OMPS EDR Overview

Ozone EDR Products

OMPS EDR Team

August 25, 2015

Outline

- SNPP/JPSS-1 OMPS Overview
- Algorithm and Cal/Val Team Members
- S-NPP Ozone Overview
- JPSS-1 Readiness and Upgrades
- Summary and Path Forward

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)

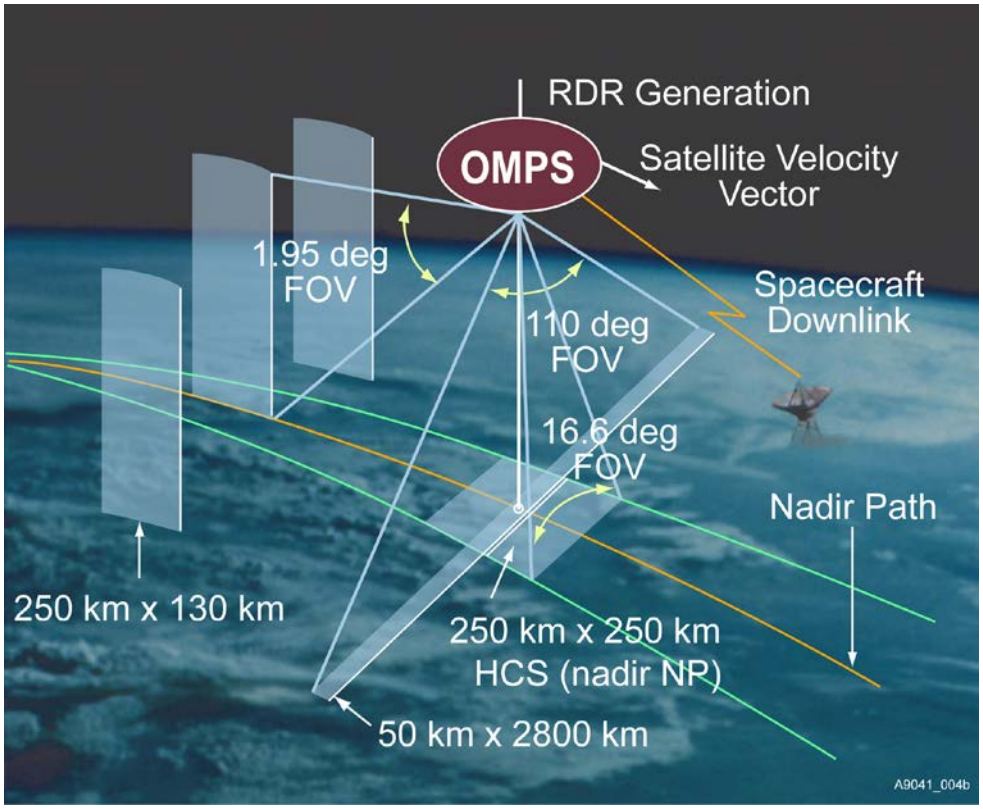
Prism spectrometer, 2-D CCD
Three vertical slits, -20 to 80 km,
290 nm to 1000 nm

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.



Ozone Cal/Val/Alg Team Membership

EDR	Name	Organization	Task
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 Application
Sub-Lead	Trevor Beck	NOAA/NESDIS/STAR	Algorithm development and ADL implementation
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
JAM	Maria Caponi	JPSS/Aerospace	Coordination

S-NPP Product Overview

- List of Products
  - Total Column Ozone (SO_2, reflectivity, Absorbing aerosol index)
    - V7MTTOz (IDPS)
    - V8TOz (IDPS Block 2.0) (Enterprise Algorithm)
    - V8TOZ/LFSO2 (NDE Planned) (No SO2 exclusion for J-01)
  - Nadir Ozone Profile
    - V8Pro (IDPS Mx8.11) (Enterprise/Heritage Algorithm)
  - Limb Ozone Profile
    - Limb V2.0 (NASA PEATE)
    - Limb V2.0 (NDE Planned)
- S-NPP Cal/Val Status
  - Preparing soft calibration adjustments
- ICVS pages are in transition from Demonstration

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	50 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

Attribute	Threshold	Objective
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. 2. The EDR shall be delivered for all SZA up to 86 degrees. 3. 6 DU SO_2 exclusion removed.		

JPSS-1 Readiness – Algorithms

- Major Accomplishments and Highlights Moving Towards J-01
  - Implemented V8Pro (IDPS Mx8.11)
  - Delivered V8TOz single granule package ADL implementation
  - Developed 16-granule moving-window version of the LFSO2 Code
  - Developed Cal/Val Plan
- J1 Algorithm Summary
  - LFSO2/V8TOz + 17x17 km^2 FOV

The V8TOZ has been implemented in ADL and delivered to the program. It will be integrated into Block 2.0 of the IDPS build in March 2016. The LFSO2/V8TOz has been adapted to run on 16-granule sequences on the STAR LINUX system using the first-run V8TOz EDR as input. We are targeting NDE as the operational system to run this product but are also investigating procedure used to create the multiple granule products for VIIRS in IDPS.

There are two components to reach the smaller FOV target. The first is the granularization of the ancillary data and the second is bookkeeping within the retrieval algorithm. We are working on both components.

  - V8Pro + 50x50 km^2 FOV

The V8Pro has been implemented in IDPS and will transition to operations with Mx8.11 next month. We are working on a glue-ware aggregator to continue creating the 250x250 km^2 FOV for S-NPP until we implement the changes to reach the smaller FOV target. We are working with the SDR team on solar activity, throughput degradation, information concentration and bandpass modeling refinements.

  - DOAS Algorithms for Trace Gases

We have implemented a DOAS algorithm to create operational NO_2 products from the EUMETSAT GOME-2 measurements. The latest versions of these algorithms can create this and additional trace gas products from the OMPS measurements.

JPSS-1 Readiness – Cal/Val

- J1 Cal/Val Overview
  - Pre-Launch Calibration/Validation Plans
    - Cal/Val Plan Readiness Review (12/2015)
    - Demonstrate V8Pro and V8TOz soft calibration capabilities with S-NPP OMPS
    - Develop and test all analysis programs as described in the plan.
  - 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
    - “Validated 3” After 1 year of measurements (L+410 days)
      - Accuracy and stability over one annual cycle

JPSS-1 Readiness – Issues & Applications

- Issues / Mitigation
  - Small FOV preparations / CCR Requesting upgrade for S-NPP OMPS to Flight Software 6.0 to allow development, testing and early demonstration of new capabilities
  - Program guidance on platform for OMPS products / Develop ADL and LINUX versions for IDPS or NDE paths
  - Total ozone ancillary data sets for smaller FOVs / Working with Raytheon
  - NP Degradation, wavelength scale, solar activity and bandpass / Working with SDR team to implement and demonstrate improvements for S-NPP OMPS.
  - Uneven records (moving targets) / Develop better reprocessing capabilities
- Users' Readiness
  - We are upgrading the BUFR products to be created from the OMPS V8 algorithm products and parameters. V8 algorithm BUFR products are already in use.
  - 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, NO_2, SO_2 and O_3 products to prepare them for the higher spatial resolution products.

Proposals for OMPS for J-03 and J-04
Expand OMPS Spectral Coverage; Improve FOV Resolution

- **Proposals**

Move and Expand the OMPS Spectral Coverage from 300 nm to 380 nm to 305 nm to 440 nm.

Improve OMPS resolution to 17 x 17 km^2 for most products and further improve to 5x10 km^2 for aerosol products.

- **Rationale**:

1. The shortest VIIRS channel is at 412 nm. Extending OMPS to 440 nm will allow measurement comparisons, help straylight corrections, and improve atmospheric NO_2 and aerosol products.
2. One of the major problems for air quality studies is clearly identifying sources. it's hard to isolate a city or power plant without good spatial resolution. The evidence for the improvements from the smaller FOVs are apparent in the research carried out with the OMI instrument. Some of the air quality and volcanic studies performed with OMI data from the EOS Aura 2014 Science Teams Meeting provide such examples and are included.
3. Aerosol products can be made at high resolution using just a few broad channels.

FY16 OMPS EDR Milestones/Deliverables

Task Category	Task/Description	Start	Finish	Deliverable
Development	Measurement Filtering using Empirical Orthogonal Functions and Nearest Neighbors	Present	Q3	Code modification for N-value subroutine
Integration & Testing	EDR capabilities for small FOV products (Glueware and V8 Algorithm upgrades)	Present	Q1, Q2, Q3	Code Logic and output changes
Calibration & Validation	New RT Tables for J01 New RT Tables for S-NPP Evaluation/validation of V8 products including SO2 Prepare tools and plan for J01	Present	Q4 Q1 Q1,Q2,Q4 Q2	New Tables New Tables Report and statistics on C/V C/V Plan CDR
Maintenance	Monitor performance and resolve anomalies	Ongoing	Ongoing	New DRs and CCRs as needed
LTM & Anomaly Resolution	Continue and expand ICVS Monitoring Trending of ground-based comparisons	Ongoing	Ongoing Q3	New ICVS content Report with V8 statistics

Summary

The S-NPP OMPS instrument is performing very well and the heritage/enterprise algorithms are entering the system. The J-01 upgrades to provide significant improvements in product quality and spatial resolution are moving forward at an acceptable pace. We have an afternoon of talks giving details on the progress and results tomorrow.

Ozone Applications	Craig Long	NOAA/CPC
OMPS Limb Profiler Products	P.K. Bhartia	NASA GSFC
OMPS Additional Trace Gases	Kai Yang	UMD (NASA)
Air Quality from OMPS	Daniel Tong	NOAA/ARL
TOAST to TACO to Limb TACO	Jianguo Niu	SRG (STAR)
V8 Algorithms	Trevor Beck	STAR
Ozone Product Monitoring	Eric Beach	IMSG (STAR)
OMPS Validation	Irina Petropavlovskikh	NOAA/ESRL
OMPS Aerosol Index Gallery	Colin Seftor	SSAI (NASA)

- Backup –
  - Near Term Plans
  - FY14-15 major accomplishments
  - FY17-20 High Priority
  - V7MTTOz Validation
- V8TOz Presentation
- V8Pro Presentation

Near Term Plans

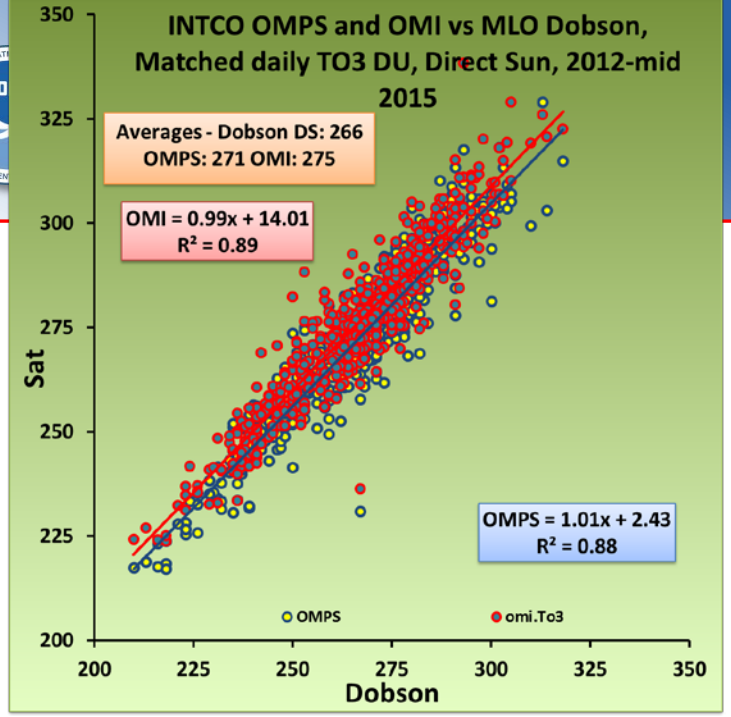
- **Assist in SRS Readiness Review**
- **Complete Validated status check list, presentation and read me**
- **Upgrade BUFR to V8 parameters**
- **For V8Pro**
  - Apply improve bandpass parameter
  - Reprocess NOAA-19 Chasing Orbit Days
    - Create soft calibration estimates
  - Implement Glueware Aggregator
  - Create smaller FOV products (50x50)
- **For V8TOz**
  - Reprocess week with OMI Chasing Orbit
  - Remove cross-track features from reflectivity, aerosols and ozone
    - Create soft calibration estimates
  - Create smaller FOV Products
  - Implement LFSO2/V8TOz in NDE

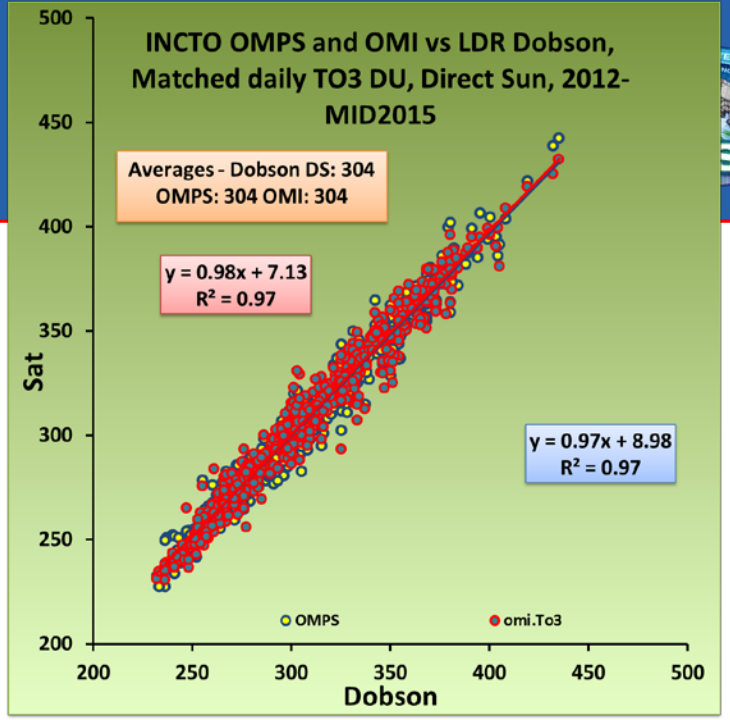
FY14-15 Top Accomplishments EDR

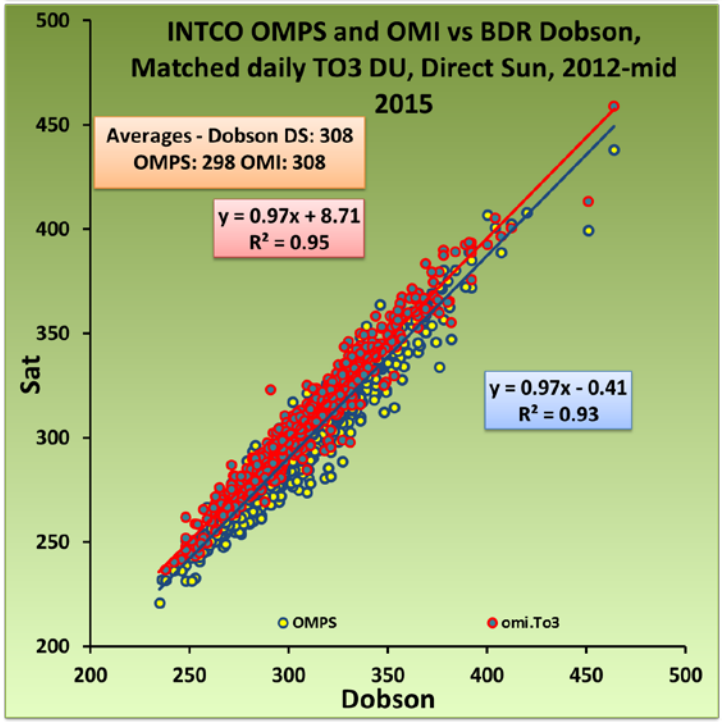
- OMPS NP V8Pro Delivery
- OMPS NM V8TOz Delivery
- Linear Fit SO2 Added to V8TOz Code (Expanded V8 ATBD)
- Developed OMPS NP Glueware for 5x5 Granules
- Regular ICVS Product Monitoring including internal consistency and SBUV/2 and GOME-2 comparisons
- Updates to SBUV/2 Chasing Orbits
- Updates to Ground-based Overpass comparisons
- JGR Paper on OMPS Products
- Developed J01 Validation Plans (Review Q4)

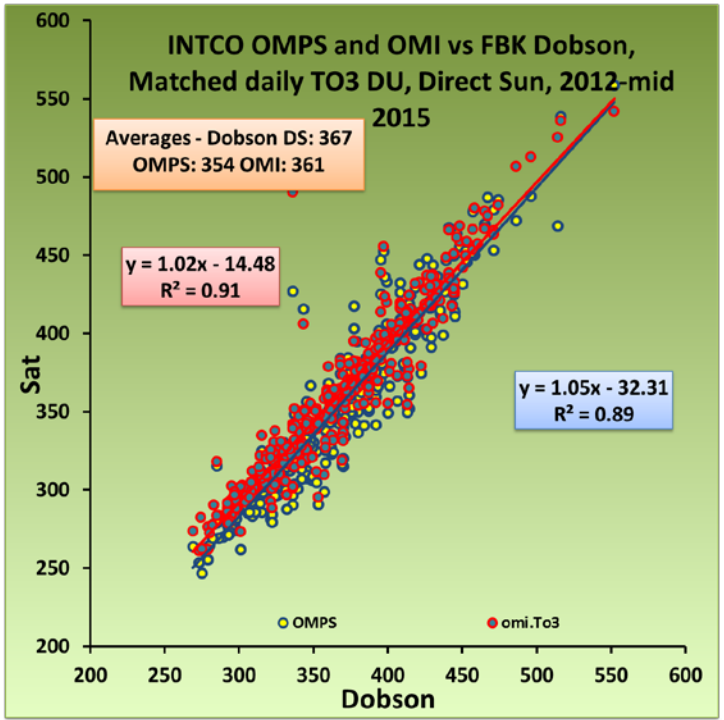
Path Forward (FY-17 thru FY-20)
High Priority Tasks/Milestones

	S-NPP	JPSS-1	JPSS-2
FY17	Monitor OMPS performance and update SDR LUTs as needed for Darks, CF Earth, Linearity, Wavelength Scale, Solar	Early Orbit Checkout, Start of SDR Validation (Beta L+4M, Provisional L+7M)	
FY18	Sustainment, monitoring, maintenance	Product reaches validated version (L+11m)	Receive calibration data from BATC, begin analysis and creation of tables
FY19	Sustainment, monitoring, maintenance	Sustainment, monitoring, maintenance	J02 SDR algorithm review including Limb Profiler
FY20		Sustainment, monitoring, maintenance	Code deliveries for J02 improvements


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


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


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


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

OMPS NM V8 Total Ozone

L. Flynn
July 29, 2015
CCR-

Outline

- Introduction to V8TOz Algorithm
- Details / Corrections
  - Aerosol,
  - Sun Glint, and
  - Profile Shape
- Enterprise Credentials
- Decisions on Multiple Triplet IP/EDR
- Input and Output
- Retrieval Sensitivities / Soft Calibration
- Path to Linear Fit SO_2
- Program Components

Introduction

The Version 8 total O3 algorithm (V8TOZ) is the most recent version of a series of BUV (backscattered ultraviolet) total O3 algorithms that have been developed since the original algorithm proposed by *Dave* & *Mateer* [*1967*], which was used to process Nimbus-4 BUV data [*Mateer* et al., *1971*]. These algorithms have been progressively refined [*Klenk* et al., *1982*; *McPeters* et al., *1996*; *Wellemeyer* et al., *1997*] with better understanding of UV radiation transfer, internal consistency checks, and comparison with ground-based instruments. However, all algorithm versions have made two key assumptions about the nature of the BUV radiation that have largely remained unchanged over all these years. 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 recent algorithm versions have incorporated procedures for identifying these special situations, and apply semi-empirical corrections, based on accurate radiative transfer models, to minimize the errors that occur in these situations. In the following sections, we will describe the forward model used to calculate the top-of-the-atmosphere (TOA) reflectances, the inverse model used to derive total O3 from the measured reflectances, and give a summary of errors.

Details

The inverse algorithm consists of a 3-step retrieval procedure.

In the first step, a good first estimate of effective reflectivity (or effective cloud fraction) and total O3 is made by using the 21 standard profile radiance tables and the measured radiance to irradiance ratios at 318 nm and 331 nm.

In step 2, this estimate is corrected by using the Jacobians and seasonally and latitudinally varying O3 and temperature climatology. These corrections typically change total O3 by less than 2%.

In the final step, scenes containing large amounts of aerosols, sea glint, volcanic SO2, or with unusual O3 profiles are detected by using an approach based on the analysis of residuals (differences between measured and computed radiances at wavelengths not used in the first two steps). We use pre-computed regression coefficients applied to these residuals to correct for these effects. These coefficients are generated by off-line analysis of the relationship between retrieval errors and residues computed by accurately modeling radiances for a representative set of interfering species/events. An important benefit of this approach is that unusual events are easily flagged so they can be identified later for careful analysis. Past analyses of such events led to the discovery of a new method of studying aerosols by using BUV radiances.

Details: Corrections for Aerosols

- When one uses the R derived from 331 nm to calculate a radiance at 360 nm, the R-λ dependence produces a residue at 360 nm. This residue is positive when absorbing aerosols are present. By Mie scattering calculation, using various types of absorbing and non-absorbing aerosols, *Torres* & *Bhartia* [*1999*] showed that for the TOMS V7 algorithm a simple linear relationship between the residues and the O3 error exists. Similar calculations using the TOMS V8TOZ algorithm indicate that O3 is overestimated by ~2.5±0.5 DU when the 360-nm residue is 1%.
- TOMS data indicate that aerosol amounts are large enough to produce a 1% residue at 360 nm roughly 30% of the time, and most of these corrections are less than 5 DU.
- Since relatively large residues, not related to aerosols, are seen at large solar zenith angles in the TOMS data, the aerosol correction is applied only when the solar zenith angle is less than 70˚.

Details: Corrections for Sun Glint

- The apparent reflectivity of the ocean in the BUV in the glint direction (roughly a cone of ±15˚ from the nadir for the OMPS) varies with wavelength due to variations in the direct to diffuse ratio of the radiation falling on the surface. The magnitude of the sea-glint, and hence the R-λ dependence it produces, decreases with increase in surface winds and by the presence of aerosols and clouds which also decrease the direct to diffuse ratio. Radiative transfer calculations [*Ahmad* & *Fraser*, private communication] show that, though the cause of the R-λ dependence produced by sea-glint is quite different, its effect on O3 and residuals is similar to that for absorbing aerosols, and the same correction procedure also applies.
- However, there is one aspect of sea-glint that is different from absorbing aerosols- the fact that they can significantly increase the apparent brightness of the surface and are easily confused with clouds. Since sea-glint increases the absorption of radiation by O3 near the surface while clouds reduce the absorption, it is important to separate the two. The V8TOZ distinguishes clouds from sea-glint using the fact that clouds do not produce residues. So, in situations where geometry indicates the potential for sea-glint, retrievals with 360 nm residue greater than 3.5% are flagged as effected by sea-glint in the OMPS V8TOZ.

Details: Corrections for Profile Shape

- Strictly speaking, the BUV radiances at all wavelengths have some sensitivity to the vertical distribution of O3. Though the wavelengths used in the V8TOZ algorithm to derive total O3 have been selected to minimize this effect, and the step 2 correction procedure described in section 2.3.2 has been designed to correct any residual systematic errors, there are situations when the profile errors become too large to be acceptable. These situations begin to occur when the O3 slant column density (SCD), $\Omega \times (\sec\theta + \sec\theta 0)$, exceeds 1500 DU. At 80˚ soar zenith angle, the SCD can vary from less than 1000 DU to more than 4000 DU due to O3 variability, and simply discarding data with very large SCD would seriously bias the zonal means. Therefore, it is important to design the algorithm such that reasonable (5%, 1σ) total O3 values can be obtained for SCD of 5000 DU. From the error analysis of the TOMS algorithm [*Wellemeyer* et al., *1997*], we have determined that errors at SCD>1500 DU typically occur when the assumed O3 profile near 10 hPa is significantly different from that assumed in step 2 (**X2**). The error occurs because the algorithm has been explicitly designed (by using the standard profiles shown in Fig. 2-1 of the ATBD) to minimize errors near 100 hPa where most of the O3 variability takes place. This makes the algorithm sensitive to O3 profile variations away from the 100 hPa region. Fig. 2-4 of the ATBD (reproduced on the next slide) shows how a 10% error in the assumed profile between 4 hPa and 32 hPa (representing roughly 1σ variation of O3 profile) affects the Step 2-derived total O3 as a function of SCD.
- Fortunately, profile errors near 10 hPa can be detected by examining the residue at shorter BUV wavelengths which are more sensitive to O3 profile than the wavelengths used for deriving total O3. Fig. 2-5 of the ATBD shows how the 312.5 nm residue responds to the profile error assumed for Fig. 2-4. More detailed analysis of this error using a set of O3 profiles derived from high latitude ozonesondes indicates that a simple correction factor of 3.5 DU for 1% residue at 312.5 nm provides adequate correction to obtain reliable total O3 values (2%, 1σ) at SCDs of up to 3000 DU. However, the correction procedure becomes increasingly unreliable as the SCD exceeds 3000 DU.

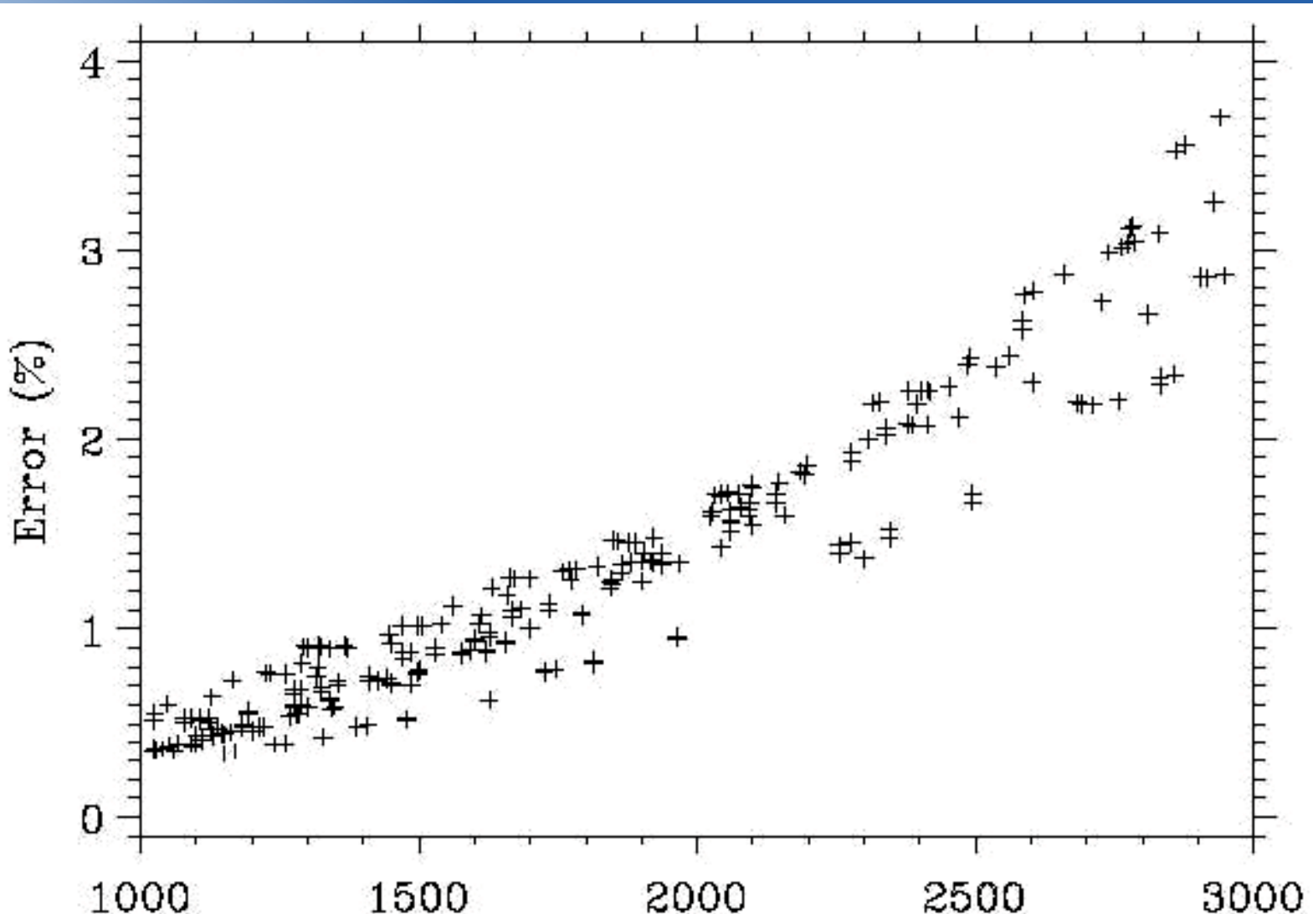


Figure 2-4: Error in retrieved total O_3 due to 10% more ozone in the 4 hPa to 32 hPa layer than assumed. The data shown are for the full range of solar zenith angles, satellite zenith angles and total O3 amounts seen by an ozone mapper.

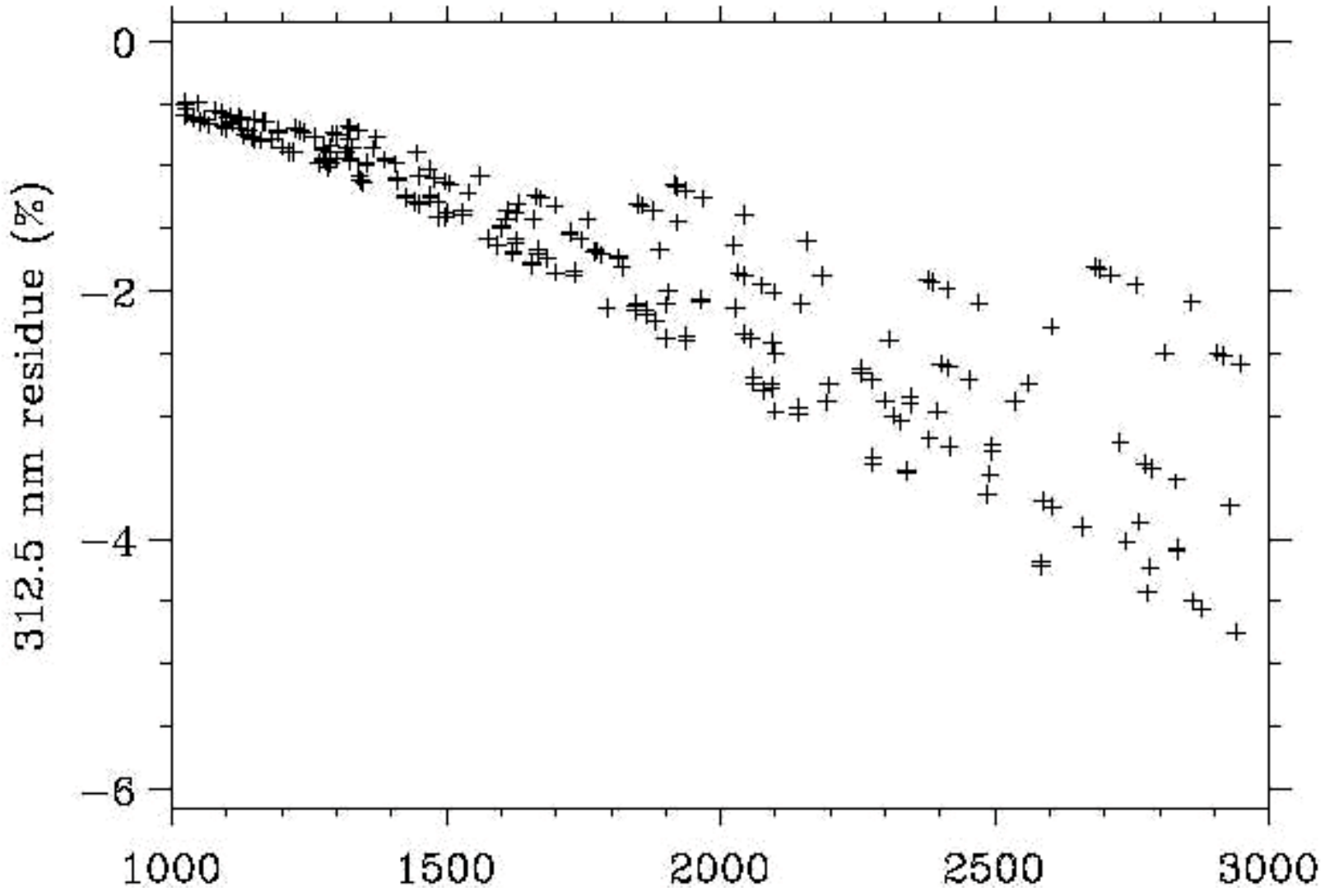


Figure 2-5: 312.5-nm residue for same profile errors as shown in Fig. 2-4.

V8TOz as the Total Column Ozone Enterprise Algorithm

- V8TOz is currently used to generate products for
  - SBUV/2 (as part of V8Pro to create NOAA operational and CDR products)
  - GOME-2 (to create NOAA operational products)
  - OMI (to create NASA direct broadcast, NRT and CDR products)
  - TOMS (to create CDR products)
- It is on its way, or already there to generate products for
  - OMPS NP (as part of V8Pro to create NOAA operational and CDR products)
  - OMPS NM (to create direct broadcast, NOAA operational and CDR products)

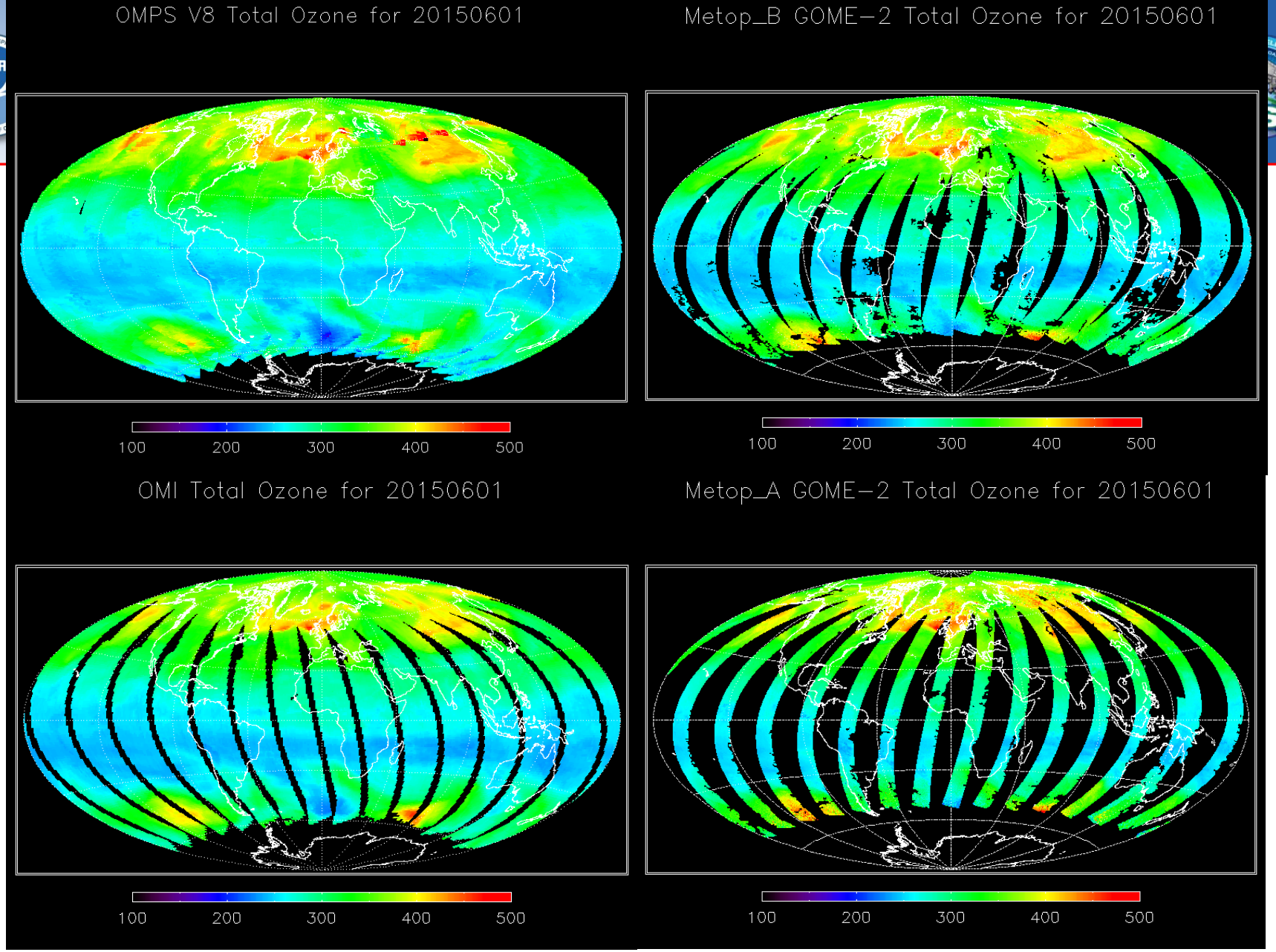


Figure 3: Daily maps of total column ozone.

The false color maps show the total column ozone in Dobson Units for June 1, 2015 for the V8TOz algorithm applied to S-NPP OMPS (Top Left), Metop-B GOME-2 (Top Right), EOS Aura (Bottom Left) and Metop-A GOME-2 (Bottom Right).

Multiple Triplet IP and EDR

- The V8TOz has been implemented as an extension of the OMPS Multiple Triplet (MT) First Guess IP process.
- The MT First Guess IP and EDR have been become almost duplicates as the original motivation has evaporated and the input auxiliary data sets have converged.
- The delivered implementation preserves the First Guess IP output. It is in a combined HDF with the new V8TOz EDR. The program could elect to write out the existing IP and then write out as second file with the combined IP/EDR as the EDR.

New Input

```
! Dims for V8 Lookup Tables from OMPS_TC_EDR_LUT xml
        INTEGER(KIND=4), PARAMETER :: npresT = 4
        INTEGER(KIND=4), PARAMETER :: nprofT = 21
        INTEGER(KIND=4), PARAMETER :: nszaT = 10
        INTEGER(KIND=4), PARAMETER :: nvzaT = 6
        INTEGER(KIND=4), PARAMETER :: nwlLUT = 12
        INTEGER(KIND=4), PARAMETER :: nLayP = 1

! Dims for OZCLIM and TMCLIM from OMPS_TC_EDR_LUT xml
        INTEGER(KIND=4), PARAMETER :: MONTH_INDEX       = 12
        INTEGER(KIND=4), PARAMETER :: MONTH_PLUS_INDEX  = 13
        INTEGER(KIND=4), PARAMETER :: LAT_RANGE_INDEX   = 18
        INTEGER(KIND=4), PARAMETER :: LAYER_INDEX       = 11
        INTEGER(KIND=4), PARAMETER :: LAYER11           = 11
        INTEGER(KIND=4), PARAMETER :: TOZ_RANGE_INDEX   = 10
        INTEGER(KIND=4), PARAMETER :: LON_HALFDEG_INDEX = 720
        INTEGER(KIND=4), PARAMETER :: LAT_HALFDEG_INDEX = 360
        INTEGER(KIND=4), PARAMETER :: LON_GRID_INDEX = 360
        INTEGER(KIND=4), PARAMETER :: LAT_GRID_INDEX = 180
          REAL(KIND=4) ::  c0_v8(nwlLUT)
          REAL(KIND=4) ::  c1_v8(nwlLUT)
          REAL(KIND=4) ::  c2_v8(nwlLUT)
          REAL(KIND=4) ::  logi0_v8(nvzaT,nszaT,nprofT,nwlLUT,npresT,TC_EDR_IFOV)
          REAL(KIND=4) ::  z1_v8(nvzaT,nszaT,nprofT,nwlLUT,npresT,TC_EDR_IFOV)
          REAL(KIND=4) ::  z2_v8(nvzaT,nszaT,nprofT,nwlLUT,npresT,TC_EDR_IFOV)
          REAL(KIND=4) ::  tr_v8(nvzaT,nszaT,nprofT,nwlLUT,npresT,TC_EDR_IFOV)
          REAL(KIND=4) ::  knb_v8(nvzaT,nszaT,nprofT,nwlLUT,npresT,TC_EDR_IFOV)
          REAL(KIND=4) ::  sb_v8(nprofT,nwlLUT,npresT,TC_EDR_IFOV)
          REAL(KIND=4) ::  wl0_v8(nwlLUT)
          REAL(KIND=4) ::  logi0_dndx_v8(nvzaT,nszaT,nprofT,nwlLUT,npresT,nLayP)
          REAL(KIND=4) ::  z1_dndx_v8(nvzaT,nszaT,nprofT,nwlLUT,npresT,nLayP)
          REAL(KIND=4) ::  z2_dndx_v8(nvzaT,nszaT,nprofT,nwlLUT,npresT,nLayP)
          REAL(KIND=4) ::  tr_dndx_v8(nvzaT,nszaT,nprofT,nwlLUT,npresT,nLayP)
          REAL(KIND=4) ::  knb_dndx_v8(nvzaT,nszaT,nprofT,nwlLUT,npresT,nLayP)
          REAL(KIND=4) ::  sb_dndx_v8(nprofT,nwlLUT,npresT,nLayP)
          REAL(KIND=4) ::  tzaprf_v8(LAYER11,TOZ_RANGE_INDEX,LAT_RANGE_INDEX,MONTH_PLUS_INDEX)
          REAL(KIND=4) ::  tmclim_v8(LAYER_INDEX,LAT_RANGE_INDEX,MONTH_INDEX)
          INTEGER(KIND=4) :: cat(LAT_HALFDEG_INDEX,LON_HALFDEG_INDEX)
          REAL(KIND=4) ::  nvcorr_v8(nwlLUT,TC_EDR_IFOV)
          REAL(KIND=4) ::  cloud_press(LON_GRID_INDEX,LAT_GRID_INDEX,MONTH_INDEX)
```

New Output

- DATASET "AerosolIndex_v8" F32LE(5, 35) -20 20 N-Value
- DATASET "AlgorithmFlag_v8" U8LE(5, 35) Flag
- DATASET "CloudFraction_V8" F32LE(5, 35) 0 to 1 Proportion
- DATASET "ColumnAmountO3_v8" F32LE(5, 35) 0 to 1000 DU
- DATASET " dNdOmega_v8" F32LE(5, 35, 12) -20 to 50 N-value/DU
- DATASET " dNdR_v8" F32LE(5, 35, 12) -600 0 N-value
- DATASET "ErrorFlag_v8" U16LE(5, 35) Flag
- DATASET "LayerEfficiency_v8" F32LE(5, 35, 11) -1 to 10 DU TOz /DU Layer
- DATASET "Latitude" F32LE(5, 35) -90 to 90 Degrees North
- DATASET "Longitude" F32LE(5, 35) -180 to 180 Degrees East
- DATASET "NValueAdjustment_v8" F32LE (5, 35, 12) -20 20 N-value
- DATASET "NValueMeasured_v8" F32LE (5, 35, 12) 0 to 6 N-value/100
- DATASET "O3BelowCloud_v8" F32LE(5, 35) 0 to 900 DU
- DATASET "Reflectivity331_v8" F32LE(5, 35) -50 150 Percent
- DATASET "Reflectivity360_v8" F32LE(5, 35) -50 150 Percent
- DATASET "RelativeAzimuthAngle" F32LE(5, 35) 0 to 360 Degrees
- DATASET "SatelliteViewAngle" F32LE(5, 35) -180 to 180 Degrees
- DATASET "So2Index_v8" F32LE(5, 35) -100 1000 DU
- DATASET "SolarZenithAngle" F32LE(5, 35) -0 to 180 Degrees
- DATASET "Step1Ozone_v8" F32LE F32LE(5, 35, 12) 0 to 1000 DU
- DATASET "Step1Residual_v8" F32LE(5, 35, 12) -50 to 50 N-value
- DATASET "Step2Ozone_v8" F32LE(5, 35) 0 to 1000 DU
- DATASET "Step2Profile_v8" F32LE(5, 35, 11) 0 to 1000 DU
- DATASET "Step2Residual_v8" F32LE(5, 35, 12) -50 to 50 N-value
- DATASET "Step3Residual_v8" F32LE(5, 35, 12) -50 to 50 N-value
- DATASET "Wavelengths_v8" F32LE(5, 35, 12) 300 to 420 nm

Using V8TOz dN/dR and dN/dO3 to determine soft calibration adjustments

The V8TOz output contains a variety of useful parameters in addition to the total column ozone estimates. In particular, the retrieval sensitivities, dy/dx can be used to give soft calibration estimates of the N-value changes to remove reflectivity and ozone bias. If you want to increase the effective reflectivity, R, and the total column ozone, Ω, by ΔR and ΔΩ then you should increase the N-values by

$$\Delta N318 = \Delta R \, dN318/dR + \Delta\Omega \, dN318/d\Omega$$

$$\Delta N331 = \Delta R \, dN331/dR + \Delta\Omega \, dN331/d\Omega$$

where dNw/dR is the rate of change of the N-value, Nw, for wavelength, w, with respect to changes in the effective reflectivity, R, and dNw/dΩ is the rate of change of the N-value, Nw, for wavelength, w, with respect to changes in the total column ozone, Ω.

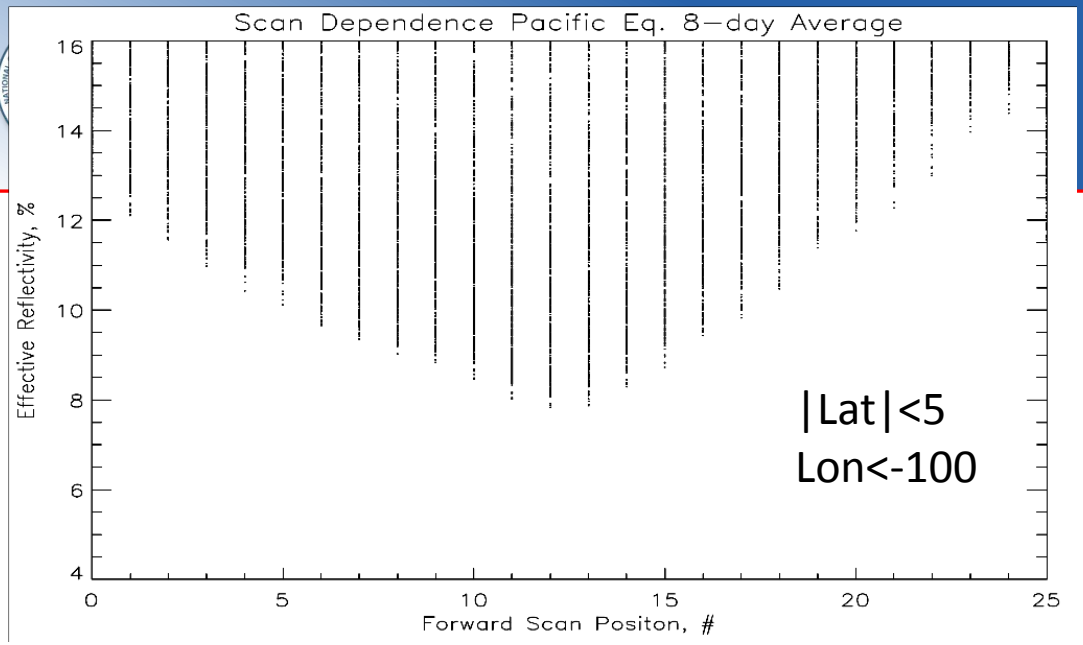
Conversely, if you increase the N values by C1=ΔN318 and C2=ΔN331, then the retrieved R and Ω increase by

$$\Delta R = [C1 * dN331/d\Omega - C2 * dN318/d\Omega] / D$$

$$\Delta\Omega = -[C1 * dN331/dR, - C2 * dN318/dR] / D$$

$$D = [dN318/dR * dN331/d\Omega - dN331/dR * dN318/d\Omega]$$

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





EAST WEST

Metop-A GOME-2 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 to the 331-nm channel 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 is sun glint contamination for those angles.

Linear Fit Algorithm: Path to SO_2

The V8 ATBD describes an algorithm to create SO_2 product from global mode UV measurements. The minimum SO_2 mass detectable by OMPS is about two orders of magnitude smaller than the detection threshold of the legacy Total Ozone Mapping Spectrometer (TOMS) SO_2 data (1978-2005) [This is due to the use of wavelengths better optimized for separating O_3 from SO_2.]

The algorithm uses the V8TOz as a starting point as a linearization step to derive an initial estimate of total ozone assuming zero SO_2. The residuals at the twelve wavelengths are then calculated as the difference between the measured and computed N-values ($N=-100*log_{10}(I/F)$, I is Earth radiance and F is solar irradiance) using a vector forward model radiative transfer code that accounts for multiple Rayleigh scattering, ozone absorption, Ring effect, and surface reflectivity, but assumes no aerosols. Cloudy scenes are treated as mixture of two opaque Lamberian surfaces, one at the terrain pressure and the other at a radiative cloud pressure from a UV-based climatology. In the presence of SO_2, the residuals contain spectral structures that correlate with the SO_2 absorption cross-section. The residuals also have contributions from other errors sources that have not yet been identified. To reduce this interference, a median residual for a sliding group of SO_2-free and cloud-free scenes, radiative cloud fraction < 0.15) covering sixteen consecutive OMPS granules (approximately 30 degrees of latitude along-track).

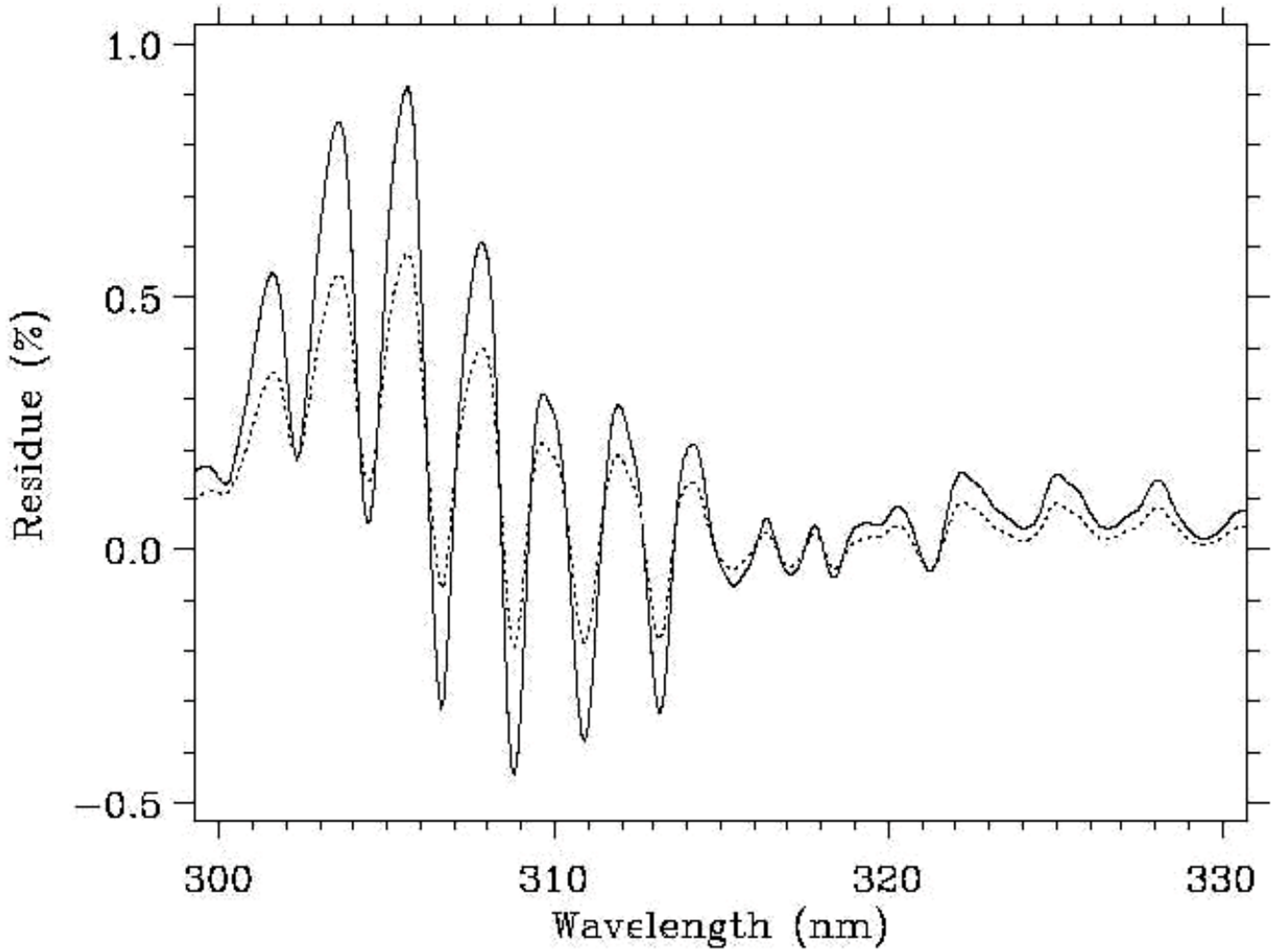
For each OMPS scene , it provides three different estimates of the column density of SO_2 in Dobson Units (1DU=$2.69 \cdot 10^{16}$ molecules/cm^2) obtained by making different assumptions about the vertical distribution of the SO_2. The users can use either the SO_2 plume height, or the center of mass altitude (CMA) derived from SO_2 vertical distribution, to interpolate between the three values:

Lower tropospheric SO_2 column (**ColumnAmountSO2_TRL**), corresponding to CMA of 2.5 km.

Middle tropospheric SO_2 column, (**ColumnAmountSO2_TRM**), usually produced by volcanic degassing, corresponding to CMA of 7.5 km,

Upper tropospheric and Stratospheric SO_2 column (**ColumnAmountSO2_STL**), usually produced by explosive volcanic eruption, corresponding to CMA of 17 km.

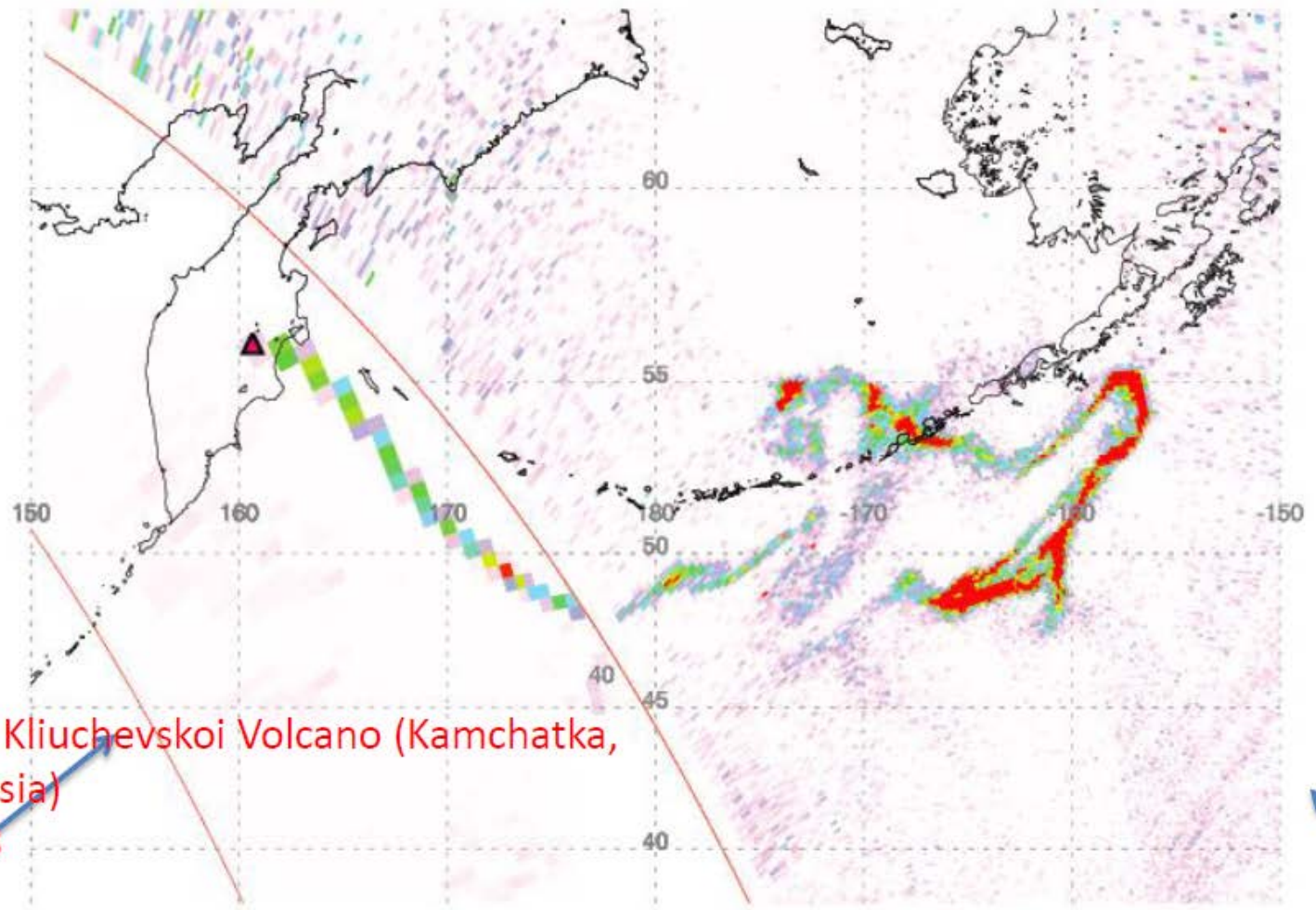
The LFSO2 algorithm has been implemented for OMPS V8TOz (NASA GSFC, NOAA STAR, Direct Broadcast)



Residuals produced by a 1 DU of SO_2 column at 45° solar zenith angle, nadir view. The Solid line is for an SO_2 layer at 7.4 km, and the Dotted line is one at for 2.5 km.

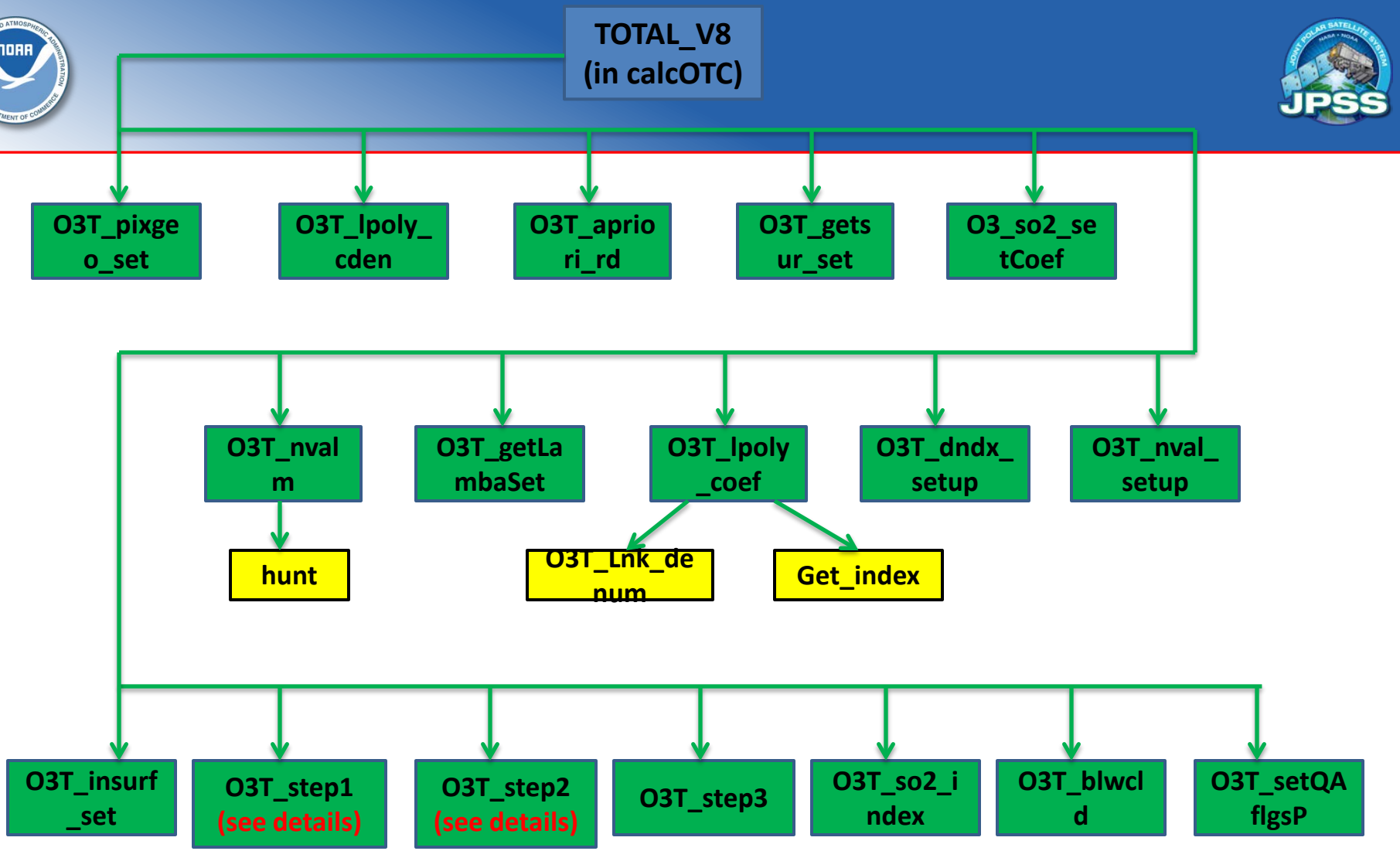
Six V8TOz channels are placed to provide sampling of these features at [308.7 310.8 311.9 312.6 313.2 314.4 317.6 322.4 331.3 345.4 360.2 372.8] nm

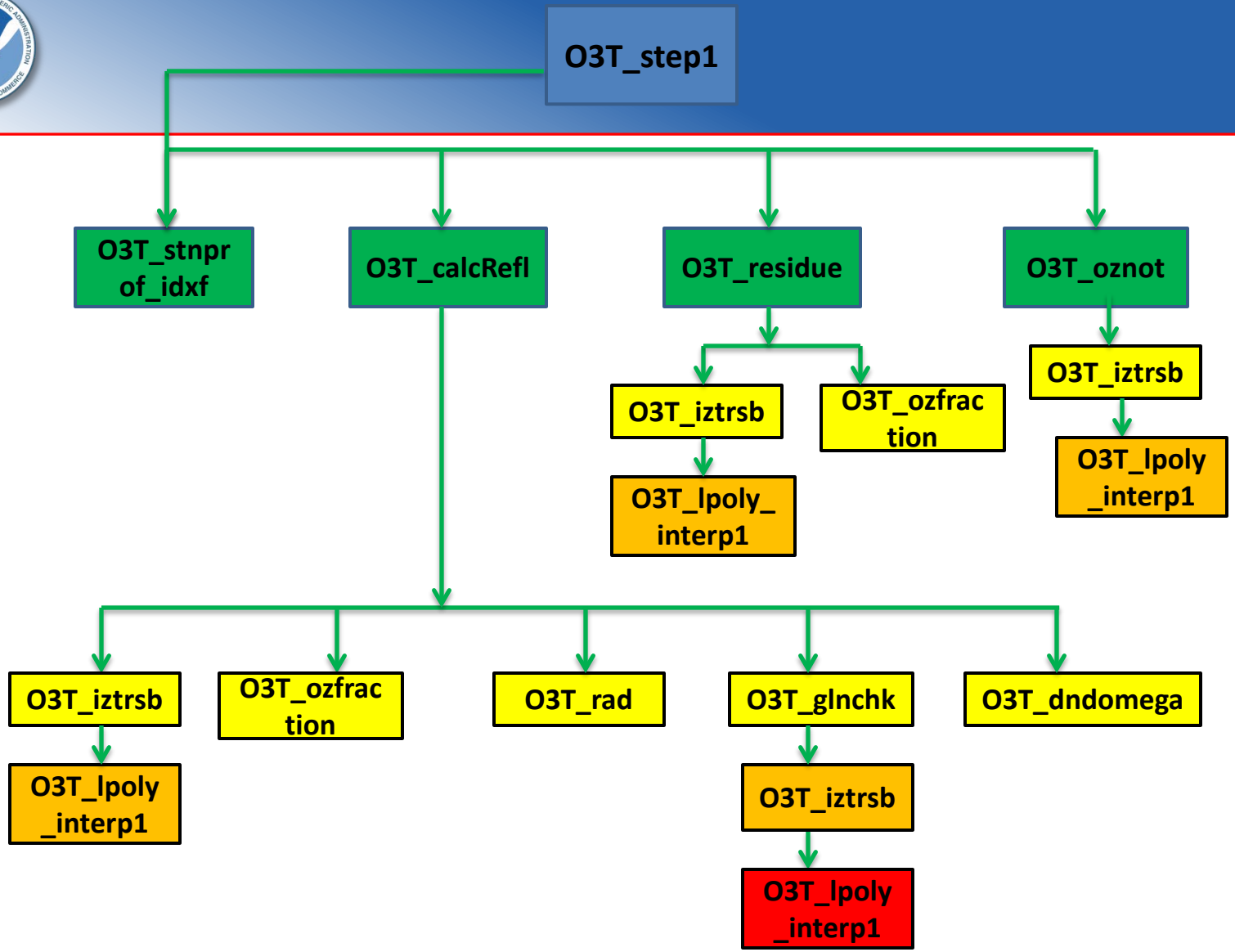
Near-Real-Time OMPS SO_2 Product

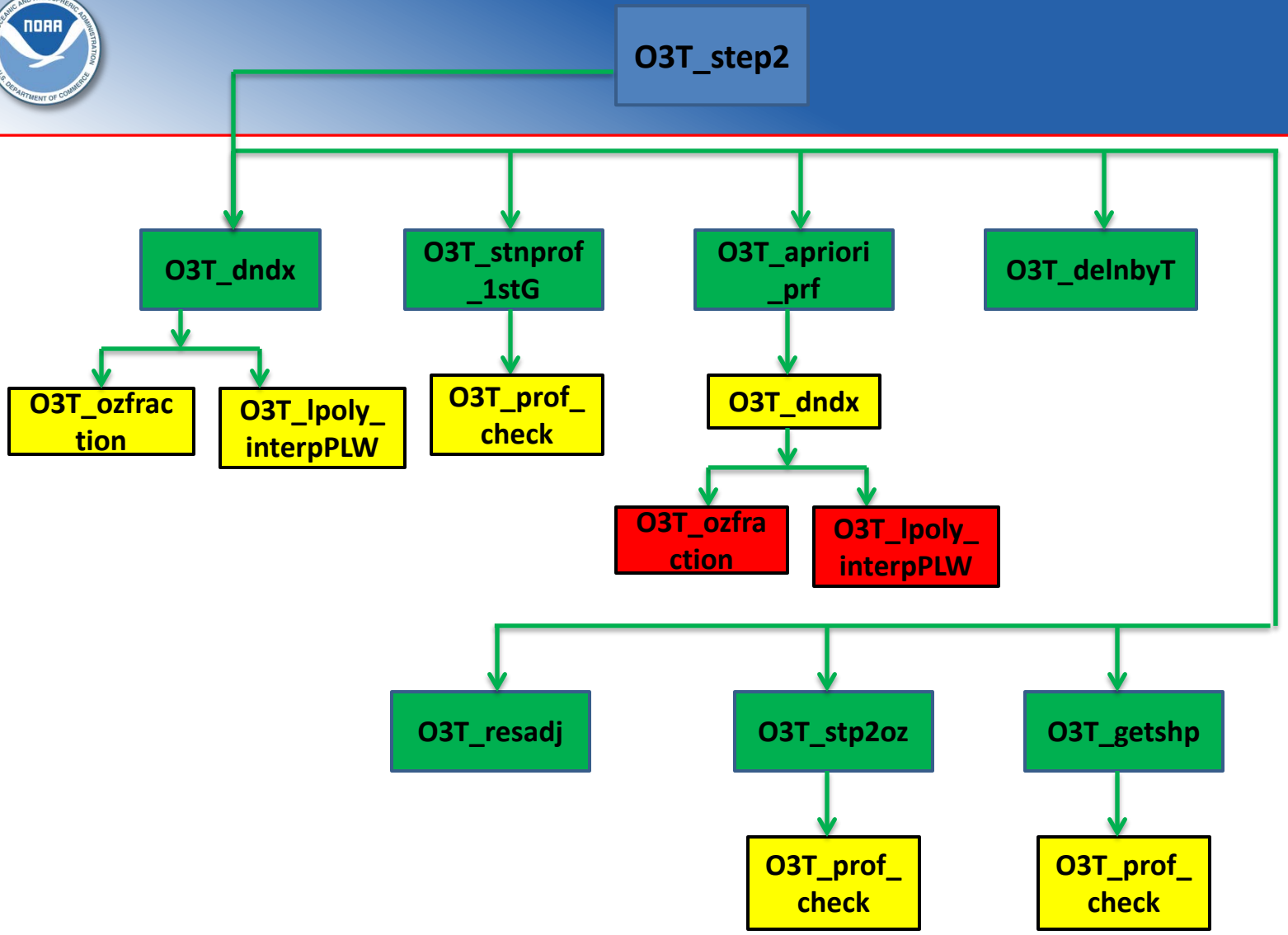


Modules for V8TOz

- GOME_Climatology_class.f
- O3T_apriori_class.f
- O3T_class.f
- O3T_const.f
- O3T_dndx_class.f
- O3T_dndx_m.f
- O3T_iztrsb_m.f
- O3T_lpolycoef_class.f
- O3T_lpolyinterp_class.f
- O3T_nval_class.f
- O3T_pixel_class.f
- O3T_so2_class.f
- O3T_stnprof_class.f
- UTIL_mmddInterp_class.f
- UTIL_tools_class.f


TOTAL_V8
(in calcOTC)
O3T_pixgeo_set
O3T_lpoly_cden
O3T_apriori_rd
O3T_getsur_set
O3_so2_setCoef
O3T_nvalm
O3T_getLambaSet
O3T_lpoly_coef
O3T_dndx_setup
O3T_nval_setup
hunt
O3T_Lnk_denum
Get_index
O3T_insurf_set
O3T_step1
(see details)
O3T_step2
(see details)
O3T_step3
O3T_so2_index
O3T_blwcld
O3T_setQAflgsP


O3T_step1
O3T_stnpr of_idxf
O3T_calcRefl
O3T_residue
O3T_oznot
O3T_iztrsb
O3T_ozfrac tion
O3T_lpoly_ interp1
O3T_iztrsb
O3T_lpoly _interp1
O3T_iztrsb
O3T_lpoly _interp1
O3T_ozfrac tion
O3T_rad
O3T_glnchk
O3T_dndomega
O3T_iztrsb
O3T_lpoly _interp1


O3T_step2
O3T_dndx
O3T_stnprof_1stG
O3T_apriori_prf
O3T_delnbyT
O3T_ozfraction
O3T_lpoly_interpPLW
O3T_prof_check
O3T_dndx
O3T_ozfraction
O3T_lpoly_interpPLW
O3T_resadj
O3T_stp2oz
O3T_getshp
O3T_prof_check
O3T_prof_check

OMPS NP Implementation of the SBUV/2 Version 8 Ozone Profile Algorithm

CCR 15 - 2354 – DR 4256

Lawrence Flynn OMPS C/V lead

April 13, 2015

Outline

- V8Pro Requirements/performance
- V8Pro on ICE
  - V8Pro Improvements
  - V8Pro Consistency
  - V8Pro Efficiency
- Monitoring and Soft Calibration
- Chasing Orbits
- Averaging Kernels, Jacobians and Measurement Contribution Functions.

The designation of ozone profile requirements as “Nadir” or “Limb” is artificial. There are ozone profile requirements and we should try to get as good performance as the measurements allow.

The Threshold requirements here are supposed to represent the heritage SBUV/2 ozone profile product performance.

Table 2.1.4 - Ozone Nadir Profile

Attribute	Threshold (1)	Objective
a. Horizontal Cell Size	250 X 250 km (2,9)	50 x 50 km^2 (10)
b. Vertical Cell Size	5 km reporting	
1. Below 30 hPa (~ < 25 km)	10 - 20 km (3)	3 km (0 - Th)
2. 30 - 1 hPa (~ 25 - 50 km)	7 - 10 km (3)	1 km (TH - 25 km)
3. Above 1 hPa (~ > 50 km)	10 - 20 km (3)	3 km (25 - 60 km)
c. Mapping Uncertainty, 1 Sigma (4)	< 25 km	5 km (10)
d. Measurement Range		
Nadir Profile, 0 - 60 km	0.1-15 ppmv	0.01 - 3 ppmv (O - TH) 0.1-15 ppmv (Th - 60 km)
e. Measurement Precision (5)		
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 (5)		
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. Latency	120 min. (6)	15 min
h. Refresh	At least 60% coverage of the globe every 7 days (monthly average) (7)	24 hrs. (7)
i. Long-term Stability (8)	2% over 7 years	1% over 7 years
		v1.4.2, 7/29/11

Notes:

1. The OMPS Limb Profiler instrument was not manifested on NPOESS. Thus, the Ozone Nadir Profile "Threshold" attributes are based upon current estimates using a variant of the SBUV/2 Version 8 algorithm with the Intermediate Product produced by the OMPS Nadir Profiler instrument. (See Note 10.) All of the Ozone Nadir Profile Threshold attributes are “TBR” until further analysis has been completed to determine the specifics of delivering the Ozone Nadir Profile EDR attributes using only the capability provided by this Intermediate Product.
2. 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). It is intended to operate the OMPS Nadir Profiler in a mode with this large FOV sub-sampled.
3. The SBUV/2 Version 8 Averaging kernels' Full Width Half Maximum values were used to define these VCS.
4. The IORD-II Mapping "Accuracy" of 25 km was changed to "Uncertainty, 1 sigma" in accordance with user desires as expressed by the OATS and JARG.
5. Values provided by L. Flynn of NOAA/NESDIS along with the two point values from BATC analysis.
6. Relaxed IORD-II Threshold requirement.
7. All OMPS measurements require sunlight, so there is no coverage in polar night areas. The IORD-II included threshold and objective Refresh requirements of 24 hrs for Ozone TC but none for Nadir Profile. This interpretation of the IORD-II Refresh requirement is consistent with the baseline OMPS Cross-track Swath Width design of ~ 250 km (16.7° FOV) for a single orbit plane. This swath width provides a good sample of the full global ozone profile pattern over ~ 7 days. A set of 4 days with 14 orbits/day by 250-km swaths will cover a little over one third of the 40,000 km equator. SBUV/2 has similar coverage over 5 days. 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.
8. Long Term Stability is not a critical attribute for achieving operational performance but it is for climate applications.
9. The OMPS and other newer CCD array BUV instruments can be operated to generate products with higher spatial resolution. Numerical weather and air quality models can make good use of this information.

10. The IORD Total Column/Profile EDR had 25 km Mapping Accuracy for both the Threshold and Objective. The Nadir Profile Objective has been changed to 5 km for the following reasons per L. Flynn. The OMPS aggregates pixels to make the current 250X250 FOV in the threshold. We would aggregate 1/5 as many pixels to make the new objective 50X50 FOV. The requested change maintains

Table 4.2.4 - Ozone Nadir Profile (OMPS-NP)

Attribute	Threshold	Objective
Ozone NP Applicable Conditions: 1. Clear, daytime only (3)		
a. Horizontal Cell Size	250 X 250 km (1)	50 x 50 km2
b. Vertical Cell Size	5 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)
	(16.7° FOV)	v2,0, 9/22/12

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.

Independence and Long Term Stability

- The OMPS 5% to 10% accuracy requirements were for its minimal performance as a stand-alone instrument.
- By using other assets we can set/correct its bias close to 0%.
- The long-term stability of the accuracy at 2% was also a stand-alone requirement, that is, the system was designed so that products' accuracy was not allowed to wander around between +5% and -5%.
- Users expect a stable product – applications are negatively affected by both short term jumps and discontinuities and longer term drifts.
- Over the course of a mission, new adjustments to the measurement characterizations are phased in as changes warrant.

Why "I should have a V8Pro"? 1. Improvements

V8Pro improves on the V6Pro SBUV(/2) algorithm described in Bhartia et al. (1996) as follows:

The V8Pro has a new set of a priori profiles varying by month and latitude, leading to better estimates in the troposphere (where SBUV/2 lacks retrieval information) and allowing simplified comparisons of SBUV/2 results to other measurement systems (in particular, to Umkehr ground-based ozone profile retrievals which use the same a priori data set).

The V8Pro has improved multiple scattering and cloud and reflectivity modeling. These corrections are updated as the algorithm iterates toward a solution.

Some errors present in the V6Pro will be reduced. These include the elimination of errors on the order of 0.5% by improved fidelity in the bandpass modeling.

The V8Pro incorporates several ad hoc Version 6 algorithm improvements directly. These include better modeling of the effects of the gravity gradient, better representation of atmospheric temperature influences on ozone absorption, and better corrections for wavelength scale errors.

The algorithm uses improved terrain height information and gives profiles relative to a climatological or forecast surface pressure.

The V8Pro is also designed to allow the use of more accurate external and climatological data and allow simpler adjustments for changes in wavelength selection.

The V8Pro has a true separation of the a priori and first guess. This simplifies averaging kernel analysis. Examples and further information are provided at

http://www.star.nesdis.noaa.gov/smcd/spb/ozone/Version8AlgorithmDesc.php

Why "I should have a V8Pro"? 2. Consistency

The V8Pro will place the OMPS NP retrievals in the fold with those from the SBUV and SBUV/2 records.

The V8Pro is used to create the current NOAA SBUV/2 operational products. These products are used by NCEP and other agencies. Creating OMPS product with the same behavior and content will ease their transition as the primary products. The V8Pro contains smaller vertical resolution products that capture the mid-stratospheric information better.

The V8Pro algorithm is in use for the production of climate data records (CDRs) for the SBUV(/2). The operational V8Pro from OMPS will be the first step in extending these records.

The V8Pro *A Prioris* and Averaging Kernels allow better comparisons to validation data sets include the ground-based Umkehr ozone profile retrieval which use a variation of the V8Pro retrieval and to higher vertical resolution products such as MLS and Balloonsonde ozone profiles.

Why "I should have a V8Pro"? 3. Efficiency

Use of the V8Pro will simplify the overall NOAA work for BUV ozone profiles.

The use of the same algorithms for OMPS and SBUV/2 will reduce the maintenance and support for algorithms. We have ten years of experience with the SBUV/2 V8Pro products.

Direct comparisons to V8Pro results from NOAA-19 SBUV/2 will be used to generate soft calibration coefficients. Chasing orbit results will quickly translate into SDR calibration adjustments. We have already been testing these in our off-line system

The extended content of the BUFR files desired by users is already in the definitions, tables and libraries for the SBUV/2 products.

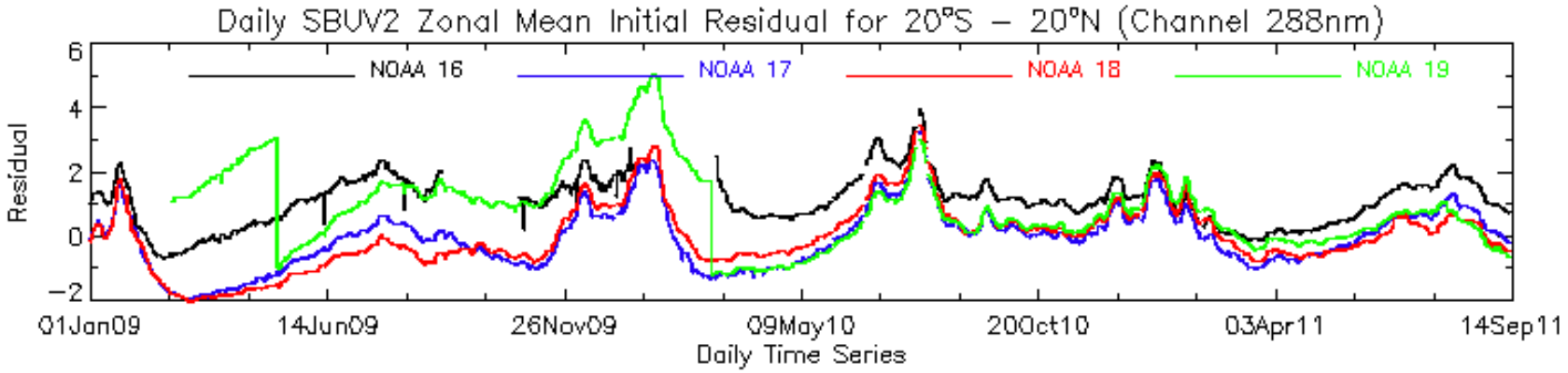
Existing V8Pro documents for the current operational processing include the Maintenance Manual, System Description, Interface Control, and Algorithm Theoretical Basis Documents.

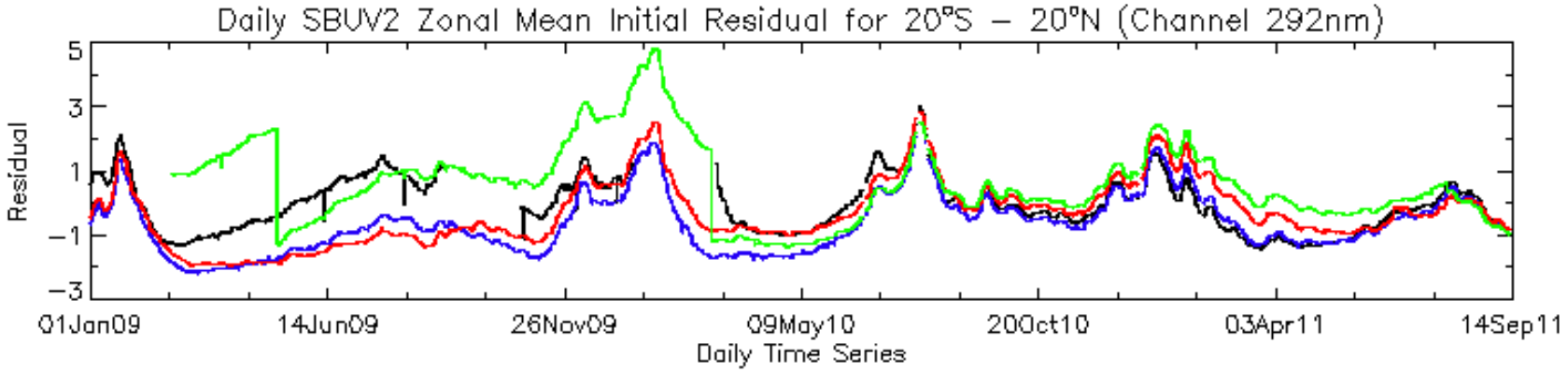
Existing ICVS monitoring pages can be simplified as we need only track the V8Pro products and can discontinue the V6Pro ones.

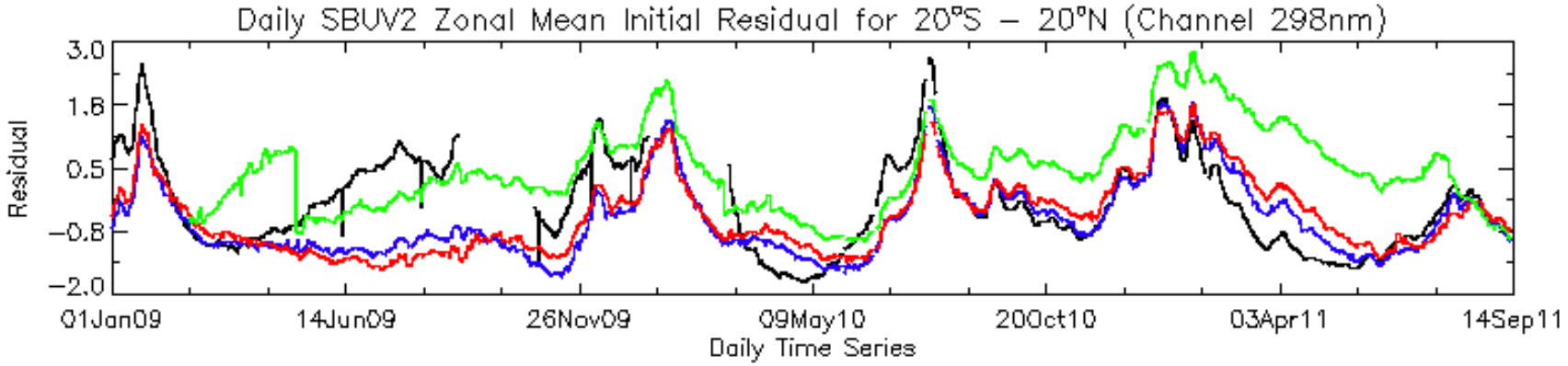
Monitoring and Soft Calibration

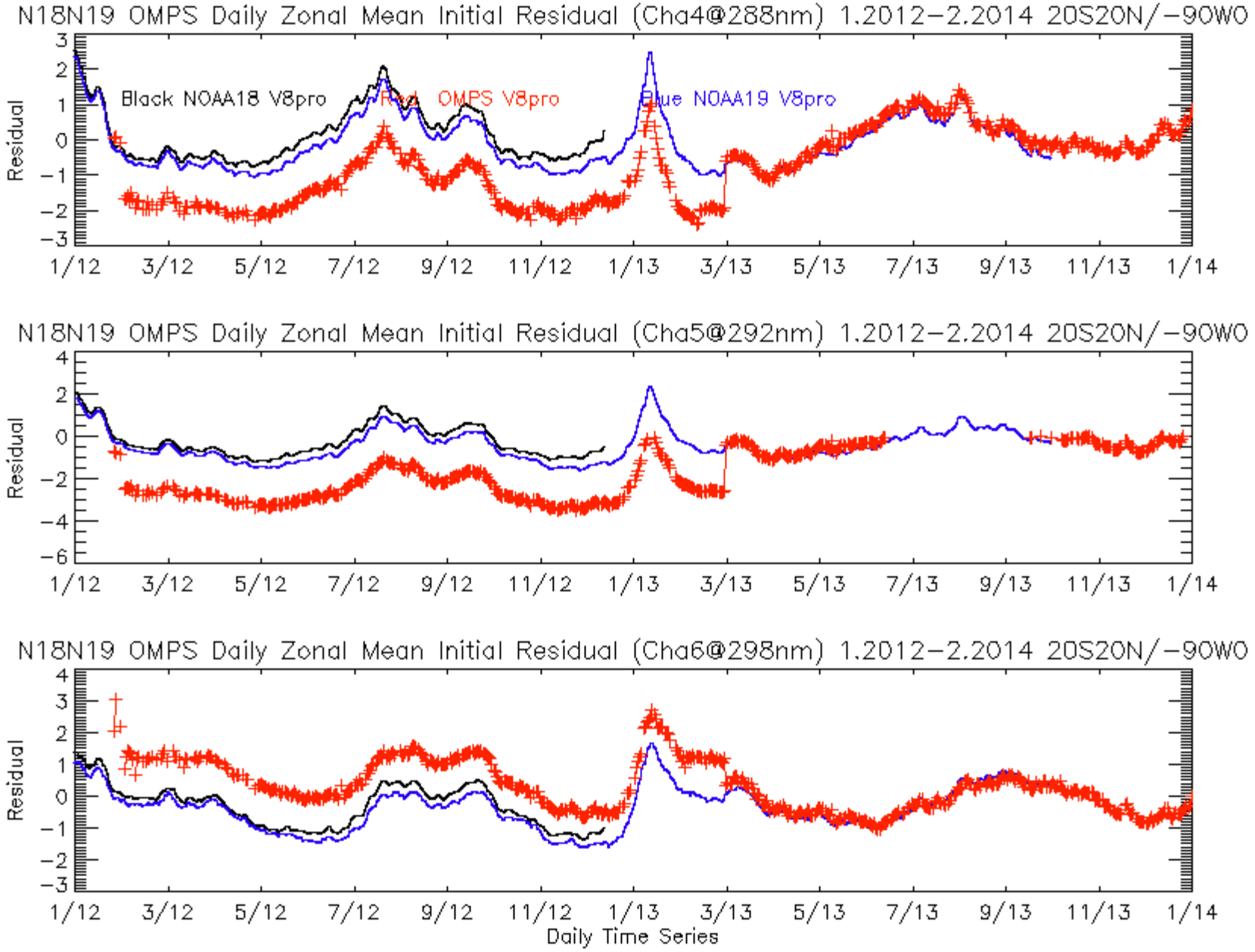
- The figure on the next two slides show time series of initial measurement residuals (measured N-values minus those predicted by a radiative transfer forward model using the first guess profile).
- The three figures on the next slide show how the NOAA-19 SBUV/2 extrapolated calibration was adjusted at different times to bring its products into agreement with those for other SBUV/2 instruments.
- The three figures on the slide after that show how the off-line processing of the OMPS V8Pro was adjusted in March 2013 and has kept good alignment with the NOAA-19 SBUV/2 results since then.

Operational Initial Residuals for SBUV/2







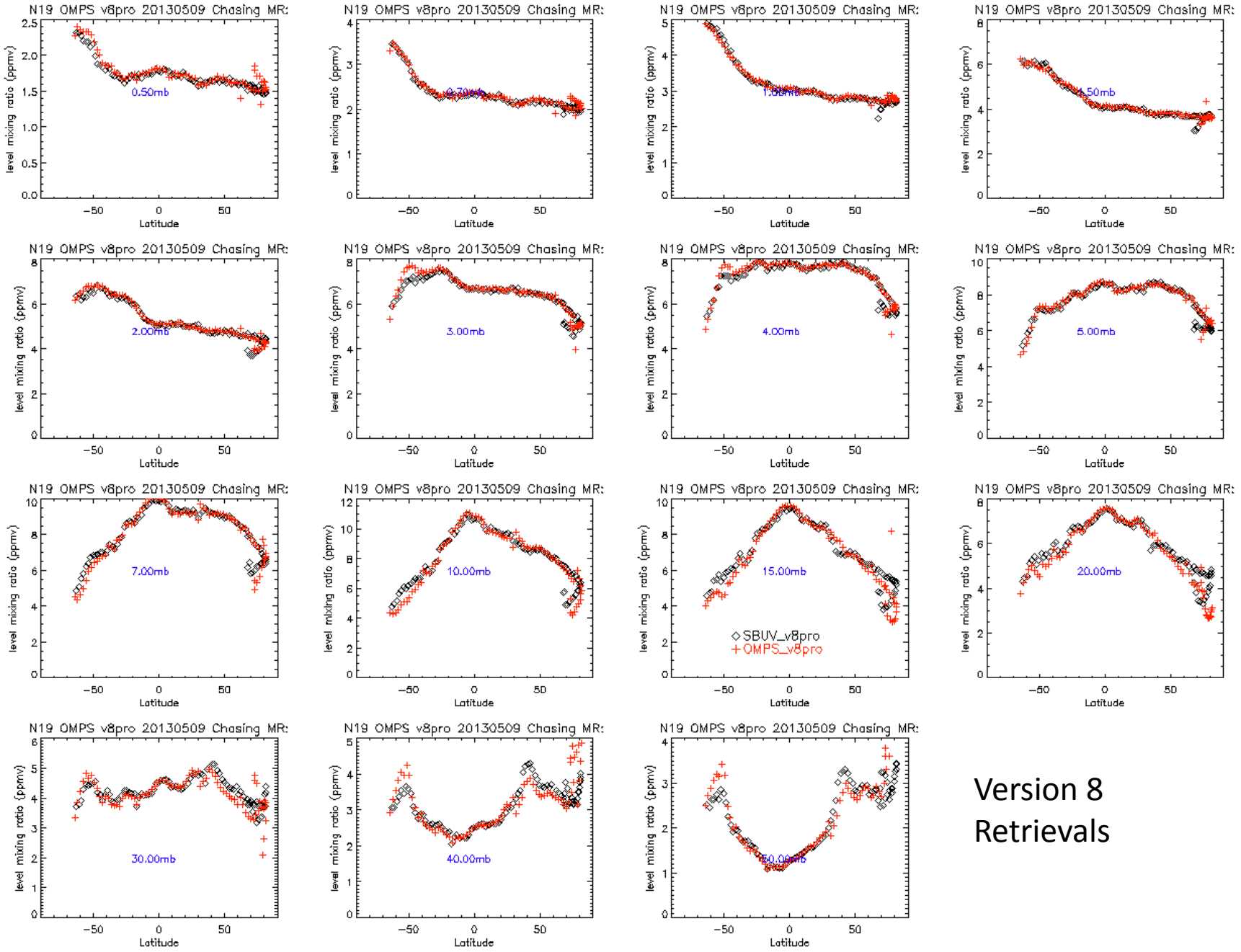

N18N19 OMPS Daily Zonal Mean Initial Residual (Cha4@288nm) 1.2012–2.2014 20S20N/–90W0
Black NOAA18 V8pro
Red OMPS V8pro
Blue NOAA19 V8pro
Residual
N18N19 OMPS Daily Zonal Mean Initial Residual (Cha5@292nm) 1.2012–2.2014 20S20N/–90W0
Residual
N18N19 OMPS Daily Zonal Mean Initial Residual (Cha6@298nm) 1.2012–2.2014 20S20N/–90W0
Residual
1/12
3/12
5/12
7/12
9/12
11/12
1/13
3/13
5/13
7/13
9/13
11/13
1/14
Daily Time Series

Chasing Orbit Comparisons of OMPS and SBUV/2 V8Pro

- The figures on the next show comparisons for the V8Pro products for OMPS and NOAA-19 SBUV/2. The plots show ozone mixing ratios for fifteen different pressure levels versus latitude for a “Chasing*” Orbit. Good agreement is seen for most latitudes
- We have discovered and corrected an error in the dN/dx tables that was affecting the accuracy for the higher latitudes in the northern hemisphere.

* Chasing orbits in this case are opportunistic formation flying that occurs once every twelve days when the S-NPP and NOAA-19 platforms follow close to the same orbital tracks.

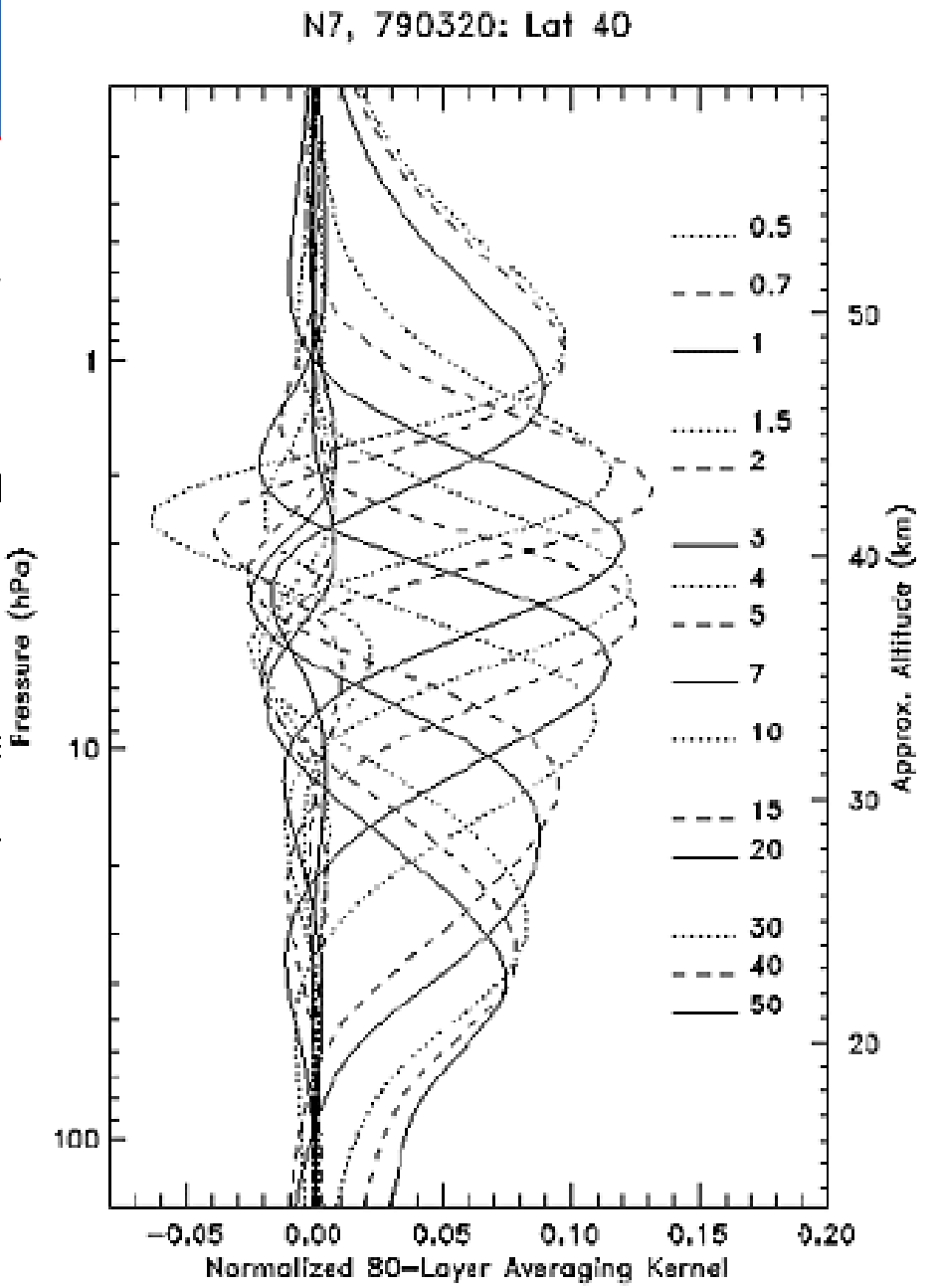
Chasing Orbit NOAA-19 SBUV/2 versus OMPS



Version 8 Retrievals

Version 8 Averaging Kernels

Averaging Kernels (AKs) (for fractional changes in ozone) at the 15 pressure levels. The short horizontal lines on the right side of the graph show the pressure levels and point to the corresponding AK. The horizontal and AK lines' styles correspond. In general, the (fractional) variation in the mixing ratio reported by SBUV at a given pressure level is a weighted average of the (fractional) variation of the mixing ratio at surrounding altitudes, relative to the a priori profile. Since the SBUV V8 a priori profiles have no inter-annual variation, the AKs also show how the algorithm would smooth a long-term trend in ozone mixing ratio. Note, however, that individual SBUV profiles usually have structures that are finer than those implied by the AKs; these structures come from the assumed a priori profile rather than from the measurements themselves. This figure shows typical AKs at the 40ºN. The AKs show best resolution of ~6 km near 3 hPa, degrading to ~10 km at 1 and 30 hPa. Outside this range the retrieved profiles have little information. For example, the (fractional) variation in ozone mixing ratio seen at 0.5 hPa actually represents the (fractional) variation from the region around 1 hPa, and the variation around 50 hPa represents the variation from around 40 hPa.



Adjustments using A, K, and Dy

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

$$A = Dy \# K$$

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

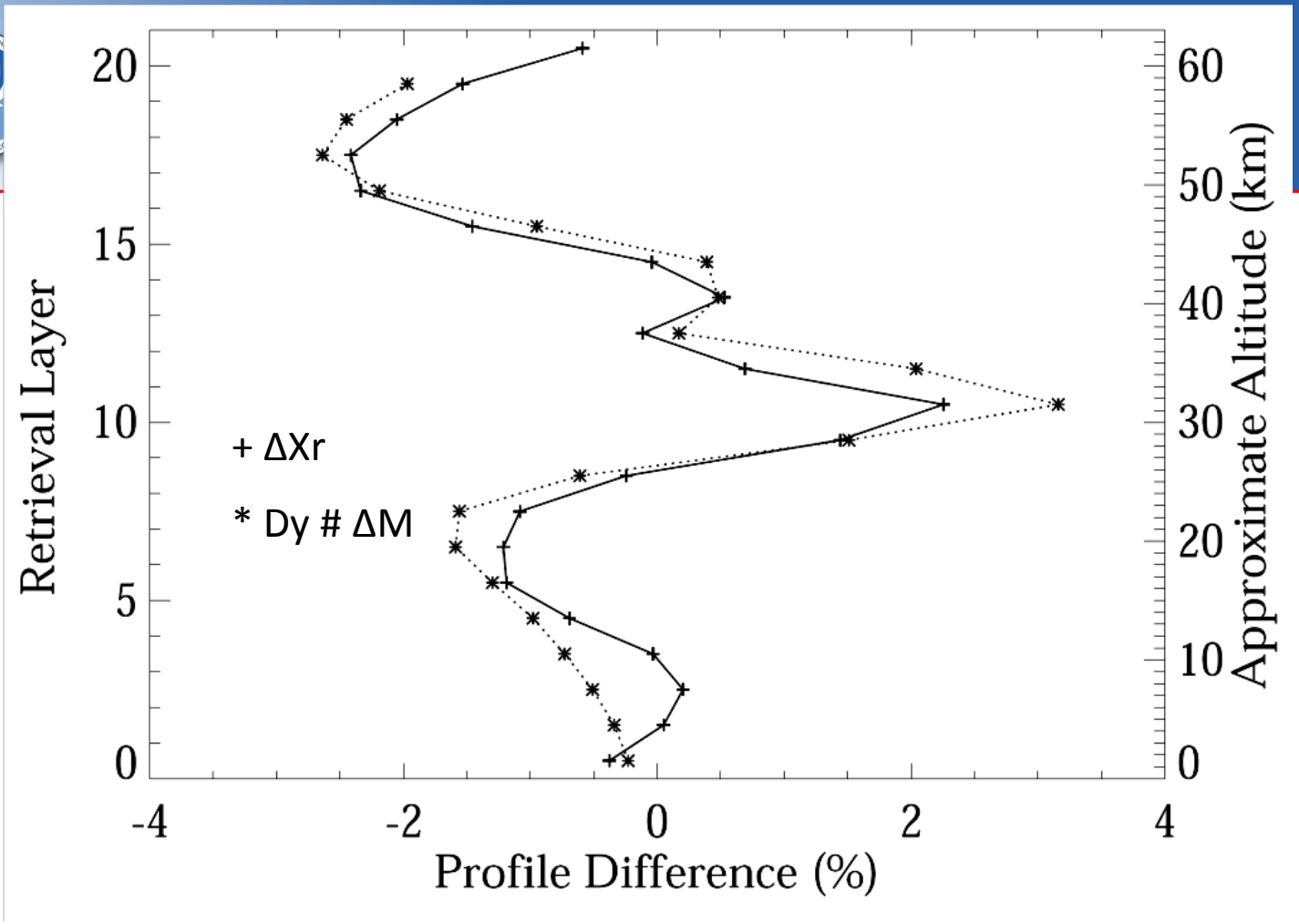
$$Xr = Xa + A \# [Xt - Xa]$$

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

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

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

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



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 their differences in their initial residuals. The "+" symbols are Δ**Xr** computed directly and the * symbols are **Dy** Δ**M** with Δ**M** computed from the initial residuals. We can produce vary homogeneous Climate Data Records by determining the Δ**M** values.

Options for Basic Implementation of V8Pro

- IDPS (Need to introduce new content and format for LUTs and output in addition to new PRO components)
  - Implement as a companion process to the V6Pro. Make use of the V6Pro input/output as input. V6Pro still runs in IDPS. (Tested in ADL at STAR.) (This was the selected path.), or
  - Replace V6Pro with V8Pro as the Program part of IPO.
- NDE (Need to implement as a new process with new output)
  - From IMOPO – no new glueware, V6Pro still runs in IDPS, or
    - Need flow of IMOPO to NDE
  - From SONPS/GONPO & SOMTC/GOTCO – New glueware (in use at STAR), Only SDRs and GEOs in IDPS
    - Need flow of SDRs and GEOs to NDE
- OSPO/POES (Need to implement as another "SBUV/2" with existing V8 processing code)
  - From IMOPO – no new glueware, V6Pro still runs in IDPS, or
    - Need flow of IMOPO to POES processing system
  - From SONPS/GONPO & SOMTC/GOTCO – New glueware (in use at STAR), Only SDRs and GEOs in IDPS
    - Need flow of SDRs and GEOs to POES processing system

Lines of Code for V8Pro at STAR

- The V8Pro was provided to DPES in an ADL implementation as a sub-module of the existing V6Pro processing. It contains approximately 20000 new lines of code.
- The output was expanded and now includes both the V6Pro and V8Pro parameters.
- The programs to create and prepare additional LUTs (Radiative Transfer and Ground Pis) will be exercised offline at STAR as needed.

What about refinements for V8Pro?

Solar Activity and Wavelength Scales in the SDR or when SDR is read in.

- The daily Mg II Index values from GOME-2 can be used to adjust the Day 1 solar by using scale factors.

  The day of year values can be used to give the expected wavelength scale from intra-annual variations. The can be used to adjust the Day 1 solar and its wavelength scale. (The V8Pro can accommodate small variations in the wavelength scale about some mean values.)

Information concentration / Noise reduction and Outlier Detection and Removal

Information concentration can be performed at the same step as the N-value creation, either in the input stage of the V6Pro or the input stage of the V8Pro (if the latter is working directly from SDRs). SONPO would maintain spectral coverage for smaller FOVs.

Smaller FOVs

For the initial delivery, these products will not flow from IDPS starting points for SDRs or EDRs as those use a glueware aggregator.

Glueware (NM/NP Matchups) modifications on the appropriate system will be made to handle new cases of FOVs J01. We will develop smaller FOV capabilities as part of J01 plans.

New ancillary Input

The systems can access better data for snow/ice and surface pressure for use in the V8Pro processing

Plans for V8Pro

- OMPS ozone profile products will be made at IDPS by using the V8Pro code as implemented for the SBUV/2.
- The operational products will be the first step in CDR generation.
- Smaller FOVs will initially be accommodated by changes in the matchup glueware. Smaller EDR products will be obtained by code enhancements as part of the J01 upgrades.
- Solar activity adjustments and intra-annual wavelength shifts will be implemented by using the existing SDR table capabilities.
- Information concentration (noise reduction) and outlier detection will be implemented in future refinements for the the OMPS data input module for the V8Pro.