Big and Little Pictures

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May 14, 2014

NOAA STAR JPSS Science Meeting

What do we need to do and when, where, how, and why?

- OMPS Nadir Profiler
  - V8Pro to Operations
  - Consistent with NOAA-19 SBUV/2
  - Products in BUFR
- OMPS Nadir Mapper
  - V8TOz to Operations
  - Consistent with OMI and GOME and SBUV/2
  - Add table profile and efficiencies
  - Add SO_2 products (Linear Fit)
- OMPS Limb Profile
  - V2 to Operations (NDE)

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.

Path Forward (Solution Key: DONE, READY, KNOWN APPROACH, UNKNOWN, *FUTURE WORK*)

A. OMPS NP Ozone Profile

A.i. Turn on the 253 nm channel in the retrieval algorithm -- DONE.

A.ii. First version of the stray light correction. – March 17 in Mx8.3 DONE.

A.iii. Improved/tuned stray light correction table -- April (SDR Table Tuning) Analysis shows there is room for improvement. Which channels are the best proxies?

A.iv. New Day 1 Solar irradiance spectrum and wavelength scale – May (SDR Table Tuning)

I recommend that this be a simple -0.115 nm shift relative to Day 0. We would revisit with annual wavelength scale variations and wavelength dependent shifts in the future. (Should this also adjust the radiometric coefficients for the shift/dichroic? Should the solar activity level be picked for the current Mg II 27-day average state?)

A.v. Proper matchup for Nadir Mapper and Nadir Profiler FOVs – TTO May 19 in Mx8.4 (EDR only).

A.vi. Error in smear subtraction creating offset bias error – Correct code (in Mx8.5), Change Input Bias to 742 counts.

A.vii. Soft Calibration adjustments including dichroic to Day 1 Solar or CF Earth -- May (SDR Table Tuning).

A.viii. Annual variations in the wavelength scale correlated with temperature gradients. SDR. Need to include dichroic interaction with wavelength and calibration factors.

A.ix. Adjustments to Day 1 Solar for solar activity. SDR.

Why "I could have had a V8Pro"?

The V8Pro algorithm is in use for the operational and CDRs for the SBUV(/2). It improves on the Version 6 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 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

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 are 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.

Finally, the V8Pro is designed for expansion to perform retrievals for hyperspectral instruments, such as the Ozone Monitoring Instrument (OMI), the Global Ozone Monitoring Experiment (GOME-2) and the Nadir Profiler in the Ozone Mapping and Profiler Suite (OMPS).

V8Pro Algorithm Paths Forward

OMPS NP V8Pro (Creates NRT and CDR ozone profiles for SBUV/2)

- A.i. Provide 12 soft calibration adjustments
- A.ii. Change to work with smaller FOVs (just along track)
- A.iii. Put in N-value fitting (Noise reduction, outlier identification and removal, and information concentration)
- A.iv. Add Solar Activity / Scale Factors
- A.v. Off-nadir retrievals
- A.vi. SO_2 profile retrieval

What about future 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. There is also a need to adjust the calibration factors for the dichroic throughput interactions with the wavelength shift. This can be done by modifying the Day 1 Solar but that is not a conceptually appealing idea.)
- 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
  - Under the current plan, these products would not flow from IDPS starting points for SDRs or EDRs as those would use an aggregator.
  - Recommend that the “aggregator” have a “non-aggregator” switch and we develop smaller FOV capabilities as part of V8Pro implementation.
  - Glueware (NM/NP Matchups) modifications on the appropriate system would be needed to handle new cases of FOVs.
- New ancillary Input
  - All three systems can access better data for snow/ice and surface pressure for use in the V8Pro processing

Recommendations for V8Pro

- OMPS ozone profile products should be made by using the V8Pro code as implemented for the SBUV/2.
  - This will require a flow of OMPS SDRs and GEOs.
  - Is this a long-term solution?
- The operational products should be the first step in CDR generation.
- Smaller FOVs should be accommodated by changes in the matchup glueware. Output products should be dynamically sized.
- Information concentration (noise reduction), outlier detection, solar activity adjustments, and intra-annual wavelength shifts should be implemented in the OMPS data input module for the V8Pro.
- Can the V8Pro in ADL jumpstart the IDPS.

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) ~ 2%	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) ~ 3%	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

Path Forward (Solution Key: DONE, READY, KNOWN APPROACH, UNKNOWN, *FUTURE WORK*)

B. OMPS NM Total Column Ozone

B.i. Measurement-based wavelength scale adjustments – February 19 Mx8.1. DONE. *Need to include dichroic interaction with wavelength and calibration factors.*

B.ii. Revised profile mixing fraction logic – March 17 in Mx8.3 (EDR only) DONE

B.iii. First version of OOR Table for the stray light correction -- May (SDR Table Tuning and Code Change)

New Table received. OOR cross-track dependence requires code change.

CCR to proceed with this for the Mx8.5 build. It is a change to the code and table dimensions. Minor ATBD and OAD and CDFCB changes.

B.iv. New Day 1 Solar irradiance spectra and wavelength scales. Should be set to middle of orbital scale variation. Cross-track dependence is complex. – May (SDR Table Tuning)

B.v. Soft Calibration adjustments to Day 1 Solar or CF Earth -- May (SDR Table Tuning)

B.vi. *Check flagging and logic for total ozone out of range and fill for triplet retrievals. (EDR)*

B.vii. *Possible bandpass changes -- ground to flight, intra-orbit.*

Why V8TOz instead of MTTOz?

Provides a set of products consistent with the TOz CDR from the TOMS/SBUV(/2)/OMI record. This also means it can serve as the first step in the CDR cycle of evaluation and reprocessing.

Versions of the algorithm are currently used in OSDPD to make the NOAA GOME-2 NRT TOz products and SBUV/2 TOz products. It is planned for use in making OMPS V8Pro TOz products.

The fundamental ozone estimates are from a single pair of channels simplifying validation studies, calibration adjustments, and anomaly resolution. The MTTOz requires soft calibration of 22 channels.

The V8TOz uses the 313 nm residual to adjust for profile shape variations. The MTTOz was going to use the Limb Profile to do this adjustment.

The V8TOz is synergistic with the Linear Fit SO2 Retrieval algorithm.

What about future refinements for V8TOz?

Path to upgrades

Information concentration

Information concentration can be performed at the same step as the N-value creation, either in the input stage of the MTTOz or the input stage of the V8TOz (if the latter is working from SDRs).

Additional channels for SO2 and NO2

These would be best implemented as stand-alone processes/products, although one of the SO2 options can work directly from the V8TOz residuals

Smaller FOVs

Under the current plan, these products would not flow from IDPS starting points for SDRs or EDRs as those would use an aggregator.

The bookkeeping for retrieving total ozone for smaller fields of view from an SDR is simple but the output products would have to be resized or be dynamically sized whether for the MTTOz or V8TOz.

New ancillary Input

IDPS can access better data for snow/ice and surface pressure and use these in the V8TOz processing

So can NDE and OSDPD

We have removed most of the dependencies on VIIRS and CrIS EDRs.

OMPS LP Performance Requirements

The OMPS Limb Profiler provides global ozone observations at high vertical resolution (< 3 km). This EDR provides a measurement of ozone concentration within a specified volume.

Requirements are TBD per L1RDS V2.9 Action: Insert OMPS Limb Profiler SDR Performance Characteristics – Deferred until S-NPP Ozone Limb Profile performance is sufficiently validated to constrain the JPSS-2 instrument acquisition.

Table 3.3.1 - Ozone Limb Profile

Attribute	Threshold (1)	Objective
a. Horizontal Cell Size	250 km	100 km (7)
b. Vertical Cell Size		
1. 0 to TH (2)	N/A	3 km
2. Th to 25 km	5 km	1 km
3. 25 to 60 km)	5 km	3 km
c. Mapping Uncertainty, 1 Sigma (3)	< 25 km	25 km
d. Measurement Range		
1. 0 to TH (2)	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 (2)	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 (2)	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	120 min. (4)	15 min
h. Refresh	At least 75% coverage of the globe every 4 days (monthly average) (5)	24 hrs (5)
i. Long-term Stability (6)	2% over 7 years	1% over 7 years
		v1.4.2, 7/29/11

Notes:

OMPS LP Path Forward

- Migrate V2 algorithm to STAR and then to NDE
- Design and create NetCDF and BUFR versions of the output.
- Arrange/coordinate dark table updates
- Validate products.

Sulfur Dioxide (SO2) Total Column EDR Description & Requirements Table – CCR in preparation

The Sulfur Dioxide Total Column EDR (also called Atmospheric SO_2) is defined as the amount of SO2 in a vertical column of the atmosphere measured in Dobson Units (milli-atm-cm). SO_2 absorption in the 305 nm to 315 nm region influence OMPS Nadir Mapper measurements of backscattered Ultraviolet radiances. Estimates of atmospheric SO_2 are obtained for three or more assumed heights for the amounts within the column averaged over the FOV from measurement residuals calculated by the OMPS total column ozone EDR algorithm. This product will continue the heritage SO_2 Index provided in the NOAA POES SBUV/2 operational Product Master File and the Atmospheric SO_2 products currently provided in NRT products from the NASA EOS Aura OMI.

Note: J1 will not have an SO_2 performance exclusion, so improved information on amounts and corrections to the ozone product will be required.

OMPS Nadir Mapper Atmospheric SO_2 Column Amount in DU*

	Threshold	Objective
a. Horizontal Cell Size:	25x25 KM^2	10X10 KM^2
b. Vertical Reporting NA	Column amount*	
c. Mapping Uncertainty, 3 Sigma	5 KM	2 KM
d. Measurement Precision	2 DU	0.5 DU
e. Measurement Accuracy	3 DU	1 DU
f. Measurement Uncertainty		
g. Latency	80 Minutes	30 Minutes
h. Refresh		
Daily global sunlit Earth** (multiple coverage at high latitudes)		

* SO_2 column amounts will be reported as calculated for three heights as appropriate for their occurrence -- local pollution, transported pollution, volcanic eruption.

** SO_2 is not sensed below clouds

CCR needs SO_2 Users

- **VAACs: The SO_2 products are used to track volcanic eruptions for aviation hazards. This is the most important NRT application.**
- **EPA & ARL: Air Quality forecasts and monitoring (SO_2 amounts, aerosol classification)**
- **USGS/AID: Passive volcanic outgassing**
- **Atmospheric chemistry and climate change research**
- **MACC II ECMWF**

OMPS Team Challenges

- How to be a climate sensor in an operational program?
- Users and NRT Users (Chicken and Egg for Applications)
- Soft Calibration
  Determination and implementation of soft calibration is a moving target as SDR improvements move into the system
- Validation
  Product validation analyses has to be repeated or adjusted as improvements and corrections enter the system.

OMPS Team Challenges

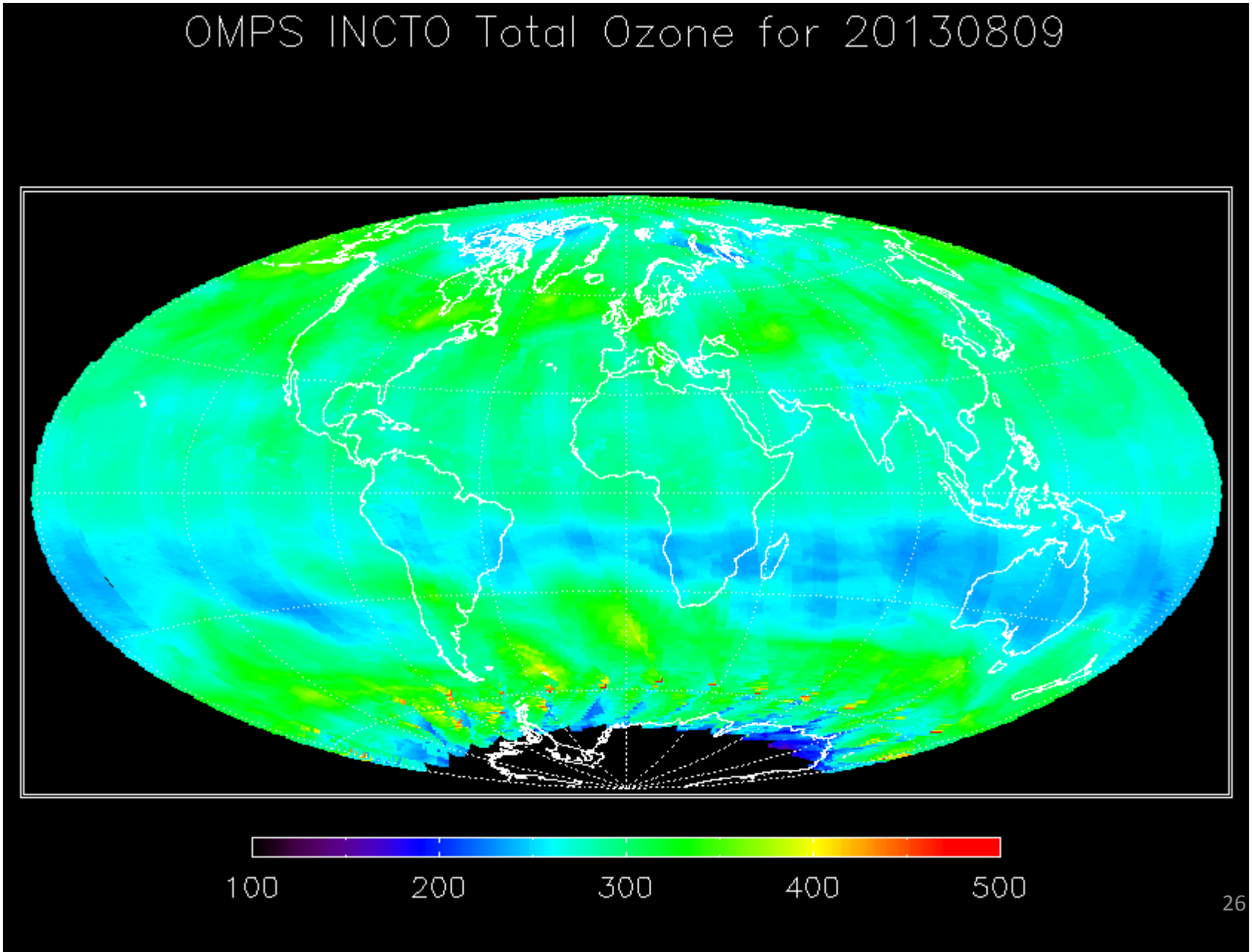
- Performance versus Schedule issues
  - V8TOz implementation schedule is in competition with V8TOz improvements – SO_2 Linear Fit Algorithm module, small FOVs, Efficiency Factors, Outlier Detection / Information Concentration
  - V8Pro implementation schedule is in competition with V8Pro improvements – Small FOVs, Solar Activity, Outlier Detection / Information Concentration
  - V2Limb implementation requires choices on aerosol products. We will need to see how NDE accommodates processing intensity.

Backup

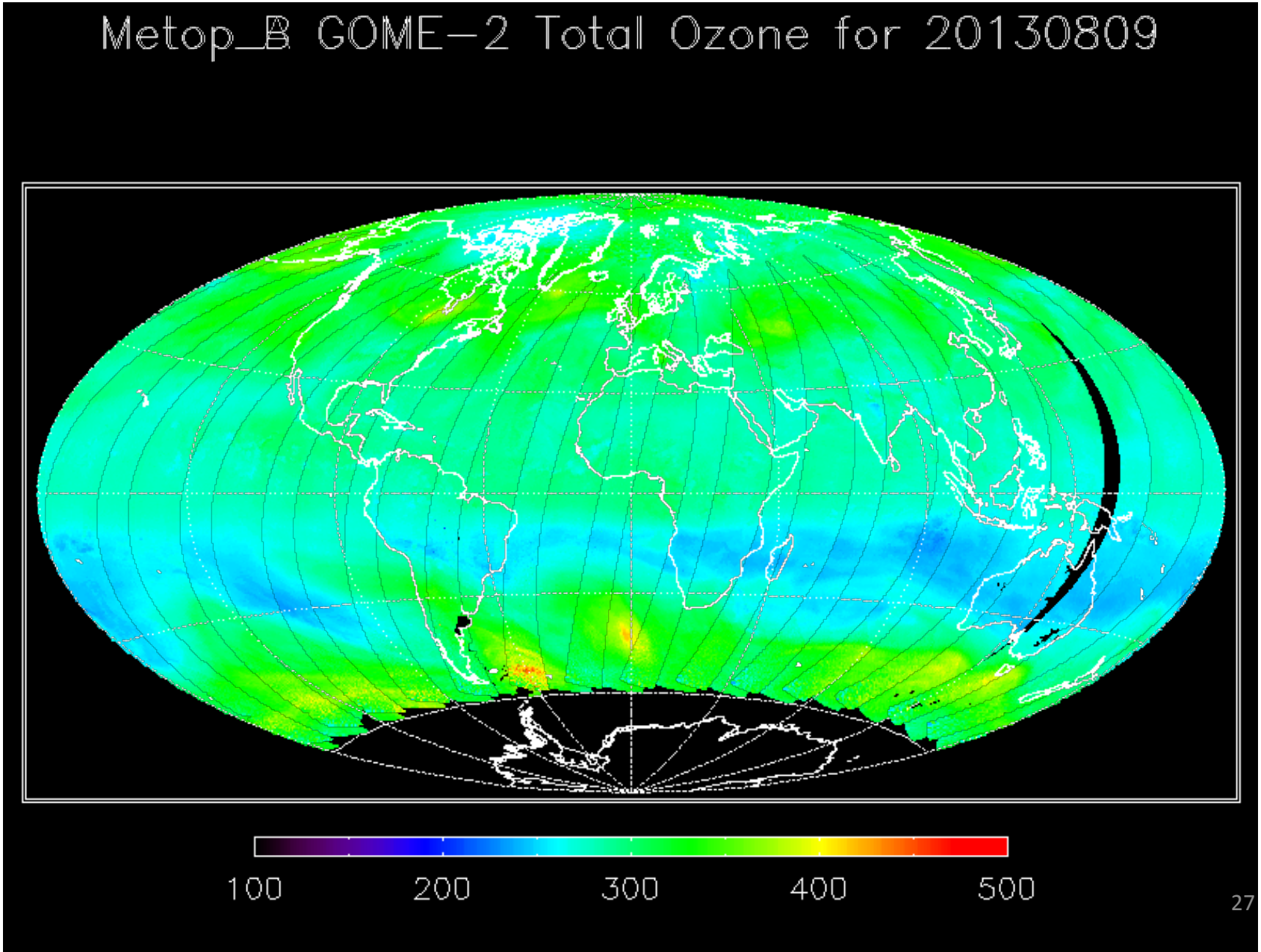
Categories of products

- In operations
  - Total column O_3, Nadir UV O_3 Profile, Aerosol Index, SO_2 Index
  - TOAST combined UV/IR analysis map
  - NUCAPS (CrIS/ATMS) trace gases (O_3, CO, CH_4, CO_2, N_2O, HNO_3, SO_2)
- Planned products
  - Limb O_3 Profile, Limb aerosol profile
- Likely future products
  - Total column SO_2
- Research products
  - Total Column NO_2
  - Combined UV/IR retrieval
  - UV absorbing aerosol optical depth, combined UV/Vis
  - UV cloud optical centroid (inelastic scattering – Ring effect)

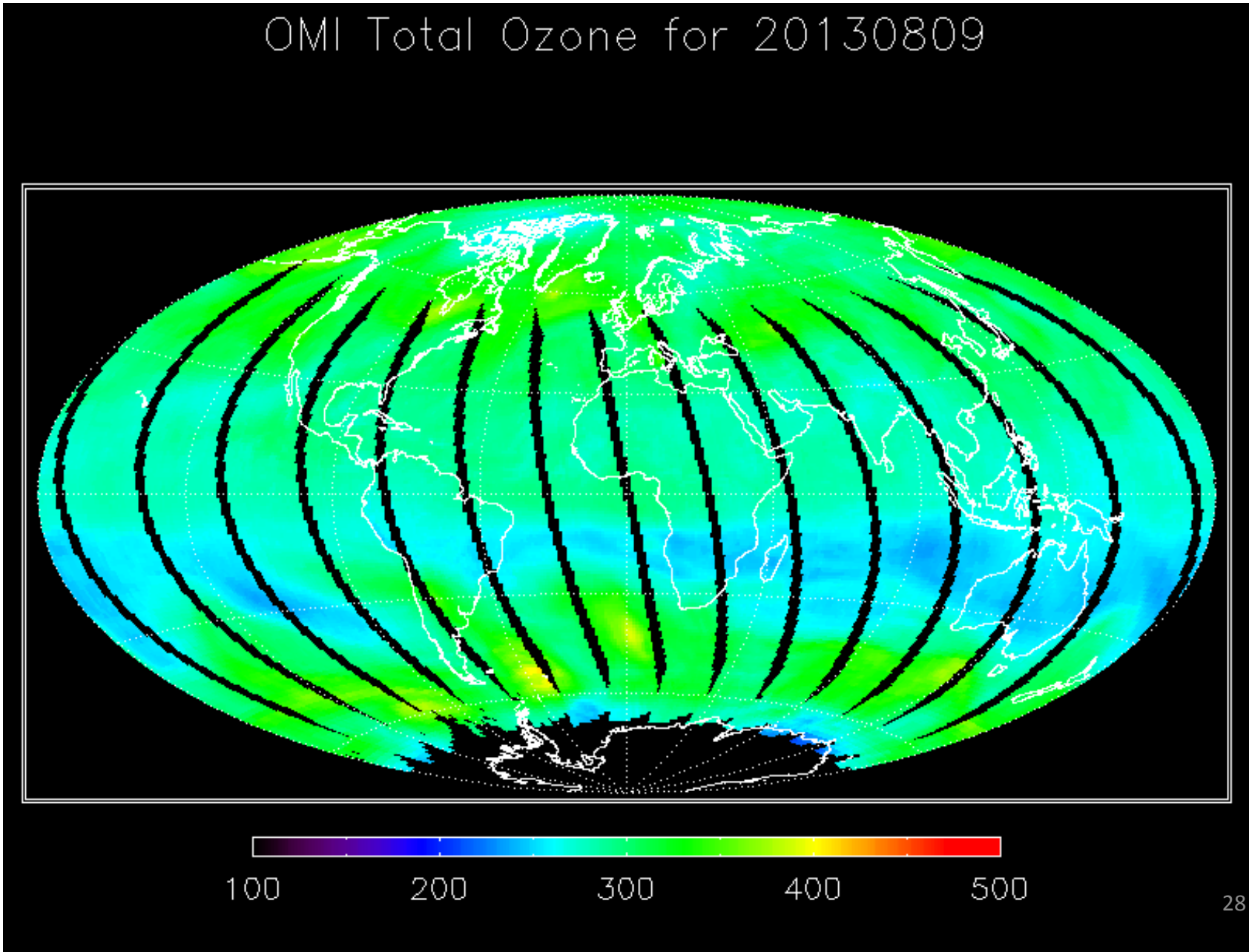
Sample OMPS INCTO Total Ozone Map



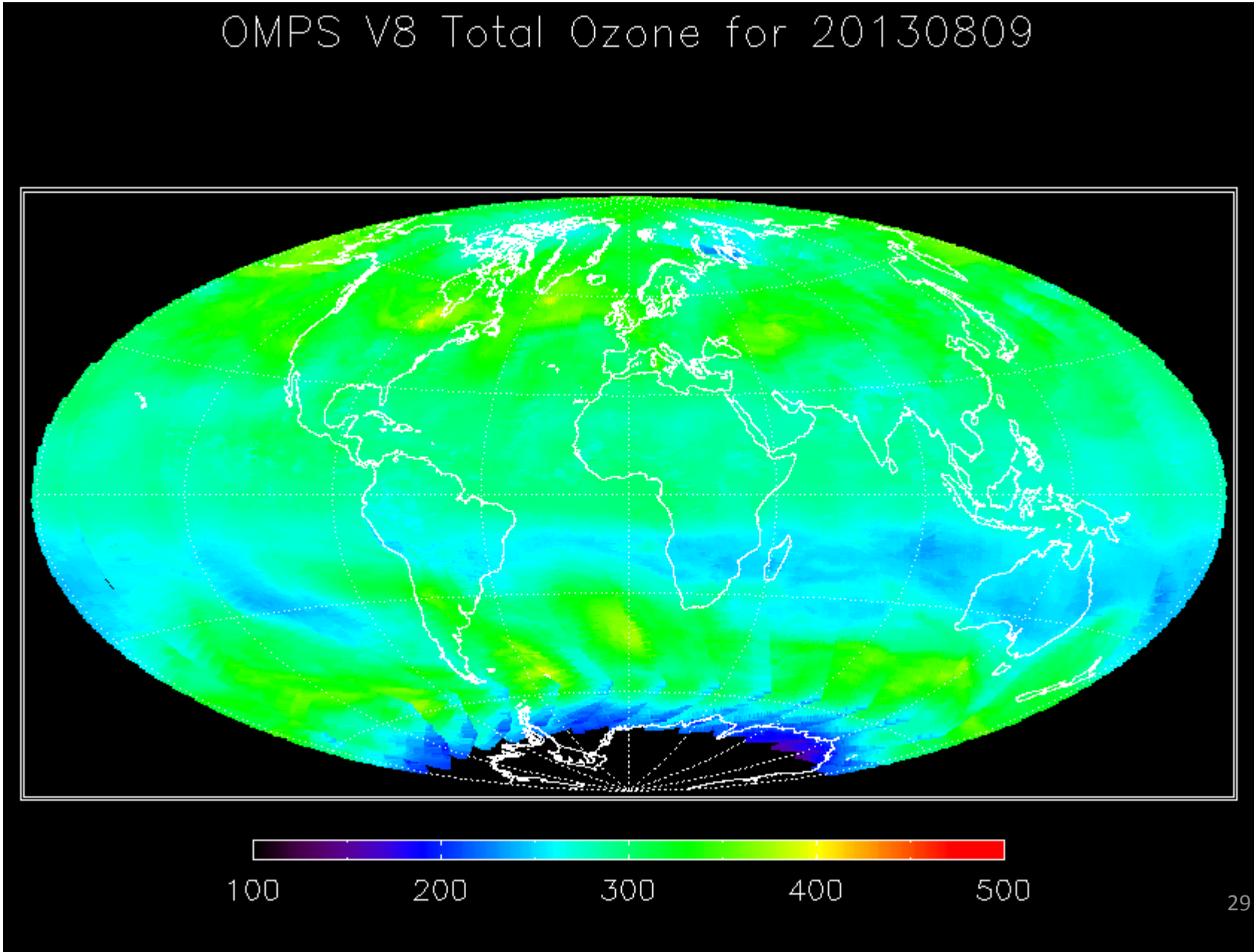
Sample MetOp-A+B GOME-2 V8 Total Ozone Map



Sample EOS Aura OMI Total Ozone Map



Sample OMPS V8TOZ Total Ozone Map



Lines of Code for V8TOz

- 1) To prepare LUT: 1252 lines
- 2) To generate files and prepare SDR and GEO for processing: 920 lines
- 3) The algorithm source codes: 19828 lines

Total lines: 22000 lines.

Options for Basic Implementation of V8TOz

- IDPS (Need to introduce new Process, LUTs and output)
  - Implement as a follow-on process to the MTTOz. Make use of the INCTO input/output as input. INCTO still run in IDPS, or
  - Replace MTTOz with V8TOz as PRO.
    - Minor changes to select 12 channels from the current 22, add/remove some input tables and output parameters.
- NDE
  - Implement as a new process
    - Transition V8TOz implementation for OMPS on LINUX in use at STAR. Only SDRs and GEOs continue in IDPS.
    - Need OMPS NM SDRs (SOMPS) and GEOs (GOTCO) delivered to the NDE system
- OSPO/POES
  - Implement as another “GOME-2” with existing V8TOz processing code
    - Reader in use at STAR can provide V8TOz with GEO and 12 channels. Only SDRs and GEOs continue in IDPS.
    - Need OMPS NM SDRs (SOMPS) and GEOs (GOTCO) delivered to the POES system

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.), 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

- 1) To prepare LUT: 1253 lines
- 2) To generate orbit files, match up FOVs, and prepare SDRs and GEOs for processing: 1228 lines
- 3) Algorithm source codes: 15319 lines

Total lines: 17800 lines.