Joint Polar Satellite System

JPSS overview and air quality applications

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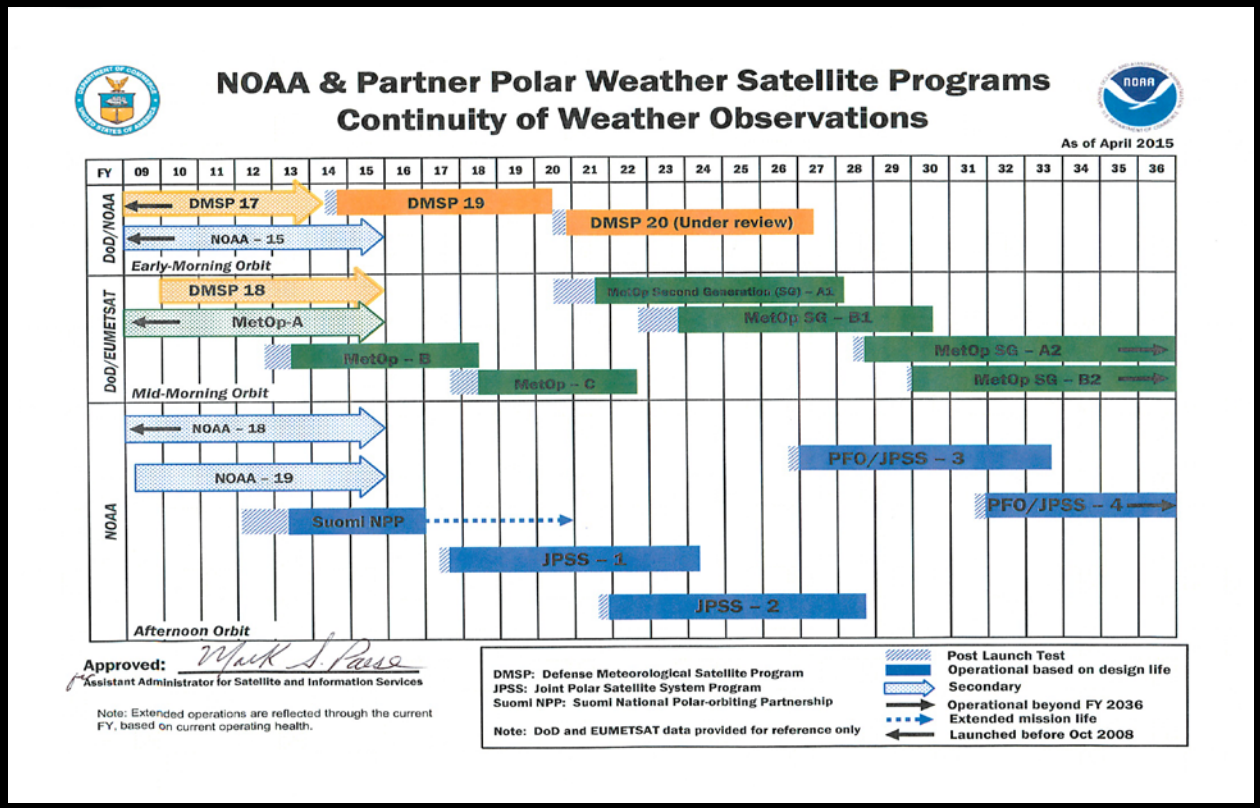
International Workshop for Air Quality Forecasting Research (IWAQFR)

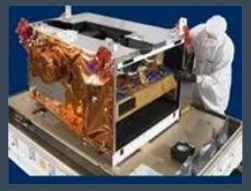
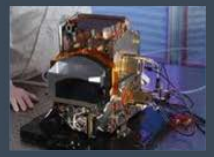
September 1, 2015

JPSS Overview

- JPSS consists of three satellites (Suomi NPP, JPSS-1, JPSS-2), ground system and operations through 2025
  - SNPP is now NOAA's primary weather polar orbiting satellite providing global data.

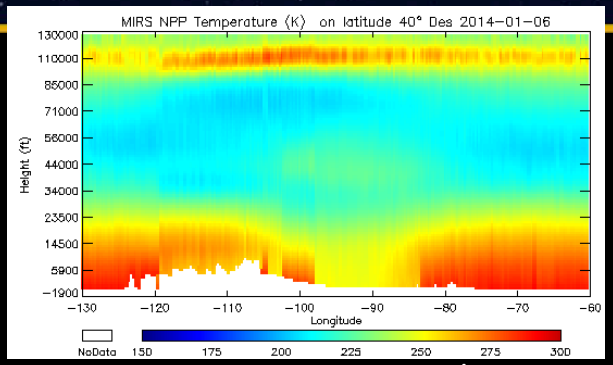


JPSS Instruments

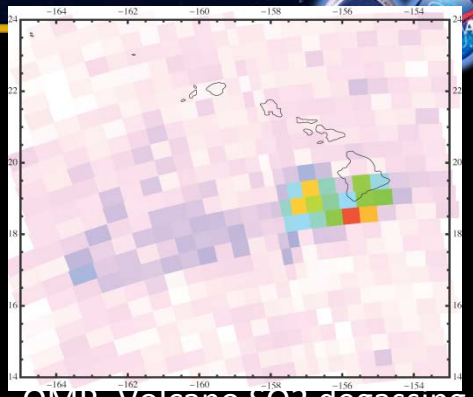
JPSS Instruments		Measurements & Products	Contractor
	**ATMS** - Advanced Technology Microwave Sounder	High vertical resolution temperature and water vapor information critical for forecasting extreme weather events, 5 to 7 days in advance	Northrup Grumman Electronic Systems
	**CrIS** - Cross-track Infrared Sounder		Exelis
	**VIIRS** – Visible Infrared Imaging Radiometer Suite	Critical imagery products, including snow/ice cover, clouds, fog, aerosols, fire, smoke plumes, vegetation health, phytoplankton abundance/chlorophyll	Raytheon Space and Airborne Systems
	**OMPS** - Ozone Mapping and Profiler Suite	Ozone spectrometers for monitoring ozone hole and recovery of stratospheric ozone and for UV index forecasts	Ball Aerospace and Technologies Corp.
	**CERES** – Clouds and the Earth's Radiant Energy System (S-NPP and JPSS-1) **RBI** – Radiation Budget Instrument (JPSS-2, 3, 4; provided by NASA)	Scanning radiometer which supports studies of Earth Radiation Budget (ERB)	CERES - Northrup Grumman Aerospace Systems RBI - Exelis

JPSS provides a wide range of capabilities

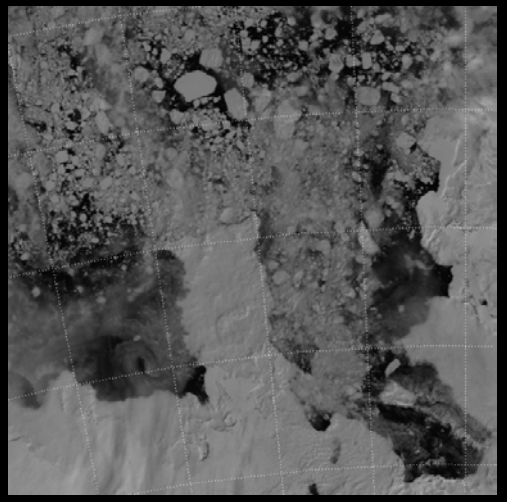
- Microwave – provides temperature and moisture soundings in cloudy conditions and rainfall rates, sea ice, snow, surface temperature
- Infrared – provides high vertical resolution temperature and moisture soundings in clear and cloud corrected regions; atmospheric chemistry - CO, CH4, SO2, … and cloud products
- Visible (day & night) and Infrared Imagery (including deep blue channels) – chlorophyll, cloud imagery, cloud products, SST, Active Fires, Smoke, Aerosols, land products, Snow, Ice, oil spills… at exceptional resolution/global coverage
- UV - ozone - Aerosols over bright surfaces, SO2 plumes, NOx (air quality)…

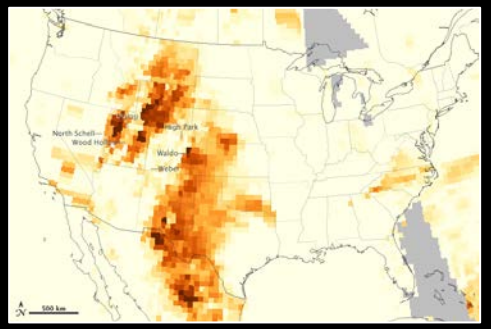


Temperature X-Section Polar Vortex


OMP- Volcano SO2 degassing


Algae in Lake Erie

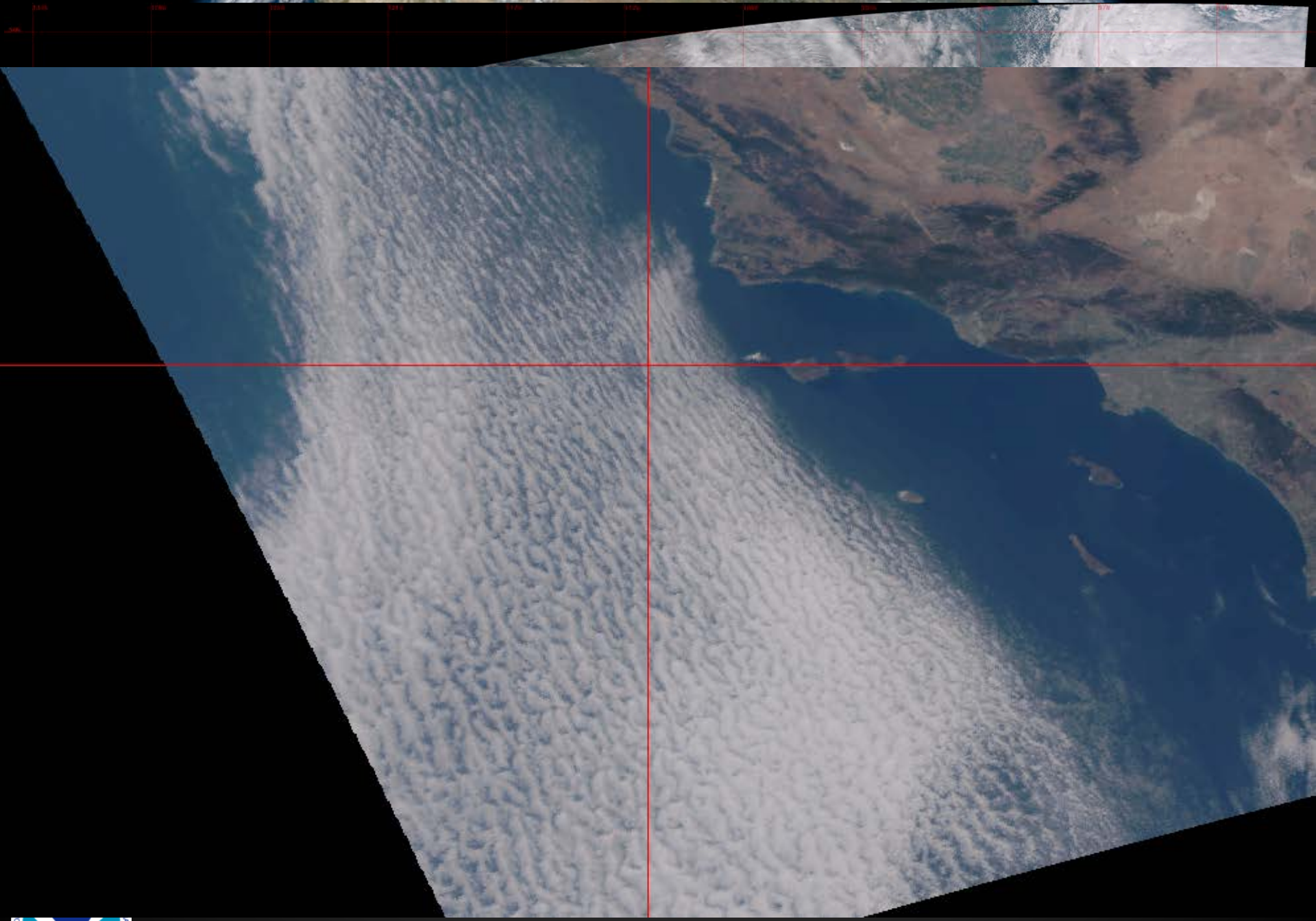

DNB Ice detection

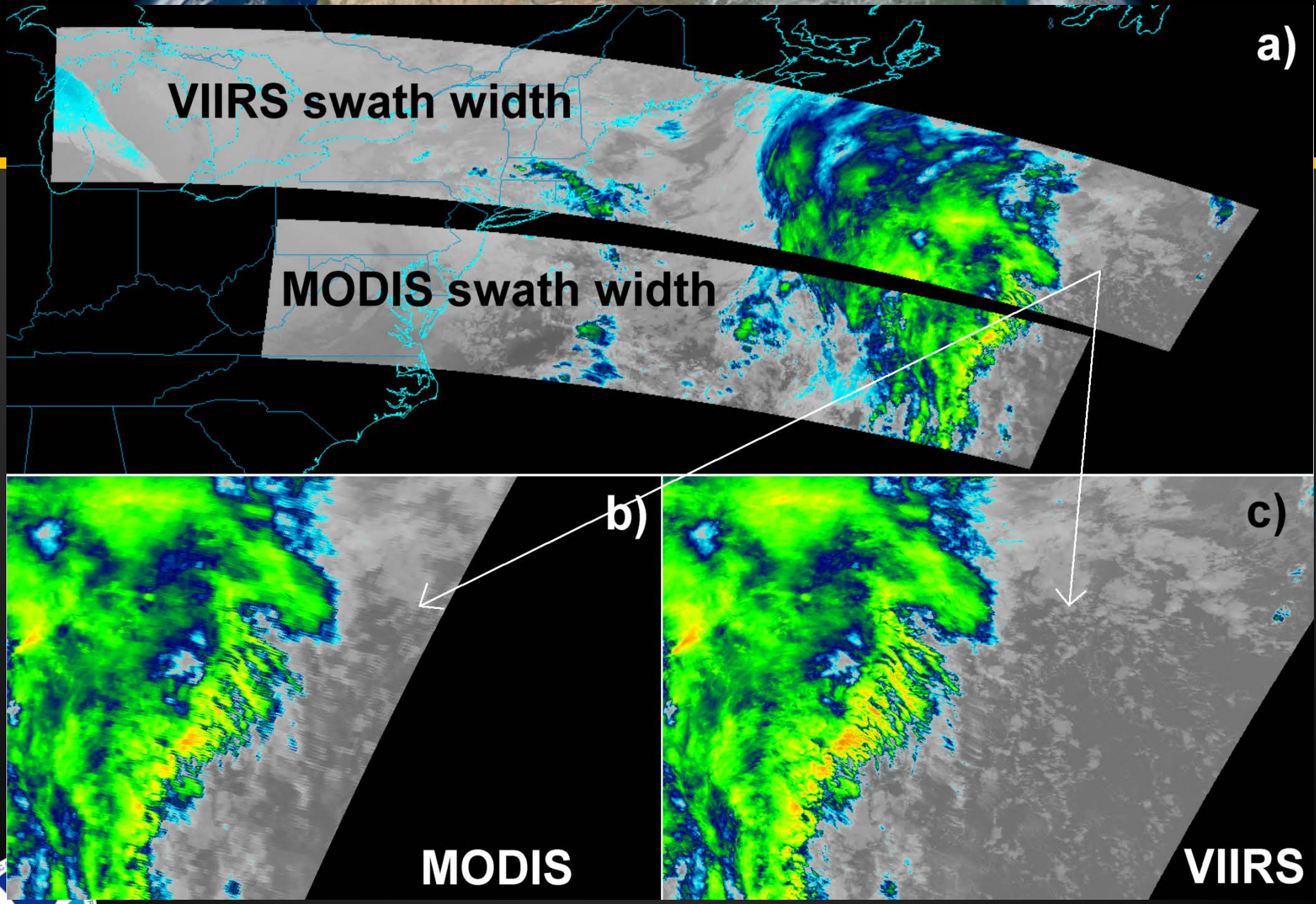

OMPS Aerosols from Fires

Important EPA Criteria Pollutants

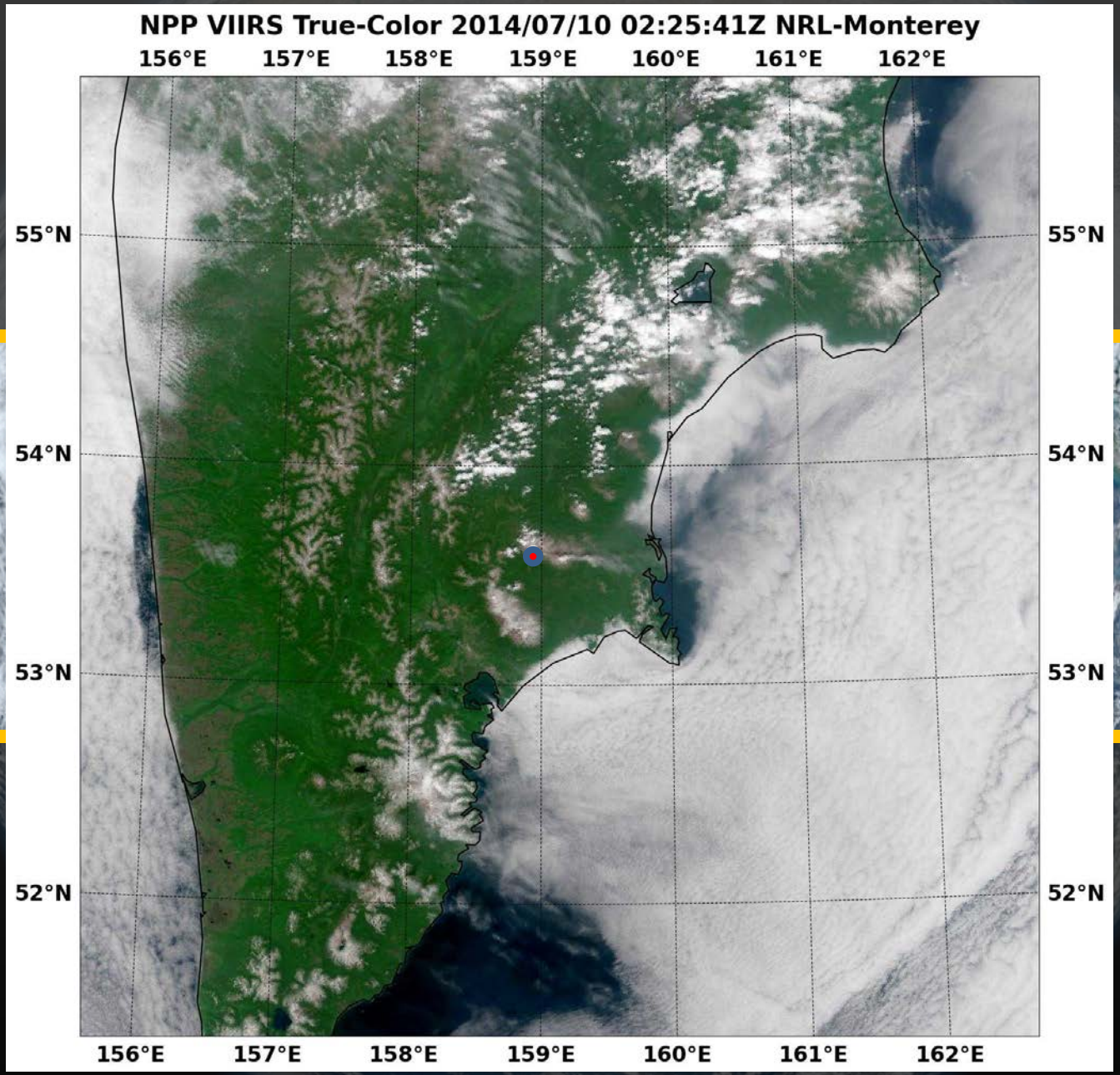
Pollutant	JPSS Sensor	Measurement	Where Pollutant is Present
Sulfur dioxide (SO2)	OMPS, CrIS, VIIRS	Column	Troposphere/stratosphere for volcanic eruptions
Carbon monoxide (CO)	CrIS	Column	Troposphere
Nitrogen dioxide (NO2)	OMPS	Column	Troposphere
Ozone (O3)	OMPS, CrIS	Profile	Troposphere*
Particulate Matter (PM2.5)	VIIRS, OMPS	Column	Troposphere

**** Possible with large uncertainties due to large stratospheric signal.***

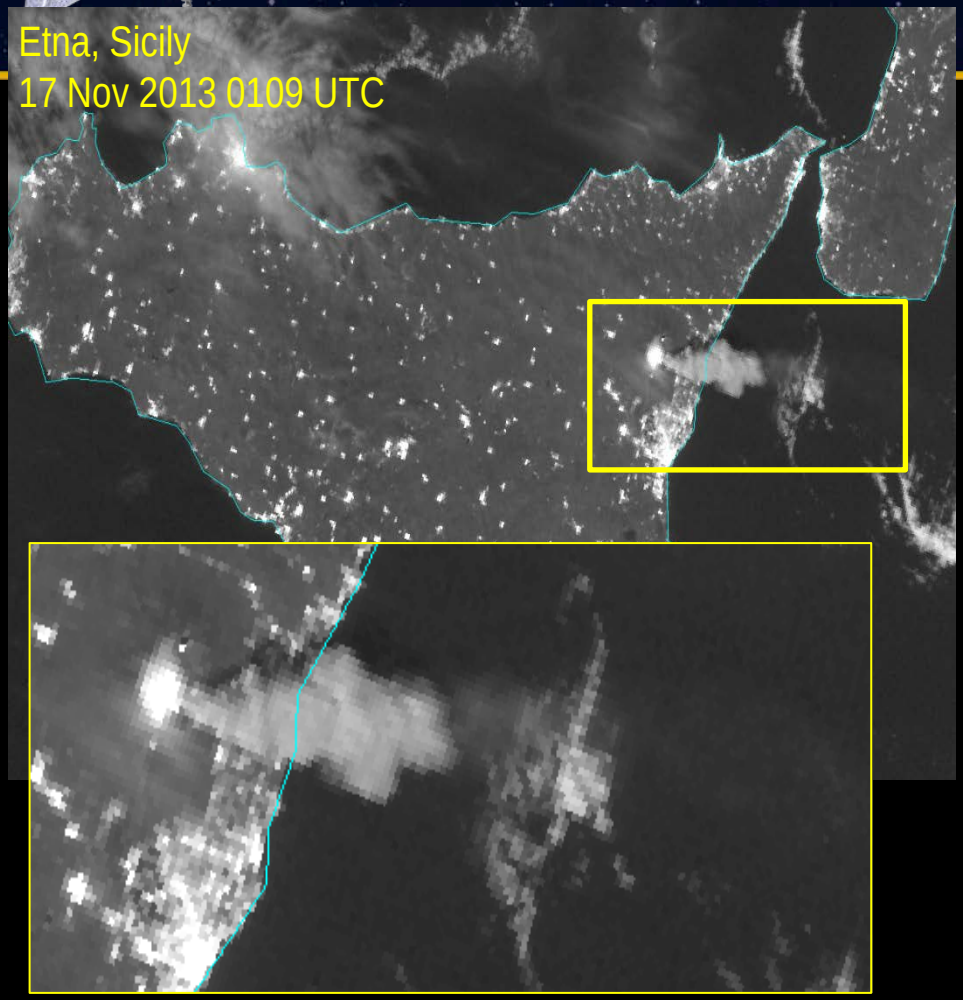


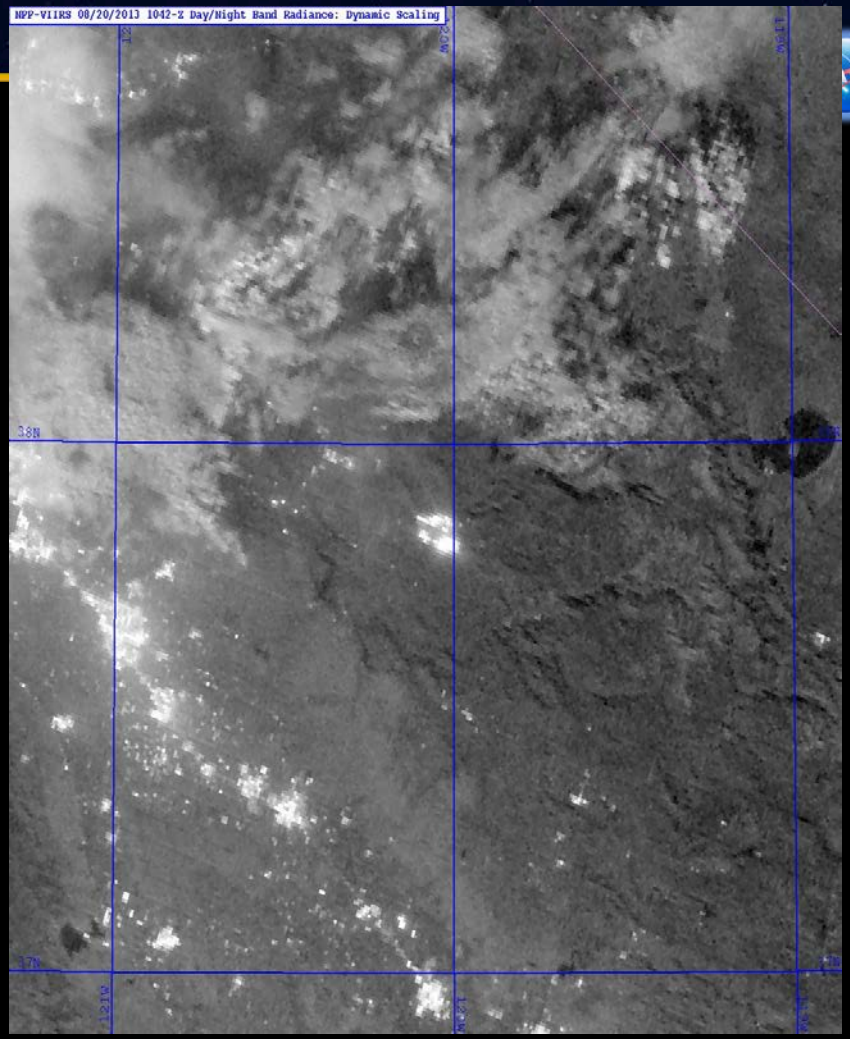

a)
VIIRS swath width
MODIS swath width
b)
c)
MODIS
VIIRS

Comparing MODIS (250m) to VIIRS (375m) Edge of Scan



The ‘Pyrosphere’ and its Atmospheric Effluents

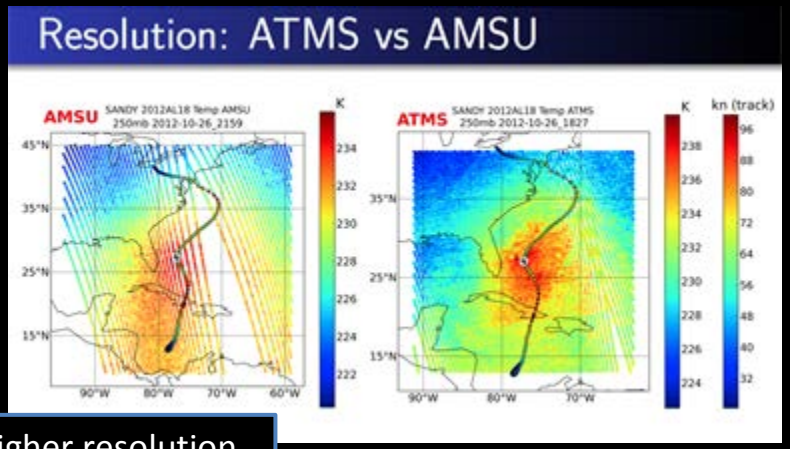




Complementary information on ash/smoke particles having weak IR signatures.

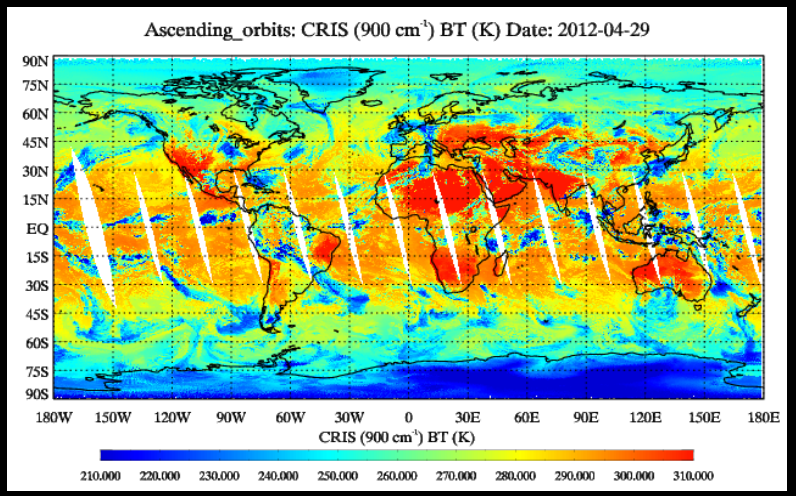
JPSS Next Generation Instruments

Advanced Technology Microwave Sounder



Higher resolution, wider swath, smaller gaps

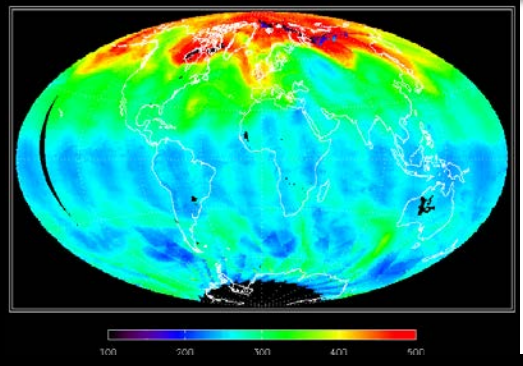
Cross-track Infrared Sounder

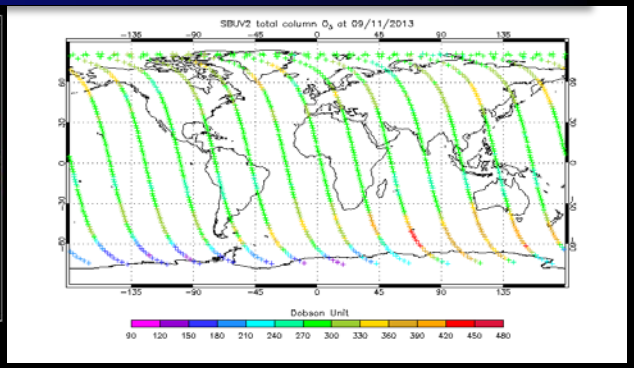


6x more vertical resolving power

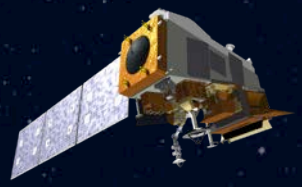
Ozone Mapping Profiler Suite

Resolution: OMPS vs SBUV/2





Provides global coverage ozone monitoring



S-NPP and JPSS Data Products

VIIRS (24)
ALBEDO (SURFACE)
CLOUD BASE HEIGHT
CLOUD COVER/LAYERS
CLOUD EFFECTIVE PART SIZE
CLOUD OPTICAL THICKNESS
CLOUD TOP HEIGHT
CLOUD TOP PRESSURE
CLOUD TOP TEMPERATURE
ICE SURFACE TEMPERATURE
OCEAN COLOR/CHLOROPHYLL
SUSPENDED MATTER
VEGETATION INDEX, FRACTION, HEALTH
AEROSOL OPTICAL THICKNESS
AEROSOL PARTICLE SIZE
ACTIVE FIRES
POLAR WINDS
IMAGERY
SEA ICE CHARACTERIZATION
SNOW COVER
SEA SURFACE TEMPERATURE
LAND SURFACE TEMP
SURFACE TYPE

CrIS/ATMS (3)
ATM VERT MOIST PROFILE
ATM VERT TEMP PROFILE
CARBON (CO2, CH4, CO)
OUTGOING LONGWAVE RADIATION

ATMS (11)
CLOUD LIQUID WATER
PRECIPITATION RATE
PRECIPITABLE WATER
LAND SURFACE EMISSIVITY
ICE WATER PATH
LAND SURFACE TEMPERATURE
SEA ICE CONCENTRATION
SNOW COVER
SNOW WATER EQUIVALENT
ATM TEMPERATURE PROFILE
ATM MOISTURE PROFILE

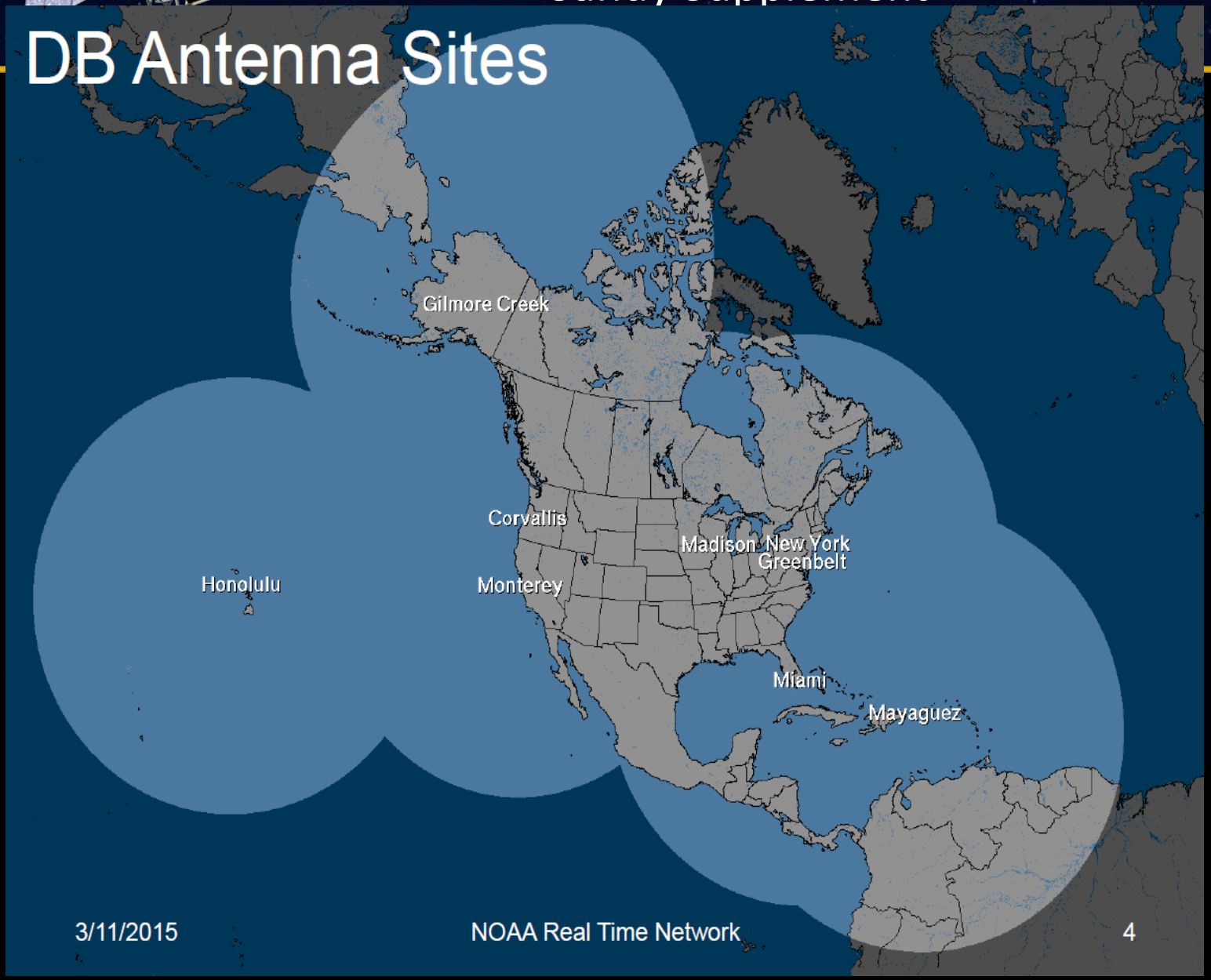
CERES(1)
RDRs

OMPS (2)
O_3 TOTAL COLUMN
O_3 NADIR PROFILE
SO2 and Aerosol Index

GCOM AMSR-2 (11)
CLOUD LIQUID WATER
PRECIPITATION TYPE/RATE
PRECIPITABLE WATER
SEA SURFACE WINDS SPEED
SOIL MOISTURE
SNOW WATER EQUIVALENT
IMAGERY
SEA ICE CHARACTERIZATION
SNOW COVER/DEPTH
SEA SURFACE TEMPERATURE
SURFACE TYPE

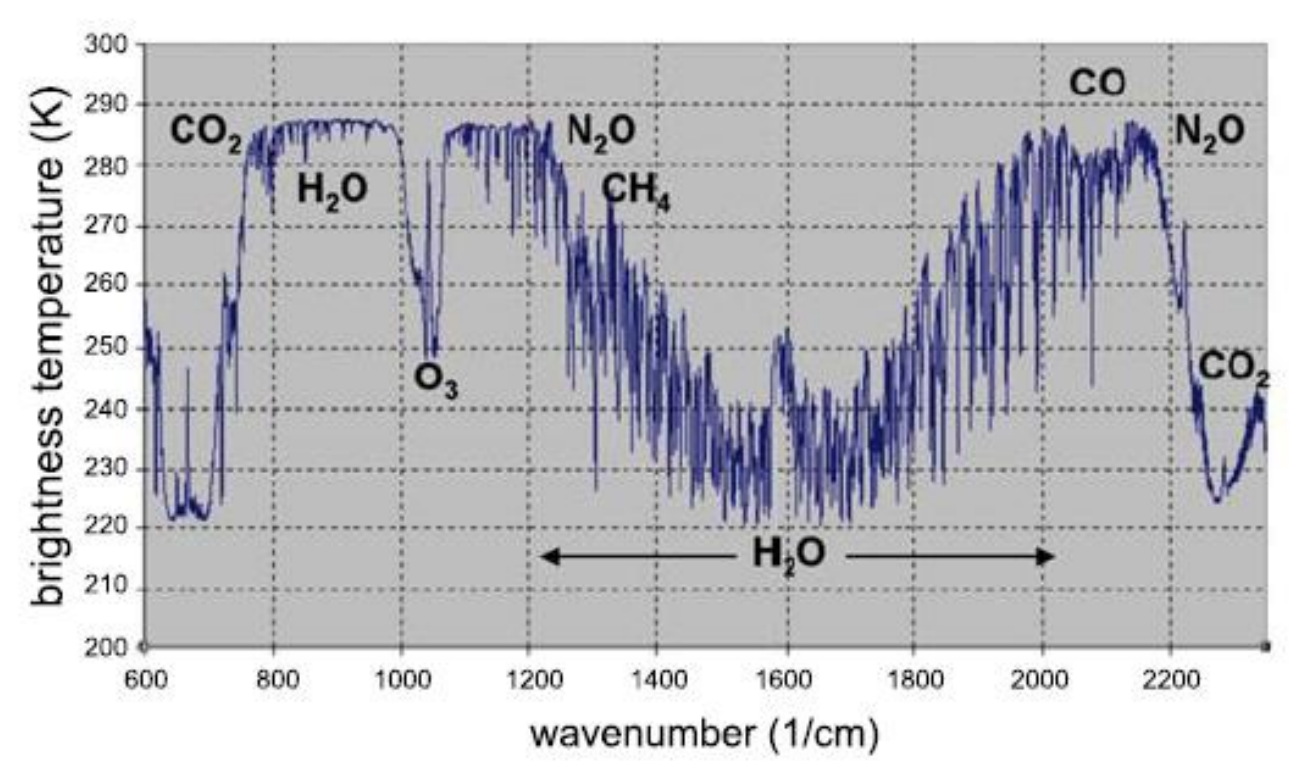
Data available through PDA , CLASS, and Direct Readout

NOAA DB Network Antenna Sites funded through the Sandy Supplement



Currently antennas at Hawaii, Alaska, and Wisconsin, are being used routinely by weather forecast offices using AWIPS's Local Data Acquisition and Dissemination (LDAD)

The Infrared Radiance Spectrum



Products:

Water vapor (soundings, fluxes, winds)

Temperature (sounding, stability)

Carbon monoxide concentration (2 layers) and total CO_2 concentration

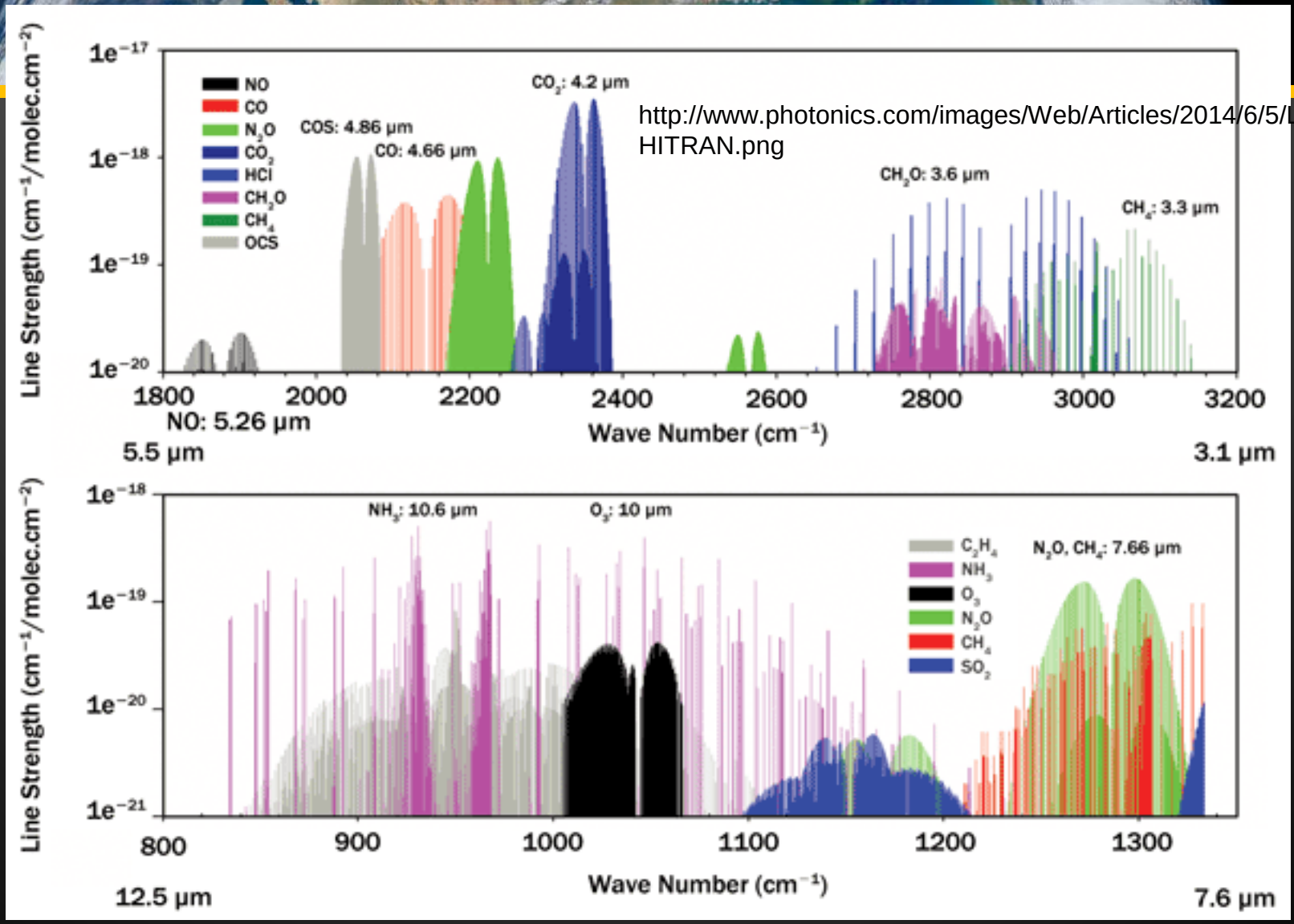
Methane concentration (total column)

Ozone concentration (4 layers)

Surface temperature, Emissivity, Land characterization

Clouds (altitude, optical depth, microphysical properties, winds)

Aerosol concentration and depth



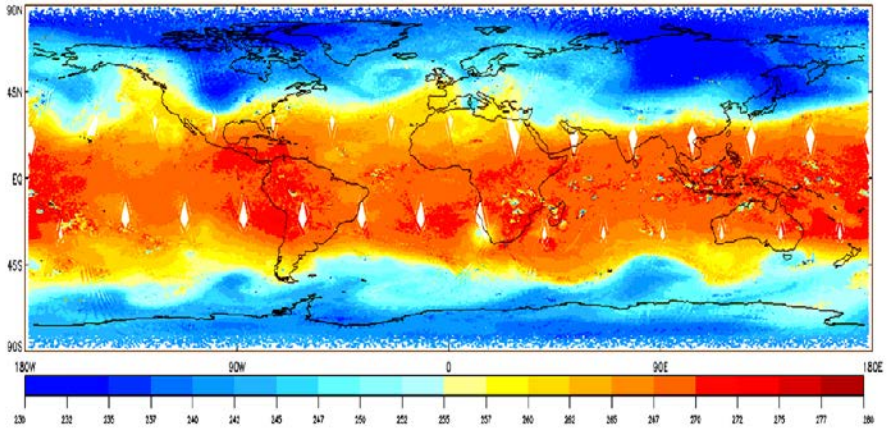
http://www.photonics.com/images/Web/Articles/2014/6/5/Lasers_HITRAN.png

List of operational retrieval products

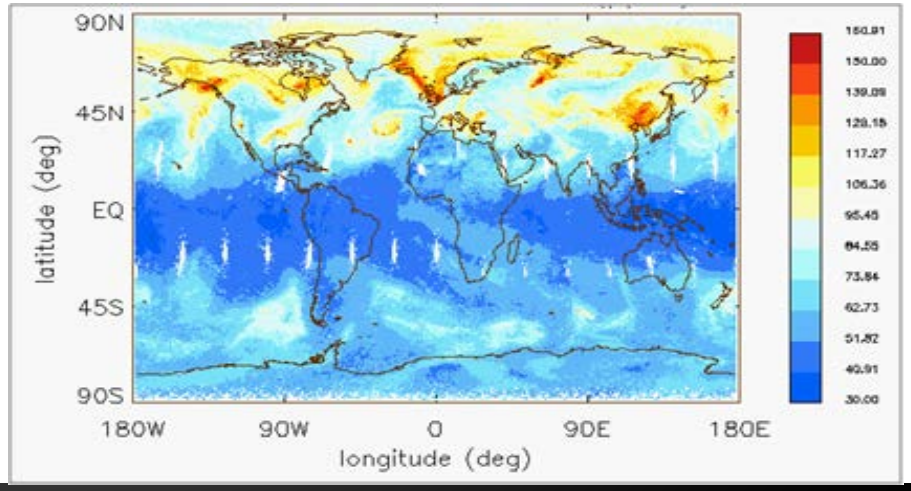
Retrieval Products

Cloud Cleared Radiances	660-750 cm-1 2200-2400 cm-1
Cloud fraction and Top Pressure	660-750 cm-1
Surface temperature	window
Temperature	660-750 cm-1 2200-2400 cm-1
Water Vapor	780 – 1090 cm-1 1200-1750 cm-1
O3	990 – 1070 cm-1
CO	2155 – 2220 cm-1
CH4	1220-1350 cm-1
CO2	660-760 cm-1
N2O	1290-1300cm-1 2190-2240cm-1
HNO3	760-1320cm-1
SO2	1343-1383cm-1

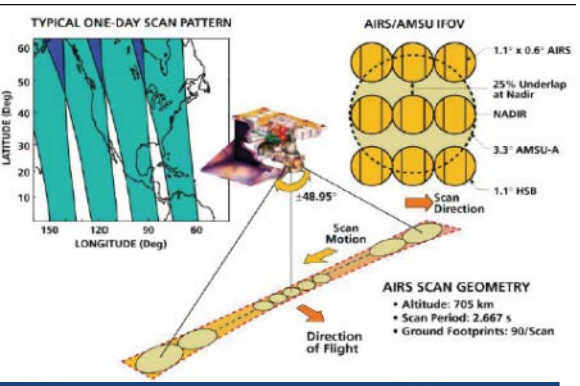
NUCAPS Temperature retrieval @ 500mb

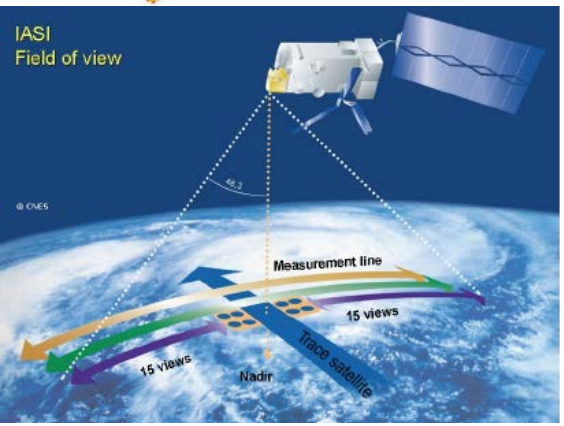


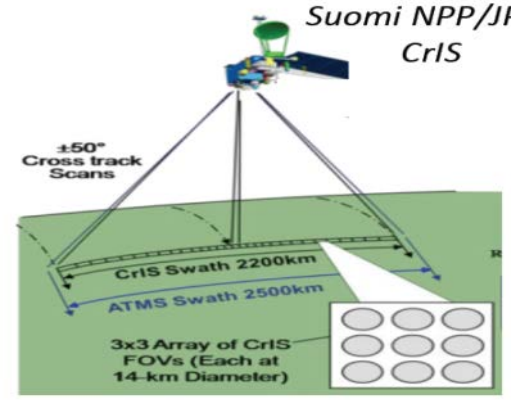
NUCAPS Ozone retrieval @ 500mb



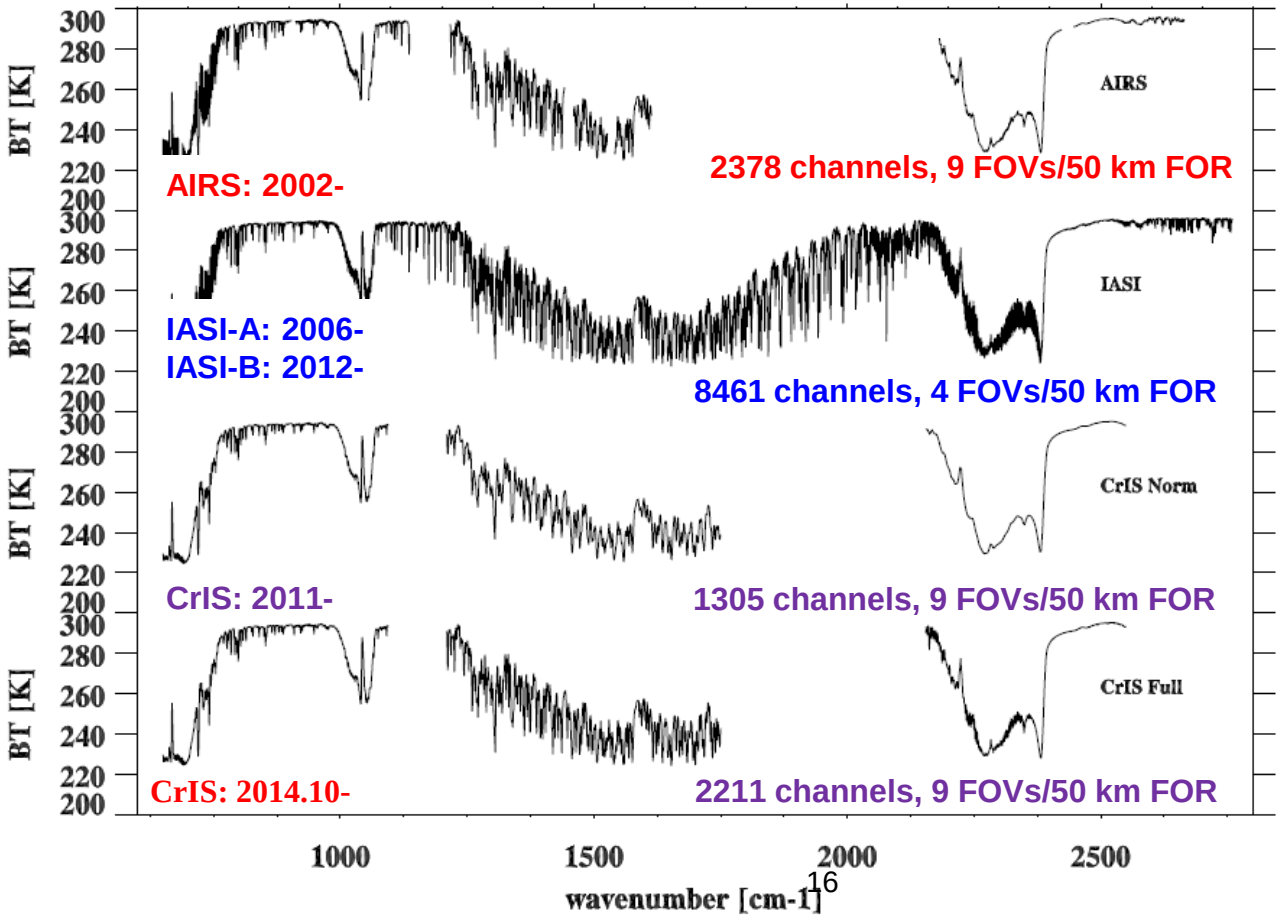
Instrument and Spectral Characteristics

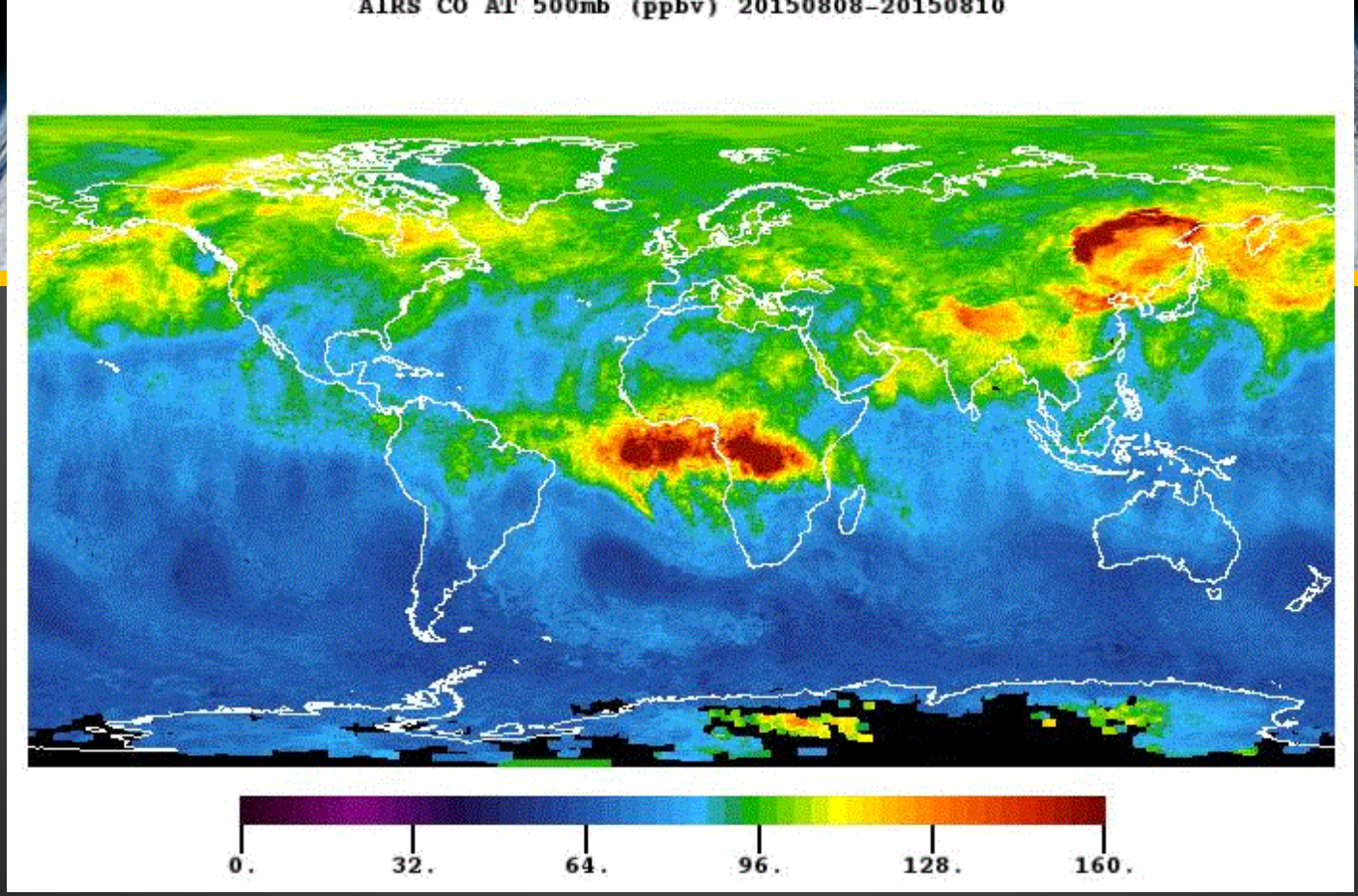






Spectral Coverage and Resolution of AIRS, IASI, and CrIS





In this animation made with data from the Atmospheric Infrared Sounder on NASA's Aqua satellite, the plume of carbon monoxide released by sixteen wildfires in Washington state can be seen to bloom and transport east, from August 9 through 24, 2015. The AIRS instrument is sensitive to carbon monoxide at roughly 18,000 feet altitude and at this height we can see how the gas is transported eastward along the U.S.–Canadian border, pushed along by the lower reaches of the polar jet stream. The leading edge of the plume reaches the U.S. east coast over the Saint Lawrence Seaway on August 25, five days after it initially became visible by AIRS in the imagery shown here.

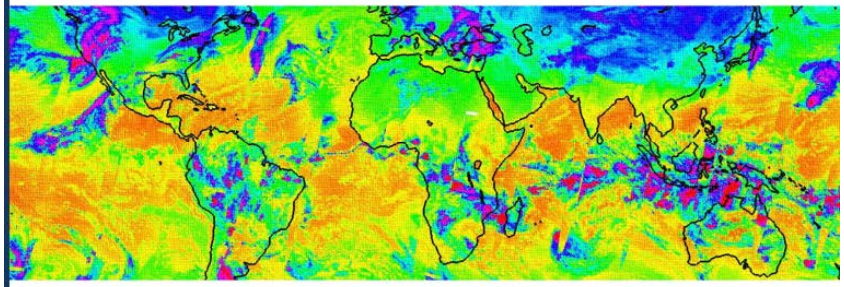
Also visible in this animation is carbon monoxide released from Siberian boreal forest wildfires and slash-and-burn agriculture in Africa and South America.

Credit

NASA/JPL AIRS Project

Advancing Atmospheric Chemistry Through the Use of Satellite Observations from the Cross-track Infrared Sounder (CrIS)

CrIS Atmospheric Chemistry Data User's Workshop Report
Sept. 18-19, 2014. College Park, MD.



doi:10.7289/V50V89SS
Published: August 2015
NOAA Climate Program Office
Atmospheric Chemistry, Carbon Cycle, & Climate Program (AC4)

Recommendation 3b:

More frequent NOAA Earth System Research Laboratory (ESRL) aircraft flights are needed for validation of trace gas retrievals from CrIS (as well as from other satellite observations) for both climate-relevant and air quality-relevant species, including flights designed to investigate apparent anomalies in the CrIS trace gas retrievals. Since CrIS is sensitive to different altitude ranges for different gases, fights of a variety of aircraft with different instrumentation and altitude ranges will be required to validate all of the trace gases retrieved by CrIS.

Recommendation 3c:

In addition to the above activities, additional field campaigns and validation activities should be performed to fully validate the CrIS trace gas products, including products from future JPSS missions. These campaigns should involve both the retrieval development and the product user community.

Recommendation 3d:

All validation data should be added to the NESDIS Validation Archive (VALAR) so that future CrIS retrieval algorithms can be more easily evaluated against these data sets.

Conclusion 4:

We find that CrIS can continue most of the NASA EOS TIR trace gas data records (e.g., CO, O_3, CH_4, CO_2, NH_3, N_2O, SO_2, HNO_3, CH_3OH; see Sections 4 and 7.1), with the key exceptions of formic acid (HCOOH) and peroxyacetyl nitrate (PAN), which fall in the CrIS spectral gaps. In addition, the remarkably low noise of CrIS opens the possibility for several new trace gas retrieval products (see Section 7.2), including important species such as ethane (C_2H_6), acetylene (C_2H_2), ethylene (C_2H_4), hydrogen cyanide (HCN), and acetic acid (CH_3COOH).

Recommendation 4a:

We recommend that the CrIS retrieval community explore the development and validation of retrievals for the potential new species in close coordination with atmospheric chemistry research users who desire these products.

Recommendation 4b:

We recommend that the current spectral gap between the long-wave and mid-wave bands of CrIS be closed for JPSS-2, allowing the continuation of the EOS trace gas data records for HCOOH and PAN. We note that closing these spectral gaps was also a recommendation of the "JPSS 2 and Beyond: Instrument Improvements for Science Benefits" Workshop held on October 23, 2014.

Recommendation 4c:

We recommend that for post-JPSS planning, NOAA continue the polar-orbiting IR sounder program, and that NOAA consider approaches to both reduce the noise and increase the resolution of future versions of CrIS, as is being done in the New Generation of Infrared Atmospheric Sounding Interferometer (IASI-NG) program.

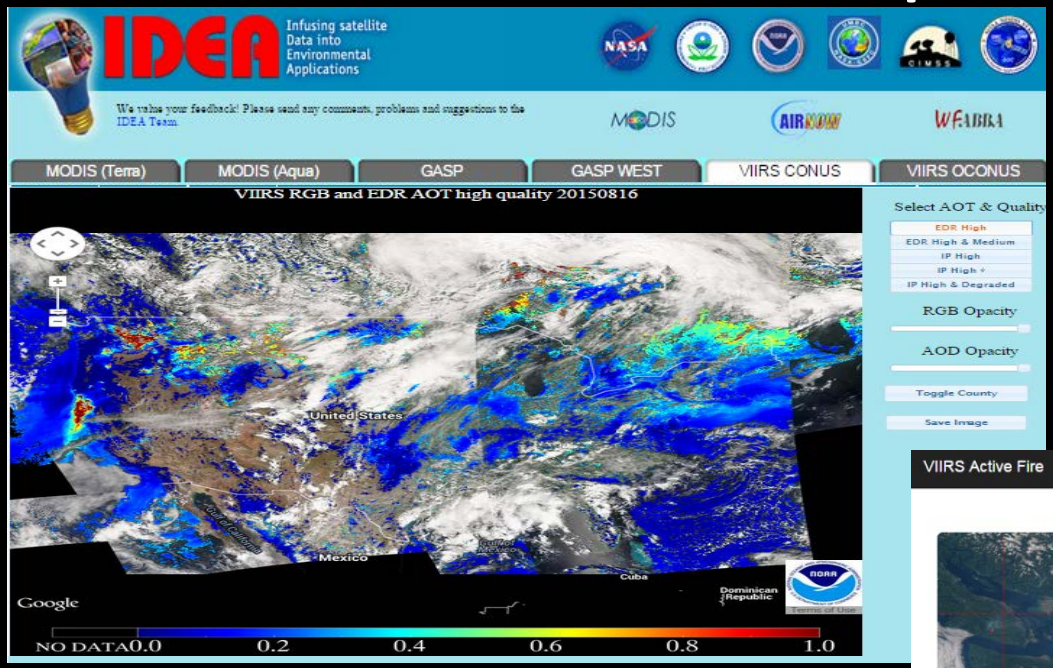
JPSS Proving Ground & Risk Reduction Program

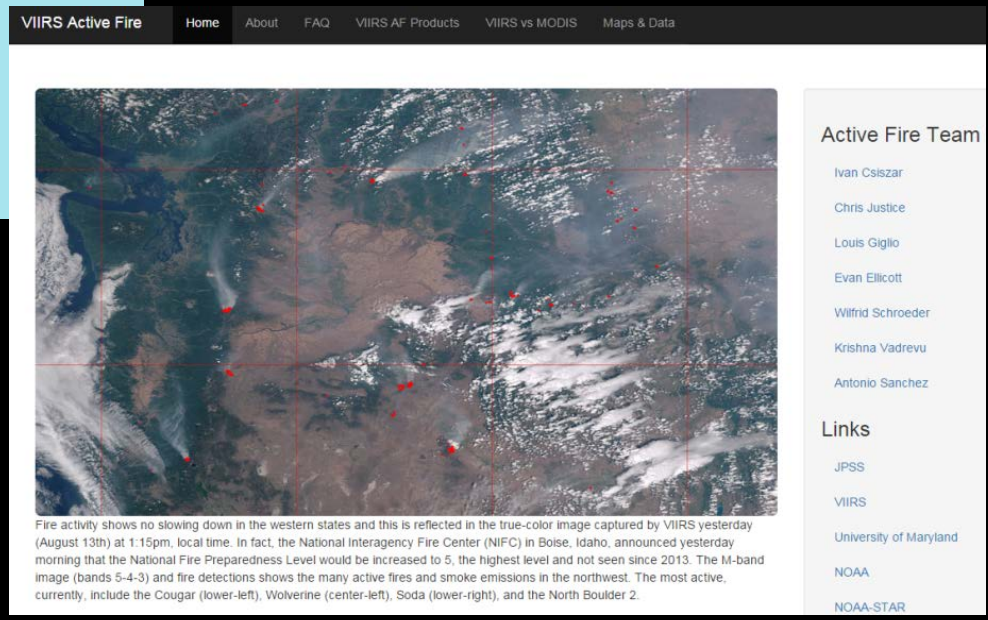
The JPSS Proving Ground and Risk Reduction program's primary objective is to maximize the benefits and performance of NPP/JPSS data, algorithms, and products for downstream operational and research users (gateways to the public) through:

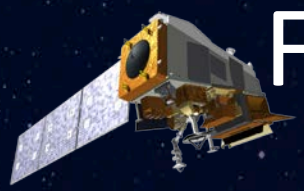
- Engaging users to enhance/improve their applications through the optimal utilization of JPSS data.
- Education, Training and Outreach
- Facilitating transition of improved algorithms to operations.
- Detailed characterization of data attributes such as uncertainty (accuracy and precision) and long-term stability
- Provides user feedback to the cal/val program

Significant amount of NOAA operational use of SNPP data has been made possible through JPSS PGRR and Direct Readout

Visualization and interacting with data is important







FY15 & 16 Call for Proposals

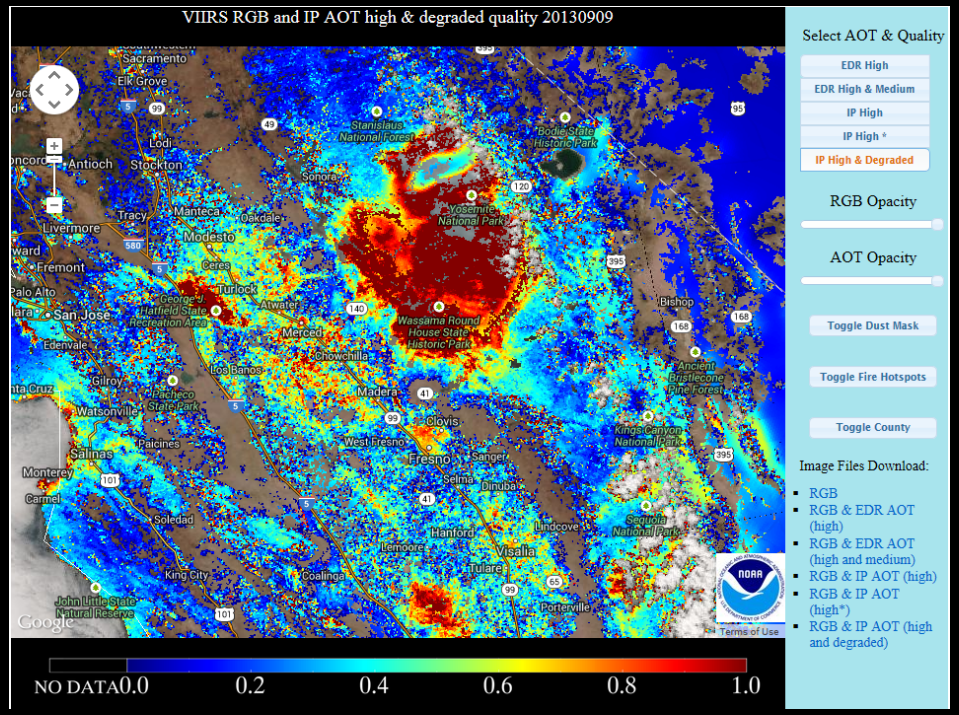
- New JPSS PGRR Call for Proposals was released on December 2, 2014.
  - Call focuses on 13 initiatives
- Over 130 Letters of Intent were received.
- New projects will be selected by the JPSS PGRR Executive Board (with feedback from relevant users and stakeholders) in March/April

PGRR Initiatives

About 40 proposals selected so far out of 87 full proposals out of 136 LOIs

- Aerosol Data Assimilation
- Fire and Smoke
- River Ice and Flooding
- Atmospheric Sounding Applications
- NWP impact studies (via HRRR and GFS) and other critical weather applications
- OCONUS and NCEP Service Centers AWIPS Initiative
- Cryosphere Initiative
- Land Data Assimilation
- Ocean and Coastal
- Atmospheric Chemistry
- Hydrology
- Innovation
- Training

Aerosol Data Assimilation (1)



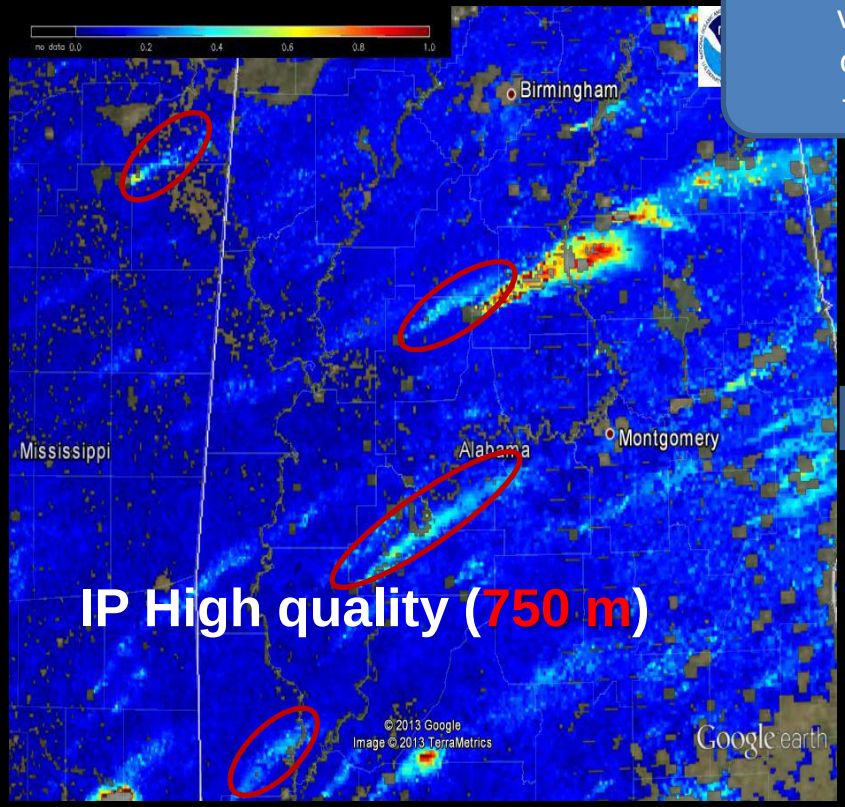
- Improve the use of VIIRS and OMPS aerosol products in operational models at NWP centers or developmental models at partner agencies that have defined pathways to transition to NWP centers.
- Make use and demonstrate the value of VIIRS aerosol optical depth, aerosol (smoke, dust, volcanic ash) detection, and OMPS UV Aerosol Index products in improving forecasts.

Current Air Quality Applications

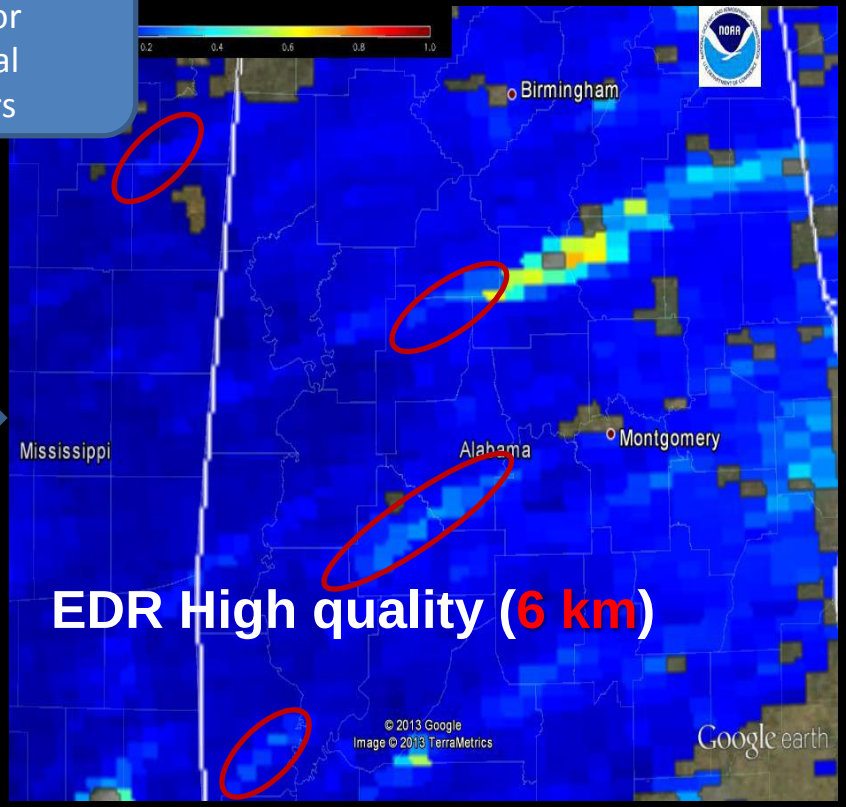
Pixel level AOT clearly shows smoke plumes from different fires including the small ones.

EDR AOT looks pixelated with smoke plumes not very obviously visible

High spatial resolution valuable for operational forecasters



IP High quality (750 m)



EDR High quality (6 km)

NOAA Cal/Val web: VIIRS aerosol information and gridded AOT

http://www.star.nesdis.noaa.gov/smcd/emb/viirs_aerosol/index.php

Products page has a link to FTP site for data download

Document links to ATBD, user's guide, etc.

Software to display VIIRS aerosol products and convert data to MODIS-like EOS HDF format are available for download

Latency for daily global gridded product availability is 1-2 days

NOAA STAR CENTER FOR SATELLITE APPLICATIONS AND RESEARCH

National Oceanographic & Atmospheric Administration website

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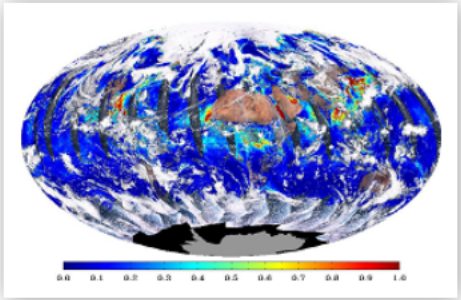
STAR / SMCD / VIIRS Aerosol Calibration and Validation

VIIRS AEROSOL | GRIDDED DATA | AOT MOVIE | SOFTWARE

Aerosol from SNPP/VIIRS

The Visible Infrared Imaging Radiometer Suite (VIIRS) sensor onboard the Suomi National Polar-orbiting Partnership (SNPP) satellite provides a key set of aerosol Environmental Data Records (EDRs) based on daily global observations from space. These products are:

- **Aerosol Optical Thickness (AOT)**, providing a measure of the aerosol content of the atmospheric column,
- **Aerosol Particle Size Parameter (APSP)**, given as the Ångström Exponent (AE), a qualitative measure of particle size with larger AE corresponding to smaller particles, and vice-versa,
- **Suspended Matter (SM)**, indicating the presence of dust, smoke, sea salt, volcanic ash above a threshold amount.



Global high quality AOT EDR at 550 nm on May 22, 2013. True color (RGB) image is provided as background to show the absence of retrievals due to cloud, sunglint and bright surface.

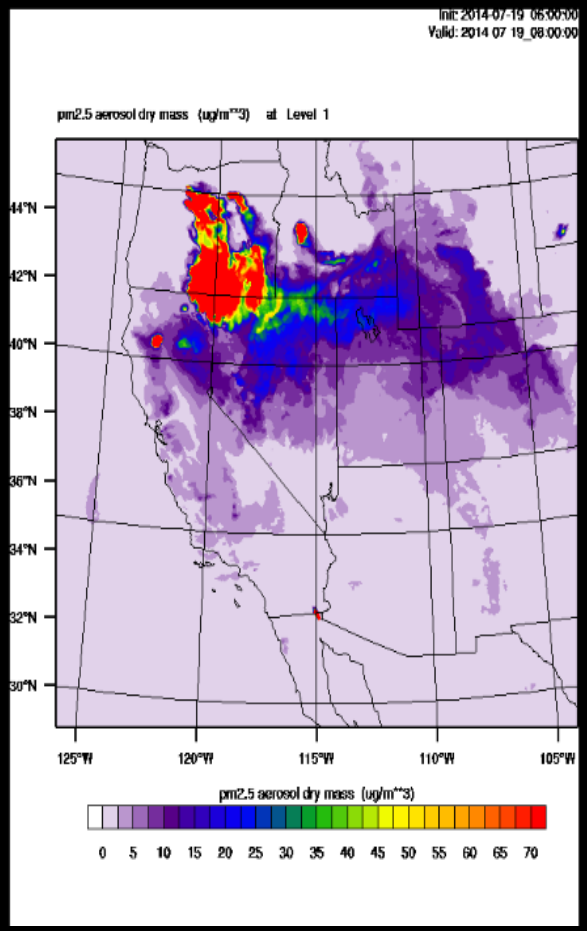
More information on these products is available from the Products page. Detailed instructions on how to access the data from their official archive location at the NOAA Comprehensive Large Array-data Stewardship System (CLASS) are provided in the subpages of the Products page.

Global gridded aerosol optical thickness

The operational VIIRS 550-nm AOT EDRs at nominal 6-km resolution, and collected during a 24-h period, are gridded at STAR on a regular 0.25 x 0.25-degree equal angle (~28x28 km at the equator) grid.

daily gridded AOTs can be displayed from the Gridded Data page. The gridded data can also be downloaded from the

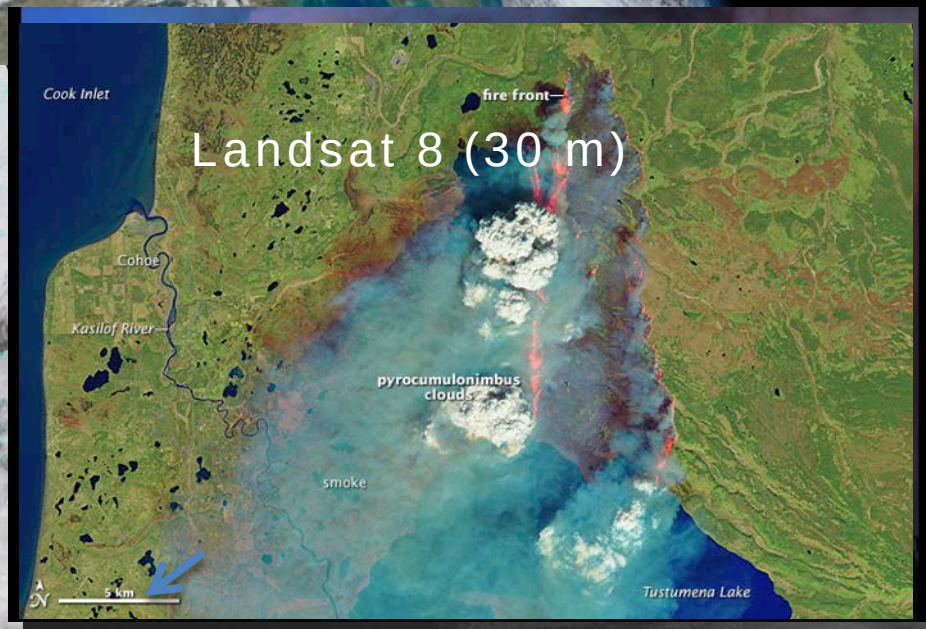
Fire and Smoke (4)



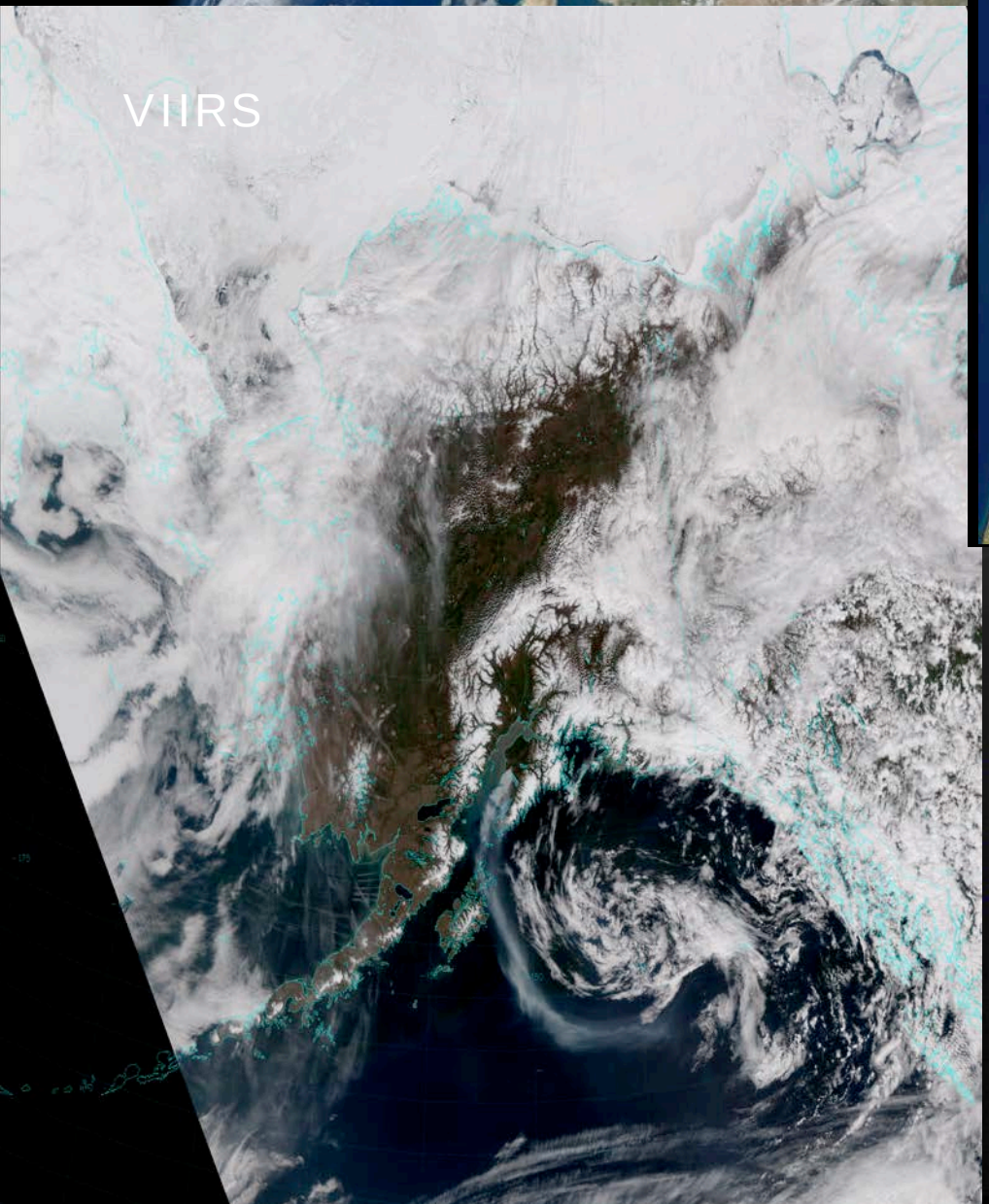
- Makes use of the VIIRS active fire location, fire radiative power and aerosol optical depth, and potentially OMPS derived aerosols to predict fire movement and dispersion of smoke using high spatial resolution and timely forecast models
- Products focus on determining the current location of a fire and gathering as much information as possible on its history.

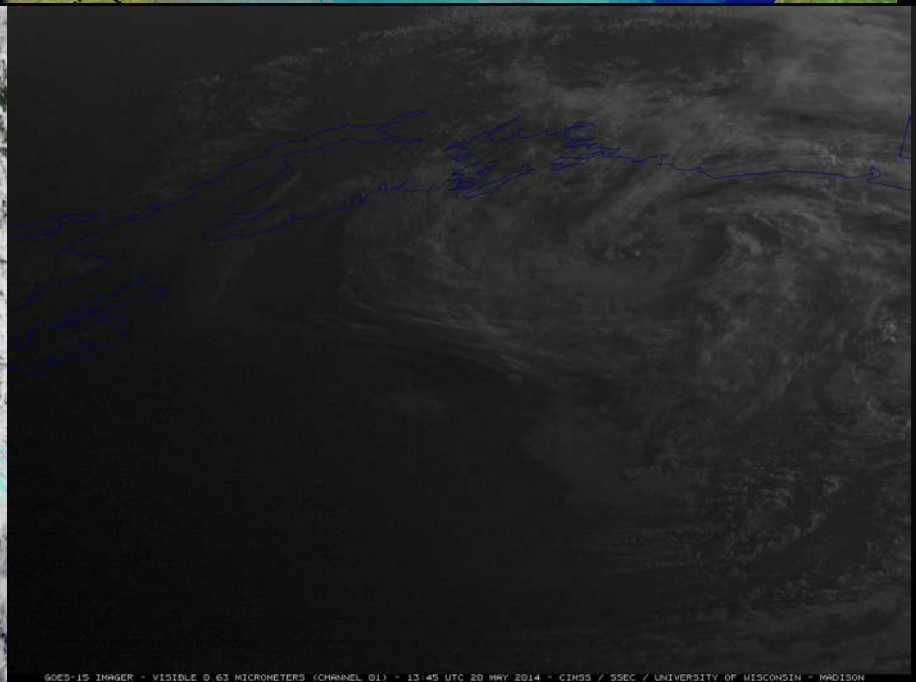
Integrating various satellite data is well recognized and emphasized

Funny River Fire – Alaska - May 20, 2014

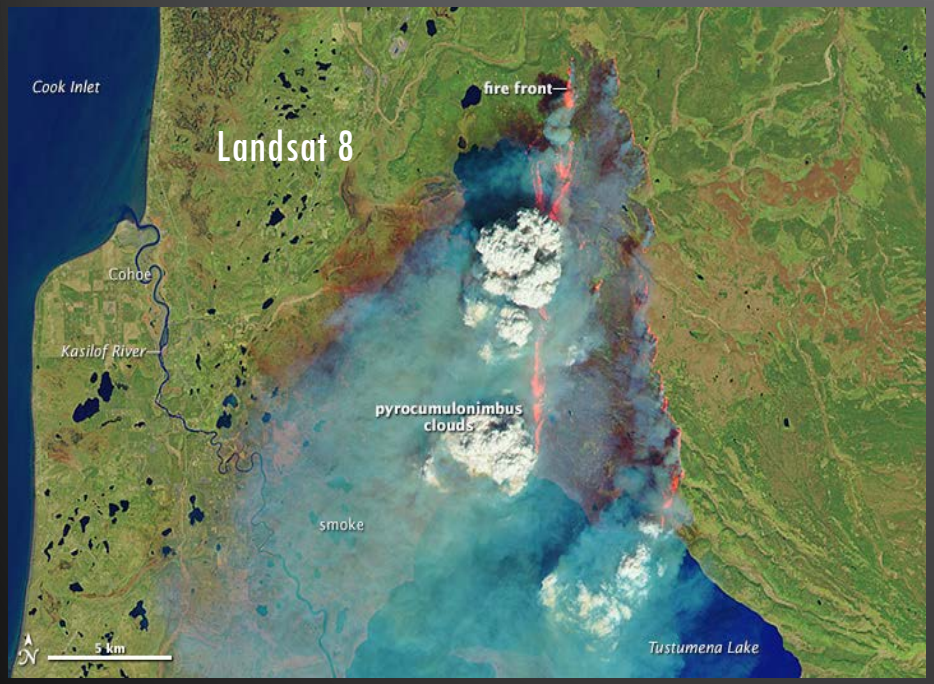


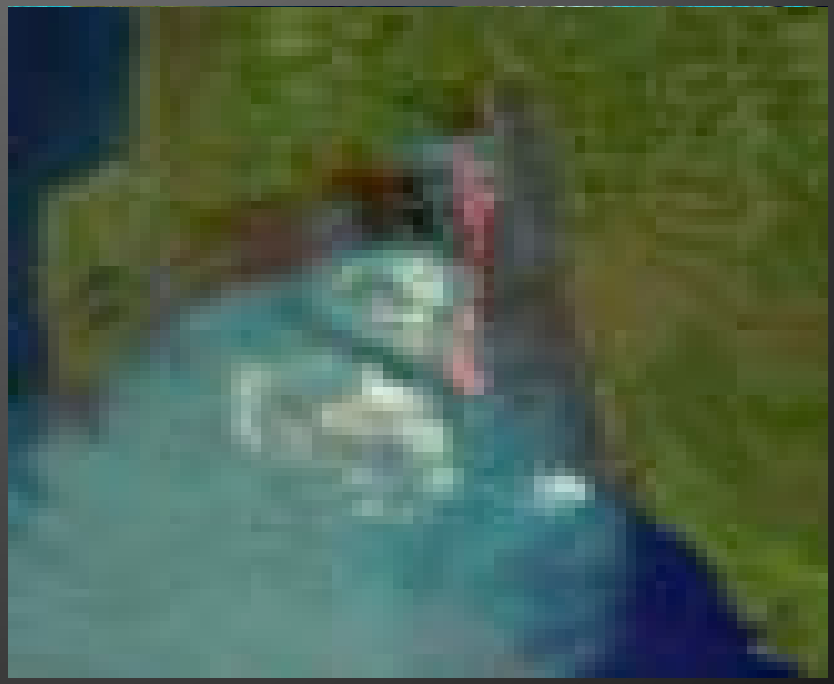
VIIRS





LANDSAT 8 (30 meter resolution vs VIIRS (375 meter resolution)

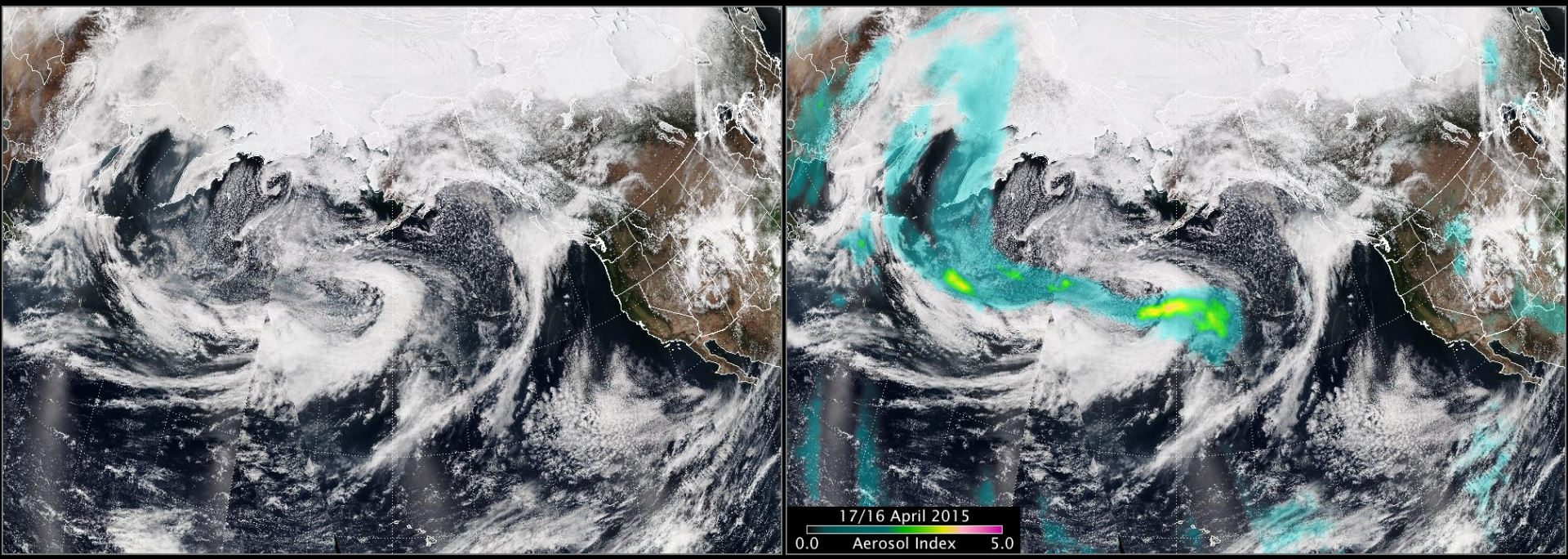




But Landsat has a 16 day repeat cycle – it will not observe this location for another 16 days

VIIRSS 375 meter resolution is adequate for fire behavior modeling – predicting fire movement and smoke direction and speed. GOES-R will tell you where the smoke came from, but difficult to predict because of spatial resolution (need < 500 meter resolution)

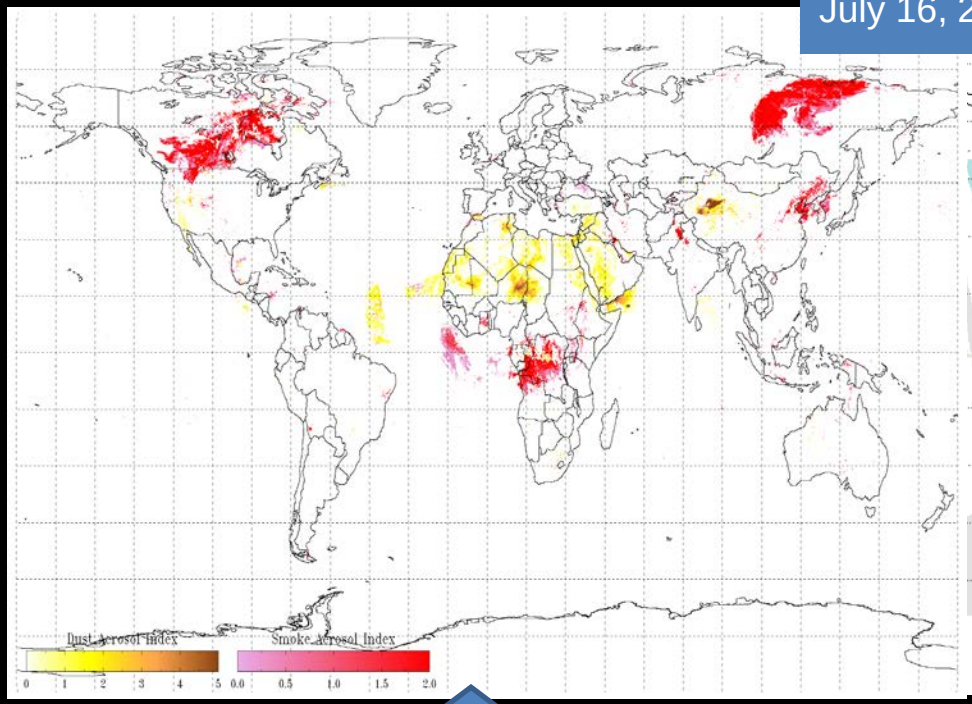
Transport of Russian Smoke Across Pacific (OMPS AI over VIIRS RGB)

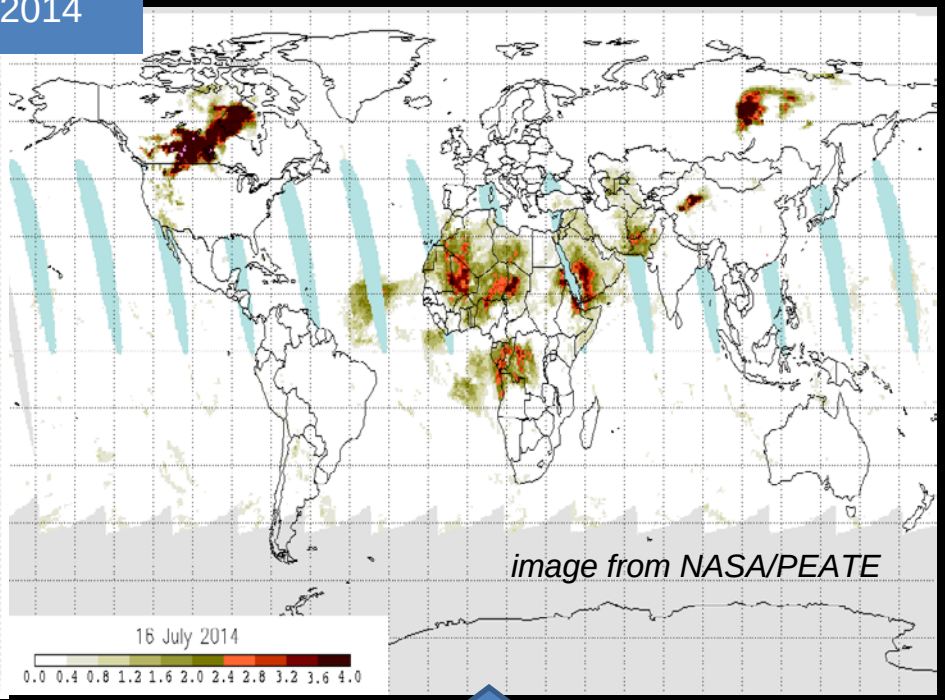


Credit: Colin Seftor (NASA)

Combine VIIRS and OMPS radiances to generate aerosol indices that can clearly separate smoke, dust, urban/industrial aerosol

July 16, 2014





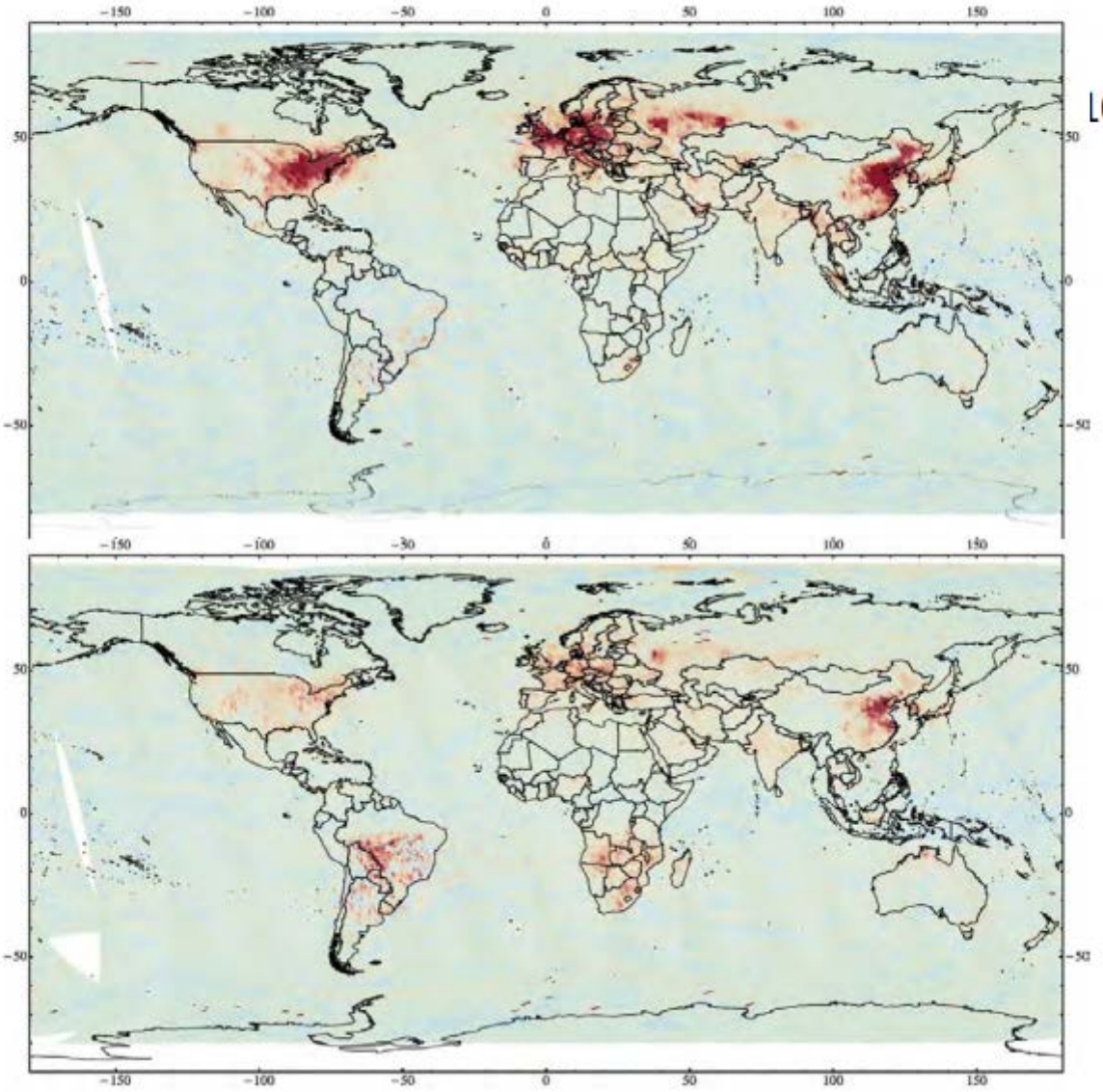
VIIRS: Aerosol Index separates dust and smoke but urban haze (sulfate aerosol) can be mis-identified as smoke

OMPS: Aerosol Index separates absorbing aerosol (dust and smoke) from scattering aerosol (sulfate aerosol).

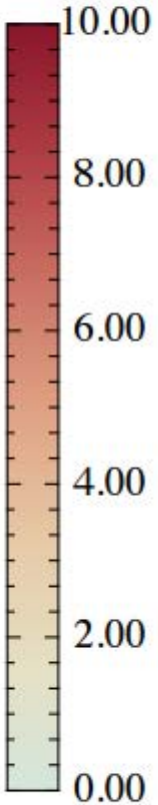
OMPS: NO_2 Trop Vertical Columns

03/21/2013

09/22/2013



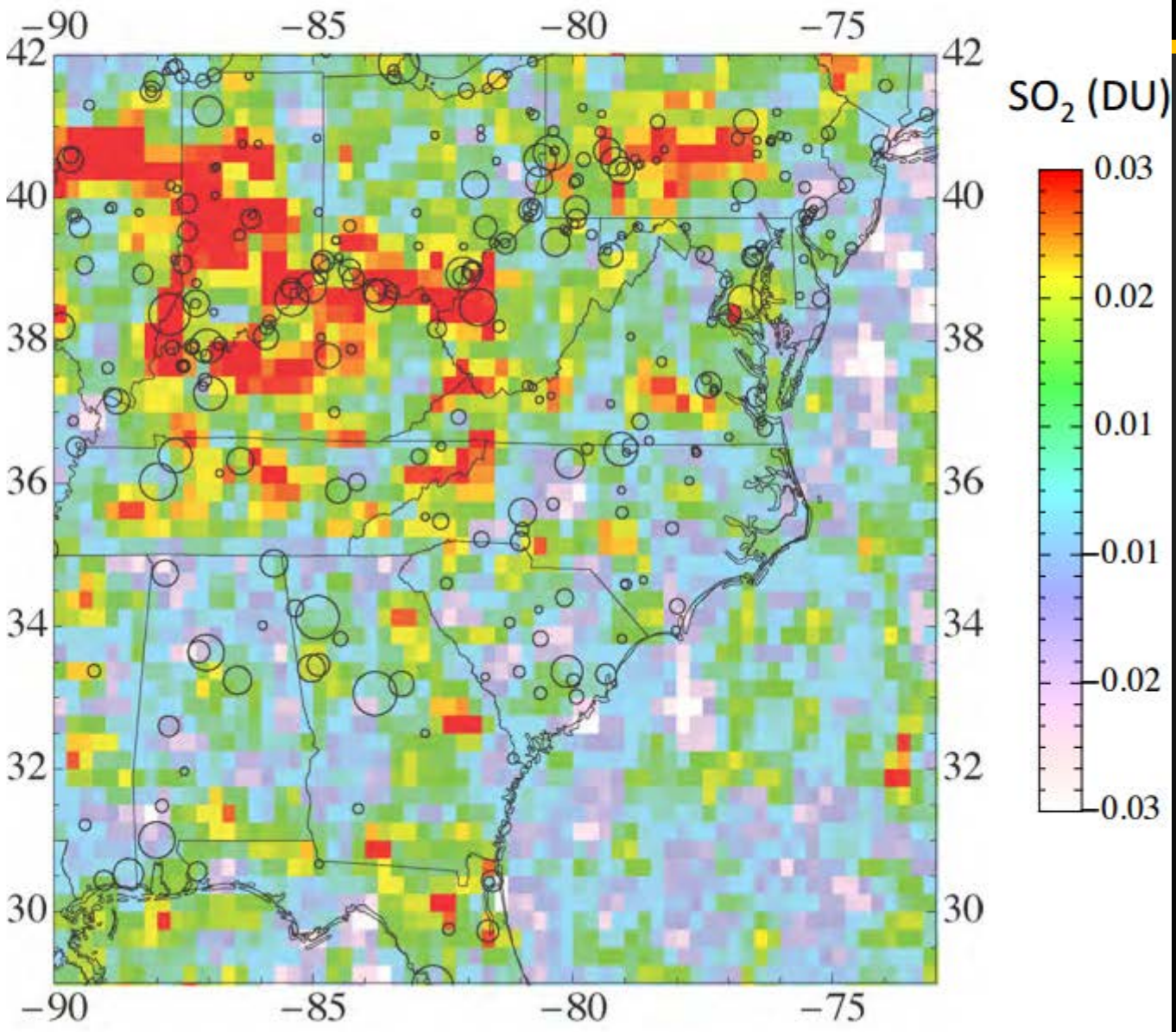
NO_2
10^{15} molecules/cm^2



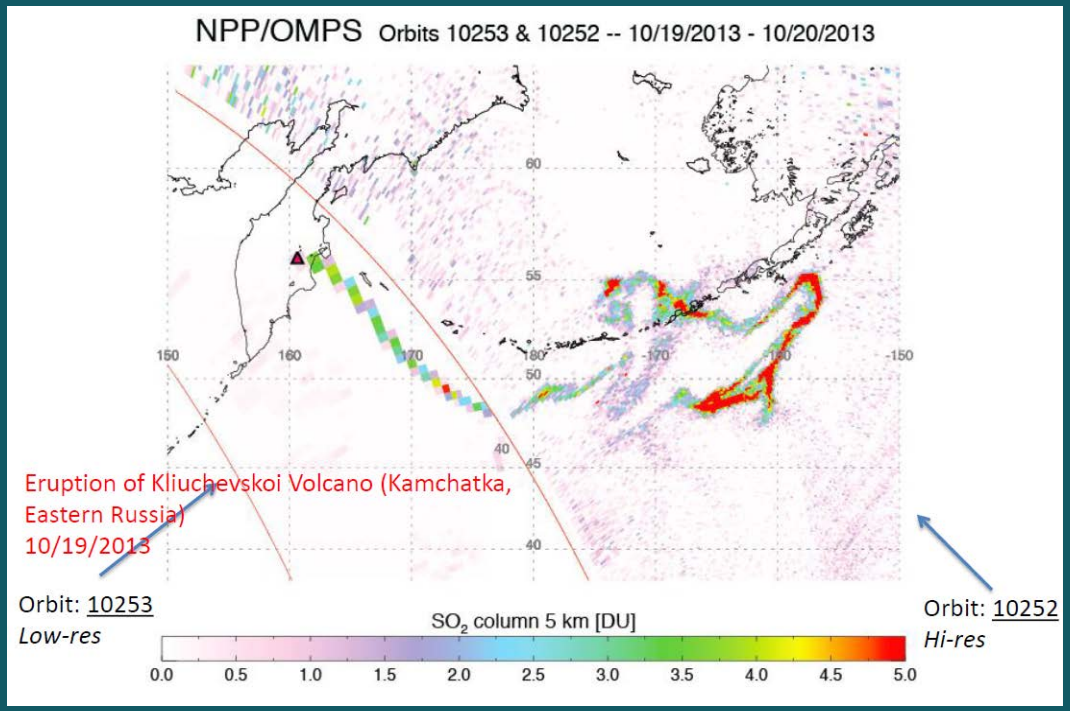
Credit: Kai Yang, UMD

Unprecedented SO_2 Sensitivity: Pollution over US

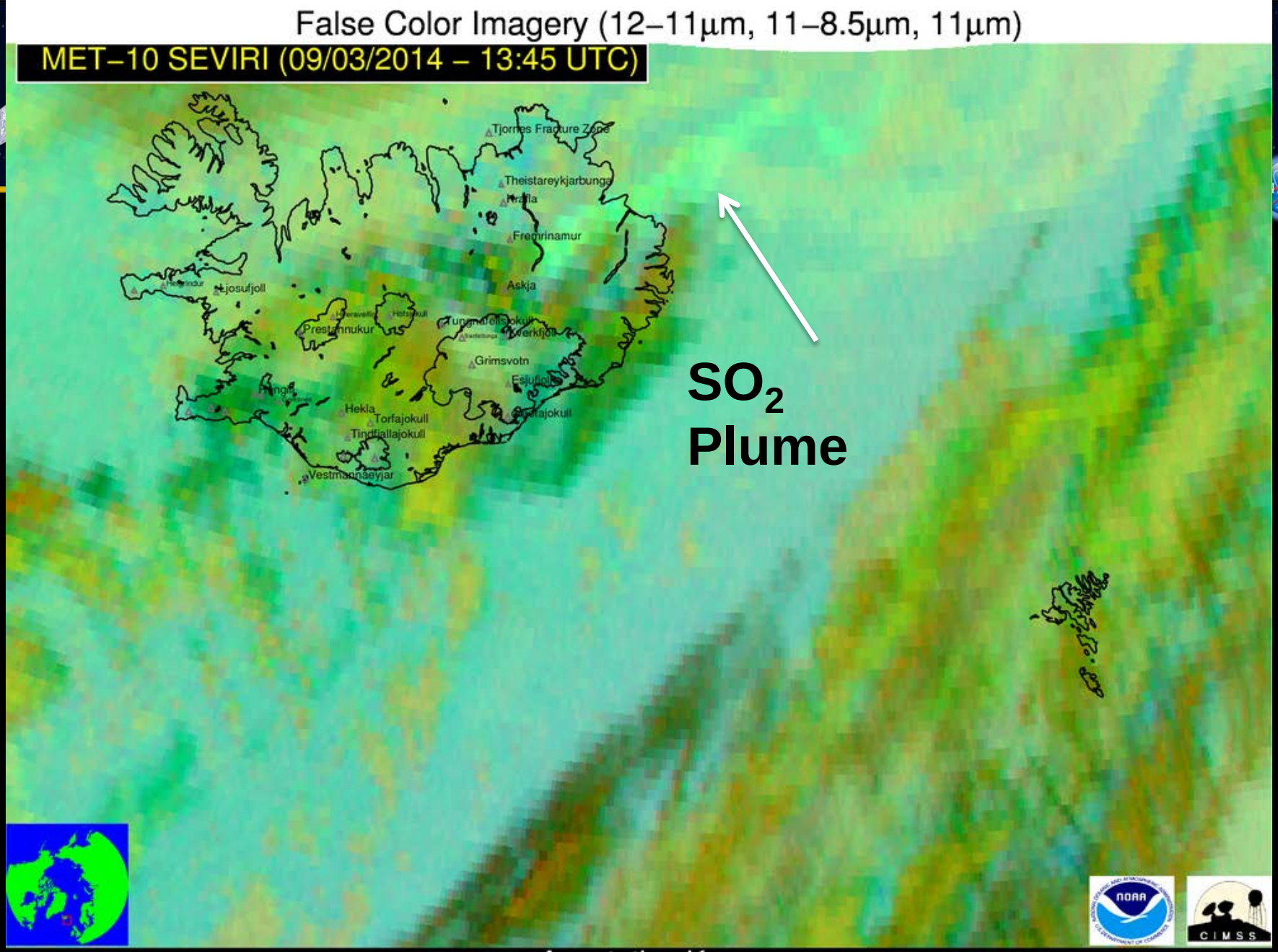
SNPP/OMPS
October 2013
Monthly Mean
DVCF Algorithm



Credit: Kai Yang, UMD

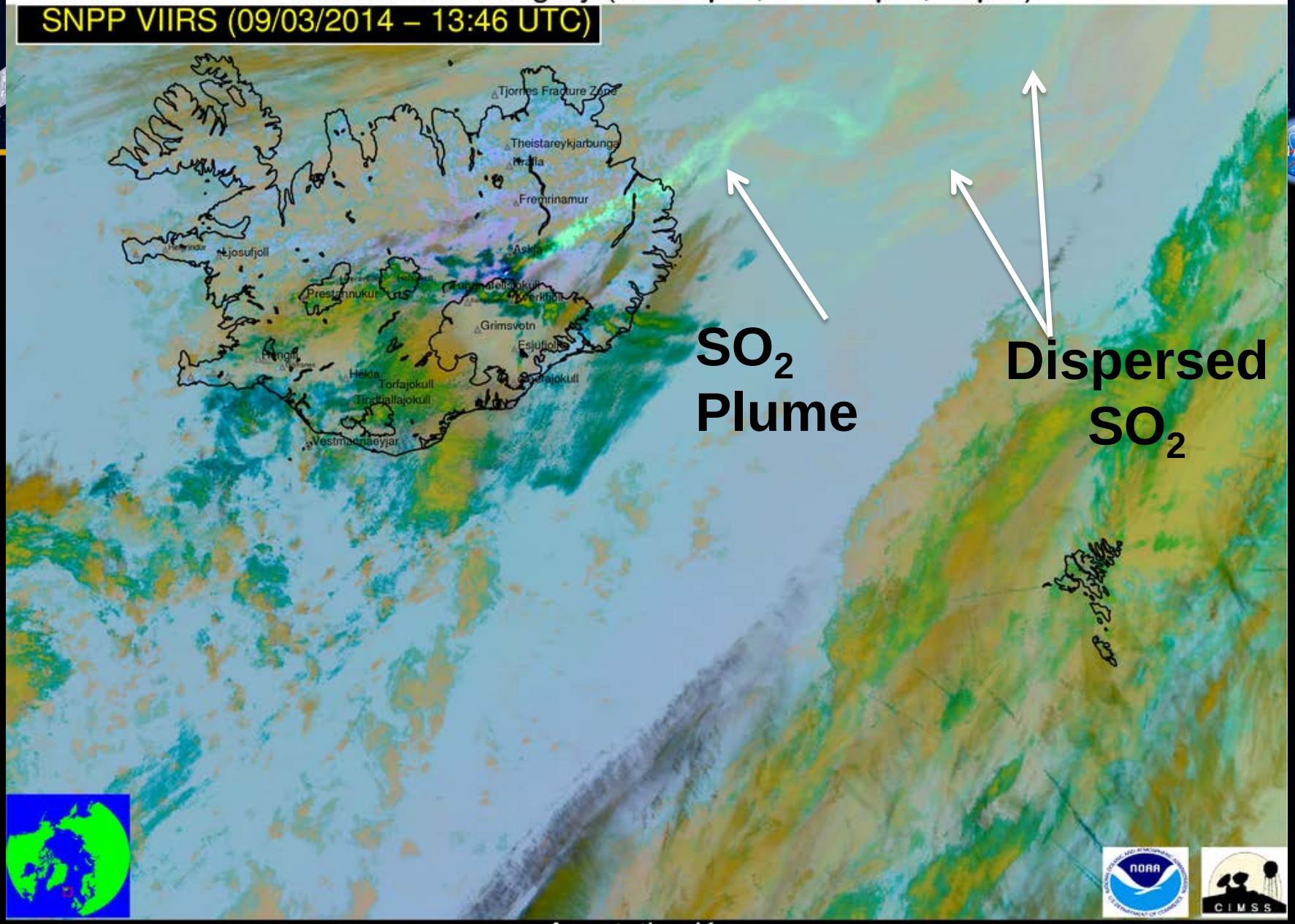


SO_2 products from processing by K. Yang, NASA OMPS Science Team Member. The data for the low-resolution orbit has 35 cross-track FOVs 50x50 KM^2 at nadir. The high-resolution orbit has 175 cross track FOVs 10x10 KM^2 at nadir. Lower resolution data will be obtained starting with OMPS on JPSS01. The data shows the volcanic SO_2 plume from Kliuchecevskoi (located at the red triangle) as observed by S-NPP OMPS for October 19-20 2013.



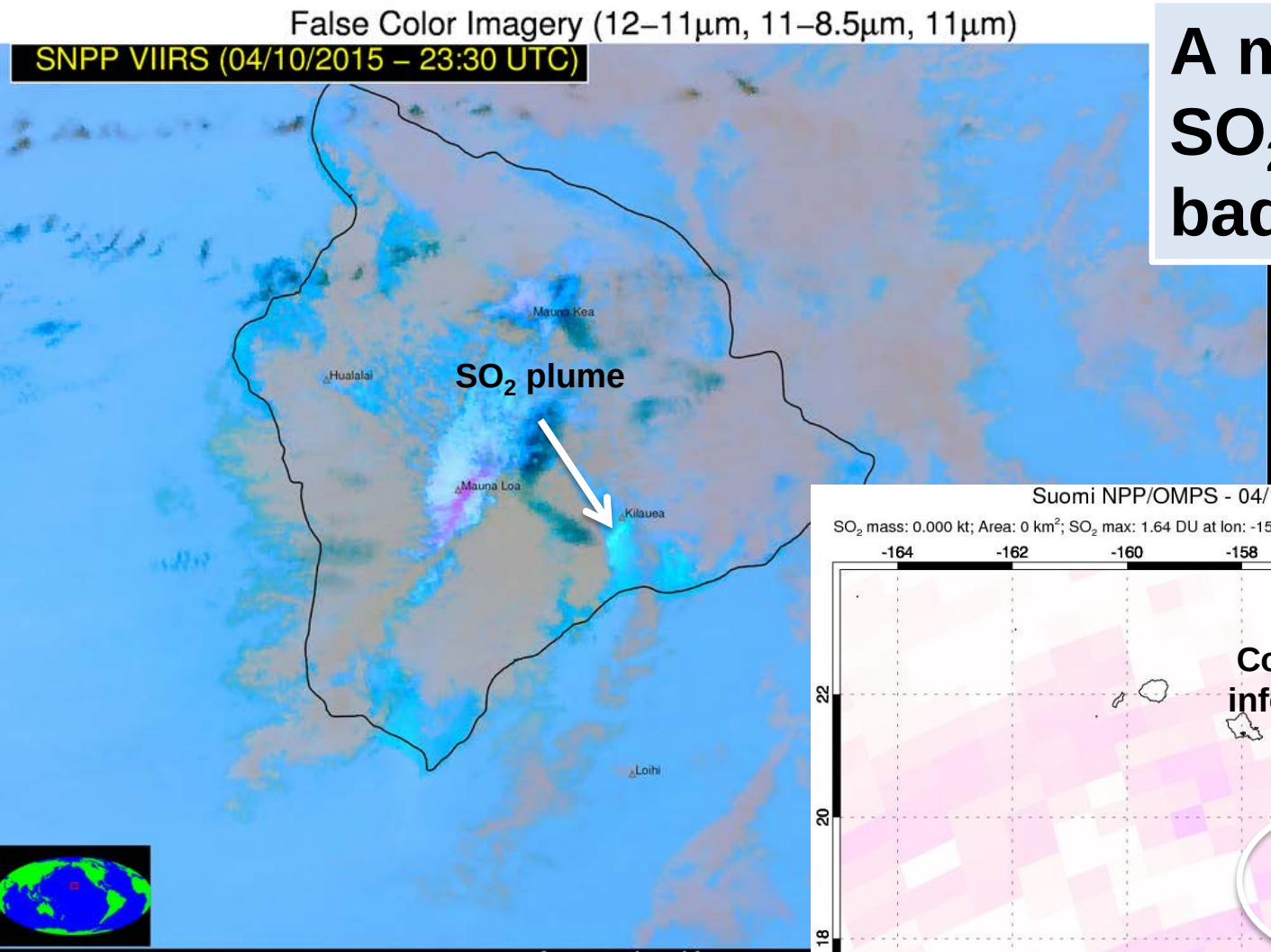
Annotation Key
(annotation colors are not related to colors in underlying image)
Ash/Dust Cloud Volcanic Cb SO_2 Thermal Anomaly

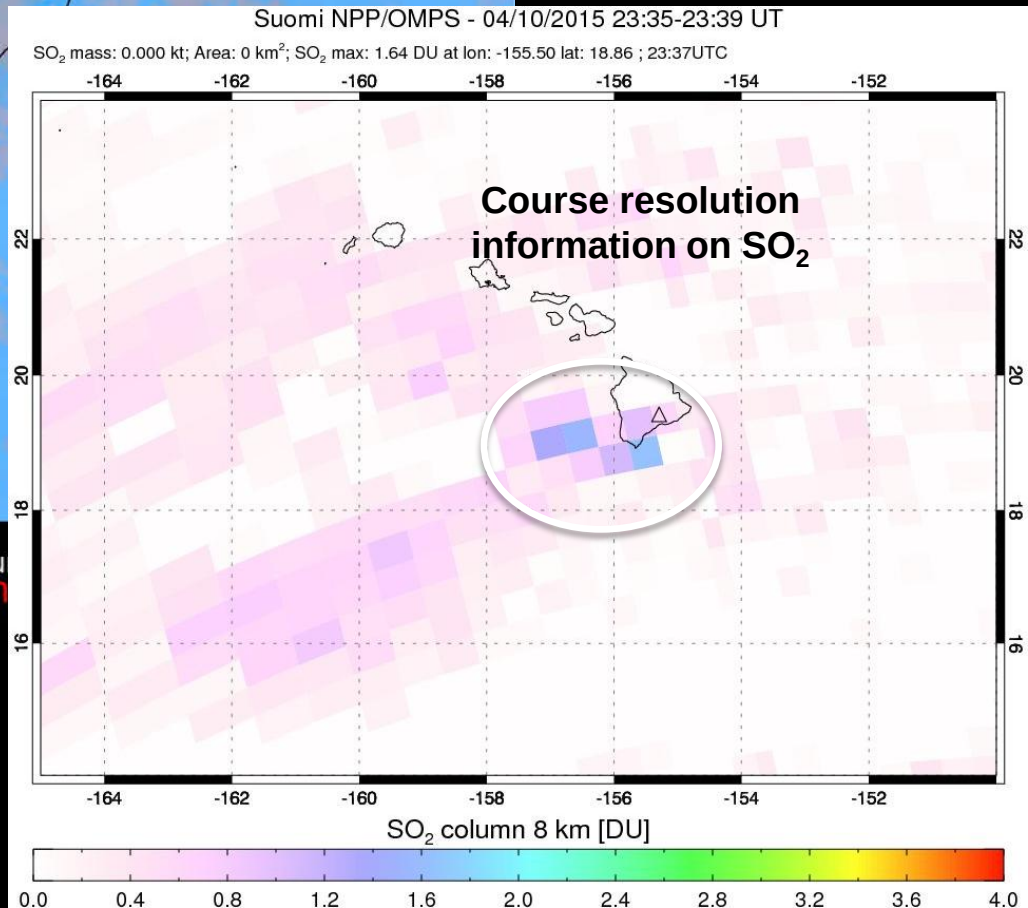
False Color Imagery (12–11μm, 11–8.5μm, 11μm)

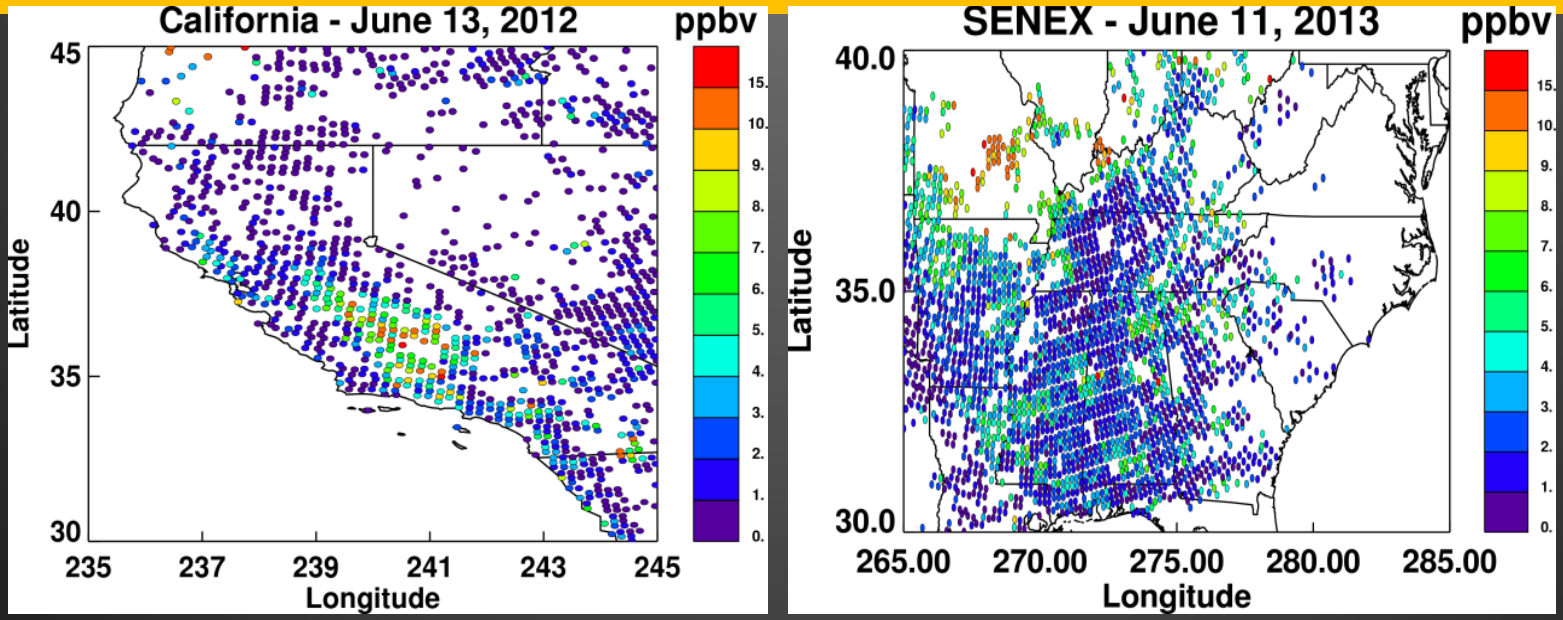


Annotation Key
(annotation colors are not related to colors in underlying image)
Ash/Dust Cloud Volcanic Cb SO_2 Thermal Anomaly

A multi-sensor SO_2 analysis is badly needed



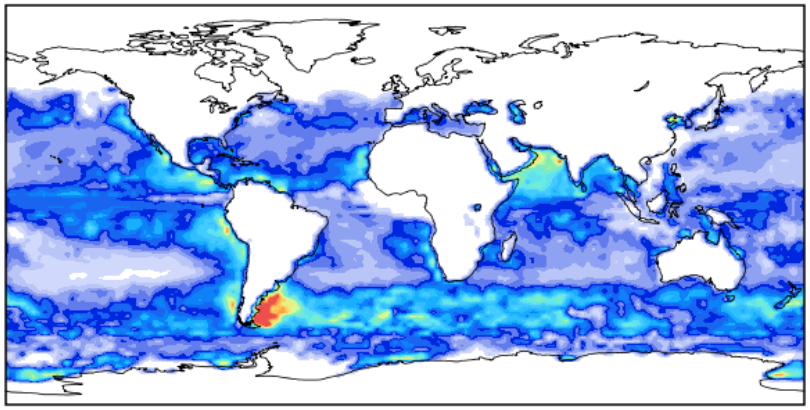




(left) CrIS NH_3 retrieval results over California plotted using the NH_3 representative volume mixing ratio (RVMR), which is approximately the retrieved value at the height of peak sensitivity of CrIS to NH_3. Most missing data is due to the presence of clouds. (right) The same but for the Southeast US during the NOAA SENEX campaign.

Global Distribution of Marine Isoprene

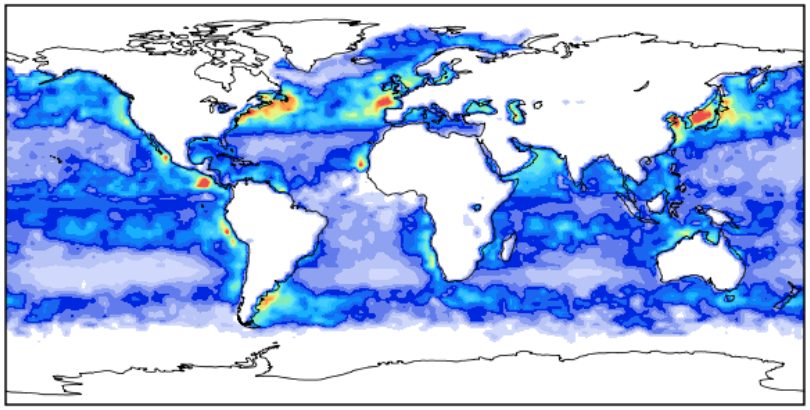
JAN



Marine Isoprene Emissions (molecules/cm2/s)

0.0E+00 1.0E+05 2.0E+05 3.0E+05

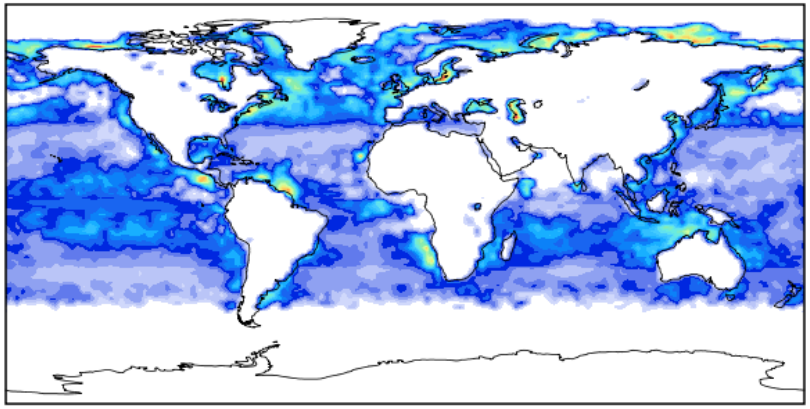
APR



Marine Isoprene Emissions (molecules/cm2/s)

0.0E+00 1.0E+05 2.0E+05 3.0E+05

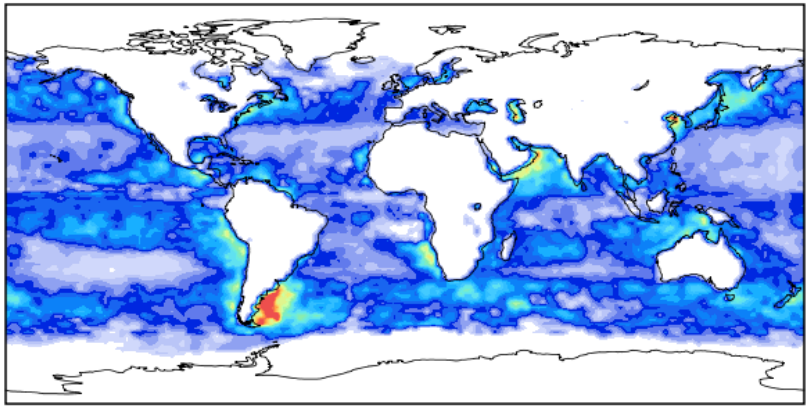
JUL



Marine Isoprene Emissions (molecules/cm2/s)

0.0E+00 1.0E+05 2.0E+05 3.0E+05

OCT



Marine Isoprene Emissions (molecules/cm2/s)

0.0E+00 1.0E+05 2.0E+05 3.0E+05

Path Forward

- The JPSS Proving Ground program is working with NOAA users to further promote the use of SNPP and JPSS data for operational use.
  - Use of fire location and radiative power in regional fire and smoke models
  - Assimilation of VIIRS aerosols and land products in NCEP global models
  - Working with OAR to validate the NUCAPS CO and CH4 products
- But what we need from you is a clear plan of your operational product and services, and JPSS will support demonstration of your highest priority utilization of JPSS data.

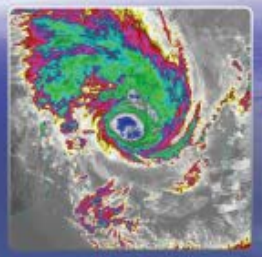
Want to learn more?

- 2013 and 2014 Annual Science Digests are available
- Join our monthly JPSS Science Seminars http://www.jpss.noaa.gov/science-seminars.html
- Check out the JPSS Website http://www.jpss.noaa.gov/science.html

JPSS

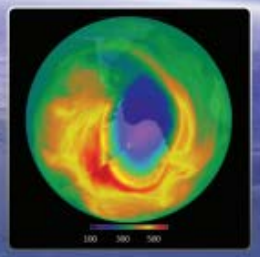
JOINT POLAR SATELLITE SYSTEM

The next generation of polar-orbiting environmental satellites



Advanced weather prediction instruments

High-resolution weather monitoring



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