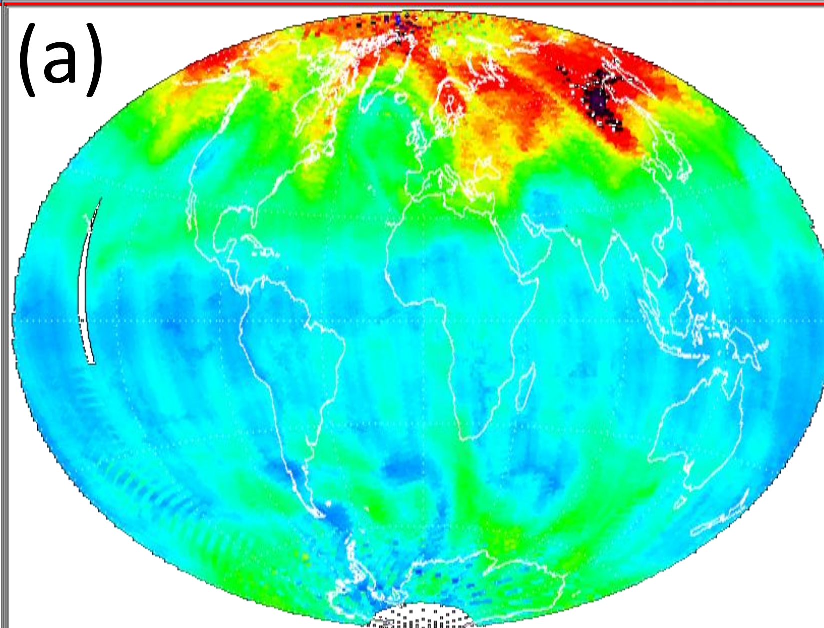
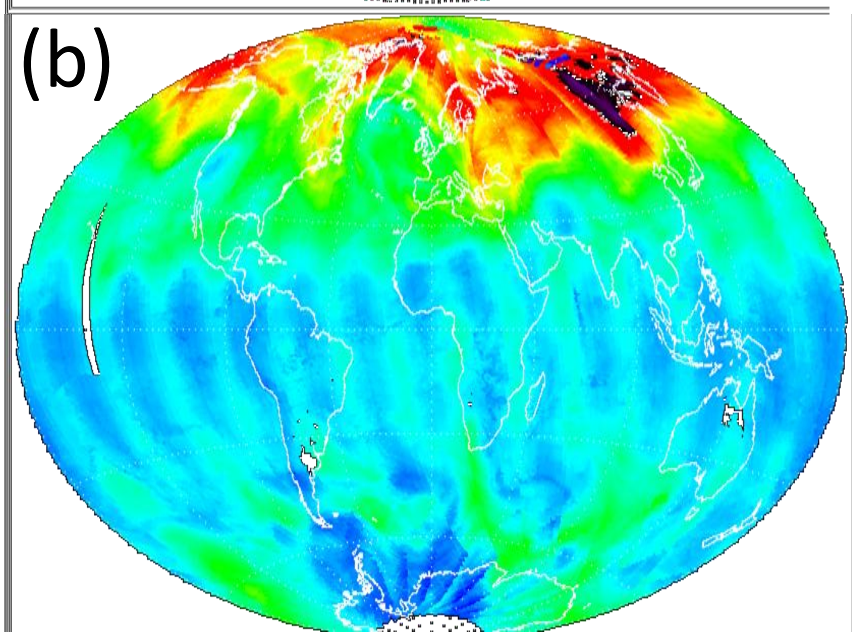
JPSS DPA Program Planning Meeting
Ozone EDR Team

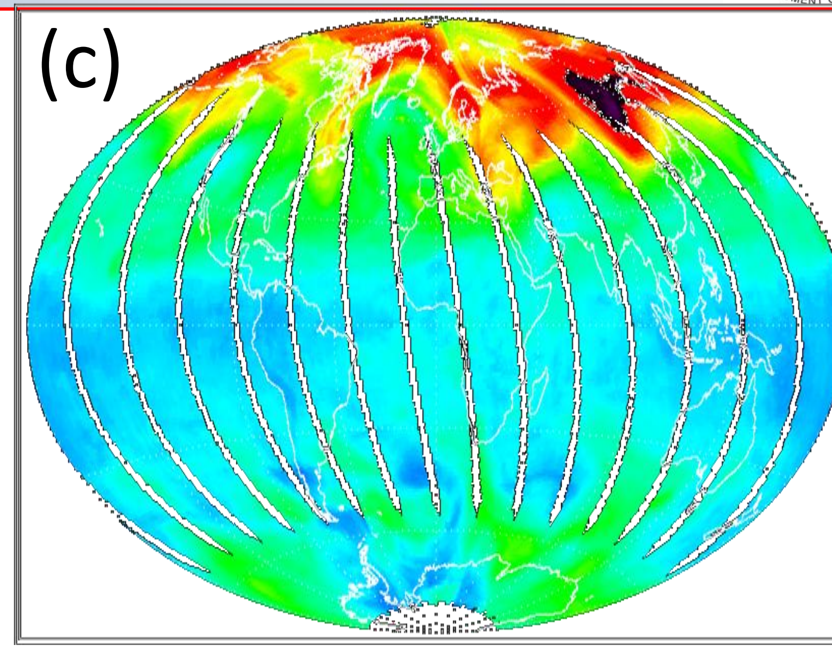
Lawrence Flynn
Ozone EDR Lead

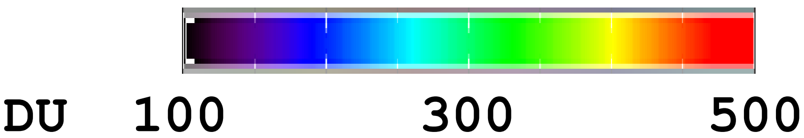
September 18 & 21, 2012

Overview of Data Products



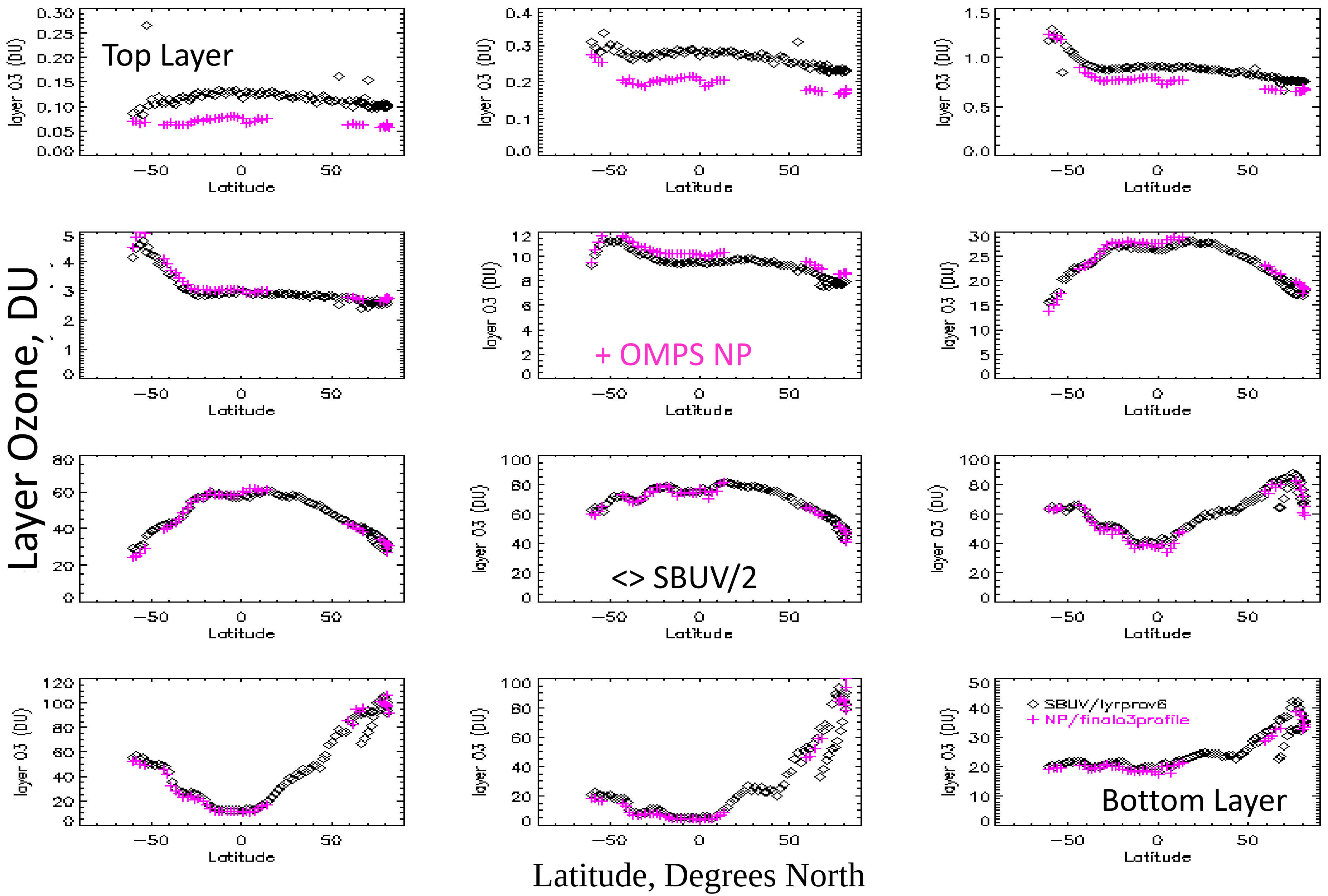




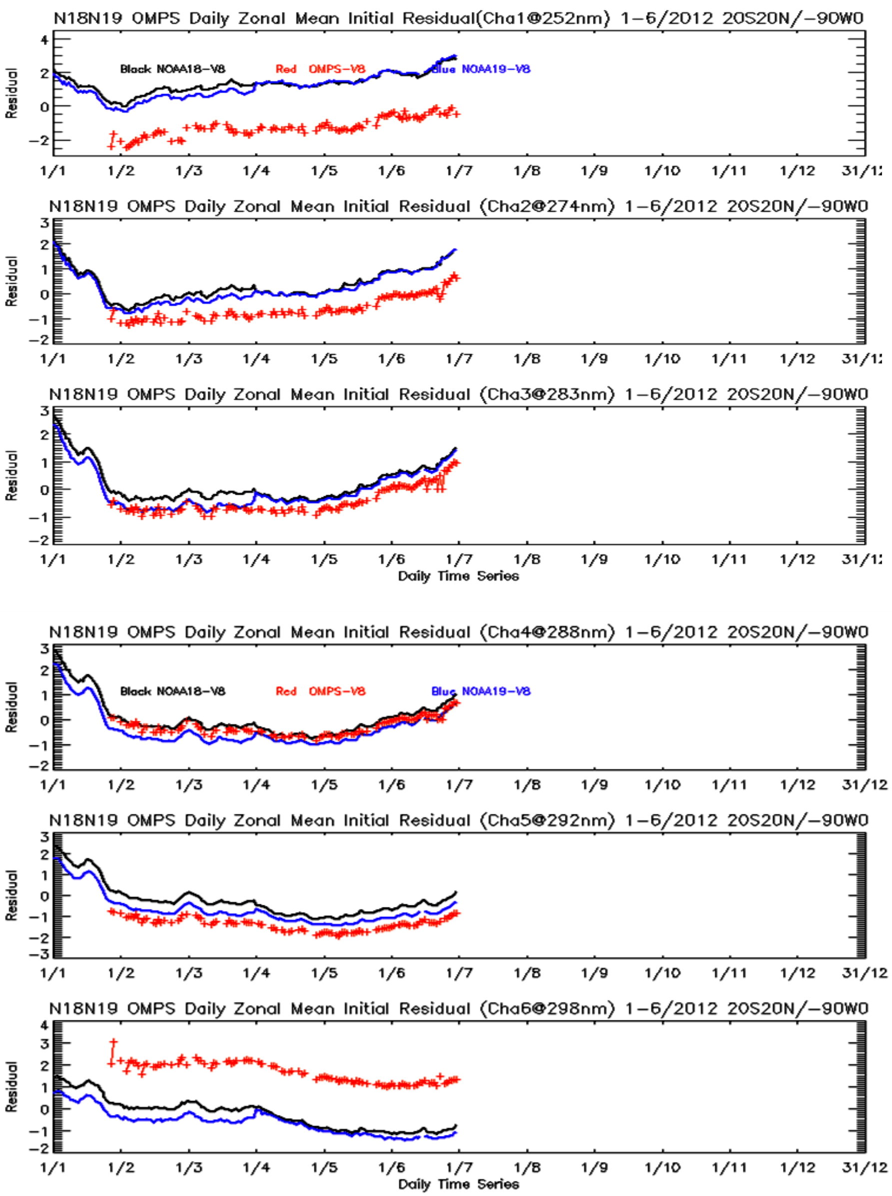


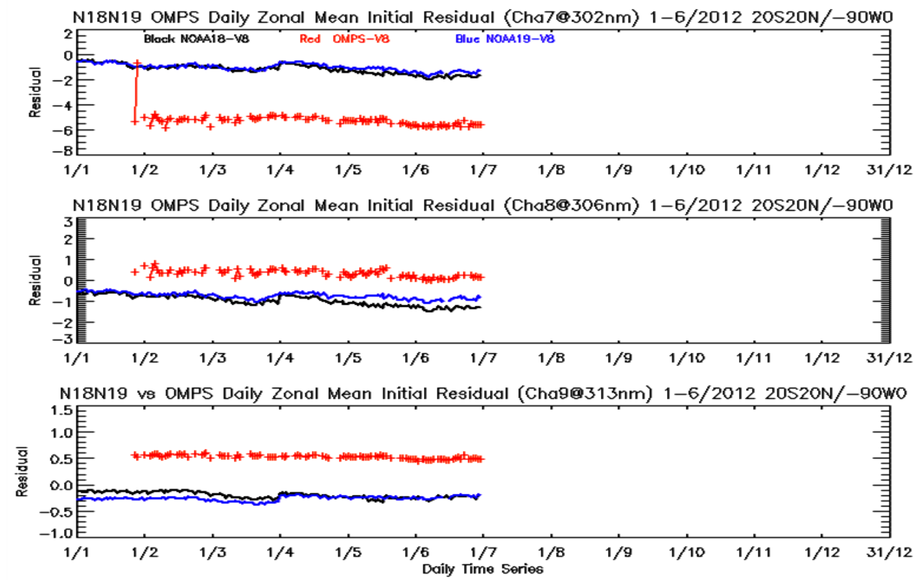
Daily Total Column Ozone map comparisons between (a) IDPS OMPS First Guess Multiple Triplet product, (b) NOAA OMPS V8 product, and (c) NASA OMI V8.6 product for March 30, 2012. Cross-track features in OMPS products are related to the use of preliminary calibration values.

Chasing orbit: OMPS NP EDR vs. SBUV/2 V6



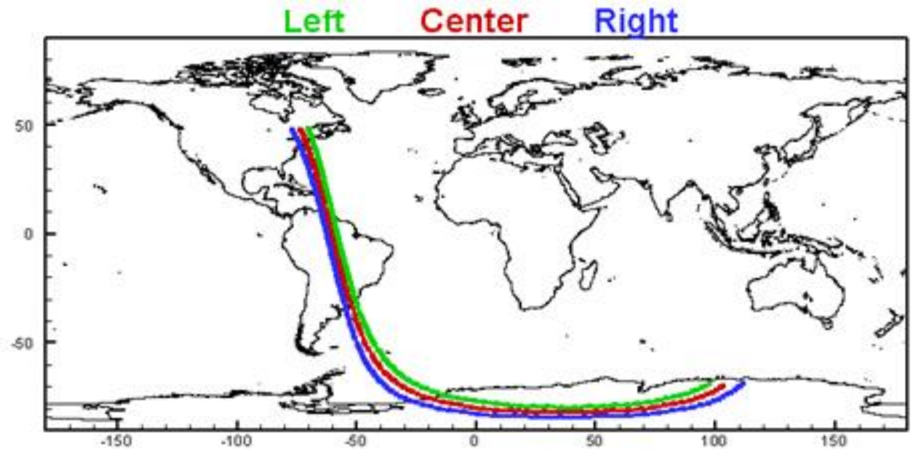
Time series of initial V8PRO residuals for OMPS NP February through June

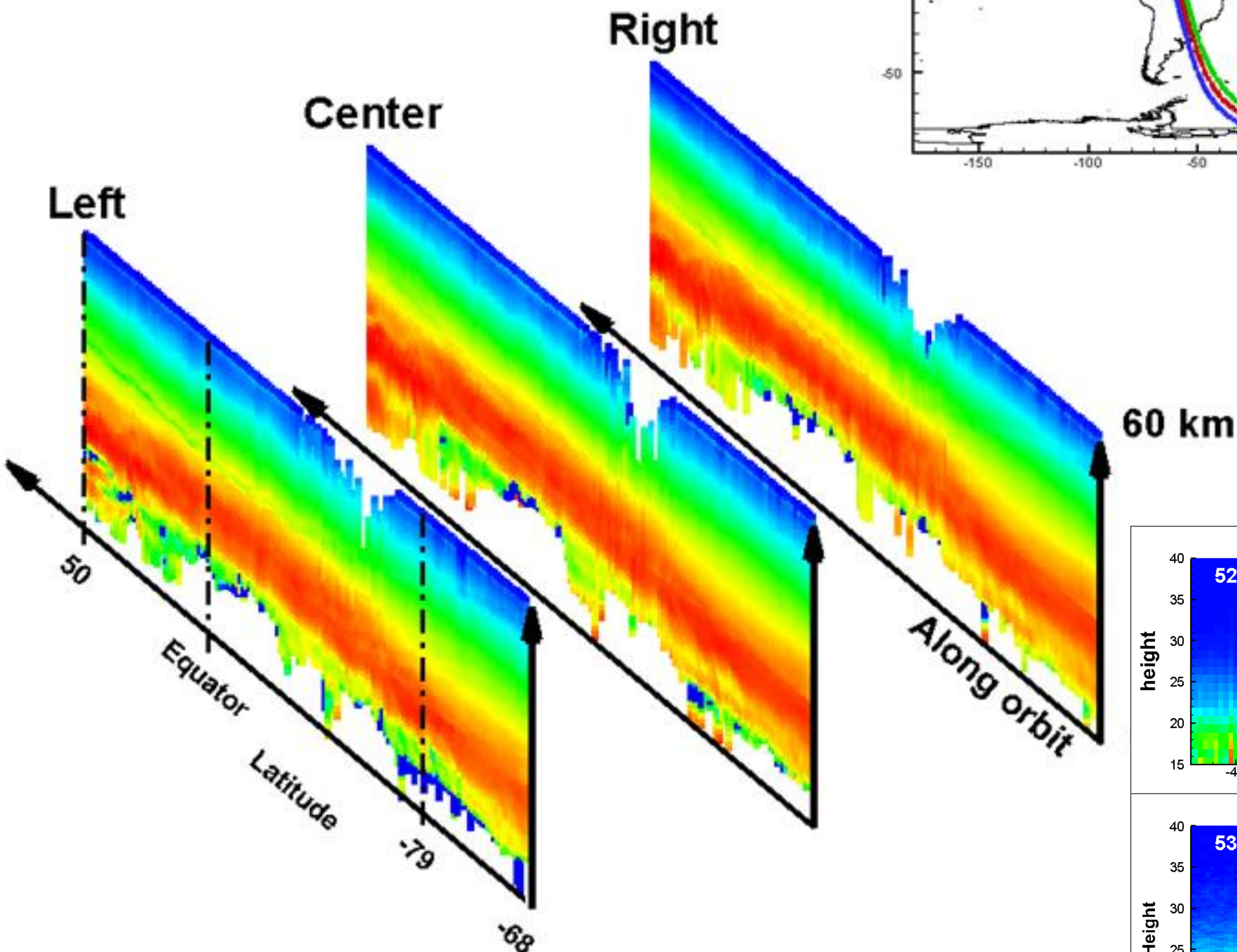


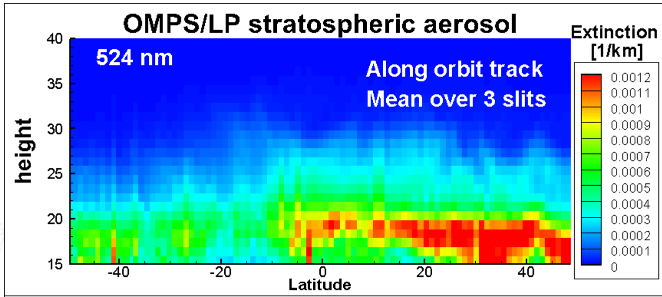


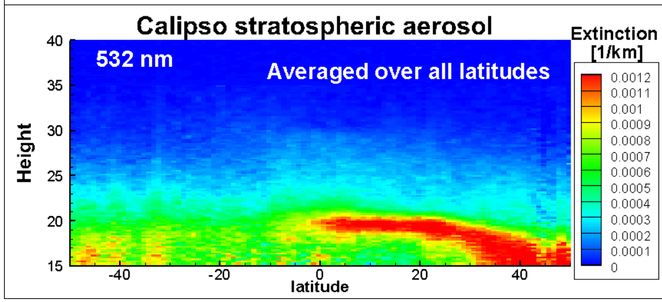
Initial Measurement Residuals for the OMPS NP Version 8 Profile Product: The nine figures show the initial residuals for profile wavelengths [252, 274, 283, 288, 292, 298, 302, 306 and 313 nm, (a) to (i), respectively] for the V8PRO product from S-NPP **OMPS** compared to the same product for the operational **NOAA-18** and **NOAA-19** SBUV/2 for the equatorial daily zonal means (20N to 20S) with 0-90W removed to avoid South Atlantic Anomaly effects. The residuals are in N-values (1 N unit ~ 2.3%). The time period is the first six months of this year (February to June for OMPS). Notice that the residuals for OMPS, have maintained a persistent bias relative to the SBUV/2 residuals. This processing uses a fixed day one solar spectrum only adjusted for Earth/Sun distance .

OMPS/LP retrieved ozone profile
Jan 10, 2012





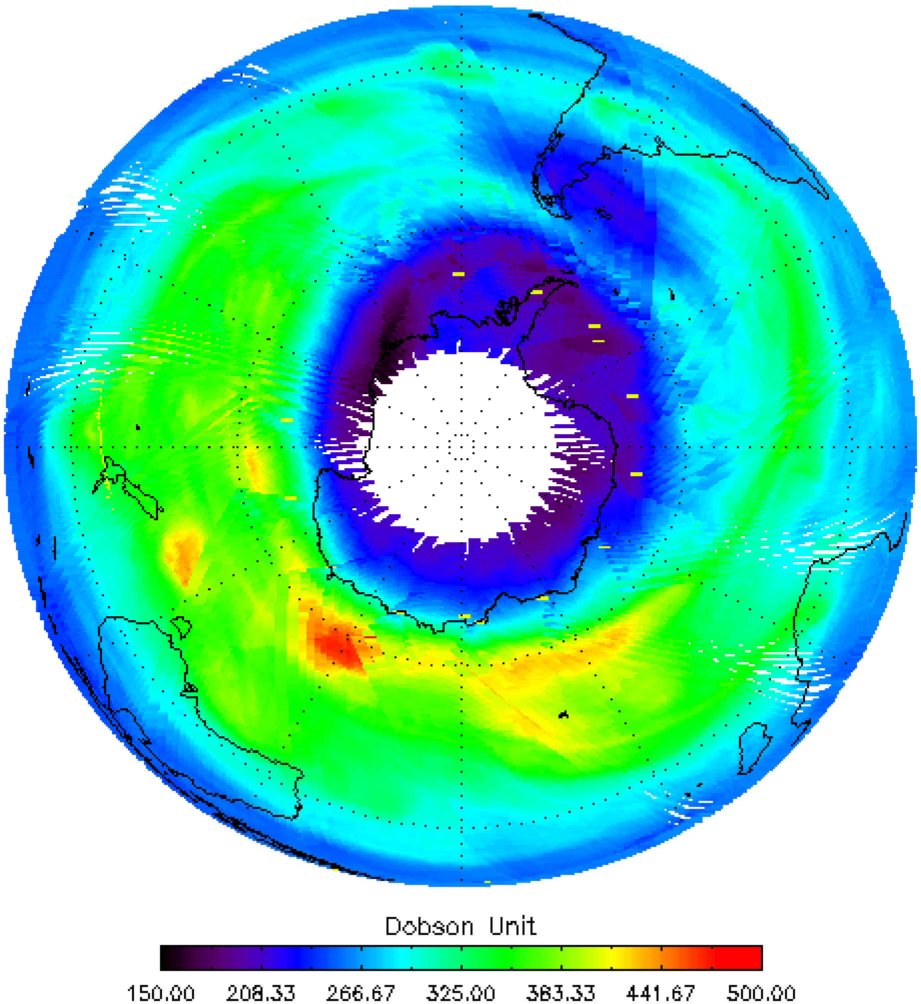


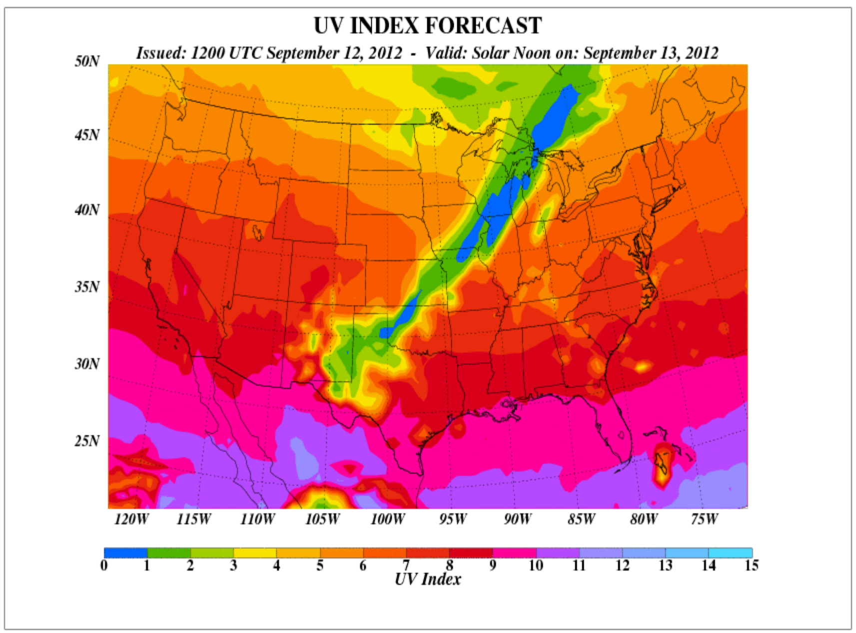


Overview of Data Products

- No KPPs in Atmospheric Ozone Discipline
- Ozone
  - Total Column Ozone
  - Ozone Profile Nadir EDR
  - Ozone Profile Limb EDR
  - CrIS Ozone (RIP/DIP)

Southern Hemisphere Total ozone map from OMPS for 09/06/2012





← UV Index Forecast for September 13, 2012

Overview of Data Products

- Total Column Ozone (1st pass RIP) and EDR
  - Global coverage of atmospheric ozone column
    - Operational Assimilation (Weather and UV forecast)
    - Daily Maps (Ozone Hole/Layer monitoring)
    - Climate Data Records (Ozone Layer assessments)
  - UV Effective reflectivity IP
  - UV Aerosol Index IP
  - SO2 Index
- Ozone Vertical Profile EDR (Nadir)
  - Layer amounts and mixing ratios
  - Mg II Solar Index
- CrIS IR Ozone Delivered IP
  - Ozone total column and profile
  - Will be used as input for new TOAST product

Ozone Products Team Members' Roles & Responsibilities

Area	Name	Organization	Funding Agency	Task
Cal/Val	L. Flynn (0.2 L) I.Petropavlovskikh(L) C. Long/H. Liu (L/C) W. Yu/E. Beach (C/C)	NOAA/STAR NOAA/ESRL NOAA/NCEP NOAA/STAR	STAR ESRL/JPSS NWS/JPSS JPSS	Plan/Lead/Coord. Ground-based Assimilation Satellite/Internal
Nadir Algorithms	L.Flynn/T. Beck (0.4) Z.Zhang/J.Niu (C/C) C.Seftor (C) + 1 FTE W.Wolf's Team (C)	NOAA/STAR NOAA/STAR NASA GSFC NOAA/STAR	STAR JPSS NPP ST/PEATE JPSS	(Evaluate, Develop, Improve, Document, Implement)
Limb Algorithms	P.K. Bhartia (L) M.Linda (C) L.Flynn (0.2) E-M Devaliere (C)	NASA LaRC NASA GSFC NOAA/STAR NOAA/STAR	NPP ST PEATE STAR PSDI	Research Development Transition Lead Science Code Transfer
Climate Data Records	R.McPeters (L) 2 FTEs (C/C) L.Flynn (0.2 L) Z.Zhang/E.Beach (C/C)	NASA GSFC NASA GSFC NOAA/STAR NOAA/STAR	NPP ST ST/MEASURES STAR NOAA/JPSS	(Implementation, Evaluation, Validation, & Reprocessing)

(L) Team Lead, (C) Contractor

FY-12 Accomplishments

- Regular flow of all EDRs and IPs to STAR
- Products to Beta Maturity
  - TIM presentations and Readme files
- Populated ICVS monitoring pages
  - http://www.star.nesdis.noaa.gov/icvs/PROD/proOMPSbeta.php
- Discovered and resolved issues (DRs and CCRs)
- Instances of ADL have been hosted
- Talks and posters at AMS, IGARSS, IYCS, and QOS
- Feedback to SDR Team on C/V Tests 1-7; calibration, internal consistency, stray light, SNR, and wavelength registration
- C/V Tests 8-21 including comparisons to existing satellite and ground-based ozone measurements are proceeding

FY12 Accomplishments: Key DRs

DR number	Short Description
4712 CCR484	NM EDR to Beta Maturity (Awaiting public access to INCTO)
4840 CCR516	NP EDR to Beta Maturity
4269 CCR385	NM Improved cloud top pressure climatology
4266 CCR419	NM correct partial cloud algorithm; use in place of VIIRS cloud fraction
4262 CCR343	NM New RT-LUTs - correct smile and new cross sections
4860 CCR595	NP Surface pressure limit too restrictive
4798 CCR481	NM Adjust solar for Earth/Sun Distance
4256	NP Replace V6 with V8 (V8 demonstrated on LINUX, ADL is next)
4823	NP Stray light correction (Under development)
4802	NP Snow/Ice missing (resolve with V8 implementation)
4678	NM Snow/Ice from VIIRS is not updated (VIIRS Team issue)
4562 PCR29464	Error in DOY code for February

Scientific Advancements

- Conducted checks of error flags and analysis of internal consistency for IMOPO, INCTO, and OOTCO.
  - Reported in TIMs, Beta reviews and at ICVS.
- Provided improved Cloud Top Pressure climatology and revised partial cloud logic.
- Demonstrated V8TOZ and V8Pro Processing of OMPS SDRs.
- Evaluated stray light and wavelength registration
- Began comparisons of OMPS and CrIS ozone products to each other and to GOME-2, OMI, SBUV/2 and ground-based data sets. (Pacific Box, No-local-time difference zonal means, “chasing” orbits, overpass)

Issues, Challenges, Setbacks

- ADL is still a work in progress and each new build requires time to get back up to speed
- Empirical Nadir Profiler Stray light differs quantitatively from prelaunch values
- Change process for IDPS implementation takes too long

Changes in Strategy (due to funding constraints)

- Pushed CrIS IR Ozone evaluation to the right (started last month)
  - TOAST replacement project under PSDI
- Pushed OMPS Limb Profile transition moved to the right (SDR now progressing very well on path to NDE)
  - Some R2O support from PSDI
- Ozone CDR project did not receive new funding in FY12

FY-13 Schedule and Milestones

- Regular flow of overpass product files 12/2012
- Provisional Maturity 2/2013
  - Depends on ability to resolve issues and implement calibration adjustments, code changes, and INCTO access at CLASS.
- V8Pro demonstrated in ADL 6/2013

Path Forward (FY-13 thru FY-17)

(assume "FYxx" runs from April 1, 20xx to March 31, 20xx+1)

	Suomi NPP	JPSS J1
FY13	Complete validation to Provisional status for OMPS Ozone products, Provide V8Pro DAP with FOV and FM flexibility. (Assume larger role in SDR calibration processing/analysis.) Resolve any issues in applications of OMPS products in place of SBUV/2 and OMI products.	Work with spacecraft to increase polling rate/packet size for OMPS communication. Adapt SDR & EDR algorithms to handle smaller FOVs.
FY14	Complete Validation of OMPS Ozone Products through Level 3. Provide V8TOZ DAP with FOV and FM flexibility. Develop combined UV/IR ozone retrieval using OMPS NM & NP and CrIS.	Provide tables (RT LUT, Stray Light corrections, solar wavelength scale adjustments, bandpasses) and ancillary files for as characterized FM2. Begin to incorporate EOS Aura OMI algorithms/products into J1 OMPS system
FY15	Generate reprocessed ozone EDRs meeting long-term stability requirements. Complete validation of OMPS Limb Profiler products.	Begin Calibration/Validation sequence and monitoring for ozone products from J1.
FY16	Continue monitoring and maintenance of products and algorithms. Continue reprocessing.	Continue and work with users to assure application needs are met.
FY17		Continue monitoring and maintenance of products and algorithms. Begin reprocessing.

Summary

- The validation tasks for the OMPS Total Column Ozone and Ozone Profile product are proceeding. The instrument is performing well and shows little degradation.
- The Total Column Ozone EDR Algorithm as applied for the First Guess Product has better performance than the EDR as the ancillary data products are problematic.
- The V8Pro algorithm has been demonstrated with OMPS data and is starting the transition to operations
- The OMPS Limb Profiler algorithms have been demonstrated by the NASA NPP ST. The SDR algorithm is advancing toward operational implementation.

Ozone
Backup

Related Roles & Responsibilities for OMPS Products

Area	Name	Organization	Funding Agency	Task
Nadir SDR Sensor Scientist	F. Wu (0.2L) T. Beck (0.4) C. Pan G. Jaross (CL) 3 FTE (C) R. Buss	NOAA/STAR NOAA/STAR UMD NASA GSFC NASA GSFC Raytheon	STAR STAR JPSS NPP ST JPSS JPSS	(Calibrate, maintain, improve, validate, evaluate, and monitor)
Limb SDR	G. Jaross (CL) M. Linda (C)	SSAI SSAI	NPP ST PEATE/NPP ST	"Calibrate, ... "
Instr.Scientist Instr.Manager	S. Janz (L) M Matsumura (L)	NASA GSFC NASA GSFC	JPSS JPSS	Calibration,Acquisition Eng. Support
Nadir Products	M. Caponi (J) B. Sen, K. Jordan, M. Novicki (C)	DPA NGAS	JPSS JPSS	Dev/Test ConOps (ADA, Science Algorithms)
IDPS	D. Stuhmer, D. Cumpton, etc.	Raytheon	JPSS	EV and Cal; RDR, SDR, and EDR
JPSS	Numerous	DPA, DPE, etc.	JPSS	(AT)DRs, ConOPS, ADL, Data, Code, etc.

(L) Team Lead, (C) Contractor, (J) JAM

Implementation of the Version 8 Total Ozone and Ozone Profile Algorithms with the Ozone Mapping and Profiler Suite (OMPS) to Continue Ozone Climate Data Records

D. Swales[1,4], Z.-H. Zhang[1], L. Flynn[2], E. Beach[1], W. Yu[3]3, J. Niu[3], Y. Hao[1]
1 I.M. Systems Group Rockville MD 20852; 2 NOAA NESDIS 5200 Auth Rd. Camp Springs MD 20746; 3 Earth Resource Technology Laurel MD 20707; 4 Currently with CIRES, Boulder CO 80305

Introduction

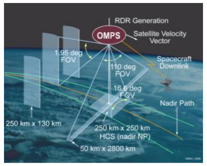
NOAA, through the Joint Polar Satellite System (JPSS) program, is advancing its polar-orbiting satellite system with new instruments for weather forecast and climate monitoring. The first satellite, the Suomi Nation Polar-orbiting Partnership satellite (S-NPP), was launched on October 28, 2011 [in partnership with National Aeronautical Space Administration (NASA)]. See http://npp.gsfc.nasa.gov/ for information on the payload compliment of other instruments. The Ozone Mapping and Profiler Suite (OMPS) onboard the S-NPP satellite (and future JPSS satellites) is the next generation of US operational space-borne UV and ozone monitoring instruments.

The suite consists of two telescopes feeding three detectors measuring solar radiance scattered by the Earth's atmosphere and solar irradiance by using diffusers. The measurements are used to generate estimates of total column ozone and vertical ozone profiles.[1,2] NOAA and NASA are working to continue the Satellite BUV Climate Data Records for Total Column Ozone and Ozone Profiles with the measurements from these new instruments. The total ozone (V8TOZ) and vertical ozone profile (V8PRO) climate data records (CDRs) are long-term datasets that have been derived by applying the Version 8 retrieval algorithms[3] to measurements obtained over the last 33 years from several UV spectrometers onboard various satellites. The V8TOZ CDR is derived from measurements obtained by the SBUV, SBUV/2, TOMS, and OMI instruments. The V8PRO CDR is derived from data obtained by the SBUV and SBUV/2 instruments. The OMPS Nadir Profiler (OMPS NP) replaces the NOAA Solar Backscatter Ultraviolet (SBUV/2) series of instruments as a source of measurements for the profile CDR and the OMPS Nadir Mapper (OMPS NM) replaces the SBUV/2 and TOMS series.

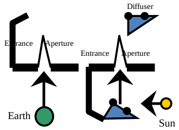
The OMPS consists of three spectrometers; two nadir viewing and one limb viewing, however only the products from the nadir instruments will be discussed here. (See related presentation at this meeting on the OMPS Limb Profiler: in 4D *Ozone vertical profile measurements with the OMPS Limb Profiler*, in 3Ea *Initial assessment of OMPS sensor performance*, and in 3Ea *Data from the OMPS Limb Profiler: How and when it will be available, etc*.)

The OMPS NM (total column ozone sensor) uses a single grating and a CCD array detector to make measurements every 0.42 nm from 300 nm to 380 nm with 1.0-nm resolution. It has a 110° cross-track FOV and 0.27° along-track slit width FOV. The measurements are combined into 35 cross-track FOVs: 3.35° (50 km) at nadir, and 2.84° at ±55°. The resolution is 50 km along-track at nadir, with a 7.6-second reporting/aggregation period.

The OMPS NP (nadir ozone profile sensor) uses a double monochromator and a CCD array detector to make measurements every 0.42 nm from 250 nm to 310 nm with 1.0-nm resolution. It has a 16.6° cross-track FOV, 0.26° along-track slit width. The reporting period is 38 seconds giving it a 250 km x 250 km cell size collocated with the five central Nadir Mapper cells.



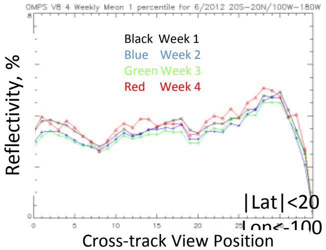
Instrument Fields of View. Schematic from Ball Aerospace &Technology



Each instrument has two solar diffusers; a working and a

Calibration System and Soft Calibration

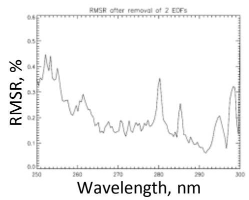
The OMPS instruments (Nadir Mapper, Nadir Profiler, and Limb Profiler) are designed to take a set of measurements to allow analysts to maintain the instrument characterization and calibration.[4] For each of the instruments, this task can be broken into two components, tracking the performance of the CCD array detectors and electronics, and tracking the performance of the optical components, that is, the telescopes and spectrometers. The OMPS also has multiple diffusers, one working and one reference, which allows for tracking long-term solar measurement degradation to produce a stable calibration critical for climate monitoring applications. The instrument makes additional measurements to track dark current, linearity, detector gain, and wavelength scale. These are augmented by soft calibration and internal consistency checks.

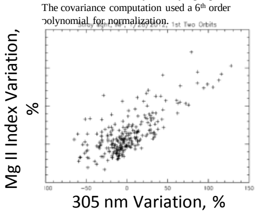


OMPS Minimum Reflectivity Cross-Track Dependence.
The lines in the figure show the weekly, one-percentile effective reflectivity values for the four weeks in the month of June for all the data in a latitude/longitude box in the Equatorial Pacific versus cross-track view position. (17 is the nadir position 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 different values and the cross-track dependence observed here are due to inaccuracies in the initial solar spectra and radiance calibration. While each pixel in an OMPS CCD array can be considered as an independent instrument, reproducible internal comparisons such as this one allow us to track their relative calibration very accurately.

Noise and Stray Light for OMPS NP Radiances

Estimates of noise in the OMPS NP measurements. The Root-Mean-Squared Residuals (RMSRs in % of the average signal) estimates on the right were computed by using Empirical Orthogonal Function analysis of the covariance matrix for clean data for 230 spectra. A spectral screen detected and removed one deviant value on average from each of the 120-wavelength spectra. The removal of the second EOF pattern was somewhat arbitrary as it and the third EOF may be stray light patterns. The covariance computation used a 6th order polynomial for normalization.



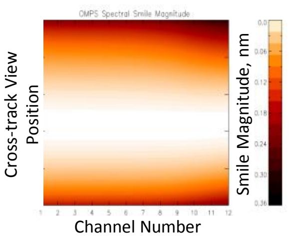


The scatter plot on the left compares simple three-wavelength Mg II core-to-wing ratio variations (radiance at 280 nm divided by the average of 277 nm and 282 nm) with longer wavelength variations at 305 nm. There is no geophysical reason to expect the two to be correlated, and the exposed relationship is symptomatic of out-of-band stray light. The core average is ~0.4 of wings, so this -0.5% to 1.5% variation represents (1.0/0.4 – 1 =) 1.5 times the expected stray light variations in the wings. This means that the 283 nm channel used in the retrieval will need to have a correction applied.

Algorithm Adaptation

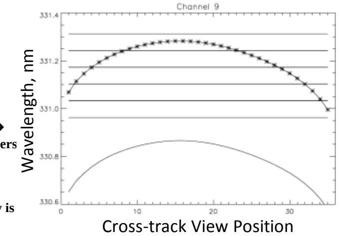
To properly adapt the V8PRO and V8TOZ algorithms to be used with measurements obtained from the OMPS instrument, new radiative transfer look-up-tables (RT LUTs) had to be created by using monochromatic radiance forward model results and the OMPS instrument slit functions. The Ring effect was incorporated into the monochromatic radiance prior to the convolution with the OMPS slit functions. To account for the effects of a spectral smile in the OMPS NM data, RT LUT results are generated over a range around each channel's target wavelength. The RT LUT's entries are interpolated within the retrieval algorithm to construct a table at the proper wavelength center. The 12 channels for the V8TOZ have nominal band centers 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. This RT LUT interpolation scheme also allows for the correction of any identified intra-orbital shifts or long-term drift in the wavelength scale.

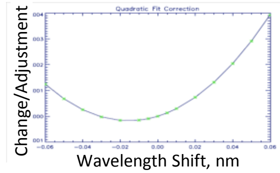
For the V8PRO, the OMPS NP slit function was implemented into the retrieval algorithm for single-scattering calculations at the shorter wavelengths; λ < 287nm. The 12 channels currently used in the V8PRO have band centers at: [252,273,283,288,292,298,302,306,313,318,331,340] nm. The eight shortest channels are taken from the OMPS NP and the four longer channels are taken from the OMPS NM (aggregated to match the OMPS NP 250X250 KM^2 FOV)



← The OMPS NM has an asymmetrical spectral smile across the 110° FOV that increases with magnitude at longer wavelengths. The smile magnitude varies from 0.19-0.27nm to the left and 0.22-0.36nm to the right of nadir. The longest wavelength is observed approximately at cross-track position 16.

Illustration of wavelength choices for OMPS NM → The stars represent the actual wavelength band centers as measured on the OMPS NM CCD-array. The horizontal lines give the band centers used in the instrument RT LUT nodes for this channel. The spectrally adjacent (-0.42 nm) row in the CCD-array is also shown below the target row.



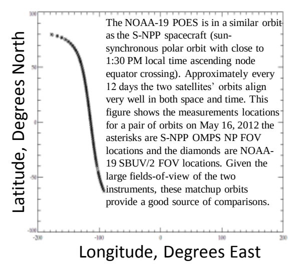


A set of corrections to adjust the Solar irradiance spectra to match the Earth radiance spectra is computed by the following method. For each of the 196 wavelengths and each of the 35 cross-track pixel aggregations, a high-spectral resolution reference solar spectra is convolved with the OMPS bandpasses for a discrete set of band centers placed from -0.06 to +0.06 nm about the nominal Earth-view band center. The changes in the solar irradiance for wavelength scale shift is well approximated by a quadratic in this shift quantity as shown in the figure above. The green dots represent the computed shifted proxy solar irradiances relative to the unshifted value. The solid line represents the quadratic fit to these differences to use as a correction. A 196X35X3 matrix of the quadratic coefficients is read into the program and used to calculate adjustments to the solar irradiance for the wavelength scale differences with the Earth radiance scales.

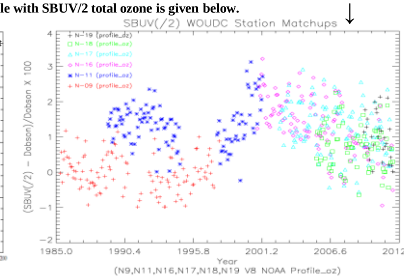
Comparisons to Contemporaneous Record Components

While the OMPS is a new suite of instruments, we are fortunate that its ozone records will overlap with those from other instruments contributing to the ozone CDRs. For the total ozone products, we can make extensive comparisons with zonal means and the full daily maps from other satellite products. We will also compare each individual component of the record to ground-based assets, e.g., the Dobson Network. An example with SBUV/2 total ozone is given below. ↓

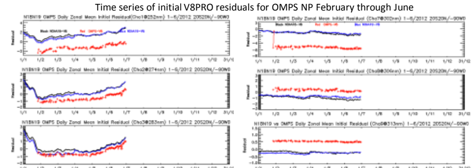
For the ozone profile products will make zonal mean comparisons. We will also use chasing orbit comparisons – orbits with nadir tracks closely matched in space and time. An example pair of orbits is given in the figure to the right. We will also use no-local-time-difference latitude comparisons – If one examines a pair of ascending and descending polar-orbiting satellites, e.g., S-NPP and NOAA-17, they will find two latitudes where the nadir views are at the same local time of day for both. One is on the day side and the other 180° away on the night side with a 12-hour difference in local time. This allows comparisons with similar viewing conditions and avoids complications from diurnal effects.

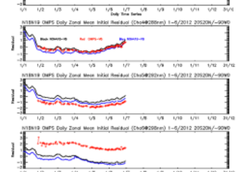


The NOAA-19 POES is in a similar orbit as the S-NPP spacecraft (sun-synchronous polar orbit with close to 1:30 PM local time ascending node equator crossing). Approximately every 12 days the two satellites' orbits align very well in both space and time. This figure shows the measurements locations for a pair of orbits on May 16, 2012 the asterisks are S-NPP OMPS NP FOV locations and the diamonds are NOAA-19 SBUV/2 FOV locations. Given the large fields-of-view of the two instruments, these matchup orbits provide a good source of comparisons.



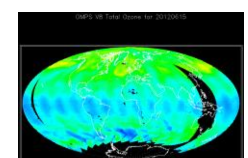
Time series of initial V8PRO residuals for OMPS NP February through June

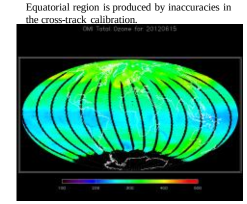


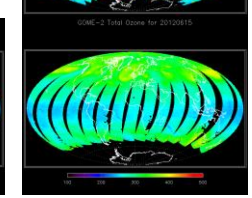


Initial Measurement Residuals for the OMPS NP Version 8 Profile Product: The nine figures show the initial residuals for profile wavelengths [252, 274, 283, 288, 292, 298, 302, 306 and 313 nm, (a) to (i), respectively] for the V8PRO product from S-NPP **OMPS** compared to the same product for the operational **NOAA-18** and NOAA-19 SBUV/2 for the equatorial daily zonal means (20N to 20S) with 0-90W removed to avoid South Atlantic Anomaly effects. The residuals are in N-values (1 N unit ~ 2.3%). The time period is the first six months of this year (February to June for OMPS). Notice that the residuals for OMPS, have maintained a persistent bias relative to the SBUV/2 residuals. This processing uses a fixed day one solar spectrum only adjusted for Earth/Sun distance . This will be refined in the future to use the Mg II Solar Index and response scale factors to adjust for changes in solar activity.

Comparisons of OMPS Total Ozone Retrievals with those from EOS Aura OMI and EuMetSat MetOp-A GOME-2. Data for all three maps are processed with the Version 8 algorithm. (OMI is processed by the NASA EOS Aura Science Team.) There is general agreement between the three products but the OMPS requires additional work before it will be of Climate Data Record quality. For example, the "scalloping" in the Equatorial region is produced by inaccuracies in the cross-track calibration.







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[1] Juan V. Rodriguez, et al., "An overview of the nadir sensor and algorithms for the NPOESS ozone mapping and profiler suite (OMPS)," *Proc. SPIE*, 4891, April 2003, DOI: 10.1117/12.467525.

[2] *Earth Science Satellite Remote Sensing Vol.1: Science and Instruments*, Qu, J.J, et al. (Eds.), 2006, Springer Verlag, ISBN: 978-3-540-35606-6. "Chapter 21: Introduction to the Ozone Mapping and Profiler Suite (OMPS)," L. Flynn, C. Seftor, J. Larsen, and P. Xu, Springer Verlag, July 2004.

[3] *Solar Backscatter Ultraviolet Instrument (SBUV/2) Version 8 Ozone Retrieval Algorithm Theoretical Basis Document (V8 ATBD)*, Edited by L. Flynn (Last Revision February 2, 2007) www.star.nesdis.noaa.gov/smcd/spb/calibration/icvs/sbuv/doc/SBUV2_V8_ATBD_020207.pdf

[4] Quinn P. Remund, et al., "The ozone mapping and profiler suite (OMPS): on-orbit calibration design," *Proc. SPIE*, 5652, pp.165-173. December 2004.

Related talks and posters at the QOS 2012:

3Ea *Verification and early Operations for the Ozone Mapping and Profiler Suite (OMPS)*

4C *The Use of OMPS Nadir Data to Extend Long-term Ozone Climate Records*

NOAA Satellite Ozone Product Monitoring:

http://www.star.nesdis.noaa.gov/icvs/PROD/proOMPSbeta.TOZ_V8.php

http://www.ospo.noaa.gov/Products/atmosphere/

Opinions expressed are those of the authors and do not imply any official positions of NOAA or the JPSS Program.

Work was support by NOAA, NASA, the JPSS Program, and the NDCD Science Data Stewardship Program.

OMPS data used in figures are at Beta maturity level – minimal validation with changes expected and not ready for use in scientific studies.

Suomi-NPP Product Validation for the Ozone Mapping and Profiler Suite (OMPS)

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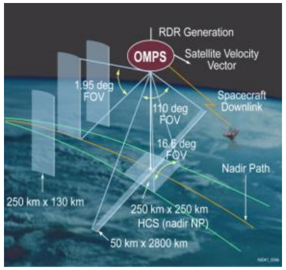
Introduction

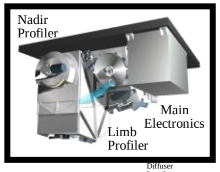
NOAA, through the Joint Polar Satellite System (JPSS) program, in partnership with National Aeronautical Space Administration (NASA), launched The Suomi-National Polar-orbiting Partnership (S-NPP) satellite on October 28, 2011. The JPSS program is executing the S-NPP Calibration & Validation program to ensure the data products comply with the requirements of the sponsoring agencies. The Ozone Mapping and Profiler Suite (OMPS) consists of two telescopes feeding three detectors measuring solar radiance scattered by the Earth's atmosphere and solar irradiance by using diffusers [1]. The measurements are used to generate estimates of total column ozone and vertical ozone profiles. The validation efforts make use of external resources in the form of ground-based and satellite measurements for comparisons, and internal consistency methods developed over the last thirty years. This poster provides information on the state of the execution of the OMPS Cal/Val Plan with emphasis on the measures of the instrument performance from internal consistency analysis techniques and comparisons to other satellite instrument products for the validation of the NPP OMPS environmental data products.

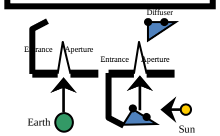
Instruments & Measurements

The total column sensor uses a single grating and a CCD array detector to make measurements every 0.42 nm from 300 nm to 380 nm with 1.0-nm resolution. It has a 110° cross-track FOV and 0.27° along-track slit width FOV. The measurements are combined into 35 cross-track bins: 3.35° (50 km) at nadir, and 2.84° at ±55°. The resolution is 50 km along-track at nadir, with a 7.6-second reporting period. (This resolution choice is changeable; we are investigating the use smaller FOVs.)
The nadir profile sensor uses a double monochromator and a CCD array detector to make measurements every 0.42 nm from 250 nm to 310 nm with 1.0-nm resolution. It has a 16.6° cross-track FOV, 0.26° along-track slit width. The reporting period is 38 seconds giving it a 250 km x 250 km cell size collocated with the five central total column cells.
The limb profile sensor is a prism spectrometer with spectral coverage from 290 nm to 1000 nm. It has three slits separated by 4.25° with a 19-second reporting period that equates to 125 km along-track motion. The slits have 112 km (1.95°) vertical FOVs equating to 0 to 60 km coverage at the limb, plus offsets for pointing uncertainty, orbital variation, and Earth oblateness. The CCD array detector provides measurements every 1.1 km with 2.1-km vertical resolution. The products for the Limb Profiler are not discussed here. (See the OMPS Limb Presentation in Session 4D for more information.)

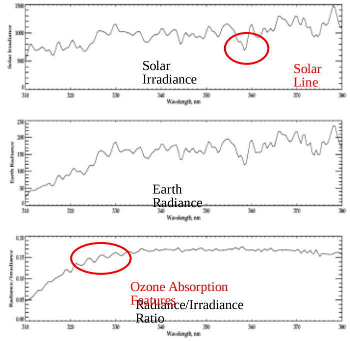


Instrument Fields of View. Schematic from Ball Aerospace and Technology Corporation.





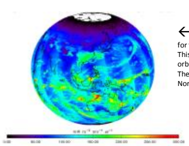
Each instrument has two solar diffusers; a working and a reference.



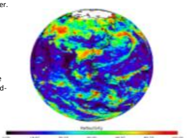
Typical spectra from 310 to 380 nm for OMPS Nadir Mapper

Calibration System

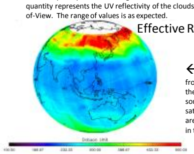
The OMPS instruments (Nadir Mapper, Nadir Profiler, and Limb Profiler) are designed to take a set of measurements to allow analysts to maintain the instrument characterization and calibration.[2] For each of the instruments, this task can be broken into two components, tracking the performance of the CCD array detectors and electronics, and tracking the performance of the optical components, that is, the telescopes and spectrometers. The instruments make measurements on the night side of orbits with the apertures closed. One set is made without any sources and is used to track the CCD array dark currents. Another set is made with illumination by an LED and is used to track CCD non-linearity and pixel-to-pixel non-uniform response. The instruments also make solar measurements using pairs of diffusers. Judicious operation of working and reference diffusers allows analysts to track the diffuser degradation. The solar measurements also provide check on the wave-length scale and bandpass. The instruments have completed multiple passes through their internal dark and nonlinearity calibration sequences and are beginning to make solar measurements.



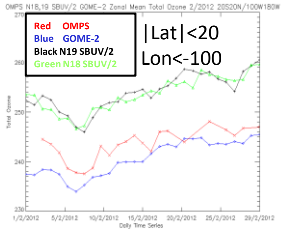
← 331-nm Channel Radiances
for the first eight orbits of OMPS Nadir Mapper measurement (1/26-27/2012). This image shows the expected range of values and variations across the orbital track and with solar zenith angles at the times of the measurements. The white circle around the North Pole is the region of polar night during the Northern Hemisphere Winter.



The multiple triplet retrieval algorithm in IDPS for the same eight orbits. The quantity represents the UV reflectivity of the clouds and surface in each Field-of-View. The range of values is as expected.
Effective Reflectivity →



← Total Ozone
from the multiple triplet retrieval algorithm first guess product in IDPS for the same eight orbits for the first pass ozone retrieval The values show some cross track variations and are offset approximately 5% from another satellite ozone product. These uncertainty levels for preliminary products are consistent with the use of prelaunch calibration parameters and tables in the initial operational system.

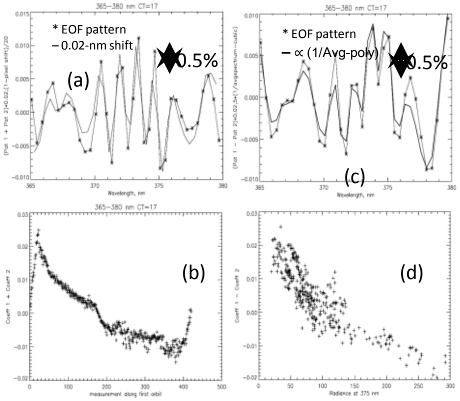


Comparison of daily mean total column ozone estimates from SBUV/2 NOAA-18 (**BLACK**) & NOAA-19 (**GREEN**), NPP OMPS (**RED**) and MetOP-A GOME-2 NOAA V8 Processing (**BLUE**) for February 2012 for a latitude/longitude box in the Equatorial Pacific.

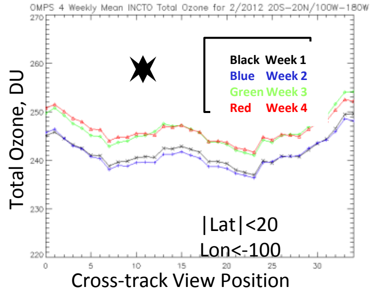
First Light Products are Beta Quality

Internal Consistency and Measurement Information Content

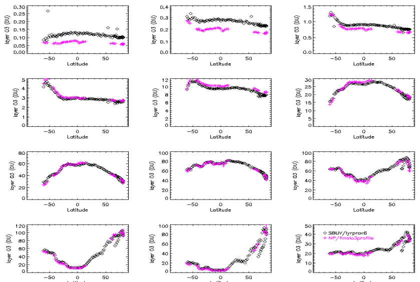
The product retrieval algorithms are designed to use ratios of Earth radiance to solar irradiance, to make use of pairs and triplets of measurements, and, in the case of the Limb profiler, to use normalization to measurements at reference tangent heights, greatly reducing sensitivity to instrument throughput changes [3]. The hyperspectral nature of the detectors provides information at wavelengths not used directly in the retrieval algorithm. Residuals for these measurements are used to check the consistency of the retrieved quantities. For example, differences in the ozone absorption cross-section for channels between 306 nm and 313 nm provide a test of the retrievals for equatorial viewing conditions. The differential sensitivity of the top of atmosphere radiances at reflectivity channels from 340 nm to 360 nm to satellite viewing angles and solar zenith angles provide opportunities to check the calibration by comparisons of derived cross track minimum reflectivity estimates. Empirical Orthogonal Function (EOF) analysis was conducted on the covariance matrix for spectra for the central cross-track position for the 365 nm to 380 nm wavelength range for parts of six orbits on 1/28/2012. The first two patterns contain 90% of the variability after removing a 3rd order polynomial from Radiance divided by the Average Radiance. The two patterns are primarily combinations of Wavelength Scale Shift and Ring Effect/Stray Light variations.



Figures (a) and (b) show the sum of the first two EOF patterns (a) and the coefficients (b) for the first orbit. (a) also has the computed variations expected from a 0.02-nm wavelength scale shift. The two curves agree very well. The pattern of the coefficients in (b) may be related to wave-length scale changes produced by intra-orbital variations in the optical bench temperatures. While the shifts are small, we plan to implement a correction/adjustment to improve the ozone products. Figure (c) shows the differences of the first two EOF patterns. Now the additional curve is a scaled reciprocal of the average spectrum pattern. Again, the two curves agree very well. One would expect this pattern to be produced by inelastic scattering (Ring Effect) or out-of-band stray light. The figure on the Bottom Right tests this by looking at the dependence of the coefficients (y-axis) with the 375 nm radiances (x-axis). The inverse relationship between the two suggest that the major source of these variations is the Ring Effect – not Stray Light. The OMPS NPP Science Team has plans to exploit this signal to create UV cloud optical centroid estimates. Given the radiance levels, a 0.01 pattern in values in figures (a) and (c) equates to approximately a 1% radiance variations.



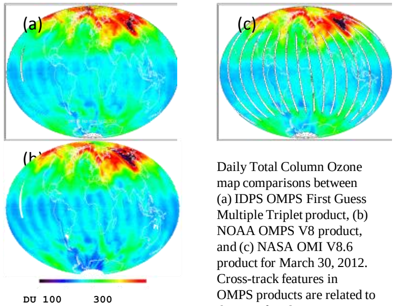
February weekly-mean total column ozone (OMPS Nadir Mapper First Guess retrievals) as a function of the cross-track view angle for the region defined by 20S to 20N Latitude and 100W to 180W Longitude. The persistent cross-track bias are produced by deficiencies in the initial radiance calibration relative to the solar data irradiance values.



The figures above have comparisons of the ozone profile retrievals between the OMPS Nadir Mapper operational (Currently Version 6) ozone profiles and the NOAA-19 SBUV/2 processed with the Version 6 ozone profile retrieval algorithm. The data are from a single pair of orbits on May 16, 2012 where the two satellites are flying in formation (orbital tracks within 50 KM and sensing times with 10 minutes). The ozone profile retrievals are reported in Dobson units for 12 pressure layers. They are plotted here versus Latitude. The 12 Umkehr layers boundaries are at:
[0.0,0.25,0.50,0.99,1.98,3.96,7.92,15.8,31.7,63.3,127.0,253.0,1013] hPa.
The top three layers' results are in the top row with the topmost layer on the upper left. The lowest layer's results are in the figure on the bottom right. The OMPS Nadir Profiler values are in Pink and the **SBUV/2 are shown in Black.** The figures show general agreement between the retrievals for the two instruments but with the OMPS NP retrieving much smaller values at the top of the profiles. This is probably due to inaccuracies in the initial calibration of the shorter wavelength channels but could also be symptomatic of stray light.

Rapid Comparison to Other Products

The ozone products from the OMPS Nadir Profiler are compared to similar products from the operational Solar Backscatter Ultraviolet instruments (SBUV/2) and ground-based Dobson and Brewer instruments operated in the Umkehr mode. Comparisons of the OMPS NP zonal means of ozone profiles and initial measurement residuals with the currently monitored set of results for the SBUV/2 instruments on NOAA-16, -17 -18, and -19 are taking place. Of particular interest are those computed for instruments in similar orbits (NOAA-19 and NOAA-18 SBUV/2s) at all latitudes and for those computed for NOAA-17 SBUV/2 in a morning orbit for no-local-time difference latitudes. (If one examines a pair of ascending and descending polar-orbiting satellites, they will find two latitudes where the nadir views are at the same local time of day for both. One on the day side and the other 180 degrees away on the night side with a 12-hour difference in local time.) For the OMPS Nadir Mapper, we are making comparisons of its global ozone, effective reflectivity and aerosol products to similar ones from the Ozone Monitoring Instrument (OMI) and to the Global Ozone Monitoring Experiment (GOME-2). Sets of overpass match up values for the satellite instruments with ground-based locations have been expanded to include OMPS products.



Daily Total Column Ozone map comparisons between (a) IDPS OMPS First Guess Multiple Triplet product, (b) NOAA OMPS V8 product, and (c) NASA OMI V8.6 product for March 30, 2012. Cross-track features in OMPS products are related to the use of preliminary calibration values.

Related talks & posters at the QOS 2012

4C The Use of OMPS Nadir Data to Extend Long-term Ozone Climate Records
4D Ozone vertical profile measurements with the OMPS Limb Profiler
3Ea Initial assessment of OMPS sensor performance
3Ea Implementation of the Version 8 Total Ozone and Ozone Profile Algorithm for OMPS to Continue Ozone Climate Data Records
3Ea Data from the OMPS Limb Profiler: How and when it will be available, etc.

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[2] Quinn P. Remund, et al., "The ozone mapping and profiler suite (OMPS): on-orbit calibration design," *Proc. SPIE*, 5652, pp.165-173. December 2004,.
[3] *Earth Science Satellite Remote Sensing Vol.1: Science and Instruments*, Qu, J.J.; Gao, W.; Kafatos, M.; Murphy, R.E.; Salomonson, V.V. (Eds.), 2006, Springer Verlag,. "Chapter 21: Introduction to the Ozone Mapping and Profiler Suite (OMPS)," L. Flynn, C. Seftor, J. Larsen, and P. Xu, Springer Verlag, July 2004.

Satellite Monitoring http://www.star.nesdis.noaa.gov/icvs/PROD/proComparison.php
OMPS NM and NP Data archive http://www.nsof.class.noaa.gov/saa/products/search?datatype_family=OMPS
Operational BUFR ozone products http://projects.osd.noaa.gov/NDE/index.htm
Ground-based http://www.esrl.noaa.gov/gmd/grad/neubrew/ProductDisplays.jsp

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OMPS data are at Beta maturity levels; minimally validated with changes expected and not ready for use in scientific studies. The OMPS SDR and EDR data sets are available to the public at http://www.nsof.class.noaa.gov .

Operational Ozone Sensors and Beyond

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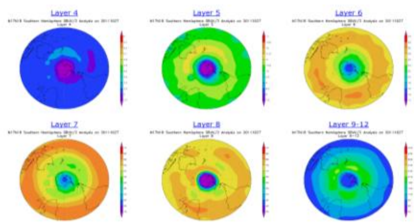
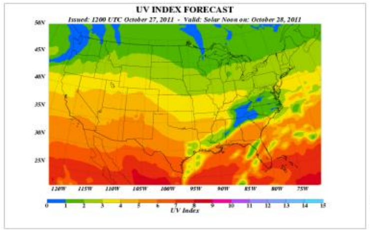
INTRODUCTION: The last two decades have seen exceptional advances in research sensors and data products for atmospheric chemistry studies. These advances are moving forward into the operational arena. This poster presents information on the measurements, capabilities and applications for the new set of ozone sensors operated by meteorological agencies concentrating on those making solar backscatter measurements in the Ultraviolet. The instruments covered include the NOAA/NASA Ozone Mapping and Profiler Suite (OMPS) just launched on the NPP spacecraft on October 28, 2011, the EuMetSat Global Ozone Monitoring Experiment (GOME-2) launched on MetOp-A in 2006 and scheduled for launch on MetOp-B in April 2012, the CMA Solar Backscatter Ultraviolet Sounders (SBUS) and Total Ozone Units (TOU) launched on FY-3a and FY-3b in 2008 and 2010, respectively, and the NOAA Solar Backscatter Ultraviolet instruments (SBUV/2) launched on POES-18, and -19 in 2005 and 2009, respectively.

SBUV/2

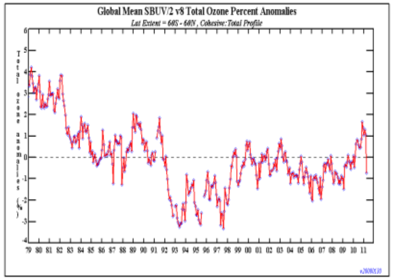
The NOAA Polar-orbiting Operational Environmental Satellite System (POES) has been flying operational ozone monitoring sensors for over 25 years. Measurements from these Solar Backscatter Ultraviolet radiometer (SBUV/2) instruments continue to extend the satellite-based ozone Climate Data Records (CDRs) started by the NASA Nimbus-7 SBUV in 1979. The SBUV/2 instruments make measurements at 12 wavelengths from 252 nm to 340 nm providing information on the total ozone and ozone vertical profile estimates. The ozone measurements are also used to monitor the Ozone Hole and in the creation of daily UV Index Forecasts. There are currently four SBUV/2 instruments in operation on NOAA-16, -17, -18 and -19 POES. See http://www.cpc.ncep.noaa.gov/products/stratosphere/sbuv2to/ and http://www.osdpd.noaa.gov/ml/air/sbuv.html for more information.



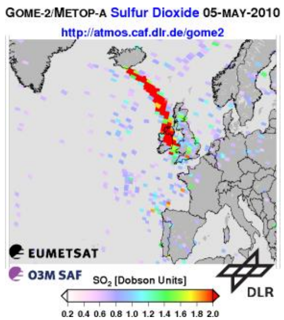
SBUV/2 ozone profile layers give a 3-dimensional view, from the top down, of the Antarctic Ozone Hole on 10/27/2011.



UV Index forecast derived by using SBUV/2 ozone information



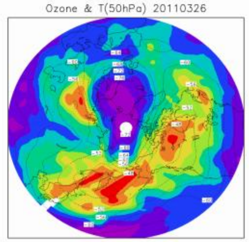
Time series of quasi-global (60°N–60°S) averages of total ozone deseasonalized anomalies (in percent) for the period 1979–2010 from the SBUV(/2) ozone data set.



GOME-2 SO2 column amounts for an Icelandic eruption.

TOU & SBUS

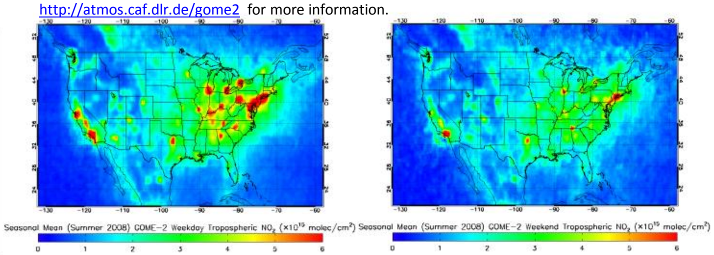
The Chinese Meteorological Administration (CMA) is flying the FengYun-3 (FY-3) series of polar-orbiting weather satellites. The first two, FY-3A and FY-3b, have been launched in May 2008 and November 2010, respectively. Their instrument complement includes the Solar Backscatter Ultraviolet Sounder (SBUS) and the Total Ozone Mapping Unit (TOU). The SBUS has capabilities similar to the NOAA SBUV/2 instrument series and the TOU has capabilities similar to the NASA Total Ozone Mapping Spectrometer (TOMS) including daily global maps of total ozone. The CMA is developing a next generation of ozone instruments including the Ozone Monitoring Sensor (OMS) with capabilities similar to the EOS Aura Ozone Monitoring Instrument (OMI) for service starting later in this decade.



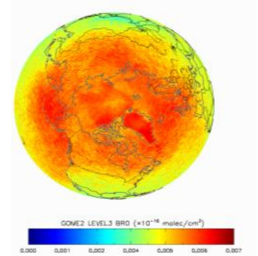
Composite of TOU total column ozone in DU with an overlay of contour lines for temperature in °C at 50 hPa for the Arctic, March 26, 2011.

GOME-2

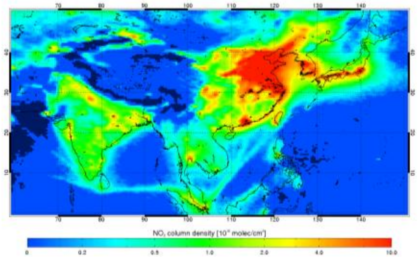
The European Organisation for the Exploitation of Meteorological Satellites (EuMetSat) is flying the MetOP series of Meteorological Operational Polar satellites. The first one, MetOP-A, was launched in October 2006, the second, MetOP-B, is scheduled for launch early next year, and a third will follow in 2017. These satellites carry the Global Ozone Monitoring Experiment (GOME-2) instruments. The GOME-2 uses four detectors to measure light scattered from the Earth's atmosphere from 240 nm to 790 nm with a wide field of view covering two-thirds of the Earth each day. The GOME-2 high spectral resolution and good signal to noise make it an extremely productive source of information on the composition of the Earth's atmosphere. Products include: estimates of vertical ozone profiles, aerosol indices and cloud height and reflectivity, and estimates of total columns of ozone, BrO, NO2, SO2 and HCHO. The last three products are featured in new uses of satellite data in Air Quality applications. See http://atmos.caf.dlr.de/gome2 for more information.



Comparisons of GOME-2 Tropospheric NO2 for weekdays (left) and weekends (right)



Monthly average total column BrO estimates from MetOP-A GOME-2 measurements for August 2010.

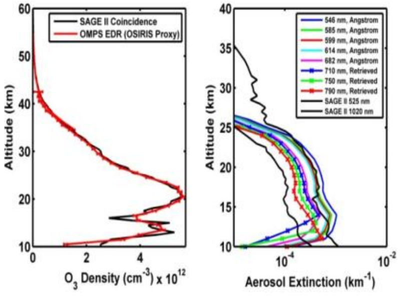


Three-year average (2007-2009) of GOME-2 tropospheric NO2 estimates for Asia.

Satellites	Instruments	Launch Dates	Products
NOAA POES	SBUV/2	N-18 2005 N-19 2009	Total &Profile Ozone
NOAA NPP & JPSS	OMPS	NPP 2011 J1 2016 J2 2020	Total &Profile Ozone, SO2, Aerosol Index
EuMetSat Metop	GOME-2	M-A 2006 M-B 2012 M-C 2017	Total &Profile Ozone, NO2, BrO, SO2, Aerosol Index
CMA FY-3	TOU, SBUS	FY-3A 2009 FY-3B 2011	Total &Profile Ozone, Aerosol Index

OMPS

NOAA and NASA have just launched the NPP satellite, the first US component of the Joint Polar Satellite System (JPSS). Two more launches are planned, with J1 in 2016 and J2 in 2020. The NPP satellite carries a three-instrument suite of ozone sensors, the Ozone Mapping and Profiler Suite (OMPS). The OMPS Nadir Profiler will measure BUV from 250 nm to 305 nm. These measurements will be used to continue the SBUV/2 record of ozone vertical profiles. The OMPS Nadir Mapper will measure BUV from 305 nm to 380 nm. This instrument will provide information to create daily global estimates of aerosol indices and cloud height and reflectivity, and estimates of total columns of ozone and SO2. The OMPS on NPP and on J2 will have a third component, the OMPS Limb Profiler. This instrument measures the radiance scattered from the Earth's atmospheric limb from 290 to 1000 nm. The OMPS Limb profiler is intended to make global measurements of vertical ozone distribution in the Earth upper atmosphere (from cloud top to 60 km) at a vertical resolution of 3 km. The goal is to further extend the 30-year ozone climate data record established by the SAGE, HALOE and MLS instruments. This is especially important for studies of the interaction between ozone chemistry and global climate changes that occur in the lower stratosphere. A secondary product is the stratospheric aerosol vertical distribution from cloud top to 35 km.



Expected performance of OMPS Limb Profiler ozone and aerosol profiles versus SAGE II.

Table 2.1.3 - Ozone Total Column		
EDR Attribute	**Threshold (1,2)**	**Objective**
a. Horizontal Cell Size	50 x 50 km^2 @ nadir (10)	10 x 10 km^2 (10)
b. Vertical Cell Size	0 - 60 km	0 - 60 km
c. Mapping Uncertainty, 1 Sigma (3)	5 km at Nadir (3)	5 km
d. Measurement Range	50 - 650 milli-atm-cm	50-650 milli-atm-cm
e. Measurement Precision (4)		
1. X < 0.25 atm-cm	6.0 milli-atm-cm (4,5)	1.0 milli-atm-cm
2. 0.25 < X < 0.45 atm-cm	7.7 milli-atm-cm (4,5)	1.0 milli-atm-cm
3. X > 0.45 atm-cm	2.8 milli-atm-cm + 1.1% (4,5)	1.0 milli-atm-cm
f. Measurement Accuracy (6)		
1. X < 0.25 atm-cm	9.5 milli-atm-cm (6,5)	5.0 milli-atm-cm
2. 0.25 < X < 0.45 atm-cm	13.0 milli-atm-cm (6,5)	5.0 milli-atm-cm
3. X > 0.45 atm-cm	16.0 milli-atm-cm (6,5)	5.0 milli-atm-cm
g. Latency	120 min. (7)	15 min
h. Refresh	At least 90% coverage of the globe every 24 hours (monthly average) (8)	24 hrs. (8)
i. Long-term Stability (9)	1% over 7 years	0.5% over 7 years
		v1.4.2, 7/29/11

Notes:

1. The OMPS Limb Profiler instrument does not fly on JPSS-1. Thus, only the Ozone Total Column elements are shown in this Table.
2. The loss of the OMPS Limb Profiler has had a small effect on the total column performance as the estimates of the profile shape and the tropospheric ozone are poorer, so the corrections are also poorer. There is new information that the OMPS algorithm use of the IR cloud top pressures will lead to errors as the IR values tend to be higher than the UV ones that should be used. A Discrepancy Report has been submitted and this error contribution is being carried as a risk with known mitigation in the form of improved climatology and measurement-based UV pressure estimates. The values in brackets are the performance requirements prior to OMPS Limb Profiler demanifestation.
3. The IORD-II Mapping "Accuracy" of 5 km at nadir was changed to "Uncertainty, 1 sigma" in accordance with user desires as expressed by the OATS and JARG.
4. The IORD-II required TC Measurement Precision of 3.0 milli-atm-cm + 0.5% of Measured Ozone. However, the TC Measurement Precision attributes are driven by the limitations of the nadir instrument when the contributions of the limb instrument are not available. The Government agrees with the contractor that the revised Threshold specifications represent realistic performance targets based on TOMS-EP heritage and EDR performance assessments.
5. The performance requirements with the contribution of an OMPS Limb Profiler would be as follows: Attribute e(1): 2.5 + 0.5% of measured ozone; Attribute e(2): 2.75 + 0.5%; Attribute e(3): 3.0 + 0.5%; Attribute f(1): 9.0; Attribute f(2): 12; Attribute f(3): 15.
6. The IORD-II TC Measurement Accuracy requirement is 15.0 milli-atm-cm. The TC Measurement Accuracy of 16 milli-atm-cm for Total Column > 450 milli-atm-cm is driven by the limitations of the nadir instrument when the contributions of the limb instrument are not available. The Government agrees with the contractor that the revised specifications represent realistic performance targets based on TOMS-EP heritage and EDR performance assessments.
7. Relaxed IORD-II Threshold requirement.
8. The IORD-II included Refresh threshold and objective requirements of 24 hrs which accommodate the stated requirement that the product be delivered under clear, daytime conditions only. This interpretation of the IORD-II Refresh requirement is consistent with the baseline OMPS Cross-track Swath Width design of ~ 2800 km (110° FOV) for a single orbit plane. All OMPS measurements require sunlight, so there is no coverage in polar night areas. This EDR is currently measured by the SBUV and High Resolution Infrared Sounder (HIRS) on POES, but the EDR produced by this legacy system does not satisfy JPSS threshold requirements.
9. Long Term Stability is not a critical attribute for achieving operational performance but it is for climate applications. Retrospective

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 the relative error for these smaller FOVs. We expect to have 1KM accuracy on the location of individual pixels relative to spacecraft

Overview and status of ozone data products

- Requirements
  - L1RD reproduces the IORD II Total Ozone EDR numbers
  - L1RD Supplement includes requirements for Nadir Profiler ozone profile EDR product (formerly DIP/RIP)
  - CrIS Ozone Product remains a requirementless DIP/RIP.
  - L1RD Supplement provides for future ozone profile EDR from OMPS Limb Profiler measurements
- Current baseline algorithm and code
  - The OMPS Total Ozone EDR uses an extension of the Version 7 TOMS algorithm called the multiple triplet algorithm
  - The OMPS Nadir Profiler EDR uses an old Version 6 SBUV/2 algorithm
  - The CrIS IR Ozone product is an intermediate product of the CrIS temperature profile EDR algorithm in IDPS.
  - The OMPS Limb Profiler ozone profile retrieval algorithm is under development by the NASA NPP Science Team

Overview and status of ozone data products

- Known and/or expected performance
  - Total Ozone EDR
    - Working with First Guess product
  - Nadir Profile EDR
    - Upgrade to V8
    - Minor errors from FOV representation
    - Include Stray Light correction
  - CrIS O3 product should be an improvement on HIRS
  - Limb Profile EDR R&D and R2O is progressing
- Risks and issues
  - Limb retrieval algorithm is computationally complex and intense
  - Getting changes into IDPS is lengthy process

Mitigation: pathway to mission success

- IDPS
  - For the Total Ozone multiple triplet algorithm, we are currently relying on the science code implementations at NGAS and the Ozone PEATE
  - For the Nadir Profile, we have extensive experience with the V6Pro with SBUV/2 and are working to implement the V8Pro
  - We are moving forward to develop expertise with OMPS algorithms in the ADL and ADA
- NDE
  - We are pursuing this option for the OMPS LP SDR and EDR

Mitigation: pathway to mission success

- Actions Needed / Alternative algorithms
  - Total Ozone EDR
    - ✓Remove use of VIIRS cloud fraction and use UV-based Cloud Top Pressure
    - ✓Provide new Instrument RT Look-Up Table
    - Switch to V8 TOZ; already adapted for OMPS CDRs
      - In use for SBUV/2 and GOME-2 at NOAA
      - Consistent daily map products with GOME-2 and CDR
      - Path to future improvements
        - » V8.6 and other OMI products will be adapted for OMPS by the NPP ST
      - Replace current algorithm with V8
  - Nadir Profile Ozone EDR
    - Update to V8 Pro; already adapted for OMPS CDR
      - In use for SBUV/2 and OMPS at NOAA
      - Consistent products with SBUV/2 and CDR
      - Replace V6 in IDPS with V8
  - Limb Profile Ozone EDR
    - Code in R&D and testing at NASA PEATE
    - Transition to NDE started for SDR

OMPS Instrument Design

Total Ozone Mapper

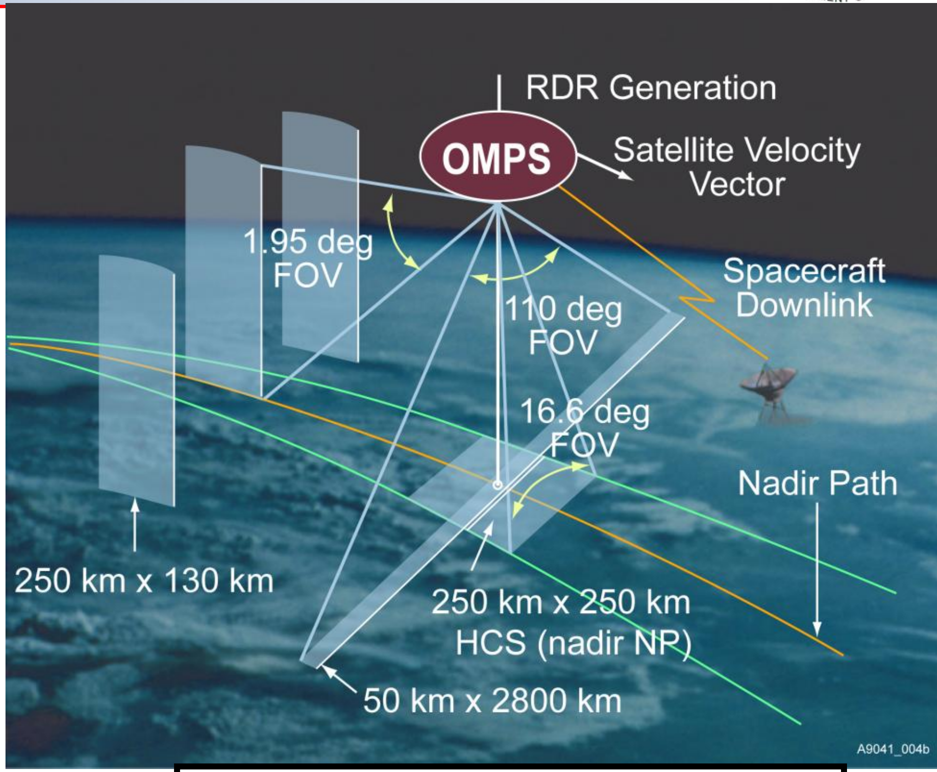
UV Backscatter, grating spectrometer, 2-D CCD
TOMS, SBUV(/2), GOME(-2), OMI, SCIAMACHY
110 deg. cross track, 300 to 380 nm spectral, 1.1nm FWHM bandpass

Nadir Profiler

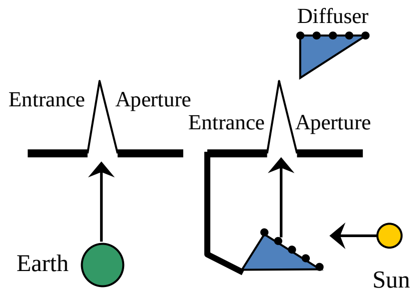
UV Backscatter, grating spectrometer, 2-D CCD
SBUV(/2), GOME(-2), SCIAMACHY, OMI
Nadir view, 250 km cross track, 270 to 310 nm spectral, 1.1 nm FWHM bandpass

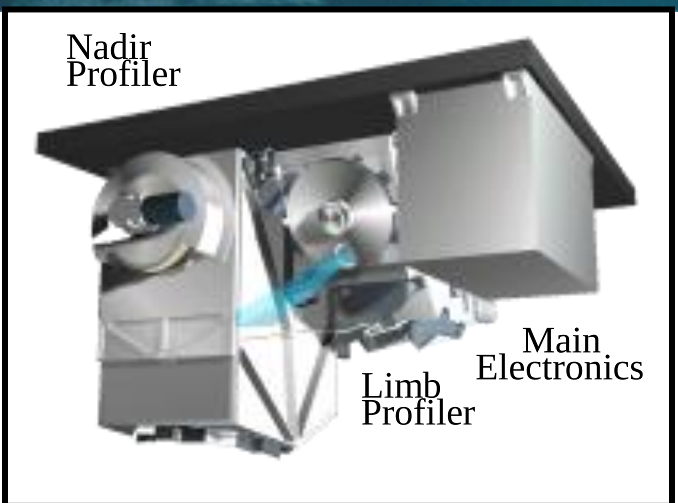
Limb Profiler

UV/Visible Limb Scatter, prism, 2-D CCD array
SOLSE/LORE, OSIRIS, SAGE III, SCIAMACHY
Three 100-KM vertical slits, 290 to 1000 nm spectral



The calibration concept uses working and reference solar diffusers.





Schedule Outline

- Pre-Launch Phase (L-24M to L)
  - Develop Match-up and statistical analysis tools and readers
  - Implement and exercise forward models for radiative transfer
  - Create and manipulate sample, synthetic, and proxy SDR, EDR, and DIP data sets
  - Collect and exercise calibration parameters and instrument models
  - Implement alternative/heritage algorithms
  - Improve Ground-based assets operations and access
- Early Orbit Check Out Phase (L to L+3M)
  - Check parameters and instrument behavior
  - Perform internal consistency checks
  - Provide feedback to SDR Team
  - Test tools and alternate algorithms with real data
- Intensive Cal/Val Phase (L+3M to L+15M)
  - Perform external comparisons to satellite products
  - Perform sub-orbital comparison/validation
  - Provide feedback to IPO and NGAS
  - Evaluate product applications
  - Begin trending and automated monitoring

Product Team SDR Tasks*

- ✓Test OMPS_E1 Dark Signal, Noise, SAA
- ✓Test OMPS_E2 Working Solar
- ✓Test OMPS_E3 Reference Solar
- ✓+Test OMPS_E4 Solar Ref/Work, SNR, Mg II
- ✓+Test OMPS_E5 Earth EOF Patterns & SNR & SAA Filter
- ✓+Test OMPS_E6 Earth Stray Light & Mg II
- ✓+Test OMPS_E7 Intra-orbit λ-scale

The objectives of these test duplicate a subset of the SDR Team's SDR tasks. Results will be discussed and exchanged.

✓ Tasks have completed initial analysis

\+ Follow-on activities are taking place – more work is planned

EDR Tasks

- ✓+Test OMPS_E8 V8 TOZ Internal Consistency
- ✓+Test OMPS_E9 V8 PRO Internal Consistency
- ✓+Test OMPS_E10 EDR consistency & residuals
- ✓+Test OMPS_E11 Compare V8 TOZ and EDR
- ✓+Test OMPS_E12 Compare V8 Pro and DIP
- ✓+Test OMPS_E13 Evaluate Performance in Pacific Box
- ✓+Test OMPS_E14 Satellite Intercomparisons (OMI, GOME-2, SBUV/2, MLS, CrIS)

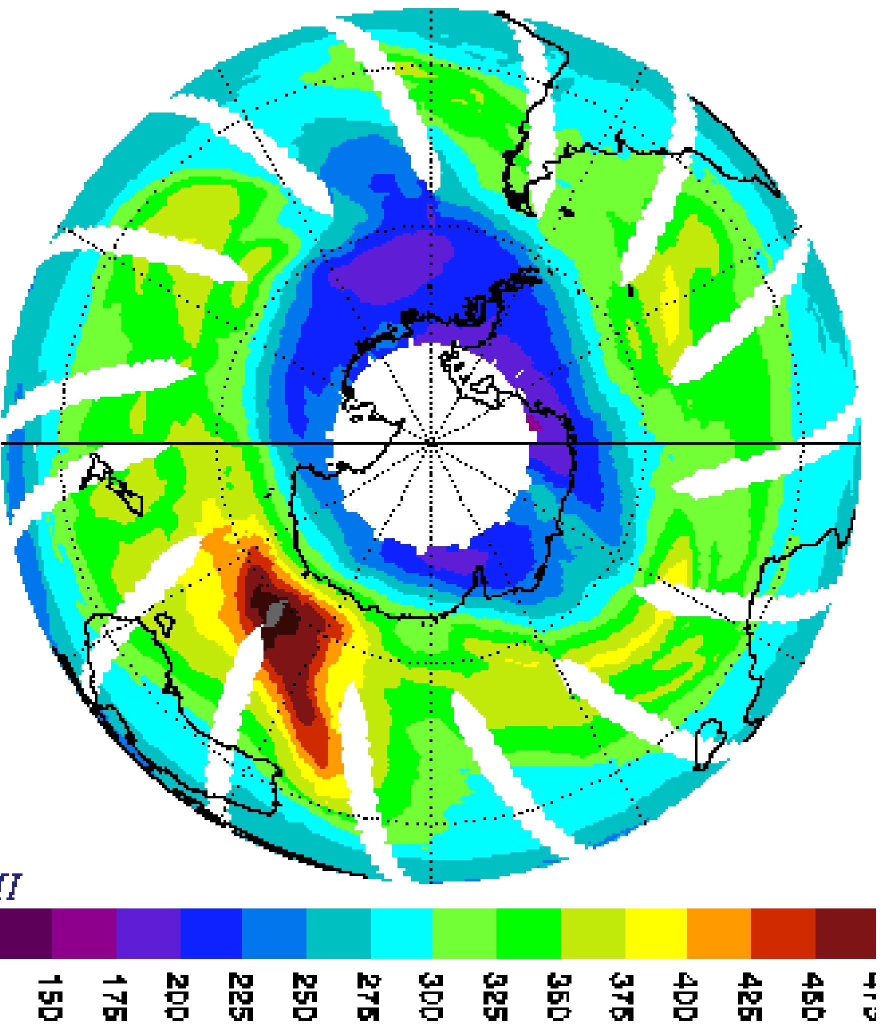
Trending Tasks

- ✓+Test OMPS_E15 Implement GOME-2 and SBUV/2 ICVS monitoring for OMPS
- Test OMPS_E16 Ground-based Match-Up
- ✓+ Test OMPS_E17 SNO (EOS Aura, NOAA-x, MetOP A)
  - Chasing orbits and No-Local-Time-Difference latitudes
- Test OMPS_E18 Assimilation
- ✓+ Test OMPS_E19 ICVS trending
- Test OMPS_E20 Solar and Mg II Trending
- Test OMPS_E21 Continue Ground-based Val.

Ozone team management approach

- L. Flynn's O3OAT & Cal/Val positions combined
  - New fracture with SDR Deputy position
- Communication and coordination
  - Weekly working meeting (Wed) and ad hoc meetings (Fri)
  - DRs and ATDRs and solutions circulating and addressed by fiat/SME
- Planned meetings
  - Weekly working meeting Wed 11:00 AM ET
  - Focused meetings Fri 11:00 AM ET as needed
  - Tag up meetings provide overview of status
- Coordination of SOWs
- Coordination with other teams
  - No boundary between OMPS EDR and SDR Teams
  - Close long-term working relationship with NASA OMPS NPP ST and Ozone PEATE (25-year Ozone Processing Team collaboration on SBUV/2)
  - Limited dependencies on other product but existing relationship with IR Ozone products and VIIRS Aerosol products teams
- Interaction with stakeholders and leveraging
  - Attending bi-weekly NASA OMPS NPP Science Team meetings
  - Drawing on SDS/PEATE expertise and assets for the Multiple Triplet Algorithm trouble-shooting
  - NGAS – transition of algorithm ownership
    - Good working relationship with SDR Cal/Val tool developer
    - Developed Instrument RT Look Up Table for NGAS Science for delivery to IDPS operations.
    - Communication, SME input on ATDRs
  - Raytheon/IDPS - code
    - communication, Programmer/SME input on ATDRs
  - GRAVITE
  - Moving to V8Pro and V8TOZ consistent with other operational products
  - Co-chair Atmospheric Chemistry Product Oversight Panel

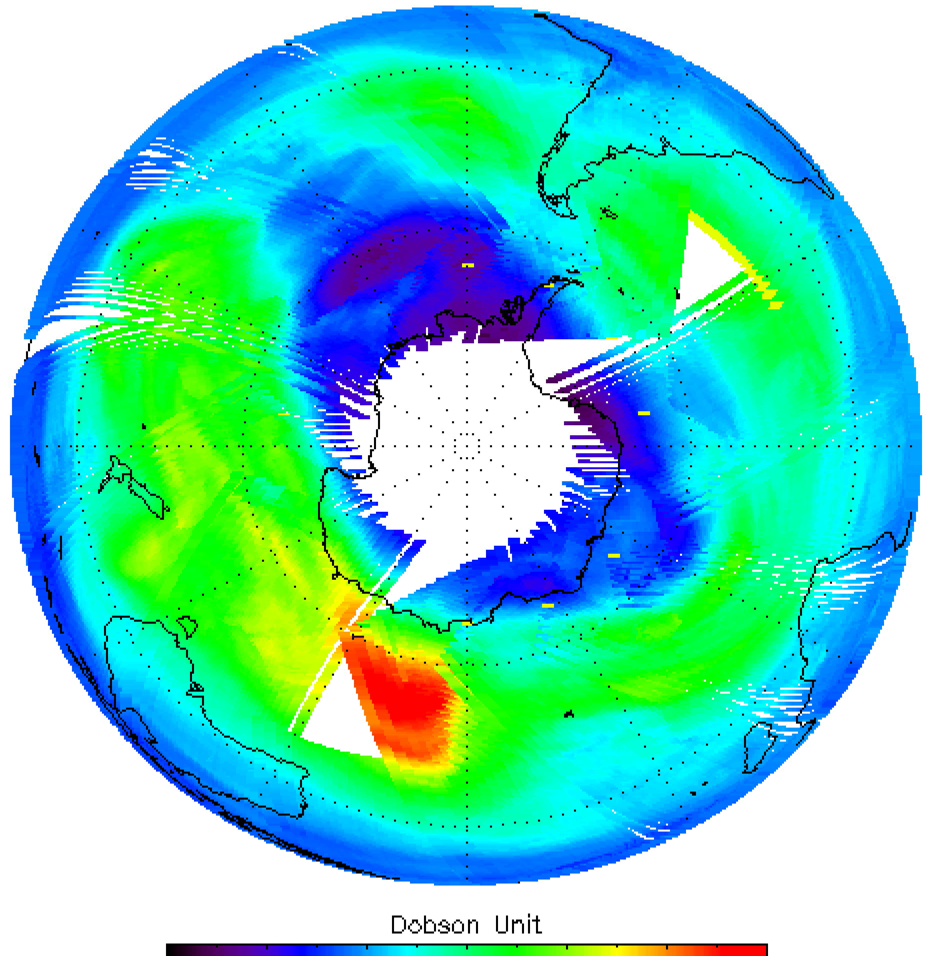
OMI Total Ozone for Sep 3, 2012



Dobson Units

Dark Gray < 100 and > 500 DU

OMPS/INTCO Initial total column O_3 at 09/02/2012



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