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

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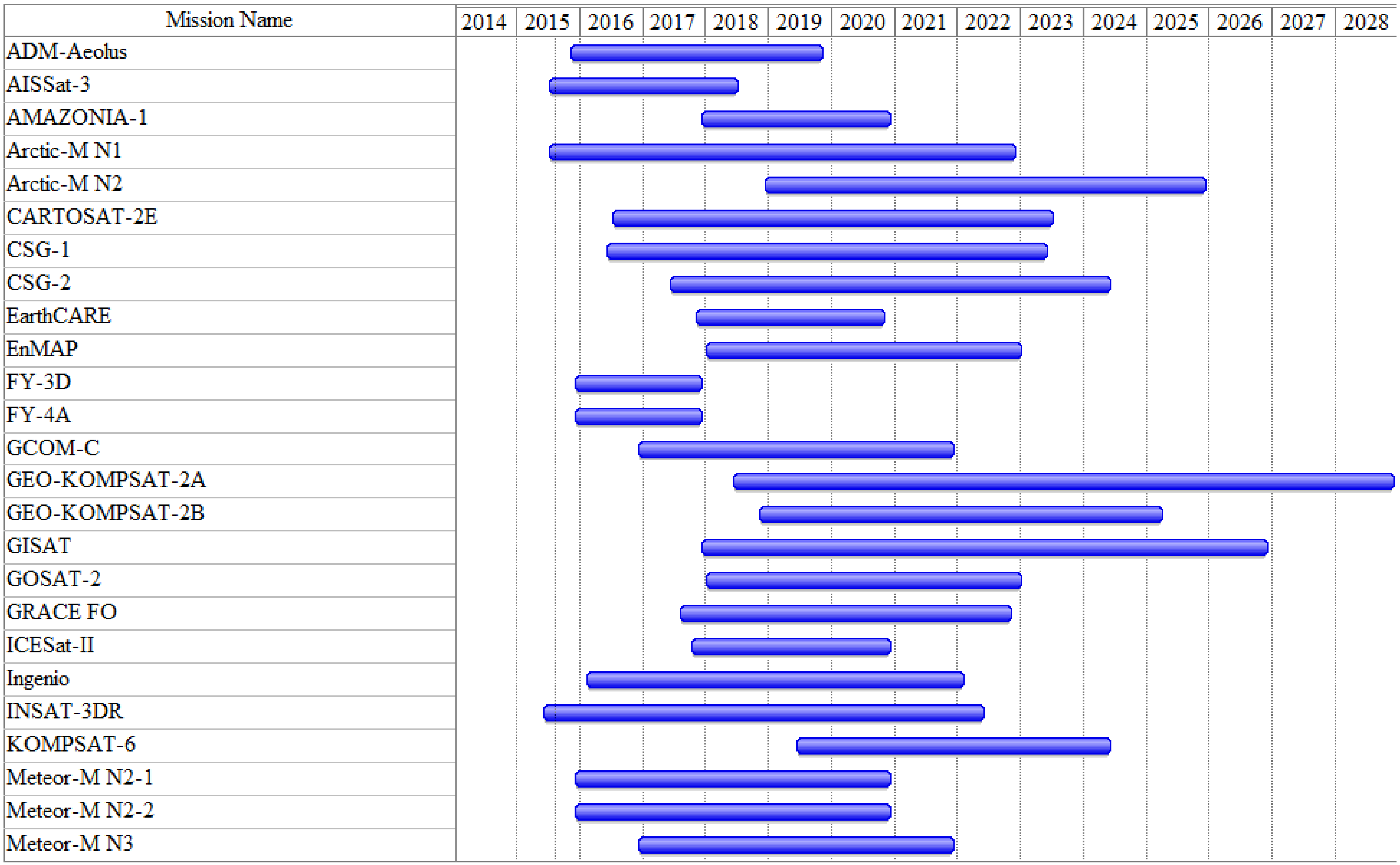
2015 STAR JPSS Annual Science Team Meeting

25 August 2015
College Park, Maryland USA

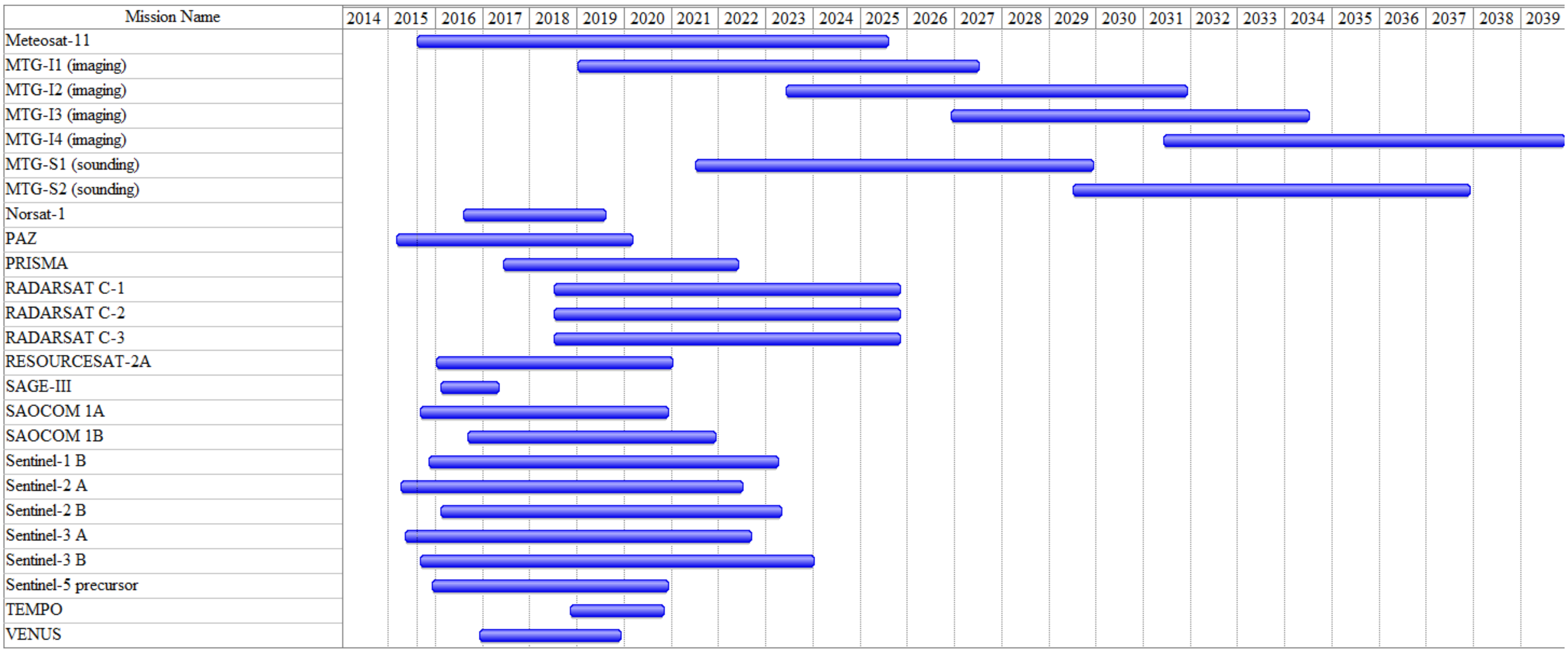
Opportunities & Challenges for Leveraging Non-NOAA Satellite Data

- 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)



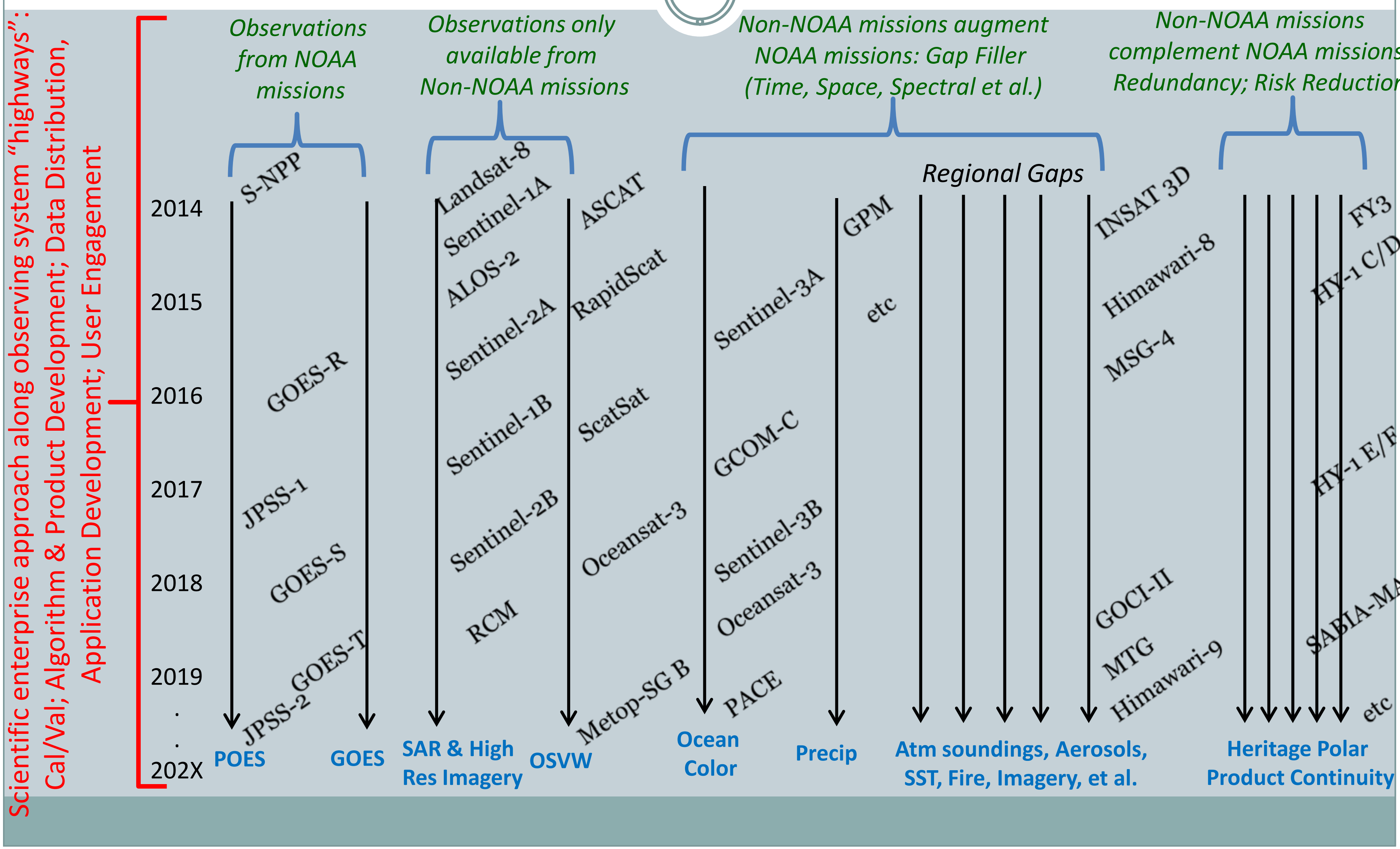
Non-NOAA Satellite Fly Out From the CEOS Database (2, et al.)



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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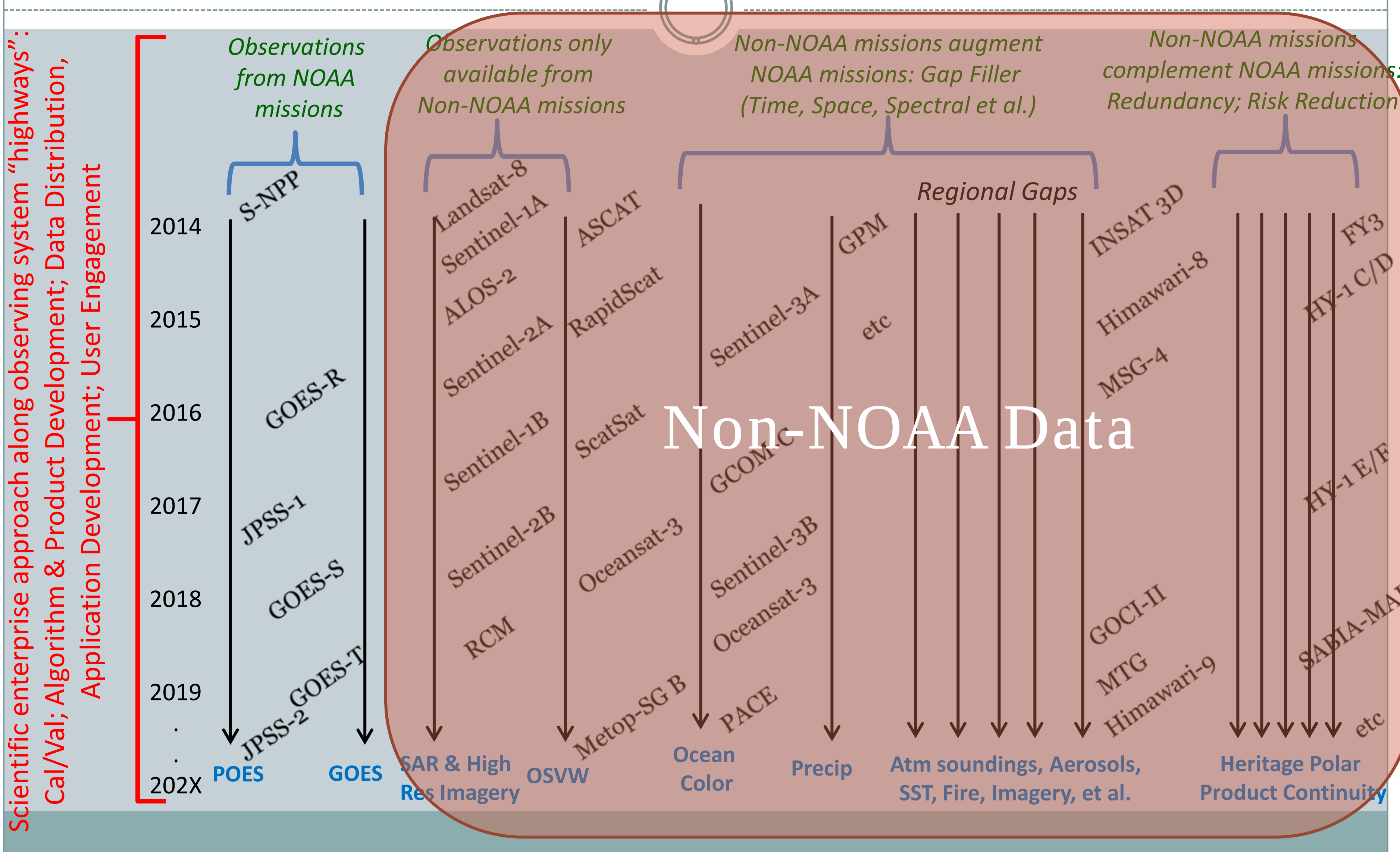
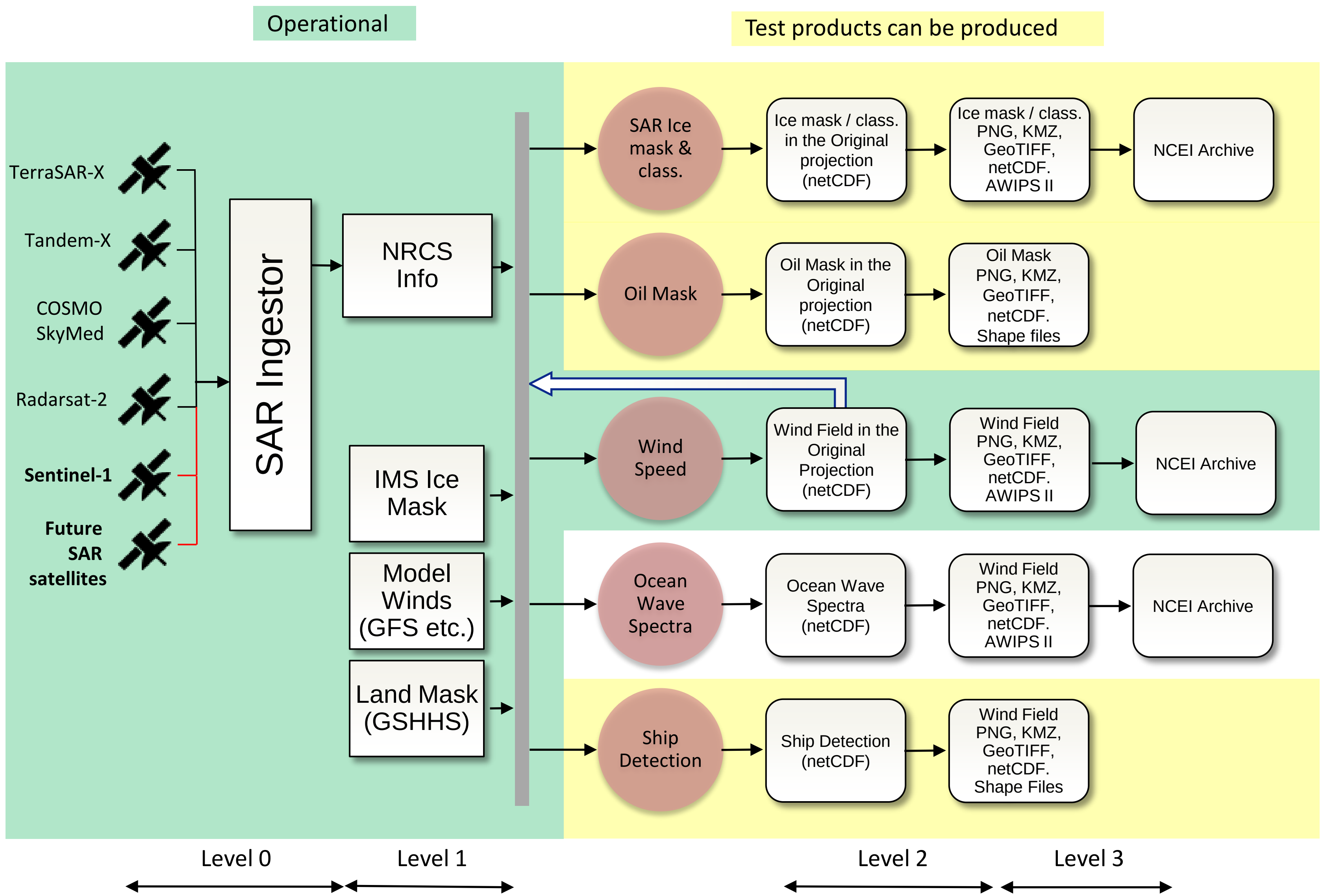


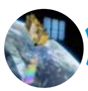
Example of mission-agnostic, measurement-based enterprise approach: SAROPS Processing Chain



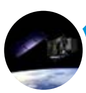
Copernicus Missions: The Sentinel Series

- 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

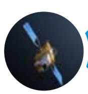
S1A/B: Radar Mission



S2A/B: High Resolution Optical Mission



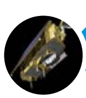
S3A/B: Medium Resolution Imaging and Altimetry Mission



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)

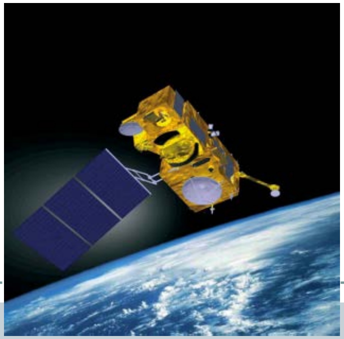
C-band synthetic aperture radar (SAR)

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



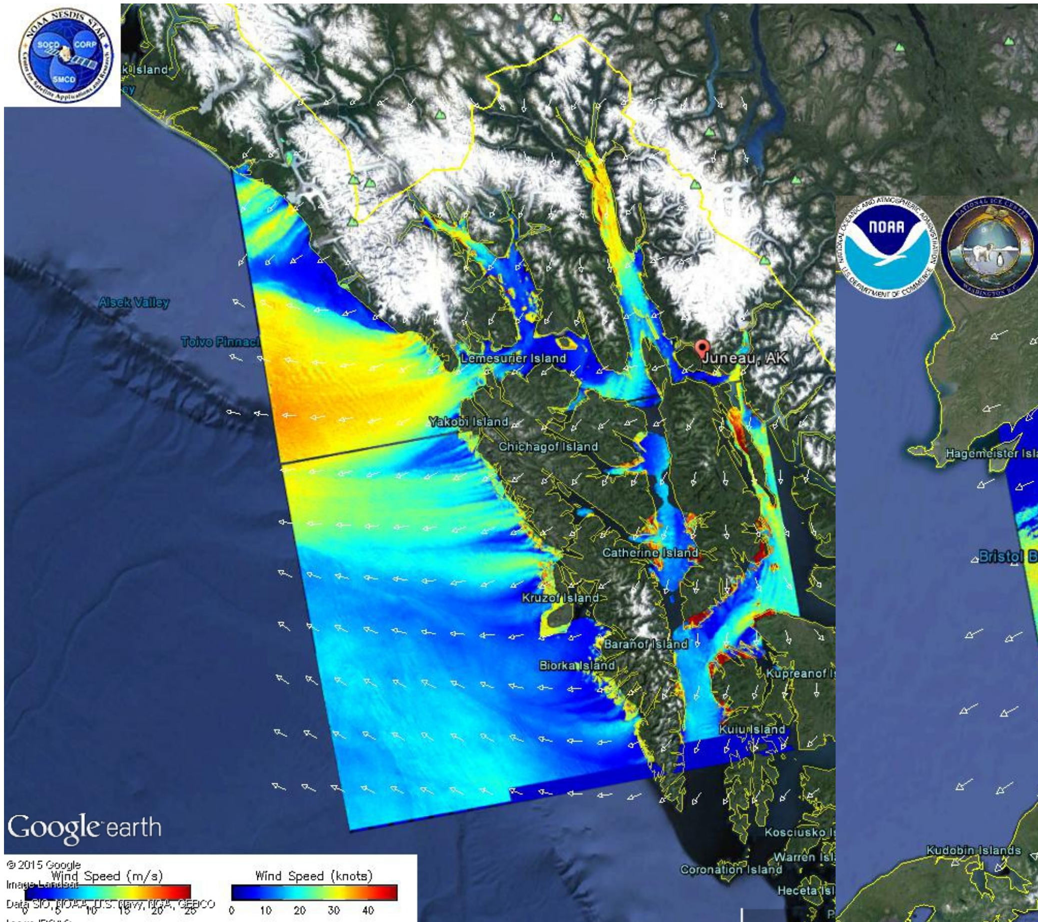
Sentinel-3A/B
(~31 Oct 2015, 2017)

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

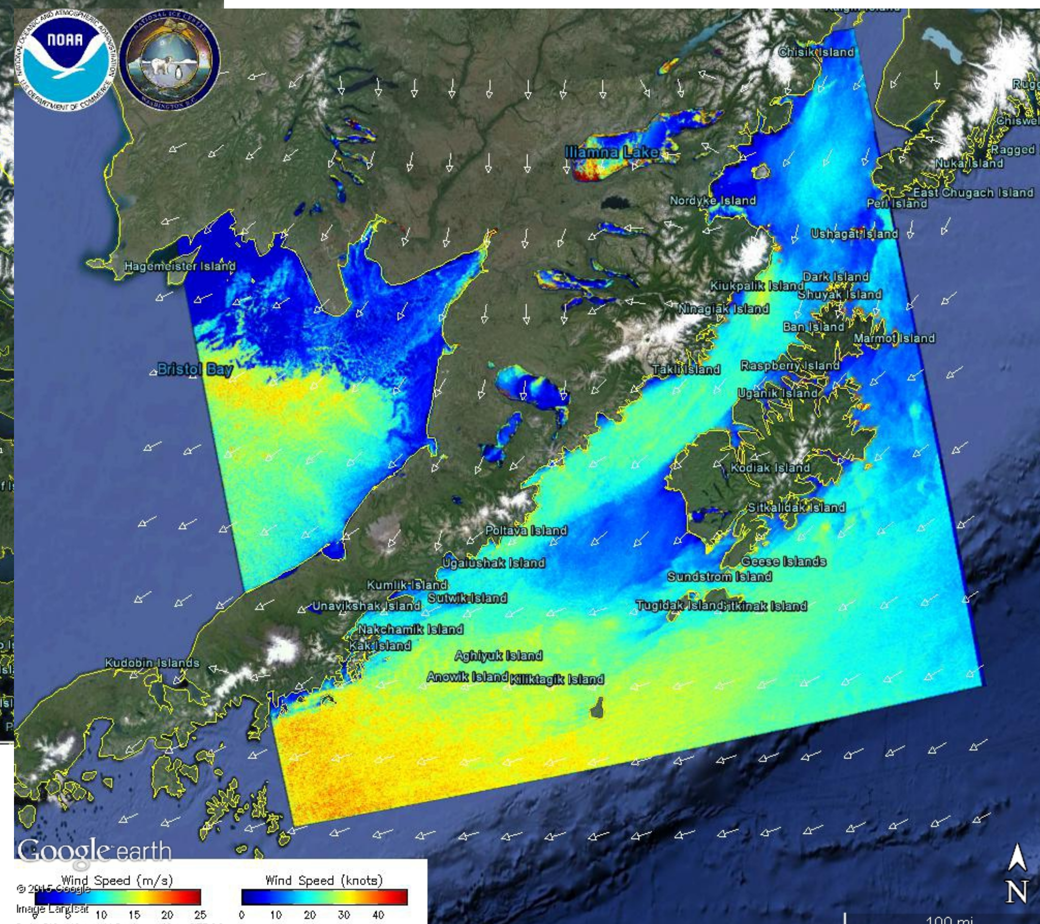
High-Resolution SAR-Derived Wind Speed Products

Bill Pichel & Frank Monaldo



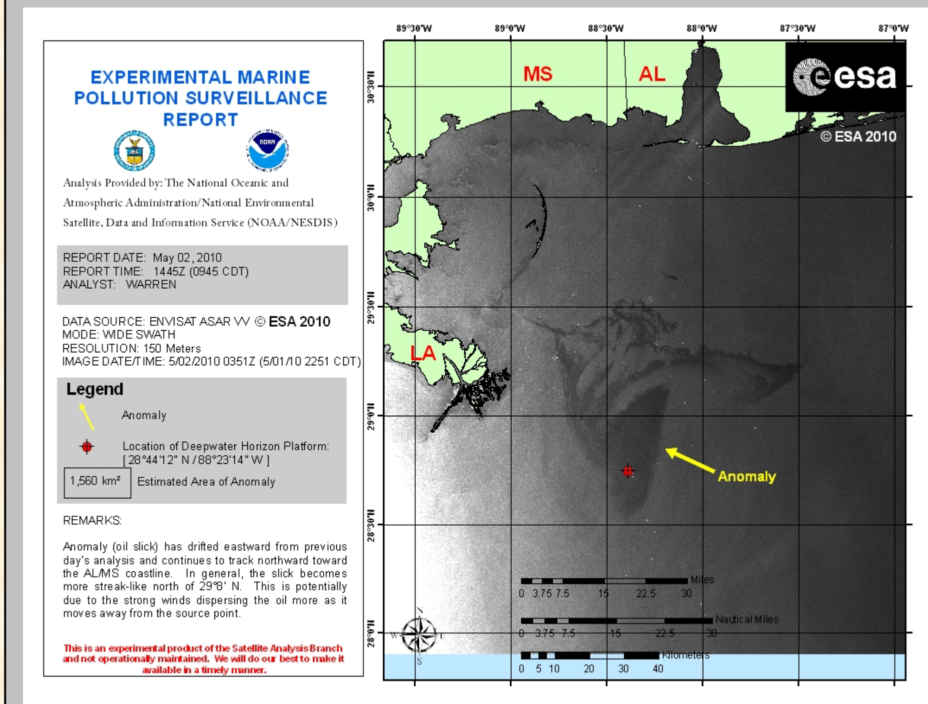
Pre-operational S1A wind speed
2015-01-08 02:46 UT

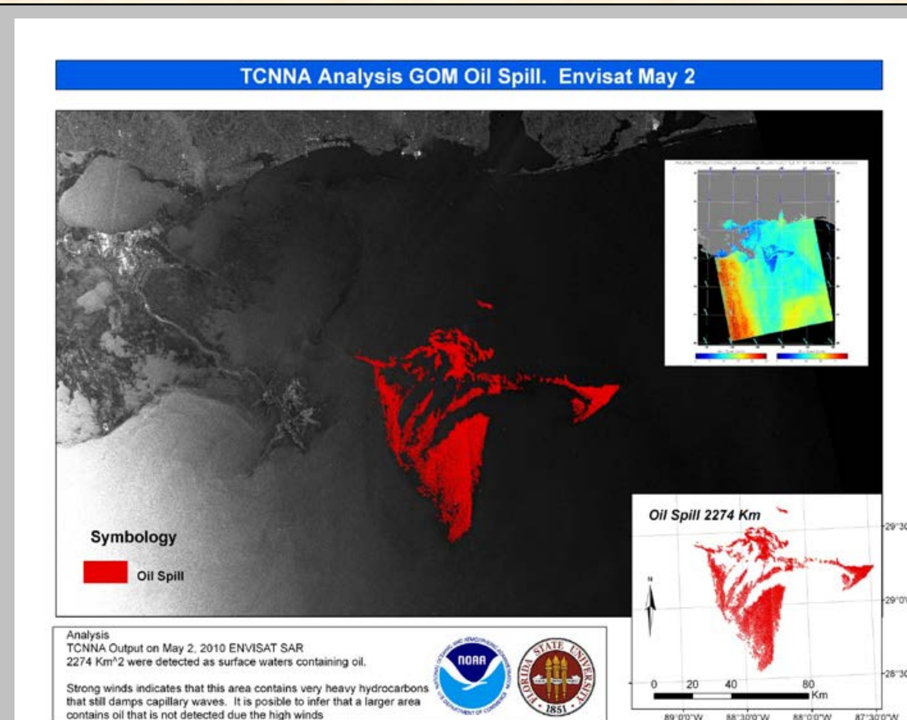
Operational RSAT2 wind speed
2015-02-04 04:05 UT



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

Deepwater Horizon Fire 4/21/2010



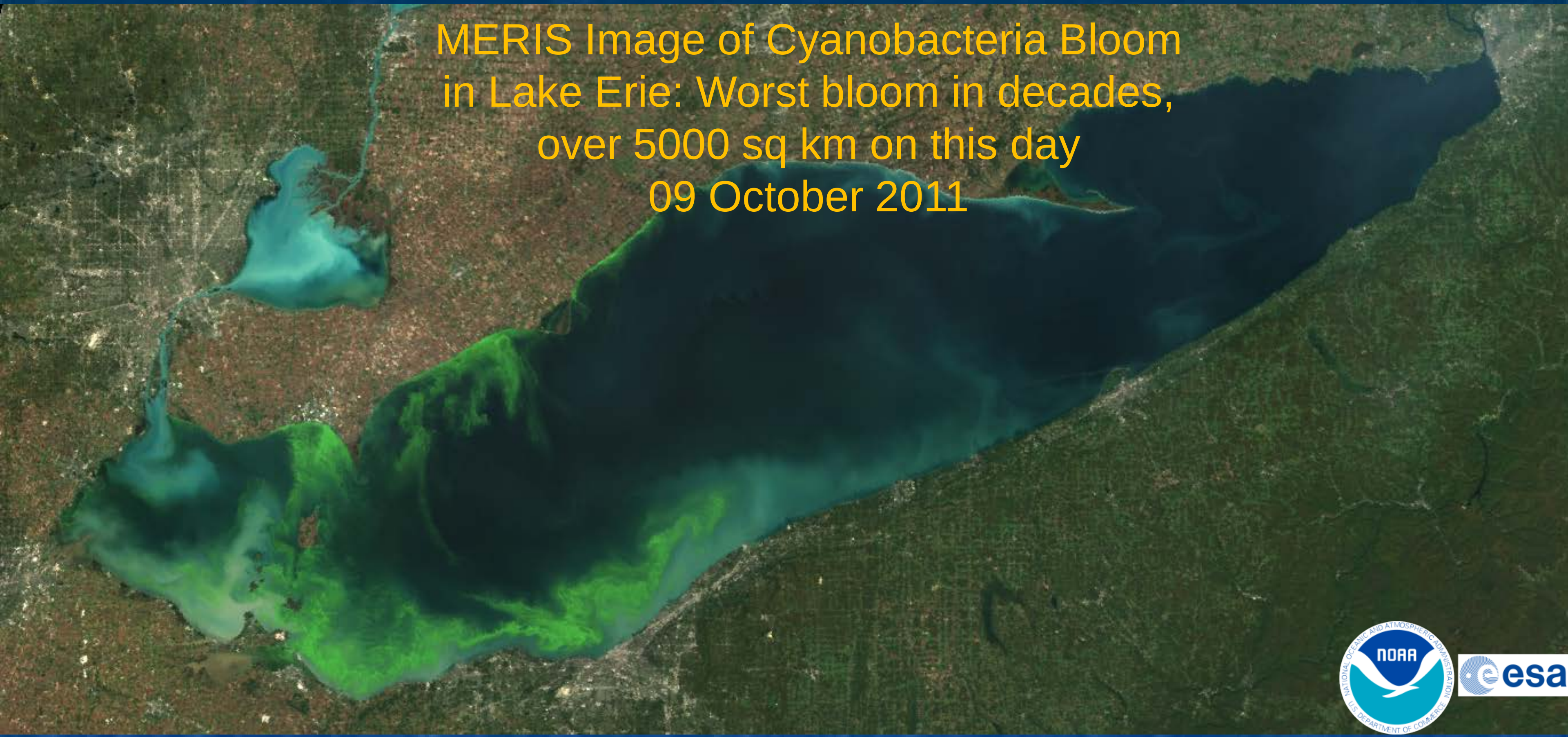


Interactively derived Marine Pollution Surveillance Report issued by NESDIS/OSPO Satellite Analysis Branch for May 2, 2010, during the Deepwater Horizon incident.

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



WEATHER

Mostly cloudy 74°

Complete Forecast→

THE BLADE

One of America's Great Newspapers

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

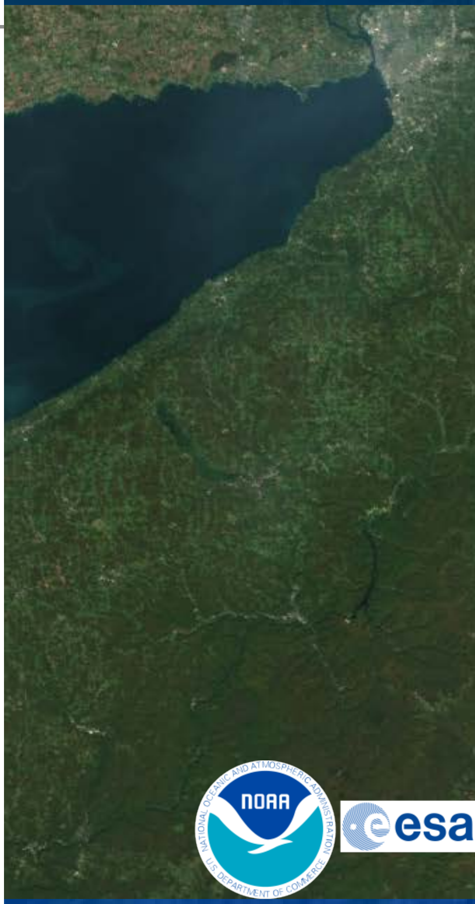
08/02/2014

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

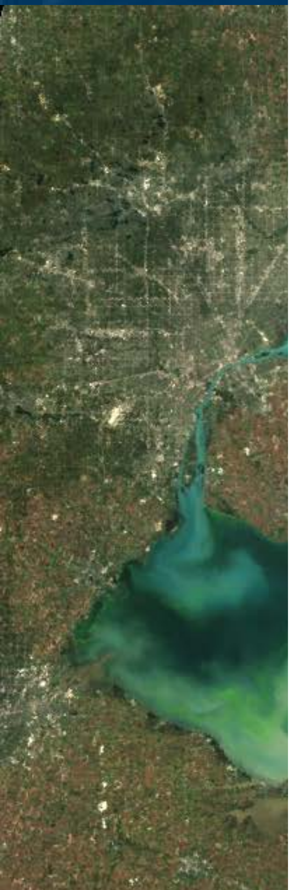
24 August, 2015, Bulletin 13

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



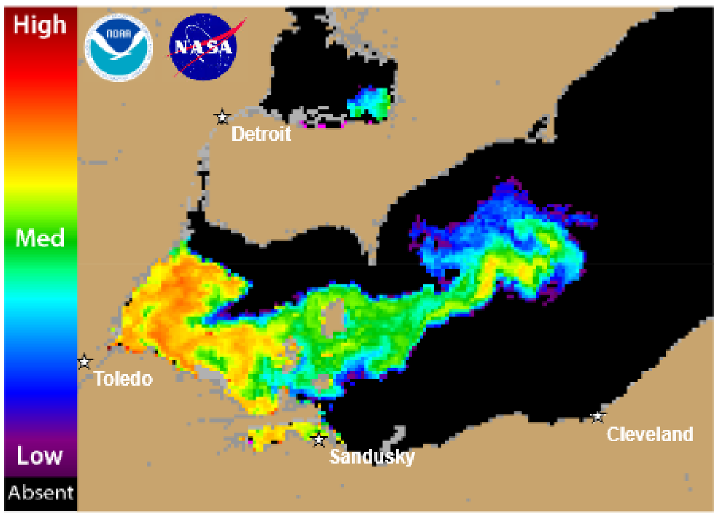


Figure 1. Cyanobacterial Index from NASA's MODIS- Aqua data collected 22 August, 2015 at 13:10 EST. Grey indicates clouds or missing data. Black represents no cyanobacteria detected. Colored pixels indicate the presence of cyanobacteria. Cooler colors (blue and purple) indicate low concentrations and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

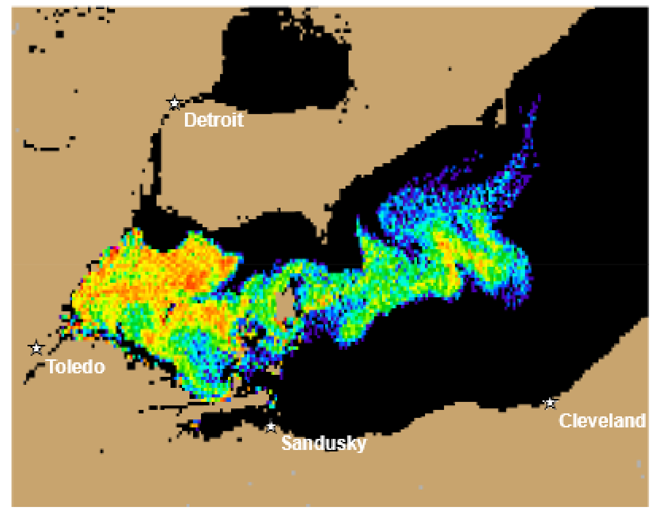


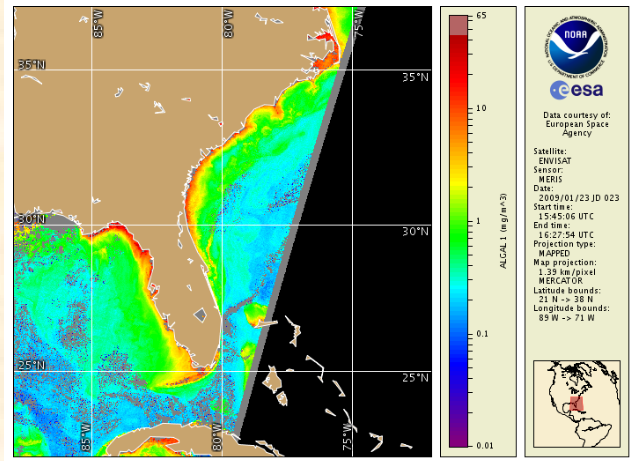
Figure 2. Nowcast position of bloom for 24 August, 2015 using GLCFS modeled currents to move the bloom from the 22 August, 2015 image.

NOAA/NOS/CO-OPS

said during an evening news conference.

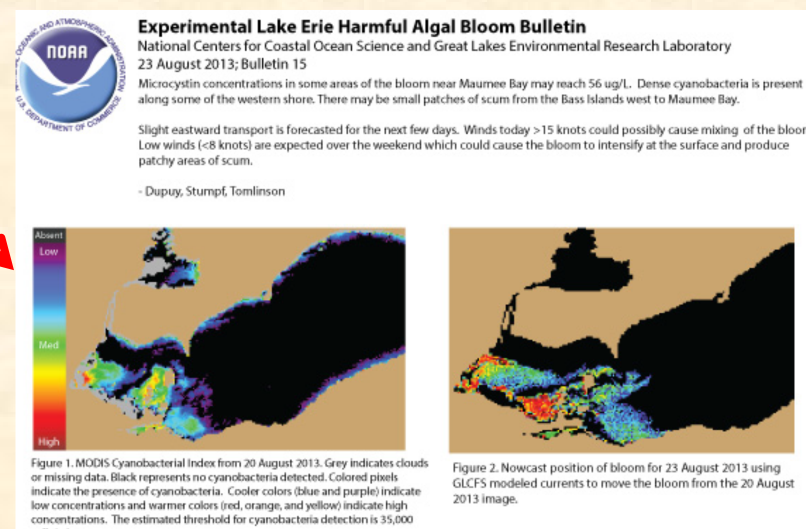
NOAA Utilization of MERIS/OLCI Ocean Color Data: Harmful Algal Blooms, Ecological Forecasting & More!

- 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

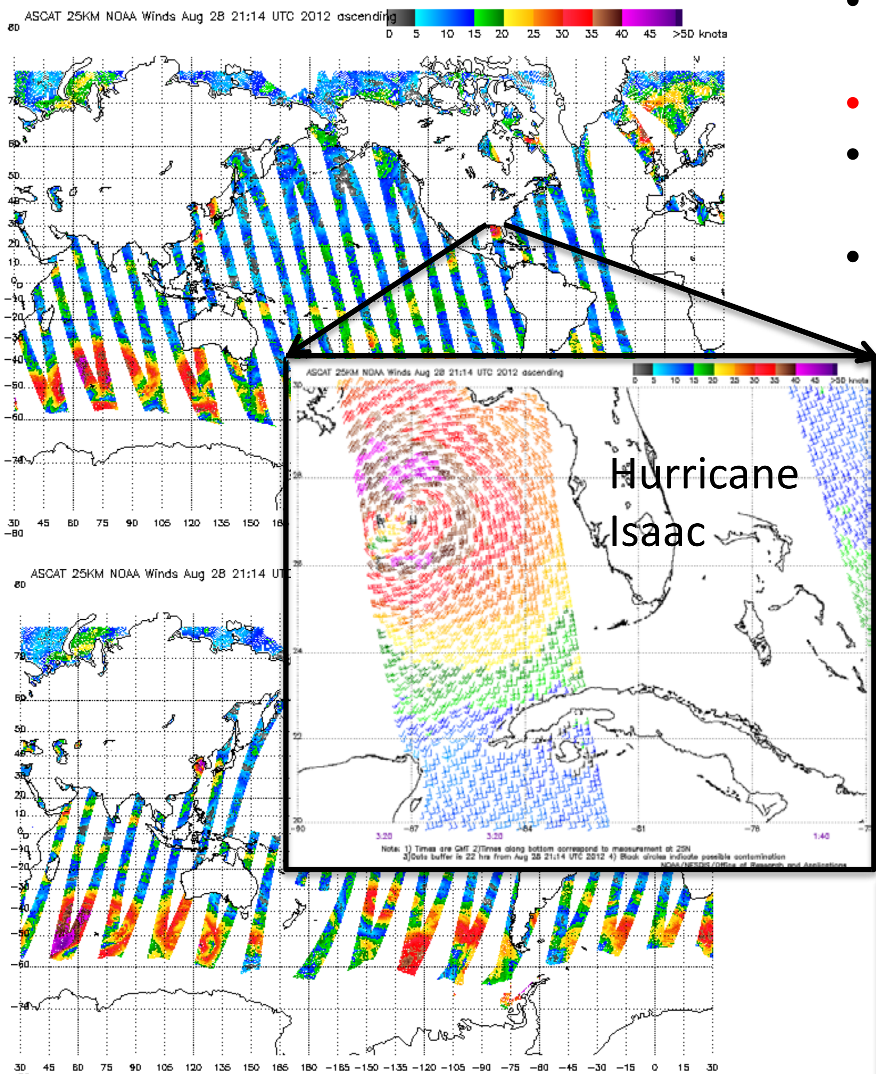
Figure 2. Nowcast position of bloom for 23 August 2013 using GLCFS modeled currents to move the bloom from the 20 August 2013 image.

Key Sentinel land data needs

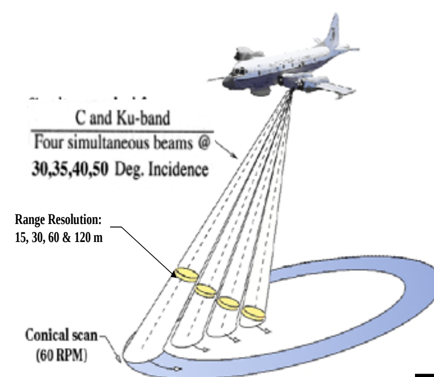
- *SLSTR*: Active fire detection and fire radiative power
  - Provide MODIS/VIIRS compatible fire observations on mid-morning orbit to monitor diurnal cycle
- *SLSTR*: Land surface temperature
  - Additional LST observations combining with VIIRS compatible LST observations for gridded LST data that can 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

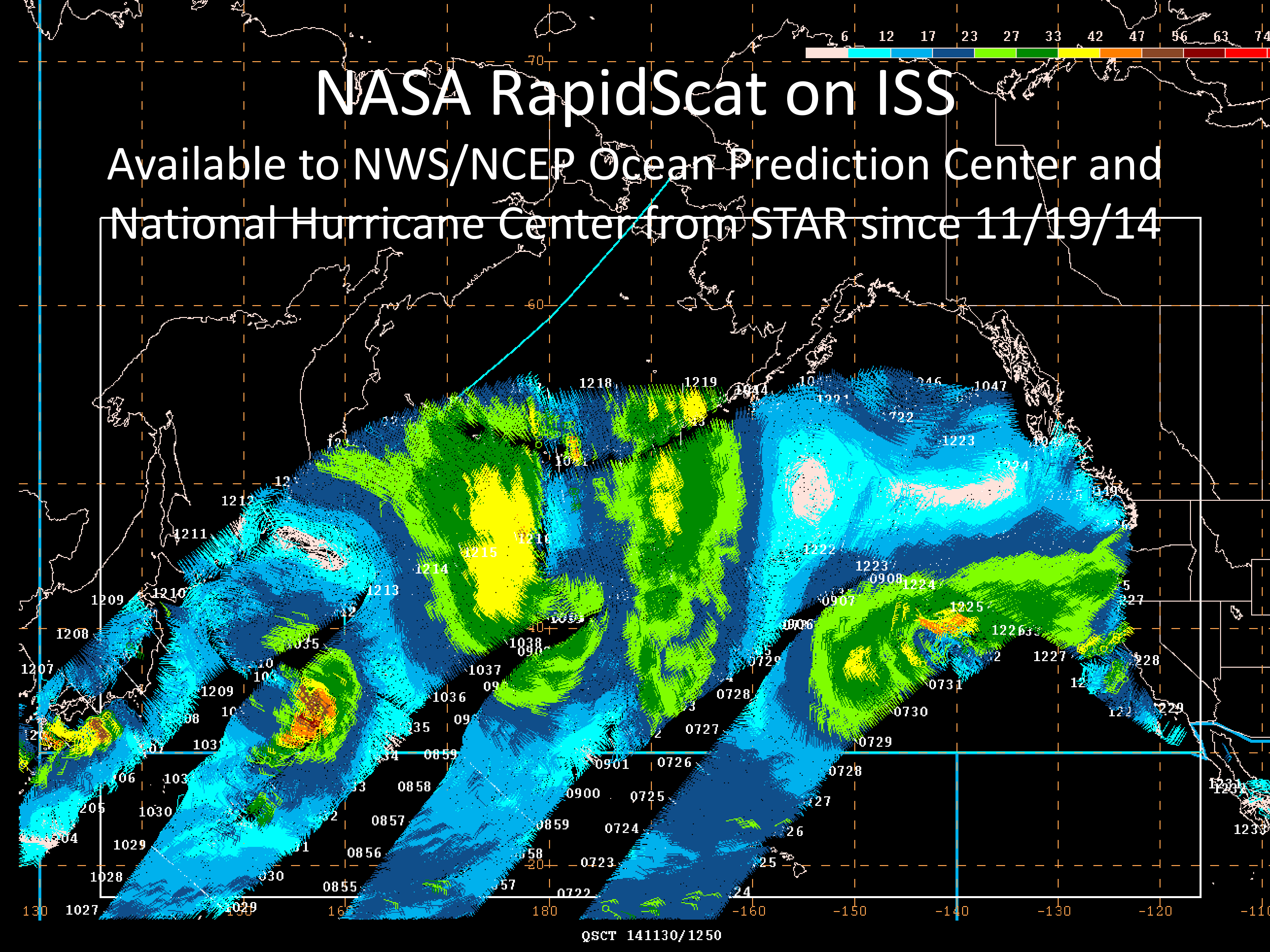


Goal: Provide the best possible product and training to end users

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

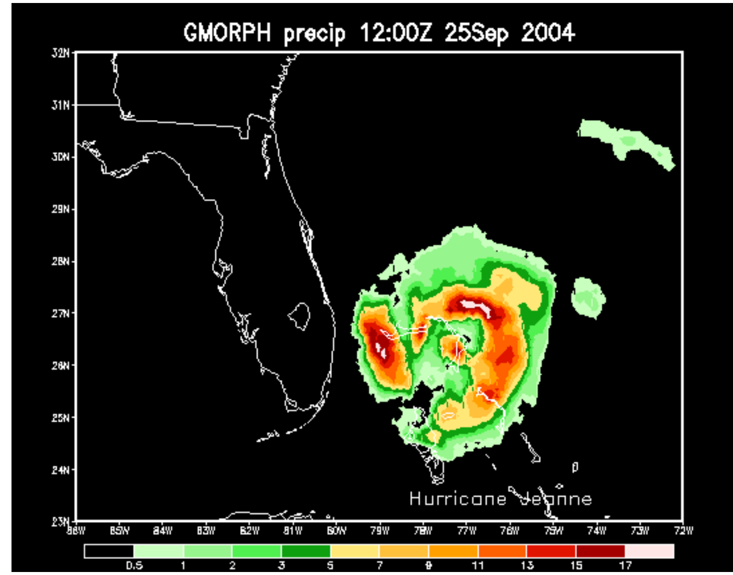


Importance of GPM from NOAA's Perspective

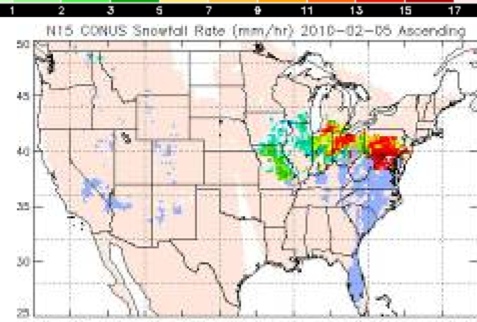
- Strong connection to several NOAA mission goals
  - Weather Ready Nation, Climate Adaptation and Mitigation
  - Only agency responsible for operational "water" forecasts
- Continuity of "operations" for TRMM
  - GPM-core - higher inclination than TRMM (65 vs. 35 deg.)
    - Serves as calibration anchor 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

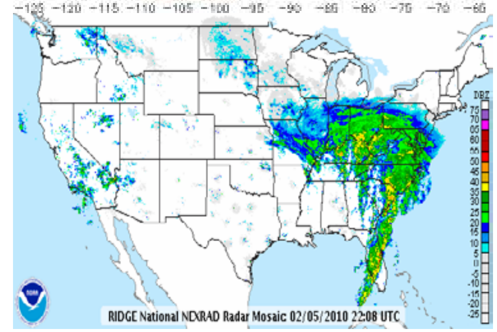
- Achieve ≤ 3-hourly global coverage
  - Global monitoring of “storms”
  - Tuning of merged GEO/MW algorithms (<30 min)
    - GOES & GOES-R
  - NWP data assimilation (L1 data)
    - OSSE’s show improved TC track prediction
  - Climate monitoring and prediction
    - NOAA/CMORPH, GPM/IMERG



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

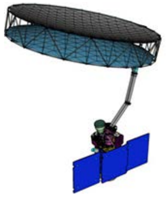


- High latitude precipitation - Alaska
  - Beyond GOES capability
  - Sensitive to cold season precipitation



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

Satellite Sea-surface Salinity (SSS)



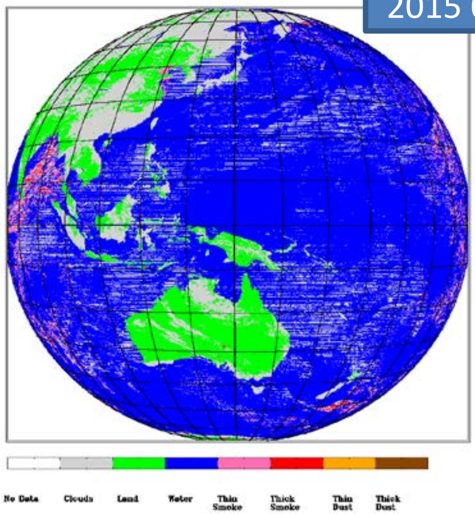
- **Salinity = fundamental ocean state parameter**
- **Satellite SSS data availability:**
  - ***Only non-NOAA sources***
  - **ESA** Soil Moisture – Ocean Salinity (SMOS) mission
  - **NASA** Soil Moisture Active-Passive (SMAP) mission
- **Application:**
  - **Ocean/regional modeling/prediction**
    - **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

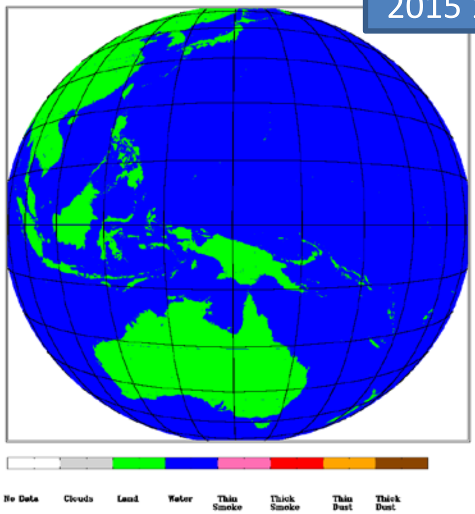
- Himawari-8 L1B data obtained from AIT
- Himawari-8 Cloud Mask data obtained from UW-Madison
- Aerosol Detection Product algorithm applied to H-8 data collected on March 25, 2015
  - No dust of smoke detected for 1700 UTC (night) but false smoke detected for 0230 UTC (day).
  - Data artifacts (false 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

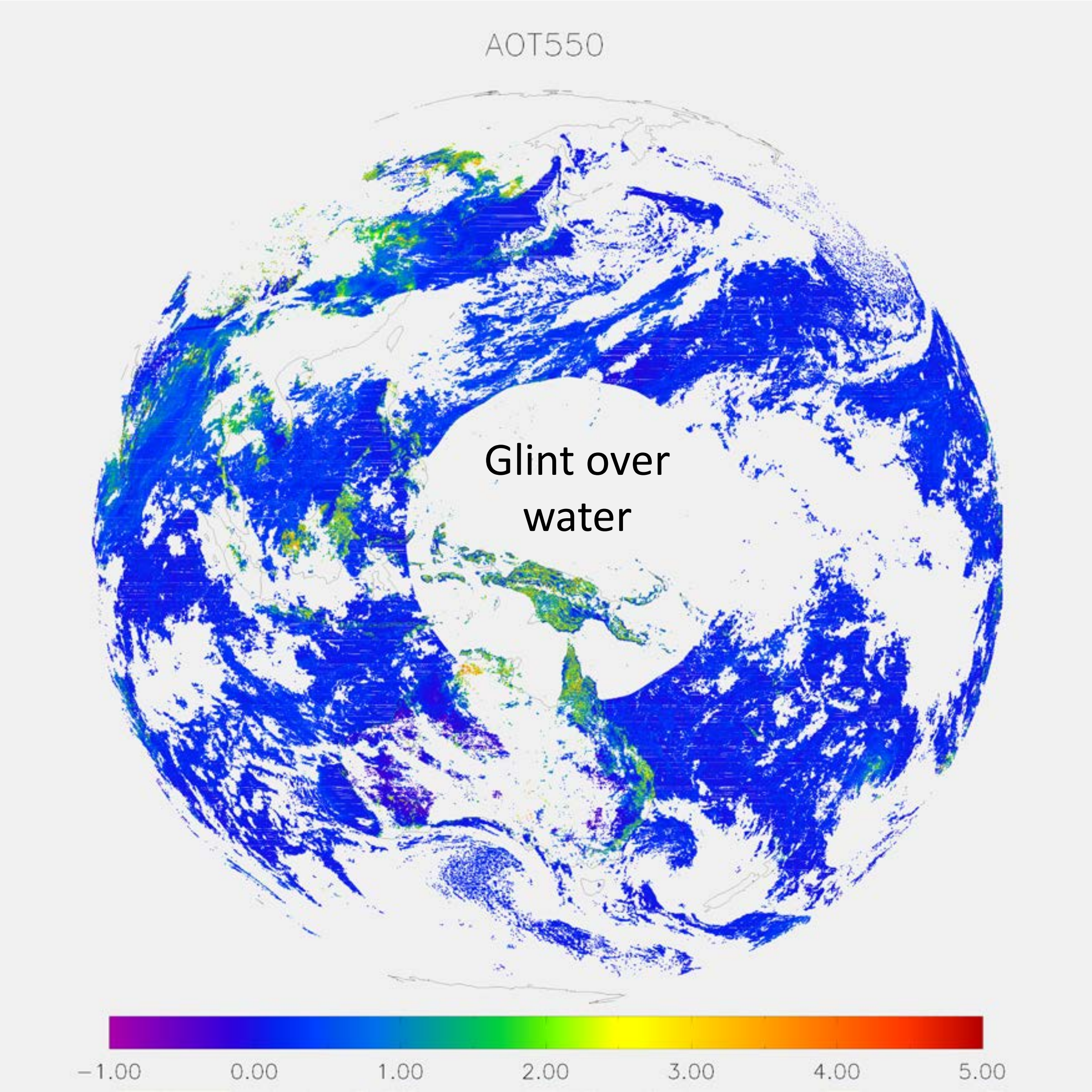
March 25, 2015 0230 UTC



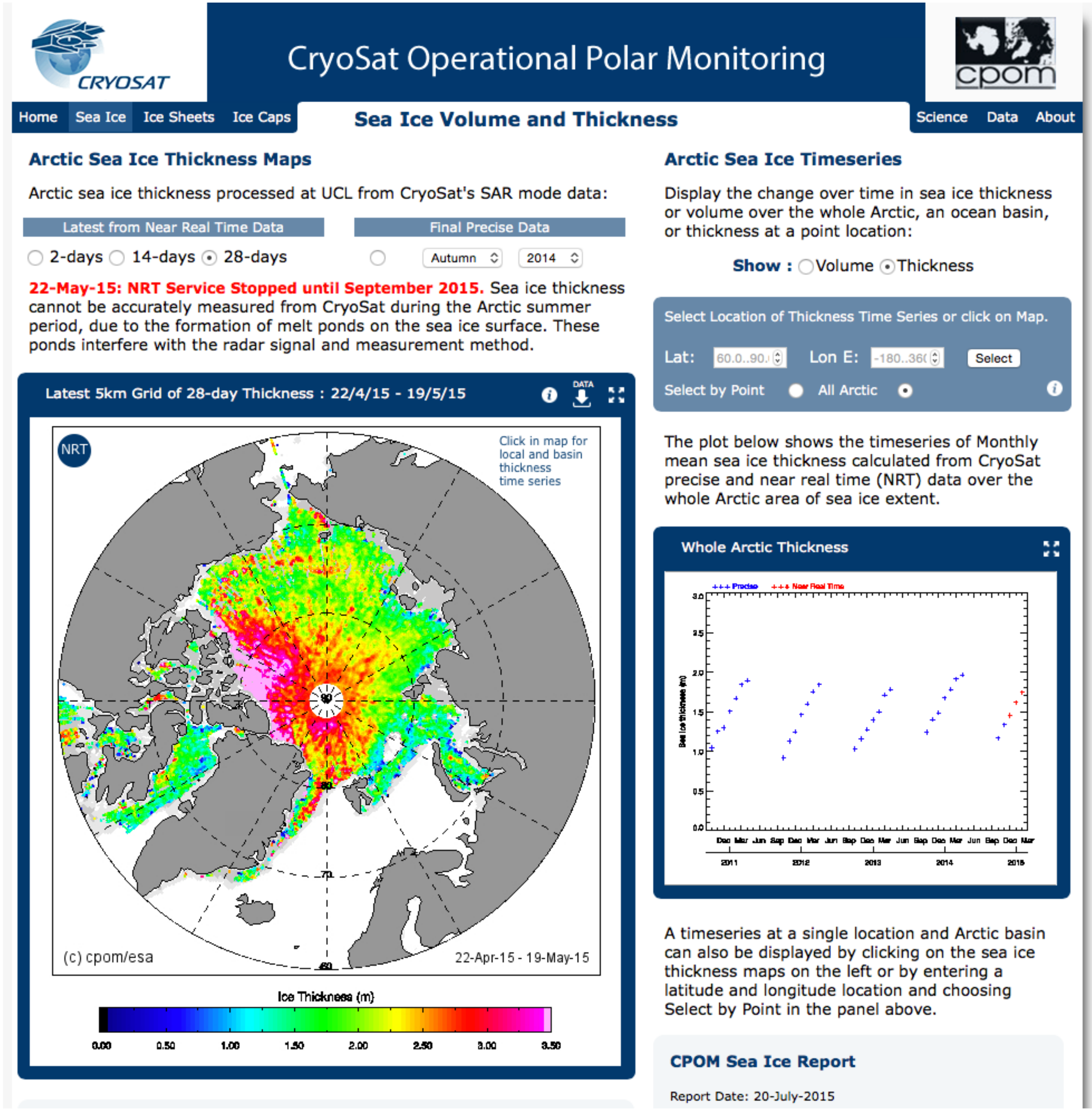
March 25, 2015 1700 UTC



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.



Credit: University College London

So, the question is.......

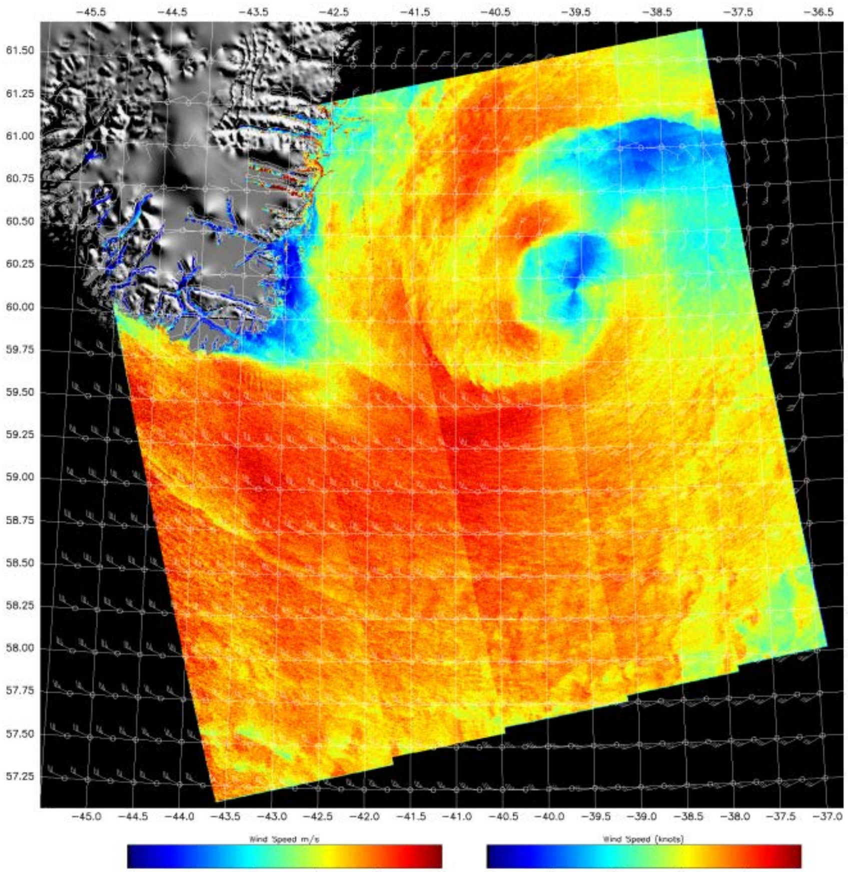
So, the question is…….

- 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?

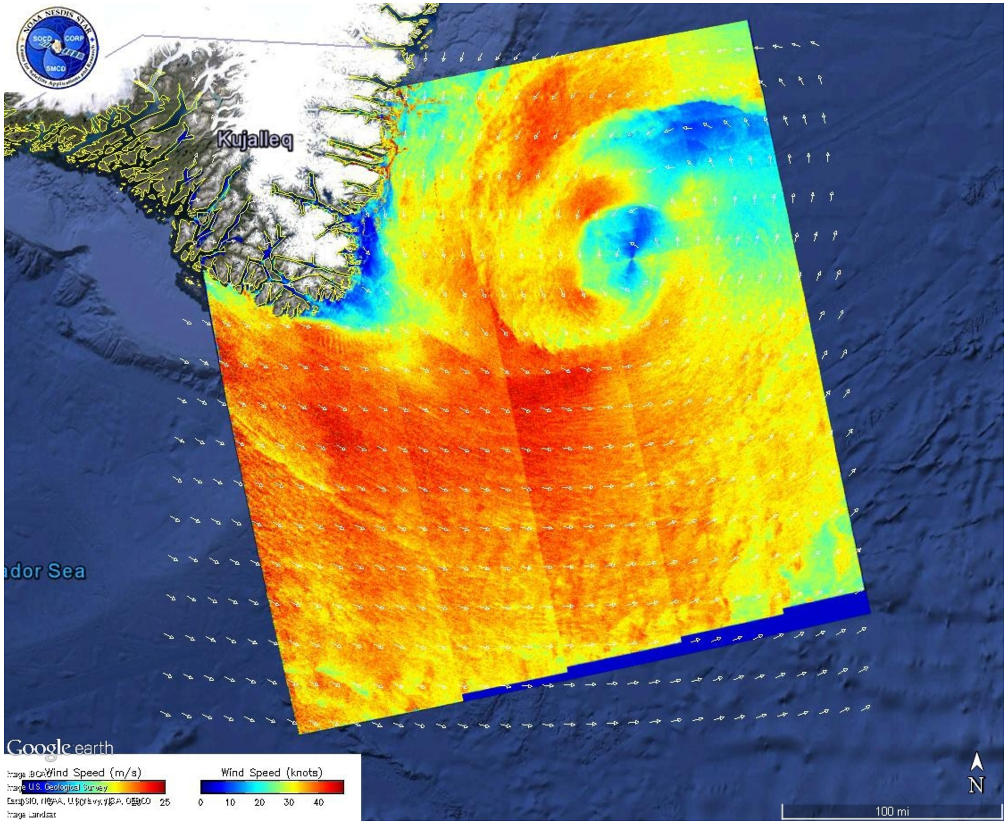
But don’t worry Mitch (and JPSS) - you are still beloved!!

Backup slides

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

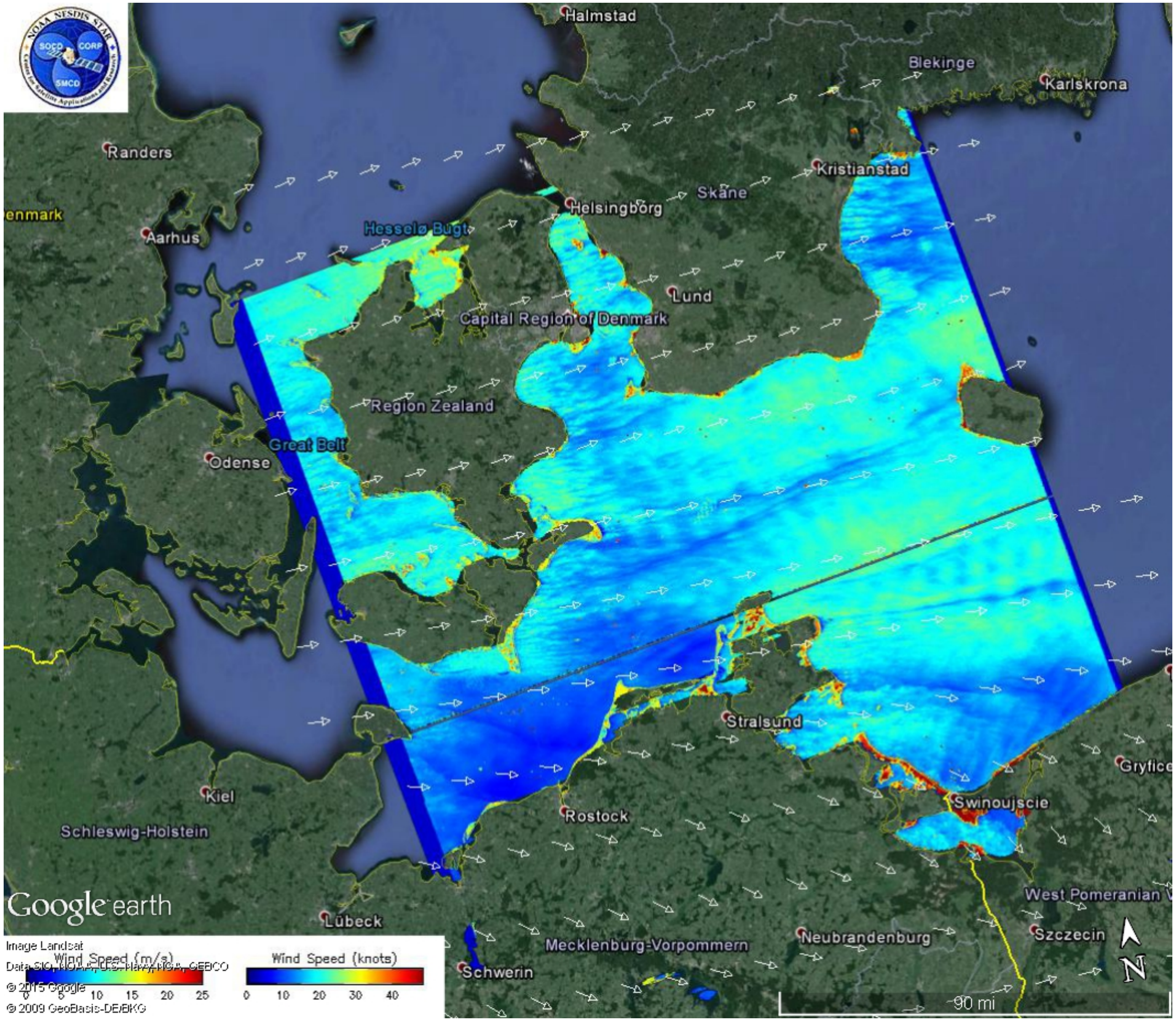


PNG Image



KMZ File

Sentinel-1A Wind Speed Retrieval Baltic Sea



July 6, 2015, 1652

Initial biogeochemical modeling at NOAA/NCEP: Using VIIRS ocean color data for validation and data assimilation

Lead PI: Avichal Mehra[1]

Co-PI's: Hae-Cheol Kim[2], Eric Bayler[3], David Behringer[1]

Collaborators: Sudhir Nadiga[2], Vladimir Krasnopolsky[1], Zulema Garraffo[2], Carlos Lozano[1], Watson Gregg[4]

1: NOAA/NWS/NCEP/EMC; 2: IMSG at NOAA/NWS/NCEP/EMC

3: NOAA/NESDIS/STAR; 4: NASA/GMAO

Project Descriptions

(Background)

• The NOAA Ecological Forecasting Roadmap (EFR) for 2015-2019 states that its objective is "to provide dependable, higher quality forecast products, derived from the successful transition of research and development into useful applications…."

• In support of the NOAA-approved roadmap, this project proposes to evaluate approaches and develop a prototype foundational global biogeochemical modeling capability for NOAA's operational Real-Time Ocean Forecast System (RTOFS) for reliably providing the global modeling fields required to support the ecological forecasts of the EFR technical teams

Project Descriptions

(Background)

- Specifically,
  - to establish a component for the national modeling 'backbone' that will generate global predictions of the common physical and biogeochemical variables used by ecological forecasts

  - to address key linkages and gaps within the EFR infrastructure framework via JPSS VIIRS ocean color data and physical-biogeochemical numerical modeling because ocean color data from VIIRS provides a unique path toward ecological forecasting through biogeochemical (BGC) analyses and forecasts, facilitating both real-time and scenario-based marine ecosystem applications

Project Descriptions

(Identification of Users)

- Targeted users within NOAA:
  - ➢ Ecological Forecasting Roadmap technical teams (harmful algal blooms, hypoxia, habitats),
  - ➢ Those explicitly involved with numerical modeling and prediction in conjunction with the NOAA Ecological Forecasting Infrastructure and Process team

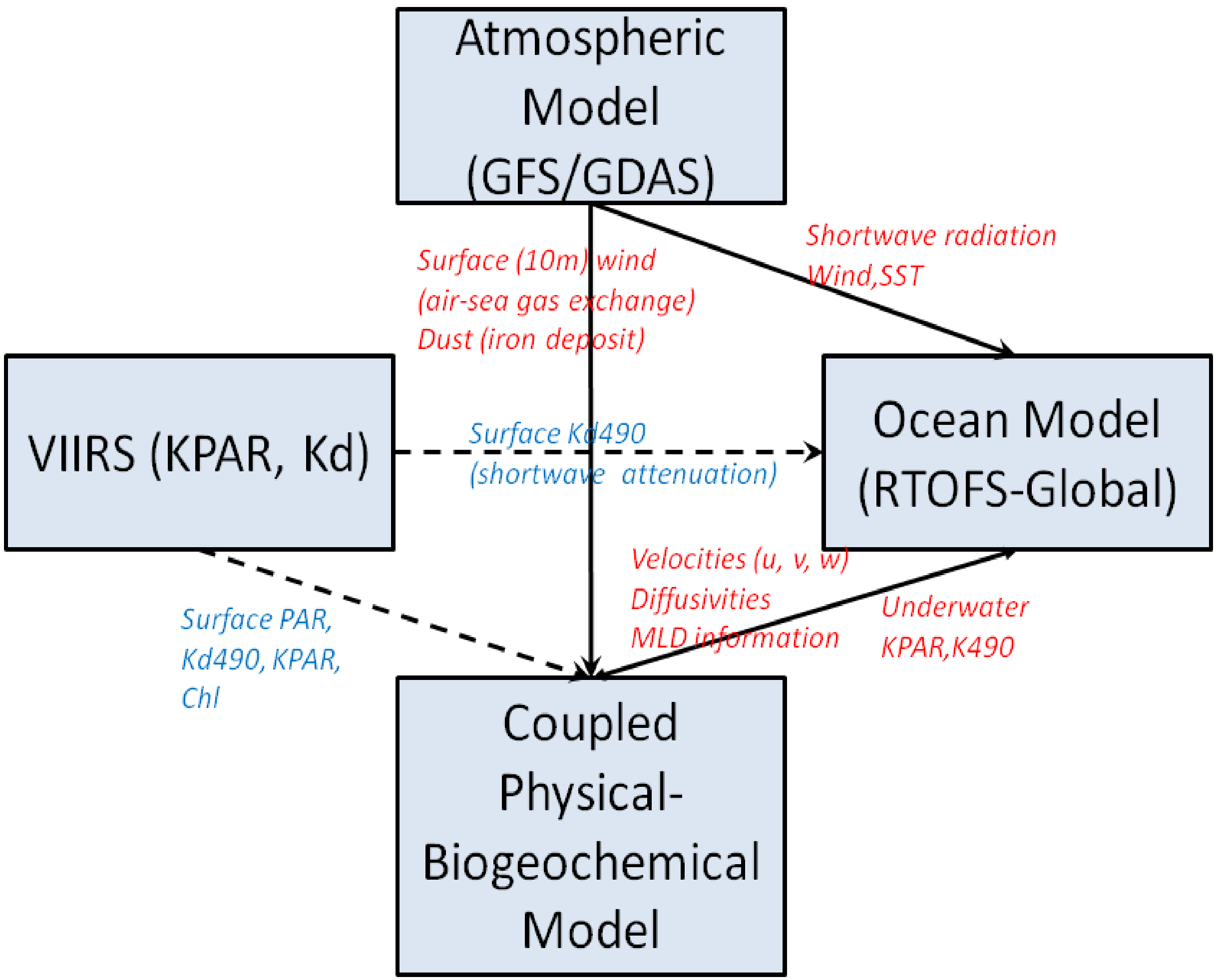
- The external user community:
  - ➢ Local, state, federal governments, non-governmental organizations (NGO's), and academic and industry entities using derivative analyses and predictions.

Scientific Objectives

- Employing coupled BGC-physical modeling to improve NWS forecasting skill at short-term and seasonal scales
    - ➢ by including the effects of biological heating on upper-ocean thermal structure
    - ➢ by exploring the direct assimilation of VIIRS products (K_{d490}) in conjunction with radiative transfer (RT) computations using existing validated algorithms (Lee, 2006; Gregg, 2002).
- Providing scenario-based forecasting
    - ➢ to predict system responses to potential changes by drivers (natural or through ecosystem management decisions)
- Assessing the effects of carbon dynamics between the atmosphere and the ocean and subsequent changes in the acidity of the global ocean
- Exploring BGC model to support for upper-trophic-level modeling

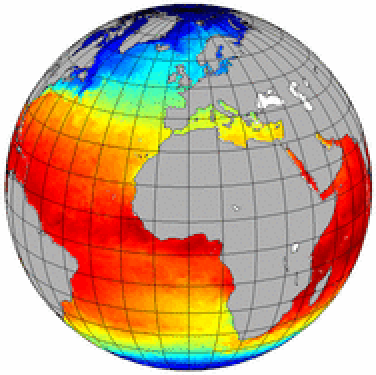
Approaches

(Schematic Diagram)



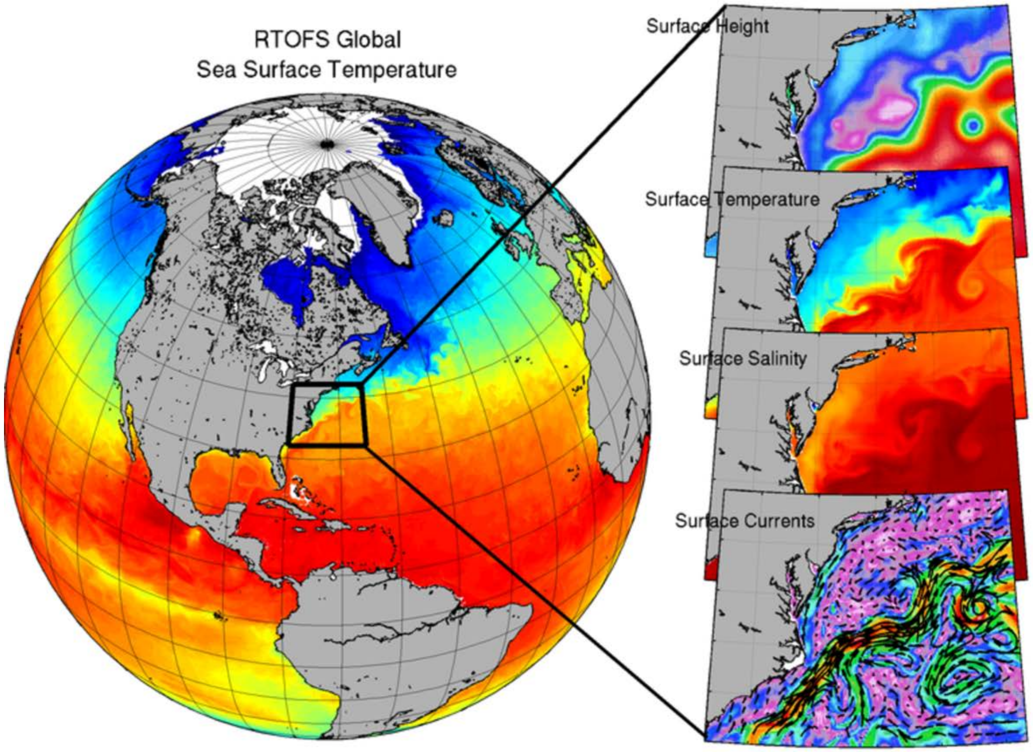
Approaches

(Ocean Model: RTOFS-Global)



- RTOFS-Global
  - ➢ Hybrid Coordinate Ocean Model (HYCOM) based system with 1/12° and 41 layers
  - ➢ iso-pycnal (deep ocean), z-levels (surface), σ (coasts)
  - ➢ Tripole grid (1 at South Pole and 2 from Arctic bipole)
  - ➢ Recti-linear (<47°N) and curve-linear (>47°N)

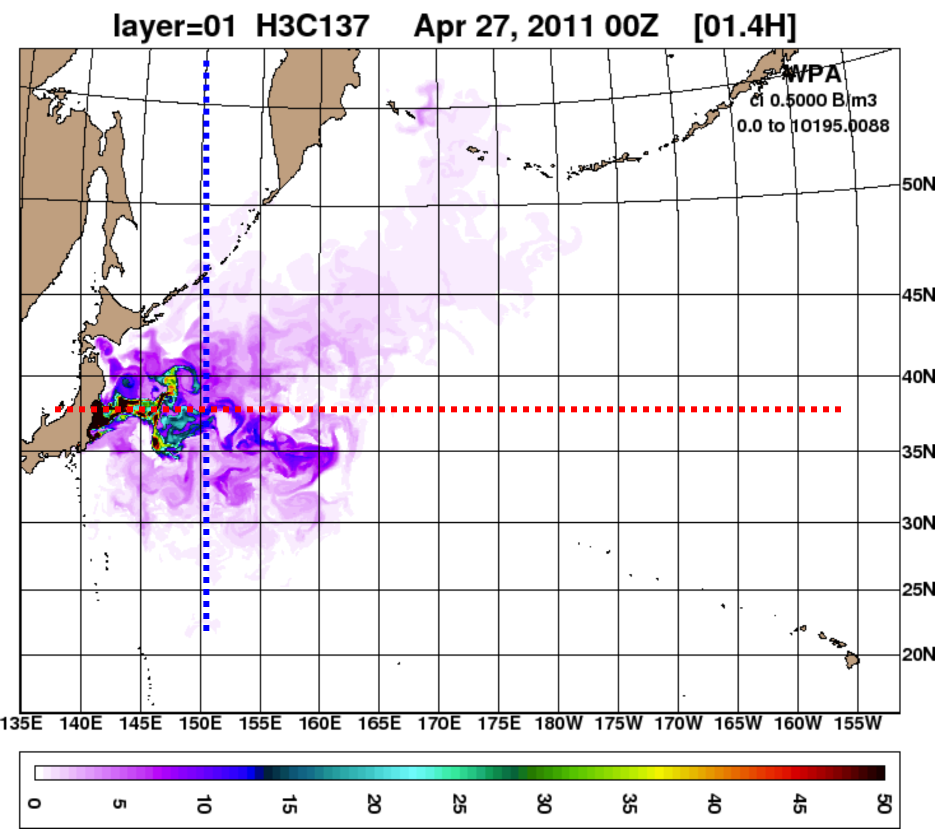
- RTOFS-Global
  - ➢ NAVOCEANO daily initialization with MVOI (now 3DVAR) data assimilation from NCODA (Navy Coupled Ocean Data Assimilation)
  - ➢ KPP for vertical mixing
  - ➢ 2-day nowcast (GDAS) and 6-day forecast (GFS)

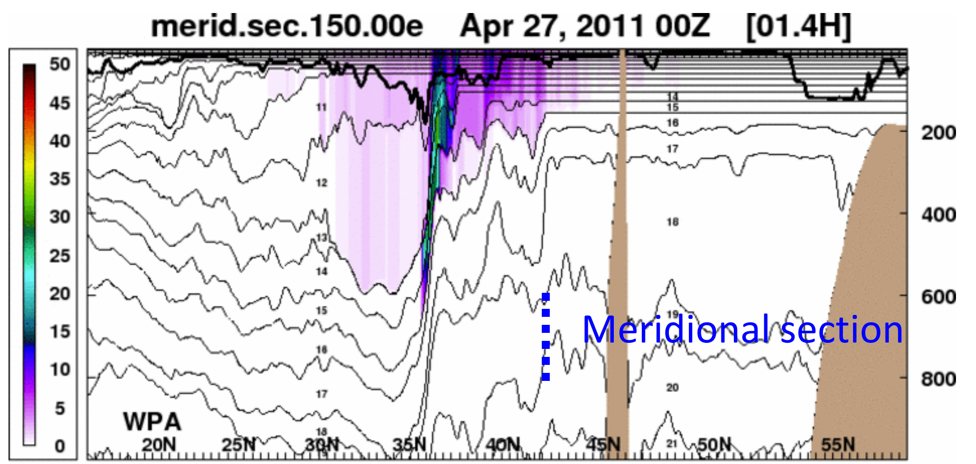


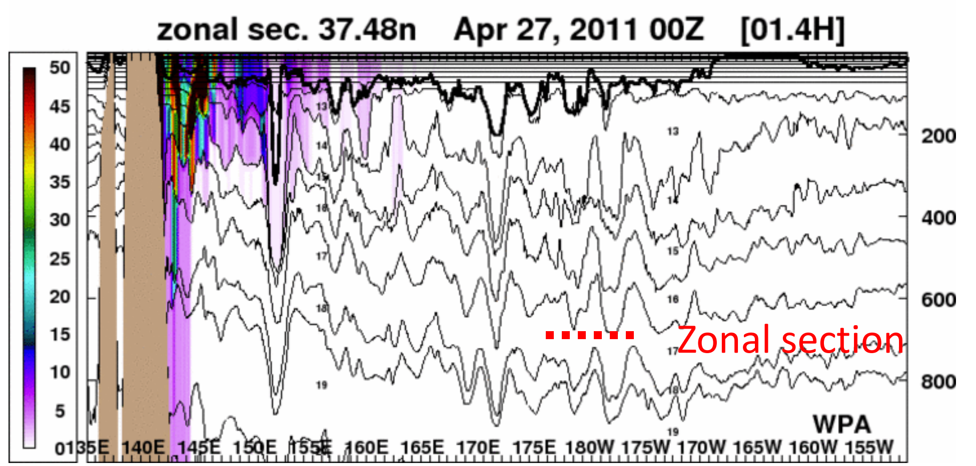
(credit: Spindler)

Approaches

(Ocean Model: RTOFS-Global)

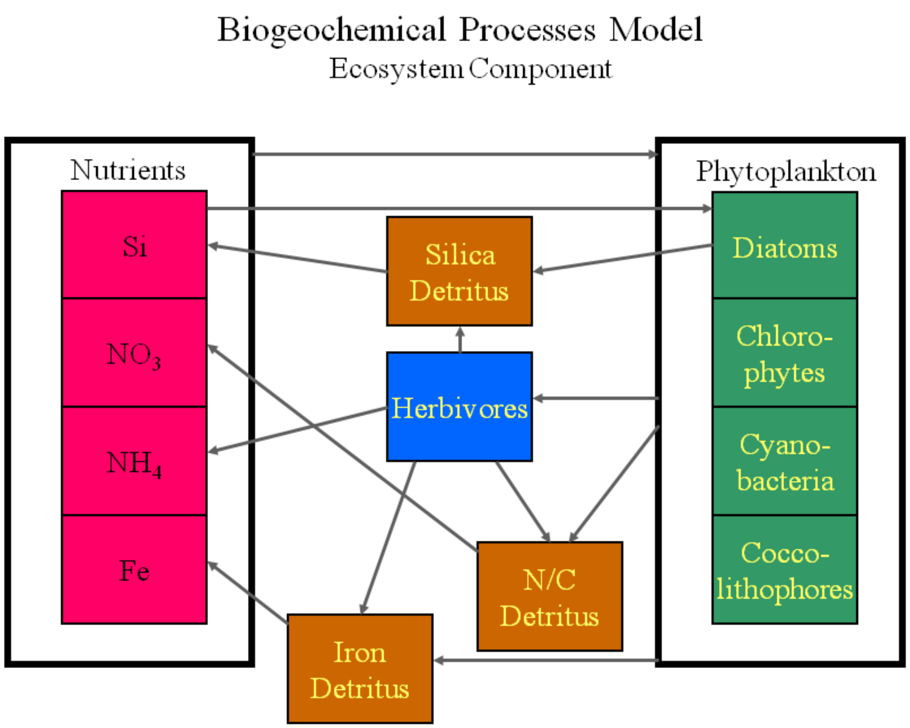


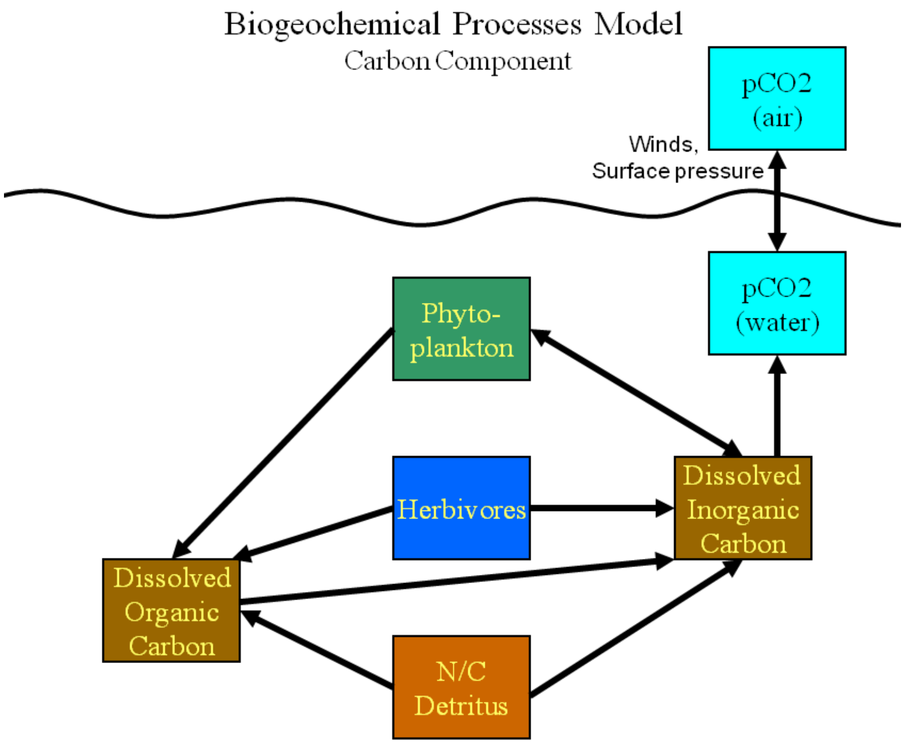




Approaches

(NOBM: NASA Ocean Biogeochemcial Model)





Gregg (2002; http://gmao.gsfc.nasa.gov/research/oceanbiology/description.php)

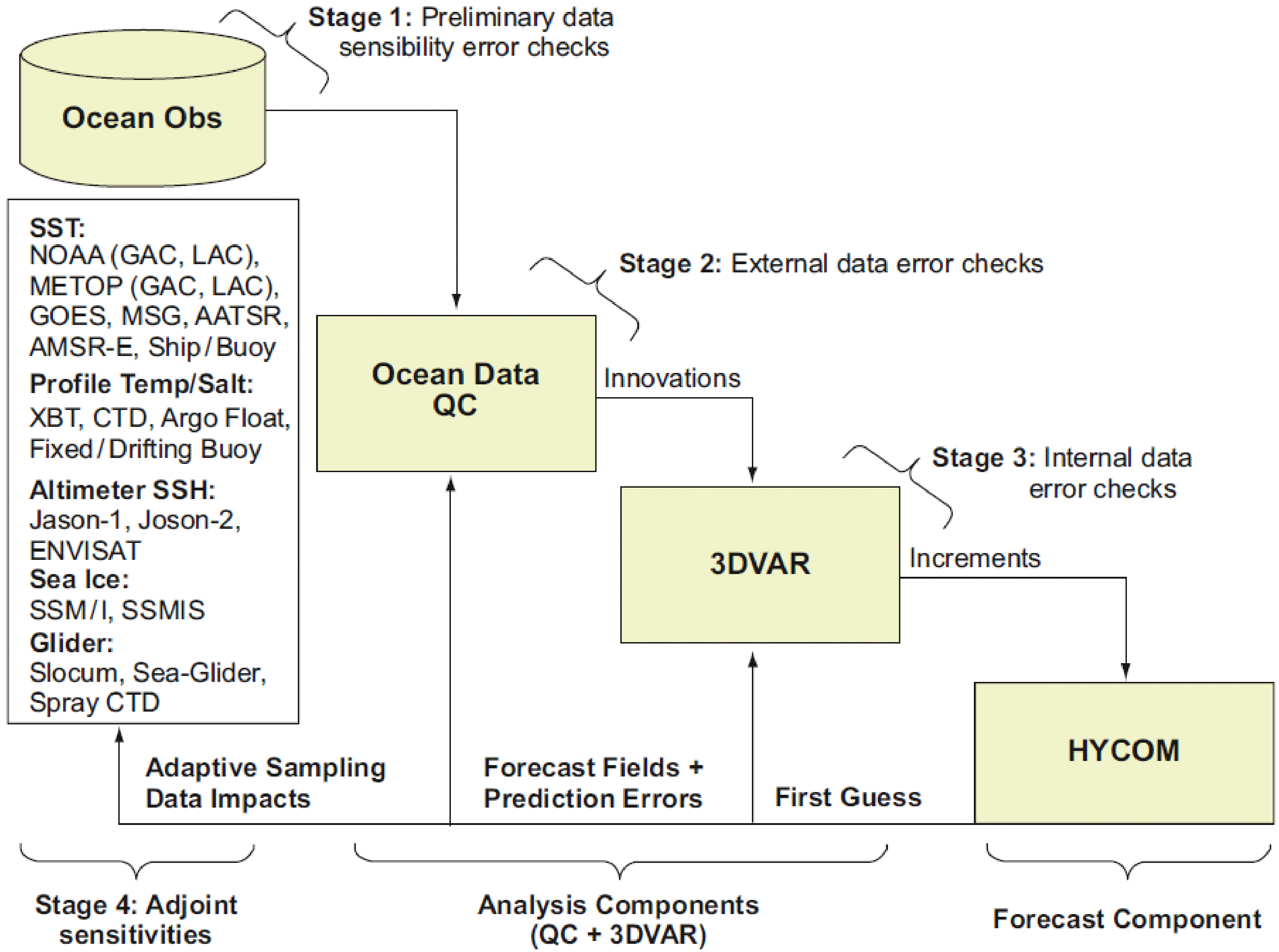
Approaches

(Data Assimilation: 2DVAR)

- Step 1. Integrate model for a certain period with no nudging from t=0 (beginning of cycle) to t=T. Initial condition is X(t=0). End condition is X(t=T)
- Step 2. Carry out CHL analysis at 0-hr and at T-hr
- Use CHL from X(t) as a background $X_{b.}$
  - $X_a=X_b+K(y_0-H(X_b))$

  where X_a: analysis; X_b: background; K: Kalman gain; y_0: observations (VIIRS); H: observation operator; $[y_0-H(X_b)]$: innovation, distance between model and observation
  - Data points will be assimilated (e.g., VIIRS) with a certain time window for data pooling
- Step 3. Create linearly interpolated CHL field between the two consecutive CHL analyses X_a (t=0) and X_a (t=T).
- Step 4. Integrate model for T hours with nudging from t=0 (beginning of cycle) to t=Thrs. Initial condition is X(t=0). End condition is X(t=T)
- Next cycle: re-label end condition of integration with nudging as the initial condition if the next cycle.

Approaches
(Data Assimilation: NCODA)



Cummings (2011)

Milestones

- *Year 1:*
  - ➢ Use VIIRS-derived K_{dPAR} and K_{d490} with a two-band scheme (Lee et al., 2006)

- *Year 2:*
  - ➢ Implement coupling of the modified BGC model with online HYCOM/RTOFS-Global
  - ➢ Modify NOBM (Gregg, 2002; 2003) biogeochemical module to include air-sea oxygen dynamics

- *Year 3:*
  - ➢ Implement simple data assimilation techniques (2DVAR) to nudge model values to better represent VIIRS observations
  - ➢ Validate model-derived Chl-a against independent *in situ* observations (e.g., BIO-Argo) and VIIRS data.

Thanks!

Robust VIIRS Reflective Solar Bands On-Orbit Calibration for Ocean Color Data Processing

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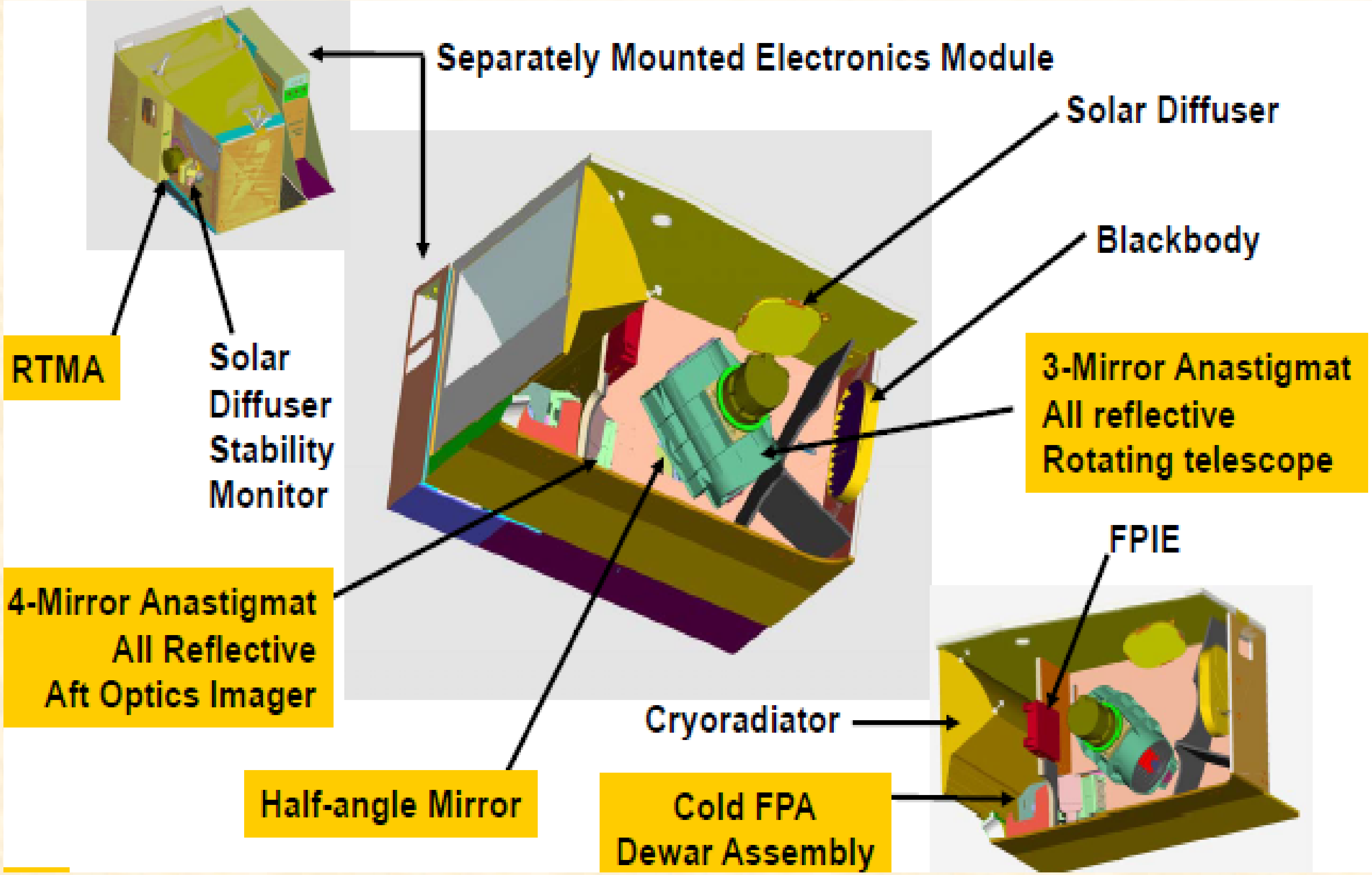
8/25/2015 4:00-4:15 PM

Outline

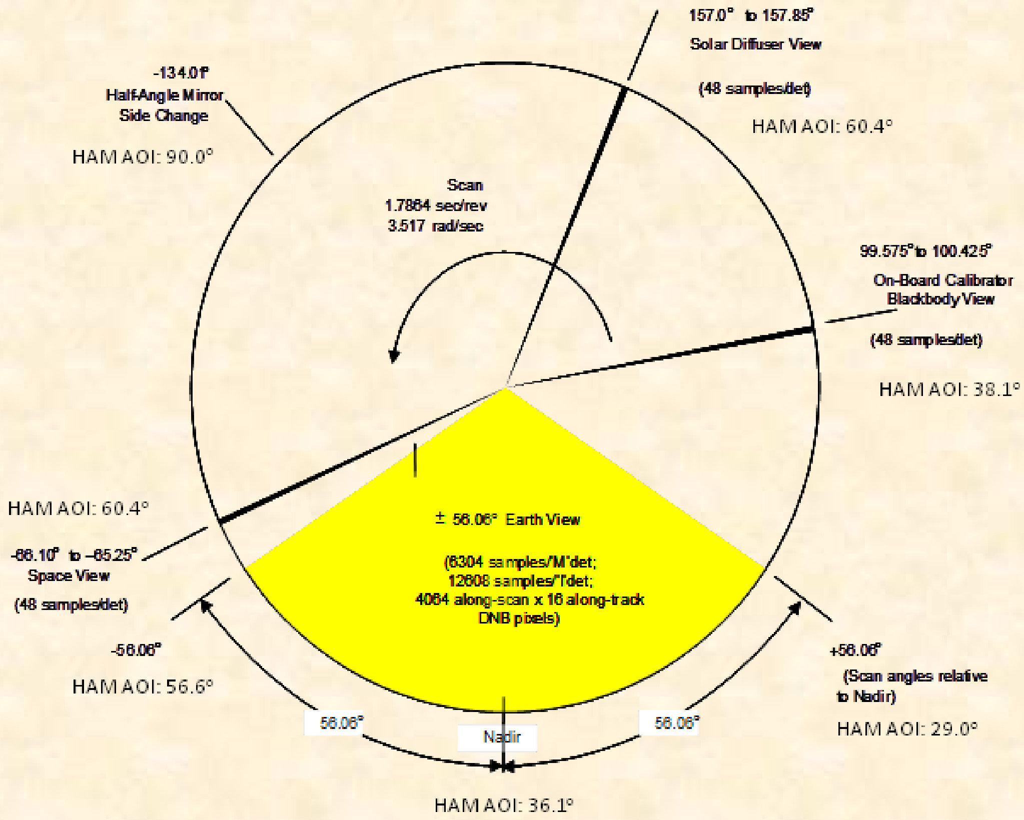
- Introduction
  - VIIRS Instrument Background
  - Reflective Solar Bands (RSB) On-Orbit Calibration
- SDSM Calibration
  - Algorithms, data analysis, and performance
- SD Calibration
  - Algorithms, data analysis, and performance
- Lunar Calibration
  - Algorithms, data analysis, and performance
- Hybrid Approach
  - Algorithms and hybrid calibration coefficients
- Improvements in Ocean Color Products
- Summary

VIIRS Background



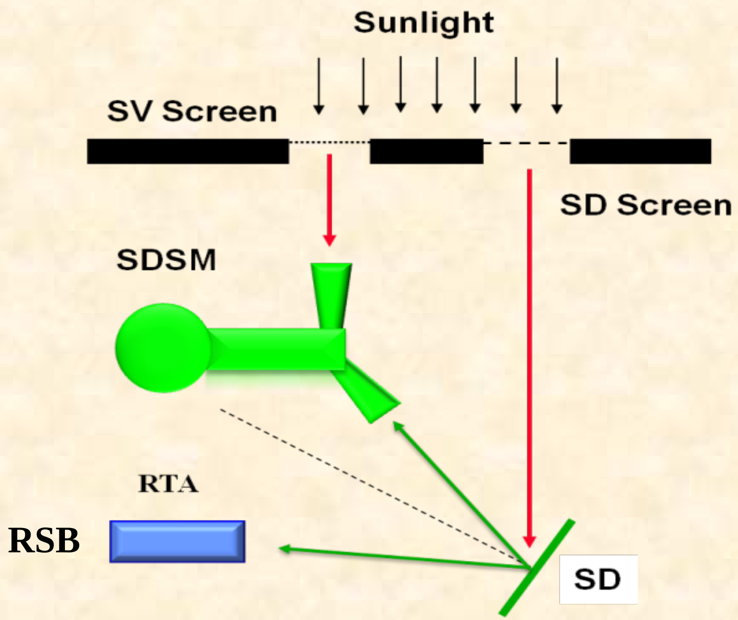
RSB On-Orbit Calibration

- **VIIRS has 22 spectral bands covering a spectral range from 410 nm to 12.013 µm**
- **14 Reflective Solar Bands (RSB) : 3 image bands, I1-I3, and eleven moderate bands, M1-M11**
- **The VIIRS RSB are calibrated on orbit by SD/SDSM calibration**
- **VIIRS has also been scheduled to view the moon monthly through its space view (SV) since launch.**
- **For VIIRS, the angle of incidence (AOI) of the SV is exactly the same as that of the SD. Lunar observations should provide identical on-orbit gain change for VIIRS RSB as SD/SDSM calibration.**



VIIRS RSB uncertainty specification is 2%; For ocean color EDR products, the ocean bands (M1-M7) are required to be calibrated with an uncertainty of ~0.1-0.3%.

SD/SDSM Calibration Overview



- *SD and SDSM sun view screens:*
  - *Prevent RSB and SDSM saturation*
  - *Vignetting functions (VFs)*
  - *VFs measured prelaunch and validated by yaw measurements*
  - *SD bidirectional reflectance factors (BRFs)*
- *BRFs measured prelaunch and validated by yaw measurements*
  - *SD on-orbit degradation is tracked by the SDSM measurements at 8 wavelength from 412 nm to 935 nm*

- *Key assumption: SD degrades uniformly with respect to both incident and outgoing directions*

Fist step: Carefully derive BRFs and VFs from the yaw measurements

J. Sun and M. Wang, "On-orbit characterization of the VIIRS solar diffuser and solar diffuser screen," Appl. Opt., 54, 236 -252(2015).

SDSM Calibration Algorithm

- SDSM is a ratio radiometer, which views SD, Sun, and an internal dark scene successively in three-scan cycles.

- SD BRF for SDSM view direction

$$BRF_{SD,SDSM}(\lambda) = \rho_{SD,SDSM}(\lambda)H(\lambda)$$

  - $\rho_{SD,SDSM}(\lambda)$: Prelaunch BRF for SDSM view direction
  - $H(\lambda)$ is solar diffuser degradation since launch

- SD degradation, H factors, for SDSM view direction at the wavelength of the SDSM detector D

$$H(\lambda_D) = \left\langle \frac{dc_{SD,D}}{\rho_{SD,SDSM}(\lambda_D)\tau_{SDS}\cos(\theta_{SD})} \right\rangle_{Scan} \Big/ \left\langle \frac{dc_{SV,D}}{\tau_{SVS}} \right\rangle_{Scan}$$

- ***Improvements***
  - ***Carefully derived the VFs and BRFs from yaw measurements***
  - ***Ratio of the averages***
  - ***Sweet spots selection***

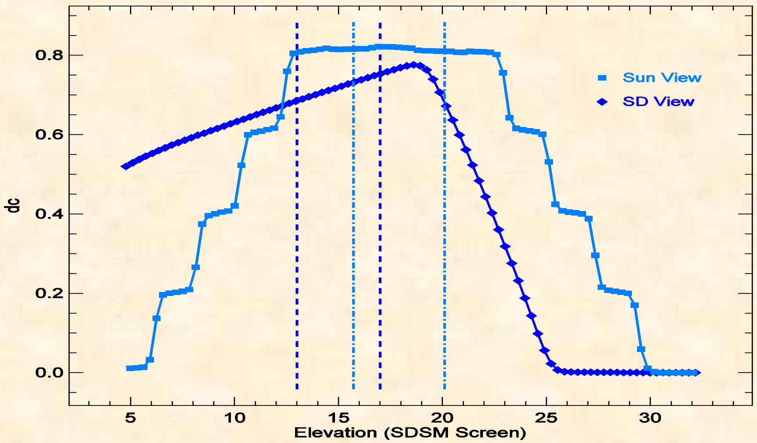
SDSM operations: Every orbit first few months, then once per day for about two years, and once per two days since May, 2014.

J. Sun and M. Wang, "Visible infrared image radiometer suite solar diffuser calibration and its challenges using solar diffuser stability monitor," Appl. Opt., 53, 8571-8584 (2014).

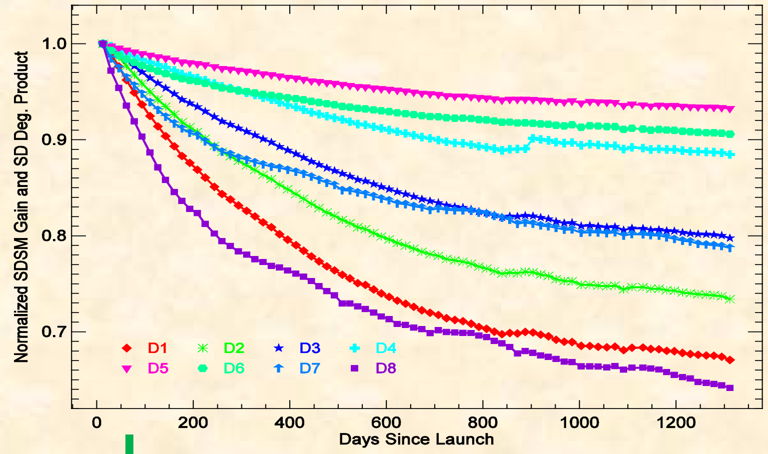
SDSM Calibration Results

SD Degradation (H-Factors)

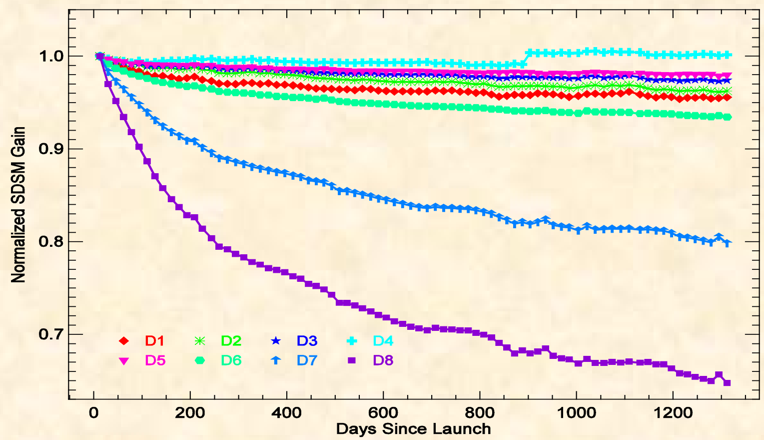
Sweet spots



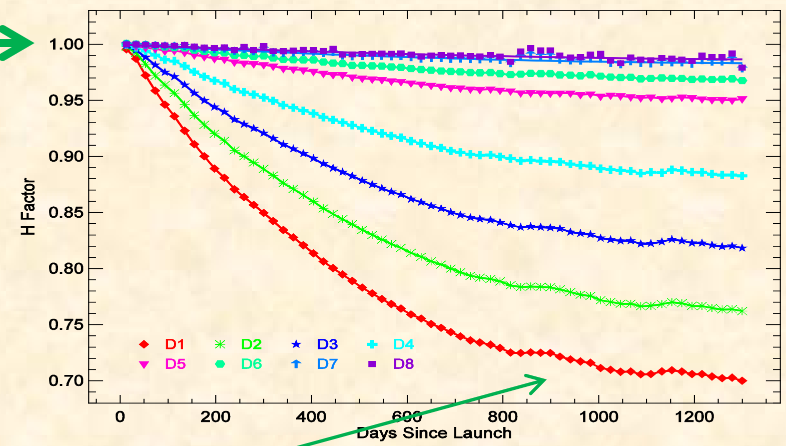
SD view response trending



Sun view response trending



SD degradation



Unexpected but real degradation (Nov., 2014)

SDSM can accurately track the SD degradation for SDSM direction

SD Calibration Algorithm

- SD is made of Spectralon®, near Lambertian property
- Solar radinace reflected by the SD

$$L_{SD}(\lambda) = I_{Sun}(\lambda) \cdot \tau_{SDS} \cdot \cos(\theta_{SD}) \cdot \rho_{SD,RTA}(\lambda) \cdot h(\lambda) / d_{VS}^2$$

  - $\rho_{RSD,RTA}(\lambda)$: Prelaunch BRF for RTA view direction
  - $h(\lambda)$: SD degradation for SDSM view direction is used as the SD degradation for the RTA direction

- RSB calibration coefficients, F factors

$$F(B,D,M,G) = \frac{RVS_{B,SD} \cdot \int RSR_B(\lambda) \cdot L_{SD}(\lambda) \cdot d\lambda}{\sum_i c_i(B,D,M,G) \cdot dn^i \cdot \int RSR_B(\lambda) \cdot d\lambda}$$

  - *B, D, M, G*: Band, Detector, HAM side, and gain status

J. Sun and M. Wang, "On-orbit calibration of Visible Infrared Imaging Radiometer Suite reflective solar bands and its challenges using a solar," Appl. Opt., 54, 7210-7223 (2015).

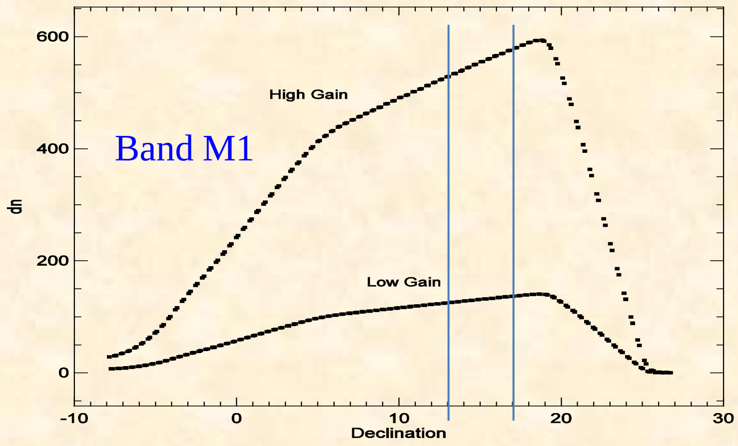
SD Calibration: Every orbit

- ***Improvements***
  - ***Carefully derived the VFs and BRFs from yaw measurements***
  - ***Improved H factors***
  - ***Sweet spot selection***
  - ***Time-dependent RSR***

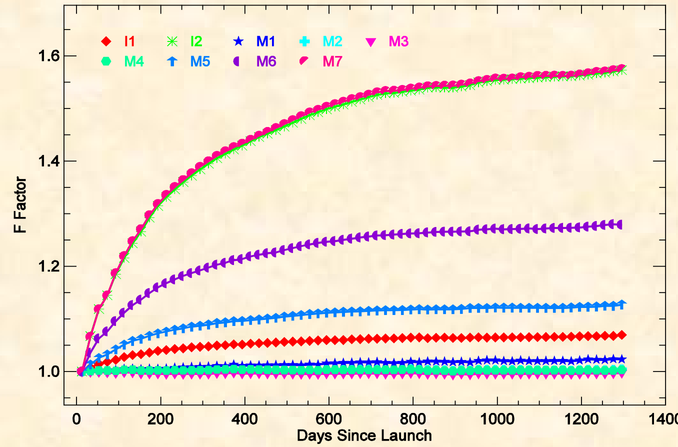
SD Calibration Results

RSB Calibration Coefficients (SD F-Factors)

Sweet spot

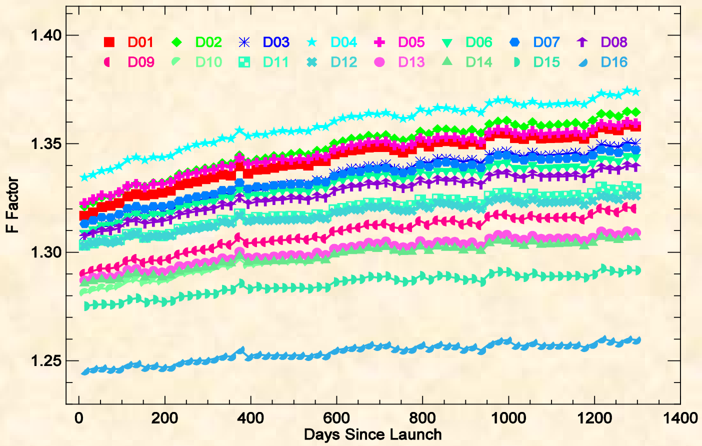


Band averaged HAM 1 HG F-factors

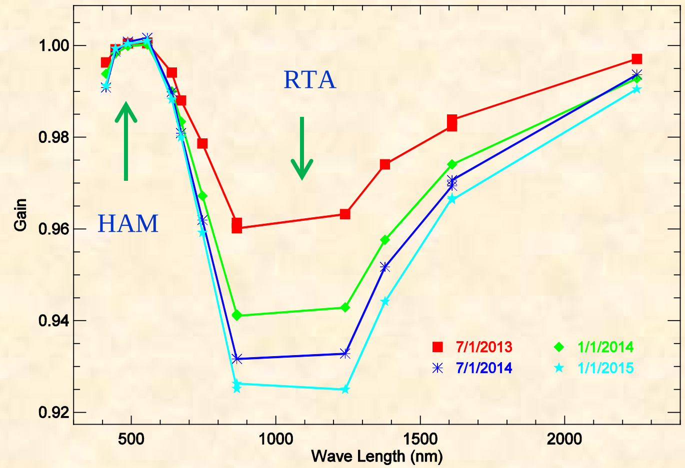


HG = High Gain
LG = Low Gain

Band M1 HAM 1 HG F-factors



Band averaged gains



SD can accurately track the RSB gain change as long as SD degradation for the RTA view can be approximated as that for the SDSM view.

Lunar Calibration Algorithm

- Moon is very stable in its reflectance
- RSB calibration coefficients , F factors, from lunar observations

$$F(B,M)=\frac{g(B)N_{t,M}}{\sum_{D,S,N} L_{pl}(B,D,S,N)\delta(M,M_N)},$$

- – *g(B)*: View geometric effect correction (ROLO lunar model and extra correction)

SNPP VIIRS is scheduled to view the Moon approximately monthly (about nine months every year)

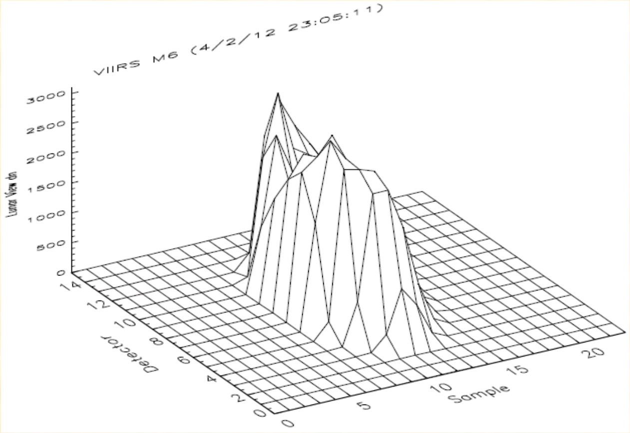
- ***Advantages***
  - ***Lunar surface reflectance has no observable degradation***
  - ***Can be used for inter-comparison***

J. Sun, X. Xiong, and J. Butler, "NPP VIIRS on-orbit calibration and characterization using the moon", Proc. SPIE, 8510,85101I, (2012).
X. Xiong, J. Sun, J. Fulbright, Z. Wang, and J. Butler, "Lunar Calibration and Performance for S-NPP VIIRS reflective Solar Bands", IEEE Trans. Geosci. Remote Sens., accepted.

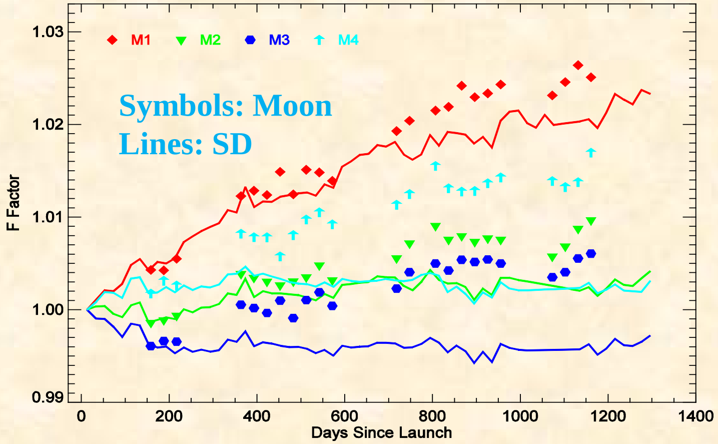
Lunar Calibration Results

RSB Calibration Coefficients (Lunar F-Factors)

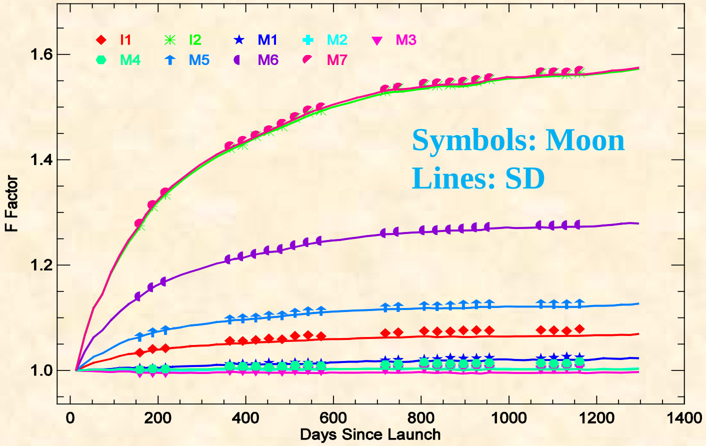
Lunar image (M6 in April, 2012)



Lunar and SD F factors



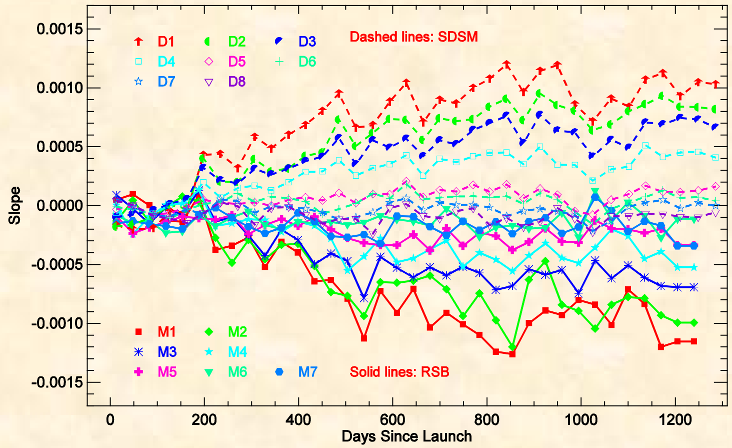
Lunar and SD F Factors



- ***The differences between the SD F-factors and lunar F-factors increase with time, especially for short wavelength RSB***
- ***Which is correct?***

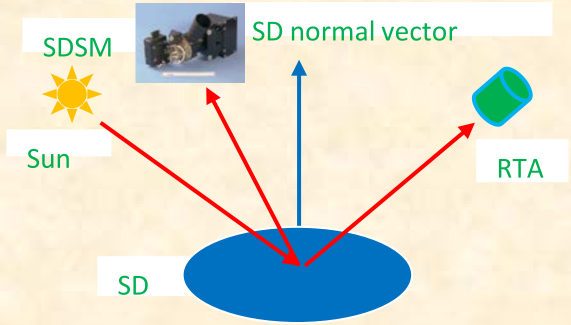
Non-Uniformity of the SD Degradation

Non-uniformity of SD degradation



Slopes of H-factors and F-factors in each individual event with respect to solar declination

SDSM and RTA views



- SD degrades non-uniformly with respect to the incident angle for SDSM view direction
- SD degrades non-uniformly with respect to the incident angle for rotating telescope assembly (RTA, RSB) view direction
- According to *optical reciprocity*, then SD also degrades non-uniformly with respect to the outgoing direction
- The different signs of the variation slopes of the H-Factors and F-Factors with respect to incident direction confirm that SD degrades non-uniformly with respect to outgoing direction

- *0.1% per degree; 1% per 10 degrees for 412 nm (D1 and M1)*
- *Angle between SDSM view direction and RTA view direction is larger than 100 degree?*
- ***SD calibration is not accurate enough for ocean color data processing***

Hybrid Approach

- SD Calibration
  - SD degrades non-uniformly, resulting long-term drifts
  - Results are stable and smooth
  - Observation in every orbit
- Lunar Calibration
  - No degradation issue
  - Infrequent and no observation in three months every year
- Hybrid Approach

F-Factors Ratios are fitted to quadratic polynomials of time

$$\mathcal{F}(B,D,M,G) = R(B,t)\cdot F(B,D,M,G)$$

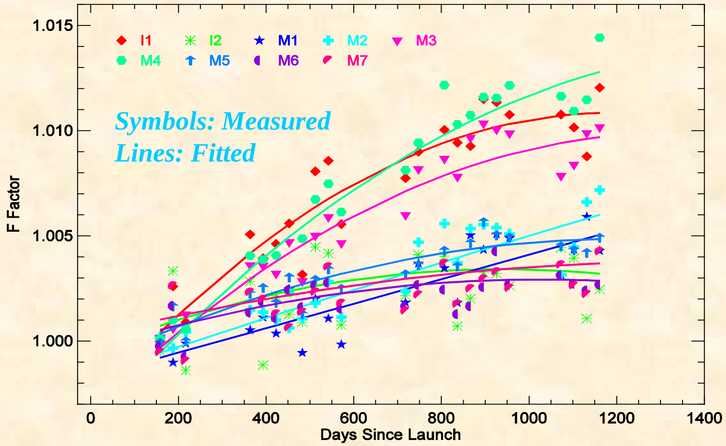
$$R(B,t) = \left\langle f(B,M,t)\right\rangle_M / \left\langle F(B,D,M,0,t)\right\rangle_{D,t-15<t_i<t+15,M}$$

  - **Lunar calibration provides long-term baseline**
  - **SD calibration provides smoothness and frequency**

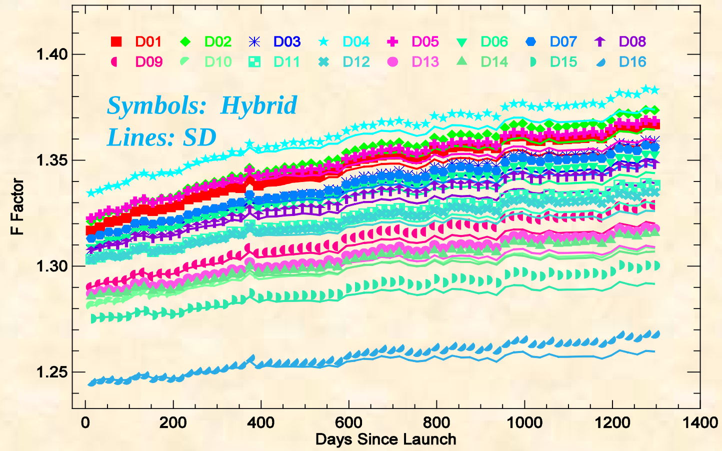
J. Sun and M. Wang, "Radiometric Calibration of the VIIRS Reflective Solar Bands with Robust Characterizations and Hybrid Calibration Coefficients," submitted to Applied Optics.

Hybrid Calibration Coefficients

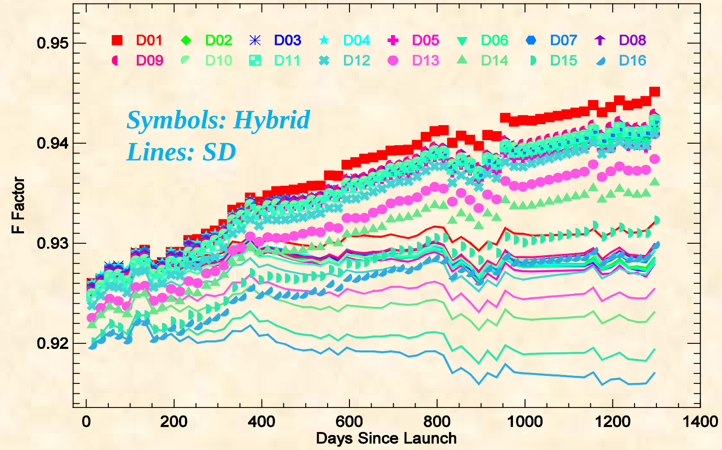
Calibration coefficients Ratios



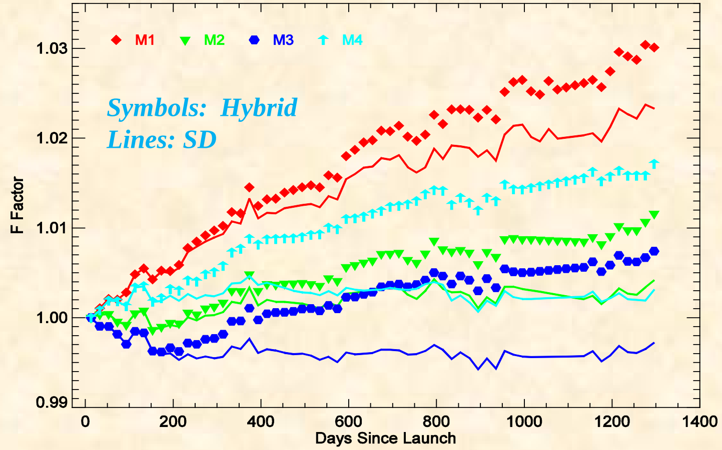
Calibration Coefficients (M1)



Calibration Coefficients (M4)

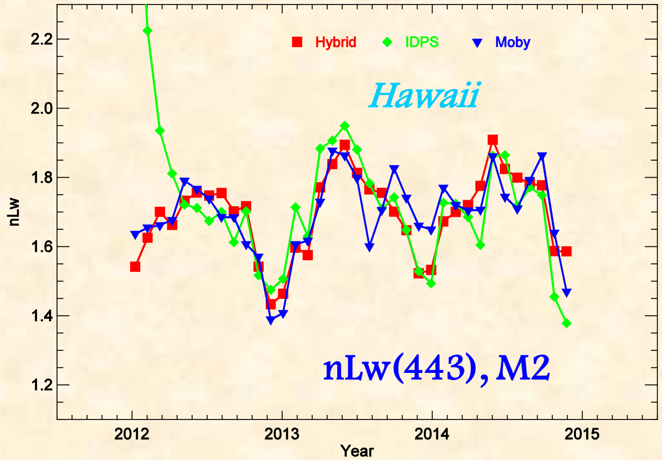


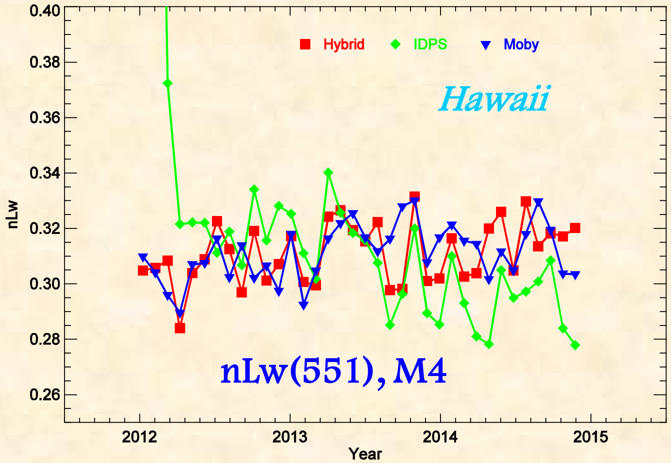
Calibration Coefficients

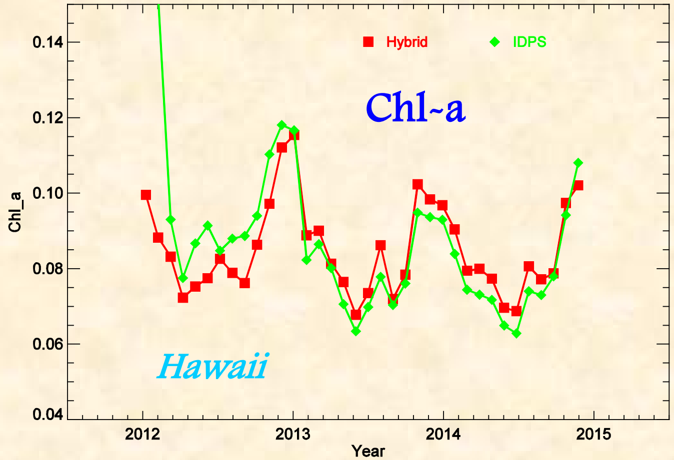


Improvements in Ocean Color Products

- VIIRS data were reprocessed using **MSL12** with SDR generated with updated hybrid calibration coefficients.
- NOAA ocean color products produced with the hybrid calibration coefficients have met validated maturity in March 2015.
- **Hybrid results agree with MOBY in situ!**







Green: VIIRS IDPS; Red: VIIRS Hybrid; Blue: Moby in Situ

- *J. Sun and M. Wang, "VIIRS Reflective Solar Bands On-Orbit Calibration and Performance: A Three-Year Update," Proc. SPIE, 9264, 92640L (2014).*
- *M. Wang, et al, "Evaluation of VIIRS ocean color products," Proc. SPIE 9261, 92610E (2014).*

Summary

- It is shown that SD/SDSM calibration can provide stable and clean calibration coefficients with all carefully derived input components.
- The “degradation uniformity condition”, a key assumption in SD/SDSM calibration methodology, has recently proved to be untrue, which results in a long-term bias into the calibration coefficients.
- Lunar observations provide stable and clean calibration coefficients without surface degradation issue even but are infrequent.
- An hybrid approach properly combining the SD and lunar calibration coefficients restores the accuracy of the calibration coefficients from the non-uniformity issue and other various effects.
- The hybrid coefficients significantly reduce the long-term drifts in the ocean color EDR products and improves the VIIRS ocean products to high quality, capable to support of the science research and various operational applications.
- “Degradation uniformity condition” will be a key issue for all instruments such as VIIRS J1, VIIRS J2, etc, that use SD/SDSM for reflective solar bands calibration.
- Lunar calibration is a necessary component of an accurate calibration for reflective solar bands for SNPP VIIRS, J1 VIIRS, J2 VIIRS, etc.
- **With good calibration, SNPP VIIRS is showing to be a beautiful instrument.**

More detail technique discussions will be presented in Thursday ocean color breakout session.

Backup

Table 1. Specification for SNPP VIIRS RSBs and SDSM detectors.

VIIRS Band	CW* (nm)	Band Gain	Detectors	Resolution*	SDSD Detector	CW* (nm)
M1	410	DG	16	742m x 776m	D1	412
M2	443	DG	16	742m x 776m	D2	450
M3	486	DG	16	742m x 776m	D3	488
M4	551	DG	16	742m x 776m	D4	555
I1	640	SG	32	371m x 387m	NA	NA
M5	671	DG	16	742m x 776m	D5	672
M6	745	SG	16	742m x 776m	D6	746
M7	862	DG	16	742m x 776m	D7	865
I2	862	SG	32	371m x 387m	D7	865
NA	NA	N	16		D8	935
M8	1238	SG	16	742m x 776m	NA	NA
M9	1378	SG	16	742m x 776m	NA	NA
M10	1610	SG	16	742m x 776m	NA	NA
I3	1610	SG	32	371m x 387m	NA	NA
M11	2250	SG	16	742m x 776m	NA	NA

*CW: Center Wavelength; DG: Dual Gain; SG: Singla Gain; Resolution: Track x Scan at Nadir after aggregation

VIIRS Marine Isoprene:
Linking Ocean Phytoplankton to Air Quality and Climate

Daniel Tong, Hang Lei, Li Pan, Pius Lee
NOAA Air Resources Laboratory (ARL), College Park, MD

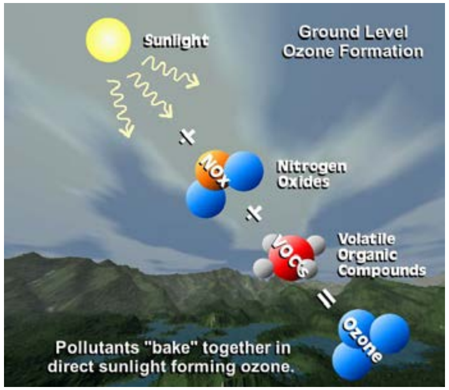
Menghua Wang
NOAA Center for Satellite Applications and Research (STAR), College Park, MD

Acknowledge: NOAA JPSS Program for funding support;

What is isoprene

Isoprene ($CH_2=CH-C(CH_3)=CH_2$) is a biogenic hydrocarbon emitted by trees, grasses and ocean phytoplankton.

- **Purpose of emission:** combat abiotic stresses;

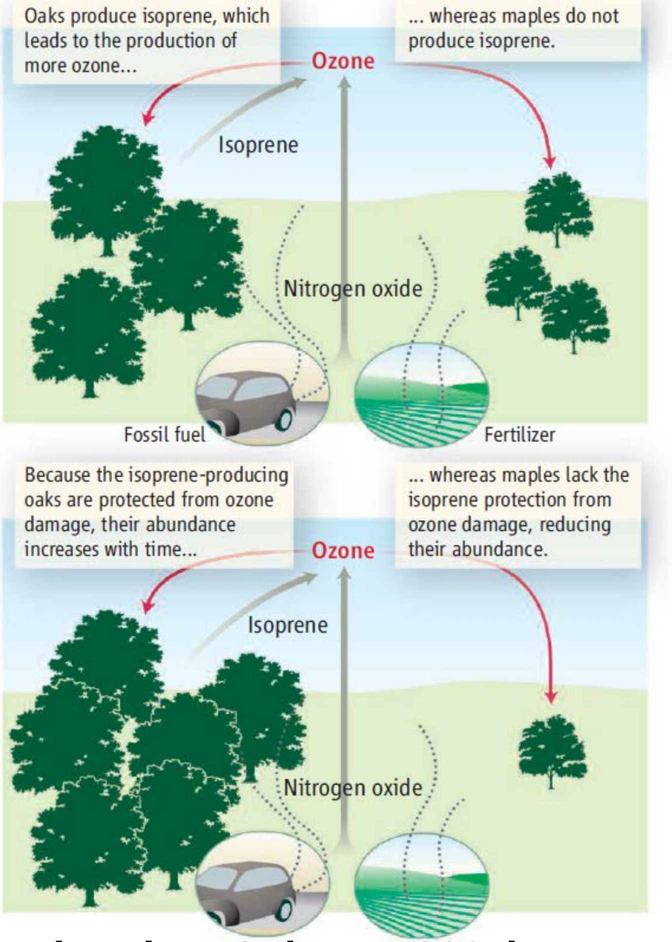


- **Ozone formation:**
- **Aerosol formation:**

$$\mathrm{VOC} + \mathrm{OX} \rightarrow \sum_{i=1}^{N} \alpha_i \times P_i \rightarrow \mathrm{SOA}$$

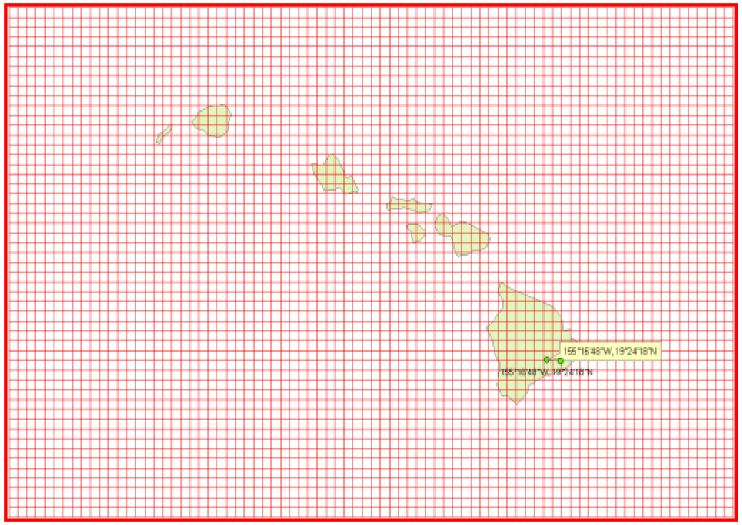
- **Cloud formation:** Cloud Condensation Nuclei (CCN);

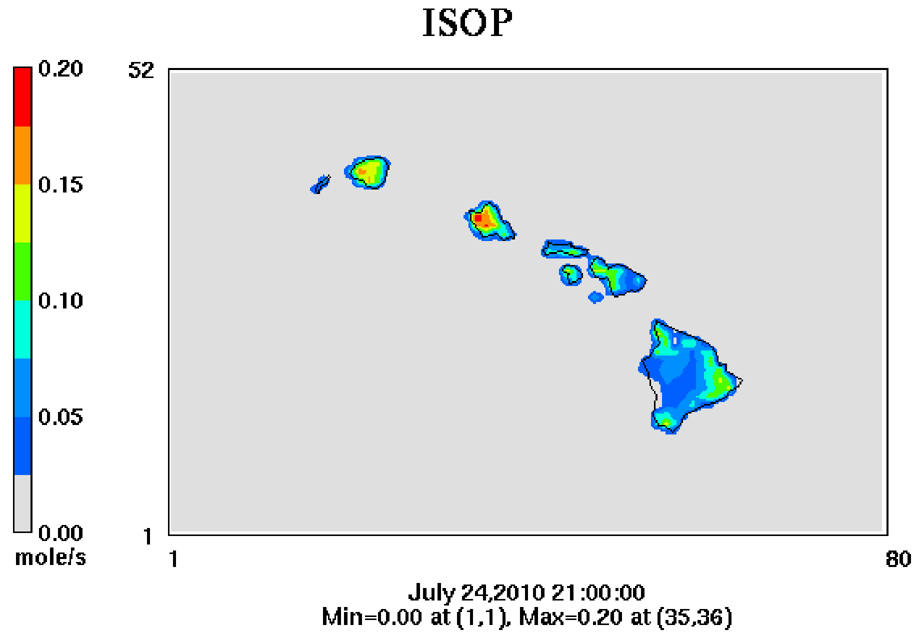
Ozone, Aerosol, cloudiness all at the central stage of climate change debate



(Lerdau, *Science*, 2007)

National Air Quality Forecast over Hawaii

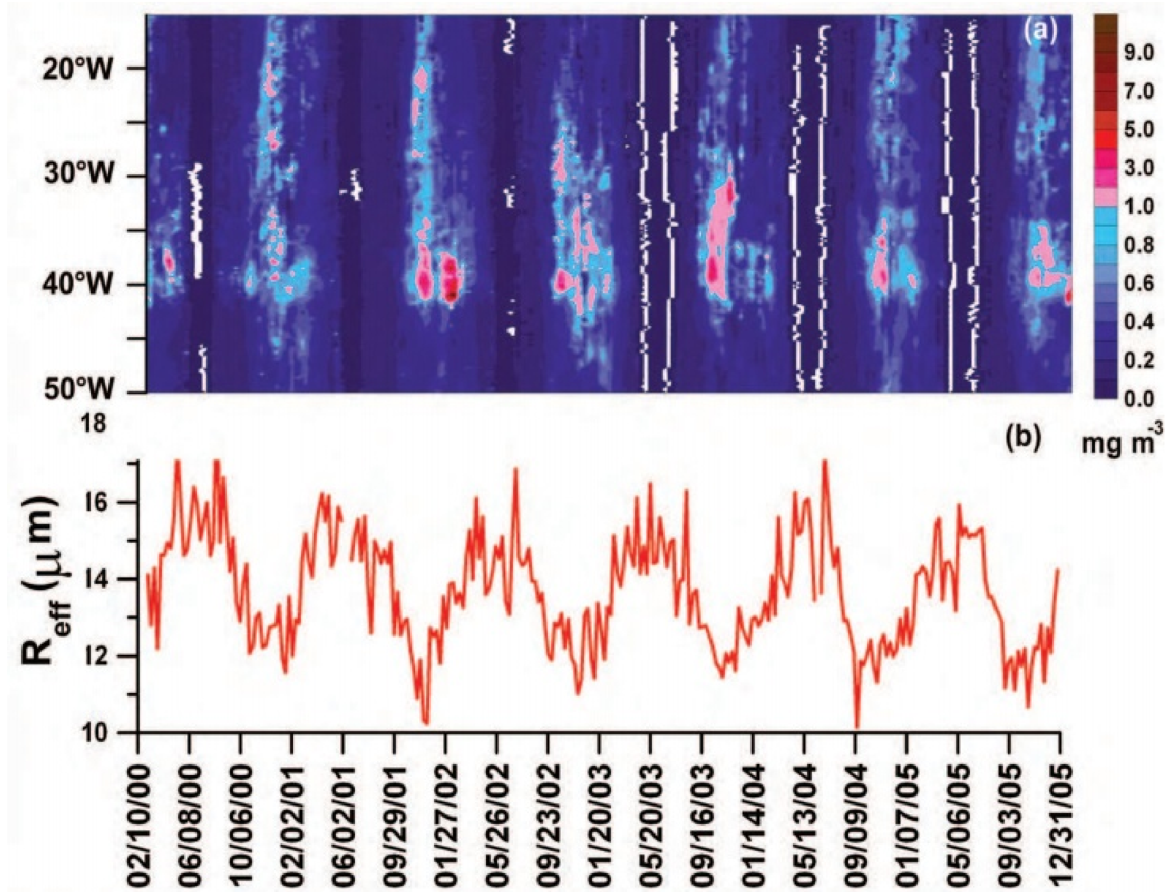




A suite of reactive gases and aerosols emitted from the Ocean:

- **Isoprene;**
- **Dimethyl Sulfide (DMS);**
- **Organic Aerosols;**

Algae Bloom and Ocean Cloudiness



(Meskhidze and Nenes, Science, 2006)

A Review of Approaches for Marine Isoprene Emissions

- **Shaw et al. (2003):**

$$E_{iso} = [Chl - a] * V * EF$$

- **Palmer & Shaw (2005):**

$$E_{iso} = K_{AS} * (C_W - H * C_A)$$

$$P - C_W(k_i * C_{Xi} + k_{bio} + k_{AS} / Z_{ML}) - L_{MIX} = 0$$

k_i – chemical reaction rate for oxidant i;
k_{bio} – bacterial loss rate;
L_{MIX} – loss due to downward mixing;

- **Gantt et al. (2009):**

$$E_{iso} = SA * H_{max} * [Chl - a] * F_{iso} * \int_0^{H\max} P dh$$

E_{iso} - Isoprene emission;

[Chl-a] - Isoprene emission;

V – euphotic water volume;

EF – Emission factor;

k_{AS} – exchange coeff.;

C_W – isop. conc. in water

C_A – isop. conc. in the air

H – Henry's law constant;

P – isoprene production;

H_{max} – euphotic zone height;

Z_{ML} – mixing layer height;

JPSS marine Isoprene algorithm (V1.0)

❖ **Built upon several pioneering works:**

$$F = a \times [Chl] \times \sum_{i=1}^{N} (EF_i \times f_i) \times H_{max} \times \gamma$$

JPSS Products Used:

- **[Chl-a]**
- **Kd490**
- **PAR**

Euphotic zone height (Gantt et al., 2009)

$$H\max = (-\ln(\frac{2.5}{I_0}) / K_{490})$$

I_0 – ground radiation; K490 – defuse attenuation coefficient in water

Phytoplankton Functional Types (PFTs) (Arnold et al., 2009)

Determine emission factor (EF) and abundance (f);
No data available from JPSS, using SeaWiFS climatological data

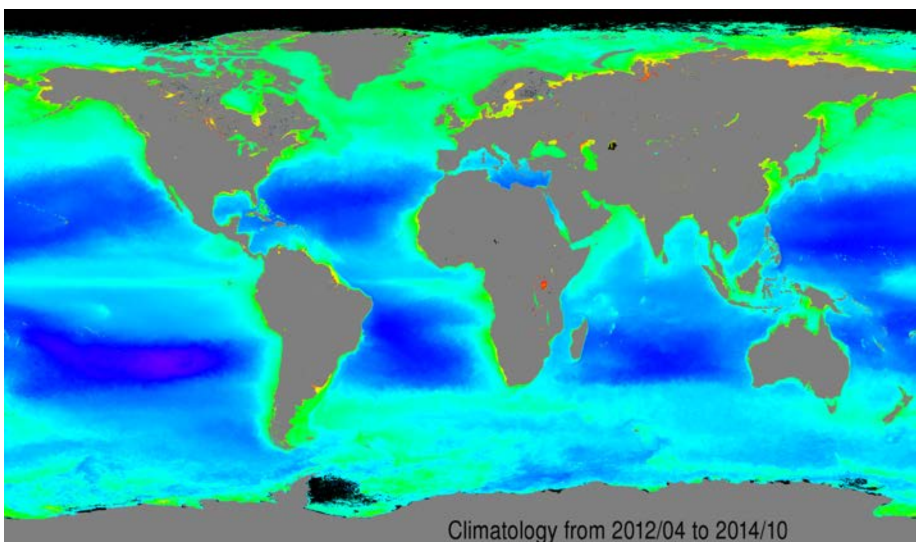
Chlorophyll-a and K_d(490)

- **Sensor/Satellite**: Visible Infrared Imaging Radiometer Suite (VIIRS) on SNPP
- **Ocean Color Data Processing:**

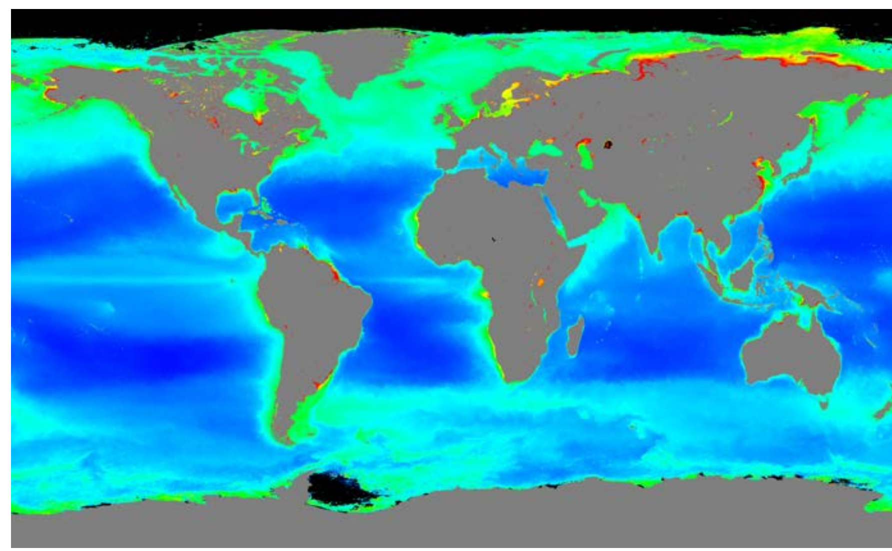
  - Multi-Sensor Level-1 to Level-2 (MSL12) is used for VIIRS ocean color data processing

  - Routine ocean color data production from SDR (Level-1B) to ocean color EDR (Level-2), and to global Level-3 data, including nL_w, chlorophyll-a, and K_d(490).

  - Level 3: Products are mapped to the CoastWatch geographic regions
- **Algorithms (Ocean Color EDR Team):**
  – Chlorophyll-a concentration: VIIRS OC3 algorithm
  – Diffuse attenuation coefficient at 490 nm K_d(490): *Wang et al.* (2009) algorithm



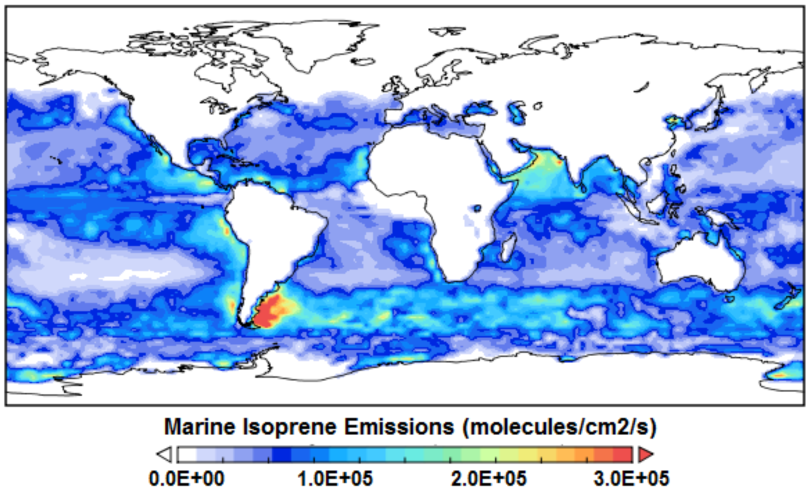
Chlorophyll-a



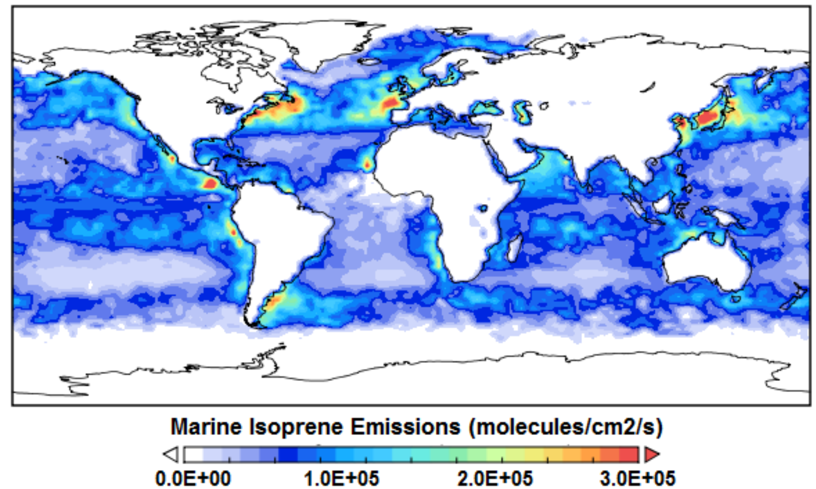
K_d(490)

Global Distribution of Marine Isoprene

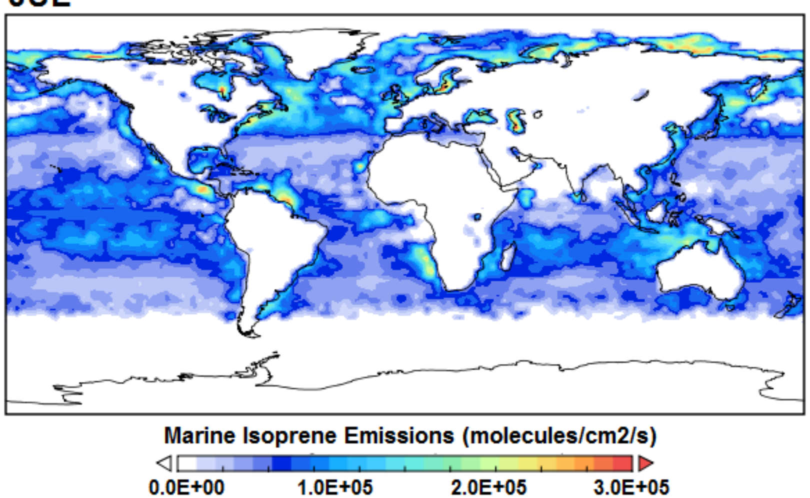
JAN



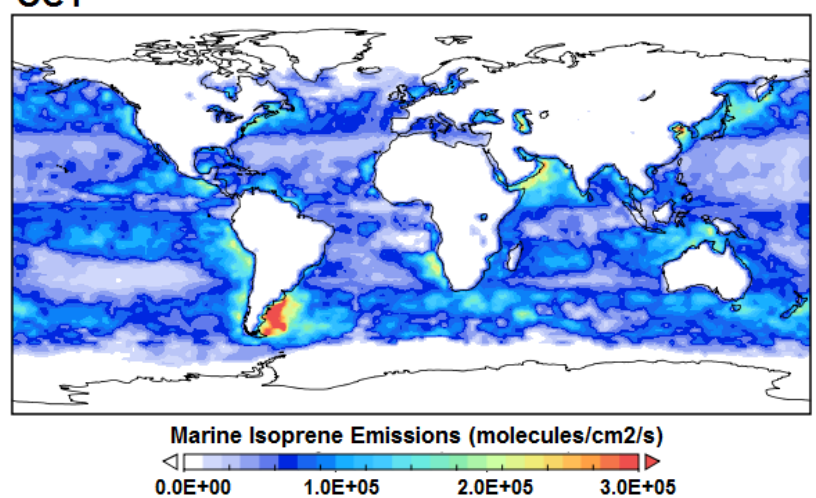
APR



JUL

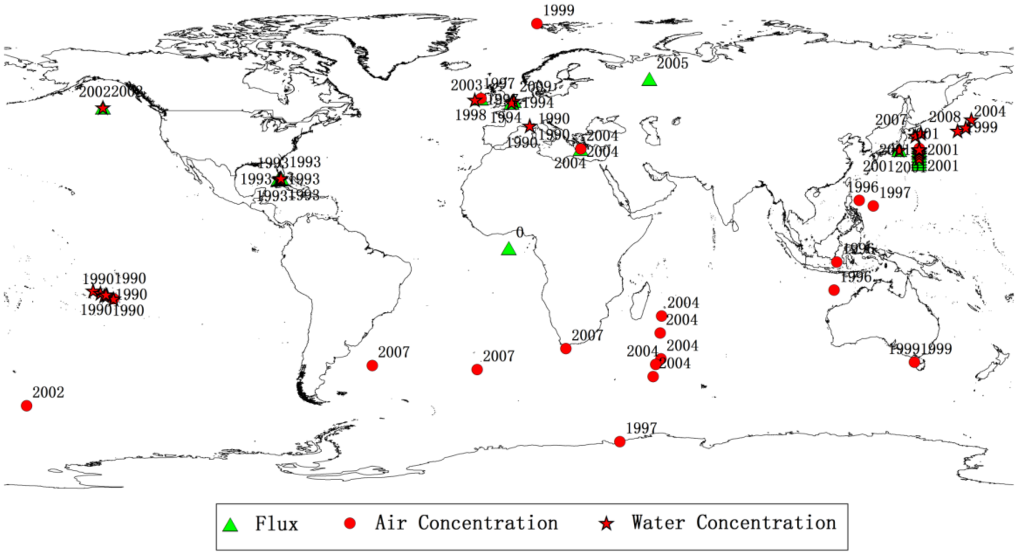


OCT



Isoprene Observations and Reprocessing

Issue: Some data can not be directly used for product validation.
Reprocessing Approach: Air-sea mass transfer.



Convert seawater conc into flux:

$$E_{iso} = K_{AS} * (C_W - H * C_A)$$

k_{AS} – exchange coeff.;
C_W – isop. conc. in water
C_A – isop. conc. in the air
H – Henry's law constant;

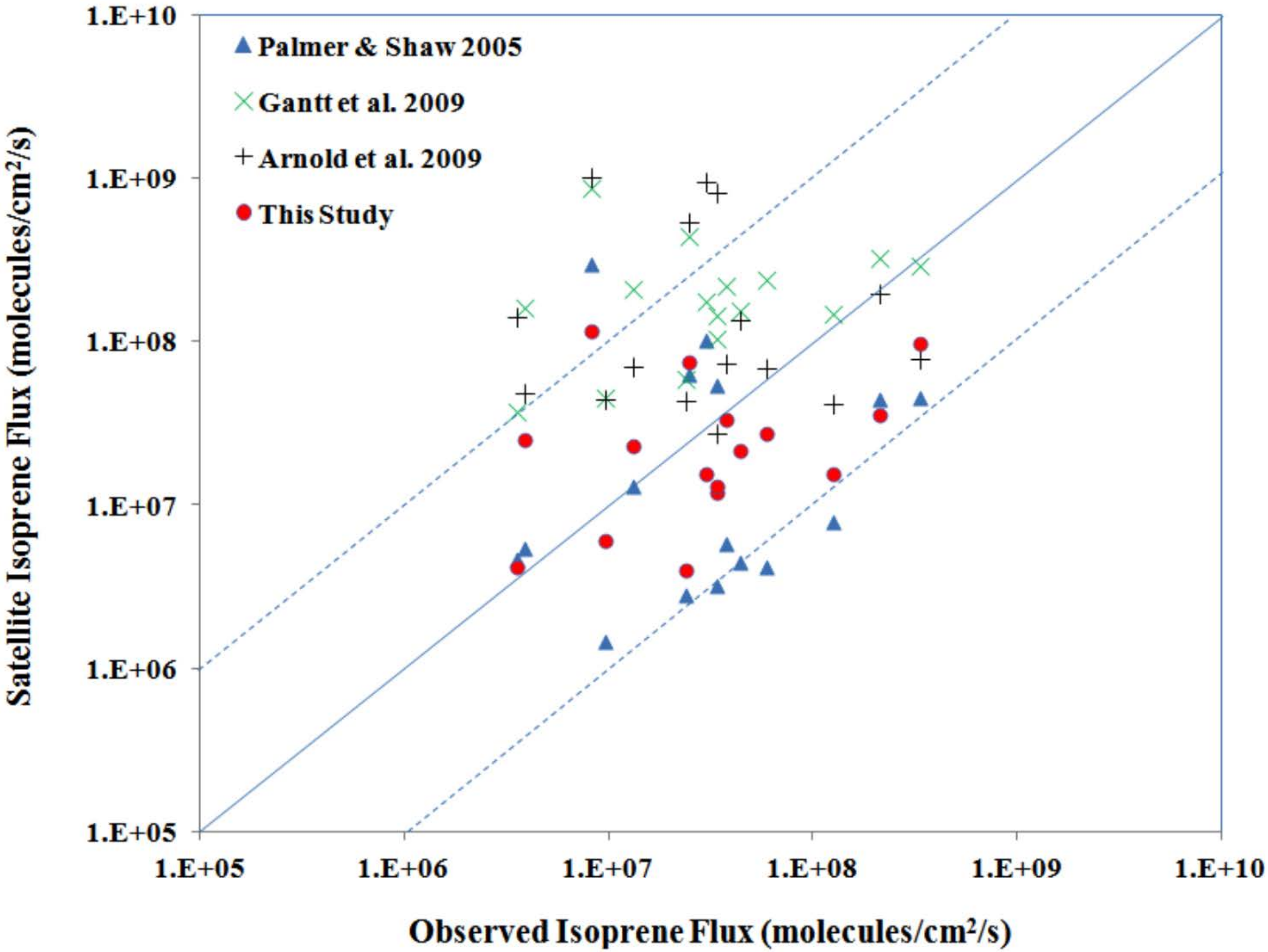
Calculate exchange coeff based on wind speed:

$$K_{AS} = 0.31 * U^2((3913.15 - 162.13T + 2.67T^2 - 0.012T^3)/660)^{-0.5}$$

U – surface wind speed; **T** – Sea surface Temperature

(Wanninkhof et al., 2004)

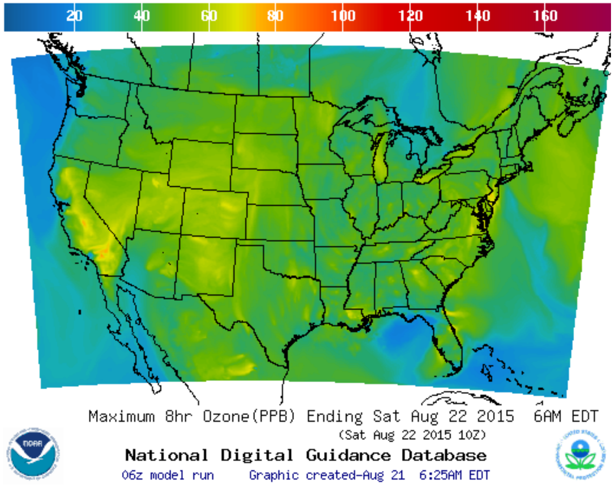
Isoprene Product Validation (Cont.)



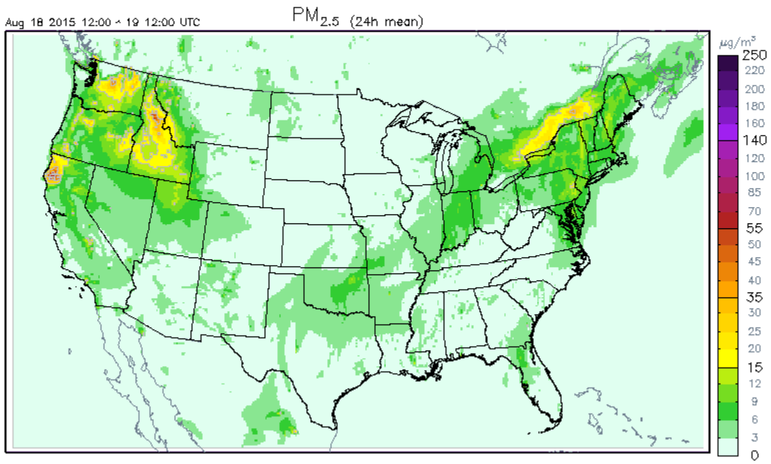
NOAA National Air Quality Forecast Capability (NAQFC)

- Developed by OAR/Air Resources Laboratory; Operated by National Weather Service (NWS) (PM: I. Stajner).
- Provides national numeric air quality guidance for ozone (operational product) and $PM_{2.5}$ (particulate matter with diameter < 2.5 μm);

O_3 Forecasting



$PM_{2.5}$ Forecasting

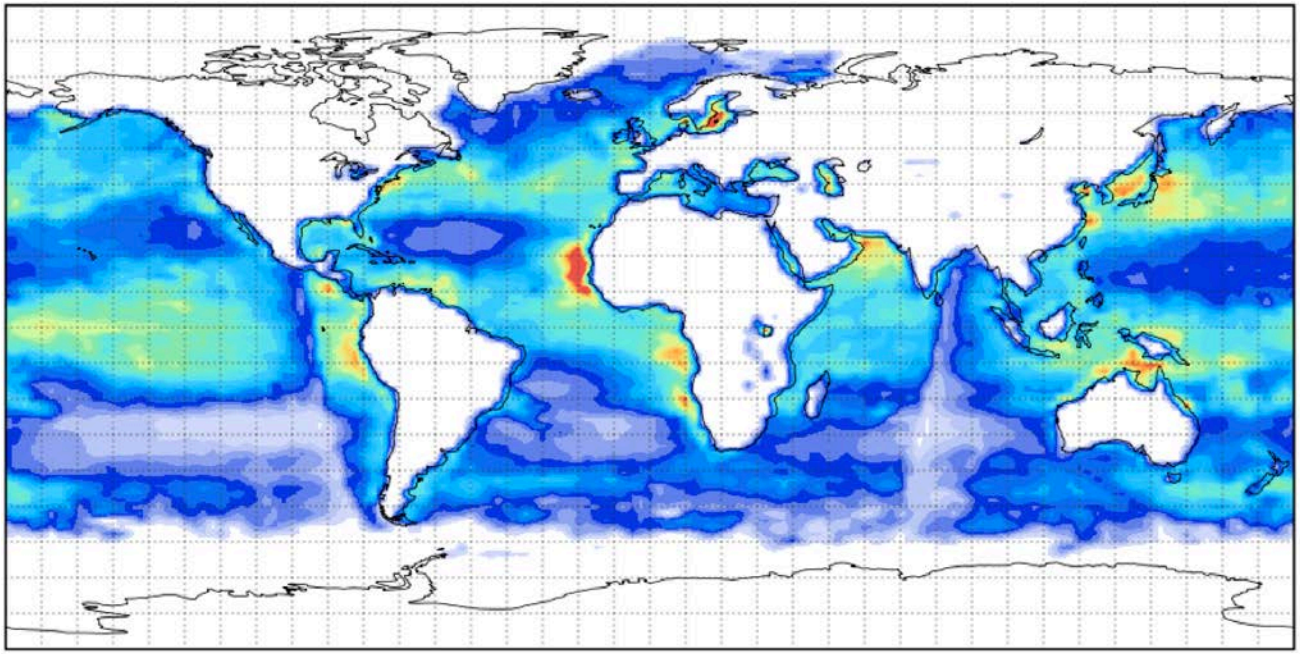


http://airquality.weather.gov/

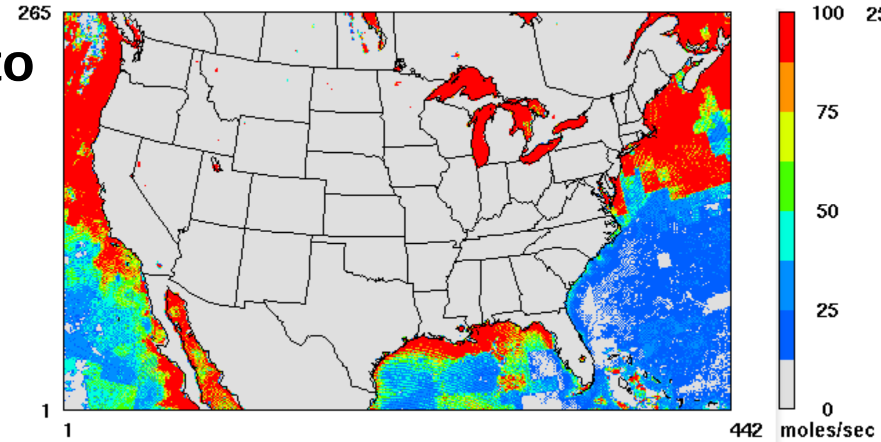
<u>NAQFC is one of the major gateways to disseminate NOAA satellite observations and model prediction of air quality to the public.</u>

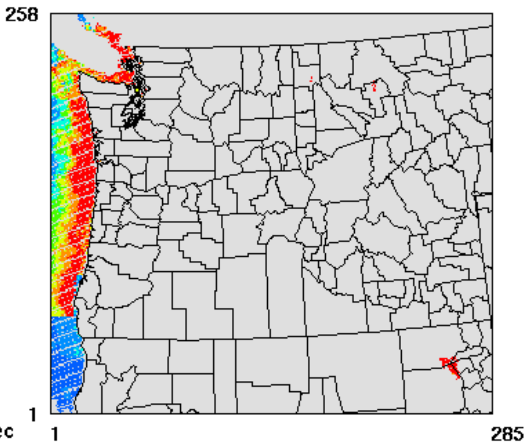
Isoprene applications: National and regional air quality forecasting

Global Isoprene (April 2014)



Isoprene into model domains

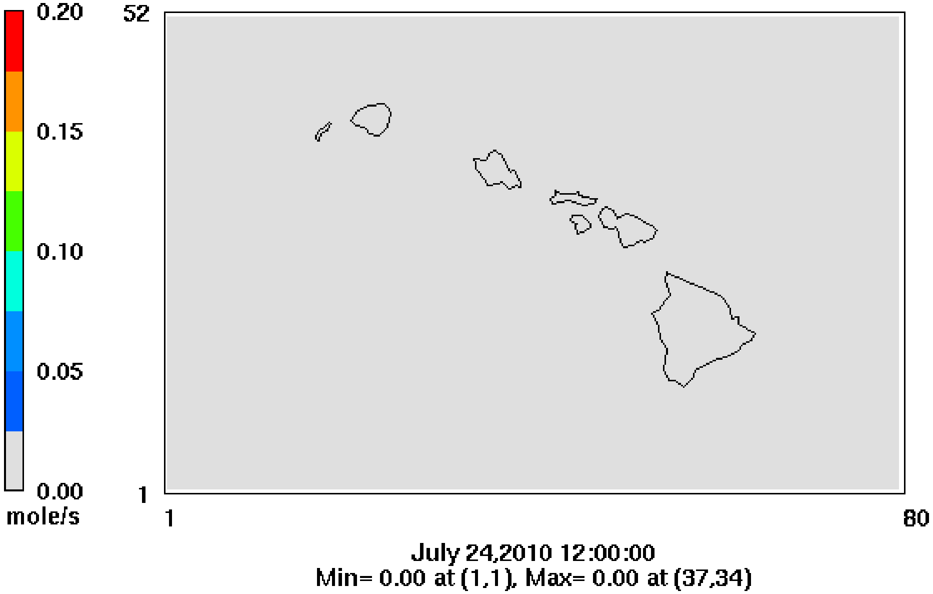




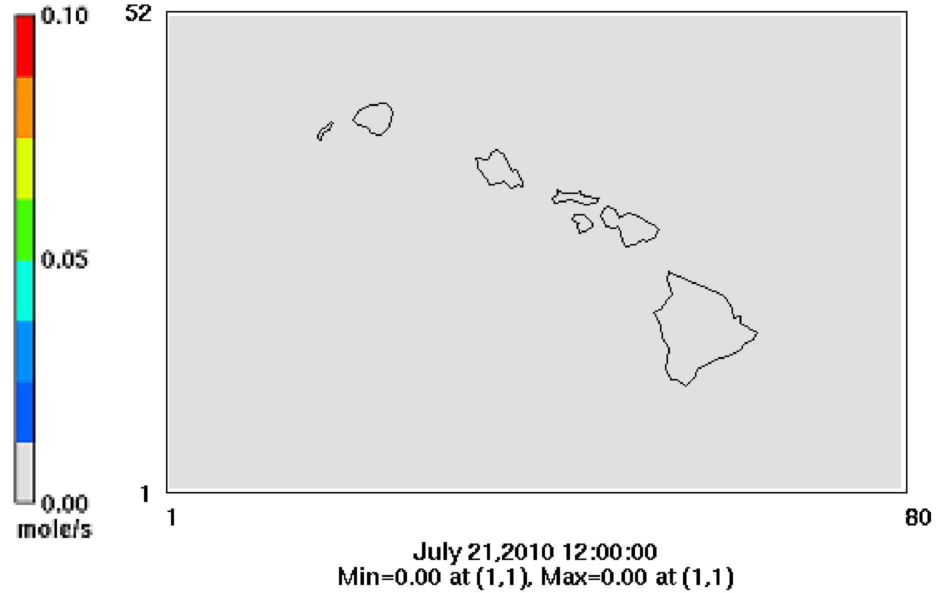
Terrestrial vs. marine isoprene emissions

(Preliminary Results)

Land Emission



Marine Emission



JPSS Isoprene product fills the gap of missing ocean emissions in air quality and climate models

JPSS Isoprene User Workshop: September 2, 2015 in College Park, MD
Contact: Daniel.Tong@noaa.gov for details

JPSS 2015 Annual Science Meeting

Operational Monitoring and Forecasting of Land Surface Phenology from JPSS VIIRS Observations and its Applications

Xiaoyang Zhang, Yunyue Yu,
Lingling Liu, Yihua Wu, and
Michael Ek

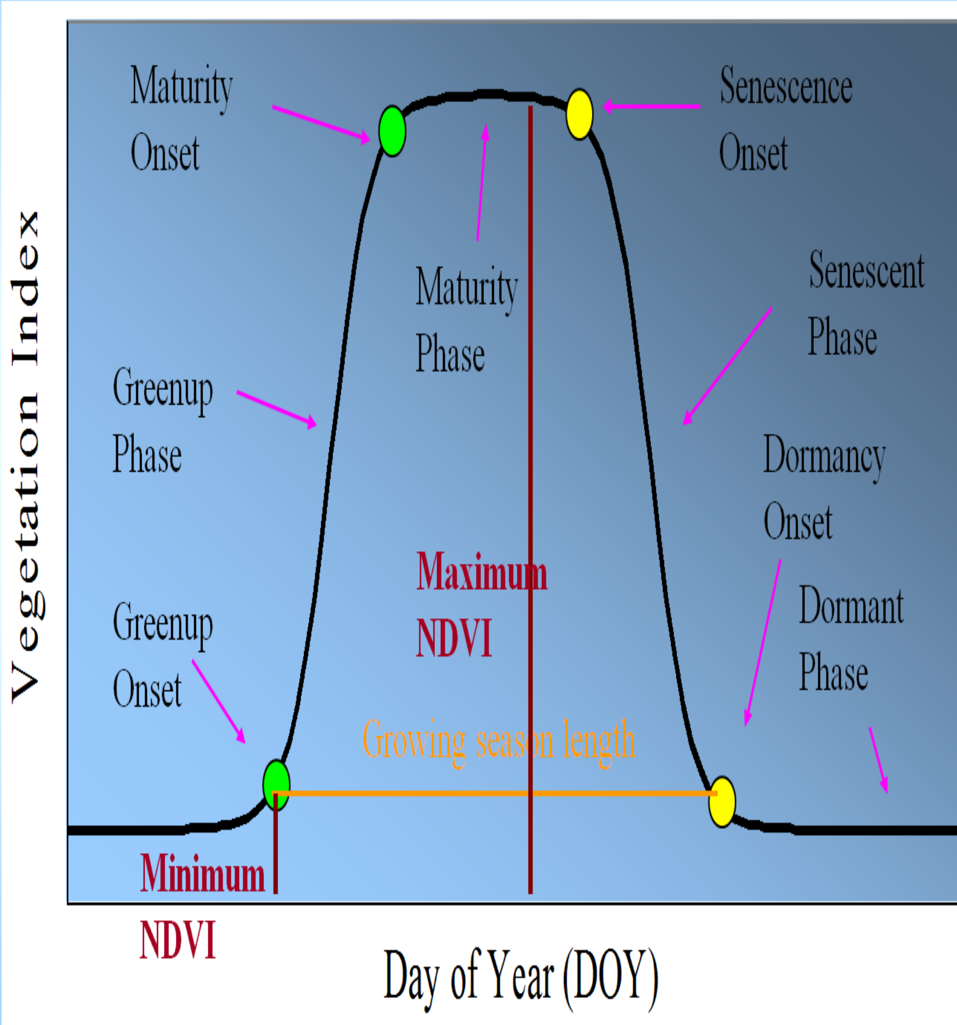
August 25, 2015

Objectives

- Goal(s):
  - To establish a system for monitoring in real-time and forecasting in short term temporal development of vegetation growth in North America and across the globe from JPSS VIIRS.
- Targeted users:
  - Numerical Weather Prediction Systems at NOAA Environmental Modeling Center
  - Agriculture and forest management
  - Climate monitoring

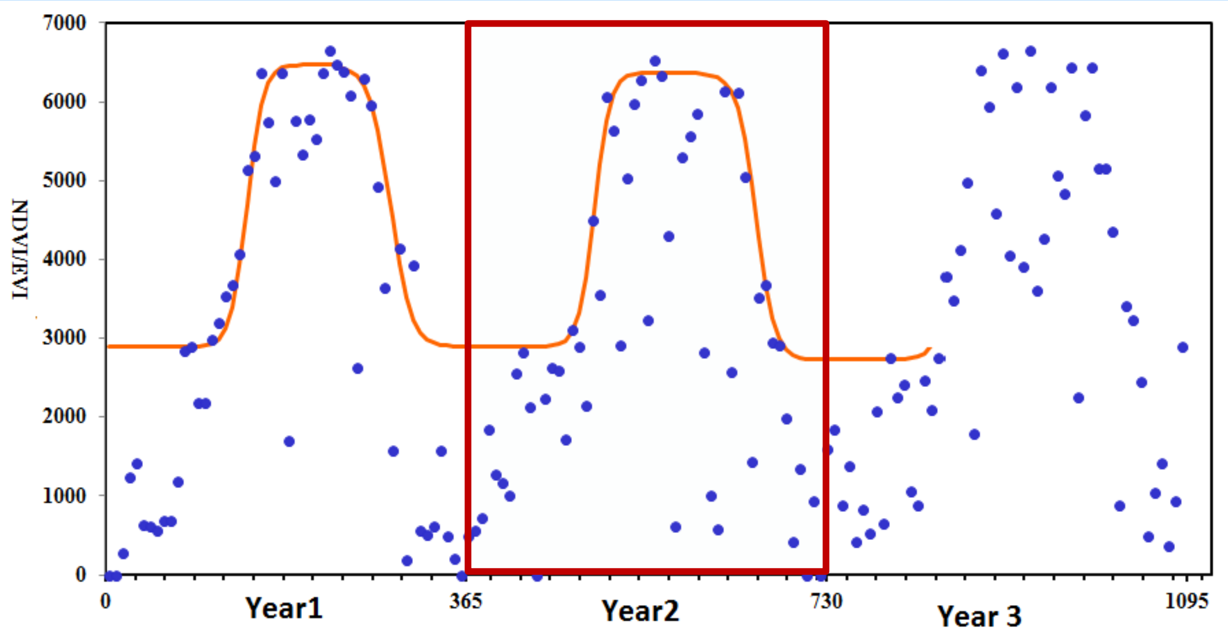
Metrics of Land Surface Phenology/Dynamics

1. Onset of greenness increase
2. Onset of greenness maximum
3. Onset of greenness decrease
4. Onset of greenness minimum
5. Growing season VI minimum
6. Growing season VI maximum
7. Summation of VI for growing season length
8. Rate of change in greenness increase;
9. Rate of change in greenness decrease
10. Onset of fall foliage low coloration
11. Onset of fall foliage moderate coloration
12. Onset of fall foliage near peak coloration
13. Onset of fall foliage peak coloration
14. Onset of fall foliage post peak coloration

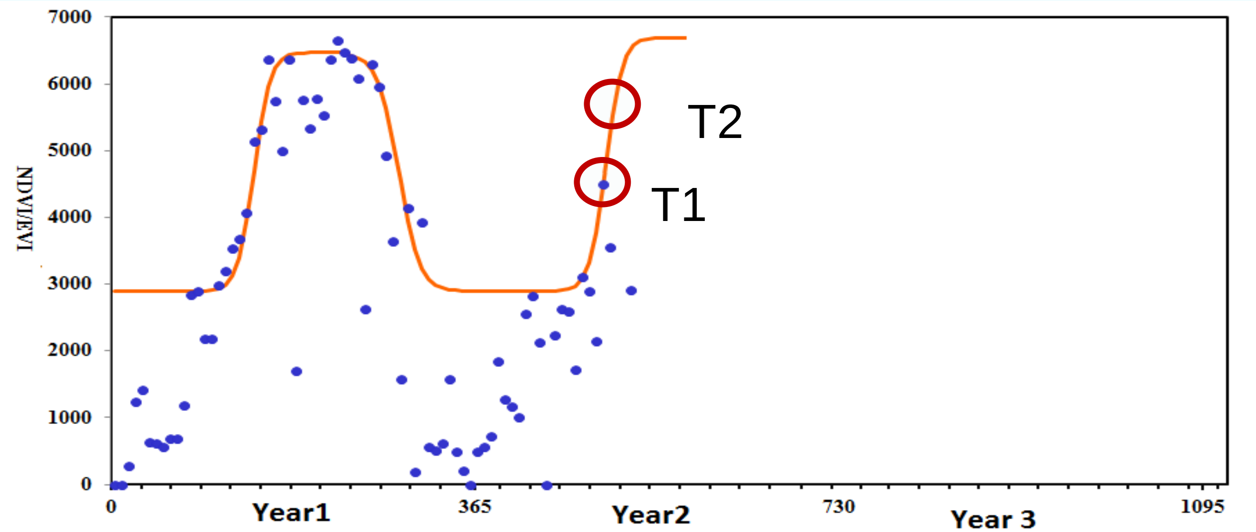


Establishment of Phenology Climate Data Record and Detection of Real Time Phenology

Climate data record of phenology is detected from annual time series of satellite data with a latency longer than half year

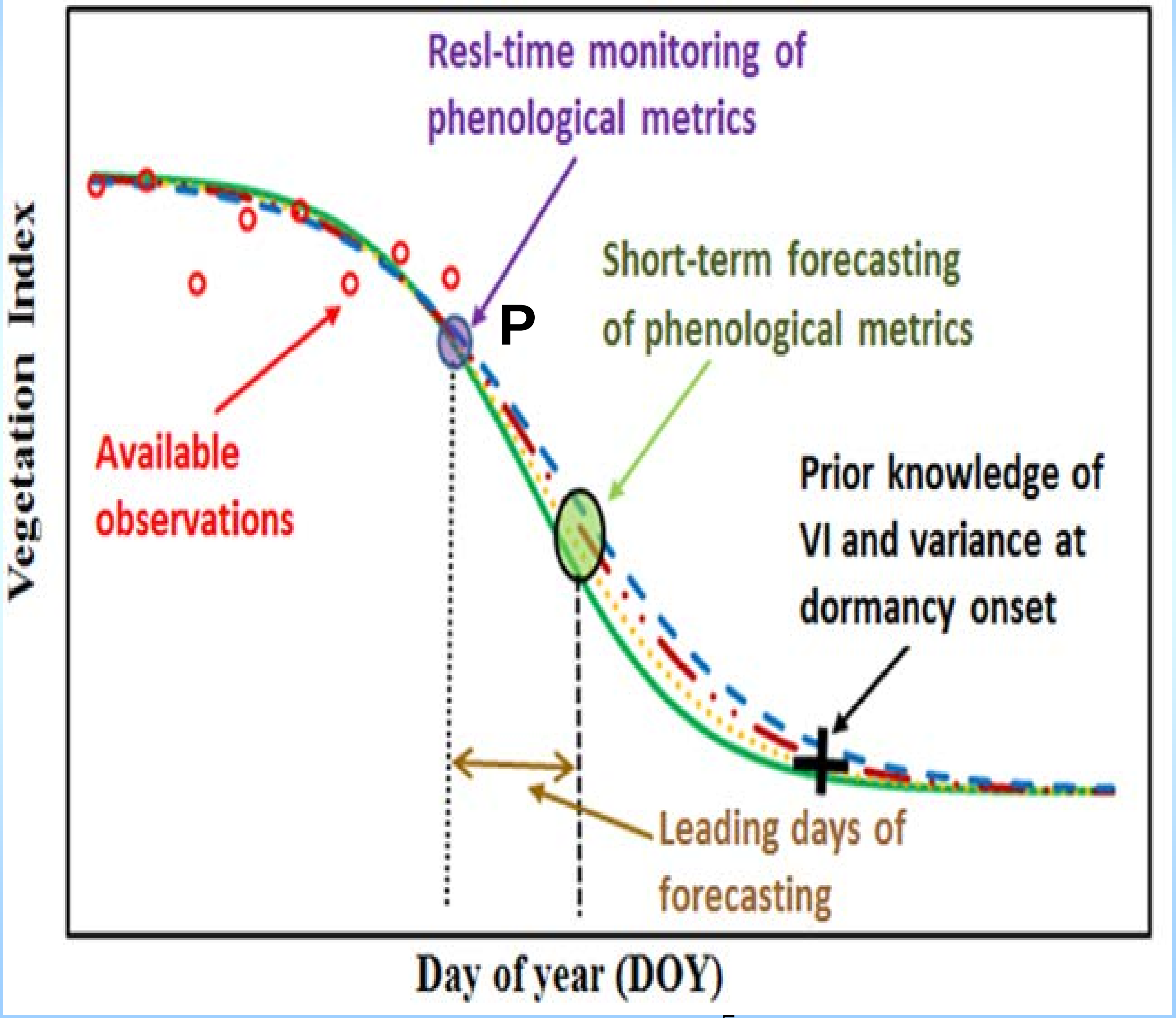


Real Time phenology is detected from currently available time series of satellite data without any latency

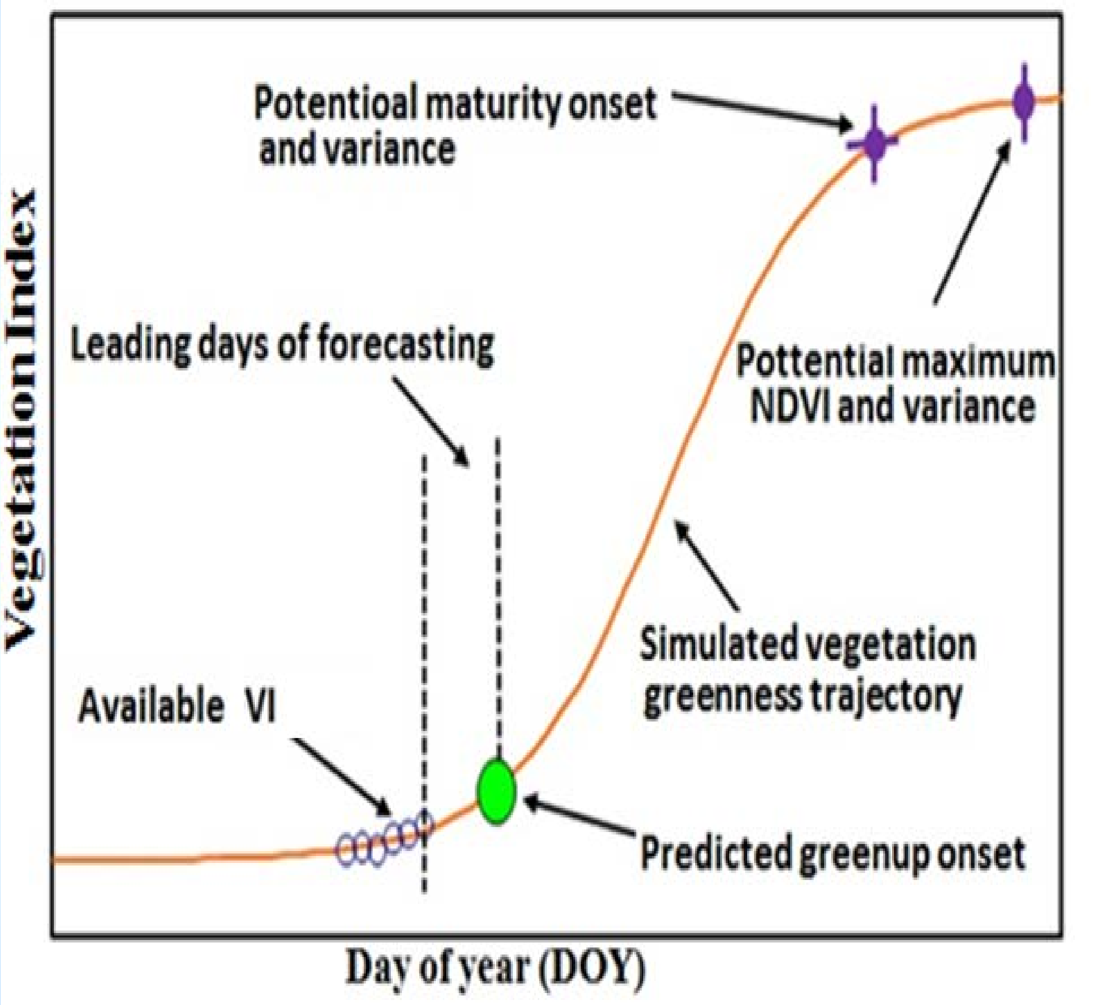


Prediction of Temporal Greenness Trajectory in Autumn

A set of potential VI trajectories in a senescent phase are modeled in near-real time for a pixel from the available observations (dots) and climatology.

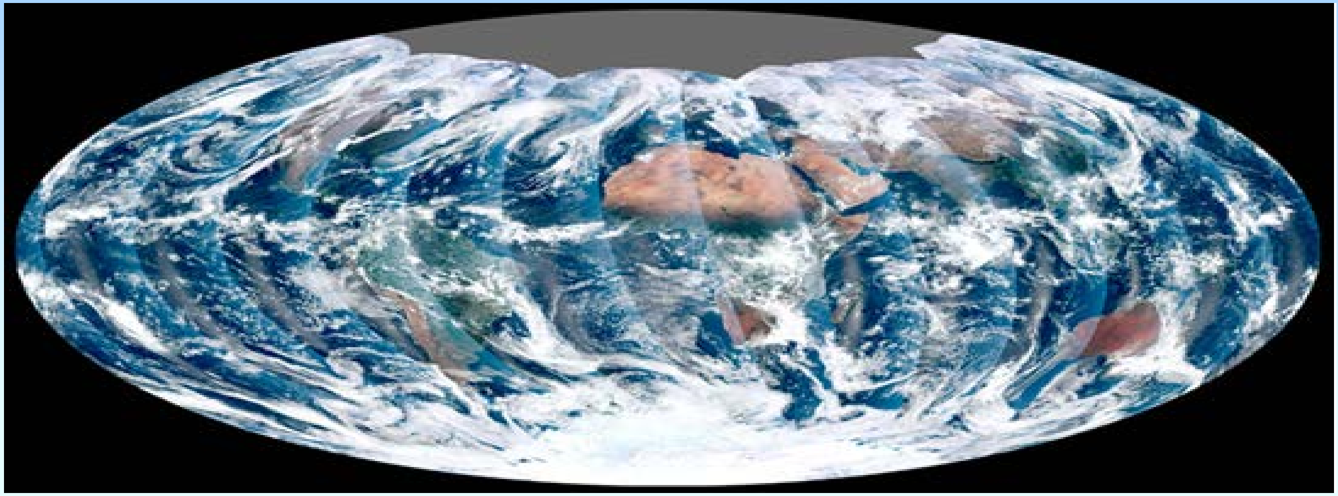


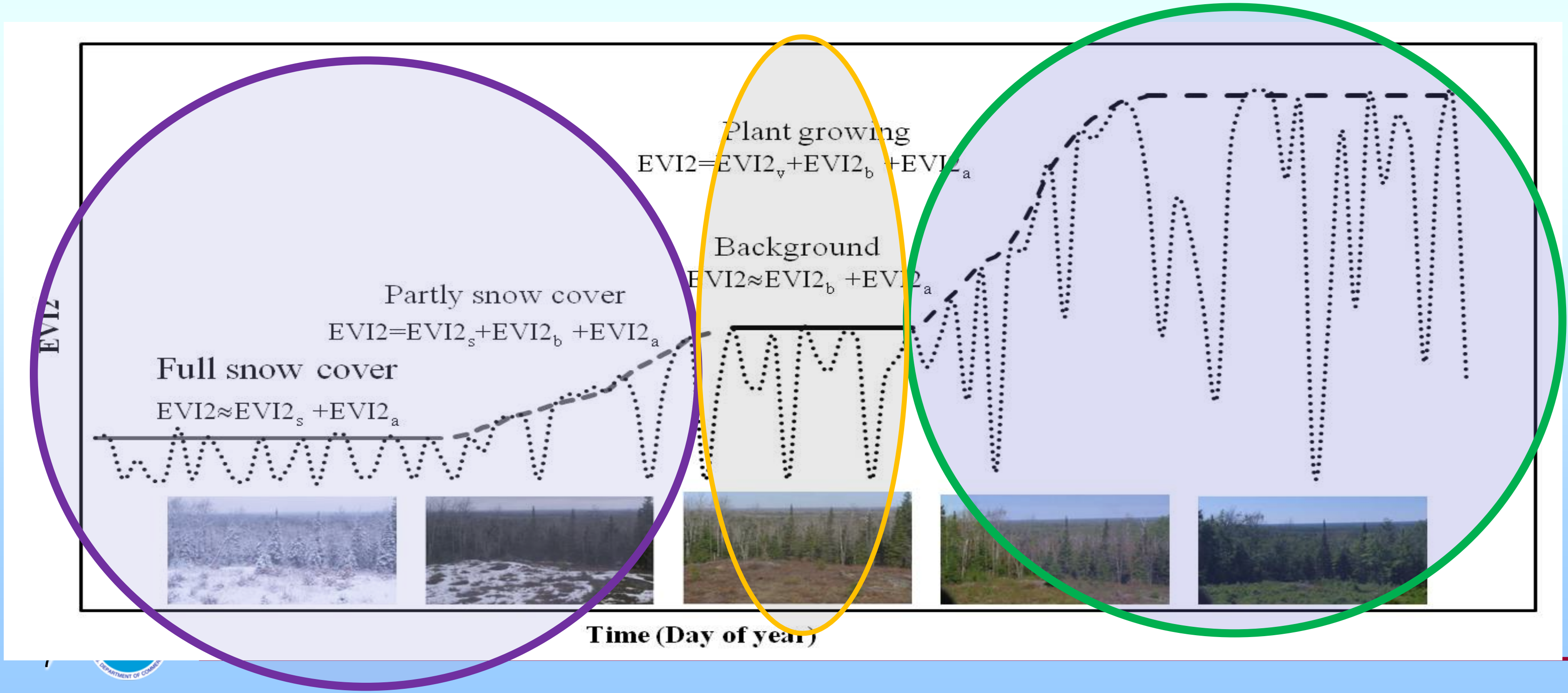
Prediction of Temporal Greenness Trajectory in Spring



Simulating the potential temporal trajectory from available daily VI data (circles) and monitoring and forecasting phenological events in spring green-up phase.

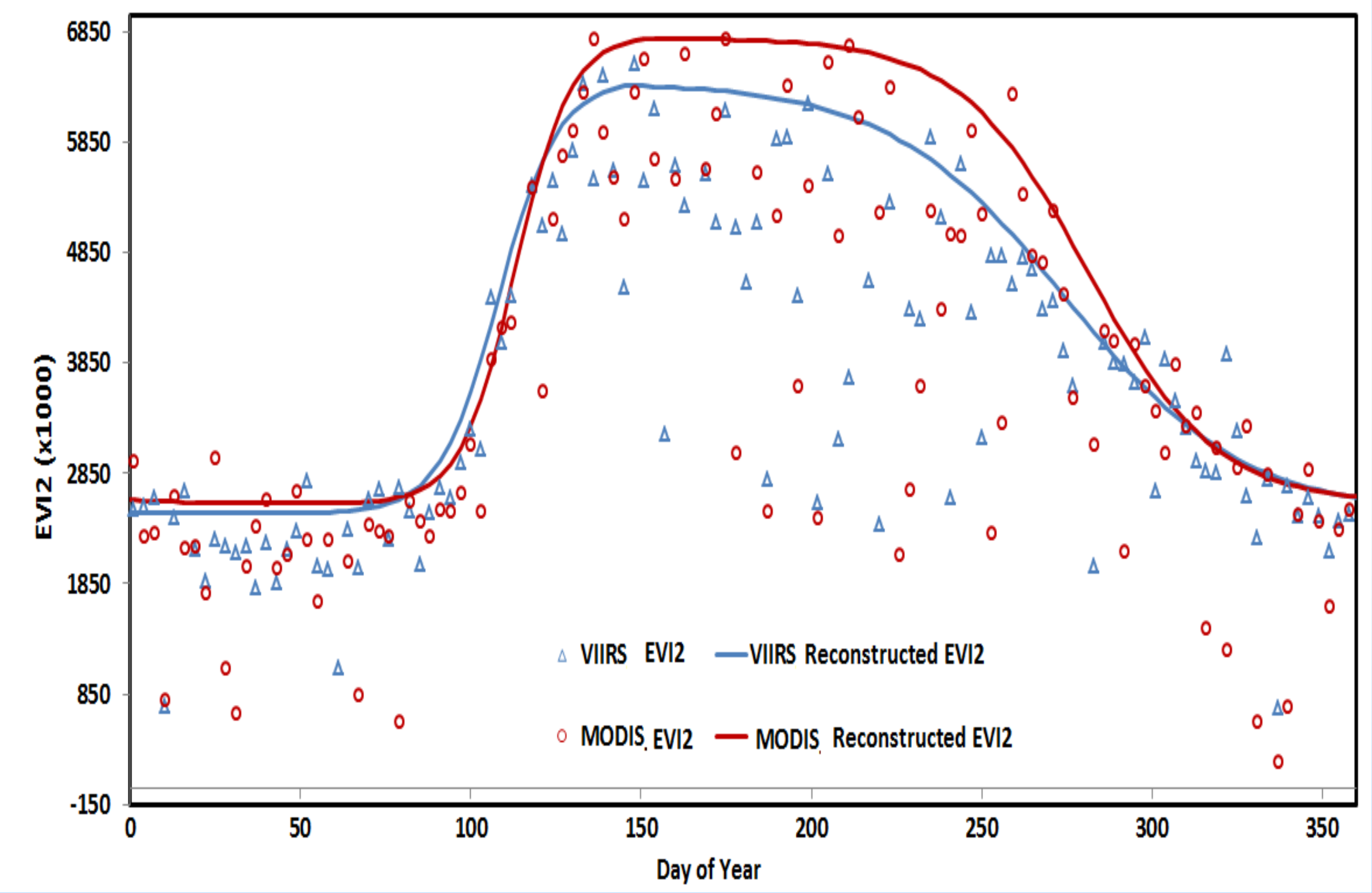
Biophysically Understanding Temporal Trajectory of Satellite Vegetation Index (VI)





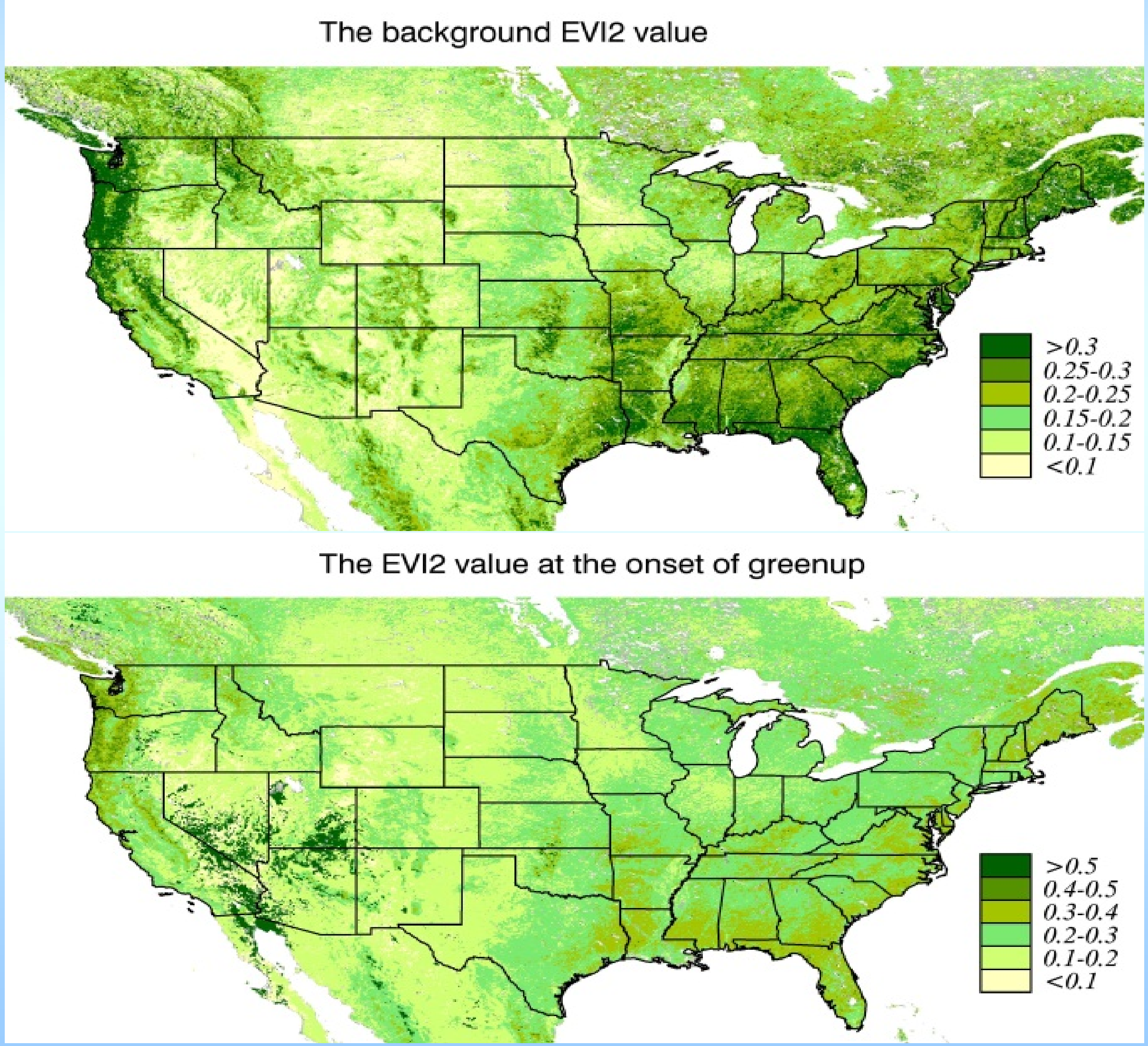
Calibration of Climatological Phenology Trajectory (from MODIS) to be comparable with VIIRS Data

- **MODIS EVI and VIIRS EVI are not exactly the same**
- **Climatological EVI from MODIS needs to be calibrated to be comparable to VIIRS EVI**



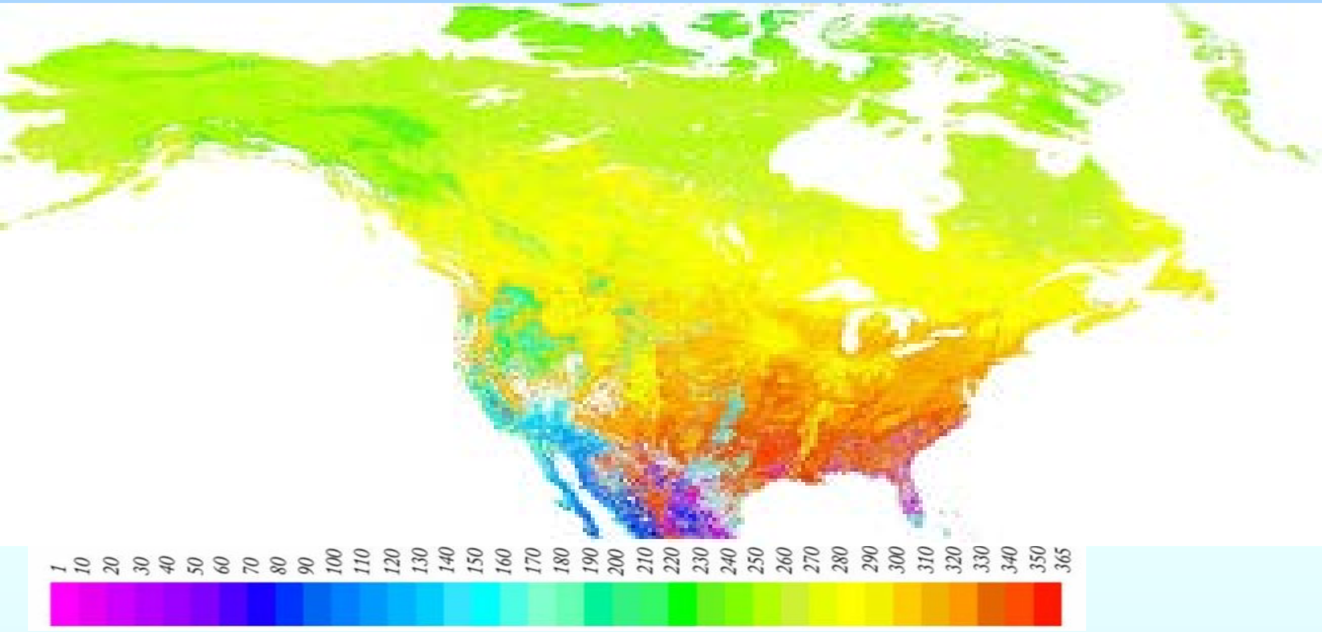
Climatological MODIS Vegetation Index for Real-time Monitoring from VIIRS data

Climatology MODIS vegetation index (2001-2012) calibrated using annual time series of MODIS and VIIRS data in 2013.

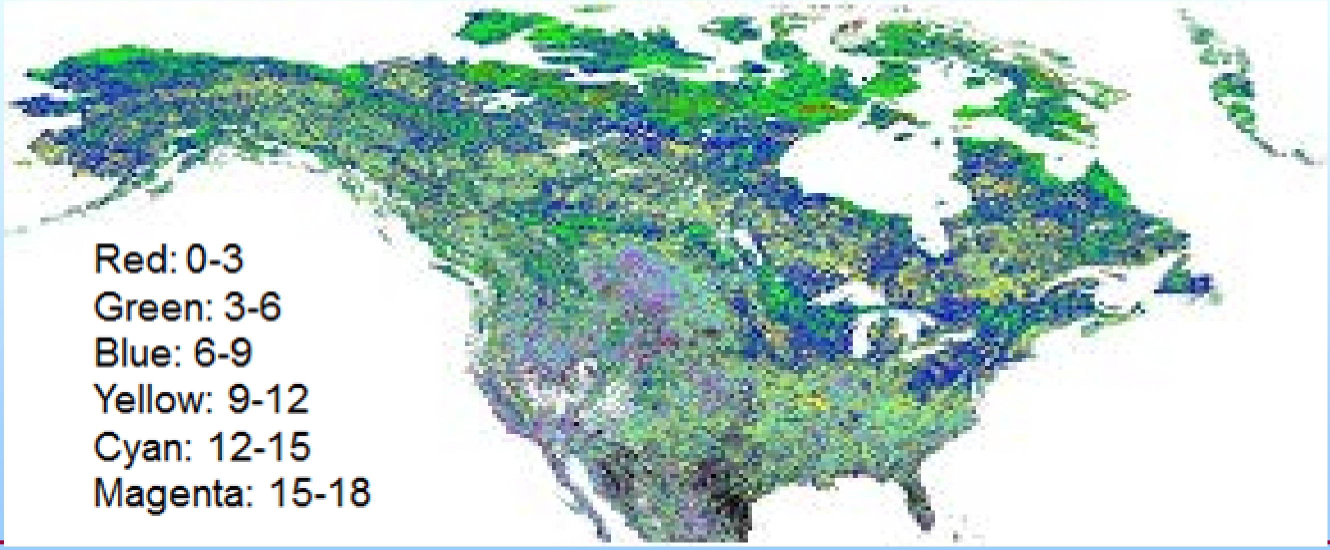


Climatology of Dormancy Onset and Standard Variation

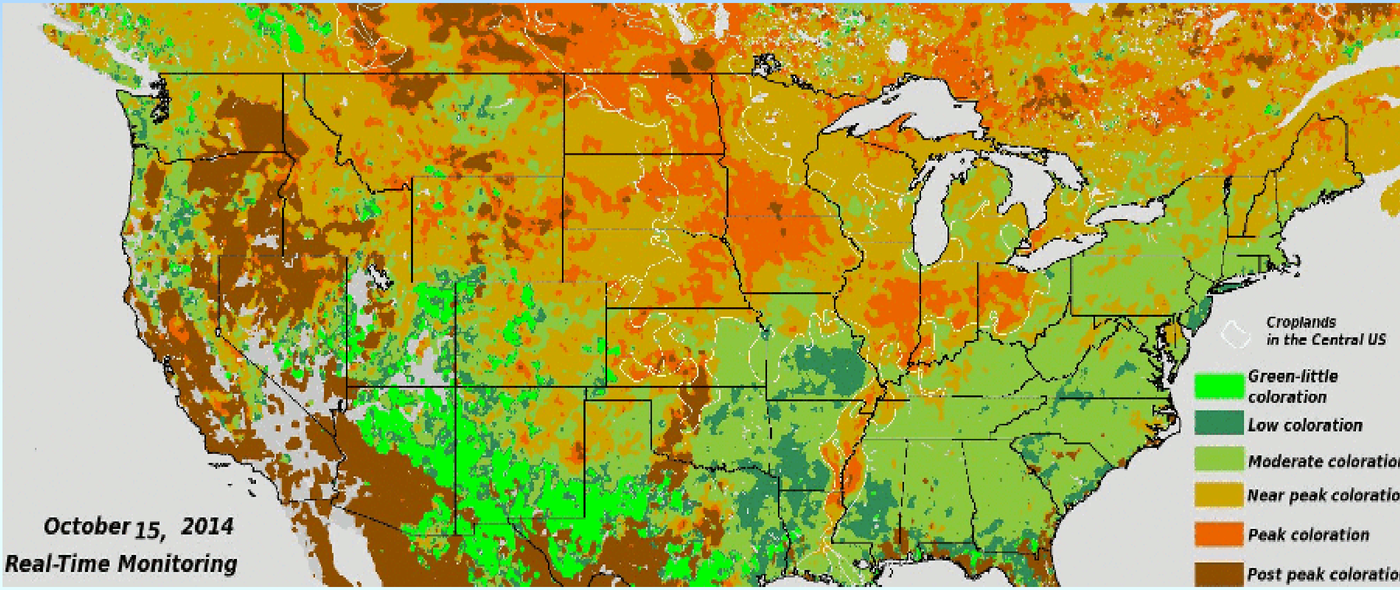
Climatology from MODIS data from 2001-2012

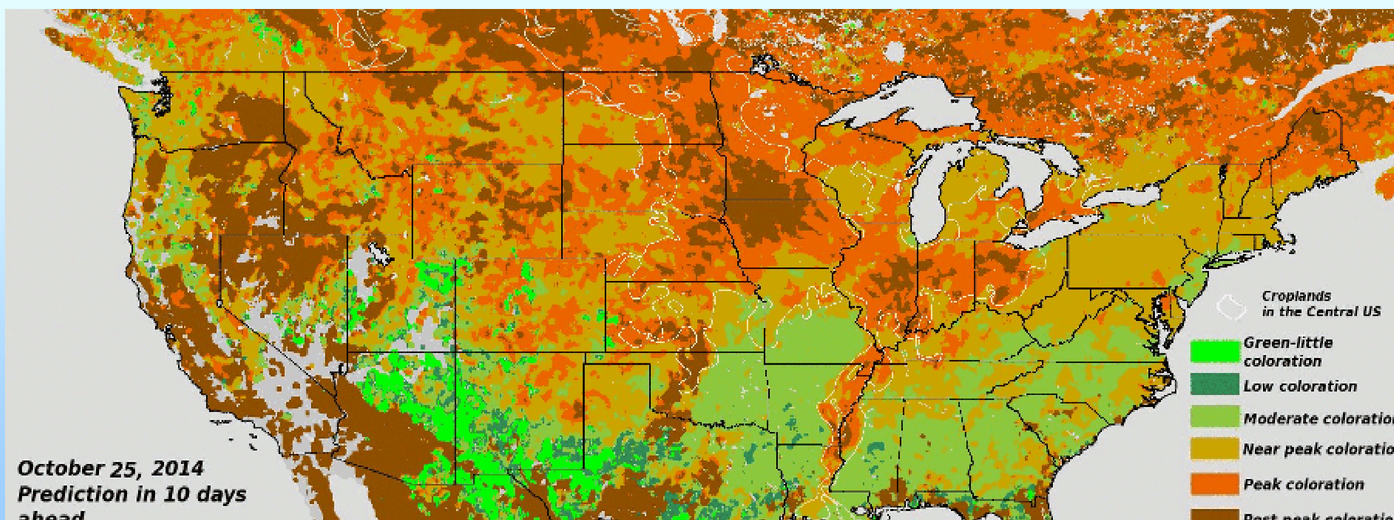


Standard variation of dormancy onset (2001-2012)

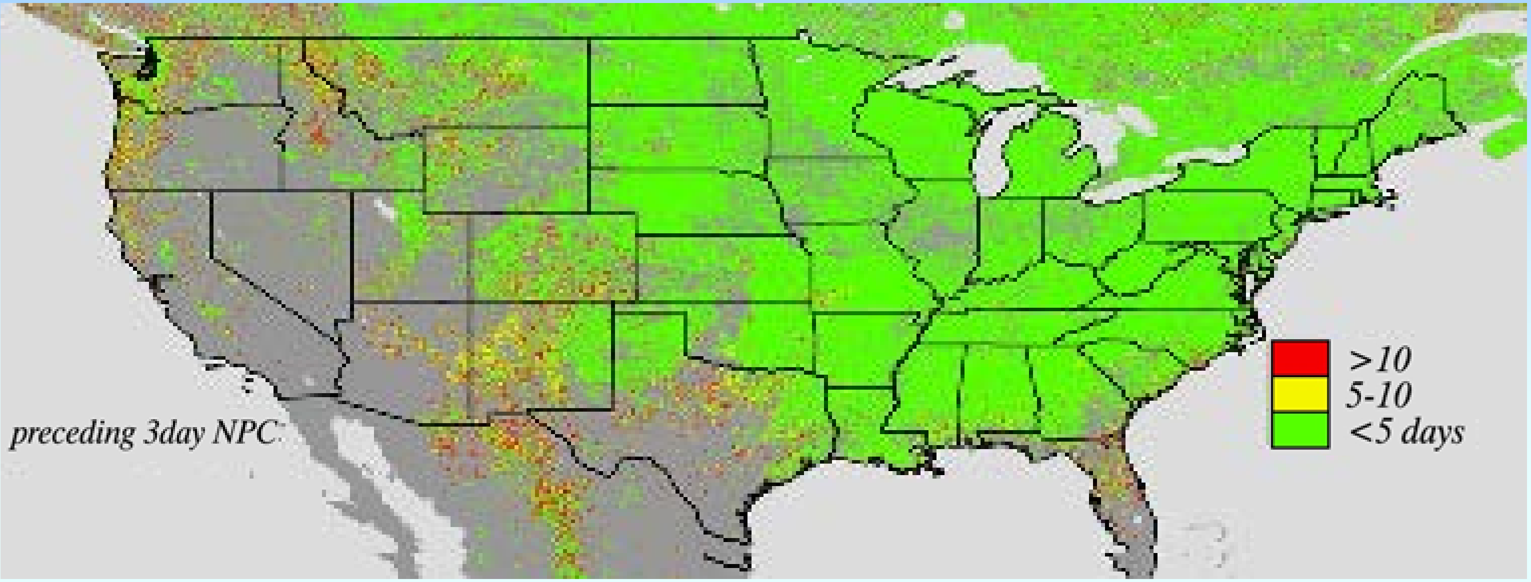


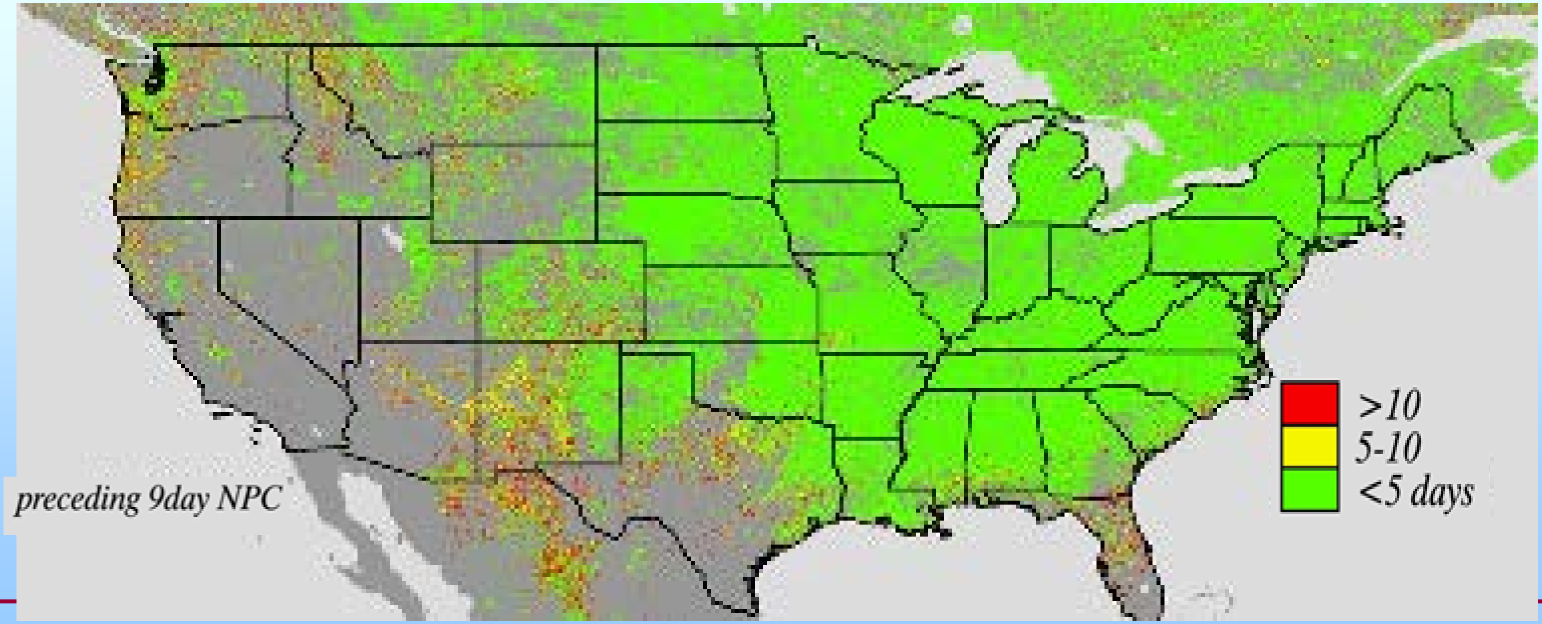
Real-time Monitoring and Short-term Forecasting of Fall Foliage from JPSS VIIRS



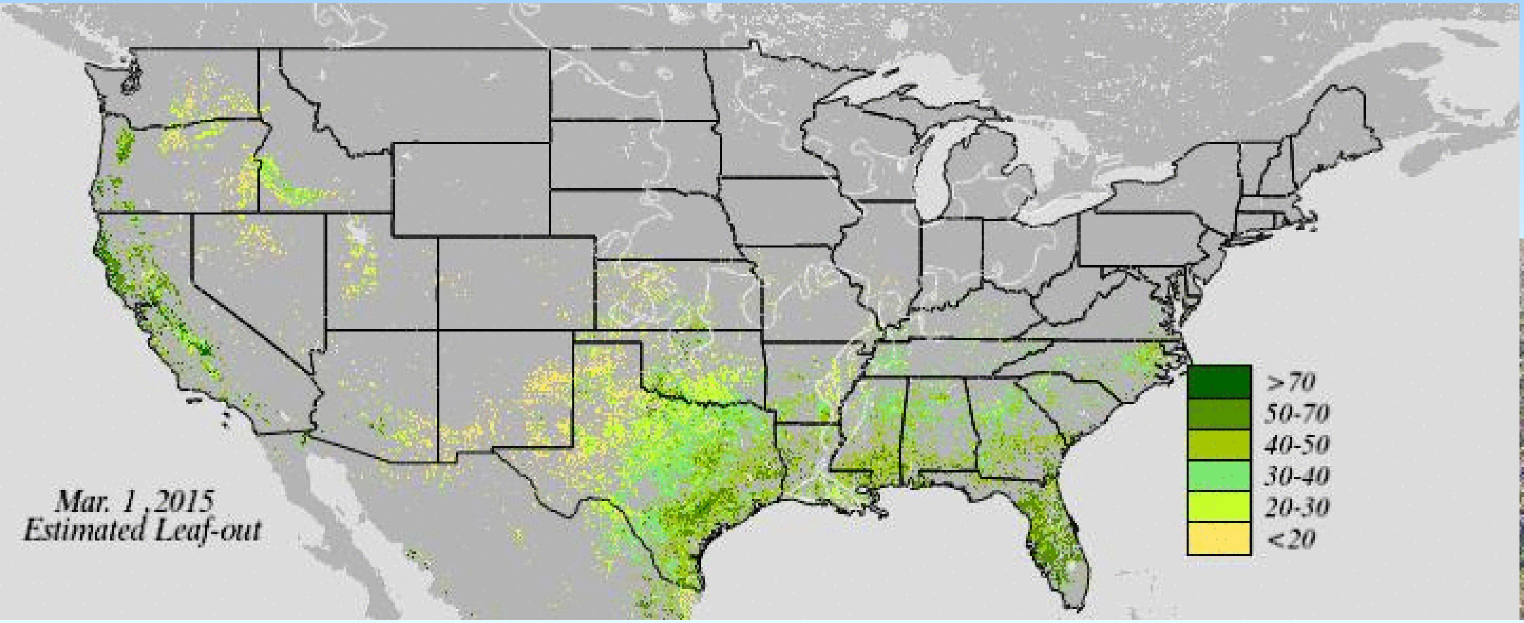


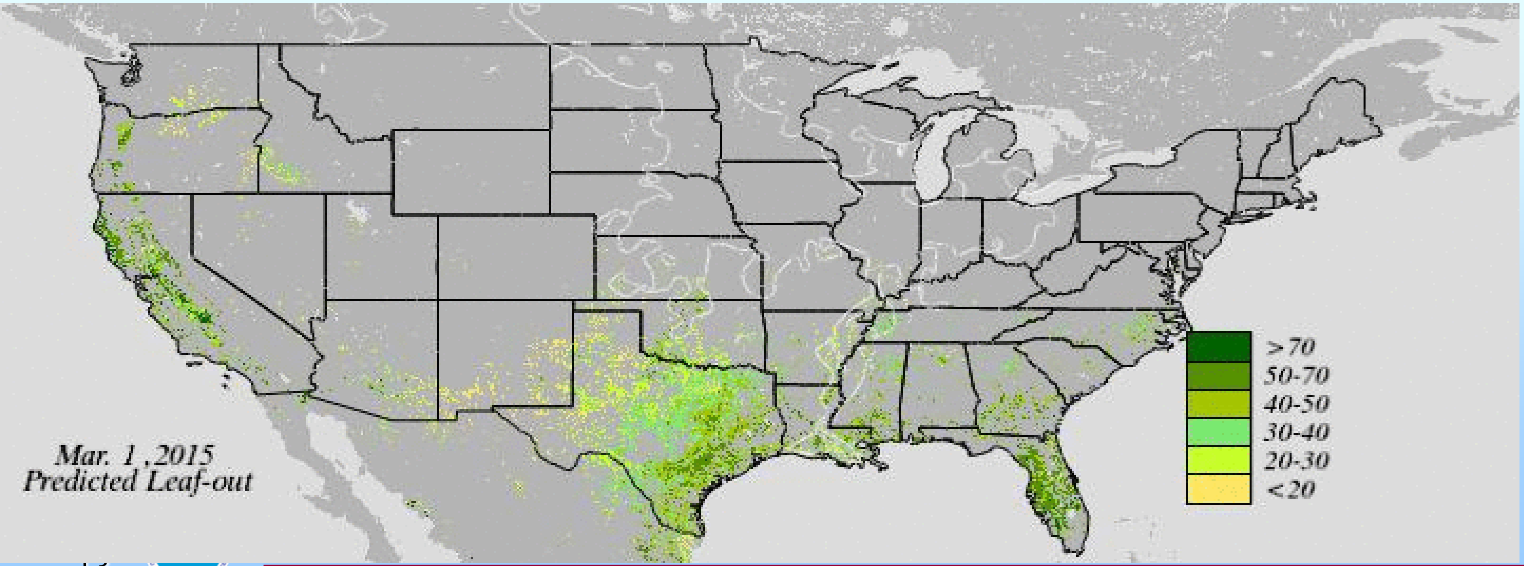
Uncertainty of Color Foliage Monitoring



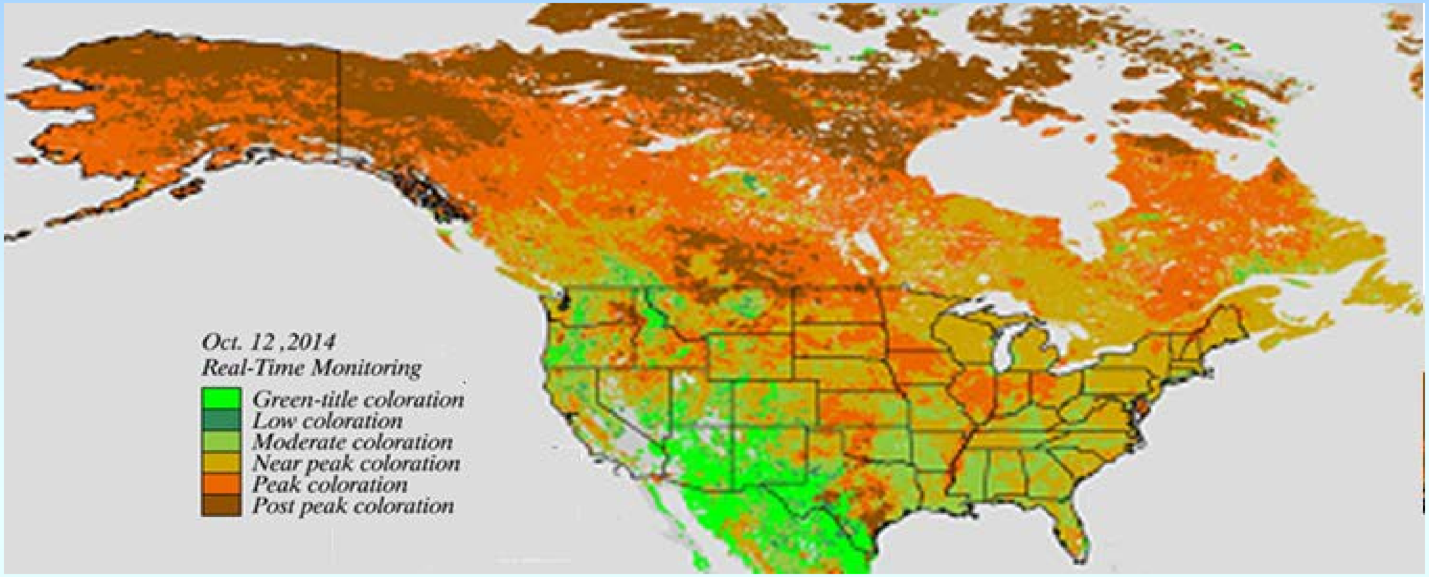


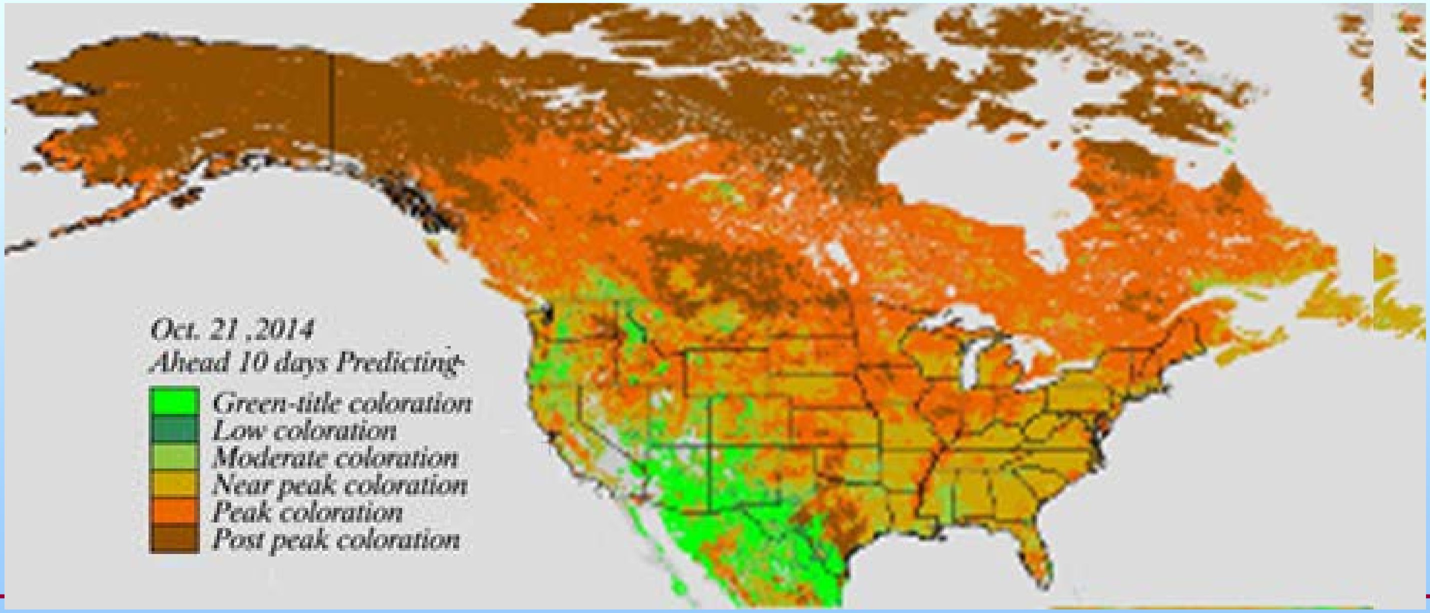
Monitoring and Forecasting of Spring Vegetation Progress





VIIRS Monitoring Across North America





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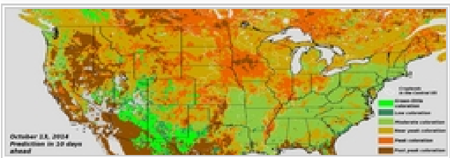
STAR developed new Foliage Phase Prediction system



Foliage Phase Prediction Derived from VIIRS NDVI

Image: NOAA

Two scientists of the Center for satellite Applications and Research (STAR), the scientific arm of the NOAA Satellite and Information Service (NESDIS), have elaborated a new method to observe and forecast short-term fall foliage coloration.

The latest STAR system was created with the support of the JPSS Proving Ground and Risk Reduction Program and it employs the VIIRS daily vegetation index to monitor foliage indicators across the United States with a time-pace of 3 days and to generate predictions of 10 days.

The STAR product represents the first instrument that can evaluate and forecast the fall foliage coloration phenomenon from a satellite data time series. The information will be useful for a wide variety of purposes, such as monitoring drought and crops germination, individuating hurricane destruction, forest pests, disease outbreaks, and species invasion.

Read full story: NOAA

Processed on Nov 6th 2014

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changes in visible light and in infrared. The forecast is updated every three days.

NOAA • NESDIS JPSS Joint Polar Satellite System

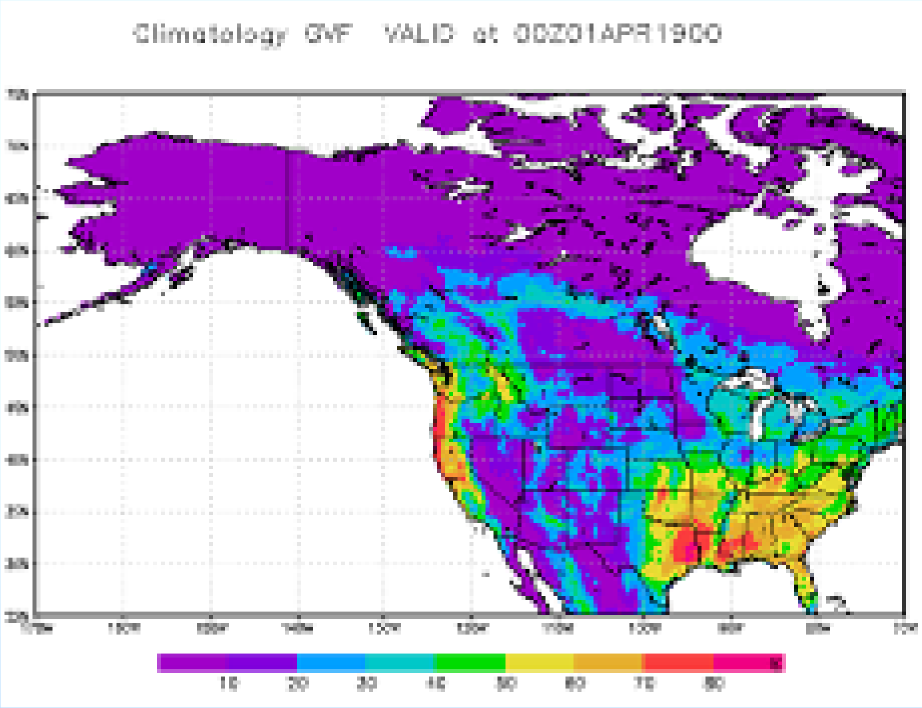
Fall Foliage Monitoring from NOAA National Weather Service Weather Forecast Office

VIIRS real time monitoring of fall foliage coloration can serve the prediction from weather data in NOAA National Weather Service.

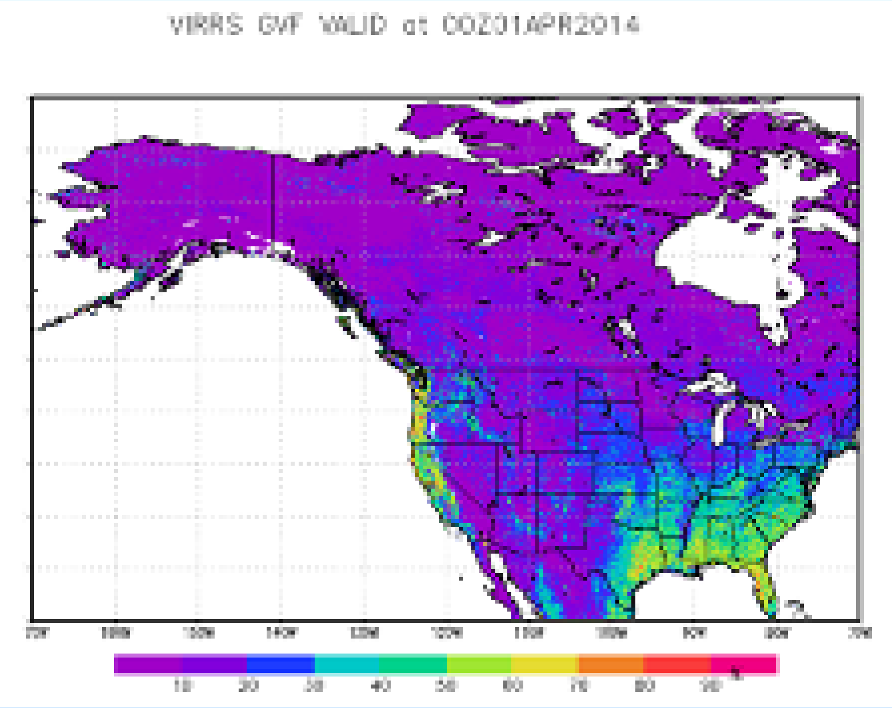
Real Time Phenology for Land Modeling (in NOAA EMC)

Metrics of phenology – the seasonal vegetation dynamics

- Estimate surface energy balance,
- Determine the partition of surface sensible and latent heat fluxes
- Predict boundary layer structures in the global and regional numerical weather prediction models

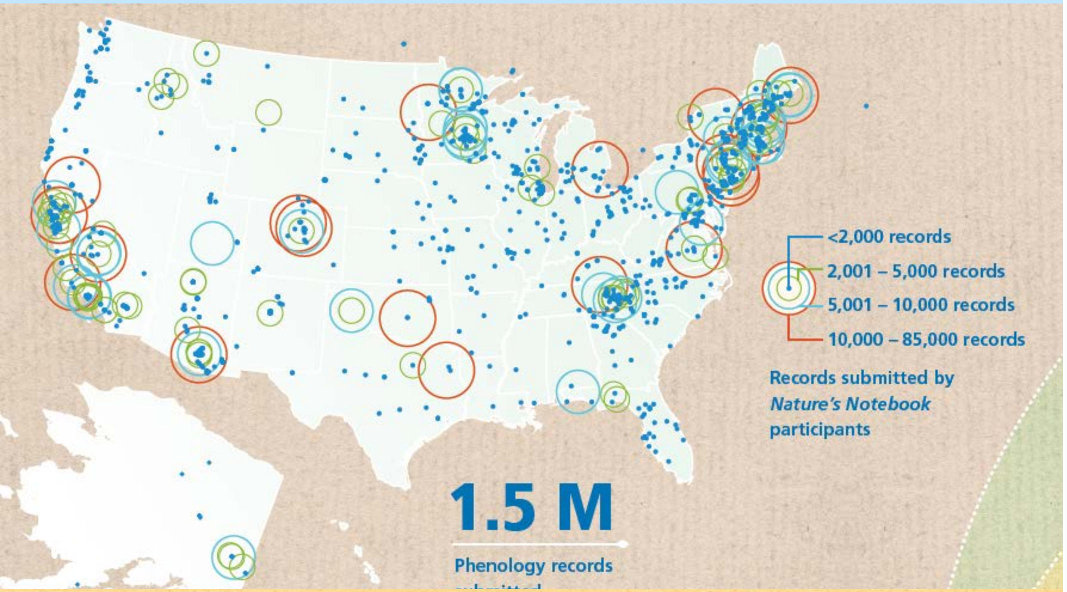


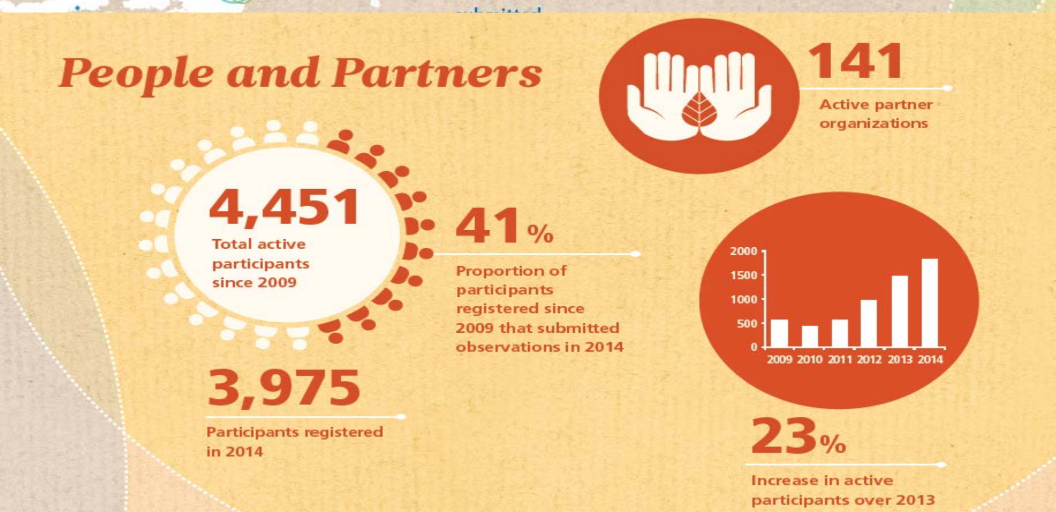
Climatology greenness currently used in Land Model in EMC



Real Time VIIRS data from phenological detection

Assistance in USA National Phenology Network





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Of Special Interest: Maples, Oaks, and Poplars

nature's notebook
A project of the USA-NPN

Track the "Green Wave" across the country as trees progress through seasonal changes

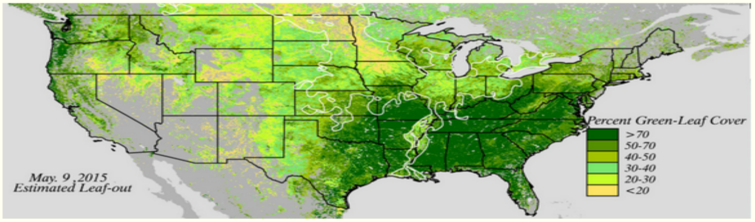
Oak leaves, © Ellen Denny

Spring has finally sprung! Across the country, trees are responding. Are the trees in your yard putting on their leaves?

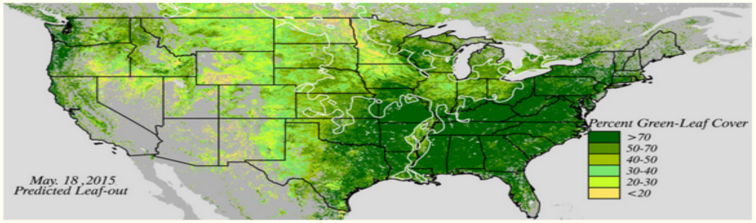
Since our last email, more of you have submitted observations for the **Great Plains North Green Wave Campaign** - thank you!

This spring, we have a new way for you to know when to expect leaves on your maples, oaks and poplars. A team of scientists including Drs Xiaoyang Zhang and Lingling Liu (South Dakota State University) and Dr Yunyue Yu (NOAA/NESDIS/STAR/SMCD/EMB) have created predictions of green-up across the country, based on historical and current satellite information and temperature. Click the links below to see a larger version of these maps.

Does the **Estimated Leaf-out map** match what you see on your trees?



If you are not yet seeing leaf-out on your trees, the **Predicted Leaf-out map** will show you if you can expect to see leaves on your trees in the next week. Don't forget to log your observations in *Nature's Notebook* to help verify whether these models are correct!



***Thank you** for helping out on this important project!*
Through this effort, you are contributing directly to scientific discovery and your participation is truly appreciated.

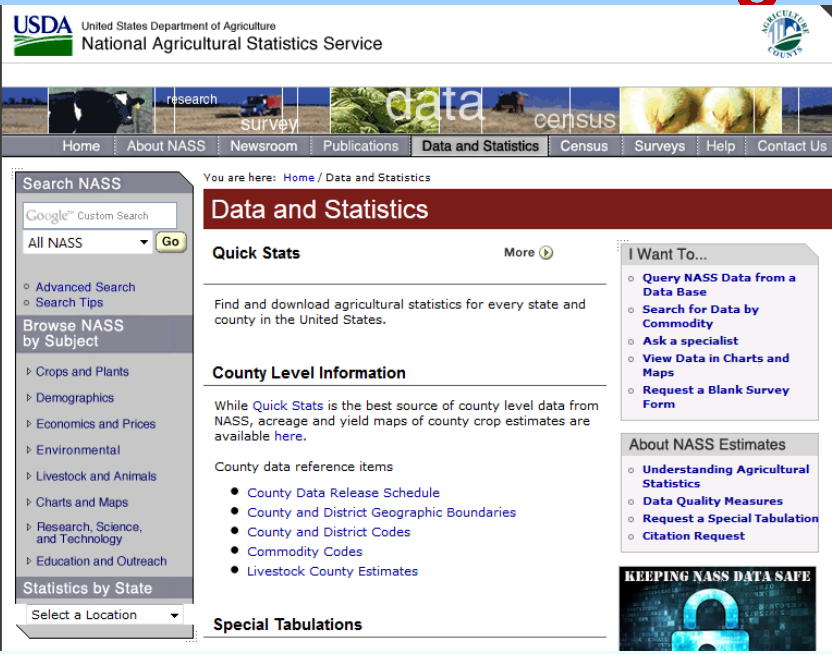
Forward to a Friend

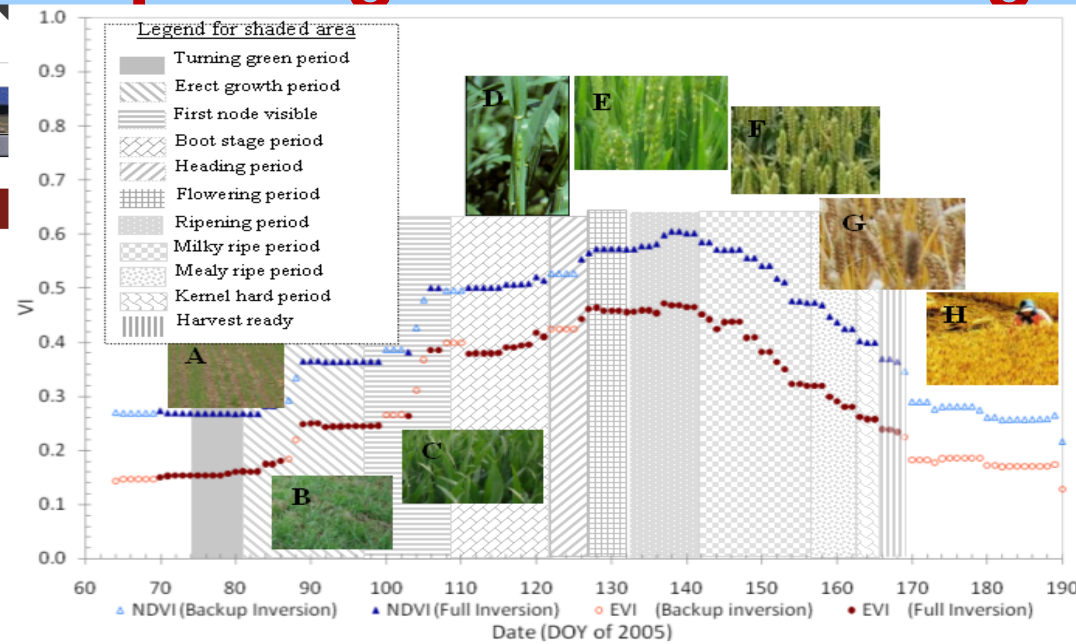
Erin Posthumus
Outreach Associate
erin@usanpn.org / p 520.622.0363
bio

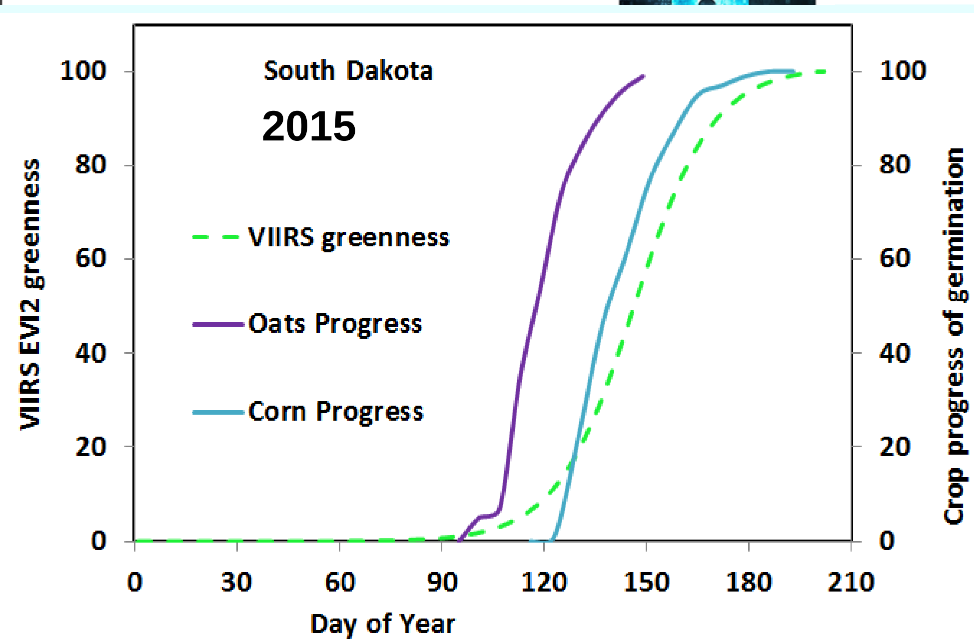
USA npn National Phenology Network

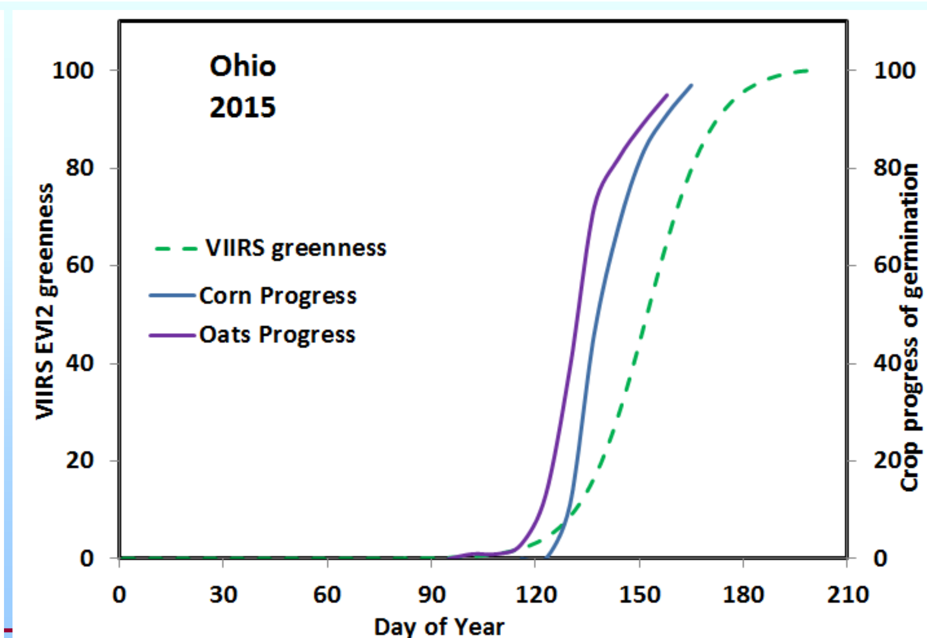
Forward email

Serving Crop Progress Monitoring



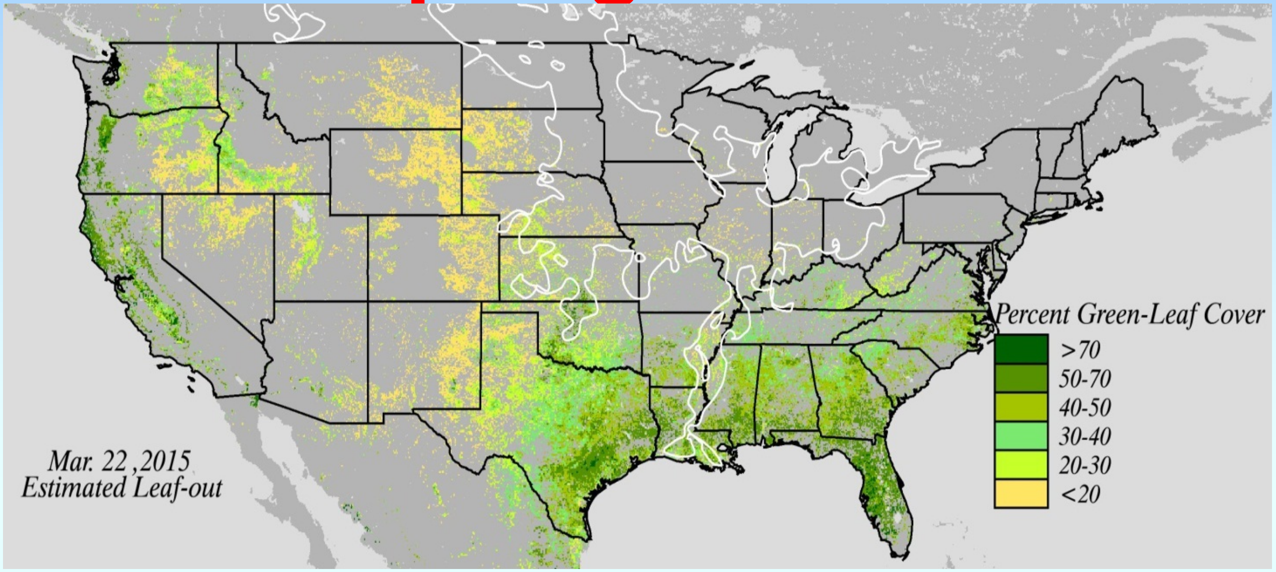




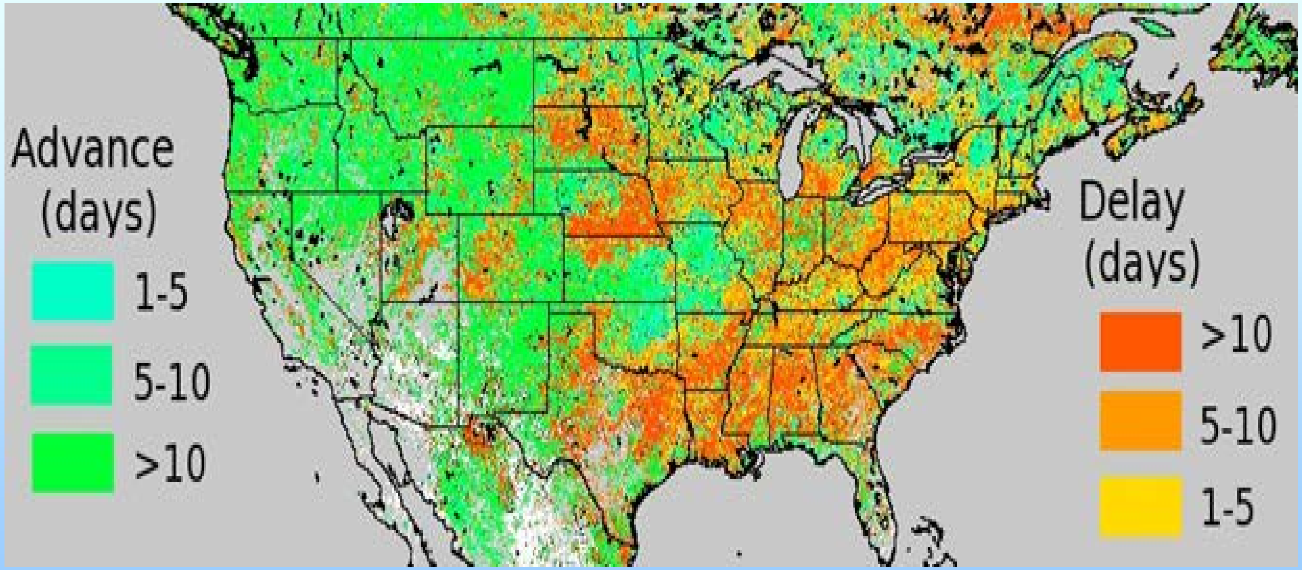


Climate Indicator – Spring 2015

Real time monitoring shows a earlier spring in the western region than eastern area in 2015



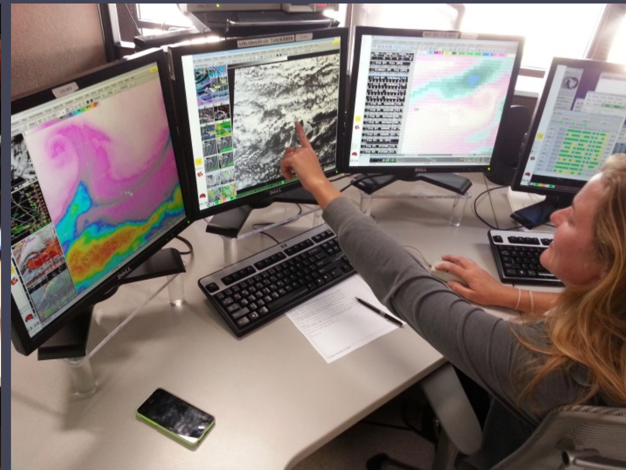
Comparison of the spring event in 2015 with climatology (2000-2011) shows the spring was advanced in western region while it was delayed in eastern area.



Summary and Issues

1. Near real time VIIRS observations make it possible to reconstruct the potential trajectories of daily vegetation dynamics timely.
2. The preliminary results indicate VIIRS real-time monitoring of phenology has wide applications.

3. This project has been very successful with the support from JPSS Risk Reduction during the past two years.
4. How to continue this effort is a major issue because the funding support will end before next summer.


Nowcasting Applications

Jordan Gerth

University of Wisconsin

STAR JPSS Science Team Meeting

25 August 2015

Challenges

- What NPP and JPSS spectral bands and science products have a direct application to operational responsibilities of NWS meteorologists?
- How do we deliver polar satellite information so that it is timely enough for nowcasting?
- How do we present that information in the field?

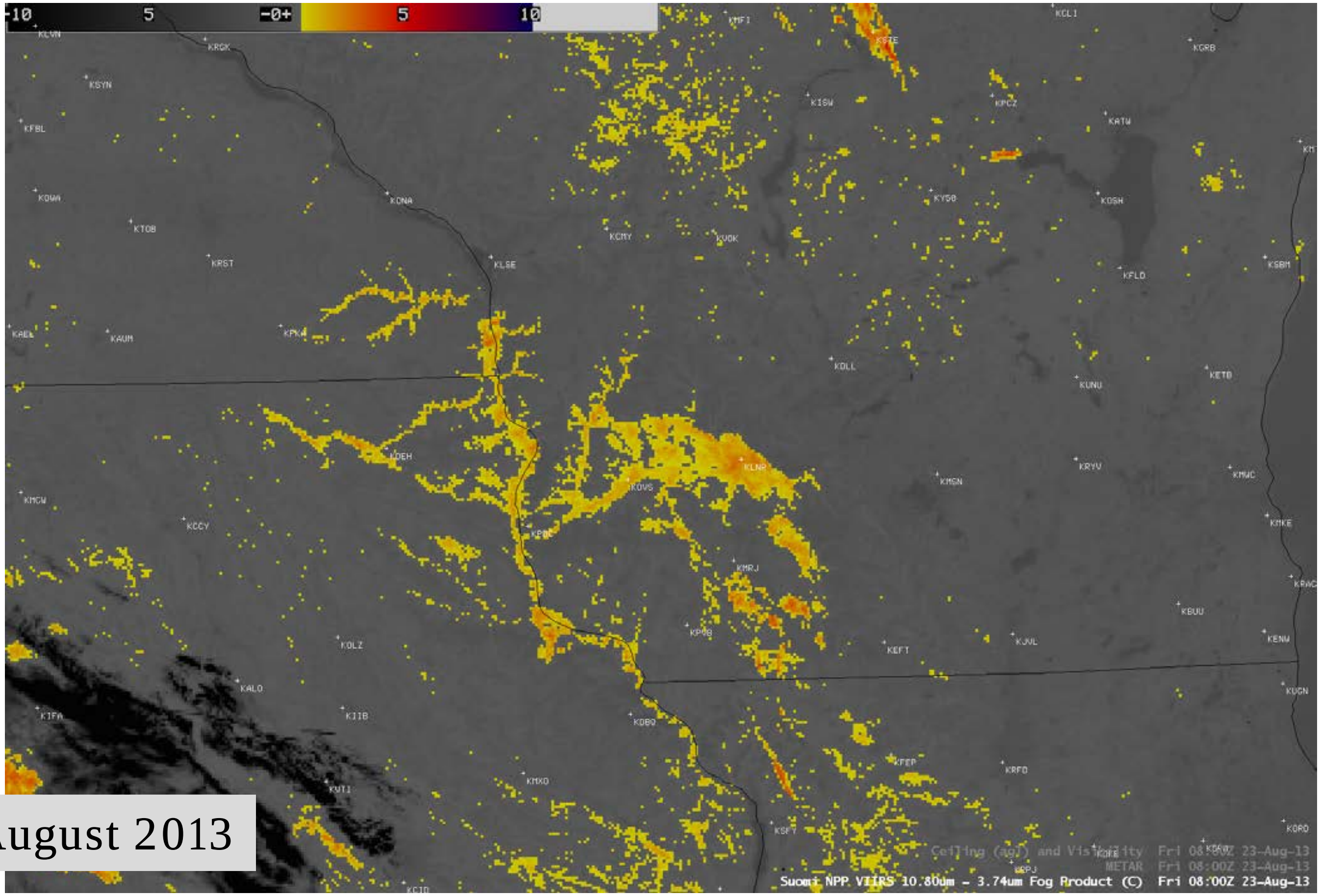
NPP and JPSS

- What instruments/capabilities of NPP and JPSS provide added value over geostationary satellites for nowcasting applications?
  - VIIRS Day/Night Band
  - Higher spatial resolution for imaging (VIIRS), especially in polar regions
  - Microwave products (ATMS)
  - Additional spectral information (CrIS) for characterizing clear scenes

Deliver and Display

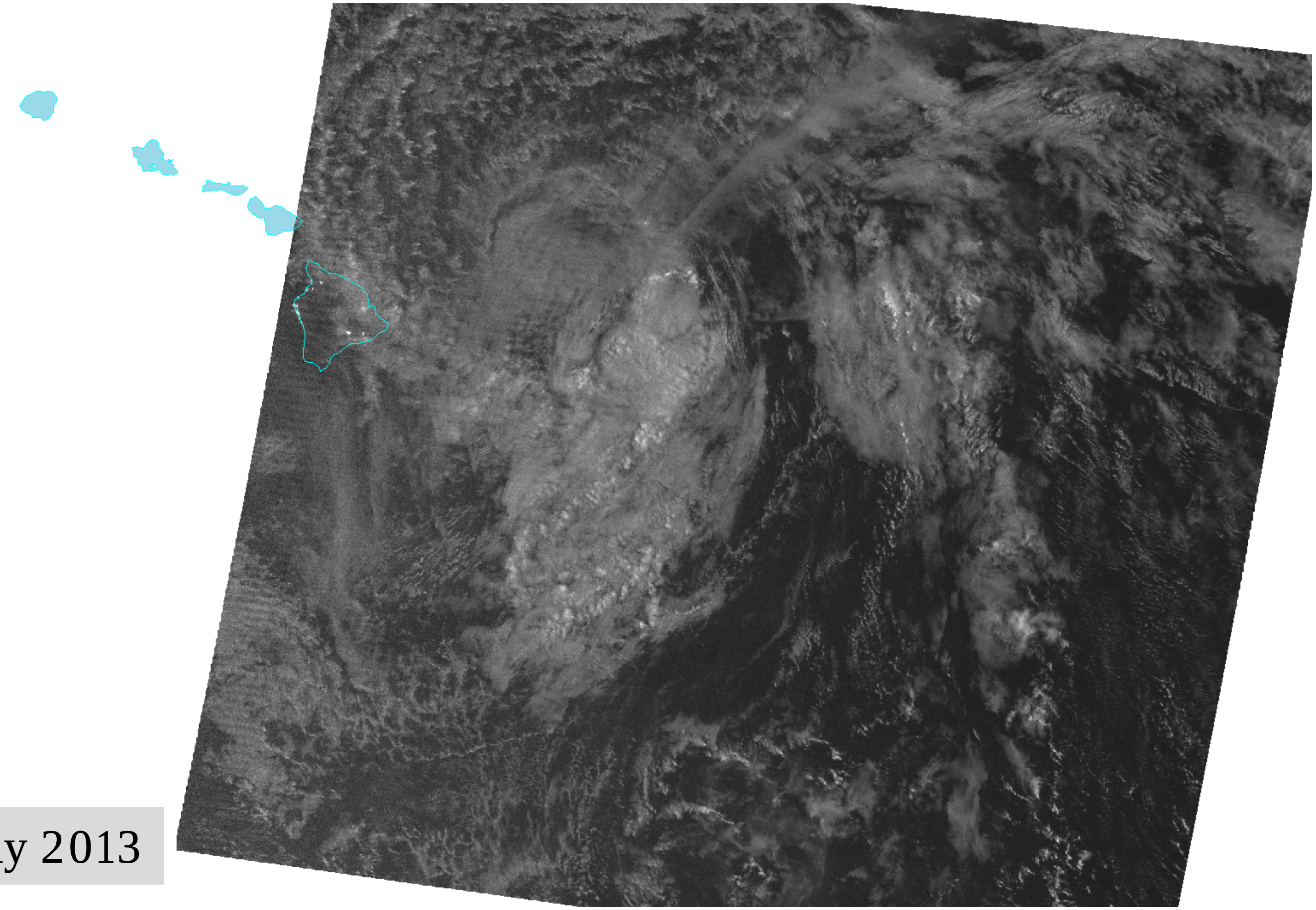
- Timely delivery is facilitated by:
  - A network of L/X-band antennas across the United States to capture and produce imagery and products with the Community Satellite Processing Package (CSPP)
  - Improved bandwidth, especially in OCONUS, to reach NWS forecast offices
- Imagery and science products arriving at NWS offices are displayable within the Advanced Weather Interactive Processing System (AWIPS)

The Early Days: Valley Fog



23 August 2013

The Early Days: Flossie



29 July 2013

The Early Days: Flossie

TROPICAL STORM FLOSSIE DISCUSSION NUMBER 19

NWS CENTRAL PACIFIC HURRICANE CENTER HONOLULU HI EP062013

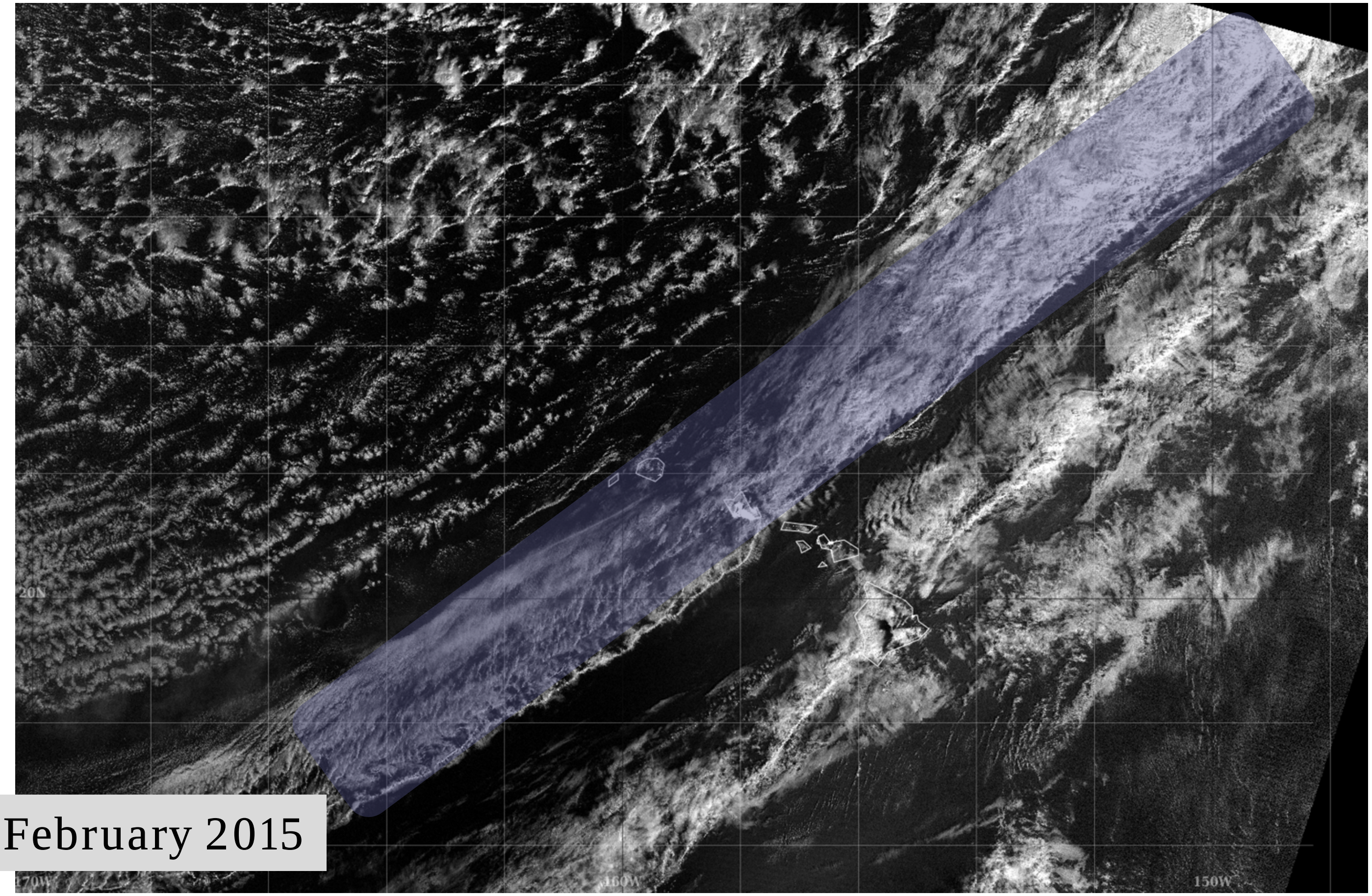
500 AM HST MON JUL 29 2013

THE CENTER OF FLOSSIE WAS HIDDEN BY HIGH CLOUDS MOST OF THE NIGHT BEFORE VIRS NIGHTTIME VISUAL SATELLITE IMAGERY REVEALED AN EXPOSED LOW LEVEL CIRCULATION CENTER FARTHER NORTH THAN EXPECTED. WE RE-BESTED THE 0600 UTC POSITION BASED ON THE VISIBLE DATA. SUBJECTIVE DVORAK ANALYSES CONTINUED SHOW CURRENT INTENSITIES OF 3.0 BUT SATELLITE LOOPS SUGGEST A RAPID WEAKENING TREND WITH THE LOW LEVEL CENTER PULLING AWAY FROM A SMALL AREA OF CONVECTION SOUTHEAST OF THE CENTER. IT IS LIKELY THAT CONTINUED NORTHWEST SHEAR WILL MAINTAIN THIS WEAKENING TREND.

THE TRACK HAS BEEN SHIFTED NORTH TO REFLECT THE RE-LOCATED CENTER. THE TRACK GUIDANCE SHIFTED FOLLOWING THE TRACK CHANGE AND WAS CONSISTENT WITH A NEW TRACK FARTHER TO THE NORTH.

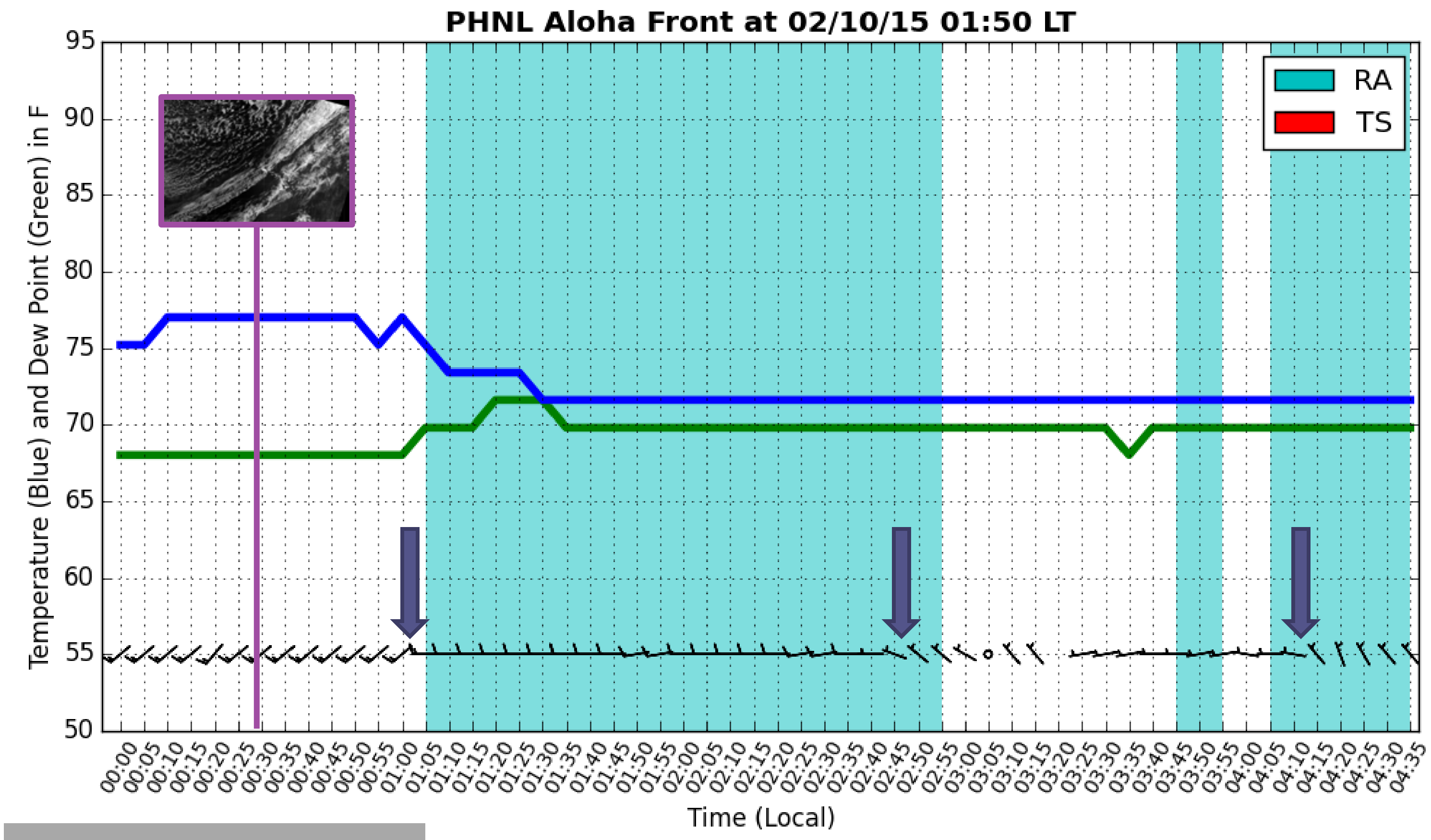
. . .

Recent Application: Fronts



10 February 2015

Frontal Passages in Hawaii



NWS Collaborator: Eric Lau

New Activities

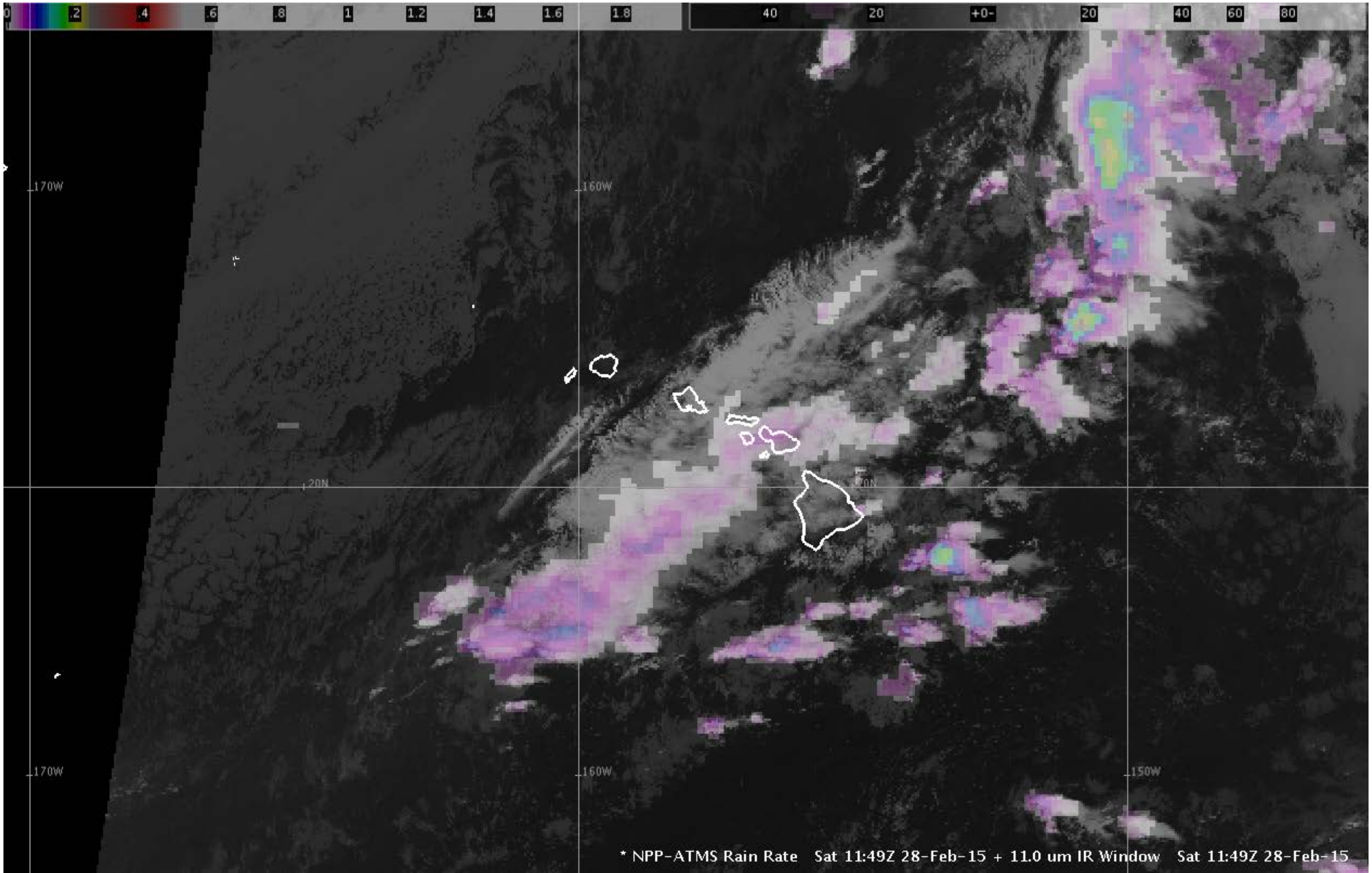
- Products for coastal forecasting applications
  - ASCPO Sea Surface Temperature
  - MIRS 90 GHz and Rain Rate

- Full-resolution VIIRS imagery in AWIPS II

- Enhancing AWIPS II and providing corrected reflectances for select VIIRS bands to support RGB multi-spectral applications

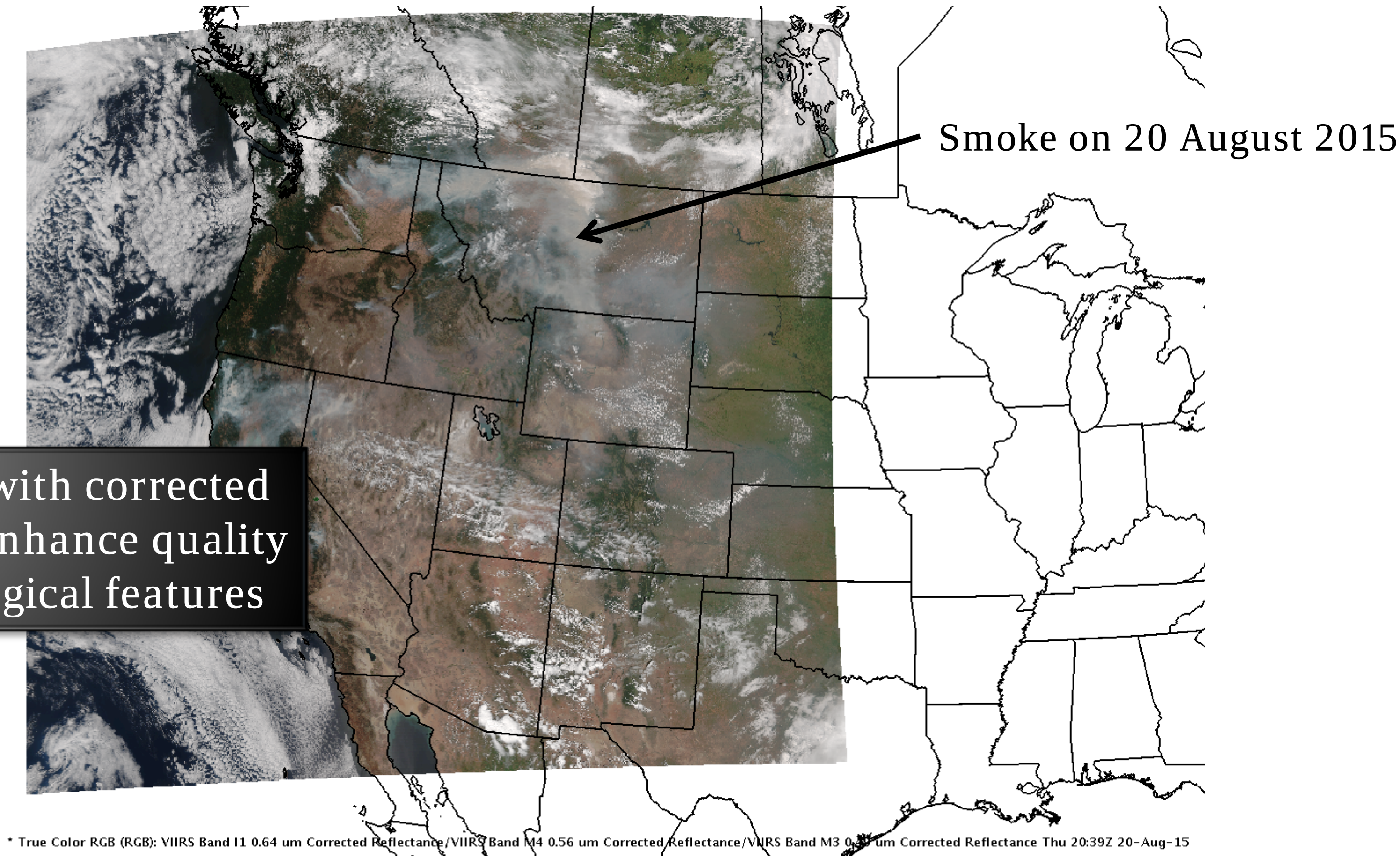
28 February 2015 11:49 UTC

Example of NPP-ATMS Rain Rate and 11.0 μm IR Window in AWIPS II



VIIRS True Color RGB in AWIPS II

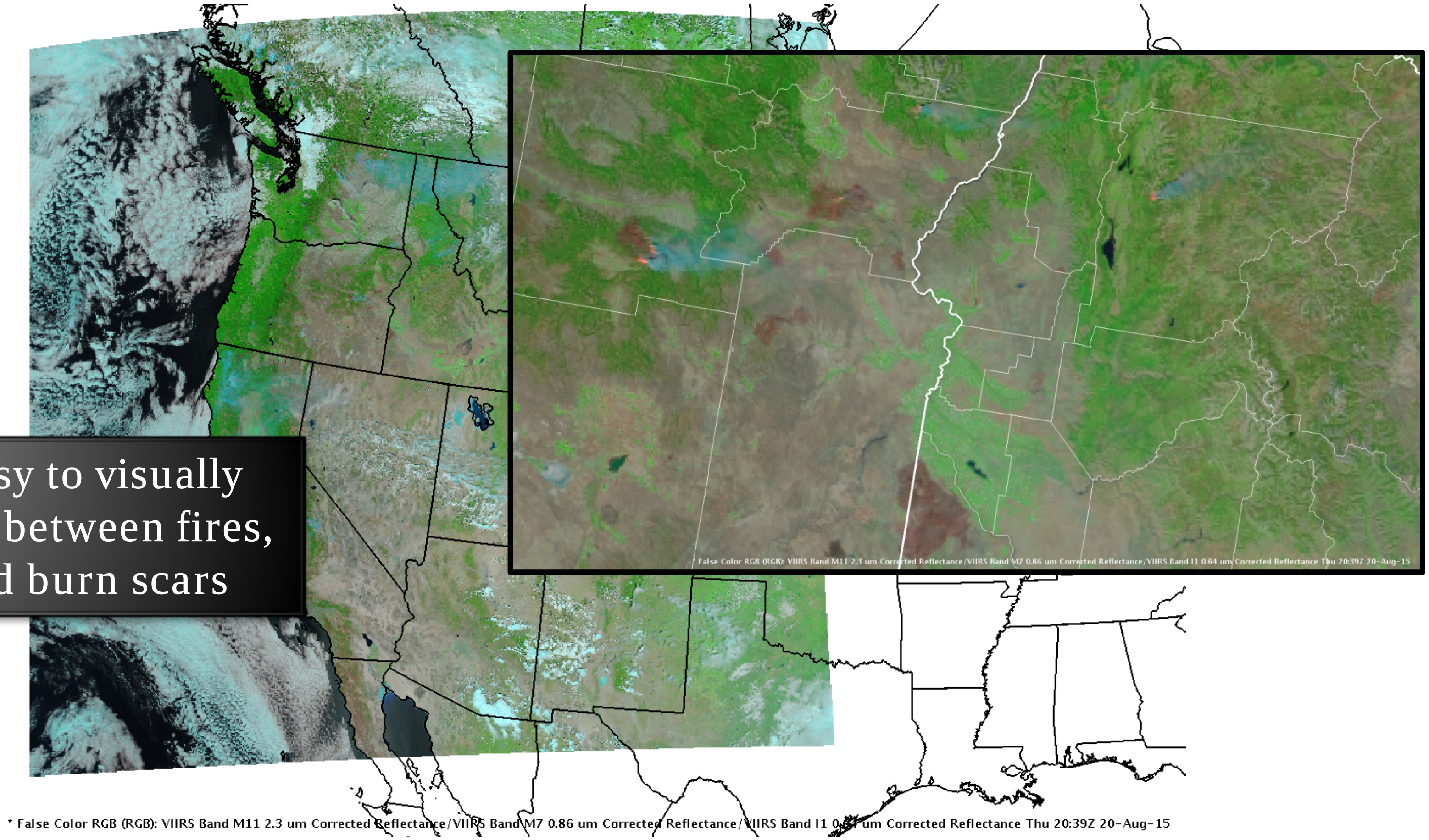
(Full Bit Depth)



Composites with corrected reflectances enhance quality of meteorological features

VIIRS False Color RGB in AWIPS II

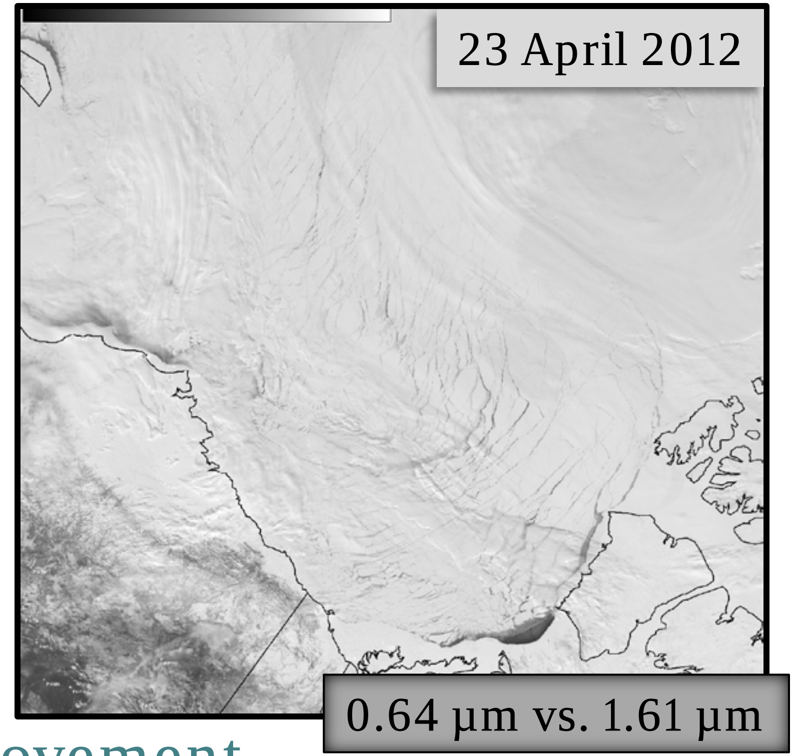
(Full Bit Depth)



Benefit: Easy to visually discriminate between fires, smoke, and burn scars

Other Applications

- Phenomena-based products:
  - Aerosols
  - Active fires
  - Land surface properties
  - River ice and flooding
  - Sea ice characterization and movement
  - Snow and ice cover
  - Volcanic ash detection
- Comparing to short-term numerical weather prediction forecasts
- Feature discrimination



Source: CIMSS Satellite Blog

The Future

- What can we assimilate into models, integrate into products, and combine with other observations while maintaining the integrity of the disparate sources?

- How do we further improve the implementation of satellite imagery and products in our weather visualization tools (e.g., AWIPS II)?

Thank You

- If you are interested in learning more about how NWS conducts operations in the OCONUS and have a science product with an application to demonstrate, consider the NWS Pacific Region Visiting Scientist Program.

- Questions? Comments?
  - Jordan.Gerth@noaa.gov

Nighttime VIIRS products: Fires, Flares, Lights, and Boats

Christopher D. Elvidge, Ph.D.
Earth Observation Group
NOAA National Geophysical Data Center
Boulder, Colorado USA
chris.elvidge@noaa.gov

Kimberly Baugh, Feng-Chi Hsu, Mikhail Zhizhin, Tilottama Ghosh
Cooperative Institute for Research in the Environmental Sciences
University of Colorado

August 25, 2015

Lights At Night!

Boats

Cities and human settlements

Industrial Sites

Gas Flares

Fires

UN Initiative to end routine flaring by 2030

THE WORLD BANK | Working for a World Free of Poverty
IBRD • IDA

ABOUT DATA RESEARCH LEARNING NEWS PROJECTS & OPERATIONS PUBLI

Zero Routine Flaring by 2030

TWEET LIKE SHARE +

FEATURED 2 / 2

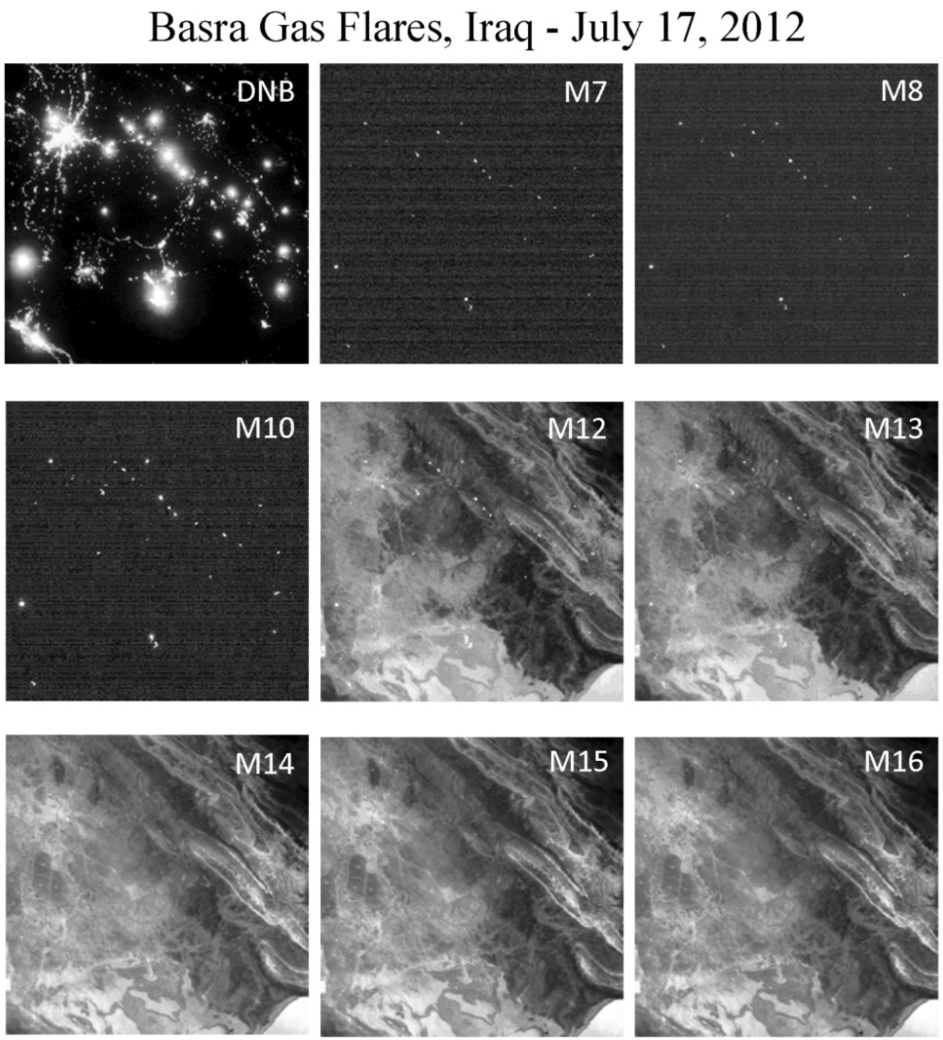
The Zero Routine Flaring Initiative

May 22, 2015 — The initiative was launched by UNSG Ban Ki-moon and WBG President Jim Yong Kim with governments, oil
Read More »

Initiative | Q&A | Quick Facts | Endorsers | Get Involved | Related Information | Flaring in the News

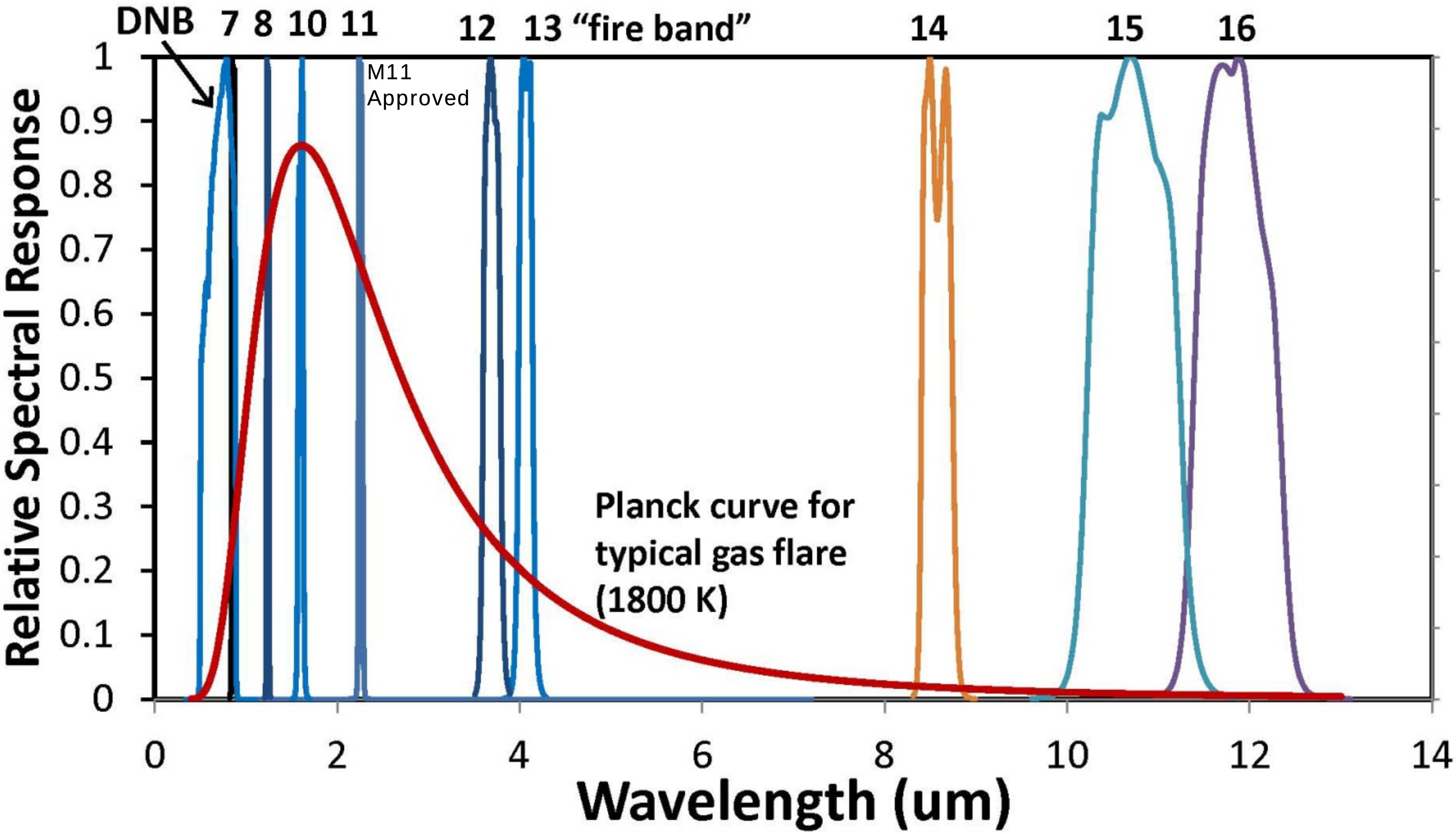
During oil production, associated gas is produced from the reservoir together with the oil.

How will progress be tracked? VIIRS!



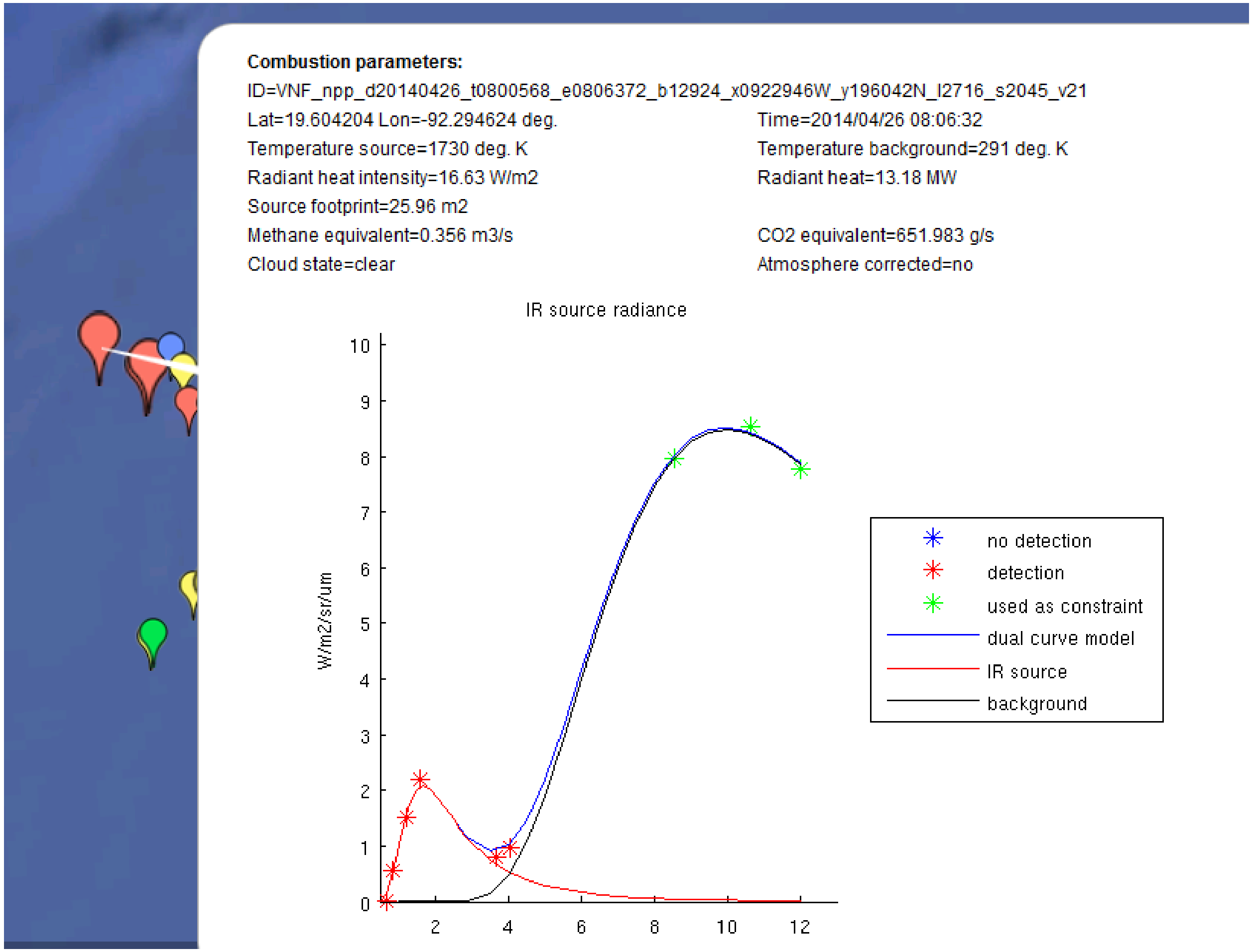
Gas flares are readily detected in the VIIRS M10 spectral band

VIIRS Nightfire (VNF): A global multispectral fire product
Nine channels of data are collected at night



Nighttime collection of channel 11 is expected to start in 2015

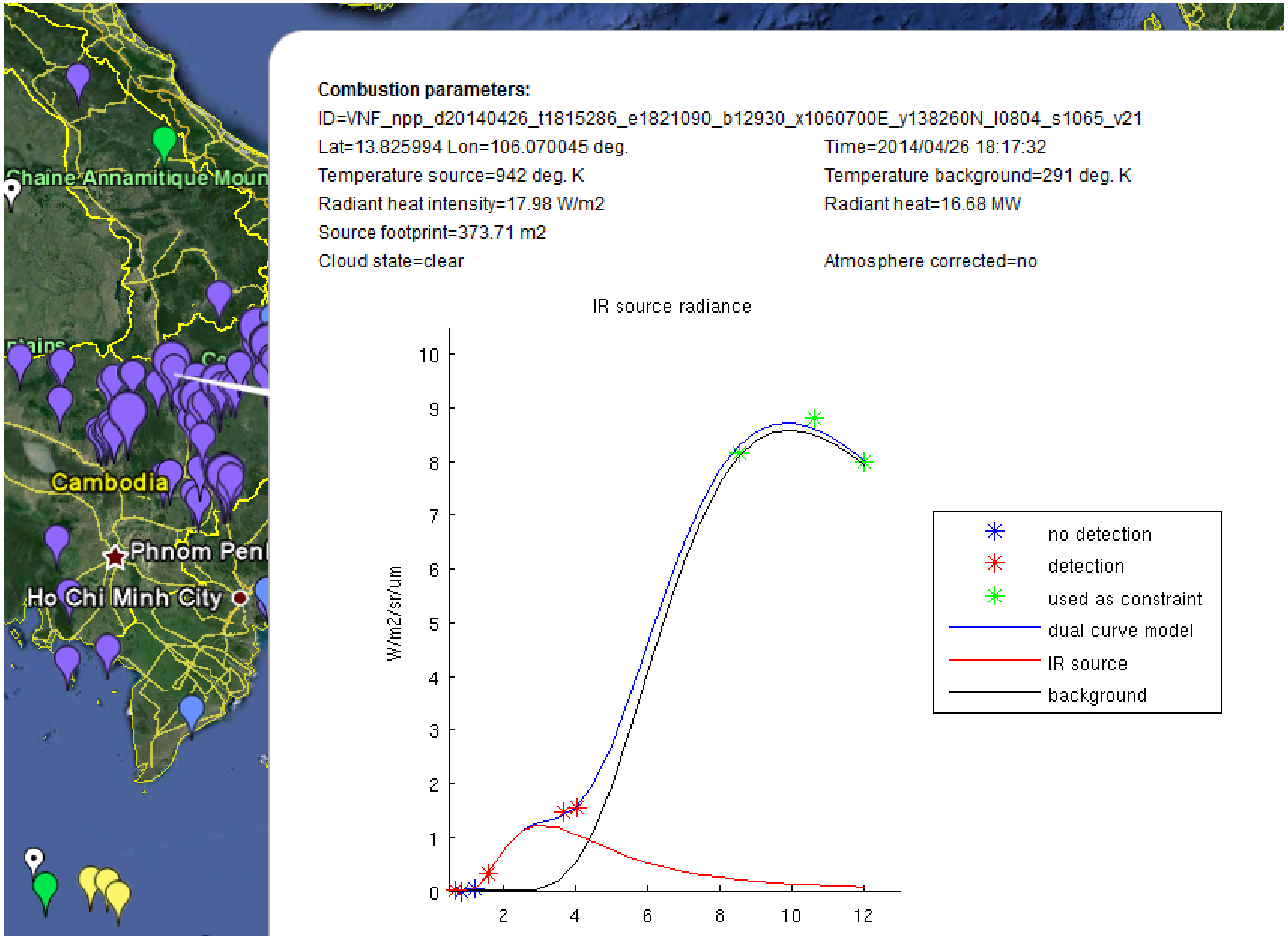
Why Multispectral?



To get at the Planck curves!

Daily files are in csv and kmz formats

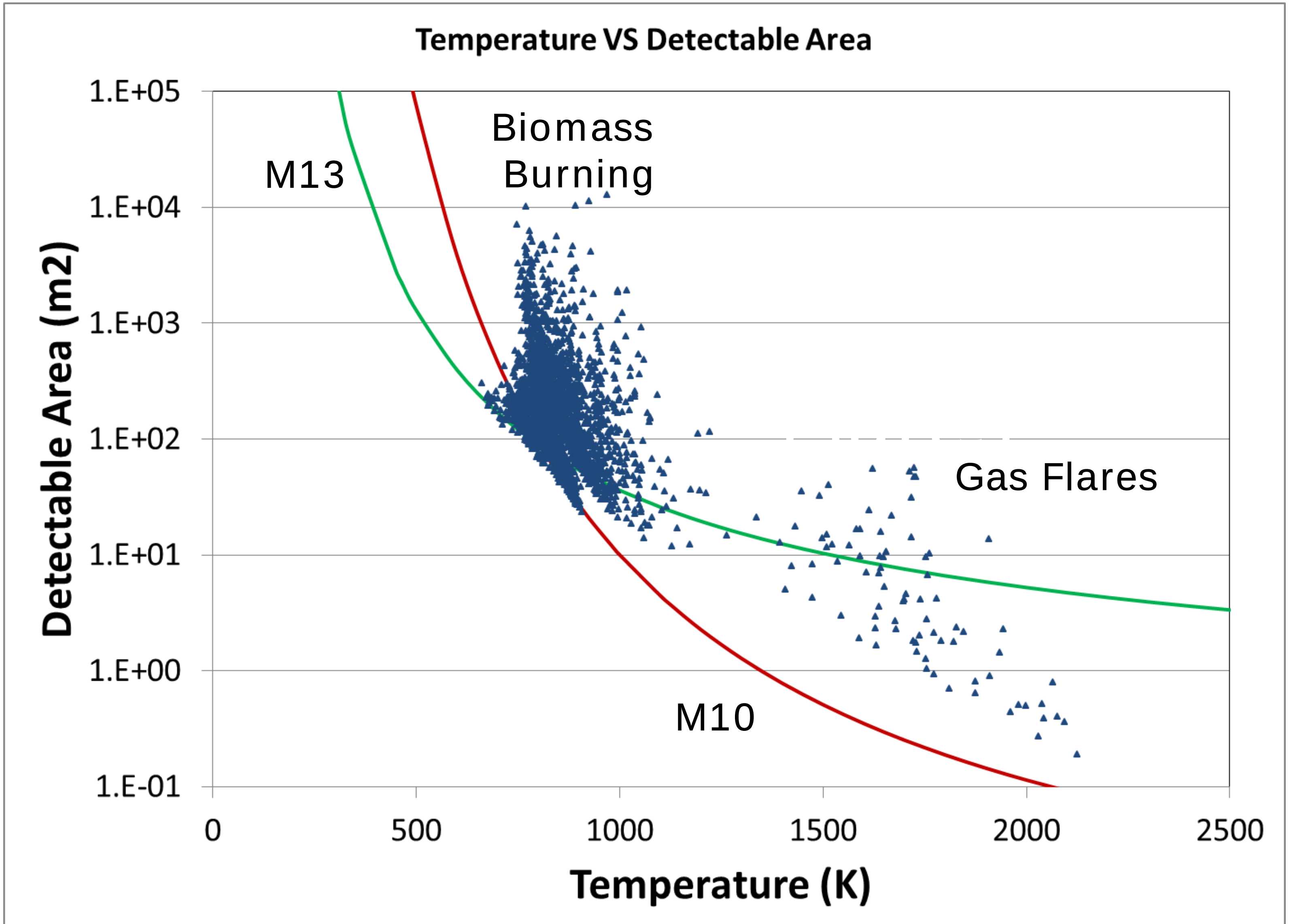
Typical Biomass Burning Detection



Lower temperature than gas flaring. Often these have larger source size than gas flares.

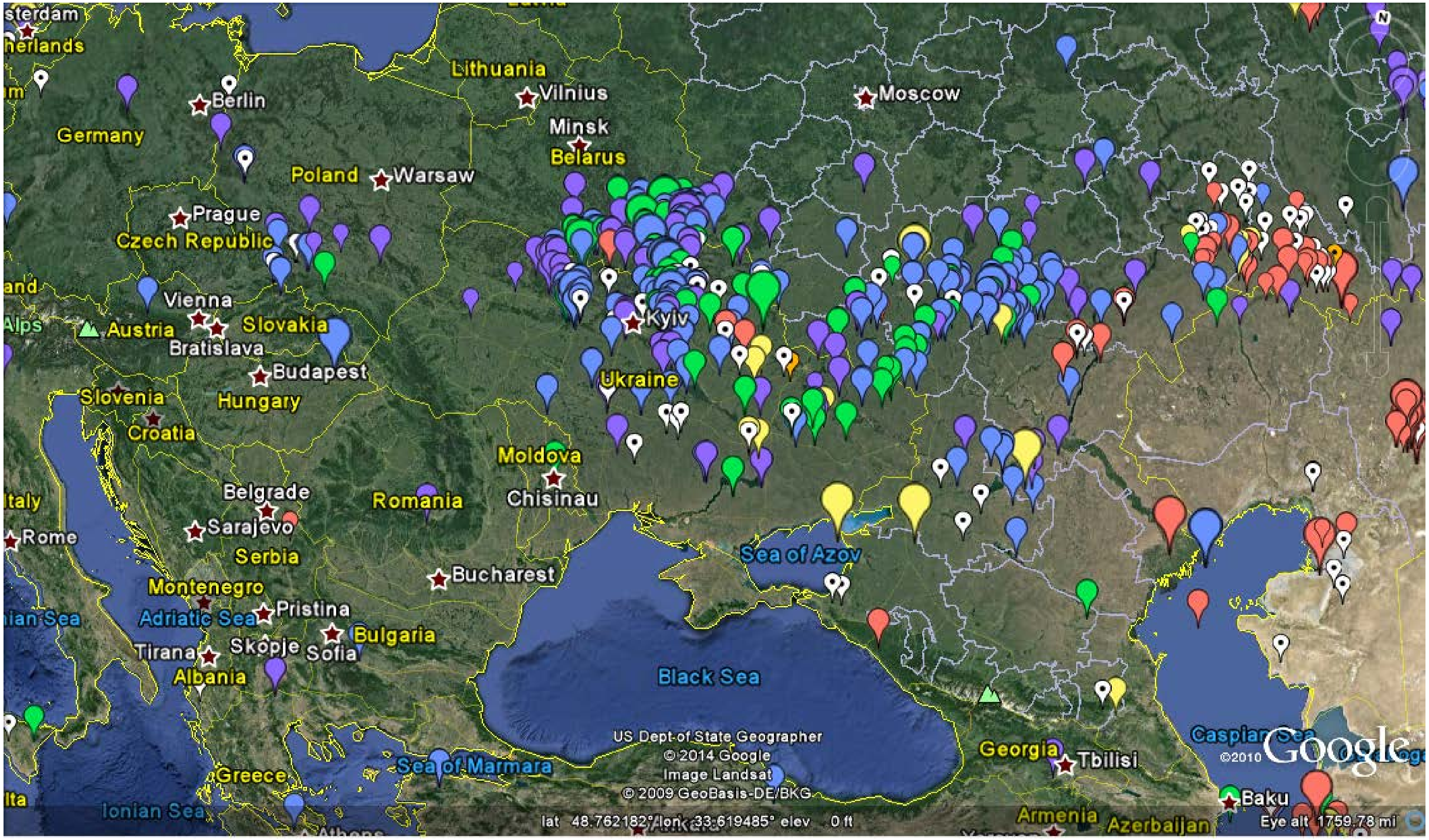
Detection Limits

At 1800 K flares as small as 0.25 m² are detectable



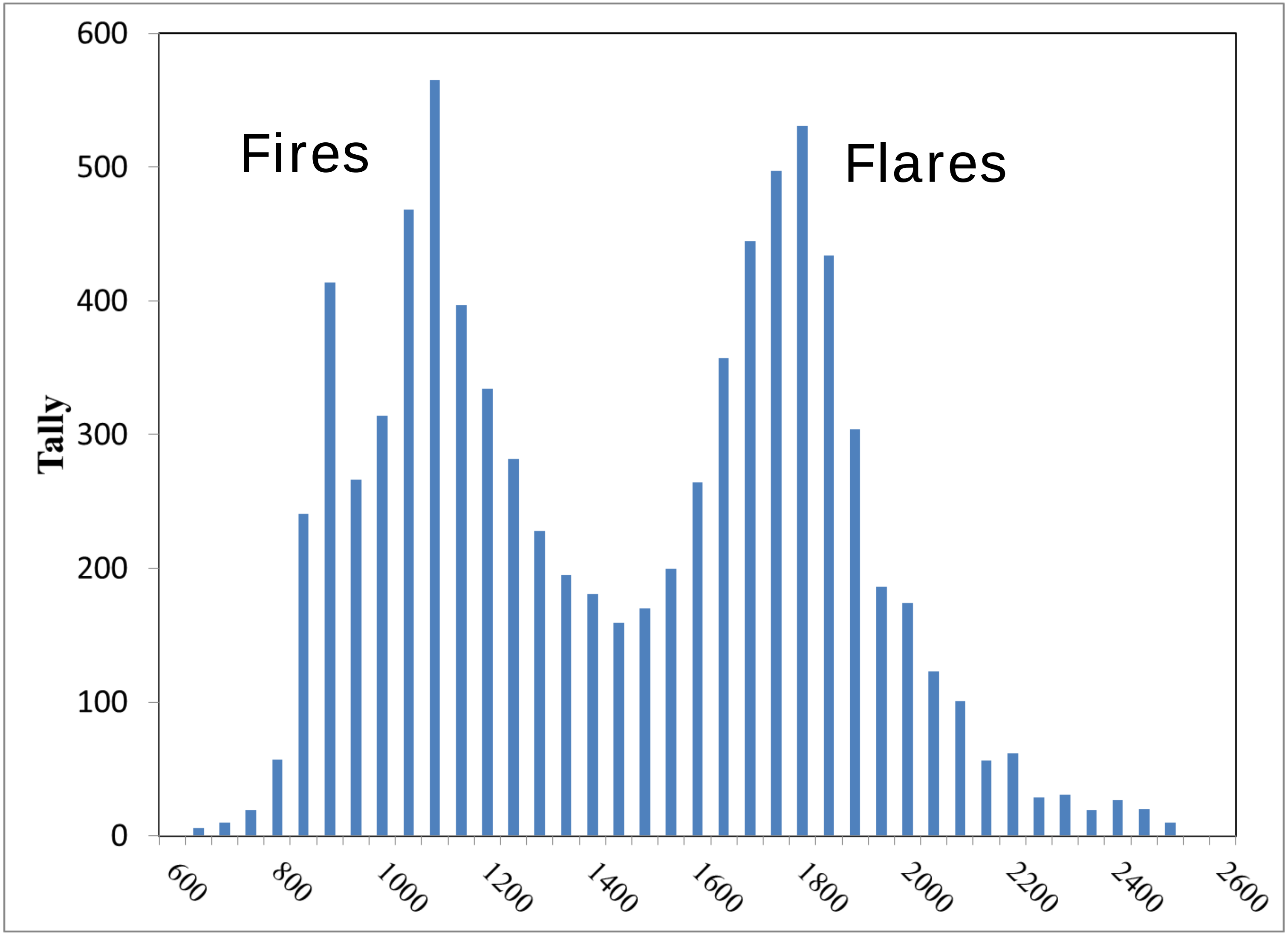
Daily VNF data are available at:

http://ngdc.noaa.gov/eog/viirs/download_viirs_fire.html

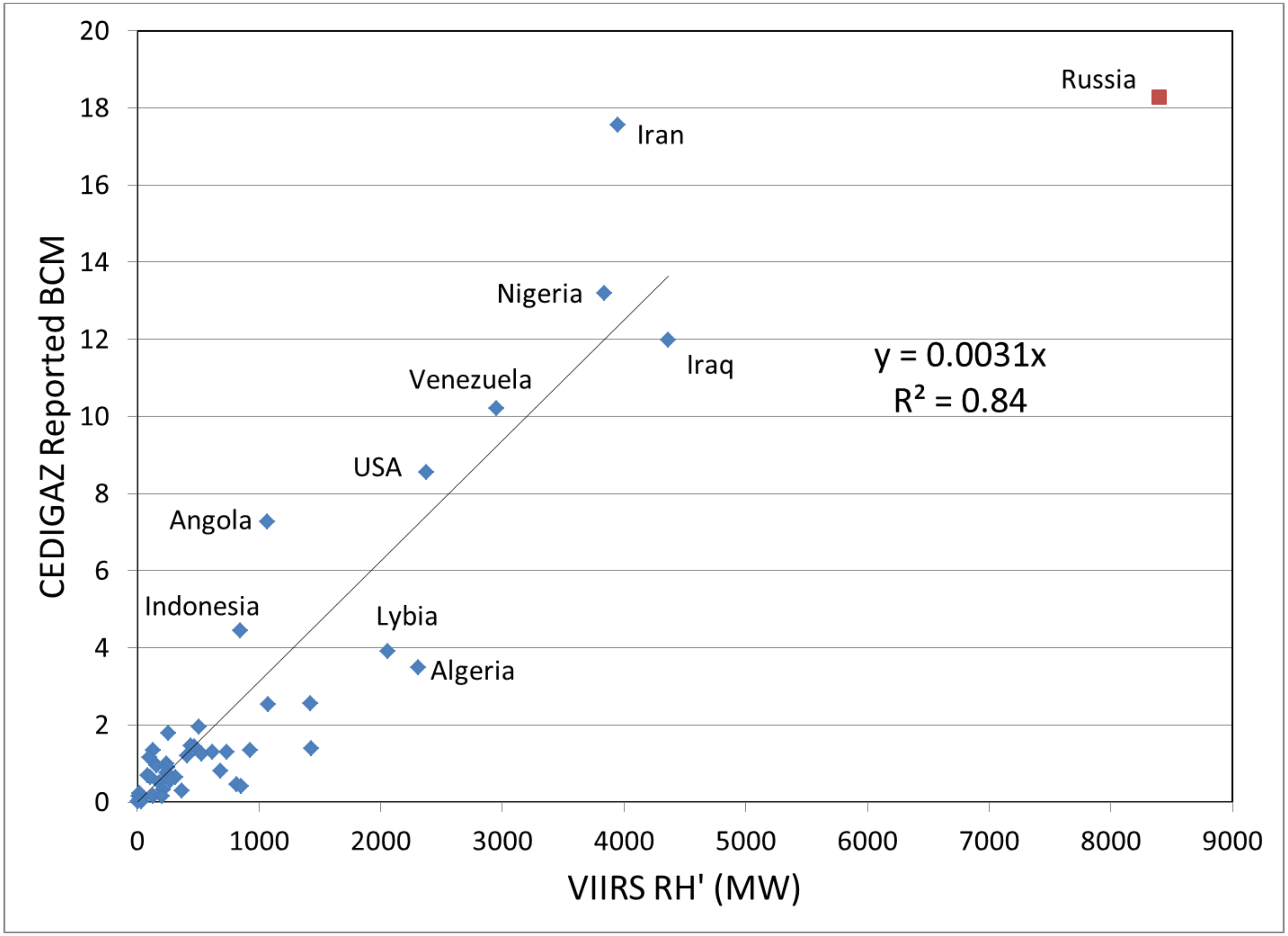


Current processing typically runs with a four hour delay

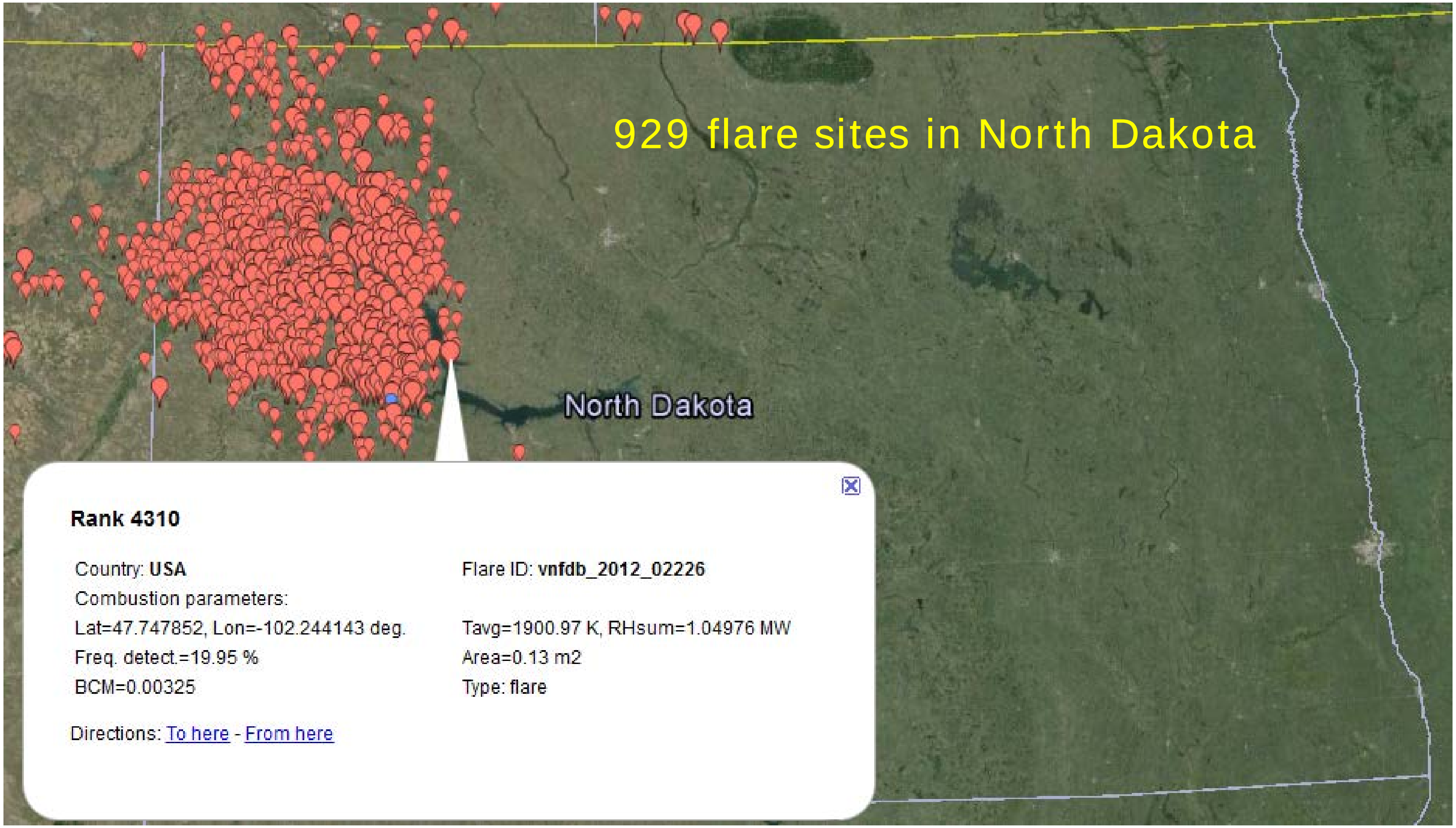
Temperatures are bimodal



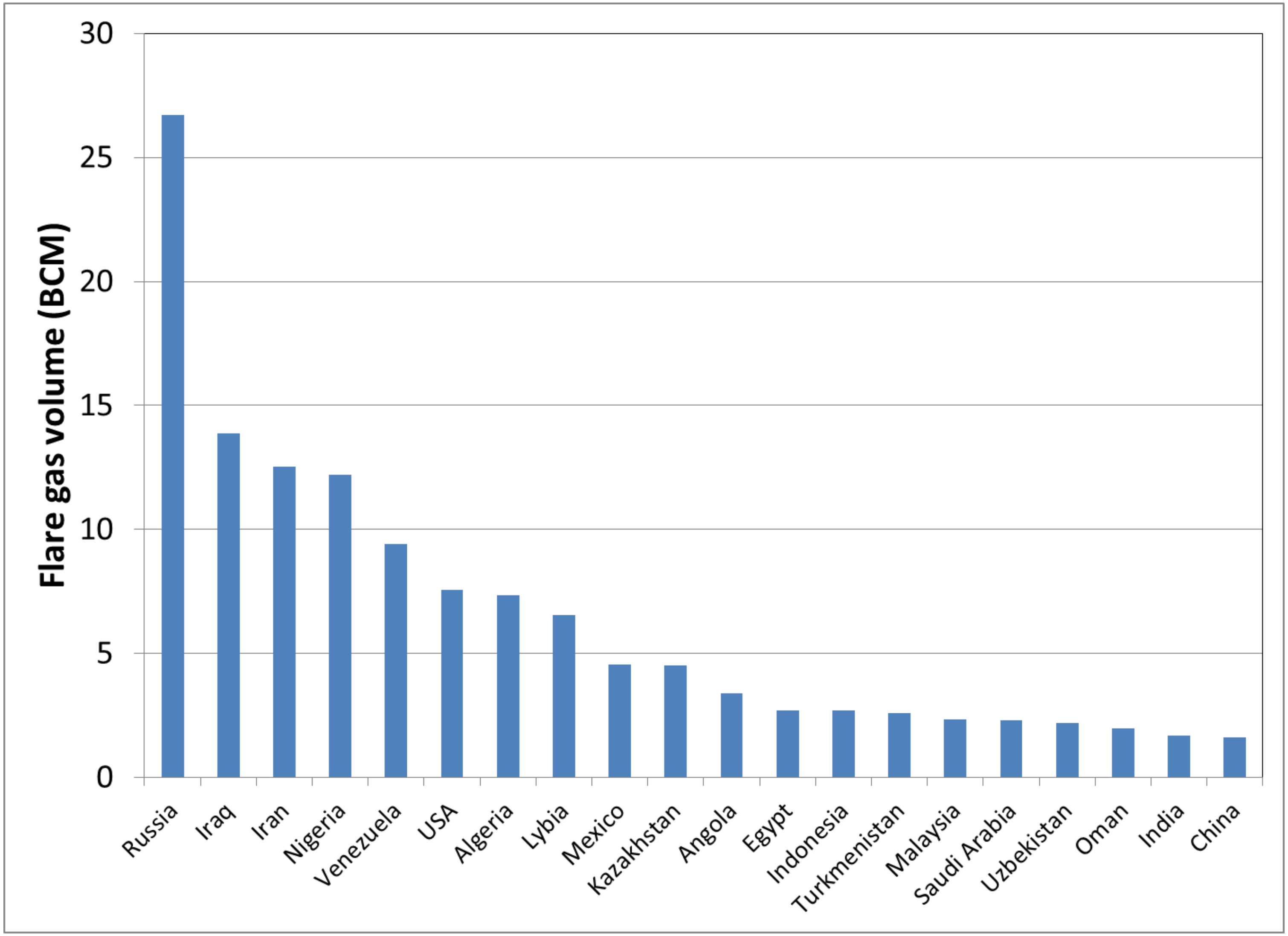
Calibration fore estimating BCM from radiant heat



Gas flaring volumes estimated at 7438 sites worldwide

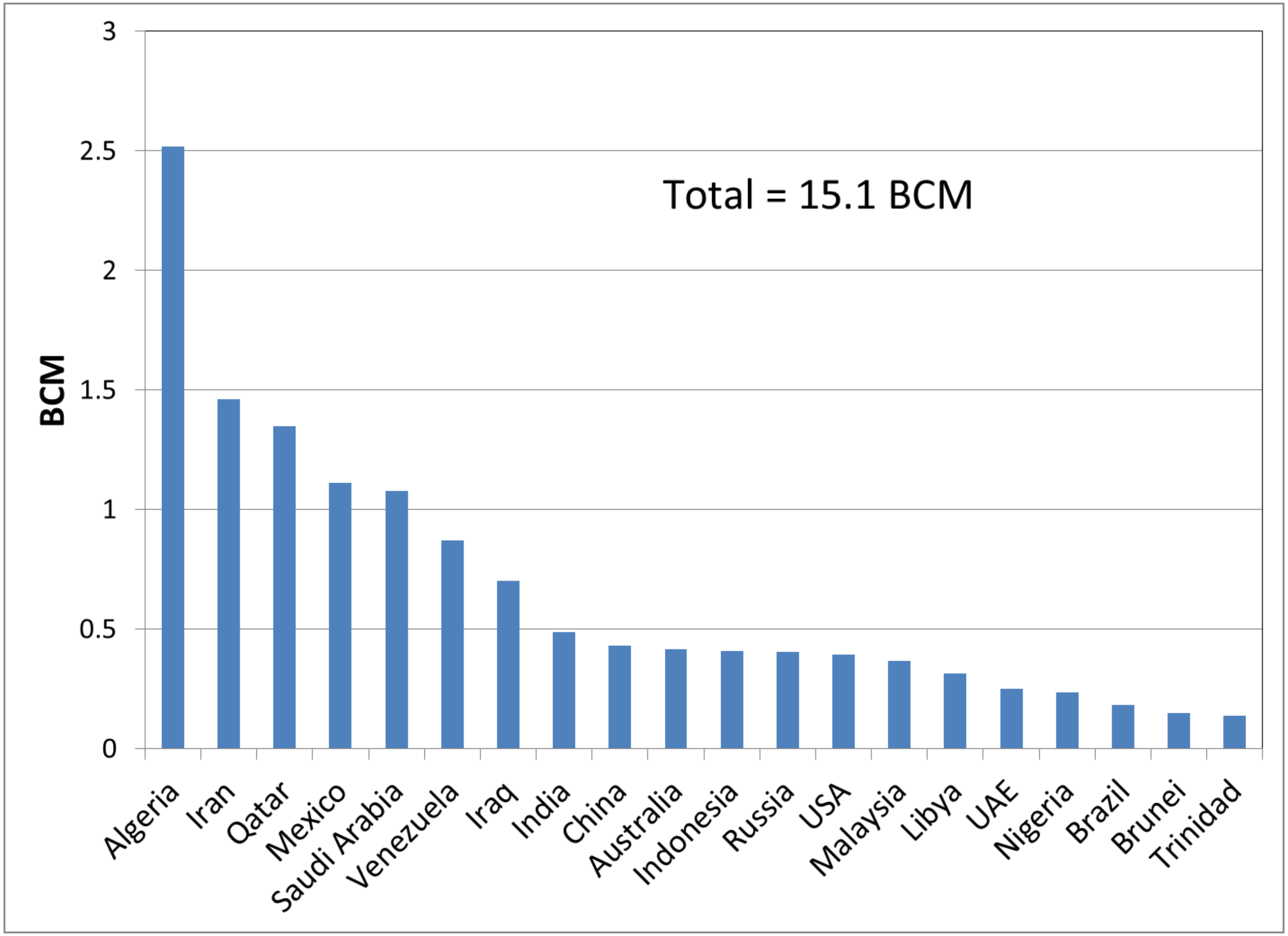


Upstream gas flaring by country in billions of cubic meters (BCM)

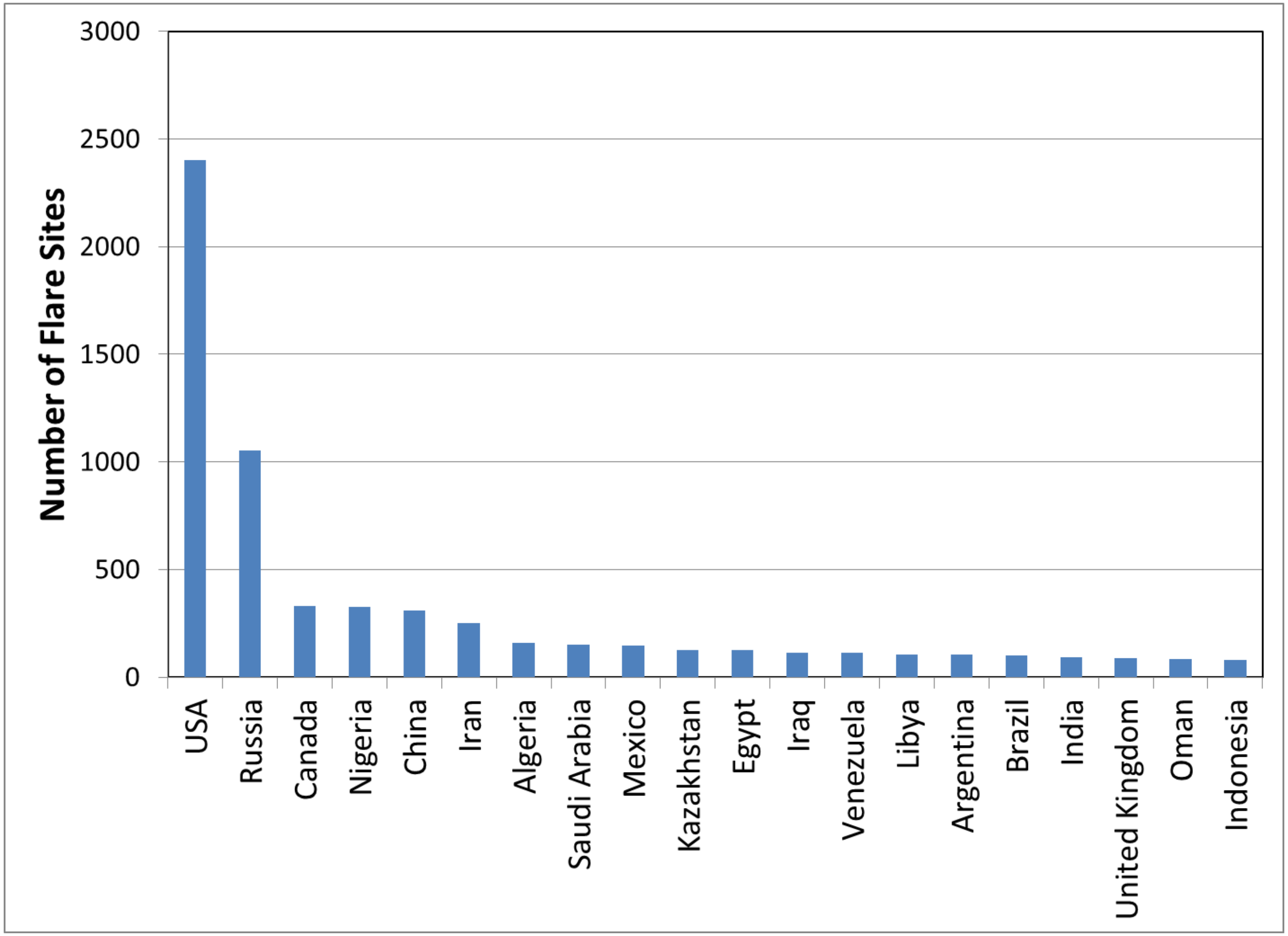


Global total 145 BCM

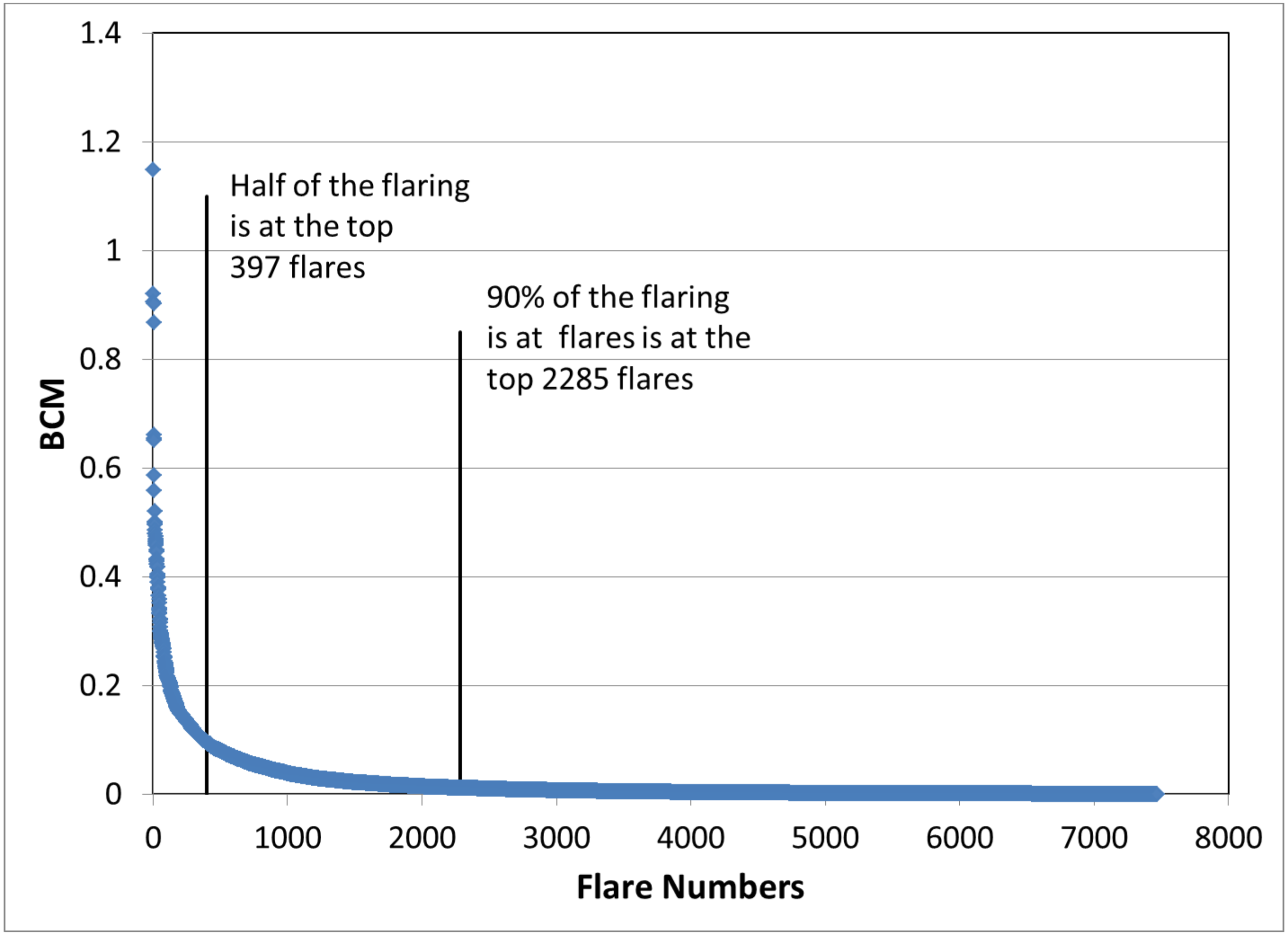
Downstream flaring by country in billions of cubic meters (BCM)



Flare site numbers by country
30% of flare sites are in the USA



Gas flaring site numbers by country.



Discrimination of flaming and smoldering combustion

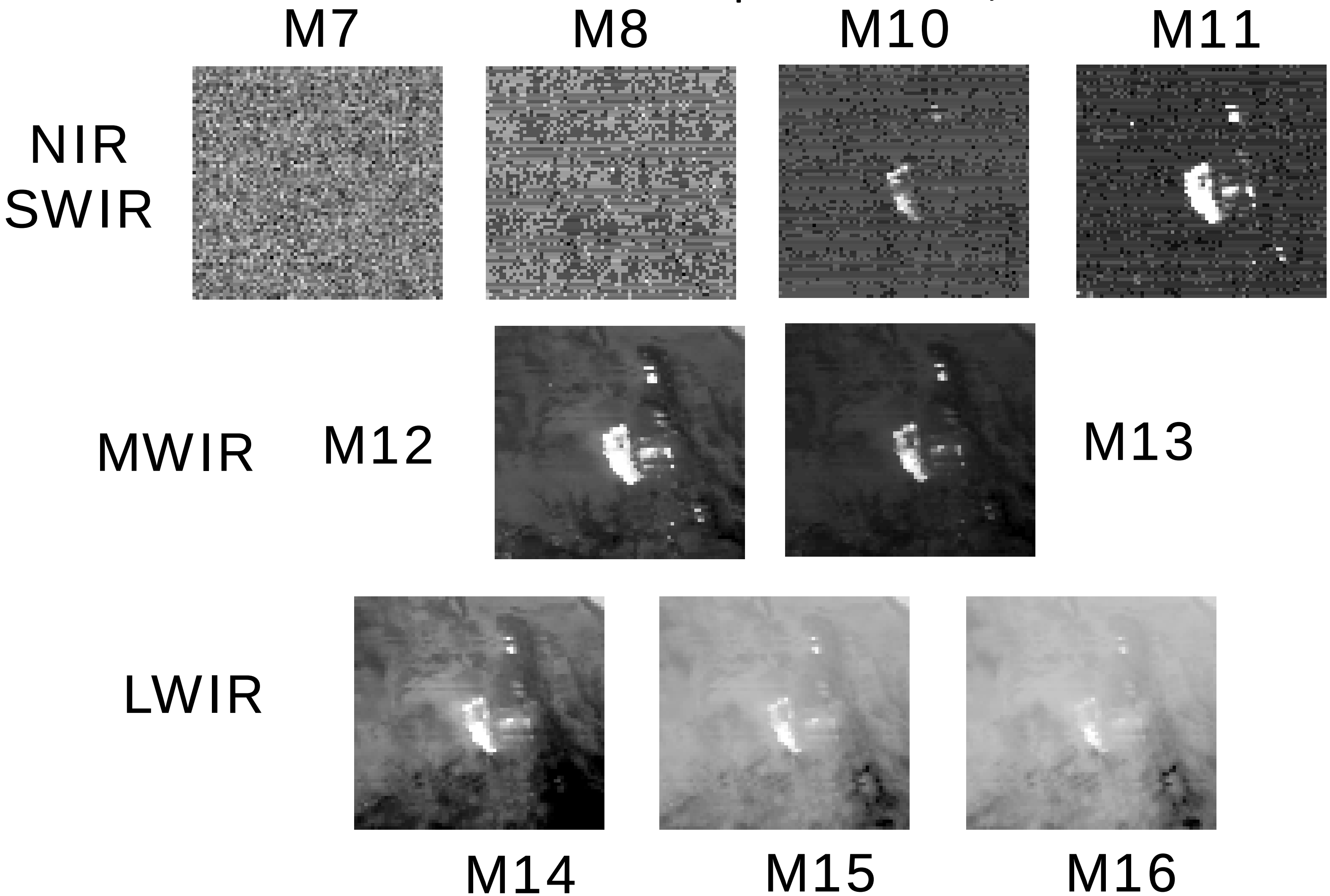
- There are two distinct combustion phases
- Flaming: higher temperature 700-1200 K, good oxidation, low smoke
- Smoldering about half as hot as flaming 350-450 K, poor oxidation, high smoke production
- Discriminating between flaming and smoldering could improve emission modeling
- There is a 400-500 K temperature differential
- Is the temperature differential sufficient to discriminate flaming and smoldering with VIIRS data?

Approach

- Prototype method developed with nighttime Landsat 8 data
- Model the flaming phase by Planck curve fitting the M10 & M11 radiances, producing flaming phase radiance estimates in long wave bands
- Subtract the flaming phase radiance and background radiance in bands M12,13,14,15,16
- Residual thermal anomalies suggest smoldering

Sumatra Peat Fire Study

With M11 – September 26, 2014

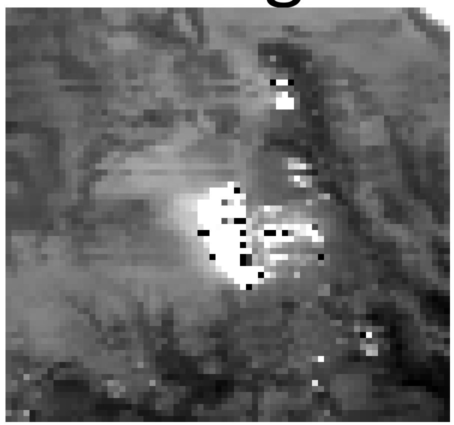


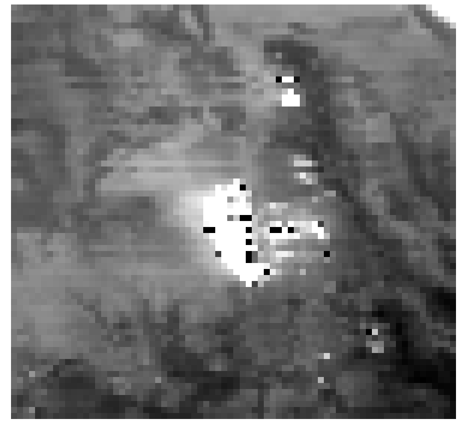
Temperature and source area from M10 & M11 Planck curve fitting

Residuals

After subtracting flaming phase and average background radiances

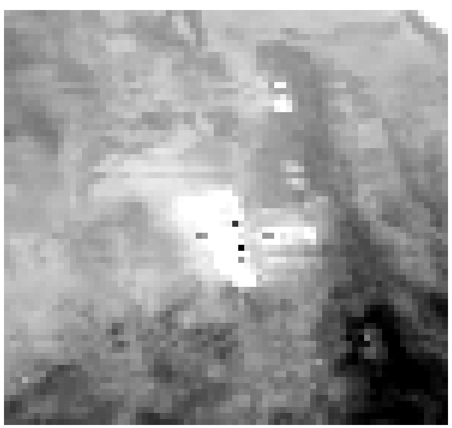
M12



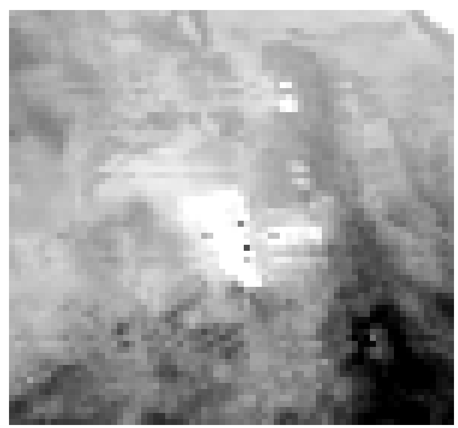


M13

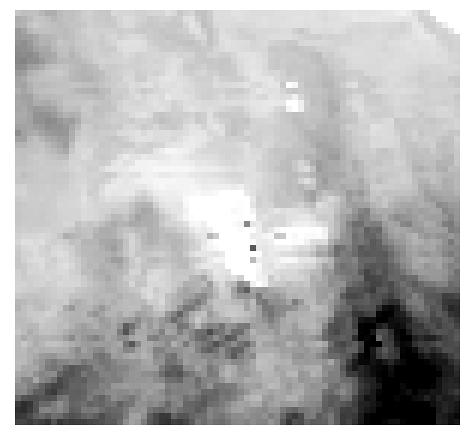
M14



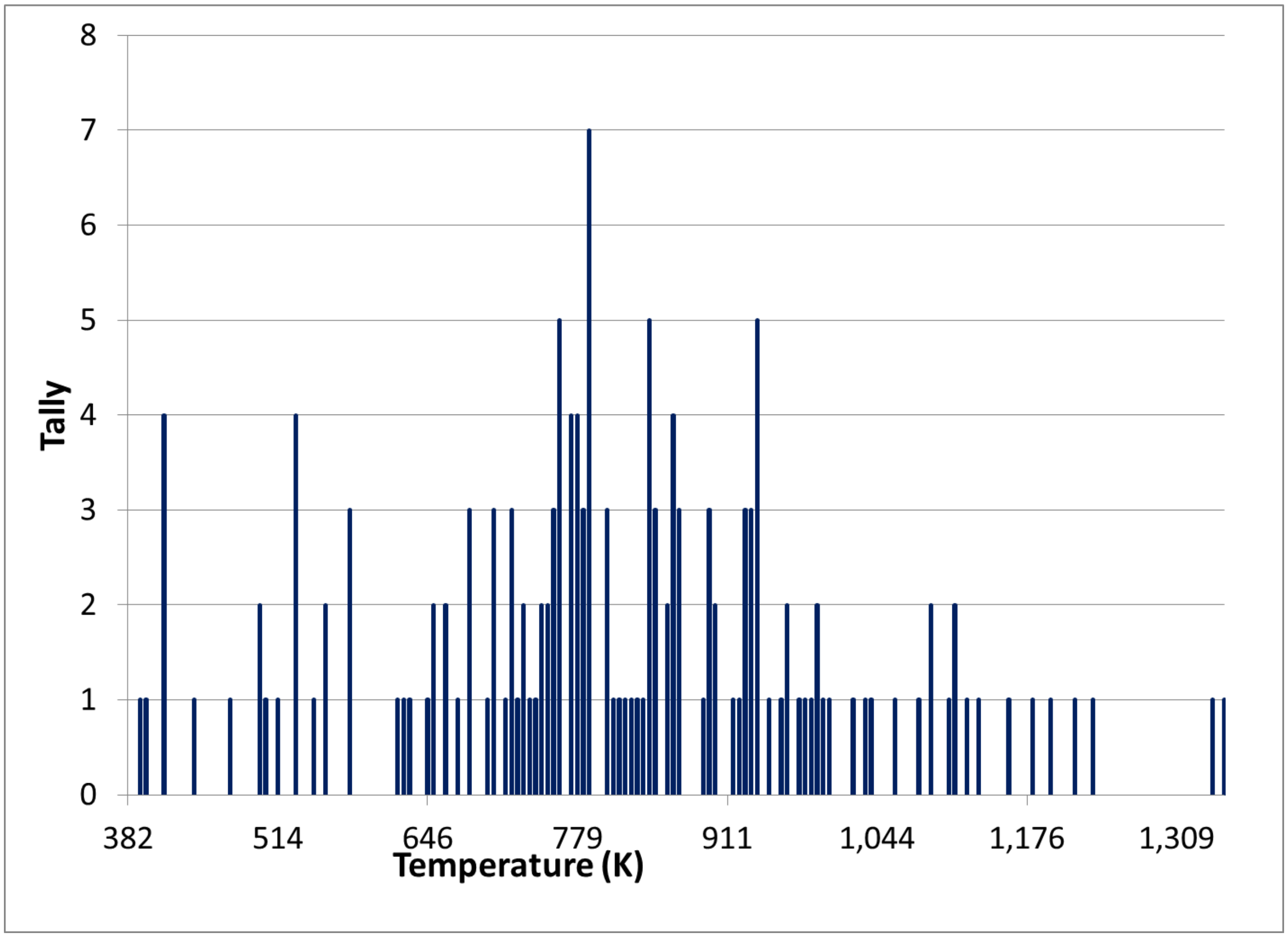
M15



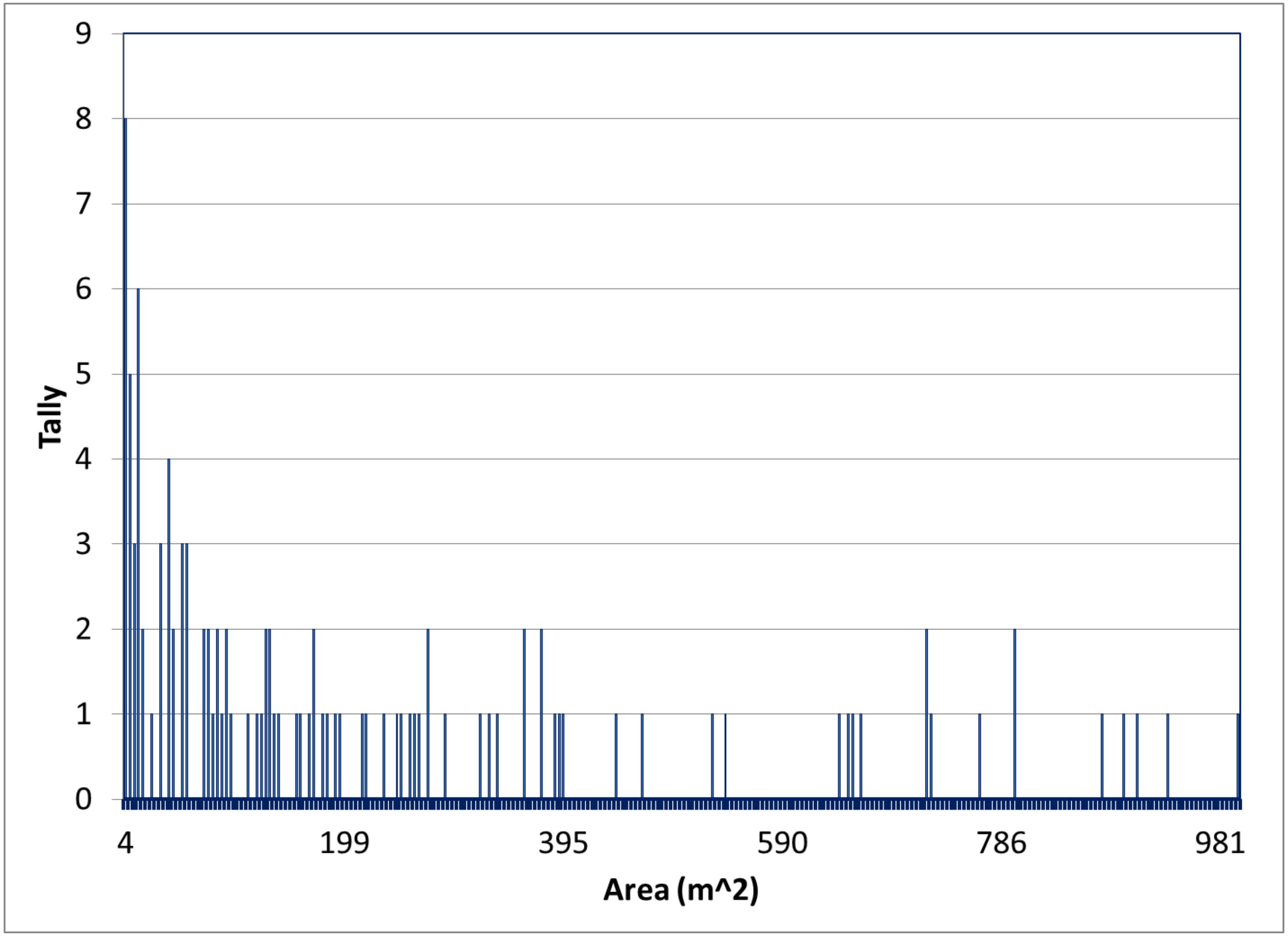
M16



Temperatures from M10 & M11 Planck curve fit – Sumatra September 26, 2014



Source areas from M10 & M11 Planck curve fit – Sumatra September 26, 2014



Summary on Flaming vs Smoldering with VIIRS

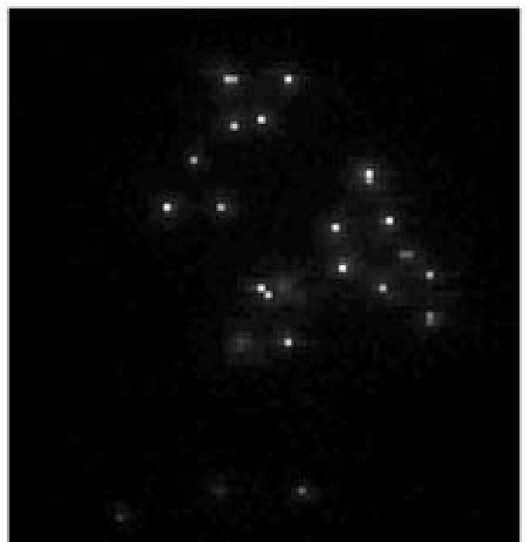
- M10 & M11 radiances can be used to extract flaming phase temperatures and source areas
- The presence of residual hotspot radiances in mid-long wave infrared channels after subtracting flaming phase and background radiances suggests the presence of smoldering in Sumatra peat fires.
- Can smoldering phase temperatures and source areas be estimated?
- The method needs to be tested more widely.

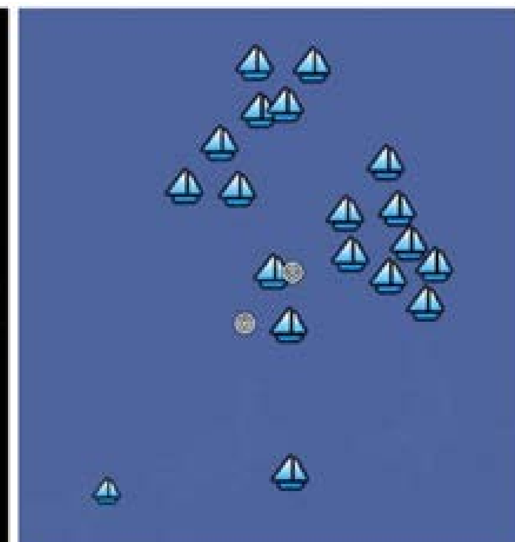
VIIRS detects lights from boats at night

Near real time service running for Indonesia.
Expansion to other regions begins later this year.

VIIRS day/night band (DNB) nighttime

Boat detection data (points)





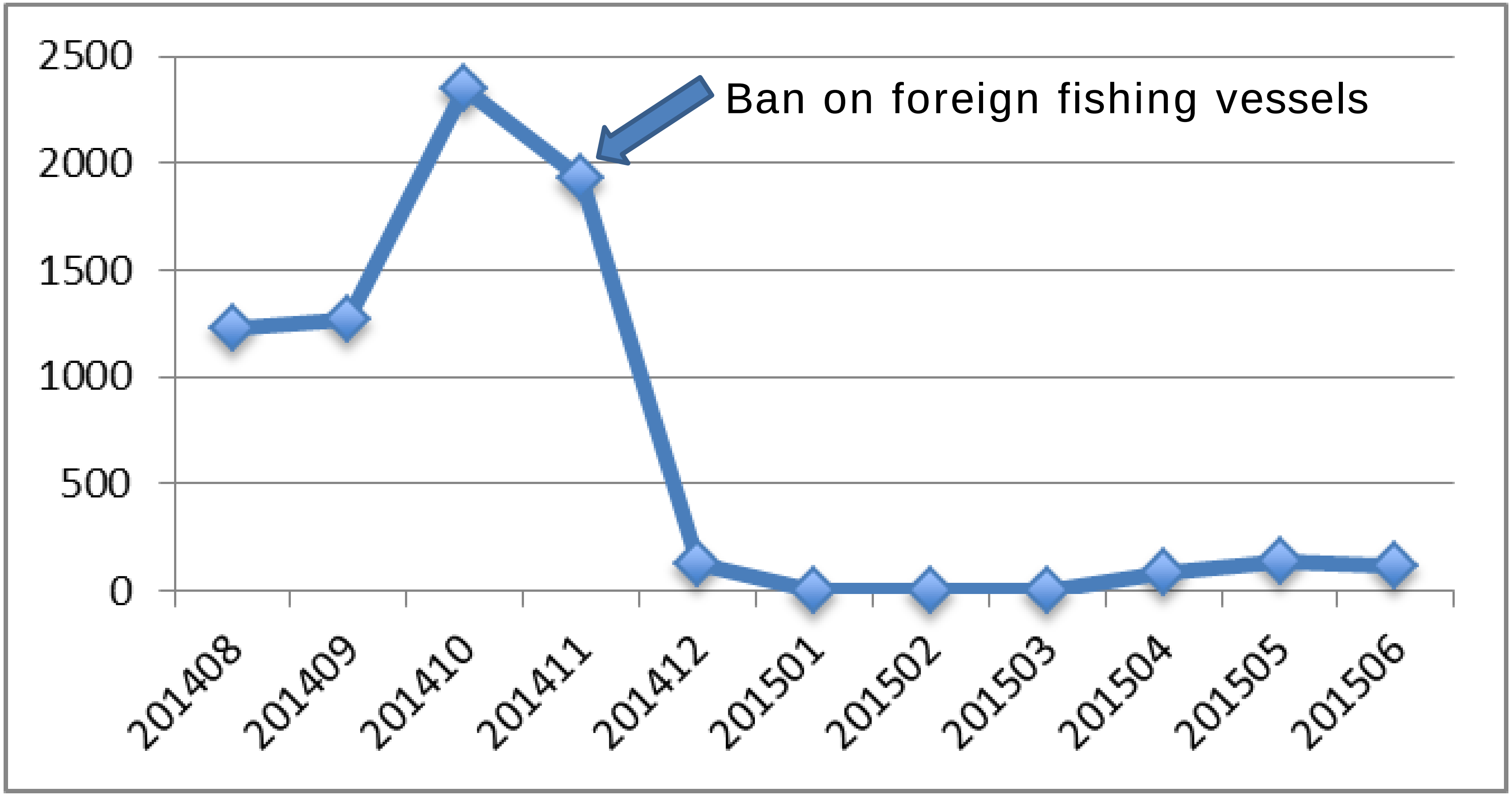
http://www.ngdc.noaa.gov/eog/viirs/download_indo_boat.html

Applications for VIIRS boat detections

- Supply alerts for boats detected in “no-take” and Marine Protected Areas
- Cross correlate with GPS beacon data to ID potentially illegal fishing
- Monitor for transboundary foreign vessels
- Assess the impacts of new regulations and enforcement regimes

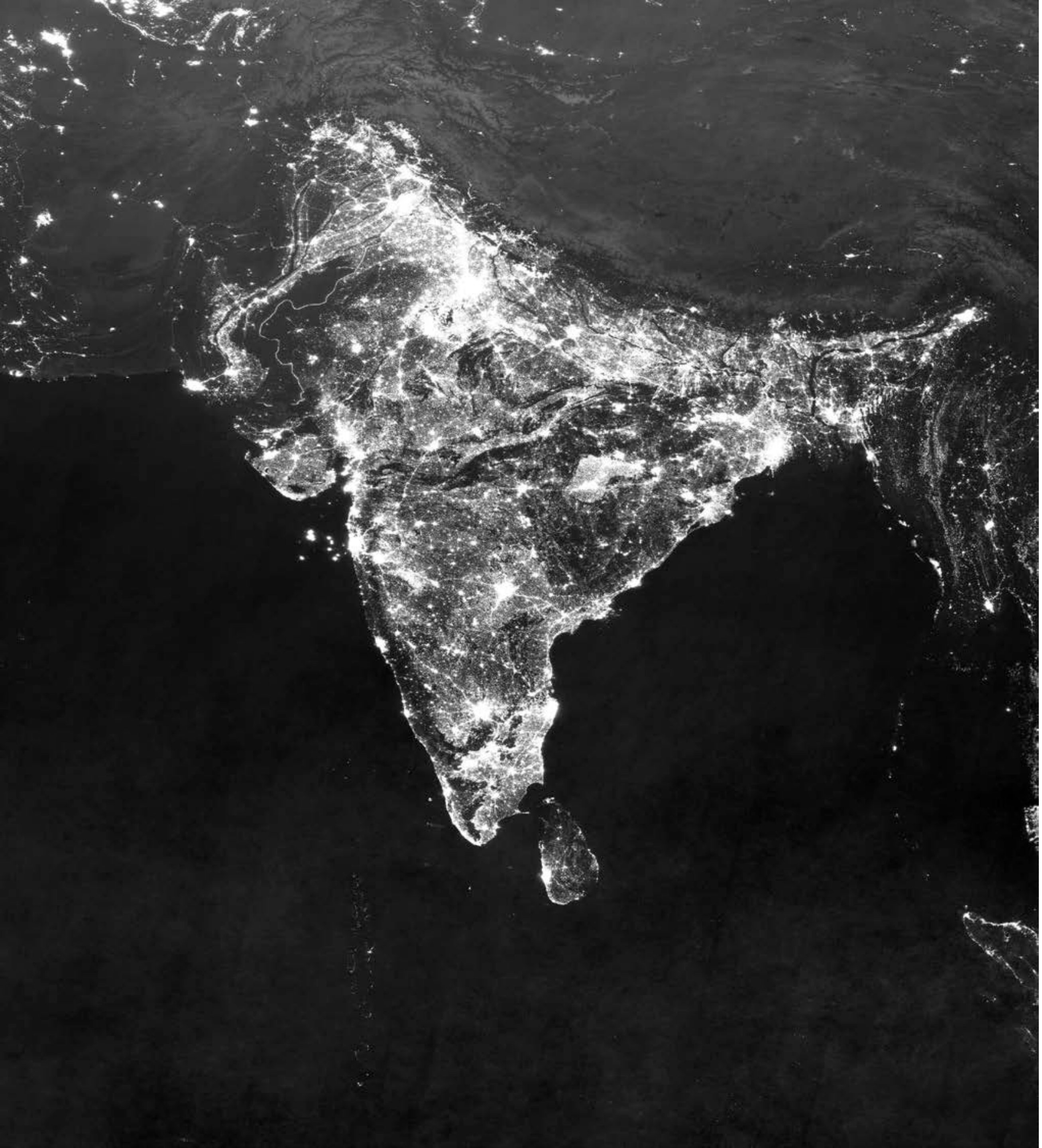
Boat Detections Running for Indonesia

Documenting effectiveness of regulations Aru Island, Arafura Sea



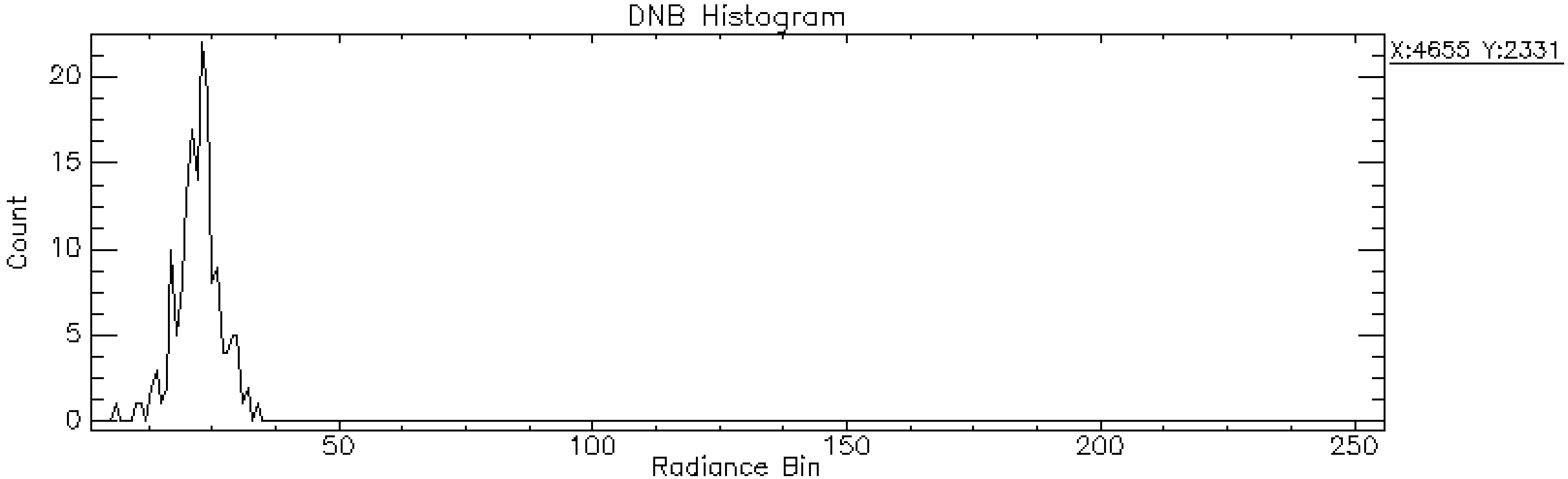
VIIRS Nighttime Lights Algorithm Development

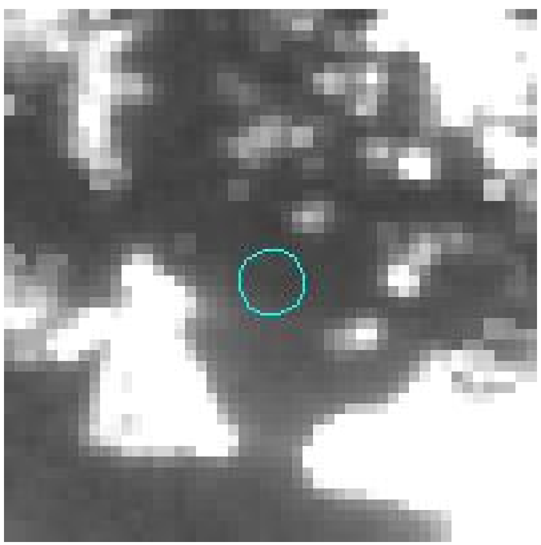
- Algorithms developed to remove lighting and fires.
- The DNB based fire removal algorithm should work well for removing South Atlantic Anomaly (SAA) detector hits and may also remove aurora.
- Last major hurdle is removal of background.



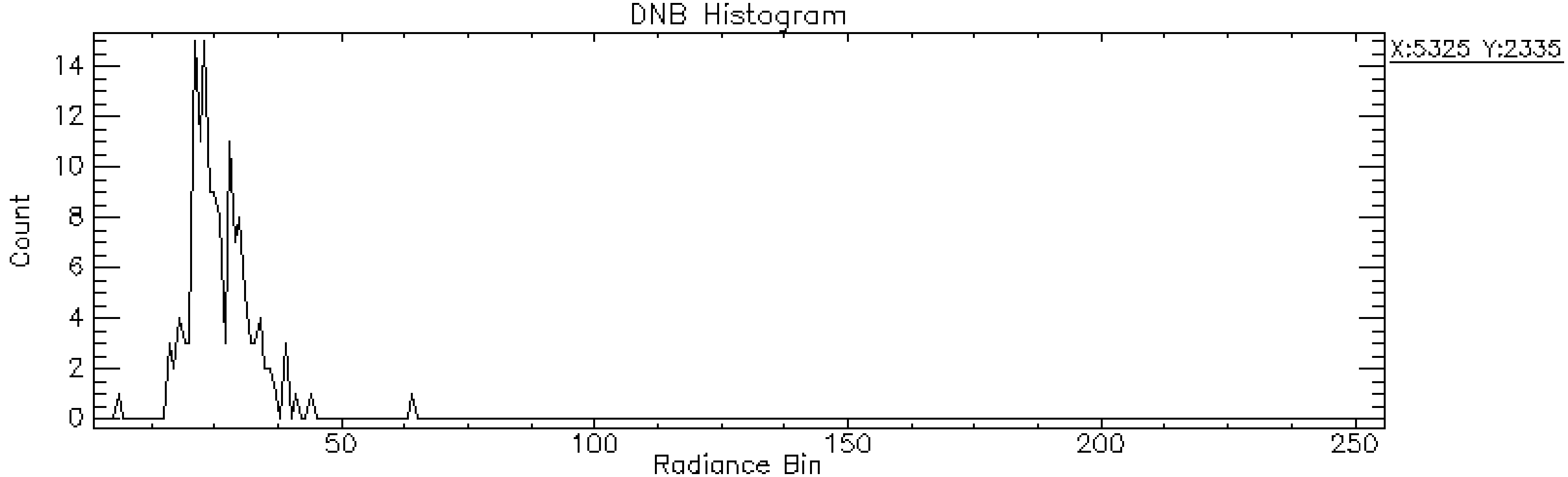
South Asia DNB cloud-free composite

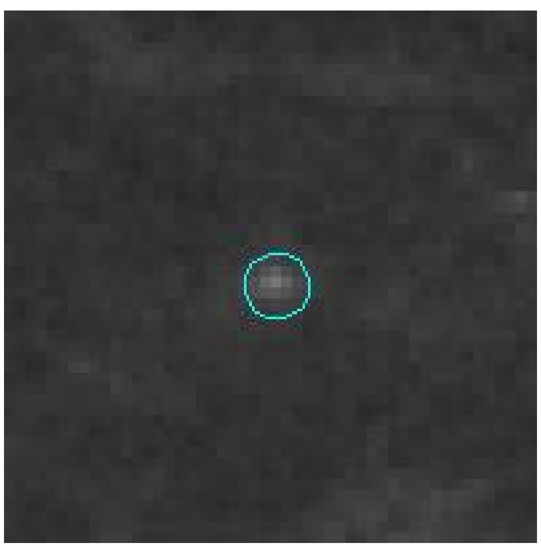
Background


DNB Histogram
X:4655 Y:2331
Count
0
5
10
15
20
50
100
150
200
250
Radiance Bin

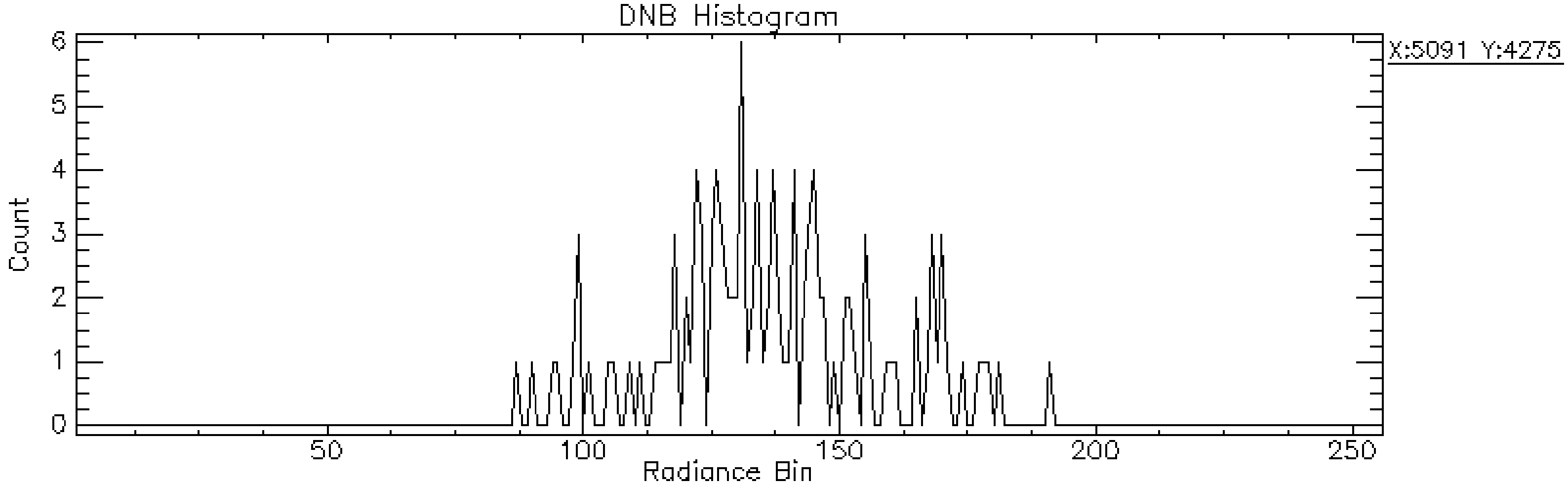


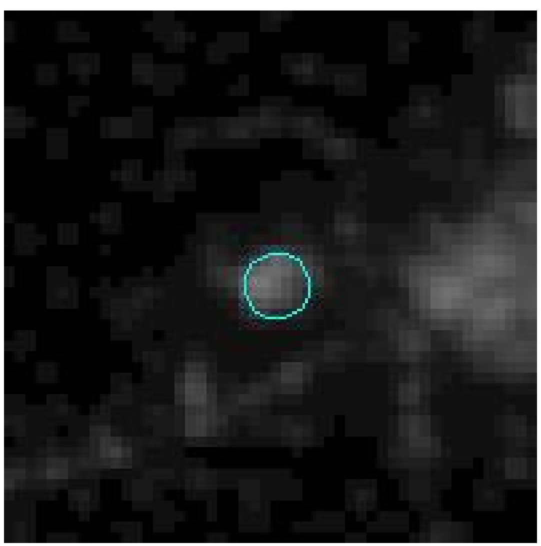
Background with infrequent light



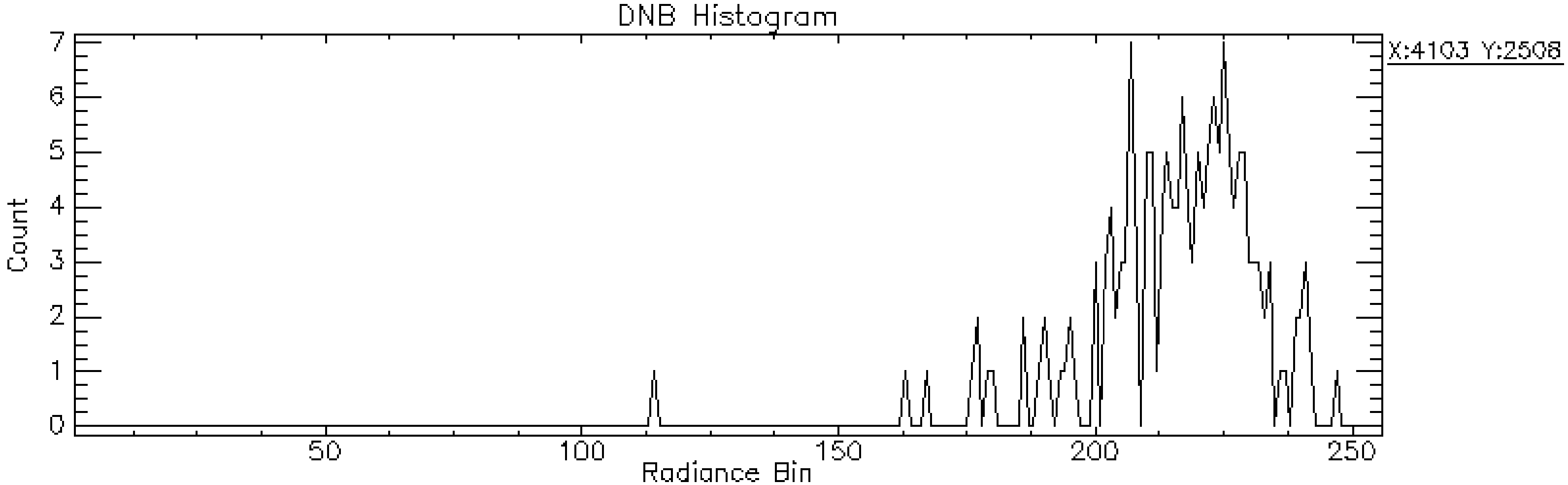


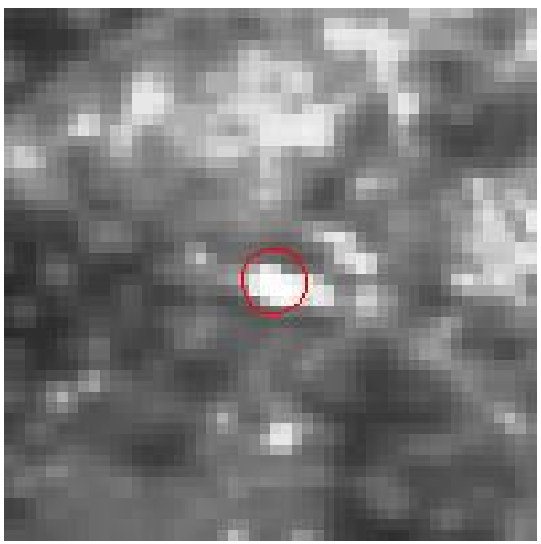
Minor urban area



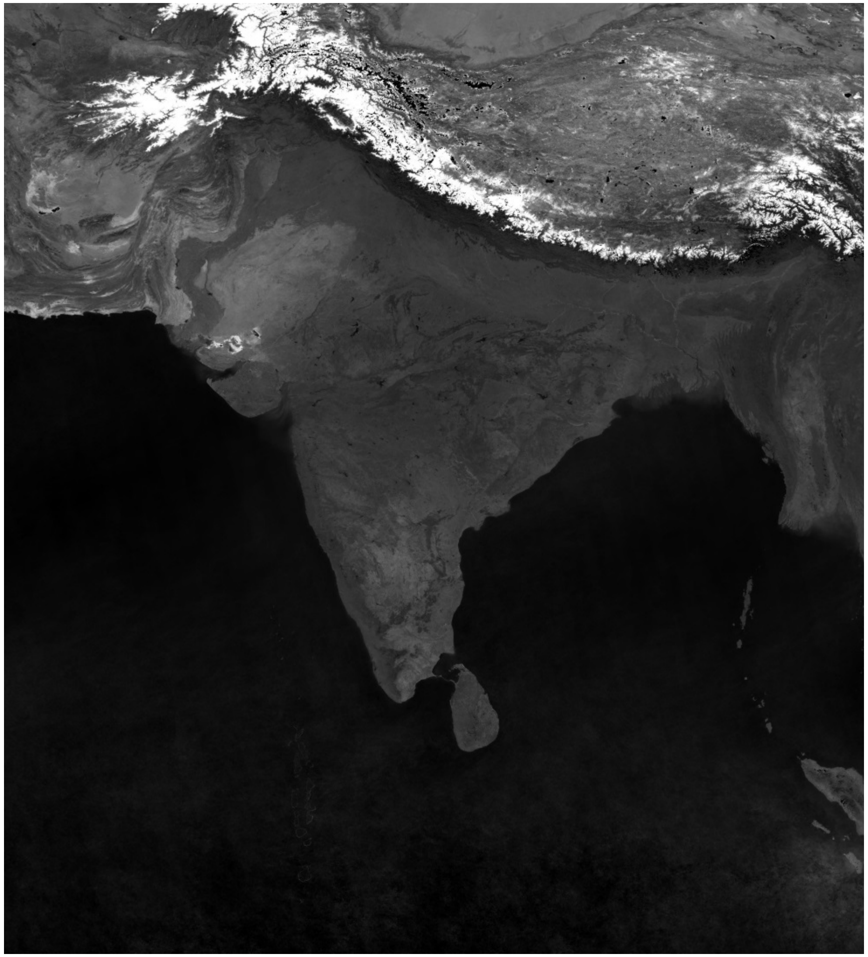


Brighter urban area

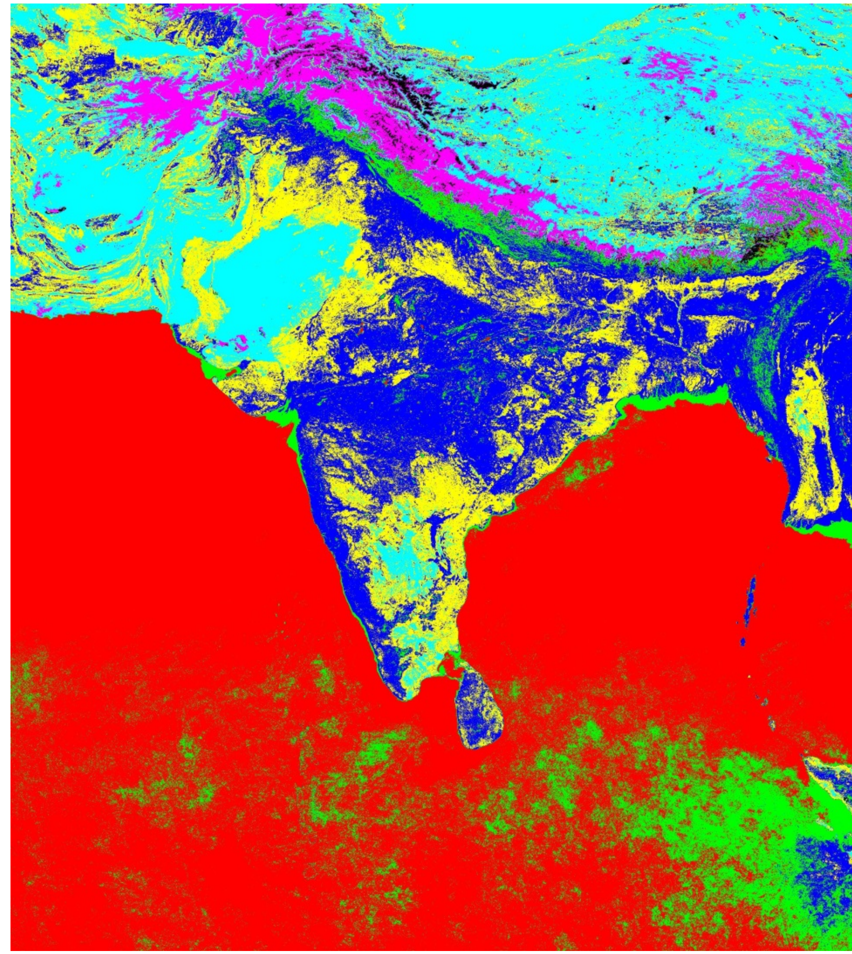




Daytime DNB Cloud-free Composite



Ten brightness classes



Summary

- There are four unique types of nighttime VIIRS products:
- VIIRS Nightfire (VNF) produced globally on 24 hour increments. Gas flaring observations used to estimate flared gas volumes worldwide. Research is ongoing on discrimination of subpixel flaming and smoldering.
- VIIRS boat detections (VBD) currently running for Indonesia. Will begin the expand to other areas this year.
- VIIRS nighttime lights (VNL) last hurdle is the background removal algorithm.

EOG Publications

- Long-wave infrared identification of smoldering peat fires in Indonesia with nighttime Landsat data http://iopscience.iop.org/1748-9326/10/6/065002/
- Automatic Boat Identification System for VIIRS Low Light Imaging Data http://www.mdpi.com/2072-4292/7/3/3020
- VIIRS Nightfire: Satellite pyrometry at night http://www.mdpi.com/2072-4292/5/9/4423
- What is so great about nighttime VIIRS data for the detection and characterization of combustion sources? http://dx.doi.org/10.7125/APAN.35.5
- Using the short-wave infrared for nocturnal detection of combustion sources in VIIRS data http://dx.doi.org/10.7125/APAN.35.6
- Why VIIRS data are superior to DMSP for mapping nighttime lights http://dx.doi.org/10.7125/APAN.35.7
- Nighttime lights compositing using the VIIRS day-night band: Preliminary results http://dx.doi.org/10.7125/APAN.35.8




Marco Fulle - www.stromboli.net

The Development of JPSS Volcanic Cloud Applications

Michael Pavolonis

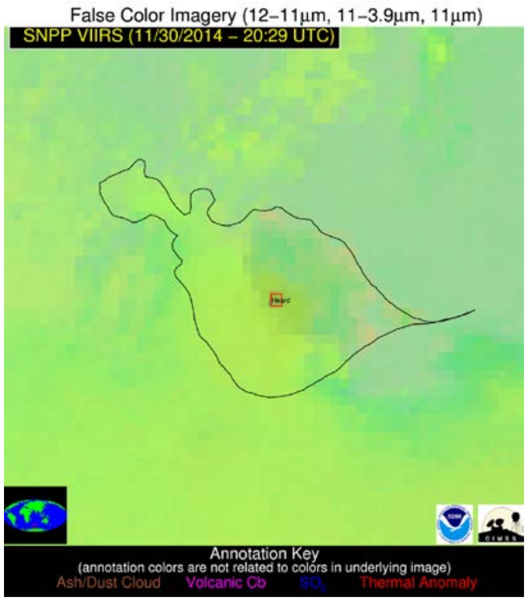
(NOAA/NESDIS/STAR)

Justin Sieglaff, and John Cintineo

(UW-CIMSS)

Development of a Multi-sensor System

1). Unrest Alerts



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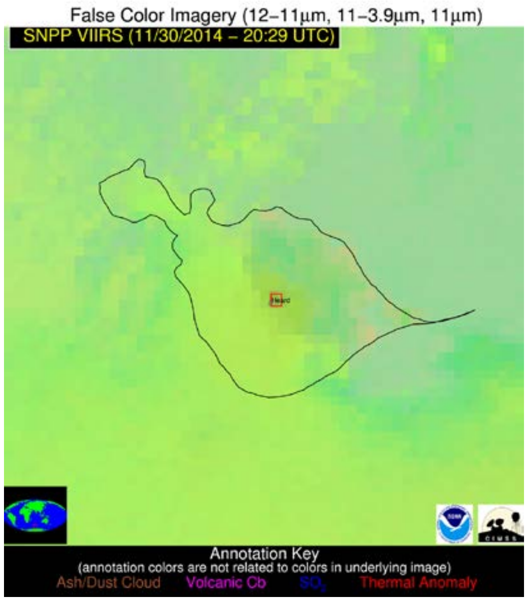
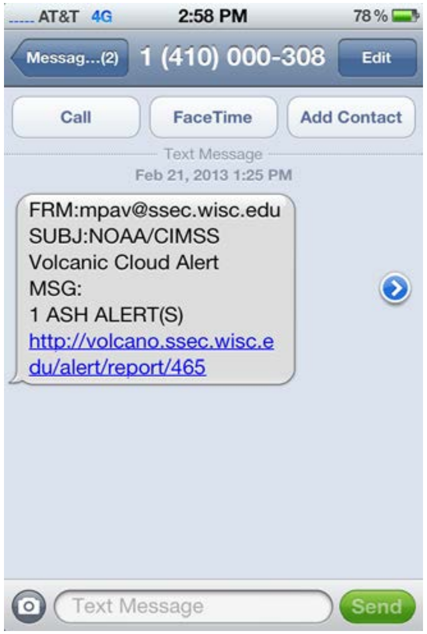


2). Eruption Alerts



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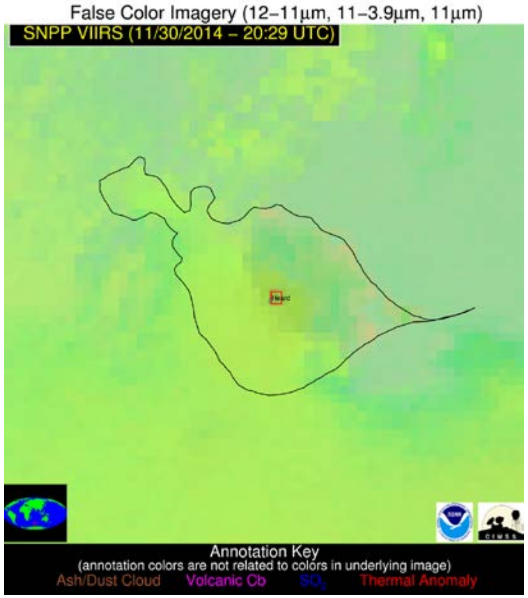

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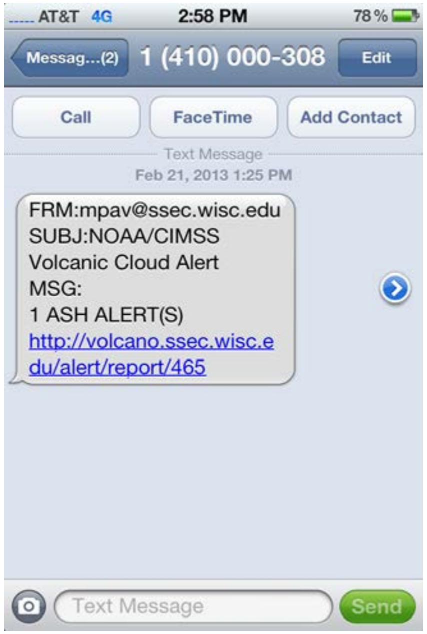
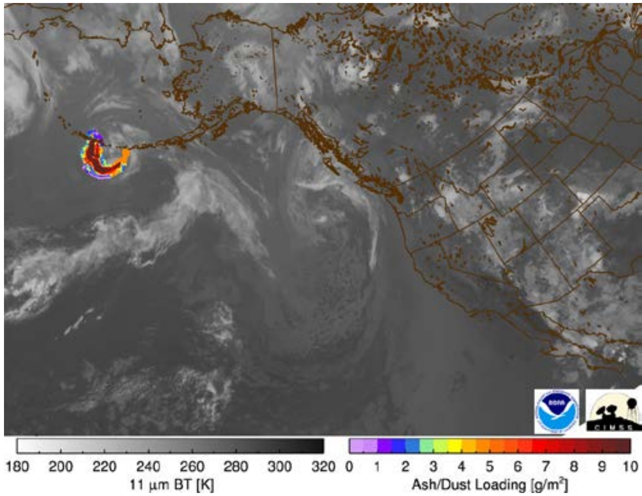


3). Volcanic Cloud Tracking



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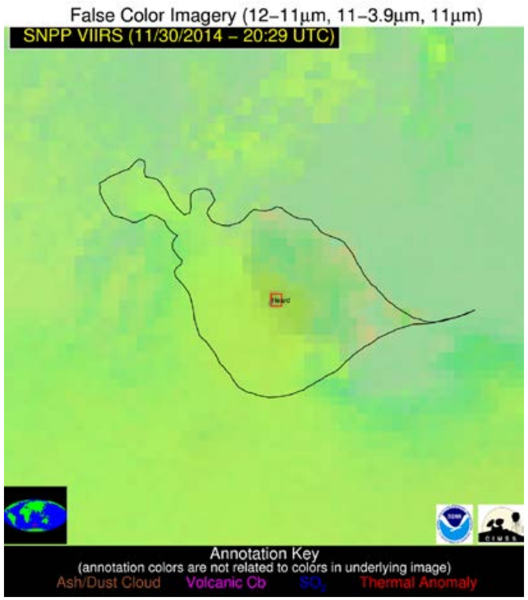

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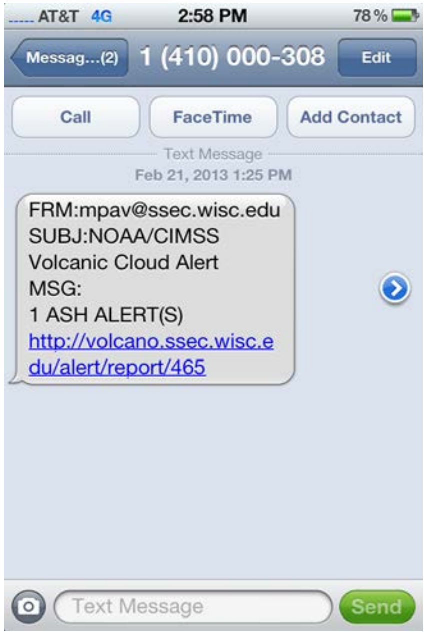

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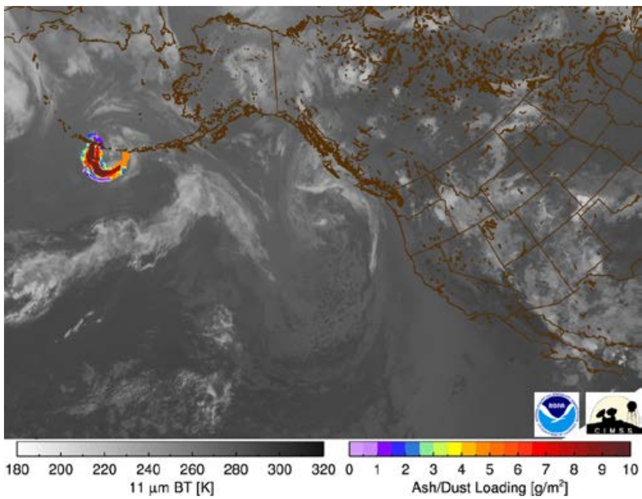
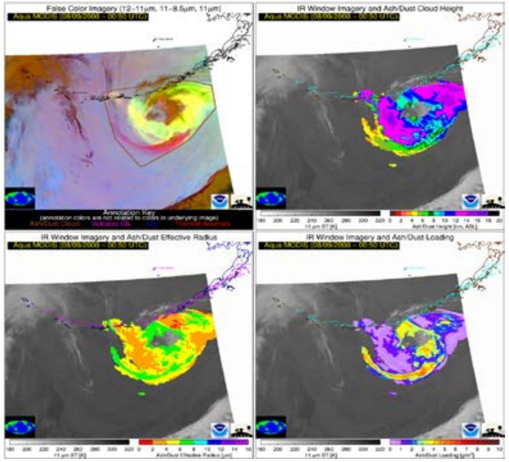


4). Volcanic Cloud Characterization



Development of a Multi-sensor System

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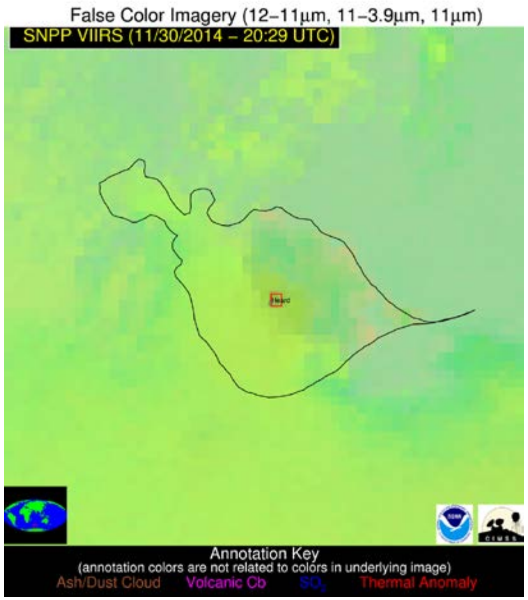

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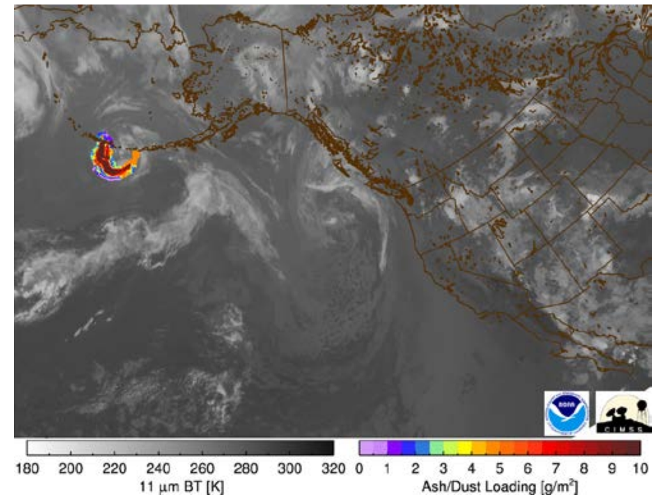

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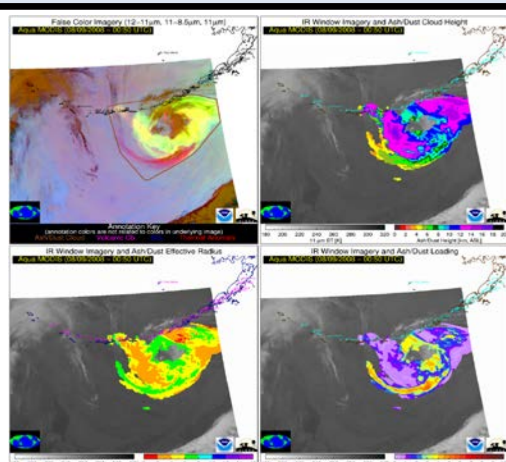
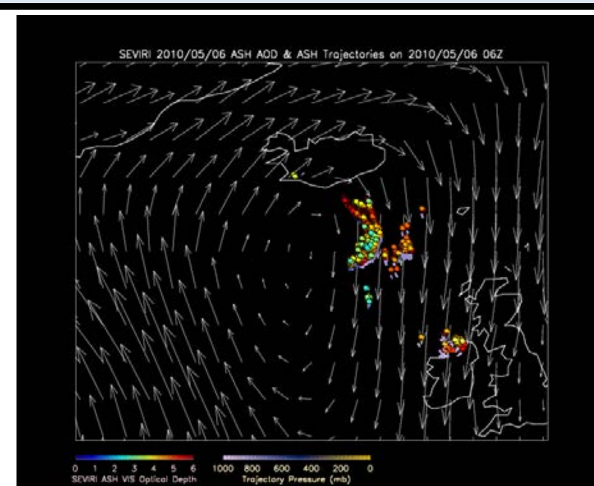
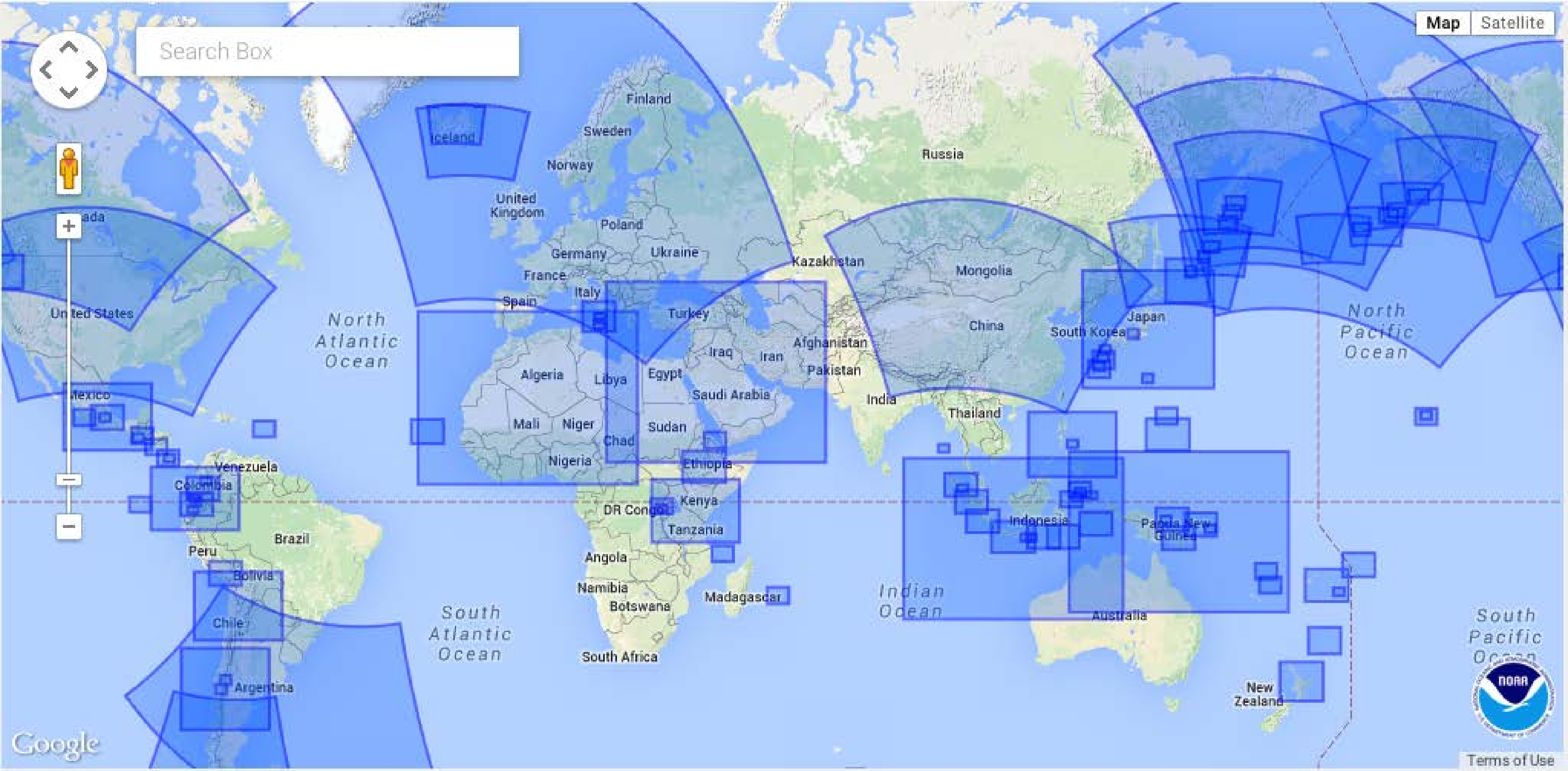


5). Dispersion Forecasting



http://volcano.ssec.wisc.edu



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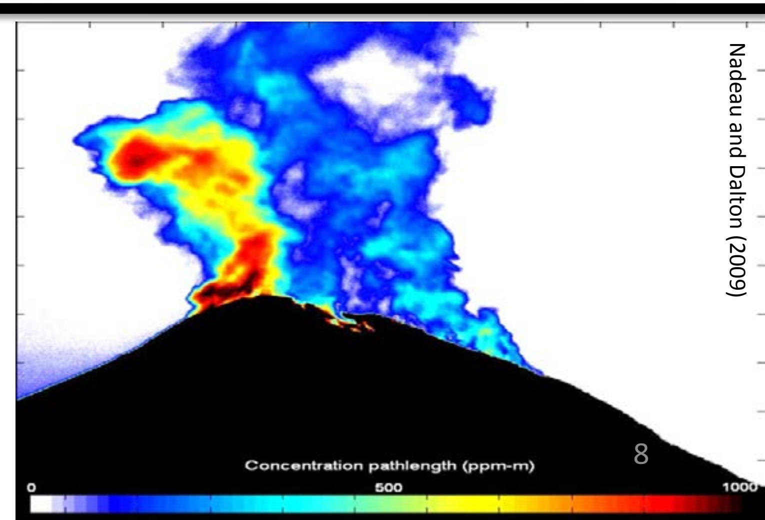

Nadeau and Dalton (2009)

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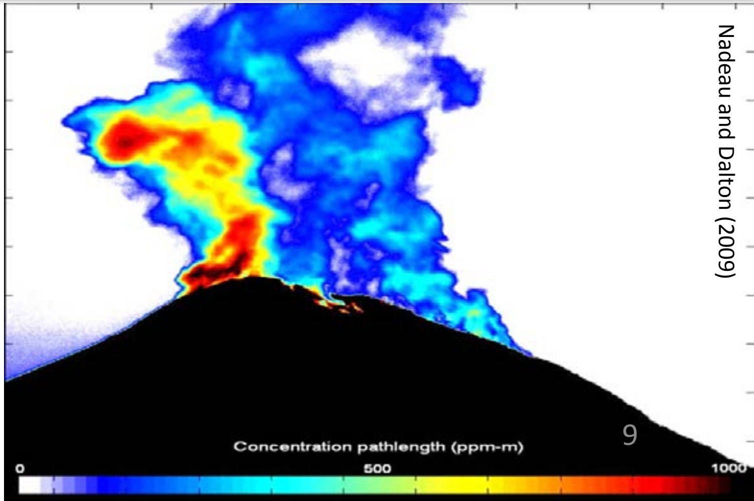
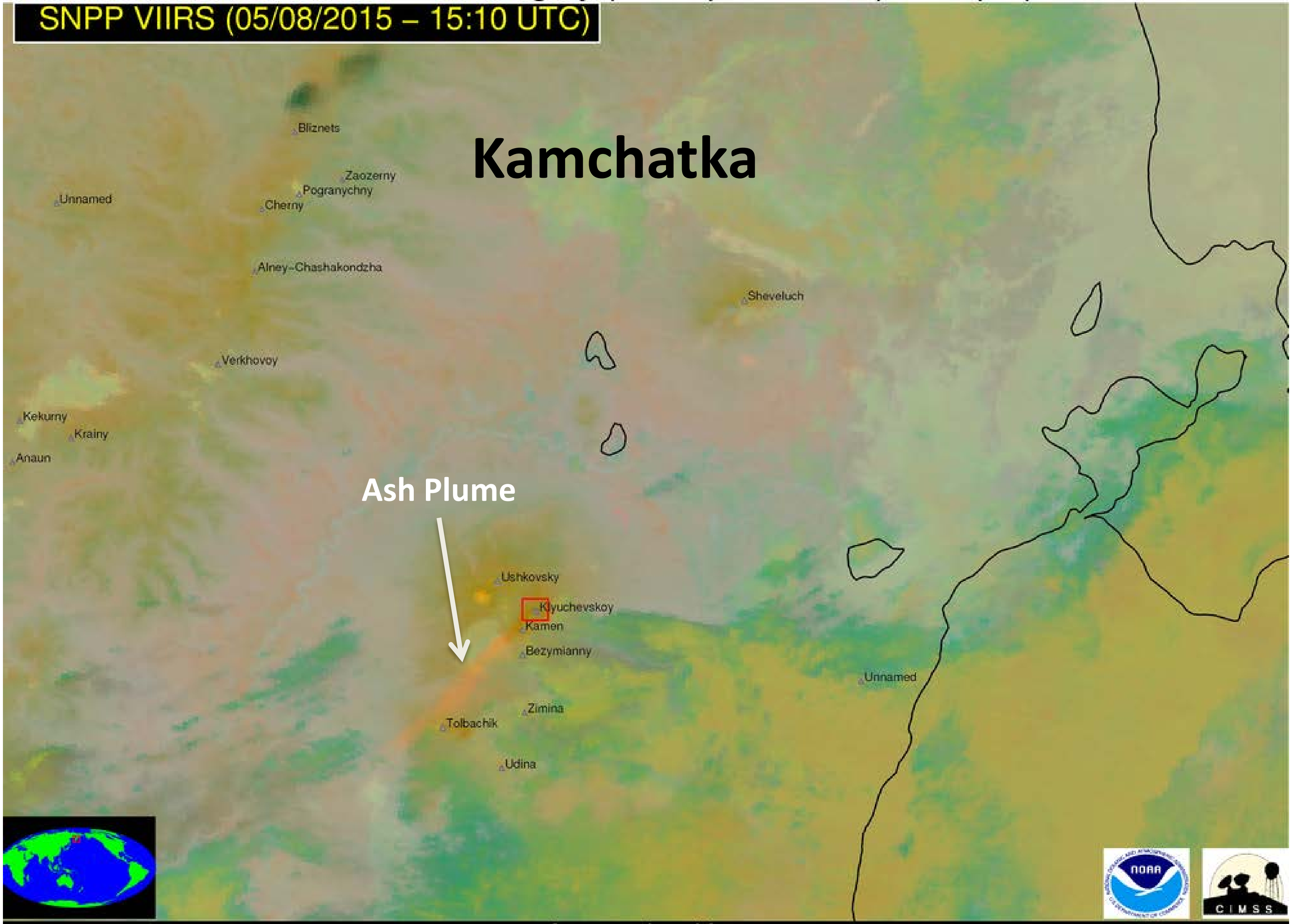
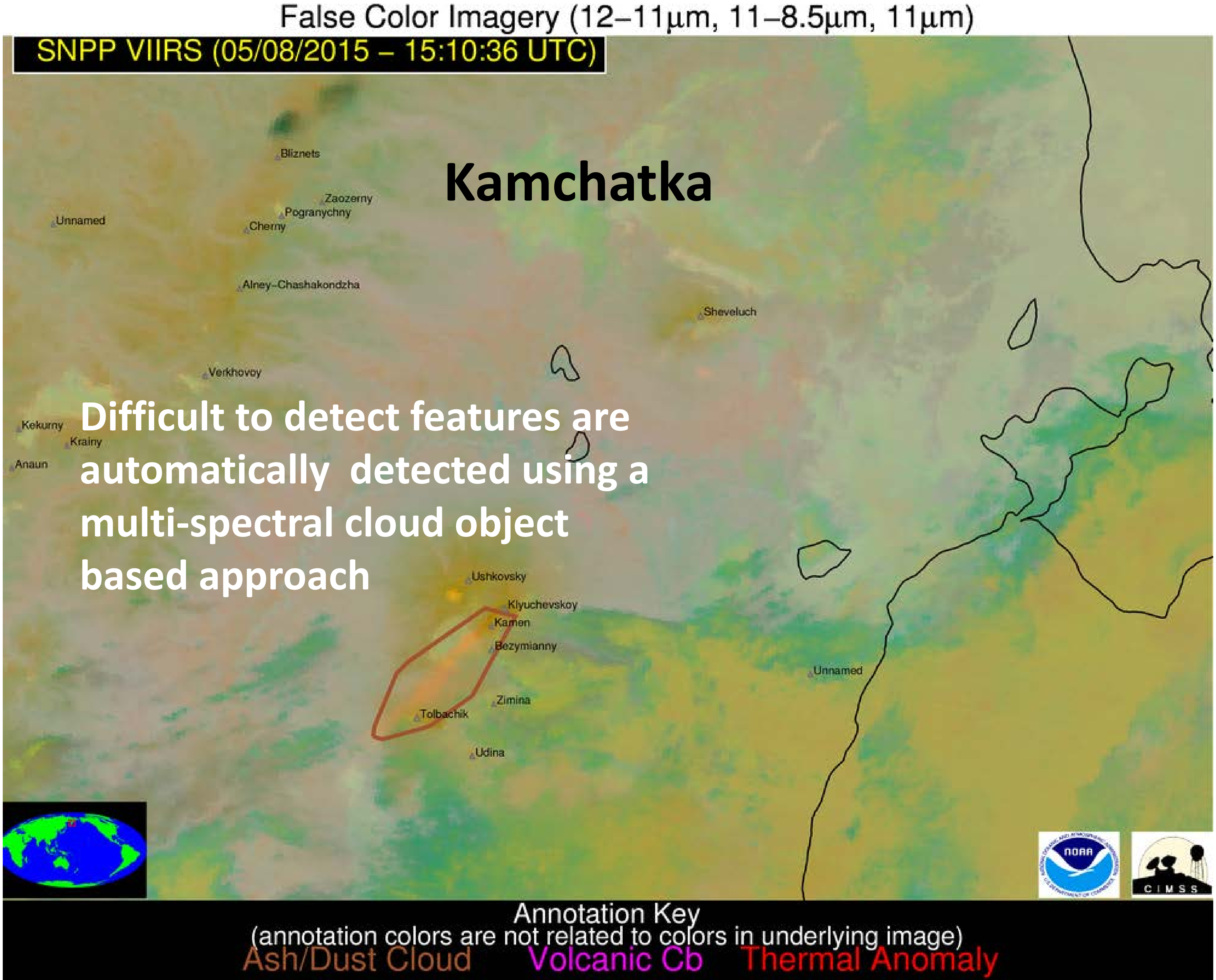


Nadeau and Dalton (2009)

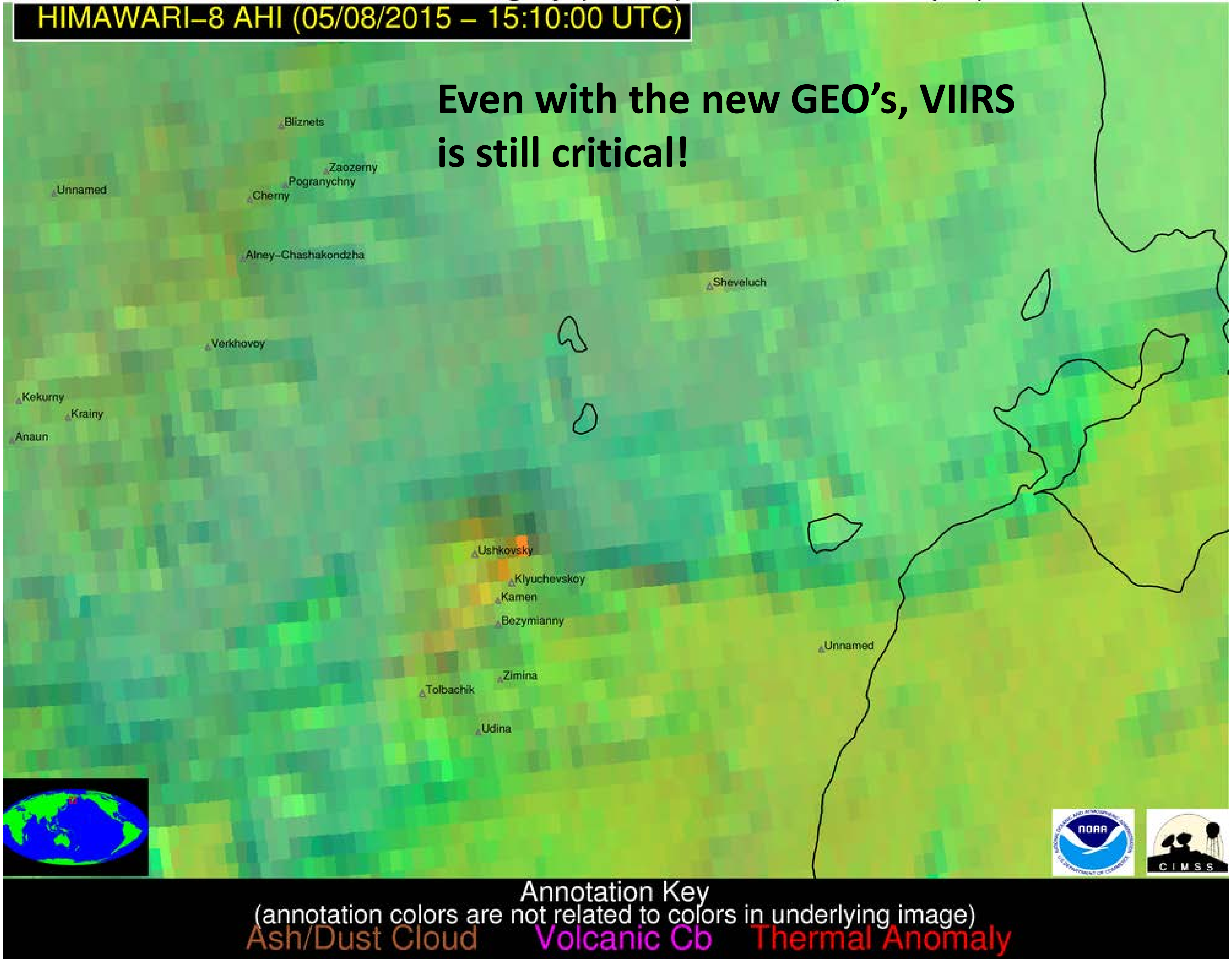
False Color Imagery (12–11µm, 11–8.5µm, 11µm)



Annotation Key
(annotation colors are not related to colors in underlying image)
Ash/Dust Cloud Volcanic Cb Thermal Anomaly


False Color Imagery (12–11µm, 11–8.5µm, 11µm)
SNPP VIIRS (05/08/2015 – 15:10:36 UTC)
Kamchatka
Difficult to detect features are automatically detected using a multi-spectral cloud object based approach
Bliznets
Zaozerny
Pogranychny
Cherny
Unnamed
Alney-Chashakondzha
Sheveluch
Verkhovoy
Kekurny
Krainy
Anaun
Ushkovsky
Klyuchevskoy
Kamen
Bezymianny
Unnamed
Zimina
Tolbachik
Udina
Annotation Key
(annotation colors are not related to colors in underlying image)
Ash/Dust Cloud
Volcanic Cb
Thermal Anomaly

False Color Imagery (12–11µm, 11–8.5µm, 11µm)



Detect and Alert

Within our automated alerting system, VIIRS identifies the most volcanic ash clouds due to its enhanced sensitivity to small-scale features (even at large viewing angles)

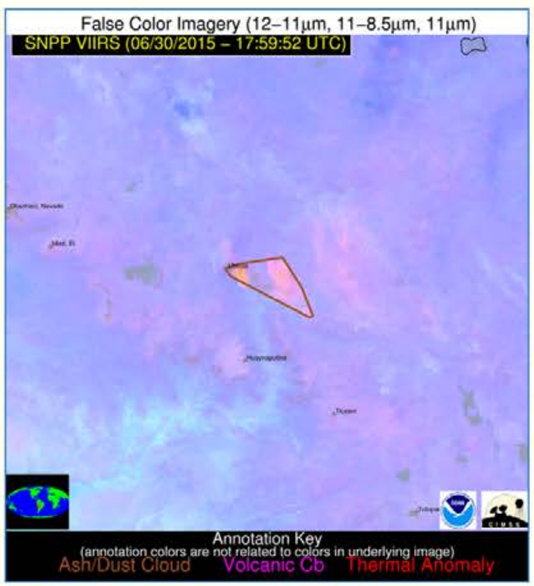
Volcanic Cloud Alert Report

Ubinas (Peru): June 30, 2015

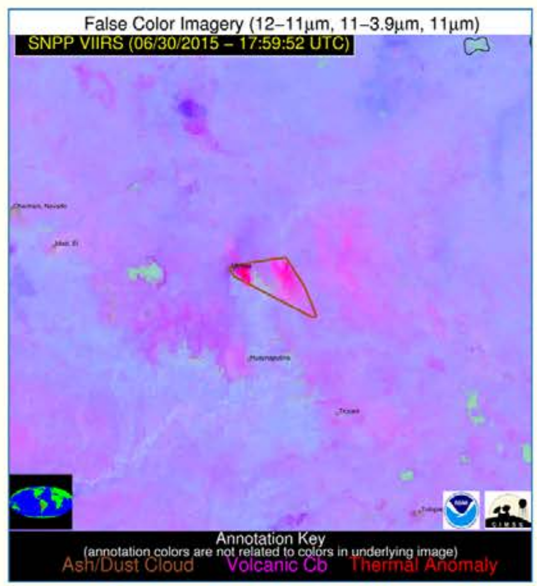
DATE:	2015-06-30
TIME:	17:59:52
Production Date and Time:	2015-06-30 21:29:46 UTC
PRIMARY INSTRUMENT:	NPP VIIRS

More details ▼

Possible Volcanic Ash Cloud



False Color Image (12-11, 11-8.5, 11) [zoomed-in]



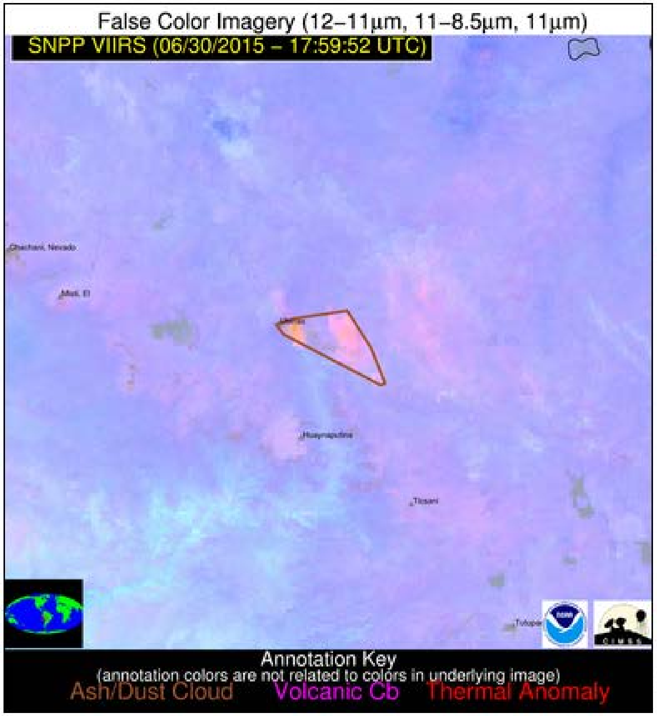
False Color Image (12-11, 11-3.9, 11) [zoomed-in]

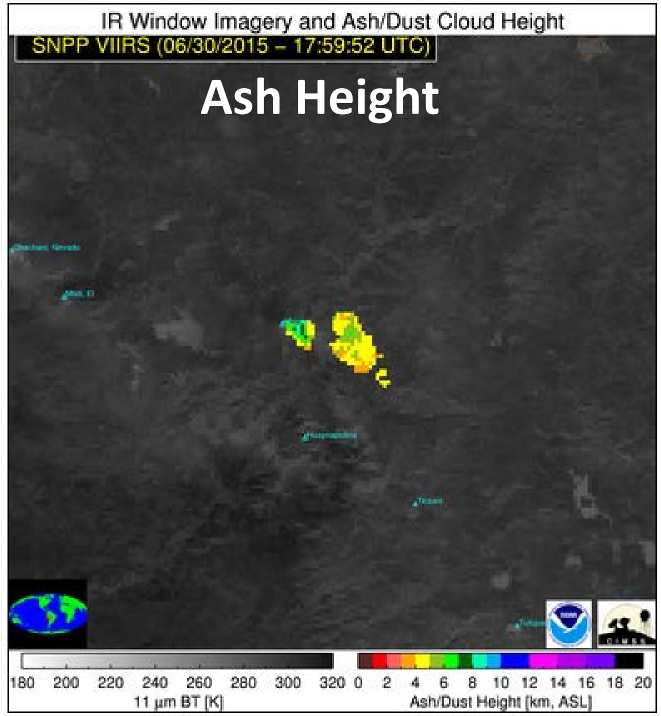
Basic Information

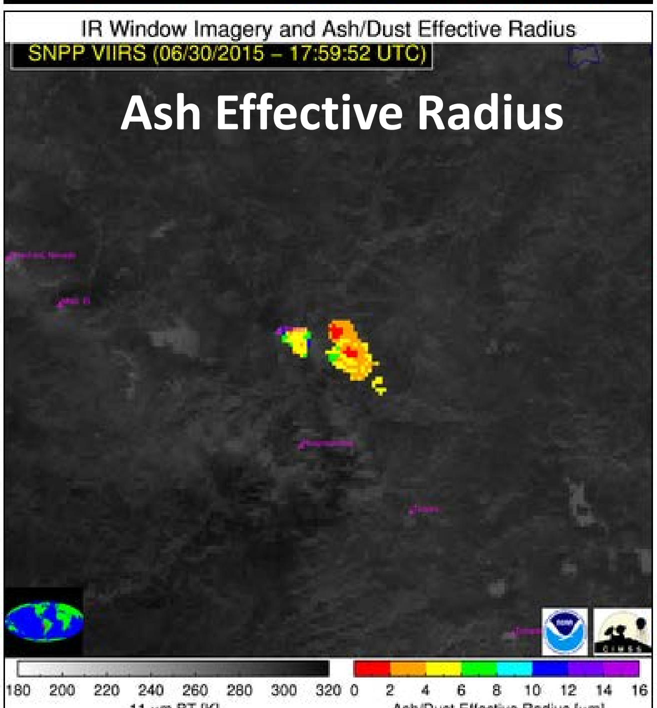
Volcanic Region(s)	South America
Country/Countries	Peru
Volcanic Subregion(s)	Peru
VAAC Region(s) of Nearby Volcanoes	Buenos Aires
Mean Object Date/Time	2015-06-30 17:59:52UTC
Radiative Center (Lat, Lon):	-16.350 °, -70.900 °
Nearby Volcanoes (meeting alert criteria):	Ubinas (0.00 km) Huaynaputina (28.70 km) Misti, El (54.50 km) Ticsani (55.30 km) Chachani, Nevado (69.40 km)
Maximum Height [AMSL]	9.30 km; 30512 ft
90th Percentile Height [AMSL]	5.60 km; 18373 ft
Mean Tropopause Height [AMSL]	16.50 km; 54134 ft

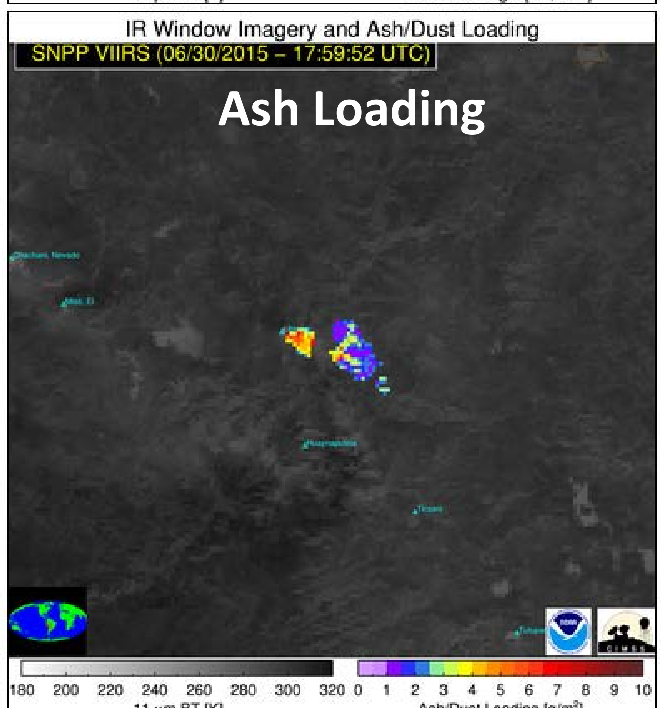
Show More ▲

View all event imagery »





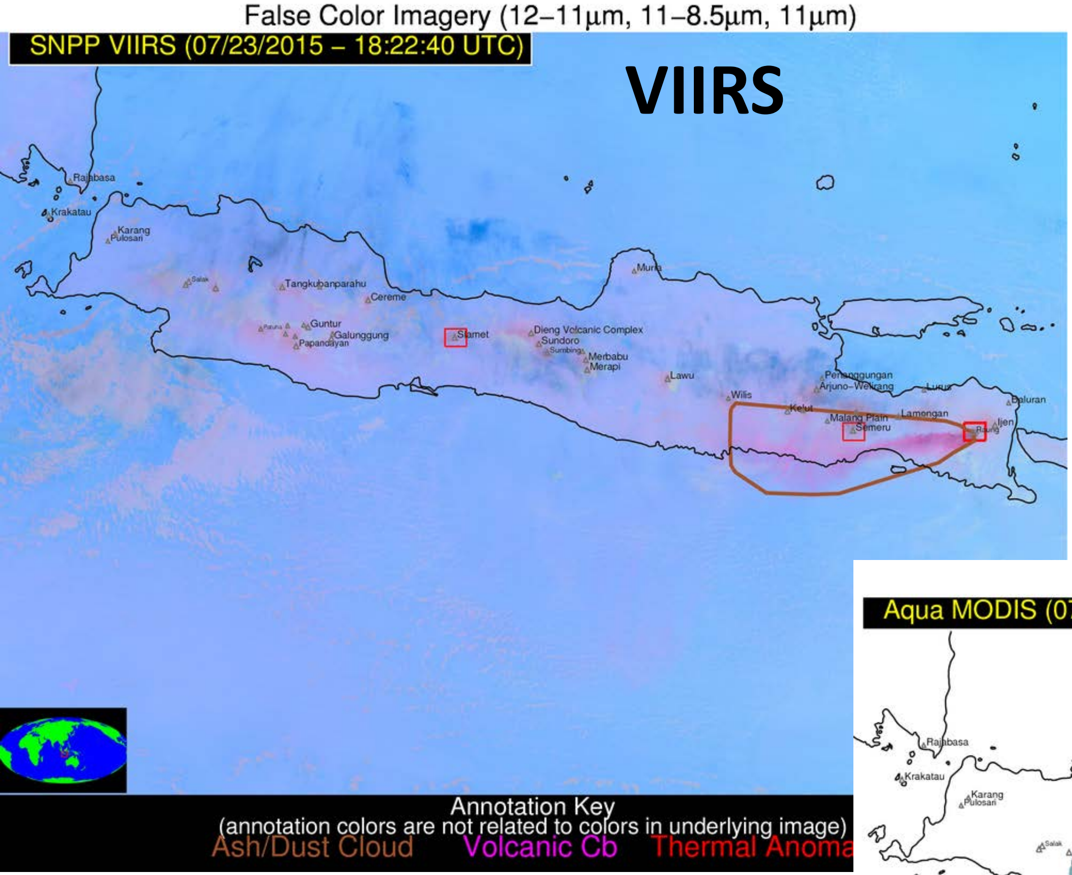


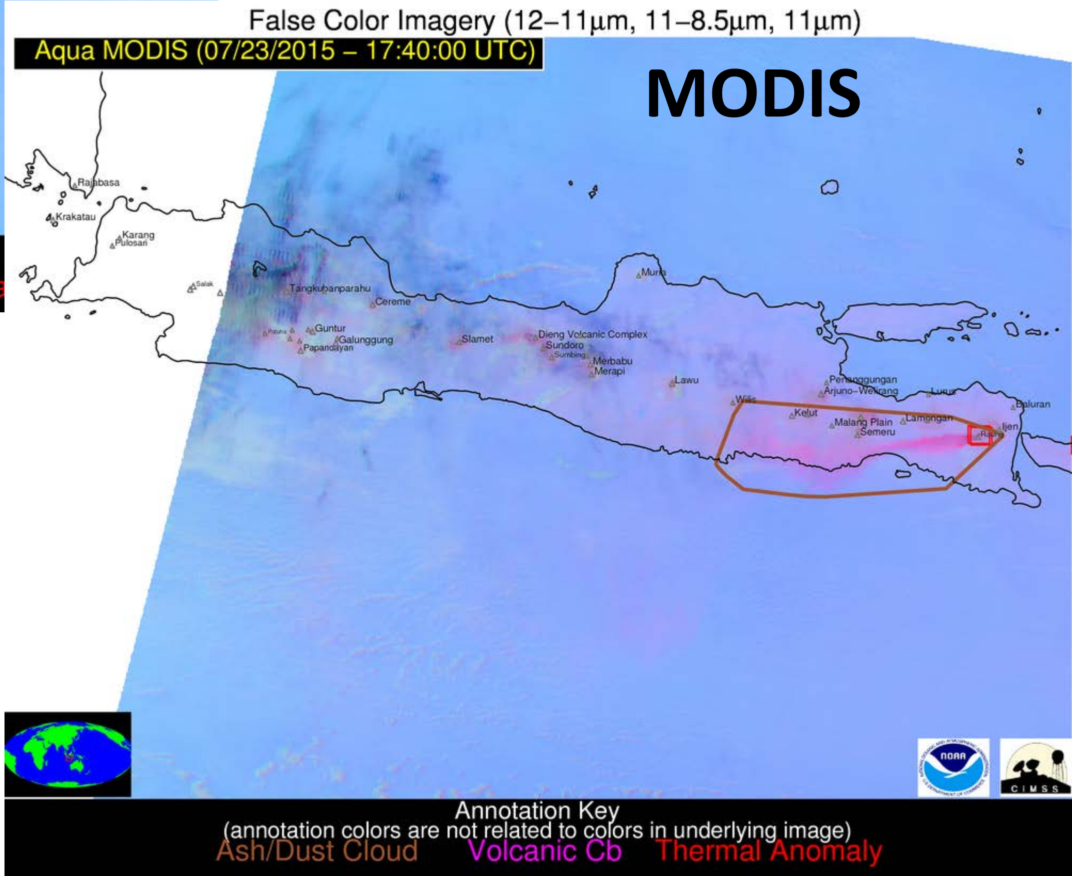


Detect and characterize

Ubinas (Peru): June 30, 2015

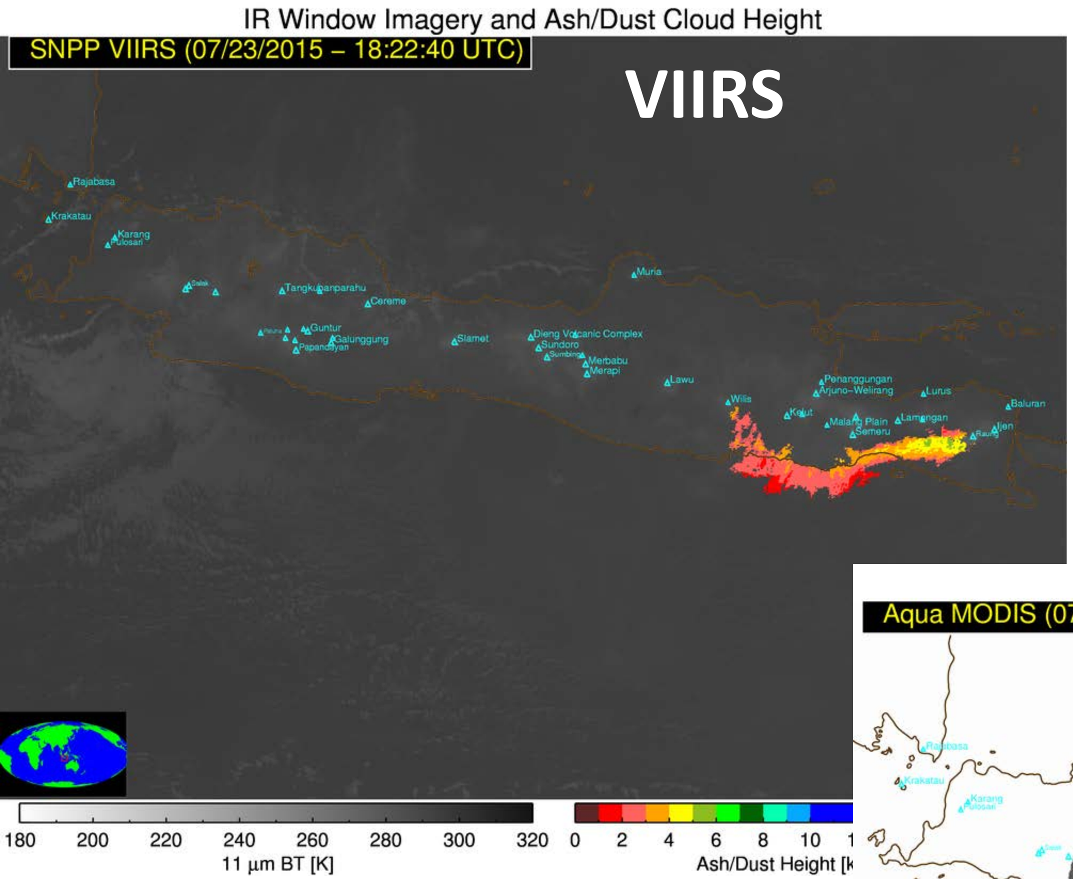
Raung (Indonesia)
July 23, 2015

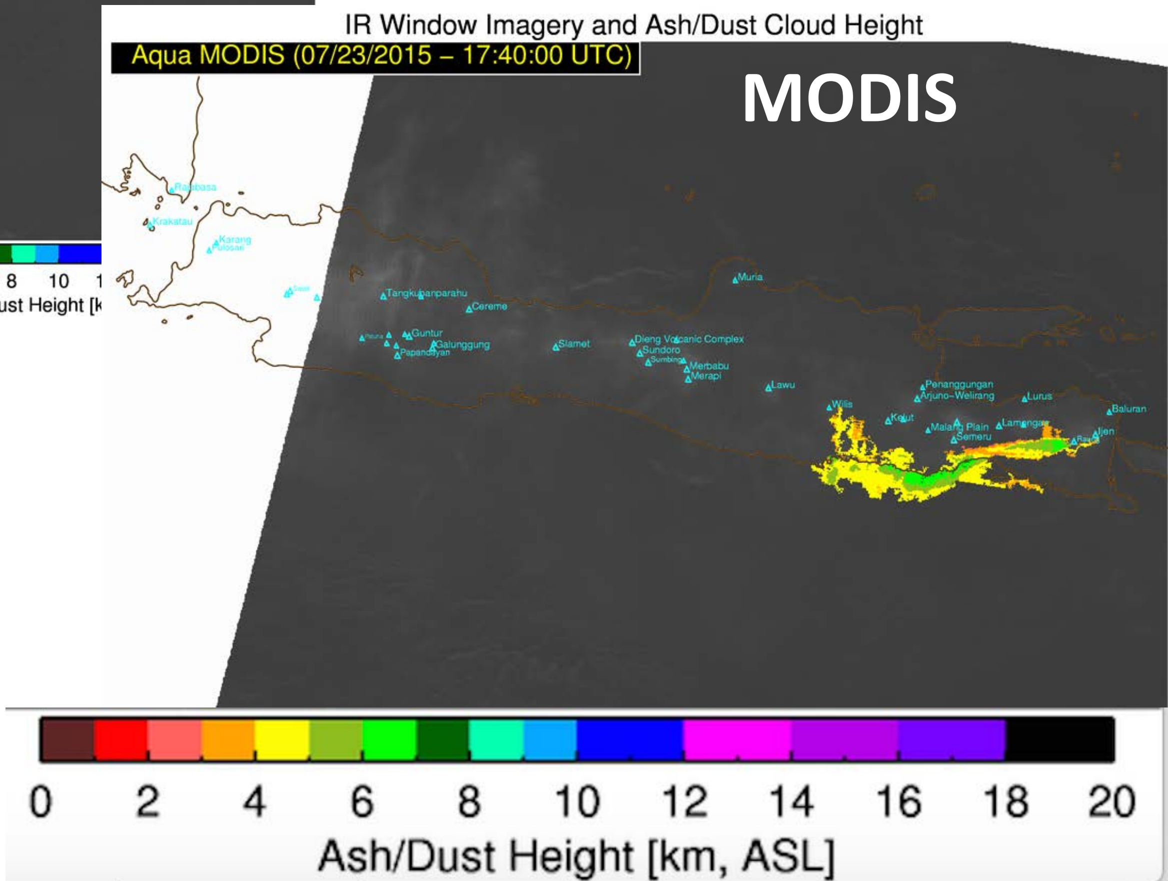




Raung (Indonesia)
July 23, 2015

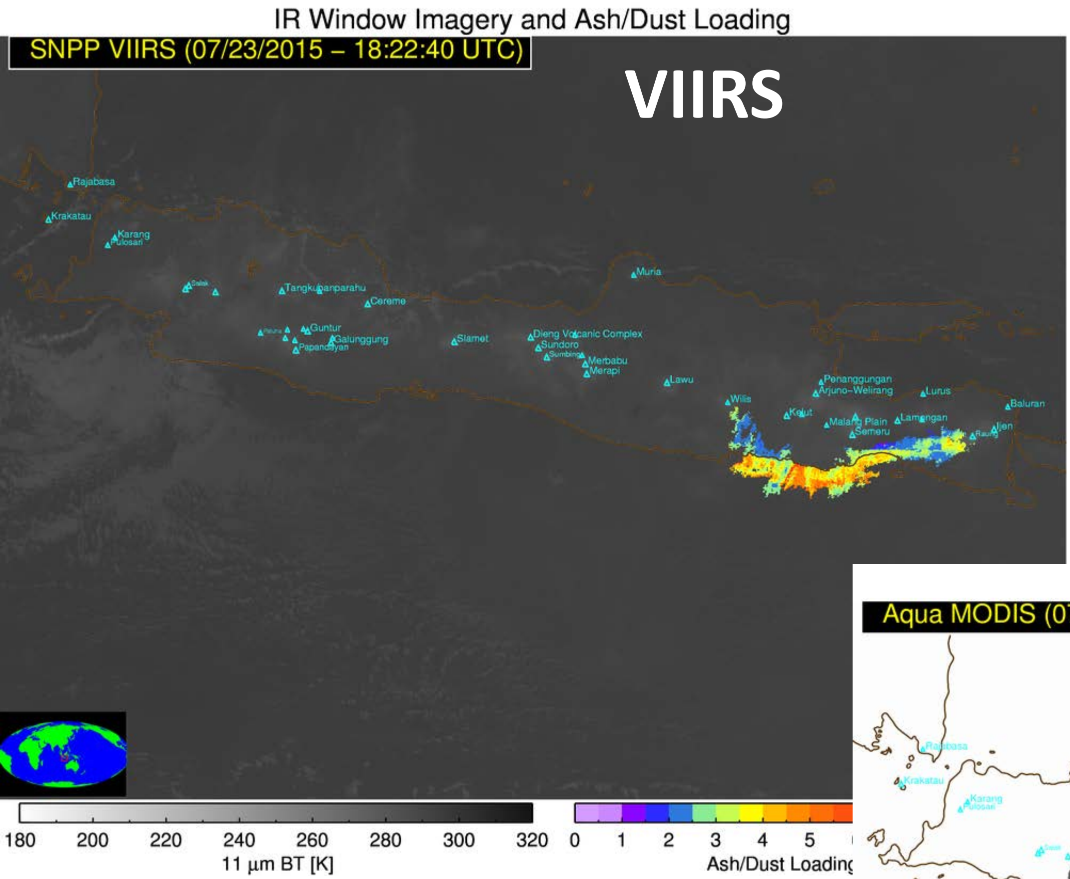
Ash Cloud Height

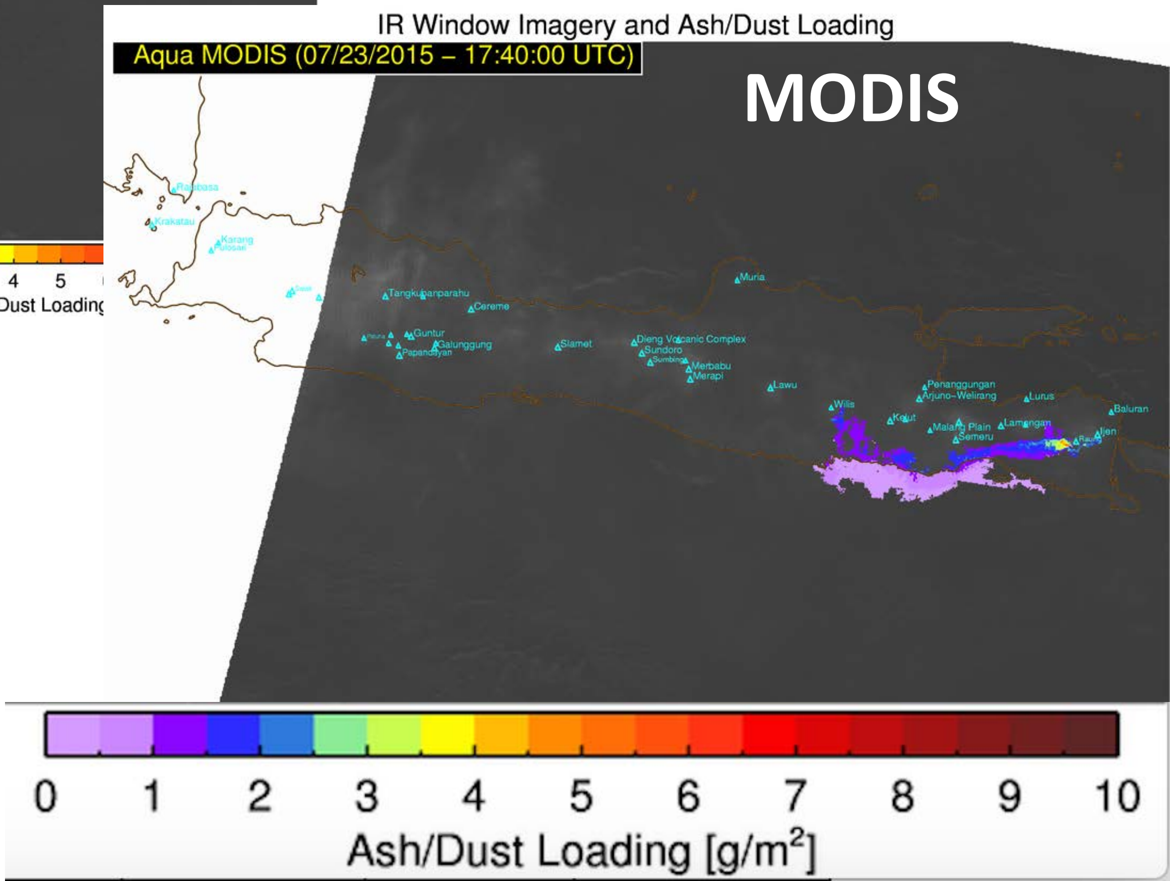




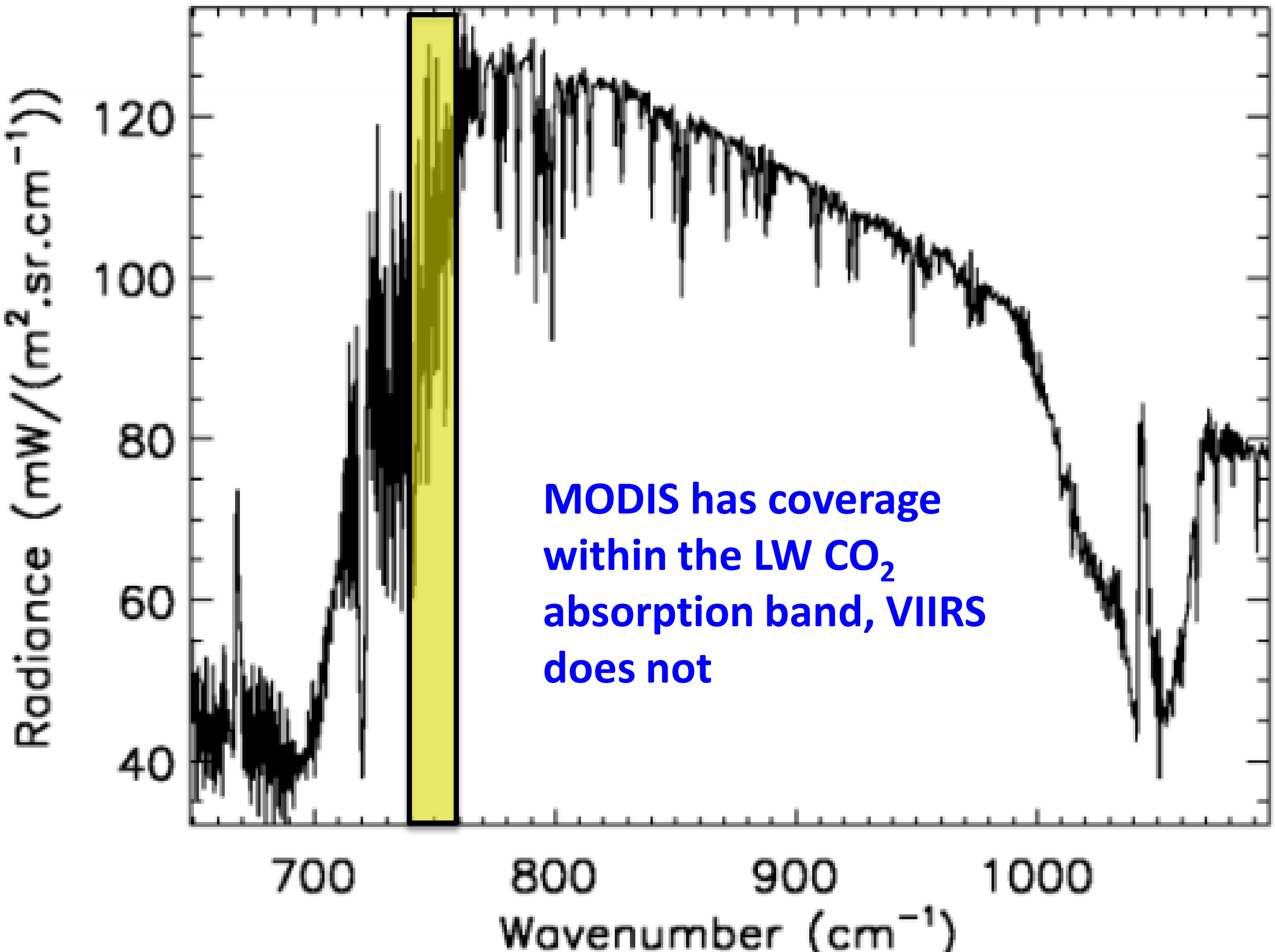
Raung (Indonesia)
July 23, 2015

Ash Mass Loading





Absorption channels are needed to gain sensitivity to cloud height - VIIRS + CrIS can be used to obtain high quality IR-based cloud property retrievals



MODIS has coverage within the LW CO_2 absorption band, VIIRS does not

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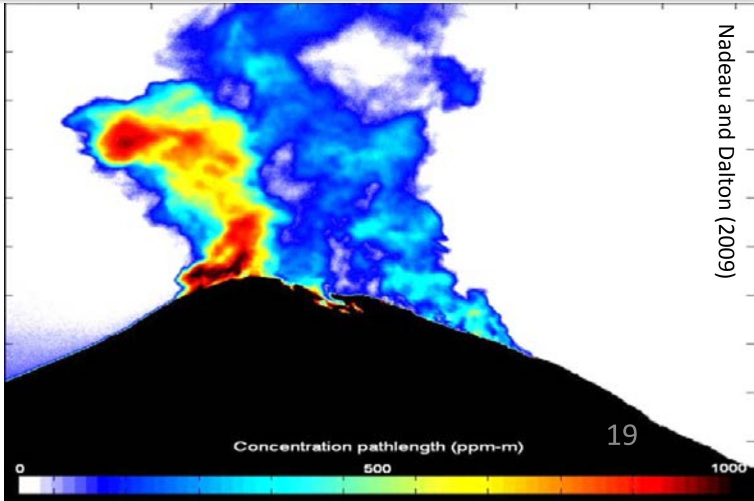


Nadeau and Dalton (2009)

Calbucco, Chile
April 22-23, 2015

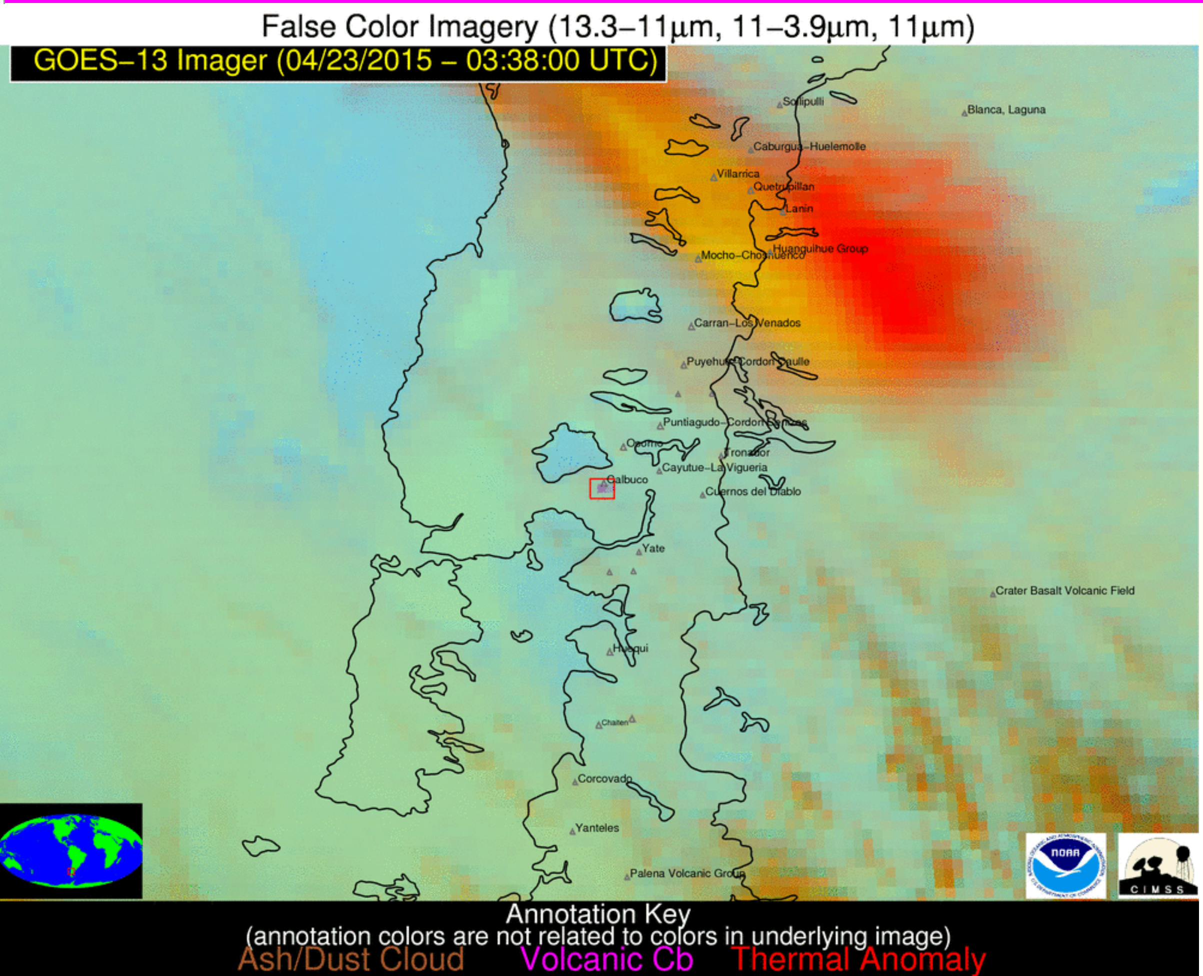

Servicio Nacional de Geología y Minería


David Cortes Serey - AP

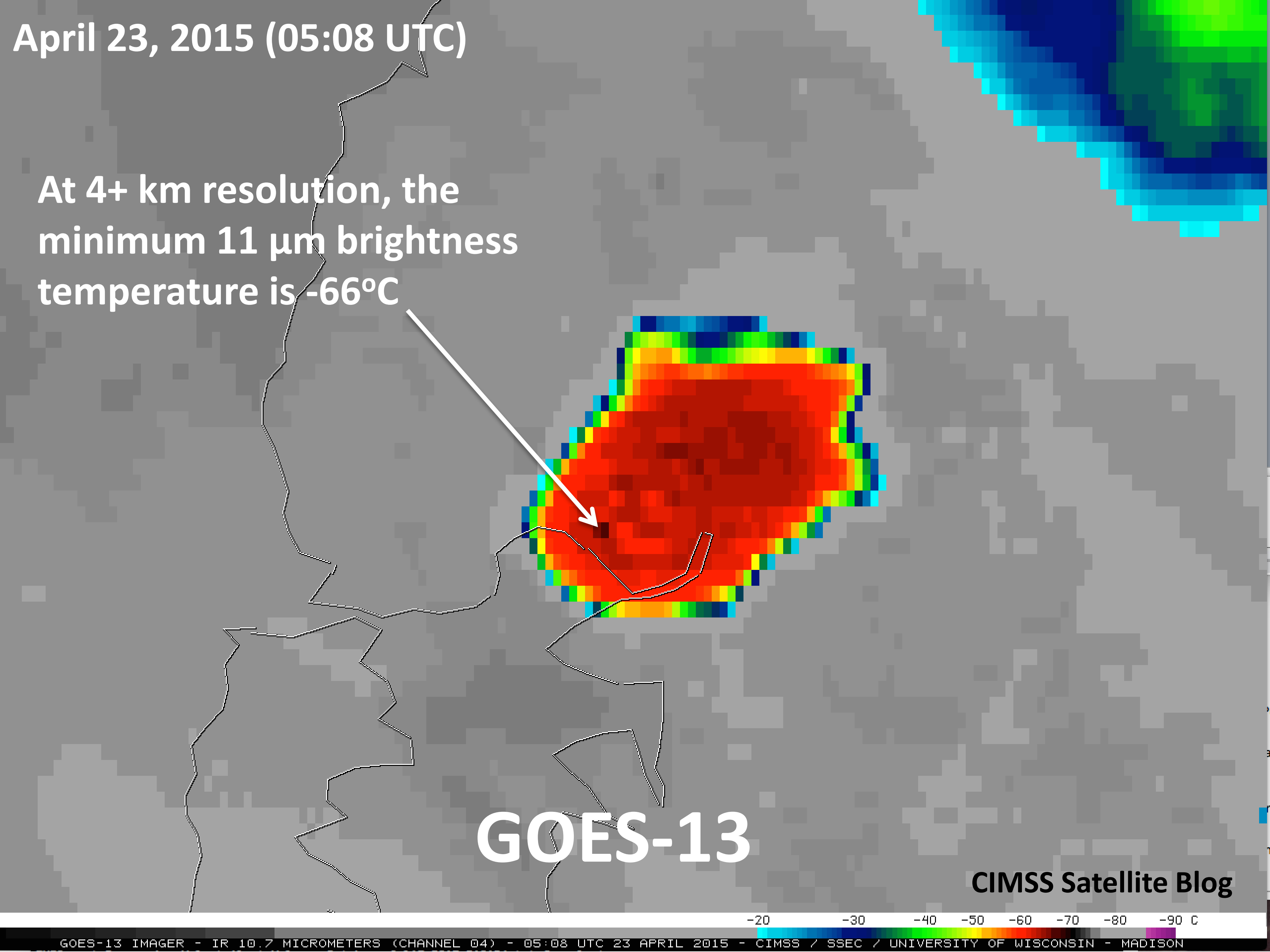

Diego Main- Getty Images

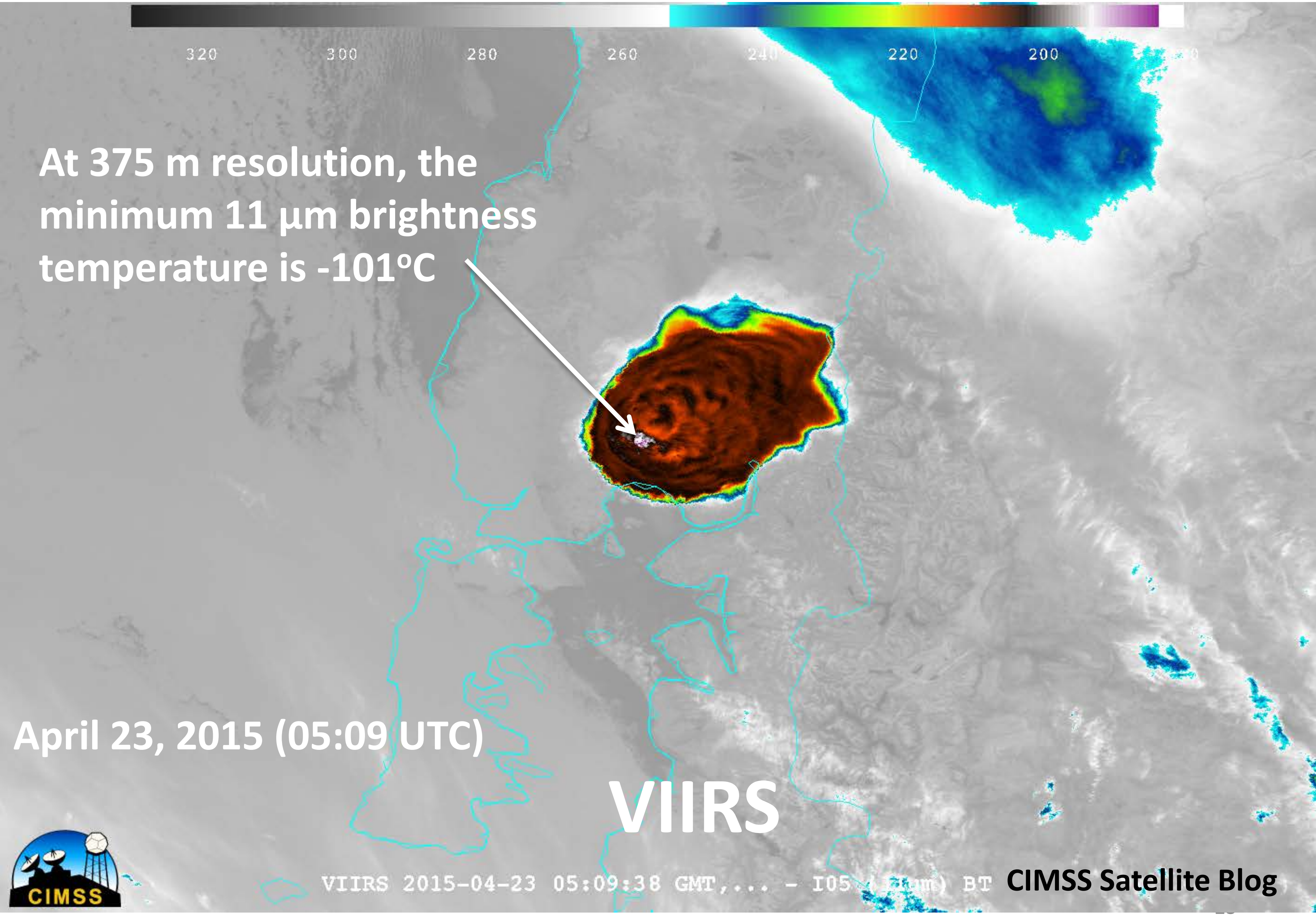
Geostationary satellites are needed for timely detection of explosive eruptions, but JPSS adds significant value – benefit of a multi-sensor/ multi-orbit approach

Possible Volcanic Cb

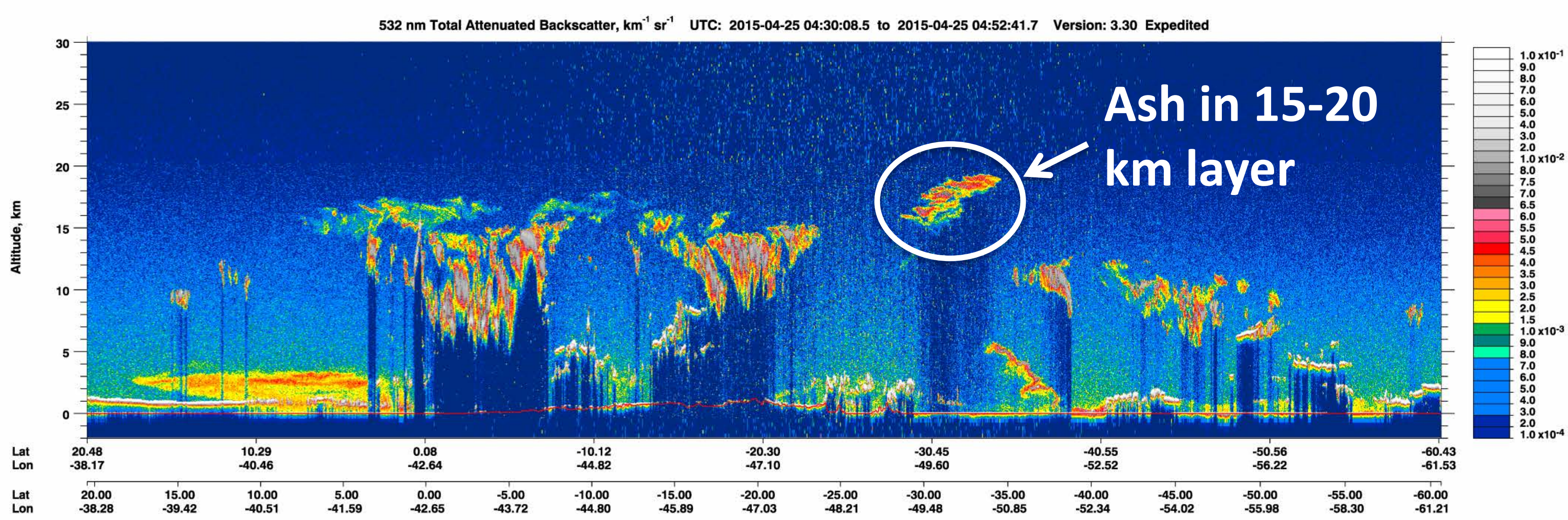


Basic Information	
VAAC Regions of Nearby Volcanoes	Buenos Aires
Mean Object Date/Time	2015-04-23 04:11:48UTC
Radiative Center (Lat, Lon):	-41.310 °, -72.570 °
Nearby Volcanoes (meeting alert criteria):	Calbuco (3.20 km)
Trend in IR Brightness Temperature	-59.50 °C
Vertical Growth Rate Time Interval	30 minutes
Vertical Growth Rate Anomaly	11.50 number of stddev above mean
Total Area	515.00 km^2
Additional Information	
Alert Status	New Alert Object
Mean Viewing Angle	48.10 °
Mean Solar Zenith Angle	149.50 °
Maximum Height [AMSL]	11.70 km; 38386 ft
90th Percentile Height [AMSL]	11.10 km; 36417 ft
Mean Tropopause Height [AMSL]	12.10 km; 39698 ft
Geographic Regions of Nearby Volcanoes	Chile-S


April 23, 2015 (05:08 UTC)
At 4+ km resolution, the minimum 11 µm brightness temperature is -66ºC
GOES-13
CIMSS Satellite Blog
-20 -30 -40 -50 -60 -70 -80 -90 C
GOES-13 IMAGER - IR 10.7 MICROMETERS (CHANNEL 04) - 05:08 UTC 23 APRIL 2015 - CIMSS / SSEC / UNIVERSITY OF WISCONSIN - MADISON


320
300
280
260
240
220
200
At 375 m resolution, the minimum 11 µm brightness temperature is -101°C
April 23, 2015 (05:09 UTC)
VIIRS
CIMSS
VIIRS 2015-04-23 05:09:38 GMT,... - I05
BT
CIMSS Satellite Blog

NASA's CALIOP lidar later verified that ash was present at least up to 20 km!



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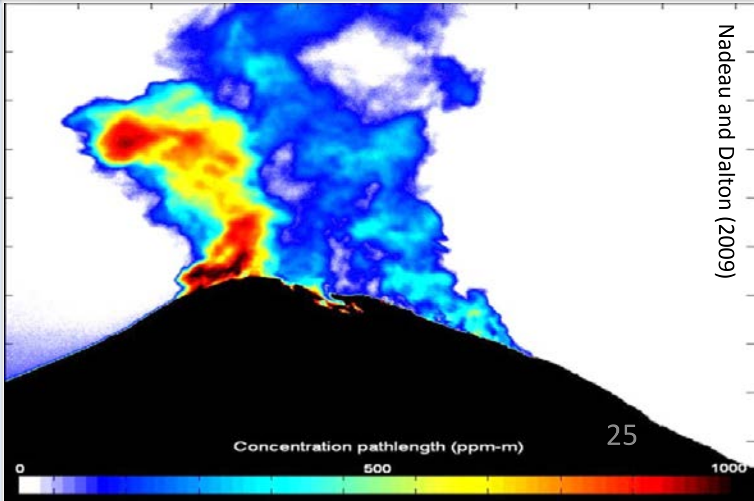
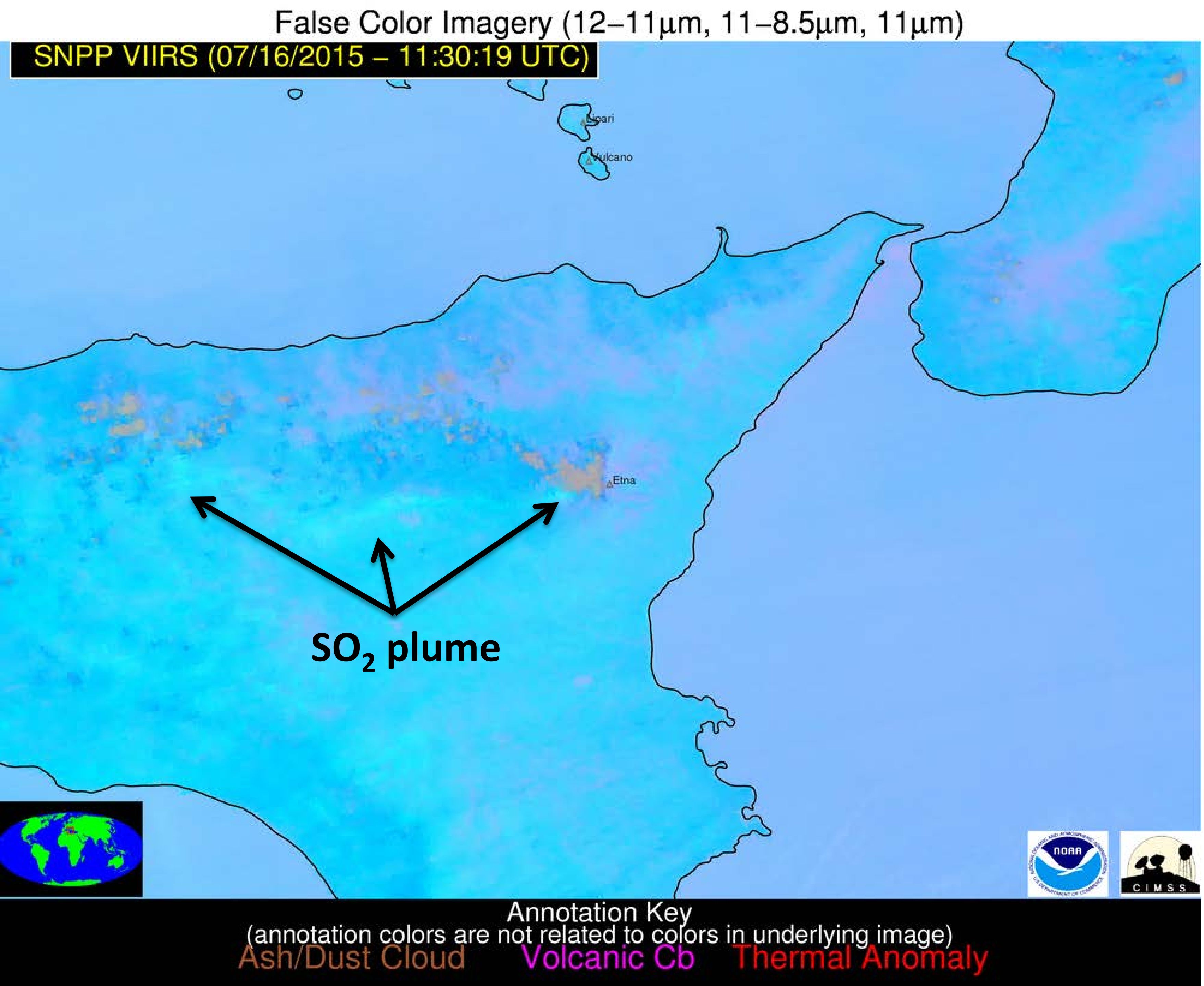
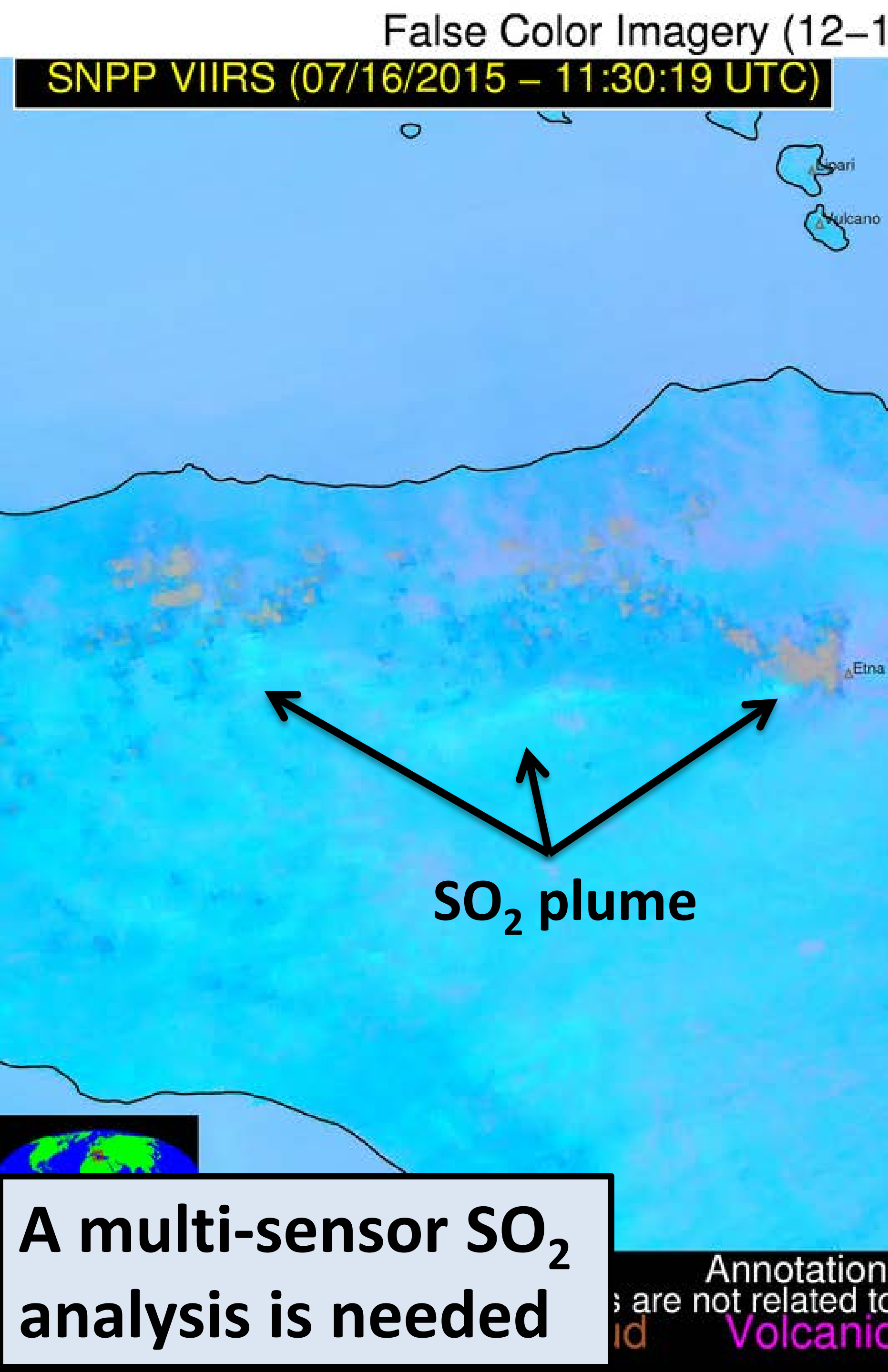
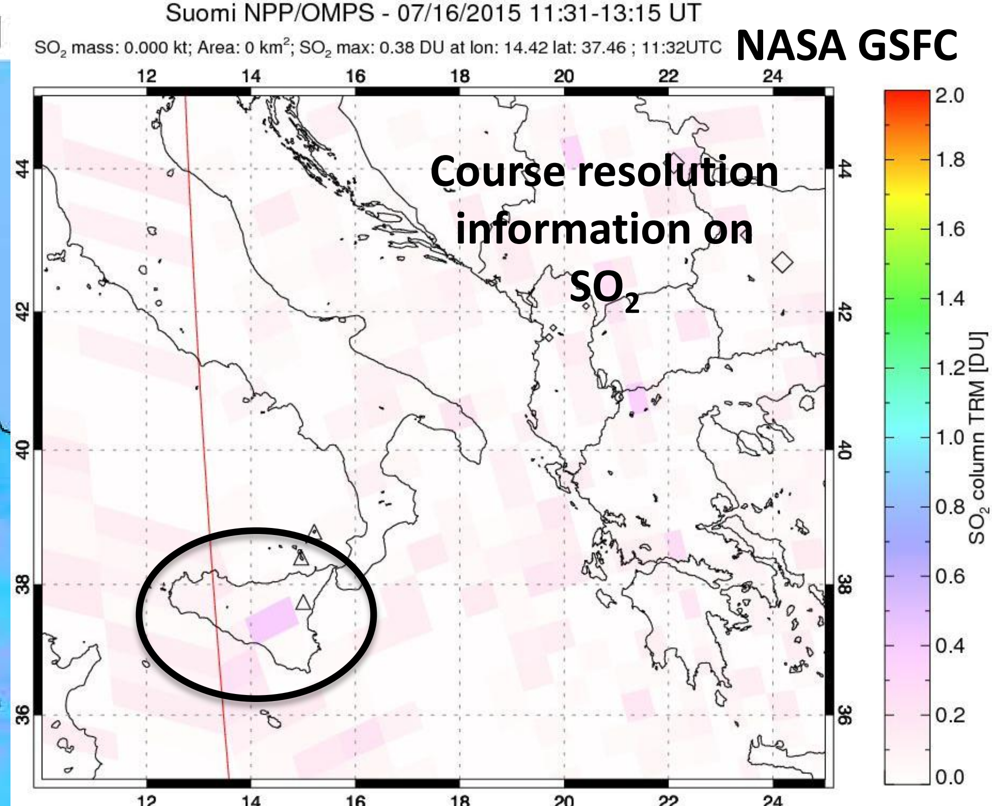


Nadeau and Dalton (2009)


False Color Imagery (12–11µm, 11–8.5µm, 11µm)
SNPP VIIRS (07/16/2015 – 11:30:19 UTC)
Lipari
Vulcano
Etna
SO2 plume
Annotation Key
(annotation colors are not related to colors in underlying image)
Ash/Dust Cloud
Volcanic Cb
Thermal Anomaly





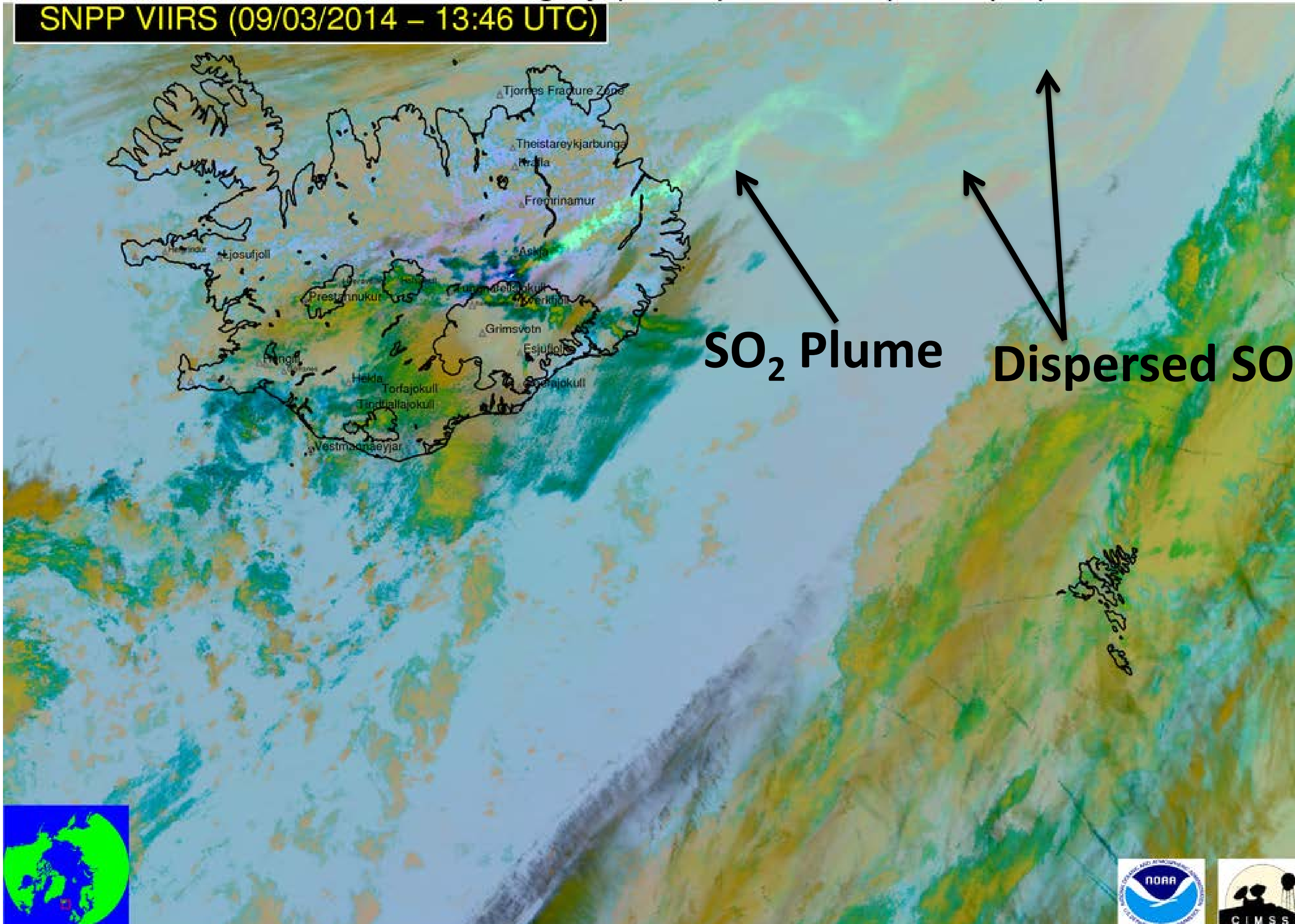
NASA GSFC

Course resolution information on SO_2

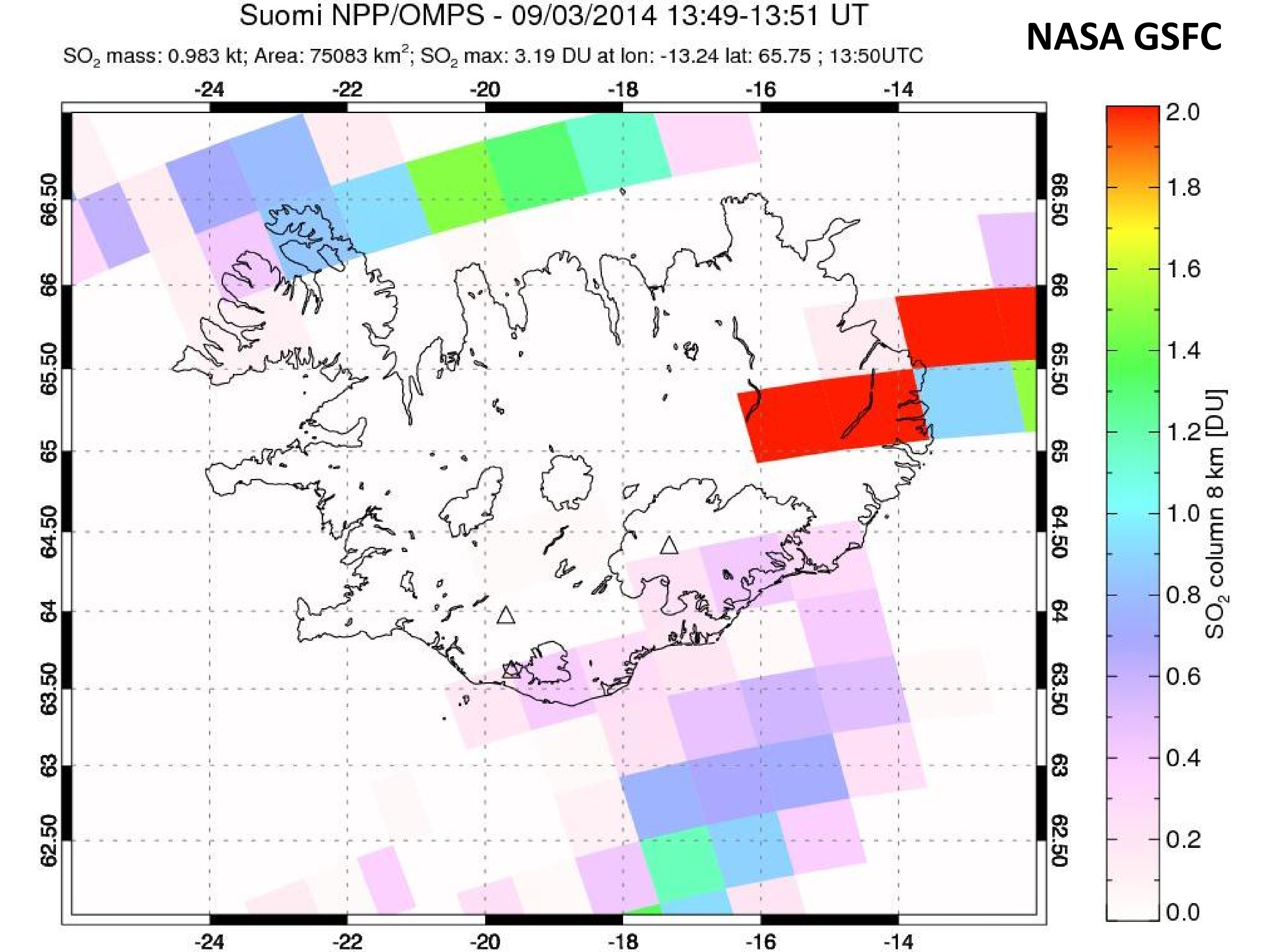
SO_2 plume

A multi-sensor SO_2 analysis is needed

False Color Imagery (12–11μm, 11–8.5μm, 11μm)



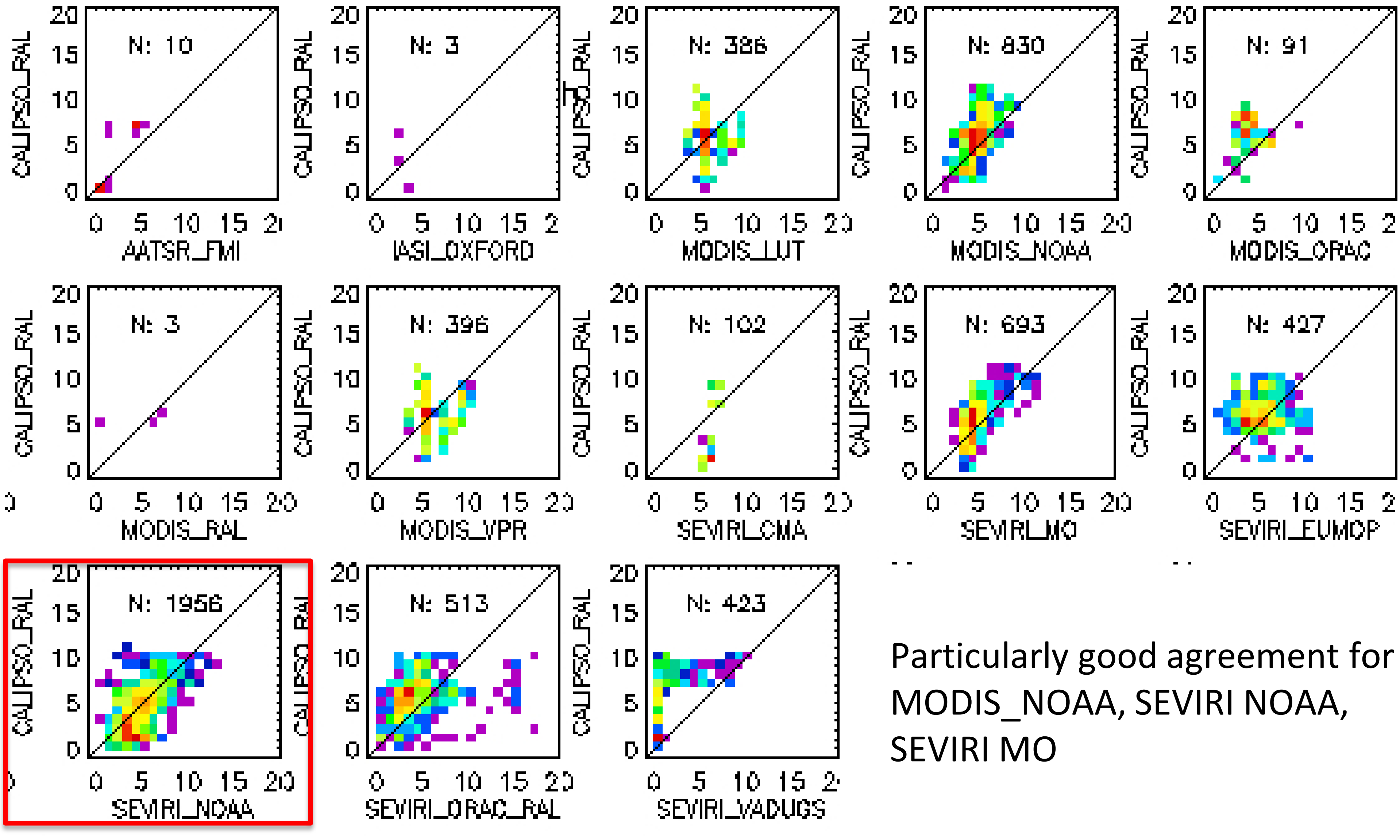
Annotation Key
(annotation colors are not related to colors in underlying image)
Ash/Dust Cloud   Volcanic Cb SO_2 Thermal Anomaly


Suomi NPP/OMPS - 09/03/2014 13:49-13:51 UT
NASA GSFC
SO2 mass: 0.983 kt; Area: 75083 km2; SO2 max: 3.19 DU at lon: -13.24 lat: 65.75 ; 13:50UTC
-24
-22
-20
-18
-16
-14
66.50
66
65.50
65
64.50
64
63.50
63
62.50
SO2 column 8 km [DU]
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0

WMO Intercomparison of Satellite-based Volcanic Ash Retrieval Algorithms Workshop

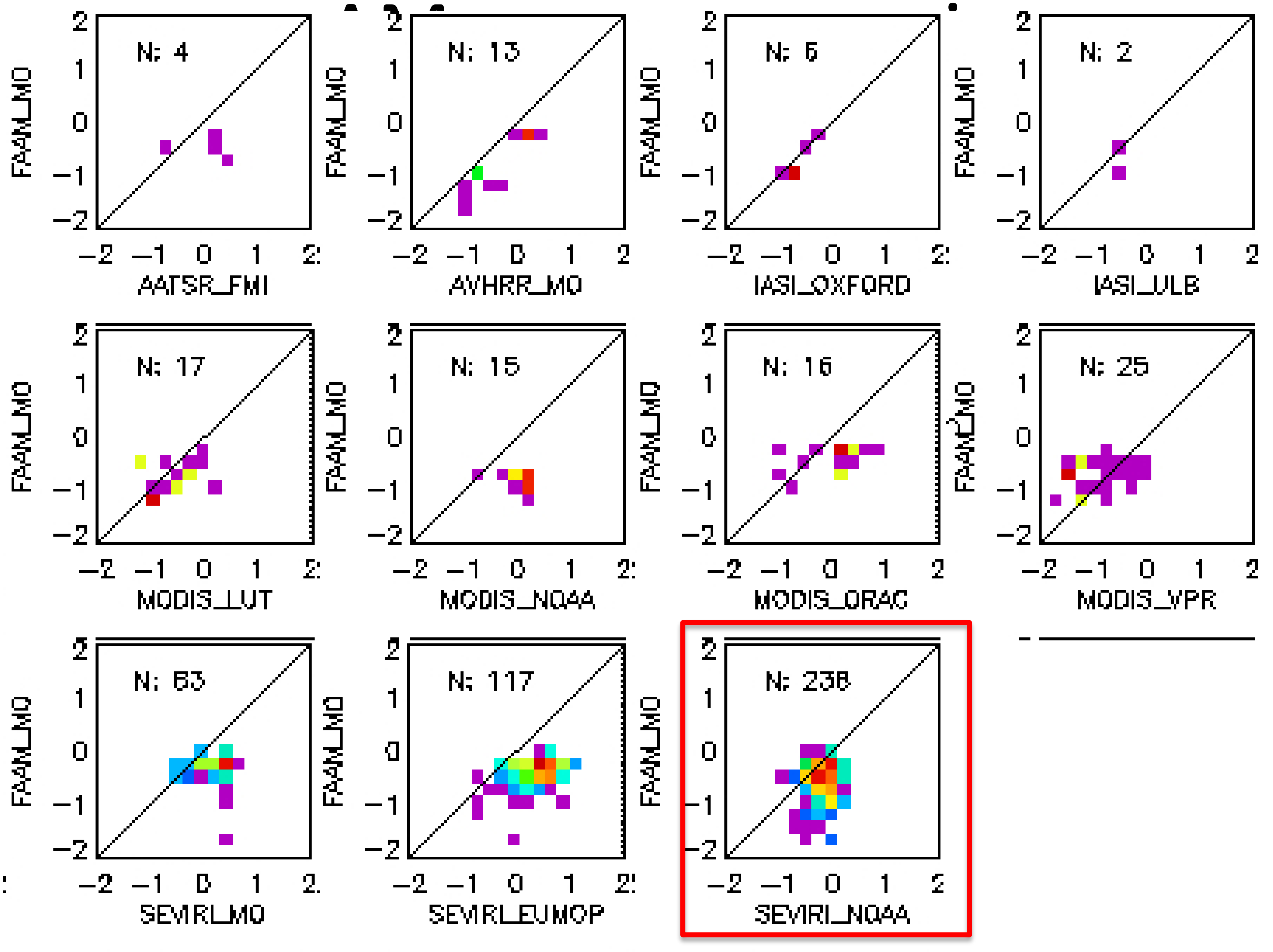
29 June - 2 July 2015
The Pyle Center
University of Wisconsin-Madison

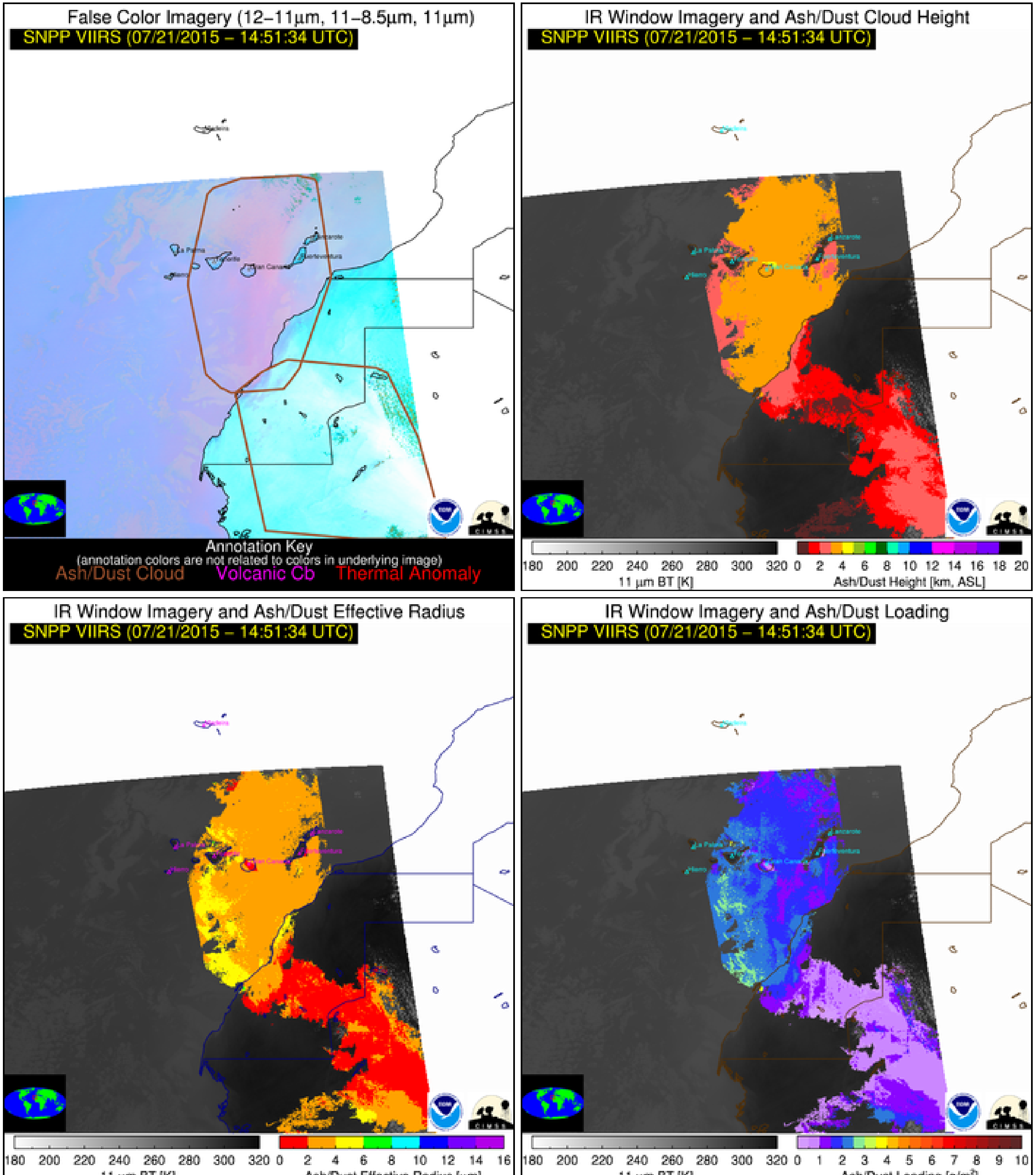
CALIOP Ash Cloud Height Validation



Particularly good agreement for MODIS_NOAA, SEVIRI NOAA, SEVIRI MO

Aircraft-based Ash Mass Loading Validation



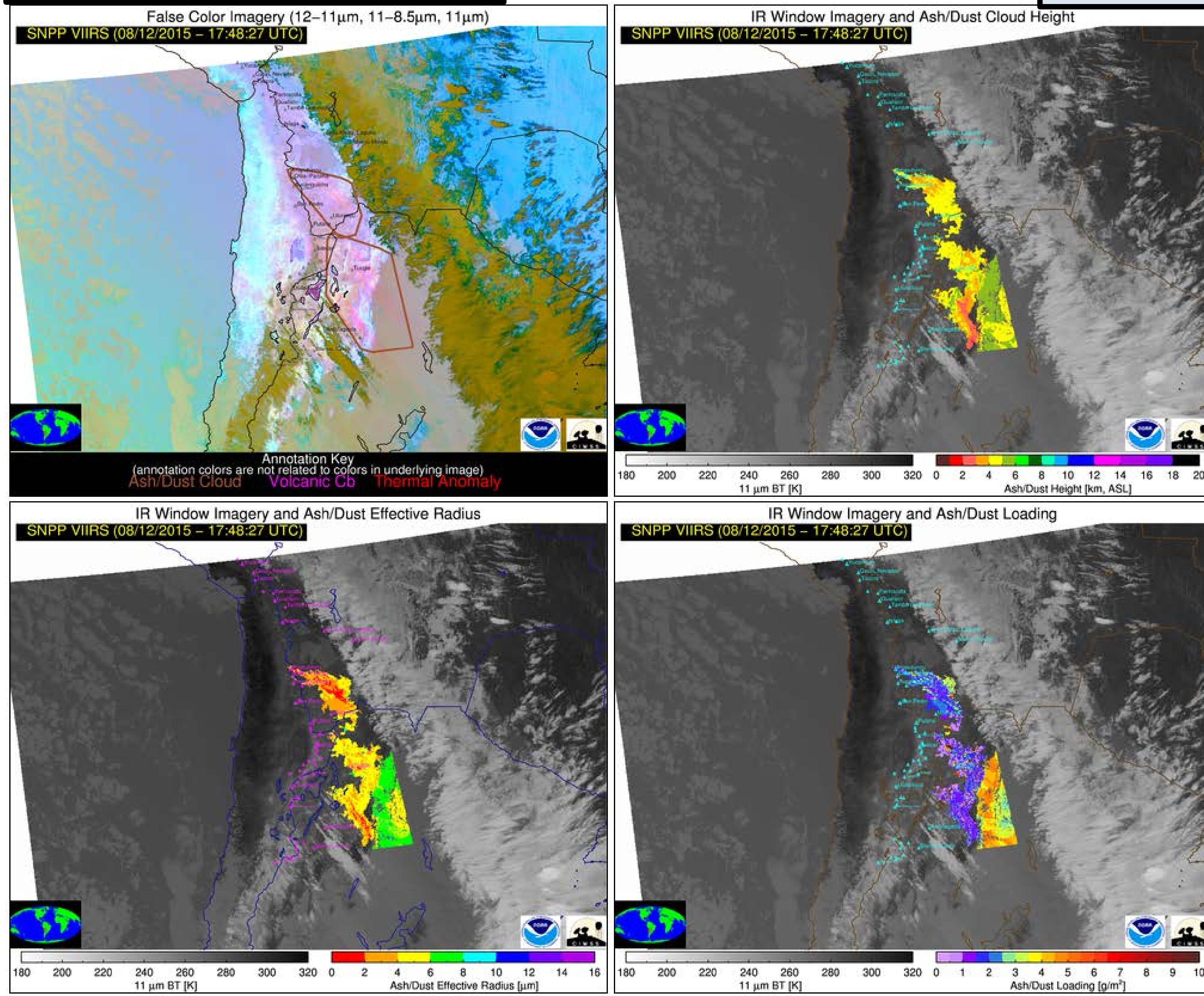


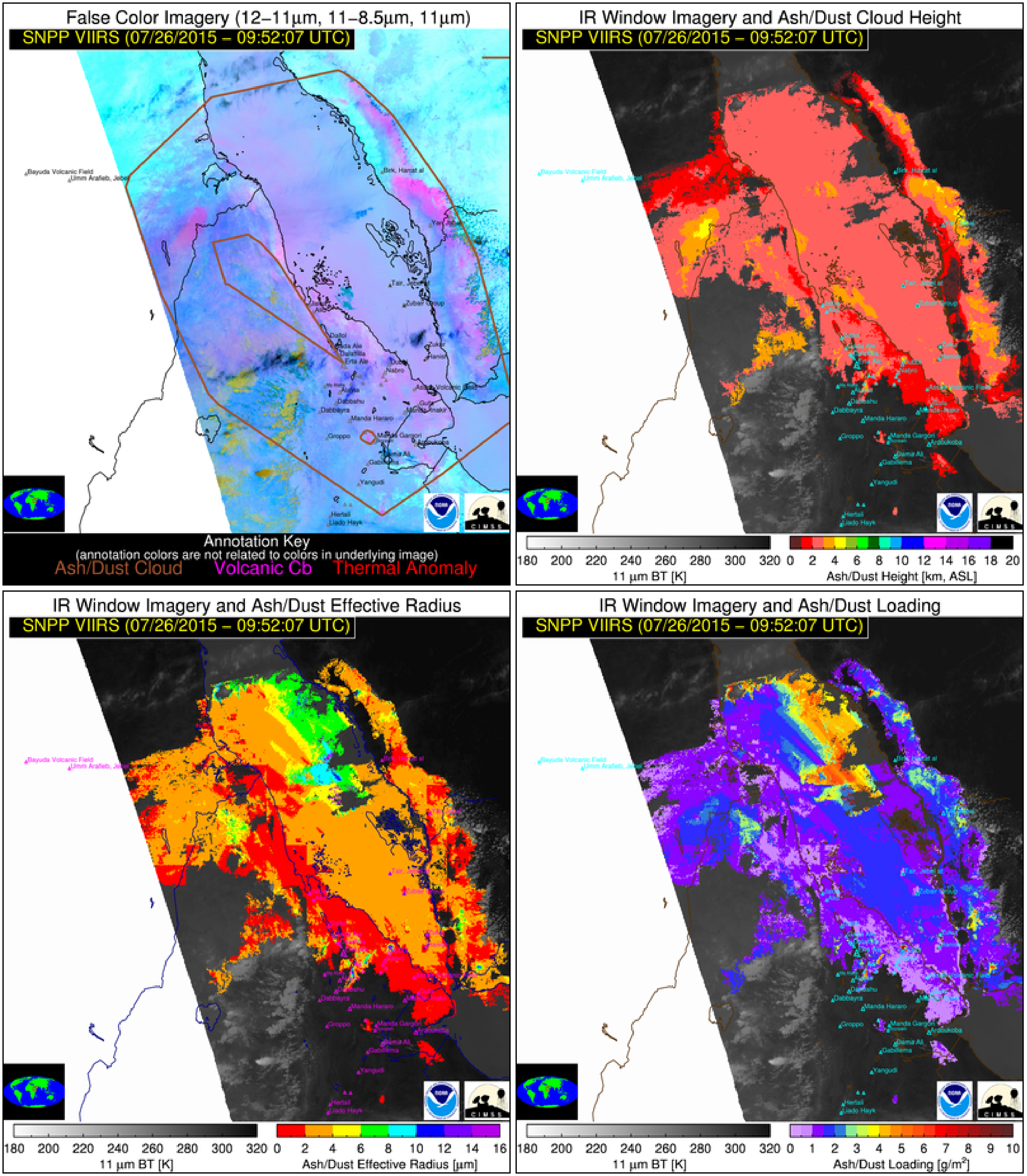
Application to desert dust

Day and night, Land and water

Application to desert dust

Day and night, Land and water





Application to desert dust

Day and night, Land and water

Summary

- **In the era of "Big Data" automation is critical for generating environmental intelligence for mitigating natural hazards**
- **Low latency (< 20 minutes) data are critical (need to utilize DB sites to the fullest extent)**
- **The IDPS aerosol and VCM products are not well suited for volcanic cloud applications across the full spectrum of cloud types. The JPSS Risk Reduction projects are a significant improvement, but the multi-sensor VOLCAT system is the long-term solution.**

References

- Pavolonis, M. J., W. F. Feltz, A. K. Heidinger, and G. M. Gallina, 2006: A daytime complement to the reverse absorption technique for improved automated detection of volcanic ash. J.Atmos.Ocean.Technol., 23, 1422-1444.

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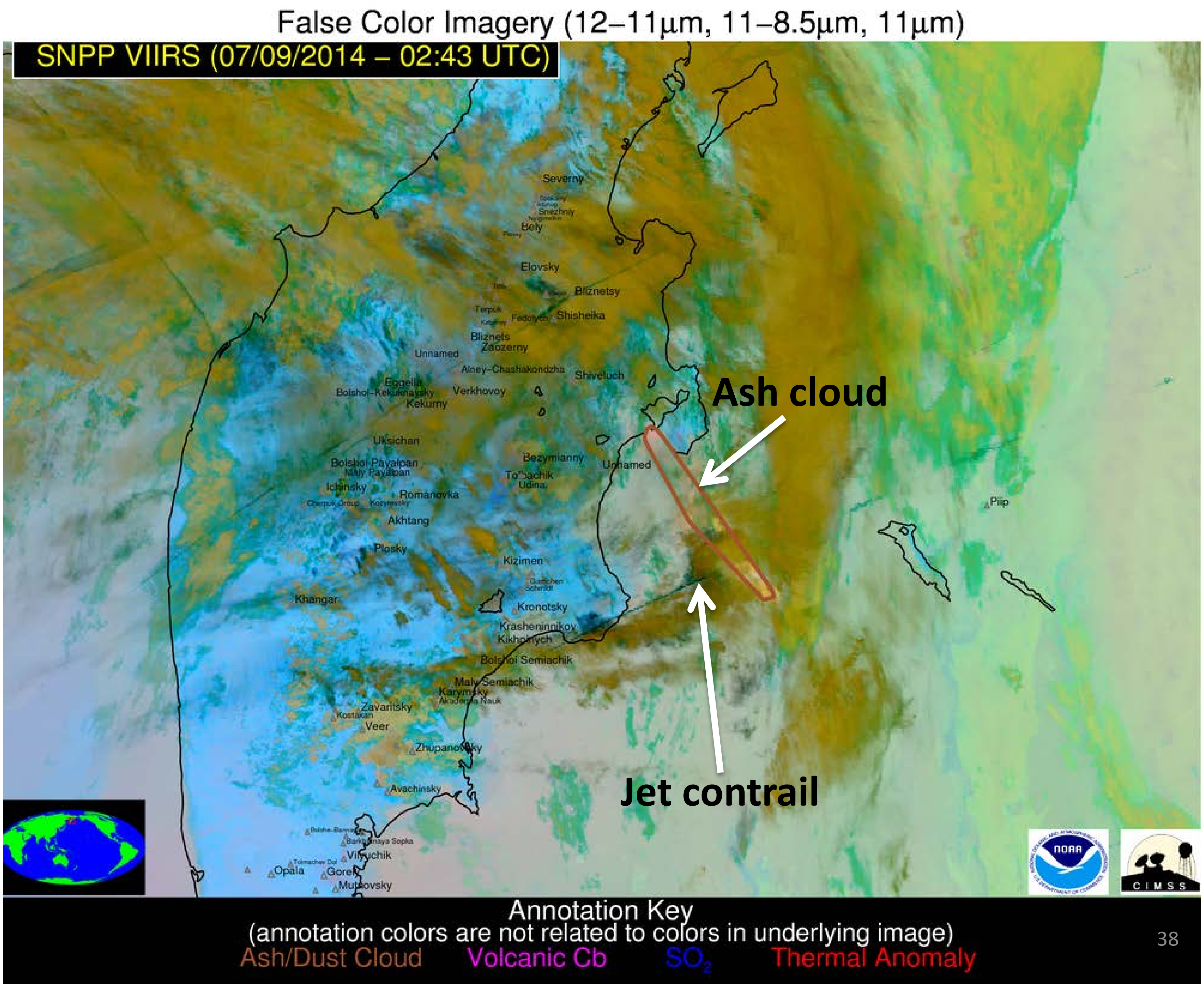
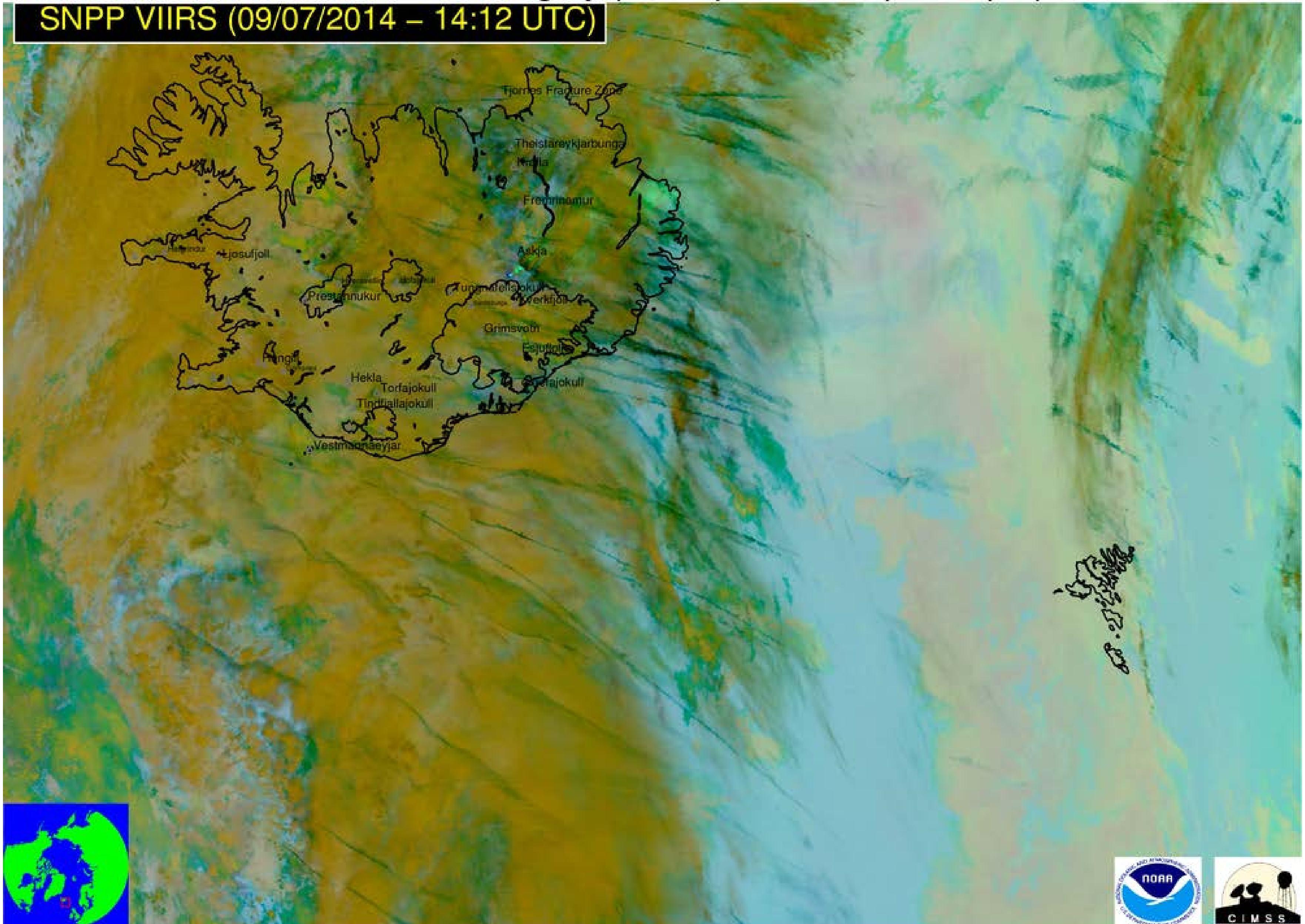
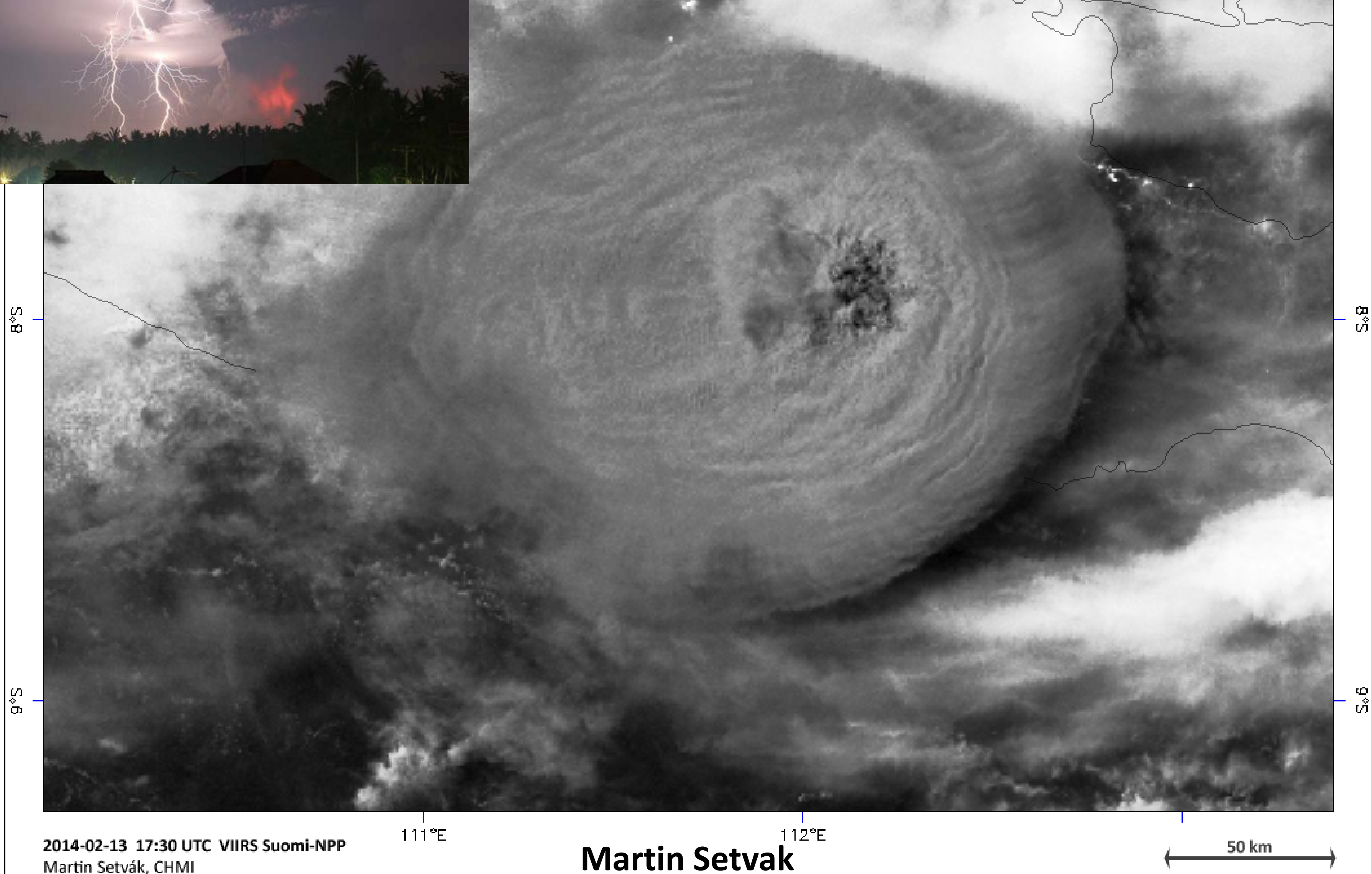

False Color Imagery (12–11µm, 11–8.5µm, 11µm)
SNPP VIIRS (07/09/2014 – 02:43 UTC)
Ash cloud
Jet contrail
Severny
Snezhniy
Bely
Elovsky
Bliznetsy
Shisheika
Bliznets
Zaozerny
Unnamed
Alney-Chashakondzha
Sheveluch
Eggella
Bolshoi-Kekuknaysky
Verkhovoy
Kekurny
Uksichan
Bezymianny
Bolshoi Payalpan
Maly Payalpan
Tolbachik
Udina
Ichinsky
Romanovka
Akhtang
Plosky
Kizimen
Khangar
Kronotsky
Krasheninnikov
Kikhpinych
Bolshoi Semiachik
Maly Semiachik
Karymsky
Zavaritsky
Veer
Zhupanovsky
Avachinsky
Piip
Vilyuchik
Opala
Gorely
Mutnovsky
Annotation Key
(annotation colors are not related to colors in underlying image)
Ash/Dust Cloud Volcanic Cb SO2 Thermal Anomaly

False Color Imagery (12–11µm, 11–8.5µm, 11µm)



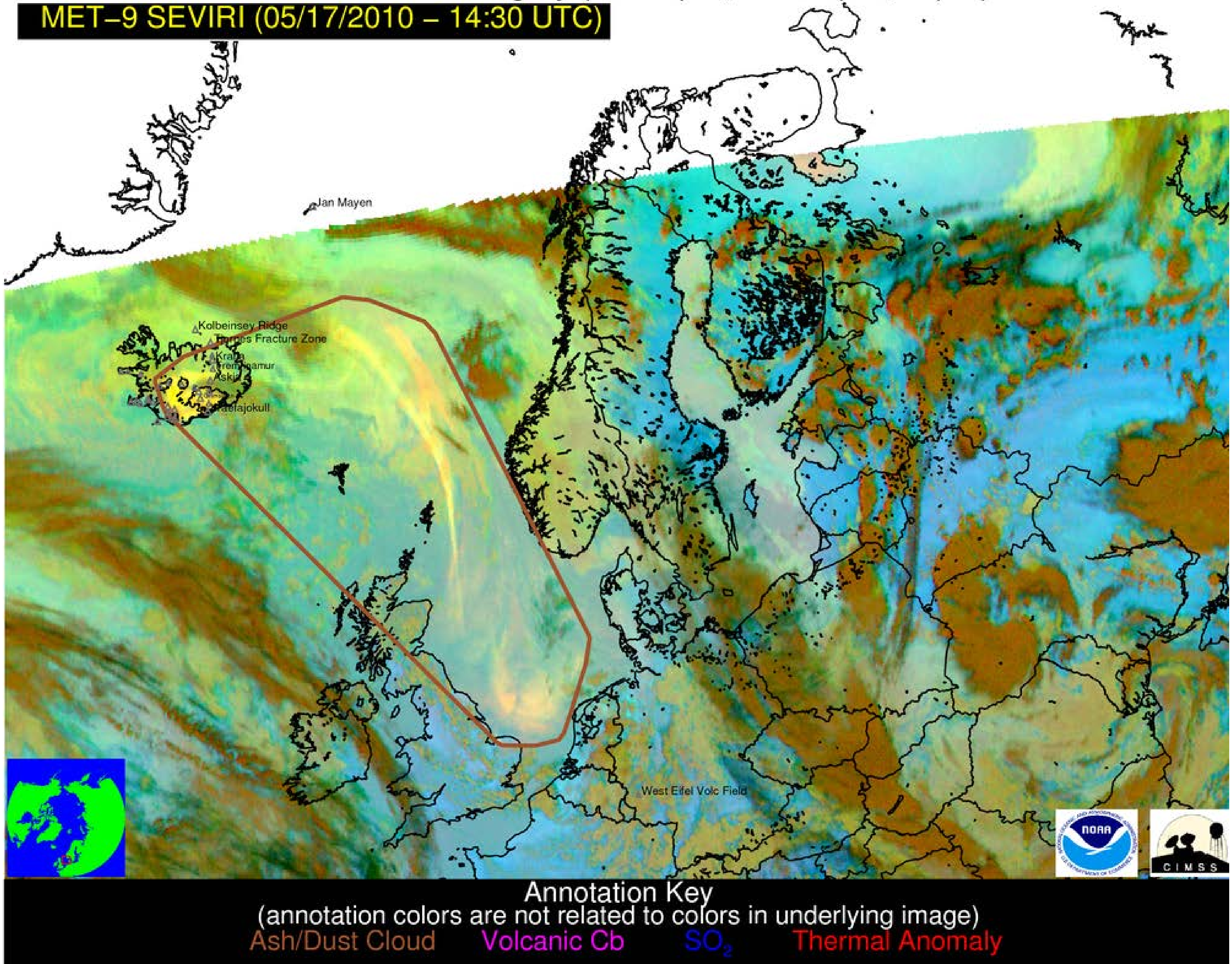
Annotation Key
(annotation colors are not related to colors in underlying image)
Ash/Dust Cloud Volcanic Cb SO_2 Thermal Anomaly

Kelut Eruption (February 13, 2014)

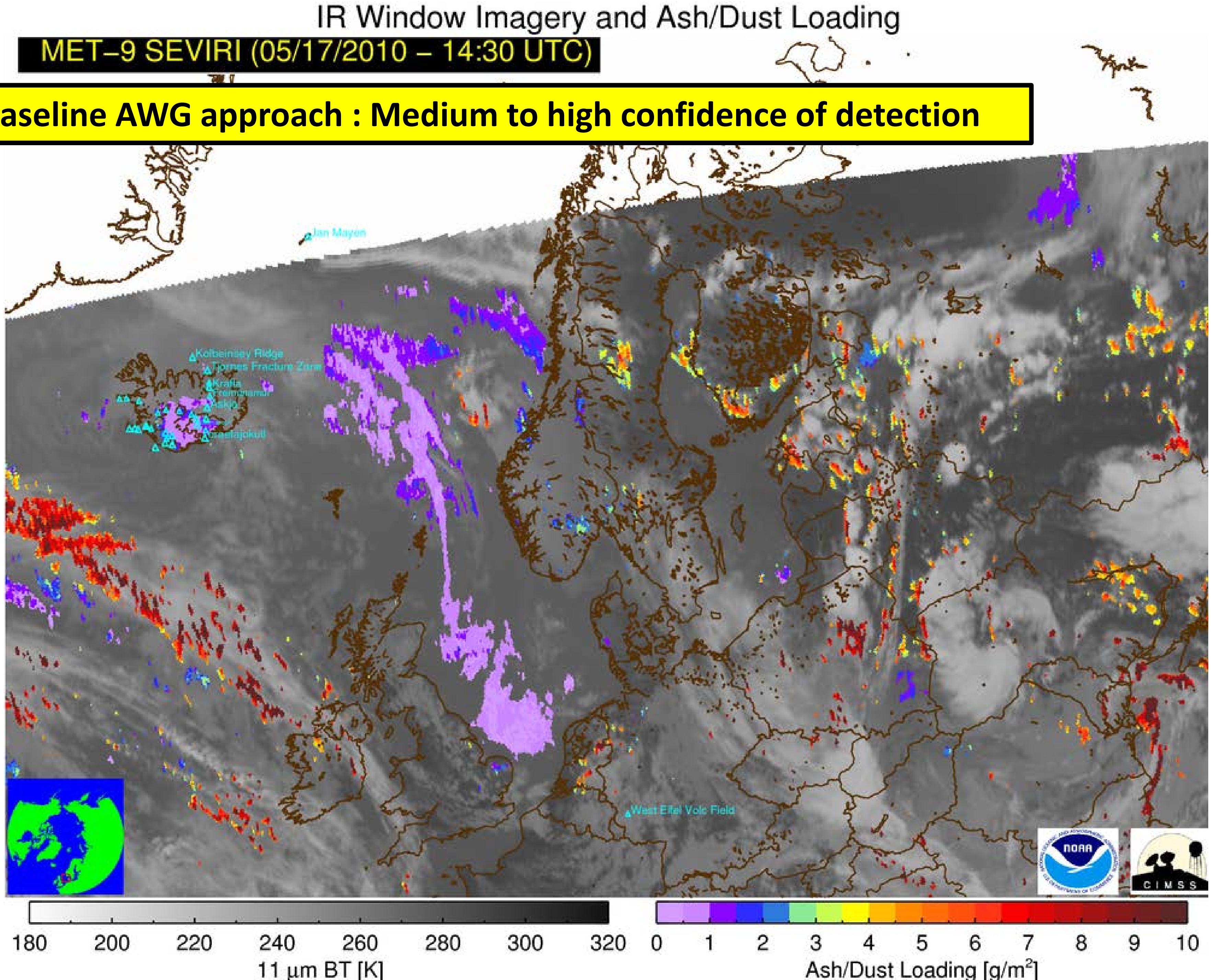


Martin Setvak

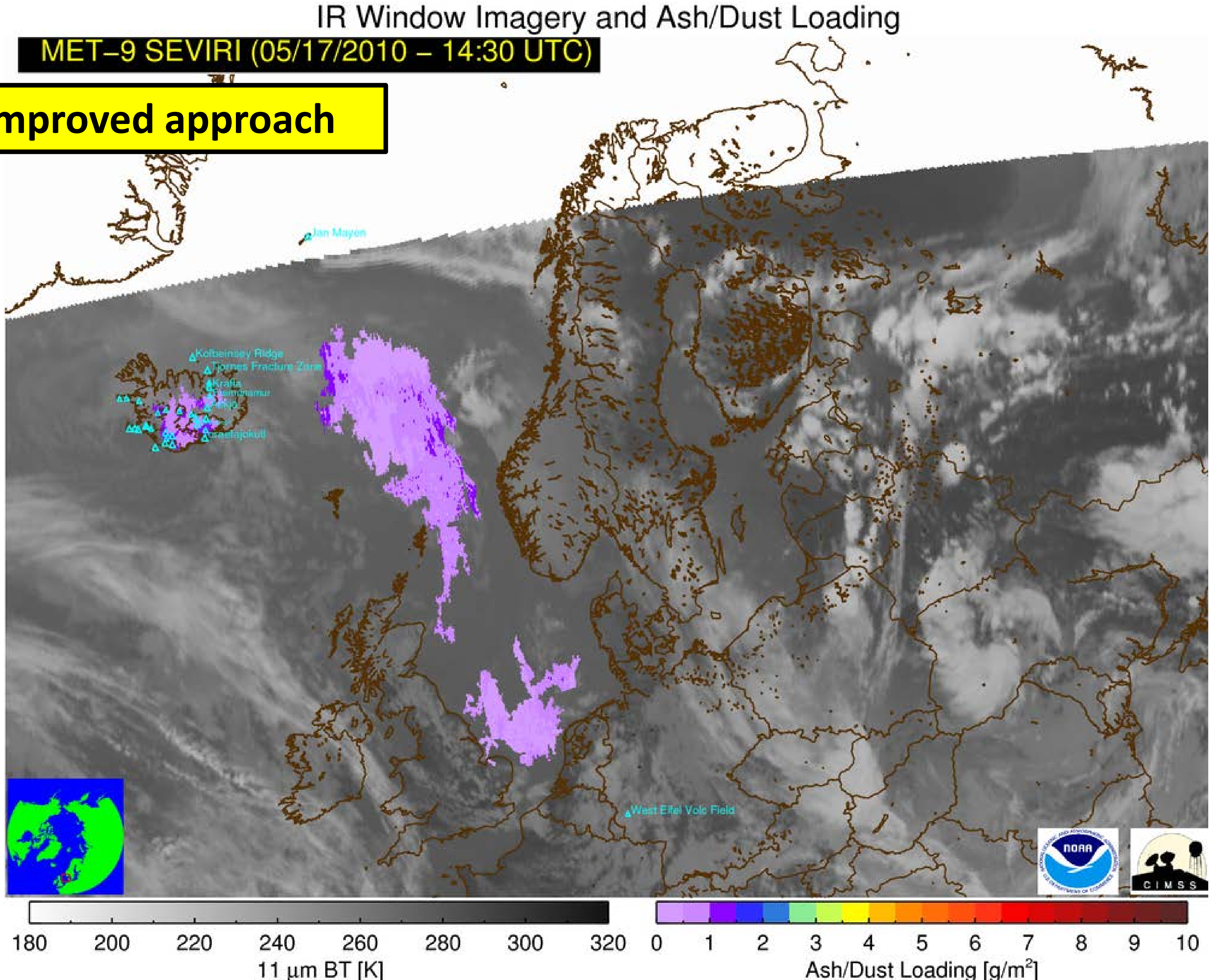
False Color Imagery (12−11µm, 11−8.5µm, 11µm)



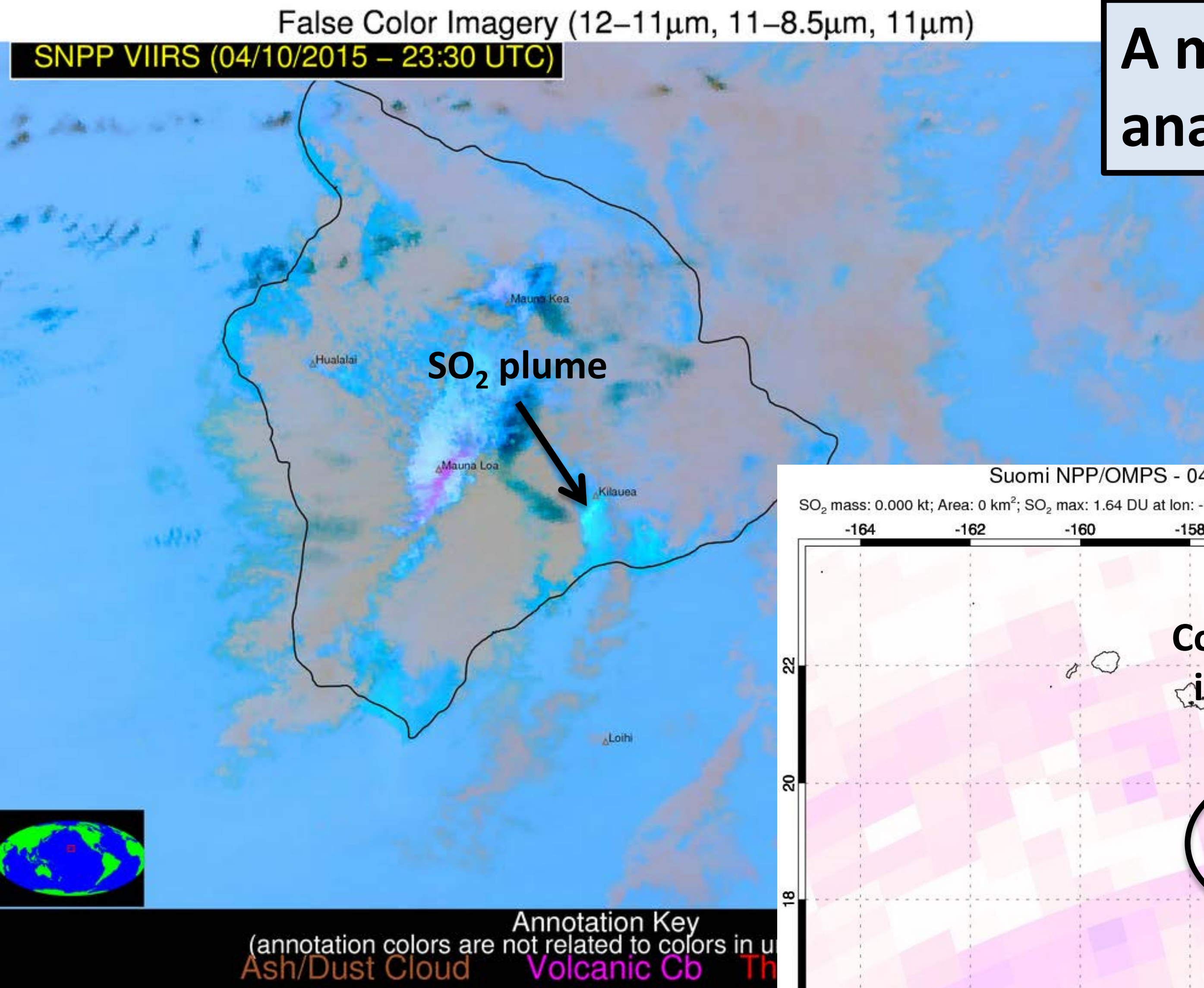
Baseline AWG approach : Medium to high confidence of detection

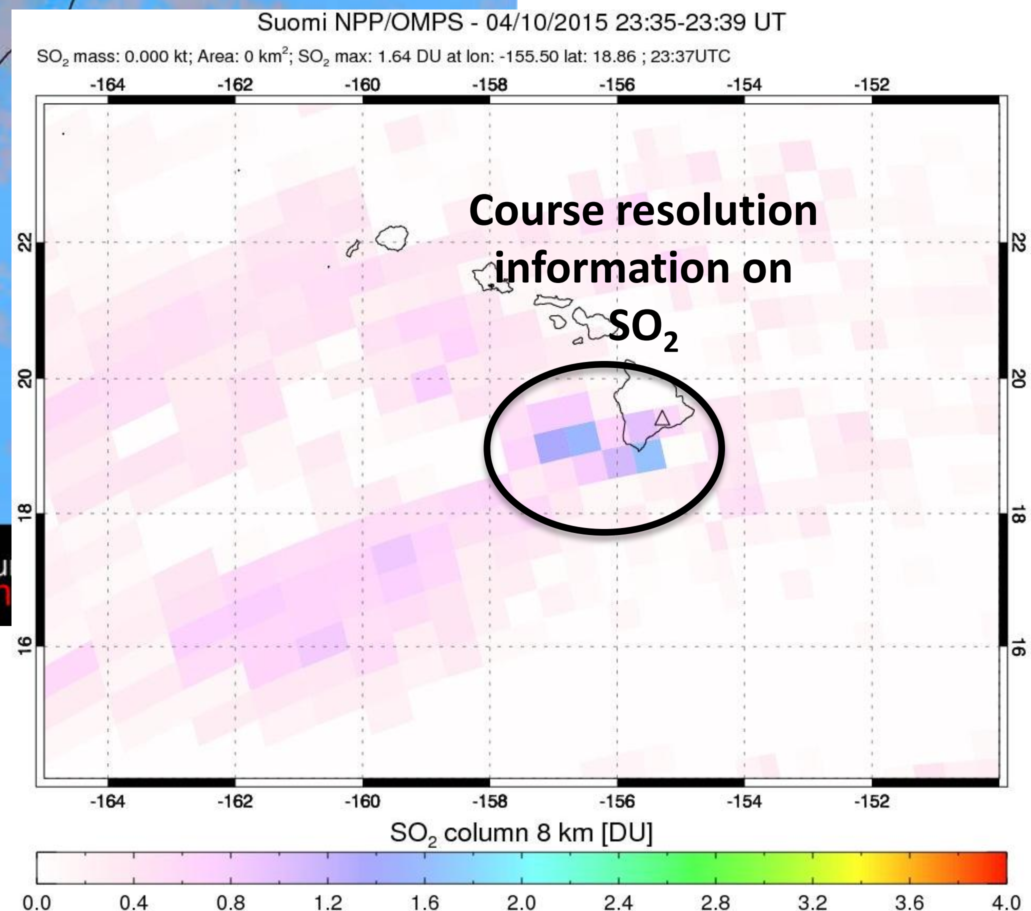


Improved approach

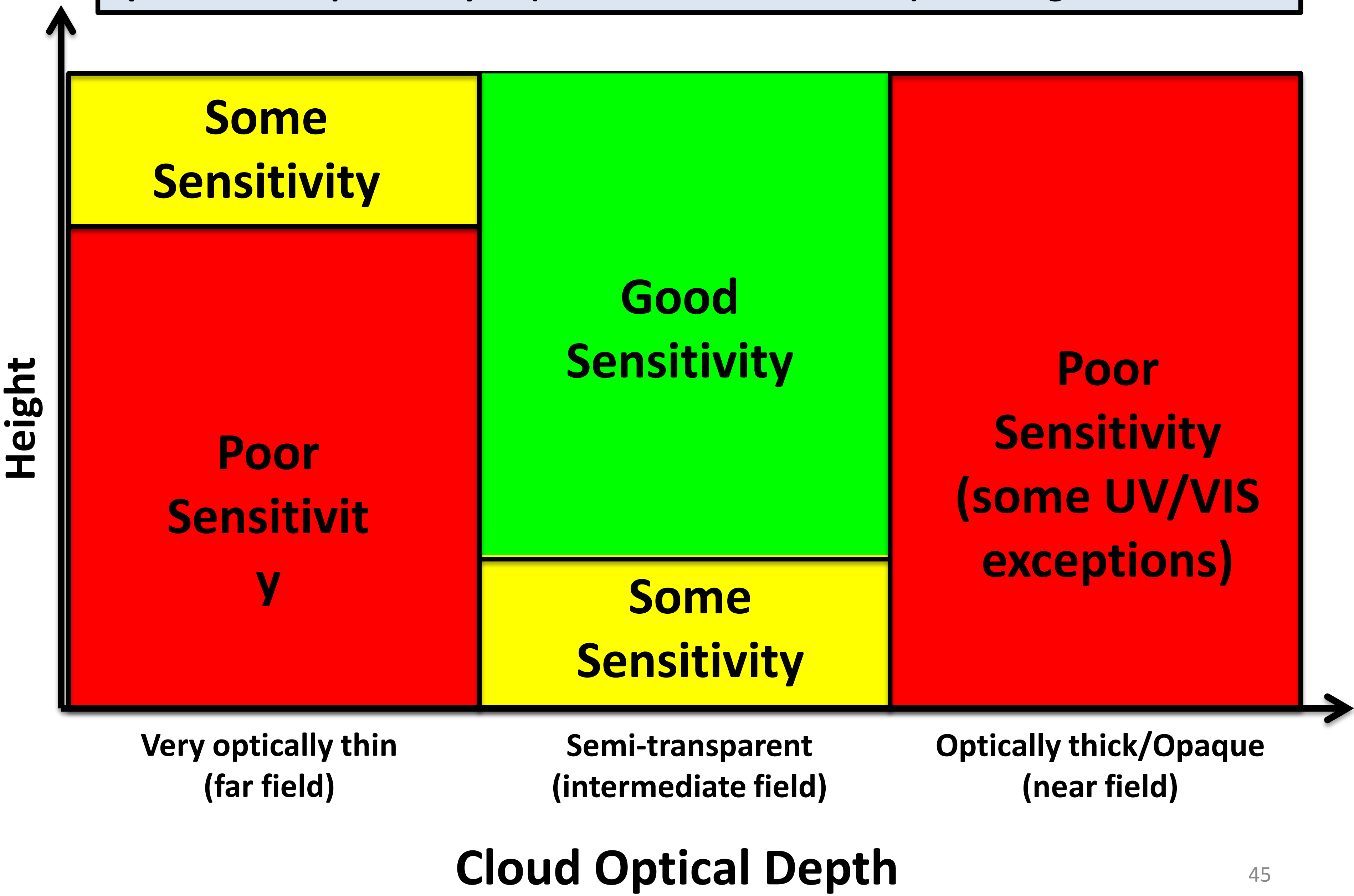


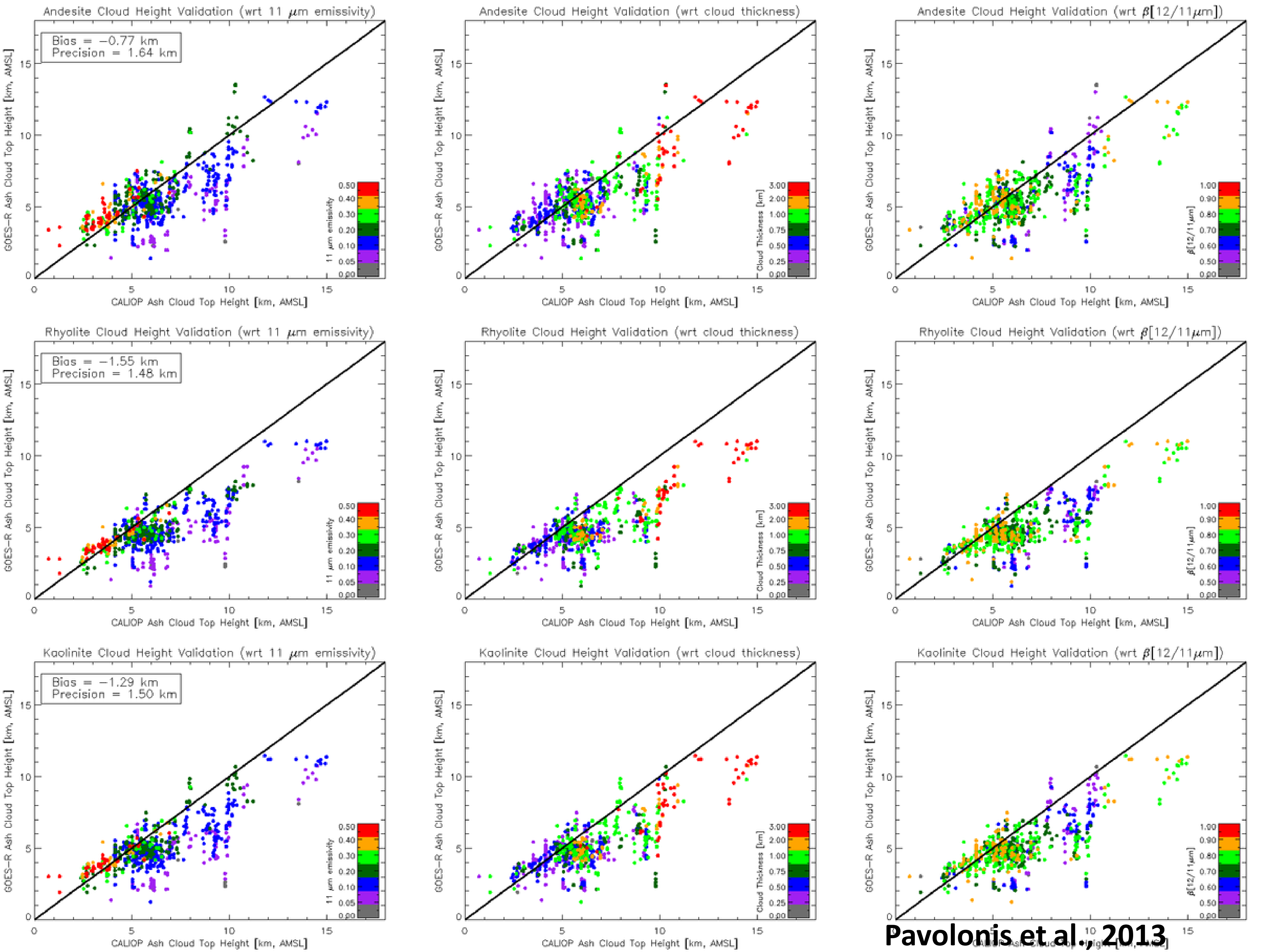
A multi-sensor SO_2 analysis is needed



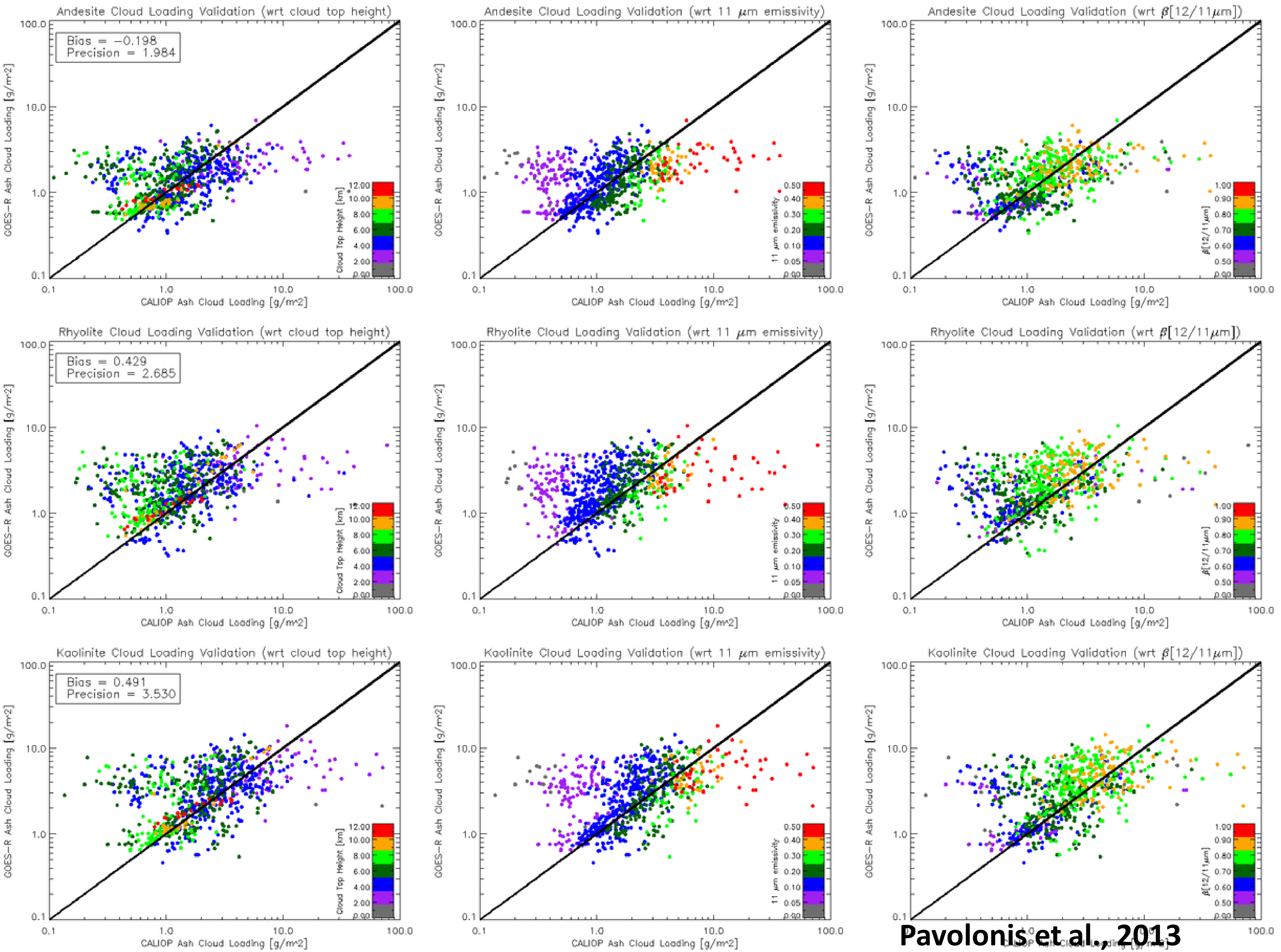


More consistent ash detection capabilities are needed across the spectrum of optical depth (down to detection limit) and height

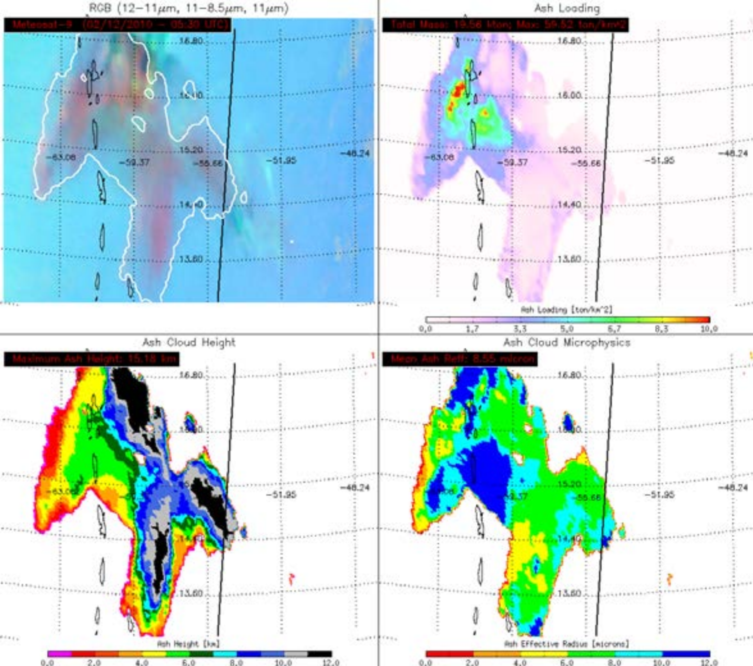




Pavolonis et al., 2013



Pavolonis et al., 2013



- •Single channel IR window
- •11/13.3 μm retrieval
- •11/12 μm retrieval
- •11/12/13.3 μm retrieval