Ozone Session Agenda

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

General

- Copies of the presentations
  - Please provide final copies of presentations for general release by Monday

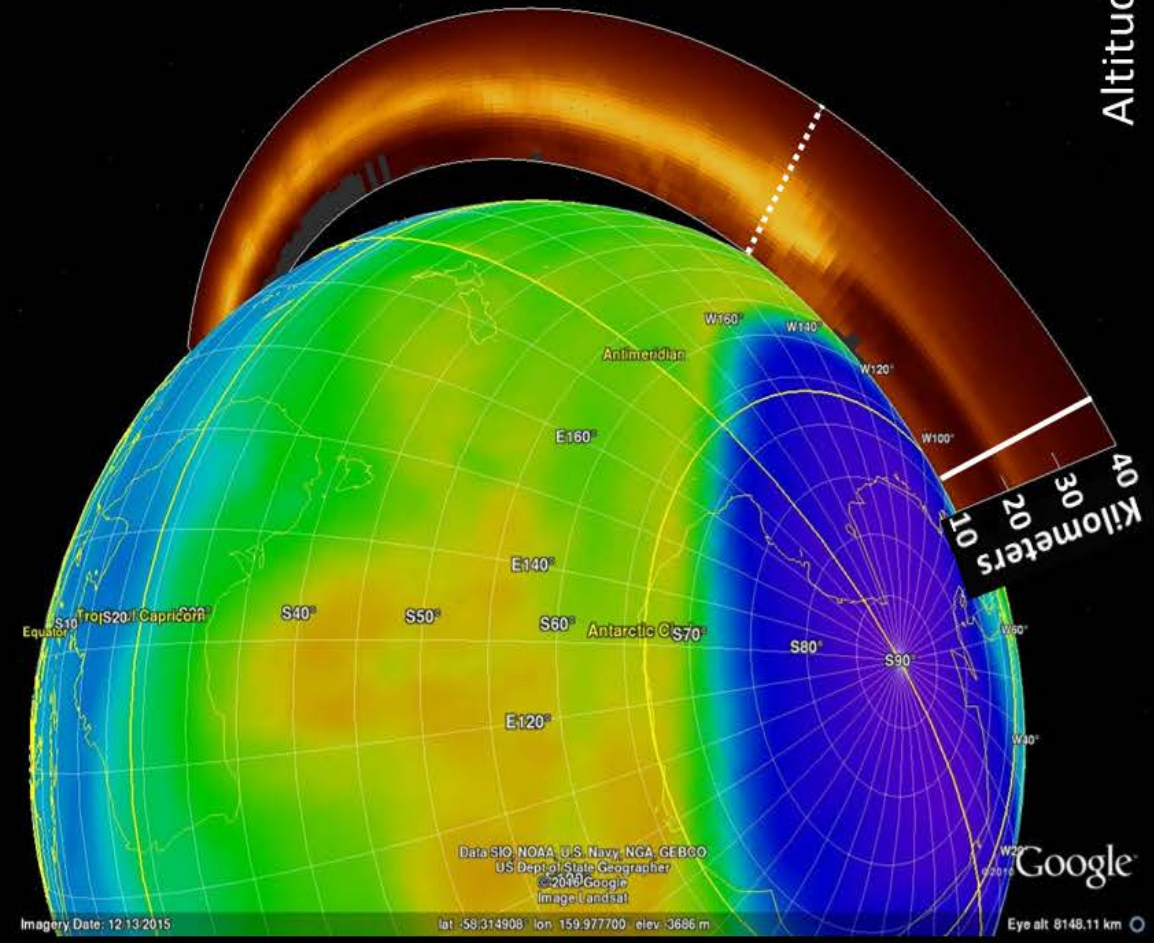
- Break
  - We will have one break at 10:15 AM

OMPS Products Algorithm and Validation Plans

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

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

Lawrence.E.Flynn@noaa.gov



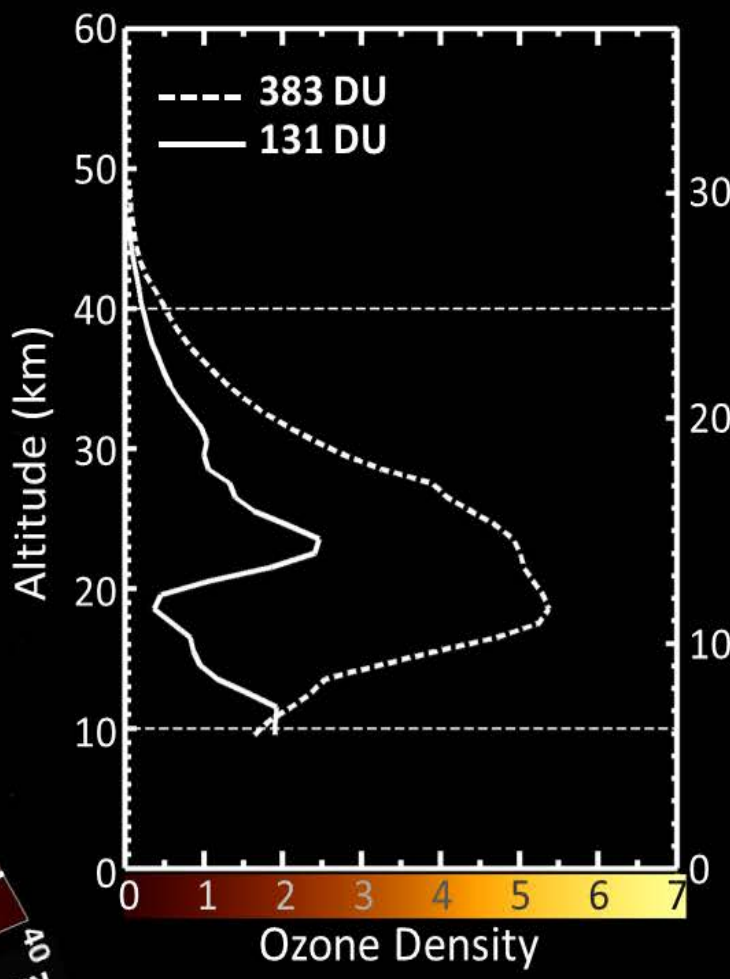


Figure provided by Colin Seftor, NASA GSFC (SSAI)

Outline

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

Ozone Cal/Val/Alg Team Membership

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

Measurement Overview

Nadir Mapper (NM)

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

Nadir Profiler (NP)

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

Limb Profiler (LP)

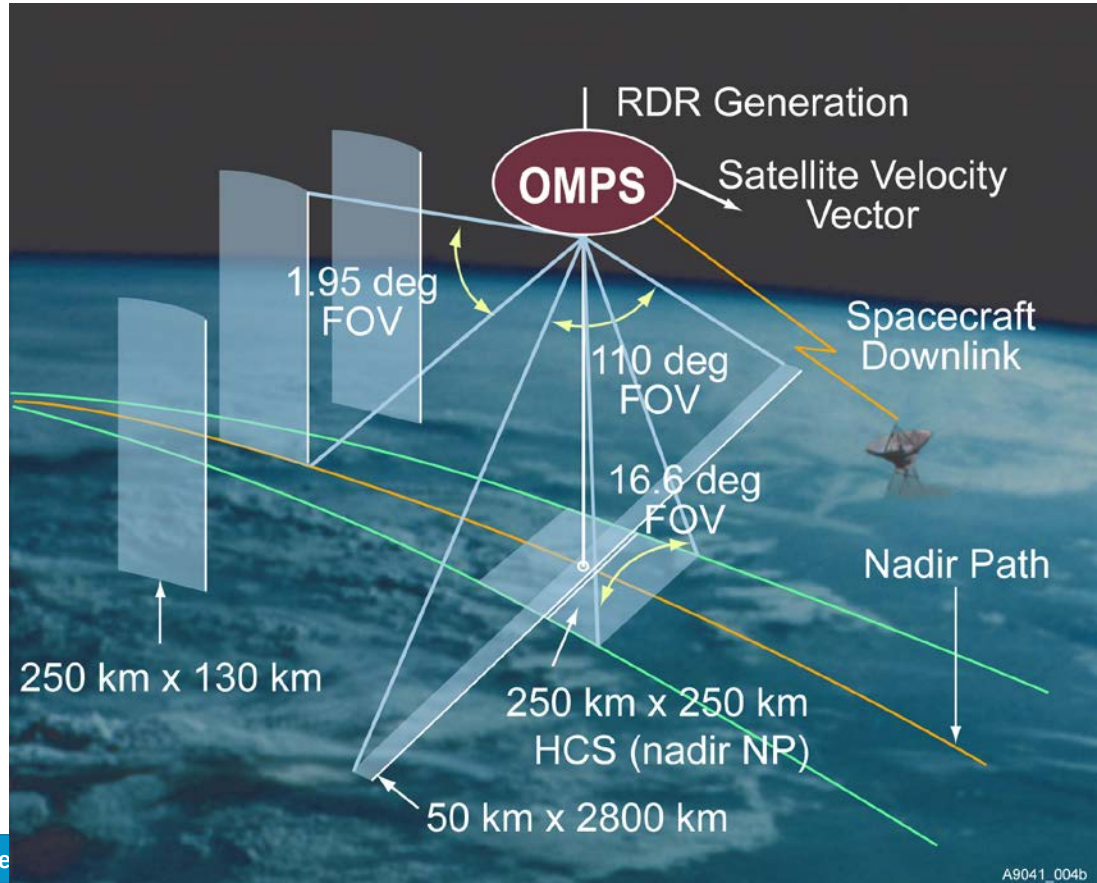
Prism spectrometer, 2-D CCD
Three vertical slits, -20 to 80 km,
290 nm to 1000 nm

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

Ozone Mapping & Profiler Suite

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

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



OMPS Version 8 Total Ozone EDR Requirements

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

Table 5.2.11 - Ozone Total Column (O

EDR Attribute	Threshold
Ozone TC Applicable Conditions: 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.	
a. Horizontal Cell Size	50 x 50 km^2 @ nadir
b. Vertical Cell Size	0 - 60 km
c. Mapping Uncertainty, 1 Sigma	5 km at Nadir
d. Measurement Range	50 - 650 milli-atm-cm
e. Measurement Precision	
1. X < 0.25 atm-cm	6.0 milli-atm-cm
2. 0.25 < X < 0.45 atm-cm	7.7 milli-atm-cm ~2%
3. X > 0.45 atm-cm	2.8 milli-atm-cm + 1.1%
f. Measurement Accuracy	
1. X < 0.25 atm-cm	9.5 milli-atm-cm
2. 0.25 < X < 0.45 atm-cm	13.0 milli-atm-cm ~3%
3. X > 0.45 atm-cm	16.0 milli-atm-cm
g. Refresh	At least 90% coverage of the globe every 24 hours (monthly average)

Verification of Performance:

a. 20-Pixel Aggregation and 7-S along track integration.
b. 318 nm channel BUV comes from the surface to top of atmosphere. Standard profiles in tables account for full range.
c. Confirmed by coastlines and comparison to 750x750 m^2 VIIRS.
d. Confirmed by standard profiles and four years of processing and ground-based matchup scatter.
e. Precision estimates from Nearest Neighbor analysis. Use of 1512 Latitude/Month/TOz profiles.
f. Accuracy is adjusted by soft calibration and checked by zonal mean and overpass statistics.
g. 105° cross-track swath provides full daily coverage.

OMPS Version 8 Ozone Profile EDR Requirements

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

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

Verification of Performance:

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

OMPS Total Ozone Products Algorithm Status and Approach

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

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

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

OMPS Nadir Ozone Profile Products Algorithm Status and Approach

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

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

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

S-NPP Product Overview (1/2)

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

S-NPP Product Overview (2/2)

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

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

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

NOAA-20 Readiness – Algorithms

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

  The V8TOz has been implemented on LINUX systems with NetCDF output. The LFSO2/V8TOz has been adapted to run on 15-granule sequences on the STAR LINUX system using the first-run V8TOz EDR as input. Both algorithms have been delivered with the capability to handle large and medium FOV SDR products. The V8TOz NOAA-20 capable code is on the Development system at NDE.
  - V8Pro for medium FOV data

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

JPSS-01 Readiness – Cal/Val

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

JPSS-01 Readiness – Issues & Applications

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

Summary and Path Forward

- Heritage/Enterprise Version 8 algorithms are implemented at NDE and provide the capability to process medium FOV NOAA-20 OMPS data. The V8TOz at NDE will be applied to GOME-2.
- The products will meet the program requirements.
- OMPS Limb Profiler products will also be made operationally at NDE.
- Blended UV/IR Ozone products (TOAST) will be transitioned to NDE.

FY18 OMPS EDR Milestones/Deliverables

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

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

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

OMPS NP EDR Performance Characteristics

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

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

OMPS TC EDR Performance Characteristics

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

OMPS LP EDR Performance Characteristics

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