winds in rapidly updating regional models

Cloud analysis products for RAP/HRRR

- **GOES cloud-top pres/temp**
  (from NESDIS and Langley)
- **METAR ceilometers, RVR** *(fog building)*
- **Polar orbiter cloud products** *(for RRFS)*

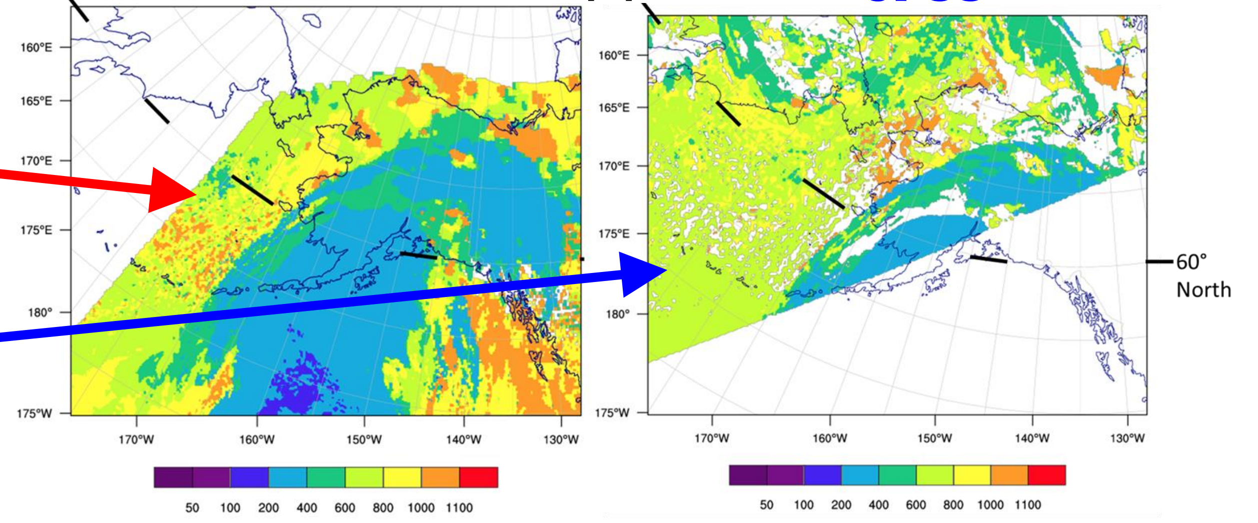
Related surface assimilation products

- **VIIRS Green Vegetation Fractions**
- **IMS snow cover product**

Products based on time evolution

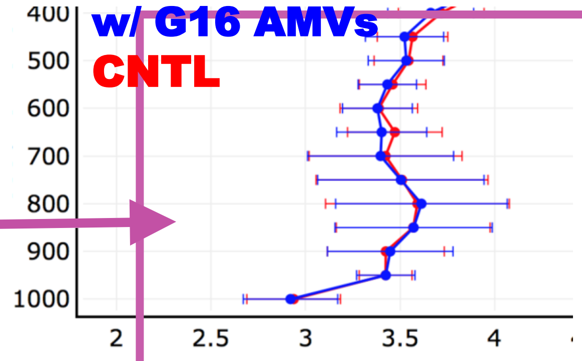
- **Atmospheric Motion Vectors**
- **Cloud-top cooling rate**

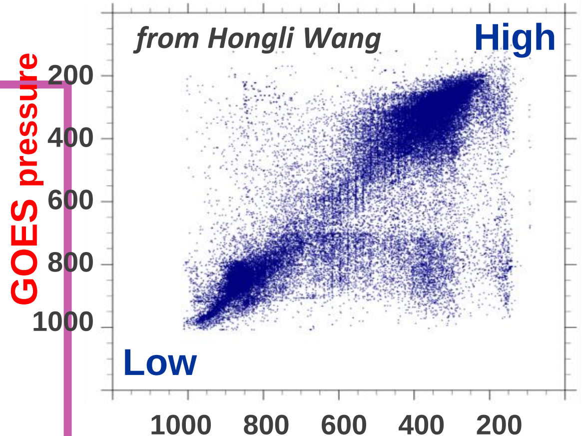
GOES **Cloud-top pressures** **JPSS**



Comparison GOES vs. JPSS Cloud-top Pressures

*Impact from adding GOES-16 AMVs **
(CNTL=all conv. obs. w/ other AMVs)





RAP/HRRR cloud analysis group members:
Terra Ladwig, Stan Benjamin, Eric James

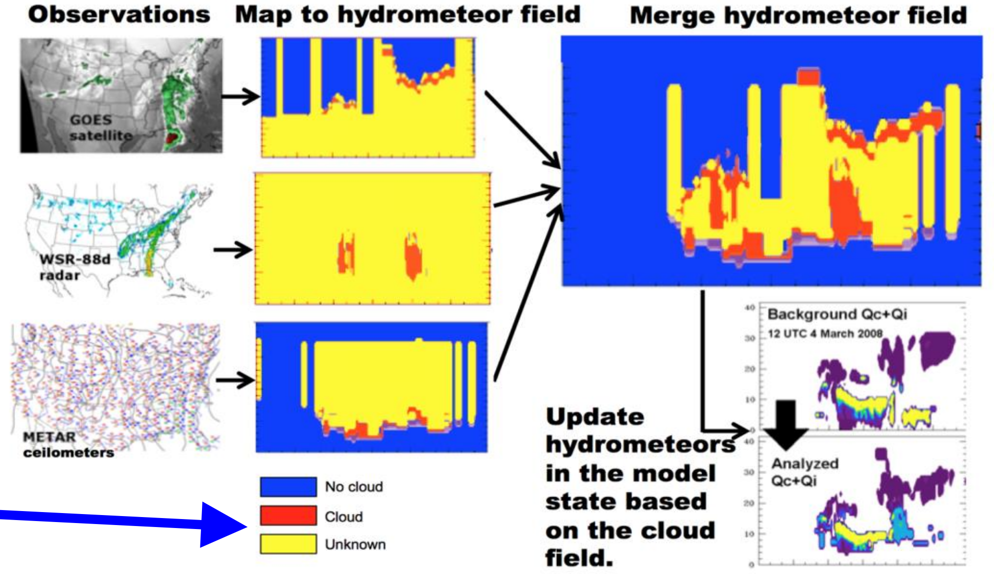
Steve Weygandt, NOAA/ESRL – Amanda Back, NOAA/ESRL, CIRA

winds in rapidly updating regional models

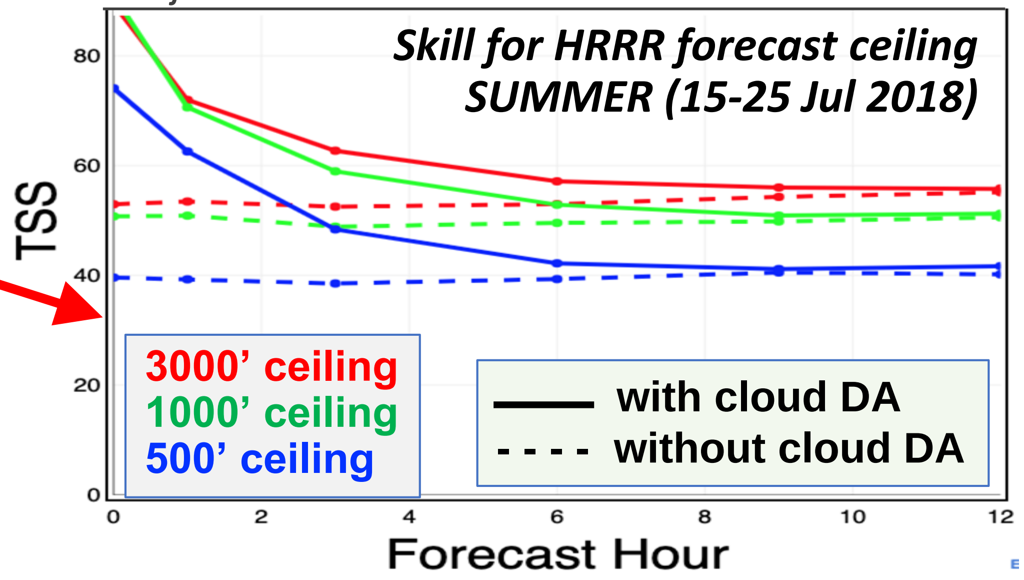
Cloud building / clearing using satellite products

** real-time experimental*

- **Current RAP / HRRR / 3D-RTMA* uses non-variational cloud "specification" method to modify cycled cloud hydrometeors**
  - Work to extend RAP/HRRR cloud analysis to variational / ensemble framework **(T. Ladwig)**
- **Significant positive impact for short-range cloud forecasts (ceiling and visibility)**
  - Key for aviation applications, including HRRR-AK
- **Sub-grid cloud faction included for RAPv5/HRRRv4**
  - Work to project cloud DA onto cloud fraction



Benjamin et al. 2020



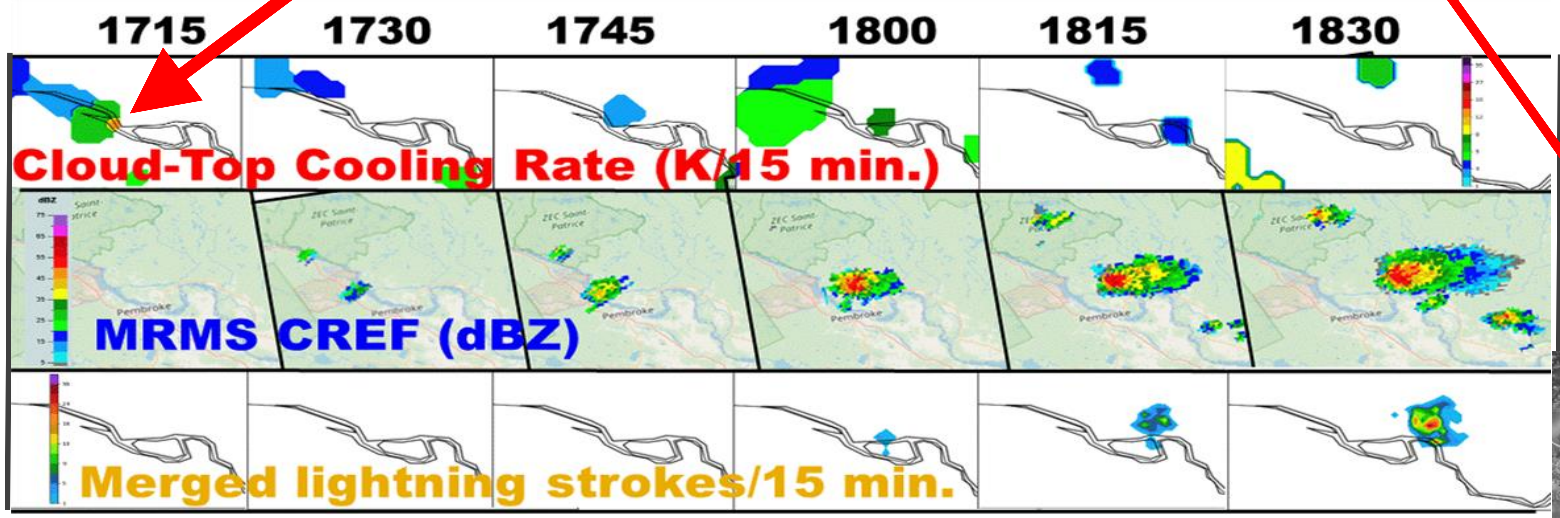
winds in rapidly updating regional models

AMVs and Cloud-top Cooling Rates

- **GOES-16 AMVs** being assimilated into RAPv5/HRRRv4 **(large total # of AMVS important hourly obs source)**
- **Cloud-top cooling rate data (CTCR)** complements **reflectivity** and **merged lightning data** for capturing **convective initiation** part of storm evolution

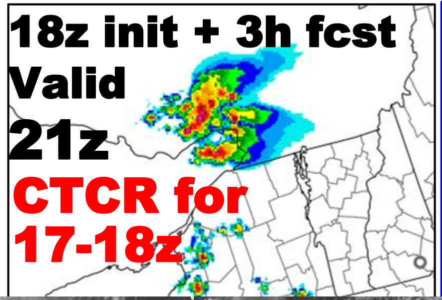
Avg. HOURLY RAP/HRRR AMV obs counts

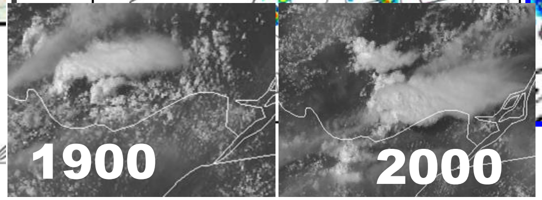
1596	GOES-15 IR long-wave cloud (245)
3076	**GOES-16 IR long-wave cloud (245)**
872	GOES-15 deep layer cloud top (246)
1308	**GOES-16 deep layer cloud top (246)**
586	GOES-15 deep layer wat vap (247)
667	**GOES-16 deep layer wat vap (247)**
1600	EUMETSAT total (243+253)
1503	JMA total (242+250+252+254)
11208	**Average Total AMV obs. per hour**

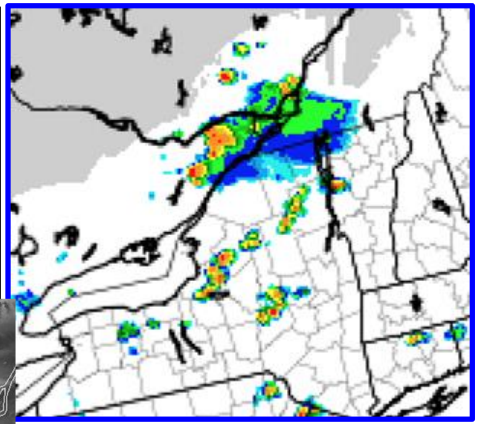


from Amanda Back

Assimilating CTCR during pre-forecast hour crucial for ability of 18z init HRRR to capture storm initiation







21z MRMS obs

winds in rapidly updating regional models

Science / Tech for Clouds

- Variational / ensemble cloud DA
- Using cloud depth information
- Cloud DA: balance / retention
- Building multiple cloud layers
- Merging GOES/JPSS products, using cloud products for radiance DA

Evolving / future needs for satellite clouds & AMVs

Science / Tech for AMVs

- Cloud height assignments
- QC and quality flags
- Further impact evaluation (AMV category / level, regional vs. global, land vs. ocean)

Flight Category	Ceiling threshold (feet)	Visibility threshold (miles)
LIFR	< 500	< 1
IFR	500 - 1000	1 - 3
MVFR	1000 - 3000	3 - 5
VFR	> 3000	> 5

Accurate cloud analysis is crucial for improving ceiling and visibility forecast skill, which is very important for aviation weather

Use of time evolution

- Further testing of cloud-top cooling rate assimilation
- Consider assimilation of storm-top divergence, other information from time series of images

Use of Cloud and Winds Products in NWP at NCEP

Andrew Collard
IMSG@NOAA/NCEP/EMC

How do we use cloud information in NWP?

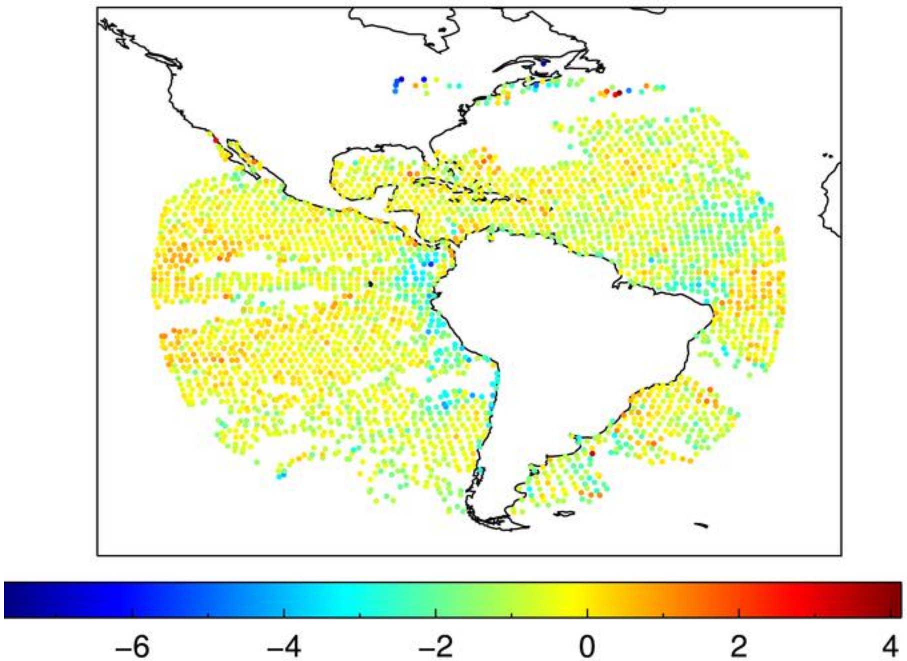
- In our NWP systems we use cloud information from both geostationary and polar imagers.
- Cloud information from VIIRS, mapped onto the CrIS FOV, is used to constrain the thinning choices for CrIS.
  - For IASI we use AVHRR radiance cluster information within the FOV
- We are also testing the use of VIIRS cloud information mapped onto the ATMS field of view to help identify areas of supercooled water clouds – with encouraging results.

Clear Sky Radiances

- Averaged Clear sky radiance products are used for
  - Geostationary Imagers (mostly water vapor channels)
  - AVHRR and VIIRS (window channels used in sea surface temperature analysis)
- The quality of the clear-sky radiance product is crucially dependent on the quality of the cloud product.

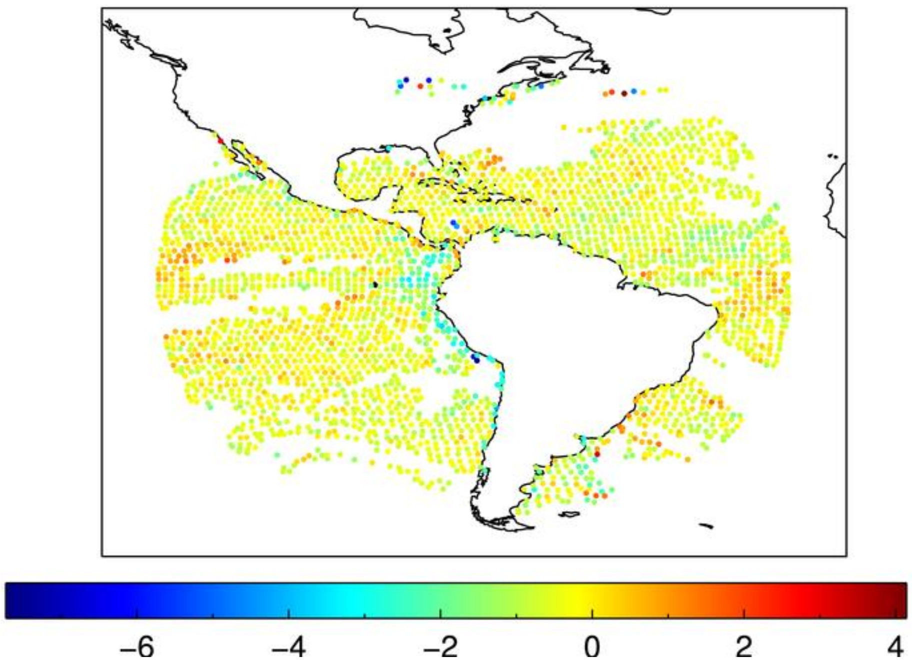
ABI_G16 CSR Data: Cloud Mask Impact

Obs – Fcst (OmF) for surface channel



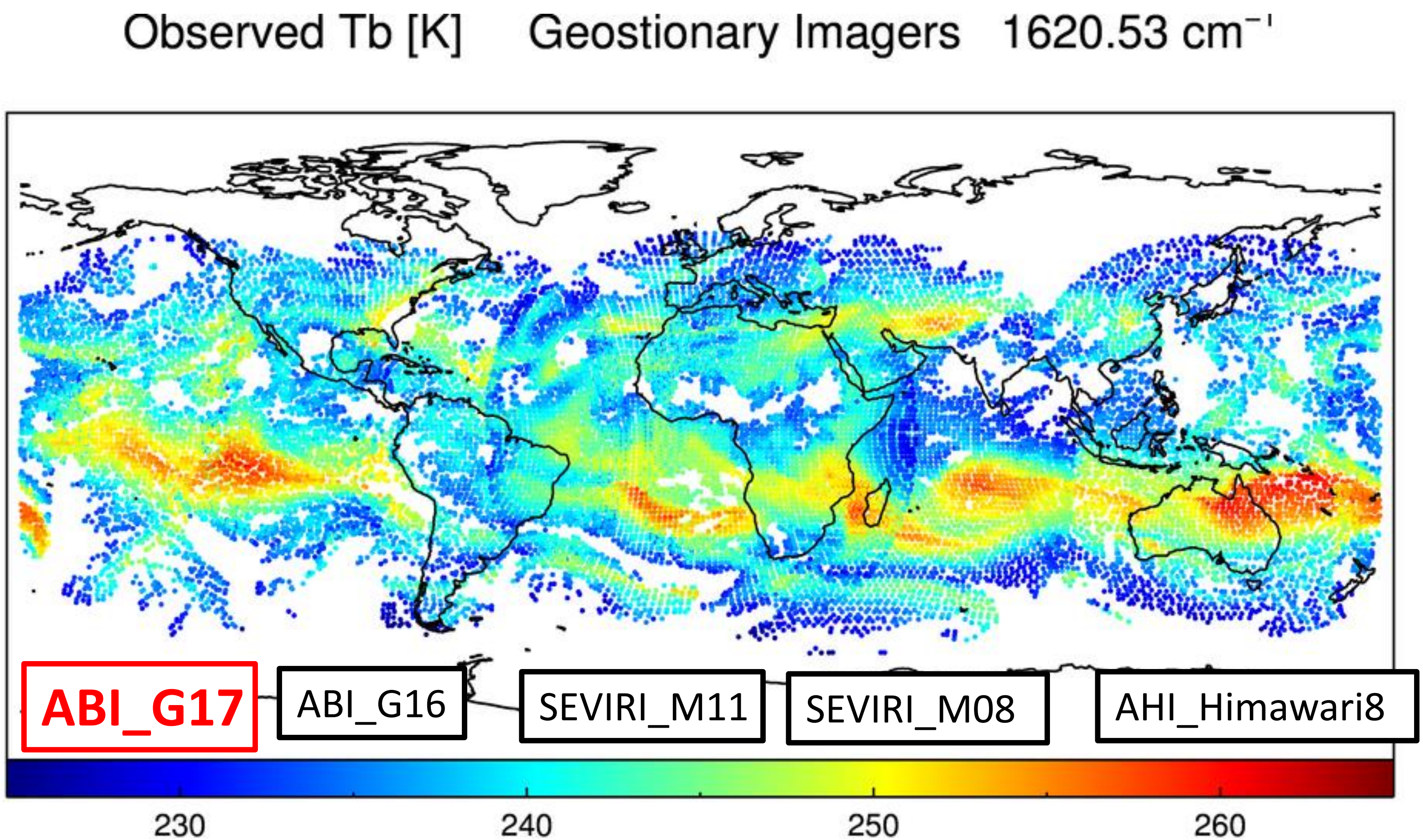
Baseline cloud mask

Obs – Fcst (OmF) for surface channel



Enterprise cloud mask

ABI_G17 CSR Data Initial View



Atmospheric Motion Vectors

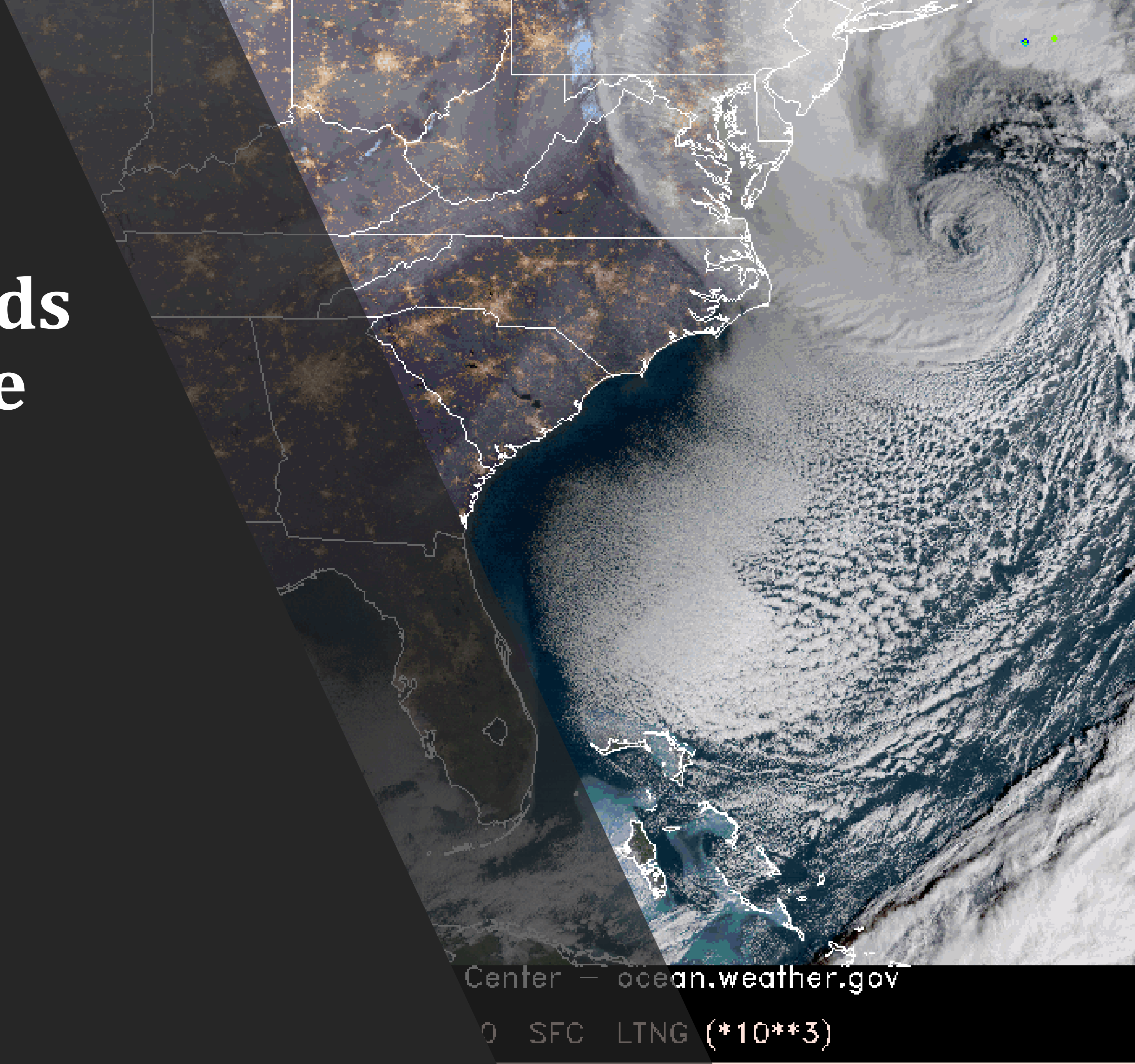
- The global forecast system makes extensive use of AMVs from both Geostationary and Polar platforms
- We are currently assimilating cloud top infrared; cloud top water vapor and clear sky water vapor winds.
- … from GOES-16, GOES-17, Meteosat-8, Meteosat-11 and Himawari-9 in geostationary orbit
- AVHRR; MODIS and VIIRS in polar orbit
- ASCAT from MetOp satellites (not strictly AMVs)

- We are testing LEO-GEO winds

The Future

- Continue to explore additional winds sources
  - Currently evaluating ADM-Aeolus
- Explore the use of situation dependent observation error (proxy for height assignment uncertainty)
- How should we extract wind information from hyperspectral geostationary sounders?
  - Level-2 products or direct radiance assimilation.

Use of Clouds/Winds Satellite Data at the Ocean Prediction Center



Michael J. Folmer
Marine Forecaster
Tropical/Satellite/Training Focal Point
NOAA/NWS/Ocean Prediction Center

Ocean Prediction Center (OPC)

- Location: College Park, Maryland

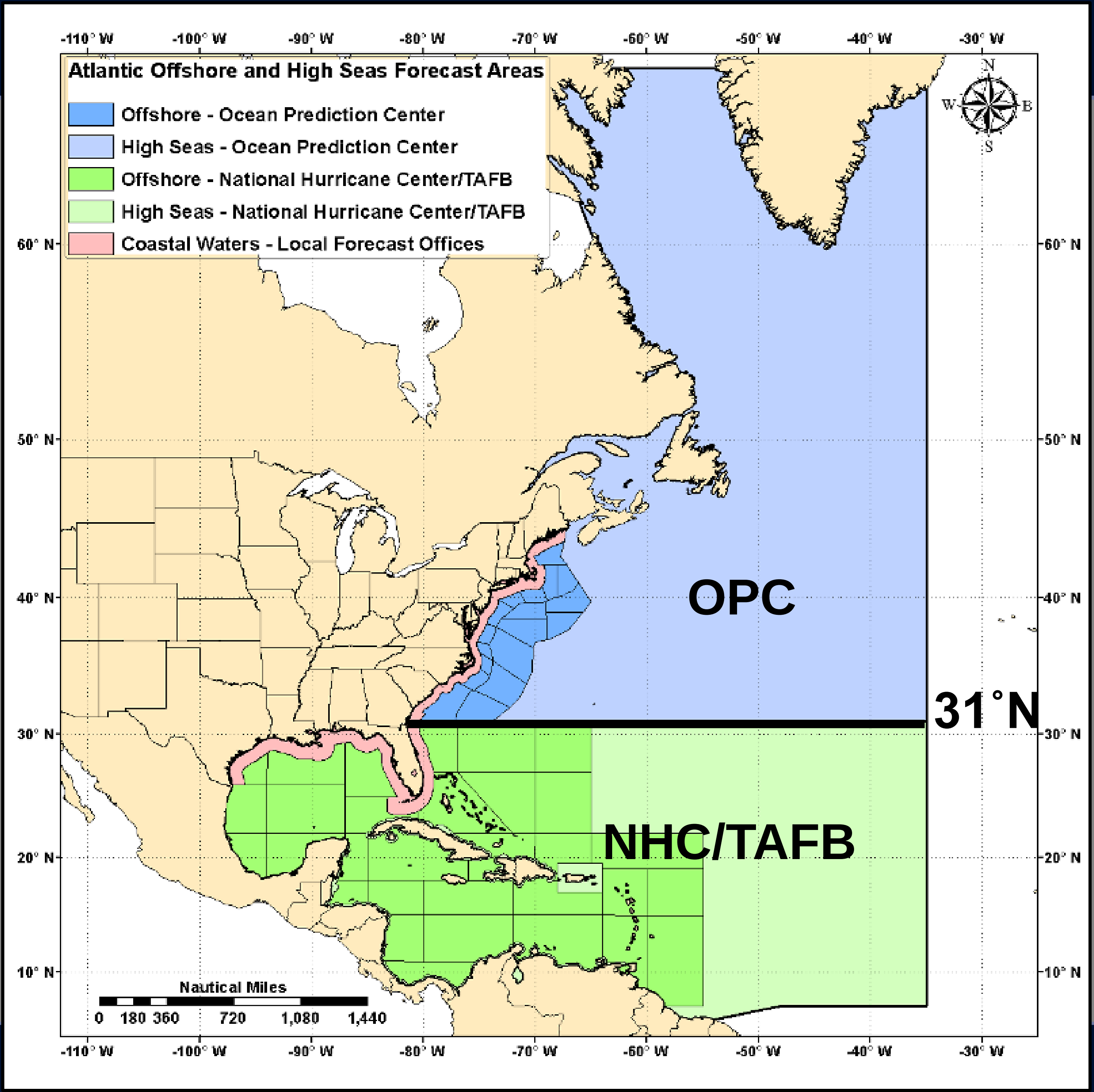
- OPC issues marine warnings, forecasts, & guidance in text, graphical, and gridded format for mariners N of 31°N in the Atlantic and N of 30 °N in the Pacific oceans.

- 24/7/365 operation with 20 marine forecasters that staff five operational desks every day

PREDICTION
OCEAN
CENTER
NOAA
The Mariner's Weather Lifeline

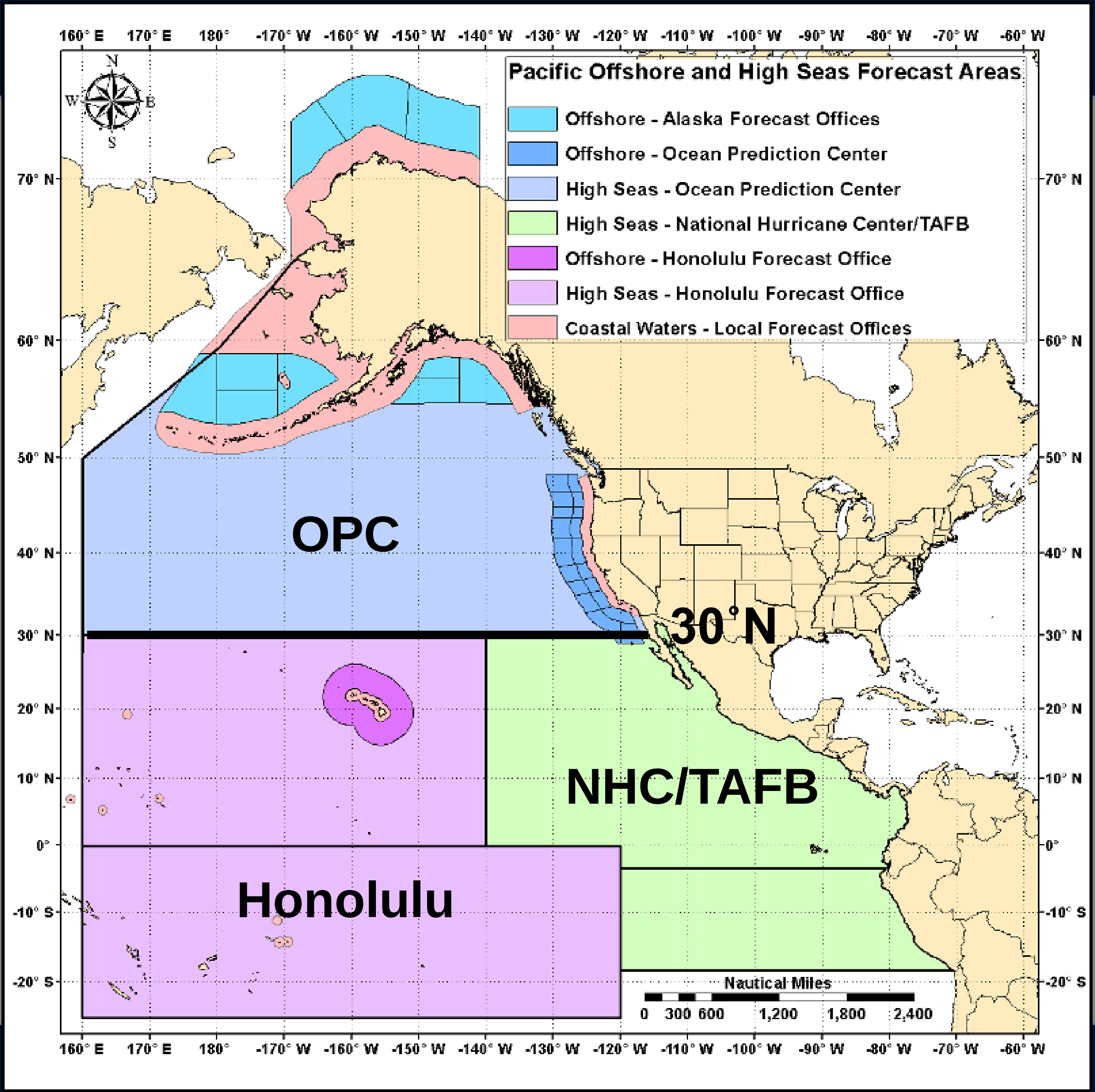
NWS Atlantic Marine Zones

OPC high seas forecast waters are shaded light blue, the offshore forecast waters in darker blue.

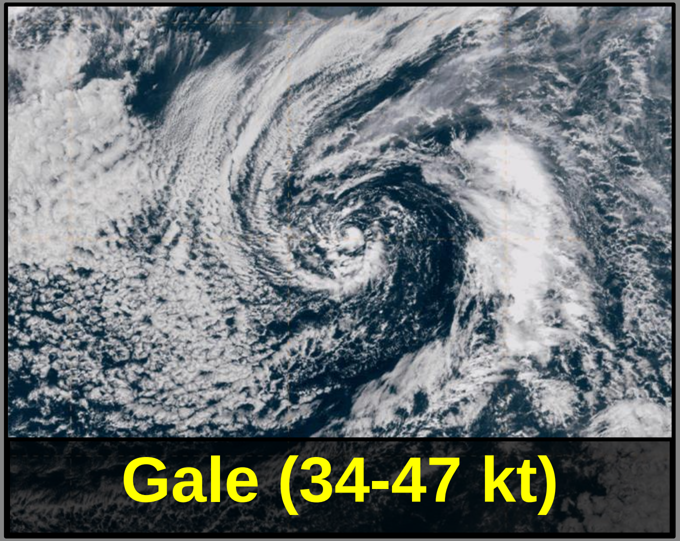


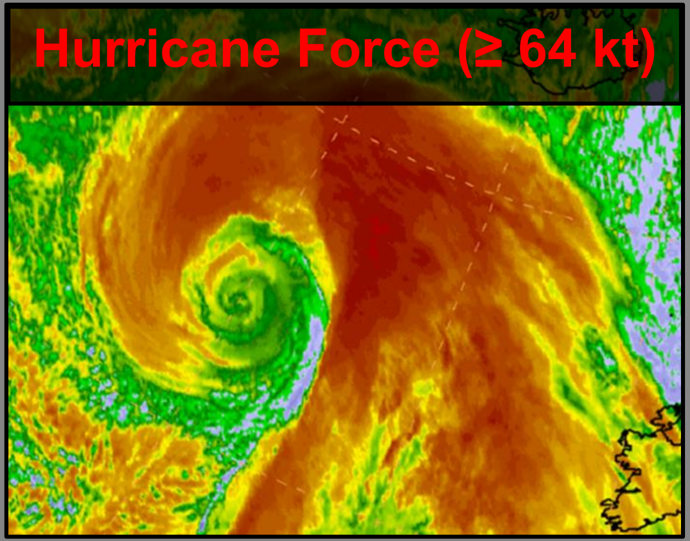
NWS Pacific Marine Zones

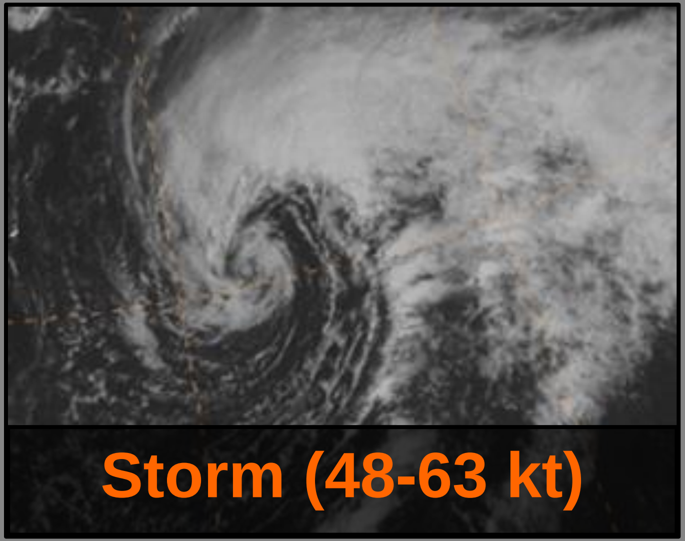
OPC high seas forecast waters are shaded light blue, the offshore forecast waters in darker blue.



OPC Marine Warnings

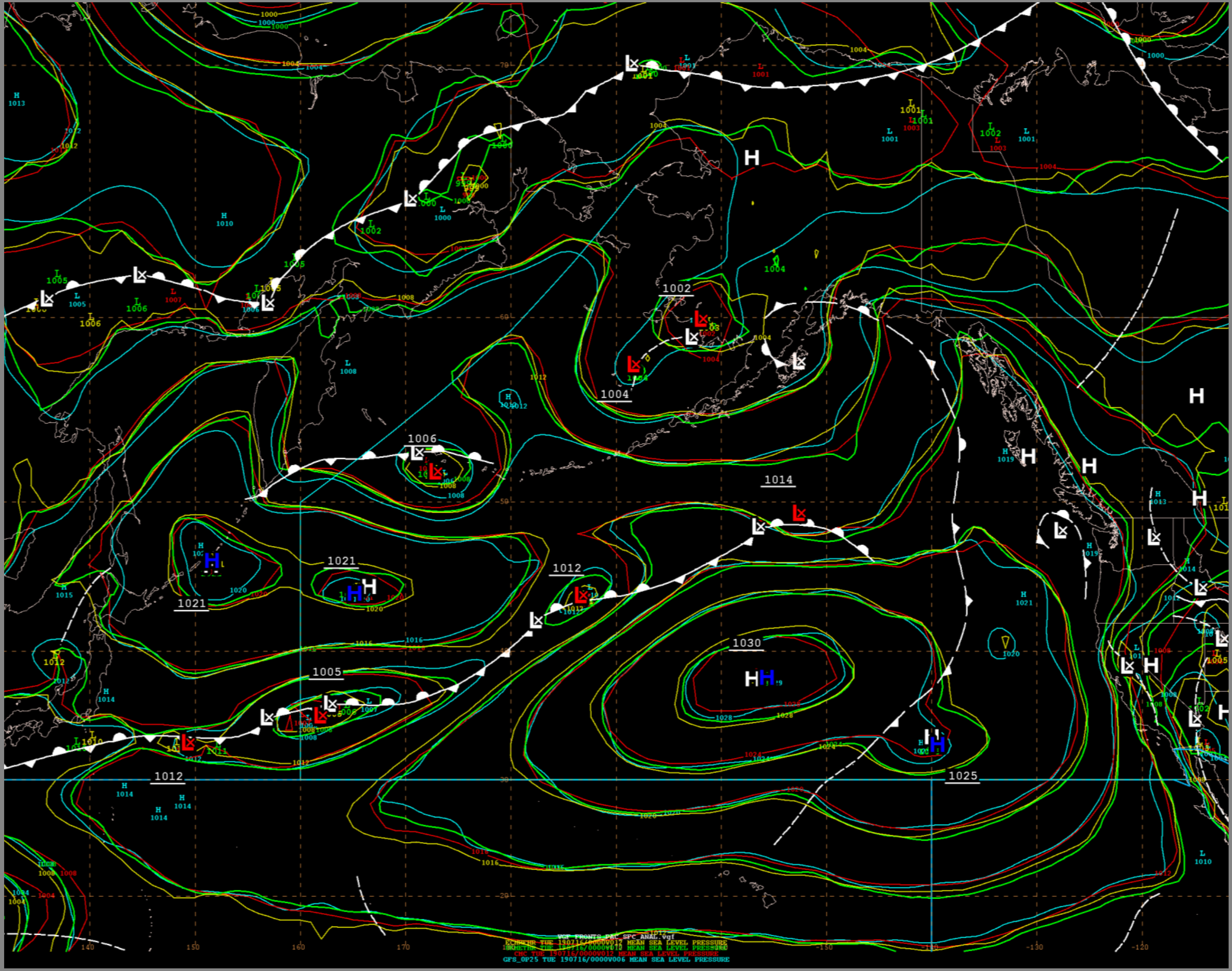






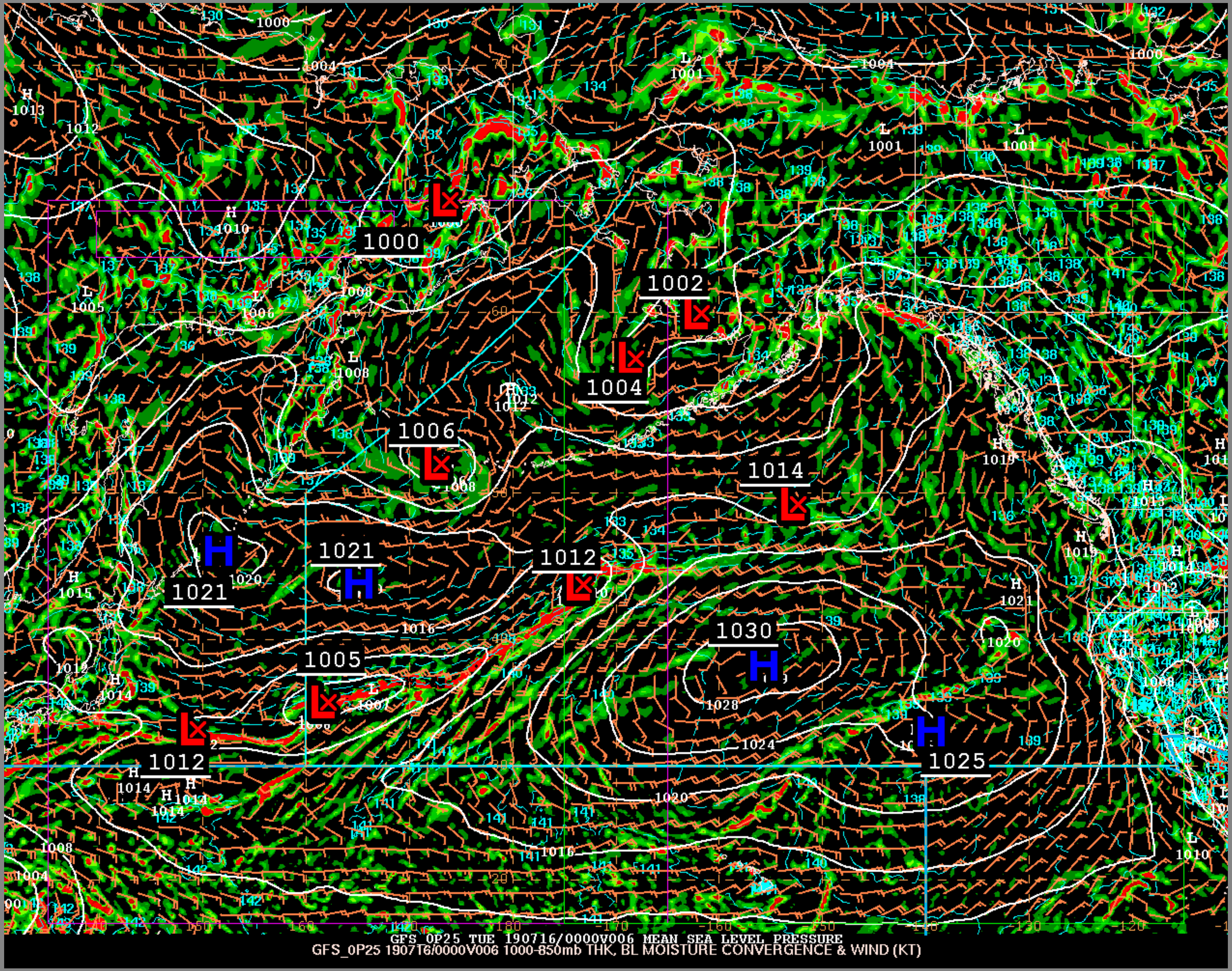
Surface Analysis – Method

- Global model initialization and comparison
- Previous analysis in attempt to keep close continuity
- Place first guess highs and lows



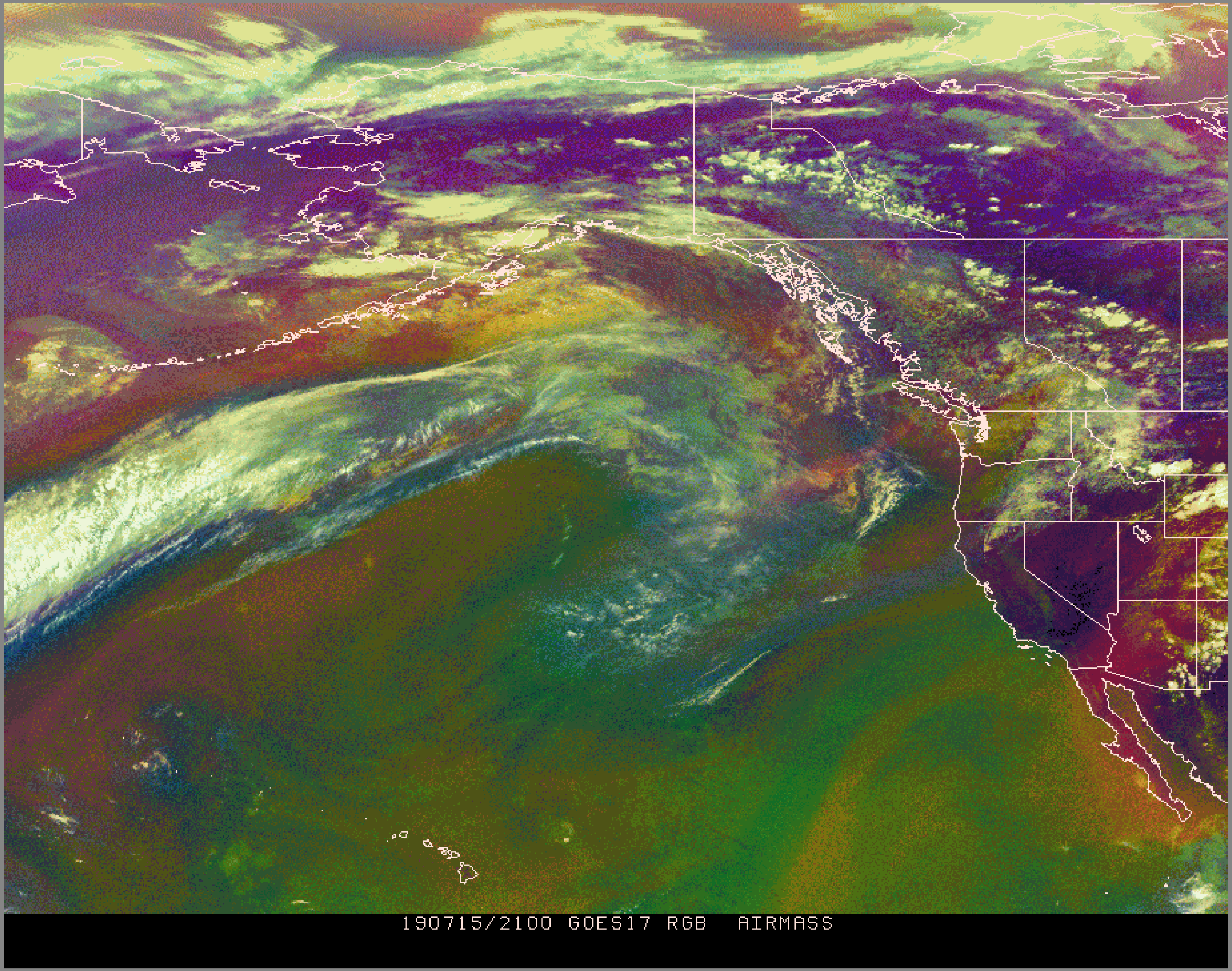
Surface Analysis – Method

- Global model boundary layer moisture convergence and wind, 1000 – 850 mb thickness
- First guess for placement of cold, warm, occluded fronts, and stationary fronts.



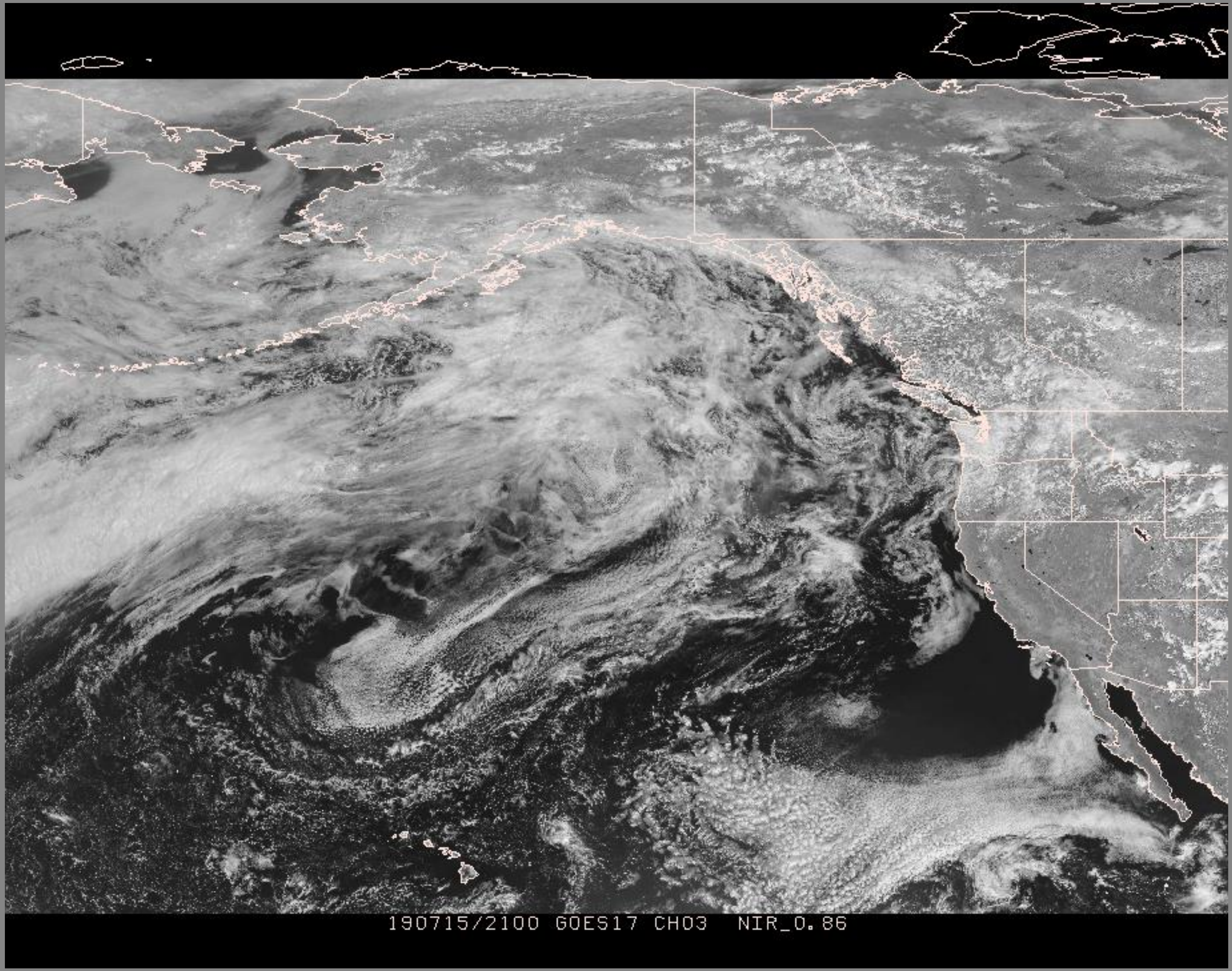
Surface Analysis – Incorporating Satellite

- GOES – 17 Air Mass RGB used to compare mid- and upper-level features



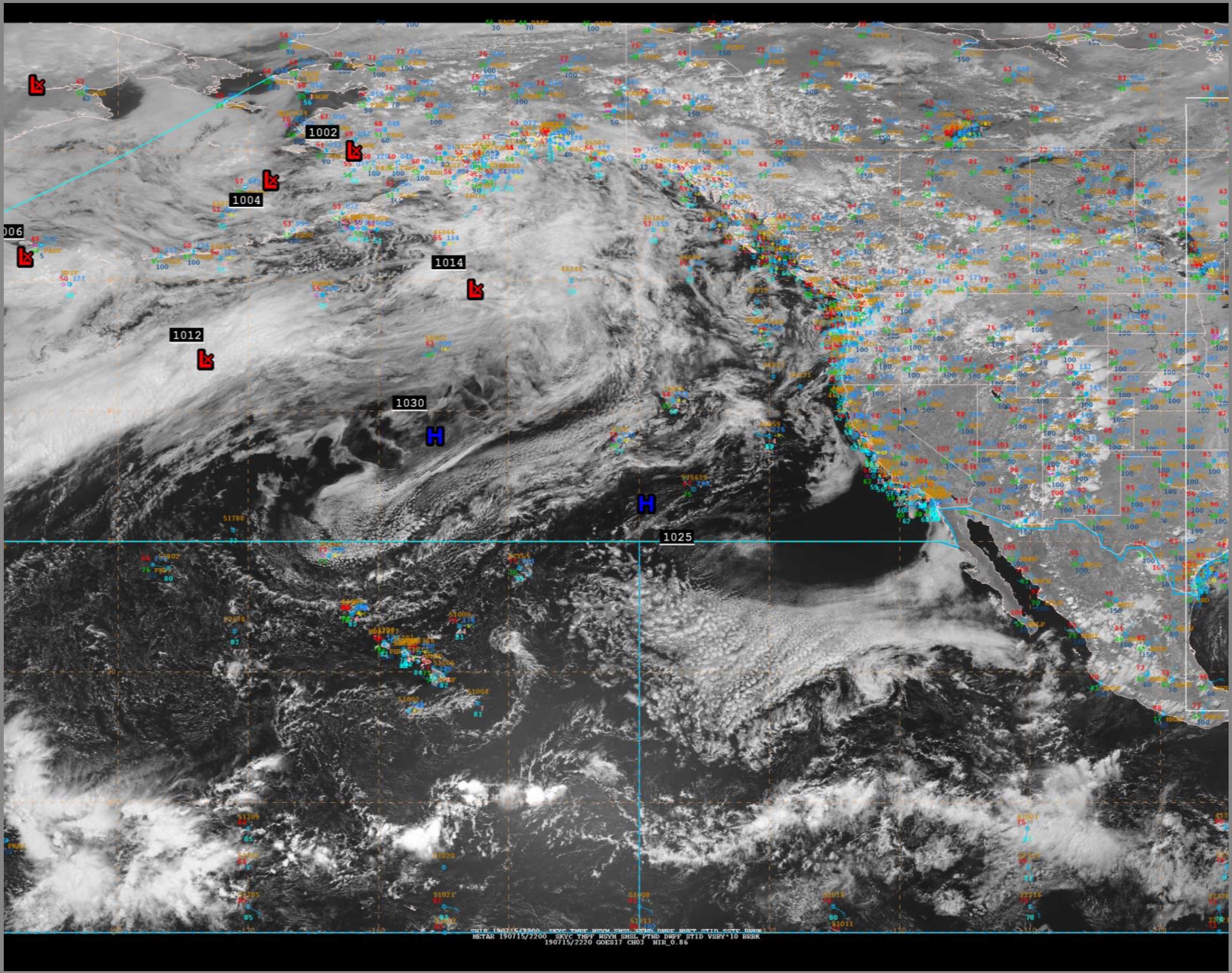
Surface Analysis – Incorporating Satellite

- **GOES – 17 NIR 0.86 µm used to locate low level boundaries and features.**



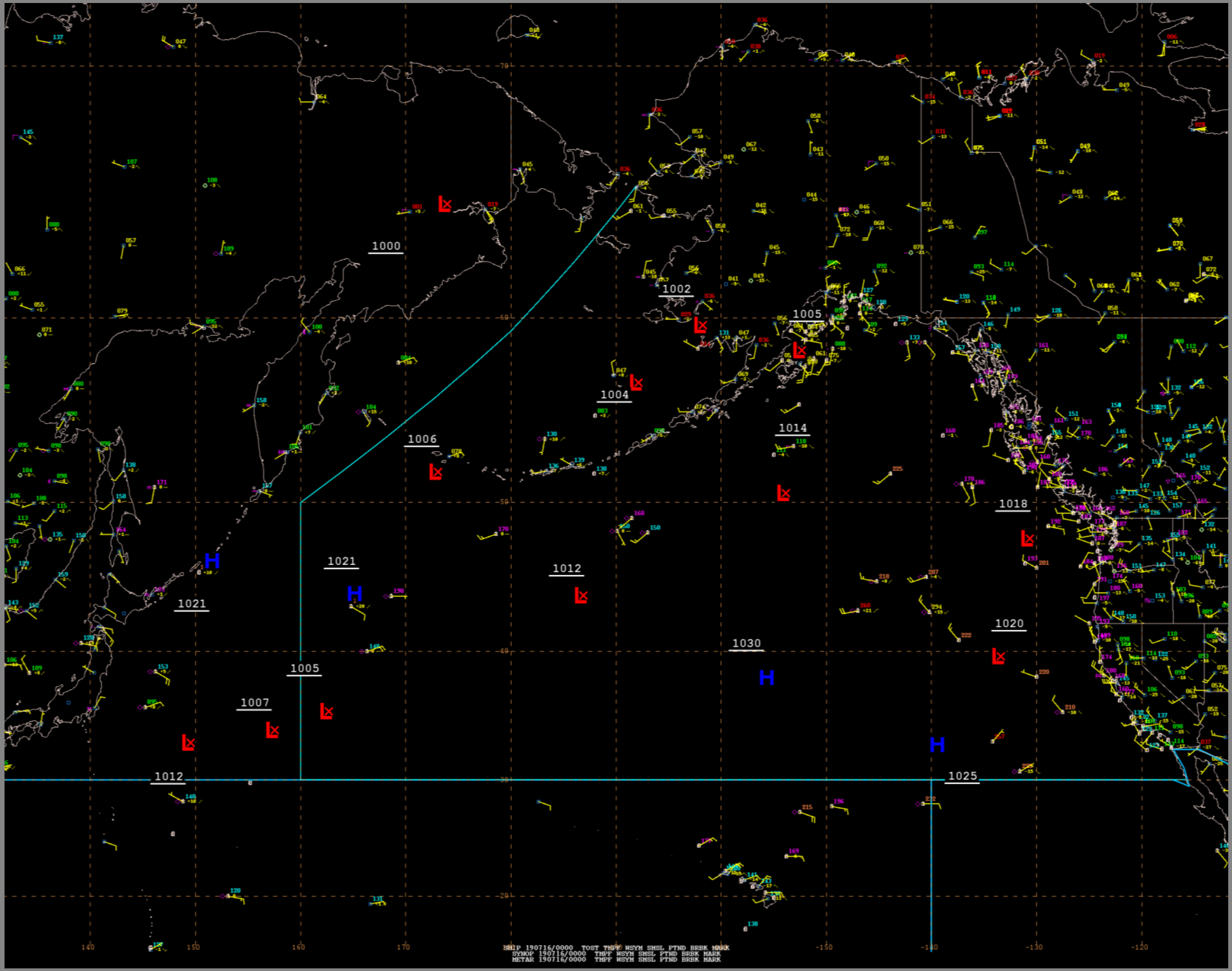
Surface Analysis – Incorporating Satellite

- GOES – 17 NIR 0.86 µm with ship and buoy observations
- Preliminary highs and lows



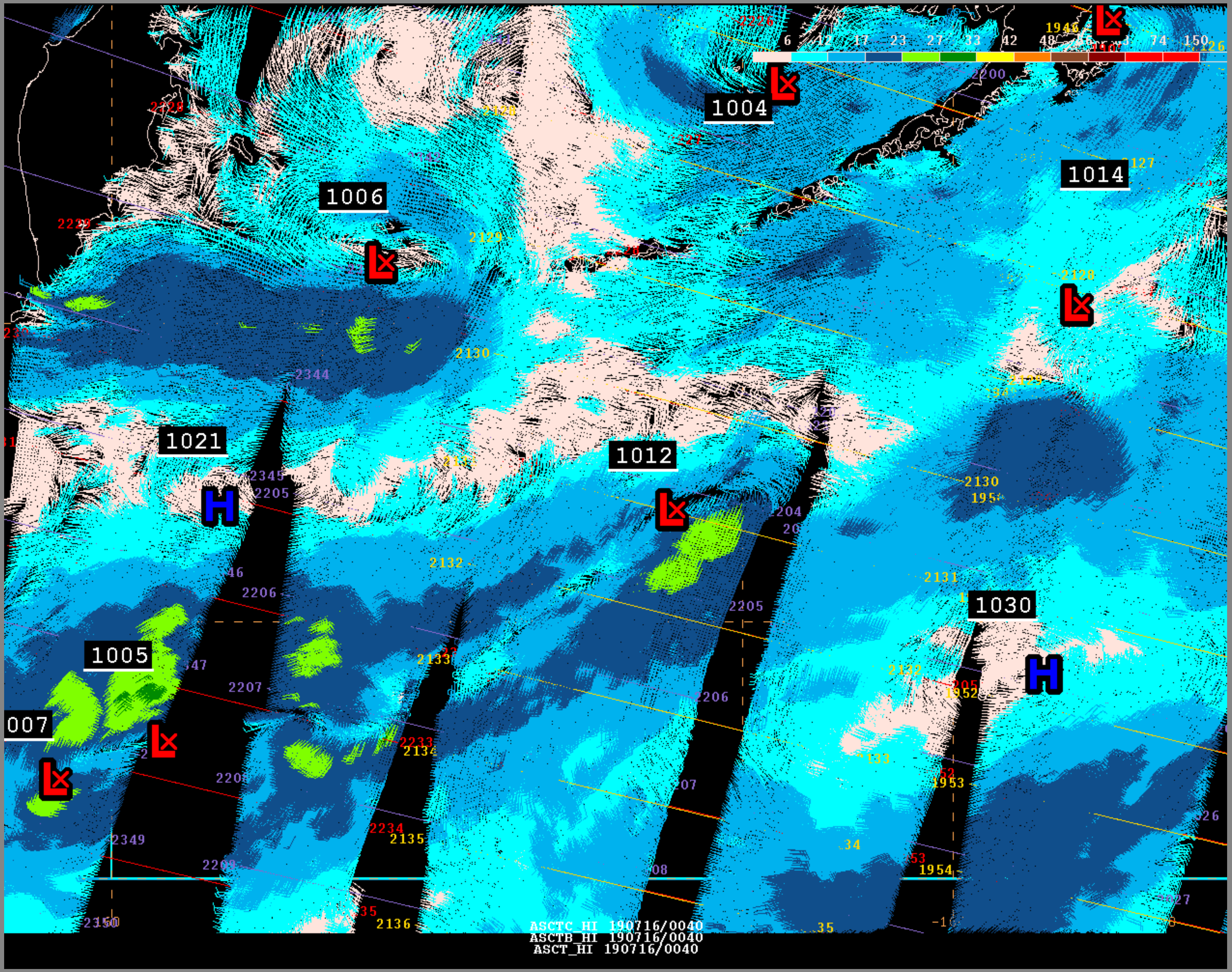
Surface Analysis – Metar Comparison

- Land, Ship, and Buoy observations used to help with the location of the surface features.
  - Note how few observations over ocean!!!!



Surface Analysis – ASCAT (zooming in)

- Ascat -A, -B, and -C
- Preliminary highs and lows
  - Notice the circulation hidden by high clouds, but evident in ASCAT winds.



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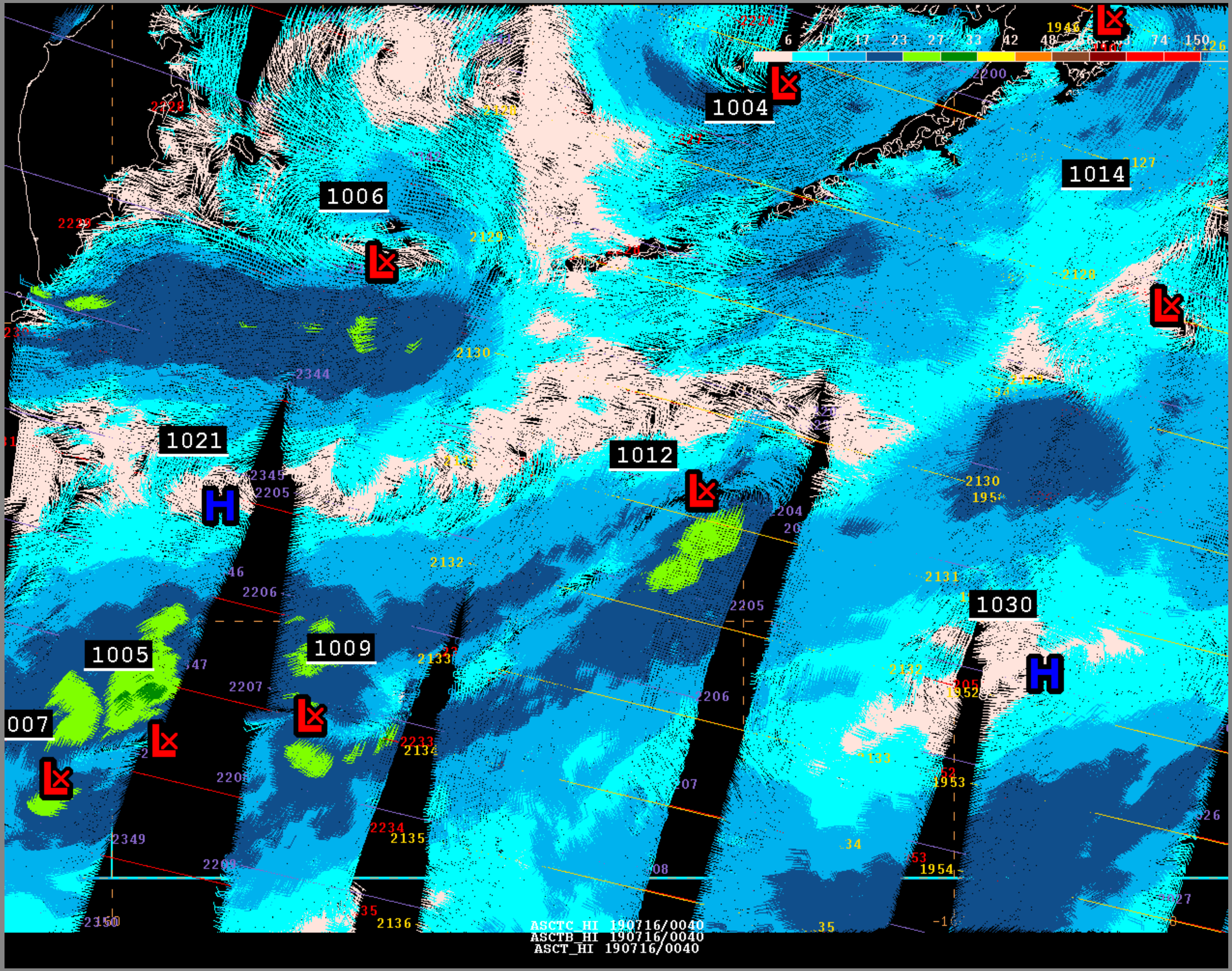
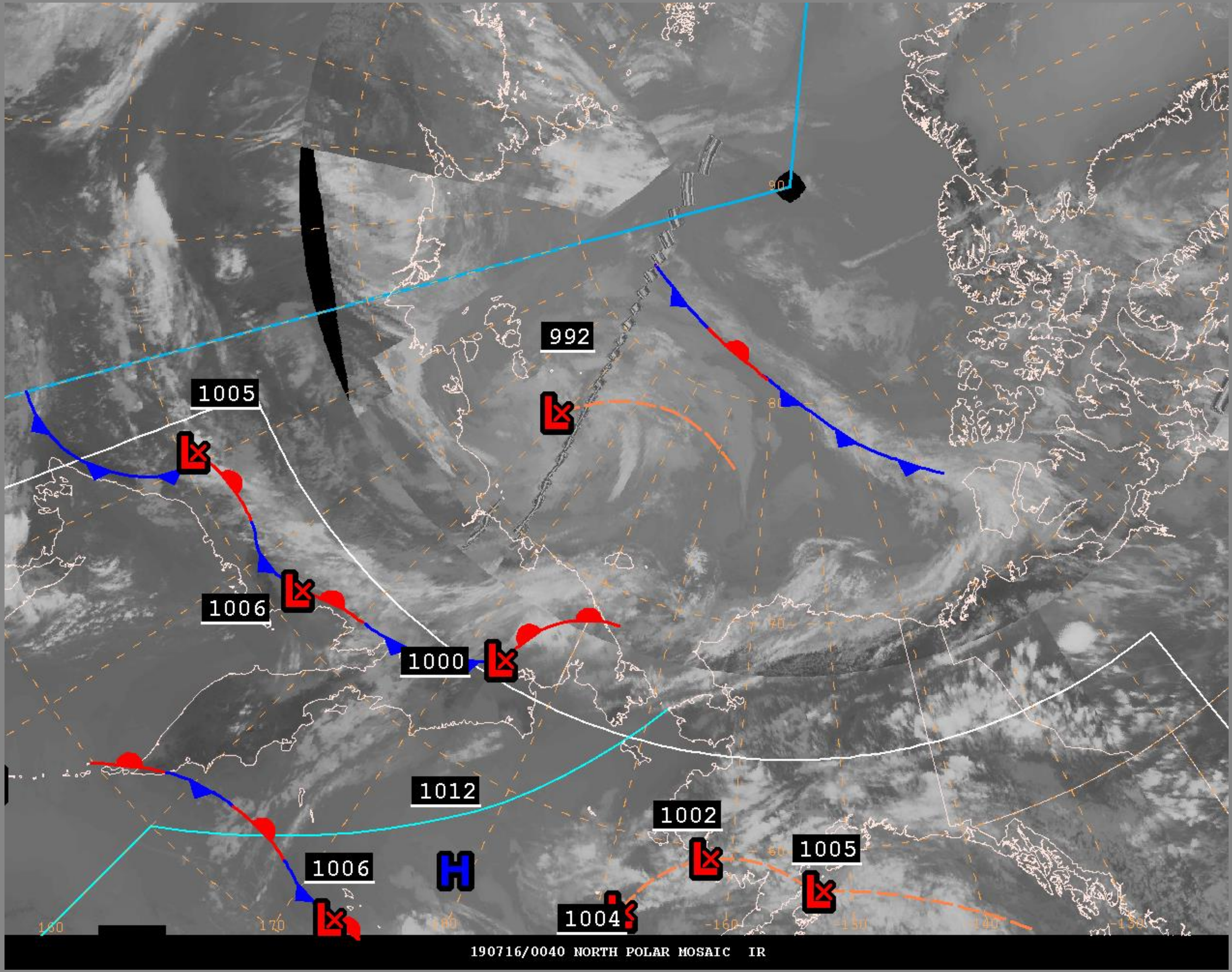


Surface Analysis – Polar Analysis

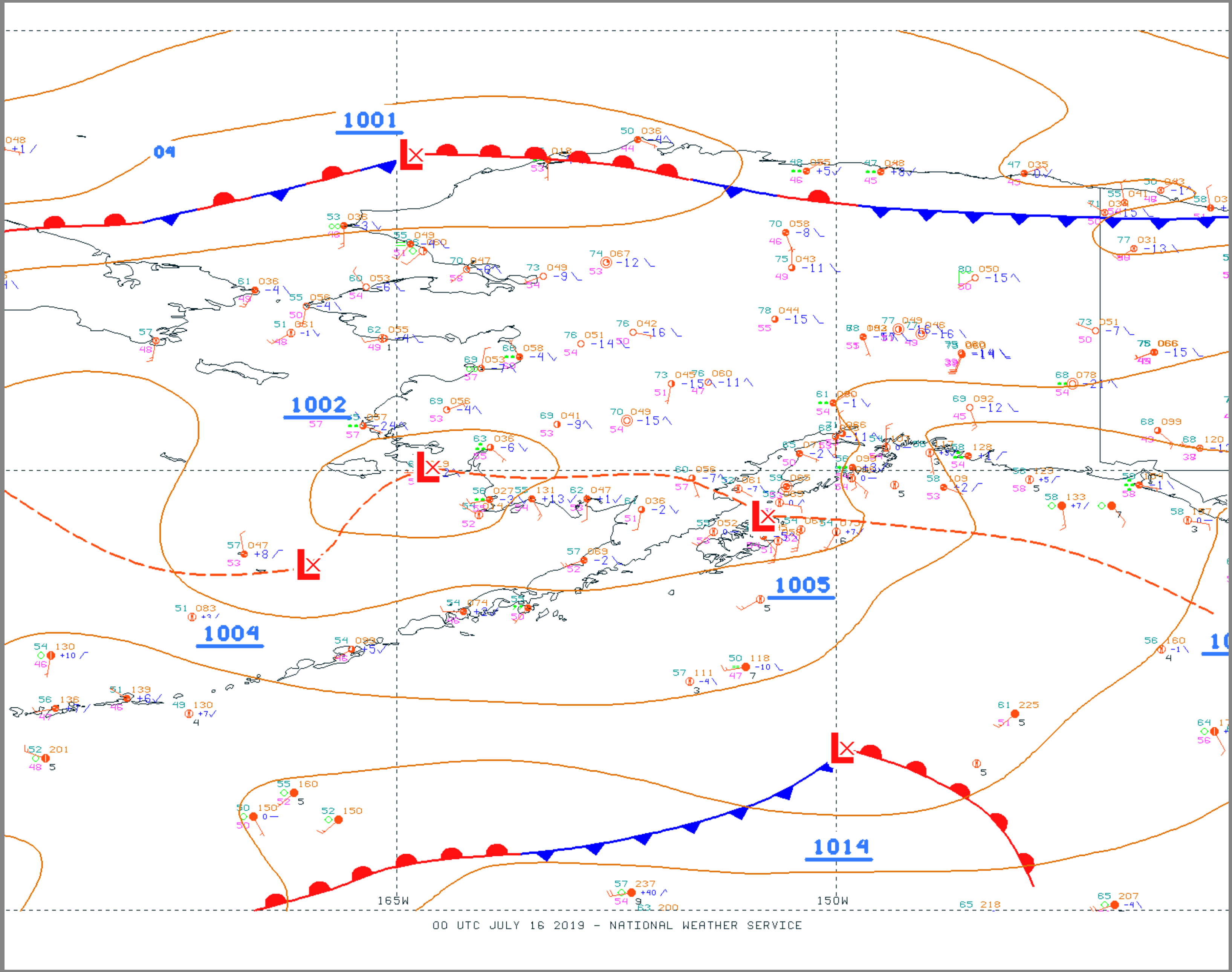
- Mosaic IR (courtesy of AWC – Amanda T) to help time reference polar passes with the geostationary imagery.

- By animating the imagery and referencing your favorite objective analysis, features are then added to Polar region bounded by the blue lines.



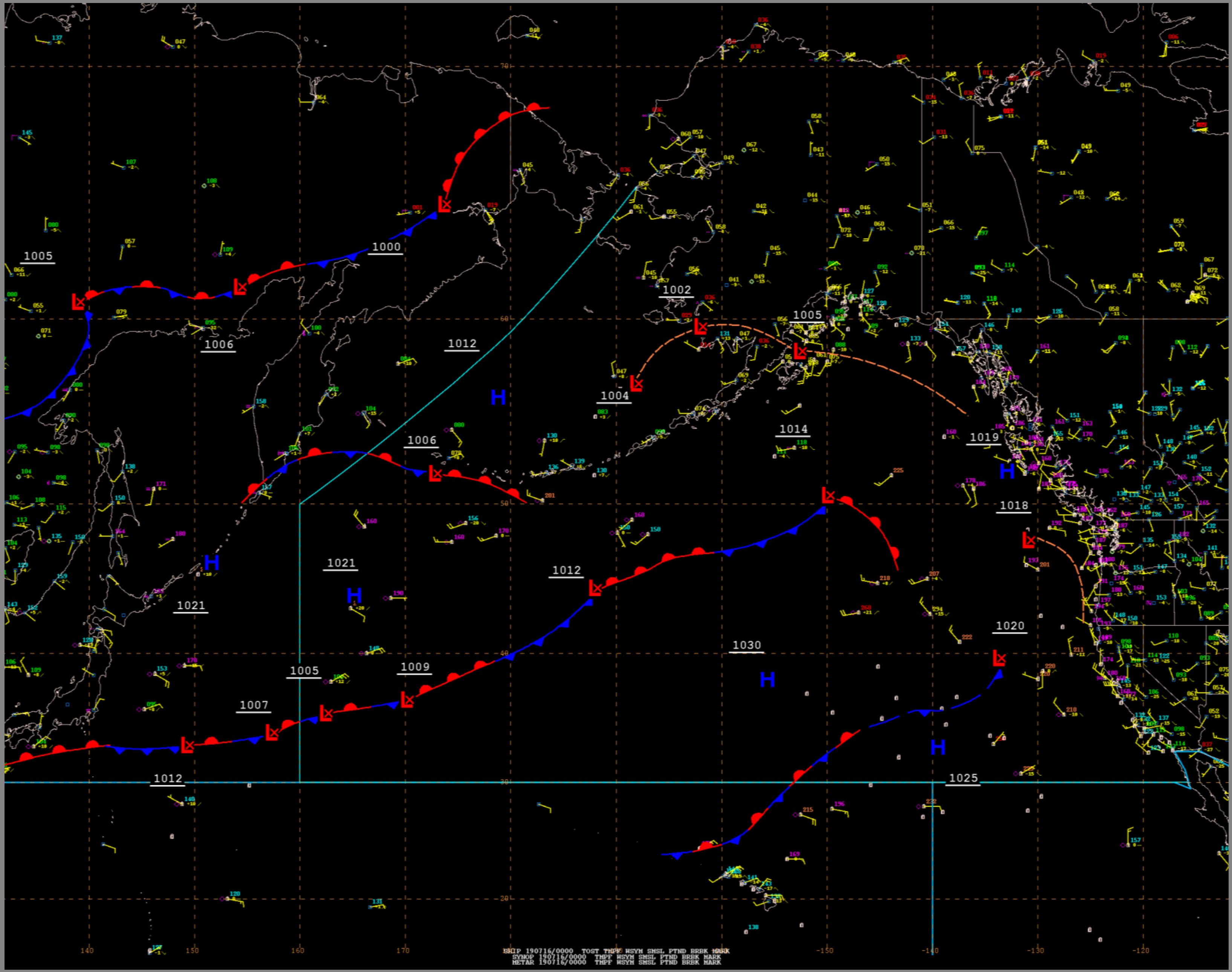
Surface Analysis – Polar Analysis

- Sample final product of the Alaska portion of the map.

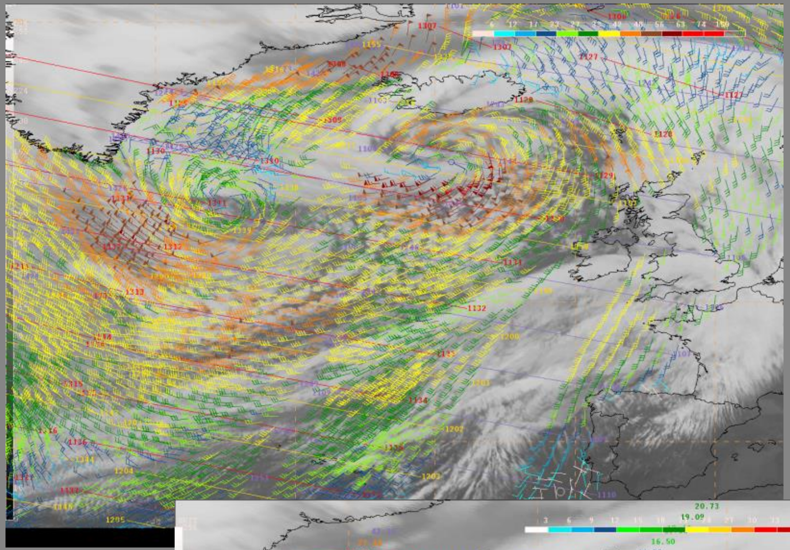


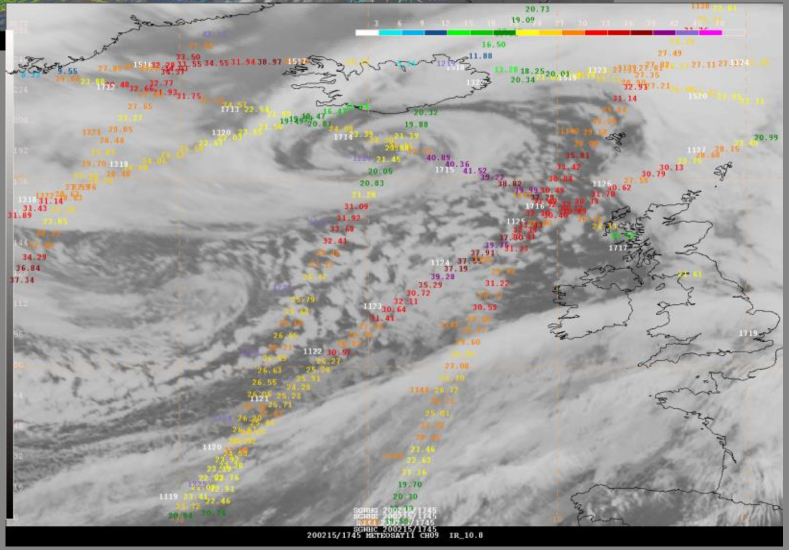
Surface Analysis – METARS and Isobars

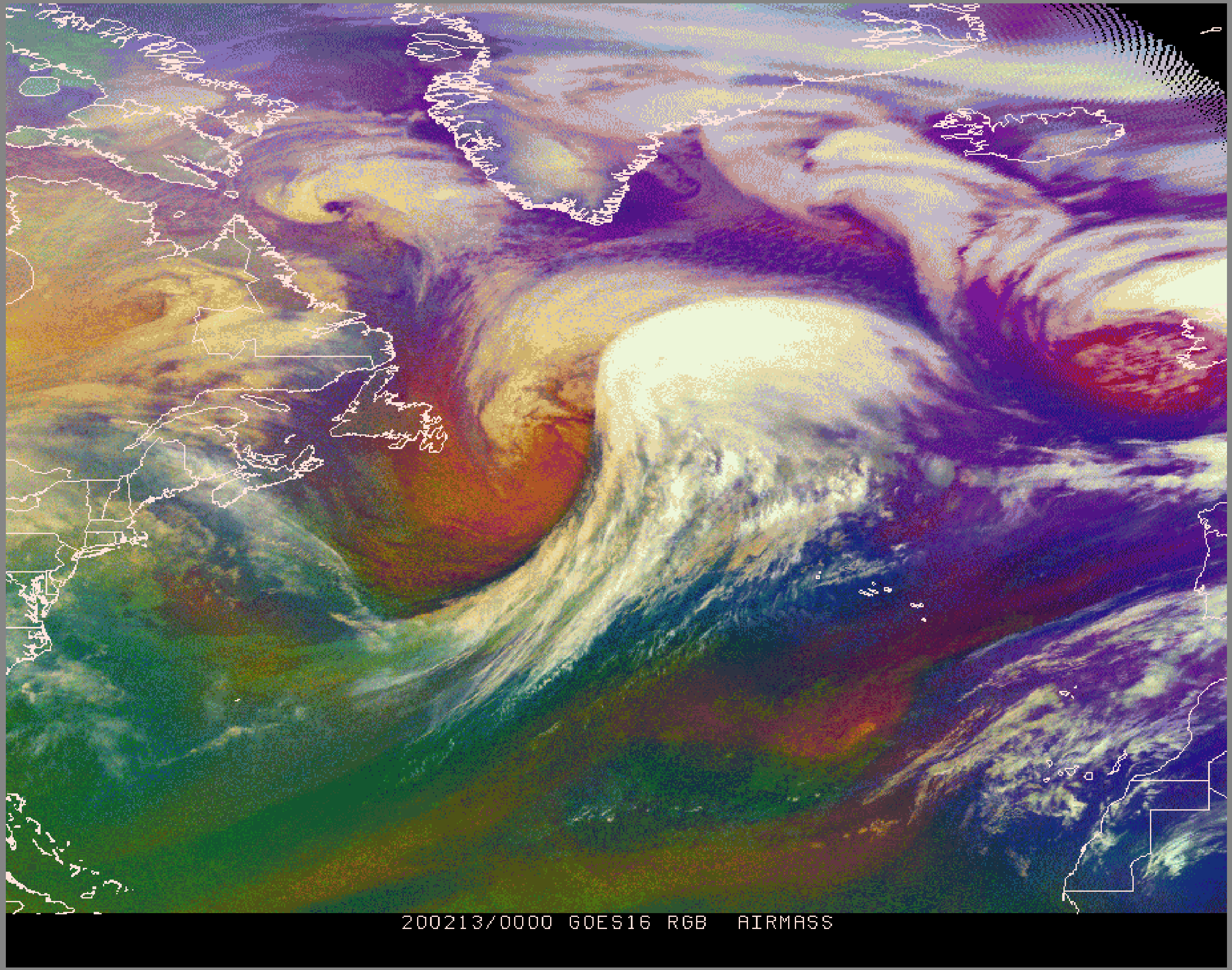
- The final stages including going back to the METARS and adding the objective analysis-based isobars (unless you want to draw them manually).



Stormy North Atlantic 02/13/20 – 02/15/20



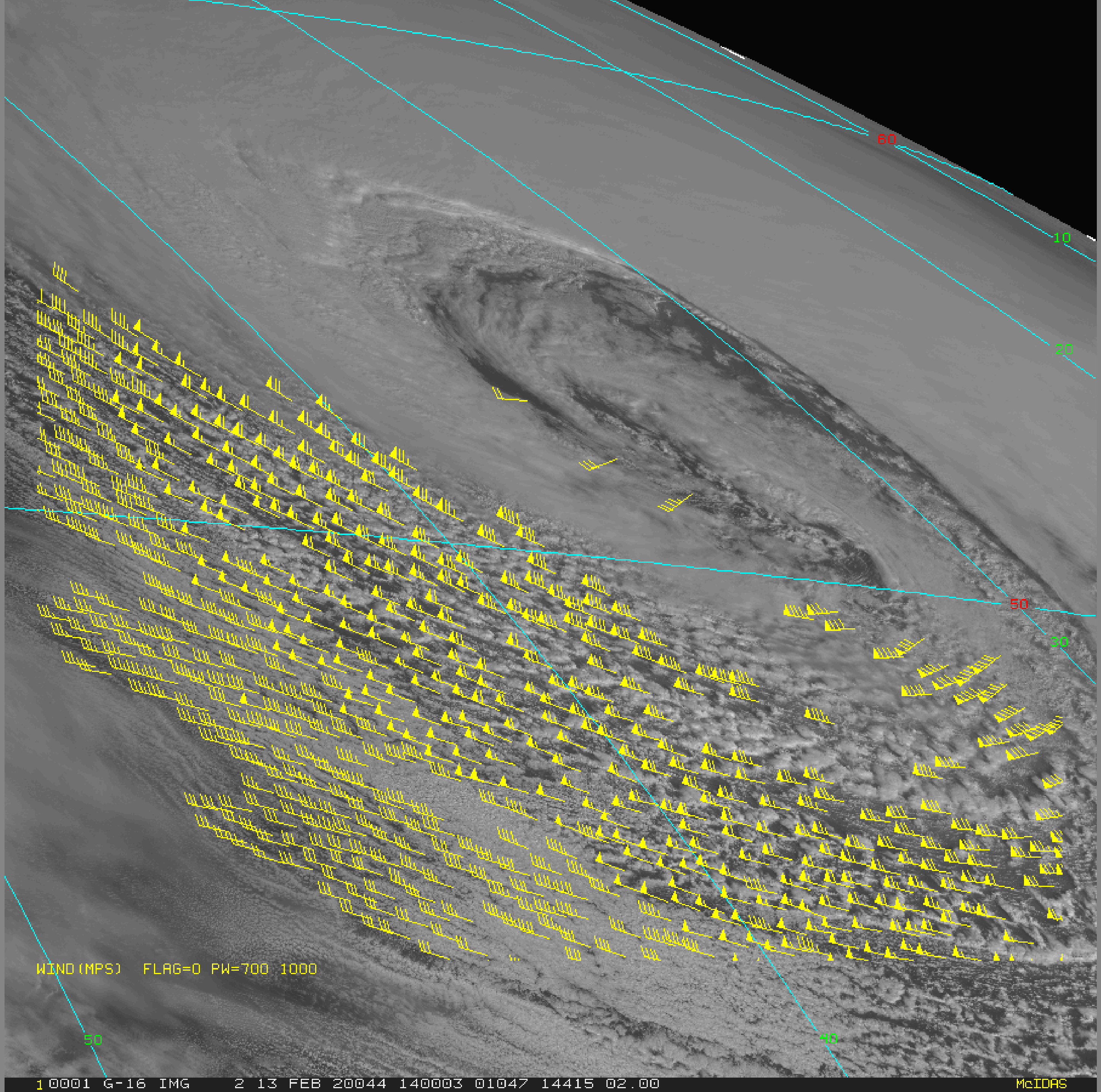




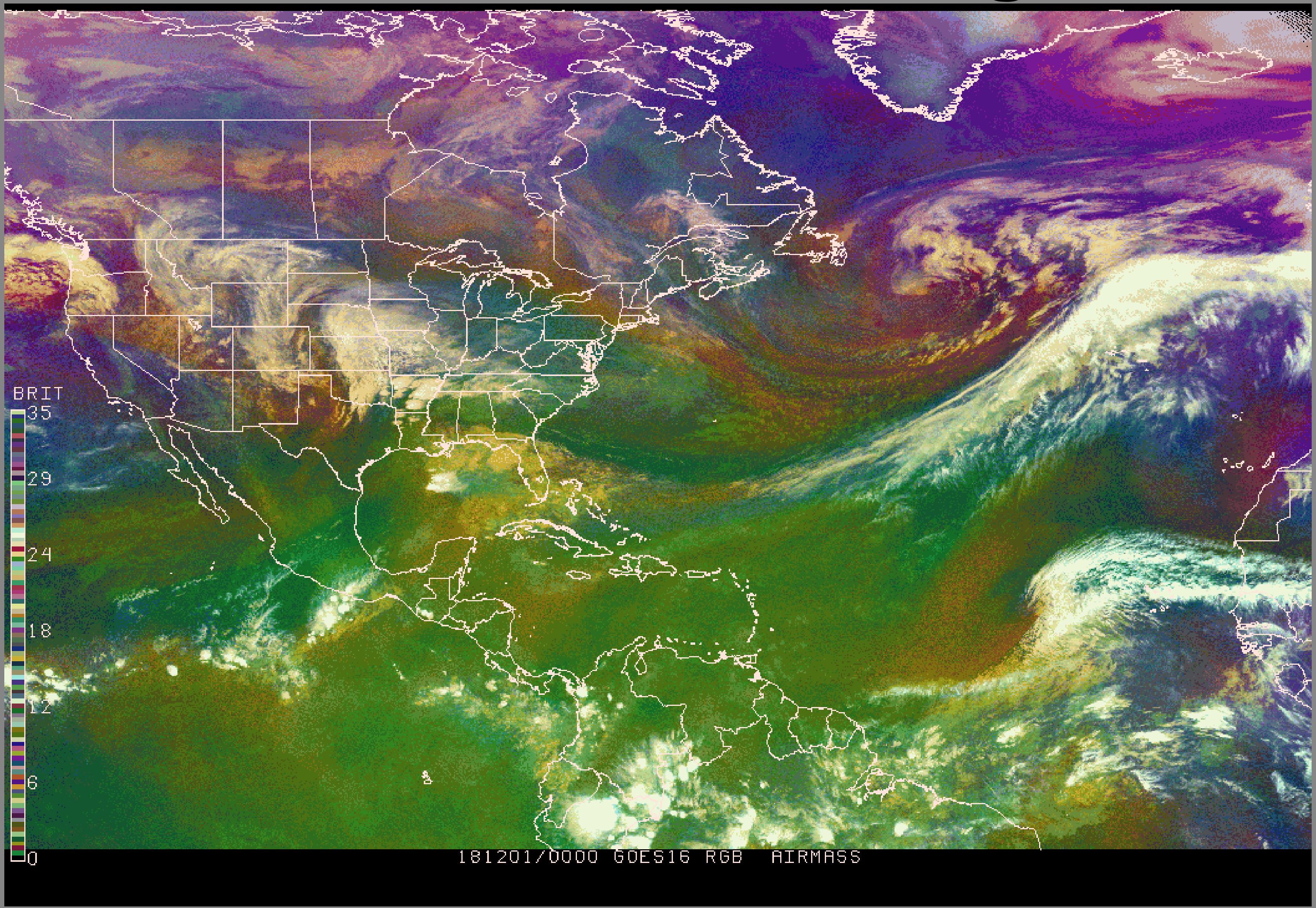
https://satelliteliaisonblog.com/2020/02/16/north-atlantic-storminess-february-13-15-2020/

Near-Storm Analysis– Future Use of AMVs

- Could lower level AMVs be used in conjunction with available ASCAT data to estimate wind speed?
- Use AMVs to compare with NWP on jets?



Questions?
michael.folmer@noaa.gov



Cloud Base and Cloud Cover/Layers

Y. J. Noh, Steve Miller, John Haynes, Curtis Seaman, John Forsythe

(CIRA/Colorado State University)

Andy Heidinger (NOAA/NESDIS/STAR)

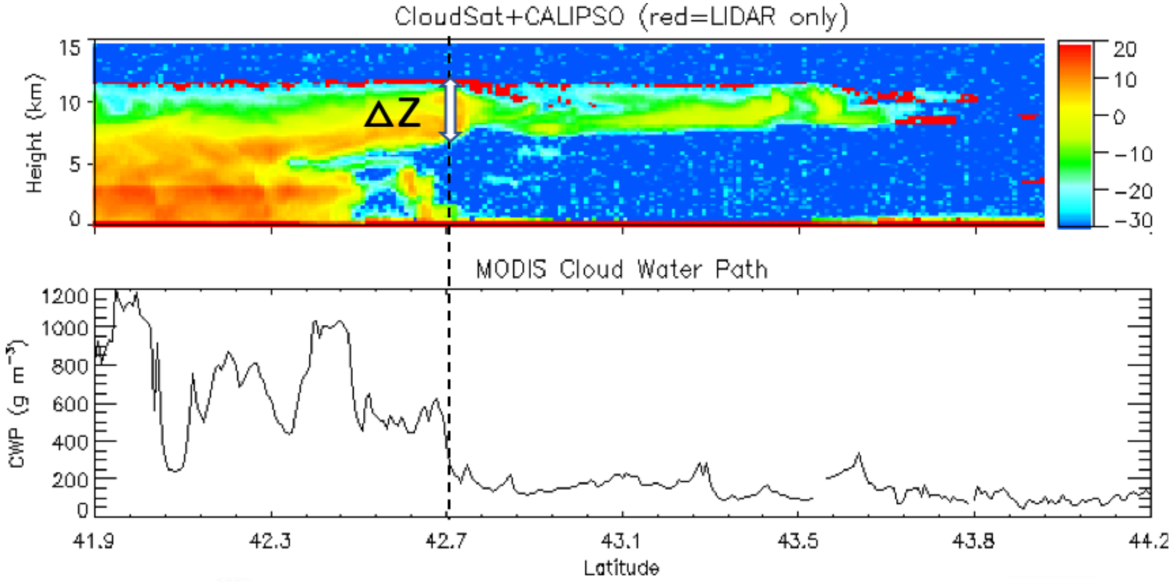
Yue Li, Steve Wanzong, William Straka (CIMSS)

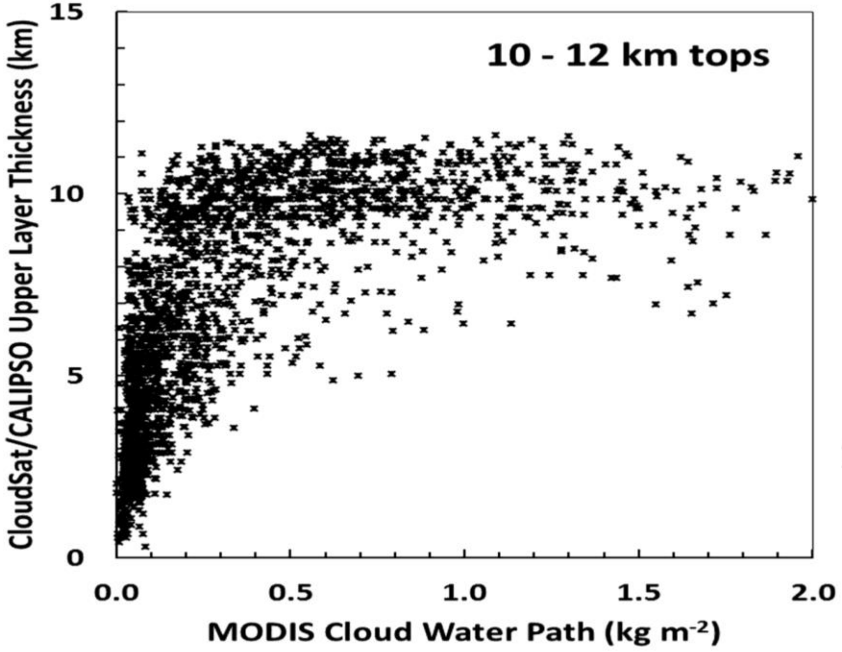
Thanks to our collaborators and Alaska users:

Jeff Weinrich (NOAA JPSS Aviation Initiative), Tom George (Aircraft Owners & Pilots Association), Adam White (Alaska Airmen Assoc.), Nadia Smith and Rebekah Esmaili (STCNET), Carl Dierking and Jay Cable (GINA)

yjnoh@colostate.edu

Cloud Base Height Algorithm



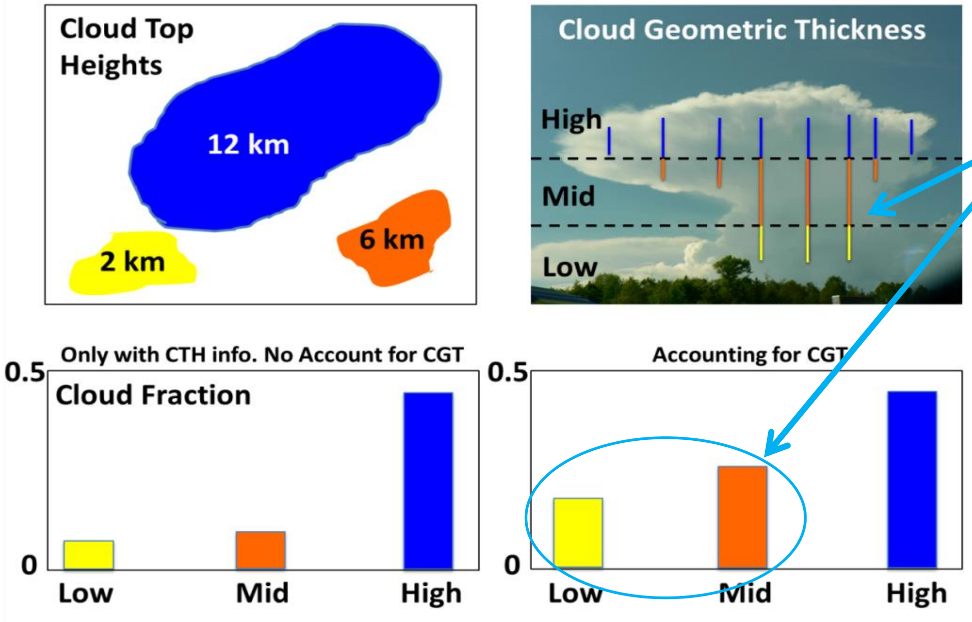


- Information of 3-D cloud structure is significant, but Cloud Base Height (CBH) retrieval is challenging to passive radiometers
- Developed a CBH/CGT algorithm constrained by Cloud Top Height (CTH) and Cloud Water Path (CWP) using a statistical analysis of A-Train satellite data (*Noh et al. 2017 JTECH*)

CBH = CTH – ΔZ **(CGT; Cloud Geometric Thickness)**

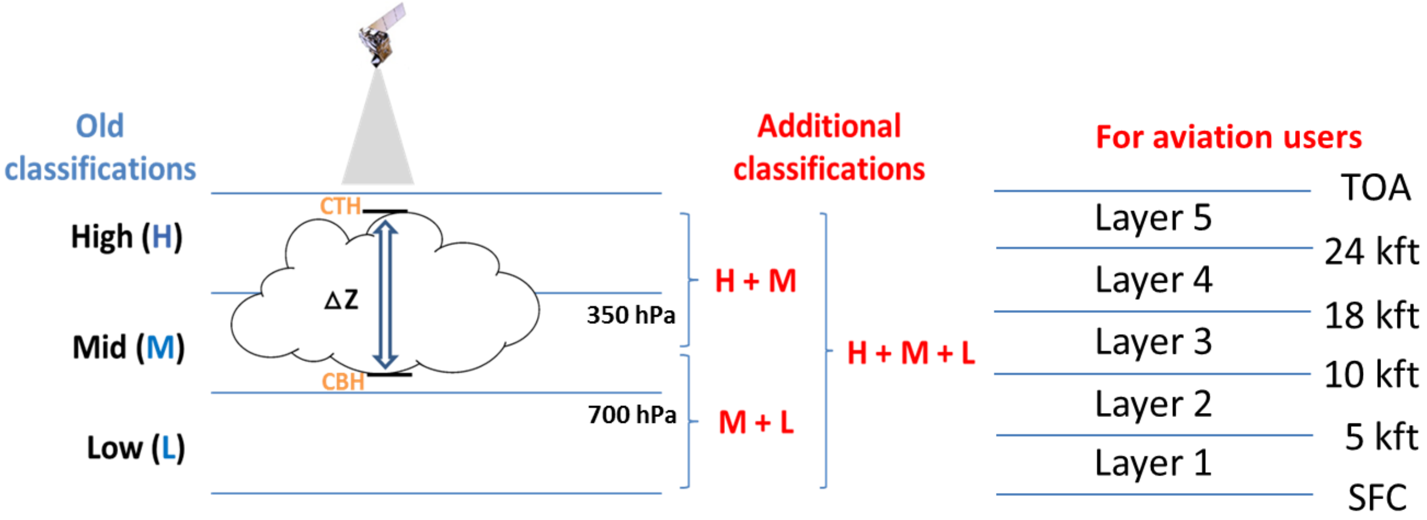
- Applied to S-NPP VIIRS and intensively validated against CloudSat/CALIPSO (outperforms the old operational algorithm)
- Now operational as part of the NOAA Enterprise Cloud Algorithm
  - ✓ JPSS Validated Maturity Review in May 2019, v2r1 data publically available at NOAA CLASS
  - ✓ Not yet operational for GOES ABI

Improvement of Cloud Cover Layers with CBH



Enhance lower cloud layer fractions by introducing additional cloud coverage hidden below cloud top

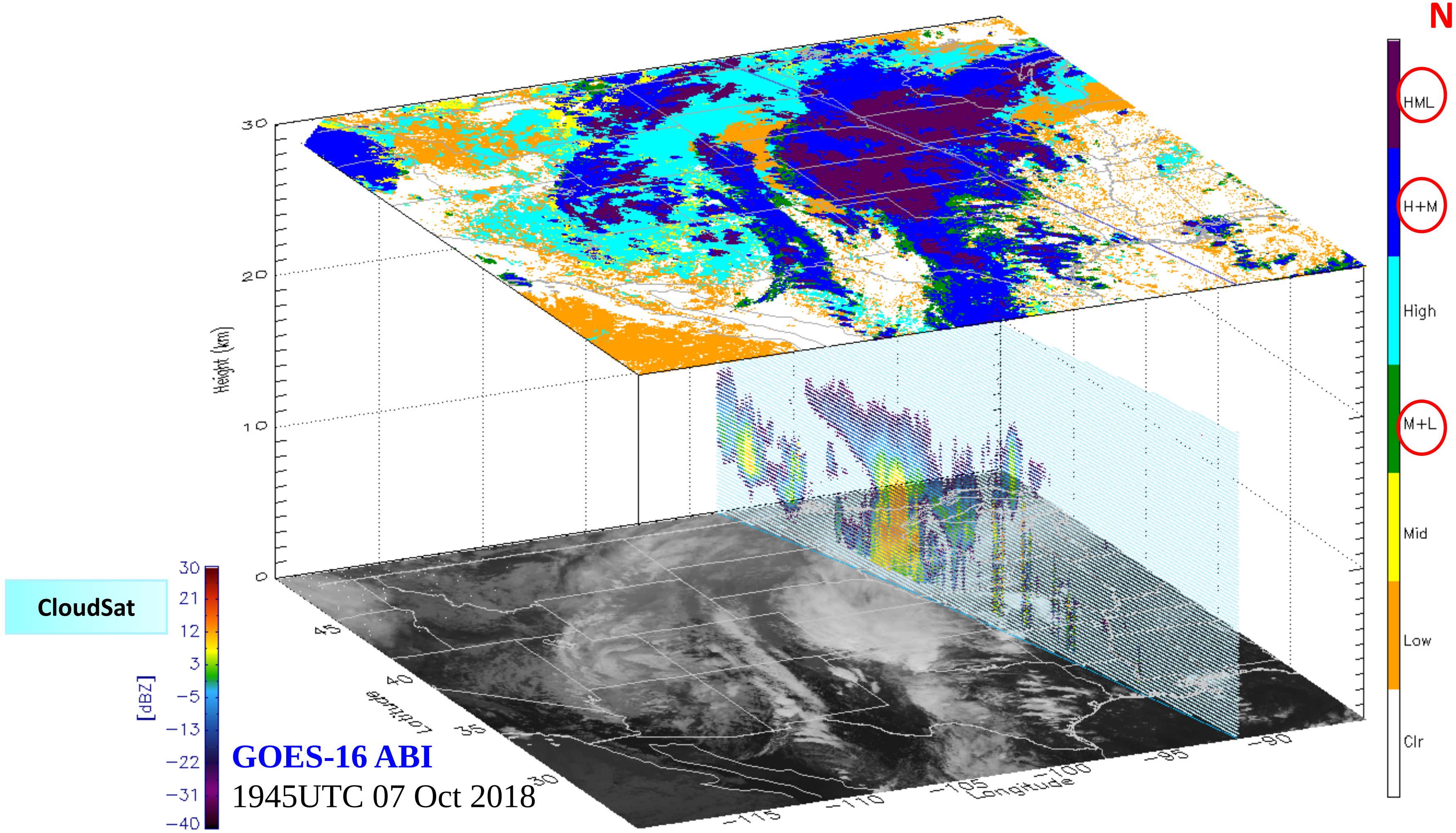
- High and low layer thresholds: 642 hPa, 350 hPa
- Expansion from 3 layers –> 5 flight level-based layers for operational users (5–24 kft & up)
  - ✓ Testing for VIIRS (available at CIRA's Polar SLIDER)



Improvement of Cloud Cover Layers with CBH

- **Applicable to both polar and geostationary satellite sensors (JPSS VIIRS and GOES-16/17 ABI)**
- Real-time display for the products available in CIRA's SLIDER (http://rammb-slider.cira.colostate.edu)

New with CGT



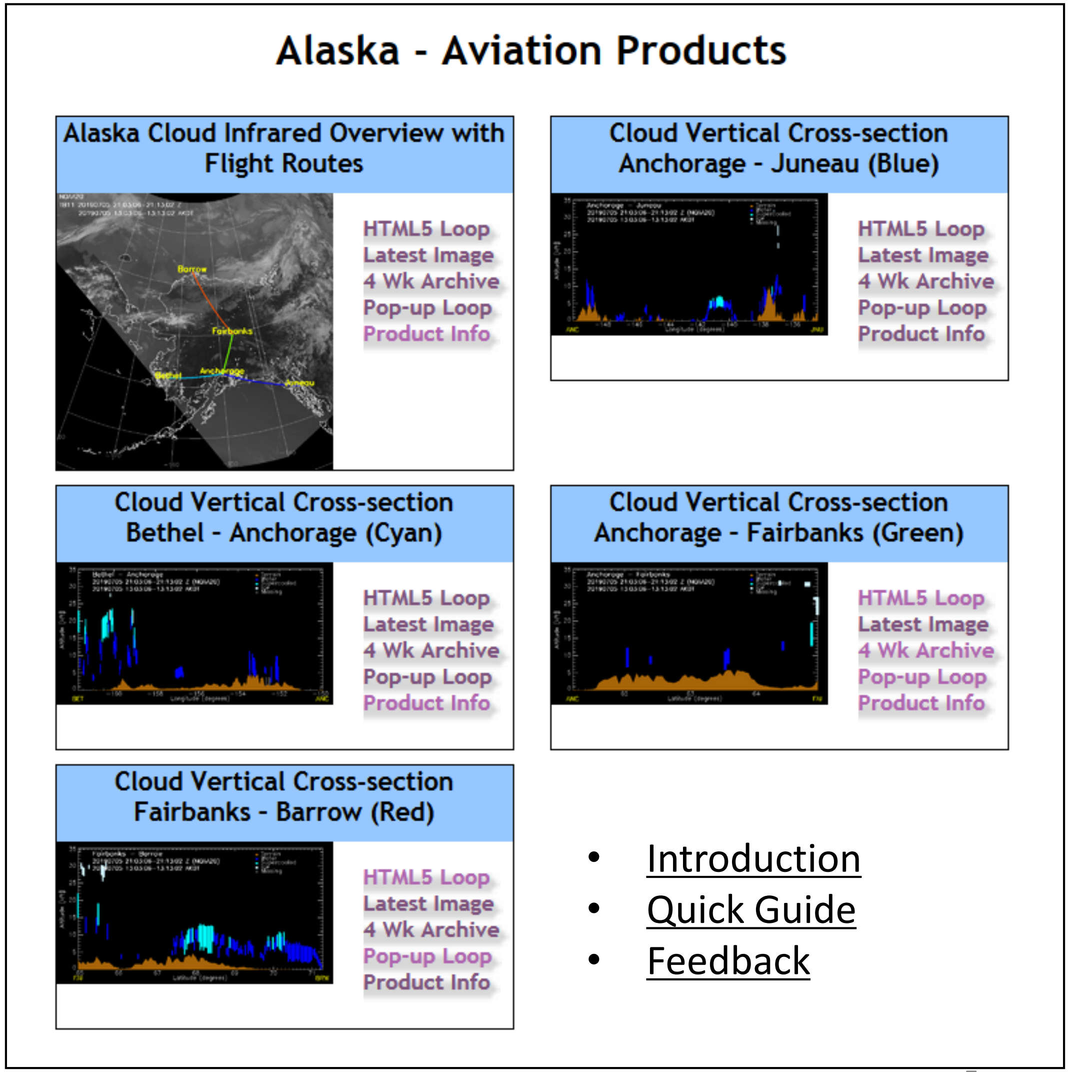
Improved CCL with CBH will be 'ON' for VIIRS soon

Also considered for ABI

VIIRS Cloud Vertical Cross-section products over Alaska

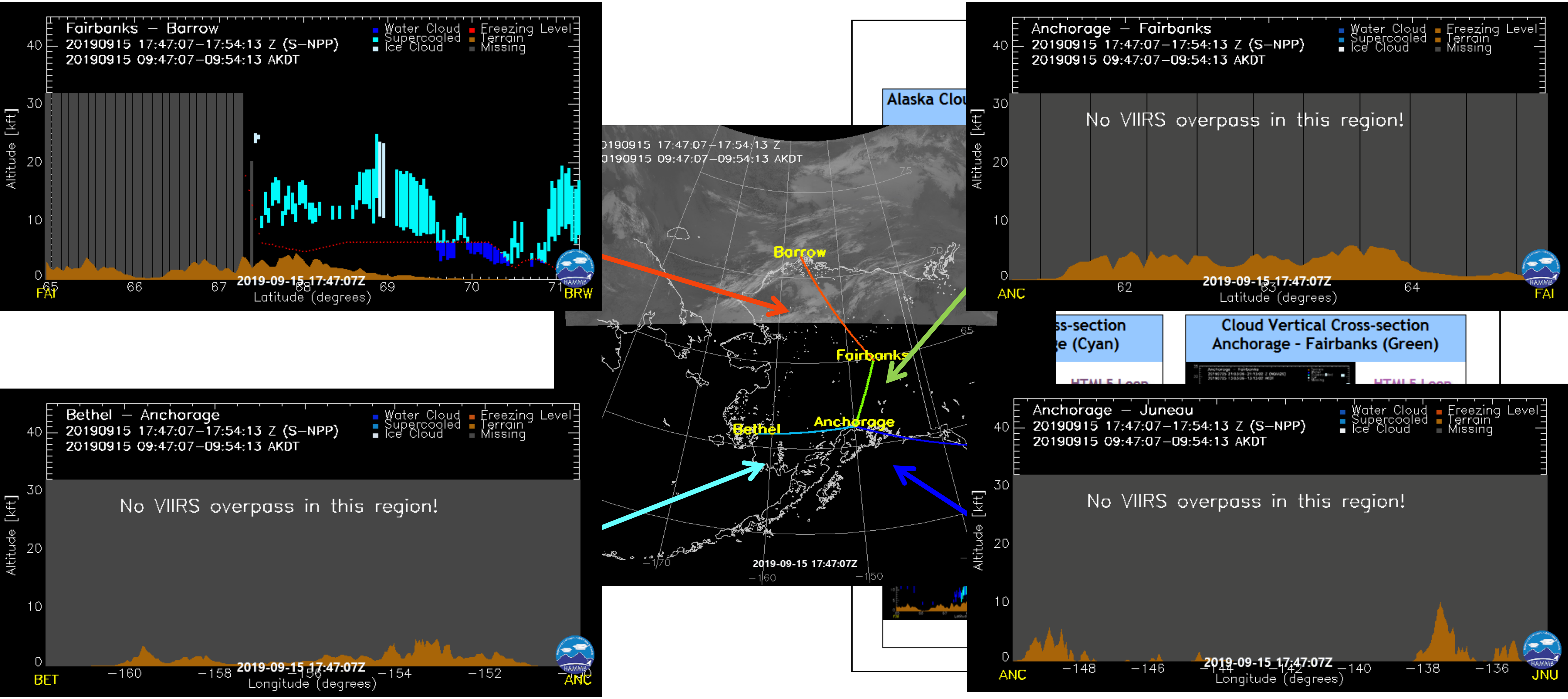
http://rammb.cira.colostate.edu/ramsdis/online/npp_viirs_arctic_aviation.asp

- **Experimental products for aviation users**
  - ✓ NOAA JPSS Aviation Initiative / JPSS Cloud Product Alaska Demonstration
- **Cloud Vertical Cross-sections** (CVC) along flight routes over AK are obtained by connecting Cloud Top and Base Heights from S-NPP and NOAA-20 VIIRS
  - ✓ Colors corresponding to Cloud Top Phase
  - ✓ Freezing Level from NWP + NUCAPS temperature profiles
- Provide training/display tools based on user feedback
  - ✓ User guide and summary documents available
- **Thanks to Aviation users for your active participation!**
  - ✓ Feedback on display and documents, PIREPs
- To be extended to ABI and develop an AWPIS interactive display tool in collaboration with AWC



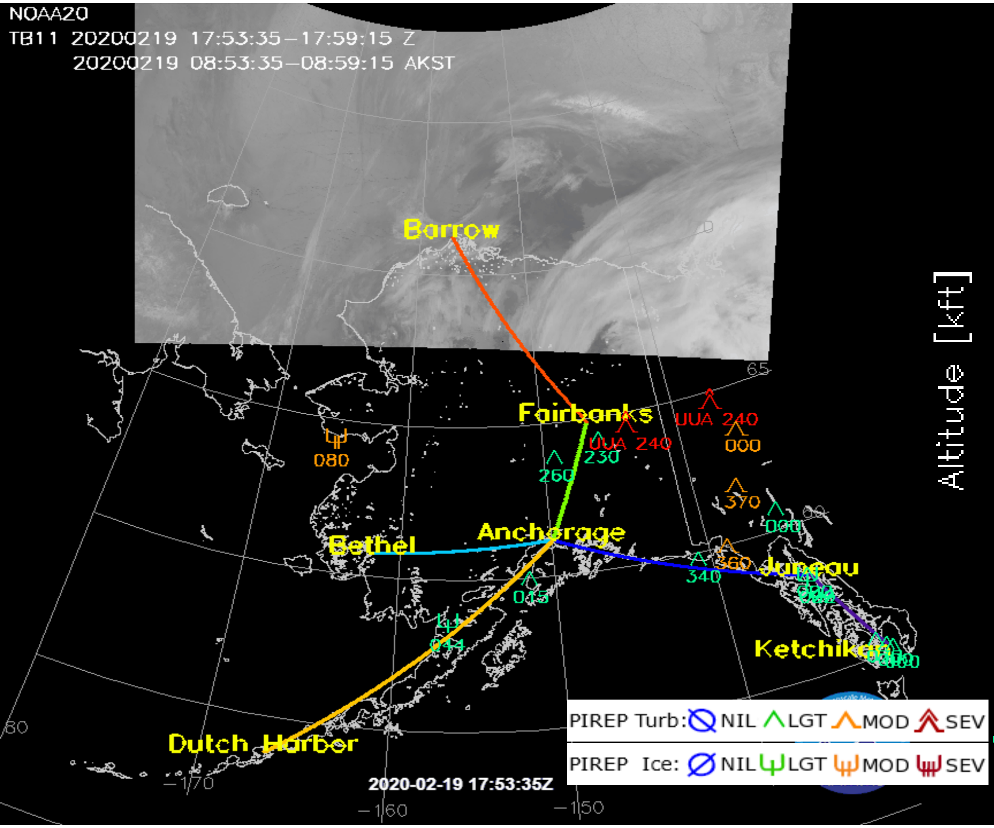
VIIRS Cloud Vertical Cross-section products over Alaska

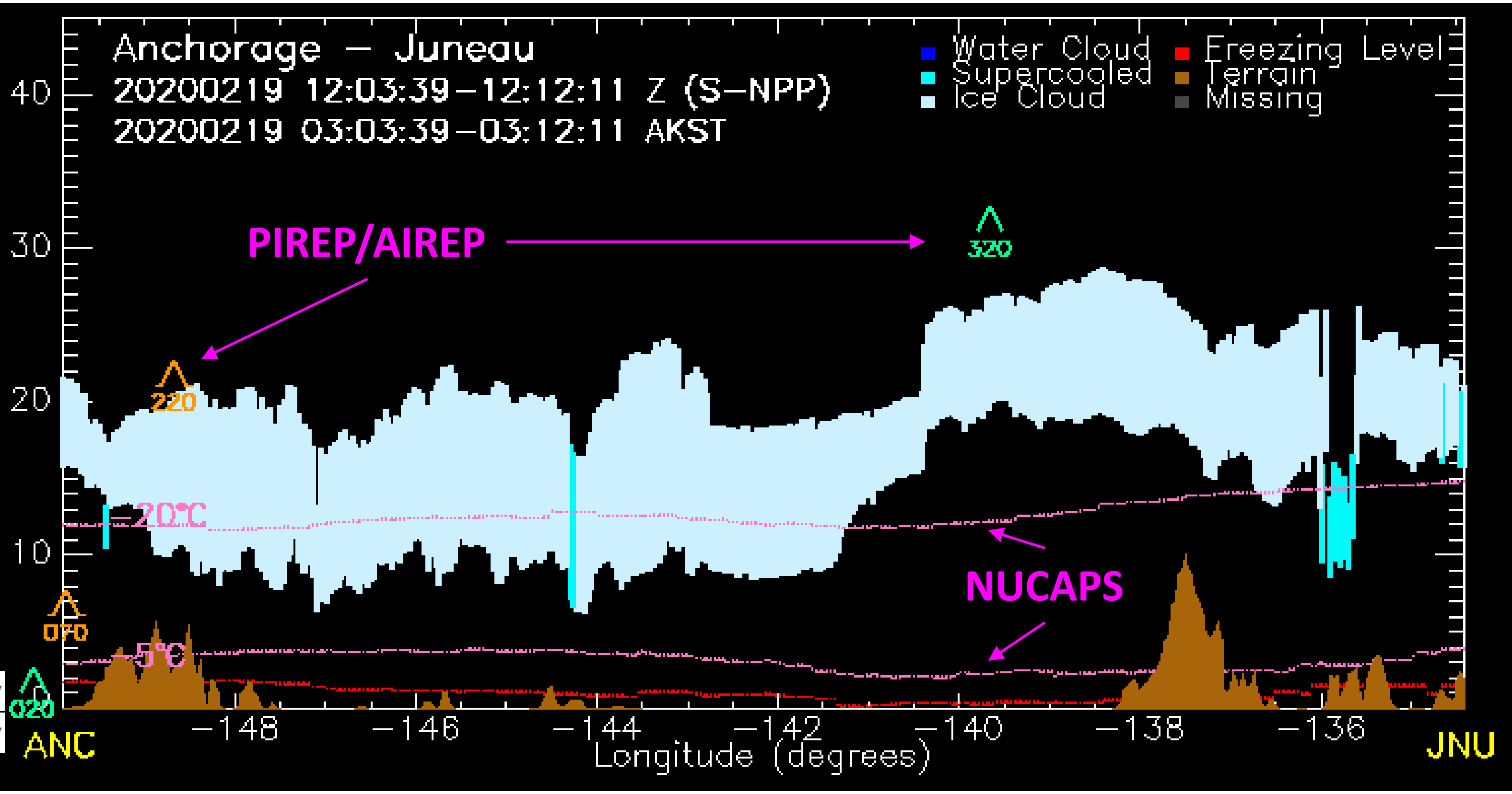
http://rammb.cira.colostate.edu/ramsdis/online/npp_viirs_arctic_aviation.asp



More information can be implemented in this display platform!

(Example with PIREPs and NUCAPS temperatures requested by users)



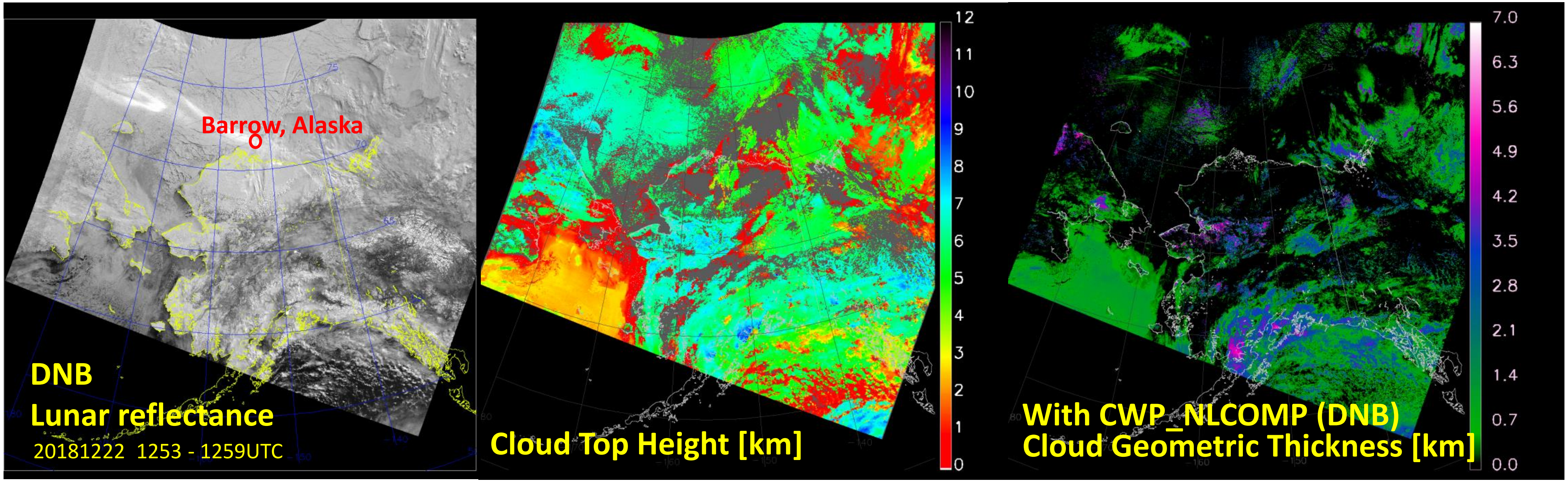


Utilizing VIIRS DNB for Nighttime CBH/CCL

Ongoing Improvements (1) – JPSS PGRR

- Lack of reliable CWP input for CBH at night
- CWP from the NLCOMP (Nighttime Lunar Cloud Optical and Microphysical Properties) algorithm utilizing DNB
- Use NWP as supplementary data, and the use of MIRS-ATMS is ongoing

Example with CWPs [kg/m^2] for a full-moon case over Alaska (1253-1259 UTC on 22 Dec 2018)



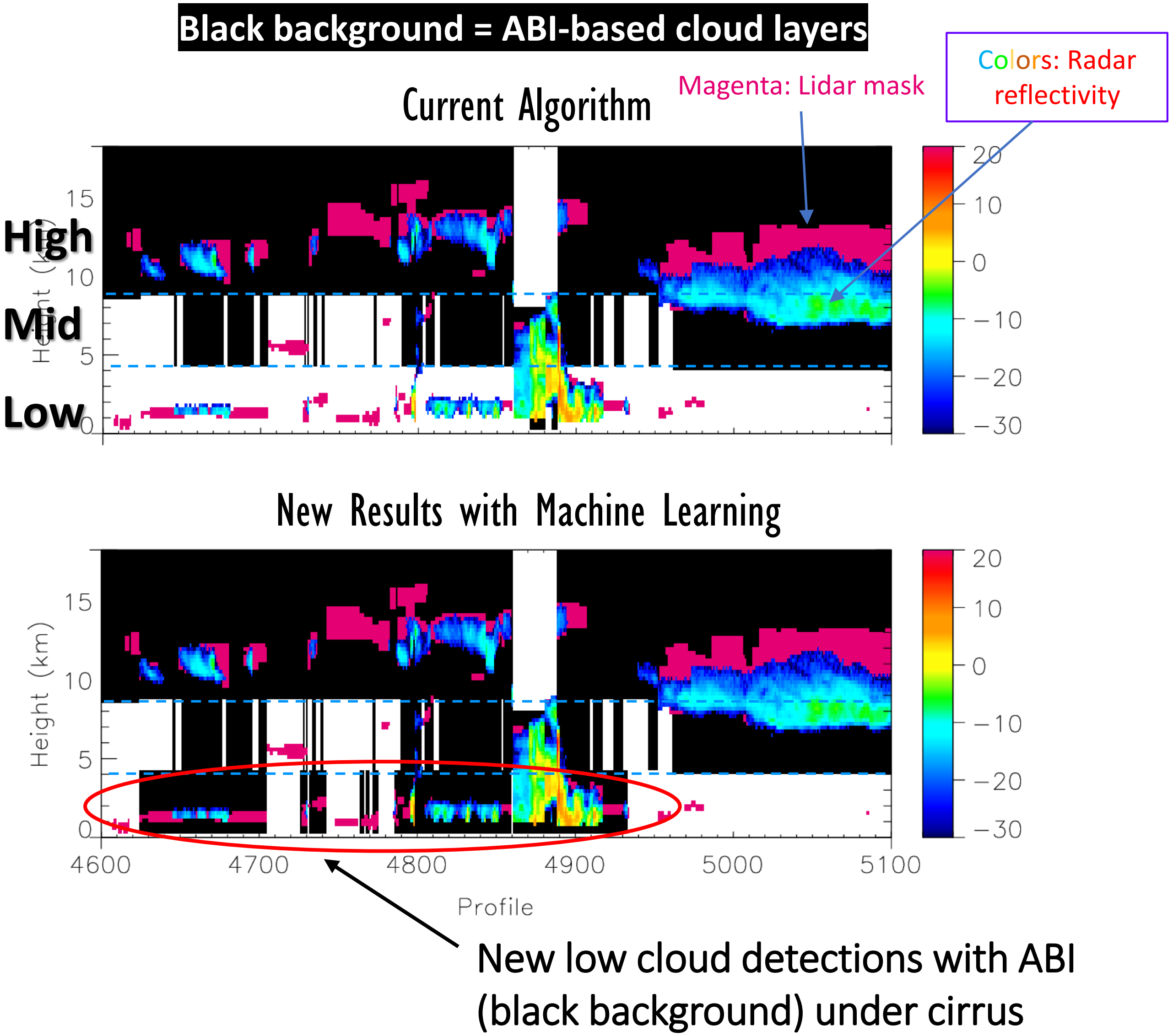
Improved Cloud Boundary Detection with the GOES ABI

Ongoing Improvements (2) – GOES-R PGRR

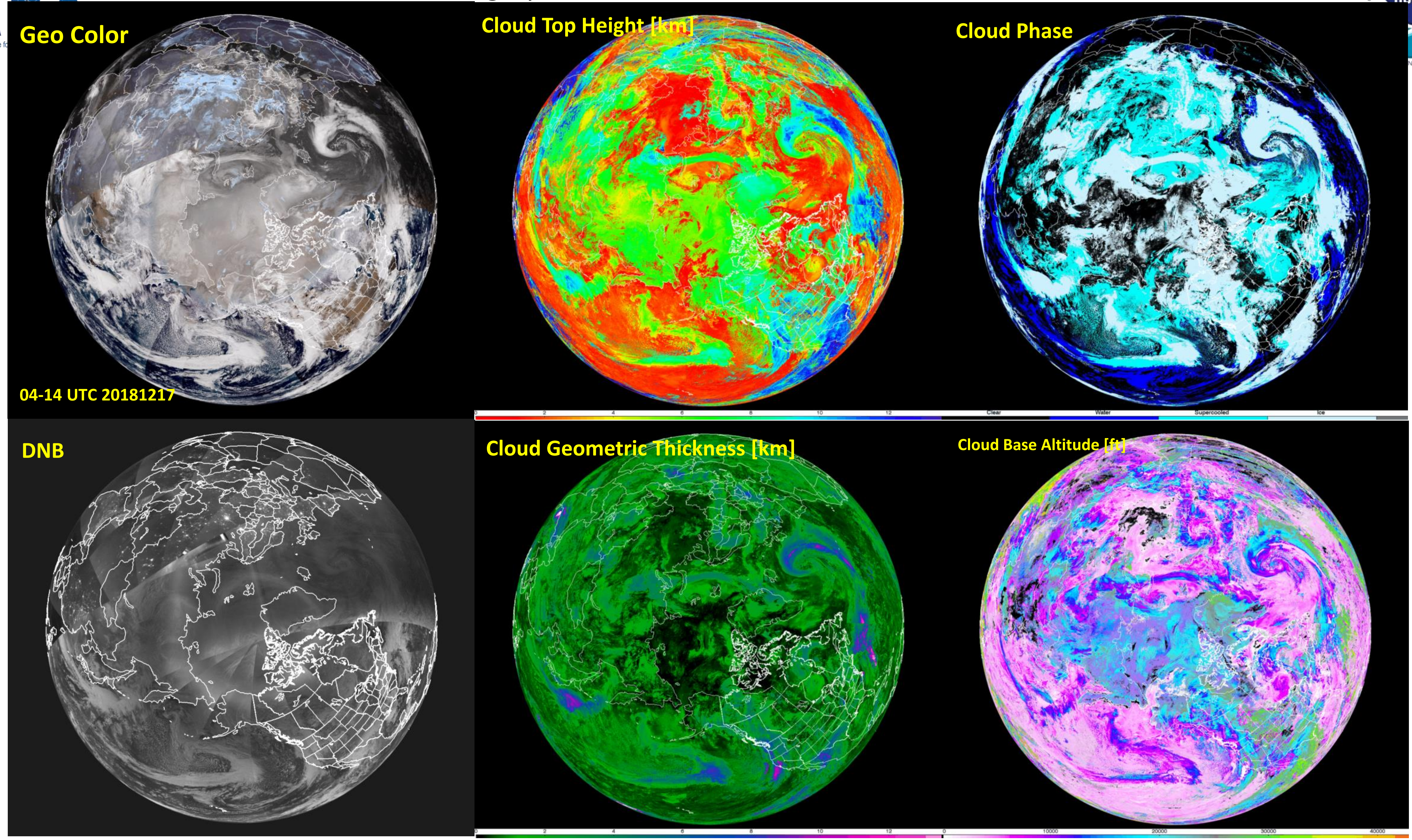
- ► **ABI-only cloud detection of low clouds can be challenging in multi-layer scenes**
  - Aviation is particularly concerned with the location of low clouds (IFR conditions, icing, etc.)
- ► **A method to detect low cloud is being developed that uses ABI multispectral information and layer humidity to identify low clouds**
  - Our method is trained using ‘truth’ from spaceborne radar and lidar
  - Machine learning (Random Forest) is used to identify low clouds using ABI observations
- ► **Our method shows improvements in ABI-based low cloud detection**
  - Probability of detection of low cloud under cirrus increased from 22% to 69%
  - Allows addition of a **H**igh + **L**ow cloud classification

Example of cross sections

(through ABI-Identified Cirrus)

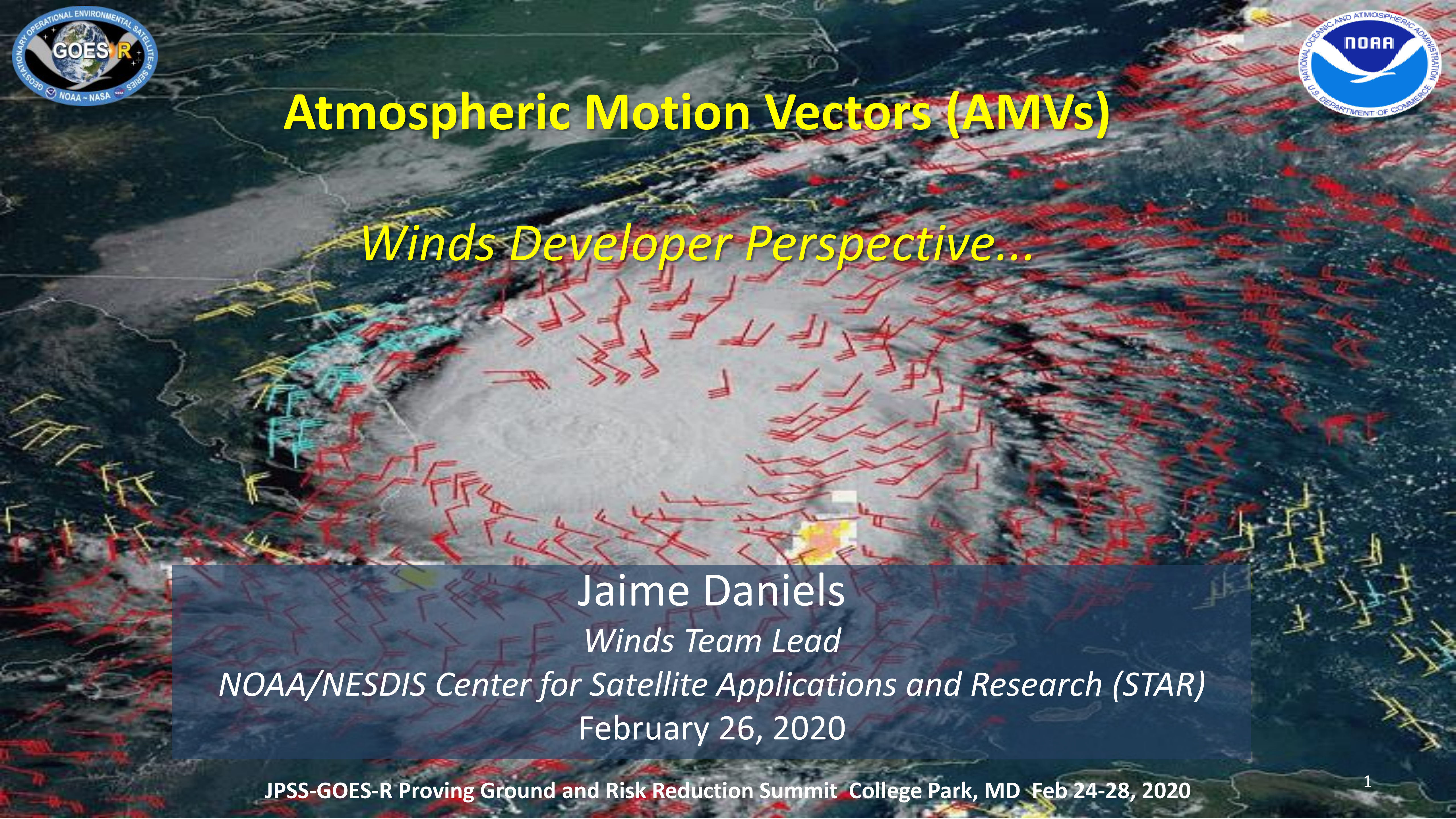


Polar SLIDER for JPSS VIIRS Imagery & Cloud Products http://rammb-slider.cira.colostate.edu (Satellite "*JPSS*")



Summary and Conclusions

- **The statistical CBH algorithm is operational as part of the NOAA Enterprise Cloud Algorithms and used for improved Cloud Cover-Layers (CCL)**
  - ✓ CBH algorithm version v2r1 for JPSS VIIRS (available at NOAA CLASS as "JPSS VIIRS Products (Granule)(JPSS_GRAN)" Don't be confused with VIIRS EDR from the old IDPS!)
  - ✓ CCL with CBH to be available soon for JPSS VIIRS, Not yet fully operational for GOES ABI
- **Ongoing improvements**
  - ✓ Apply the NLCOMP utilizing VIIRS DNB for nighttime retrievals (+ NWP, ATMS)
  - ✓ Leveraging GOES-R research for multilayer clouds using machine learning
  - ✓ Validation against surface-based measurements and spaceborne active sensors
- **CIRA's VIIRS Cloud Vertical Cross-section website and SLIDER**
  - ✓ **User-engaged improvement** of the products and display/training tools



Atmospheric Motion Vectors (AMVs)

Winds Developer Perspective…

Jaime Daniels

Winds Team Lead

NOAA/NESDIS Center for Satellite Applications and Research (STAR)

February 26, 2020

JPSS-GOES-R Proving Ground and Risk Reduction Summit College Park, MD Feb 24-28, 2020

Topics

- Introducing the Winds team
- Wind Products
- Challenges
- New products and applications: Work in progress or planned
- Posters

NESDIS/STAR's Winds Science Team

Team Member	Affiliation
Jaime Daniels (Lead)*	NESDIS/STAR, College Park, MD
Jeff Key*	NESDIS/STAR, Madison, WI
Wayne Bresky	IMSG, Inc.
Andrew Bailey*	IMSG, Inc.
Jim Carr*	Carr Astronautics
Houria Madani*	Carr Astronautics
Chris Velden	Univ. of Wisconsin/CIMSS
Steve Wanzong	Univ. of Wisconsin/CIMSS
Dave Stettner	Univ. of Wisconsin/CIMSS
Dave Santek	Univ. of Wisconsin/CIMSS
Rich Dworak*	Univ. of Wisconsin/CIMSS

* In attendance

Meso-Winds Working Group

Member	Affiliation
Jaime Daniels*	NESDIS/STAR, College Park, MD
Chris Velden	Univ. of Wisconsin/CIMSS
Wayne Bresky	IMSG, Inc.
Andrew Bailey*	IMSG, Inc.
Steve Wanzong	Univ. of Wisconsin/CIMSS
Dave Stettner	Univ. of Wisconsin/CIMSS
Dave Santek	Univ. of Wisconsin/CIMSS
Jason Apke*	CIRA
Kris Bedka*	NASA Langley
Bob Rabin*	NOAA/NSSL

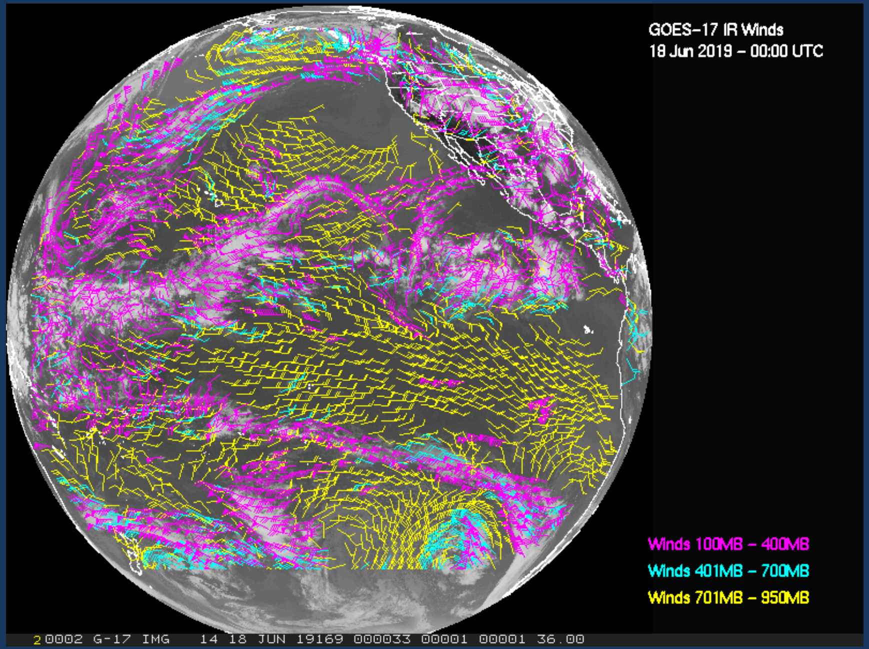
Goals of this working group:

- o Increase collaborations between those doing work on meso-AMVs
- o Leverage collaborations to share and test new approaches, algorithms, and applications on common datasets
- o Identify maturing approaches and applications that may be suited for operationalization
- o Actively engage and collaborate with potential users of mesoscale AMVs

Wind Products

Satellite	Instrument
GOES-R (16/17)	ABI
Himawari-8	AHI
JPSS (SNPP, NOAA-20)	VIIRS
NOAA-15/18/19; MetOp A/B/C	AVHRR
Terra/Aqua	MODIS

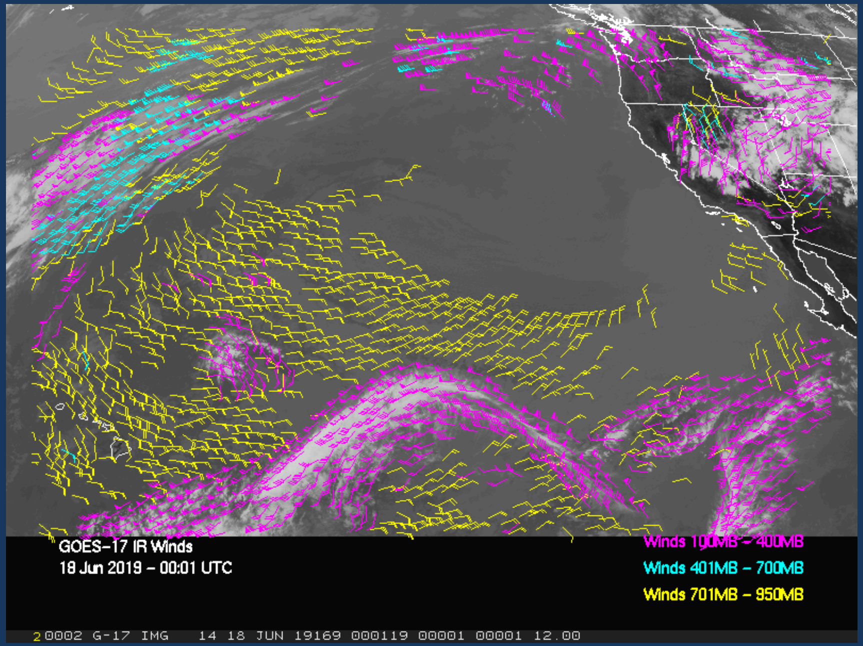
GOES-17 Winds



Band 14 *(11um)* LWIR AMVs

Full Disk AMV Product cadence:

60 mins



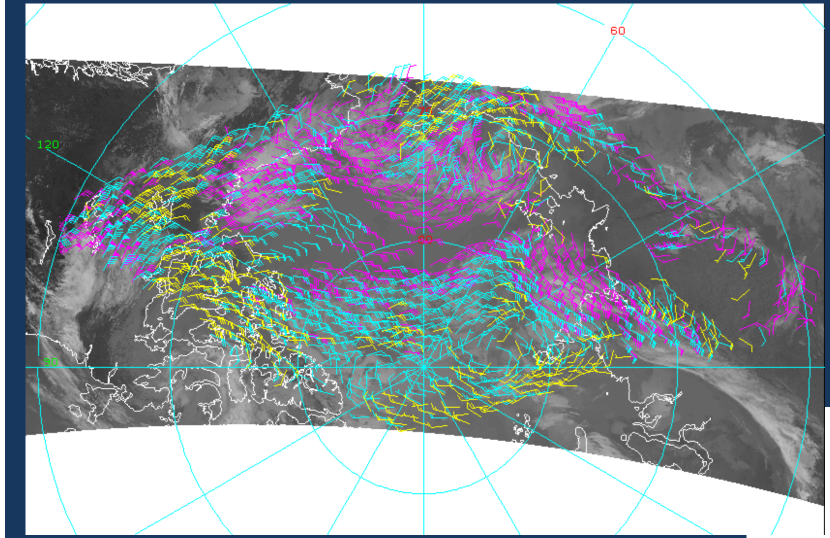
CONUS AMV Product cadence:

15 mins

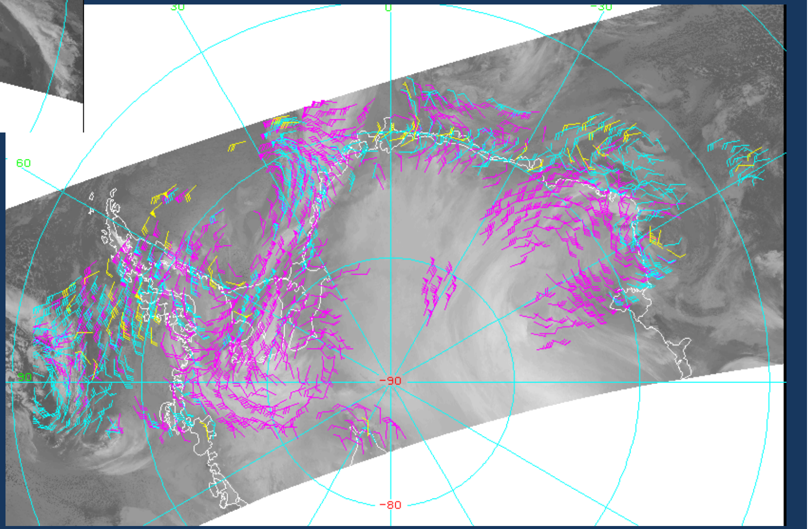
Wind Products

Satellite	Instrument
GOES-R (16/17)	ABI
Himawari-8	AHI
JPSS (SNPP, NOAA-20)	VIIRS
NOAA-15/18/19; MetOp A/B/C	AVHRR
Terra/Aqua	MODIS

NOAA-20 VIIRS Winds



Arctic, 28 July 2018, 1942Z



Antarctic, 28 July 2018, 2033Z

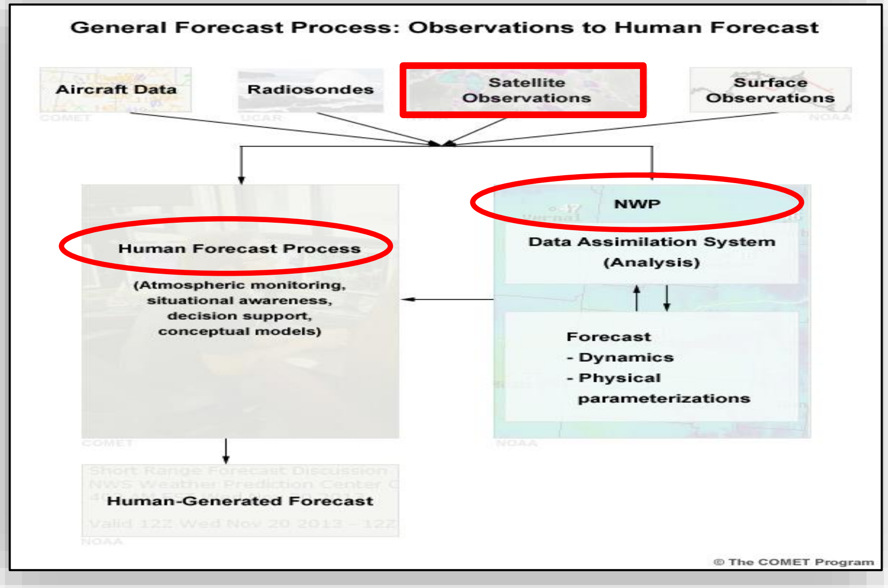
Winds Developer Goals

- **Develop high quality satellite-derived wind products to meet varying needs of users:**
  - **NWS:** WFOs, NCEP (NCO, EMC, OPC, AWC, NHC, TPC, NWC, WPC, SPC)
  - **U.S. DoD:** NRL/FNMOC
  - **International NWP Centers:** ECMWF, MetOffice, CMC, JMA, DwD, MeteoFrance, BoM, KMA

- **Support efforts aimed at optimizing the utilization of NOAA AMVs**
  - Assimilation into ***global and regional NWP forecast systems*** to improve forecast skill
  - Situational awareness for NWS forecasters at NWS WFOs and National Centers

- **Improve maintainability of satellite winds software**

- **Identify and pursue new approaches/applications for deriving winds from satellite measurements**



Atmospheric Motion Vectors

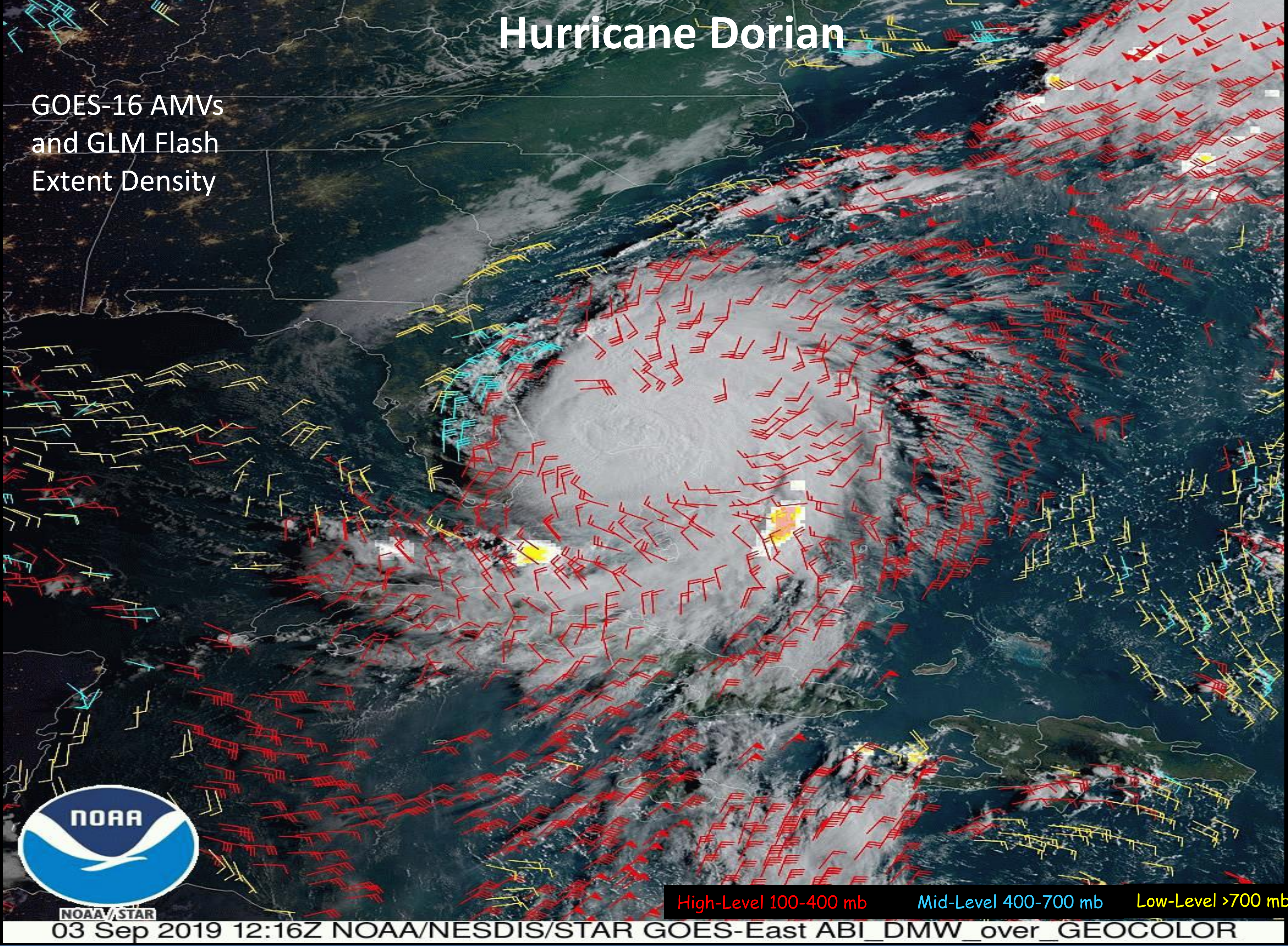
Challenges	Approach
AMV height assignment	*Improve IR-based cloud height retrievals; Employ stereographic methods; Leverage Cloud Optimal Estimation (OE) retrieved error estimates in AMV algorithm; Close coordination with cloud team*
AMVs are a single level product	*Higher spatial resolution AMVs; New methods involving new/future instruments aimed at retrieving vertical wind profiles*
GOES-17 ABI Loop Heat Pipe (LHP) anomaly	*New calibration approaches; Alternative channel usage by L2 algorithms; Develop stereographic approaches to retrieve cloud height*
Improve utilization of AMVs in NWP global and regional data assimilation	*Improve winds product quality, Clearly communicate AMV error characteristics, Develop effective data assimilation to achieve positive impact, Close coordination between satellite and NWP developers (NESDIS/CIs with NCEP/EMC, OAR/ESRL, and other NOAA Labs (AOML))*

New Products and Applications

Work in progress or planned…

- ❑ **Enhanced Vortex-Scale AMVs for Hurricane Applications**
- ❑ **GOES-GOES Stereo Winds**
- ❑ **Global NOAA-20/S-NPP Dual VIIRS Winds Product**
- ❑ **Exploration of Optical Flow Approaches for Deriving Winds from GOES-R Series ABI Imagery**

Hurricane Dorian



Enhanced Vortex-Scale Atmospheric Motion Vectors for Hurricane Applications

- **Alter** GOES-R winds algorithm configurations enabling the generation of higher spatial-temporal AMVs in tropical cyclone and severe storm mesoscale environments.
  - Reduce size of target scenes to be tracked
  - Loosen gradient constraints
  - Expand generation of visible winds above 700 mb.
  - Use 1-min imagery to derive winds

- **Envision** a multi-tiered, scale-dependent approach to AMV processing.

- All of these processing strategies are aimed at enhancing AMV coverage to **resolve the scales of the flow fields associated with the TC vortex and its nearby environment.**

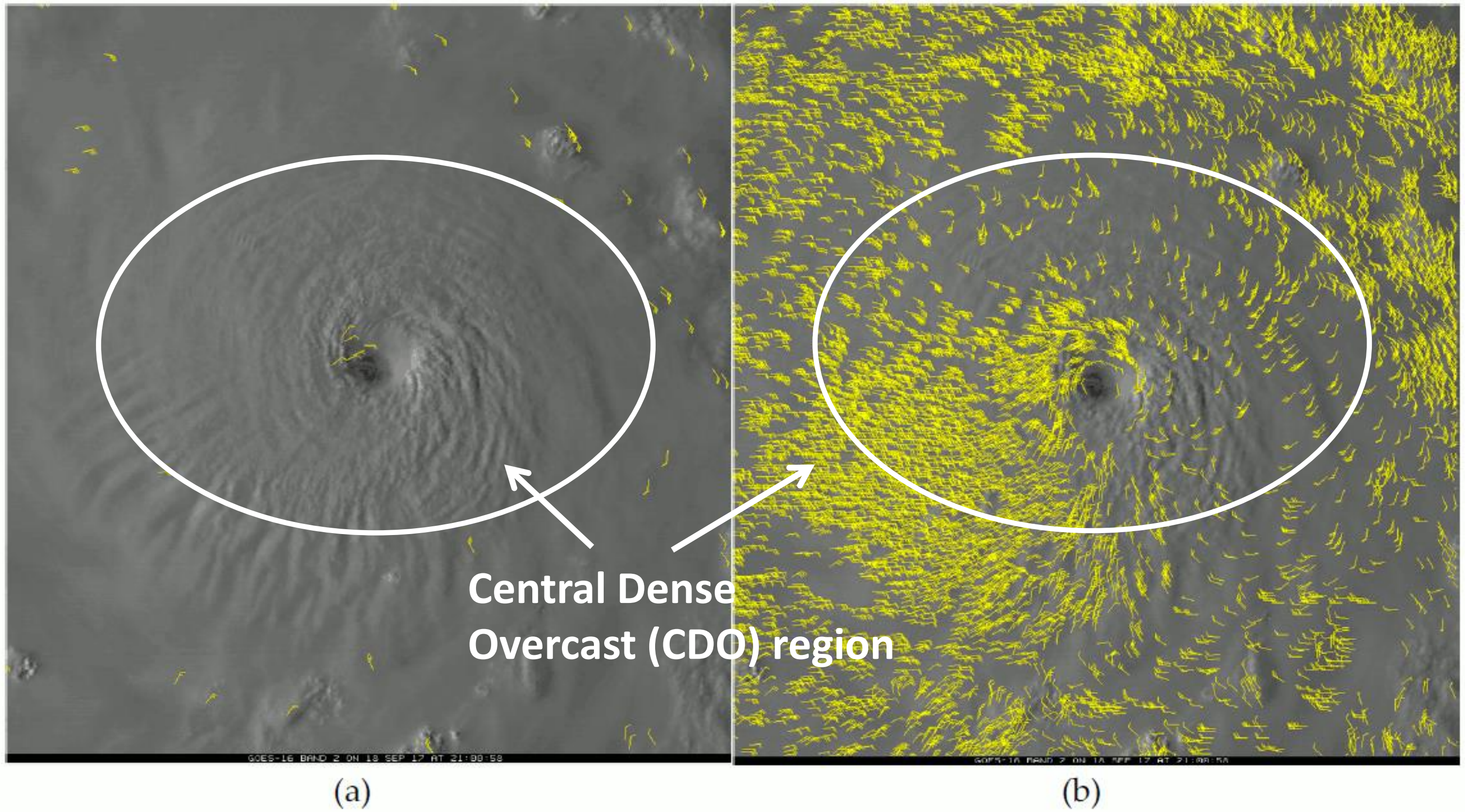
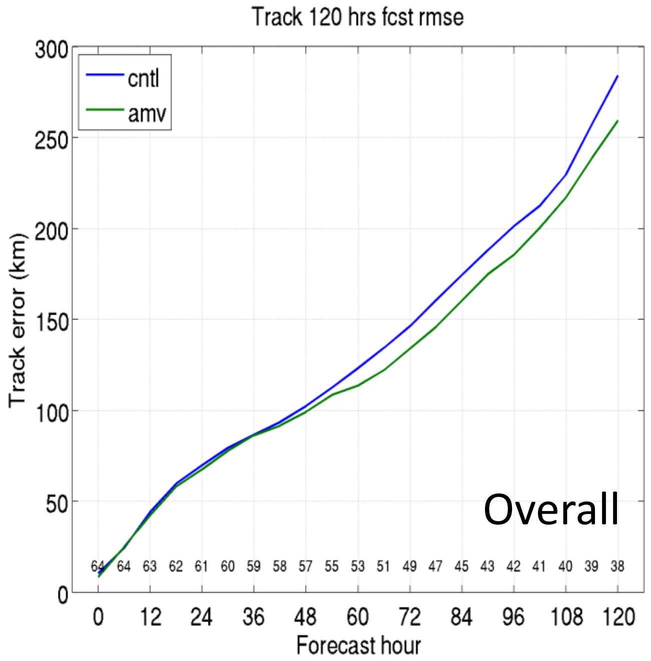
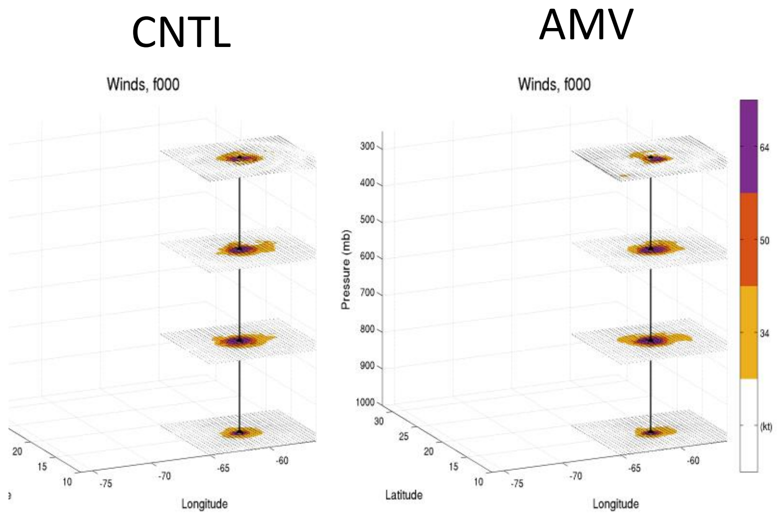


Figure 6. GOES-16 VIS imagery of Hurricane Maria (2017), overlain with: (**a**) Upper-level AMVs generated using operational processing settings, and (**b**) AMVs generated using all of the processing enhancements noted above to capture hurricane-scale flow fields.

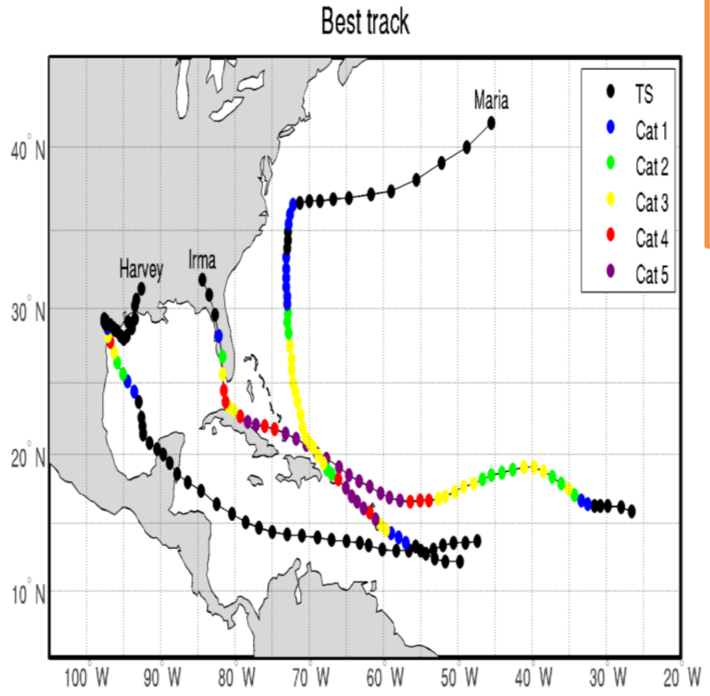
Stettner, D., C. Velden, R. Rabin, S. Wanzong, J. Daniels, W. Bresky, 2019: Development of Enhanced Vortex-Scale Atmospheric Motion Vectors for Hurricane Applications. *Remote Sens*, *11*; doi:10.3390/rs11171981





The HWRF wind structure forecasts for Hurricane Maria for 4 pressure levels (250, 500, 750, 1000 hPa) starting from 18 UTC 18 September 2017. Left column is for the control run, right column is for the GOES-16 AMV run. The three colors represent the 3 different wind speed ranges, purple for >64 kt wind, orange for >50 kt wind, and yellow for >34 kt winds. The black vertical line in the plot is the observed hurricane center location at the forecast time.

- Assimilation of vortex-scale rapid scan AMVs in the HWRF results in consistent track and size prediction improvements for Hurricanes Harvey, Irma, and Maria
- Improvements are mainly from better initialization of the wind fields in the vortex-scale region and near environment.

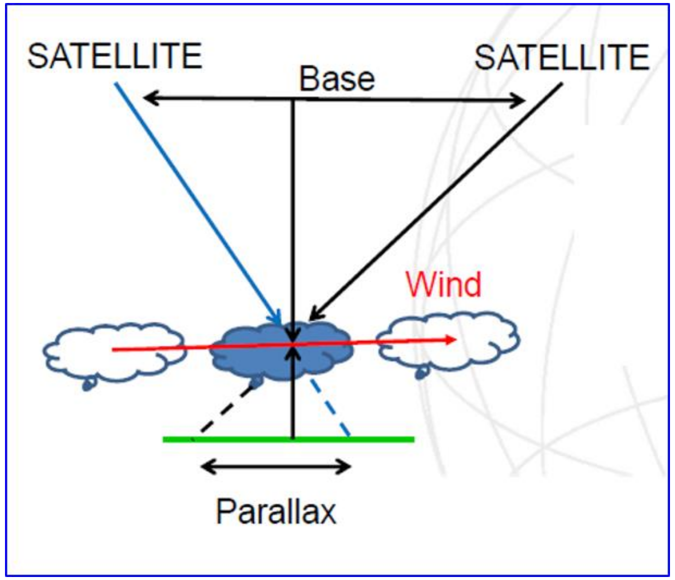


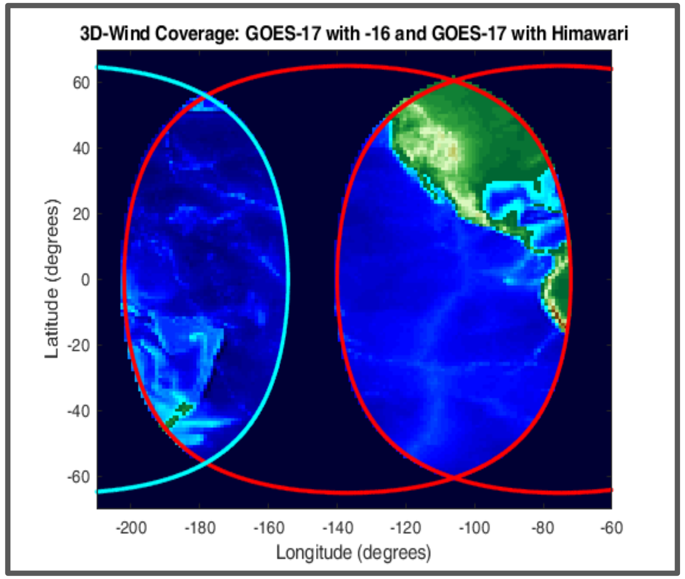
Li, J., Li, J., Velden, C., Wang, P., Schmit, T. J., & Sippel, J. (2020). Impact of rapid-scan-based dynamical information from GOES-16 on HWRF hurricane forecasts. *Journal of Geophysical Research: Atmospheres*,*125*, e2019JD031647. https://doi.org/ 10.1029/2019JD031647

GEO-GEO Stereo Winds

- We are leveraging NASA 's development of a stereo algorithm to derive AMVs from LEO-GEO combinations and GEO-GEO combinations
- **Goal: Generate *GOES-16/GOES-17* and *GOES-17/Himawari-8* stereo winds**
- Stereographic approach is ***purely geometric*** that takes advantage of the high quality INR associated with the new ABI class imagers. ***NWP model independent.***
- **Good mitigation** for the GOES-17 ABI Loop Heat Pipe (LHP) failure that will provide good cloud heights needed for AMV height assignment.
- We are currently working towards developing a ***fully coupled approach*** that combines the GOES-R series derived motion winds algorithm with the stereo-based algorithm such that it can be implemented in NESDIS operations

Foresee extension to GOES-VIIRS



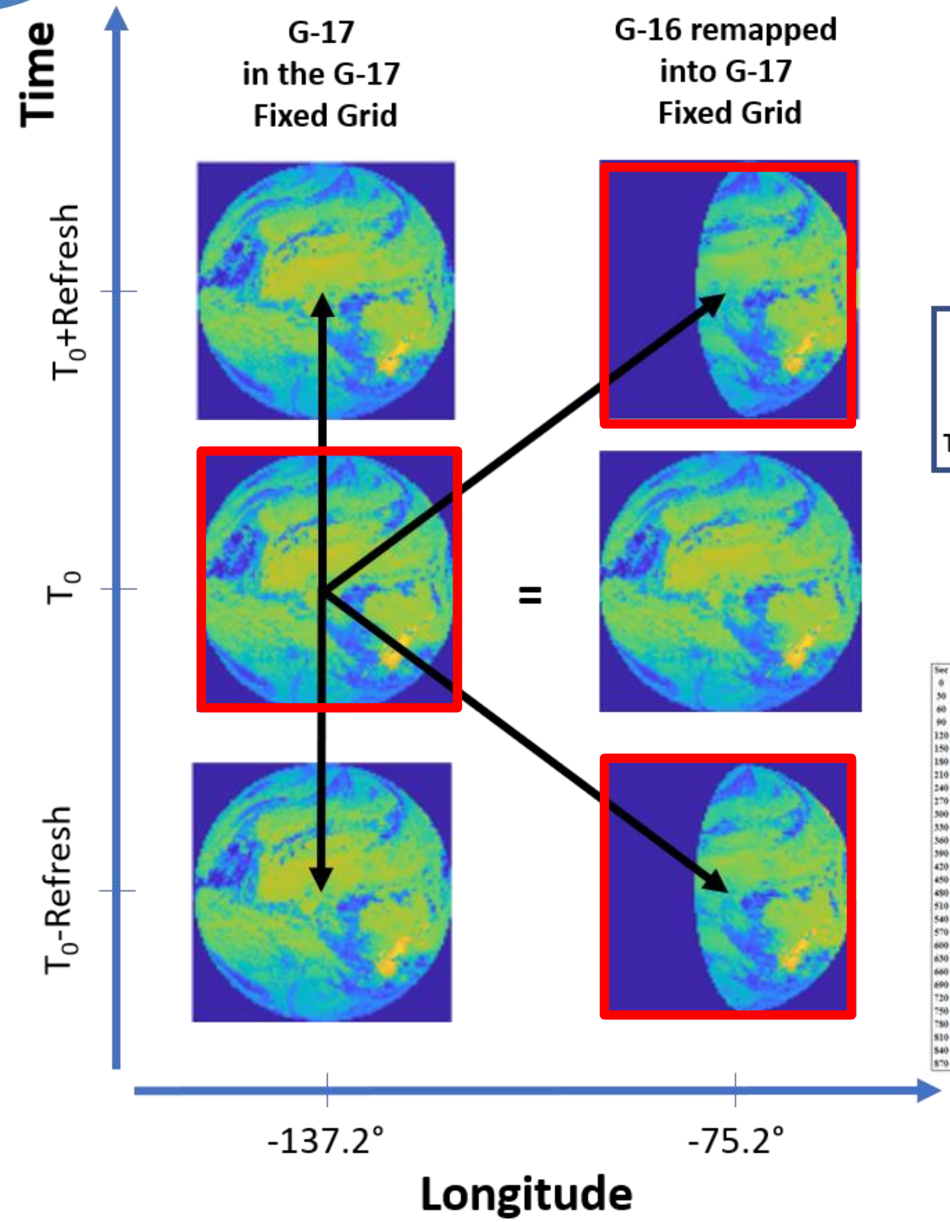


Stereo methods rely on using imagery where target scenes are viewed from different angles to determine cloud heights using the parallax displacement of observed features such as clouds.

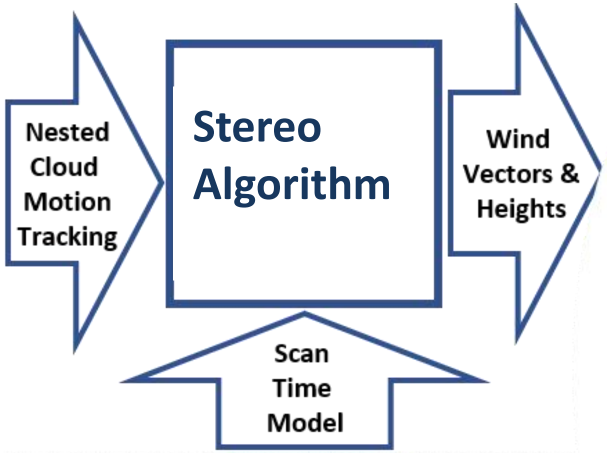
NOAA Collaboration *(Focus on GEO-GEO combinations)*
Jaime Daniels/Jeff Key (NESDIS/STAR); Wayne Bresky (IMSG)
Jim Carr/Houria Madani (Carr Astronautics)

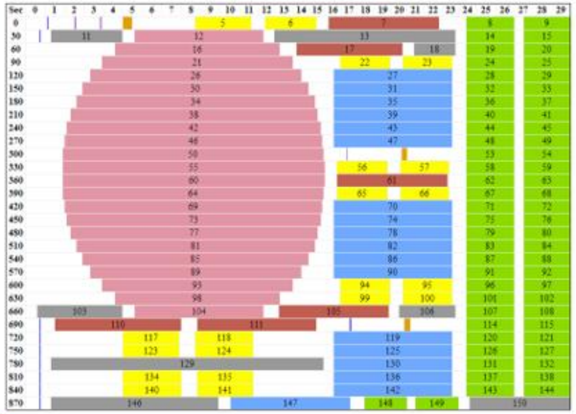
NASA Collaboration *(Focus on LEO-GEO combinations)*
Dong Wu (NASA), Michael Kelly (APL), Jim Carr (Carr Astronautics)

GEO-GEO Stereo Winds



Computed cloud displacements are a mix of real motion and parallax. Retrieval algorithm un-mixes the two and interprets them as wind vectors in 3D (x,y,z)

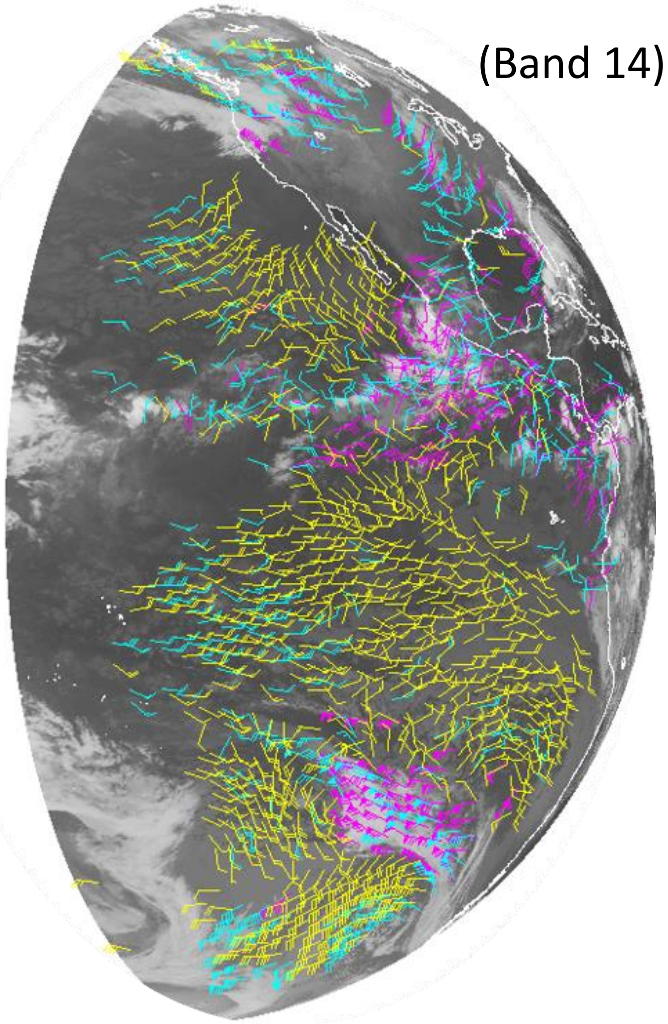




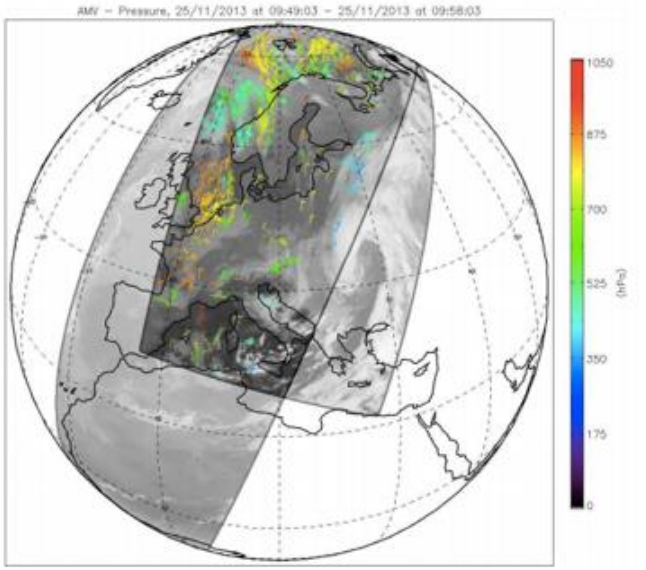
ABI Timelines

GOES-16/17 Stereo Winds

(Band 14)



NOAA-20/S-NPP Dual VIIRS Winds Product



- ❑ Takes advantage of tandem observations from S-NPP and NOAA-20

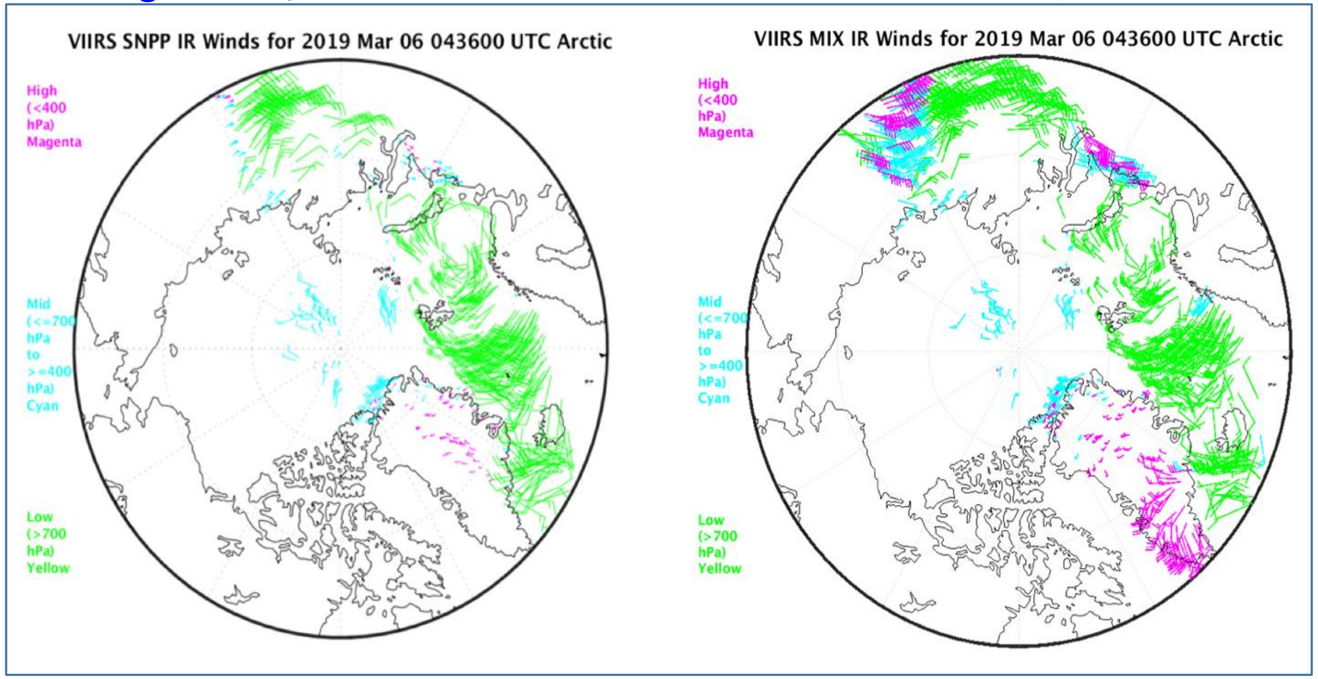
- ❑ Global coverage is possible

- ❑ Greater spatial coverage
  - ➢ Large orbital overlap area
  - ➢ Shorter time interval between consecutive orbits

- ❑ Develop new VIIRS wind types derived from the VIIRS SWIR (2.25um) and day-night bands.

Single SNPP/VIIRS Winds

Dual SNPP-NOAA-20/VIIRS Winds

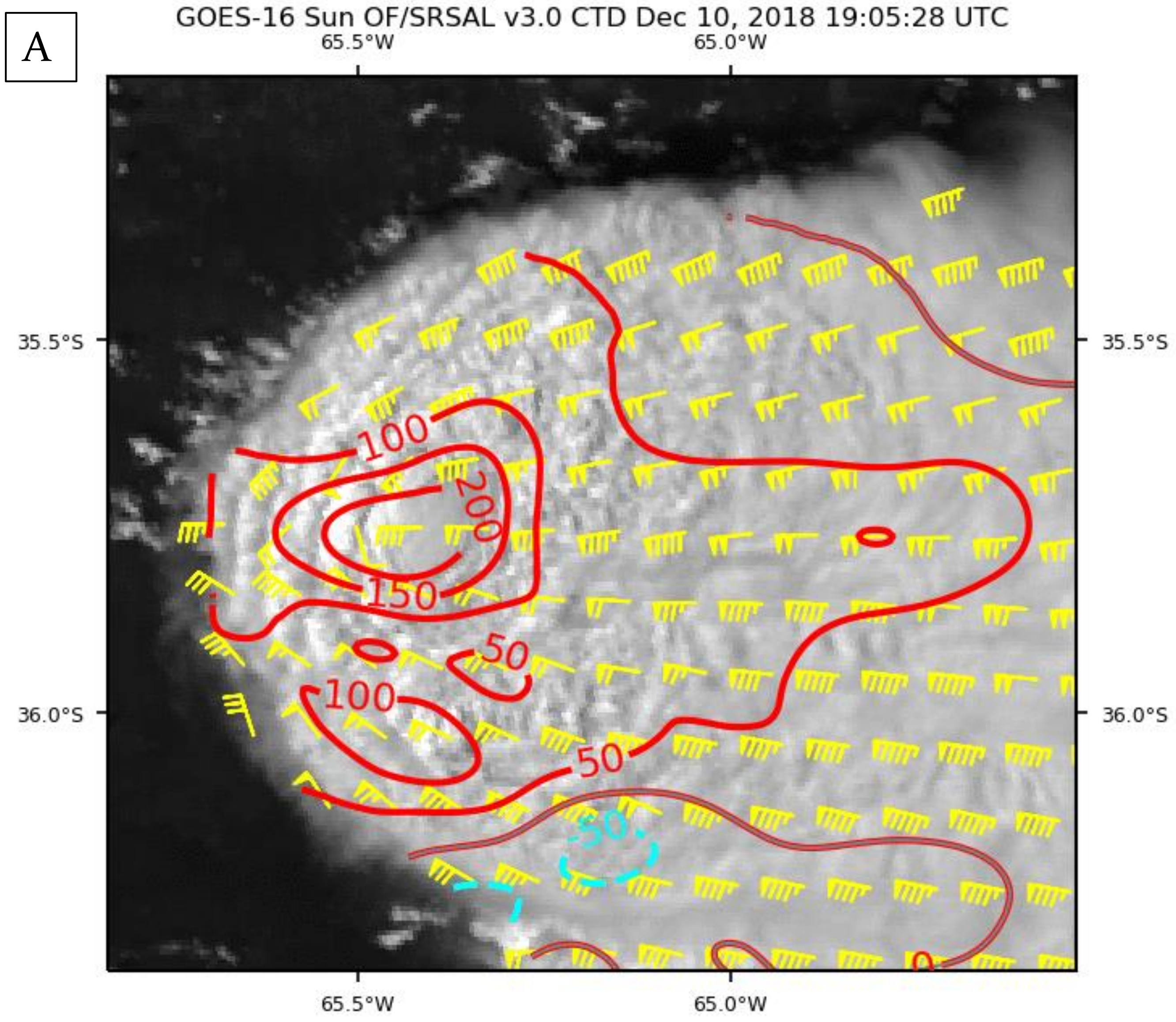


JPSS Proving Ground (PG) funded effort
(PI: Jeff Key; Co-I: Jaime Daniels)

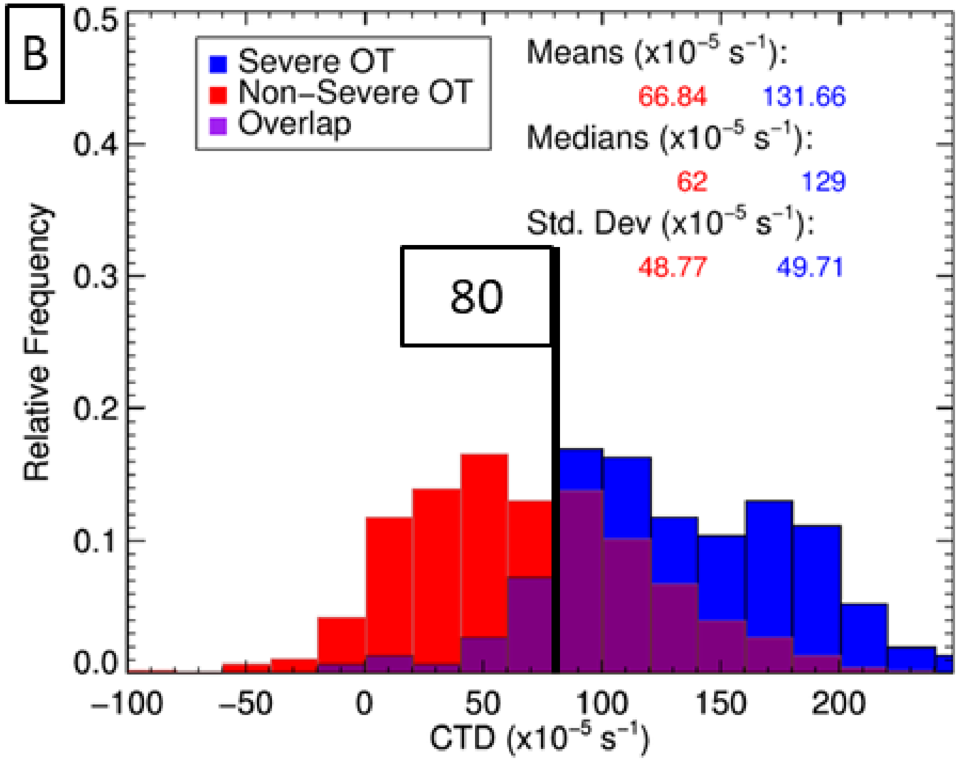
Exploration of Optical Flow Approaches for Deriving Winds from GOES-R Series ABI Imagery

- Optical flow is defined as the apparent motion of image brightness patterns in an image sequence

- Optical flow technologies enable the retrieval of super high spatial and resolution winds in tropical cyclone and severe storm mesoscale environments.
  - Application: Use high spatio-temporal GOES-16/17 meso imagery for detailed diagnoses of deep convection cloud-top flow kinematics



- Derived from dense optical flow, deep convection cloud-top divergence highlights the most intense updrafts in image loops
- From a large sample of updrafts (>10,000), overshooting tops with higher CTD were more likely to be associated with deep, severe weather producing convection



Slide courtesy of Jason Apke (CIRA)

Posters

- Use of Deep-Dive Analysis Tools to Validate GOES-16/17 Atmospheric Motion Vectors (Andrew Bailey)
- GEO-GEO Stereo 3D Winds with a Path into NOAA Operations (Houria Madani)
- LEO-GEO Stereo Winds: a Demonstration using MODIS and ABI (James Carr)
- Dense Optical Flow Applications for Operational Users (Jason Apke)

Backups

Future Satellite Launches

- GOES-18 (Launch date: Dec 2021)
- NOAA-21 (Launch date: Dec 2022)
- METOP-SG A1 (Launch date: Dec 2022)
- METOP-SG B1 (Launch date: Dec 2023)
- GOES-19 (Launch date: Apr 2024)
- NOAA-22 winds (Launch date: Dec 2026)

User Engagement from the Cloud Product Team Developers

Andrew Heidinger, NOAA/NESDIS
Cloud Team comprised of NESDIS, CIMSS & CIRA Scientists

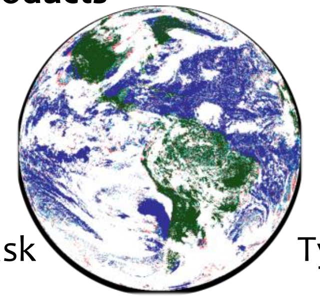
PGRR Summit, Feb 22-25, 2020 NCWCP

NOAA Enterprise Cloud Products.

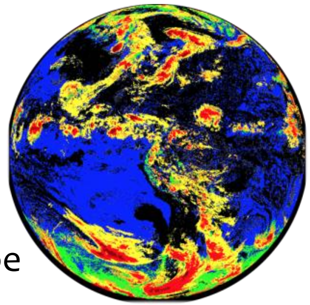
Foundational Products

Cloud Presence

Mask

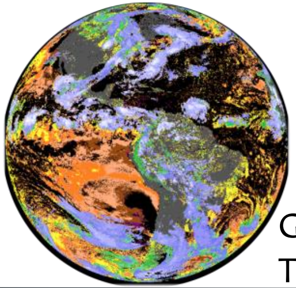


Type

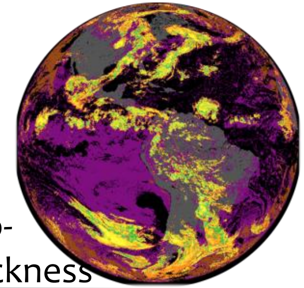


Cloud Vertical Structure

Top-Pressure

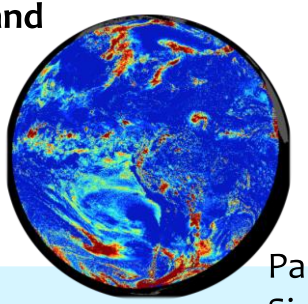


Geo-Thickness

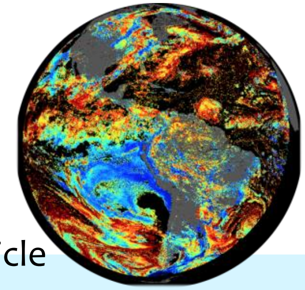


Cloud Optical and Microphysical Properties

Optical Depth



Particle Size



Users

Applications
Cross-Sections
ASOS
Sky Cover
Icing
Precipitation

NOAA Users

Internal NESDIS

Applications/Algorithms
Derived Motion Winds

NCEP/All-Sky Radiance Products

NWP

Non-NOAA Users

Airlines
PGRR Demos
DOE/NREL
NASA SNPP
Taiwan CWB

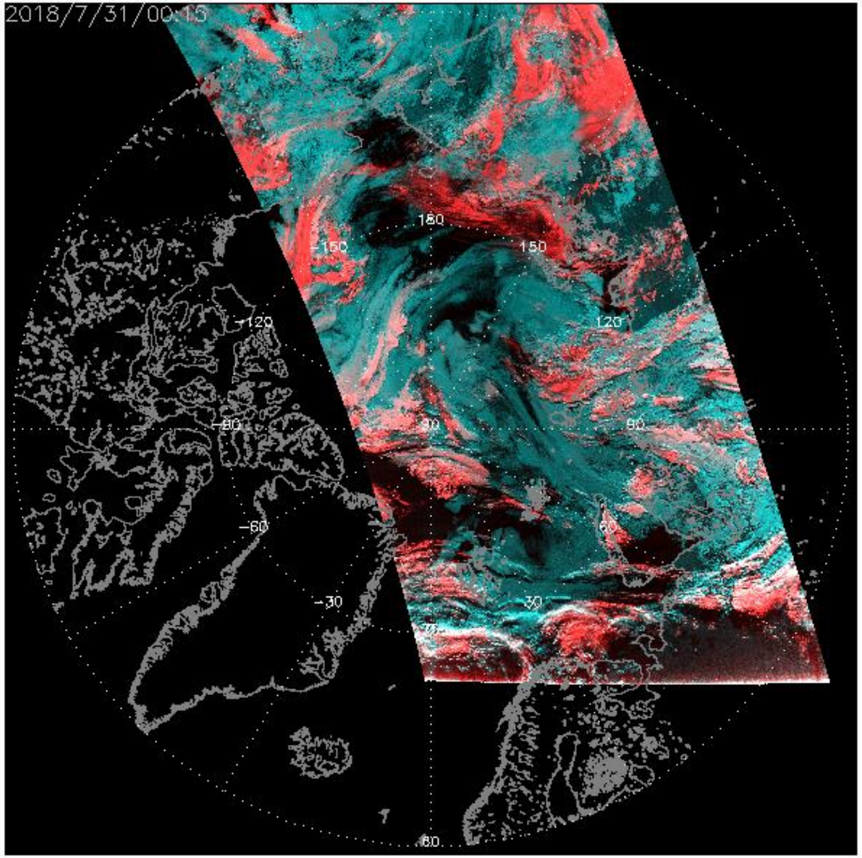
Unmet Users

ESRL/HRRR

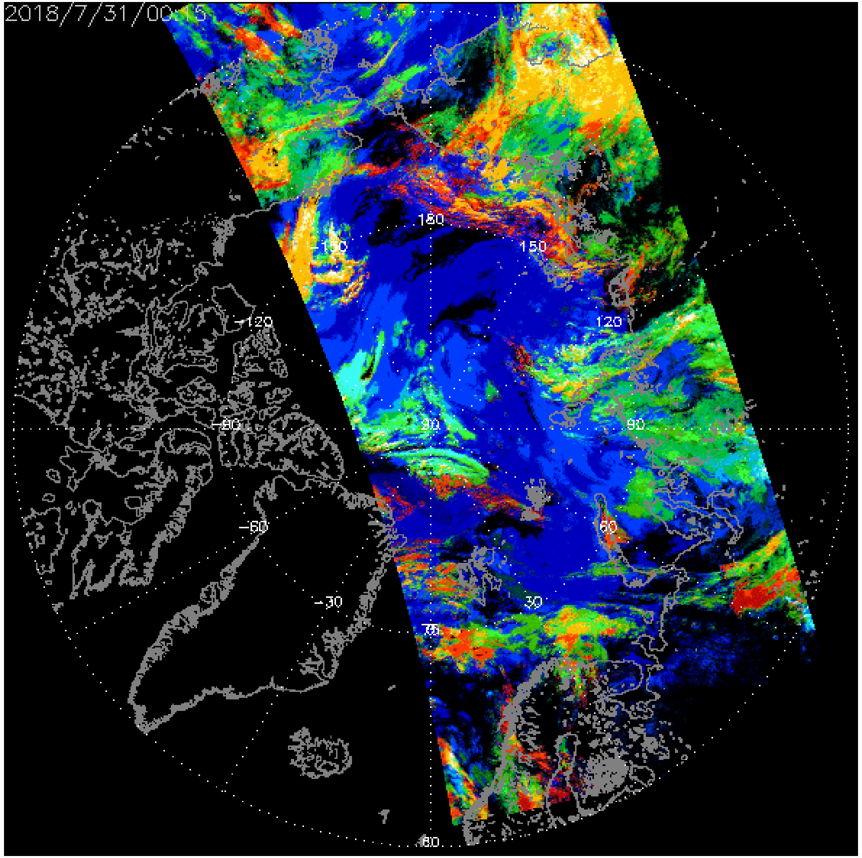
NWS/AWC

JPSS/VIIRS 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)



Acknowledge: Jeff Weinrich, Carl Dierking and Jay Cable for the Alaskan Cloud Demo

NESDIS Cloud Product Status (NESDIS/CIMSS/CIRA)

JPSS

- NOAA Enterprise Versions 2.1 is operational
- Cloud Mask LUT just updated to resolved a snow detection issue
- GOES-R LWP versions will be implemented soon.

GOES-R

- GOES-R Baseline still operational on GOES-16 and GOES-17
- NOAA Enterprise Version modified to handle GOES-17 LHP delivered and moving through ASSISTT into GOES-R GS. Implementation into DE ~March 2020

POES, GOES

- Older versions of NOAA Enterprise

EPS-SG

- We are starting to evolve NOAA Enterprise for MetImage

Future

- Multiple Enterprise algorithms are already employing Machine Learning and more advanced techniques are being explored.
- Fusing Sounders and Imagers
- Pushing GOES-R/VIIRS clouds to highest spatial resolution possible.
- Cloud products are part of AWS Cloud Pilot.

Developmental Path Example (Cloud Mask)

POES/GOES Operational

2000

GOES-R Baseline

2006

NOAA Enterprise Machine Learning

2011

NOAA Enterprise Deeper Machine Learning

2020

NOAA Enterprise Arti. Intell (AI)

2020+

We support:

- AVHRR, MODIS, VIIRS, Fy3DI
- ABI,AHI,GOES-I/P,MSG,MTSAT,COMS, Fy4A
- ***Source and ground system agnostic***

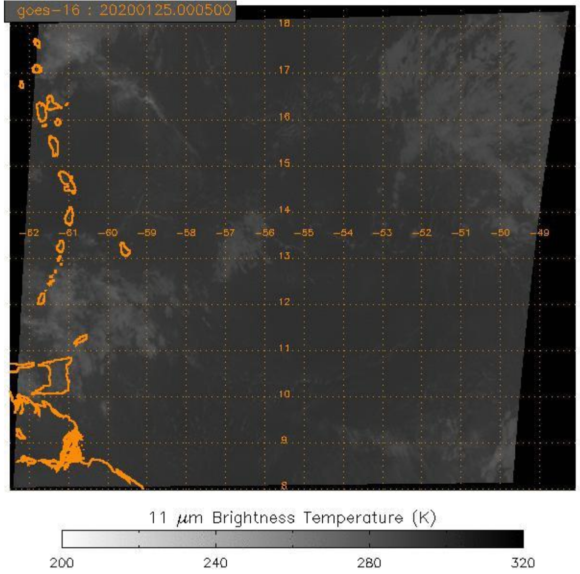
our goal has always been to stay as close as we can to state of the art while remaining fast enough for real-time generation

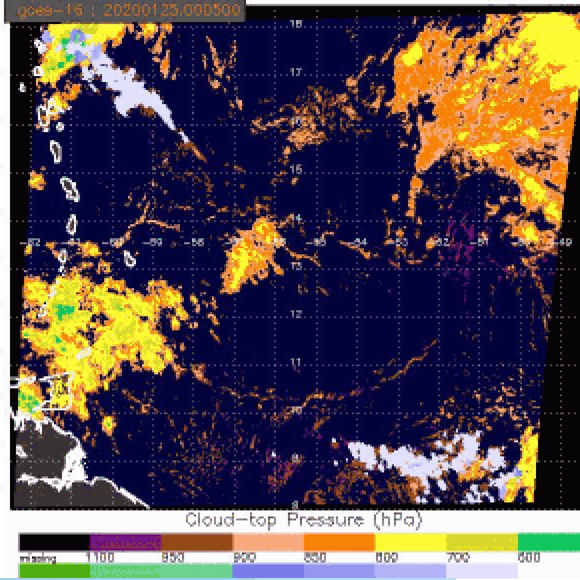
Roughly new version every 5 years but development is continual and driven by user feedback

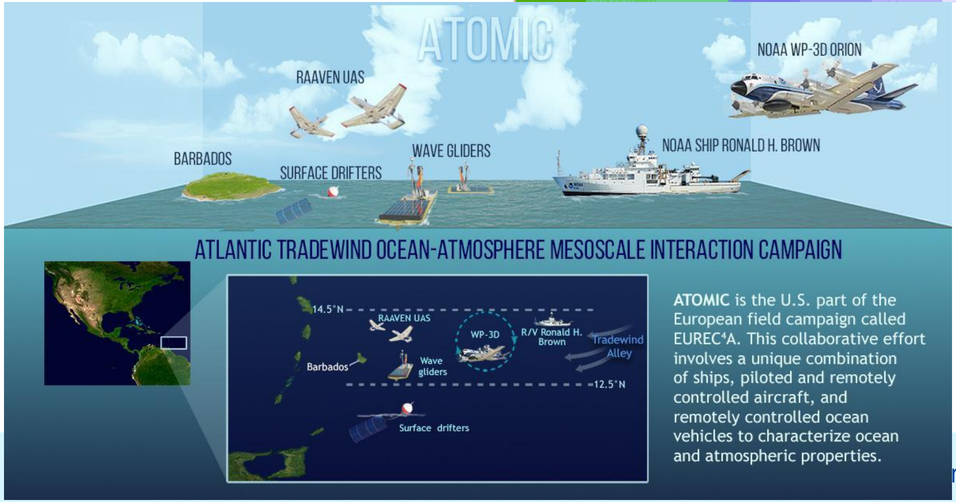
Cloud Product User Examples That Fall Outside This Panel

Field Campaign Support

- The Cloud Team participates regularly in provided satellite cloud products to Field Campaigns.
- We just finished supporting the NOAA/OAR ATOMIC mission centered over Barbados.
- We benefit for exposing researchers to our latest algorithms.
- We need to run these ourselves to provide highest resolution.
- Support for this comes from leveraging the AWG and JPSS projects.

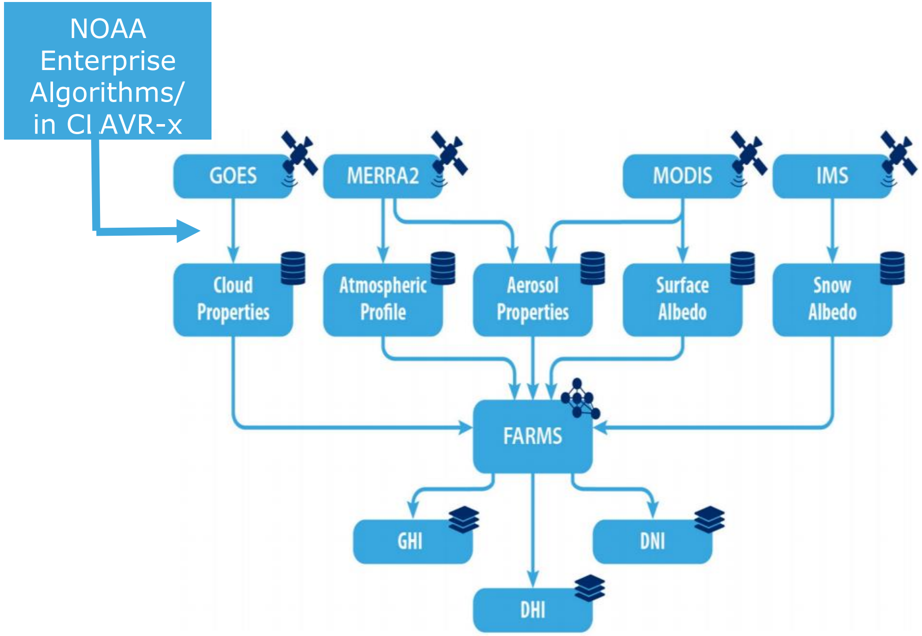


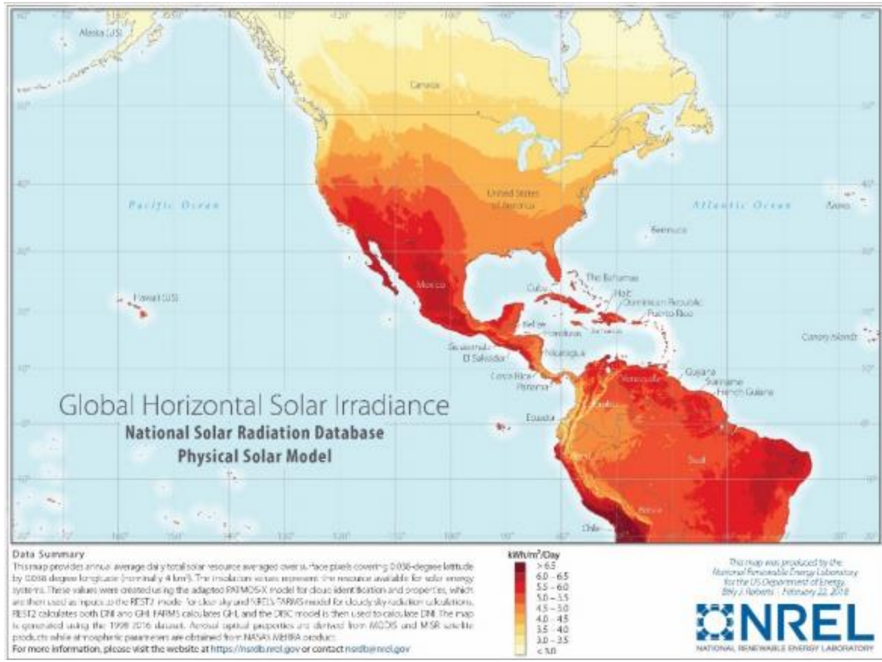




User Example: National Solar Radiation Database

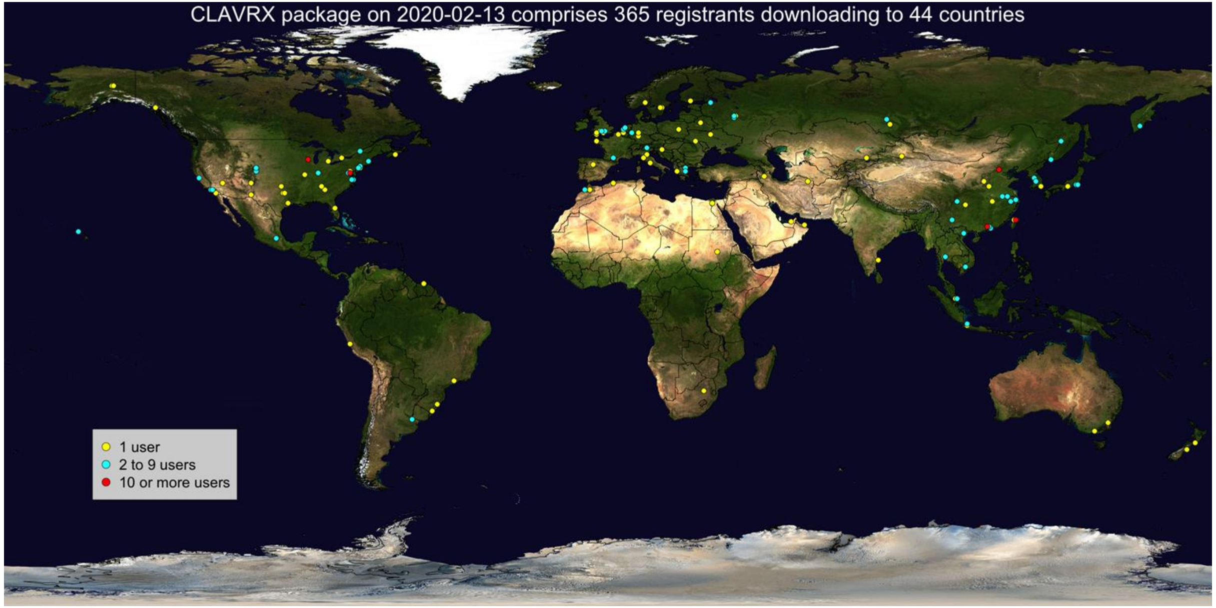
- DOE/NREL uses GOES-16/17 Cloud Optical Properties as an input to their National Solar Radiation Database.
- NSRDB has 60,000 users per year. GOES-R GS Cloud Optical Depth is too coarse spatially (4km FD).
- **Should we migrate them to GOESR-GS? Is it ok to serve data like this long-term? More than PGRR.**



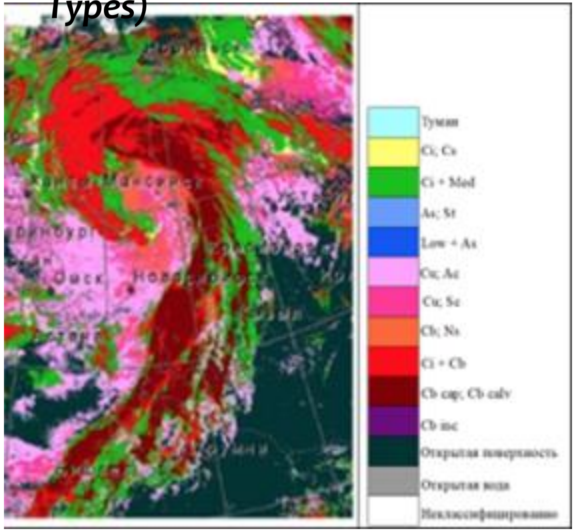


Direct Broadcast Users

- GOES-R and JPSS Support for Direct Broadcast has been successful in getting NOAA Cloud Algorithms into a global and diverse community.
- Developers receive no specific support for this.
- We have benefited from these interactions - no formal or funded interactions.



Example of a Russian Modification of NOAA Enterprise Cloud Properties using CSPP/LEO. (Met. Cloud Types)



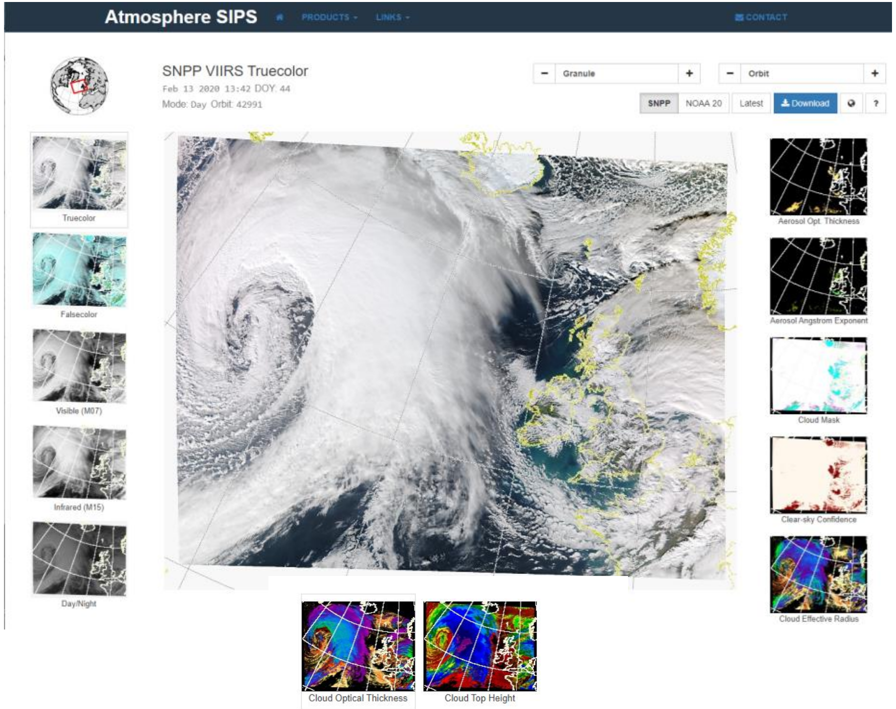
Conclusions

- Cloud team makes many foundational products and several applications.
- We have many users outside of NOAA including the research community.
- We place a large priority on our impact on Winds and the All-Sky Radiance Products since the impact NWP.
- We very much want to build on this with use of cloud properties by users such as ESRL and the Aviation Weather Center.

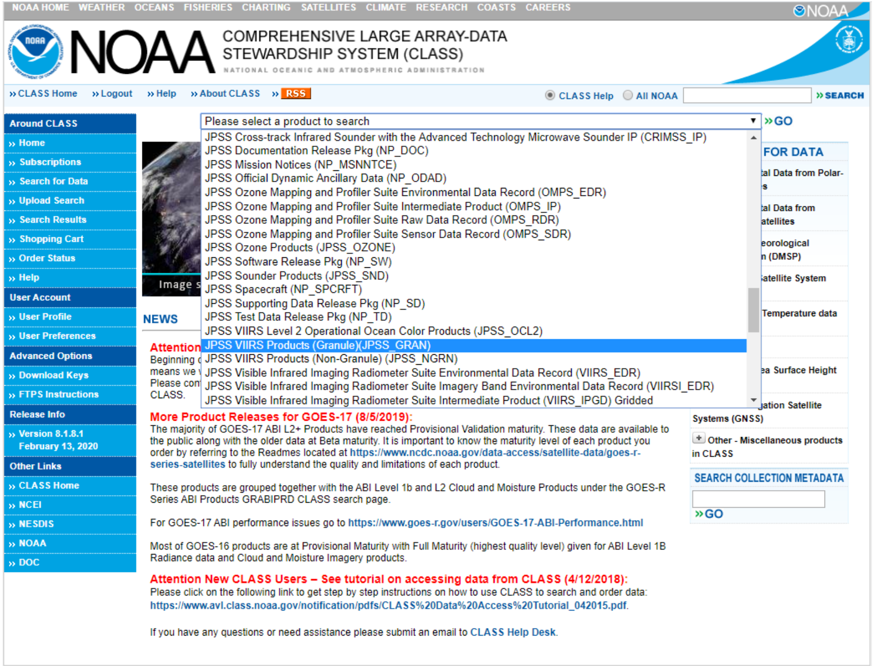
Thank you

User Interfaces (NOAA versus NASA)

- There is benefit to having an easy and appealing interface to the public.
- NASA invests a lot of funds for this and benefits from increased public usage.
- NOAA should consider a new front-end to CLASS that is more appealing and straightforward.



NASA interface allows viewing of imagery and products and direct download.



JPSS products (JPSS_Gran) are #80 out of 112 in the drop-down menu.

WMO CGMS High Level Priority Plan (HLPP 2019 - 2023)

High Level Priority Tasks

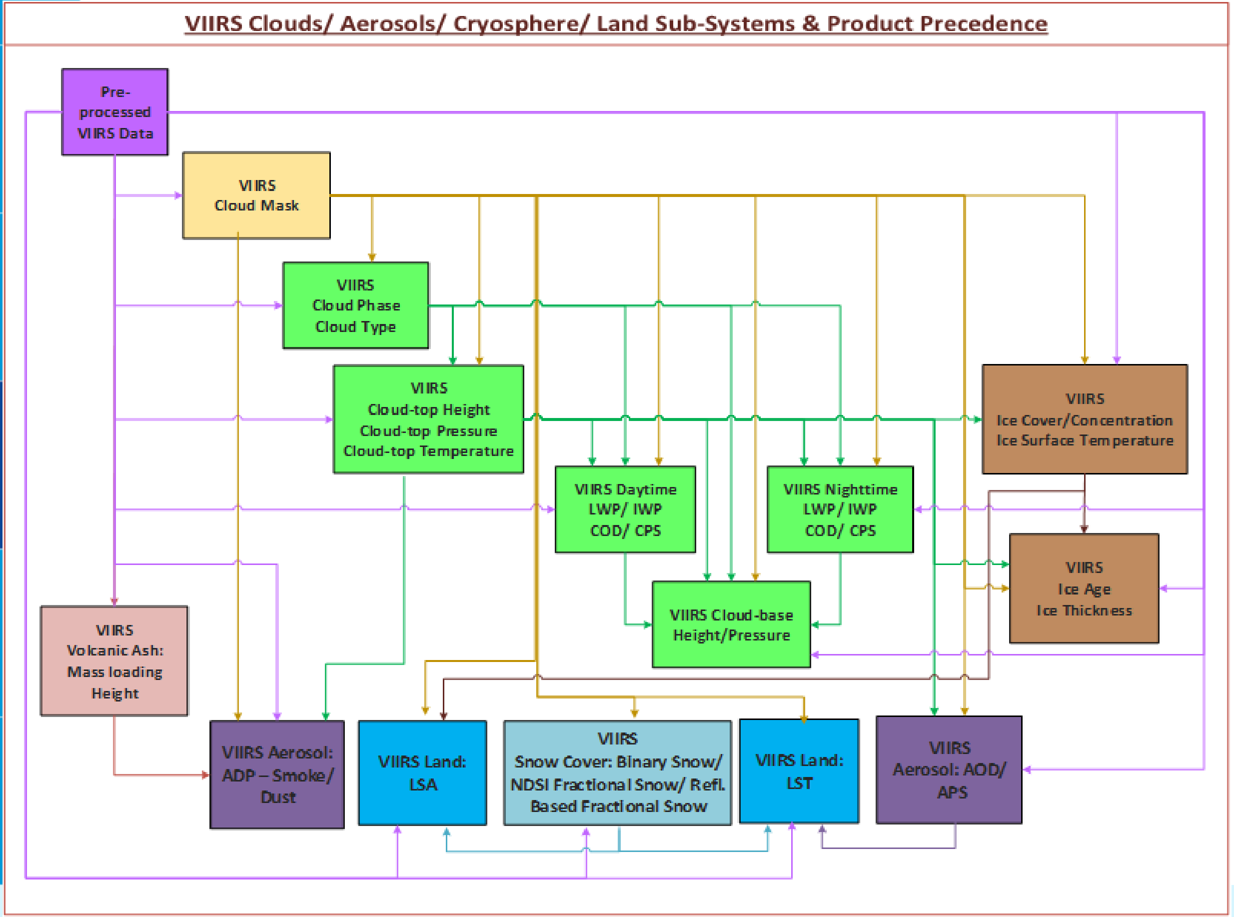
→ 4.3 - Foster the continuous improvement of products through validation and inter-comparison through international working groups and SCOPE-type mechanisms.

- Continuous improvement of products is achieved via the ICWG inter-comparisons.
- SCOPE-CM is set up to facilitate international activities to generate Climate Data Records.
  - NOAA is under-represented in this community.
  - SEP 14 Meeting (7-8 February 2019) [Most recent meeting]
    - SCOPE-CM #10 - AMV and CSR/ASR
    - Partners include NOAA/CIMSS
    - Project lead is JMA, but never contacted NOAA or CIMSS for input.

Cloud Climate Users

- In terms of numbers, the climate community is very large.
- NOAA Enterprise Cloud Algorithms have two climate activities
  - The Pathfinder Atmospheres Extended (PATMOS-x) on AVHRR (40+ years).
  - The NASA SNPP MODIS/VIIRS Continuity Project uses the NOAA Enterprise Cloud Height Suite of Products.
- NASA is also developing climate-centric products for the advanced Geostationary Imagers.
  - What is the NOAA role? We can't compete with their reprocessing infrastructure.
- The International Satellite Cloud Climatology Project (ISCCP) is being reimagined on the new advanced geostationary imagers. This will bring together research and space agencies.
  - I expect Reanalysis and Climate Users will gravitate to this for clouds and maybe aerosol climate products.

Cloud Algorithm Dependency
"The first algorithms in the chain"



Users of VIIRS Cloud Products outside of processing system

- NCEP (ECM)
- VIIRS Polar Winds (ACHA)
- USAF (ECM, indirectly via snow cover)
- GINA/NWS (ACHA, CCL)
- Field Campaigns
- Any downstream users of algorithms dependent on the cloud products