# Ozone Session Agenda

| | | | |
|---|---|---|---|
| 0915 - 1155 | **Ozone<br>Chairs: Larry Flynn<br>ESSIC 4102** | | |
| 0915 - 0930 | *Why are we using V8TOz and V8Pro for OMPS Ozone Retrievals?* | Larry Flynn | NOAA/STAR |
| 0930 - 0945 | *Suomi NPP OMPS Reprocessing and Soft Calibration* | Zhihua Zhang | NOAA/STAR |
| 0945 - 1000 | *J1 Plans for Smaller FOV and Algorithm Refinements* | Trevor Beck | NOAA/STAR |
| 1000 - 1015 | *Validation of OMPS Limb Profile Products* | Natalya Kramarova | NASA/SSAI |
| 1015 - 1030 | ***Break*** | | |
| 1030 - 1040 | *TOAST and Combined UV/IR Part 1* | Jianguo Niu | NOAA/STAR |
| 1040 - 1050 | *TOAST and Combined UV/IR Part 2* | Steven Buckner | CREST/HU |
| 1050 - 1105 | *OMPS ozone product comparisons with ground-based stations* | Irina Petropavlovskikh | NOAA/ESRL |
| 1105 - 1120 | *User Validation and Applications* | Craig Long | NOAA/NCEP |
| 1120 - 1130 | *ICVS and Operational Monitoring Part 1* | Eric Beach | NOAA/STAR |
| 1130 - 1140 | *ICVS and Operational Monitoring Part 2* | Vaishali Kapoor | NOAA/OSPO |
| 1140 - 1155 | *GSICS UV Projects* | Larry Flynn | NOAA/STAR |

# General

- Copies of the presentations
  - Please provide final copies of presentations for general release by Monday
- Break
  - We will have one break at 10:15 AM

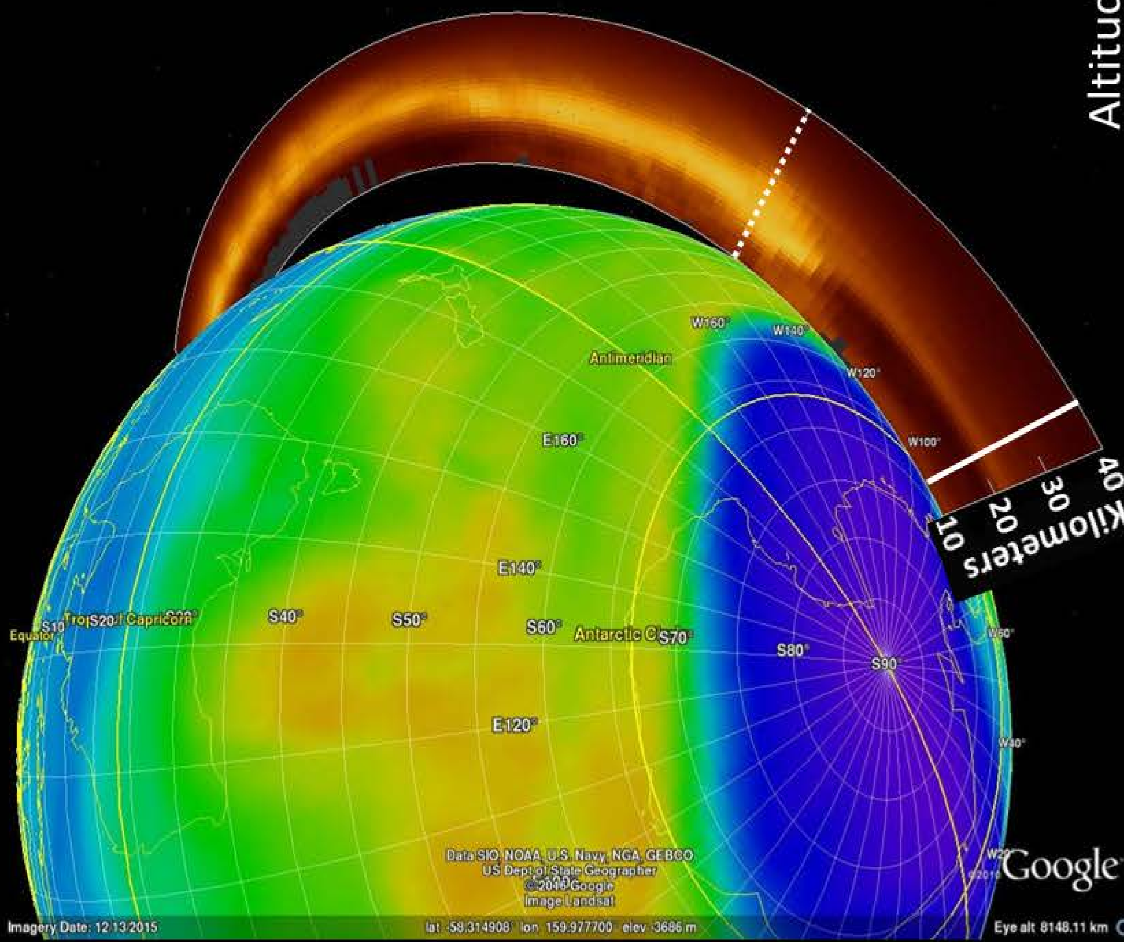
# OMPS Products

## Algorithm and Validation Plans

***Why are we using V8TOz and V8Pro for OMPS Ozone Retrievals?***

**L. Flynn, C.T. Beck, C. Long, and I. Petropavlovskikh**

**Lawrence.E.Flynn@noaa.gov**



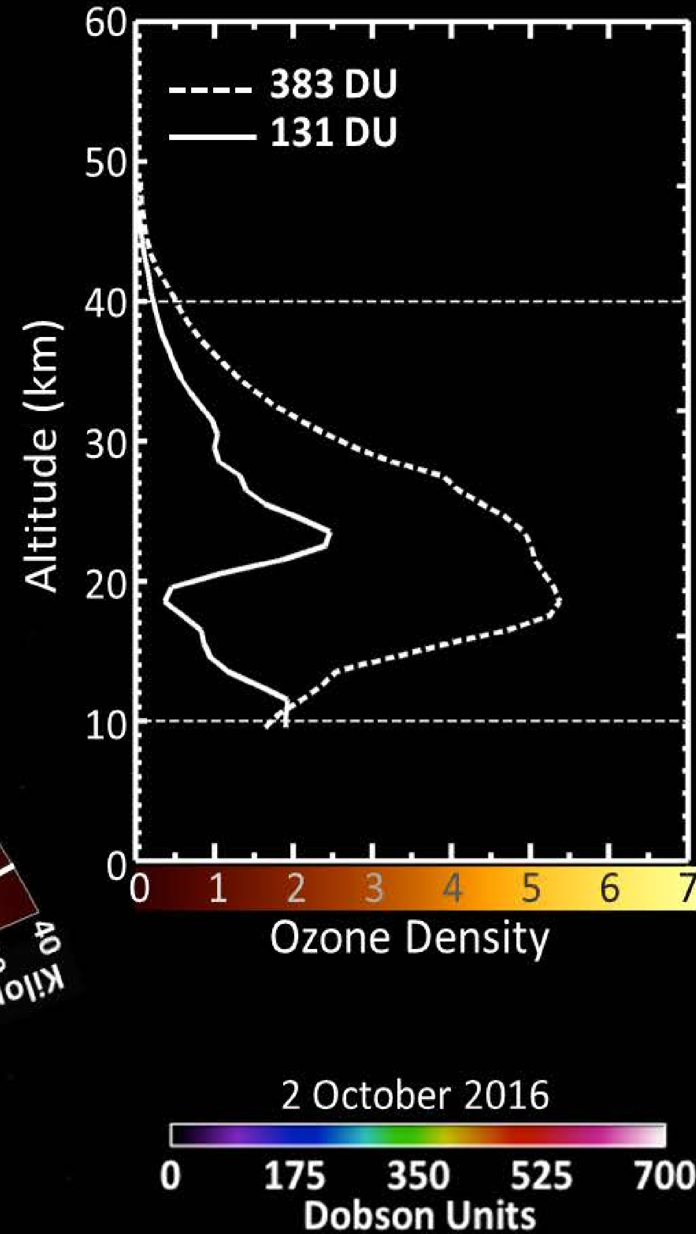




Figure provided by Colin Seftor, NASA GSFC (SSAI)

# Outline

- Cal/Val/Alg Team Members
- Sensor Overview
- Algorithm Overview
- Product Overview
- JPSS-01 Readiness
- Summary and Path Forward

# Ozone Cal/Val/Alg Team Membership

| EDR | Name | Organization | Tasks and Responsibilities |
|---|---|---|---|
| Lead | Lawrence Flynn | NOAA/NESDIS/STAR | Ozone EDR Team |
| Sub-Lead | Irina Petropavlovskikh | NOAA/ESRL/CIRES | Ground-based validation |
| Sub-Lead | Craig Long | NOAA/NWS/NCEP | Product applications |
| Sub-Lead | Trevor Beck | NOAA/NESDIS/STAR | Algorithm development and reprocessing |
| Member | Jianguo Niu | STAR/IMSG/SRG | Algorithm development, trouble shooting, Limb Profiler science |
| Member | Eric Beach | STAR/IMSG | Validation, ICVS/Monitoring, Data management |
| Member | Zhihua Zhang | STAR/IMSG | V8 Algorithms implementation and modification |
| Member | Eve-Marie Devaliere | STAR/ERT | Limb Profiler algorithms |
| JAM | Laura Dunlap | JPSS/Aerospace | Coordination |
| Adjunct | Bigyani Das | STAR/AIT | Deliveries |
| Ozone PAL | Vaishali Kapoor | OSDPD | Ozone Product Area Lead |

# Measurement Overview

## Nadir Mapper (NM)

**Grating spectrometer, 2-D CCD**
**110 deg. cross track,**
**300 nm to 380 nm spectral,**
**1.1nm FWHM bandpass**

## Nadir Profiler (NP)

**Grating spectrometer, 2-D CCD**
**Nadir view, 250 km cross track,**
**250 nm to 310 nm spectral,**
**1.1 nm FWHM bandpass**

## Limb Profiler (LP)

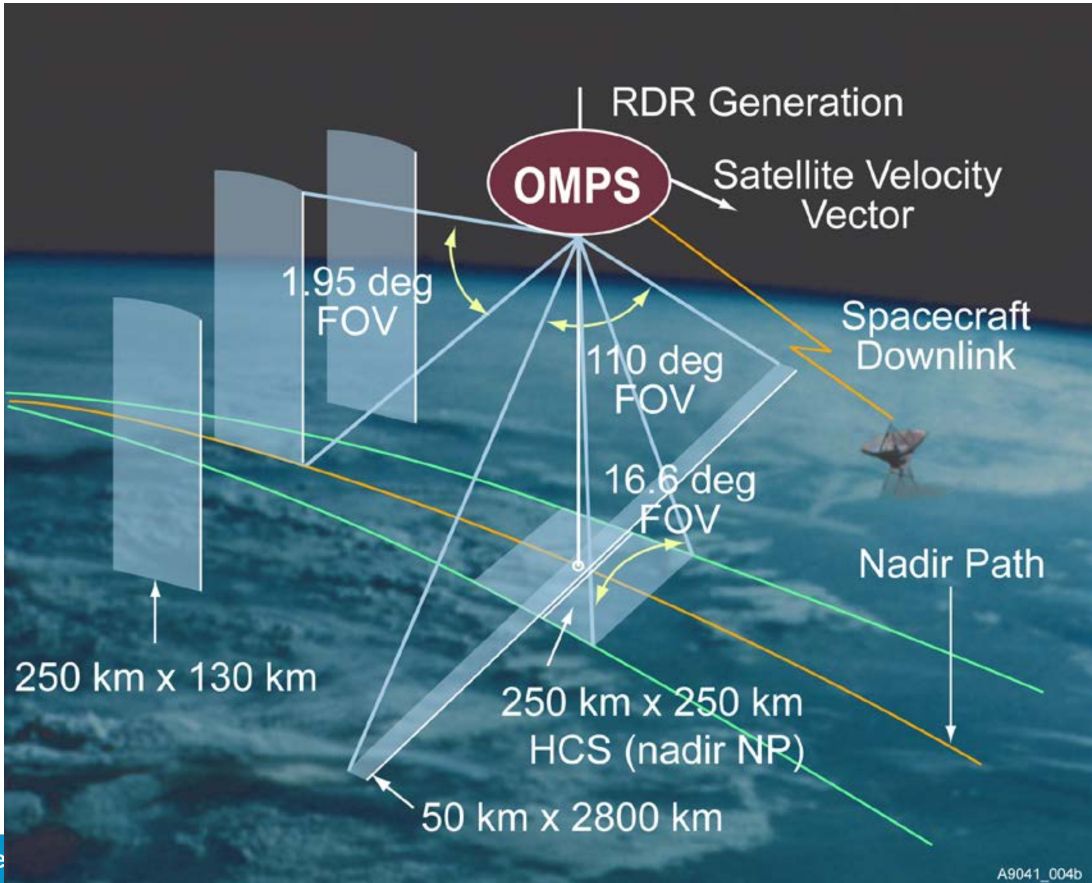
**Prism spectrometer, 2-D CCD**
**Three vertical slits, -20 to 80 km,**
**290 nm to 1000 nm**

**The calibration systems use pairs of working and reference solar diffusers.**

## Ozone Mapping & Profiler Suite

**Global daily monitoring of the three dimensional distribution of ozone and other atmospheric constituents.**

**Continues the NOAA SBUV/2, EOS-AURA OMI and SOLSE/LORE records.**



# OMPS Version 8 Total Ozone EDR Requirements

- JPSS Level 1 Requirements Document (L1RD) Supplement for the OMPS Ozone Total Column Environmental Data Records (EDRs)

| Table 5.2.11 - Ozone Total Column (O | |
|---|---|
| EDR Attribute | Threshold |
| | |
| **Ozone TC Applicable Conditions:**<br>1. Threshold requirements only apply under daytime conditions with Solar Zenith Angles (SZA) up to 80 degrees.<br>2. The EDR shall be delivered for all SZA | |
| a. Horizontal Cell Size | 50 x 50 km² @ nadir |
| b. Vertical Cell Size | 0 - 60 km |
| c. Mapping Uncertainty, 1 Sigma | 5 km at Nadir |
| d. Measurement Range | 50 - 650 milli-atm-cm |
| e. Measurement Precision | |
| 1. X < 0.25 atm-cm | 6.0 milli-atm-cm |
| 2. 0.25 < X < 0.45 atm-cm | 7.7 milli-atm-cm ~2% |
| 3. X > 0.45 atm-cm | 2.8 milli-atm-cm + 1.1% |
| f. Measurement Accuracy | |
| 1. X < 0.25 atm-cm | 9.5 milli-atm-cm |
| 2. 0.25 < X < 0.45 atm-cm | 13.0 milli-atm-cm ~3% |
| 3. X > 0.45 atm-cm | 16.0 milli-atm-cm |
| g. Refresh | At least 90% coverage of the globe every 24 hours (monthly average) |
| | |

Verification of Performance:

a. 20-Pixel Aggregation and 7-S along track integration.

b. 318 nm channel BUV comes from the surface to top of atmosphere. Standard profiles in tables account for full range.

c. Confirmed by coastlines and comparison to 750x750 m^2 VIIRS.

d. Confirmed by standard profiles and four years of processing and ground-based matchup scatter.

e. Precision estimates from Nearest Neighbor analysis. Use of 1512 Latitude/Month/TOz profiles.

f. Accuracy is adjusted by soft calibration and checked by zonal mean and overpass statistics.

g. 105° cross-track swath provides full daily coverage.

# OMPS Version 8 Ozone Profile EDR Requirements

| Ozone Nadir Profile (OMPS-NP) (3) | |
|---|---|
| **Attribute** | **Threshold** |
| a. Horizontal Cell Size | 250 x 250 km^2 (1) |
| b. Vertical Cell Size | 3 km reporting |
| 1. Below 30 hPa ( ~ < 25 km) | 10 -20 km |
| 2. 30 -1 hPa ( ~ 25 -50 km) | 7 -10 km |
| 3. Above 1 hPa ( ~ > 50 km) | 10 -20 km |
| c. Mapping Uncertainty, 1 Sigma | < 25 km |
| d. Measurement Range 0-60 km | 0.1-15.0 ppmv |
| e. Measurement Precision (2) | |
| 1. Below 30 hPa ( ~ < 25 km) | Greater of 20 % or 0.1 ppmv |
| 2. 30 -1 hPa ( ~ 25 -50 km) | 5% -10% |
| 3. Above 1 hPa ( ~ > 50 km) | Greater of 10% or 0.1 ppmv |
| f. Measurement Accuracy (2) | |
| 1. Below 30 hPa ( ~ < 25 km) | Greater of 10 % or 0.1 ppmv |
| 2. 30 -1 hPa ( ~ 25 -50 km) | 5% -10% |
| 3. Above 1 hPa ( ~ > 50 km) | Greater of 10 % or 0.1 ppmv |
| g. Refresh | At least 60% coverage of the globe every 7 days (monthly average) (2,3) |

**Notes:** 1. SDRs will go to 50x50 km^2 for J-01. 2. The OMPS Nadir Profiler performance is expected to degrade in the area of the South Atlantic Anomaly (SAA) due to the impact of periodic charged particle effects in this region. 3. All OMPS measurements require sunlight, so there is no coverage in polar night areas.

Verification of Performance:

a. 93-Pixel Aggregation and 37.5-S along track integration.
b. Version 8 Algorithm Averaging Kernels
c. Confirmed by Nadir Mapper and Pixel size.
d. Confirmed by four years of processing and ground-based matchup scatter.
e. Precision estimates from SNR and Version 8 performance.
f. Accuracy is adjusted by soft calibration and checked by zonal mean statistics and Version 8 measurement functions and a priori profiles
g. Suborbital track and precession of orbits.

# OMPS Total Ozone Products Algorithm Status and Approach

- Current status of algorithms
  - The Version 8 total ozone algorithm (V8TOz) and Linear Fit $SO_2$ (LFSO2) algorithm were developed by NASA OMI Science Team.
  - Versions of the total ozone algorithm have been in use at NOAA for operational processing of SBUV/2 and GOME-2 measurements and for offline processing of the OMPS NM measurements.
- Overview of technical approach of the algorithm and its implementation
  - The V8TOz has been implemented at NDE on granule processing to create EDRs. The algorithm combines radiance/irradiance ratios at 12 channels with climatological information and radiative transfer tables for standard ozone profiles to compute estimates of total column ozone, effective reflectivity and aerosols.
  - The algorithm will process up to 105 cross-track by 15 along-track FOVs/granule.
  - The LFSO2 algorithm uses the measurement residuals from the V8TOz retrievals to estimate the $SO_2$ using three sensitive channels and adjusts the final ozone estimate for the $SO_2$ absorption effects.
  - The algorithms uses the OMPS NM SDR and GEO products, climatological ancillary data, and radiative transfer look-up tables. We expect to refine the ancillary data in the future, e.g., to use daily snow/ice tiles in place of climatology.
  - Concept of operations
    - Obtain operational NRT OMPS NM SDR and GEO from IDPS at NDE
    - Process SDRs to EDRs granule by granule
    - Process 15 EDR granules at a time to produce the final $SO_2$ /$O_3$ estimates.
    - The algorithm uses a set of soft calibration adjustments that will be updated infrequently as OMPS NM as shown little degradation.

# OMPS Total Ozone Products Algorithm Status and Approach (Cont.)

- Validation concept
  - Validation is concentrating on comparisons to total ozone retrievals from other total ozone mapping satellite instruments (e.g., SBUV/2, OMI, and GOME-2) and to ground-based records from Dobson and Brewer station.
  - The NOAA JPSS Ozone Team and NASA S-NPP Science Team validated V8TOz products for the first four years of S-NPP data. OMPS LFSO2 products are in use at the European VAAC from the FMI Fast Delivery direct broadcast system.

# OMPS Nadir Ozone Profile Products
# Algorithm Status and Approach

- Current status of algorithms
  - NASA developed the Version 8 nadir ozone profile algorithm (V8Pro) over ten years ago. It has been in use for the NOAA SBUV/2 program since then.
- Overview of technical approach of the algorithm and its implementation
  - The V8Pro has been implemented at NDE as granule processing to create EDRs. The algorithm combines radiance/irradiance ratios at 12 channels with climatological information and radiative transfer tables for standard ozone profiles to compute maximum likelihood estimates of ozone vertical profiles, effective reflectivity and aerosols.
  - The algorithm is designed for producing retrievals for Nadir centered FOVs.
  - The algorithm uses the OMPS NM and NP SDR and GEO products, climatological ancillary data, and radiative transfer look-up tables. We expect to refine the ancillary data in the future, e.g., use daily snow/ice tiles in place of climatology.
  - Concept of operations
    - Obtain OMPS NM and NP SDR and GEO from IDPS
    - Process SDRs to EDRs granule by matching up NM and NP Granules/Scans/FOVs.
    - The algorithm uses a set of soft calibration adjustments that will be updated infrequently. The OMPS NP has shown some wavelength-dependent degradation.

# OMPS Nadir Ozone Profile Products Algorithm Status and Approach (Cont.)

- Validation Concept
  - Validation is concentrating on comparisons to ozone retrievals from other ozone profile instruments (e.g., SBUV/2) and to ground-based records from Umkehr and Ozonesonde stations.
  - The NOAA JPSS Ozone Team and NASA S-NPP Science Team have validated V8Pro products for the first four years of S-NPP data.

# S-NPP Product Overview (1/2)

- List of Products
  - Total Column Ozone (O3, SO2, Reflectivity, UV Absorbing Aerosol Index)
    - V8TOZ (NDE) (Enterprise/Heritage Algorithm)
    - LFSO2 (NDE) (No SO2 exclusion for NOAA-20)
  - Nadir Ozone Profile
    - V8Pro (NDE) (Enterprise/Heritage Algorithm)
  - Limb Ozone Profile (high vertical resolution)
    - Limb V2.5 (NDE)
  - TOAST (CrIS NUCAPS Ozone with OMPS V8Pro Ozone)
  - BUFR products from NDE are in testing and development with user input.

# S-NPP Product Overview (2/2)

- Reprocessing as better SDRs are provided
  - Total Column Ozone (O3, SO2, reflectivity, UV Aerosol Index)
    - V8TOZ/LFSO2 (STAR)
  - Nadir Ozone Profile
    - V8Pro (STAR)
  - Limb Ozone Profile will be reprocessed by NASA
    - Limb V2.5 (NASA SIPS)
- S-NPP Cal/Val Status
  - Finalized V8 soft calibration adjustments for NDE.
- ICVS pages are in transition from Demonstration to Permanent

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

www.star.nesdis.noaa.gov/jpss/EDRs/products_ozone.php

# NOAA-20 Readiness – Algorithms

- Major Accomplishments and Highlights Moving Towards NOAA-20
  - V8Pro and V8TOz are ready for promotion to operational for S-NPP OMPS EDRs
  - Delivered 15-granule moving-window version of the LFSO2 Code to NDE
  - Working with NASA on early operations and Cal/Val Plan test timelines
- NOAA-20 Algorithm Summary
  - LFSO2/V8TOz for 17x17 km2 FOV

  The V8TOz has been implemented on LINUX systems with NetCDF output. The LFSO2/V8TOz has been adapted to run on 15-granule sequences on the STAR LINUX system using the first-run V8TOz EDR as input. Both algorithms have been delivered with the capability to handle large and medium FOV SDR products. The V8TOz NOAA-20 capable code is on the Development system at NDE.

  - V8Pro for medium FOV data

  The V8Pro to process data from NOAA-20 OMPS NP is in NDE I&T. We developed a new glue-ware aggregator to create 50x250 km2 or 50x50 km2 FOVs EDR product from the full range of large and medium FOV SDR products. The V8Pro NOAA-20 capable code is on the Integration and Testing system at NDE.

# JPSS-01 Readiness – Cal/Val

- NOAA-20 Cal/Val Overview
  - Pre-Launch Calibration/Validation Plans
    - Ozone Cal/Val Plan Completed January 2016
    - Demonstrating V8Pro & V8TOz soft calibration capabilities with S-NPP
    - Working to develop and test all analysis programs as described in the plan with new medium FOV data sets.
  - Post-Launch Calibration/Validation Plans
    - "Beta" ten days after activation and doors open (launch plus 60 days).
      - Geolocation, product range and reporting
    - "Provisional" L+120 days.
      - Precision and first iteration of soft calibration
    - "Validated 1" after ICV (L+210 days)
      - Accuracy and stability from six months of data
    - “Validated 3” After 1 year of measurements (L+410 days)
      - Accuracy and stability over one annual cycle

# JPSS-01 Readiness – Issues & Applications

- Issues / Mitigation
  - Program guidance on platform for OMPS products – NDE Transition
    - Products in NetCDF4 (+ changes for downstream)
    - Details for product deliveries to Users (new BUFR) , STAR and CLASS
    - New system (NDE versus IDPS) for algorithm maintenance and table deliveries
  - NP Degradation, wavelength scale, solar activity and bandpass
    - On-orbit degradation creates uncertainty.
    - Wavelength scale and bandpass mismatch in key calibration data.
    - Biweekly solar and wavelength scale deliveries by the SDR Team added to existing weekly dark updates.
- Users' Readiness
  - STAR has upgraded the BUFR tool for products to be created from the OMPS V8 algorithm products and parameters. V8 algorithm BUFR products from other instruments are already in use at NWS.
  - We are working on soft calibration to homogenize the suite of ozone products from OMPS, SBUV/2, OMI and GOME.
  - We are working with users of aerosol, SO2 and O3 products to prepare them for the higher spatial resolution products.

# Summary and Path Forward

- Heritage/Enterprise Version 8 algorithms are implemented at NDE and provide the capability to process medium FOV NOAA-20 OMPS data. The V8TOz at NDE will be applied to GOME-2.

- The products will meet the program requirements.

- OMPS Limb Profiler products will also be made operationally at NDE.

- Blended UV/IR Ozone products (TOAST) will be transitioned to NDE.

# FY18 OMPS EDR Milestones/Deliverables

| Task Category | Task/Description | Start | Finish | Deliverable |
|---|---|---|---|---|
| Development (D) | **Deferred algorithm improvements (EOFs, Solar, Wavelengths, Bandpasses]**<br>**Develop Cloud Optical Centroid and DOAS $NO_2$ and $SO_2$ Retrievals** | **Present** | **Q3**<br><br><br>**Q4** | **Code modification** |
| Integration & Testing (I) | **Assist with LFSO2 and provide 64-bit V2LP algorithm delivery to NDE** | **Present** | **Q1, Q2** | **Code logic and output changes** |
| Calibration & Validation (C ) | **Final RT Tables for N-20**<br>**Evaluation/validation of S-NPP V8 products including SO2**<br>**Prepare, demonstrate and exercise tools for N-20**<br>**Complete Cal/Val Plan**<br>**Soft Calibration for N-20** | **Present** | **Q2**<br>**Q1**<br><br>**Q1, Q2**<br><br>**Q3** | **New Tables**<br>**Report and statistics on C/V**<br>**C/V Plan RR and execution**<br>**Validation Report**<br>**Adjustment LUTs** |
| Maintenance | **Monitor performance and resolve anomalies**<br>**Release S-NPP Reprocessing** | **Ongoing** | **Ongoing**<br><br>**Q2** | **New DRs and CCRs as needed**<br>**6-year V8 CDRs** |
| LTM & Anomaly Resolution (L) | **Continue and expand ICVS Monitoring**<br>**Trending of ground-based comparisons** | **Ongoing**<br><br>**Ongoing** | **Ongoing**<br><br>**Q1 and Q4** | **New ICVS content Reports for S-NPP and N-20** |

# Path Forward (FY-19 thru FY-22)
# High Priority Ozone Tasks/Milestones

| | S-NPP | JPSS-1 | JPSS-2 |
|---|---|---|---|
| FY19 | **Sustainment, monitoring, maintenance**<br>**Implement Cloud Optical Centroid and DOAS $NO_2$ and $SO_2$ Retrievals** | **Provide feedback to SDR Team**<br>**Complete reprocessing of Ozone Profile, Total Column Ozone, Aerosol Index, and Total Column $SO_2$** | **Review FM3 performance and evaluate impact of any waivers etc.** |
| FY20 | **Sustainment, monitoring, maintenance, reprocessing** | **Complete coordination with users for applications**<br>**Sustainment, monitoring, maintenance** | **J-02 product algorithm review including Limb Profiler** |
| FY21 | | **Sustainment, monitoring, maintenance, reprocessing** | **Deliveries for J-02 tables and code specifics** |
| FY22 | | **Sustainment, monitoring, maintenance, reprocessing** | **Prepare resources and analysis tools to execute Cal/Val Plan** |

# OMPS NP EDR Performance Characteristics

| Table 4.2.4 - Ozone Nadir Profile (OMPS-NP) | | |
|---|---|---|
| **Attribute** | **Threshold** | **Objective** |
| **Ozone NP Applicable Conditions:** 1. daytime only (3) | | |
| a. Horizontal Cell Size | 250 X 50 km^2 (1) | 50 x 50 km^2 |
| b. Vertical Cell Size | 3 km reporting | |
| 1. Below 30 hPa ( ~ < 25 km) | 10 -20 km | 3 km (0 -Th) |
| 2. 30 -1 hPa ( ~ 25 -50 km) | 7 -10 km | 1 km (TH -25 km) |
| 3. Above 1 hPa ( ~ > 50 km) | 10 -20 km | 3 km (25 -60 km) |
| c. Mapping Uncertainty, 1 Sigma | < 25 km | 5 km |
| d. Measurement Range | | |
| Nadir Profile, 0 - 60 km | 0.1-15 ppmv | 0.01 -3 ppmv (0-TH) 0.1-15 ppmv (TH-60 km) |
| e. Measurement Precision (2) | | |
| 1. Below 30 hPa ( ~ < 25 km) | Greater of 20 % or 0.1 ppmv | 10% (0 -TH) |
| 2. At 30 hPa ( ~ 25 km) | Greater of 10 % or 0.1 ppmv | 3% |
| 3. 30 -1 hPa ( ~ 25 -50 km) | 5% -10% | 1% |
| 4. Above 1 hPa ( ~ > 50 km) | Greater of 10% or 0.1 ppmv | 3% |
| f. Measurement Accuracy (2) | | |
| 1. Below 30 hPa ( ~ < 25 km) | Greater of 10 % or 0.1 ppmv | 10% (0 -15 km) |
| 2. 30 -1 hPa ( ~ 25 -50 km) | 5% -10% | 5% (15 -60 km) |
| 3. At 1 hPa ( ~ 50 km) | Greater of 10 % or 0.1 ppmv | 5% (15 -60 km) |
| 4. Above 1 hPa ( ~ > 50 km) | Greater of 10 % or 0.1 ppmv | 5% (15 -60 km) |
| g. Refresh | At least 60% coverage of the globe every 7 days (monthly average) (2,3) | 24 hrs. (2,3) |

**Notes:** 1. The SBUV/2 has a 180 km X 180 km cross-track by along -track FOV. It makes its 12 measurements over 24 Samples (160 km of along-track motion). The OMPS Nadir Profiler is designed to be operated in a mode that is able to subsample the required HCS. 2. The OMPS Nadir Profiler performance is expected to degrade in the area of the South Atlantic Anomaly (SAA) due to the impact of periodic charged particle effects in this region. 3. All OMPS measurements require sunlight, so there is no coverage in polar night areas.

# OMPS TC EDR Performance Characteristics

| | Threshold | Objective |
|---|---|---|
| **Ozone TC Applicable Conditions 1, 2.** | | |
| a. Horizontal Cell Size | 50 x 50 km2 @ nadir | 10 x 10 km2 |
| b. Vertical Cell Size | 0 - 60 km | 0 - 60 km |
| c. Mapping Uncertainty, 1 Sigma | 5 km at Nadir | 5 km |
| d. Measurement Range | 50 - 650 milli-atm-cm | 50-650 milli-atm-cm |
| e. Measurement Precision | . | . |
| 1. X < 0.25 atm-cm | 6.0 milli-atm-cm | 1.0 milli-atm-cm |
| 2. 0.25 < X < 0.45 atm-cm | 7.7 milli-atm-cm | 1.0 milli-atm-cm |
| 3. X > 0.45 atm-cm | 2.8 milli-atm-cm + 1.1% | 1.0 milli-atm-cm |
| f. Measurement Accuracy | . | . |
| 1. X < 0.25 atm-cm | 9.5 milli-atm-cm | 5.0 milli-atm-cm |
| 2. 0.25 < X < 0.45 atm-cm | 13.0 milli-atm-cm | 5.0 milli-atm-cm |
| 3. X > 0.45 atm-cm | 16.0 milli-atm-cm | 5.0 milli-atm-cm |
| g. Latency | 90 min. | 15 min. |
| h. Refresh | At least 90% coverage of the globe Every 24 hours (monthly average) | 24 hrs. |
| i. Long-term Stability | 1% over 7 years | 0.5 % over 7 years |
| 1. Threshold requirements only apply under daytime conditions with Solar Zenith Angles (SZA) up to 80 degrees.<br>2. The EDR shall be delivered for all SZA.<br>3. SO2 exclusion removed. | | |

# OMPS LP EDR Performance Characteristics

| Table 3.3.1 - Ozone Limb Profile (OMPS-L) | | |
|---|---|---|
| **Attribute** | **Threshold** | **Objective** |
| Ozone LP Applicable Conditions | SZA < 80 degrees | SZA < 88 degrees |
| a. Horizontal Attributes | | |
| 1. Horizontal Cell Size | 250 km | 125 km |
| 2. Horizontal Reporting | 125 km | 50 km |
| b. Vertical Attributes | | |
| 1. Vertical Coverage | TH to 60 km | 0 km to 60 km |
| 2. Vertical Reporting | 1 km | 1 km |
| 3. Vertical Resolution | | |
| i. 0 to TH (1) | N/A | 3 km |
| ii. TH to 25 | 5 km | 1 km |
| iii. 25 km to 60 km | 5 km | 3 km |
| c. Mapping Uncertainty, 1 Sigma | < 25 km | < 5 km |
| d. Measurement Range | | |
| 1. 0 to TH (1) | N/A | 0.01 to 3 ppmv |
| 2. Th - 60 km | 0.1 to 15 ppmv | 0.1 to 15 ppmv |
| e. Measurement Precision | | |
| 1. 0 to TH (1) | N/A | 10% |
| 2. TH to 15 km | Greater of 10 % or 0.1 ppmv | 3% |
| 3. 15 to 50 km | Greater of 3 % or 0.05 ppmv | 1% |
| 4. 50 to 60 km | Greater of 10% or 0.1 ppmv | 3% |
| f. Measurement Accuracy | | |
| 1. 0 to TH (1) | N/A | 10% |
| 2. TH to 15 km | Greater of 20 % or 0.1 ppmv | 10% |
| 3. 15 to 60 km | Greater of 10 % or 0.1 ppmv | 5% |
| g. Latency | 90 minutes | 15 minutes |
| g. Refresh | At least 75% coverage of the globe every 4 days (monthly average) (2) | 24 hrs (2) |
| h. Long-term Stability | 2% over 7 years | 1% over 7 years |
| Notes: | | |
| 1. TH is Tropopause Height or 8 km, whichever is greater as determined by ancillary data. | | |
| 2. All OMPS measurements require sunlight, so there is no coverage in polar night areas. With three limb curtains (each with a Vertical FOV of ~ 1.85° ) positioned at Nadir and 250 km (+/- 4.3 degrees) on each side, the measurements are taken to give a good representation of the ozone profile in the central 750 Km of the orbital track. With a 4-day repeat cycle in the orbital tracks, this will yield a 4-day revisit time (approximately) for 30,000 km out of 40,000 km equator. | | |

# S-NPP OMPS Reprocessing and Soft calibration

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**Aug. 16, 2017**

# OUTLINE

- Introduction to S-NPP OMPS and Ozone retrievals
- General Description of Soft Calibration
- Soft Calibration Statistics (V8TOZ)
- Soft Calibration Statistics (V8PRO)
- OMPS V8TOZ/V8PRO retrieval products
- Conclusion

# Introduction to S-NPP OMPS and Ozone retrievals

- The Ozone Mapping and Profiler Suite (OMPS) onboard the S-NPP satellite (JPSS) is the next generation of US operational space-borne UV and ozone monitoring instruments, which was launched on October 28, 2011

- There are three spectrometers onboard; OMPS NM (total column ozone sensor) , OMPS NP (nadir ozone profile sensor)  and OMPS limb profile

- The Version8 total O3 (V8TOZ) algorithm and Version8 O3 profile (V8PRO) algorithm, developed by NASA Ozone Science Team, are the most recent  version of a series of BUV (backscattered ultraviolet) ozone retrieval algorithm (Applied to SBUV/2, GOME-2, OMI, OMPS and TOMS)

# Introduction to S-NPP OMPS and Ozone retrievals

## Current Status of NOAA S-NPP OMPS

- V8TOZ/V8PRO have been routinely used for processing at STAR with IDPS-produce SDR data
- We have made a third delivery of V8TOZ/V8PRO to NDE (new adjustments, codes working for both NPP and J01 SDR input data)
- We completed OMPS EDR reprocessing for both V8PRO and V8TOZ, the retrievals were saved at:
  / data/data074/NPP/OMPS/DATA/NM/yyyy/mm/dd/V8TOZ_REP
  /data/data074/NPP/OMPS/DATA/NP/yyyy/mm/dd/V8PRO_REP
  Retrievals for 2012-01-26 to 2015-09-09 were based on re-processed SDR data
  Retrievals for 2015-09-10 to 2017-05-31 were based on IDPS SDR data

# General Description of Soft calibration

## The main purposes of soft-calibration:

- Adjust ozone retrievals between different instruments (SBUV/2, OMPS) to make consistent long-term climate data records.

- Remove bias between the retrieved ozone and a “truth” data set.

- Remove the systematic cross-track bias in ozone, reflectivity and aerosol index, mainly for NM total column ozone retrievals .

# General Description of Soft calibration

## The procedure of soft-calibration:

1) Determine ΔΩ (ozone differences) and ΔR (reflectivity differences):
   * For V8TOZ, those are the biases of retrieved total ozone and reflectivity related to cross-track positions;
   * For V8PRO, those are the difference of ozone and reflectivity between two instruments (SBUV/2, OMPS)

2) Calculate N-Value adjustments for ozone (318nm) and reflectivity (331nm), using N-Value sensitivity to ozone and reflectivity

$$\Delta N_{(318)} = \Delta R * dN_{(318)}/dR + \Delta\Omega * dN_{(318)}/d\Omega$$
$$\Delta N_{(331)} = \Delta R * dN_{(331)}/dR + \Delta\Omega * dN_{(331)}/d\Omega$$

3) * For the rest of 10 channels of V8TOZ algorithm, calculate the N-Value adjustments by averaging the adjusted step2 residuals from ΔΩ and ΔR

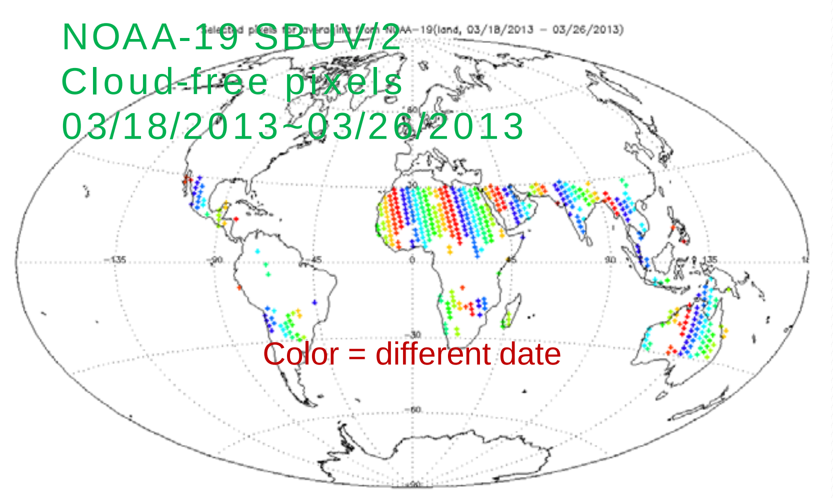
$$\Delta N_{(wl)} = \text{mean}(\text{Step2Res}_{(wl)} - \Delta R * dN_{(wl)}/dR - \Delta\Omega * dN_{(wl)}/d\Omega)$$

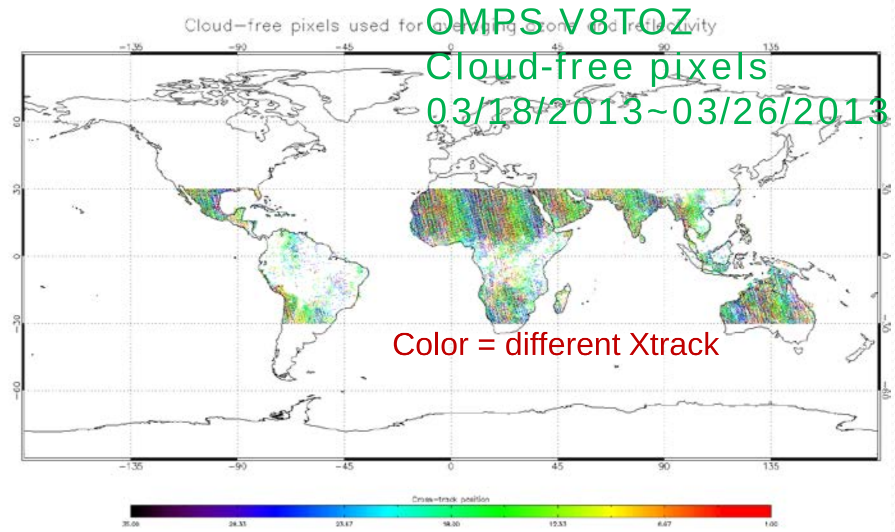
   * For the rest channels of V8PRO algorithm, we make the measurement residual agree between two instruments.

# General Description of Soft calibration

OMPS V8TOZ soft-calibration:

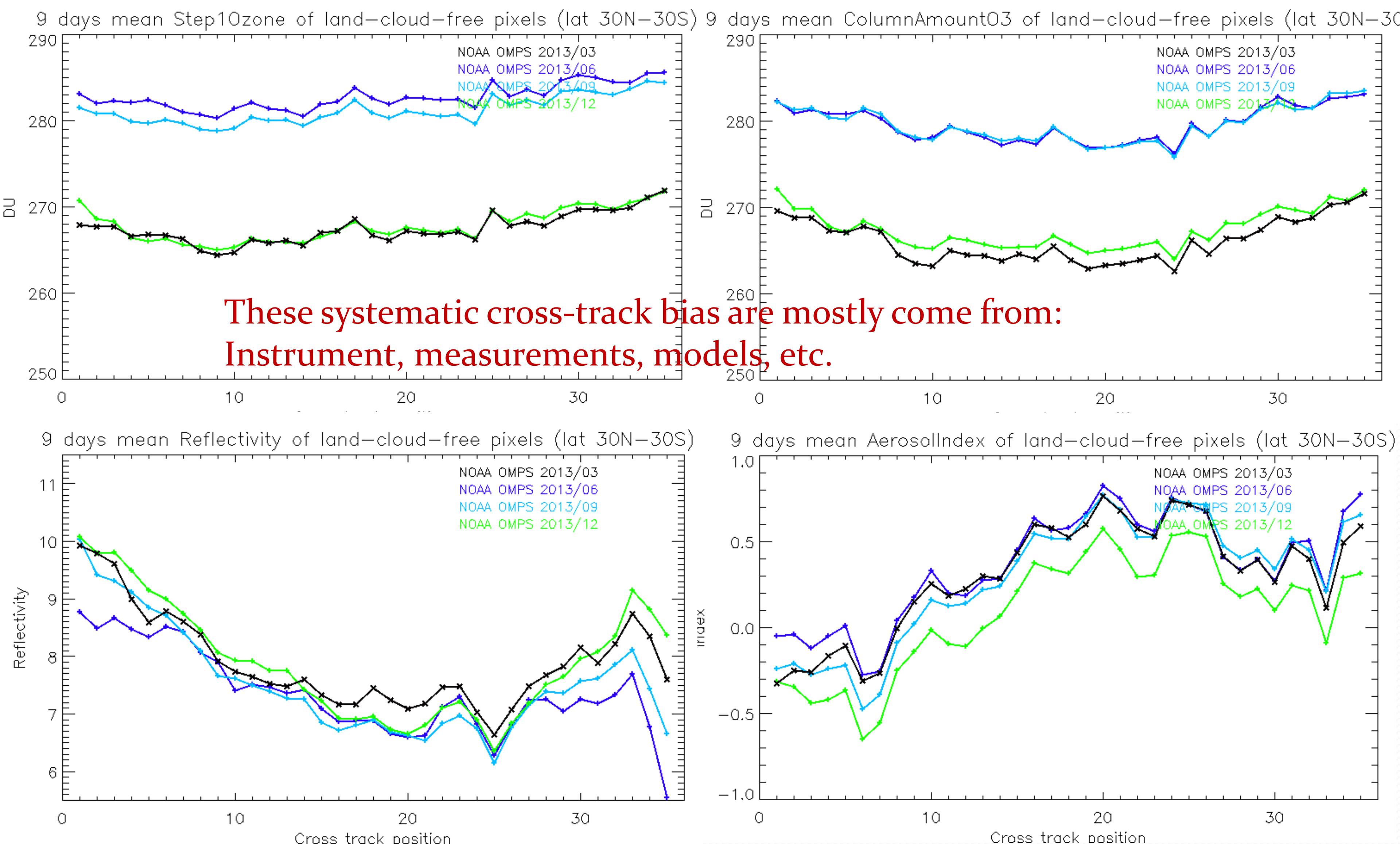
- Remove cross-track structure in OMPS total ozone and reflectivity, and make the averaged retrieval values close to those from NOAA-19 SBUV/2
- Choosing 9 day's of data because OMPS orbits will go back close to the same position after 9 day's run
- Choosing land pixels to avoid potential contamination from sun glint
- Choosing cloud-free pixels to avoid potential contamination from cloud



# Soft Calibration Statistics (V8TOZ)

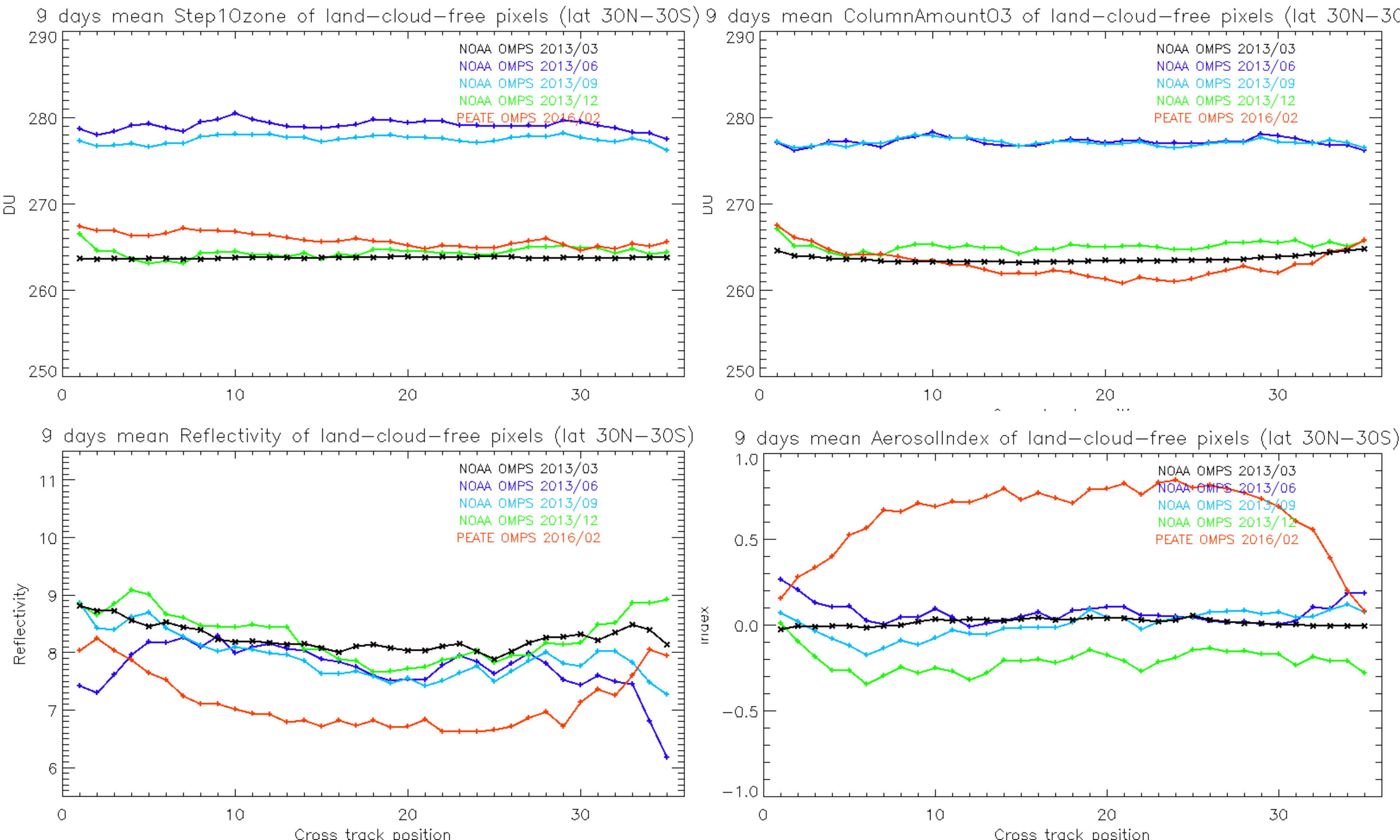
Cross-track related retrieval statistics for different seasons
Land-cloud-free pixels (lat 30N – 30S), before adjust




These systematic cross-track bias are mostly come from:
Instrument, measurements, models, etc.

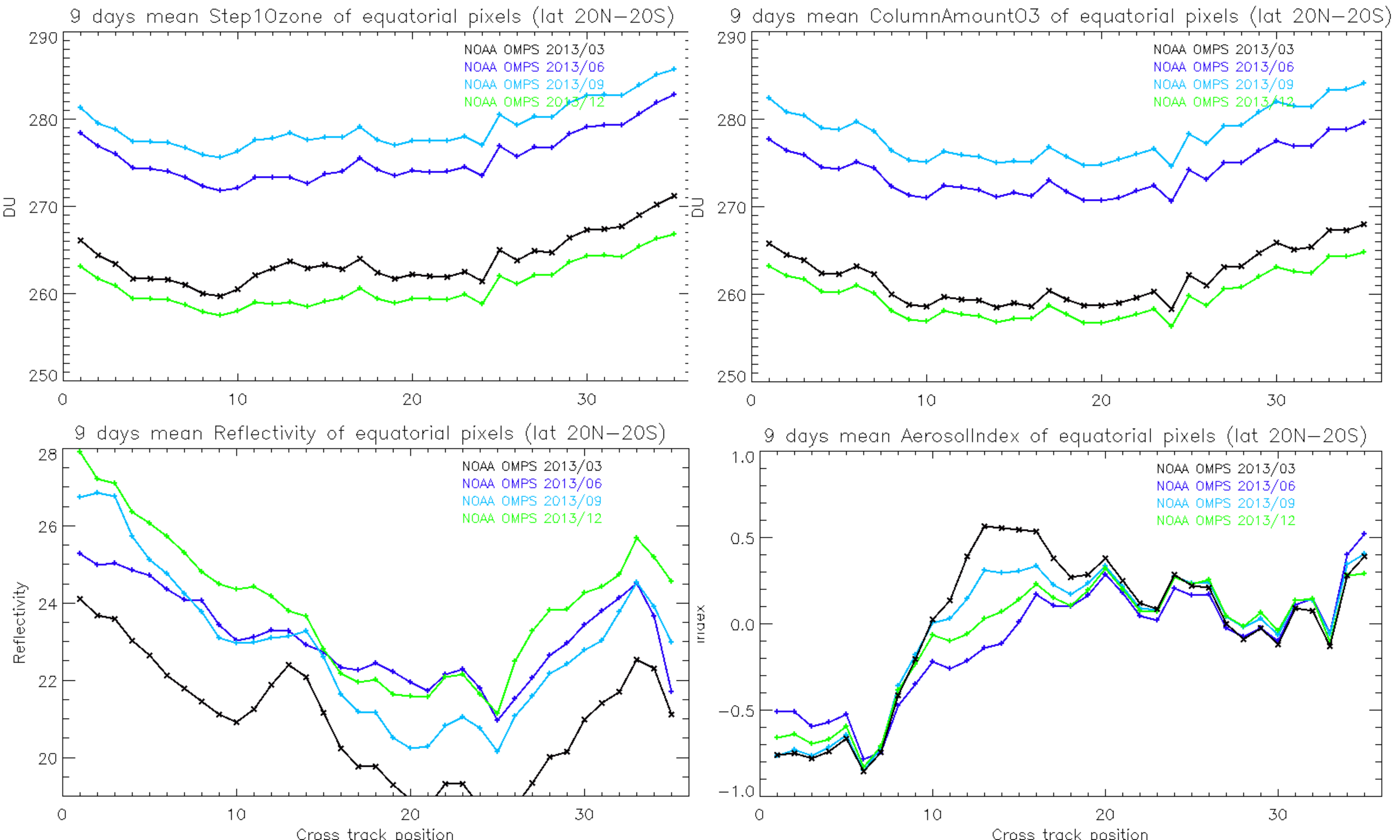
# Soft Calibration Statistics (V8TOZ)

Cross-track related retrieval statistics for different seasons
Land-cloud-free pixels (lat 30N – 30S), after adjust



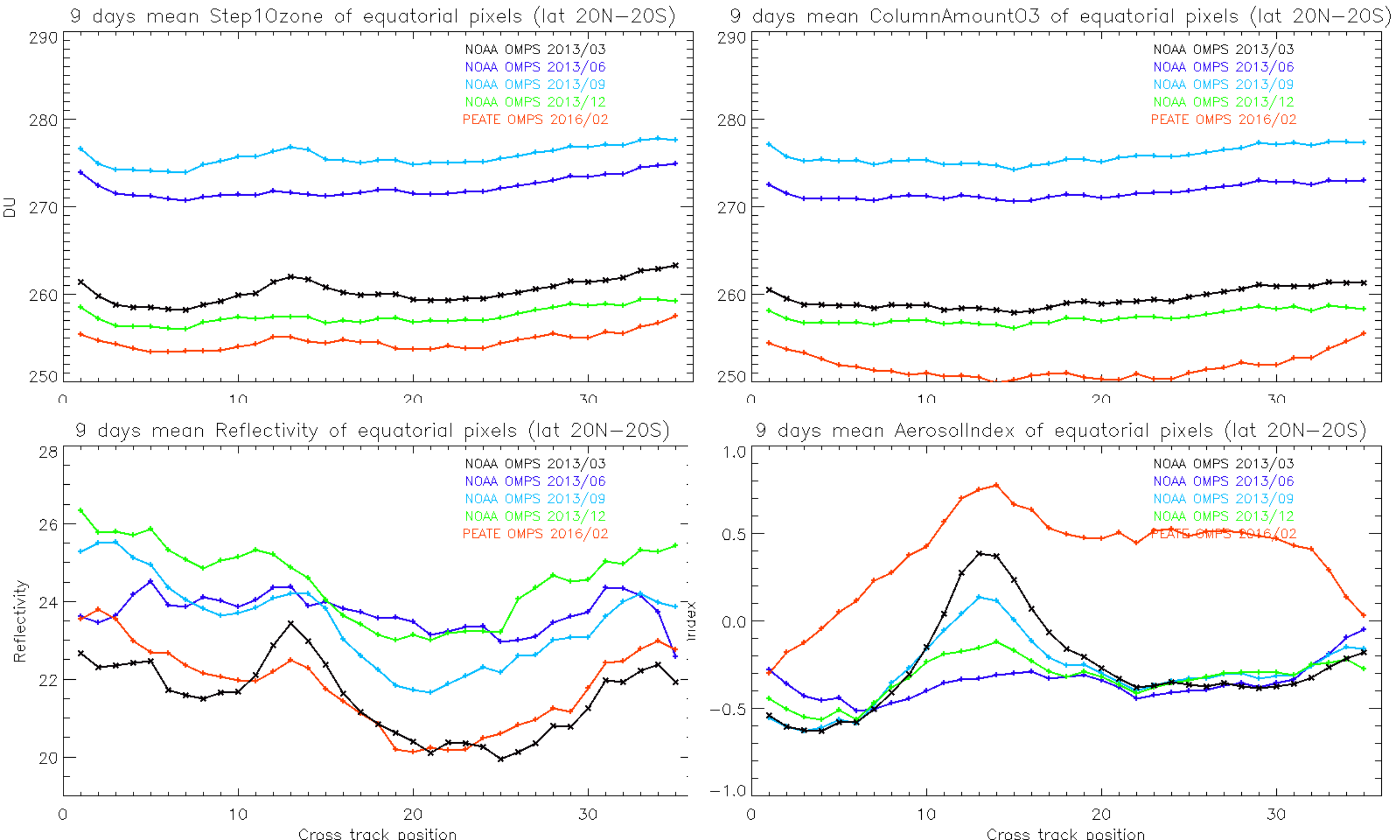
# Soft Calibration Statistics (V8TOZ)

Cross-track related retrieval statistics for different seasons
All equatorial pixels (lat 20N – 20S), before adjust

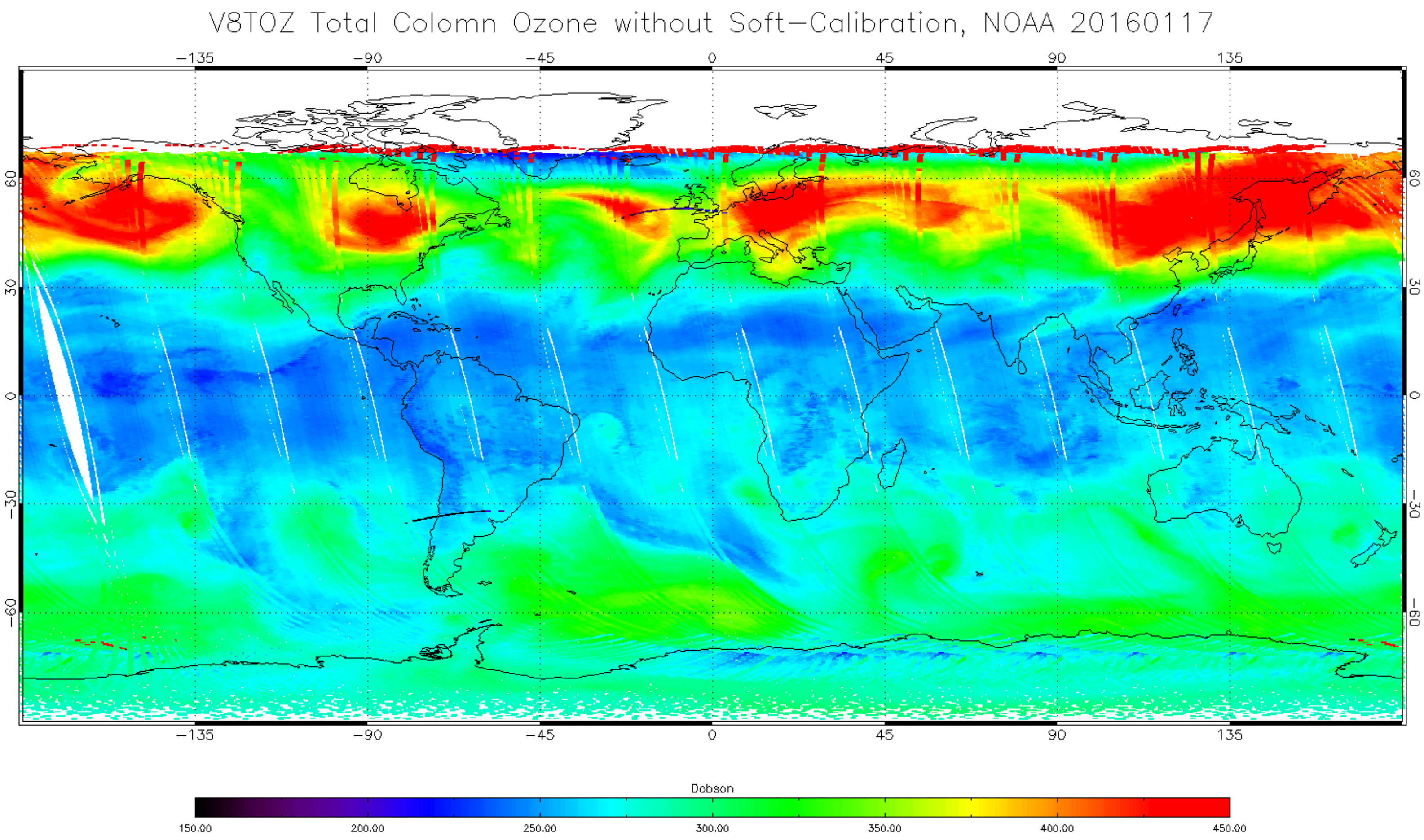


# Soft Calibration Statistics (V8TOZ)

Cross-track related retrieval statistics for different seasons
All equatorial pixels (lat 20N – 20S), after adjust

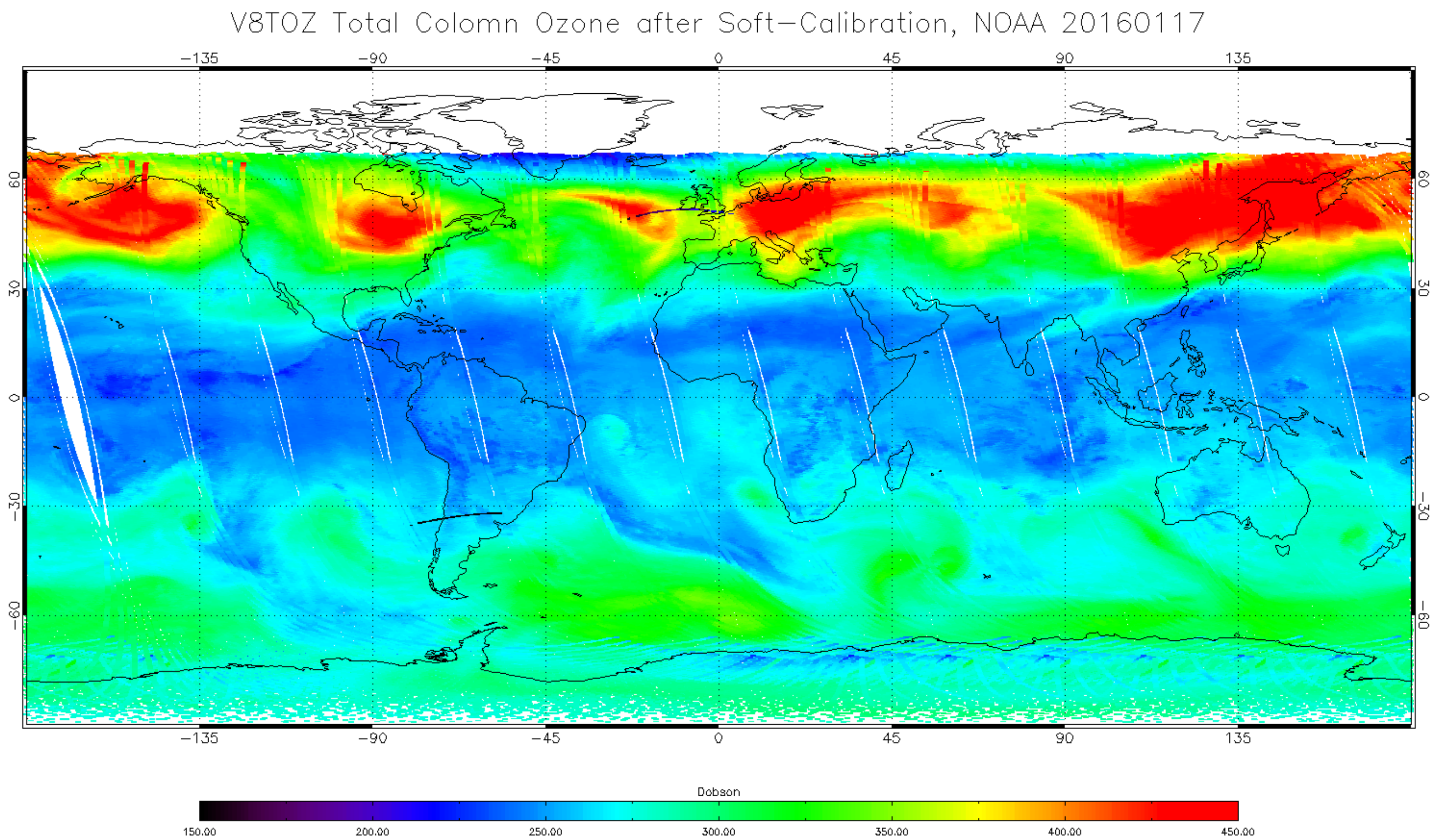


# OMPS V8TOZ Retrieval Products



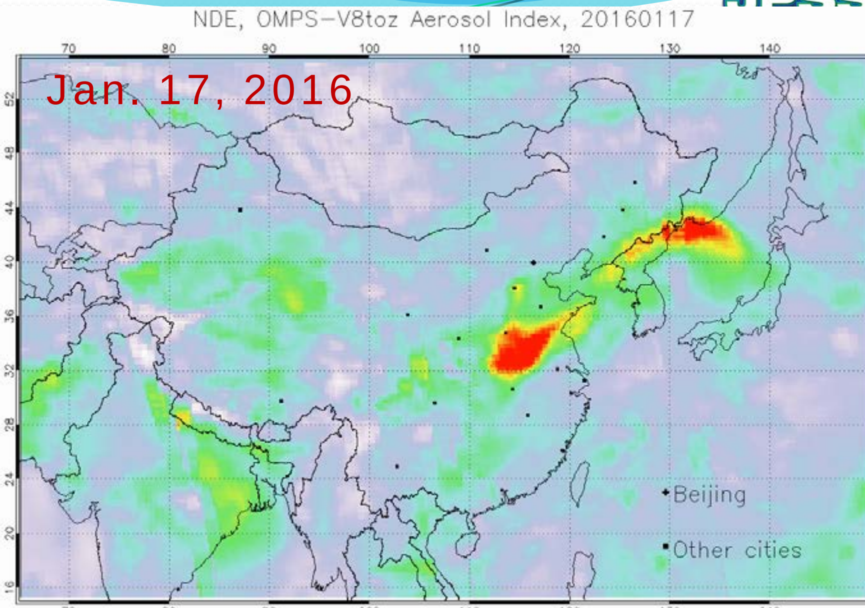

Retrieved Total Column Ozone without Soft-Calibration

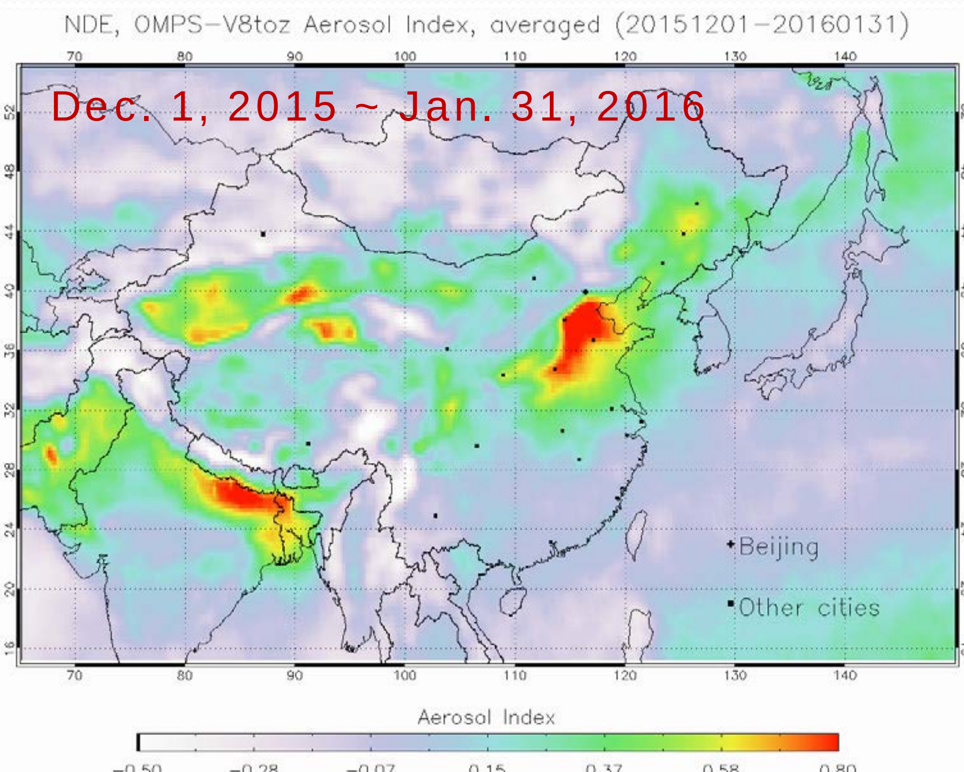
# OMPS V8TOZ Retrieval Products

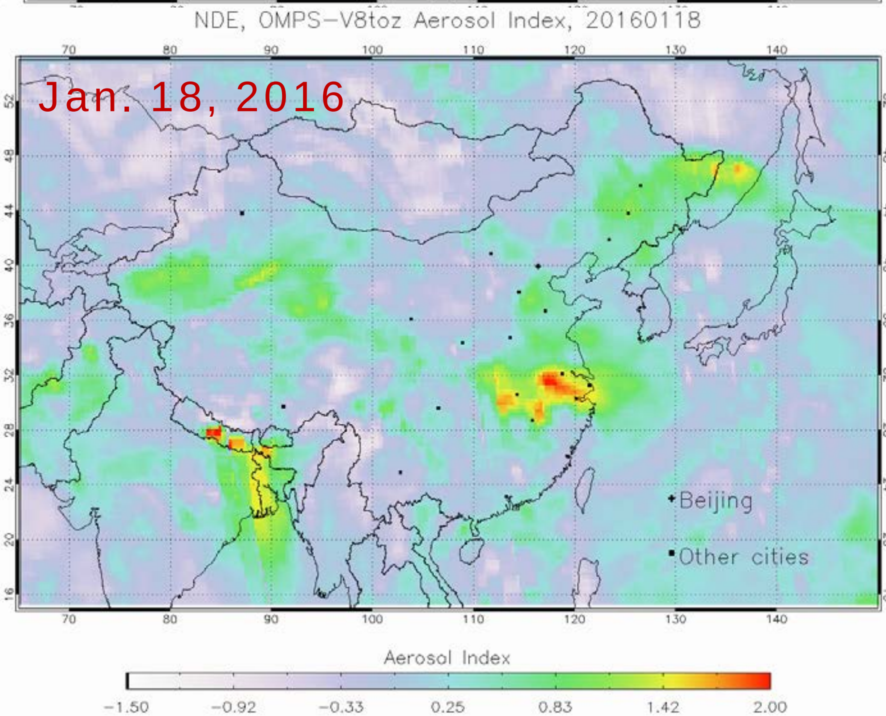



Retrieved Total Column Ozone after Soft-Calibration

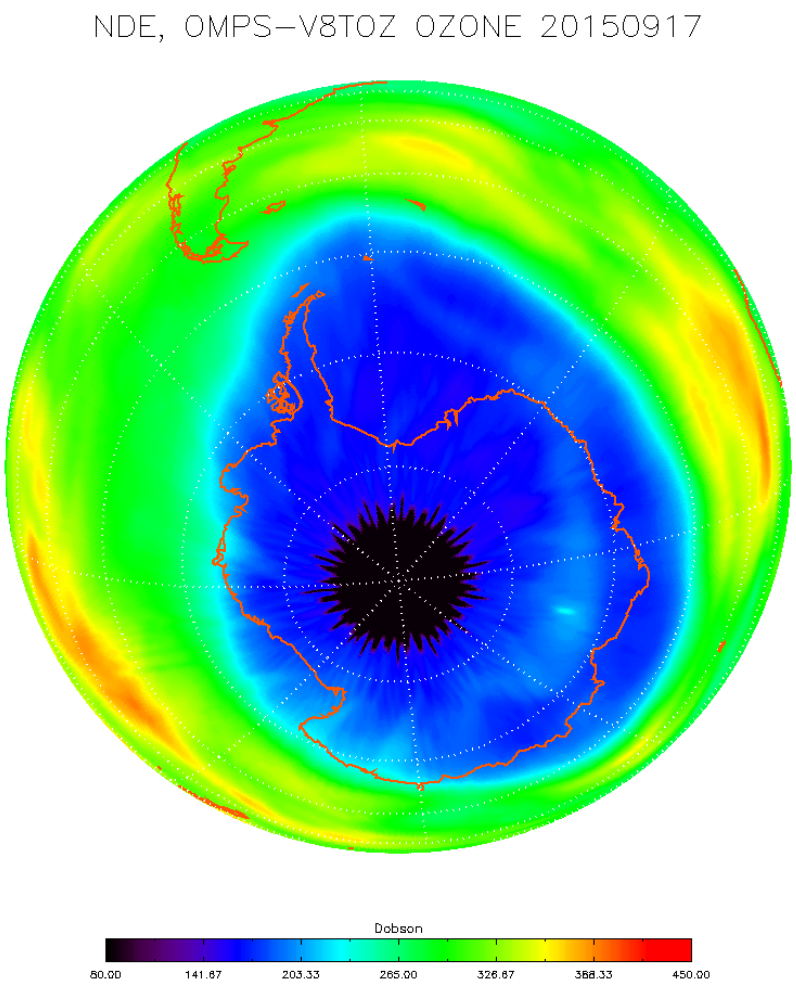
# OMPS V8TOZ Retrieval Products

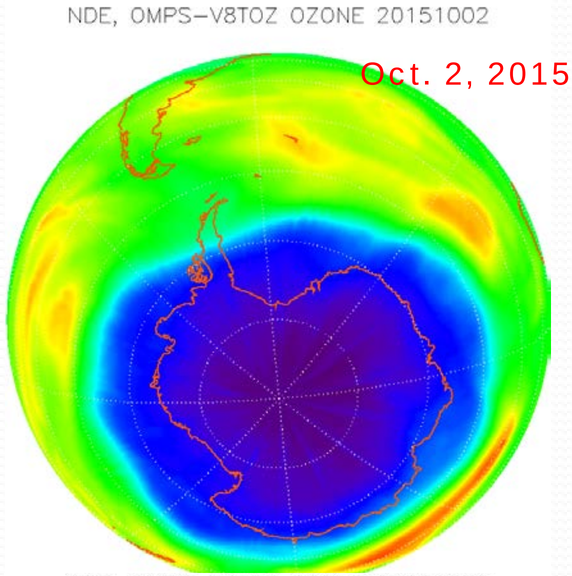



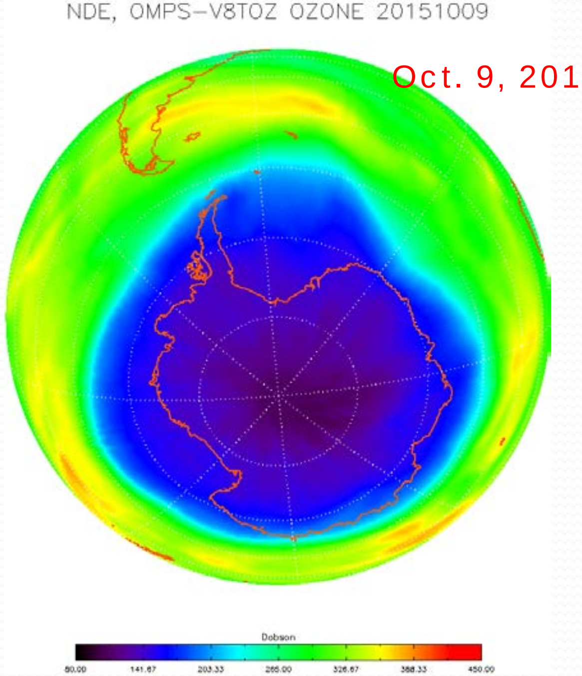



# OMPS V8TOZ Retrieval Products



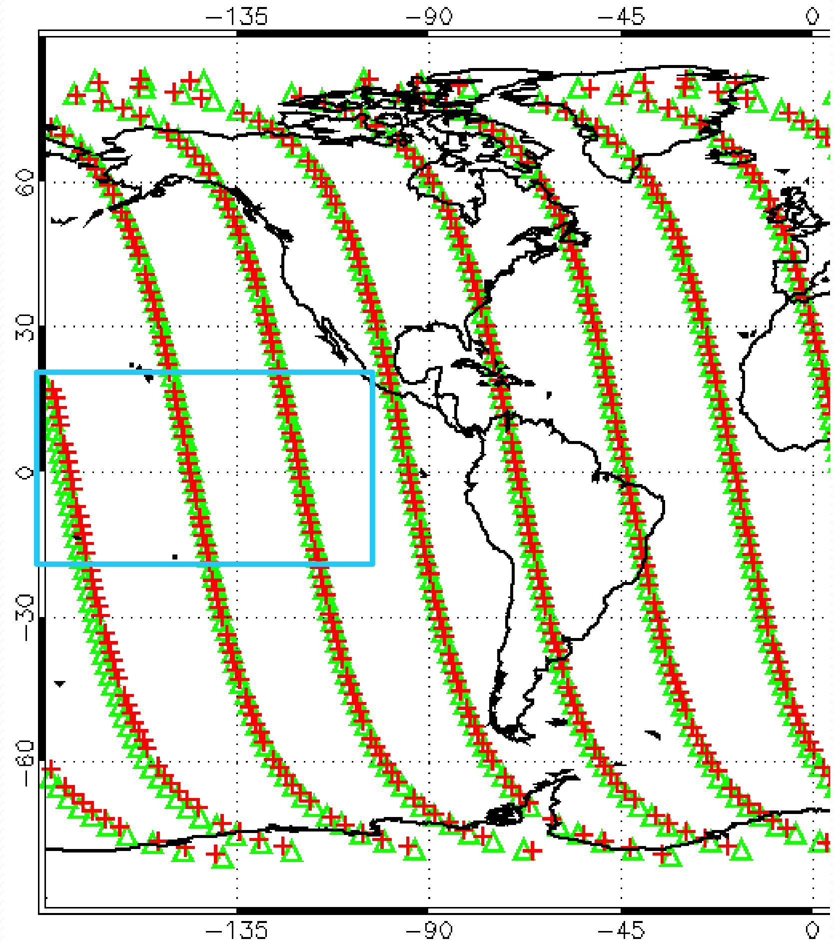

Daily Ozone Hole Change in 2015

# General Description of Soft calibration

OMPS V8PRO soft-calibration:

- Make the STAR reprocessing of OMPS ozone profile retrievals close to those from NOAA-19 SBUV/2.
- We choose 03/20/2013 to make soft-calibration for STAR reprocessed V8PRO, because OMPS and N19 have very close chasing orbits and have stable measurements at that time.

OMPS (green) and NOAA-19 (red) have chasing orbits (Time<600sec., Dis<110Km) on 03/20/2013



# Soft Calibration Statistics (V8PRO)

## 1) Adjusting STAR re-processed V8PRO to N19 SBUV/2, 03/20/2013

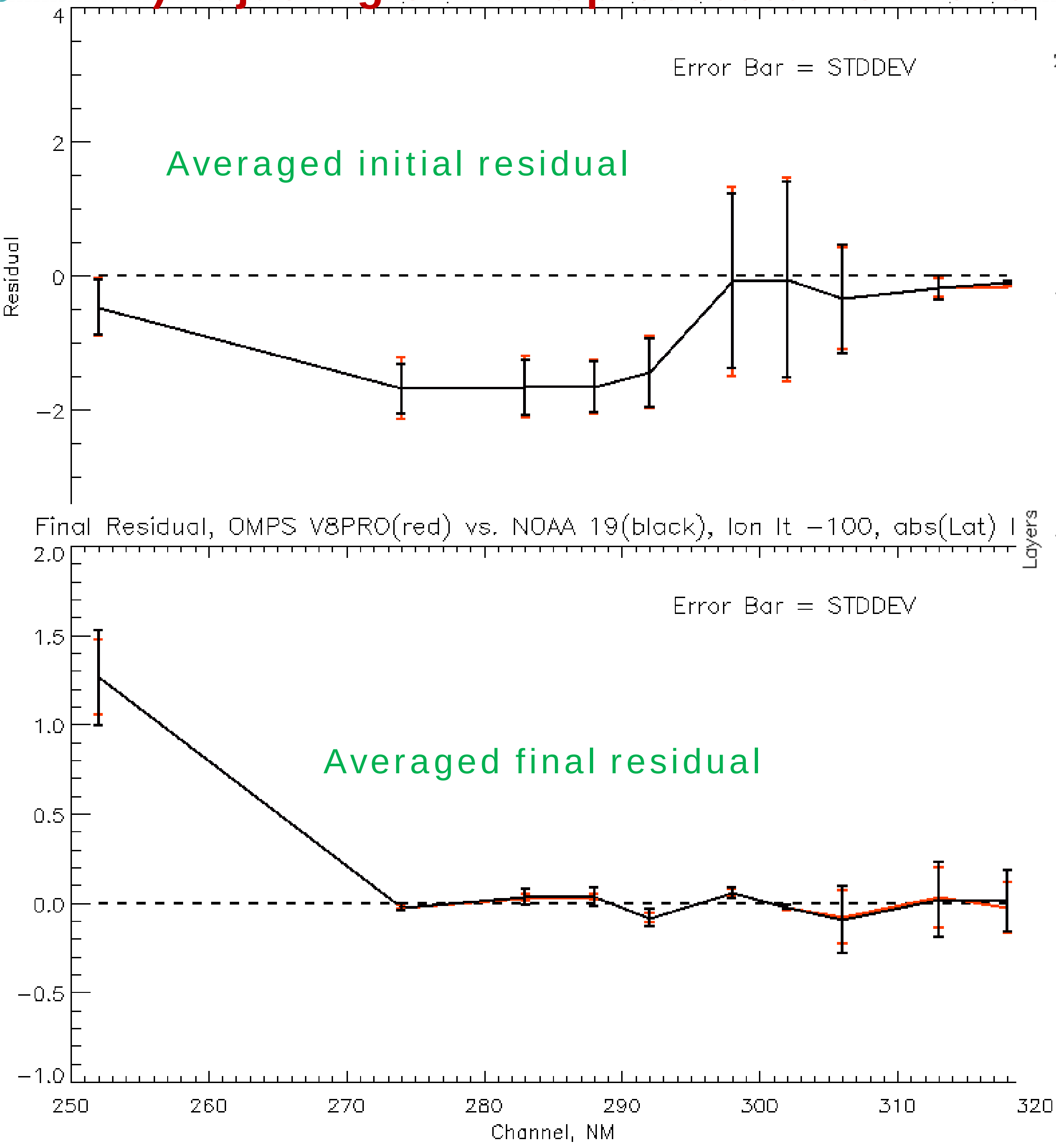
------ The OMPS NP solar measurements were analyzed with a model using components for solar activity, wavelength shifts and separate degradation rates for the diffusers and instrument throughput.

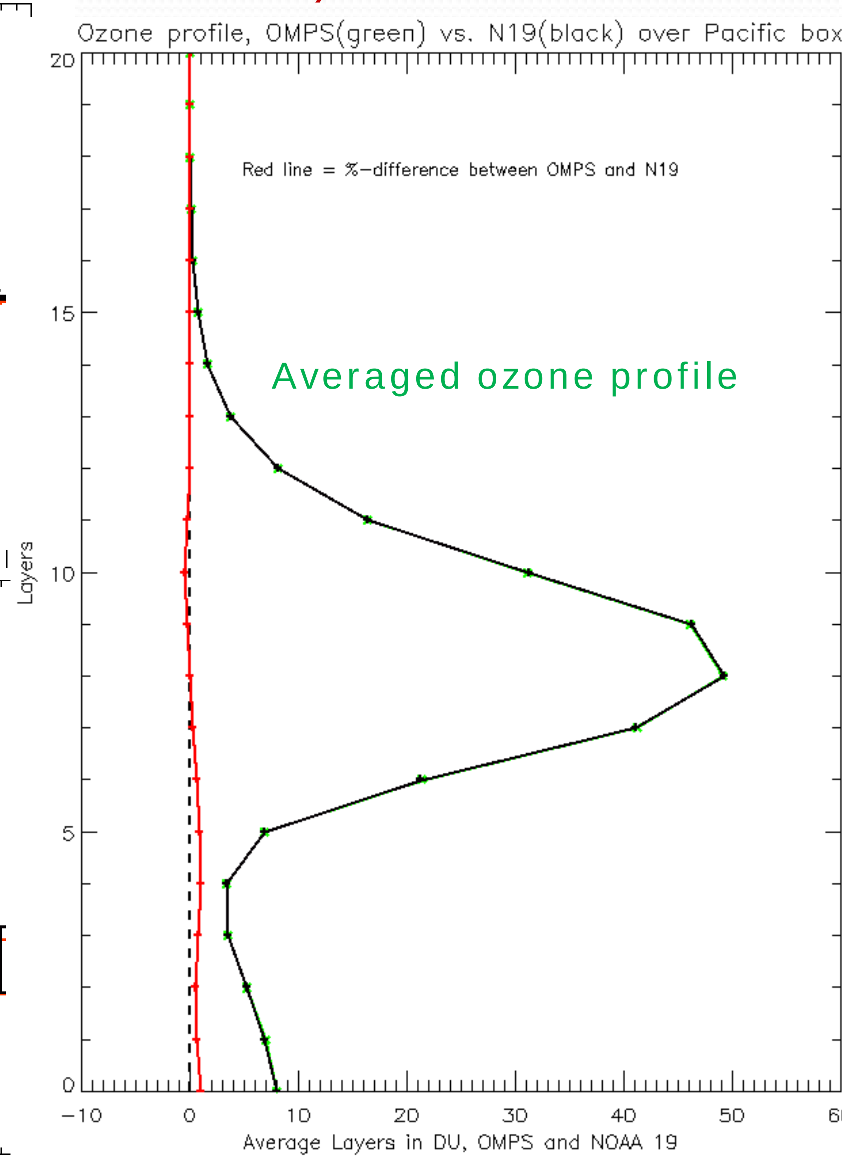
### Statistics over equatorial Pacific after adjustment

```
---------------------------------------------------------
the average NOAA19 reflectivity is:              0.208
the average STAR OMPS reflectivity is:           0.208

NOAA19 stp1oz is:                                256.8
STAR OMPS stp1oz is:                             256.8

NOAA19 stp2oz is:                                254.9
STAR OMPS stp2oz is:                             255.3

the average NOAA19 aerosol index is:             0.42
the average  STAR OMPS aerosol index is:         0.42

NOAA19 stp3oz(bsttoz) is:                        253.7
STAR OMPS stp3oz(bsttoz) is:                     254.1
---------------------------------------------------------
```

# Soft Calibration Statistics (V8PRO)

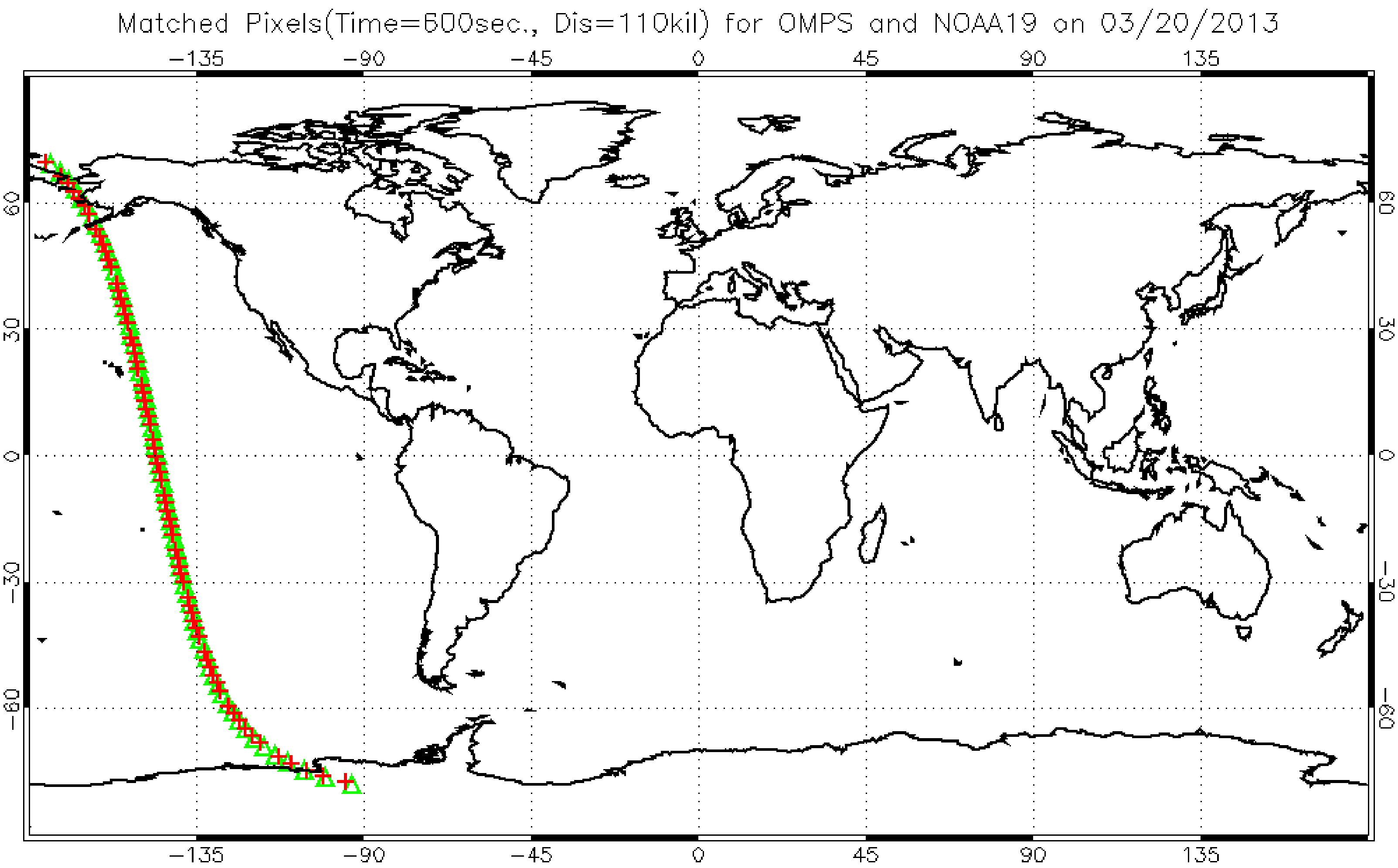
## 1) Adjusting STAR re-processed V8PRO to N19 SBUV/2, 03/20/2013



# Soft Calibration Statistics (V8PRO)

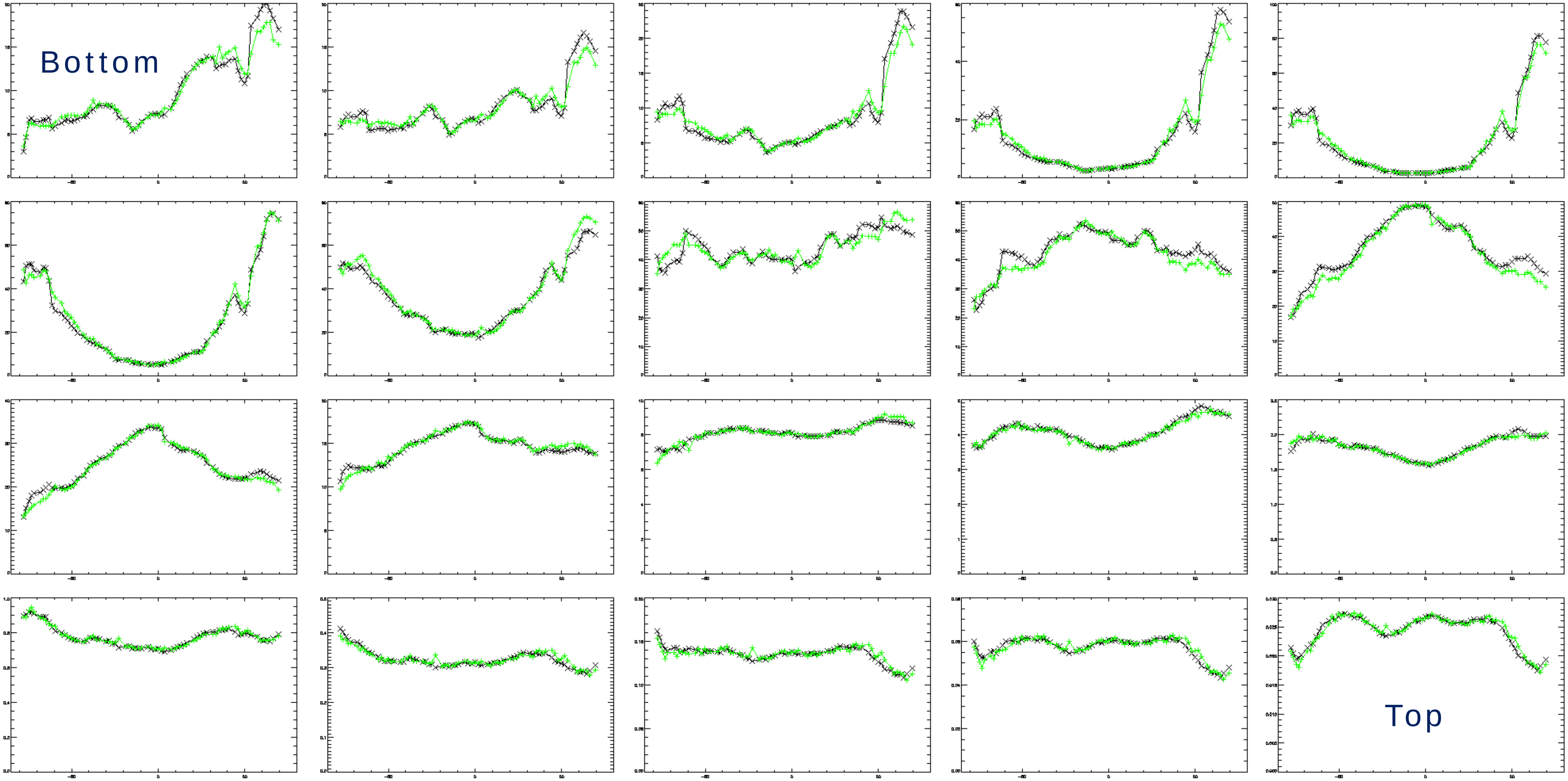
**1) Adjusting STAR re-processed V8PRO to N19 SBUV/2, 03/20/2013**



# Soft Calibration Statistics (V8PRO)

## 1) Adjusting STAR re-processed V8PRO to N19 SBUV/2, 03/20/2013

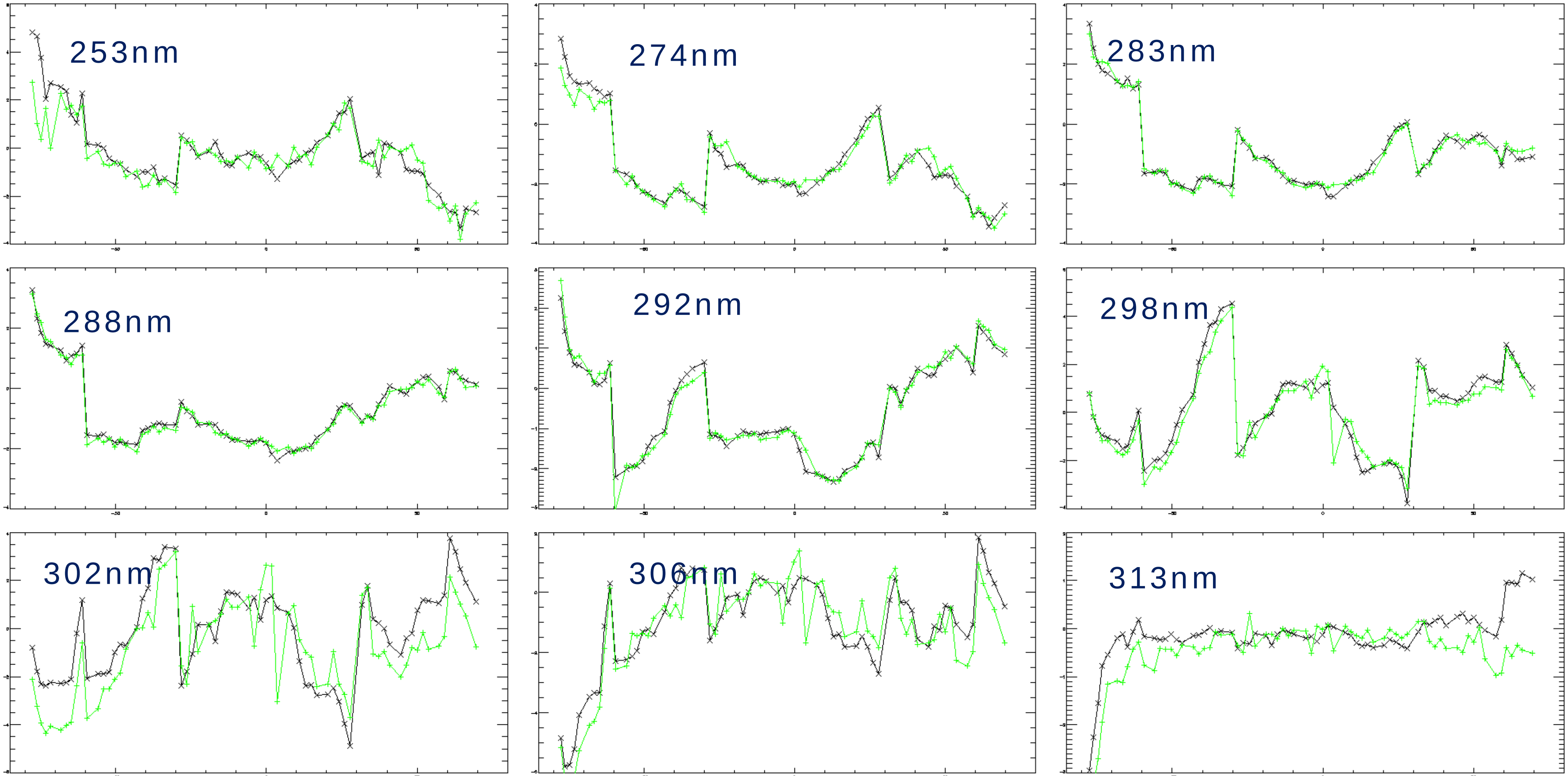
Layer ozone along orbit, OMPS (black), N19 (green)



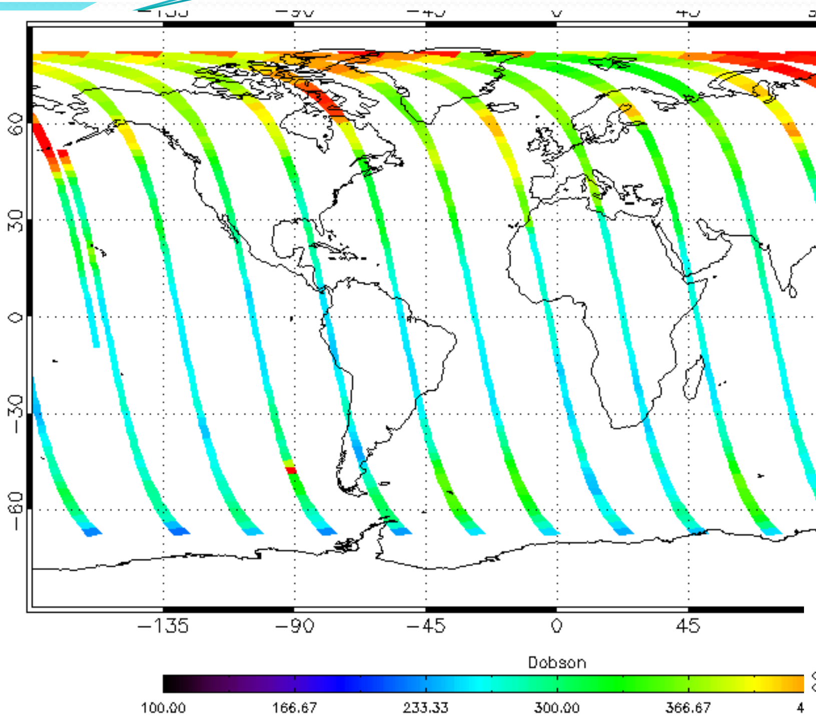
# Soft Calibration Statistics (V8PRO)

## 1) Adjusting STAR re-processed V8PRO to N19 SBUV/2, 03/20/2013

Initial residual along orbit, OMPS (black), N19 (green)

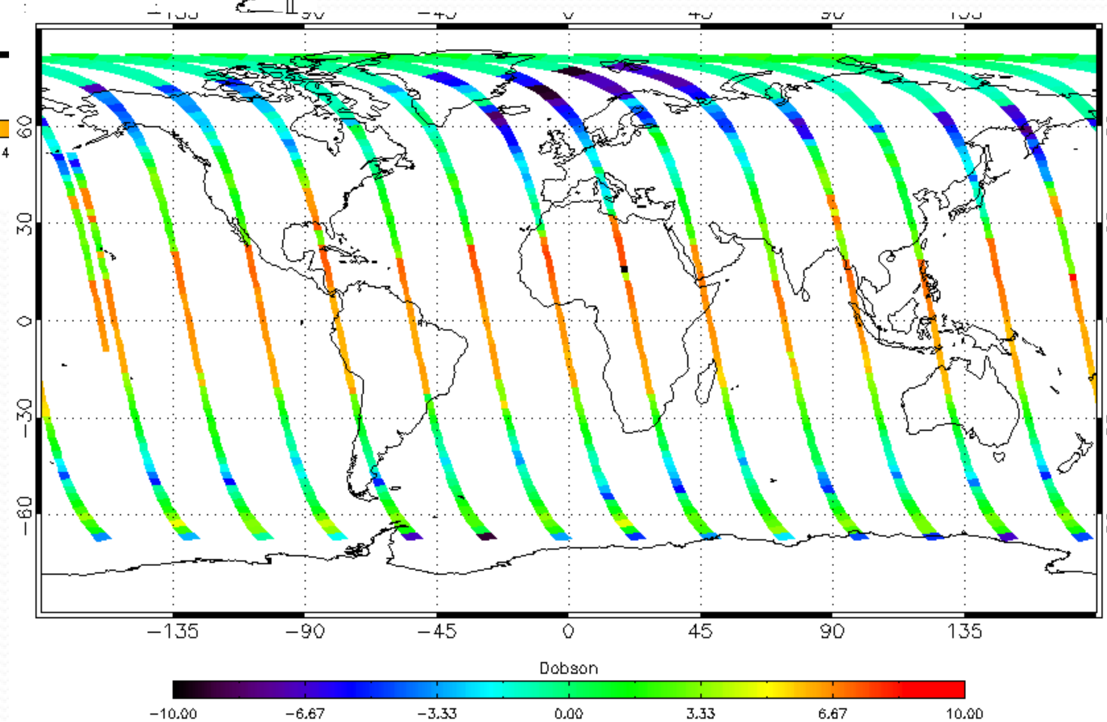


# OMPS V8PRO Retrieval Products

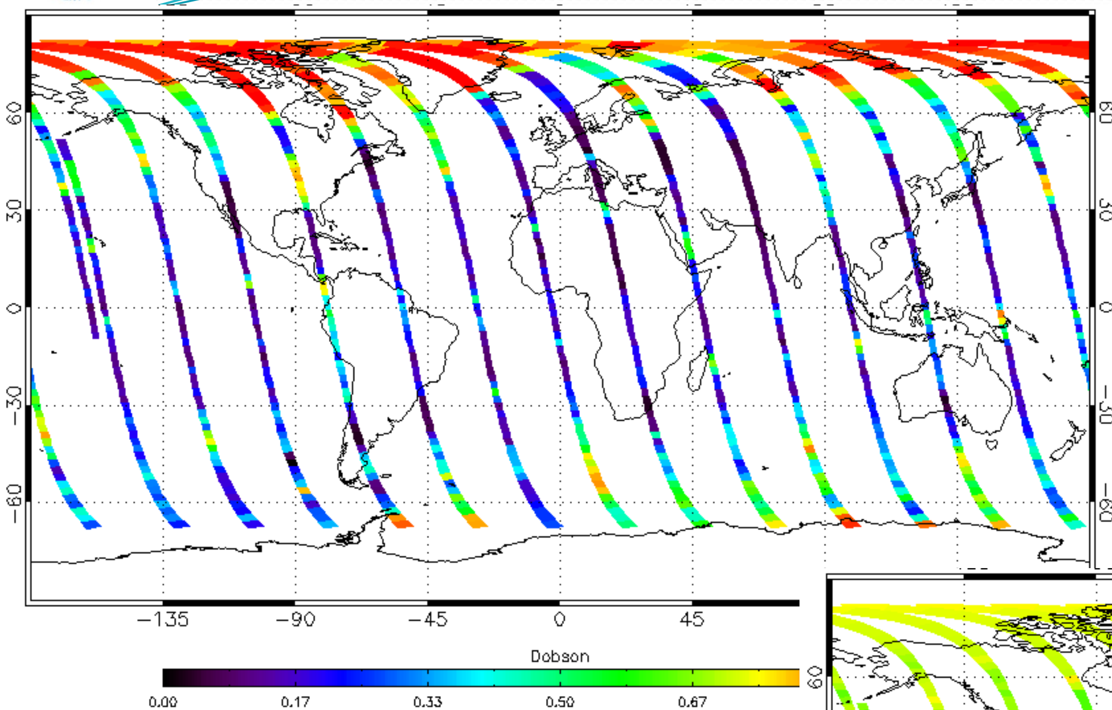



OMPS V8PRO retrieved total ozone profile, 04/30/2017

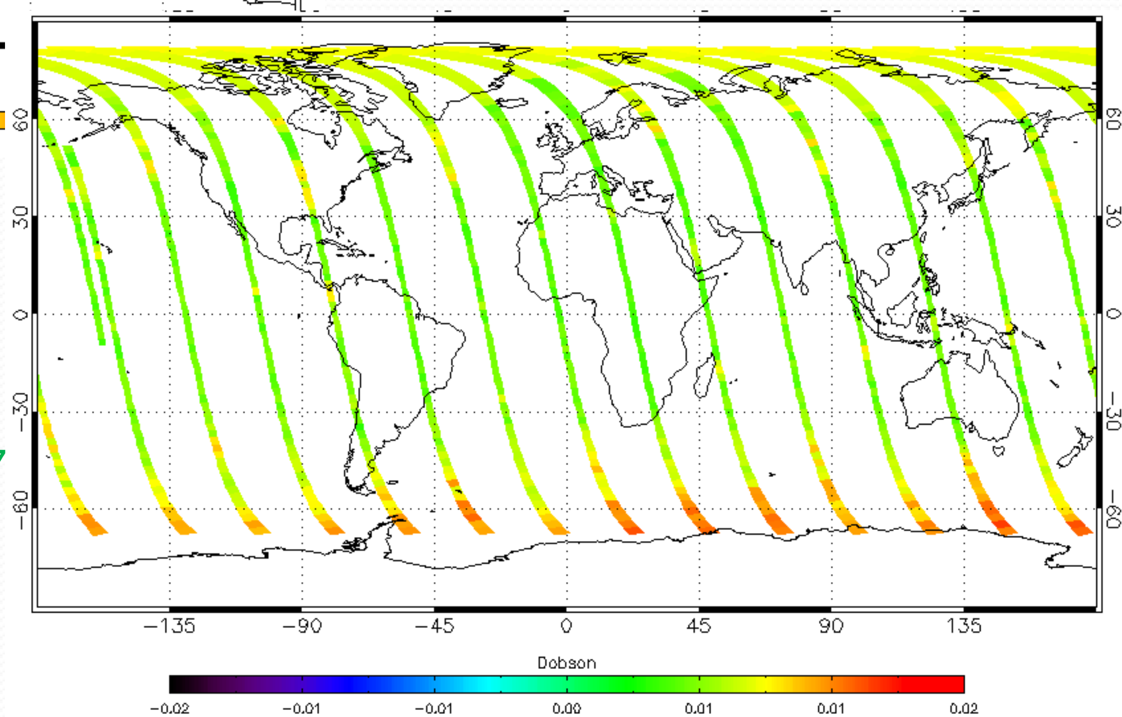
The adjustment of total ozone profile by soft calibration, 04/30/2017



# OMPS V8PRO Retrieval Products




OMPS V8PRO retrieved reflectivity, 04/30/2017




The adjustment of reflectivity by soft calibration, 04/30/2017

# Conclusion

- The systematic bias in OMPS V8TOz retrievals can be removed to produce consistent products for all FOVs.
- Using land and cloud-free pixels in soft calibration for OMPS V8TOz can avoid potential contamination from sun glint and clouds.
- Using chasing orbit matchups between OMPS and N19 for generating OMPS V8PRO soft calibration, can largely avoid noise from atmospheric variation in time and space.
- Soft calibration can make ozone retrievals from different satellite in agree with each other, and provides a continuation of the long-term climatology record.

# Thanks!

# Soft Calibration Statistics (V8PRO)

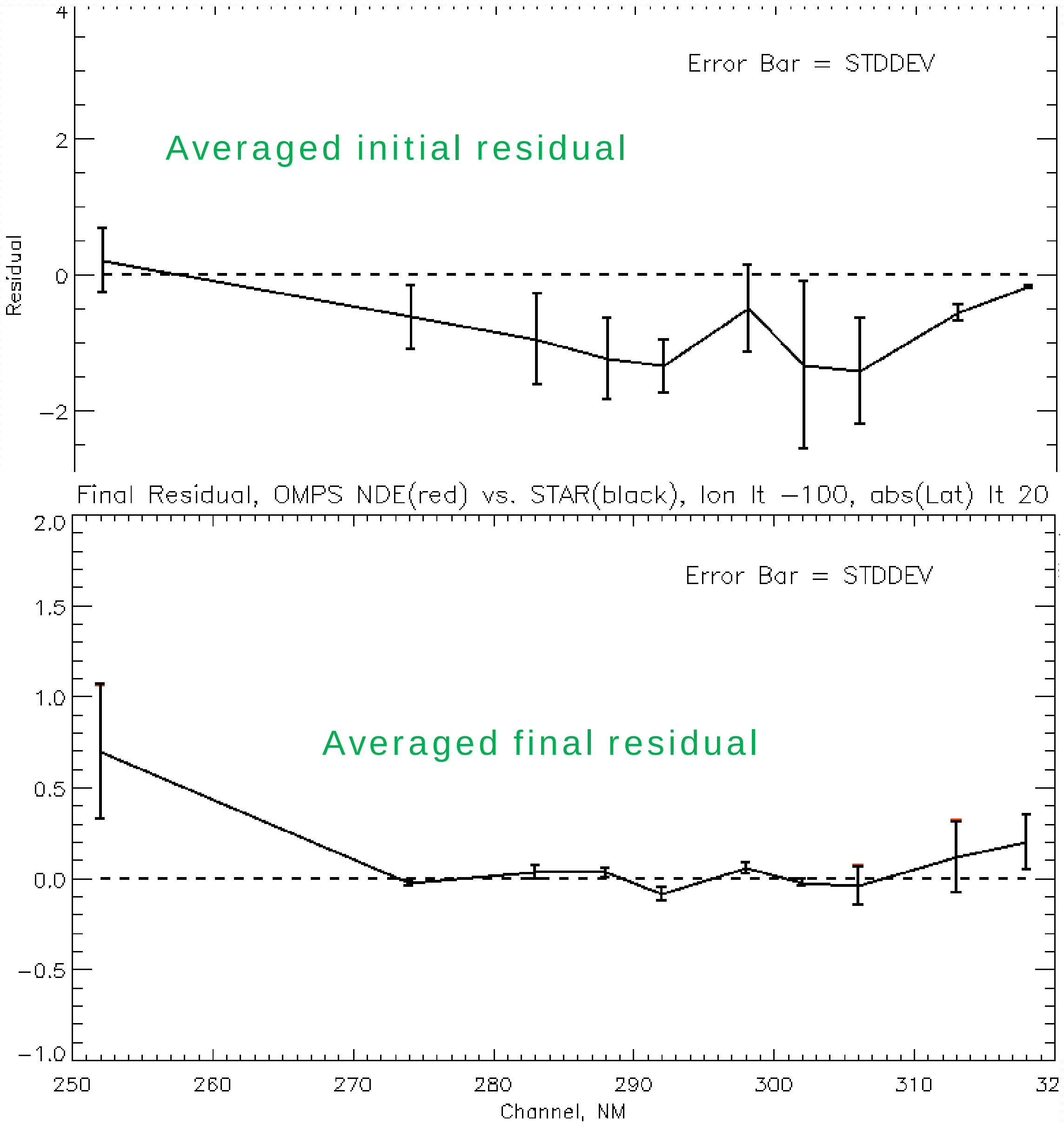
## 2) Adjusting V8PRO at NDE to STAR re-processed V8PRO, 04/30/2017

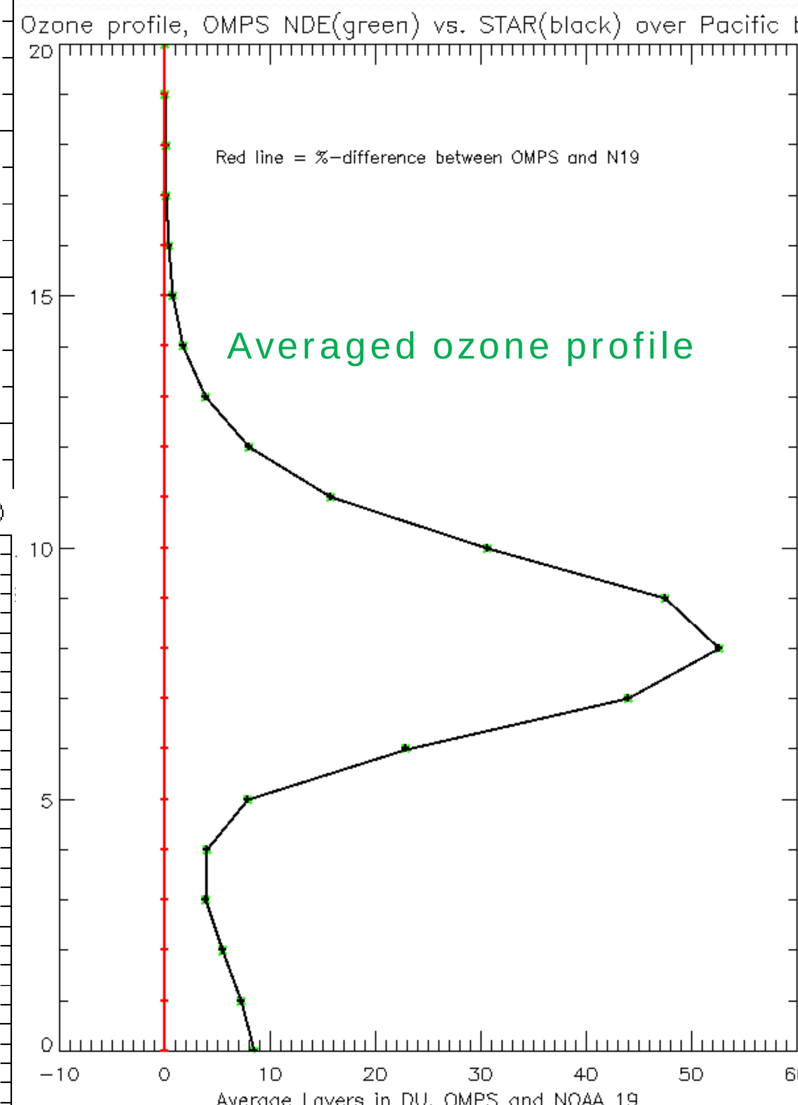
### Statistics over equatorial Pacific after adjustment

```
--------------------------------------------------------
the average OMPS STAR reflectivity is:        0.181
the average OMPS NDE reflecitivity is:        0.181

OMPS SATR stp1oz is:                          271.6
OMPS NDE stp1oz is:                           271.5

OMPS STAR stp2oz is:                          269.8
OMPS NDE stp2oz is:                           269.8

the average OMPS STAR aerosol index is:       -0.08
the average OMPS NDE aerosol index is:        -0.08

OMPS STAR stp3oz(bsttoz) is:                  270.0
OMPS NDE stp3oz(bsttoz) is:                   269.9
--------------------------------------------------------
```

# Soft Calibration Statistics (V8PRO)

## 2) Adjusting V8PRO at NDE to STAR re-processed V8PRO, 04/30/2017

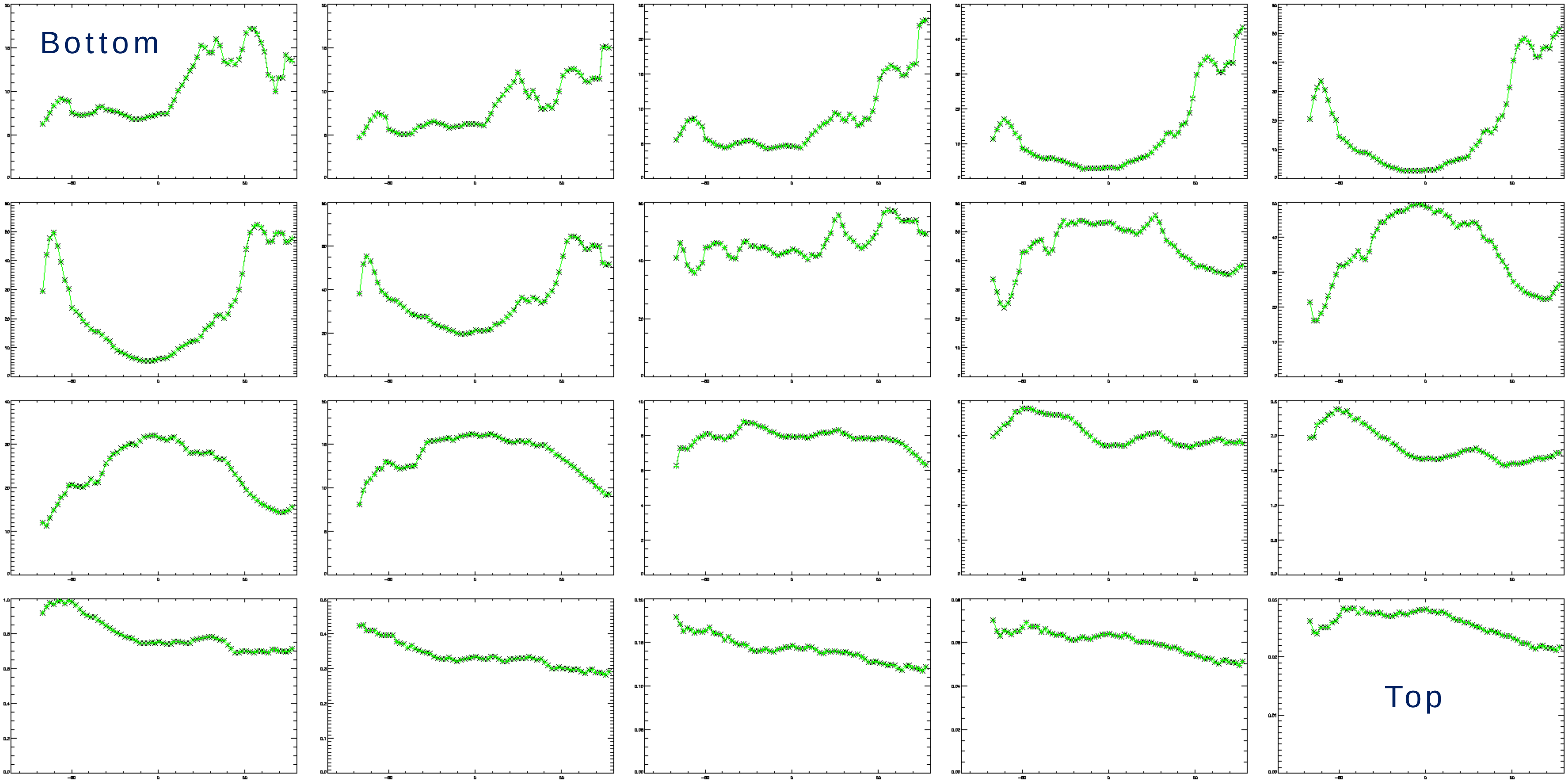


# Soft Calibration Statistics (V8PRO)

## 2) Adjusting V8PRO at NDE to STAR re-processed V8PRO, 04/30/2017

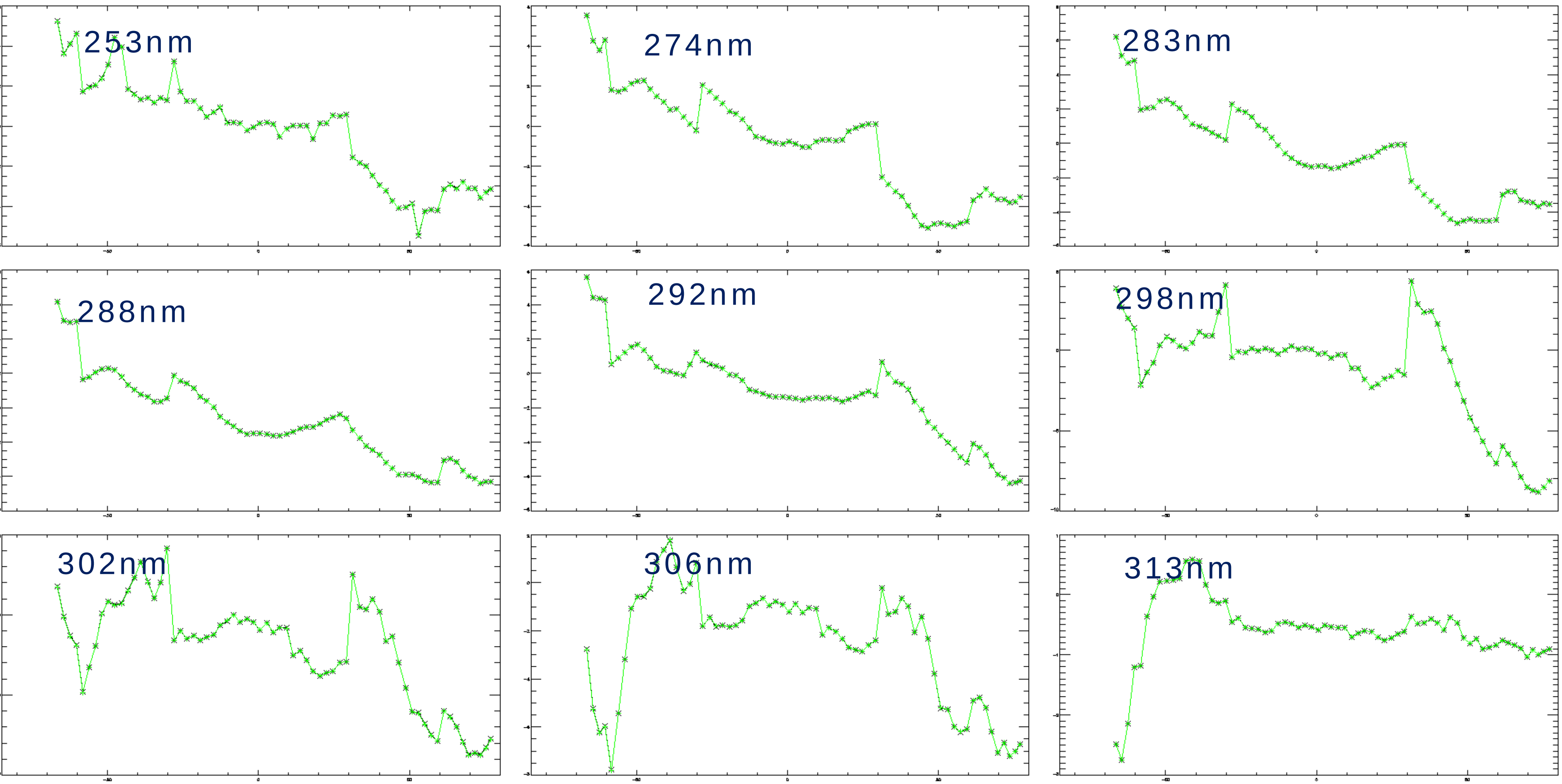
Layer ozone along orbit, NDE(black), STAR(green)

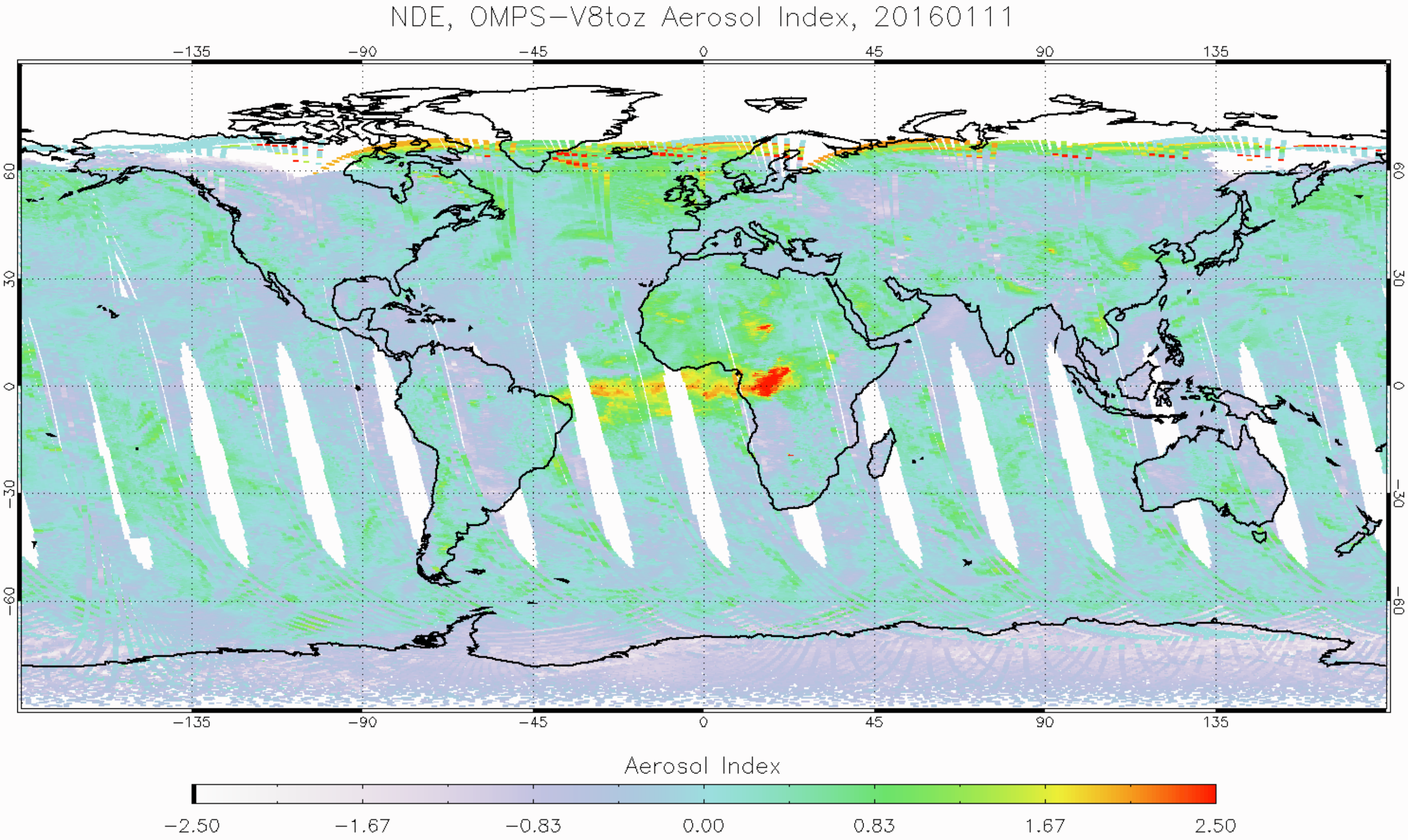


# Soft Calibration Statistics (V8PRO)

## 2) Adjusting V8PRO at NDE to STAR re-processed V8PRO, 04/30/2017

Initial residual along orbit, NDE(black), STAR(green)





NDE, OMPS−V8toz Aerosol Index, 20160111
−135
−90
−45
0
45
90
135
60
30
0
−30
−60
Aerosol Index
−2.50
−1.67
−0.83
0.00
0.83
1.67
2.50

# J1 Plans for Smaller FOV and Algorithm Refinements

*Trevor Beck*

*NOAA/NESDIS/STAR*

*August 16, 2017*

# Outline

- S-NPP/J01 IDPS capable of producing OMPS SDR MedRes NP and NM ( MX04 and later)
- JPSS-1 OMPS-NM Low and Medium Resolution SDR
- JPSS-1 OMPS-NP Medium Resolution SDR
- Medium Resolution EDR total ozone products from NDE
- J01 EDR ozone profile enhancements
- Future Algorithm Refinements

# Expected J01 SDR Measurements

J01 SDR NM from IDPS in of two configurations:
1) NM LowRes, 35 xtrack and 5 scans per granule, 50km x 50km
2) NM MedRes, 103 xtrack and 15 scans per granule, 17km x 17km

NP MedRes, 5x5, 5 scans per granule X 5 xtracks. 400 scans per orbit, 150 wavelengths from 250nm to 310nm.

Images shown in this presentation are J01 Proxy data derived from NPP and NPP diagnostic, from off-line ADL runs at NOAA by the OMPS STAR SDR team.

Prior to the L+90 day handover the J1 NM RDR will be done in low, medium, high resolution modes. The IDPS system will aggregate pixels to produce either 35x5 or 103x15. ***Along track aggregation will not be done in nominal operations phase, the short granule problem prevents it.***. Across track aggregation may be done.

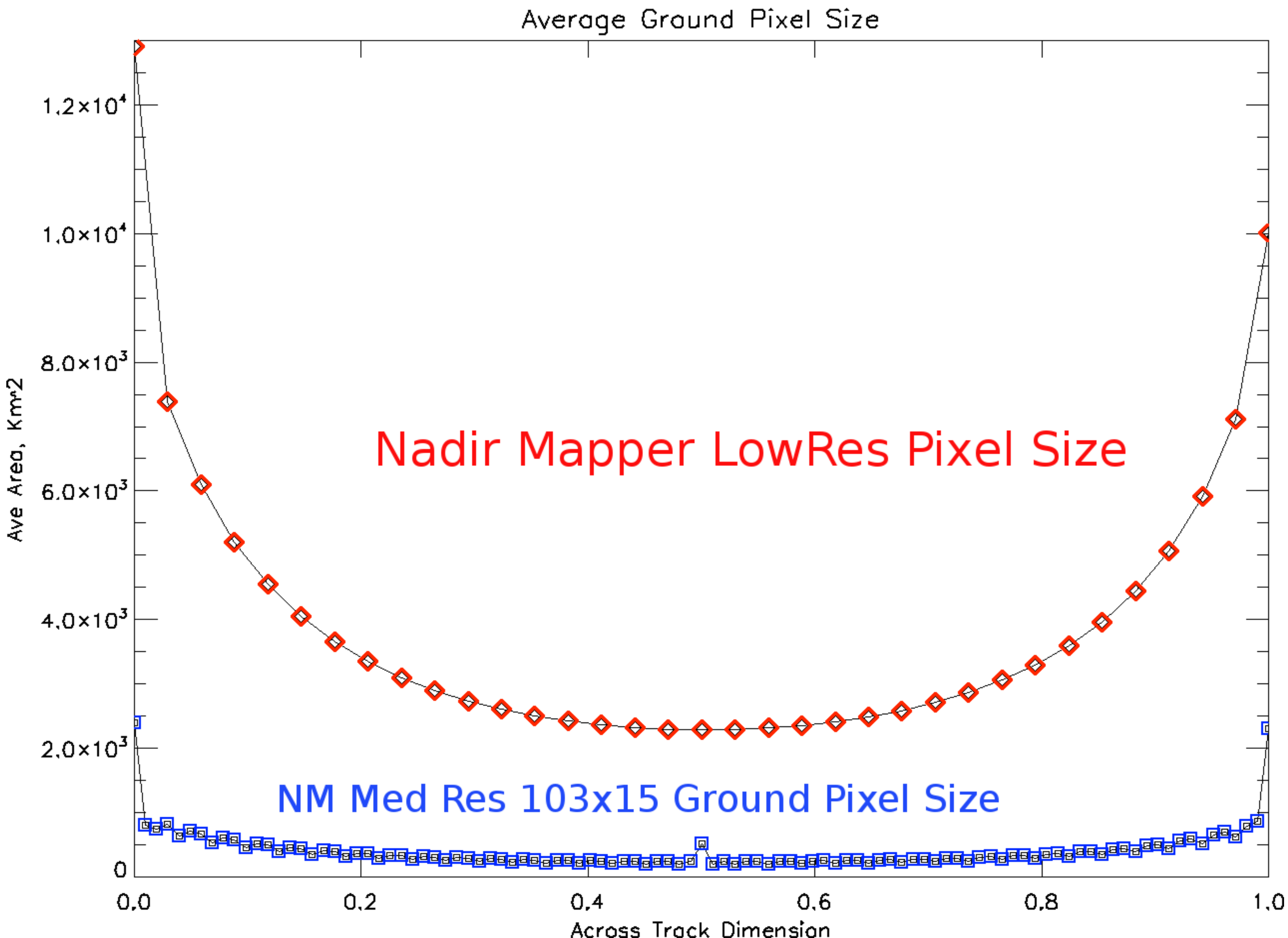
# NM Low Res SDR Format

- Same number of ground pixels as current nominal NPP SDR. 35X5.
- This is the expected nominal SDR format from L+3 months to L+9 months
- Approximate same wavelength dimensions and coverage as S-NPP 35x5( the RDR will contain measurements beyond 400nm, how many channels depends on the how much data can be brought down).
- There will be a one day per week diagnostic measurement using the medRes config, 17x17km^2.

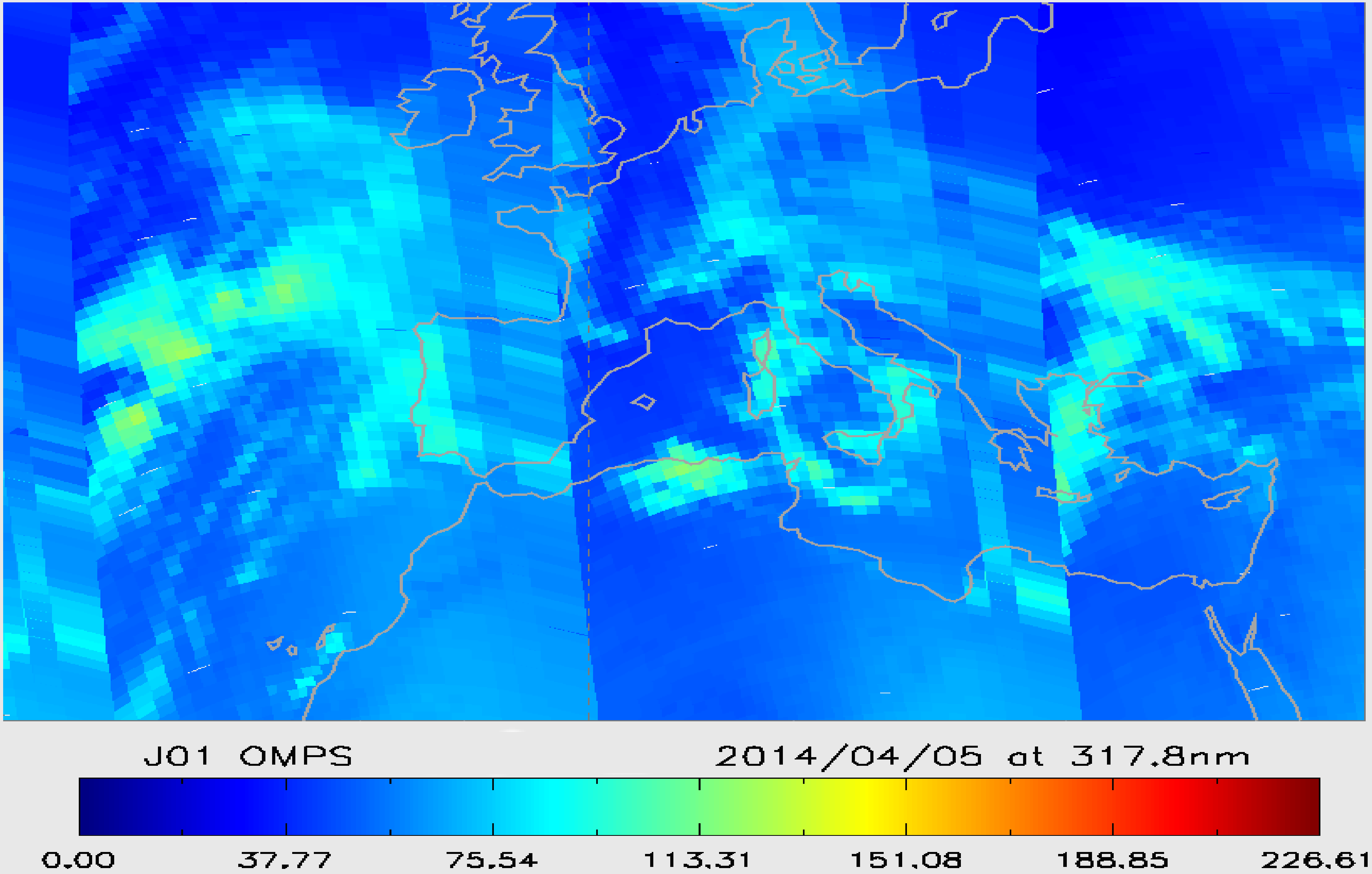
# NM Med Res SDR Format

- This is the expected nominal SDR format from L+9 months onward( depends on approval).
- 15 scans per granule, 103 xtrack pixels, 17km by 17km at at nadir.
- Approximate same wavelength dimension and range as current IDPS generated NPP NM SDR.

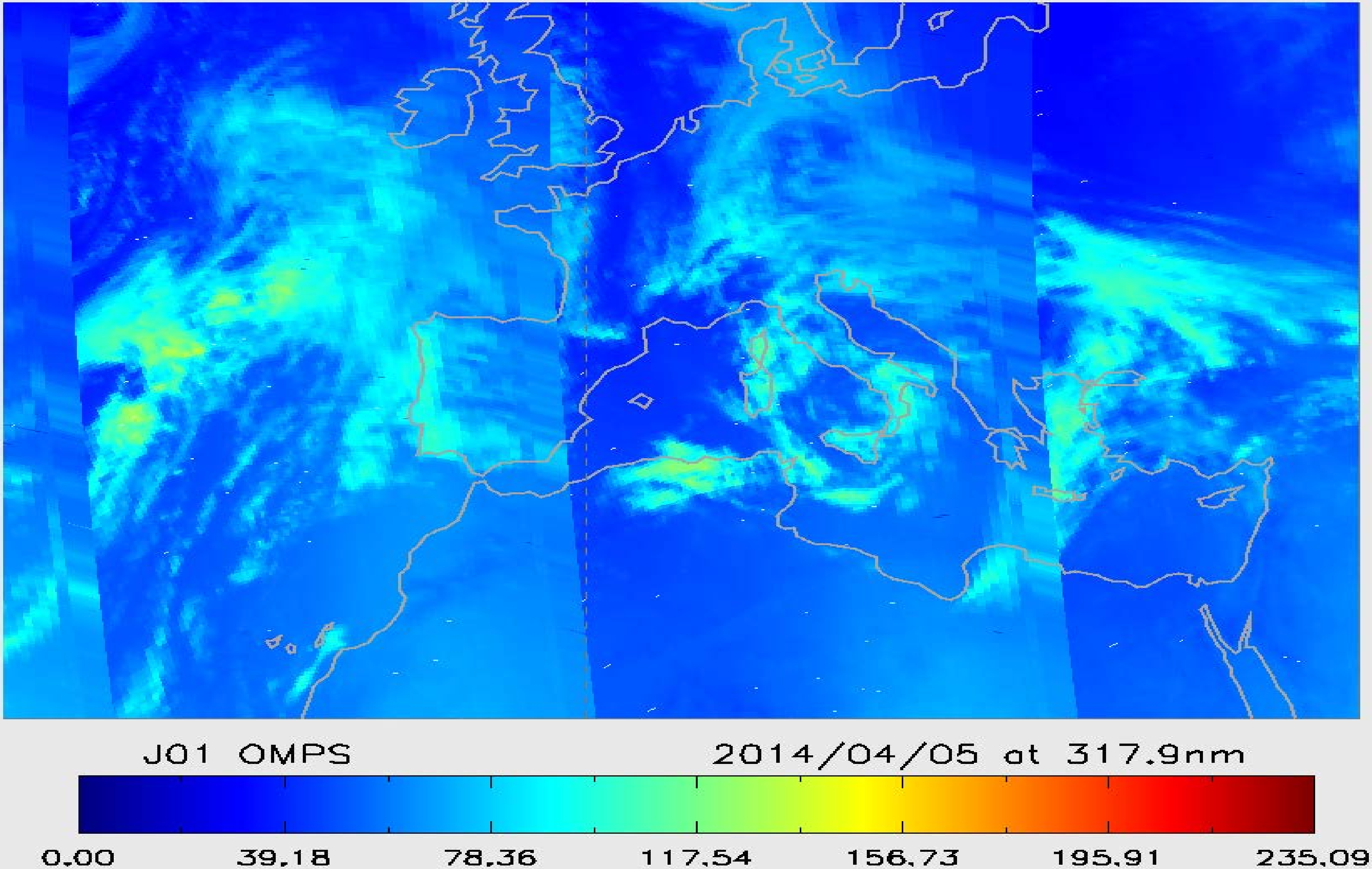
# NM Ground Pixel Sizes



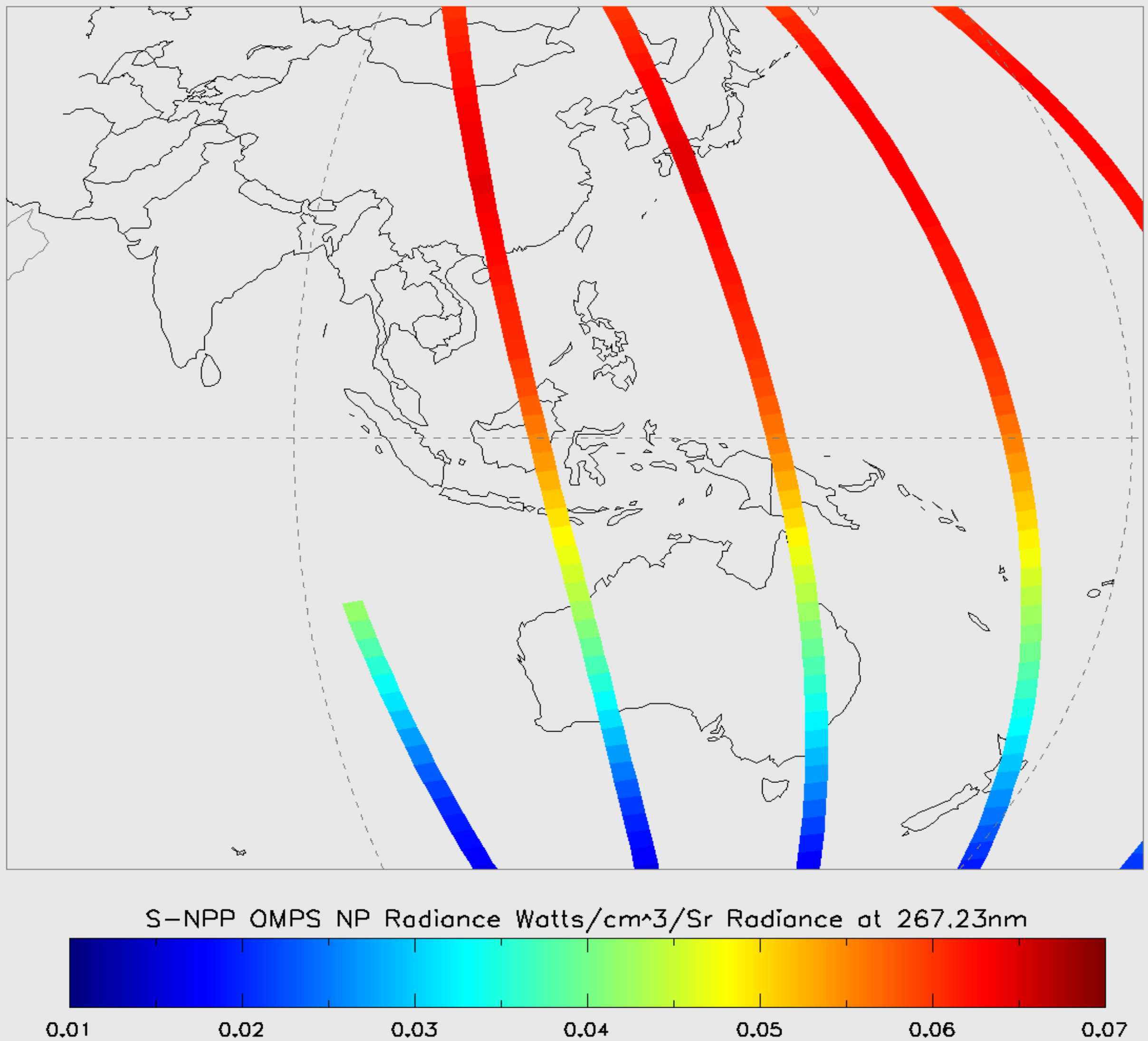
# LowRes Radiance



# Med Res Radiance



# J01 and  S-NPP NP SDR




**S-NPP Configuration**

Ground pixel size:
250Km . 250Km

80 ground pixels per orbit

Viewing Zenith Angle
Approximately zero°

**J01 Configuration**

J01 Ground Pixel size:
50Km . 50Km

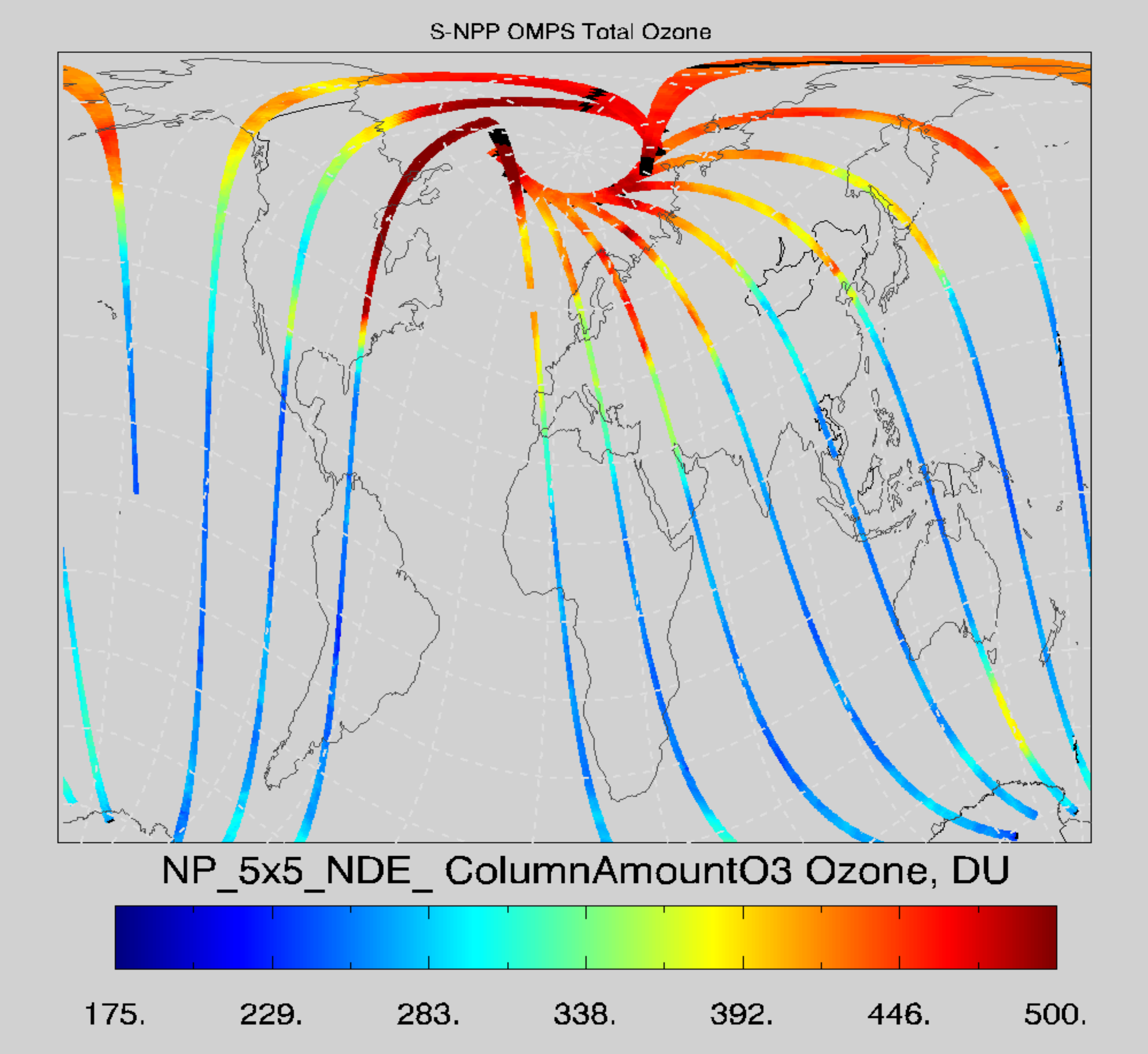
2000 pixels per
orbit=80*5*5

Viewing Zenith Angle
ranges from -7.5° to 7.5°

# Research V8PRO Version

- Based on the V8SBUV version 8.
- Sized to 5x5 output, netcdf-4.
- 2000 profiles per orbit.
- RT lookup tables include VZA index.  Total ozone computation uses VZA,RAZA.
- Profile single scatter RT code uses modified path length:  assume we are looking Nadir but a longer path length:  1/cos(VZA) + 1/cos(SZA).
- Reasonable approximation since max VZA is 7.5°
- Our implementation relaxes some SBUV/2 specific constraints in the V8SBUV code:  grating drive, 12 monochromator & 12 photometer paired measurements, nadir only.  There was a major rewrite done to the SBUV/2 code.
- We can account for separate viewing geometries in the NM, NP SDR inputs. This was developed using OMI inputs:  UV1,UV2 differences.

# 5x5 Ozone Retrieval NP

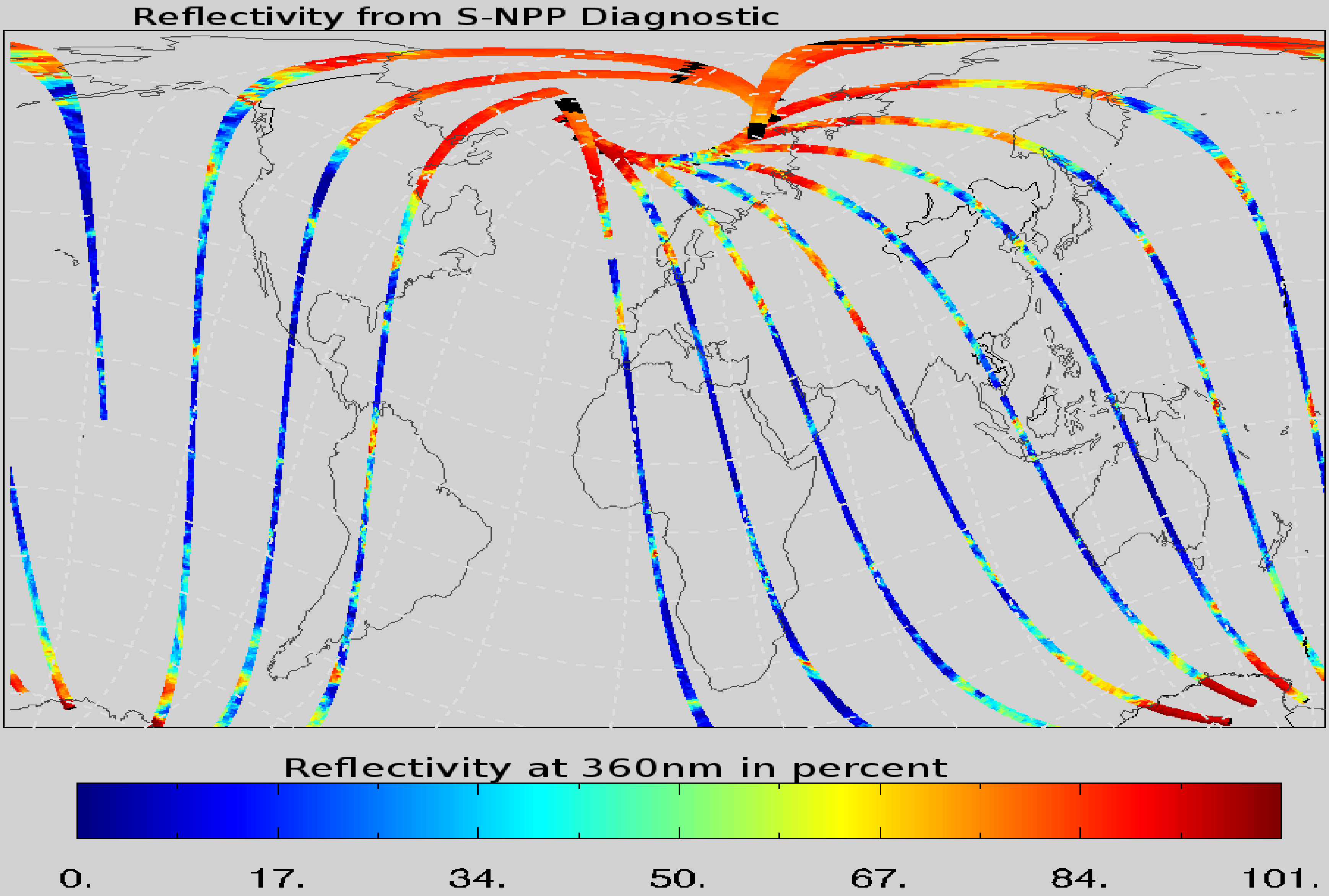



5x5 Ozone retrieval Example.

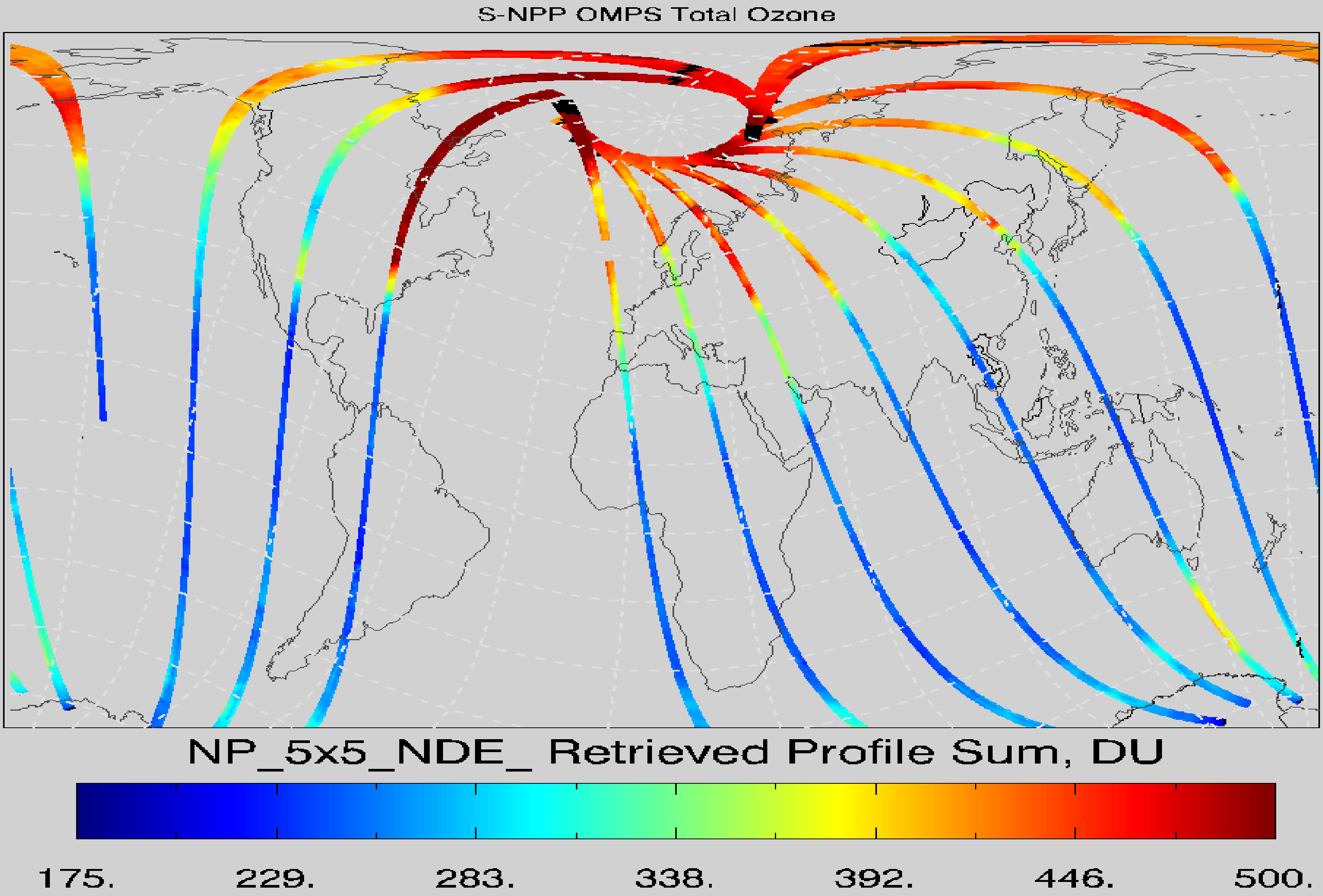
We took S-NPP diagnostic data and converted to Nominal. Then it is processed through ADL BLK2.0 to SDR level.

The image is created by the V8Pro ozone profile retrieval code step3 total ozone field.

# Reflectivity V8pro 2016/04/02



# Retrieved Column 2016/04/02
# Sum of Retrieved 21 layer profile



# Algorithm Refinements

- Better Snow ice
  - In operational NDE environment there are daily snow/ice maps available.
- Solar Activity
  - Daily Earthview Mg-II indices to scale solar flux for NP

- Information Concentration
  - EOF analysis
  - least square polynomial fits of normalized radiance
- Increased number of single scatter channels ( wlen < 290 nm )
  - The primary purpose is noise reduction in the retrieval
  - Currently uses 252nm, 273nm, 282nm, 288nm.
  - Possibly use 12 channels below 290nm.

- Spectrally aggregated pixels in some or all channels
  - Reduces Raman scattering influence
  - Spectral aggregation done in albedo, not radiance.
  - Noise Reduction

# Conclusion

- JPSS-1 OMPS-NP SDR will be at medium Resolution field of view
- JPSS-1 OMPS-NM SDR has a path forward to be measured at 17x17km^2 ( 1st 9 months at 50km^2).

- Smaller field of view ozone products
  - Algorithm development needed to achieve medRes ozone profile
  - MedRes total ozone EDR ready but we will be limited by lowRes RDR measurements before L+270 days.

# Validation of OMPS LP ozone profile retrievals from NASA GSFC version 2.5 against correlative satellite measurements

N. Kramarova[1], P.K. Bhartia[2], P. Xu[3], M. DeLand[1], Z. Chen[1], G. Jaross[2] and L. Moy[1]
[1] Science Systems and Applications Inc., Lanham, MD, USA
[2] NASA GSFC, Greenbelt, MD, USA
[3] Science Applications International Corporation, MD, USA



*STAR JPSS 2017 Annual Science Team Meeting*

# Key changes in version 2.5

- **Stray light correction for the VIS wavelengths;**
- **Sensor pointing errors [L. Moy et al., AMT 2017];**
- **New cloud height detection [Chen et al., AMT, 2016].**

## OMPS-LP v2 algorithm

- 43 UV pairs and 17 VIS triplets;
- Radiances are normalized at 65 km for UV and 45 km for VIS ranges;
- Aerosol correction module is turned off

OMPS LP $O_3$ retrieval algorithm by [*Rault and Loughman, 2013*]

## OMPS-LP v2.5 algorithm

- 3 UV pairs and 1 VIS triplet;
- Radiances are normalized at 55 km for UV and 40 km for VIS ranges;
- Include the explicit aerosol correction by using LP aerosol v1;
- Algorithm uses realistic a priori covariance matrices instead of Tikhanov regularization;

**April-May 2017:** Reprocessing LP data with the new 2.5 retrieval algorithm **DONE**

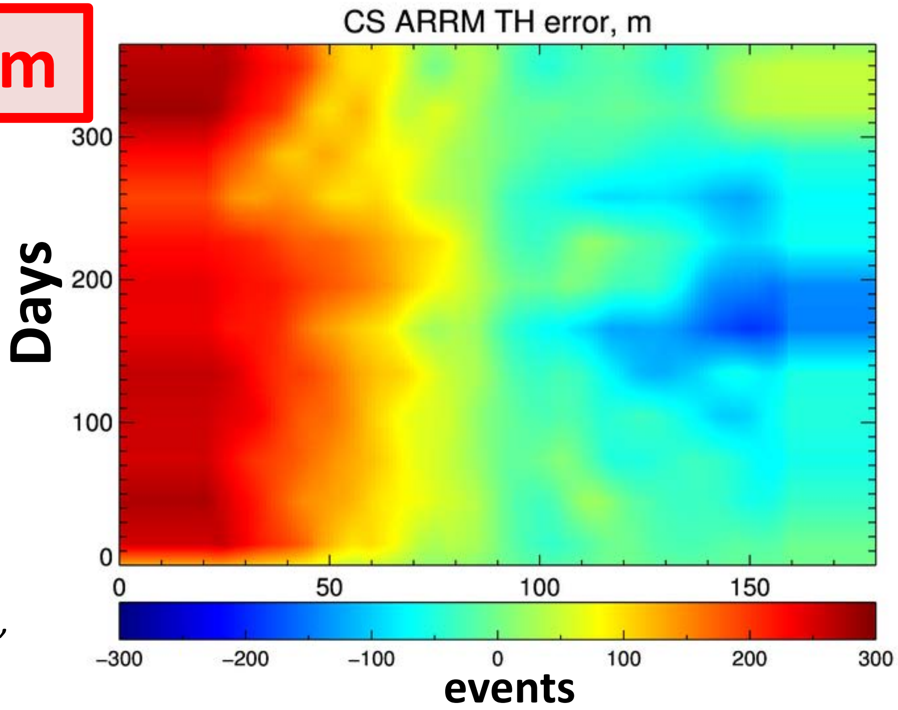
**August 2017:** Public release of the version 2.5 ozone profiles **DONE**

# Sensor pointing corrections in version 2.5

- ***Static corrections*** of 1.12/1.37/1.52 km for the left/center/right slits, correspondently;
- ***Time-dependent +0.1 km adjustments for all 3 slits*** on April 25, 2013 and on September 5, 2014 due to the spacecraft pitch and inclination adjustment maneuvers, respectively;
- ***Slit based, intra-orbital, seasonally varying TH*** corrections of ~0.3-0.4 km.

| TH error, m | LEFT | CENTER | RIGHT |
|---|---|---|---|
| Version 2 | 0.58 | 1.18 | 1.75 |
| Version 2.5 | 1.12 | 1.37 | 1.52 |

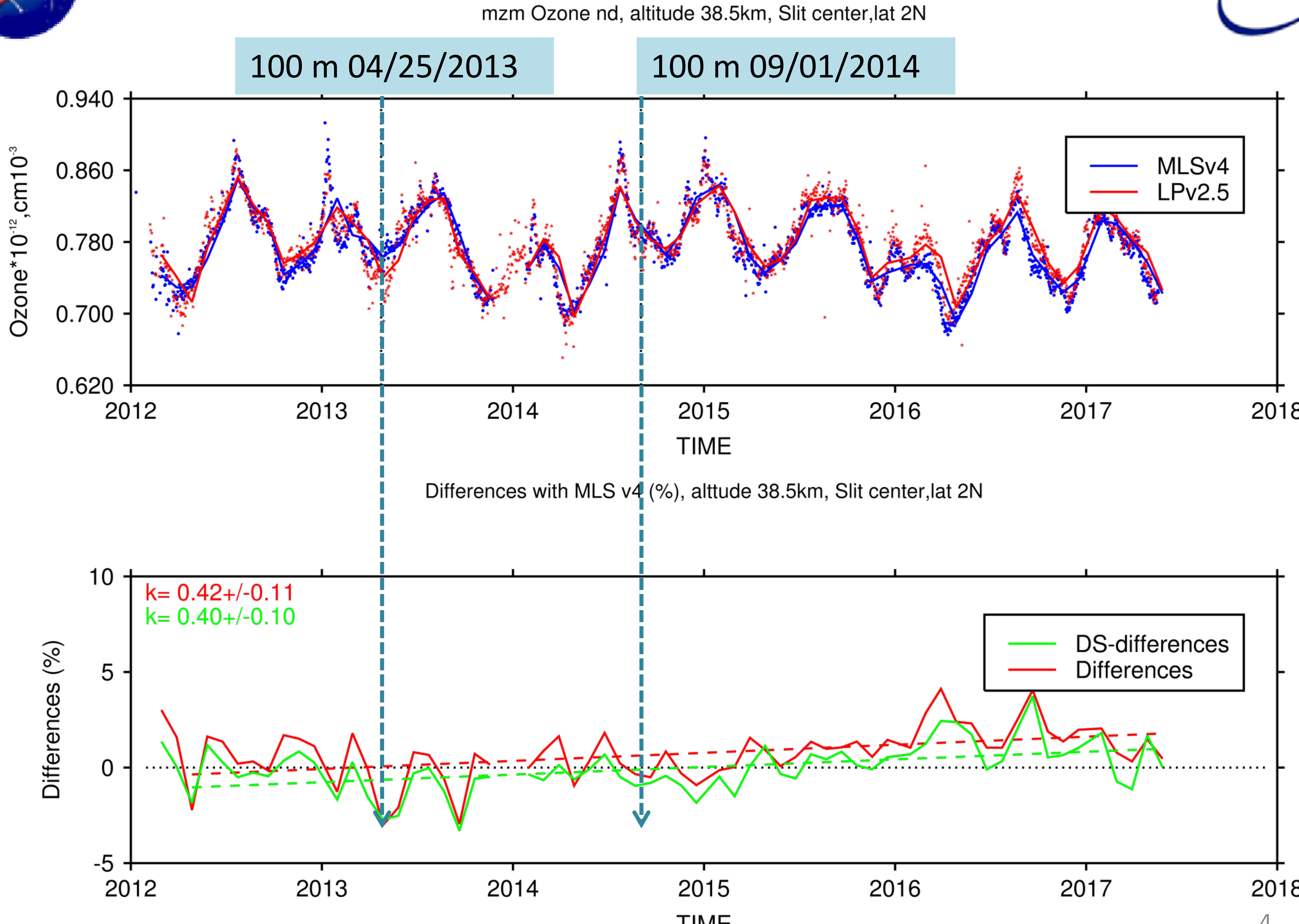
**±200 m**





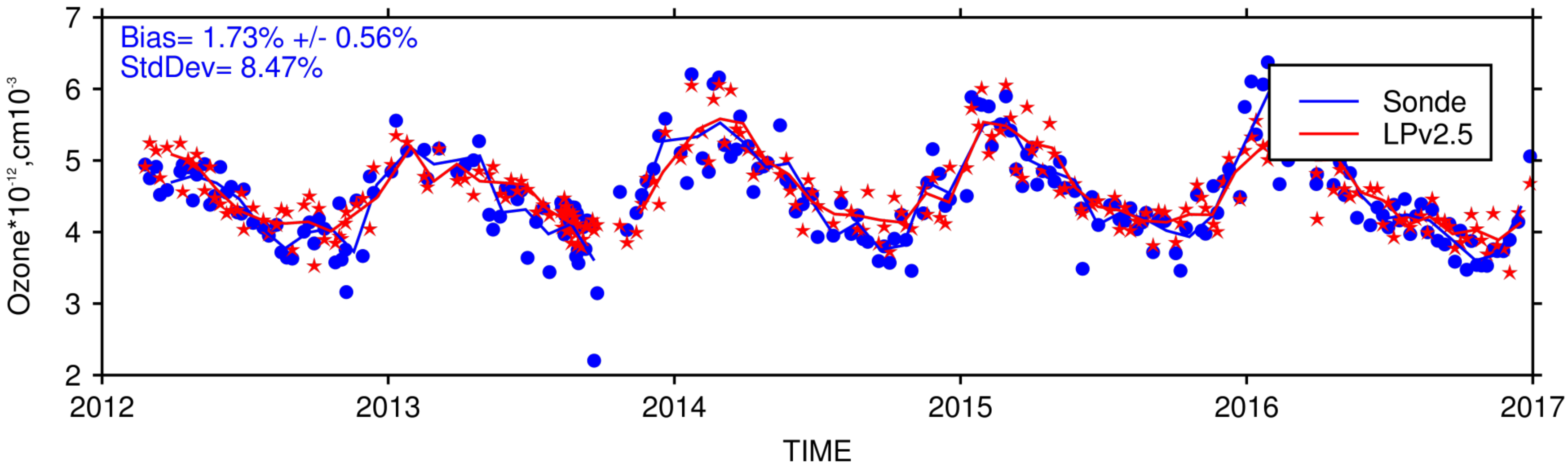
*Moy, L., Bhartia, P. K., Jaross, G., Loughman, R., Kramarova, N., Chen, Z., Taha, G., Chen, G., and Xu, P.: Altitude registration of limb-scattered radiation, Atmos. Meas. Tech., 10, 167-178, doi:10.5194/amt-10-167-2017, 2017.*

# Ozone Time Series

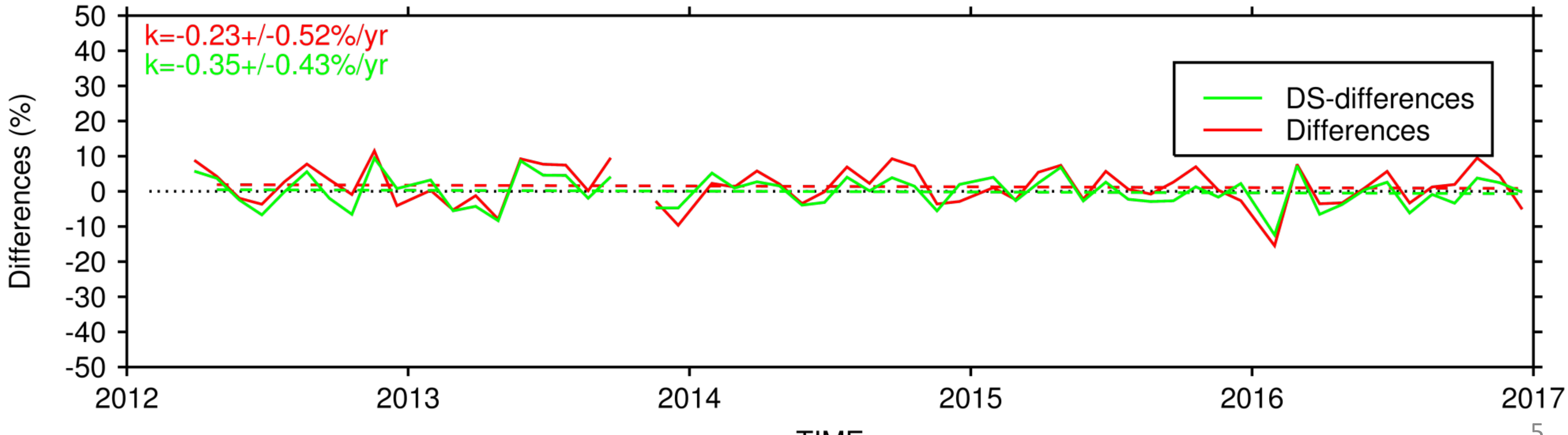


# Ozone Time Series

Ozone nd, altitude 22.5km, Slit center, boulder, [39N,105W]

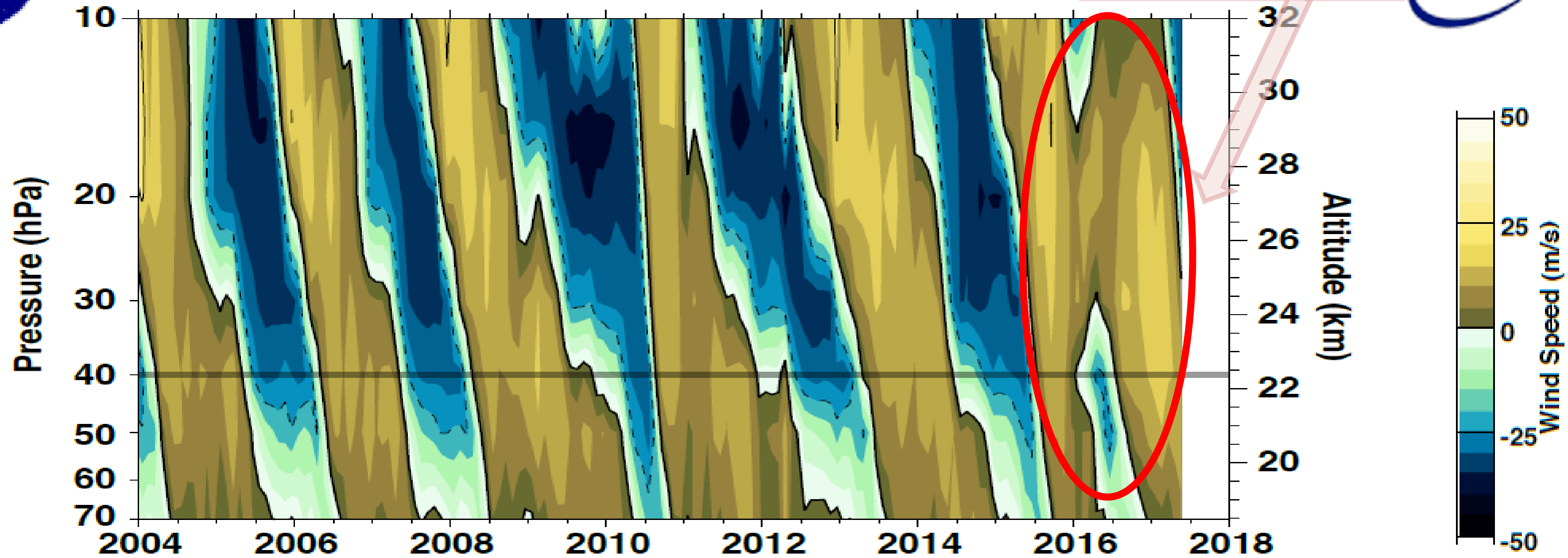



Differences with Sonde (%), altitude 22.5km, boulder, [39N,105W]



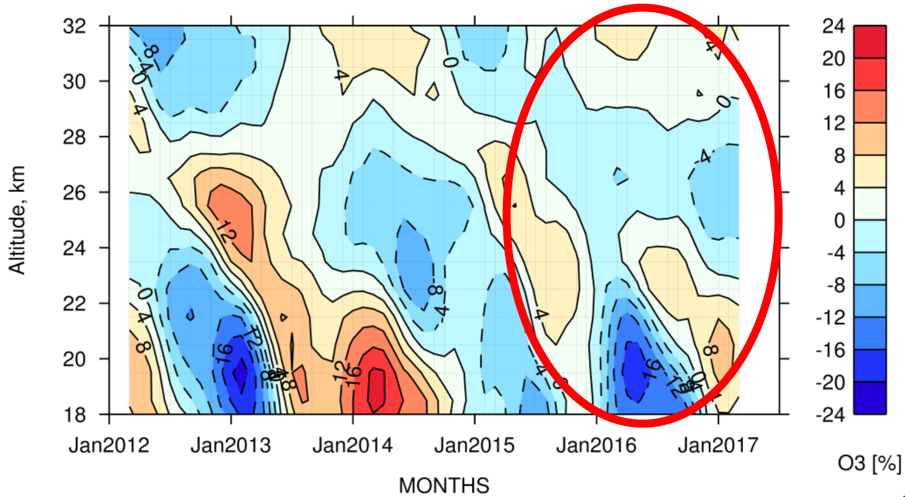
# Disrupted QBO

Disrupted 2015-2016 QBO

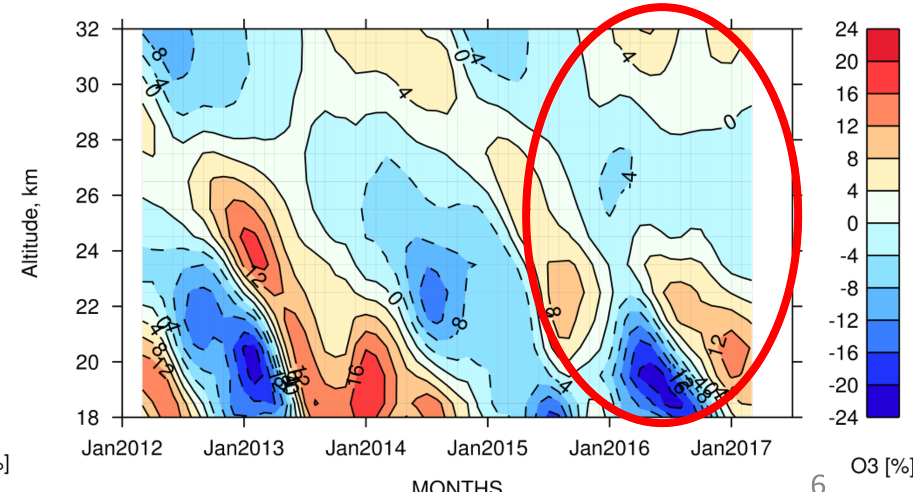



*Updated from Newman et al., 2016*

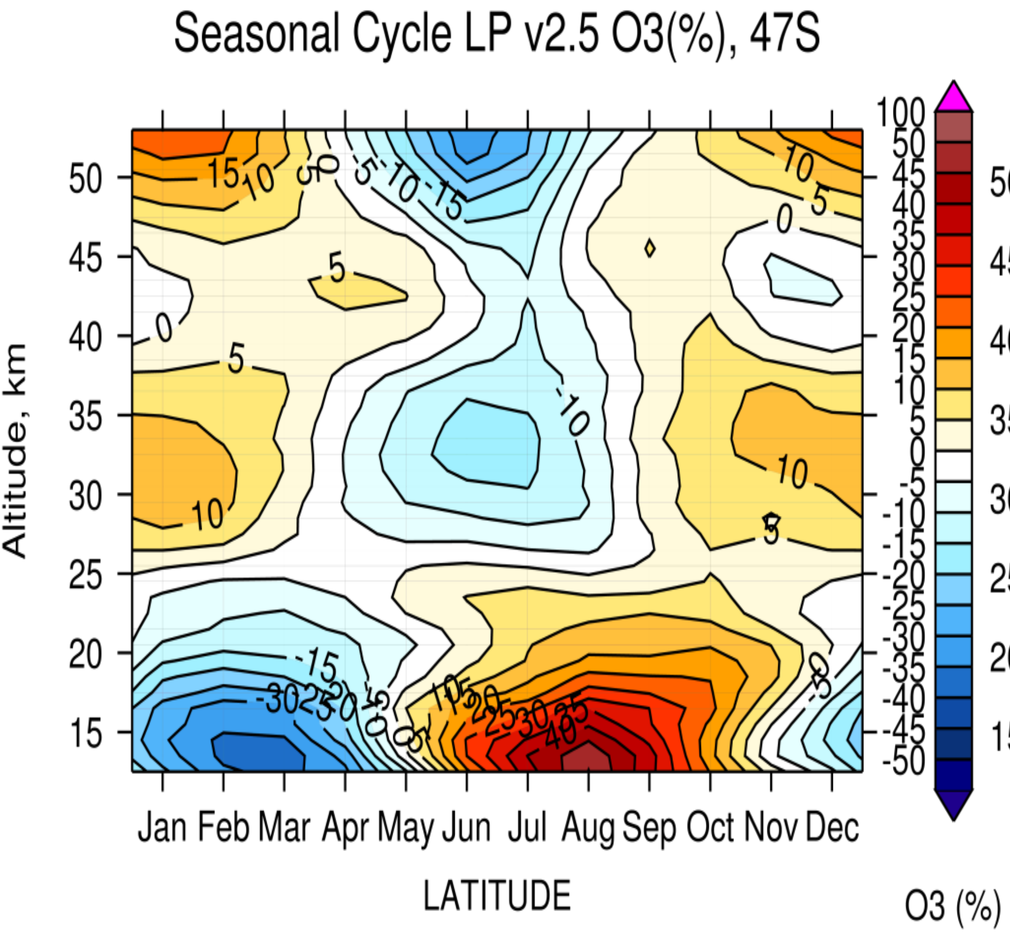
OMPS-LP v2.5 Ozone [%], 5S-5N

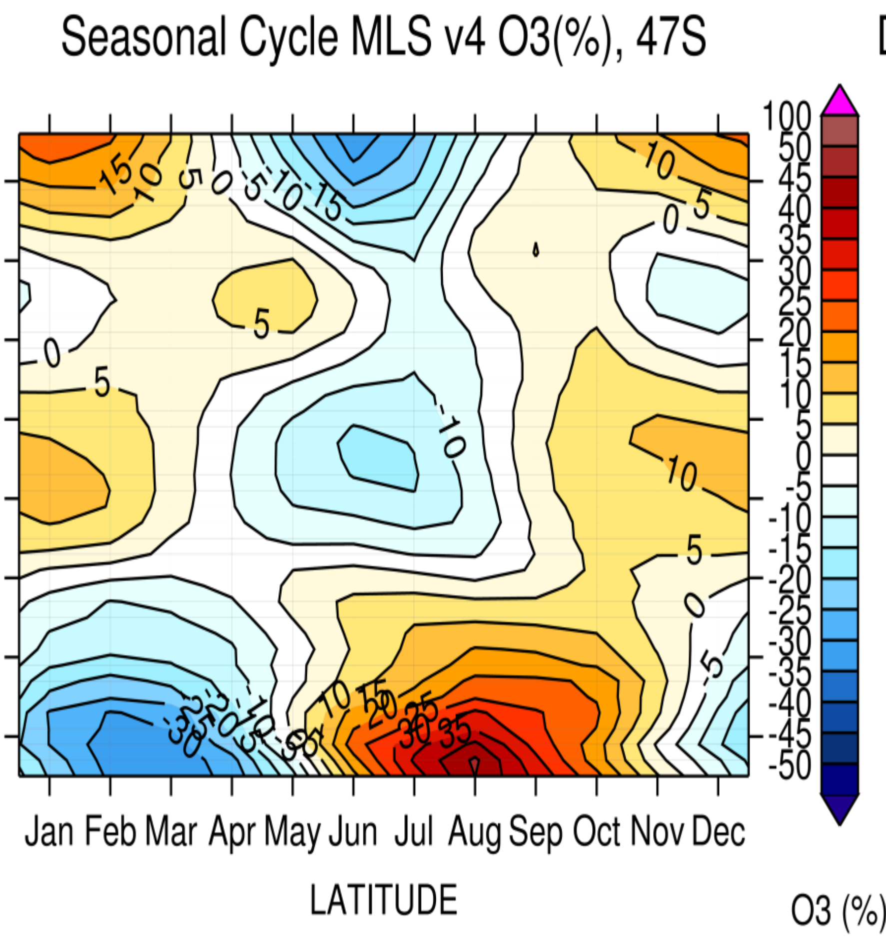



Aura-MLS v4 Ozone [%], 5S-5N



# Ozone Seasonal Cycle

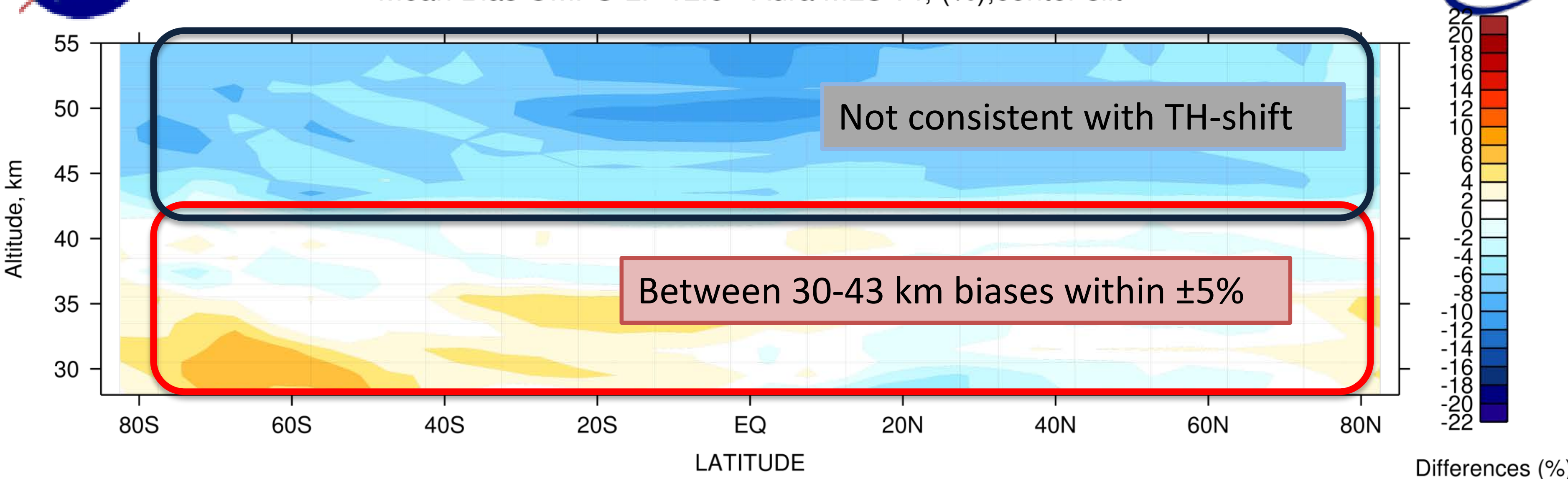


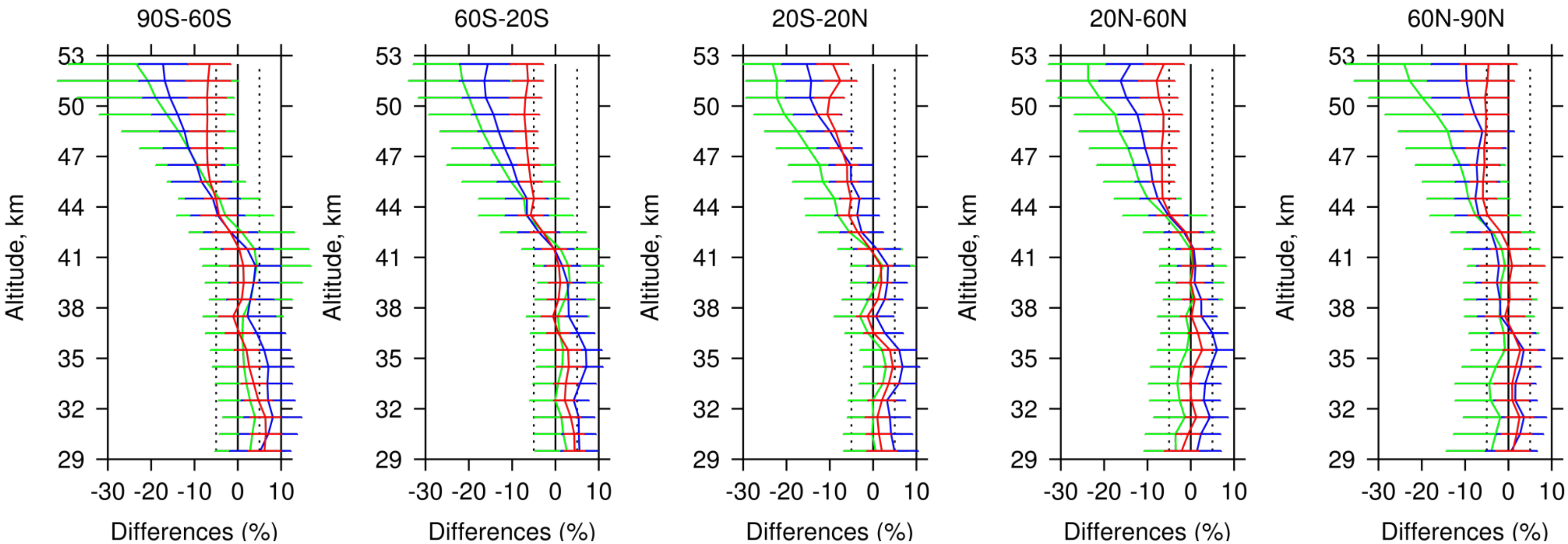
# Overview of uncertainties in OMPS LP O3 retrievals [%]

| Altitude [km] | Vertical res. [km] | Precision | TH error ±200 m | Drift in TH ~80m RSAS [%/yr] | Syst. error in measurements | Background aerosol effect |
|---|---|---|---|---|---|---|
| <15km | ~2.0-6.0 | ~10-50 | ~5-10 | ~0.4-0.8 | ±3 | ??10-60 |
| 20 km | ~1.6-2.8 | 6-10 | ~10 | ~0.8 | ±3 | 5 |
| 25 km | ~1.7-2.2 | 5-8 | ~0 | ~0 | ±3 | - |
| 30 km | ~1.8-2.8 | 6-9 | ~2 | ~0.16 | ±3 | ~<1 |
| 35 km | ~2.2-3.0 | 7-10 | ~5 | ~0.4 | ±3 | n/a |
| 40 km | ~1.6-2.0 | 6-8 | ~5 | ~0.4 | ±3 | n/a |
| 45 km | ~1.5-1.8 | 6-7 | ~5 | ~0.4 | ±3 | n/a |
| 50 km | ~2.2-3.0 | 8-12 | ~5 | ~0.4 | ±3 | n/a |

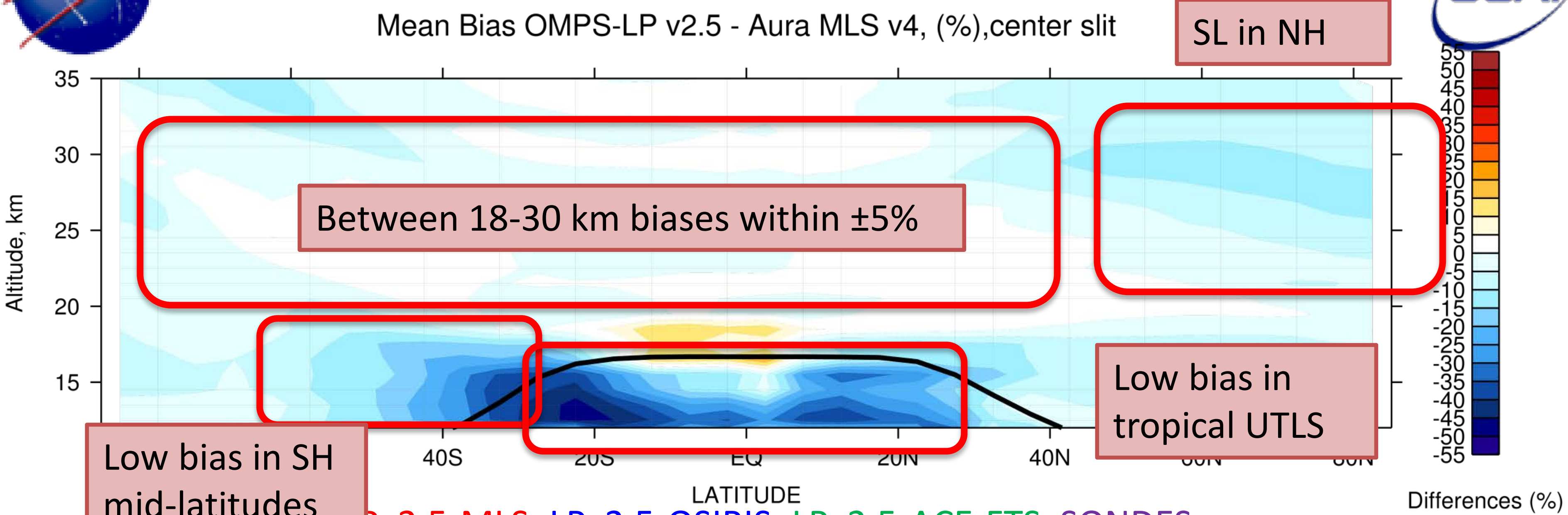
# Mean Biases UV



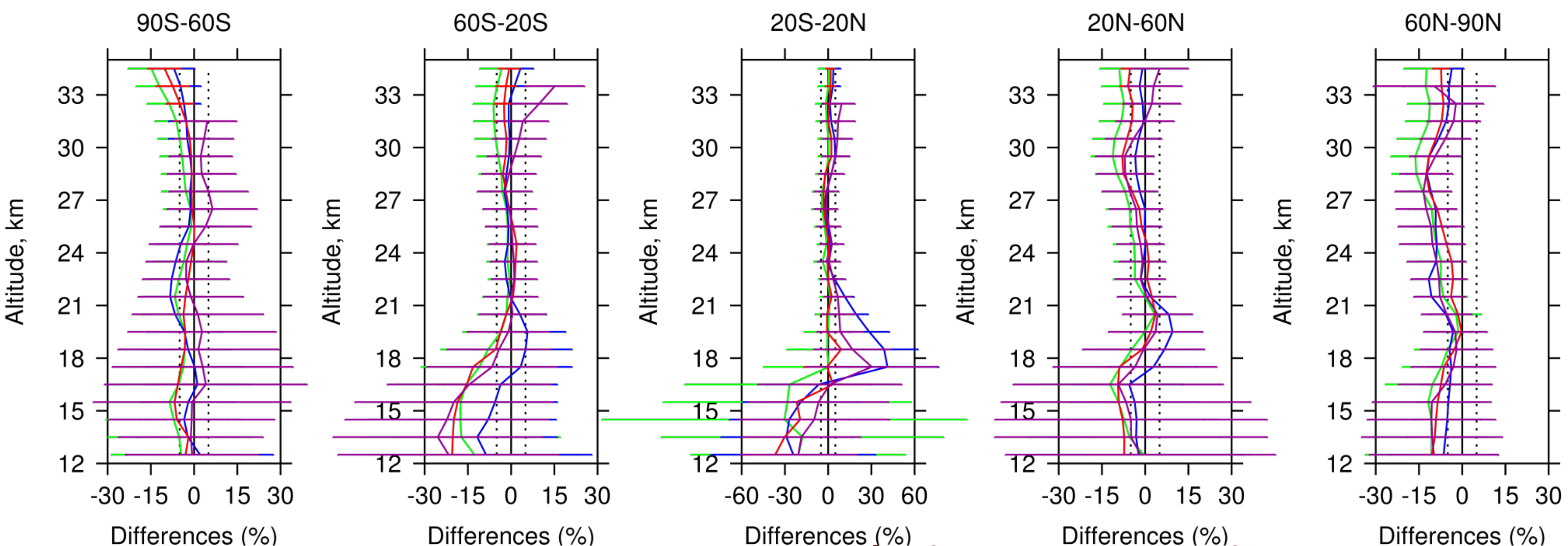

LPv2.5-MLS; LPv2.5-OSIRIS; LPv2.5-ACE



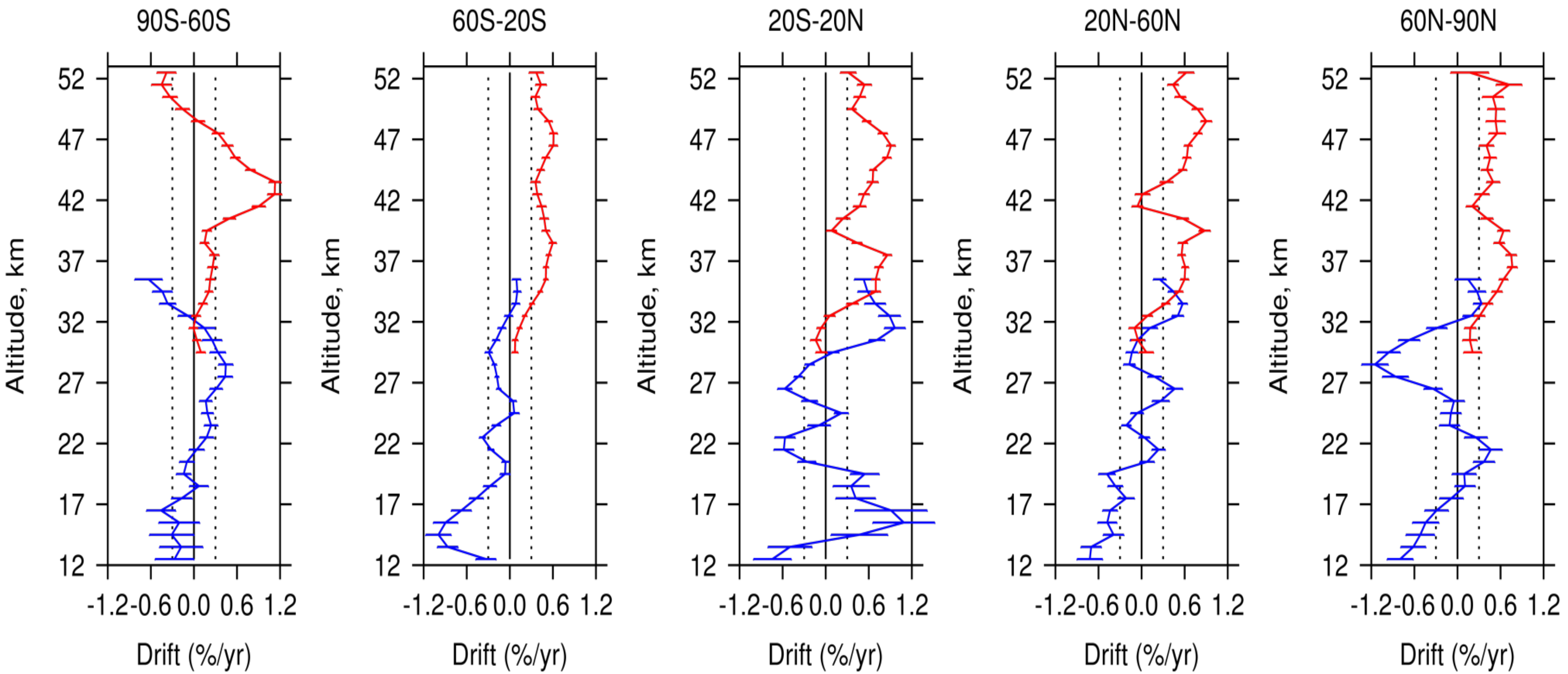
# Mean Biases VIS




Pv2.5-MLS; LPv2.5-OSIRIS; LPv2.5-ACE-FTS, SONDES



# Relative drift against Aura MLS




UV LPv2.5, VIS LPv2.5

# Conclusions

**Systematic errors in LP version 2.5 (internal analysis):**

- ✓ absolute sensor pointing error ±200 m (~5% above 35 km);
- ✓ quasi-random measurement errors (±3% everywhere);
- ✓ background aerosol (expected to be small after the explicit corrections in v2.5 );
- ✓ drift in sensor pointing ~80m over 5 years (~0.4%/yr ).

**Comparisons with correlative satellite measurements:**

**OMPS LP v2.5 UV:**

- within ±5% with Aura MLS, ACE-FTS and OSIRIS between 30-42 km;
- above 43 km bias of -6% – -12%, within quoted uncertainties for LP/MLS;

**OMPS LP v2.5 VIS:**

- within ±5% between 20 and 30 km, except for high NH latitudes where differences are larger due to instrumental errors;
- ~-15% differences in the SH mid-latitudes (20S-60S) below 18 km;
- ~-30% differences in the tropical UTLS;

**Absolute TH registration:** comparisons with correlative satellite instruments did not reveal patterns in O3 biases consistent with the TH shift.

**Drift in TH registration:** drift in O3 relative to MLS and OMPS NP ~0.5%/yr (or 2.5% over 5 years) at altitudes above 35 km. The pattern is consistent with the detected 80-meter drift in TH.

# TOAST, Blended UV and IR Gridded 1° Ozone Products


*Jianguo Niu*
*System Research Group@NOAA/NESDIS/STAR*

*Larry Flynn,*
*NOAA/NESDIS/STAR*

*Eric Beach, Zhihua Zhang*
*I.M.S. Group @NOAA/NESDIS/STAR*

*Ev-Marie Devaliere*
*ERT @NOAA/NESDIS/STAR*



**STAR JPSS Annual Meeting**
**August 16, 2017**

# Current available TOAST products from OSPO

- Current operational TOAST for TOVS + SBUV
- Current operational eTOAST v03 for CrIS + SBUV

# Archives of TOAST and eTOAST

- **TOAST archived (available from 2007 ~ current):**

  /net/www/aftp/pub/smcd/spb/ozone/toast/data/
  "TOAST": TOAST blended total ozone (toast_yyyymmdd.bin)
  "SBUV" : objective analyzed SBUV layer & total ozone (sbuv_yyyymmdd.bin)
  "TOVS" : objective analyzed TOVS total ozone (tovs_yyyymmdd.bin)
  "UTLS" : objective analyzed TOVS's UTLS total ozone (tovsutls_yyyymmdd.bin)
  "TOAST/GRIB": TOAST blended total ozone in GRIB format (TOAST_yymmdd.grb)
  …
  ***DVD archived 2002 ~ 2006 TOAST data (contact to eric.beach@noaaa.gov)***

- **eTOAST archived (available from 2015 ~ current):**

  /net/www/aftp/pub/smcd/spb/ozone/etoast/data/
  "ETOAST": eTOAST blended total ozone (TOAST_Blended-bin_CRIS_N19_SBUV_yyyymmdd.bin)
  "SBUV" : objective analyzed SBUV layer & total ozone (TOAST_UV-bin_N19_SBUV_yyyymmdd.bin)
  "CRIS" : objective analyzed CRIS total ozone (TOAST_IR-bin_SNP_CRIS_yyyymmdd.bin)
  "UTLS" : objective analyzed CrIS's UTLS total ozone (etoast_crisftls_yyyymmdd.bin)
  "GRIB" : eTOAST blended total ozone in GRIB format
  (TOAST_Blended-grb_SNP_CRIS_N19_SBUV_yyyymmdd.grb)

# Both products were saved in big endian binary format

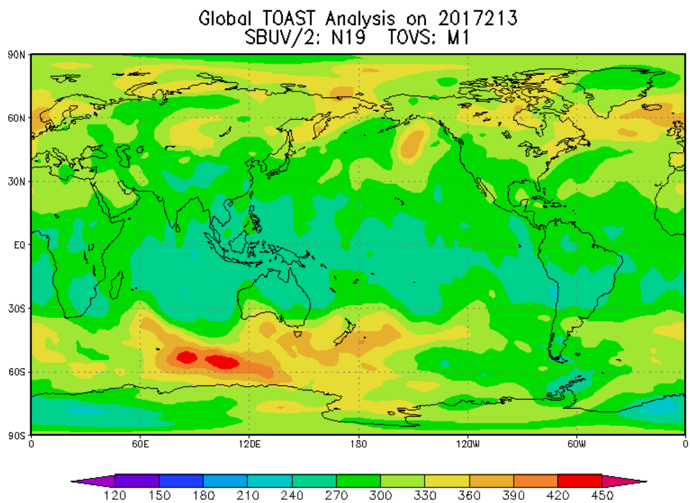
## TOAST

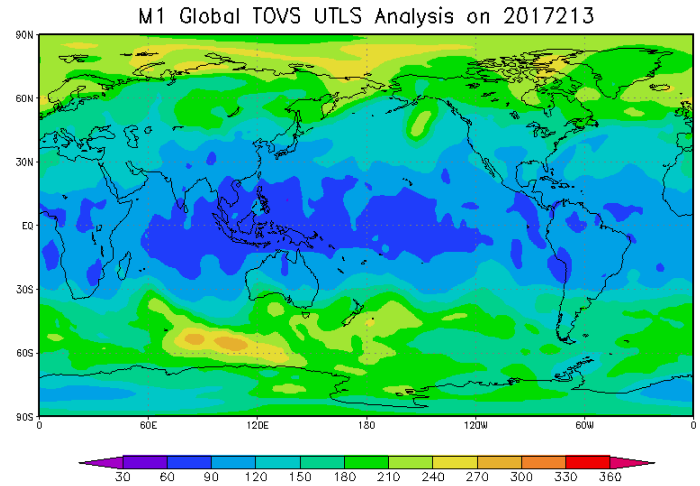
| | Product | Unit | Dimes. | size |
|---|---|---|---|---|
| TOAST | VCD | DU | 360 x 181 | 260640 |
| TOVS | VCD | DU | 360 x 181 | 260640 |
| TOVS | UTLS | DU | 360 x 181 | 260640 |
| SBUV | VCD & PROF. | DU | 360 x 181 x 13 | 3388320 |

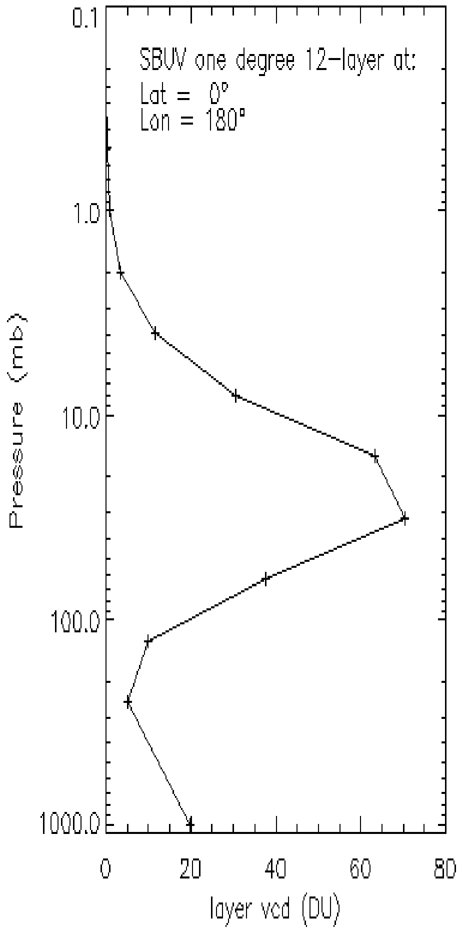
## eTOAST-V03

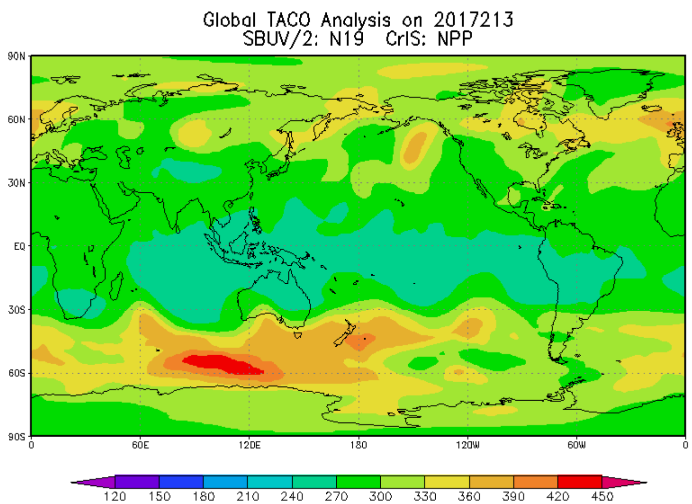
| | Product | Unit | Dimens. | Size |
|---|---|---|---|---|
| eTOAST | VCD | DU | 360 x 181 | 260640 |
| CrIS | VCD | DU | 360 x 181 | 260640 |
| CrIS | FTLS | DU | 360 x 181 | 260640 |
| SBUV | VCD & PROF. | DU | 360 x 181 x 13 | 3388320 |

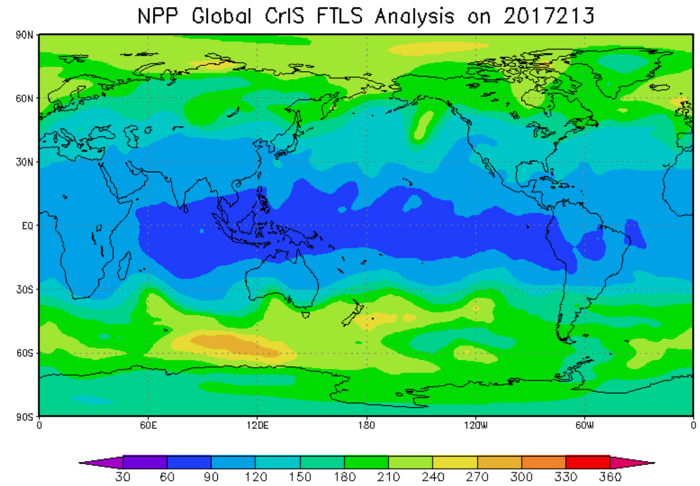
# Current available TOAST products (Aug. 1, 2017)



# eTOAST future

- Future eTOAST-v04 for CrIS + V8PRO
- Future eTOAST-v05 for CrIS + Limb (12 layer analysis)
- Future eTOAST-v05.100 for CrIS + Limb 100 layer analysis
- eTOAST v05.2, as a local supporting version, has been prepared to validate eTOAST v05, using CrIS and PEATE Limb L2 daily data to provide similar product as eTOAST v05.

# Future products (little endian currently)

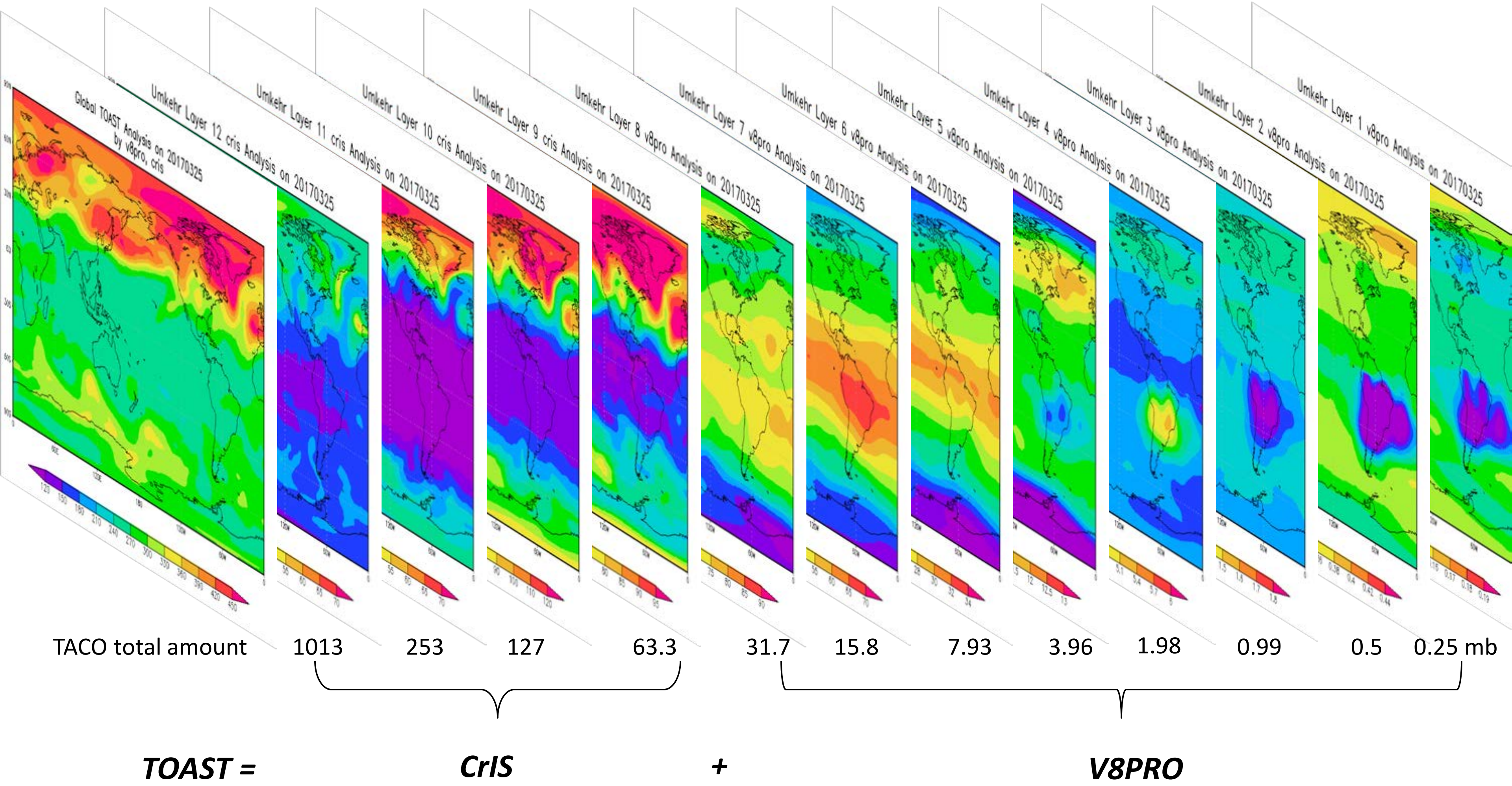
**eTOAST-v04**

| | Product | Unit | Dimens. | Size |
|---|---|---|---|---|
| eTOAST | VCD | DU | 360 x 181 | 260640 |
| CrIS | FTLS | DU | 360 x 181 | 260640 |
| CrIS | VCD & PRO | DU | 360 x 181 x 13 | 3388320 |
| V8PRO | MSUS | DU | 360 x 181 | 260640 |
| V8PRO | UVPRO | DU | 360 x 181 x 13 | 3388320 |

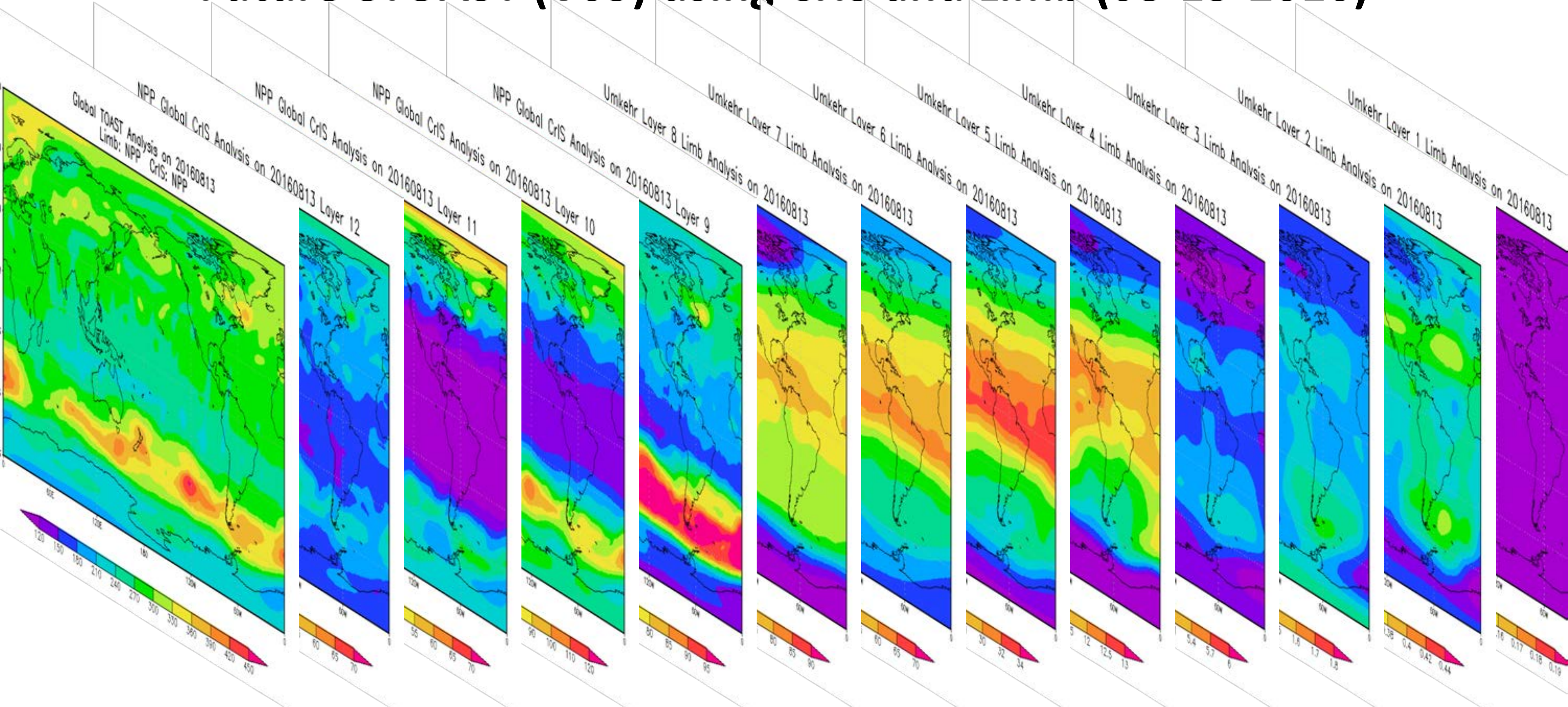
**eTOAST-v05**

| | Product | Unit | Dimens. | Size |
|---|---|---|---|---|
| eTOAST | VCD | DU | 360 x 181 | 260640 |
| CrIS | FTLS | DU | 360 x 181 | 260640 |
| CrIS | VCD & PRO | DU | 360 x 181 x 13 | 3388320 |
| LIMB | MSUS | DU | 360 x 181 | 260640 |
| LIMB | Limb PRO | DU | 360 x 181 x 13 | 3388320 |

# Future eTOAST (V04) using CrIS and V8PRO (03-25-2017)



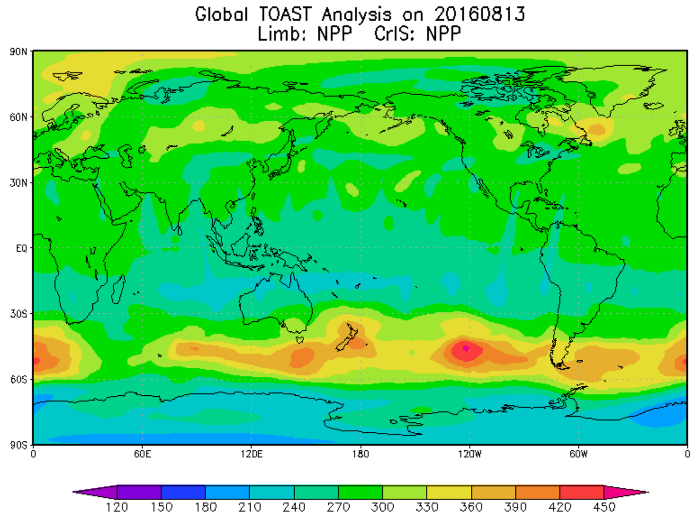
# Future eTOAST (V05) using CrIS and Limb (08-13-2016)

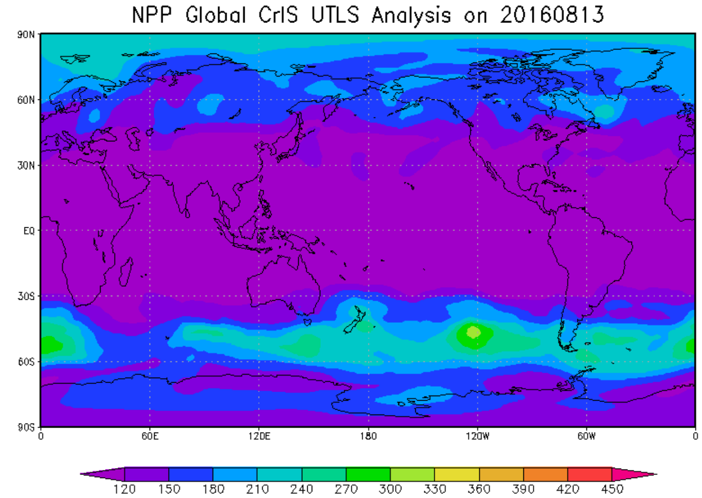


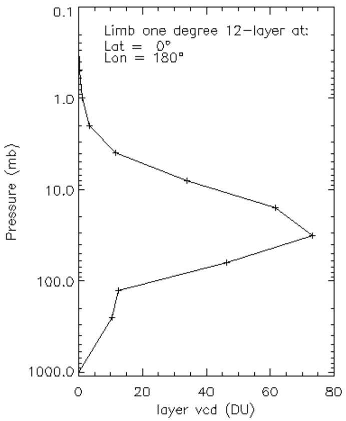

TACO total amount 1013 253 127 63.3 31.7 15.8 7.93 3.96 1.98 0.99 0.5 0.25 mb

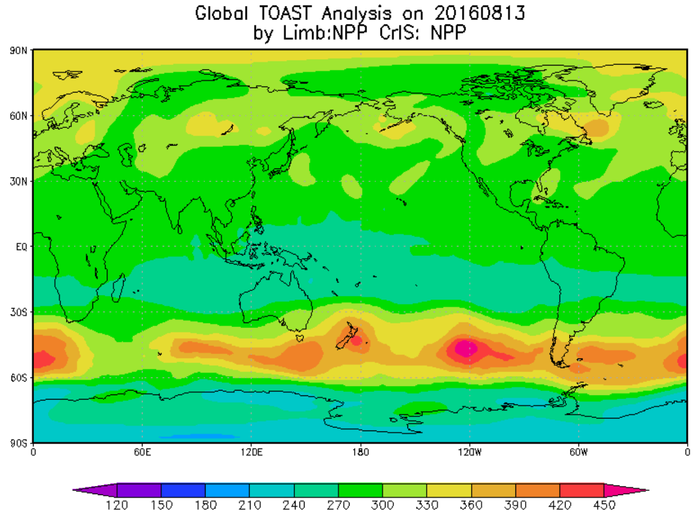
***TOAST=*** ***CrIS*** ***+*** ***OMPS /Limb***

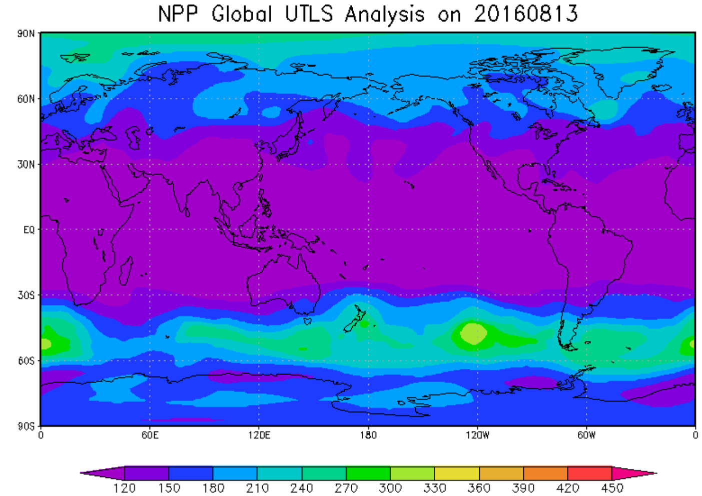
# Future available Limb eTOAST-v05 and v05.100 products

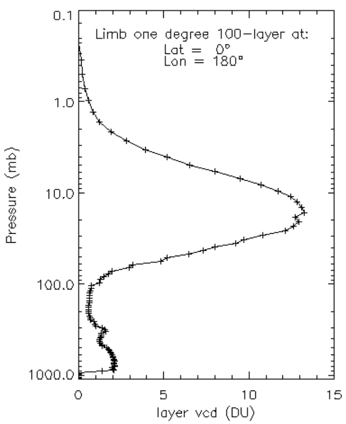


# Future plan

- Steven Bucker (UMBC) is working on using the OMPS Limb profile 100 layer analysis as an a priori for CrIS NUCAPS ozone combined retrieval.

- eTOAST-V04 and eTOAST-V05 is going to be operational products at NDE.

- The legacy code need to be rewritten; there are lots of GOTOs and output files need to be reorganized

# Data reorganize is planed

**eTOAST-v04**

| | Product | Unit | Dimens. | Size |
|---|---|---|---|---|
| eTOAST | VCD | DU | 360 x 181 | 260640 |
| CrIS | VCD & FTLS & PRO | DU | 360 x 181 x 14 | 3648960 |
| V8PRO | UVPRO & MSUS | DU | 360 x 181 x 14 | 3648960 |

**eTOAST-v05**

| | Product | Unit | Dimens. | Size |
|---|---|---|---|---|
| eTOAST | VCD | DU | 360 x 181 | 260640 |
| CrIS | VCD & FTLS & PRO | DU | 360 x 181 x 14 | 3648960 |
| LIMB | Limb PRO & MSUS | DU | 360 x 181 x 14 | 3648960 |

THANKS

# Monthly Ozone Residual Comparisons Between OMPS-LP and MLS

**Steven Buckner**[1], Lawrence Flynn[2], M. Patrick McCormick[1], John Anderson[1]

Hampton University[1]

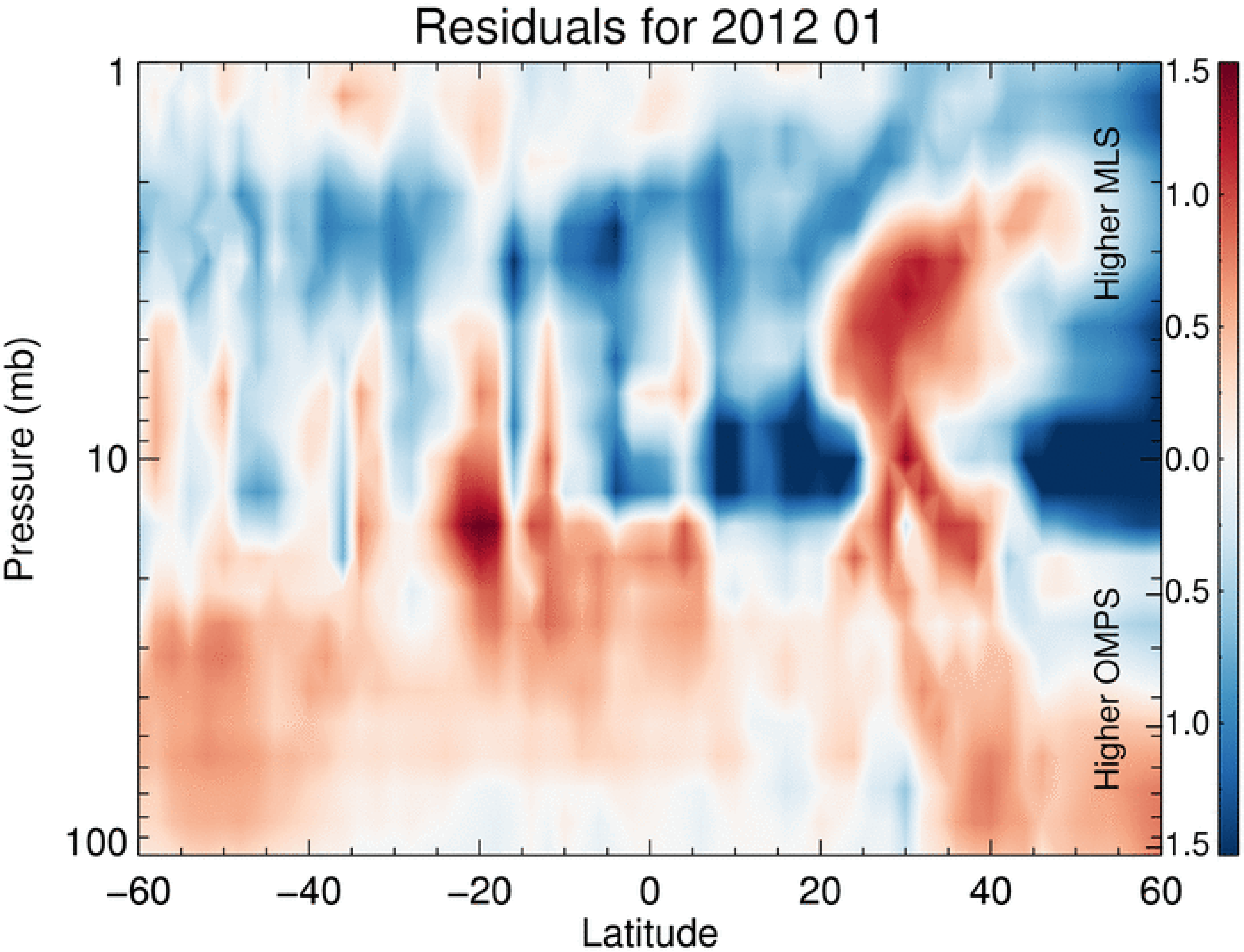
NOAA NESDIS STAR[2]

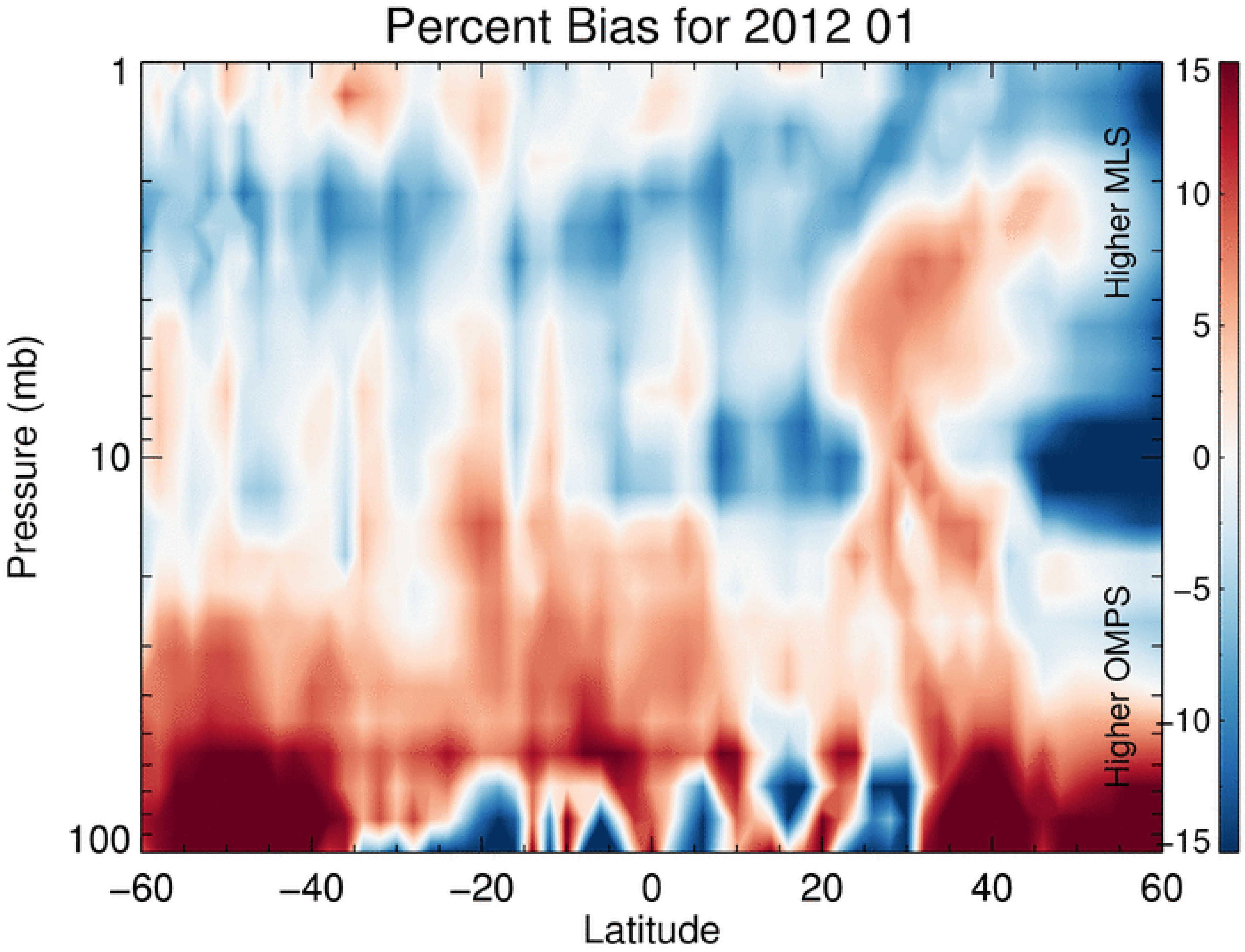
# Background

- Performed using daily OMPS-LP and MLS data files
  - Comparisons done for the entire length of the OMPS-LP data record, ranging from January 2012 through June 2017
- Daily zonal means were created for each day and averaged together across an entire month
  - Zonal means were done with a 2-degree latitude bin from 60 South to 60 North
  - A spline was used to bring the OMPS vertical (pressure) resolution down to that of MLS so 1-to-1 comparisons could be made
  - Study focused mainly on stratosphere, from 100mb to 1mb

# Background (cont.)

- Differences between the MLS and OMPS monthly zonal means were calculated for each month
- Correlation calculations were done for each month
- Percent Bias plots were also calculated for each moth


Residuals for 2012 01
Pressure (mb)
1
10
100
Latitude
−60
−40
−20
0
20
40
60
Higher MLS
Higher OMPS
1.5
1.0
0.5
0.0
−0.5
−1.0
−1.5



Percent Bias for 2012 01
Pressure (mb)
1
10
100
−60
−40
−20
0
20
40
60
Latitude
Higher MLS
Higher OMPS
15
10
5
0
−5
−10
−15

# Notes About the Plots

- The loss in coverage poleward of 50 degrees during June July and August of each year seems to come from the OMPS data, potentially due to either polar night or solar zenith angle.
  - Impacts both hemispheres due to a potential wrap-around effect during the spline process
- Vertical striations in the OMPS data present starting in April of 2017 and continuing through the summer

# Correlation Statistics

- Average Correlation: 97.8582%
- Maximum Correlation: 99.5729%
- Minimum Correlation: 92.9895%
- Standard Deviation: 2.1935%

# Thank You

# Ground-based validation

Irina Petropavlovskikh[1], K. Miyagawa[1], G. McConville[1], A. McClure[1], Eric Beach[2], L. Flynn[3] and N. Kramarova[4]

[1] NOAA/CU
[2] NOAA/STAR
[3] NOAA/NESDIS
[4] NASA/SSA

# Objective for validation activities

- Provide NOAA Dobson and Brewer TO and ozone-sonde data in near real time
  - WinDobson automation system
    ftp://aftp.cmdl.noaa.gov/data/ozwv/Dobson/WinDobson/
  - Brewer online daily processing, plots of satellite/Brewer
    https://www.esrl.noaa.gov/gmd/grad/neubrew/ProductDisplays.jsp#o3timeseries
  - Skysonde software for ozone-sonde data processing
    ftp://aftp.cmdl.noaa.gov/data/ozwv/Ozonesonde/
- Produce calibrated and quality assured data
  - Dobson data reprocessing to homogenize record, paper is in reviews (Evans et al, ACPD, https://www.atmos-chem-phys-discuss.net/acp-2017-383/), submission of new version of NOAA data to WOUDC and NDACC is planned at the end of 2017, data are updated on NOAA aftp web site (see links above)
  - Ozone –sonde data reprocessing for homogenization – done, data available on NOAA aftp, paper is in preparation
  - Brewer/Dobson/sonde data comparisons, verification of 2014 Dobson calibration at MLO, assessment of seasonal biases
  - Dobson/Pandora - 3 years comparison – paper in reviews (J. Herman et al., AMTD, https://www.atmos-meas-tech-discuss.net/amt-2017-157/)
  - Dobson data correction for stratospheric temperature variability

# TCO comparison between Dobson and OMPS overpass

NOAA NM (<50 km, 24 hour)

ftp://ftp.star.nesdis.noaa.gov/pub/smcd/spb/ozone/irina/NPP/NM/V8/reproc_jun_2017/

NOAA NP (<250 km)

ftp://ftp.star.nesdis.noaa.gov/pub/smcd/spb/ozone/irina/NPP/NP/V8/reproc_jun_2017/

NASA (<50 km)

ftp://toms.gsfc.nasa.gov/pub/omps_tc/overpass

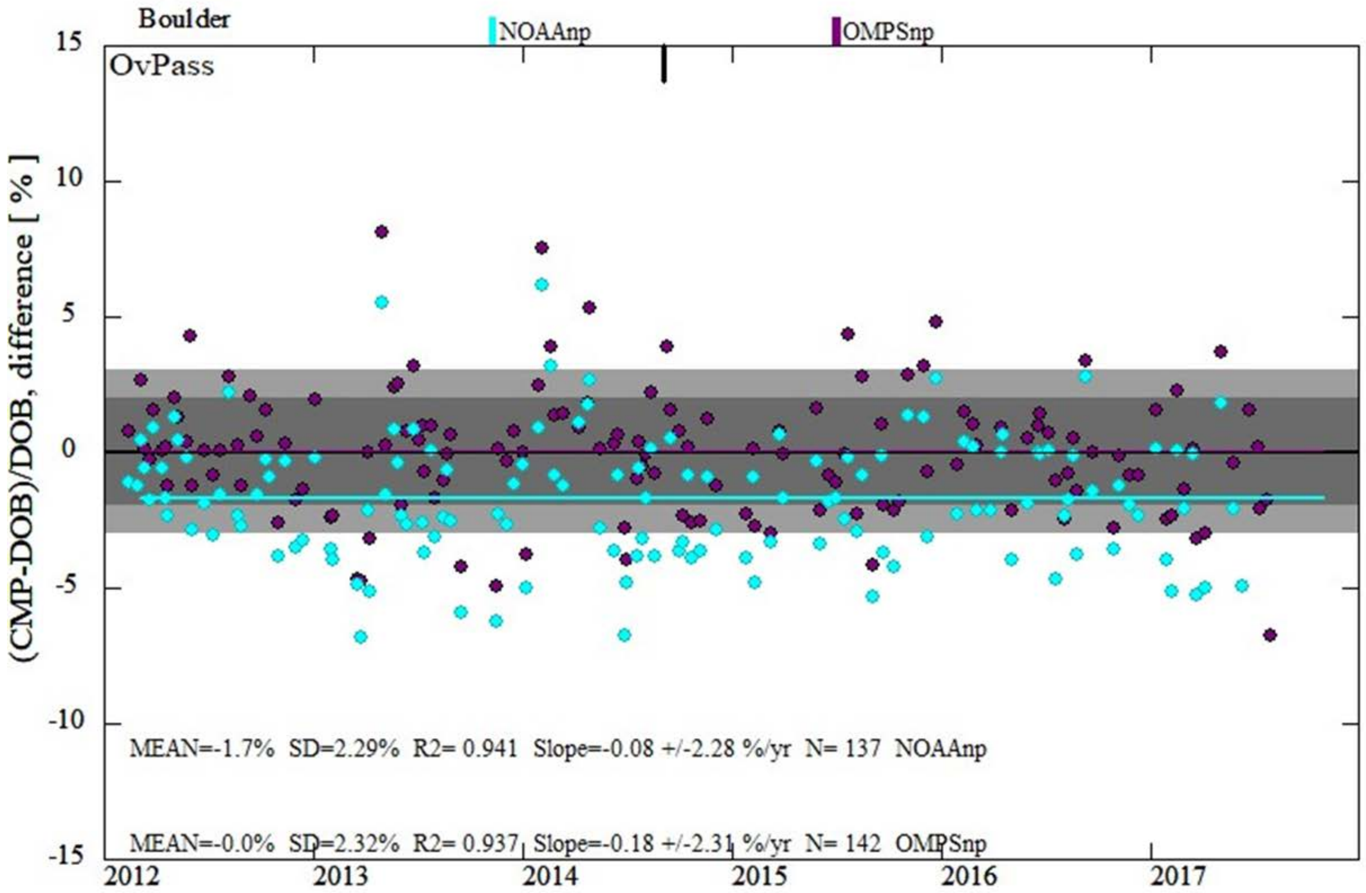
NASA Profile (<250 km)

ftp://toms.gsfc.nasa.gov/pub/omps_np/overpass

Dobson

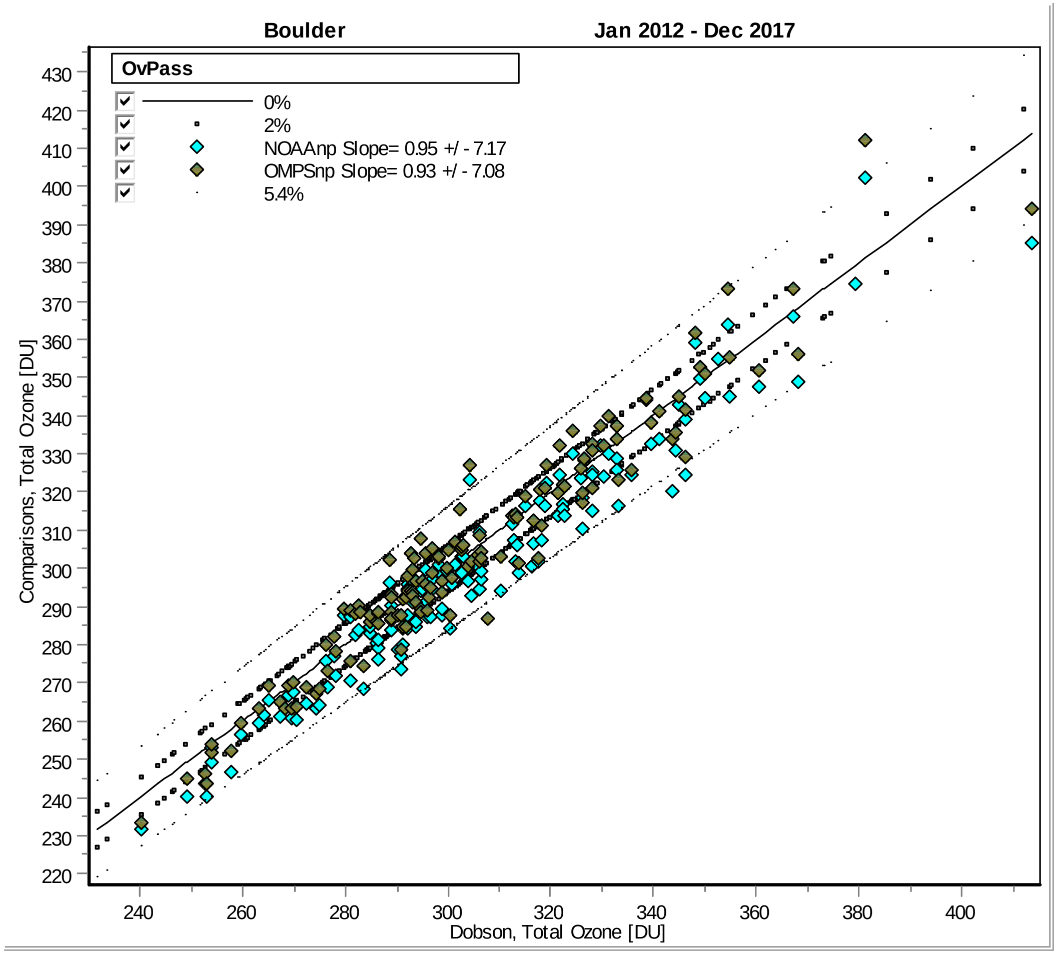
ftp://aftp.cmdl.noaa.gov/data/ozwv/Dobson/WinDobson/ + Windobson

# Total ozone data, Boulder, 2012-2017
# **NOAA** (R2=0.94) and **NASA** (0.94)



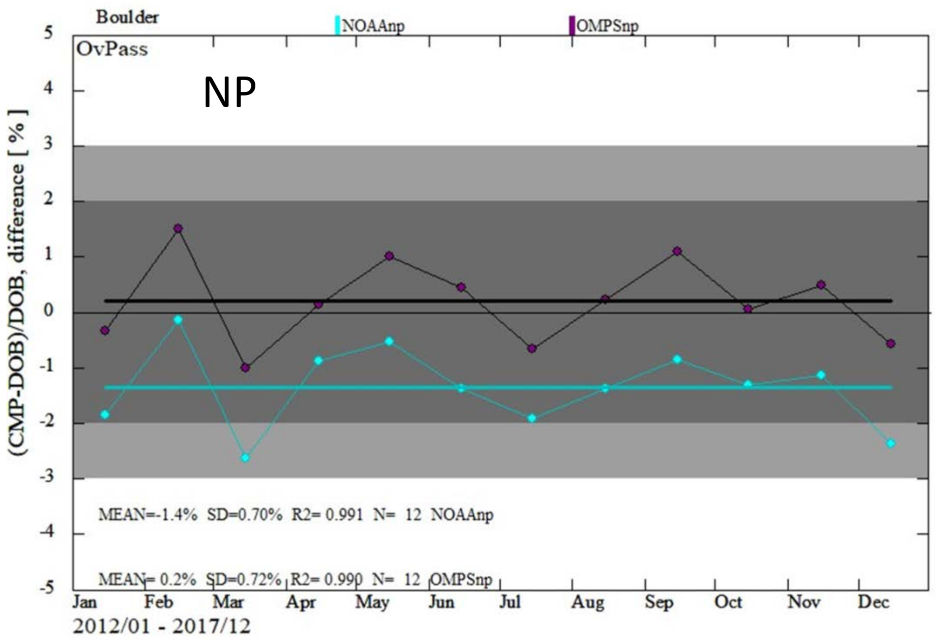
# Total ozone data, Boulder, 2012-2017

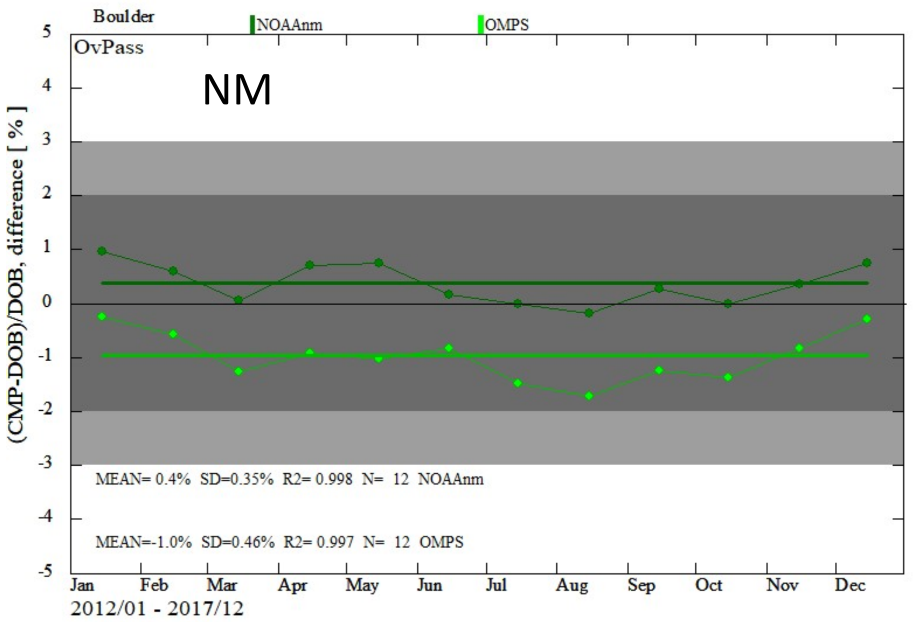
# NOAA (slope=0.95) and NASA (0.93)



# Total ozone data, Boulder, 2012-2017

# NOAA and NASA vs. DB, seasonal av.

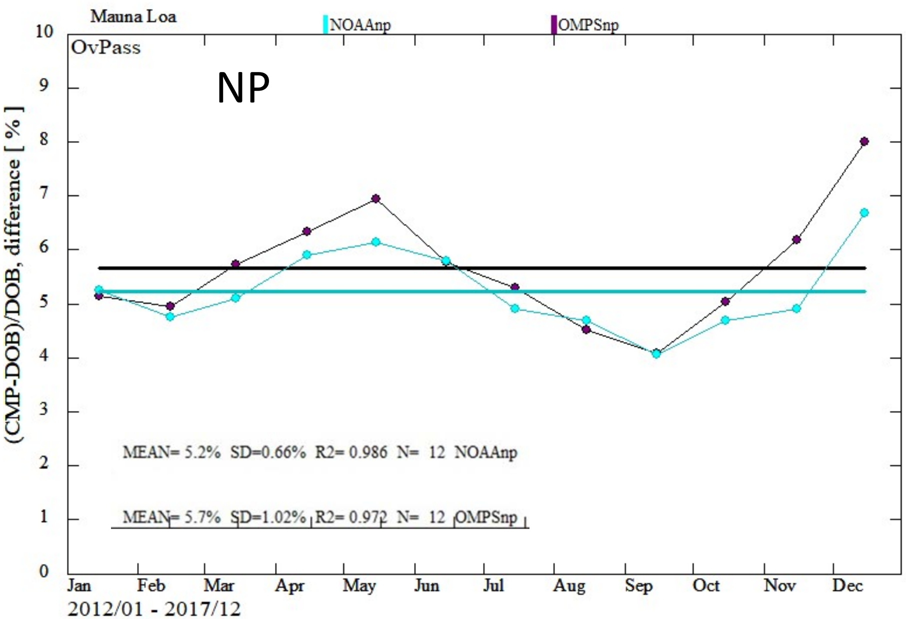


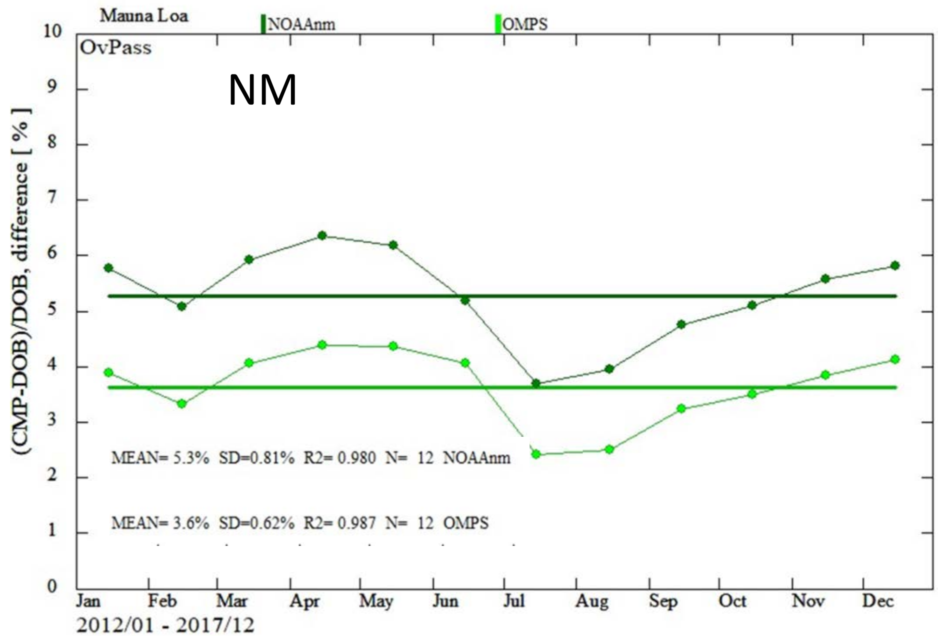




1) OMPS-NP: 2 % bias between NOAA and NASA version, NASA is higher, Dobson TO seasonal bias is corrected by daily GMI/MERRA2 effective temperatures, <250 km matching distance criteria might influence comparisons
2) OMPS-NM : still 2% bias, but it is reverse, NOAA is higher than NASA, smaller deviations

# Total ozone data, MLO, 2012-2017

# NOAA and NASA vs. DB, seasonal av.



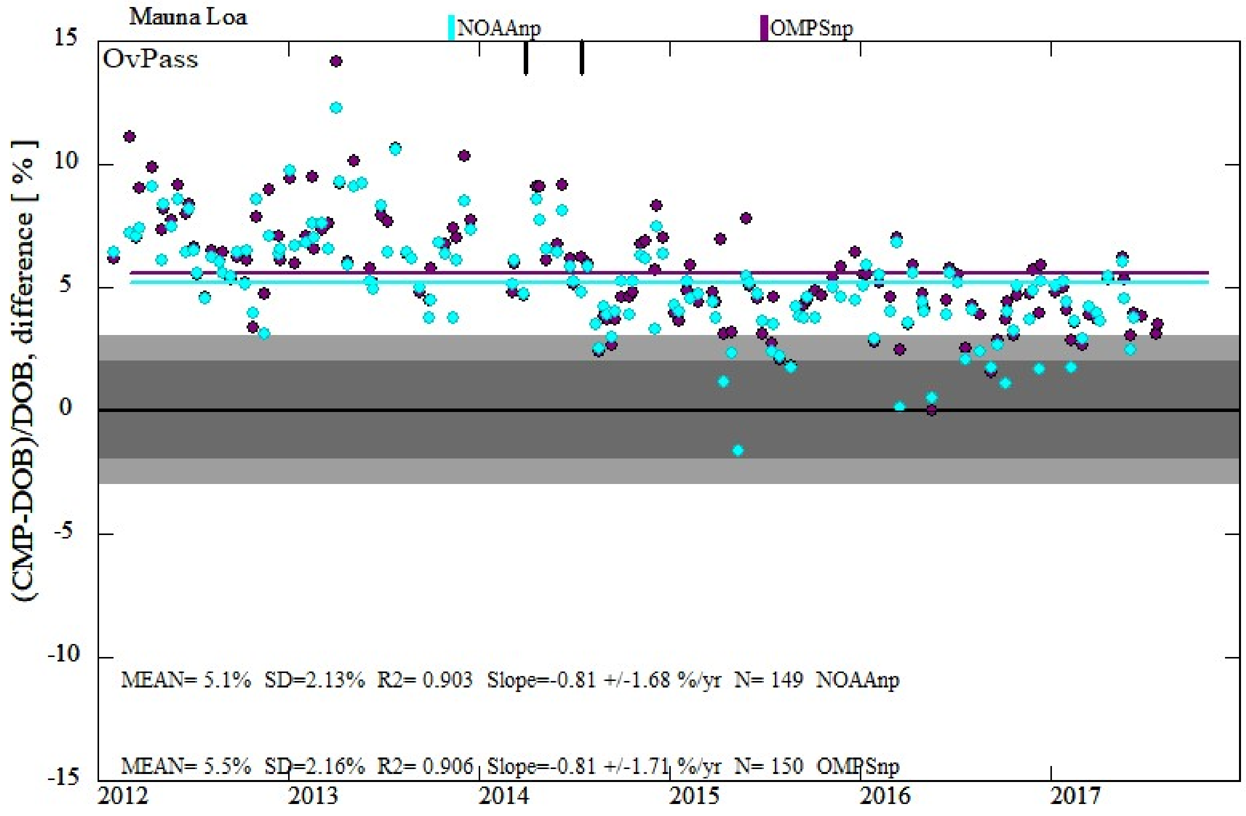




MEAN= 5.3%

MEAN= 3.6%

1) OMPS-NP: 2 % bias between NOAA and NASA version, NASA is higher, Dobson seasonal bias is corrected by daily GMI/MERRA2 effective temperatures, <250 matching distance criteria might influence comparisons
2) OMP-NM : still 2% bias, but it is reverse, NOAA is higher than NASA, smaller deviations

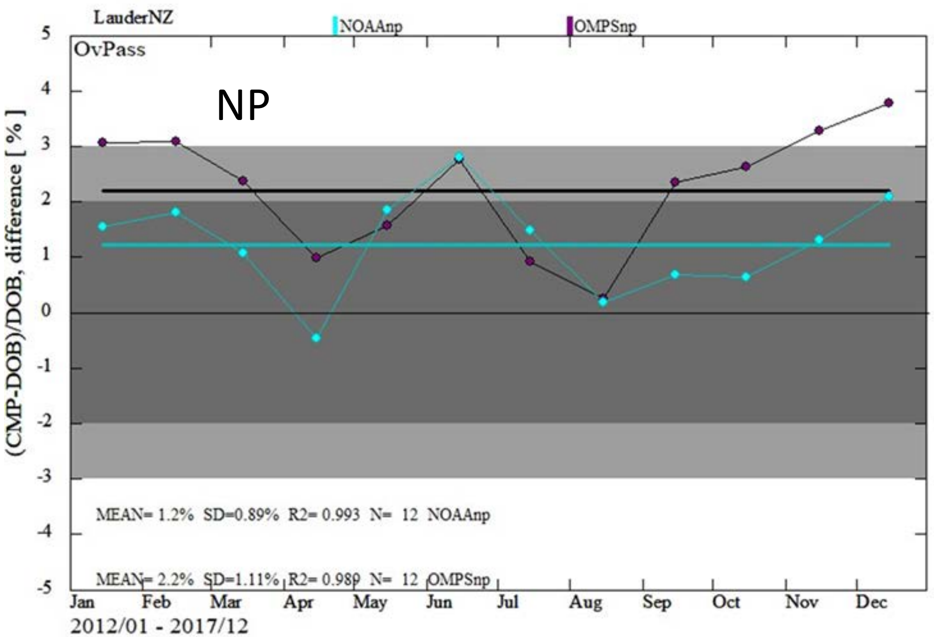
# Total ozone data, MLO, 2012-2017
# NOAA (R2=0.90) and NASA (0.91)

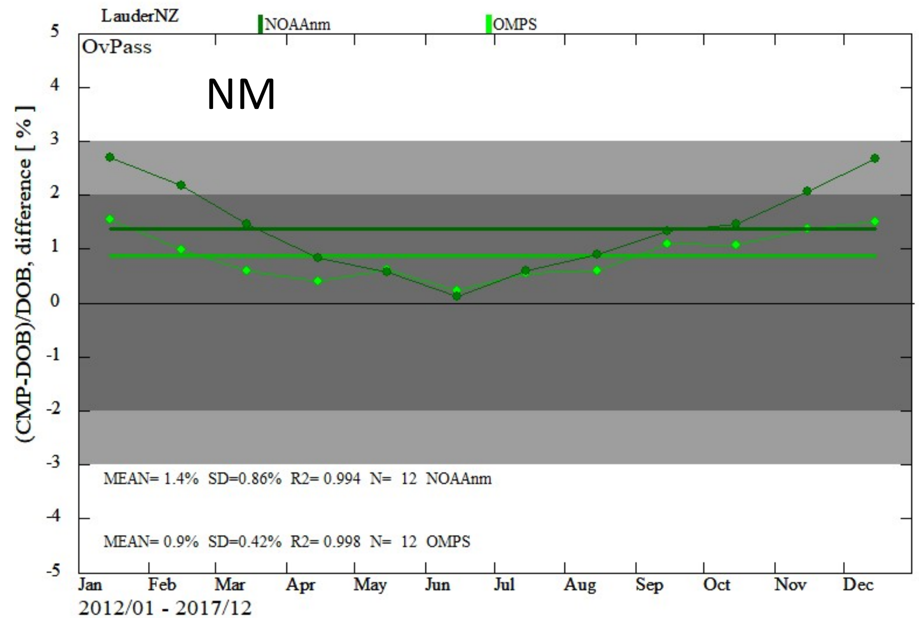



Apparent drift or step change in 2014, determined to be Dobson processing issue, ongoing work to correct for change in Q-table temperature sensitivity

# Total ozone data, Lauder, 2012-2017

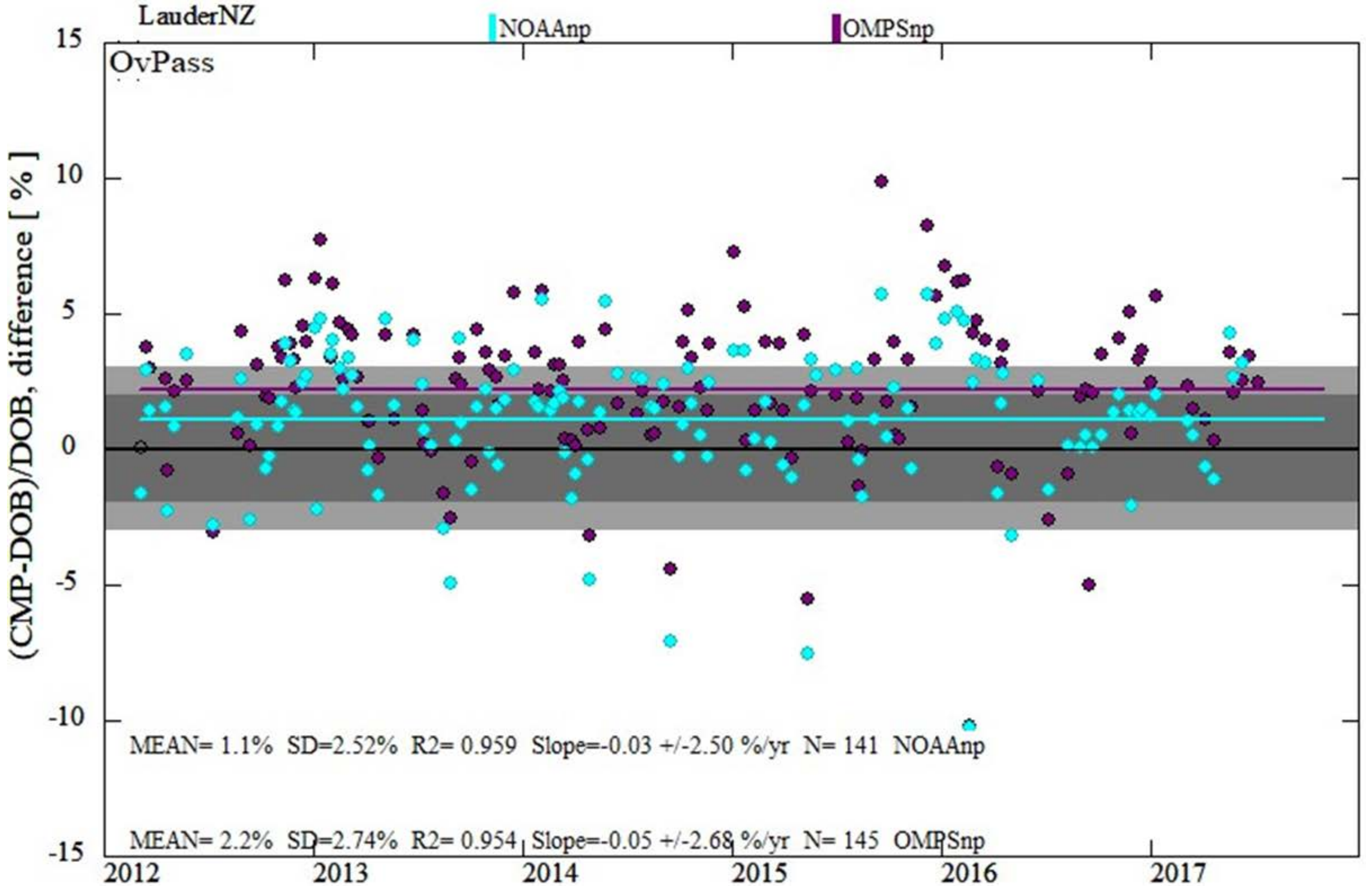
# NOAA and NASA vs. DB, seasonal av.



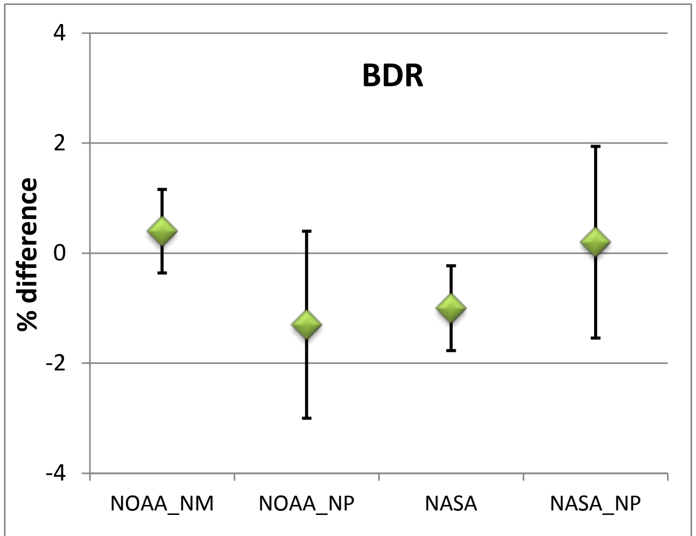

1) OMPS-NP: 1-2 % bias between NOAA and NASA, except in summer, NASA is still higher, bias varies across season
2) OMPS-NM : smaller bias, NOAA is higher than NASA (reversed from NP), smooth seasonal bias

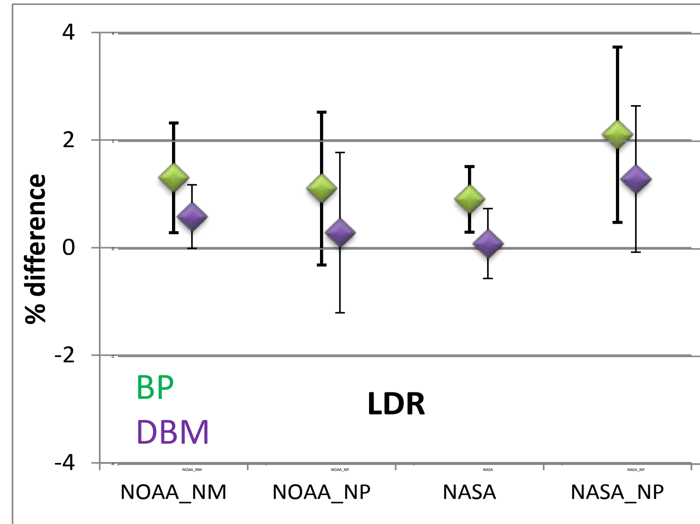
# Total ozone data, Lauder, 2012-2017
# NOAA (R2=0.95) and NASA (0.95)

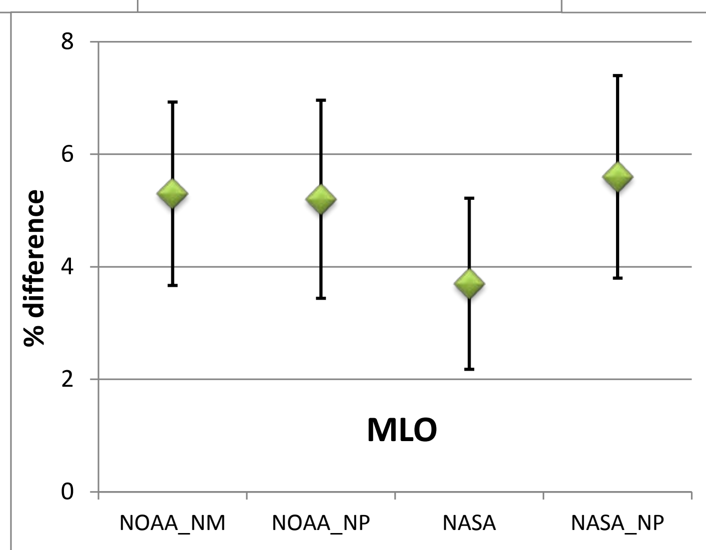



Noise in data comparisons are partially related to ozone spatial variability and the matching criteria to compare station observation with the OMPS overpass.
J1 option for 17x17 km resolution (along orbit) sampling will help to evaluate ozone variability.

# Summary for Boulder, Lauder and MLO. NOAA and NASA OMPS vs Dobson



## Monthly mean O3 pofile Time Series Comparison
## Umkehr , MLS V4.2, SBUV (NASA, aggregated),
## OMPS-NP (NASA V01, NOAA V8)
## MLO, BLD, LDR station

- Distance < 200 km, within +/-24 hours
- AK to MLS is applied
- A new WinDobson processing system was updated on January, 2012
- Reprocessed Total ozone is applied for Umkehr retrievals, AM and PM selected TO (old system used one daily value)
- No stray light correction is applied (provides improvement above 30 hPa, but distortion of profile below)
- Reprocessing of historical Umkehr data from primary R values (removal of old calibration parameters, homogenization)
- Operational Umkehr measurements are evaluated for cloud interference in the field of view

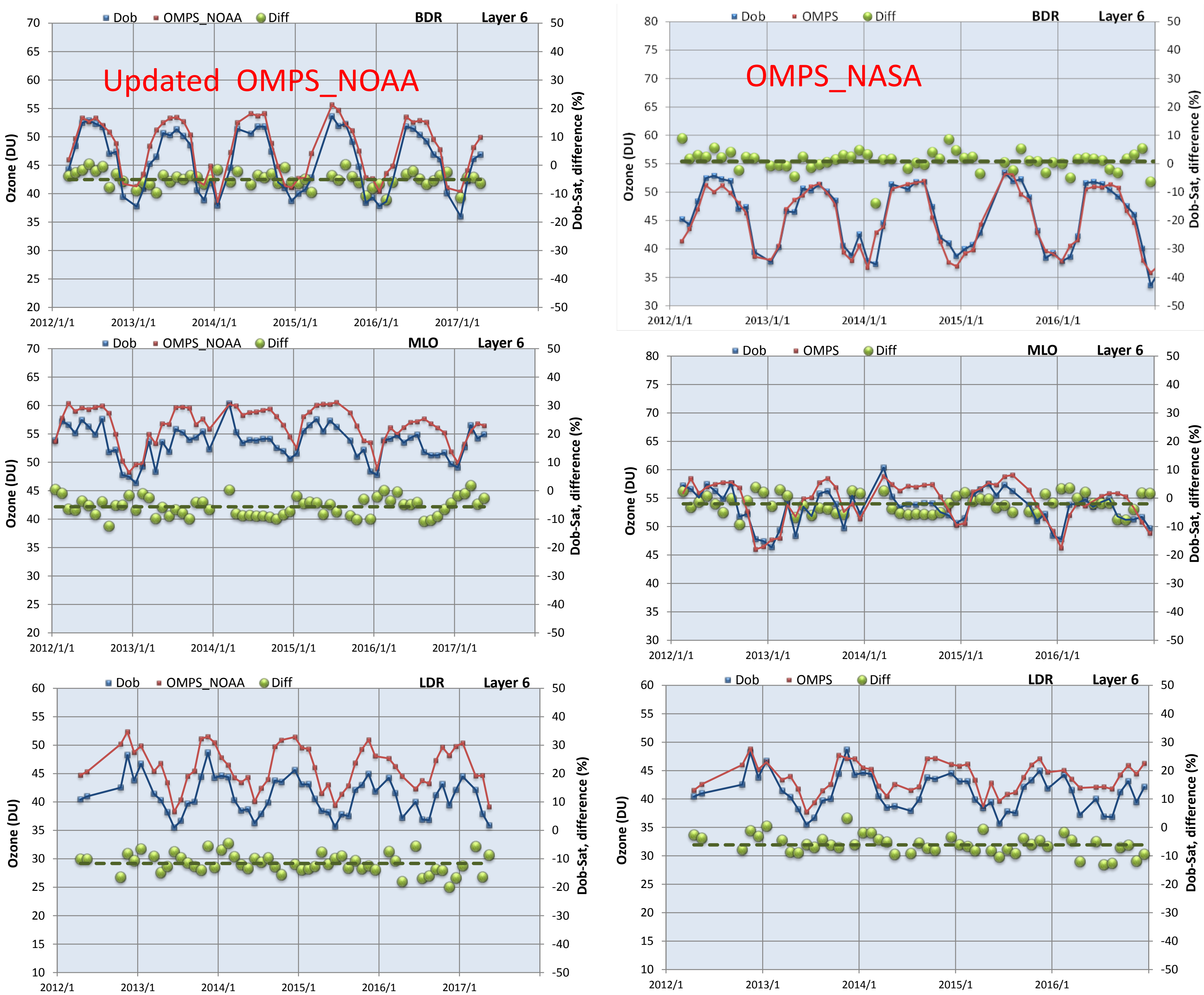
# Ozone profile Datasets

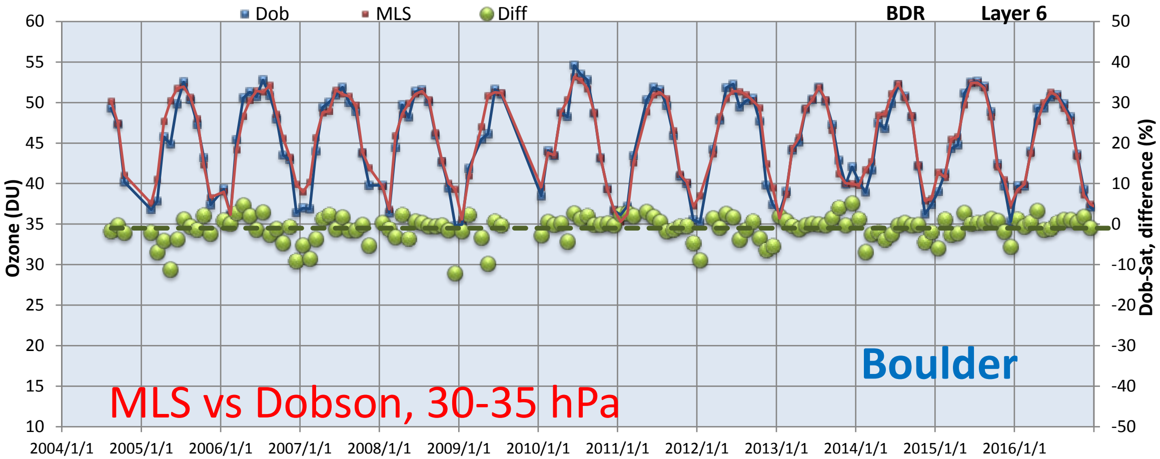
- MLS, V04
- http://avdc.gsfc.nasa.gov/pub/data/satellite/Aura/MLS/V04/L2GPOVP/O3/

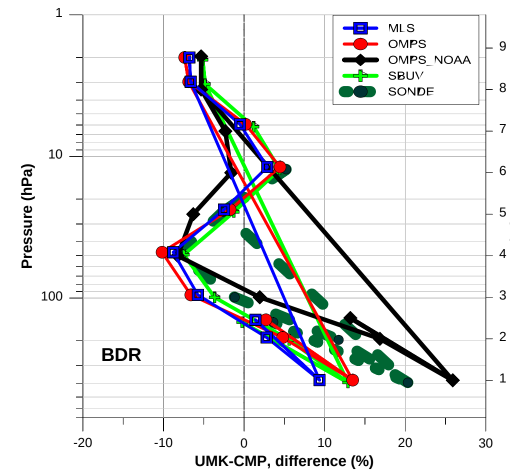
- OMPS –NP, V01 (NASA)
- http://avdc.gsfc.nasa.gov/pub/data/satellite/Suomi_NPP/L2OVP/NP_DAILYO3/du/

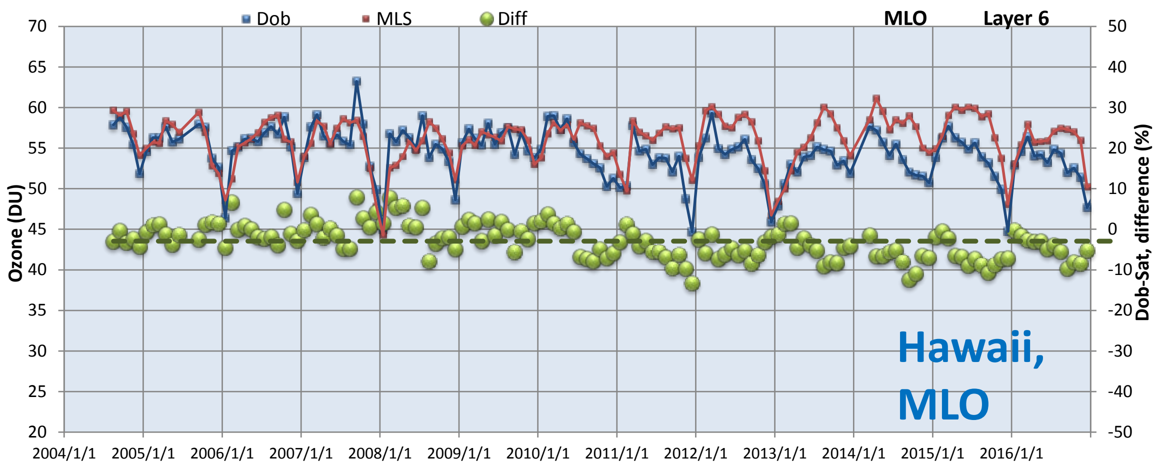
- SBUV (NASA) used 16 layers (aggregated)
- jwocky.gsfc.nasa.gov/pub/sbuv/aggregated

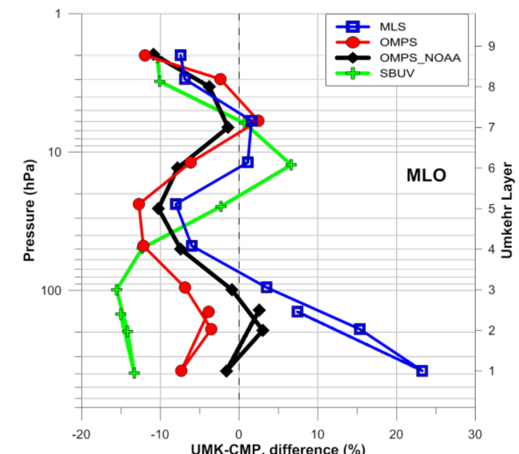
- OMPS-NP (NOAA), V8
- /pub/smcd/spb/ozone/irina/NPP/NP/V8/reproc_jun_2017

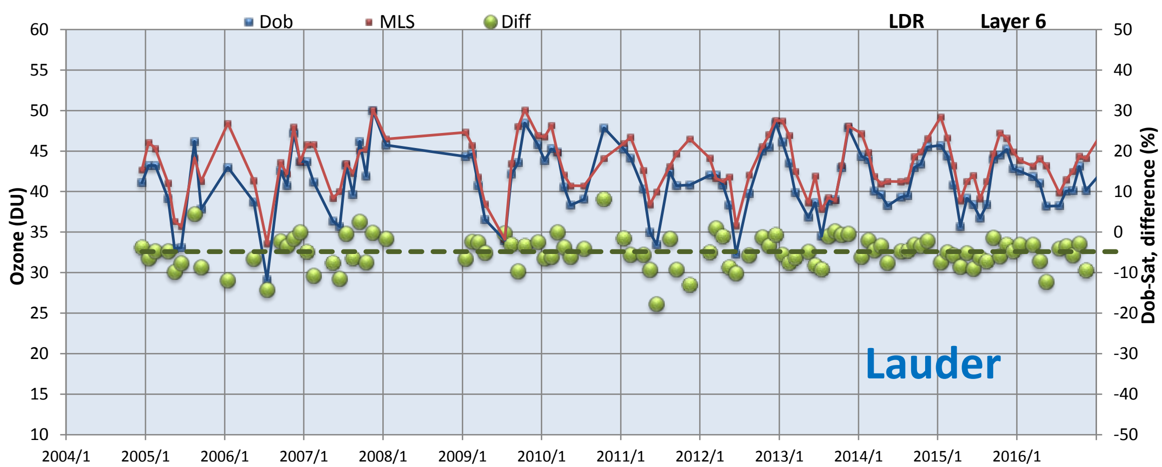

Updated OMPS_NOAA
OMPS_NASA
Dob
OMPS_NOAA
OMPS
Diff
BDR
MLO
LDR
Layer 6
Ozone (DU)
Dob-Sat, difference (%)
2012/1/1
2013/1/1
2014/1/1
2015/1/1
2016/1/1
2017/1/1
2012/1
2013/1
2014/1
2015/1
2016/1
2017/1

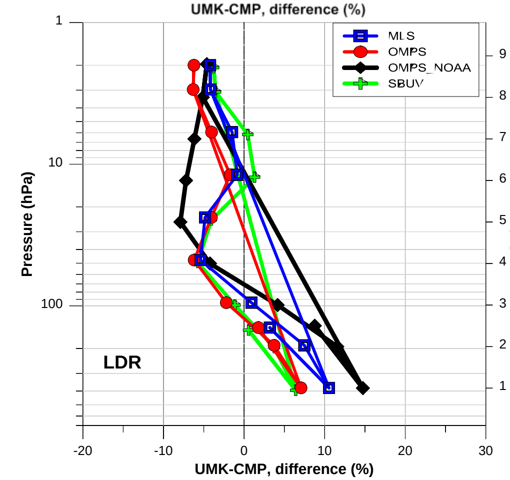

Dob
MLS
Diff
BDR
Layer 6
Boulder
MLS vs Dobson, 30-35 hPa
Ozone (DU)
Dob-Sat, difference (%)


MLS
OMPS
OMPS_NOAA
SBUV
SONDE
BDR
Pressure (hPa)
Umkehr Layer
UMK-CMP, difference (%)


Dob
MLS
Diff
MLO
Layer 6
Hawaii,
MLO
Ozone (DU)
Dob-Sat, difference (%)

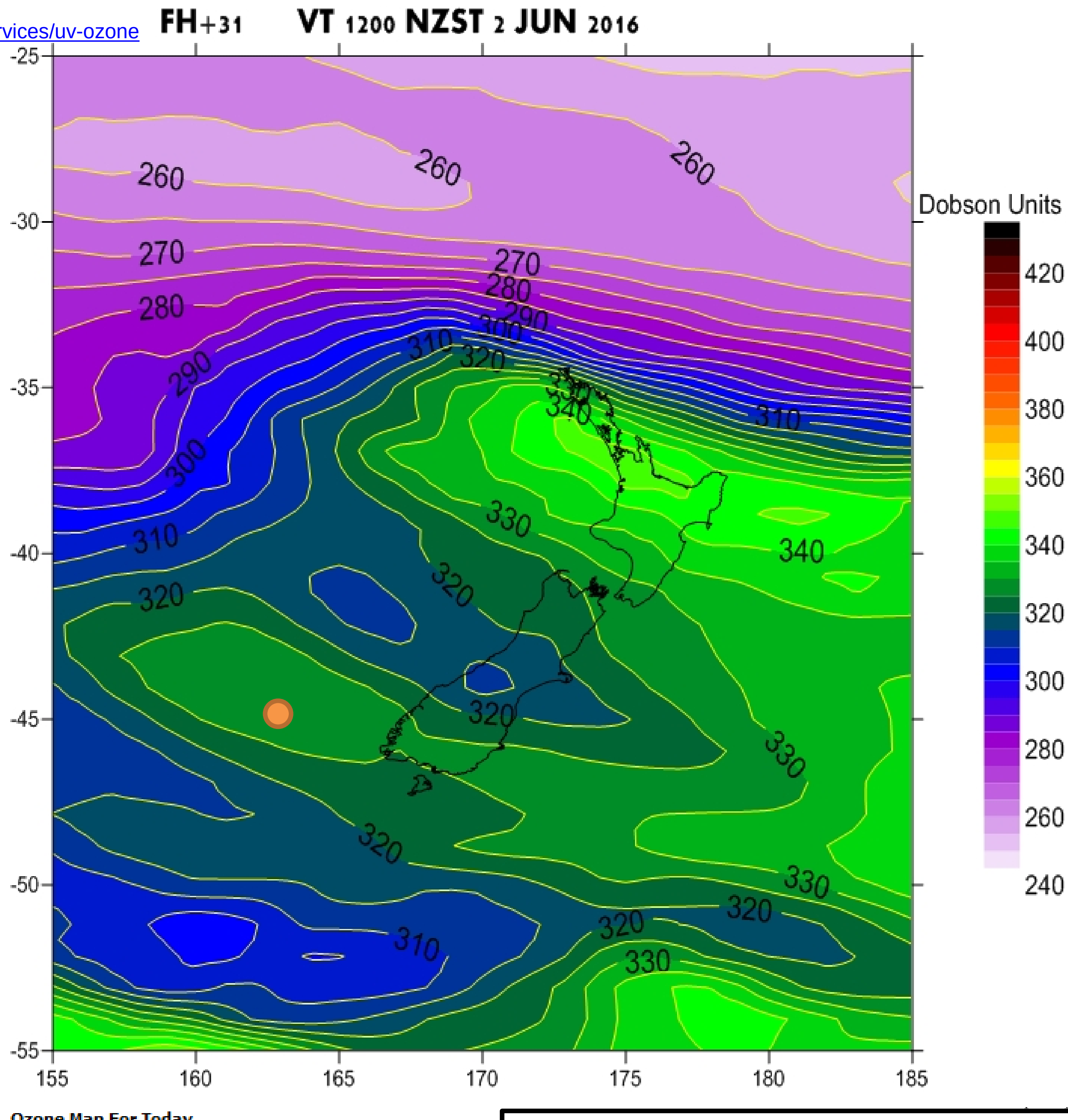

MLS
OMPS
OMPS_NOAA
SBUV
MLO
Pressure (hPa)
Umkehr Layer
UMK-CMP, difference (%)


Dob
MLS
Diff
LDR
Layer 6
Lauder
Ozone (DU)
Dob-Sat, difference (%)


MLS
OMPS
OMPS_NOAA
SBUV
LDR
Pressure (hPa)
Umkehr Layer
UMK-CMP, difference (%)

https://www.niwa.co.nz/our-services/online-services/uv-ozone

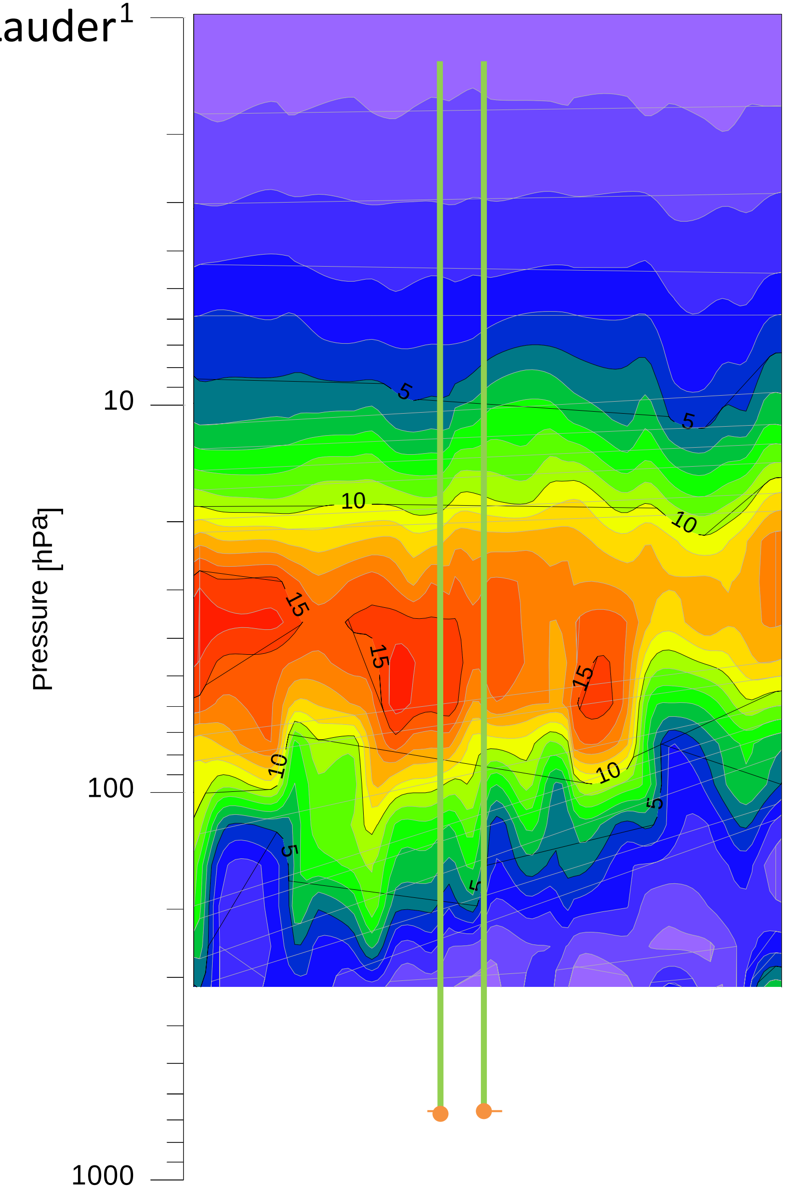
Lauder June 2, 2016



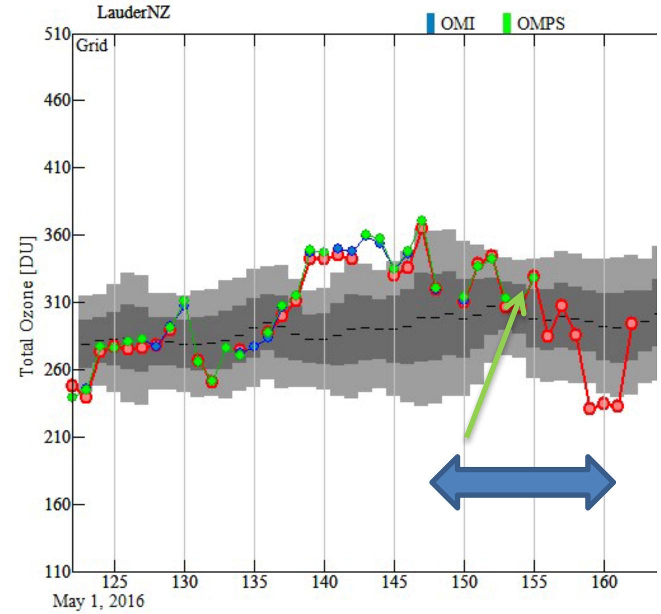

https://www.niwa.co.nz/our-services/online-services/uv-ozone

**New Zealand ozone maps for noon (12:00NZST, 0:00GMT)**

# MLS over Lauder[1]

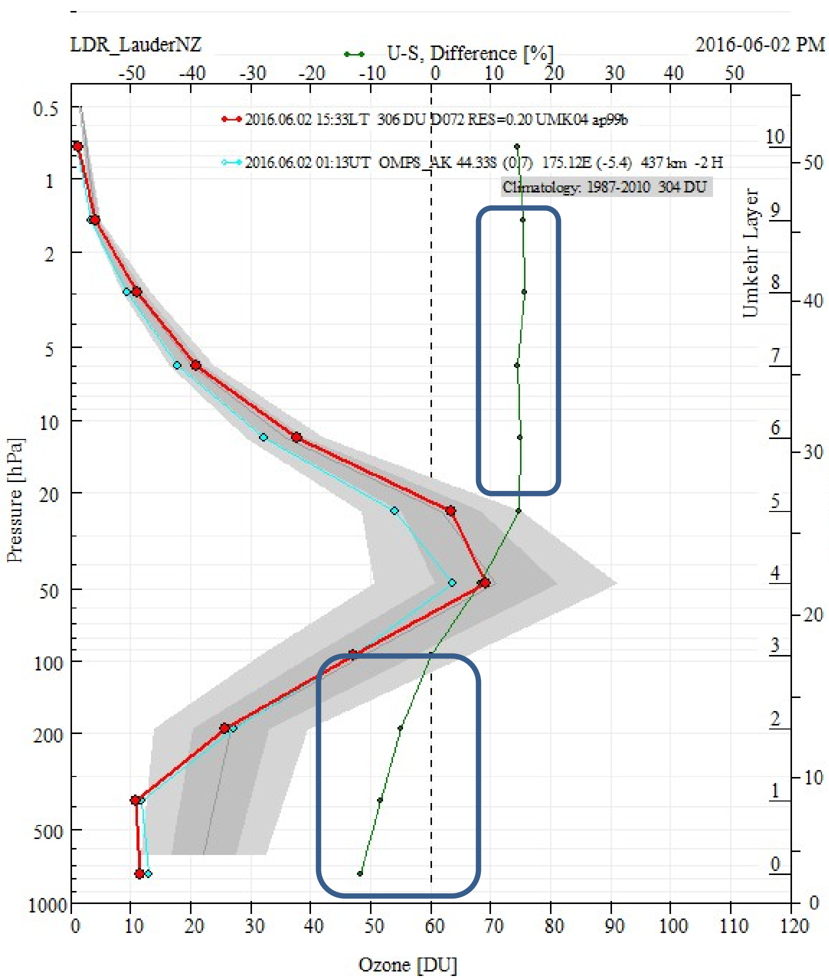



Umkehr AM PM

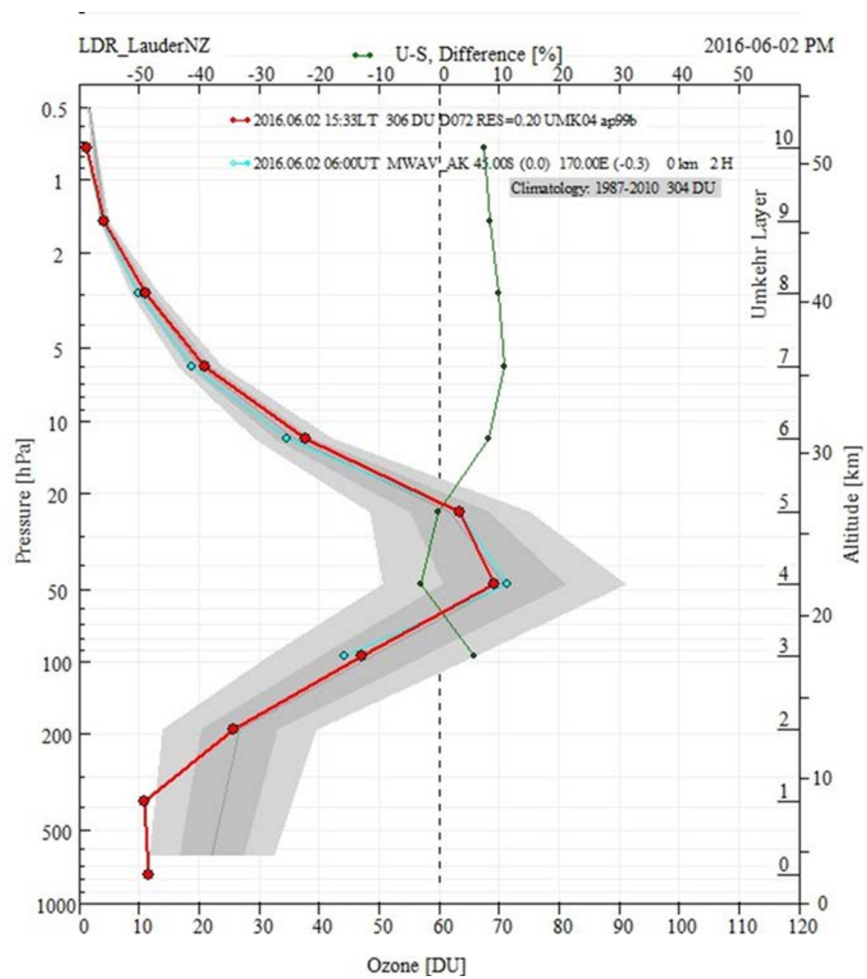


# Case study: Lauder, June 2, 2016
# Umkehr vs OMPS-LP V2 and NIWA Microwave

OMPS_LP V2, Dis= 437 km, dT = -2 hrs

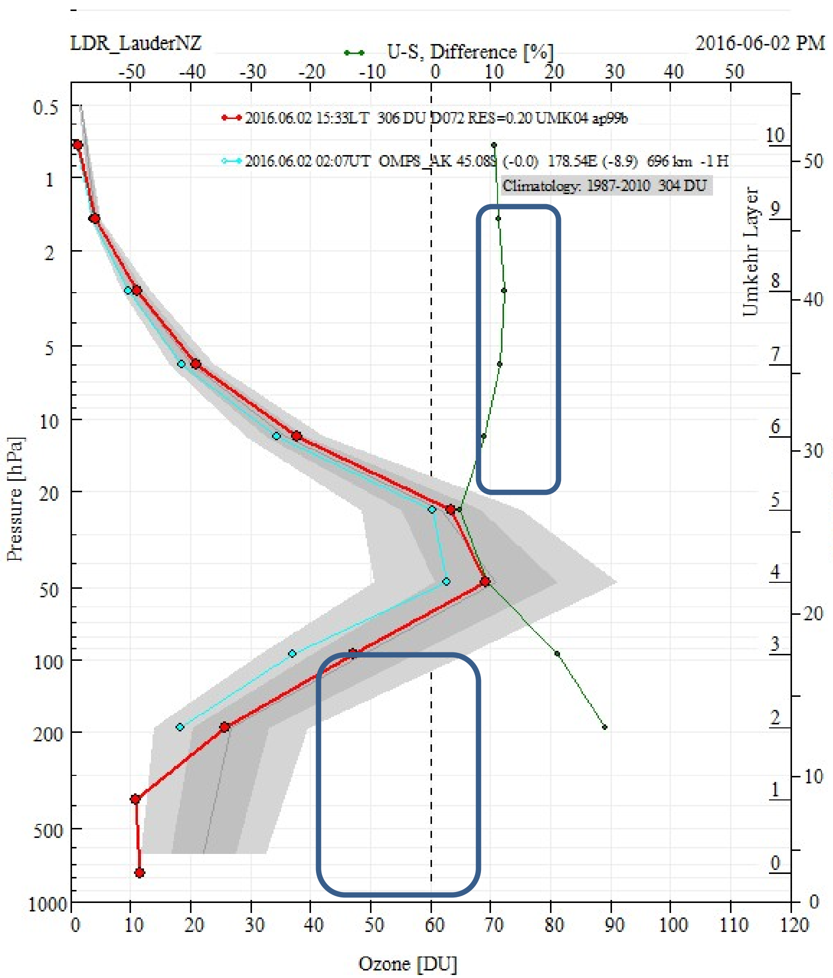



MW, Dis= 0 km, dT = 2 hrs

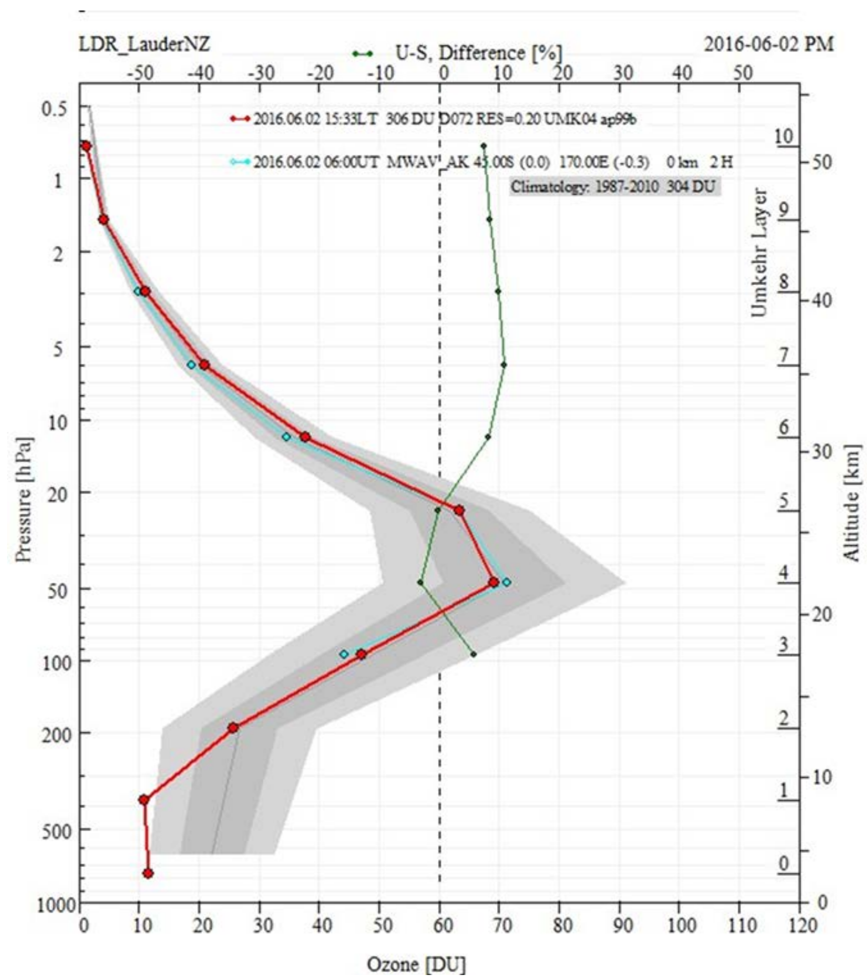


# Case study: Lauder, June 2, 2016
# Umkehr OMPS-LP V2.5  and NIWA Microwave

OMPS_LP V2.5, Dis= 696 km, dT = -1 hrs

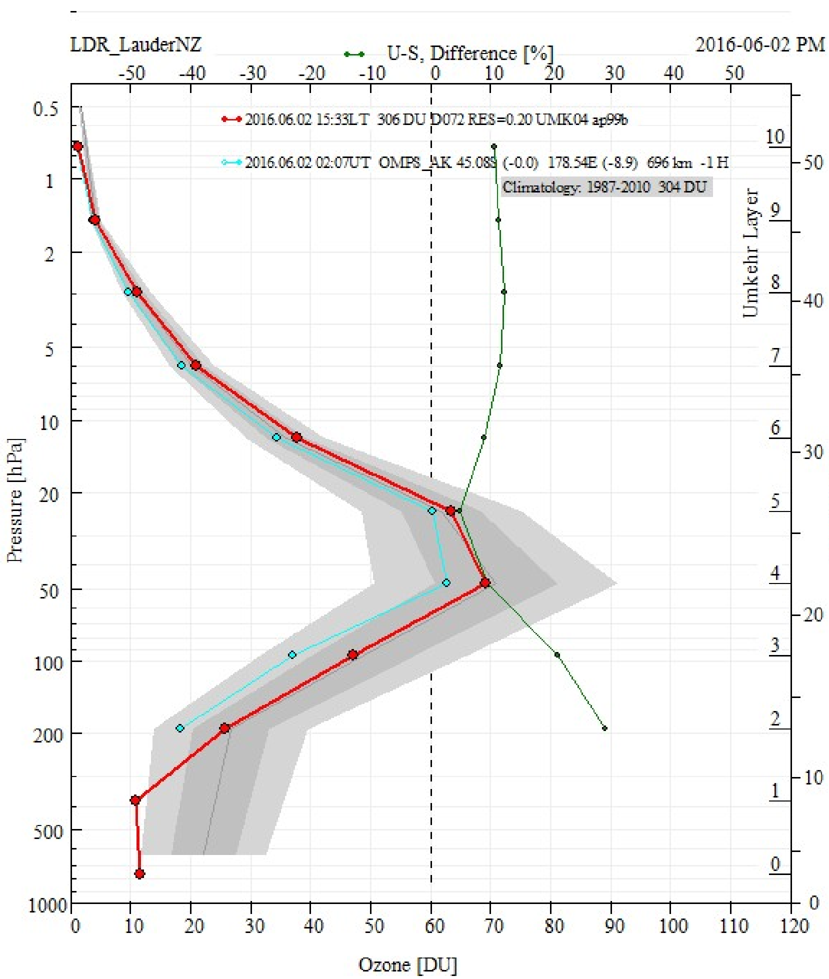



MW, Dis= 0 km, dT = 2 hrs

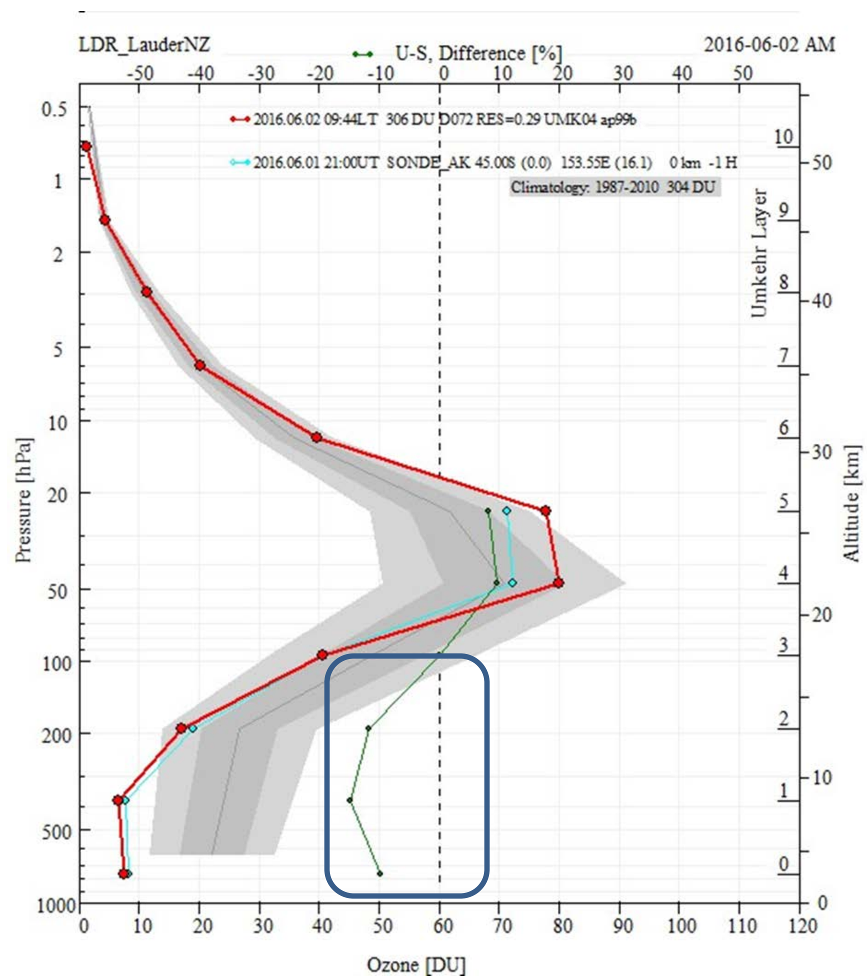


# Case study: Lauder, June 2, 2016
# Umkehr OMPS-LP V2.5 and NIWA Microwave

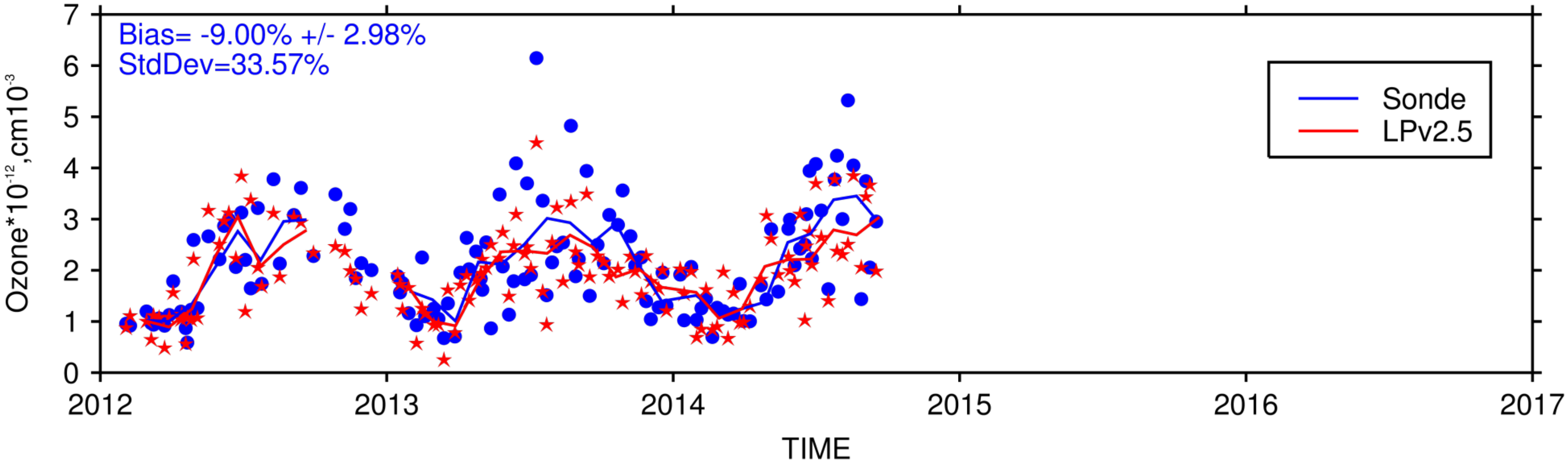
OMPS_LP V2.5, Dis= 696 km, dT = -1 hrs



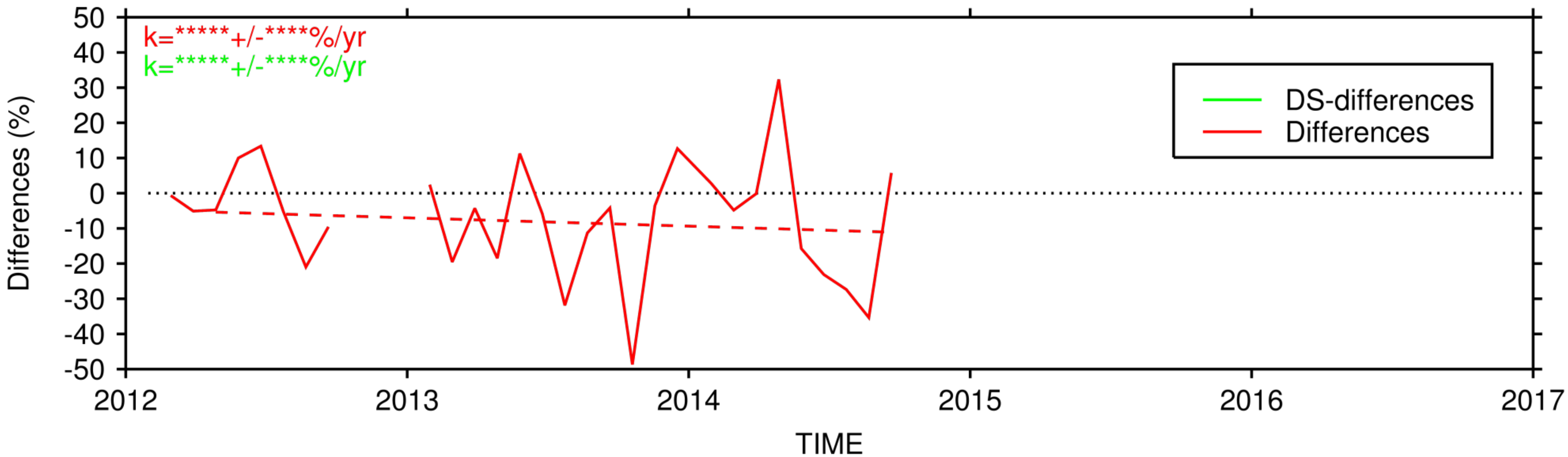

Ozone sond, Dis= 0 km, dT = -1 hrs



Ozone nd, altitude 16.5km, Slit center, lauder, [45S,169E]




Differences with Sonde (%), altitude 16.5km, lauder, [45S,169E]



# Conclusions

- TO and ozone profiles from OMPS NM and NP, V8 appear to be stable over 2012-2017 time period over Boulder, MLO, and Lauder
- TO from NOAA and NASA processing of the OMPS NM show bias over Boulder and MLO, but not over Lauder.
- TO from NM and NP also show bias, station dependent
- Umkehr stray light correction distorts the lower potion of the profile, although it reduces bias above 16 hPa – further work is needed
- MLO Dobson record before 2014 needs further adjustment to account for change in the instrument temperature sensitivity
- Spatial and temporal matching in troposphere is important when comparing profile to profile – looking forward to J-1 OMPS-NM with 17x17 km resolution data along the track to detect ozone field inhomogeneity

# OMPS Ozone Product Utilization @NCEP

**Craig Long and Jeannette Wild***

*NOAA/NWS/NCEP/*

*Climate Prediction Center*

**Innovim*

*JPSS Annual Meeting – August 16, 2017 – NCWCP College Park, MD*

# Uses of OMPS Products

- **NCEP Operations:**
  - V8TOZ Total column ozone mapper product to replace Aura/OMI mapper
  - V8PRO nadir ozone profiles to be added to N-19 SBUV/2 profiles
- **CPC monitoring**
  - V8TOZ will replace OOTCO mapper total column ozone
  - V8PRO will replace V6PRO ozone profiles

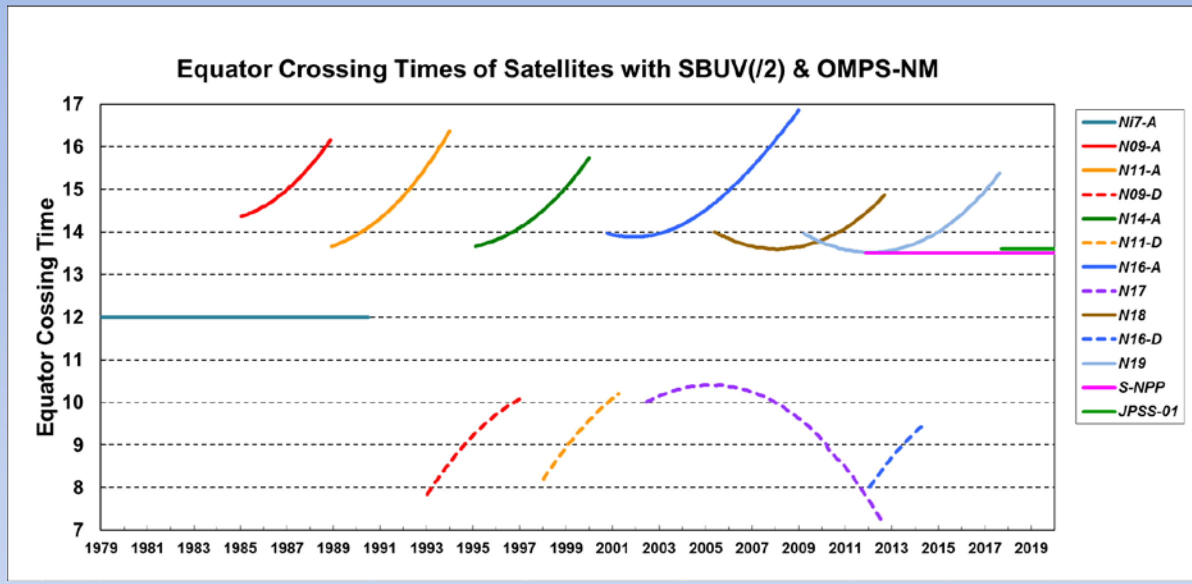
# NCEP Operations

- V8TOZ and V8PRO BUFR test files have been delivered to NCEP
- NCEP has verified the file contents and generated internal BUFR files for operations.
- ***Would like*** to get latest (final) versions so internal evaluation can be started
- ***Would like*** to get OMPS ozone products operationally assimilated in 2018Q1 data set update to GFS model.

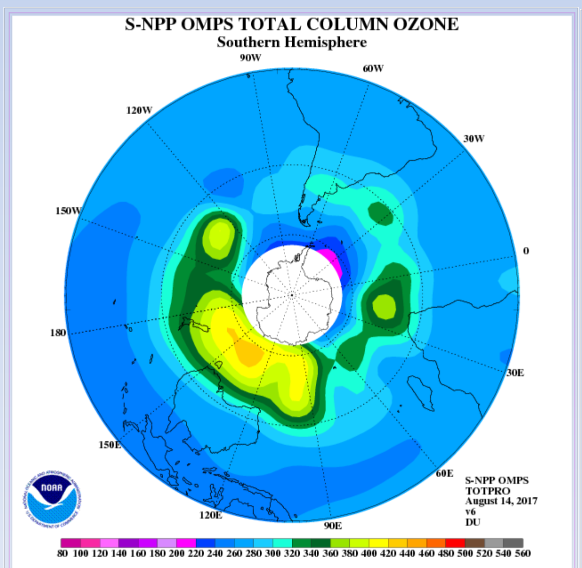
# CPC Monitoring

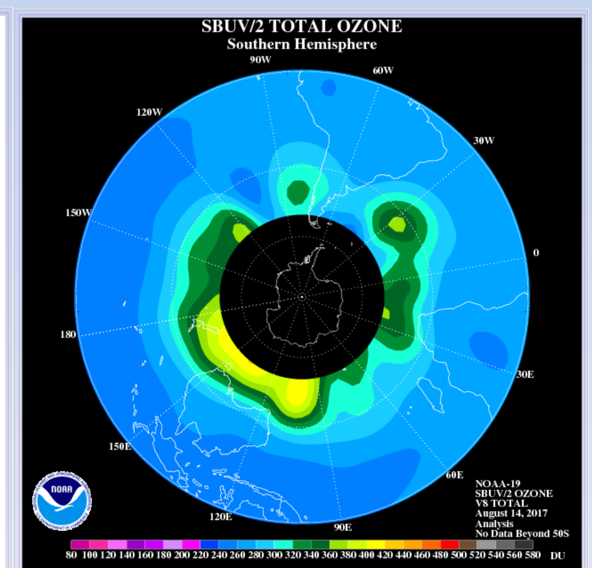
- Thanks to Lihang for supporting CPC monitoring/evaluation activities.
- Have been using v6 ozone profile and OOTCO mapper products for several years.
- Have noted differences between the v6 and SBUV/2 v8 profiles
- Use profile O3MR and total profile to generate global ozone analyses
- Use total column mapper to generate global Level 3 products
- Use the above to determine ozone hole size
- Part of CPC's suite of ozone hole monitoring products
- Eric has provided 2012-2017 data set of V8PRO and V8TOZ products
- CPC will use these products to extend its long term TOZ and profile data sets
  - Replace several years of N19 SBUV/2 due to poor latitudinal coverage.
  - Used for monitoring ozone recovery and climate change impacts in the vertical
  - QBO effects on ozone amounts, residual circulation
  - Participate in SPARC ozone trend and accuracy initiatives

# NOAA-19 Precession



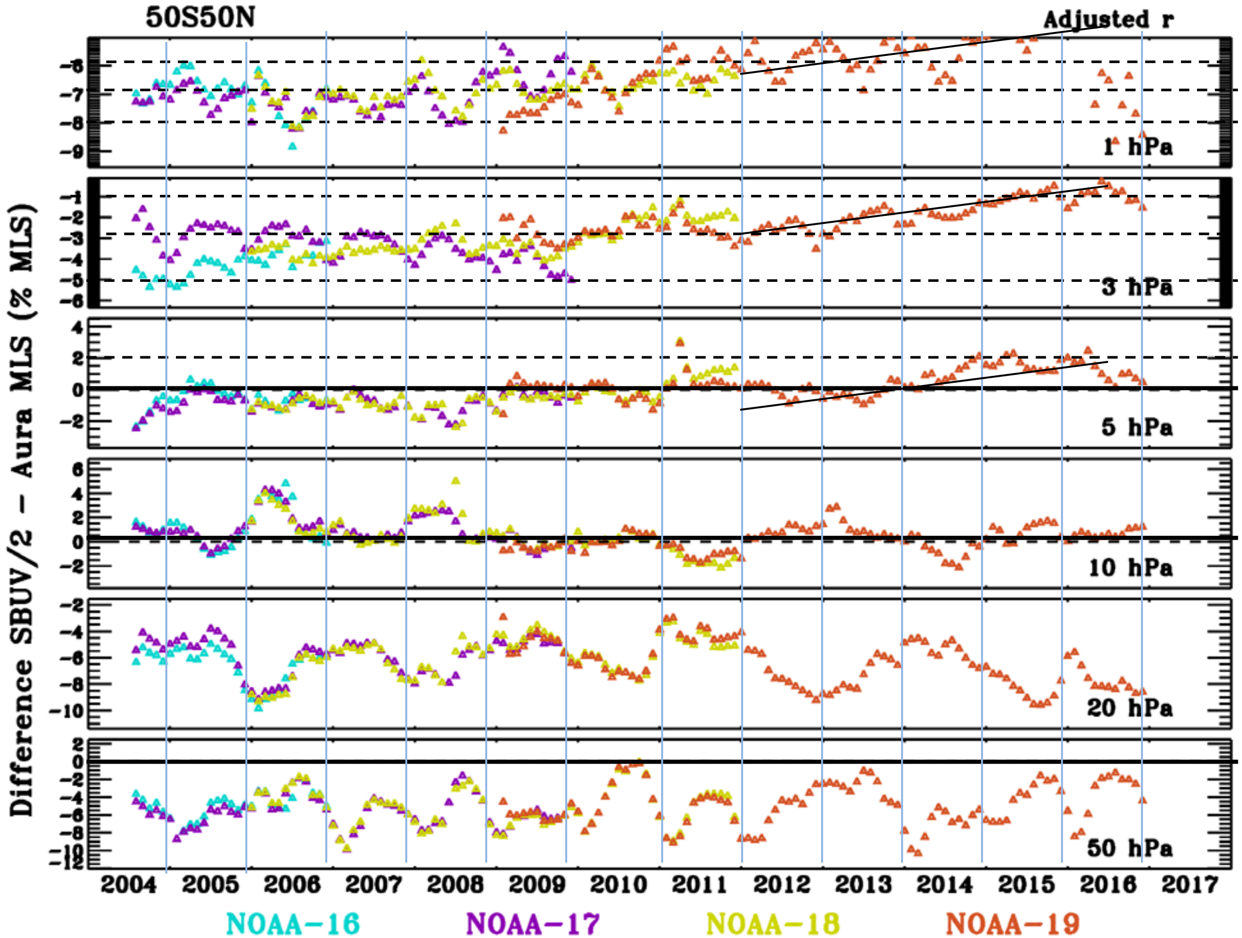

OMPS latitude extent is currently 65S




No observations poleward of 50S

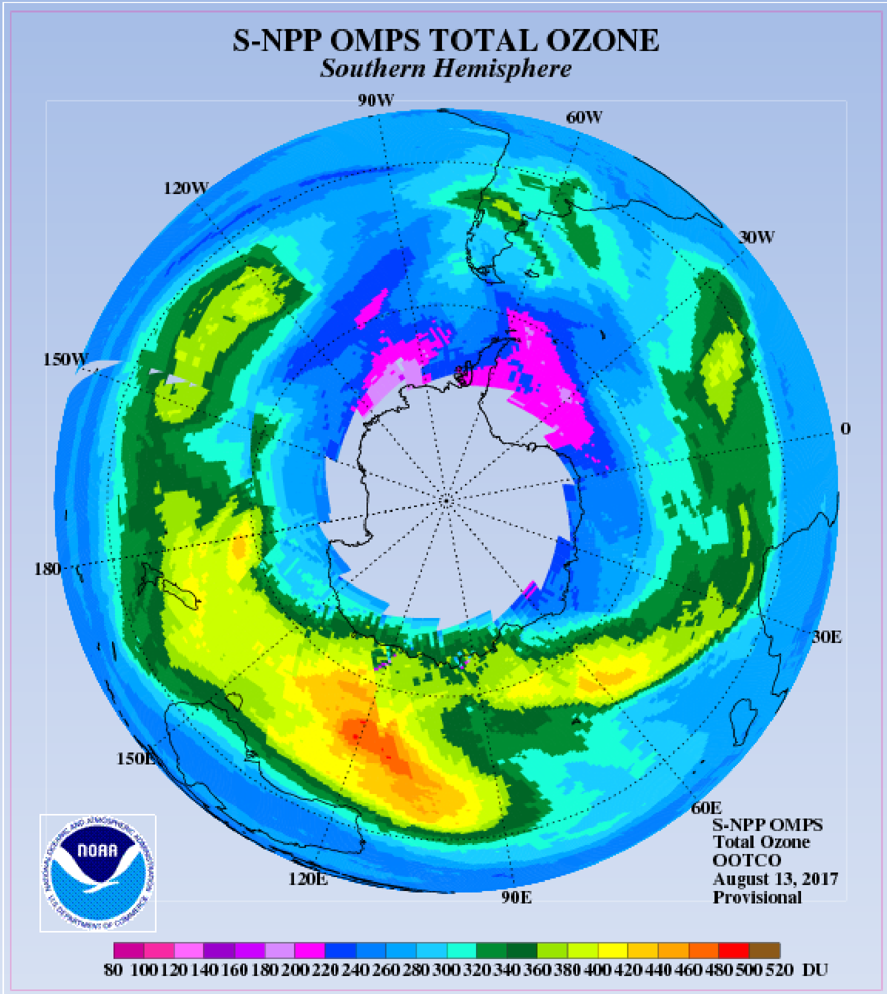
# N19 Precession Impacts on Comparing SBUV/2 with MLS

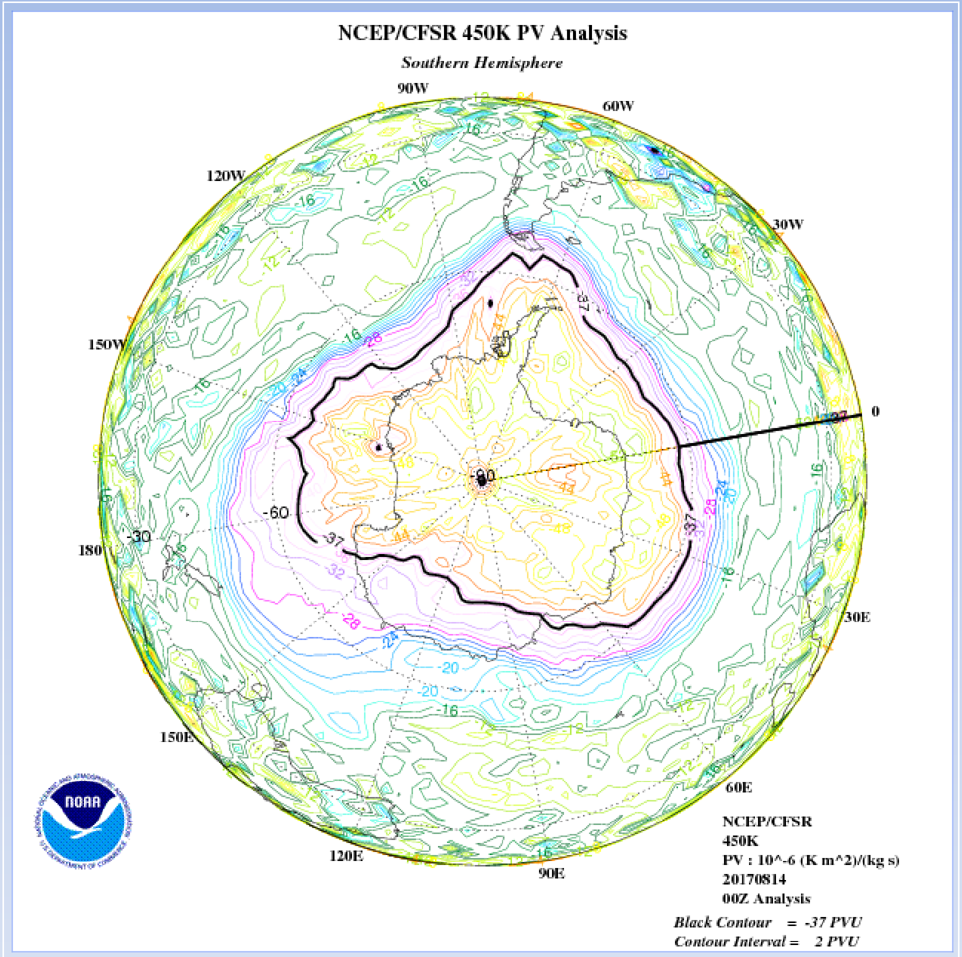



*Ozone diurnal cycle is larger in the upper strat than middle and lower strat*

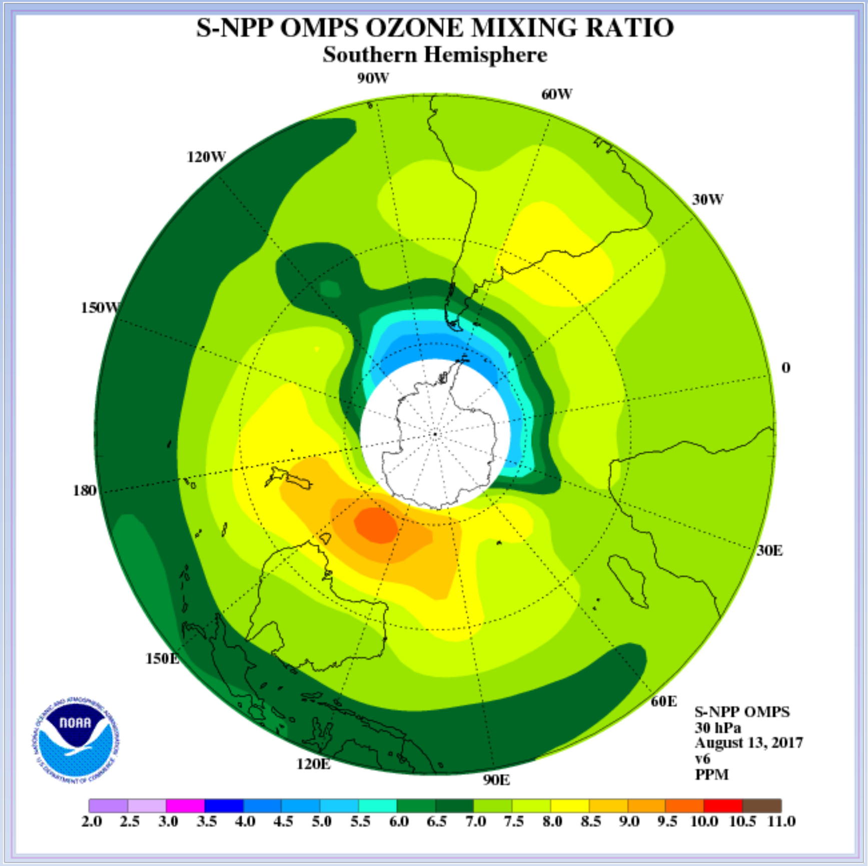
*N19 SBUV/2 upper strat differences with MLS are changing due to orbital drift to later Eq times.*

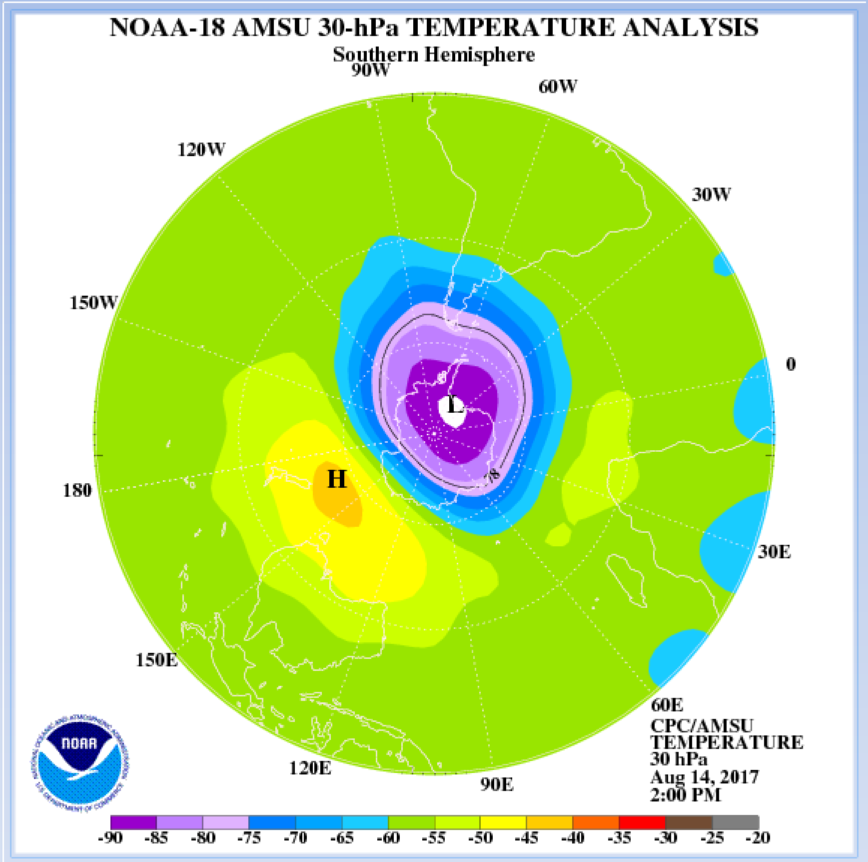
# Ozone Depletion Has Started this Year



# Ozone Depletion Has Started this Year



*See you next year with J-01 OMPS evaluation*

# STAR JPSS 2017 Annual Science Team Meeting

## OMPS Product Demonstration Site

### (OMPS Product Monitoring at the ICVS)

Eric Beach, IMSG@NOAA/STAR

Aug. 16, 2017

# OMPS Product Demo Site URL:

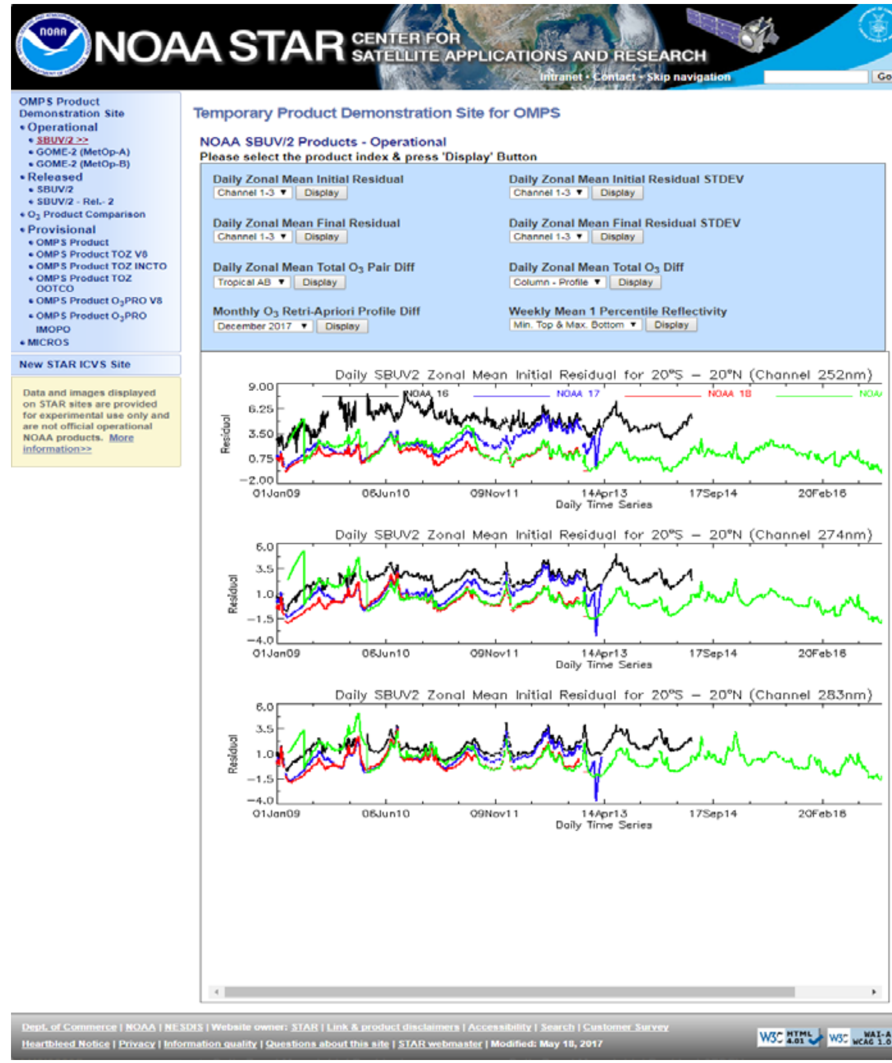
http://www.star.nesdis.noaa.gov/icvs/prodDemos/index.php

General Characteristics of site:

- Depicts performance of products from OMPS, GOME-2 and SBUV/2 measurements
- 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 in process of being redesigned and relocated

# SBUV/2 V8 Operational Performance

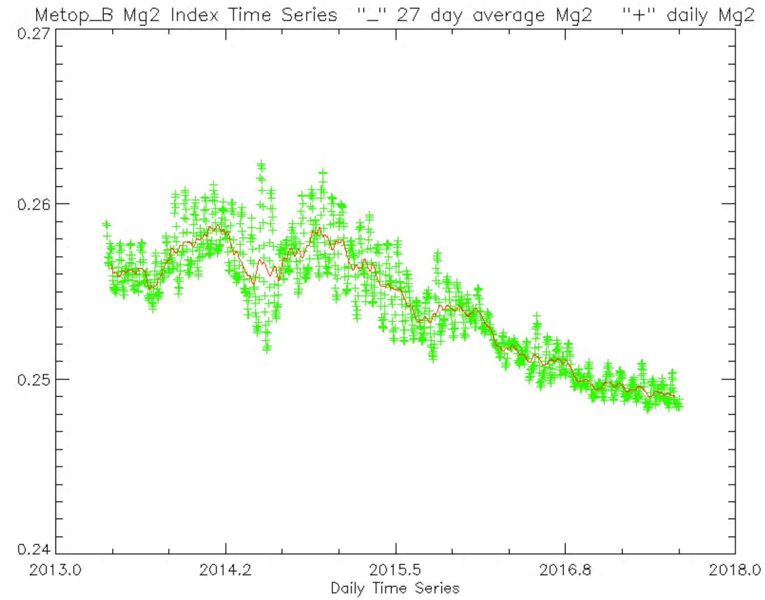
- SBUV/2 data products are monitored long term
- Parameters plotted include:
  - Daily zonal mean initial/final residual
  - Daily zonal mean initial/final residual standard deviation
  - Daily zonal mean total ozone pair difference
  - Monthly ozone retrieved a priori profile difference
  - Weekly mean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

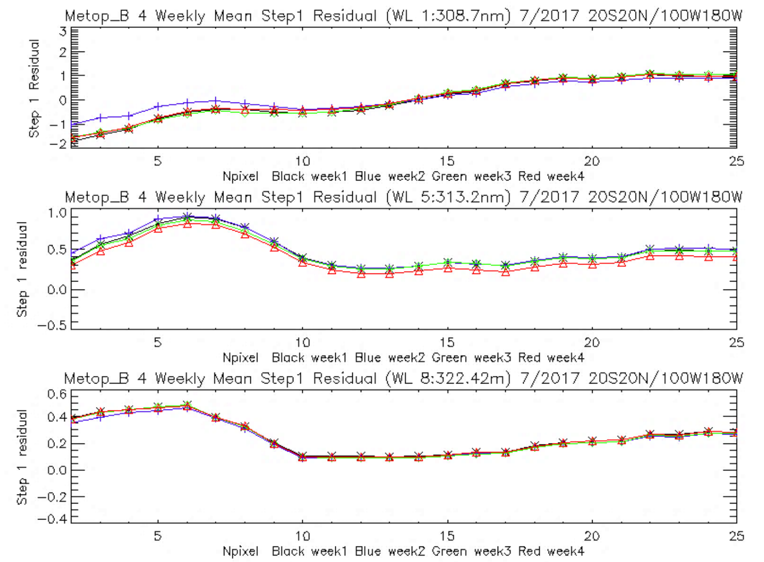


# GOME-2 V8 (Metop A/B)

Parameters plotted include:

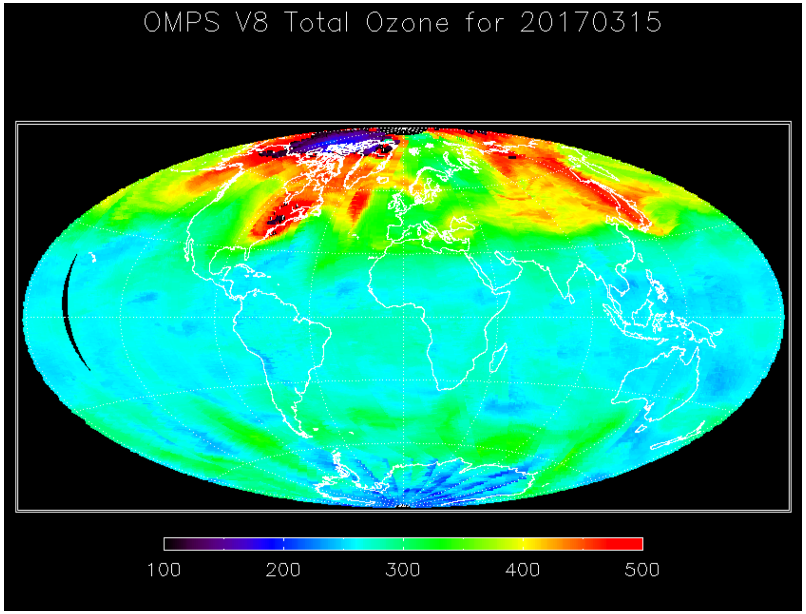
- Mg-II index
- Daily zonal mean total ozone, aerosol index, reflectivity, step 1 residual
- 4-Weekly mean total ozone, reflectivity, aerosol index, step 1 residual versus cross-track

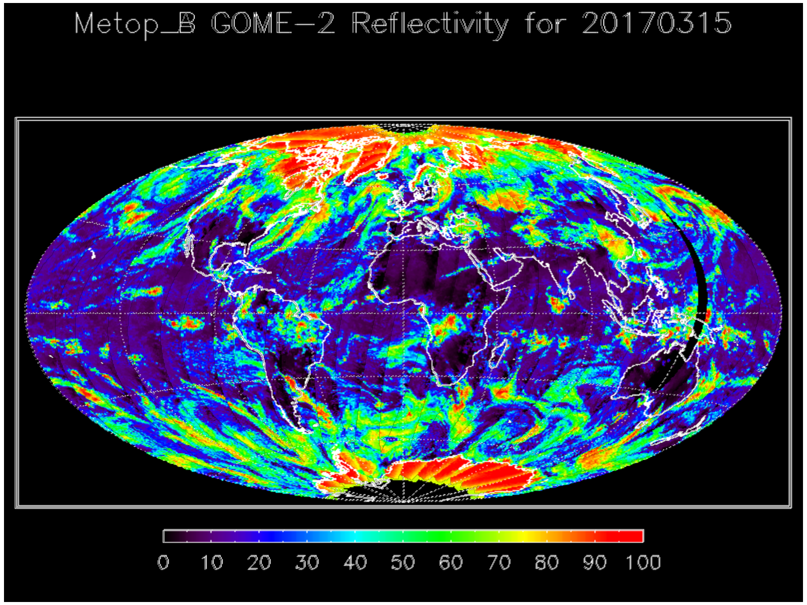


# V8 OMPS, GOME-2, and OMI Maps

- Daily "postage stamp" images depicting total ozone, reflectivity, and aerosol index
- OMPS V8TOz, INCTO*, OOTCO*, METOP A/B GOME-2, and OMI products are available



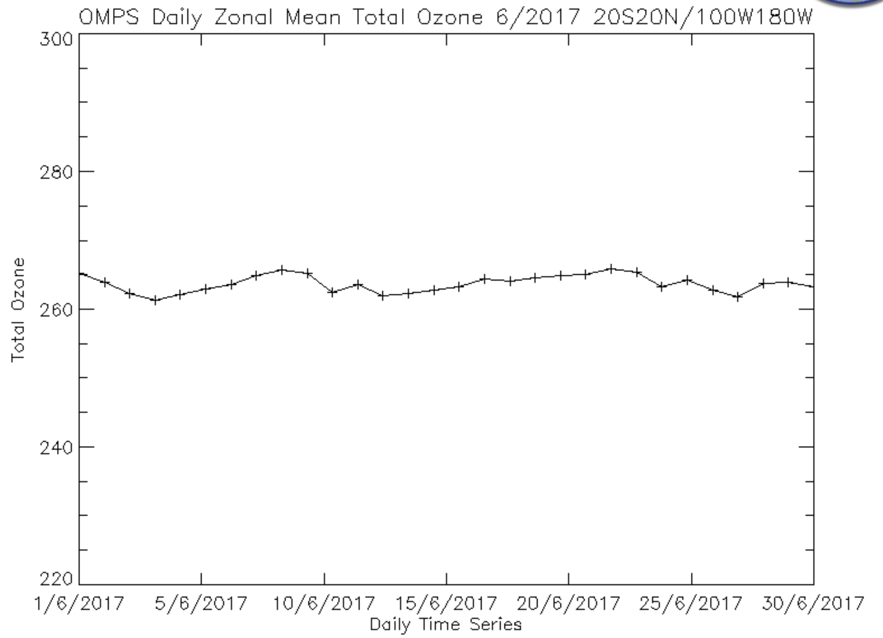



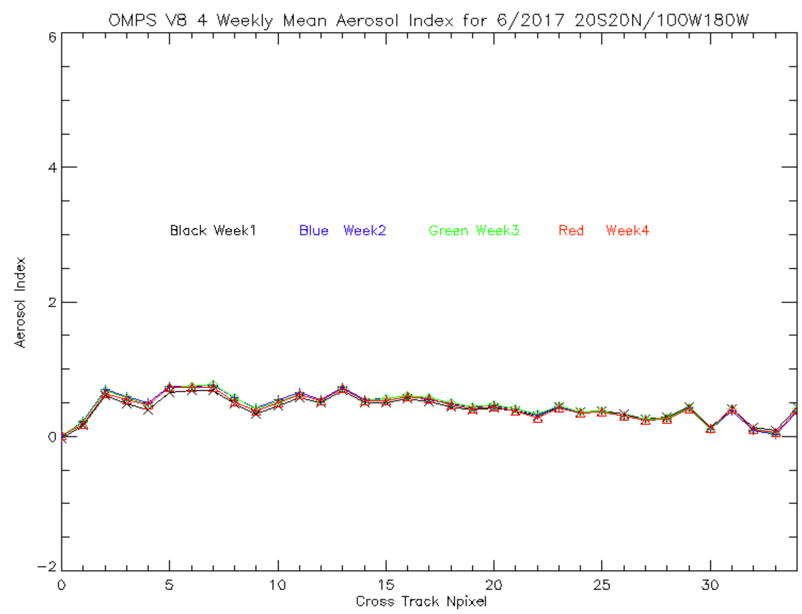

* - IDPS Products will be discontinued after V8TOz at NDE becomes operational

NOAA-20 and METOP-C will be added in the future.

# OMPS V8 Total Ozone

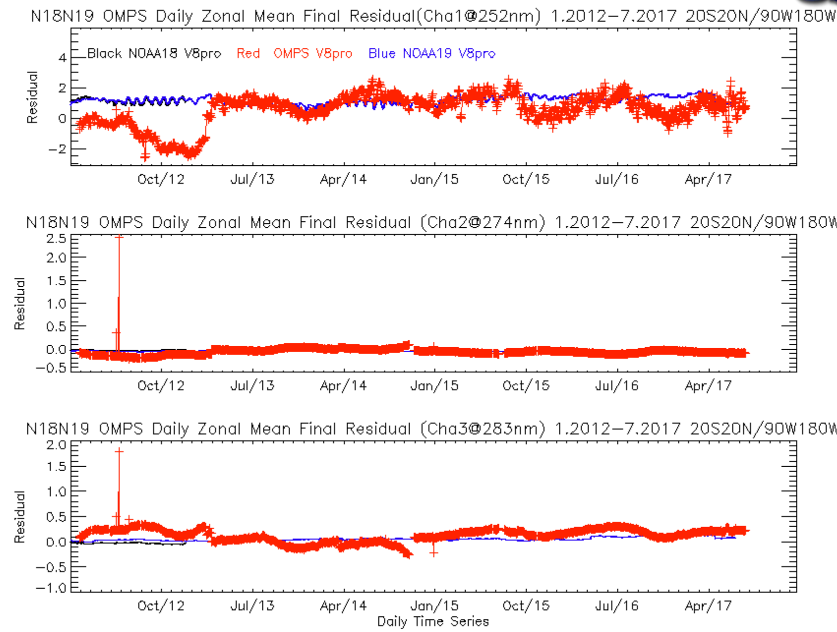
- Monitor the performance of the V8 ozone, reflectivity, and aerosol index products
- Daily zonal mean and 4 weekly mean plots are available for each product
- Weekly mean plots monitor the cross-track bias dependence

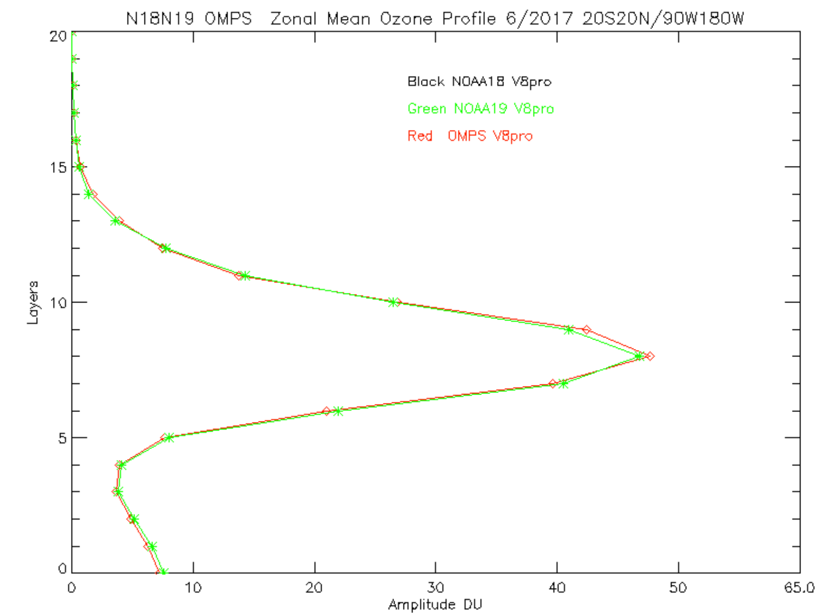


# OMPS V8 Profile Product

- Monitor the performance of the V8Pro products
- Plots produced:
  - Daily zonal mean initial/final residual
  - Zonal mean total column O3 minus profile total O3
  - Monthly average retrieved profiles minus A priori profiles



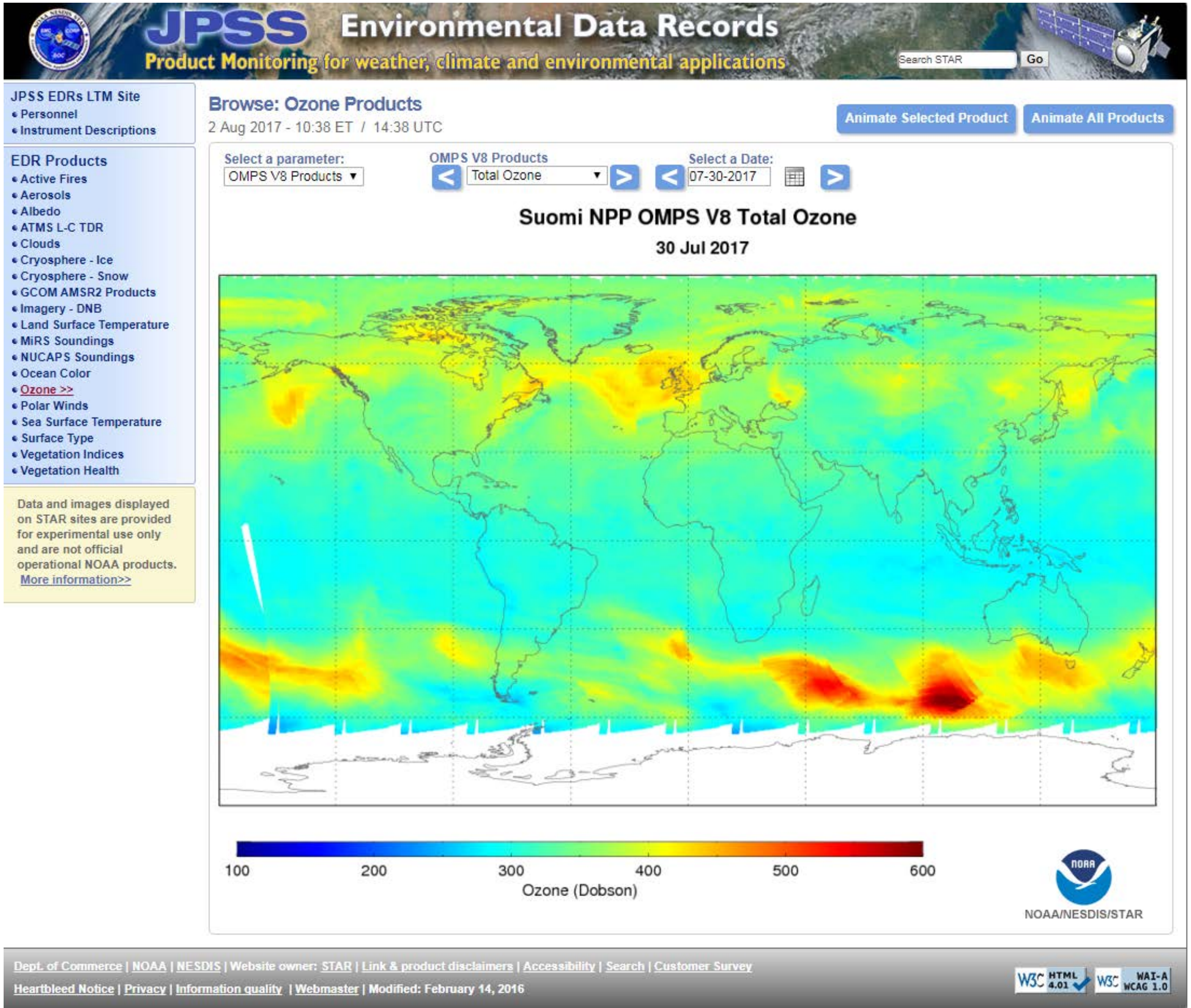



# New OMPS EDR Site Features

- Plots and images have consistent projections, labels, fonts, and sizes
- Navigation improvements 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 and saved as an animated GIF image.

# JPSS EDR LTM Site

https://www.star.nesdis.noaa.gov/JPSS/EDRs/products_ozone.php



# Conclusion

- Quick demo of web site
- Current EDR ICVS URL: https://www.star.nesdis.noaa.gov/smcd/spb/OMPSDemo/index.php
- New EDR ICVS site URL: https://www.star.nesdis.noaa.gov/jpss/EDRs/products_ozone.php

# Operational Ozone Products Available from NOAA/NESDIS

## Date: 08/16/2017

Vaishali Kapoor, OSPO
Robert Lindsay, Maximus

# Introduction

- There are many organizations, agencies and instruments that make ozone products from satellite data.
- These slides explain the operational ozone products produced by the National Oceanic and Atmospheric Administration (NOAA), National Environmental Satellite, Data, and Information Service (NESDIS) that are available to support near-real time operations.
- These products are used by United States and international environmental modeling groups for input into weather models, into other satellite algorithms to enhance radiative transfer models, for UV forecast models, and for climate monitoring.
- These products are available to users in a variety of formats such as BUFR, Binary, GRIB, GRIB2, and ASCII.
- Slides will also provide information on how to obtain operational access to the following products.

# Solar Backscatter Ultraviolet Version 2 (SBUV/2) Products

- **NOAA currently produces near-real-time (NRT) total ozone and profile ozone products from the SBUV/2 instruments on the NOAA Polar-orbiting Operational Environmental Satellites (POES) NOAA-19.**

# SBUV/2

- The SBUV/2 instruments are non-scanning, nadir viewing (field-of-view directly below the satellite path) instruments designed to measure scene radiance in the spectral region from 160 to 400 nm. SBUV/2 data are used to determine total and profile ozone in the atmosphere, and solar spectral irradiance.

- An improved version of the SBUV/2 (Version 8) algorithm was implemented in January 2007. Products are available in binary or WMO compliant BUFR formats.

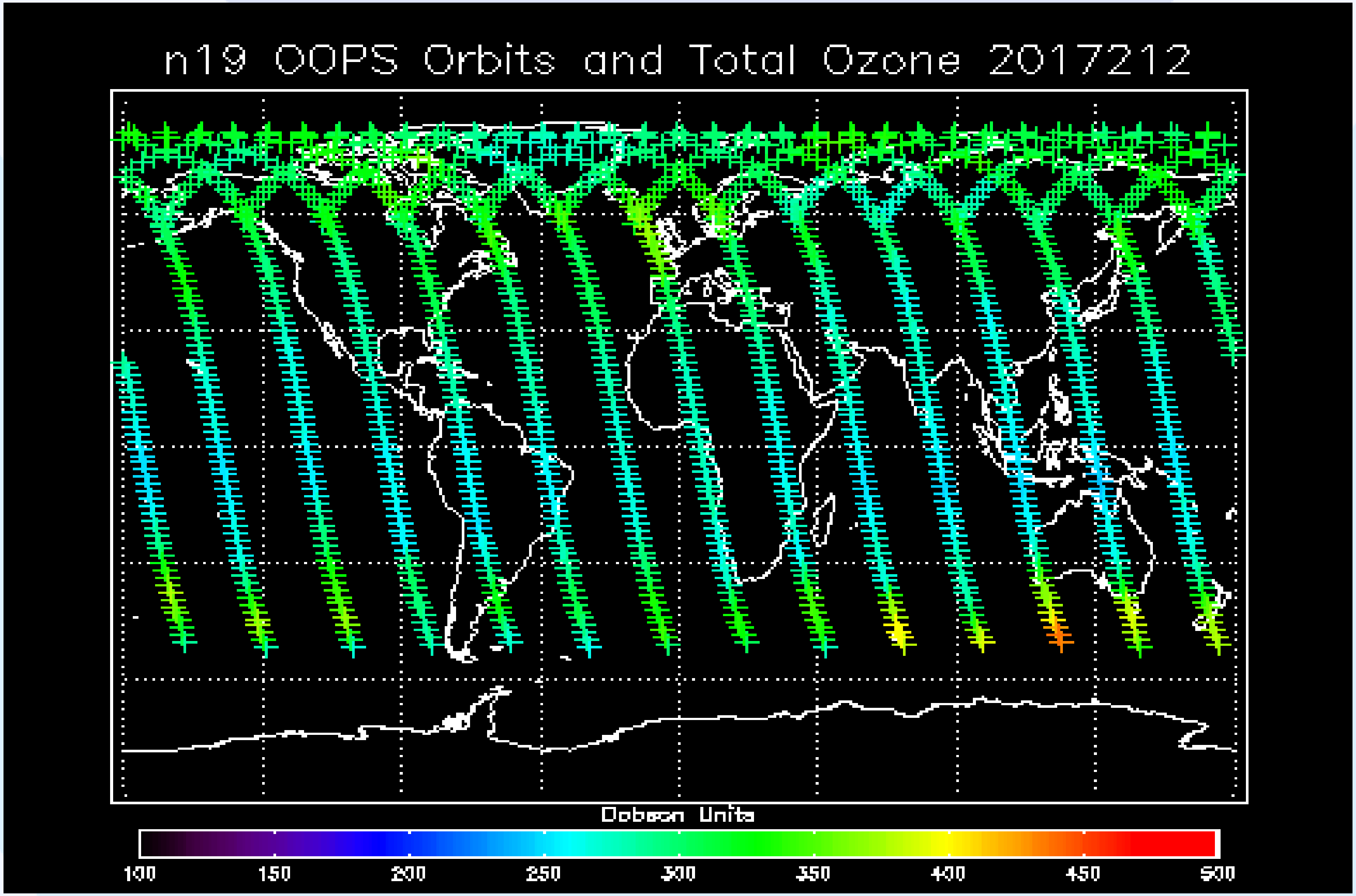
# SBUV/2

- **All SBUV/2 products are available in daily (from the Operational Ozone Processing system - OOPS) or orbital format (from the Real-time Ozone Processing Extended System - ROPES) for near-realtime users.**

- **The products in binary format are archived at CLASS, accumulated in monthly datasets available within 3 days after each new month.**

- **http://www.ospo.noaa.gov/ml/air/ozone.html**

# Orbital Tracks of Total Column Ozone
# NOAA-19 SBUV/2

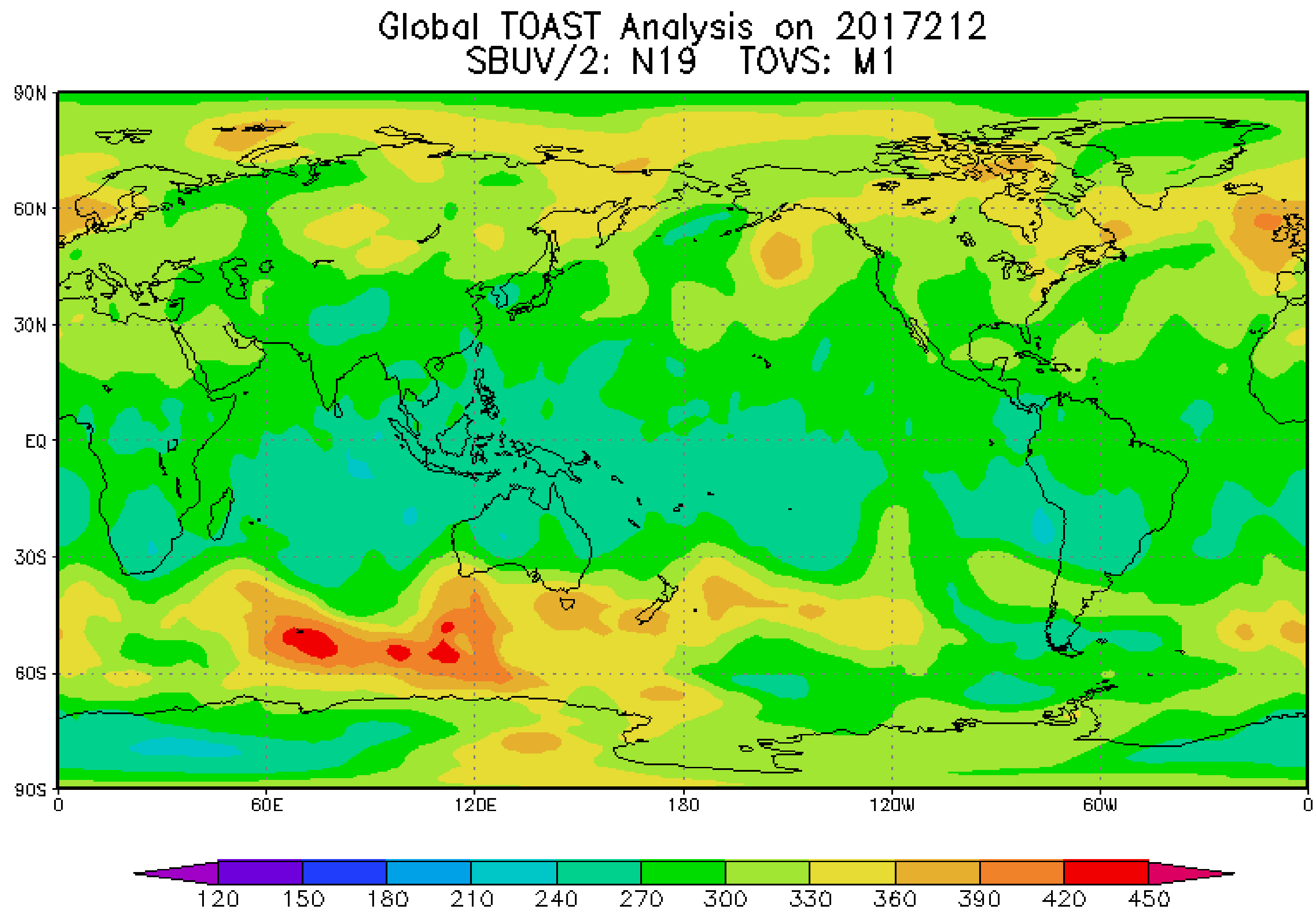



SBUV Page: http://www.osdpd.noaa.gov/ml/air/sbuv.html

# TOAST
## (Total Ozone Analysis using Stratospheric & Tropospheric components)

- **TOAST is a near real-time operational ozone map generated by combining Advanced TIROS Operational Vertical Sounder (ATOVS) tropospheric and lower stratospheric (4 to 23 km) ozone retrievals with SBUV/2 spatially smoothed mid-to-upper stratospheric (24 to 54 km) layer ozone retrievals. Products are created daily in imagery (png), binary or GRIB format.**

# TOAST from NOAA-19 and Metop-B TOVS

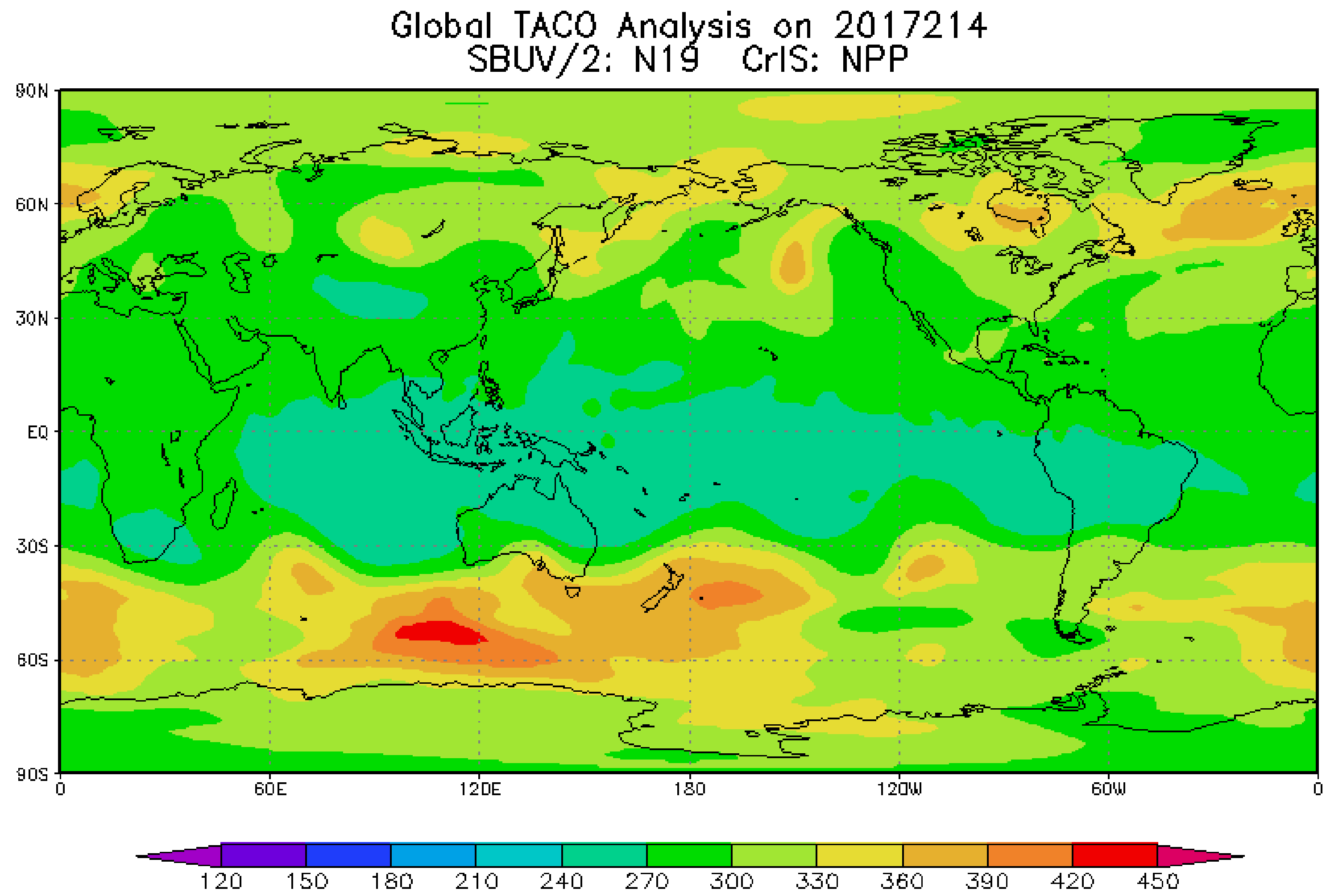



TOAST Page: http://www.ospo.noaa.gov/Products/atmosphere/toast/index.html

# Enhanced TOAST

- An algorithm using Total Ozone Analysis of CrIS (NUCAPS) and SBUV/2 (V8Pro) has been developed to generate combined IR and UV ozone retrievals. This algorithm is a new version of the current TOAST.
- The most significant improvement of the algorithm is in the IR-derived product replacement of the column amount retrievals from the High resolution InfraRed Sounder (HIRS) with the CrIS profile retrievals. This allows the algorithm to provide ozone not only global 1°x1° total amount map but also the same spatial resolution profile maps at 12 Umkehr layers. The new products have significantly increased accuracy in their troposphere ozone estimation.

# TOAST from S-NPP CrIS and NOAA-19 SBUV/2

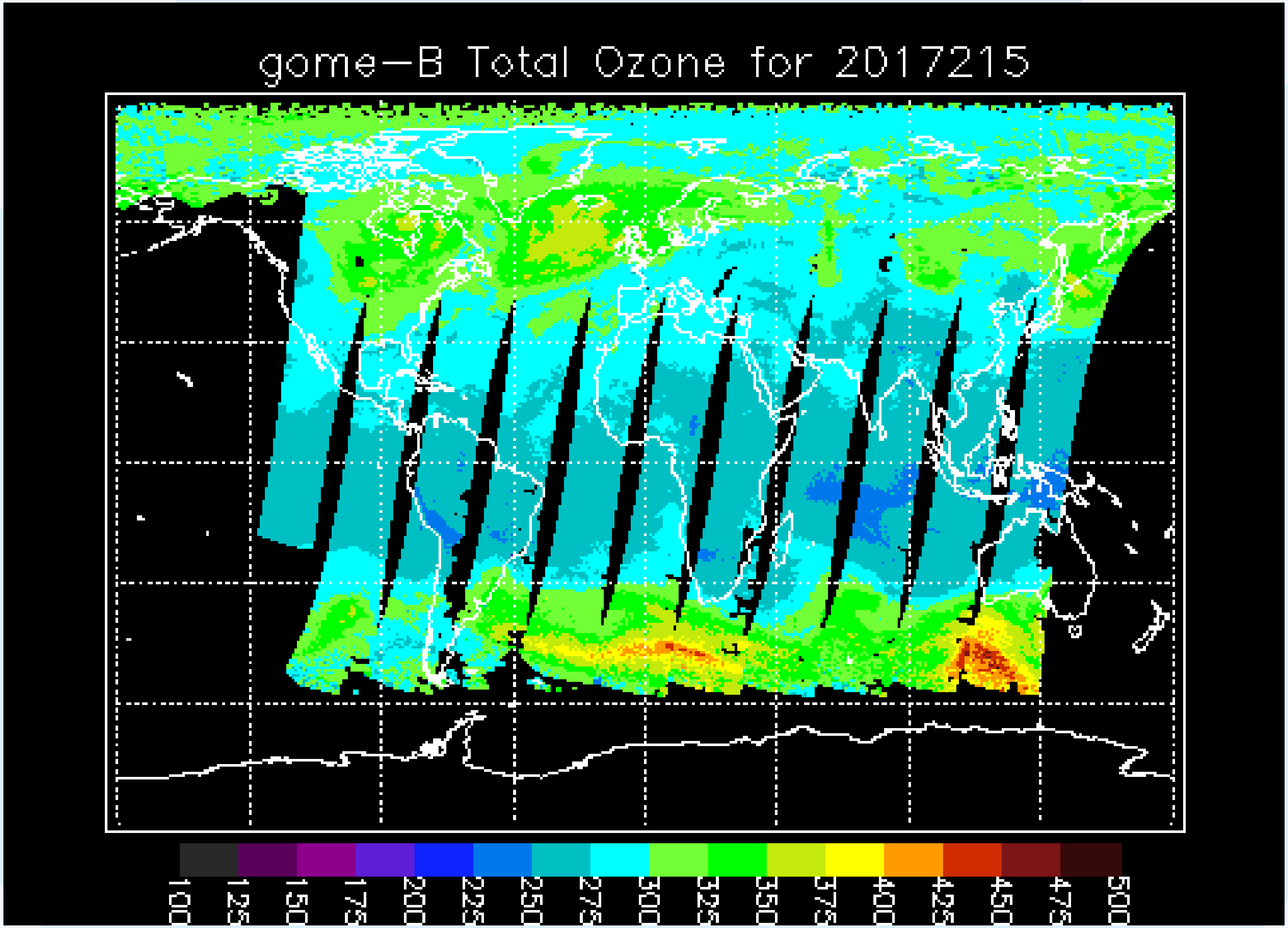



E TOAST Page: http://www.ospo.noaa.gov/Products/atmosphere/etoast/index.html

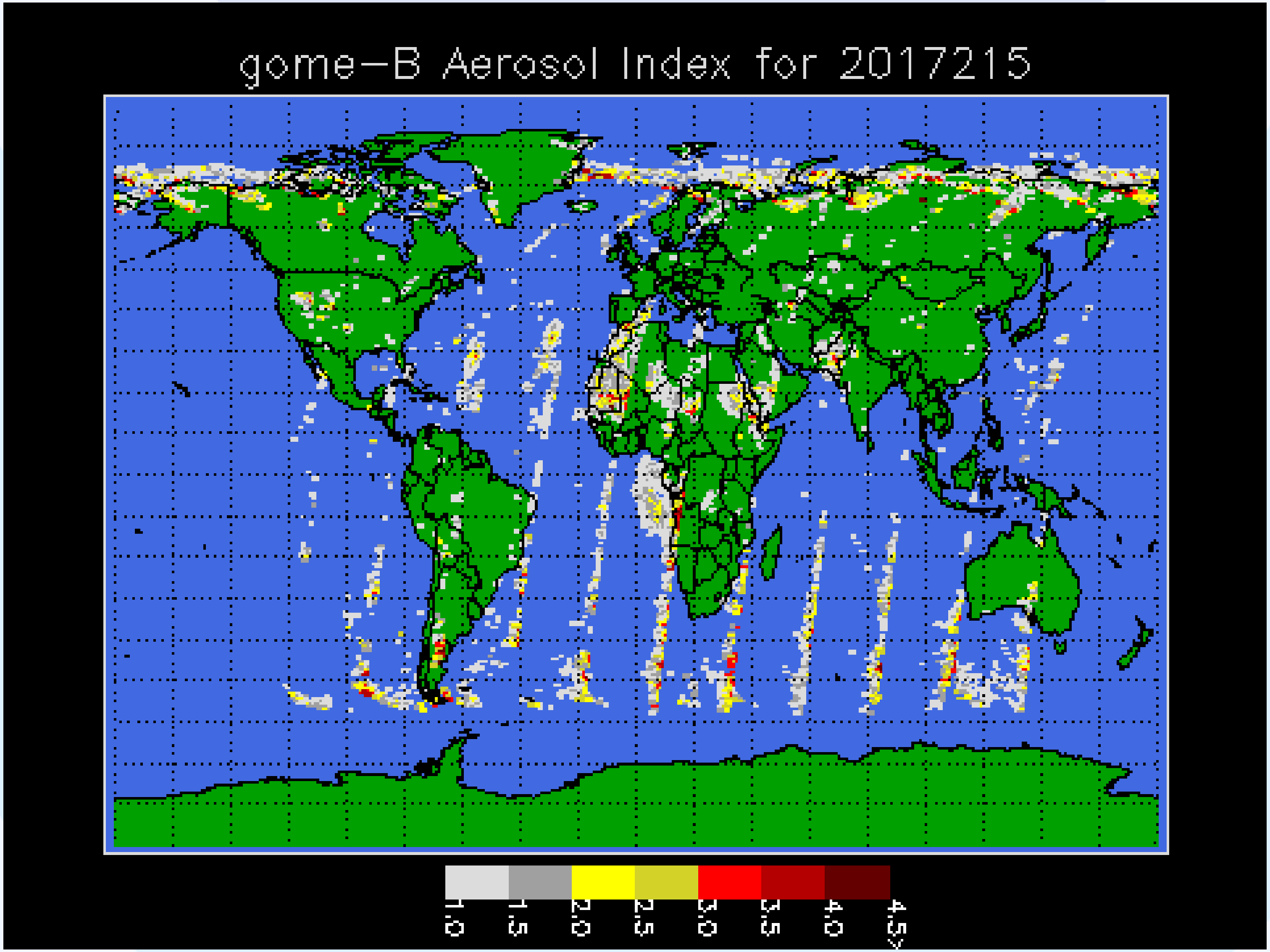
# Global Ozone Monitoring Experiment (GOME-2) Total Ozone Products

- The GOME-2 instrument was designed by the European Space Agency to measure radiation in the ultraviolet and visible part of the spectrum (240 - 790 nm) and derive measurements of atmospheric ozone and other trace gases. It is a scanning instrument (scan width 1920 km) with near global coverage daily. The field-of-view on the ground is 80 km X 40 km.
- The GOME-2 (MetOp-B and MetOp-A) total ozone product, UV Aerosol Index and UV Reflectivity estimates, from the V8TOz algorithm are available in binary and BUFR formats. The algorithm also produces aerosol index and reflectivity values, which are included in the total ozone binary product.
- Granule products are available as imagery (gif), binary or BUFR, and daily products (1 x 1.25 deg maps) are available in ASCII or GRIB2 format.
- Magnesium II index (MgII) information is provided in a daily ASCII file for our solar and space users.
- MetOp-B GOME-2 1B granules (raw data), total ozone binary files, gridded ASCII files and MgII index files are currently archived at CLASS.

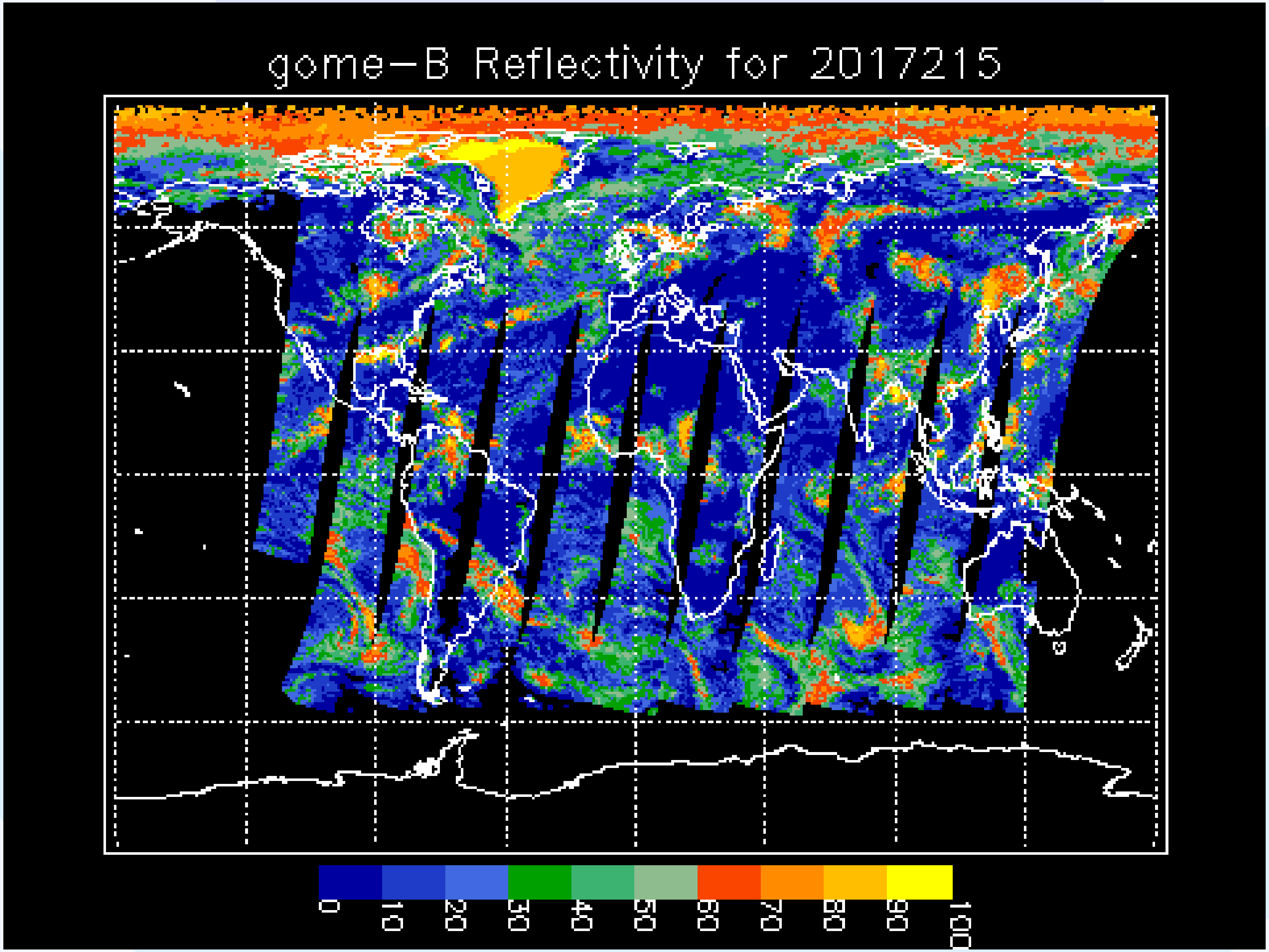
# Total Column Ozone for GOME-2 on MetOp-B



# Aerosol Index for GOME-2 on MetOp-B



# UV Reflectivity for GOME-2 on MetOp-B

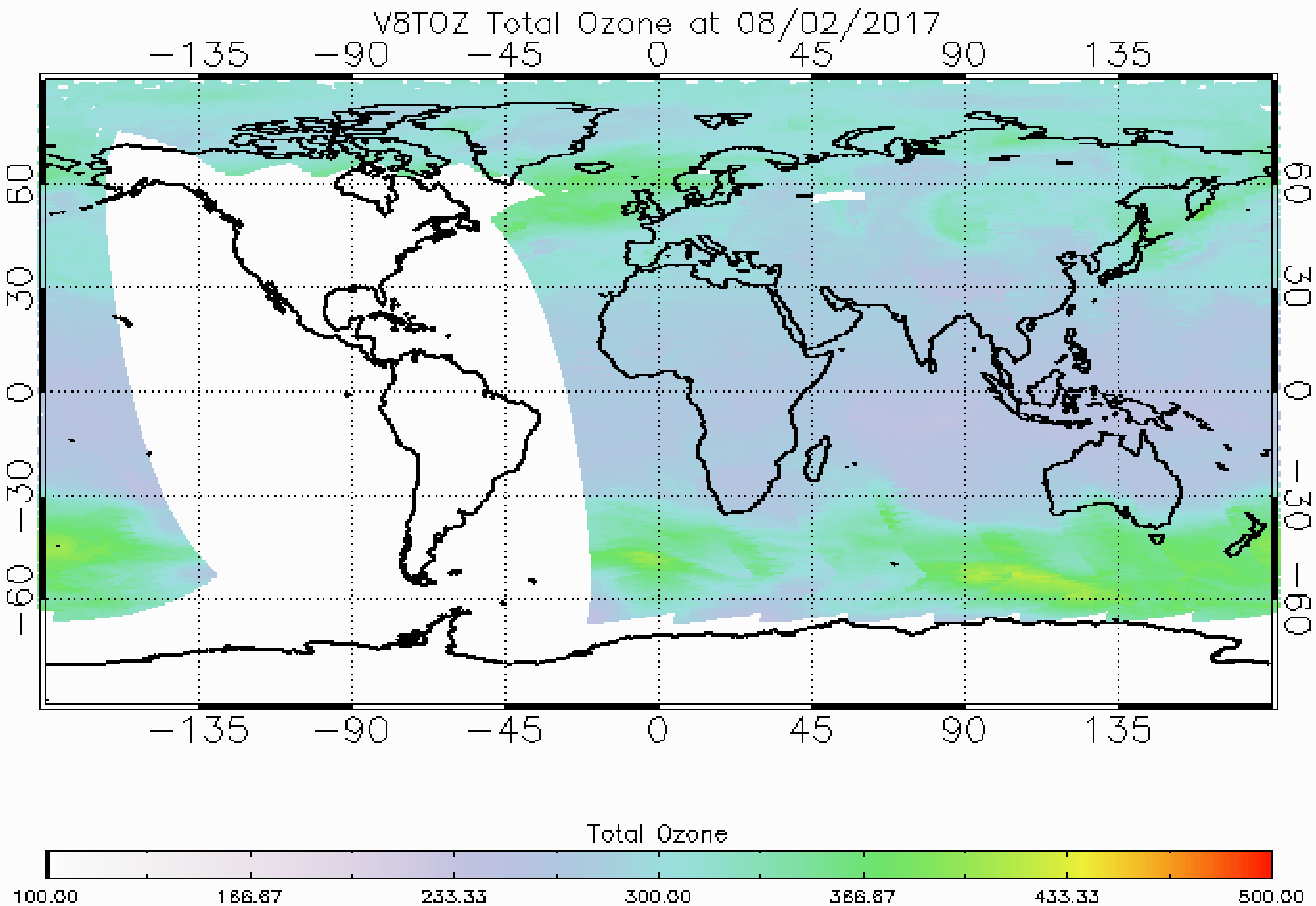


# OMPS

- OMPS (Ozone Mapper Product Suite) is a three-part instrument: a nadir mapper that maps global ozone with about 50-km ground-resolution, a nadir profiler that measures the vertical distribution of ozone in the stratosphere, and a limb profiler that measures ozone in the lower stratosphere and troposphere with high vertical resolution.

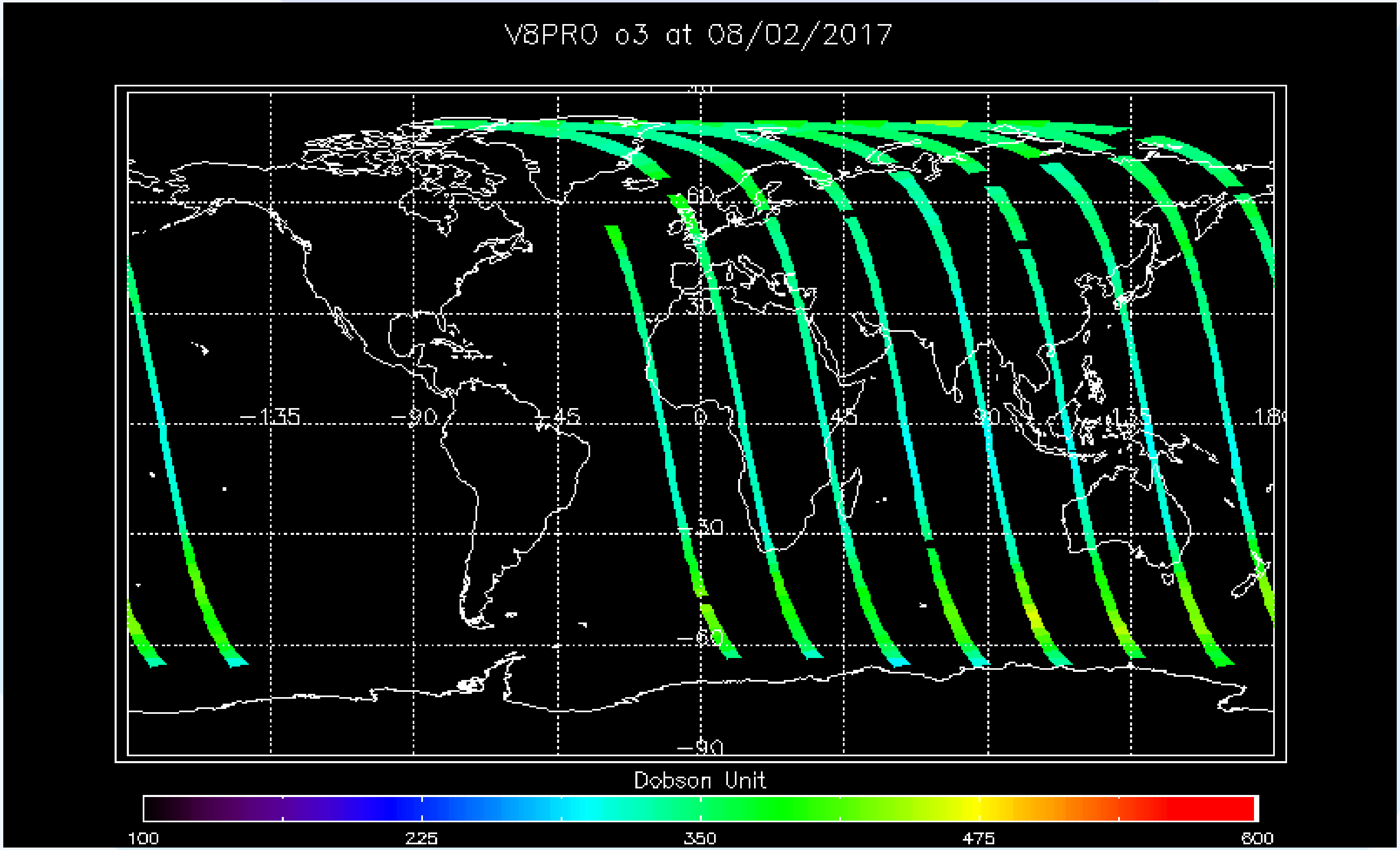
- OMPS, an advanced suite of two hyper spectral instruments, extends the 35-plus year total-ozone and ozone-profile records. These records are used by ozone-assessment researchers and policy makers to track the health of the ozone layer. The improved vertical resolution of OMPS data products allows for better testing and monitoring of the complex chemistry involved in ozone destruction near the troposphere. OMPS products, when combined with cloud predictions, also help produce better ultraviolet index forecasts.

# OMPS V8TOz




http://www.ospo.noaa.gov/data/atmosphere/ozone/Products_atmosphere_OMPS.html

# Orbital Tracks of Total Column Ozone S-NPP OMPS V8Pro




http://www.ospo.noaa.gov/data/atmosphere/ozone/Products_atmosphere_OMPS.html

# How to Obtain Access

- Operational users can obtain access to these near-real time products via PDA. To set up access.

Contact -

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# Websites for More Information

**Operational Pages:**

Main Ozone Page: http://www.ospo.noaa.gov/ml/air/ozone.html

SBUV Page: http://www.osdpd.noaa.gov/ml/air/sbuv.html

Gome Page: http://www.ospo.noaa.gov/Products/atmosphere/gome/gome-B.html

TOAST Page: http://www.ospo.noaa.gov/Products/atmosphere/toast/index.html

Enhanced TOAST Page:

http://www.ospo.noaa.gov/Products/atmosphere/etoast/index.html

OMPS Page:

http://www.ospo.noaa.gov/data/atmosphere/ozone/Products_atmosphere_OMPS.html

**Archive Page:**

Class: http://www.class.ncdc.noaa.gov/saa/products/welcome

**Research Group:**

STAR: http://www.star.nesdis.noaa.gov/smcd/spb/ozone/

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# 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 $\lambda 1$ and $\lambda 2$ where $S1*\alpha 1 = S2* \alpha 2$, where S values give the path lengths and $\alpha$ 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

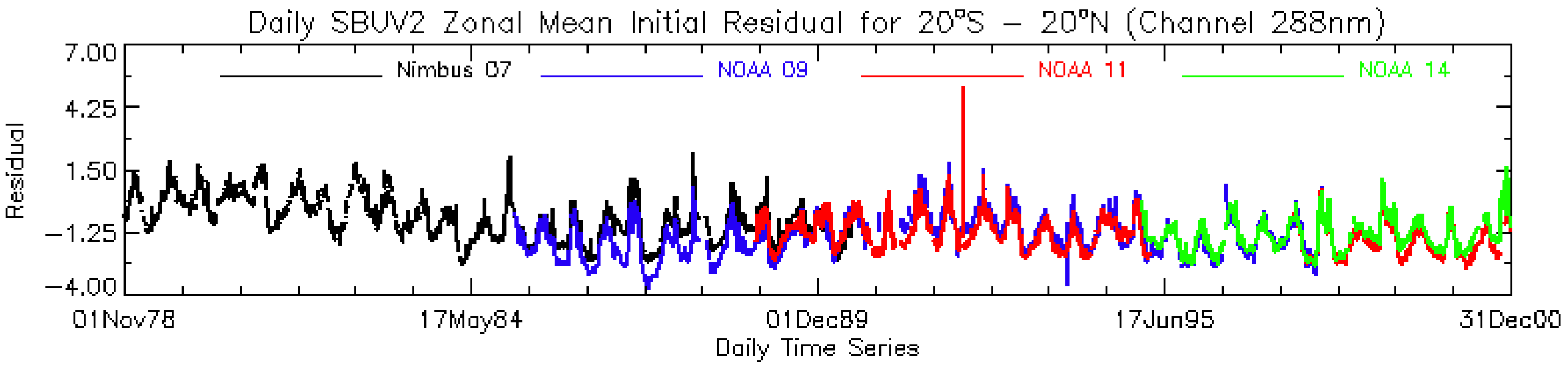
- V8 SBUV/2 forward model and *A Priori* as transfer for Viewing conditions

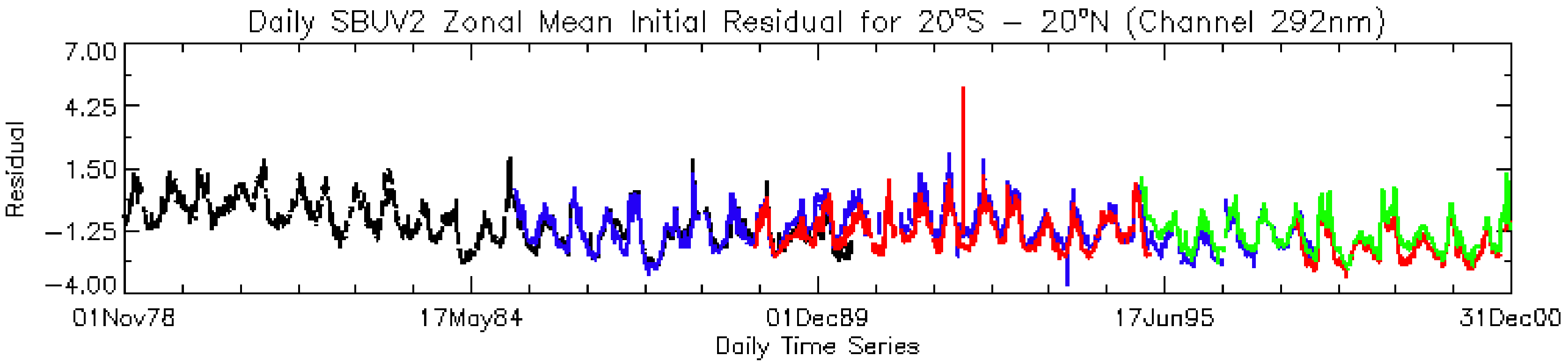
Complications from real diurnal variations in the ozone profiles

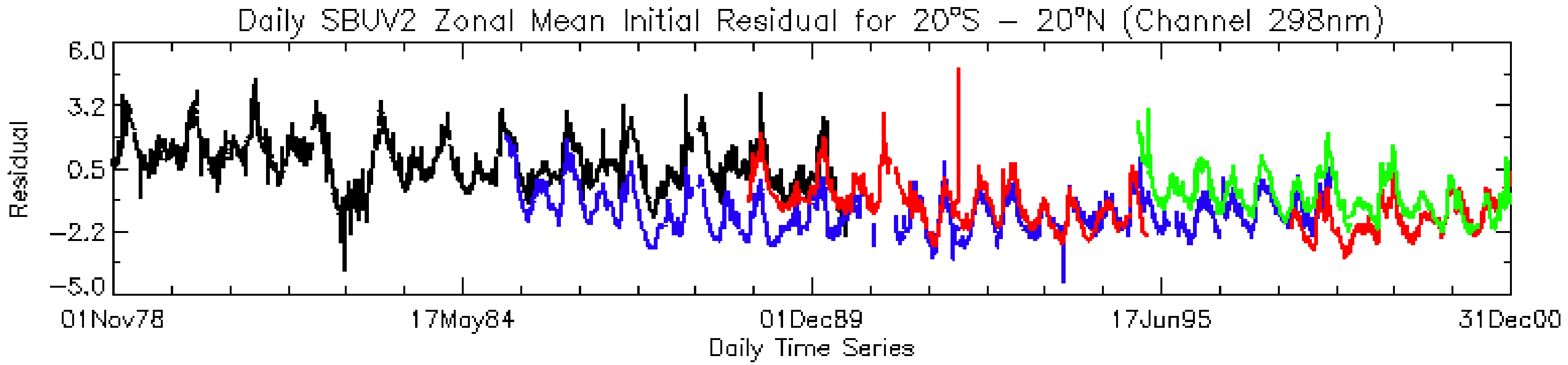
Complications if best ozone product values differ and initial residuals are used

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

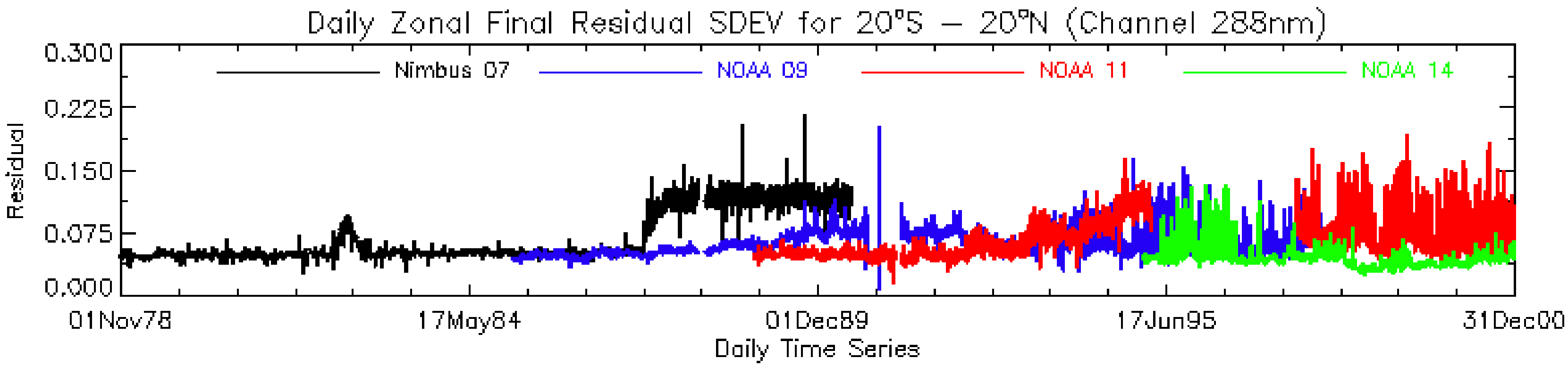
# Long-term Inter-calibrated Initial Residuals for SBUV/2

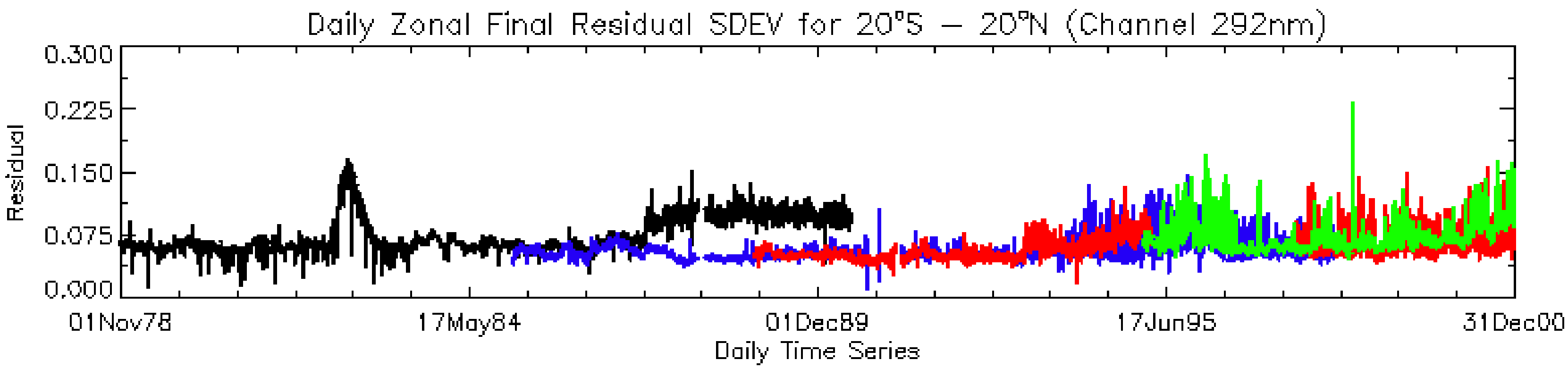


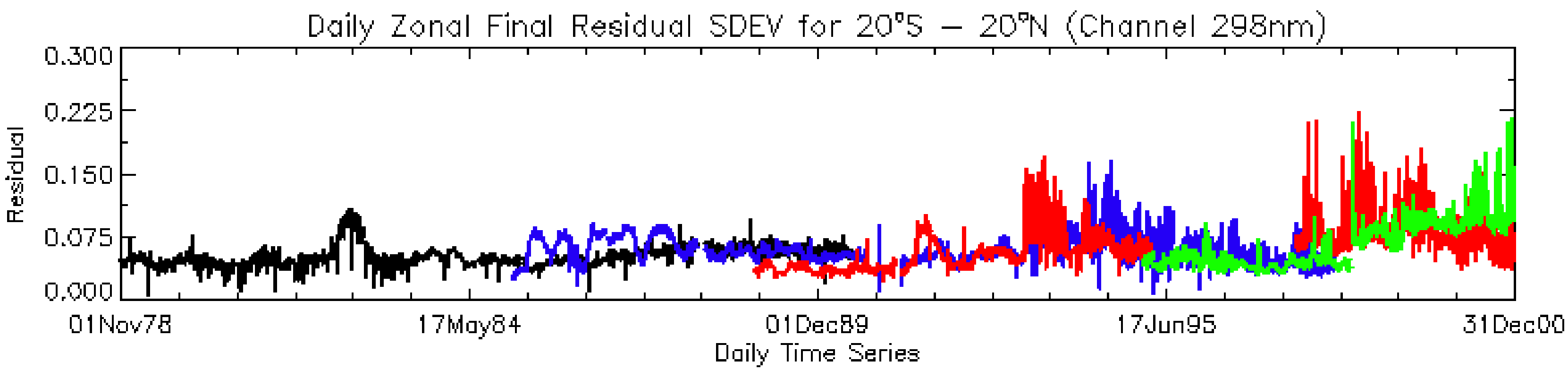



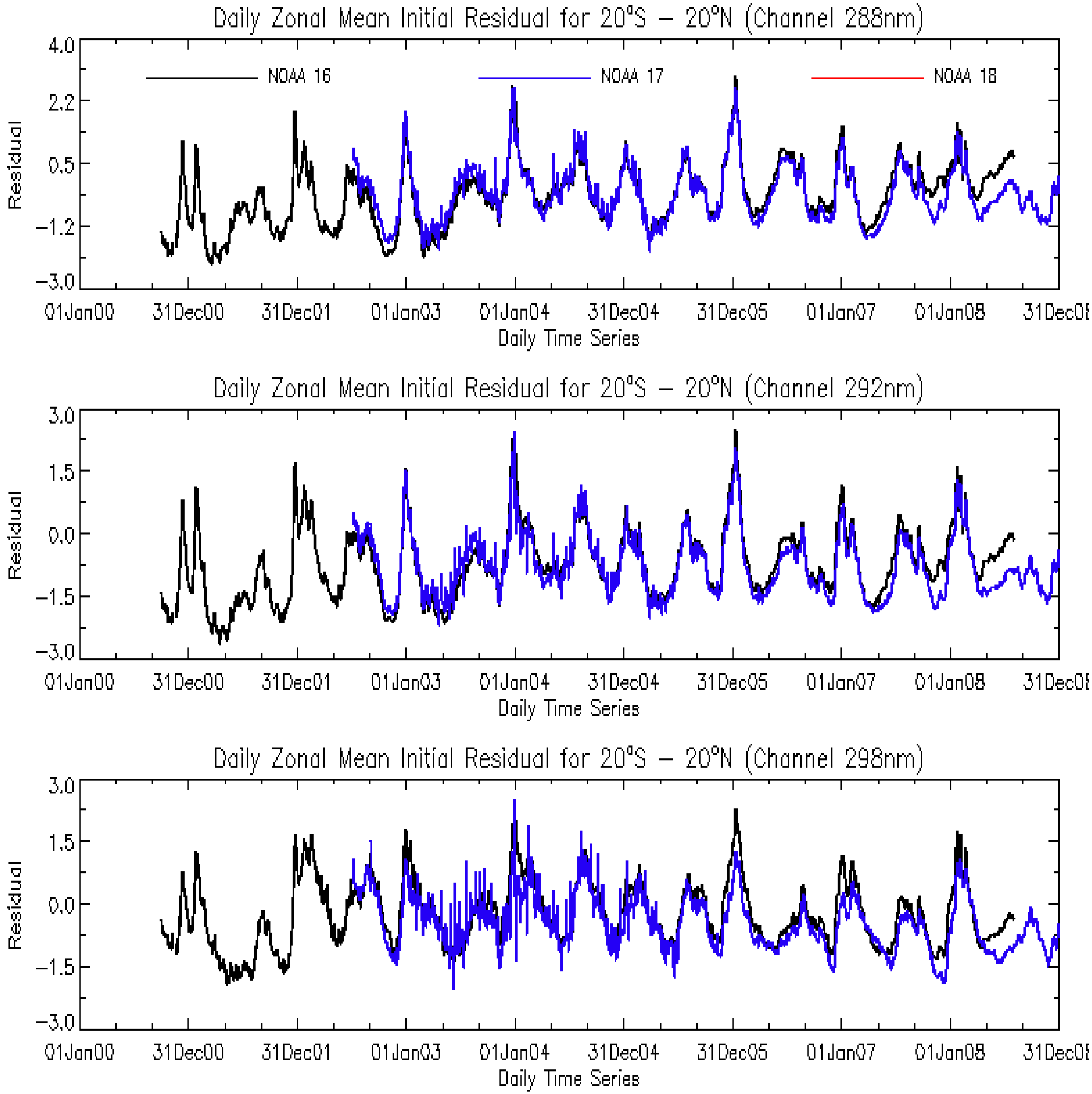
# Long-term Inter-calibrated Final Residuals for SBUV/2



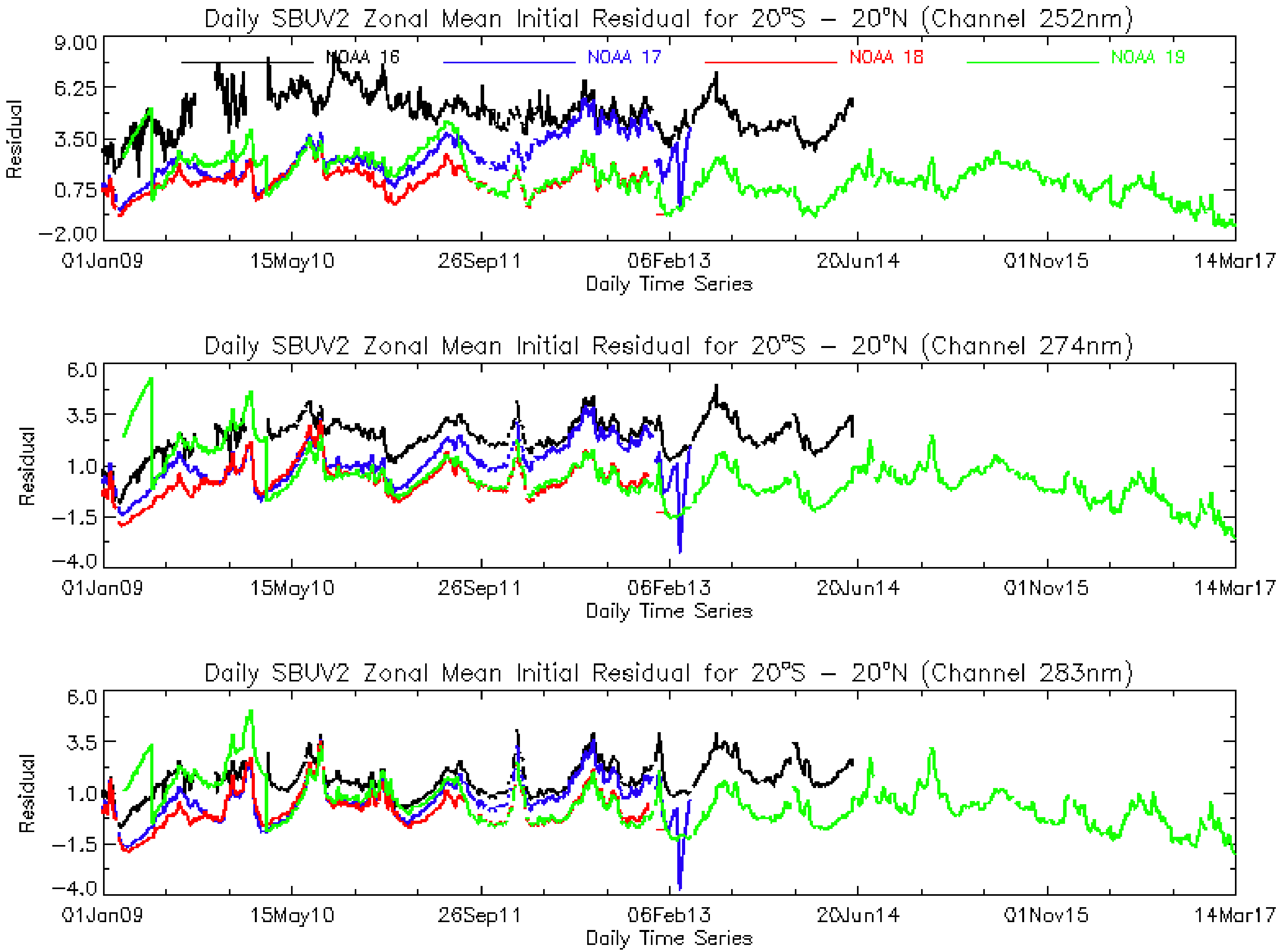



# Inter-calibrated Initial Residuals for SBUV/2 with SZA Drift

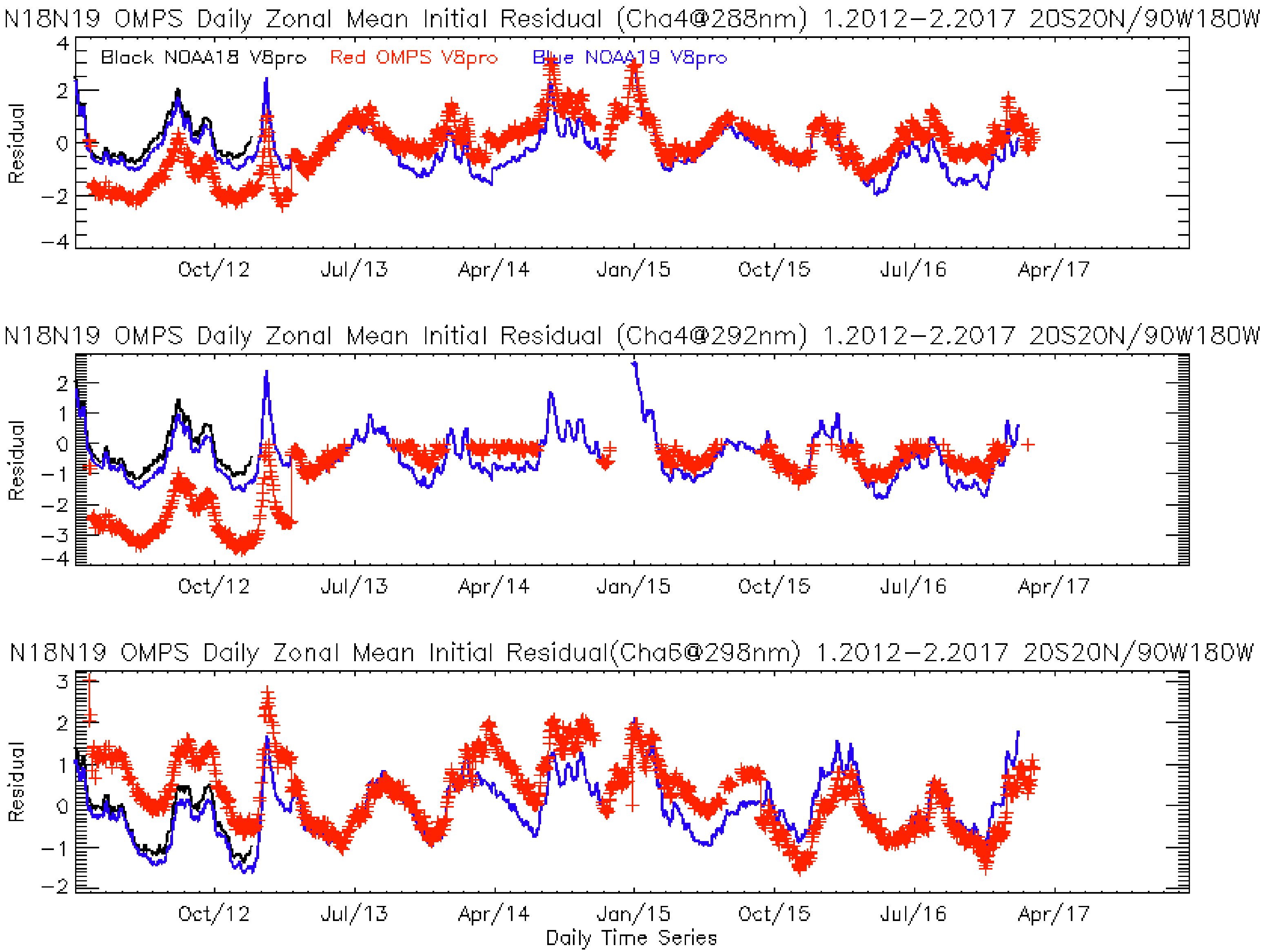



The figures show the initial measurement residuals for three profile wavelengths (Top 288 nm, Middle 292 nm, and Bottom 298 nm) for the V8PRO product for the equatorial daily zonal means (20N to 20S). The two sets of data are for the NOAA-16 SBUV/2 and the NOAA-17 SBUV/2. The units are N-values (~2.3%). 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

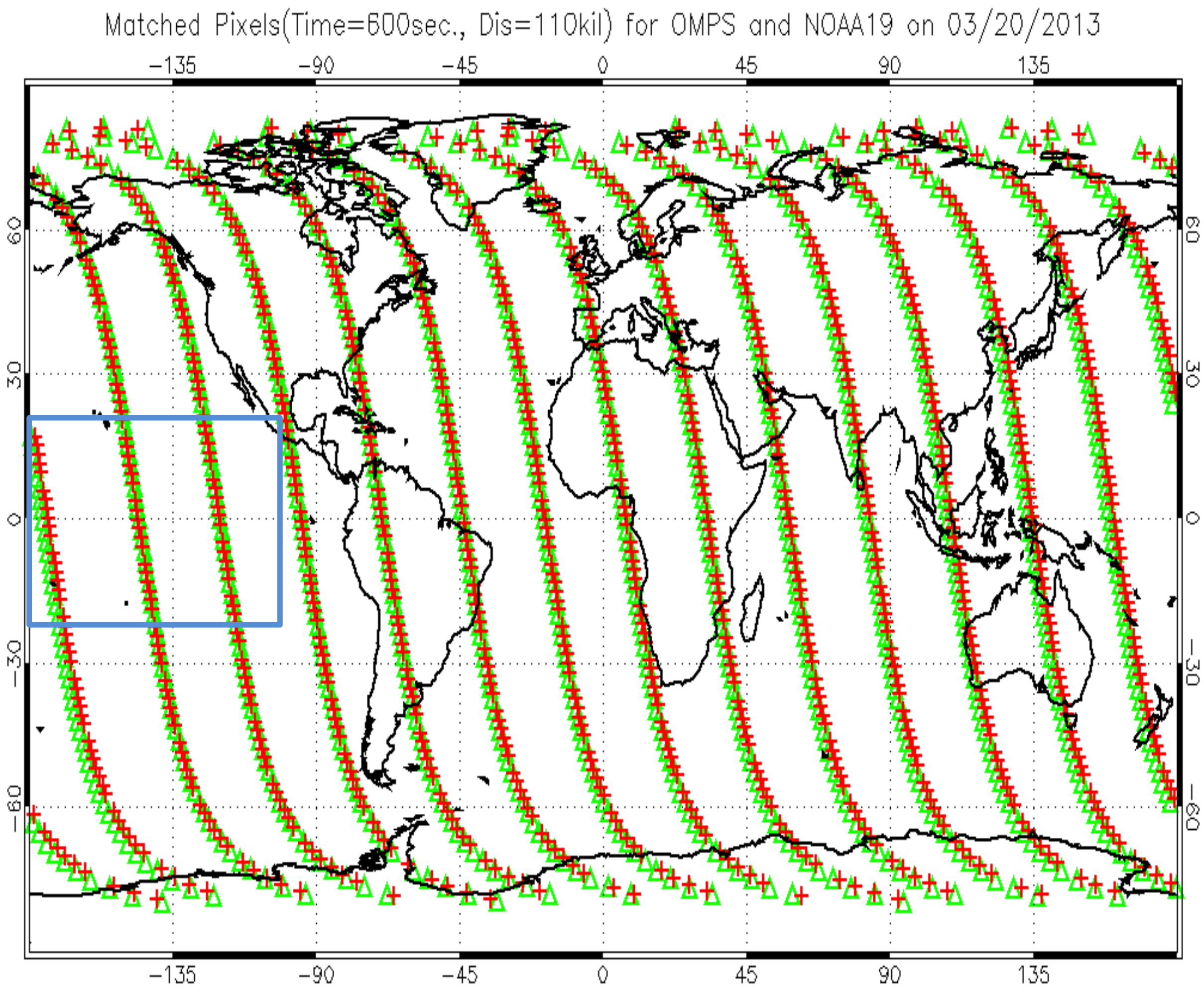


# Operational Initial Residuals for SBUV/2 & OMPS with Operational Adjustments

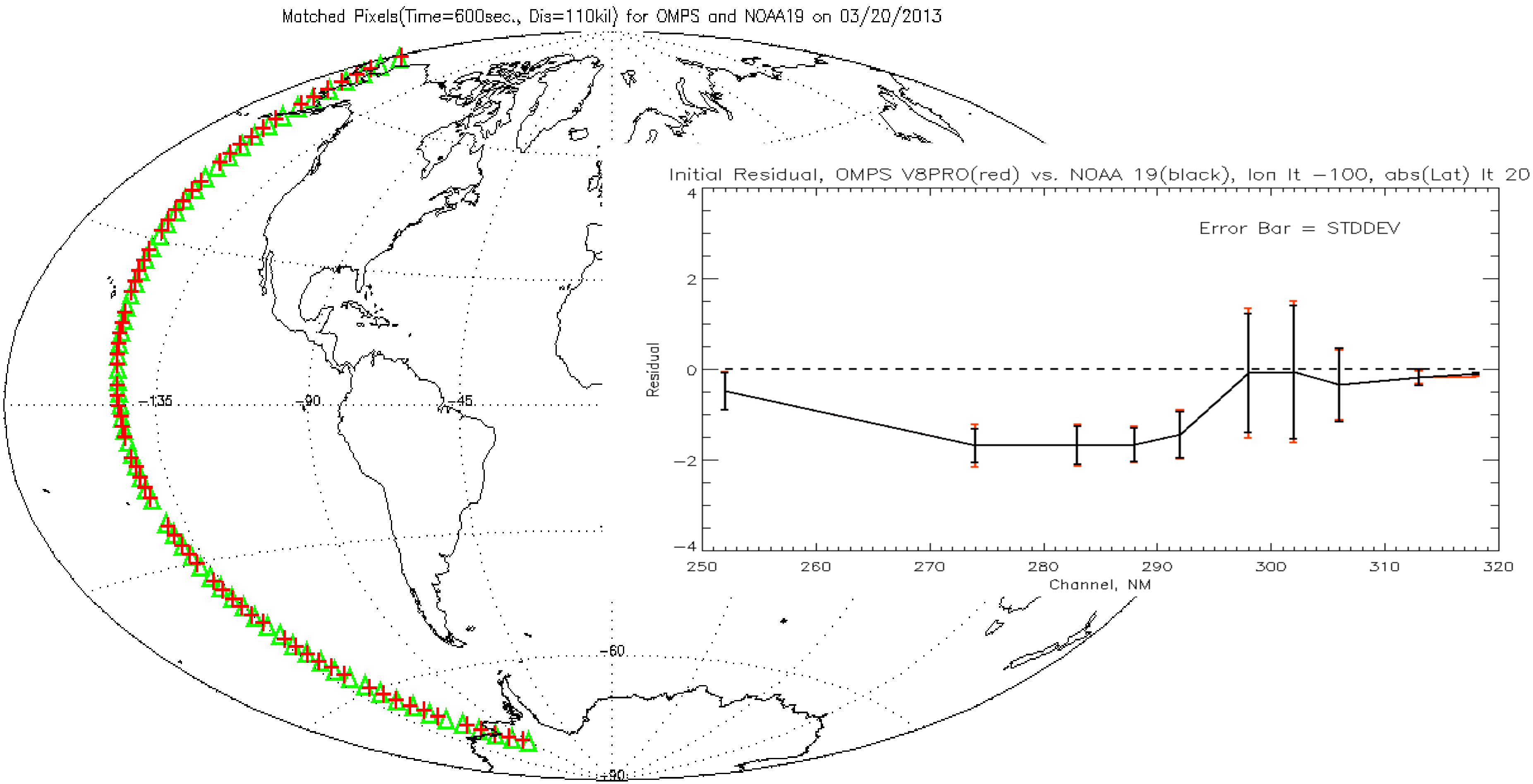


# Adjusting STAR re-processed V8PRO to N19 SBUV/2

**Region of retrieval for generating adjustments**



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

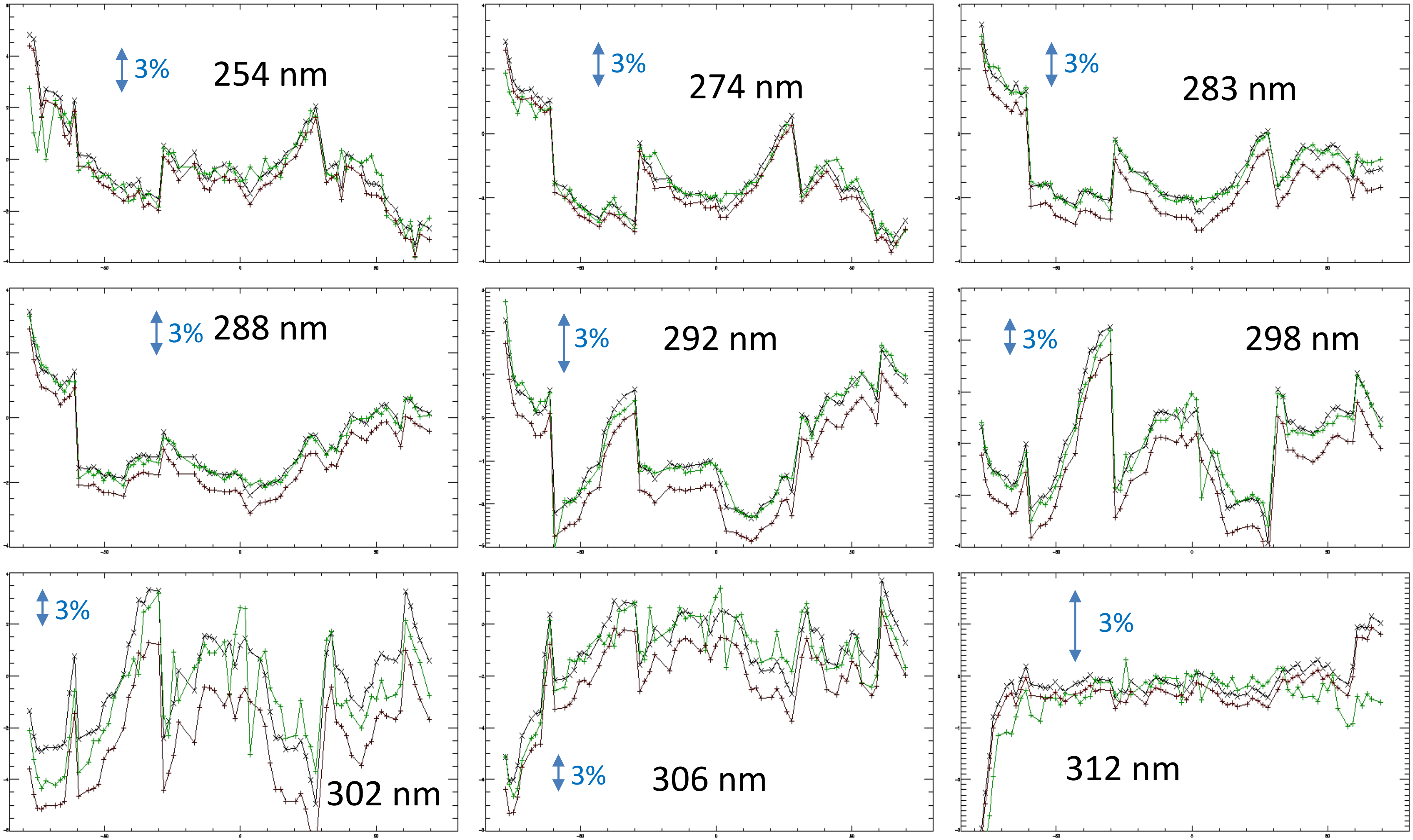


# V8Pro Initial Residuals along Chasing Orbit

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

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

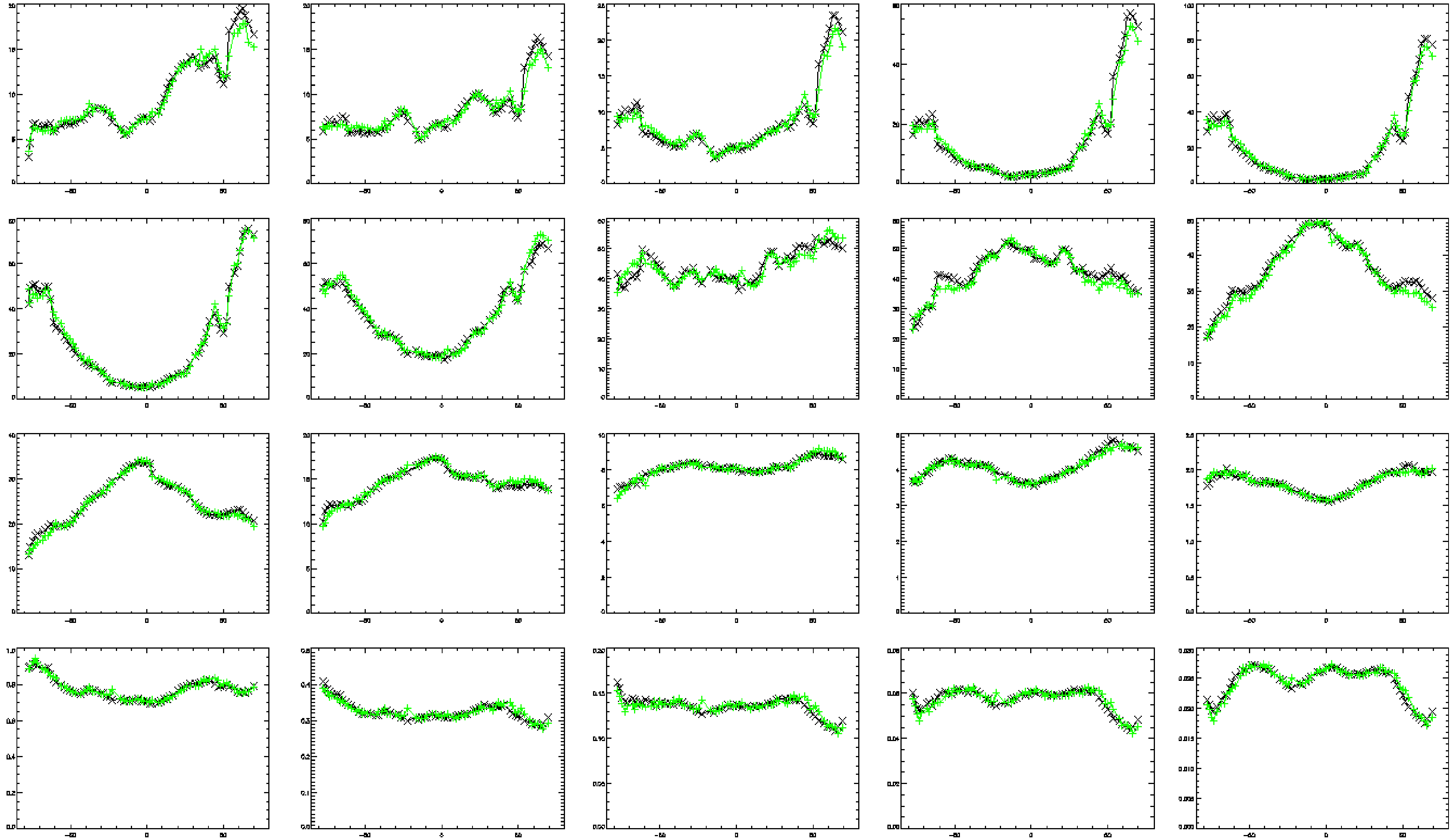
Adjustments: 254 0.4; 274 0.3; 283 0.6; 288 0.5; 292 0.5; 298 1.1; 302 2.3; 306 1.3; 312 0.3




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.



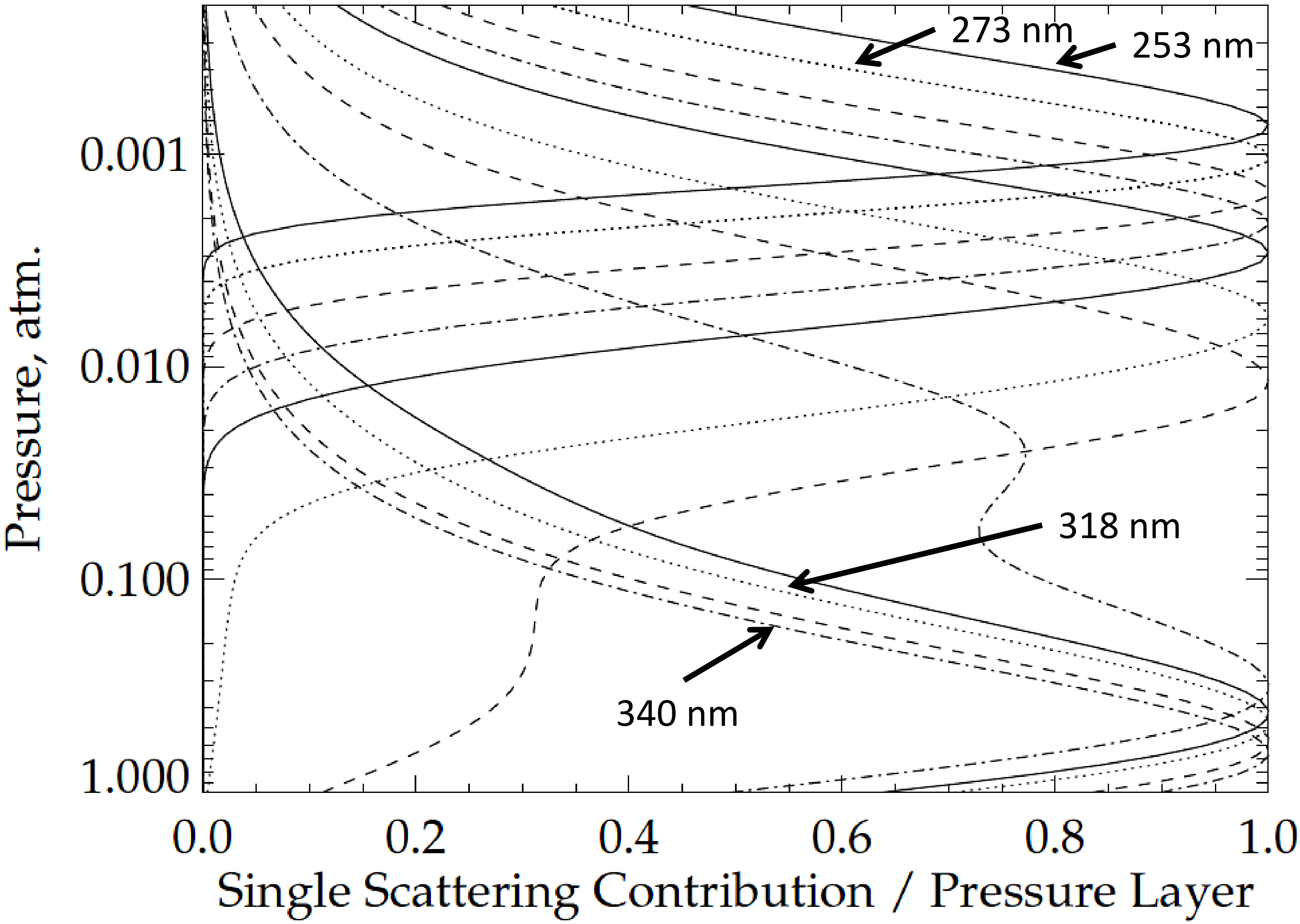



**Figure 6.a. Normalized Single Scattering Contribution Functions for 12 wavelengths at [253,273,283,288,292,297,302,306,313,318,331,340] nm for a 325 DU total column ozone profile for Solar Zenith Angle $\theta_0$ = 30°.**

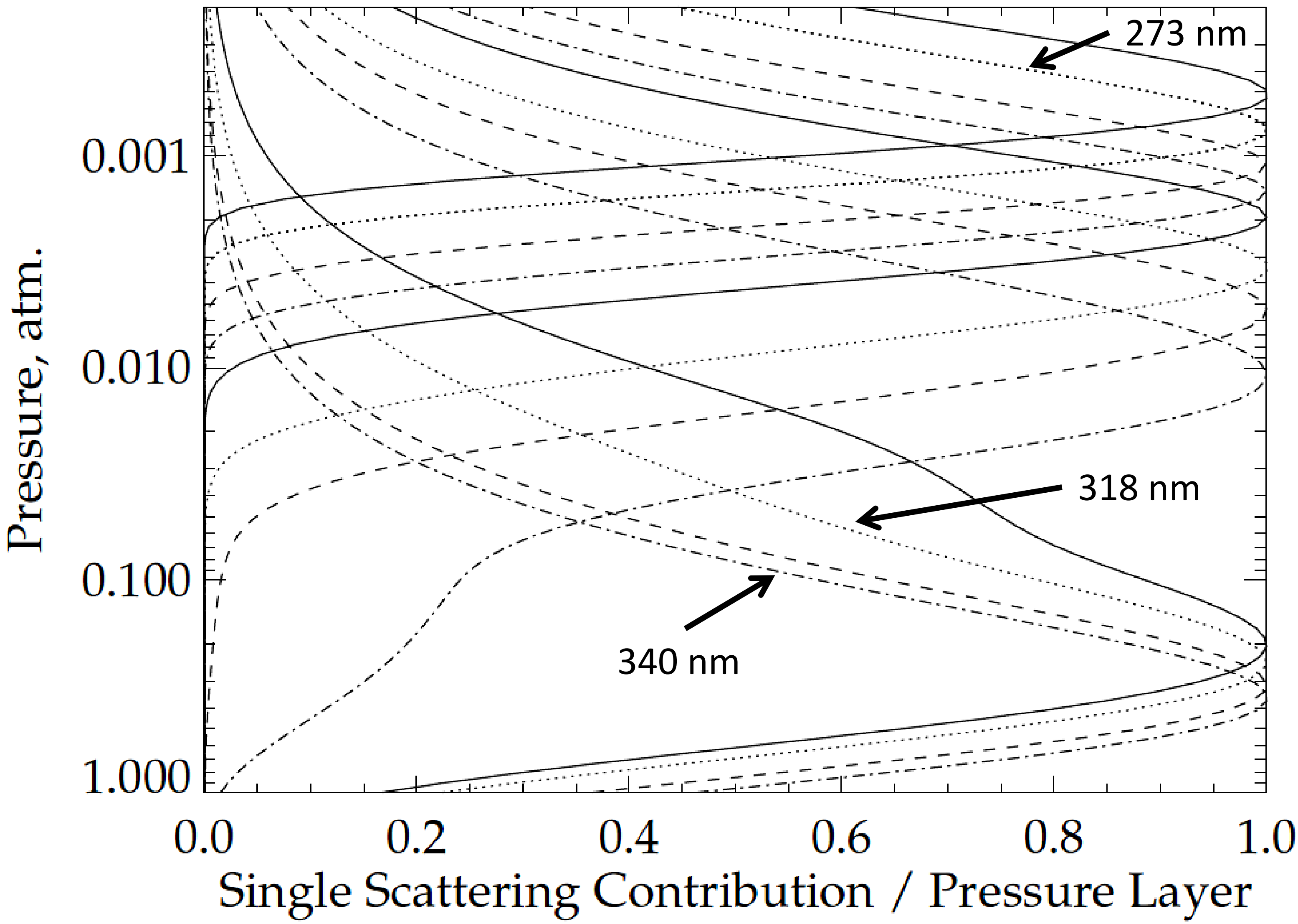



**Figure 6.b. Normalized Single Scattering Contribution Functions for 12 wavelengths at [253,273,283,288,292,297,302,306,313,318,331,340] nm for a 325 DU total column ozone profile for Solar Zenith Angle $\theta_0$ = 70°.**

# 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]

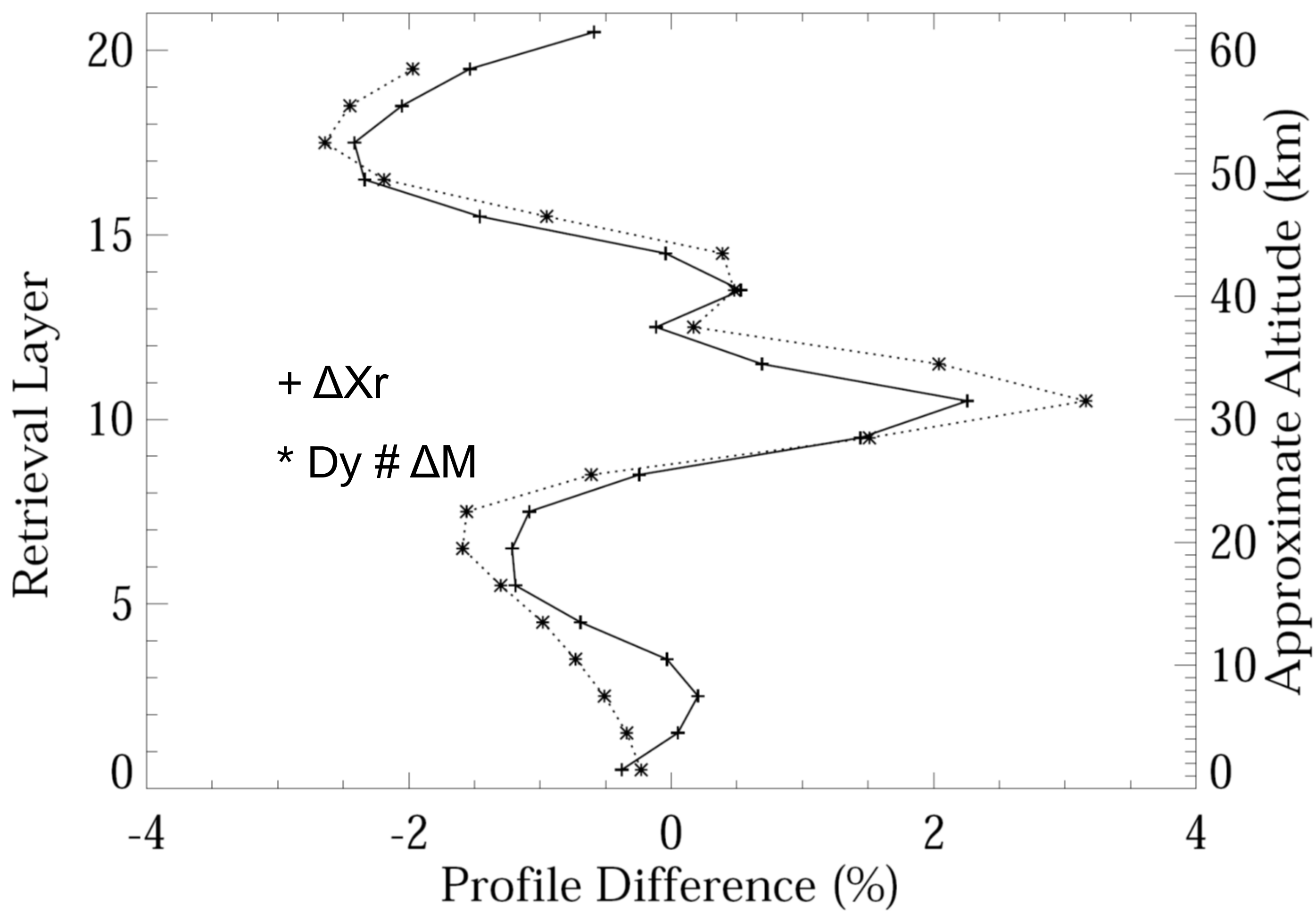
The measurement change, ΔM, is the Jacobian times a profile change, ΔX:

ΔM = K # ΔX

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

ΔXr = Dy # ΔM

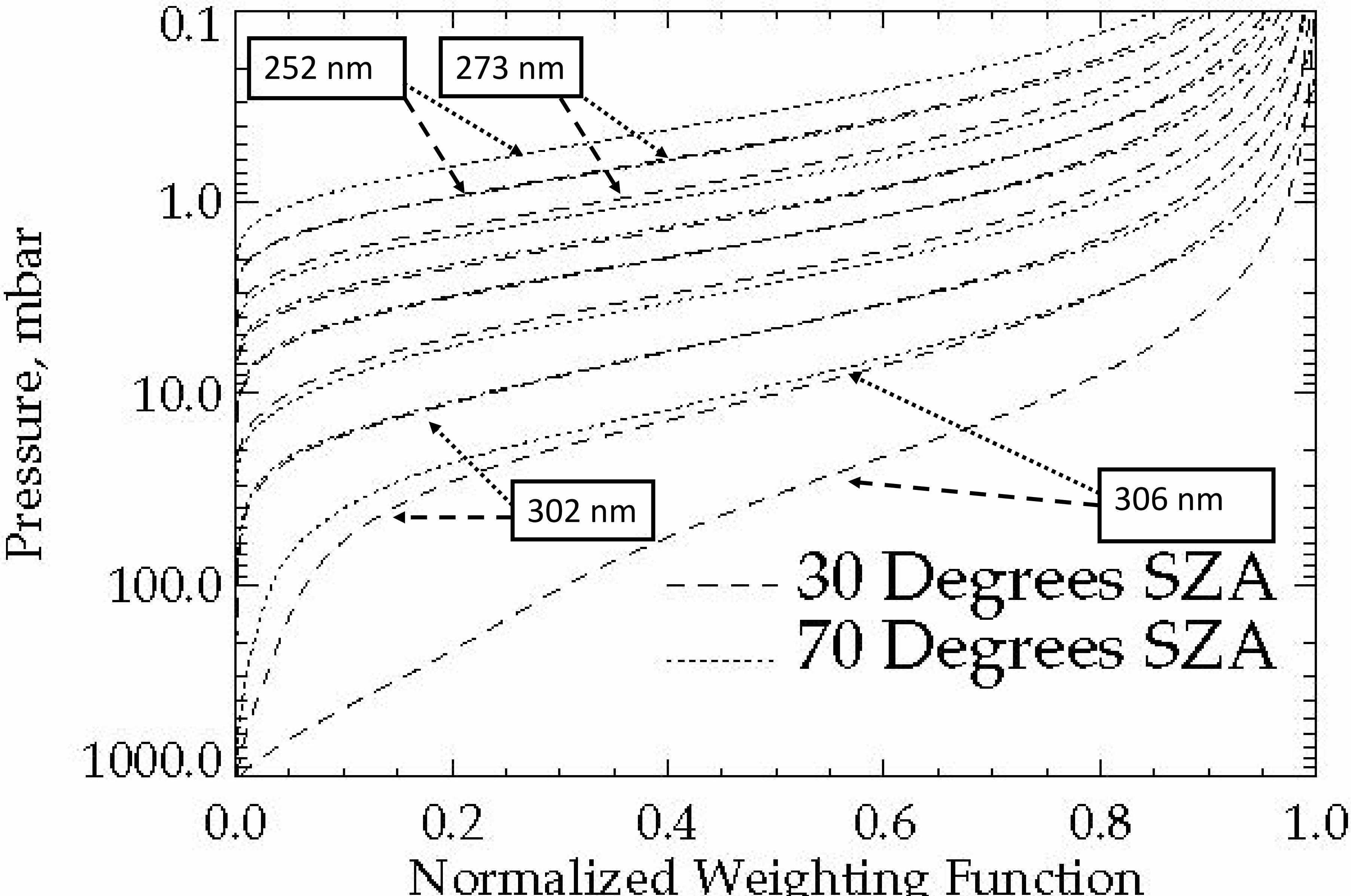
$$D_y = S_a K_a^T \left[ K_a S_a K_a^T + S_M \right]^{-1}$$




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**.

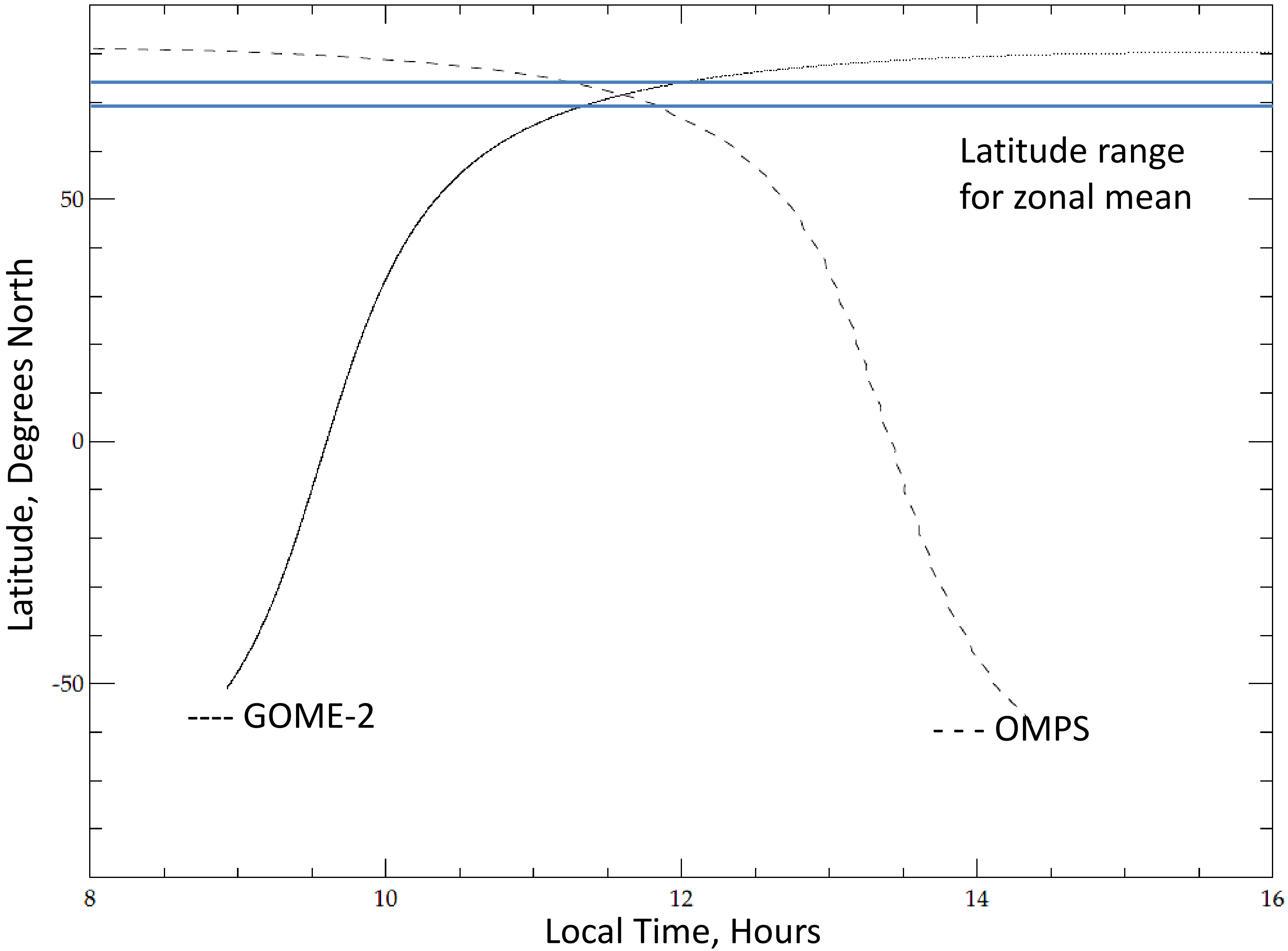
# Comparison Considerations

- 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

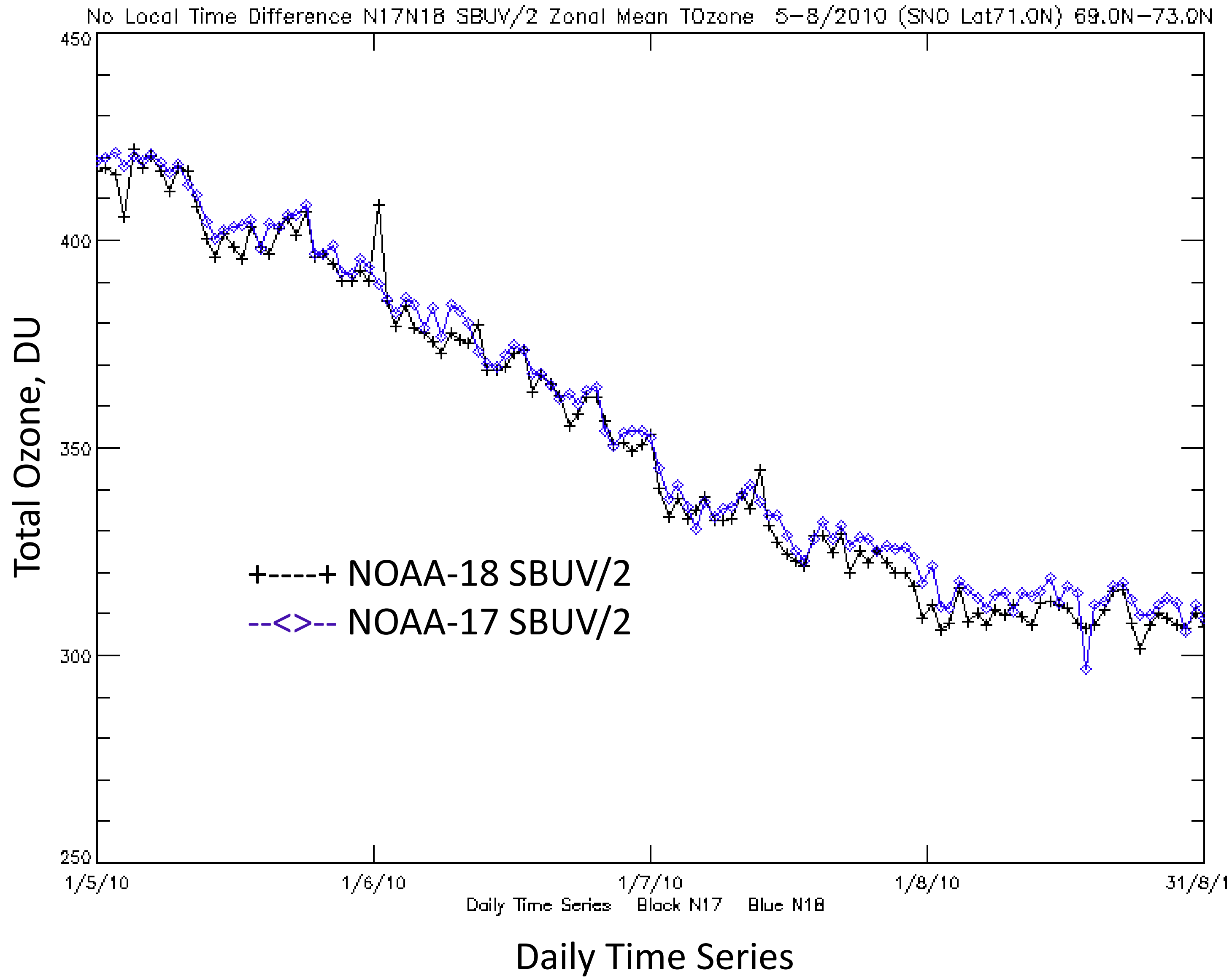



S1*α1 = S2* α2, Si = 1 + sec(SZAi) for nadir viewing

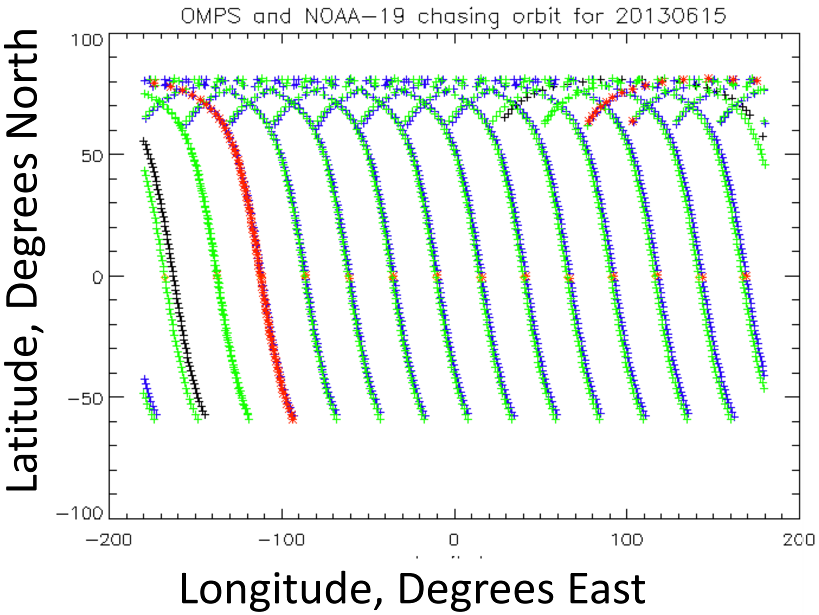
# Simultaneous Nadir Overpass and No Local Time Difference Comparisons



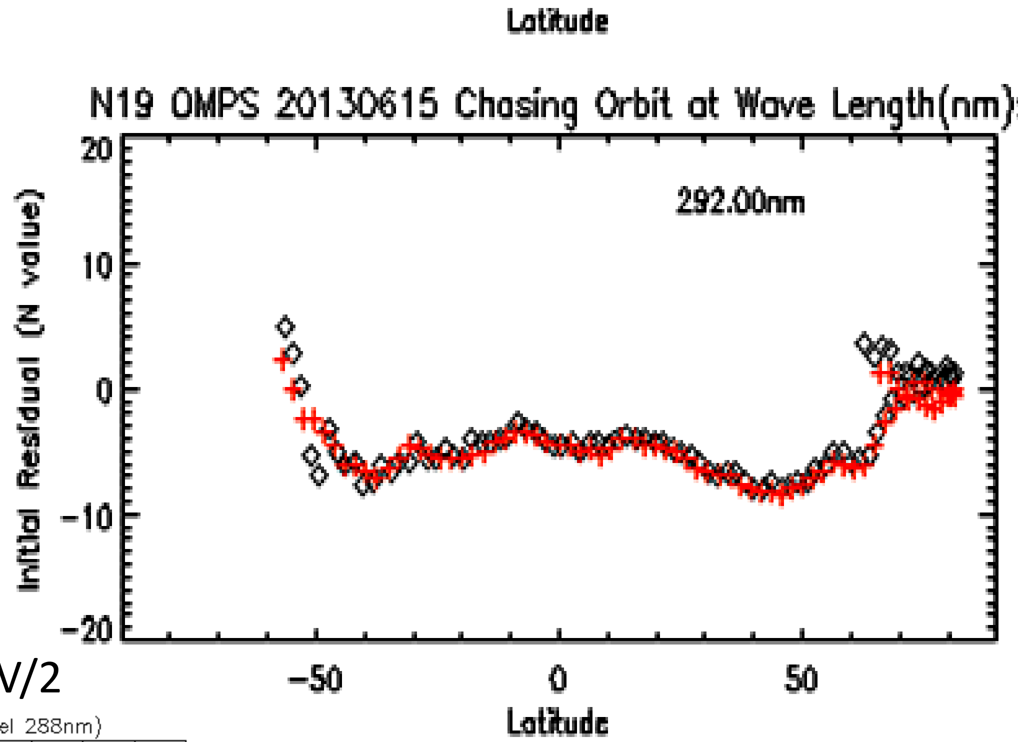
No Local Time Difference Comparisons, NOAA-17 SBUV/2 & NOAA-18 SBUV/2
May-August 2010, 69 N to 73 N, Daily Zonal Mean



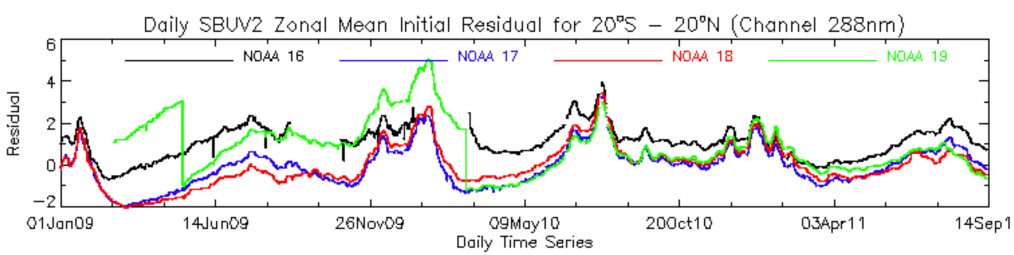
# Well-matched Orbits for 6/15/2013

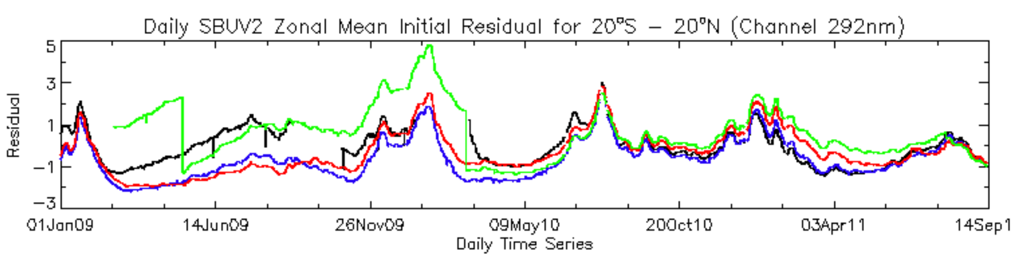



## Comparison of Initial V6 Measurement Residuals for S-NPP OMPS NP and NOAA-19 SBUV/2




## 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

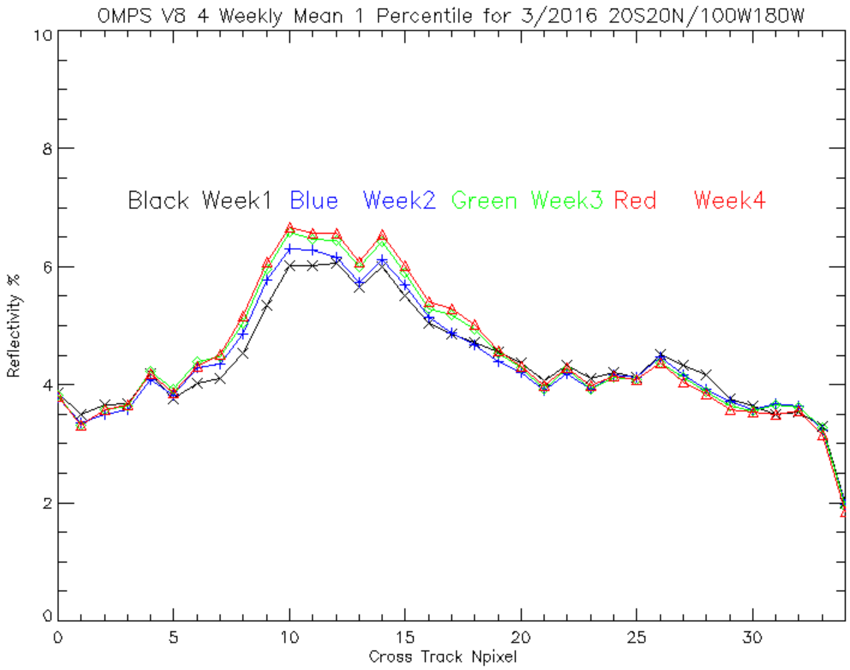
# Version 8 Total Ozone Algorithm

- 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

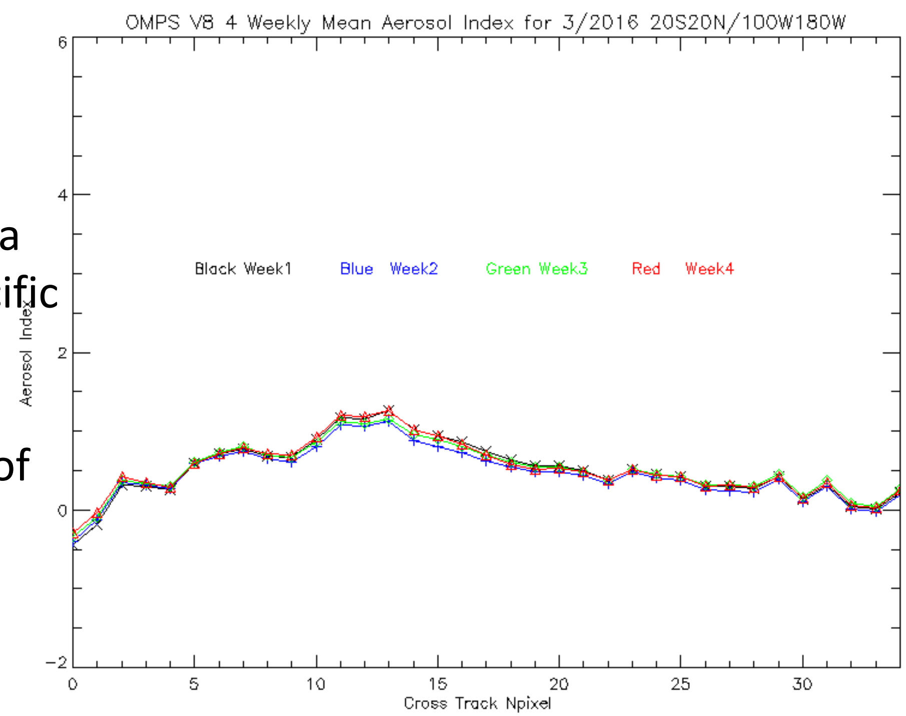
- The lines on the next slide show weekly 1-percentile effective reflectivity, total column ozone and aerosol index values (measurement residuals for wavelengths in the 360-nm range using effective reflectivity calculated for the 331-nm range) for the V8 algorithm for all the data in a latitude/longitude 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.

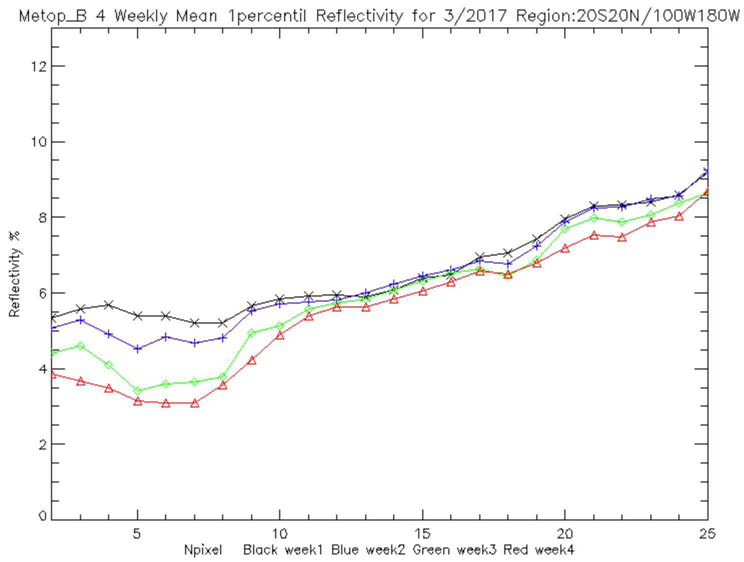
# Cross-Track Internal Consistency for OMPS

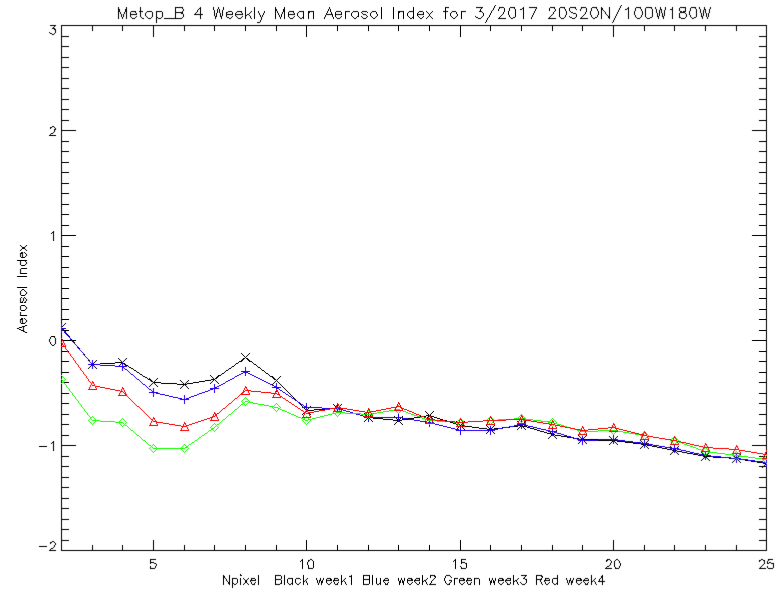


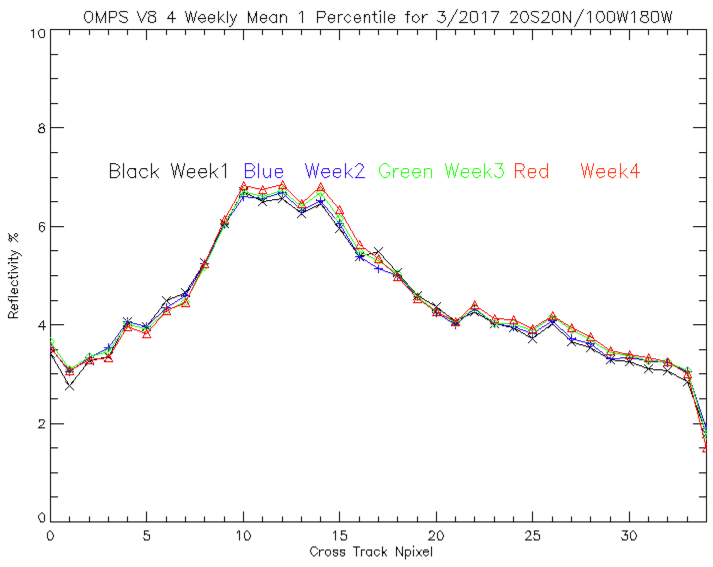

← Weekly Effective Reflectivity values for the V8 algorithm for March2016 for all the data in a latitude/ longitude box in the Equatorial Pacific versus cross-track view position, 17 is nadir. We expect the values to be approximately 5% for this region of the globe. The cross-track variations for positions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

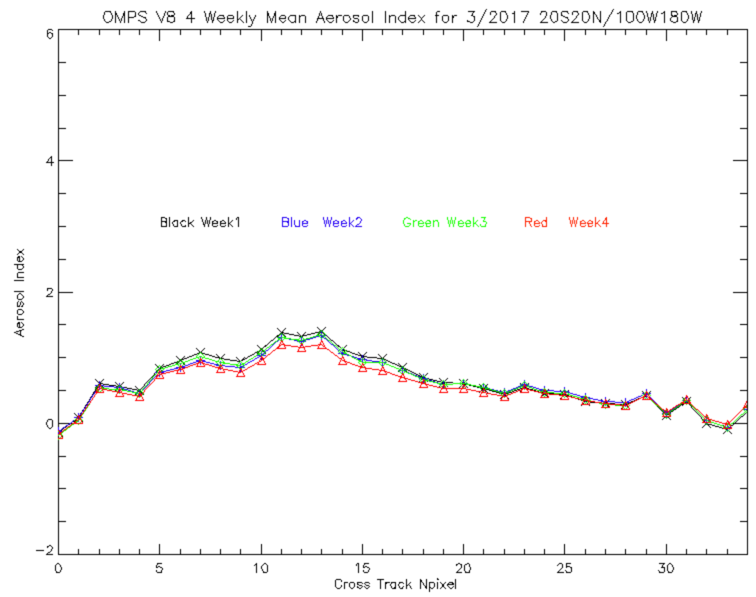
Weekly Aerosol Index values for the V8 → algorithm for March 2016 for all the data in a latitude/ longitude box in the Equatorial Pacific versus cross-track view position, 17 is nadir. We expect the aerosol index values to be approximately zero N-values for this region of the globe. The cross-track variations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



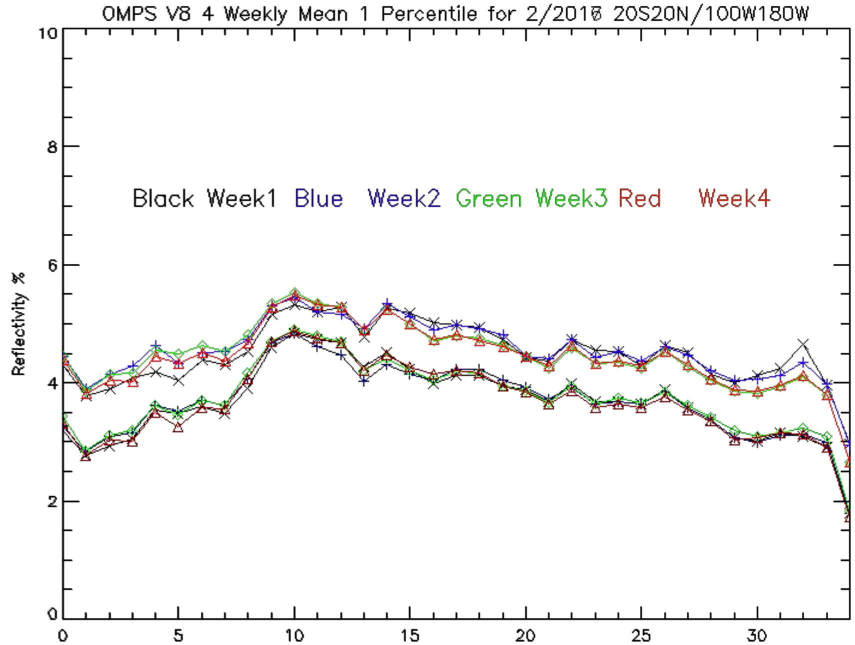

Metop_B 4 Weekly Mean 1percentil Reflectivity for 3/2017 Region:20S20N/100W180W
Reflectivity %
Npixel Black week1 Blue week2 Green week3 Red week4

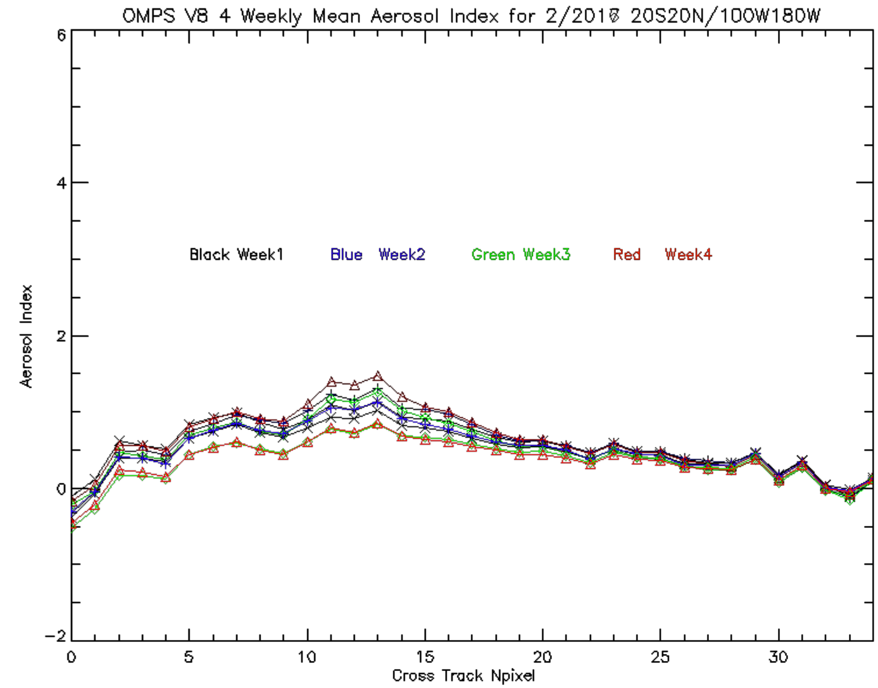

Metop_B 4 Weekly Mean Aerosol Index for 3/2017 20S20N/100W180W
Aerosol Index
Npixel Black week1 Blue week2 Green week3 Red week4

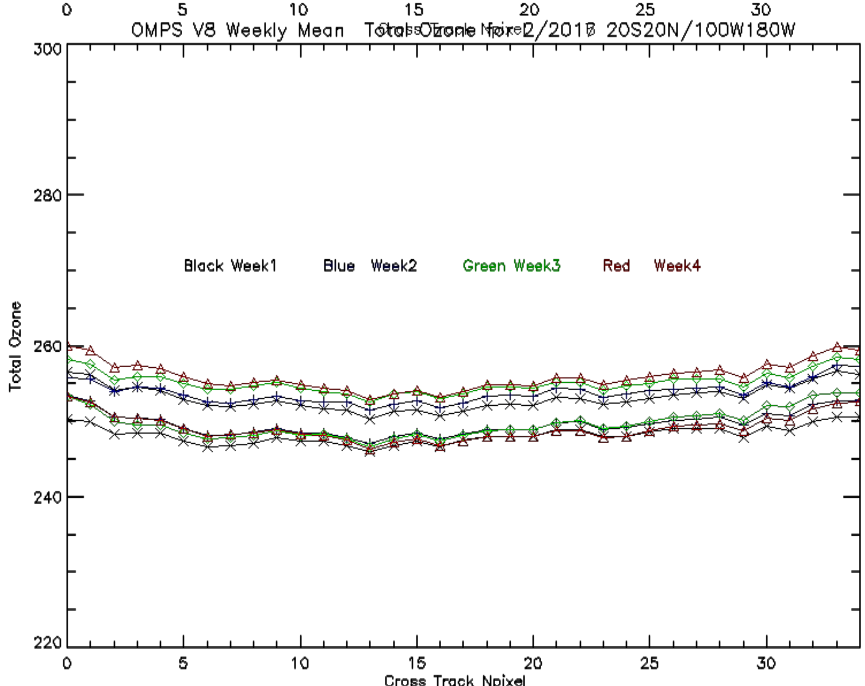

OMPS V8 4 Weekly Mean 1 Percentile for 3/2017 20S20N/100W180W
Black Week1 Blue Week2 Green Week3 Red Week4
Reflectivity %
Cross Track Npixel


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

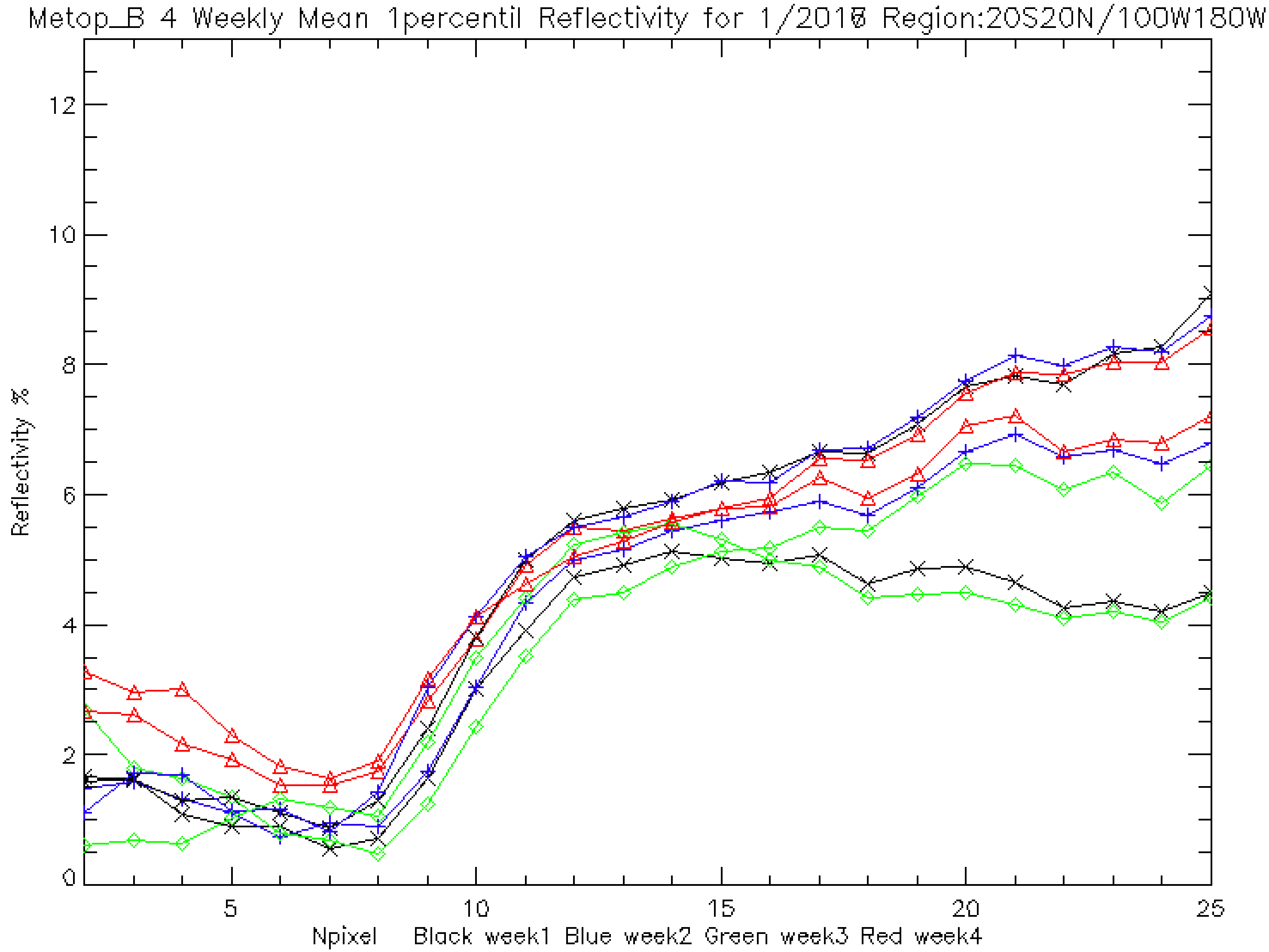
# Weekly Averages over the Target Area



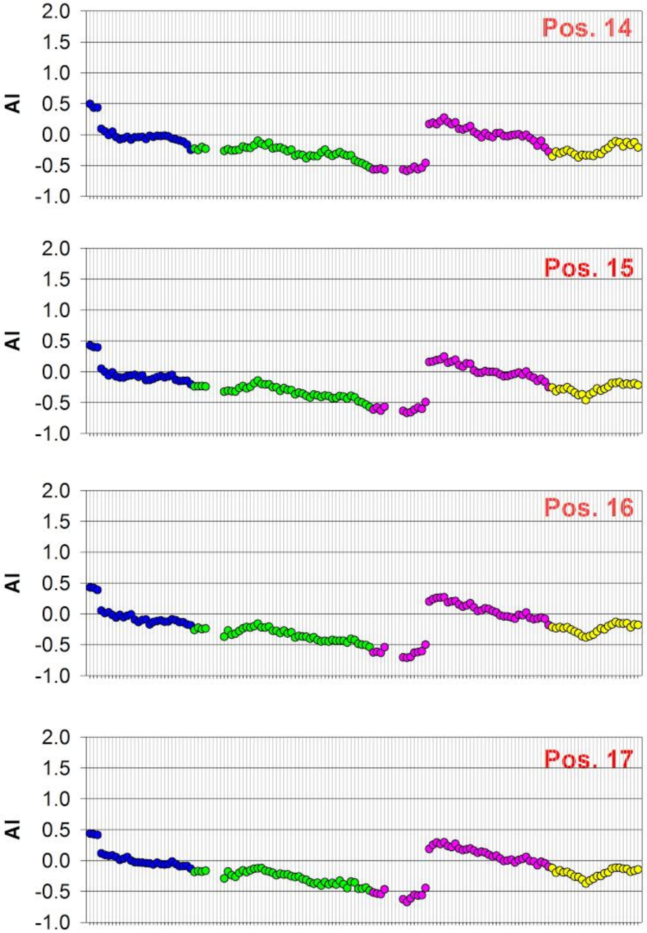




Weekly values for February 2017 for OMPS V8 Total Ozone algorithm products fading to weekly values for February 2016. We need to use the reprocessed SDR data and redo these figures.



Metop_B 4 Weekly Mean 1percentil Reflectivity for 1/2017 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

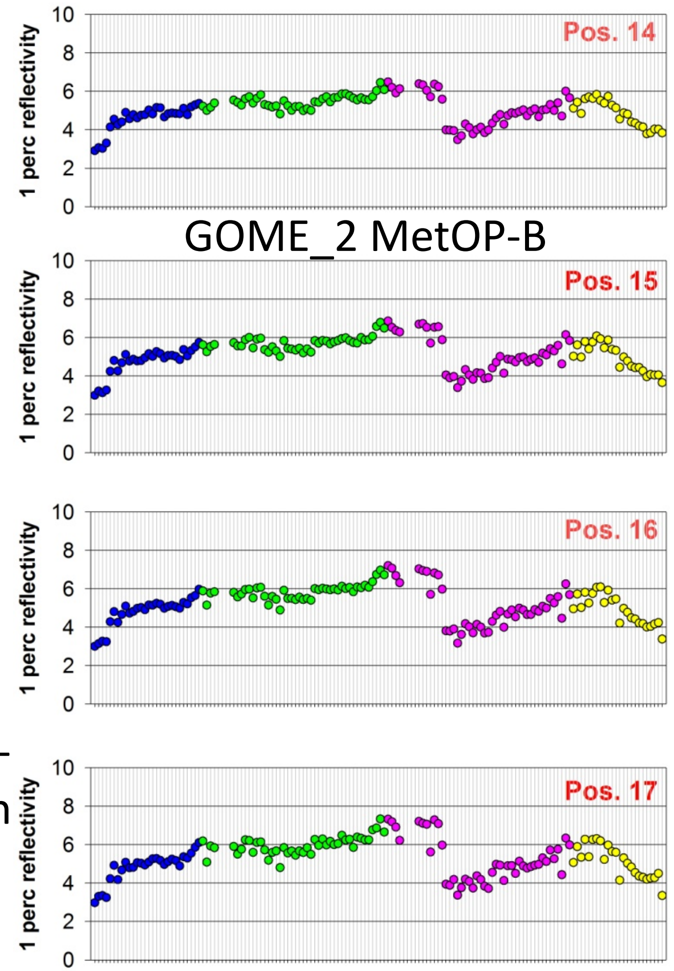
# We are examining the V8 TOMS algorithm reflectivity and Aerosol Index Values for an Equatorial Pacific Region for OMPS, OMI and GOME-2




←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

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

$A1 = dN318/dR$, $B1 = dN318/d\Omega$, $C1 = \Delta N318$
$A2 = dN331/dR$, $B2 = dN331/d\Omega$, $C2 = \Delta N331$
$D = [A1 * B2 - A2 * B1]$ $-D = [A2 * B1 - A1 * B2]$

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:

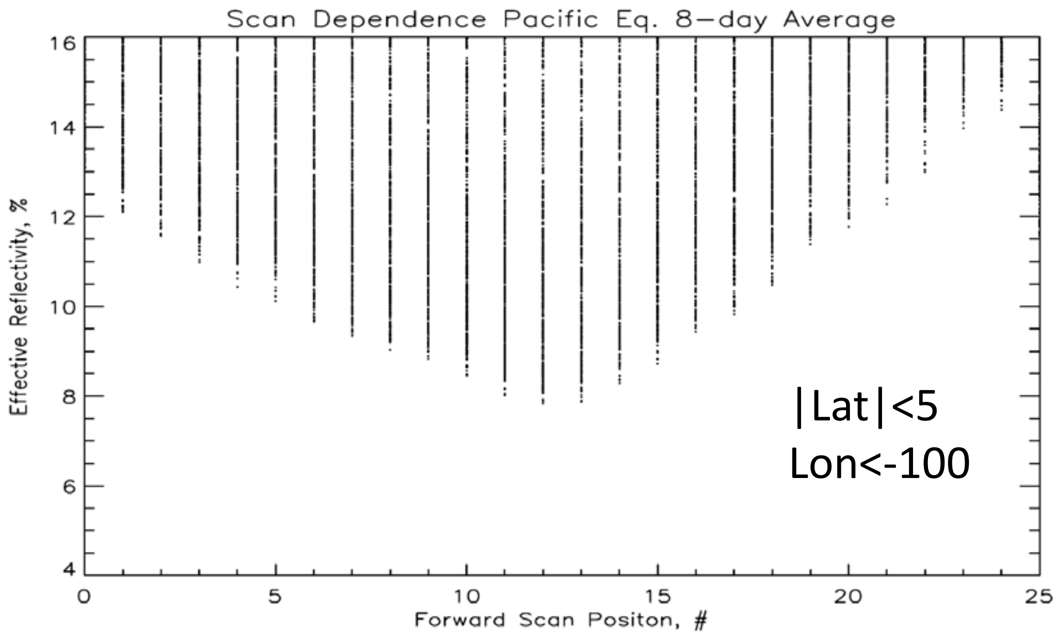
$$C1i = \Delta N318i = dN318/dxi \quad C2i = \Delta N331i = dN331/dxi$$
$$\Delta\Omega i = [A2 * C1i - A1 * C2i] / [A2 * B1 - A1 * B2]$$
$$Ei = \Delta\Omega i / [SUM(\Delta\Omega i) / N]$$

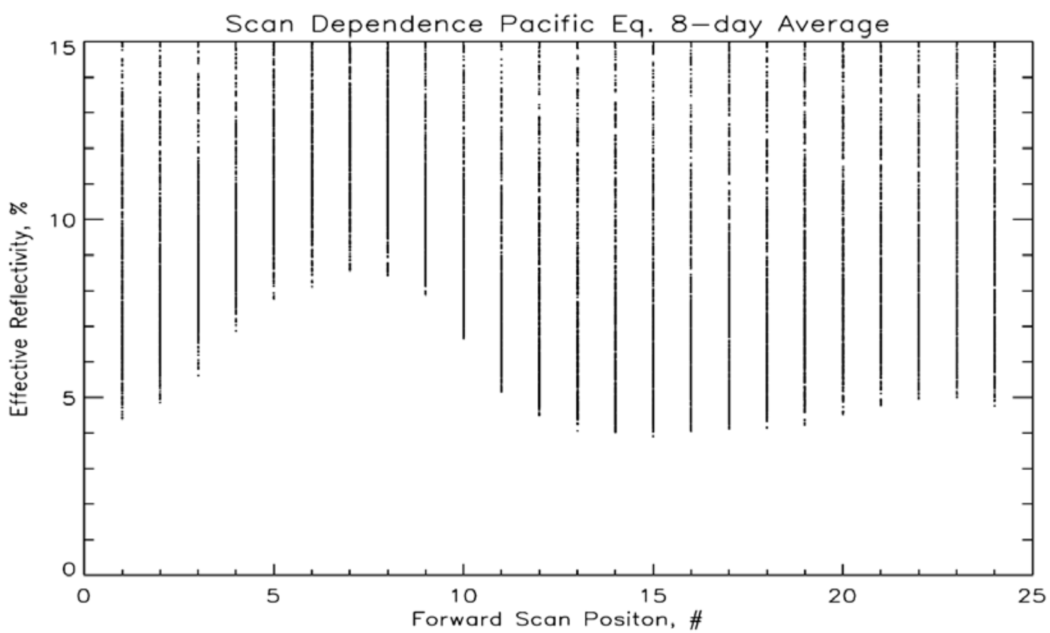
This assumes all ozone changes are absolute (e.g., in DU). These values should blend the clear and cloudy results appropriately by using the radiative fractions.

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.

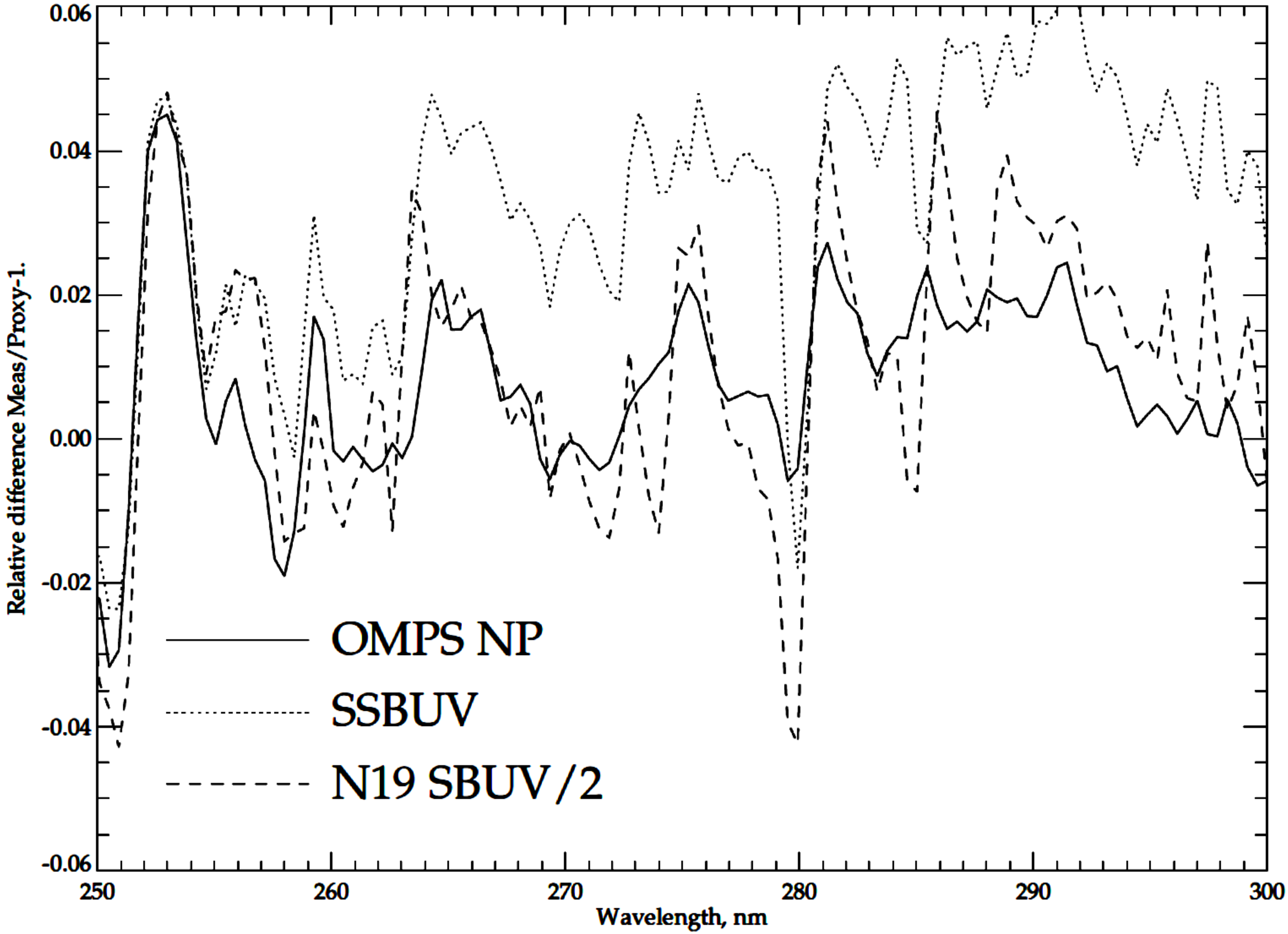
# Summary, Questions & Future

- 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?

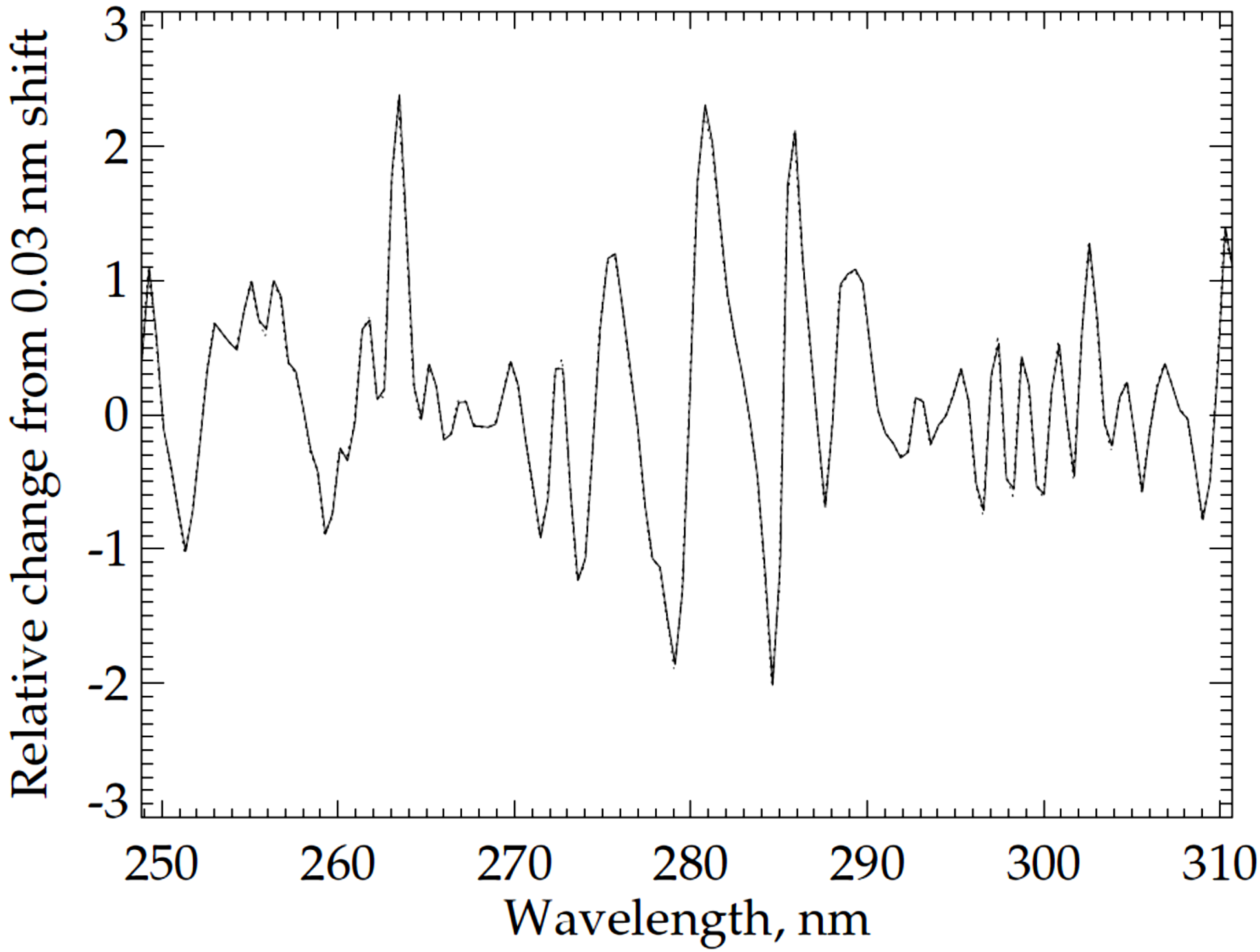
# Project to Compare Solar Measurements

- 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

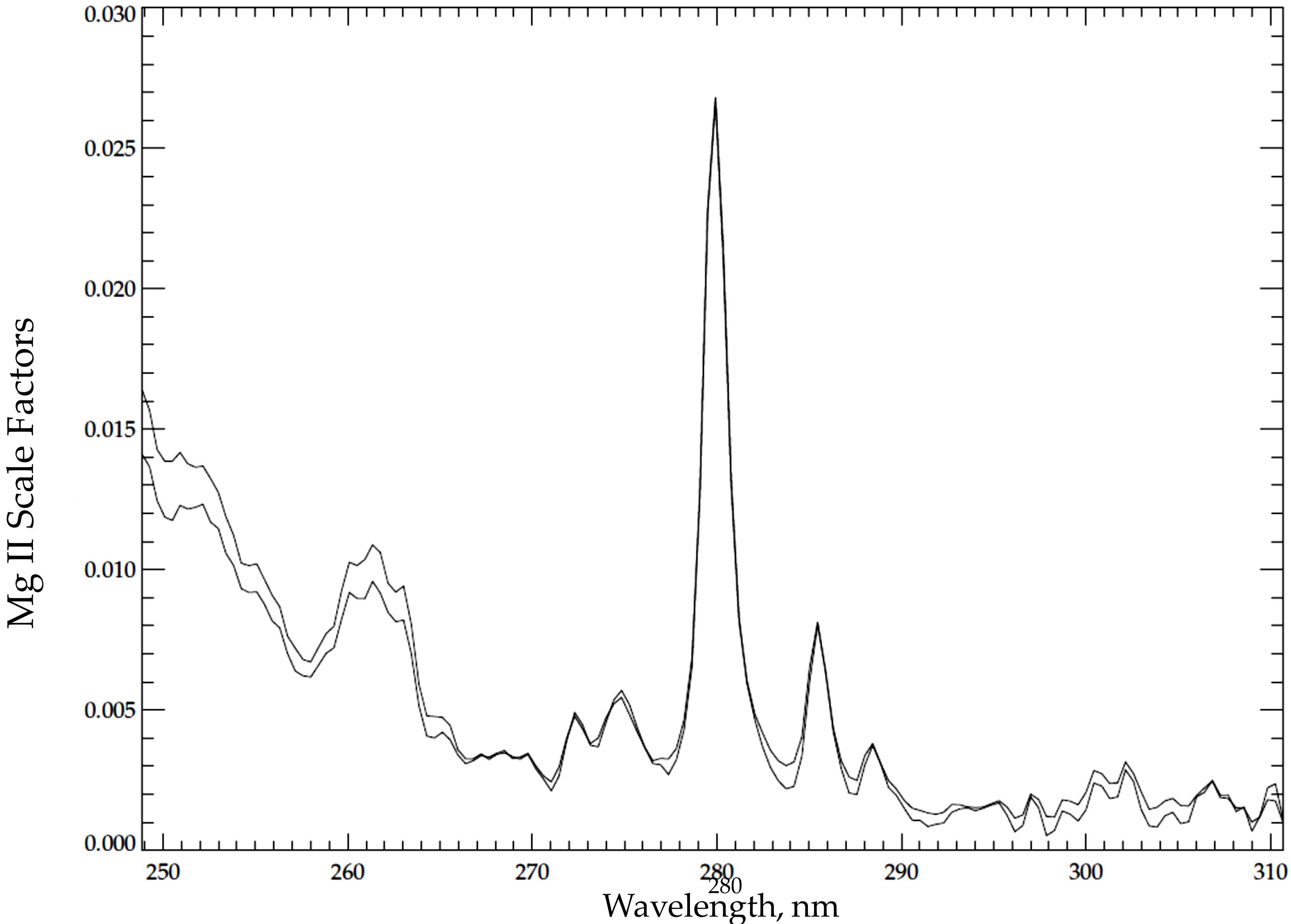
# Solar Measurement Comparisons to KNMI Proxy



# 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

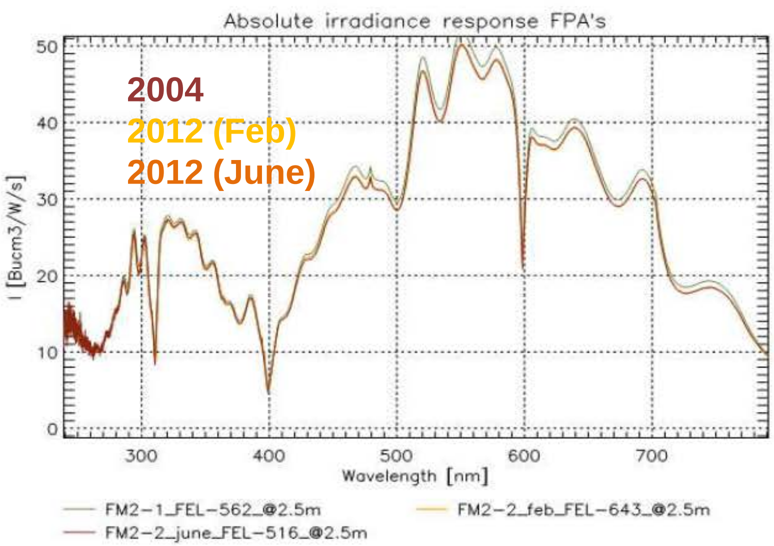
IX..........?

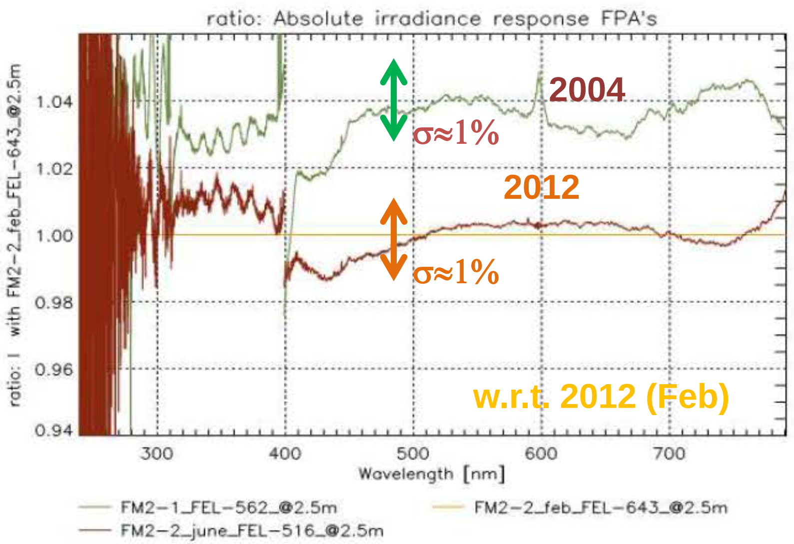
*Editor: Ruediger Lang,*
*Co-Editors: Marcel Dobber, Rose Munro*

## Some selected examples

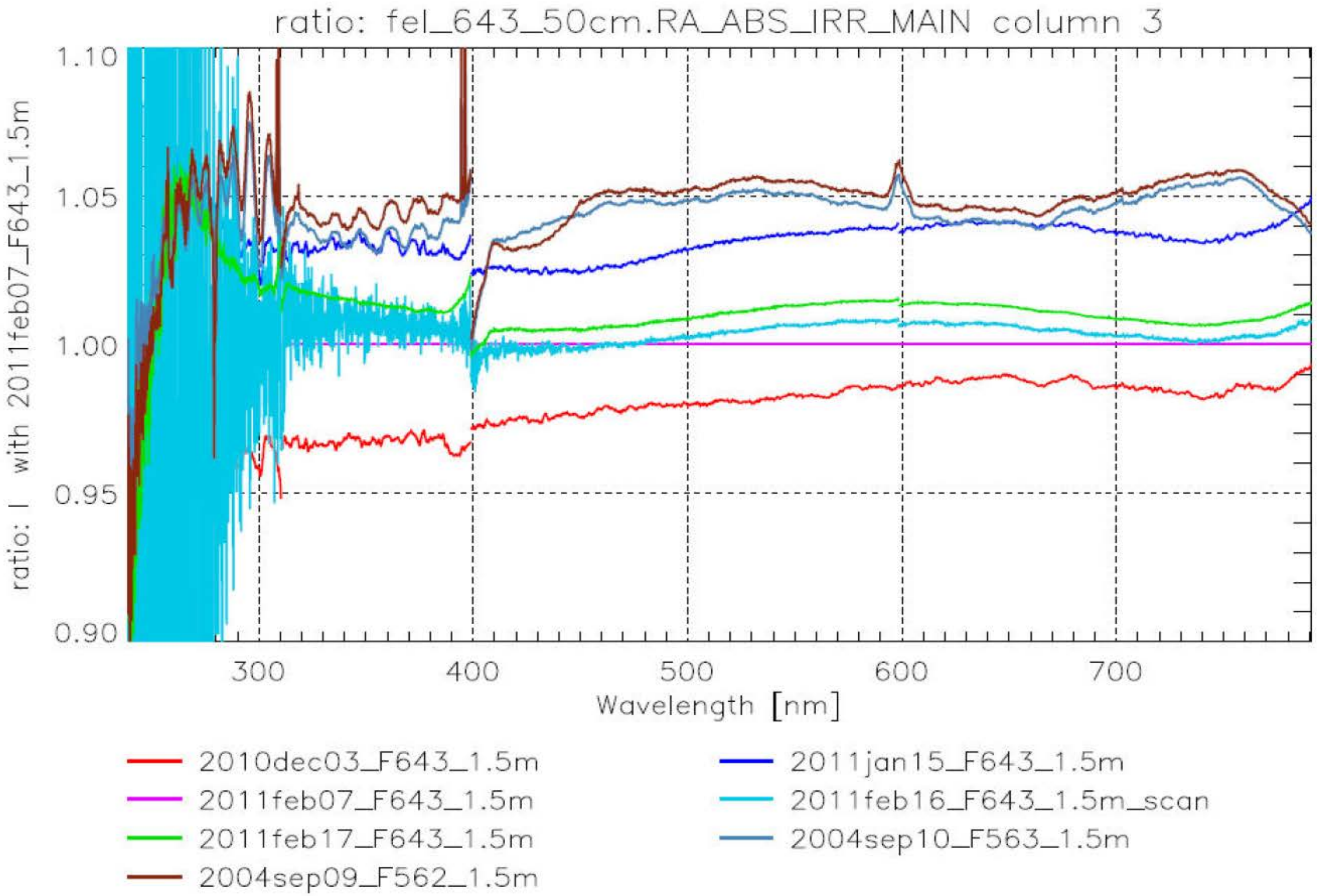
GOME-2 FM2
Metop-B

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



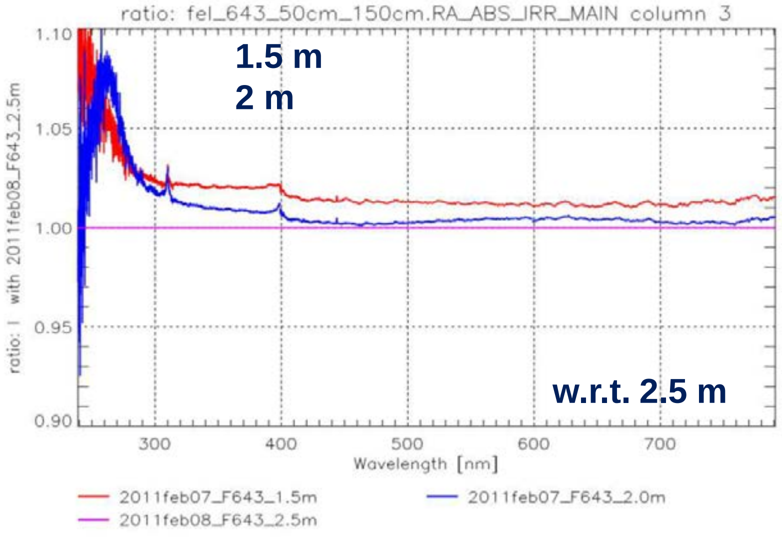



GOME-2 FM2
Metop-B

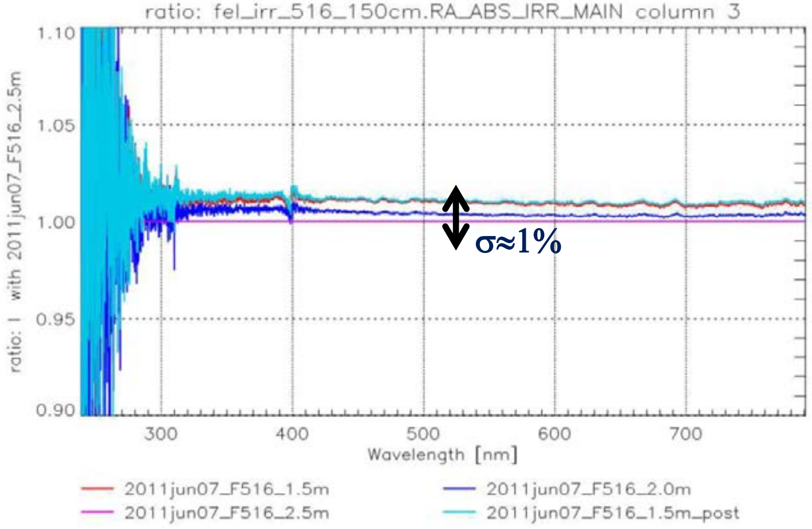


GOME-2 FM2
Metop-B

Multiple source / instrument distance measurements

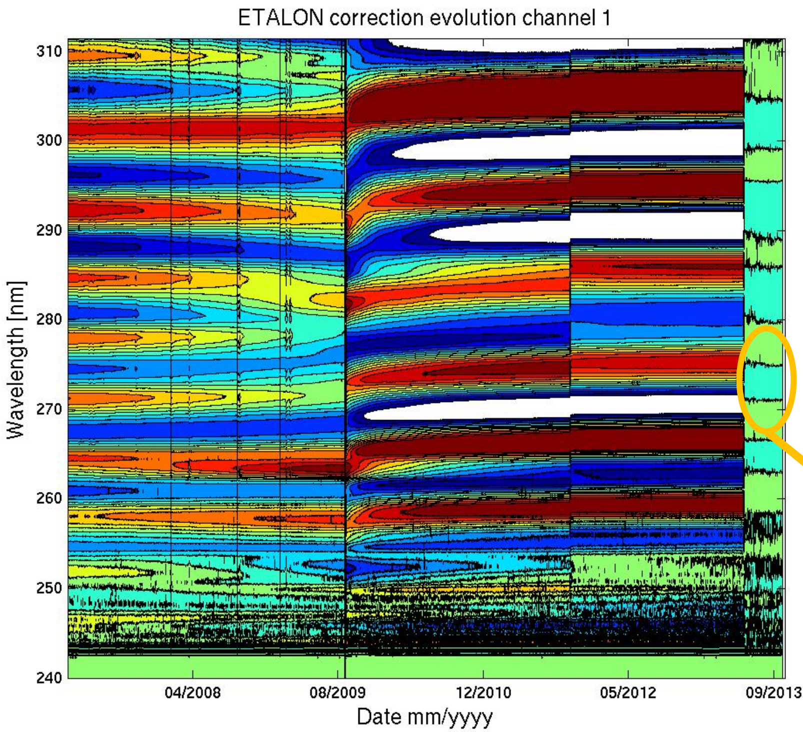


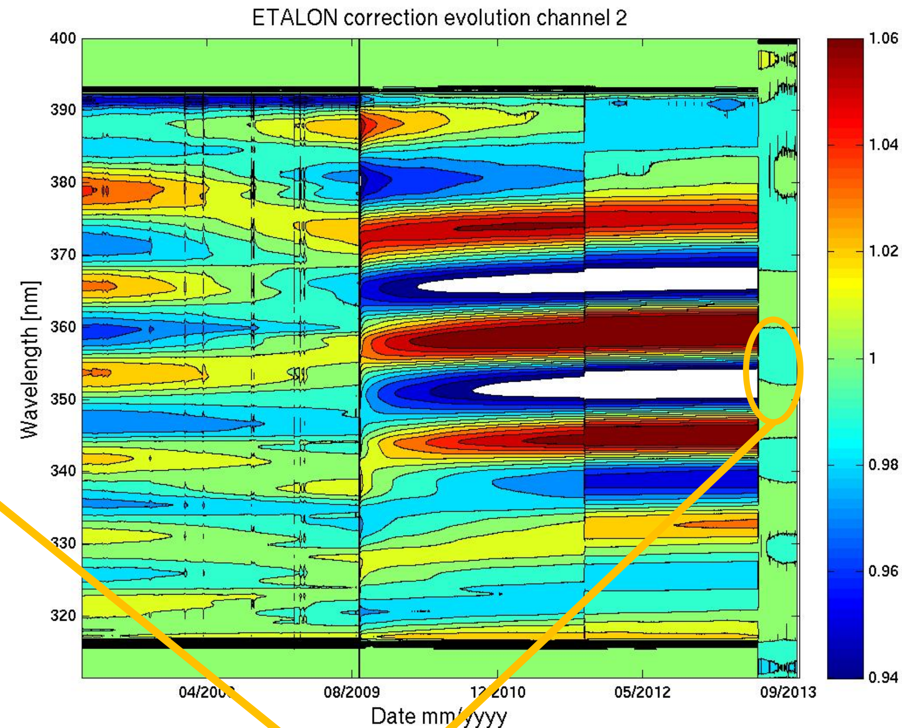

Final setup and alignement procedures




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

**GOME-2 FM3**
**Metop-A**

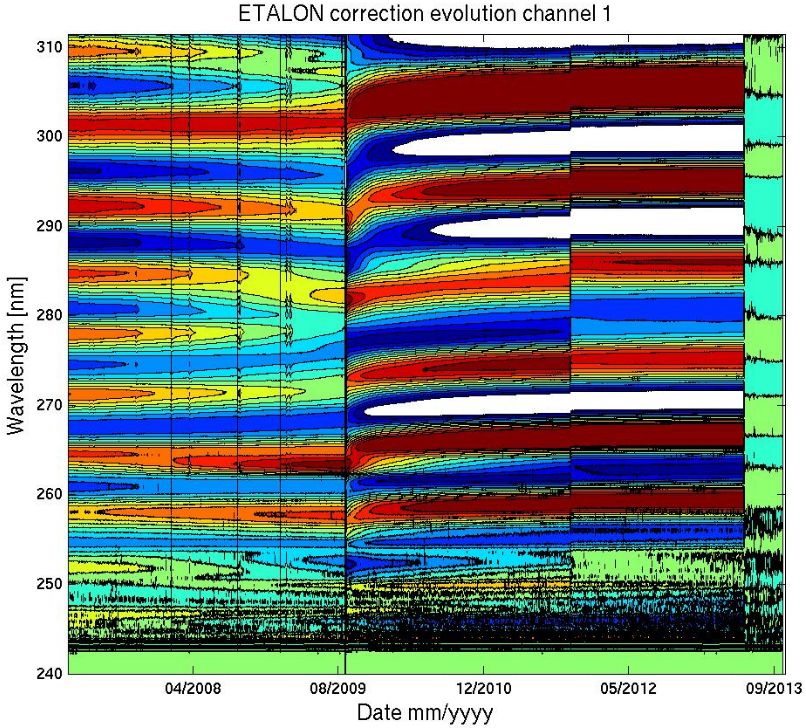


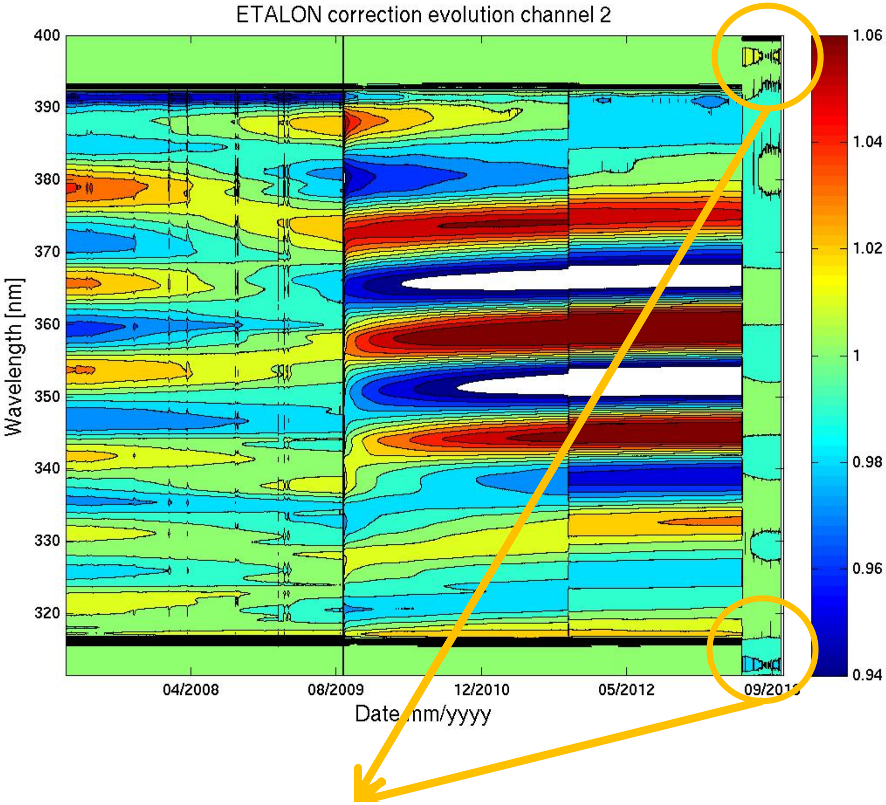




Modification of on-ground radiometric response functions to include in-orbit etalon

- 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

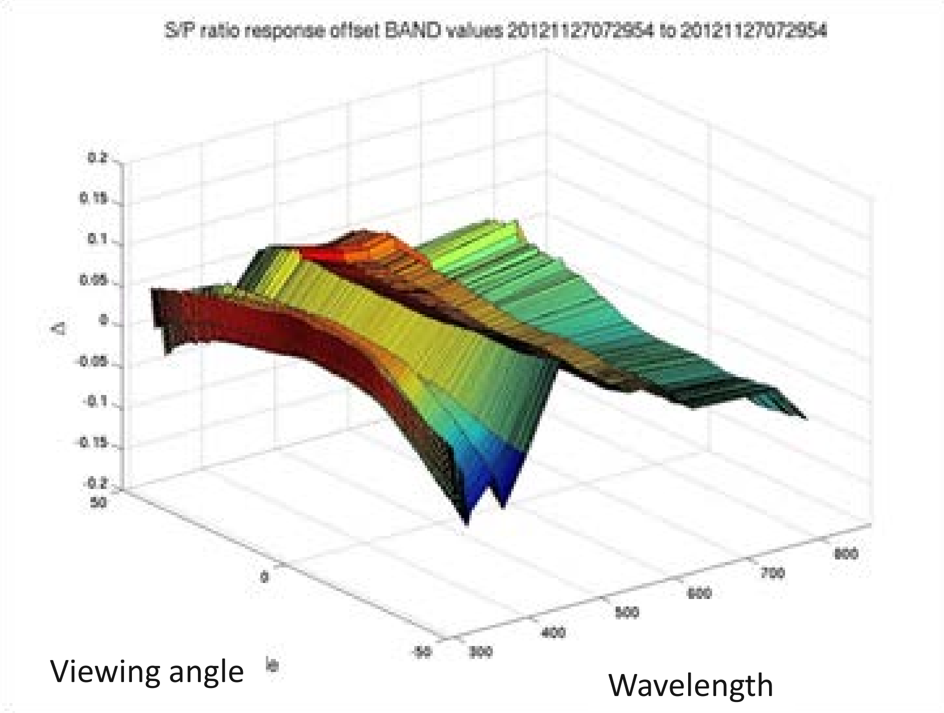
| |
|---|
| GOME-2 FM3 Metop-A |
| GOME-2 FM2 Metop-B |

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

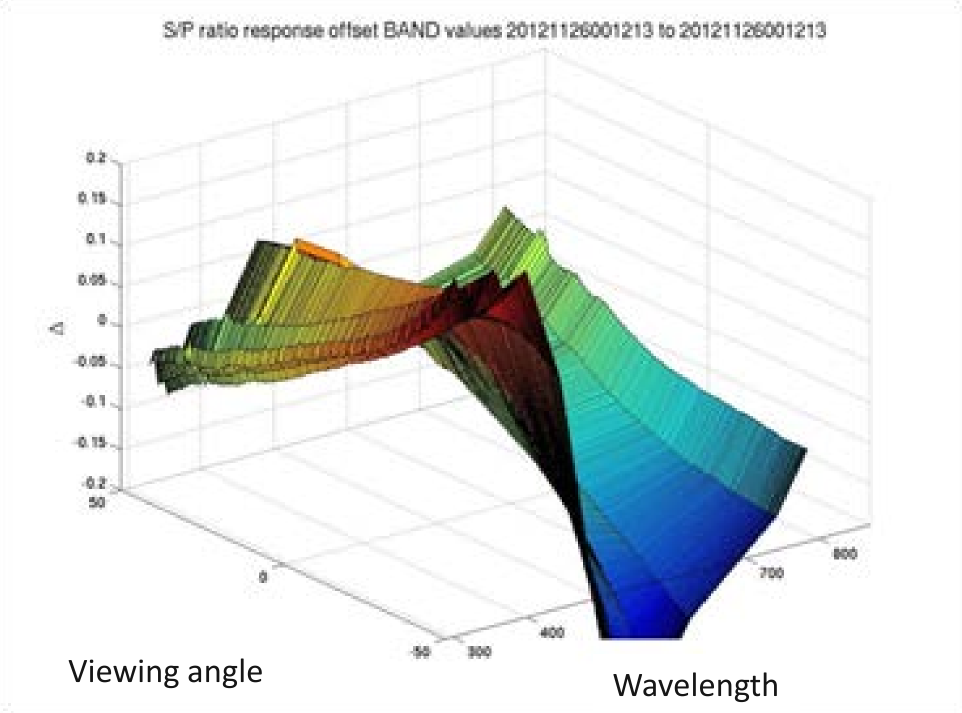
Used for aerosol retrieval (PMAp)
and for correction of polarisation sensitivity of the instrument

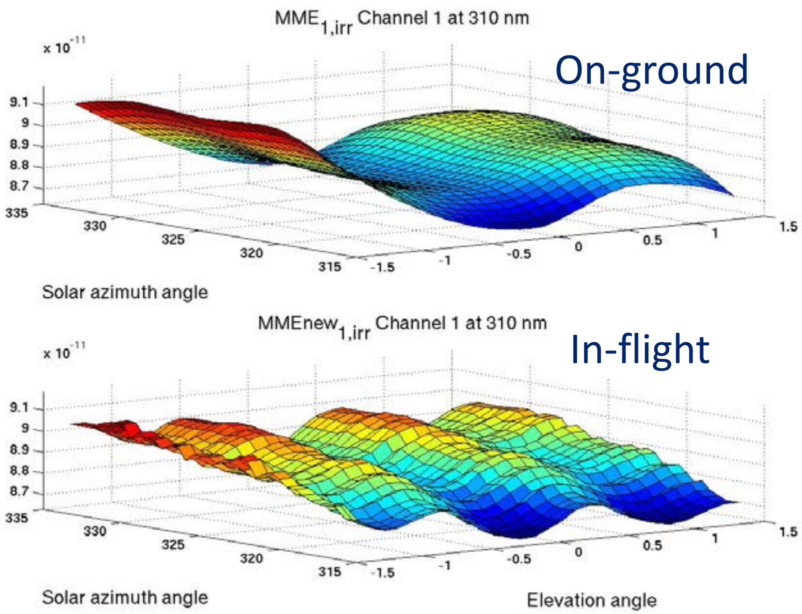
Correction surface automatically updated 2 to 4 times per month

## Metop-B / FM2



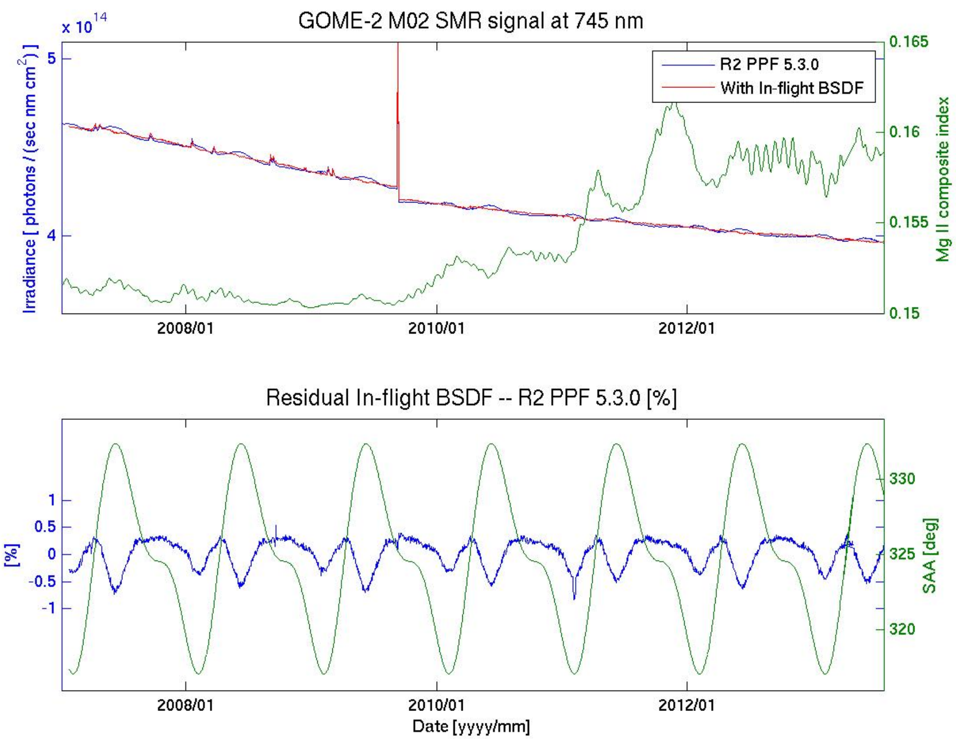

## Metop-A / FM3






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:*

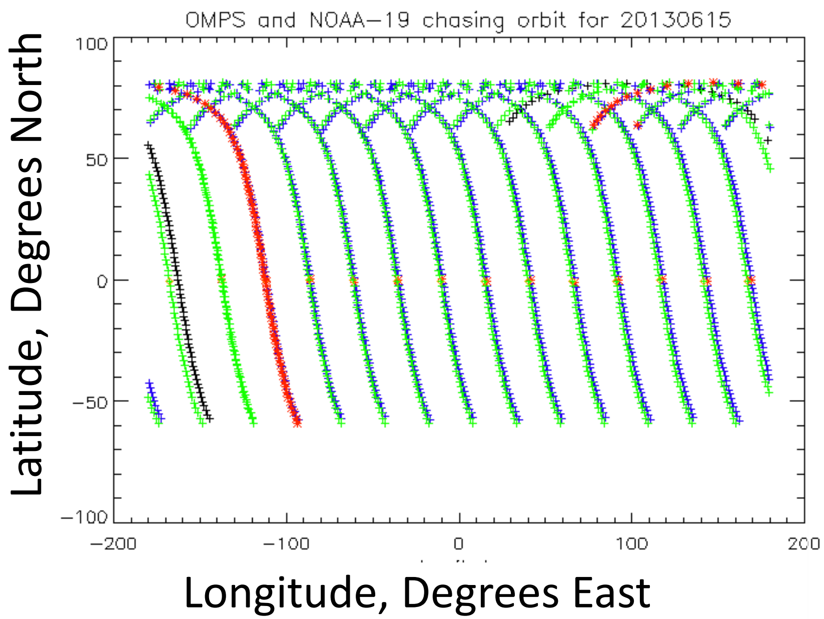
- What are we missing in the TOC?
- Do we want/need to have an "in-orbit" section?
- Do we want to include vicarious calibration?
- Do we need more fundamental/philosophical sections like:
    1. Calibration campaign organisation,
    2. Campaign schedules,
    3. Campaign planning, etc...?
- In-situ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

# Match-Up Comparisons

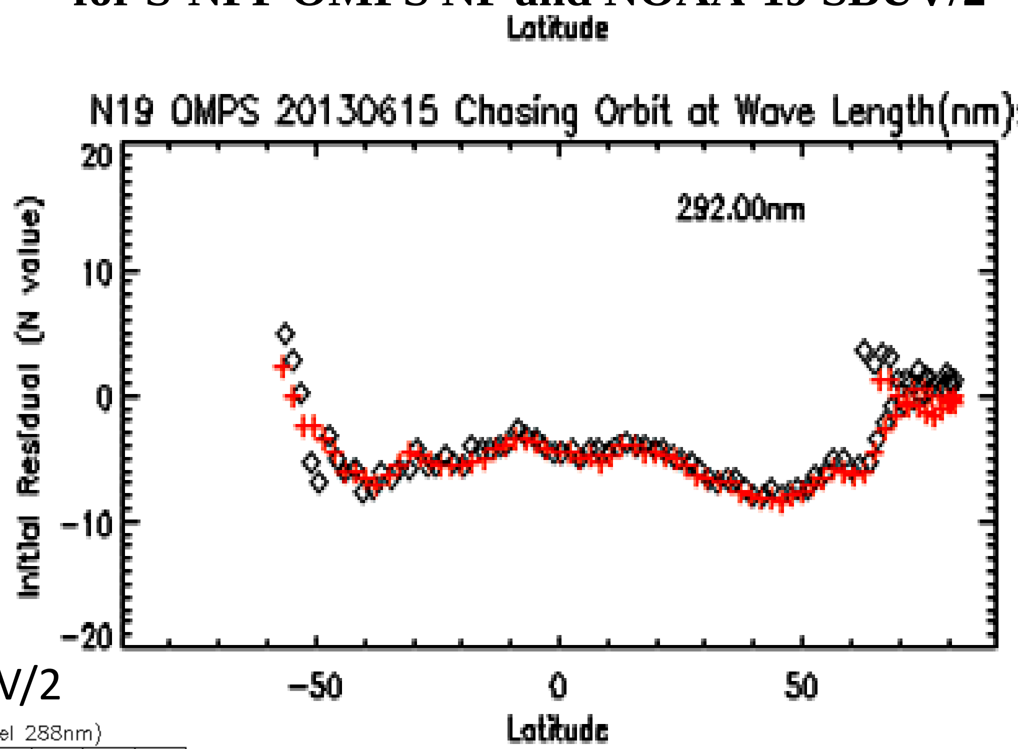
We would also like to expand the use of matchup comparisons for UV instruments. Current approaches include:

- 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 – $S1*\alpha1 = S2*\alpha2$)

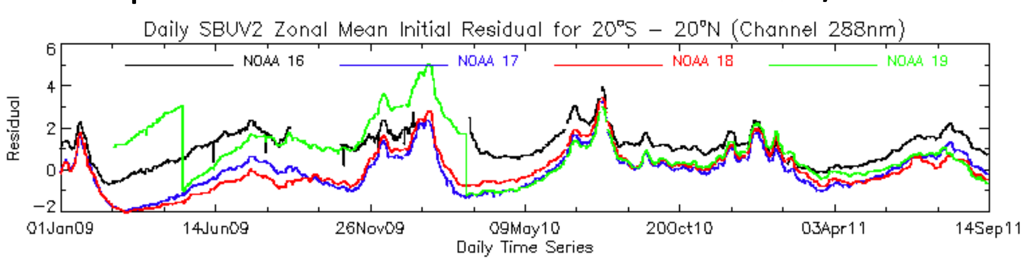
# Well-matched Orbits for 6/15/2013

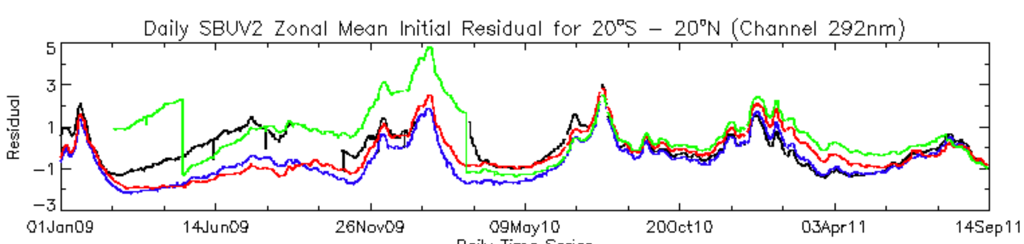



## Comparison of Initial V6 Measurement Residuals for S-NPP OMPS NP and NOAA-19 SBUV/2

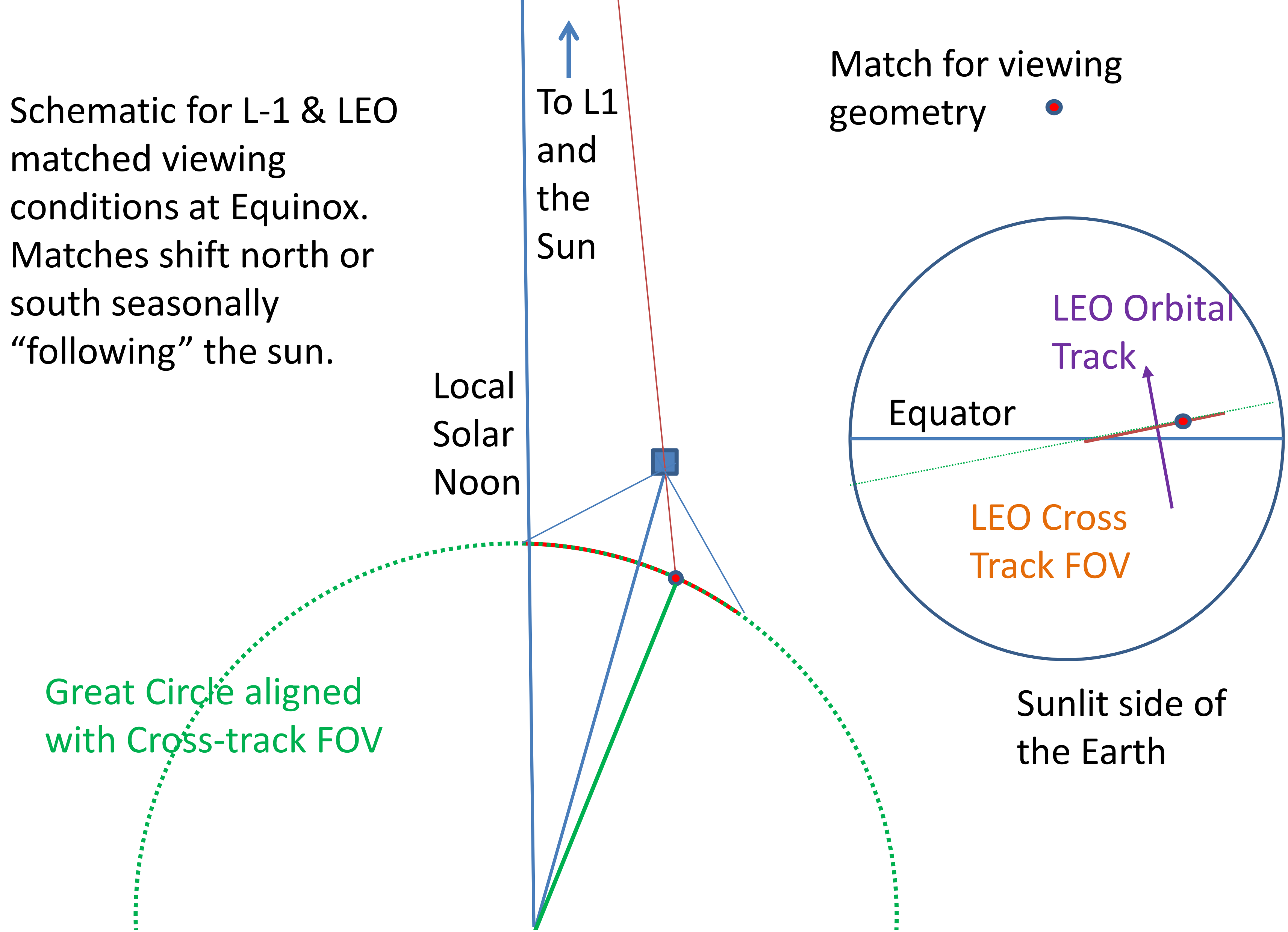



## Operational Initial Residuals for SBUV/2




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

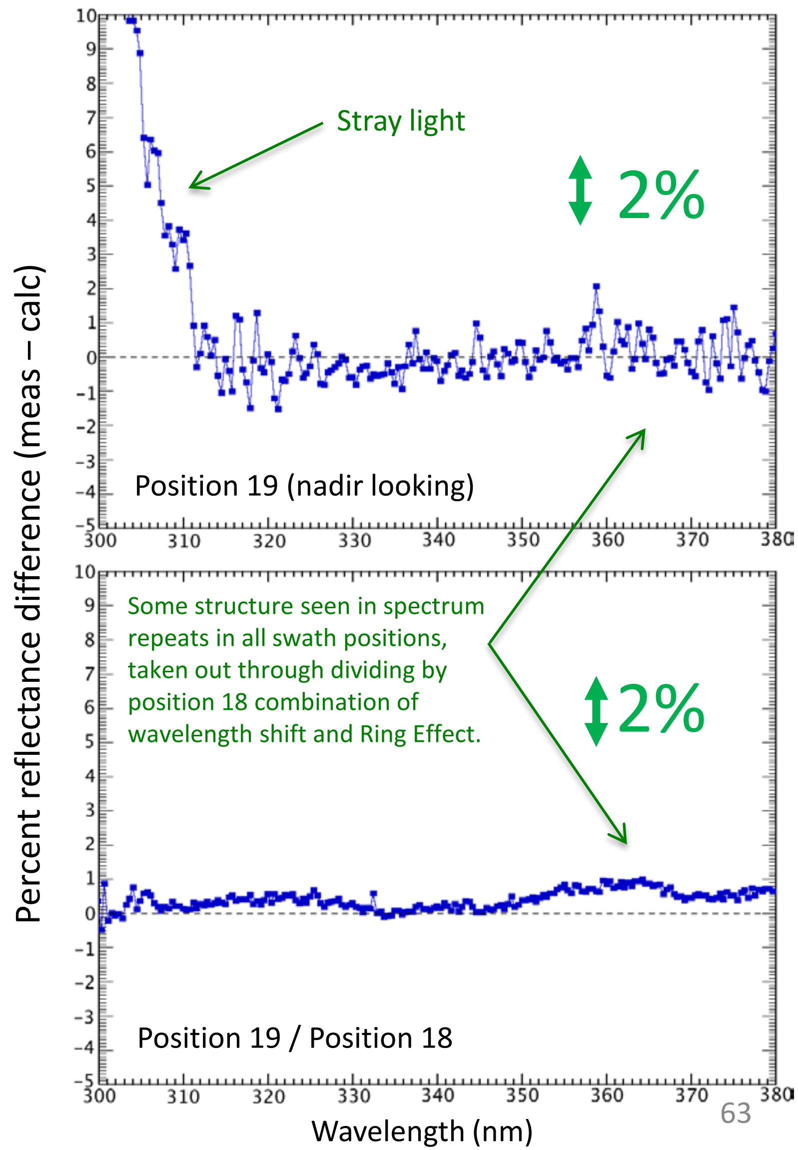



Simultaneous View Path (SVP) match up between DSCOVR EPIC at 0° offset with the Earth/Sun line and S-NPP OMPS. Matches will be present for any BUV instrument on a GEO platform with one in a LEO orbit as the LEO orbital tracks pass near the GEO sub-satellite point.

# *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



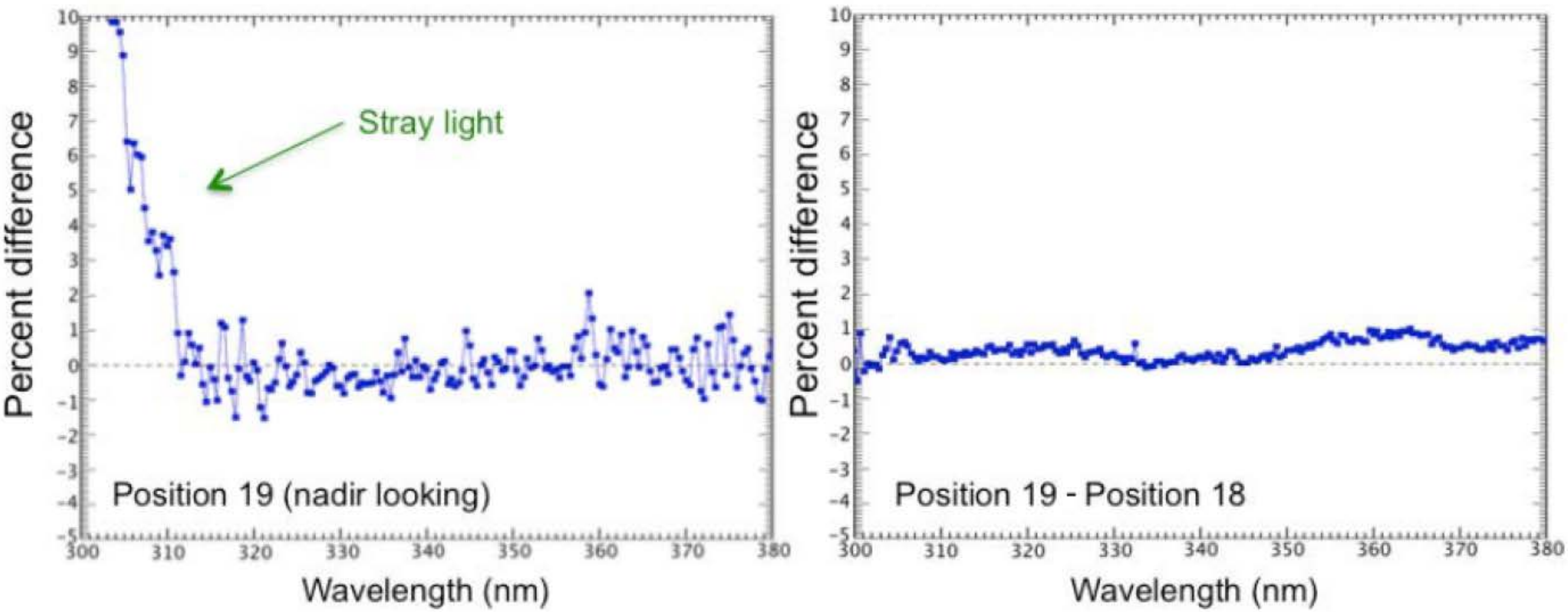


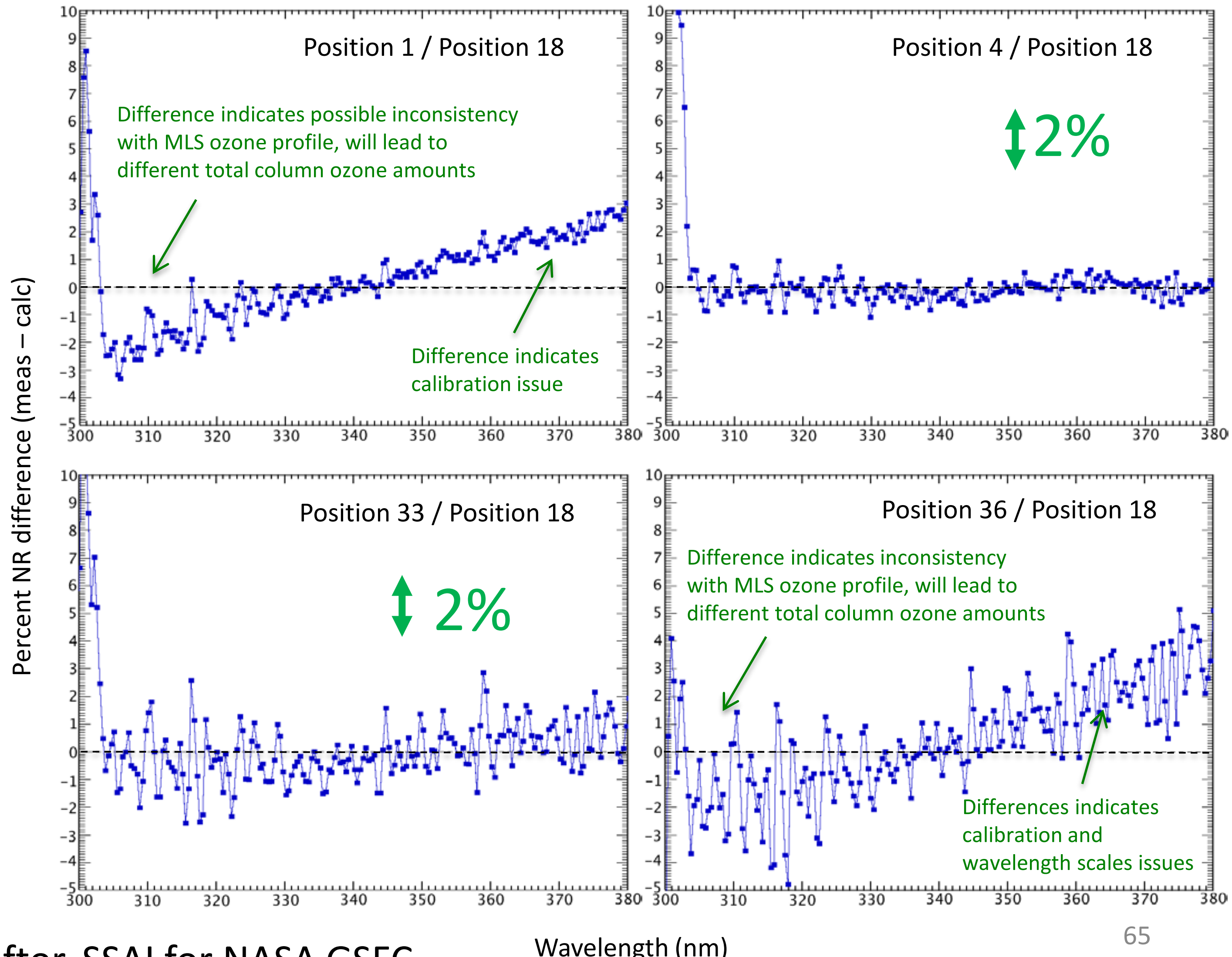

Figure 4: The left plot shows a comparison of normalized radiances calculated using MLS ozone and temperature profiles co-located with OMPS retrievals using the OMPS viewing conditions for cross-track position 19. The average is over 20 degrees south to 20 degrees north latitude for June. In the right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

Results from C. Seftor, SSAI for NASA GSFC

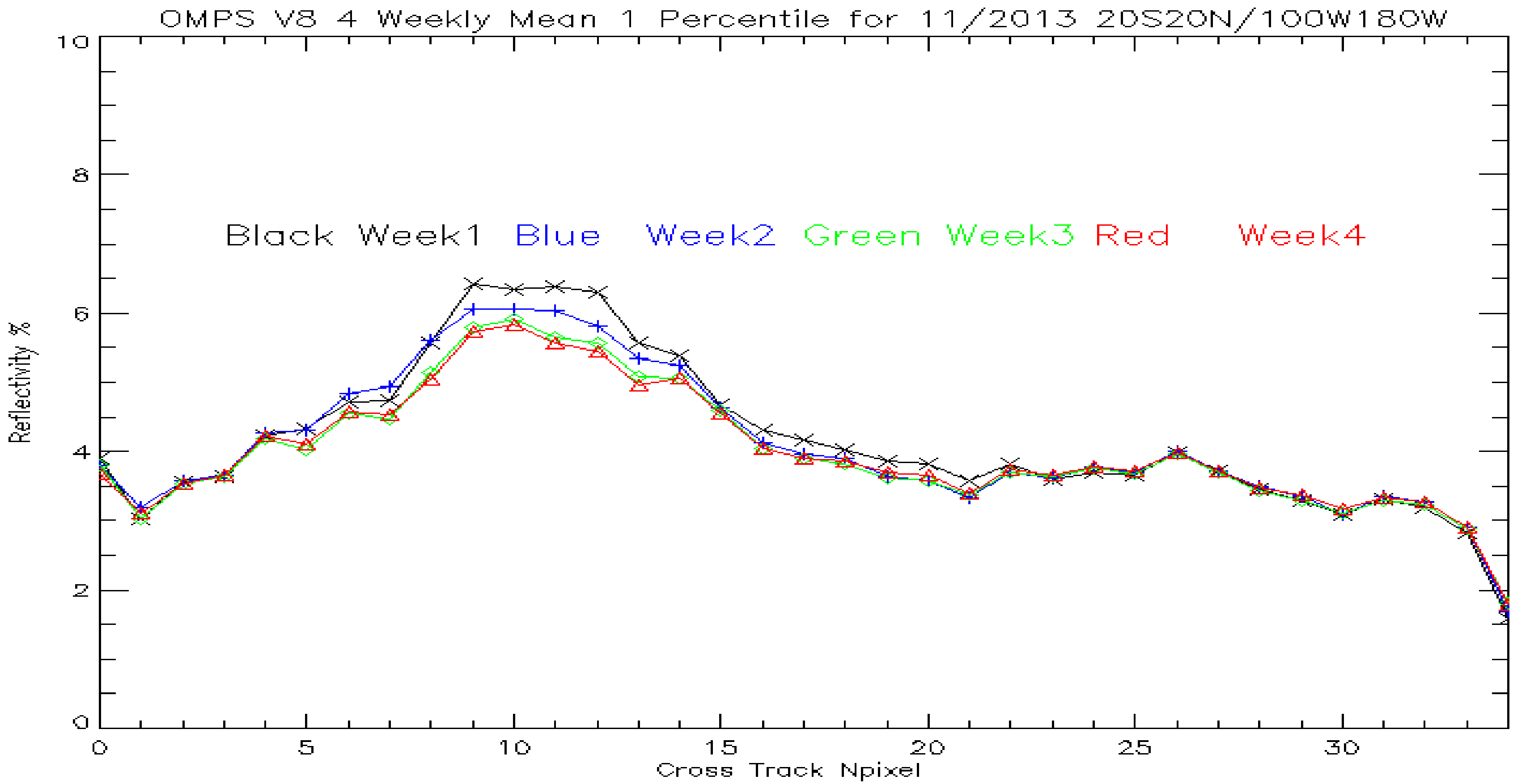
# *OMPS TC cross-track calibration is typical;*
# *Will require soft calibration adjustments.*

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

**Not unusual but should be corrected.**

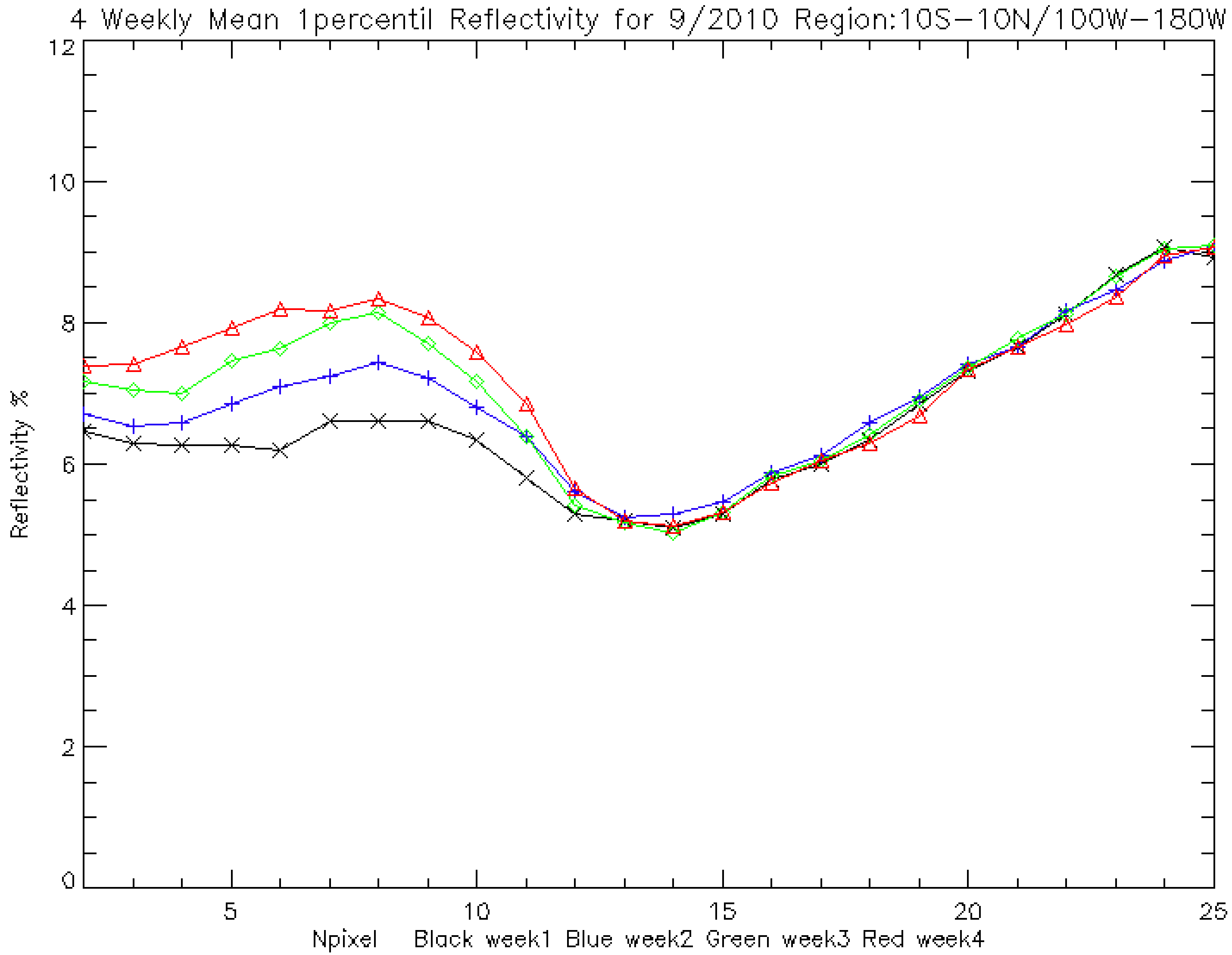


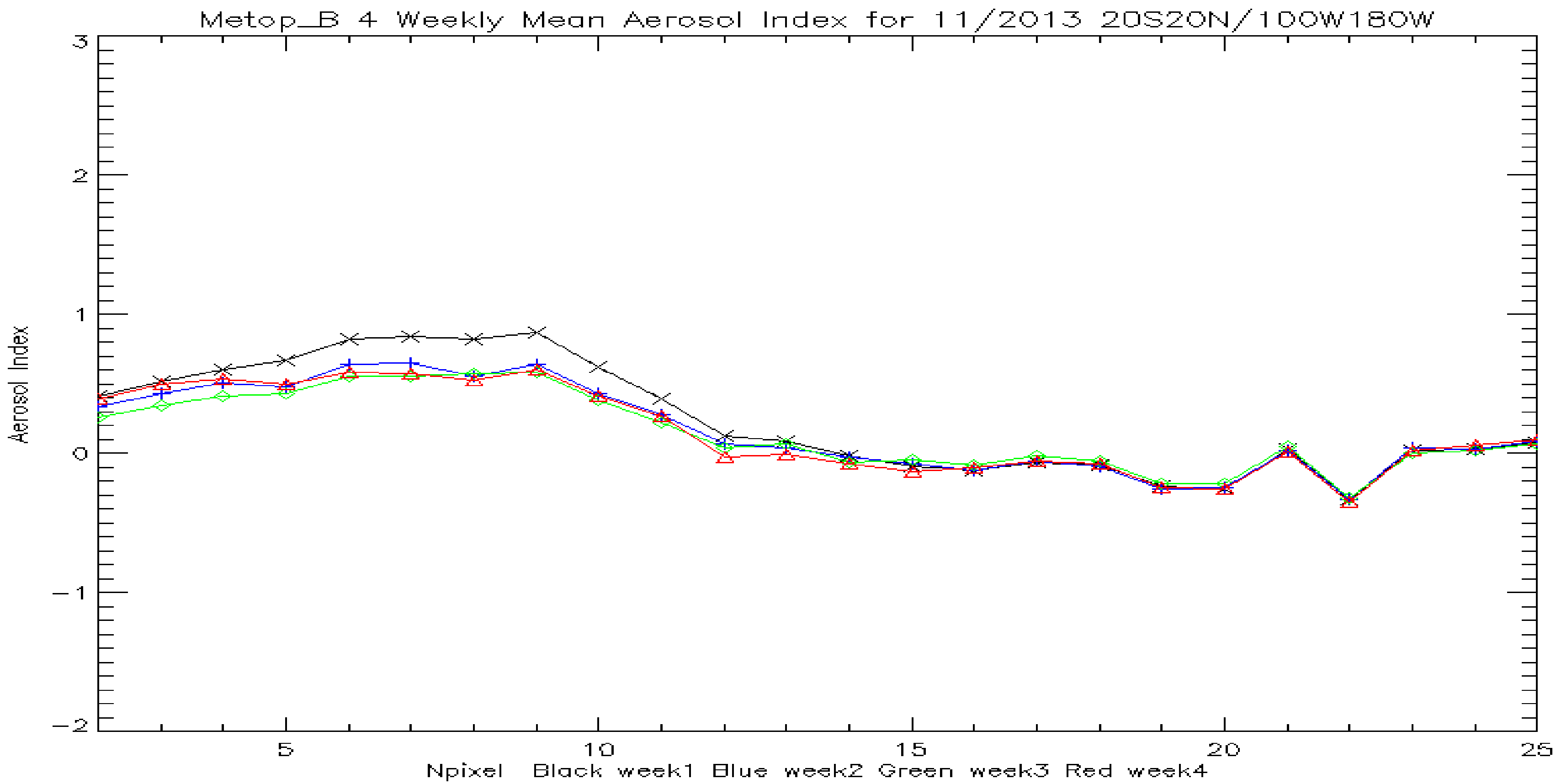

MLS results from C. Seftor, SSAI for NASA GSFC




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