OMPS SDR Calibration and Validation

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Introduction

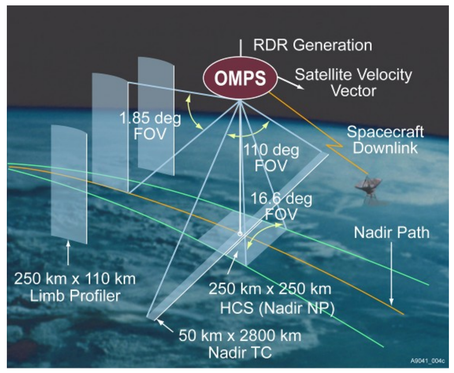
The Ozone Mapper and Profiler Suite (OMPS) is scheduled to be launched on the NPOESS Preparatory Project (NPP) platform in 2011. The OMPS will continue monitoring ozone from space, using three instruments, namely the Total Column Mapper (heritage: TOMS), the Nadir Profiler (heritage: SBUV) and the Limb Profiler (heritage: SOLSE/LORE). The Total Column Mapper (TC) sensor images the Earth through a slit, nadir-cell horizontally spaced at 49.5 km cross-track with an along-track reporting interval of 50 km. The total field of view (FOV) cross-track is 110° to provide daily global coverage. The TC sensor, a grating spectrometer, provides 0.45 nm spectral sampling across the wavelength range of 300–380 nm. The calibration stability, which is essential to enable long-term ozone monitoring, is maintained by periodic observations of the Sun, using a diffuser to redirect the solar irradiance into the sensor. We describe the plans to calibrate the TC sensor and validate the radiance data (TC Sensor Data Record or TC SDR) after launch. We discuss the measurements planned during the Intensive Cal/Val (ICV) phase of NPP mission, the data analysis methodology and results from the analysis of OMPS calibration measurements.

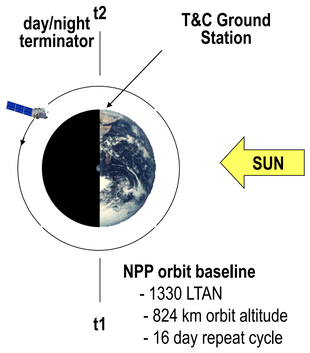
Overview of OMPS Sensor Suite and Operations

The nadir sensor has 2 UV spectrometers, a Total Column (TC) spectrometer based on TOMS heritage, which covers a 2800 km 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 σ) so channels from the TC can be used in generation of the NP product.

The Limb Profiler (LP) 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.





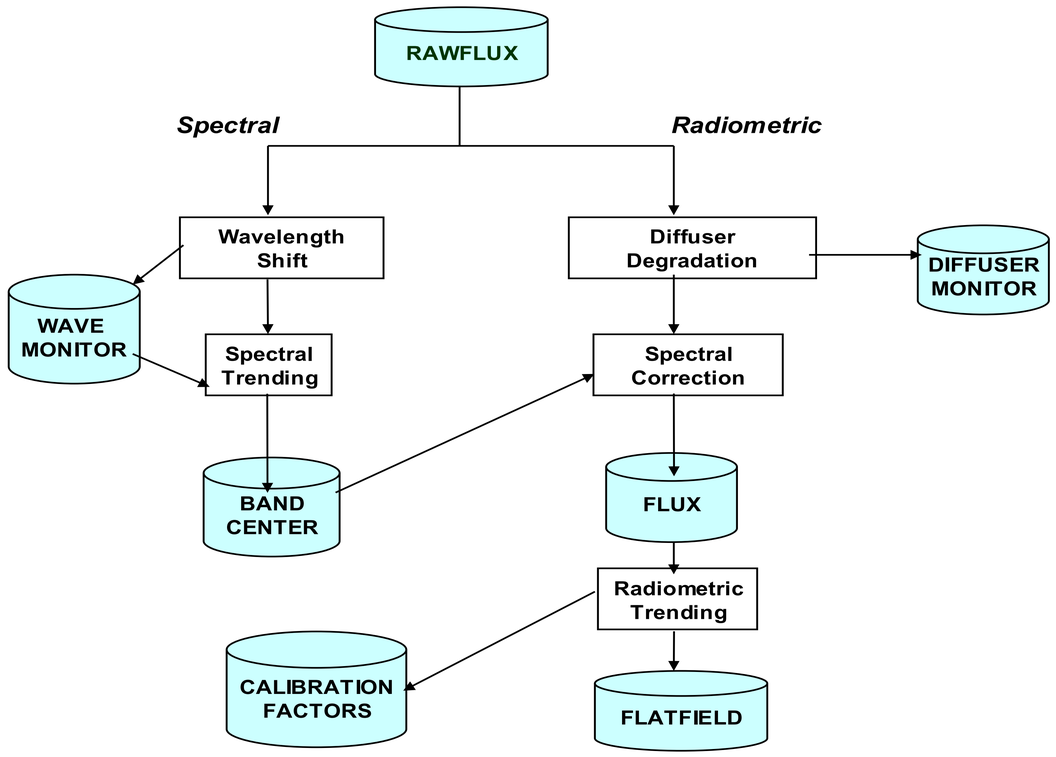
Earth View (EV) Command Block Memory (CBM) executes during the day side of the NPP orbit. OMPS Command Sequence Memory (CSM) is responsible for the timing of command execution. CSM is programmed to start the Nadir EV CBM at time t1 (SZA ~ 88°). Nominally, the Nadir EV CBM runs for 80 EV Loops, each 37.44 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.

Telemetry and Command (T&C) contact is made once per orbit. OMPS ground commanding is performed while NPP is in contact with the ground station.

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

Orbital Solar Data Analysis Method



Analysis Tools

We have developed a variety of semi-automated tools for analyzing samples of the raw data record (RDR) and processed sensor data record (SDR), as well as for examining the databases highlighted above in blue. The tools perform statistical analyses and other mathematical operations on single images or groups of images, including Solar, Dark, Lamp, and Earth View data. Tools have been developed to display and fit data trends with both time and sensor temperatures, and tools to display sensor parameter metadata. Moreover, we have created tools to process special calibration RDR data into SDR data with the resulting uncertainties computed and stored. The suite of tools enables us to check the sensor calibrations output by the SDR Algorithm, to monitor the state of the sensor, and to evaluate the precision and accuracy of the various RDR, SDR, and history database data products.

Sensor Data Record Algorithm and Calibration Science

SDR Algorithm Science

- All EV and calibration data processing is driven by sample tables
  - Macro table: EV macropixel location and bin size
  - EV sample table: bad pixel table, actual macropixel location and bin size
  - SC sample table: solar data location, size, and structure
  - LED sample table: lamp data location, size and structure
- Added sufficient flexibility to handle possible variations of the operational data in size and structure
  - Solar: binned smear, bias or no bias, any spatial/spectral dimension
  - Dark: Full Frame
  - Lamp: bias/no bias, binned smear or no smear, any pixel location
  - Earth view: any spatial/spectral dimension, any spatial bin size
- Linearity table generation and nonlinearity correction
  - Same approach used by sensor vendor; table-based nonlinearity correction
- Bias correction
  - Computed from dark; after linearity correction; scaled by image co-adds
- Geolocation
  - Consistent definition of look angles; computation of macropixel LOS
- Gain correction (Flat-field table generation)
  - Computed from radiance calibration coefficients and sensor through-put degradation factor
- Radiance calibration
  - Applied prelaunch radiance calibration coefficients
- Solar data processing
  - Modified to deal with solar image overlap regions; matching irradiance calibration coefficients and goniometry correction coefficients to solar data
- Bad-pixel identification and table generation
  - Based on dark values; table generated and combined with EV sample table in offline process

SDR Calibration Science

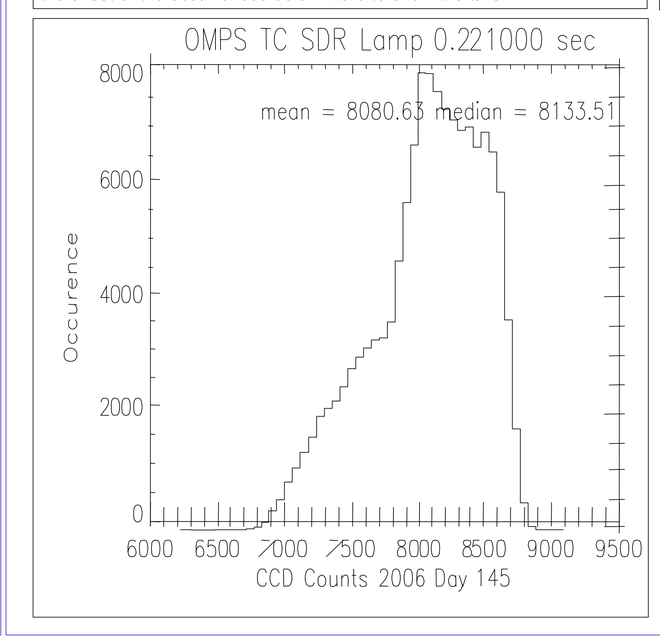
Early in the mission, within the sensor checkout and intensive calibration and validation periods, special calibration observations will be conducted continuously, and gradually phasing in full observations of the Earth. Thereafter, once per week, the OMPS sensor will perform a series of calibration measurements (Solar, Dark Current and LED/Linearity). This nominal calibration data set will be 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 (Sample Tables, Pixel Gain (part of Radiance), and LED/Linearity) will need to be converted to a sensor compatible format and uploaded, most likely monthly or bi-monthly, to the sensor processor.

With the exception of the pixel Sample Tables, new coefficients are automatically implemented by the ground algorithm, although they will be checked manually to ensure there are no adverse impacts to the error performance or consistency of the data products (large changes will be phased in slowly to avoid undesirable discontinuities in data products). The data products will be assigned calibration and validation confidences of experimental, provisional, and verified levels, depending on internal checks of the data as well as on external comparisons with data from other sensors.

Laboratory Data Results

Lamp Linearity Calibration

The linearity is assessed by a series of Lamp exposures of varying duration 0.0 to 2.4 sec to probe the range of count levels on a CCD, up to about 14,500 counts. Below is an example exposure histogram showing a range of counts for a single 0.221 sec exposure. The range is clarified by the offset of the occurrences below zero to show the tails.



Dark Current Measurement

The Dark was measured by the Ball Aerospace manufacturer. We processed this RDR with the SDR Algorithm to obtain corrected counts. The Total Column CCDs have excellent dark noise below 1 count/sec and almost no overly active pixels such as those few below that are less than 40 count/sec.