Addressing Data Product Requirement Deltas from Suomi NPOESS Preparatory Project to Joint Polar Satellite System

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Outline

- Background
- Categories of modifications
- Specific changes
- Implementation schedule
- Summary

Background

- Original development of requirements for Suomi National Polar-orbiting Partnership (S-NPP) data products
  - Tri-agency program (NPOESS) agreed upon a fully defined set of integrated, operational requirements that would meet the needs of the nation's civil and military users of polar environmental satellite data
  - Supported military and civilian weather, space weather, and oceanic forecasting operations in addition to providing continuity of observations for NASA's earth and space science research missions
- Development of requirements for S-NPP data products post-NPOESS
  - Post NPOESS era, Joint Polar Satellite System (JPSS) inherited the NPOESS baseline and captured NOAA's performance requirements in the JPSS Level 1 Requirements Document (L1RD) and L1RD Supplement
  - The L1RD was updated to reflect additional environmental satellite requirements beyond NPOESS to include NOAA polar legacy data products that will be supported by JPSS
  - JPSS L1RD became the baseline for S-NPP data product performance with the inclusion of Appendix D, which identifies JPSS mission-specific performance requirements within the document that are not retroactively applied to the S-NPP mission

JPSS Program Data Products

VIIRS (28 EDRs)

RDR & SDR (for each of 22 bands)

EDRs

- Active Fires
- Albedo (Surface)
- Aerosol Optical Thickness
- Aerosol Particle Size Parameter
- Cloud Base Height
- Cloud Cover/Layers
- Cloud Effective Particle Size
- Cloud Optical Thickness
- Cloud Top Height
- Cloud Top Pressure
- Cloud Top Temperature
- Cloud Mask
- Ice Surface Temperature
- ○ Imagery
- Land Surface Temperature
- Ocean Color/Chlorophyll
- Quarterly Surface Type
- Sea Ice Characterization
- Sea Surface Temperature
- Snow Cover
- Surface Type
- Suspended Matter
- Vegetation Indices
- *Green Vegetation Fraction Index*
- *Ocean Color/Chlorophyll*
- *Polar Winds*
- *Sea Surface Temperature*
- *Vegetation Health Index Suite*

CERES[1]

RDR

CrIS (5 EDRs)

RDR & ○ SDR

EDRs:

- *Carbon Dioxide*
- *Carbon Monoxide*
- *Infrared Ozone Profile*
- *Methane*
- *Outgoing Longwave Radiation*

AMSR2 (11 EDRs)[3]

RDR, *SDR, TDR*

EDRs:

- *Cloud Liquid Water*
- *Imagery*
- *Precipitation Type/Rate*
- *Precipitable Water*
- *Sea Ice Characterization*
- *Sea Surface Temperature*
- *Sea Surface Wind Speed*
- *Snow Cover/Depth*
- *Snow Water Equivalent*
- *Soil Moisture*
- *Surface Type*

CrIS/ATMS (2 EDRs)

EDRs:

- *Atm Vertical Temperature Profile*
- *Atm Vertical Moisture Profile*

ATMS (11 EDRs)

RDR, ○ SDR, TDR

EDRs:

- *Cloud Liquid Water*
- *Imagery*
- *Land Surface Emissivity*
- *Land Surface Temperature*
- *Moisture Profile*
- *Rainfall Rate*
- *Sea Ice Concentration*
- *Snow Cover/Depth*
- *Snow Water Equivalent*
- *Temperature Profile*
- *Total Precipitable Water*

OMPS-Nadir (2 EDRs)

OMPS-N RDR & SDR

EDRs:

- O_3 Total Column
- O_3 Nadir Profile

OMPS-Limb[2]

OMPS-L RDR[2]

KEY

RDR – Raw Data Record
SDR – Sensor Data Record
TDR – Temperature Data Record
EDR – Environmental Data Record
○ – Products with Key Performance Parameters
Bold – Indicates JPSS Ground System xDR
Italics – Indicates NOAA Polar Legacy (ESPC) xDR

Notes:

[1]RDRs for the JPSS-2 Mission are contingent on NASA manifest of the Radiation Budget Instrument (RBI)
[2]Not applicable to JPSS-1; contingent on NASA manifest of OMPS-Limb on the JPSS-2 Mission
[3]Dependent on the Global Change Observation Mission (GCOM) provided by the Japan Aerospace Exploration Agency

The JPSS Program includes Ground System Support for the Metop, DMSP, GCOM, and Polar Free Flyer missions

December 12, 2013

This chart is controlled by JPSS Program Systems Engineering

JPSS-P Rev B

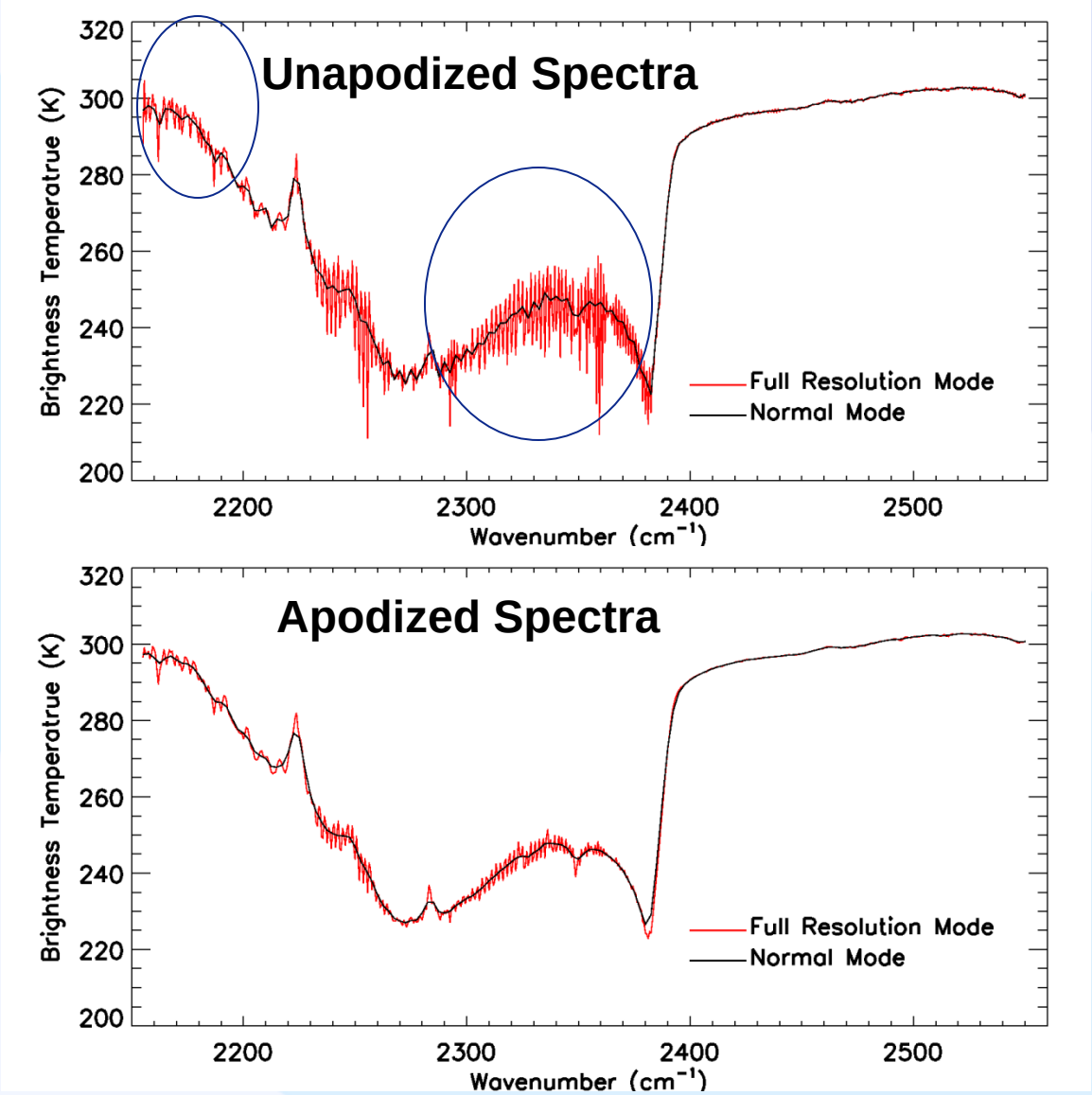
Categories of Modifications

- Spatial and Spectral Resolutions
- Addition of Product Parameters
- Algorithm Alternatives
- Retyping/Reclassifying
- Addition of Legacy NOAA Polar Data Products

Spatial/Spectral Resolution Changes

- **Cross-track Infrared Sounder (CrIS)**
  - Retrieve and process high and low spectral resolutions for the Sensor Data Record (SDR) product
    - Current: Full-length interferograms in the LWIR spectral band and truncated interferograms in the MWIR and SWIR spectral bands
    - Future: Full-length interferograms collected in all three spectral bands
      - Improved retrieval of trace gases (CO, CO2, and CH4 data products)
      - Improved humidity profiles for National Weather Service Field Offices and offline verification of Numerical Weather Prediction models
      - On-orbit validation of spectral calibration throughout the mission
- **Ozone Mapping and Profiler Suite (OMPS) – Total Column**
  - Extend spectral range from 300-380 nm to 300-420 nm
  - Reduce horizontal cell size from 50 km to 10 km at nadir
- **OMPS – Nadir Profile**
  - Reduce horizontal cell size from 250 km to 50 km at nadir
    - Increases noise but provides finer detail in identifying SO_2 plume locations, aerosol sources, and sinks

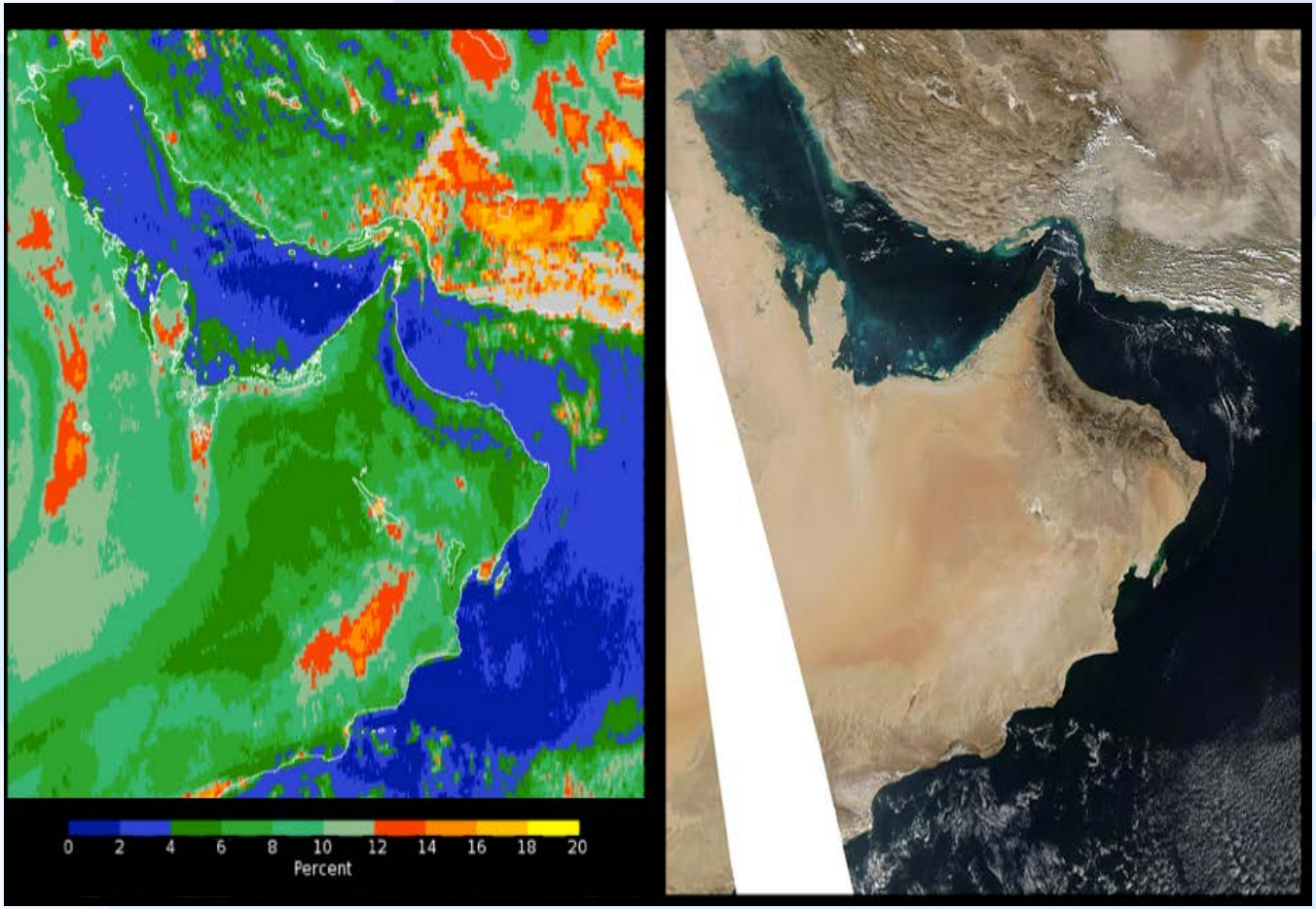
CrIS Normal Mode and Full Resolution Mode Spectra



- An example of CrIS SWIR normal, and full resolution spectra when the CrIS was operated in the full spectral resolution mode on 08/28/2013.
- CO absorption band (2155-2190 cm^{-1}), and CO_2 absorption band (2300-2370 cm^{-1}).

Courtesy of Yong Chen, Yong Han from NESDIS/STAR

OMPS High Spatial Resolution Example

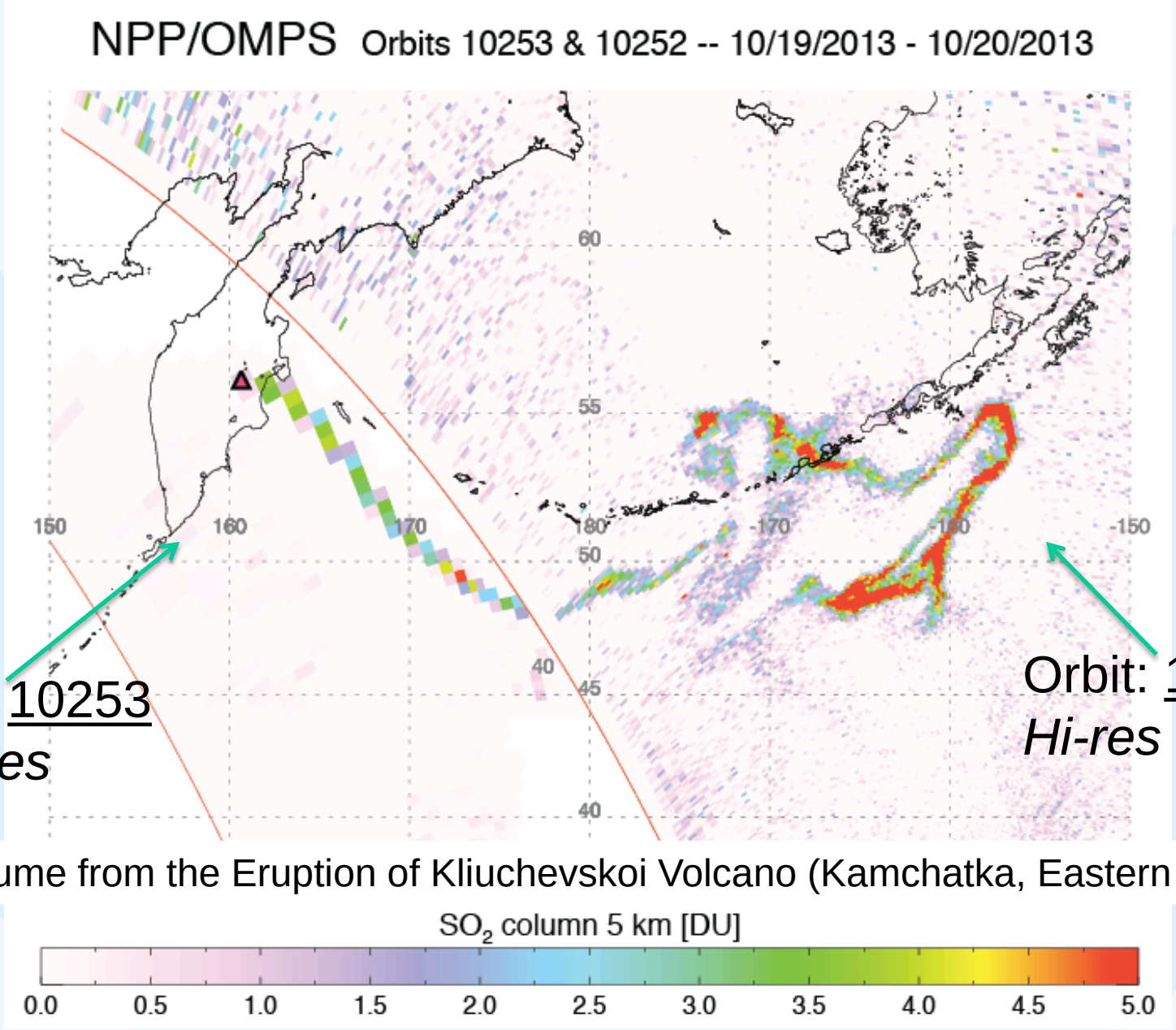


The image on the left shows a false color map of the OMPS effective reflectivity (at 380 nm) over the Arabian Peninsula region for 01/30/2012 during a special set of high-spatial-resolution measurements with 5×10 km^2 FOVs at nadir. 0 to 2 % in dark blue to 18 to 20 % in yellow. The image on the right is an Aqua Moderate Resolution Imaging Spectroradiometer (MODIS) Red-Green-Blue visible image for the same day.

The instrument is very stable, extremely flexible, and has excellent SNRs.

Courtesy of Colin Seftor and Larry Flynn

Near-Real-Time OMPS SO2 Identification



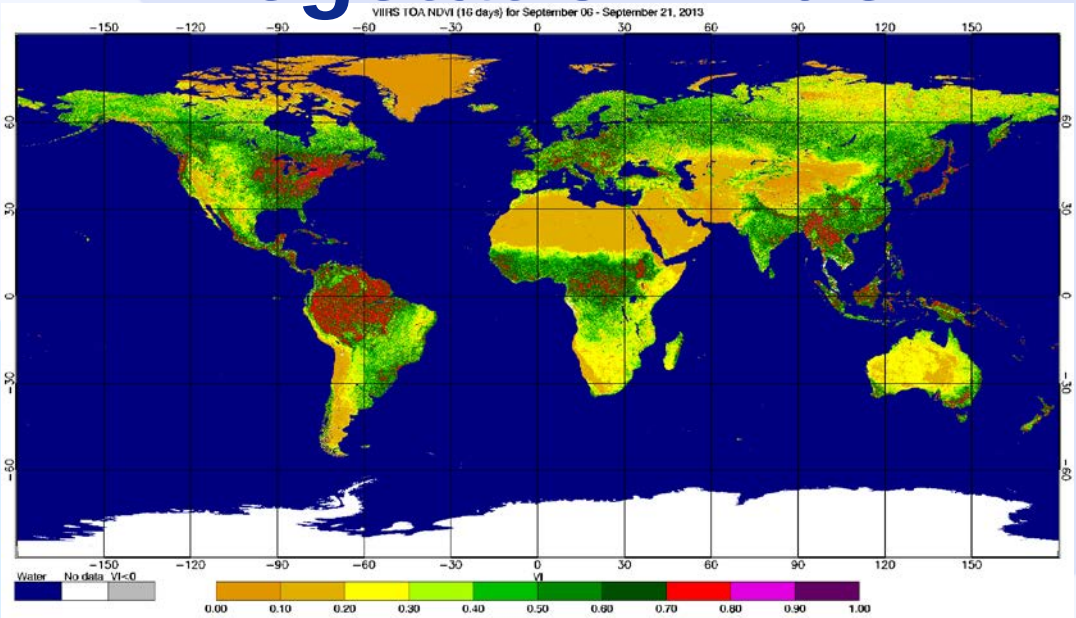
SO_2 plume from the Eruption of Kliuchevskoi Volcano (Kamchatka, Eastern Russia)

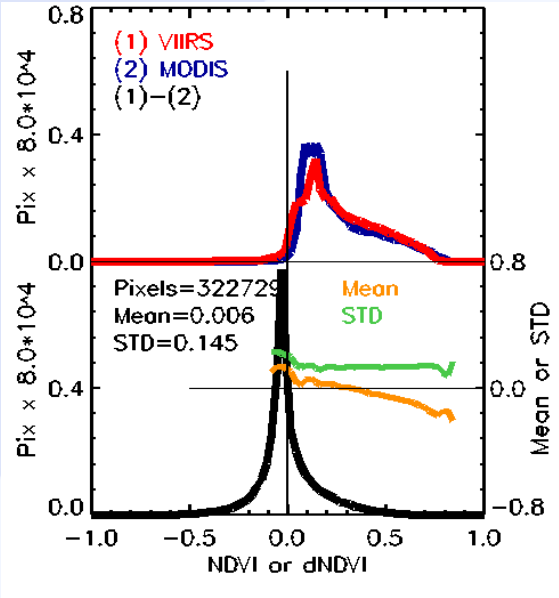
Addition of Product Parameters

- **Vegetation Index**
  - Current: Top of Atmosphere Normalized Difference Vegetation Index (NDVI) and Top of Canopy Enhanced Vegetation Index (EVI)
  - New: Addition of Top of Canopy (TOC) NDVI to product
- **Active Fires**
  - Current: Sparse array of lat/lon location of fire locations
  - New: Additional Information
    - Fire Radiative Power (measured radiant heat output of detected fires)
    - 2-D array of values representing thematic classes of each pixel

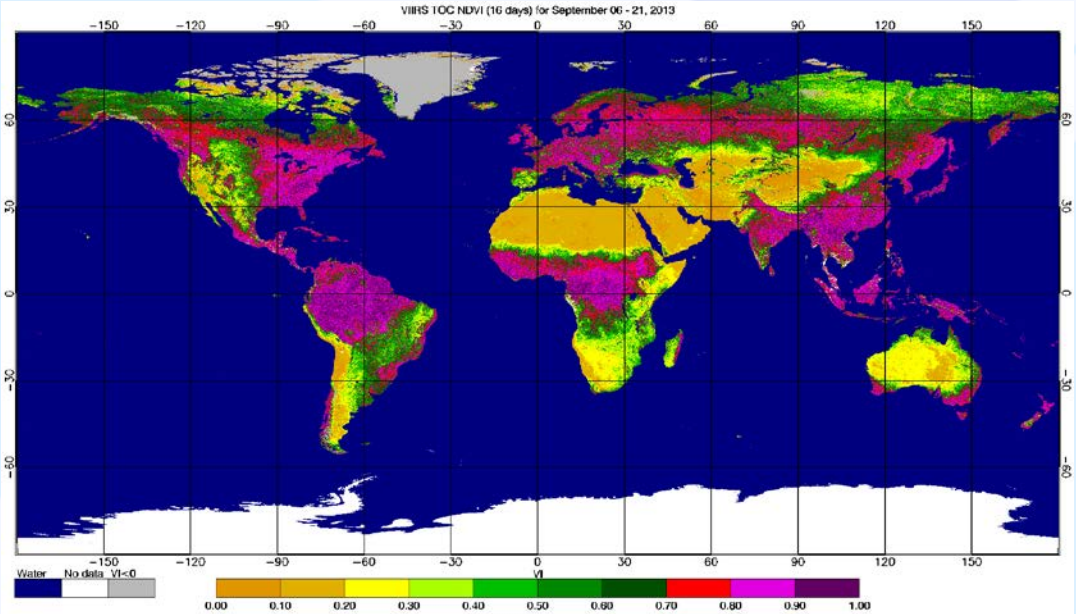
Vegetation Index Example

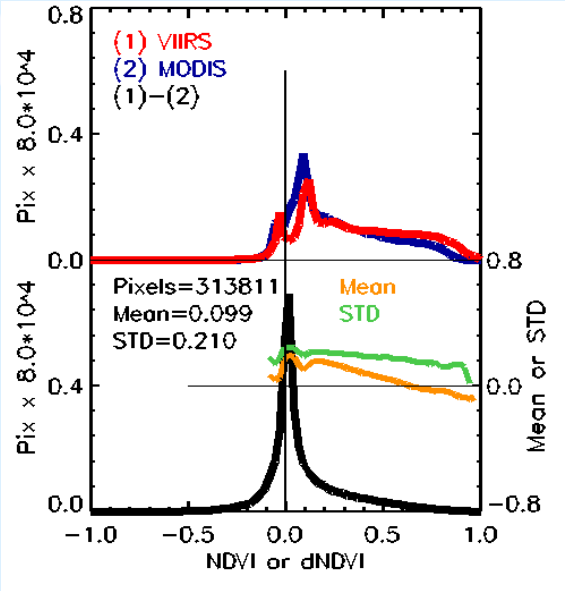
TOA NDVI





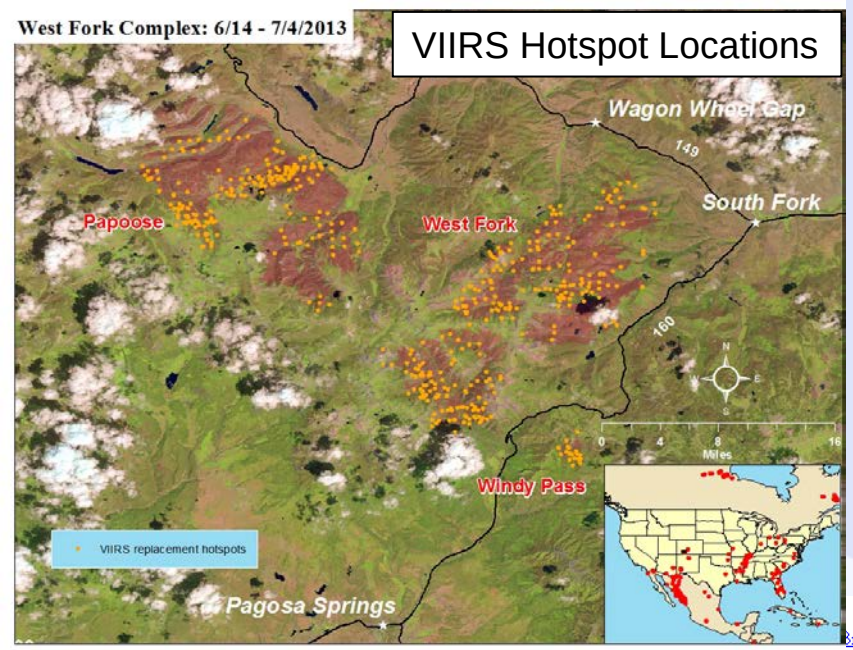
TOC NDVI

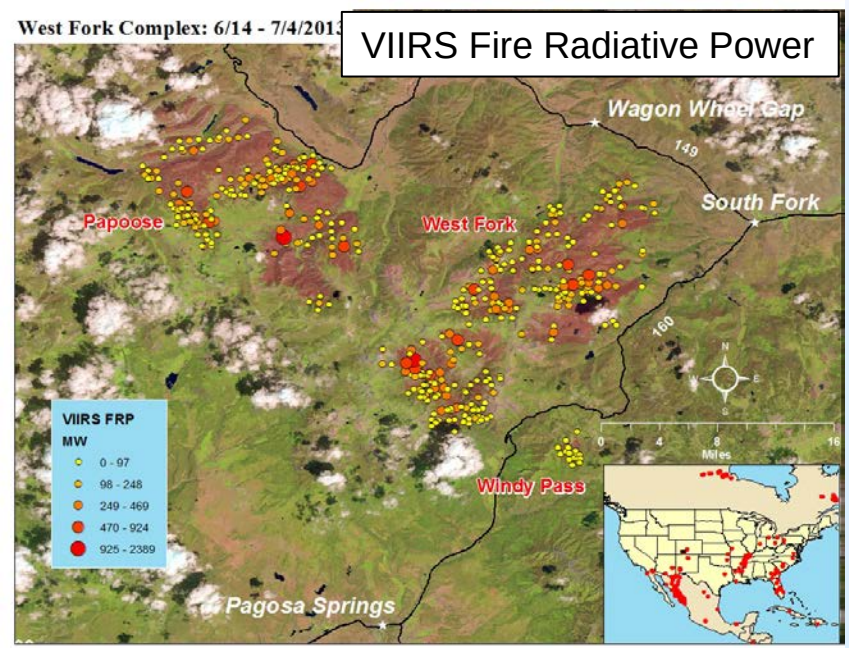


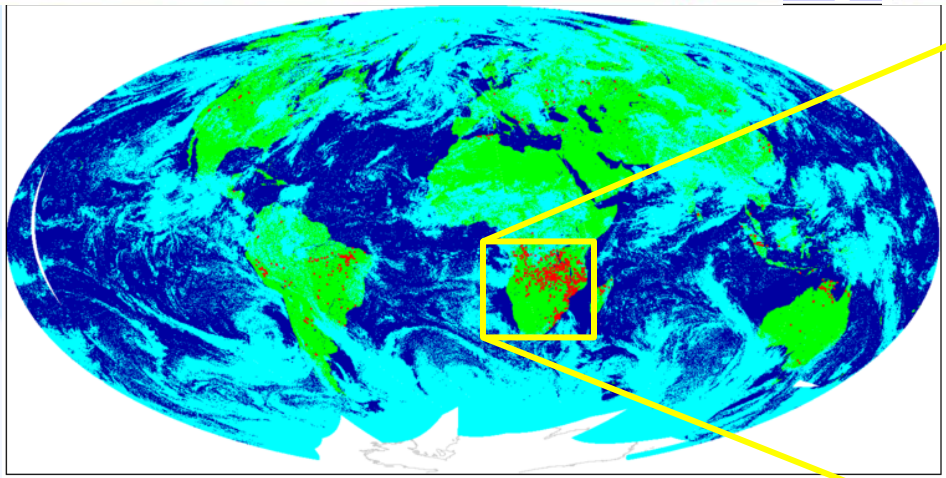


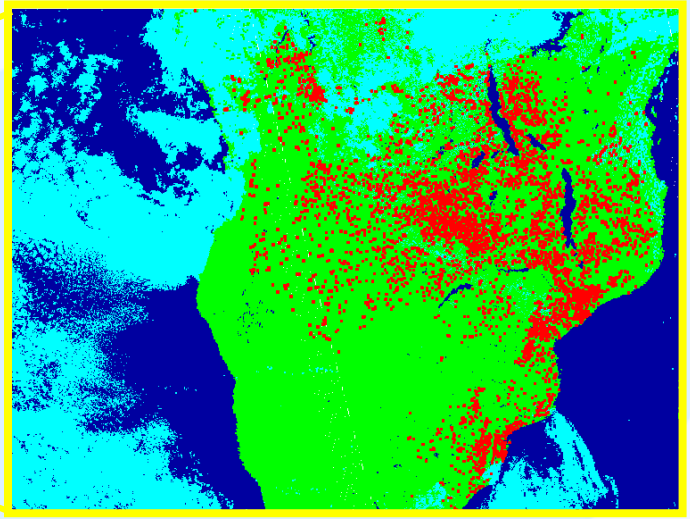
Atmospheric correction (of the SDR input bands I1 and I2) removes the effect of the atmosphere (air molecules, aerosols, water vapor, etc). TOC-NDVI provides more accurate information of the land surface. TOC NDVI (compared to TOA NDVI) has improved sensitivity to vegetation and its dynamic range is higher. (Courtesy of Marco Vargas and Nikolay Shabanov)

Active Fires Example









Fire
Cloud
Water
Land
Not Processed
Missing Data

Thematic Classes for Each Pixel

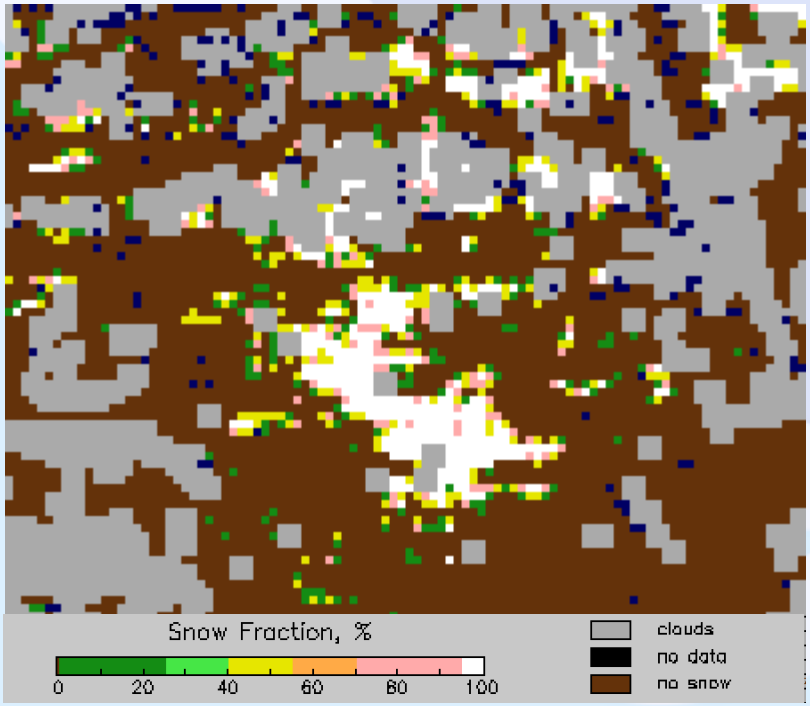
Courtesy of Ivan Csiszar, NOAA/NESDIS/STAR

Algorithm Alternatives

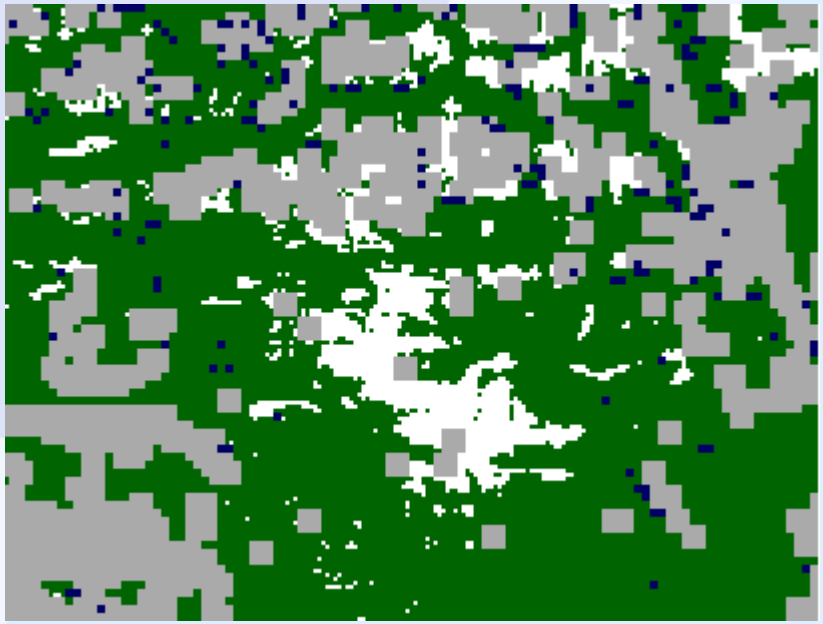
- **Snow Fraction**
  - Current: 2x2 aggregation algorithm indicating snow fraction
  - New: pixel by pixel algorithm to determine snow fraction
    - algorithm changes are required in the snow cover fraction Environmental Data Record (EDR) to meet the L1RD measurement uncertainty requirement of 10%. The current 2x2 aggregation algorithm by design will have uncertainties as high as 13%.
- **Suspended Matter (SM)**
  - Current: Algorithm not meeting accuracy requirement
  - New: Improvement needed for probabilities of correct typing (i.e. Volcanic Ash)
- **Ocean Color/Chlorophyll (OC/C)**
  - Current: Performance over coastal and inland water not optimal due to atmospheric correction problems
  - New: Development of new module for OC/C for coastal and inland water

Snow Fraction Example

Granule date: 20130915 time: 0355267



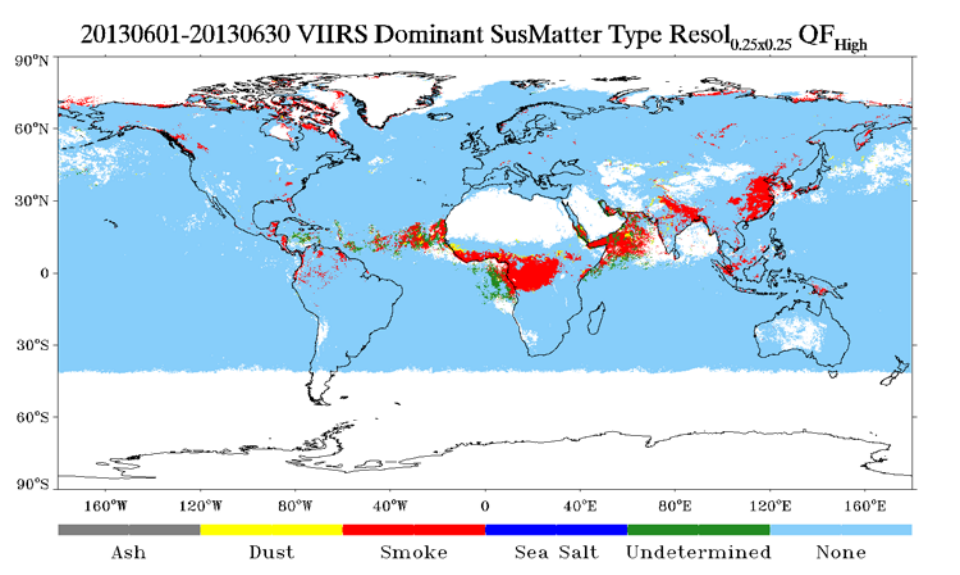
Snow fraction map (granule fragment)
750 m spatial resolution



Binary snow map (granule fragment)
375 m spatial resolution

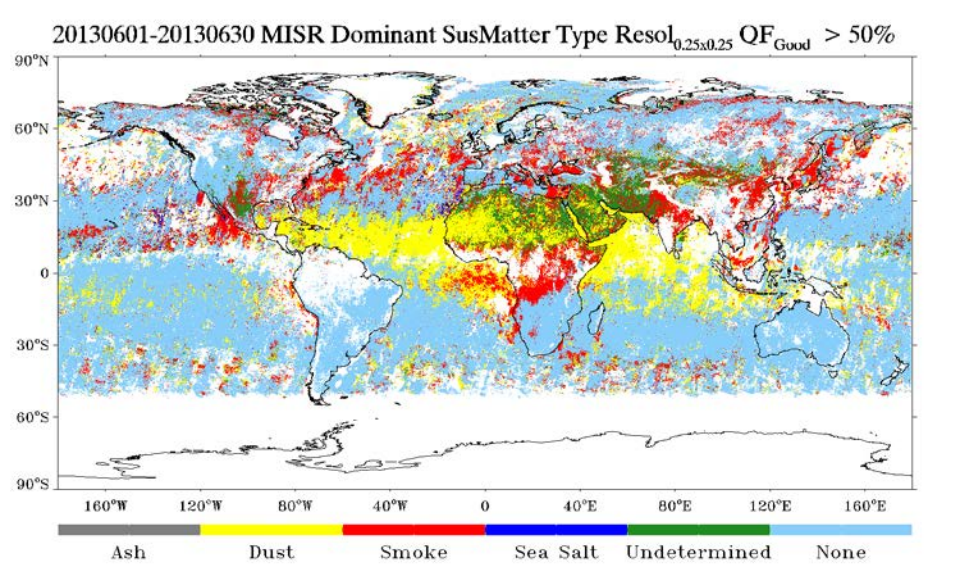
VIIRS Snow Fraction Algorithm correctly converts binary snow cover map data into coarser resolution snow fraction but adds little value, especially for the land modelers who need a snow fraction that accounts for patchiness of the snow cover on the ground and for masking of snow cover by vegetation/trees.

June 2013 Suspended Matter
S-NPP VIIRS vs. Terra MISR



- SM is not a legacy NASA MODIS product
- VIIRS SM algorithm relies on Aerosol Optical Thickness (AOT) and other internal parameters (not validated) to identify and type SM.
- SM product very difficult to evaluate and validate due to non-availability of "truth" dataset. Comparisons with Multi-angle Imaging SpectroRadiometer (MISR) show that VIIRS SM doesn't identify dust near the source and dust outflow regions (Sahara and Atlantic Ocean).
- The VIIRS SM product is not recommended for use in any applications. An alternate algorithm has been developed and is being tested.

VIIRS SM accuracy is < 20% (requirement is 80%)



Courtesy of Kondragunta, NESDIS/STAR

Retyping/Reclassifying

- **Application Related Product promoted to EDR**
  - Active Fires
- **Intermediate Products promoted to EDRs**
  - Ozone NP
  - Quarterly Surface Type
  - CrIS IR Ozone
  - Cloud Mask

So what does it mean now that these products are now EDRs?

→ Performance Requirements

→ Archival in CLASS for life of mission

Legacy NOAA Polar Data Products

- **ATMS**
  - Cloud Liquid Water
  - Imagery
  - Land Surface Emissivity
  - Land Surface Temperature
  - Moisture Profile
  - Precipitable Water
  - Rainfall Rate
  - Sea Ice Concentration
  - Snow Cover
  - Snow Water Equivalent
  - Temperature Profile

Microwave Integrated Retrieval System (MiRS)

- **CrIS**
  - Greenhouse Gasses (CO2, CO, CH4)
  - Infrared Ozone Profile
  - Outgoing Longwave Radiation
- **CrIMSS**
  - Atm Vertical Moisture Profile
  - Atm Vertical Temperature Profile

NOAA Unique CrIS-ATMS Product System (NUCAPS)

- **OMPS**
  - Ozone Limb Profile
- **VIIRS**
  - Green Vegetation Fraction
  - Polar Winds
  - Sea Surface Temperature
  - Vegetation Health Index Suite

Advanced Clear Sky Processor for Ocean (ACSPO)

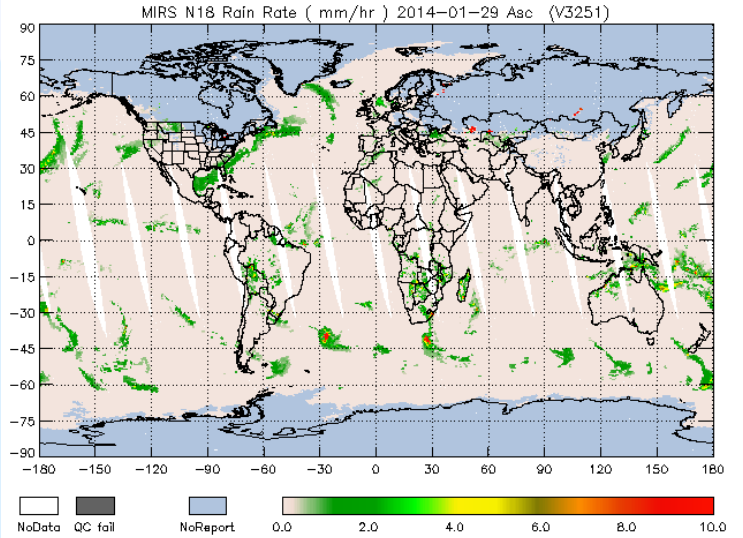
- **AMSR-2**
  - Cloud Liquid Water
  - Imagery
  - Precipitation (Type/Rate)
  - Precipitable Water
  - Sea Ice Characterization
  - Sea Surface Temperature
  - Sea Surface Wind Speed
  - Snow Cover/Depth
  - Snow Water Equivalent
  - Soil Moisture
  - Surface Type

ATMS: Advanced Technology Microwave Sounder
CrIS: Cross-track Infrared Sounder
CrIMSS: Cross-track Infrared and Microwave Sounder Suite

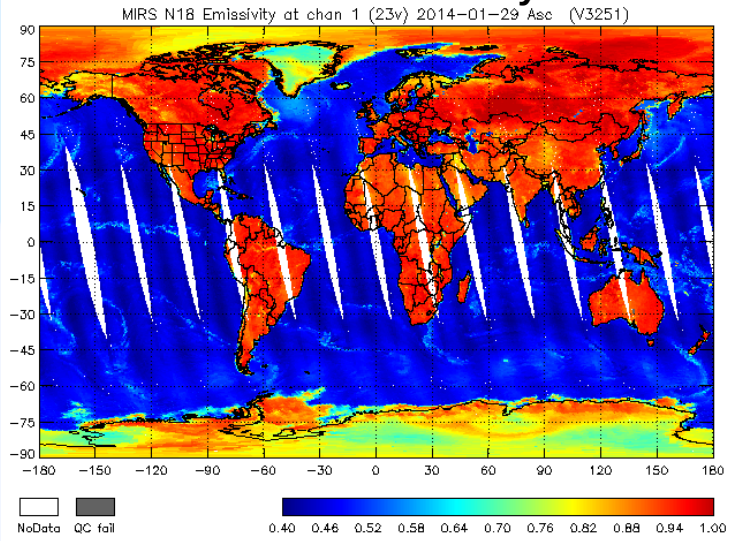
OMPS: Ozone Mapping and Profiler Suite
VIIRS: Visible Infrared Imaging Radiometer Suite
AMSR-2: Advanced Microwave Scanning Radiometer

Legacy NOAA Polar Data Products
Two Examples

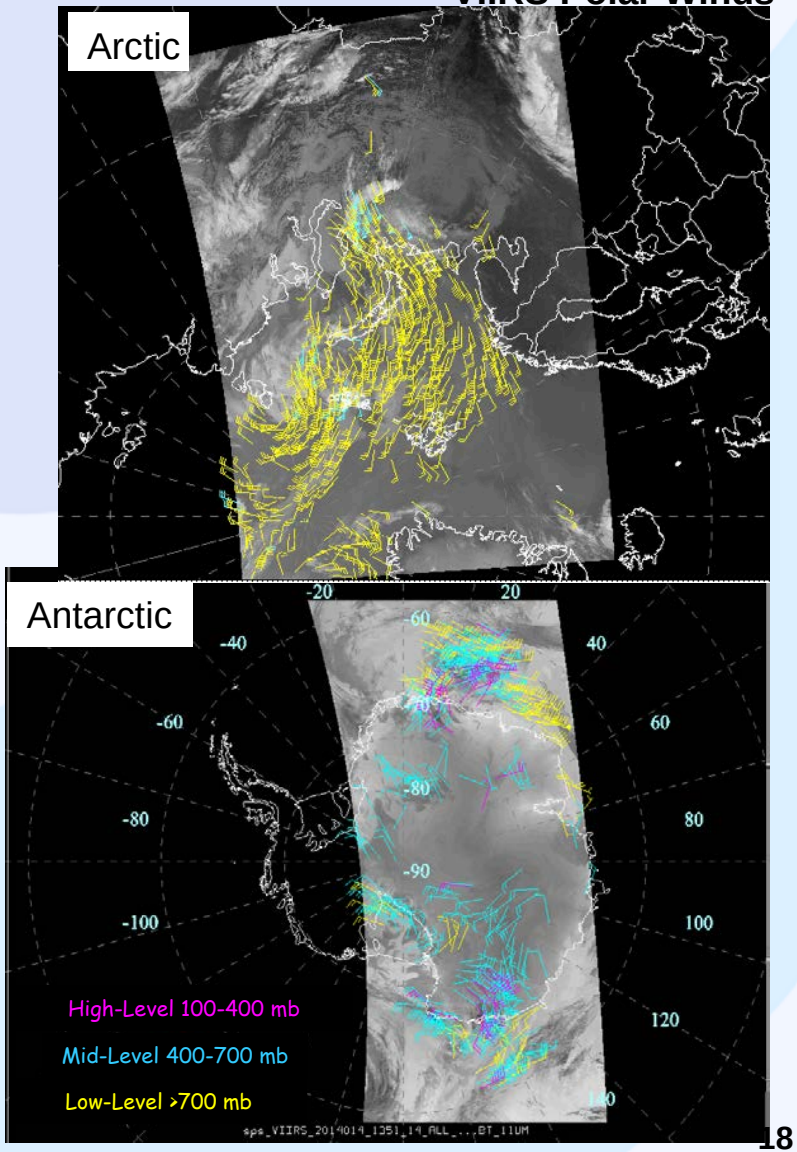
MiRS Rain Rate



MiRS Land Surface Emissivity

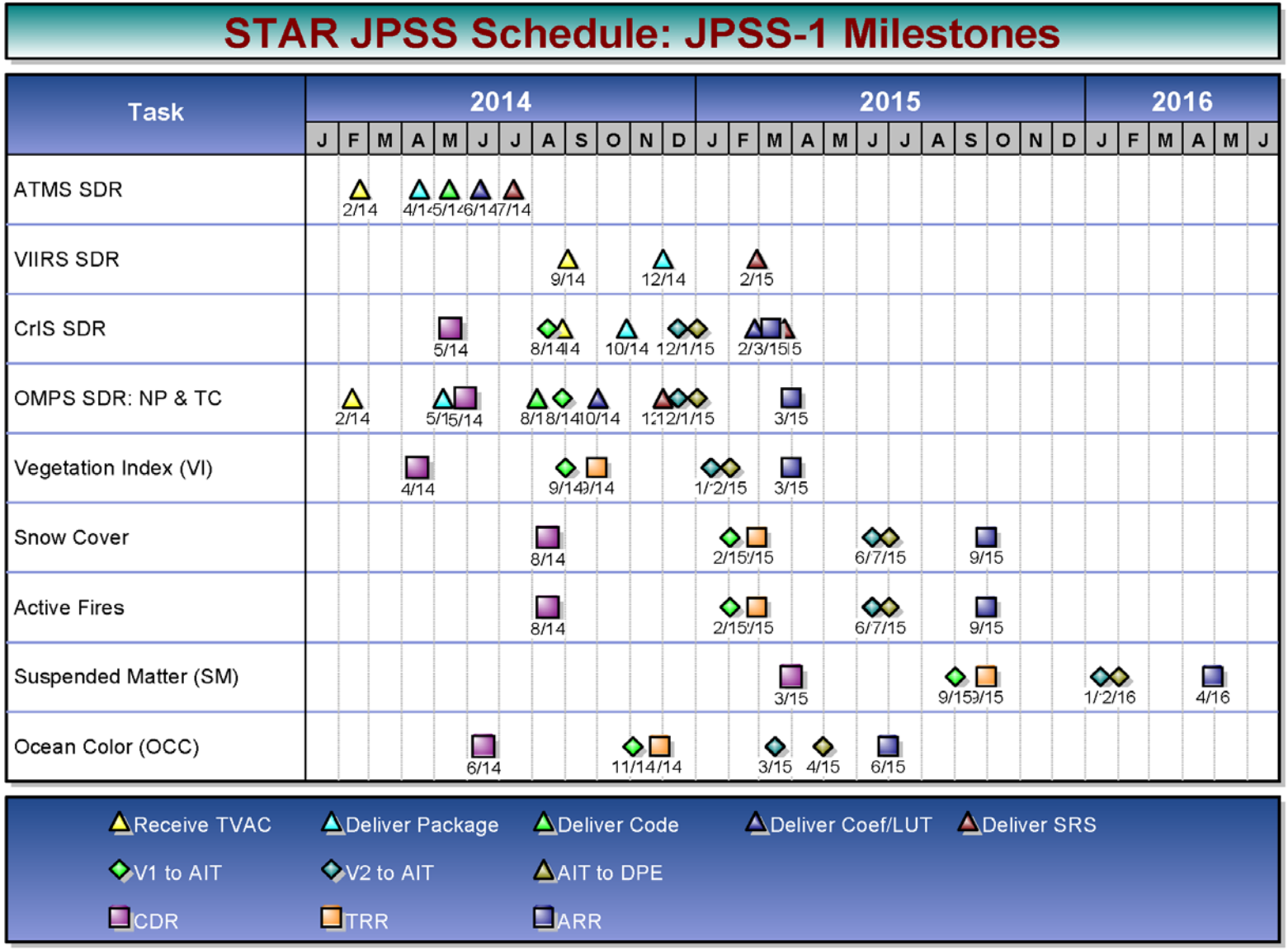


VIIRS Polar Winds



Courtesy of Jeff Key, NESDIS/STAR

Implementation Schedule



Summary

- JPSS has modified product requirements based on S-NPP performance and user feedback
- Types of modifications cover spatial/spectral resolution changes, algorithm alternatives, the addition of product parameters, and the addition of NOAA polar legacy products supported by JPSS
- Plan is in place for development and implementation of the product requirement deltas prior to JPSS-1 Launch