9.3 # VALIDATING VIIRS LAND AND CRYOSPHERE PRODUCTS FROM THE NPOESS PREPARATORY PROJECT (NPP)

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1. Introduction

The National Polar-orbiting Operational Environmental Satellite System (NPOESS) Preparatory Project (NPP) (launch expected in 2011) and afternoon overpass NPOESS platforms (launches expected in 2014 and 2021) will each carry the 22-band Visible/Infrared Imager/Radiometer Suite (VIIRS). Data from VIIRS will be used to operationally generate a suite of land and cryosphere products, including Environmental Data Products (EDRs), Application Required Products (ARPs) and Intermediate Products (IPs). The NPOESS VIIRS Land and Cryosphere Validation Plan describes the approaches that will be used to verify and validate the operational land and cryosphere products in the NPP era. In turn, the NPP activities are designed to be a pathfinder for a cost-effective and scientifically defensible ongoing validation program throughout the NPOESS era (nominally ending in 2027). This article describes the general methods and data sources that will be used to validate NPOESS land and cryosphere operational products, including methods differing from as well as adapted from those used with NASA's Earth Observing System (EOS) [1].

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2. General Approaches

The VIIRS Land and Cryosphere Validation Team will validate a total of 14 different products within nine general product categories (see Table 1). In many cases, multiple data products comprise the general EDR. Because the products are so diverse (from sea ice to active fire characterization), their validation requires a broad set of dedicated activities and expertise. Land and cryosphere validation is particularly challenging due to the major expected and unexpected temporal changes in spectral and structural properties (e.g., due to vegetation phenology, episodic snow/fire/water inundation, diurnal snow/water/ice transitions, and variations in sea ice cover over even shorter time periods). The challenges are complicated by the often discrete spatial transitions (e.g., around pivot irrigation systems or urban structure) and the resulting need to appropriately "scale up" high resolution correlative validation data (e.g., tower-based measurements). Typically this requires a fine resolution imaging source (e.g., Landsat data).

To address these challenges, the Land Team has developed a plan that leverages existing EOS and operational program investments and defines a path towards routine cost-effective evaluation and validation throughout the NPOESS era. In contrast to NASA's EOS program, which initially focused on relatively costly field campaigns for land product validation, the VIIRS Land Team will focus on existing routine measurement systems, such as operation field networks (e.g., NOAA's Climate Reference Network (CRN)) to provide independent correlative data.

Besides ensuring the operational utility and quantitative performance of the VIIRS products, the Land Team will address the new validation protocols of the Committee for Earth Observing Satellites (CEOS), as defined through the Working Group for Calibration and Validation (WGCV) and its subgroups [3]. This provides a medium for validation community outreach, as well as insights into state of the art methods, tools, data handling and collaboration opportunities.

The Land Team works closely with the NASA's Land Project Evaluation and Test Element (PEATE) [2] and NASA NPP Science Team, which together pursue the related goal of assessing the usefulness of VIIRS operational products for NASA's climate research needs. The relationship allows the Land Team to leverage the PEATE's tools and large-scale product generation capabilities in addition to expert support, analysis and data handling (including field data provision in some cases).

In the NPP pre-launch and early post-launch era, the Land Team will emphasize comparisons with MODIS, AVHRR and other validated satellite systems such that early VIIRS assessments are available in a timely fashion and appropriate algorithmic adjustments can be implemented. The Land Team is working with the PEATE to ensure this can be conducted efficiently and appropriately (e.g., via re-projecting data as needed). However, the Land Team will be simultaneously pursuing more rigorous albeit sometimes tedious techniques that can be economically sustained past the end of the MODIS and/or AVHRR eras. Below we describe the four general techniques.

2.1. Point Location Validation

This technique will be applied for Albedo (Land), Land Surface Temperature, Vegetation Index, Surface Reflectance IP, Snow Cover/Depth, Ice Surface Temperature, and Ice Motion. This validation data can be acquired using ground-based instruments in fixed locations, often as part of large field networks [4]. These data tend to be operationally quality-checked and archived using standard formats, metadata and documentation.

2.2. Remote Sensing Validation

This technique will be applied for Sea Ice Characterization, Ice Surface Temperature, and Albedo (Cryosphere). Validation data are typically acquired by research investigators using satellite data along with specialized sensors onboard manned and unmanned aircraft. The latter data tend to take more time and resources to be geolocated, quality-checked and archived, and may or may not adhere to standard formats, metadata and documentation. The aircraft operations are sometimes augmented by in-situ observations.

2.3. Episodic Remote Sensing Validation

This technique will be applied for Active Fires. Validation data are typically acquired by operational agencies (e.g., national fire services) or research investigators using specialized aircraft sensors, or by tasked acquisition satellite systems (e.g., Landsat). Depending on the source, these data can take a variable amount of time and resources to be geolocated, quality-checked and archived, and may or may not adhere to standard formats, metadata and documentation.

2.4. Land Cover Typed Remote Sensing Validation

This technique will be applied for Surface Type and Sea Ice Characterization. Validation data are typically acquired by tasked acquisition, fine resolution satellite systems (e.g., Landsat, Hyperion, RADARSAT, ENVISAT, ICESat). Images must be independently classified and validated before being useful for VIIRS validation. The process can take a variable amount of time and resources, and may or may not adhere to standard formats, metadata and documentation.

3. Major Team Activities by NPP Validation Phase

In the NPP pre-launch period, the key activity for the Land team will be to fully characterize the VIIRS operational algorithm performance using proxy data sets, primarily those generated by applying the VIIRS algorithms to MODIS data in the PEATE. The Team will also plan and test aircraft-based validation methods, especially those for the Fire and Cryosphere products. Finally, the team will conduct several small-scale field experiments – primarily to confirm scaling-up approaches that utilize operational tower-based measurements.

During the on-orbit check-out period (approximately 0- to 60 days post launch), the Land Team will focus on examining diagnostic-mode (unaggregated) VIIRS sensor data collected over carefully chosen field sites. Because onboard aggregation and constrained pixel growth features are new to the civilian AVHRR/MODIS community, the Land Team will particularly consider the aggregation "step points" that could potentially impart undesired artifacts in the products.

During the Intensive Calibration and Validation Period (roughly from the start of science operations to 18 months thereafter), the Land Team will work closely with the upstream algorithm validation experts (Sensor Data Record, Cloud Mask and Aerosol Optical Depth) to help assess the algorithms and the downstream impacts. The Team will maximize their collection of correlative data sets (e.g., field and aircraft), and process and analyze these data vis-à-vis the VIIRS products. The results will be provided to the NPOESS Prime Contractor (Northrop Grumman Aerospace Systems) and to NOAA's National Climatic Data Center (NCDC) for archiving. The Land Team will continue to work with the PEATE to conduct chain-testing of algorithm fixes and improvements, and provide resulting recommendations for changes to the official algorithms to the Integrated Program Office (IPO) and the Prime Contractor.

Finally, during the Post-Intensive Calibration/Validation Period, the Land Team will work to stabilize and systematize the validation approaches, techniques and tools for long-term application and monitoring. They will continue providing results and recommendations to the NPOESS Program Office and Prime Contractor, and begin developing methods to inter-compare and inter-calibrate NPP and NPOESS C1 VIIRS products.

4. Conclusion

Since its inception in 2008, the VIIRS Land and Cryosphere Validation Team has developed a detailed plan for providing sustained validation of the NPP and NPOESS operational products. The Plan adapts mature techniques from NASA's EOS Program and the CEOS WGCV, and strongly emphasizes the use of correlation data sets provided by operational in-situ networks where possible. The Plan was reviewed and strongly supported by an external expert review team in 2009, but remains a working document such that it can evolve with scientific and programmatic changes. The Plan will become publicly available in the near future, and will be available through the NPOESS Program Office website (URL: http://www.ipo.noaa.gov/). The Land and Cryosphere Validation Team works in partnership with the NPOESS Prime Contractor and the NPOESS Program Office.

5. References

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6. Tables

Table 1. NPP Land and Cryosphere Product Groups Dependent on VIIRS.

General Product Group	**Number of VIIRS-based Products**
Land Surface Temperature (LST)	1
Surface Type	2
Albedo (Surface)	2
Vegetation Index	2
Sea Ice Characterization* (age)	1
Ice Surface Temperature (IST)	1
Snow Cover/Depth	2
Active Fires ARP	2
Surface Reflectance IP	1