Opportunities & Challenges for Leveraging Non-NOAA Satellite Data in Support of NOAA User Needs

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2015 STAR JPSS Annual Science Team Meeting

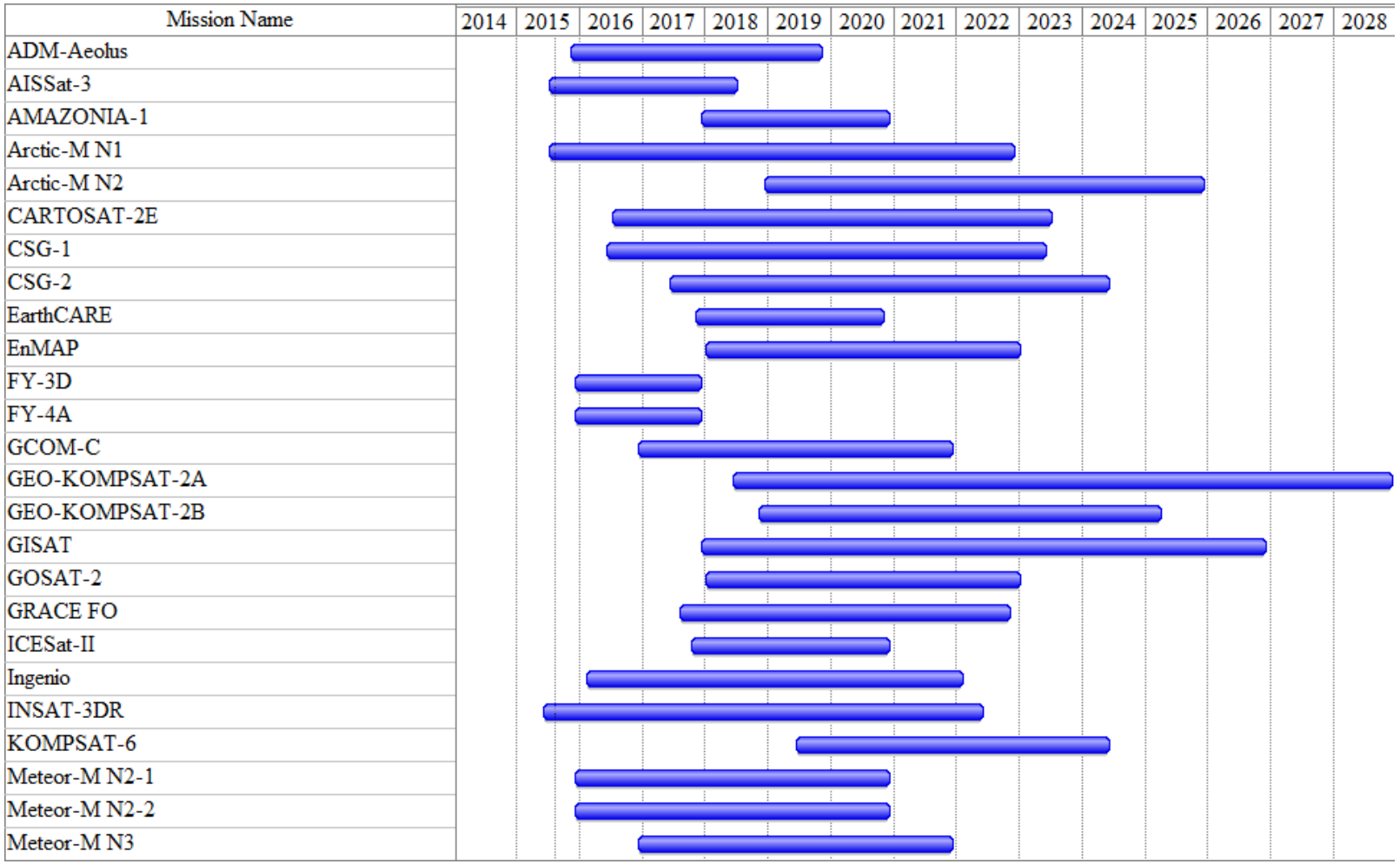
25 August 2015
College Park, Maryland USA

NOAA Satellites and Information
National Environmental Satellite, Data, and Information Service

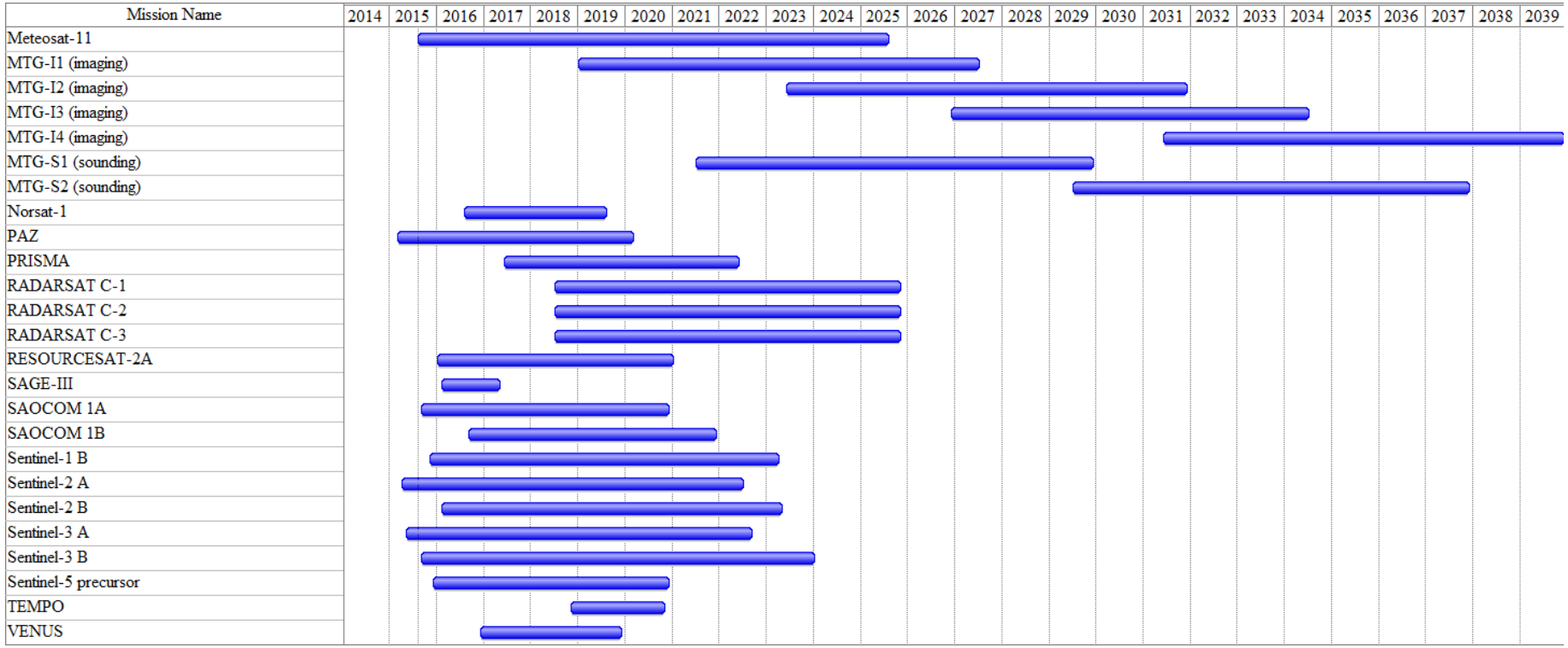
Opportunities & Challenges for Leveraging Non-NOAA Satellite Data

- NOAA's geostationary and polar satellite programs do not meet all existing and evolving NOAA user data and information needs.
- NOAA can close some of these observing system gaps by leveraging extensive investments that other space agencies have made in environmental satellites.
- This cost effective approach, leveraging non-NOAA resources at a fraction of a complete satellite mission life cycle cost, enhances NOAA's ability to successfully execute its mission, with corresponding socio-economic benefits.
- However, no overarching institutional framework or infrastructure within NOAA systematically acquires, processes and distributes non-NOAA satellite data in support of user needs.
- Therefore, need to implement within NOAA the capabilities for timely, routine and sustained exploitation of high priority non-NOAA environmental satellite data from operational as well as research & development missions.
- Capabilities required include acquisition & (secure) ingest of data, development of algorithms, products, applications, and data assimilation demonstration, and the generation, calibration, validation, distribution, monitoring, transition to operations and utilization of these data.
- These can be provided through an enterprise satellite mission-services framework that employs consistent processes (scientific, technical, & programmatic) to exploit non-NOAA mission data.
- A mission agnostic, measurement-based approach will ensure highest priority key observables across the atmospheric, oceanic and terrestrial domains are generated on a routine and sustained basis.

Ex. Non-NOAA Satellite Fly Out From the CEOS Database (1)



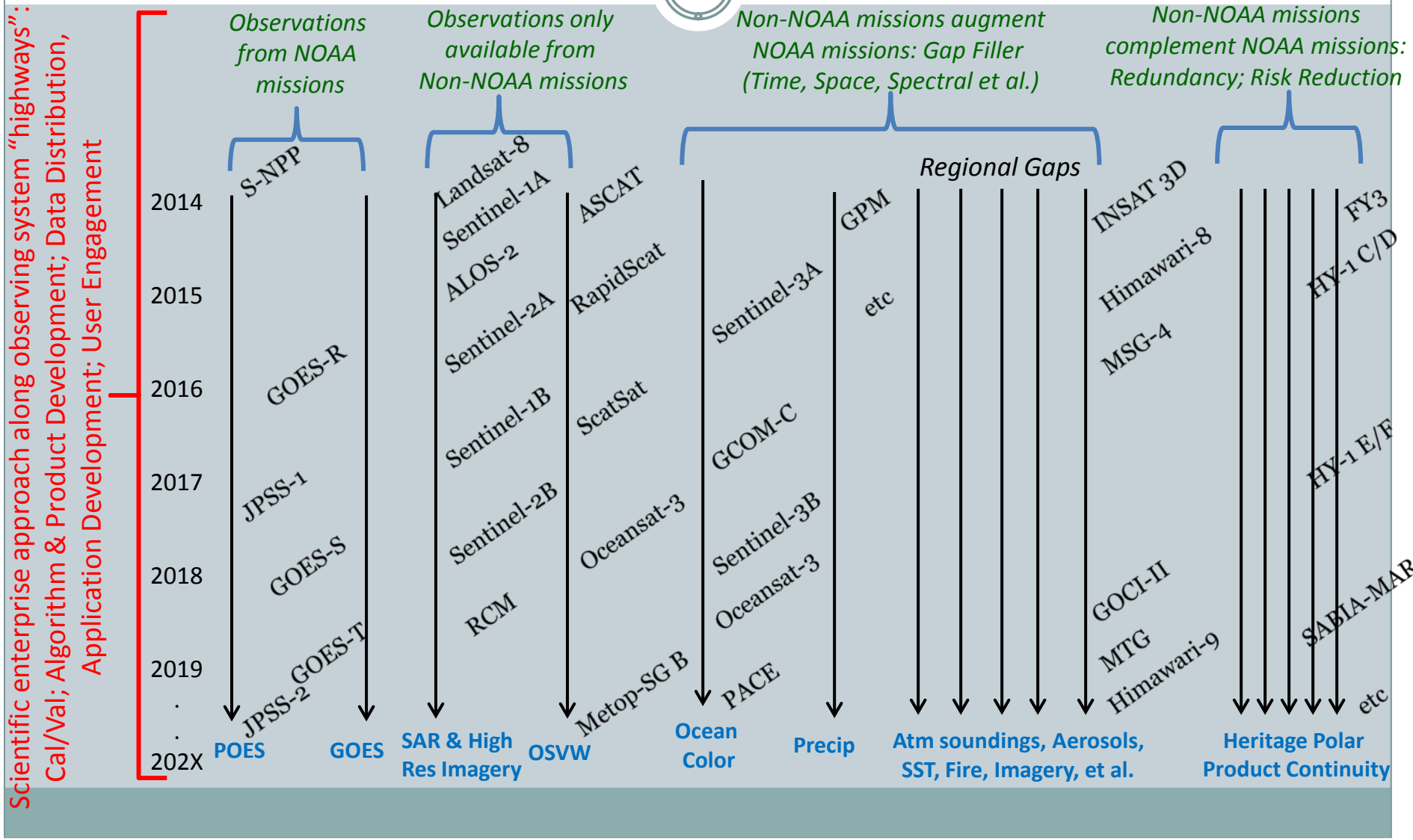
Non-NOAA Satellite Fly Out From the CEOS Database (2, et al.)



Measurement-based approach in support of users: Ensuring continuity & coverage

Observing System Highways: Utilize satellite data from NOAA & non-NOAA missions

Leverages existing science, technical, programmatic et al. infrastructure in NESDIS



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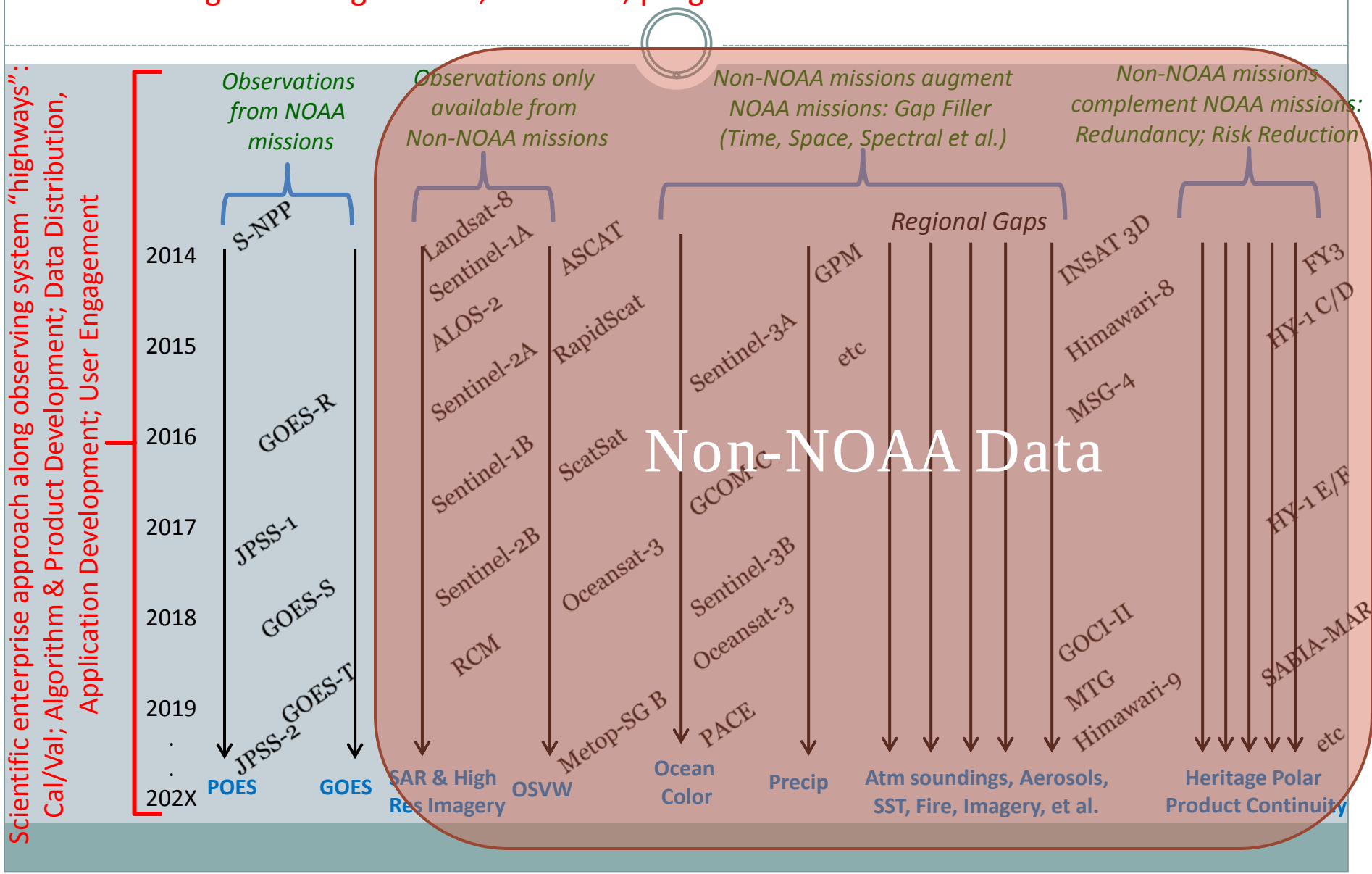
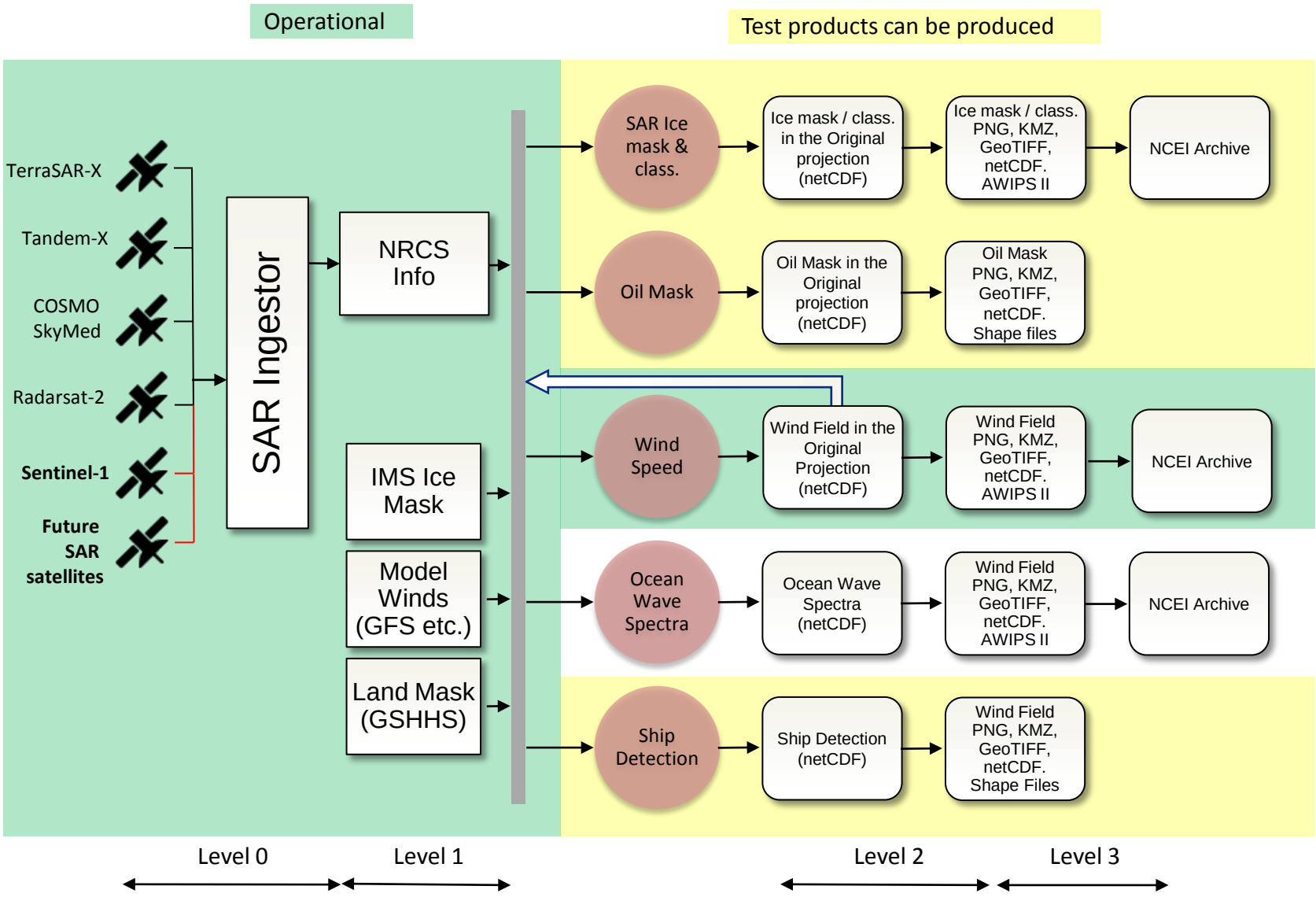


Example of mission-agnostic, measurement-based enterprise approach: SAROPS Processing Chain



Copernicus Missions: The Sentinel Series

- Flagship of the European Space Policy
- Led by the European Union
- Europe's contribution to GEOSS
- European capacity for global, timely and easily accessible information about climate, environment & security

S1A/B: Radar Mission

S2A/B: High Resolution Optical Mission

S3A/B: Medium Resolution Imaging and Altimetry Mission

S4A/B: Geostationary Atmospheric Chemistry Mission

S5P: Low Earth Orbit Atmospheric Chemistry Precursor Mission

S5A/B/C: Low Earth Orbit Atmospheric Chemistry Mission

Jason-CS/Sentinel-6 A/B: Altimetry Mission

Copernicus: European Sentinel Missions

Sentinel-1A/B
(3 Apr 2014, 2016)

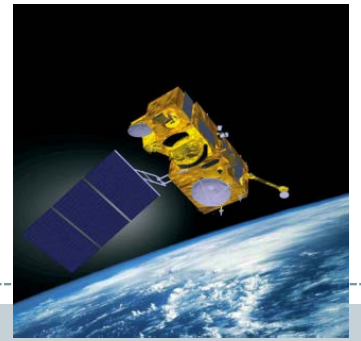
C-band synthetic aperture radar (SAR)

Applications:
- Sea Ice/Cryosphere
- Marine winds and waves
- Oil spills
- Ship detection
- Coastal monitoring, etc.

Sentinel-2A/B
(23 Jun 2015, 2017)

Optical imagery -13 bands for land observation (MSI)

Applications:
- Land management
- Biomass
- Water management
- Urban Mapping



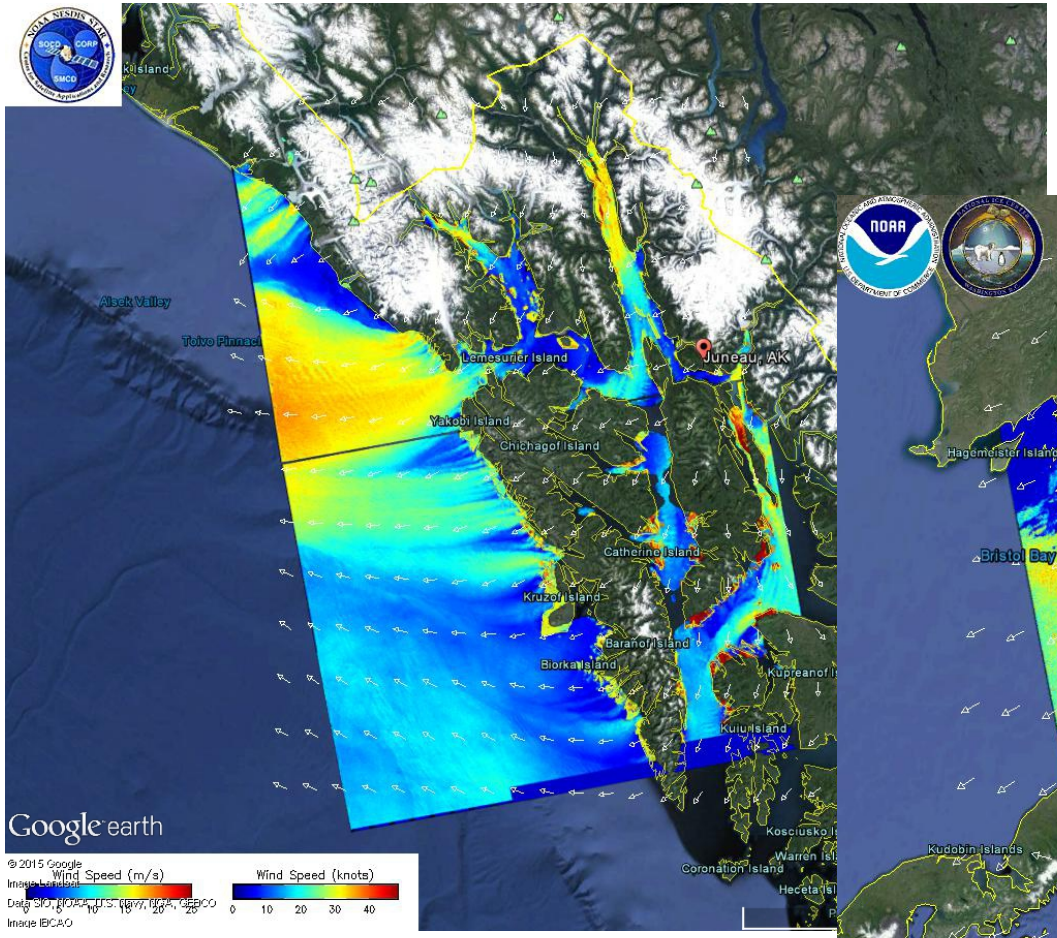
Sentinel-3A/B
(~31 Oct 2015, 2017)

Sea and Land Surface Temperature Radiometer (SLSTR), Ocean and Land Color Instrument (OLCI), Synthetic aperture radar altimeter (SRAL)

Applications:
- Ocean color and land reflectance
- Sea, land, and ice surface temperature
- Fire monitoring
- Sea surface topography, winds, significant wave height

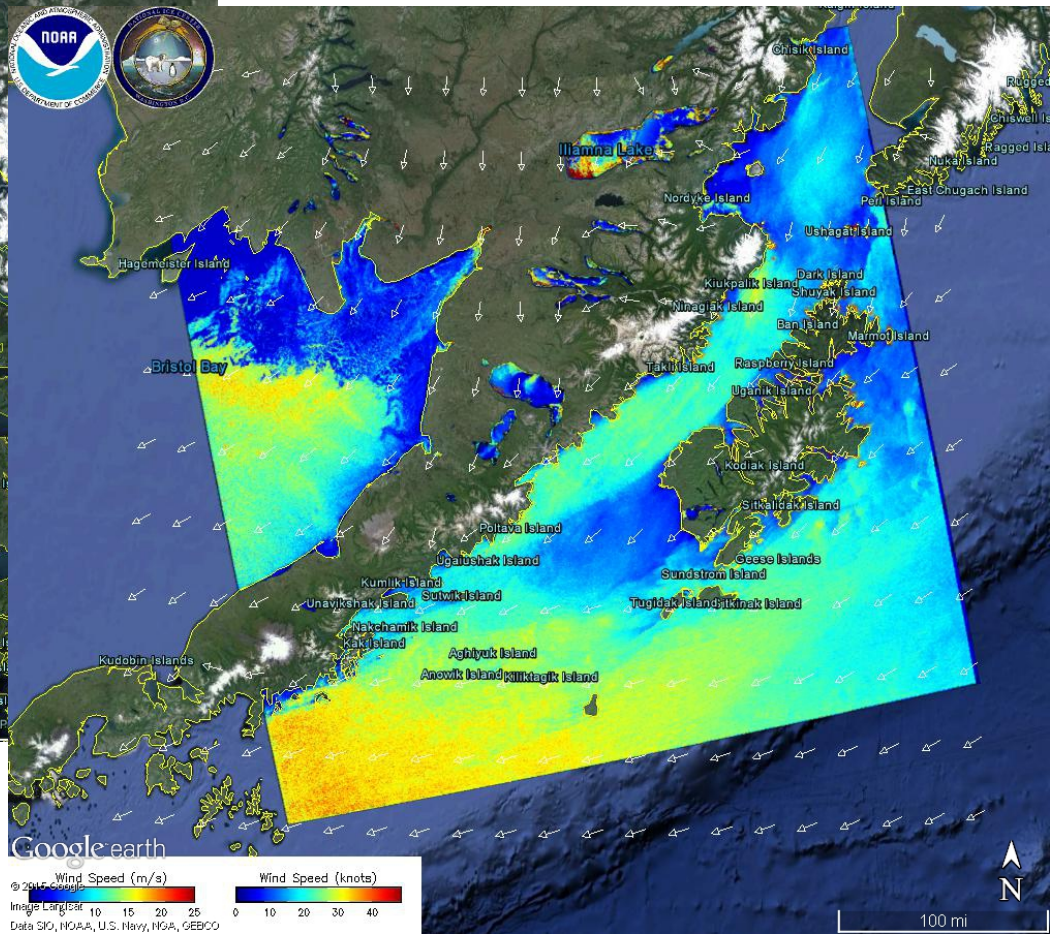
High-Resolution SAR-Derived Wind Speed Products

Bill Pichel & Frank Monaldo



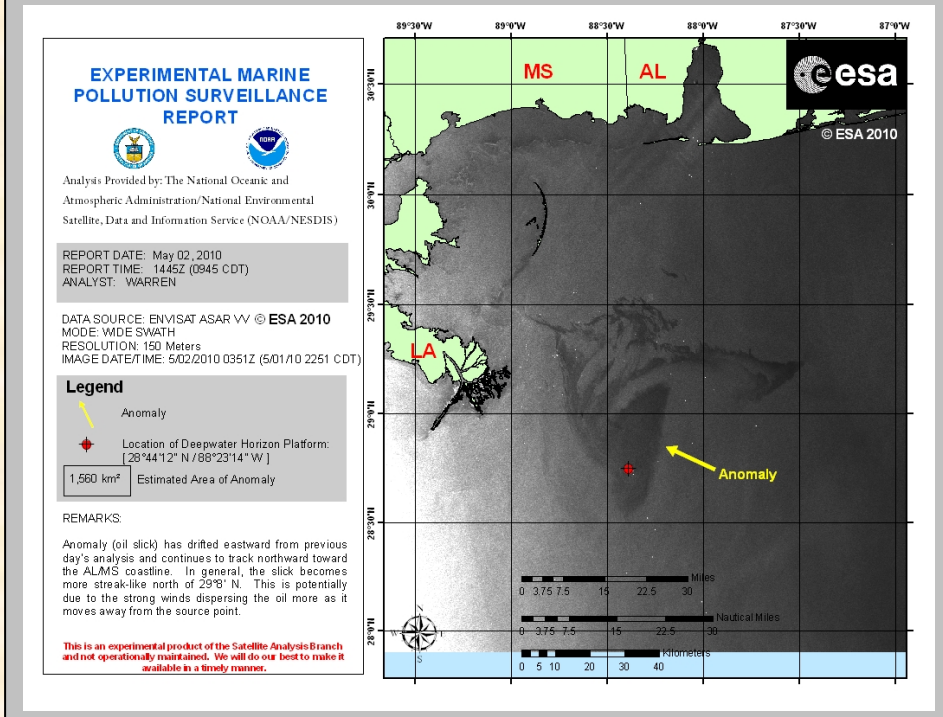
Pre-operational S1A wind speed
2015-01-08 02:46 UT

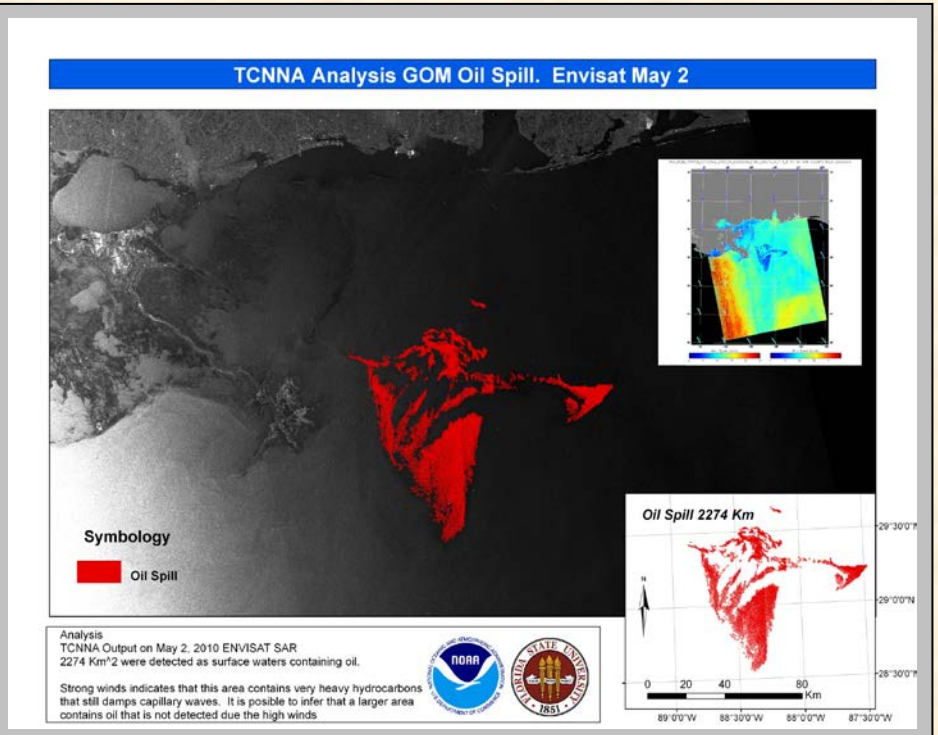
Operational RSAT2 wind speed
2015-02-04 04:05 UT



Interactive and Automated Techniques for Oil Spill Analysis Using (SAR) Imagery

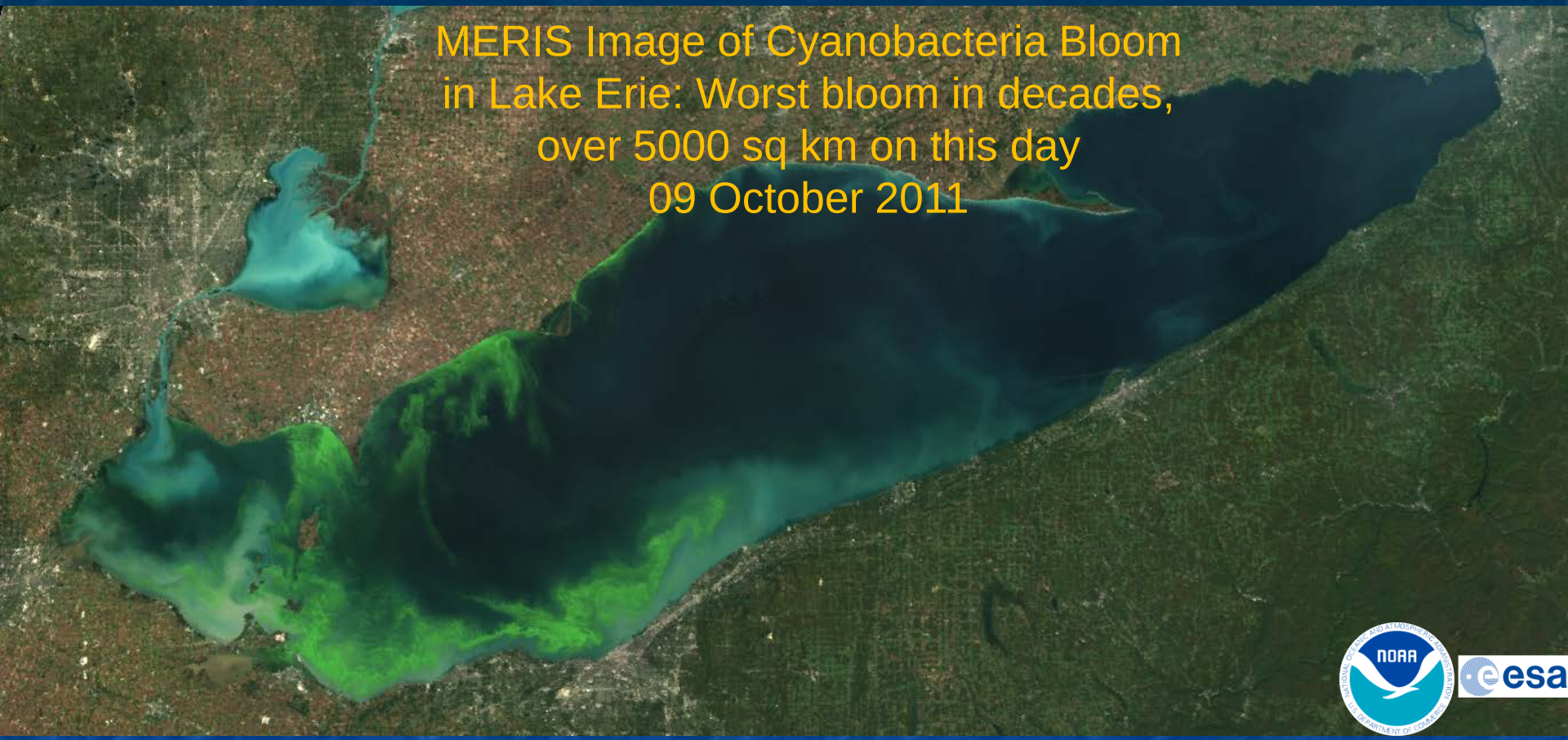
Deepwater Horizon Fire 4/21/2010





Interactively derived Marine Pollution Surveillance Report issued by NESDIS/OSPO Satellite Analysis Branch for May 2, 2010, during the Deepwater Horizon incident.

Automated Texture Classifying Neural Network (TCNNA) oil spill map for the same day. This algorithm is being developed in a collaboration between NESDIS/STAR and Florida State Univ. for future use as an automated oil spill mapping tool.


MERIS Image of Cyanobacteria Bloom
in Lake Erie: Worst bloom in decades,
over 5000 sq km on this day
09 October 2011
NOAA
esa

WEATHER

Mostly cloudy 74°

Complete Forecast→

THE BLADE

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Print Story

Scenes like this were common this morning as area residents traveled all over in search of bottled water.
THE BLADE/ JETTA FRASER

Enlarge | Buy This Photo

Published: Saturday, 8/2/2014 - Updated: 1 year ago

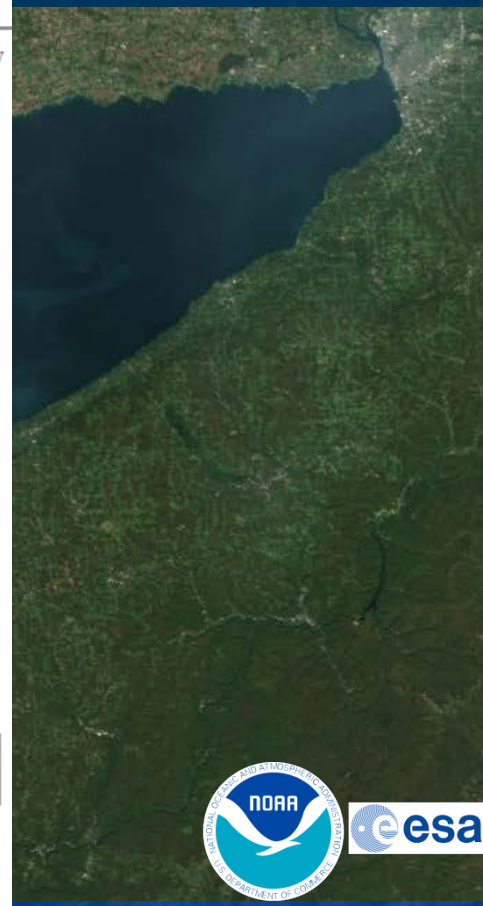
08/02/2014

Toledo-area water advisory expected to continue through Sunday as leaders await tests; water stations to remain open

Microcystin found in samples; boiling not recommended

BY TAYLOR DUNGJEN AND DAVID PATCH
BLADE STAFF WRITERS

Toledo's public water will remain under a do-not-drink advisory until at least 6 a.m. Sunday pending the return of results from test samples sent out to three different laboratories, Mayor D. Michael Collins said during an evening news conference.



WEATHER

Experimental Lake Erie Harmful Algal Bloom Bulletin

National Centers for Coastal Ocean Science and Great Lakes Environmental Research Laboratory

24 August, 2015, Bulletin 13

The *Microcystis* cyanobacteria bloom continues across a large part of the western basin along the Michigan and Ohio coasts and into the central basin. The recent southwesterly winds have pushed the bloom northward along the Michigan coast. Moderate to high concentrations extend eastward to midway between Cleveland and Rondeau, Ontario. Scum has been scattered in the last few days. Microcystin toxins are still present in the bloom, but the concentration has decreased in general. However, scum areas remain a significant risk.

Strong, westerly winds are expected through Tuesday, creating strong mixing. A possible shift to NW winds on Wed and Thursday may favor southward movement. Milder winds on Thursday may reduce mixing, giving greater potential for scum formation. The persistent bloom in Sandusky Bay continues. No other blooms are evident in the central and eastern basins.

Please check for updates on Ohio State Parks at Ohio EPA's site, http://epa.ohio.gov/habalgae.aspx. Keep your pets and yourself out of the water in areas where scum is forming.

-Stumpf, Tomlinson

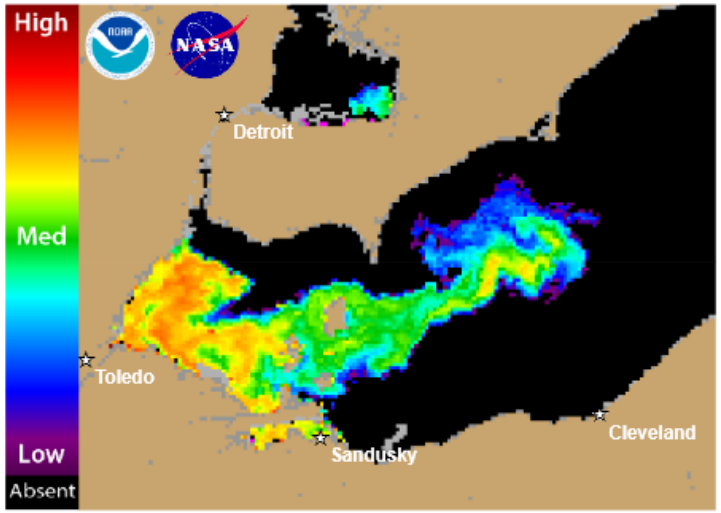


Figure 1. Cyanobacterial Index from NASA's MODIS- Aqua data collected 22 August, 2015 at 13:10 EST. Grey indicates clouds or missing data. Black represents no cyanobacteria detected. Colored pixels indicate the presence of cyanobacteria. Cooler colors (blue and purple) indicate low concentrations and warmer colors (red, orange, and yellow) indicate high concentrations. The estimated threshold for cyanobacteria detection is 20,000 cells/mL.

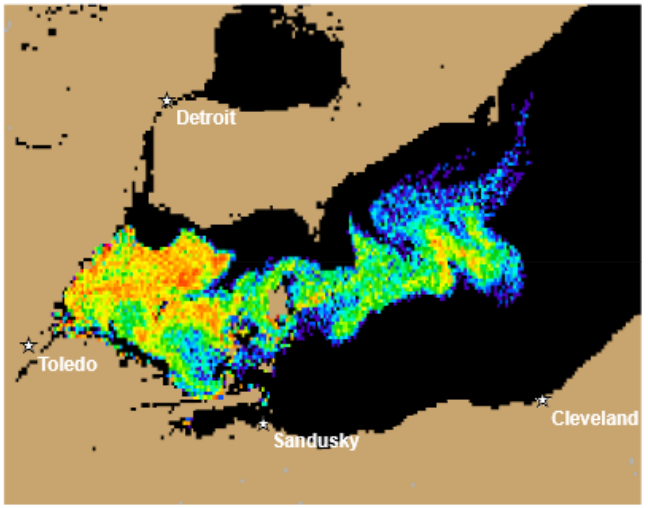


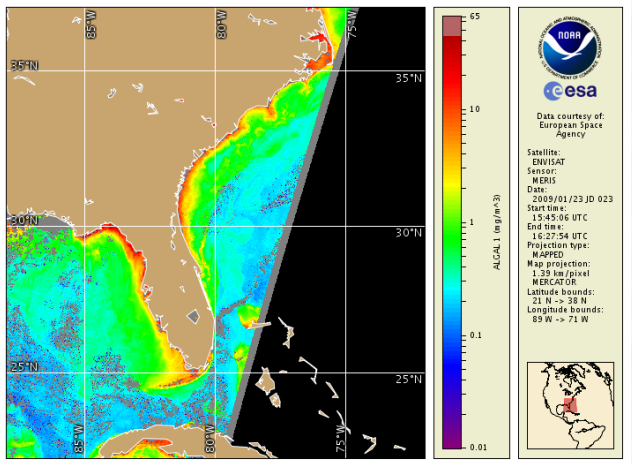
Figure 2. Nowcast position of bloom for 24 August, 2015 using GLCFS modeled currents to move the bloom from the 22 August, 2015 image.

NOAA/NOS/CO-OPS

said during an evening news conference.

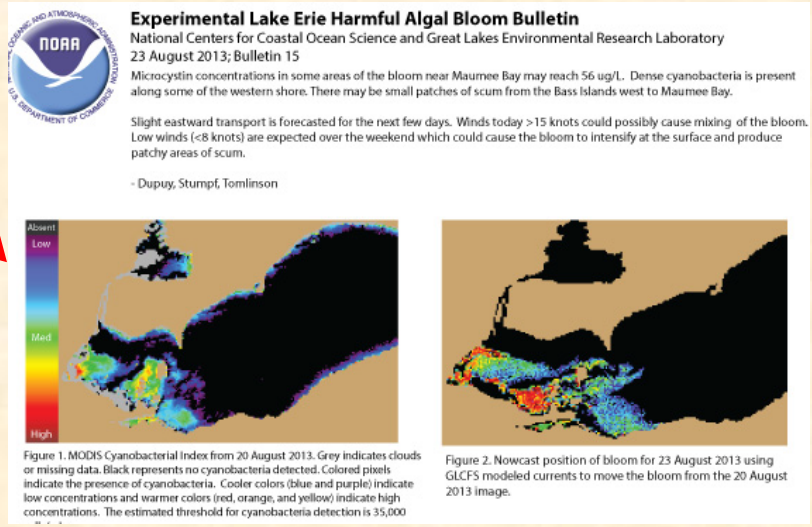
NOAA Utilization of MERIS/OLCI Ocean Color Data: Harmful Algal Blooms, Ecological Forecasting & More!

- MERIS data declared operational by SPSRB in Jan 2009; however, Envisat failed in 2012.
- Chlorophyll-a/anomalies were generated from MERIS amongst other ocean color products, supporting NOS et al. users
- Coastwatch/NOAA was a “Champion User” for the ESA Coast Colour Project, supporting coastal users internationally.
- STAR and others in NESDIS are now actively working to facilitate acquisition of the follow-on Sentinel-3 (OLCI et al.) data to support NOS HAB & other U.S. user needs.
- Sentinel-3/OLCI, like Envisat/MERIS, has improved spatial resolution (300 m), useful for coastal/inland waters, and especially has additional spectral bands – and as such is a vital complementary capability to VIIRS (especially as provides mid-morning orbit).
- STAR is supporting ESA/EUMETSAT as part of the Sentinel-3 Validation Team (3 projects)



http://coastwatch.noaa.gov

NESDIS efforts have resulted in the generation and flow of experimental and operational ocean color products to the NOAA & broader user communities.



Experimental Lake Erie Harmful Algal Bloom Bulletin

National Centers for Coastal Ocean Science and Great Lakes Environmental Research Laboratory

23 August 2013; Bulletin 15

Microcystin concentrations in some areas of the bloom near Maumee Bay may reach 56 ug/L. Dense cyanobacteria is present along some of the western shore. There may be small patches of scum from the Bass Islands west to Maumee Bay.

Slight eastward transport is forecasted for the next few days. Winds today >15 knots could possibly cause mixing of the bloom. Low winds (<8 knots) are expected over the weekend which could cause the bloom to intensify at the surface and produce patchy areas of scum.

- Dupuy, Stumpf, Tomlinson

Figure 1. MODIS Cyanobacterial Index from 20 August 2013. Grey indicates clouds or missing data. Black represents no cyanobacteria detected. Colored pixels indicate the presence of cyanobacteria. Cooler colors (blue and purple) indicate low concentrations and warmer colors (red, orange, and yellow) indicate high concentrations. The estimated threshold for cyanobacteria detection is 35,000

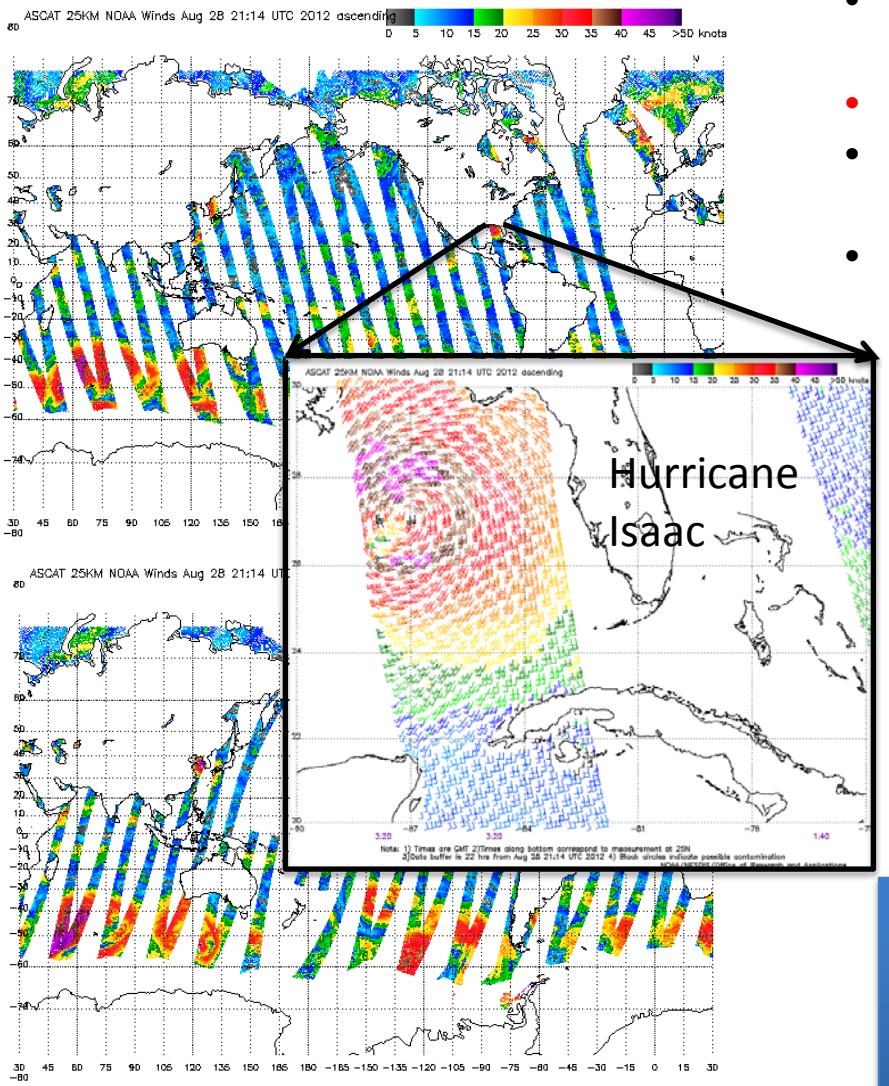
Figure 2. Nowcast position of bloom for 23 August 2013 using GLCFS modeled currents to move the bloom from the 20 August 2013 image.

Key Sentinel land data needs

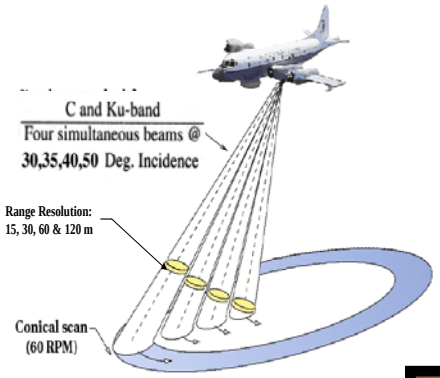
- *SLSTR*: Active fire detection and fire radiative power
  - Provide MODIS/VIIRS compatible fire observations on mid-morning orbit to monitor diurnal cycle
- *SLSTR*: Land surface temperature
  - Additional LST observations combining with VIIRS compatible LST observations for gridded LST data that can be used for Weather model assimilation and evaluation
- *OLCI*: Vegetation indices
  - can be designed to provide continuity and potential gap filler with derived SNPP/JPSS VIIRS Vegetation Indices
- *SLSTR / OLCI / MSI*: Integration within Land Product Characterization System (LPCS)
  - intercomparison with NOAA land products
- *SLSTR / MSI*: surface type change detection
  - complimentary to VIIRS observations and for validation of VIIRS surface type products

Satellite Ocean Surface Vector Winds

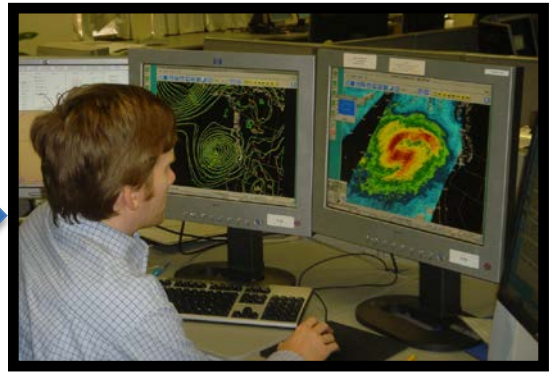
ASCAT Daily Coverage Example



- OSVW data supports wind and wave warning and forecasting
- ASCAT data from EUMETSAT operational at NOAA
- OSCAT data from ISRO was in operational demonstration phase prior to its failure in 2014
- NOAA P-3 used to fly a profiling scatterometer system (IWRAP) for validation and improvement of satellite algorithms in tropical (hurricanes) and extratropical cyclone conditions



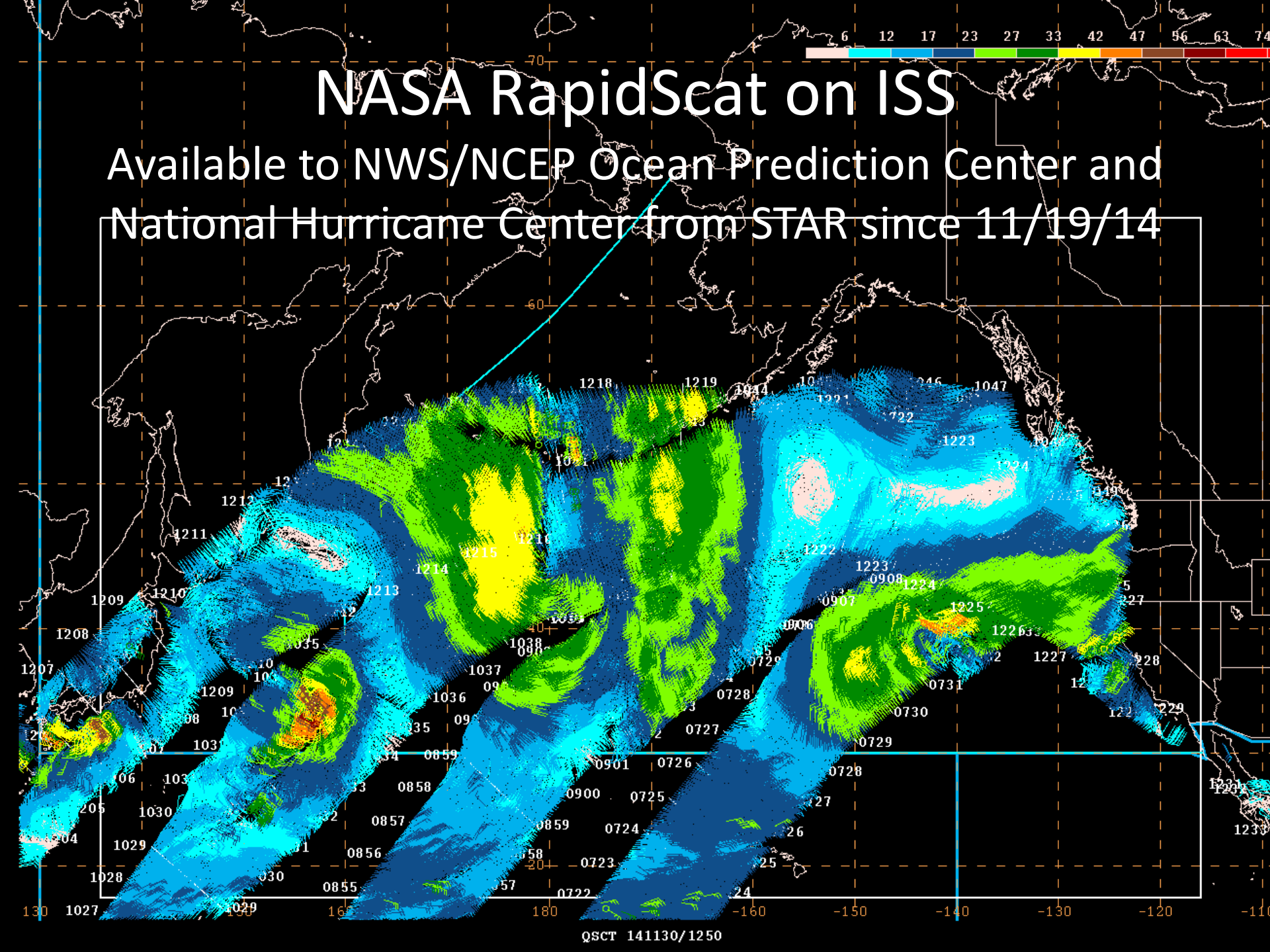
Goal: Provide the best possible product and training to end users



NOAA Satellite Ocean Surface Winds Science Team
http://manati.star.nesdis.noaa.gov/

NASA RapidScat on ISS

Available to NWS/NCEP Ocean Prediction Center and National Hurricane Center from STAR since 11/19/14

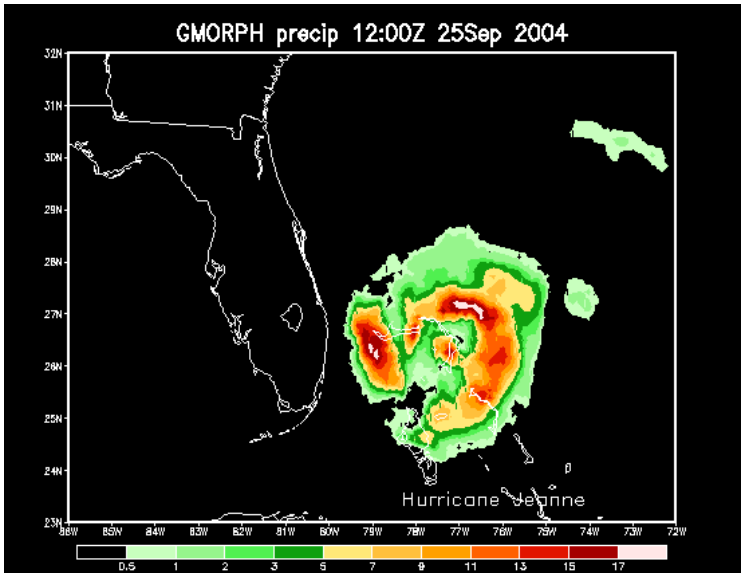


Importance of GPM from NOAA's Perspective

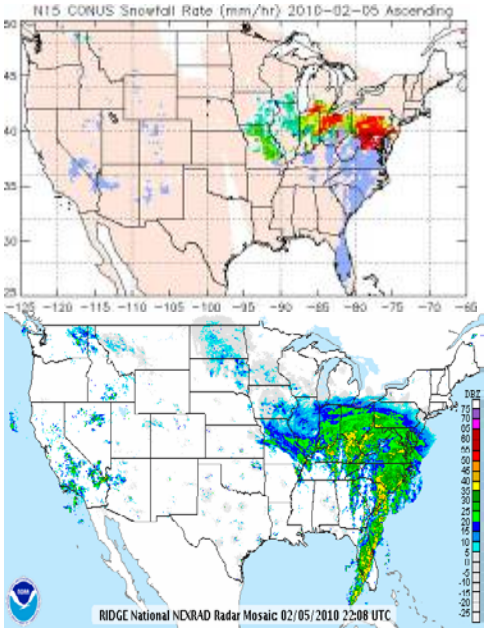
- Strong connection to several NOAA mission goals
  - Weather Ready Nation, Climate Adaptation and Mitigation
  - Only agency responsible for operational "water" forecasts
- Continuity of "operations" for TRMM
  - GPM-core - higher inclination than TRMM (65 vs. 35 deg.)
    - Serves as calibration anchor for algorithm development/tuning
  - GPM has more advanced payloads (GMI vs. TMI; DPR vs. PR)
- Precipitation Constellation
  - DMSP, POES, MetOp, JPSS, GCOM, … are all part of it
  - Synergy with our own satellite programs (POES/JPSS and GOES/GOES-R)
  - Enables new multi-sensor (+ in-situ) blended precipitation products that will lead to major improvements for
    - Operational monitoring/forecasting
    - Monitoring of seasonal to inter-annual variations, as well as long-term trends
  - Can improve our understanding of precipitation impact on other variables, e.g., soil moisture (SMAP, SMOS) and salinity (SMOS)
- We are leveraging off huge investment from NASA & JAXA
  - Sensors and launch vehicles…. ~ $1 Billion
  - NASA science team ~ $8 M/yr – state of the art science & processing system
    - NOAA "historical" investment about $500 K/year from a variety of programs

Benefits of GPM Precipitation Constellation to NOAA

- Achieve ≤ 3-hourly global coverage
  - Global monitoring of "storms"
  - Tuning of merged GEO/MW algorithms (<30 min)
    - GOES & GOES-R
  - NWP data assimilation (L1 data)
    - OSSE's show improved TC track prediction
  - Climate monitoring and prediction
    - NOAA/CMORPH, GPM/IMERG



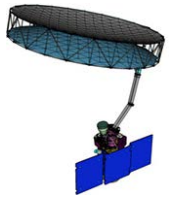
- Develop inter-satellite calibrated data sets for Climate Data Records
  - Need high precision GMI as anchor



- High latitude precipitation - Alaska
  - Beyond GOES capability
  - Sensitive to cold season precipitation

- Integrated precipitation products
  - Satellite + radar + gauge
  - Reduce number of NOAA product systems

Satellite Sea-surface Salinity (SSS)



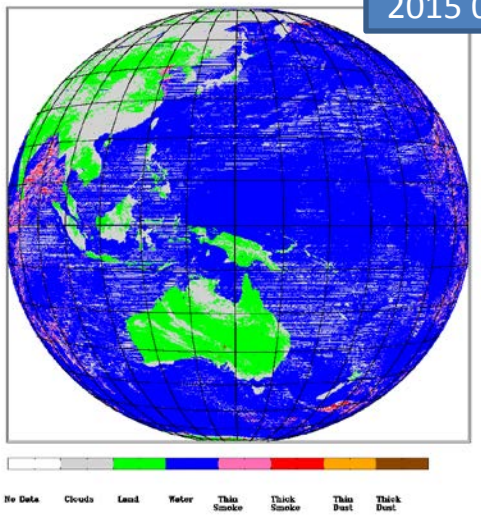
- **Salinity = fundamental ocean state parameter**
- **Satellite SSS data availability:**
  - ***Only non-NOAA sources***
  - **ESA** Soil Moisture – Ocean Salinity (SMOS) mission
  - **NASA** Soil Moisture Active-Passive (SMAP) mission
- **Application:**
  - **Ocean/regional modeling/prediction**
    - **NOAA's Real-Time Ocean Forecast System (RTOFS)**
    - **NOAA's West Coast Operational Forecast System (WCOFS, under development)**
  - **Coupled modeling/prediction**
    - NOAA's seasonal-interannual **Climate Forecast System (CFS) - Global Ocean Data Assimilation System (GODAS)**
    - Coupled hurricane modeling
    - Coupled ocean-atmosphere-cryosphere modeling
  - **Hydrological cycle**
    - **Climate Prediction Center** operational salinity/evaporation/precipitation analyses and trends
  - **Ecological forecasting**
    - Ocean acidification
      - Fundamental for deriving acidification parameters and rates
    - Habitats
    - Density fronts

GOES-R ABI Aerosol Detection Product Algorithm on H-8 Data

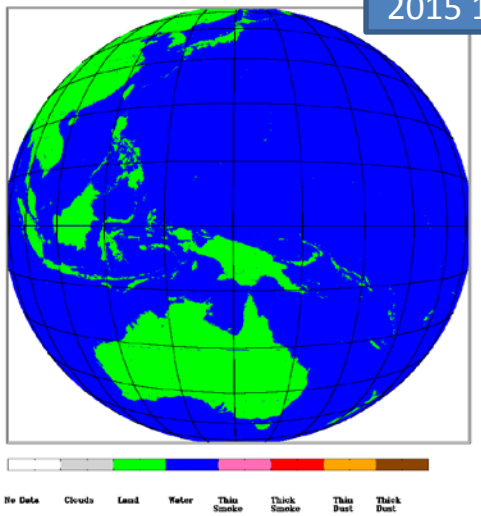
- Himawari-8 L1B data obtained from AIT
- Himawari-8 Cloud Mask data obtained from UW-Madison
- Aerosol Detection Product algorithm applied to H-8 data collected on March 25, 2015
  - No dust of smoke detected for 1700 UTC (night) but false smoke detected for 0230 UTC (day).
  - Data artifacts (false smoke) in H-8 data due to striping. RGB images for every hour of the day were also generated. Significant striping especially in the twilight zone (movie available but not shown here).
  - JAXA working on a fix to the striping issue

GOES-R ABI algorithms ran successfully on H-8 data and results indicate that L1B radiances need to be accurate to minimize data artifacts in retrieved products

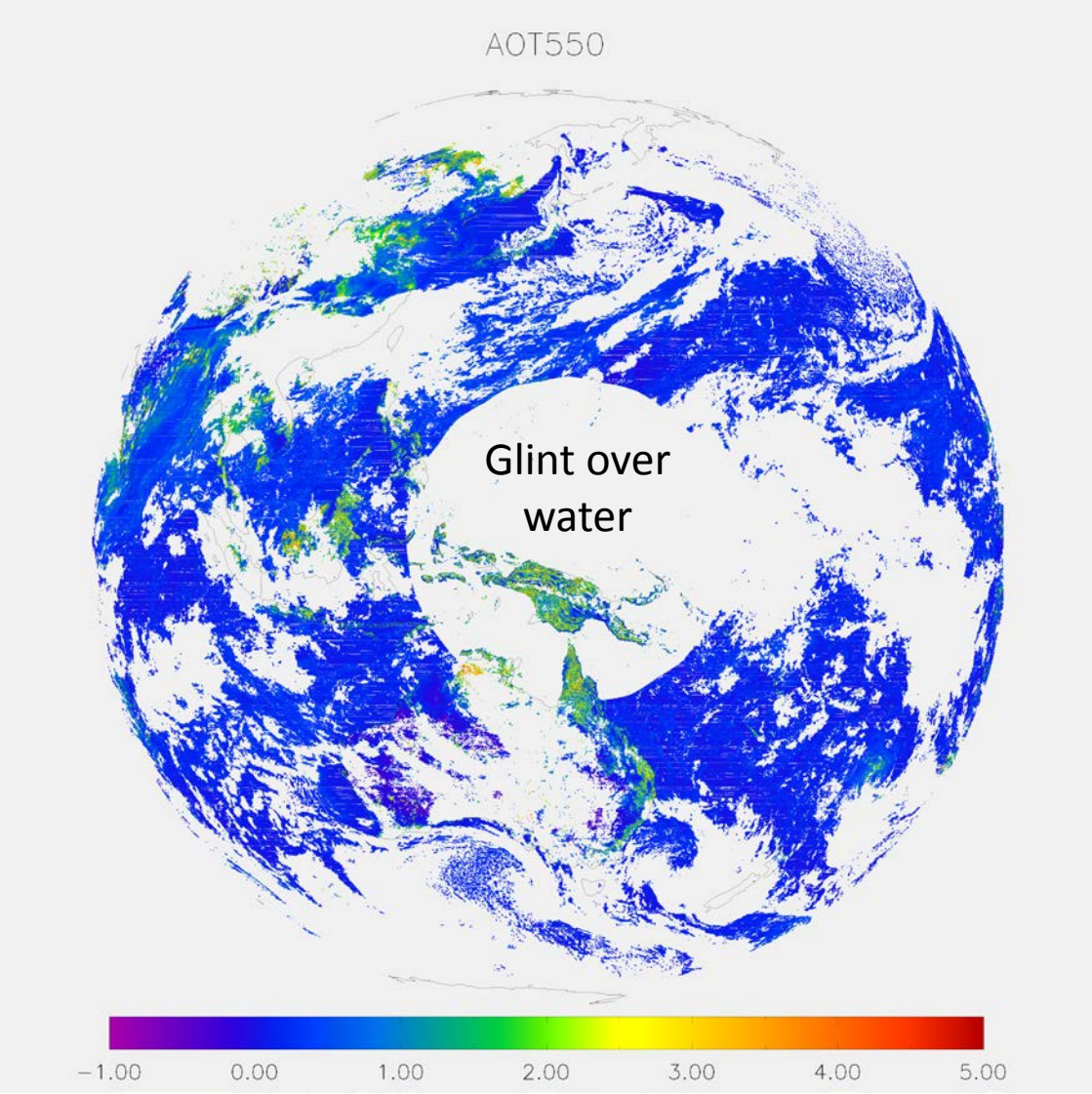
March 25, 2015 0230 UTC



March 25, 2015 1700 UTC



Aerosol Optical Depth from Himawari-8



- Aerosol optical depth (AOD) estimated from Advanced Himawari Imager (AHI) data at 2:30 UTC on March 25, 2015. The GOES-R ABI algorithm was used.
- NCEP reanalysis data for water vapor, wind speed/direction, model surface pressure/height were used
- O_3 is from climatology.

CryoSat Operational Polar Monitoring

Home | Sea Ice | Ice Sheets | Ice Caps | **Sea Ice Volume and Thickness** | Science | Data | About

Arctic Sea Ice Thickness Maps

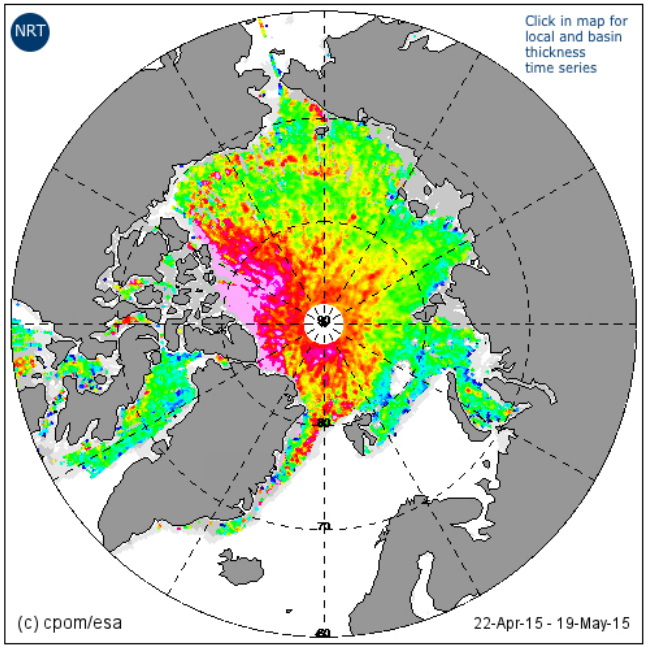
Arctic sea ice thickness processed at UCL from CryoSat's SAR mode data:

Latest from Near Real Time Data | Final Precise Data

2-days | 14-days | 28-days | Autumn | 2014

22-May-15: NRT Service Stopped until September 2015. Sea ice thickness cannot be accurately measured from CryoSat during the Arctic summer period, due to the formation of melt ponds on the sea ice surface. These ponds interfere with the radar signal and measurement method.

Latest 5km Grid of 28-day Thickness : 22/4/15 - 19/5/15



Arctic Sea Ice Timeseries

Display the change over time in sea ice thickness or volume over the whole Arctic, an ocean basin, or thickness at a point location:

Show : Volume | Thickness

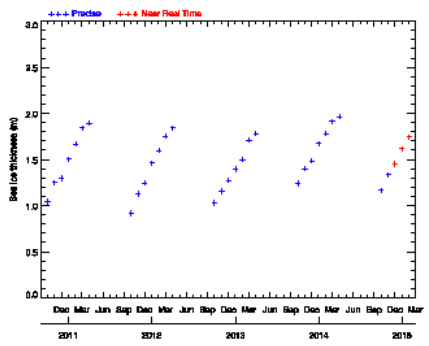
Select Location of Thickness Time Series or click on Map.

Lat: 60.0..90.0 Lon E: -180..360 Select

Select by Point | All Arctic

The plot below shows the timeseries of Monthly mean sea ice thickness calculated from CryoSat precise and near real time (NRT) data over the whole Arctic area of sea ice extent.

Whole Arctic Thickness



A timeseries at a single location and Arctic basin can also be displayed by clicking on the sea ice thickness maps on the left or by entering a latitude and longitude location and choosing Select by Point in the panel above.

CPOM Sea Ice Report

Report Date: 20-July-2015

Credit: University College London

So, the question is…….

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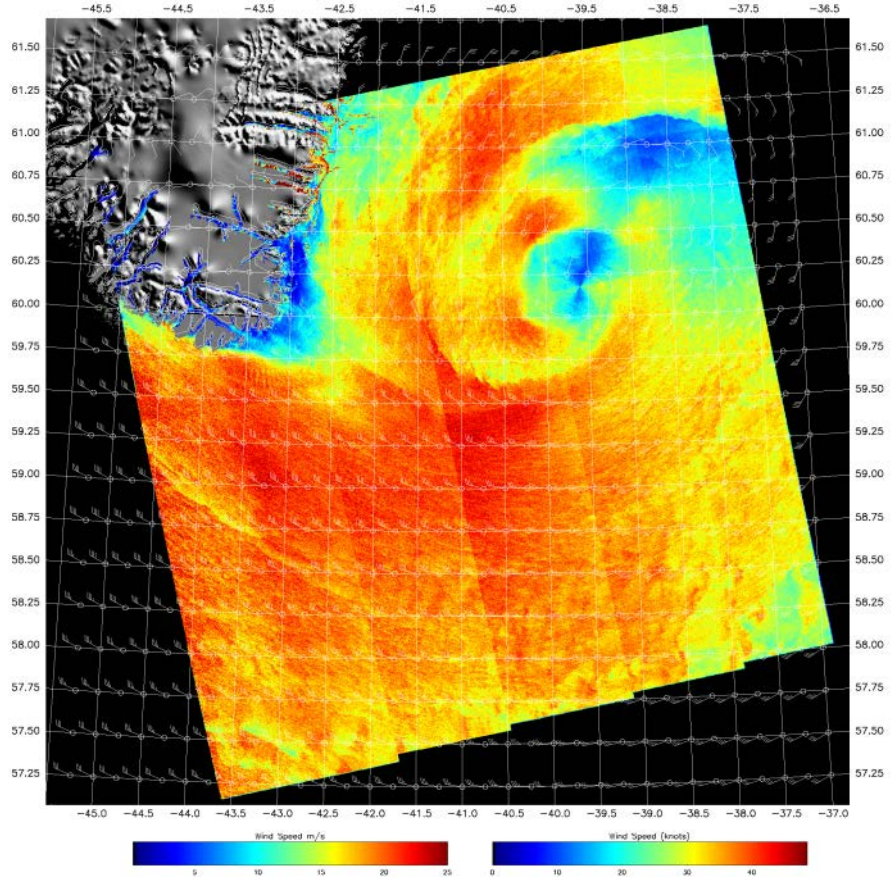
- How do we (NOAA) proceed with the acquisition, development and (operational) distribution et al. of non-NOAA data (foreign & domestic) in the JPSS (polar)/GOES-R (geo) era in support of user needs?

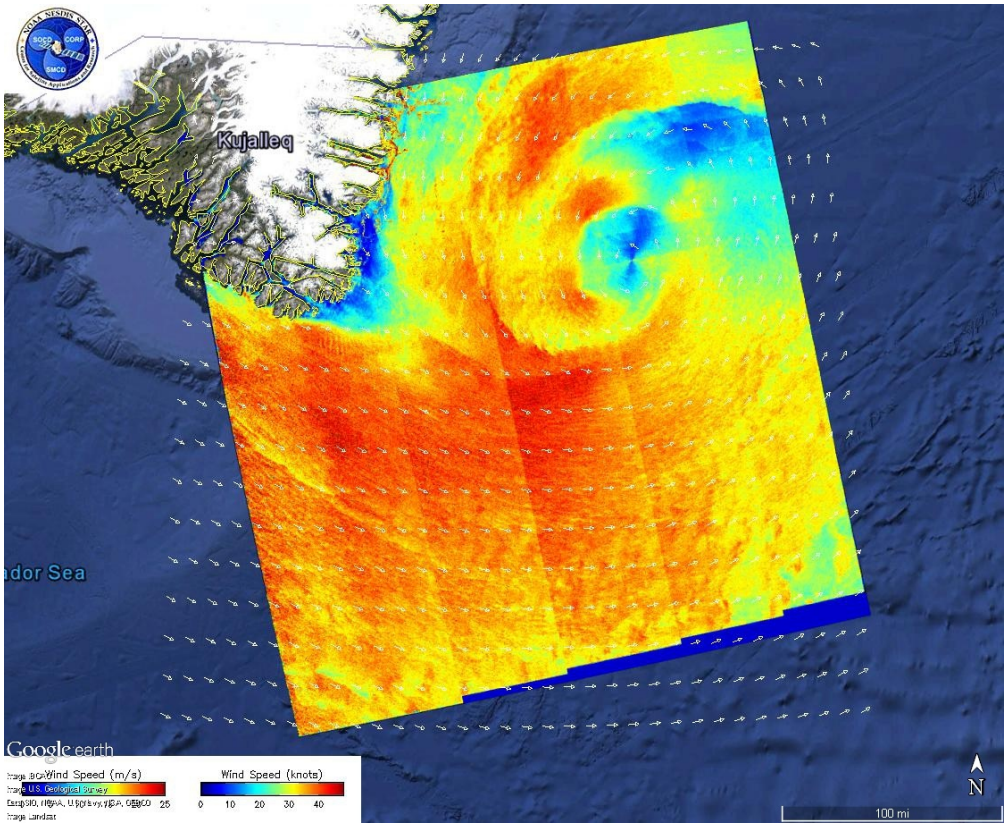
But don’t worry Mitch (and JPSS) - you are still beloved!!

Backup slides

Sample Sentinel-1A wind images: 2014-12-31 20:19:38 UTC

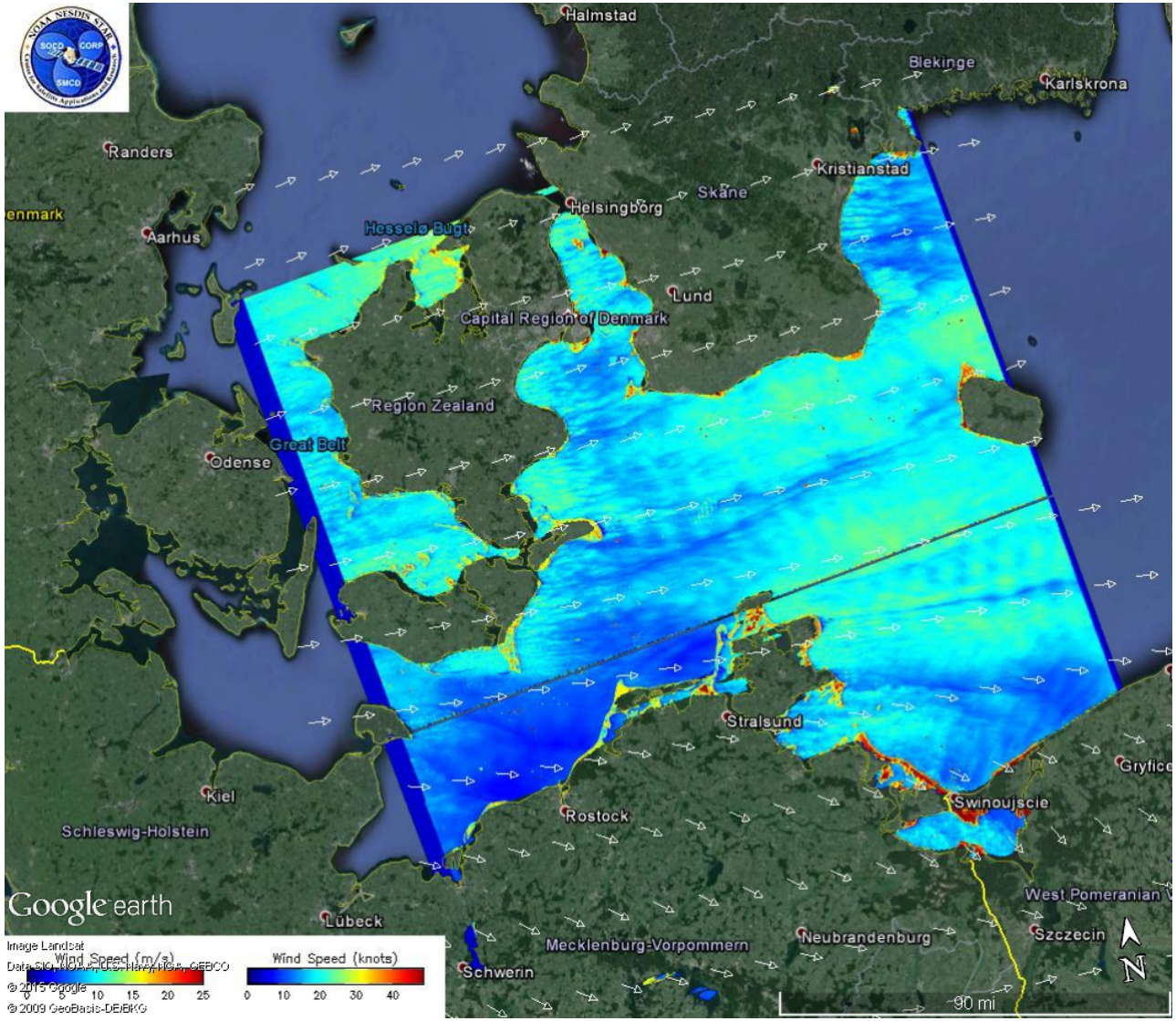


PNG Image



KMZ File

Sentinel-1A Wind Speed Retrieval Baltic Sea



July 6, 2015, 1652