UV Projects for GSICS

L. Flynn

With contributions from NOAA, NASA, CMA, EuMetSat and other GSICS partners

See http://gsics.atmos.umd.edu/bin/view/Development/20170320 for recent GSICS Presentations

Using Version 8 Ozone Profile algorithm initial and final residuals to track calibration drift and estimate biases between instruments.

By L. Flynn, Z. Zhang & C.T. Beck

www.star.nesdis.noaa.gov/smcd/spb/OMPSDemo/

Outline

- Project Overview
- SBUV/2 CDR Example
- Drifting Orbit (SZA) Examples
- Operational Examples
- Radiance Comparison Ideas
- Contribution Function Equivalences

Initial Measurement Residual Project

The purpose of this project is to use initial measurement residuals from the Version 8 ozone profile retrieval algorithm to compare channels from 240 nm to 290 nm. (Note, this will require modification of the first guess creation to use consistent total ozone starting values as inputs.)

- Ascending/descending equivalent channel ideas will be used with hyperspectral measurements.
- Zonal mean and other matchup criteria will be used both to establish offsets and track relative drifts.
- Expand SBUV(/2) results to other sensors (OMPS, SBUS, OMI, GOME-2)
- Monitor time dependence for multiple instruments.

http://www.star.nesdis.noaa.gov/smcd/spb/OMPSDemo/proSBUV2released-2.php
http://www.star.nesdis.noaa.gov/smcd/spb/OMPSDemo/proOMPSbeta.O3PRO_V8.php

- Goals
  - Agreement at 2% for Profile channels by using the Version 8 *A Priori* Profiles with TOMRad Tables and single scattering.

Outline of an Approach for Comparisons of radiance/irradiance ratios from 240 nm to 300 nm

Double Difference using Climatology:

Compute the measurement residuals using a forward model with the effective scene reflectivity of the clouds and surface determined from longer channel measurements, and the ozone profile prescribed by the Version 8 *a priori* climatology. Use viewing geometries and bandpasses are as reported for each instrument.

Compare residuals for channels λ1 and λ2 where $S1*\alpha1 = S2*\alpha2$, where S values give the path lengths and α values give the ozone absorption cross sections. That is, works with pairs of wavelengths where the measurement contribution functions are similar.

Perform comparisons (statistical trade off in quantity of matchups vs. quality)

- Simultaneous nadir overpass matchups
- Zonal means (and No-local-time-difference zonal means)
- Opportunistic formation flying / Chasing orbits
- Benign geographic regions (e.g., Equatorial Pacific Box)
- Ascending/descending zonal means (In the Summer hemisphere, the same latitude is observed twice so one can obtain a set of internal comparisons.)

Forward model and measurements

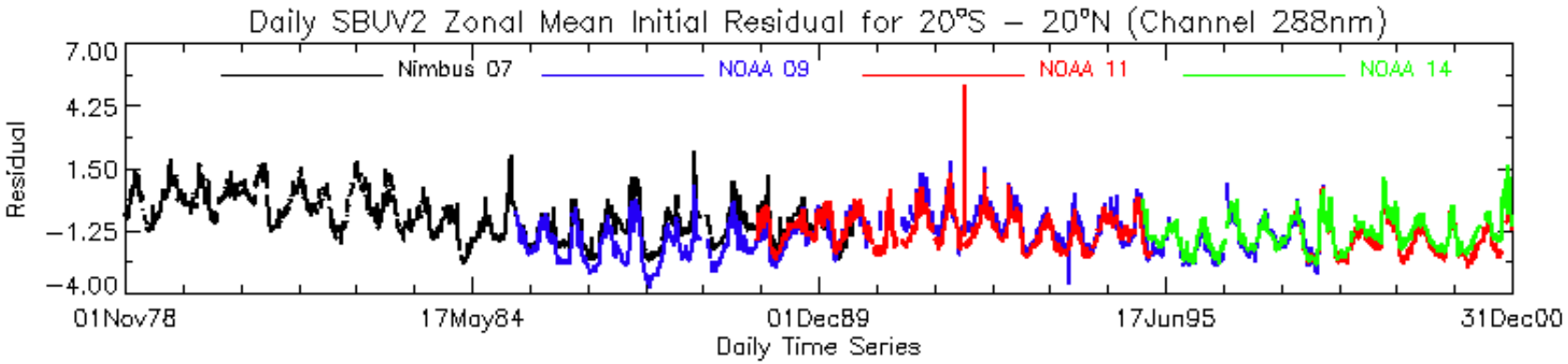
- V8 SBUV/2 forward model and *A Priori* as transfer for Viewing conditions

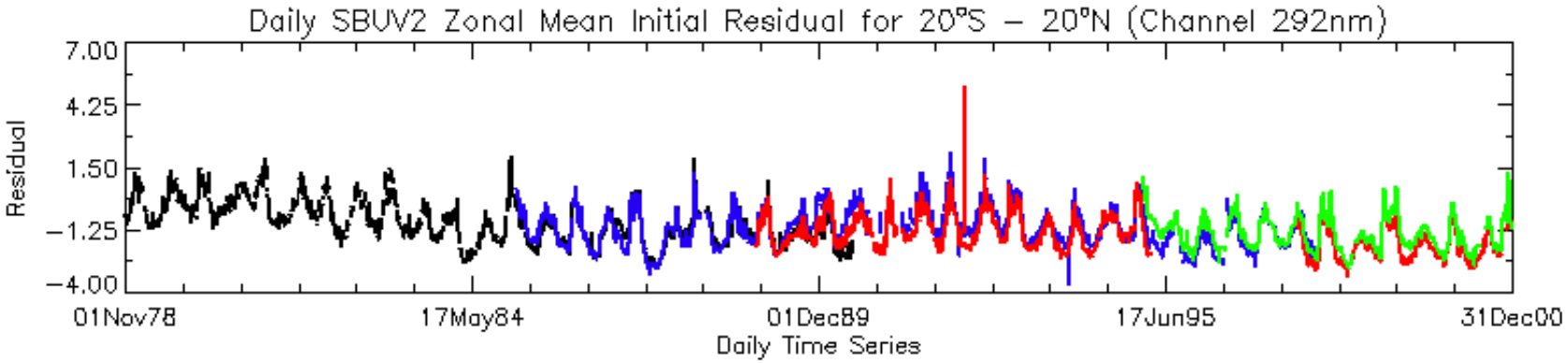
Complications from real diurnal variations in the ozone profiles

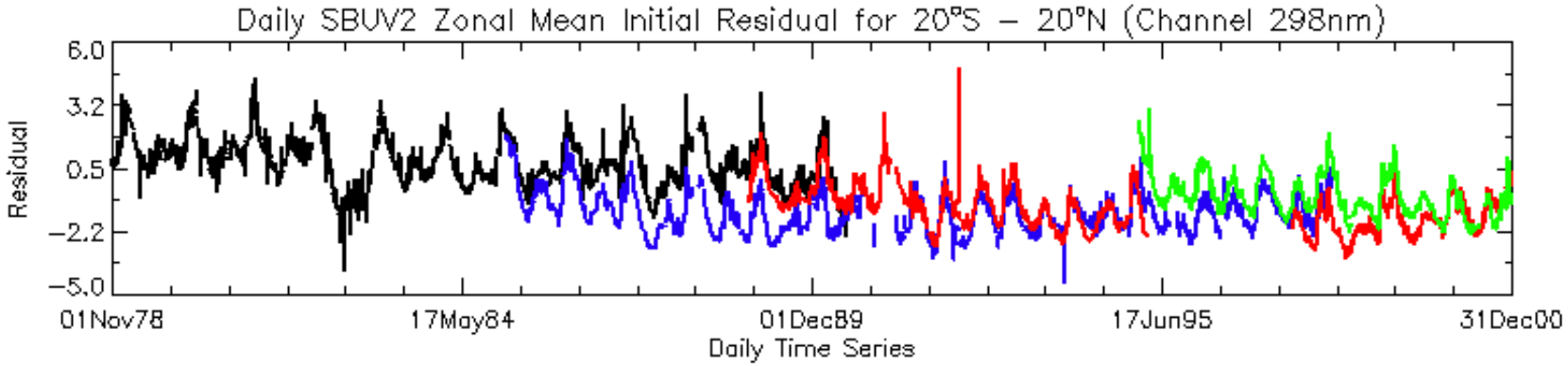
Complications if best ozone product values differ and initial residuals are used

Measurement residuals' correlation with scene reflectivity for longer wavelengths can disclose stray light contamination.

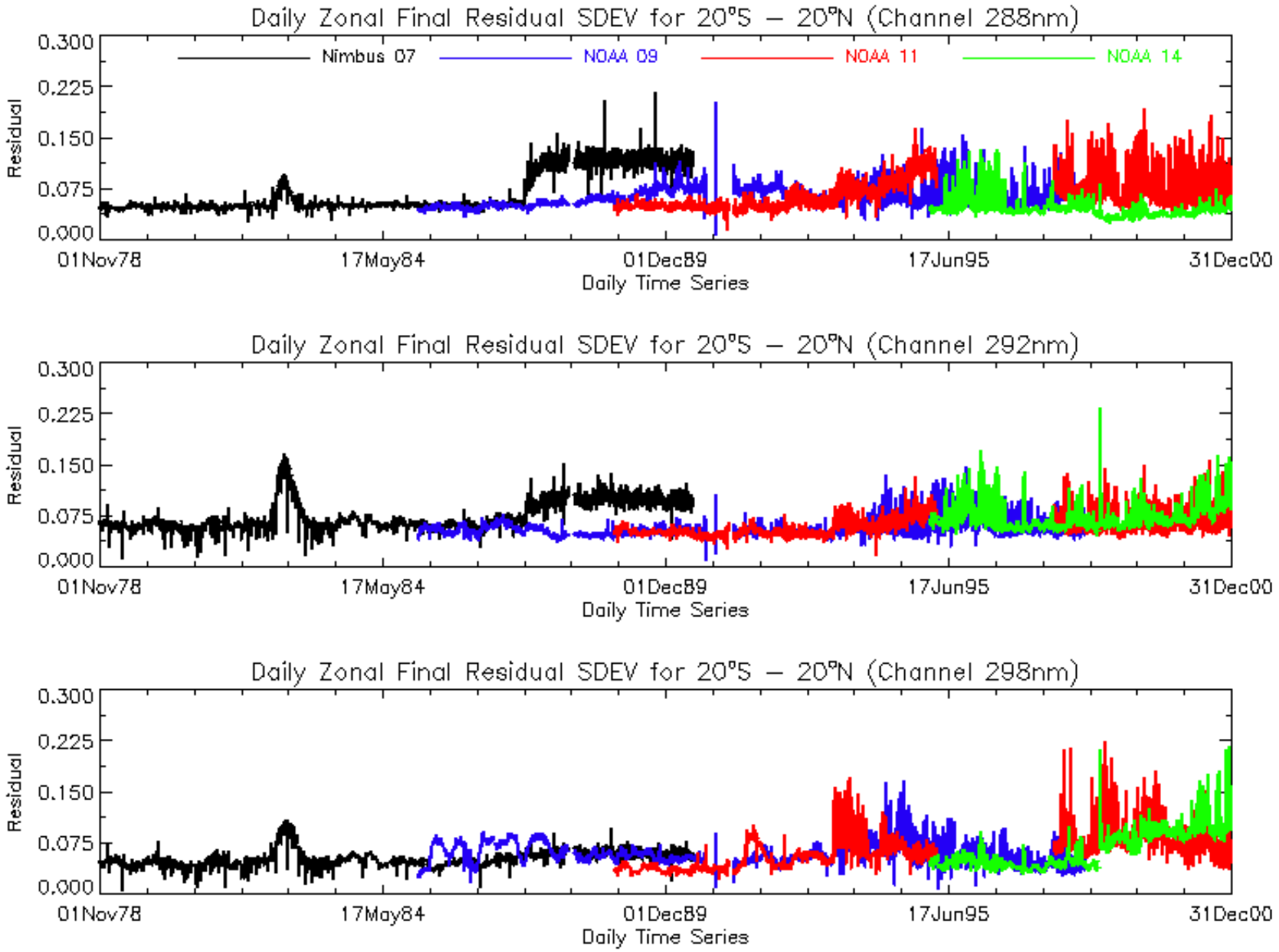
Long-term Inter-calibrated Initial Residuals for SBUV/2



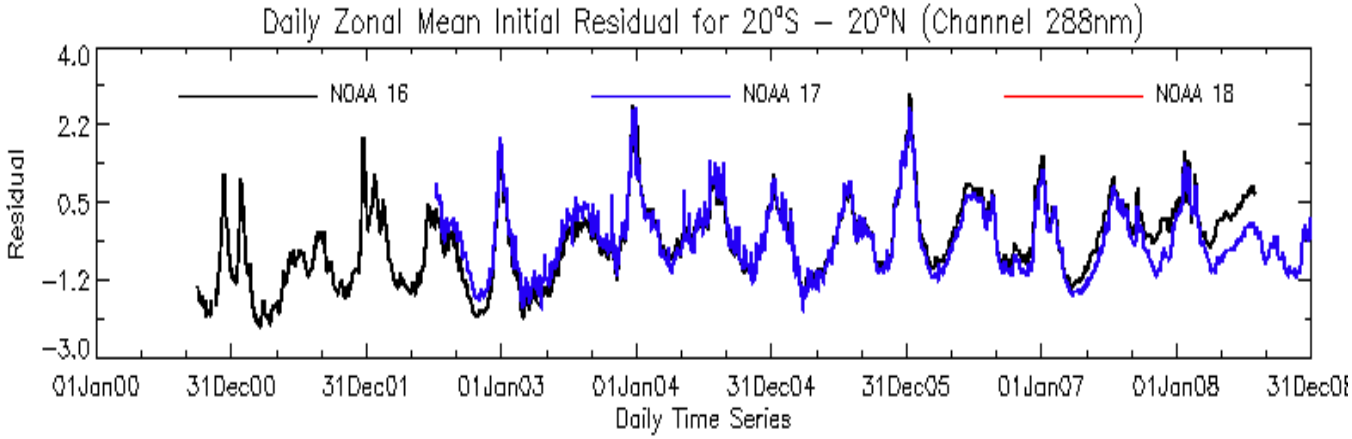


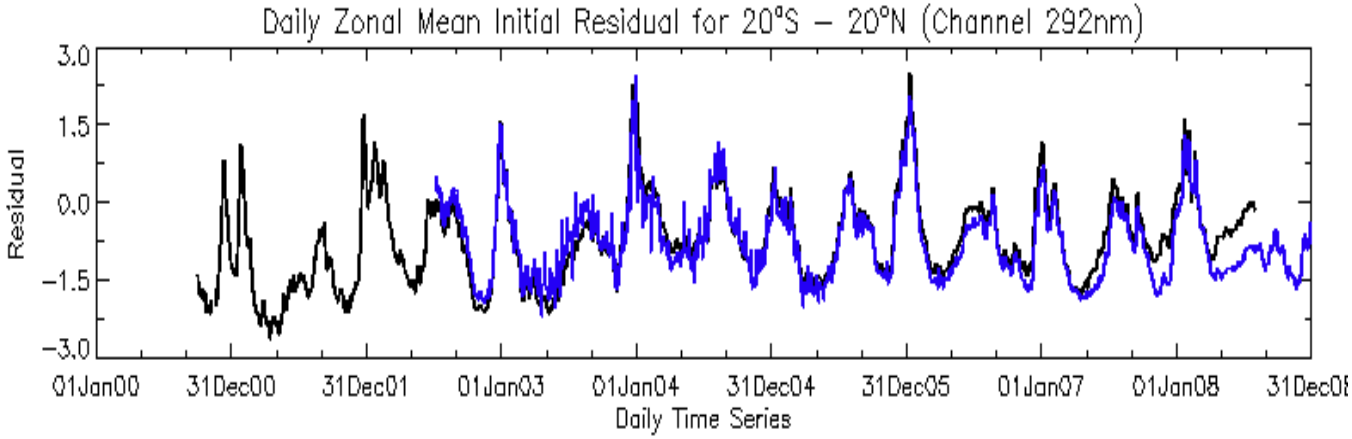


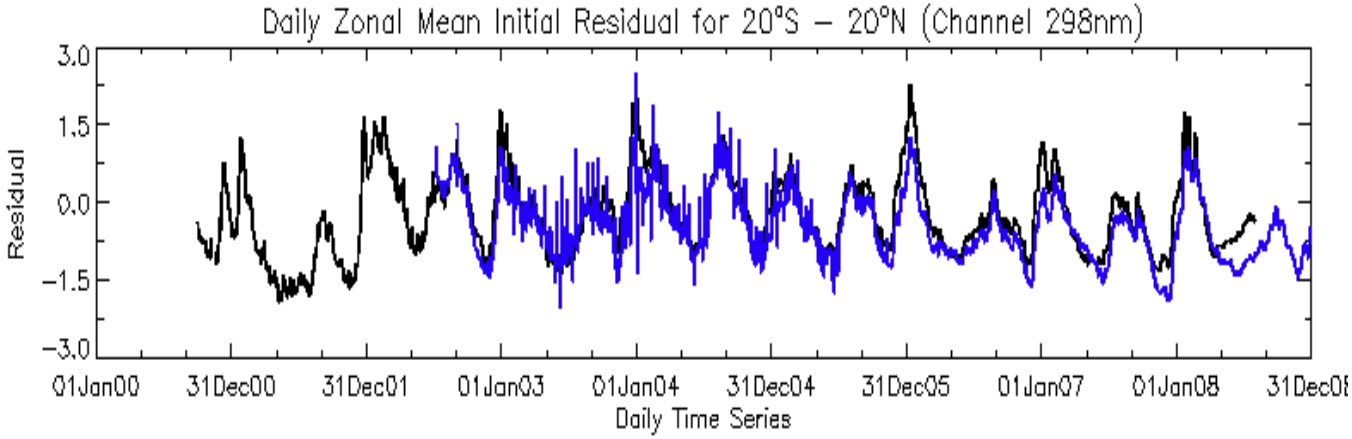
Long-term Inter-calibrated Final Residuals for SBUV/2



Inter-calibrated Initial Residuals for SBUV/2 with SZA Drift

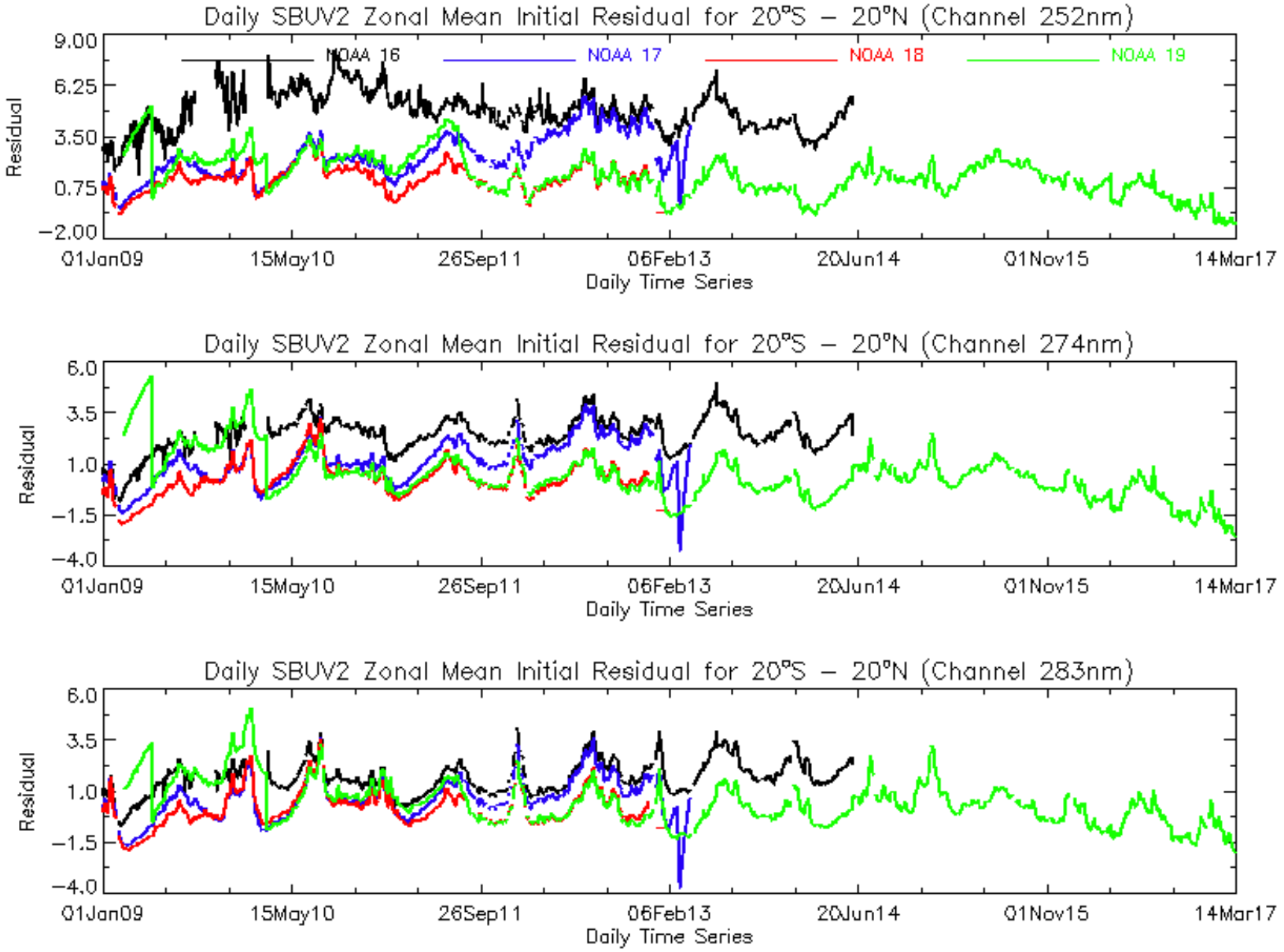




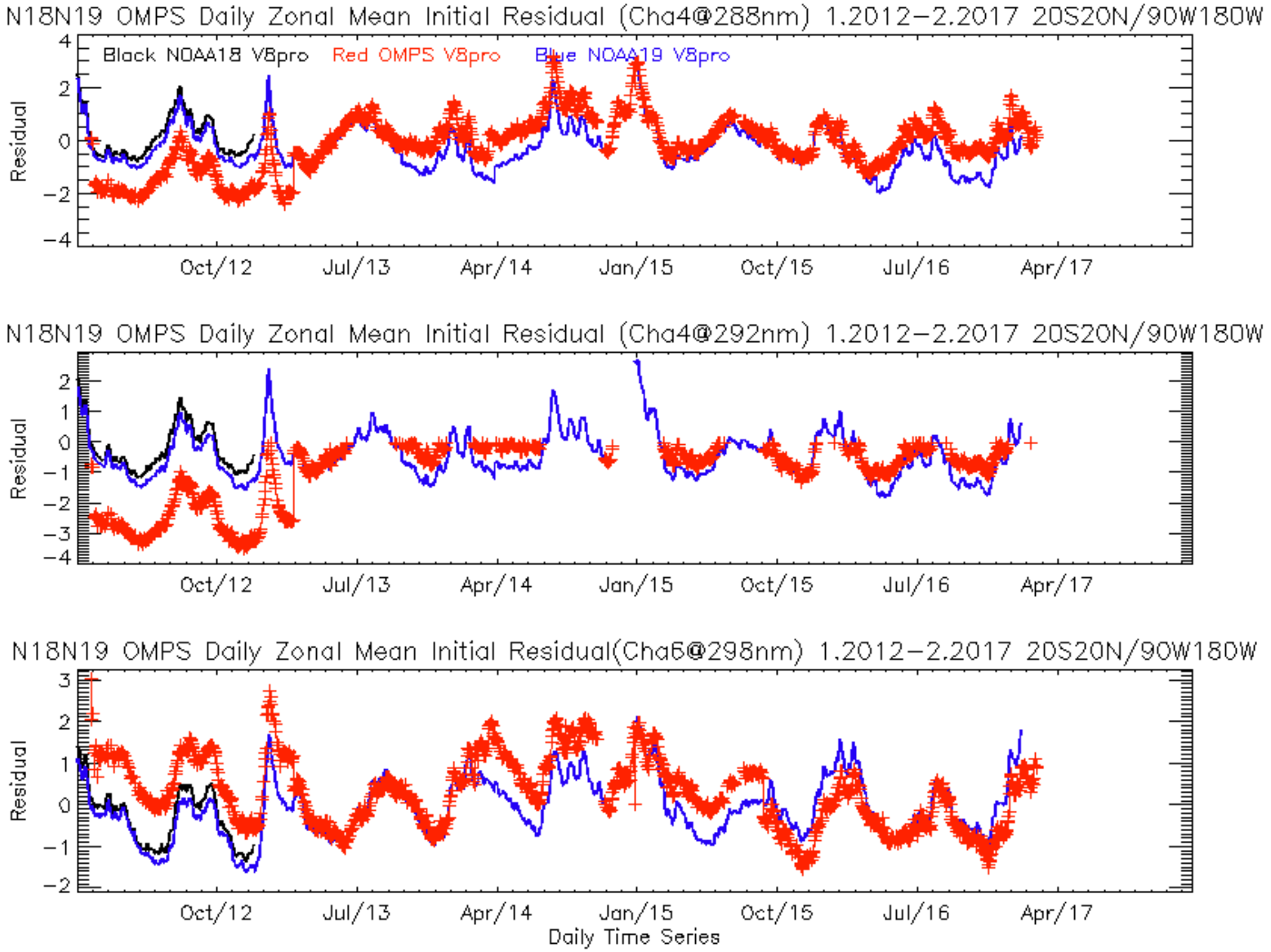


The figures show the initial measurement residuals for three profile wavelengths (Top 288 nm, Middle 292 nm, and Bottom 298 nm) for the V8PRO product for the equatorial daily zonal means (20N to 20S). The two sets of data are for the NOAA-16 SBUV/2 and the NOAA-17 SBUV/2. The units are N-values (~2.3%). The Version 8 algorithm a priori ozone profiles and forward model have been used to allow direct comparison of the radiance/irradiance ratios for the two instruments. NOAA-16 was an afternoon satellite and NOAA-17 was a morning satellite during this period. By the end of the record, the NOAA-16 satellite was in a late afternoon orbit.

Operational Initial Residuals for SBUV/2 with SZA Drift and Calibration Adjustments

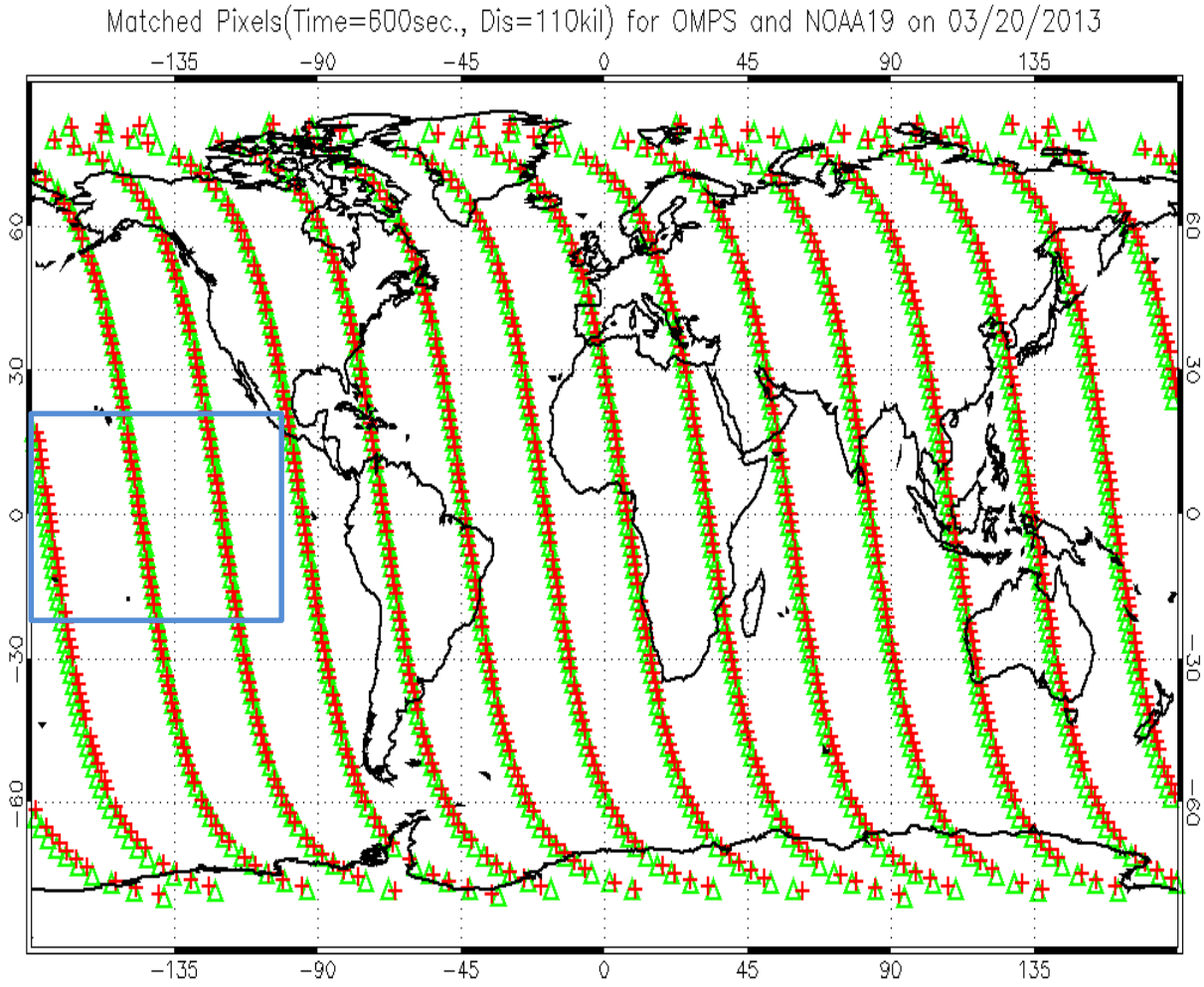


Operational Initial Residuals for SBUV/2 & OMPS with Operational Adjustments

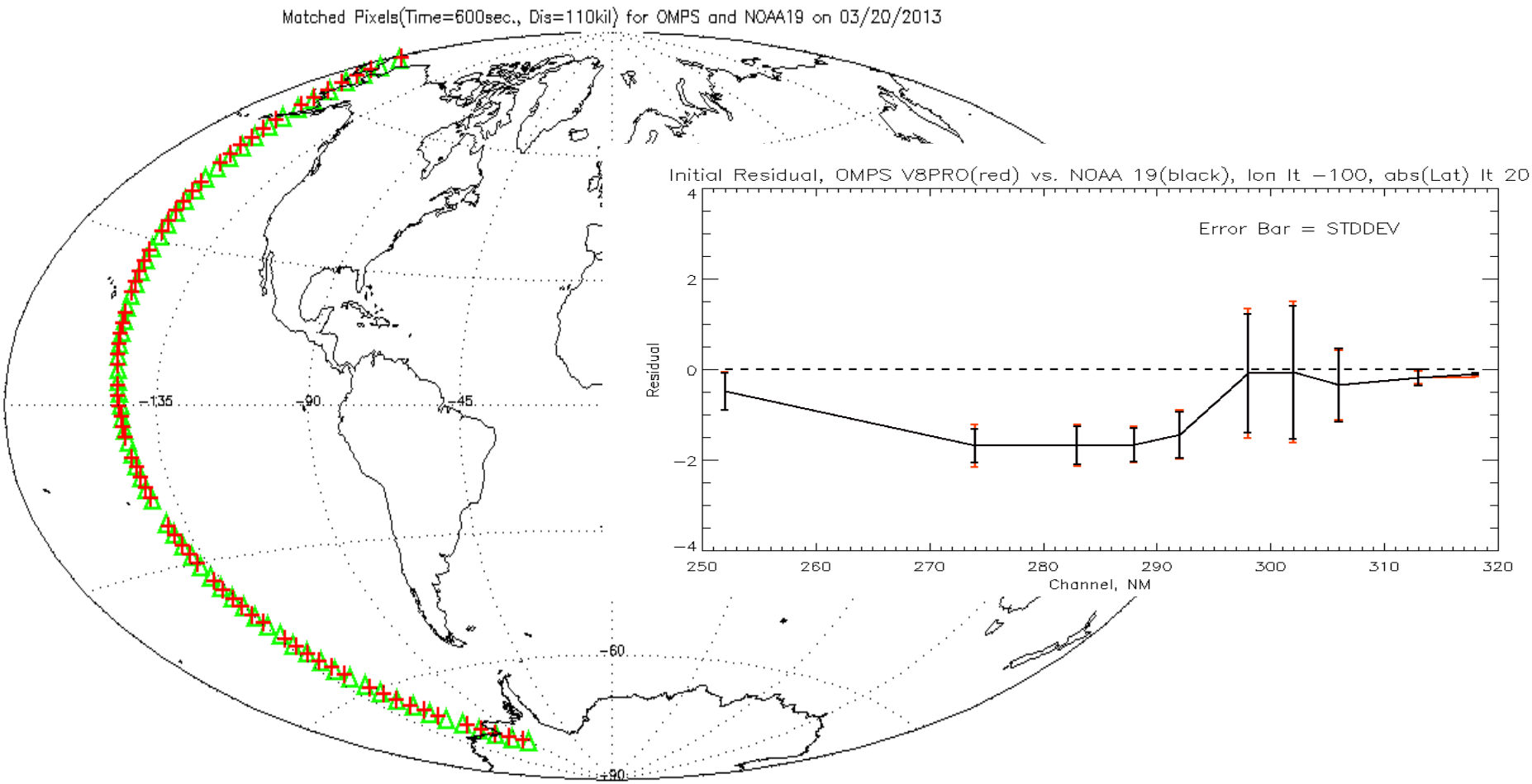


Adjusting STAR re-processed V8PRO to N19 SBUV/2

Region of retrieval for generating adjustments



Matching orbit on 3/20/2013 for S-NPP OMPS and NOAA-19 SBUV/2

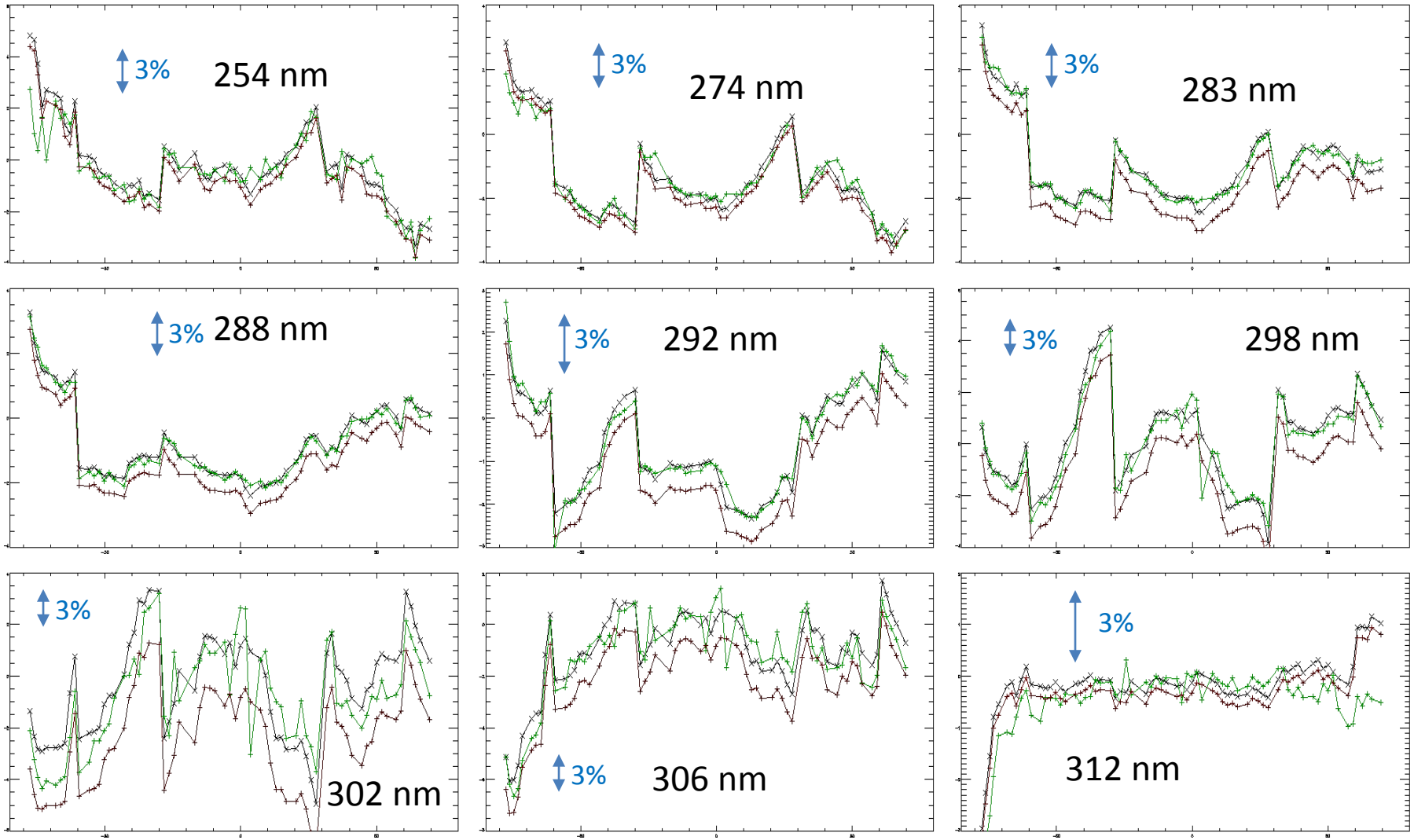


V8Pro Initial Residuals along Chasing Orbit

Red and Black OMPS (Before and After), Green SBUV/2.

Jumps at 30N/S and 60 N/S where climatologies switch latitude bins.

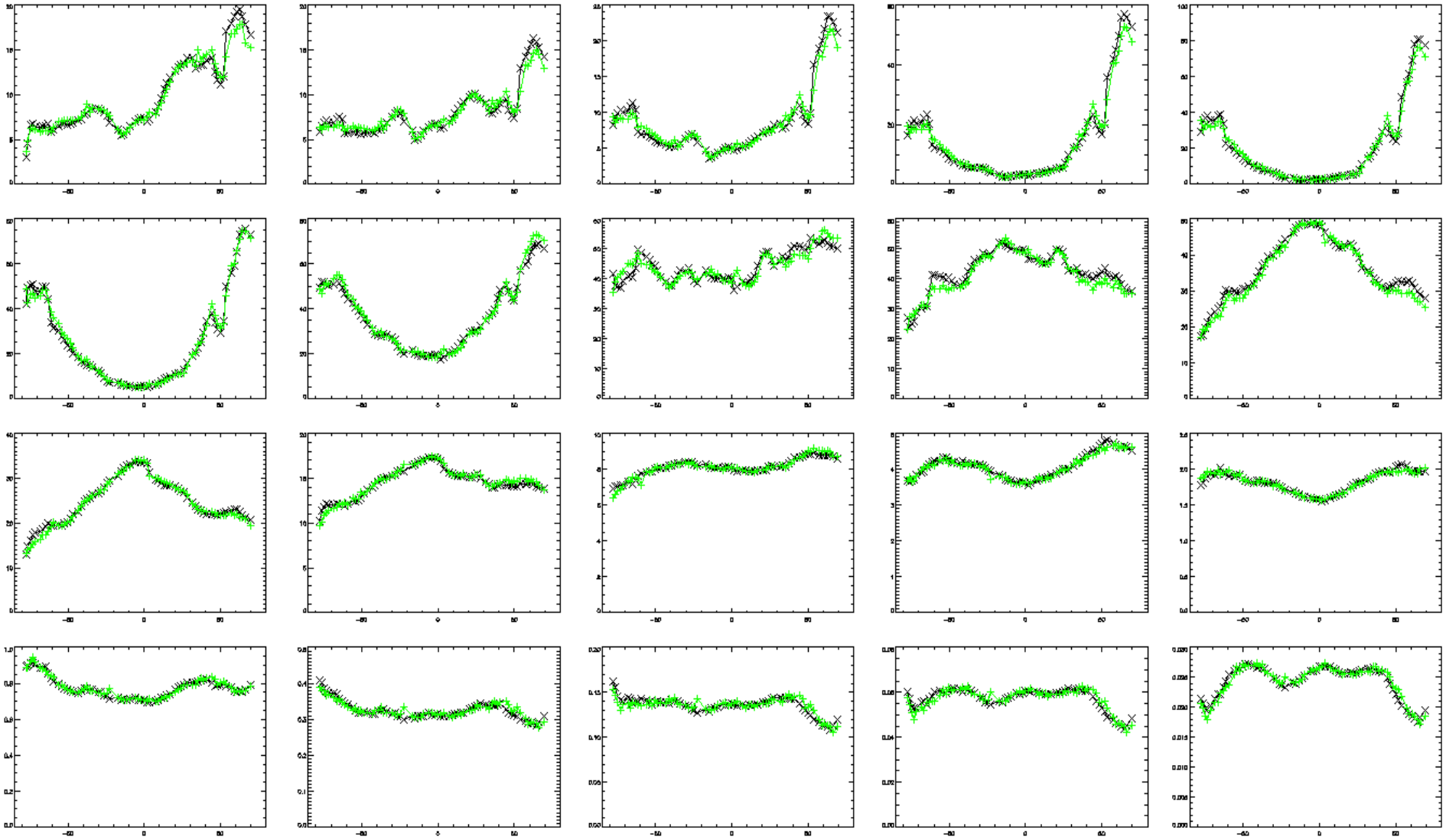
Adjustments: 254 0.4; 274 0.3; 283 0.6; 288 0.5; 292 0.5; 298 1.1; 302 2.3; 306 1.3; 312 0.3



Changes at 30N/S and 60N/S are changes in profile climatologies.

V8Pro Layer Ozone, Bottom to Top

Bottom to top, Black OMPS (After) and Green SBUV/2.



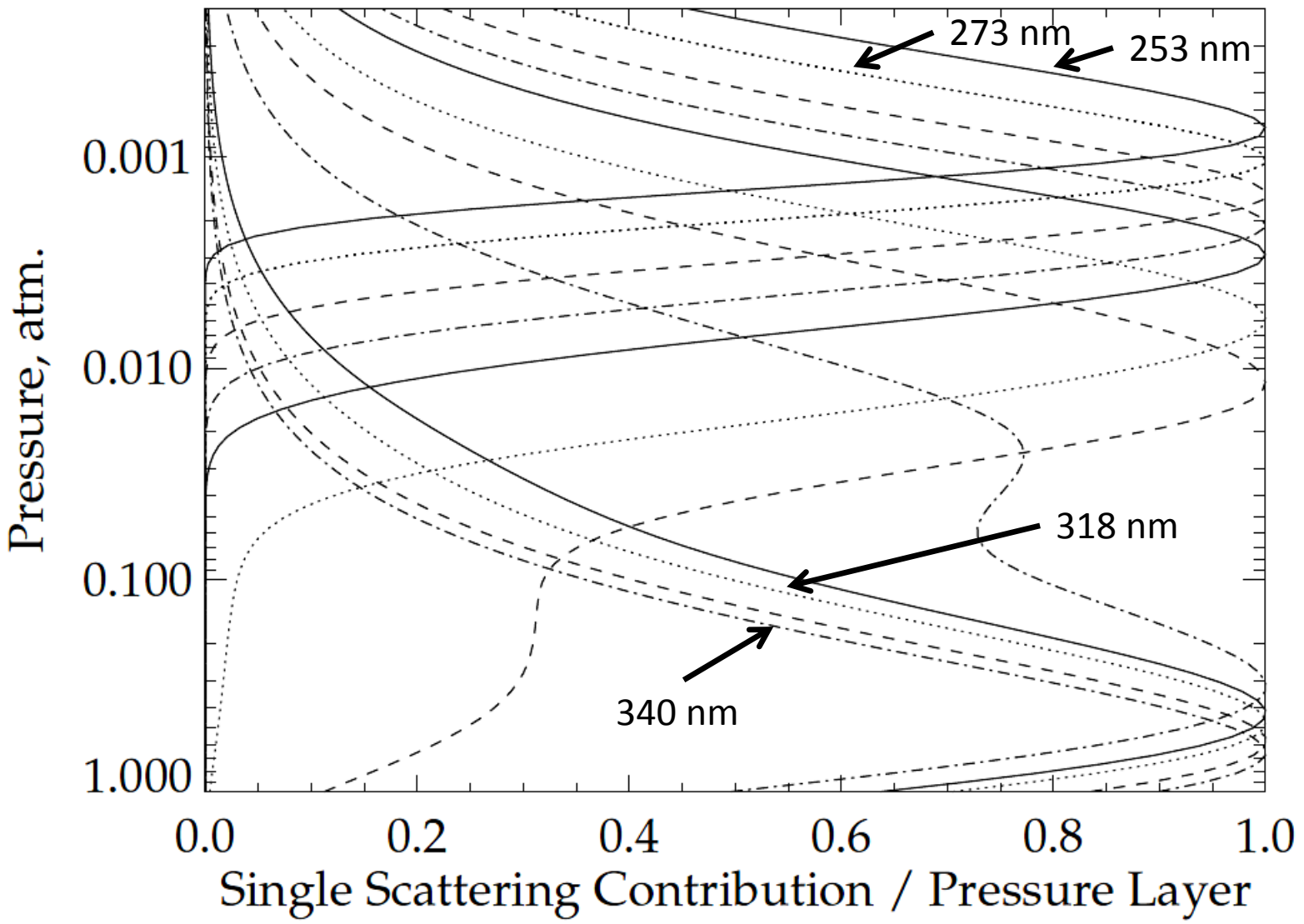


Figure 6.a. Normalized Single Scattering Contribution Functions for 12 wavelengths at [253,273,283,288,292,297,302,306,313,318,331,340] nm for a 325 DU total column ozone profile for Solar Zenith Angle θ_0 = 30°.

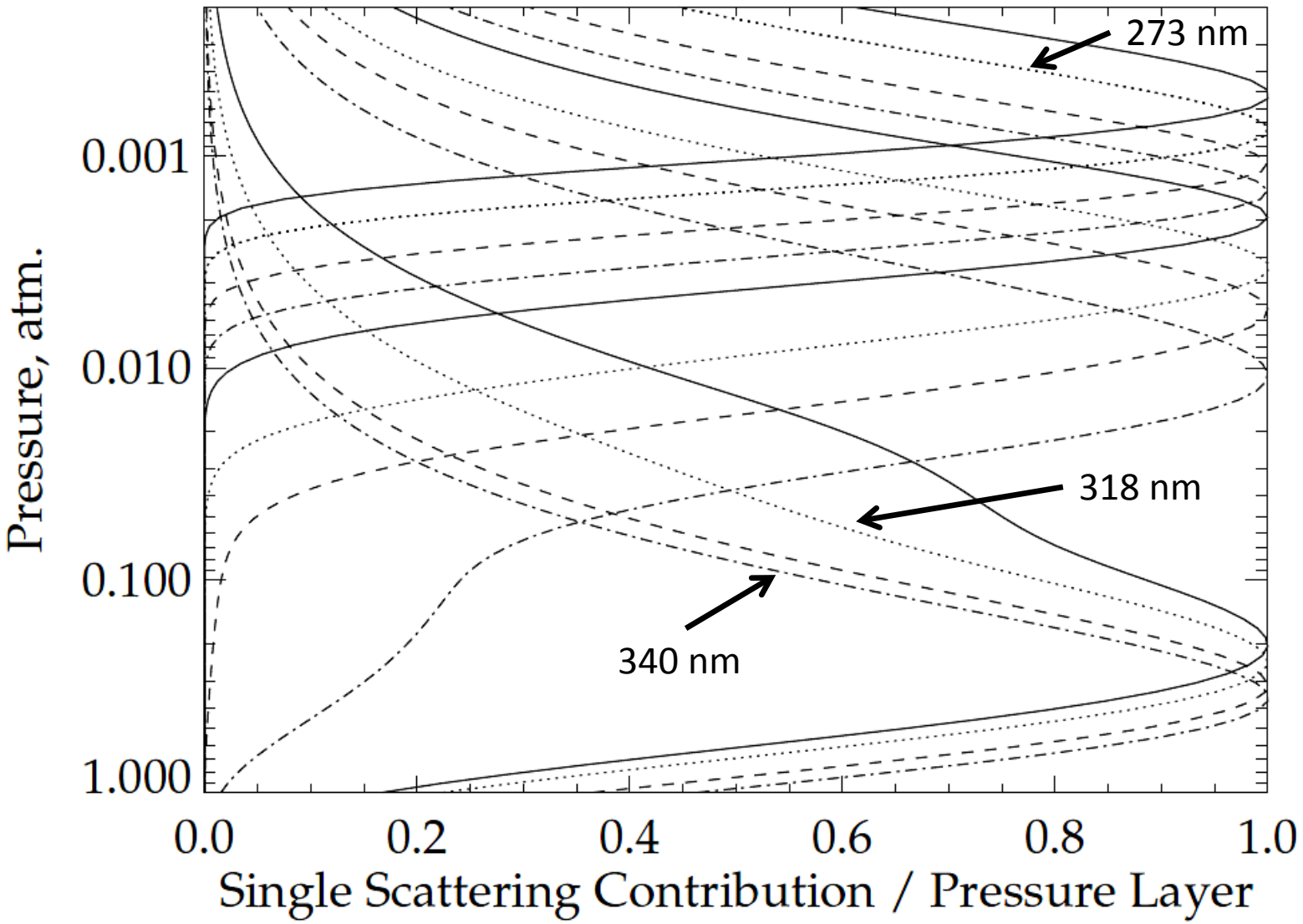


Figure 6.b. Normalized Single Scattering Contribution Functions for 12 wavelengths at [253,273,283,288,292,297,302,306,313,318,331,340] nm for a 325 DU total column ozone profile for Solar Zenith Angle θ_0 = 70°.

Pseudo-Channels in the UV from 250 nm to 300 nm

- As the SZA or SVA increases, the contribution functions shift up. One can find combinations (linear?) of radiances for longer channels that can represent (capture the response to ozone changes) a measurement at a shorter channel at SZA=0 and SVA=0. (MW Pseudo-Channel Ideas)
- We can compare instruments measuring at different viewing geometries or times of day.
- This can help to determine both internal and external biases.
- Diurnal ozone variations will present an involved complication.
- Changing channel emphasis can introduce wavelength-dependent biases.

Summary, Questions and Future

- Initial measurement residuals can identify calibration biases between instruments.
- Provide tools to create initial residuals for other instruments.
- Expand and formalize matchup techniques.
- Reprocess and Homogenize NOAA-16 through NOAA-19 SBUV/2 and OMPS NP for a post-2000 Ozone Profile CDR.
- Create invariant channel combinations under SZA & SVA changes.

Backup Slides

- Ascending/Descending

https://ntrs.nasa.gov/search.jsp?R=19950044660

-

Adjustments using A, K, and Dy

The Averaging Kernel, A, is the product of the Jacobian of partial derivatives of the measurements with respect to the ozone profile layers, K, and the measurement retrieval contribution function, Dy:

$$A = Dy \# K$$

For a linear problem, the retrieved profile, Xr, is the sum of the A Priori Profile, Xa, plus the product of the Averaging Kernel, A, times the difference between the Truth Profile, Xt, and Xa:

$$Xr = Xa + A \# [Xt - Xa]$$

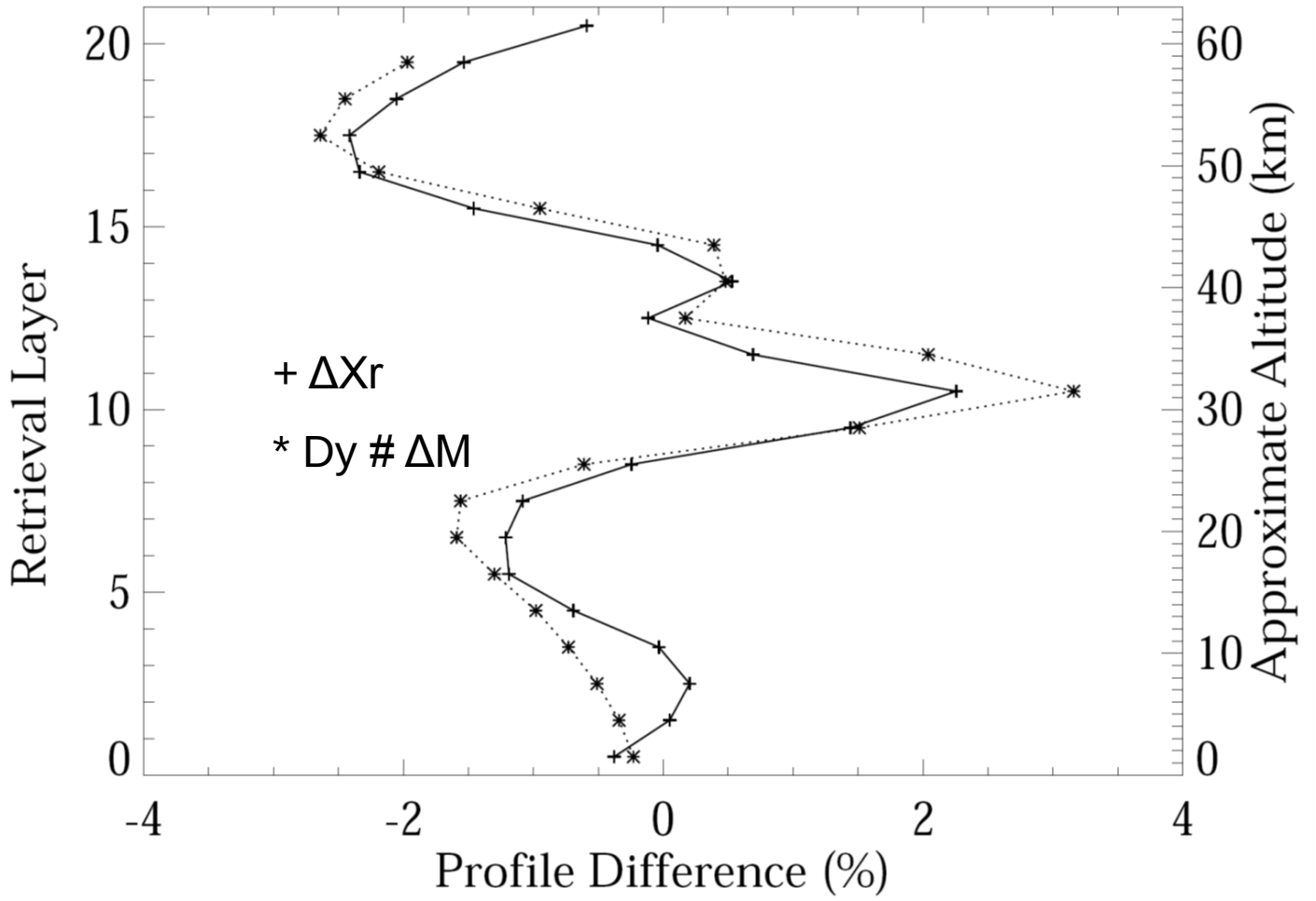
The measurement change, ΔM, is the Jacobian times a profile change, ΔX:

$$\Delta M = K \# \Delta X$$

The retrieval change, ΔXr, is the contribution function times a measurement change, ΔM:

$$\Delta Xr = Dy \# \Delta M$$

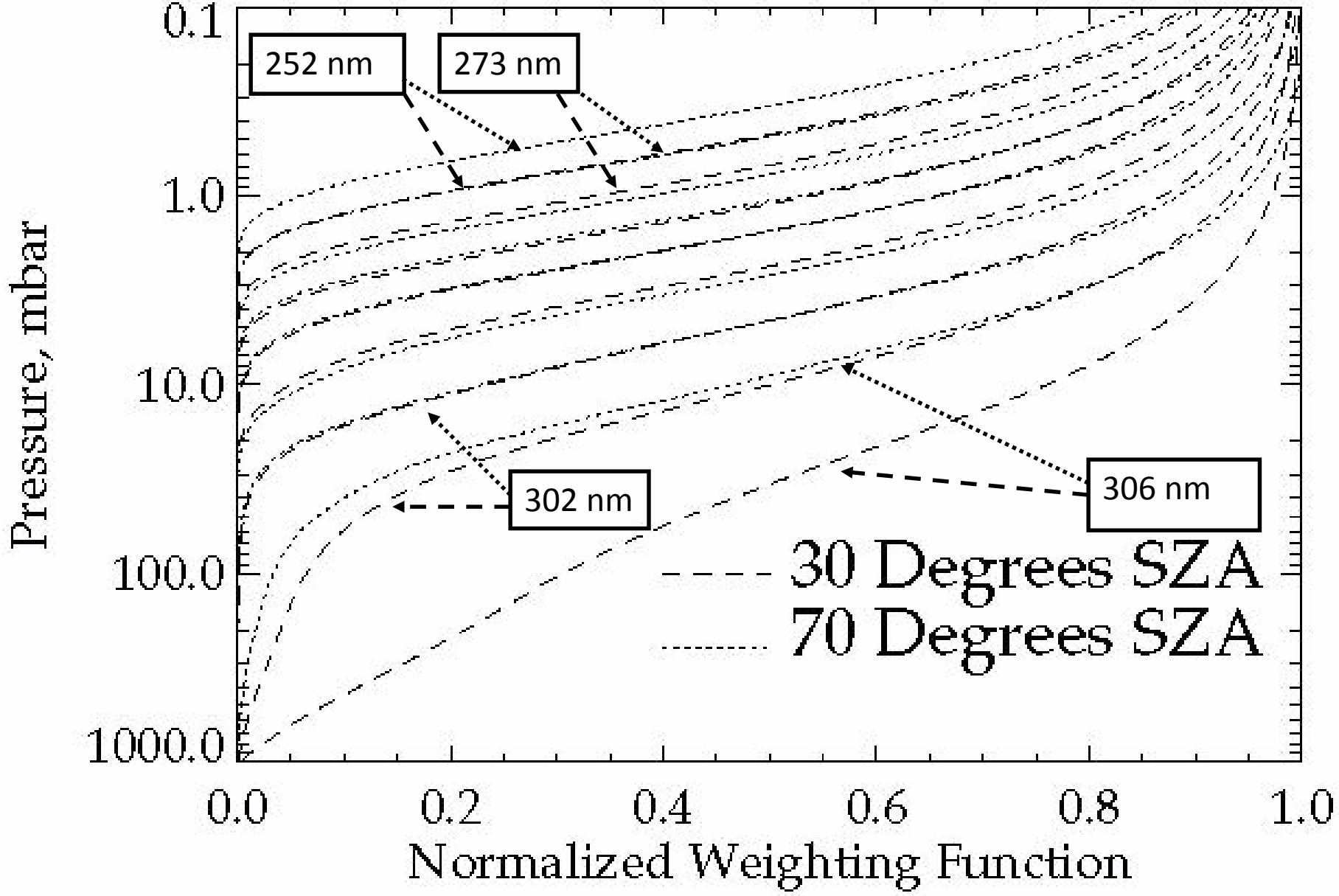
$$\mathbf{D_y = S_a K_a^T \left[K_a S_a K_a^T + S_M \right]^{-1}}$$



Comparison of actual differences in annual tropical zonal mean profiles retrieved by NOAA-16 and NOAA-17 SBUV/2 for 2003 with those predicted by the differences in their initial residuals. The "+" symbols are Δ**Xr** computed directly and the * symbols are **Dy** Δ**M**.

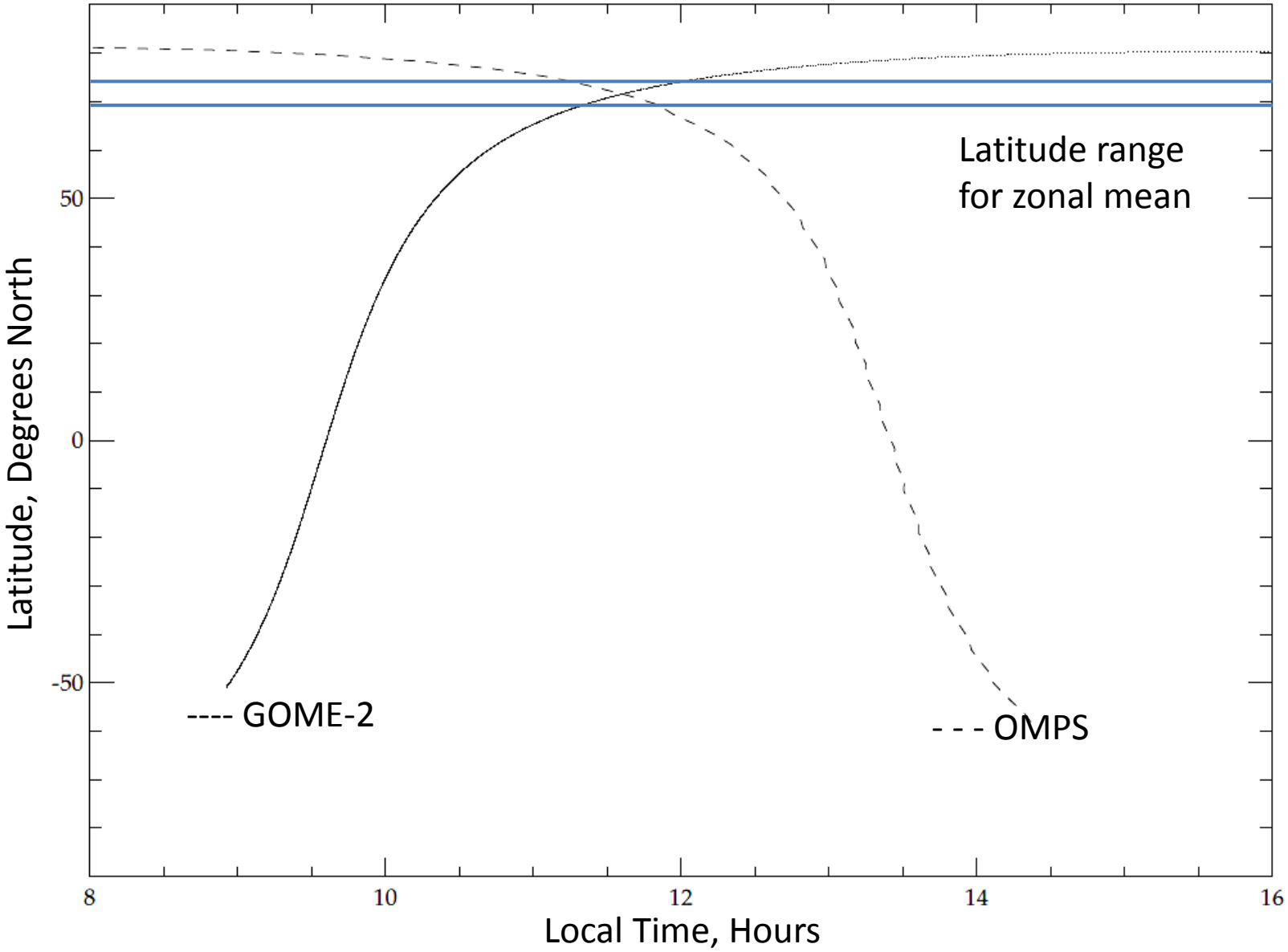
Comparison Considerations

- Different spectral and spatial resolution
  - Forward models can remove these dependencies
- Chasing orbits
  - If orbital periods are slightly off, then beat frequency matchups are better.
- SNO for AM with PM (+product comparisons?)
  - No-local-time difference zonal means
- Asc/Desc Langley –> S1*alpha1 = S2*alpha2

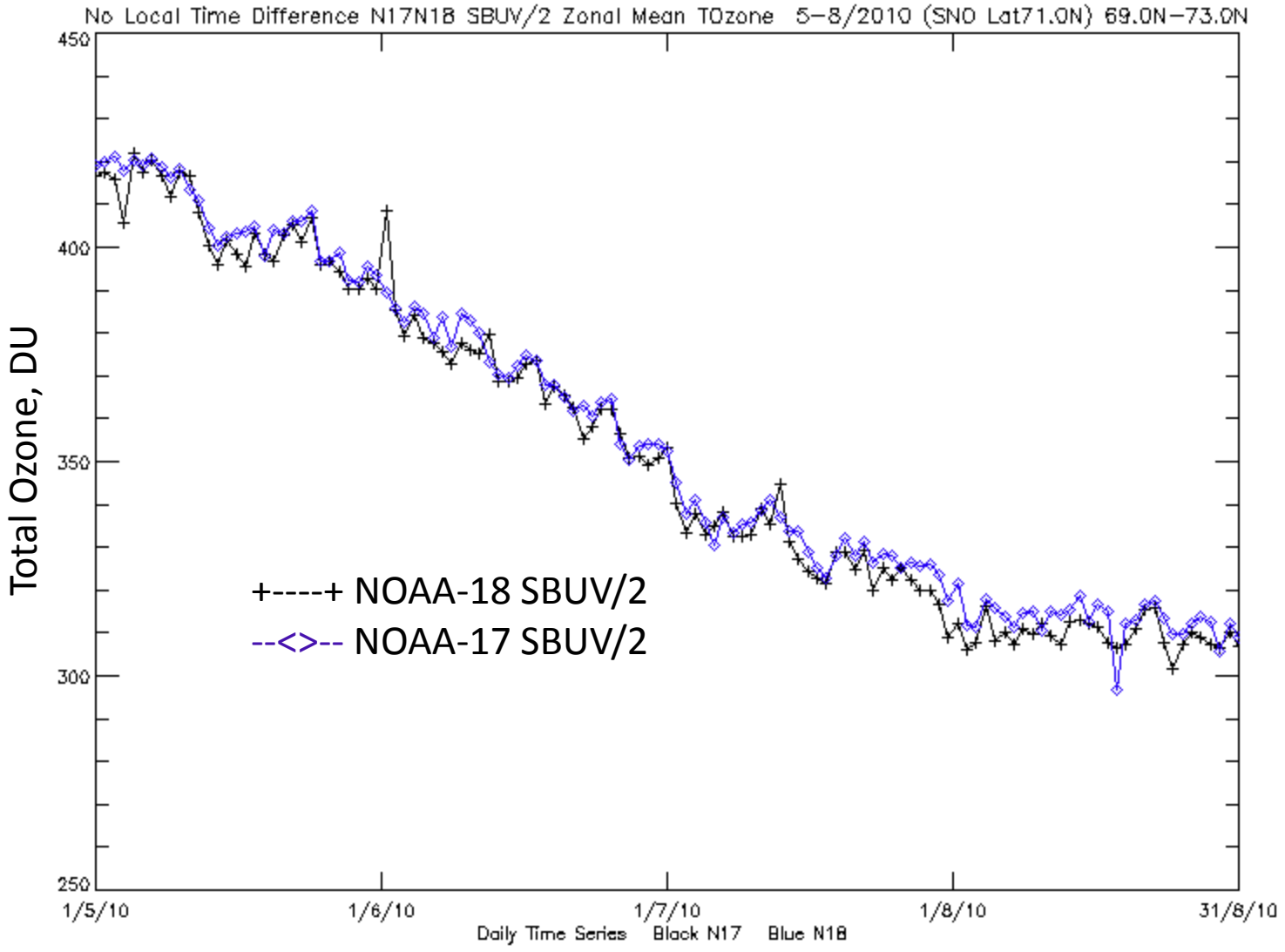


S1*α1 = S2* α2, Si = 1 + sec(SZAi) for nadir viewing

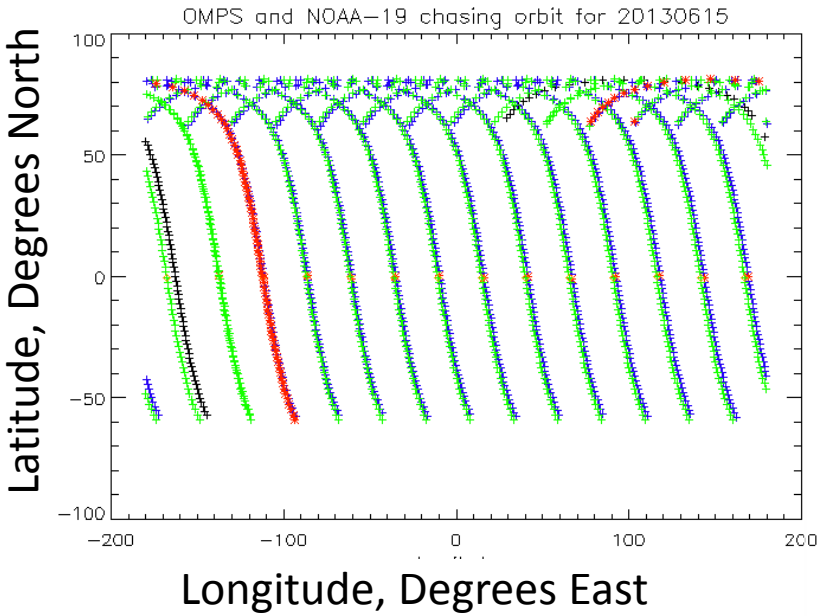
Simultaneous Nadir Overpass and No Local Time Difference Comparisons



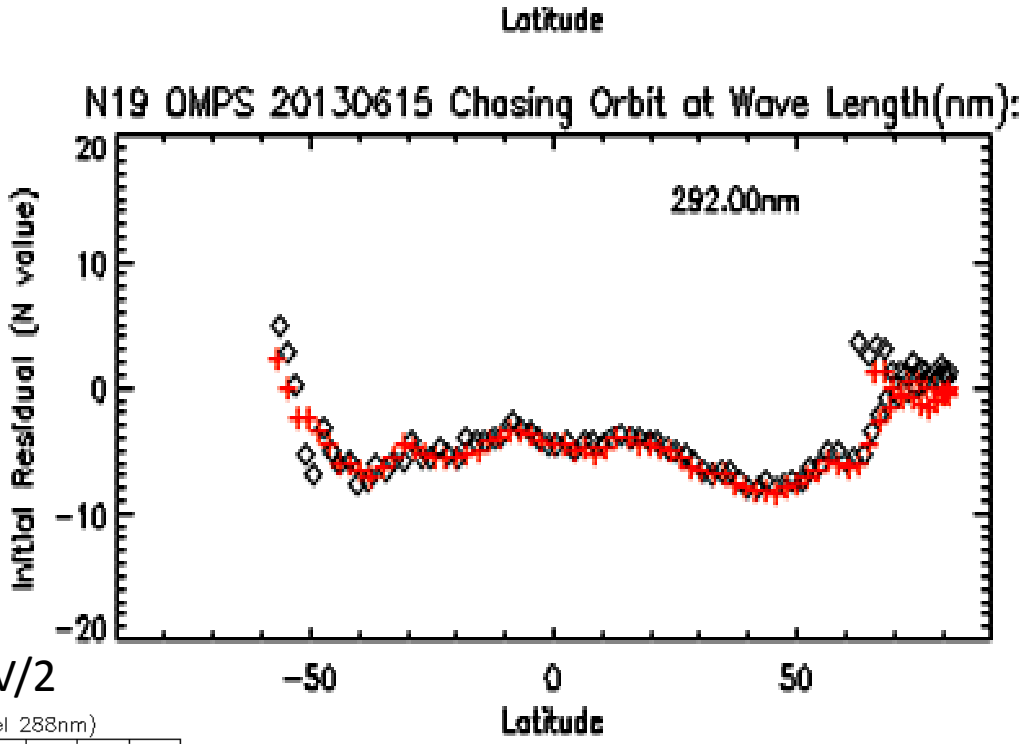
No Local Time Difference Comparisons, NOAA-17 SBUV/2 & NOAA-18 SBUV/2
May-August 2010, 69 N to 73 N, Daily Zonal Mean



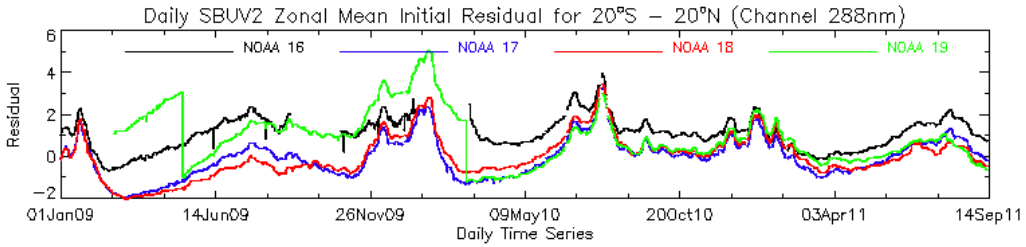
Well-matched Orbits for 6/15/2013

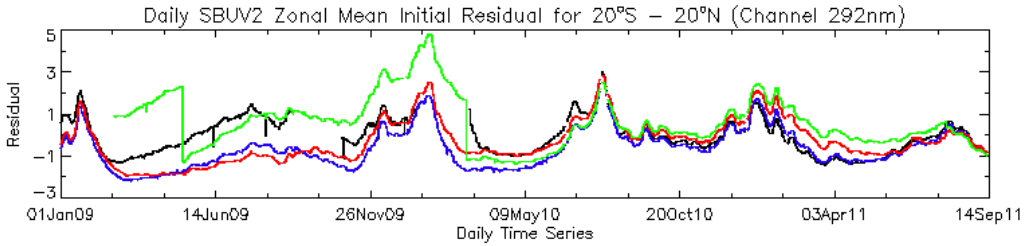


Comparison of Initial V6 Measurement Residuals for S-NPP OMPS NP and NOAA-19 SBUV/2



Operational Initial Residuals for SBUV/2





Daily Means
Equatorial Pacific Box
20S – 20N Latitude
100W to 180W Longitude

Vicarious calibration by using statistical properties for ozone, reflectivity and aerosol index products in a latitude/longitude box over the equatorial Pacific

By L. Flynn, Z. Zhang, E. Beach, Y. Pachepsky

Outline

- Project Background
- Version 8 Total Ozone Algorithm Description
- Target area, cross-track segregation, weekly
- Reflectivity Results (1-percentile)
- Aerosol Index Results (average)
- Total Column Ozone (average)

Background: Effective Reflectivity Project

The aim is to produce over-pass comparisons of UV/Vis sensors for specific target sites or regions in use by the community. As a first step, summaries of methods and results for target sites currently in use will be collected. We will compare measurements at reflectivity channels from 330 nm to 500 nm.

- Ice, desert and open ocean targets.
- Absolute Radiance/Irradiance check; Track variations over time.
- Reflectivity range/distribution, 1-percentile, Deep Convective Clouds (DCC)
- Wavelength Dependence – Aerosol Indices, Clean atmospheres
- Complications
  - Viewing and Solar angle considerations
  - Sun Glint
  - Surface pressure
  - Partially cloudy scenes
  - Polarisation
  - Inelastic Scattering
  - Turbidity, chlorophyll
- Compare Global monthly surface reflectivity data bases
- Goals
  - Agreement at 1% on cloud free scene reflectivity for 340 nm. Desert, Equatorial Pacific, Polar Ice.
  - Agreement at 1% on aerosol index – wavelength dependence of reflectivity.
  - Long-term reflectivity channels at 0.5% stability

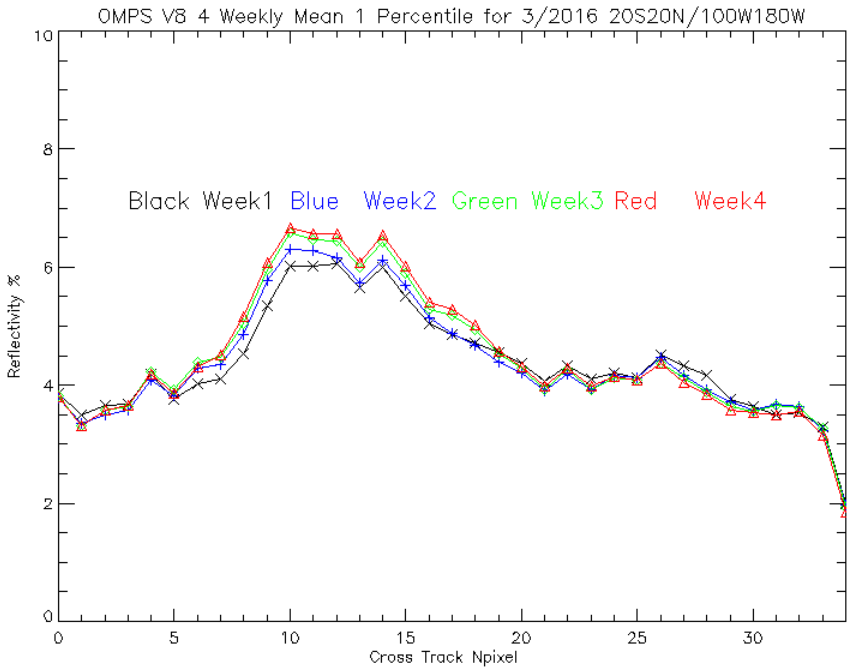
Version 8 Total Ozone Algorithm

- The algorithm makes two key assumptions about the nature of the BUV radiation. Firstly, we assume that the BUV radiances at wavelengths greater than 310 nm are primarily a function of total O3 amount, with only a weak dependence on O3 profile that can be accounted for using a set of standard profiles. Secondly, we assume that a relatively simple radiative transfer model that treats clouds, aerosols, and surfaces as Lambertian reflectors can account for most of the spectral dependence of BUV radiation, though corrections are required to handle special situations. The algorithm uses measurements at 12 channels to estimate the effective reflectivity and create absorbing aerosol and SO2 indices. A radiative transfer lookup table created using standard ozone profiles is used to match the viewing conditions and an ozone absorbing channel measurement.

Pacific Box Statistics

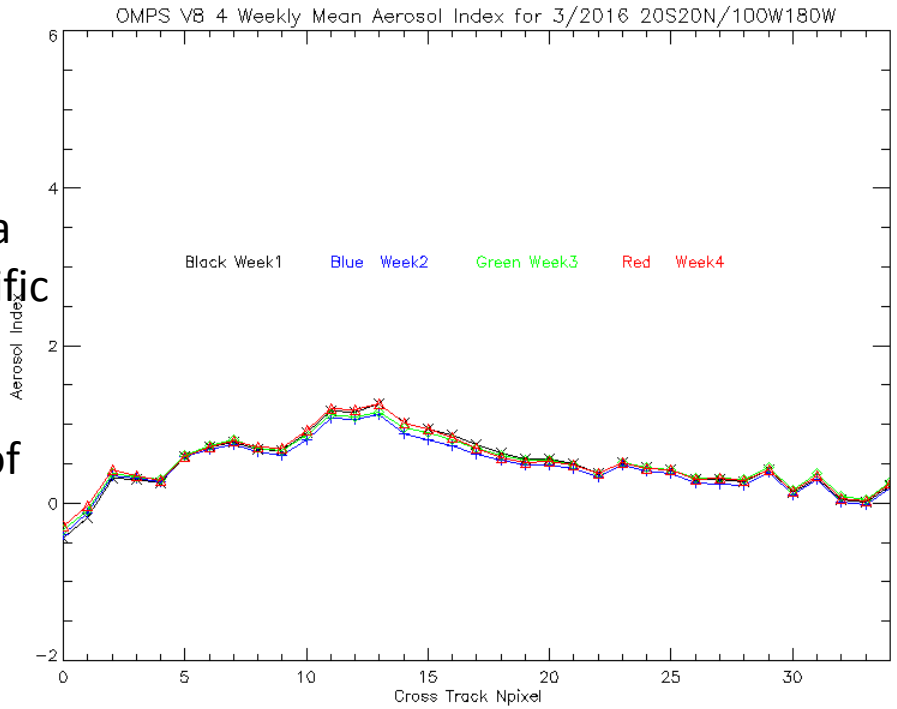
- The lines on the next slide show weekly 1-percentile effective reflectivity, total column ozone and aerosol index values (measurement residuals for wavelengths in the 360-nm range using effective reflectivity calculated for the 331-nm range) for the V8 algorithm for all the data in a latitude/ longitude box in the Equatorial Pacific versus cross-track view position. We expect the reflectivity minimum to be between 4% and 6% for open ozone, and we expect the aerosol index values to be approximately zero N-values for this region of the globe. The cross-track variations for positions around position #10 are related to sun glint effects. Consistent variations versus cross-track are due to calibration biases across the instrument CCD array.

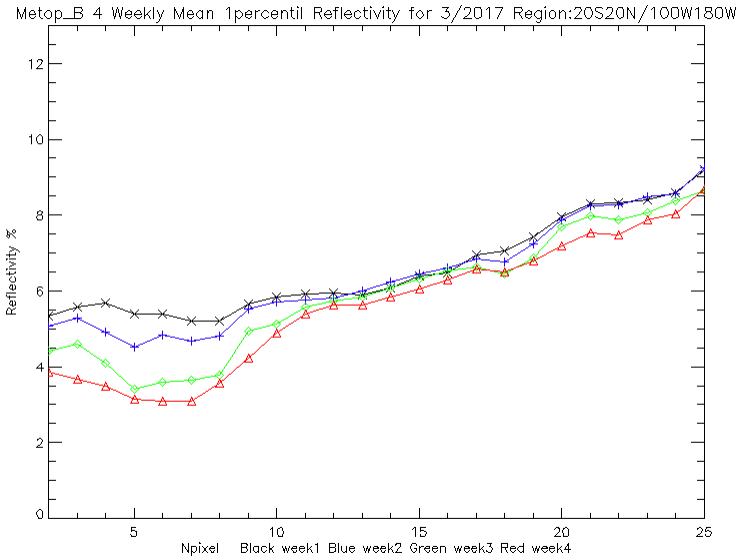
Cross-Track Internal Consistency for OMPS

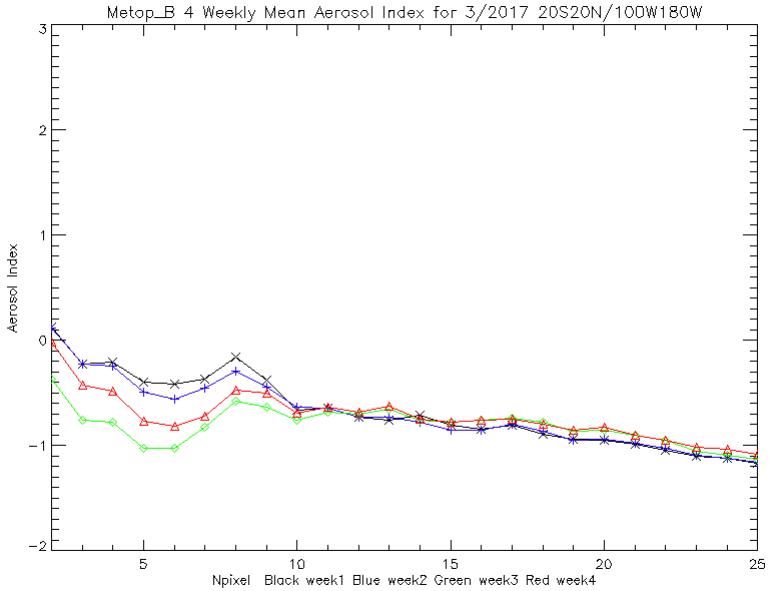


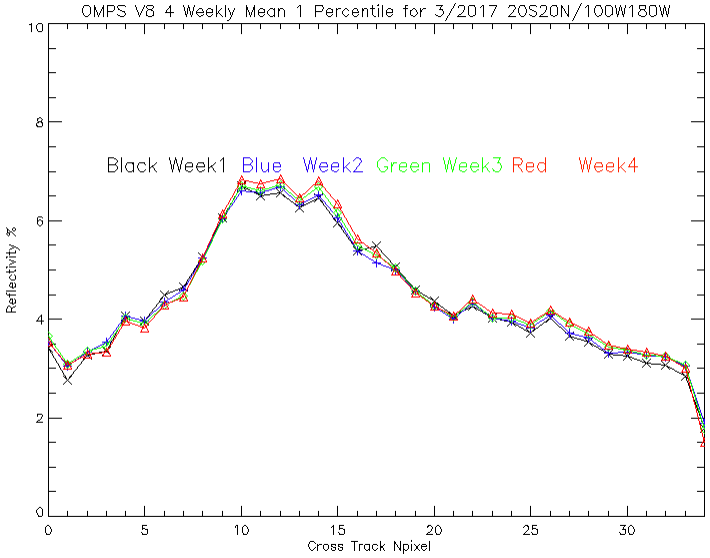
← Weekly Effective Reflectivity values for the V8 algorithm for March2016 for all the data in a latitude/ longitude box in the Equatorial Pacific versus cross-track view position, 17 is nadir. We expect the values to be approximately 5% for this region of the globe. The cross-track variations for positions 8 to 15 are related to sun glint effects.

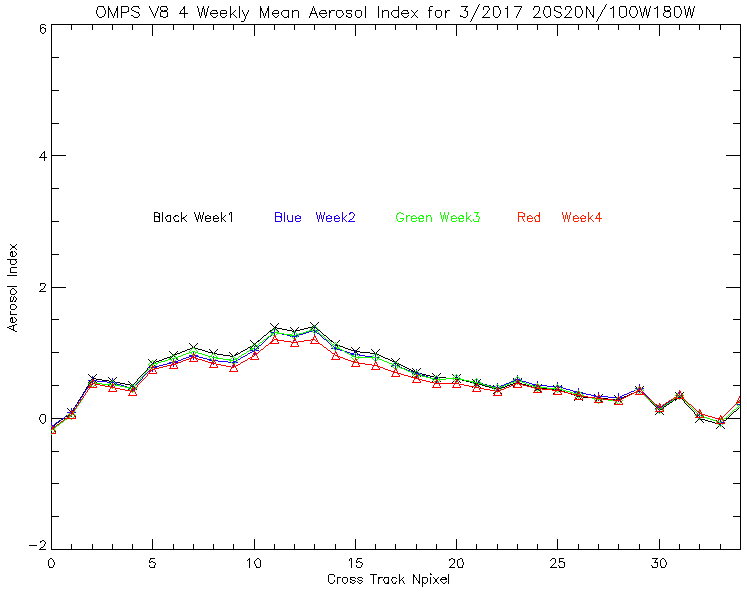
Weekly Aerosol Index values for the V8 → algorithm for March 2016 for all the data in a latitude/ longitude box in the Equatorial Pacific versus cross-track view position, 17 is nadir. We expect the aerosol index values to be approximately zero N-values for this region of the globe. The cross-track variations for positions 8 to 15 are related to sun glint effects.



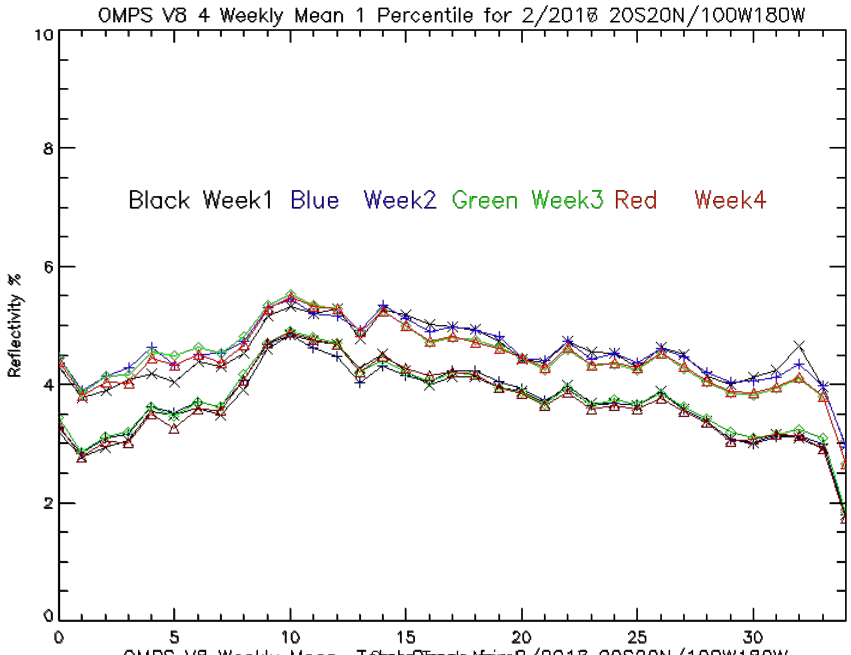

Metop_B 4 Weekly Mean 1percentil Reflectivity for 3/2017 Region:20S20N/100W180W
Reflectivity %
Npixel Black week1 Blue week2 Green week3 Red week4

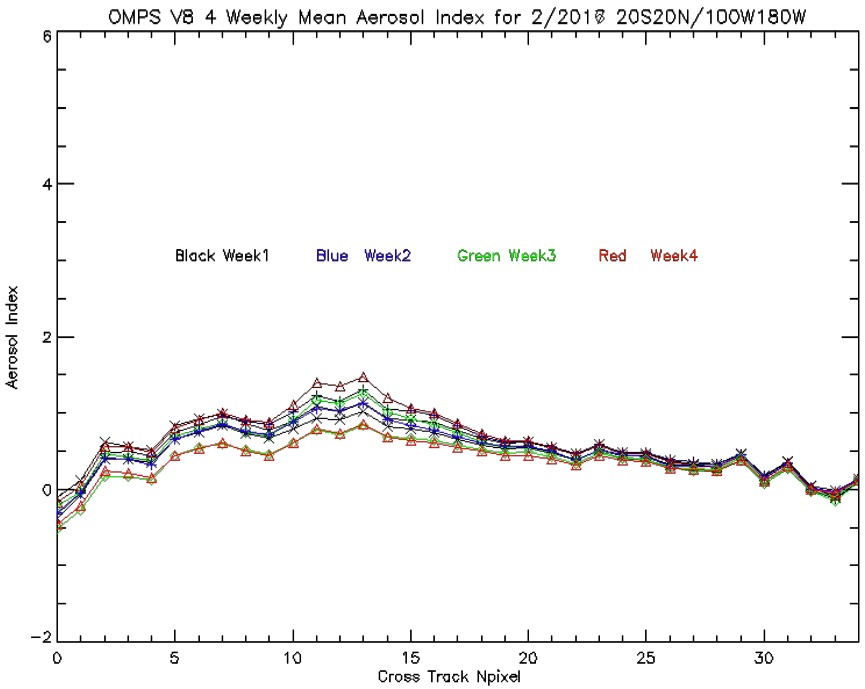

Metop_B 4 Weekly Mean Aerosol Index for 3/2017 20S20N/100W180W
Aerosol Index
Npixel Black week1 Blue week2 Green week3 Red week4

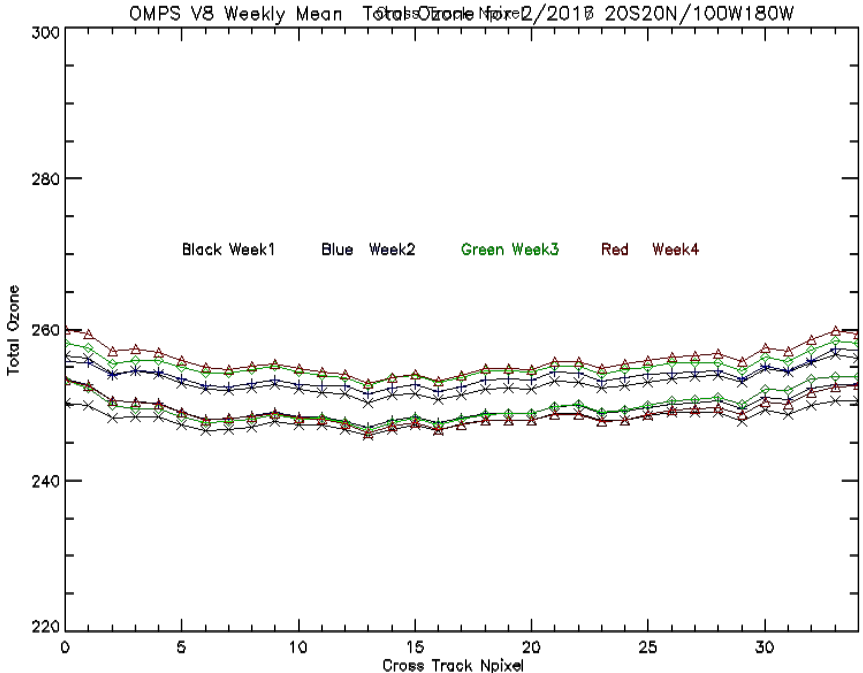

OMPS V8 4 Weekly Mean 1 Percentile for 3/2017 20S20N/100W180W
Black Week1 Blue Week2 Green Week3 Red Week4
Reflectivity %
Cross Track Npixel


OMPS V8 4 Weekly Mean Aerosol Index for 3/2017 20S20N/100W180W
Black Week1 Blue Week2 Green Week3 Red Week4
Aerosol Index
Cross Track Npixel

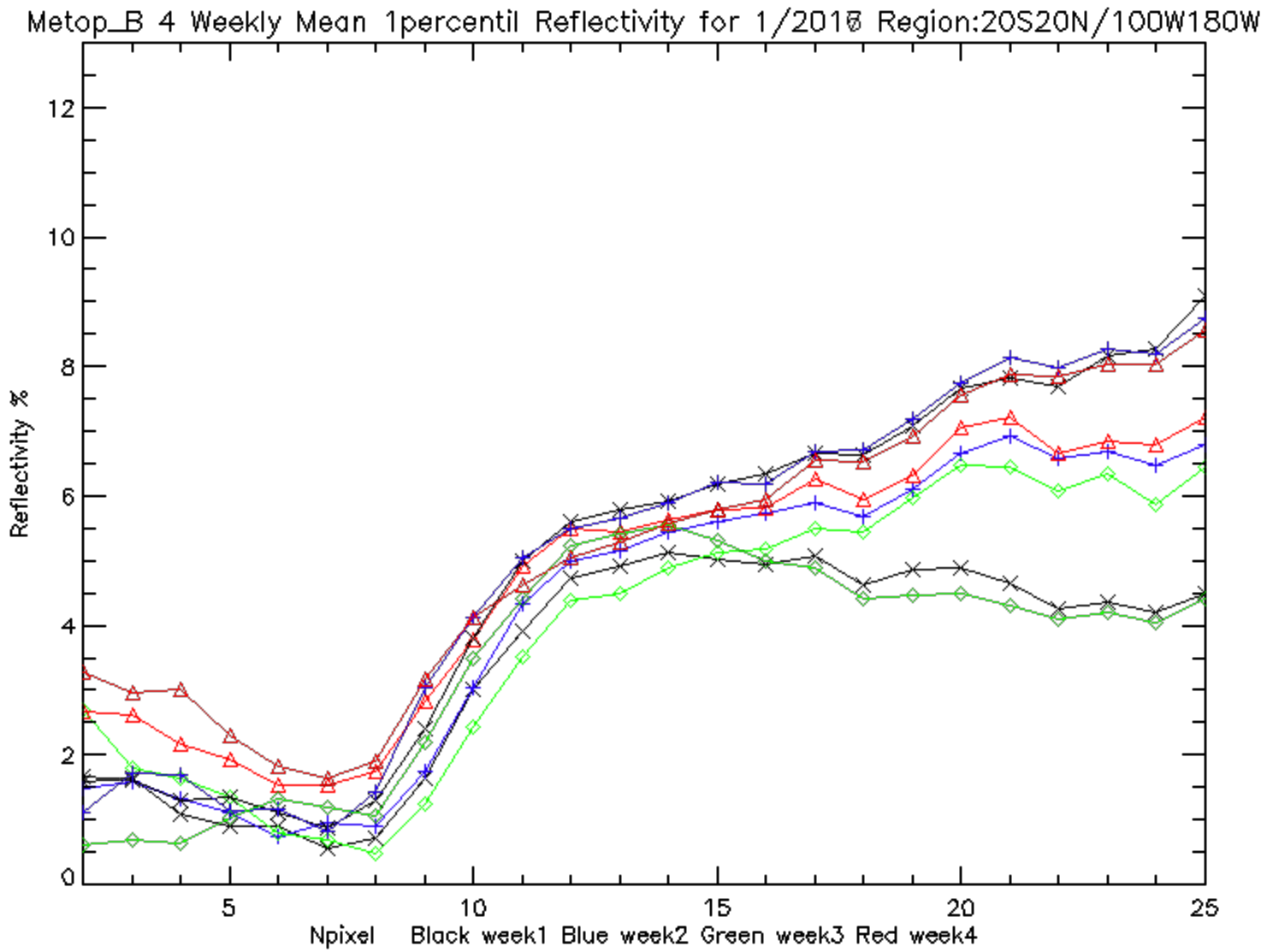
Weekly Averages over the Target Area



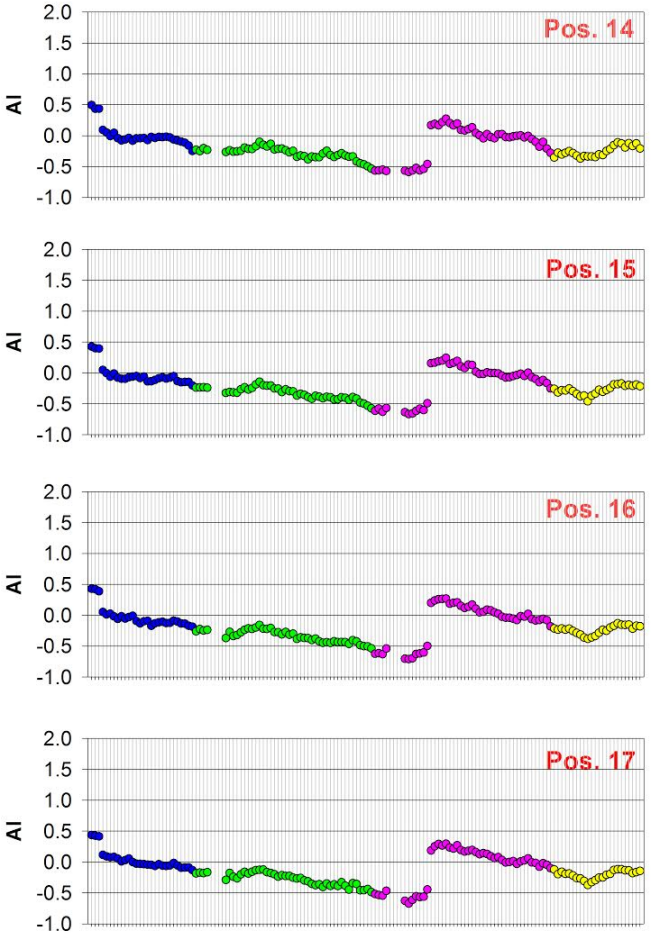




Weekly values for February 2017 for OMPS V8 Total Ozone algorithm products fading to weekly values for February 2016. We need to use the reprocessed SDR data and redo these figures.


Metop_B 4 Weekly Mean 1percentil Reflectivity for 1/2018 Region:20S20N/100W180W
Reflectivity %
0
2
4
6
8
10
12
5
10
15
20
25
Npixel Black week1 Blue week2 Green week3 Red week4

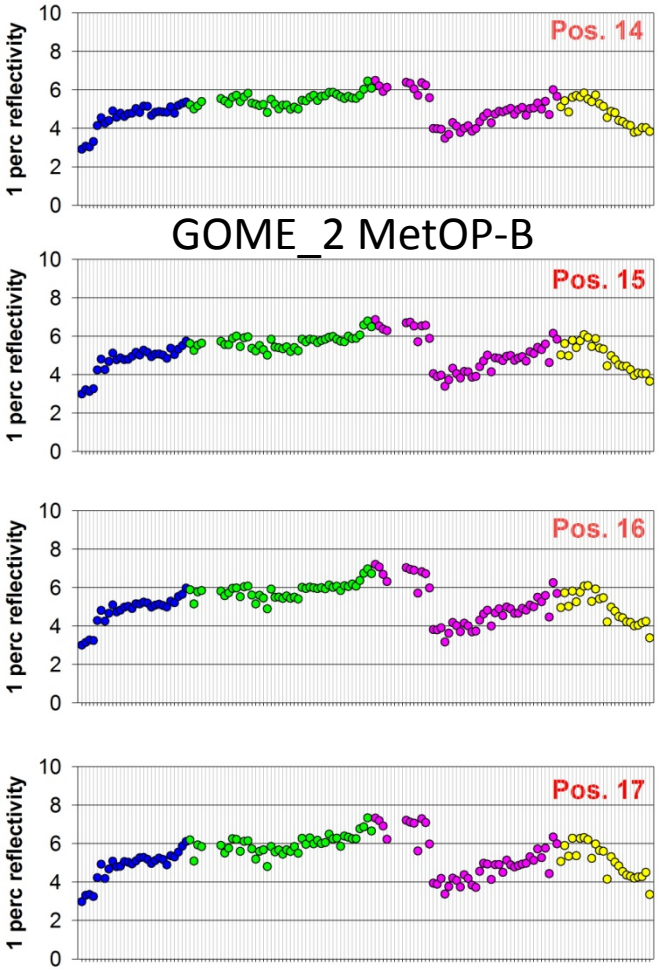
We are examining the V8 TOMS algorithm reflectivity and Aerosol Index Values for an Equatorial Pacific Region for OMPS, OMI and GOME-2



←Time Series of GOME-2 Aerosol Index (360 nm vs 331 nm) Equatorial Pacific

Time Series of → GOME-2 1-percentile Reflectivity Equatorial Pacific

Jumps are from NOAA-applied soft calibration adjustments to the operational products.



Adjustments and Layer Efficiencies using V8TOz dN/dR, dN/dxi and dN/dΩ

If you want to increase R and Ω by ΔR and ΔΩ then increase the N-values by

$$\Delta N318 = \Delta R\, dN318/dR + \Delta\Omega\, dN318/d\Omega = \Delta R\, A1 + \Delta\Omega\, B1$$
$$\Delta N331 = \Delta R\, dN331/dR + \Delta\Omega\, dN331/d\Omega = \Delta R\, A2 + \Delta\Omega\, B2$$

If you increase the N values by ΔN318 and ΔN331, then the R and Ω increase by

$$\Delta R = [C1 * B2 - C2 * B1] / [A1 * B2 - A2 * B1]$$
$$\Delta\Omega = [C1 * A2 - C2 * A1] / [A2 * B1 - A1 * B2]$$

$A1 = dN318/dR$, $B1 = dN318/d\Omega$, $C1 = \Delta N318$

$A2 = dN331/dR$, $B2 = dN331/d\Omega$, $C2 = \Delta N331$

$D = [A1 * B2 - A2 * B1]$ $\quad -D = [A2 * B1 - A1 * B2]$

Given an ozone profile X = {xi} (i=1,N), and sensitivities dN318/dxi and dN331/dxi, the relative layer efficiencies, Ei, for B-pair are computed as follows:

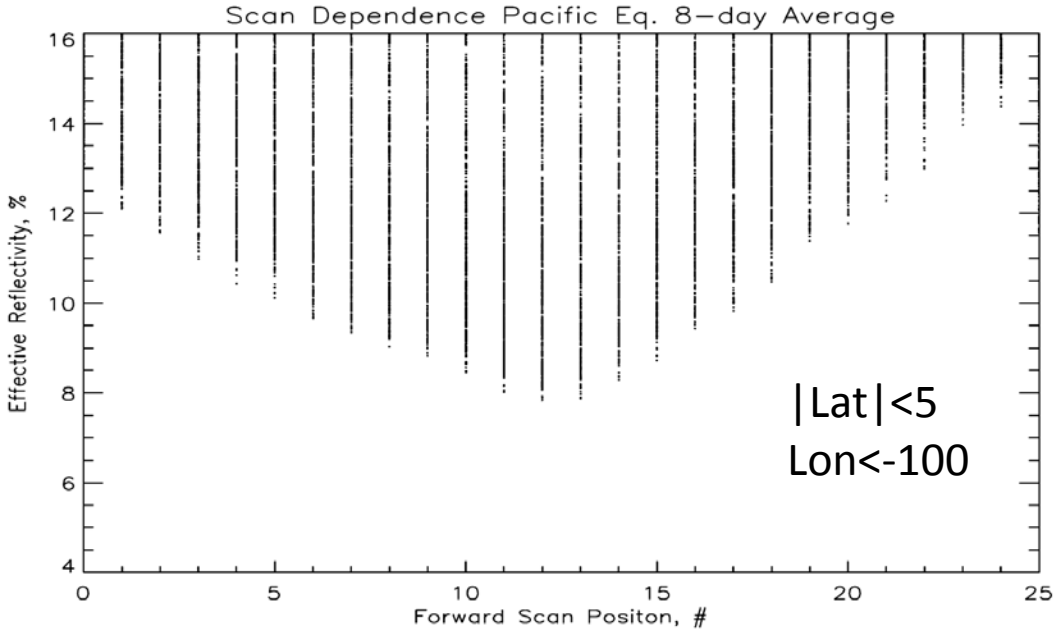
$$C1i = \Delta N318i = dN318/dxi \quad C2i = \Delta N331i = dN331/dxi$$
$$\Delta\Omega i = [A2 * C1i - A1 * C2i\,] / [A2 * B1 - A1 * B2]$$
$$Ei = \Delta\Omega i / [SUM(\Delta\Omega i) / N]$$

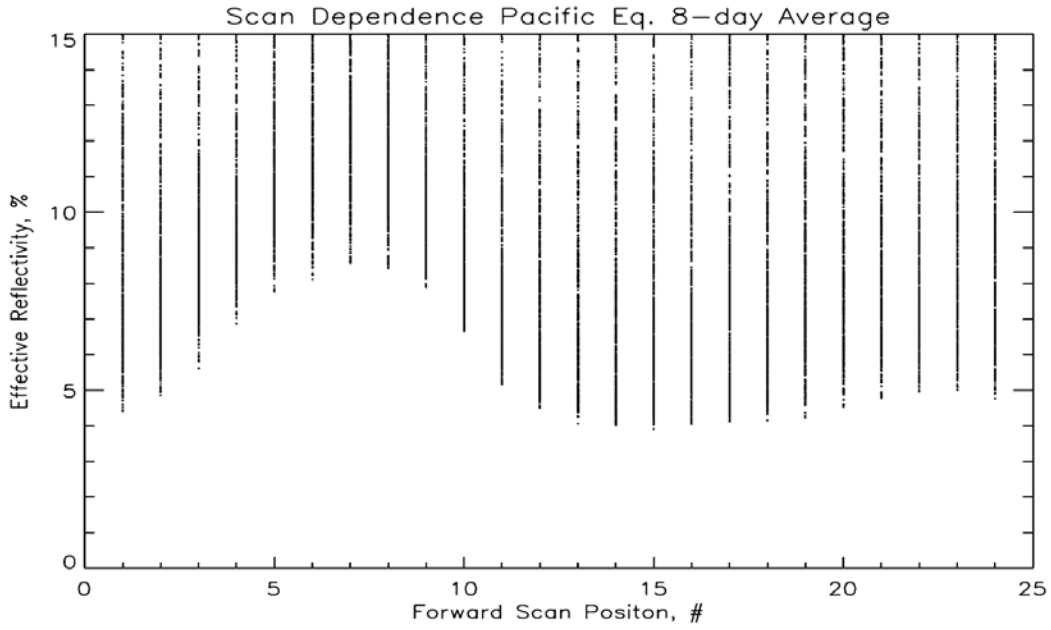
This assumes all ozone changes are absolute (e.g., in DU). These values should blend the clear and cloudy results appropriately by using the radiative fractions.

One can check the consistency of alternative profile, Xf = {xfi}, by computing

$$SUM[Ei * (xi - xfi)]$$

Ω is total ozone in DU, R is effective reflectivity, and N is -100*log10(I/F)





EAST

WEST

Version 8 331-nm Reflectivity for a box in the Equatorial Pacific.

The unadjusted values in the top plot reach a minimum of 8% (higher than expected for the open ocean) for the Nadir scan position.

A single calibration adjustment lowers this value to 4% and also flattens out the scan dependence for West-viewing positions. The East-viewing results are not as good but there could be sun glint contamination for those angles.

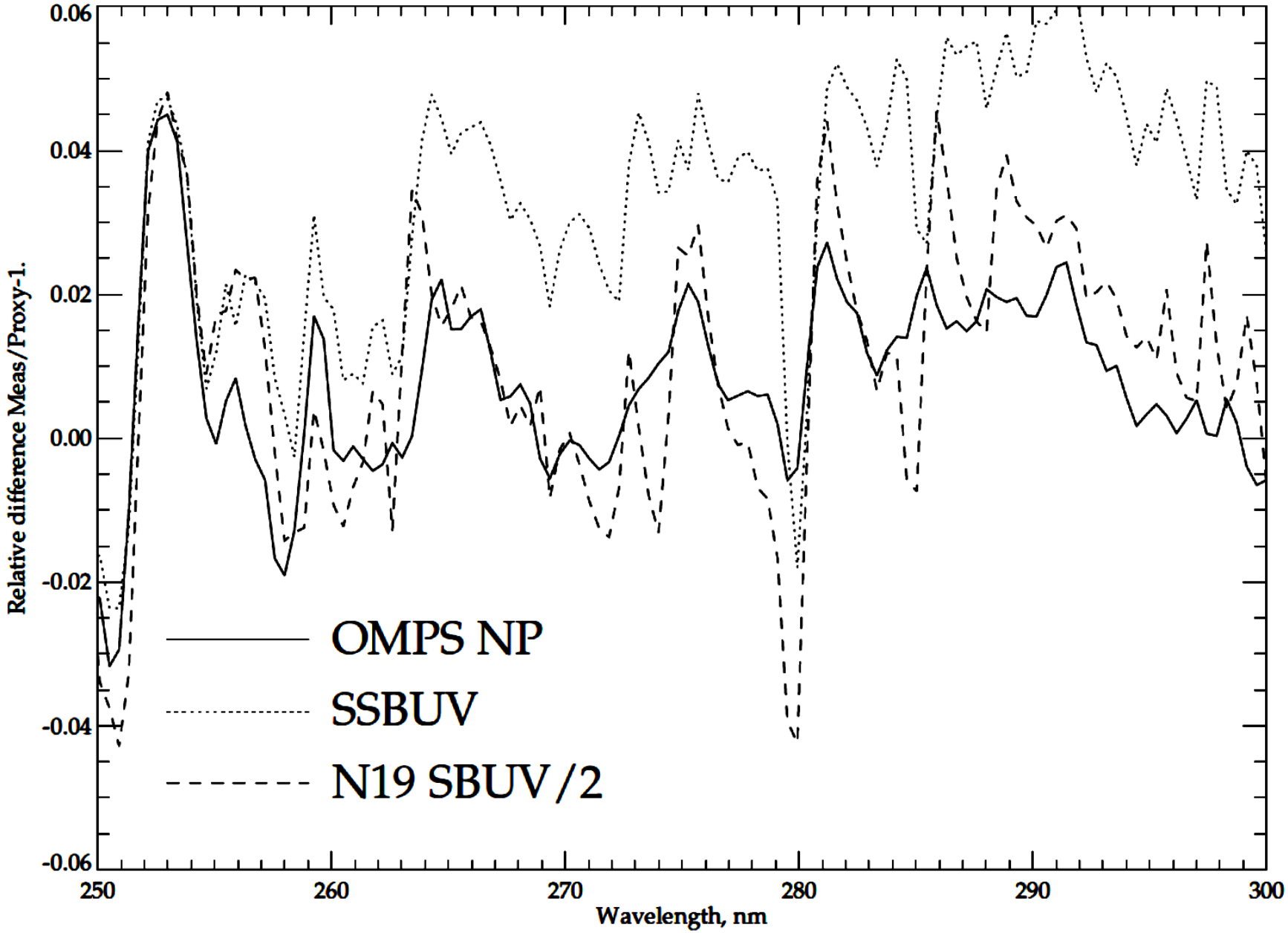
Summary, Questions & Future

- How stable are the values year-to-year? What factors produce the most instability?
- What should the 1-percentile values be? Can the method be used for absolute calibration?
- Can minimum reflectivities over land be used for sunglint FOVs? Do we need to screen for aerosols?
- We plan to generate and compare Equatorial Box time series for OMI, OMPS and GOME-2.
- Can we develop a V8TOz tool to allow similar computations for other instruments' measurements?

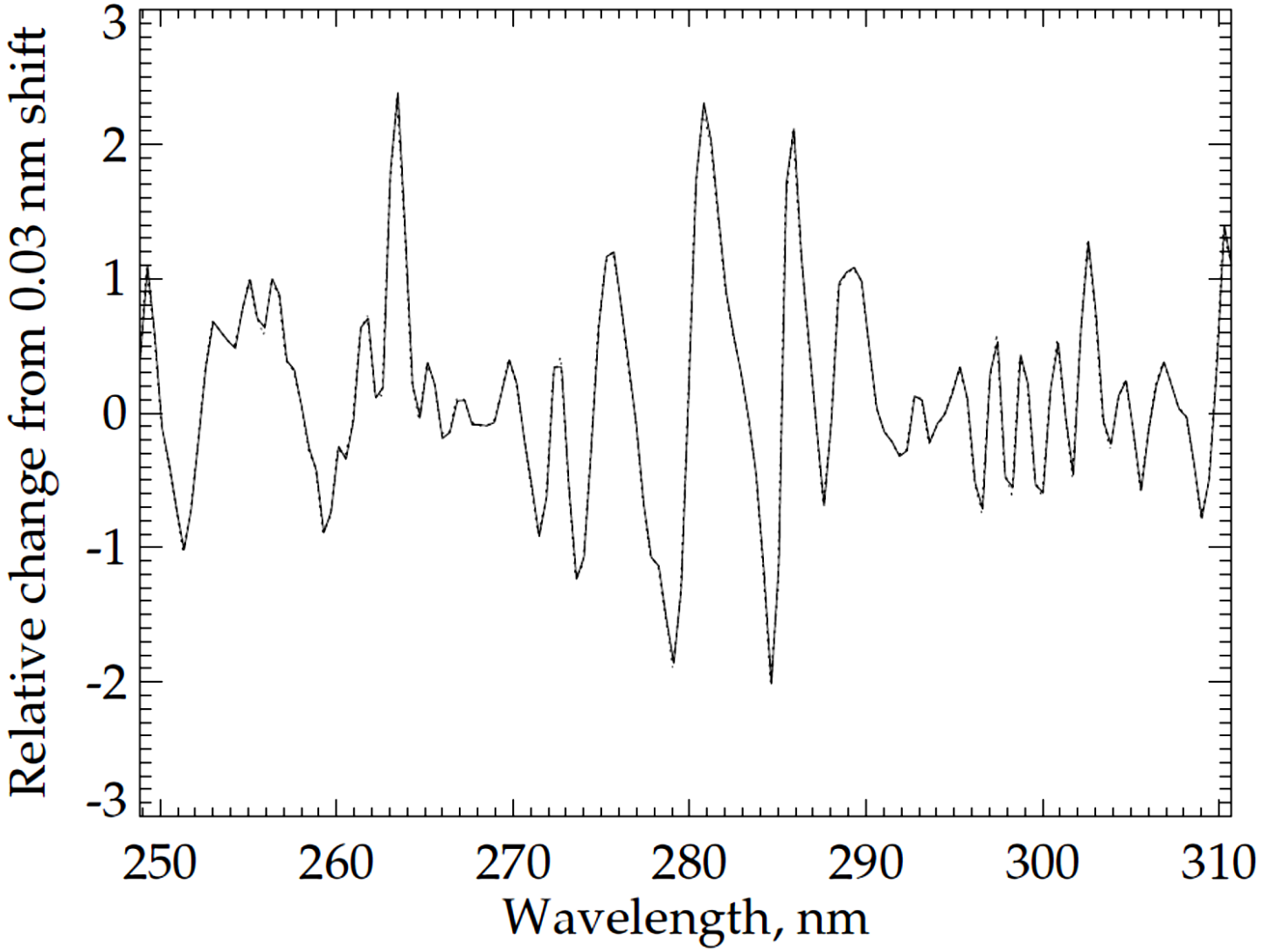
Project to Compare Solar Measurements

- High resolution solar reference spectra
  - Reference high resolution solar Spectra (Everybody has a favorite. How do they compare?)
  - Mg II Index time series, Scale factors at high resolution
- Instrument data bases
  - Bandpasses, wavelength scales
  - Day 1 solar, time series with error bars
  - Mg II Indices and scale factors at instrument resolution
  - Reference calibration and validation papers
- Using the information from above we can compare spectra from different instruments and times

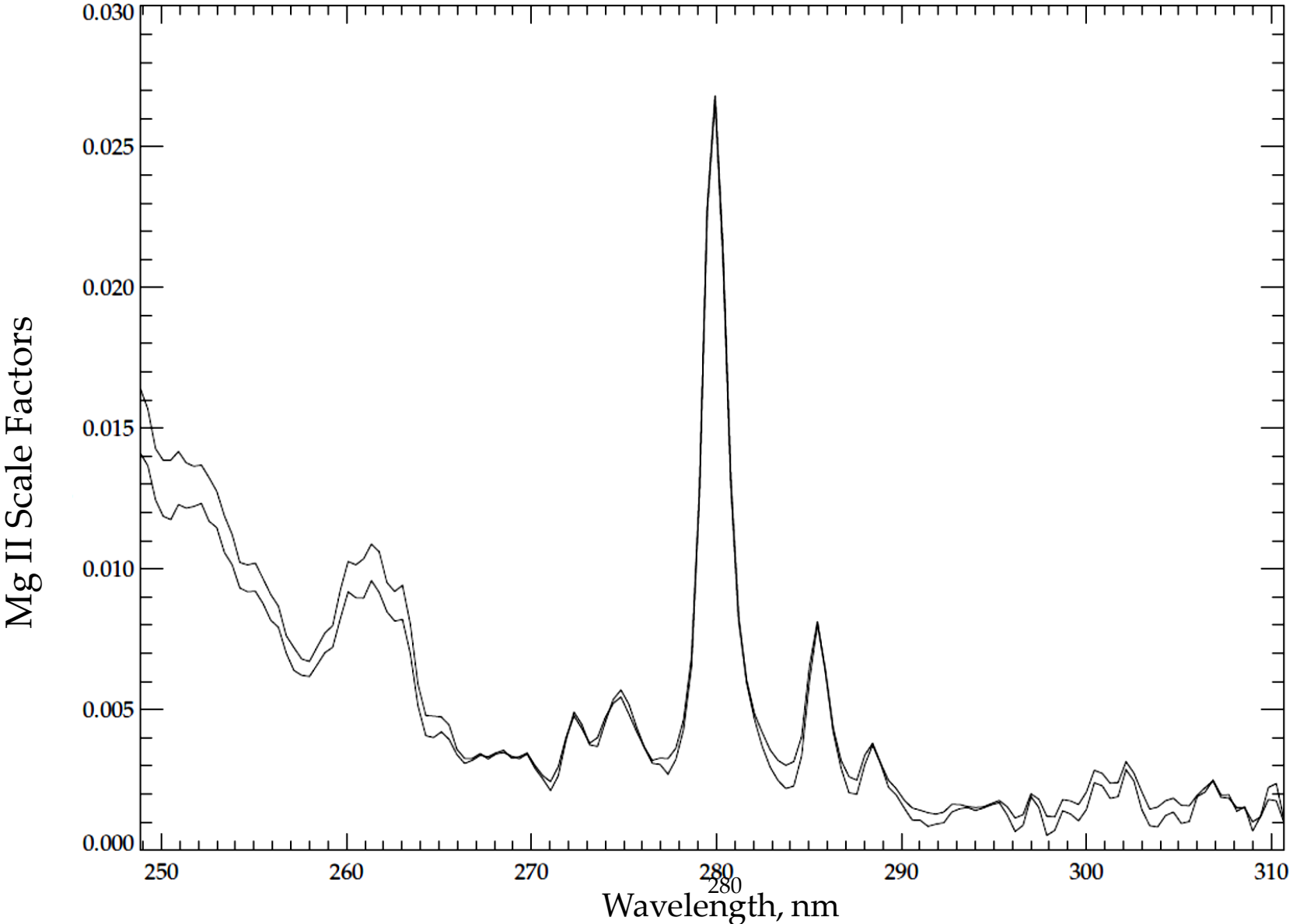
Solar Measurement Comparisons to KNMI Proxy



Wavelength shift for OMPS NP from KNMI Proxy.



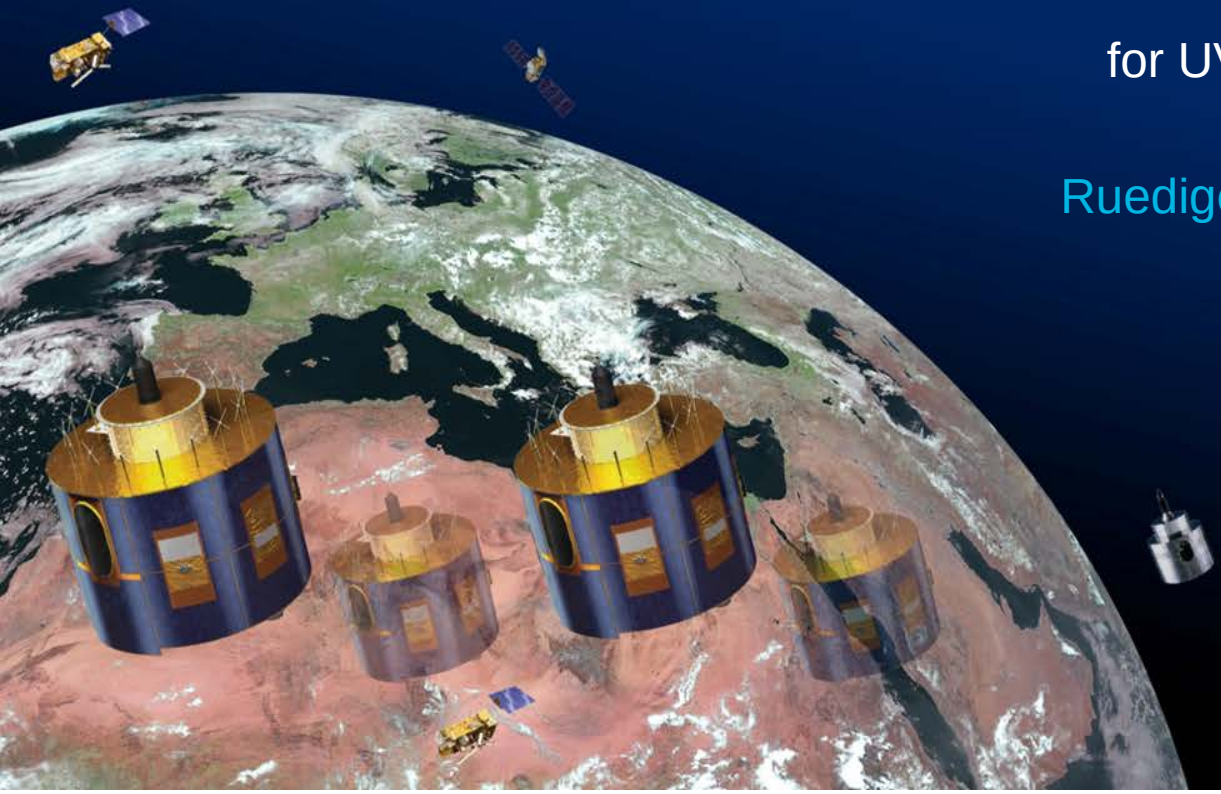
Mg II Relative Scale Factors from 4-week up/down excursions



Proposal for (on-ground) calibration white paper

for UVNS hyper-spectral sensors

Ruediger Lang, Marcel Dobber and Rose Munro



Accuracy, sensitivity and repeatability

I. Sources / commissioning

II. Thermal and pressure environment / stability and characterization

Instrument components

I. Detector level (CCD/linear diode arrays)
   a) Noise
   b) PRNU/PPG/RTS
   c) SMEAR
   d) Etaloning
   e) Linearity

II. Stray-light

III. Grating and alignment (ISRF)
   a) Spectral assignment
   b) Spectral stability
   c) Slit Irregularity

IV. Pointing and Spatial stability (ISRF/PSF)
   a) Spatial and spectral aliasing
   b) Radiometric and spectral scene in-homogeneity errors.
   c) Detector co-registration (overlap)

V. Polarisation sensitivity

VI. Radiometric response
   a) Sources
   b) Geometry

VII. Diffuser characterisation

VIII. Degradation and contamination

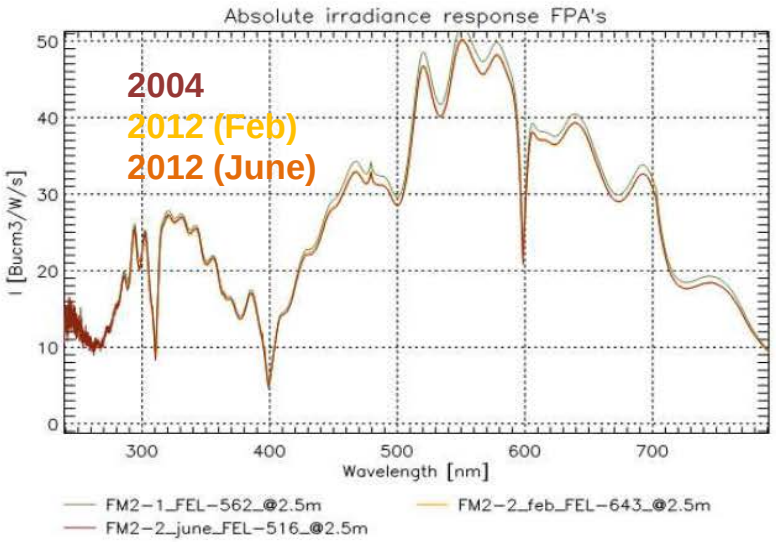
IX.....?

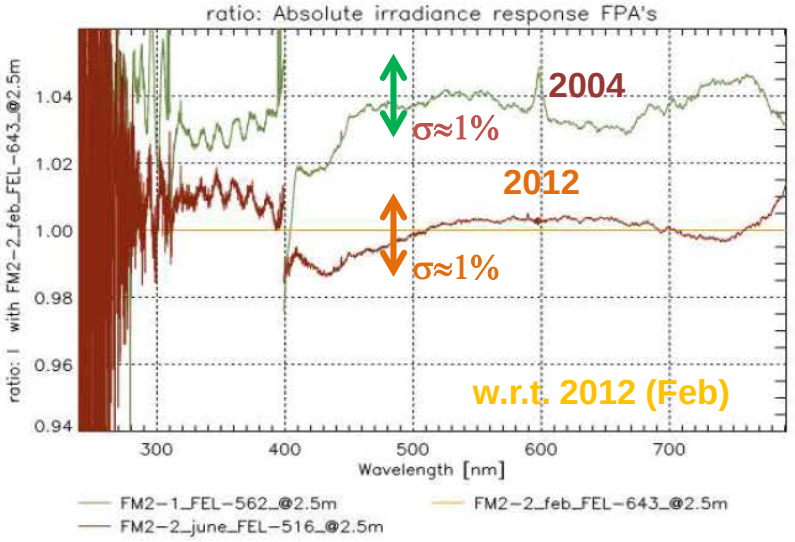
Editor: Ruediger Lang,
Co-Editors: Marcel Dobber, Rose Munro

Some selected examples

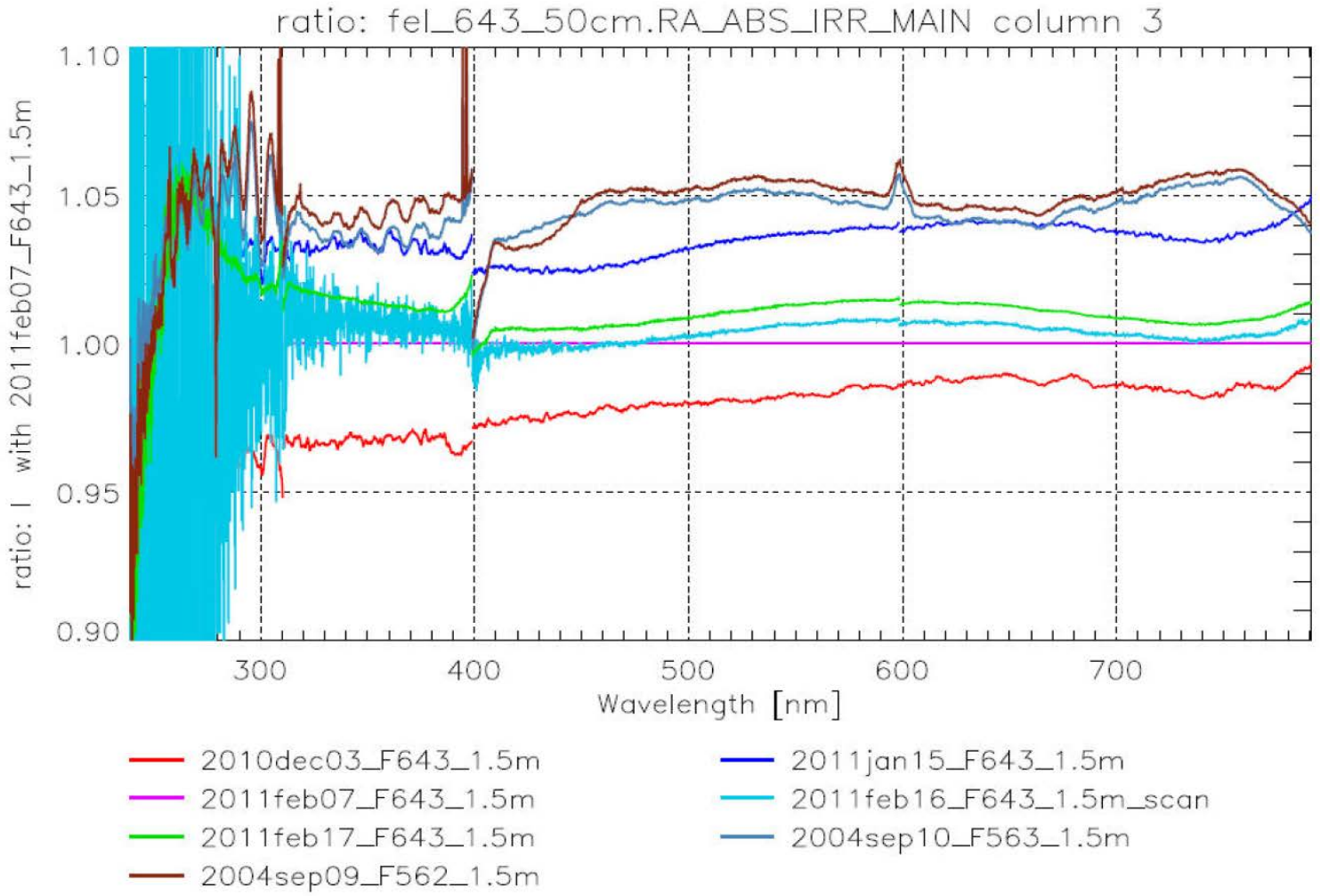
GOME-2 FM2
Metop-B

Example: Radiometric response of the solar (irradiance) measurement port
FM2: Campaigns 2004 / 2011



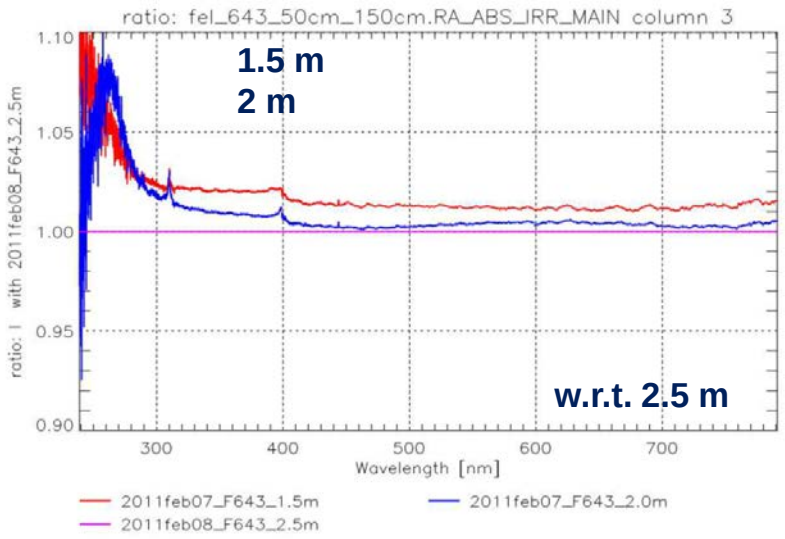


GOME-2 FM2
Metop-B

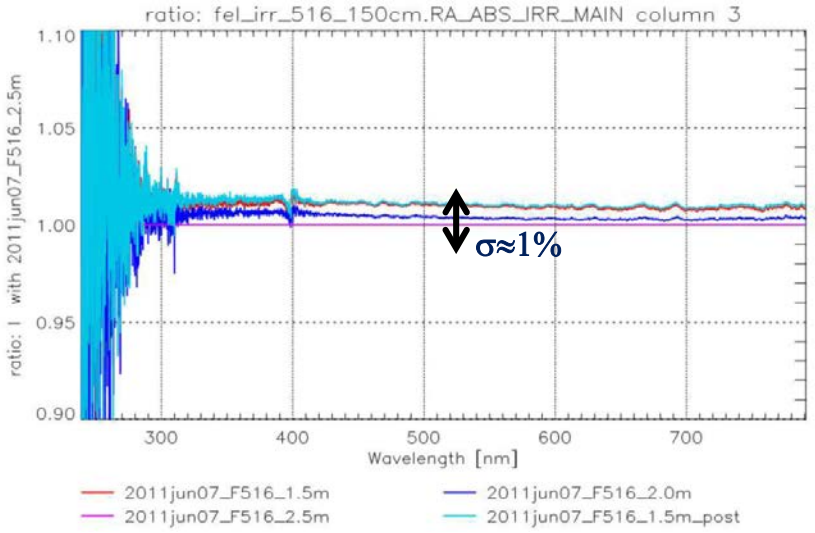


GOME-2 FM2
Metop-B

Multiple source / instrument distance measurements

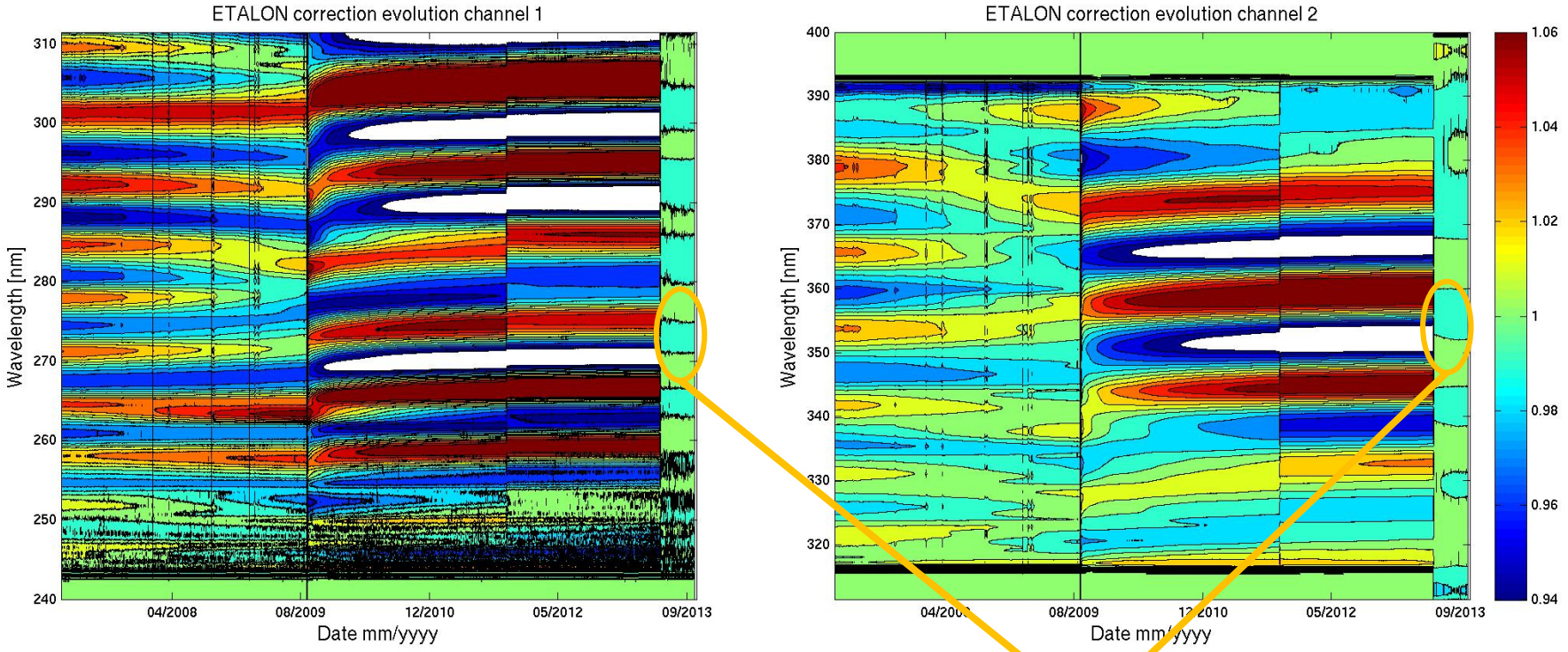


Final setup and alignement procedures



Example: Identification of alignement problems from multiple source/instrument distance measurements

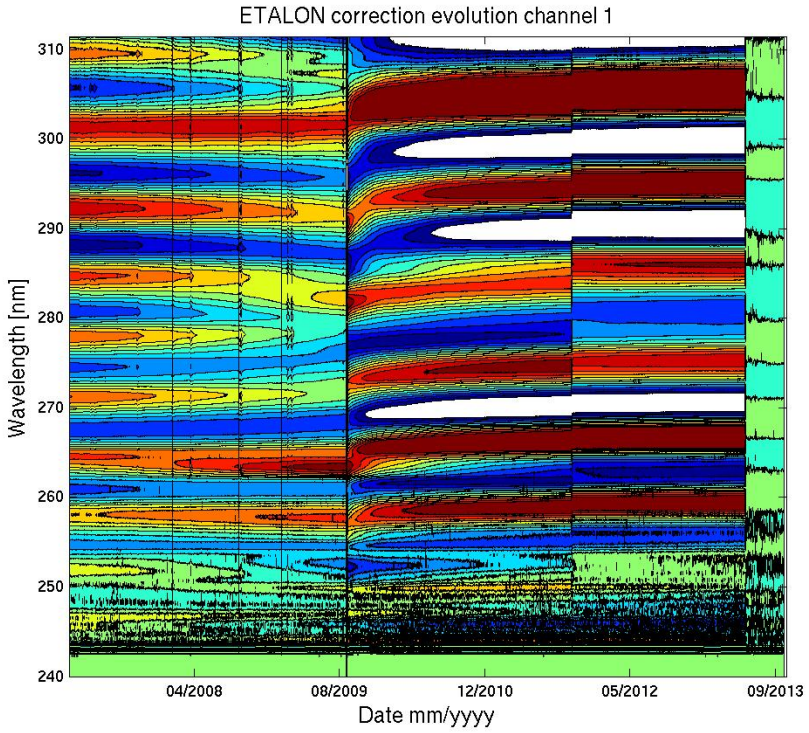
GOME-2 FM3
Metop-A

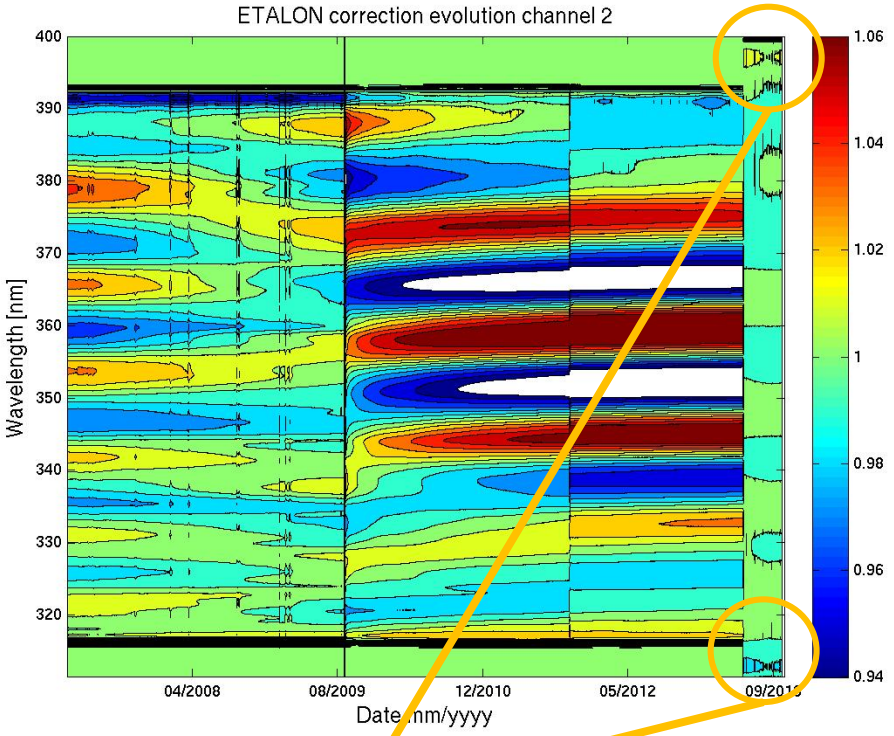


Modification of on-ground radiometric response functions to include in-orbit etalon

➢ Reduction of magnitude of in-orbit etalon correction ... plus

GOME-2 FM3
Metop-A





Modification of on-ground radiometric response functions to include in-orbit etalon

➢ extension of region spectral region corrected

GOME-2 FM3
Metop-A

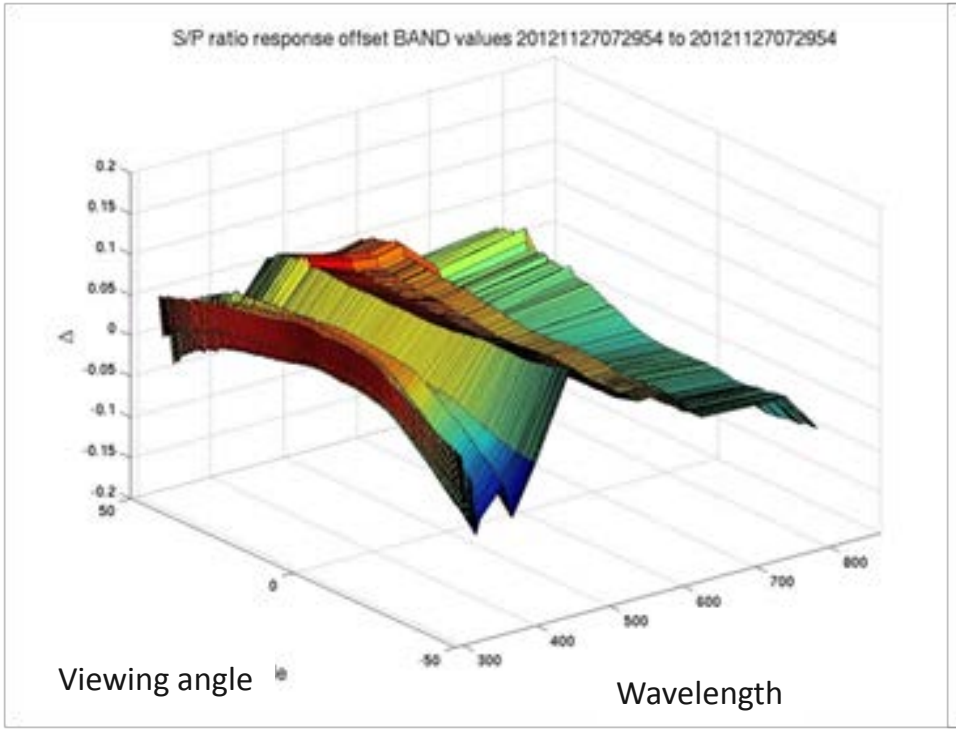
GOME-2 FM2
Metop-B

Online in-orbit correction of GOME-2 measured Stokes fractions using special geometries for which q=!0

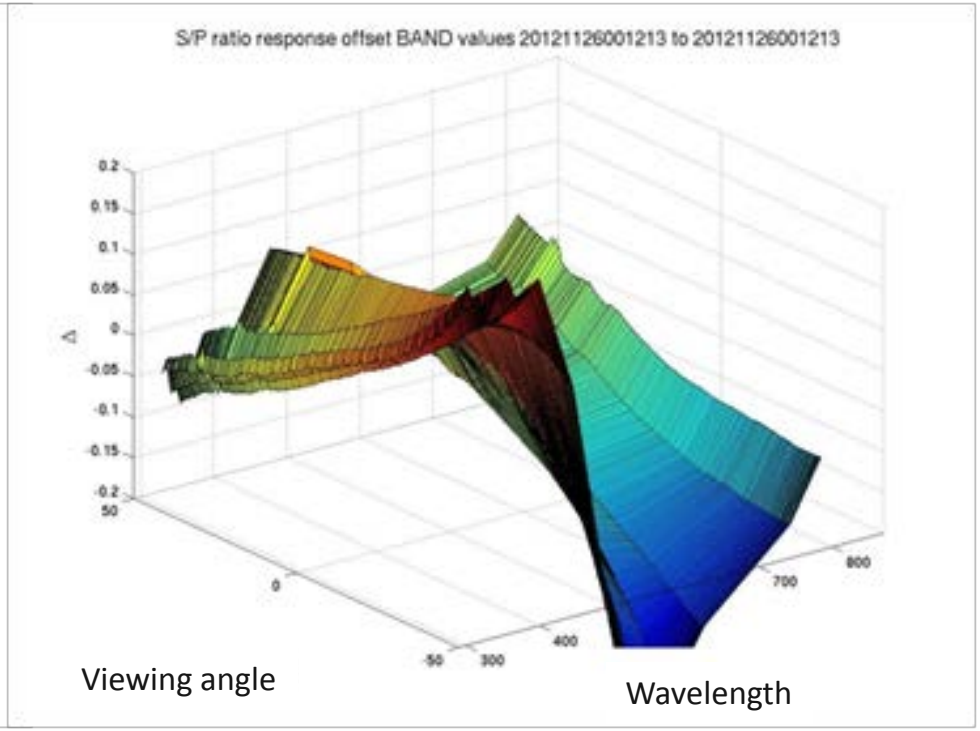
Used for aerosol retrieval (PMAp)
and for correction of polarisation sensitivity of the instrument

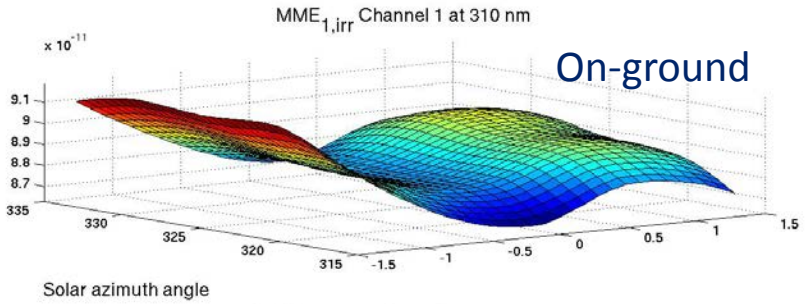
Correction surface automatically updated 2 to 4 times per month

Metop-B / FM2

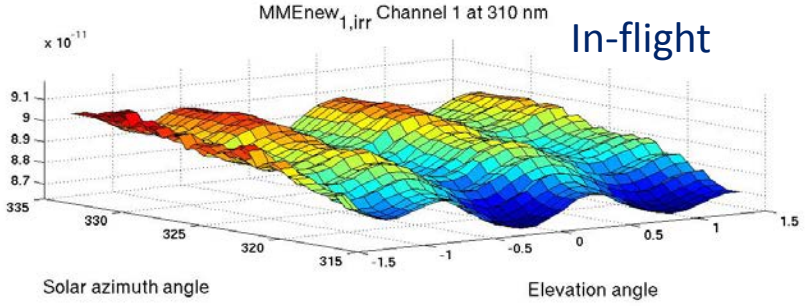


Metop-A / FM3

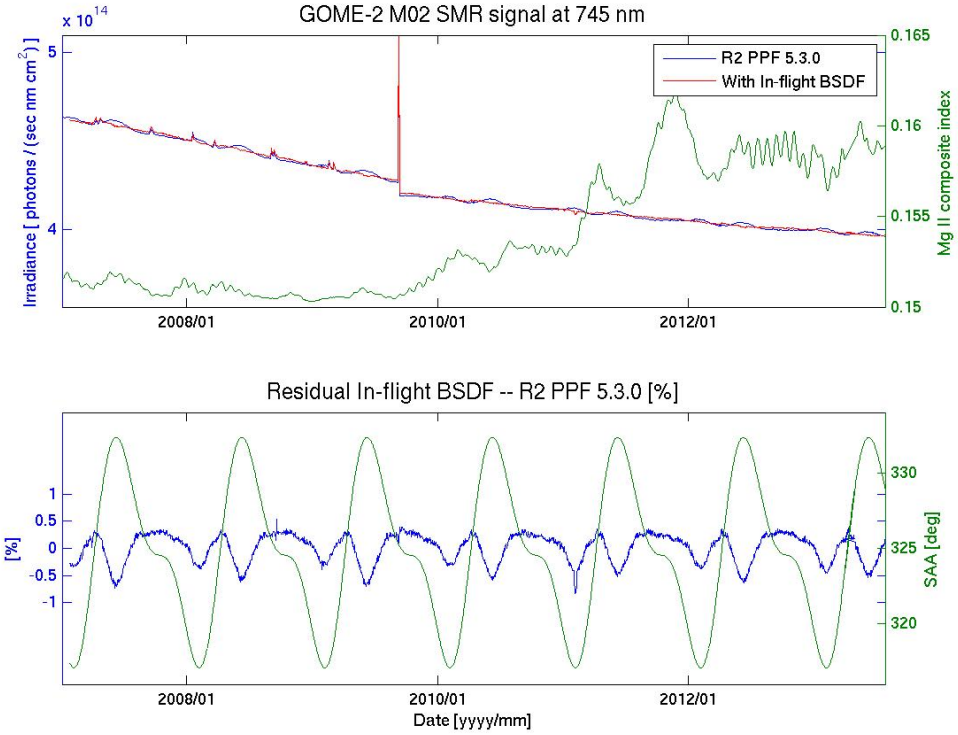




On-ground



In-flight



In-flight--On Ground

On-ground vs. In-flight

Accuracy, sensitivity and repeatability

I. Sources / commissioning (in-orbit/on-ground/both)
II. Thermal and pressure environment / stability and characterization (in-orbit/on-ground/both)

Instrument components

I. Detector level
   a) Noise (in-orbit/on-ground/both)
   b) PRNU/PPG/RTS (in-orbit/on-ground/both)
   c) SMEAR (in-orbit/on-ground/both)
   d) Etaloning (in-orbit/on-ground/both)
   e) Linearity
II. Stray-light (in-orbit/on-ground/both)....
III. Grating and alignment (ISRF)
   a)Spectral assignment
   b)Spectral stability
   c) Slit irregularity
IV. Pointing and Spatial stability (ISRF/PSF)
   a) Spatial and spectral aliasing
   b) Radiometric and spectral scene in-homogeneity errors.
   c) Detector co-registration (overlap)
V. Polarisation sensitivity
VI. Radiometric response
   a) Sources
   b) Geometry
VII. Diffuser characterisation
VIII. Degradation and contamination
IX.....?

– criticality / complexity / schedule impact

Accuracy, sensitivity and repeatability

I. Sources / commissioning (criticality / complexity / schedule)
II. Thermal and pressure environment / stability and characterization (criticality / complexity / schedule)

Instrument components

I. Detector level
   a) Noise (criticality / complexity / schedule)
   b) PRNU/PPG/RTS (criticality / complexity / schedule)
   c) SMEAR (criticality / complexity / schedule)
   d) Etaloning (criticality / complexity / schedule)
   e) Linearity (criticality / complexity / schedule)
II. Stray-light (criticality / complexity / schedule)....
III. Grating and alignment (ISRF)
   a)Spectral assignment
   b)Spectral stability
   c) Slit irregularity
IV. Pointing and Spatial stability (ISRF/PSF)
   a) Spatial and spectral aliasing
   b) Radiometric and spectral scene in-homogeneity errors.
   c) Detector co-registration (overlap)
V. Polarisation sensitivity
VI. Radiometric response
   a) Sources
   b) Geometry
VII. Diffuser characterisation
VIII. Degradation and contamination
IX.....?

Accuracy, sensitivity and repeatability

I. Sources / commissioning (Author: ..... It *could be you!!!*)

II. Thermal and pressure environment / stability and characterization (Author: ..... It *could be you!!!*)

Instrument components

I. Detector level (Author: ..... It *could be you!!!*)
   a) Noise (Author: ..... It could be you!!!)
   b) PRNU/PPG/RTS (Author: ..... It *could be you!!!*)
   c) SMEAR (Author: ..... It *could be you!!!*)
   d) Etaloning (Author: ..... It *could be you!!!*)
   e) Linearity (...)

II. Stray-light

III. Grating and alignment (ISRF)
   a)Spectral assignment
   b)Spectral stability
   c) Slit irregularity

IV. Pointing and Spatial stability (ISRF/PSF)
   a) Spatial and spectral aliasing
   b) Radiometric and spectral scene in-homogeneity errors.
   c) Detector co-registration (overlap)

V. Polarisation sensitivity

VI.Radiometric response
   a) Sources
   b) Geometry

VII.Diffuser characterisation

VIII.Degradation and contamination

IX.....?

Call for contributors

• Call for contributions to a white-paper on (on-ground) hyper-spectral instrument calibration.
• Contributors can take responsibility for a particular sub-section of the paper per interest and experience.
• Reviewing by GSICS community (and potentially “external” reviewers / Industry?)

For discussion:

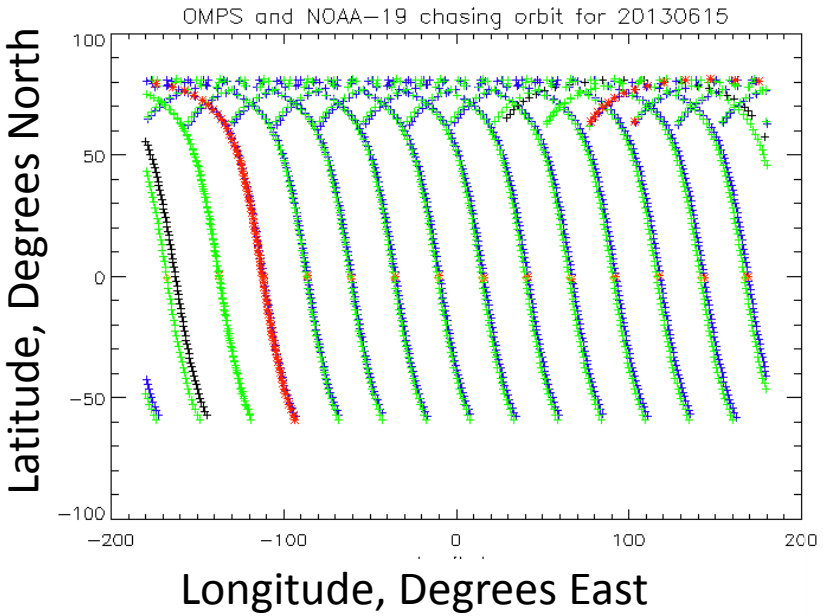
• What are we missing in the TOC?
• Do we want/need to have an “in-orbit” section?
• Do we want to include vicarious calibration?
• Do we need more fundamental/philosophical sections like:
    1. Calibration campaign organisation,
    2. Campaign schedules,
    3. Campaign planning, etc...?
• In-situ (“open-roof”) measurements?
• Novel sources (for hyper-spectral calibrations / stray-light)?

Match-Up Comparisons

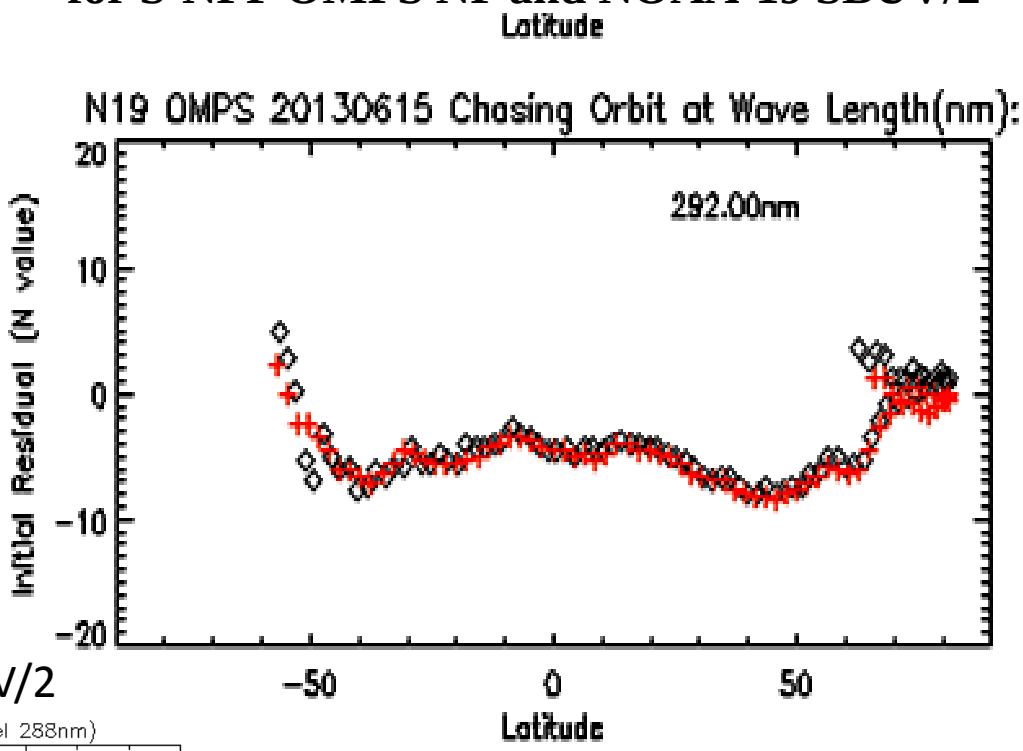
We would also like to expand the use of matchup comparisons for UV instruments. Current approaches include:

- Chasing Orbits (Opportunistic Formation Flying)
  - S-NPP and EOS-Aura have 16-day repeat cycles but one makes 227 orbits and the other 233 so every 64 hours they are flying with orbital tracks within (360/14)*110*3/(14*8*2) ~ 40 km of each other, 15 minutes apart.
  - For NOAA-19 and S-NPP, the matchups are every 12 days – (360/14)*110/(14*12*2) ~ 9 km.
- LEO vs LEO Simultaneous Nadir Overpass (and its non-simultaneous No-Local-Time-Difference zonal means)
- LEO underflights of GEO and L-1 instruments – Coincident Line-of-Sight Observations. (GOME-2 vs. SEVIRI, OMPS vs. TEMPO)
- Zonal Means (including ascending/descending repeat coverage – $S1*\alpha1 = S2*\alpha2$)

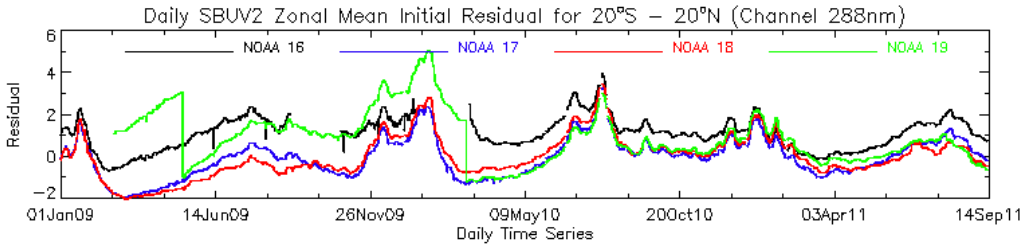
Well-matched Orbits for 6/15/2013

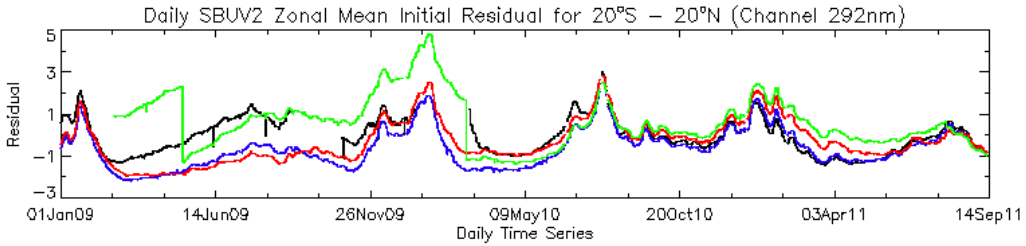


Comparison of Initial V6 Measurement Residuals for S-NPP OMPS NP and NOAA-19 SBUV/2

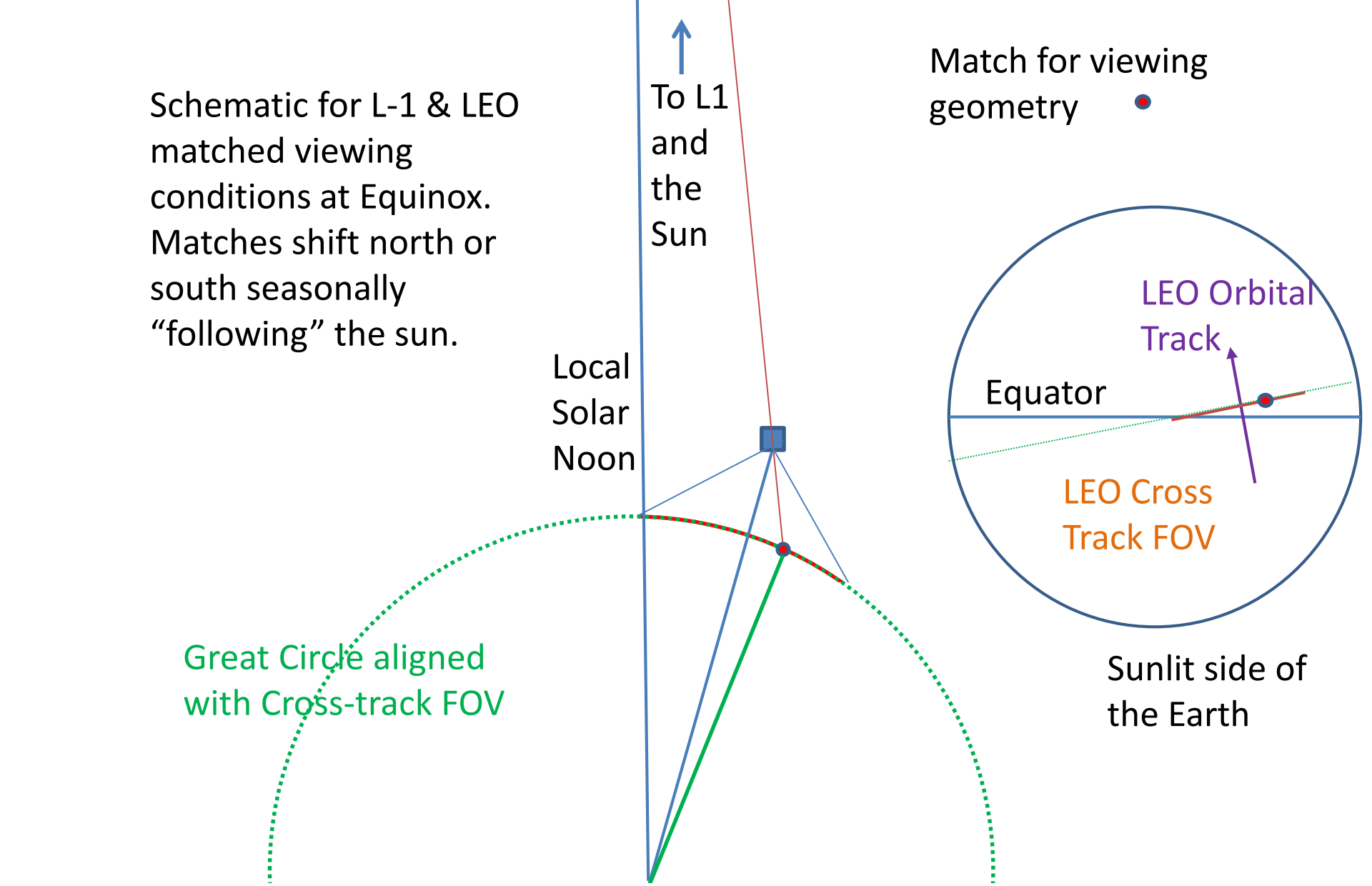


Operational Initial Residuals for SBUV/2





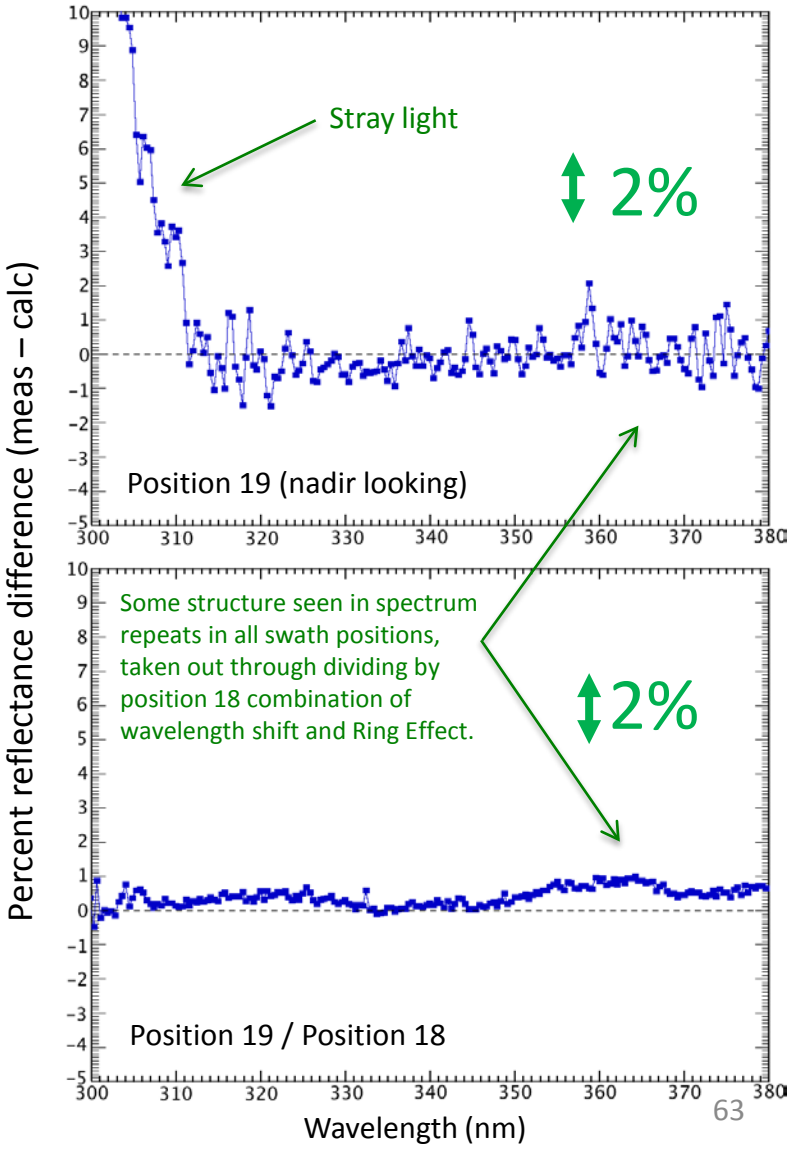
Daily Means
Equatorial Pacific Box
20S – 20N Latitude
100W to 180W Longitude



Simultaneous View Path (SVP) match up between DSCOVR EPIC at 0º offset with the Earth/Sun line and S-NPP OMPS. Matches will be present for any BUV instrument on a GEO platform with one in a LEO orbit as the LEO orbital tracks pass near the GEO sub-satellite point.

OMPS TC comparisons with modeled Top-of-atmosphere reflectances using MLS ozone retrievals as truth are quite good

- Co-locate MLS temperature and ozone profiles to OMPS TC measurements
  - Reflectivity < 0.10
  - -20 < latitude < 20 degrees
  - June 2012
- Calculate TOA reflectances (radiance / solar flux) from TC viewing conditions, MLS profiles using radiative transfer code (TOMRAD)
- Compare measured OMPS TC reflectance with calculated reflectance
  - Agreement seen to within 1% for wavelengths > 312 nm
- Stray light seen for wavelengths < 312 nm
  - Consistent with pre-launch sensor characterization



MLS results from C. Seftor, SSAI for NASA GSFC

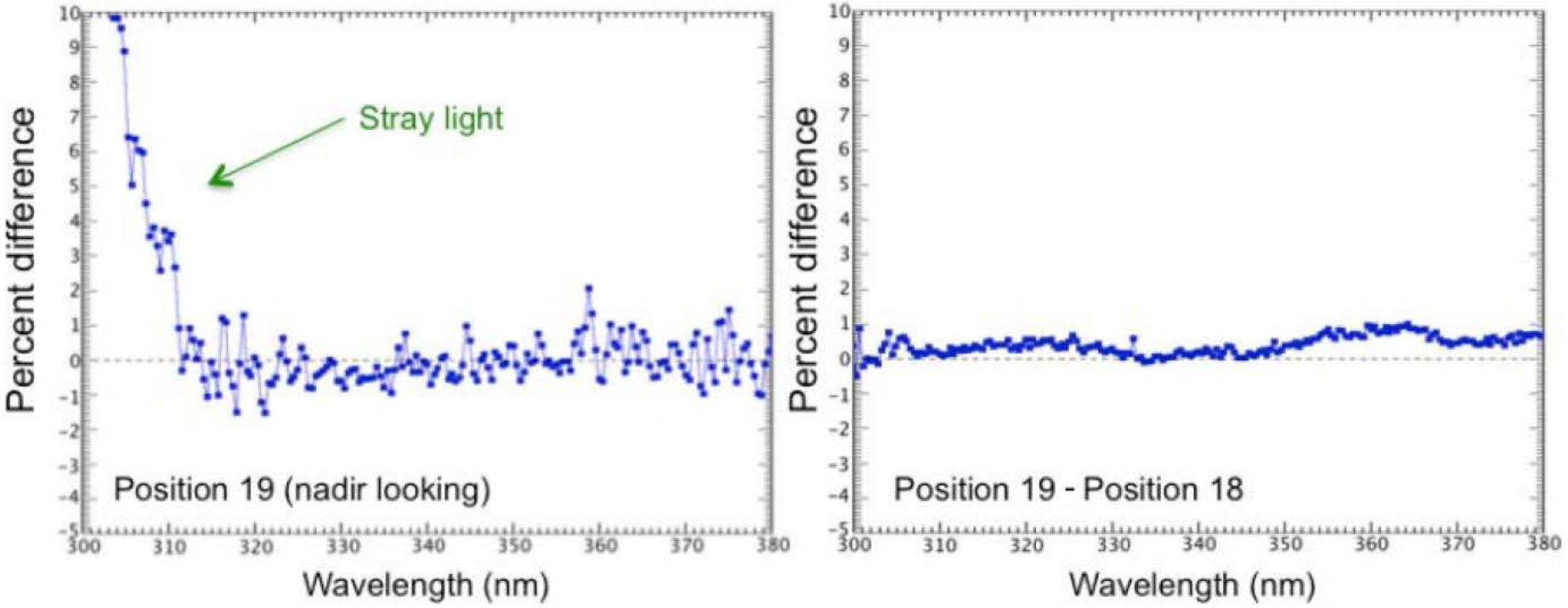


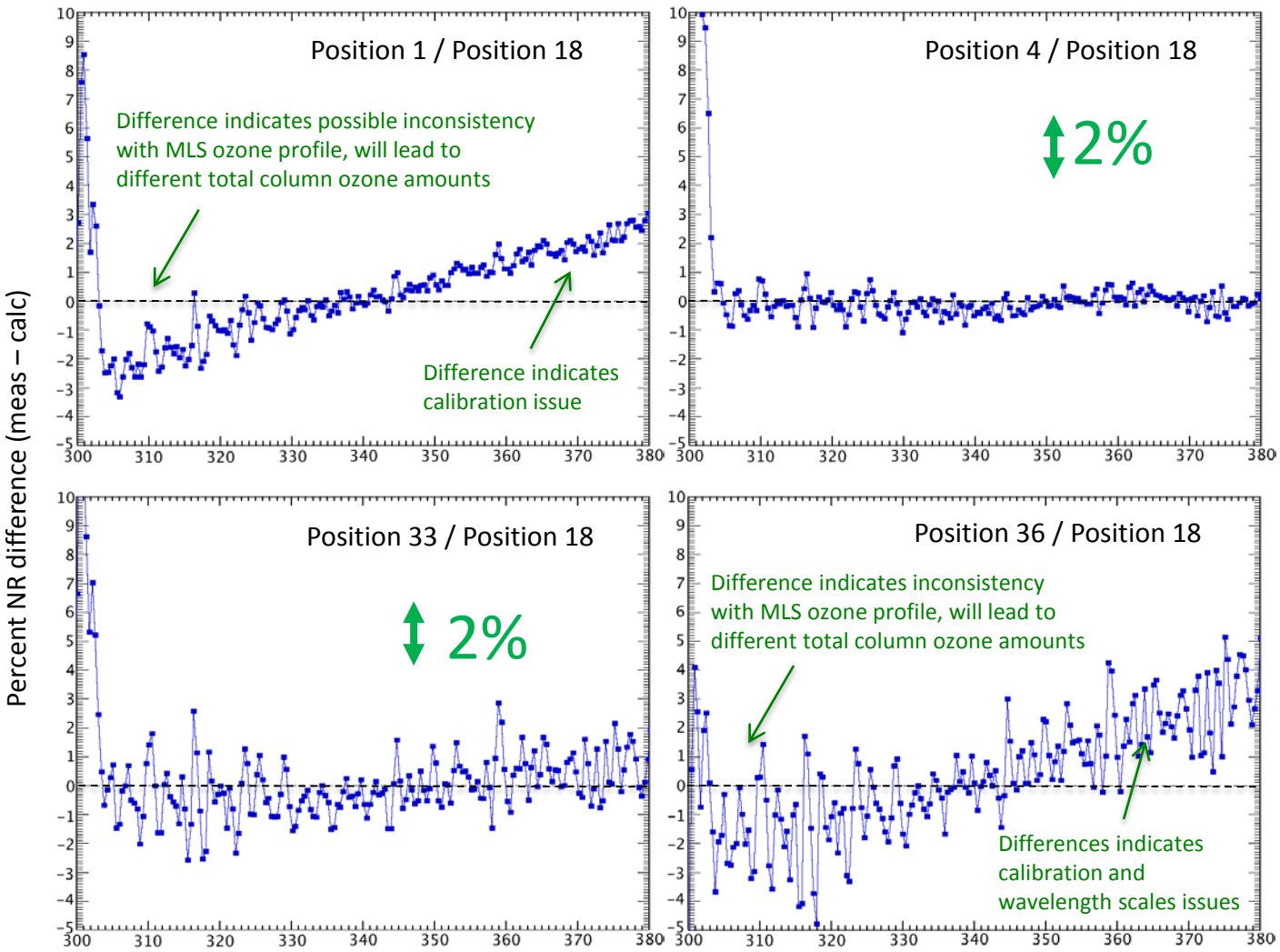
Figure 4: The left plot shows a comparison of normalized radiances calculated using MLS ozone and temperature profiles co-located with OMPS retrievals using the OMPS viewing conditions for cross-track position 19. The average is over 20 degrees south to 20 degrees north latitude for June. In the right plot, the difference for position 18 is subtracted from position 19.

Results from C. Seftor, SSAI for NASA GSFC

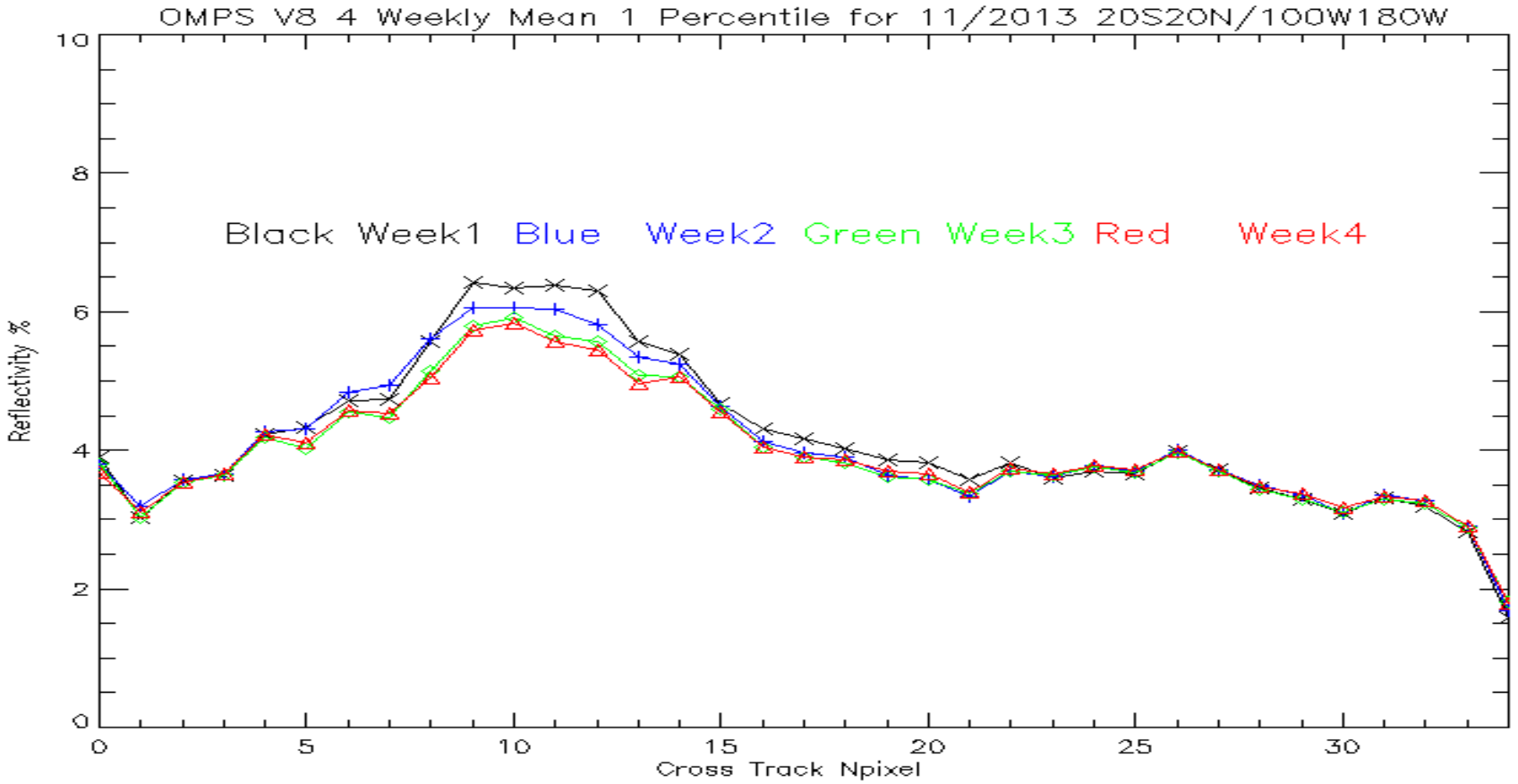
OMPS TC cross-track calibration is typical;
Will require soft calibration adjustments.

Problems at the far off-nadir positions lead to swath dependent ozone effects

Not unusual but should be corrected.

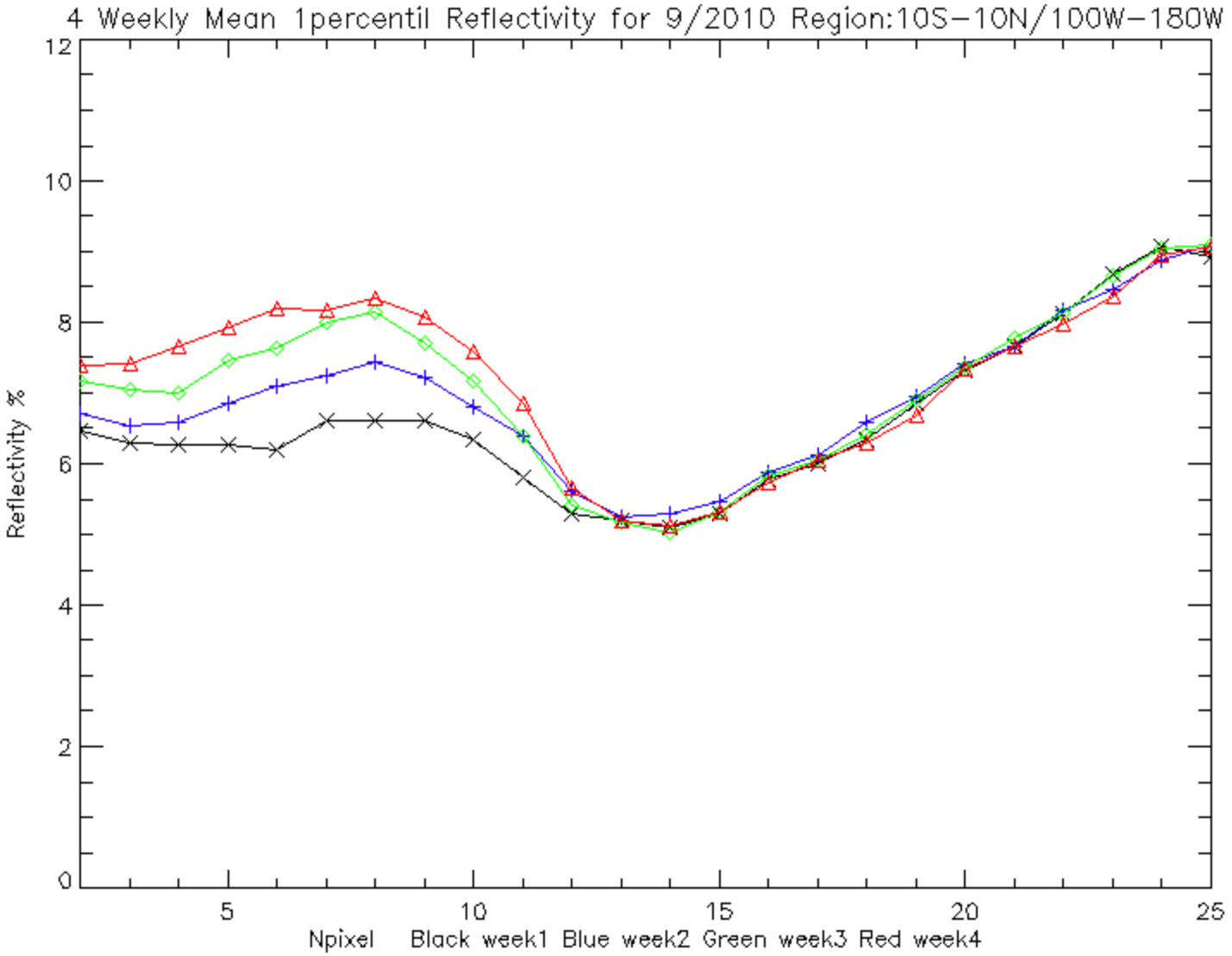


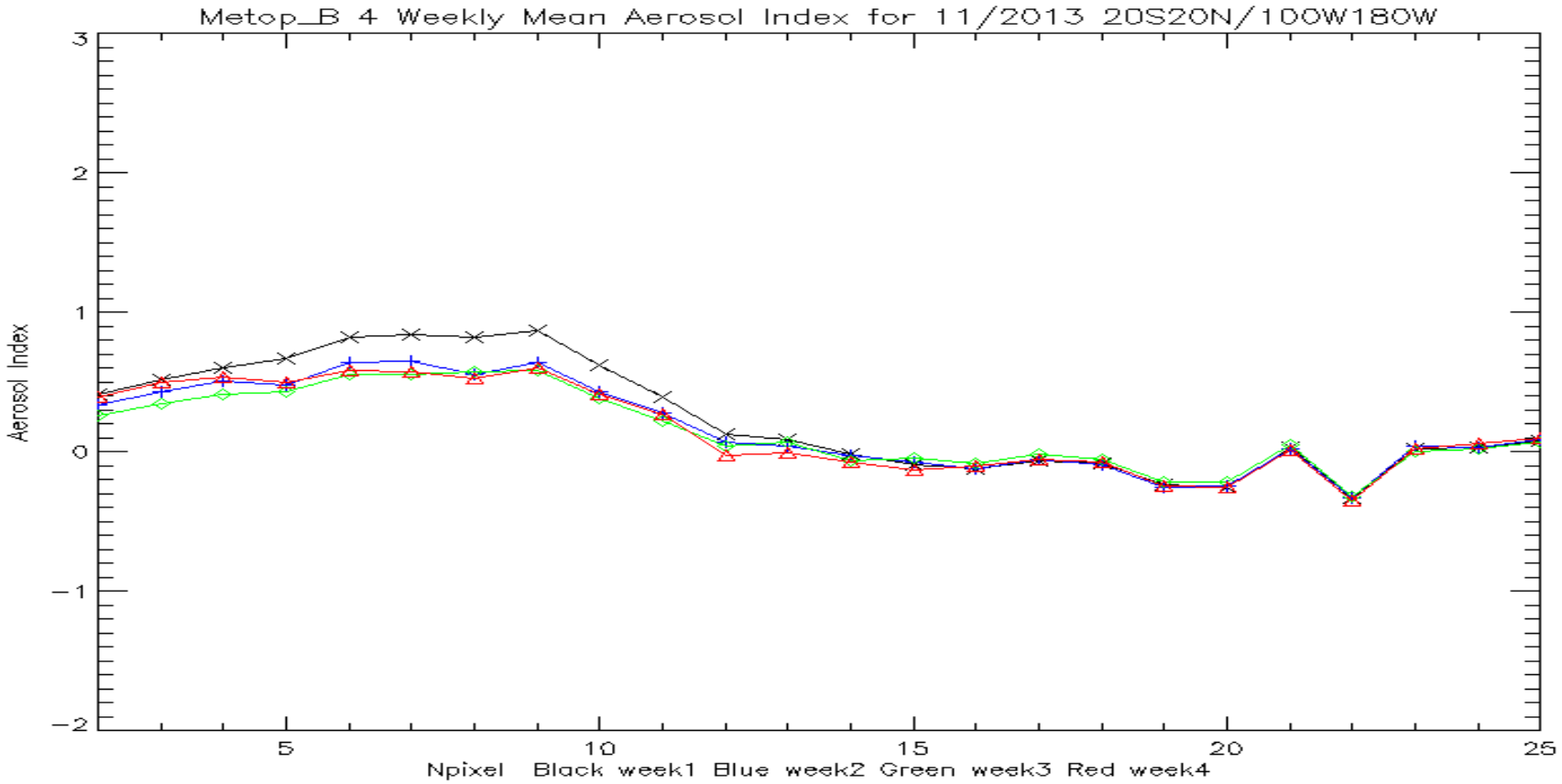
MLS results from C. Seftor, SSAI for NASA GSFC



The lines show the S-NPP OMPS weekly, one-percentile effective reflectivity values for the Version 8 algorithm (331-nm channels) for November 2013 for all the data in a latitude/ longitude box in the Equatorial Pacific versus cross-track view position. (17 is the nadir position and 0 and 34 are the extreme viewing angles.) We expect the one-percentile effective reflectivity values to be approximately 4% for this region of the globe from climatological measurements made by other instruments. The cross-track variations for positions 5 to 15 are related to sun glint effects. Consistent deviations by position are from imperfections in calibration coefficients across the CCD array and intra-orbit wavelength scale shifts.

Reflectivity for GOME-2 on METOP-A





The lines show the MetOP-B GOME-2 weekly aerosol index values for the V8 algorithm (measurement residuals for wavelengths in the 360-nm range using effective reflectivity calculated for the 331-nm range) for November 2013 for all the data in a latitude/ longitude box in the Equatorial Pacific versus cross-track view position. (12/13 are the nadir position and 2 and 25 are the extreme viewing angles.) We expect the aerosol index values to be approximately zero N-values for this region of the globe. The cross-track variations for positions 4 to 10 are related to sun glint effects. Consistent deviations by position are probably from calibration imperfections but are surprising given the scanning nature of GOME-2.

Goals/Topics for the UV Subgroup

1. Exchanges and traceability of standards
   - NIST and SIRCUS
   - Integrating Spheres, diffusers, lamps, lasers, etc.
2. Establish a library of solar measurements
   - Reference high resolution solar (SOLSTICE, SIM, Kitt Peak, etc.)
   - Mg II Index time series, Scale factors at resolution (new OMI)
3. Establish a library of instrument data bases
   - Bandpasses, calibration constants, wavelength scales
   - Day 1 solar, time series with error bars
   - Mg II Indices and scale factors
   - FOVs, Polarization sensitivity,
   - Reference papers, ATBDs, validation, Shift & Squeeze,
4. Establish a library Absorption data bases
   - O3 in the UV with wavelength and temperature dependence
     - at instrument resolution – from DOAS?
   - UV compared to Visible and IR
   - other species -- SO2, NO2, etc.
5. Standard climatologies; vicarious calibration & residual studies
   - Ozone and temperature profiles, covariances
   - Neural net, with tropopause information
   - Averaging kernels or efficiency factors, measurement contribution functions, and Jacobians
6. Analysis of on-board systems
   - Diffusers, stable orbits
   - White lights, spectral lamps, LEDs
   - Moon views

Stray light, linearity, gains, offsets, mirrors, polarisation, λ-scale, bandpass

7. Considerations for comparisons
   - Complications from diurnal variations, SZA, SVA, RAA
   - Zonal means
   - Simultaneous nadir overpass (Rad/Irrad or products)
   - Formation flying / Chasing orbits
   - No-local-time differences
   - Ice, desert and open ocean targets
   - Pacific Box
   - LEO to GEO to L1
8. Internal consistency techniques
   - Ascending/descending -- Langley methods
   - Pair justification
   - DOAS (and EOF analysis) (Closure polynomials)
   - Stray light correlation
   - Wavelength scale, shift and squeeze, etc.
   - Measurement Residuals, reflectivity range/distribution
9. Forward model and measurements
   - Rayleigh
   - Absorption
   - Spherical geometry
   - Inelastic scattering (Ring Effect), Stray light, solar activity
   - Aerosols
   - Polarization
   - TOMRAD, VLIDORT, SCIATrans, CRTM, etc.
   - V8 SBUV/2 and *A Priori* as transfer for Viewing conditions…
10. Reflectivity
    - Surface (database and snow/ice forecasts), Variations in surface reflectivity with season, sza and sva.
    - Surface pressure
    - Clouds (Cloud top pressure)
    - Cloud-optical-centroids (Ring Effect, 02-02, O2 A band)
11. Aerosols
    - Climatology/Type, height
    - Wavelength or polarization dependence (Aerosol Indices)
12. Nadir Instruments LEO
    - TropOMI, GOME(-2), OMPS, TOU/SBUS, OMS,
    - SCIAMACHY, OMI, TOMS, SBUV(/2)

12. Nadir Instruments GEO or L1
    - TEMPO, GEMS, UVN and EPIC

13. Limb instruments
    - SAGE III, ACE/MAESTRO, OSIRIS, MLS,
    - GOMOS, SCIAMACHY, OMPS-LP

14. Ground-based
    - WOUDC, Dobson, Brewer, Lidar, MW and Ozonesondes