OMPS Sensor Performance and Algorithms

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Introduction

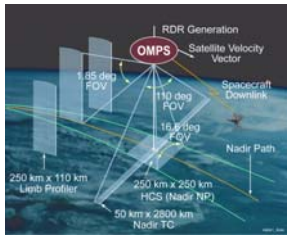
The OMPS Proto-Flight Model (PFM) successfully completed testing and was delivered in November 2008. Review and acceptance of the design verification, and analysis of test results are complete. The three UV spectrometers are stable, well behaved and exhibit performance that meets and in many cases exceeds heritage sensors. This poster focuses on the two Nadir pointing spectrometers, Total Column (TC) and Nadir Profiler (NP), which will produce operational NPOESS data products. The Limb Profiler (LP) is flying on NPP only as an experiment and is the subject of a separate poster.

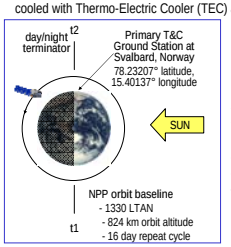
Overview of OMPS Sensor Suite and Operations

The Nadir sensor has 2 UV spectrometers, a Nadir Total Column (TC) spectrometer based on TOMS heritage, which covers a 2800km cross-track swath (110° FOV), and a Nadir Profile (NP) spectrometer based on SBUV/2 heritage, which covers a (250 km)^2 cell. For on-orbit calibration, there are dual reflective solar diffusers (working and reference) mounted on a rotating mechanism. The diffuser wheel also works as a shutter for dark field measurements and linearity calibrations of the focal plane array using Light Emitting Diodes (LEDs). Nadir TC and NP spectrometers are co-boresighted to 0.1°, 3 sigma, so channels from the TC can be used in generation of the NP product.

The Limb Sensor (experimental) provides a 1.85° vertical field of view (FOV) (tropopause to 60 km), with 1 km sampling along 3 aft-pointing slits.

All three spectrometers use identical Charge Coupled Device (CCD) detector arrays, cooled with Thermo-Electric Cooler (TEC) and passive radiators.





Earth View (EV) Command Block Memory (CBM) executes during the day side of the NPP orbit. OMPS Command Sequence Memory (CSM) is responsible for the timing of command execution. CSM is programmed to start the Nadir EV CBM at time t1 (SZA ~ 88°). Nominally, the Nadir EV CBM runs for 80 EV Loops, each 37.44 sec long, which ends at t2 (SZA ~ 88°). Data products are produced for Solar Zenith Angles (SZAs) out to 88°, but Environmental Data Product (EDR) performance is specified for 80° or less.

Command start times are updated periodically to compensate for seasonal variation of terminator orientation. Calibration CBMs start just prior to the terminator and execute during the dark side of the orbit.

T&C contact is made once per orbit. OMPS ground commanding (table uploads) is performed while NPP is in contact with primary T&C ground station at Svalbard, Norway

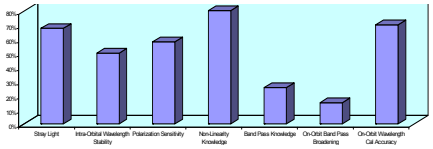
Seasonal variations will change the duration of contact time that is in darkness (EV CBM not running).

Proto-Flight Model Measurement Performance

After completing all ground tests, including environmental, characterization and calibration, the PFM has demonstrated positive margin for those key instrument performance parameters that drive Nadir Total Column EDR accuracy.

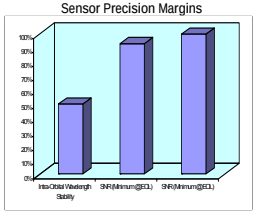
The bar graph to the right illustrates the margin for these ozone EDR accuracy performance drivers, in descending order of impact from left to right (sensor performance parameter most dominating EDR accuracy error on the far left).

Nadir Total Column Sensor Accuracy Margins



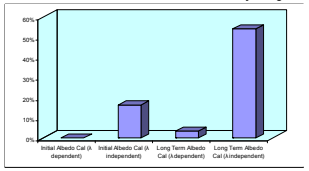
Similar to the graph above, the bar graph to the left illustrates the positive margins for precision performance drivers, in descending order of impact from left to right (sensor performance parameter most dominating EDR precision error on the far left).

Nadir Total Column Sensor Precision Margins



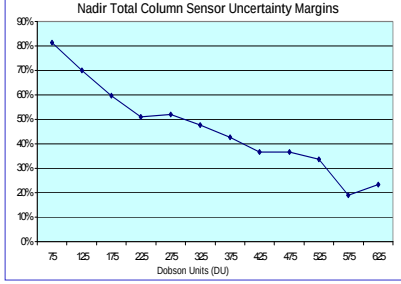
Calibration of the albedo, or normalized radiance (Earth View Radiance divided by Solar Flux), is the aggregate measure of the uncertainty in sensor measurements and calibration coefficients. The graph to the right shows the positive margins achieved by the PFM unit during the calibration test program.

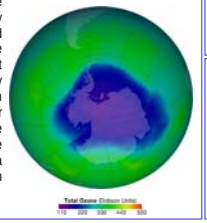
Nadir Total Column Calibration Uncertainty Margins



The fullest assessment of sensor measurement performance is the uncertainty contribution to total EDR uncertainty or error, which is the combination of accuracy (mean) and precision (standard deviation) errors in quadrature (RSS). The plot to the left (below) shows that the positive margin of combined error uncertainty, when compared to the allocated error uncertainty, covers the full measurement range of the OMPS Total Column ozone EDR. It is important to note that the highest margins are at the low end of the Total Column ozone range. This performance in very low ozone conditions allows higher fidelity monitoring of the severity and geographical extent of the ozone hole, which is of significant concern to the scientific community and general public. Although improvements were realized over the past 30 years, the ozone hole over Antarctica this year was the fifth biggest on record, reaching a maximum area of 10.5 million square miles in September 2008.

Nadir Total Column Sensor Uncertainty Margins





Comparison to Heritage Sensors

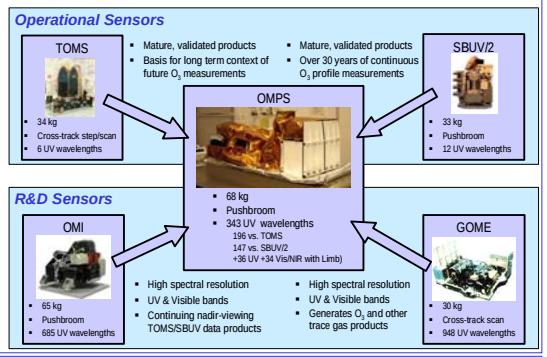
OMPS is designed to incorporate key features from and improve upon previous Operational and R&D sensors.

OMPS combines the high reliability, high availability, long operating life and data product consistency of operational sensors with the high resolution, hyperspectral features of the latest generation R&D sensors.

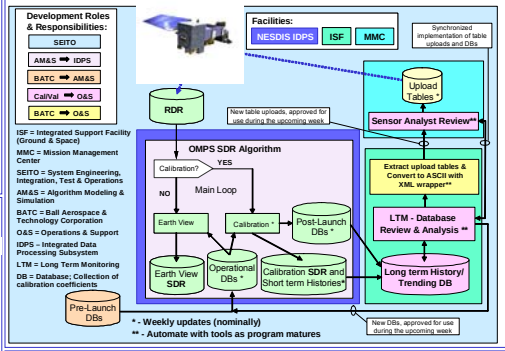
Reliability, availability and operating life are achieved with dual redundancy and fewer moving parts through use of a wide FOV pushbroom telescope (stare & integrate vs. scan or step/scan).

Data product consistency is achieved by applying strict operational configuration controls to ground processing algorithms and coefficient tables (see box below).

High resolution, oversampled spectral measurement capability is balanced with data rate considerations.



Sensor Data Record (SDR) Algorithm and Calibration Data Flow



Once per week the OMPS sensor performs a series of calibration measurements (Solar, Dark Current and LED/Linearity). The calibration data is processed by the IDPS at NOAA/NESDIS to update the calibration databases used in the ground SDR algorithm (Sample Tables, Channel Band Centers, Dark Current, and Zero Input Offset). Some of these databases will need to be converted to a sensor compatible format and uploaded (Sample Tables, Pixel Gain (part of Radiance aka PRNU), and LED/Linearity), most likely on a monthly or bi-monthly basis.

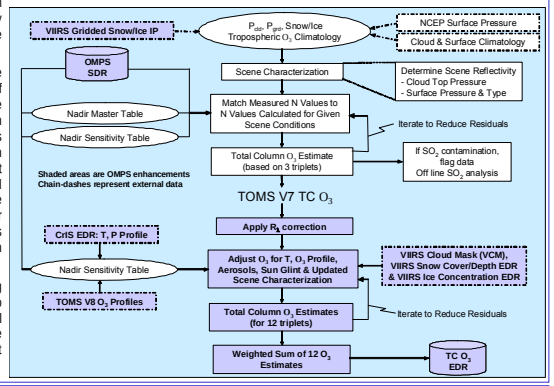
With the exception of Sample Tables, new coefficients are automatically implemented by the ground algorithm, although they are checked off line to ensure no adverse impact to data product error performance or consistency (large changes will be phased in slowly to avoid undesirable discontinuities in data products).

Total Column Environmental Data Record (EDR) Algorithm Flow

The NGST/BATC OMPS EDR algorithm enhances the TOMS Version 7 algorithm by leveraging OMPS sensor capability and the availability of other NPOESS sensor EDRs.

Using the hyperspectral capability of the sensor, the algorithm selects multiple sets of wavelength triplets to balance ozone sensitivity over a range of ozone column amounts and solar zenith angles. This capability also provides wavelengths that can be used to retrieve ozone cross-sections that are insensitive to temperature. An additional correction for temperature is made using the NPOESS Cross-track Infrared Sounder (CrIS) Temperature Profile EDR, which is spatially and temporally coincident with OMPS.

The NPOESS Visible Infrared Imaging Radiometer Suite (VIIRS) EDRs are used to characterize scene reflectivity. An aerosol index is generated to adjust the ozone estimate to correct for wavelength dependent effects of aerosols on reflectivity.



Conclusions

- The Proto-Flight OMPS Model for the NPP mission has successfully completed all testing and sell-off efforts
- The Nadir spectrometers are stable, well behaved and exhibit performance that meets or exceeds heritage performance
- Sensor performance supports NPOESS EDR requirements with positive margin, with the highest performance margins at low Ozone conditions to accurately monitor the severity and geographical extent of the ozone hole
- NGST /Raytheon operational algorithm development is well along and will be complete and verified prior to NPP launch