OMPS SDR OVERVIEW

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OMPS SDR Team

Outline

- Cal/Val Team Members
- Sensor Overview
- S-NPP SDR Product Overview
  - SDR Performance Summary
  - Reprocessing Status and Block 2.0 system
  - Long Term Monitoring
  - Users feedback
- JPSS-1 Readiness
  - Significant Algorithm changes from S-NPP to JPSS-1
  - Pre-launch Characterization- Results/Accomplishments
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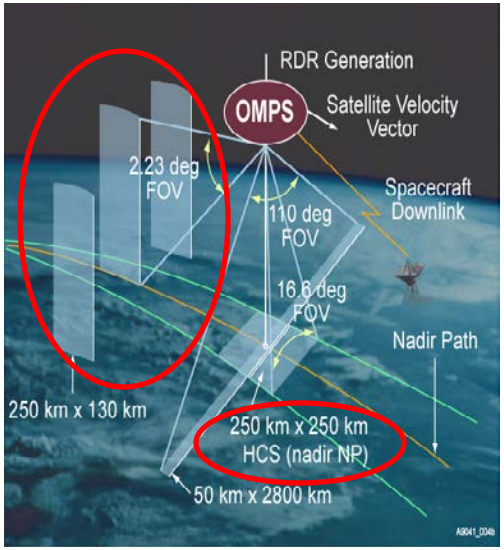
  - Schedules and Milestones
  - Accomplishments and Highlights Moving Towards J1
  - Major Risks/Issues/Challenges/and Mitigation
  - Collaboration with Stake Holders/User Agencies
- Summary and Path Forward

Cal/Val Team Members

PI	Organization	Team Members	Roles and Responsibilities
Fuzhong Weng	NOAA/STAR	C. Pan, T. Beck, Eve-Marie, eve-marie Devaliere, Sri Madhavan, Shouguo Ding, D. Liang	Budget and coordination; instrument and product performance monitoring; TOMRAD/VLIDORT modeling
Glen Jaross	NASA	Tom Kelly, Rama. Mundakkara, Mike Haken, Collin Seftor	Instrument scientist; TVAC data acquisition and analysis; SDR algorithm.
Laura Dunlap	STC/AMP		Algorithm changes coordination; DR and issues tracking
Sarah Lipscy	BATC		Instrument scientist; prelaunch test
Wael Ibrahim	Raytheon	Derek Stuhmer, Daniel Cumpton	IDPS operations

OMPS Instrument Overview

- **Enhanced spatial resolution with new timing patterns**
  - Provides Total Column ozone data w/ 50x50 km^2 IFOV at nadir
  - Provides ozone profiles in 5 ground pixels of 50x50^2 km at nadir
- **Configuration**
  - Push-broom 110 deg. cross-track FOV telescope
  - Two grating spectrometers
    - » NM covers 300 – 380, 420 nm
    - » NP covers 250 nm to 310 nm
  - CCD optical detector for each spectrometer
- **Onboard Calibrators**
  - Light-emitting diode provides linearity calibration
  - Reflective quasi-volume diffusers (QVD) maintains calibration stability
- **Products**
  - Provide globe maps every 24 hours of amount of ozone and volumetric concentration in a vertical column of atmosphere with a 4- days revisit



Spatial resolution will be altered to provide low, medium and high spatial resolution data

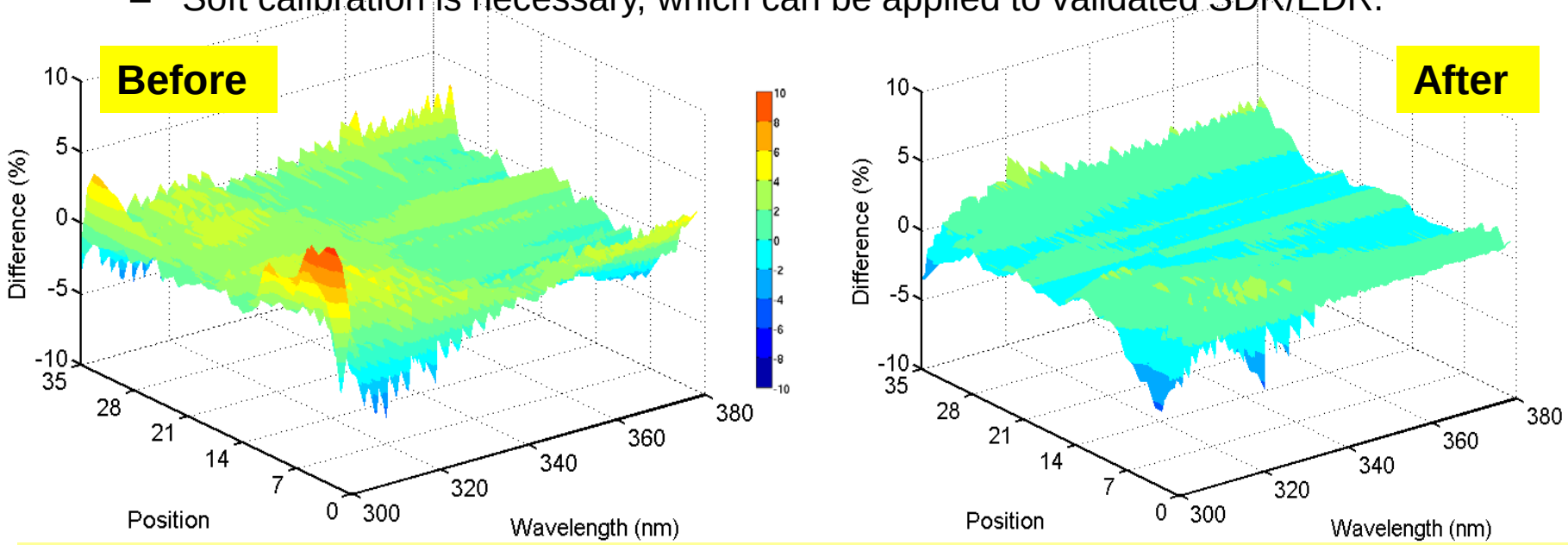
- The LP will not be present for J-1
- NM slit redesigned to reduce "puckering"
- Optical mounts redesigned to improve boresight stability
- Modified optical alignment permits wavelengths up to ~420nm -- potentially enhances science products and help to correct nadir geolocation and stray light OOB.
- Generation of three SDR products: EV SDRs, Cal. SDRs (offline), and GEOs

SNPP SDR Product Overview

- OMPS EV SDR Maturity
  - ✓ Beta since March 2012; Provisional since March 2013 and Validated since September 2015
- OMPS EV SDRs meet SDR performance requirement as well as EDR products requirement
  - ✓ The cross-track direction radiance error is minimized < 2.0
  - ✓ The NM and NP consistency in 300-310 nm has been improved by 2-10%
  - ✓ Sensor orbital performance is stable and meet expectation in general
  - ✓ Geo-location accuracy error < 5.0 km
- OMPS EV SDRs have following features
  - ✓ On-orbit sensor performance is characterized
  - ✓ SDR product uncertainties are defined for representative conditions
  - ✓ Calibration parameters are adjusted according to EDR requirement
  - ✓ High quality documentation is completed
  - ✓ SDR data is well defined for applications and scientific publication

Justification for OMPS EV SDR Quality

- Requirements (Performance Since Validation)
  - Instrument: **meeting specifications with adequate margins.**
  - SDR: **stable (quality and quantity)** and free of major errors.
- SDR software
  - IDPS has been producing satisfactory products.
  - Incremental improvements are planned and will continue.
- Applications:
  - **Information contents are sufficient to make positive impacts**.
  - Soft calibration is necessary, which can be applied to validated SDR/EDR.



Evaluated by comparison w/ MLS on the SDR level and NOAA 19 SBUV/2 on EDR level

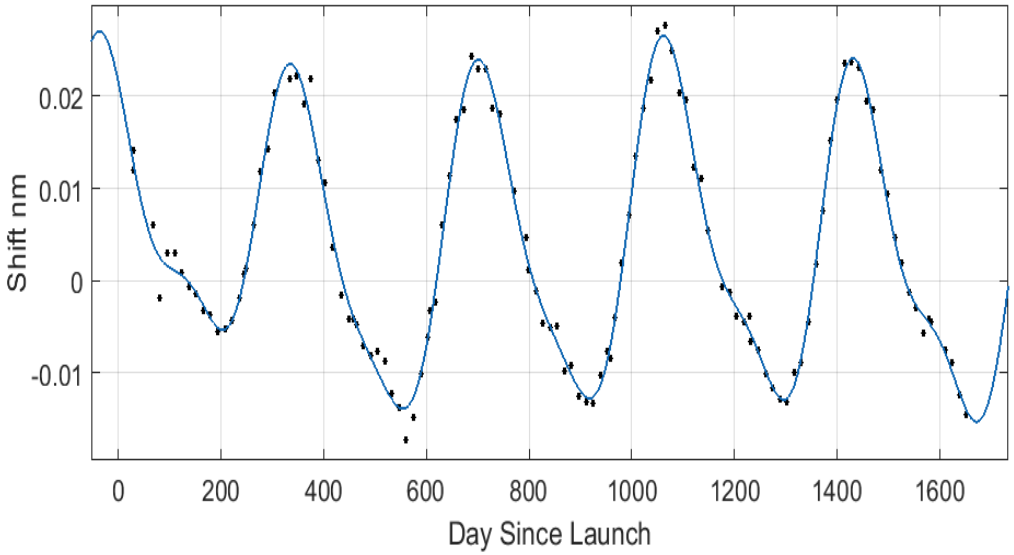
SNPP NM Performance Summary

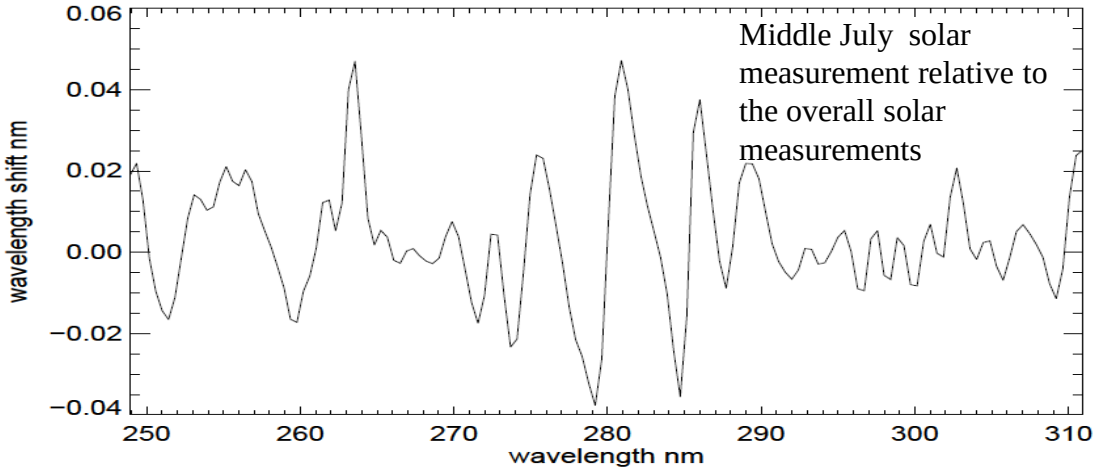
SDR Budget Term	Requirement/Allocation	On-Orbit Performance
Non-linearity Accuracy	< 0.2%	< 0.2%
Stray Light NM Out-of-Band + Out-of-Field Response	≤ 2	≤ 2%
SNR	1000	> 1000
Orbital thermal Wavelength Shift	Allocation (flow down from EDR error budget) = 0.02 nm	~0.006 nm
Absolute Irradiance Calibration Accuracy	< 7%	< 7% for most of the channels
Absolute Radiance Calibration Accuracy	< 8%	< 8%
Albedo Calibration Accuracy	< 2%	< 2% for most of the channels

SNPP NP Performance Summary

SDR Budget Term	Requirement/Allocation	On-Orbit Performance
Non-linearity Accuracy	< 0.2%	< 0.2%
Stray Light NP Out-of-Band + Out-of-Field Response	≤ 2%	≤ 2% for most of the channels
SNR	45-400 channel dependent	meet requirement
Orbital Thermal Wavelength Shift	Allocation (flow down from EDR error budget) = 0.02 nm	~0.03 nm
Absolute Irradiance Calibration Accuracy	< 7%	< 7% for most of the channels
Absolute Radiance Calibration Accuracy	< 8%	< 8%
Albedo Calibration Accuracy	< 2%	< 2%

Correction of NP Wavelength Shift





- User feedback

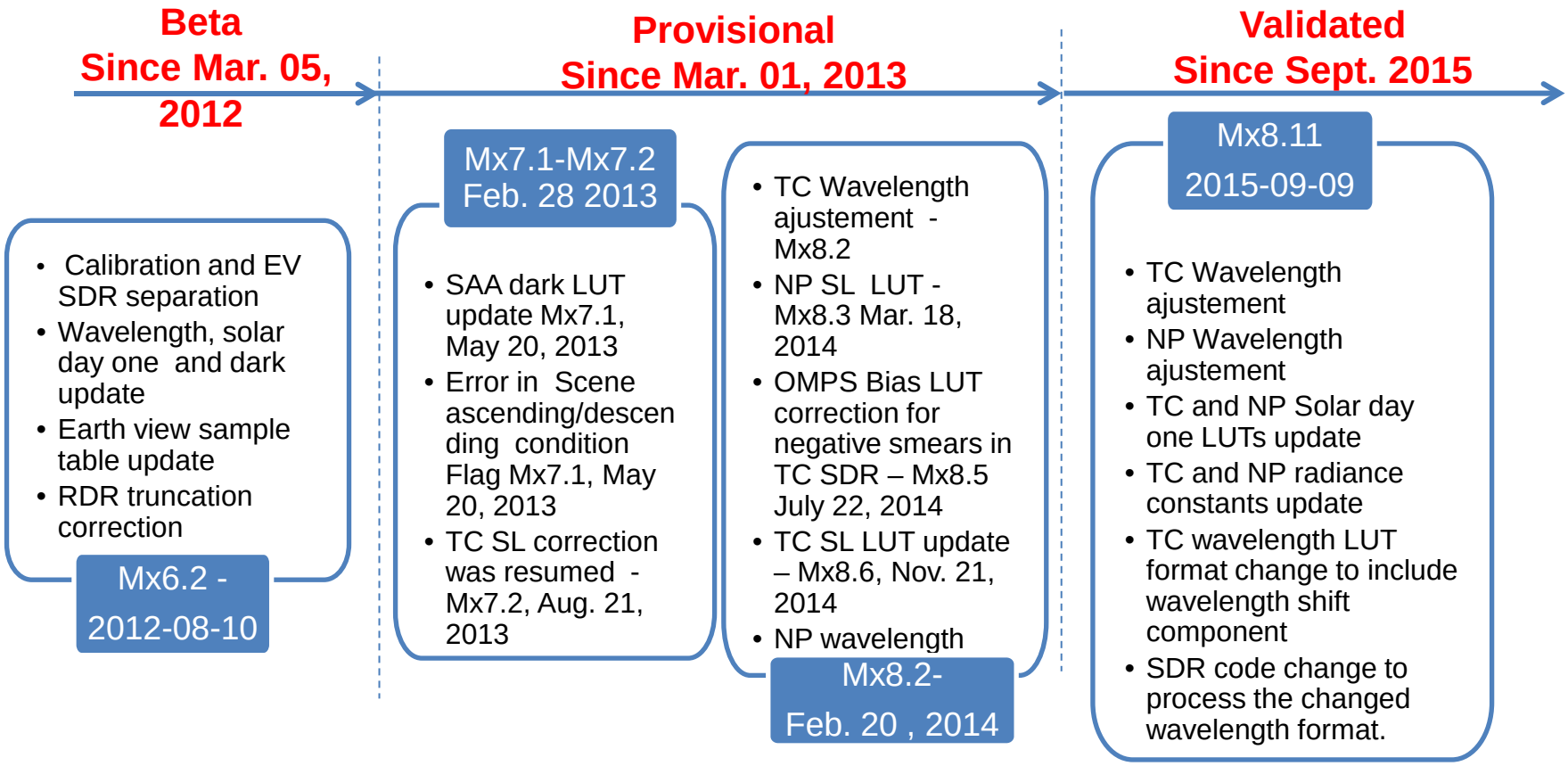
f(x) =
a1*sin(b1*x+c1) +
a2*sin(b2*x+c2) +
a3*sin(b3*x+c3) +
a4*sin(b4*x+c4)

Linear model: f(x) = p1*x + p2
Coefficients (@ 95% confidence bounds):
p1 = 32.68 and p2 = 0.006929

Goodness of fit: SSE: 1.32
R-square: 0.8
RMSE: 0.1549

The requirement of 0.02nm shift was waived at the instrument level. The correction will be made on SDR level to meet EDR requirements.

Why Reprocessing OMPS SDR



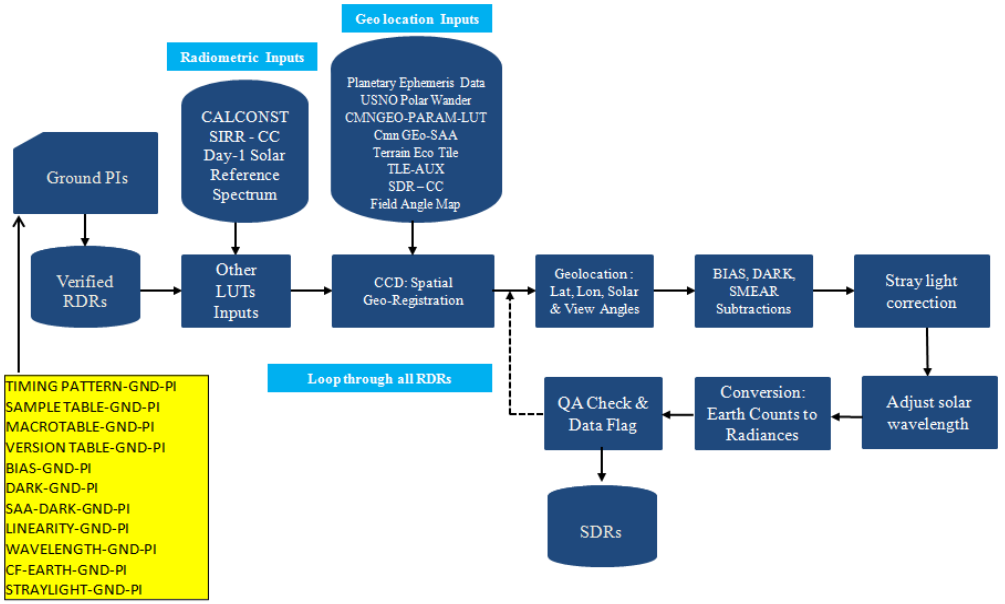
- SDR quality chronologically improved since launch via measurement sequence, algorithm, LUTs, ground operational codes
- Produce consistent SDRs at the attainable quality level.
- Apply consistent weekly routine dark corrections to all of the data records.
- Use up-to-dated calibration LUTs and algorithm in OMPS SDR life-cycle with upgraded IDPS system B2.0

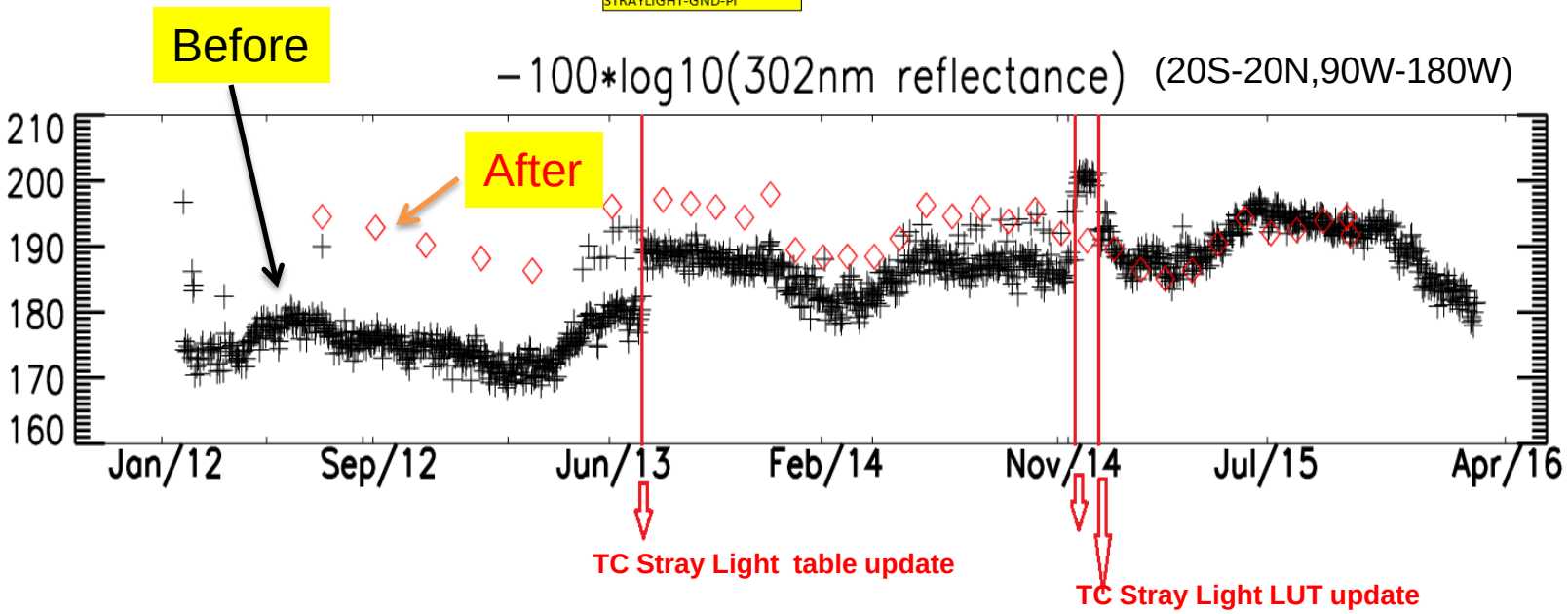
Preliminary Results from Reprocessing

Schematic showing Earth View SDR generation process

Use ADL5.3 tool package

Preliminary reprocessing results of daily average N-value over the Tropical Pacific region from SNPP NP 302 nm channel



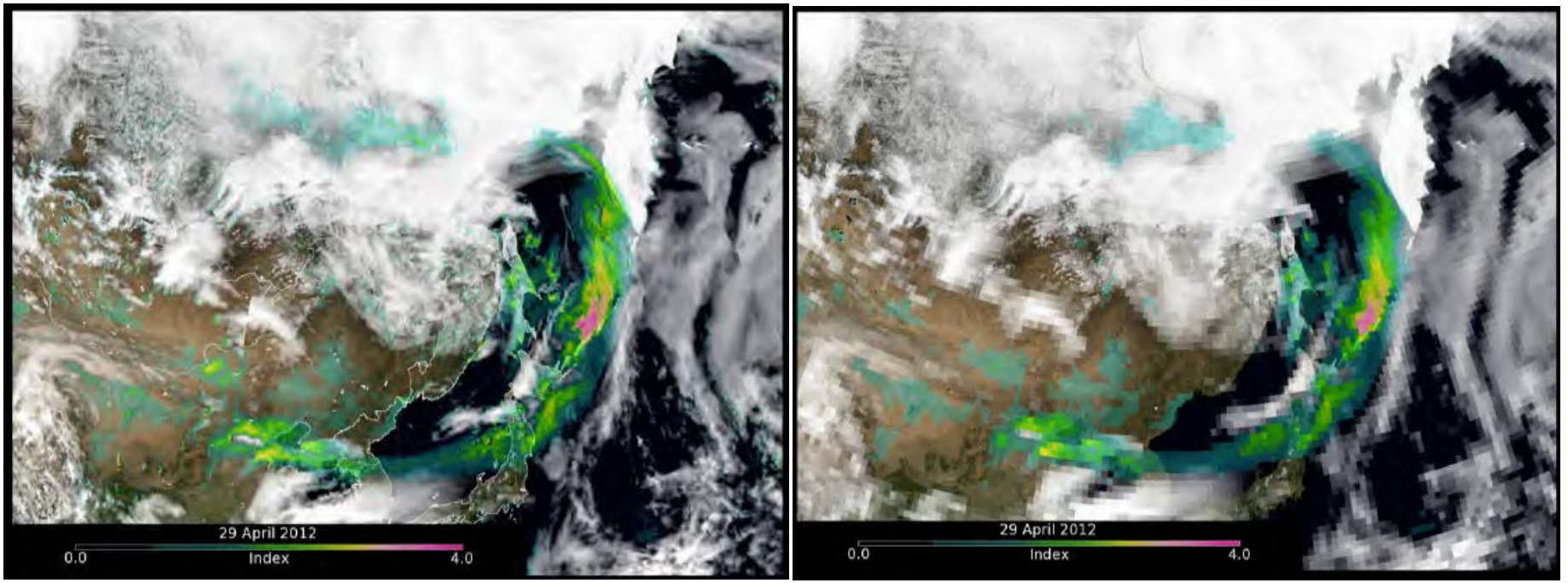


Expected Results from Reprocessing

- No long term time-dependent change relative to NOAA-19 SBUV/2.
  - OMPS NM bias of near zero and NP bias of about 0.5% (V8 algorithm).
- Produce consistent SDRs that meet the users' satisfaction. The SDRs will have
  - Minimized cross-track IFOV radiometric error < 2%.
  - Consistent data records between NP and NM in 300-310 nm.
  - Stray light correction is adequate.
  - Less than 5.0 km geometric uncertainty at nadir using MODIS as reference
  - All channels meet SNR requirement
  - For the most channels the wavelength independent albedo uncertainty is < 2% using MLS as a reference.

Higher Spatial Resolution Data

- User feedback

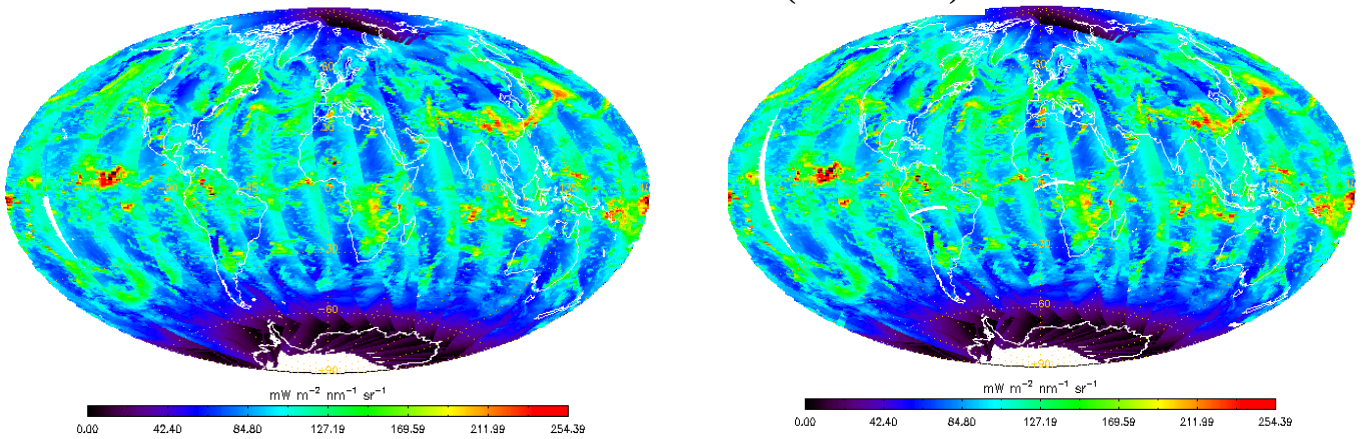


- Aerosol Studies from Colin Seftor/SSAI: On 29 April 2012, OMPS aerosol index data (10 km x10 km data left) captured a dust cloud from China's Taklamaken Desert. Color bar is optical depth. Right is the same scene with the OMPS data degraded to 50 km x 50 km resolution.
- High resolution data collection requires FSW 6.0
- B2.0 SDR algorithm is capable to process 17 km x 17 km resolution data

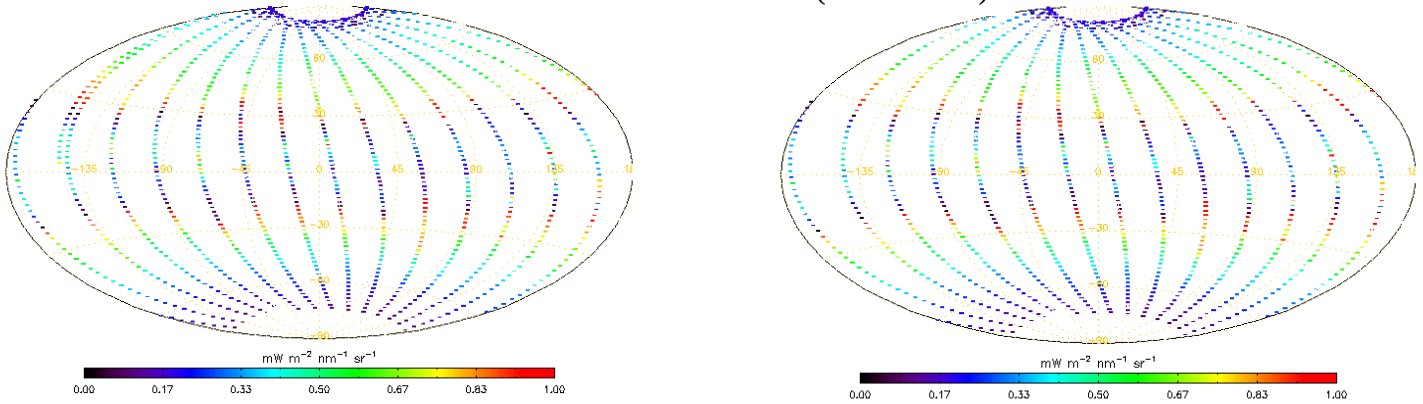
SNPP B2.0 System Verification

- Delivered B2.0 algorithm tables and LUTs
- Verified SDR science data and geo-location data

TC data with B1.2 vs. B2.0 (331.434 nm)



NP data with B1.2 vs. B2.0 (301.078 nm)



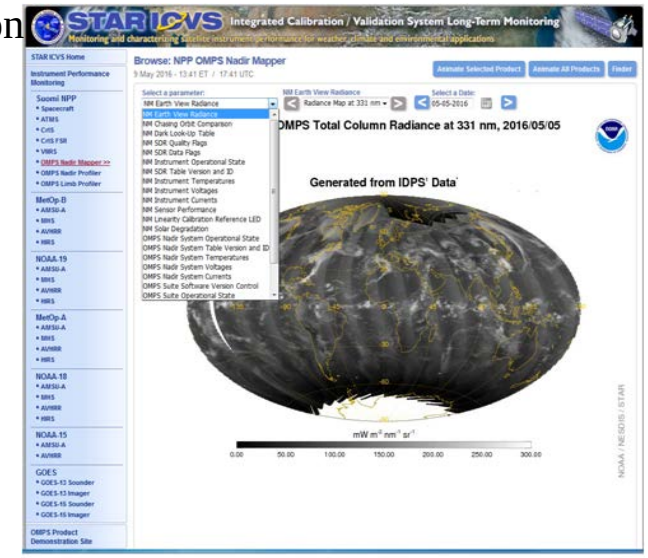
From Eve-Marie

STAR ICVS OMPS Monitoring

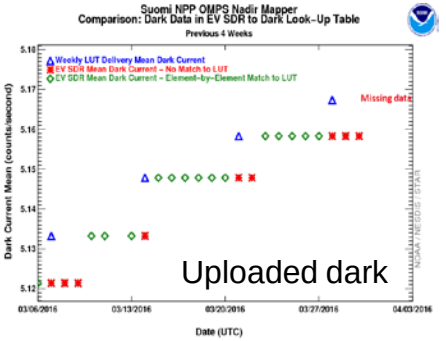
NM: http://www.star.nesdis.noaa.gov/icvs/status_NPP_OMPS_NM.php
NP: http://www.star.nesdis.noaa.gov/icvs/status_NPP_OMPS_NP.php
LP: http://www.star.nesdis.noaa.gov/icvs/status_NPP_OMPS_LP.php

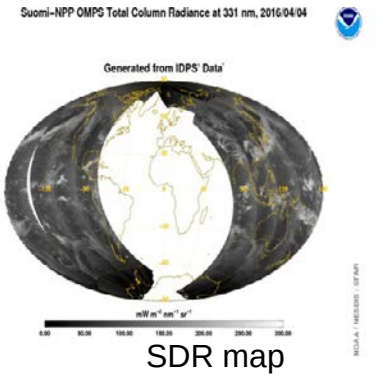
Provides much of the information to characterize the OMPS in the cal/val studies.

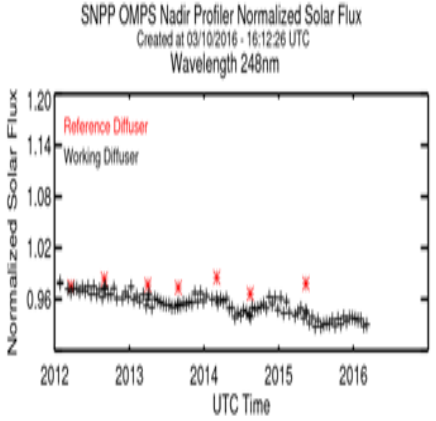
- Instrument Health and Safety
- Sensor Performance
- SDR Product Monitoring
- Data Quality Assessments
- Anomaly Detection and Notification

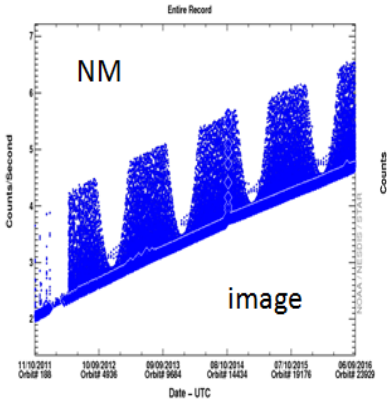


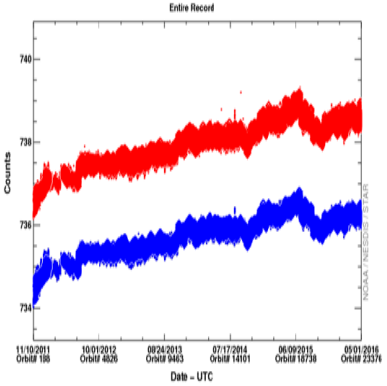
Anomalies

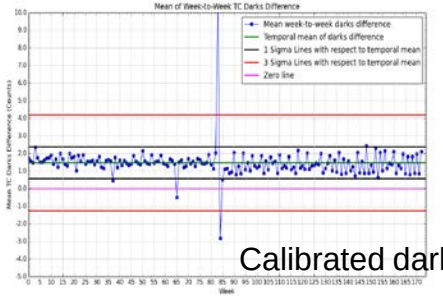












J1 Calibration and Characterization

Prelaunch lab test shows that J1 OMPS calibration stability and accuracy meets science requirements

Source of Uncertainty	Absolute 1σ Fractional Uncertainty (%)				Albedo 1σ Fractional Uncertainty (%)			
	Radiance		Irradiance		λ - independent		λ - dependent	
	NP	TC	NP	TC	NP	TC	NP	TC
SNPP Goniometry	0	0	0.38	0.41	0.38	0.41	0.15	0.36
J1 Goniometry	0	0	0.21	0.21	0.21	0.21	0.1	0.11
OMPS NPP RSS Total	3.383	3.067	3.499	3.194	1.653	1.717	0.426	0.497
OMPS J1 RSS Total	2.637	1.646	2.731	1.8	1.587	1.389	0.405	0.437
Requirement	8.0	8.0	7.0	7.0	2.0	2.0	0.5	0.5

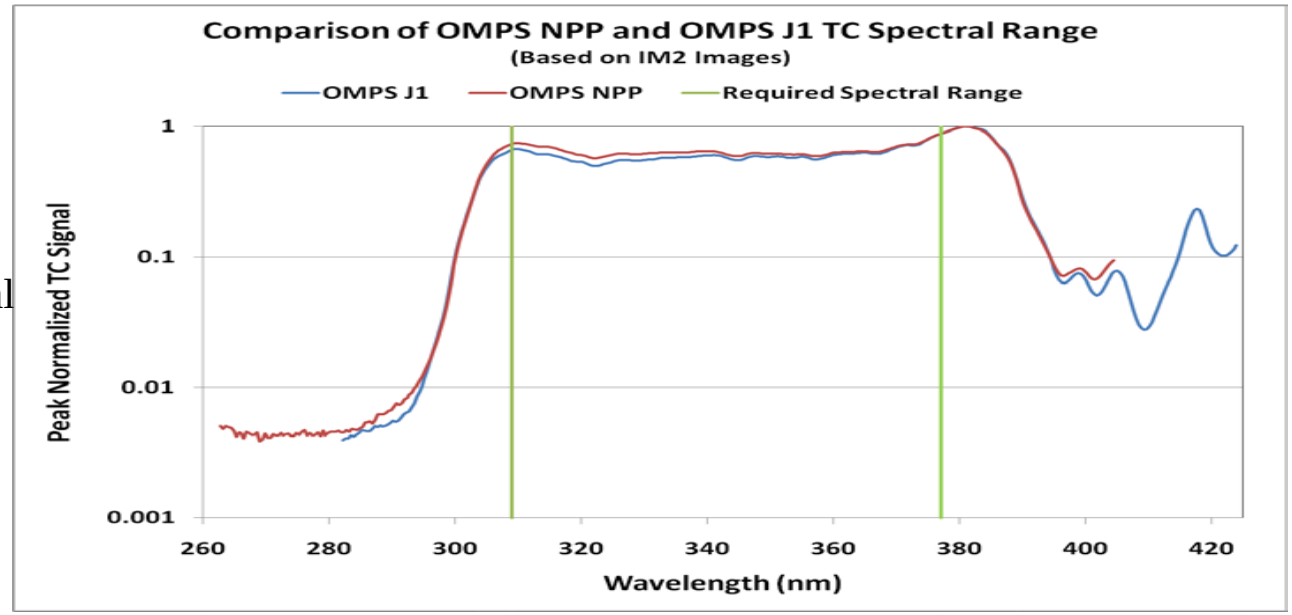
- QVD implementation yields improvements in the albedo uncertainty budget.
- Extended wavelength coverage potentially enhances science return and no significant stray light effects.

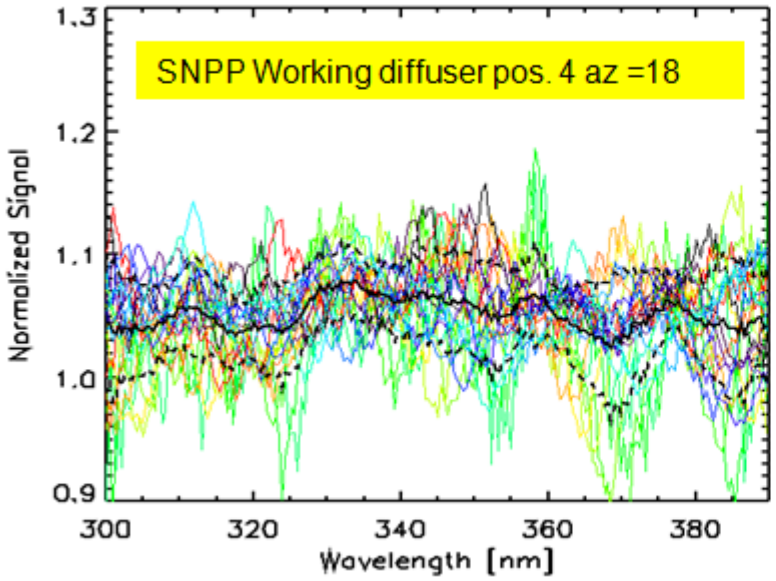
Example of Prelaunch Data Analysis

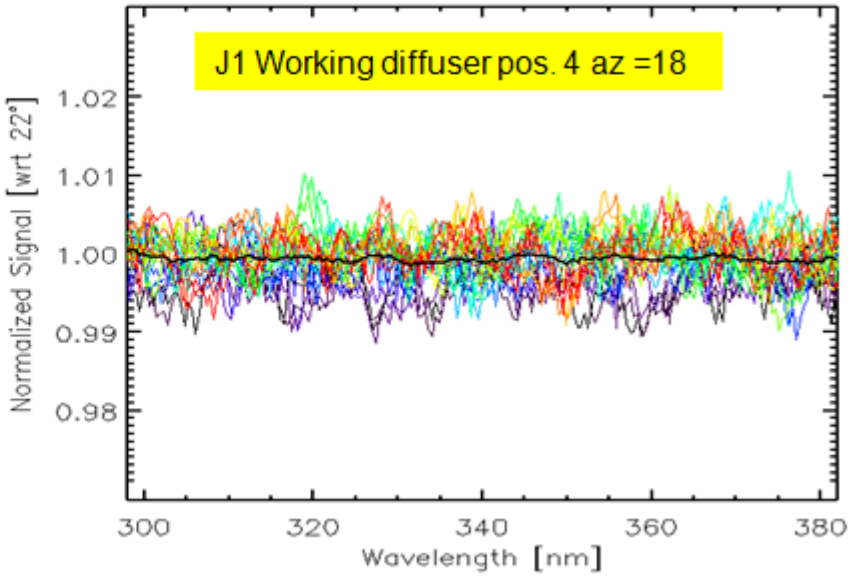
TC: 305-380, 420nm

Diffuser features significantly reduced in J1 QVD.

- Colored lines are individual rows.
- Solid black is the macro-pixel average.

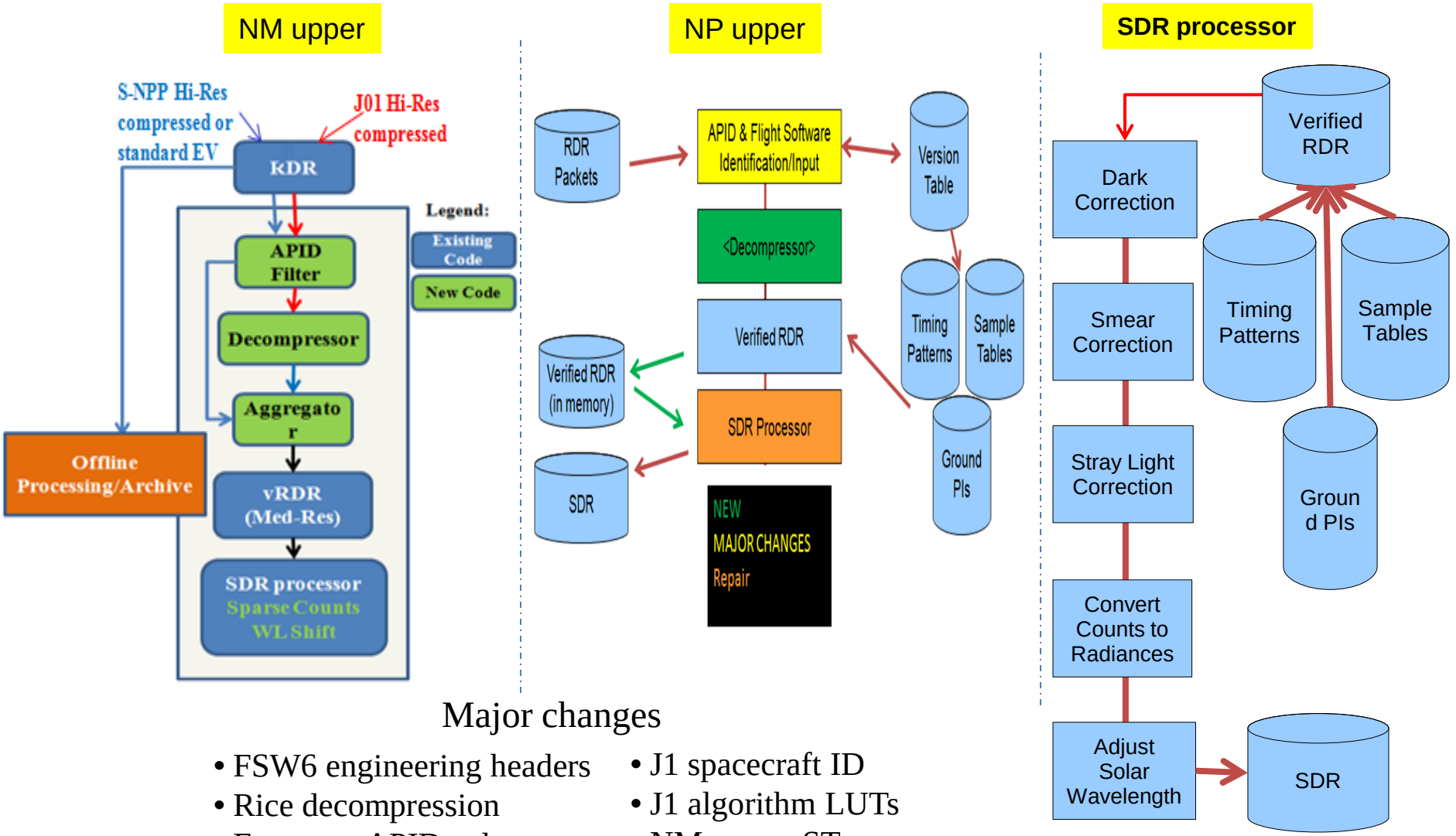






From Matthew Kowalewski /USRA GESTAR

Enhanced J1 SDR Algorithm

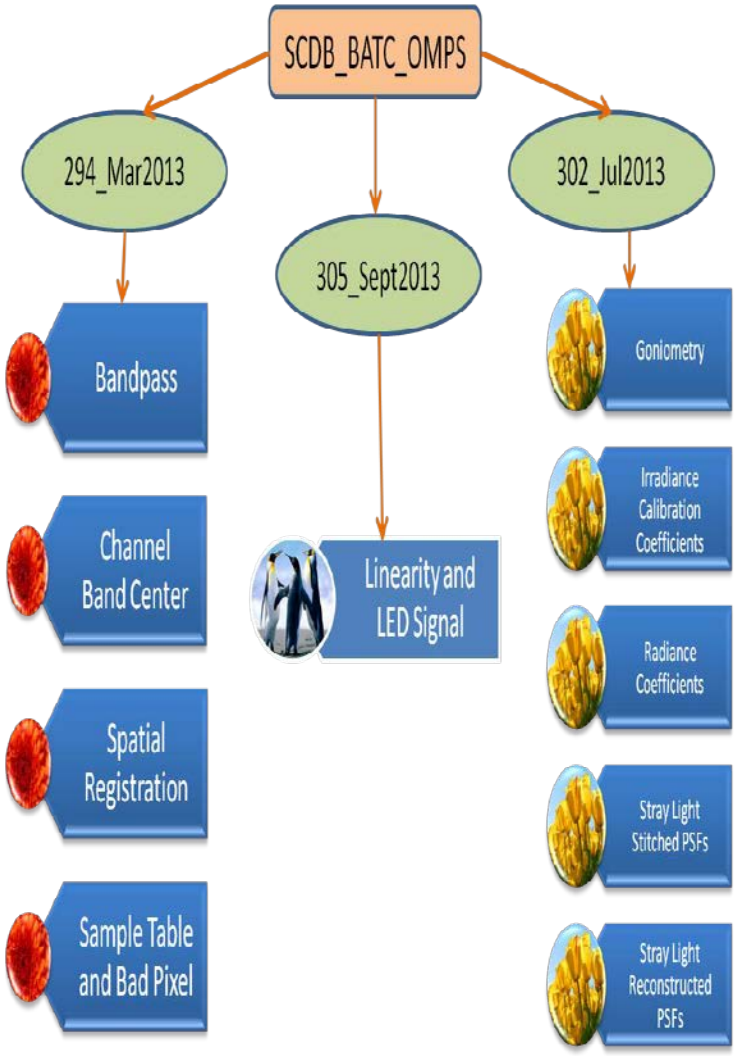


Major changes

- FSW6 engineering headers
- Rice decompression
- Four new APID values
- J1 spacecraft ID
- J1 algorithm LUTs
- NM sparse ST process

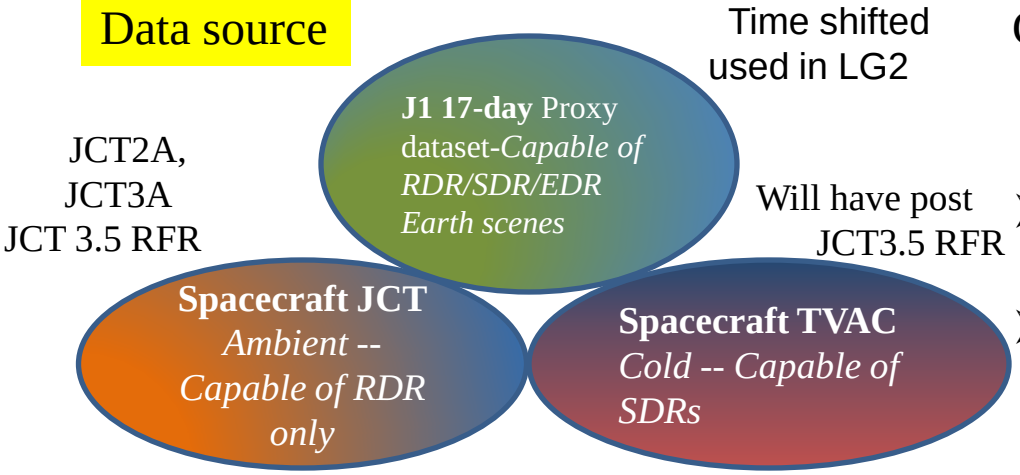
SDR Algorithm Lookup Tables

- OMPS algorithm lookup tables (LUTs) were analyzed and generated from the SCDB which are then read and processed, as necessary
- SDR algorithm LUTs
  - Measurement: Earth View Sample Table, Macrotable, Timing Pattern
  - Spectrometric LUTs: Spectral Response, Spectral Registration, Wavelengths
  - Radiometric LUTS: Calibration Coefficients, CF-Earth, Darks, Linearity, Stray Light, Solar Irradiance, Observed Solar, Predicted Solar
  - Geolocation LUT: Mounting Matrix and Field Angle Map
  - Table version LUT map OMPS NM and NP measurement tables to SDR algorithm LUT



OMPS J1 Algorithm Evaluation

Data source



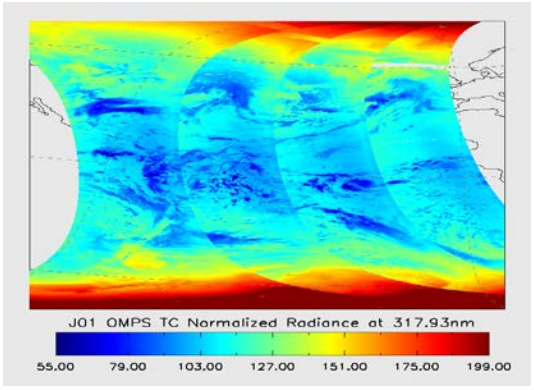
Cal/val. test data have been used to test and evaluate block 2.0 J1 algorithm and algorithm tables/LUTs:

- JCT2.0, JCT3 and JCT3.5; OMPS43A/B
- OMPS closeouts for TVAC – a duration of 50 days
  - All OMPS flight APIDs are expected to be used during TVAC DITL executions
  - OMPS will monitor housekeeping data

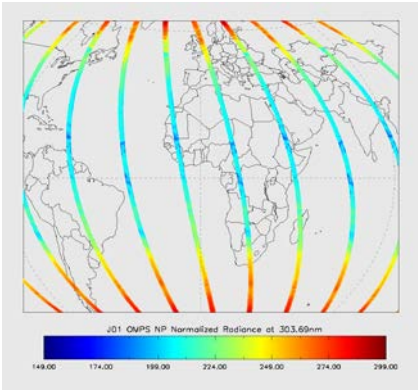
Fix anomalies

- IDPS & LG2 Comparison verified ADL5.3 build: resumed stray-light correction in J1 algorithm, added missing pad back
- OMPS 43 test data analysis found core dump associated with the compressor.
  - PCR057204: LAY-A-341-R. Closed
- Sample tables, timing pattern and other LUTs were modified to generate

Result Example



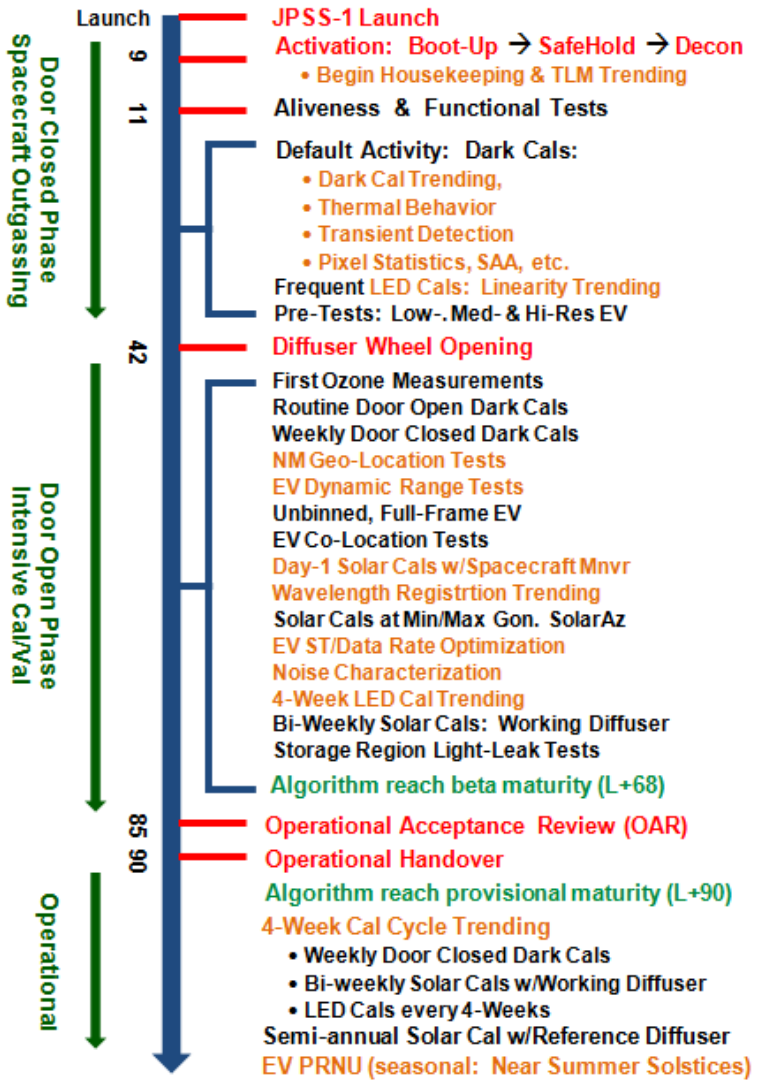
OMPS43A, 103 x 15 TC SDR Radiance



OMPS43A Proxy, NP-SDR 5x5 Radiance

From Trevor

J1 Post-launch Cal/Val Plan



Operational milestones Post-Launch Test (PLT)
Most critical activities SDR maturity

- SDR Maturity Timeline
  - "Beta" L+ 68D
  - "Provisional" around L+ 90D.
  - "Validated/calibrated" around L+9M
- Pre-Launch Calibration/Validation Plans

Year, Phase	Tasks/Activities	Deliverables
2017, PLT to ICV	• Execute the Cal/Val tasks described in the Calval. Plan • Baseline instrument • Adjust instrument settings • Modify measurement sequences when needed • Update appropriate SDR LUTs	Provisional
2018, ICV to LTM	• Improve the calibration; establish LTM • Validate the SDR products • Provide stable and accurate SDR to users.	Validated

OMPS SDR Users/Stake Holders

- OMPS SDR users/stake holders
  - CPC Climate Prediction Center
  - NCEP National Centers for Environmental Prediction
  - NRL Naval Research Laboratory
  - USGS United States Geological Survey
  - EPA Environmental Protection Agency
  - NOAA ARL Air Resources Laboratory
  - NOAA VAAC Volcanic Ash Advisory Center
  - STAR Center for Satellite Applications and Research
  - CLASS Comprehensive Large Array-data Stewardship System

Major Risks/Challenges/and Mitigation

- OMPS SNPP Nadir EV SDR products are table, meet the product requirement.
  - Our current strategy is to stabilize and monitor SDR quality conditions at the already established product maturity that represent sensor attainable levels.
  - Utilize ADL and GADA for testing of calibration tables and data anomaly analysis
  - Deploy already established forward model for cross-sensor calibration
- OMPS J1 plans and tasks are well defined and on schedule. Risk is low for performance.
  - Prelaunch calibration analysis shows OMPS J1 meets system requirement
  - J1 algorithm LUTs and tables were refined and verified through integrated tests from RDR, SDR to EDR.
  - J1 algorithm via IDPS B2.0 are tested, evaluated and reviewed by OMPS science team through a series of JCT tests. Core dump issue was fixed
  - The J1 OMPS products will be used by the users the same way as they use SNPP data. Users won't be negatively impacted with the J1 data that is of comparable quality as SNPP SDR and EDR products.
- The SDR and EDR team have significant interaction and cooperative planning and development at these algorithms move forward.

Summary

- OMPS J1cal/val Tasks and plans are well defined and on schedule. Risk is low.
  - Successfully completed J1 SDR algorithm readiness review
  - Delivered J1 launch ready Tables and LUTs in March (initial) and July (final)
  - Performed ground system test to check J1 algorithm chain of RDR-SDR-EDR
    - SNPP proxy datasets and Brass broad J1 data were used to test full range of spatial and spectral domain of J1 sensor beyond NPP sensor capabilities
    - Fixed anomalies in J1 RDR codes and in SDR algorithm: stray light correction, compressed data process and core dump issue
- SNPP SDRs are stable and produce quality data reflects sensor attainable level that meet users' requirement
  - Reprocessing generates prospective quality SDR that meets users' needs
  - Verified Block 2.0 IDPS
  - There will be refinements in SNPP thermal spectral sensitivity
  - Cal. Dark calibration package were delivered, transition is in progress
- Outreach to Community: AMS, SPIE and IGARSS.

Path Forward

FY17 Milestones

- J1 SDR Beta and provisional status
- Alternate Algorithms and Future Improvements
  - Correction of SNPP NP wavelength thermal sensitivity
  - Generate SNPP high spatial resolution data

J2 and Beyond

- OMPS Limb Profiler SDR algorithm preparation
  - Gridded measurements of atmospheric limb Earth-view measurements for three Nadir orbital track.
  - Spectral coverage from 290 to 1000 nm at 1-KM tangent height spacing.