2016 STAR JPSS Annual Science Team Meeting

Summary of JPSS-1/OMPS LEO&A Activities

T.J. Kelly, G.R. Jaross

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Some SNPP & J1 OMPS Comparisons

- Same instrument flight hardware design
  - No Limb Profiler (LP) on J1
  - Different diffusers:
    - SNPP: Aluminum
    - J1: QVD (diffuser features are much less)

    } Compare on-orbit performance
  - Bus rate upgrade
    - SNPP: 196.6 kb/s (shared among NM, NP & LP)
    - J1: 409.6 kb/s

    } ~2X increase
  - Flight S/W
    - SNPP uses FSW v3.6
    - J1 uses FSW v6.0
      - Major instrument performance upgrades
        - » data compression: throughput upgrade . . . . > ~2X increase
        - » reduced-frame EV Timing Pattern: . . . . optimizes efficiency
      - **Effective, estimated data throughput = 800+ kb/s** . . . . **> ~4X overall increase**
- J1/EV_HI_RES capability to collect data at higher resolution:
  - Spatial: ~4X (from SNPP/BF=20 to J1/BF=5)
  - Temporal: ~6X (from SNPP/6 coadds to J1/no coadds)

J1 Mission Timeline & Opening the OMPS Door

- General Orbit Characteristics:
  - J1 *final* orbit is essentially the same as SNPP
    - J1 ~½ orbit ahead of SNPP (relative phasing)
- J1 Orbit Raising Campaign (ORC) is based upon SNPP ORC
  - SNPP ORC achieved final orbit by ~L+18
- ORC for J1:
  - First step: Get proper relative phasing of ½ orbit
    - Wait for right relative phase
      - Utilizes a ~10 km lower orbit for J1 *(safe distance from SNPP)*
      - Moves J1 relative phase ahead by ~13 s/orbit, or ~3 min/day
    - Minimizes fuel consumption
    - Range of Phasing Duration varies from ~3 to ~35 days
  - Second step: Execute J1's ORC
    - Best Case: 12 days
    - Worst Case: 24 days
- Effective range of OMPS door opening is from approximately L+38 to L+70
  - OMPS is powered on first, and opens its door last
  - Other instruments have sequences that have variable times to complete
- Reduce door open time prior to OAR & Operational Handover?

OMPS Notional Summary Timeline

Launch

Activation

(L + ~10)

Door Closed Phase

SAA Transients: ≤ 6 Orbits/Day

Nom. Door Closed Dark Cal Sequence: ≥ 1/Day

Nom Door Closed LED Cal Sequence: ≥ 1/Day

Diag Med-IT Dark (IMG/STO): Fills several orbits per day

Nominal EV Orbits: ≥ 2/Day

Pre-tests of NomOps CBM Activities

Pre-tests of EV Low-Res & EV Med-Res

- Initial OMPS Table Upload L + ~10
- Nominal Flight Diffuser Wheel Mech Options Table ID 4 upload immediately prior to Door Opening
- Load CBM table with EV_MED_RES mated with Cal activities before L+90

Door Open Phase

(L + ~38 to 70)

First High-Res EV Ozone

Day-1 Solar Cals

Extended SolEA Solar Cals

Geo-Location

EV ST & Date Rate Optimization

Low-Res EV Science Data Collection

Medium-Res EV Science Data Collection

Dynamic Range & Full-Frame EV

Solar Cals with S/C Maneuvers

Storage Region Light Leak

Lunar Opposition & Door Open Dark Cals

Orbit-Raising Campaign ends **(L + ~20 to ~62)**

- Operational Acceptance Review (OAR) at L + ~85
- Operational Handover at L + 90
  - NASA/JPSS → NOAA/OSPO
  - NASA/MOST → NOAA/MOT
- Time from start of Door Open Phase to OAR is ~ 52 down to 15 days

NomOps

(L + 90)

EV_MED_RES: Default Activity (up to 15 Orbits/Day)

Diag. Door Open Dark Cals: Default (≤ 15 Seq./Day)

Nom. Door Closed Dark Cal Sequence: 1/Week

LED Cal Sequence: Once every 4 Weeks

Solar Working Cals: Once every 2 Weeks

Solar Ref Cals: Semi-annually

Notes on *"Day-1"* Solar Cals

- No solar peeks planned during the Door Closed Phase
- *"Day-1"* Solar Cal:
  - If ORC not completed, then must wait for later Solar Cal to validate CBM timing
  - May need to work around the Orbit Raising Campaign
    - Similar to Inclination Adjustment Maneuver on SNPP & Solar Ref Cals in August of 2014
- Follow-up Solar Cals every 2 weeks, as occur on SNPP
  - TBD: Whether to use the 1-orbit or the 3-orbit Solar Cals?
  - 3-orbit = better SolEA coverage: ~16 images per Diff.Pos. covers most of Gon. SolEA
  - 1-orbit = fewer mech movements: 3 image per Diff.Pos.

Example of Consecutive Sequence of Initial Solar Cals

Sequence begins between Orbits-of-the-Day 5 through 10, so nightside Door Closed Dark Cals are collected outside of the SAA

Relative Orbit Number	CBM Activity	Nightside Activity	Notes
1, 2 & 3	3orb_EV_WRK_SCAL	Door Closed & Open Dark Cals	~16 images/DiffPos
4	EV_WRK_SCAL	Door Closed Dark Cals	3 images/DiffPos
5	EV_ExtSCAL4_TC	Door Open Dark Cals	Extended SolEA=[-15°,15°] @ Diff.Pos. #4
6	EV_ExtSCAL_NP	Door Open Dark Cals	Same Extended SolEA Range

Solar Cals with Spacecraft Yaw Mnvrs

- Desire is to measure Solar Cals at the angles used in the lab
  - Speak in terms of Solar Azimuth Angles instead of Solar Beta Angles
  - The 2 are very close during Solar Cals, where Solar Elevation Angle (SolEA) = ~0°
    - *SolarAz – SolarBeta = ~0.3°*
    - Need to check difference for J1 at SolEA = 0°
- Utilize 3-orbit Solar Cals with Working Diffuser
  - Covers most of Goniometric Solar Elevation Angles
- Exact *Reference Solar Azimuth Angle* is TBD
- Question: Collect 3-orbit Solar Cals with Reference Diffuser too? (at Ref.Azimuth Angle)

Example of Sequence of Solar Cals using Spacecraft Yaw Maneuvers

This sequence is very similar to the 5th Solar Reference Calibrations collected on SNPP/OMPS on 2014-March-4 that used a S/C Yaw Mnvr to the *Reference Azimuth Angle*

Relative Orbit Number	CBM Activity	Desired Goniometric Solar Azimuth Angle	Notes
1 – 3	3orb_EV_WRK_SCAL	Reference Az. Angle	Door Closed Dark Cals will occur 3 times here, and span a difference of 6 orbits from the 1st to the last, so at least 1 of the Door Closed Dark Cals will fall outside the SAA.
4 – 6	3orb_EV_WRK_SCAL	Min Gon. Az. Angle (12°)	
7 -9	3orb_EV_WRK_SCAL	Max Gon. Az. Angle (32°)	
10- 12	3orb_EV_REF_SCAL	Reference Az. Angle	May or may NOT be included

Notional Mission Timeline: Dark and LED Cals

Activity	Door Closed Phase	Door Open Phase (Early)	Door Open Phase (Later)
Door open Dark Cal	Frequent	Very frequently	Nearly every orbit
Door Closed Dark Cal	Daily	Transitioning	Once a week
LED Cal (Door Closed)	Daily	Transitioning	Once every 4 weeks
Note: Above Door Closed Dark and LED Cals follow EV Hi-Res data collection on the dayside			

Special EV CBM Activity Summary

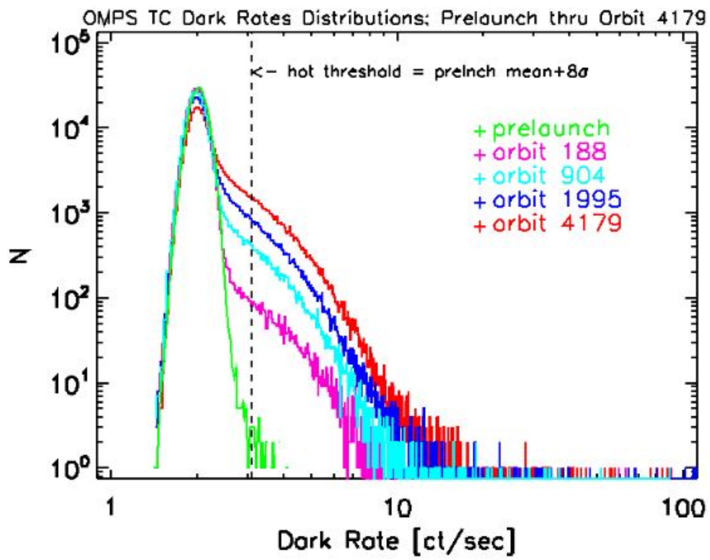
CBM Activity (PLT Tasks)	**Coverage**	**Targets: Regions & Data**
EV_GeoLoc (PLT-4 & 5)	Run for several days	Geo-Location: Cloud-free land Dynamic Range: Bright, cloudy scenes, usually over oceans & seas
EV_CoLoc	Run over land masses	Correlate NP EV imagery relative to NTC/NM EV imagery
EV_FF_TC	Run for entire day Weekly collection	To observe any spectral shifts through the orbits Monitor and λ shifts with orbital or seasonal dependence.
EV_FF_NP	Run for entire day Weekly collection	To observe any spectral shifts through the orbits Monitor and λ shifts with orbital or seasonal dependence.
EV_PRNU_NORTH **EV_PRNU_SOUTH**	Seasonal; run for part of the day	Pixel Response Non-Uniformity Greenland & Antarctica around Summer Solstices
EV_360	Run for entire day	Provide SolZA coverage >88° for all FOV in both Hemispheres.
EV_LOW_RES	Run for entire day	Required data collection.
EV_MED_RES	Run for entire day	Required data collection.
Note: EV_HI_RES is primary EV (Science Data) operating mode during the transition into NomOps.		

OMPS Post-Launch Tests (PLTs) & Operational Handover

- Demonstrate that the systems are ready for Operational Handover at L+90 days
  - Includes spacecraft & all instruments
  - Operational Acceptance Review (OAR) at L+85
  - Begin in Door Closed Phase:
    - OMPS Trending
    - OMPS Noise Characterization
  - Begin in Door Open Phase
    - OMPS Calibration
    - OMPS Geolocation/ Pointing Accuracy
    - OMPS Dynamic Range
    - OMPS Data Rate Characterization

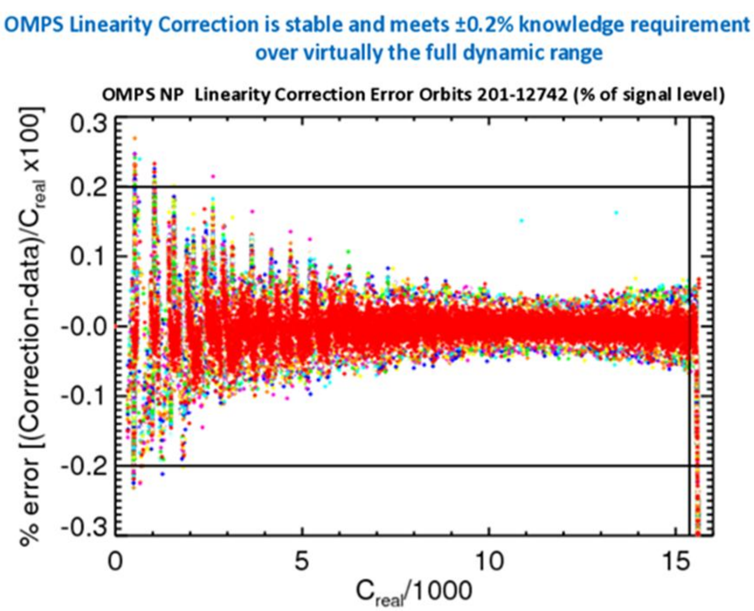
- Not an evaluation if systems meet requirements

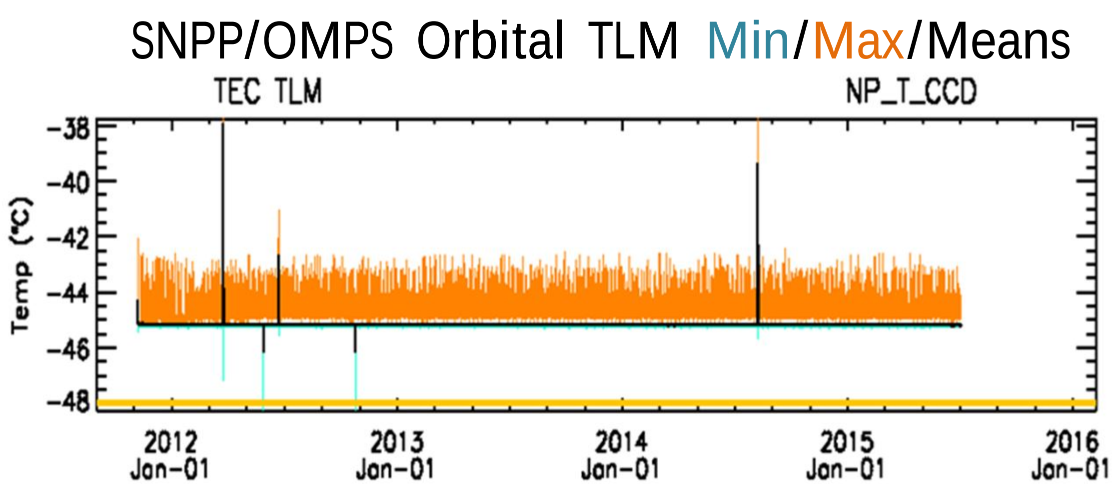
J1/OMPS Trending PLT



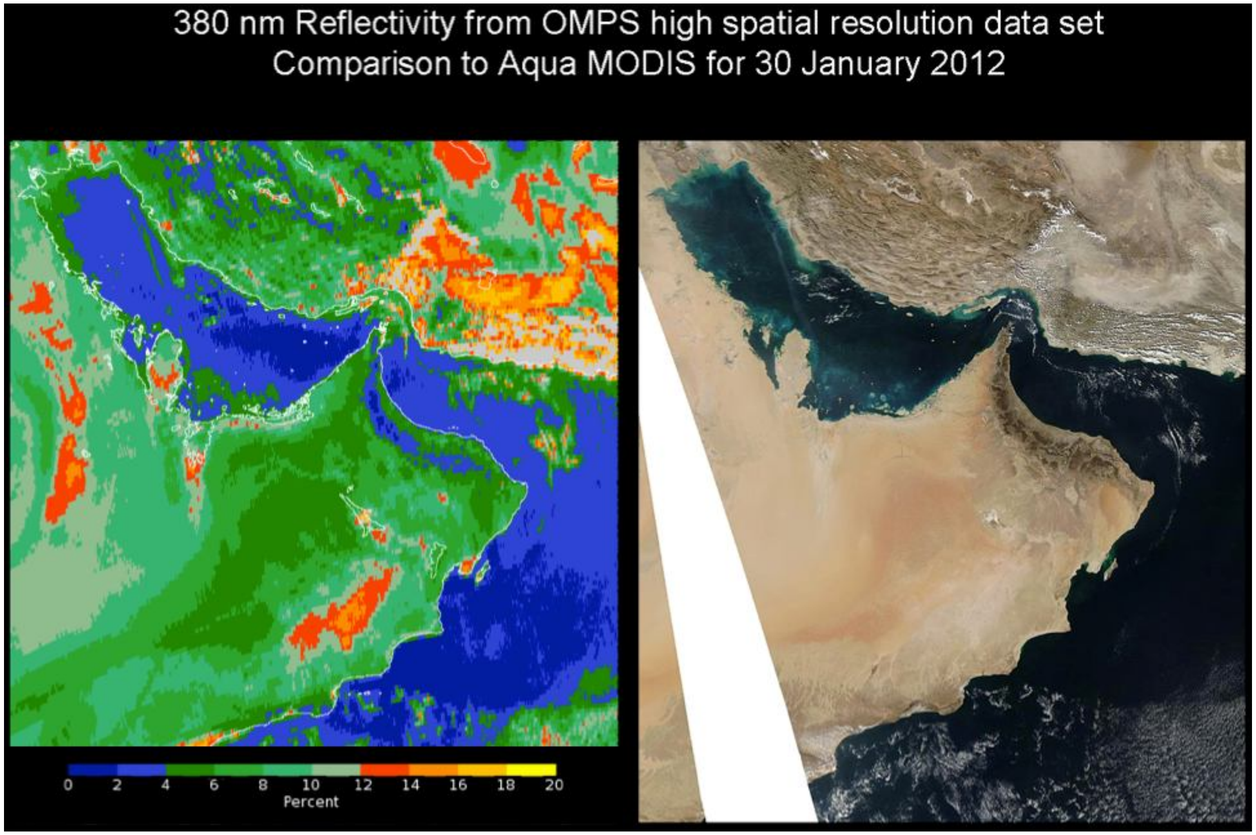
S-NPP/OMPS Examples of

- TC Dark Cal distributions,
- NP LED Linearity Cals performance, &
- instrument TLM Min/Max/Mean trending





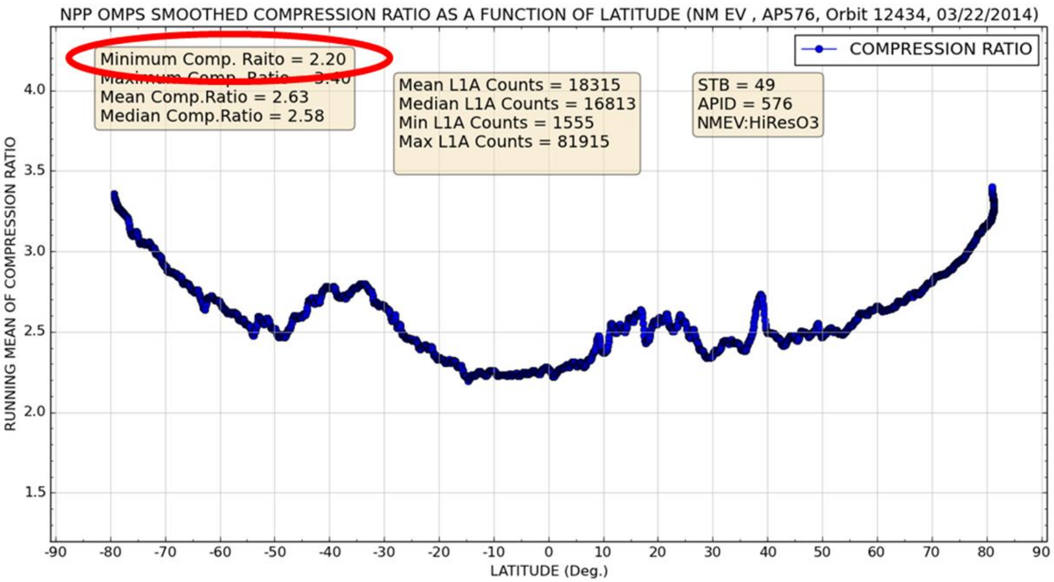
Example of J1/OMPS Geolocation



Geo-location Results of S-NPP/OMPS and MODIS images

- Figure shows S-NPP/OMPS geo-location results (left) and MODIS (right) images
- MODIS image shows clear water/land boundaries (plus some clouds, silt in the water, etc.)
- IDL s/w tools provide an outline of land edges (white)
- Agreement between expected land-edges locations and S-NPP/OMPS reflectivity is accurate to near the highest resolution (BinFactor = 1), well within the goals for this PLT.

J1/OMPS Data Rate Characterization PLT



An Example
of Data Compression
from S-NPP/OMPS
EV_HiResO3 Measurements

- Typical minimum compression found empirically ≈ 2.2X
  - EV_HiRes_O3 ST are sparse
- BATC assumed ~2X compression factor
  - Excludes BinFactor = 2 for aerosol λ's (~892 additional macro-pixels)
- Data Compression Fault halts current data stream.
  - Nightside activities will start nominally.
  - If a fault occurs, then, generally, it may be best to return to EV collection using the *baseline* NM EV ST, i.e., stop Secondary CSM and run Primary CSM.
  - Iterate to new version of *trial* NM EV ST and run on-orbit to test

J1/OMPS NomOps Summary @ L+90:
(Similar to SNPP/OMPS Overall)

Science Data : Default for All Orbits		
Orbits-of-the-Day	**Dayside**	**Dark Cals**
1 -14/15	**EV_MED_RES**	**Door Open**

Preliminary Calibration Schedule				Solar Ref Cals
Week 1	**Week 2**	**Week 3**	**Week 4**	**Semi-Annual**
Solar-Working		Solar-Working		Solar-Ref & Solar-Work
Door Closed Dark	Door Closed Dark	Door Closed Dark	Door Closed Dark	Door Closed Dark
	LED			

Potential Remaining Cal/Val Measurements:

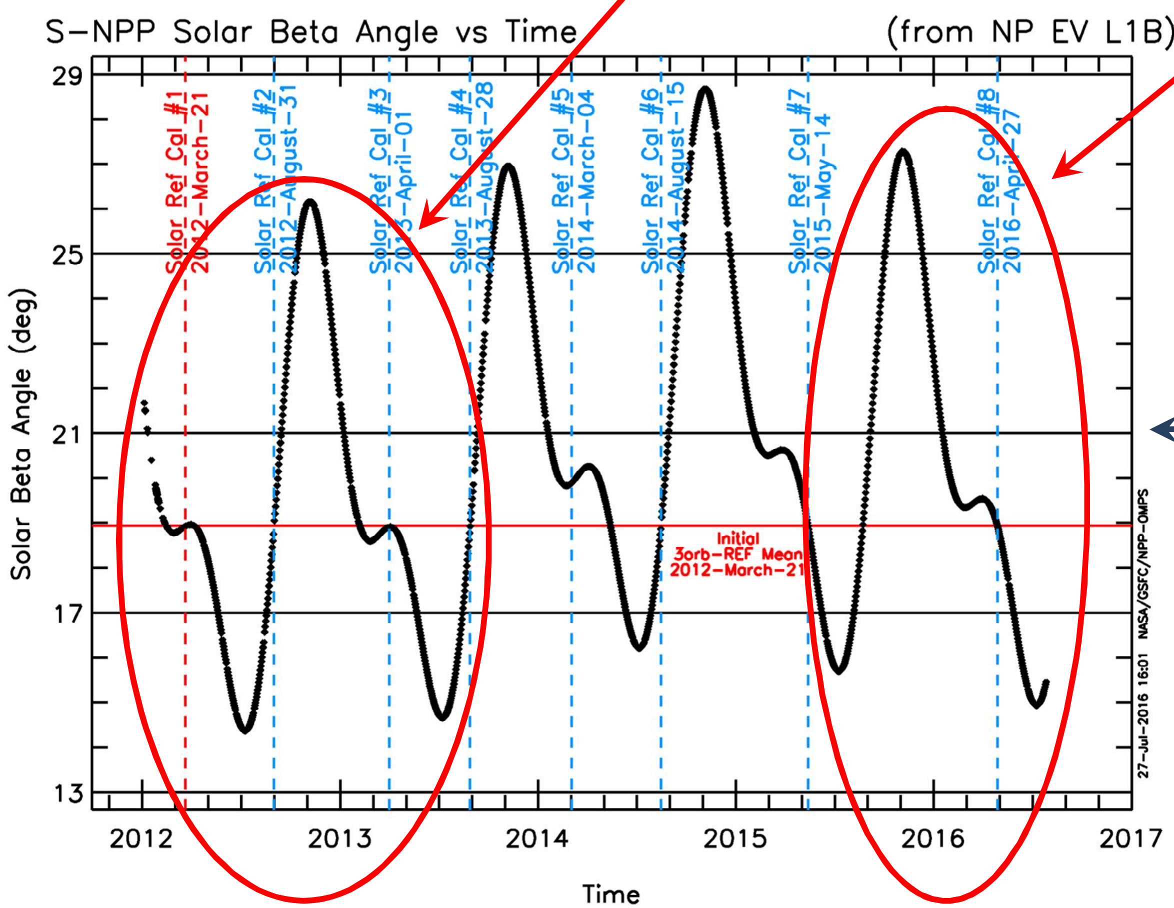
- Full-Frame EV Measurements to characterize orbital & seasonal variabilities: collected weekly/bi-weekly into 1st or 2nd year?
- EV Data Rate Optimization (seasonally dependent)
- PRNU (seasonally dependent: Solstice $\pm$~6 weeks

Backup Slides

1. Expected range of J1 Solar Beta Angle
2. PLT Summary
3. J1/OMPS Calibration PLT Example
4. J1/OMPS Dynamic Range
5. Two Examples of J1/OMPS NomOps CBM

Expected J1 Solar Beta Angle Cycle

J1 Orbit Maintenance LTAN = 13:25 ± 1 min



Expected range of J1 Solar Beta Angle most like these 2 time periods

Goniometric Reference Azimuth Angle = 21.0° for SNPP & JPSS-1

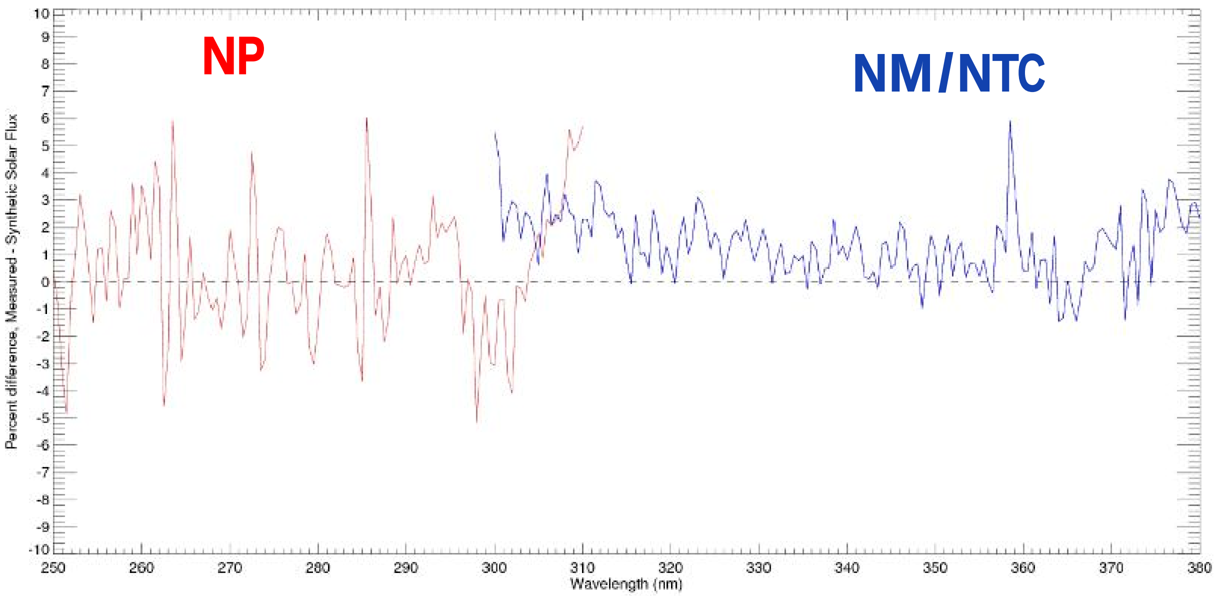
J1 Goniometric Azimuth Angle Range = [12.0, 32.0]

PLT Summary

#	PLT Name	Data	Description & Success Criteria
1	**OMPS Activation**	BATC/MOST activity	Instrument powered-on, runs functionality tests, and is approved as ready for operations
2	**OMPS Trending**	Dark & LED Cals, transient detection, TLM monitoring, etc.	1) TLM stays within its defined yellow (& red) limits, analyze data to understand why out-of-range violations occur. 2) Establish baselines & trends to characterize on-orbit behavior, including the LED and Dark Cals.
3	**OMPS Noise Characterization**	Estimate SNR from LED data	1) Measure LED signal variance in individual pixels relative to their neighbors in an attempt to estimate noise as a function of the signal level. 2) The theoretical SNR should not exceed the variance by more than 50%. Be aware of the location of the instruments relative to the SAA.
4	**OMPS Calibration**	Solar Cal & EV	1) Measured solar spectra agree with synthesized spectra to within ±5% over the full spectral range excluding 300-310 nm. Agreement at this level requires both good radiometric and wavelength calibration. The first validation will be performed with the Working Diffuser. 2) If a nearly coincident EV match-up occurs between J1 and OMI or SNPP, in both time & FOV, then can compare radiances, as has been done between SNPP & OMI.
5	**OMPS Geolocation/ Pointing Accuracy**	EV pixel radiances *match* calculated geo-locations	1) Check at various wavelengths w/BF=1: Limits & middle of image regions, VIIRS correlative λ's, etc. 2) Geographic feature mismatches should not exceed 1 ground pixel.
6	**OMPS Dynamic Range**	Max EV & Solar signals do not saturate any pixels	1) Assess EV dynamic range by observing sensor response over very bright scenes (i.e, clouds) at wavelengths of maximum signal response, & for max Solar Cal signals. 2) That at least 10% margin exists before saturation in the highest signal scenes.
7	**OMPS Data Rate Characterization**	Optimize NTC/NM EV High-Res ST	1) Test updated NM EV ST on-orbit; monitor compression margins through the ground processing. 2) Adjust NM EV ST and replace onboard table if necessary; continue iterating until ST is finalized, preserving a 10% margin & watching seasonal dependence.

J1/OMPS Calibration PLT

Comparison of Day 1 solar flux to Synthetic (KNMI) solar flux

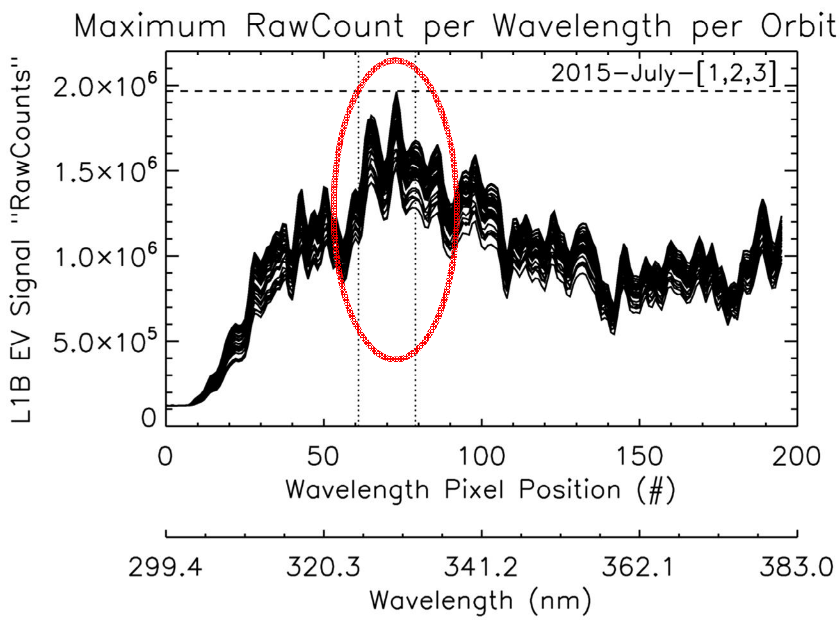


Differences of S-NPP/OMPS Day-1 Solar and Synthetic Spectra < ~6%

- Differences from both NP and NM are relatively small
  - Max differences are ~6%
  - Typical differences ~3%

J1/OMPS Dynamic Range

<u>SNPP/NM data review:</u>
Highest count levels across NM spectra: Approximate Wavelength-pixels:
65 ⇔ 326.4 nm
73 ⇔ 329.7 nm
(Due to higher instrument sensitivity and stronger radiances at those wavelengths.)



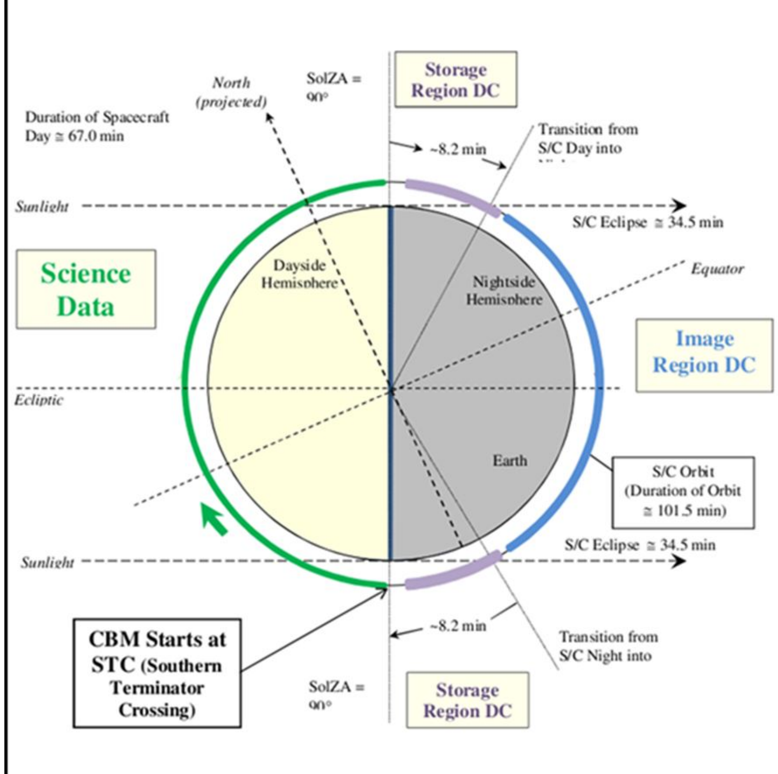
Peak signals in NM EV data, from S-NPP/OMPS

- Two signal peaks provide good sampling of max signal level
- Special NM EV ST uses 4 or 5 λ's to sample each peak, w/ BinFactor = 1.
  - Catches the brightest scenes without binning (i.e., averaging) from any adjacent pixels
- Plenty of room in Special ST for geo-location
  - Direct benefit from reduced-frame imaging and data compression
  - Still some room for Ozone too

J1/OMPS NomOps:
Science Data w/Dark & LED Cals

Figure 1. EV_HIRES

(Dayside Science Data (EV) with Nightside Door Open Dark Cals)



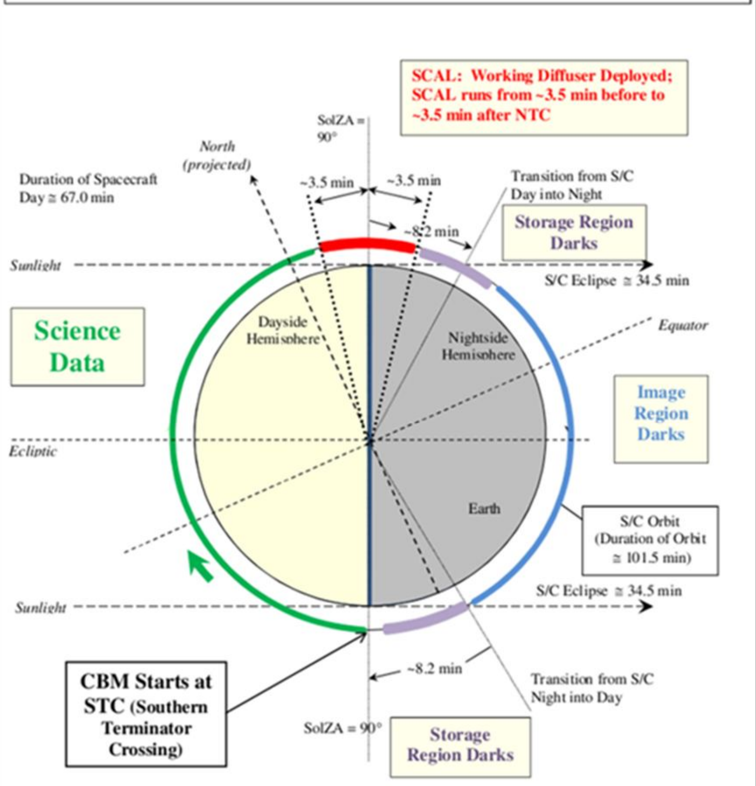
The orbit of the spacecraft around the Earth is shown, along with dayside Science Data (EV) and nightside Dark Cal (DC) activities, and with some orbital events identified. The Ascending Node of the orbit is on the dayside, so the direction of the orbit in the diagram is clockwise. The CBM begins at the STC, and collects Science Data, shown in green, on the dayside hemisphere as indicated, up to a SolZA=~88°. All Dark Cals are performed in the Nightside Hemisphere, with storage region Darks shown in violet and image region shown in blue.

- No LP on J01
- NomOps: **EV_HI_RES**
  - Default Science Data collection activity
  - Not "Extended-EV" past sub-satellite SolZA=88
    - Need to start ~75 sec prior to STC (2 EV-TPG *loops*)
    - Finish at NTC is similar
  - Open Door Dark Cals
    - Storage Region 2 sets of images in twilight
      - 5 images with IT = 30 sec
      - 5 images with IT = 10 sec
    - Image Region in S/C Night:
      - 41 images with IT = 30 sec
      - 21 images with IT = 10 sec
- Closed Door Cals:
  - Same dayside EV coverage **EV_CLOSED_DARK** is Closed Door version of above
  - **EV_CLOSED_LED:** Replace Dark w/LED Cals

J1/OMPS NomOps: Science Data w/Solar Cals

Figure 4. EV_WRK_SCAL

(Dayside Science Data (EV) with Solar Cals near NTC, & Nightside Dark Cals)



The orbit of the spacecraft around the Earth is shown, along with dayside Science Data (EV), Solar Calibration (SCAL) and DC Cal activities. The CBM begins at the STC, and collects Science Data, shown in green, on the dayside hemisphere, until approximately 4 min prior to the Northern Terminator Crossing (NTC). The Solar Working Diffuser is deployed, and SCAL data are collected, as shown in red. Then nightside Dark Cals are performed, with storage region Darks shown in violet and the image region shown in blue; if the door was closed, it is re-opened after the Darks have been completed, prior to the next STC.

No LP instrument on JPSS-1/OMPS NomOps:

- **3orb_EV_WRK_SCAL** or
- **EV_WRK_SCAL**
- New QVD Diffuser
  - Decreased diffuser features vs SNPP/OMPS
  - Evaluate on-orbit
- Differences are
  - EV_WRK_SCAL runs in single orbit
    - 3 Solar Measurements per 7 NM/TC Diffuser Positions
    - 9 per NP DiffPos
    - Closed Door Dark Cals
  - 3orb uses 3-orbits
    - 16 or 17 measurements per NM/TC DiffPos
    - Except 23 for TC4 and 16 for NP
    - Closed & Open Door Dark Cals
  - Similar image & Storage Dark Cals
  - Solar Cals take a bite out of EV near NTC