NPOESS
Northrop Grumman
Raytheon
DOC • DoD
NASA

Transitioning from MODIS to VIIRS

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Workshop: Antena Chetumal, 22-24 de Abril, México D.F., ICC

CONABIO

[1]IPO: Integrated Programe Office, NOAA
[2]DRL:Direct Readout Laboratory, NASA

What is NPP / NPOESS ?

NPP - NPOESS Preparatory Program
The Bridge Mission between the EOS satellite missions and NPOESS

NPOESS - National Polar-orbiting Operational Environmental Satellite System
NPOESS is the satellite program following NPP

IPO – Integrated Programe Office
The IPO jointly organizes NPP/NPOESS and is staffed with personnel from the Department of Defense, Department of Commerce (NOAA), and the National Aeronautics and Space Administration (NASA)

Sensors: VIIRS, ATMS, CrIS, OMPS

VIIRS: Visible Infrared Imager Radiometer Suite

The NPP mission collects and distributes remotely-sensed land, ocean, and atmospheric data to the meteorological and global climate change communities as the responsibility for these measurements transitions from existing Earth-observing missions such as Aqua, Terra and Aura, to the NPOESS. It will provide atmospheric and sea surface temperatures, humidity sounding, land and ocean biological productivity, and cloud and aerosol properties.

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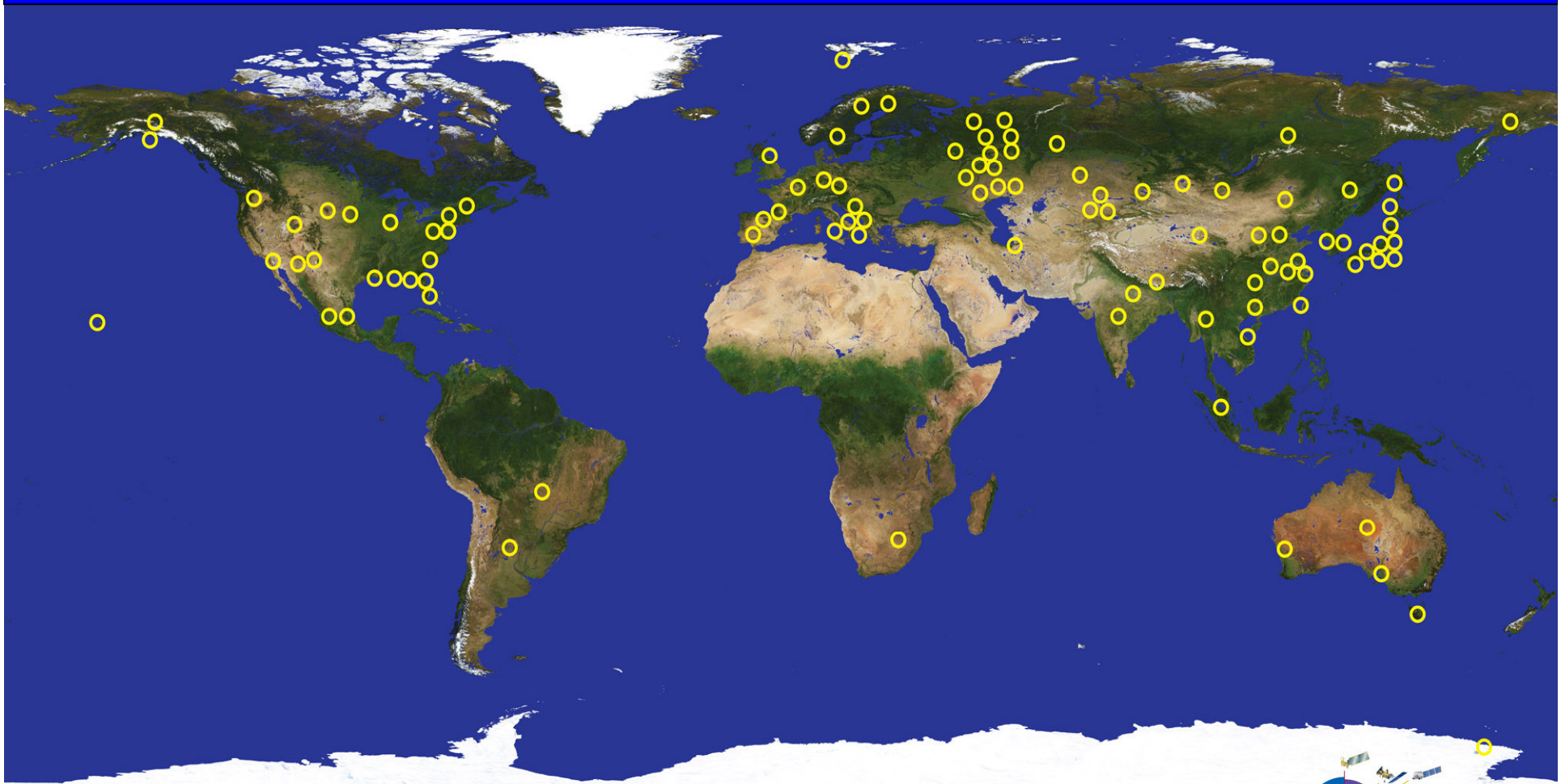
DB Community
Registered X-Band Receiving Stations



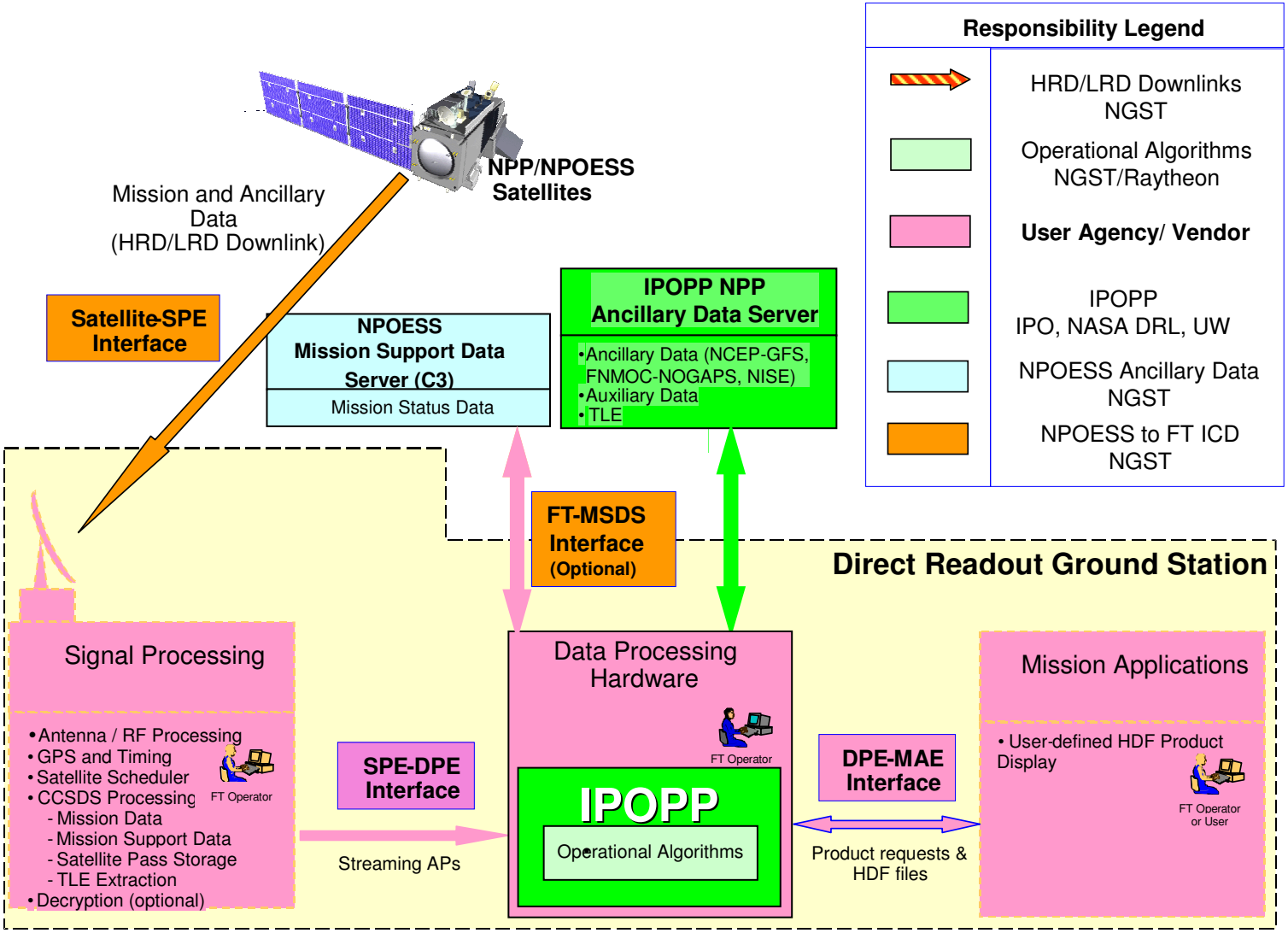
125 confirmed EOS direct readout ground systems world-wide.

50% owned by government agencies and organization, 35% owned by educational institutions,
15% owned by the commercial sector, 30 countries, 85 % support near-realtime aplications

www.nasa.gov

DIRECT READOUT
directreadout.gsfc.nasa.gov

NPP/NPOESS Direct Readout Architecture



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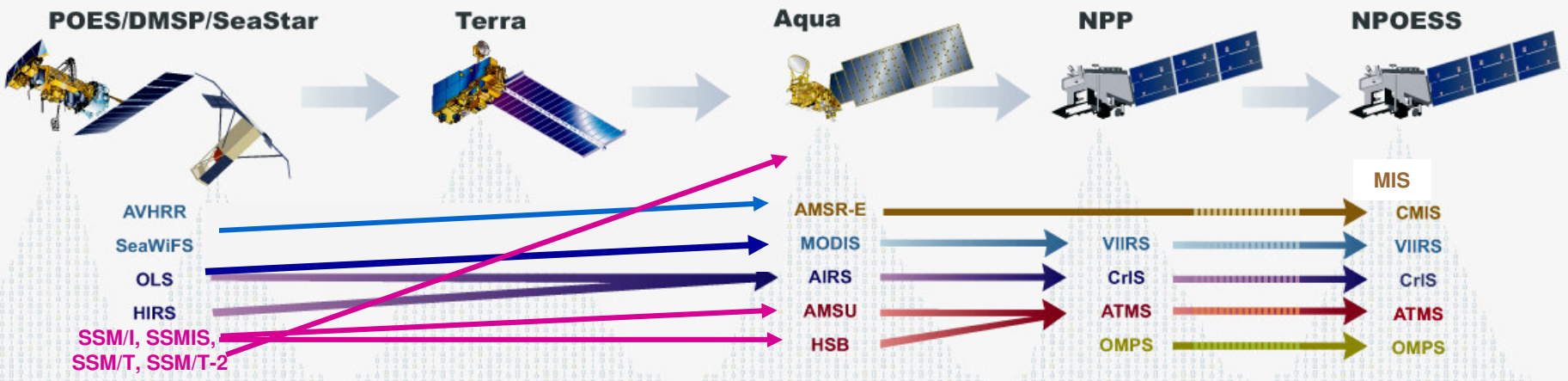
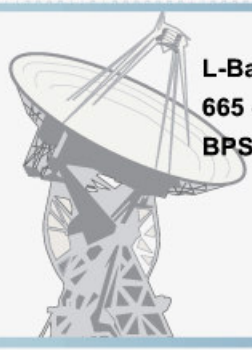
Direct Broadcast Continuous Evolution



Spacecraft and Instrument Evolution



L-Band, S-Band
665 - 2 Mbps
BPSK

X-Band
13.1 Mbps
Convolutional
UOQPSK
NRZ-M

X-Band
15 Mbps
OQPSK
NRZ-M

X-Band
15 Mbps
Convolutional
QPSK
NRZ-M
Compression

X-Band, L-Band
20 Mbps/3.8 Mbps
Convolutional
QPSK
NRZ-M
Compression

Standardization and Increasing RF, Modulation, and Bandwidth Requirements

- Custom Formatters and Ingest Software
- Analog Custom Receivers
- NOAA Level B (AVHRR)
- Limited Data Distribution Mechanisms

- Spacecraft Specific STPS
- Level-0
- Return Link Processor
- Analog Configurable Receivers
- MODIS Level-1
- MODIS Simulcast

- Reconfigurable RT-STPS
- Return Link Processor
- Digital Configurable Receivers
- MODIS and AIRS Level-1
- NEpster with Level-0 and Level-1 Data
- MODIS Simulcast

- Reconfigurable RT-STPS
- Digital Reconfigurable Receiver (PC-based)
- Select Instrument Level-1 Software
- NEpster with Level-0, Level-1, and Select Level-2 Data Products
- Simulcast of Select instruments
- Multi-Mission Scheduler

Evolution of Concurrent Ground Systems Supporting Technologies and Algorithm Development

VIIRS at a Glance

- VIIRS: Visible Infrared Imager Radiometer Suite
- VIIRS Heritage
  - OLS: Operational Line Scanner
  - AVHRR: Advanced Very High Resolution Radiometer
  - SeaWiFS: Sea viewing Wide Field-of-view Sensor
  - MODIS: Moderate Resolution Imaging Spectroradiometer
- VIIRS will provide operational and research users with:
  - Spectral coverage from 412 nm to 12 microns in 22 bands
    - Imagery at ~375 m nadir resolution in 5 bands
    - Moderate resolution (~750 m at nadir) radiometric quality data
  - Complete global daily coverage with a single sensor
- Routine data products
  - Cloud cover, cloud layers
  - Cloud and aerosol physical properties
  - Land & ocean biosphere properties, snow & ice
  - Sea Surface Temperature, Land & Ice Temperatures
  - Fire detection

VIIRS Design - Evolutionary from MODIS

- Spatial resolution improved
  - From 500 m & 1000 m to 375 m & 750 m at nadir
  - Reduced pixel growth from nadir to edge of scan
- Spectral coverage slightly smaller
  - From 0.412 – 14.4 microns to 0.412 – 12 microns
  - Longer IR bands for CO_2 covered by sounding instrument, Cross-track Infrared Sounder (CrIS)
- Improved stray light control
  - From Paddle Wheel to Rotating telescope design
- Added "day-night" band for cross-terminator imaging
- Higher orbit yields full global coverage in one day
  - From ~705 km to ~830 km
- Comparable radiometric and spectral quality
  - 12 bit data
  - Similar on-board calibrators
  - Characterization equivalent to Aqua MODIS
  - Bandpasses widened with little loss of specificity
    - Minimal impact to Vegetation Index
- Bandset reduced from 36 to 22
  - Partially offset due to 7 dual gain bands on VIIRS
  - Ocean Color bands reduced by 1

Comparison of MODIS & VIIRS Bands

MODIS		VIIRS	
Band #	λ	λ	Band ID
1	620 - 670	600 - 680	I-1
2	841 - 876	845 - 885	I-2
3	459 - 479		
4	545 - 565		
5	1230 - 1250	1230 - 1250	M-8
6	1628 - 1652	1580 - 1670	M-10
		1580 - 1610	I-3
7	2105 - 2155	2225 - 2275	M-11
8	405 - 420	402-422	M-1
9	438 - 448	436-454	M-2
10	483 - 493	478-498	M-3
11	526 - 536		
12	546 - 556	545-565	M-4
13	662 - 672	662-682	M-5
14	673 - 683		
15	743 - 753	739-754	M-6
16	862 - 877	846-885	M-7
17	890 - 920		
18	931 - 941		
19	915 - 965		

MODIS		VIIRS	
Band #	λ	λ	Band ID
20	3.660 - 3.840	3.610 - 3.790	M-12
		3.550 - 3.930	I-4
21	3.929 - 3.989		
22	3.940 - 4.001		
23	4.020 - 4.080	3.973 - 4.128	M-13
24	4.433 - 4.498		
25	4.482 - 4.549		
26	1.360 - 1.390	1.371--1.386	M-9
27	6.535 - 6.895		
28	7.175 - 7.475		
29	8.400 - 8.700	8.400 - 8.700	M-14
30	9.580 - 9.880		
31	10.780 - 11.280	10.263 - 11.263	M-15
		10.050 - 12.400	I-5
32	11.770 - 12.270	11.538 - 12.488	M-16
33	13.185 - 13.485		
34	13.485 - 13.785		
35	13.785 - 14.085		
36	14.085 - 14.385		

MODIS Bands 1-2 are 250 m at Nadir
MODIS Bands 3-7 are 500 m at Nadir
MODIS Bands 8-36 are 1,000 m at Nadir

VIIRS EDRs, IPs, and ARPs

EDR-Environmental Data Record | IP-Intermediate Product | ARP-Application Related Product

Land

- Active Fire [ARP]
- Land Surface Albedo
- Land Surface Temperature
  Ice Surface Temperature
- Sea Ice Characterization
- Snow Cover/Depth
- Vegetation Index
- Surface Type

Ocean

- Sea Surface Temperature
- Ocean Color/Chlorophyll

Imagery & Cloud

- Imagery
- Cloud Mask [IP]
- Cloud Optical Thickness
- Cloud Effective Particle Size Parameter
- Cloud Top Parameters
- Cloud Base Height
- Cloud Cover/Layers

Aerosol

- Aerosol Optical Thickness
- Aerosol Particle Size Parameter
- Suspended Matter

VIIRS Active Fires ARP

Algorithm Overview

- This deliverable Application Related Product (ARP) provides:
  - Geolocation of the pixels in which active fires are detected,
  - The sub-pixel average temperature of each active fire, and
  - The sub-pixel area of each active fire.
- Execution Conditions:
  - Both day and night
  - Confident Clear pixels
- HCS @ Nadir: 0.75 km

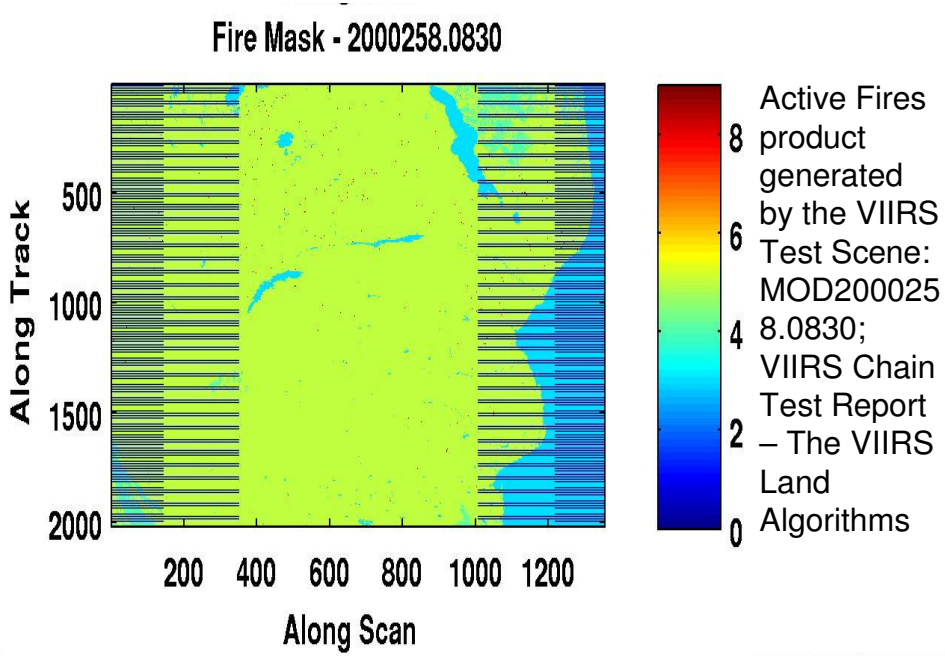
Inputs Required

- VIIRS Moderate Resolution Reflectances and Brightness Temperatures
  - M5, M7, M11, M13, M15, M16
- VIIRS Quarterly Surface Types IP
- Ancillary Data
  - Land-Water Mask

Corresponding MODIS Algorithm

MODIS Thermal Anomalies/Fire products are primarily derived from MODIS 4- and 11-micrometer radiances. The fire detection strategy is based on absolute detection of a fire (when the fire strength is sufficient to detect), and on detection relative to its background (to account for variability of the surface temperature and reflection by sunlight). Numerous tests are employed to reject typical false alarm sources like sun glint or an unmasked coastline. This products includes fire-mask, algorithm quality, radiative power, and numerous layers describing fire pixel attributes.

HCS @ Nadir: 1 km



Active Fires product generated by the VIIRS Test Scene: MOD2000258.0830; VIIRS Chain Test Report – The VIIRS Land Algorithms

VIIRS Vegetation Index

Algorithm Overview

- Normalized Difference Vegetation Index (Top of the Atmosphere; TOA) uses the traditional NDVI formulation with TOA reflectance inputs. NDVI is most directly related to absorption of photosynthetically active radiation, but is often correlated with biomass or primary productivity. Red spectral measurements are sensitive to the chlorophyll content of vegetation and the near IR to the mesophyll structure of leaves.
- This EDR also contains a Top of the Canopy (TOC) Enhanced Vegetation Index (EVI), based on the MODIS equation.

- Execution Conditions
  - Land Pixel
  - Confident Clear pixels
  - During daytime

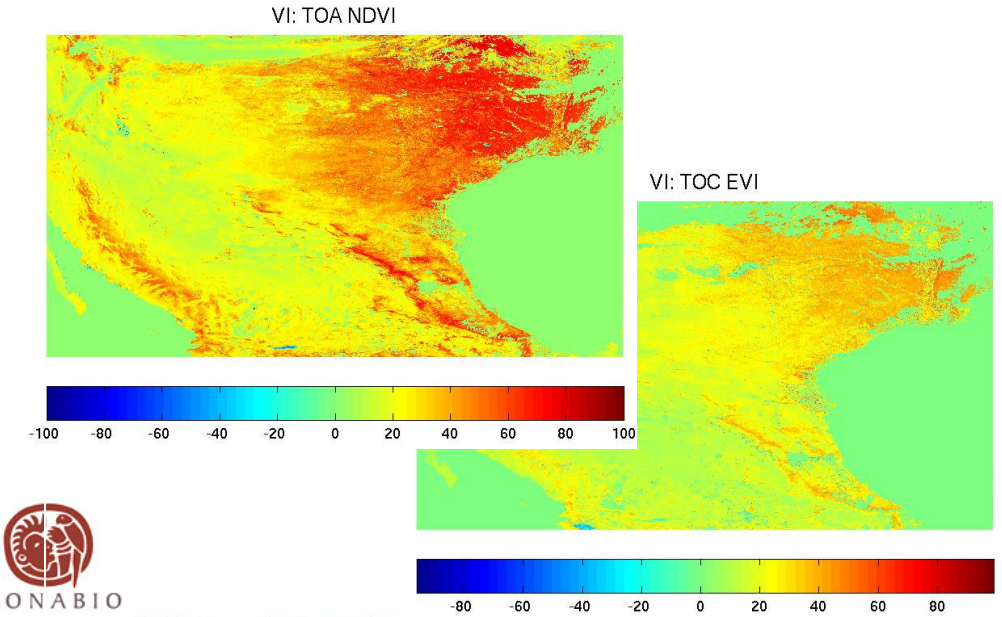
- HCS @ Nadir: 0.375 km

Inputs Required

- VIIRS Imagery Resolution Reflectances
  - I1 & I2
- Surface Reflectance IP
- No Ancillary Data

Corresponding MODIS Algorithm

The MODIS TOC NDVI complements NOAA's Advanced Very High Resolution Radiometer (AVHRR) TOA NDVI products and provides continuity for time series historical applications. MODIS also includes a new EVI that minimizes canopy background variations and maintains sensitivity over dense vegetation conditions. The EVI also uses the blue band to remove residual atmosphere contamination caused by smoke and sub-pixel thin cloud clouds. The MODIS NDVI and EVI products are computed from atmospherically corrected bi-directional surface reflectances that have been masked for water, clouds, heavy aerosols, and cloud shadows. The resolution for this product is 500 m.



VIIRS Sea Surface Temperature

Algorithm Overview

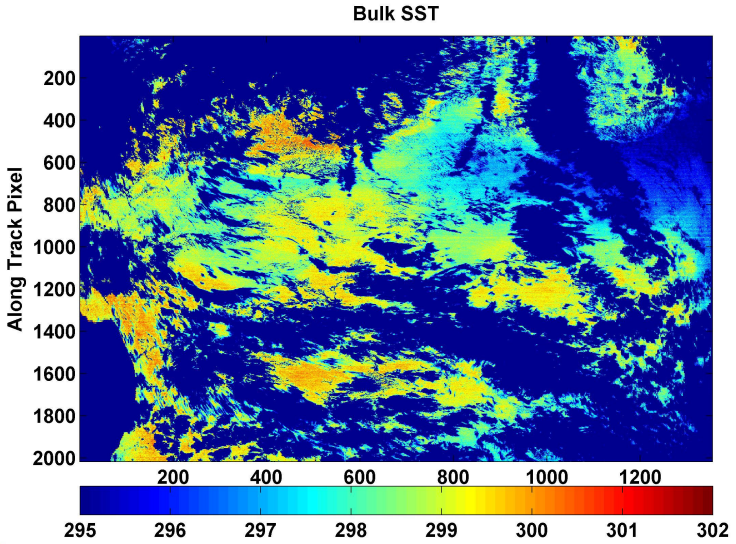
- Sea surface temperature (SST) is defined as a measurement of the temperature of the surface boundary layer (skin) and upper 1 meter (bulk) of ocean water.
- Retrievals are made using separate relations for skin and bulk SST.
- Execution Conditions
  - Ocean pixels
  - Current and adjacent pixels are Confident Clear
  - No thin cirrus
- HCS @ Nadir: 0.75 km

Corresponding MODIS Algorithm

MODIS Sea Surface Temperature (MOD28) is generally referred to the non-linear SST (NLSST) algorithm. It is currently being produced and distributed by the Ocean Biology Processing Group at NASA/GSFC. This algorithm uses the same split window algorithm VIIRS has adopted with has heritage back to AVHRR.

Inputs Required

- VIIRS Moderate Resolution Brightness Temperatures
  - M12, M15, M16
- VIIRS Cloud Mask IP
- VIIRS Ice Concentration IP
- VIIRS Aerosol Optical Thickness IP
- Ancillary Data
  - Surface Temperature



Test Scene 2001213_1220 Bulk Sea Surface Temperature

VIIRS Chain Test Report – The VIIRS Sea Surface Temperature Algorithm

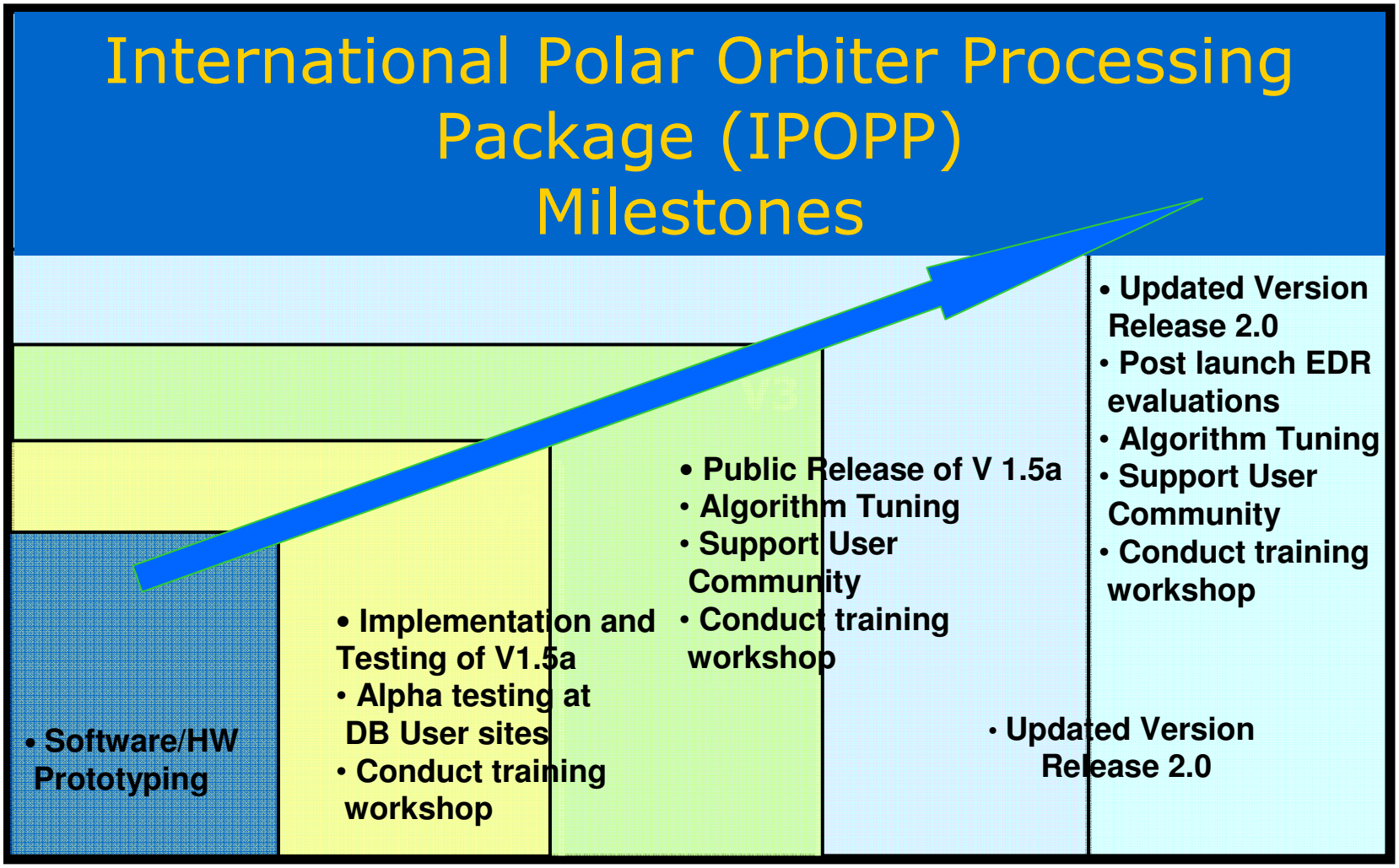
International Polar Orbiter Processing Package
IPOPP

- Provide software to generate Environmental Data Records (Level 2) in near real-time from Direct Broadcast of EOS to NPOESS High Rate Data and NPOESS Low Rate Data

  - Open source (GPL)
  - Freely available (no COTS licenses required)
  - Easy to install & run
  - Multi-platform (e.g., Linux, Solaris, OS X)
  - HDF5 data format (NPP and NPOESS)
  - Self-contained, Modular
  - Uses consistent & up to date calibration Look Up Tables
  - Leverage legacy software development lessons learned (IMAPP)
  - Build on NPP In-Situ Ground Station foundation

Smoothly transition from EOS to NPOESS (IMAPP → IPOPP)

International Polar Orbiter Processing Package (IPOPP) Milestones



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IPOPP Alpha Testing

Test Stations participating today in testing IPOPP version 1.5a (MODIS)

- US Government
  - NASA Direct Readout Laboratory (SN)
  - USDA Forest Service Remote Sensing Applications Center (RSAC) (SN)
  - USAF MARK IV (coming soon)
- Universities
  - Oregon State University (OSU) (SN)
  - University of South Florida (USF)
  - University of Wisconsin (UW – CIMSS) (coming soon) (SN)
  - University of New Mexico
- International
  - Instituto Nacional de Pesquisas Espaciais (INPE) (Brazil's National Institute for Space Research) (coming soon)
  - CONABIO, Mexico (SN)
  - Bureau of Meteorology and LANDGATE, Australia (coming soon)
  - India National Remote Sensing Agency (NRSA) (Pending Approval)
  - MAFFIN, Japan (coming soon)