Merged Navy-Relevant Optical Products from Multiple Satellite-Borne Sensors (NP331)

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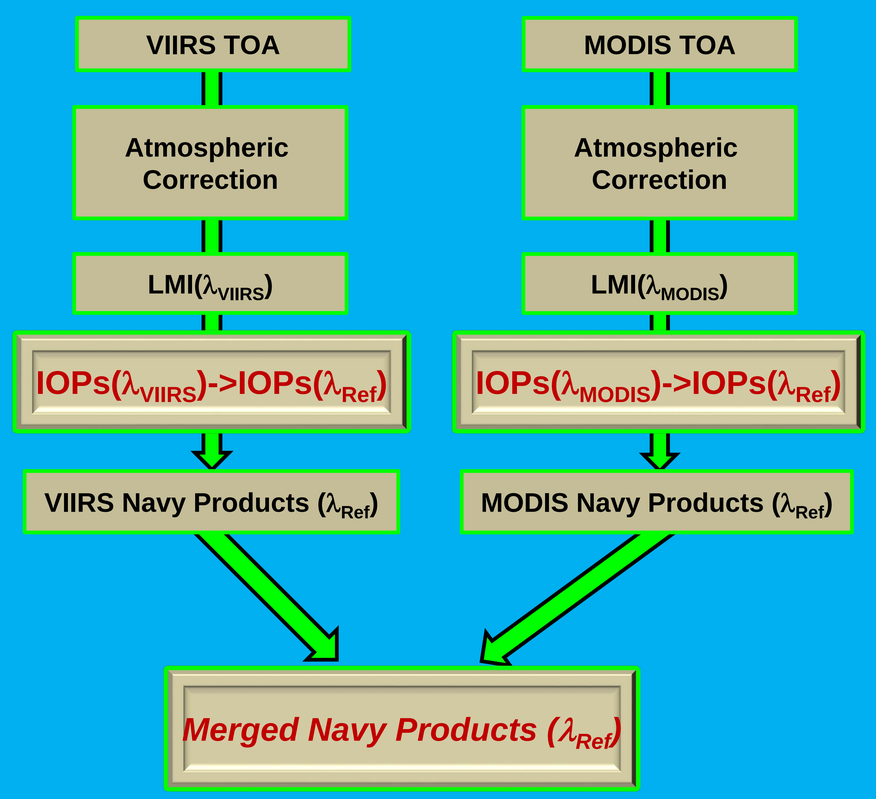
I. Abstract

The production of in-water optical properties from satellite data is challenging due to the fact that only ~5% of the light measured by a satellite is useful in retrieving in-water optical properties, the rest being from the atmosphere which must be removed. The production of in-water optical products from multiple satellite sensors poses additional problems because different satellite borne sensors have different band sets and different calibrations. The Naval Oceanographic Office in-water optical properties satellite processing software suite is the Automated Optical Processing System (AOPS). Previous versions of AOPS could only produce optical products at the wavelengths that existed on each sensor on each satellite. This resulted in multiple versions of the optical products, each at different wavelengths. A new set of algorithms have been implemented in AOPS which allows for the translation of inherent optical properties such as absorption, back scattering and attenuation from the wavelengths on each sensor to a common reference wavelength. The inherent optical properties at the reference wavelength are then used to produce Navy-relevant optical products (i.e. horizontal and vertical visibility, lidar penetration depth/performance). It is important that each sensor used in creating the merged products is calibrated using the same source for inter-sensor product consistency. This technique results in the ability to merge products from all satellite borne sensors at different wavelengths into single products that are delivered to the fleet for MIW, ASW and NSW/EXW use. In this poster, we show the benefits of using this approach as well as several examples of products that are slated to go into operational use beginning in the fall of 2015.

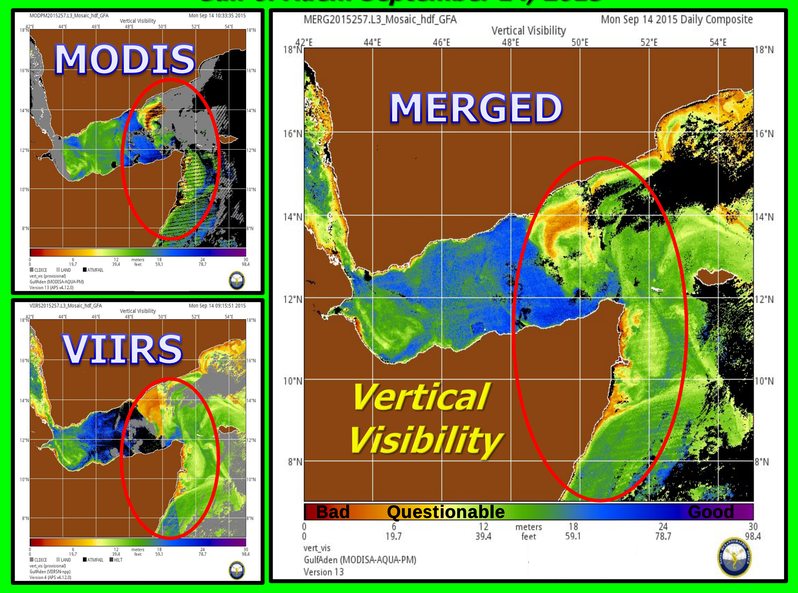
II. Automated Optical Processing System (AOPS): *Sensor Merge Capability Flow Chart*



This sensor merging capability provides optimal (number of images and improved quality) delivery to operations by averaging "good" pixels and filling those contaminated due to clouds, glint, atmospheric and algorithm failures, stray light and saturation for multiple images into one single support product. Note all satellite ocean color sensors do not always have the optimal/desired wavelength to support operational sensors. For example, MODIS has a 531nm channel and VIIRS has 486nm and 551nm channels and the desired wavelength for horizontal and vertical diver visibility is 532nm. The ability to derive Inherent Optical Products (Linear Matrix Inversion – LMI Algorithm) at a desired wavelength optimal for operational sensors (laser, camera, human eye, etc.) is very important. The LMI algorithm uses spectral models to provide IOP's / Navy Products at any desired wavelength allowing for identical Navy products for multiple sensors that can be merged into a single support product.

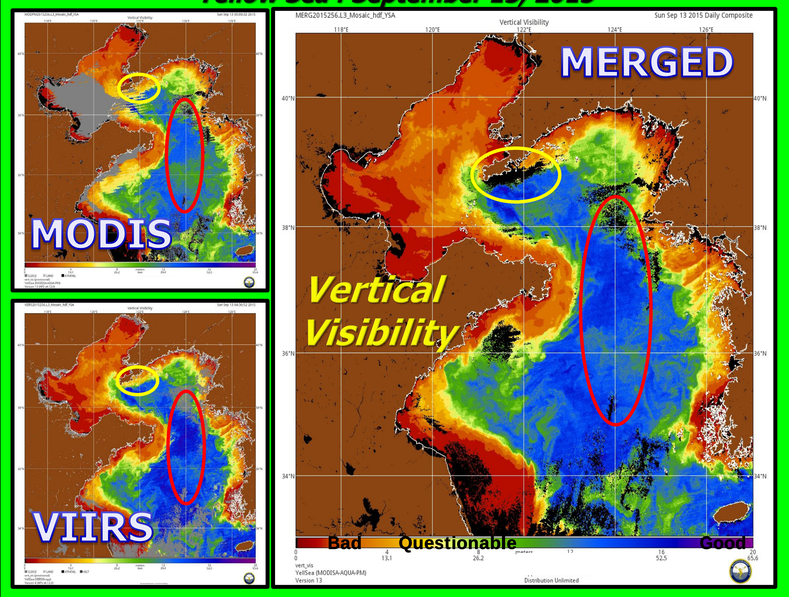
III. Daily Merged Composites

Gulf of Aden: September 14, 2015



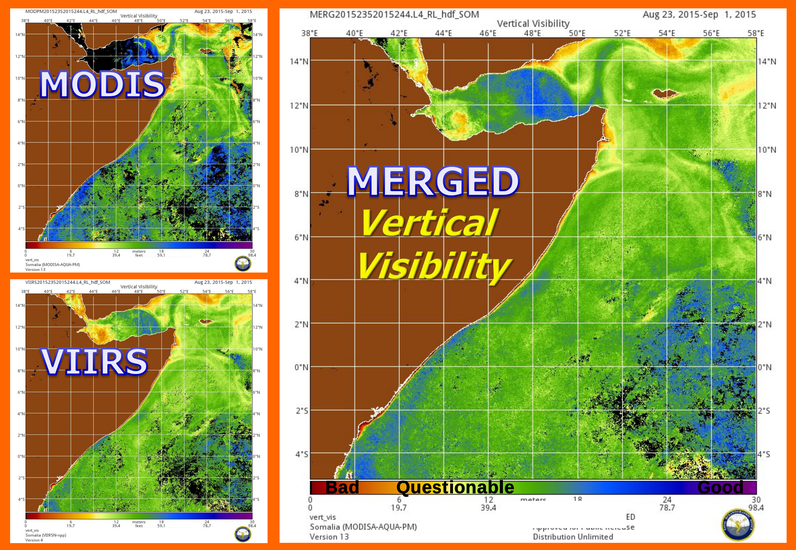
MODIS and VIIRS daily and merged vertical visibility for the Gulf of Aden on September 14, 2015. Both sensors agree very well and final merged product is a better overall representation of the environment. Red circles are areas that contain artifacts in the individual daily images for VIIRS and MODIS (top and bottom left images) due to edge of swath / sensor angles (MODIS) and orbital overlap (VIIRS). The merged image provides an improved operational support product.

Yellow Sea : September 13, 2015



MODIS and VIIRS daily and merged vertical visibility (swimmer) for the Yellow Sea on September 13, 2015. Both sensors agree well but show small differences in diver visibility in clearer waters (red circles) due to changing angles, light conditions (BRDF), atmospheric/rayleigh correction, IOP algorithm errors, etc. A merged image omits operational confusion and provides an improved mean product. Yellow circles in daily images (top and bottom left) show area of relaxed masking where merged image shows masked pixels due to more aggressive masking for better quality product.

IV. Temporally Averaged Merged Composites 10 Days



MODIS and VIIRS 10 day mean and merged vertical visibility for the Gulf of Aden August 23 – September 01, 2015. Both sensors agree very well and final merged product is a better overall mean representation of the environment due to high temporal and spatial variability caused by biology and sediment processes and advection.

V. Summary

- This sensor merging capability provides optimal (number of images and improved quality) delivery to operations by averaging "good quality" pixels and filling those contaminated due to sensor viewing and solar geometry, clouds, glint, atmospheric and algorithm failures, stray light and saturation for multiple images into one single support product.
- Inter-sensor consistency / calibration and validation of Navy products are very important.
- Temporal differences in acquisition time for multiple sensors yield atmospheric and geometric challenges.
- Merging allows compositing for daily, weekly, multi-day running, and monthly averaged optical Navy support products
- Reduces number of support images and confusion for multiple sensors / same product type.
- Sentinel OLCI will provide a morning/AM orbit alternative to evaluate diurnal/natural variability and provide more complete/filled-in images. MODIS and VIIRS are in afternoon/PM orbits.
- Biology and sediment plumes & bottom re-suspension optical/turbidity layers affect diver operations (visibility and vulnerability, MCM laser performance, laser bathymetry estimates / penetration and target detection and identification.

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