Early Performance Predictions of Ocean Environmental Data Records for the NPOESS Preparatory Project VIIRS Sensor

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The VIIRS flight sensor for the NPOESS Preparatory Project (NPP) is now undergoing its final pre-launch characterization and calibration. The NPOESS Integrated Program Office (IPO) Data Products Division (DPD) has generated the performance assessments for the Ocean Environmental Data Records (EDRs) of the Visible/Infrared Imaging Radiometer Suite (VIIRS). The VIIRS Ocean EDRs include the Ocean Color/Chlorophyll (OC/C) and Sea Surface Temperature (SST).

The EDR Assessments were developed by the DPD in consultation with subject matter experts from government labs and universities to collect and track algorithm development status and expected performance against contractual specifications and applicability to user missions.

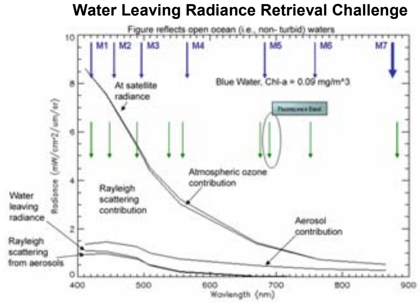
This poster summarizes the ocean assessments and provides an overview of the NPP ocean data products. For each algorithm, the current best estimate, performance drivers, watch items, and mitigation strategies are presented. The NPP EDR Assessments are used to capture and communicate algorithm issues and expected performance to the Program stakeholders and will be updated as sensor testing and algorithm development continue.

The VIIRS SST EDR is predicted to meet heritage performance, however, the VIIRS Ocean Color products are expected to perform at a lower quality than is currently obtained with the Aqua MODIS ocean products due to VIIRS optical cross-talk effects.

Ocean Color/Chlorophyll Algorithm Overview

The VIIRS Ocean Color/Chlorophyll EDR uses the spectrum of normalized water-leaving radiances, from which the concentration of phytoplankton pigment chlorophyll and optical properties of surface water can be derived. NGST has adapted the Carder Semi-Analytic algorithm, which were the initial Terra/MODIS and Aqua/MODIS algorithms, for OC/C EDR retrieval. The VIIRS algorithm uses bands M6 (0.746 um) and M7 (0.865 um) to establish atmosphere and aerosol models to convert top-of-atmosphere radiance to water-leaving radiance.

Water Leaving Radiance Retrieval Challenge



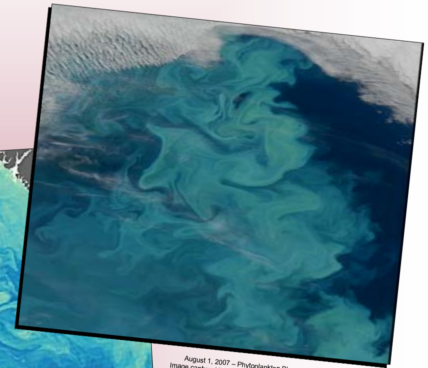
VIIRS Wavelengths **MODIS Wavelengths** **Line width scaled to bandwidth**

Bands M6-M7 are used to establish Atmosphere and Aerosol Models to Convert top-of-atmosphere radiance to water-leaving radiance

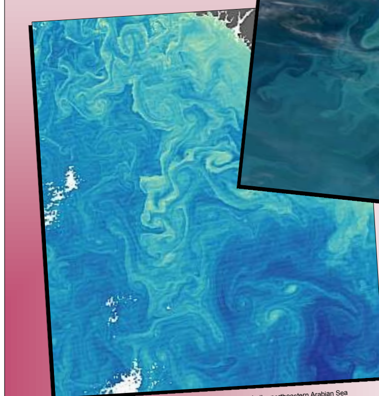
Predicted Performance

Pre-launch performance testing of the OC/C algorithm with synthetic and MODIS proxy data shows results comparable with other operational and research OC/C products. The performance of the data product is expected to be at a lower quality than specification due to cross-talk issues in the as-built NPP VIIRS. NGST is currently developing corrections within the algorithm to mitigate these issues. Initial NGST results show that their mitigation strategy will greatly improve the NPP expected performance to approach the specified values in pixels away from high contrast, such as cloud edges.

EDR/Attribute	Appendix D Specification
Horizontal Cell Size	
1. Worst Case	1.3 km
2. Nadir	0.75 km
Horizontal Reporting Interval	HCS
Horizontal Coverage	Oceans
Measurement Range	
1. Ocean Color	0.1 - 40 W m^{-2} micrometer^{-1} sr^{-1}
2. Optical Properties, Absorption	0.01 - 10 m^{-1}
3. Optical Properties, Scattering	0.01 - 50 m^{-1}
4. Optical Properties, Chlorophyll	0.05 - 50 mg/m^{3}
Measurement Accuracy	
1. Ocean Color, Operational	Greater of 10% or 0.1 W m^{-2} micrometer^{-1} sr^{-1}
2. Optical Properties, Operational	40%
3. Chlorophyll, Operational, Chl < 1.0 mg/m3	40%
4. Chlorophyll, Operational, 1.0 Chl < 10 mg/m3	40%
5. Chlorophyll, Operational, Chl > 10 mg/m3	50%
Measurement Precision	
1. Ocean Color, Operational	Greater of 5% or 0.05 W m^{-2} micrometer^{-1} sr^{-1}
2. Optical Properties, Operational	20%
3. Chlorophyll, Operational, Chl < 1.0 mg/m3	20%
4. Chlorophyll, Operational, 1.0 < Chl < 10 mg/m3	30%
5. Chlorophyll, Operational, Chl > 10 mg/m3	50%
Mapping Uncertainty, 3 Sigma	
1. Worst Case	1.5 km
2. Nadir	0.4 km
Max Local Average Revisit Time	24 hrs
Long Term Stability (W m^{-2} micrometer^{-1} sr^{-1}) (C)	Max Chl Absorption 0.5, Min Chl Absorption 0.25, Atmospheric Correction 0.08
Latency, Operational	NPP - 140 min. NPOESS - 28 min.
Degradation Condition: Shallow water less than 50 m	TBR
Excluded Measurement Conditions	
1. Strongly Absorbing Aerosols With Single Scattering Albedo $\omega_0(555) < 0.7$	
2. Dissolved Organic Matter Absorption Dominant Waters, DOM Absorption a(410) > 2m^{-1}	
3. Very Turbid Coastal Waters, Mass Loading > 60 mg/l	
4. Sun Glint < 36 deg	
5. Orbit Other Than Nominal 1330 Orbit	
6. With scattering error greater than would exist at a point 12 milliradians away from the VIIRS Bright Target	
7. Beyond a Swath Width of 1700 km	
8. Aerosol Optical Thickness > 0.3	
9. The ratio of the Rayleigh-corrected radiance of Band M2 to Band M4 is greater than or equal to 0.95 (TBR)	
10. Ice-covered oceans	



August 1, 2007 – Phytoplankton Bloom in the Barents Sea
Image captured by the MODIS instrument aboard the Terra satellite
http://oceancolor.gsfc.nasa.gov/cgi/image_archive.cgi?c=CHLOROPHYLL



February 22, 2005 - Chlorophyll Concentrations in the northeastern Arabian Sea
Image captured by MODIS on the Aqua Satellite
http://oceancolor.gsfc.nasa.gov/cgi/image_archive.cgi?c=CHLOROPHYLL

Sea Surface Temperature Algorithm Overview

The VIIRS Sea surface temperature EDR provides the measurement of the temperature of the surface boundary layer (skin) and upper 1 meter (bulk) of ocean water. The daytime algorithm is a non-linear sea surface temperature (NLSST) retrieval and the night time is a multi-channel sea surface temperature (MCSST) retrieval.

Day NLSST:

$$SST = a_0 + a_1 T_{11} + a_2 (T_{11} - T_{12}) RSST + a_3 (T_{11} - T_{12})(\sec(z) - 1)$$

Night Triple-Window MCSST:

$$SST = a_0 + a_1 T_{11} + a_2 (T_{3.7} - T_{12}) RSST + a_3 (\sec(z) - 1)$$

a0, a1, a2, a3: Regression coefficients
T11: Brightness temperature at 11 mm
RSST: Model sea surface temperature
T3.7: Brightness temperature at 3.7 mm
T12: Brightness temperature at 12 mm
z: Sensor zenith angle

Basic Sensor Capability

VIIRS			MODIS			AVHRR (N17)		
λc (μm)	Δλ (μm)	NEΔT (mK)	λc (μm)	Δλ (μm)	NEΔT (mK)	λc (μm)	Δλ (μm)	NEΔT (mK)
Day Algorithm								
10.763	1	< 70	10.78	0.5	50	10.98	1	< 120
12.0313	1	< 72	11.995	0.5	50	11.74	1.03	< 120
Night Algorithm								
3.7	0.18	116	3.77	0.18	50	3.736	0.384	< 120
Absent			3.959	0.06	70	Absent		
10.763	1	< 70	10.78	0.5	50	10.98	1	< 120
12.013	1	< 72	11.995	0.5	50	11.74	1.03	< 120

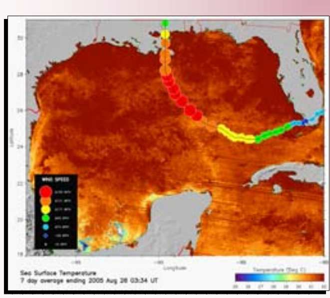
NEΔT quoted at 300K for all bands

VIIRS NEΔT for single pixel. Improves by a factor of 1.6 for 3-pixel aggregation and 1.4 for 2-pixel aggregation.

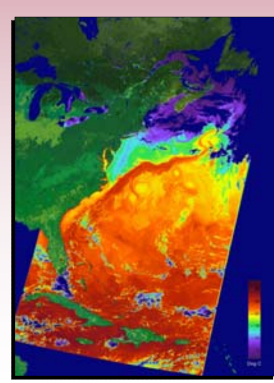
Predicted Performance

The VIIRS sensor and the SST algorithm have intrinsic capability to meet NPOESS Measurement Uncertainty specification. The bias to buoy match-up datasets is about ±25mK, and the standard deviation is about 450mK. The algorithm, which is similar to current operational algorithms, is ready for operational implementation and is predicted to obtain heritage performance achieved with AVHRR and MODIS data and support on-going user missions.

EDR/Attribute	Appendix D Specification
Horizontal Cell Size	
1. Nadir, Clear	0.75 km
2. Worst Case, Clear	1.3 km
b. Horizontal Reporting Interval	HCS
c. Horizontal Coverage	Oceans
d. Measurement Range	271 K - 313 K
Measurement Uncertainty (Skin)	
1. Satellite Zenith Angle < 40 degrees	0.4 K
2. 40 degrees < Satellite Zenith Angle < 53 degrees	0.7 K
Measurement Uncertainty (Bulk)	
1. Satellite Zenith Angle < 40 degrees	0.5 K
2. 40 degrees < Satellite Zenith Angle < 53 degrees	0.7 K
Measurement Accuracy (Skin and Bulk)	0.1 K
Mapping Uncertainty, 3 Sigma	
1. Nadir	0.4 km
2. Worst Case	1.5 km
Maximum Local Average Revisit Time	
1. Clear	6 hrs
Long Term Stability	0.1 K
Latency	NPP - 140 min. NPOESS - 28 min.
Measurement Uncertainty Degradation Conditions (Skin and Bulk)	
1. SST measurement above 305 K	0.8 K
2. Aerosol Optical Thickness exceeding 0.6 tau	1.0 K
3. Satellite Zenith Angle > 53 degrees	0.7 K
Measurement Uncertainty Exclusion Conditions	
1. Aerosol Optical Thickness > 1.0	



August 23, 2005 – Hurricane Katrina
Derived from NOAA Satellite AVHRR data over the 7 days ending 26 August 2005
http://fermi.jhuapl.edu/hurr/05/katrina/katrina_gm_overview.gif



December 2000 - Image captured by the MODIS Instrument
http://val.gsfc.nasa.gov/projects/modis_sst/20000508_modis_sst_med.jpg