Updates on Suomi NPP and NOAA-20 OMPS Sensor Data Records (SDRs)

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Topics and Scopes

• Introduction
  - Instrument overview
  - OMPS Sensor Data Records (SDRs)
  - SDR science applications

• From Suomi-NPP to JPSS-1 (NOAA-20)
  - Suomi-NPP OMPS SDR reprocessing
  - Status of NOAA-20 OMPS operation
  - NOAA-20 OMPS SDR Pre-operational performance
  - Schedules and Milestones
  - Long Term Monitoring

• Summary
The Joint Polar Satellite System (JPSS) satellites provides continuity of global environmental data. The Suomi National Polar-Orbiting Partnership (S-NPP) Satellite is the first Satellite in the JPSS constellation of satellites.

OMPS is one of five instruments flying on JPSS-1 satellite on Nov. 18th 2017. The first OMPS is on board the Suomi-NPP satellite launched in Oct. 2011.

OMPS heritage sensors are SBUV/2 and TOMS, providing ozone total column and vertical profile data that continues ozone daily global data with higher calibration accuracy and higher spatial and spectral resolution.

OMPS: Ozone Mapping Profiler Suite

JPSS-1 reached polar orbit on Saturday, November 18; it officially became known as NOAA-20.
Instrument Configuration

Nadir Technical Specification

<table>
<thead>
<tr>
<th>Telescope</th>
<th>One telescope w/ two grating CCD spectrometers Nair Profiler NP and Nadir Mapper (NM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Swath Width</td>
<td>NM: 2800 x 50 km²; NP: 250 x 250 km²</td>
</tr>
<tr>
<td>Field of View (FOV)</td>
<td>NM: 110°; NP: 16.7° (square)</td>
</tr>
<tr>
<td>Spectral Range</td>
<td>NM: 300 to 380 nm; NP: 250 to 310 nm</td>
</tr>
<tr>
<td>Spectral Sampling Interval</td>
<td>2.4 pixels per FWHM</td>
</tr>
<tr>
<td>Spectral Resolution</td>
<td>1.0 nm</td>
</tr>
<tr>
<td>CCD Detector Cooling</td>
<td>Thermo-Electric Coolers (TECs)</td>
</tr>
<tr>
<td>Operational set point</td>
<td>NM: -45.0 °C; NP: -30.0 °C</td>
</tr>
<tr>
<td>Calibration</td>
<td>On-board light-emitting diodes (LEDs) and dual Solar diffusers</td>
</tr>
<tr>
<td>Products</td>
<td>Provide globe maps every 24 hours of amount of ozone and volumetric concentration in a vertical column of atmosphere with a 4- days revisit</td>
</tr>
</tbody>
</table>

Courtesy of Ball Technology Corp.
OMPS Measurement Technique

**OMPS Measurement Technique**

![Diagram showing SV and EV radiance](image)

**Equations:**

- **EV radiance**
  \[ I_{jk}^m(t) = \frac{C_{jk}^r k_{jk}^r}{\tau_{jk}(t)} \]

- **SV irradiance**
  \[ F_{jk}^m(t) = \frac{C_{jk}^i k_{jk}^i}{g \rho(t) \tau_{jk}(t)} \]

- **Normalized radiance**
  \[ \frac{I_{jk}}{F_{jk}^m} = K_{jk} \frac{C_{jk}^r}{C_{jk}^i} g \rho(t) \]

- \( C_{jk}(t) \): initially calibrated radiance counts
- \( k_{jk} \): radiance calibration constant
- \( \tau_{jk}(t) \): pixel response changes
- \( \rho(t) \): solar diffuser plate reflectivity
- \( g \): relative angular irradiance response

CCD detector performance, stray light, wavelength registration are the primary factors.
OMPS SDRs and Applications

- GEOs: Earth geo-location information of measurements
- Calibration SDRs (offline): ancillary information, including radiometric and geometric calibration coefficients.
- EV SDRs: calibrated radiance and key parameters such as wavelength, solar flux, dark, smear, electronic bias etc.
- SDR algorithm was developed to function on the processing hardware to meet product requirements.
- Primary application: continue three decades of total ozone and ozone profile records; measure other atmospheric particles like sulfur dioxide and ash that result from volcanic eruptions.

https://www.star.nesdis.noaa.gov/jpss/documents/ATBD/D0001-M01-S01-005_JPSS_ATBD_OMPS-NP-Ozone_A.pdf
Reprocessing of Suomi NPP SDR

- SDR quality chronologically improved since Suomi NPP launch
- Use up-to-dated calibration LUTs and algorithm in OMPS SDR life-cycle reprocessing
- Produce consistent SDRs at the attainable quality level.
Improvement of Solar Calibration

(a) Degradation error
(b) Wavelength shift error
(c) Solar activity error
(d) Calibration error
Improvement of Data Accuracy

Albedo accuracy improvement %

Evaluated by comparison w/ MLS on the SDR level and NOAA 19 SBUV/2 on EDR level
- No long term time-dependent change relative to NOAA-19 SBUV/2.
- OMPS Nadir Mapper bias is near zero on average and a profiler bias of about 0.5%.

MLS: Microwave Limb Sounder
BSUV/2: Solar Backscatter Ultraviolet Radiometer -2
NOAA-20 OMPS Aliveness Test

NOAA-20 OMPS instrument was activated on 11/28/2017. The Aliveness Test took dark and LED images, followed by a Self-Compatibility test.
Rates calculated from mean of only non-transient pixel values in sequence.

Storage region rates are measured with a similar but shorter sequence.

**Dark current correction:**

\[ im(i, j) = im_i(i, j) * t_i - im_s(i, j) \]

Rates x integration time - dark current accumulated in storage region during CCD readout.

NOAA-20 OMPS weekly dark current calibration starts on 1/18/2018
NOAA-20 OMPS Nonlinearity Calibration

NOAA-20 OMPS system linearity is nearly identical before and after launch.
Similar impact of South Atlantic Anomaly (SAA) region has been observed in S-NPP OMPS.
# NOAA-20 OMPS SDR Milestone

<table>
<thead>
<tr>
<th>Launch</th>
<th>Post-launch Testing (PLT)</th>
<th>Operations</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-months</td>
<td>2-months</td>
<td>2-months</td>
</tr>
<tr>
<td>L + 1 m</td>
<td>L + 3 m</td>
<td>L + 9 m</td>
</tr>
<tr>
<td>L + 68 days</td>
<td></td>
<td></td>
</tr>
<tr>
<td>L + 90 days</td>
<td></td>
<td></td>
</tr>
<tr>
<td>L + 270 days</td>
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**SDRs**
- **Beta**: Initial calibration is applied. Rapid modification is expected. For users to familiar with data. Not ready for scientific publication.
- **Provisional**: SDR may not be optimal, but are ready for operational evaluation. Users feedback are encouraged to participate in the data quality QA.
- **Validated**: Sensor performance has characterized and calibration meets sensor design criteria. Ready for scientific publication.
- **LTM**: through life of sensor mission

**Phases of Post Launch SDR Cal/Val:**
1. **Early Orbit Check-out (L + 90 days)** – System Calibration & Characterization
2. **Intensive Cal/Val (L + 270 days)**; SDR Validation
3. **Long-Term Monitoring (LTM)**; through life of sensor mission

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## Expected NOAA-20 Performance

<table>
<thead>
<tr>
<th>Source of Uncertainty</th>
<th>Pre-launch Error Budget</th>
<th>Pre-launch Performance</th>
<th>Post-launch Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Irradiance Absolute $1\sigma$ Fractional Uncertainty (%)</td>
<td>$\leq 7.0$</td>
<td>$\leq 3.194$</td>
<td>$\leq 7.0$</td>
</tr>
<tr>
<td>Intro-orbital wavelength drift(nm)</td>
<td>$\leq 0.01$</td>
<td>$\leq 0.01$</td>
<td>$\leq 0.016$</td>
</tr>
<tr>
<td>Wavelength Registration( nm)</td>
<td>$\leq 0.02$</td>
<td>$\leq 0.018$</td>
<td>$\leq 0.01$</td>
</tr>
<tr>
<td>Stary Light (%)</td>
<td>$\leq 2.0$</td>
<td>$\leq 0.5$</td>
<td>$\leq 2.0^*$</td>
</tr>
<tr>
<td>Nonlinearity (%)</td>
<td>$\leq 2.0$</td>
<td>$\leq 2$</td>
<td>$\leq 0.5$</td>
</tr>
<tr>
<td>radiance SNR</td>
<td>$\geq 1000$</td>
<td>$\geq 3547$</td>
<td>$\geq 1000-2000$</td>
</tr>
<tr>
<td>$\lambda$ - independent Albedo $1\sigma$ Fractional Uncertainty (%)</td>
<td>$\leq 2.0$</td>
<td>$\leq 1.717$</td>
<td>$\leq 2.0^*$</td>
</tr>
<tr>
<td>$\lambda$ - dependent Albedo $1\sigma$ Fractional Uncertainty (%)</td>
<td>$\leq 0.5$</td>
<td>$\leq 0.497$</td>
<td>$\leq 0.5$</td>
</tr>
</tbody>
</table>
Summary

- Suomi-NPP OMPS NM and NP EV SDRs have life-cycle data reprocessed.
  - Maintain the stability of the SDRs at the already established attainable quality level
  - Provide experience for NOAA-20 OMPS SDR calibration

- NOAA-20 OMPS sensor performs well
  - A successful sensor orbital decontamination calibration leads to Beta maturity SDRs.
  - SDR quality level is expected to be comparable to the SNPP OMPS SDRs