Characterization of SNPP OMPS Cross-Track Uncertainty

C. Pan, F. Weng, T. Beck, S. Ding and A. Tolea

NOAA/NESDIS/STAR

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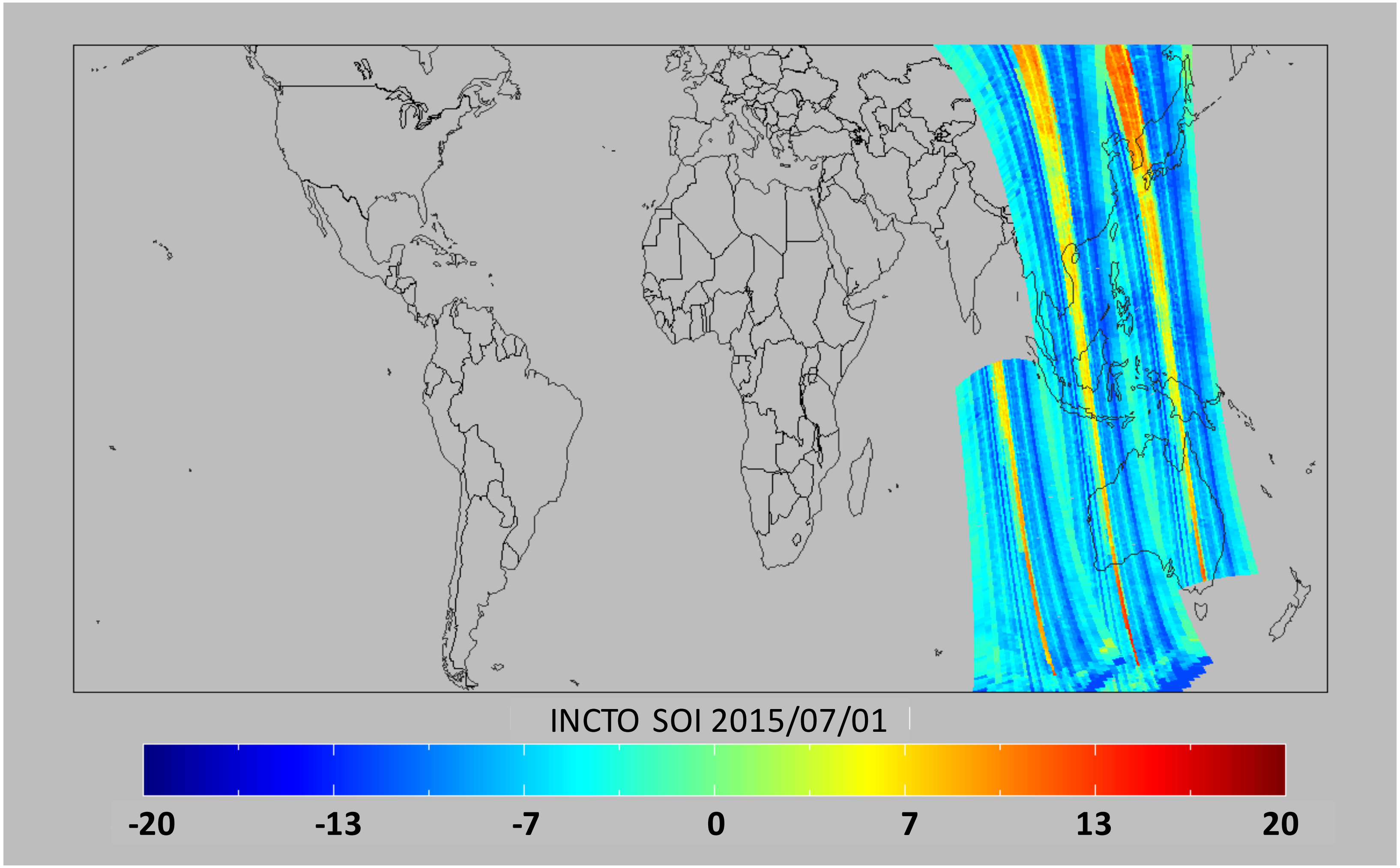
Outline

- Observed OMPS NM Cross-track Errors
- Methodology for Reducing the Cross-track Dependent Errors
- Characterization of OMPS Cross-track Error Using TOMRAD
- Impacts of Improved OMPS SDR on EDR
- Path Forward for SNPP Further Improvement

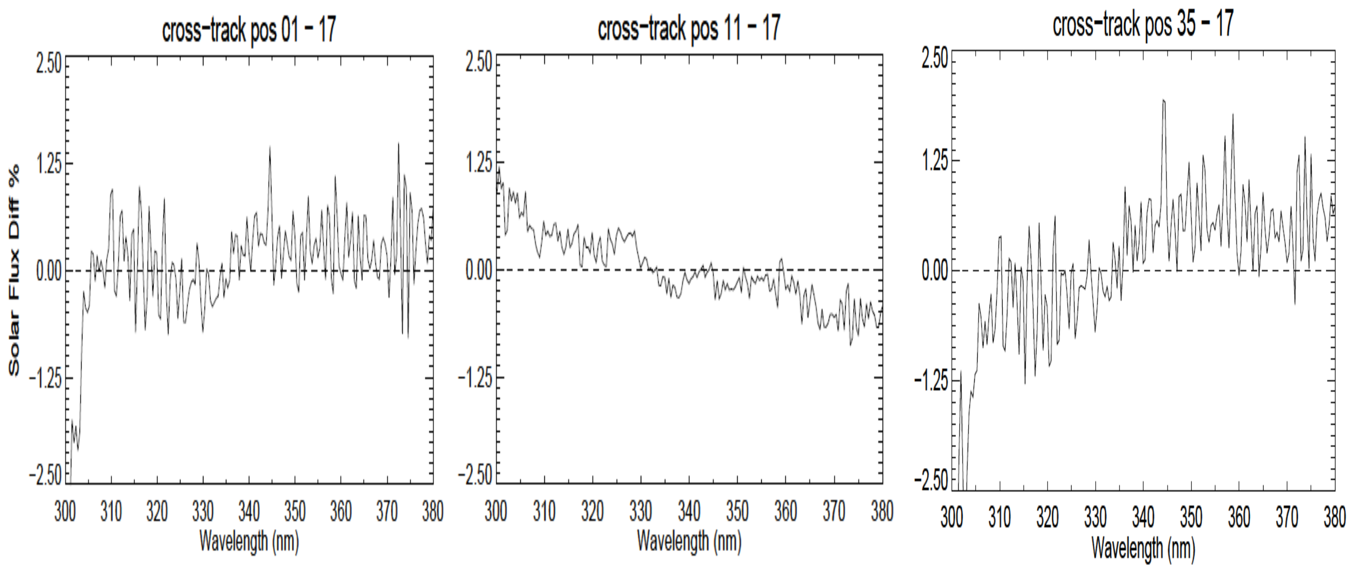
Cross-Track Dependence in SO2 Index Derived from OMPS NM SDR

SO2 Index Comparison before Wavelength Update



OMPS NM Solar Flux Cross-Track Difference

Previous wavelength LUT cause errors in cross-track position.



- Irradiance error is percent difference between observed solar flux and modeled synthetic solar flux.

$$Error = \left(1 - \frac{flux_{observed}}{flux_{synt\ hetic}}\right) * 100$$

- Figures show the errors for 3 different cross-track position relative to the nadir position

- Solar flux and wavelength data were read from Nov. 06, 2013 SDRs to demonstrate cross-track position error.
- The OMPS NM synthetic solar flux is computed by convolving the lab band-passes with the high-resolution solar reference spectrum.

Methodology for Reducing NM Cross-Track Dependent Errors

- The cross-track errors are primarily associated with bandpass shape/bandwidth changes.

- We reduced/minimized the errors by aliased wavelength shifts.

- The new NM (TC) wavelength LUT and day-one solar LUT minimizes radiance/irradiance cross–track direction errors.

- Additionally, the new radiometric calibration LUTs improved radiance consistency between NM &NP in 300-310 nm.

LUTs Updated for NM

- NM GND-PI and LUT updates as indicated below.

  The new NM (TC) wavelength minimizes radiance/irradiance cross–track direction errors. The new radiance coefficients for NM account for ground to orbit thermal loading changes, as well as radiance consistency between NM and NP in 300-310 nm. The new day one solar LUT accounts for new radiance cal coefficients.

- WAS: OMPS-TC-WAVELENGTH-GND-PI_npp_20141005000000Z_20140905000000Z_ee00000000000000Z_PS-1-O-CCR-14-2052-NOAA-JPSS-002-PE-ID000-V001-001_noaa_cv0_all-_all.bin

  IS: OMPS-TC-WAVELENGTH-GND-PI_npp_20150718000000Z_20150701000000Z_ee00000000000000Z_PS-1-O-CCR-15-2547-NOAA-JPSS-003-PE-ID000-V001-001_noaa_cv0_all-_all.bin

- WAS: OMPS-TC-OSOL-LUT_npp_20141005000000Z_20140905000000Z_ee00000000000000Z_PS-1-O-CCR-14-2052-JPSS-NOAA-003-PE-_noaa_cv0_all-_all.bin

  IS: OMPS-TC-OSOL-LUT_npp_20150718000000Z_20150701000000Z _ee00000000000000Z_PS-1-O-474-CCR-15-2547-NOAA-JPSS-004-PE_noaa_all_all-_all.bin

- WAS: OMPS-TC-CALCONST-LUT_npp_20020101010000Z_20020101010000Z_ee00000000000000Z_PS-1-D-NPP-1-PE-_devl_dev_all-_all.bin

  IS: OMPS-TC-CALCONST-LUT_npp_20150718010000Z_20150701010000Z_ee00000000000000Z_PS-1-O-474-CCR-15-2547-NOAA-JPSS-002-PE-_ noaa_all_all-_all.bin

LUTs Updated for NP

- NP GND-PI and LUT updates as indicated below.

  The new radiance coefficients for NP account for ground to orbit thermal loading changes, as well as radiance consistency between NM and NP in 300-310 nm. The new day one solar LUT accounts for new radiance cal coefficients. The new NP wavelength is computed in accordance with the new day one solar LUT.

- WAS: OMPS-NP-WAVELENGTH-GND-PI_npp_20141005000000Z_20140905000000Z_ee00000000000000Z_PS-1-O-CCR-14-2053-NOAA-JPSS-002-PE-ID000-V001-001_noaa_cv0_all-_all.bin

  IS: OMPS-NP-WAVELENGTH-GND-PI_npp_20150718000000Z_20150718000000Z_ee00000000000000Z_PS-1-O-CCR-15-2548-NOAA-JPSS-003-PE-ID000-V001-001_noaa_cv0_all-_all.bin

- WAS: OMPS-NP-OSOL-LUT_npp_20120412114100Z_20120702120000Z_ee00000000000000Z_PS-1-O-474-CCR-12-0458-JPSS-DPA-NGAS-002-PE_noaa_all_all-_all.bin

  IS: OMPS-NP-OSOL-LUT_npp_20150718000000Z_20150723000000Z _ee00000000000000Z_PS-1-O-474-CCR-15-2548-NOAA-JPSS-003-PE_noaa_all_all-_all.bin

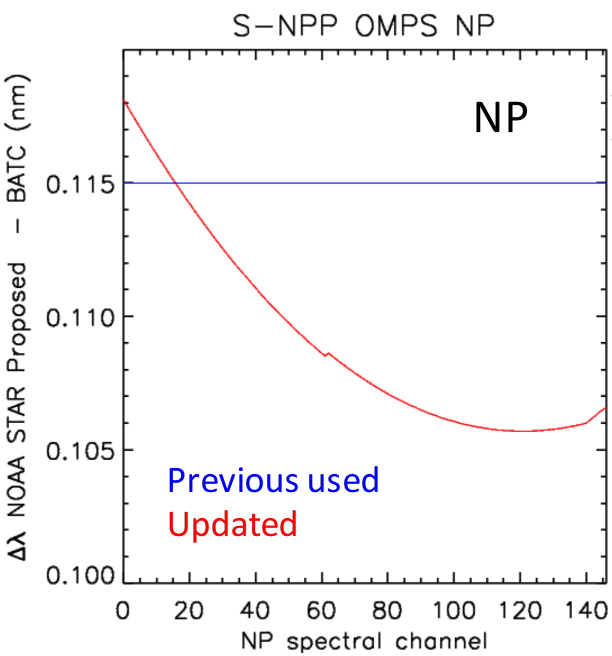
- WAS: OMPS-NP-CALCONST-LUT_npp_20020101010000Z_20020101010000Z_ee00000000000000Z_PS-1-D-NPP-1-PE-_devl_dev_all-_all.bin

  IS: OMPS-NP-CALCONST-LUT_npp_20150718010000Z_20150723010000Z_ee00000000000000Z_PS-1-O-474-CCR-15-2548-NOAA-JPSS-002-PE-_ noaa_all_all-_all.bin

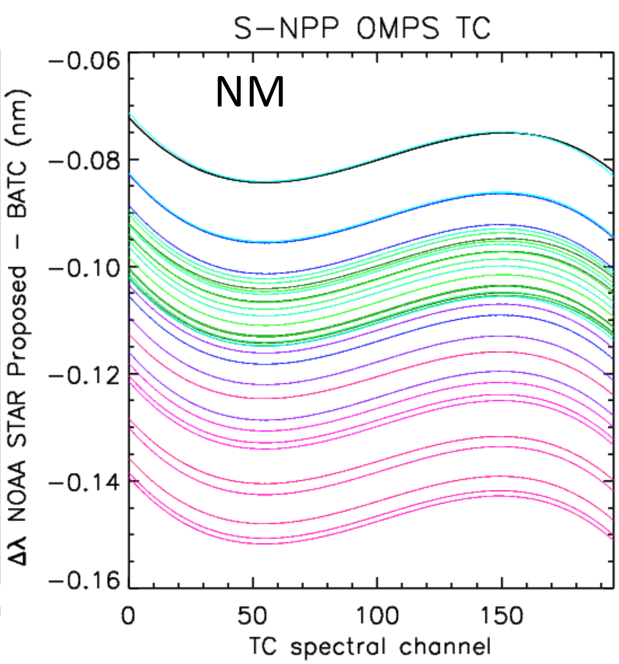
Wavelength Shifts before/after Updates

Difference between LUTs and prelaunch data

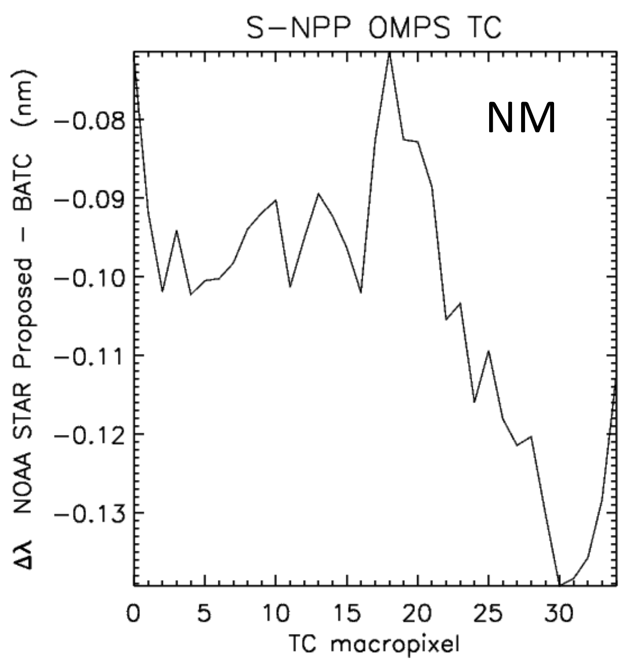
Difference between the updated and prelaunch data



Shifts vs. spectral channels



Shifts vs. spectral channels



Shifts vs. spatial 35 cells

Wavelength LUTs are modified for both NM and NP.

Building on-Orbit Truth for Estimating OMPS Earth View SDR Accuracy

- Develop the "truth" simulated from the forward radiative transfer model at OMPS EV location (Macropixel)
  - The Microwave Limb Sounder (MLS) is well calibrated
  - The temperature profile from MLS was assumed to be accurate
  - The MLS ozone profile was assumed to be accurate
  - The OMPS sensor were co-located, within 50 km, to measurements from the MLS sensor

- Radiative transfer model must include comprehensive scattering and absorption processes at UV regions
  - Roma scattering would be significant and

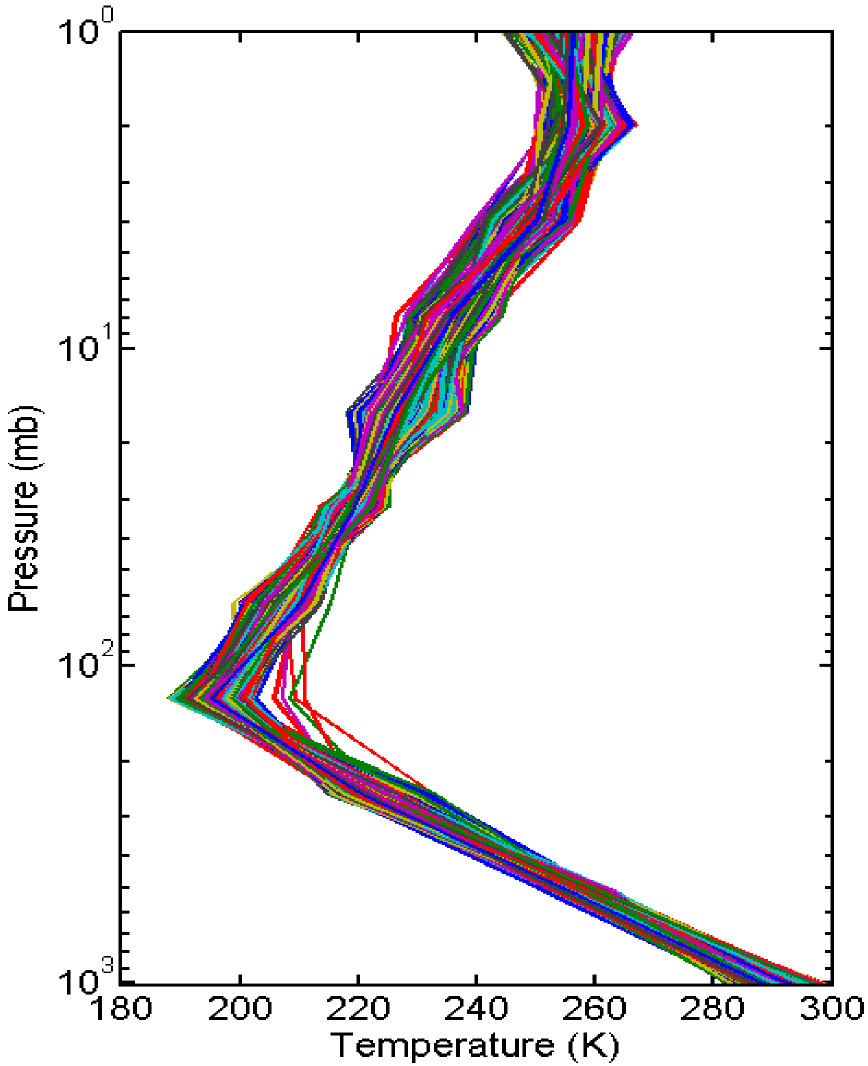
- Accurate understanding of atmospheric and surface status at OMPS EV location.

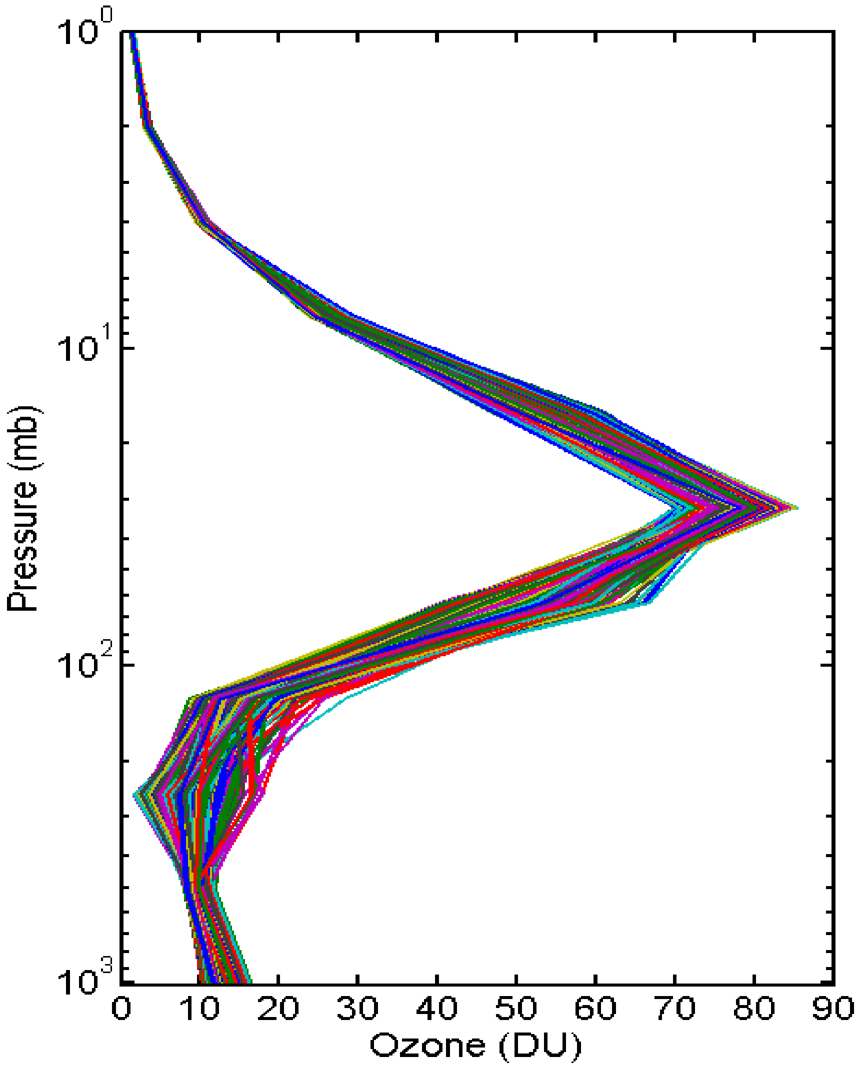
- The difference between observations and simulations is used as an estimate of on-board calibration accuracy

OMPS EV Radiative Transfer Simulations

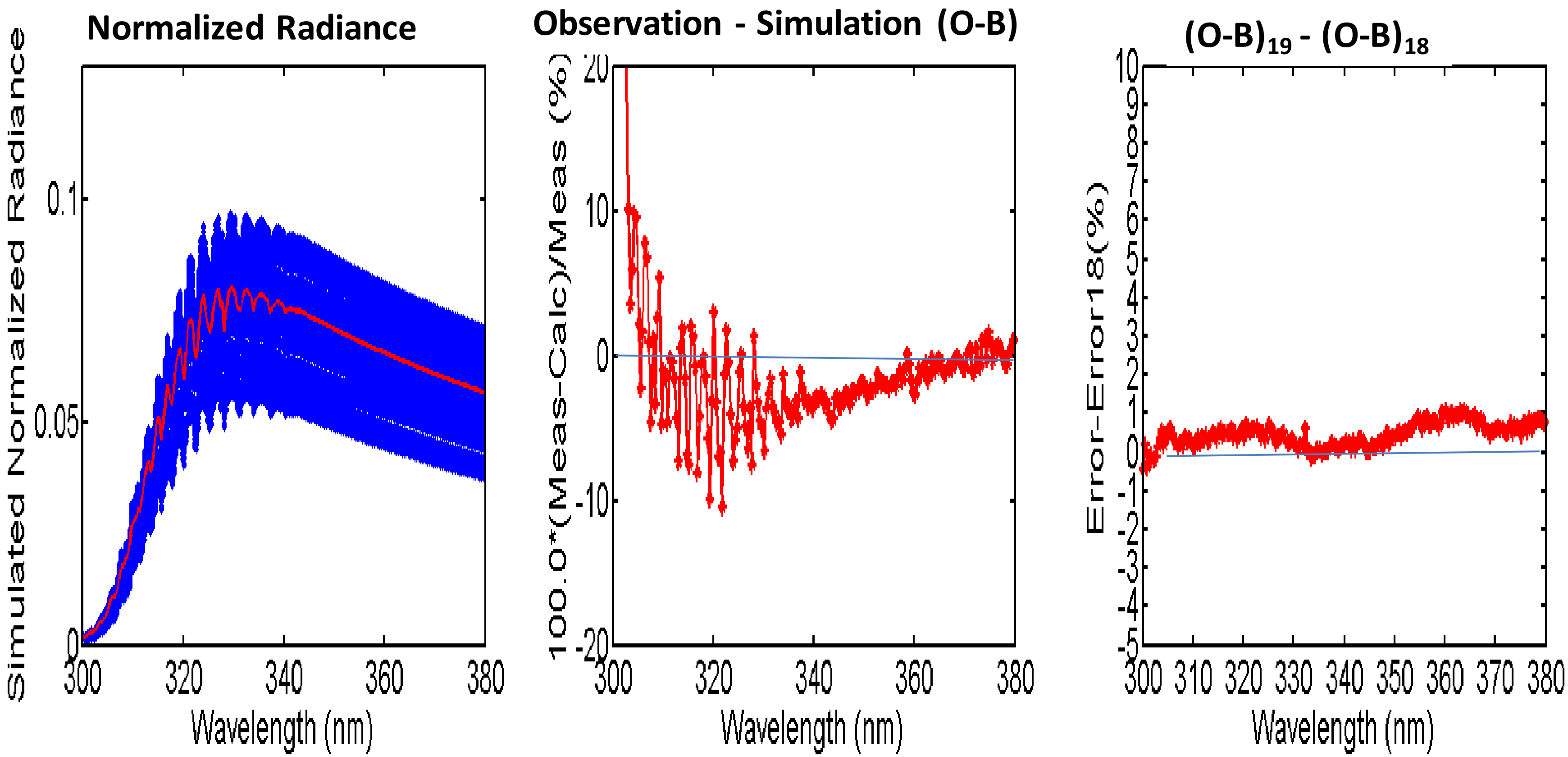
- TOMRAD-2.24: TOMS (Total Ozone Mapping Spectrometer) Radiative Transfer Model
  - Rayleigh scattering atmosphere with ozone and other gaseous absorption
  - Spherical correction for the incident light
  - Molecular anisotropy and Raman scattering
- Inputs to TOMRAD
  - Wavelength, solar and satellite viewing geometry, surface albedo, temperature and ozone profile
  - Climatology temperature profile
  - Ozone profile from Aura Microwave Limb Sounder (MLS)
  - Collocated OMPS/MLS data generated at STAR using NASA algorithm
    - a) reflectivity < 0.10 to eliminate cloud effects
    - b) Latitude: -20 ~ 20 degrees
- Outputs from TOMRAD
  - Normalized radiance (NR=reflected radiance/solar flux) or N-Value (N=-100*$\log_{10}$NR)

Co-located OMPS/MLS Temperature and Ozone Profiles





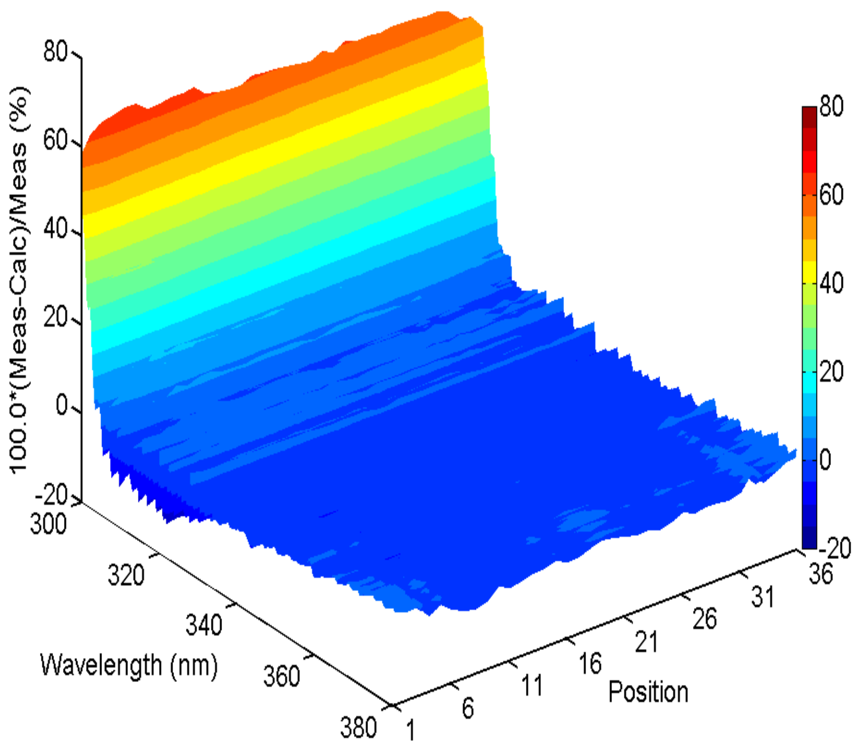
Simulated Normalized Radiance at OMPS Macropixel Position 19



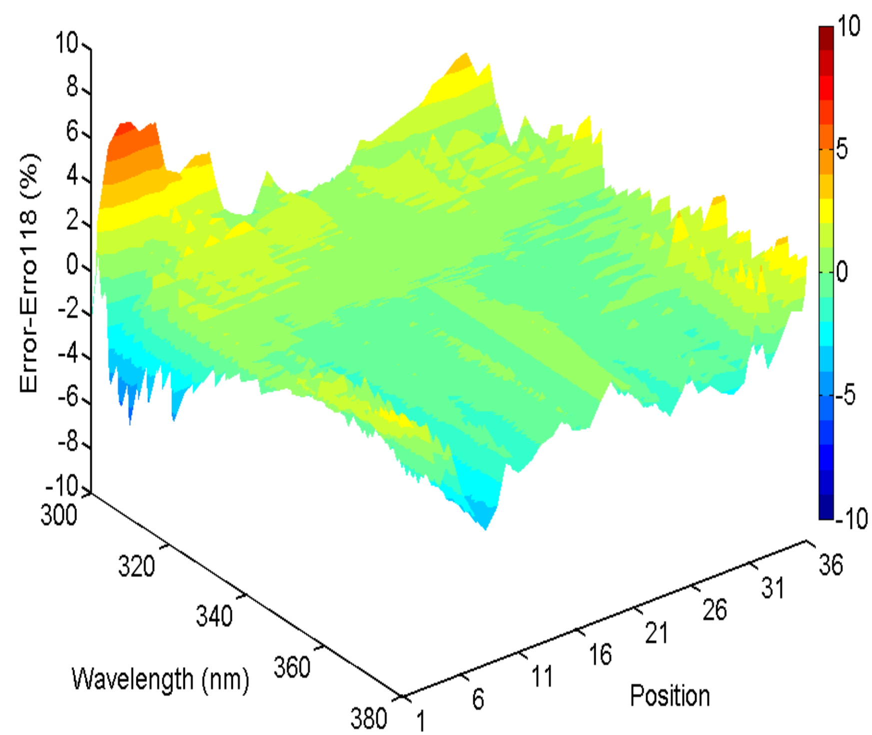
The left plot shows the calculates OMPS normalized using MLS ozone and temperature profiles co-located with OMPS for cross-track position 19. The middle plot shows percent difference between observed and calculated data. In the right plot, the relative percent difference between position 19 and 18.

Observation minus Simulation (O-B)

Relative Error

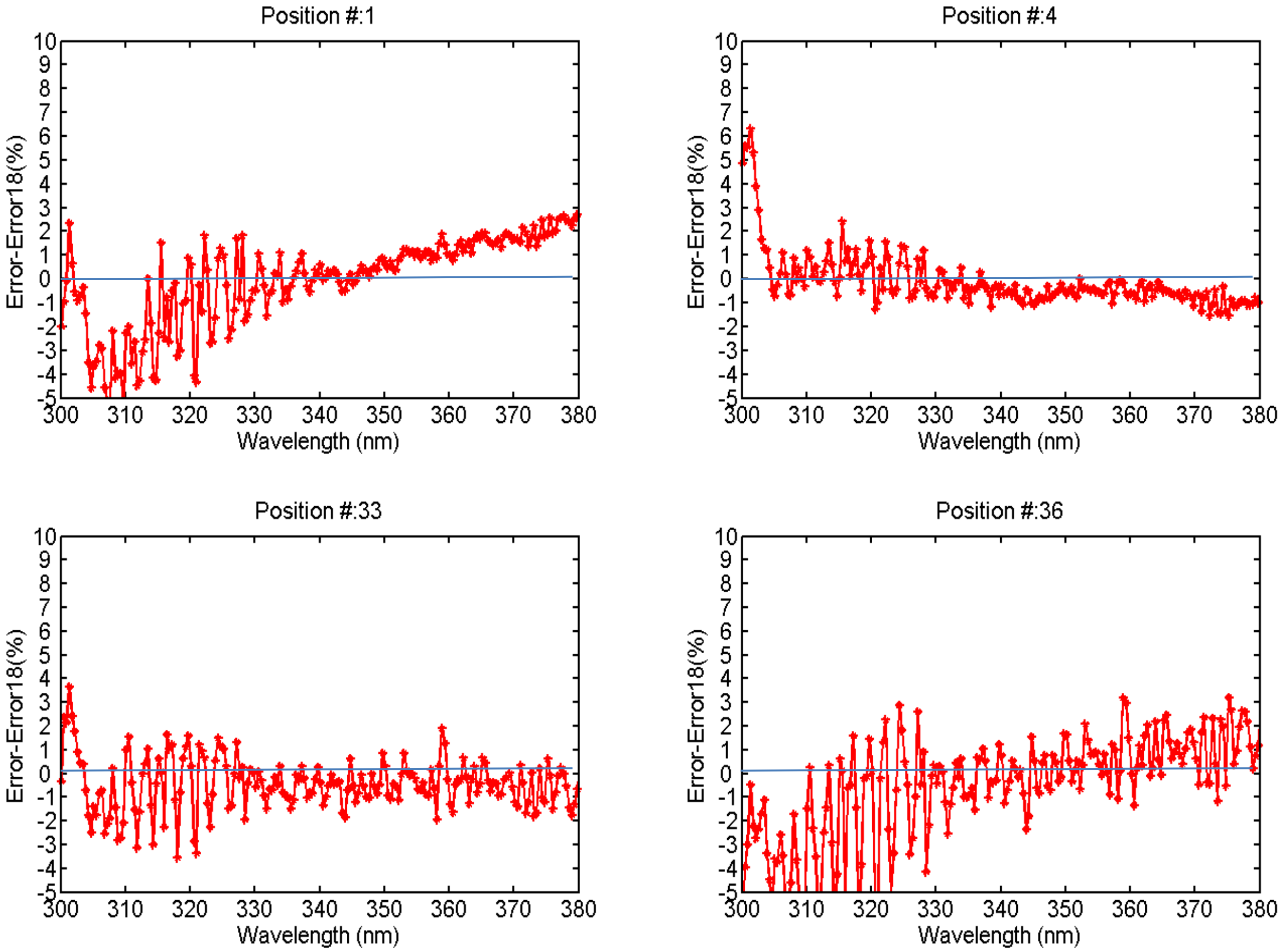


Relative error wrt to Position 18 (nadir)



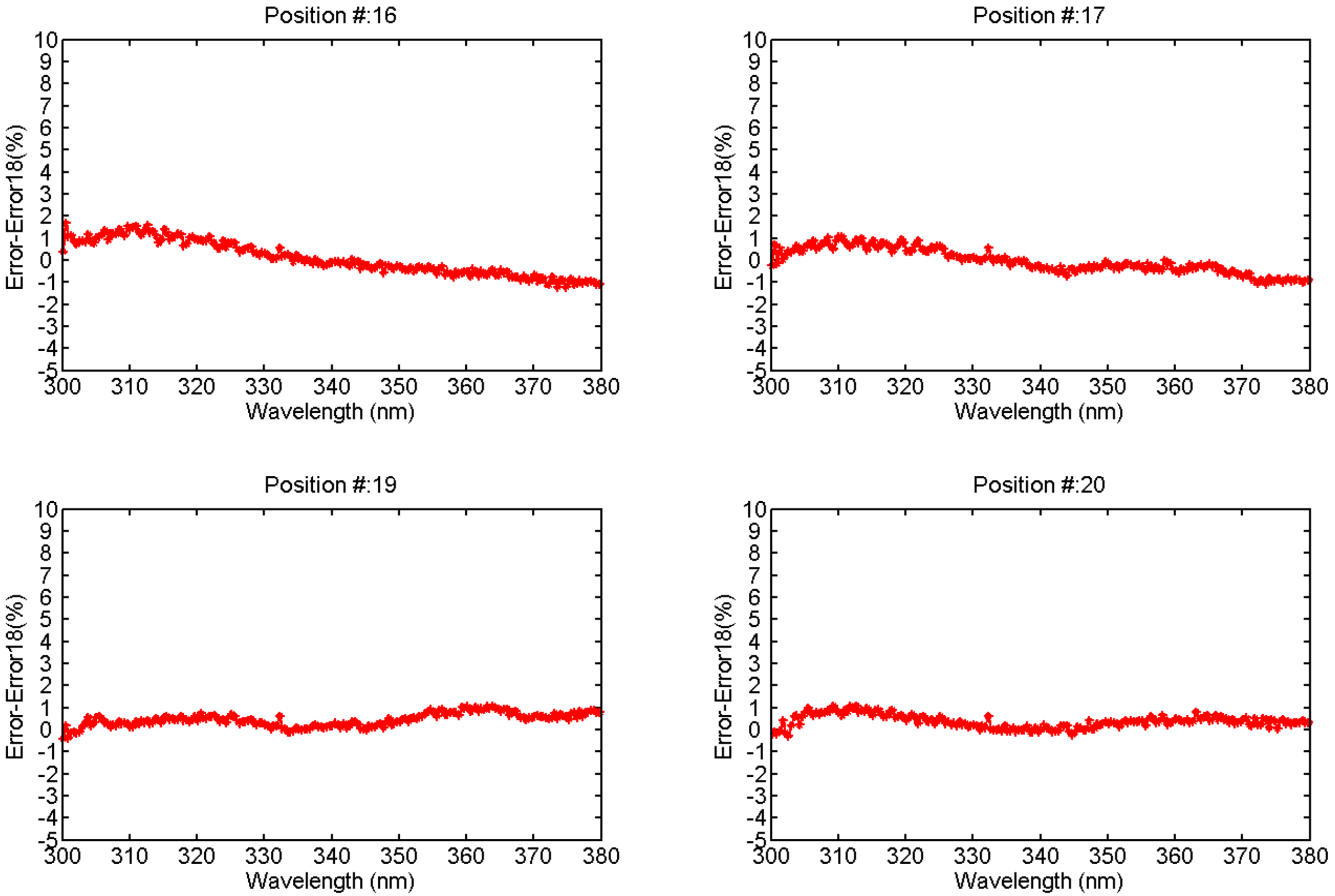
The bias in cross-track direction is generally less than 2% except at shorter wavelengths where simulations may become less accurate due to complex scattering process. The bias is also larger in side pixel locations

Observation minus Simulation at Wing Positions



The biases at far wing positions (1-4 and 33-36) are out of specifications at wavelengths less than 320 nm. The causes can be related to complex RT processes, etc.

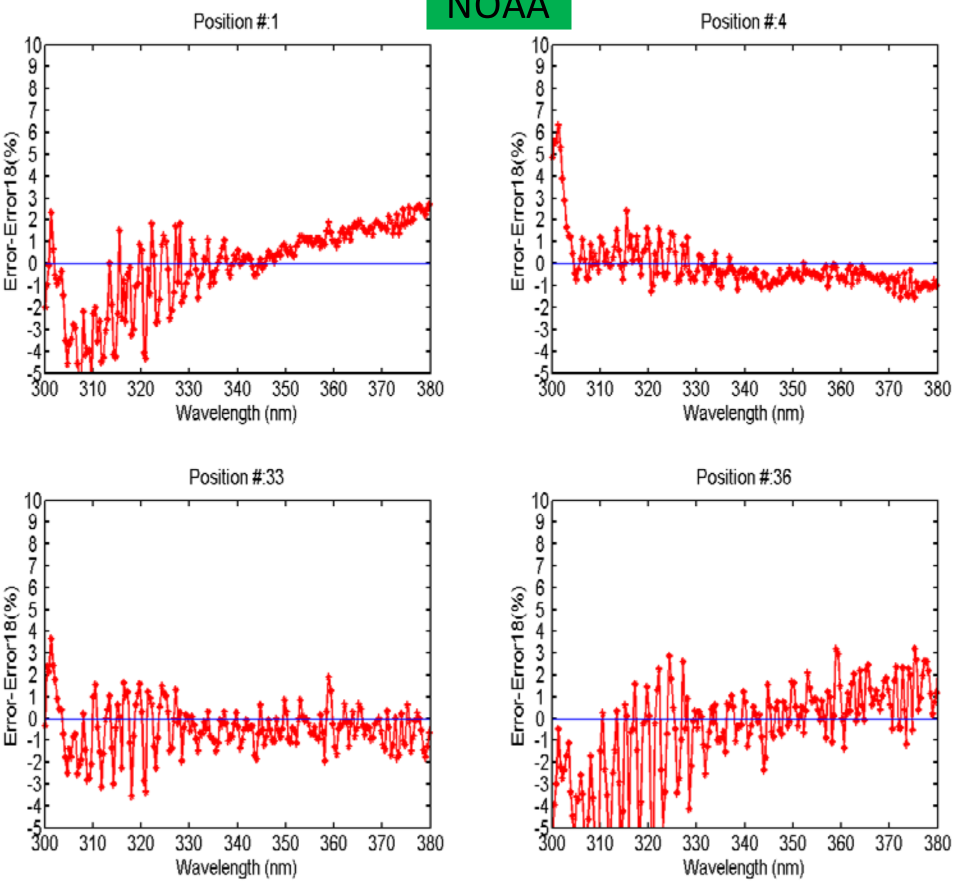
Observation minus Simulation near Center



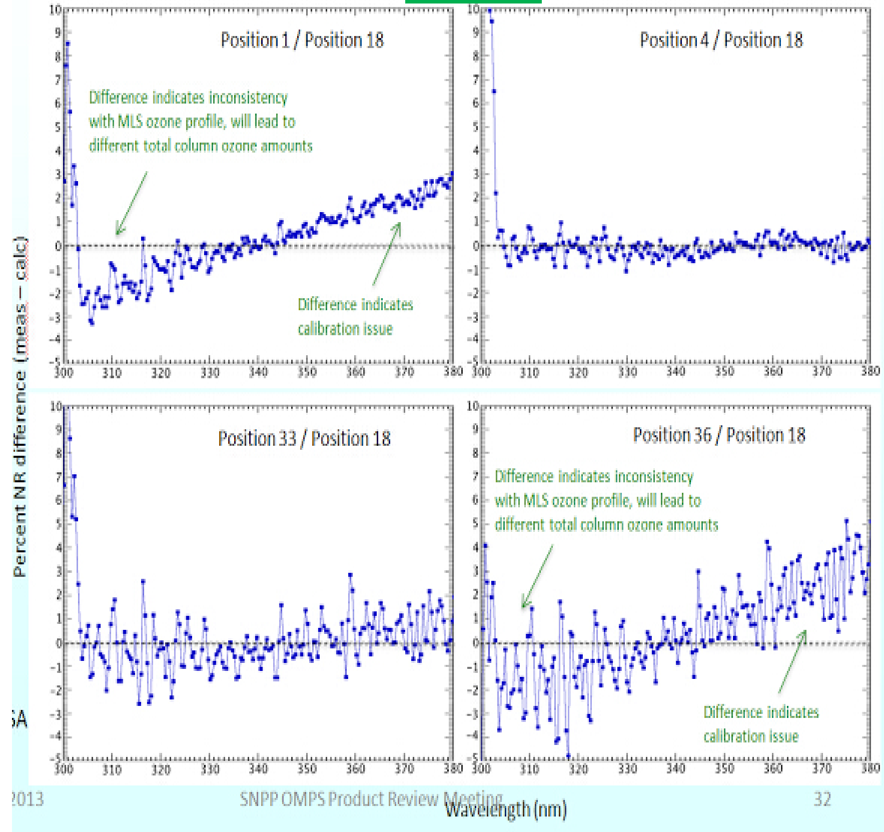
The biases near center all meet specifications at all wavelengths

Observation minus Simulation (NOAA vs. NASA)

NOAA

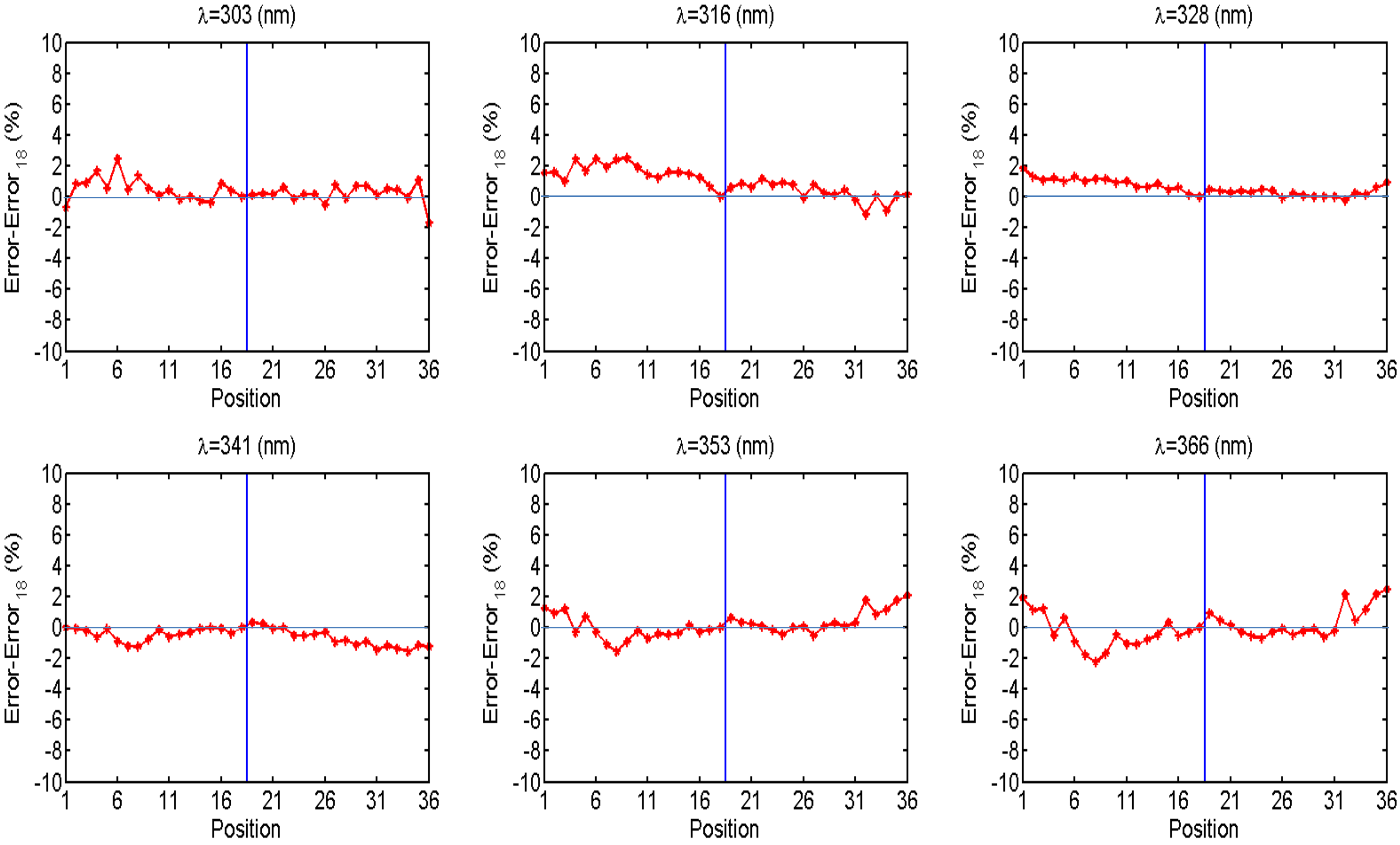


NASA



The bias characteristics simulated from NOAA (left red curves) and NASA (left blue curves) are consistent in cross-track direction and wavelength domain.

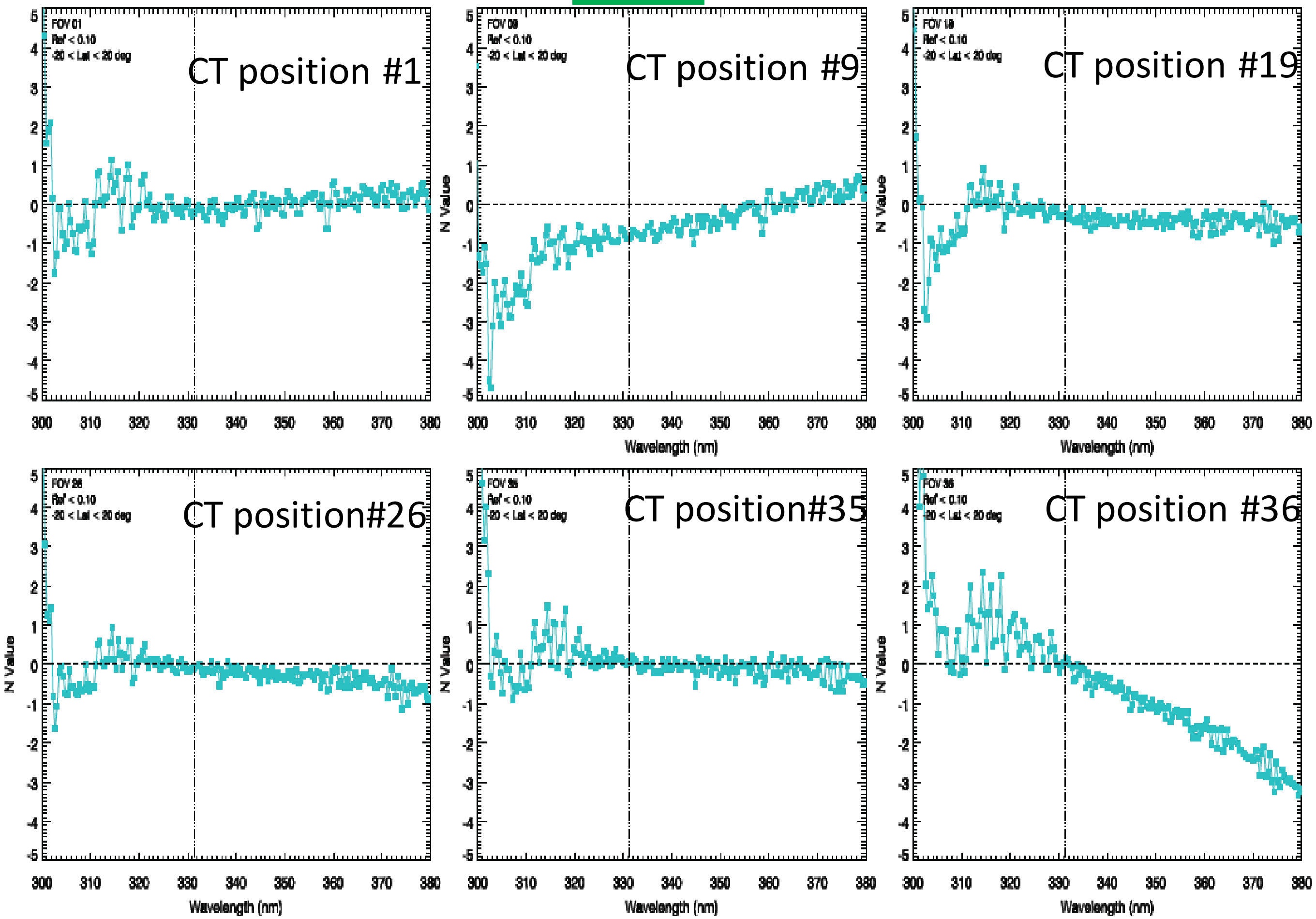
Error vs. Scan Position



Cross-Track Difference for Earth View N-Value or Radiance

Wavelength-dependent Cross-Track Normalized Radiance Error Meets Requirement

NASA



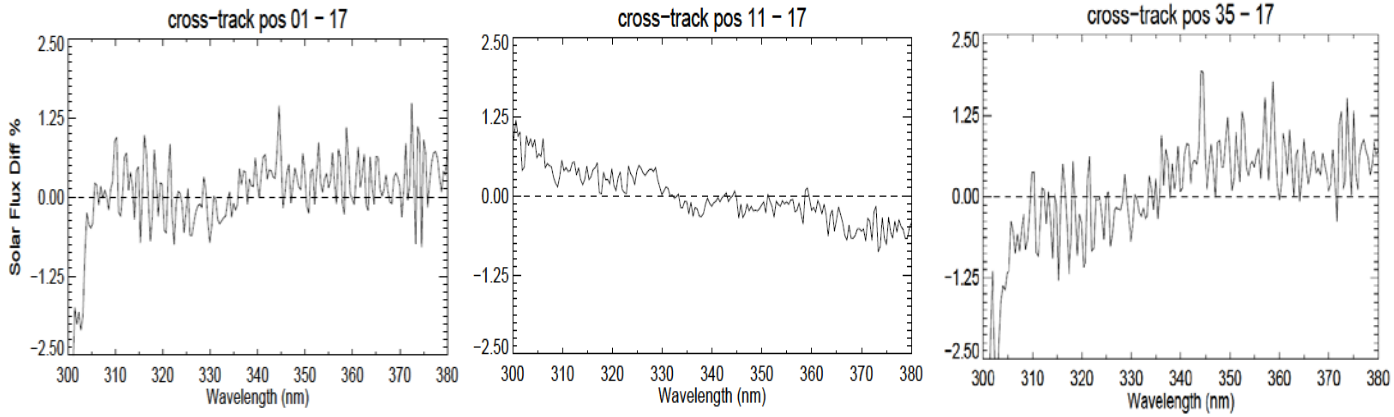
- Normalized radiance error is percent difference between Observed and Calculated N-values
- Figures shows the errors for 6 different cross-track (CT) positions
- Errors were minimized < 2% for most of the channels.
- Except ion is CT#36 on wavelength > 360 nm. Soft calibration are being implemented to eliminate this residual error.

Wavelength-dependent normalized radiance errors are within 2% (except for FOV 36) which meets the performance requirement.

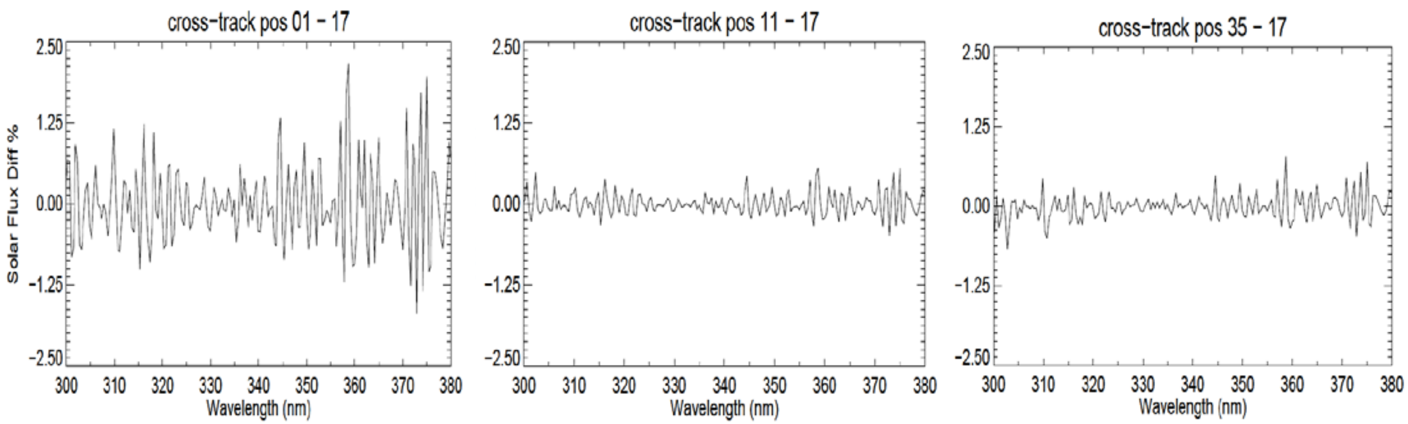
Solar Irradiance (Flux) Cross-Track Difference for NM

Wavelength Dependent Cross-Track Solar Irradiance Error Was Eliminated

Previous wavelength LUT cause errors in cross-track position.



Updated wavelength LUT eliminates errors in cross-track position.



- Irradiance error is percent difference between observed solar flux and modeled solar synthetic flux.

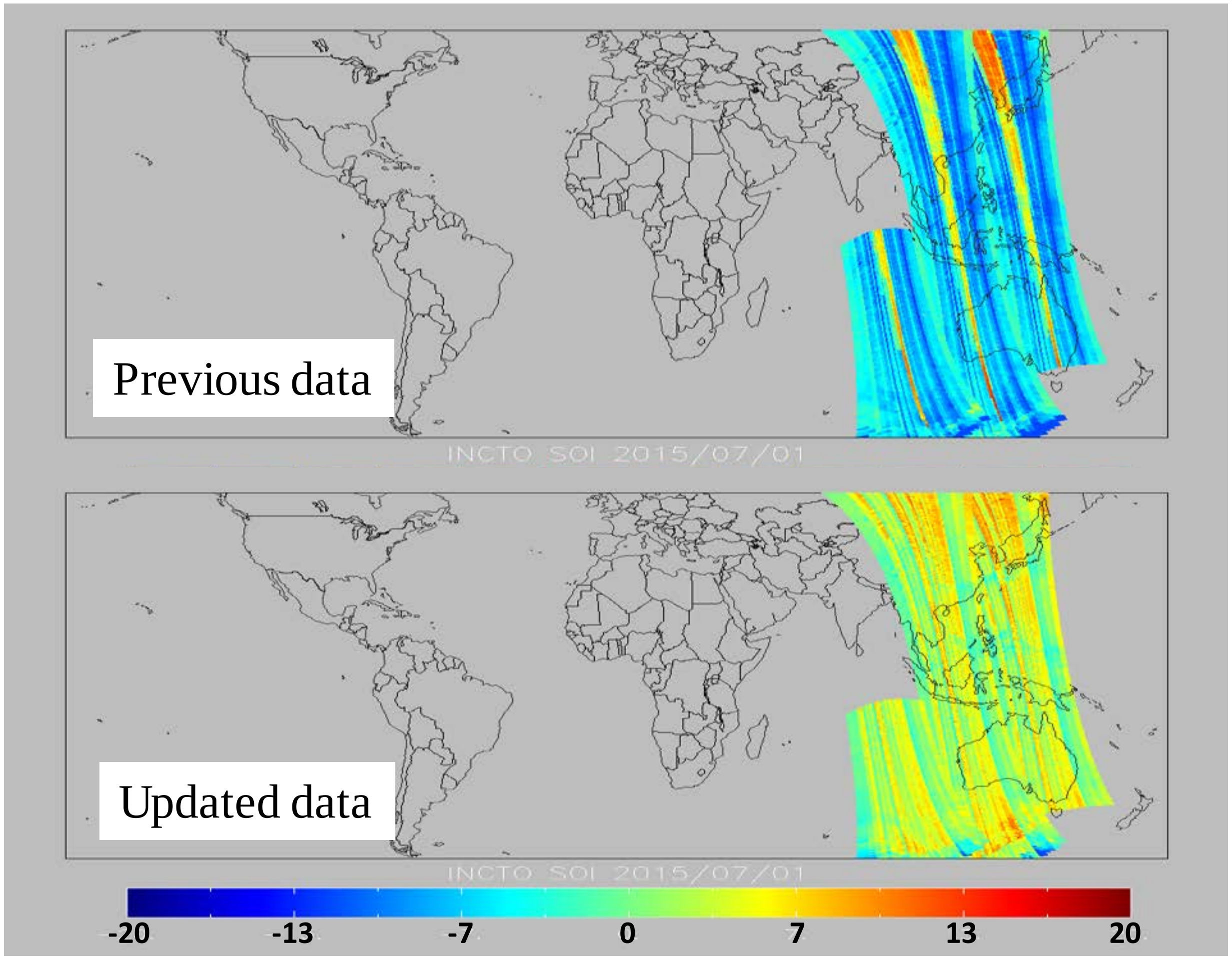
$$Error = \left(1 - \frac{flux_{observed}}{flux_{synthetic}}\right) * 100$$

- Figures show the errors for 6 different cross-track position relative to the nadir position
- Updated wavelength and solar flux LUTs have eliminated cross-track irradiance error .
- Up to 2.5 -3.0 % improvement has been achieved

Solar irradiance error in cross-track direction is eliminated.

Reduced Cross-Track Dependence in OMPS NM Derived EDR (SO2)

SO2 Index Comparison before and after Wavelength Update

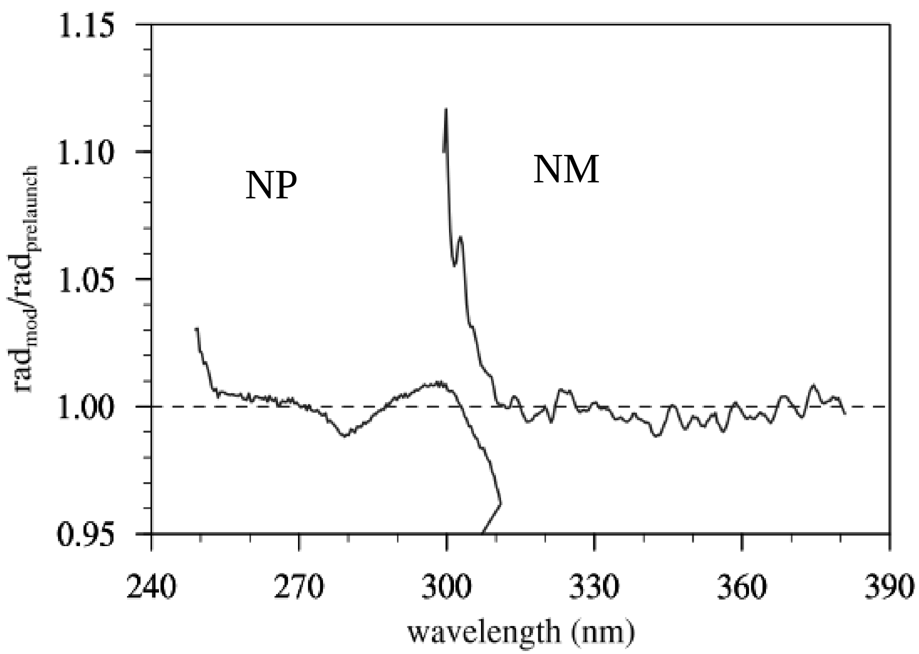


- SO2 index cross-track variation was minimized from -13 ~ 13 to 6~7/8.
- Residual error are caused by EDR V7 TOZ algorithm, that inappropriately exaggerates the impact of wavelength variation.
- The residual error can be corrected by EDR V8 algorithm with an appropriate n-value adjustment.
- Data comes from OMPS NM EDR products INCTO SO2 2015/07/01

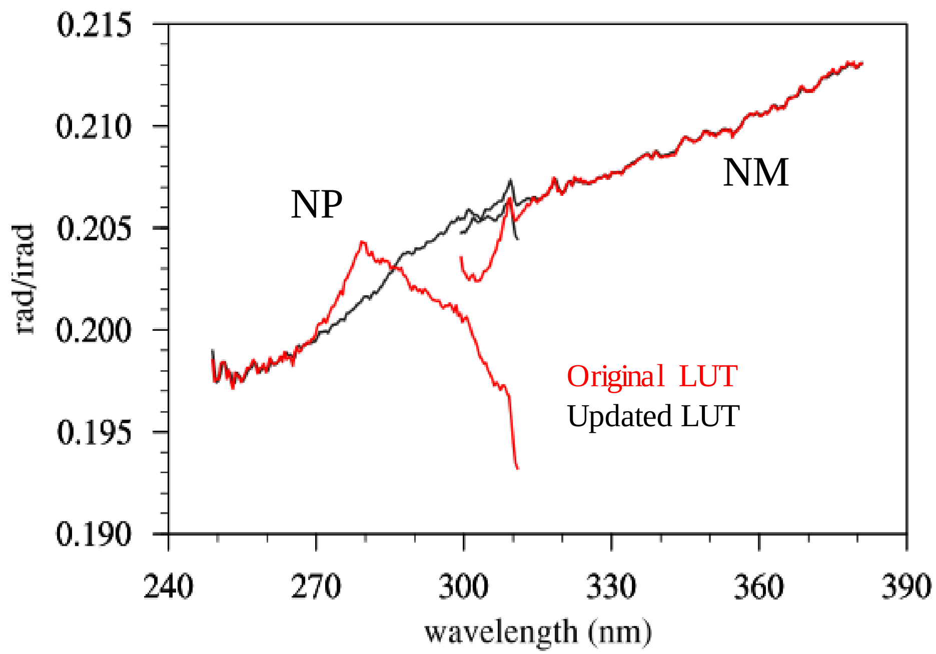
Radiometric Calibration Coefficients is Improved

- Radiance/irradiance coefficients were modified to account for ground to orbit wavelength shifts, as well as normalized radiance consistency between NP and NM
- Updated day-one solar LUT accounts for updated irradiance cal coefficients.

Radiance Ratio before/after Updates



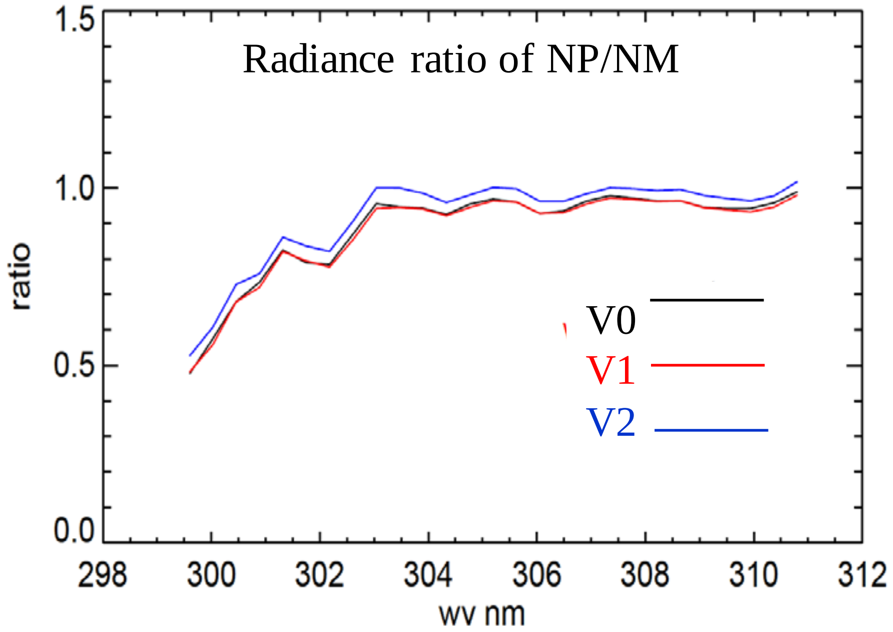
Ratio of Radiance/irradiance coefficients

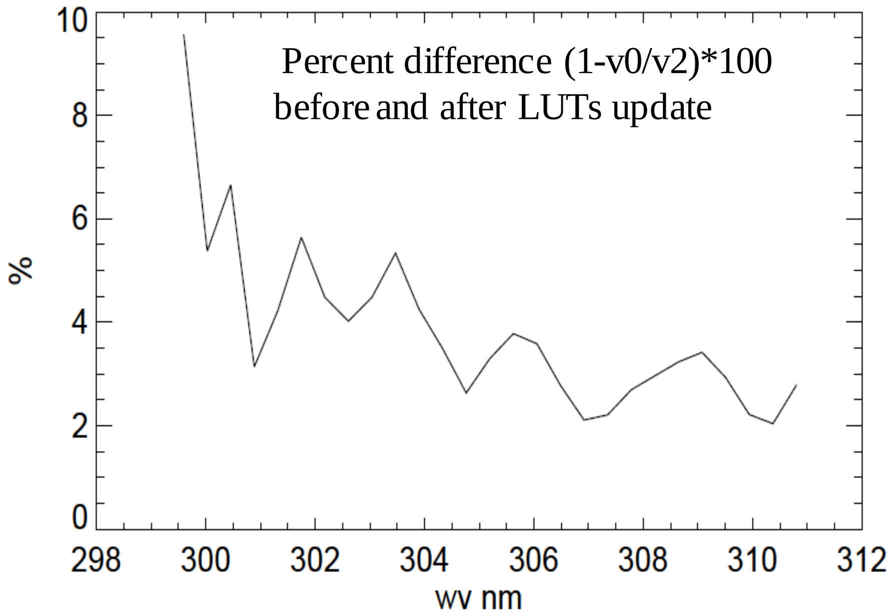


Updated radiance coefficient LUTs improve normalized radiance consistency up to ~10% between NP and NM in 300-310 nm.

Radiance consistency is improved by 2-10%

Improvement in the Spectral Range of 300 - 310 nm





- The improvement was validated via SDR products from both NP and NM.
- EV Radiance from NP and NM are collocated spatially and spectrally
- 1174 granules (globe coverage) were used for validation
- Radiance is computed via old LUTs (V0), updated wavelength & day one solar (V1) and updated wavelength, day one solar, radiance/irradiance LUTs (V2)

NM & NP consistency in SDR radiance is improved by ~2-10%.

Summary

- **OMPS EV SDRs meet SDR performance requirement as well as EDR products requirement**
  - ✓ The cross-track direction normalized radiance accuracy meets spec and the error is less than 2.0% with updated wavelength and day one solar LUTs
  - ✓ The NM and NP consistency in 300-310 nm has been improved by 2-10% with updated radiance calibration coefficients
  - ✓ Sensor orbital performance is stable and meet expectation

- **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 ready for applications and scientific publication

- ***Both OMPS NM and NP EV SDRs are declared as validated-maturity products***

JPSS-1 OMPS calibration and test status

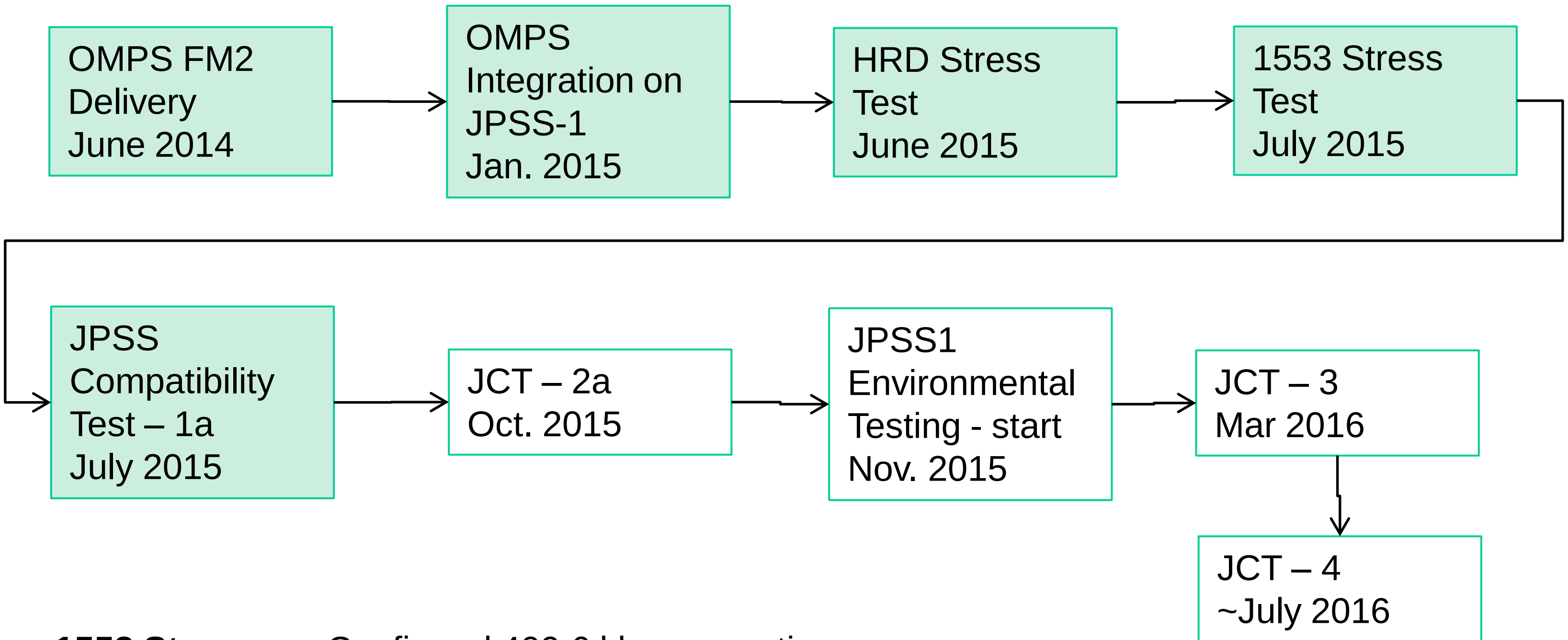
NASA OMPS J1 team
(as of now)

Haken, L-K.Huang, Janz, Jaross, Kelly, Kowalewski, Linda, Mundakkara, Su, Warner

OMPS Integration
Dec. 22, 2014

Courtesy of BATC

OMPS integration is complete



1553 Stress Test	Confirmed 409.6 kbps operations
JCT1a	Verified nominal on-orbit commanding
JCT2a	Will verify nominal EV operations and data collection
JCT3	Will verify Cal. and Diag. operations
JCT4	???

a portions: Flight
b portions: Ground

Not clear when b occurs

Performance summary

Reqt ID	Requirement	Value	Performance	Margin
O_PRD-11307	Albedo Calibration (λ-independent)	≤ 2% rms	NM: 1.39%	0.61% (31%)
			NP: 1.59%	0.41% (21%)
O_PRD-11308	Relative accuracy (λ-dependent)	≤ 0.5% rms	NM: 0.44%	0.06% (12%)
			NP: 0.41%	0.09% (18%)
O_PRD-11309	Prediction of absolute calibration change in 7 year period	<3%	≤ 2.3%/7 years (0.69% per measurement)	≥ 0.7% (23%)
O_PRD-11373	Short-term Radiometric Stability	≤ 1%	NM: 0.03%	0.97% (97%)
			NP: 0.03%	0.97% (97%)
O_PRD-11429	Response Uniformity	≤ 1%	< 0.7%	≥ 0.3% (≥ 30%)
O_PRD-11349	Signal-to-Noise Ratio (NM)	≥ 1000	≥ 1519	≥ 519 (≥ 51.9%)
O_PRD-11350	Signal-to-Noise Ratio (NP)	≥ 35 (252 nm)	48	13 (37.1%)
		≥ 100 (273 nm)	229	129 (129%)
		≥ 200 (283 nm)	403	203 (102%)
		≥ 260 (288 nm)	486	226 (86.9%)
		≥ 400 (292-306 nm)	≥ 722	≥ 322 (≥ 80.5%)
O_PRD-11437	NM: Stray Light Rejection	≤ 2%	≤ 1.56%	≥ 0.44% (≥ 22%)
O_PRD-11438	NP: Stray Light Rejection	≤ 2%	≤ 1.83%	≥ 0.17% (≥ 8.5%)

Selected parameters

Courtesy of BATC

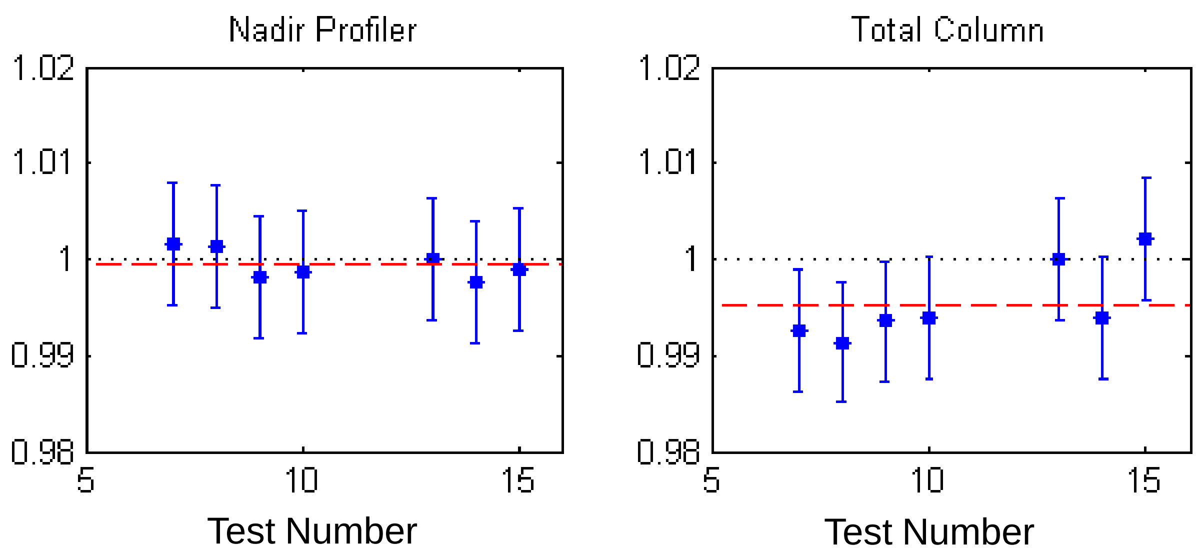
Trending Results

Last report was just after integration

No significant trends observed in:

- Irradiance sensitivity (see plots)
- Readout noise
- Dark current
- Gain
- Detector full-well
- LED output

OOTT Results



Courtesy of BATC

OMPS goals for JCT2

- Conduct nominal EV measurements
  - Construct and execute CSMs for orbital operations (a)
  - Collect and store 2400 NM Hi-res, 400 NP Med-res images per orbit (a)
  - Collect and store open-door dark currents (a)
  - Confirm that IDPS creates Hi-res, Med-res RDRs (b)
  - Confirm that SDR aggregates NM to Med-res and creates product (b)
  - Confirm creation of NP SDR (b)

- Exercise table loads
  - MOST to halt CSMs and load updates
  - SOC generation of paired sample tables and gain tables (a,b)
  - GND-PI sample table switch-over to NM Low-res output (b)
  - Load and execute NM Med-res flight tables (a)
  - Load and execute NM Low-res flight tables (a)
  - Confirm SDR output is unchanged with flight table load (b)

a portions: Flight
b portions: Ground

Not clear when b occurs

OMPS goals for JCT3

- Conduct nominal Cal measurements
  - Construct and execute CSMs for operations of all cal. orbits (a)
  - Collect and store 2400 NM Hi-res, 400 NP Med-res images per orbit (a)
  - Collect and store open, closed-door darks, 1-orb and 3-orb solar cals, LEDs (a)
  - Confirm that IDPS creates nominal and diag. Cal. RDRs (b)
  - Confirm Cal. data processing in GRAVITE (b)

- Execute extended-orbit EV
  - Load and execute new CBMs to support longer EV orbital operations (a)
  - Confirm SDR processes additional granules (b)

- Execute diagnostic activities
  - Full-frame
  - PRNU ice radiance
  - Full orbit (EV360)

Proxy data processing status

- OMPS 43 and MDR 40 data
  - Based on BBMEB and NPP OMPS data from Feb. and April, 2014
  - NM Hi-res and Low-res; NP Med-res and Low-res images
  - BBMEB data are entirely J1 OMPS, but have no signals
  - NASA DPES synthesized RDRs by combining BBMEB and NPP flight data and fusing J1 OMPS headers to NPP flight images

- OMPS SIPS processed BBMEB data
  - Successfully processed into 43 Level 1A orbits
  - 12 images failed to decompress; corrupted at BATC
  - Re-transferred data processed correctly

- OMPS SIPS still working on RDR processing
  - Creating production rules for automated processing
  - RDRs still contain corrupt images

J1 OMPS SCDBs

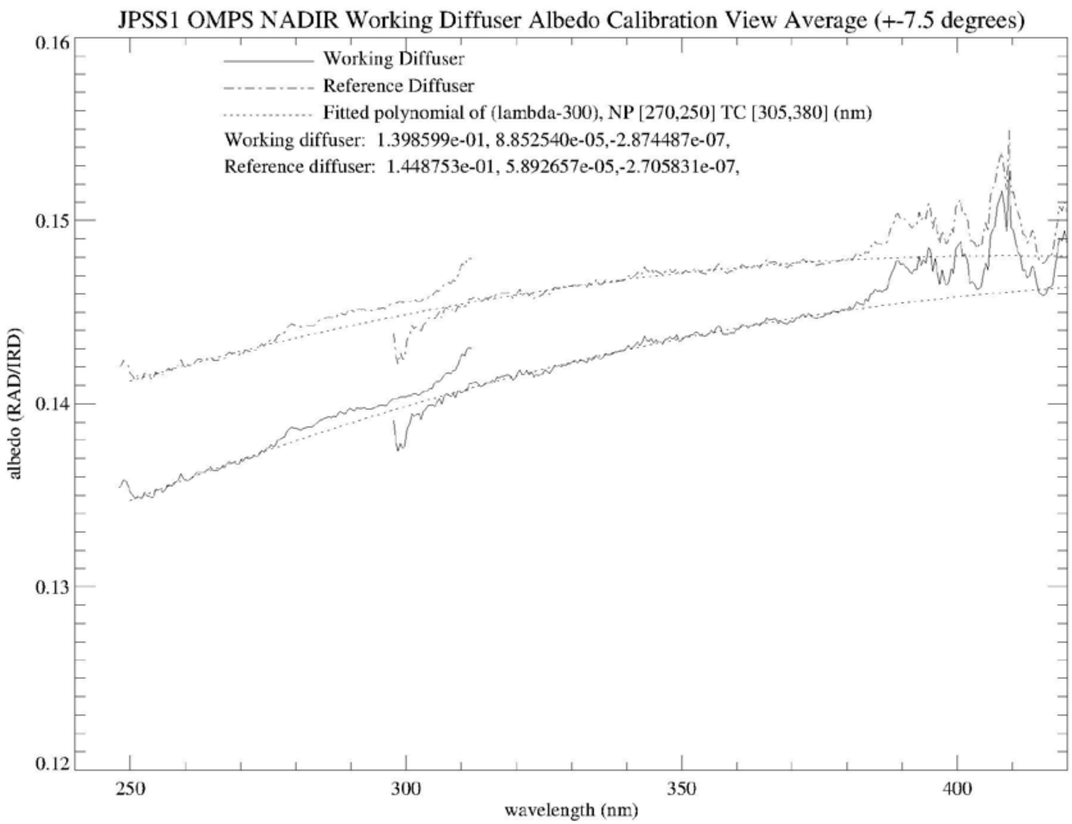
Macropixel information removed from all DBs

Short Name	Final delivery date	Changes from NPP OMPS
CBC	2/5/2014	Extended to all pixels
SRG	5/5/2014	Extended to all pixels
BPS	5/5/2014	NASA will remove 295 nm and refit; add dichroic corr.
STB	5/16/2014	NASA replacing all EV tables; Cal. tables unchanged
RAD	9/23/2014	NASA smoothing albedo cal. in dichroic region
SLT stitched	12/18/2013	DB unchanged; 417 nm added
SLT recon.	12/18/2013	DB unchanged; 417 nm added
SLT tuned	12/18/2013	DB unchanged; 417 nm added
IRD	4/30/2014	DB unchanged
GON	4/23/2014	Fine structure added; angle grid changed to 1° from 0.5°
LED	5/16/2014	DB unchanged
DCT	-	discontinued
ZIO	-	discontinued

All SCDBs and associated documentation available from the Data Management team (DMO) under the NASA JPSS Flight Project gsfc-jpss-dmo@mail.nasa.gov

RAD database update

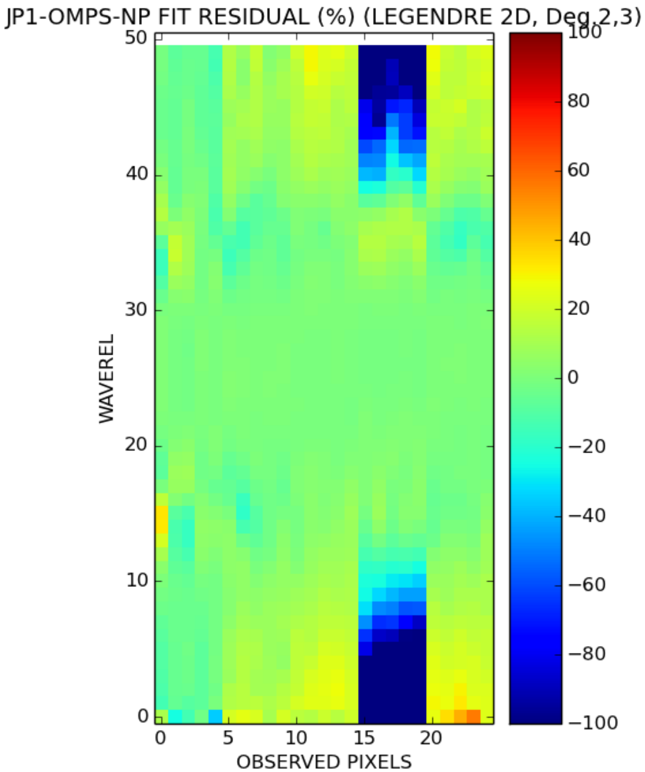
- Albedo Cal. (RAD/IRD) doesn't look like diffuser BRDF
- Anomaly may be related to H2O contamination problem during pre-launch cal.
- Similar "straightening" on NPP OMPS shows improved MLS comparisons
- Approach:
  - Divide out PRNU from RAD
  - Low-order poly fit to center 15° albedo cal.
  - Derive albedo correction and apply to full NM swath in RAD coefficients
  - Reintroduce PRNU



NPP OMPS correction required some post-launch iterations; J1 OMPS may as well

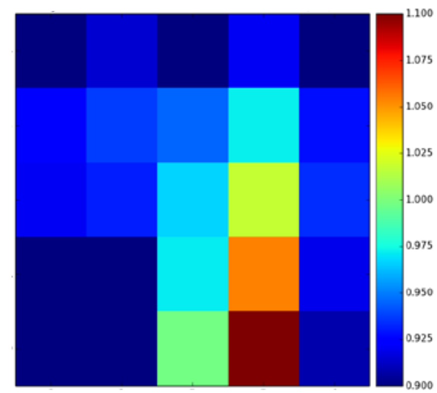
BPS database update

BATC uses Legendre polynomials to extend the 5x5 (spectral x spatial) observed bandpass functions to all pixels



Fit residuals indicate an anomaly in 295 nm observations

Observed FWHM (nm)



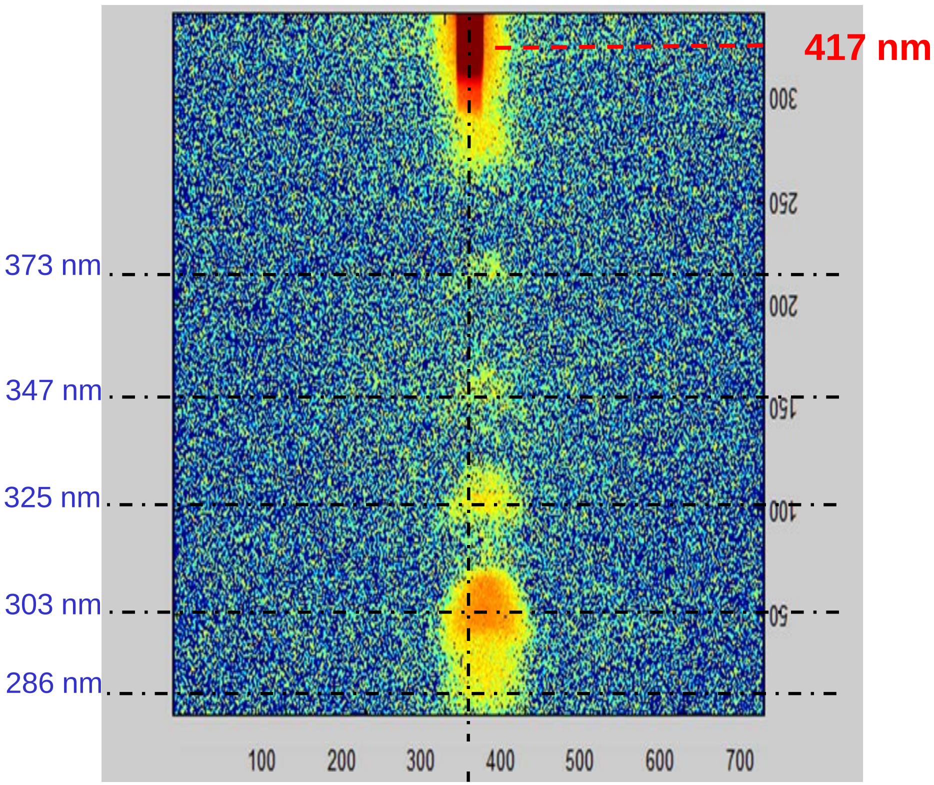
Root cause appears to be an unusually wide 295 nm bandpass (no such anomaly in NPP OMPS)

The BATC approach of stitching multiple measurements together removes the effect of spectral gradients (e.g. dichroic cutoff) on the BPS functions.

NASA is reintroducing the spectral response into the NM and NP BPS after the new NP surface fit.

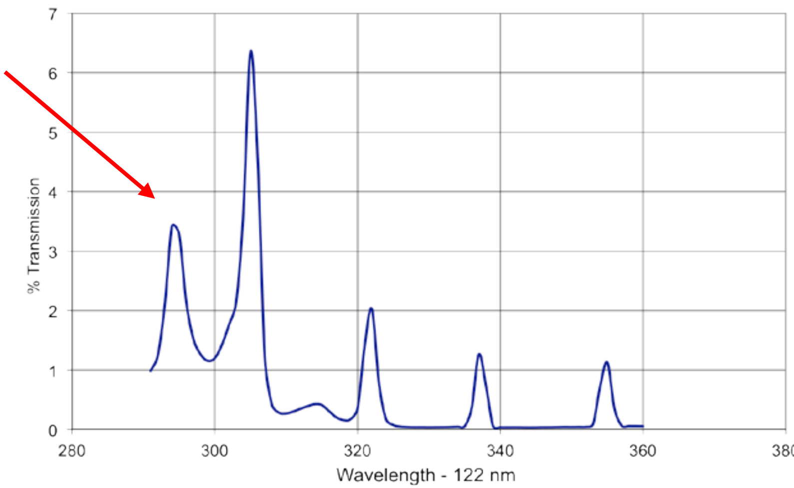
OOR ghost correction simpler with 417 nm

Broadband VIS source
(410 nm cutoff filter)



Courtesy of BATC

Witness Filter spectrum shifted 122 nm



Measurements at 417 nm provide a more direct measure of longer line signals

NPP OMPS estimates based on 370, 380 nm

Extra slides

Limited Life Items and Consumables

Program Phase	Motor Steps
Nadir ATP	1,145,000
ISS I&T + Nadir Re-calibration	1,074,000
Observatory I&T (estimate)	317,000
Total Ground Usage (actual + estimate)	2,536,000
Margin vs. Ground Allocation Budget	601,000 (19%)

Courtesy of BATC

IM2/OOTT Overview

Run	Date	ΔT	Description
1	2 August 2012	–	Pre "cleaning" test
2	6 March 2013	7 months	Post cleaning test
3	28 March 2013	3 weeks	EGSE measurement for calibration transfer
4	11 April 2013	2 weeks	Redundant MEB measurement for calibration transfer
5	15 April 2013	4 days	Primary MEB measurement for calibration transfer
6	24 April 2013	1 week	-20°C CCD temperature, OOTT #1
7	1 July 2013	10 weeks	OOTT #2 with LCC serial number 001
8	2 July 2013	–	OOTT #3 with LCC serial number 002
9	1 October 2013	3 months	Post TVAC test, OOTT #4
10	25 November 2013	8 weeks	Post EMI test, OOTT #5
11	17 December 2013	3 weeks	Abbreviated IM2, pre-G&I testing
12	18 February, 2014	4 weeks	Full IM2, post-G&I testing
13	8 April, 2014	7 weeks	Post Nadir level testing, OOTT #6
14	26 September, 2014	24 weeks	Post storage test, OOTT #7
15	31 January, 2015	18 weeks	Post installation onto spacecraft, OOTT #8

Courtesy of BATC

Ozone Mapping and Profiler Suite (OMPS)

Overview

Dr. Sarah Lipscy

Ball Aerospace and Technologies Corp.

OMPS Instrument Scientist &

OMPS Deputy Program Manager

August 26, 2015

Ozone Mapping and Profiler Suite (OMPS)

S-NPP OMPS

Nadir Sensor:
Nadir Mapper (NM) Spectrometer
&
Nadir Profile (NP) Spectrometer

Limb Profile (LP) Spectrometer

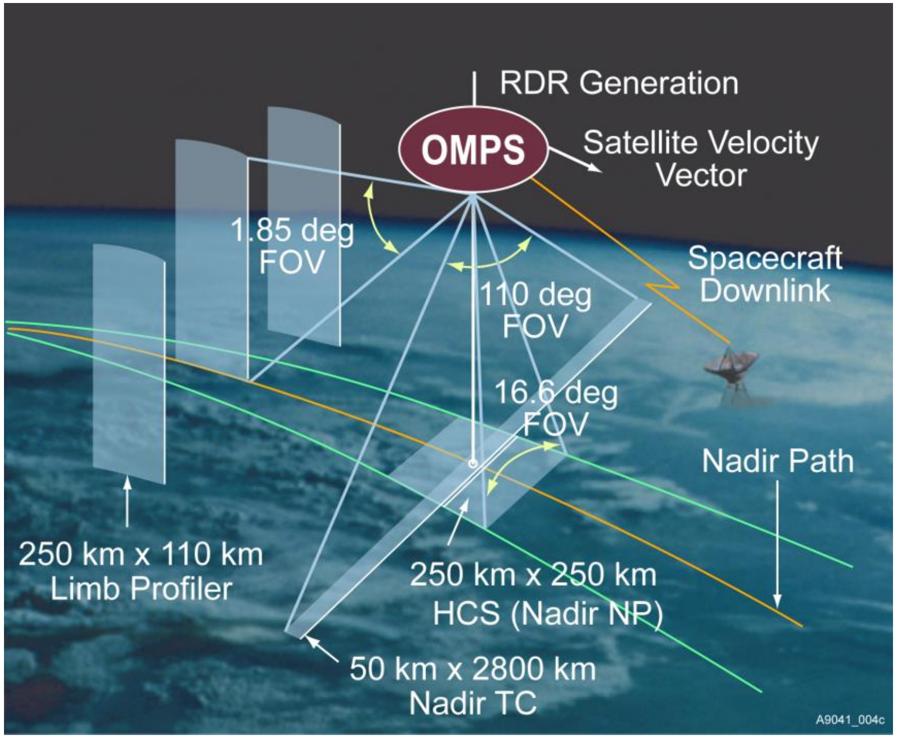
Main Electronics Box (MEB)

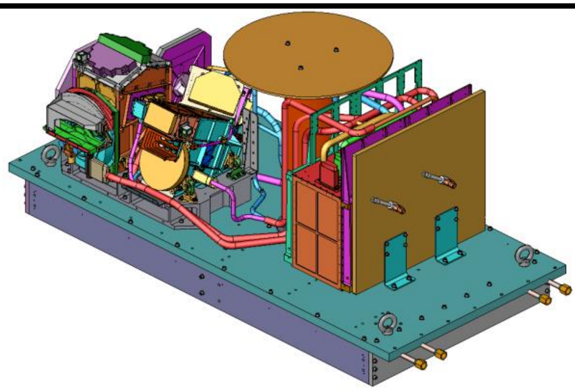
S-NPP Spacecraft

Satellite Velocity Vector

OMPS Configurations and Views

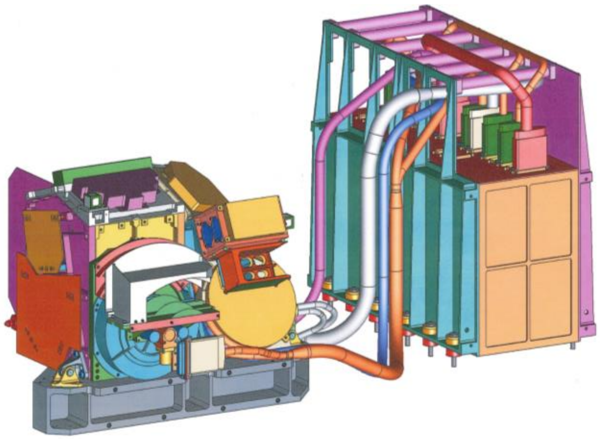
- **OMPS sensors - nadir and limb - use the same electronics box**
- **Nadir spectrometer footprints overlap**





S-NPP OMPS: Nadir and Limb sensors
- **Launched October 2011**

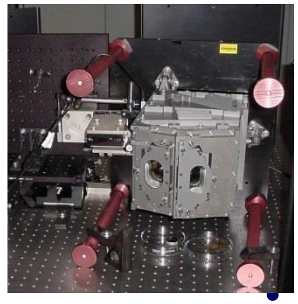
JPSS-2 OMPS: Nadir and Limb sensors



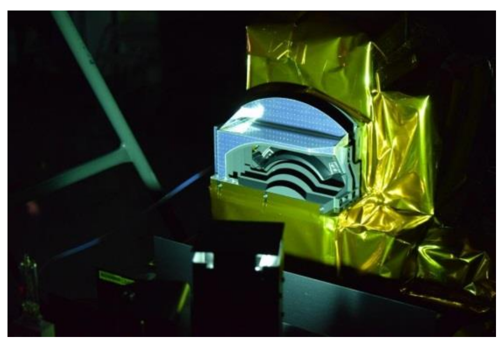
JPSS-1 OMPS: Nadir sensor only

Ball Aerospace's Role in OMPS

- **Spectrometers:**
  - Design
  - Integrate & Align
  - Characterize & Calibrate
  - Environmental Test
  - Modeling
  - Day 1 Calibration Tables (SCDBs)

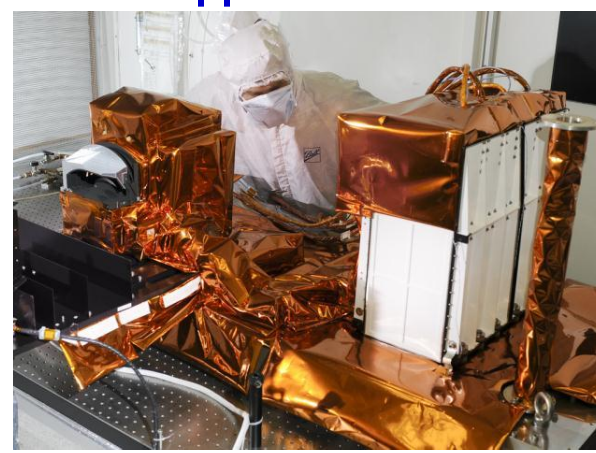


- **Focal Plane Assemblies:**
  - Procure Chip-on-Carriers
  - Design and build FPA
  - Environmental Test
  - Modeling
- **Electronics:**
  - Design
  - Integrate & Test
  - Environmental Test
  - Modeling



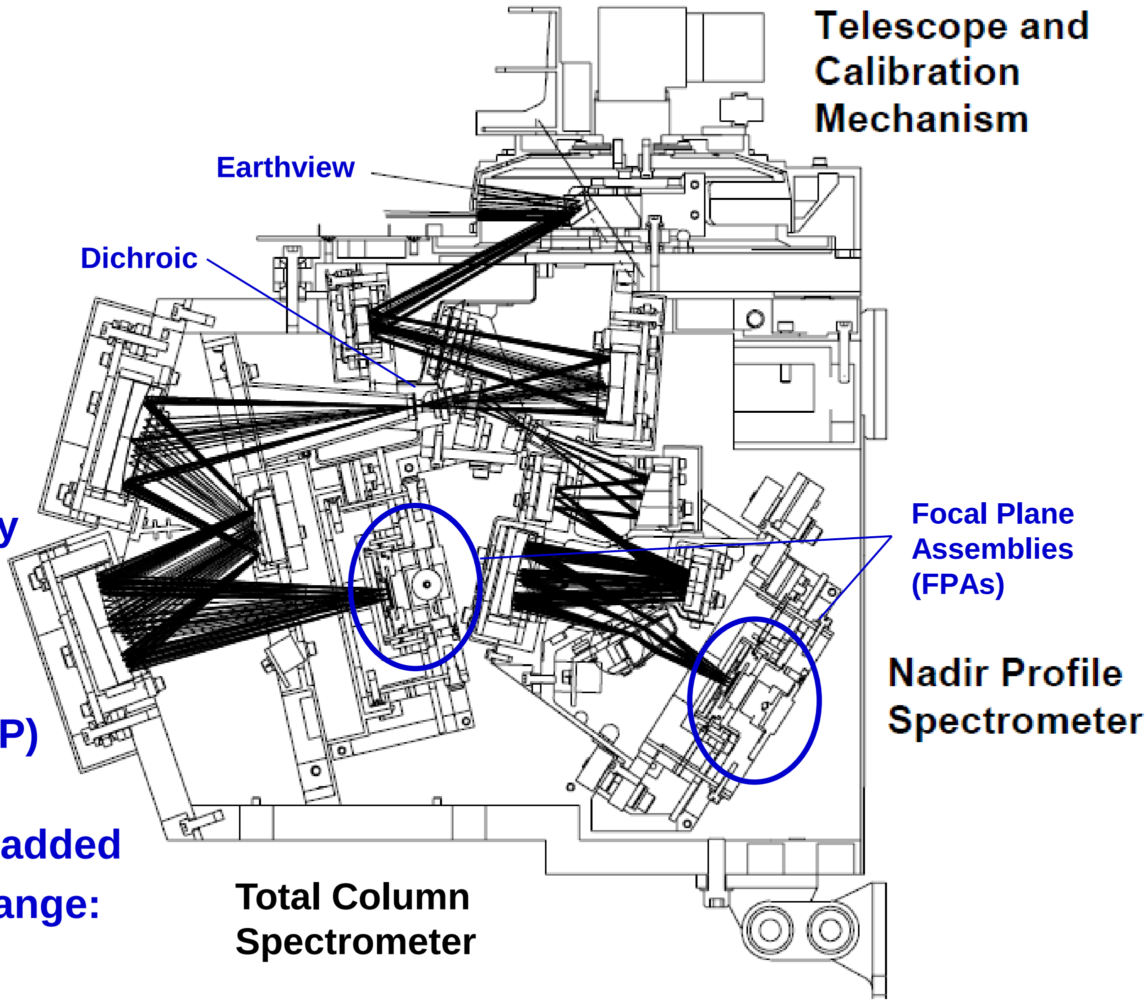
- **Integrated Sensor Suite**
  - Integrate
  - Environmental Test
  - Modeling
  - Day 1 CONOPS Tables

- **Post-Delivery Support**
  - Pre-Launch Support
  - Post-Launch Support



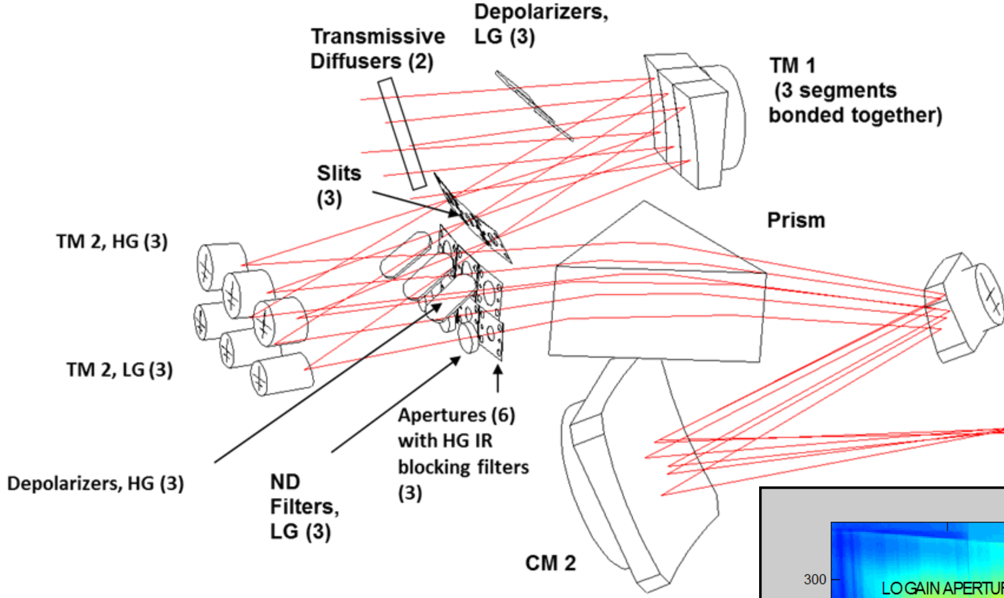
OMPS Sensors: Nadir Mapper and Profiler

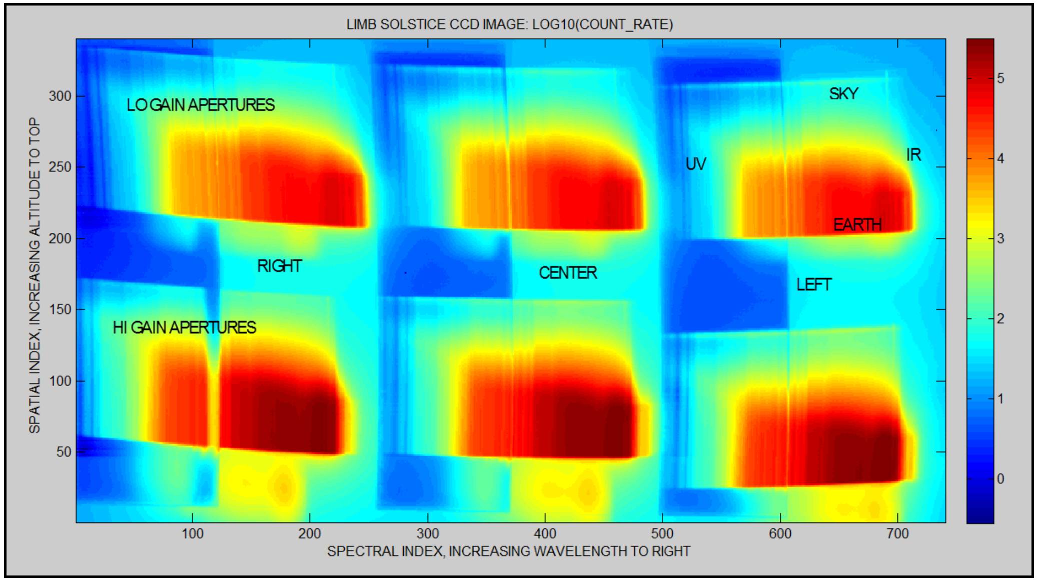
- Nadir Profiler (250 - 310 nm)
- Nadir Mapper (300 - 380 nm)
- Shared telescope; separate spectrometers and FPAs
- Shutter-less
- Changes S-NPP OMPS to J1 OMPS:
  - Diffuser: Al to QVD; ~67% reduction in irradiance and albedo calibration uncertainty due to decreased fine structure effects
  - Data Rate: Maximum rate increased from 196 kbps (NPP) to 409.6 kbps (J1)
  - Data compression capability added
  - NM Calibrated Wavelength Range: 380 nm to 417 nm (~420 nm)



OMPS Sensors: Limb Profiler

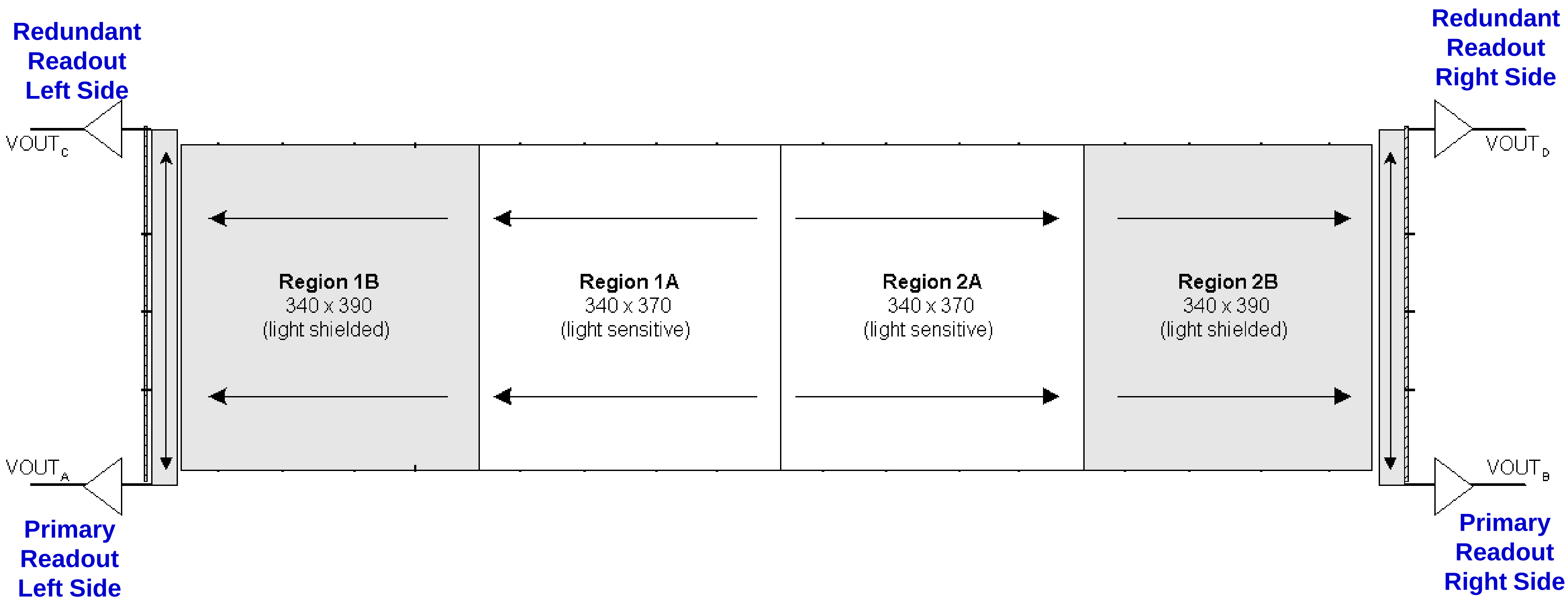
- Limb Profiler (290-1000nm)
- Single Focal Plane Assembly (FPA)
- Shutter-less
- No Limb Profiler on JPSS-1



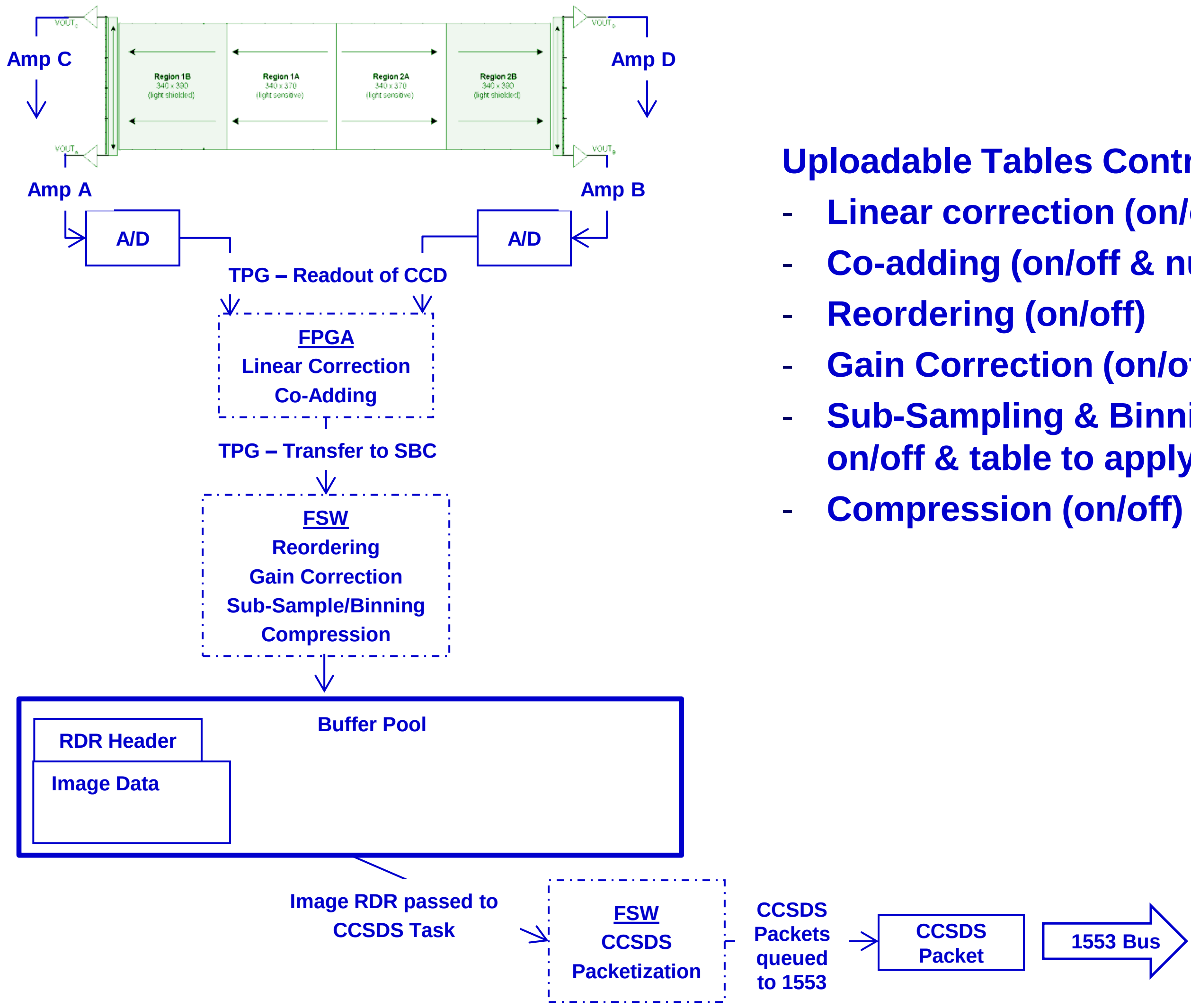


OMPS Focal Planes

- Operated at -45C (NP and LP) or -30C (NM)
- Custom split frame transfer CCDs operated in backside illuminated configuration. Two halves read out separately.
  - Binning can occur only along readout
- Equipped with anti-blooming drains



OMPS Image Data Flow



Uploadable Tables Control:

- Linear correction (on/off & table to apply)
- Co-adding (on/off & number)
- Reordering (on/off)
- Gain Correction (on/off & table to apply)
- Sub-Sampling & Binning (a.k.a. Sample Table; on/off & table to apply)
- Compression (on/off)

OMPS Flexibility

- **With the uploadable tables, OMPS is very flexible**
  - **TPGs: Integration times, Coadds, Binning, Sub-sampling, and Linearity Correction Tables**

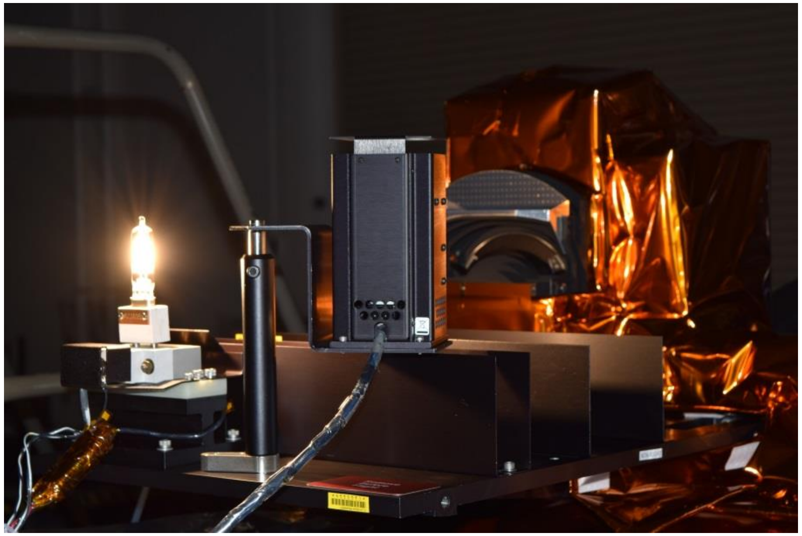
BATC-delivered Image Data Products	Along-Track Resolution	Cross-Track Resolution	Spectral Pixels
NM – NPP Earthview	Image every 7.5 seconds – (6 co-added frames of 1.25 seconds)	Each macro-pixel is binned from 20 individual pixels	196 wavelength pixels
NM – J1 "Hi-Res" Earthview	Image every 1.25 seconds - (No co-adding)	Each macro-pixel is binned from 5 individual pixels	210 wavelength pixels
NP – NPP Earthview	Image every 37.4 seconds – (3 co-added frames of 12.5 seconds)	All spatial pixels binned into a single "spatial" column	148 wavelength pixels
NP – J1 "Hi-Res" Earthview	Image every 7.5 seconds – (No co-adding)	Spatial pixels binned into 5 different "spatial" columns	148 wavelength pixels

With increased data rate allocation and available on-board data compression for OMPS J1, we have increased along-track resolution of Nadir Mapper Earthview image product by ~6x, and the cross track by ~4x – in addition to sending ~420 nm wavelength pixels.

  - **Stored Command Sequences (CBM): allow modification to on-orbit timing**
    - » **i.e. begin/end of Earthview imaging or calibration or change to activities on dark-side**

OMPS Status

- S-NPP OMPS: Performing on-orbit
- JPSS-1 OMPS: January 2015 successful integration to spacecraft
- JPSS-2 OMPS: Delivery Planned August 2018



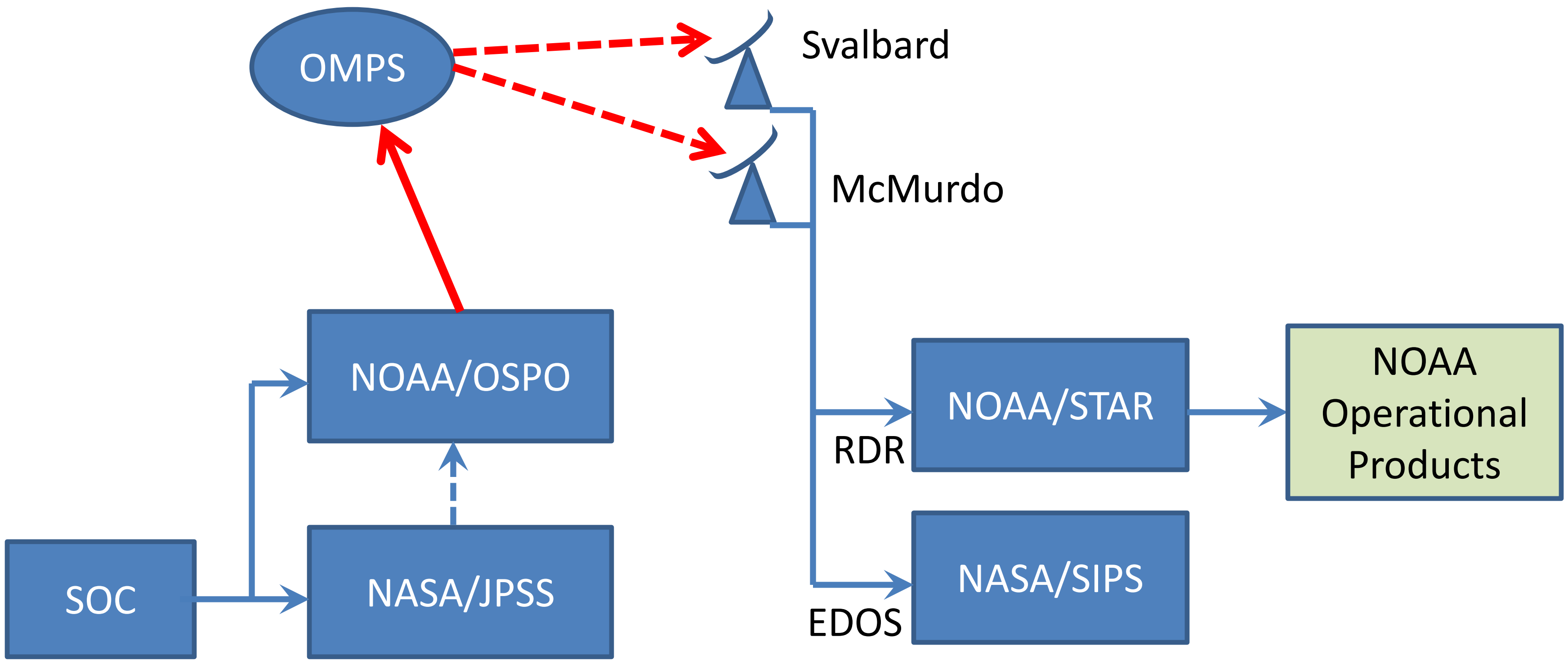
2015 STAR JPSS Annual Science Team Meeting

JPSS-1/OMPS Operations Plan

T.J. Kelly, G.R. Jaross

August 24-28, 2015

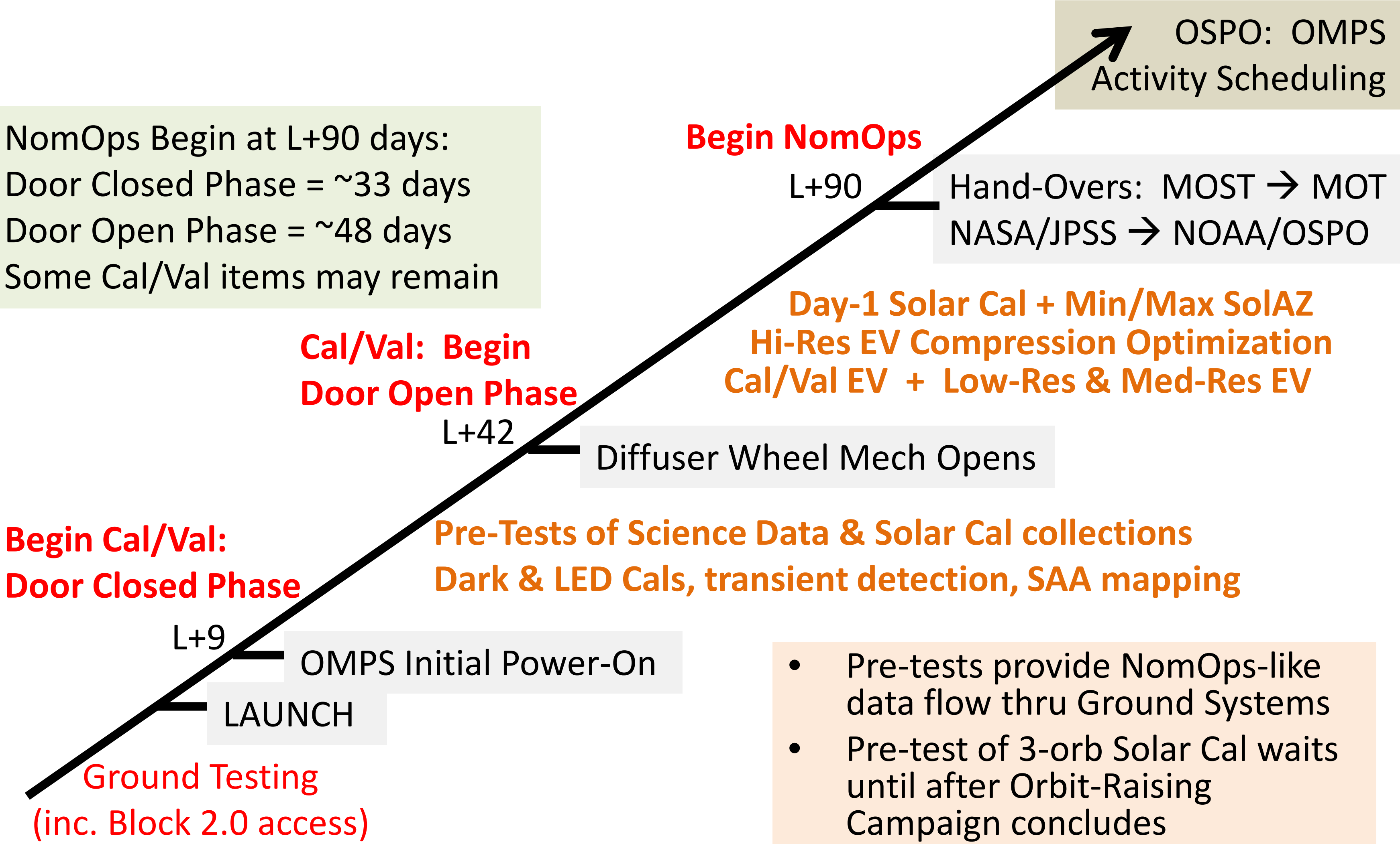
From OMPS Instrument Commands to NOAA Operational Products



- Support from NASA/JPSS to NOAA/OSPO concludes at the L+90 days Operational Hand-over

LEO&A/Commissioning Schedule

NomOps Begin at L+90 days:
Door Closed Phase = ~33 days
Door Open Phase = ~48 days
Some Cal/Val items may remain



- Pre-tests provide NomOps-like data flow thru Ground Systems
- Pre-test of 3-orb Solar Cal waits until after Orbit-Raising Campaign concludes

Post-Launch Tests (PLT) for Hand-Over: Subset of Cal/Val Activities

	Activity	Objective
Door Closed Phase ↓ 34 days	Instrument Activation	Demonstrate basic instrument functionality
	Trending	Instrument health and safety; pixel statistics of Dark & LED Cals, including LED lamp warm-up behavior
	Calibration	Instrument characterization: Dark & LED Cals, pixel statistics, transient detection, SAA, LED linearity, biases
	CBM pre-tests	*Preparations for Door Open Phase*
Door Open Phase ↓ 42 days	Trending	Add monitoring of wavelength registration
	EV Data Rate Optimization	Monitor compression rates, evaluate trial NM EV ST
	Noise Characterization	SNR estimates
	Dynamic Range	Check for possible saturation in EV and Solar
	Calibration	Add wavelength registration, Day-1 Solar, PRNU
	Geolocation/Pointing Accuracy	Evaluate location of pixels' observations
OAR at L+85	*Complete data collections*	*Processing & analyses completed for OAR*

PLT responsibilities belong to BATC, NASA & NOAA

J01/OMPS NomOps Activity Highlights: Similar to SNPP/OMPS

Science Data : Default for All Orbits		
Orbits	Dayside	Dark Cals
1 -14/15	EV_HI_RES	Door Open

Future mod:
Extend all EV Xtrack-FOVs past SolZA=88°

Preliminary Calibration Schedule				Solar Ref Cals
Week 1	**Week 2**	**Week 3**	**Week 4**	**Semi-Annual**
Solar-Work (QVD vs Al Diff?)		Solar-Work		Solar-Ref & Solar-Work
Door Closed Dark	Door Closed Dark	Door Closed Dark	Door Closed Dark	Door Closed Dark
	LED			

Dark Cals: Compare Door Open with Door Closed
Solar Cals: Compare J01/QVD vs SNPP Aluminum diffuser

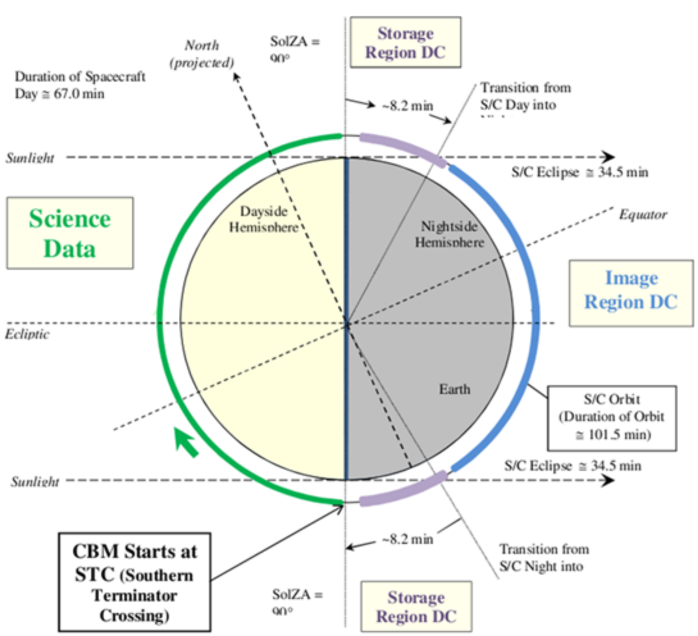
Potential Remaining Cal/Val Measurements:

- EV Data Rate Optimization (seasonally dependent)
- PRNU (seasonally dependent: Solstice $\pm$~6 weeks)
- Full-Frame EV Measurements

J01/OMPS NomOps: Science Data w/Dark & LED Cals

Figure 1. EV_HIRES

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



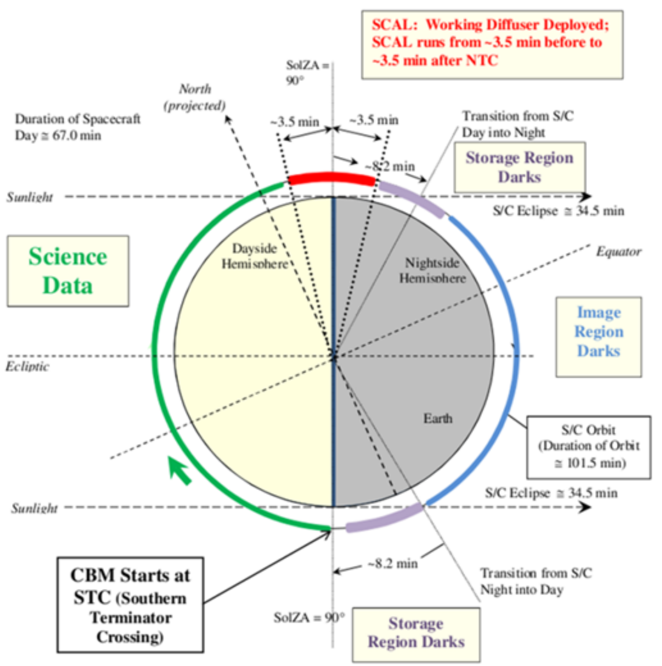
The orbit of the spacecraft around the Earth is shown, along with dayside Science Data (EV) and nightside Dark Cal (DC) activities, and with some orbital events identified. The Ascending Node of the orbit is on the dayside, so the direction of the orbit in the diagram is clockwise. The CBM begins at 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:
  - **EV_CLOSED_DARK** is Closed Door version
  - **EV_CLOSED_LED** collects LED Cals
  - Same dayside EV coverage

J01/OMPS NomOps: Science Data w/Solar Cals

Figure 4. EV_WRK_SCAL

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

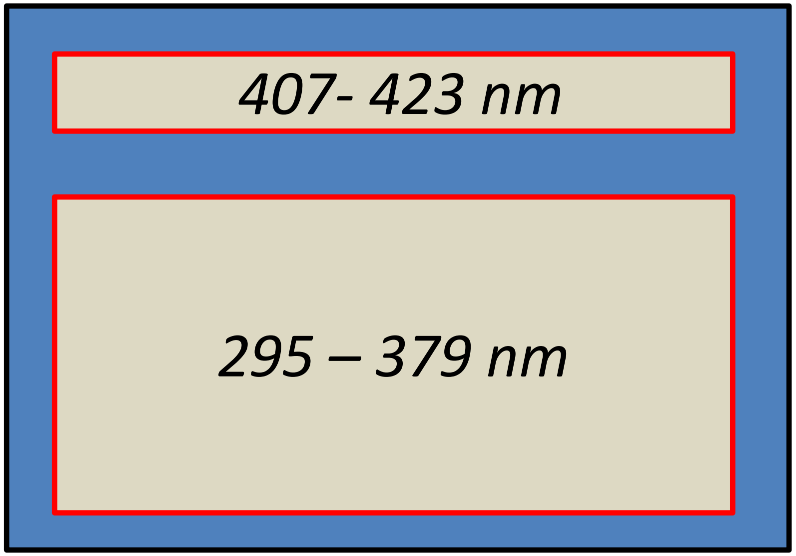


The orbit of the spacecraft around the Earth is shown, along with dayside Science Data (EV), Solar Calibration (SCAL) and DC Cal activities. The CBM begins at the STC, and collects Science Data, shown in green, on the dayside hemisphere, until approximately 4 min prior to the Northern Terminator Crossing (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

EV High-Res Data Collection



- EV Hi-Res Situation:
  - Maximize spatial resolution:
    - 147, BF=5 macro-pixels
    - 210 wavelength pixels
    - 30870 pixels (at data rate limitation)
  - Reduced Frame limits λ's from 295-423 nm
  - Limit insensitive λ 's
    - Sparse spectral: 2 λ regions

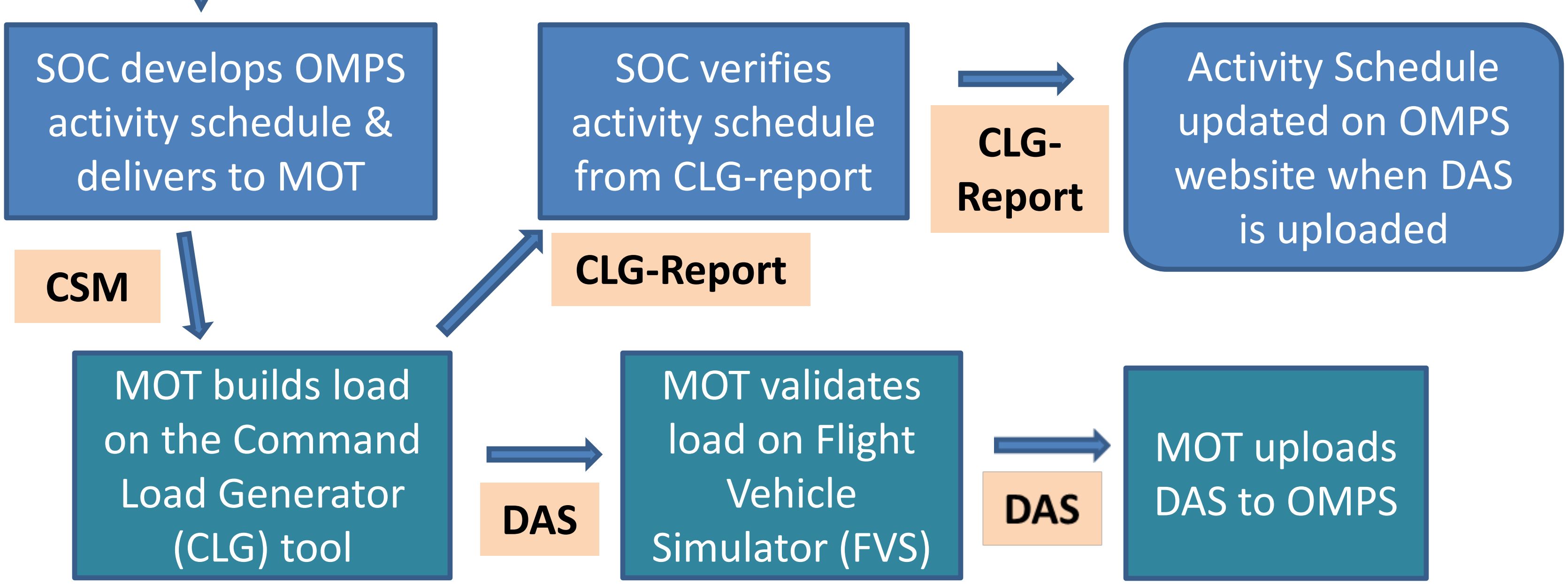
Possible enhancements:

- BATC assumes 2X compression, believe 2.2X achievable
- No BF=2 aerosol wavelengths (~4 λ's; ~892 additional macropixels)
- No accommodation for off-nadir FOV swell

OMPS Activity-Schedule Flow

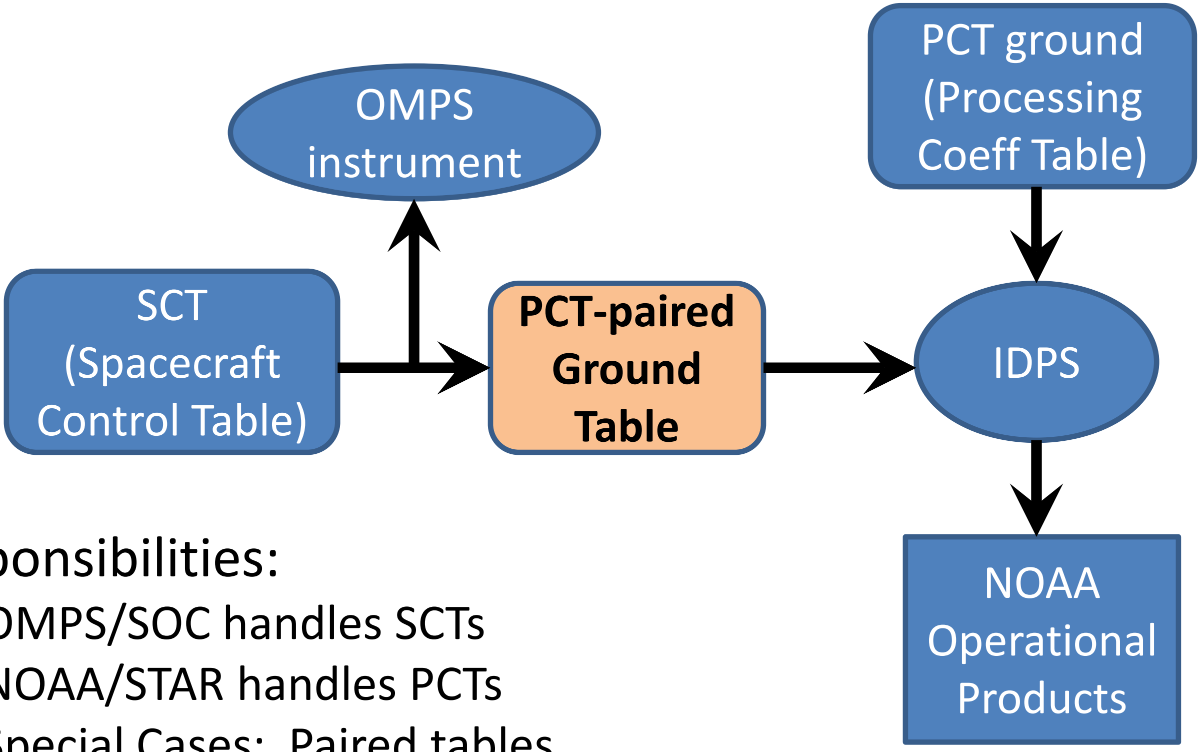
CSM Generation Input

- Southern Terminator Crossing (STC) information
- LP lunar observations predictions (only for SNPP & J02)
- OMPS observations schedule (~4-week cycle)
- Approximate semi-annual Solar Ref Cals, special obs., etc.



Weekly update cycle | CSM covers 23 days | DAS covers 16 days

OMPS Table Flow: General Case



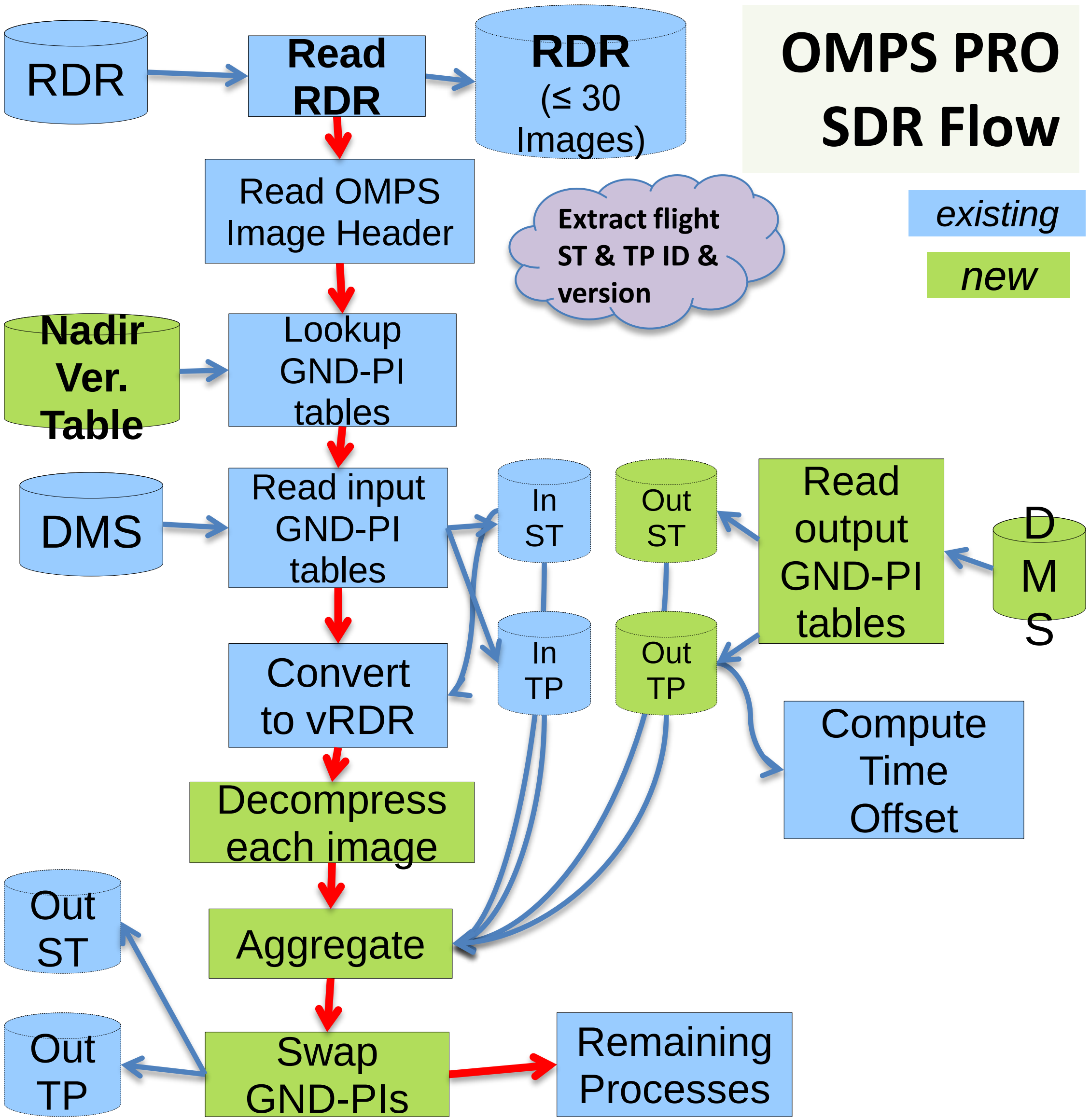
- Responsibilities:
  - OMPS/SOC handles SCTs
  - NOAA/STAR handles PCTs
  - Special Cases: Paired tables
- NOAA/STAR handles all ground tables EXCEPT PCT-paired tables

Block 1.2 to 2.0
GND_PI Table Transitions

GND_PI TABLES	BLOCK 1.2	BLOCK 2.0
Sample	SOC	SOC
Macro	"	SOC
Timing Pattern	"	SOC
CF_Earth	"	STAR
Wavelength	"	STAR
LUTS	STAR	STAR
DARKS	SOC → STAR	STAR

- Paired tables:
  - EV Sample table
  - EV Macrotable
  - EV Timing Pattern
- Block 2.0/Aggregator changed some PCT-paired tables to PCT only:
  - CF_Earth & Wavelength
- Block 2.0 changes go forward and are independent of J01 changes

EV Tables for Aggregator



- Aggregator will exist for SNPP irrespective of any new FSW upgrades
- Paired tables include both the input and output tables:
  - Input matches data
  - Output matches SDR
- 3 paired tables:
  - EV ST
  - EV Macrotable
  - EV Timing Pattern Table
- For output-side of paired tables, per NOAA/STAR's instructions:
  - SOC can supply output side of paired tables, or
  - STAR can supply to SOC

Backup Slides

- Notional On-Orbit Commissioning Timeline
- EV_HiResO3 Data Compression Sample: 1 Orbit
- EV Hi-Res ST Optimization
- Risk Mitigation

Notional On-Orbit Commissioning Timeline

L+0 to L+10

JPSS-1 Launch

Spacecraft Bus Commissioning

Spacecraft Subsystem Performance Tests

L+10 to L+40

Instrument Activation and Outgassing

Initial Power-On

OMPS/VIIRS: L+10
CrIS/ATMS: L+11
CERES: L+12

Final Orbit Insertion

Outgassing

OMPS: L+10 to L+48
VIIRS: L+10 to L+39
CrIS: L+11 to L+39
CERES: L+12 to L+39

Initial Instrument Performance Tests

ATMS: L+11 to L+33
Roll Calibration Maneuvers

L+40 to L+75

Instrument Commissioning

VIIRS/CrIS
L+40 Door Deploy
CERES
L+42 Covers Open
OMPS
L+48 Diffuser Open

JPSS-1 Instrument Specification Testing

ATMS: L+42 - L+50
CERES: L+42 - L+56
OMPS: L+49 - L+63
VIIRS: L+40 - L+75
CrIS: L+40 - L+75

Calibration Maneuvers

L+75 to L+90

NOAA Operational Science Testing

JPSS-1 Instrument "Operationally Ready"

ATMS: L+55
CERES: L+55
OMPS: L+63
VIIRS: L+75
CrIS: L+75

L+80 to L+90 MOST-to-NOAA Operations Transition

L + 85 JPSS-1 Operational Acceptance Review (OAR)

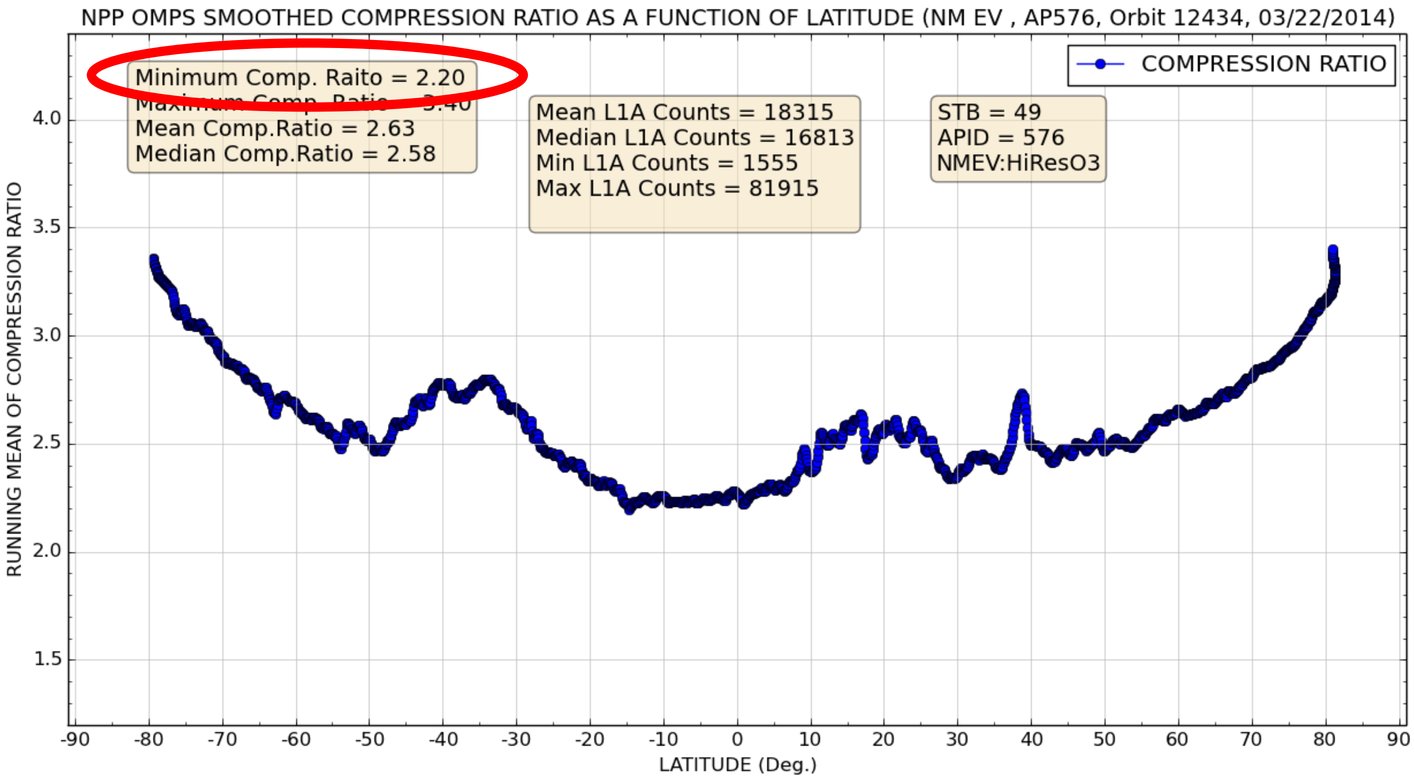
L+90

JPSS-1 Operational Handover Review

JPSS Program to NOAA/OSPO

<- - - - Post Launch Testing (PLT) - - - ->

EV_HiResO3 Data Compression Sample: 1 Orbit



EV Hi-Res ST Optimization

Data Rate Estimates: Compression-Rate Dependent						
BATC tests used a non-optimized value = 2				30870 EV macro-pixels		
Non-compressed estimate = 15435/coadd_IT				coadd_IT = 1.25 sec		
	Data Compression Rate					
Compression Rate	1.0	2.0	2.1	2.2	2.3	2.4
Net No. of Pixels	15435	30870	32413	33957	35500	37044

- Optimization Limitation:
  - If can't get the compressed packets thru in time, the TP halts & Science Data stops

- Create *trial* EV Hi-Res STs w/more pixels (& compression rate needs)
  - Run trial STs on-orbit as Diagnostic Science data
  - Configuration: Use available, alternate ST slots
  - Benefits:
    - Pre-load STs in advance (avoid space weather delays)
    - Monitor with MOT ground controllers

Risk Mitigation, etc.

- Risk Mitigation
  - Diffuser Wheel Mech stays closed until just prior to Door Open Phase
    - *All-Mech-Positions-Closed* MECH OPTIONS TABLE loaded (follow in APID 544)
    - Solar *peeks* not in current plan, but could be (done on SNPP)
  - Tracking of Diffuser Wheel Mech movement budget
  - Follow instrument TLM health and safety (follow in APID 544)
  - SOP: No NVM table uploads during S2 solar activity level or greater
  - SOP: OMPS is safed in case of any maneuver (RMM, ColA, DMU, etc.)
  - BATC can test new ST/GT/TP/etc. on BB in advance

- Optimizations
  - Pre-load CBM activities when possible
  - Diag EV CBM to test *trial* EV ST

OMPS J01 SDR Algorithm Implementation

OMPS-TC-SDR and OMPS-NP-SDR

Trevor Beck

August 26, 2015

Outline

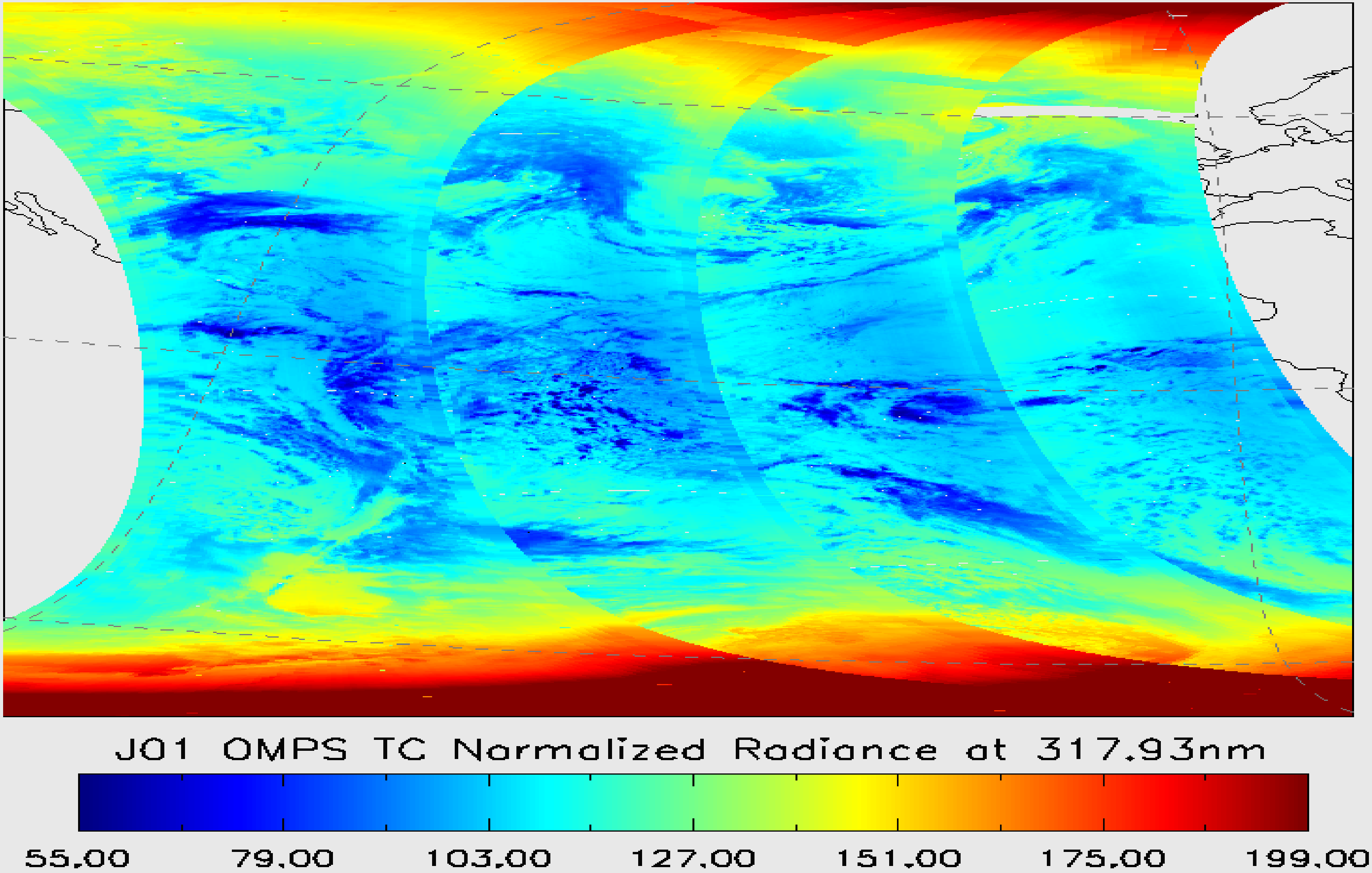
- NOAA STAR responsible to provide updates for IDPS SDR processor to handle JPSS1 OMPS for TC and NP
- JPSS1 OMPS has significant changes in the RDR format, primarily Rice compression of instrument counts.
- Star developed code updates for TC and NP SDR using ADL.
- The SDR processor has been implemented and passed important tests using J01 proxy data and J01 electronics test data.
- Backward compatible with NPP is required: One executable handles both NPP and J01
- This work has three broad components:
    1) Understanding the J01 RDR format and test data
    2) NP SDR Changes: 5x5, new tables, spacecraft ID
    3) TC SDR specific changes: sparse spectral, aggregation, new tables

- Summary of results and methods.

J01 TC-SDR Updates

- New APID values.
- Updated image/engineering headers for FSW6
- Rice Decompression on instrument counts
- Pixel aggregation, temporal and spatial.
- Updated straylight algorithm to handle sparse spectral
- J01 GroundPi and LUTs (work in Progress)
- Wavelength table improvement using thermal model.
- 13 orbits medium resolution TC-RDR tested
- 13 orbits high resolution TC-RDR tested.

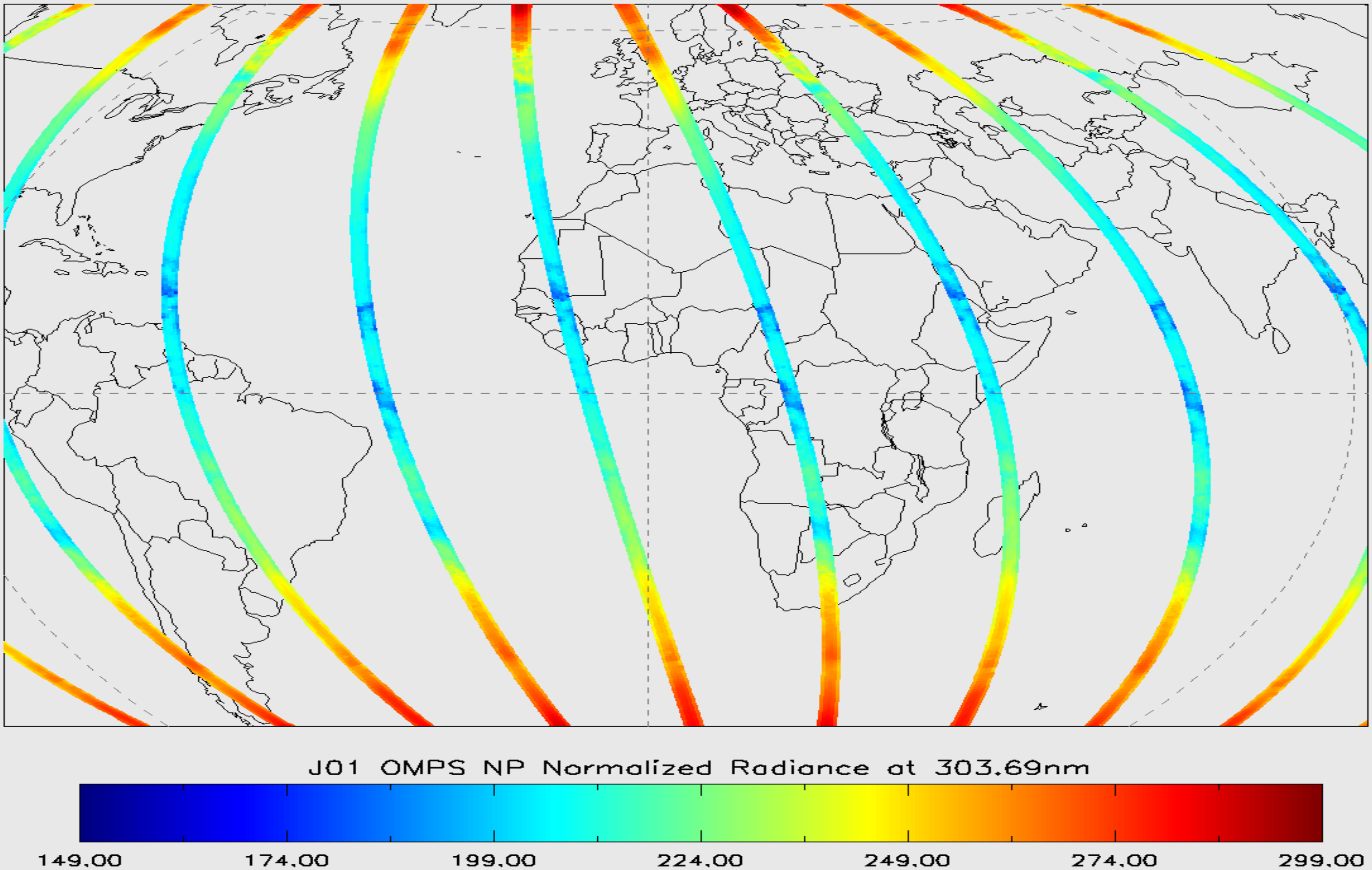
103 x 15 TC SDR Radiance



J01 NP-SDR Updates

- New APID values.
- Updated image/engineering headers for FSW6
- Rice Decompression on instrument counts
- J01 GroundPi and LUTs (work in Progress)
- 13 orbits medium resolution NP-RDR (NPP Proxy)
- 13 orbits medium resolution NP-RDR (BBMEB)

NP-SDR 5x5 Radiance



OMPS RDR Format Change

- J01 OMPS will use FSW6.0(Flight SoftWare 6.0).
- FSW6.0 introduces compressed instrument counts using Rice Compression(SZIP2.1).
- Image/engineering headers very similar but code to parse them needs to be updated.
- FSW6 introduces at least 14 new APIDs, two existing APID values have a modified format.
- Eight of the new APID will not be implemented in ADL/IDPS.

Version	APID	J01	Compression
FSW 3.6	560 TC-RDR		
FSW6.0	560 TC-RDR	x	NO
FSW6.0	592 TC-RDR-RF	x	NO
FSW6.0	608 TC-RDR-RF	x	YES
FSW6.0	616 TC-RDR	x	YES

OMPS RDR Format Change

Version	APID	J01	Compression
FSW 3.6	561 NP-RDR		
FSW6.0	561 NP-RDR	x	NO
FSW6.0	593 NP-RDR-RF	x	NO
FSW6.0	609 NP-RDR-RF	x	YES
FSW6.0	617 NP-RDR	x	YES

- J01 nominal RDR will be compressed
- Instrument vendor supplied documentation on how the counts were compressed
- The compression algorithm is the same as VIIRS but the implementation is simpler for OMPS, they use different compression parameters.
- Szip compression is part of the CCSDS standard.

OMPS RDR Test Data

- NASA Test data group created 42 hour test with 26 orbits useful for developing J1 OMPS capability in the IDPS SDR processor.
- First task: create a J1 RDR reader to find out what is in the data.
- High level summary of the test datasets used

Description	NmacroPixel	Spectral x Spatial	nTimes	Source
TC RDR MedRes	10042	61 x 156	30	NPP
TC RDR HiRes	30870	147 x 208	30	J1 Electronics
NP RDR MedRes	894	147 x 5	5	NPP
NP RDR MedRes	942	157 x 5	5	J1 Electronics

OMPS-RDR Test dataset Cont'd

- Two source of test data: NPP measured or BBMEB in lab prototype with J1 electronics
- TC has medium spatial resolution and high spatial resolution.
- Data was supplied in both compressed and uncompressed formats.
- TC data uses a timing pattern of 30 scans per 37 second granule. Current NPP TC-RDR uses 5 scans per 37 seconds granule.
- NP data uses a timing pattern of 5 scans per 37 second granule.

TC Med Res/Hi Res in IDPS

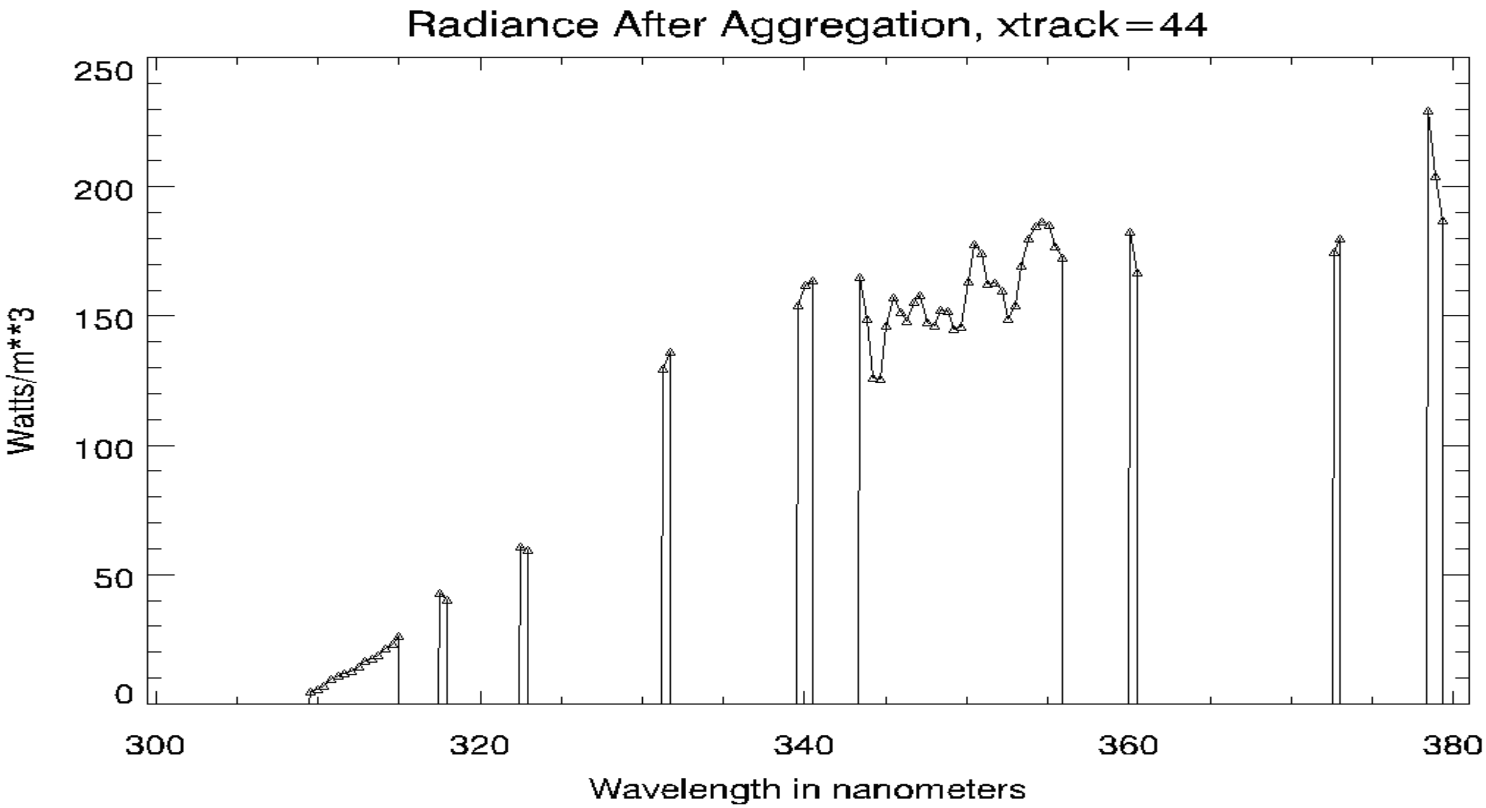
- OMPS TC SDR in IDPS has a size restriction of 260 wavelengths by 15 scans along track by 105 cross track pixels. Both OMPS J01 spatial dimensions are expected to exceed this limit in the nominal earthview mode.
- NASA PEATE proposed a solution using pixel aggregation.
- Along track pixels will be temporally aggregated to reduce spatial resolution.
- Across track pixels will be aggregated to fit within the 105 spatial limit.
- NASA PEATE supplied demonstration code and NOAA STAR implemented and tested it in the ADL/IDPS framework.
- Pixel aggregation is done in units of counts. It occurs as part of the VerifiedRDR creation. Pixels are aggregated and geolocation is established prior to the SDR science code.

TC Med Res/Hi Res in IDPS

- In the current J01 Block2 SDR implementation the TC-RDR temporal aggregation takes 30 scans per granule and aggregates to 15 scans per granule, it effectively doubles the ground pixel size in the along track dimension.
- The across track dimension is aggregated to 103 spatial pixels. Both high resolution mode and medium resolution TC earthview modes will be aggregated to 103 spatial cross track by 15 along track.
- The NP SDR processor will not have spatial aggregation, it fits within the existing 5 scans by 5 across track size limit defined by the IDPS.

TC-SDR Sparse Spectral

- A new feature of the J01 TC-SDR is the sparse spectral coverage. There will be groups of measurements that will not be downlinked to ground.
- The straylight algorithm was updated to work with sparse spectral measurements.
- The following image shows the SDR radiance for a sparse spectral case, there are eight spectral gaps.
- Test data has 61 measurement wavelengths.



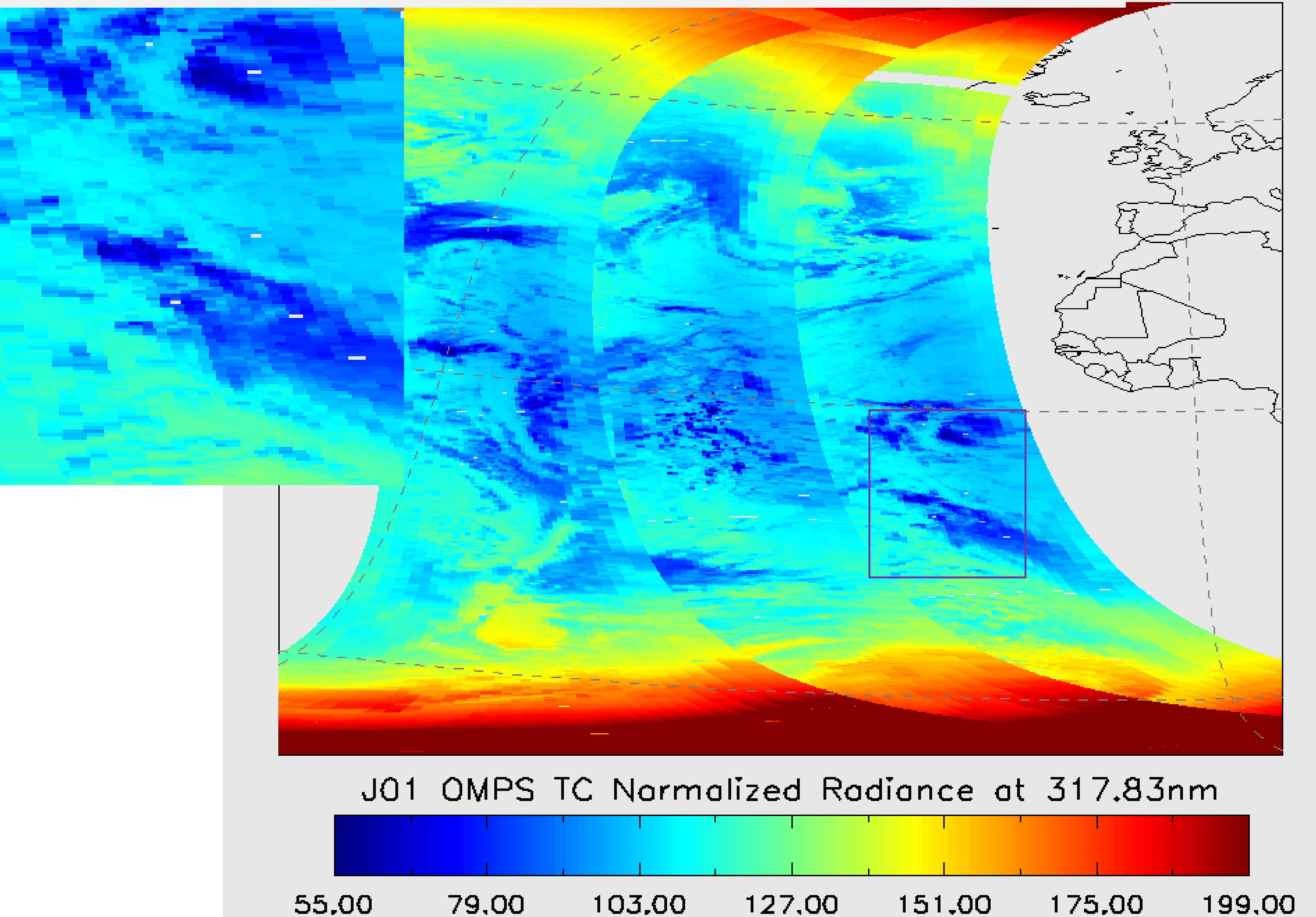
Sparse Spectral for TC

- Our medium resolution test data has 61 wavelengths. The aggregation maps the 61 values onto the full spectral range of 364 wavelengths.
- This allows the RDR to limit spectral coverage in order to increase spatial resolution.
- Sparse spectral is handled as part of the spatial aggregation algorithm. The sample table and macro tables will double in size relative to the NPP SDR tables. The dual tables have an input component that describes the where the measurements originate on the CCD detector. The output component of the dual table describes where the pixels will map to on the CCD detector.
- At runtime the dual tables control how the pixel aggregation is performed.
- There is a timing pattern dual table that controls how the temporal pixel aggregation.
- In summary there are three dual tables that control pixel aggregation:
  - OMPS-TC-TIMINGPATTERN-GND-PI
  - OMPS-TC-MACROTABLE-GND-PI
  - OMPS-TC-SAMPLETABLE-EV-GND-PI

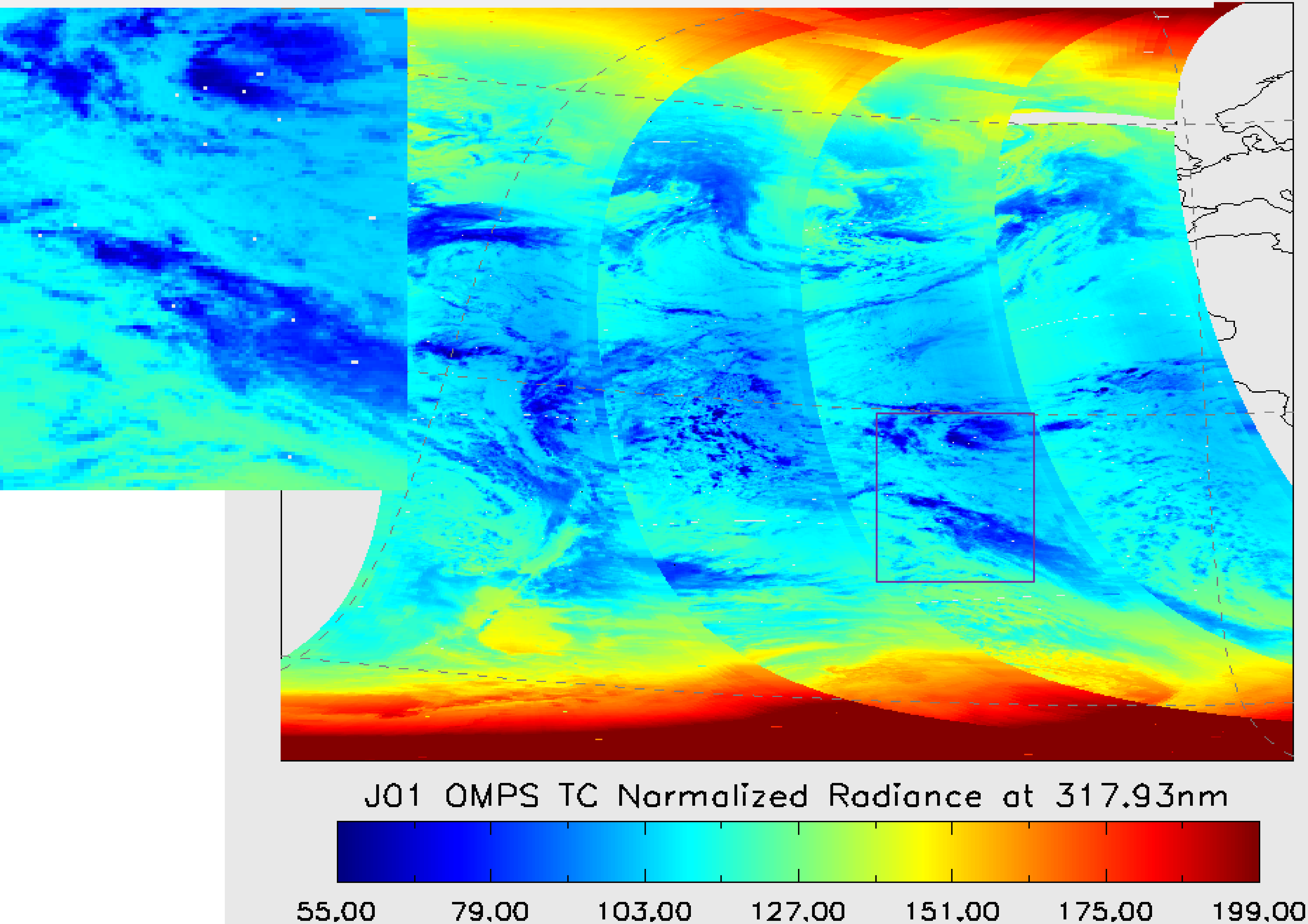
J1 Ground Pixel Resolution

- NP SDR goes from 1 pixel per granule to 25 pixels per granule
- TC SDR goes from 35x5 ground pixels per granule to 103x15(from 175 ground pixels to 1545 ground pixels per granule)
- Following slides demonstrate qualitative increase in spatial resolution for TC-SDR. In the next slide the TC-SDR has been aggregated to 35 x 5. The subsequent slide is aggregated to 103 x 15.

Three orbits with current low resolution 35 cross-track x 5 along-track FOVs.



Four orbits with current medium resolution 103 cross-track x 15 along-track FOVs.



Summary

- NOAA STAR worked in collaboration with multiple partners to develop and implement the JPSS1 OMPS TC and NP SDR processor.

- The NASA Peate provided the initial aggregation algorithm. BATC provided us the necessary documentation to understand the format. Raytheon helped implement the changes for ADL/IDPS. Star AIT assisted with testing and code deliveries.

- Algorithm readiness review in September.

- J01 SDR algorithm is ready for both TC and NP
  - Algorithm has been Tested for software validation and a limited amount of geophysical validation
  - Delivered to DPES for further operational testing
  - Currently in block2 integration

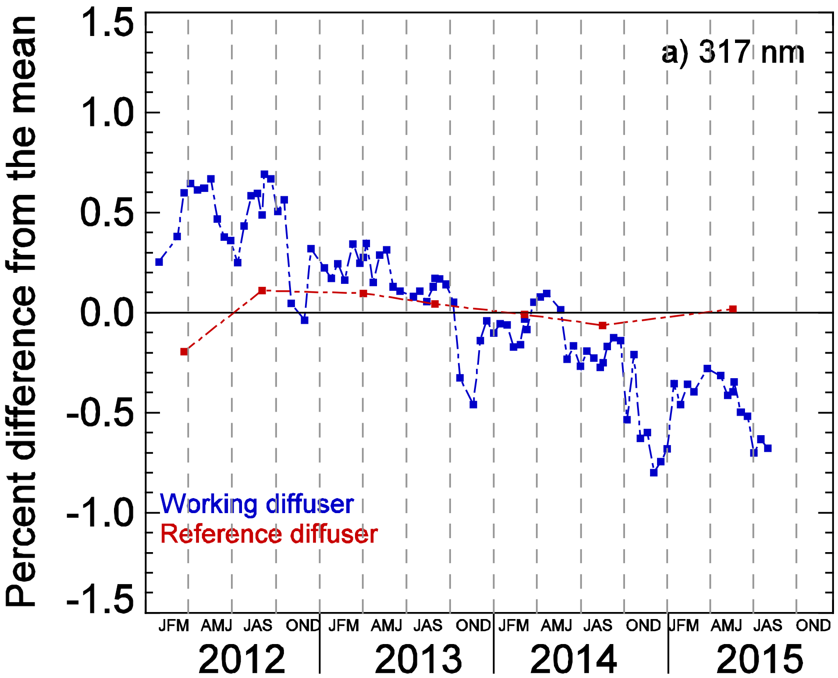
Path Forward

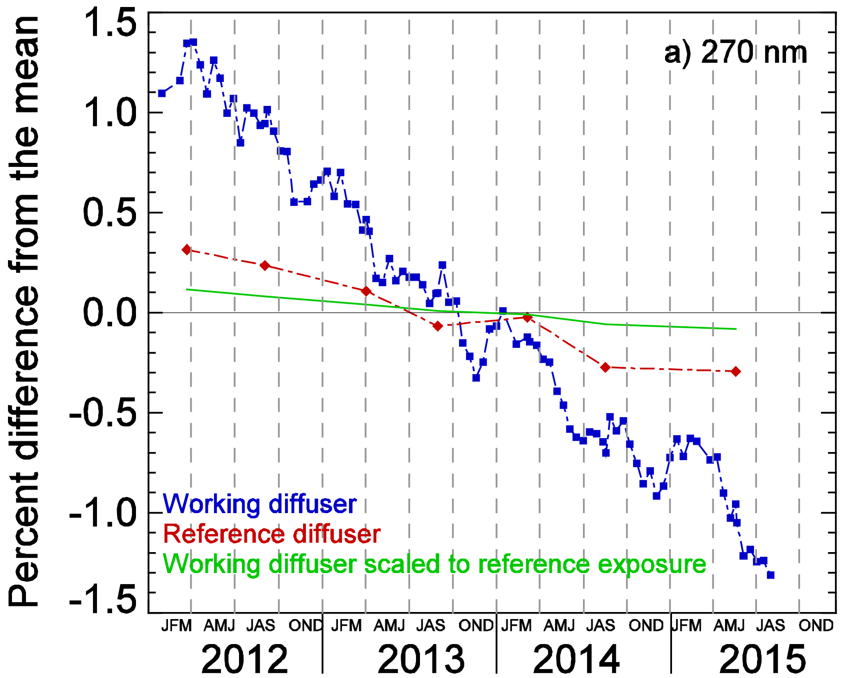
- We are working to further test and verify the algorithm lookup tables
- End-to-end RDR to EDR test in progress.

OMPS Nadir Radiometric Calibration

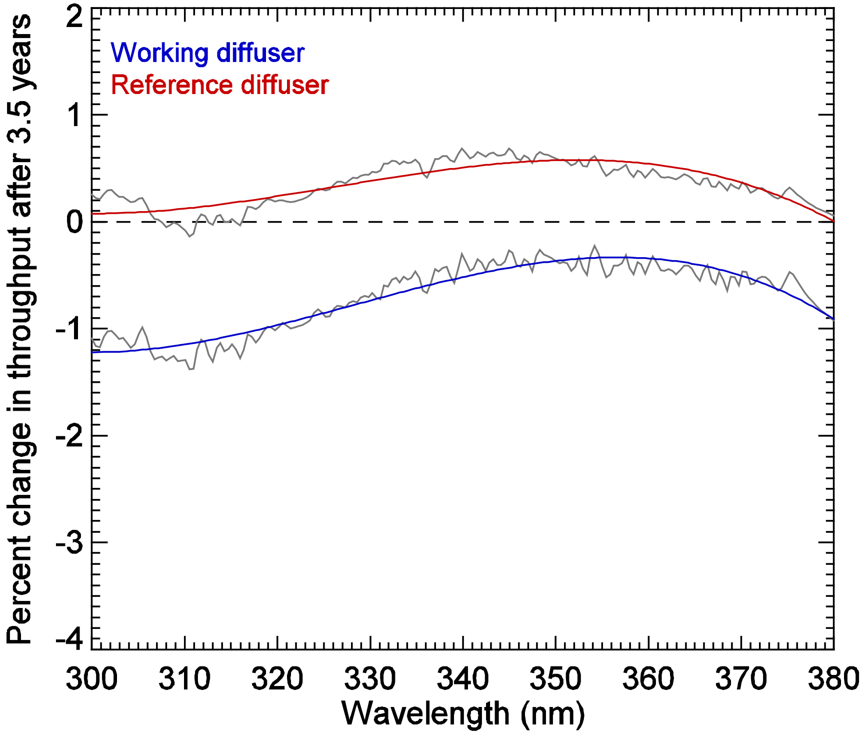
Colin Seftor, Glen Jaross, Liang-Kang Huang,
Rama Mundakkara, Mark Kowitt

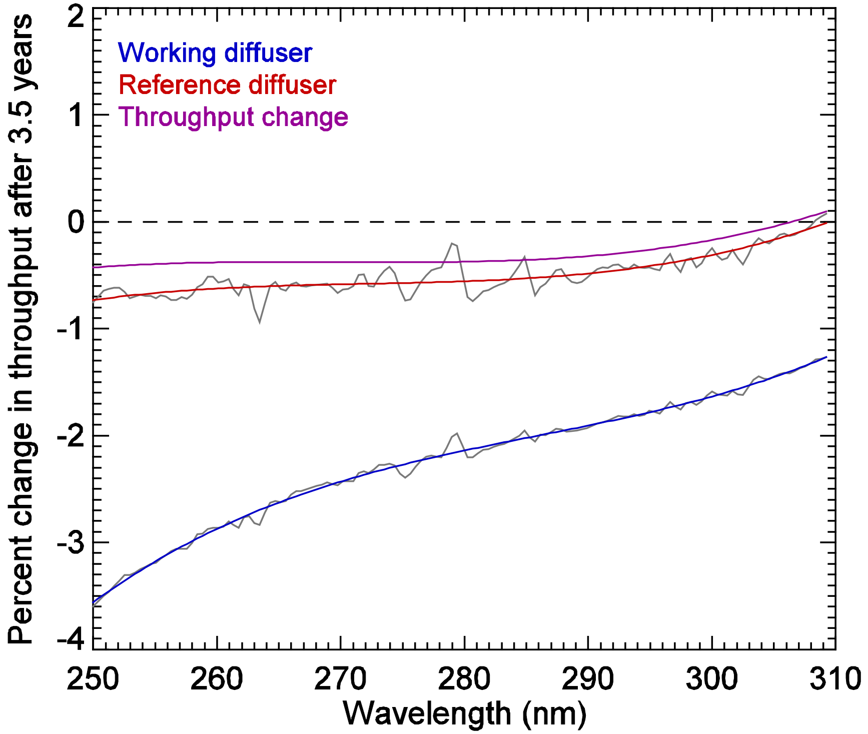
Both the NM and NP sensors are extremely stable



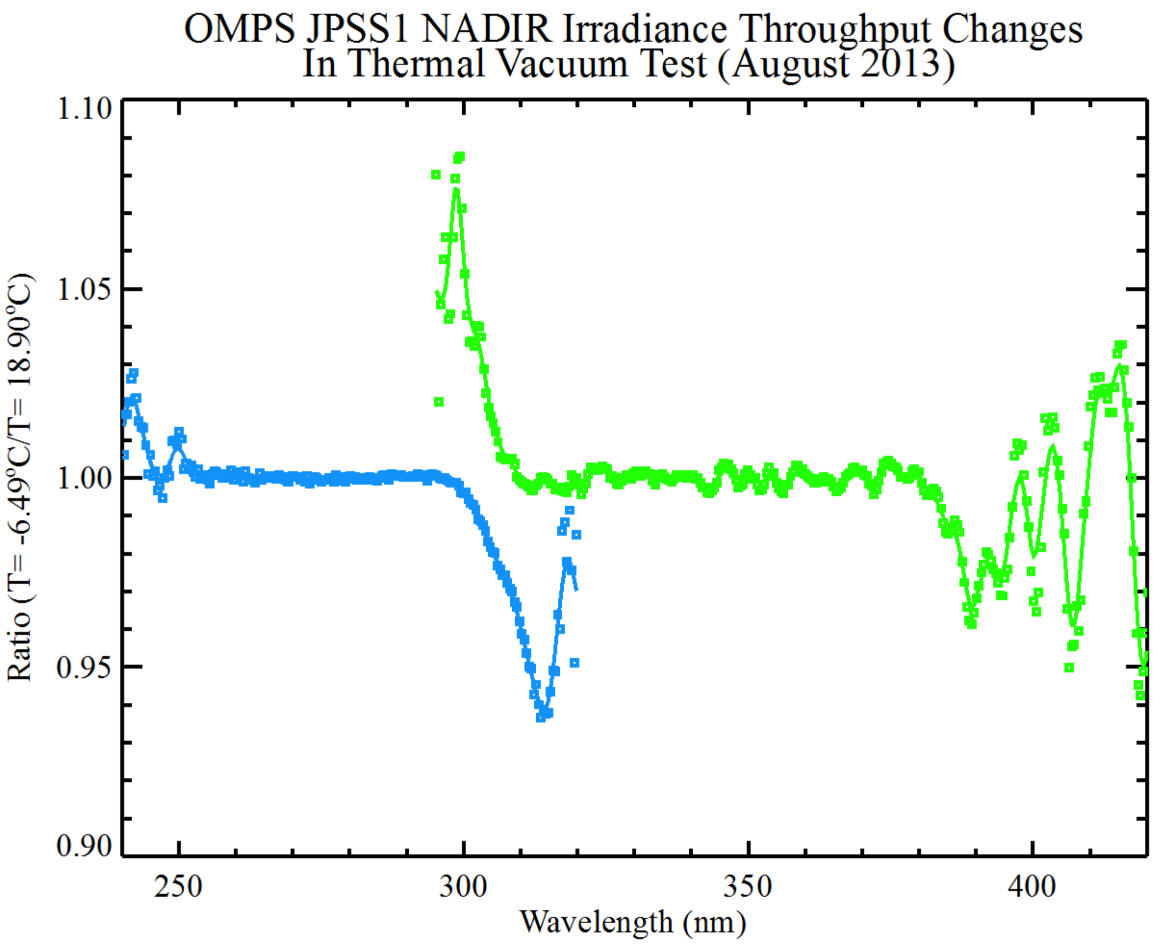


Both the NM and NP sensors are extremely stable



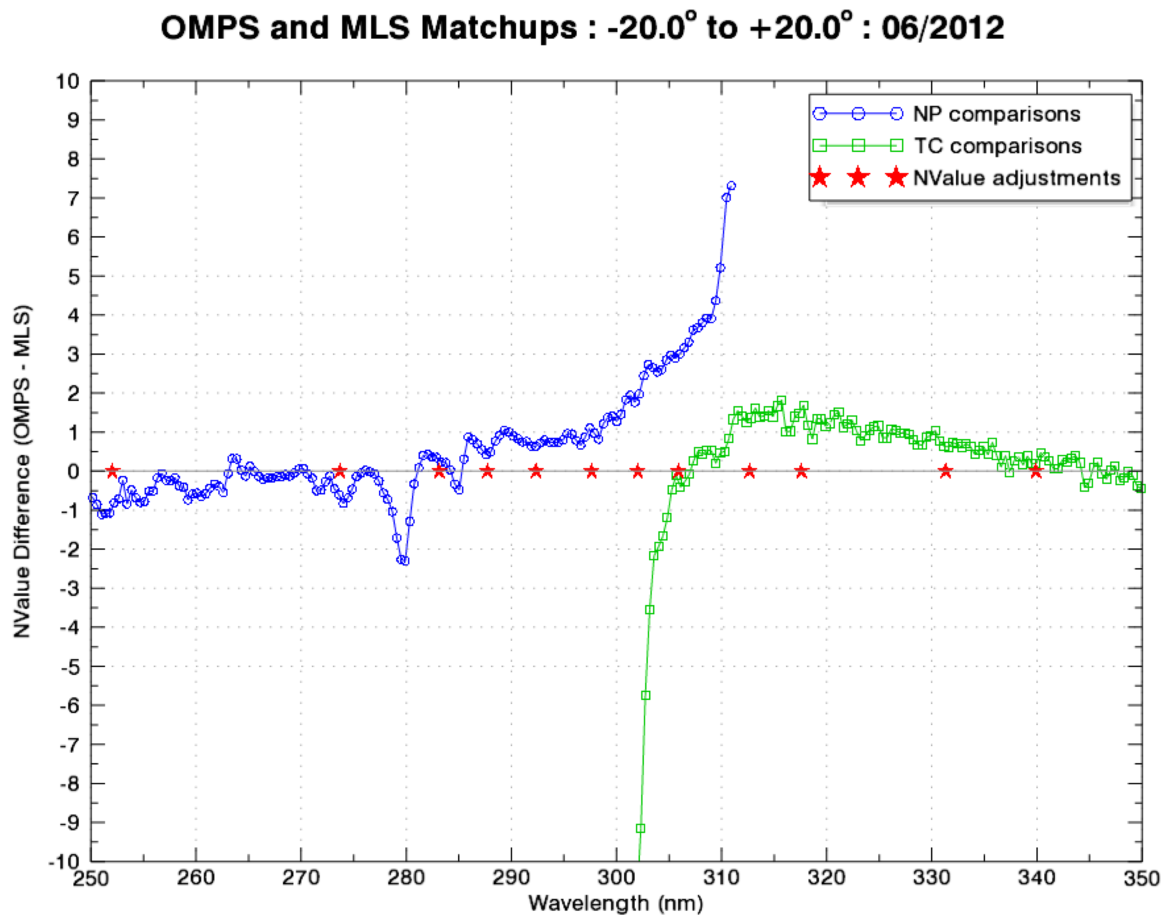


Adjustments needed to account for changes in throughput, particularly in dichroic region

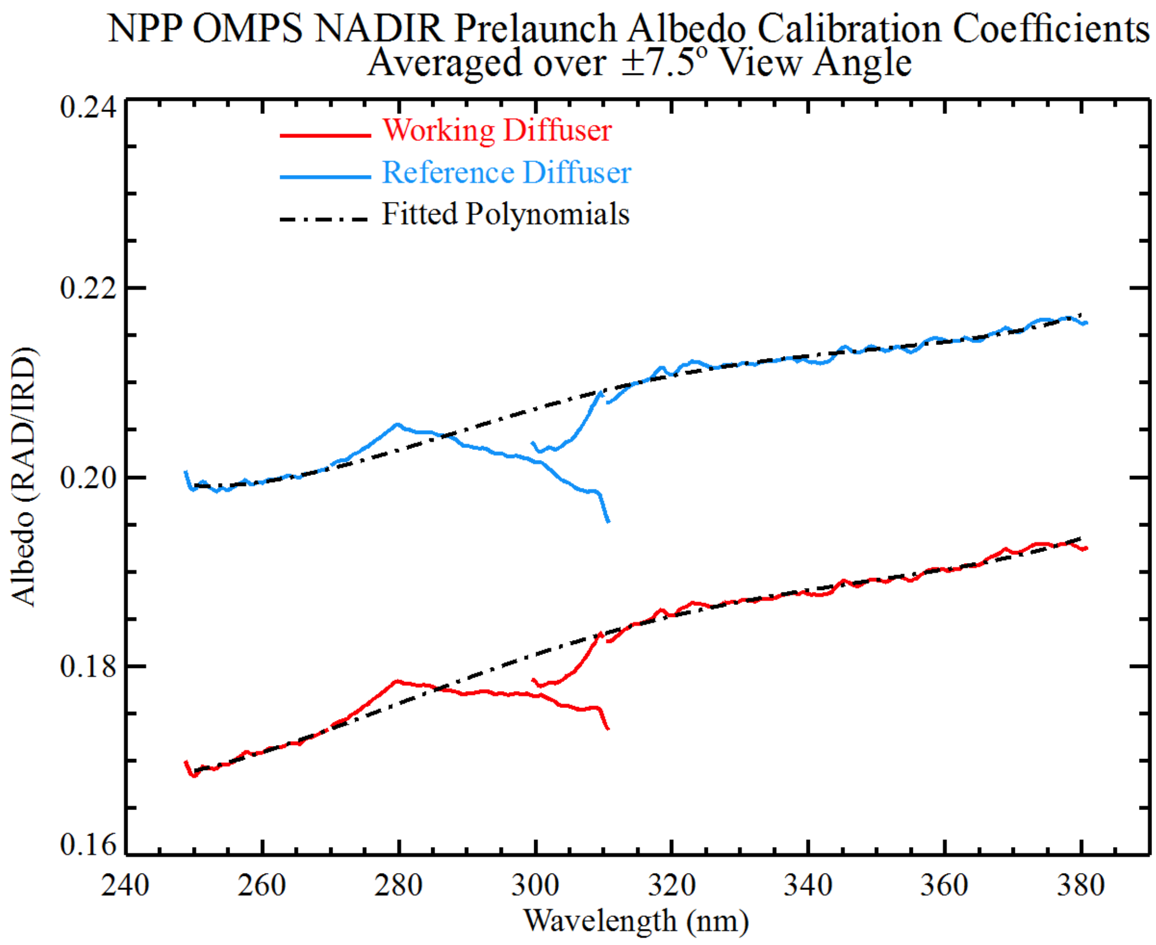


V1 OMPS/MLS matchup comparisons showed problems unrelated to dichroic adjustment

- MLS ozone/temp profiles from matched up dataset used in radiative transfer calculations of normalized radiances
- Calculated NR compared to OMPS measured NR
- N values difference compared
    - $N = -100\log_{10}(NR)$
    - $\Delta N = -2.3\%$ radiance difference

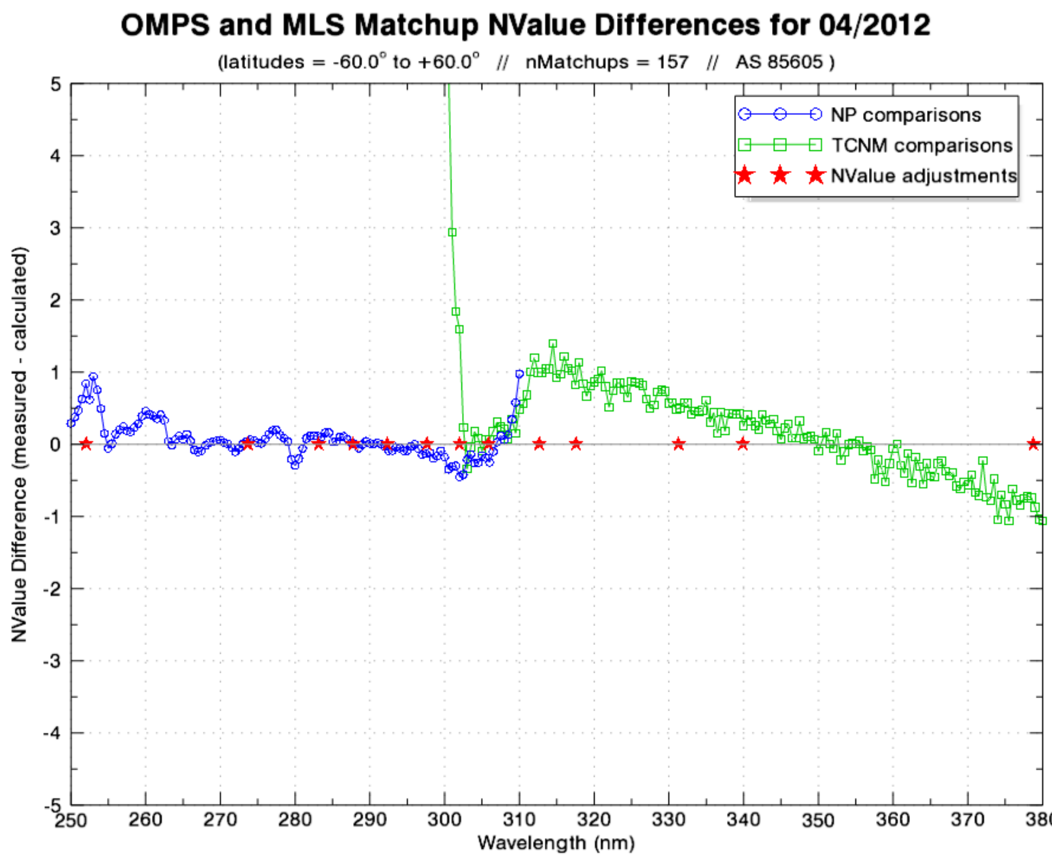


Adjustments needed to account for "unphysical" behavior of cal coefficients

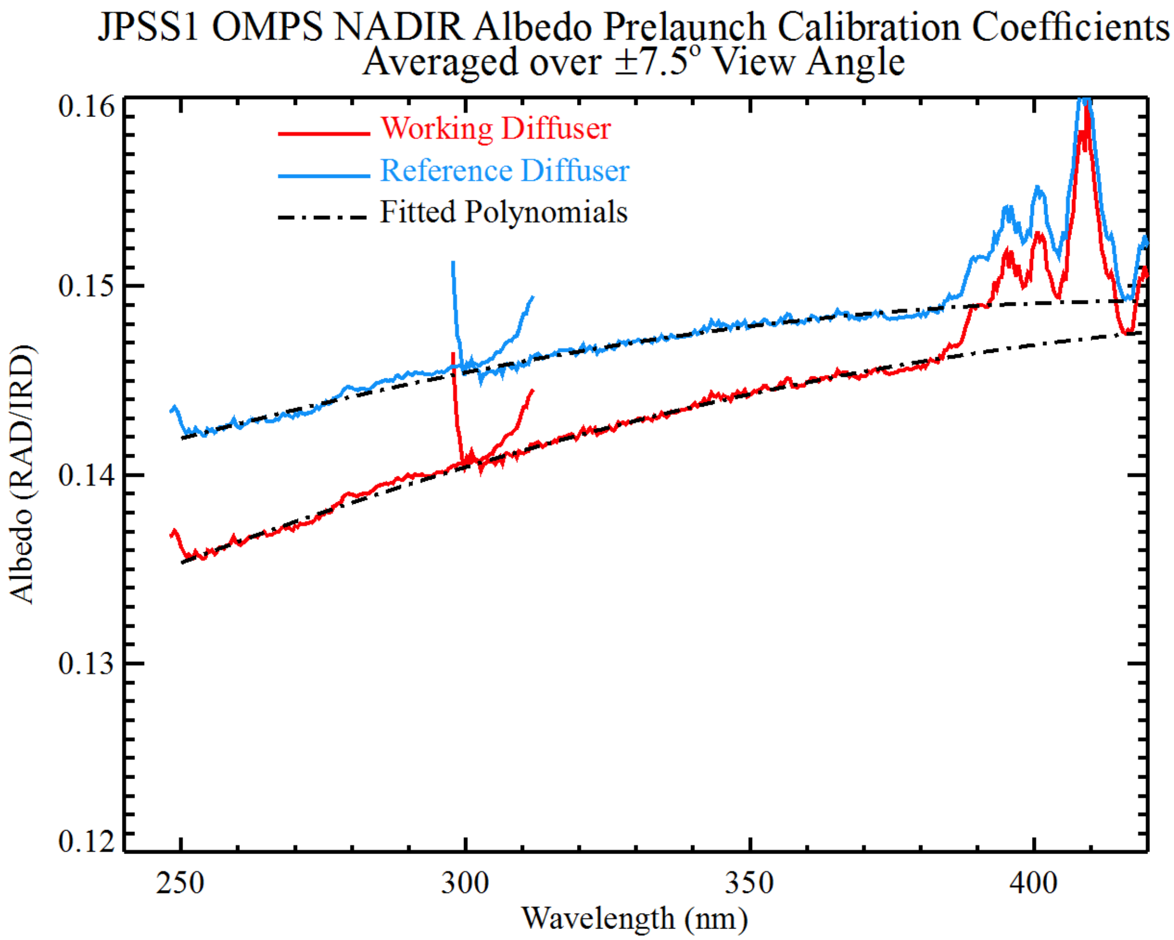


V2 OMPS/MLS matchup comparisons showed better performance with new coefficients

- Includes corrections for dichroic region
- Includes corrections for stray light



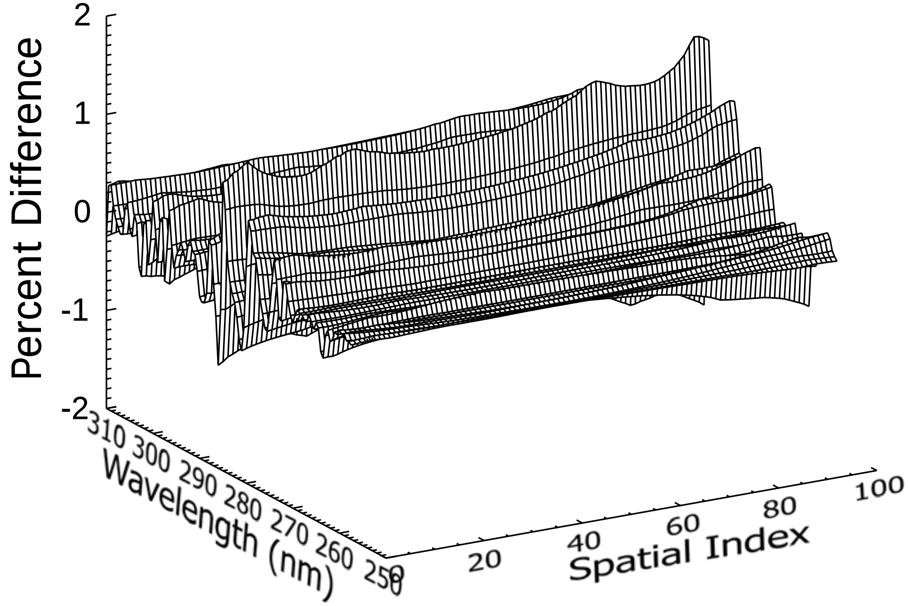
J1 calibration coefficients show the same type of unphysical behavior



Corrections for incorrect S-NPP NP bandpasses are being evaluated

- Data provided by Ball contain errors in channel bandcenters
  - J1 also had problems with measurements around 295 nm
- The following changes are currently being evaluated to determine their effect on S-NPP NP retrieval performance
  - Weighted average bandcenter correction
  - Fit with/without 295 nm measurements
  - Adjustment for change in sensitivity across dichroic region

Comparisons of synthetic solar flux convolved with weighted average bandcenter correction to solar flux without correction



Path forward for NPP nadir sensors

- Version 2
  - Freeze current NASA processing
  - Includes dichroic adjustments, stray light correction, wavelength shift corrections into L1b processing stream
  - Includes “soft calibration” adjustments for V2 processing.
  - Includes new “Day 1” measured solar flux
    - Created using solar measurements from April/May of 2012
    - Used to create normalized radiances for retrieval algorithms
  - Run through 2015 “ozone hole season”
- Version 2.1
  - Use updated NP bandpasses
    - Only if evaluation indicates such a change is necessary
  - Incorporate “tweaked” stray light correction
  - Add a few “enhancements” to L1B processor
    - Determine FOV corners, add to L1B file

Status Update: Wavelength Calibration at NASA for S-NPP/OMPS Nadir Mapper (NM) and Profiler (NP) Sensors

Mark Kowitt, NASA Contr. (SSAI)

26 August 2015

For the NOAA STAR JPSS Annual Science Team Meeting

College Park, MD

Agenda

- Brief review of wavelength registration approach
- What's new since the last Science Team Meeting?
  - Solar CBCs updated for new Initial Reference solar Flux [IRF] tables
    - Irradiance residuals
    - Radiance residuals
  - BPS grid parameter frozen and unfrozen
    - Improved intraorbital wavelength shift results (and chi-squared) for NM
    - NP much less sensitive to unfrozen BPS grid
  - For NM EV, studying correlations among reflectivity (or reflectance) fluctuations, BPS grid differences, and changes in a0
  - Implemented CBC generation routine for Nadir L1B (SDR)
    - NM: Based on tabulated intraorbital EV wavelength variation (no seasonal component)
    - NP: Based on tabulated seasonal solar wavelength variation (no intraorbital component)
- Plans for further development
  - Root hardware cause of NM temperature sensitivity, and fixes for J1 and J2 (from BATC)

NASA Wavelength Registration Algorithm (Update)

- A high-res solar spectrum (intially sampled at 0.01 nm) developed by KNMI for OMI is convolved with ~~the preflight~~ bandpasses centered in turn at each band center and separated by a variable grid parameter to form a synthetic solar spectrum
- For OMPS NP, solar activity corrections are applied to the synthetic spectrum
- A polynomial scaling function (useful for solar calibration, essential for EV) morphs synthetic irradiance into synthetic radiance
- An implementation of the Levenberg-Marquardt nonlinear least squares algorithm used to minimize the difference between synthetic and measured irradiance or radiance
- The final optimizing CBC and the spectral calibration coefficients used to constitute it at each spatial index are the principal products.

Dispersion Relation (Update)

- For both nadir sensors, each spatial index has an independent band center solution whose coefficients are applied as follows:

  $$CBC(iSpat,iSpec) = a0(iSpat) + a1(iSpat)*(iSpec-iSpec0) + a2(iSpat)*(iSpec-iSpec0)^2 + a3(iSpat)*(iSpec-iSpec0)^3$$

  where iSpat is the spatial pixel index, iSpec the spectral pixel index, and iSpec0 is the spectral pixel index of the fitting window lower bound.

- The current version of the algorithm varies only the constant offset term, a0, freezing a1, a2, and a3 at the values underlying the original BATC CBC. Small spatial irregularities in a0 reflect analogous structures along the slit edge found by BATC in prelaunch studies.

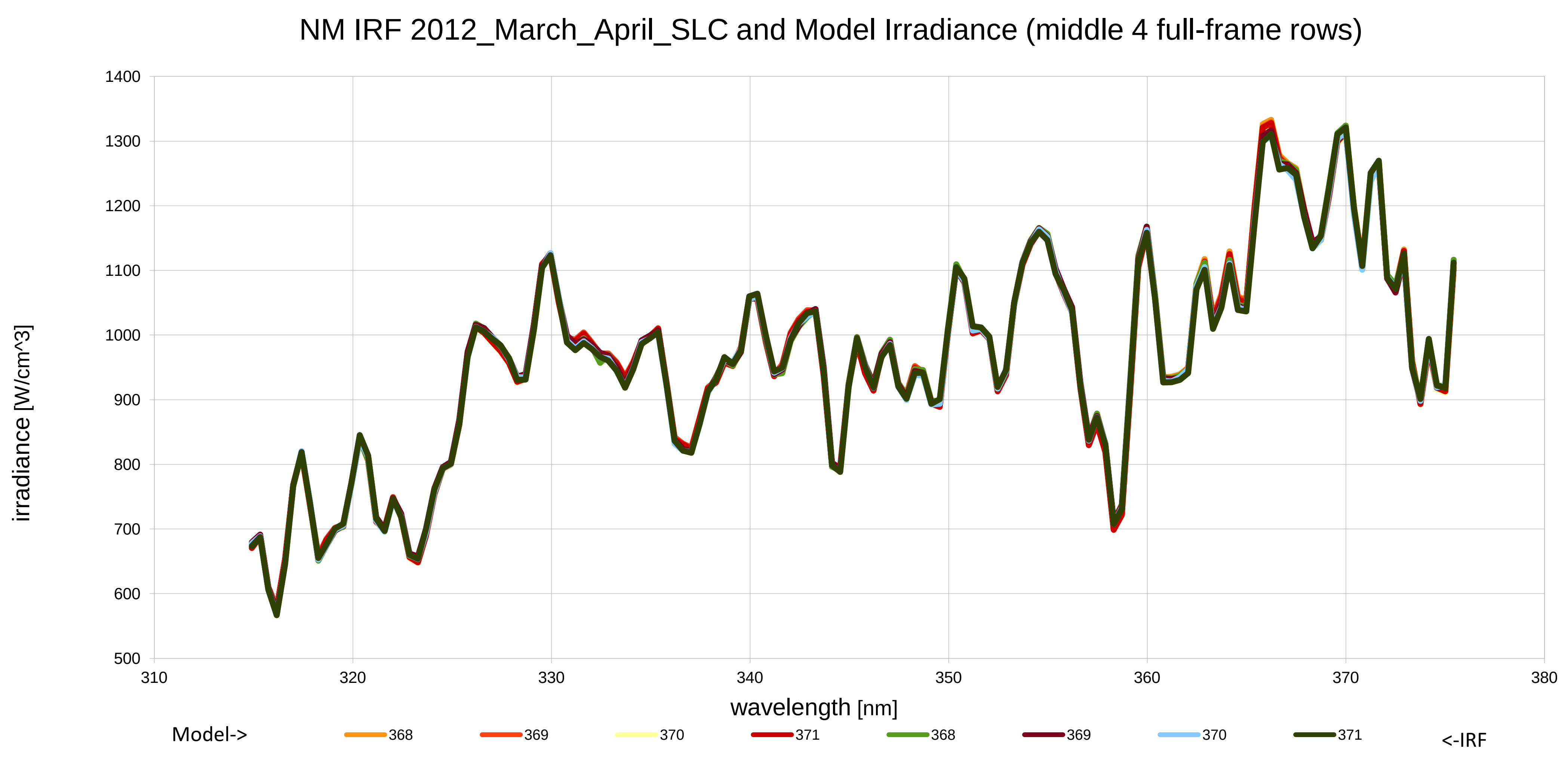
Spectral and Spatial Bounds used for NM and NP Irradiance and Radiance Fitting Windows

- NM solar calibration (Full-Frame)
  - Spatial Indices 16-763 (except for smear rows 370-409)
  - Spectral Indices 137-282 (about 315-375 nm)
- NM EV (Full-Frame)
  - Spatial Indices 16-763 (except for smear rows 370-409)
  - Spectral Indices 220-282 (about 349-375 nm) – avoids ozone
- NM EV (nominal and EV360)
  - Spatial Indices 0-35
  - Spectral Indices 108-182 (about 344-375 nm)
- NP solar calibration (Full-Frame)
  - Spatial Indices 36-135
  - Spectral Indices 64-164 (about 252-294 nm)
- NP EV (Full-Frame)
  - Spatial Indices 36-135
  - Spectral Indices 82-158 (about 259-292 nm) – avoids ozone
- NP EV (nominal) – 1 spatial index
  - Spectral Indices 26-102 (about 259-292 nm)

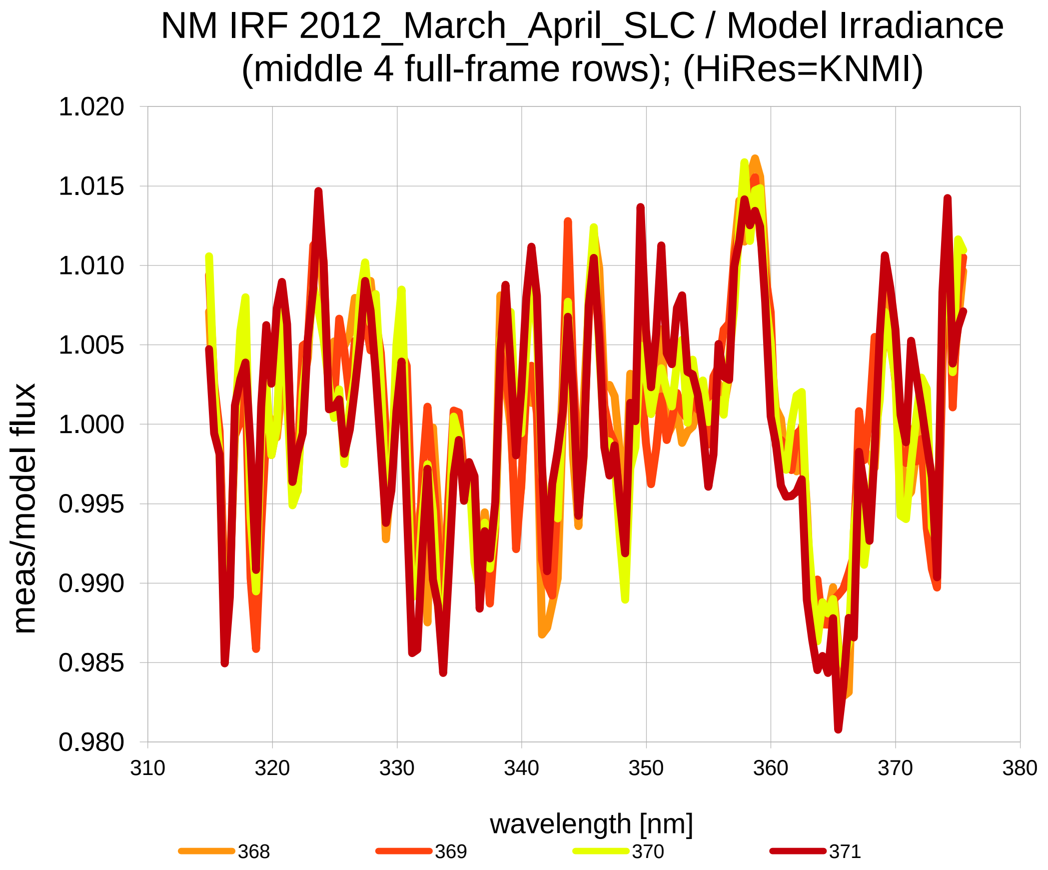
NM Irradiance Residuals

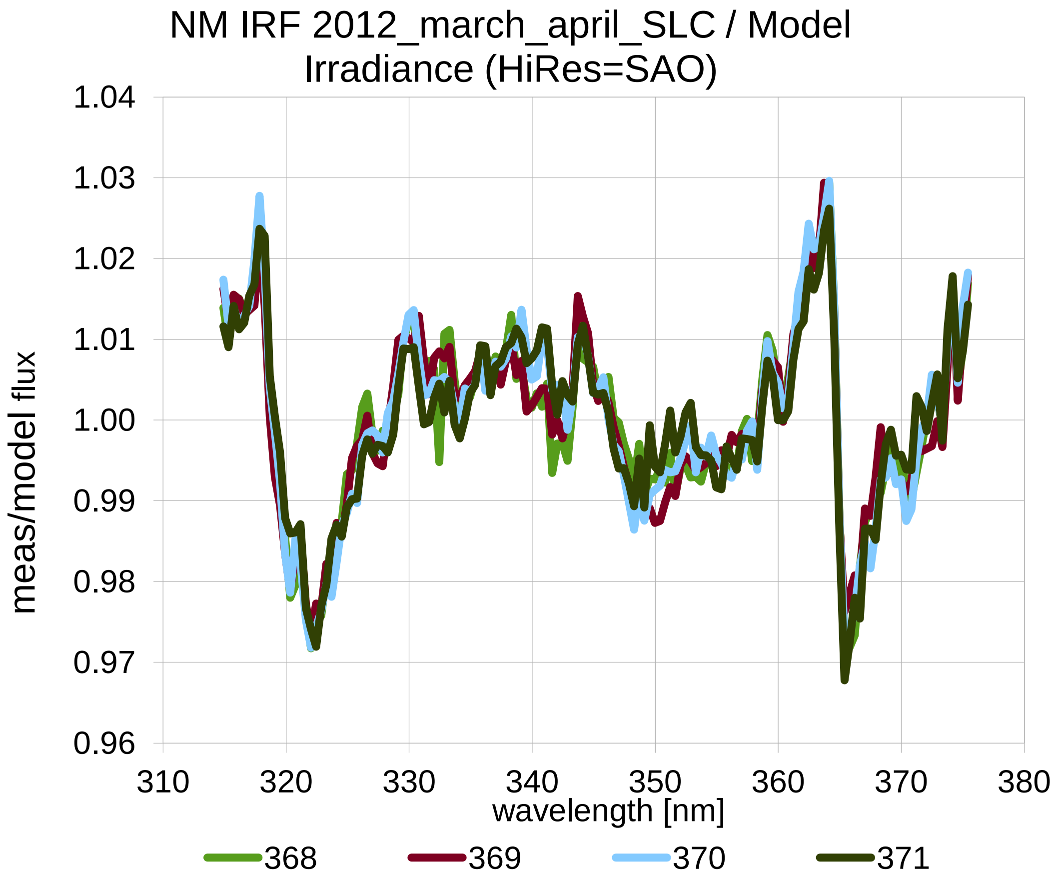
- Flux residuals here refer to the of measured flux / model flux from 1.
- Residuals demonstrate the quality of CBC and bandpass solutions
- Although a few “features” ~2% persist for different IRFs, different features on this scale appear when synthetic flux uses a different high-resolution reference solar flux (e.g., Kurucz-Chance 2010 (SAO) vs the KNMI flux used for OMI and preferred by NASA for OMPS
  - Most of these features appear to be artifacts of the high-res solar spectrum rather than of the algorithm used to derive the CBC
  - If they were caused by diffuser features, they should appear in both models
  - In any case, a0 (and therefore CBC) values generally differ by <0.01 nm when different high-resolution solar spectra are used.

NM Day 1 Solar Flux (IRF) and Model Flux



NM IRF Irradiance Residuals using Hi-Res Solar Flux from KNMI vs SAO (Kurucz-Chance)

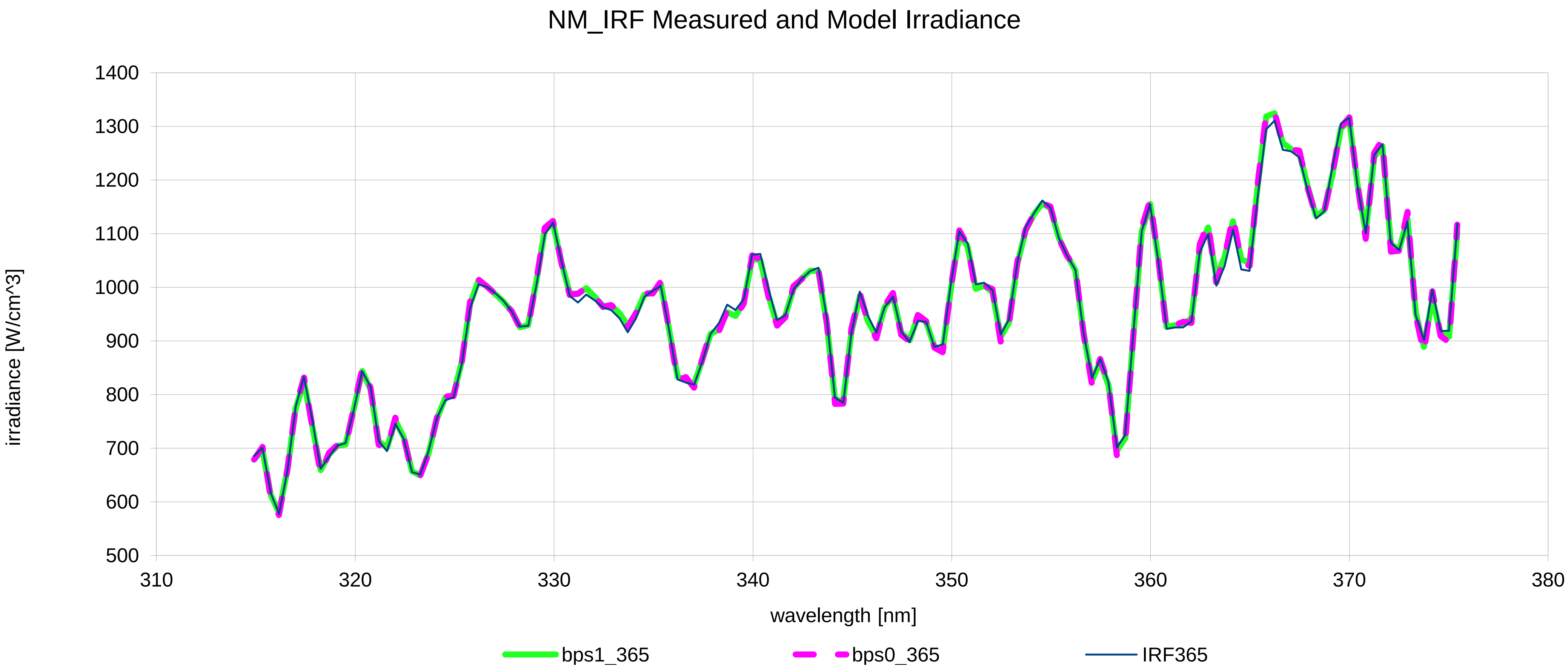




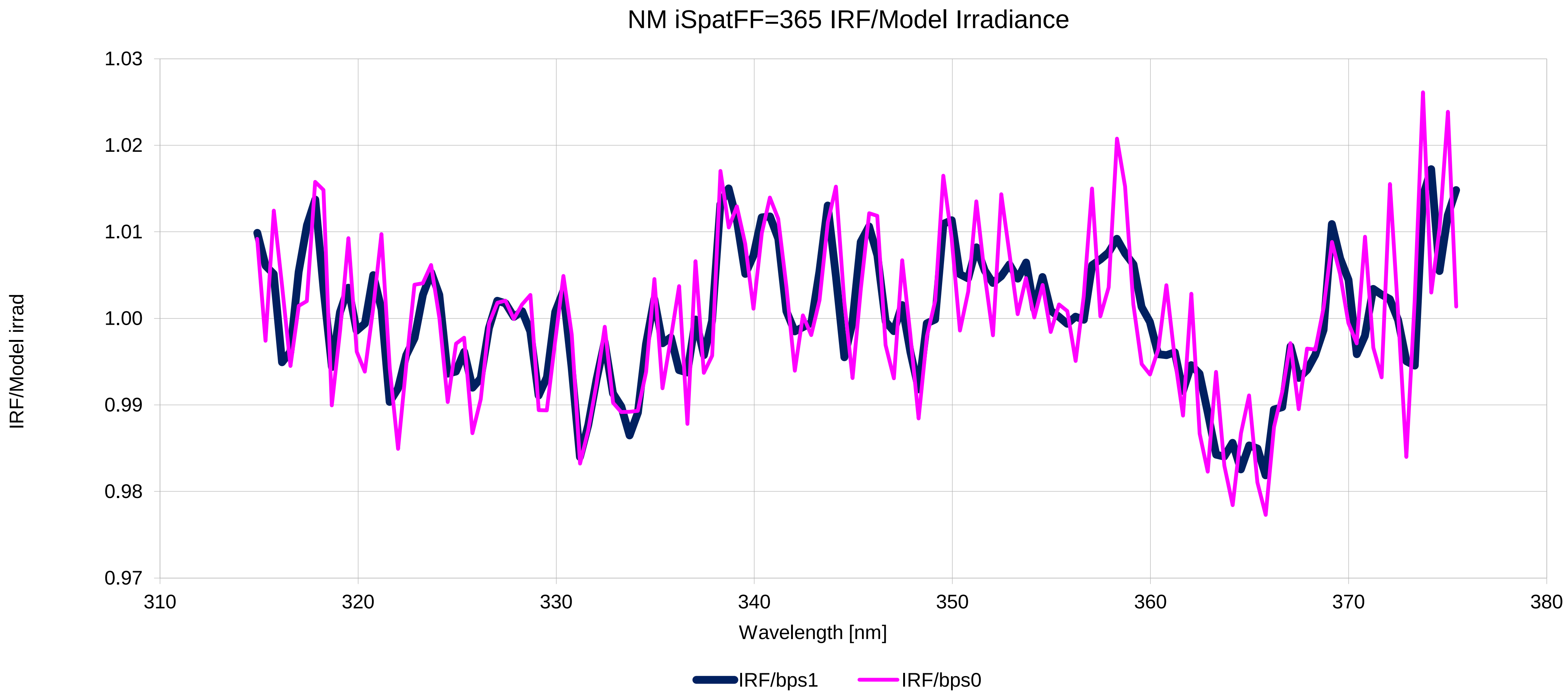
NM IRF and Model Flux – Free vs Frozen BPS grid parameter

- Even with the BPS grid parameter free, the high-res SAO spectrum generates synthetic flux with significantly larger residuals than the KNMI spectrum (whether or not the BPS grid parameter is frozen); only examples using the KNMI high-res spectrum will be shown.
- The free grid parameter produces significantly smaller residuals with the KNMI spectrum. This is the current model used for OMPS Nadir wavelength registration at NASA.

NM Measured (IRF) plus Model Flux with free (bps1) or frozen (bps0) grid parameter



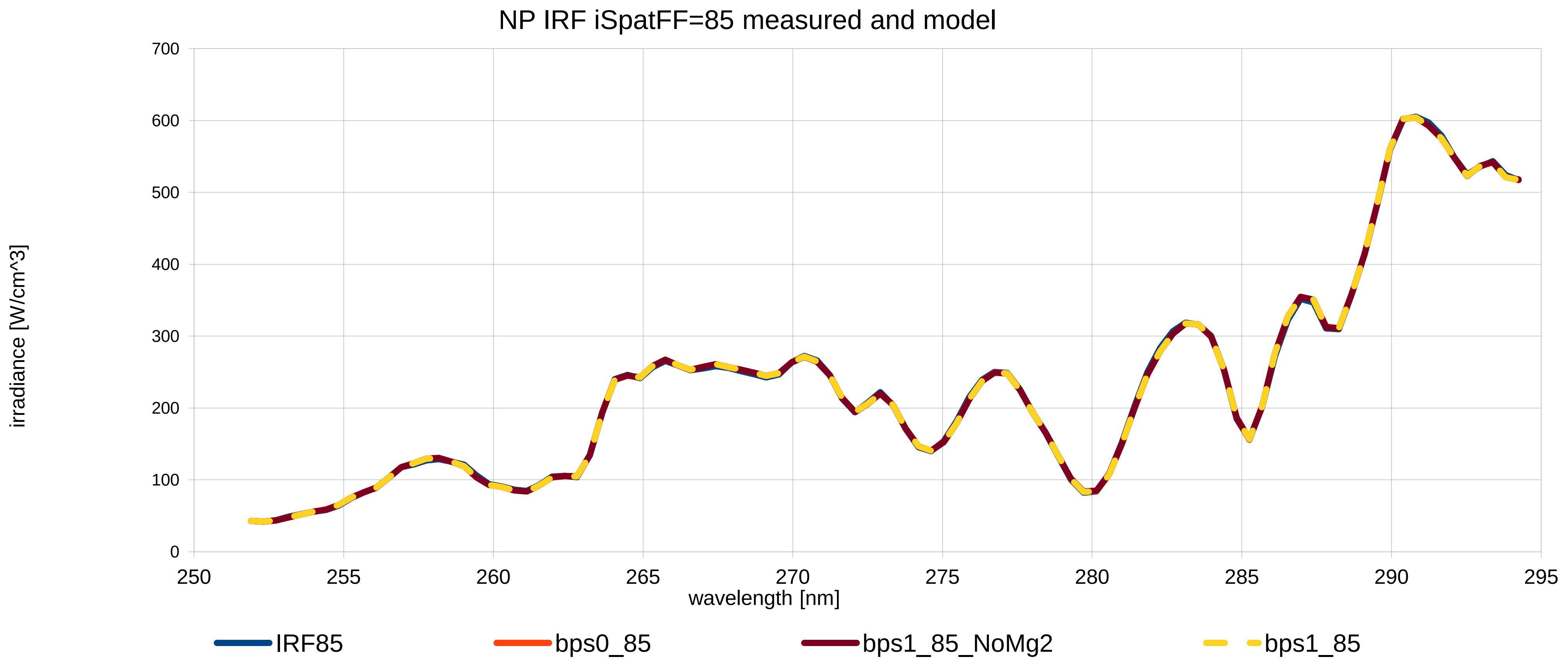
NM Measured/Model Irradiance
BPS Grid Free or Frozen



NP Irradiance Residuals

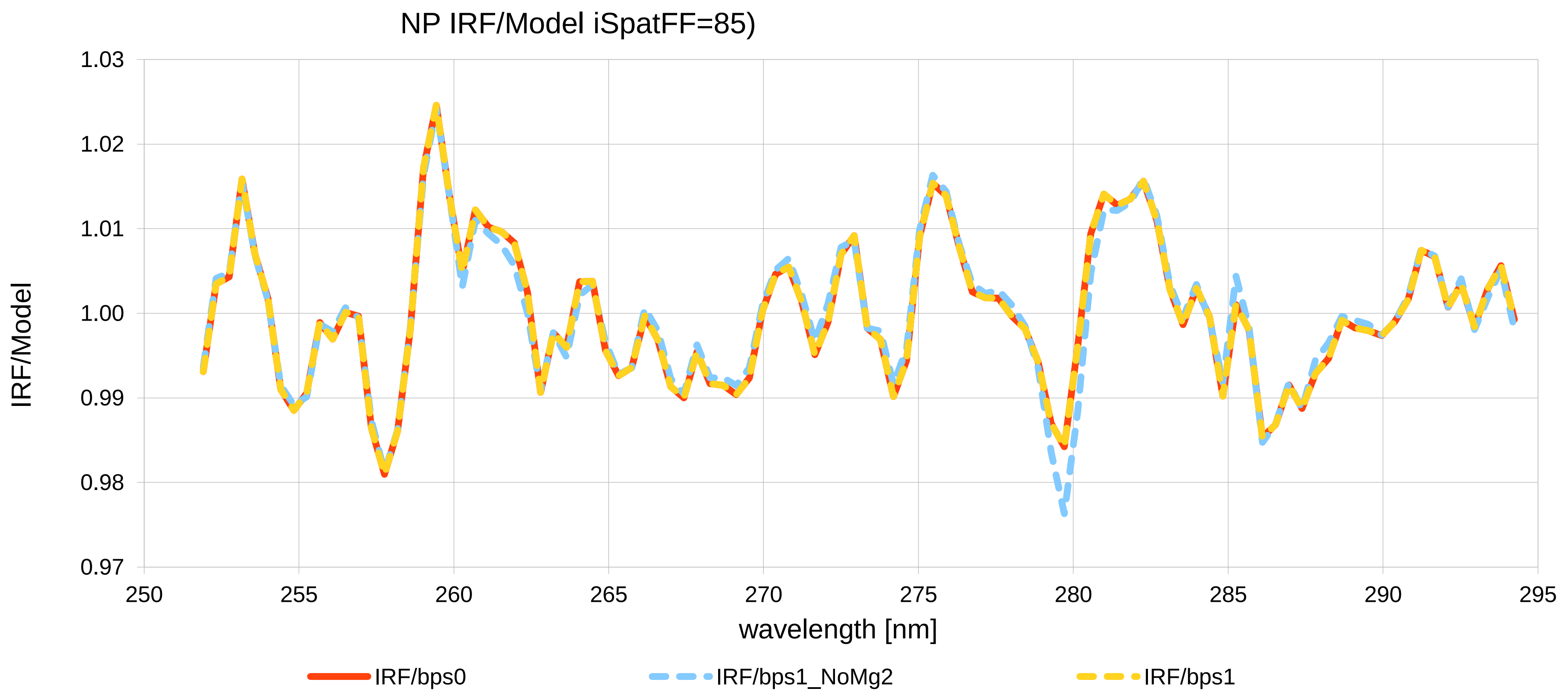
- The following slides compare NP irradiance residuals with and without BPS grid variation, solar activity corrections, and models using the SAO high-res solar spectrum as well as the KNMI spectrum
- Unlike NM, NP is almost insensitive to bandpass grid variation
- Note: Our composite IRF uses solar flux for 4 different dates, each with its own Mg II index; test used a date (April 17, 2012) with Mg II index ~mean
- Show current a0 as a function of date, compare with N_T_Telescope

NP Irradiance – IRF and Various Models:
BPS grid frozen or free, solar activity corrected or not



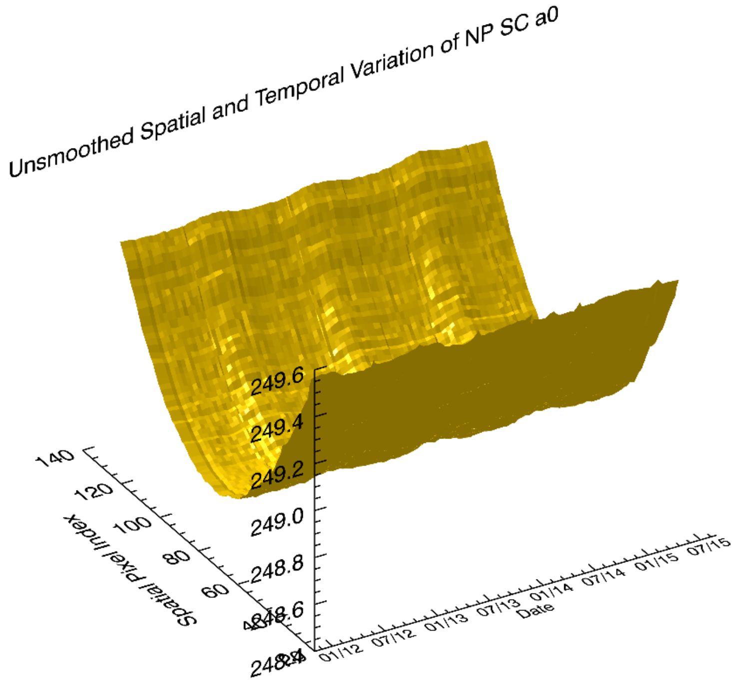
NP Irradiance Residuals Near Nadir

NP IRF/Model Flux near nadir (iSpat=85), BPS grid free and frozen; also shown is a BPS free-grid example w/o solar activity correction (NoMg2).

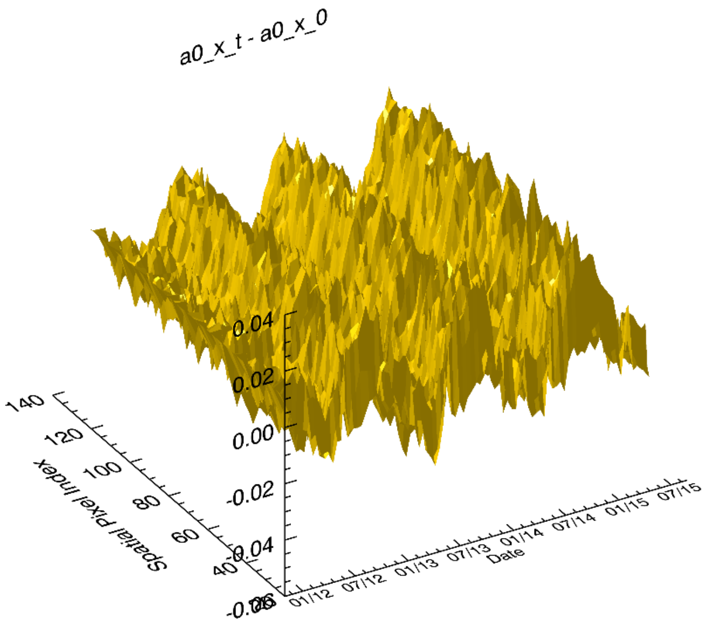


Seasonal Variation of NP Wavelength Scale

NP Solar Calibration -- Seasonal Variation of Wavelength Scale Offset a0



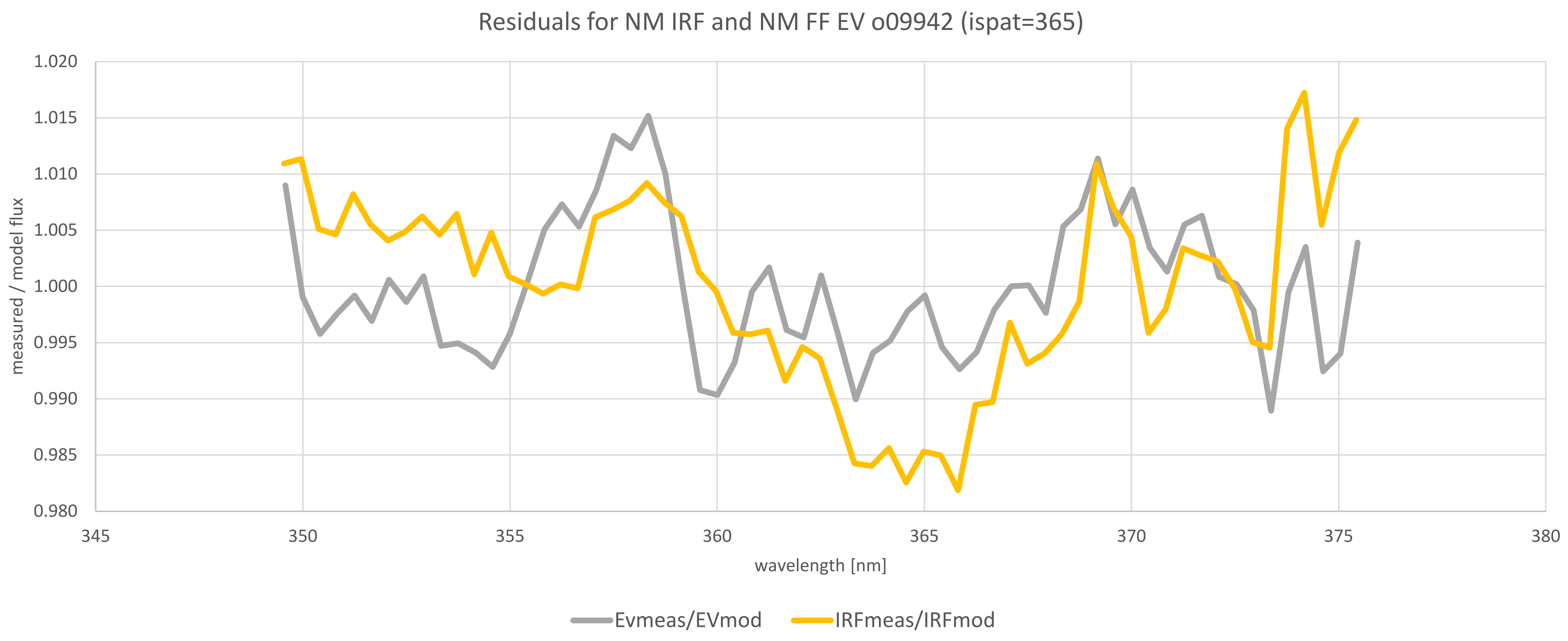
Seasonal Variation of da0, that is, a0(t) – a0 for 28 Jan 2012



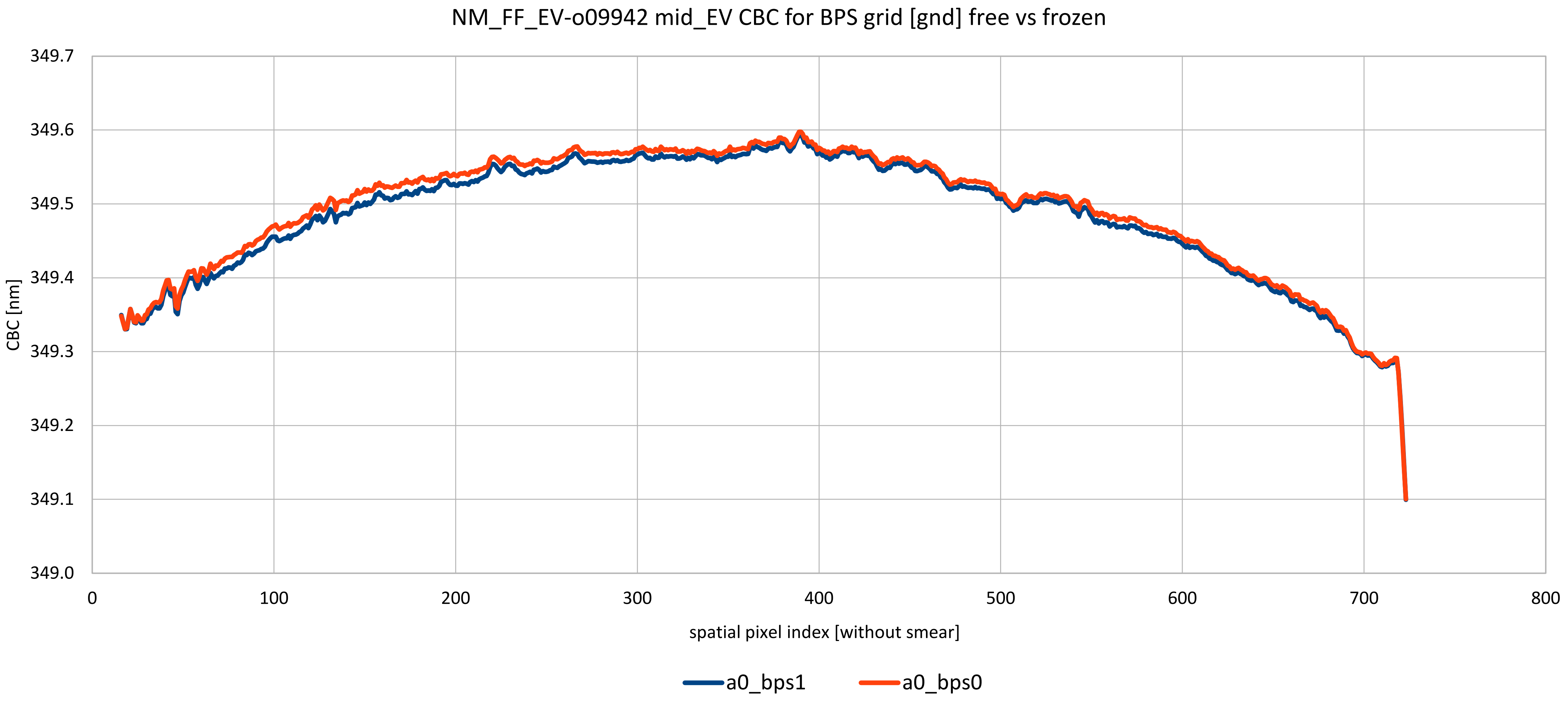
NM Radiance Residuals

- The [NASA] OMPS Nadir wavelength registration algorithm was designed for solar calibration, but can be used effectively (not necessarily in real time) for direct solutions of EV wavelength scale when spectral fitting windows are limited to wavelengths not absorbed by ozone.
- Steering clear of the “dichroic region” is desirable for solar as well as EV wavelength registration.
- For NM, a useful EV window is about 349-375 nm; whereas for solar calibration, 315-375 nm can be fitted and may be compared with a fit using the EV window.
- The following chart compares residuals (meas/model flux) for full-frame EV and for the IRF for the EV spectral fitting window for spatial index 365. They are of similar magnitude and appear topologically similar, which may be an artifact of the high-resolution solar spectrum (KNMI) used to construct the model flux in both cases.

Measured / Model Flux for NM IRF and full-frame EV near nadir

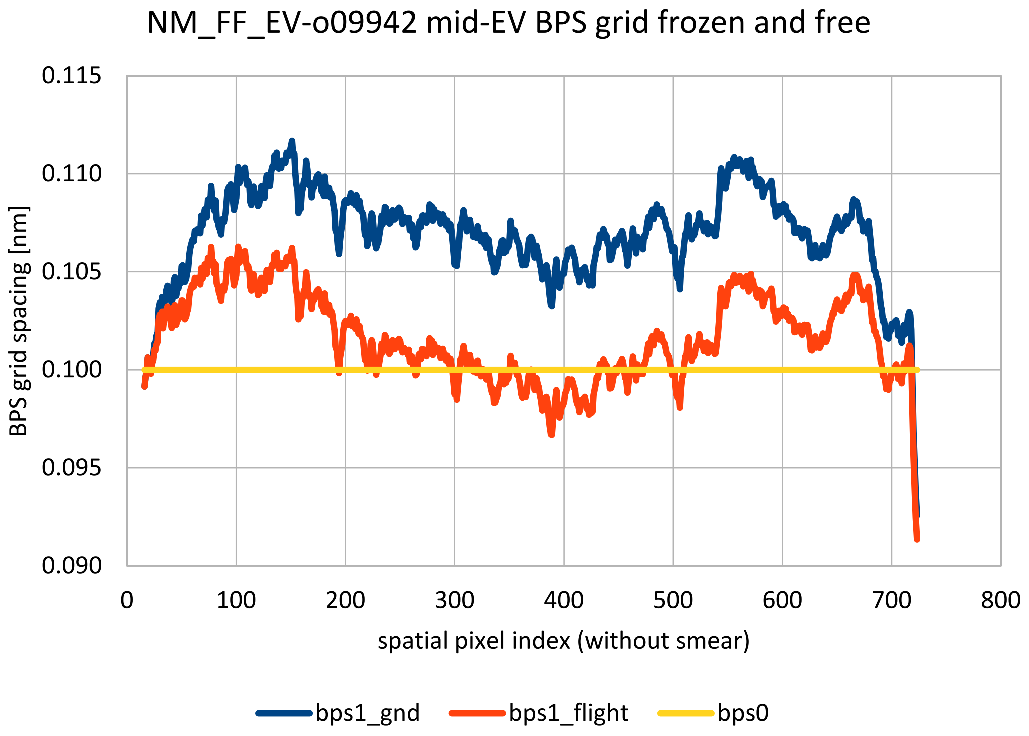


NM mid-EV a0 values when BPS Grid Spacing is Free (a0_bps1) or Frozen (a0_bps0)

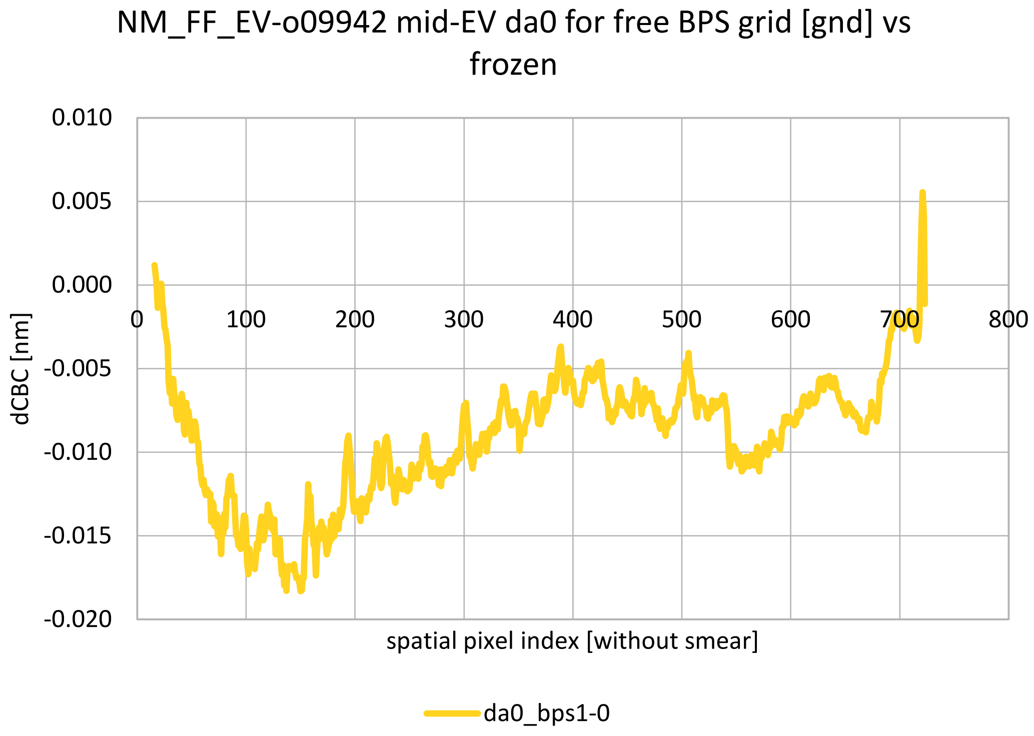


NM BPS Grid Parameter Variation and a0

Bandpass grid parameter solutions for NM_FF_EV using BANDPASS_GROUND vs BANDPASS_FLIGHT (original BATC estimate)



Differences between a0 for frozen vs free BPS grid parameter for NM_FF_EV, using BANDPASS_GROUND as the baseline



NM EV vs Solar Cal Cross-Track Spectral Divergence

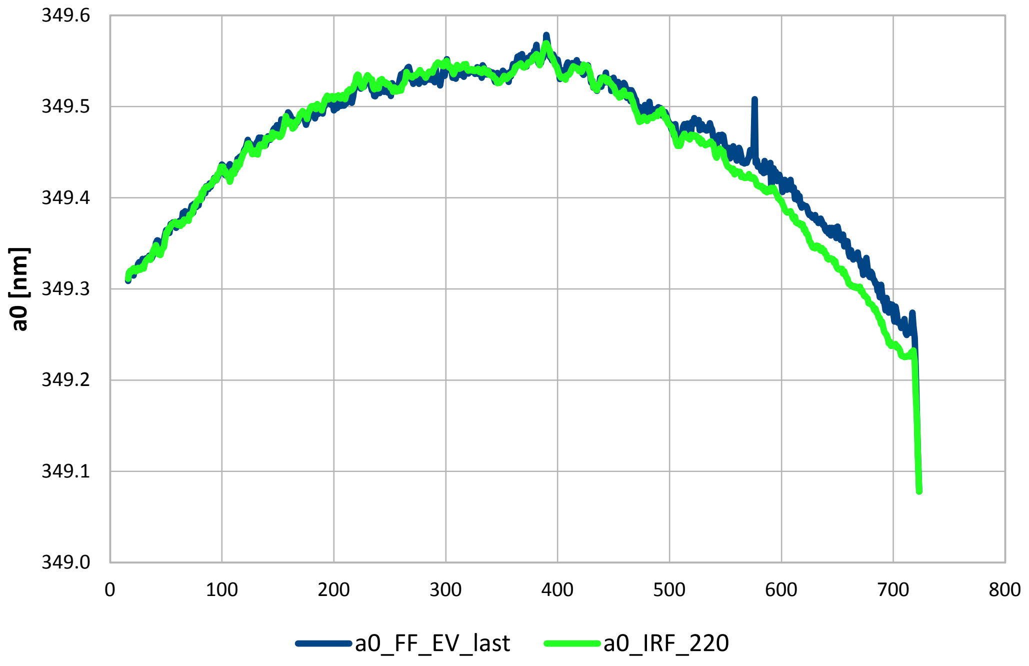
- The NM EV intraorbital wavelength offset, a0, converges to solar a0 except for the diffuser positions whose data are acquired beyond the range of nominal EV…

a0 for last EarthView frame vs a0 for the IRF

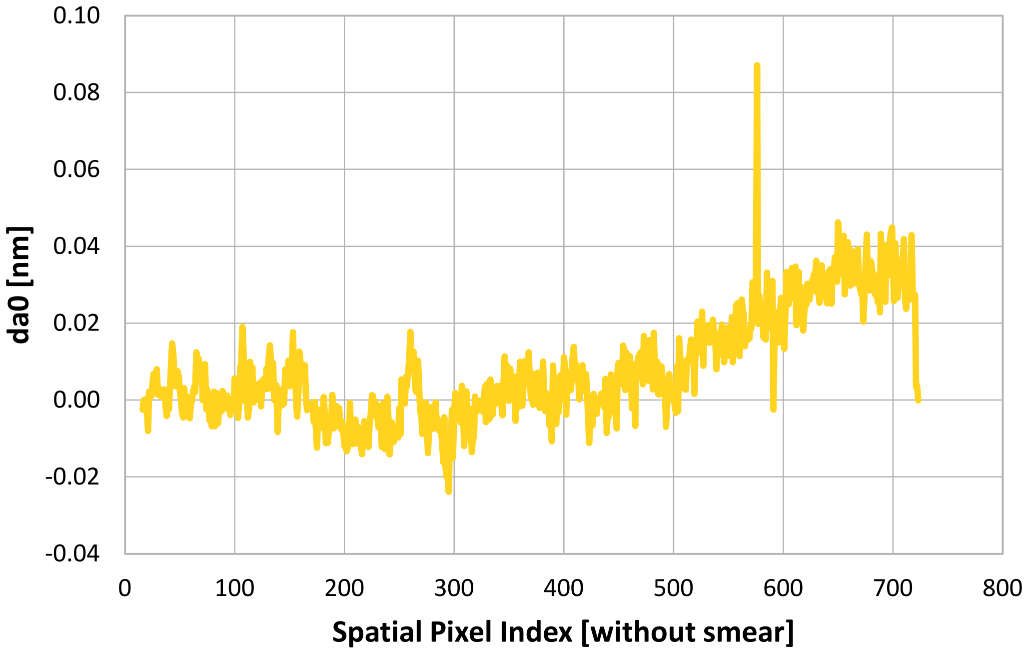
Note divergence of EV and solar a0 for spatial indices to the far right

da0 vanishes except for diffuser positions at SZA > 90 degrees

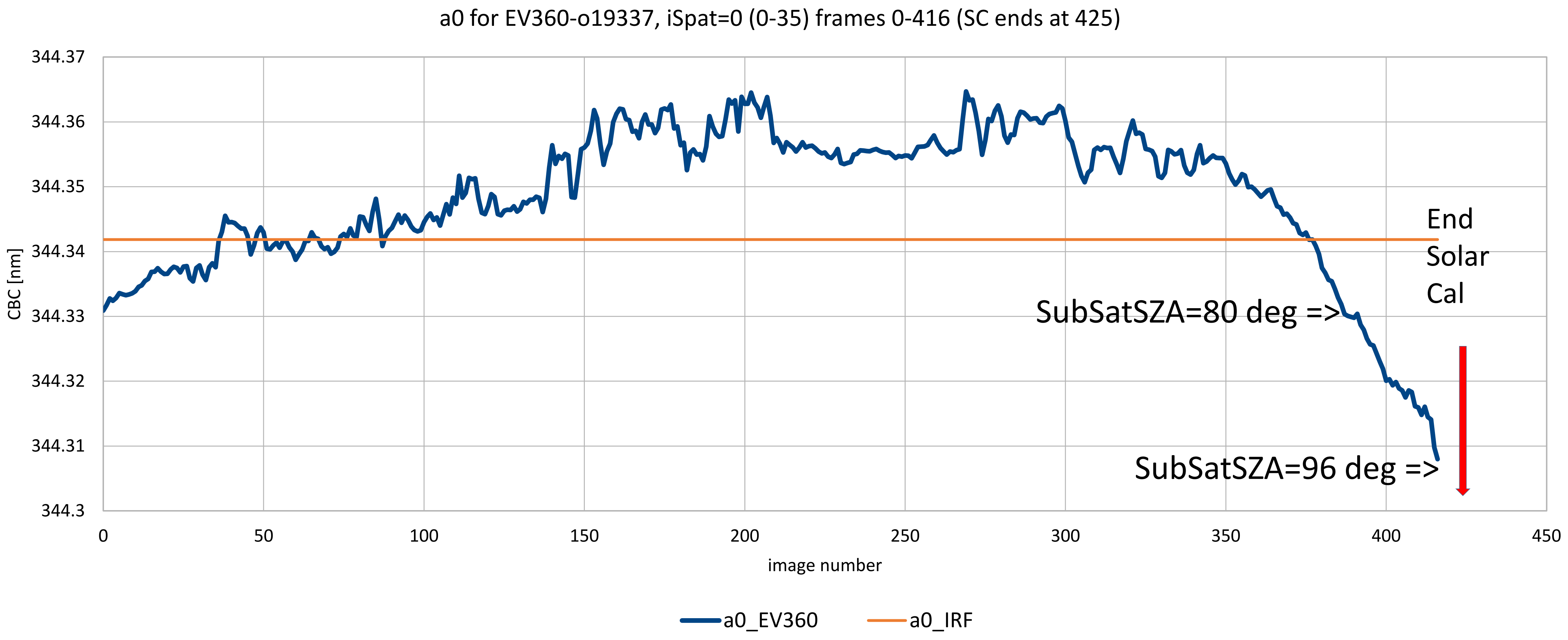
NM_FF_EV-o09942 a0 for last frame vs a0_IRF



a0 (last FF image, NM_FF_EV-o09942) - a0(IRF)

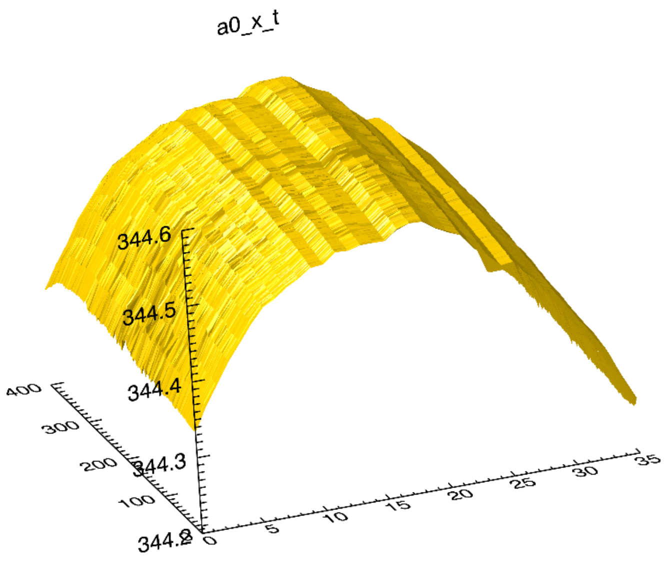


a0 (EV360), spatial macropixel=0, frames 0-416, and a0 for the IRF binned in new mCBC

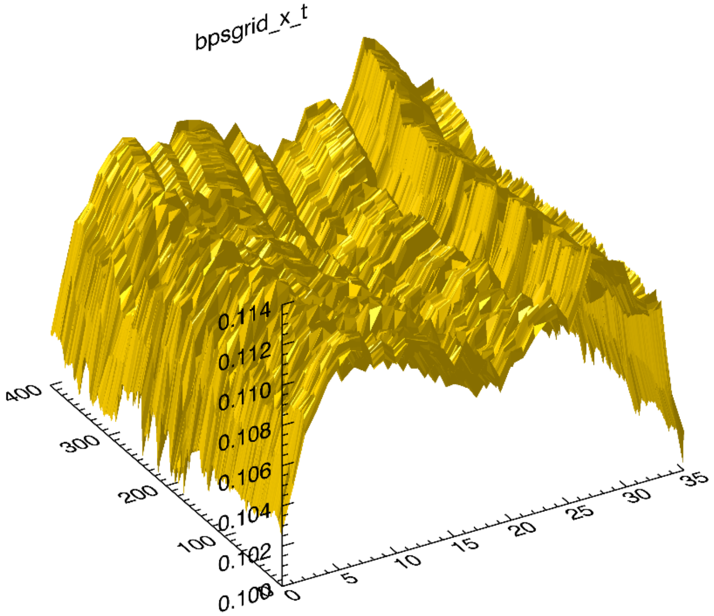


NM EV spatial and temporal dependence of a0 and BPS grid for nominal EarthView

NM_EV-o07231, a0 as a function of macropixel spatial index and frame

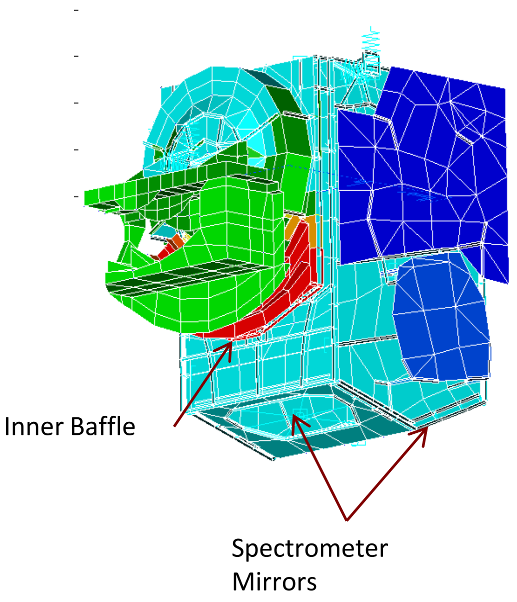


NM_EV-o07231, BPS grid as a function of spatial index and frame (baseline was BANDPASS_GROUND)



Task 5 Conduction to / from the Calibration Assembly is a Major Contributor

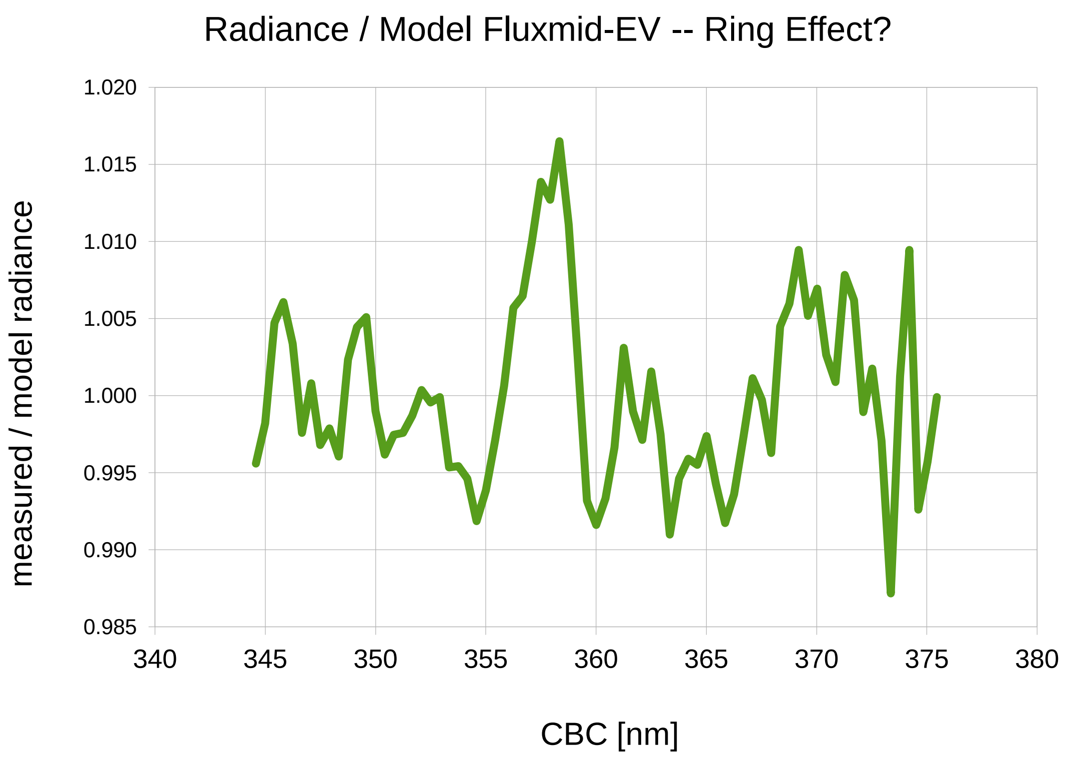
The baffles go through larger temperature swings than the telescope structure
Conduction to and from the Calibration Mechanism Assembly causes localized deformation on the front of the total column housing



Backup Slides

NM Radiance Residuals vs Ring Effect?

Mid-EV NM radiance residuals for TC_EV o07231, nominal EarthView



Ring effect near NM EV fitting window and spectral res., from Wagner, Chance, et al., Proc. of 1st DOAS Workshop, 1/2001, p. 6

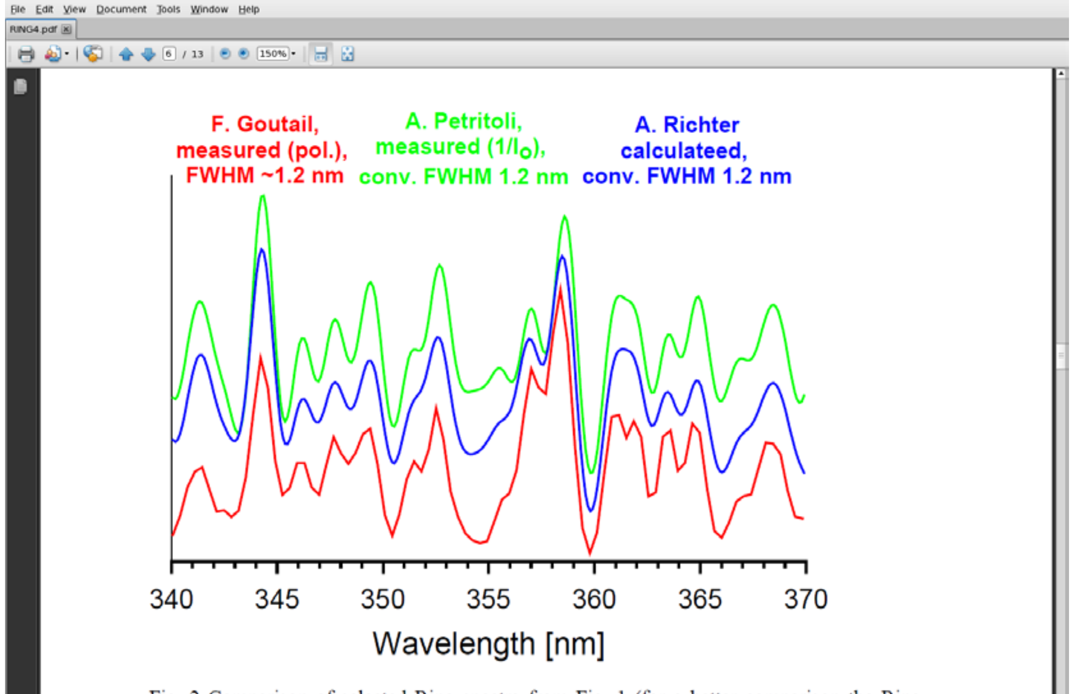


Fig. 2 Comparison of selected Ring spectra from Fig. 1 (for a better comparison the Ring spectra from A. Petritoli and A. Richer have been convolved with a Gaussian function of a FWHM of 1.2 nm).

Integrated Cal/Val System (ICVS) for OMPS

Ding Liang, Ninghai Sun, Fuzhong Weng, Chunhui Pan, Wanchun Chen, Lori Brown

August 26, 2015

Outline

- Calibration principle
- Key performance parameters monitoring
- Solar degradation monitoring
- Instrument health and safety related parameters monitoring
- Summary and future plan

The NM/NP Calibration Principle

$$Q^{c}_{jk} = \frac{Q^{ADC}_{jk} - Q_0}{g\ m_{jk}} - Q^{s}_{k} - Q^{dark}_{jk}$$

Q^{ADC}_{jk} : raw counts at the output of the analog-digital-converter

g : non-linearity of the electronics chain

Q^{dark}_{jk}: observed dark

Q_0 : zero input response

m_{jk} : relative pixel gain level

Q^{s}_{k} : observed smear(contain the offset)

$$L^{m}_{jk} = \frac{Q^{r}_{jk} k^{r}_{jk}}{\tau_{jk}(t)}$$

L^{m}_{jk} : calibrated earth radiance

Q^{r}_{jk} : corrected earth radiance counts

k^{r}_{jk} : pre-launch measured radiance calibration coefficient

τ_{jk} : sensor response changes

$$E^{m}_{jk}(t) = \frac{Q^{i}_{jk} k^{i}_{jk}}{g_{jk}(\theta,\phi)\rho_{jk}(t)\tau_{jk}(t)}$$

E^{m}_{jk} : Calibrated solar irradiance

Q^{i}_{jk} : corrected solar irradiance counts

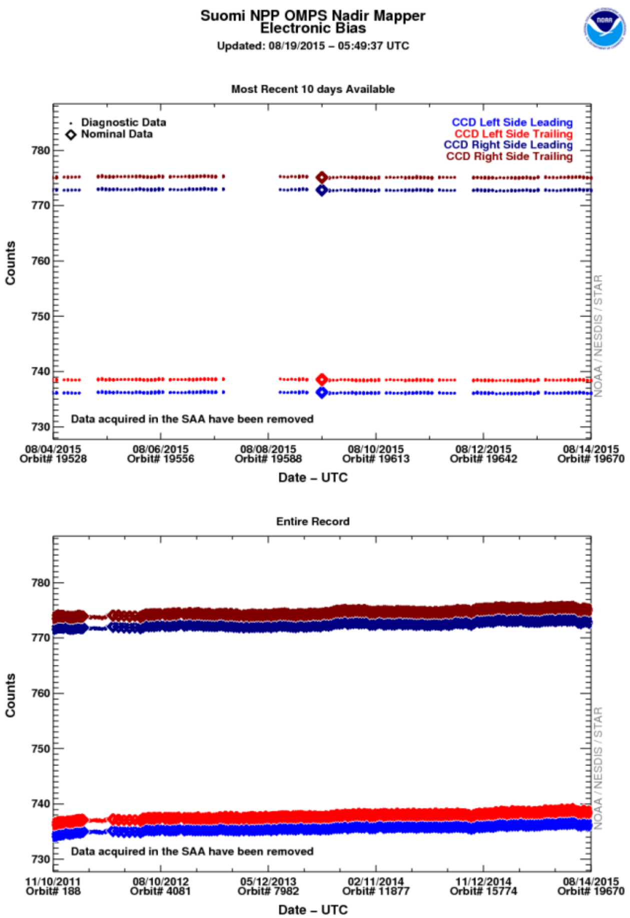
k^{i}_{jk} : pre-launch measured irradiance calibration coefficient

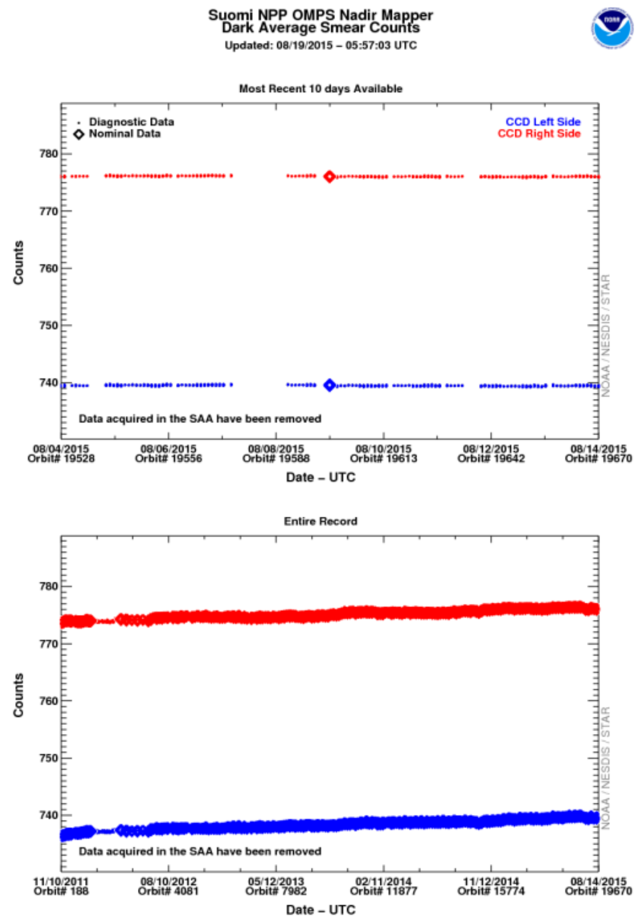
g_{jk} : goniometric response

ρ_{jk} : long-term solar diffuser reflectivity changes

Key Performance Parameters

ICVS monitoring of mean value and standard deviation for offset and smear

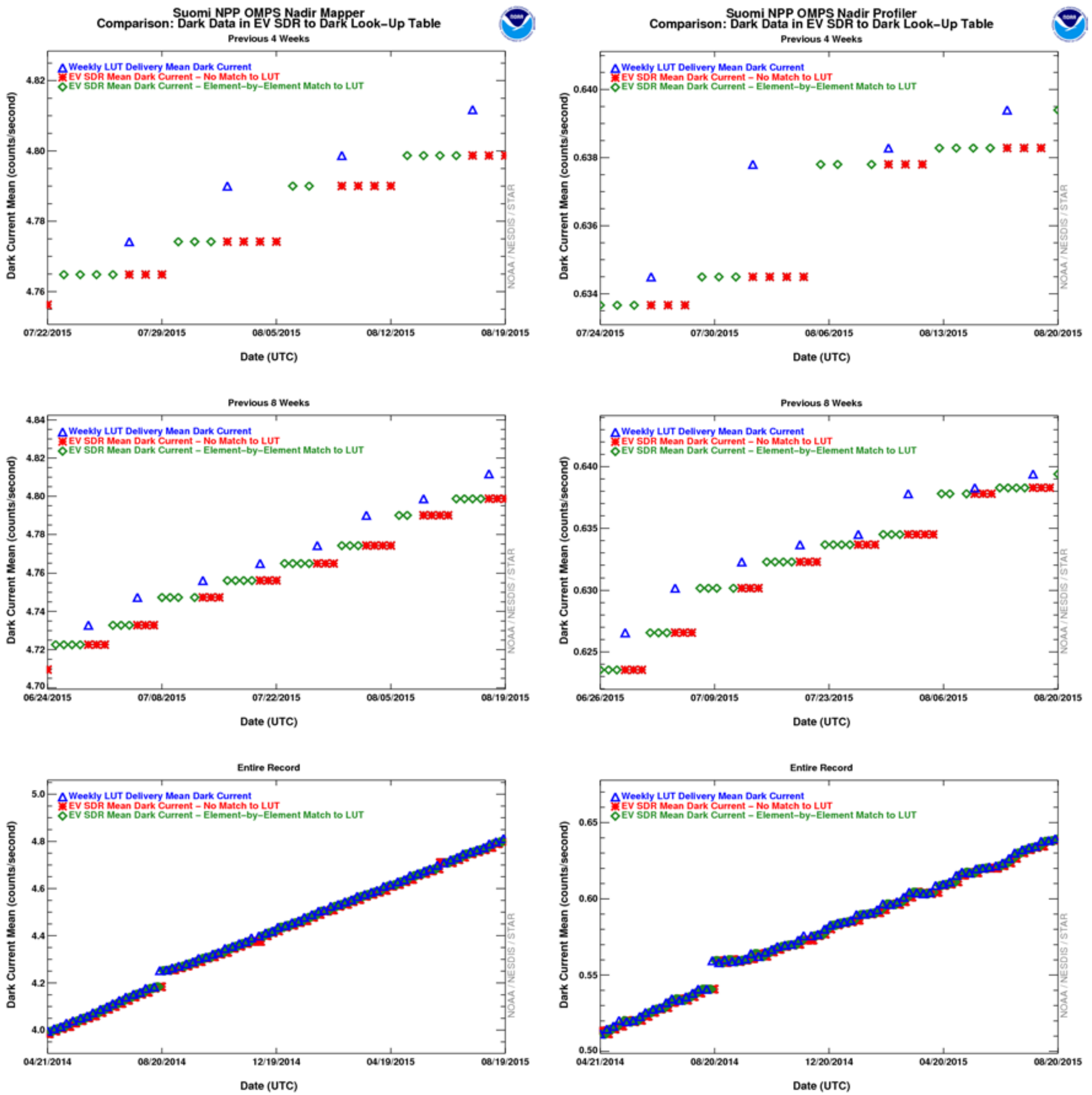




NM/NP Dark Current LUT Updates

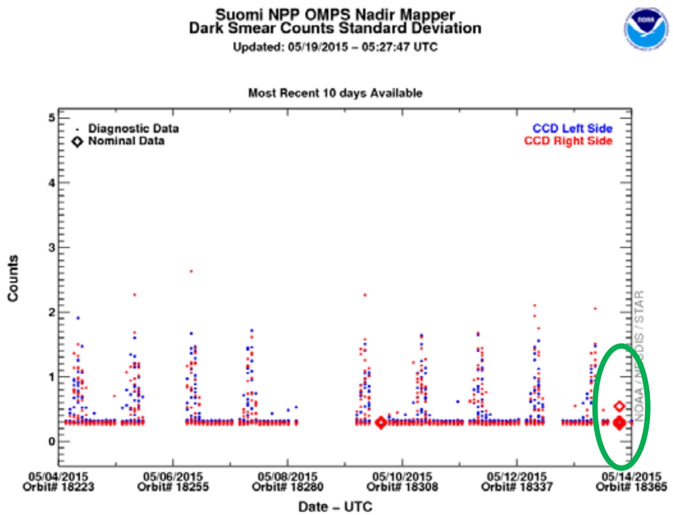
ICVS monitoring of NM/NP dark current LUT updates:

- Timely weekly updates of the dark current LUT for calibration
- Implementation of the weekly dark LUT (transition from red to green) into the Earthview SDR
- Expected steady increase of the dark current

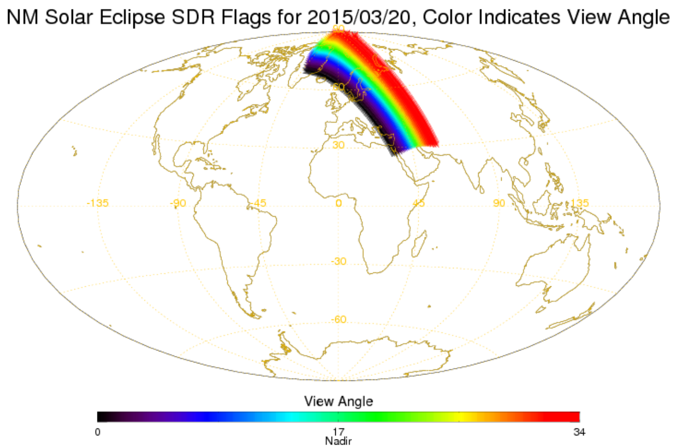


Expected Anomaly Detection

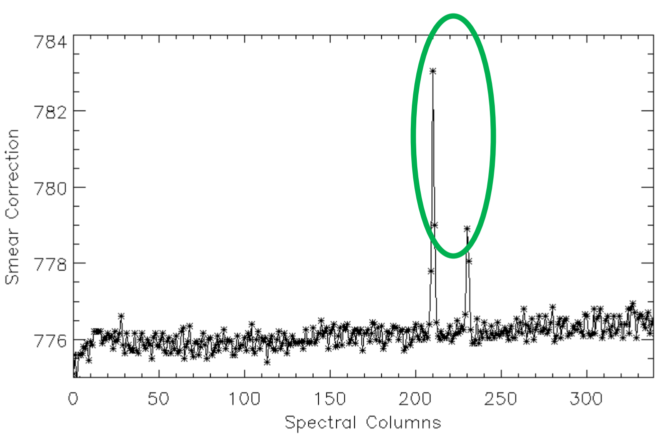
Automated anomaly detection and email warnings are established for radiance and key performance parameters



Time series of average OMPS NM dark smear counts for ten days



Solar eclipse as identified by OMPS eclipse flag



Transient in OMPS NP dark smear on orbit 18362 and image 24 for May 14, 2015

NM Solar Diffuser Sample Table

- OMPS Sensor stability are monitored by observing the changes in the observed solar flux via a reflective working diffuser for short-term monitoring and via a reflective reference diffuser for long term monitoring.
- Nominally, The working diffuser is deployed once every two weeks. The reference diffuser is deployed twice per year.
- The diffuser moves through seven different positions to cover the entire sensor FOV of 110 degree
- Plots on the right are solar calibration sample table which shows the CCD pixels collected during the solar calibration when diffuser moves from positions 1 to 7

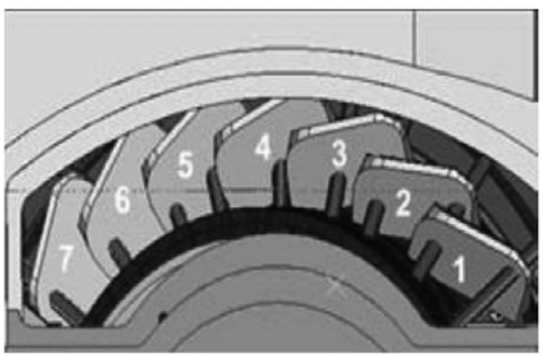
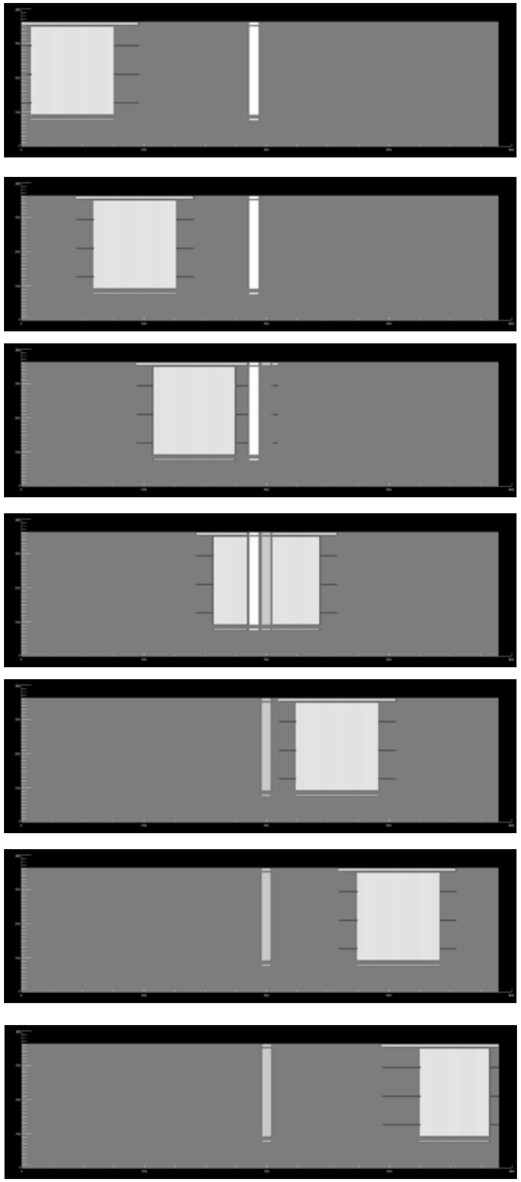
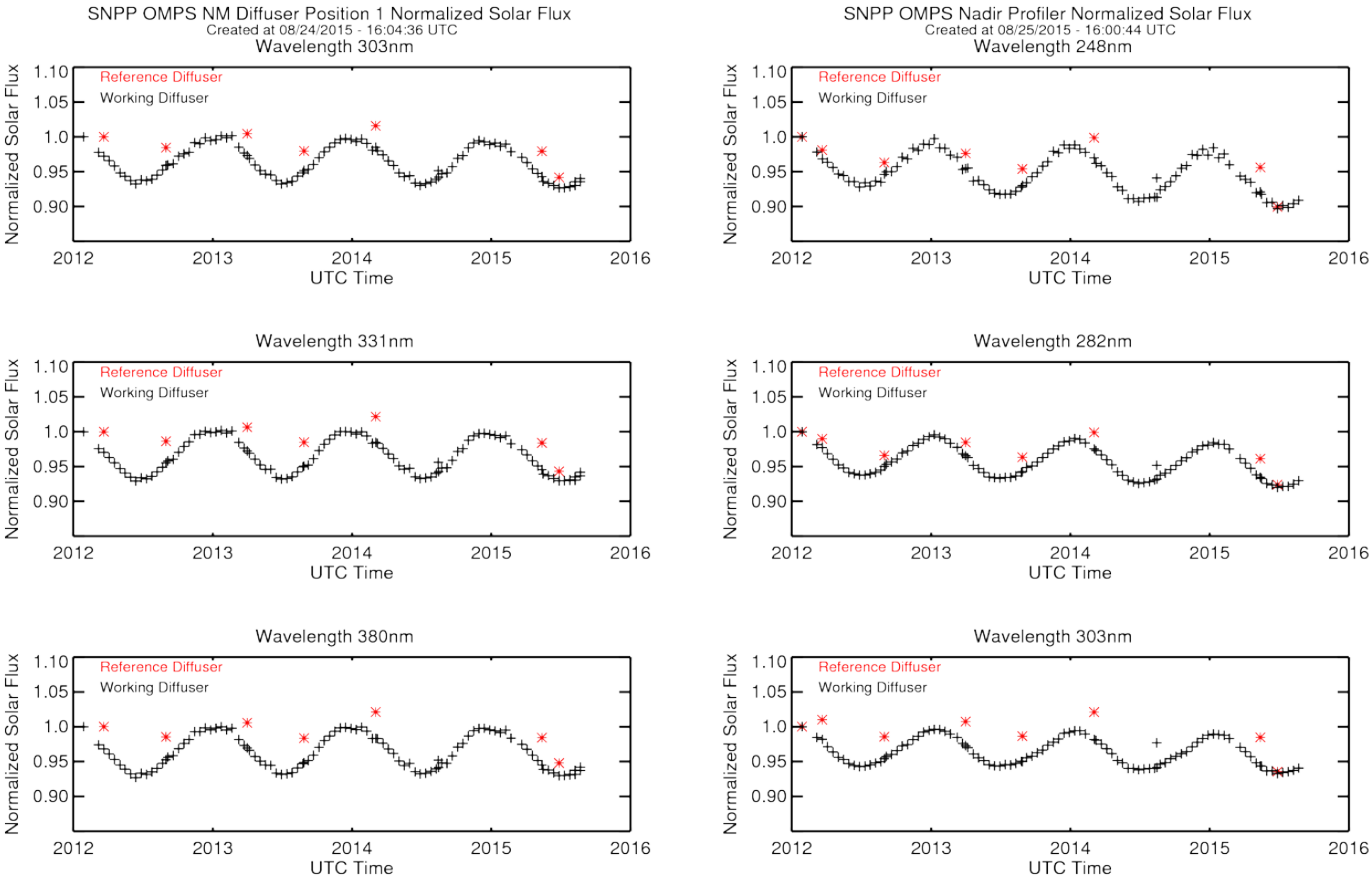


Diagram of seven solar diffuser positions in OMPS Nadir solar measurement



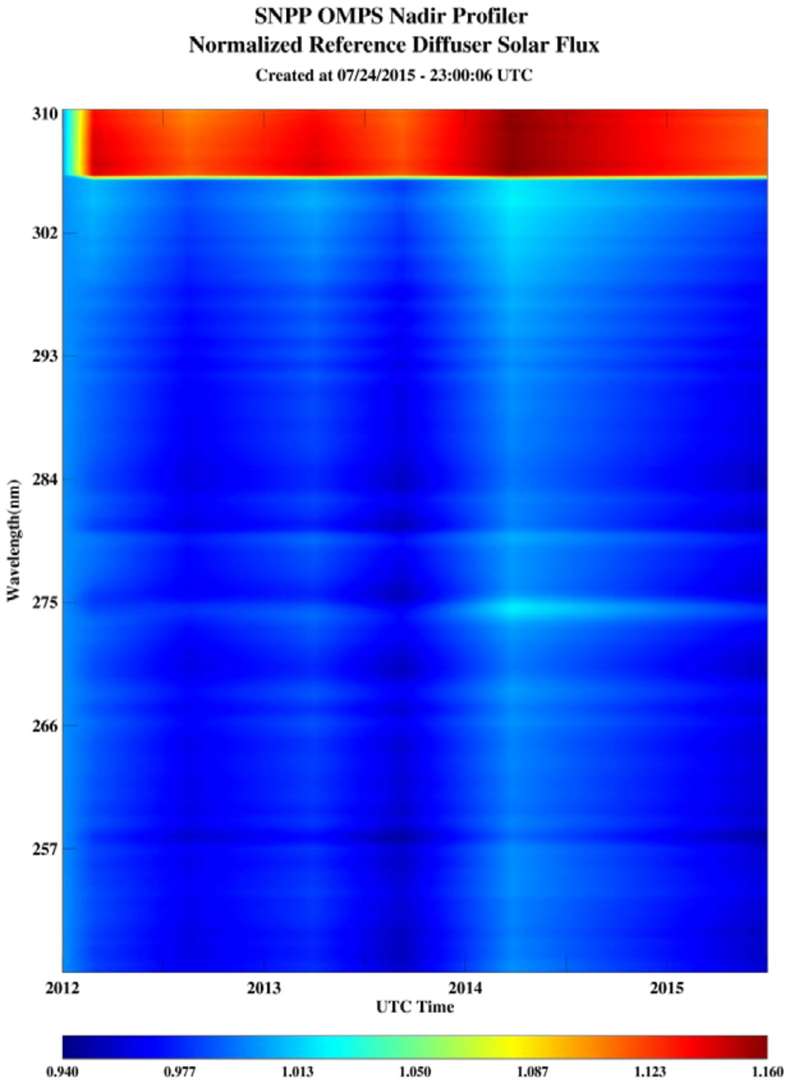
1
2
3
4
5
6
7

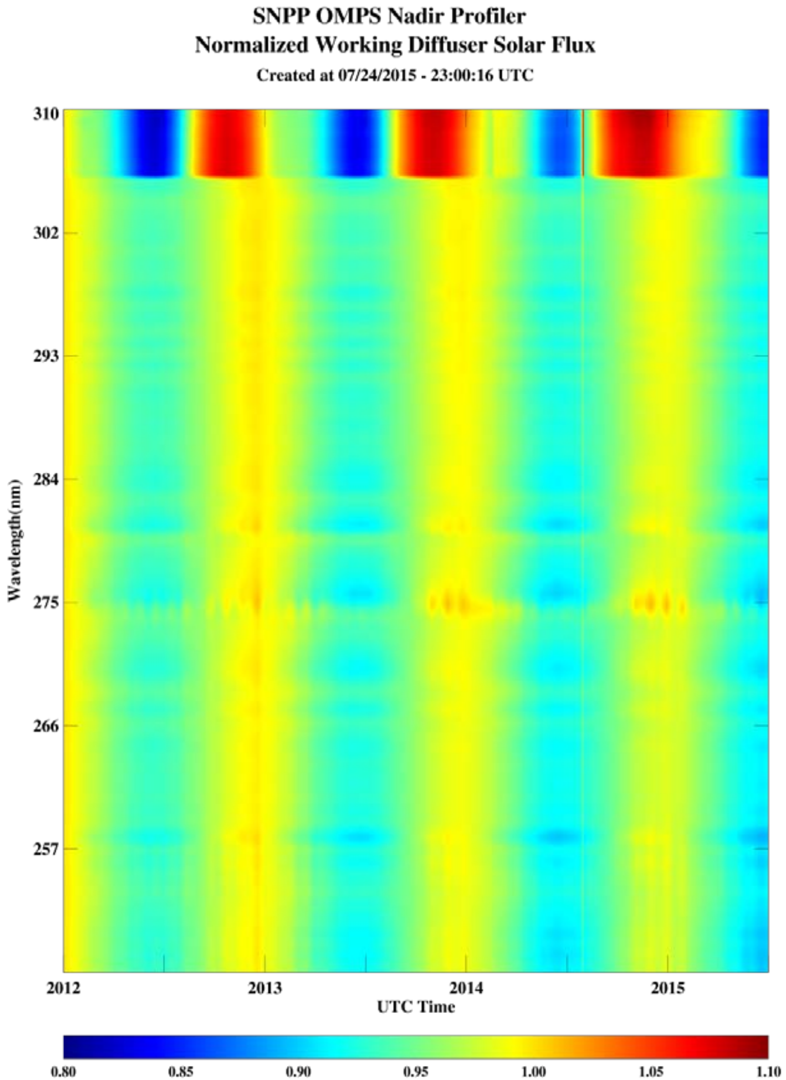
Normalized Solar Flux for NM and NP



Solar Flux value are normalized by the first day measurement. Solar Flux Measurements show minimal degradation in NM and NP. These plots show the expected patterns of annual cycles associated with the spacecraft orientation

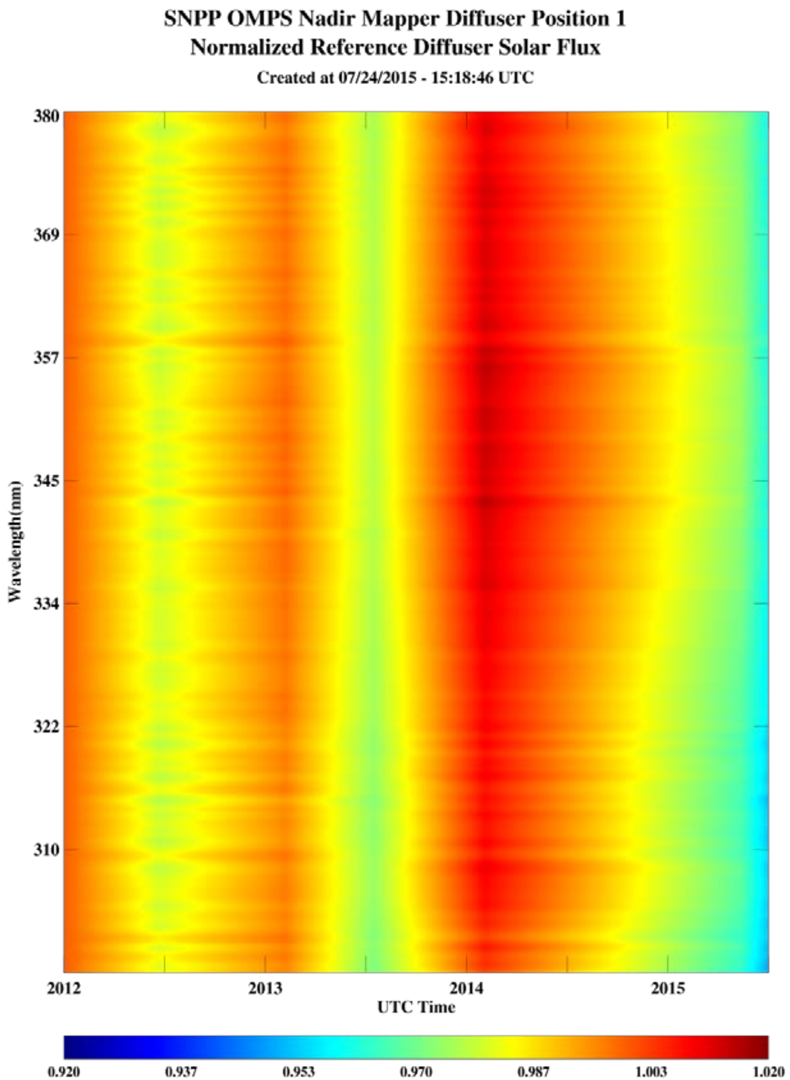
Normalized Solar Flux from NP Diffuser

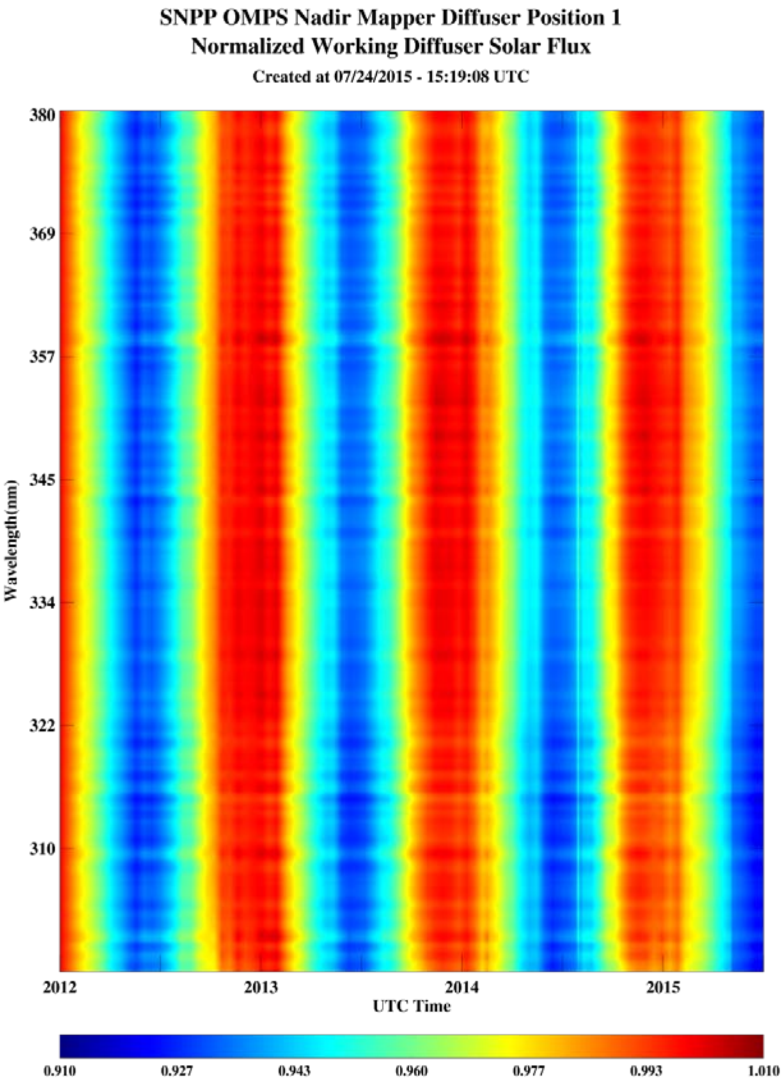




Solar Flux value are normalized by the first day measurement.

Normalized Solar Flux from NM Diffuser

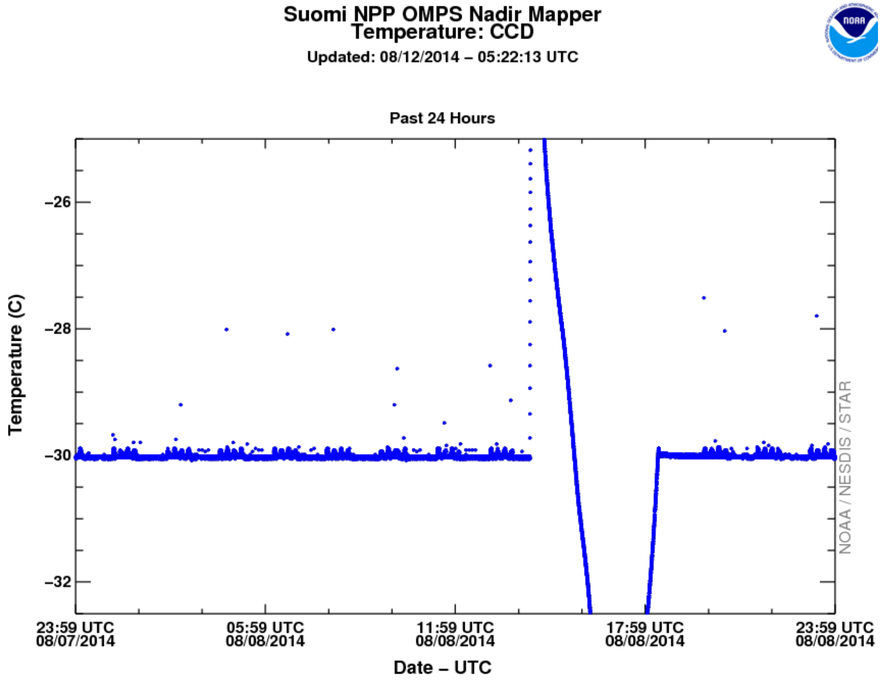


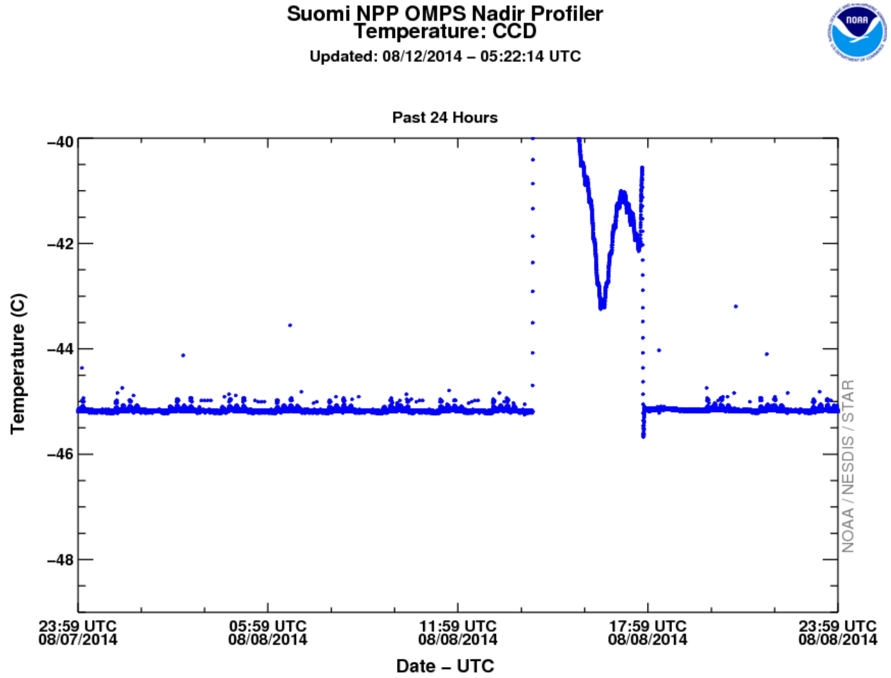


Solar Flux from NM diffuser position 1 and normalized by the first day measurement.

Health and Safety Related Parameters

ICVS monitoring of parameters important to instrument health and safety, such as temperatures, electronic voltages and currents, and scan motor encoder output.



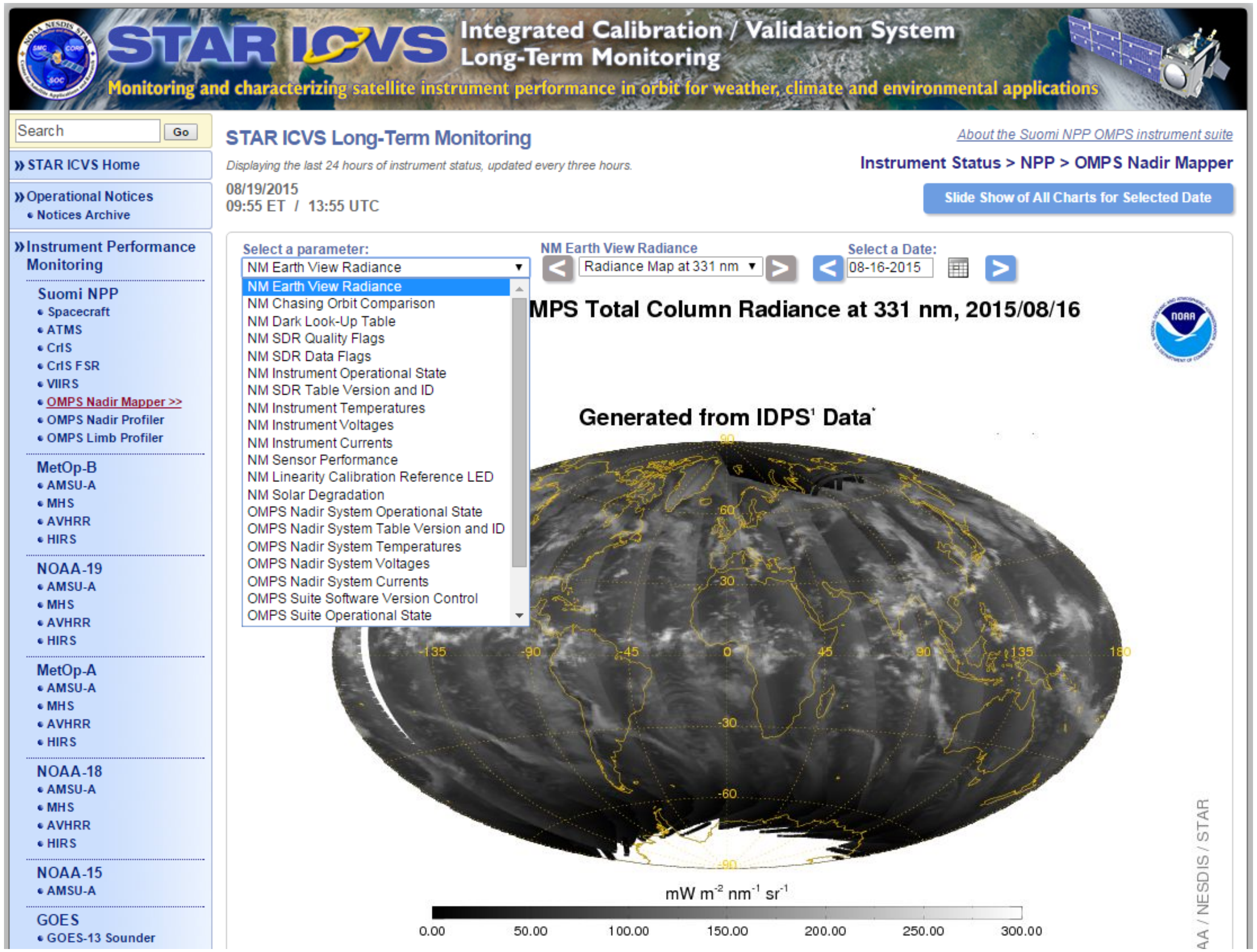


Introduction

Module	Parameters	Description
OMPS SDR	EV Radiance	Global radiance map
	Sensor Performance	Average and standard of Dark current, offset, smear
	Chasing Orbit Comparison	Reflectance comparison between SBUV/2 and OMPS
	SDR Quality Flags	solar eclipse events
	Dark Look-Up Table	Dark LUT statistics
	Linearity Calibration Reference LED	Reference LED counts statistics: left side, right side, earth view, full frame
	Solar Degradation	Solar flux Working diffuser and reference diffuse
OMPS RDR	SDR Data Flags	Linearity correction, gain correction, bin imager, reorder image
	Instrument Operational State	Fixed coadd count,
	SDR Table Version and ID	Gain correction, linearity correction, sample
	Instrument Temperatures	Housing, window, conduction bar, CCD
	Instrument Voltages	TEC error
	Instrument Currents	TEC, CCD output reset bias, CCD output drain bias
	OMPS Nadir System Operational State	Active Nadir Profile ID
	OMPS Nadir System Table Version and ID	Active timing pattern table version, timingpattern table ID
	OMPS Nadir System Temperatures	Signal board, timing board,telescope, calibration housing, diffuser motor
	OMPS Nadir System Voltages	CCD, signal board, timing board
	OMPS Nadir System Currents	Phase A motor drive, phase B motor drive
	OMPS Suite Software Version Control	Flight software version
	OMPS Suite Operational State	Calibration LED state, active main electronics box side
	OMPS Suite Temperatures	Motor driver board, SBC board, processor interface board
	OMPS Suite Voltages	TEC driver/reference, motor driver, CPE, motor/resolver electronics
	OMPS Suite Currents	Active calibration LED, CPE, TEC total

Introduction

Near real-time and long-term performance monitoring for SNPP/OMPS since 2011



http://www.star.nesdis.noaa.gov/icvs/status_NPP_OMPS_NM.php

Summary and Future Plan

- Comprehensive near real time and long term instrument status and performance monitoring
- Real time support for sensor calibration activities
- Automated anomaly detection and email warnings are established for radiance and key performance parameters
- New parameters will be monitored according to requirements from OMPS SDR team
- J1 proxy data will be tested

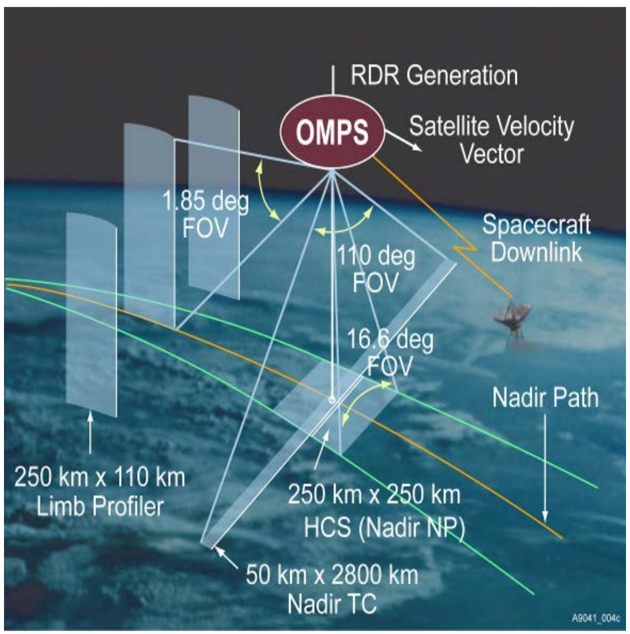
SNPP Limb sensor performance update and Level 1 status

NASA OMPS Limb instrument & L1 team

G.Chen, DeLand, Haken, Janz, Jaross, Kahn, Kelly, Kowalewski, Kowitt, Linda, Moy, Taha, Warner

Additional Material:

N. Gorkavyi, D. Soo



Wavelength: 290 –1000 nm

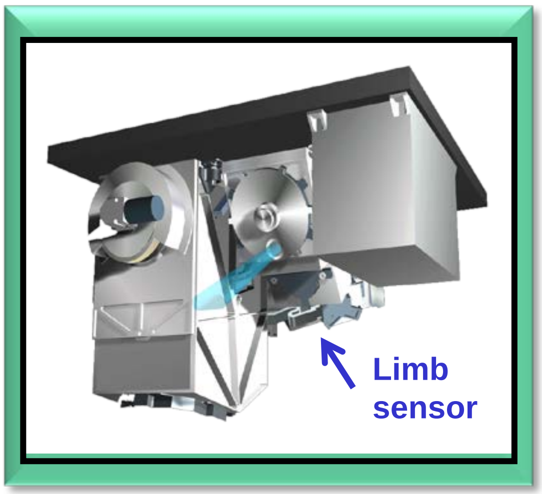
Bandwidth: 1 – 30 nm

Vertical range: 105 km (0-60 km permanently)

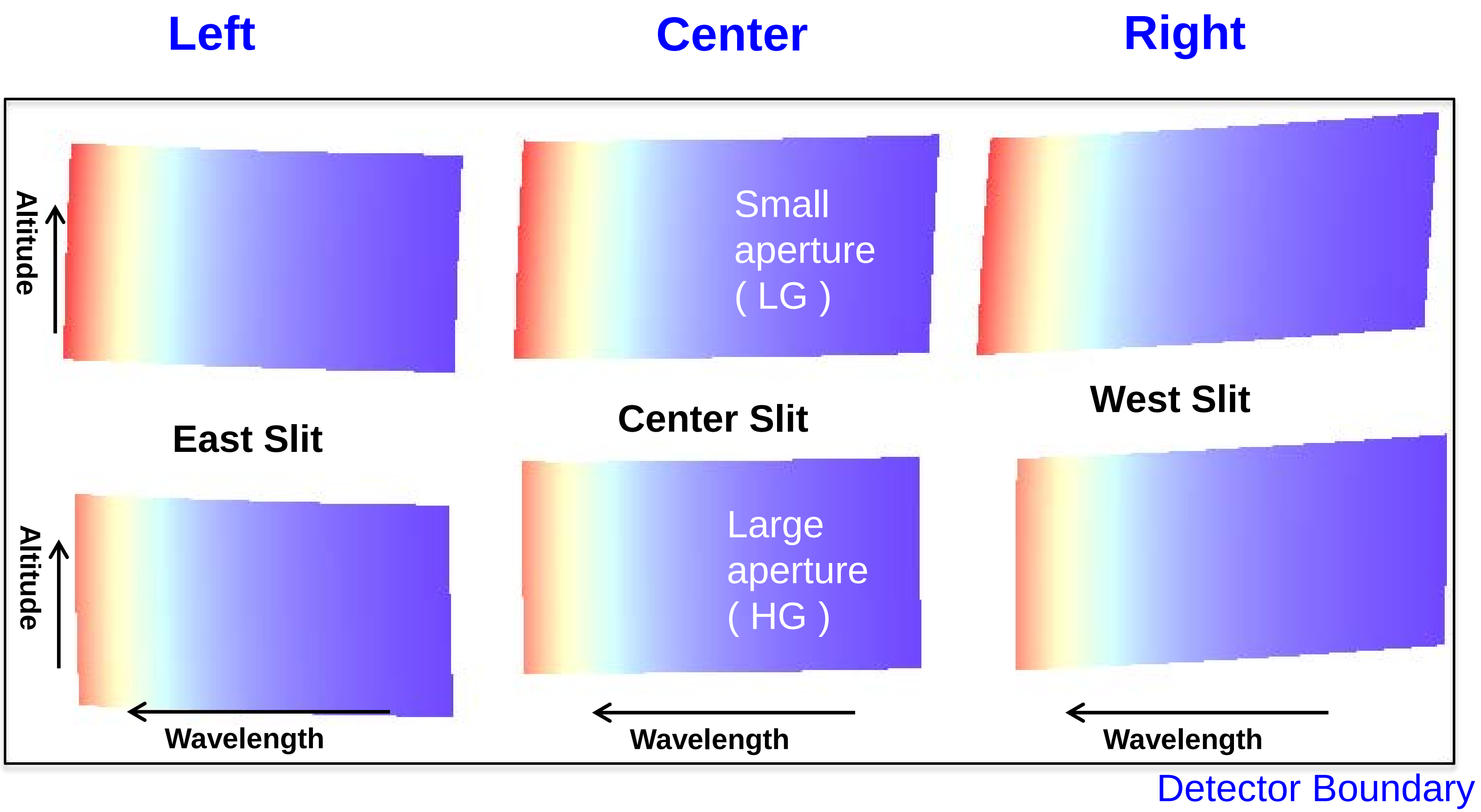
3 vertical slits; view aft

Primary error sources

- ***Pointing***
- ***Stray light***

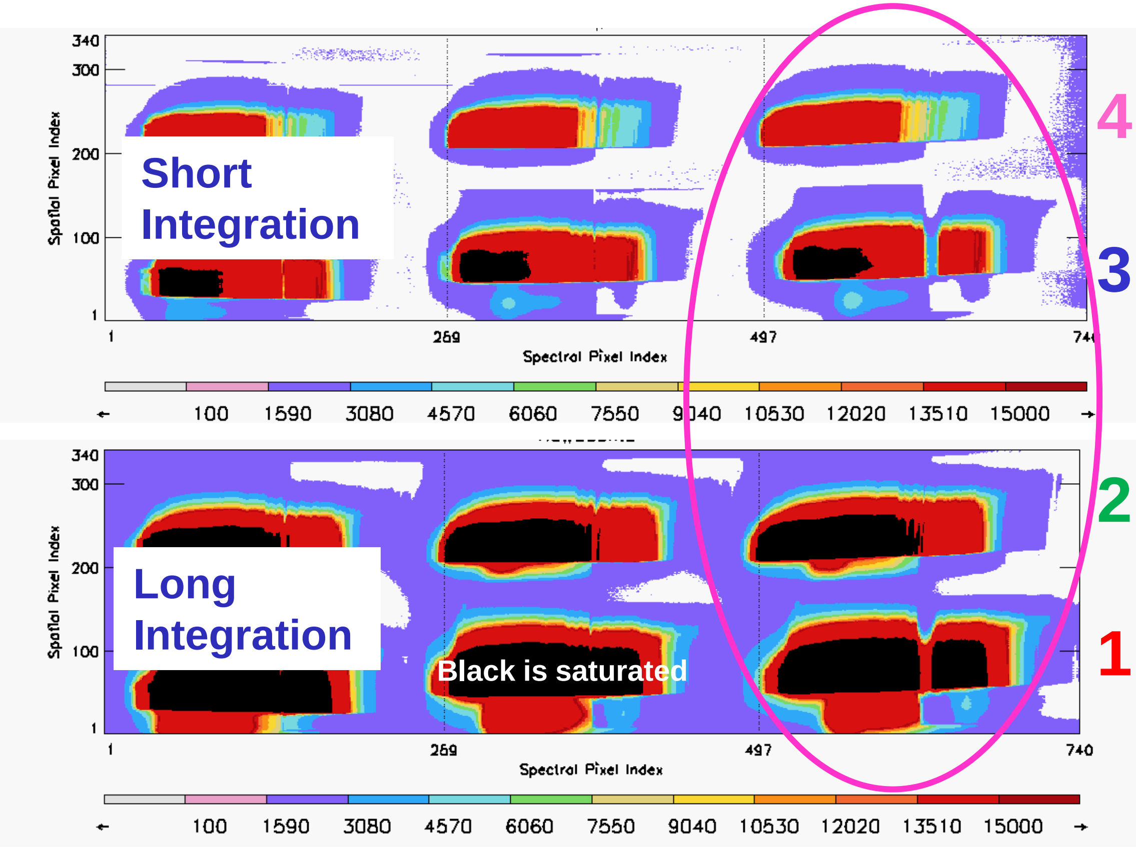


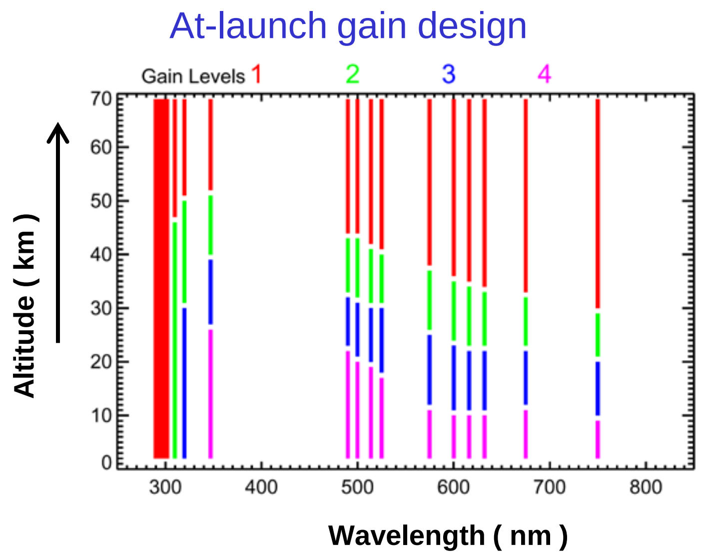
6 images collected on detector



Of the 250,000 photosensitive pixels, fewer than 70,000 are sent to the ground (mostly within the 6 aperture regions)

Original Gain stitching has been modified as of v2 release





Gain 1	HiGain Long
Gain 2	LoGain Short
Gain 3	HiGain Long
Gain 4	LoGain Short

Combining LoGain and HiGain created radiance discontinuities

Current operations (since Dec., 2013):

HiGain (280 - 500 nm) LoGain (450 - 1020 nm)

Gain 1 & Gain 3 Gain 2 & Gain 4

Stepped IT timing sequence

Current Timing:

Short – 0.04 s x 15
Long – 1.25 s x 10
} *interleaved*

time of median photons close to half of report interval

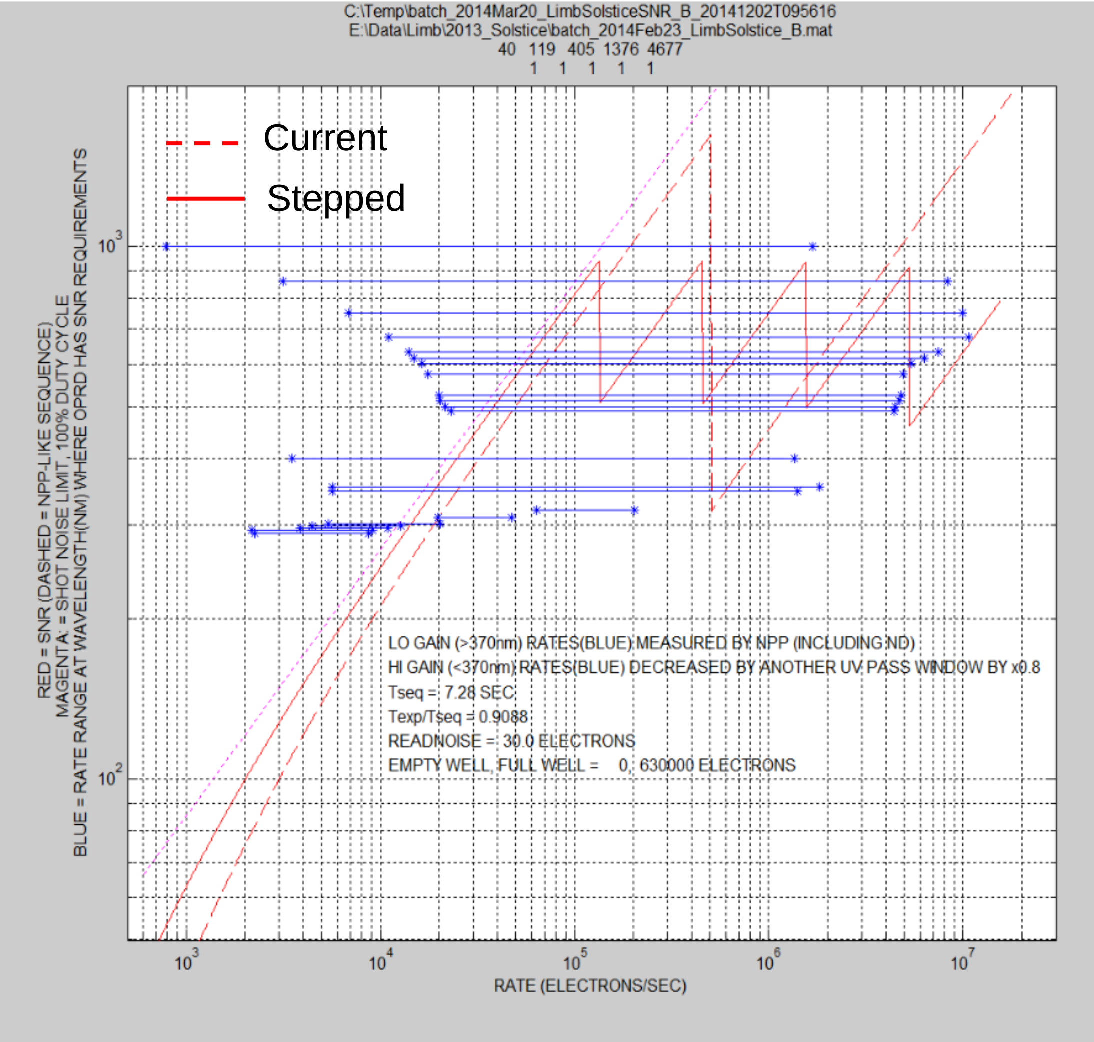
Flight hardware has the ability to discard saturated ITs on per-pixel basis

Proposed Timing:

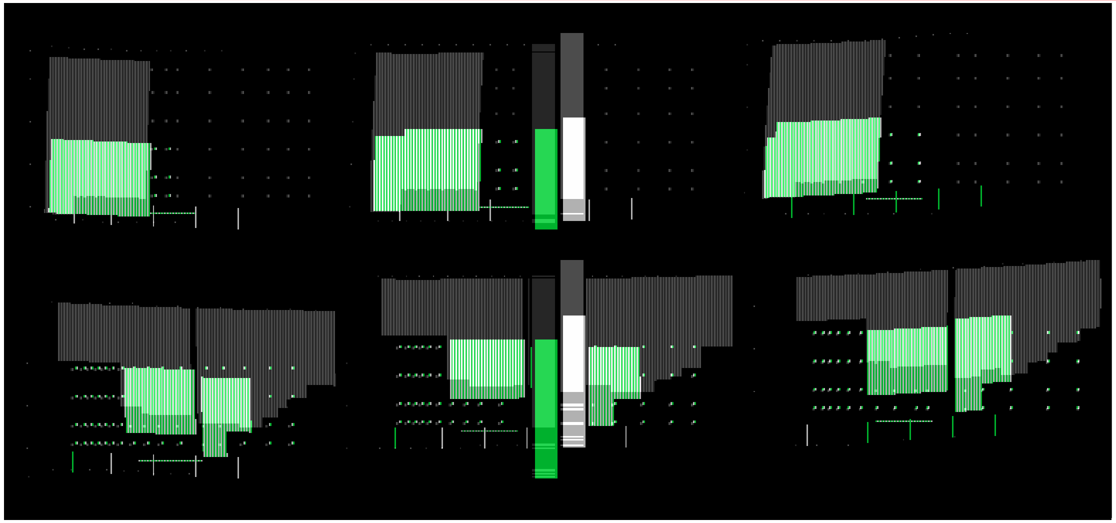
12.7 s
1.13 s
0.04 s
0.34 s
0.10 s
3.78 s
} *sequential*

time of median photons varies with altitude and wavelength

SNR vs. Signal Rate



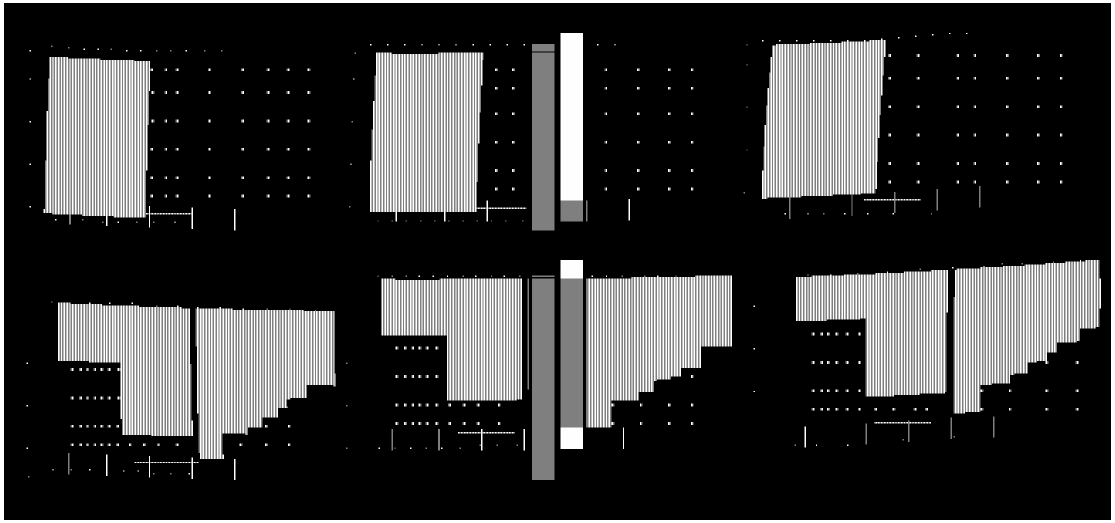
New timing reduces sampled pixels



Current v0.8 Sample Tables

- Long: 62,000 pixels
- Short: 26,500 pixels

Total: 88,500 pixels



Stepped IT Sample Table

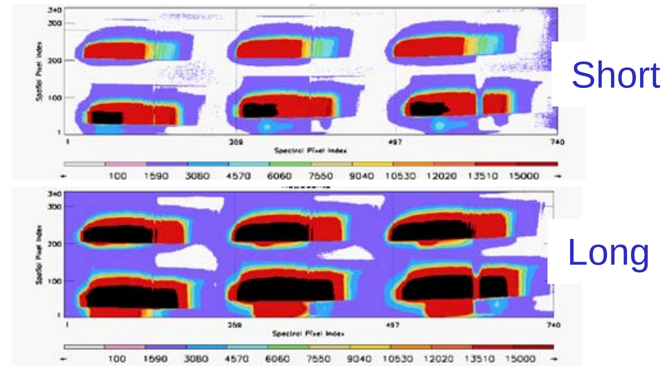
- Merged Long + Short
- 68,400 pixels
- Could eliminate high alt. VIS / NIR
- Could eliminate 2 UV slits

Implementation is still TBD

Level 1 Products

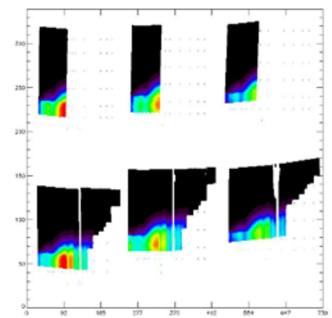
Level 1A

Counts-short [pixel x time]
Counts-long [pixel x time]



Level 1B

Radiance [pixel x time]
Irradiance [pixel x time]
Wavelength [pixel x time]
Geolocation [pixel x time]

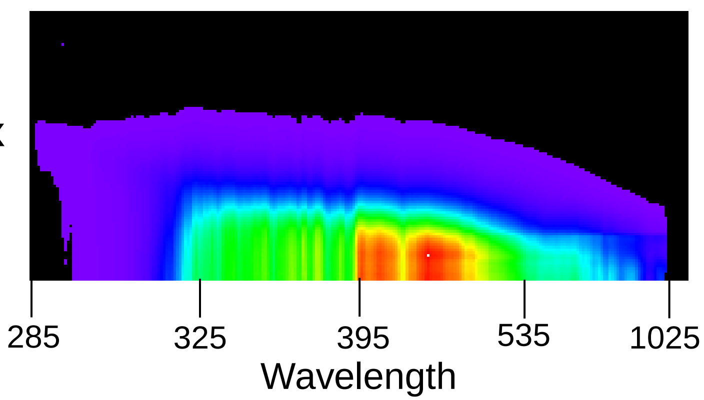


Level 1G **[release product]**

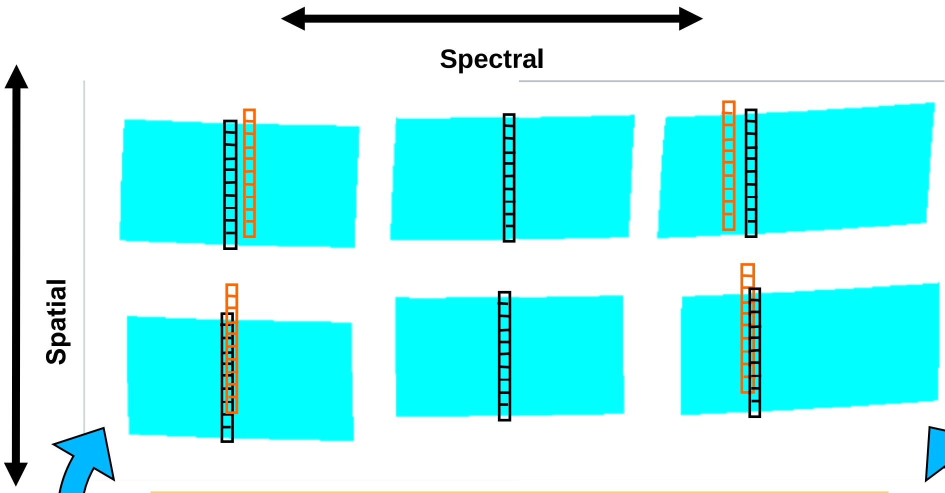
TOA Reflectance [TH x WVL x time x slit]
Recon. Radiance [TH x WVL x time x slit]
View conditions [time x slit]

Associated **L1_ANC** contains colocated temperature, pressure, ozone

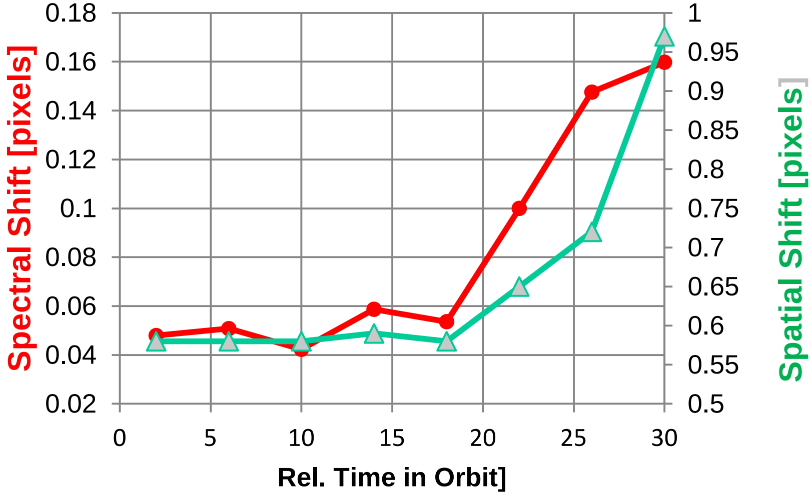
3 Slits x

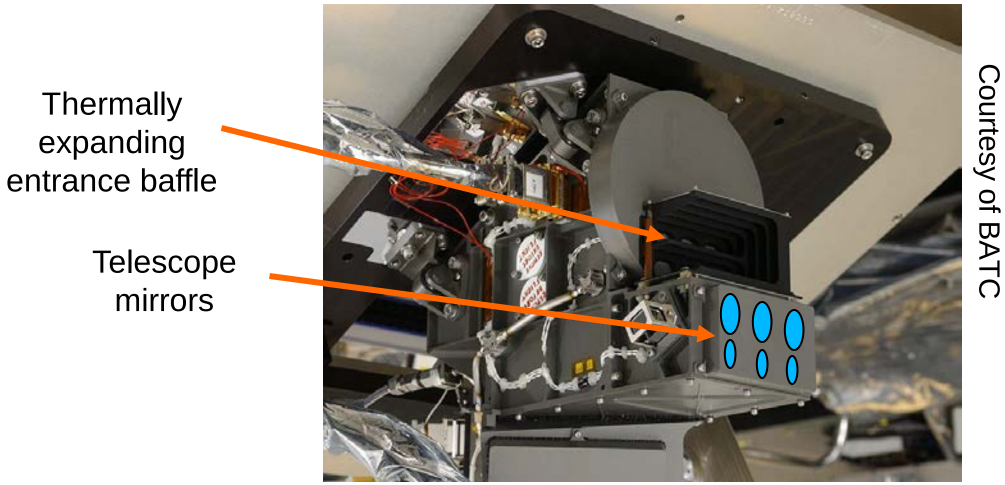


Variation in telescope temperature causes CCD images to shift



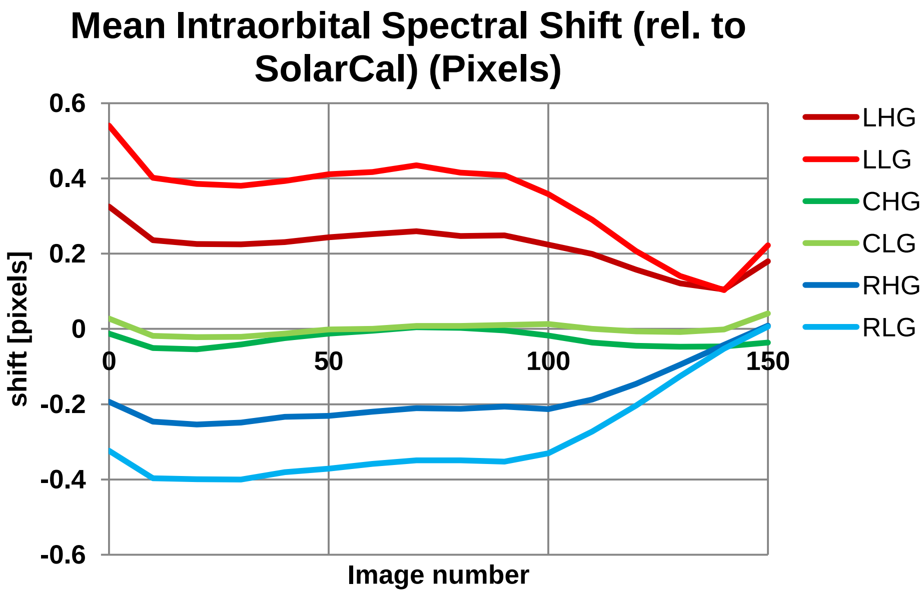
Slit images at focal plane shift due to stress on the telescope mirrors

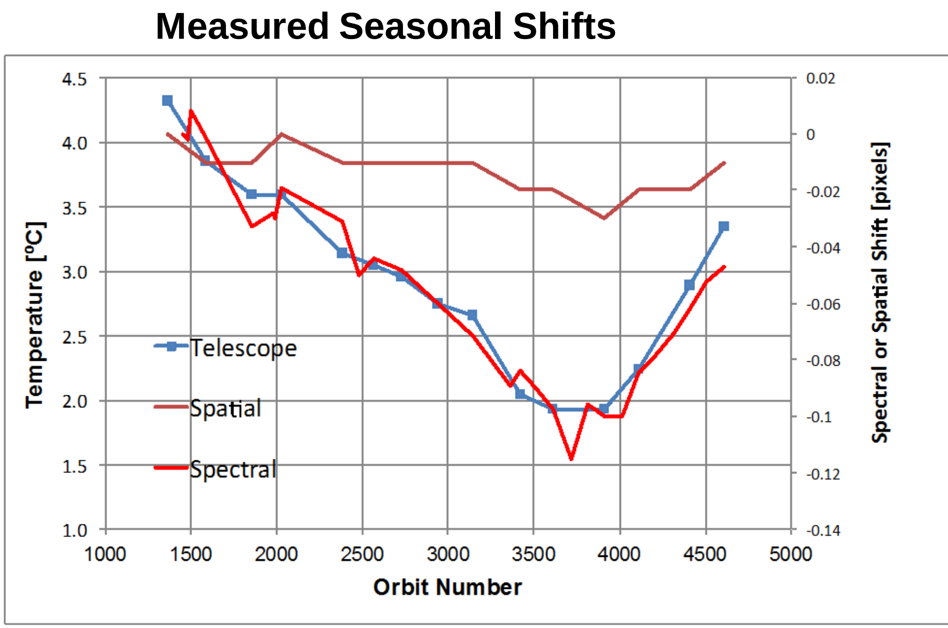




Shifts occur when sunlight illuminates the entrance baffle

Spectral shifts have been characterized





Orbital dependence is highly repeatable

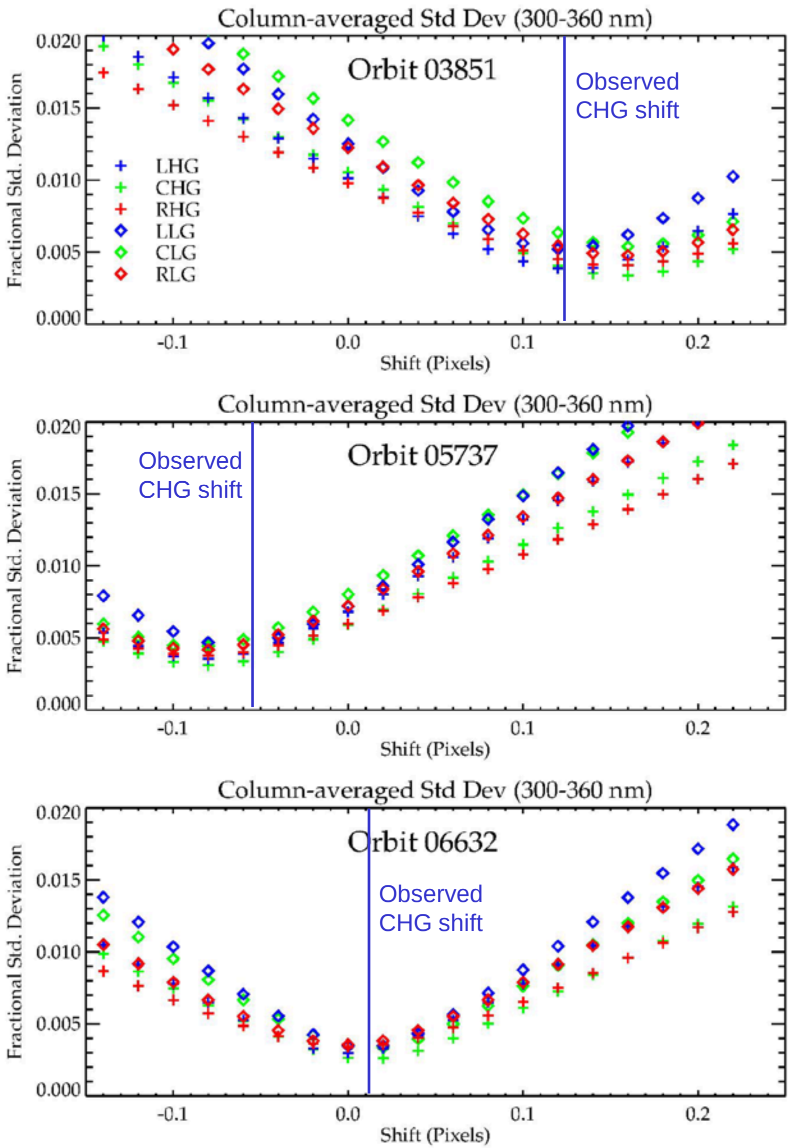
Corrections in Level 1B product

	Intra-orbital	Seasonal
Spectral Shift	Parameterized v. time in orbit	Parameterized v. orbit number
Spatial Shift	Parameterized v. time in orbit	Parameterized v. solar beta angle *

L1B solar irradiance synthesized from Day 1 measurement

Irradiance Scale factors derived from Hi-res reference spectrum – tabulated vs. spectral shift

Comparisons between a measured UV solar spectrum and the Day 1 spectrum are best when it is adjusted to the new wavelength scale

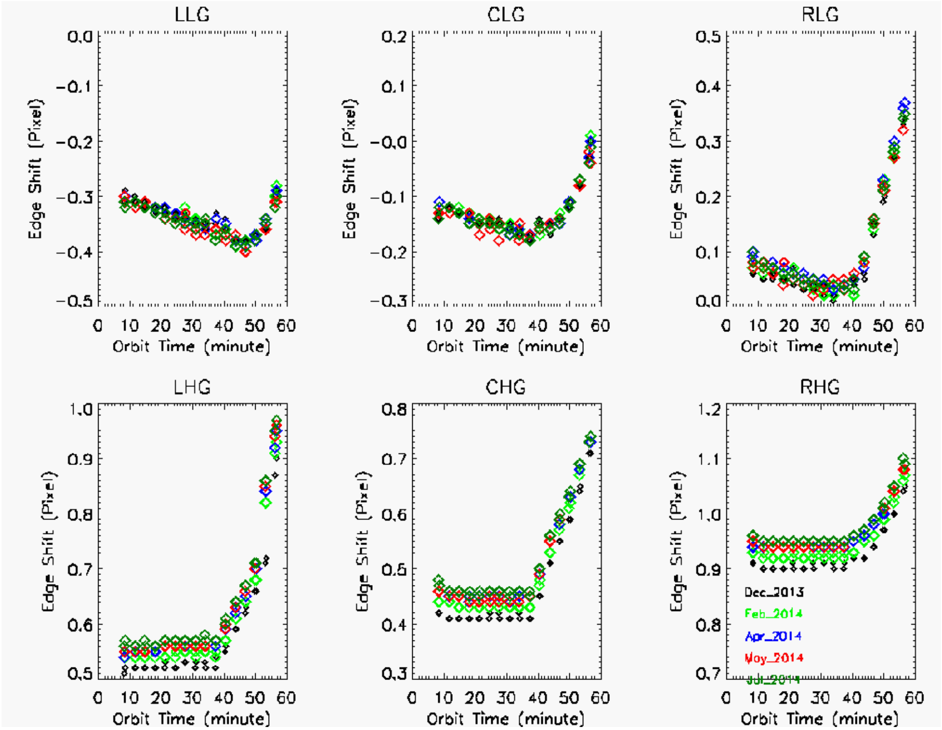


Additional pointing shifts beyond internal ones

We understand pointing changes caused by internal mirror shifts (using slit edge images).

Slit Edge offsets (km)

	L	C	R
Low Gain	-0.30	-0.10	0.10
High Gain	0.55	0.45	0.95



Additional pointing errors have been detected

350 nm Scene-based offsets (km)

	L	C	R
Low Gain	1.40	1.60	1.70
High Gain	1.20	1.40	1.50

Limb points higher than SC Diary indicates

Comparison to VIIRS

OMPS Residual vertical offsets (arcsec)

	East	Center	West
LoGain	78	90	96
HiGain	72	84	90

→ Mean (pitch) = 85 arcsec

Difference (roll) = 124 arcsec

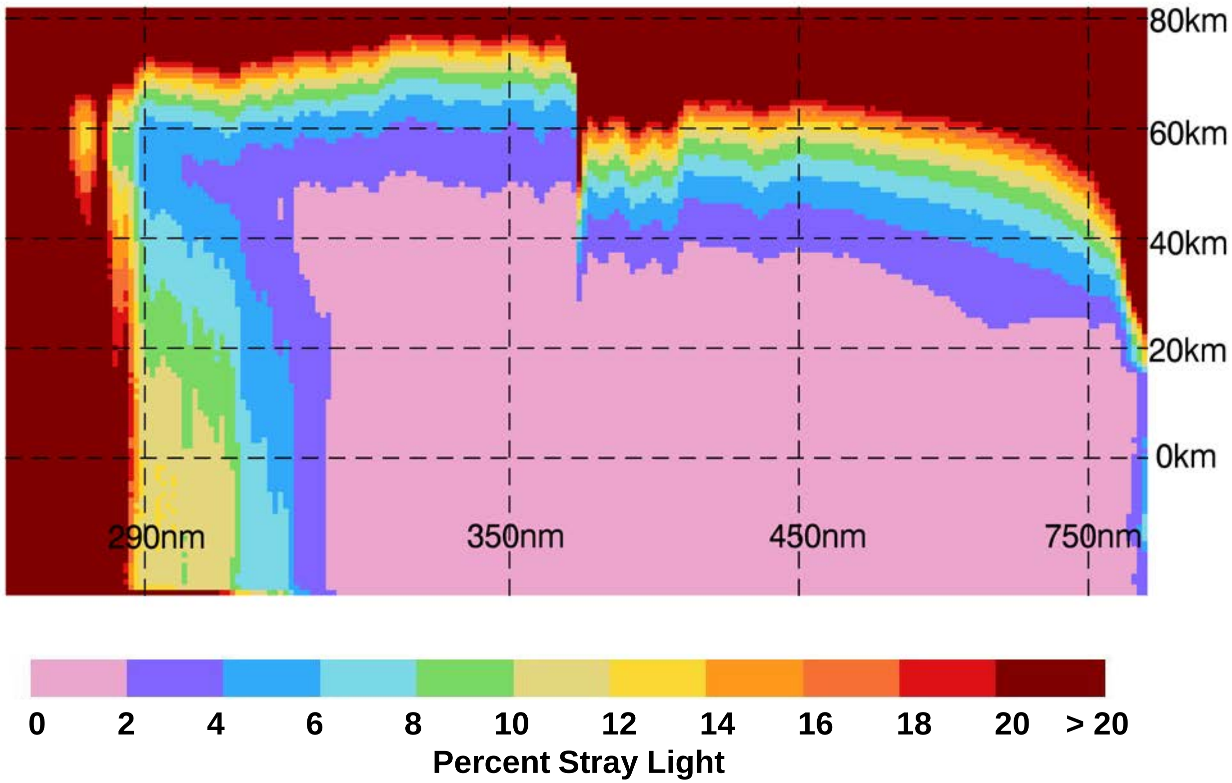
SNPP-VIIRS Angle adjustments (transformation is yaw, roll, pitch order)

Angle	Current (arcsec)	Proposed (arcsec)	Delta (P – C) (arcsec)
Yaw	33.2	95.4	62.2
Roll	41.2	-227.3	-268.5
Pitch	-59.3	153.2	212.5

From VIIRS SDR/GEO LUT Update 002

Feb. 2, 2012

Stray light correction ≅ stray light model

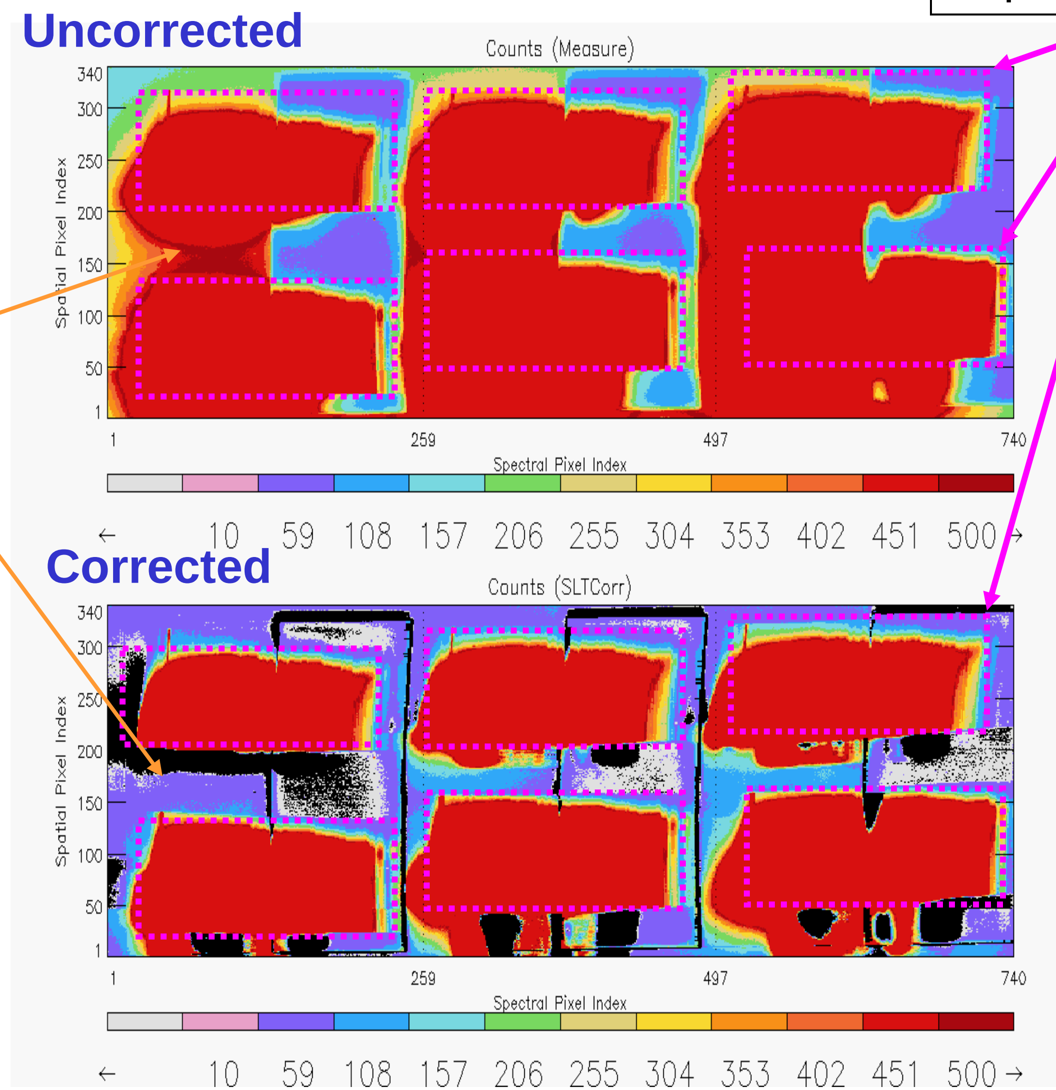


- Low signal levels
- Physically close to other apertures
- Increased reflection within detector
- Etalon effect makes scattered light difficult to characterize

MPS

Stray light verifications

Optical Region

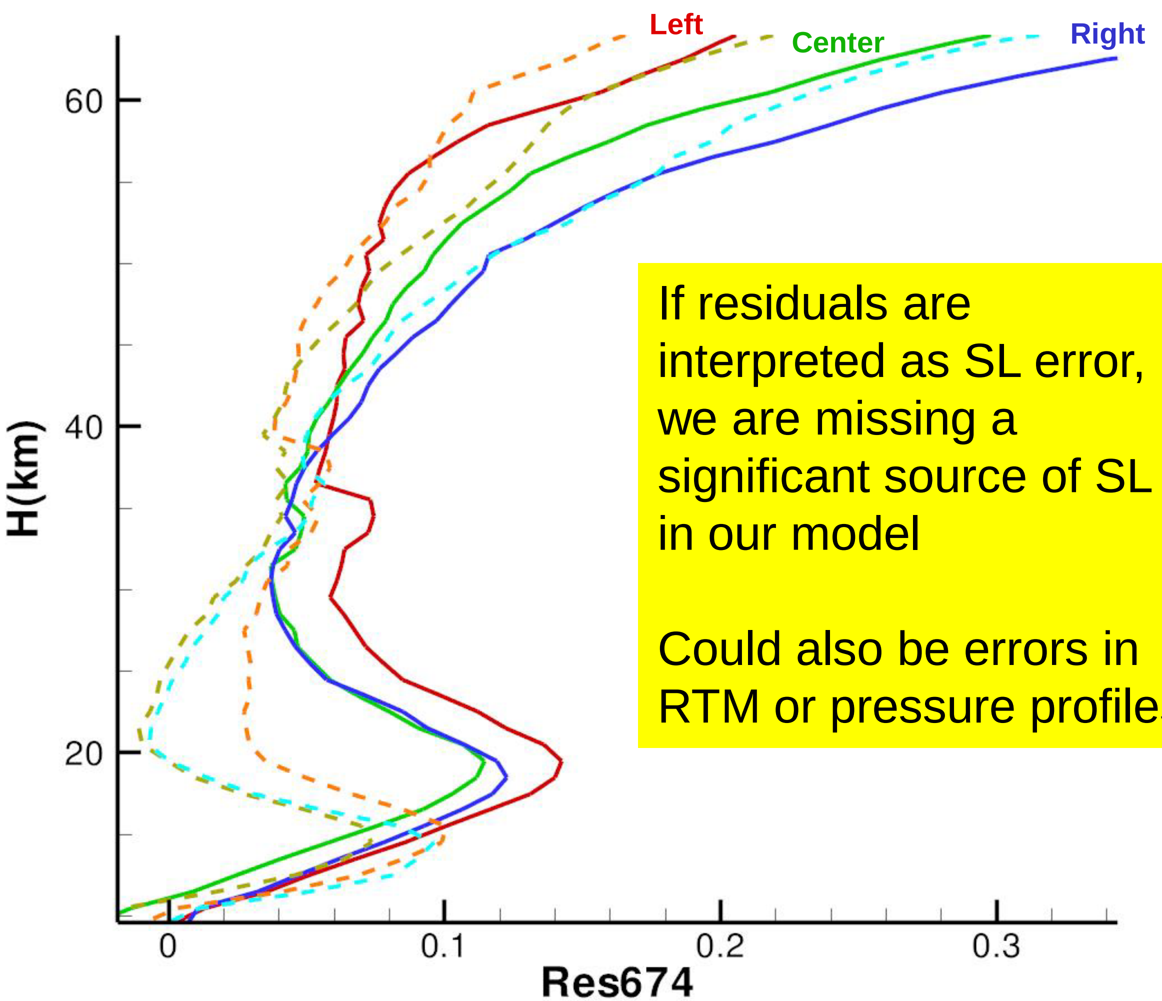


Stray light correction evaluated using non-optical regions on detector

Stray light errors remain in high-altitude VIS / NIR

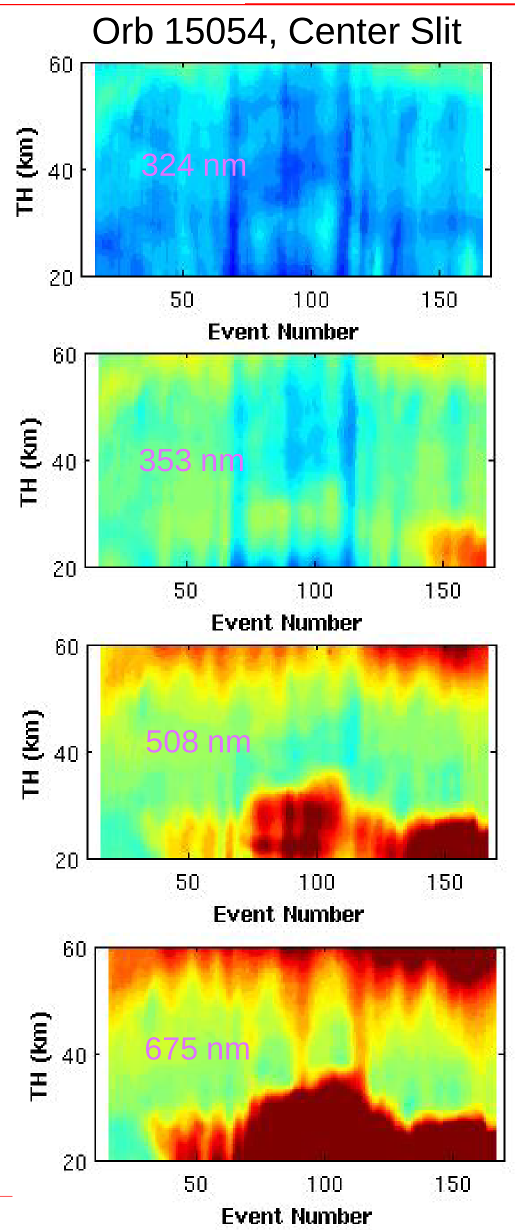
Residuals have stray light signature

Residual 674 nm for **Frame 20**,
Daily average for **March 25** and **October 13 (dashed)**, 2013

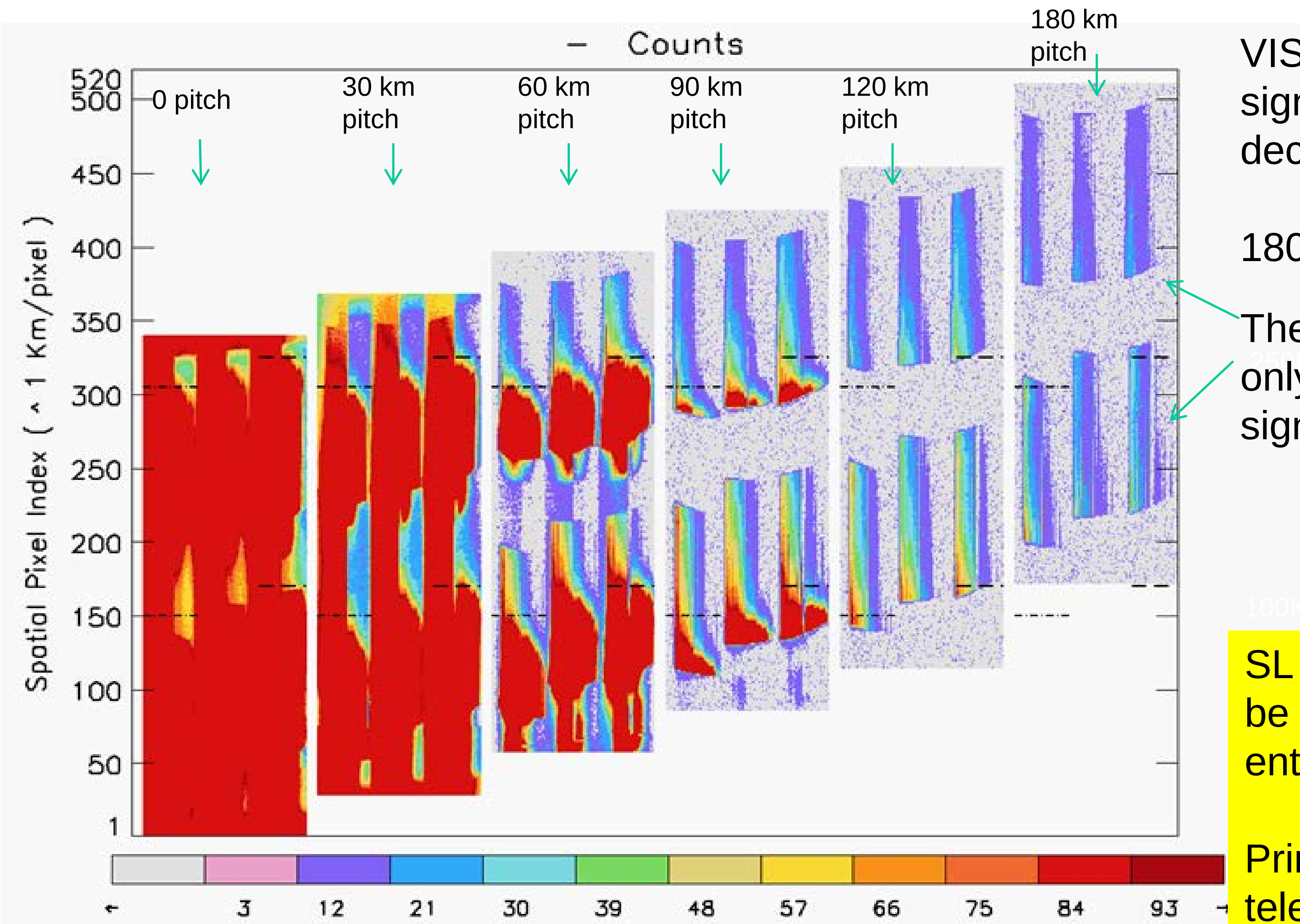


If residuals are interpreted as SL error, we are missing a significant source of SL in our model

Could also be errors in RTM or pressure profiles



Pitch-up suggests additional stray light source



VIS backscatter signal drops one decade per 20 km

180 km ➔ 10^{-9}

There should be only background signal

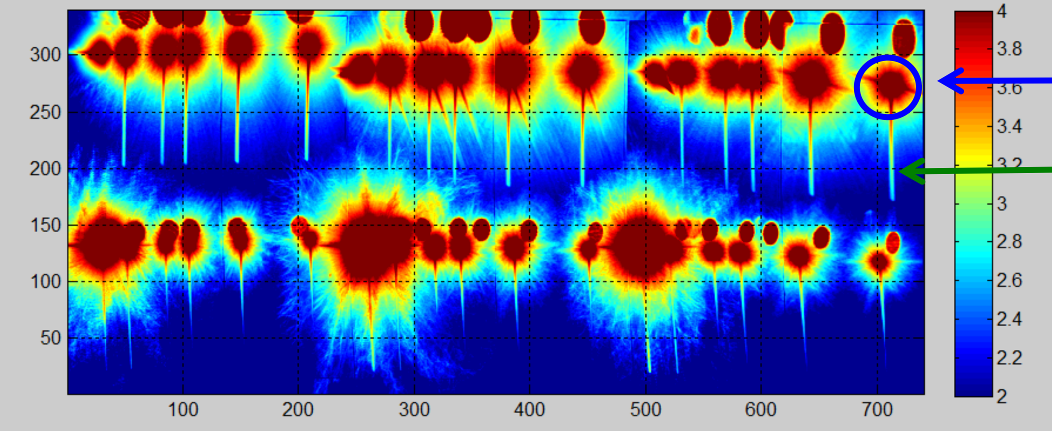
SL source must be prior to entrance slit

🡻

Primary telescope mirror

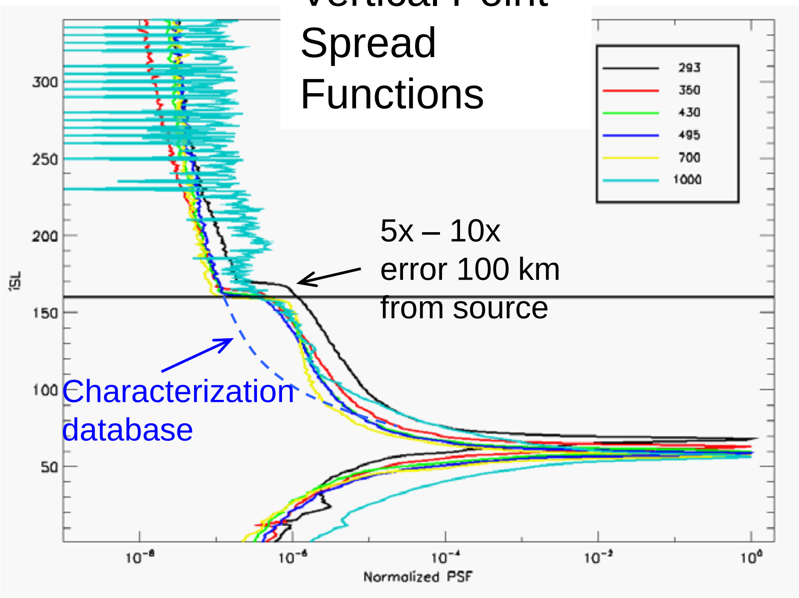
Current SL correction ignores telescope scatter

Composite PSF measurements



Spectrometer scatter

Primary mirror (telescope) scatter

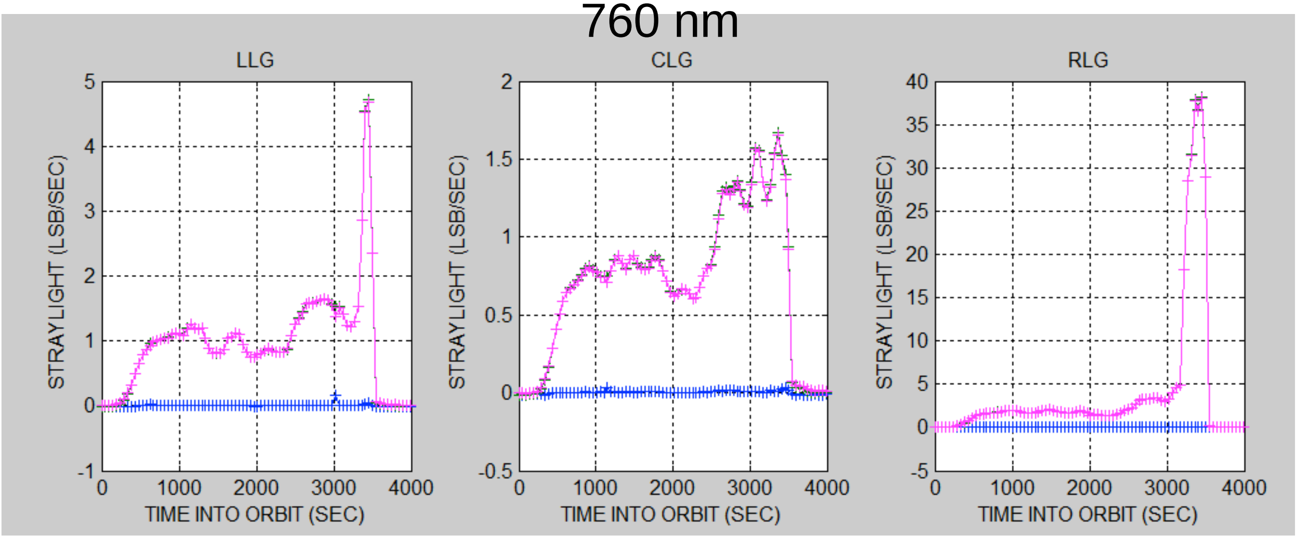


Greatest difference is for source pixels far from target (e.g. Earth surface)

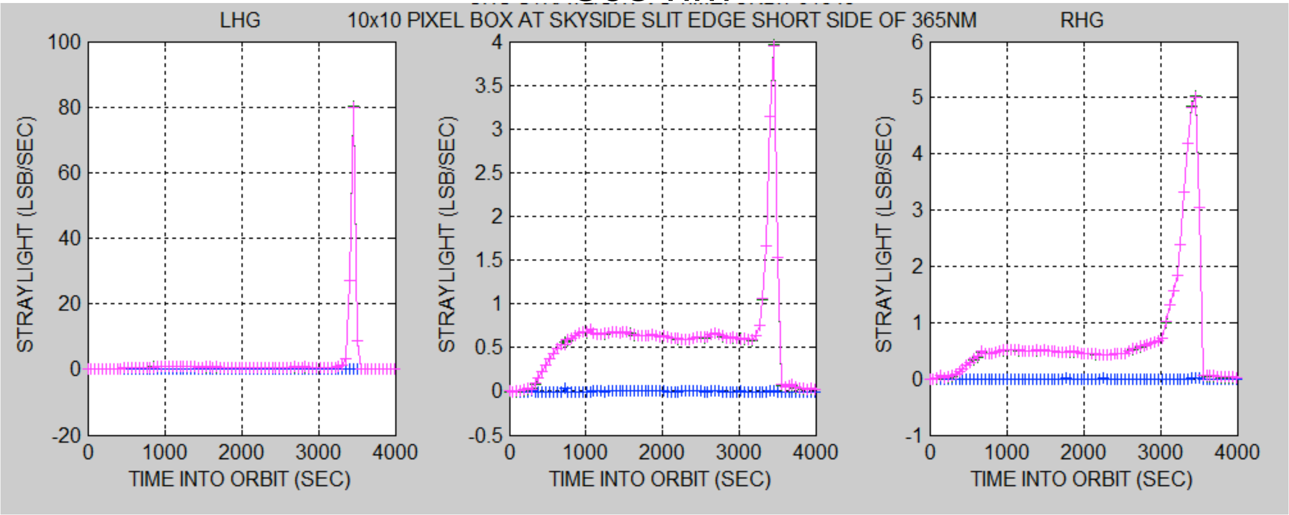
Largest Earth limb vertical contrast is in the NIR, so largest error occurs there

Pitch-up confirms sun intrusion at end of orbit

760 nm



365 nm



Occurs earliest in Right slit (closest to sun)

As low as SZA=78°

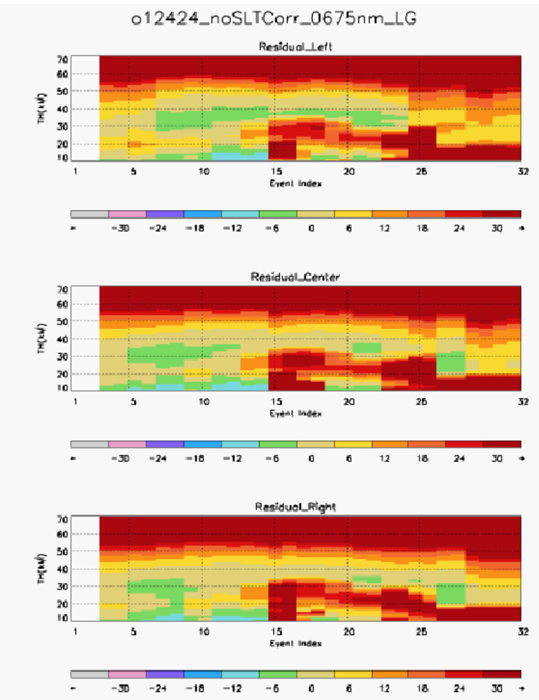
Expect it to be worst in early July, but have not investigated

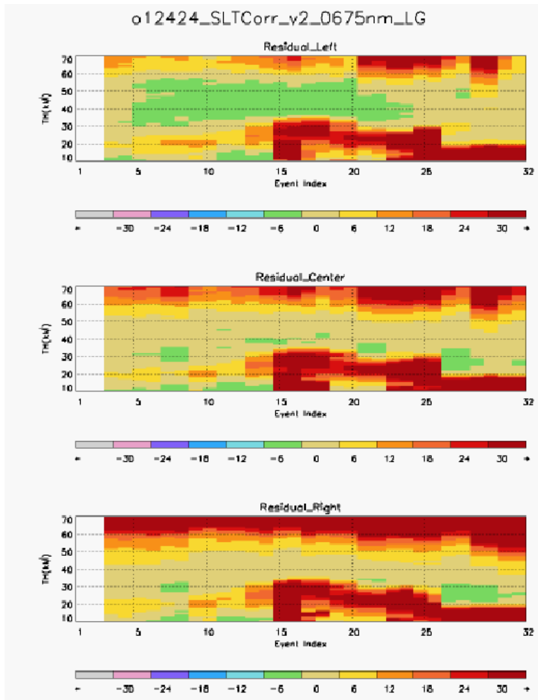
Summary of L1G changes for next release

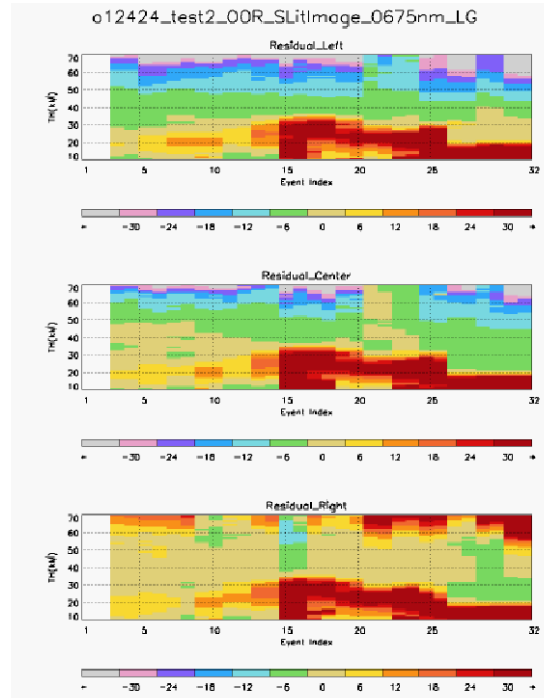
	Version 2	Next Release	Long Term
Radiometric	Calibrated radiances on uniform grid	Sun-normalized radiances on uniform grid	L-T trend corrections
Wavelength registration	Varies intra-orbitally & seasonally	same	L-T trend corrections using solar cal.
Altitude registration	Static offset corrected via early RSAS analysis; intra-orbital variation	Zero all 3 slits using updated RSAS (100-300m); remove small seasonal cycle using slit edge	Intra-orbital & L-T drifts; still measuring the moon
Stray Light	Jacobian based on delivered PSFs	Simple empirical scaling of correction	Correction for telescope SL and >1μm leakage; sun leakage corr.
Transients	No flagging	Smear transient flagging	Pixel transient rejection

Extra slides

Stray Light improvements







CPC Ozone Applications

Craig S Long
Jeannette Wild, Hai-Tien Lee, Shuntai Zhou
NOAA/NWS/NCEP/Climate Prediction Center

Ozone Data Sets Used at CPC

- CPC has been monitoring ozone since the mid 1970’s.
- Monitoring / Evaluation / Intercomparison
- SBUV/2
  - Operational v8.0
  - Recalibrated v8.0
  - Recalibrated v8.6
- SBUV(/2) Merged Cohesive CDR
  - Provided to NCEI
- OMPS
  - Nadir Profiler (v6, waiting for v8)
  - Nadir Mapper (v7 OOTCO, waiting for v8)
  - Limb Profiler (waiting to be provided operationally)
- GFS ozone analyses/forecasts
  - Evaluate what is assimilated and quality of forecasts
- NDACC Lidar
- Reanalyses
  - CFSR, MERRA, ERA-I, JRA-55, etc

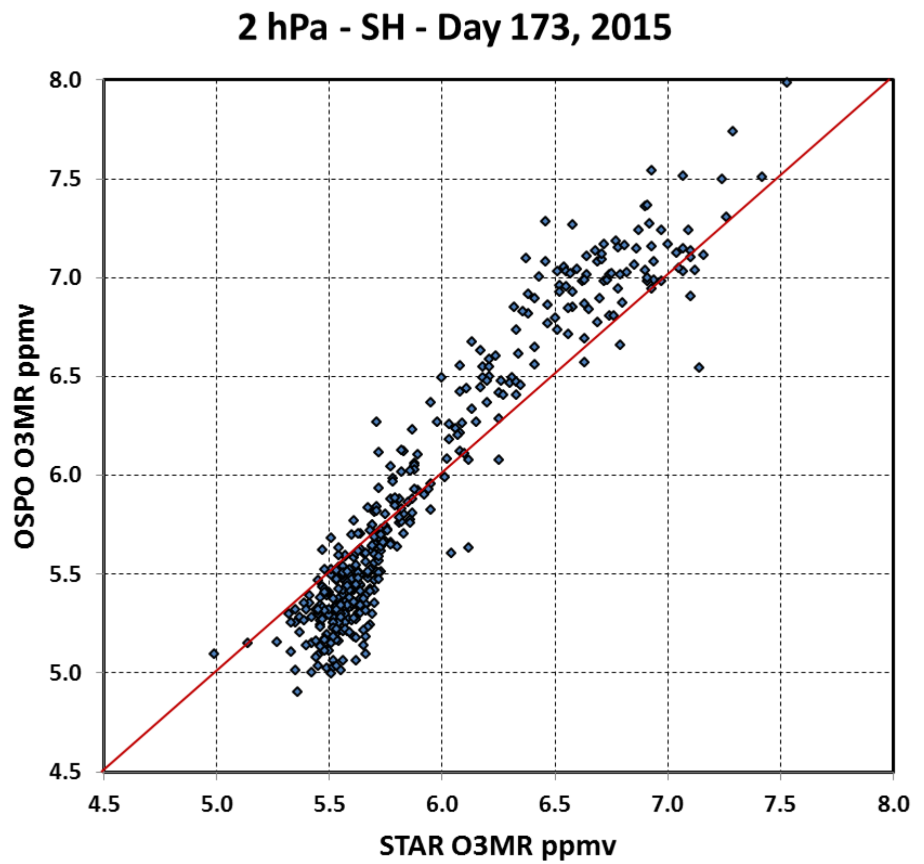
Operational / Recalibrated SBUV/2

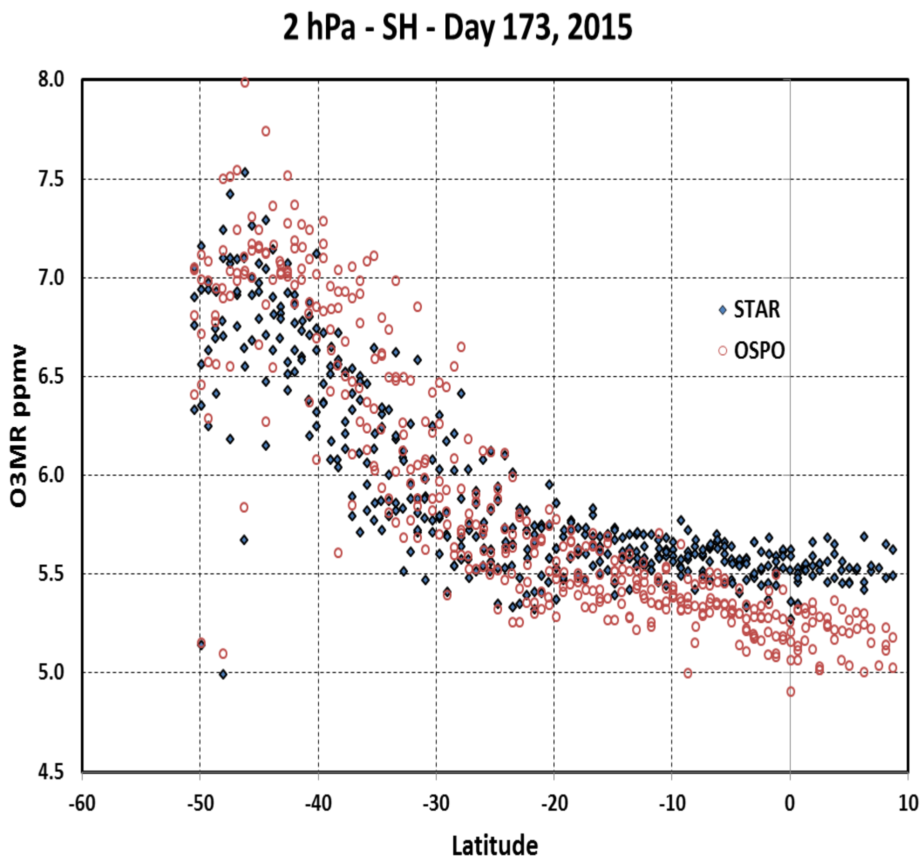
- Operational orbital SBUV/2 products are assimilated into the GFS/CFS and CPC analyses.
  - GFS : ozone forecasts : UV Index
  - CPC : ozone analyses : ozone hole area
- End-of-month recalibrated SBUV/2 products are used for monitoring long term trends
- CPC monitors both and inform OSPO and STAR when the two differ significantly.

Diff between OSPO and STAR

- OSPO : operational processing
- STAR : end of month reprocessing
- Disagree at 2 hPa
- 252nm channel
  - OSPO uses
  - STAR does not
- Which is right?
- Importance : OSPO is put into CLASS
  - STAR is used for long term monitoring

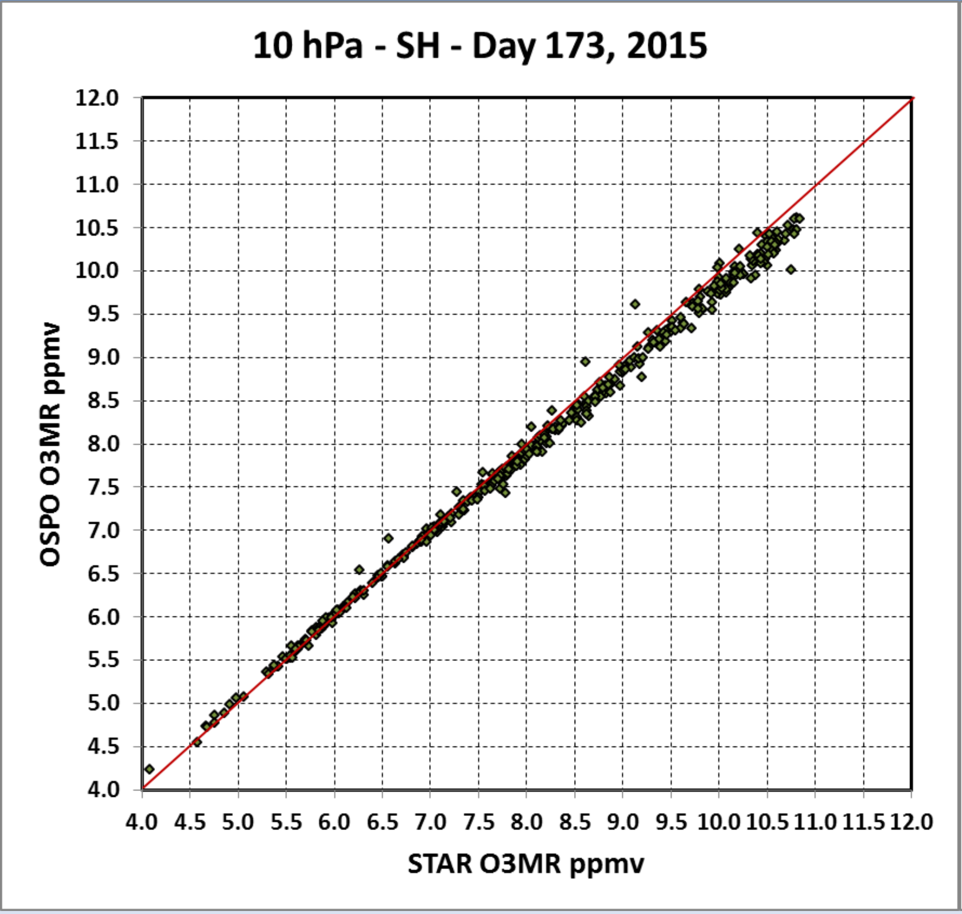
Diff between OSPO and STAR

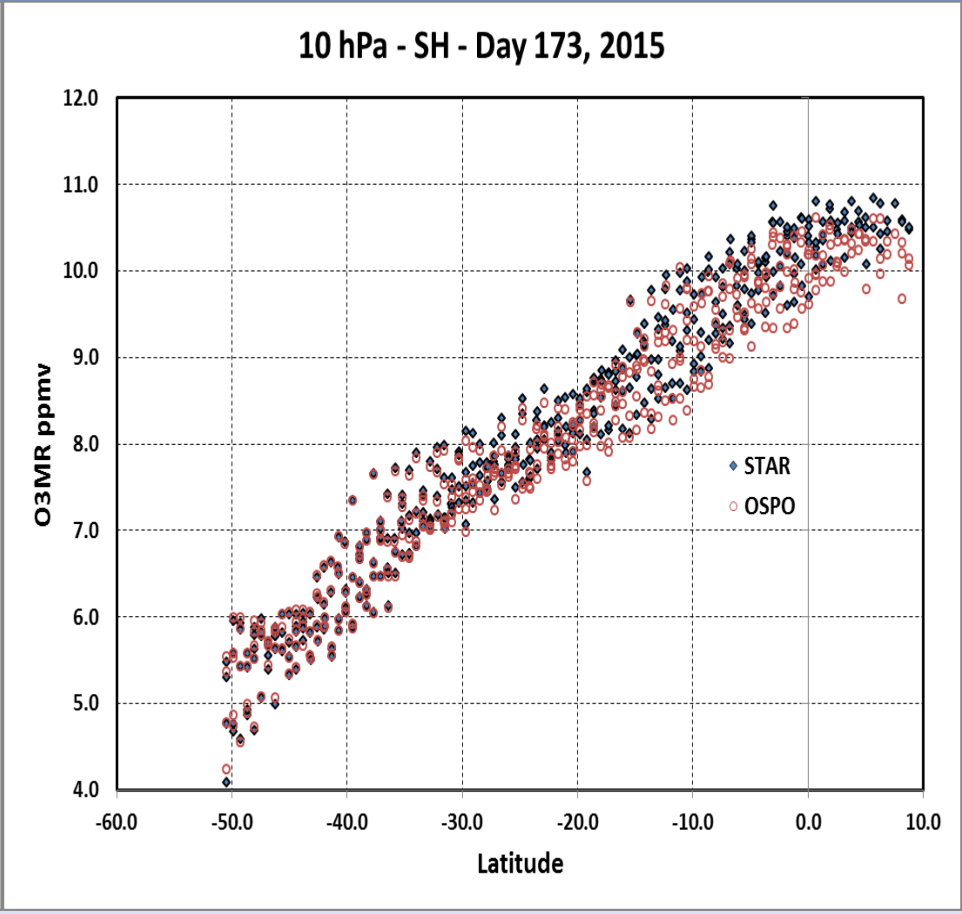




Disagreement in upper stratosphere

Diff between OSPO and STAR

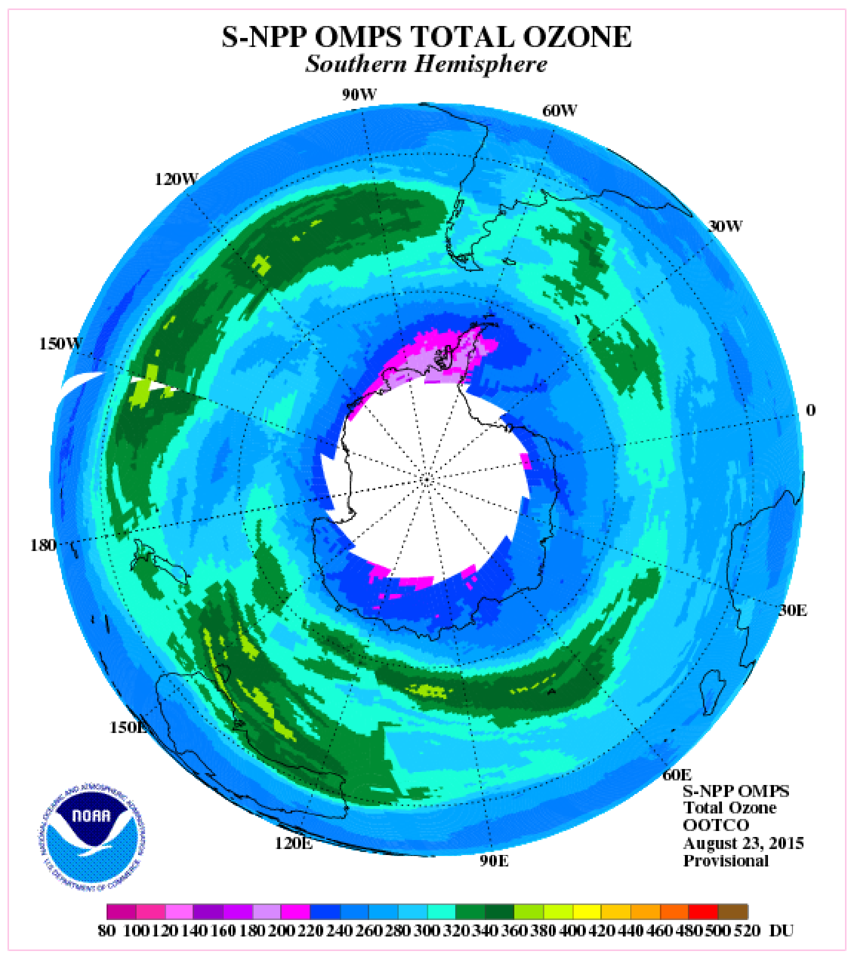




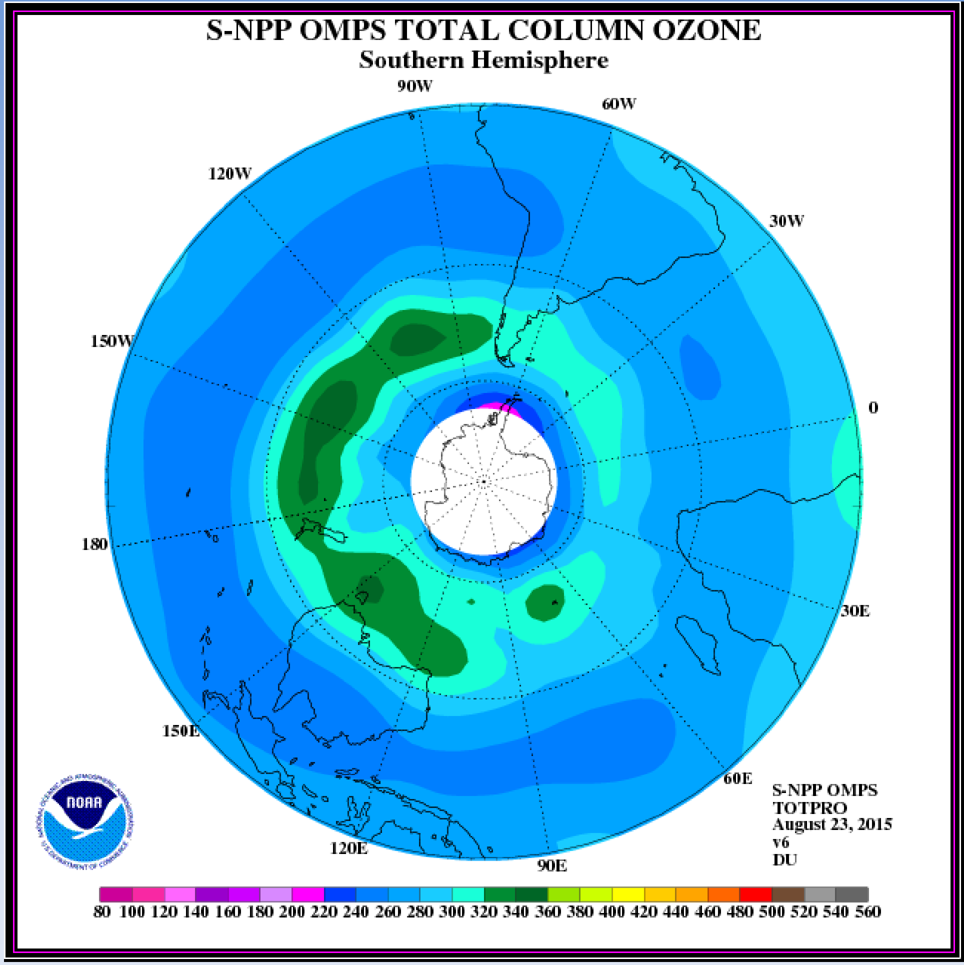
Agreement in middle stratosphere

OMPS Ozone Analyses

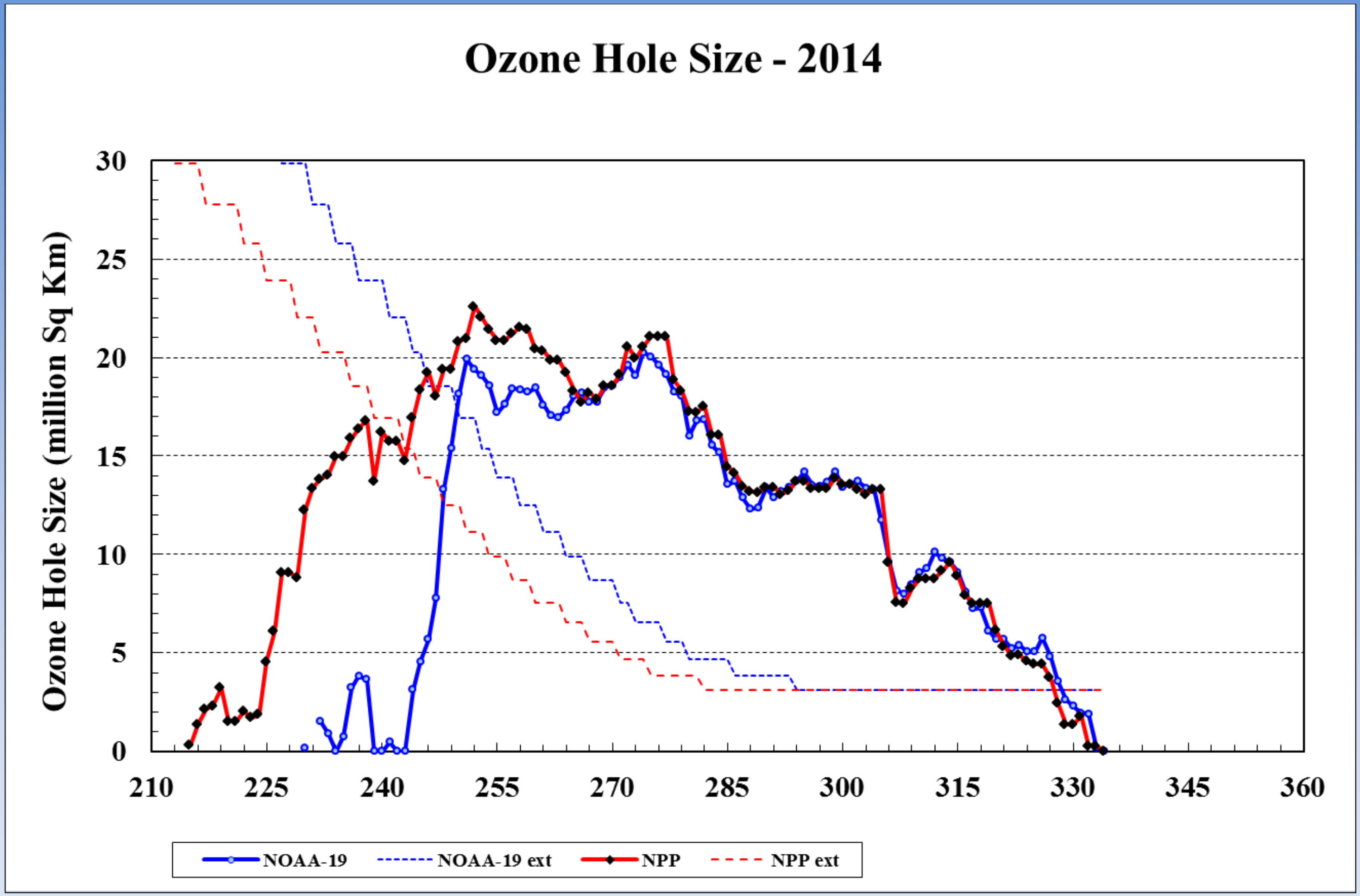
Total Column Mapper



Analysis using Total Profile

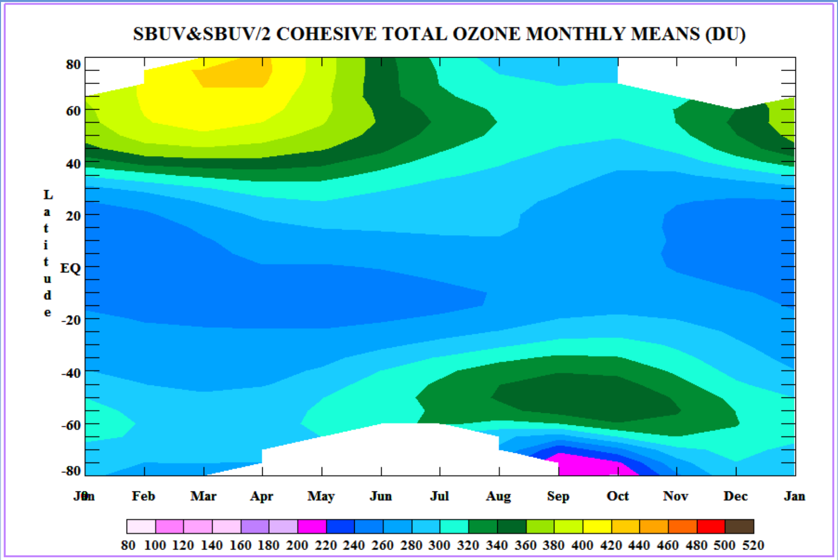


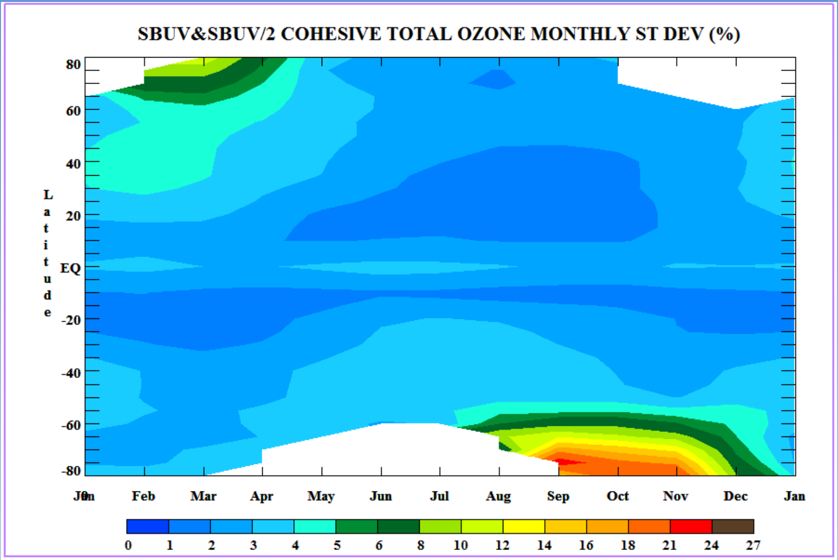
OMPS Ozone Hole Monitoring

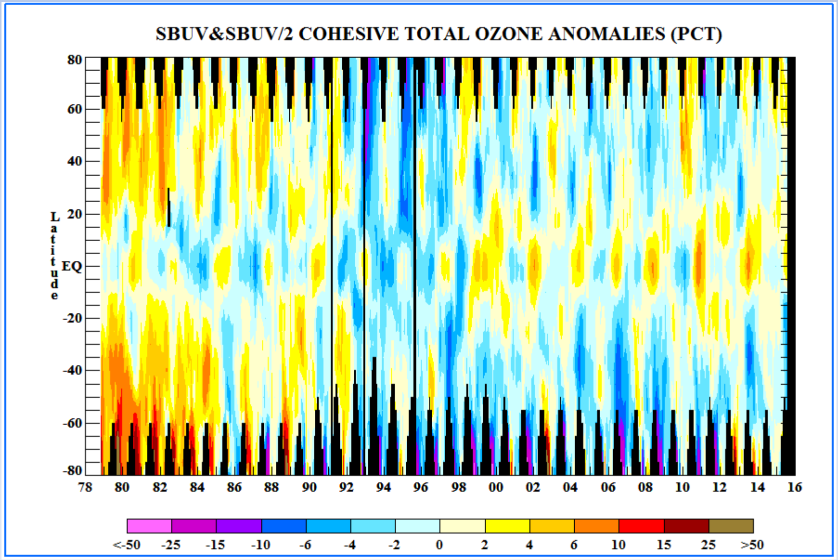


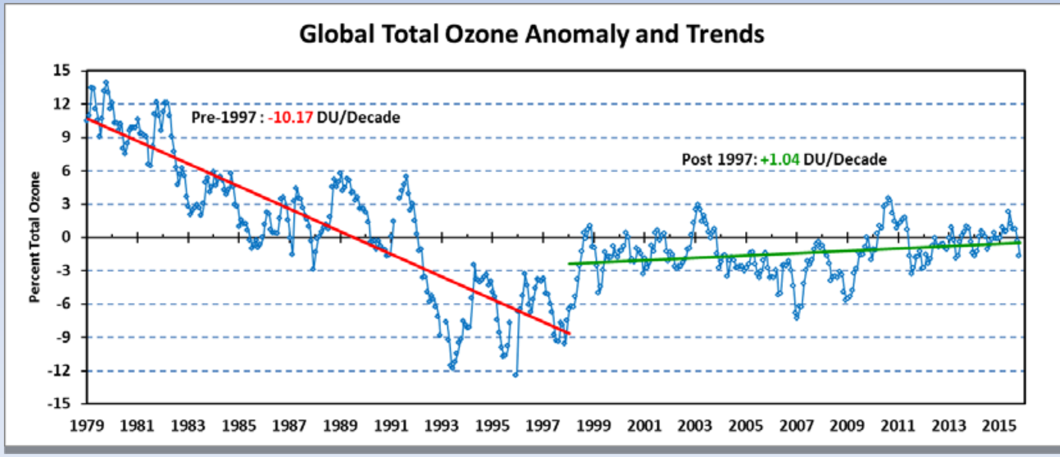
SNPP orbit allows for earlier observation of ozone hole than N19

Long Term Total Ozone Monitoring



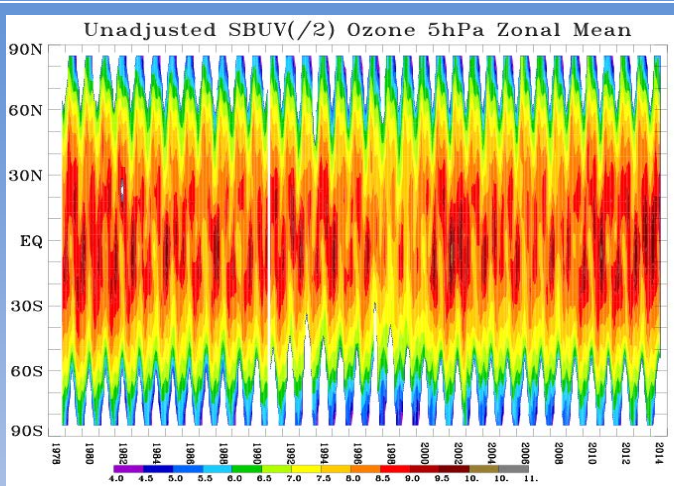


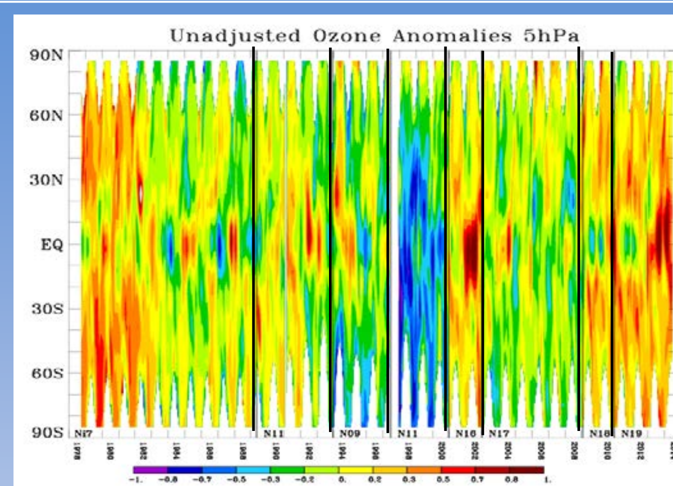




Merged Cohesive SBUV(/2) CDR

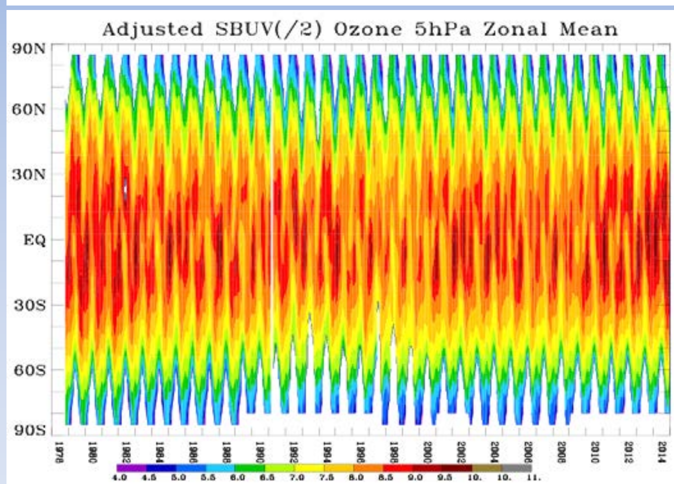
v8.6
unadjusted
5 hPa O3MR

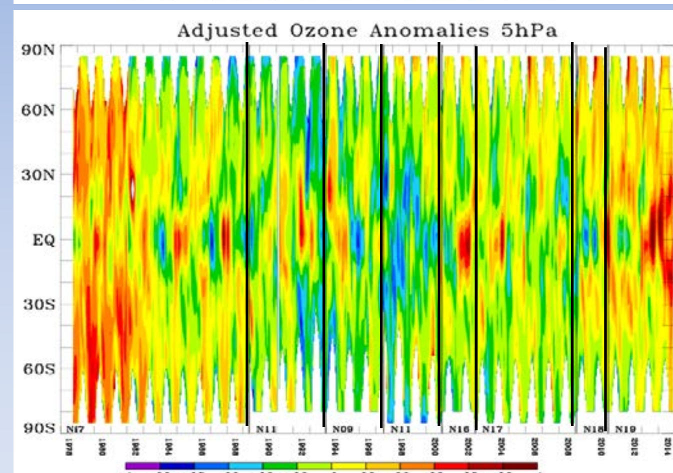




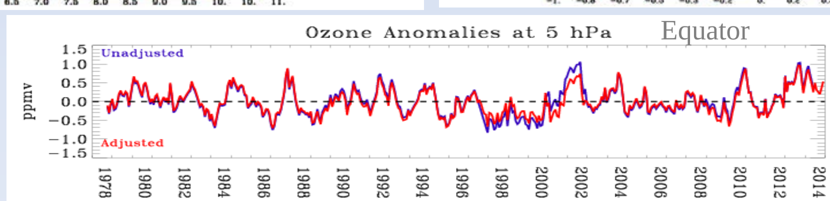
unadjusted
5 hPa O3MR
anomalies

v8.6
adjusted
5 hPa O3MR



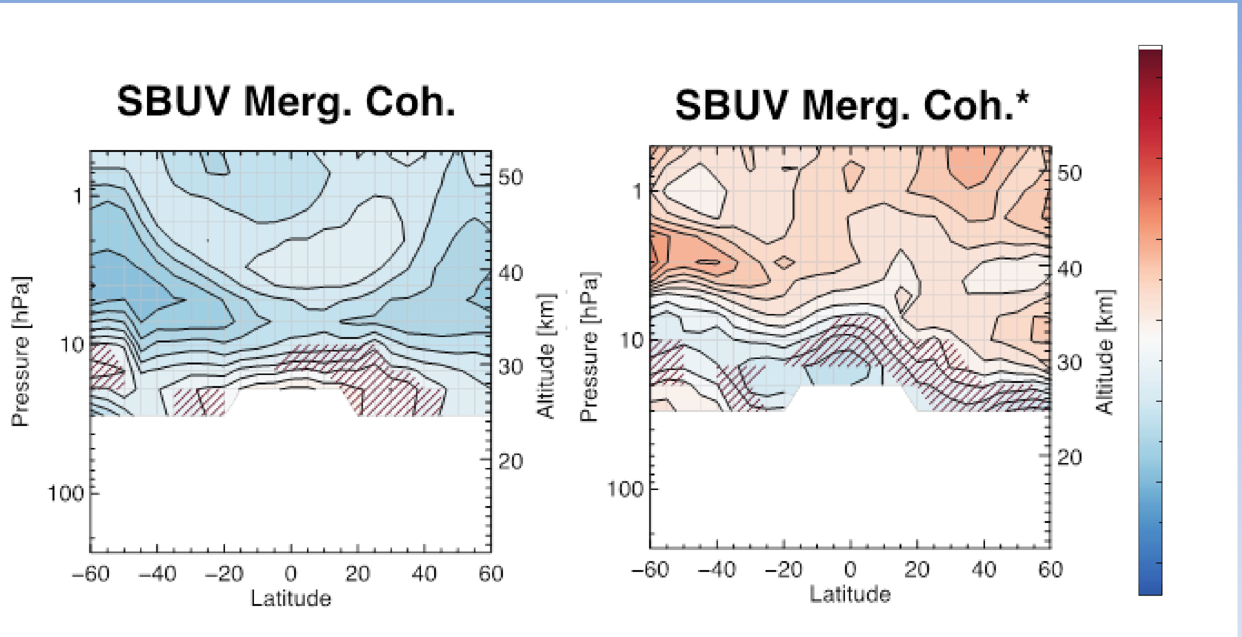


Adjusted
5 hPa O3MR
anomalies



Long Term Profile Ozone Monitoring

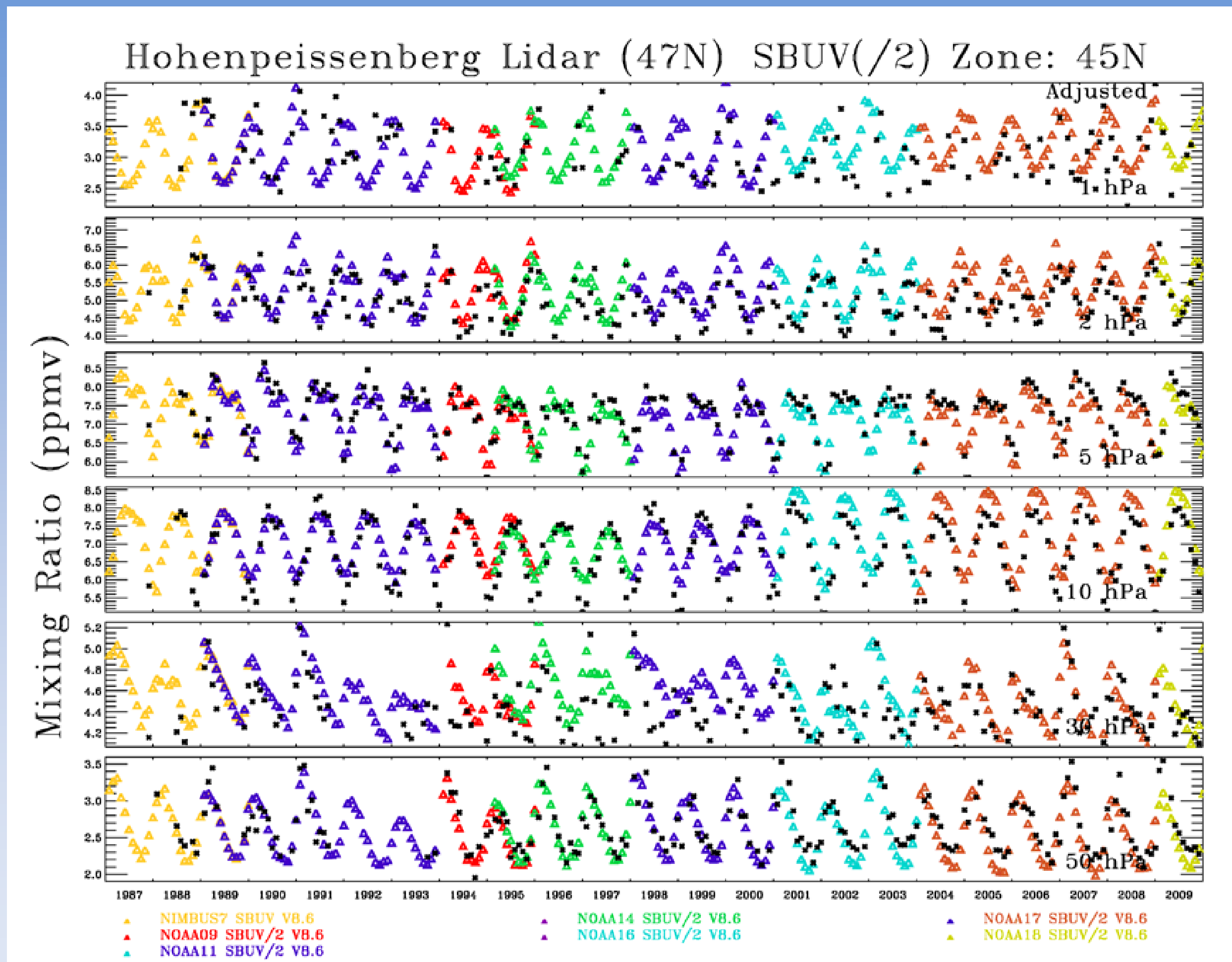
Ozone Profile Trends (%/Decade)



1979-1997 1998-2012

From Harris et al, 2015

Utilization of NDACC Ozone Lidar for Validation



1 hPa

2 hPa

5 hPa

10 hPa

30 hPa

50 hPa

Comparison of monthly mean adjusted zonal O3MR with monthly mean Lidar Obs

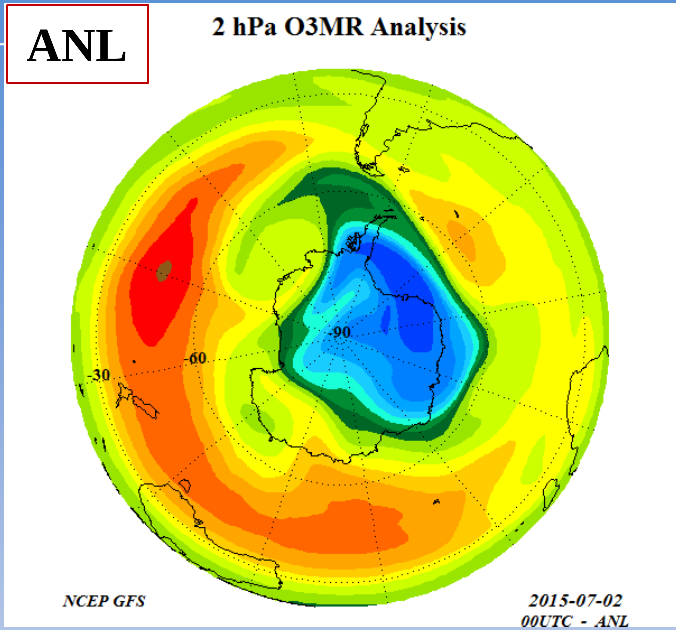
GFS Large O-G Episode

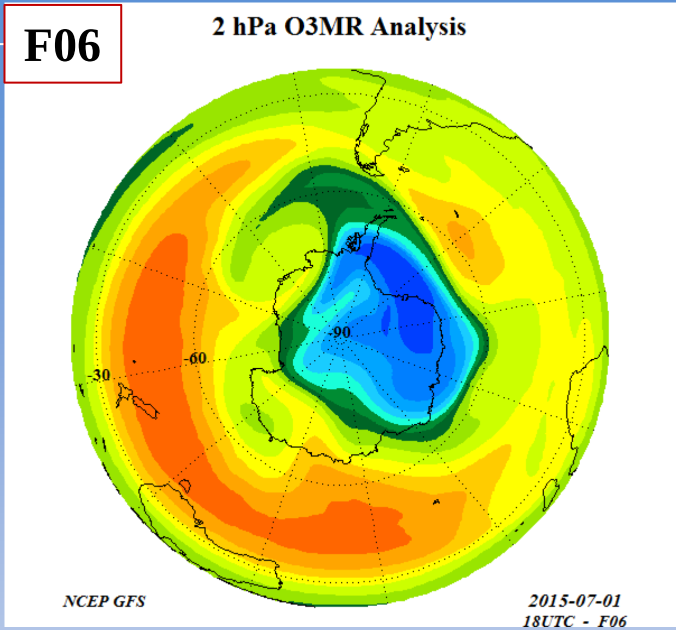
- Obs-Guess is used for monitoring the operational GFS ozone production
- Was high between June 25 and Jun 30, 2015 at 2 hPa
- What was cause?
  - Model or data?
- An unusual wave one pushed the 2 hPa max values off of the pole favoring the Australia quadrant.

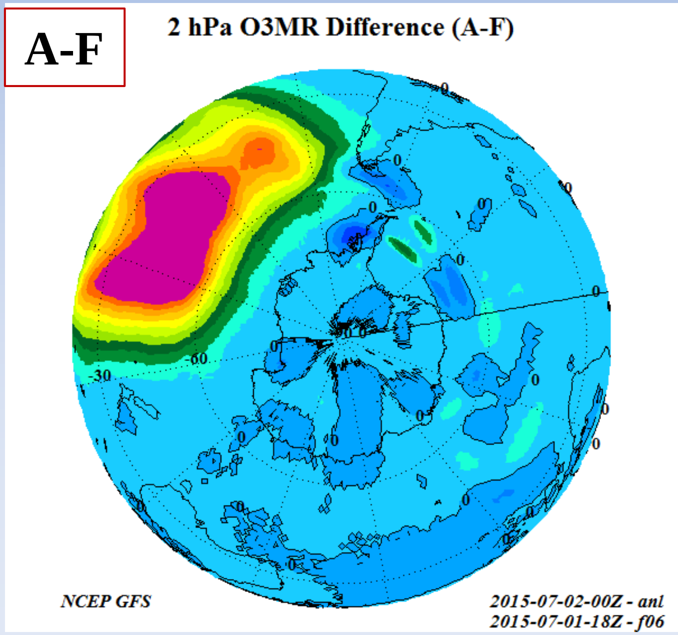
Anal – Fcst Plots at 2 hPa

- Anl files for 2015070200
- F06 (Guess) files for 2015070118
- Analyses differ from forecast only where observations occur.
- Analysis adds ozone
- Analysis contours every 0.5 mg/kg
  - Blue is 5.0 mg/kg
  - Red is 11.0 mg/kg
- Difference contours every 0.05 mg/kg
  - 0 diff is contoured

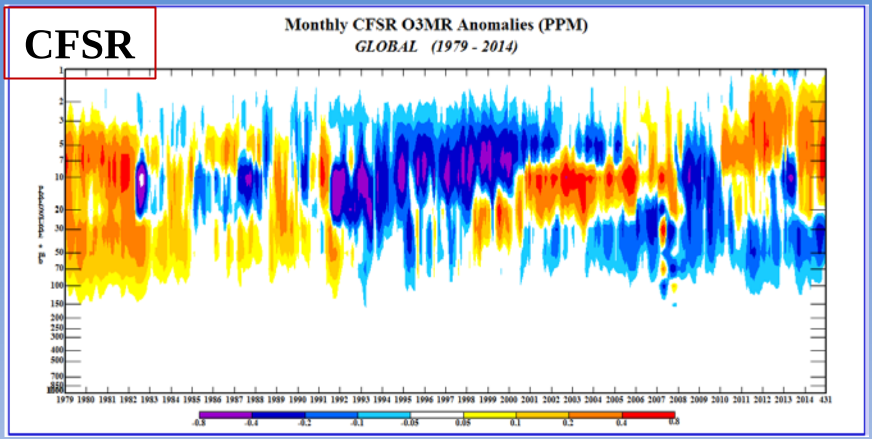
Anal – Fcst Plots at 2 hPa

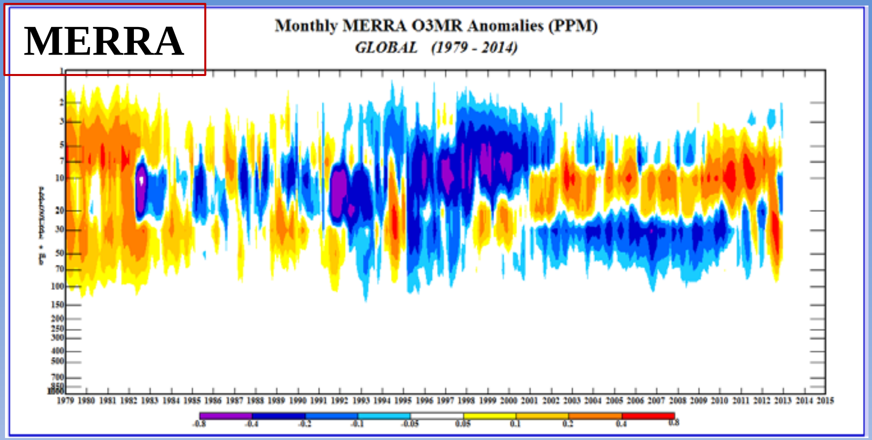


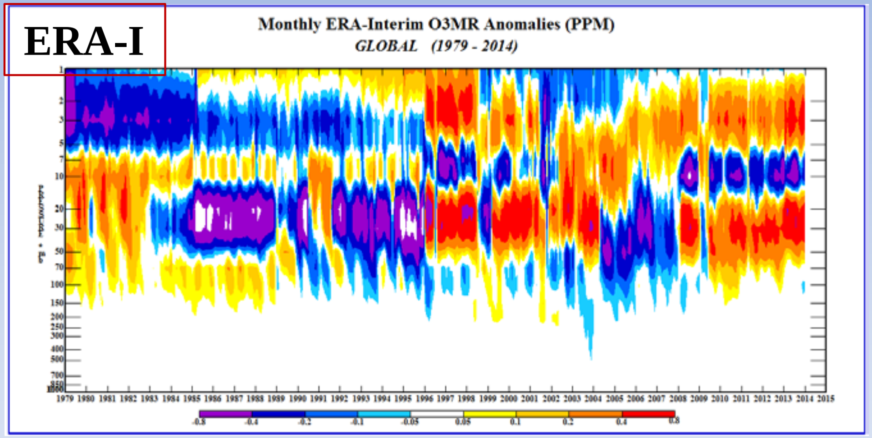


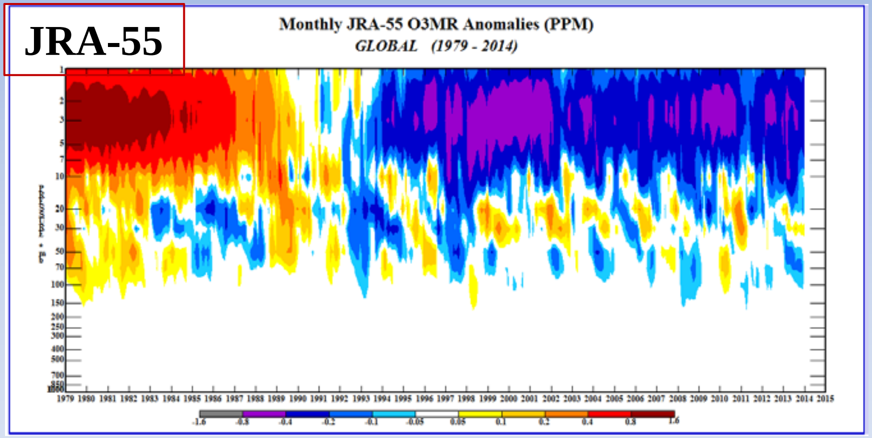


Ozone in Reanalysis









Global mean O3MR anomalies time series shows discontinuities in ozone sources
Is assimilation of multiple sources better? Need to have similar characteristics.

Summary & Pros about OMPS

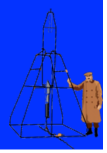
- CPC has been monitoring ozone since the mid1970’s.
- CPC monitors ozone on various time scales.
- CPC primarily monitors ozone via the SBUV(/2), OMI, and now OMPS.
- OMPS will continue SBUV/2 ozone monitoring heritage.
- OMPS provides additional ozone products to monitor ozone .
- OMPS Limb provides finer vertical resolution and extend down to cloud top
  - Needs to be assimilated ASAP after NM and NP
    - *Also means that NESDIS needs to provide in operations*
  - Will help NCEP AQ forecasts.
- Reprocessed OMPS needs to be available for users and reanalysis
  - Preferably in CLASS

OMPS Limb Profiler L2 Products

Pawan K. Bhartia

Earth Sciences Division- Atmospheres

NASA Goddard Space Flight Center



Operational Products

- O_3 Vertical Profile (cloud-top to 60 km)
  - V2 algorithm released in mid 2014
  - Number density vs alt profiles are primary. Mixing Ratio vs p produced using assimilated GPH and temp data from NASA GMAO (MERRA)
  - No explicit aerosol correction
  - Central slit data are best
- Cloud-top Height
  - New product
- Aerosol Extinction Profile
  - V0.5 algorithm ready, data are currently reprocessed
- Pressure/temperature profile (40-70 km)
  - Under development

LP Altitude Registration Methods

- 350 nm radiance ratio method (aka RSAS)
  - @350 nm I(32 km)/I(20 km) varies by ~12%/km
  - Not affected by instrument drift or diffuse upwelling radiation, but affected by aerosols.
  - Works best in the S. polar region.
- 305 nm/60 km radiance method
  - Less accurate than RSAS but works at all latitudes

Absolute Accuracy: ±200m
Relative Accuracy: ±100m
Precision: ~50m

Key Results

Tangent height error (km)

(after slit edge correction)

	Left Slit	Center Slit	Right Slit
Low Gain	1.4	1.6	1.7
High Gain	1.2	1.4	1.5

Central slit: 1 km ≡1 arc-min pitch error

Left/right-central slit: 80 m ≡1 arc-min roll error

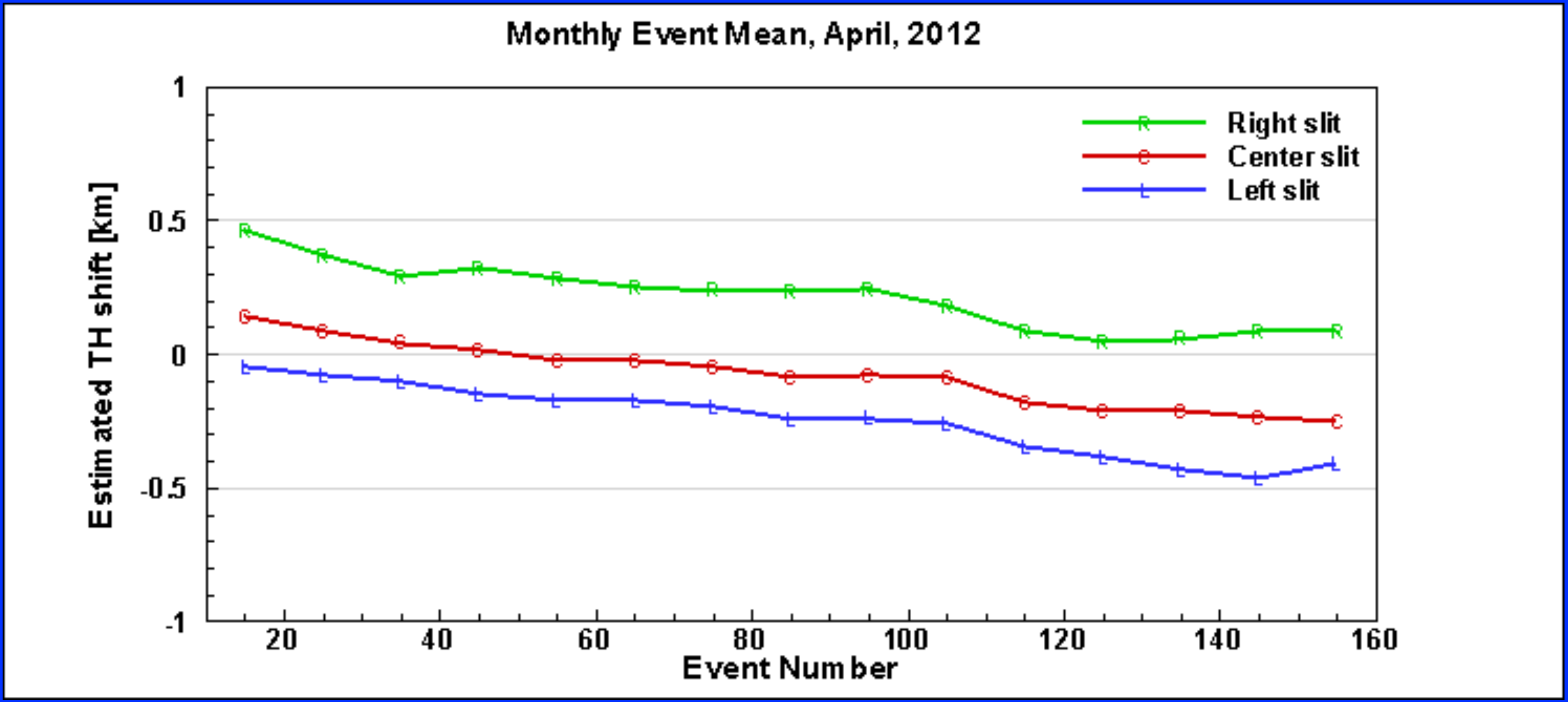
Time dependence : 100 m shift on April 28, 2013

- occurred when both star trackers were used for the first time indicating 12 arc-sec pitch bias between them.

Lat dependence: ~300 m variation (after slit edge correction)

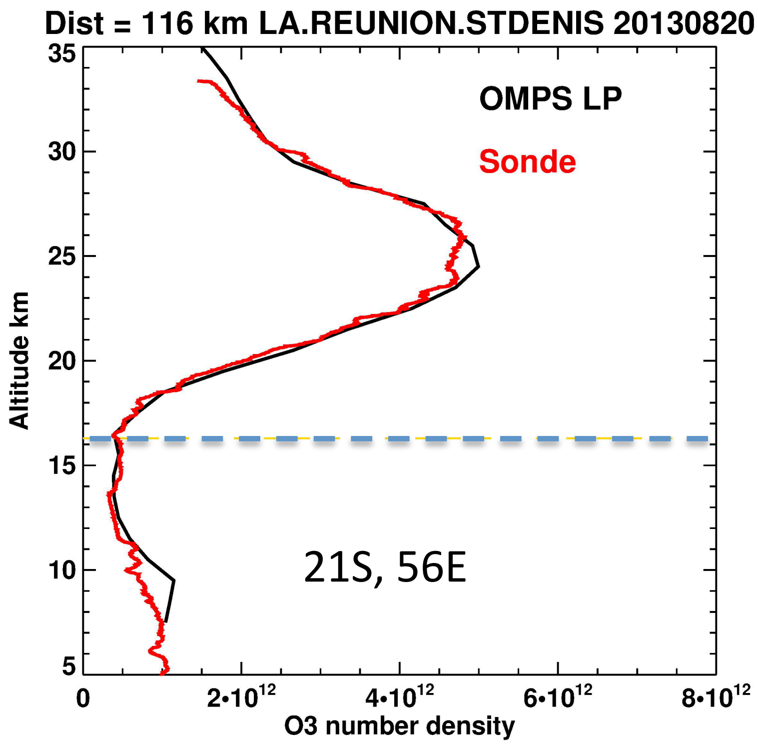
Along-orbit variations in altitude error

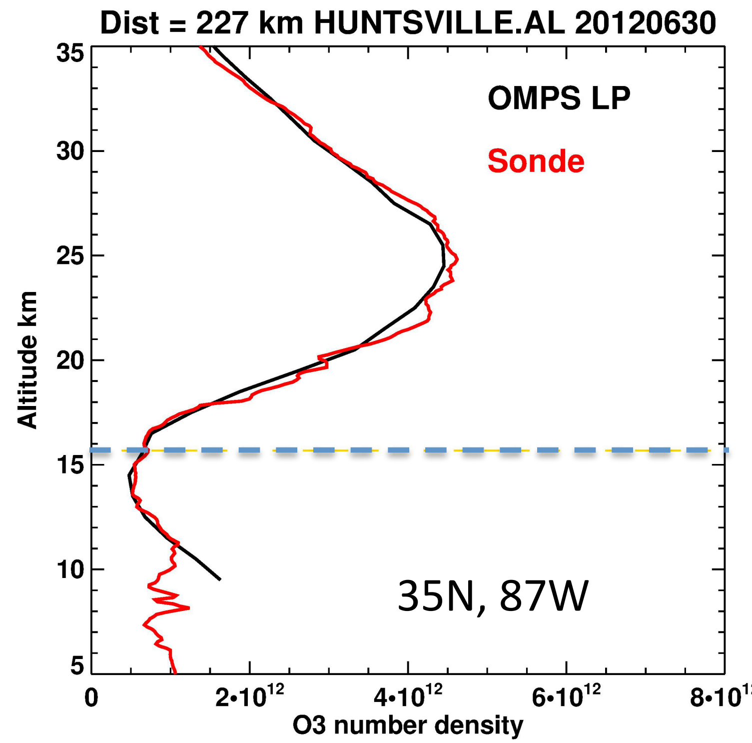
Shows the corrections that need to be applied to the V2 high gain data, which were adjusted by -1.65 km based on preliminary RSAS results



Event numbers are counted from the southern to northern terminator. They are 1.1° apart in latitude, except in the polar regions.

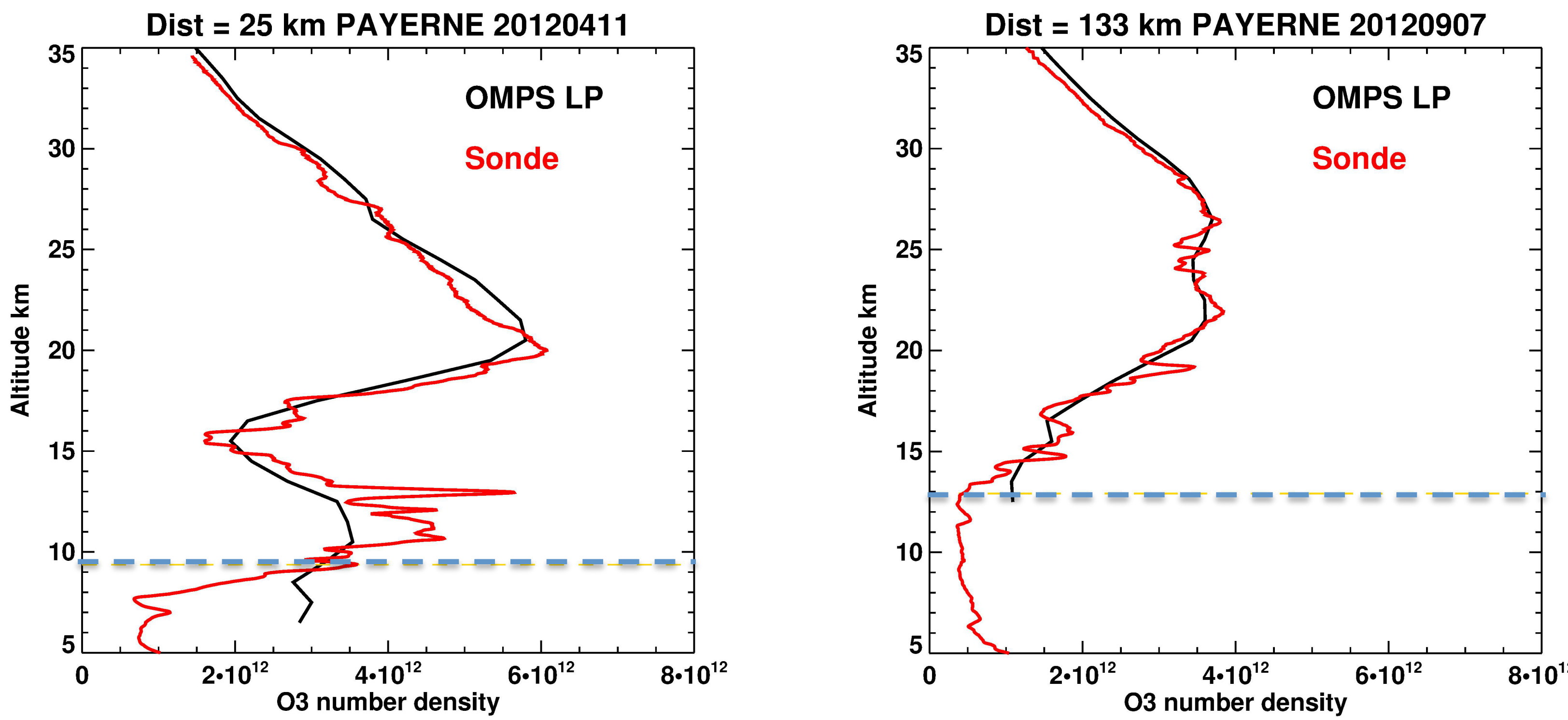
Comparison with High Trop Ozonesondes



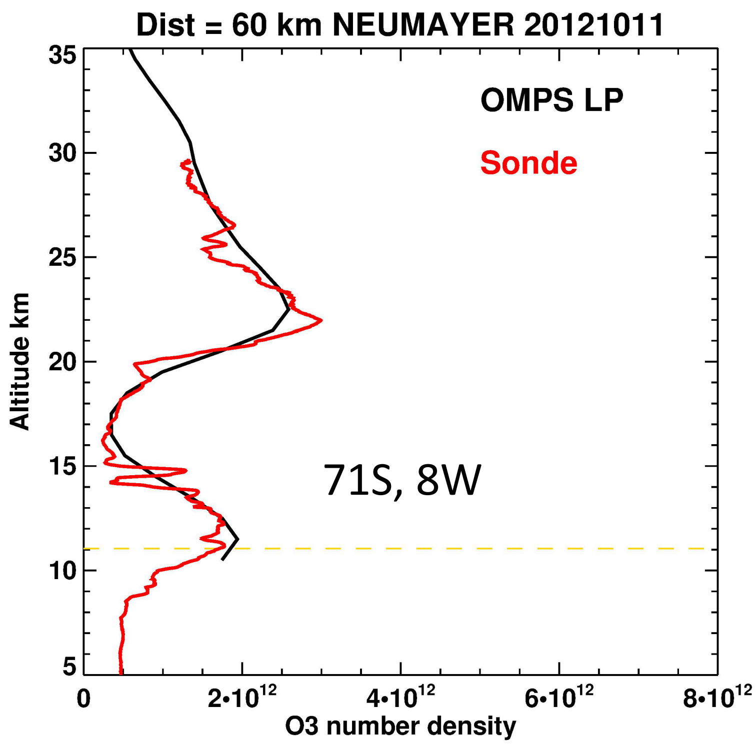


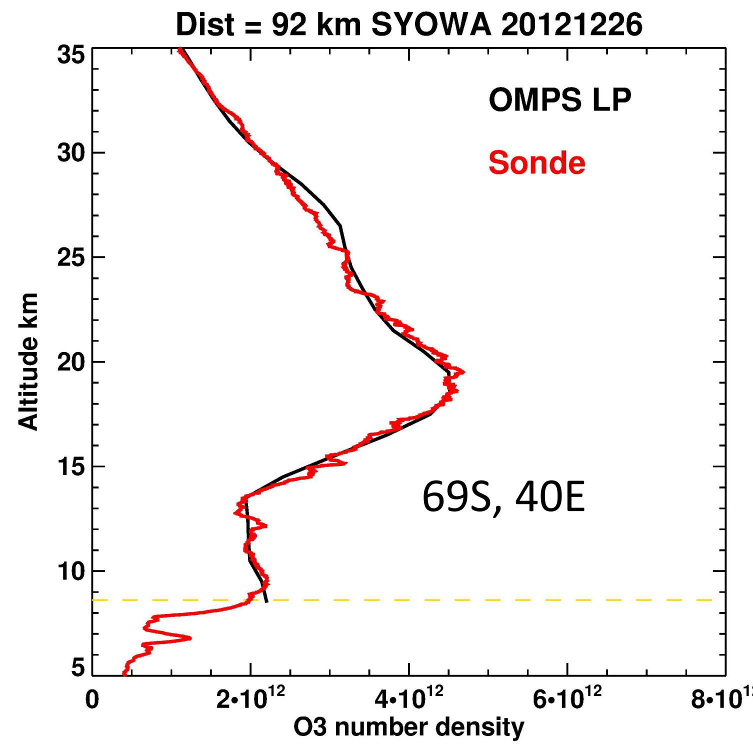
LP has ~ 1.8 km vertical and ~200 km horizontal res

Comparison with Payerne (47N, 7E) Ozonesondes



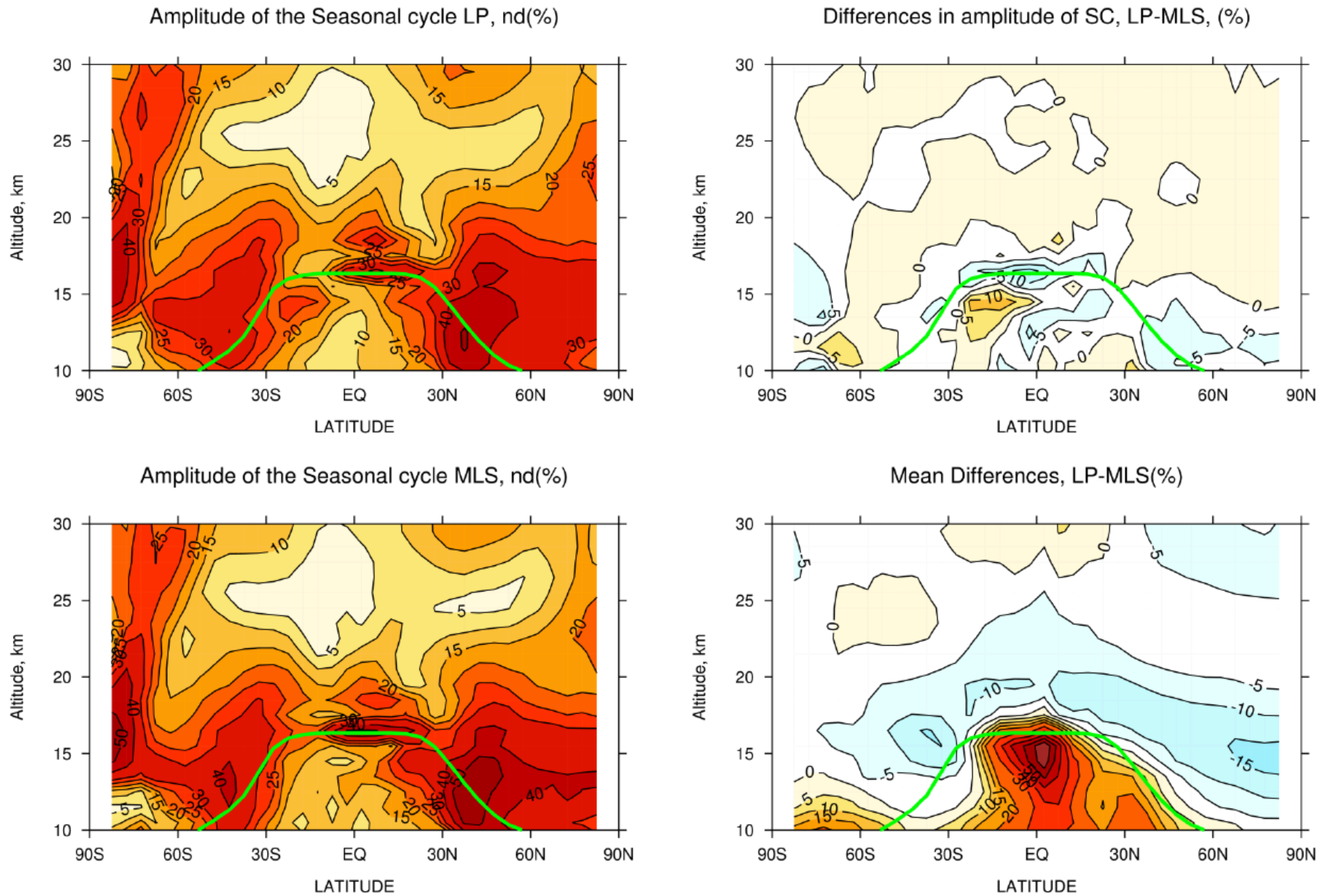
Comparison with Antarctic Ozonesondes





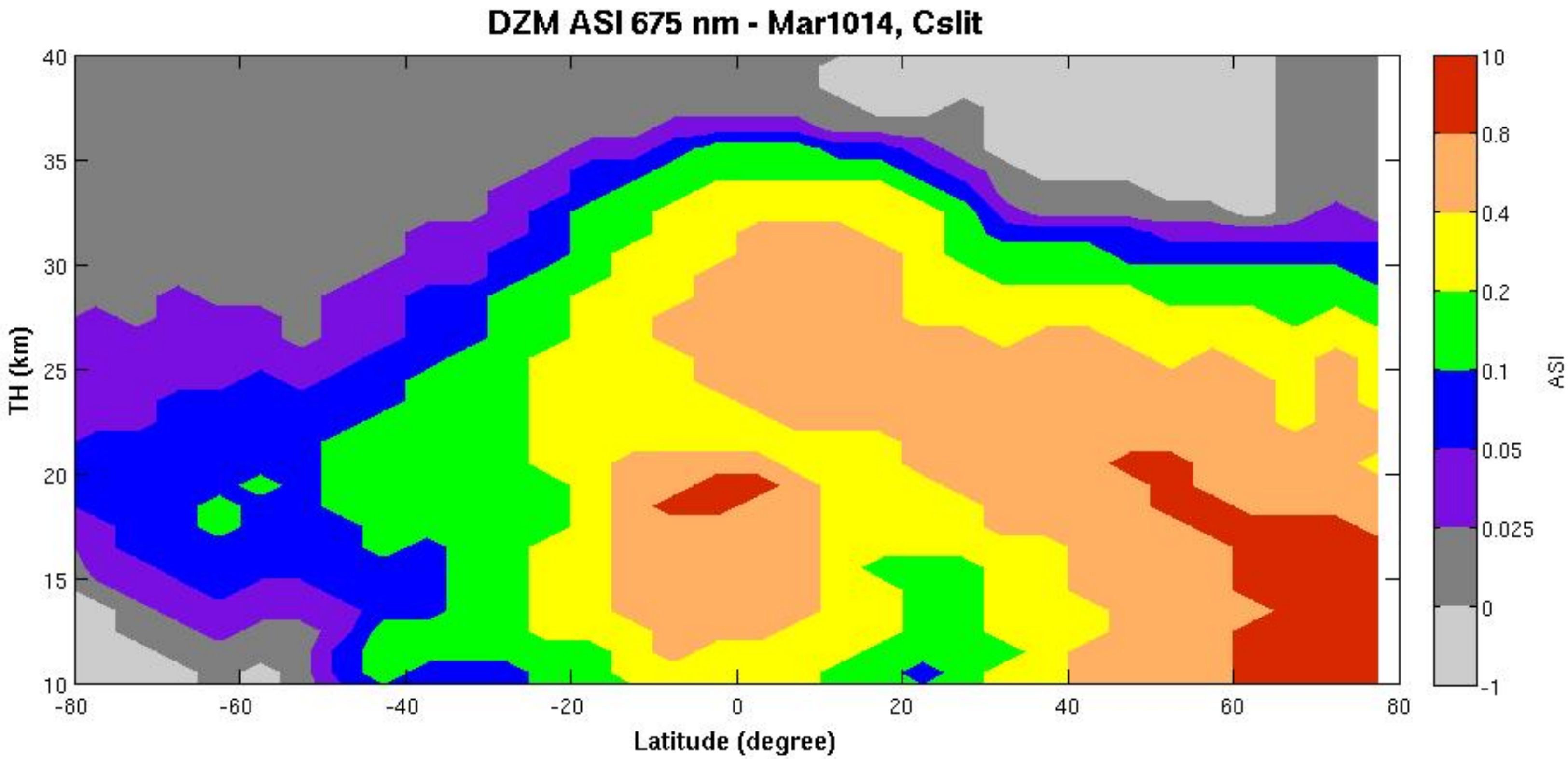
Summary of MLS comparison

OMPS LP vs Aura MLS



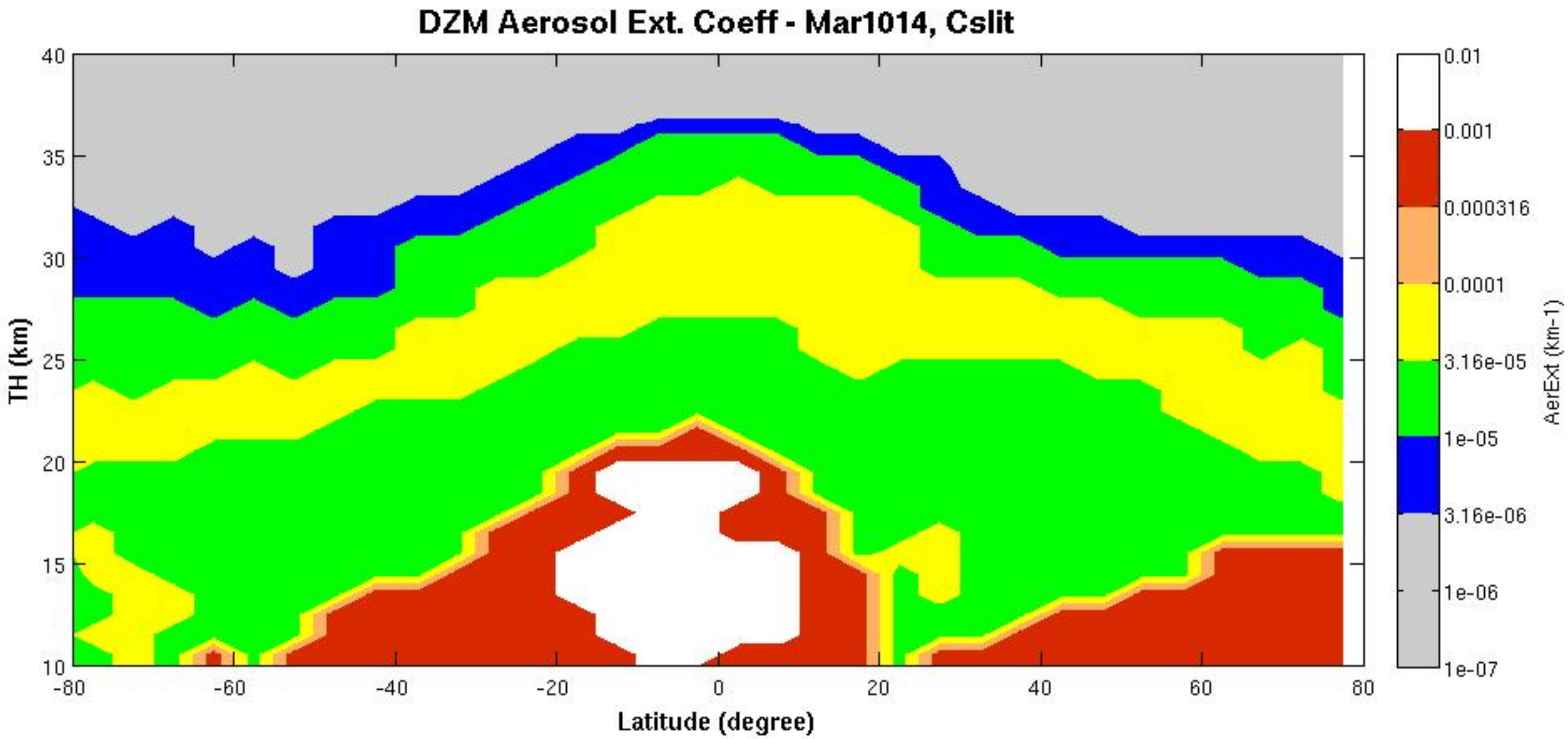
Aerosol Scattering Index (ASI)

$$ASI = (I_m - I_R)/I_R \leq I_a/I_R$$



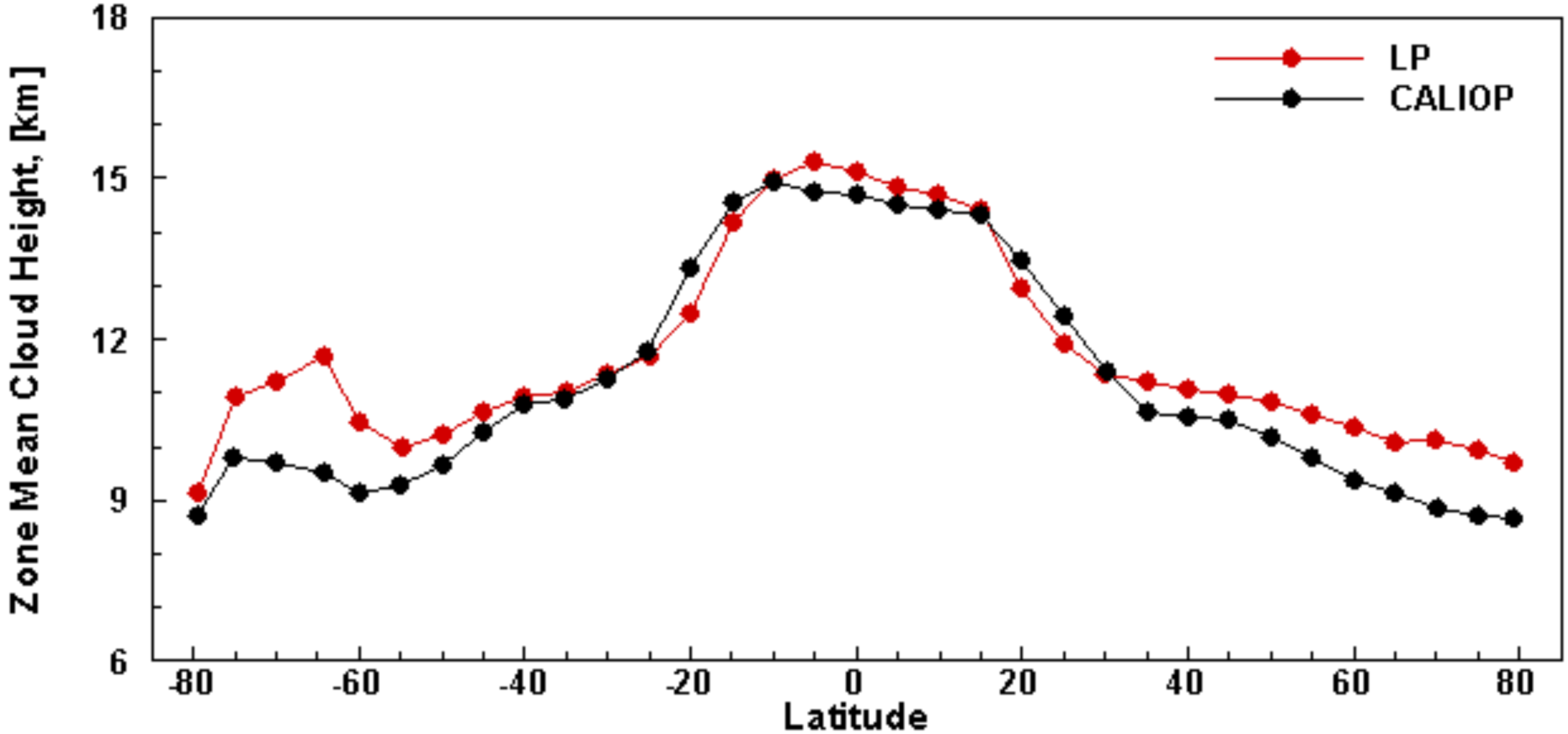
- N/S bias is caused by difference in scattering angle
- Produces >10 times variation in ASI for same aerosol extinction

Retrieved Aerosol Extinction



- Retrieved extinctions are approx hemispherically symmetric

Cloud-top Height



Cloud index (CI)

$$CI = \frac{d \ln I(\lambda_1, z)}{dz} - \frac{d \ln I(\lambda_2, z)}{dz} \quad \lambda_1\text{=674 nm, } \lambda_2\text{=868}$$

CI > 0.15 is defined as clouds

Summary

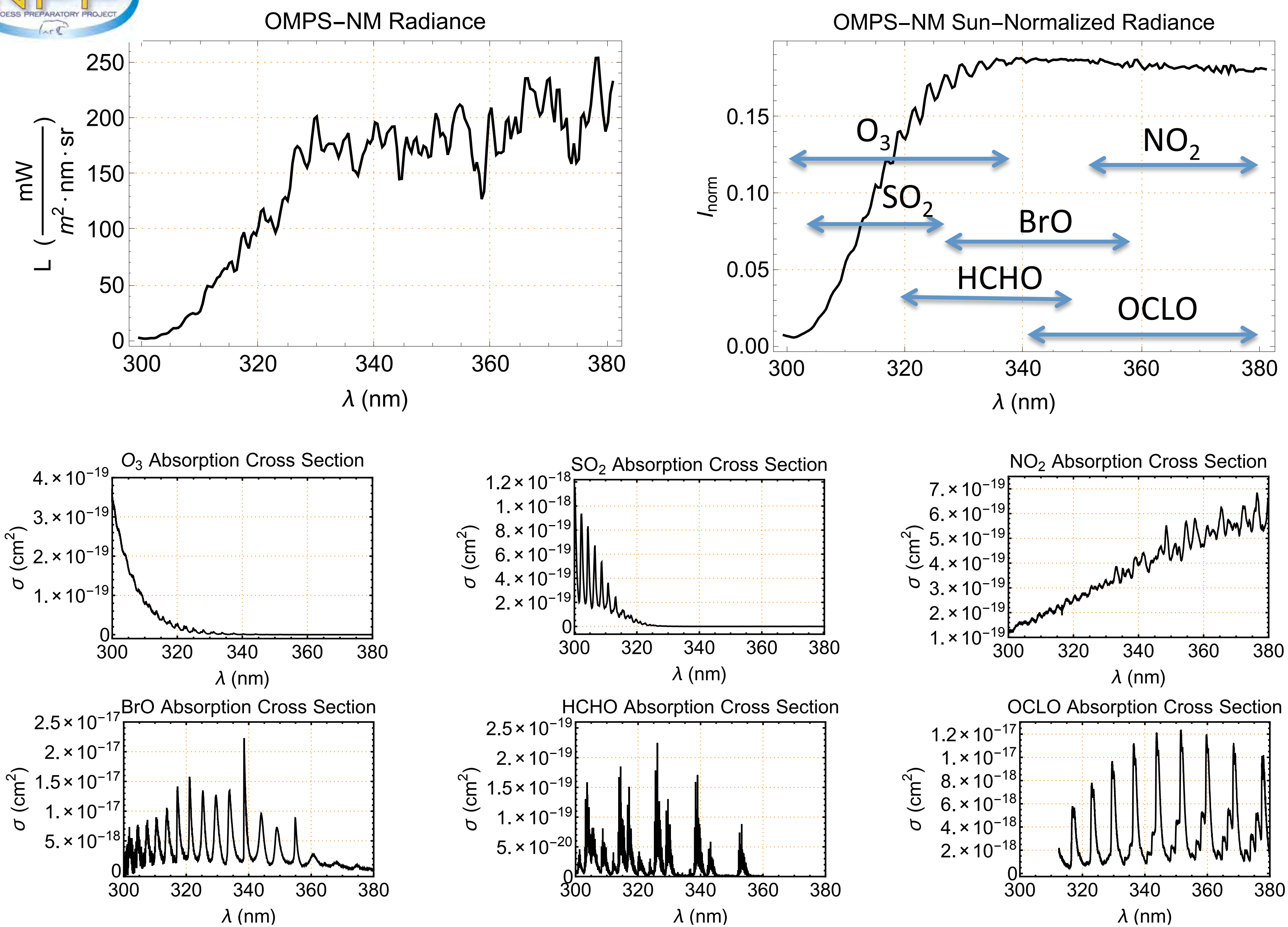
- V2 Ozone algorithm is about a year old
  - TH and aerosols are the primary error sources
  - TH errors are reasonably well known. Correction can be easily applied to the processed data. Aerosol correction is under investigation.
- V0.5 Aerosol product will be available soon
- Cloud-top height dataset is available
- An algorithm to estimate 40-70 km pressure profile is being developed.

OMPS Additional Trace Gases: NO_2 and SO_2 Products

Kai Yang
University of Maryland College Park

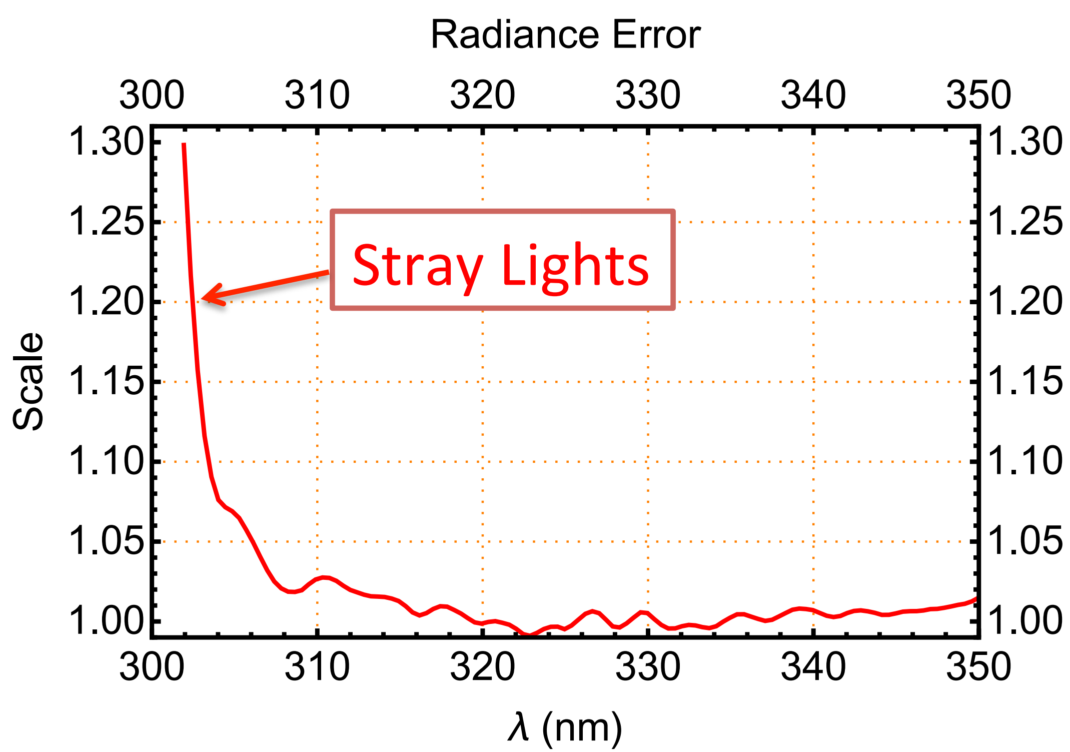
JPSS Annual Science Team Meeting, August 26, 2015

Suomi NPP/OMPS-NM

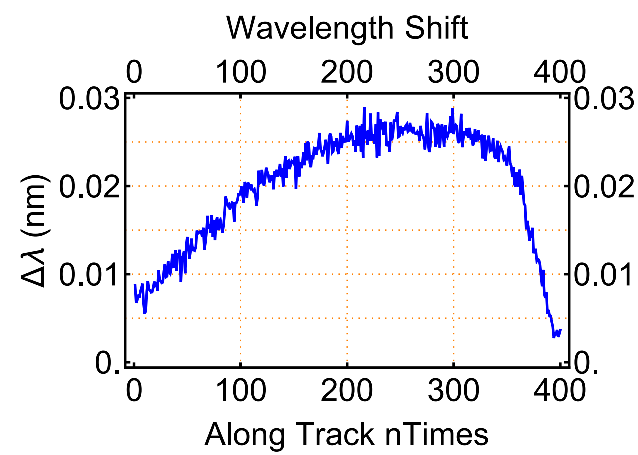


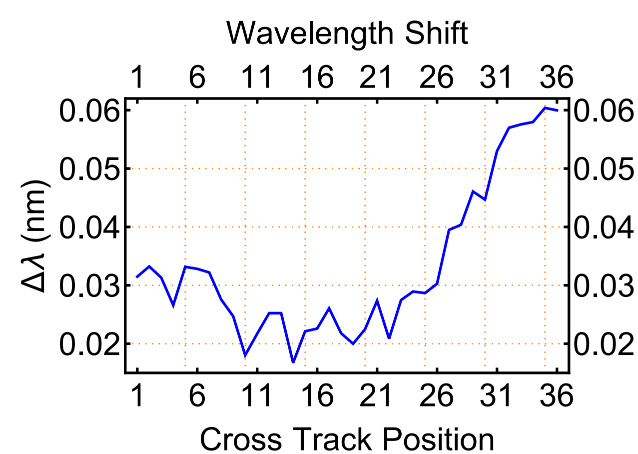
Suomi NPP/OMPS-NM

- Stable performance
- high signal-to-noise ratio
- But significant stray lights, and other instrumental artifacts



Wavelength Variation





Objectives

Retrieve NO_2 and SO_2 from SNPP/OMPS with sufficient quality to extend Aura/OMI record.

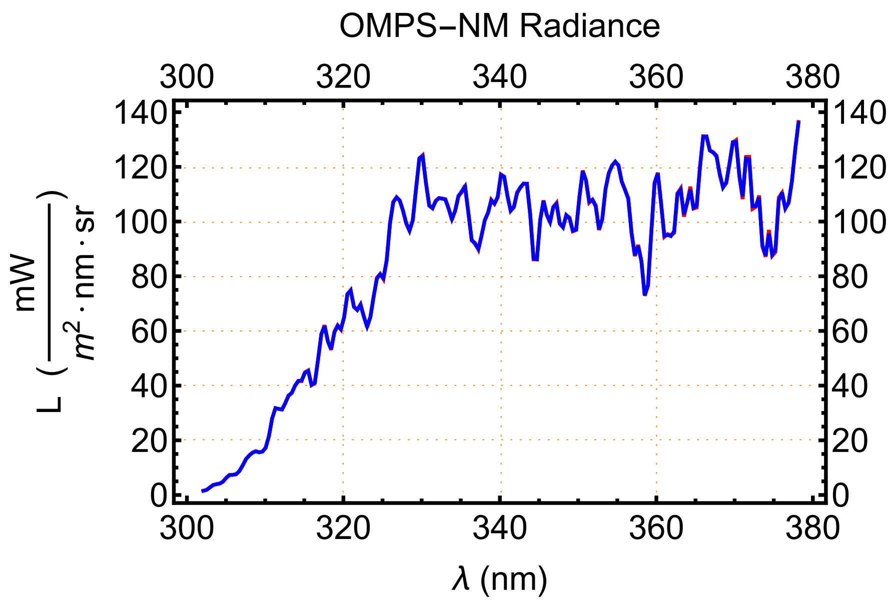
- Standard Products
  - SO_2 Vertical Columns
    - Volcanic SO_2 at various altitudes
    - Boundary Layer SO_2
  - NO_2 Vertical Columns
    - Tropospheric, Stratospheric, and Total NO_2
- Near-Real-Time (NRT) Products
  - SO_2 Vertical Columns

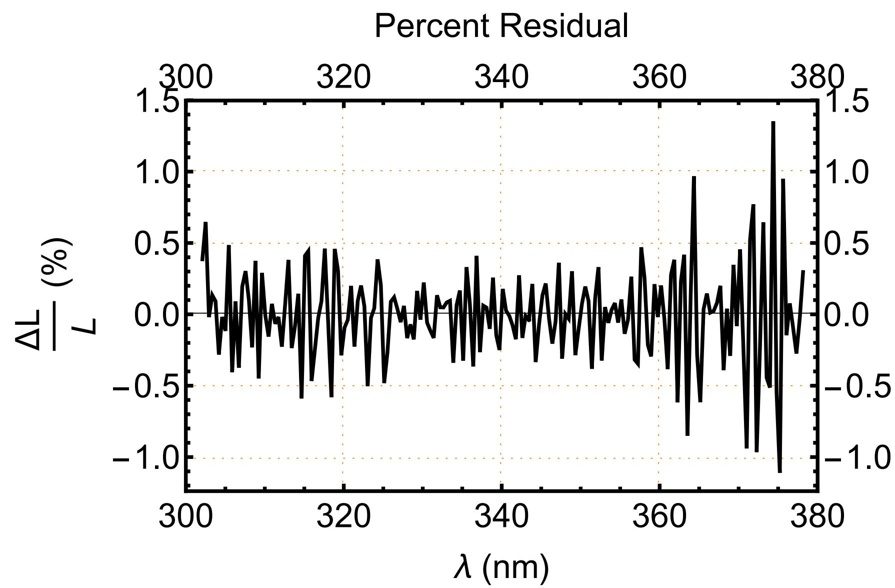
Retrieval Algorithm

To achieve high product quality, Direct Vertical Column Fitting (DVCF) Algorithm:

- State-of-the art algorithm physics: accurate of radiative transfer including RRS scattering (Ring effect)
- Effective schemes to account for varying instrumental effects: wavelength registration, spectral response, under sampling, and spectral interferences

Direct Radiance Fitting





Radiance:
Model (Blue) vs. Measurement (Red)

Residual Standard Deviation: 0.3%

Spectral Ranges

Direct Vertical Column Fitting (DVCF)

1. O_3 and SO_2 : 308 – 360 nm

- SO_2/O_3 : 308 – 333 nm
- Reflectivity/cloud fraction, aerosol index : 333 – 360 nm

2. NO_2 :345 – 378 nm

- Full range: NO_2: 345 – 378 nm
- reflectivity/cloud fraction, pressures, aerosol index: 350 – 378 nm

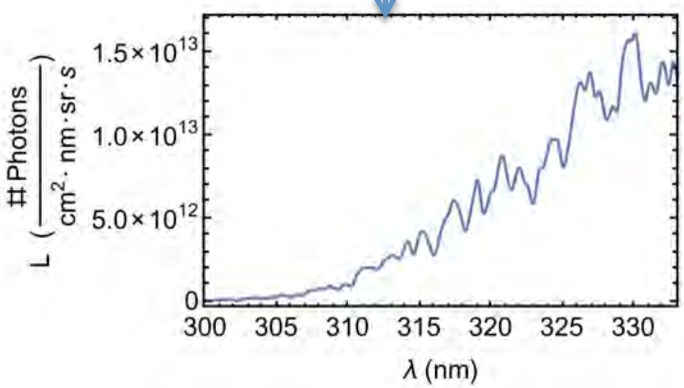
By-Products: O_3 profile and column, and surface parameters: reflectivity/cloud fraction, aerosol index, and pressure

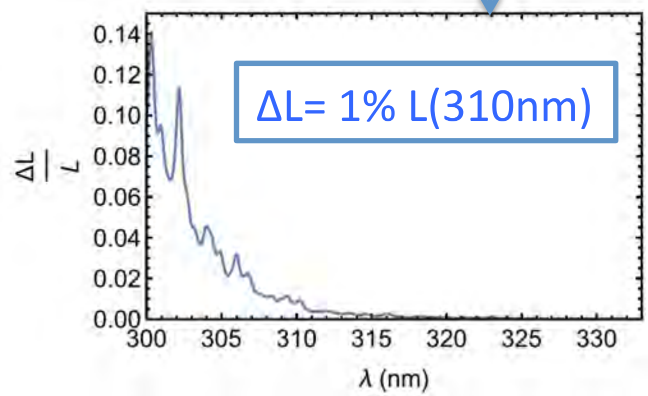
Spectral interference

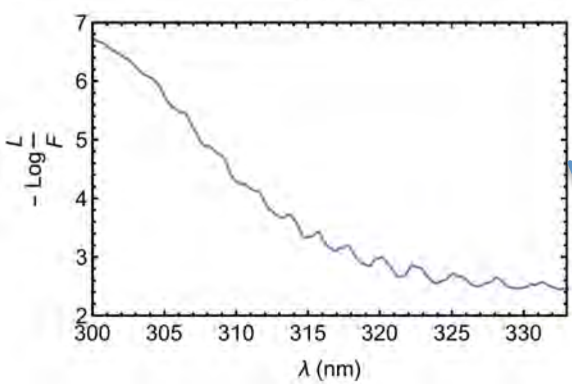
- Due to measurement imperfection and instrumental artifacts, such as stray lights, ghosting, etc.
- Spectral interference is the main factor limiting the sensitivity and accuracy of the retrieved trace gas columns.

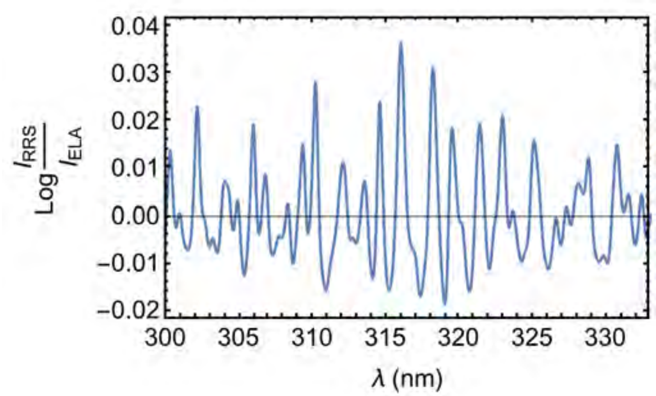
Spectral interference: Signal Dependence

$$Log\left[\frac{L+\Delta L}{F}\right] = Log\left[\frac{L}{F}\right] + \frac{\Delta L}{L}$$









Ring Spectrum

Characterizing Spectral interference

Error Covariance Matrix:

$$Cov[i,j] = < \varepsilon(\lambda_i) \, . \, \varepsilon(\lambda_j) >$$

where $\varepsilon(\lambda_i)$ is the residual:

$$\varepsilon(\lambda_i) = Log[\, I_{measured}(\lambda_i)/I_{modeled}(\lambda_i)]$$

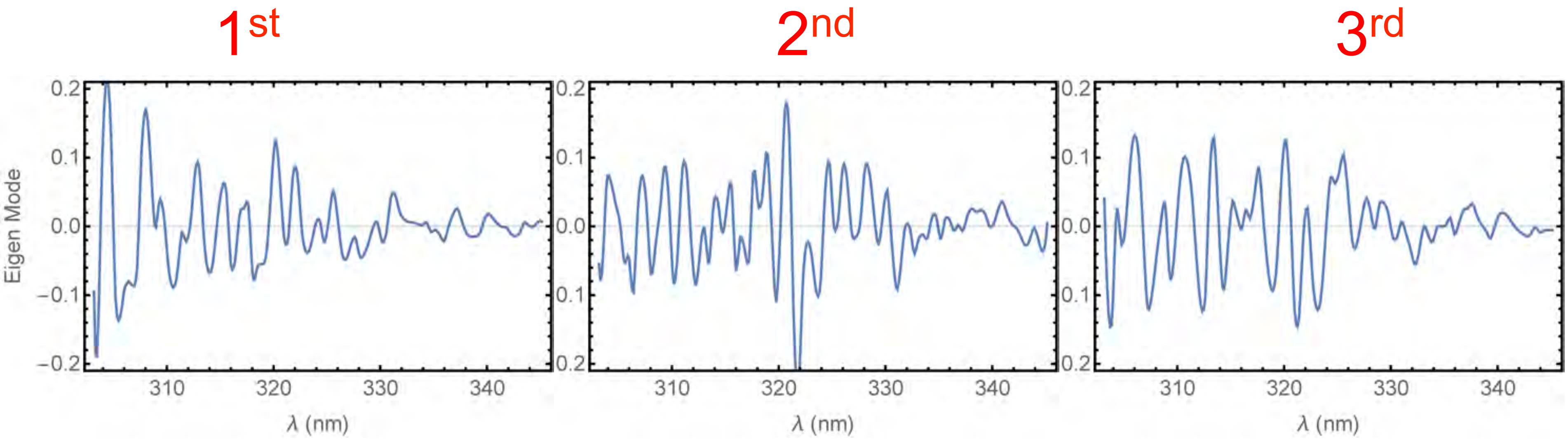
$I_{measured}$: Sun-normalized radiance measurements

$I_{modeled}$: Radiance from accurate RT modeling

Covariance Matrices : constructed for various conditions, such as solar and viewing angles, and scene reflectivity

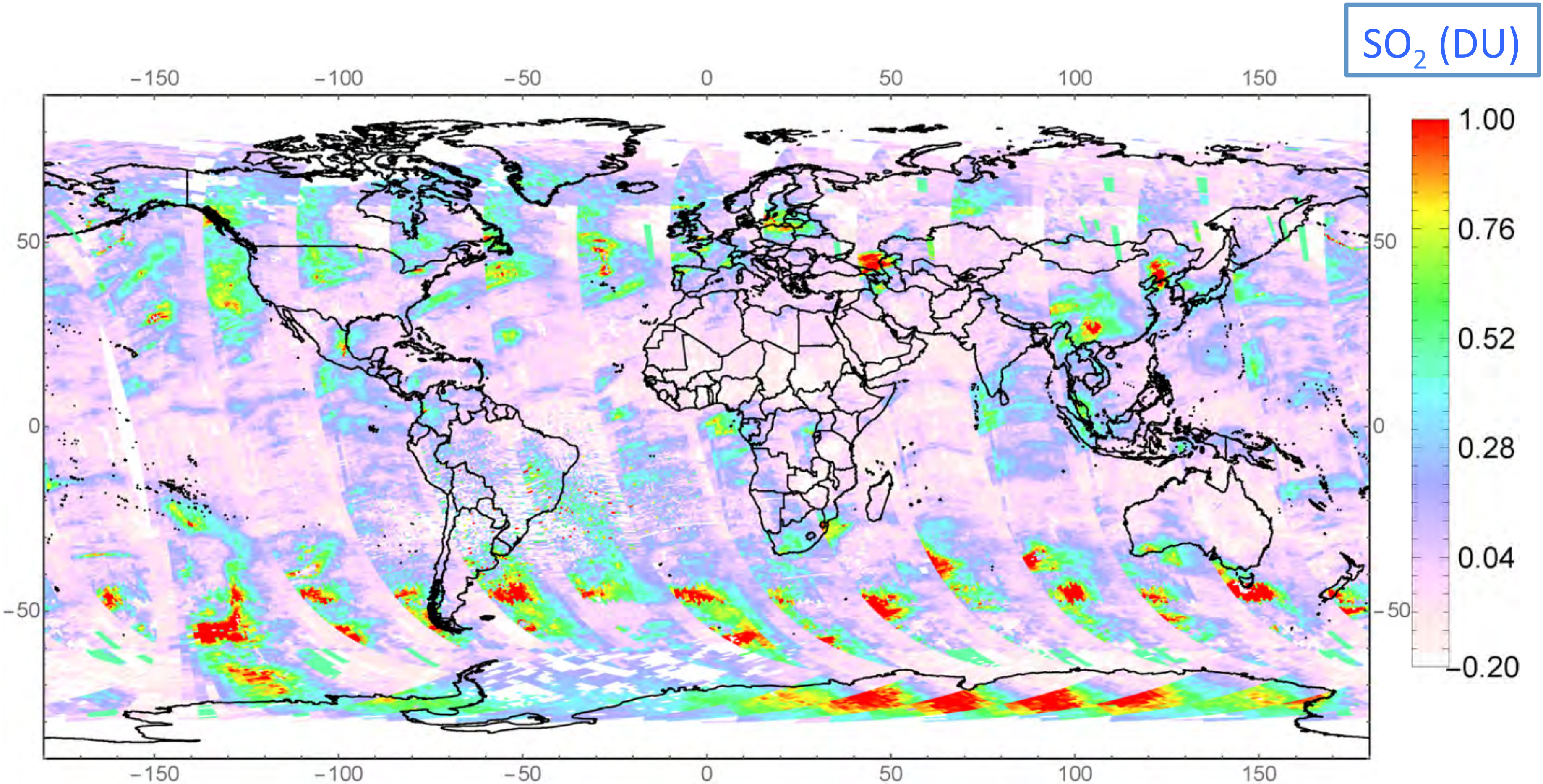
Mitigating Spectral Interference

Eigen functions of the Covariance Matrix

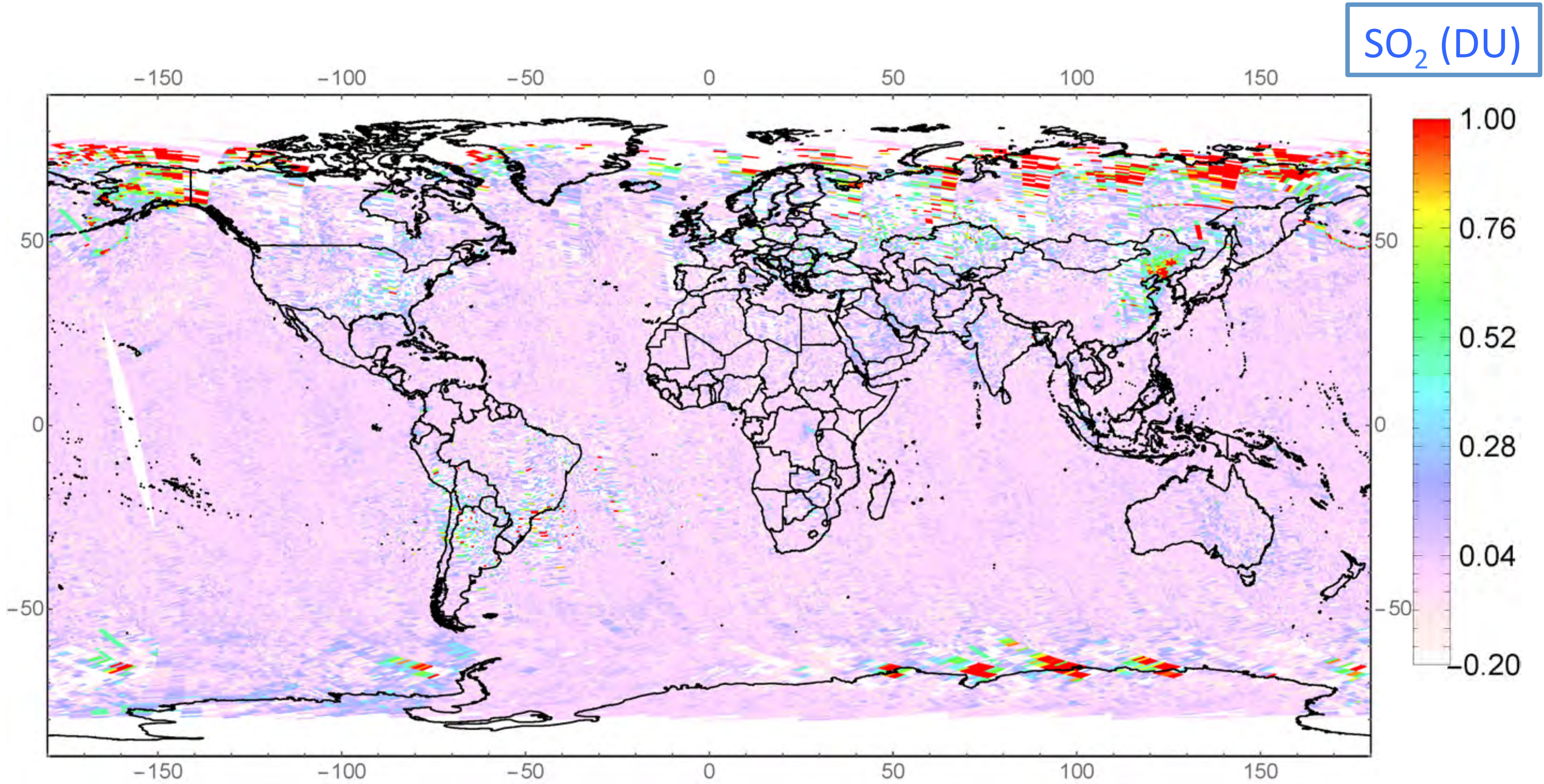


- Fitting of the first few Eigen functions would significantly reduce the impacts of spectral interference

OMPS Boundary Layer SO_2: Without Correction

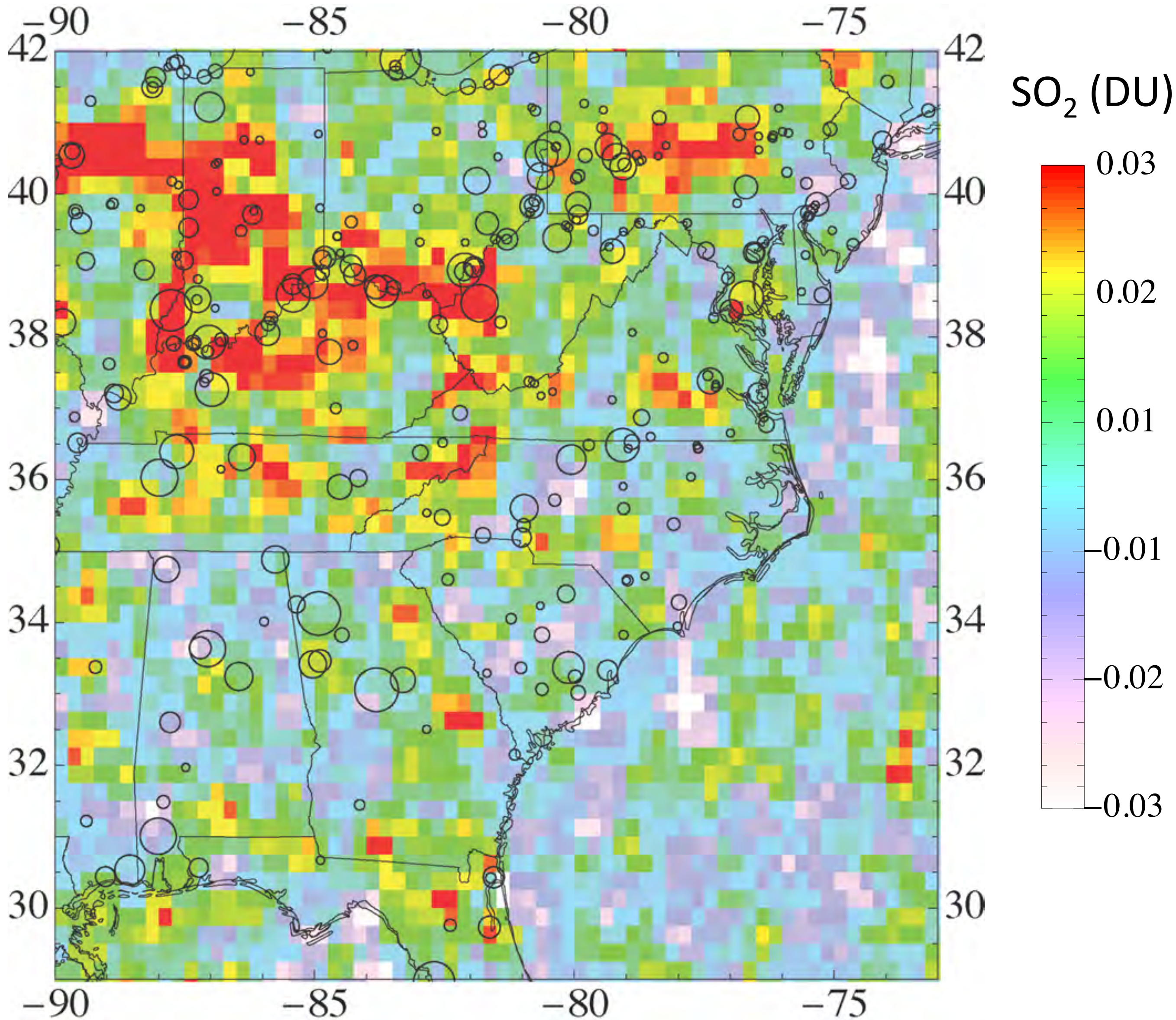


OMPS Boundary Layer SO_2: With Correction



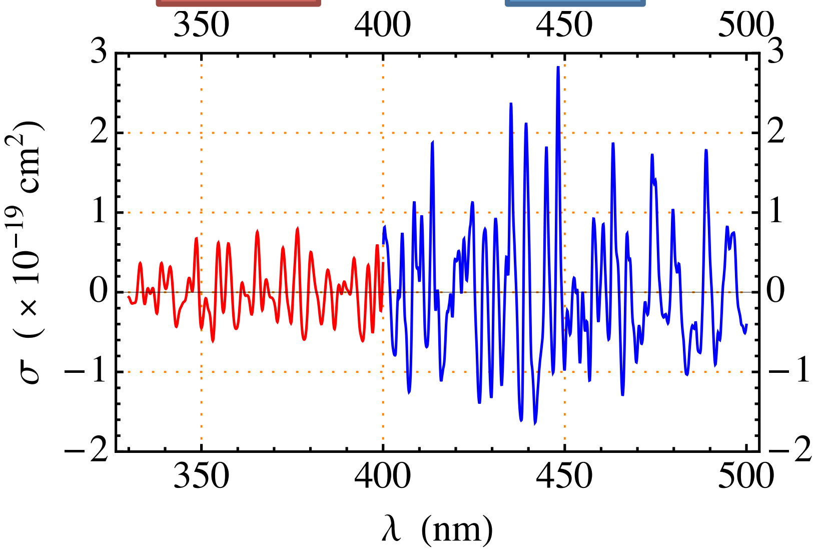
Unprecedented SO_2 Sensitivity: Pollution over US

SNPP/OMPS
October 2013
Monthly Mean
DVCF Algorithm



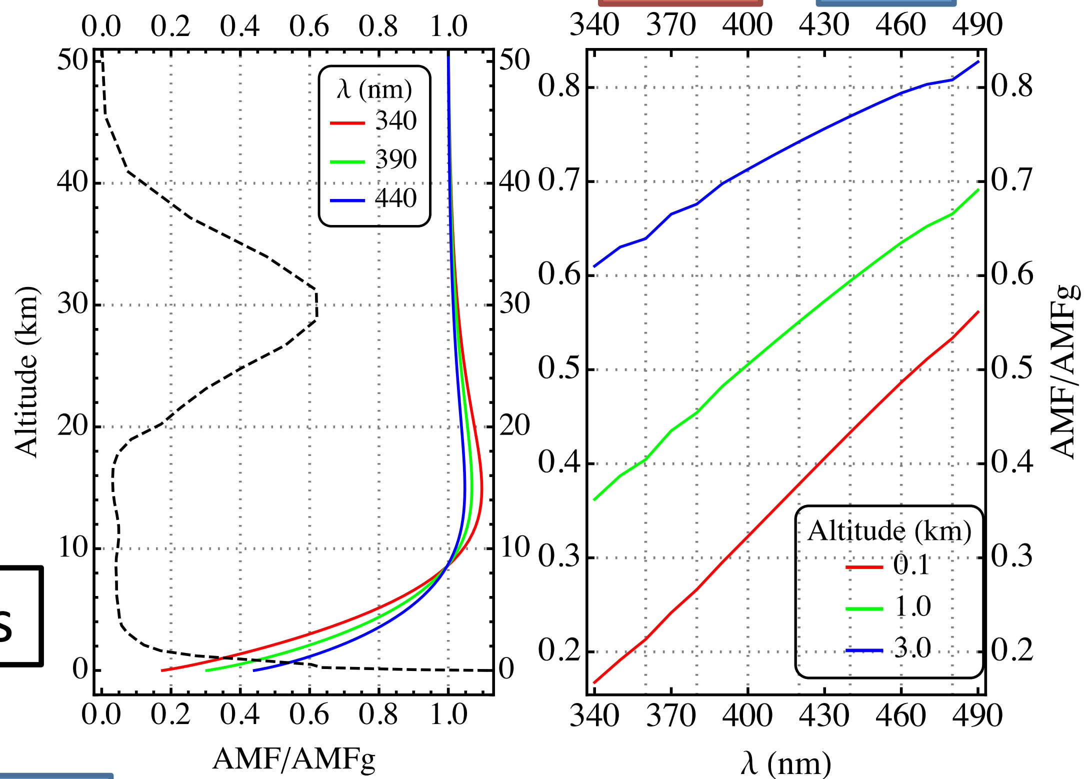
NO_2 Measurement Sensitivity :
Cross Section × Air Mass Factor

OMPS : 1 OMI : 3



NO_2 Differential Cross Sections

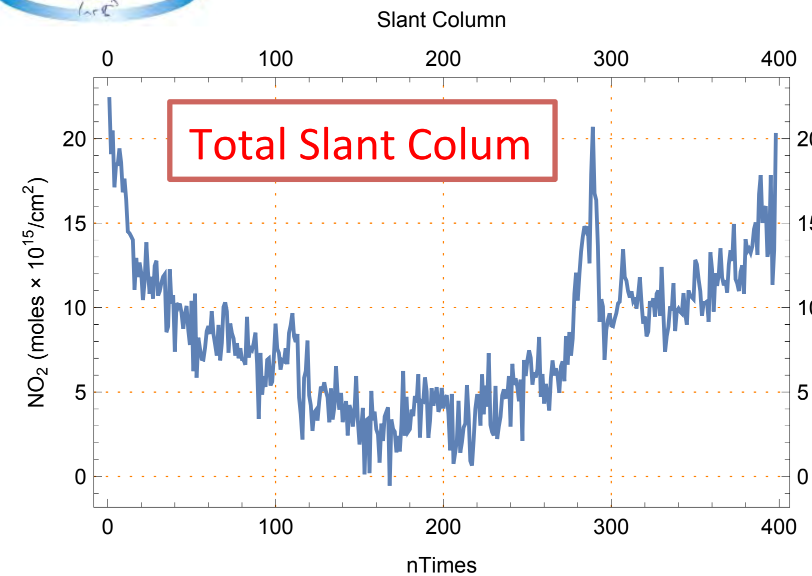
OMPS : 1 OMI : 2



Sensitivity to tropospheric NO_2 :
OMI 4 to 10 times > OMPS

Altitude-Resolved AMFs

OMPS NO_2 Measurement Sensitivity



Precision of slant column:

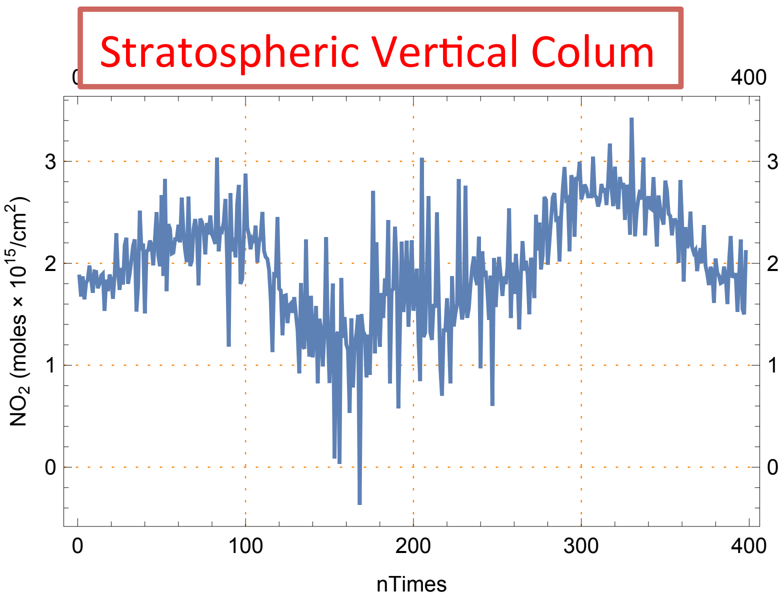
OMPS ~ $1x10^{15}$ molecules/cm^2

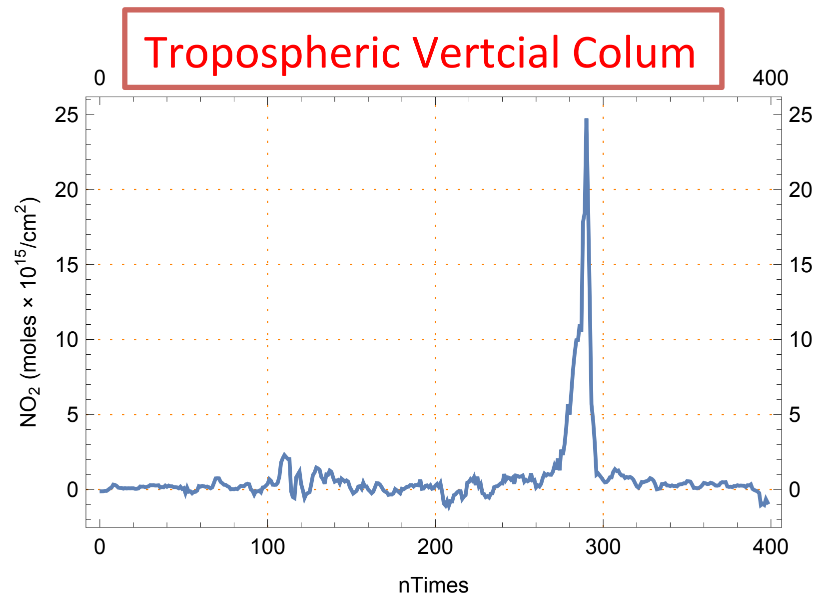
OMI ~ $1x10^{15}$ molecules/cm^2

Precision of vertical tropospheric column:

OMPS ~ $0.5x10^{15}$ molecules/cm^2

OMI ~ $1.0 x10^{15}$ molecules/cm^2





NO_2 Strat-Trop Separation (STS): Orbit-Based Technique

Basic idea

- Localized (small scale) features in the strat fields are attributed to tropospheric signals due to shape factor prescription mismatch.
- Smoothing out these localized features improve both strat and trop NO_2 fields.

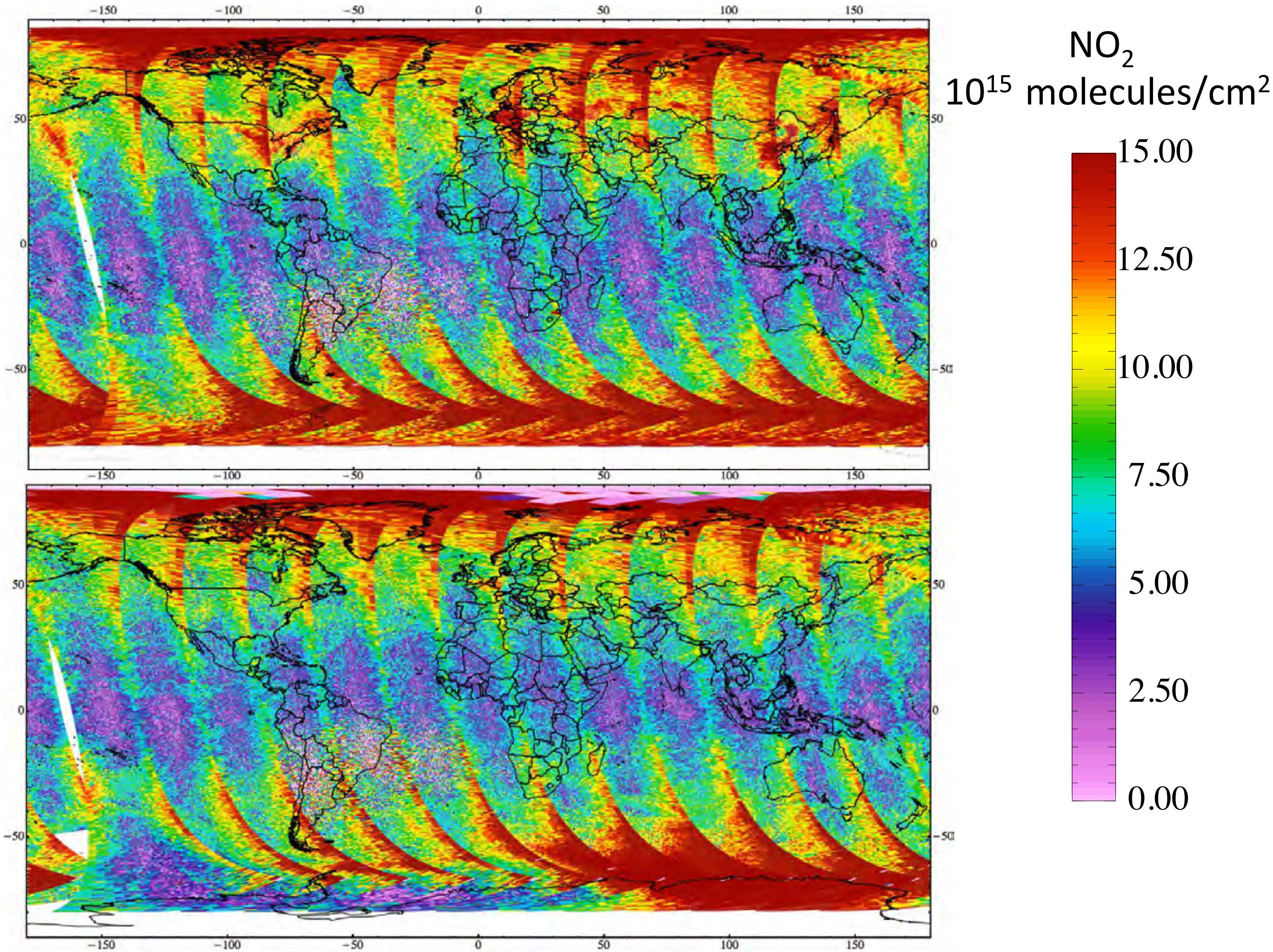
Procedure

- Initial STS done using tropopause and shape factor
- Two smoothed strat fields from sliding median of each cross-track position of an orbit: ~2° and ~20° latitude bands
- The excesses (+) and deficits (−) of strat NO_2 are the difference between the two smoothed fields.
- Trop columns adjustment: strat excesses are added to and deficits are subtracted from the trop fields, whilst accounting for their different measurement sensitivities.

OMPS: NO_2 Total Slant Columns

03/21/2013

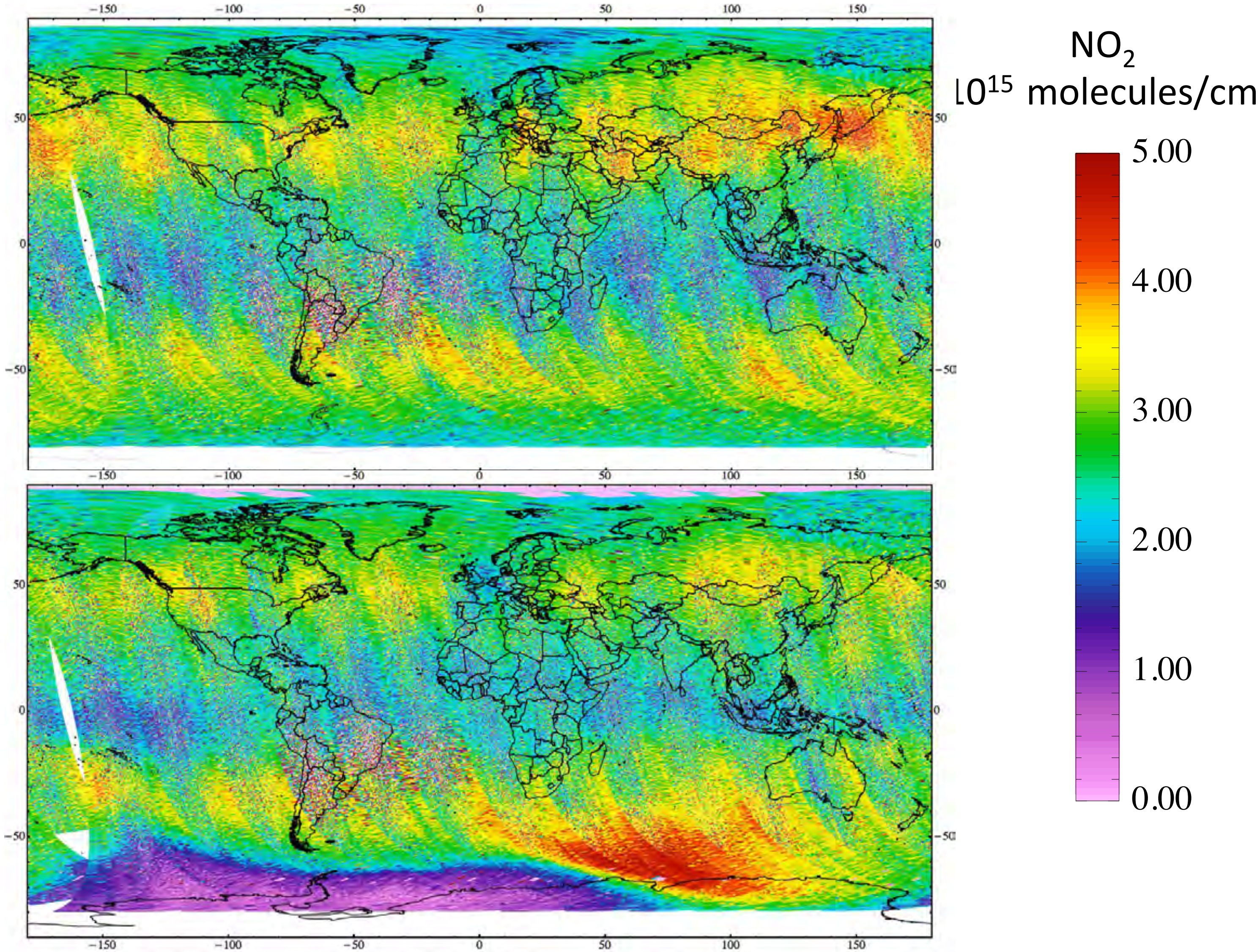
09/22/2013



OMPS: NO_2 Strat Vertical Columns

03/21/2013

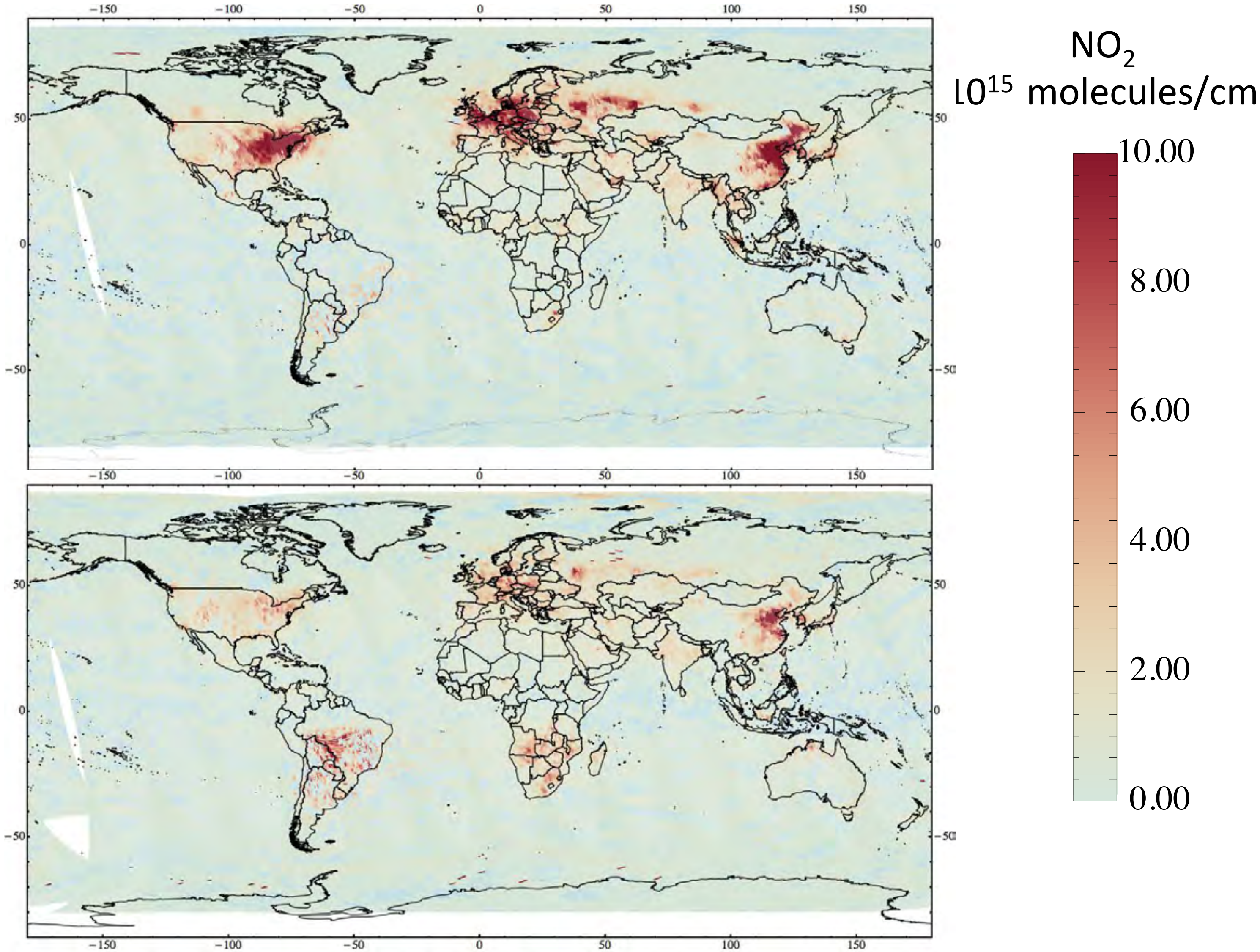
09/22/2013



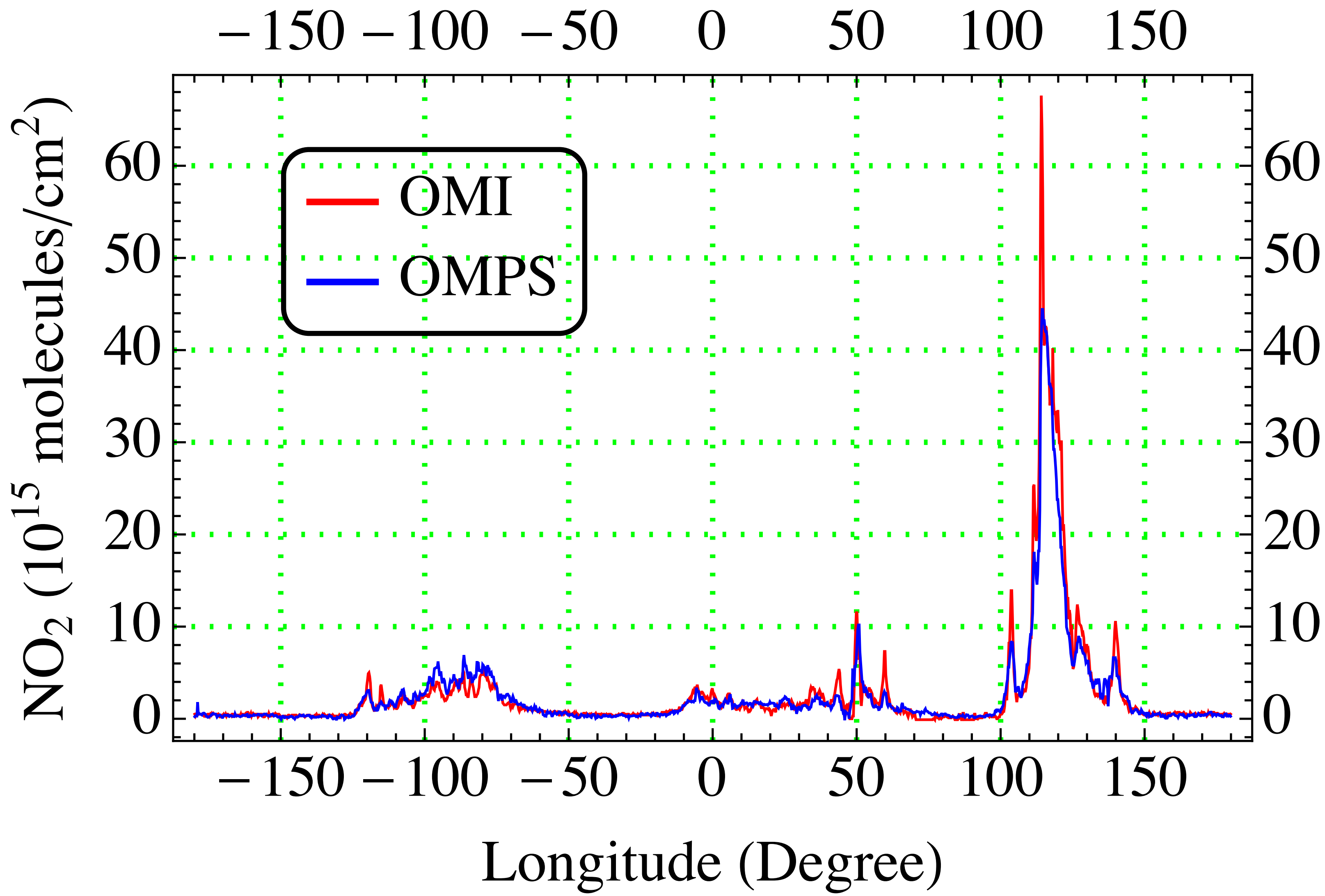
OMPS: NO_2 Trop Vertical Columns

03/21/2013

09/22/2013

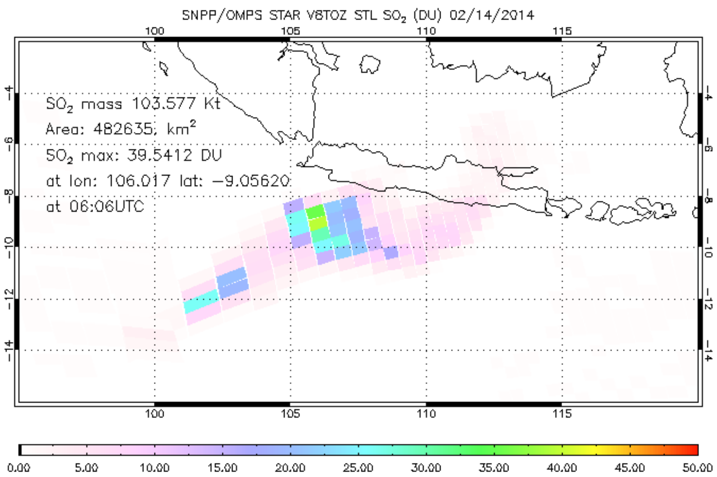


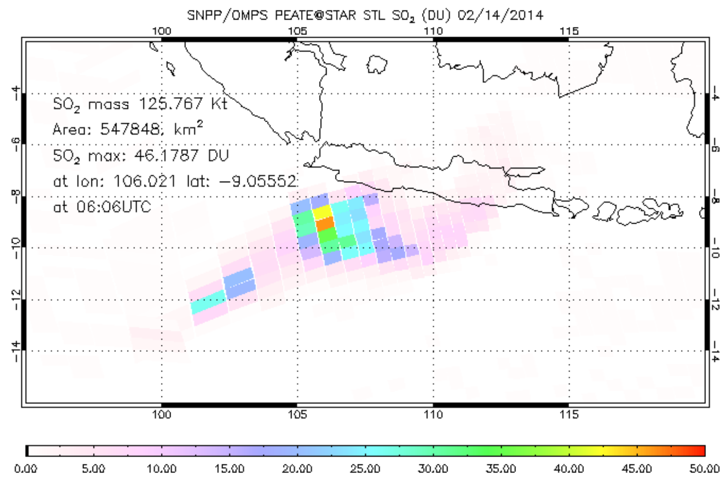
Comparison: OMI vs OMPS
Monthly Mean: December 2013



Near-Real-Time SO_2 Product

- NRT SO_2/Ash are processed with the reliable Linear Fit (LF) algorithm. Data available at Ozone SIPS and LANCE.
- LF algorithm successfully transferred to NOAA.





Eruption of Kelud 2014/02/14. Figures from J. Niu (NOAA STAR)

Summary

- Advanced algorithm with more complete algorithm physics treatment and many improvements, including state-of-the-art radiative transfer modeling, accurate treatment of instrumental effect, and advanced soft calibration, have been developed and implemented for OMPS processing.
- These advances have enabled sensitive and unbiased measurements of tropospheric SO_2 and NO_2 from SNPP/OMPS-NM, achieving data quality that matches or exceeds those of its predecessors.

Acknowledgement

This work is supported by NASA.

Rapid Refreshing of Anthropogenic NO_x Emissions to Support NWS O_3 Forecasting

Daniel Tong, Emission Scientist
NOAA National Air Quality Forecast Capability (NAQFC)
NOAA Air Resources Lab/UMD/GMU

With contribution from:

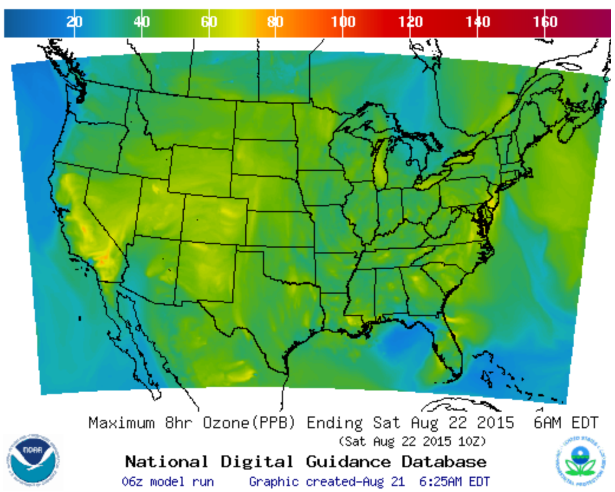
ARL Team: Li Pan, Charles Ding, Hyuncheol Kim, Tianfeng Chai, Min Huang, Youhua Tang and Pius Lee
NWS: Ivanka Stajner and Jeff McQueen
NESDIS: Shobha Kondragunta, Larry Flynn
NASA: Lok Lamsal and Kenneth E. Pickering

NOAA National Air Quality Forecast Capability (NAQFC)

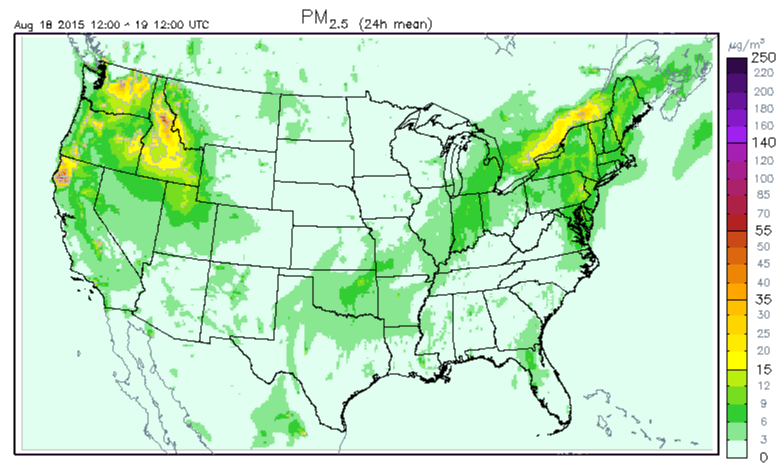
- **Developed by OAR/Air Resources Laboratory; Operated by National Weather Service (NWS) (PM: I. Stajner).**

- **Provides national numeric air quality guidance for ozone (operational product) and $PM_{2.5}$ (particulate matter with diameter < 2.5 μm);**

O_3 Forecasting



$PM_{2.5}$ Forecasting



http://airquality.weather.gov/

<u>NAQFC is one of the major gateways to disseminate NOAA satellite observations and model prediction of air quality to the public.</u>

Challenges in NAQFC Emission Forecasting

❖ **Time lag is a major obstacle for NAQFC emission forecasting.**

Forecasters want: ***emission of tomorrow;***

Data availability: ***emission data 4+ years old*****.**
(three years labor, one year QA, post-processing and release).

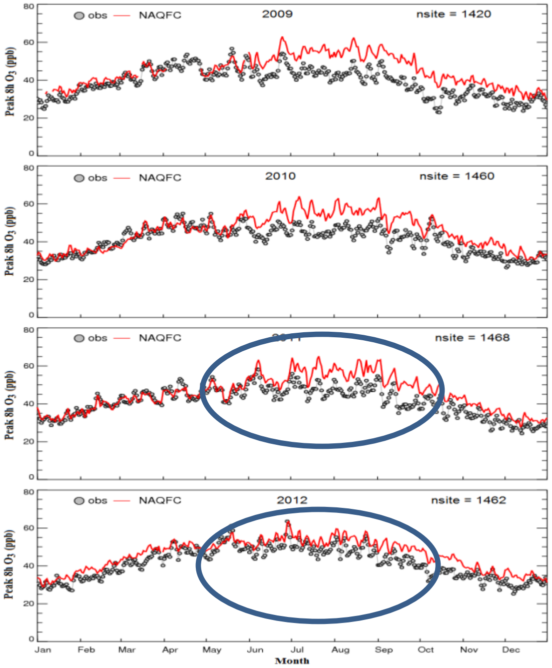
How to overcome this problem?

❖ **NAQFC Practices:**

Option 1, no update (2007-2011) - Dear price paid;

Option 2, use EPA emission projection (2012-2015).

Option 3, emission data assimilation (2016-?).



(Tong et al., Atmos. Environ. 2015)

Impact of the Great Recession on US Air Quality

- **Starting – Ending time: December 2007 – October 2009;**

- **Cause: Bursting of the housing bubble in 2007, followed by a subprime mortgage crisis in 2008;**

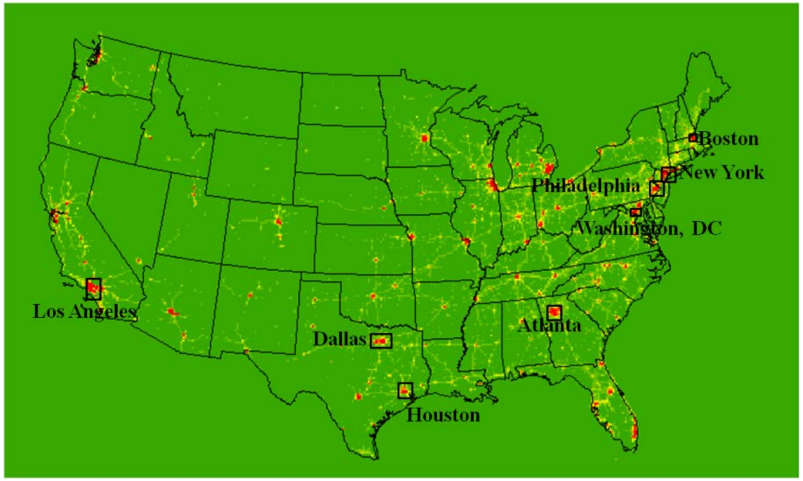
- **Impacts:**
  - **Unemployment rate: 4.7% in Nov 2007 → 10.1% in Oct 2009.**
  - **Income level: dropped to 1996 level after inflation adjustment;**
  - **Poverty rate: 12% → 16% (50 millions);**
  - **GDP: contract by 5.1%;**

- **Worst economic recession since the Great Depression**

Question: What does it mean to Air Quality (and Emissions)?

Methodology

- **Emission Indicator – Urban NOx in Summer**
  - **Short lifetime → proximity to emission sources**
  - **Urban NO2 dominated by local sources;**
  - **High emission density → low noise/signal ratio;**
- **NOx Data sources**
  - **Satellite remote sensing (OMI-Aura NO2).**
  - **Ground monitoring (EPA AQS NOx);**
  - **Emission data (NOAA National Air Quality Forecast Capability operational emissions);**
- **Deriving the trend:** (Y2–Y1)/Y1 × 100%
- **Selection of urban areas**

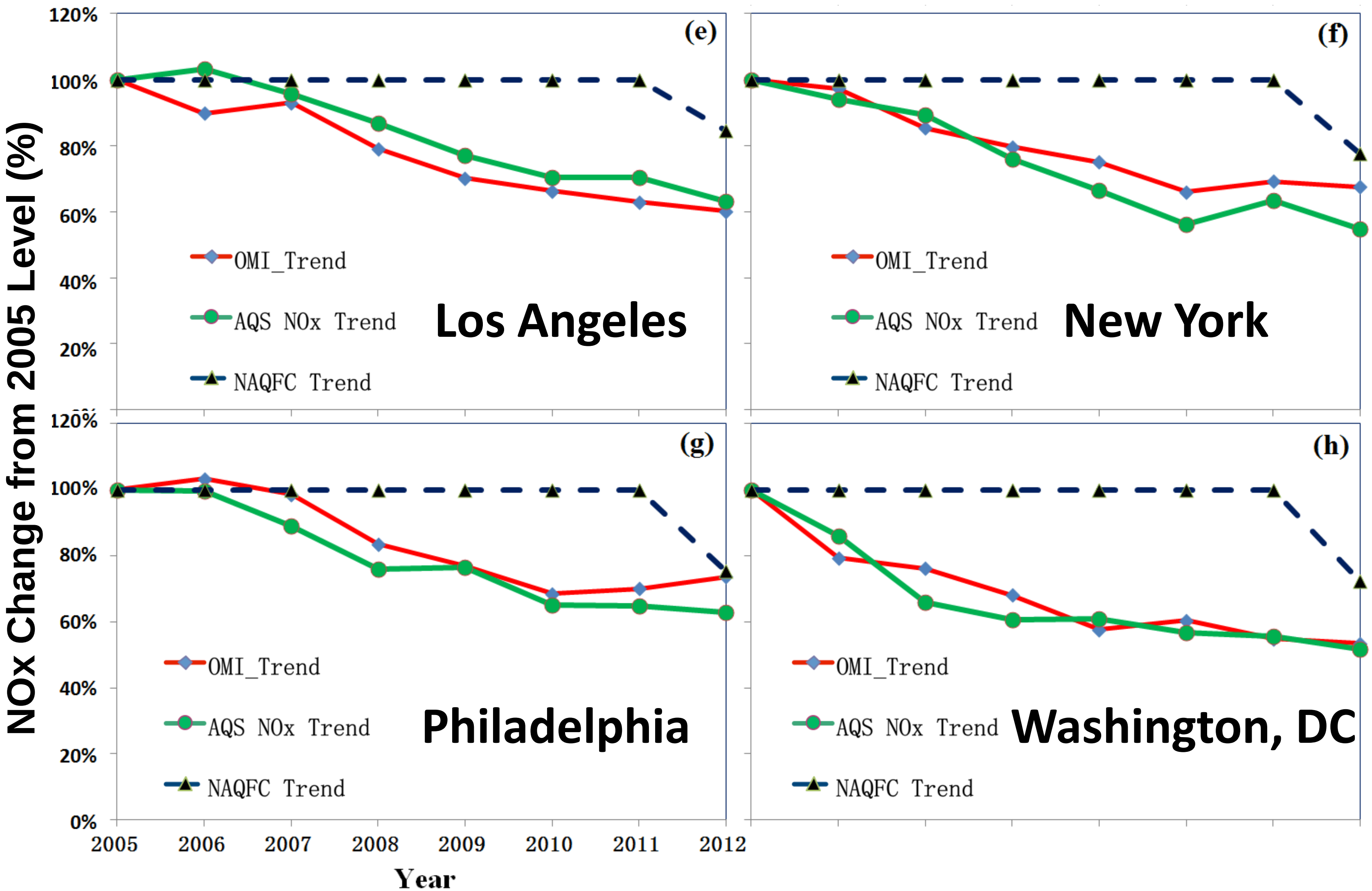


NOx Changes
Prior to, during and after the Recession

Stage	Sources	Atlanta	Boston	Dallas	Houston	Los Angeles	New York	Philadel-phia	Washing-ton, DC	Mean
Before	OMI SP	-11.7	-9.4	-7.5	-5.7	-3.3	-7.5	-0.6	-12.3	-7.3
	AQS	-9.9	-2.1	-5.2	0.7	-2.0	-5.5	-5.5	-18.7	-6.0
During	OMI SP	-5.5	-7.5	-8.9	-7.9	-13.1	-6.2	-11.7	-13.0	-9.2
	AQS	-17.5	-7.0	-13.0	-14.0	-10.3	-13.6	-7.0	-3.7	-10.8
After	OMI SP	-6.0	-3.3	-2.1	0.4	-5.0	-3.2	-1.2	-2.3	-2.8
	AQS	1.4	-6.1	0.1	0.2	-6.4	-5.4	-6.1	-5.3	-3.4

- **Distinct regional difference;**
- **Average NOx changes are consistent for OMI and AQS data;**
- **-6%/yr - -7%/yr prior to Recession;**
- **-9%/yr - -11%/yr during Recession;**
- **-3%/yr after Recession (Recovery?).**

Inter-Comparison of OMI, AQS and NAQFC



Feasibility Study: Emission Data Assimilation

(Project funded by OAR USWRP program, PM: J. Cortinas)

Can satellite data be used to rapidly refresh NOx emission?

Approach: Replace EPA projection factors by observation-based factors

Use both satellite and ground observations;

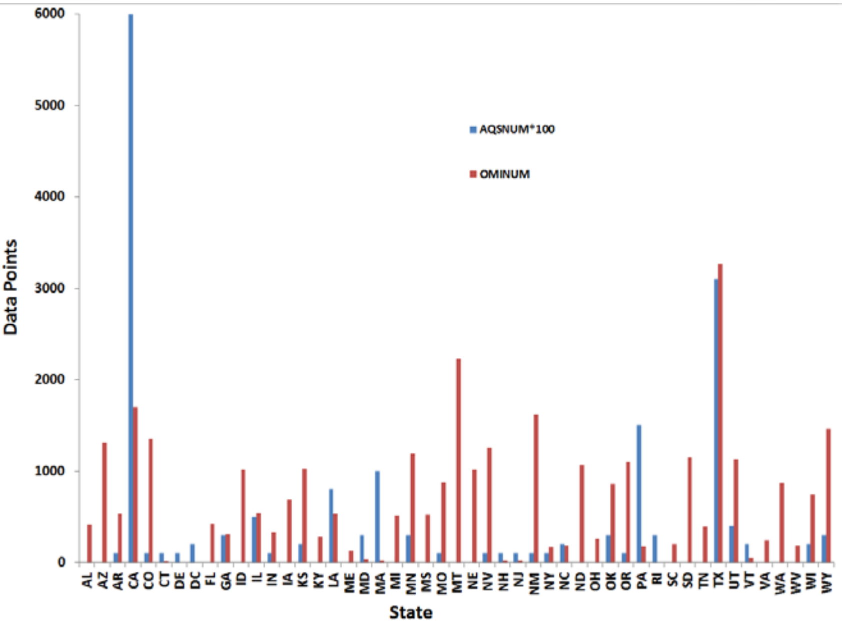
Optimal data fusion algorithm.

$$AF = \frac{\Delta S \times f_S + \Delta G \times f_G}{N_S \times f_S + N_G \times f_G}$$

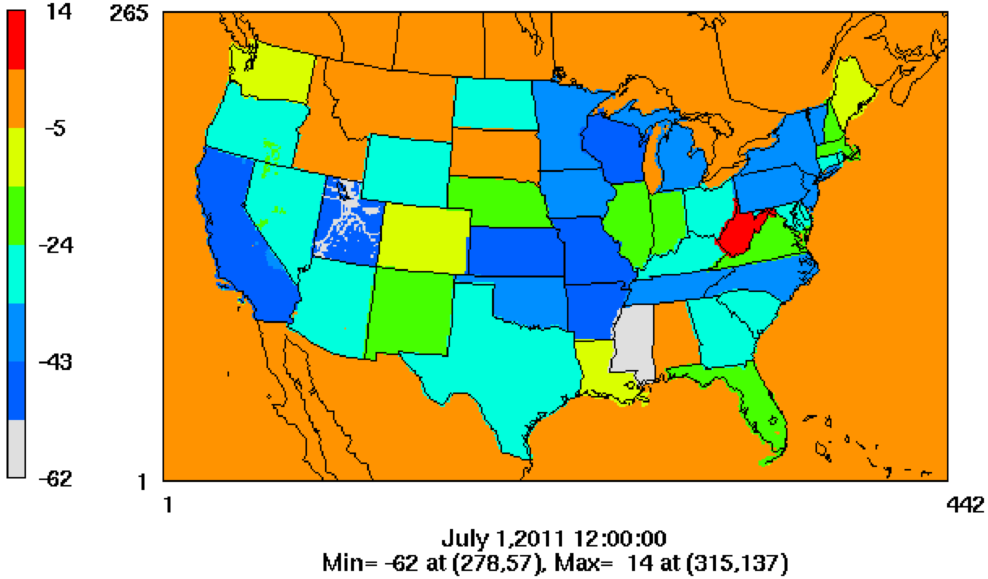
ΔS and N_S - changing rate and data number of satellite data;
ΔG and N_G -- rate and number of ground data;
f_S and f_G -- weighting factors for satellite and ground data;

Why both satellite and ground observations?

Comparison of OMI and AQS (x100) Samples



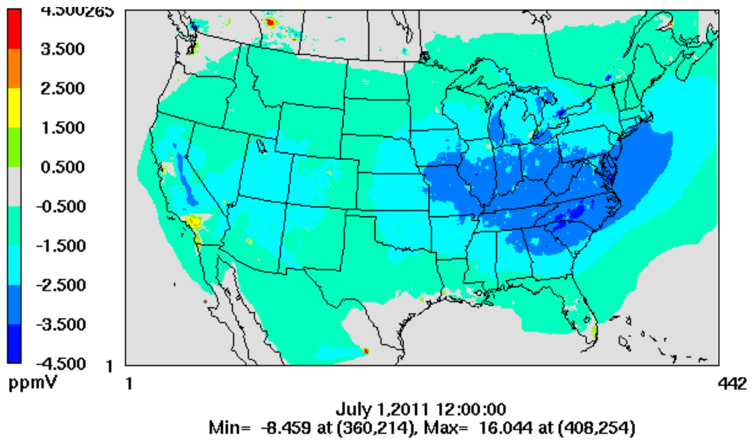
State-level Projection Factors from OMI and AQS



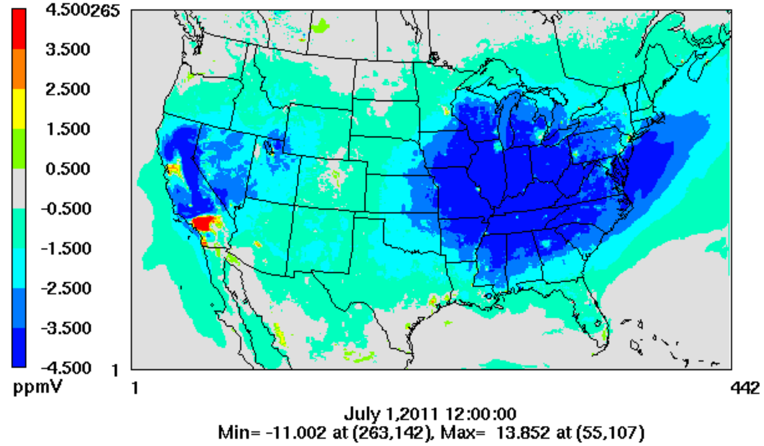
OMI Preprocessing: 1) Quality filter; 2) Set a cut-off value; 3) Calculate lower and higher 25% percentiles

Performance Evaluation of NAQFC O_3 Forecasting

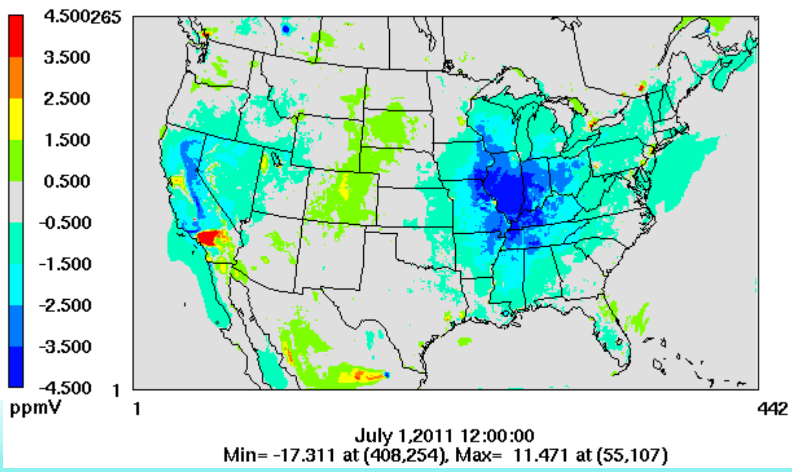
Effect of Using EPA Projection



Effect of Using New Factors



Difference



Model Performance Evaluation

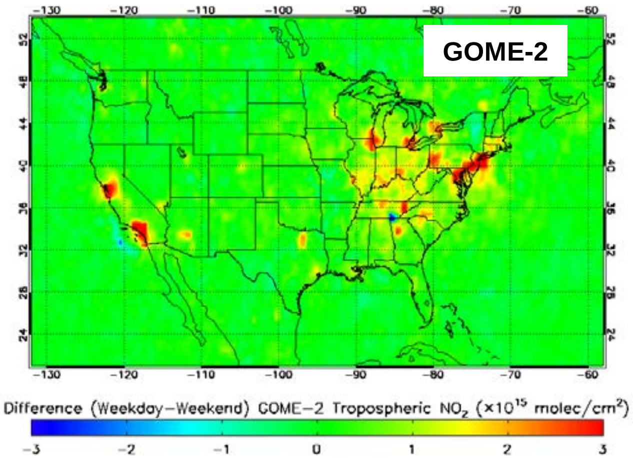
Performance Metrics

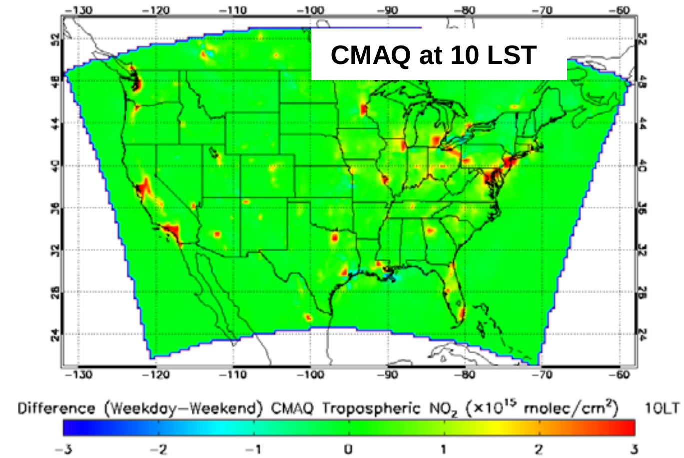
			MOD_MEAN			RMSE			NME			MB			NMB			R		
TYPE	COUNT	OBS_MEA	BASE	NEI2012	JPSS	BASE	NEI2012	JPSS	BASE	NEI2012	JPSS	BASE	NEI2012	JPSS	BASE	NEI2012	JPSS	BASE	NEI2012	JPSS
Hourly		AQS	NEI2005	PROJ2012	NOx_EDA	NEI2005	PROJ2012	NOx_EDA	NEI2005	PROJ2012	NOx_EDA	NEI2005	PROJ2012	NOx_EDA	NEI2005	PROJ2012	NOx_EDA	NEI2005	PROJ2012	NOx_EDA
CONUS	15930	40.09	52.37	52	51.58	23.25	23.07	22.68	43.11	42.83	41.94	12.28	11.91	11.49	30.63	29.71	28.67	0.57	0.56	0.58
NE	2055	39.83	40.41	39.94	39.57	14.38	14.39	14.27	26.71	26.82	26.42	0.59	0.11	-0.25	1.47	0.28	-0.63	0.61	0.61	0.62
SE	2805	45.7	58.11	57.38	56.97	24.01	23.8	23.17	40.39	40.42	39.12	12.41	11.68	11.28	27.16	25.56	24.67	0.51	0.5	0.53
UM	3615	46.74	57.94	57.54	56.02	23.11	22.82	22.09	35.38	34.86	33.75	11.2	10.8	9.27	23.96	23.09	19.84	0.48	0.48	0.49
LM	2190	32.35	53.15	52.99	52.16	27.32	27.17	26.4	68.74	68.32	66.09	20.8	20.64	19.81	64.31	63.8	61.23	0.57	0.56	0.58
RM	1560	43.38	55.25	55.09	55.34	22.83	22.61	22.73	37.63	37.28	37.54	11.87	11.71	11.96	27.36	27	27.57	0.56	0.57	0.57
PC	2160	39.06	54.24	54.57	55.61	26.63	26.63	26.85	49.62	49.78	49.83	15.18	15.52	16.55	38.87	39.72	42.37	0.65	0.66	0.68

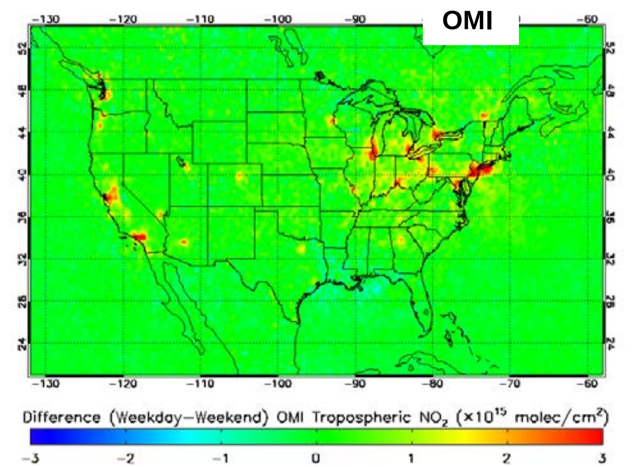
			MOD_MEAN			RMSE			NME			MB			NMB			R		
Max 8hr		AQS	NEI2005	PROJ2012	NOx_EDA	NEI2005	PROJ2012	NOx_EDA	NEI2005	PROJ2012	NOx_EDA	NEI2005	PROJ2012	NOx_EDA	NEI2005	PROJ2012	NOx_EDA	NEI2005	PROJ2012	NOx_EDA
CONUS	1062	48.57	59.32	58.44	58.32	21.85	21.52	21.44	31.73	31.19	31.11	10.75	9.87	9.74	22.13	20.32	20.06	0.52	0.51	0.52
NE	137	47.36	46.35	45.22	45.16	11.29	11.61	11.57	18.78	18.91	18.83	-1.02	-2.15	-2.21	-2.15	-4.53	-4.66	0.77	0.77	0.75
SE	187	56.42	63.83	62.52	62.77	19.62	19.19	18.91	25.75	25.51	25.07	7.4	6.1	6.34	13.12	10.8	11.24	0.51	0.49	0.53
UM	241	55.32	64.33	63.25	61.94	20.83	20.49	20.15	25.04	24.71	24.57	9.01	7.93	6.61	16.28	14.33	11.96	0.48	0.47	0.46
LM	146	39.47	62.72	62.09	61.45	29.32	28.95	28.23	60.42	59.25	57.61	23.25	22.61	21.97	58.89	57.28	55.66	0.43	0.4	0.43
RM	104	51.88	61.85	60.98	61.65	21.11	20.61	20.98	26.16	25.35	25.93	9.97	9.1	9.77	19.21	17.53	18.83	0.44	0.45	0.45
PC	144	49.61	63.96	63.9	65.3	25.75	25.62	26.42	34.75	34.34	35.44	14.36	14.3	15.69	28.94	28.82	31.63	0.52	0.53	0.54

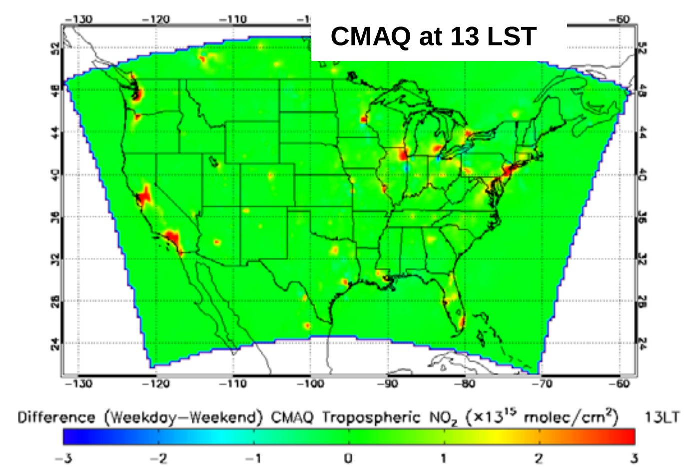
Prediction with the new assimilated emission data outperforms the current operational system.

Observed and Modeled Weekday/Weekend Difference in Tropospheric NO_2









(Courtesy: S. Kondragunta)

Summary & Future Plan

- **Satellite observations can be used to detect emission changes consistent with ground observations;**
- **Demonstrate the feasibility of assimilating satellite and ground observations to rapidly update anthropogenic emissions;**
- **The assimilated emission data can improve NAQFC forecasting capability, outperforming the current operational system.**
- **Future plans include testing with GOME-2 and OMPS NO2 products beyond monthly means (e.g., daily change, over land and ocean).**

Total Ozone from Assimilation of Stratosphere and Troposphere (TOAST) Its past, current and future versions

Jianguo Niu
System Research Group@NOAA/NESDIS/STAR

Larry Flynn,
NOAA/NESDIS/STAR

STAR JPSS Annual Science Team Meeting August 26, 2015

TOAST objective analysis

- **Basic consideration:**
  1. IR obs. possess higher sensitivity to lower atmosphere
  2. UV obs. Possess higher sensitivity to upper atmosphere.
  3. Mix the IR and UV retrieved O3 may increase O3 accuracy
  4. Fill in the UV observation gaps
- **Basic procedures:**
  1. Convert IR and UV O_3 pressure scale into same pressure scales.
  2. Coordinate transform from geographic into stereographic.
  3. Objective analysis.
  4. Analyzed global ozone data are transformed back to the geographic coordinate with 1˚× 1˚ resolution.

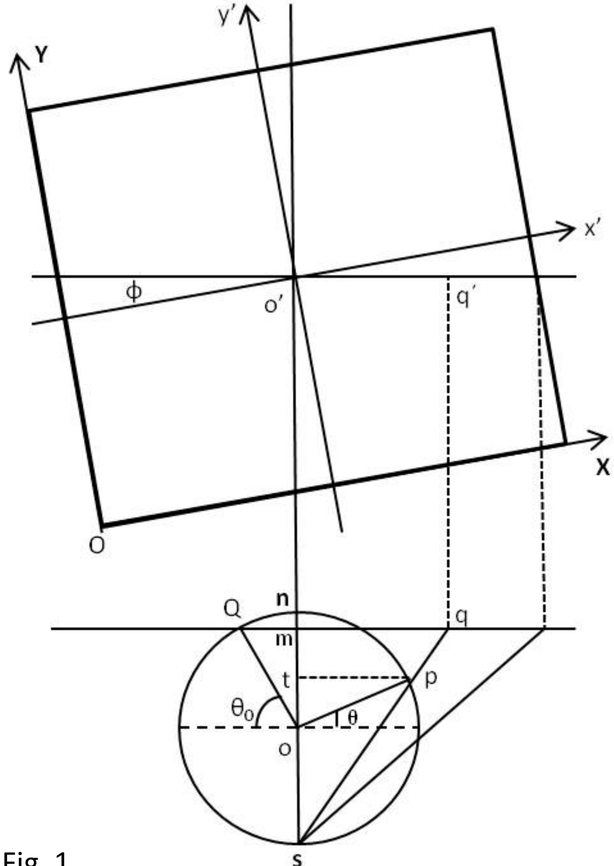


Fig. 1

$$X = \cos\theta \cdot \cos\phi \cdot \frac{\sin\theta_0 + 1}{\sin\theta + 1} \cdot \frac{Re}{mesh} + \frac{N-1}{2} \qquad (1)$$

$$Y = \cos\theta \cdot \sin\phi \cdot \frac{\sin\theta_0 + 1}{\sin\theta + 1} \cdot \frac{Re}{mesh} + \frac{N-1}{2} \qquad (2)$$

mesh=24,384/(N-1) km, θ_0=60˚; N is mesh grid number;
For CrIS N=245; for OMPS N=65

Fig 1. coordinate transformation from geographic to Stereographic.

$$C = WE \qquad (3)$$

$$W = \frac{R^2 - d^2}{R^2 + d^2} \qquad (4)$$

Any initial value on the grid within radius R and the origin point A determined circle will be corrected by the correction value C , where E is the difference between observation and the initial value at A, W is a weighting factor.

Fig. 2

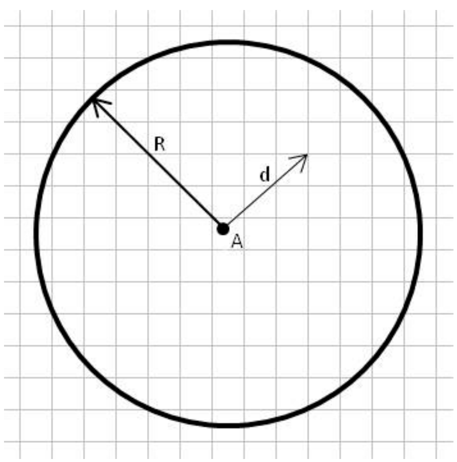
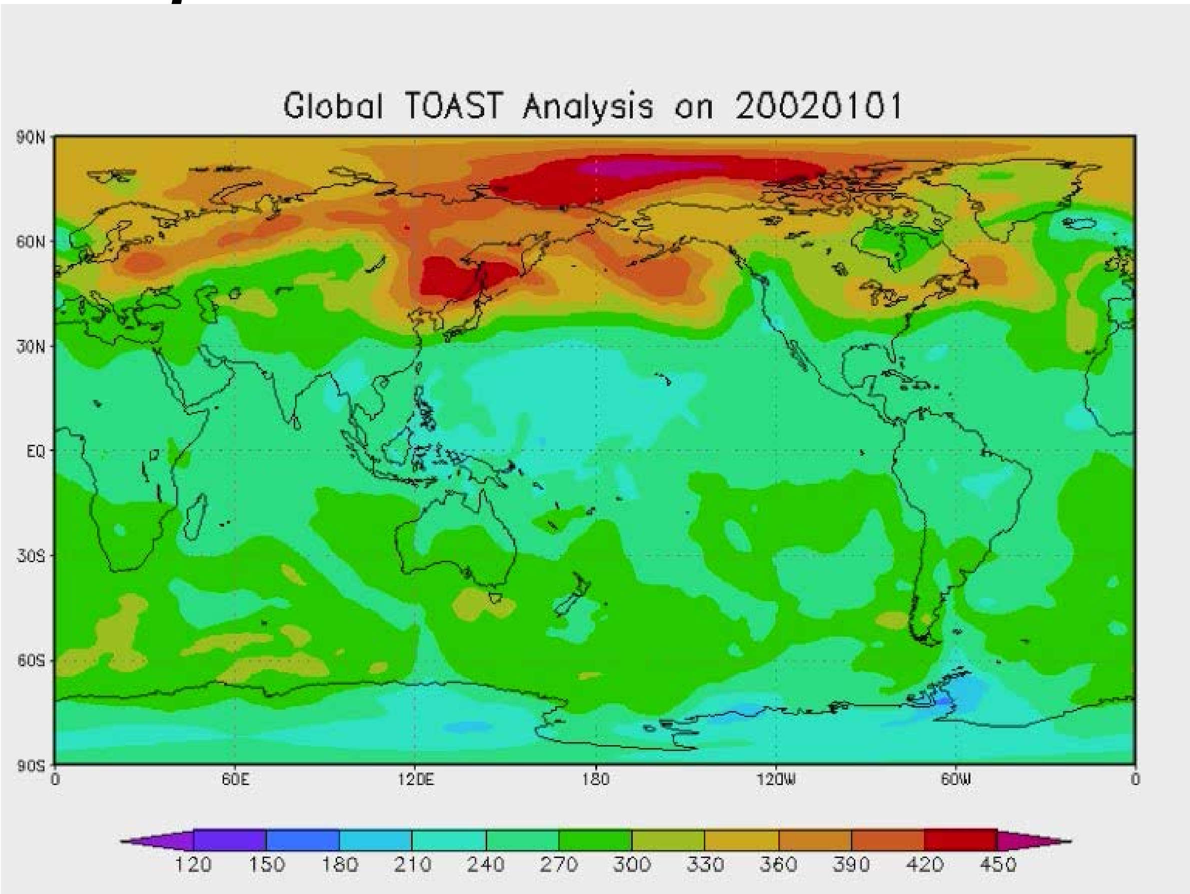


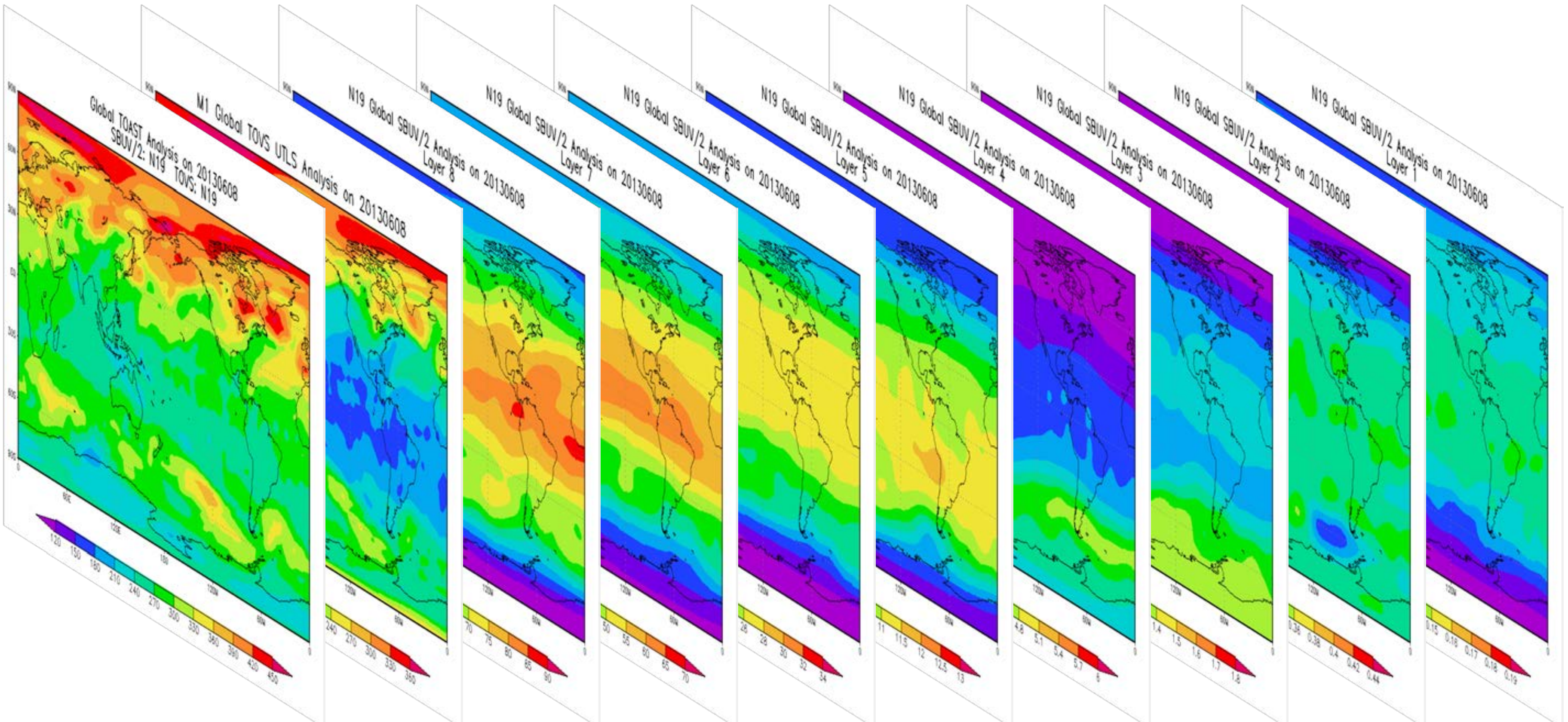
Fig 2. scheme of objective analysis

The past TOAST : from 2002 to 2014



- Started from 01/01/2002 and has accumulated 11^{+} years data.
- Provide global 1˚ × 1˚ total O_3
- Provide global 1˚ × 1˚ for eight Umkehr layer O_3 at 31.7, 15.8, 7.93, 3.96, 1.98, 0.99, 0.50, 0.25 mb.

TOAST using TOVS and SBUV-2
(06-08-2013)



TOAST total amount | UTLS | 31.7 mb | 15.8 mb | 7.93 mb | 3.96 mb | 1.98 mb | 0.99 mb | 0.5 mb | 0.25 mb

TOAST = TOVS + SBUV-2

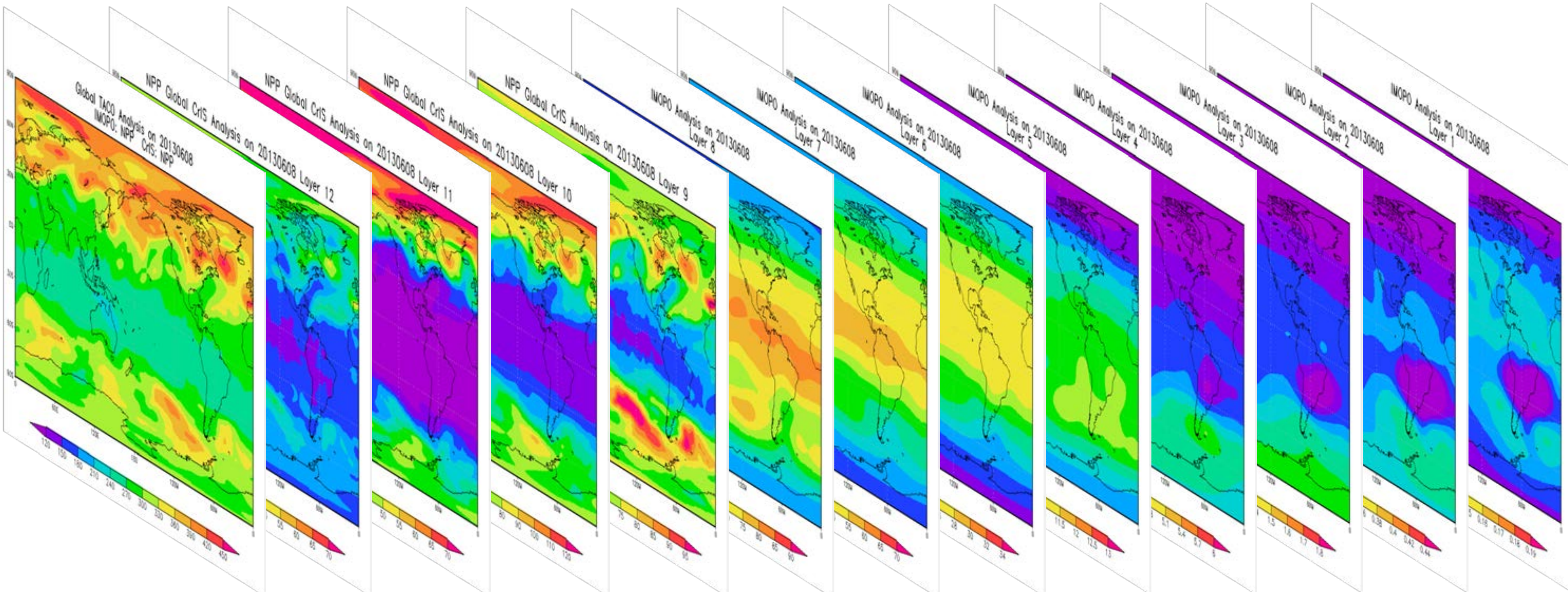
From 2012, S-NPP provided the following ozone sensors

- CrIS IR sensor monitoring global O3 profiles
- OMPS NP nadir view profiler
- OMPS NM nadir mapper
- OMPS limb

The current TOAST

•**T**otal **O**zone from **A**ssimilation of CrIS and OMPS (NP) or SBUV2 in **S**tratosphere and **T**roposphere
•Current operational ***TOAST*** is running CrIS + SBUV/2 (N19) until OMPS advances into validated maturity.

TOAST using CrIS and OMPS/NP (or SBUV-2)
(06-08-2013)



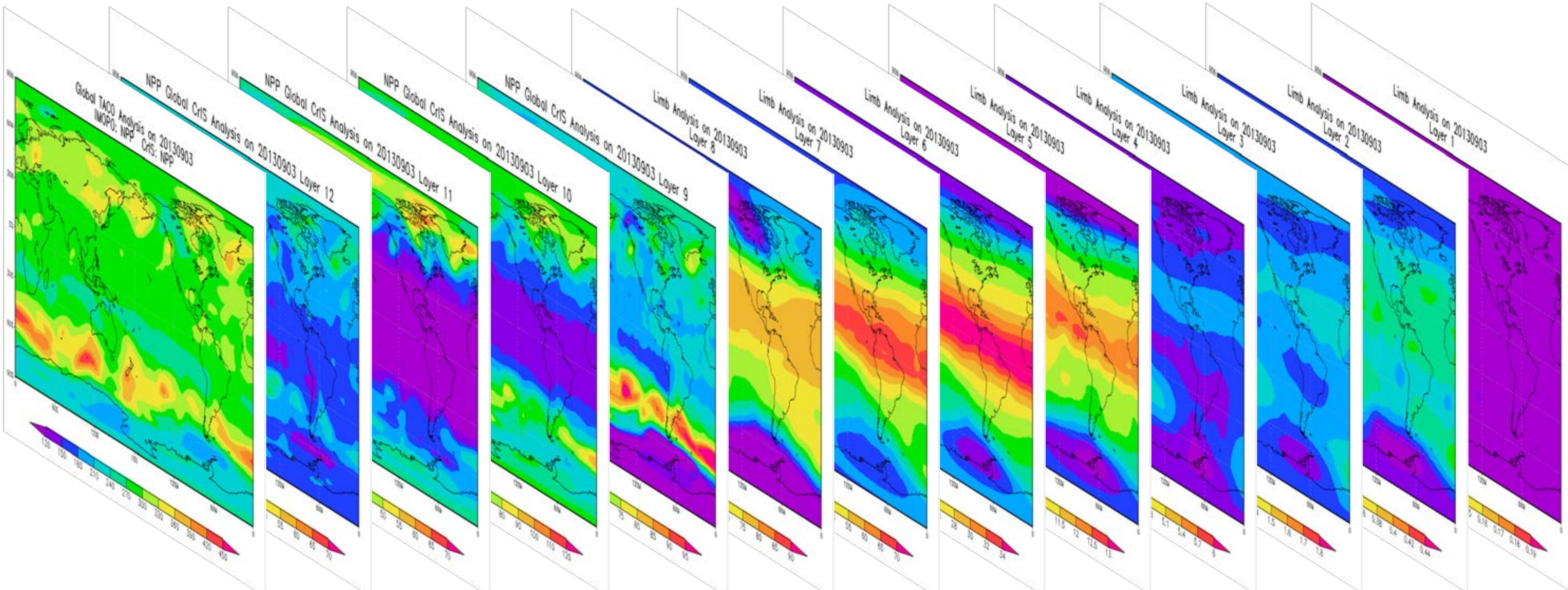
TACO total amount 1013 253 127 63.3 31.7 15.8 7.93 3.96 1.98 0.99 0.5 0.25 mb

TOAST = CrIS + OMPS/NP or SBUV

The upcoming TOAST (CrIS + OMPS/Limb)

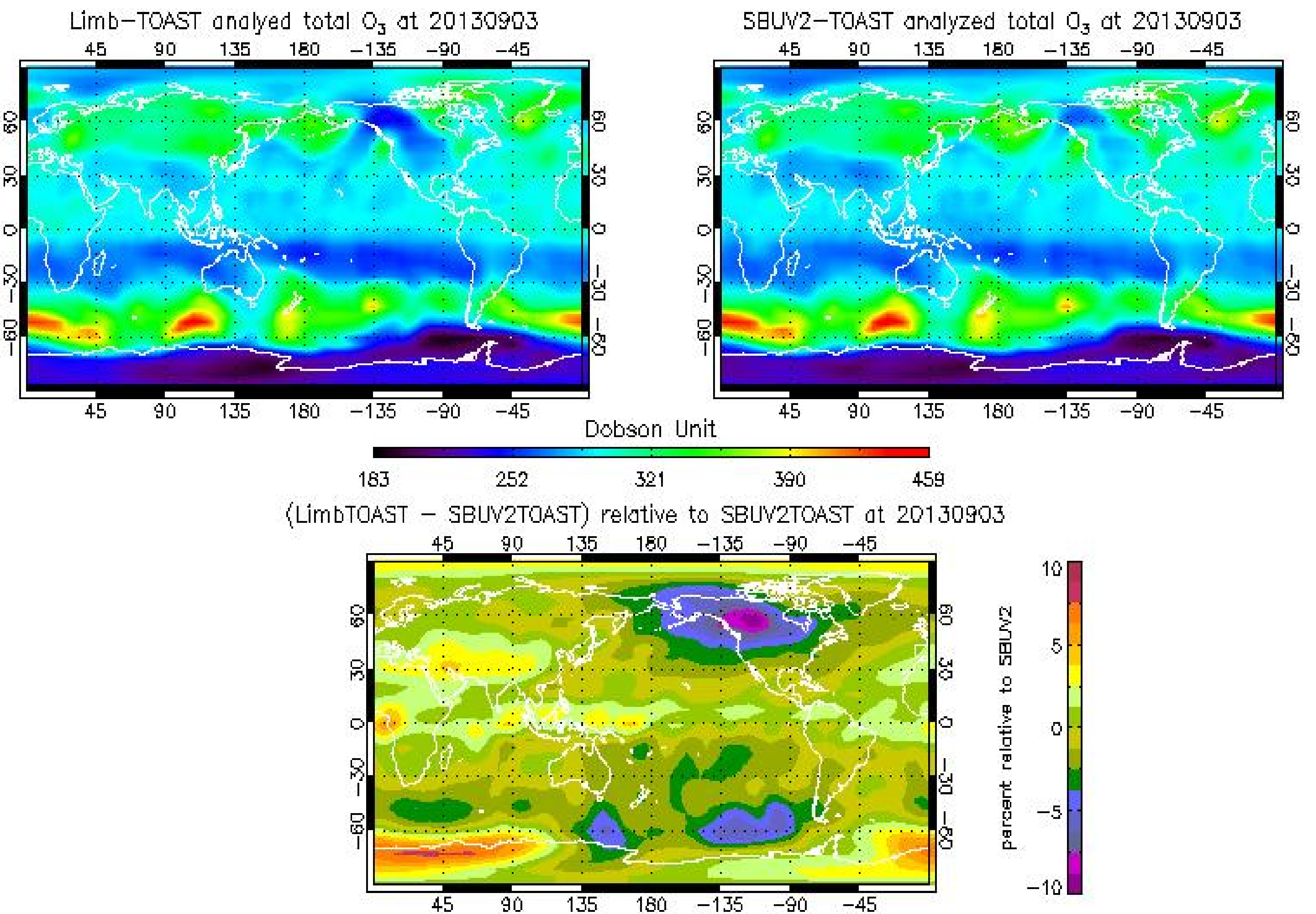
- Using **C**rIS and OMPS Limb (61 one-kilometer-thick layers)
- Provide global 1˚ × 1˚ total O_3
- Provide global 1˚ × 1˚ O_3 maps of eight Umkehr layers at 31.7, 15.8, 7.93, 3.96, 1.98, 0.99, 0.50, 0.25 mb from OMPS Limb objective analyzed maps
- Provide global 1˚ × 1˚ O_3 maps of four Umkehr layers at 1013, 253, 127, 63.3 mb derived from CrIS NUCAPS product.
- Intend to provide 21 layer (V8 layers ~3km) analyzed maps
- Intend to provide Limb 61 layers analyzed maps

TOAST using CrIS and Limb
(09-03-2013)



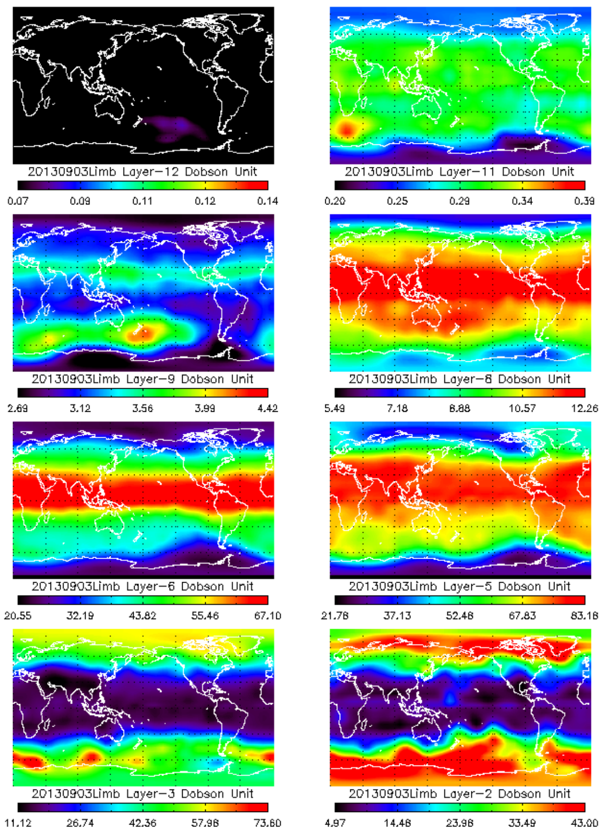
TACO total amount 1013 253 127 63.3 31.7 15.8 7.93 3.96 1.98 0.99 0.5 0.25 mb

TOAST= CrIS + OMPS /Limb

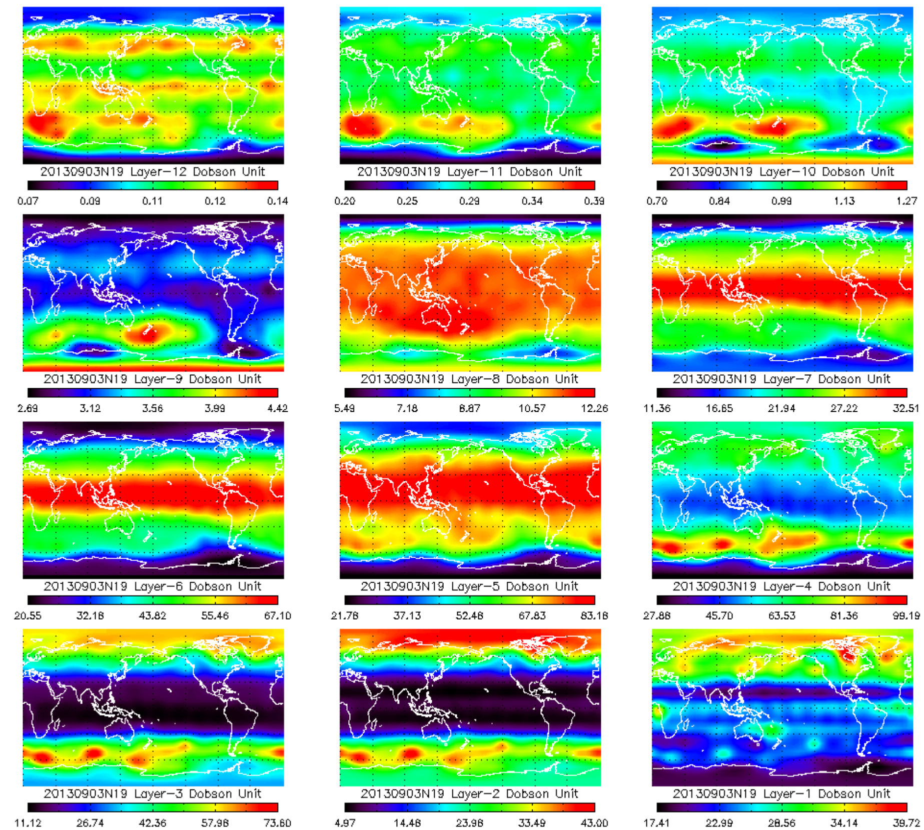

Limb–TOAST analyed total O_3 at 20130903
SBUV2–TOAST analyzed total O_3 at 20130903
45 90 135 180 –135 –90 –45
60 30 0 –30 –60
Dobson Unit
183 252 321 390 459
(LimbTOAST – SBUV2TOAST) relative to SBUV2TOAST at 20130903
percent relative to SBUV2
10 5 0 –5 –10

12 Umkehr layers analyzed O_3 09-03-2013

Limb

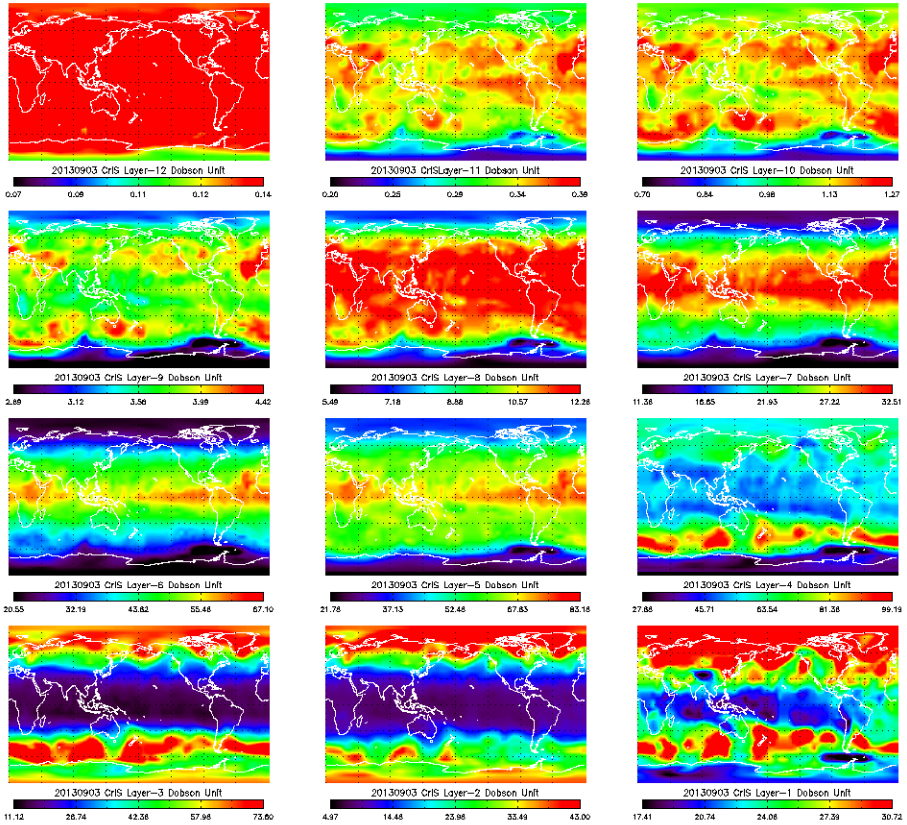


SBUV

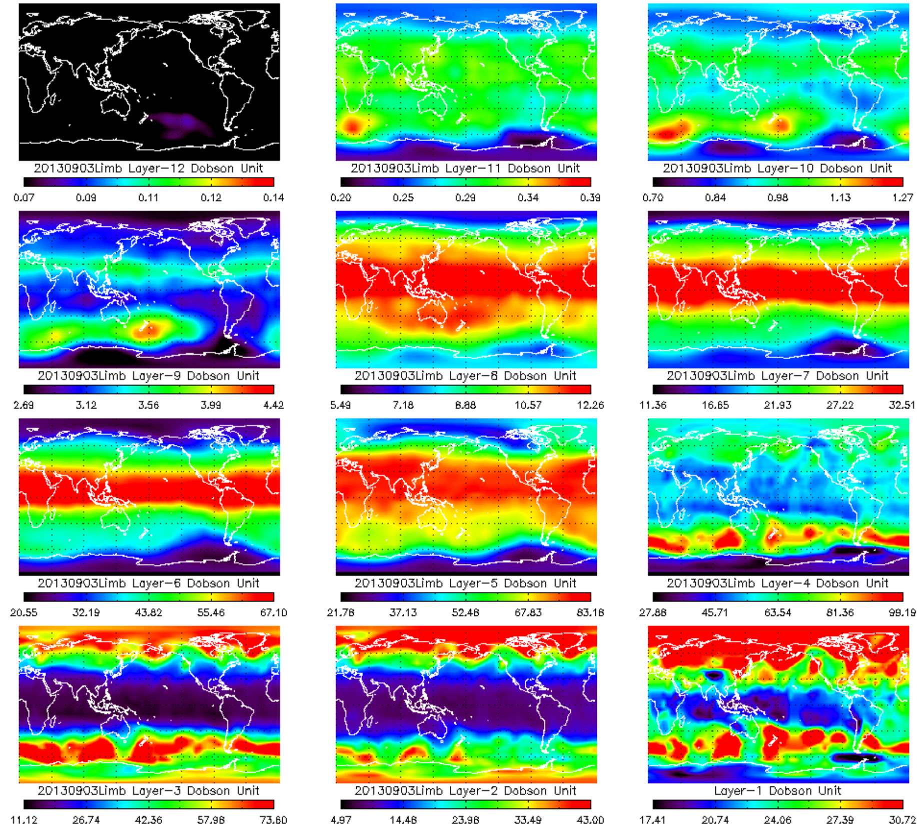


12 Umkehr layers analyzed O_3 09-03-2013

CrIS

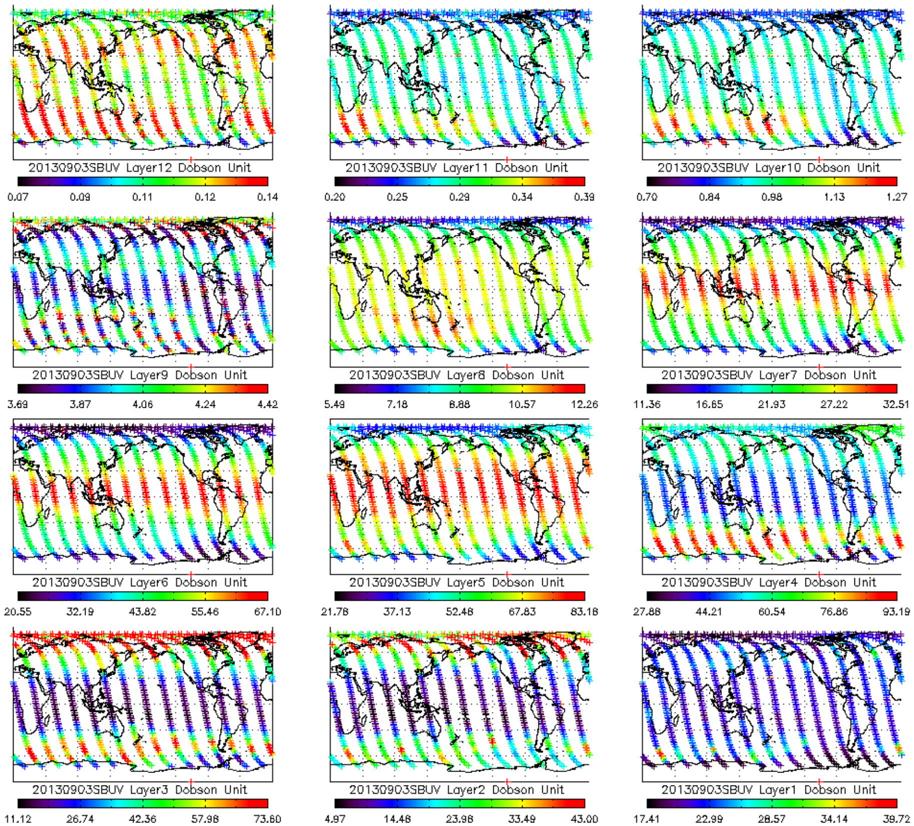


CrIS + Limb

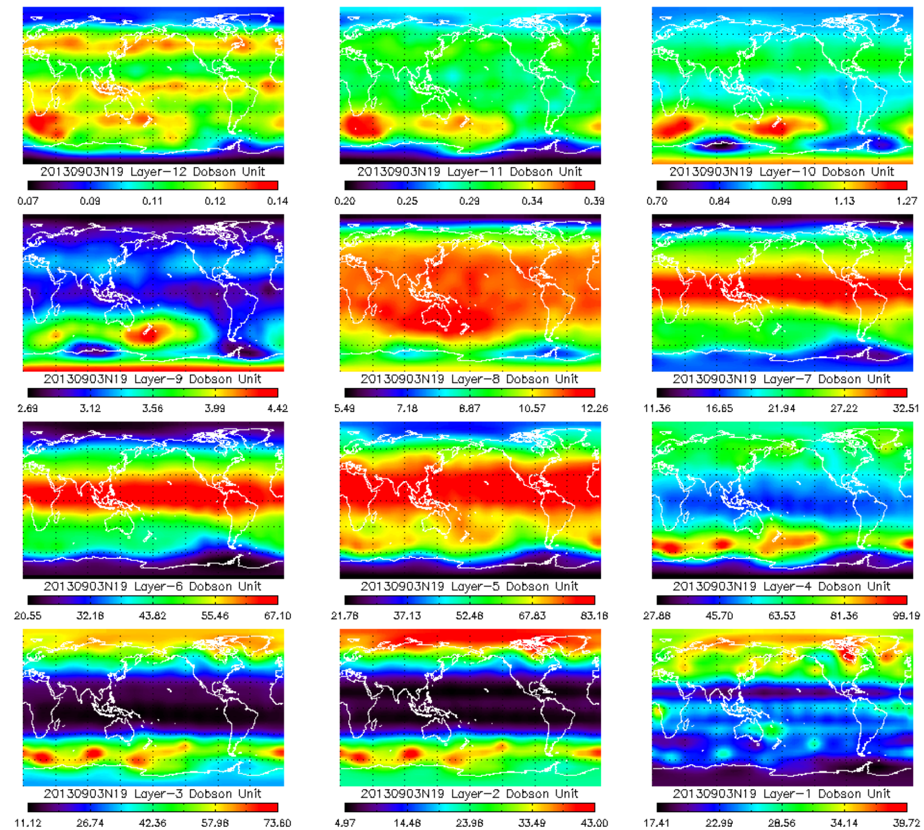


SBUV 12-layer vs. analyzed 09-03-2013

SBUV-2 input

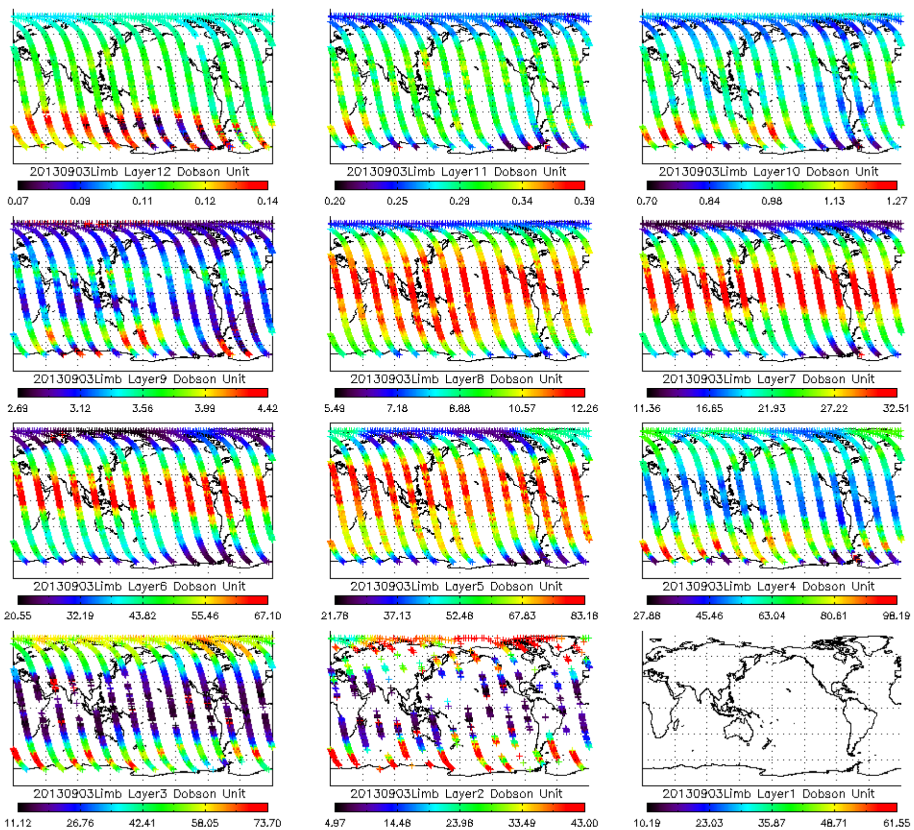


TOAST SBUV-2 analyzed

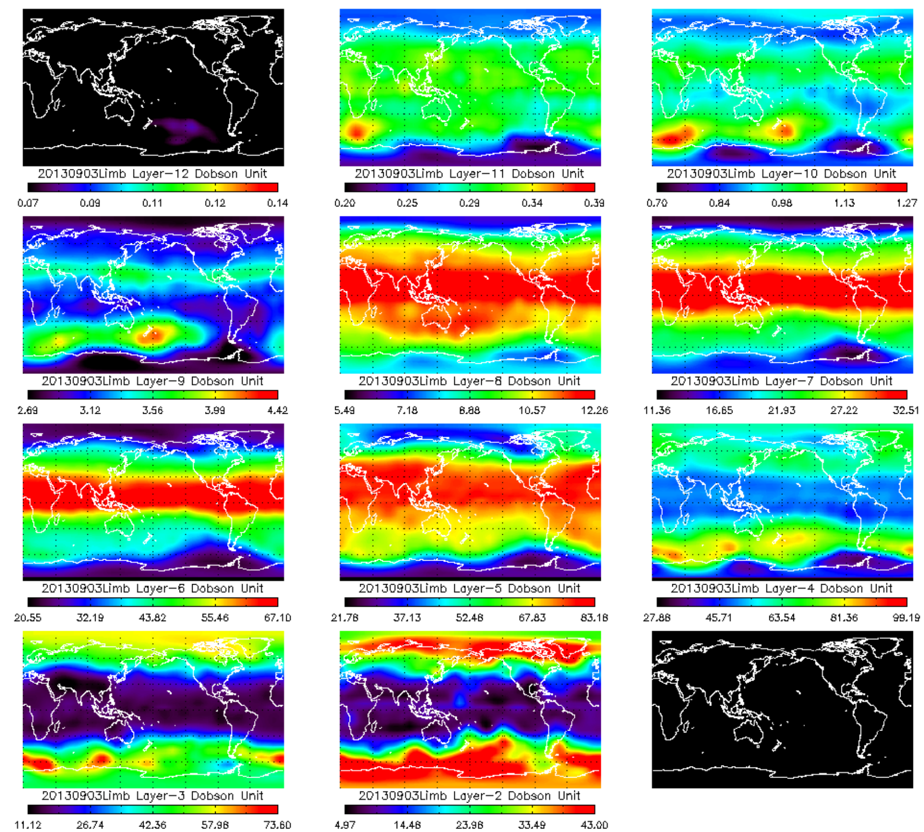


Limb Layer reformed vs. analyzed

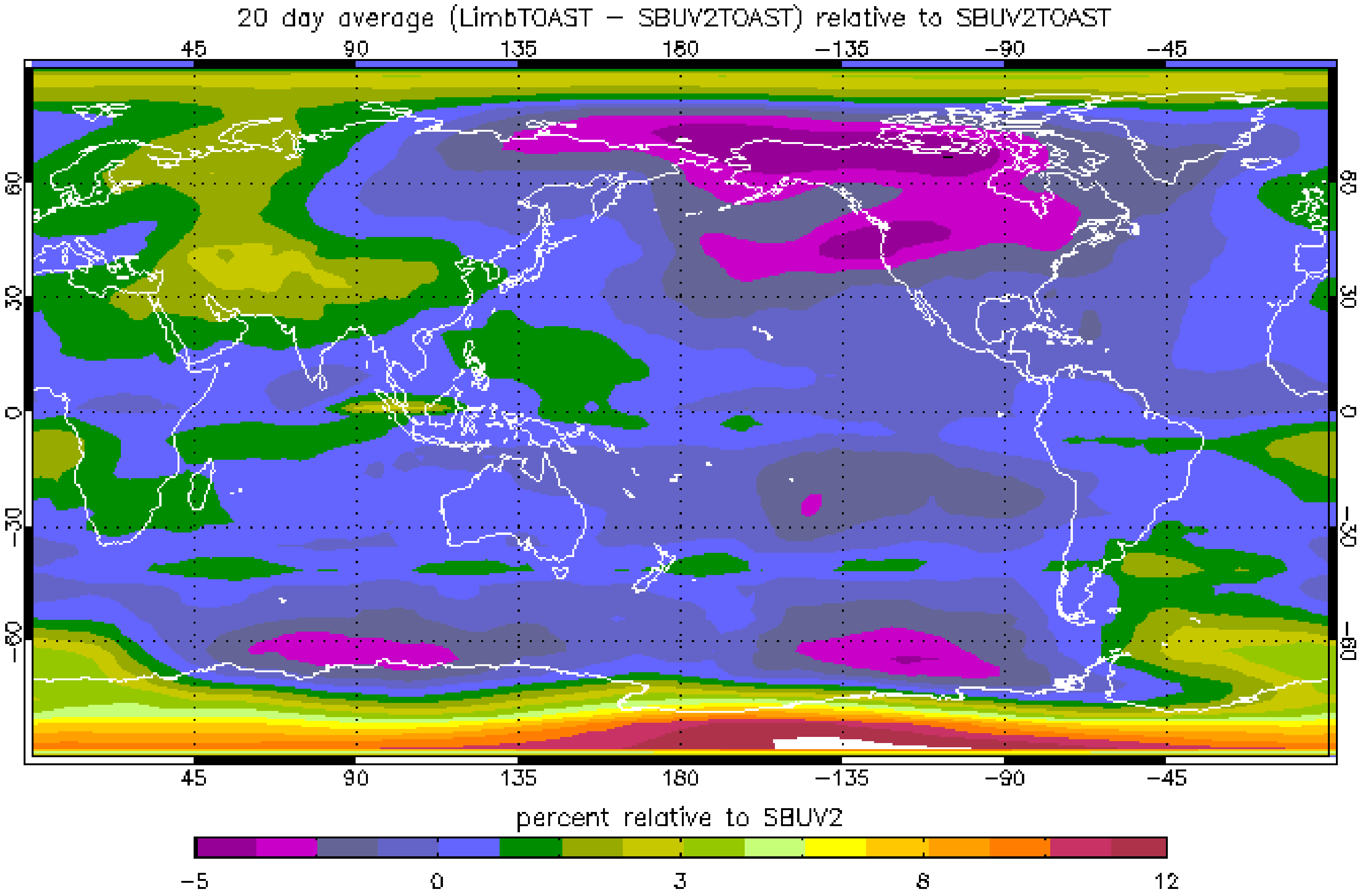
Layer reformed Limb input



Limb TOAST analyzed



20 day average of the relative differences to current version from 09-03-2013 to 09-22-2013



What we have achieved

- Limb TOAST and SBUV TOAST show similar global patterns and values in the upper layers (comparison need to introduce retrieval averaging kernels)
- Limb and SBUV2 analysis algorithm functions well from the comparison of the EDR input and analyzed figures
- 20 days of total column Ozone analysis have been conducted
- The averaged relative differences shows Limb TOAST total amount analysis has ±5% difference relative to current operational version (SBUV2 TOAST).

Conclusion

- TOAST has provided global one by one degree total ozone product for 11^+ years.
- TOAST using CrIS and SBUV2, as a new version has been in operation and will be shifted to use CrIS + OMPS/NP mode whenever OMPS advances to its validated maturity.
- TOAST using CrIS and OMPS Limb preliminary total column analysis shows promising results.
- TOAST (CrIS+Limb) further work will be on detailed layer analysis by introducing retrieval averaging kernel.

THANKS

OMPS EDR Version 8 Ozone

OMPS-TC-EDR and OMPS-NP-EDR

Trevor Beck, Zhihua Zhang

August 26, 2015

Outline

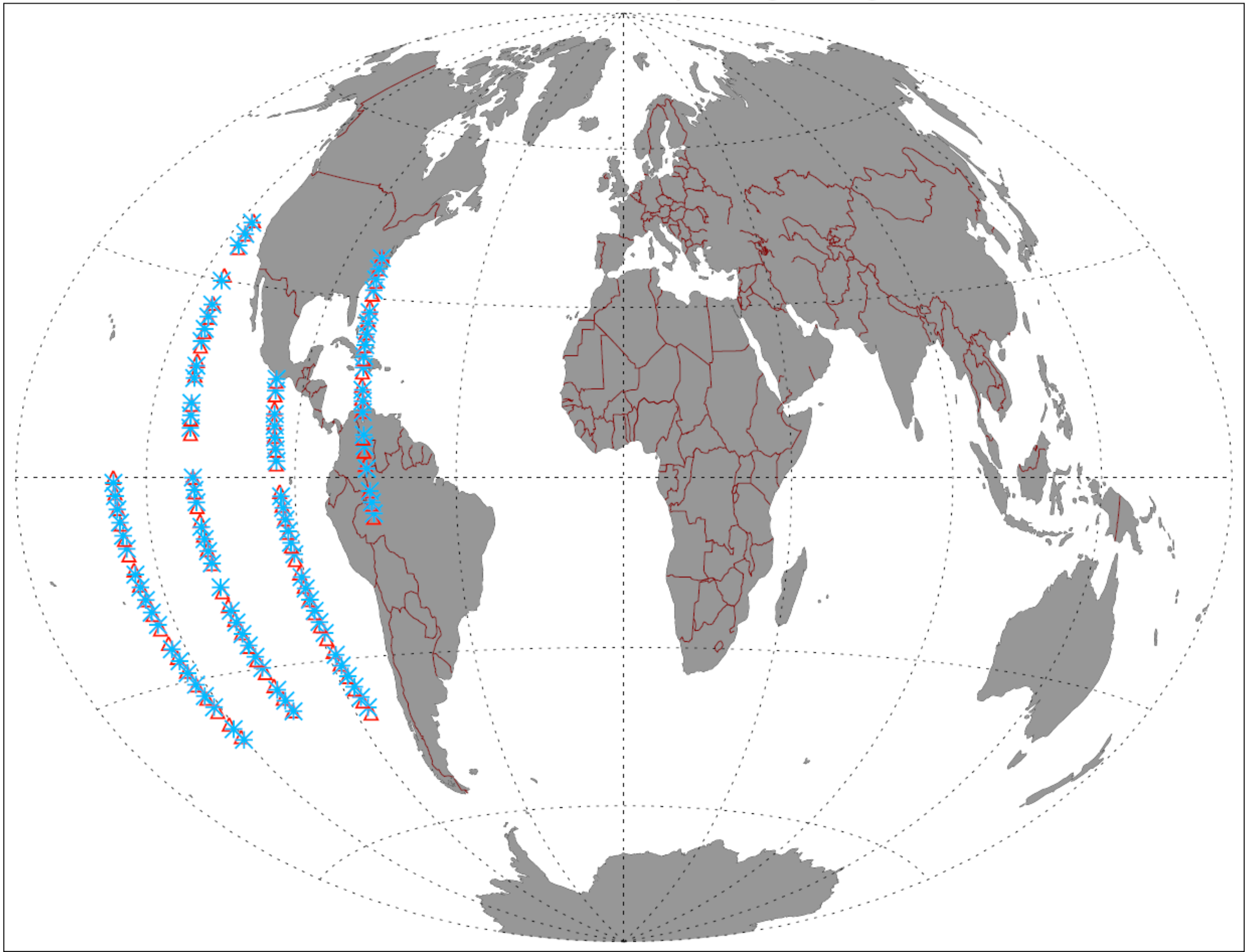
- NOAA STAR implemented the SBUV/2 Ozone profile algorithm in ADL/IDPS, unofficially named o3prov8.
- MX8.11 will be the first official build with o3prov8
- Results in this presentation use SDR with recently updated tables
- On August 20 new tables were approved by AERB for both TC and NP
- SDR updated tables(provided by NASA PEATE):
  1) TC-OSOL   Observed Solar
  2) TC-Wavelength
  3) TC-CALCONST   Calibration Constants
  4) NP-OSOL Observed Solar
  5) NP-Wavelength
  6) NP-CALCONST   Calibration Constants
- Reprocessed several days and updated nvalue adjustments

Implementation Details

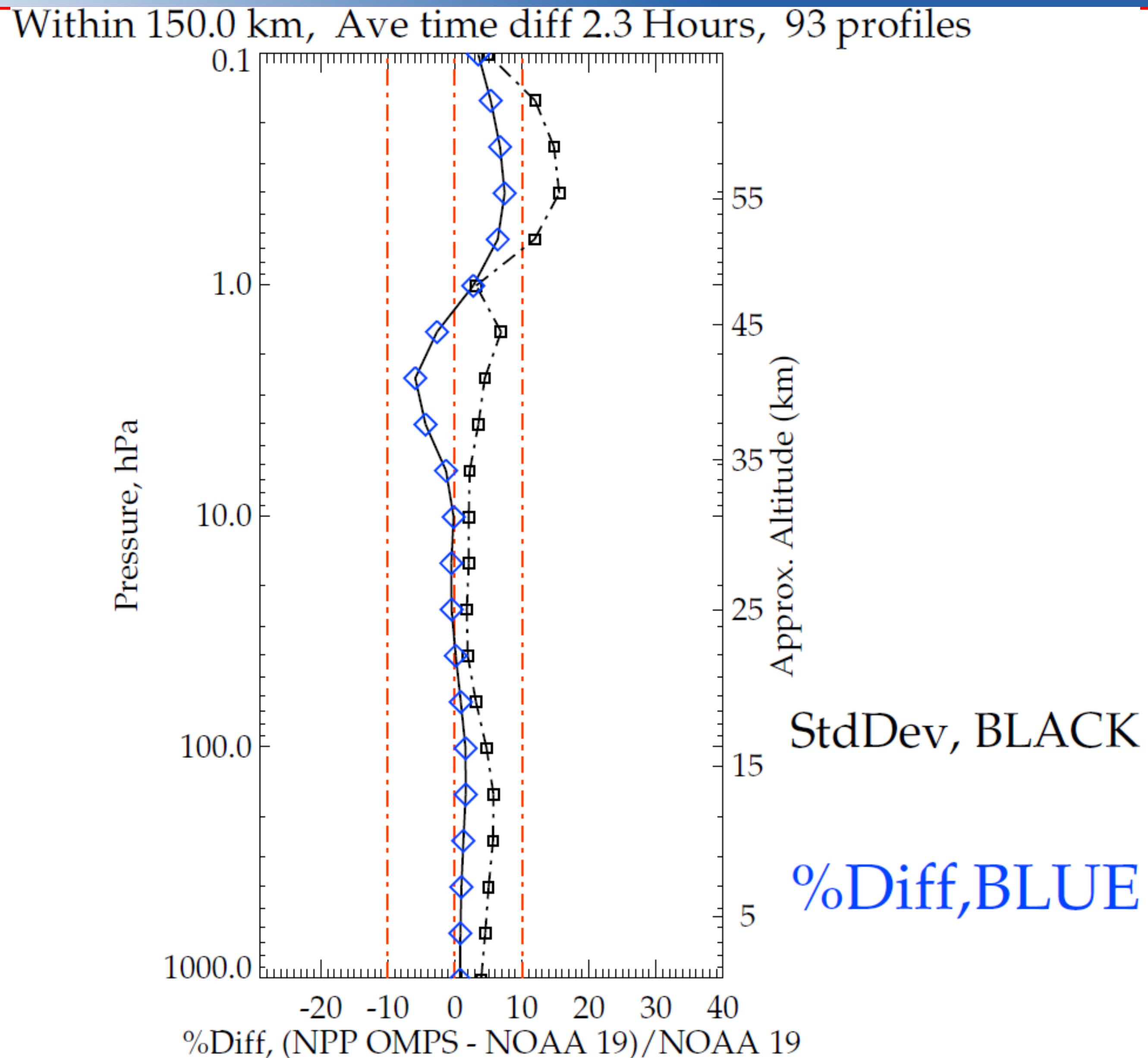
- OMPS-NP-EDR in IDPS Ozone profile came the version 6
- Added / Appended V8 code on top of V6, uses same measurement wavelengths as version6.
- Generated instrument tables using OMPS bandpass functions
- New version 8 outputs appended to existing HDF5 output
- Software validation with off-line version
- Comparisons to NOAA-19 SBUV/2 datasets
  - Matchups
  - Chasing orbits
- Comparisons to EOS-AURA MLS
  - Matchups

Matchups within 150km

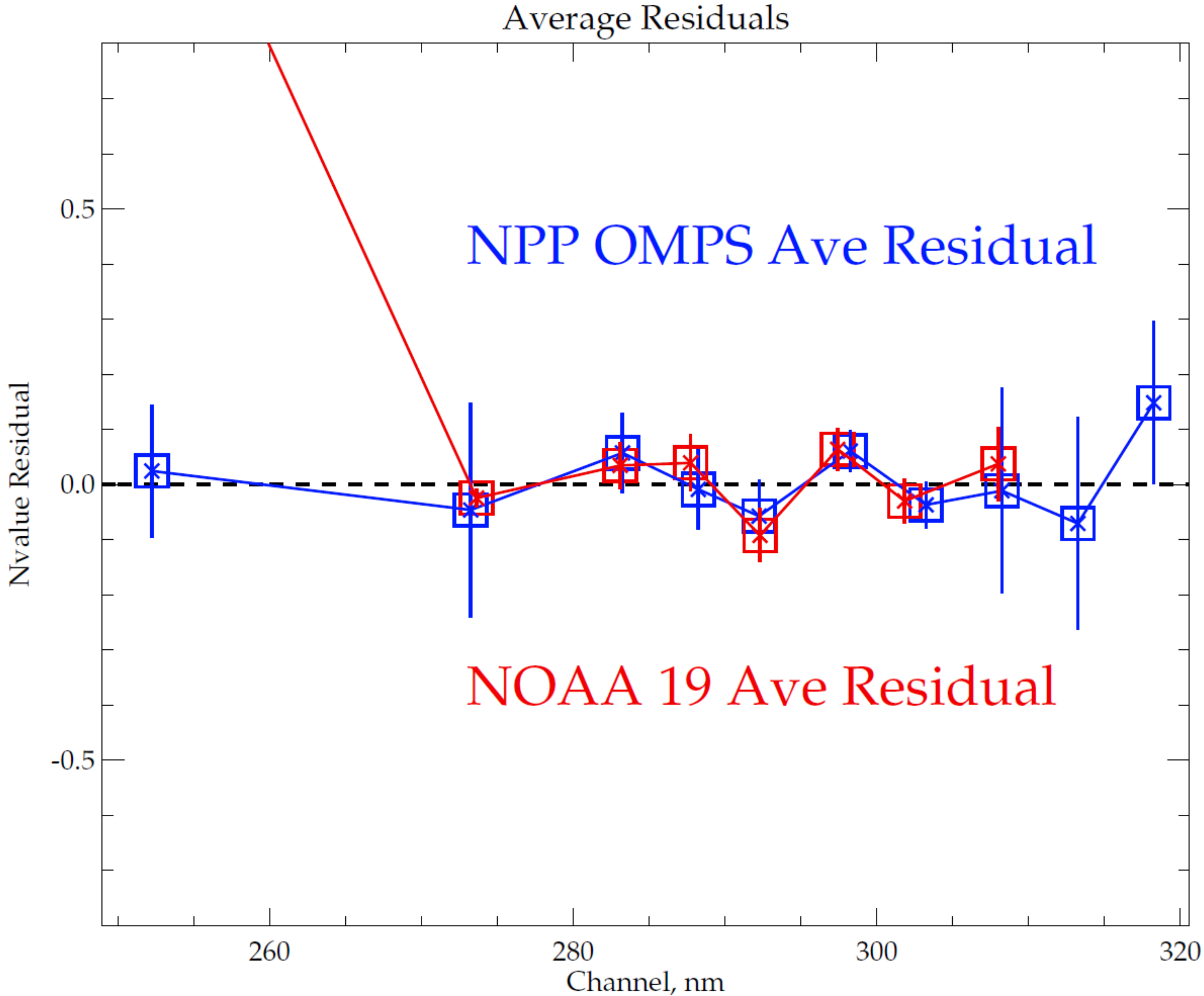
NPP OMPS and NOAA 19 for 1 Days, Beginning on 2013/03/20



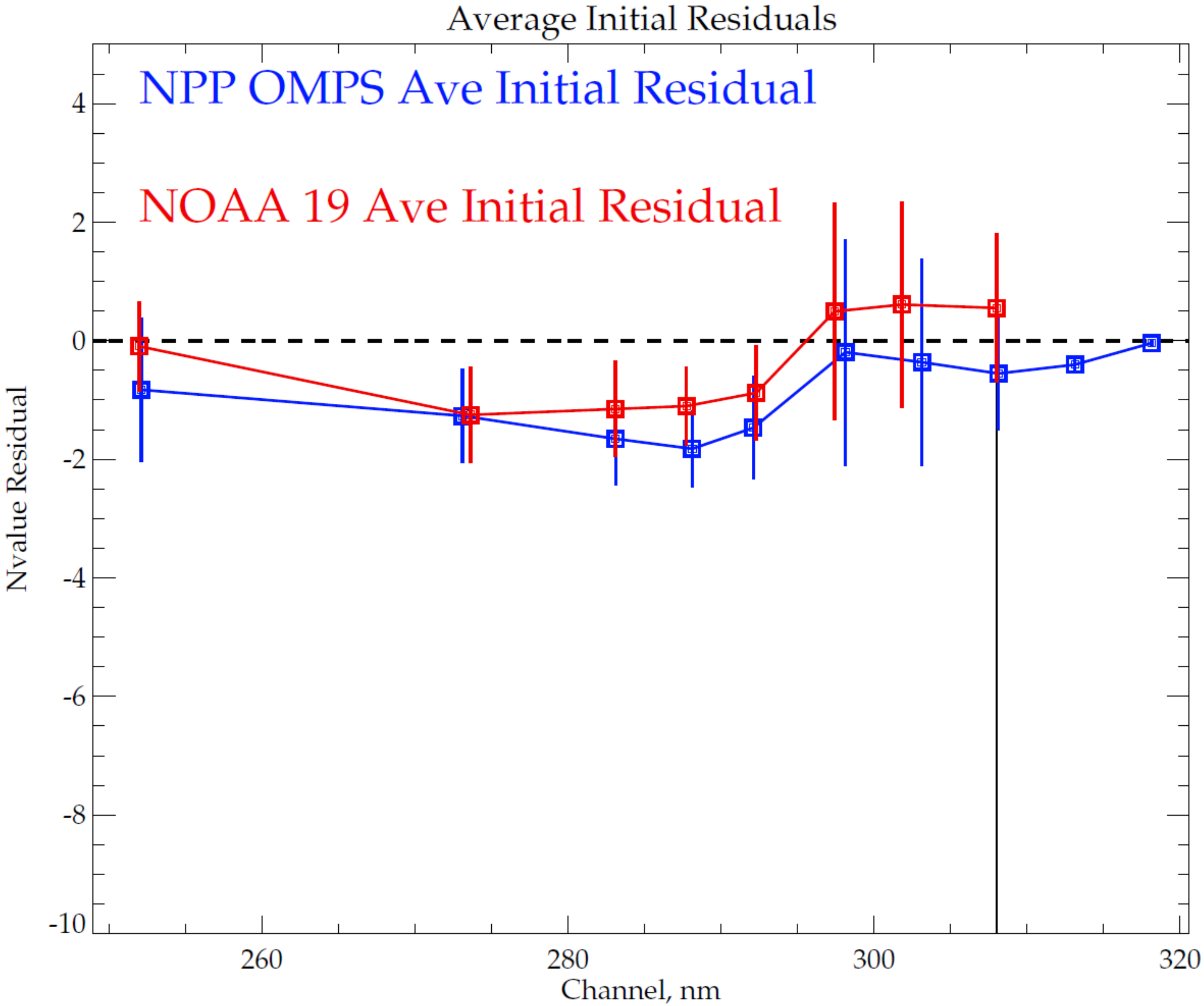
Profile Average Difference



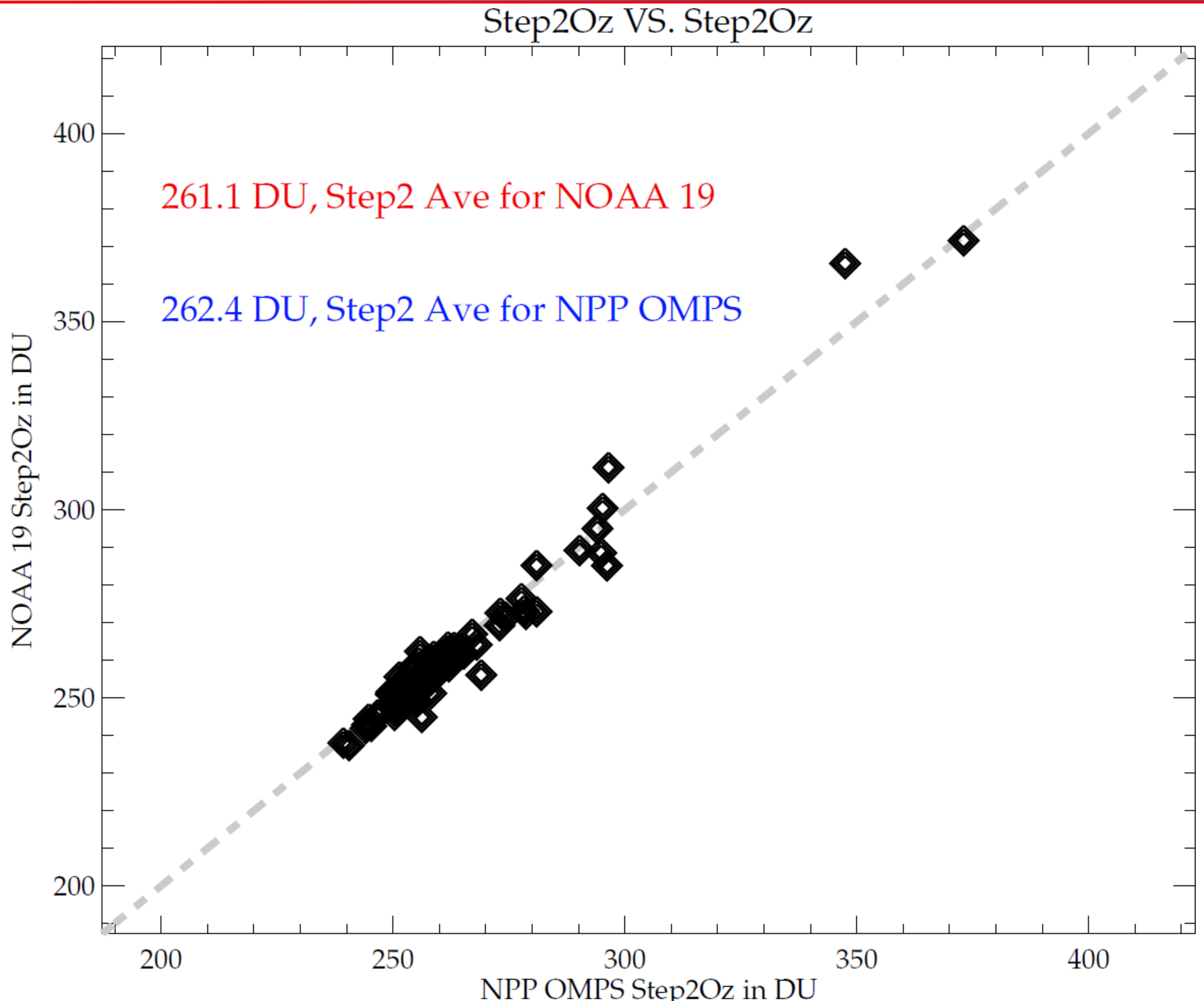
Final Residual



Initial Residual

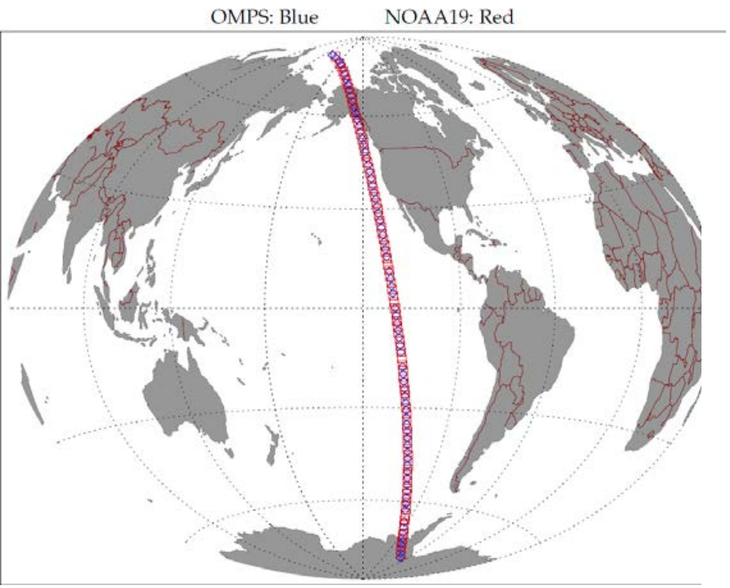


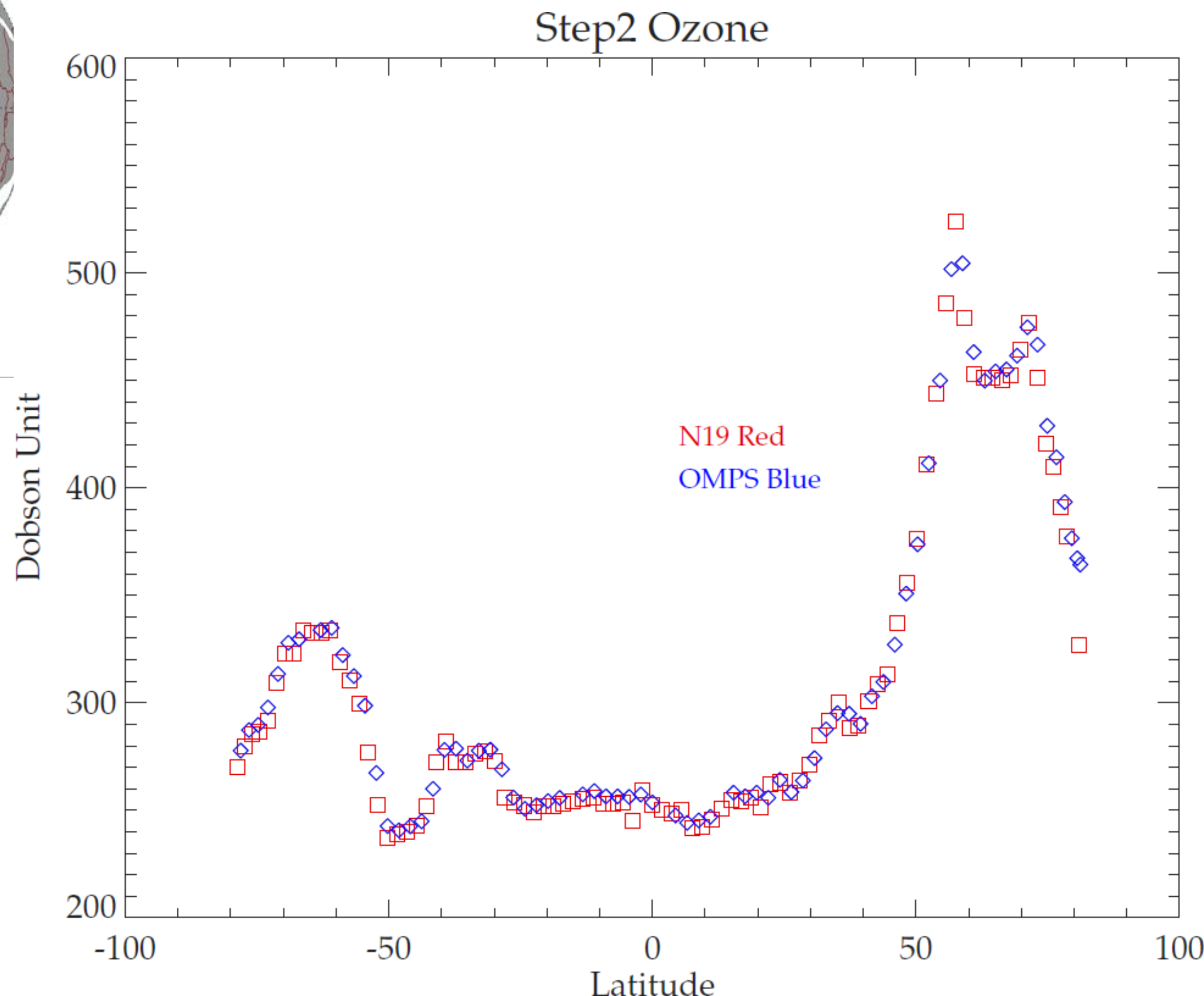
Step 2 Ozone



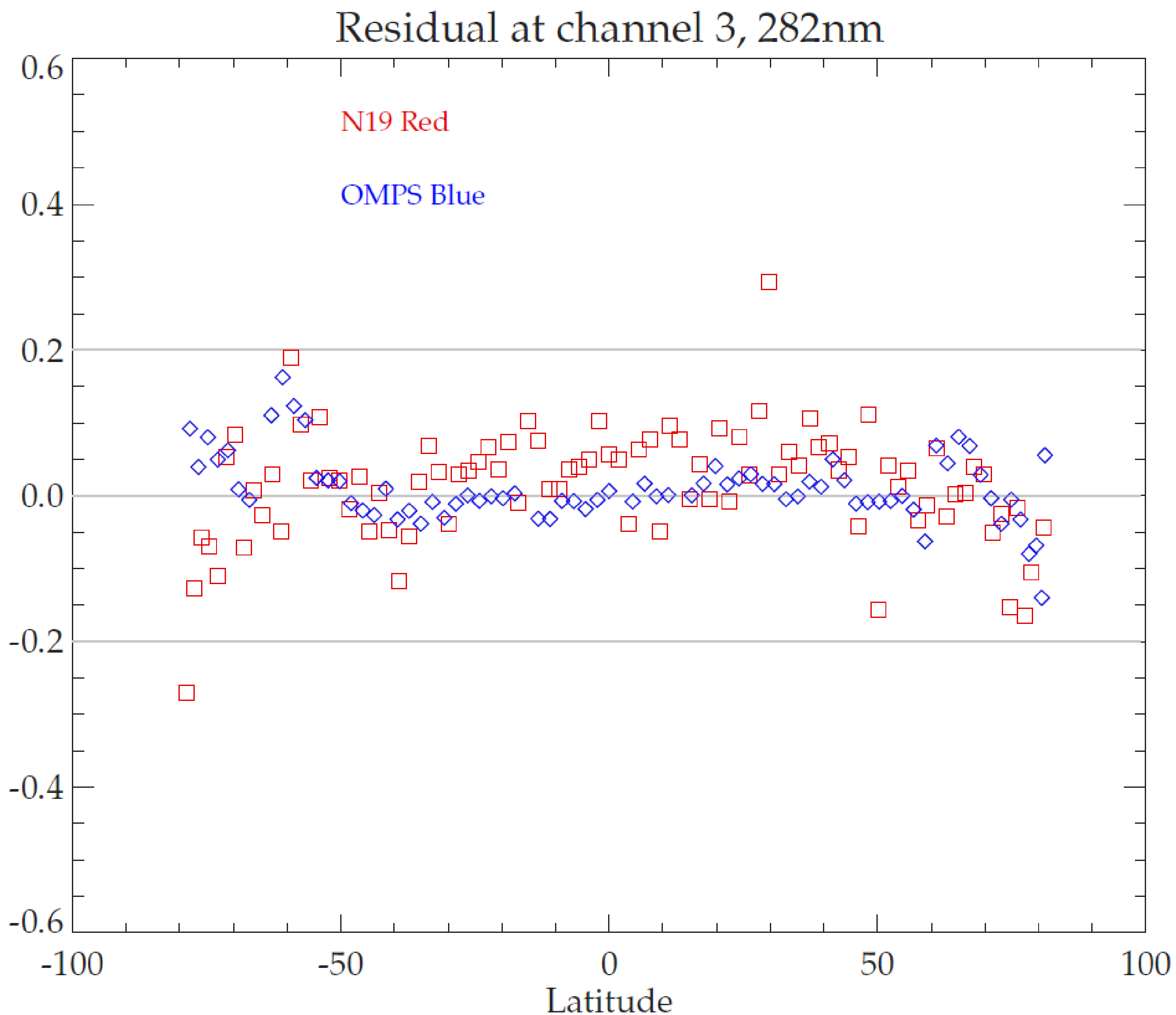
Step2Oz VS. Step2Oz
261.1 DU, Step2 Ave for NOAA 19
262.4 DU, Step2 Ave for NPP OMPS
NOAA 19 Step2Oz in DU
NPP OMPS Step2Oz in DU
200
250
300
350
400

OMPS & NOAA-19 Chasing Orbit

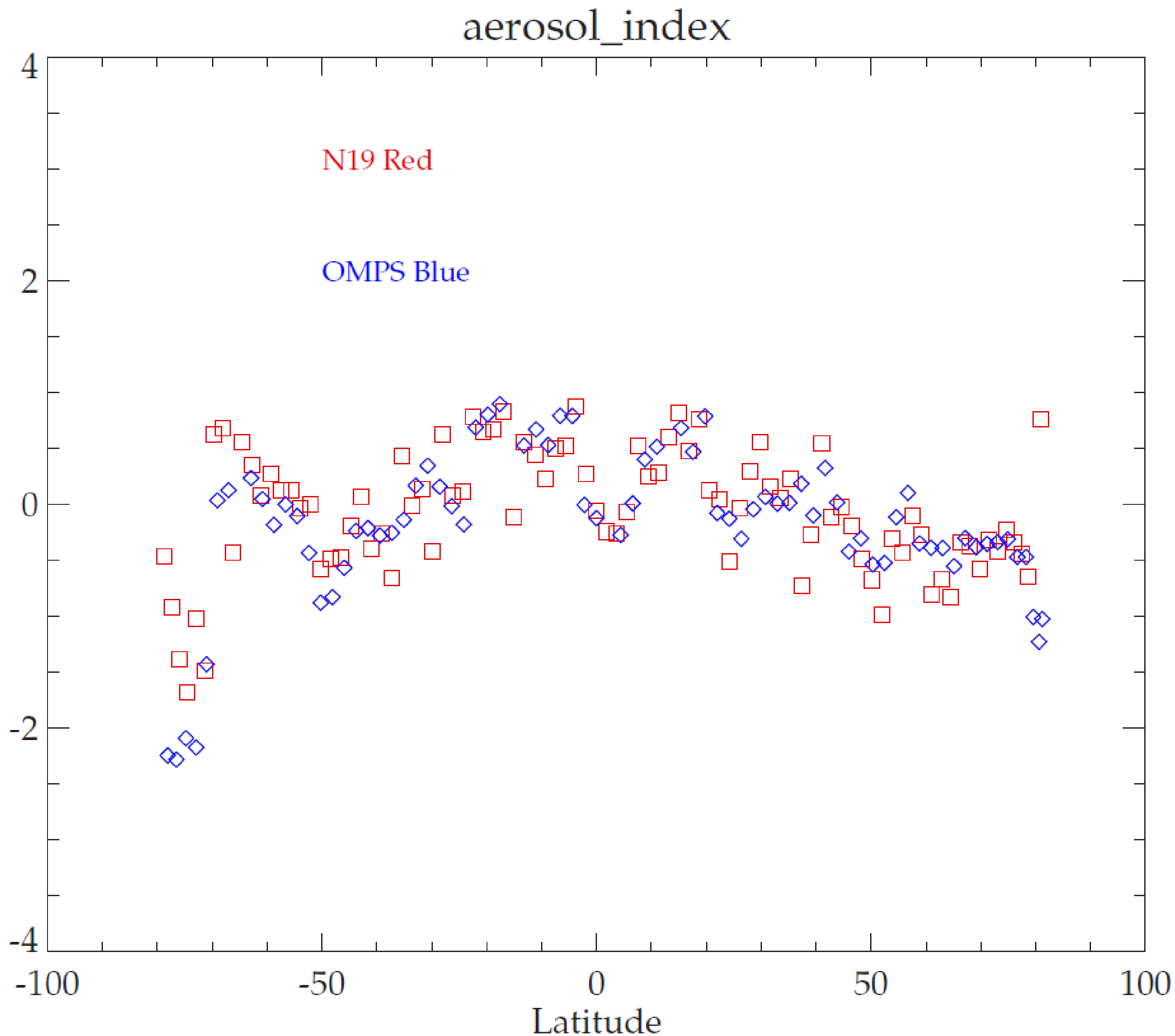




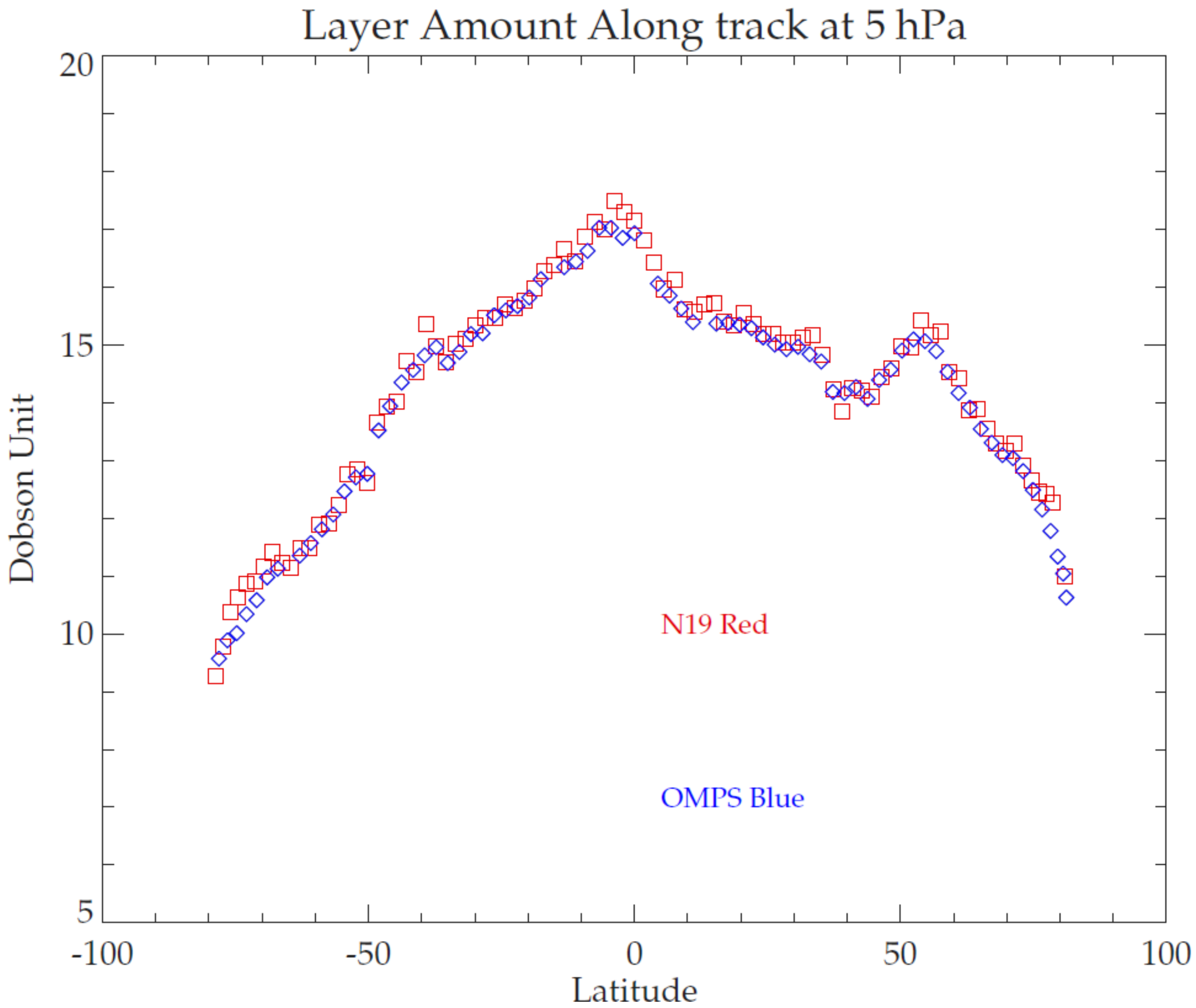
Residual at 282nm Measurement



Aerosol Index

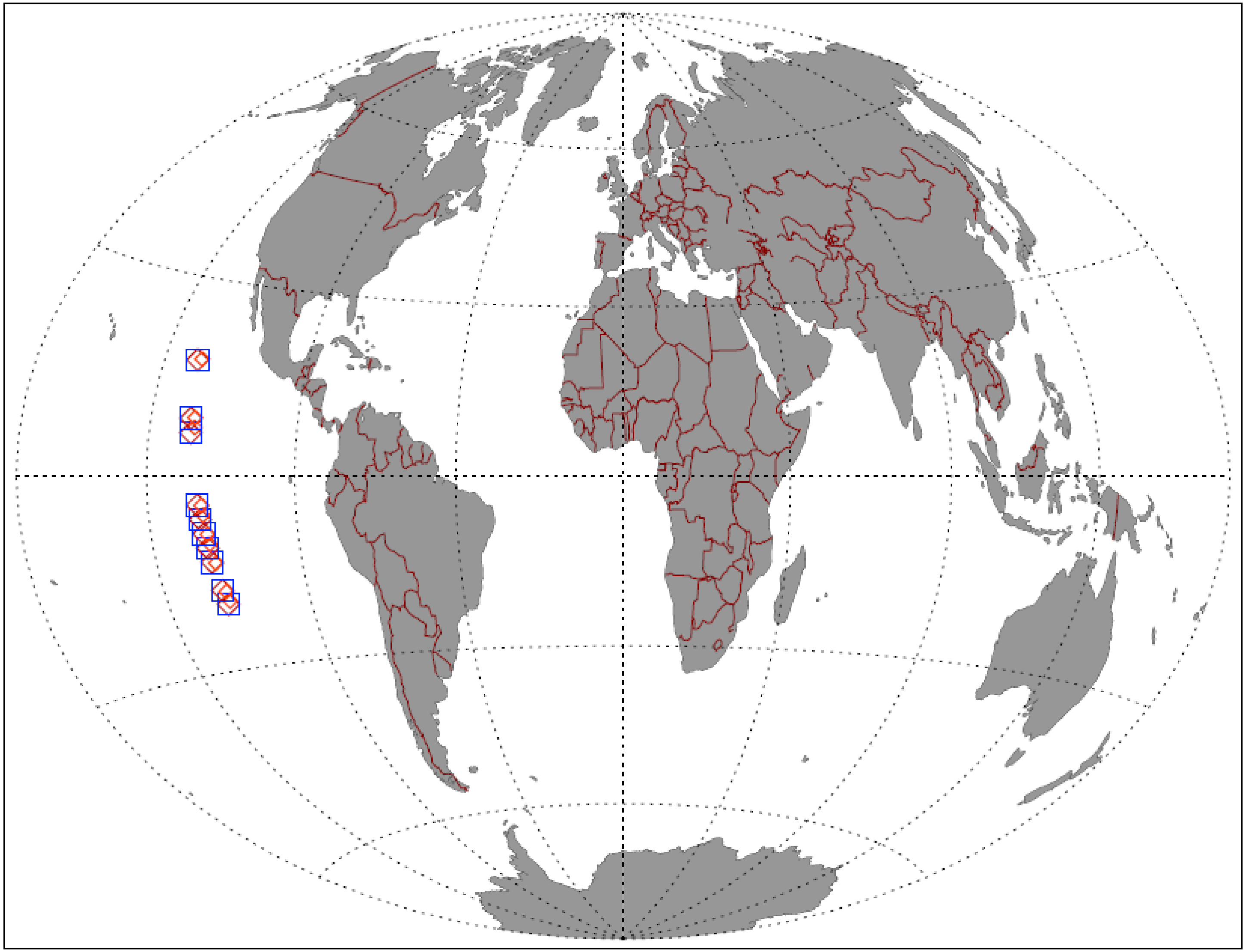


Layer 12 ozone

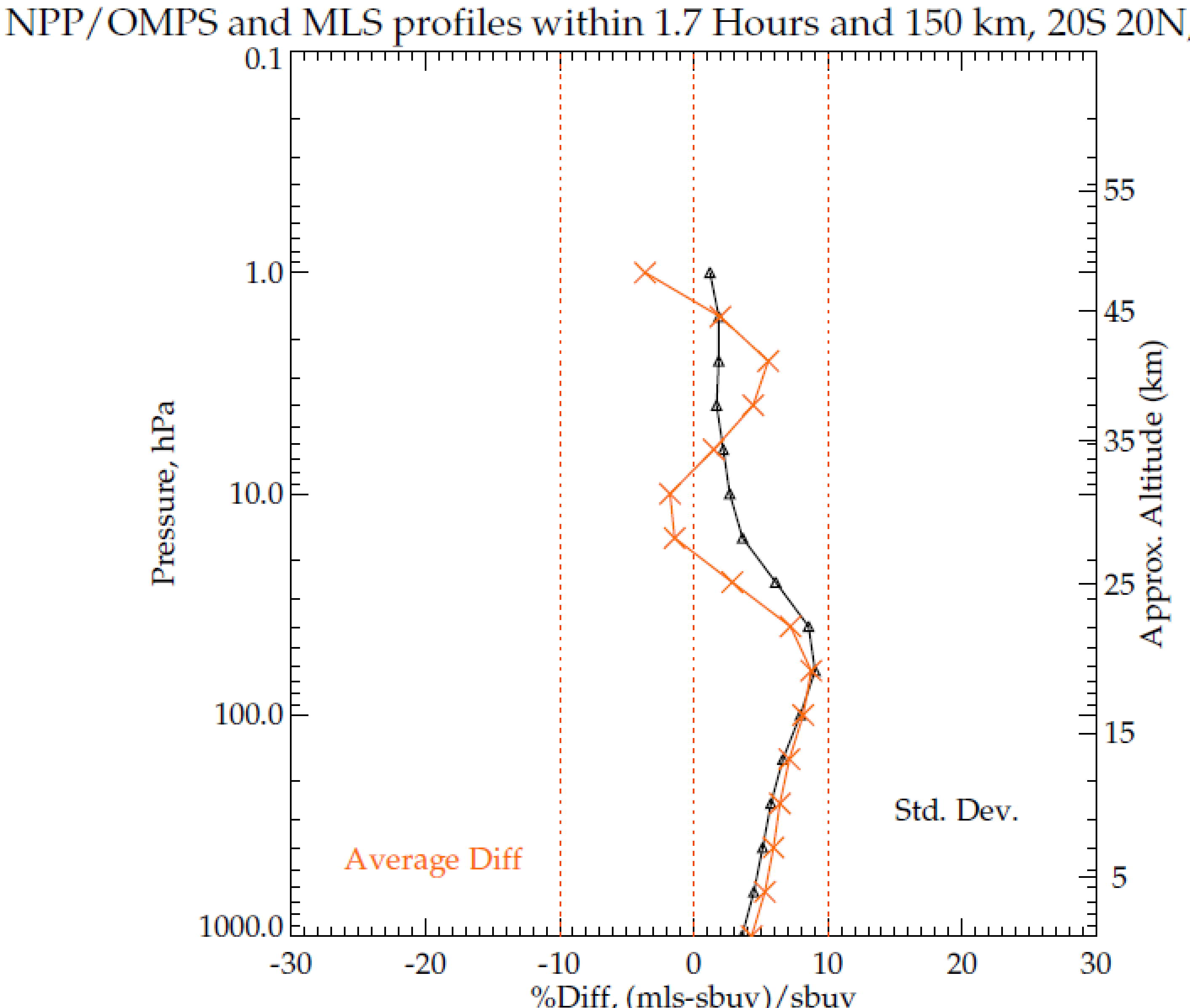


OMPS and MLS Matchups

NPP/OMPS SBUV and MLS



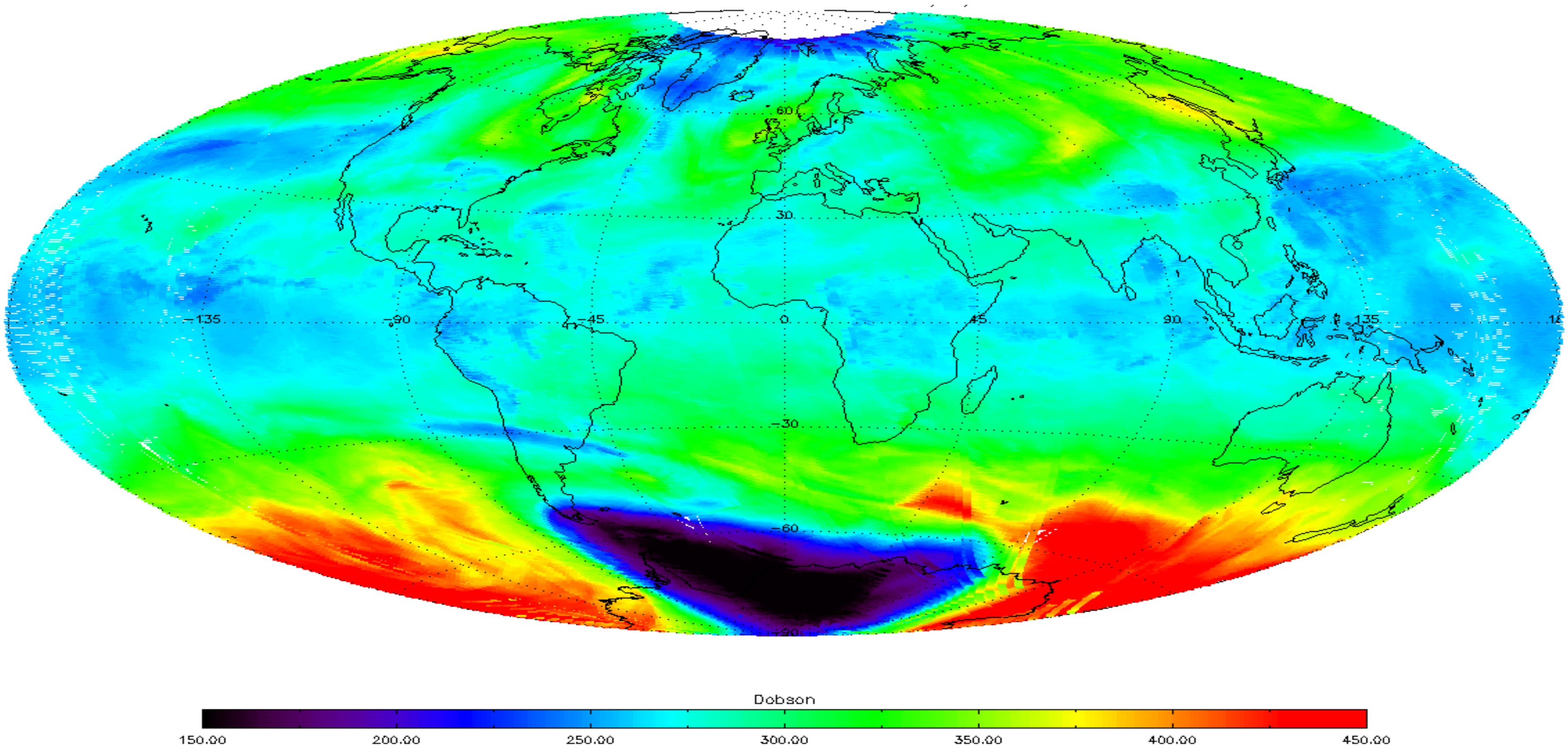
MLS and OMPS



NPP/OMPS and MLS profiles within 1.7 Hours and 150 km, 20S 20N, AK's used
Pressure, hPa
0.1
1.0
10.0
100.0
1000.0
Approx. Altitude (km)
55
45
35
25
15
5
-30
-20
-10
0
10
20
30
%Diff, (mls-sbuv)/sbuv
Std. Dev.
Average Diff

V8 Total Ozone

- STAR delivered a V8 Total Ozone to update/replace existing V7 triplet total ozone algorithm
- Possibility it will make it into MX 8.12 build deadline



Summary

- V8Pro Ozone algorithm in MX8.11 build
- V8Total Ozone algorithm hopefully in MX8.12 build
- New NPP OMPS TC and NP SDR tables produce reasonable NP-EDR ozone profiles
- EDR Will be ready for J01, waiting for Block2 SDR Integration
- J01 NP SDR will operate at medium resolution 5 scans per granule
- Evaluate J01 NP SDR and decide if we will do J01 NP-EDR with 5 scans per granule or 1 scan per granule.

STAR JPSS 2015 Annual Science Team Meeting

OMPS Product Demonstration Site

(OMPS Product Monitoring at the ICVS)

Eric Beach, IMSG@NOAA/STAR
Lawrence Flynn, NOAA/STAR

Aug. 26, 2015

OMPS Product Demo Site URL:

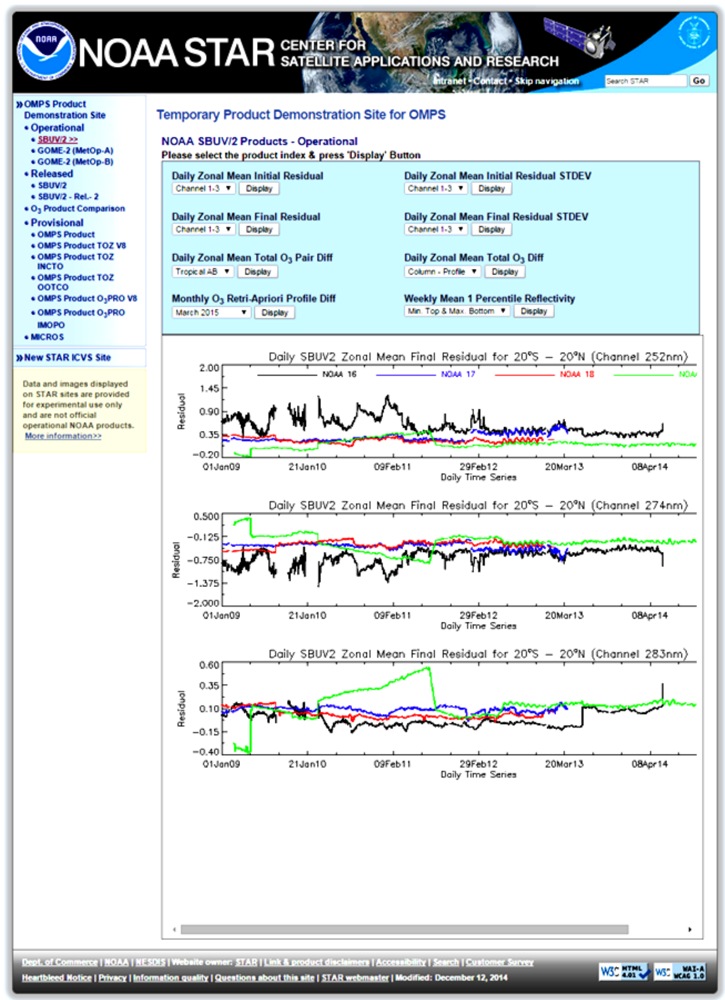
http://www.star.nesdis.noaa.gov/icvs/prodDemos/index.php

General Characteristics of site:

- Depicts performance of OMPS, GOME-2 and SBUV/2 instruments
- Updated daily, weekly, or monthly depending upon the type of plot
- Navigable via menu on left side of page. Pull down menus are available for most plot types to select previous time periods.
- Site is currently being redesigned.

SBUV/2 Operational Performance

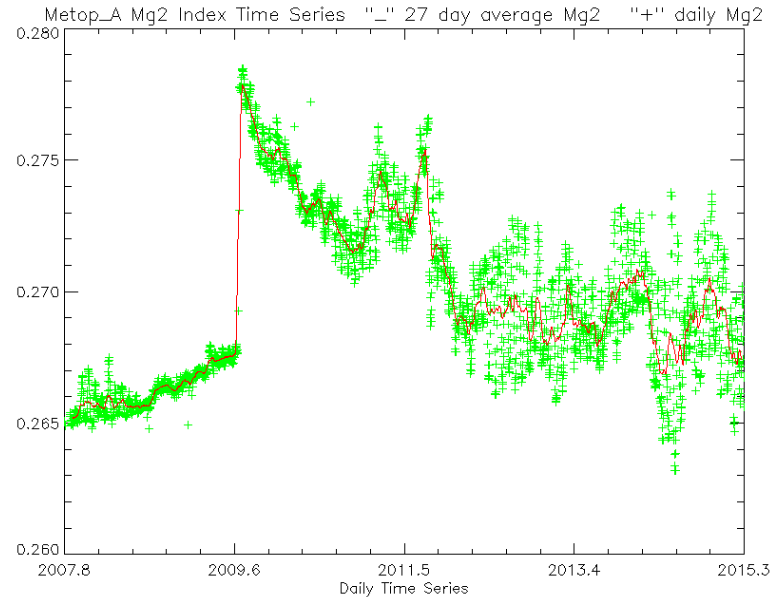
- SBUV/2 data products are monitored long term
- Parameters plotted include:
  - Daily zonal mean initial/final residual
  - Daily zonal mean initial/final residual standard deviation
  - Daily zonal mean total ozone pair difference
  - Monthly ozone retrieved apriori profile difference
  - Weekly mean 1 percentile reflectivity

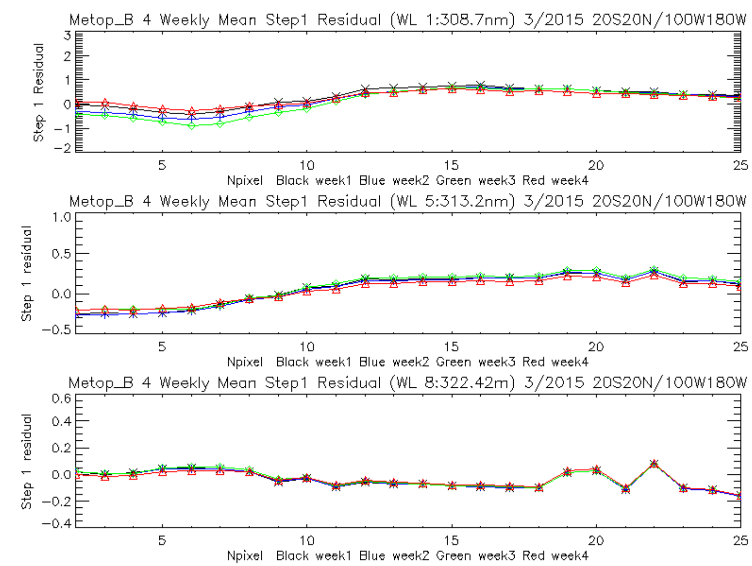


GOME-2 (Metop A/B)

Parameters plotted include:

- Mg-II index
- Daily zonal mean total ozone, aerosol index, reflectivity, step 1 residual
- 4-Weekly mean total ozone, reflectivity, aerosol index, step 1 residual

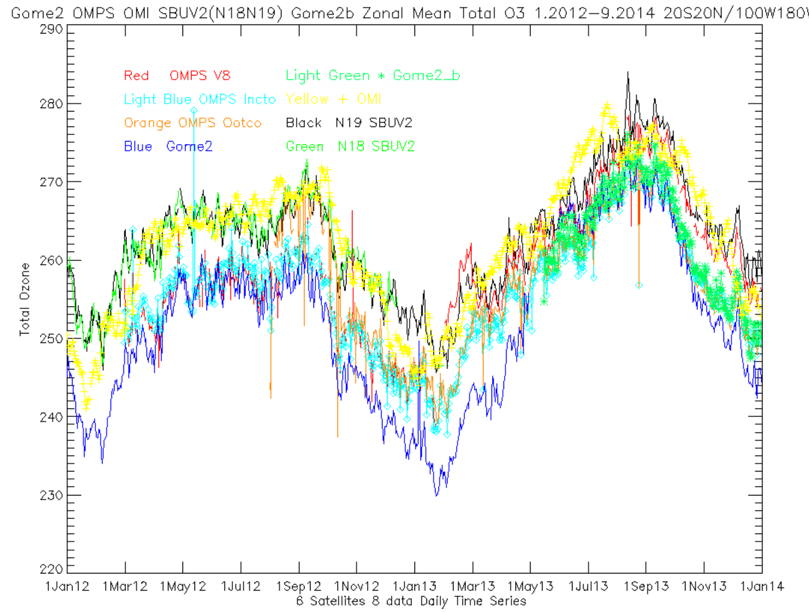


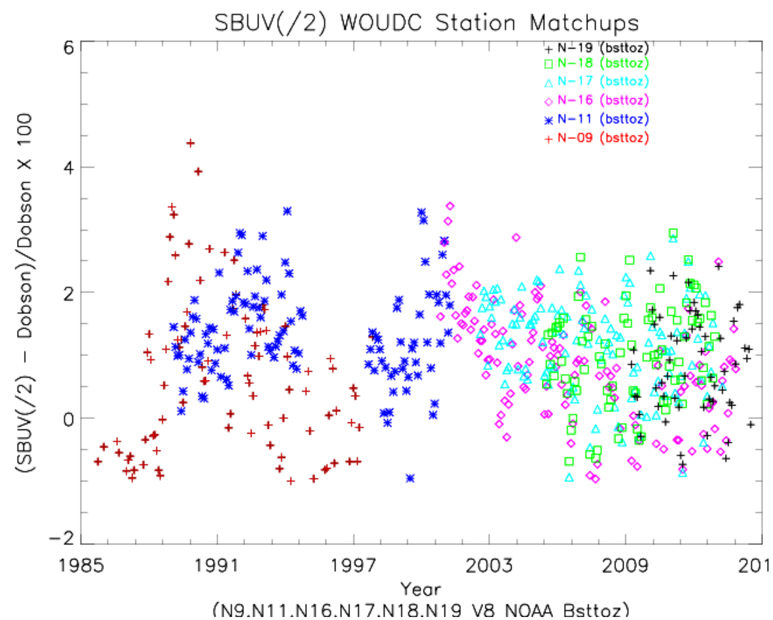


Ozone Product Comparisons

Plots compare multiple ozone instruments

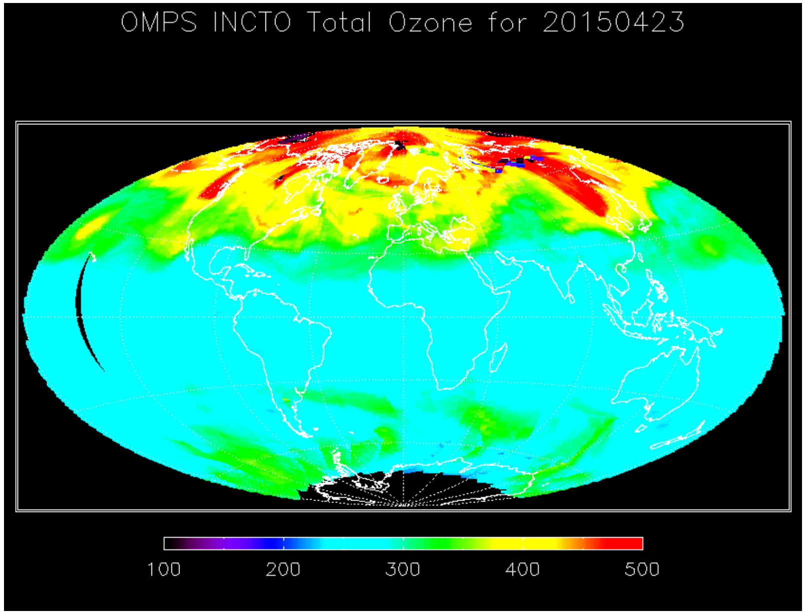
- Daily zonal mean comparisons
- Chasing orbit comparisons
- Comparisons with Dobson ground stations

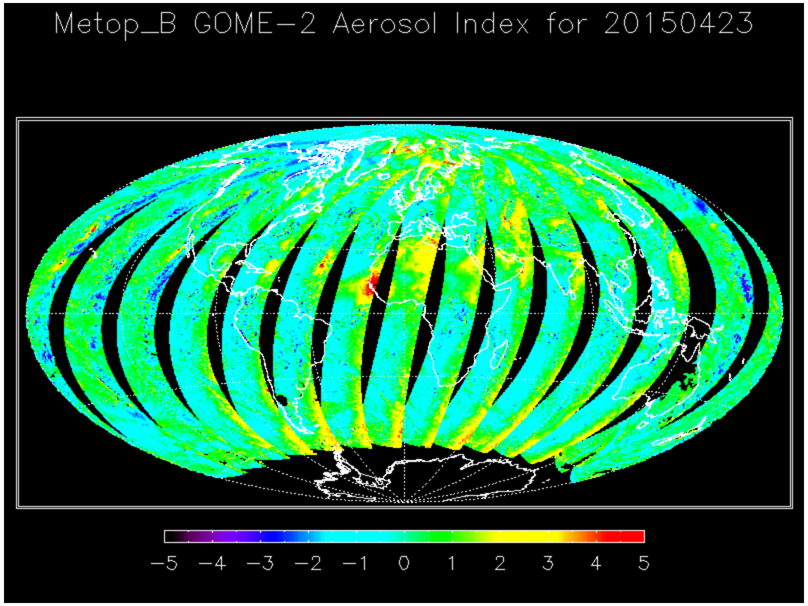




OMPS, GOME-2, and OMI Maps

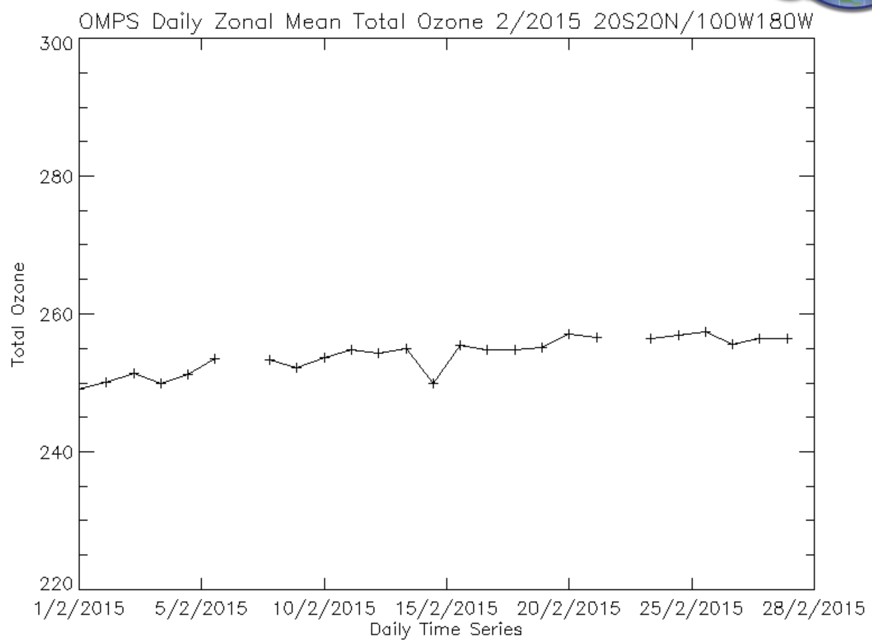
- Daily “postage stamp” images depicting total ozone, reflectivity, and aerosol index
- OMPS V8, INCTO, OOTCO, and OMI products are available

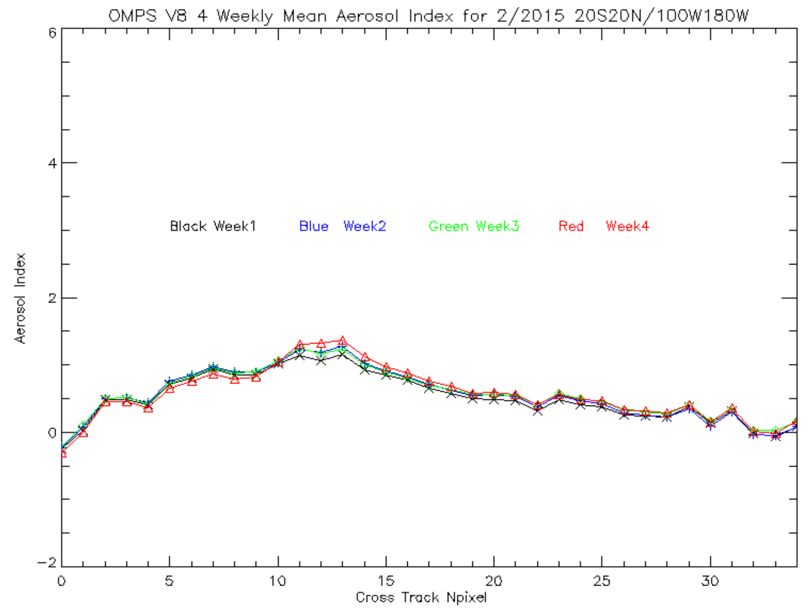




OMPS V8 Total Ozone

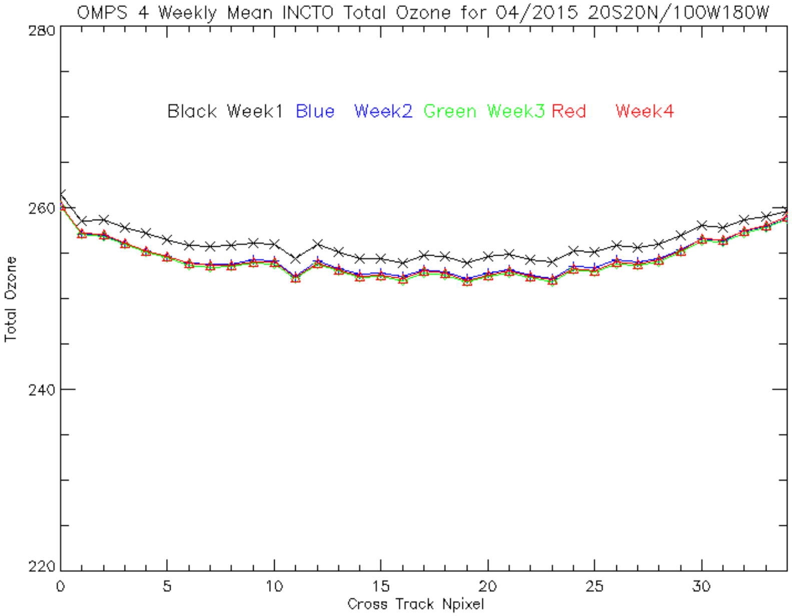
- Monitor the performance of the V8 ozone, reflectivity, and aerosol products
- Daily zonal mean and 4 weekly mean plots are available for each product

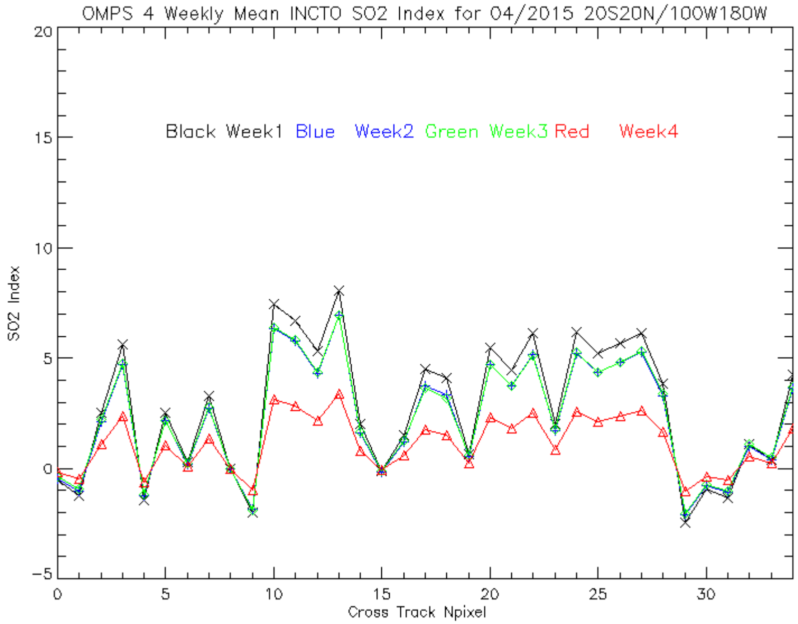




OMPS INCTO Product

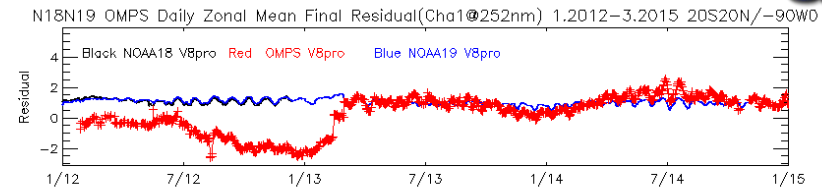
- Monitor the performance of the operational INCTO product
- Graphs produced:
  - Daily zonal mean (Ozone, Aerosol, and SO2 index)
  - 4-weekly mean and daily zonal 1 percentile plots are available for each product
  - Percent good rate
- Similar plots are made for the OOTCO product

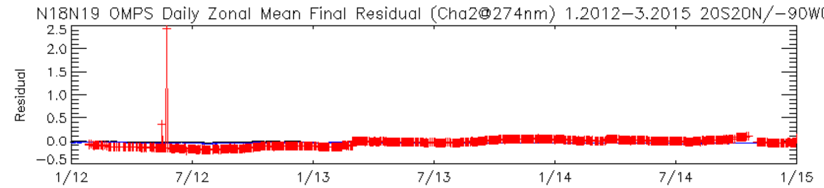


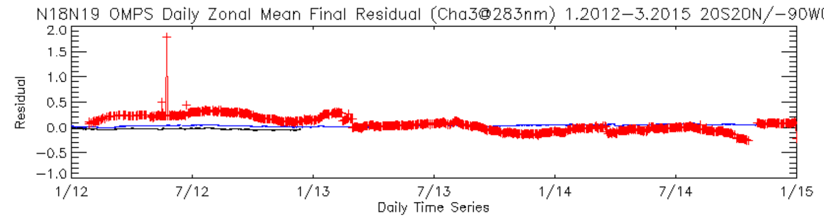


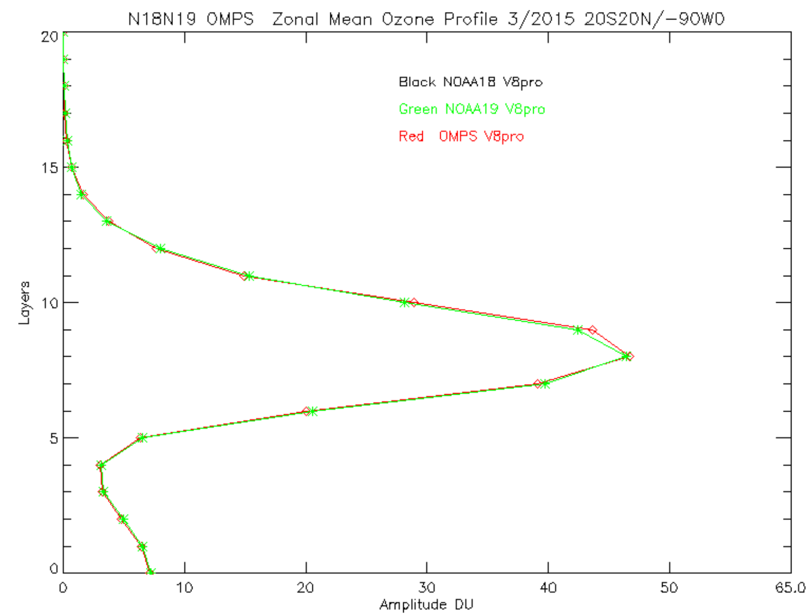
OMPS V8 Profile Product

- Monitor the performance of the V8 profile product
- Plots produced:
  - Daily zonal mean initial/final residual
  - Zonal mean total column O3 – profile O3
  - Retrieved – A priori plots



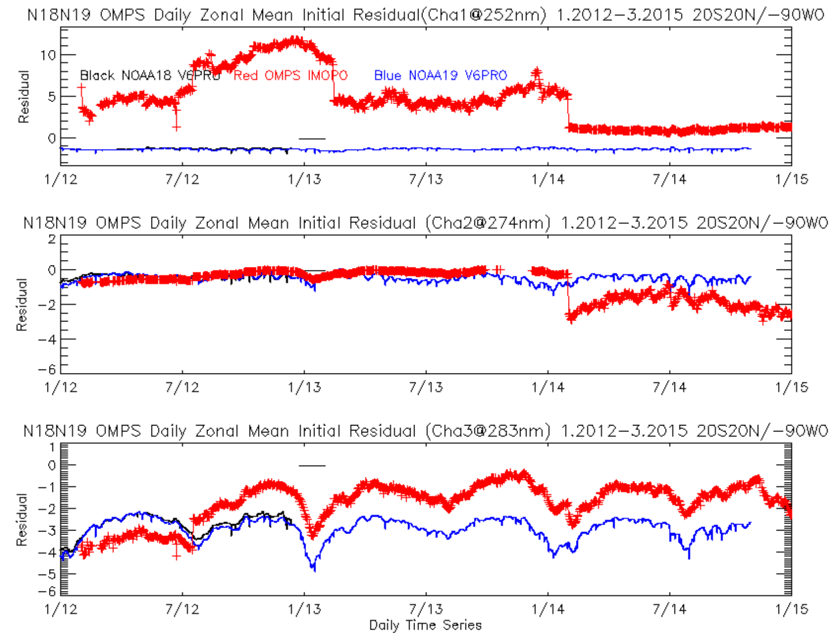


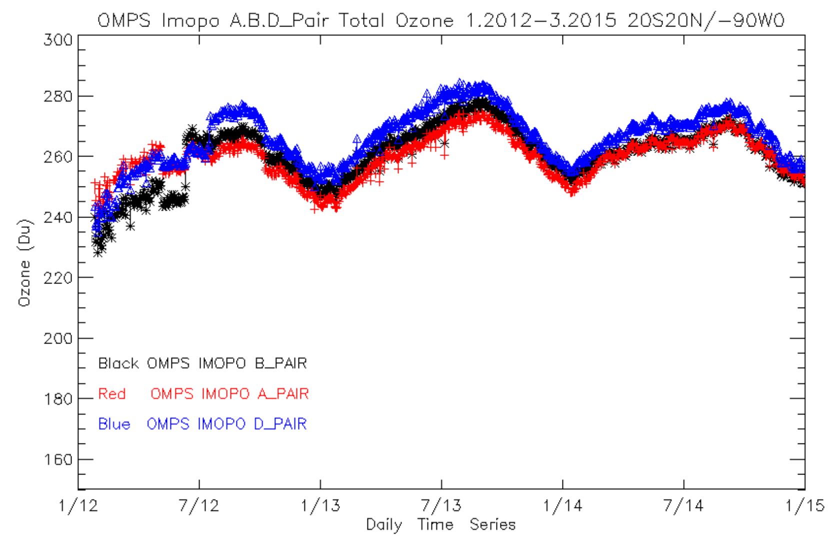




OMPS IMOPO Profile Product

- Monitor the performance of the operational IMOPO profile product
- Plots produced include:
  - Daily zonal mean initial/final residual, pair difference, and A,B,D pair total ozone
  - Column – profile
  - Retrieved – A priori
  - Percent good rate





New OMPS EDR Site Features

- Plots and images will have consistent projections, labels, fonts, and sizes
- Navigation improvements will include:
  - Parameters selected via pull down menu
  - Selectable dates or products via forward or reverse buttons. Also enable date selection via a calendar interface
  - For daily image products, animations can be produced

Conclusion

- Quick demo of web site
- Current EDR ICVS URL: http://www.star.nesdis.noaa.gov/icvs/prodDemos/index.php
- New EDR ICVS site URL: http://www.star.nesdis.noaa.gov/jpss/EDRs/products_ozone.php

OMPS data validation with NOAA ground-based systems

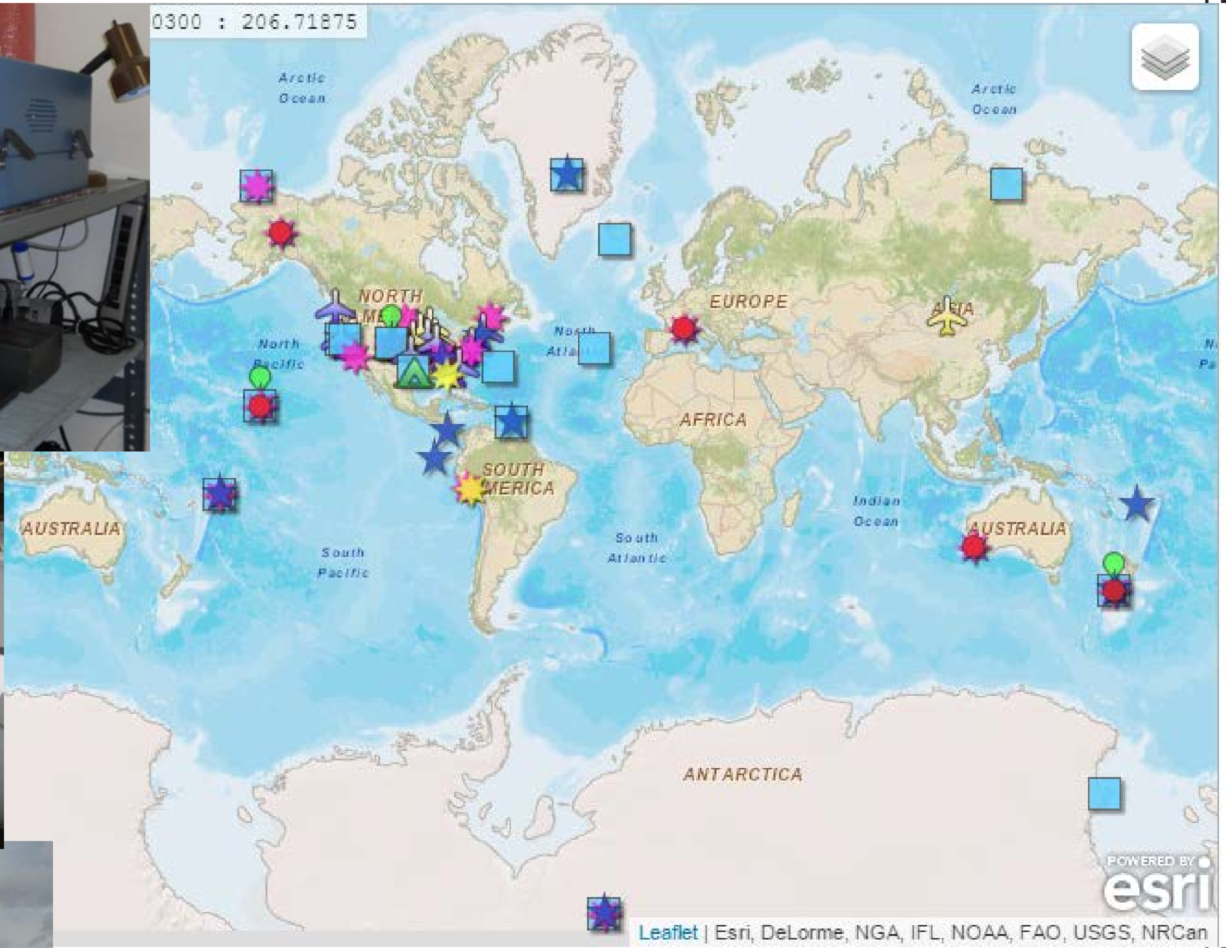
Robert Evans, Bryan Johnson, Irina Petropavlovskikh, Glen McConville Patrick Cullis, Audra McClure-Begley, Allen Jordan

(NOAA/CIRES)

and

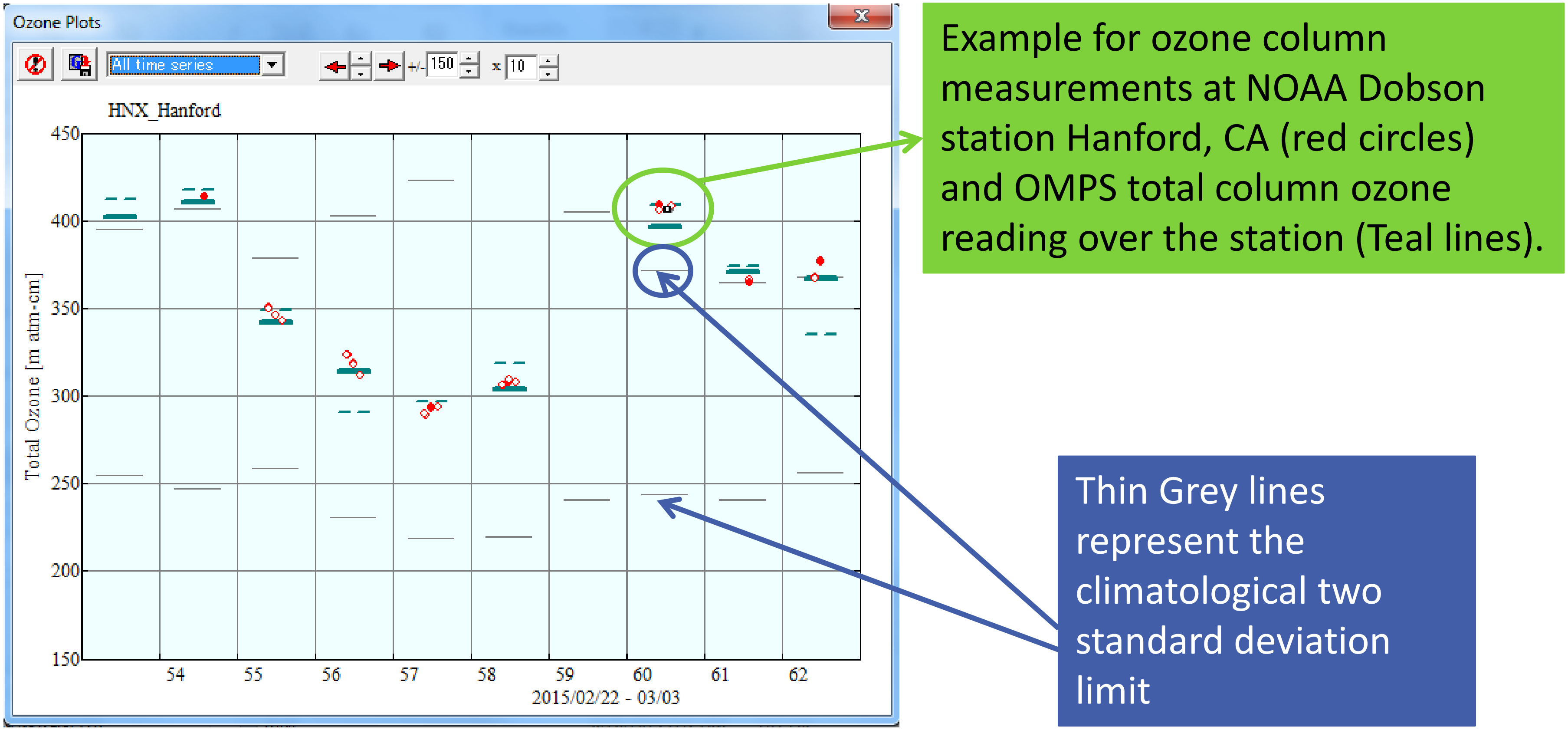
Eric Beach, Trevor Beck, Zhihua Zhang, L. Flynn
(NOAA/STAR)

Introduction to NOAA's Ozone Network



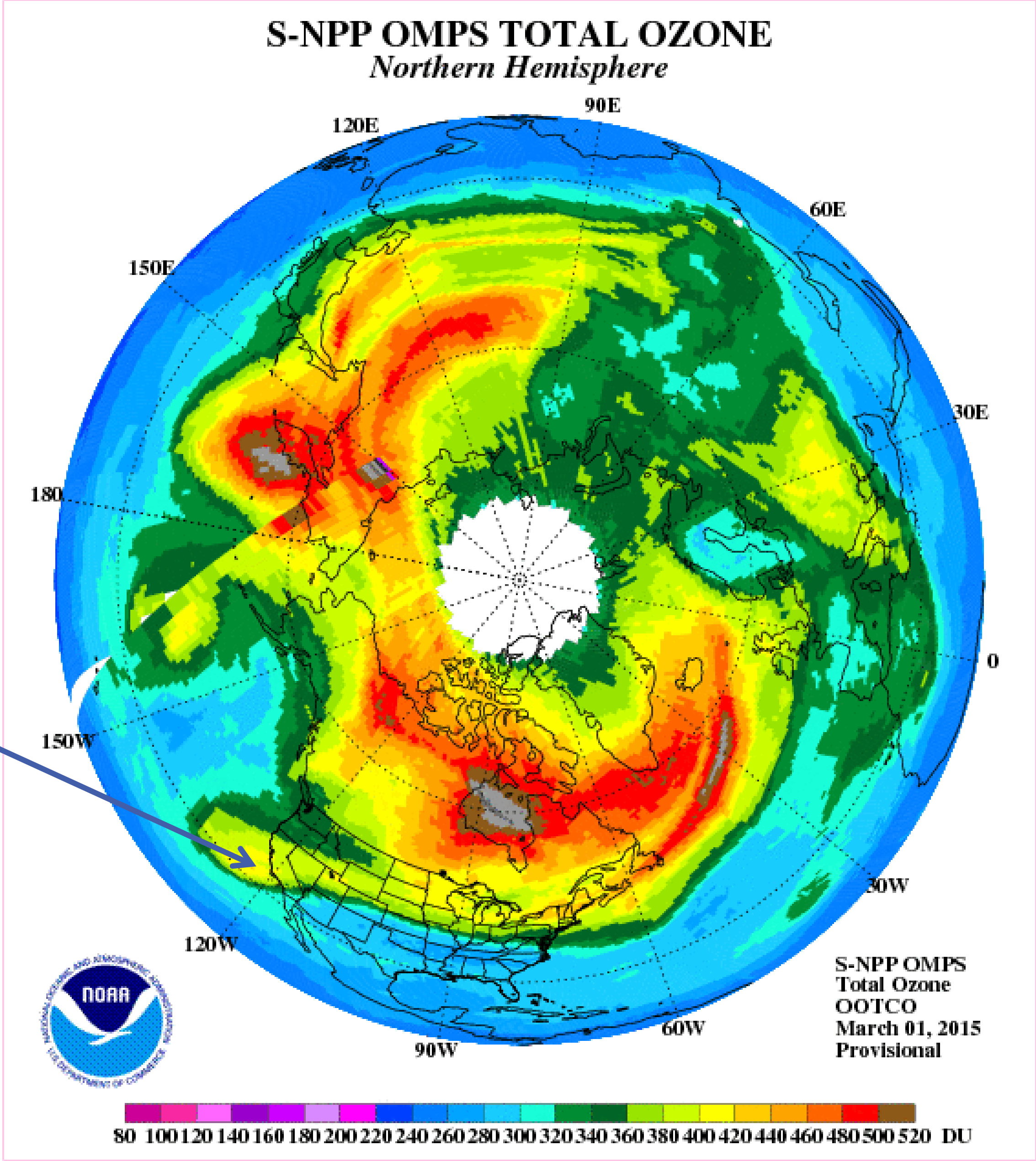
NOAA GMD ozone and water vapor group maintains long-term records of total column and ozone profiles at 20+ unique locations around the globe.

Comparison of Daily Total Ozone Variability

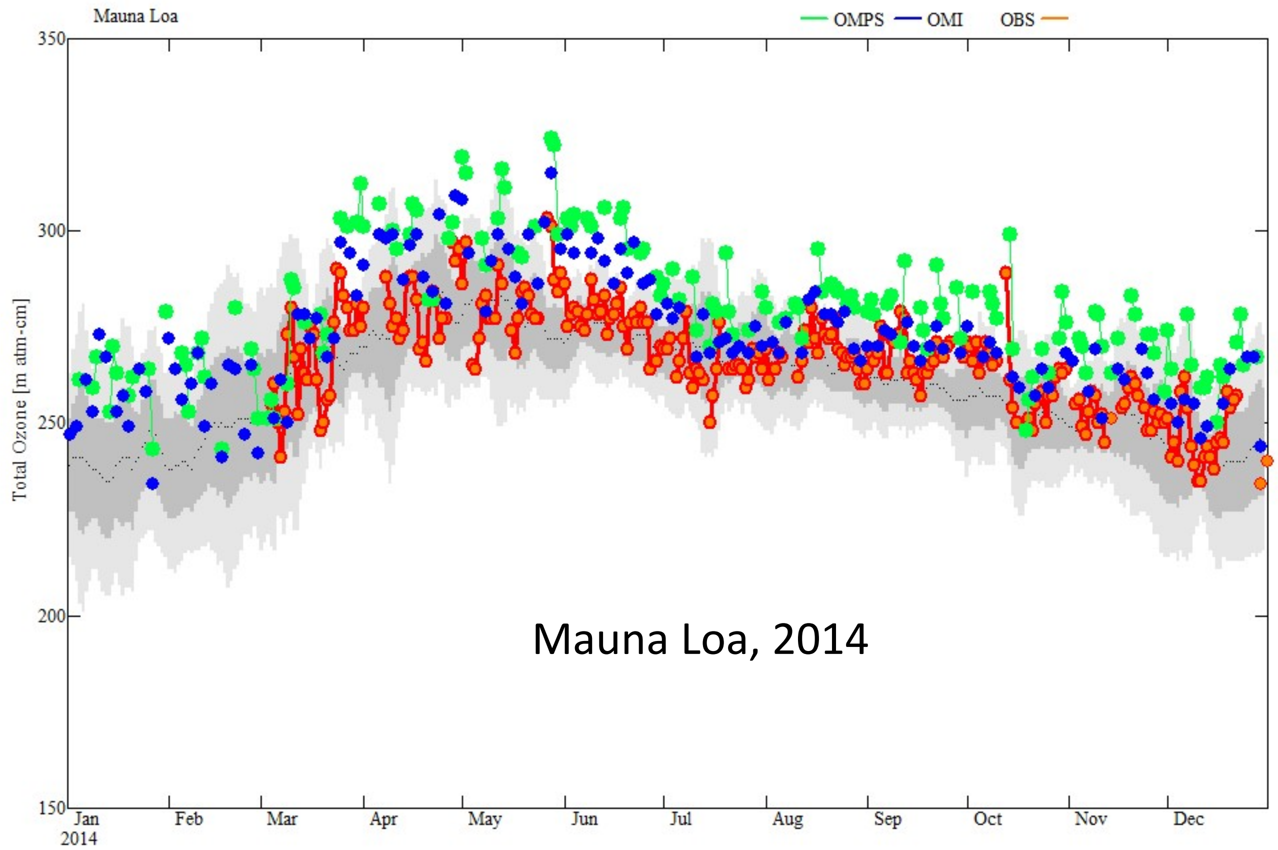


- As a part of routine quality checks, Dobson and OMPS daily total ozone measurements are compared to long-term averages and standard deviation for each respective station.
- In the example from Hanford, California, the unusually high total column ozone was observed on March 1, 2015 by both systems.
- If there is unusually large and abrupt change in the Dobson ozone measurements (outside of two standard deviation limits), the OMPS total ozone maps are used to interpret spatial ozone variability.

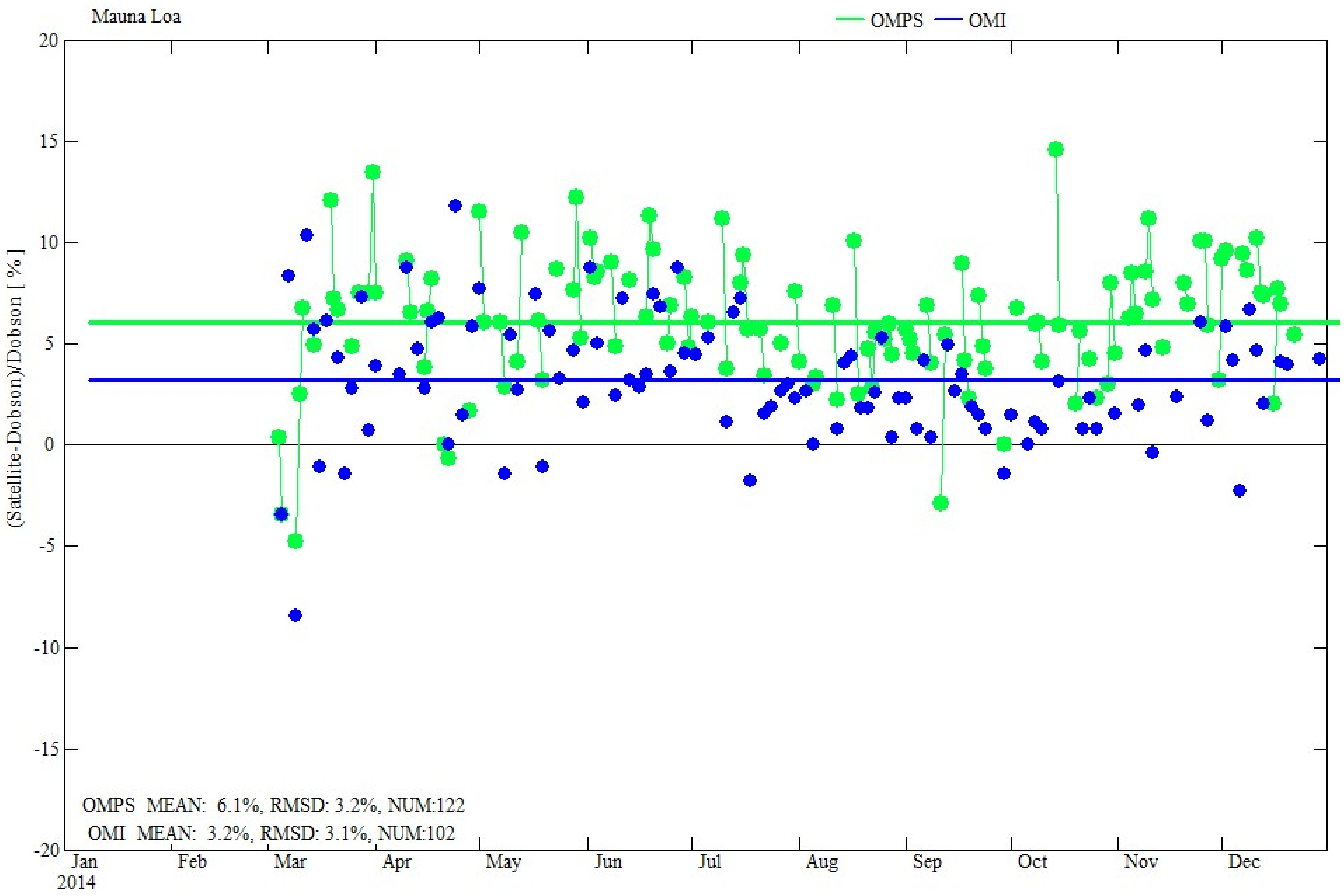
The origin of elevated ozone is also seen from the OMPS daily gridded map for March 1, 2015. The high ozone filament was transported from high latitudes and brought over Hanford CA.



Seasonal Comparison with Dobson Total Ozone

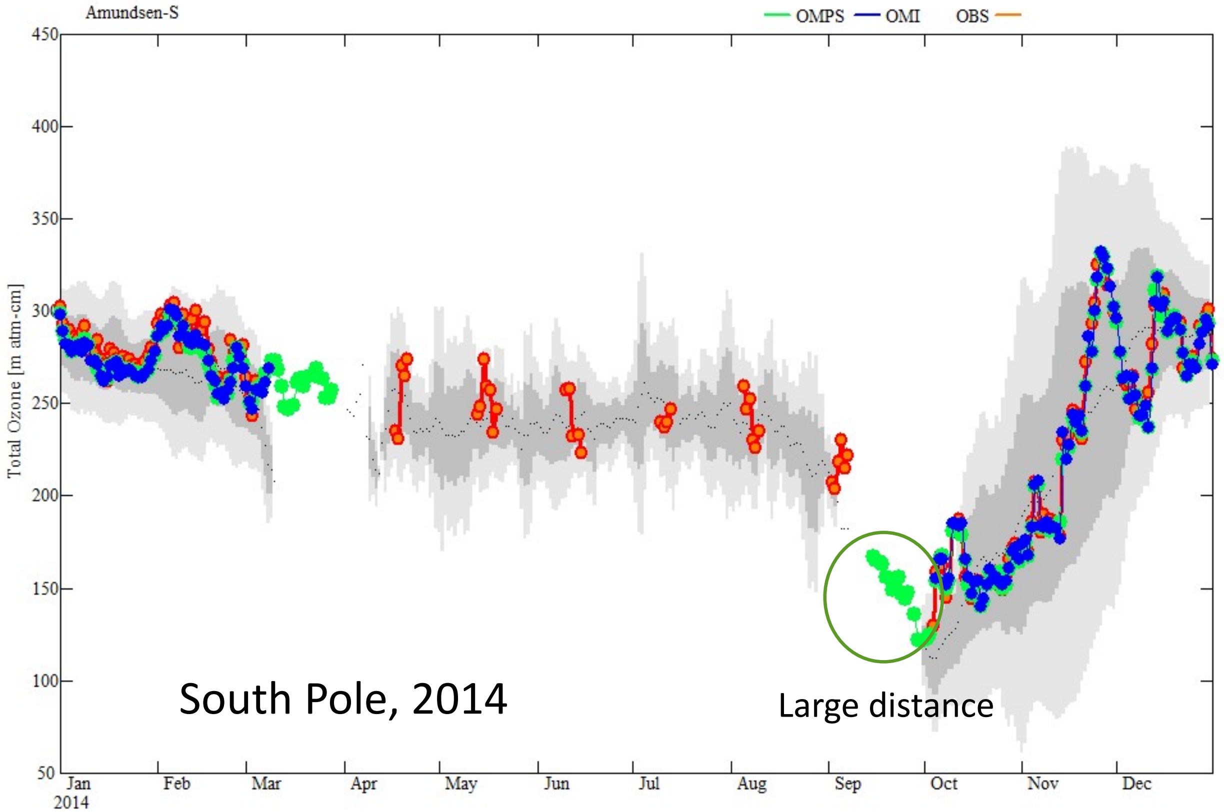


Daily total ozone values (large red dots) from the Dobson Ozone Spectrophotometer (red) at MLO, Hawaii are plotted with co-incident ozone values from Aura/OMI (blue) and JPSS/OMPS satellite data (green). Apparent annual ozone cycle in Dobson measurements is shown with dark line (smoothed). The 1 and 2 STD are shown in grey. This plot is used for assessment of the inter-seasonal ozone variability and identifies measurements that exceed expected variation limits.

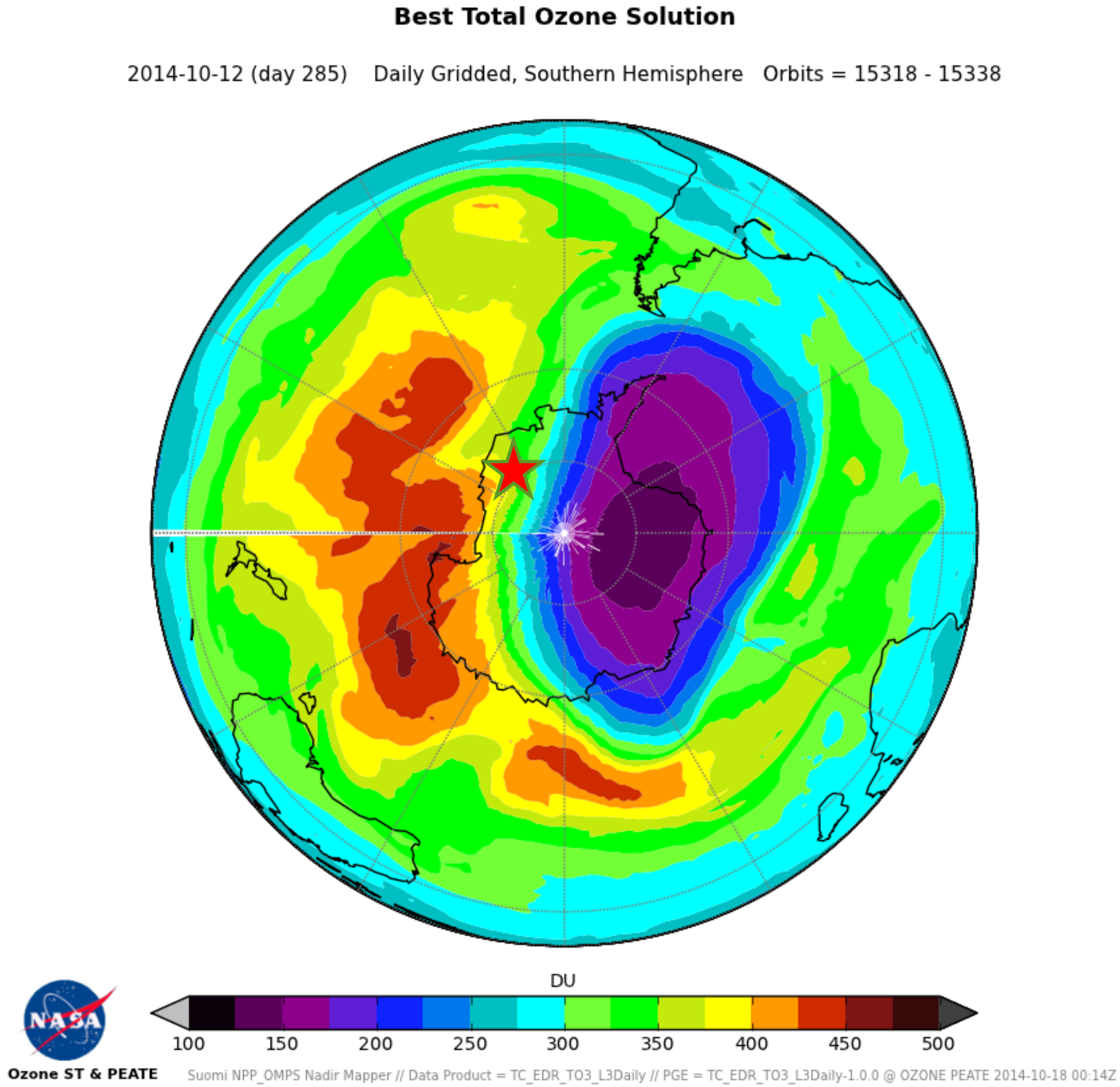


Example of comparisons for MLO. Data are matched by date and location. Looking for offset and apparent seasonal cycle caused by temperature sensitivity of ozone cross sections or stray light.

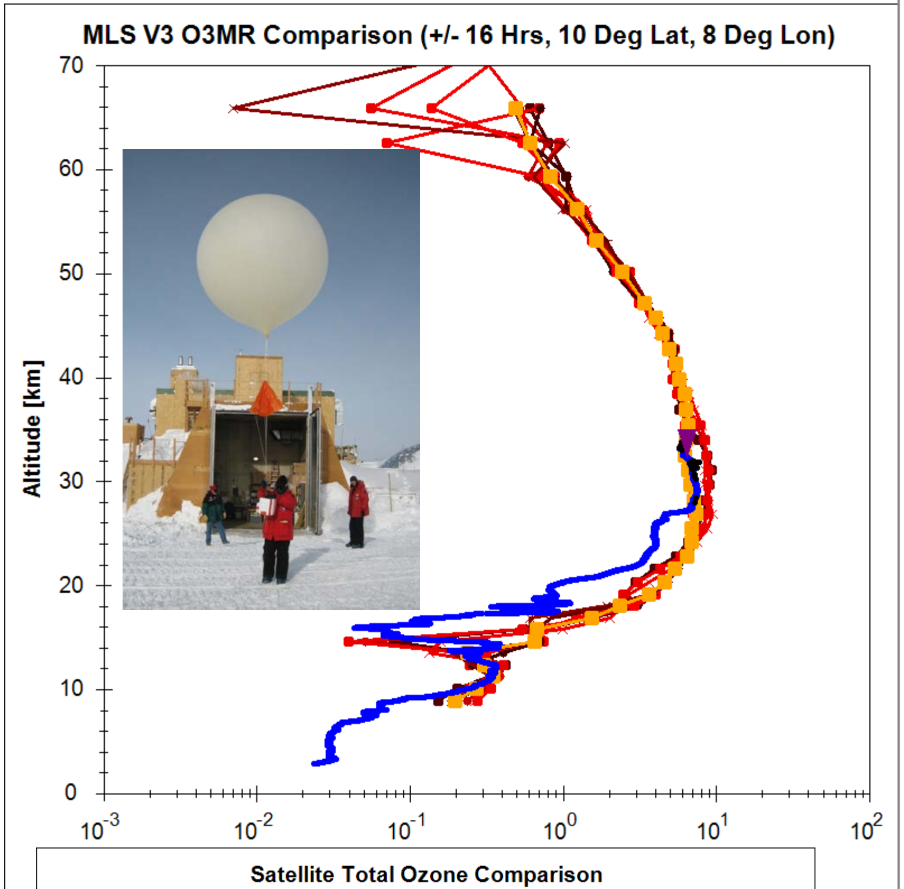
Long-term Stratospheric Ozone Depletion Monitoring

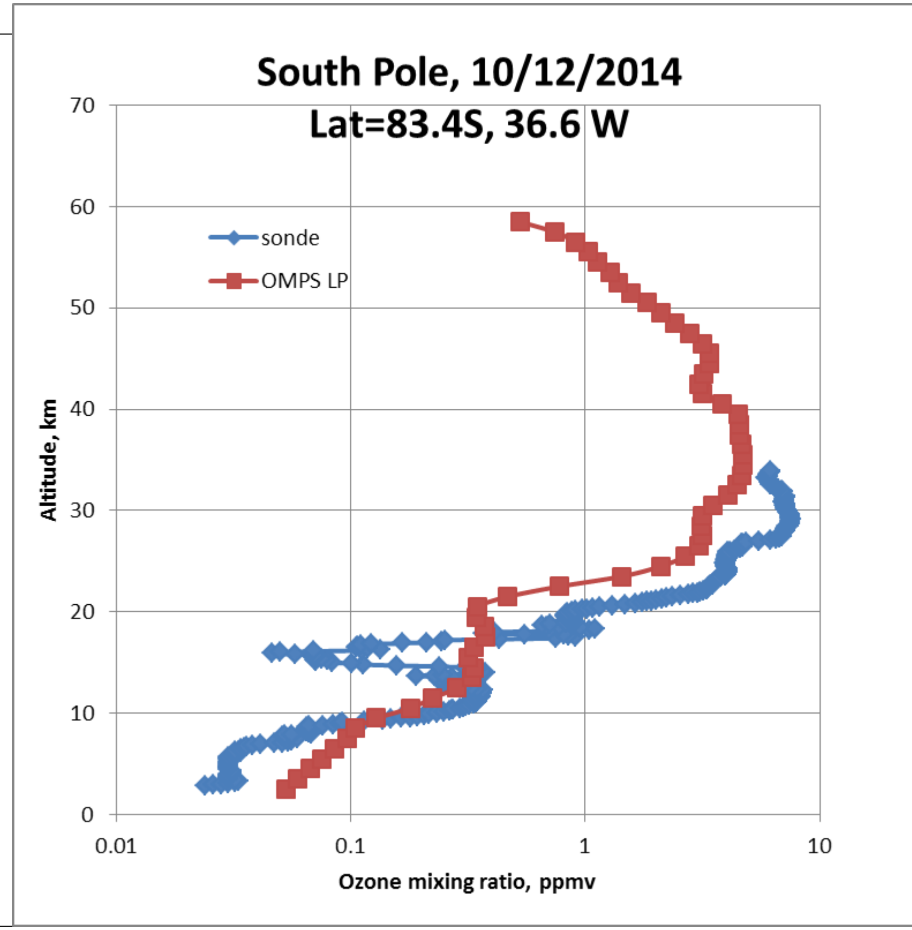


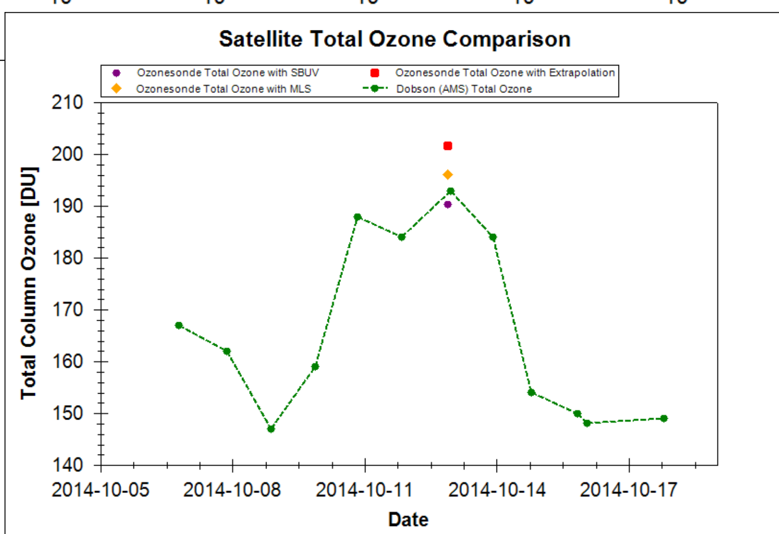
Dobson Total Column ozone measurements have been maintained since 1960 providing a reliable, long-term record of the ozone hole each year. This record is used for understanding of trends and levels of on-going recovery in the ozone layer.



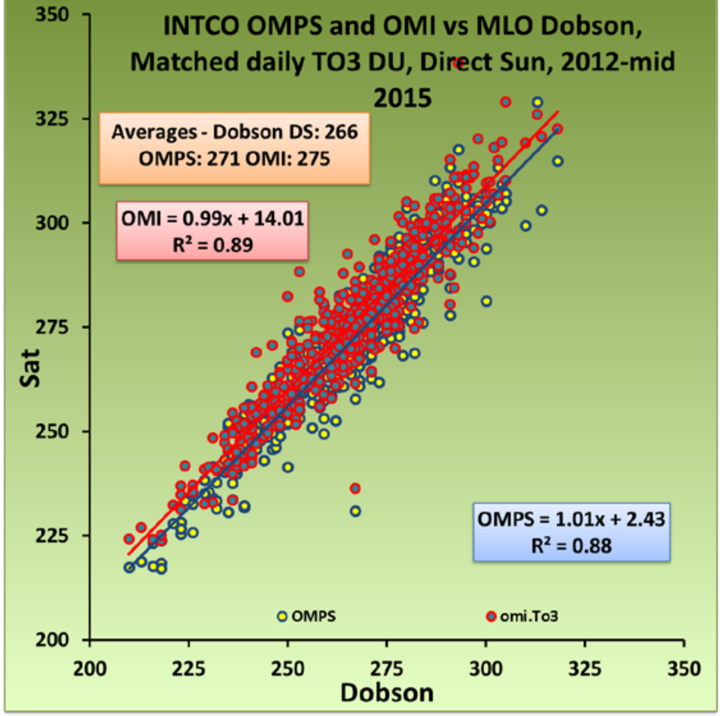
Problem with satellite comparisons in Sept/Oct – difficult to match satellite tracks with SP ozone sonde profiles (matching overpass satellite data are large distance away from SP, or by 8-10 degrees in latitude)

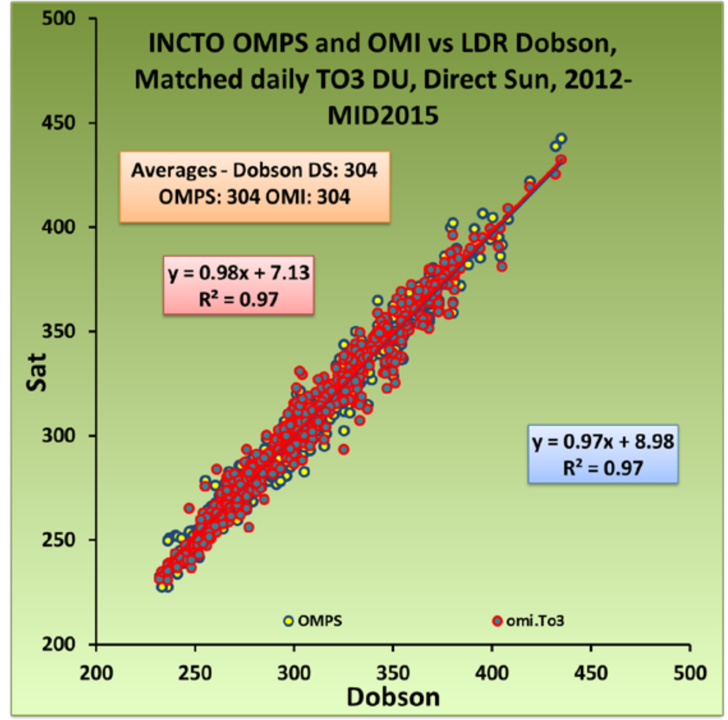


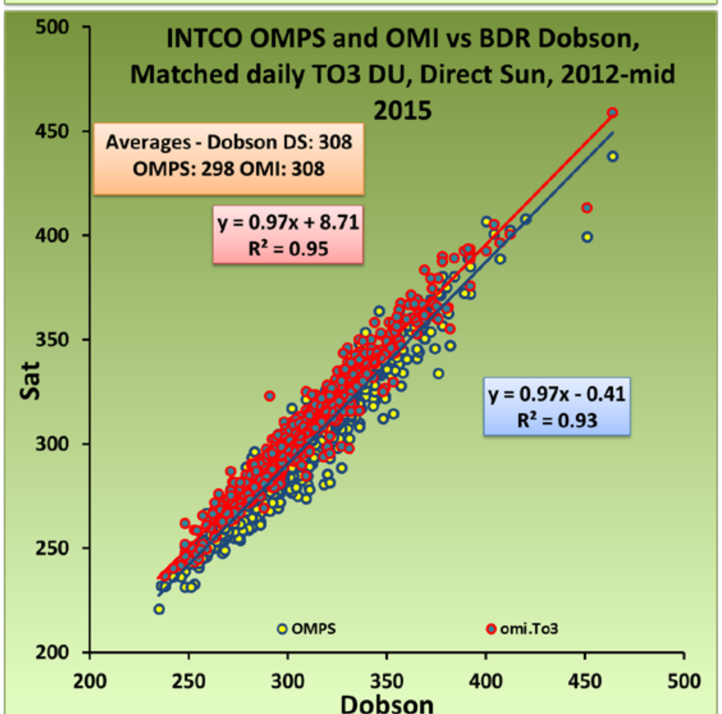


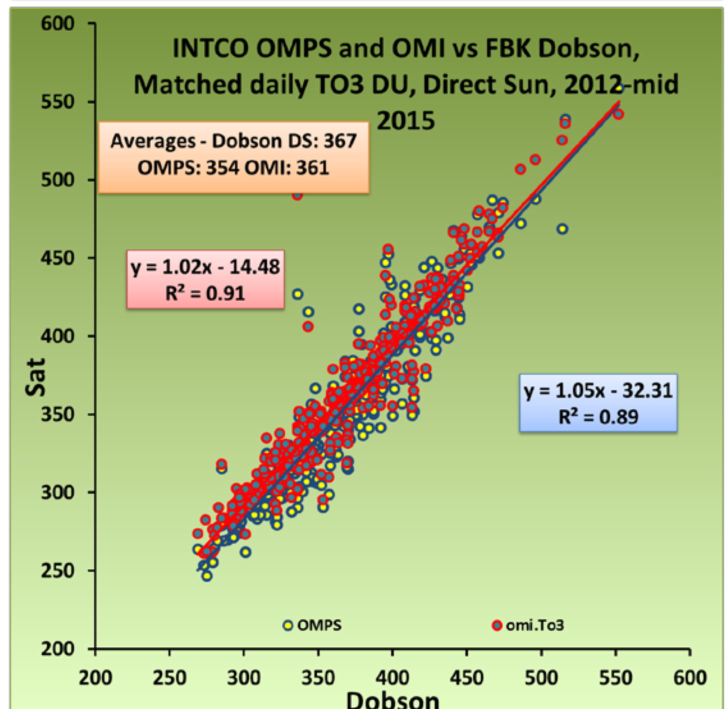


Issues with ground based/satellite comparisons in Sept/Oct –OMPS, OMI, or MLS overpass is lower by 8-10 degrees in latitude from SP location.

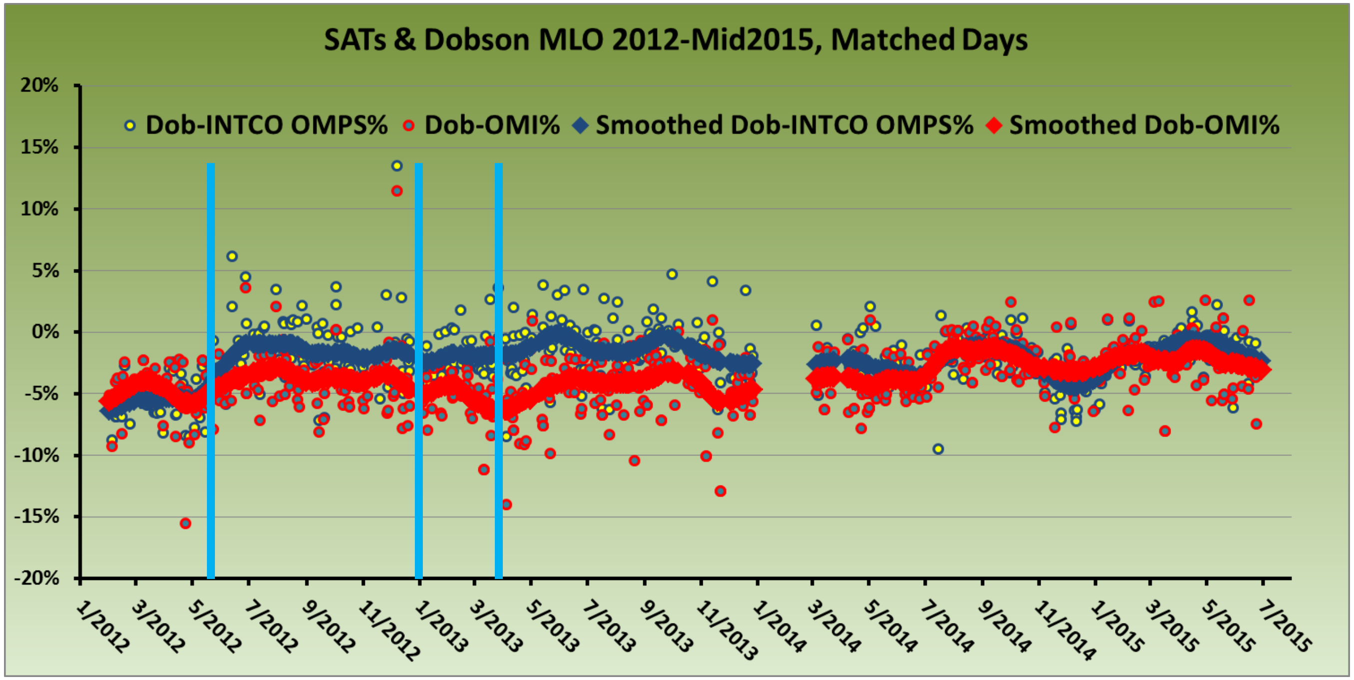

INTCO OMPS and OMI vs MLO Dobson, Matched daily TO3 DU, Direct Sun, 2012-mid 2015
Averages - Dobson DS: 266 OMPS: 271 OMI: 275
OMI = 0.99x + 14.01 R² = 0.89
OMPS = 1.01x + 2.43 R² = 0.88
OMPS
omi.To3
Sat
Dobson
200
225
250
275
300
325
350


INCTO OMPS and OMI vs LDR Dobson, Matched daily TO3 DU, Direct Sun, 2012-MID2015
Averages - Dobson DS: 304 OMPS: 304 OMI: 304
y = 0.98x + 7.13 R² = 0.97
y = 0.97x + 8.98 R² = 0.97
OMPS
omi.To3
Sat
Dobson
200
250
300
350
400
450
500

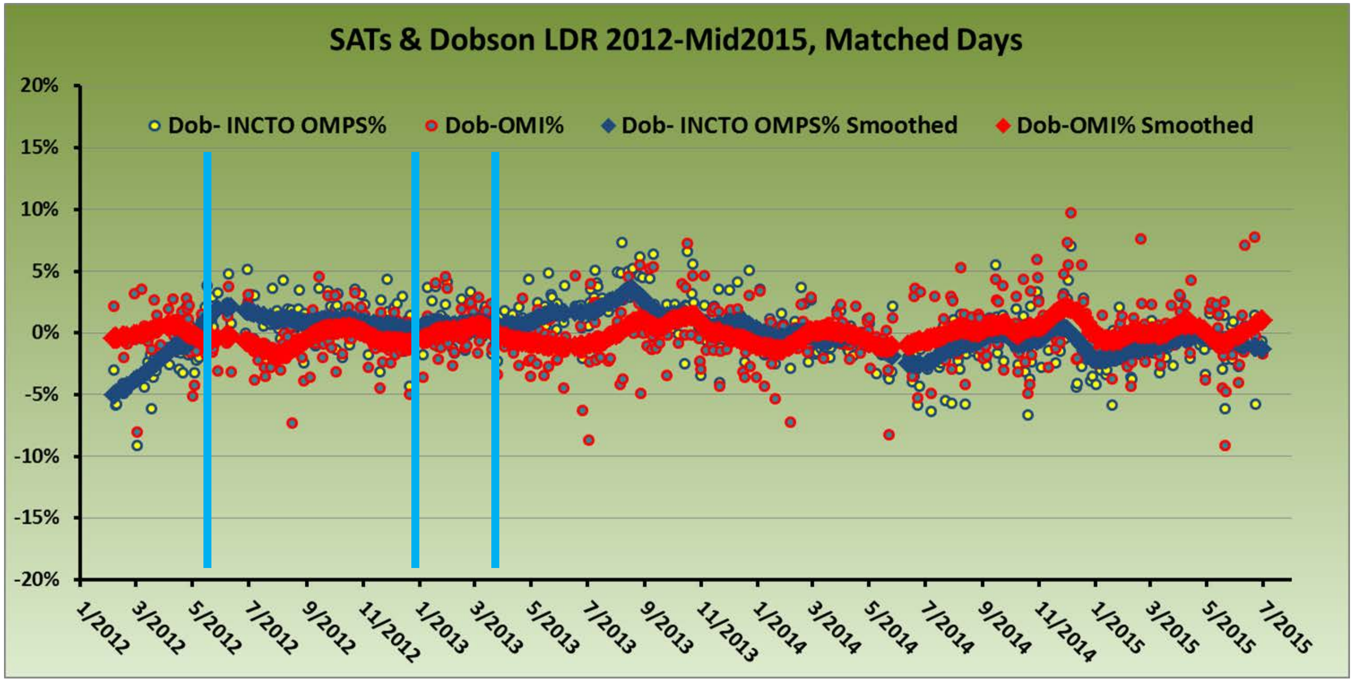

INTCO OMPS and OMI vs BDR Dobson, Matched daily TO3 DU, Direct Sun, 2012-mid 2015
Averages - Dobson DS: 308 OMPS: 298 OMI: 308
y = 0.97x + 8.71 R² = 0.95
y = 0.97x - 0.41 R² = 0.93
OMPS
omi.To3
Sat
Dobson
200
250
300
350
400
450
500


INTCO OMPS and OMI vs FBK Dobson, Matched daily TO3 DU, Direct Sun, 2012-mid 2015
Averages - Dobson DS: 367 OMPS: 354 OMI: 361
y = 1.02x - 14.48 R² = 0.91
y = 1.05x - 32.31 R² = 0.89
OMPS
omi.To3
Sat
Dobson
200
250
300
350
400
450
500
550
600

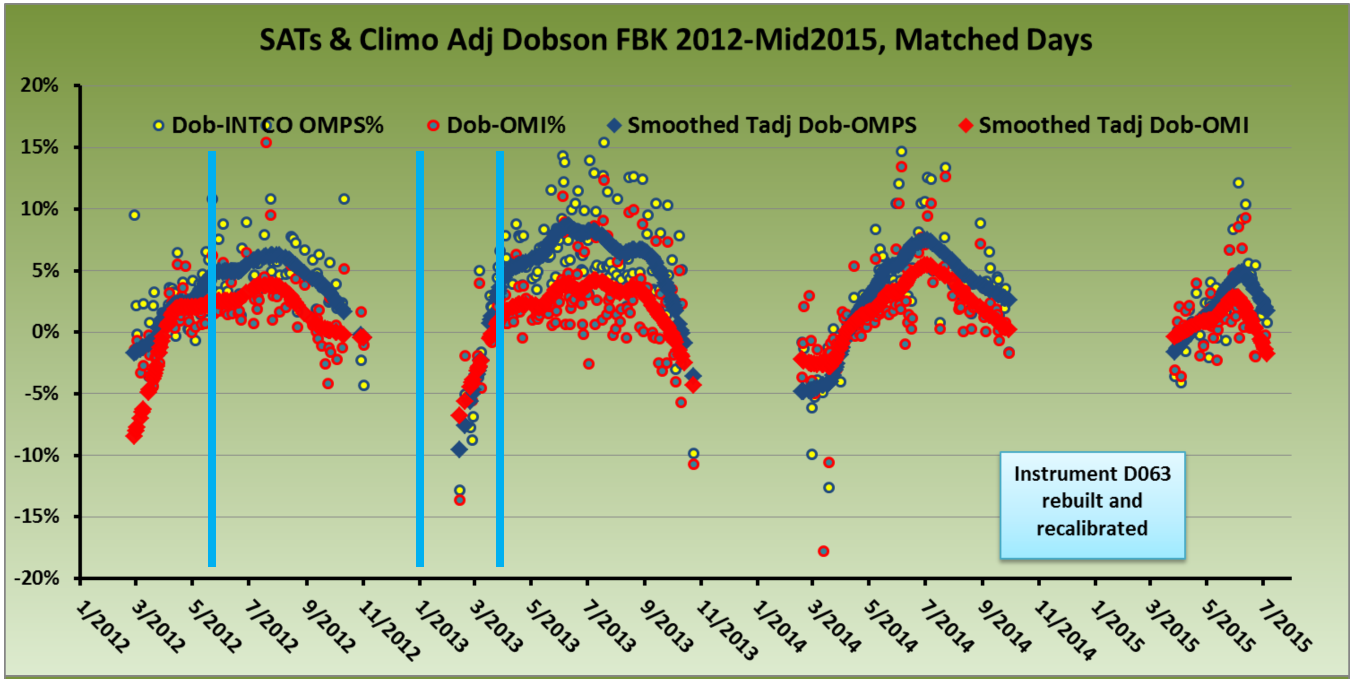
Mauna Loa



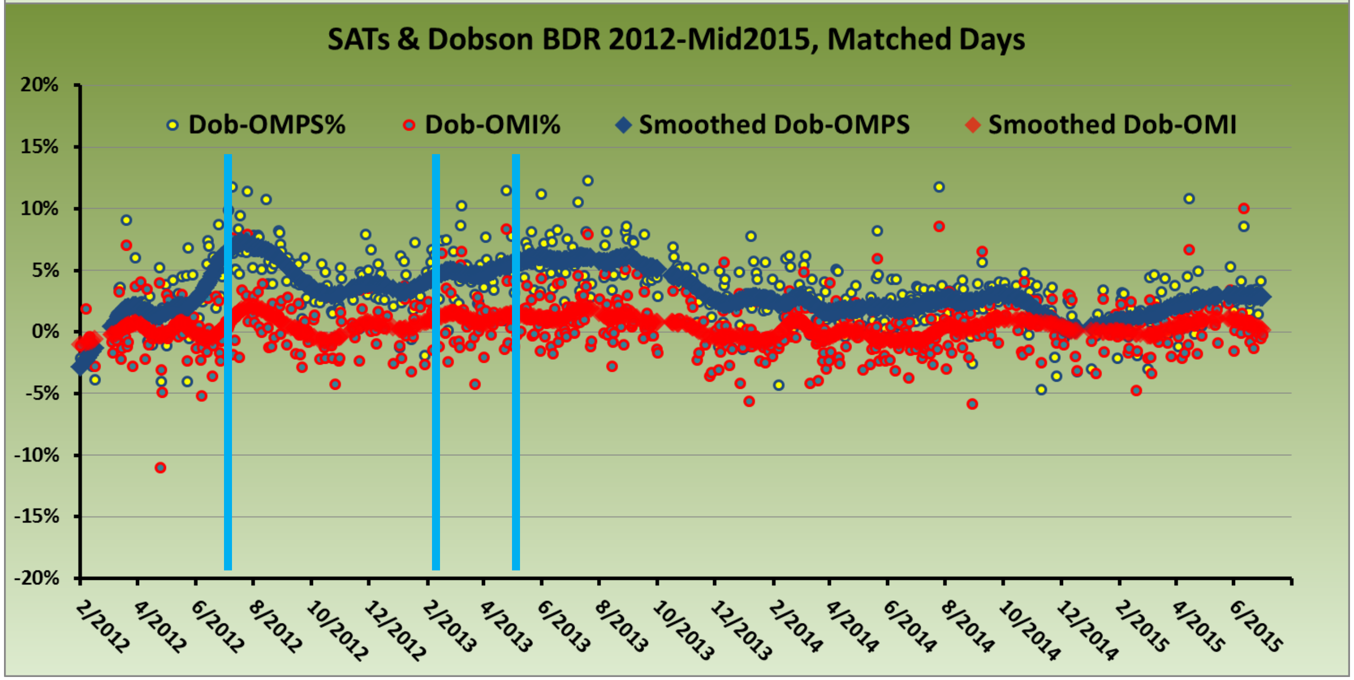
Lauder



Fairbanks

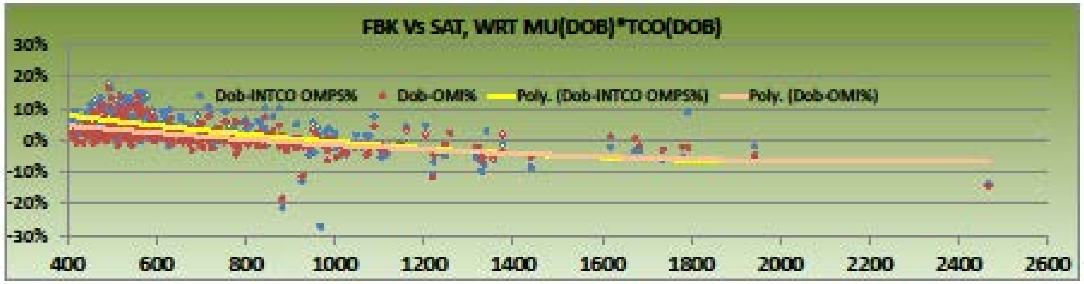


Boulder

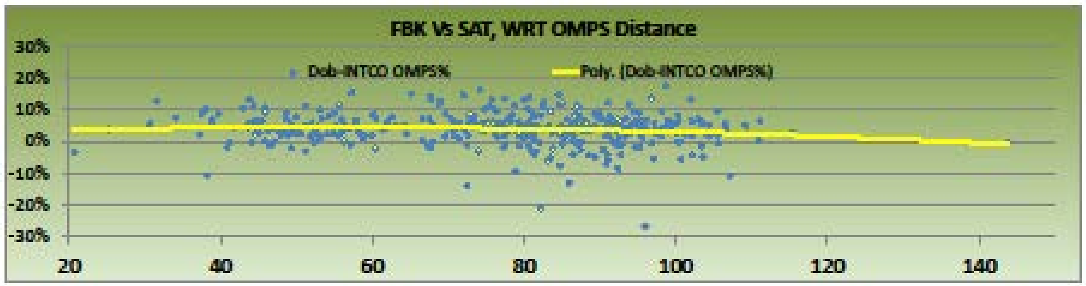


FBK Vs SAT, WRT MU(DOB)*TCO(DOB) FBK Vs SAT, WRT OMPS Distance FBK Vs SAT, WRT OMPS Time FBK Vs SAT, WRT abs(Dob-OMPS) Time

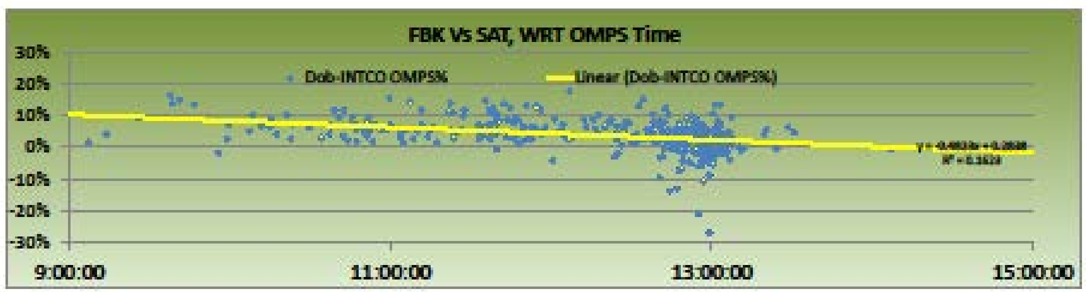
TOC*airmass



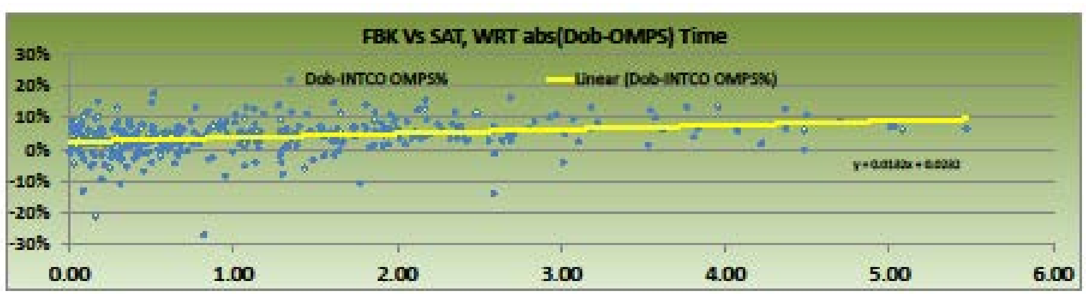
Distance from stations

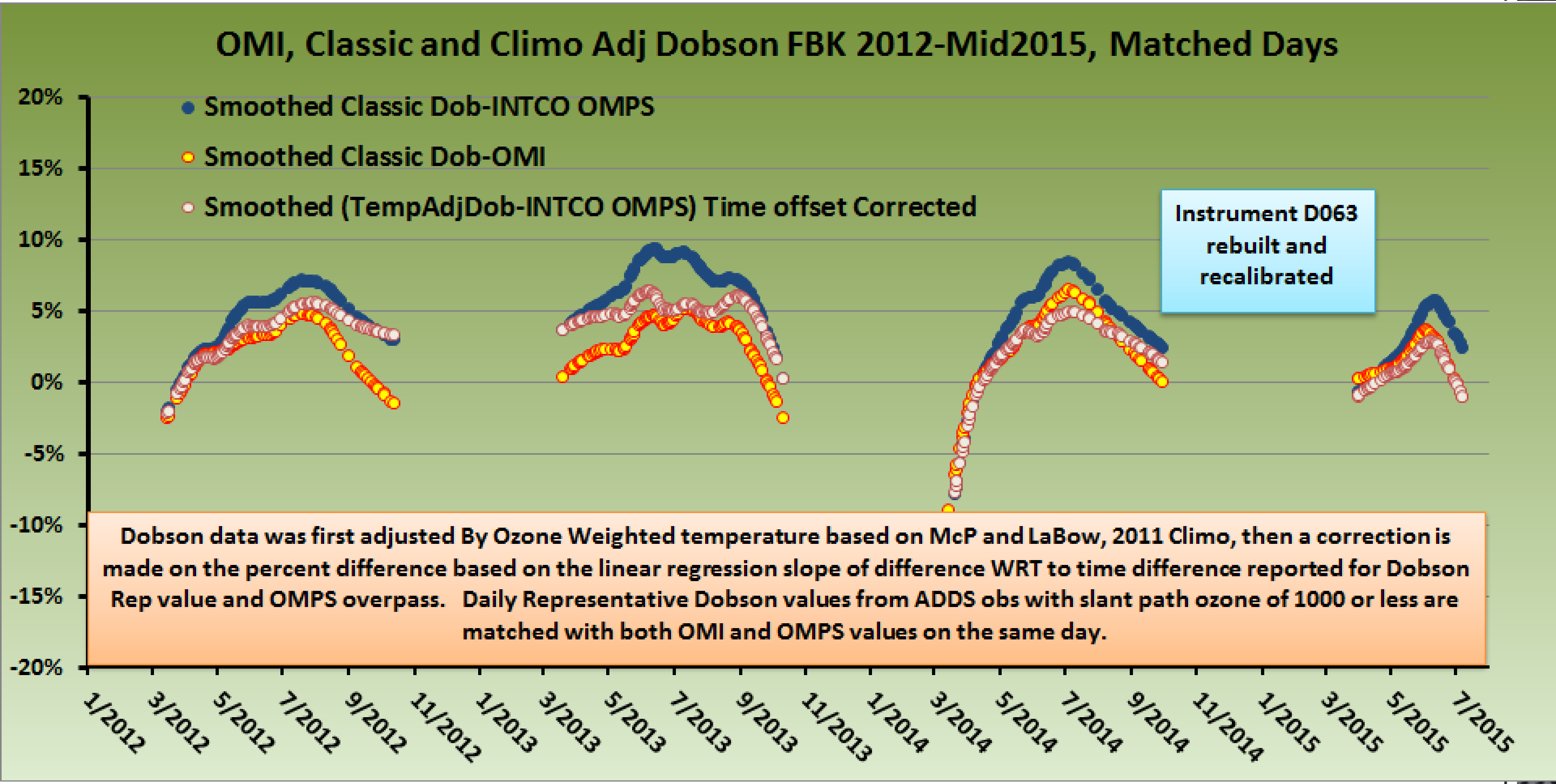


Time of satellite overpass



Time difference between satellite overpass and Dobson measurement



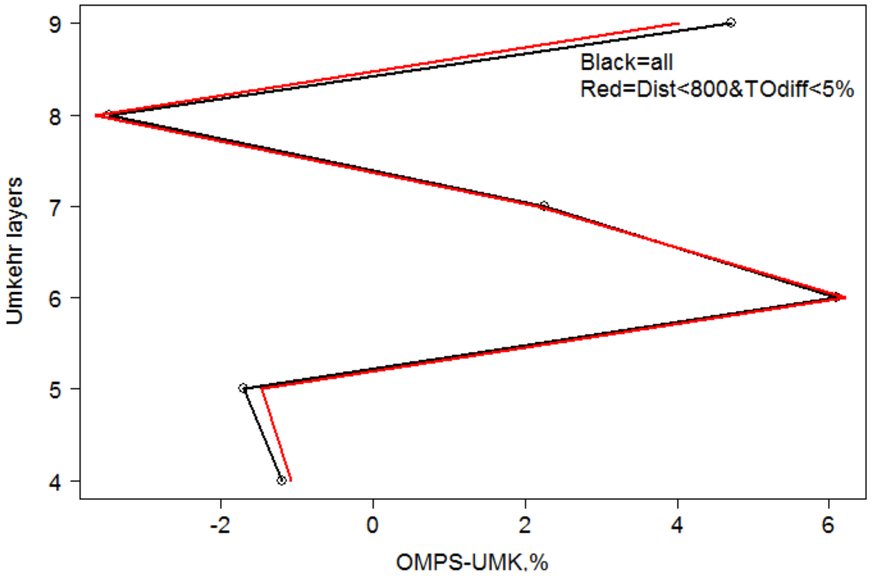


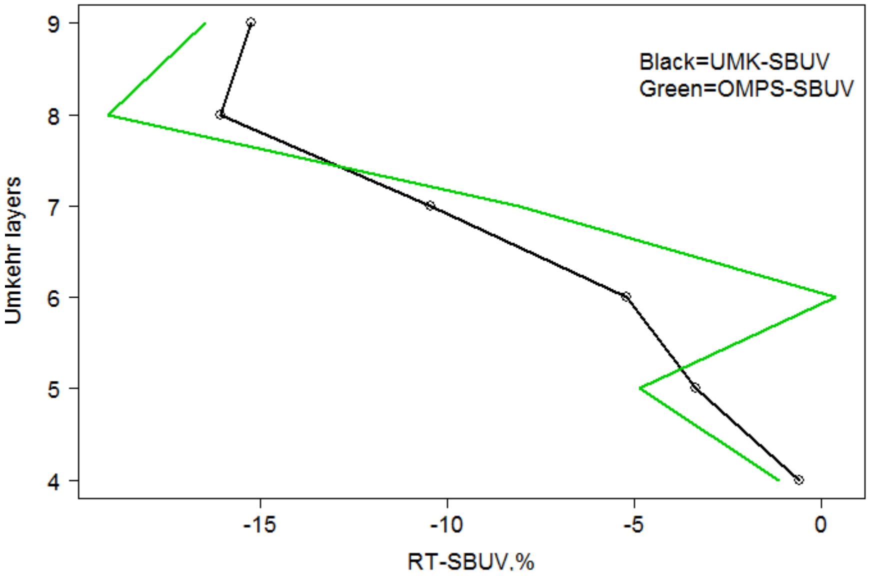
OMI, Classic and Climo Adj Dobson FBK 2012-Mid2015, Matched Days
Smoothed Classic Dob-INTCO OMPS
Smoothed Classic Dob-OMI
Smoothed (TempAdjDob-INTCO OMPS) Time offset Corrected
Instrument D063 rebuilt and recalibrated
20%
15%
10%
5%
0%
-5%
-10%
-15%
-20%
Dobson data was first adjusted By Ozone Weighted temperature based on McP and LaBow, 2011 Climo, then a correction is made on the percent difference based on the linear regression slope of difference WRT to time difference reported for Dobson Rep value and OMPS overpass. Daily Representative Dobson values from ADDS obs with slant path ozone of 1000 or less are matched with both OMI and OMPS values on the same day.
1/2012
3/2012
5/2012
7/2012
9/2012
11/2012
1/2013
3/2013
5/2013
7/2013
9/2013
11/2013
1/2014
3/2014
5/2014
7/2014
9/2014
11/2014
1/2015
3/2015
5/2015
7/2015

Comparisons of vertical ozone profiles between Umkehr, SBUV (NOAA19) and OMPS (IMOPO, V6).

The overpass satellite data are tested for dependence on distance and TO differences.

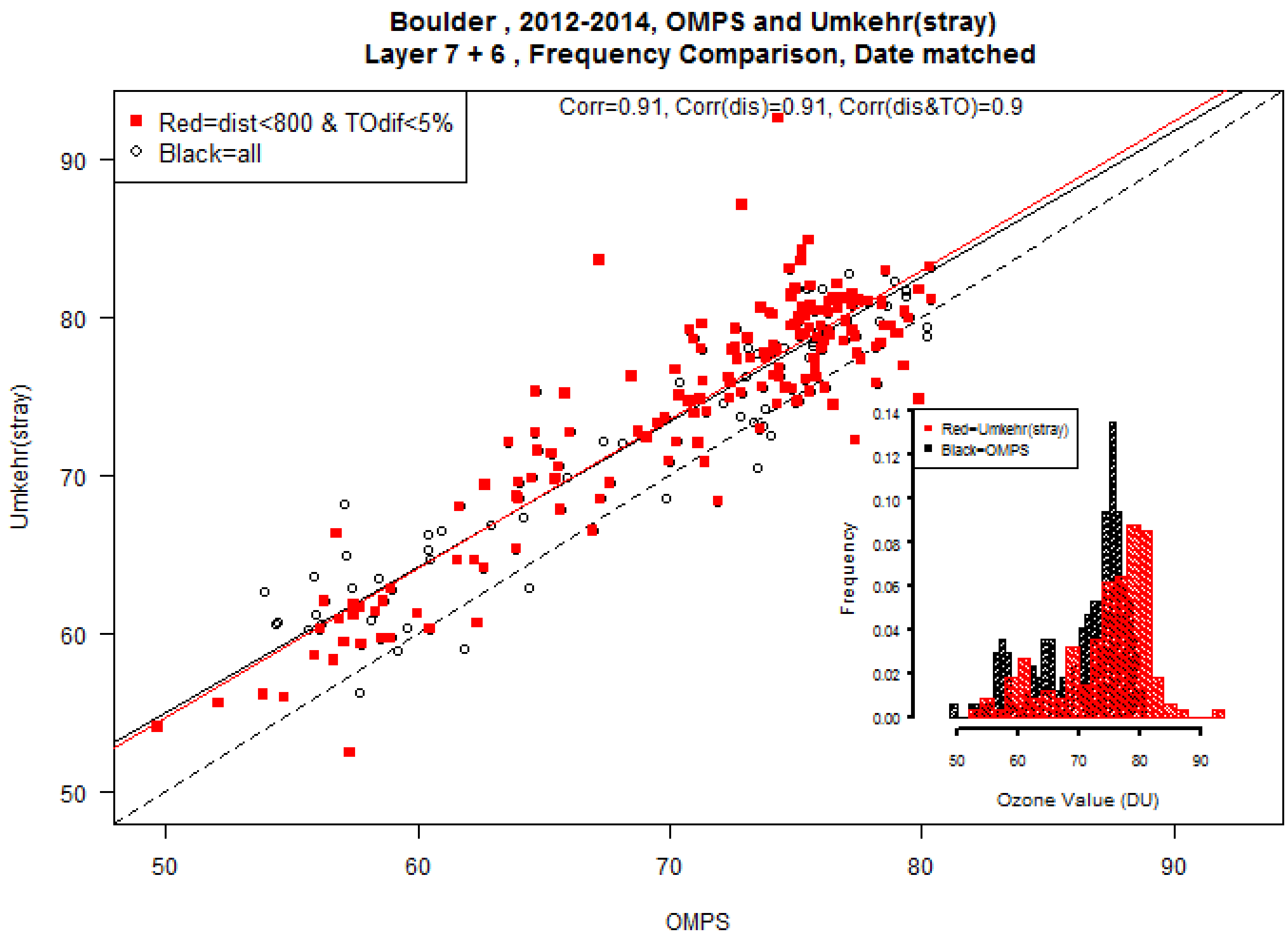
Boulder, 2012-2014





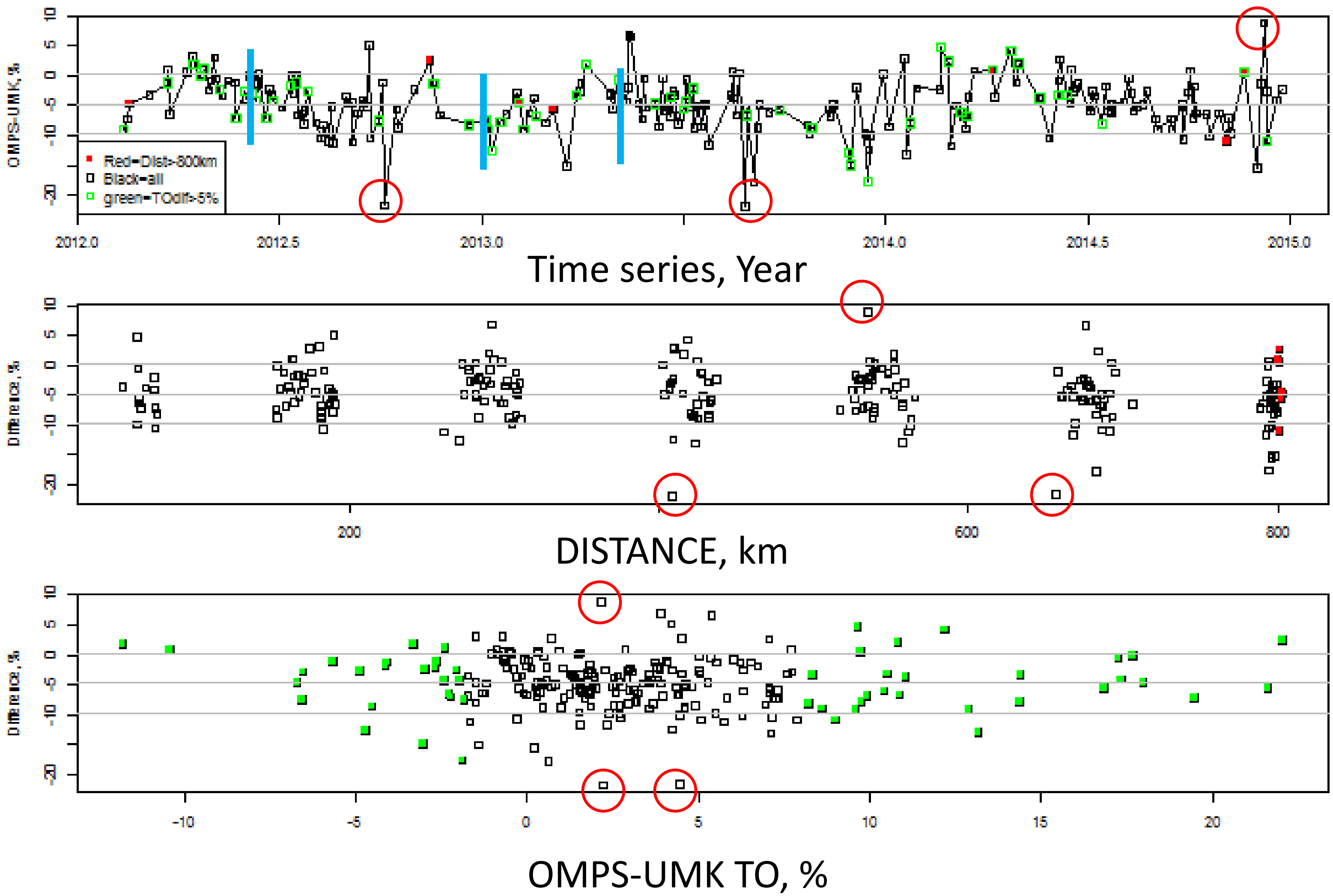
OMPS/Dobson Bias in layers 4-9 is within +/- 5 %

Bias between OMPS or Umkehr relative to SBUV N19 in layers 4-9 increases with altitude, note negative 15-20 % offset in layer 8.

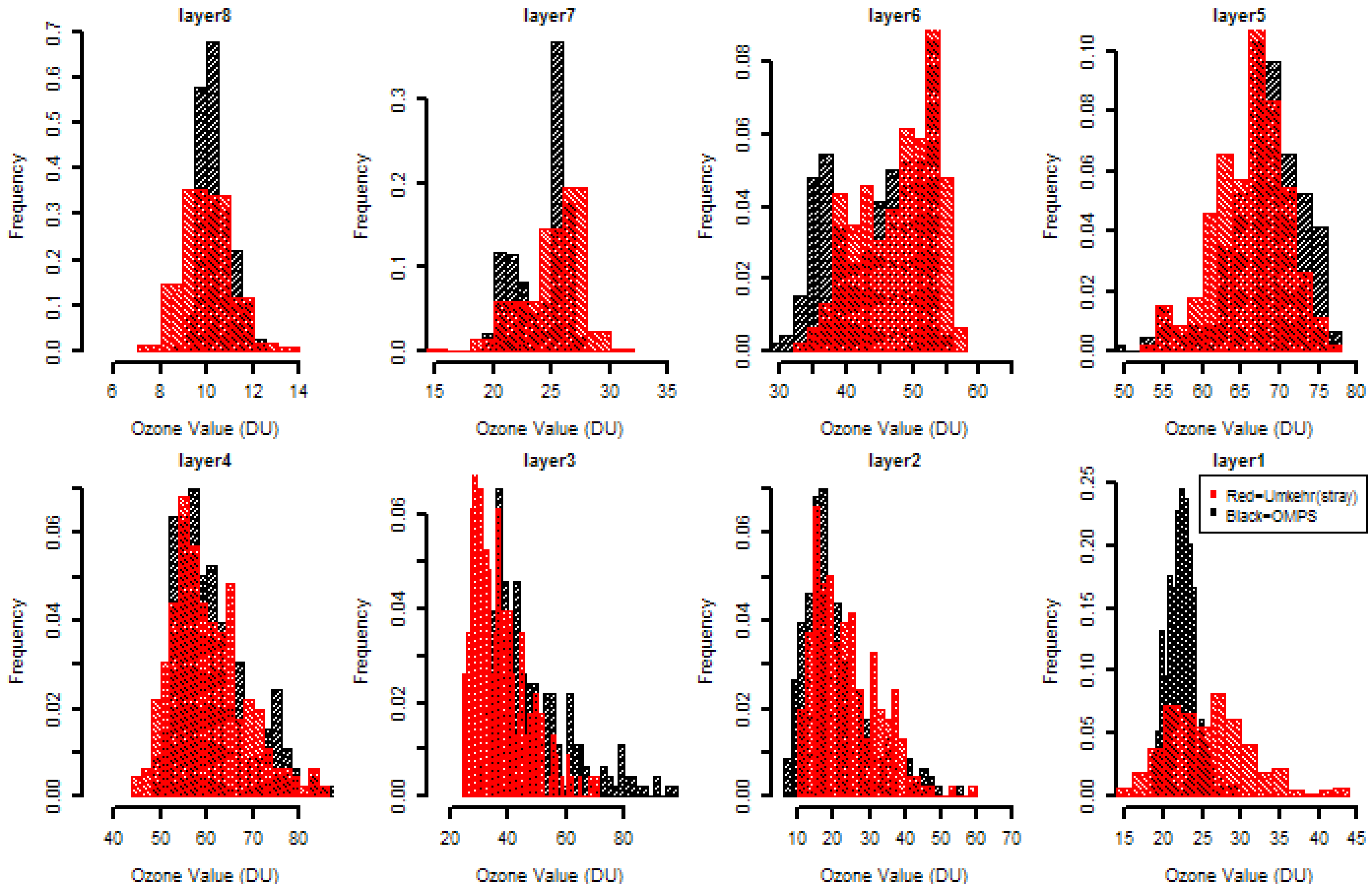


Boulder , 2012-2014, OMPS and Umkehr(stray)
Layer 7 + 6 , Frequency Comparison, Date matched
Red=dist<800 & TOdif<5%
Black=all
Corr=0.91, Corr(dis)=0.91, Corr(dis&TO)=0.9
Umkehr(stray)
OMPS
Red=Umkehr(stray)
Black=OMPS
Frequency
Ozone Value (DU)

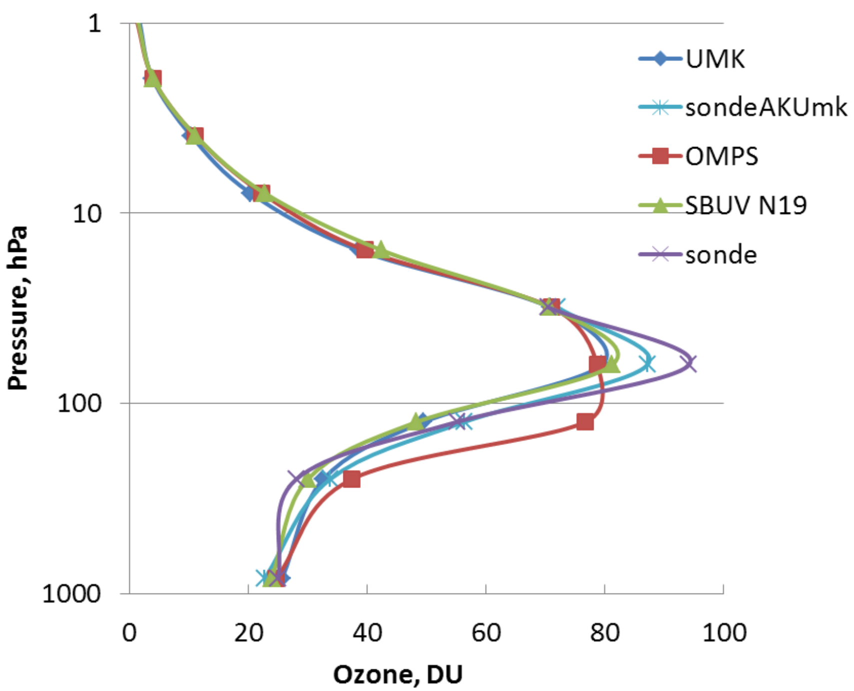
Boulder , 2012-2014, OMPS and Umkehr(stray)
Layer 7 + 6 , Difference, Date matched

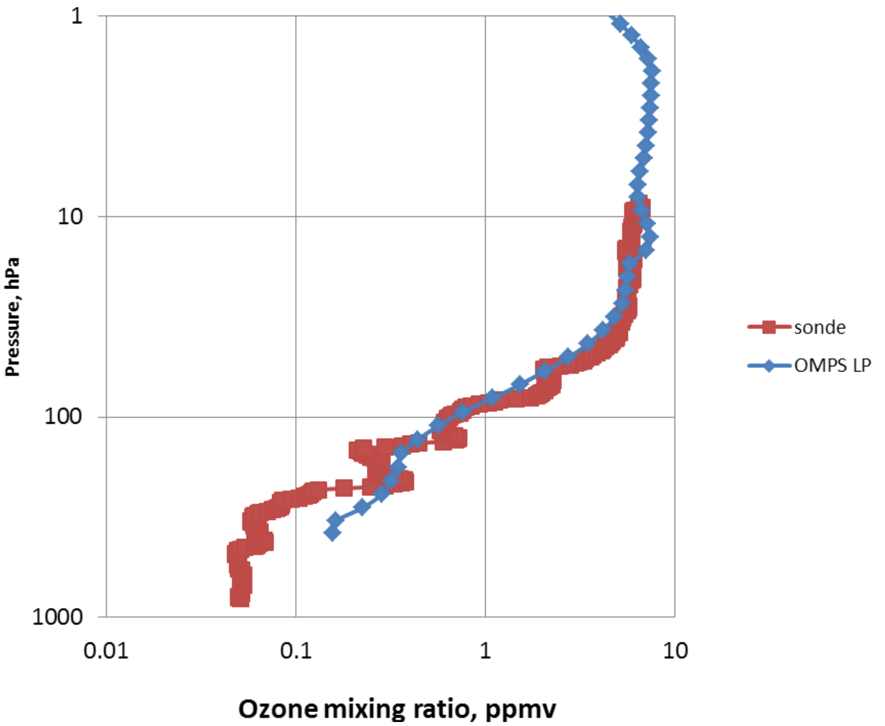


Boulder , 2012-2014, OMPS and Umkehr(stray)
Frequency Comparison, Matched Date



Boulder 02/19/2014





- Profile comparisons show OMPS has different profile shape as compared to Umkehr and SBUV.
- Ozone sonde integrated in Umkehr layers has more ozone in layer 5 than in satellite or Umkehr retrieval. Note, improved agreement with AK smoothed sonde.
- The plot with high resolution reveals several lamina in the ozone-sonde measured vertical structure. Although OMPS LP does not capture these lamina, it captures profile shape in stratosphere fairly well.

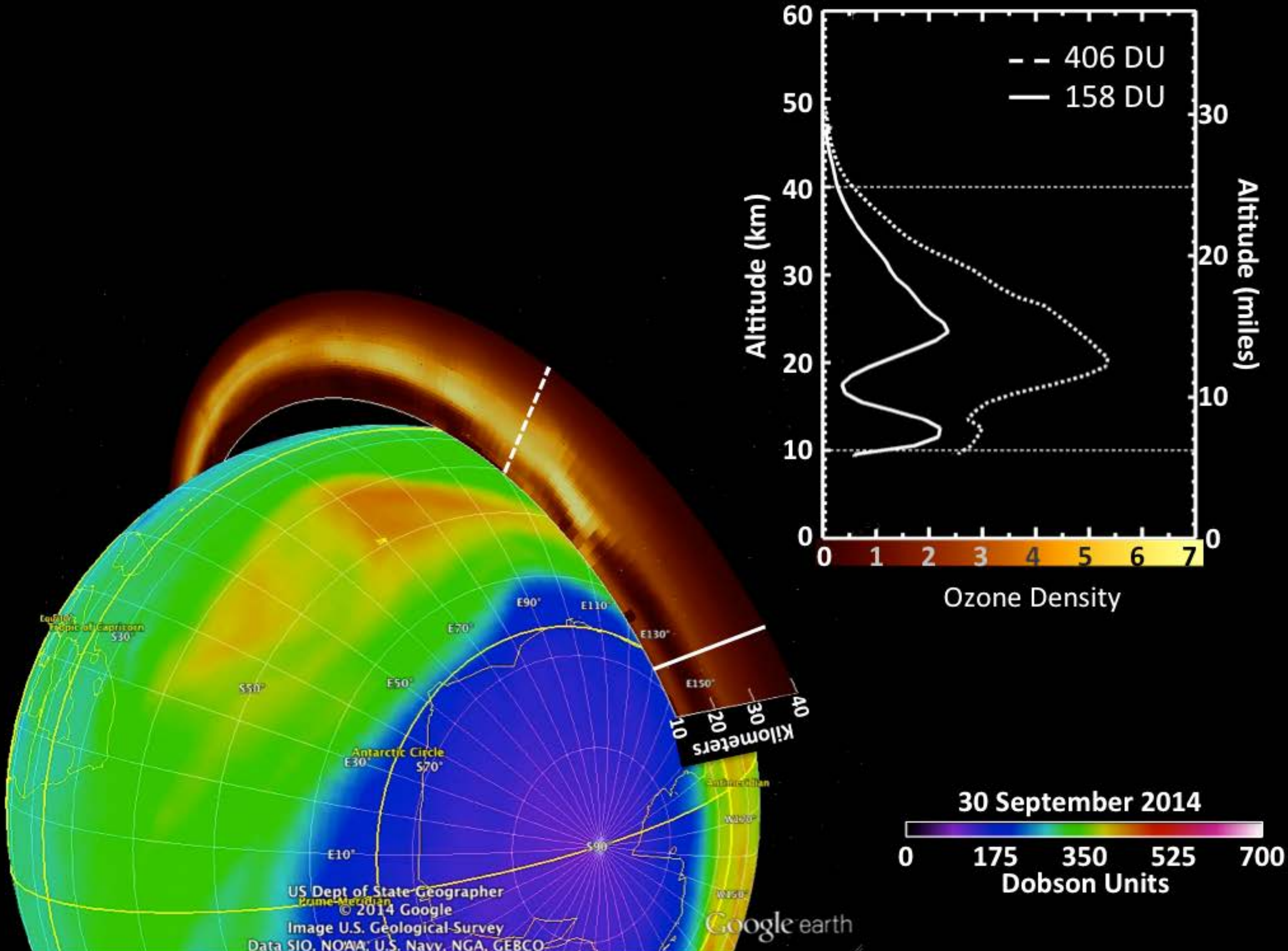
Conclusions

- Ground-based Dobson data have been regularly used to keep track of temporal and spatial variability in overpass OMPS (SDR, level1) ozone column and profile data
- 5 Dobson stations are currently outfitted with the automation system. Real time data comparison capability is available from the associated WinDobson software package.
- Correlations in TOC are between 0.88 and 0.97 (distance/time)
- The mean bias and seasonal cycle offsets are noticed in MLO, Boulder, and Fairbanks stations. Lauder appear to compare very well.
- The overpass NM INCTO data are created within a box that is +/- 0.5 degrees in latitude and +/- (1/cos(lat*pi/180)) in longitude, but it may need to be more restrictive to have adequate comparisons.
- Profile comparisons between NP IMOPO and Umkehr are within +/- 5 % in stratosphere (or above 68 hPa pressure level).
- In troposphere and lower stratosphere agreement depends on a priori and algorithm's difficulty to resolve profile around the tropopause.
- Looking forward to work on validation of the V8 data

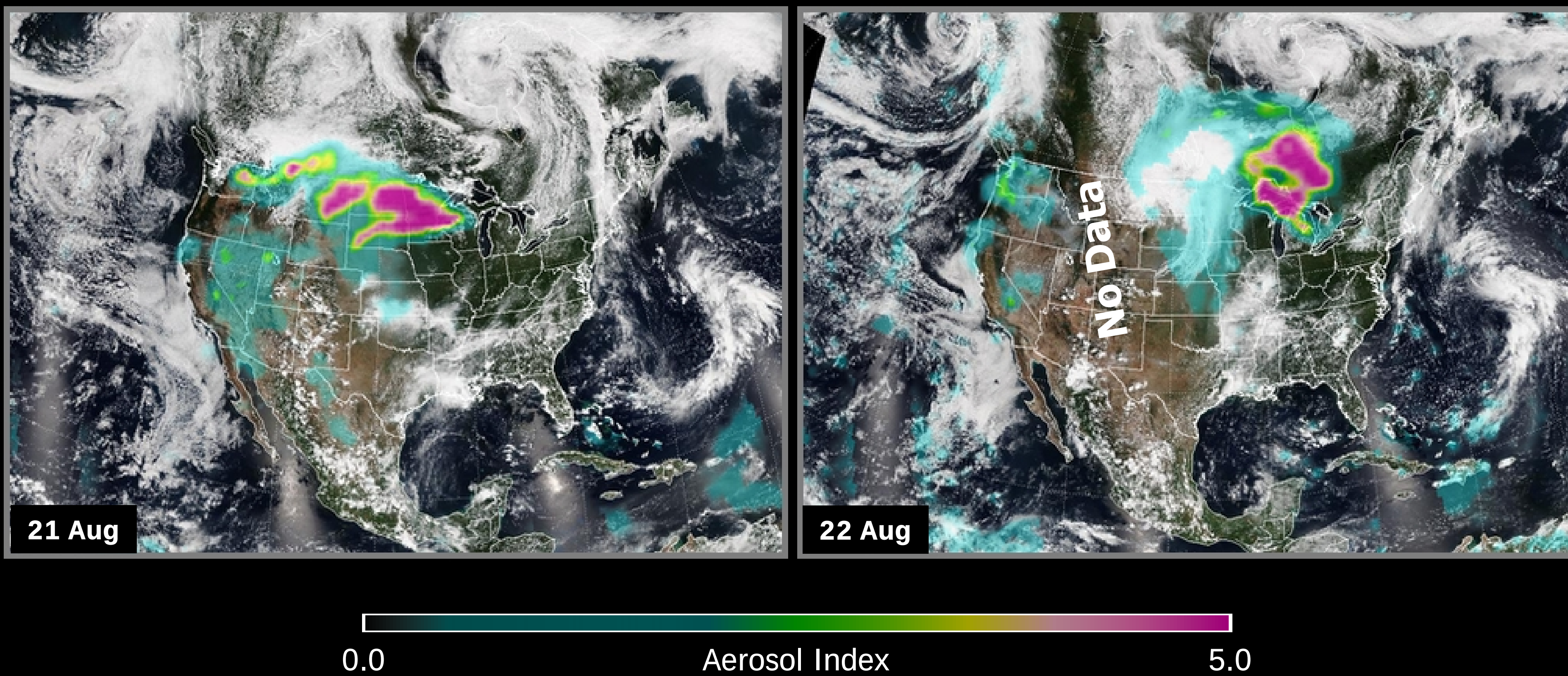
OMPS Gallery

Colin Seftor

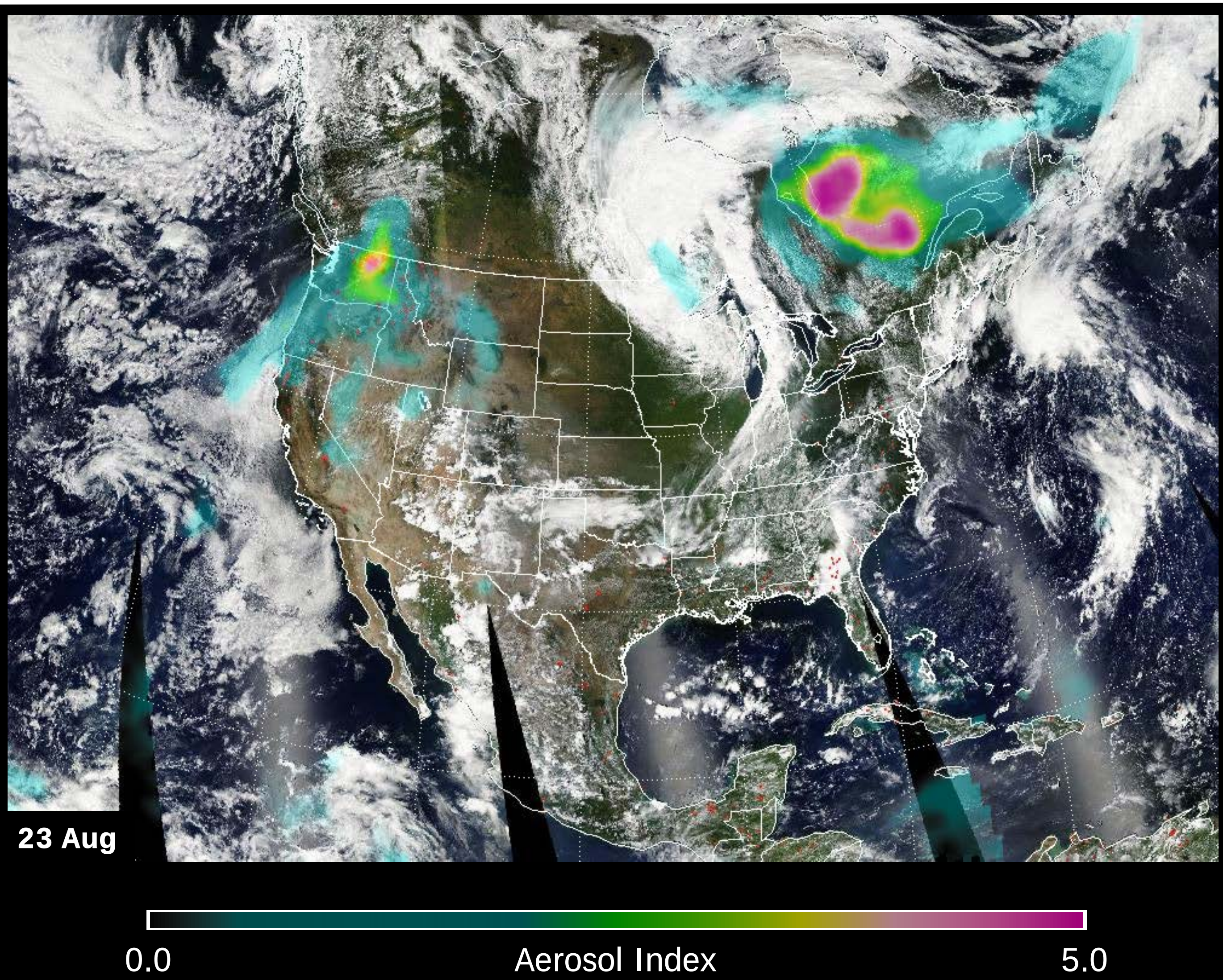
2014 Ozone Hole as seen by OMPS



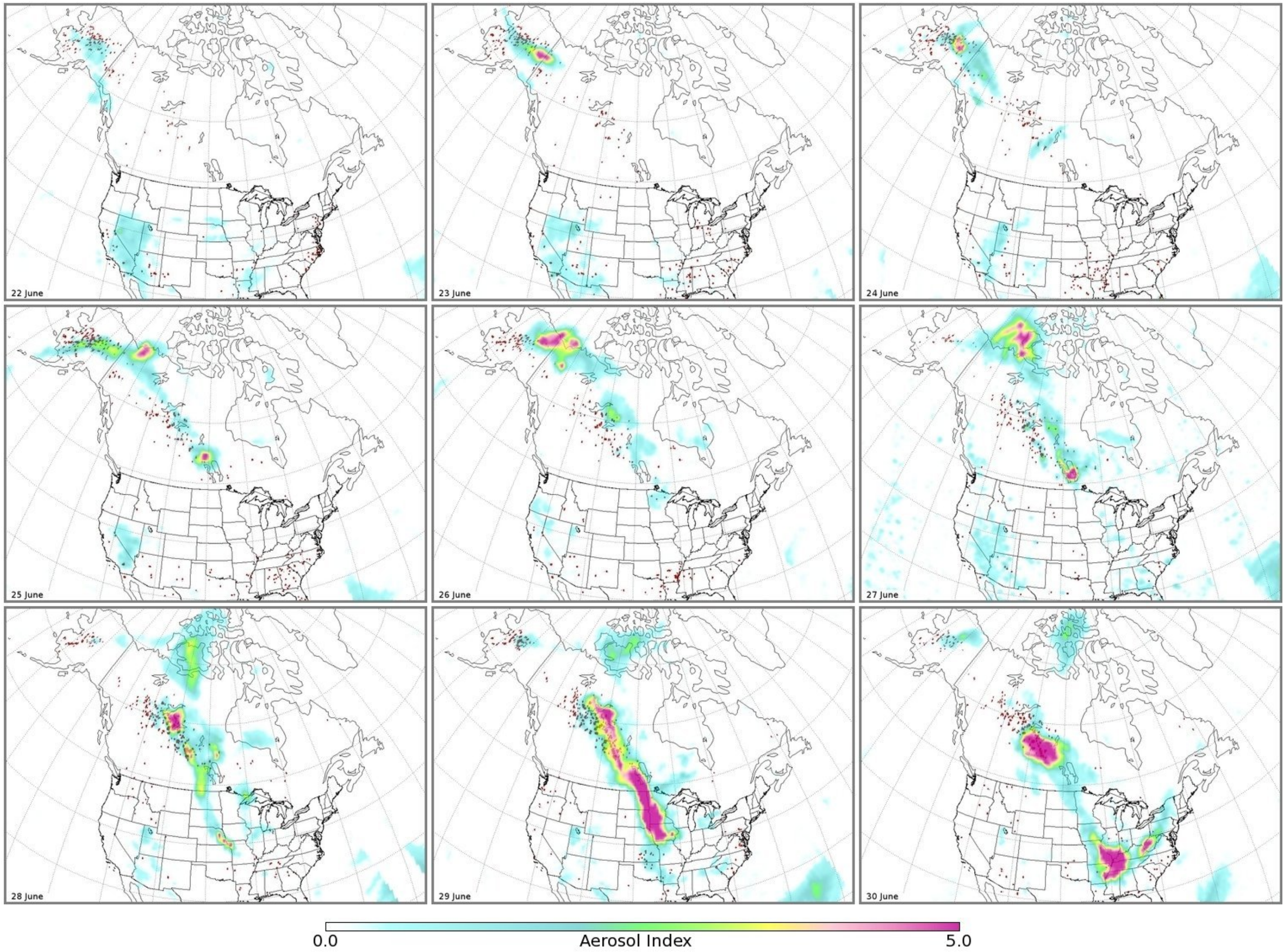
Smoke From US Fires
(OMPS Aerosol Index over VIIRS RGB)



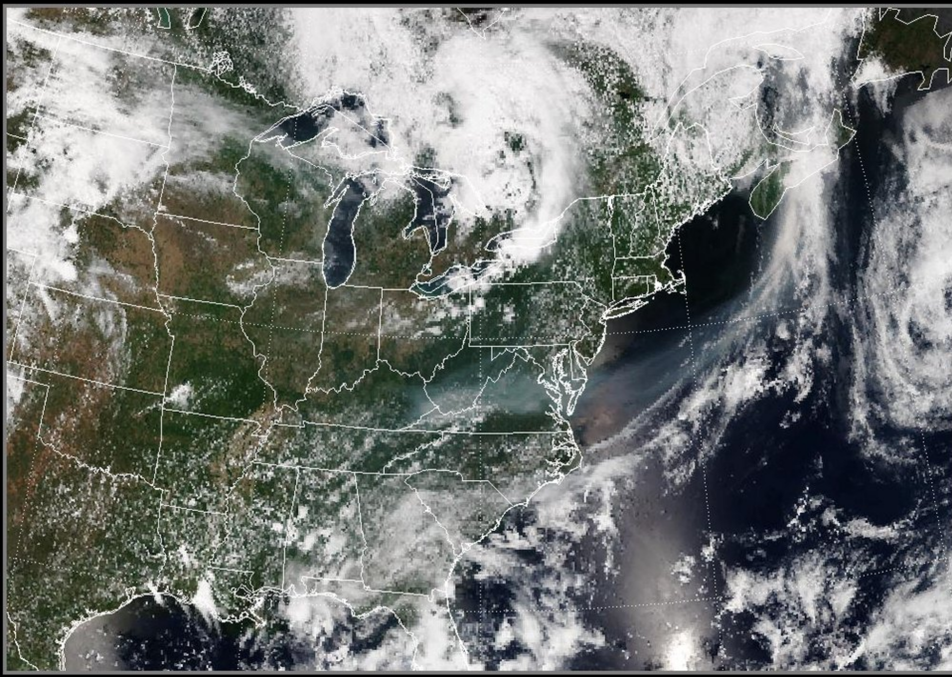
Smoke From US Fires
(OMPS Aerosol Index over MODIS RGB)

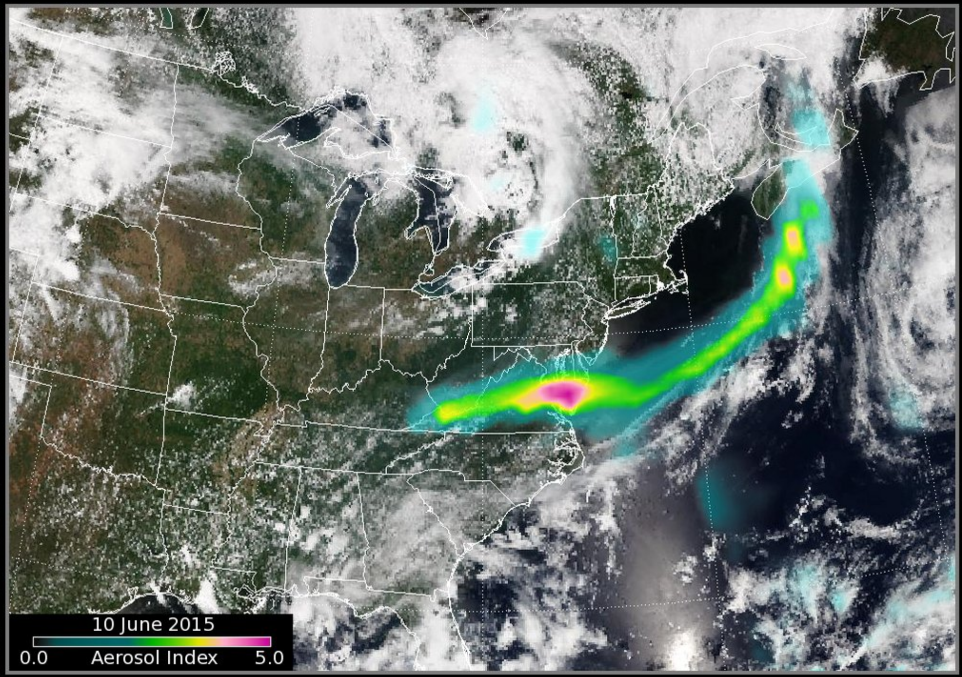


Canadian Smoke over the US (OMPS AI over VIIRS RGB)

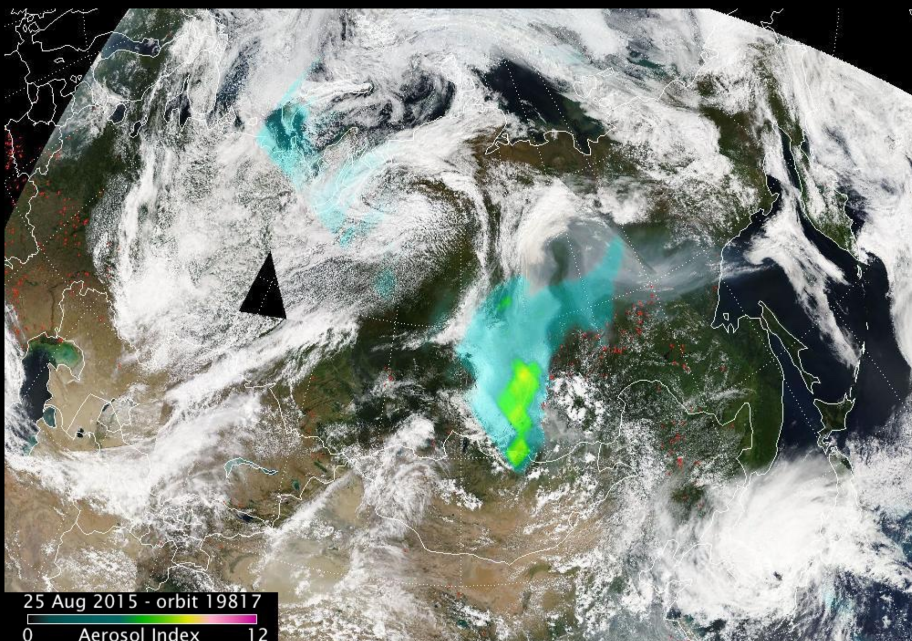


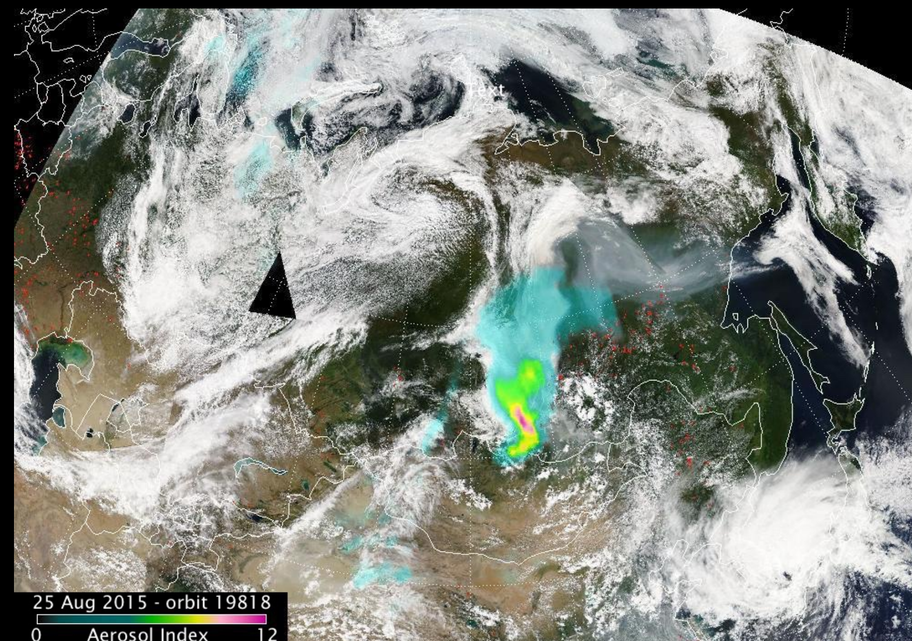
Canadian Smoke over the US
(OMPS AI over VIIRS RGB)



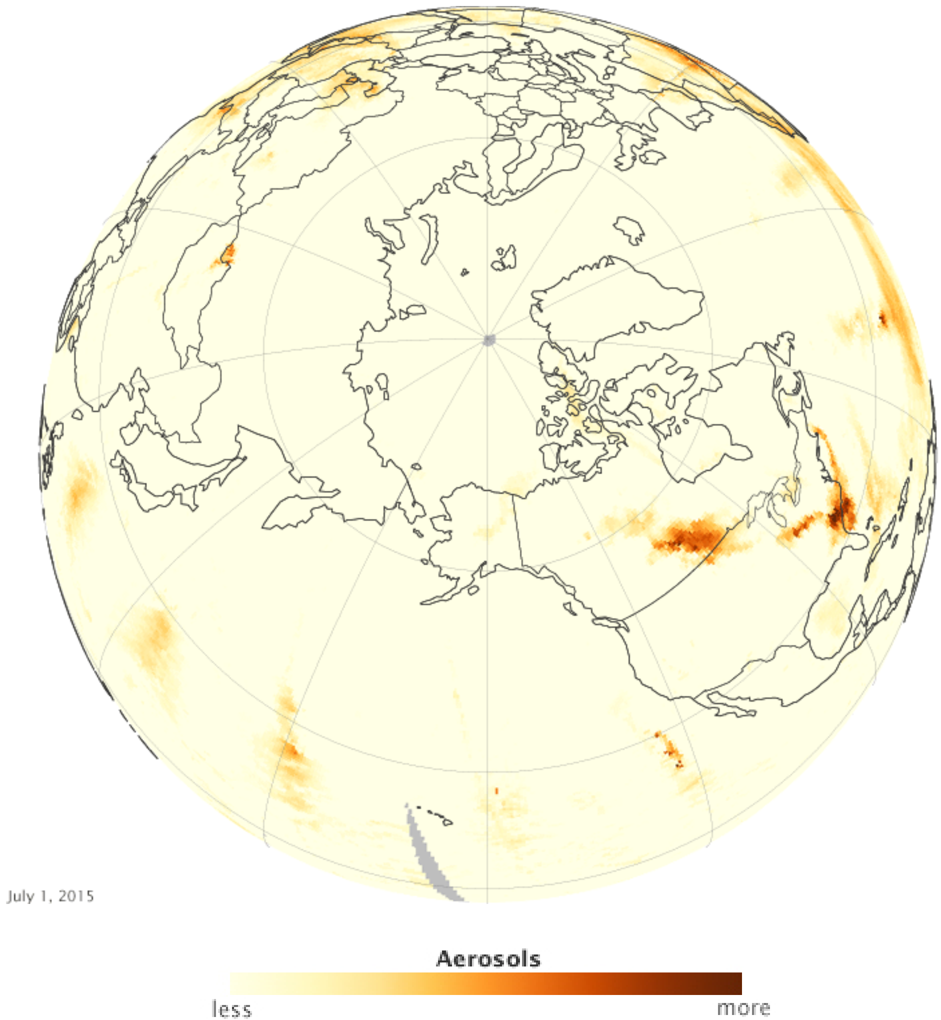


Creation of a PyroCb near Lake Baikal (OMPS AI over MODIS RGB)

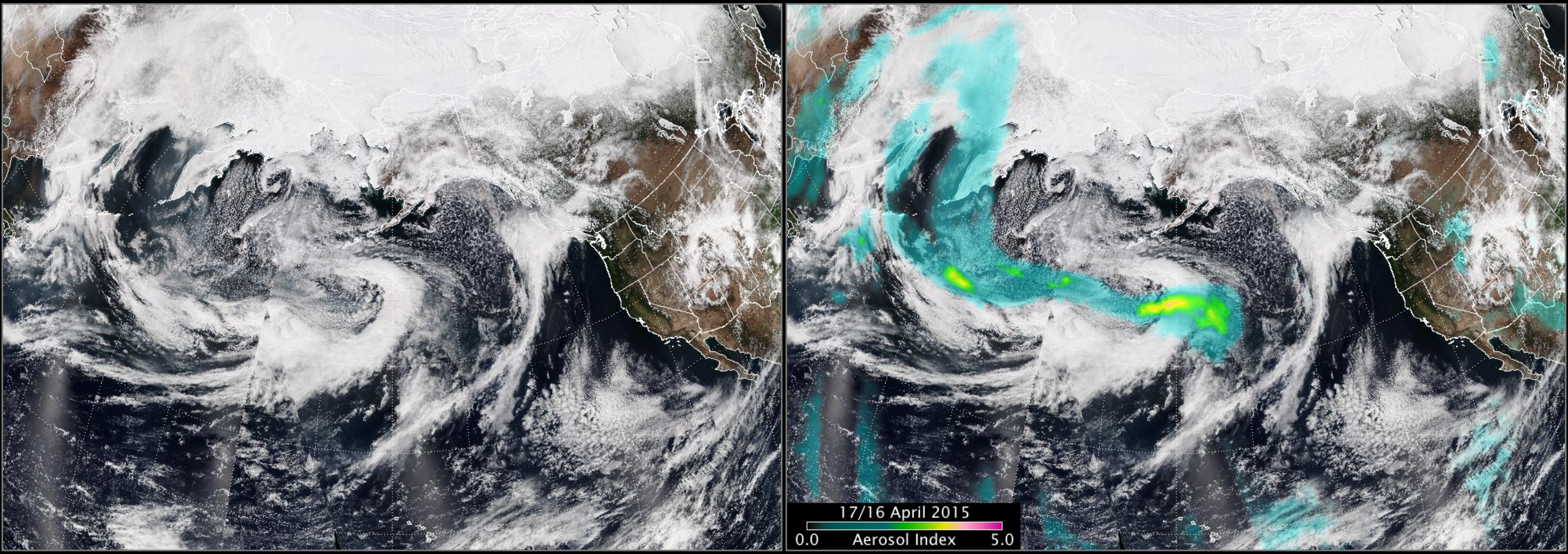




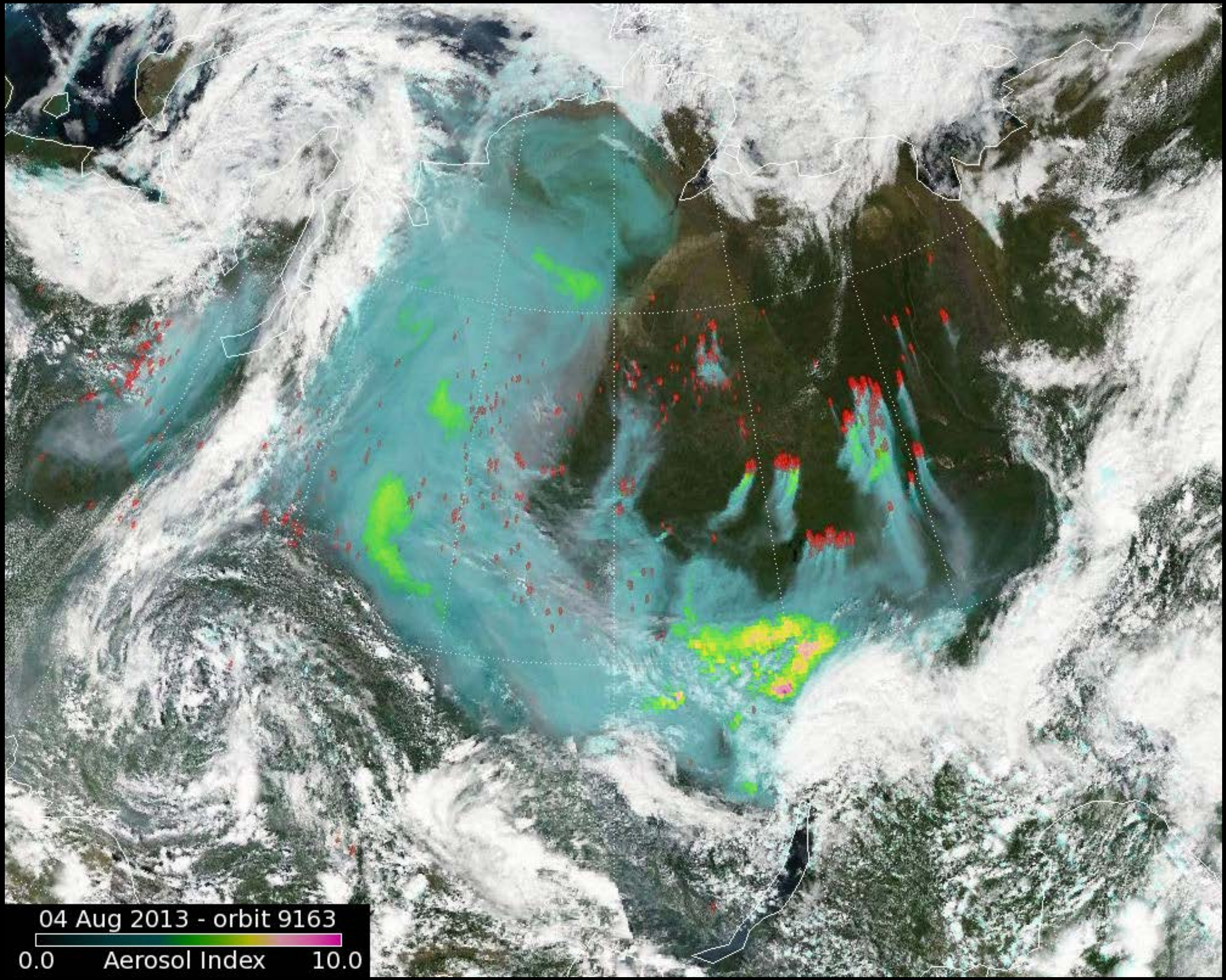
Transport of Alaskan Smoke to Greenland, Canadian Smoke to Europe



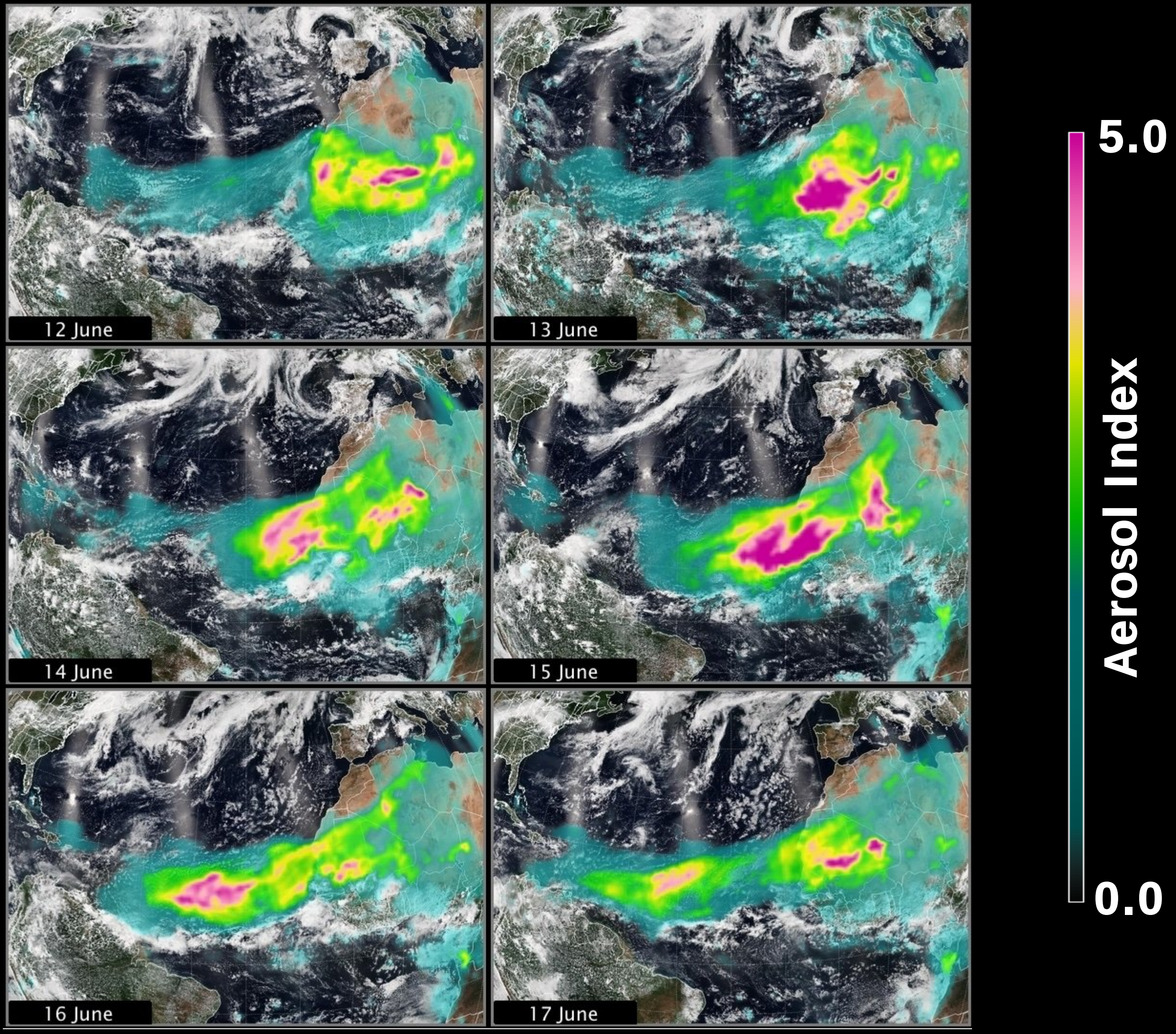
Transport of Russian Smoke Across Pacific (OMPS AI over VIIRS RGB)



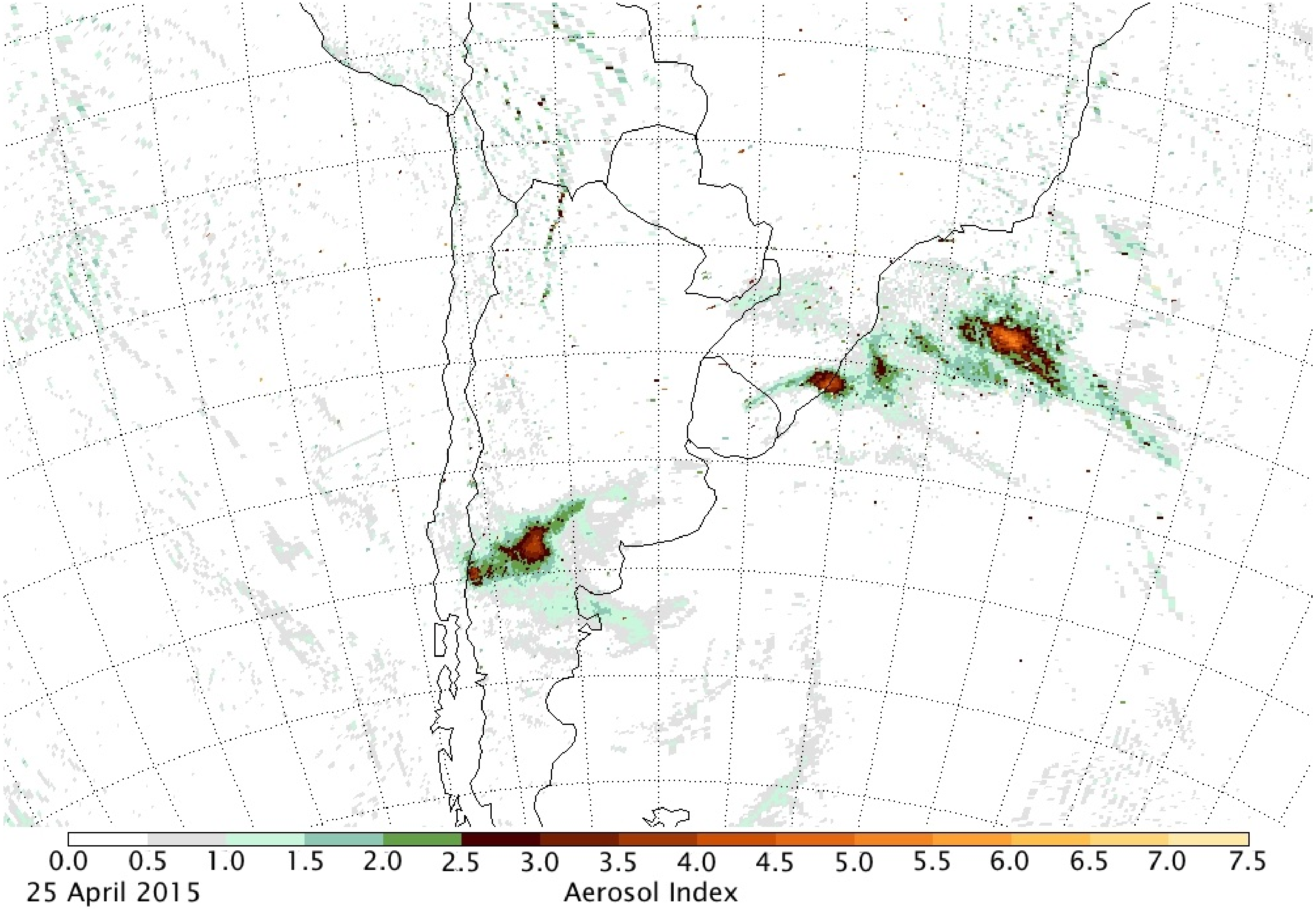
Smoke From Russian Fires
(Hi Res OMPS AIover MODIS RGB)



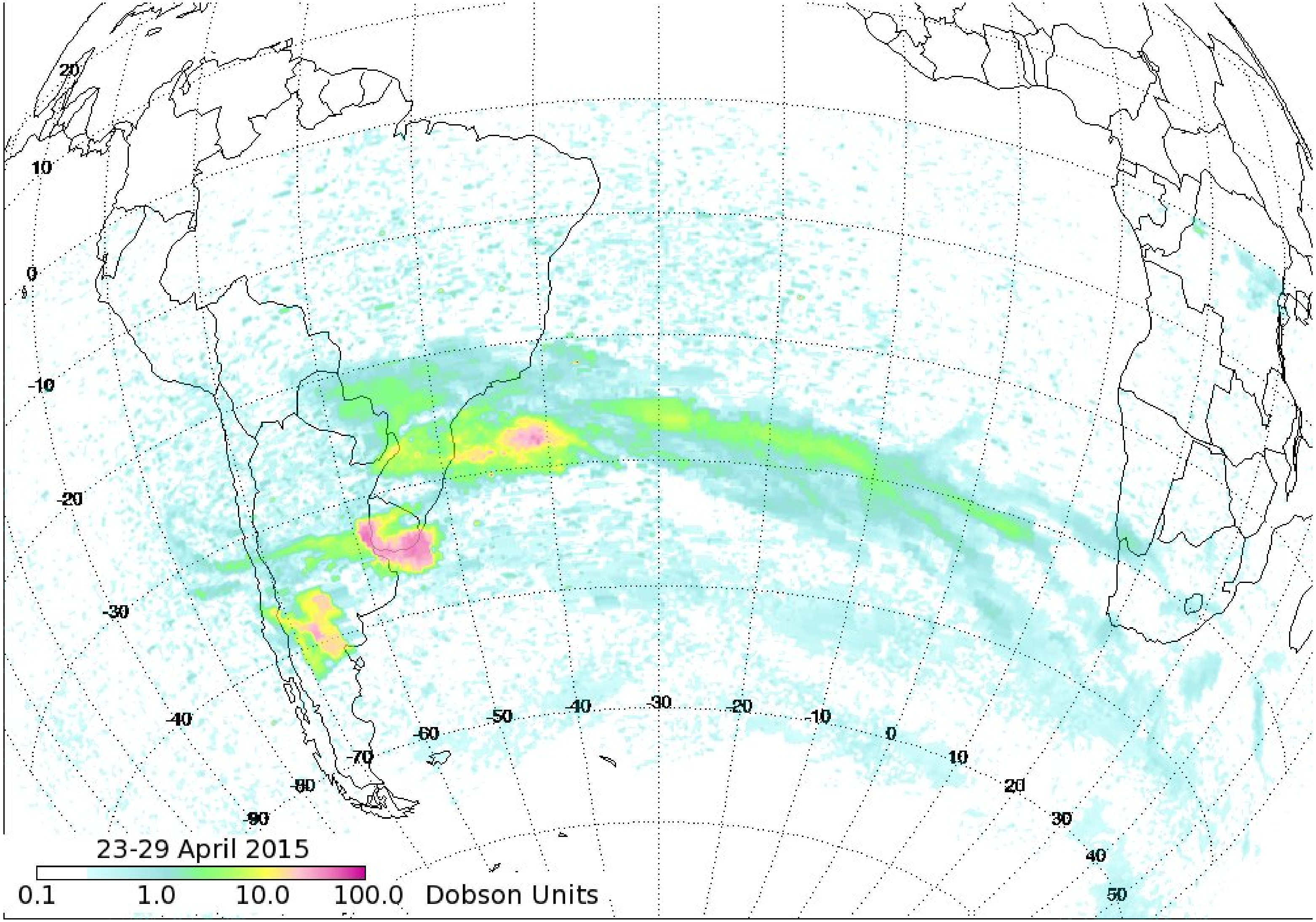
Saharan Dust Transport Across the Atlantic



Ash From Calbuco
(Two days after the eruption)



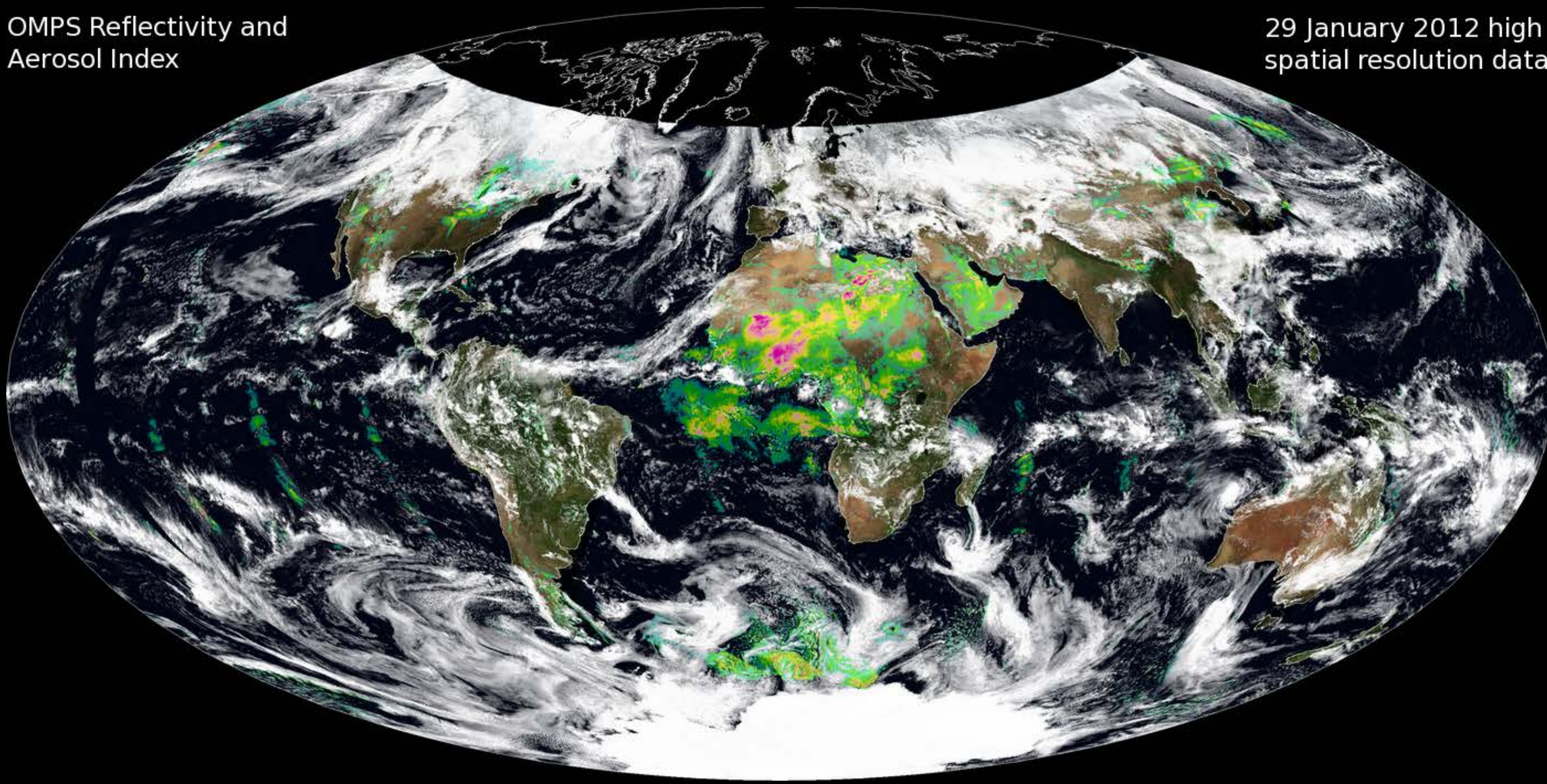
SO2 From Calbuco
(Compilation, 23-29 April 2015)



OMPS Reflectivity and Aerosol Index (Super High Resolution Mode – Single Pixel)

OMPS Reflectivity and Aerosol Index

29 January 2012 high spatial resolution data



GSICS Coordination Centre

Supported by JPSS Mission

Manik Bali and Lawrence E Flynn

Introduction

GSICS Coordination Center(GCC)

- ✓ *GSICS Quarterly Newsletter*
- ✓ *(3 Special Issues + 2 General)*
- ✓ *Meeting Support*
- ✓ *(User Workshop Shanghai)*
- ✓ *GPPA and Product Acceptance (Timeliness, WGCV).*
- ✓ *Definition of GSICS Products and Deliverables.*
- ✓ *Awards and Outreach (Call issued for awards)*
- ✓ *How good are GSICS References*

GCC and JPSS Mission

- ✓*OMPS EDR SDR*
- ✓*CrIS as a reference*
- ✓*ATMS- Inter comparison with MSU/AMSU***
- ✓*Selection of In-orbit References.*
- ✓ *VIS Integrated method to improve calibration accuracy from multiple vicarious method*
- ✓*SSU recalibration for CDR development.*

GSICS Data Working Group

- ✓ Past-Chaired the GDWG
- ✓ Satellite 'Instrument Event Logging
- ✓ Archiving GSICS Products.
- ✓ Evaluation of doi for GSICS Products
- ✓ MW metadata and filenaming conventions
- ✓ Support Lunar Calibration WS in Darmstadt (code sharing).
- ✓ Proposed Document Management plan to GSICS.

****Contributes to JPSS mission contributes towards JPSS goals and initiatives*****

OMPS CrIS ATMS

GSICS Global Space-based Inter-Calibration System

GCC – GSICS Quarterly Newsletter

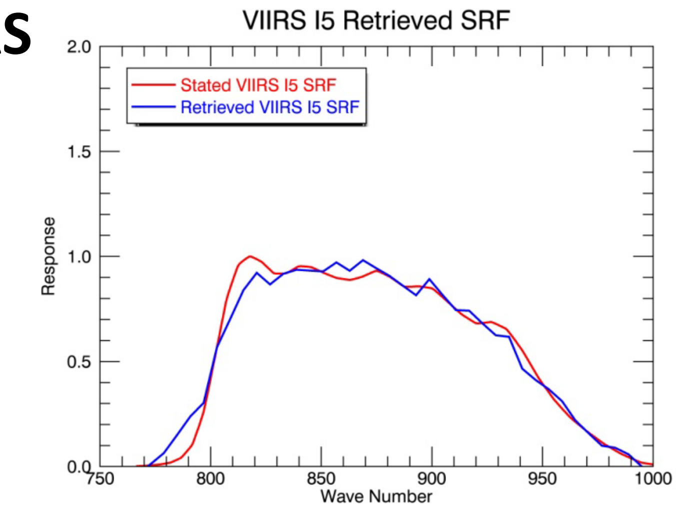
GSICS Quarterly Newsletter Features

- Since Fall 2013, brand new format .
- Since Winter 2014, the Newsletter has a doi.
- Accepts articles on topics related to calibration (Pre and Post launch).
- New Landing page on the GCC website.
- Rate and Comment section: readers and authors can interact.
- Articles are reviewed by subject experts
- Help available to non native English speaking contributors.
- Since Fall 2014, new navigation features added to the Cover Letter.

Journal of Physics and Chemistry of Earth invited Authors of GSICS Microwave issue to submit articles based on their submission to GSICS Newsletter .

Retrieval of Spectral Response Function using Hyper-Spectral Radiances

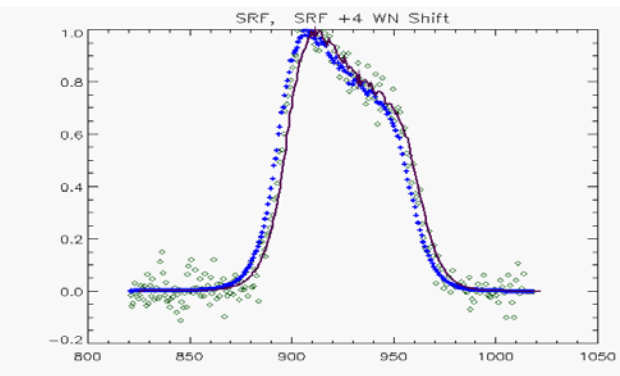
Developed a Method to retrieve spectral response functions using In-Orbit Inter- Comparison with CrIS/IASI/AIRS

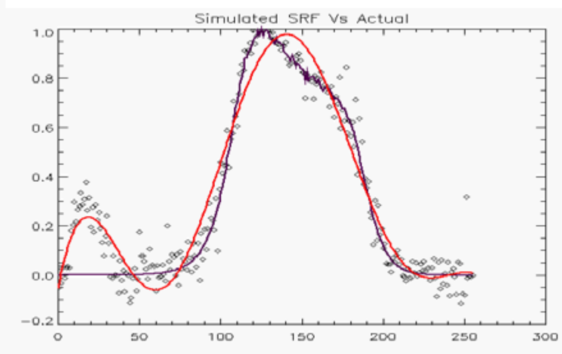


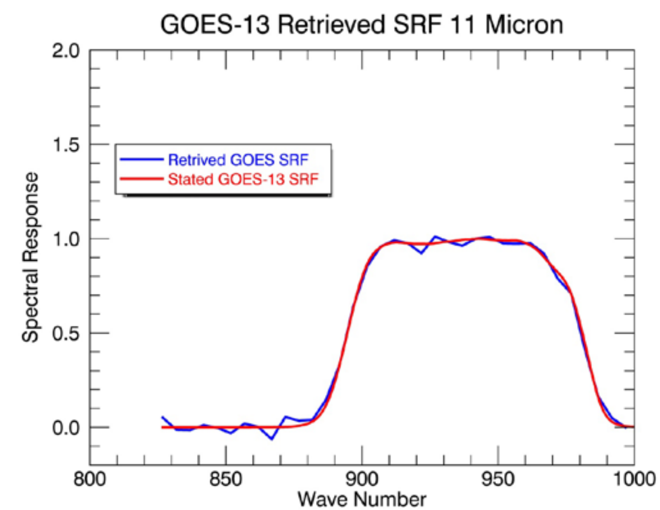
$$\begin{bmatrix} a_{1,1} & \cdots & a_{1,n} \\ \vdots & \ddots & \vdots \\ a_{n,1} & \cdots & a_{n,n} \end{bmatrix} \begin{bmatrix} x_1 \\ \vdots \\ x_n \end{bmatrix} = \begin{bmatrix} b_1 \\ \vdots \\ b_n \end{bmatrix}$$

SRF (b_i) = A^{-1} B

Validation







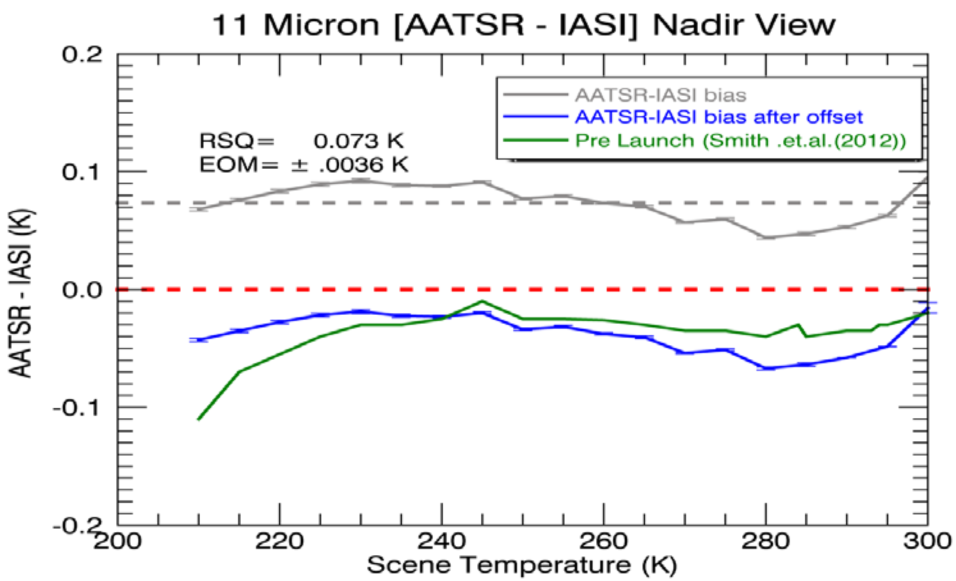
Method Detects shift and leaks in SRF

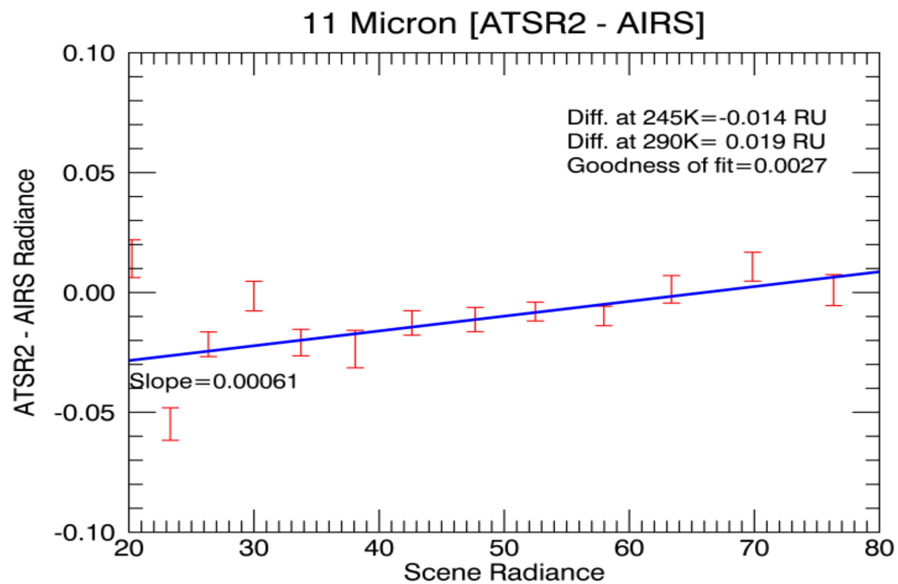
CrIS-VIIRS collocation data curtsey: Likun Wang

Global Space-based Inter-Calibration System

GCC- How good are GSICS References
IASI and AIRS

Study was done at GCC/NOAA to investigate the reliability of GSICS references instruments by comparing with extremely accurate instrument (A/ATSR , Climate Satellite by design).





Top left image shows that IASI and AIRS (right) are nearly as good as pre-launch references.
While the IASI has an offset of nearly 0.073K the AIRS seems the have an offset of nearly 0.
Bali, Mittaz, Goldberg, 2015, Submitted to AMT

IASI and AIRS nearly as good as Pre-Launch reference
Growing need to use instruments that yield climate scale corrections

GSICS Global Space-based Inter-Calibration System

Selection of Reference Instruments-Future Monitoring

GRWG

IR

AIRS
IASI A/B/C
Primary Ref*
CrIS*

Monitored instrument overlaps with spectrum of hyper-spectral instruments

MW

GP-X *
ATMS*
MSU AMSU
SSMI *

MW spectrum is large and not spanned by a single reference instrument. Multiple broad band instruments can be candidates.

UV

OMI*
GOME-2*

VIS

Aqua Modi+ DCC

Complexity of in-orbit Inter - comparision enhanced as by surface reflectance Solar Zenith Angle. viewing geometry impact A-B .

Stability of Transfer targets such as DCC, Desert kicks in instrument monitoring algo.

Diverse requirements across (even within subgroups)

Selecting Reference Instrument Process and a Scoring Scheme

Selection Process Reference for MW

A sub-group meeting is organized to identify instrument to be monitored

↓

Group wishes to monitor GPM satellites spread over a range of roughly 25S to 25N (for eg

↓

Group evaluates ATMS and SAPHIR.

↓

Group considers that SAPHIR are the first radiometers in the 183 GhZ in low inclination orbit (Wilheit)

→

Instrument info on OSCAR and NRT monitoring on ICVS is considered

↓

Despite not presenting global observations SAPHIR also scores higher because the intended goal is to inter-calibrate low inclination instruments. Input from scoring is considered.

On the other hand if goal would have been to monitor Polar instruments ATMS could have been a better choice.

OSCAR provides limited but critical information on instruments. (spectral, temporal and geographical coverage)

Detailed information is obtained via ATBD

Both SAPHIR and ATMS can score the same marks

...ene for GSICS Re-Analysis Correction for Meteosat Second Generation IR Channels

		Threshold		Saturation			MetopA/IASI				
		Min	Max	Min	Max	Weight	Min	Max	Compliant	%Perfect	Score
		1	1	1	1	1	1	1	Pass		
		013	2013	2006	2030	100	2007	2020	Pass	63%	63.4
		-10	10	-90	90	2	-90	90	Pass	100%	2.0
		-10	10	-180	180	2	-180	180	Pass	100%	2.0
		270	300	180	330	5	180	310	Pass	67%	3.3
		746	2564	650	2800	10	645	2760	Pass	92%	9.2
		5	15	0	90	2	0.5	55	Pass	72%	1.4
						0			Pass		0.0
						0			Pass		0.0
						0			Pass		0.0
						0			Pass		0.0
		9	10	0	12	5	7.8	11.2	Pass	36%	1.8
			300		3	1		12	Pass	97%	1.0
						0			Pass		0.0
		1		10000		5	30000		Pass		0.0
			10		0.1	10		3.3	Pass	68%	6.8
									Pass		0.0
Radiometric Stability	K/yr		1		0.001	10		0.05	Pass	95%	9.5
Orbital Stability	hr/yr		12		0.1	0		0.001	Pass	100%	0.0
Radiometric Noise	K		10		0.1	1		0.15	Pass	99%	1.0
Spectral Resolution	cm-1		100		0.5	10		0.25	Pass	100%	10.0
Spectral Stability	cm-1/yr		2		0.01	10		0.000002	Pass	100%	10.0
SBAF Uncertainty	K		1		0.001	0		0.15	Pass	85%	0.0
Absolute Calibration Acc	K		1		0.001	10		0.05	Pass	95%	9.5
Inter-channel calibration	K								Pass		0.0
Traceability									Fail		
Documentation									Pass		
Community adoption									Pass		
Total						**184**			**96%**	**71%**	**130.9**

More Stable and accurate references being explored For Eg. AMSU / MSU FCDR.

- *MW metadata and filenaming conventions*
- **NOAA GDWG in collaboration with MW former Chair Cheng-Zhi formulated the MW metadata and fileneming conventions for MW GSICS Products.**
- **The conventions were accepted by the GDWG members and would be put up on the wiki.**
- *Proposed Document Management plan to GSICS.*

  NOAA proposed to GSICS a Document Management Plan based on the DMS existing at NOAA library. Review of this plan underway

Summary

- GCC actively engaged in JPSS Instrument in-orbit calibration.
- GSICS Coordination Center leading efforts in In-Orbit Reference (radiance) Instrument Identification, Cross Calibration Product Maturity and Data Standardizations.
- Developed new technique to retrieve in-orbit SRF .