Operationalizing a Research Sensor: MODIS to VIIRS

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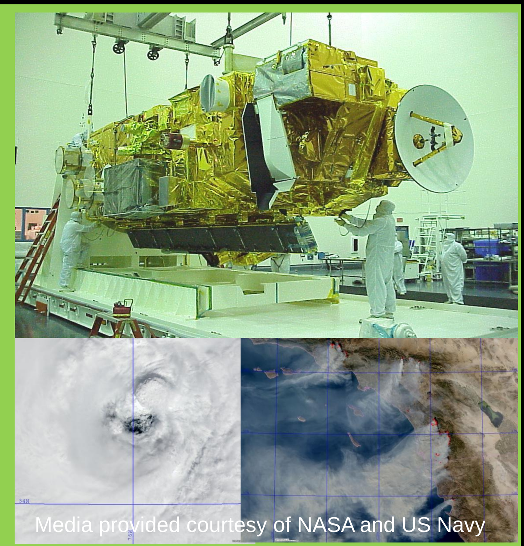
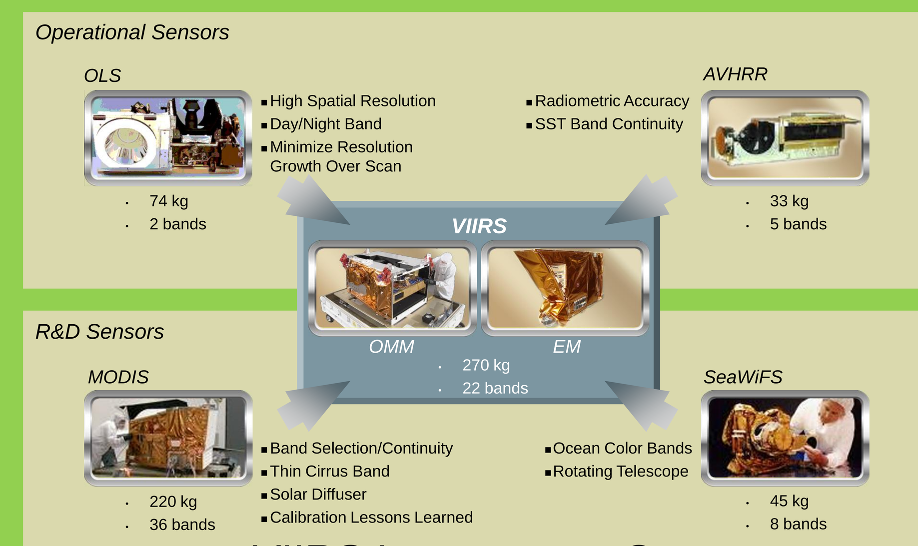
Operationalizing the Sensor

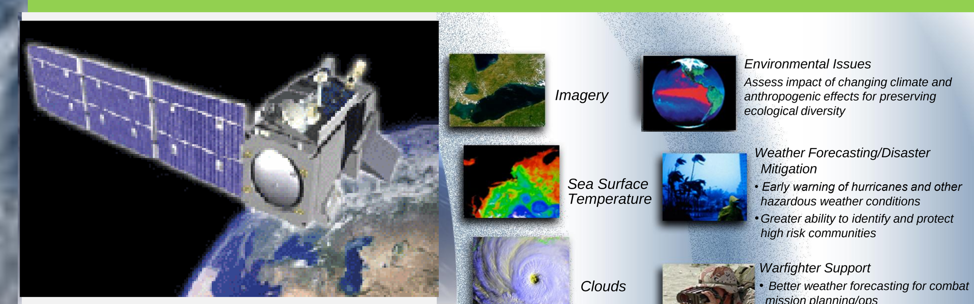
- MODerate resolution Imaging Spectroradiometer (MODIS) built by Raytheon for NASA's Earth Observing System (EOS)
- Research instrument with:
  - 36 spectral bands, ranging in wavelength from 0.4 µm to 14.4 µm
  - Spatial resolution: 2 bands at 250 m, 5 bands at 500 m and 29 bands at 1 km
  - Full aperture end-to-end onboard calibration for all spectral bands
- MODIS data has provided unprecedented insight into large-scale Earth system science questions related to cloud and aerosol characteristics, surface emissivity and processes occurring in the oceans, on land, and in the lower atmosphere
- MODIS has been operating on the EOS Terra satellite since 1999 and on the EOS Aqua satellite since 2002, providing excellent data for scientific research and operational use


Media provided courtesy of NASA and US Navy

Research Sensor - MODIS



VIIRS Improves on Current Operational and R&D Sensors



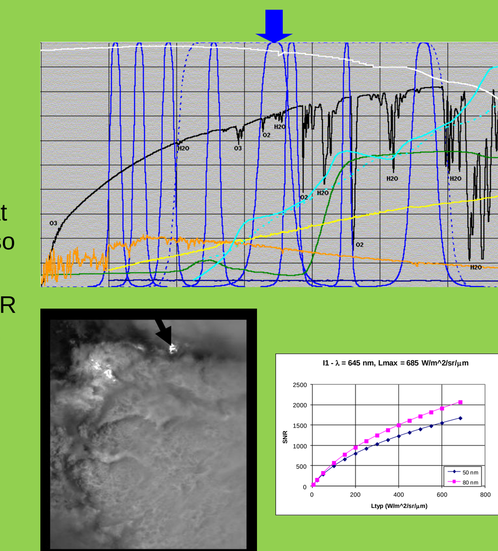
- Much improved spectral coverage and spectral resolution of VIIRS versus AVHRR enables new weather, climate, ocean color and agricultural data products
- Much better spatial resolution of VIIRS versus AVHRR in the VNIR bands enables much sharper imagery
- Fully calibrated solar reflectance bands provide unprecedented radiometric accuracy

Updating the Science

- Merged the best features of the MODIS and CLAVR algorithm heritage to arrive at an initial VCM algorithm
- Updated the VCM algorithm based on new capabilities of VIIRS, e.g.:
  - Detection of thin cirrus (VIIRS Band M9 was narrowed to minimize out-of-band response)
  - Detection of clouds over snow and ice (VIIRS Band I3 provides unprecedented global resolution in the shortwave infrared to highlight snow/ice absorption)
  - Discrimination of cloud phase both day and night (VIIRS dynamic range and SNR were optimized based on early Terra MODIS results)

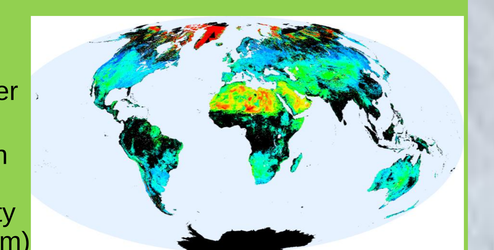
Example: the VIIRS Cloud Mask (VCM)

- Key input for multiple EDRs
- Originally designed to be spectrally equivalent to MODIS band 1 (620-670nm)
- Once Terra MODIS data were available, it was determined that I1 would saturate over clouds, so Lmax was increased
- When Lmax was increased, SNR performance at lower radiances was compromised
- To recover SNR, band was widened to 80 nm
- To preserve chlorophyll response, band was shifted to 640 nm



VIIRS Band I1 – Evolution Over Time

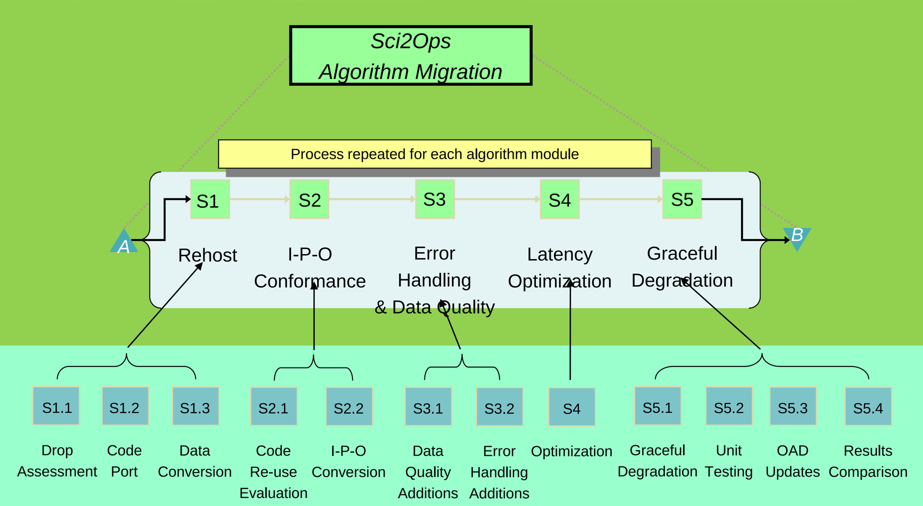
- PDR solution was a nonlinear regression approach, deemed the only way to meet requirements over bright surfaces (snow, desert)
- After VIIRS down-select, Raytheon had the freedom to engage with albedo experts at Boston University (developers of the MODIS algorithm)
- Surface Albedo algorithm was converted to a hybrid solution:
  - Bright Pixel Sub-Algorithm (BPSA) employs nonlinear regression approach
  - Dark Pixel Sub-Algorithm (DPSA) employs MODIS approach
  - Both outputs reported globally



- New gridded products and algorithms were added to support the DPSA
  - Surface Reflectance, Black and White Sky Albedos, etc.

Surface Albedo Algorithm Evolved from VIIRS PDR to CDR

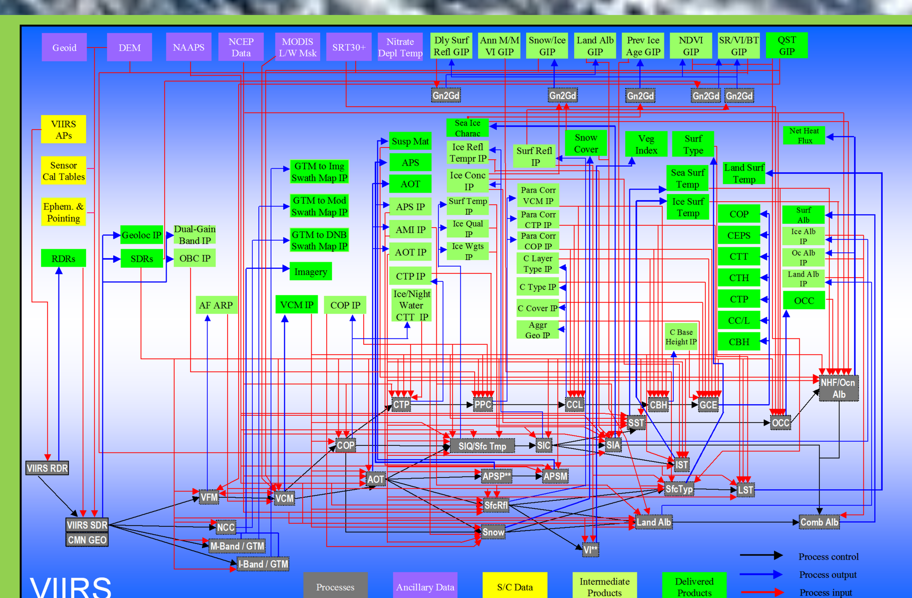
Operationalizing the Algorithms



Operationalizing Science

Category	Requirements	Implementation
Robustness		Coding standards
	24 x 7 ops tempo	Interface standards for output,
	Manage missing inputs	mnmonics, constraints
	Assess data "goodness"	Common utilities
Performance		Ao = 0.9999
	Latency	Latency (detection to
	Availability	delivery) = 80 mins (J1)
	Fidelity	30 mins (J2)
Maintainability		Standardized implementation
	Life Cycle Cost	Coding best practices, standard
	Rapid Updates	libraries and languages

Implementing Operational Production Needs



Operational VIIRS Chain

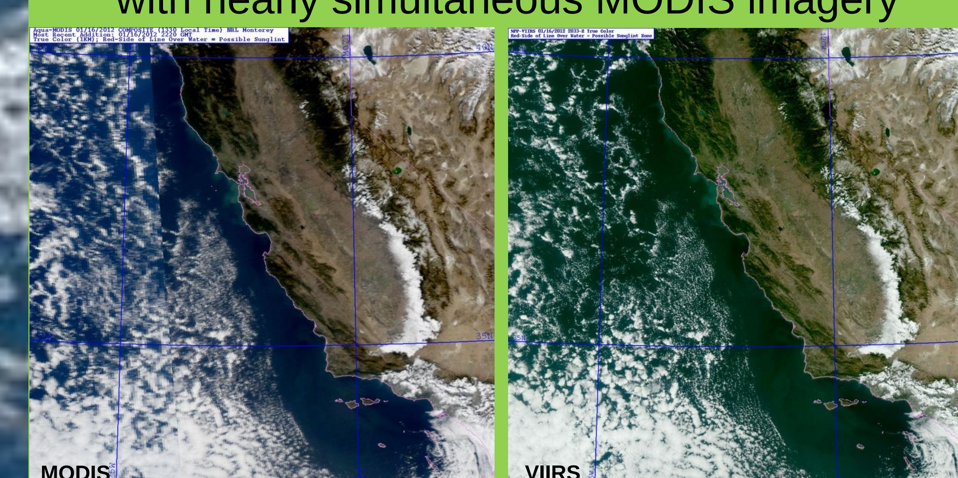
Results

Lessons learned from MODIS helped enabled quick turnaround of VIIRS results

- After 6+ months of operation, all VIIRS bands continue to produce excellent images with expected high quality
- Sensitivity (SNR and NEdT) meets sensor requirements for all detectors and all bands , consistent with pre-launch values
- On-orbit calibration coefficients consistent with pre-launch values, except for M13 (4 µm) which is being updated
- On-orbit anomalies are well understood and are being tracked


Amazon Delta
Media provided by NASA GSFC

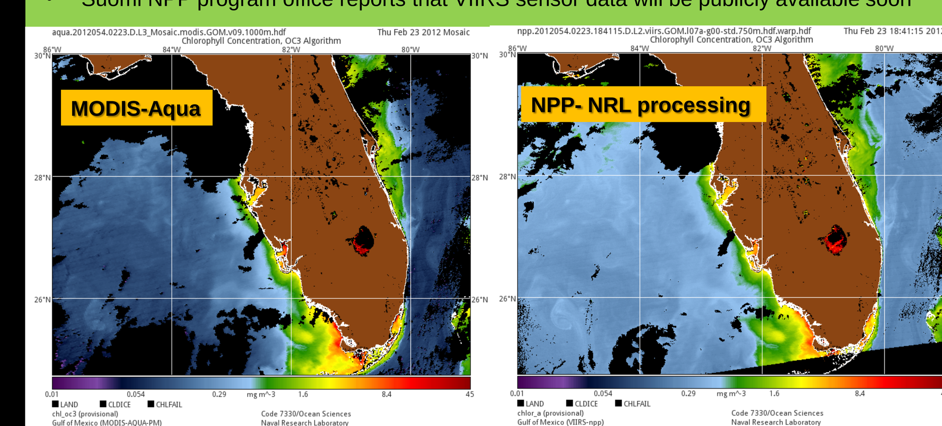
VIIRS true color imagery compares very well with nearly simultaneous MODIS imagery



California from MODIS at 2028Z and VIIRS at 2033Z
Media provided by Arunas Kuciauskas et al. at US Naval Research Lab Monterey

Work continues to validate VIIRS data products and complete operationalization

- VIIRS data is flowing through the ground system to major data centers including NESDIS, AFWA and CLASS and is being analyzed continuously
- Radiometry and geolocation look good
- Initial VIIRS data products for ocean features, retrieved nLW and chlorophyll have similar quality as MODIS
- Ongoing work is tuning cloud masks and other algorithms
- Suomi NPP program office reports that VIIRS sensor data will be publicly available soon



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