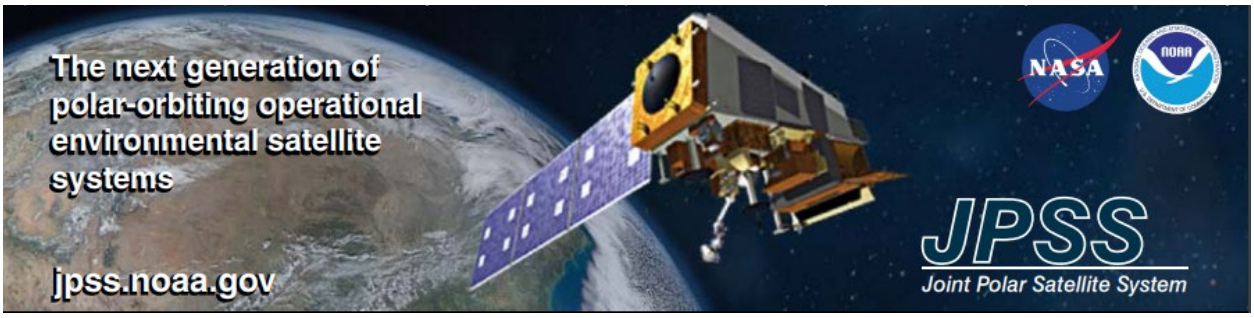


JPSS/GOES-R Proving Ground and Risk Reduction Summit

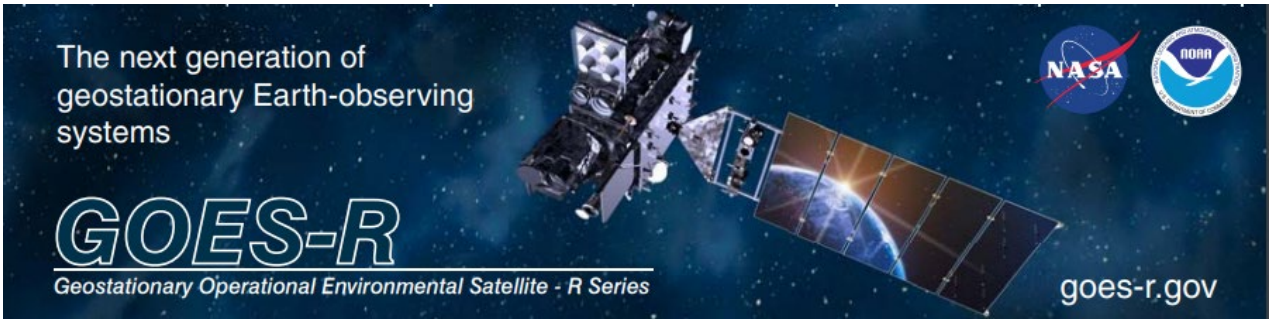
Meeting Report

NOAA Center for Weather and Climate Prediction Conference Center, College Park, Maryland
February 24-28, 2020

Summit Organizing Committee

Mitch Goldberg, Lihang Zhou, Jaime Daniels, Tom Atkins, Kat Hawley, and Dan Lindsey

Prepared for National Oceanic and Atmospheric Administration Scientists, their Collaborators, Workshop Participants and the Summit Organizing Committee.



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This report was prepared by Julie Price (Science and Technology Corporation), working for the Joint Polar Satellite System (with contributions from the Summit Organizing Committee, session moderators, and panel members).

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This report describes the proceedings from the first JPSS/GOES-R Proving Ground and Risk Reduction Summit, held 24-28 February, 2020 in College Park, Maryland. The meeting focused on delivering user-inspired science to maximize the utility of the NESDIS operational and research products. The weeklong event featured individual sessions on various proving ground initiatives. The sessions provided opportunities for algorithm developers and users to share information on ongoing activities and future needs within each product group. Additionally, poster sessions provided more opportunities for participants to present further descriptions of their work.

INTRODUCTION

Background

The National Oceanic and Atmospheric Administration (NOAA) operates a fleet of environmental satellites that provide critical observations of the Earth and space. The fleet includes Polar-orbiting Environmental Satellites (POES) in the low Earth orbit, complemented by the higher altitude Geostationary Operational Environmental Satellites (GOES).

The polar-orbiting satellites provide global daily observations and the geostationary satellites provide observations of the entire Western Hemisphere every ten minutes. Over the last 50 years, since 1960, satellites, including NOAA 20, Suomi NPP, GOES-East, GOES –West, and other stars of the fleet have enabled NOAA to closely monitor weather systems across the globe. These satellites have delivered daily data allowing for watches and warnings for all types of weather and environmental conditions, and powering forecast models. The Joint Polar Satellite System (JPSS) is a five-satellite program (two in orbit and three in production that will provide a continuous consistent record out to 2038, while the GOES-R Series is a four-satellite program (GOES-R/S/T/U) that will extend its record through 2036.

NOAA's operational and research users as well as those from other federal agencies and JPSS and GOES-R product developers met for a summit conference to discuss enhancements to mission applications and provide feedback on future satellite data and algorithm needs. The goal of NOAA's Satellite Proving Grounds is to improve NOAA Services through optimizing the use of satellite data along with other sources of data and information. The Proving Grounds leverage satellite observations to feed into services and provide benefits to stakeholders.

The JPSS/GOES-R Proving Ground and Risk Reduction Summit was held 24-28 February, 2020 in College Park, Maryland. It was designed to enable satellite scientists, data users, and algorithm developers to meet face-to-face with key partners including academic users, researchers, federal, state, and local decision makers, and other stakeholders. The Summit focused on delivering user-inspired science to maximize the utility of operational and research products from the JPSS/GOES-R programs, and informing the National Environmental Satellite, Data, and Information Service (NESDIS) about underserved user needs as it develops future architectures.

Participants

Participants included staff from: multiple federal agencies including, NOAA, NASA, Department of Agriculture (USDA), Federal Aviation Administration (FAA), Naval Research Laboratory (NRL), Air Force Weather, and Federal Emergency Management Agency (FEMA); Cooperative Institutes including CIMMS, CIRA; universities including OU, UW, GMU and CCNY; and others such as the Geographic Information Network of Alaska (GINA). Additional participants included industry and international partners.

Meeting Objective

The objective of the Summit were to bring together satellite scientists, data users, and algorithm developers and key partners — including academic users, researchers, federal, state, and local decision makers, and other stakeholders – to discuss areas of strength, opportunity and improvement across the broad array of operational and research products from the JPSS/GOES-R programs and to inform NESDIS about underserved user needs as it develops future architectures. The priorities identified and discussed at the summit, which are described in this document, also fed into calls for proposals for FY 2021-2023 under the Proving Ground and Risk Reduction (PGRR) Program.

Meeting Format

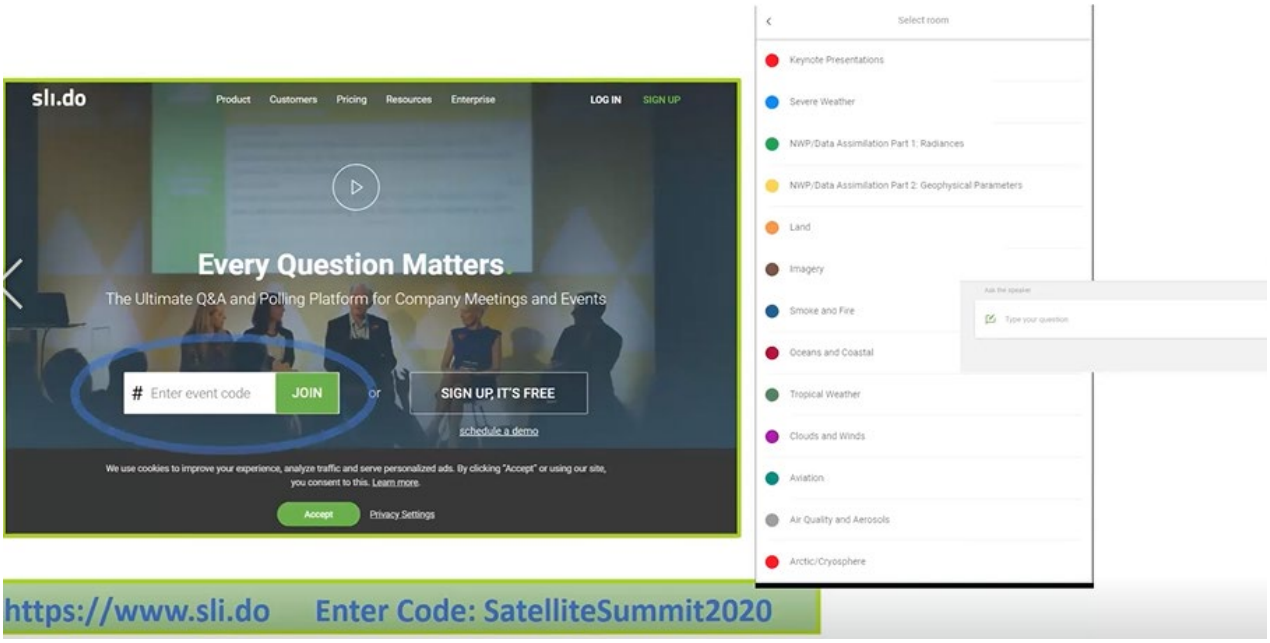
Keynote addresses and program overviews: The summit included keynote addresses and organizational and programmatic overviews. The scope emphasized how JPSS/GOES-R investments and services support the nation though NOAA's impact based decision support, community engagement, and collaborative applications.

Panel Sessions: Each session was facilitated by a moderator. Sessions were broken out by area of application and consisted of a six-person panel – comprised of three members from user communities and three members from product development communities – who provided their perspective on the tasks that they perform within their organizations.

Members of the user community discussed their areas of expertise, and identified areas of significance. In addition, they provided step-by-step approaches to decision making and task completion in their respective areas of application. Users also highlighted the issues that make their tasks time-consuming, unpredictable, and in some cases, inefficient; they described how they applied satellite data in their respective areas and offered up some ideas and suggestions on ways to improve the use of satellite data in their respective areas.

Members of the product development community described the needs their product(s) served; the status of the product's development; and future improvements to products and applications.

The session continued with in-depth open discussions between the members of the panel and stakeholders in attendance on hot topics from the session, as well as audience questions/comments via an interactive Slido poll. All relevant questions and respective answers are documented in this report.



Splinter meetings: Technical discussions took place in splinter meetings throughout the summit.

Poster sessions: Poster sessions took place on Tuesday, Wednesday, and Thursday afternoon. These sessions served as an opportunity for attendees to further discuss unmet user needs and explore current or future products. They were also an opportunity for principal investigators and/or algorithm leads or their teams to present additional technical details.

Breakout Sessions: Participants were encouraged to hold splinter group meetings for more detailed/extended discussions and collaboration.

Details from the keynote addresses and program overviews, and general sessions are also described.

	Monday 24 February	Tuesday 25 February	Wednesday 26 February	Thursday 27 February	Friday 28 February
8:30 - 10:00	Keynotes + Program Overviews I	Land Products	Tropical Weather	Arctic / Cryosphere	Special Topics
10:00 - 10:30	Break	Break	Break	Break	Break
10:30 - 12:00	Severe Weather Keynotes II	Imagery	Clouds and Winds	River Ice and Flooding	Session Summaries Closing Remarks
12:00 - 1:15	Lunch	Lunch	Lunch	Lunch	
1:15 - 2:45	NWP / Data Assimilation - Part I	Smoke and Fire	Aviation Products	Hydrology	
2:45 - 3:00	Break	Break	Break	Break	
3:00 - 4:30	NWP / Data Assimilation - Part II	Ocean and Coastal	Air Quality / Aerosols	Atmospheric Composition	
4:45 - 6:00		Poster Session 1	Poster Session 2	Poster Session 3	

Keynotes and Program Overviews

Dr. Mitch Goldberg, JPSS Program Scientist, and Dr. Dan Lindsey, GOES-R Program Scientist; served as Chair and Co-Chair, respectively, for the keynote sessions and program overviews. These sessions featured high level strategic views from a wide range of organizations. Representatives included Dr. Louis W. Uccellini, National Weather Service Director; Ellen Mecray, NOAA National Centers for Environmental Information Eastern Region Climate Services Director; Dr. Chris J. Lauer, Economist, Performance, Risk and Social Science/ Office of the Chief Financial Officer; Harry Cikanek, Director, Center for Satellite Applications and Research (STAR); Greg Mandt, Program Director, Joint Polar Satellite System; Pam Sullivan, GOES-R System Program Director; and Dr. Stephen Volz, Assistant Administrator for NOAA Satellites and Information Services.

Purpose of the Summit:
Panel discussions for wide range of applications areas with users, developers and audience to discuss needs and capabilities.
– Mitch Goldberg, Dan Lindsey, Keynotes Session Moderators

Dr. Mitch Goldberg, JPSS Program Scientist, described the proving ground and its goals. He outlined the Satellite Proving Ground goal to improve NOAA Services through optimizing the use of satellite data along with other sources of data and information. He explained that the purpose of the proving ground is to leverage satellite observations to feed into services and provide benefits to stakeholders. He stated that the whole idea is for the proving ground to develop projects to work in NOAA mission service areas to improve their applications, so they can provide better information to stakeholders. He added that the service areas are really "the gateways to the public."

Dr. Goldberg stated that the purpose of the summit was to engage users, developers and audience members in panel discussions on the needs and capabilities covering a wide range of applications areas.

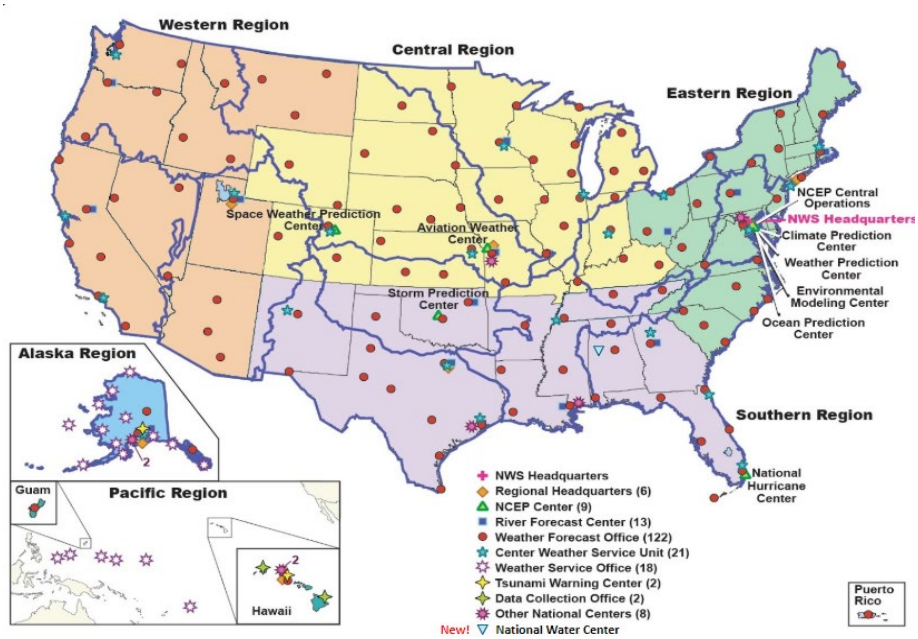
Next, the GOES-R Program Scientist, Dr. Daniel Lindsey, continued to welcome attendees and introduced the NWS Director, Dr. Louis W. Uccellini.

A Holistic View of the Use of Satellite Data in the National Weather Service

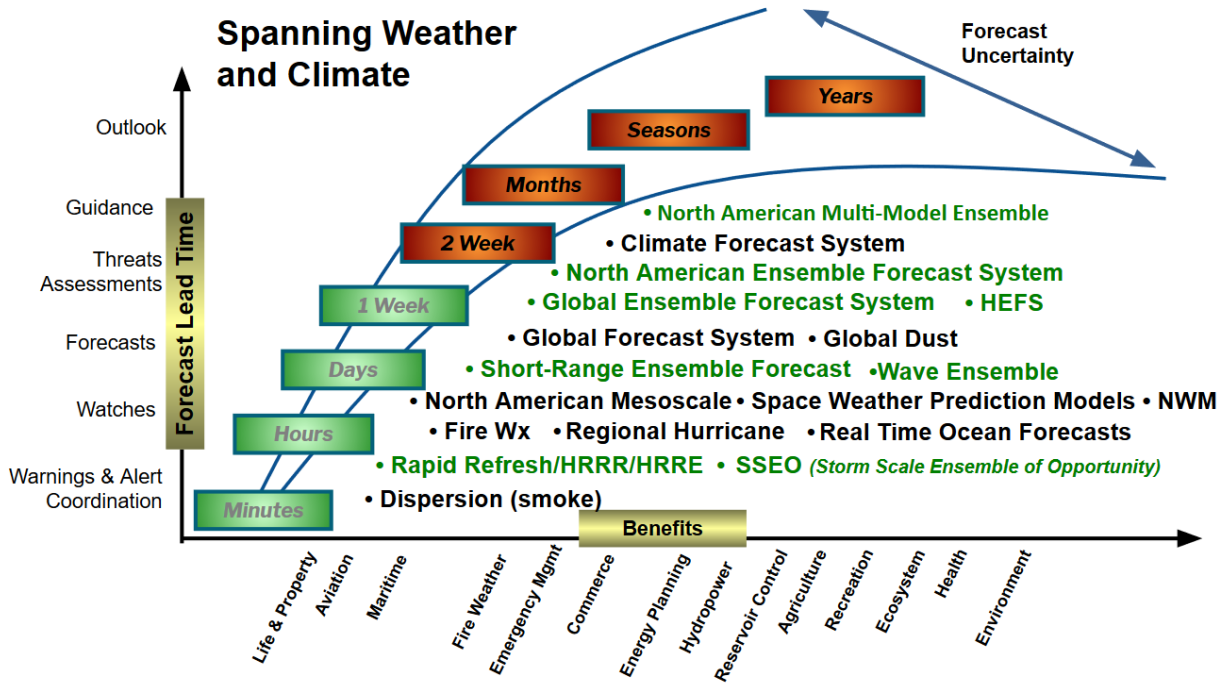
Dr. Louis W. Uccellini, NWS Director

Dr. Uccellini presented a holistic view on the use of satellite data in the NWS. He opined that the breadth and application of the NWS' mission and vision is not fully appreciated. He emphasized that the NWS mission "to provide weather, water, and seasonal data, forecasts and warnings for the protection of life and property and the enhancement of the national economy," gives a strong indication of its two-part work approach. He stated that one aspect deals with Earth systems science, the other, with service. He added that the NWS' vision for "a Weather-Ready Nation where society is prepared for and responds to weather and water events; where communities are "Ready, Responsive and Resilient," signifies the service aspect of the agency's mission statement.

The NWS consists of national and regional centers, and 122 local weather forecast offices (WFOs). To provide some perspective on the breadth of efforts the organization covers, Dr. Uccellini emphasized that it is responsible for an aerial domain space that is approximately one-third of the Earth's surface, including the North Pacific and North Atlantic oceans.



Dr. Uccellini also talked about the seamless suite of model forecasts that are presently run on 6-hour cycles, which he noted is markedly shorter than the previous 12-hour cycle runs. He stressed the importance the 6-hour cycles had on latency and how they have helped get more data into models.



Dr. Uccellini discussed the ongoing historic transition in the use of satellite data in forecast offices and models, including the shift from deterministic to multi-model ensembles. He discussed the ongoing historic transition in the use of satellite data in forecast offices and models, and in particular, the increasing blurriness between the Low Earth Orbit (LEO) and geostationary (GEO) missions. He said that LEO has traditionally served global NWP modeling, whereas GEO serves short-term forecasting, nowcasting and warning, situational awareness. He noted that this application gulf is blurring as GEO data is now being used in models, and forecasters are increasingly adopting LEO in day-to-day operations. He also spoke on ongoing and upcoming advancements in satellite product development including blended products such as the flood monitoring product, which was originally developed for the Visible Infrared Imaging Radiometer Suite (VIIRS), but expanded to a combined VIIRS/ Advanced Baseline Imager (ABI) product, as well as blended SST, TPW, among many other products. He gave examples of high-resolution models (RAP and HRRR) and the impact of their output in various areas of application, especially regional models with more stringent latency requirements. Beyond NWP models, Dr. Uccellini gave examples of inputs that have enhanced the spectral and spatial resolution of the earth system, including satellite-derived soundings (convective destabilization); high-resolution nighttime visible imagery (fog); ozone sensing of aerosols and volcanic emissions (air quality); passive microwave cloud and precipitation detection (hurricanes); and improved monitoring of the arctic (river ice and flooding). He reflected upon latency in the transmission of all satellite data to the users, noting the more that GEO & LEO satellites are used for situational awareness, the more the demand will be to reduce latency from hours/minutes to minutes/seconds.

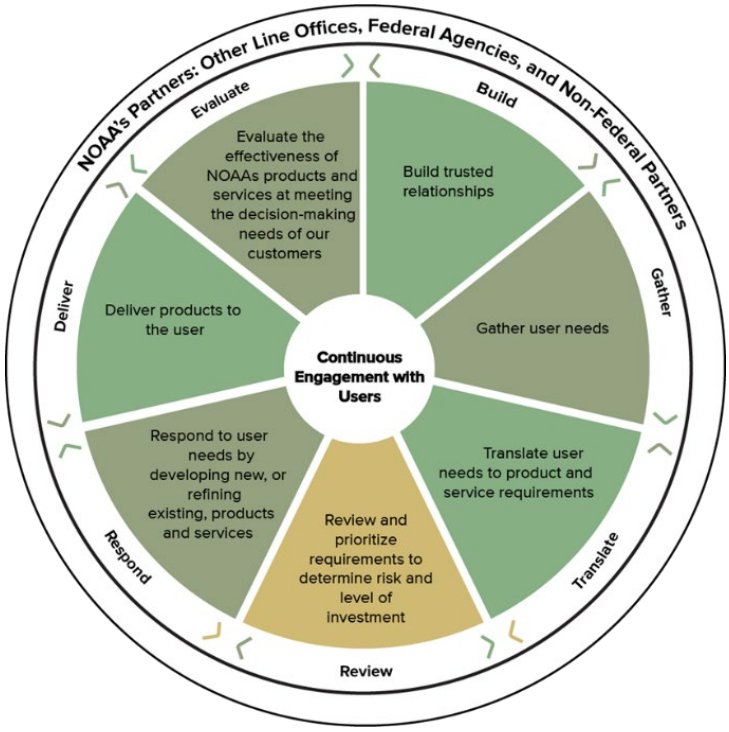
He concluded his talk with some reflections beginning with Verner Suomi's vision for, and scientific contributions in, the use of satellites for meteorological research and real-time access for operational applications. He pointed out that even though this historic journey has been 60+ years in the making, we are just scratching the surface. He emphasized that the biggest next step is the GEO hyperspectral sounder! Which is bound to address the high resolution ΔT opportunity observed across the entire Earth

System. He pointed out that the United States has scaled back its role on the world stage, and needs to reassert its past leadership position as Europe and Asia are leading the effort to launch and operate Geostationary Sounders.

Decision Support at Regional Scales: Connecting Products and Technologies to User Needs in a NOAA Services Framework

Ellen Mecray, NCEI Regional Climate Services

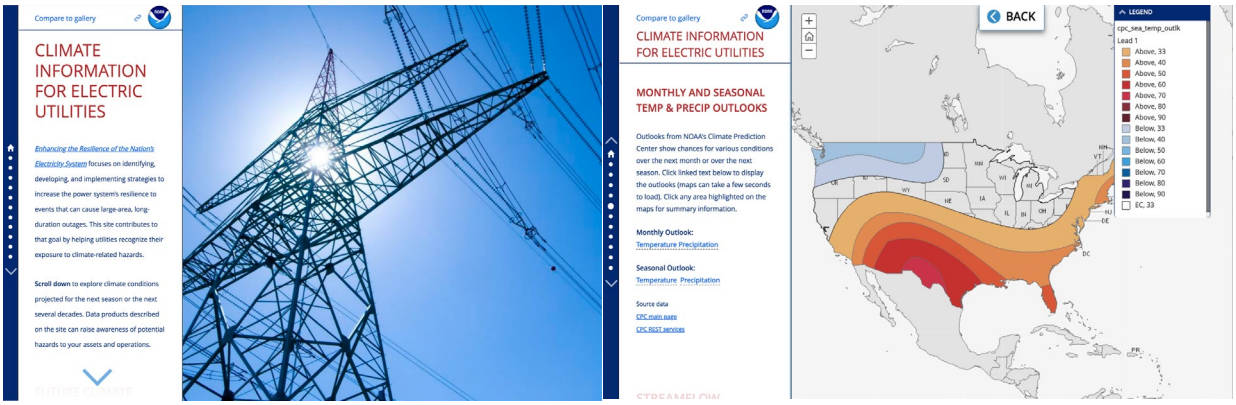
Ms. Mecray's talk centered upon the rising demand for NOAA's environmental information to meet various societal challenges including climate and weather extremes, for example icing, wind and heat events, impacts on water resources leading to events such as flooding and drought. She talked about the breadth of NOAA's information and gave examples of its application in various sectors including agriculture, energy, health, transportation and marine ecosystems. She cited the need for an integrated service delivery and decision support mechanism in NOAA that carefully leverages partnerships and informs the development of use-inspired products and services. Specifically, a timely effort meant to best serve NOAA's customers, particularly under changing weather, water, and climate conditions.



Ms. Mecray noted that many NOAA organizations engage in customer engagement/service delivery. However, each had their own methods of operation and objectives. Ms. Mecray talked about a service delivery framework built around a mission objective for NOAA to "build a network of trusted agents who engage internally and with partners to inform NOAA's product and service development to be useful, usable, and used." She presented the service delivery model highlighting its user-focused, iterative, interconnected process. The Dotted lines represent porous two-way communication.

Ms. Mecray touched upon NOAA's Services Enterprise, noting that it connects science, services and people. Specifically, she noted that NOAA has a long standing history of regional climate science and service, as well as extensive service delivery capacity.

She highlighted some of NOAA's investments in regional service delivery in sectors such as transportation and energy. For example, for the energy sector she stated that NOAA is working in a government to government relationship to offer weather and climate information to meet the requirements of the Department of Energy (DOE) and its core partners. Sample frames from the Story Map - http://arcg.is/1jOLCb shown on the next page.



Ms. Mecray concluded her presentation with a brief discussion on readiness levels. She encouraged the inclusion of user engagement, which nurtures relationships based on a foundation of trust and mutual respect, as the impetus. User engagement ensures "co-production with the user community through each phase." Ms. Mecray further pointed out that user requirements are derived from an understanding of their decision challenges, and more importantly, that timely response to their requirements form the basis of ongoing engagement and use-inspired product improvement.

The Value of Satellite Data

Chris Lauer, NOAA Office of the CFO

The session continued with a talk on the value of satellite data from Dr. Chris Lauer, NOAA Office of the CFO.

Dr. Lauer's talk focused on three issues: the importance of measuring benefits; the value satellite data creates; and, current valuation efforts at NOAA.

Dr. Lauer noted the importance valuation had on understanding the impact of past investments, justifying budget requests for future investments, and aligning agency operation and investments with public value.

When considering how satellite data creates value, he mentioned cost effective ways to increase benefits of environmental data (Williamson et al 2002), investments in understanding user communities, and improving the flow of information. He noted that data have value when they are used in decision making. If not, then the economic value of such data/information is effectively zero.

Dr. Lauer posed the following key questions:

- What do we produce?
- Who uses it?
- What gets better and how much?

He stated that significant collaboration (which is illustrated in the figure shown on the next page) is required to answer these questions.

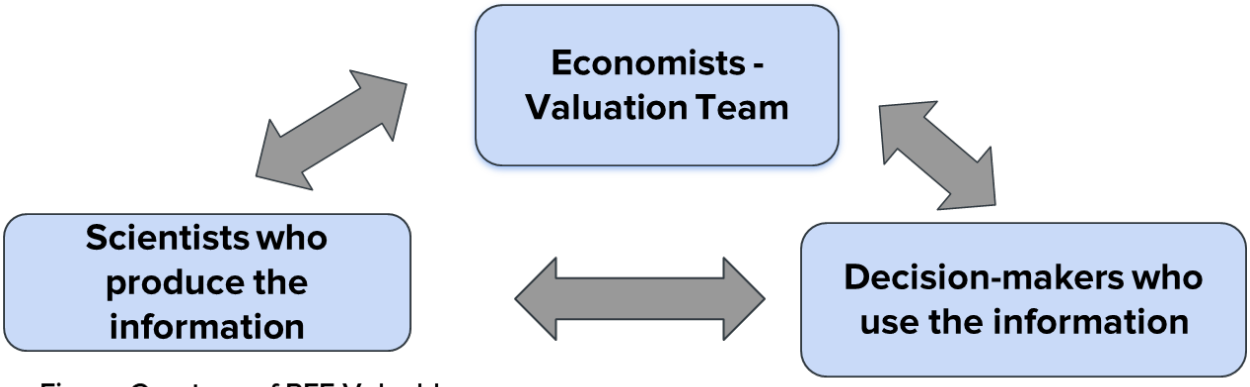


Figure Courtesy of RFF Valuables

The value chain for NOAA's weather, climate, and observational products and services. He described the value chain as a tool for analysis of linkage between all activities that lead to creation of value. He added that it is useful as a communication tool, and that it creates a common understanding of the value creation process.

Dr. Lauer also touched briefly on current valuation and customer engagement efforts at NOAA, providing several examples including studies ta NESDIS on: the impact of Space Weather; GOES-R Improvements Valuation; and the benefits of hyperspectral sounders. And, GEO-XO planning, TPIO NOSIA refresh and user engagement, as well as NCEI Customer Engagement. He also presented examples of other satellite related valuation work, including the NWS IDSS study, Social Coast valuation study, IOOS user survey, and OAR funded studies of value for severe weather forecasts.

Dr. Lauer concluded his talk with a summary of key points. Specifically, he noted:

- Valuation work can help NOAA organizations better serve their user communities.
- This requires knowing their users and investing in collecting data about them.
- Value chains can help identify product inputs and user decisions.
- Collaboration between information providers, users and economists is crucial for valuation efforts.

STAR Introduction

Harry Cikanek, STAR

Mr. Cikanek, Director STAR, discussed the value of the information that NOAA provides as well as the value of the instruments, which gather the information. He noted the NESDIS mission requirement to provide secure and timely access to global environmental data and information from satellites and other sources to promote and protect the Nation's security, environment, economy, and quality of life. He pointed out that as part of a bigger system (the Global Observing System), NOAA has an objective to deliver weather information to the global community. Mr. Cikanek pointed to some changes, which have provided an impetus for an integrated capability to deliver environmental information to the world, including an unprecedented pace of technological advancements, increasing environmental challenges as well as demands for more data and faster.

The Joint Polar Satellite System

Greg Mandt, Program Director

The session continued with Mr. Greg Mandt, the JPSS Program Director briefing on the JPSS suite of satellites and the successes in the PGRR Program. He began with an overview of JPSS, which will provide a continuous on-orbit presence from 2011 through 2038. He pointed out that the current focus of JPSS is on increasing data availability through the launch of JPSS-2, and supporting partner missions.

Mr. Mandt stated that the JPSS instruments are a rich source of information that allow for the provision and improvement of NOAA and partner services. He gave brief overviews of instruments including: ATMS, which gives all sky soundings, as well as precipitation and cryosphere measurements; CrIS, which gives higher vertical resolution soundings plus trace gases like carbon monoxide from wildfires; VIIRS, which provides global imagery and helps monitor the ocean, cryosphere, land and aerosols, as well as providing the unique day night band; and OMPS, which monitors ozone. He emphasized that the JPSS Program has been successful in creating and improving NOAA and partner services through the Proving Grounds.

"The Proving Grounds," he said, are designed to "improve NOAA services by facilitating collaboration between users and product developers to optimize the use of satellite data." He stated that their success is achieved by setting clear objectives, holding frequent interactions with stakeholders and users, and transitioning experimental products to operations. He provided examples of useful and usable innovative products from JPSS that were developed, in part, in response to consumer requests.

Mr. Mandt pointed out that direct broadcast – a pathway for faster delivery of data to users – is a vital conduit for the PGRR to demonstrate the value of regional applications, the distribution of very low latency JPSS products to NWS, and evaluate the impact of reductions in latency.

He concluded his talk by noting that the stability and longevity of the JPSS constellation will allow for testing of new architecture concepts, including smallsats, to supplement the JPSS constellation and continue to optimize satellite data products to meet user needs.

GOES-R and Geostationary and Extended Orbits (GEO-XO)

Pam Sullivan, Program Director

Ms. Sullivan presented updates of GOES-16 and -17. She stated that GOES-16 has been in operational service as GOES East since December 2017, while GOES-17 has been in operational service as GOES West since February 2019. She noted that both satellites 17 transitioned to 10-minute full disk cadence on April 2, 2019. She added that all data products were in operational use, at provisional or full maturity level, while new data products were in development, and many more new products were being researched.

She also gave updates on the status of follow-on satellites GOES-T and –U. She stated that, as of the time of the meeting, the GOES-T spacecraft is assembled and awaiting delivery of the ABI and Geostationary Lightning Mapper (GLM). The spacecraft is expected to launch in December 2021 on the Atlas V-541 launch vehicle provided by United Launch Alliance (ULA). The GOES-U satellite is planned to launch in 2024, she reported that integration is underway, including modifications to add the Compact Coronagraph (CCOR) coronal mass ejection detection instrument, which completed its Critical Design Review (CDR) in June.

She gave a brief introduction of the Geostationary and Extended Orbits (GEO-XO) missions to follow GOES-R and Space Weather Follow-On (SWFO) mission. The GEO-XO missions are expected to operate in the 2030-2050 timeframe. She noted that the missions will provide continuity for observations from GEO and Sun-Earth L1, and potentially expand into new areas including the highly elliptical "Tundra" and L5 orbits. The missions will employ government spacecraft including all NOAA assets deployed above LEO, instruments or payloads hosted on commercial or partner spacecraft, and potential commercial services and observational data.

Ms. Sullivan concluded with some plans for the GEO-XO within the next year, including a defined plan for formulation, industry studies and user engagement.

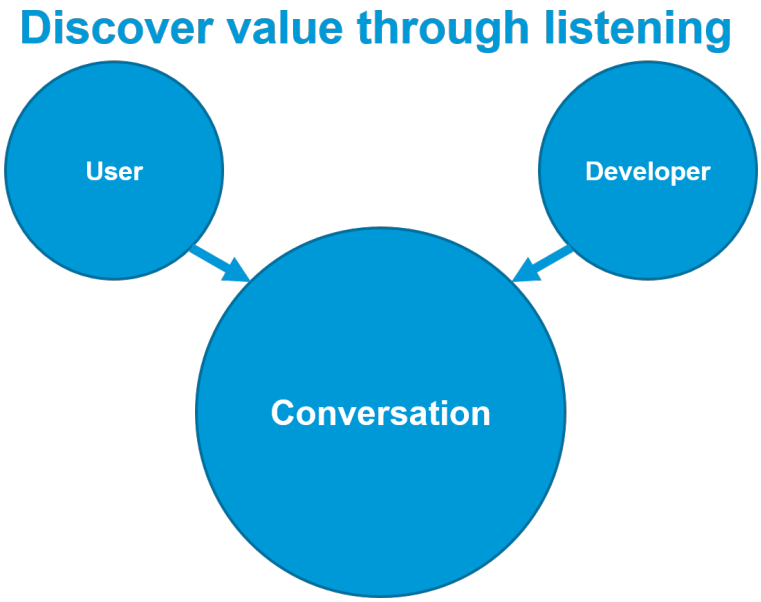
Keynote Presentation

Steve Volz, Assistant Administrator for NOAA Satellites and Information Services

Keynote presentation

The final Keynote presentation was given by the Assistant Administrator for NOAA Satellites and Information Services, Dr. Steve Volz. He emphasized the NESDIS aspiration to provide "a truly integrated digital understanding of our Earth environment that can evolve quickly to meet changing user expectations by leveraging our own capabilities and partnerships."

He explained that no one satellite was capable of addressing all the needs of all users over multiple ranges of time (for example, from minutes to days to centuries) and space (from meters to kilometers to global). And, added that the overall constellation of Earth observations can and should be taped into, and utilized to address all of these needs, and in different ways. He further emphasized that an integrated Earth observation system and Earth system model would offer a scalable and variable method to address user needs across the whole spectrum of applications.



Dr. Volz concluded with a comment on how instrumental dialogues, particularly those between product developers and users, were in helping to quantify the value of NOAA's work. He specifically pointed out the crucial role listening had in facilitating the discovery of NOAA's value.

Questions/Discussion

Dan Lindsey

Following the keynote presentations, Dr. Daniel Lindsey, the GOES-R Program Scientist and Summit Co-chair, provided a summary of the talks. He started off with the tone-setting question: If we cannot quantify the impact of what we do, what is the value of what we do?

Dr. Lindsey stated that impact quantification is an essential element of NOAA's, yet it is really hard to do. He explained that quantifying the impact of NOAA efforts is difficult because one can't easily put metrics into an equation to spit out a dollar value for every measurement and its impact score. He also underlined that NOAA's efforts do not and cannot "wait for an algorithm that shows what the impacts are before continuing to do work." Adding to this, he said that NOAA missions serve many different purposes, different customer bases, users, stakeholders, etc. He stated that NOAA has a science objective and science mission to achieve and accomplish, for example delivering environmental or climate data records, or climate information for the world that would be useful to current and future generations. He also pointed out that there are mission objectives where impact is defined by someone else, as well as service and community objectives for the user base for example NCEI and NOAA CFO, whereby the value of what NOAA does is demonstrated through the impact of, and successes from, its work on individuals and society as a whole.

He pointed out that there are remarkable examples from the JPSS and GOES-R Proving Grounds of products that were not necessarily in the mission requirement set, some five, ten or even 20 years ago. A big part of this, Dr. Lindsey said, was through feedback, and through working with user communities and having people working down in the community, which provided information on possible undertakings as well as those that would be useful to undertake. He stated that the Proving Grounds have been very effectual. Still he put forward the question whether the integrated JPSS and GOES-R yearly meeting was a sufficient path forward. Dr. Lindsey stated that in his view, it was an excellent start, but it was not enough.

He noted the need for integration, particularly as environmental challenges and the ways to address them continue to grow over the future. He stated that the importance of integration was highlighted throughout the keynote talks, and especially in Mr. Cikanek's talk. He added that imagery, such as that shown in Ms. Pam Sullivan's introductory presentation slide – which was derived from the Japanese Himawari 8 and the U.S. GOES-17 satellites – also emphasized the importance of integration. He echoed the opinions of previous speakers that the biggest challenge of our time is to understand how the Earth works as a system and how each piece fits into the overall system, specifically, the need to understand how an impact or effect in one area of the environment is felt in many other areas. He emphasized that "as we start to change, adjust, mitigate and improve we have to be really sensitive to how all these pieces fit together."

He also commented on changes that have been occurring in NESDIS over the past year leading to a reframing of the challenges going forward. The objective now is not to only provide more and better data for weather and services, but to pull together a truly integrated digital understanding of the Earth, and the environment, and that evolves quickly to the changes and expectations in the environment, and communities, and takes advantage of not only the nation's satellites but those of other nations too. He also noted that it should also take advantage of ground instruments, improved models, questions that were not even thought of a decade ago that we need to be ready for so that the system is ready to adapt.

He highlighted the importance of bringing together satellite and in situ datasets in an interoperable and functional way so that users have access to them on a regular basis. He emphasized that more data is not always the answer, but better information is, and that the summit by was a great step in heading towards that direction as it sought answers to questions including:

- *what can we do?*
- *what should we do?*
- *what should we provide and what products should be produced?*
- *who do we work with on a regular basis?*

Following Dr. Lindsey's presentation, participants had the opportunity to ask questions. Key questions and answers are presented in the following section:

Question	**Answer**
How can NWS dramatically increase the availability and greatly reduce the latency of JPSS data before the next generation of polar satellites?	There is a university network of direct broadcast stations. What would be helpful for us to know is whether these are adequate or should be push for more. Additionally there is an explosion of smallsats from commercial entities. This is an area we can explore to see whether we can tap into and get even faster latency.
How can GOESR update the algorithms for 16 and 17 more quickly?	We have several cloud project underway. The long-term goal is to get everybody into the cloud.
Dr. Volz, what is your response to NWS Director's comment that in the satellite arena we (US) have become followers and no longer leading.	We have been pioneering observations for decades. We are now operating in a competitive Earth observations environment. Yes, the Europeans will be flying the hyperspectral geo sounder in the 2022-23 timeframe, but I wouldn't say that we are behind in the satellite arena. When it comes to individual measurements we are flying some of the best in the world. One of the best things we have is collaboration with our international partners. Bringing in those extra datasets will be a great value added. We are leading in how we integrate the data, how we look at our integrated observing systems, how we merge data products, how we provide GEO-LEO merging, how we do proving ground demonstrations. So while we may not be the first ones to have a geo sounder in space, we will be among the first in using the sounder data effectively.

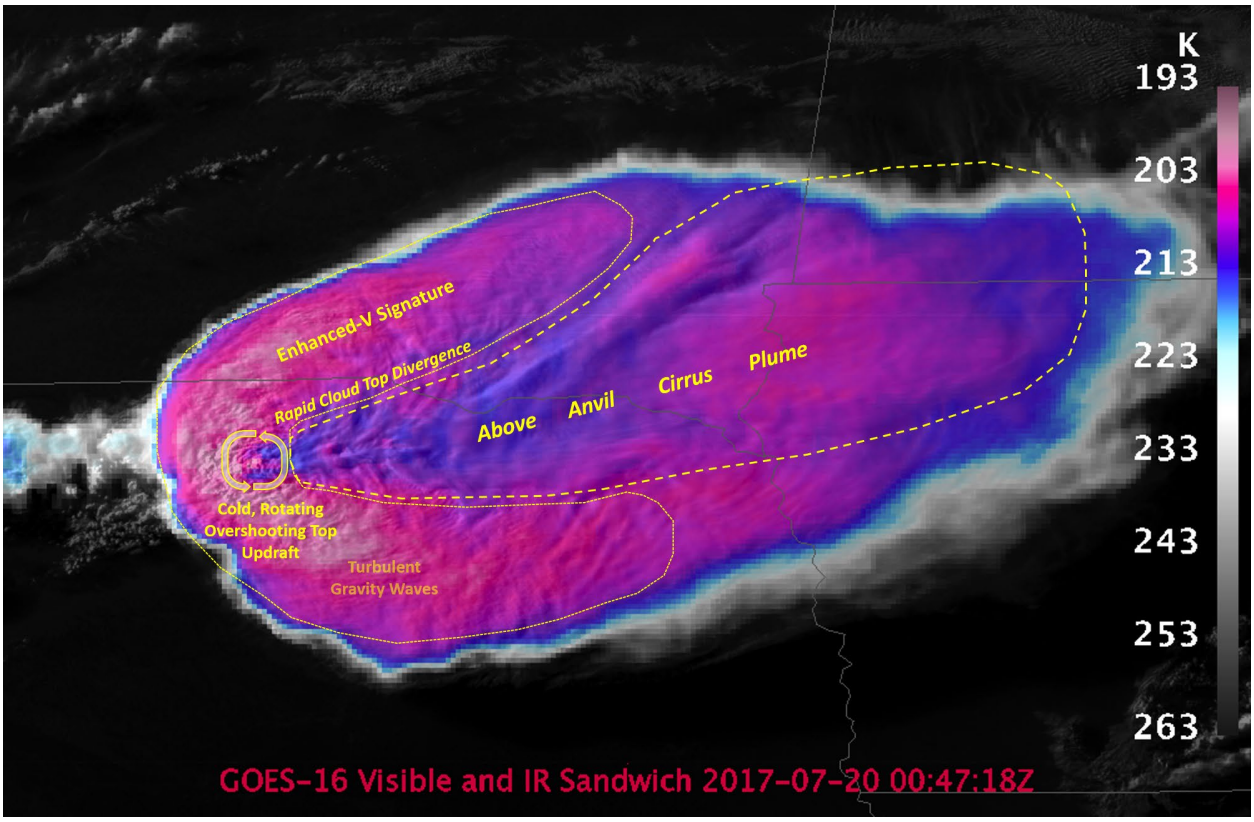
Users probably don't know today what they will need 10 years from now. How can we develop systems and budget plans that are agile?	1. I was thinking about the readiness levels and saying that it would be great to go back to users periodically but it's difficult when things are baked in. How can we fill that gap? Maybe this is an opportunity for smallsats to think about gathering those needs from users then being able to use the smallsats to fill that space. 2. Another thing might be a completely different visionary exercise and maybe look and think forward and imagine how the future can be and try and stretch things that way. 3. One of the things we are doing in NESDIS is moving into a ground system capability that is more agile i.e., cloud based type architecture. On the user side they are moving more towards full Earth system prediction and looking into more continuous integration of datasets into the models. 4. In the budget plans we have to start moving more towards a portfolio approach. We have to change the way we structure our product requirements and so forth to allow for continuous improvement, agility and flexibility to be able to respond to the needs of users. 5. Next, as are we doing in this workshop, we have to integrate between users and providers so that we get a constant communication between the critical issues and problems that need to be solved to help figure out the right roadmaps and priorities to go down to best optimize the resources we have that derive the best benefits for all those missions. 6. While we may not know exactly the next questions the user communities may have fine or ten years from now, there are certain trends which are

	irrepetible and clearly indicated and we have to invest in, including greater integration of all datasets, greater accessibility of all data even from disparate observing systems (in situ, in the ocean, satellite, airborne, etc.) so that they data are all available and readily useful. These are trends that are only going to make the answers more powerful to the questions that are raised. And any challenge and solution that we are given and give in the coming years will require access to quality validated/calibrated data, long term data records all in a form and format that can be used without having to move massive amounts of data around.
How does NESDIS 'hit the pause button' and truly integrate its satellite program. The current mission plans seemed etched in stone.	We can't really hit the pause button. What we can do is adjust and adapt. It's not easy to do but it is appropriate. What we do is make adjustments and significant investments about what products we produce. The new satellite constellation approach allows us to, with a relative small investment, get new measurements up in space which complement the ones that we have. So we are augmenting and not replacing right away.
Chris, from your outside perspective (economics) on satellites is there a valuation area we could best direct our efforts?	One of the real challenges of doing valuation work for satellite data is that value is created all throughout the process of generating observables, running the models and so forth. But it is realized with the end users. The richest areas of really understanding the value of satellite data is actually in other groups outside of NESDIS. There are some cases where it is really clear that satellite data (with or without it) really
Can JPSS maintain data flow from 3 satellites at once to support NWSFO uses? More observations close in time has its advantages.	Right now the ground system hardware is designed to handle three. However that means two in orbit and one preparing to launch. We are moving our level 1 processing to the cloud, and hopefully by then the level 2 processing will be there. We are working to get the data processing system to the cloud. This will make it

	easier to assess the cost and implementation. With respect to flying the limitation is that OSPO would have trouble manning three. We are trying to look at ways to make devOps environment for manned control. That would let us take more risk in operating it in a research type mode where the developers could support it and learn how they can modify operations based on that.
What is the status of adding a synthetic green channel to the GOES R/S Ground system and the ABIs for T and U?	The ABI design is fixed. The optical channels are fixed. Dr. Steve Miller has developed a geo color algorithm and it does create a synthetic green band. However it is experimental. So the question may be asking how we can transition that or something like it into ground operations. This is where we need users to tell us how they are applying the product and what is the impact. If that can be articulated well by the user community, then it allows us quantify, invest, reinvest or prioritize based on their testimonials.

Severe Weather

Moderator: Bill Line, STAR



Severe thunderstorms pose a significant threat to public safety throughout the United States, including property damage, serious injuries, and loss of life. When sufficient lead-time is given to the communities facing potential thunderstorm impacts, actions can be taken to lessen the risk of life and property loss. For high impact and rapidly evolving severe weather events, an accurate and prompt forecast can make the difference between life and death. GOES-R and JPSS satellites provide forecasters with information needed to provide the public with timely and accurate forecasts and warnings of severe weather.

1) Session Purpose

a) The severe weather session brought together three operational users of satellite data during severe weather situations, and three developers of satellite-based tools and applications that have the potential to aid users during severe weather events. The users highlighted some of the key challenges they face during severe weather operations (both meteorological and software/hardware related), and how satellite-based products are currently used during such situations. They also presented items and improvements they'd like to see from the satellite community that may address some of their needs. The developers introduced both recently developed and future satellite products that have the potential to aid forecasters during severe weather operations. A discussion between the two groups and the audience followed, and expanded upon the above topics.

2) Agenda

Presentation	Speaker	Affiliation
Severe Weather Applications: A SPC Perspective	Michael Bowlan	CIMMS/HWT/SPC
NWS Regional Support of Integrating Satellite Data for Severe Weather	Chad Gravelle	NWS SRH
Severe Weather Applications: A WFO User Perspective	Chauncy Schultz	NWS WFO BIS
Adapting Satellite Soundings for Operational Forecasting	Rebekah Esmaili	STC
Analysis and Detection of Hazardous Thunderstorms Through Remote Sensing Data Fusion	Kris Bedka	NASA
Geostationary Lightning Mapper Update and Applications	Scott Rudlosky	STAR

3) Key Takeaways

a) Users and Developers

i) Forecasters face information overload, especially during severe weather operations. However, if they find a new tool to be useful, they will fit it into their operational procedures

ii) Satellite data is vital for successful severe weather forecasts and warnings, from days out to convective initiation to decay

iii) Strong indicators of a severe storm are routinely present in imagery. Recent automated analyses have quantified the importance of these features

iv) Successful product development and implementation requires interaction between developer and user throughout the development and testing process

v) Testbeds and Proving Grounds are needed in order to research and develop topics/tools most relevant to NWS operations

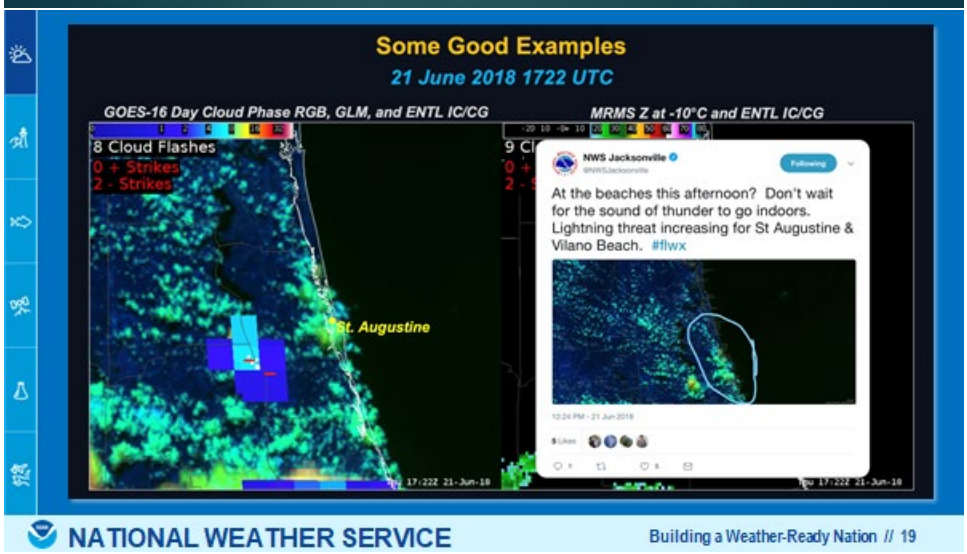
vi) Sharing of satellite-related use cases and best practices through blogs, webinars, meetings, etc. is valuable to both the end-user and developer

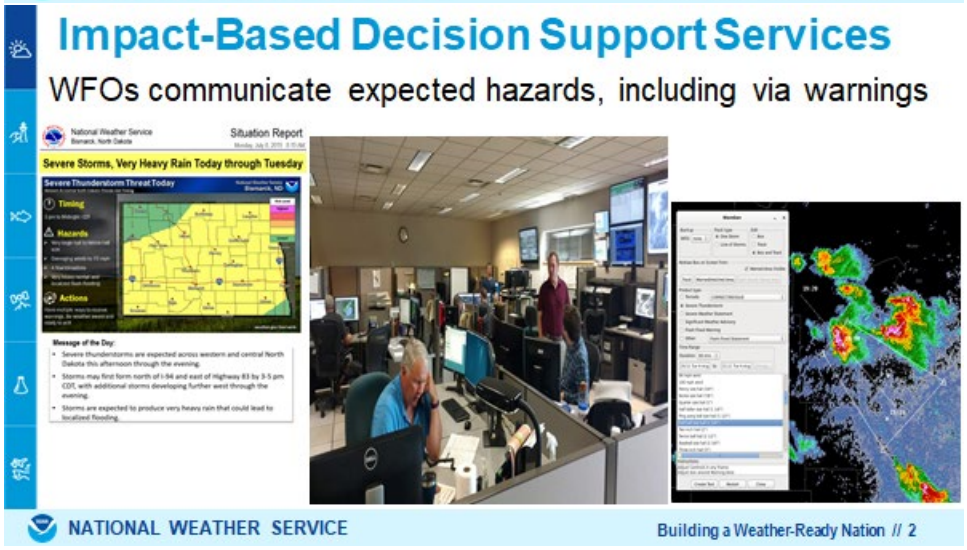
vii) Impact-based Decision Support Services (IDSS) is now and will continue to be a very important part of NWS operations. It is important developers understand this service, and keep this in mind as they develop new tools and applications

4) Graphics

SPC Operational Challenges and Opportunities for Improvement

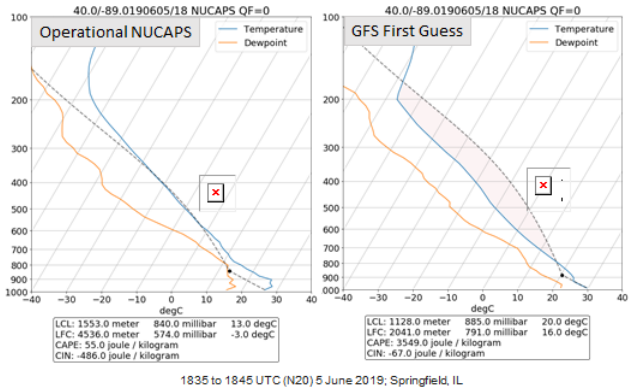
- Still using NAWIPS to issue products and many satellite products are not currently available on SPC NAWIPS or are degraded somewhat by limited color availability
  - Satellite Derived Winds, GLM Products, RGBs, TPW etc...
- Information overload can occur with many areas to monitor nationally
- Being able to see through or more easily detect multiple cloud layers
- Satellite soundings that adequately depict the boundary layer for data sparse regions to compare to model soundings
- Low-Level Water Vapor retrievals closer to the surface
- Cloud top delta T product tracking features
- Pre-cloud glaciation products





Future Improvement: **Better boundary layer**

- CAPE values too low in left retrieval
- Re-ran retrieval with GFS as the first guess
- → CAPE values significantly improved due to more realistic boundary layer



1835 to 1845 UTC (N20) 5 June 2019; Springfield, IL

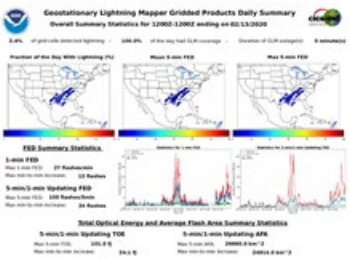
2/24/20 Visit https://weather.msfc.nasa.gov/nucaps 7

Key Findings From Recent Research

- Analysis of over 8000 storms revealed that, on average, tornadic storm updrafts are more intense than those within other storm types based on almost every radar, lightning, and satellite-derived metric (Sandmael et al. 2019)
- Storm top divergence and rotation can be retrieved from 1-min GEO data, and these properties are closely linked to storm updraft evolution and severity (Apke et al. 2016, 2018)
- Quantification of visible texture is better linked to above-anvil radar echo penetration than IR temperature patterns (Bedka and Khlopenkov 2016; Sandmael et al. 2019)
- The combination of tropopause-relative IR temp, storm-top divergence, above anvil cirrus plume presence, and ENTLN lightning flash rate combined with NEXRAD-derived indicators can improve severe storm detection beyond NEXRAD alone (Mecikalski et al. 2020)
- Assimilation of GOES cloud water path retrievals within the NSSL WRF model improved severe storm forecasts (Jones et al. 2016; Skinner et al. 2018)
- Aircraft ice crystal icing (ICI) conditions most often occur in cold, optically thick cloud within 40 km of an overshooting cloud top (Yost et al. 2018; Bedka et al. 2019). Automated overshooting top and ICI detection products were very well received by NOAA Southern Region CWSU forecasters during an evaluation conducted in Spring 2019 by NASA SPoRT.
- Overshooting top climatologies derived from GEO data have been extremely useful for determining regions most often impacted by hazardous storms across the world (Punge et al. 2017; Thiery et al. 2017; Bedka et al. 2018)
- Based on analysis of 1-min GOES-14/16 data, nearly 60% of storms that generated an above anvil cirrus plume were responsible for reported severe weather (Bedka et al. 2015, 2018)

GLM Outreach

- **Aim to promote proper use and interpretation (e.g., new visualization website)**
  - https://lightning.umd.edu/glm/
- **NWS VLab Webpage**
  - https://vlab.ncep.noaa.gov/web/geostationary-lightning-mapper



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5) Questions/Answers

Question	Answer
Michael, do spc forecasters view GLM lightning data? Does it provide them valuable information they aren't already getting from ground based lightning networks?	Not right now, as GLM is not available in the operational NAWIPS system. However, they are close to getting GLM working in this system.
All: Given the successes with NUCAPS Can Chauncey or others comment on the expectations for GEO hyperspectral sounder obs/products for severe storm forecasting?	GEO sounders would allow users to see changes in space and time. In addition to providing more atmospheric profiles to improve pre-convective monitoring, additional soundings in time could lead to the development of automated hazard detection. Such a product can alert forecasters when pockets of instability develop in their focus area, which can assist with the burden of data overload on the forecasters.
Michael: Is there a plan for SPC to transition from NAWIPS to AWIPS?	There are plans to transition, but not in the immediate future. There is one AWIPS machine at each workstation, but it is not used often. Forecasters issue all of their products using NAWIPS, so they are viewing most of their data in NAWIPS. Therefore, if a forecaster is to view a product routinely, it should be in NAWIPS currently.
Chauncey and Scott: Pls tell us more about what you would like in a GLM product to assist in tracking “lightning jumps”	Scott discussed how this capability is built into ProbSevere Chauncy: It would be very useful to have a gridded product highlighting storms that have displayed a significant upward trend in GLM flash extent density in the recent past in order to assist with forecaster situational awareness. It’s true that this is also built into ProbSevere which forecasters make heavy use of, but it might be nice to independently view jump imagery, as well.
Chad: How does the NWS Southern Region communicate with its individual WFOs on satellite issues	Primarily via NWSchat
Chauncy and Rebekah: It seemed like the NUCAPS missed the inverted V signal in the sounding. Isn’t that important?	Chauncy: This is very important, however there are features above the boundary layer that are relevant to the forecaster that are captured by NUCAPS. Ideally, NUCAPS could capture features closer to the surface routinely, but we understand the capabilities and limitation of the tool Rebekah: We have examples of where NUCAPS did capture inversions and some finer features. So, NUCAPS can capture medium to large structure, particularly closer to nadir. Having more profiles (from existing satellite platforms or from a future GEO sounder) would mean that the following overpass may capture these details. However, NUCAPS is (at best) a 50km diameter retrieval and soundings are volume measurements, they will never look exactly like a “point” observation in a RAOB.

Chauncy: Can you give an example of recent IDSS your office provided, and how satellite data was utilized to provide the service? How could satellite imagery/products/applications be improved to better serve the IDSS mission	A great example of this is from a high-end severe weather day, when our office conducted a short-notice conference call with our broadcast meteorologist partners and emergency managers to provide them detailed information on expected storm evolution in the next few hours. We used satellite imagery extensively to assist with this as we could determine the most likely areas of convective initiation using trends in visible images that showed cirrus (implying approaching deep-layer ascent/cooling) and areas of enhanced cumulus, along with other products. Satellite products could be improved to help us provide IDSS by drawing out features of particular interest while sticking to the highest-possible spatiotemporal resolution. The success of RGBs is a great example of the type of product that can help us provide IDSS. More pointedly, perhaps similar types of imagery using water vapor channels would help us identify shortwaves and other features of interest, too.
Users: Can you summarize the extent to which GOES derived products are utilized in operations? What are some characteristics that make for a successful product?	Pretty much none at all currently at SPC in severe operations at least. Some of the fire products do get looked at on the fire weather desk occasionally but the others not so much. Primarily it is again related to none of those products being currently available in NAWIPS. I do think that the winds, and TPW would begin to be used by some if they were available on their operational system.
Michael: Does SPC have access to NUCAPS soundings? If so, how often are they utilized and how?	Currently, the only access to NUCAPS soundings at SPC is the operational version in AWIPS. As stated earlier, forecasters rarely look at anything in AWIPS currently since their products are issued in NAWIPS. As NUCAPS currently is, they do not get any use in SPC operations due mainly to the boundary layer issues and latency. Forecasters are clamoring for more observed soundings, so if the boundary layer can become more realistic for convective weather and the soundings can get in front of the forecaster in 30 minutes or so then they would see greater use. They also should continue to pursue other methods of displaying the data than AWIPS NSHARP as it has many shortcomings that forecasters do not like and therefore do not use. Pursuing getting these in SHARpy or something of the like would be more desirable.
Developers: What are your most significant challenges when developing products to serve user needs, and how do you think these challenges could be alleviated?	Rebekah: One challenge is making progress to retrieval algorithms with the user in mind, rather than developing in isolation. Forums such as this summit, the hazardous weather testbed, and directly talking to forecasters improve communication channels. This leads to research that is relevant to NWS operations.
Kris: There is not an overshooting top product from GOES-R because forecasters can use their eyes on the VIS/IR	Chauncy: That's a good question. It's possible they're missing some overshooting tops on a really busy or messy convective day, I suppose. However, in general I think that they are catching them, and since they are viewing the data at its native resolution rather than perhaps a blockier overshooting top product, they may

imagery. What are forecasters missing without it?	actually be getting more out of looking at the VIS/IR imagery with their eyes. They can see and appreciate the full texture and other characteristics of the overshooting tops and related updrafts and inflow-region storm-scale features by viewing the VIS/IR imagery rather than a derived product. It may seem counterintuitive, but forecasters may actually benefit from a workload perspective by viewing the VIS/IR imagery because they need to view that imagery to pick out other mesoscale features anyway, so adding an overshooting top product would actually add an image for them to look at. Of course, we don't have the overshooting top product, so maybe it would be more useful than we think! Kris: If one is focused on a particular WFO sized domain and there are just a few storms, then a forecaster could conceivably monitor individual overshooting tops (OTs) throughout their lifetime. In widespread storm outbreaks it would be extremely challenging if not impossible to track each and every OT region. But, simply seeing that an overshooting top is present is only part of the story. Differences in texture in visible (VIS) imagery between neighboring OTs tell you that one OT is higher above anvil than the other which indicates a stronger updraft and a greater likelihood of hazardous weather conditions. The same can be said for infrared (IR) imagery, if one is colder than another then the cloud top is higher and updraft is more intense. New OT detection methods, funded by the GOES-R Risk Reduction program and NASA resources, can detect and quantify the relative intensity of each OT in VIS and IR data to allow forecasters to quickly monitor trends in updraft activity which offers advantages beyond VIS/IR imagery alone. Beyond WFO-scale applications, OT detection is important for assessing the likelihood of aviation icing or turbulence over broad regions where radar is not available.
Michael: Does SPC do any additional outreach to TV broadcasters?	Most of the broadcast outreach is done by management, primarily the WCM. Forecasters rarely interact with the media, but SPC does do outreach with its broadcast partners.
All: Multiple satellites close in overpass time is advantageous; NESDIS likes to retire older satellites. How can we ensure that all satellites can support NWSFO?	Show products to be useful for forecast problems and get the users to clamor when products disappear. The more people requesting the data or showings its use the more likely to keep receiving that product and possibly receiving more. Rebekah: User requests are really important. If a satellite is going to be removed from operations, if nobody is using it or it provides minimal value, then there is justification for doing so and resources should be allocated to other projects. However, if the data is critical, users and developers need to document its utility (and advocate for it) and voice their concerns over missions being retired.
Chauncy: How often would you ideally like to receive nucaps-like profiles?	Hourly would be optimal

Chauncey: does the field have access to the automated adjusted boundary layer version of NUCAPS that was evaluated at the last few HWTs?	Rebekah: The product is still experimental, so no. However, if an office wants the product, they can request and evaluate it currently (contact NASA/SPoRT)
Rebekah: How do the number of NUCAPS Soundings vary with latitude?	Higher latitudes benefit from having many JPSS satellite overpasses a day, unlike the mid-latitudes and tropics which can only have up to two per day (fewer if a location is in the gap). Alaskan forecasters have benefited from these additional overpasses. The NUCAPS cold air aloft product (http://rammb.cira.colostate.edu/ramsdis/online/cold_air_aloft.asp) has been useful for aviation forecasting 30-90°N. If air temps drop below -65°C within flight altitudes, which is common along polar flight routes where the tropopause heights are low, the aircraft fuel can gel and it is a dangerous situation. Since NUCAPS retrieves air temperature at different heights, this can be used to know where and at what height cold air aloft exists. So this is one example of how many overpasses at high latitudes can improve the utility of NUCAPS for monitoring hazards.
Rebekah: Are NuCaps Soundings used in Warn on Forecast?	We are unaware of NUCAPS being used in Warn-on-Forecast, but it could be an area of future work. Having multiple data sources in operations (e.g. Suomi-NPP and NOAA-20) would enable users to see changes in stability over time, which could be useful for this system.
Michael: How does SPC stay current on satellite developments	Short answer is through me. I am the satellite liaison to SPC and connect with the satellite community to stay up to date on current developments relevant to SPC operations.
Kris: For the automated hazardous storm detection, how is parallax corrected to better place and resolve the 'surface' features for the end users?	Kris: Parallax corrections are based on cloud top height retrievals for clouds considered to be optically thick anvils. We provide these parallax corrections in our NetCDF output files that contain the storm detections. Applying per-pixel parallax correction to imagery can be challenging if one seeks a visually appealing product. Two pixels can be shifted to the same spot, and there may be no pixel that moves into their former locations. A better method is to use the tropopause height or a constant height assumption (i.e. all storms are 15 km high) to move storms closer to their true ground-relative locations.
Users: What are the challenges associated with multi-layer clouds in severe convection forecasting? What are user needs for improvement here?	Chauncy: Challenges here definitely involve being able to pick out the different features of importance, which can sometimes be obscured when multi-layer clouds are present. We also have difficulty picking out very subtle features at times -- e.g., thin/high cirrus approaching a surface frontal zone that's marked by cumulus often signals convective initiation since the cirrus represents an approaching jet streak or shortwave trough. However, sometimes that cirrus is nearly transparent and in "filaments". So, for user needs, I'd say anything that can help draw out features of interest, be it updraft trends or high-level clouds,

	would be useful. Perhaps continual expansion and pushing the limits of what can be done with RGBs would greatly benefit users in these scenarios.
Rebekah: Are the locations of nucaps parallax corrected if over plotted on a GOES image?	NUCAPS is not parallax corrected. However, within the NUCAPS algorithm, the radiative transfer model accounts for differences in viewing angles.
Rebekah: Are there any statistics on the performance of NUCAPS vs. MiRS soundings?	Yes, we've performed intercomparisons; Galina Chirakova has a poster on Wednesday showing some results. However, in operations, MIRS and NUCAPS have different purposes. One major difference between these two products is that MIRS is microwave-only whereas NUCAPS uses both microwave and infrared sounders. From a user standpoint, MIRS is more useful for sampling within clouds and in precipitating conditions whereas NUCAPS is recommended for clear to partly cloudy scenes. While NUCAPS performs cloud clearing, when cloud cover is 100%, the infrared sounding is unable to penetrate the cloud and the retrieval will have high errors below the cloud top. If the user is interested in atmospheric composition, NUCAPS uses the combined MW and IR channels to provide retrievals of ozone, carbon monoxide, methane, and other trace gases.
Chauncy: What cloud heights are the typical severe thunderstorms in ND? Are you able to use satellite products to track cloud heights as precursors to severe weather/ (edited)	Chauncy: Typical severe thunderstorms in North Dakota have cloud heights of 40,000 to 50,000 feet AGL. Honestly, to date we haven't looked at using satellite data to directly analyze the cloud heights much. We do that with radar, but even there it's more of an anecdotal observation since it's more the characteristics of the tops (e.g., are they overshooting, are there AACPs?) that gives us more confidence that a storm is severe or significantly-severe. Kris: Cloud top height retrievals can be biased low by several kilometers in the most intense storms, those that generate warm anomalies within their anvils due to enhanced-V signatures / above anvil cirrus plumes (AACPs). Cloud height algorithms assume that clouds reside in the troposphere. If an AACP is 10 K warmer than surrounding anvil, the height could be assigned 3 km too low. But I agree with Chauncy that heights around 14-15 km are common with severe storms over ND.
Michael: Should GOES-R Cloud Top Temperatures be produced for the CONUS domain?	The cloud top temperatures maybe not so much, but I do hear from forecasters how a cloud top delta T product would be useful, showing the trends in cloud top temperatures in a quick product would be desired in SPC operations. Tracking those features can be hard for a product like that but seeing trends in a quantitative way would be very helpful with the lack of sampling currently available in NAWIPS and the transition to AWIPS years away most likely for SPC. If that is just producing the cloud top temperature value for now, that can be a good place to start.

6) Key Challenges for Users/Developers

a) Users

i) Information Overload

ii) Lack of new GOES-R and JPSS products in National Centers NAWIPS
iii) Convective situations when multiple cloud layers are present
iv) Lack of boundary layer observations
v) Lack of pre-glaciation information/products
vi) Difficulty balancing board-scale feature in wv imagery with model data
vii) Difficulty identifying subtle cloud features quickly and on the fly
viii) Lack of trend tools (cloud tops, environmental)

b) Developers

i) Gathering feedback from users
ii) Implementing new product into operations
iii) Building greater user understanding of products
iv) Budgeting sufficient resources to develop/give training modules

7) Ideas for Improving the User Experience

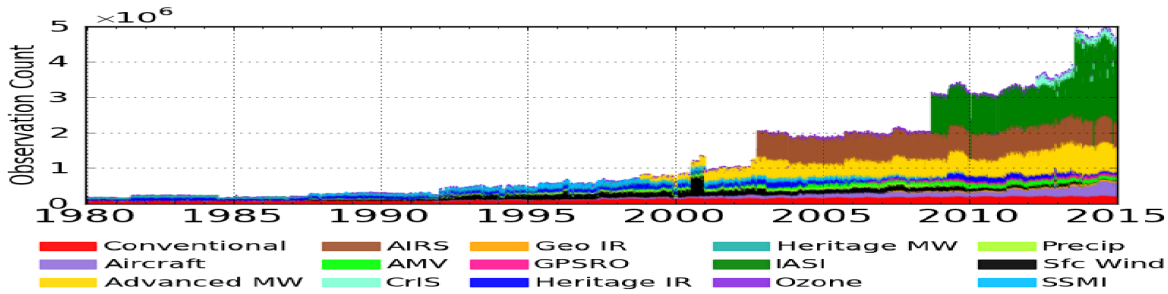
a) See recommendations below

8) Recommendations

a) Improvements to NUCAPS must continue to be explored in order to improve its usefulness in operations
   i) Automated surface-PBL blending with observations/NWP
   ii) Changes to the algorithm that trades model independence for initialization with GFS or the RAP to better resolve the BL
b) Explore the value of Suomi NPP and NOAA-20 (imagery and products) both being used in operations for additional CONUS afternoon overpasses. To demonstrate the value for diurnal cycle/geo sounders, could incorporate MetOp and Aqua satellites as well.
c) Increased development of and training on unique ways to combine imagery and products (from satellite and other datasets) into single displays in AWIPS
d) Continue to promote sharing of examples and best practices for using satellite imagery and products in NWS forecast and warning operations, via blogs, webinars, meeting presentations, etc.
e) Developers should strive to better understand NWS forecast/warning/DSS operations
   i) Visit a forecast office, testbed, or proving ground

Numerical Weather Prediction/Data Assimilation: Radiances

Moderator: James Yoe



Operational Numerical Weather Prediction (NWP) models provide the routine, basic guidance to support weather forecasting for virtually all spatial and temporal scales. Successful NWP depends on effective assimilation of observational data to provide initial conditions. Microwave and infrared radiances provided by satellite sensors have been and remain among the most significant classes of observations supporting NWP, in terms both of volume and contribution to forecast skill.

1) Session Purpose

The purpose of this session is to identify shortcomings in the current use of satellite radiances, opportunities and challenges of using them in evolving NWP systems, and likewise the opportunities and challenges presented to the NWP user community by radiometric sensors that are more capable than their predecessors. Note that for radiance data in NWP, the distinction between developers and users is decidedly less pronounced than for most other applications addressed during the Summit.

2) Agenda

Presentation	Speaker	Affiliation
NWP/Data Assimilation - Users		
(No Formal Presentation nor Slides)	Ben Ruston	NRL
Modeling and Data Assimilation for UFS Applications	Vijay Tallpragada	NWS/NCEP/EMC
Satellite Data Assimilation at the GMAO	Will McCarty	NASA/GMAO
NWP/Data Assimilation - Developers		
NESDIS Support to NWP Radiance Assimilation	Kevin Garrett (Kevin Gallo presenting)	NESDIS/STAR
Satellite Radiance Assimilation for Rapidly Updating Regional and Global Models	Steve Weygandt	OAR/ESRL
Use of Radiances in Global data Assimilation at NOAA/NCEP	Andrew Collard	IMSG @ NWS/NCEP/EMC

3) Key Takeaways

Users And Developers

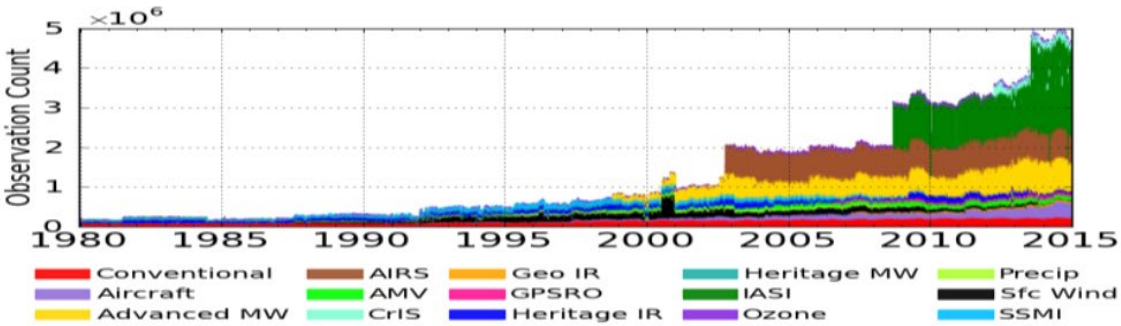
i) Radiance remain crucial to successful NWP
   - By volume (see graphic) and spatial and temporal distribution of data
   - By forecast skill imparted

ii) New Sensors offer opportunities - and challenges

iii) High-resolution/regional models are ripe for improved radiance DA
   - with unique challenges
     (a) Bias correction
     (b) Alternative channel selection and adaptive thinning
     (c) Lower latency requirement

iv) New model and high performance computing development and implementation
   - Complement improved satellite observations and data assimilation
   - Compete for resources (and impact) - (will simplified UFS applications help longer term?)

4) Graphics



5) Questions/Answers

Question	Answer
What are the biggest hurdles to getting all-sky radiances into operational models?	The most significant challenge is that intensive system-dependent development efforts are needed. Each NWP Center has its own model and microphysics package that has to be linked to CRTM scattering, for virtually each instrument. Extensive error tuning is required for each, too (WM)
Is there any publicly available data to tell which satellite data was assimilated across the domain for a given model run?	NCEP Central Operations (NCO) and NCEP's Environmental Modeling Center (EMC) both have links to this information on public-facing websites (VT.) The Naval Research Laboratory does, too (BR.)
Is there any hope of creating a 4D radiance "shell" for all operational satellites' instruments in the NESDIS, NWS, or NOAA cloud platform??	The panel was not entirely certain of the meaning of the question, and asked for clarification which was not forthcoming. However, it was suggested that it might be possible to re-format data into a common repository to

	simplify access to radiance for multiple systems and applications (BR.)
When do you expect to assimilate more radiance's over land?	Limited channels are assimilated over land now. The opportunity to leap forward is expected to come when we move to coupled modeling and DA, which will provide consistent constraints to avoid aliasing land surface signals into the atmosphere. There are current efforts to improve surface emissivity models now (BR and AC.)
Can anyone comment the future challenges of forward operators (like CRTM) in the perspective of data assimilation? What is the priority that needs to advance?	Currently FOs for radiances are all via the CRTM. There are areas that need to be advanced, for example, in the UV, to advance active sensors (i.e. Lidar) as well as passive ones. FOs for radars are needed, too. JEDI framework is expected to help develop these with wide applicability (WM.) The current CRTM Active Sensors Module (CASM) is a start but needs to be accelerated (JY.)
HRRR: are there plans to output simulated imagery from ABI bands? Currently is only previous imager bands IR and wv.	Although this is not yet being done, it can be accomplished straightforwardly.
What's your thought of using observation-minus-forecast residuals instead of adjoint approaches as discussed in a 2017 ECMWF paper by Mohamed Dahoui	Although this was not explicit in the panelists' presentations, the US NWP centers routinely DO calculate fit-to-observations. When there are model system changes including new data or new DA techniques, looking for residuals to be reduced (BR.) Acknowledge that NCEP could do (and communicate) use of this methodology more extensively, note that every validation methodology has both strengths and limitations to inform (AC.)
In devops environment, algorithms can be updated frequently but it still takes time to validate. Can you be a trusted source and change algorithms-frequently?	This is an important question that touches the nature of how we make implementations in operational NWP systems. For example, in NCEP there is a long implementation queue, because each improvement developed needs to be validated. Validation maintains the trust, but impedes the frequency of updating operationally (AC.)
What should satellite DA researchers focus on in order to maximize our satellite obs' utility in the models in the timeliest manner possible?	If considering a "legacy" sensor the primary focus should be on plumbing (data paths, formats) to ensure minimal time is lost after launch to exploit data that are already well-understood and for which the science portion of assimilation is well understood. For a completely new observation type, scientific insight into the physics of the measurement technique, proxy data, and a forward model, or observation operator, and the means validate it (BR.)

	Be prepared to focus on details, end-to-end, from ingest to validation. Appreciate how the instrument/sensor works, what observation errors, biases should be expected, readiness of relevant components of the CRTM, effectiveness of the quality control (AC.) For regional modeling, we need to focus on all-sky radiance assimilation, and characterization of correlated observation errors (SW.) ADM Aeolus provides an excellent example of the value of realistic proxy data. NASA/GMAO was able to ingest the first science data received almost immediately as a result of having proxy data that accurately depicted both technical and science aspects of the data products to come. JEDI should provide a more flexible and user-friendly development environment in the future (WM.) Need to balance the competing needs for operational NWP systems to be reliable and resilient - and agile enough to support improvements of every kind. Should focus on the applications of the modeling systems, and improvements to outcomes based on the model products, not just the increased use of observations. Note that JEDI and the UFS are expected to enhance innovation, and should do so in a way that makes development and testing outcomes more relevant to operations (VT.)
Previous studies have shown more impact from CrIS than from AIRS. Since CrIS will be around for another 20 years, what is being done to increase its impact for NWP?	There is awareness that more impact should be obtained from CrIS. The upcoming model implementation at NCEP, now being tested, includes improved correlated observation errors and enhanced (slightly tightened) quality control to help achieve that impact. In addition, the use of cloud-impacted radiances in the future. (AC)

6) Key Challenges for Users/Developers

a) Users

I. Optimal use of high volume data sets
   a. How to benefit fully from GEO Hyperspectral IR Sounders
   b. Strategies for thinning (scene dependent) , super-obbing, etc

II. Assimilation of data from Small Sats and/or commercial satellite data sources
   a. w/ short mission lives and/or contracted length data delivery; a solid calibration, implementation and monitoring strategy would be required to maximize return on investment.

III. Assessing and/or mitigating RF contamination risk at key MW frequencies
   a. Including impact on regional models

IV. Optimizing use of current sounders
   a. Address low relative forecast benefit of CrIS compared to AIRS, IASI in GSI-based systems.

b) Developers

I. Reduce Data Latency
   - Especially to support regional/high temporal resolution models

II. Timely CRTM development & extension to support
   - All-sky and all-surface DA
   - Including clouds, scattering, aerosol, and chemistry (trace gases)
   - Coupled DA – atmosphere, land, ocean, ice

III. New Sensor Planning/Preparation
   - MTG IRS, etc.
   - Ability to simulate hypothetical sensors

IV. Small Satellites (Cubesats)
   - Rapid check-out, commissioning, post-launch cal/val

7) Ideas for Improving the User Experience

a) Explore ML/AI approaches to address key challenges
   i) Can we gain requisite computational performance w/o losing ties to underlying science and physics involved in the measurement; reproducible?

b) Use Open DA Environment (JEDI) to share, accelerate capability
   i) Ability of researchers to access, compile, run operational code
   ii) Model agnostic to the greatest extent possible

c) Improved metrics for data impact assessment
   i) & Recognition of limitations, underlying assumptions, common tools between centers and research for ease in comparison
   ii) Generation of core simulated imagery from forecasts for assessment w/ developers and broader audience

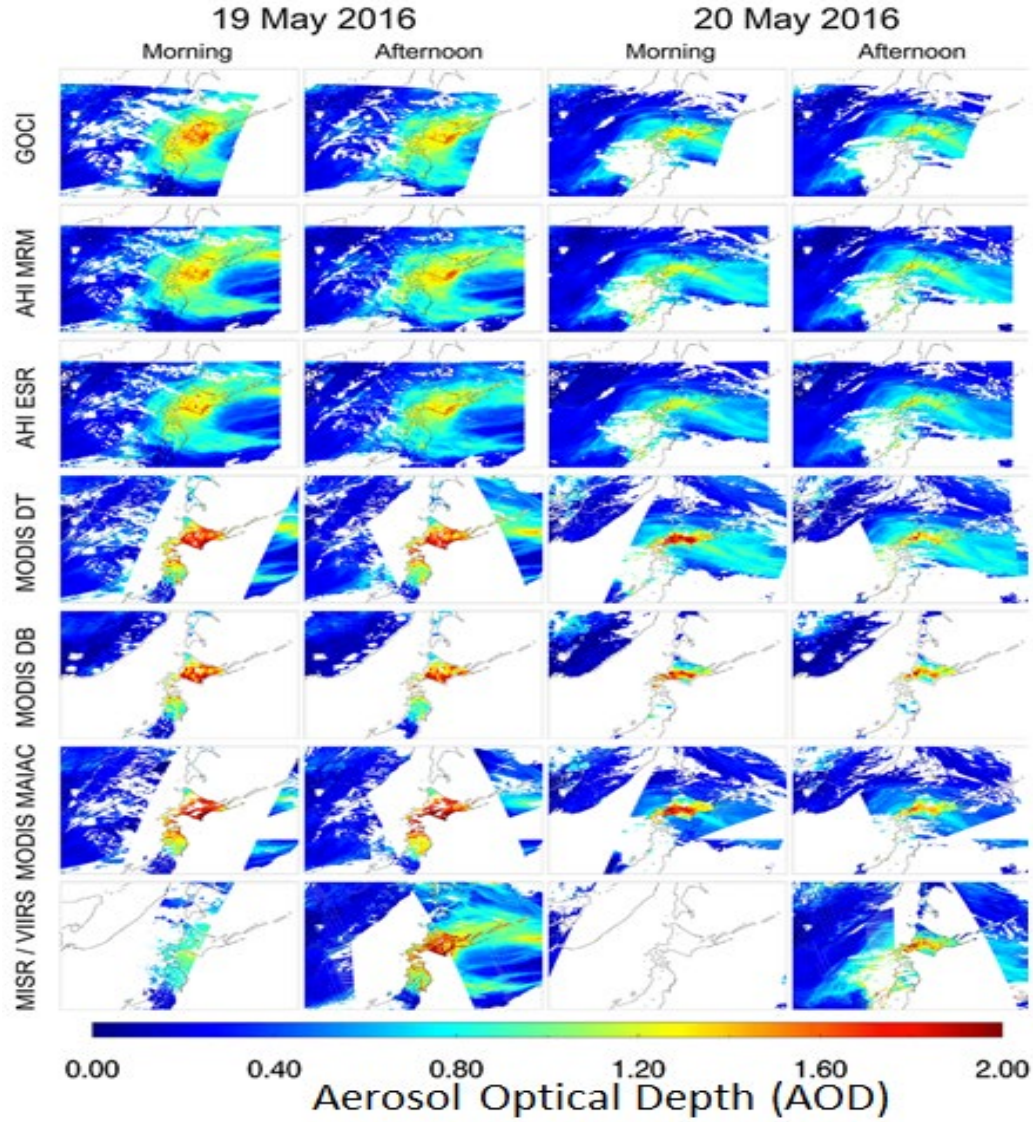
8) Recommendations

a) Ensure that new research and optimization of current methods result in deliverables that are readily transferred to new data assimilation system (i.e. are applicable to JEDI)
b) Develop radiative transfer algorithm advances are being developed to maximize the capability for exploitation within data assimilation (e.g. fast model development into the near-IR, visible, and UV; validation of new MW frequencies, extension to active sensors)
c) Strengthen the scientific base to maintain existing capabilities in a traceable manner (e.g. transmittance model training, definition of scattering properties/tables)
d) Pursue agile implementation of model, DA, and observation improvements to complement and exploit more agile development in the framework of the UFS and JEDI
e) Continue to provide access to satellite data as soon after launch as possible to allow NWP centers to implement in a timely manner and to allow the NWP centers to assist in Cal/Val activities.
f) Wherever possible, continue to provide data from older, yet still functional, satellites. There is a specific recommendation from ITSC to "Continue to provide AIRS Aqua data in real-time to NWP centers for as long as calibration of the instrument is possible.", and now there are questions on the continuation of older NOAA-xx data streams.

g) Move forward as rapidly as possible with existing requests for certain data streams, including those for remapped AMSR-2 and VIIRS cluster info in the CrIS FOV.

Numerical Weather Prediction/Data Assimilation: Geophysical Parameters

Moderator: Nazmi Chowdhury



1) Session Purpose

Numerical Weather Prediction (NWP) forms the forecast basis for scales from global to local scale, including those for winter storms, hurricanes, convective and marine weather, and aviation applications. The purpose of this session is to discuss the current and upcoming challenges of assimilating geophysical parameters into operational NWP models. The user speakers in this sessions discussed the current and upcoming challenges to implement assimilation of data after testing, ongoing and future needs for the Rapid Refresh models that users think satellite products can best address, overview of aerosol product data assimilation in the Navy weather models etc. Developers on the other hand discussed about the challenges and opportunities in this field, showed examples of areas of untapped potential for

GOES-R observations, issues and challenges associated with assimilating GOES-16 clear air and cloudy radiance observations to improve rapidly developing storm prediction and ozone product assimilation at NCEP/EMC in global data assimilation system.

2) Agenda

Presentation	Speaker	Affiliation
Satellite Data Use at NOAA/ESRL for Rapid Refresh Analysis and Forecast Systems	Amanda Back	CIRA/ESRL
NWP and Assimilation (Geophysical Parameters)	Jim Yoe	JCSDA
Navy Requirements for EO/Aerosol Research	Ed Hyer	NRL
NWP/Data Assimilation Part II: Geophysical Parameters	Kyle Hilburn	CIRA
Improving Rapidly Developing Storm Prediction by Assimilating High-resolution GOES 16 ABI Infrared Water Vapor and Cloud Sensitive Radiances: Issues and Challenges	Xuguang Wang	OU
Ozone Data Assimilation at NCEP,	Haixia Liu	EMC

3) Key Takeaways

Users and Developers

i) Assimilating more (sat) obs is better for more accurate NWP
   (1) More useful forecast products at Centers, WFOs, RFCs
   (2) Improved Decision Support to government agencies, individual citizens, and everyone in between

ii) Users look for Near Real Time products while choosing satellite data products for DA.

iii) Information into the model is a function of ability to resolve uncertainty. Data assimilation must always “assume the worst” about the observations.

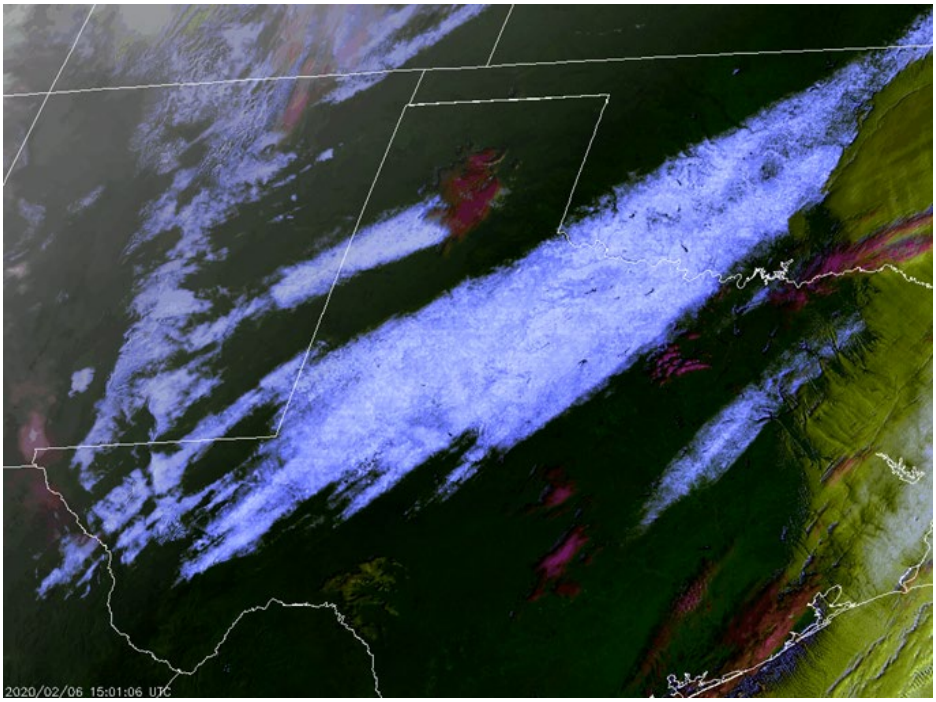
iv) Resolution and uncertainty tradeoff for many types of retrieval. Question remains: who will manage that tradeoff-developers or users?

v) For Aerosol Modeling Daily mean matters most.

vi) High resolution ABI observations can be complementary to radar observations and if assimilated can add lead time to NWP of rapidly developing storms.

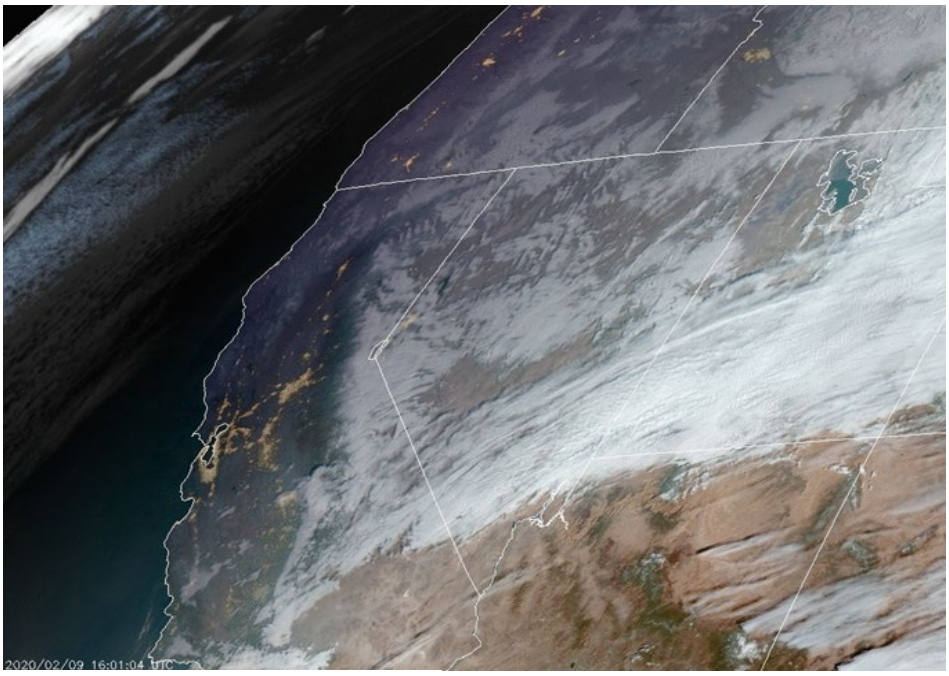
vii) Ozone observations from satellite instruments are important to constraint the ozone field in global model.

4) Graphics



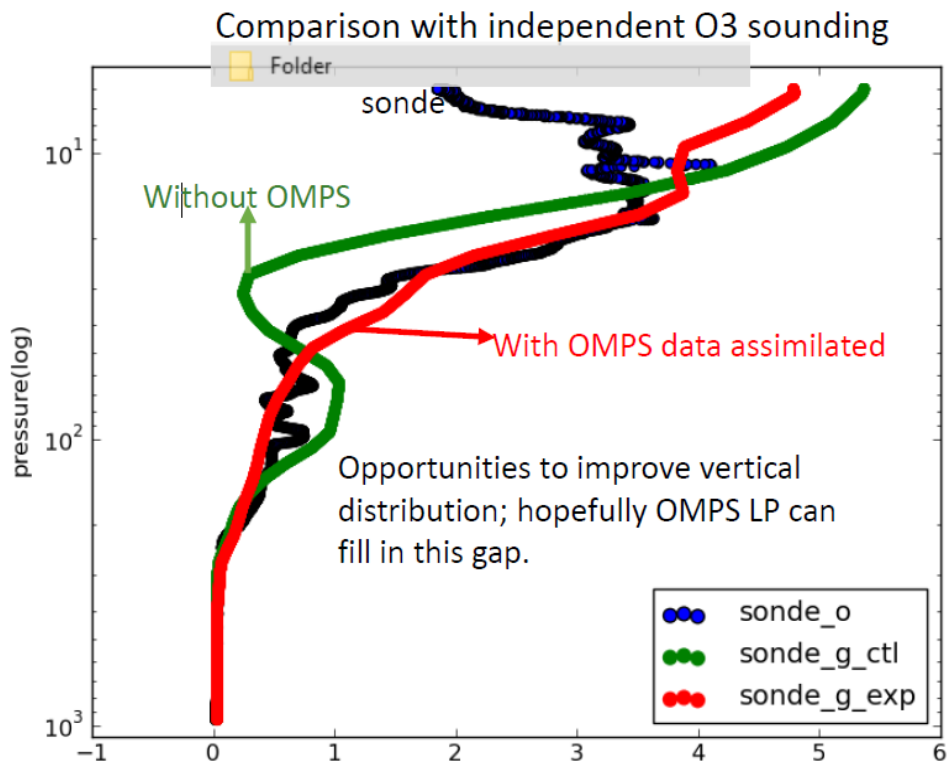
Melting snow over Texas
GOES-16 CIRA Snow-Cloud/Layers

http://rammb.cira.colostate.edu/ramsdis/online/loop_of_the_day/



High winds loft dust from
dry lake beds in Nevada
GOES-16 CIRA GeoColor

http://rammb.cira.colostate.edu/ramsdis/online/loop_of_the_day/



Impact of OMPS-NPP Assimilation

5) Questions/Answers

Question	Answer
How can info from parameter assimilation be fed back into constraint of variables that co-vary with, but not included in, the variables in the forward operator?	Kyle Hilburn: If you for example assimilate aerosol on constraint that optical depth that will feed back on clouds if you have aerosol aware microphysics, it will feedback on radiation. But I think, within analysis systems like GSI, they do apply balance constraints that was discussed a little bit earlier at least for the hydrostatic models where if you change temperature, you change wind etc. through balance constraints.
There is an observational gap with vertical profile of smoke. How can we provide forecasters confidence the profile of smoke from the HRRR is representative?	Amanda Back: One way is through field campaigns that use aircrafts to record data that we could validate our forecast against. Edward: There has been some attempt to these very clever products- the MYAC products that actually has done some limited validation of smoke heights, it requires the smoke to be fairly thick. But this goes back to the earlier issue of what do we do with 1 minute data. The answer is we accumulate

	signal for secondary attributes such as microphysical properties of the smoke and potentially also some of the vertical properties of the smoke.
What do DA scientists want to see from NESDIS to make better use of geophysical parameters for DA? Is there anybody that coordinates this communication?	Haixia Liu: I am the data user of using the NESDIS data that is generated for us. So once… I have experience that sometimes the data has issues and we are not informed and also sometimes the algorithm changes on the NESDIS side and we would like to be informed on those changes so that as DA developers we can know that is coming up and we can monitor that and test with those modifications.
Are there plans to assimilate any goes 17 level 2 products? If so, is there enough meta data on the quality? E.g. detector temperatures, flags, etc.	Amanda Back: I am doing some experiments assimilating level 2 GLM from GOES-17 right now, it does have quality flags and that is the metadata of what I need for what I am doing. The kind of weather that are prediction that depends most on the lightning is not so much in the west where GOES-17 is. But we are also looking at some fire weather stuff coming up in the future- that research hasn't started yet, and I expect that GLM level 2 to be useful for that as well Edward Hyer- In the quality flags of ABI data, I haven't done a rigorous assessment on whether they are really sufficient but this is something that varies in a systematic way with time of day and time of year and I think between that, knowing that variability and the metadata provided, I think you can make good use of the GOES-17 information.
Question for Jim Yoe: What is being done (in those areas you identified that keep you up at night) that would help you get more sleep?	First thing we need to have the awareness that we don't have that complimentary planning and strategy on the implementation compared to what we have on the developing side. There is a lot of support on development of what you call unified forecasting system. Having a simpler forecast system will help with having more agile implementation meaning testing upgrades to either model code or to new data assimilation or to new observations being assimilated will become more straight forward. While we come to the door of operations, you can do a really good job in the operations parallel system showing that yes we know how to handle these data, they actually convey benefit to our operational model. You still have to be careful about two things while

	doing the implementation- 1- don't break the workflow/schedule, because they are the dependencies of performances as well as functionality. 1st control expectations and make sure that we do strategic planning end to end so that we are covering the R2O and finally R2S- looking at the service demonstration as well.
Might you consider assimilating derived GOES products like snow or aerosols? This might be clearer than via RGB imagery.	Amanda: I think we are definitely interested in a snow GOES product for the land surface for the HRRR model, we have something right now which is coarsely resolved and also daily updating. So, I think GOES can help us improve that. Edward: I would like to take the opportunity to ask the reverse question that gets asked relatively frequently- why is our aerosol DA efforts are organized just around level 2 products rather than radiances which have many constraints. The answer is: The aerosol signal is the strongest in the near and visible solar part of the spectrum. Getting that aerosol information requires you to carry around an extremely high resolution rendition of the reflecting surface. So there is basically just a lot of moving parts to an aerosol retrieval that will have to become a part of your model in effective radiance assimilation for aerosol. We are continuing to rely on data providers to give us good level 2 products that allow us to assimilate and constrain our aerosol model without as many moving parts as we would need to use the radiance directly.
I've noticed several presentations where data from NOAA-20 is not being ingested, yet S-NPP is being ingested. How can the JPSS program help?	Jim Yoe: For us it's making sure that we have adequate opportunities to implement. Mitch to Edward: With NOAA-20 you will get double the coverage for aerosols, it fills in gaps-the large viewing geometry. Edward: I am processing the data every day, I just have not done the validation test that I will have to and report actually when to switch.

6) Key Challenges for Users/Developers

a) Users

i) Quality/bias correction: It's expensive for users to develop their own bias correction. Reliability of quality control is also another challenge for users.

ii) Resources (computer time and people) needed to test products: DA Development and Testing requires even more High Performance Computing.

iii) Vertical Info for Satellite Products: Many satellite products are 2D, but model fields are 3D.

iv) Users need centralized location to share new products; not “ad hoc”
v) Users need high resolution, real time Land/Sea Surface products
vi) Tools are needed especially for Global Model assessment.
vii) O2R is NOT sufficient for achieving R2O: Observation, DA, & Models compete for implementation. There is acceleration on the research side but no complementary acceleration on operational implementation.

b) Developers

i) Data assimilation algorithms are becoming more complex and application dependent
ii) Utilizing observations presents challenges as data is getting bigger and bigger
iii) Bias (model and obs.) correction
iv) Quality Control during DA
v) Observation error estimation (operator error, representativeness error, etc.)
vi) Effective assimilation of multiple channels.
vii) Lack of independent ozone sounding data for validation.

7) Ideas for Improving the User Experience

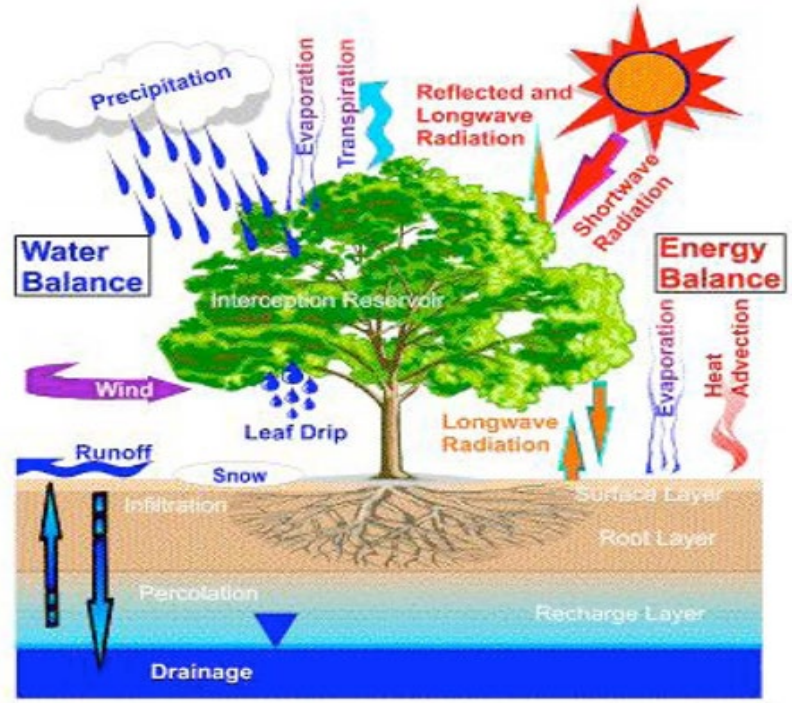
a) Improve bias correction and QC at the developer level.
b) Increased resources for High Performance Computing.
c) Consider cloud computing for Big Data.
d) Use of Direct Broadcast data in cases of need for NRT data.
e) Better planning for operational implementation for successful R2O.

8) Recommendations (need input from panelists/check recording)

a) …..
b) …..
c) …..
d) …..
e) ……

Land

Moderator: Kevin Gallo, NOAA-STAR



General schematic of land surface processes

Introduction

The land surface inputs to numerical weather prediction models have been increasingly recognized as a critical contribution to improvement of model prediction capabilities. Remotely sensed (e.g., satellite-derived) land surface data and products are increasingly used as input to, and validation of, models due to their spatial and temporal availability.

1) Session Purpose

Similar to other sessions the overall goal of the Land session was to provide a forum for data and product users/stakeholders and product developers to meet and discuss the current products with a goal of maximizing the value of the products and documenting the priorities that might be included in the next PGRR call for proposals. Product users included those from the numerical weather modeling and operational assessment communities. Product producers included several NESDIS-STAR scientists that oversee production of a variety of land-related products. An underlying objective of the Session was to identify what additional land data and products will be required in the next few years and include these requirements in preparation of the 2021 JPSS PGRR Program Call for Proposals. Presenting the product user perspectives Helin Wei and Mike Ek discussed the current and future plans for land surface data sets within NCEP modeling systems. Harlan Shannon described how STAR Vegetation Health products are used within the USDA for preparing crop yield assessments. Christa Peters-Lidard discussed the progress of land data assimilation and examples of the improvement in estimates of several land surface variables as a result of data/product assimilation. The product developer presentations were lead with a discussion of current and planned STAR land products by Bob Yu that included current JPSS and GOES-R products (e.g., Land Surface Temperature, Albedo, and Vegetation Indices, and Green

Vegetation Fraction) as well as products under development (Emissivity). Jerry Zhan continued the discussion of available JPSS and GOES-R products that included Surface Type, Soil Moisture, and Evapotranspiration products. Felix Kogan presented the suite of Vegetation Health products and application examples.

2) Agenda

Presentation	Speakers	Affiliation
Data/Product Users		
Land Surface Datasets Used in NCWP Modeling Systems: Current Status and Future Plans	Mike Ek Helin Wei	UCAR NOAA-NCEP
Vegetation Health Applications in USDA	Harlan Shannon	USDA-WAOB
Land Data Assimilation Capabilities and Opportunities	Christa Peters-Lidard	NASA-GSFC
Data Developers		
STAR Land Product Development	Bob Yu	NOAA-STAR
Satellite Data Products for NWP and NWM	Jerry Zhan	NOAA-STAR
Vegetation Health 1981-2020 Applications	Felix Kogan	NOAA-STAR

3) Key Takeaways

a) Users

I. Satellite land data products are critical for Numerical Weather Prediction (one day to >seasonal)
   - Demonstrated improvement in estimation of land surface variables (e.g., soil moisture assimilation improves evaporation, snow assimilation improves streamflow)
   - Proper initialization and characterization (surface conditions, fluxes) critical (high quality)
   - Several products in current EMC model (e.g., Green Vegetation Fraction and Land Surface Type) require updates to VIIRS products.

II. New satellite products (e.g., Leaf Area Index) will be required in future land models. Numerous land-surface datasets are currently used in land surface models as direct input, assimilation and data evaluation. (Ek/Wei)

III. Issues related to the use of land products include validation and uncertainty assessment, representativeness of the data, temporal stability, course resolution of products, and product latency. (Ek/Wei)

IV. Satellite data were historically used to corroborate weather data, however, now used more robustly in USDA crop weather assessments. (Shannon)

V. Reprocessing of products required to achieve consistency due to changes in satellites/sensors used to produce products and other factors that may change over time.

VI. Land data assimilation has steadily evolved over the last 30 years. (Peters-Lidard)

VII. Recent assimilation of soil moisture, snow depth, LAI and albedo have resulted in improved estimates, respectively, of evaporation, streamflow, water and carbon budgets, and snow depth. (Peters-Lidard)

VIII. A team effort (product users and developers) that includes frequent start to finish communication on products is required for successful R2O transition of satellite products.

b) Developers

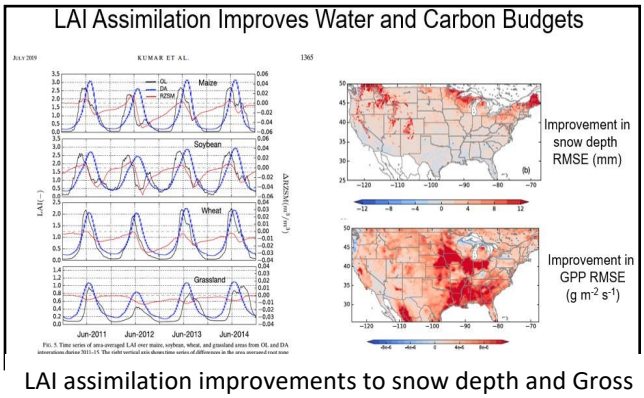
I. Several operational products including Land Surface Temperature, Albedo, Vegetation Indices and Green Vegetation Fraction are available. (Yu)

II. Annual Surface Type product now available for 2018, integrated daily surface type product in evaluation (Zhan)

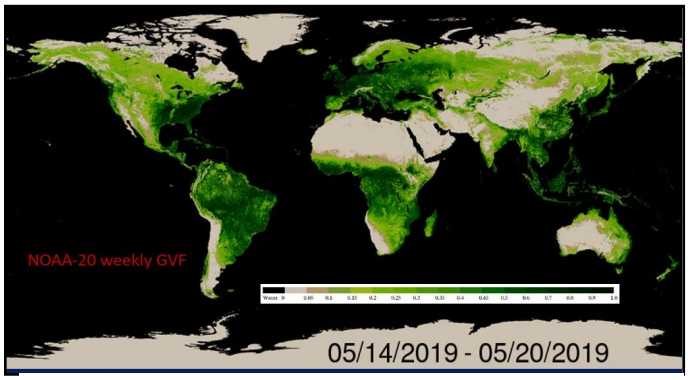
III. Surface type and soil moisture products routinely available, high-resolution soil moisture product and ET and drought products in evaluation (Zhan)

IV. Vegetation Health products are available that span a 40-year interval (blended AVHRR-VIIRS, 1981 – 2018). (Kogan)

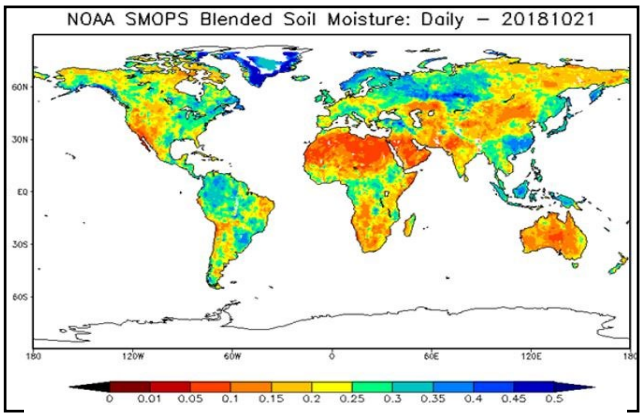
4) Graphics



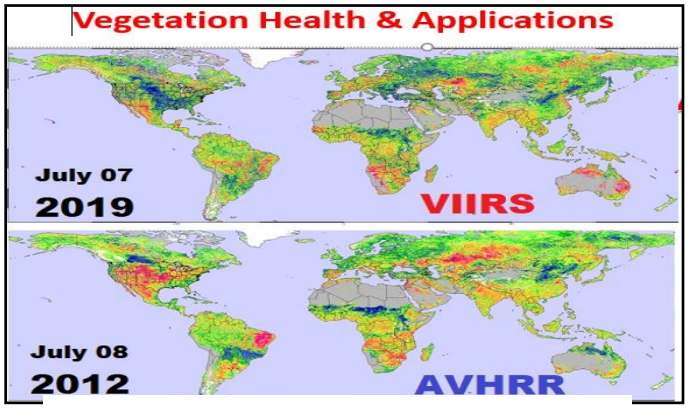
LAI assimilation improvements to snow depth and Gross Primary Production.



Green Vegetation Fraction derived from NOAA-20 VIIRS.



Soil Moisture Operational Product System (SMOPS) daily product.



Vegetation Health products from 2012 and 2019.

Questions	Answers
What is the biggest need in land data that remote sensing may fill?	Noah-MP land surface model uses leaf area index (LAI) to represent the vegetation dynamics of land surface in addition to the green vegetation fraction (GVF). The Noah-MP LSM is one of the core components of the operational National Water Model and may become the land component of the NWP models in NCEP. LAI is not generated from STAR-JPSS. So the LAI product is the gap to fill. What is the current surface state (e.g. GVF/LAI, snow, soil moisture), and surface fluxes (e.g. H, LE, Lup).
Surfaces change at timescales faster than hourly. Any plans to exploit GOES-R's temporal abilities for sfc properties like temperature. Every 5 minutes?	GOES-R high temporal resolution data is surely useful for tracking the diurnal cycle of surface temperature and energy fluxes such as ET. Current ET algorithm uses only two time LST retrievals in the morning. We could at least explore the LST diurnal cycle for the validation of the daily ET product. GOES-R satellite product for land does have the capability to observe the Earth surface every 5 minutes. The program office may choice to performance different observation modes upon users requirement. High temporal resolution for Tskin allows for a nice verification data set. Also it could be assimilated (I suppose) in some manner, e.g. if Tskin (without memory) could yield information about sub-surface temperatures, (with more memory—the deeper you go). Also the Tskin effect on surface fluxes (moisture, heat).
What improvements are needed in soil moisture satellite products?	Current SMOPS spatial resolution is 25km while the National Water Model needs 1km soil moisture data product for validation and assimilation. Operational downscaling algorithms are being explored by the SMOPS team. But implementation of the downscaling algorithm for operation is not funded. Additionally for the same users Level 4 soil moisture data product with spatial resolution as high as 1km for NOAA and other users could be generated via assimilation of high resolution soil moisture related variables (sentinel backscatter, VIIRS LST/VI/LAI, ESI from GET-D product system) into a high resolution land surface model. How to best infer deeper soil moisture and thus more memory – important for predictability. How to better deal with vegetation which degrades the soil moisture signal.
Why aren't more land products available via geo tiff to GIS users?	I strongly encourage NESDIS to make as many products as possible available in a GeoTiff format. Simply put, GeoTiffs are much more user friendly when compared with many other image formats. On numerous occasions I have passed on exploring various raster data sets because the files are too large, need

Cont.	additional processing, require specialized software, etc. By providing data in a GeoTiff format, NESDIS makes it much easier for the user community to consume, or at the very least explore, various products. Based on the number of "hits" from the Slido session, many others are interested in this format as well. SMOPS, GET-D and VIIRS ST product or product systems were specifically developed for meeting those requirements specified by user request or NOAA JPSS level 1 requirements. Geo Tiff format was not requested. Limited by supports, the teams did not include the data format for other uses. However, the teams will surely consider the need once user request is requested. The satellite product format is defined the requirement review board at NESDIS. As the product developer, we have no problem to have multiple formats available to users, or we can provide data format convertor to users if that is required.
Good to see the land remote sensing data is used in NCEP modeling. Any plan to use VIIRS Land Surface products	VIIRS greenness fraction and surface albedo data are top two candidates we plan to include in GFSV17
Where do you see the role of SAR in monitoring land data products?	SAR data (e.g. Sentinel-1a/b, NISAR, etc) are useful and have been used for soil moisture data products for higher spatial resolution. They are useful for snow and ice cover too. We plan to SAR data to downscale SMOPS coarse resolution product to higher resolution for National Water Model and other users. To refine surface type product, especially daily surface type, we plan to incorporate proven algorithms for the refinement of our VIIRS annual surface type and daily surface type products using SAR data once resources become available. Currently it is not in our scope. Users suggestions and recommendation are greatly appreciated, and we will conduct investigation based on that. We are limited with the resource to investigate
Describe the pathway of NASA research to NOAA operations for land modeling. Are there obstacles? What needs to be done?	The GSFC-EMC collaboration started with the NLDAS project back in the 90s, when Ken Mitchell was land lead. GSFC developed, tested and freely shared code and capabilities with EMC, such as the code for NLDAS/Mosaic (LIS) and the NLDAS Drought Monitor, and CFS/GLDAS (LIS). With Mike Ek's departure, we have delivered code for new LSMs (e.g., Noah-MP, Catchment LSM) as well as soil moisture and snow data assimilation--including testing on EMC systems--but this code has not been implemented due to lack of land leadership and staffing. Much of this was supported by NOAA's MAPP program. Further, with FV3

	and JEDI, priorities and roadmap for land have changed without community discussion. This may change with new land lead.

6) Key Challenges for Users/Developers

a) Users

I. Users require uncertainty associated with products (validation and uncertainty assessment, representativeness of data, temporal and spatial stability).

II. Users are concerned with data accessibility (e.g., automated access to products), formats (e.g., many users required GIS-friendly format), and latency.

III. Product consistency (long track record of product).

- Required for long-term satellite data sets (1979 onward), e.g., consistent GVF (AVHHR to MODIS to VIIRS) and snow cover (multiple sensors). Critical for Earth System Model reanalysis.
- Consistency between products e.g., a burned-area observed within fire product should be reflected in albedo (lower) which in turn is reflected in surface emissivity, soil moisture, etc.
- Blended products from multiple sensors (e.g. SMOPS) utilize LEO and GEO platforms with characteristics that may change over time (may be included in DA process).

b) Developers

I. Developers need comprehensive, documented, and communicated requirements related to requirements of new satellite products.

II. Some required products (e.g., evapotranspiration, LAI, soil moisture) require deeper scientific investigation and more complicated models, which requires significant and consistent development support.

7) Ideas for Improving the User Experience

a) User communication of satellite product requirements to Developers.

b) Developer interaction with Users through the product development stage (User requirements of uncertainty, etc.) and product evaluation. A dedicated team to facilitate the R2O transition.

c) Key Data Distribution Challenges include:

I. Data availability from easily accessible and easily navigated locations (non-complimentary mention of some NOAA data/product distribution sites).

II. Products easily accessible in user friendly and GIS compatible format. “Tailoring” of data to meet user preferred formats (e.g., GeoTIFF rather than NetCDF, Albers EA rather than Sinusoidal projection).

III. Well designed (easy to navigate and automated downloads) product web site.

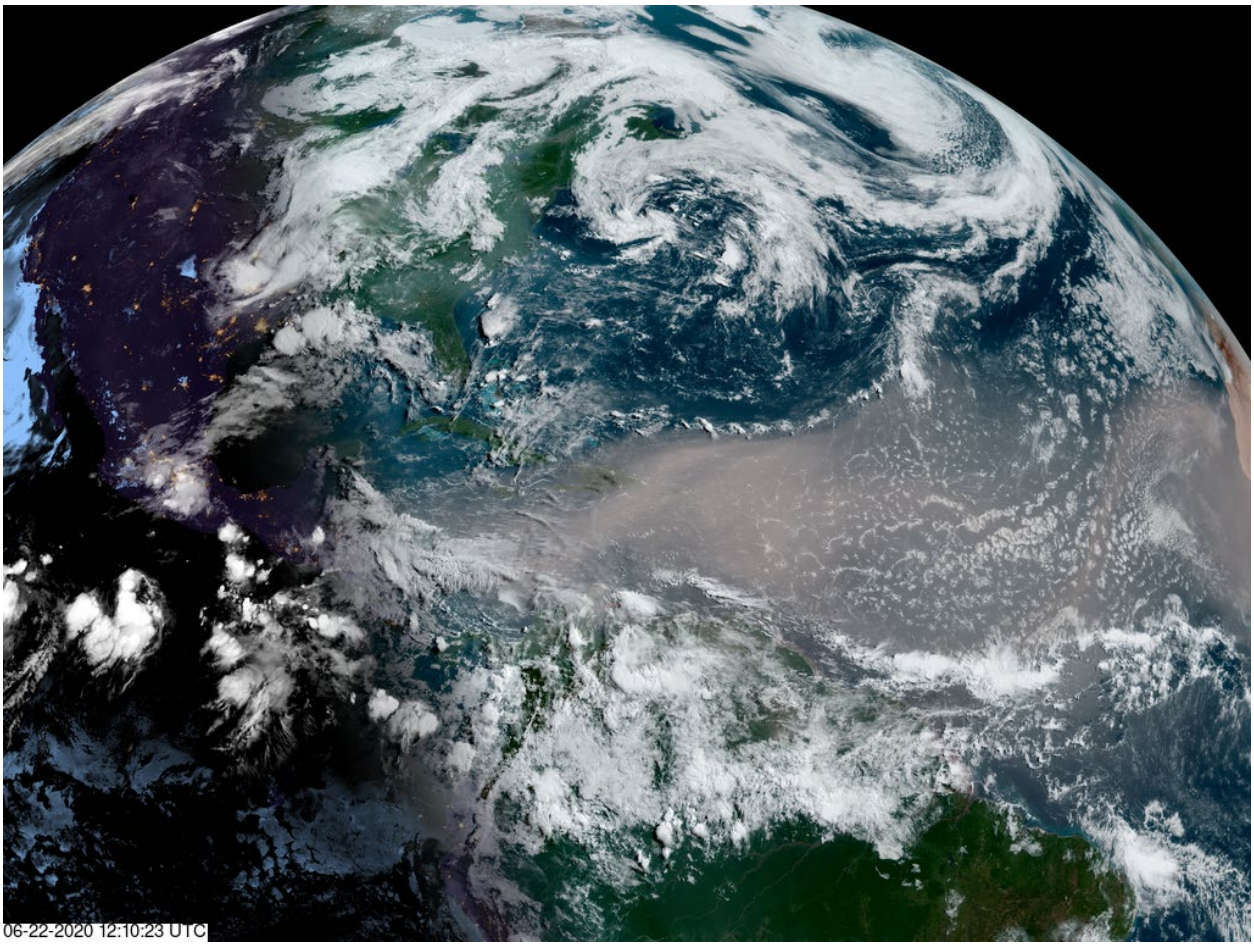
8) Recommendations

a) Coordination of modelers (users) with NESDIS staff (developers) to test impact of new products prior to use in Global Forecast System V17 and Unified Forecast System. (Ek/Wei)

b) Key aspects of useful products include: data with long track record, updated frequently, consistent in time, easily accessible, user friendly and GIS compatible format (GeoTiff). (Shannon)
c) Land information can provide valuable information for weather to climate time scales however improved models and analyses are needed to exploit this information (Peters-Lidard).
d) Land Surface Emissivity product in development. (Yu)
e) Products should be easily accessible in user friendly and GIS compatible format. “Tailoring” of data to meet user preferred formats (e.g., GeoTIFF rather than NetCDF format, Albers Equal Area rather than Sinusoidal projection).
f) Products should be made available via user-friendly websites that are easy to navigate and enable users to automate product and data downloads.

Imagery

Moderator: Dan Lindsey



GOES-16 GeoColor image from 22 June 2020 showing a large Saharan dust plume. Courtesy CIRA.

Introduction

Qualitative use of GOES-R ABI data via imagery is perhaps its number one use; forecasters view an animation of clouds and make important inferences about the state of the atmosphere. This includes tracking storms, identifying the center of rotation for tropical cyclones, and monitoring convective boundaries prior to convective initiation, among others. Imagery is also important for Suomi NPP/NOAA-20 VIIRS given its high resolution relative to geostationary observations.

1) Session Purpose

a) One of the key uses of data from both the GOES-16/17 ABI and SNPP/NOAA-20 VIIRS is direct use of images, where the radiances are mapped to a color palette and displayed in a mapped projection. In the case of geostationary imagery, the images are then animated to allow for cloud motion. Feedback from users indicate that geostationary imagery is used significantly more than the GOES-R Level-2 products, so that alone warranted the inclusion of an Imagery session at this Summit. One common way to combine imagery from multiple spectral bands is

via Red/Green/Blue (RGB) composites – this allows a satellite analyst to quickly and efficiently glean valuable information from different bands. This panel brought NWS forecasters from Alaska and Virginia, and scientists who specialize in imagery visualization from NOAA and CIRA to discuss forecaster needs and developer challenges.

2) Agenda

Presentation	Speaker	Affiliation
User Imagery from National Weather Service WFO Fairbanks	Melissa Kreller	NWS/AFG
WFO (LWX) Perspective: Satellite Imaging	Steve Zubrick	NWS/LWX
Imagery: Global coverage, product generation, and distribution	Don Hillger	NESDIS/STAR
Imagery Panel	Tim Schmit	NESDIS/STAR
Satellite Imagery: A Developer's Perspective	Steve Miller	CIRA

3) Key Takeaways

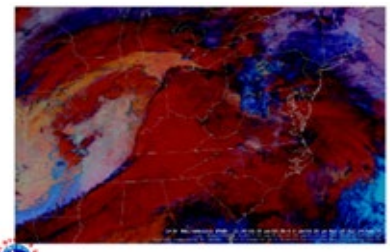
<u>User Challenges</u>

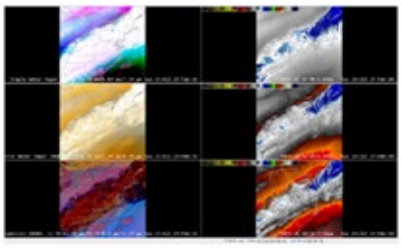
a) More training needed on imagery – office visits and AWIPS help guides are good
b) How to manage data overload? There are lots of new RGBs – which of them are best for local issues?
c) AWIPS struggles with 4-panel complex RGB displays

<u>Developer Takeaways</u>

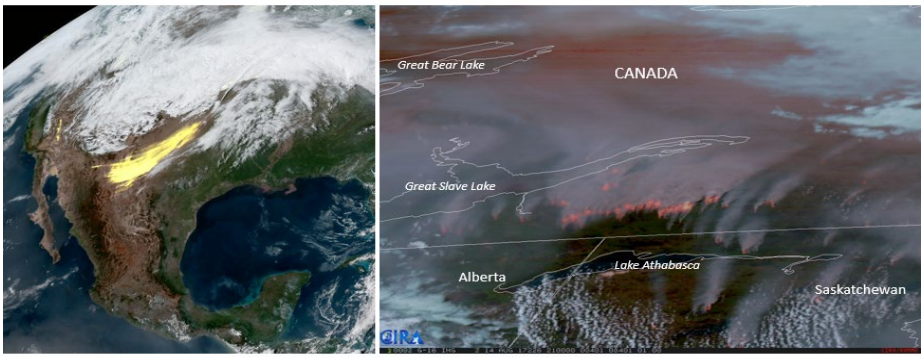
a) VIIRS EDRs need terrain correction to fix navigation errors
b) Be wary of artifacts
c) Use rapid scan (1-min) data for more than just imagery – AMVs and Fire Detection
d) Complex RGB displays can provide very intuitive and operationally useful decision aids
e) Put a low-light sensor in geostationary orbit – it would remove the latency and fills in the full nighttime period with visible wavelength information

4) Graphics





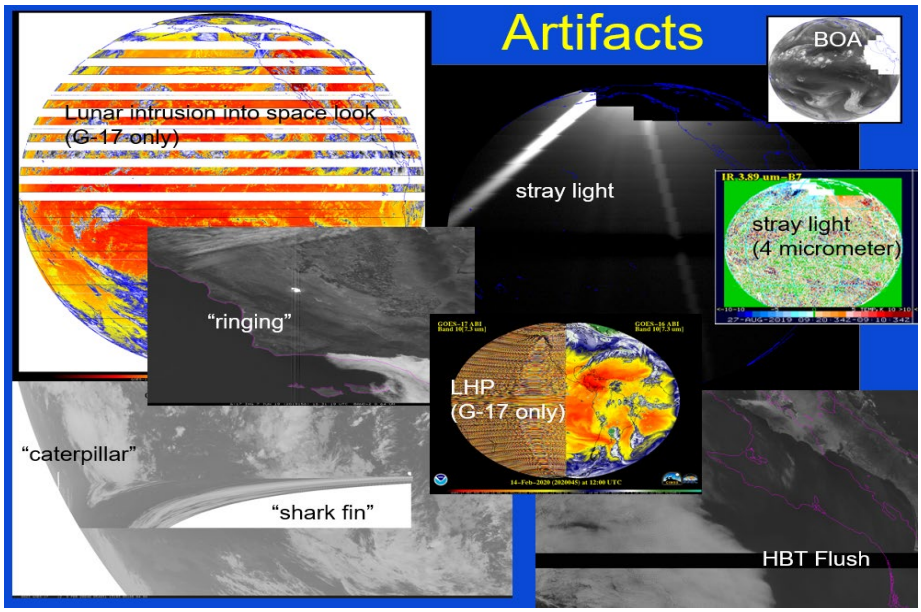
Bring Things Together…



→ **Combining enhancements, when it makes sense, can save the forecasters time**

"A four-birds-eye view of fires in Alberta" blog - 2019
http://rammb.cira.colostate.edu/projects/alaska/blog/ (C. Seaman, CIRA)

Comparison between GOES-17 ABI, S-NPP VIIRS, and GOES-16 ABI Fire Temperature RGB images (2000 UTC, 19 May 2019) zoomed in at 400%



5) Questions/Answers

Question	Answer
Is there any user push for more GEO/LEO product fusion?	Melissa: Yes. Having GEO's high temporal capability and the ability to combine the higher resolution LEO data when available is helpful. Steve W.: Over CONUS we rely more heavily on GEO data, but we could take a look at any fusion product to see whether or not it provides value. Steve M.: From the developer's standpoint, one example where combining GEO/LEO makes sense would be with the city lights on the Day Night Band - with dynamically changing lights information, you could identify power outages in a product like GeoColor.
How much of the data used in your office is coming via the Direct Broadcast antenna at GINA?	Melissa: I don't know the percentage. The forecasters do like the data that comes from GINA because it has lower latency than when it comes from other channels, where the latency can be over 2 hours.
Would users be interested in parallax corrected cloud positions, despite the possibilities of data voids and holes?	Melissa: Moving the cloud to where it should be could be beneficial. Steve W.: Yes. We would like to see the effects of the data voids and holes that would result from a parallax correction. Bill L.: This was tested at the HWT one year, and the users did not like the parallax-corrected imagery due to the artifacts it produced.
Users: what mode of training have you found to be most effective? Blogs, live webinars, recorded training, in person, etc.	Steve W.: All of the above. The key thing is to get the user involved and make sure they're involved. If they're just staring at a screen that they don't get as much out of it. We try to use one on one training as much as we can, but since we're a 24x7 office, it

	makes it challenging. We have 4 workshops per year, and I always have a satellite component to each of the workshops. But we don't get all of the staff at those. Melissa: We are co-located with GINA, and they had someone come over and sit with the forecaster - this was very helpful. I agree with Steve's answer of 'all of the above.' Getting the forecaster to interact with the data in a real time mode is helpful too.
Steve - how easily can these enhancements get to NWS field offices (not going through the AWIPS program office and waiting 3 years). Is there heavy processing?	Steve M.: Sometimes there's heavy processing and sometimes not. GeoColor and DEBRA require ancillary datasets and RTMs, making these more difficult. There's a current effort to put the processing with the data at the forecast office to remove the need to pipe data around.

6) Recommendations

a) Continue the development of imagery training, particularly on RGBs, and use a variety of training formats.
b) Fix AWIPS so that it can better handle the display and especially animation of complex RGBs.
c) Perform terrain correction on all VIIRS imagery in order to fix navigation.
d) Combine information where it makes sense into imagery products.

Fire and Smoke

Moderator: Bill Sjoberg, JPSS

A fire event can have far-reaching impact on the environment, including ecosystem change, and permanently altered landscapes. In addition, fires can have negative effects on weather, climate, and atmospheric composition. Smoke emissions affect air quality and represent a major health hazard. In the human/urban interface in particular, fire events pose the danger of life and property loss. An example of this was the 2017 Fire Season in the Western US. By the middle of September 2017, more than 8 million acres had burned with more than 500 homes and other structures destroyed. In addition, the Forest Service had spent more than $1.75 billion fighting fires and the Interior Department had spent more than $391 million since the season began. Beyond structural damages, there were further risks associated with the smoke from these fires, particularly to vulnerable groups like children, the elderly, and people with respiratory and cardiac conditions. These risk groups can often be hundreds of miles away from the fire.

The timely detection of active fires from ground-based or airborne platforms can be quite challenging, especially when there are multiple fires over large areas. In these situations, satellite-based systems are the most practical and feasible means for accurate and consistent large-scale fire monitoring. With sensors that are extremely sensitive to the radiative signal, satellites are able to spot the areas where a fire is occurring and differentiate them from the non-burning background. In addition to detecting and providing the location of fires, the VIIRS sensor and the Advanced Baseline Imager (ABI) on GOES-R have the capability to indicate fire intensity through a variable called Fire Radiative Power (FRP).

1) Session Purpose

Provide summit participants information on the societal impact of wildfires and smoke and how key users apply satellite capabilities operationally to respond in all phases of a fire event. Presentations were from personnel representing users from a wide spectrum of decision makers tasked with taking

actions to safeguard life and property. Developers engaged in the Fire and Smoke Initiative presented information on their activities to meet user requirements. Wildfires across the United States have caused millions of dollars of damage and killed dozens. The public interest resulting from these fires has reinforced the importance of the collaboration between users and developers in this initiative. Despite the tangible progress made since the initiative was founded there is still work to do. Users were asked to present their challenges and developers were to present ways to improve the user experience. There was an extended period to time for joint discussion and questions and answers. The goal was to ensure that a free exchange of ideas would lead to future actions to benefit the operational applications of satellite capabilities.

2) Agenda

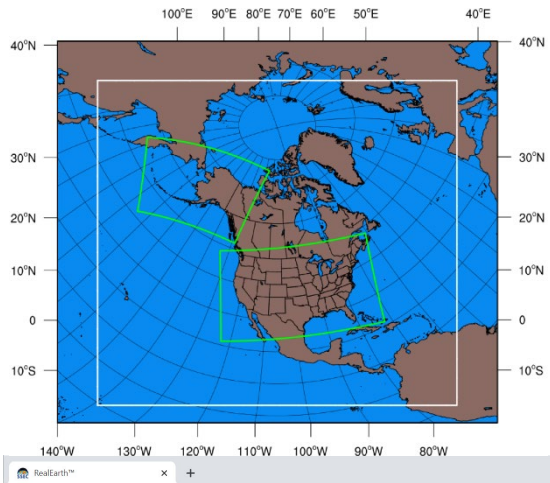
Presentation	Speaker	Affiliation
Science, Technology, and Data Applications for Disaster Operations	Adam Barker	FEMA Response Geospatial Office
Proving Ground Summit Presentation	Eric Holloway	NWS Emergency Services Branch, Alaska Region
National Water Center Integrating Model and Remote Sensing Data for a Complete Hydrology	Shawn Carter	NOAA National Water Center
AmeriGEO Earth Observations for the Americas	Angelina Gutteriez	International Projects - Lead Hydrologist - NOAA - office of Water Prediction
An Overview of the current GEO-LEO Flood Products and Future Development	Sanmei Li	George Mason University
Operational River ice monitoring and forecasting over the US and the Globe using SNPP and NOAA-20 VIIRS data	Naira Chouch	Community College of NY

3) Key Takeaways

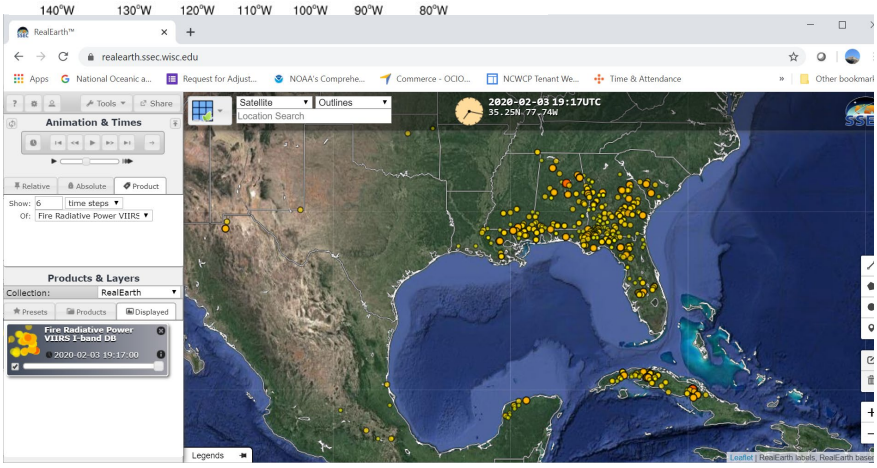
a) Users
   i) The HRRR and RAP Smoke Forecasts are becoming increasingly accepted by WFO as shown in their use on the WFO facebook sites.
   ii) In clear weather conditions the GOES imagery has proved to be very valuable in the Fire Operational Centers especially those with robust communications capabilities.
   iii) SNPP and NOAA-20 VIIRS FRP used to estimate near real time Global Biomass Burning Emissions Product (GBBEPx) that is operational and used as input to NWS operational and experimental aerosol prediction models
   iv) Wildland fire behavior intelligence (e.g., rate of spread, burn area, fire radiative power), based on polar orbiters, can be important to decisionmakers.
   v) Polar orbiter wildland fire mapping information from the Burn Intensity Delta Greenness Estimate (BRIDGE) is critical for developing an initial burn scar polygon.
   vi) VIIRS FRP is useful for situational awareness, briefings, social media.

b) Developers
   i) Satellite Active Fire (AF) information has distinct fundamental operational applications.
   ii) Need to keep working with NWS to get satellite fire products into AWIPS. Latest plan is sometime in 2020.

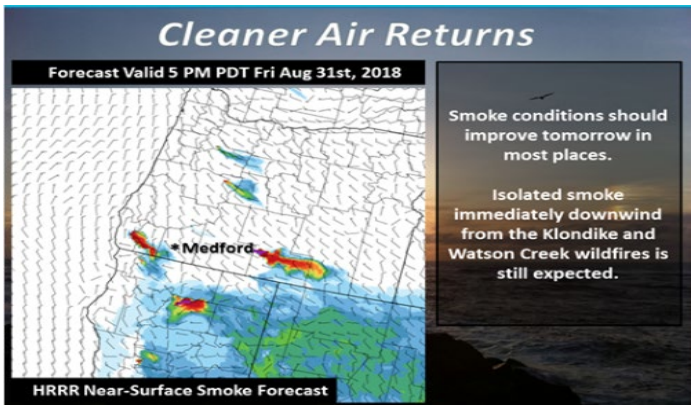
4) Graphics



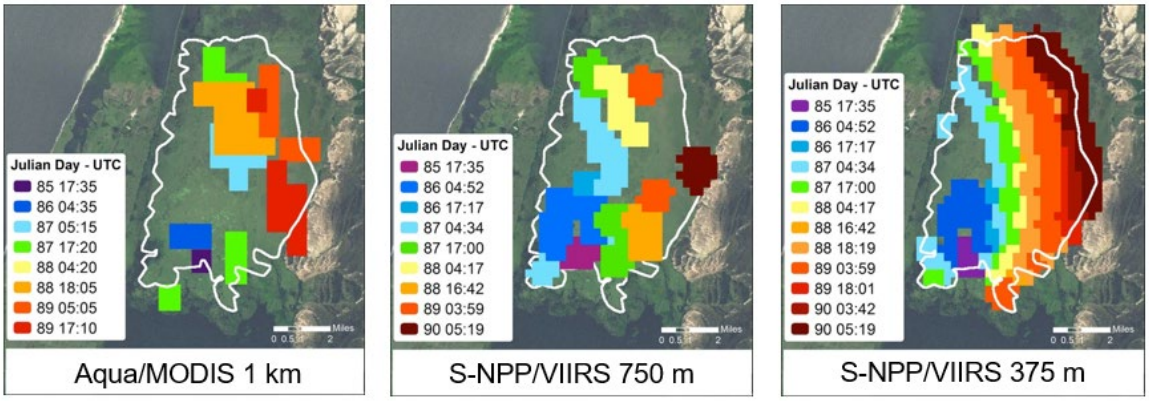
NCEP/GSD operational smoke forecast models: RAP (white), 13.5 km resolution and HRRR model domains (green), **3 km** resolution



VIIRS I-band FRP data from Direct Broadcast in RealEarth



HRRR Smoke Model Forecast on Medford Facebook



VIIRS Active Fire Detection Comparison

5) Questions/Answers

Questions	Answers
Any thoughts on the potential development of a unified GEO+LEO fire application that includes alerting and fire tracking (for auto time series generation)?	NOAA is pursuing development of its Fires Enterprise algorithm. The proposed system will contain sensor-specific detection modules and provide output in a common format that is a hybrid of what are provided by the geo and leo products today. The plan to create "fire events" which cluster fire pixels in time and space, regardless of platform, to provide a unified time series for a single fire event. Work will need to be done on how to create a consistent fire characteristics record for those fire events.
What are prospects for getting vertical resolution of smoke concentrations? Can smoke from fire obscure satellite information, e.g., for Fire Radiative Power?	The HRRR-Smoke model provides full 3D distribution of smoke. Users can use AWIIPS and other tools to make cross-section plots and visualize the vertical smoke distribution from the model output. Thick smoke can obscure the fire signal similarly to clouds. In fact, in the current products thick smoke is often flagged as "cloud" by the internal cloud detection algorithm. We are planning to re-name the "cloud" class to "cloud/thick smoke".
What are prospects for fire smoke plume 3-D visualization products, say, for first 50 km of plume?	The users can zoom on the HRRR-Smoke output to vizualize the smoke plumes near fires. The model output comes at 3km horizontal resolution. These tools or platforms can be used for visualization: AWIIPS, WAVE or NOAA's interactive map: https://hwp-viz.gsd.esrl.noaa.gov/smoke/index.html
In a few years Europe will have a 1 km operational 4 um band from GEO. Do you support this on the next generation GEO imager?	Yes, it should be coupled with a 1 km 10 or 11 um window band as well, for maximum benefit. Ivan Csiszar: sensor characteristics i.e. saturation level, remapping etc. need to meet specific requirements of hot spot detection and characterization
How close is the operational FDC algorithm to the WF-ABBA algorithm currently being run at Wisconsin?	They are the same basic algorithm, though the UW-Madison implementation of the WFABBA is considered experimental and

	subject to updates much more frequently than the operational FDC.
When will the VIIRS baseline fire products be transitioned from 750-m to 375-m?	The process is expected to take place during the spring and summer of 2020.
Why isn't the GOES-R fire product run on the Mesoscale Domain Sectors? This is a significant limitation of the GOES-R product.	The decision against running the FDC on Mesoscale sectors was made early on in the GOES-R requirements process. While the old WFABBA requirements for GOES-8 through GOES-15 were to process all images, regardless of scan schedule, for fires, that was no transitioned to GOES-R. There is an effort underway to change this and to start providing the FDC data for Mesoscale scans.
What wavelengths and resolutions do you advocate for GEO-XO to improve fire detection in the 2030s and beyond?	500 m for ~4 um and a longwave IR window band at a minimum - with a Tundra orbit we'll quickly find that we'll make good use of high resolution at higher latitudes. A lot of burning occurs in the far north and much more will as the climate warms and dries. Additional benefit can be gained with shortwave bands similar to what ABI has today.
What spatial resolution of the 3.9 um band would provide forecasters with a precision for hot spot detections that is good enough for NWS partners?	Given the wide spectrum of interested parties this is difficult to quantify. Some users are very interested in early detection, in which case the finest resolution that is technically achievable would be the right answer. In order to provide a sufficient fire signal to be reliably detected over the background for small fires, 500m would provide a quantum leap over what is possible today. It should be noted, however, that the current ABI is discerning very small fires today, it is unclear what the lower limit actually is given that house fires and what may be large slash piles on Midwestern farms have produced detectable signatures.

6) Key Challenges for Users/Developers

a) Users

I. Users need information on current fires, new fires, anticipated emergence of fire

II. Information on the vertical distribution of smoke is unavailable from GEO/LEO satellites.'

III. A LEO/GEO fused machine learning-based algorithm, analogous to ProbSevere, is needed that provides probabilistic characteristics of wildland fire

IV. There is an increasing demand for high spatial-temporal resolution smoke forecasts over the US for various applications:

a. Smoke/air quality alerts (impact on health and outdoor activities)
b. Visibility (ground transportation, aviation)
c. Smoke impact on meteorology to improve weather forecasting
d. Solar energy production

V. Extreme fine scale forecasting – hundreds of meters, potential large domain

VI. Terrain influences create dynamic, chaotic environment

VII. High resolution data sets vs. low bandwidth, floating domain

VIII. Data compression limitations

IX. Limited surface observing stations / field observations
X. No fuels data in AWIPS
XI. Assess the atmospheric environment (temperatures, RH, winds)
XII.

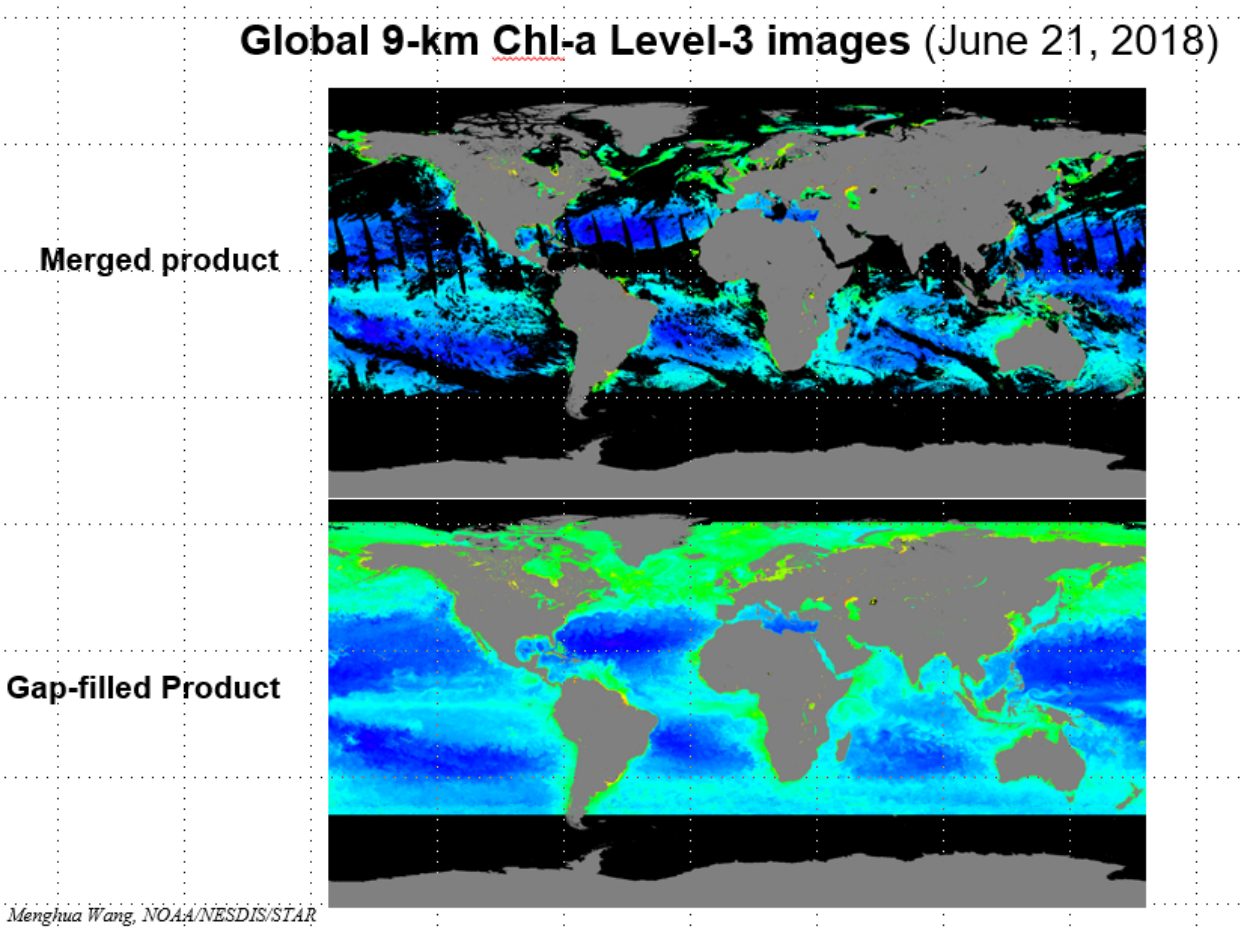
b) Developers
   I. The satellite fire products give too many anomalies and false alarms. What is identified as wildfires are fires from non-threatening sources (oil/gas flares, volcanoes, solar farms, etc.)?
   II. The "Enterprise" system for fires is currently being defined. The system would provide a unified framework for the fire detection algorithms for different platforms and a common set of output variables.

7) Ideas for Improving the User Experience
   a) Western Region SOOs provided feedback on a survey with the following question: The ATMS and VIIRS are 2 primary instruments on NOAA-20 we are making use of - ATMS provides the NUCAPS imagery, and VIIRS includes the DNB imagery, SSTs, and Active Fires. The responses showed that work was needed to improve the user experience.
   b) Identify opportunities to discuss satellite fire capabilities with other NWS regions. Use the lessons learned from the AK and Western Regions to tailor information sharing.

8) Recommendations
   a) Ingest the high-frequency GOES-R/S Fire Radiative Power (FRP) data into RAP/HRRR-Smoke
   b) Transition HRRR-Smoke to the operational system at NCEP
   c) Assimilate the VIIRS AOD in HRRR-Smoke
   d) Transition to the FV3 based convection allowing model
   e) Complete GOES-R FRP assimilation into emission modeling
   f) Increase GEO-LEO synergy
   g) Increase mid-morning polar coverage Sentinel-3 SLSTR and Metop-SG METImage
   h) Build systems to provide agile, accurate, fast automated detection / characterization products
   i) Work to provide easy data access for all stakeholders
   j) Identify ways to convergence towards a sensor-agnostic product suite
   k) Look into how satellite soundings can help in remote environments
   l) Work with the NESDIS Satellite Analysis Branch (SAB) to collaborate on support to the fire mission and help free up their resources.
   m) Tailored, more strategic detailed fire analysis for disastrous fire

Ocean and Coastal

Moderator: Veronica Lance



The ocean covers more than 70 percent of the Earth, yet it is one of the most sparsely observed parts of the globe for weather forecasting purposes. Global sampling of the ocean is feasible only from earth-observation satellites. Understanding ocean, coastal and inland water processes, both physical and biological, are essential to achieving NOAA's mission including improved extreme weather forecasting, ecological forecasting, and ecosystem-based fisheries management.

1) Session Purpose

The purpose of the Ocean and Coastal session was to provide a forum for NOAA line office users, STAR product developers and other stakeholders to discuss challenges, opportunities and priorities for meeting user needs with JPSS and GOES-R program data. The session began with a description of the role of NOAA CoastWatch/OceanWatch/PolarWatch services that bring data and users together. Next, the STAR science developers presented. Alexander Ignatov showed the latest developments of JPSS and GOES-R sea surface temperature and Menghua Wang showed the latest developments of JPSS ocean color (normalized water leaving radiances and derived products such as chlorophyll concentration and the coefficient of downwelling light attenuation). Then, user representatives from 3 NOAA line offices gave presentations to highlight only a sampling of the overall uses of ocean satellite data within NOAA (n.b. only one session to cover all ocean and coastal topics vs. other sessions detailed on relatively specific, directed topics). Michael Ford reported requirements for NMFS. Shelly Tomlinson and Alex Kurapov from NOS talked about

harmful algal bloom applications and requirements and the development of the West Coast Ocean Forecasting Service, respectively. Finally, Joe Sienkiewicz talked about extreme maritime weather and the requirements for scatterometric ocean winds in forecasting winds, waves and currents for maritime safety. A panel discussion followed with audience questions taken from the SLIDo online platform.

2) Agenda

Presentation	Speaker	Affiliation
Ocean and Coastal Developers		
Advancing Ocean Satellite Data into Applications, Information and Decisions: NOAA Coastwatch/Oceanwatch/Polarwatch,	Veronica P. Lance	STAR/SOCD, NOAA CoastWatch/OceanWatch/Polar Watch
NOAA SST Products & Priorities,	Alexander Ignatov	STAR/SOCD
VIIRS Global Ocean Color Products,	Menghua Wang	STAR/SOCD
Ocean and Coastal Users		
NMFS Satellite Summit 2020,	Michael Ford	NMFS
NOS Requirements JPSS/GOES-R Summit,	Michelle Tomlinson	NOS/NCCOS
The West Coast Ocean Forecast System (WCOFS),	Alexander Kurapov	NOS
Extreme Maritime Weather,	Joseph Sienkiewicz	NWS/OPC
Ocean and Coastal Open Discussion		

3) Key Takeaways – Overall

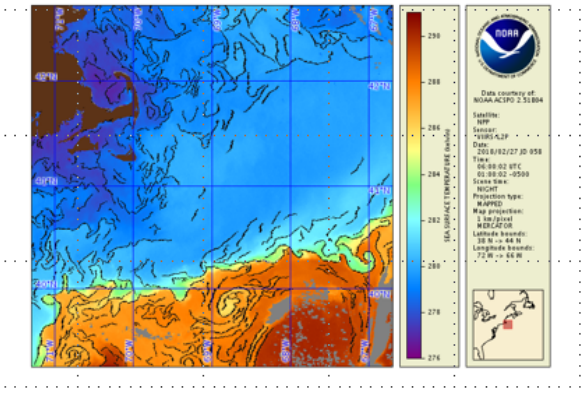
a) Golden Age of ocean satellite observations. The JPSS/GOES-R Ocean and Coastal Initiative covers only a portion of the full suite of ocean satellite observations now available. Many ocean data products are derived from non-NOAA satellites (e.g., ocean surface vector winds from scatterometry). Ocean EDR teams represented across JPSS Initiatives (e.g., cryosphere, flooding, tropical cyclones, etc.)

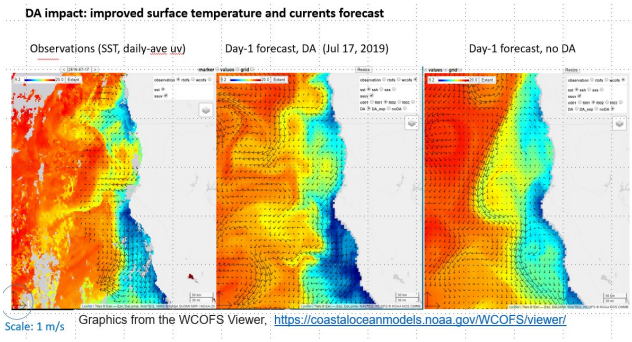
b) NOAA CoastWatch/OceanWatch/PolarWatch is user-focused/user-driven and serves as intermediary between upstream Science/Developer teams and downstream users (e.g., "**Value Chain**" from observations to data to products to applications to user decisions)

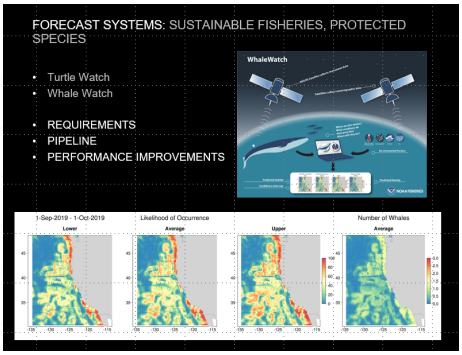
c) NOAA users of ocean satellite data include all NOAA Line Offices (NWS; NMFS; NOS; OAR; NESDIS). These have operational uses of the data. CoastWatch is filling the gap (e.g., the move to moderate assurance).

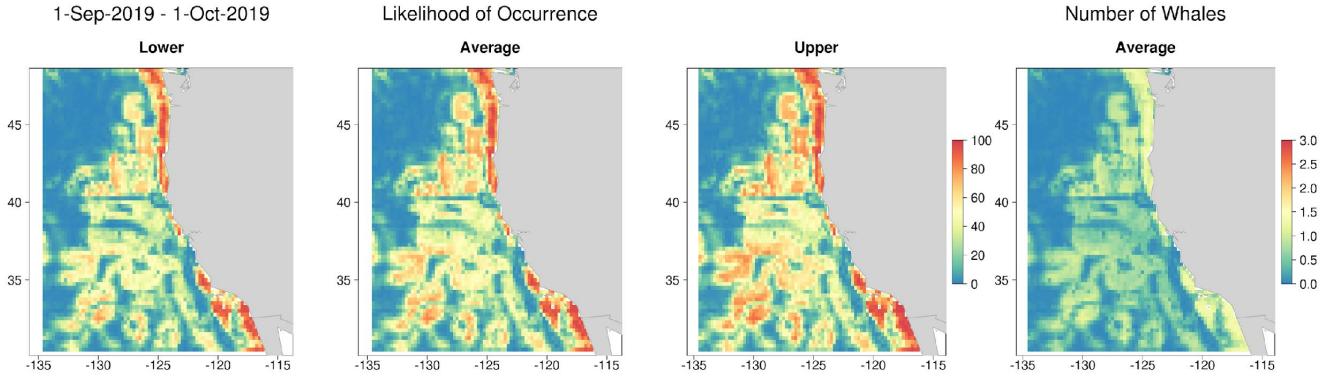
4) Graphics

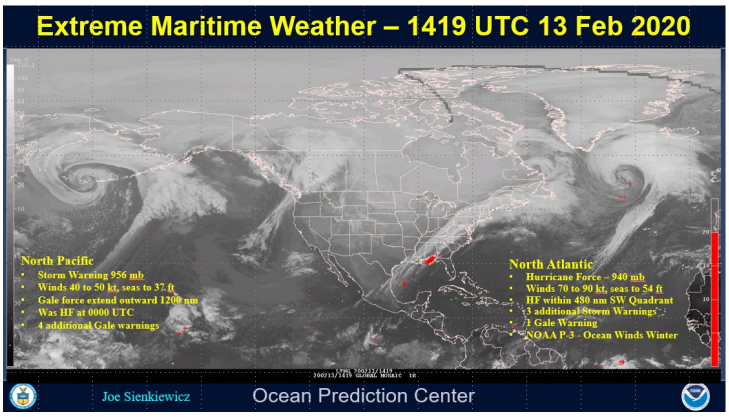
- Thermal Fronts will be first reported in ACSPO v2.80 planned for delivery to ops in Aug 2020











5) Questions/Answers – See Google Doc
https://drive.google.com/drive/u/0/folders/1EvsXVvPbxSFbkz-25Y01bEhEAv2GZG8J

Question	Answer
What spectral bands do you want to see for coastal/ocean applications on the next gen (GOES-XO) Imager? Would that be different for a Tundra/Arctic mission? Want a circulation product, also salinity with improved accuracy, application of AI to combine different sources including nWLR as a proxy for chlorophyll	Safety: Ocean winds, currents and waves spectra (wide swath) Fisheries: blended products, unified cohesive blended products to get data into their analysis, in R&D determine phytoplankton functional groups – not just chlorophyll. Access state data on this functional groups like NOS is doing with MD and VA DNR. Shelley: trends in temperature related to climate, higher spectral resolution sensors related to resolution that is on OLCI now would be great and allow continuity, unknown about tundra/arctic areas. Menghua says spectral band is needed. Sasha said – there is a blended salinity but it comes at the price of daily products, otherwise 4x/day. A 3 hr increment might be possible. An L3 product is currently available from 3 different lines – a couple of months of data, but this is experimental. Planning to continue to process NPP and NOAA20 working on METOPs next for reprocessing to generate an AM line of? Unfunded but doing it anyways as possible. Menghua said – IOC is working on this for [June?] most Joe's talk is about physical but biology is important too and has an impact on people's daily life too – should also be considered a hazard in the model, same as bad weather. Paul Chang – winds need OSVW to be embraced and supported by NOAA – international

	support, but not so much in NESDIS. Key parameter for weather service, we have good coverage, missing temporal in places. Other users focused on CHL as a primary need for validation, are there other parameters to drive the model that also need validation to better understand habitat areas? Scatterometer on JPSS – Mitch, can get down to 12km as the real resolution, can we push for what we need to resolve coastal needs – what else besides just spatial resolution?
CoastWatch VS NOWCoast – What are the differences?	NOS is NOWcoast – a server not a program. CW is a program focused on ancillary data and all parts of noaa and all regions. People go where they are comfortable. If you cannot find it go to CW.
How long chlorophyll anomaly data is available? How to access that data?	1. Viewable now on OCView online viewing tool by the NOAA Ocean Color EDR team Available since May 1, 2017 with some gaps. The data files are currently in transition to CoastWatch and datafiles will be released through CoastWatch soon. Contact CoastWatch Helpdesk with a data request if you need it sooner. 2. SNPP VIIRS only. Follow this stepwise tutorial a. Open OCViewer b. In lower left choose: i. VIIRS SNPP ii. Geographic iii. user-specific ratio (scroll to bottom of list) iv. NIR NRT v. Turn on: daily, shorelines, ocean color 3. https://www.star.nesdis.noaa.gov/socd/mecb/color/ocview/ocview.html#date=20200406/zoom=5/lat=42.7368/lon=-60.4687/tc=false/l2=true/sens=VIIRS/proj=4326/algo=noaa_msl12_nrt/prod=d61pchl/ave=daily/cbar=false/gran=false/coast=true/grid=false
When do STAR products become operational? How do you determine which products go operational and who are your main users?	In CoastWatch we provide them when they have been vetted by the science teams – 'little o' operational, not formally operational, although they can get there. OSPO drives that

	for the transition process, CW is not as formal a process but also less assurance for providing the product. If you have an operational need for Ocean Data go to Veronica with the inquiry and she can help you find out reliability/frequency/etc. and how best to get this available to you. In NESDIS, there is a formal process (SPSRB) to transition experimental products to OSPO, the capital "O" operational entity. Products need to have NOAA users to initiate that formal process. CoastWatch fills a gap between science teams and users for getting experimental products into the hands of users and to collaborate in developing downstream applications. CoastWatch also transitions experimental products to OSPO
1. What does the amount of plankton tell you about the biodiversity in that part of the oceans? 2. Is it linear? 3. Does more plankton translate to a stronger fishery?	1. Satellites cannot measure the amount of [phyto]plankton in the ocean, they report the quantity of phytoplankton pigments found near the ocean surface (not at depth), some phytoplankton types can be assessed, but not all and not species only family. Presence of phytoplankton indicates primary productivity, but some blooms can be harmful algal blooms and would have negative impacts on the biodiversity of zooplankton, the benthos, and fish (higher trophic levels). Some blooms arise due to upwelling of nutrient rich bottom waters, some arise due to land-derived nutrient inputs, some blooms persist in the absence of both upwelling and allochthanous nutrients and blooms can also be advected to new areas in the ocean. Satellites can show you phytoplankton location(s) and surface concentration over time, and some species composition. 2. No it is not linear. 3. No, phytoplankton functional types are more indicative of food webs and fisheries. Major shifts in secondary consumers, usually related to physics,

	more directly impacts fisheries than chlorophyll does. Relating seascapes to determine fisheries – lots of attention with those products.
Are all NOAA data portals authoritative trusted sources?	NESDIS Strategic plan VISION STATEMENT says NOAA is the trusted source for environmental data. We do not follow the trademarked attribute TrustedSource. According to wikipedia TrustedSource is an Internet reputation system originally developed by CipherTrust and now owned by Intel Security. It provides reputation scores for Internet identities, such as IP addresses, URLs, domains, and email/web content.
Is there a location to identify and track HABs along cost daily? CoastWatch? NOWcoast? ERMA? NWS? NESDIS STAR? So many NOAA data portals? Which is authoritative?	There is information on CW (see anomaly question above) and then there are forecasts put out by NOS COOPS found here [insert hyperlink]. STAR provides the satellite data information, for proper interpretation of this data into a HAB forecast that is an operation output by NOS-COOPS.
For Harmful Algal Blooms, what mixture of spatial/spectral/temporal would be optimal?	It varies, currently our satellite observations offer broader temporal and spatial coverage that limited in situ sampling provides. Spectral bands are limited, but higher spectral resolution satellites are in development which enables better resolution of blooms globally.
Is there an authoritative source for HABs along Florida's coast? Forecasts? Tracking?	In NOAA the authoritative source is NOS/NCCOS. For tracking of HABs along Florida's coast through in situ measurements and for responding to events, the state authoritative agency is Florida's Fish and Wildlife Conservation Commission. NOS/CO-OPS distributes forecast information on the Florida HABs, but newer capabilities are developed and presented in NOS/NCCOS.
What advantages does Korea's GEO KOMPSAT 2B provide for ocean and coastal products?	Launched last year, same domain as Himawari. Will be great for system checks and for ocean color too. Menghu says using GOCE1 ocean color. 8 spectral bands 500m products produced now from NASA. GOCE2 was launched recently, very similar and for ocean color. Sasha – worried only about access to the data since an international agreement is missing, the IIA division must do this and allow NOAA to gather the data. Geostationary may be for future NOAA OC needs.

Is the VIIRS DNB still actively used to combat illegal fishing? Mike Ford -- the VIIRS Day/Night Band (DNB) has unique capabilities to detect boat lights. Are you leveraging the DNB for surveillance support?	We know about this capability, in terms of using that for LE not quite ready to do that yet. Any information on using that for prosecution is welcomed. Menghua added that it was useful for coastal areas too – not just night also in day 2 What operational benefits would having marine vessel positioning in AWIPS provide for IDSS?
What operational benefits would having marine vessel positioning in AWIPS provide for IDSS?	If integrated with weather position, this gives impacts of weather and avoidance practices, how many and where vessels are – this breaks the myth that when a storm goes offshore it doesn't impact anyone. Using another program not AWIPS for this.
Are you aware JAXA uses AI to train AHI to GCOM-C SGLI? The results are encouraging. May want to consider to test concept with ABI.	Yes we are aware, and Menghua Wang is part of the Science Team at JAXA. The development of ABI for ocean color is a current research project in SOCD, and we are exploring AI use in satellite data.
Does the Ocean Prediction Center apply SAR wind speeds into their forecasts?	No, Joe Sienkiewicz doesn't have access to them at this time, resolution is limited and not showing smallscale features.
Joe S., does OPC/WPC have access or use SMAP, SMOS or AMSR2 winds? Are those helpful? Have you had time to evaluate?	to SMAP – yes but not operational, to SMOS - yes but not operational, to AMSR2 - winds yes, it is operational. Yes these are helpful to winds and SST for AMSR2. [editorial note: did not address helpfulness of SMOS/SMAP].
If SAR winds (like SARsat 1 and 2 and Sentinel) were in AWIPS would that improve the wind detection to go along with ASCAT?	Yes
Joe S, Does OPC or WPC have a historical database of Extra tropical cyclones with hurricane force winds that developers may use for product development?	OPC has several forecasters that contribute to an internal accounting of extra-tropical storms that we have thought to reach hurricane force. I say it that way as we do not always have "observations" as the cyclone may peak between scatterometer passes. We have been a bit hesitant to make available as it really is just a big spreadsheet and is based solely on our forecasters warning decisions in real-time. Many of those decisions are based on scatterometer winds, primarily from the ASCATs. I am not sure this is a satisfactory answer. I have to admit, due to our heavy operational load we, OPC, have not been able to publish our findings and something we are working on.

At one point there were plans for a GOES-R currents product, what is priority for working that?	*Ask Eric Lieuliette.* We do have an interest in producing a Currents Product, which would use altimetry, model winds, and GOES-R SST. It was not added to the Sea Surface Height team product line plan, but we can include it. Before a Currents Product is advanced, we would need to identify a user and have a user request. At the moment, there is not a firm understanding of what potential user requirements would be, but anyone interested in defining those may contact Dr. Deirdre Byrne.
Oceanography & meteorology over oceans are often treated with separate development. How can satellite observations of air/sea interactions be more holistic?	Joe Sienkiewicz: A very good question, I love that the meteorologists were brought in very late to the QuikSCAT effort as that scatterometer was completely designed to meet oceanographic needs and answer questions concerning ocean forcing by wind. Not a criticism, more a backhanded compliment as wind is such a key parameter for both disciplines. Both communities have benefited significantly. We are moving rapidly to earth system modeling with coupled systems that will rely on atmospheric, oceanographic, and ocean wave observations, understanding and interactions. I am lucky that my undergrad degree was Meteorology and Oceanography, still two disciplines but the interactions and reliance of both disciplines were quite evident and taught that way. Other programs like FIT have followed that model that was started by NYU. There are some instruments that do sample both the atmosphere and ocean, VIIRS with ocean color, the scatterometers measure the surface roughness and derive wind speed and direction and therefore wind stress curl from which the wind component of the ocean mass transport. An atmospheric parameter to estimate the ocean response. Such an instrument as the AMSR (Advanced Microwave Scanning Radiometer) can sample the ocean surface (SST), estimate the wind speed, and see precipitation structures or the rain structure of tropical cyclones. The GOES-R series with increased IR resolution and 5 min sampling has the ability to see the complex thermal structures of the ocean

	surface but requires some work to see such features, not just a static image. Fortunately in NWS, AWIPS has the capability for forecasters to play with display capability, narrow the temperature range and increase the contrast in gray scale and loop as quickly as can be. The subtle ocean thermal structures absolutely stand out. I am on a small team with OAR, NWS modelers, and academia concerning observations to increase hurricane intensity forecast skill and the forecasts of other extreme weather events over the oceans. For modelers, three science areas were mentioned as needing measurements to begin to understand, waves, sea spray (role in heat and moisture fluxes), and hydrology - the fresh water lense due to precip. These are ocean parameters that play a key role in intensifying tropical storms. So I have rambled a bit, I think we suffer from an under appreciation of the relationship and exchanges between the ocean and atmosphere even in the weather timescales. We certainly know there is a strong relationship when it comes to any forecasts beyond 7 to 10 days, however in the weather time scales, I do not think most meteorologists appreciate that the ocean also changes within those time scales. As we advance coupled modeling systems, we will need to have an understanding of the exchanges and contributions of ocean/atmosphere otherwise we have a chance at actually reducing forecast skill.
Is ocean modeling 20 years behind atmospheric modeling? 10 years? 30 years?	The use of satellite data in ocean models is now at a convergence where the ocean models are sophisticated enough to be improved by satellite observations (assimilation and/or boundary conditions) and the ocean satellite observations are mature enough (algorithms, validation, routine processing, multi-satellite constellations for ocean parameters, etc.) that they can be reliably pulled into models. It isn't that ocean modeling is that far behind atmospheric modeling, per se. It suffers from very limited resolution of observations (horizontal and vertical) of critical parameters

	on the scales that are significant in the short term for ocean prediction.

6) Key Challenges for Users/Developers

a) Users

i) Needs for:
- Higher-level products – fusion, super-collated, merged, gap-filled, etc., even cross-parameter model products
- Long-term time series
- Fronts
- Anomalies
- Phytoplankton functional types, primary productivity
- Higher spectral resolution needed (future development, pull from non-NOAA satellite sources)
- Shorter latencies
- Operational products derived from non-NOAA satellites (e.g., Salinity, Winds)

ii) Where to find data, data products – many sources available, what is "trusted" source?

iii) Better descriptions of data, data products, uncertainties

b) Developers

i) Resources needed (scientists, time, computational resources, etc.) to produce quantitatively valid higher level products to meet user needs (e.g., cross-platform)

ii) Reconsider NOAA-level restrictions on communication allowances (e.g., product registration, surveys, social media accounts, etc.)

iii) Leverage resources outside of science teams to reach users, e.g., better staff support for communications, outreach, graphical design, etc.

7) Ideas for Improving the User Experience

a) Produce higher-level products currently in development or experimental as operational for users.

b) Multiple approaches to reach users and respond to needs:

c) More training courses, including online learning portal

d) Better and more consistent product descriptions

e) Collaborate directly with users for innovative product development

f) Improve "branding" of various NOAA (i.e., NOAA CoastWatch; SOCD science teams; OSPO; etc.) data providers

8) Recommendations

a) …..

b) …..

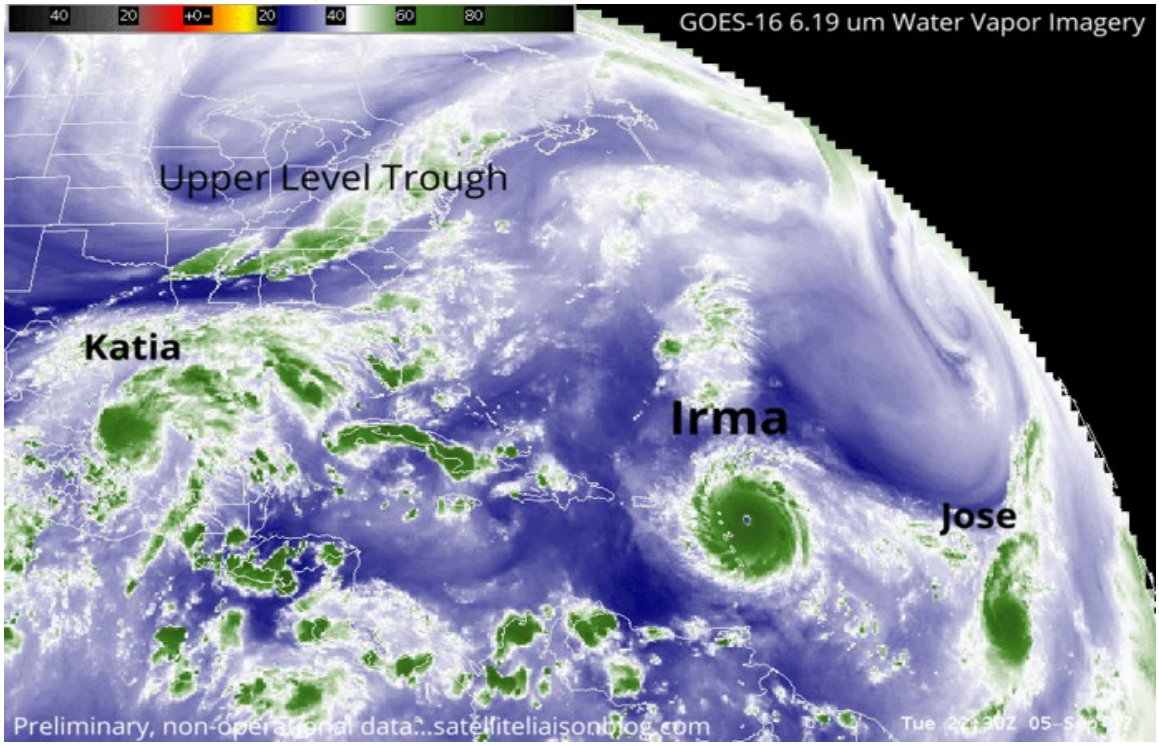
c) …..

d) …..

e) ……

Tropical Weather

Moderator: Monica Bozeman, NHC



According to NOAA's National Centers for Environmental Information (NCEI), of the 246 (as of April 2019) weather disasters since 1980, tropical cyclones have caused the most damage: $927.5 billion total, with an average cost of almost $22 billion per event. Of the 258 U.S. weather disasters since 1980, tropical cyclones have caused the most damage: $945.9 billion total, with an average cost of almost $21.5 billion per event. They are also responsible for the highest number of deaths: 6,502 since 1980.

The U.S. National Hurricane Center (NHC) is responsible for all tropical cyclone forecasts in the Atlantic and Eastern Pacific basins around North America. The center relies on data from multiple platforms, including satellites, ships, aircraft, buoys and radar, as well as ground measurements, to develop tropical cyclone forecasts. For over two decades, tailored tropical cyclone models have played a critical role in the improvement of track forecasts. Advances in data assimilation over this period have allowed for increased use of satellite data. However, accurately predicting changes in intensity has largely remained a challenging area of research. Scarce conventional data acquisition methods, such as upper-air and surface observations, ship reports, or buoy data, make it difficult to obtain measurements over the open ocean. In the absence of these methods, satellites are sometimes the only data source available.

1) Session Purpose

During the tropical weather panel session, operational users highlighted the current use of JPSS and GOES-R data within their operations and described current challenges with tropical weather forecasting related to these products while developers elaborated on their existing and/or upcoming applications and challenges with the R2O process. Both groups provided opinions from their perspective on areas for improvement with the available satellite data and tropical forecast process in the future. Throughout the question and answer section, panelists spoke frankly about the greatest gaps in current satellite

capabilities for their needs. A tropical weather breakout session occurred the next day (Thursday) to connect additional tropical users and developers attending the Interdepartmental Hurricane Conference (IHC) to compare findings between the Summit and IHC on forecasting struggles and to learn about the proposals for the future GEO-XO program series of satellites. The ultimate goal of the breakout meeting was to help the Tropical Cyclone Initiative prepare ideas for the 2020 JPSS Call for Proposals.

2) Agenda

Presentation	Speaker	Affiliation
JPSS Data Usage at the National Hurricane Center	Monica Bozeman	NWS/NCEP/NHC
National Hurricane Center GOES-R User Perspective	Stephanie Stevenson	NWS/NCEP/NHC
GOES/JPSS Use for Tropical Marine Weather Forecasting at the TAFB at NHC	Michael Folmer	NWS/NCEP/OPC
A Navy Perspective on Tropical Weather Applications and Research	Josh Cossuth	NRL
Why are Hurricanes So Important to Wisconsin Anyway?: Developing Satellite-based TC Applications at CIMSS	Tony Wimmers	CIMSS
Tropical Weather: A Developer Perspective	John Knaff	NESDIS/STAR

3) Key Takeaways

a) **Users**

i) Users still don't have enough surface wind data

ii) Instead of giving forecasters more products, come up with smart ways to combine products to save forecaster's time

iii) Forecasters have a large number of satellite products and don't know how to use many of them. Additional training is needed.

iv) Users need to work alongside developers to strengthen interaction and collaboration on products

b) Developers

i) Developers need more access to users to stimulate collaboration and gather user feedback

ii) The TC intensity and tracking space is crowded, let's start focusing on TC structure and vertical moisture products

iii) Need to improve the MIRS and NUCAPS retrievals near the TC center to better resolve the warm core.

iv) What problems can we solve with machine learning/AI techniques?

4) Graphics

HSU forecast cycle

Time (HR : MIN)	Event
00:00	**Issue Tropical Weather Outlook** **Issue Intermediate Public Advisory (if necessary)** **Synoptic time / cycle begins**
00:45	**Receive satellite fix data**
01:00	**Initialize models**
01:10	**Receive model guidance and *prepare forecast***
02:00	**NWS / DOD hotline coordination**
03:00	**Advisory deadline**
03:15	**FEMA conference call**
06:00	**New cycle begins**

Track (lat, lon): 27-33 variables

Intensity (wind): 9-11 variables

Size (wind radii at 34-, 50, 64-kt): 24-72 variables

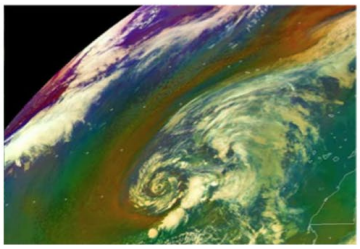
Public Advisory + Discussion + Watches/Warnings

A forecaster can sometimes be responsible for more than one storm!

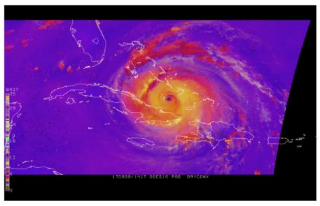
GOES-16/17 at NHC: Current data and product usage

- Other RGBs commonly used for tropical cyclones

Air Mass: useful to extratropical or tropical transition

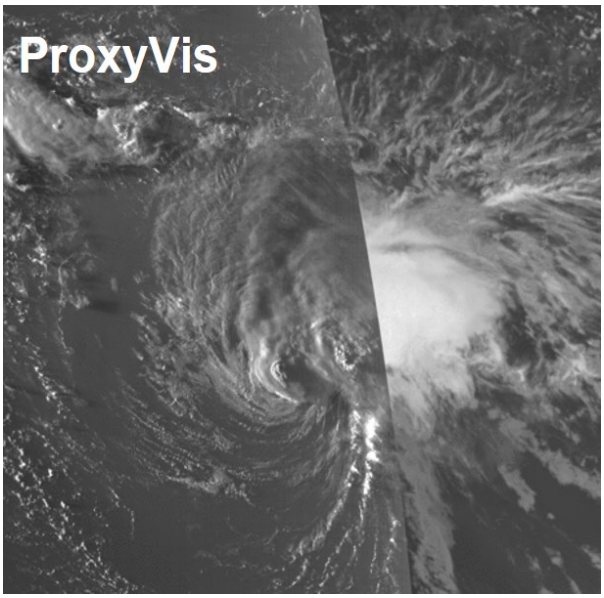


Day Cloud Convection: cloud type discrimination, genesis & intensity forecasting

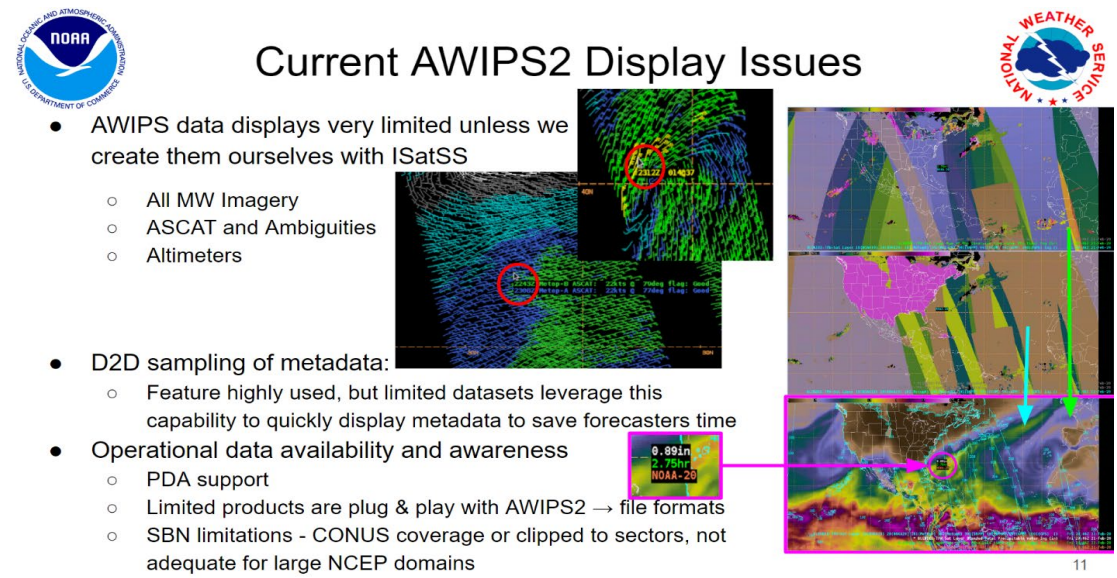


GeoColor: great for public media outreach

NHC common GOES-R RGB usage in forecast operations during daylight hours



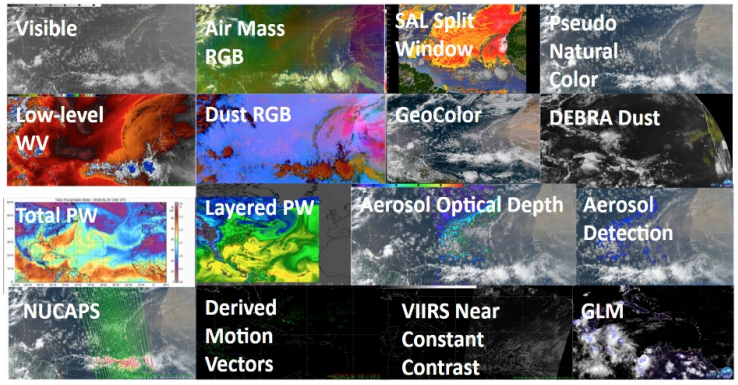
CIRA's experimental Proxy-Visible (ProxyVis) product depicting the terminator over Hurricane Florence (Sept 7th 2018) as seen in NHC's N-AWIPS operational display system



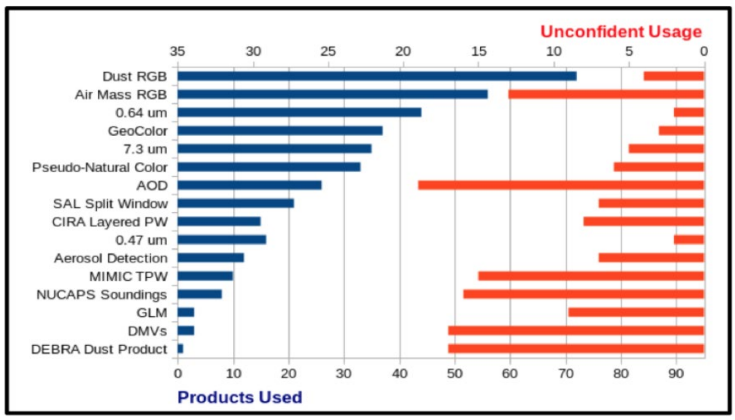
Examples of AWIPS2 polar data displays and current issues with the data availability, display features and challenges faced by operational users at NCEP

Operational user challenges with tools and products indicates a need for better integration into the operational display systems such as ATCF, AWIPS2, and N-AWIPS

Satellite Products Used for the Saharan Air Layer (SAL) Evaluation (2018)



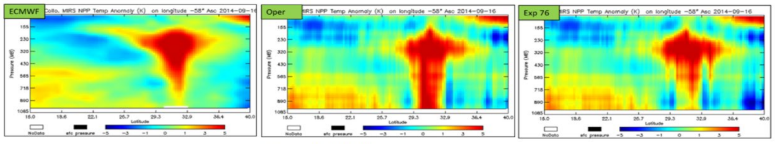
SAL Product Usage



Top: Products used during the 2018 Saharan Air Layer (SAL) evaluation. Bottom: Product usage confidence results during the SAL evaluation

Low hanging improvements… big reward

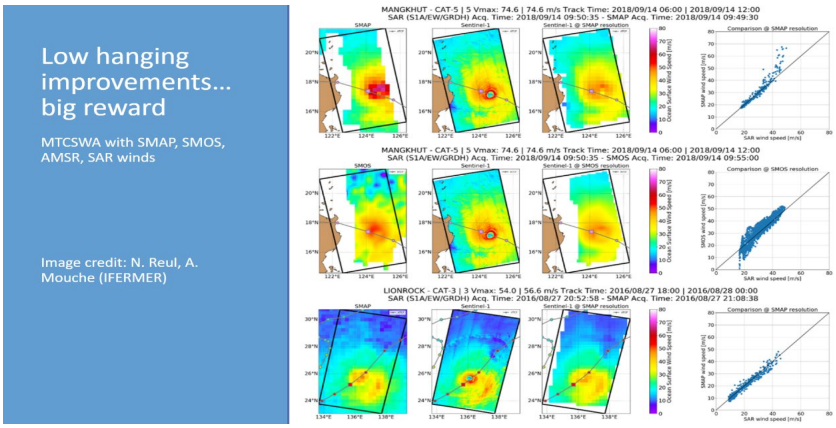
IMPROVE MIRS Retrievals



Operational MIRS
- Fails to converge to a solution near the center
- Warm core poorly estimated
- This is not a systematic error!

MIRS using a COSMIC TC climatology
- Convergence in the core
- More realistic warm core structure
- Better climatologies could be developed

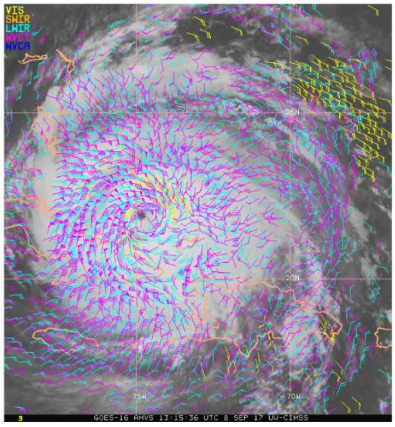
JPSS/GOES PROVING GROUND / RISK REDUCTION SUMMIT 5



High impact tropical improvements according to John Knaff – Top: Improve Mirs retrievals near TC centers, Bottom: Using additional wind observations within MTCSWA

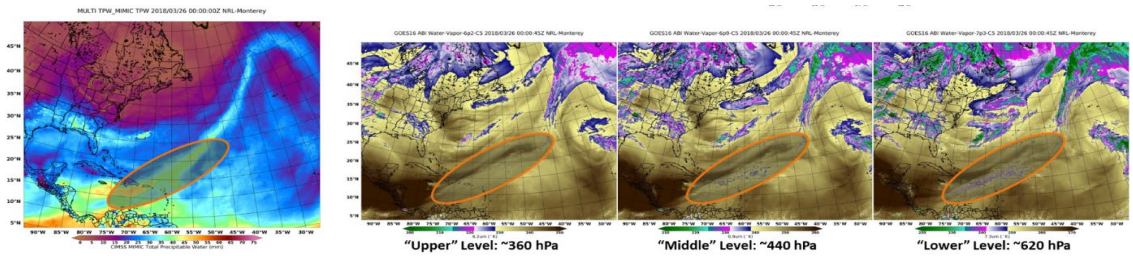
Selected TC Applications-CIMSS: GOES-16/17

Hurricane Vortex-scale Atmospheric Motion Vectors (AMVs)



Enhanced (high spatiotemporal) wind vector estimates around TCs derived from GEO satellite rapid-scan (meso sector) multispectral imagery using the NESDIS operational GOES-R tracking algorithm.

Use of GOES-R mesoscale sector AMVs for Hurricane Irma (Sept 8th 2017)



Comparing structural signature between TPW and GOES-16 water vapor channels

Develop synthetic Microwave imagery using AI and ML

JUSTIFICATION AND PLAN

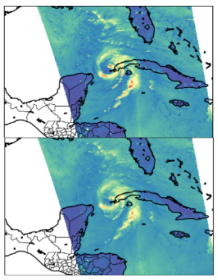
Justification:

- Microwave imagery is often used to estimate TC intensity, location and convective structure
- Microwave imagery is a key input to precipitation algorithms
- Microwave data are latent and often miss TCs
- Geostationary data is not latent and could act as risk reduction as microwave imager/sounders phase out of operations

PLAN:

- AI/ML has shown ability to estimate 89GHz during the day
- We will expand on this ability to night
- We will expand this ability to other microwave frequencies, those most useful for TCs and precipitation estimation

EXAMPLE HURRICANE MICHAEL



OBSERVED GMI

Synthetic GMI

Example of synthetic microwave imagery use for tropical cyclones to supplement available data when LEO data is missing

5) Questions/Answers

Question	Answer
To operational users: What satellite capability is most needed in your operations that does not exist or exists, but is less than optimal?	More objective and automated guidance/first guesses so the less trained forecasters can spend more time trying to add value to the analyses and forecasts instead of generating it. All offices have a need for more scatterometers and lower latency polar-orbiting satellite data, especially for VIIRS imagery. Smart ways to combine products (such as the three GOESR WV channels), storm structure increased temporal resolution, rapid assessment of the environment in addition to mid-level moisture in the tropics. Also, the vertical wind shear NOAA product models are too late and wrong.
John, Thanks for your refreshing frankness. What else does NOAA do with observations and research that some could consider as "dumb"?	NOAA not supporting an operational scatterometers. The Europeans figured out how to have an active and passive sensor on the same system, why can't we? NOAA treatment of international satellite data, Himawari and MSG data is never guaranteed 24x7x365, but is getting better supported as of late. It is really hard to figure out what is on the NESDIS PDA that we are supposed to be using for operational platforms AND it is hard to get things added onto the PDA. NESDIS is not necessarily a user of the PDA data, rather a distributor, so they should be more flexible with the users who want to put their data onto it. AWIPS is difficult to work with even to do simple things. Developers need to write a plugin to develop with and was clearly designed for a WFO and not a National Center…we need better options for whole ocean basins and for archiving in order for it to be more useful in the tropics.
Monica/Stephanie: Are the NHC forecasters willing to embrace an AI-driven tropical cyclone intensity estimate?	NHC forecasters welcome new sources of data, and they would likely use an AI-driven tropical cyclone intensity estimate if it was proven to be skillful. Intensity remains one of the most challenging aspects of forecasting tropical cyclones, and observations are sometimes more limited. AI may be one of the ways to make progress in tropical cyclone intensity. In addition to special training, we would also need to provide real-time uncertainty estimates

	as part of the product so forecasters better know how to use it. It is unlikely an AI method would completely replace the traditional Dvorak method, but would complement it.
What are some effective ways to get forecasters to use a new product in operations?	John: Get forecasters involved in the development before it is a new product. Stephanie: If it's a new satellite imagery product, have examples of past cases where it would've been useful that directly relates to an aspect the forecaster would've been looking at in real-time. If it's a predictive product (e.g., TC intensity), it helps to have verification of how it would've performed on past cases. They gain confidence in a product with time, but as John said, it can be helpful to involve a forecaster in the development process. Josh: Greater communication between researchers and forecasters. Researchers should let users know about potential capabilities and early in the process so users can comment and guide it to better operational utility. Forecasters should let researchers know their greatest gaps, needs, or time-consuming parts of the workflow so researchers can identify areas ripe for improvement. Monica: I agree with Josh and others. To that point, I've noticed that it is hard to get any traction with the forecasters to use a new product out of the blue, on their own with their tight forecast cycle...especially when the tropics get busy. However, if a developer can make the time for a scheduled visit (or a video call with screen-sharing due to COVID-19) to sit one-on-one with a forecaster (rather than doing a conference call or presentation on the product) the developer gets the forecaster's undivided attention for however long they can spare. You will get way more from 10 minutes one-on-one with a forecaster than you ever could in two hours on a conference call or with a powerpoint presentation. Do this early, and often with the forecasters then rapport will be built rather than forecasters being told to "take a look" at X number of new products. My branch, TSB, uses

	this method of interaction often when creating new data displays in AWIPS. Since we have established a feedback relationship with these short spurts of interaction, the forecasters now come directly to the TSB POC with new ideas of what else they would like to see or how to improve it without us having to pull teeth for feedback! Also, by getting these new or experimental products directly onto operational platforms such as AWIPS (rather than a website) will greatly increase the likelihood of use in operations! Tony: Get it on AWIPS.
What are the most challenging aspects you find for transitioning a new product into operations?	John: Three things are typically challenging for me 1. Determining what is needed in a product and how it might easily transition, 2. The operational tools (AWIPS2) were designed to be rather difficult to modify. So there is a need for expertise on how to get things into operational workstations. 3. There is a fair amount of necessary gatekeeping at the centers to prioritize activities. So even if a product is what is needed, the center's priorities may dictate what is done with the limited resources available for R20. Many of these issues could be solved by more and dedicated resources for such activities and better coordination between developers and forecasters on what needs to be done. Josh: Agree 100% with John. I would add training as a large component too, especially for Navy users. Tony and Derrick: I totally agree with John. Also something that I learned too late in R2O is that in order to really, truly benefit forecasters (instead of just adding to their workload), you have to design a derived product that kills 1-2 other derived products in a forecaster's ordinary routine. That is, the new product is so much better that it frees up more than enough time to use it. Adding to the forecaster work load is not going to help. In the past we have seen products go into operations and break because some component or input has

	changed. There are too few people available to fix it and at times a long queue. This makes the product go “dead” and forecasters may stop using it. One way to address this is to keep the developer in the loop and able to fix their own algorithms. They know them best. Monica: Once products are transitioned, the long-term upkeep can also be an issue. If a product requires frequent re-training, or re-coding as operational systems evolve (such as changing IT security requirements, changing computer systems, etc). Support staff at operational centers are usually close to saturation, so work by developers to reduce long-term support requirements is greatly appreciated!
Developers: What are your biggest obstacles to developing new capabilities or improving older ones?	John: I think that one of the biggest challenges for new capabilities is to make sure what you are developing has a place in the forecaster’s duties. For improving older capabilities there are several challenges, the first being the notion of “it’s good enough”, the second is there is very little resources or money to improve older capabilities. Both will also face the challenge of forecaster buy-in and how these products will be made available to the forecasters that need them and if they have time to look at them. Josh: Lack of good verification/validation data. Hard to know if what you’re doing is really better and would streamline the forecast environment without that information. Tony: I think that it says a lot that in 2020 we still use the Dvorak technique as a central tool in the routine analysis process. Not that it’s a bad technique - obviously it fills an important void - but it shows how poorly we have been able to systematically integrate the data from so many other remote-sensed and in-situ sources. John laid out exactly why that is programmatically, and Josh identified one of the key missing ingredients for progress: the ongoing limitations in the validation data. I’ll add to that that we have spent decades developing empirical and theoretical models

	that use linear simplifications to an inherently nonlinear phenomenon. The nonlinear capabilities of AI may finally allow us to break out of this mold. Derrick: To Josh's point we have a fair amount of validation but it is all in roughly the same location. So more validation outside of the Atlantic, and outside the MDR/Tropics for situations such as genesis, transition over colder SST and ET (both the thermal structure and to what degree the surface winds spin down and are connected with the flow above the surface). As John notes we have no shortage of ideas but limited resources to pursue them all. Iterating between the research and operational community helps to focus research efforts that give forecasters the biggest impact, but good ideas are left on the cutting room floor.
Are there enough opportunities for communication between developers and users?	John: No and I wish there was an easy solution. Josh: No - agree with John. There are limited opportunities for only select developers to talk with users, but I don't know how to improve that in a limited bandwidth and funding world. Tony: Conferences that bring everyone together in a room are great, but I think we'd also benefit from more round-robin small-group interactions that allow us to go down more rabbit holes. Derrick: There are times during the season when more interaction would be helpful as storms are occurring and the products are providing guidance in real-time. I realize this can be tough since time is limited. The TC message group provides one source for idea exchange and real-time feedback but perhaps a Slack group or something similar would be more interactive (and less 1990s)? Monica: I can't speak for JTWC, but at NHC, we have the Joint Hurricane Testbed (JHT) in addition to this new JPSS Tropical Cyclone Initiative. Here, developers demo their products

	to operational forecasters for feedback by leveraging a single webpage for both the testbed and initiative product case studies, links to real-time demo data and product quick guides. Setting up the site is now a responsibility of the JHT facilitator, and we hope that this site will improve communication between users and developers and could be expanded to provide a forum for user feedback. We also have good working relationships with external partners at universities and with NASA SPoRT where we routinely ask for assistance with products for operations. We are working to improve the accessibility between our forecasting or technical staff and developers, however our development branch does not have dedicated federal R2O positions, so things take a little longer to implement into operations. That being said, I do sympathize with the developers' plight of struggling to gather feedback on existing experimental products and ideas on new products that could solve problems for forecasters. Not that I want to give myself more work in my already busy day, but I think that rather than NHC having all the developer interaction happening between themselves and the testing facilitator or branch chiefs, NHC should leverage the existing TSB feds (Technology and Science Branch) with expertise (where appropriate) more so than they do now. TSB employees have the technical chops to understand the processes going on under the hood with the experimental products if “read in” by the developers to connect the dots between solving the problem with operational technical requirements that a forecaster may not be aware of (which may save both sides tons of time in implementation), PLUS the benefit of everyday exposure to the forecasters themselves to facilitate informal conversations about the products. I don’t think NHC does a good job of this currently, as I have been in a few development meetings where the users talk and talk about what they need, while the developers continually just write notes instead of having a back and forth conversation. Now that I am the Tropical JPSS Initiative facilitator

	and have been exposed to the NHC testbed process, my eyes have been opened, and I am providing the developers my technical operational environment expertise and advocating hard for forecaster feedback on the Initiative's products every time I interact with our forecasters. This is my small way of helping the developers through a broken system, but hopefully it is paying off….we shall find out this hurricane season!
Is there any expertise or training needed to better use current products?	Josh: Yes, for JTWC at least, up-to-date training materials and product changes are a constant need. Monica: As stated in Stephanie's presentation, we have a need for training on satellite products outside of CONUS using specific examples for tropical and oceanic meteorological phenomena.
What is the most glaring gap in tropical cyclone satellite observing?	Stephanie: The gap between polar passes that provide microwave imagery (to diagnose storm structure) and scatterometer data (to diagnose TC size and intensity) is an obvious pitfall of the current observing system. Both microwave imagery and scatterometers play an important role in TC analysis. John: In terms of what capability is needed that could be made available. All-weather surface wind speeds and when possible directions are missing. Everyone needs that information (OPC, WPC, NHC, TAFB, JTWC etc…) Josh: 3-dimensional wind structure. I concur with John, but expanded boundary layer and free atmosphere wind characterization in and around the storm would add significant awareness on storm initialization, analysis, and tendencies. Tony: We should also find someone who can answer this in terms of the relative importance of observing ice nucleation and the thermodynamics of cloud/precip. Wind and rain may be the most important outputs of TCs, but heat is the input.

	Derrick: What Tony said. Our current observation systems give bulk estimates of the hydrometeor type and gross estimates of distribution but the vertical resolution is still poor. Temporal resolution of the evolving TC structure and intensity from microwave may be aided by the planned cubesat missions such as TROPICS but these missions are likely to be short-lived. Monica: I agree with Stephanie, and with Derrick regarding the TROPICS mission. In addition, we also have an issue with data delivery infrastructures and having multiple file formats. Having observing systems out there is great, but not if you can't get access to the data or have to spend additional time processing it which adds to the latency causing it to become less useful within operational forecast cycles!
To operational users: What aspects of your operational requirements are the most difficult or least certain?	Josh: Speaking for JTWC (and perhaps incorrectly), it would be the lack of in-situ verification and validation of intensity and structure. That uncertainty makes it difficult to develop an accurate best track and create more precise products from that data record.
Developers: What can we do with existing satellite obs in the next 3 yrs that would significantly help with the weather forecasting and monitoring in the Tropics?	John: I like to think in short lists. The five things I think would help forecasters the most are 1. Improved capabilities to see low level cloud movements at night using geostationary satellites, 2. Quantify the relationships between GLM observed lightning and intensity and structure changes in tropical cyclones, 3. Start ingesting and displaying all of the surface wind vector and surface wind speed data sets that are available from both operational and research satellites (e.g., SMAP and SMOS wind speeds, AMSR-2 wind speeds, A-SCAT, OSCAT, HY-2A, SCATSAT, RadarSat constellation, Sentinel 1A/B-SAR) on AWIPS-2, 3. Develop and rapidly transition synthetic imagery that mimics LEO products/images using geostationary inputs (e.g., synthetic microwave imagery). 4. Coordination with operational meteorologists to start tracking or labeling things of operational significance (like TC radius of maximum winds, occurrence of secondary eyewalls, large waves, areas associated with

	hurricane force winds, severe storm locations, convective initiation), and 5. Set up programs where developers can build personal relationships and trust with their forecaster customers ---- figure out what jobs are to be done. Josh: Better DA methods to ingest storm structure information, expanded training materials and discussions, and agreed with labeling/identifying structures of operational significance. Tony: There's been a proliferation of empirical TC characterization algorithms published in the last 3-5 years, using either feature analysis or machine learning. The operational community would benefit from an effort to distill all of that knowledge into a single enhanced forecasting/analysis method. Also, while we're talking about the next three years, I think a lot of our attention should be on experimental smallsat applications in order to set up our operations for the next big wave in remote sensing. Tony and Derrick: Greater use of estimate uncertainty and distributions of parameters. The storm is not 90 knots it is 90 knots +/- ?? RMW Is not 10 km it is 10 km +/- ?? and likely to change to ??. Fold this uncertainty into the intensity forecast suite (statistical and dynamic)
Improving TC intensity forecasts continues to be a high priority – do you think we are utilizing enough of the satellite observations to tackle this problem?	Stephanie: he short answer is no. We've entered a new generation of weather satellites with an immense amount of data, and it's becoming challenging to leverage the satellite data for specific applications. There has been a tremendous amount of work to integrate the new technology into useful products for TC intensity forecasting, but more could be done. For example, only the longwave IR channel is currently used from GOES for TC intensity forecasting operationally - do the other channels have a useful signal and can the GLM also be leveraged for this purpose? These questions are still low-hanging fruit.

	Josh: By using much more of available satellite data, all-sky radiances for DA have much promise to continue improving model analysis and forecast skill. Beyond that, the greater difficulty may be in the numerical methods to resolve and accept satellite observations that are important for understanding and forecasting storm scale processes. Tony: I touched on this in another question. Fortunately there are new machine learning methods that go further than ever to identify the value of each channel in a general regression or classification scheme, and we should be using those. Derrick: How clear is it currently what satellite data is being used in the models? What tools do forecasters currently have to assess that? There are some areas of very rich satellite data but not all of that gets in. Some cases very little of it. Are these regions that forecasters should scrutinize more? If so then how can they know? Monica: No, a lot of potentially valuable data we still don't know how to use yet. Because of this, forecasters aren't looking at it to provide feedback. Training is also an issue. So much of our training materials are focused on weather phenomena over CONUS that the oceanic regions get missed, and data under-utilized. Also, some field experiments designed specifically for the tropics (e.g., TEMPEST) don't provide the operational users access to the data. I understand that it is not feasible in real-time, but after the fact when HSU is composing TCRs (Tropical Cyclone Reports) in the off-season to re-analyze the situation with additional data and time they didn't have would be greatly beneficial.
What is missing in the current satellite capabilities that could be addressed by the next generation geostationary satellite suite?	John: Two things: Geostationary microwave sounders (see convection through the cirrus, retrieve temperature), and a concentration on producing estimates of all-weather oceanic wind speeds and when possible directions. The first one probably is impossible, but maybe AMSR-2-like instrument on a LEO and a

	scatterometer on a Tundra orbiting satellite. The job is winds at the surface. Josh: Agree with John. Better winds (surface and profile) and microwave information (imagery, sounding - higher resolution temporally and spatially) Tony: Bandwidth that plays well with 5G, always push the limits of spatial/temporal resolution detector sensitivity, better federal contracts that hold primes fully accountable for failures such as the GOES-17 heat pipe loop. Monica: As many of us stated in our presentations, we need more wind measurements over the oceans!
Monica – how do you feel the use of AMSR-2 is doing at NHC?	In HSU, they make good use of the AMSR-2 microwave imagery, which is comparatively of high resolution. HSU does not use the wind data however. TAFB is very interested in the wind data, but it seems to still be under-utilized in operations in favor of the scatterometers.
Could NHC and TAFB use high resolution (500m res) SAR winds and wave spectra during TS events, even if latency is 3-6 hours?	Josh: JTWC has expressed interest in this. Monica: At NHC, there seems to be differing opinions on the usefulness of the data at those latencies. TAFB would still find SAR winds/wave spectra quite useful all year long for their extreme events (tropical cyclones, gap wind events, and extratropical cyclones) even with a latency of 6 hours. HSU on the other hand, finds that a latency of 3-6 hours would make the data less useful in real-time since they would typically be moving on to the next analysis or forecast cycle, but still have a use for it during post analysis. In that case, SAR winds would be the most useful for adjusting the best track, but they still need training on the strengths and weaknesses of it to better understand how to apply it in post analysis.
Stephanie: How easy is it for tropical forecasters to develop their own RGBs – rather than having a new RGB thrust upon them?	The AWIPS-2 platform does not easily allow forecasters to interactively create a new RGB. The formulas for making an RGB are housed on the technical side, and would require knowledge of modifying an XML file. Technical developers can create a new formula of

	channels and weights for a forecaster should they ask, but the process should be streamlined to give more control to the forecaster.
Monica: You mentioned we can't just provide a NetCDF4 file for use (for AWIPS). Is there a template or specific example of the header requirements available somewhere?	The header information needed will depend on the dataset, and therefore which AWIPS2 decoder will be processing it. In the general sense, imagery products will be processed by the GOESR decoder, while wind data to be displayed as wind barbs will be processed by the DMW decoder. Microwave data is the exception, and can be processed with the GOESR decoder as imagery (if different projections Mercator vs Polar Stereographic are specified depending on the latitude) OR, can be processed with the Pointset decoder natively (though it may take longer to display initially). NHC has contacts with the NWS Office of Observations (Lee.Byerle@noaa.gov and David.Bludis@noaa.gov) that have been helping NHC process satellite data into AWIPS2-compatible formats for NHC's migration into AWIPS2. Please send an email to myself (Monica.Bozeman@noaa.gov) and our Office of Observations contacts mentioned above so that we can discuss this further with you.
Why is it important to the forecaster which satellite makes the ob? In a fused product (e.g., SST briefed yesterday) it's not necessary if data is of good quality.	Generally speaking, users like to know where their information is coming from so that they can make educated decisions about what the data is telling them. This insight comes into play for many reasons. The forecasters do like to keep tabs on the satellite source mostly for data outages or data quality purposes, but they also like to specifically call out the specific sensors that helped them make their forecast decisions in operational product text (e.g. the Tropical Weather Discussion product) or in verification and performance statistics.
How much interaction do you have with AWIPS developers who might take your sampling improvements and implement generally (for example)?	Monica: So far I have found that there is just a very small pool of people who understand what is needed for each of the AWIPS2 data decoders due to the fact that AWIPS2 is still fairly new to NWS operations and extremely new to NCEP operations. Because of this, NWS/NCEP is still learning how they want data to be displayed within the existing decoders and how to best exploit the data. Since NHC is in the process of migrating to AWIPS2, we communicate with a

	small group of developers at the NWS Office of Observations who have helped us implement those sampling changes for us. We hope that the ideas generated from this initial implementation will allow for more flexible data decoders to be developed in the future, in addition to more developer groups getting up to speed with what is needed for these sorts of implementations.
Why can't OSPO be the trusted source for NOAA satellite data?	OSPO is one of the sources of NOAA operational satellite data. OSPO may not provide all of the data and products needed for tropical cyclone work, and more timely data may be available from direct readout sources. Thus, the OSPO-provided data stream can be enhanced through other data dissemination mechanisms, but should be a significant part of the operational data delivery system.
Please clarify the relationship between GeoIPS and AWIPS, particularly the compatibility between products developed for one platform or the other.	Josh: I can't comment too much about AWIPS since I'm not familiar with the full scope of the software and project plans, but I believe the main goal of AWIPS is the interactive front-end environment for operational meteorology **products**. GeoIPS is meant to focus on back-end processing and standardization of geospatial **datasets**, including the processing and algorithmic applications of those data to turn them into products. That output can then be fed into display systems such as AWIPS, ATCF, or simply websites as images. Monica: Josh is correct on the distinction between AWIPS and GeoIPS. NHC plans to use the processing power of GeoIPS to standardize processing and normalizing polar microwave data to create AWIPS2-compatible TC-centered products/displays for use in an apples-to-apples comparison of each of the sensor's view of the observed TCs.
How much cross-pollination is there between GeoIPS and Satpy developers in the GitHub world?	There's actually a good amount of collaboration between some of the developers of both code sets. The satellite processing components of GeoIPS are largely built using SatPy algorithms. NRL and ONR have increased interest in even supporting SatPy development towards expanding GeoIPS capabilities and I would like to see that happen as soon as later this year.

CIMSS's R2O path makes products on the web, solicits feedback, iterates, and then streams products to users. Is this working, or is a more direct approach better?	One benefit is that the latest version is always available and fixes can be implemented fairly quickly. However, CIMSS is not funded (per se) for 24/7 support. Implementation of algorithms into GeoIPS may be a pathway to a more ops-like tool.
Josh, can you speak to JTWC's plans for AWIPS2 in their operations?	Yes - JTWC is interested in sharing access to the same environment and data feeds as NHC to foster better collaboration, training, and continuity in tropical cyclone forecasting. The Navy buy-on to AWIPS2 for JTWC and the Fleet Weather Centers facilitates common access to leverage these tools and products from NOAA partners. Ultimately, JTWC's area of responsibility has little overlap with NOAA areas, and there is a need to add in other global products into AWIPS 2 as well. The short term plan has JTWC forecasters using these products for situational awareness and developing synoptic-level assessments, while concurrently using DoD tools for specific storm scale activities. I'm not as familiar with longer term plans and integration.
Are there plans to add the ATCF into AWIPS?	Josh: There are no current plans to integrate the Navy's ATCF code into non-Navy software systems. There may be projects working on mimicking ATCF-like functionality within NOAA systems, however the Navy is not aware of or part of those efforts. Monica: There is a large NWS effort funded by Central Processing to create product generation capabilities for NHC/HSU in AWIPS2. A representative from JTWC attends these meetings so that they can be kept in the loop on the project's progress. Some initial capabilities have already been created but not fully tested in operations. This effort will continue over the next few years.
Monica, why is CLASS insufficient for creating a training dataset?	Statistically-based algorithms require large datasets for training and testing. The CLASS system is designed for case studies where data over only a short time period can be requested at a time (a few days). Thus, developing a large training set spanning multiple years is extremely time consuming if CLASS is the source.

Does JTWC have plans to use GLM – can help with storm structure and microphysics, updraft strength as NWS noted.	I believe JTWC expressed interest in using lighting products to assess storm structure and intensity trends. GLM is great since it has global coverage that includes their areas of responsibility. Since this is a relatively new product for them, a heavy training component is most needed while they learn the real-time idiosyncrasies of the data as it compares to other available products in their operational suite.
Should NOAA resort to more competitions on sites like Kaggle to encourage a more generalized approach to solving tropical and other weather forecast challenges?	John: Maybe, but you would want to add the operational constraints (e.g. AWIPS, use of real-time data, independent verification, forecaster interest, a job that needs to be done) as part of the competitions and have enough support so that successful applications could be installed in front of forecasters. Tony: Yes!
Tony: What metrics will the AI competition use to determine success?	Although we're delayed due to covid-19, the idea is to estimate max winds and simply evaluate based on RMS error with respect to best track. The lessons learned from the first competition will help us decide how to weight things like RI, RW, major hurricanes, RMW, etc.
Assuming that AI-based apps can work with limitless data and create probabilistic predictions, what would you want these apps to address? What is the simplest?	Tony: I'm going to answer this presumptuously on behalf of the forecasters. I think it would be cool for AI to give a probabilistic forecast for the need to evacuate home by home, plotted over time. Or to create a range of video scenarios of the peak conditions at your house. But that's probably beyond the current research planning horizon. The simplest would be a probability of max sustained winds from a TC, and this is a very active area of AI research now. Monica: AI is well suited to provide more accurate estimates of storm structure parameters, such as max wind, radius of maximum wind and wind size estimates, along with error characteristics. That information could be used directly by forecasters, but also to provide guidance on how to apply wind forcing perturbations in NHC's P-Surge and wind speed probability models. The AI methods also have applicability to rapid intensification forecasts.

Wimmers – Can you speak more to the feasibility of using AI techniques to help detect atmospheric turbulence, especially during periods of GOES-17 ABI data degradation?	We have a real-time algorithm already that makes probabilistic estimates of aviation turbulence, and uses less-degraded IR window channels on GOES-17 when necessary.
When will ADT be running in Ops at NESDIS? Where will it be running and how will data be distributed?	Algorithm readiness review is set for May 20. The plan is to turn on the new ADT version in parallel with the old version, hopefully the first week of June 2020. Fixes will be sent to ATCF.
Can we decide if it's AMVs or DMWs please? It's confusing to the forecaster.	During the panel session, it was decided to go with AMVs.
I reviewed the tropical/marine demonstration reports on goes-r.gov and noticed a few final reports, and none since 2016. Are those missing or never conducted/written?	A 2017 report was submitted to the GOES-R/JPSS programs. A 2018 report is still in the process, but has been severely slowed due to employment changes. There will be no 2019 report as PG activities have been little to none.

6) Key Challenges for Users/Developers

a) Users

i) Not enough wind (scatterometer) and surface observations over oceans!
ii) Information overload and not enough time to use products, so they stick with their favorites.
iii) Navy users have a need for products that combine satellite and NWP to create first guess fields in their operational systems (ATCF) since JTWC forecasters have short duty assignments. For NOAA users, this would be GFE or Hazard Services-generated grids in AWIPS2.
iv) Ability to see at night
v) Forecasters need targeted training for product use outside of CONUS for tropical and marine weather phenomena
vi) Forecasters need additional training to understand using all three GOESR WV channels

b) Developers

i) Gathering feedback from users
ii) Unrealistic artifacts in MIRS and NUCAPS retrievals close to the TC center
iii) How best to work around the GOES-17 loop heat pipe issues for algorithms/models and products?
iv) Need improved algorithm operability on sub-tropical systems and storms undergoing Extratropical Transition (ET)
v) Achieving user acceptance of AI-based TC intensity estimations
vi) Unified polar data processing and normalization
vii) Require a large number of cases to train algorithms

7) Ideas for Improving the User Experience

a) Instead of giving forecasters more products, come up with smart ways to save forecaster's time – Geo/Leo combo products
b) More integration of products into the operational workstations (AWIPS2, ATCF)
c) Training on product use outside of CONUS, including GLM over oceans

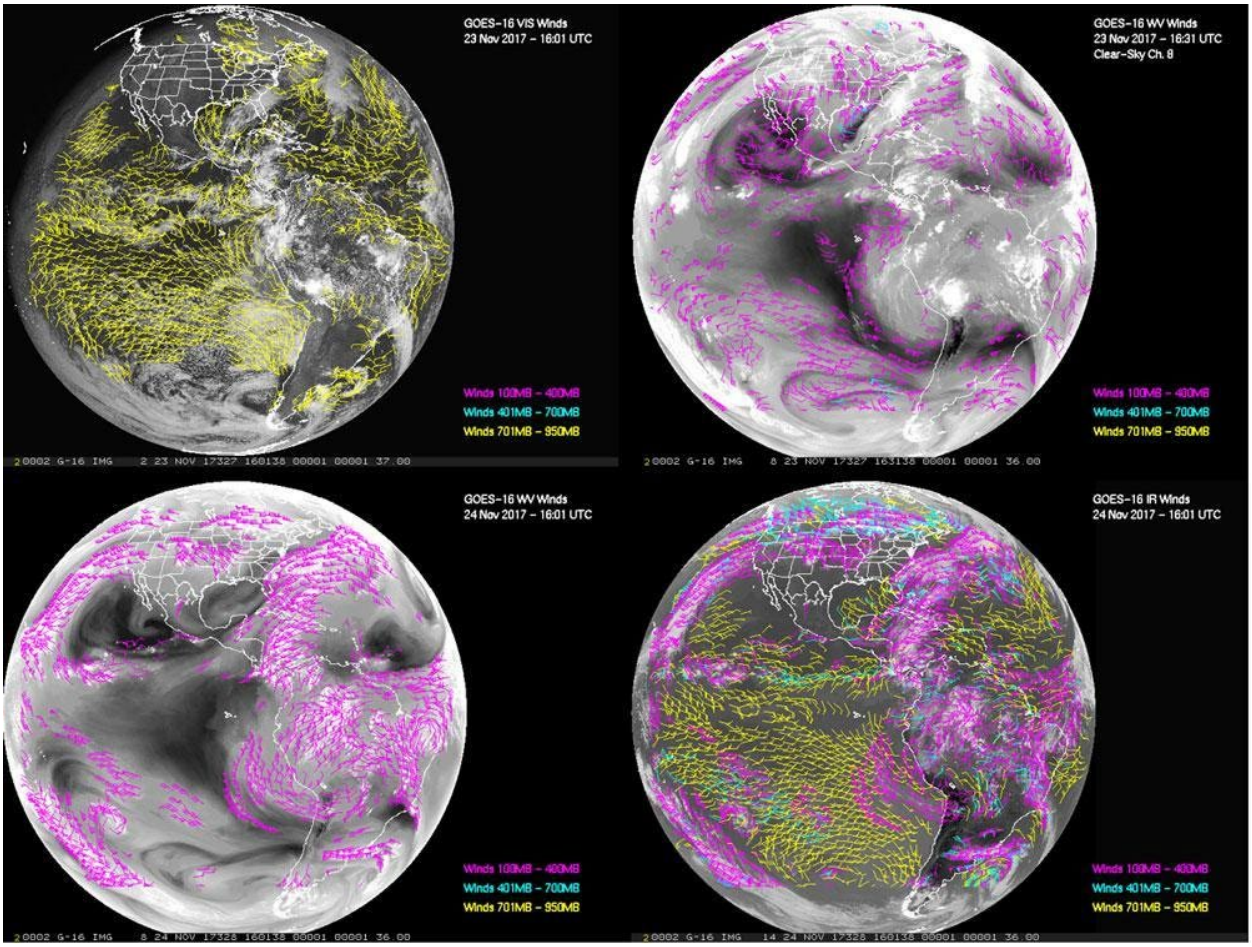
d) Better customer service model for user engagement (both operational and development users) with finding and subscribing to data on the NESDIS PDA.

8) Recommendations

a) Let's re-think how we do satellite proving grounds, and delivering demonstration and experimental products to users in order to get eyes on the products, cultivate user engagement, and methods for gathering user feedback. Incorporate methods and structures in place for the Joint Hurricane Testbed into the JPSS Tropical Cyclone Initiative and GOES product demonstrations.
b) More integration of products into the operational workstations (AWIPS2, ATCF)
c) Data providers should add metadata to datasets and work directly with APO/TOWR-S to create AWIPS2 displays that utilize sampling where appropriate.
d) Provide a wider distribution of polar data from direct readout sites to reduce latency to operations.
e) Continue improving LEO data ingest and processing systems
f) Increase use of AI/ML methods extract more operationally useful information from satellite imagery – e.g. synthetic microwave from GOES and wind structure parameters
g) Investigate greater access to existing and upcoming satellite-based surface wind estimates
h) Improvements to MIRS and NUCAPS must continue to be explored in order to increase its usefulness in operations and developmental products, especially near TC centers and other areas with strong convection
i) Explore methods that leverage JPSS/NPP data in close orbits being used in operations for additional coverage and to improve accuracy.
j) Continue holding conferences similar to the GOES-R/JPSS Summit where users and developers come together to listen and interact with each other face to face since this seems to be more difficult to do during regular working hours

Clouds and Winds

Moderator: Jaime Daniels



GOES-16 full disk visible channel winds (upper left), clear-sky water vapor winds (upper right), cloud-top water vapor winds (lower left), and longwave infrared winds (lower right) on November 23, 2017. High-level winds (100-400 hPA, located approximated 7-14 km above sea level) are shown in violet; mid-level winds (400–700 hPa, located approximately 3-7 km above sea level) are shown in cyan; and low-level winds (below 700 hPa, located less than 3 km above seas level) are shown in yellow.

Atmospheric wind, along with other fundamental variables such as temperature and moisture, are essential for estimating the state of the atmosphere at specific times and locations on the earth. This information provides field weather forecasters with a fundamental understanding and situational awareness of current weather conditions. This information also serves as initial conditions for numerical weather prediction models that provide forecasts of weather and climate.

Satellite derived winds are critical observations that support and are used in the Weather Forecast process. Operational global and regional Numerical Weather Prediction (NWP) systems actively assimilate wind observations obtained from geostationary and polar orbiting weather satellites. The importance of satellite wind observations for initializing the atmospheric state for NWP is clear given the expansive regions of the globe where other conventional winds observations are lacking. Satellite wind observations also contribute to the situational awareness of weather conditions to field forecasters and their ability to provide high quality forecasts. For example, weather forecasters often use these observations to gauge

the correctness of NWP model forecast guidance, identify localized jet streaks, and/or determine vertical wind shear.

Satellite derived cloud observations are critical observations that provide insight into many atmospheric processes. Their vertical distribution indicates the presence and strength of vertical motions. The amount of water contained within them and the size of their droplets can provide information on the presence of precipitation. Cloud products such as the presence of supercooled droplets or high values of ice water contents are used to identify aviation hazards. Cloud products are themselves used in derivation of many other products. The distribution of cloud optical depth is the main input into model of solar energy and cloud heights are used to place satellite derived wind vectors. In addition, cloud properties play a major role in the generation of clear-sky radiance observations which are critical to the data assimilation activities for numerical weather prediction.

1) Session Purpose

The purpose of this session, which is consistent with the overall goal of the summit, was to bring satellite wind and cloud product developers and users together and have them share their insights and perspectives on the current use and future needs of satellite-based cloud and wind products.

The users that presented provided excellent summaries of how they were currently utilizing the available GEO and LEO cloud and wind products in regional and global NWP and out in the field by NWS forecasters. They also discussed any existing challenges with their current utilization of the data and offered their perspectives on what would help them in the future. Hearing this directly from users is extremely valuable and underscores the need for satellite product developers and maintainers to coordinate with product users on a routine basis. The developers presentations were very forward looking and discussed new cloud and wind products/applications that were actively being developed or planned to be developed in the near future.

2) Agenda

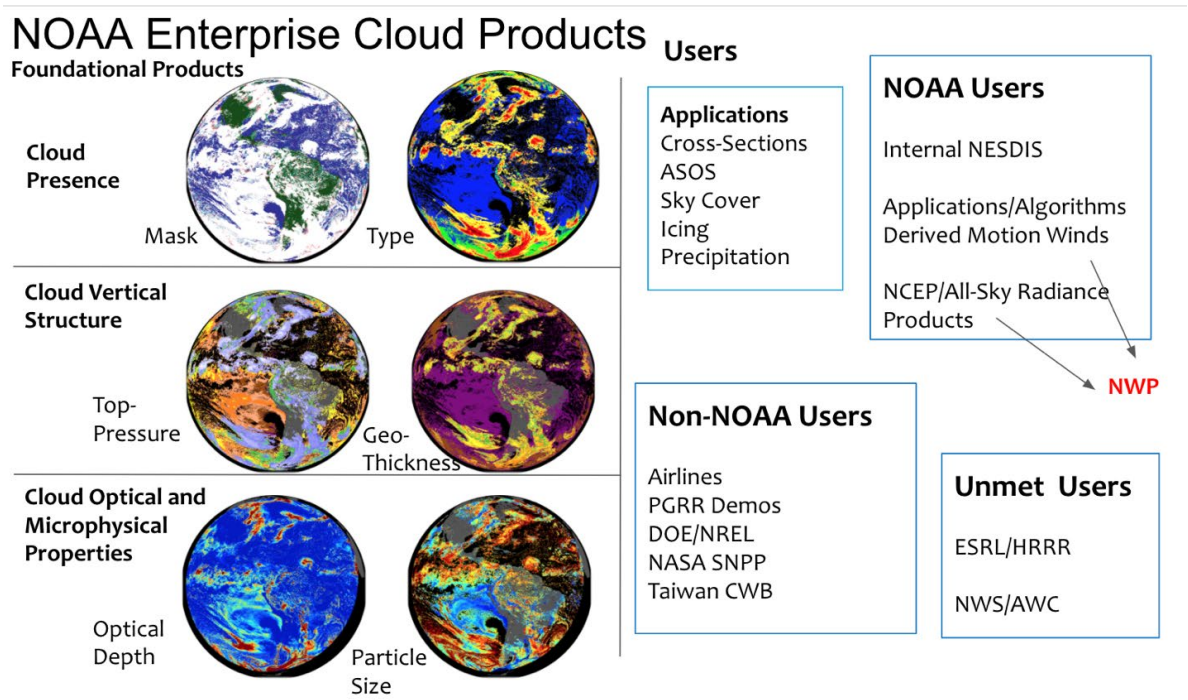
Presentation	Speaker	Affiliation
Assimilation of satellite clouds and winds in rapidly updating regional models	Steven Weygandt	NOAA/ESRL/GSD
Use of Cloud and Winds Products in NWP at NCEP	Andrew Collard	NOAA/NCEP/EMC/IMSG, Inc.
Use of Clouds/Winds Satellite Data at the Ocean Prediction Center	Michael Folmer	NOAA/NWS/OPC
Cloud Base and Cloud Cover/Layers	Yoo-Jeong Noh	CIRA
Atmospheric Motion Vectors (AMVs). A Winds Developer Perspective.	Jaime Daniels	NOAA/NESDIS/STAR
User Engagement from the Cloud Product Team Developers	Andrew Heidinger	NOAA/NESDIS/STAR

3) Key Takeaways

a) **Users**

i) Satellite winds (AMVs) are a vital observation source to NWP models (global and regional) and provide a critical hourly observation source for rapidly updating models.
ii) Satellite cloud products are an essential input to cloud analysis schemes used in rapidly updating regional models and this capability is critical for improvements in clouds forecasts.
iii) Improved model cloud forecasts enable improvements in ceiling and visibility guidance, which is very important for aviation applications.
iv) The quality of the clear-sky radiance product is crucially dependent on the quality of the cloud product.
v) Scatterometer winds are vital wind observations need by NWP and field forecasters (Very strongly pointed out by Michael Folmer (OPC)).
vi) Full resolution GOES-16/17 cloud products are strongly needed.
vii) Higher spatio-temporal GOES-16/17 AMVs in vicinity of tropical cyclones and other severe storms (application to GOES-16/17 meso sectors, for example) are needed.
viii) Close and routine coordination between satellite (NESDIS STAR/CIs) and NWP developers (NCEP/EMC, NOAA/ESRL, and other NOAA Labs (AOML)) is critical for ensuring that the correct product/information needed by the user is generated, implemented, and utilized to the extent possible.

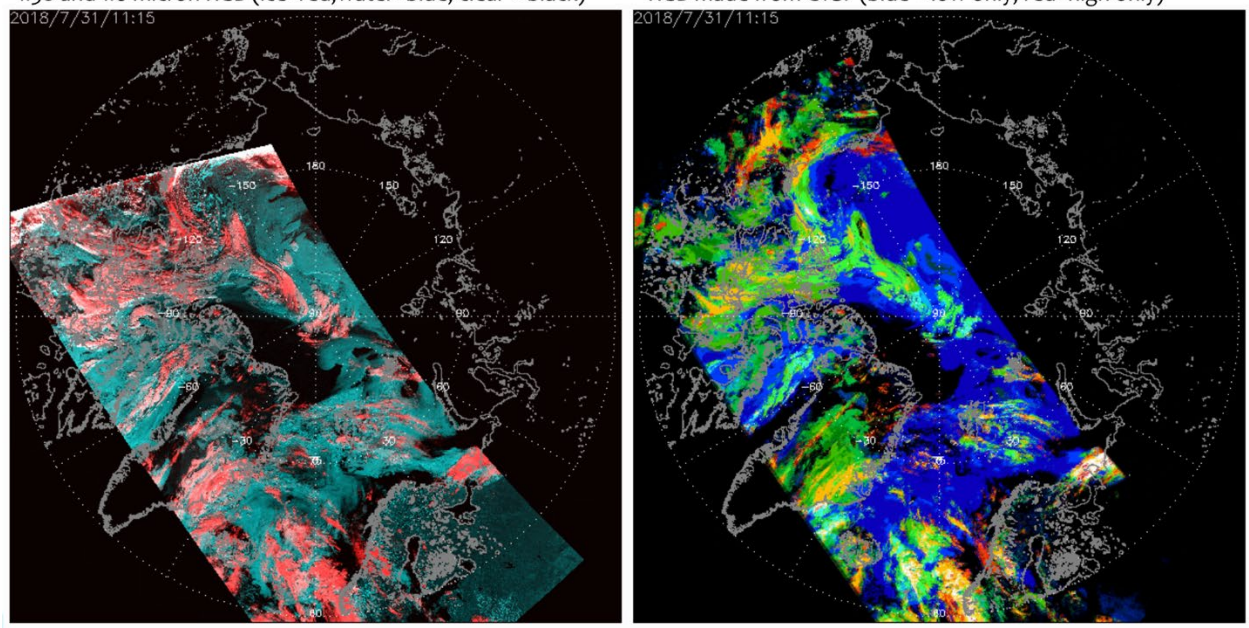
4) Graphics



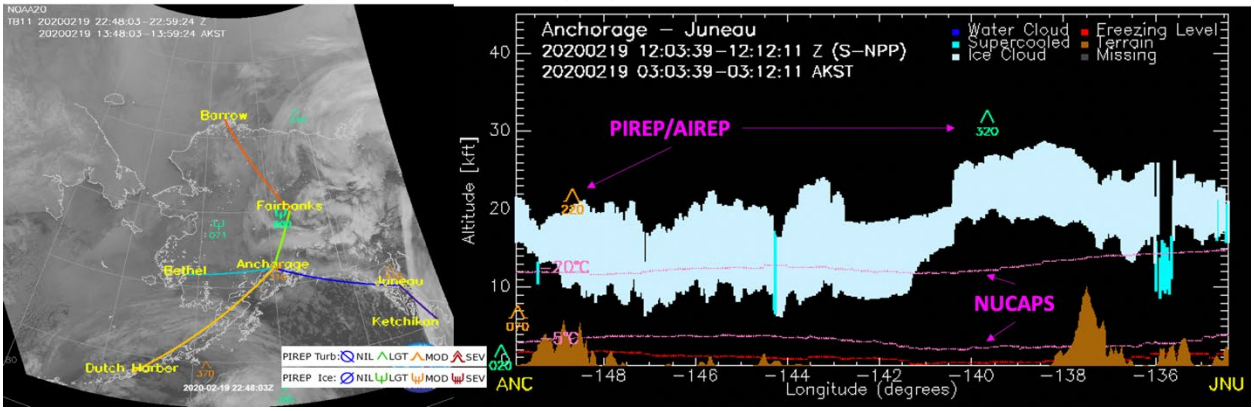
Summary of the information contained within the NOAA Enterprise Cloud Products for GOES-R and JPSS and the current list of known applications.

JPSS/VIIRS (SNPP+N20) Example of Cloud Vertical Structure (CVS) Over Arctic

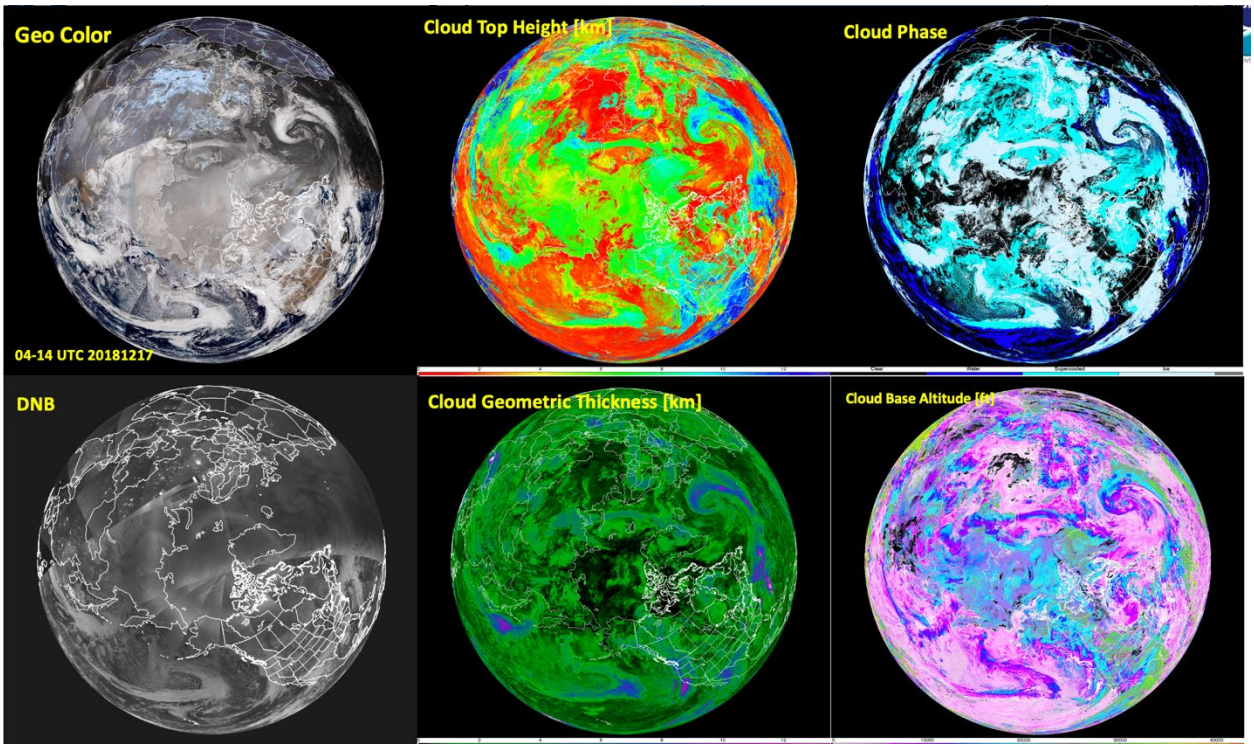
1.38 and 1.6 micron RGB (ice=red,water=blue, clear = black) RGB made from CVS. (blue = low only, red=high only)



Example of the NOAA Enterprise Cloud Cover Layer (CCL) product displayed as an RGB (right) compared to an RGB constructed from VIIRS reflectances (left).

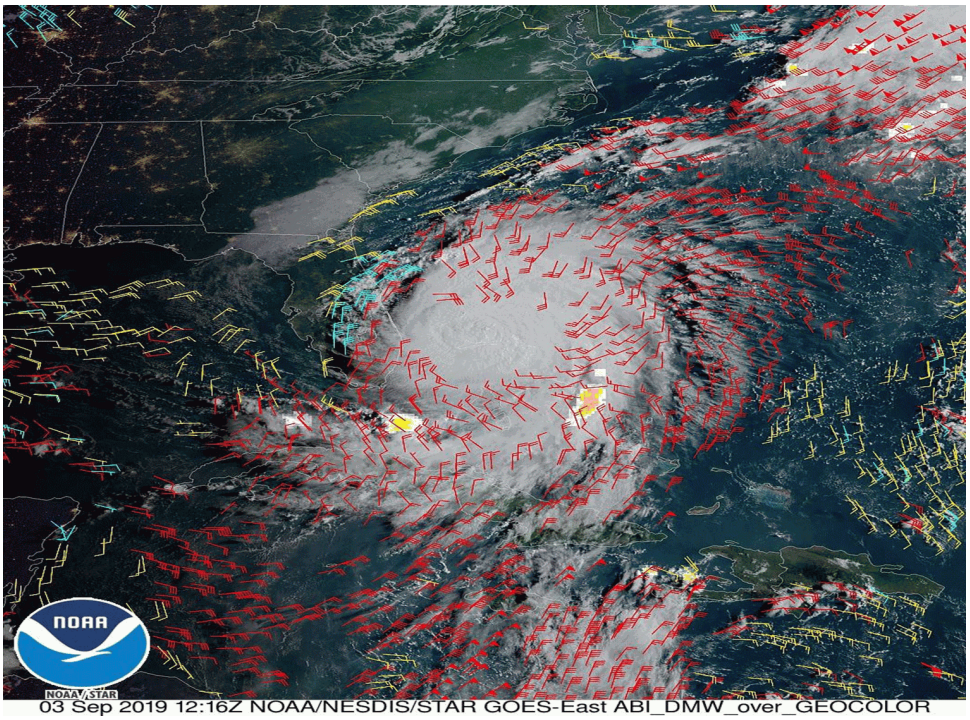


Example of NOAA Enterprise Cloud Product Cross Section from the flight path from Anchorage to Juneau Alaska. Image on the left shows the flight path overlaid onto a VIIRS 11 micron brightness temperature image. PIREPS are overlaid on the cross section for reference.

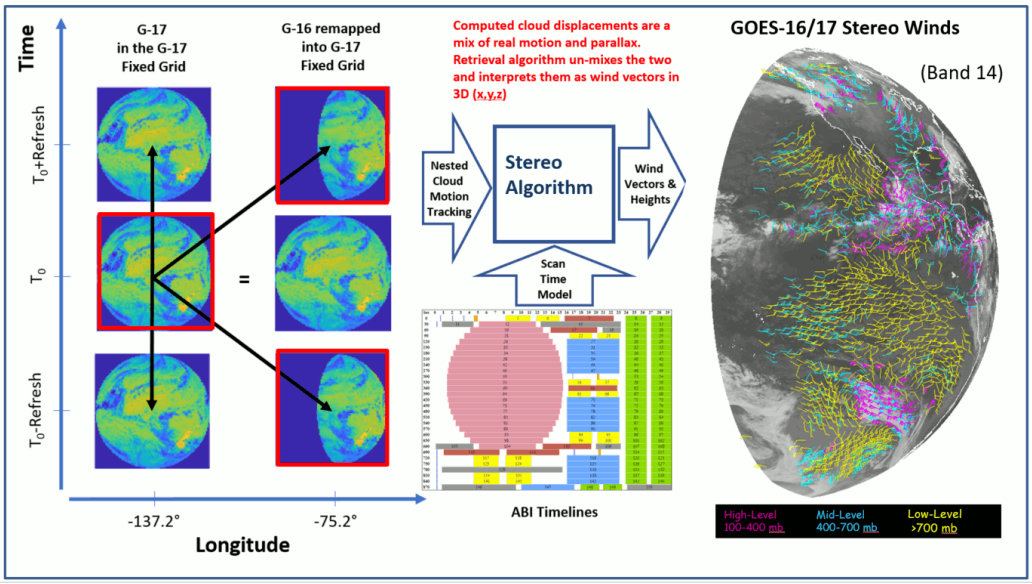


Example images of the NOAA Enterprise Cloud Products from VIIRS shown in the CIRA Polar Slider Web-based tool. (rammb-slider.cira.colostate.edu)

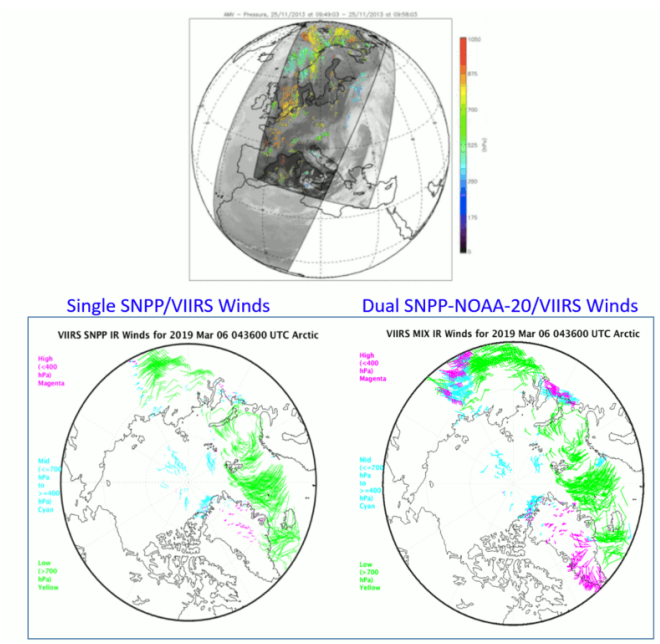
WINDS GRAPHICS



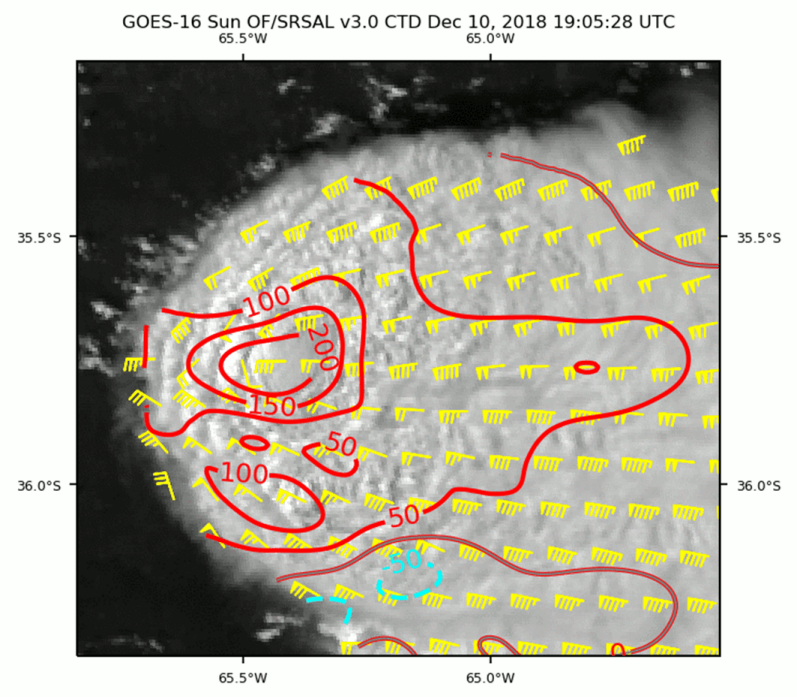
GOES-16 winds plotted over Hurricane Dorian on 03 Sept 2019 at 12:16 UTC. Red wind barbs reflect winds at upper levels (100-400 hPa), cyan wind barbs reflect winds at mid levels (400-700 hPa), and yellow wind barbs reflect winds at low levels (below 700 hPa).



Stereo winds derived from combined use of GOES-17 and GOES-16 Band 14 (11um) imagery.



Comparison of VIIRS winds derived from S-NPP passes alone (left) and from tandem use of S-NPP and NOAA-20 passes (right).



Cloud-top divergence ($x10^{-5}s^{-1}$) (red contours) derived from dense optical flow winds over a deep convective storm.

5) Questions/Answers

Question	Answer
GOES-16/17 operational cloud products are still provided at reduced spatial resolution. Is there a desire for products at the highest spatial resolution?	Andrew C.- Yes, particularly as we move toward Convection-Allowing Models, highest spatial resolution products will be very useful. Mike F.- Yes!
So: AMVs it is!	Most felt it was important to continue use of the name, Atmospheric Motion Vectors (AMVs).
ESRL uses some of the NASA Langley products. Are there features of those products that NESDIS should adopt?	Yes, historical cloud products from ESRL are being used. No work has been done with using NOAA products. This needs further assessment.
Are there any specific plans to do more assimilation testing with goes-16/17 winds in regional forecast system (HRRR, etc)?	GOES-16/17 winds are currently being assimilated into NOAA's regional models (HWRF, RAP, HRRR). Agnes Lim (University of Wisconsin/CIMSS) is currently involved in assimilation tests using the latest version of the HWRF. Steve Weygandt (ESRL/GSD) noted that more testing will be planned with the RAP and HRRR.
NESDIS cloud products generally provide uncertainties. Do users find these beneficial?	Andrew C.- Yes, they have been used to study how best to use the QC flags in the data stream and we will investigate using these directly in the future.

Ignoring cost, where should NOAA be targeting new cloud and wind observations for operations (e.g. Wind lidar, ice cloud imaging > 200 GHz, low frequency mw)	*From the winds perspective…* Jaime D.- NOAA is closely following the performance of the Aeolus instrument and derived wind observations and the impacts of these observations on global NWP forecast skill. NOAA is also closely monitoring and assessing the role of hyperspectral sounder observations for deriving wind observations or leveraging them to improve height assignments of AMVs derived from imager observations. *From the cloud perspective...* Cloudy radiance and product assimilation is still in its infancy so the answer is not clear from a NESDIS perspective. NASA, EUMETSAT and ESA are flying some exciting new sensors in the coming years and NOAA should try to operationalize those observations that NWP show to have the most value. One example is the Ice Cloud Imager (ICI) on the next EUMETSAT series of polar orbiters. NOAA should also partner with NASA to operationalize some of the key components of the EOS A-Train which are not being continued by NASA such as CALIPSO and CLOUDSAT.
Any thoughts on the impact of increasing the vertical resolution of regional models (e.g. HRRR) on assimilating clouds and storms?	Steve W. - We have compared some 1-km 65-level HRRR runs with the current 3-km 51-level HRRR as part of the ICICLICE experiment, focused on icing events in the Midwestern U.S. in Feb. 2019. The results suggested that in addition to the increased horizontal resolution (from 3-km to 1-km), the increased vertical resolution played a role in producing narrower, more intense and more numerous lake effect snow bands and even cloud streets. While these bands were not always positioned correctly, the qualitative character of the bands seemed the best in the 65 level 1-km runs compared to 51-level km runs and 51-level 3-km runs. We note that there was no additional data assimilation done for the 1-km runs -- they were initialized from the HRRR 3-km grids. While we have not examined the vertical structure in detail, we suspect that the increased vertical resolution may allow for increased vertical detail of multiple cloud layers. Again, we suspect the fields would be qualitatively more realistic, but may not have layers at the correct levels. We

	also think that increased vertical resolution could facilitate improved cloud / precipitation data assimilation, but it would depend on having accurate detailed vertical structure in cloud and precipitation observations. Near surface assimilation and prediction of fog and low clouds seems like an aspect that might benefit substantially from increased model vertical resolution near the surface.
Steve, why not using GOES-16 channel 2 (vis) DMWs? Any plans to use/test those in RAP/HRRR?	This is mostly historical. There are currently no specific plans in place, but we need to revisit this.
Question for Andrew collard: what is the best way for satellite developers to coordinate with NWP assimilation developers at NCEP?	We have some very good routine interactions between EMC and satellite developers at NOAA. Close coordination with others at STAR. Important to get information from developers.
Andrew. With respect to GEO ring clear sky radiance how do you treat overlapping satellite coverage? GOES 16 vs MSG as an example.	We treat all satellite observations as independent measurements and do not do anything special where measurements from different platforms overlap. This should be acceptable if the observation errors are tuned correctly and there are not systematic differences between the measurements (the latter is ensured by employing bias correction for all radiance observations).
Low level AMVs have been "blacklisted" in ECMWF due to poor height assignment. Are low level AMVs currently assimilated by NOAA?	At NOAA, low level AMVs are currently being assimilated in NCEP's global and regional (HWRF) forecast systems. Low level NOAA AMVs are being actively assimilated by NCEP and all International operational NWP centers. However, we are aware that ECMWF is blacklisting some low level GOES-16/17 winds in the tropics.
Is there a need for an automated hourly objective analyses based on AScat, AMVs, SHIPS, Buoys (at the surface) and at ~250 hPa based on AMV, Aircraft, & raobs?	The short answer is yes. Mike Folmer (NWS/OPC) noted that automated observationally based objective analyses, especially over oceans, could be very useful given the time constraints imposed on NWS forecasters/analysts.
ADM Aeolus provides line of sight (LOS) winds. Is it an easy matter to assimilate these, or do you require typical u-v winds (and uncertainties)?	ADM Aeolus measures Line of Sight (LOS) backscattered light which is converted to Horizontally projected LOS (HLOS) wind profiles (L2B product). Translation of these HLOS wind profiles to U and V components of the winds is straight forward which makes it easy to assimilate them in NWP forecast systems.

	More information about Aeolus data can be found at these web sites below: *https://earth.esa.int/web/sppa/mission-performance/esa-missions/aeolus/data* *Aeolus Sensor and Product Description*
Are satellite derived winds are used by the Rtma/urma for the wind analysis over the oceanic areas?	The current 2D RTMA/URMA system does currently assimilate satellite derived winds, which includes ASCAT (along with ship obs, buoys, etc.). While the system certainly is primarily land based, it does extend into adjacent waters like the Gulf of Mexico. In these areas we also provide an analysis of significant wave height. The RTMA/URMA will become 3D-RTMA with the next implementation, and will require more comprehensive wind analysis both over land and over the oceanic regions in the North American region.
For Mike: What OPC products do you deliver to the mariner out at sea to improve safety and marine transportation IDSS?	OPC issues marine warnings, forecasts, & guidance in text, graphical, and gridded format for mariners N of 31°N in the Atlantic and N of 30 °N in the Pacific oceans. OPC marine warnings for Gales (34-47kts), storms (48-63kts), hurricane force winds (>= 64kts) and freezing spray are provided. OPC generates and delivers a host of products that include various surface analysis products, wind/wave analyses, offshore and high seas forecasts, tropical marine, and gridded marine products. See: https://ocean.weather.gov/prodmon/prodmon.php?limit=20&width=normal&zoom=normal
CIRA - How difficult would it be to have some west coast cross sections added? I could see these potentially adding value for coastal aviation forecasts.	The Cloud Demo was extended into 2020 and a cross-section between LA and Hawaii was added. It is not hard and we would love to get more suggestions.
Are there any plans to work with GK2A winds?	Currently, there are no plans to work on deriving winds from GK2A. We do see some opportunity and potential benefit to derive stereo winds from simultaneous use of GK2A and Himawari imagery.
Jaime, what is the accuracy of G16/17 stereo cloud heights compared to the standard product?	Overall, the accuracy of the stereo based cloud heights compare very well with the IR-based cloud heights (ie., standard product). However, the accuracy of the stereo base cloud heights will often outperform the accuracy of the IR-based cloud heights in the following situations:

	1) In conditions where a thermal inversion exists; 2) the NWP model forecast used in the IR-based retrieval process is in error. The stereo cloud heights are NWP model independent, and therefore, have a distinct advantage over the IR-based cloud height retrieval; and 3) ABI IR calibration is suspect. An extreme example of this is GOES-17 Loop Heat Pipe (LHP) anomaly which leads to seriously degraded or missing longwave IR bands used by the IR-based cloud height algorithm. In these situations, the stereo cloud heights are significantly improved.
Jaime: Plans to generate enhanced vortex scale AMVs in real-time and deliver to NWS offices? Perhaps running constantly in meso sectors?	Yes, this is in the winds team five year plan. We envision these winds also being used in NOAA's regional NWP forecast systems (ie., HWRF, RAP, HRRR).
Should we be providing winds to forecasters in only vector format or also in a gridded or analysis form as a basis for shear products (magnitude contoured)?	Jaime: The generation and distribution of gridded/analyzed fields of divergence and divergence using satellite winds are certainly possible. If NWS forecasters find that these fields have value over and above what they already have then this will be pursued.
Where is the best site (ie. non-PDA, non-SBN delivery) to obtain digital real-time winds and cloud products?	Through NOAA's Big Data Project (BDP), three big commercial cloud providers will enable public access to NOAA"s huge sets of environmental data that include digital real-time winds and cloud products. Amazon Web Services, Google Cloud and Microsoft cloud will all host NOAA's weather data. These vendors can charge end users of the data for compute services, but public access to the data itself is free. For more information see: *https://docs.opendata.aws/noaa-goes16/cics-readme.html*
What is it going to take to get to an hourly 3D cloud product (all sensors combined)?	That is entirely possible based on a combination of the NOAA Enterprise Cloud Products on JPSS and the geostationary sensors (GOES-16, GOES-17, HIM-8/9, Meteosat-11). NESDIS would require a SPSRB request for this from a NWS User. Please see https://projects.osd.noaa.gov/SPSRB/index.htm We could also pursue a Proving Ground/Risk Reduction effort. Andy Heidinger would be happy to help this process. (Andrew.heidinger@noaa.gov).

Do you have anyone focusing on satellite applications for users outside of NOAA perhaps looking at economic drivers or is NWS the big customer?	Certainly, the NWS is NESDIS' largest customer, but NESDIS has been actively reaching out to the much broader user base (current and potential) to understand and then document/compile and share user needs via a centralized enterprise data repository. See Renata Lana's (NESDIS HQ) "User-Driven Innovation" presentation.
Are there any satellite based wind profile data out there?	Yes. The European Space Agency (ESA) Aeolus Mission is providing global observations of wind profiles from space via the Atmospheric LAser Doppler INstrument (ALADIN) onboard the ADM Aeolus satellite. More information about Aeolus data can be found at these web sites below: https://earth.esa.int/web/sppa/mission-performance/esa-missions/aeolus/data Aeolus Sensor and Product Description http://cimss.ssec.wisc.edu/iwwg/iww14/talks/04_Thursday/1000_IWW14_Aeolus_Straume.pdf

6) Key Challenges for Users/Developers

a) Users

i) Field forecasters are under demanding time constraints. Satellite data/products have to be presented in a way that enables the forecaster to acquire and digest the needed information quickly.

ii) Using cloud information more effectively in NWP and retaining the cloud information that is assimilated.

iii) Further optimizing the use of AMV data (QC, error specification, etc.) in NWP. This includes the development and use of situation dependent observation error.

b) Developers

i) Getting large volumes of data to users. NWS is constrained (ie., network) by what they can distribute to the field.

ii) Ability to accurately sense multiple cloud layers

iii) Develop approaches for extracting wind information from hyperspectral geostationary sounders. (from either L2 products or radiances)

iv) Finding ways to provide wind information at more vertical levels from existing and future instrument observations.

v) Implementing new products/applications into operations in a more timely way.

vi) Acquiring the necessary support for the development of satellite-based products/applications needed by users outside of NOAA.

7) Ideas for Improving the User Experience

a) Product developers should have well established connections with users. Set up routine developer/user meetings.

b) Developers should strive to better understand NWS forecast/warning/DSS operations
   i) Visit a forecast office, testbed, or proving ground
   ii) Use Case Coordination: Product Developers and Users could coordinate and iterate on specific cases of interest identified and archived by NWS field forecasters to determine if, where, and how a satellite-based product(s) might best contribute to information needed by a forecaster.
c) Continue to invest time and energy in data product demonstrations and training. The Alaskan Cloud Demonstration within the JPSS Program was one example of a cloud product demonstration targeted at specific application and successfully growing the user base.
d) The SPSRP process relies on an operational NOAA user to request a new product or a change to an existing product. Many of the cloud products find use outside of NOAA and NOAA should open up the SPSRB process to be more inclusive.

8) Recommendations

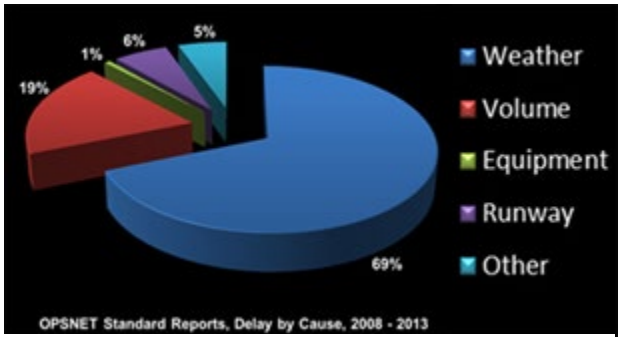
a) Improve the horizontal and vertical coverage of satellite winds
   i) In the vicinity of tropical cyclones, and in particular, in the center of the storm circulation
   ii) In the polar regions
b) Improve AMV height assignment and error characterization. Leverage all possible retrieved cloud property information and associated cloud retrieval uncertainty information in the AMV height assignment process. Pass on AMV product uncertainty information (tracking, height assignment) to the user community.
c) Explore new approaches (e.g., optical flow) and applications for deriving motion of atmospheric phenomenon (clouds, smoke, aerosols, volcanic plumes, etc.) observed in high spatial and temporal geostationary imagery.
d) For all developers in all product areas: Establish routine meetings with your users to share and exchange a wide variety of information, both technical and programmatic, that can lead to a better understanding of user needs, existing data products, future data products, and schedules (development and implementation). This will help contribute to identifying the products and applications most needed by the users, improve utilization of satellite-based products, and improving the coordination and alignment of development and implementation efforts undertaken by developers and users.
e) NOAA should tap into the vast number of AI cloud algorithms being generated and engage that community to ensure NOAA maintains state of the art products and services. The STAR AI Workshops are great place to start this.
f) NOAA suffers from not having continues or up to date archives. NOAA should follow NASA's example of reprocessing data and making since interfaces that all users to visualize a specific granule or order a long-term data set.
g) NOAA should make level-3 cloud products from their level-2 data. Level-2 is very large and overwhelms some users. Many users including NWP want data on specific grids and NOAA does not provide this service at all for its cloud products.

Aviation Weather

Moderator: Jeff Weinrich

An aircraft takes flight over a snow covered landscape dotted by trees and distant mountains with peaks hidden in low clouds. Photo credit, Adam White, Alaska Airmen Association.

With more than 570,000[1] square miles of land, Alaska is the largest state in the U.S., yet the least densely populated, with a resident population of 738,432, and only 1.3 people per square mile.[2] Much of it is virtually inaccessible to humans except through remote means such as unmanned aerial vehicles (UAV) or drones, and earth observation satellites. In fact, just 20 percent of Alaska is accessible by road. That makes other forms of transportation, such as aircrafts, especially important. For many remote towns, air travel is the only way to get about, which means it has woven its way into all aspects of life in this vast state.

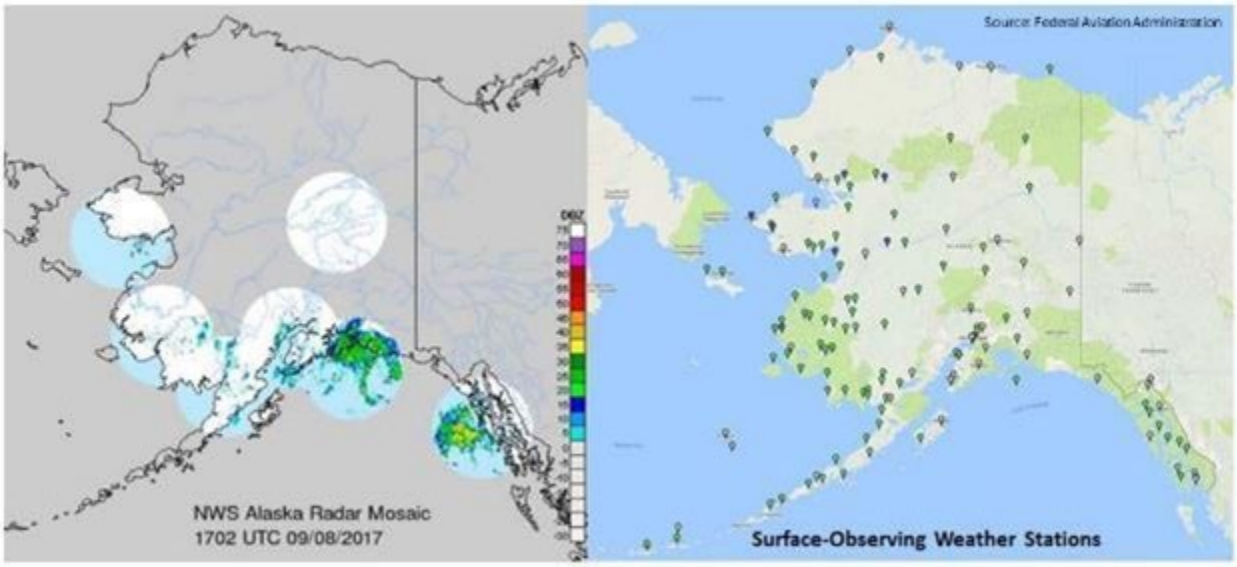


According to the U.S. Federal Aviation Administration (FAA), the largest traffic delay in the National Airspace System is caused by weather (FAA 2017). And there are times when weather

[1] National Atlas of the United States at https://nationalmap.gov/small_scale/

[2] https://state.1keydata.com/state-population-density.php

conditions can deteriorate to an extent that it becomes dangerous for planes to fly. Accurate weather information is critical to pilots and aviation safety. And in Alaska, landings and takeoffs must be performed in a complex environment with varied topography and harsh weather conditions that pose hazards in almost every season. For example, wildfires, a common occurrence in the summer in Alaska, can limit flight operations due to reduced visibility. This happened during the Swan Lake Fire in August 2019[3]. In the winter, weather hazards from cold, ice and snow, coupled with minimal hours of daylight, present treacherous flying conditions.



The challenge of surveilling weather in Alaska is that it is a comparatively large, remote, topographically complex landscape with prominent microclimates. Part of the data that is used to generate aviation weather forecasts comes from surface weather observations derived from ground stations or provided by human observers. The radar network (shown right) is limited in coverage and located mainly along coastlines, leaving much of Alaska's interior bare of this data. Moreover, these limited observation platforms cannot accurately represent large areas, as radar beams are often blocked by steep topography. According to the FAA's surface weather observation stations website, Alaska has 133 AWOS or ASOS weather station locations – a small number when compared to over 1,800 similar sites in the "contiguous 48 states". And, while the number of surface observing weather stations surpass those of radar networks, large portions of Alaska's interior remain relatively uncovered

1) Session Purpose

According to the Federal Aviation Administration (FAA) more than 44,000 flights and 2.7 million airline passengers cross more than 29 million square miles of US airspace, daily. Severe weather impacts airspace capacity and efficiency resulting in delays, cancelations, and costs. Improved real time weather data could inform flight planning and management ensuring greater efficiency and safety. The Aviation Initiative

[3] Alaska Division of Forestry. Swan Lake Fire. https://inciweb.nwcg.gov/incident/6387/

focuses on use of JPSS data and products for critical weather information for pilots and aviation safety mostly at higher latitudes where coverage from JPSS is improved with two satellites (SNPP and NOAA- 20) and from other LEO satellites, including the EUMETSAT MeTOP series. The Aviation Initiative and Alaska Cloud Demonstration showcased the application of JPSS products in addressing forecast challenges related to aviation hazards such as clouds, icing, turbulence, and cold air aloft, to pilots and forecasters. User communities include NWS Alaska Aviation Weather Unit, Aviation Weather Center and Weather Forecast Offices (WFOs); private pilots; professional associations; international users such as the German Weather Service, Iceland Weather Service, and Environment Canada. Commercial and government stakeholders include the FAA, National Transportation Safety Board (NTSB), Airlines, United States Geological Survey (USGS), and academic partners.

To improve flight planning and diagnostics of icing by aviation forecasters, the Aviation Initiative has successfully developed several satellite-based cloud products along flight paths focused in the Arctic Region. Feedback from stakeholders has improved visualization tools that examine lower cloud layers and led to the creation of cross sections of water clouds, ice clouds, supercooled liquid water along flight routes.

Pathway to operations should be identified. Some examples are official government systems such as the NWS' Advanced Weather Interactive Processing System (AWIPS), and FAA Automation System Operational and Supportability Implementation System (OASIS). There is also a need for Implementation in an operational capacity for pilot access. The session's purpose is to explore all users' aviation needs from a developer's and user's perspective from both GOES-R and JPSS.

2) Agenda

Presentation	Speaker	Affiliation
Impact-based Decision Support Services for the National Airspace System	David Bieger	NWS
Weather Satellite Data in FAA Research	Randy Bass	FAA
Cloud Research and Satellite R20 at the Aviation Weather Center	Ty Higginbotham	AWC
Product Application and Development in Support of Aviation	Mike Pavolonis	STAR
Satellite Products for Aviation: Remote Sensing Needs in High Latitudes	Carl Dierking	GINA
Aviation Initiative and Aviation Applications	Jeff Weinrich	JPSS

3) Key Takeaways

i) The FAA works closely with NWS (including AWC, NAMs and CWSUS), commercial weather providers, the research community, and users to identify weather impacts to aviation and solutions to mitigate/eliminate those impacts.

ii) In many cases, human factors are a larger issue to overcome than meteorology shortfalls.

iii) Without GOES satellites the AWC would have a very difficult time with forecasting their SIGMETs and GAIRMETs.

iv) JPSS is not used really at all at AWC.

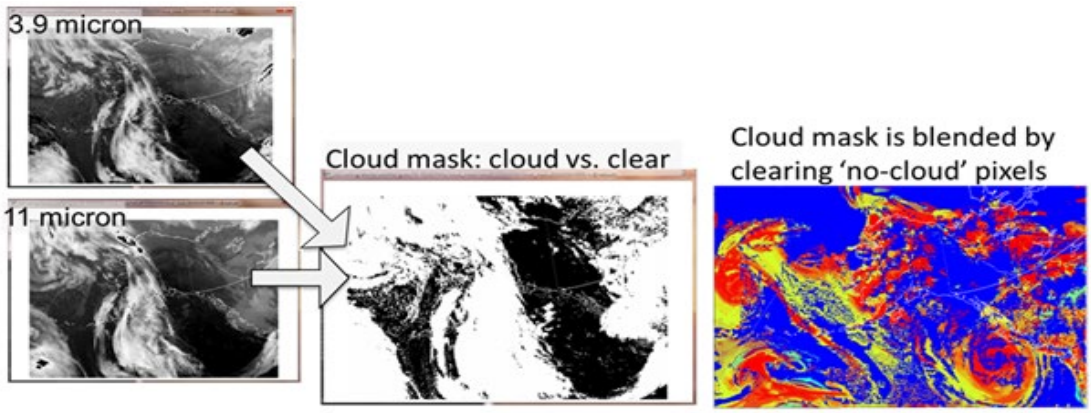
v) The FAA and AWC already have great communication with each other, but finding a better way to get R2O faster would be beneficial.

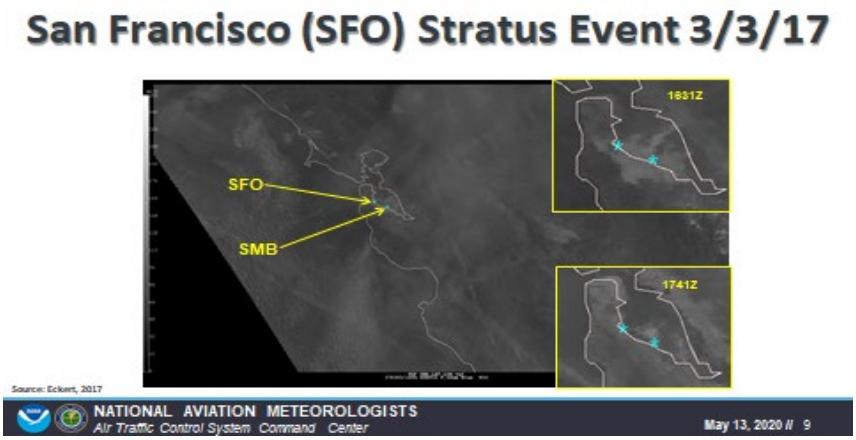
vi) Data overload - there is a strong need for application specific higher order, information rich, products (as opposed to satellite mission specific lower level products)

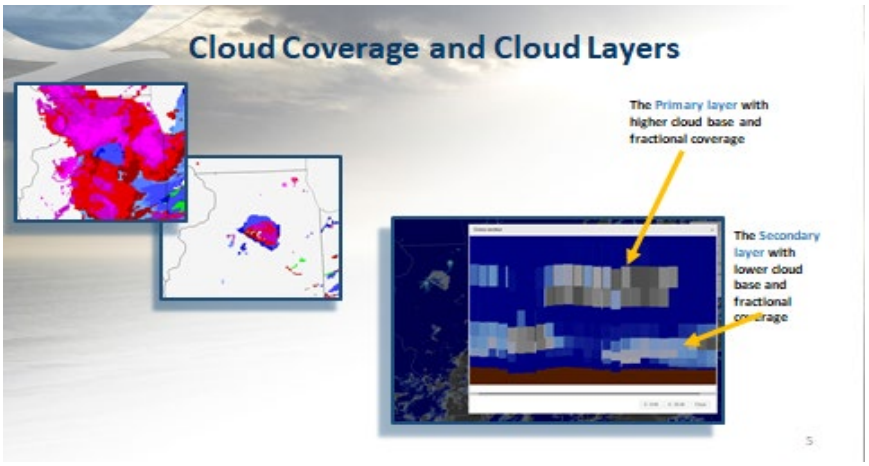
vii) Aviation trends - increasing demand for greater operational efficiency while ensuring safety

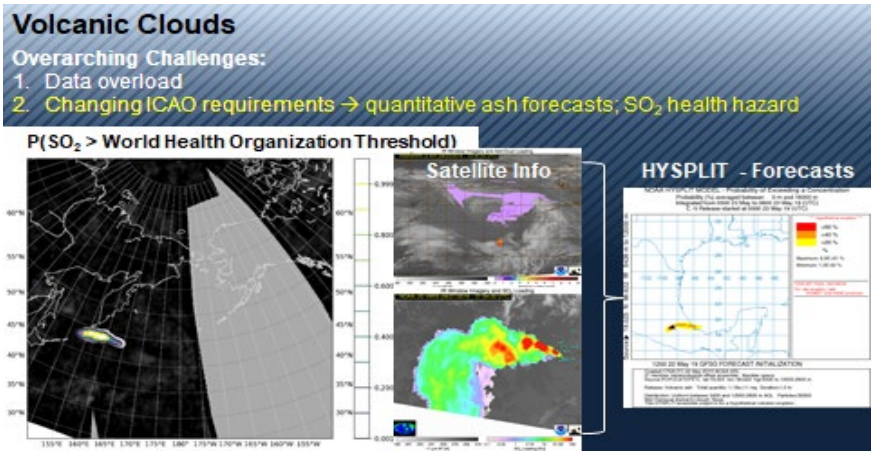
4) Graphics

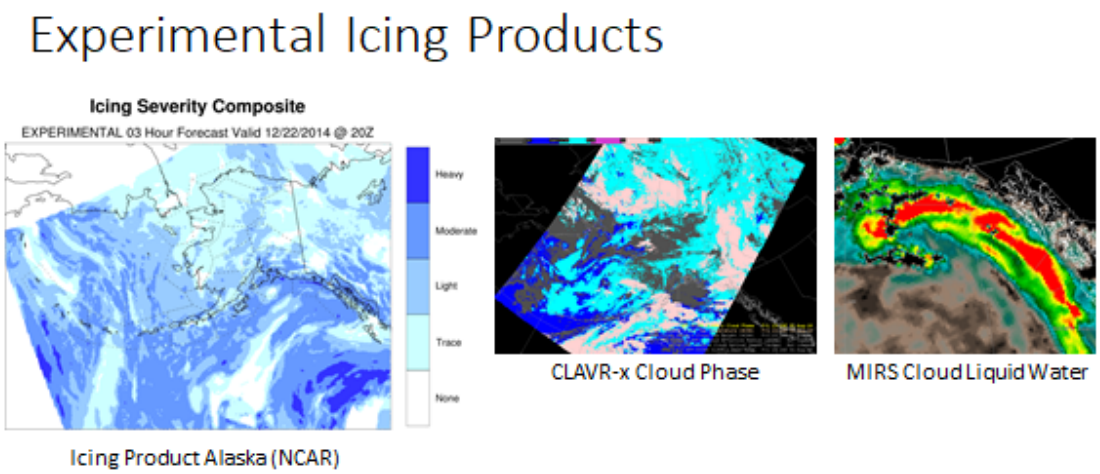
Integrate satellite cloud mask in Alaska ceiling and visibility products





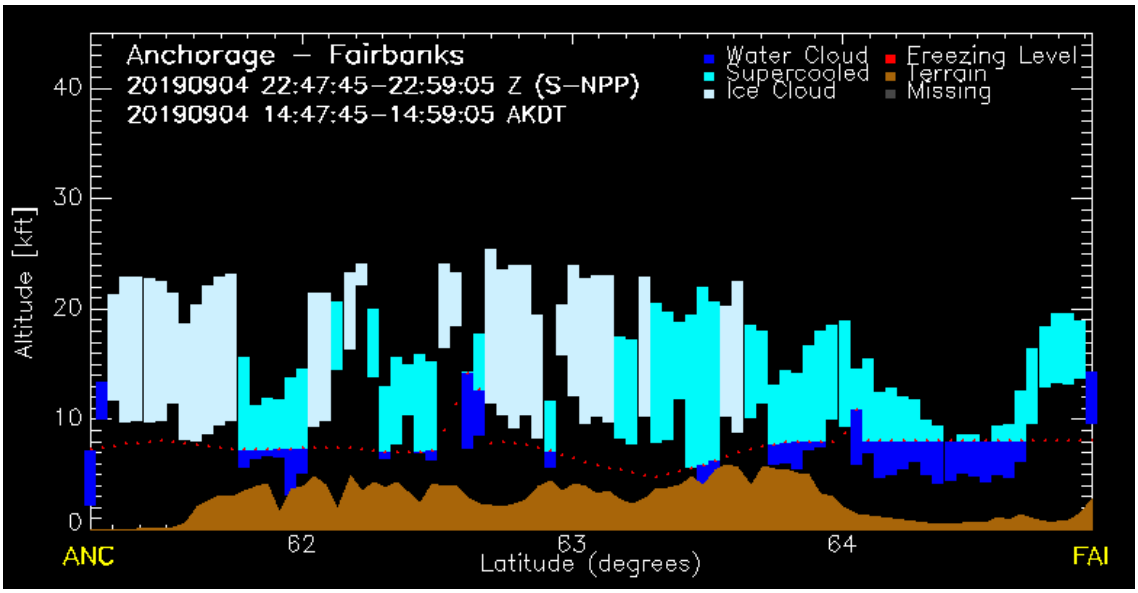






We're mainly using Icing Product Alaska (IPA), developed by NCAR through FAA- AWRP (Avn Wx Research Program). We supplement that guidance with BUFKIT, but over the whole state that's a lot to sort through all the soundings. NUCAPS or Gridded NUCAPS might assist with an analysis, but we also use satellite imagery to look at the cloud top phase, temperature. – Nate Eckstein (AAWU)

JPSS Cloud Cross Sections



5) Questions/Answers

Question	Answer
How does National Weather Service (NWS) aviation support the Federal Aviation Administration (FAA) impact smaller aircraft authorizations?	The Helicopter Emergency Medical Services Tool (HEMS) tool, maintained and operated by the Aviation Weather Center, is dedicated to low-level, small aircraft operations. It is being moved by AWC on their website for easier access by general aviation pilots. Bigger problem may be UAS Support. Commercial weather industry will cover low levels on a local scale.
How does the FAA envision closer ties with the research community? What interactions are needed to better integrate?	The FAA works well with national labs. They are getting better with Cooperative Institute for Research in the Atmosphere (CIRA) and Cooperative Institute for Mesoscale Meteorological Studies (CIMMS). Weather technology in the cockpit progress. Better collaboration with NASA is the biggest challenge. Communication involved with air traffic operations could be improved, including Center Weather Service Units (CWSUs). Biggest problem is access to FAA facilities due to cumbersome red tape.
Are there some warnings that are so short-term that they can only work by viewing them directly in the cockpit? Are there any efforts underway to enable this?	Probably such as severe storm and tornado warnings. Working on ways to get data faster and is the function of the Weather Technology in the Cockpit. They get SIGMETs but not always

	the case. Could be a communication issue. Low level wind shear needs to get to pilot immediately. Technology is not there yet to get that information to them.
There is a lot of good JPSS capabilities available to aviation....no mention in the Aviation Weather Center	Experimental product vs operational products. Many of these JPSS products have been designed to be used as expert guidance for forecasters with inherent limitations, and it is not clear whether they can/should be used as-is by non-experts. Be clear about the difference between the two, and the difference between a forecast product and guidance. Also training on JPSS capabilities.
Does the Graphical Forecasts for Aviation use only model clouds? Do they envision using new cloud capabilities being developed for ABI/JPSS (e.g. cloud base)?	GFA is indeed model-only clouds. AWC is aware of the cloud profiling capabilities we are working on at CIRA and we have discussed with them how we should do some intercomparisons as a start at better merging our capabilities.
With all the monitoring currently in place, how many volcanic eruptions have been missed in the past year that were detected by humans?	At any given time, only about 10% of the ~1500 Holocene volcanoes are monitored. Thus, most eruptions are detected using satellite remote sensing. Thanks to new satellite technology and alerting services, like VOLCAT and SACS, the latency on eruption detection has steadily decreased. Over the past 20 years, there have been large eruptions that went undetected for hours, but the probability of such delayed detection has decreased significantly due to the aforementioned factors.
Mike P, regarding increasing environmental data, is NOAA capable of developing tools to efficiently take advantage of it all? What changes must be made?	In lieu of incremental improvements to existing geophysical parameters, encourage and prioritize transformative product development that: 1). Reduces the ratio of output to input data, 2). Results in products/services that will harmonize with existing user workflows, 3). Automates time consuming user tasks, and 4). Directly address one or more NOAA MSAs through integration of all relevant environmental data (e.g. product is used at the information/decision-making interface)
Given that you also cater to user communities outside the NWS, how do you adapt your training needs to help them understand your products?	JPSS has a training coordinator. In coordination with expert scientists JPSS creates training manuals that explain the products. This includes strengths and limitations.

I recall Weather in the cockpit projects back in 1989-1991. What's taking so long?	It takes a long time to bring successful research to operations. Bandwidth issues in the cockpit are still an issue both for GA and commercial due to the cost of avionics and requires investment from the airlines. Resources issue.
Could 'weather in the cockpit' be NOAA's Moon Shot? NOAA leadership is looking for something to hold up high.	Weather in the cockpit is more of an aviation and FAA issue and not really a NOAA problem. If not getting to the cockpit it is not doing any good.
Any comments on: AI will only be as good as the humans that help program or direct the interrogation algorithms. Diversity of experts in the process helps.	The FAA's Weather Research Branch is investigating using AI and machine learning in almost all of their forecast research. They have had good success in convection identification offshore using satellite imagery as a major input. Other areas of AI focus using satellite data include ceiling and visibility for Alaska and detection of icing conditions in the CONUS.
What is the place for all this research within an international framework? Do you see the US as a leader in this area?	The FAA is the Met Authority for aviation weather in the US, and as such has members on several international committees run by ICAO and the WMO. They are also very involved in RTCA and lead several sub-groups charged with establishing aviation weather standards with other nation states and organizations.

6) Key Challenges for Users/Developers

a) Users

i) Information overload

ii) Swift, accurate, decision making

iii) Efficient and consistent workflow

iv) Getting the right information to the cockpit while overcoming communication bandwidth limitations

v) Translating weather data into products and services that non-meteorologists (pilots and controllers) can use in decision-making

vi) AWC already has great ways to communicate to pilots before takeoff and before landing, but need to work with FAA and others to try and figure a way out to get better notice while in the cockpit

vii) Having multiple cloud layers. Only get cloud top temps from top layer. Could cause an ice layer to be obscured

b) Developers

i) Rethinking product development practices - greater emphasis on data fusion that results in tools that have significant value at the information/decision interface

ii) Better understanding of aviation decision points and decision impacts

7) Ideas for Improving the User Experience

i) More thoughtful user interfaces - netcdf files on a server are insufficient for most users, including aviation users

ii) Develop more web based services

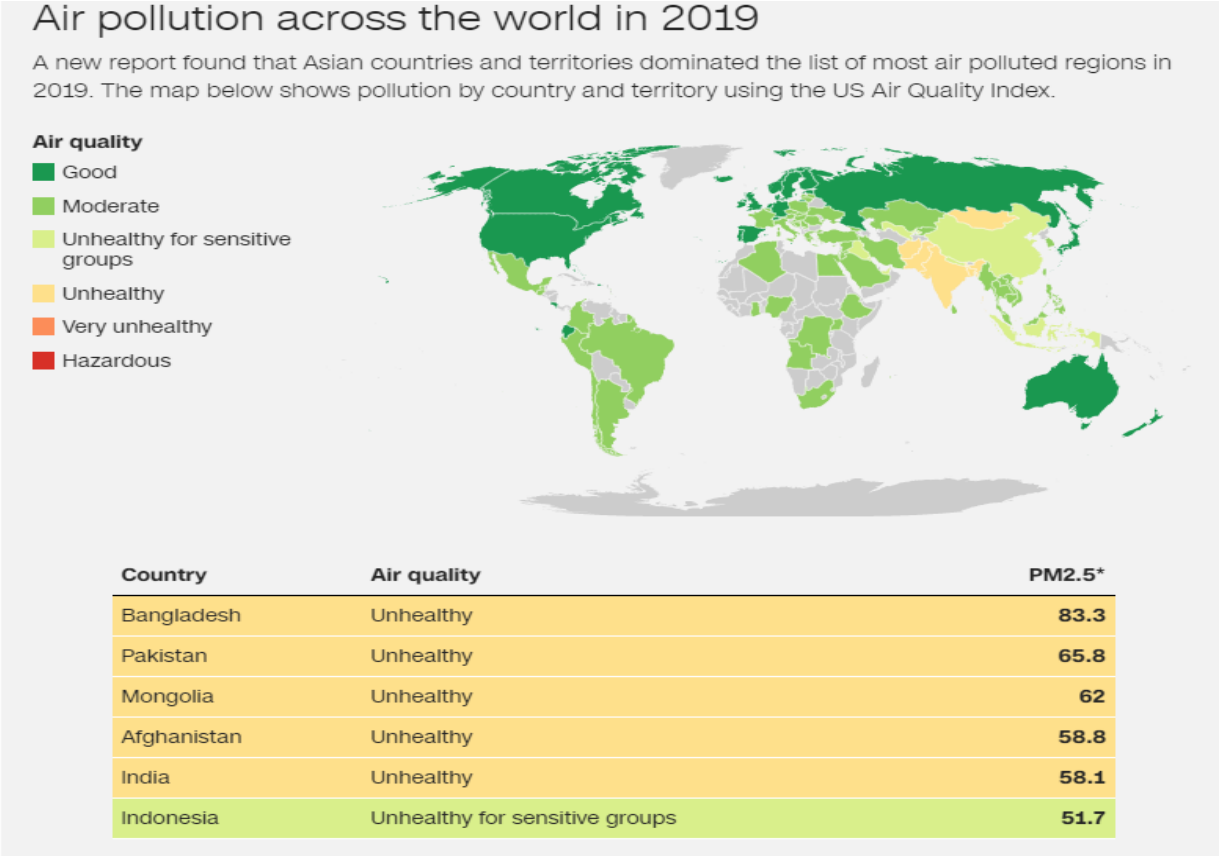
iii) Help navigate data overload and non-meteorological expertise with training

8) Recommendations

a) Build on the work with FAA to fulfill the satellite needs in aviation
b) Continue with demonstrations of aviation products to best utilize satellite products in aviation.
c) Work with Aviation Weather Center how to best utilize GOES-R and JPSS products and for different aspects of aviation.
d) Pathway to operations should be identified. Some examples are official government systems such as the National Weather Service's (NWS) Advanced Weather Interactive Processing System (AWIPs), Federal Aviation Administration's (FAA) Automation System Operational and Supportability Implementation System (OASIS). There is also a need for Implementation in an operational capacity for pilot access.
e) Expand its products in the Continental United States (CONUS) as well as internationally. Demonstrations established in the Arctic could be expanded globally.
f) Continue with Product Validation including data integration, validation by pilots and forecasters. Aviation hazards diagnostics and forecasts validated by pilots and forecasters can verify the accuracy of satellite product diagnosis and forecasts.
g) Continue incorporating Volcanic Hazards into aviation. This includes real time information for Ash and SO2 alerts, dispersion models and regional and global models, thermal anomaly detection for eruption forecasting, use of DNB, and integration of the JPSS volcanic cloud products with other types of models. Support for user engagement and enhanced application of existing and future JPSS Volcanic Hazard Products and Applications.

Air Quality/Aerosols

Moderator: Shobha Kondragunta



Country	Air quality	PM2.5*
Bangladesh	Unhealthy	83.3
Pakistan	Unhealthy	65.8
Mongolia	Unhealthy	62
Afghanistan	Unhealthy	58.8
India	Unhealthy	58.1
Indonesia	Unhealthy for sensitive groups	51.7

https://www.cnn.com/2020/02/25/health/most-polluted-cities-india-pakistan-intl-hnk/index.html

Air quality is a global issue. Most polluted places in the world are in Asia with Bangladesh having the highest annual mean PM2.5 (particulate mass of particles smaller than 2.5 µm in median diameter in units of µg/m^3) in 2018. Particles smaller than 2.5 um are important because they are small enough to penetrate through people's respiratory system and cause health issues. The annual PM2.5 standard designated by the United States Environmental Protection Agency (US EPA) is 15 µg/m^3. Most countries have PM2.5 levels three to five times more than the standard. According to World Health Organization, each year roughly seven million people die due to poor air quality. Poor air quality in fact kills more people disproportionately than severe weather. Air quality in the US has improved over the years due to various EPA's regulations such as Clean Air Act and its Amendment in 1990 and Clean Air Interstate Rule (CAIR) etc. Agencies such as NASA, NOAA, and EPA have invested in space and ground observational networks and thus are able to track pollution in near real time to issue alerts if air quality is bad and track long-term trends. Developing countries around the world where air pollution is generally bad year round do not have the luxury of investing in satellite or ground assets. It is therefore incumbent on the US and other developed nations to support global monitoring of air quality. The traditional approach is to use satellite observed aerosol optical depth (AOD) to obtain surface PM2.5. One notable aspect of PM2.5 is it is particulate mass and no information is known about speciation. It is equally important to

know aerosol composition as different aerosols have different health impacts and the scaling of satellite AOD to surface PM2.5 has a dependency on aerosol composition.

1) Session Purpose

The purpose of the aerosols and air quality session was to meet with a dedicated group of satellite aerosol product developers and users comprising of monitoring and forecasting community. Three keynote speakers were invited for each area, namely product development and product applications. The satellite aerosol algorithm/product developers were asked to provide their insights into current NASA and NOAA state of the art algorithms, product status including calibration and validation, and any shortcomings of the products. The satellite aerosol product users were asked to provide feedback on the usability of NOAA satellite aerosol products in their decision support systems. Particularly the use of aerosol optical depth, fire detection, fire emissions, and smoke/dust mask in global aerosol models for prediction of aerosols and regional air quality models for daily forecasting of air quality.

2) Agenda

Presentation	Speaker	Affiliation
Air quality and aerosol predictions at NOAA/National Weather Service	Ivanka Stajner	NOAA/NWS
Motivation – Navy Requirements for EO/Aerosol Research	Ed Hyer	NRL
Air Quality and Aerosols	Brad Pierce	UW-Madison
Aerosols and Air Quality – Spacecraft Contributions	Ralph Kahn	NASA/GSFC
Aerosol retrieval from all sorts of imagers: An integrated view of global aerosol	Rob Levy	NASA/GSFC
JPSS and GOES-R AOD Products - Current Status	Istvan Laszlo	NOAA/NESDIS

2.1) Agenda for Breakout Session

Time	Topic	Presenter
8:30 – 10:30 AM	**User Presentations**	
	Satellite aerosol products and regional air quality models	Daniel Tong (ARL)
	Aerosol assimilation in regional and global aerosol models	Mariusz Pagowski (OAR)
	Aerosol products and HRRR model	Ravan Ahmadov (OAR)
	Product Developers Presentations	
	VIIRS EPS AOD validation	Hongqing Liu (STAR)
	Bias correction approach for GOES-16 AOD	Hai Zhang (STAR)
	GOES-16 AOD algorithm improvements to address diurnal bias	Mi Zhou (STAR)
	Algorithm to scale AOD to PM2.5	Hai Zhang (STAR)
	Aerosol (smoke and dust) detection	Pubu Ciren (STAR)
	Legacy GOES AOD applications	Shobha Kondragunta (STAR)
	Open Discussion	
	Aerosol product uncertainties	All

	Quality flags	All
	User requests	All
	Open Discussion	
1:00 -3:00 PM	Continue Open Discussion	All
	AerosolWatch and JSTAR Mapper tutorial	Amy Huff (STAR)

3) Key Takeaways

The National Weather Service (NWS) reported that it is using NESDIS Global Biomass Burning Emissions Product (GBBEPx) as input to its global aerosol model for predictions and quite pleased with its performance, especially during the intense brush fires in Australia in December 2019 and January 2020. The NWS is also preparing to use Suomi NPP and NOAA-20 AOD data for assimilation into its global and regional models to improve air quality forecasts. The NWS has also expressed interest in non-NOAA satellite data such as Sentinel 5P TROPOMI (Tropospheric Ozone Monitoring Instrument) Carbon Monoxide (CO) and Nitrogen Dioxide (NO2) data along with SNPP CrIS CO to constrain emissions. The aerosols and air quality team tagged up with the atmospheric composition team during the breakout session. There is a significant overlap between the two themes and the participants felt that there should be better coordination between the two teams in the future. The academic researchers using global trace gas and aerosol models have expressed interest in geostationary satellite AOD retrievals from a constellation of satellites for assimilation into models. During the breakout session, there were two presentations by product developers involving applications of legacy GOES satellite AOD product, and some of the outstanding issues such as bias in the current operational GOES-16 AOD retrievals and how the bias is being addressed.

Subsequent to the JPSS-GOES summit, the STAR aerosol team had a meeting with the NWS on data formats and content of AOD output files. For SNPP and NOAA-20 VIIRS AOD, a request has been made to provide pixel level uncertainties in order to facilitate assimilation. The NWS has also requested for the provision of source agnostic AOD files which will create the need on the product developer side to generate tailored gridded AOD data files.

4) Graphics

VIIRS Aerosol Products

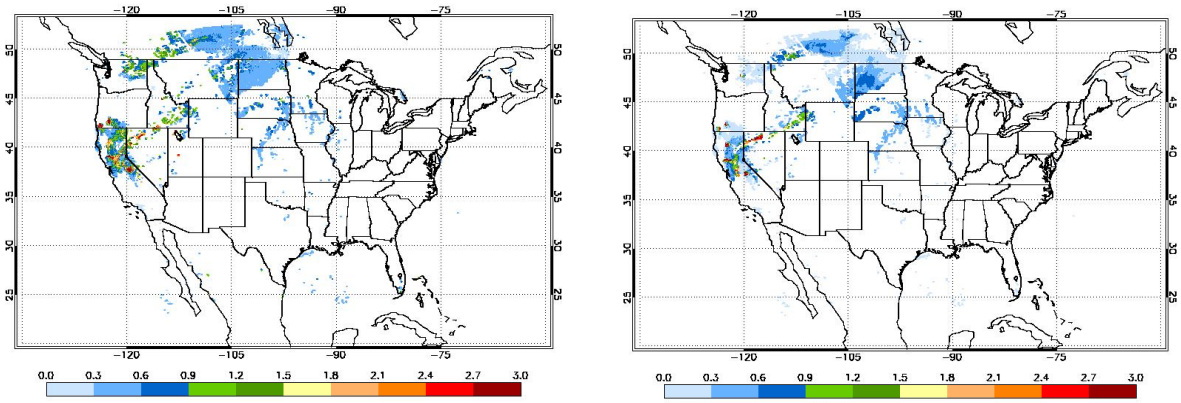


Figure: Comparison of High Resolution Rapid Refresh (HRRR) model forecast (right) with SNPP VIIRS smoke AOD for August 3, 2018 northern California wildfire case

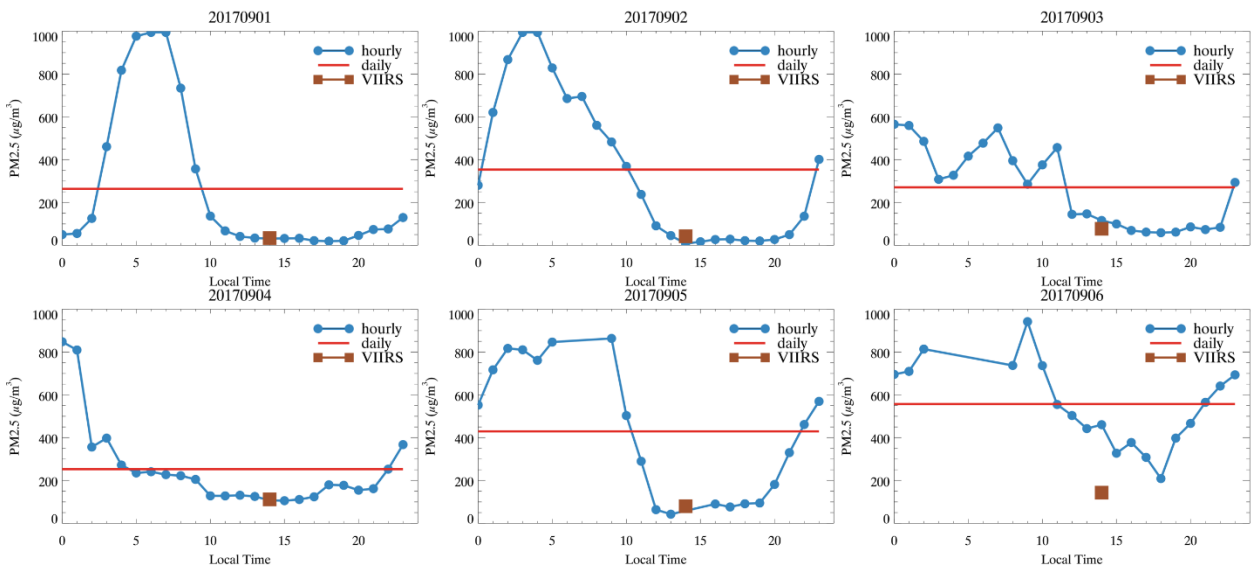


Figure: Diurnal profile of surface PM2.5 at Seely Lake, Montanna from September 1-6, 2017. Strong dirunal variaiton in surface PM2.5. Overlaid on the time series for each day is PM2.5 derived from VIIRS AOD. Satellite estimate agrees well with that one time step but the algorithm predicts daily average (solid red line) which is very different from observation in mid-afternoon. This illustrates the need for diurnal AOD from satellites such as GOES-16

5) Questions/actions

Questions	Answers
Are there plans to assimilate trace gas products (non ozone) such as NO2 in regional and global models?	Yes, the NWS has plans to assimilate NO2 in its global model
What tailored aerosol products are needed (e.g., smoke AOD, dust AOD, gridded AOD etc.) and for what applications?	The NWS is interested in smoke AOD and dust AOD in a gridded format to verity its forecasts
Regarding communication between users and developers, how can the process be improved?	The communication is an ongoing process. The aerosol product developers have to stay in touch with users and have continuous engagement
What is the DA community consensus on data thinning? if data are thinned, what is the need for developers to provide pixel level data for assimilation?	Not discussed
A lot of the aerosol detection is daytime only. What are the plans for night-time detection of, say, smoke plumes?	Ways to identify night time smoke can be looked into. One idea is using VIIRS Day Night Band
How well does GEFS perform against persistence?	Good
When NOAA updates their algorithm (e.g., ABI AOD), do they reprocess the existing data, or just forward process?	This is an ongoing discussion at NOAA. Currently hardware demands for GOES reprocessing are cost prohibitive. In the future, consideration will be given to reprocess but as of now, no reprocessing is ongoing
How do we translate this aerosol work to estimating visibility in smoke and areas of blowing snow or sea spray?	NOAA is not working on deriving visibility from its AOD product. It is not simple or straight forward to do it.
Asian dust storms exacerbated the spread of the avian flu. What can we learn from aerosols about the source and spread of certain infectious diseases?	There is some ongoing work on valley fever and dust in the southwest United States. There is an interest within NESDIS and CDC as well to investigate the use of satellite products to understand the spread of viruses and diseases that they cause

6) Key Challenges for Users/Developers

a) Users

- Timeliness of product availability. Fire emissions are one day old

Satellite team response: more frequent product delivery (six hours?) can be done

- Timely updates of anthropogenic emissions needed

Satellite team response: For NOx emissions use TROPOMI NO2 data for monthly updates?

- Apply common aerosol optical depth algorithms across multiple geostationary satellites

Satellite team response: Agree and is being done

- Apply common fire detection algorithms across multiple geostationary satellites

Satellite team response: Agree and is being done with FY19 Disaster supplemental funding

- Speciation information lacking for aerosol optical depth assimilation and an inability to provide information on aerosol mixtures

Satellite team response: begin utilizing dust and smoke mask and provide feedback

- Provide region specific uncertainties in VIIRS aerosol optical depth or pixel level uncertainties

Satellite team response: Agree and is being considered

b) Developers

- Doing the best we can for the users
  - ✔ Often, as scientist's developers want to meet and deliver user needs but are hindered by bureaucratic hurdles. *E.g., redefining QF structure and making consistent across satellites is being pushed back*
  - ✔ Would be nice to have a mechanism where user and developer work hand-in-hand to check out first if products are meeting needs and then think about operations
    - ❖ PGRR is one such opportunity. Recommend an initiative where concerns of "aerosols and air quality" and "atmospheric composition" are merged to create "aerosols and atmospheric composition" initiative.
- Developing or working on new innovative product developments
  - ✔ E.g., night time smoke detection or day night band applications
  - ✔ Multi-angle retrievals from a constellation of geostationary satellites
  - ✔ Transitioning research products such as particle shape, single scattering albedo, size distribution etc. to operations
  - ✔ Integrating models and measurements for a better solution
- Development of user training sessions
  - ✔ Road shows
- Communication channels
  - ✔ NOAA CLASS needs an overhaul…users cannot download large volumes of data. Frustrated users LEAVE and NEVER COME BACK
  - ✔ A lot of algorithm updates/product changes/instrument anomalies not communicated to users
  - ✔ Dedicated hardware to do our work
  - ✔ Short-term reprocessing (GOES and POES)
  - ✔ Long-term reprocessing

Arctic/Cryosphere

Moderator: Bonnie Reed

Understanding, monitoring and forecasting the Arctic environment is critical for safe and productive use including national security applications. NOAA's Arctic Action Plan includes goals for forecasting sea ice; improving weather and water forecasts and warnings; strengthening foundational science to understand and detect Arctic climate and ecosystem changes; improving stewardship and management of ocean and coastal resources; advancing resilient Arctic communities and economies; and enhancing international and national partnerships. Observing the Arctic is complicated by its remoteness and inaccessibility. Suomi NPP and NOAA-20 provide nearly hourly observations of the Arctic, providing critical information for monitoring, analyzing, and forecasting, in an otherwise data sparse region. Relevant JPSS products include ice age/thickness, ice concentration, ice surface temperature, and snow cover and depth.

1) Session Purpose

The Arctic session brought together three users of satellite data during whose focus area is the Arctic region, and three developers of Arctic focused geophysical products and applications based on satellite data. The users highlighted some of the key challenges they face and how satellite derived products are used in performing their jobs. They also presented items and improvements they'd like to see from the satellite community that may address some of their needs. The developers introduced both recently developed and future satellite products that have the potential to aid ice analysts. A discussion between the two groups and the audience followed, and expanded upon the above topics.

2) Agenda

Presentation	Speaker	Affiliation
Arctic/Cryosphere Product Users		
Alaska Sea Ice Program Operations	Mike Lawson	NWS/ASIP
U.S. National Ice Center: Providing Domain Awareness at High Latitude	Kevin Berberich	US NIC
Arctic Cryosphere Satellite Needs	Carl Dierking	GINA
Arctic/Cryosphere Product Developers		
Role of SAR in Operational Cryospheric Monitoring	Sean Helfrich	STAR
JPSS/GOES-R Snow Products	Peter Romanov	STAR
(More) Ice Products at NESDIS	Jeff Key	STAR

3) Key Takeaways

a) **Users**

i) For the Alaska Sea Ice Program, they are interested in data that help identify (1) Ice Edge, (2) Shorefast Ice, and (3) Old Ice

ii) Higher resolution data in areas that are most important (near events and shoreline) are preferred - the higher resolution the better, but it's a trade-off with data latency and data volume

iii) It would be good to hear more from the modelers and get more involved with sea ice modeling and their use of satellite data

iv) Users are hoping to utilize the "experimental" Ice Motion and Blended Ice Motion products

v) Product demonstrations that JPSS has been conducting is a good way to introduce JPSS level-2 products to the users.

b) Developers

i) Product demonstrations that JPSS has been conducting is a good way to introduce JPSS level-2 products to the users. Should expand to the National Ice Center and other users.

4) Graphics

The Alaska Sea Ice Program produces Ice Concentration (daily) and Ice Stage Analysis (M/W/F) maps shown in Figure 1.

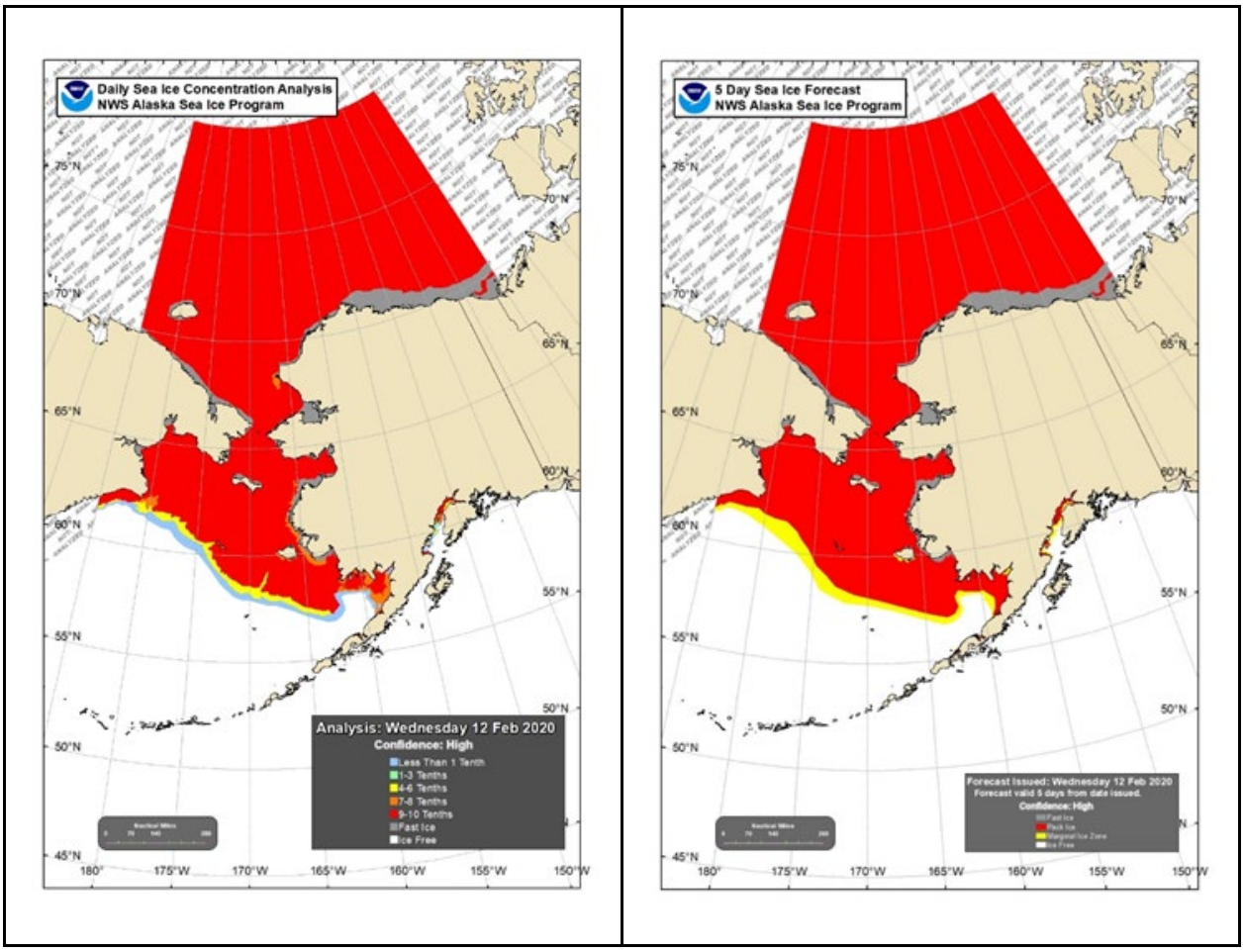


Figure 1. End user Ice Analysis products produced by ASIP (Michael Lawson)

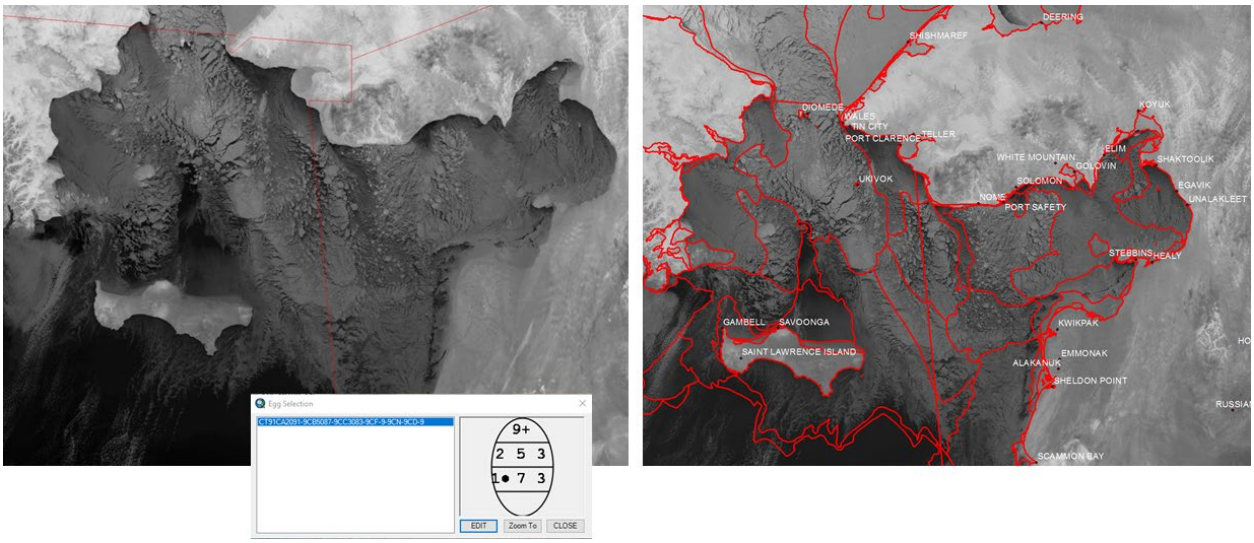


Figure 2. ASIP Initial imagery (left); End goal (right). (Michael Lawson)

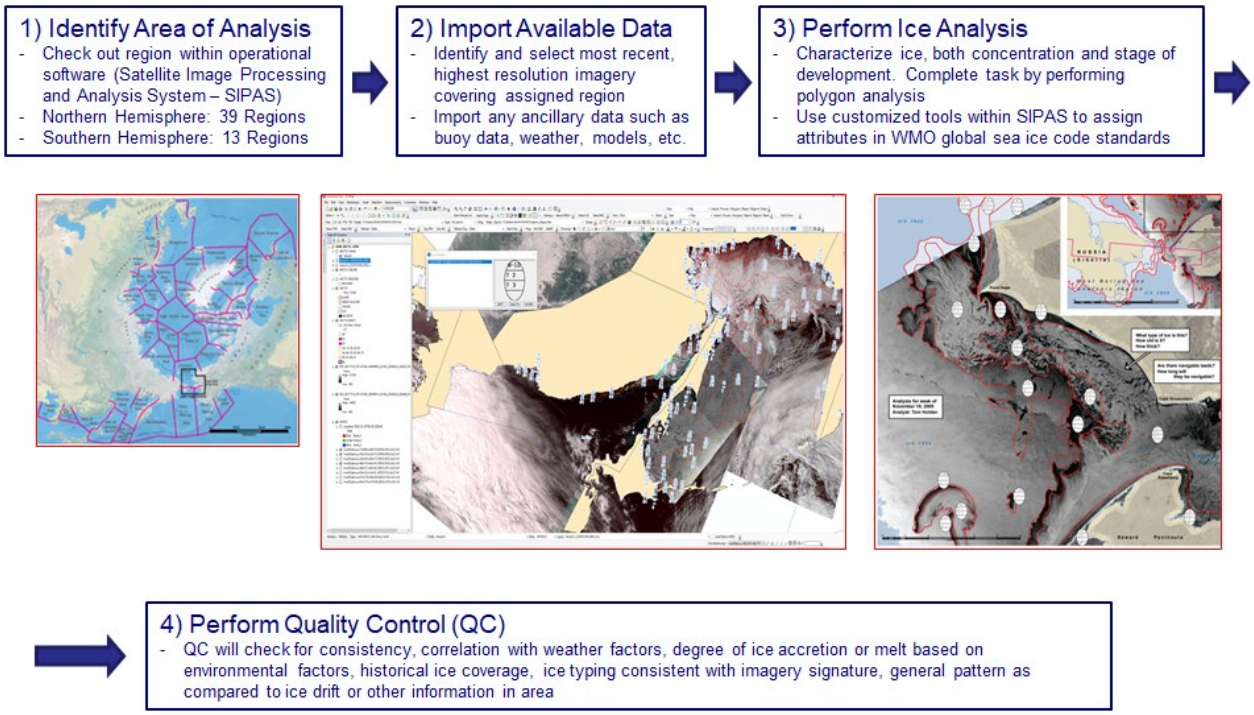


Figure 3. National Ice Center Ice Analysis Process. (Kevin Berberich)

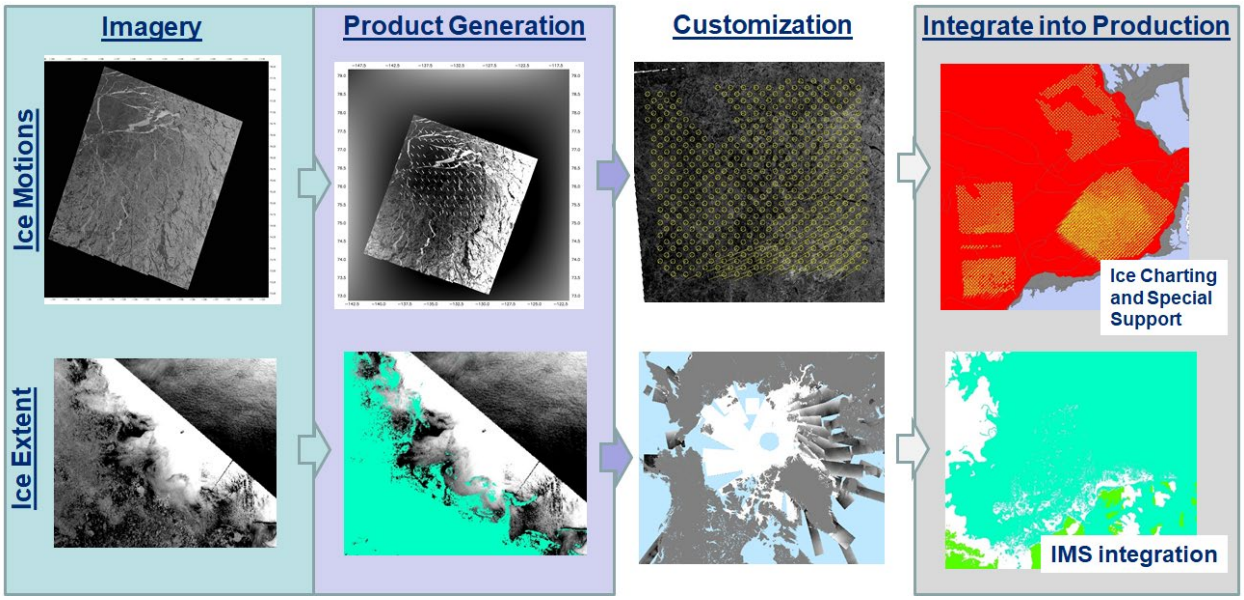


Figure 4. Fit for Purpose SAR Ice Products. (Sean Helfrich)

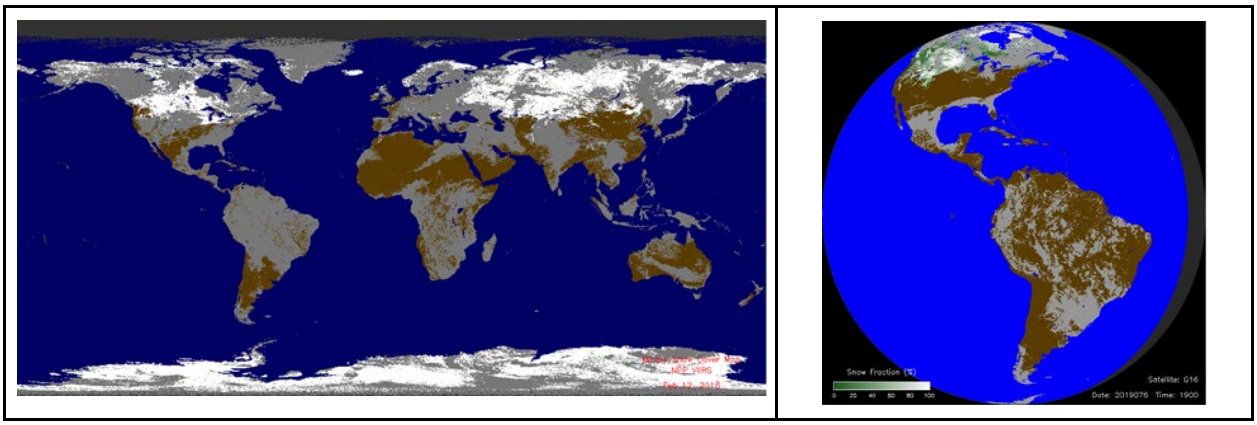


Figure 6. VIIRS Binary Snow Map (left); ABI Snow fraction (right). (Peter Romanov)

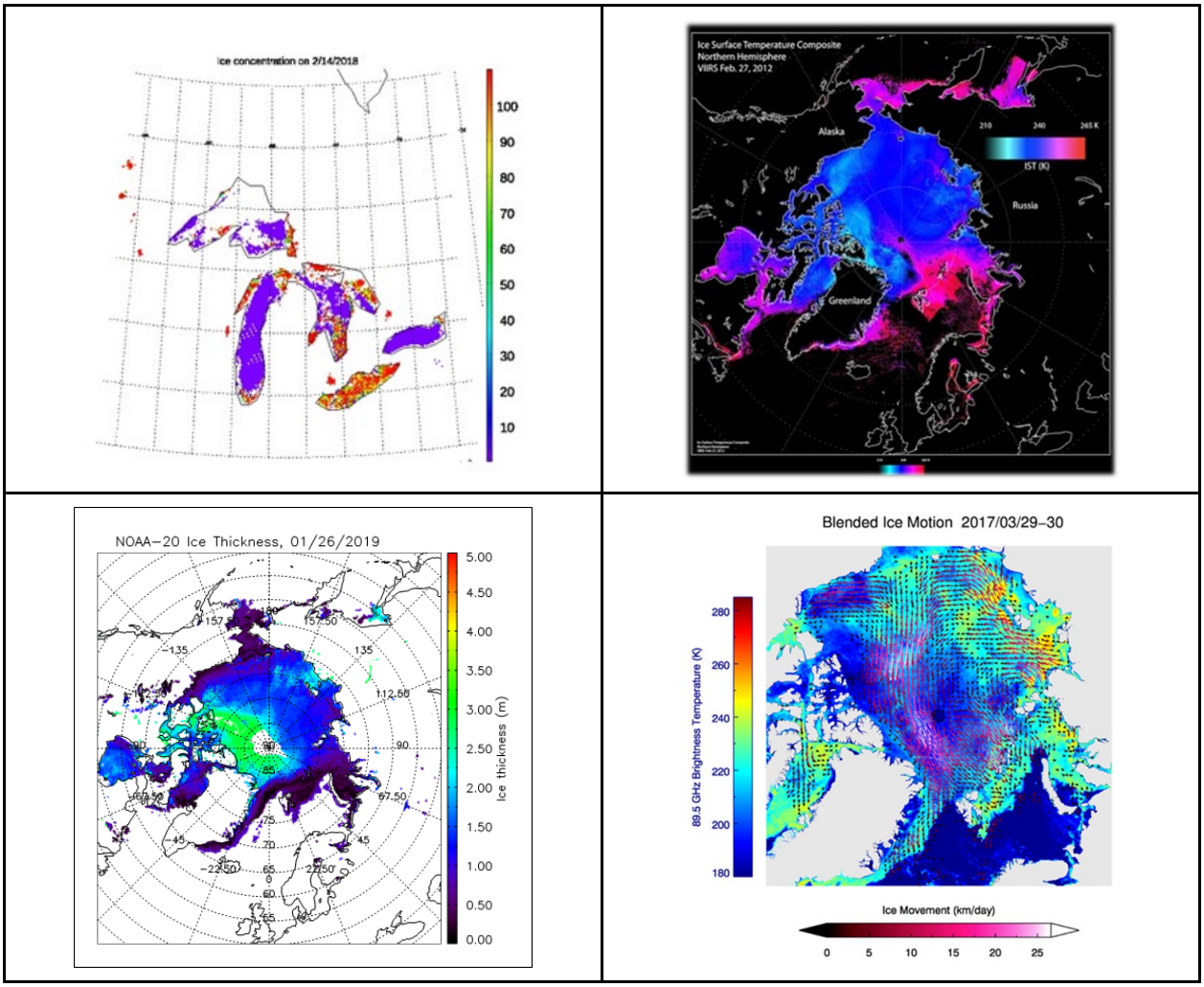


Figure 7. UL: VIIRS Ice Concentration; UL: VIIRS Ice Surface Temperature; LL: VIIRS Ice Thickness; LR: Blended Ice Motion. (Jeff Key)

5) Questions/Answers

Question	Answer
Are any snow or ice products currently assimilated in NWP or other models? Which are used for model verification?	The NIC's IMS product is a daily product that is assimilated into the models. There are two runs – one in the early afternoon and the other in the late afternoon/early evening time. Also, last year NIC was producing the daily product of ice coverage across the Great Lakes. Got a phone from the NWP community (EMC or someone else?) but the lesson learned from this call was that moving forward closer ties with the NWP community are needed. There is some work going on now to utilize ice coverage and station information within NWP models across the Great lakes. In talking with a number of modelers over the years and specifically Bob Grumbine who is with the NCEP EMC to see what products (snow and ice or ice products) he would be interested in. He expressed interest in ice motion, sometime soon but they are not quite ready for it yet. And I think that is the same for other modelling centers concerning ice thickness. Everyone wants ice thickness but they may not be equipped or ready to assimilate it yet. Similarly with Snow Water Equivalent – that's probably the most important snow property – but I think modelers may be using snow cover and sea ice cover but not SWE or sea ice thickness yet. And it's not just that products aren't available but rather that the modelers may not be in a position to assimilate those products yet. Additionally, the JCSDA has a Sea-Ice Ocean and Coupled Assimilation (SOCA) project, which is working with sea ice models and developing assimilation techniques in that arena of sea ice and coupled ocean assimilation. It is in parallel with JEDI. Bob Grumbine and other EMC folks have been involved in this as well.

If SAR data are important -- when can they be expected in AWIPS in forecast offices?	There was an effort to get SAR winds integrated into AWIPS. The code was already developed, but until recently the community didn't know it was there. John Knapp confirmed it was there because he has looked at SAR winds before. It really comes down to one question, "who is ultimately responsible for the handing off of data to make products available in AWIPS?" Having the answer to this can help us ensure that we are creating a NetCD4 compliant product that is available in AWIPS and then we can follow up with customers at testbeds.
What is the best satellite product resolution for ice operations? Is there such a thing as too high of a resolution? What about temporal frequency?	For the NIC, pretty much the highest resolution that we can feasibly get into our network systems without creating a delay to get valuable information out to the users. We need the best resolution possible and have been exploring avenues using commercial data lately. We are bringing in very high resolution data where you can see in meters, where you can see the docks, tributaries. But that's really going to change the type of support we give, too. As we advance in time and the NIC is able to get a hold of these higher res datasets our capabilities and what we can produce to the users is really going to change and allow us to do more tactical scale level support for various reasons. A lot of it comes down to "fit for purpose." If you are looking at a dock or something that requires hi res such as the ice edge, then you need that high resolution data. But if you are looking in the middle of the ice pack, that is not necessarily a place of operations where you have lives at stake, then the resolution can be more generalized, which it should be. Getting the high resolution data into the system can lead to system crashes. Ideally, it's better to have the right product available for the right task.
What is the highest SAR res you can in terms of meters?	There is a tradeoff. You want a wide swatch you have to reduce your pixel size. But that said, systems have gotten so much better over the years where we are seeing regular collections at 40 m pixels. We are now expecting some modes with greater resolution down to 3 pixels. But

	then again you get the 3m pixel, you give up the area coverage. For ASIP, if there is too high of a resolution from an analysis perspective, we will not be spending our time outlining and separating every single flow in the pack. But maybe you do want that kind of detail along the edge. There has been some work with the AWIPS group and bringing in SAR data - there is an AWIPS2 plug in for the SAR winds which has been pushed to all the users. This work has been more on a per request basis, so if there is a forecast office that needs it, let the AWIPS group know and they will work with the people at NCWCP. Additionally, the NWS AWIPS group is working with the NWC and they are going to be providing the AWIPS group with SAR imagery to help address the ice concentration and ice issues in Alaska.
How far polar-ward do you use ABI data? Do you do ice motion products?	For snow retrievals the cut off is 60 to 70 degrees N, and there's approx. an 83-85O zenith viewing angle, that is probably the farthest point that snow retrievals can be done. For Ice motion, there have been some good animations of ice motion in Lake Heron, and the Bering Sea. In a relative sense you can go pretty far up North, but if you are too far above the Arctic circle you are not going to see it. There have been some animations of river ice in Siberia, but really if we are talking about 65-70O you are kind of pushing it. For ABI, GOES East is coming into the National Ice Center. There are also animations which are primarily used on the east coast and the Great Lakes. GOES West is not coming in yet. The NIC uses ice motion products and ice classification but is beginning to apply different ice motion and weather parameters on top of that.
How do users cope with cloud-caused gaps in coverage? To what extent do these gaps	For ASIP and the NIC, this is one of the major problems in our operations where we go through long (sometimes weeks long) periods

limit/complicate the use of VIIRS and ABI products?	where we cannot see due to widespread cloud cover over the ice. During this period we fully rely upon SAR and AMSR2 data. Luckily, between sentinel radarsat we have pretty good data coverage even though that data is usually fairly old by the time we can get to it. In cases where we only have one or two radarsats over our entire area that still leaves a large portion of the area of responsibility uncovered and then we have to rely on AMSR2 which is it gets the job done as far as a real general idea of the ice edge but it's only a 12 km resolution. It's a very broad estimate of where it's at. It doesn't do a great job of depicting concentration.
There were a few mentions this morning about instances of delivering a forecast in an area where you may be lacking some of the data you want. Does your forecast include a confidence level?	For AISP, we have a really broad confidence level on the Daily Analysis product – low, moderate or high depending on the day. This could be improved upon, though.
What hampers a broader use of VIIRS cryosphere products in user applications? Expand question to include any of the NESDIS cryosphere products?	Clouds covering the scene are a big issue. Alaska has the advantage of fairly frequent coverage but frequency can be an issue depending on where you are at. Four-five years ago, the VIIRS files the NIC received were very large. There has been a lot of work to cut the data volume from VIIRS to make them usable in-house. There's a lot of reliance on MODIS at the NIC too, - they would rather bring in a MODIS image over the web rather than multiple VIIRS files. Work can be done to fix this – encourage them to use VIIRS.
Users: What NESDIS snow and ice products are you currently using? If you're not using NESDIS snow/ice products, why not?	The NIC needs to prioritize data access to some of the products. MODIS is getting old, but reliance on it in operations is still there. We need to begin to pivot over to use VIIRS data. We have had three demos of the JPSS ice products with the Alaska Sea Ice Program. Mike Lawson has given us invaluable feedback on these products (Direct Broadcast products), and we need to keep working on it together, and also with the NIC to see that these products get used.

6) **Key Challenges for Users/Developers**
   a) **Users**
      i) Data latency to the Operations floor
      ii) Data formatting/reformatting (from HDF or NetCDF to GIS-ready format)
      iii) File sizes and system lags, and
      iv) Upstream data product quality affecting downstream products

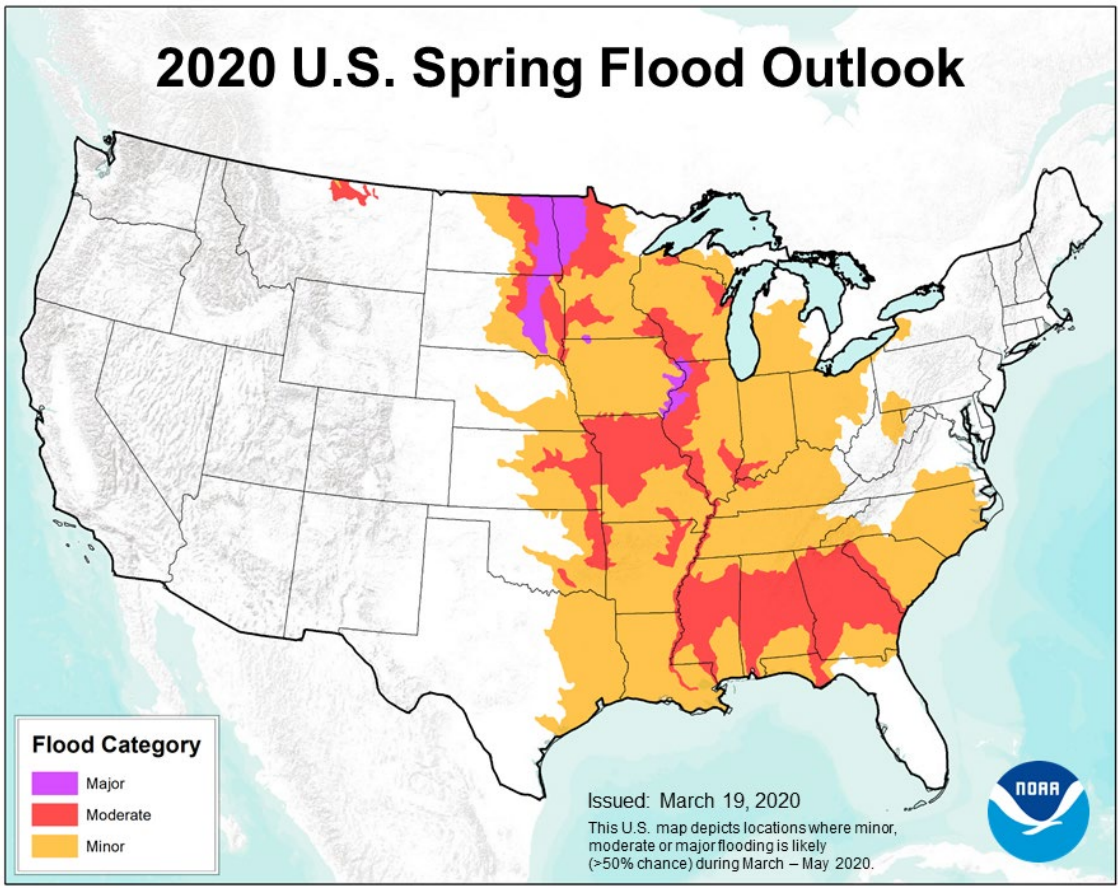
   b) **Developers**
      i) Cloud Masks need to be improved for the high latitudes, particularly in the winter.
      ii) Would like to have more interaction with the modelers to integrate sea ice data into the models.
      iii) Improving snow water equivalent and ice thickness products with only NOAA satellites is an issue. Generating a blended product with in situ and non-NOAA satellites may be necessary.

7) **Ideas for Improving the User Experience**
   a) See "recommendations" section for ideas and recommendations to improve the user experience.

8) **Recommendations**
   a) Incorporate GOES West animation into operations
   b) Incorporate VIIRS Imagery loops near the poles for ice detection
   c) Explore additional satellite derived products for operational value/use
   d) Continue to explore use of automation with operations
   e) Exploit and capitalize on recent ice forecasting modeling
   f) Integrate SAR data into AWIPS
   g) Perform trade off of data volume vs. high resolution imagery

River Ice and Flooding

Moderator: Bill Sjoberg, JPSS



This map depicts the locations where there is a greater than 50-percent chance of major, moderate or minor flooding during the spring period of March through May 2020. (NOAA)

Link to image: https://www.noaa.gov/media-release/us-spring-outlook-forecasts-another-year-of-widespread-river-flooding

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Nearly every day, dangerous flooding occurs somewhere in the United States and widespread flooding is in the forecast for many states in the months ahead.

Ed Clark, director of NOAA's National Water Center in Tuscaloosa, Alabama

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Floods are among the most common hazards in the United States. They are deadly and responsible for billions of dollars in economic losses annually. Rain, snow/ice melt, and ice jams are significant causes of river flooding across regions nationwide. In 2019, the U.S. experienced historically persistent and

destructive flooding across the Missouri, Arkansas, and Mississippi River basins, which resulted in losses of $20.0 billion, nearly half the total cost for all 14 of the billion-dollar disasters (NCEI). In March 2019, flooding – along the Missouri River and North Central parts of the U.S. – triggered by a powerful storm with heavy precipitation that intensified snow melt and flooding – was one of the costliest U.S. inland flooding events on record.

Flood predictions depend on several factors — both above and below ground — including rainfall, soil moisture, vegetation cover, topography, and much more. Weather satellites provide valuable observations, and their imagery is used to monitor both the potential for and the extent of flood events. Polar-orbiting and geostationary weather satellites provide real-time tools for flood detection and mapping using visible, infrared (IR), and composite high-resolution data that are helping forecasters better determine where and when flooding will occur. Together, these satellite datasets and other spatial data (e.g., streams, digital elevation models, roads, etc.) are making it possible to provide detailed flood analyses and forecast tools.

Who are the users of these flood maps and why are these data important to them?

Users	**Roles during a flood**	**Satellite data that are needed during a flood**
NWS/River Forecast Centers	Flood forecasting, investigation and water management	Near-real-time flood extent, river/lake ice cover, flood water surface level, flood water depth
Federal Emergency Management Agency (FEMA)	Flood mitigation, preparedness, response, recovery, education, and references	Near-real-time flood maps
US Army Corps of Engineers (USACE)	Flood investigation, mitigation and water management	Near-real-time flood maps
WMO's International Charter on Disaster	Satellite data/products sharing with disaster management authorities in a country where flood occurs	Near-real-time flood maps
U.S. Agency for International Development (USAID) and U.S. Department of Agriculture (USDA)	Flood mitigation and loss assessment	Near-real-time flood maps
Model developers and researchers	Model validation etc.	Flood extent datasets

1) Session Purpose

Provide summit participants information on how key users apply satellite capabilities operationally for a variety of different mission requirements. The focus is not only on the first order users, such as those in the NWS River Forecast Centers, but on those users they support, such as FEMA. The goal was to help the developers understand not only the final operational applications but the intermediate steps that the users take to prepare their decisionmaking systems to receive, evaluate, and use satellite capabilities. Users were also asked to identify future needs that weren't being met. George Mason University (GMU) and the Community College of New York (CCNY) developers were to provide the status of their current efforts and how they plan to prepare to respond to future requirements. The objective was to identify what additional data and products will be needed and an evaluation of whether the current initiative path will help meet those needs. All this in preparation for the 2020 JPSS Call for Proposals.

2) Agenda

Presentation	Speaker	Affiliation
Science, Technology, and Data Applications for Disaster Operations	Adam Barker	FEMA Response Geospatial Office
Proving Ground Summit Presentation	Eric Holloway	NWS Emergency Services Branch, Alaska Region
National Water Center Integrating Model and Remote Sensing Data for a Complete Hydrology	Shawn Carter	NOAA National Water Center
AmeriGEO Earth Observations for the Americas	Angelina Gutteriez	International Projects - Lead Hydrologist - NOAA - office of Water Prediction
An Overview of the current GEO-LEO Flood Products and Future Development	Sanmei Li	George Mason University
Operational River ice monitoring and forecasting over the US and the Globe using SNPP and NOAA-20 VIIRS data	Naira Chaouch	Community College of NY

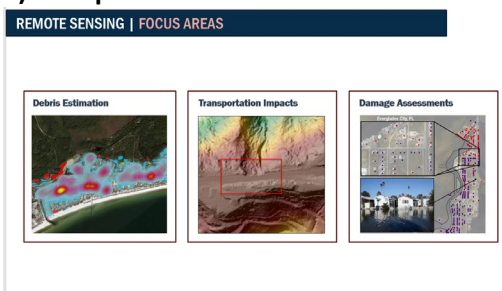
3) Key Takeaways

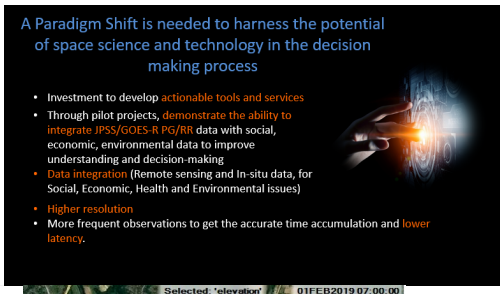
a) Users
   i) Understanding the disaster lifecycle is important to determining what type of data would have the greatest impact in each phase of the lifecycle.
   ii) The responsiveness of the developers has been critical to tailoring the flood and ice products for operational needs. In 2015 Sag river over ice flooding had a huge impact on truck movement on the Dalton Highway. The flood product was successfully tailored for this event. This application had not been anticipated early in the project.
   iii) The VIIRS Flood product is a "work horse" for the APRFC and has been used in a variety of flooding events year-round.
   iv) NWC is looking at how its stakeholders can use the forecasts from the National Water Model in their decision making.
   v) International countries are learning about River Flood Products and are interested in putting them to use. GEOGLoWS website is an effective tool to making these flood products available.

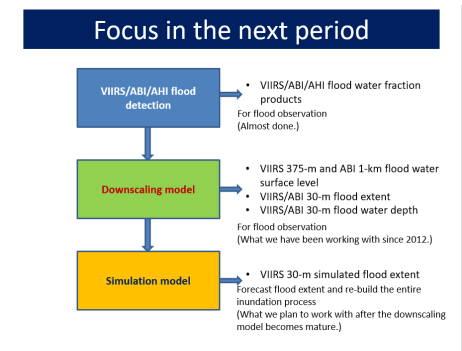
b) Developers

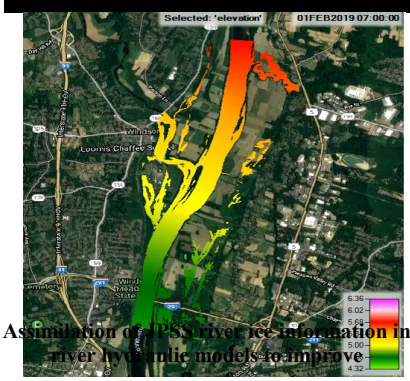
i) Direct collaboration with NWS RFCs has been vital in guiding their decisions on what changes in product algorithms will provide the most useful results.
ii) GMU has successfully provided flood products in response to global flooding events when the International Charter is activated. Foreign decisionmakers have used these products in their own systems to aid in their response to these disasters.
iii) Developers recognize the increased interest by users of SAR data due to the success of the Sentinel-series satellites. But users need to understand the pros and cons of using SAR data.

4) Graphics









Assimilation of JPSS river ice information in river hydraulic models to improve

5) Questions/Answers

Questions	Answers
NWS WFOs do not have the Flood/Ice products either and they should. Since they are briefing and working with individual emergency managers.	The River Flood product is going through the SPSRB Process to make it available to the baseline AWIPS system. In the meantime any River Forecast Center or WFO can get access through their LDM, contact Jay Hoffman (jay.hoffman@ssec.wisc.edu)for help to get the products into AWIPS-II.
During a flood event how much coverage will sentinel 1 provide over an area of interest.	Nominally, Sentinel-1 images a 250km swath. In reality, the swath and orbit dynamics can absolutely make or break our ability to leverage Sentinel-1. For example, over the Missouri River last year, the edge of the scene captured about half of the river's meanders downstream of Omaha and was not very

	useful. As with any earth observation system with multi-day temporal resolution, your area of interest can be missed by days – worst is when the area you need is right next to the current day's swath.
How does NOAA coordinate its GEO activities? My experience is that the engagement of satellite subject matter experts is rather ad hoc....	The JPSS Program has established a Satellite Disaster Coordinator to help coordinate satellite capability responses to weather disasters.
What is the time period for the VIIRS flood map archive? The ABI/AHI archive?	George Mason started archiving VIIRS/ABI/AHI flood products in Oct. 2019. Website: https://jpssflood.gmu.edu
What is the general process to validate flood inundation mapping from algorithm developers and operational users?	The algorithm developers develop the products, and do algorithm performance tests with VIIRS/ABI natural color images, and then deliver the products to the operational users, and operational users use the aerial photos, river gauge observations and flood products from other sources such as SAR image, Landsat images, hydraulic models to validate the results, and then send feedbacks to the developers for further improvements on the algorithms. We have done this way for more than five years with RFCs.
Does the flooding community have a requirement for the goes visible Green imager channel?	The George Mason team uses GOES-16/ABI visible channel (red, centering at 650nm) for flood detection. GOES-16/ABI natural color images are quite attractive in the flooding community, but aren't currently used for flood mapping
What is the role of National Water Center in providing IDSS? How do you support RFCs?	The NWC doesn't provide IDSS, we support the field offices in providing IDSS. Whether that is through text, data analysis, context, or coordination between RFC/Regions for large events

6) Key Challenges for Users/Developers

a) Users

i) FEMA - identified three top challenges (debris estimation, transportation impact, damage assessment). An example is that modeling and imagery is needed for damage assessment. Work with FEMA to determine where satellite capabilities can be of most help.

ii) Alaska

(1) Cloud cover often inhibits the receipt of River Ice and Flood products when they are needed most. The use of SAR data helps mitigate the effect of clouds but the imagery is not available frequently enough.
(2) Some flooding and ice-covered rivers are not wide enough for satellite imagery to pick up.
(3) Thinning ice on rivers is going to be an annual challenge in order for indigenous people to travel safely on these rivers. Look for ways to engage local leaders in using River Ice Products to help communities respond to unsafe ice conditions to help save live.

iii) Some River Forecast Centers are inconsistent in their use of River Ice and Flood products.

b) Developers

i) The cloud cover algorithms used in the River Flood and Ice products are different so the products are not consistently available.
ii) The River Ice Product is occasionally inconsistent on how it shows the amount of ice on rivers. Could be caused by clouds, snow along the river's edge, or other things.
iii) Getting the River Flood and Ice Products to the users fast enough and in a format that they can take life-saving action. Leverage the success in the APRFC and NCRFC in other River Forecast Centers.

7) Ideas for Improving the User Experience

a) Establish and maintain communications with the National Water Center to assist in their use of the River Ice and Flood Products.
b) Look for opportunities to encourage users to access the River Flood website during times of potential flooding in their areas.
c) Establish a process to systematically engage the NWS River Forecast Centers to show the value of the River Ice and Flood Products.
d) Continue to pursue getting the River Flood Product into the NWS AWIPS system. Determine which of the River Ice Products would be made available in AWIPS.

8) Recommendations

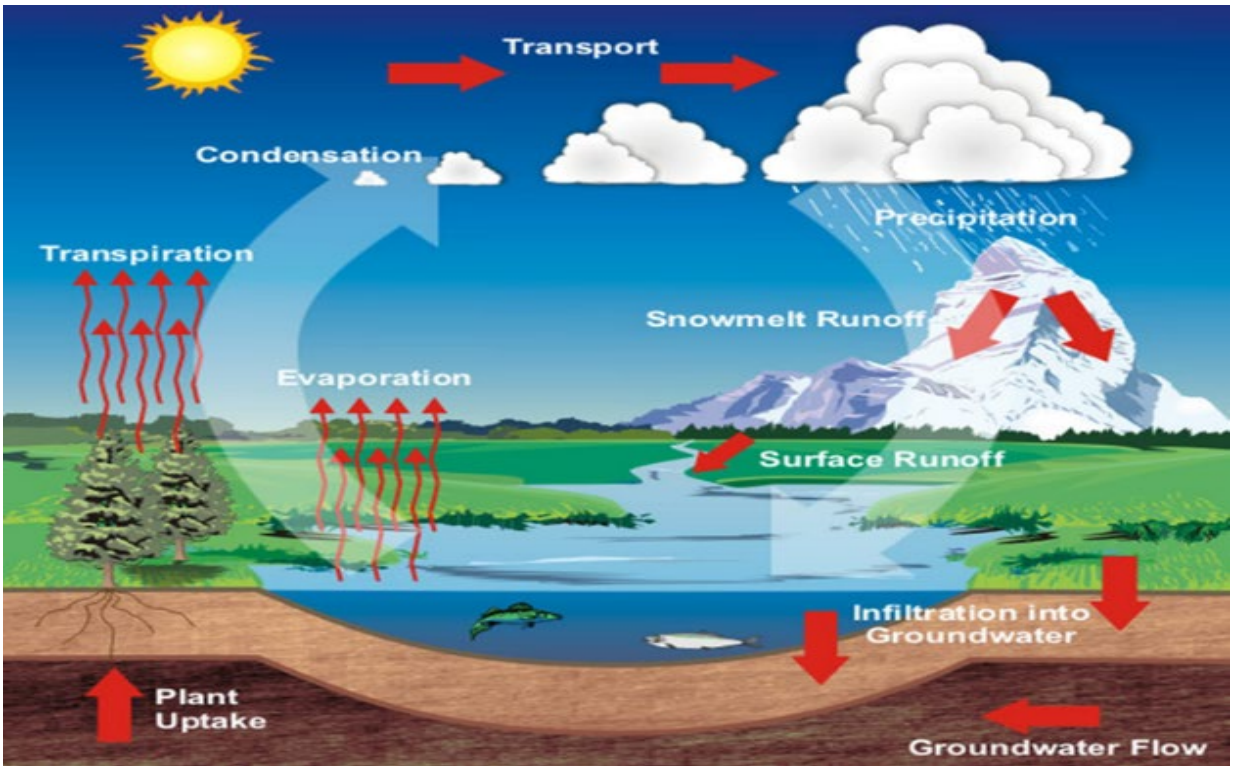
a) NWS River Forecast Centers. The APRFC and NCRFC have been the primary advocates of the River Ice and Flood Products. At least four other RFCs have been periodic users of these products. Look for ways to involve other RFCs to use the River Ice and Flooding products operationally and keep collaborating to increase the value of the products. s.
b) National Water Center - The River Ice and Flooding Initiative work with NWC to look for ways to transform information into actionable intelligence by linking hydrologic, infrastructural, economic, demographic, environmental, and political data. Determine where satellite capabilities fit in.
c) Determine how the River Ice and Flood products can be used as initial state conditions for the National Water Model and other hydrologic models.
d) Continue work on the how best to leverage SAR data in the blended GEO/LEO flood products. Determine how SAR products can be used in partnership with other satellite ice products.
e) Building on the initial GEOGLoWS success to increase international access to satellite flood products. Determine how GEOGLoWS can be used for River Ice Products. Examples of what could be considered:
   i) Investment to develop actionable tools and services
   ii) Through pilot projects, demonstrate the ability to integrate JPSS/GOES-R PG/RR data with social, economic, environmental data to improve understanding and decision-making

iii) Data integration (Remote sensing and In-situ data, for Social, Economic, Health and Environmental issues)
iv) Higher resolution
v) More frequent observations to get the accurate time accumulation and lower latency.

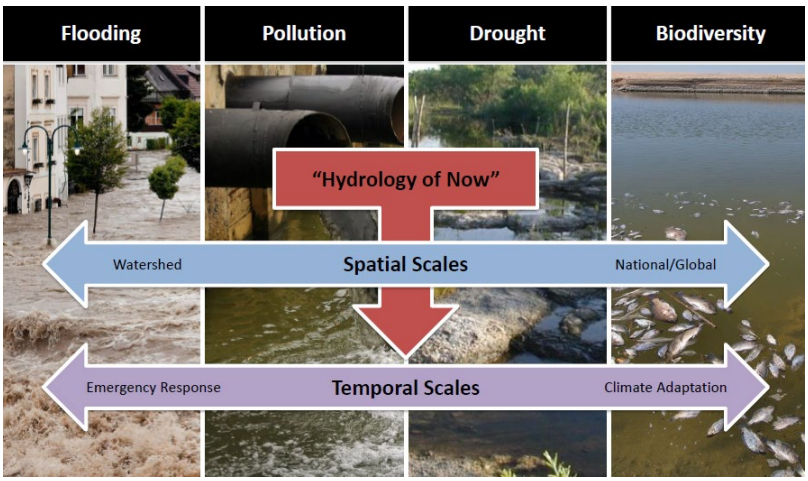
f) Future work for River Ice Product.
   i) Improvement of the retrieval over narrow rivers especially in the presence of snow on ground
   ii) Text\email alert to be generated automatically using change detection of ice condition around certain points of interest
   iii) Improvement of the consistency of the product by controlling the temporal variability of River ice concentration
   iv) Improvement of the cloud and cloud shadow determination and its impact on river ice retrieval: current version is using CLAVRX and IICMO cloud data. VICMO cloud product shows better cloud classification.
   v) Expansion of the ice product coverage toward global river ice mapping system
   vi) Investigate the potential of using DNB for river ice detection

Hydrology

Moderator: Ralph Ferraro, STAR



The hydrologic cycle, illustrated above, is the key part of extreme events such as drought and floods. Its importance is underscored in NOAA's mission areas and in the work carried out by its Line Offices to generate products and services at the national, regional and local levels to support the needs of diverse stakeholders across the United States. Moreover there is a growing demand for NOAA to provide consistent, high space- and time-resolution, integrated water analyses, predictions, and data to address critical unmet information and service gaps related to floods, droughts, water quality, water availability, and climate change.



Satellites from the vantage point of space enable views of the hydrologic cycle on a global scale. Their observations provide a wide range of products – including rainfall, snowfall rate, precipitable water (total, critical layers), soil moisture and water vapor – that span the cycle, and are vital for a wide range of applications including situational awareness and prediction at times scales ranging from nowcasting to seasonal/inter-annual forecasting.

1) Session Purpose

The purpose of the Hydrology Session was to provide a summary of the current uses of satellite products centered on precipitation and layered/total column water vapor, and summarize the current status/future challenges of the algorithm developers. (Note that other products related to hydrology like soil moisture, flooding/inundation and snow water equivalent were covered within other sessions). The users that presented provided a full range of temporal and spatial domains, spanning local and national forecast centers, as well as climate. Requirements for each of these forecast challenges can be similar but also different, thus it was important to have representatives from each of these user groups. The developers covered topics related to both low earth orbiting satellites (including JPSS) and geostationary orbiting satellites (primarily GOES-R series), and summarized both operational and emerging research products. Through the use of the interactive panel discussion, it was hoped that a general consensus of the needs of the users and the feasibility of improving products to meet them would be converged upon, and also help the Hydrology Initiative prepare for the 2020 JPSS Call for Proposals.

2) Agenda

Presentation	Speaker	Affiliation
WFO Perspective on JPSS/GOES-R Products for use in Hydrology	Aaron Jacobs	NWSFO, Juneau, AK
JPSS/GOES-R Series Data Integration into WPC Operations	Andrew Orrison	NWS/NCEP/WPC
Climate Applications for JPSS Hydrometeorology Products	Pingping Xie	NWS/NCEP/CPC
Developer Perspective on GOES-R ABI Rain Rates	Bob Kuligowski	NESDIS/STAR
LEO Level 2 and 3 Products	Ralph Ferraro	NESDIS/STAR
Blended, Multisensor Hydrometeorology Products for Forecasters	John Forsythe	Colorado State University/CIRA

3) Key Takeaways

a) **Users**

i) Users ranging from NWSFO's to National Centers rely on satellite derived products of precipitation and water vapor (and others not necessarily within our panel - imagery, soil moisture, snow water equivalent, lightning, SST, NDVI) to help fulfill their NOAA mission goals

ii) There is not a single product solution to meet their needs, as many of the existing and developmental products collectively help them with their forecasting needs

iii) The products are most useful in regions where in-situ data is lacking or unreliable, such as oceans and remote land regions (e.g., Alaska).

iv) Ocean precipitation is of interest to show a forecaster whether a NWP initialized well and the magnitudes/amounts that are moving onshore.

v) Specific applications include:

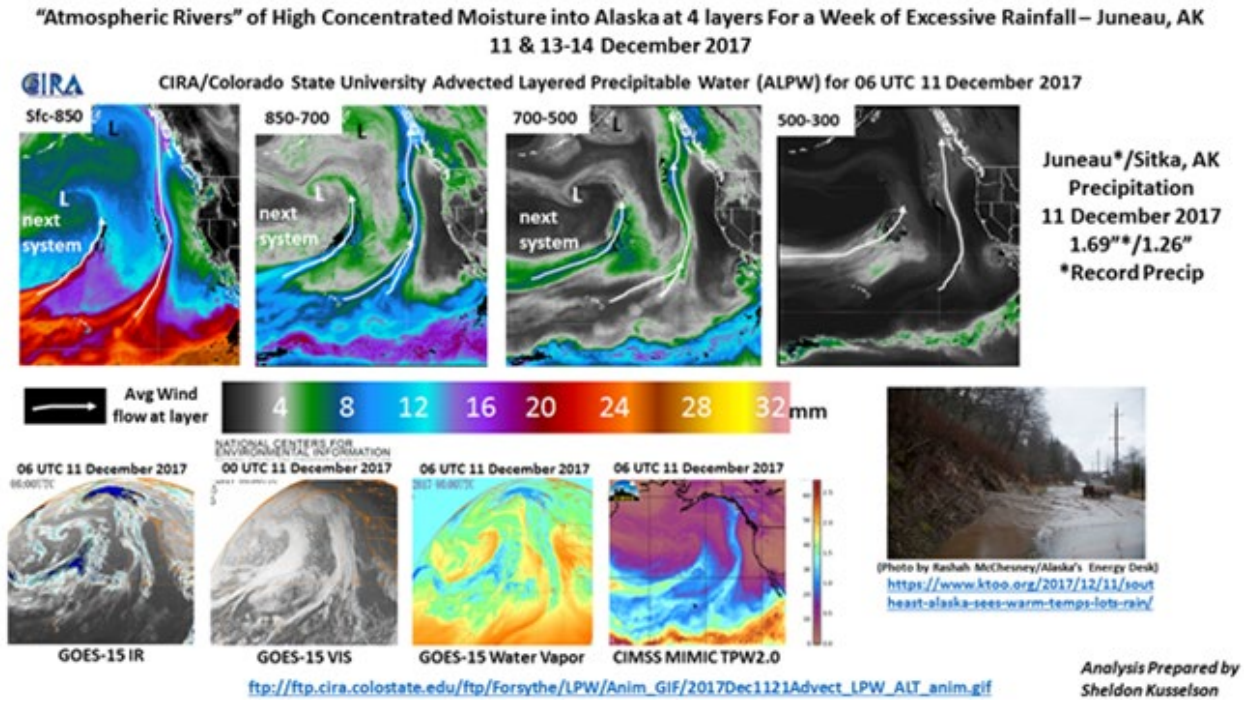
- QPF, QPE
- Magnitude of Atmospheric Rivers
- Global climate monitoring (and a need for long term, consistent time series)

b) Developers

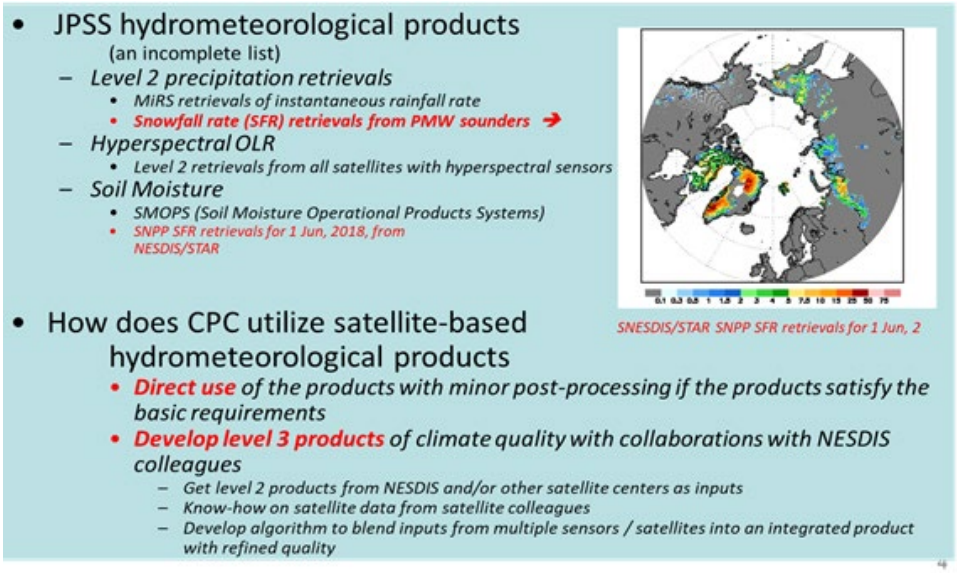
i) Developers work with a wide variety of measurements and try to fulfill the broad range of user needs ranging from “weather” to “climate”

ii) Developers are burdened with instrument mitigation activities, post-launch check out, mandated system freezes, etc. which impedes tackling difficult retrieval issues that many users are requesting

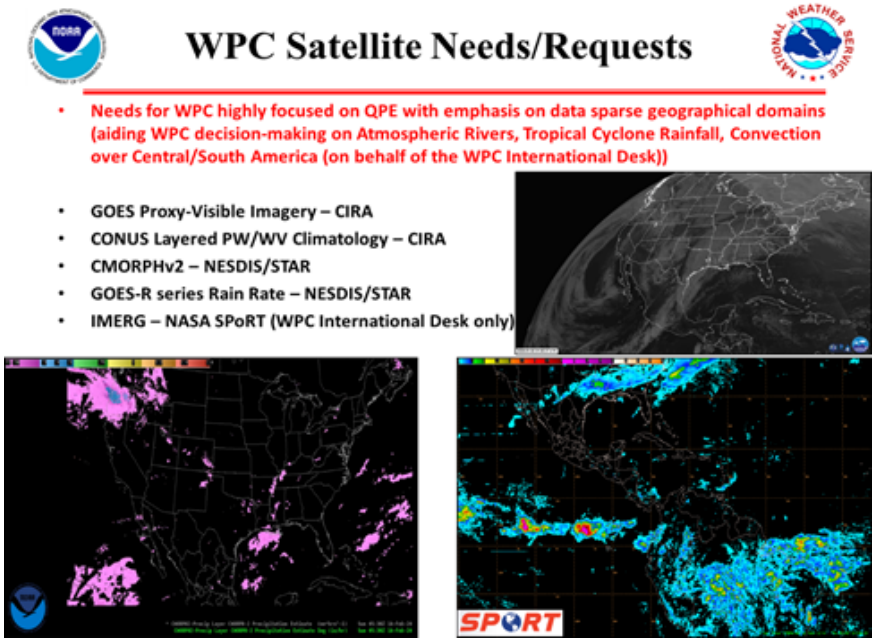
4) Graphics



Caption - An example of use of satellite water vapor products and imagery to monitor an atmospheric river event that impacted coastal Alaska in December 2017. Credit - Sheldon Kusselson, CIRA



Caption - A summary of how JPSS hydrometeorological products are used by NCEP/CPC. Credit - Pingping Xie, NWS/NCEP/CPC.



Caption - A summary of satellite needs at NCEP/Weather Prediction Center (WPC). Credit - Andrew Orrison, NWS/NCEP/WPC.

5) Questions/Answers

Question	Answer
What is more important to users: the quantitative value of a parameter or its deviation from normal? For example, TPW or % TPW of normal?	Forecasters need both products. One to see how much TPW is available in the atmosphere and then put that amount into a climate context to see how anomalous the event for that time of year. One value for one season may not be as anomalous if you saw the same values in another season (dry/wet). Raw TPW values alone can be quite important, as greater TPW values imply more warmth through the column. TPWs that exceed 2 inches for example imply a tropical airmass with high wet-bulb zero levels that are excellent for generating highly efficient rainfall rates when dealing with convection.
How is the malfunction of the G17 ABI LHP impacting rainfall rate estimates?	It is a real challenge, especially since the brightness temperature differences (BTDs) that the algorithm heavily relies on are much noisier than the individual bands because the absolute values are much smaller. The current operational version has significant issues with noisy / false / missed precip when the GOES-17 ABI heats up. By the end of 2020 (hopefully) the updated version of the algorithm that compensates for this by using only band 14 for GOES-17 (only) will be disseminated. It will have less skill than it would have if it used the full set of IR bands and if GOES-17 was in perfect working order, but it should be useful guidance. But for locations where GOES-16 and -17 are both options, I would recommend using GOES-16.
Parallax shifts of G17 precip. Is there a way to ship both parallax shifted and non? (I ask wondering about overlaying estimates on top of ABI imagery)	That's a great idea, but given data bandwidth issues I think it's going to be a very hard sell to try to pass on two separate fields without and with parallax adjustment.
How important are rainfall estimates over the ocean, away from islands/land? If it rains and no one sees it, did it really rain? How do you verify over ocean?	Rainfall estimates over water is very important when a weather system is originating over the ocean. This helps the forecaster initialize the model output when there is no ground truth also rainfall estimates over water provides information about the intensity of the rates and amounts that will affect communities as that band moves over land. NASA has historically flown and is flying active radars (TRMM, GPM-CORE) which provide validation over ocean. Having information of rainfall over the oceans that will be approaching land is highly valuable to suite of QPF and MPD products (and related messaging) that WPC produces. This is especially the case for West Coast atmospheric rivers

	and any tropical cyclone that is expected to impact land.
Does the new GOES rainrate improve the overestimate from cirrus clouds and under estimate for the low (warm) clouds that produce rain?	It does; the detection of rain from warm clouds is especially improved for the Enterprise version vs. the current operational version.
Why does WPC do not cover Alaska for atmospheric rivers in their discussions?	WPC may at some point in the future be in a position to do MPDs for Alaska that would account for atmospheric river impacts. They are definitely a major driver of the total water budget for the southern portions of the state. The simple answer is that WPC is resource constrained for OCONUS support, but additional discussions should be had at the management level to pursue this national center support function.
Andrew Orrison, from WPC, what *unique* and useful information does NUCAPS provide forecasters at WPC?	NUCAPS has the ability to provide reasonably good information on mid/upper level instability/moisture profiles that can be compared to model guidance when there is a pass of opportunity. NUCAPS can provide information on the degree of rainfall efficiency that may be in place with a heavy QPF event. By seeing the layers of enhanced moisture, and coupled with the thermal profiles, one can deduce whether rainfall rates may be particularly enhanced (i.e. via warm rain processes) or via transport alone. NUCAPS is actually quite useful in picking up eastern tropical Pacific moisture transport plumes that can drive significant rainfall across especially the southern U.S.
Why are there several products for the same climate variables? Is there a way to combine all products and give one best product to the user?	Having many products is normal, and desirable, in the climate research community. It gives an idea of the error range for a parameter. The signal in a climate record may be very low, e.g. unmasking temperature trends against a backdrop of sensor changes, instrument noise, diurnal sampling changes, and algorithm changes. The best product for a user depends on how much signal is available for the desired variable. Something with large signal (e.g. heavy precipitation occurrence) is not as affected by choice of a climate data set.

What is the interest in generating uncertainty products especially for precipitation?	The challenge is that uncertainty at a point doesn't translate readily into uncertainty on a spatial map--an entire grid of 75th percentile rain rate estimates wouldn't be physically realistic because all of the grid points aren't going to wind up at the same place in probability space; there's some degree of independence among them so any physically realistic solution will have some grid points at the low end of the probability distribution and some points at the high end with some degree of spatial coherence. I think the interest would be there, but the extension of probabilities to two or three dimensions would be a challenge.
Can you integrate GPM (when available) with GOES-R ABI to produce and/or Validate/Verify GOES-R only rain rate product?	We regularly validate the GOES-R rain rate product against GPM DPR to give an idea of how it's performing outside the CONUS. However, it's not possible to include any GPM data directly in the GOES-R ABI rain rate retrievals because of the 266-second latency requirement.
Do RFCs, WFOs, or WPC in the CONUS use the GOES-R QPE product? RFCs produce a QC'd QPE product each day.	The biggest interest in satellite QPE for the CONUS is in the coastal regions or (in the case of WGRFC) basins that have a significant OCONUS component like the Rio Grande. I don't know exactly how widespread its use is. Note: In WPC, the GOES-R QPE product is currently not available in AWIPS, but the interest in satellite QPE is quite strong as it relates to assessing atmospheric river events and tropical cyclones in near real-time that will be impacting the U.S. There is an operational usage for satellite QPE that is independent of multi-day QPE products that can be used for verification.
What’s the path forward to making reprocessed data sets available, particularly for climate applications?	NASA has this concept of "missions to measurements". Typically, projects are only supported for a sensor or satellite series, and sensor lifetime (even outstanding performance like MODIS or some SSM/I, TRMM with 20 year function) falls short of the record length we might like for climate. Multisensor, blended data sets with sensors from different agencies / countries need to be supported, with a focus on the geophysical variable sought and funding not tied to a particular sensor.
To Dev/Users: Any practical tips on engaging field forecasters and other users given the demands on their time and the overload of information / products?	For the ALPW product, getting the data into AWIPS-2 and serving it to National Centers / WFO's with an interest is key. Just putting things on the web doesn't work as well. I would add the human element, there needs to be a developer on the "push" side and a recipient on the "pull" side. The JPSS Satellite Liaison

	concept has a role here. It takes hard work as many issues aren't scientific but IT-related. Developing training (e.g. the NOAA VISIT) program is also key.
How is the CIRA ALPW product being transitioned to operations? Through NESDIS?	This is in the SPSRB review stage, a formal project has not yet started. It will run on the existing Blended TPW / Rain Rate infrastructure at OSPO. I'd say sometime later in 2021 if the process continues. In the meantime CIRA distributes to a select group (WPC, NHC, ~25 WFO's) via existing LDM methods. Being at a cooperative institute with federal employees with permission to push the data is key.
Does the footprint of the DB Antenna in Fairbanks extend far enough south to give Juneau good coverage?	The DB in Fairbanks supports Juneau WFO along with other WFOs in Alaska by GINA passing along all the data they get from the DB to Alaska regional office which then sends the satellite imagery to all WFO offices in Alaska region.
To users: For what products does the model do best / worst? Does the answer depend on whether over CONUS or over the open ocean?	This really depends on the model variable of interest and also the season, but the geographical domains can be important too since land masses (especially complex ones) and open ocean domains are capable of driving feedbacks in the model.
How important are satellite-only products for analysis and forecasting? Is the model quality comparable to the satellite products?	Satellite-only products are very important as they provide information when there is no ground truth. They can be used to inform the forecaster of the strength of the system, where it could be precipitating and this all goes into analyzing model data to see how the model is handling the feature. The model quality depends on the specific system as models do better at times and then worse at time. So having that satellite data is critical for forecasters to gain confidence in the model output that they need to make a forecast into the future. It is difficult for developers to see what satellite data a model considered / assimilated in NRT, better metadata on that could be useful for developers to understand differences between model and satellite products. Something in a time/geolocated format needed, not a web graphic.

How can the ALPW be fused with GOES-R TPW? Can a fused product be created for an hourly cadence?	ALPW is produced hourly now from all microwave data. GOES-R could provide some extra detail, especially above 500 mb, would have to be explored. See Schmidt et al. 2019 (Earth and Space Sciences) for validation of GOES upper trop moisture. GOES-R has 3 atmospheric layers of lpw. But merging IR and visible retrievals opens the door to artifacts (cloud edges), and GOES-16 uses GFS in its water vapor solution which the microwave data does not. Foy synoptic use just microwave might be preferable, but for mesoscale the high time resolution of GOES-R could be a plus. Similar comparisons are ongoing with TPW, to develop the next version. I think this idea should be explored further. NOTE: WPC is currently loading and operationally using a Merged TPW product that incorporates GOES-R TPW along with MW retrievals.

6) Key Challenges for Users/Developers

a) Users

i) Improved data latency
ii) Improved spatial resolution of some products
iii) Data delivery – timeliness of implementation, AWIPS system restrictions
iv) Staying abreast of latest product changes and performance characteristics
v) Inhomogeneous level 2 satellite product time series

b) Developers

i) Inhibited by sensor mitigation and post-launch check out activities which delays/limits product advancements to satisfy user needs
ii) Inhibited by the R20 process and often work "back door" solutions to provide users with improvements in a reasonable amount of time by exploiting alternative ways of distributing products. This can often lead to user confusion.
iii) Lack of dedicated resources for L2 product reprocessing after L1 and algorithm improvements are developed
iv) Specific retrieval areas: Orographic precipitation, Regional retrieval algorithms, Multisensor, multi-spectral approaches

7) Ideas for Improving the User Experience

a) Develop a more efficient way to fully connect users, developers, trainers and system implementers
   i) Within NESDIS, there are inconsistencies on how this is done because we have different 'paths' based on the origin of a product
   ii) Within NOAA, we have inconsistencies on how line office users (e.g., NWS, NOS, etc.), and even within a LO (e.g., NWSFO or NCEP, etc.) are engaged with developers and trainers
b) There are typically several versions of climate products to capture uncertainty. This is normal in climate research but can be confusing / unworkable for forecasters. This is an example of where training can help, to know which one to use.

8) Recommendations

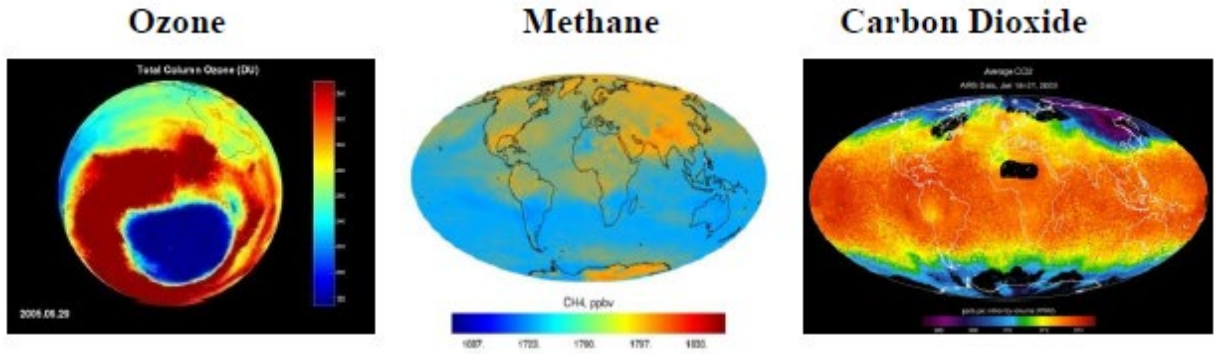
a) Develop a more robust procedure to fully connect users, developers, trainers and system implementers that goes beyond a set of requirements on a list. There are too many duplication

of efforts and inconsistencies within the current paradigm. Exploit the Hydrology Initiative to facilitate this new path forward.

b) Exploit emerging computing resources such as cloud computing to optimize and expedite the development of AWIPS applications that can serve all NWS regions and proving grounds.
c) Develop level 2 homogeneous satellite product time series to improve current product baselines (e.g., TPW percent of normal, soil moisture percent of normal, etc.) and to allow for level 3 product developers (e.g., CMORPH2, SMOPS, etc.) to develop improved time series
d) Resources are needed to ensure that product developers and operational providers can have the manpower to continue to enhance and implement current product lines during periods of post-launch check out and mitigating sensor issues
e) The upcoming JPSS PGRR call for proposal should encourage R&D focusing on enterprise solutions to hydrologic products, improving products in historically challenging retrieval problems (e.g., orography, warm top precipitation, retrievals in complex terrain and land/water boundaries, etc.).
f) The development of an integrated vapor transport product is critical for the monitoring and prediction of atmospheric rivers

Atmospheric Composition

Moderator: Monika Kopacz



As already mentioned in the Aerosol and Air Quality session, air pollution is a global and domestic issue. In addition to aerosols, all types of trace gases are either greenhouse gases, air pollutants, their precursors and/or useful tracers. In general, trace gases and aerosols that make up atmospheric composition are markers of all types of human and natural activity - burning of fossil fuels and wildfires, agricultural production, photosynthesis, emissions of all types of chemicals and their evolution in the atmosphere. Many trace gases can be and are observable from space, including the major greenhouse gases - carbon dioxide and methane, air pollutants and their precursors, as well as stratospheric ozone - and its hopeful recovery. Given the global nature of JPSS products and national nature of GOES products, satellite observations of atmospheric composition are perfectly positioned for the purposes of prediction and, most importantly, monitoring of atmospheric composition.

1) Session Purpose

The purpose of the atmospheric composition was to present the breadth of products and their applications for all types of atmospheric composition science and informing decisions. Assessment of the status of greenhouse gas levels, stratospheric ozone recovery and deeper understanding of aerosol formation from their numerous precursors are possible with JPSS and GOES-R products. The developers and users present at the session and its side meeting included scientists from NESDIS and its affiliates, OAR laboratories, academia and private sector.

2) Agenda

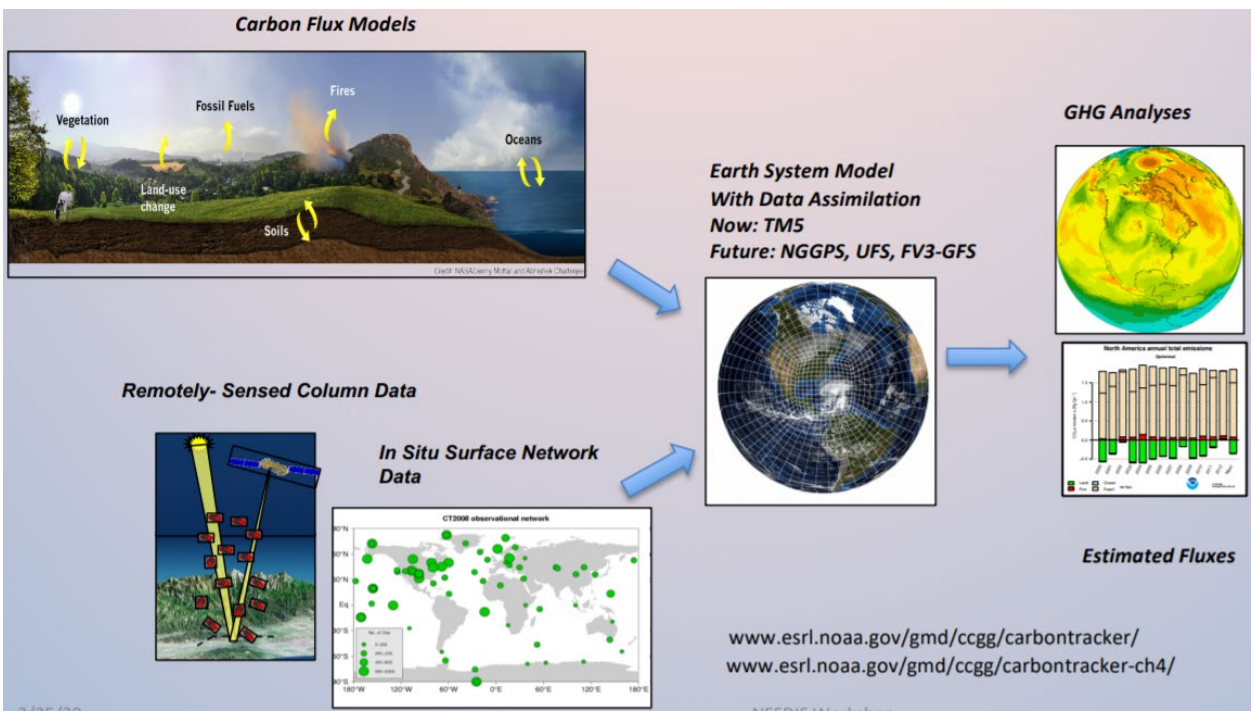
Presentation	Speaker	Affiliation
On the Role of Spaced-based Observations in Understanding Atmospheric Carbon	Lori Bruhwiler	NOAA/ESRL/GML
CrIS NH3 and CO Retrievals: From Idea to Applications	Matthew Alvarado	Atmospheric and Environmental Reserach, Inc.
Use and Applications for the JPSS and Ground-based Ozone Products	Irina Petropavlovskikh	NOAA/ESRL/GML
Composition Products from Hyperspectral Thermal Sounders	Chris Barnet	STC

NUCAPS Trace Gas Recent Updates	Juying Warner	University of Maryland
Atmospheric Composition Products from Space-Based Hyperspectral Scattered Solar Measurements	Larry Flynn	NOAA/NESDIS

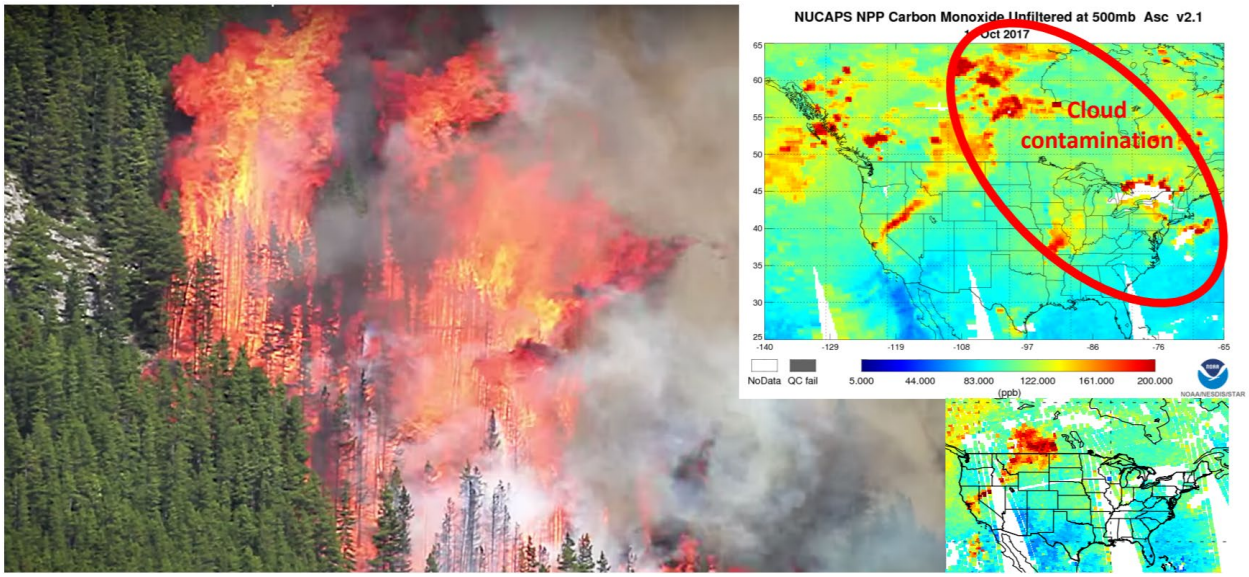
3) Key Takeaways (from developers and users)

- There are several years of data available for several operational species, and they are mature
- There are several years of data in the research community for products that are useful for science but currently do not have near real-time applications (e.g. HCHO, NH3) – would be nice to have more NOAA connection to those developed with NOAA funding
- Issues remain regarding data availability for particular applications, although several levels of data streams for different users could be a working solution (e.g. near-real-time, with averaging kernels etc.)
- More user-developer interactions are needed, e.g. through workshops
- Most atmospheric composition users are still focused on science applications and don't have low latency requirements outside of field campaign deployment
- "Geoengineering" should be kept in mind as an important future monitoring application, current volcanic ash product is a good precursor

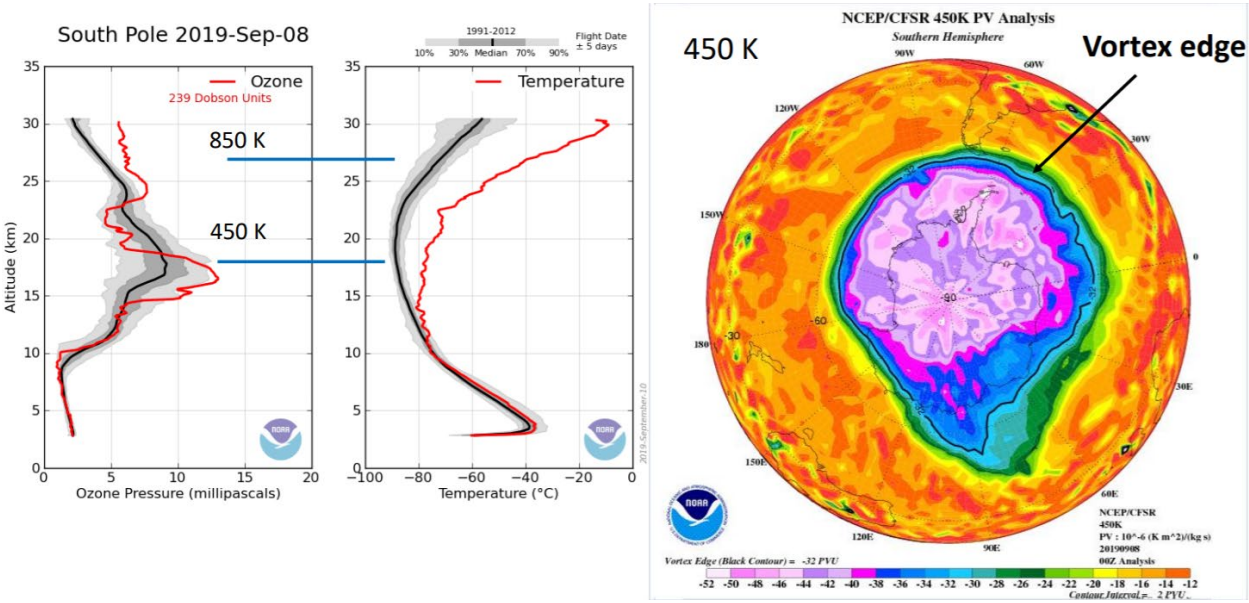
4) Graphics



CarbonTracker NGGPS (funded by NOAA CPO AC4)



JPSS NUCAPS Carbon Monoxide of Santa Rosa Fire 20171011



2019 was a special year when vortex was shifted from South Pole: Satellite provides interpretation and explanation of the event.

5) Questions/Answers

Question	Answer
Can you use VIIRS to quality control the cloud cleared CrIS to screen out the cloud contaminated CRIS CO product?	The cloud cleared radiances are generated using ATMS data. VIIRS is at much higher spatial resolution (750m) than CrIS (50 km). What we can do is certainly create a cloud fraction from VIIRS pixels that fall into CrIS footprint and see if

	there is a correlation between cloud fraction and bias in CO.
Will trace gas averaging kernels be added to NUCAPS netCDF files?	In our NASA CLIMCAPS system we have developed and tested the operational use of averaging kernels (AK's). Nadia Smith (STC) has been providing the science community the NUCAPS AK's based on the NASA approach for a couple of years now. In order to expedite the implementation of AK's in NUCAPS, Nadia has: a. provided NOAA/STAR with the NASA NETCDF file formats and codes and all the down-stream tools to unpack and use the averaging kernels for users. b. presented this information to NOAA/STAR staff in a technical interchange meeting. c. provided numerous examples of averaging kernel files for STAR to analyze and emulate. Our understanding in implementing operational averaging kernels is a high priority for STAR.
If one retrieval has, for instance, Temperature and CO2 interdependent, can a different source of Temp information improve constraint?	The Jacobian of T(p) and CO2 are very similar. In NUCAPS we use microwave information from the 57 GHz O2 band, the nitrous oxide information in the 4.5 um region, as well as subtle differences in CO2 absorption between the 15 um and 4.3 um regions to separate CO2 from T(p). Adding additional information about T(p) or CO2 will help in the separability of these parameters. In the NASA/CLIMCAPS we used Merra-2 for this purpose. Recently, in NUCAPS, Juying Warner added an improved CO2 climatology that helps to improve the separability. For NUCAPS, STC has developed an experimental version of NUCAPS, called NECAPS, that uses GFS T(p) and q(p) as an a-priori. This system is analogous to the CLIMCAPS system except that it uses a forecast model instead of a re-analysis; therefore, maintaining real-time processing capability. Trace gases are improved; however, in NECAPS

	the cloud clearing, T(p), and q(p) now have a significant model-dependence that in the opinion of some of our AWIPS users is a bad idea. Note that the pro's and con's of using model a-priori for T(p) and q(p) can be easily tested by comparing the NASA/CLIMCAPS product and the NOAA/NUCAPS product as both are available operationally for the full missions of S-NPP and NOAA-20. We have found that use of the model T(p) and q(p) significantly improves the trace gas products.

6) Key Challenges for Users/Developers

a) Users

i) Awareness of available data (need more communication)

ii) Lack of programmatic/funding space where users and developers can work together

b) Developers

i) Reaching the users remains a challenge

ii) Identifying and getting commitment from operational users

7) Ideas for Improving the User Experience

Please note that all issues, ideas and recommendations from the Aerosol and Air Quality session apply here as well.

a) Hold more workshops
   -- To exchange experience and information, to connect developers and users
   -- To demonstrate the utility of atmospheric composition products

b) Create programmatic/funding space where developers and users can work together

c) Allow for seed funding and pilot projects for exploring new data products

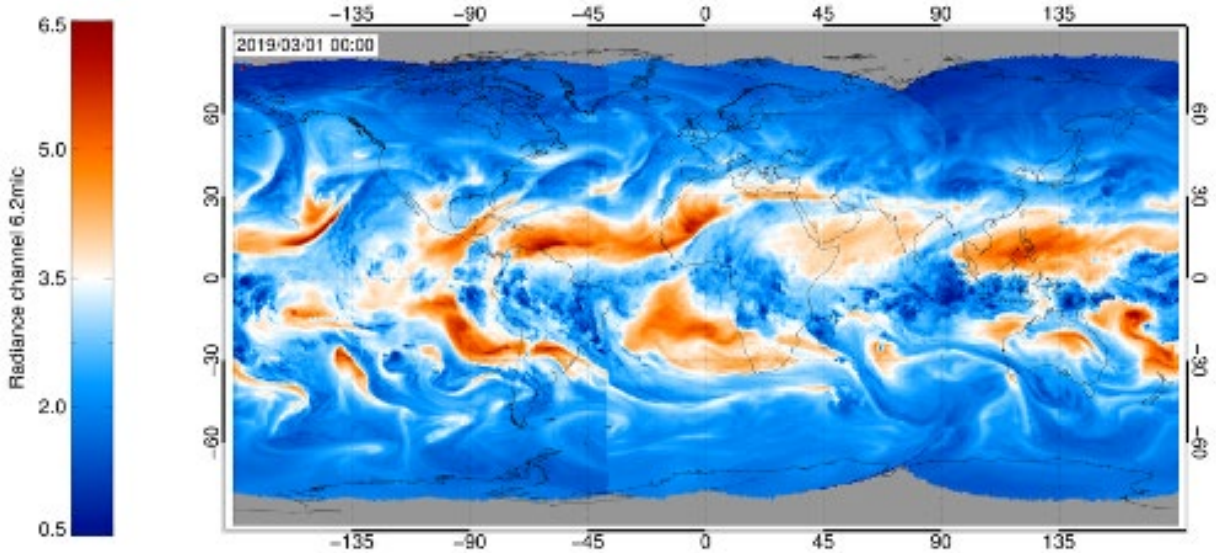
d) Engage users in the earliest stages of product development (and ensure early feedback to developers)

e) Ensure atmospheric composition capabilities in future NESDIS instruments, especially geostationary

f) Explore the sustained assessment effort as one of the core applications of atmospheric composition data

Special Topics/Innovation

Moderator: Lihang Zhou



1) Session Purpose

NOAA's broad and comprehensive mission evolves with society's rapidly changing demand for environmental intelligence. In response, the JPSS Proving Ground Risk Reduction Program established an innovation initiative to uncover and cultivate new ideas, methods, and ways of doing things. In the GOES-R NOAA/NASA ROSES call for proposals announced recently, the focus on the NOAA side is also the new ideas and applications using geo data and producing products or applications for operational use. Innovation is critical to keep NOAA science fresh and cutting edge, it will pay benefits throughout many aspects of the NOAA missions and operations.

The purpose of this session is to provide the summit participants information on the innovated areas of satellite products and applications, such as Artificial Intelligence (AI) for Sounding Applications, Reprocessing long term data records; and the new ways of products development and operation, such as Agile development, Cloud Computing; and the new concept to connect users with innovation. The special topics that may be highly interesting to the summit audience and did not include in the other sessions of the summit, e.g. the keynote briefings on the Air Force Space-Based Environment Monitoring (SBEM) programs, and space weather are also presented in this special session.

2) Agenda

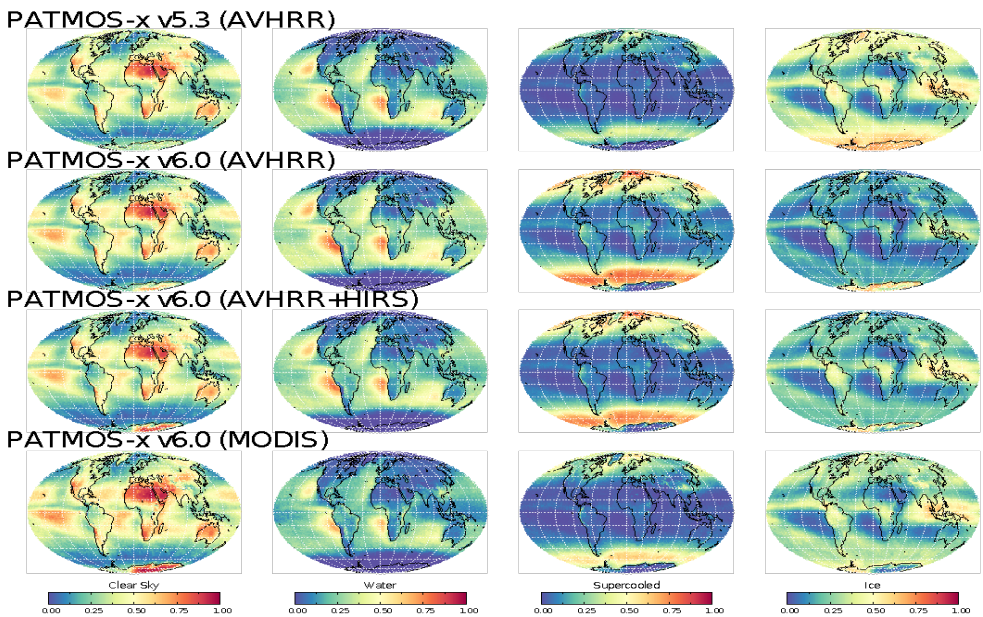
Presentation	Speaker	Affiliation
NUCAPS and ABI-Stronger together using AI	Jun Li	CIMSS
Applications of JPSS and GOES-R for long-term monitoring	Cheng-Zhi Zou Andrew Heidinger	STAR

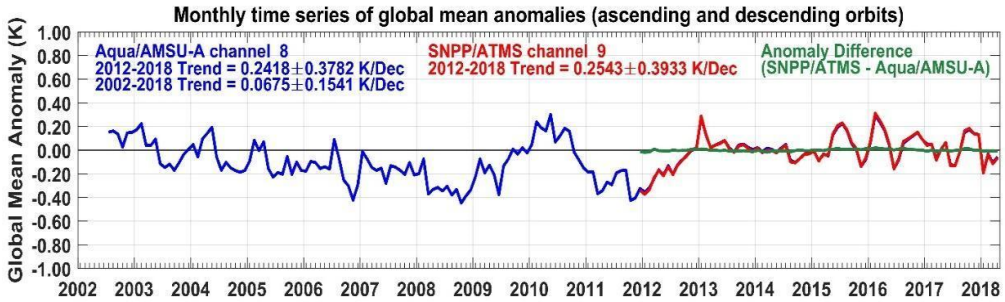
Lesson learned from VOLCAT and ProbSevere	Mike Pavolonis	STAR
Cloud Computing	Kathryn Shontz	OSAAP
User-Driven Innovation	Renata Lana	NESDIS HQ
Air Force Weather User Needs	Adam Demarco	DOD/Air Force
Space weather	Elsayed Talaat	OPPA

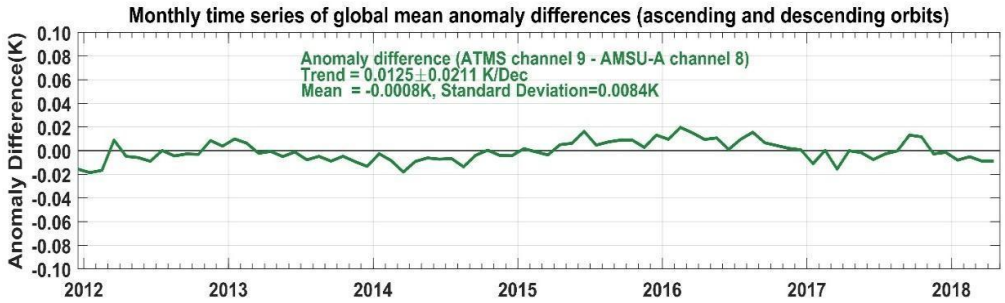
3) Key Takeaways

- Understanding our users is the missing link to successful innovation.
    - We must bring as sophisticated an approach to understanding our users as we do to the science and engineering of our products.
- New information + new technique => new improvements
- Reprocessed SNPP data => CDR => long-term monitoring of environmental changes

4) Graphics



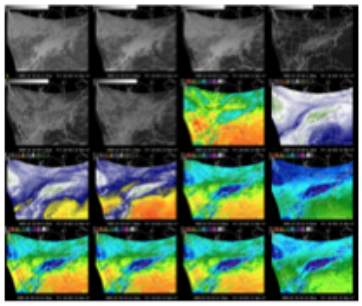


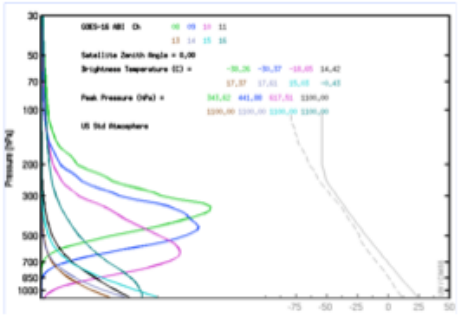


ABI

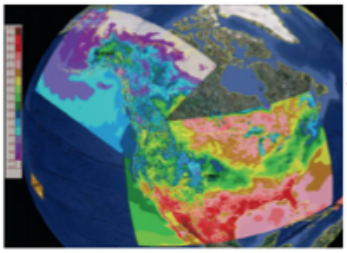
COMPARISON GOES-R SERIES ABI VS CURRENT GOES

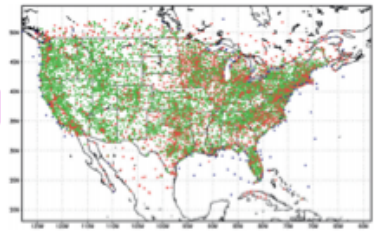
ATTRIBUTE :	ABI	CURRENT GOES IMAGER
Spectral Coverage	16 bands	5 bands
Spatial Resolution		
0.64 µm Visible	0.5 km	~ 1 km
Other visible/near-IR	1.0 km	n/a
Bands (>2 µm)	2 km	~ 4 km
Spatial Coverage		
Full Disk	4 per hour	Scheduled (3 hrly)
CONUS	12 per hour	~4 per hour
Mesoscale	30 or 60 sec	n/a
Visible (reflective bands)		
On-orbit calibration	Yes	No





RTMA





A representative map of the temperature stations used at a given analysis time. The example is from the 1500 UTC 20 Nov 2009 analysis. Green dots represent Mesonets, red dots show land synoptic and METAR stations, and blue dots show marine stations. The total number of stations is 14 299.

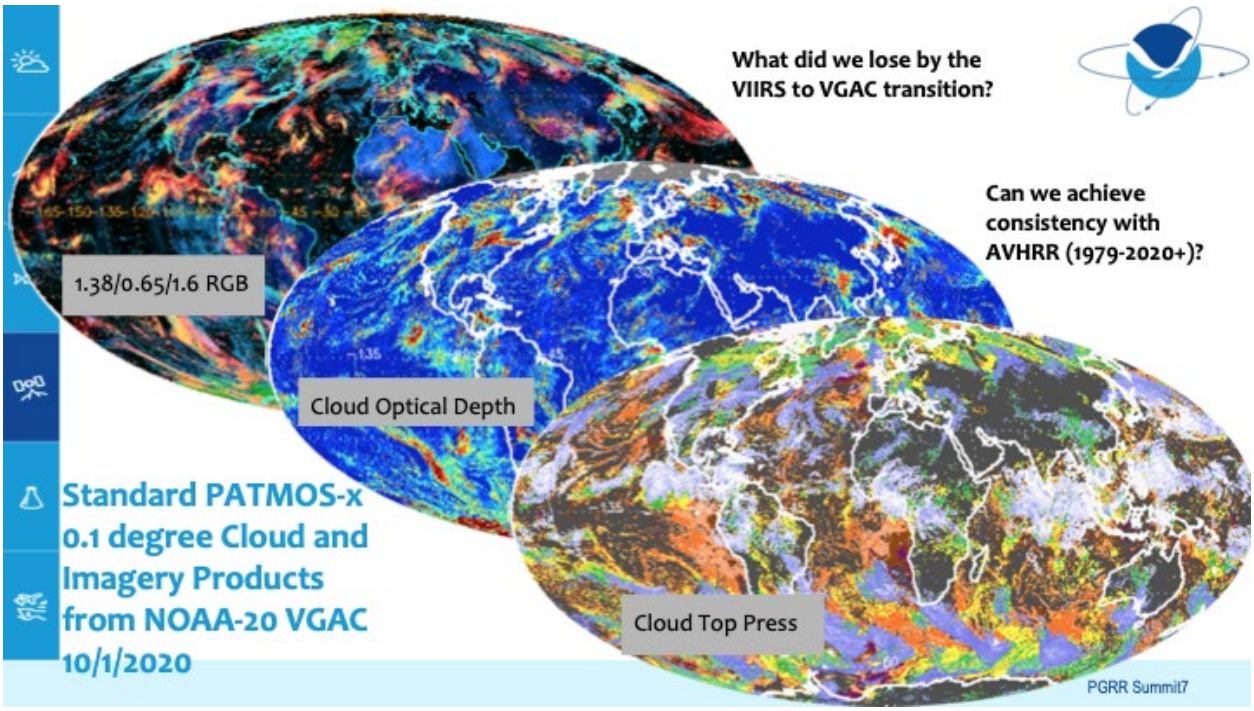
ABI :

- **Fine spatial resolution(2km for IR) and fast scan rate (5 minutes for CONUS)**
- **Bands (11/13/14/15/16) sensitive to lower atmosphere, together with three H_2O bands (8/9/10), containing important information for profiles in the lower atmosphere.**

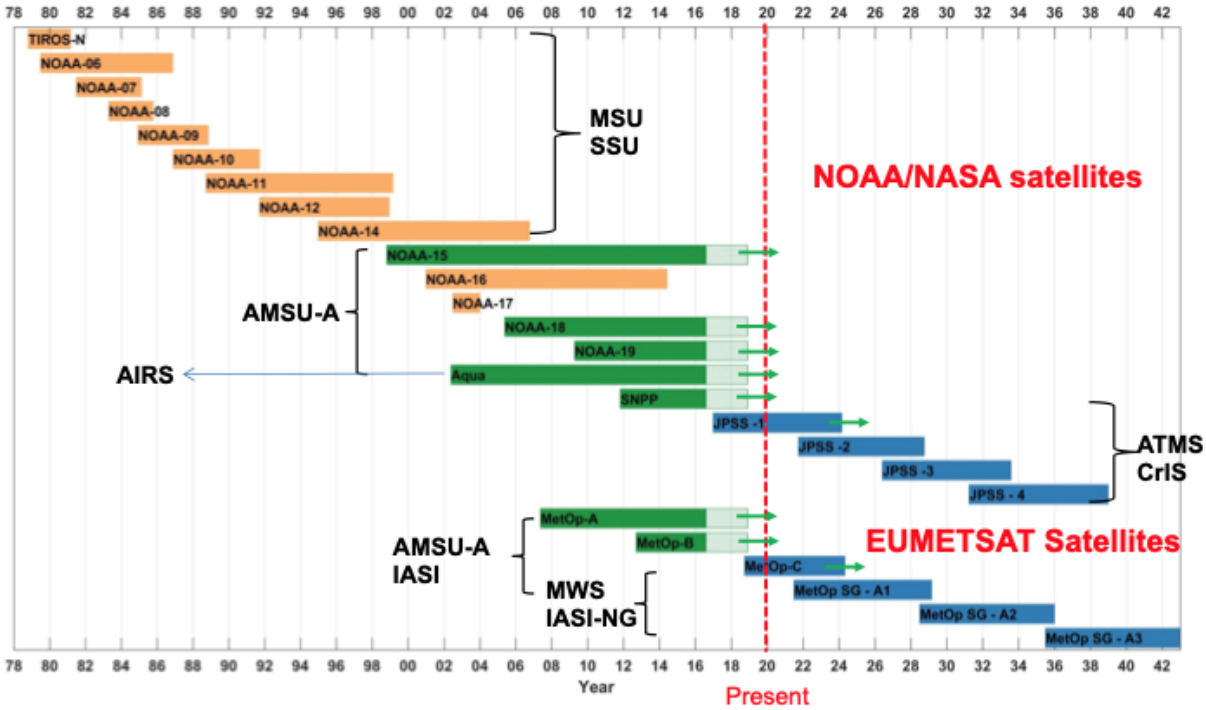
RTMA :

- **Hourly, high spatial resolution (2.5 km) of gridded fields of 2-m temperature/specific humidity/dewpoint, 10-m U/V components, and surface pressure.**
- **Conventional and satellite-derived observations assimilated.**

4

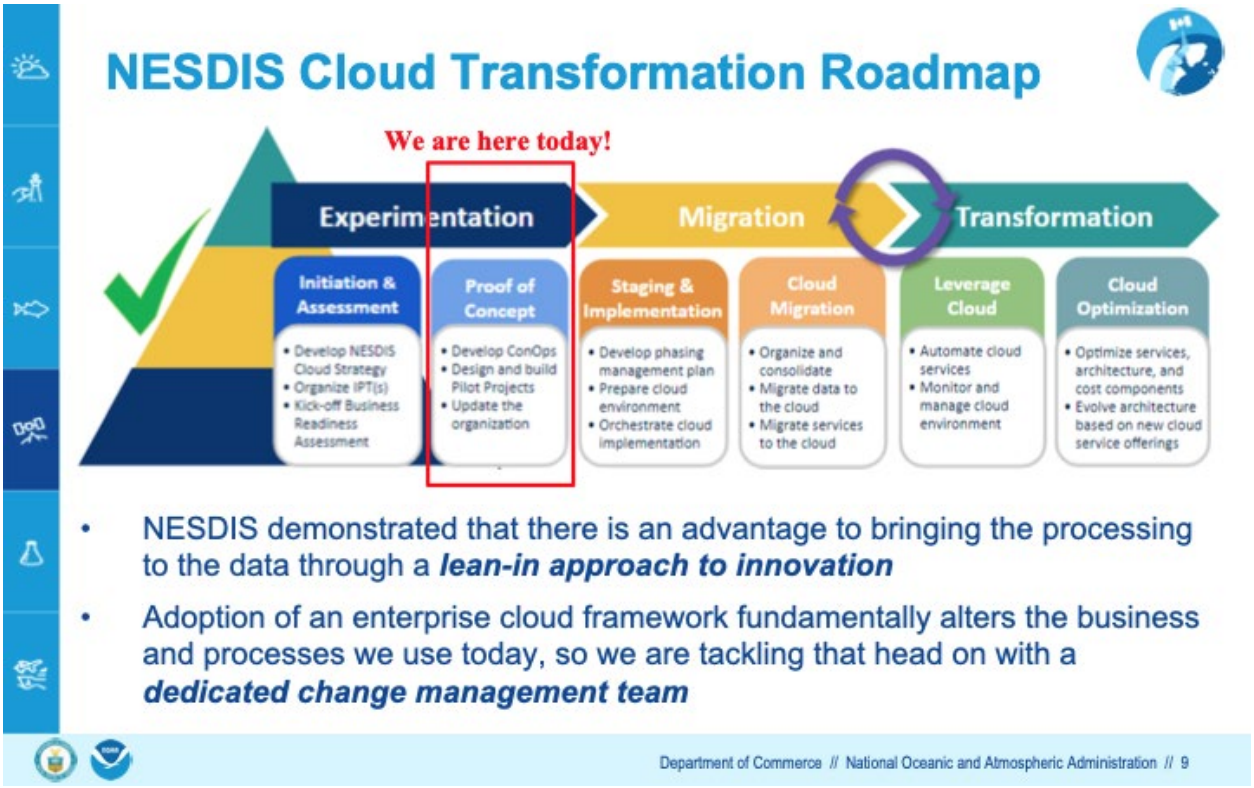


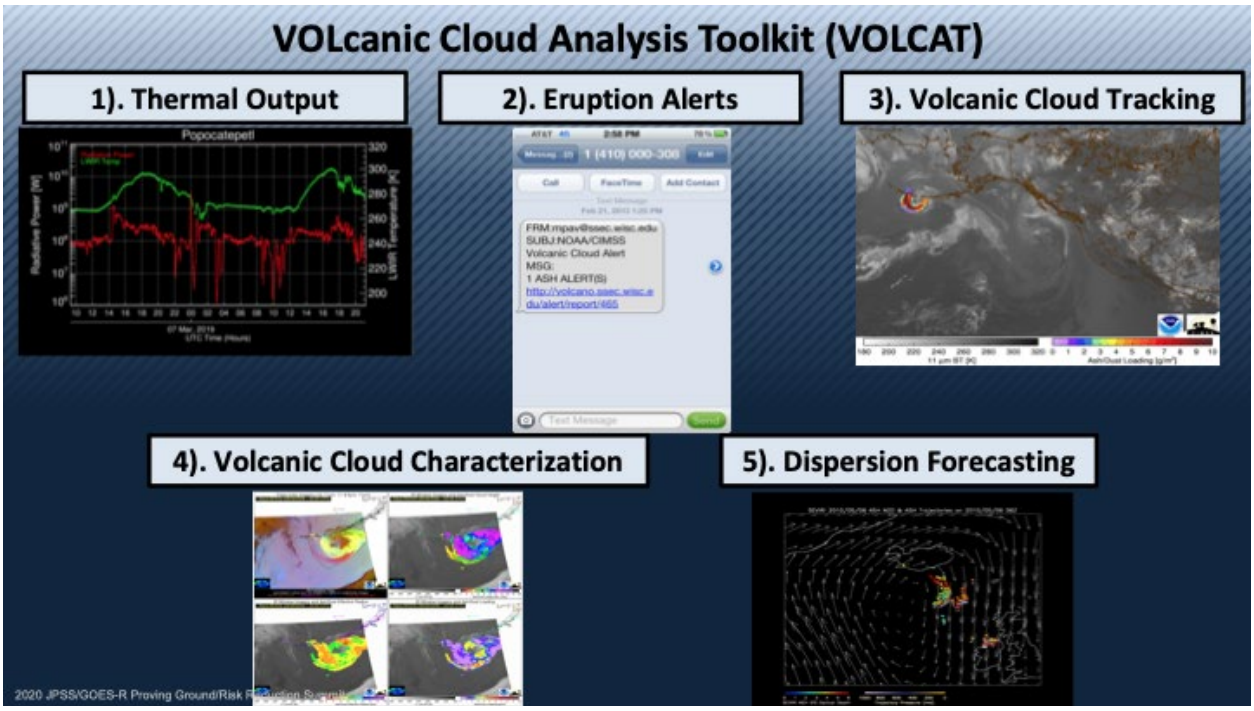
- Satellites are the only means available to provide upper-air temperature observations with global coverage for long-term monitoring
- NOAA satellites have been continuously observing upper-air temperatures for over 40 years
- JPSS Program carries the NOAA operational temperature sounding capability into the future
- Inter-satellite calibration and satellite merging are needed to develop climate data record (CDR) for long-term monitoring



User-Driven Innovation

Renata Lana, NESDIS
renata.lana@noaa.gov





U.S. AIR FORCE

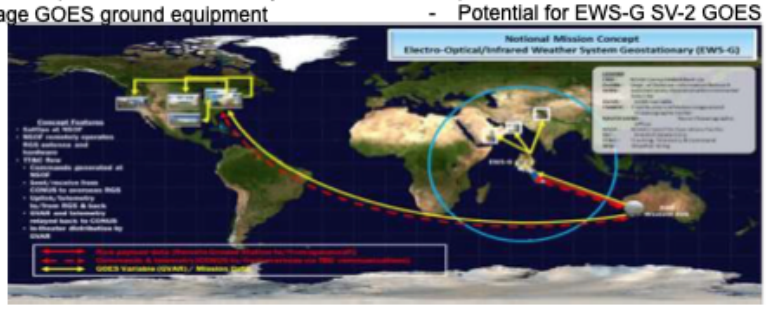
EO/IR Weather System-Geostationary (EWS-G)

What:

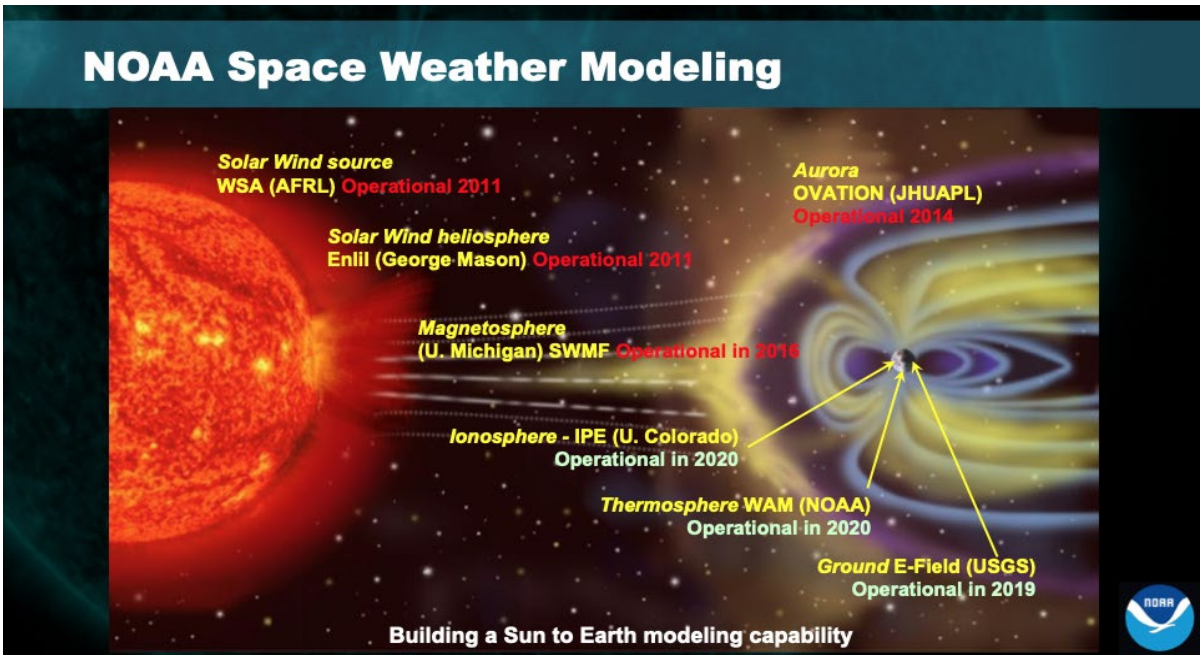
- JROC directed a temporary non-material solution for Cloud Characterization & Theater Weather Imagery over the Indian Ocean
  - Based on projected EUMETSAT MET-8 End-of-Life
- Moving a legacy National Oceanic and Atmospheric Administration (NOAA) Geostationary satellite (GOES-13)
- Leveraging NASA to establish remote ground station in Western Australia for operations and data relay
  - Using heritage GOES ground equipment

Ongoing Activities

- Satellite drift began - Jul 19
- Initial antenna transport to AUS began - Jul 19
- Nov 19 - Remote ground station reconstruction complete
- Nov/Dec 19 – Ground Station testing w/GOES-13
- Satellite arrived at final location (61.5 E) – 18 Feb 20
- IOC - Apr 2020, FOC - ~Jun/Jul 2020
- EOL ~ 2023 based on fuel for station-keeping, w/ potential to extend to 2025 w/ software mods
- Potential for EWS-G SV-2 GOES transfer



Integrity - Service - Excellence



5) Questions/Answers

Question	Answer
John Knaff: Are scientists and activities at the Cooperative Institutes part of your NESDIS Cloud Framework? Can I use all these "tools" in Colorado on an edu domain?	Yes.
Jun Li: What was the comparison with radiosonde profiles?	Will provide the comparison with radiosonde profiles
Just putting NOAA data in the cloud is not the solution. NOAA must provide the data in useable formats and services to maintain trusted source credentials.	Kathryn will provide a response and will added here.

6) Key Challenges for Users/Developers

a) Users

- Users don't necessarily know what to ask for and/or don't know how to tell you what they need.
- Understanding the physics behind the limitation of product, the potential solutions and why.
- Large volume of data
- Thin data sets
- Blended/Data fusion
- Higher order products and applications

b) Developers

- Developers don't have the benefit of robust user engagement practices to help them inform their development.
- NOAA must field and fund user engagement that is as sophisticated as the science and engineering we conduct.
- Feedback from users on the issues of the product is very important
- Lack of funding for continuing development is challenge for developers.

7) Ideas for Improving the User Experience

- We operate on anecdote most of the time; we need to find ways to get serious about collecting data about and from our users.
- Users training on the algorithms (physics, math), data processing, product generation and distribution.
- Research on issues users identified, provide timely solution to the issues, and establish users' confidence on the product.
- Make the dataset available with popular data format
- Users will have good experience if satellite data solve their problems/mysteries and improve operation status in user's fields

8) **Recommendations/Summary**

a) Combining NUCAPS and collocated high spatial resolution ABI using AI makes better lower level temperature and moisture soundings. Adding surface T/q observations (or analysis) further improves boundary layer profiles.

b) Reprocessing datasets bring benefits for the users from the National and international climate assessment programs (i.e., IPCC, WCRP), Climate modelers, NWP centers for data assimilation, and Satellite cal/val programs that can use the reprocessed data as reference.

c) Higher order products provide benefits for the products and services including: Minimize the dataset size; Bring new capability to users by integrating to user's workflow; Provide automated assistant to users; and Provide different kinds of stovepipe applications.

d) NESDIS Cloud Framework Architecture enables a set of services to work together to deliver mission value.

e) Observe our users, observe the environment, and ask the right questions.

f) The AF is restructuring its Space-Based Environment Monitoring (SBEM) architecture and acquisition strategy to focus on resilient constellations vs single point of failure; initial focus on Electro-Optical/Infrared (EO/IR) – Cloud Characterization (CC) & Theater Weather Imagery (TWI) are their top sensing priorities.

g) NOAA Space Weather Prediction Center (SWPC) alerts, watches and warning, it provides 24x7 analysis and forecasting of space weather storms. SWPC uses observations and measurements from Low-Earth Orbit, Geostationary Orbit and L1 data to enhance the performance of space weather forecasts. Coronal Mass Ejection (CME) Imagery and Solar Wind In-Site at Sun-Earth Lagrange are two major prediction products. NESDIS also works on COSMIC-2/FORMOSAT-7 Mission. NESDIS has established the baseline operational Space Weather Follow-on (SWFO) program.