Operational Ozone Sensors and Beyond

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AMS New Orleans, January 23, 2012

Related talks and posters in remaining session:

Tuesday, 24 January 2012: 8:30 AM OMPS Early Orbit Evaluation and Calibration Room 257
Tuesday, 24 January 2012: 1:45 PM End-to-End OMPS Mission Data Modeling and Simulation Room 343/344
Tuesday, 24 January 2012: 4:00 PM Overview of NPP/JPSS Environmental Data Products and Algorithm Development Room 343/344
Tuesday, 24 January 2012: 4:30 PM NOAA Operational Calibration Support to NPP/JPSS Program Room 343/344
Wednesday, 25 January 2012 NPP Product Validation for the OMPS Hall E

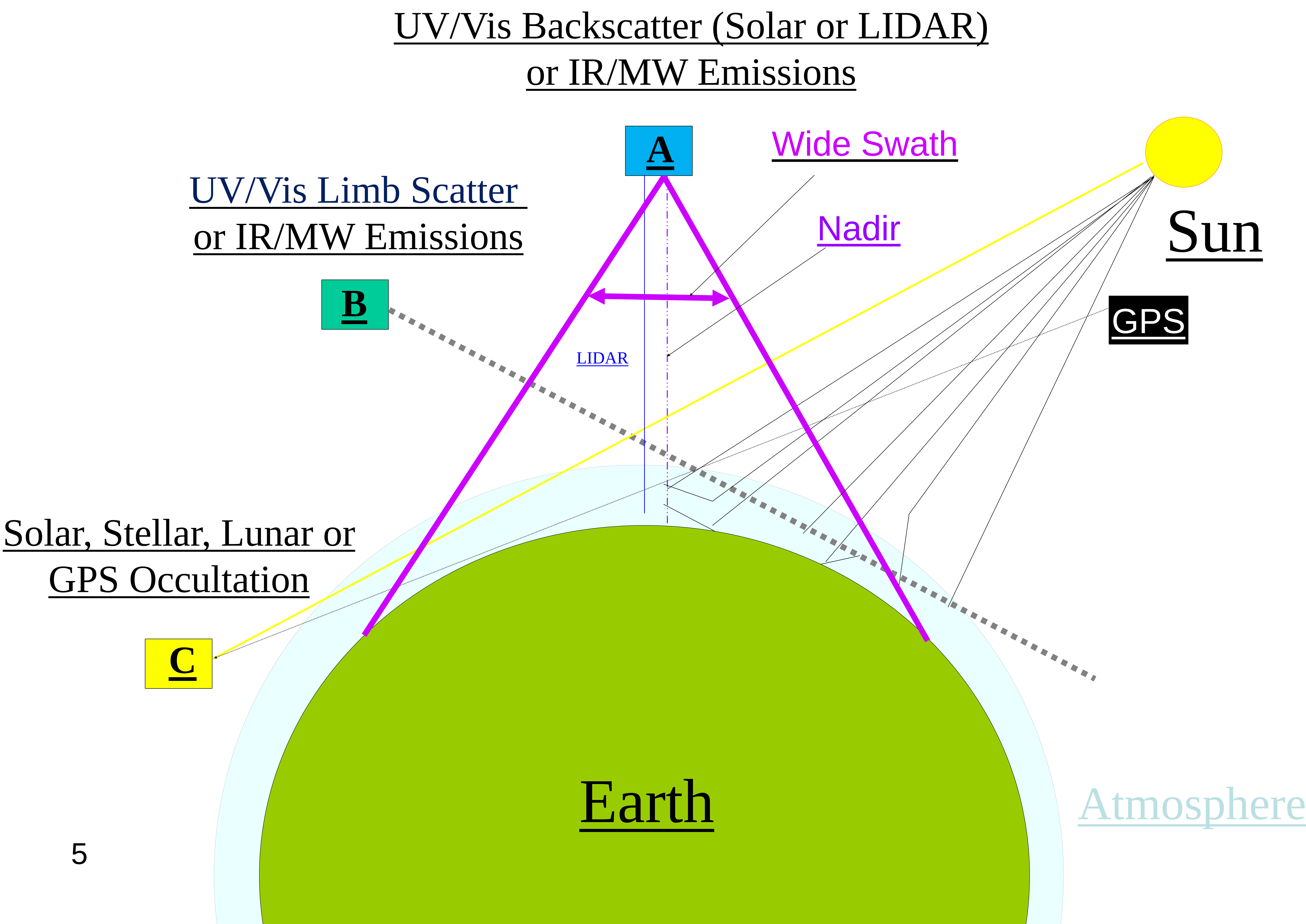
Outline

- Introduction
- Viewing Geometry
- Instrument Table
- SBUV/2
- TOU & SBUS
- GOME-2
- OMPS Nadir
- OMPS Limb

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 talk 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.

Lines of Sight and Fields of View for Space–Based Remote Sensing for Atmospheric Chemistry Measurements



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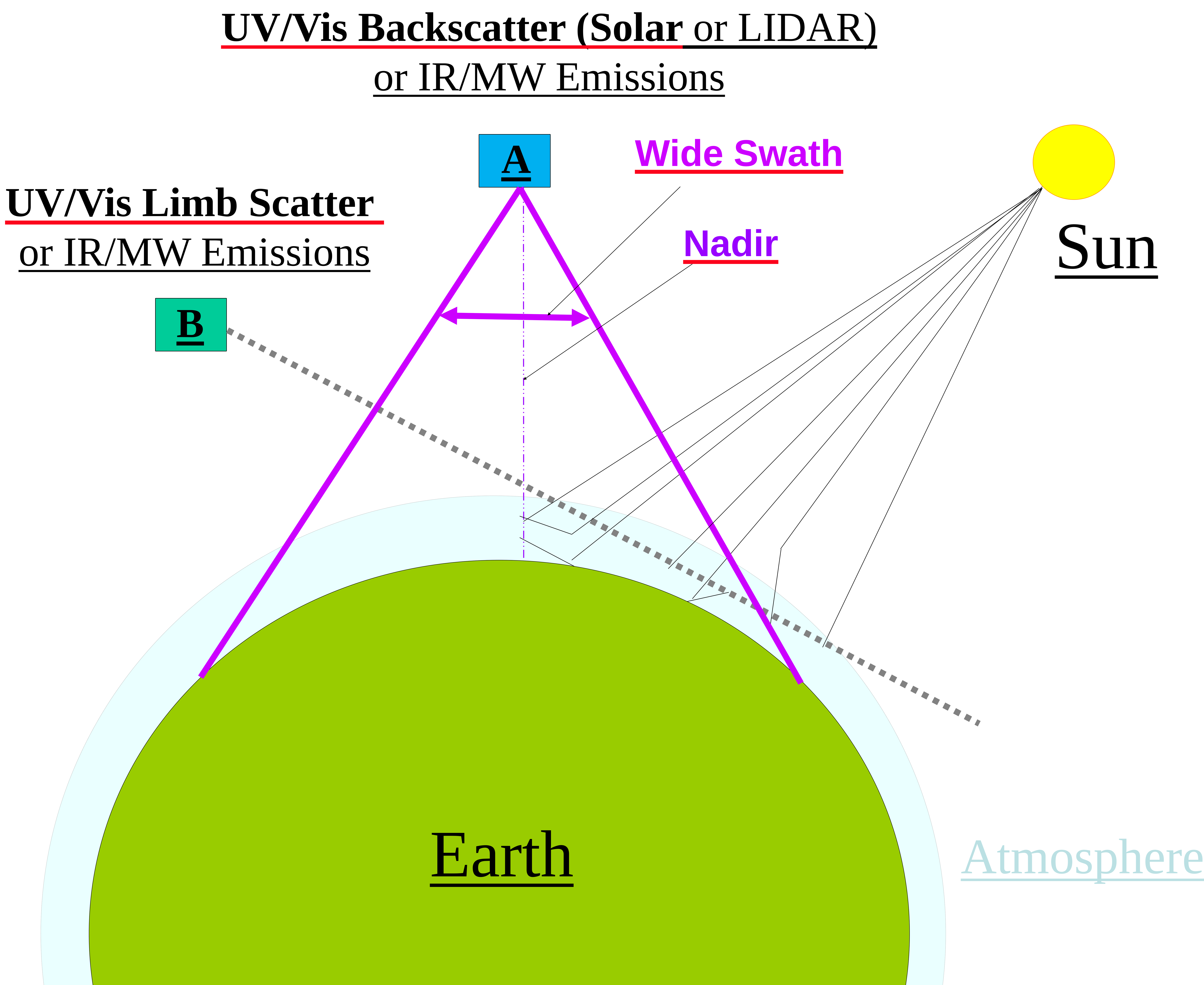


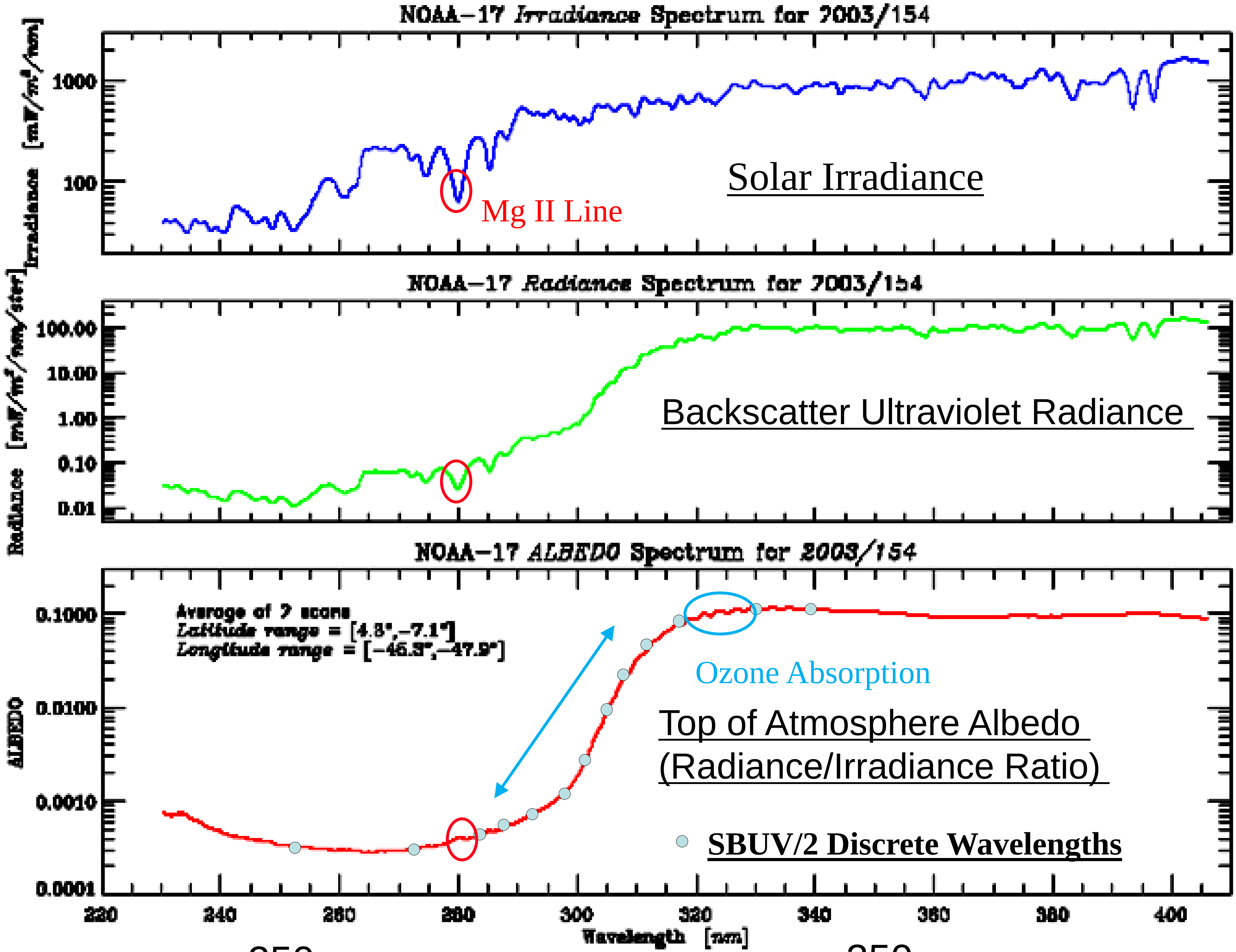
BUV Instrument Summary

Institutes Satellites	Instruments Spectra	Launch Dates	Products
NOAA POES	SBUV/2 250-400 nm	N-18 2005 N-19 2009	Total &Profile Ozone
NOAA NPP & JPSS	OMPS 250-310 nm 300-380 nm 290-1000 nm	NPP 2011 J1 2016 J2 2021	Total &Profile Ozone, SO2, Aerosol Index
EuMetSat Metop	GOME-2 240-790 nm	M-A 2006 M-B 2012 M-C 2017	Total &Profile Ozone, NO2, BrO, SO2, Aerosol Index
CMA FY-3	TOU & SBUS 308-360 nm 250-400 nm	FY-3A 2009 FY-3B 2011	Total &Profile Ozone, Aerosol Index

SBUV/2

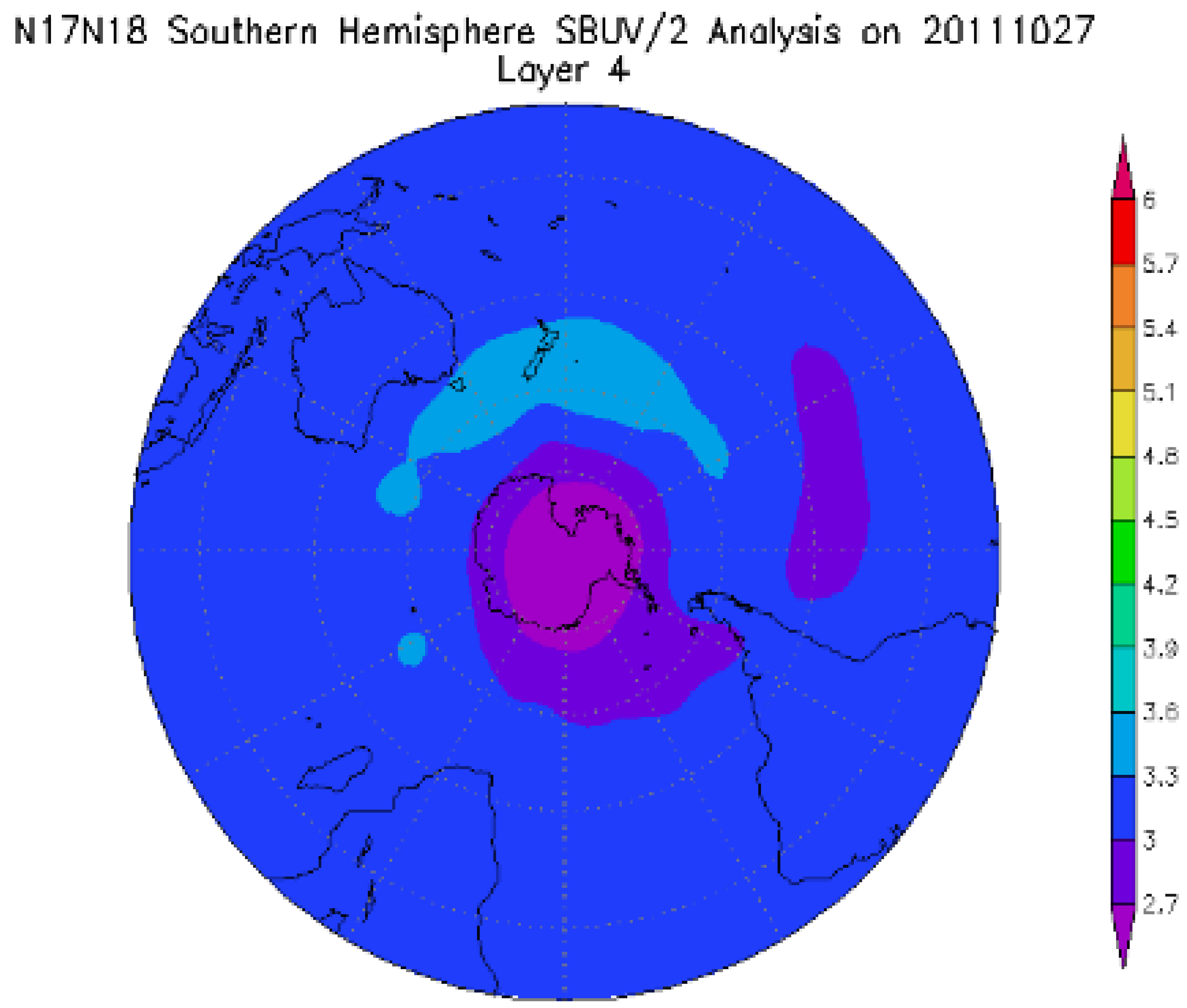
The NOAA Polar-orbiting Operational Environmental Satellite System (POES) has been flying operational ozone monitoring sensors for over 25 years. Measurements from these Solar Backscatter Ultraviolet radiometer (SBUV/2) instruments continue to extend the satellite-based ozone Climate Data Records (CDRs) 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.

Continuous Scan SBUV/2 Spectra

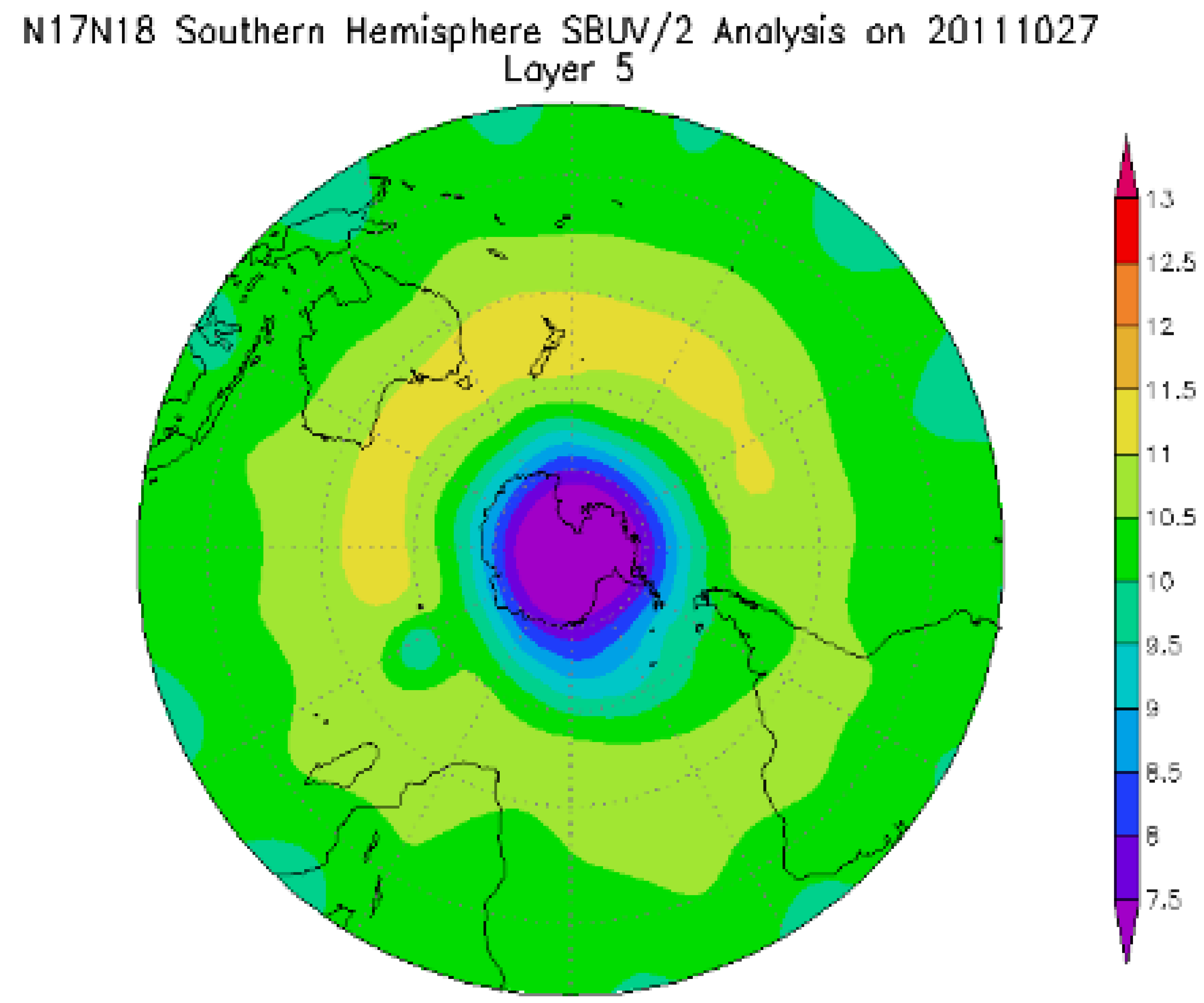


250 Wavelength (nm) 350

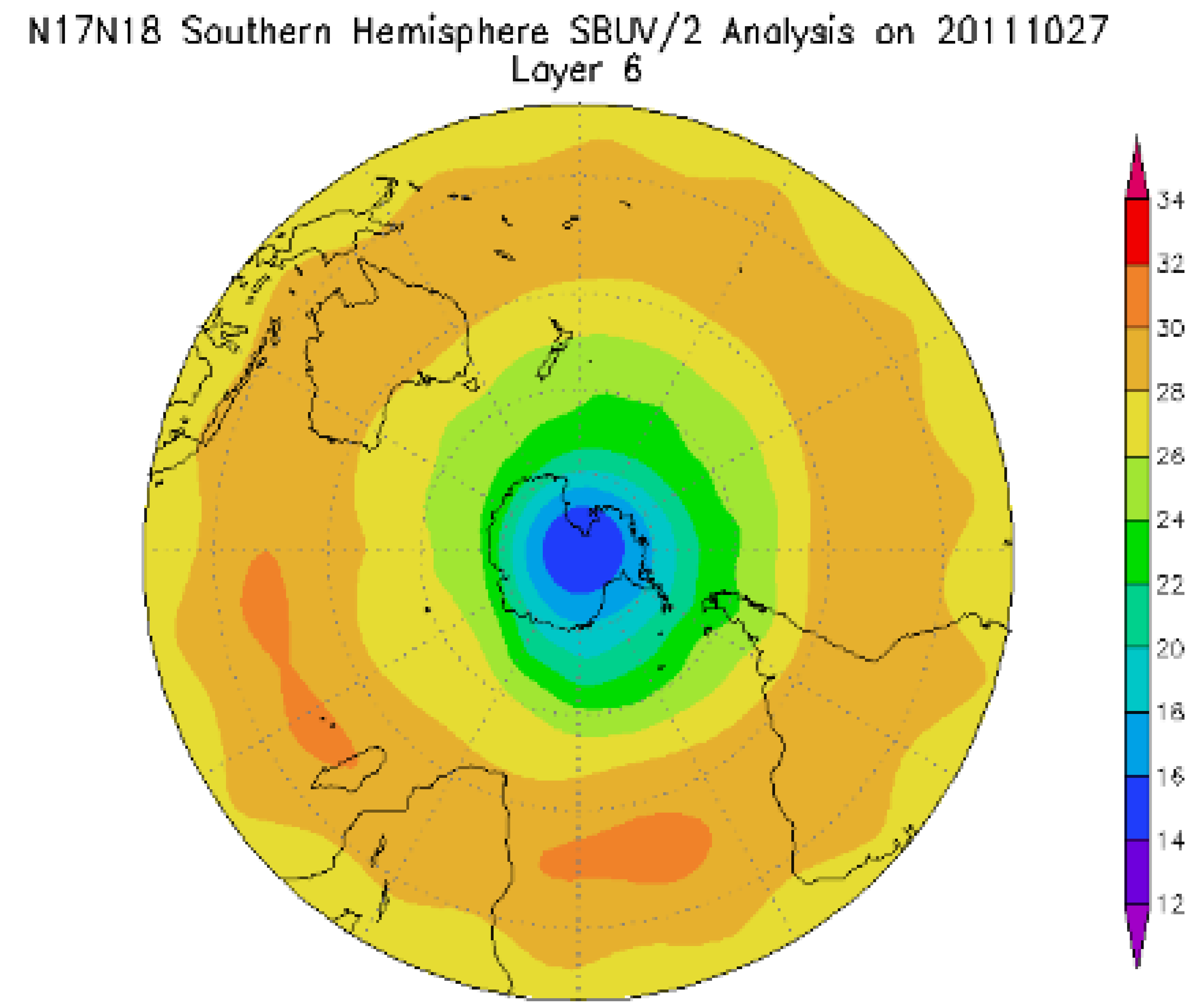
Layer 4



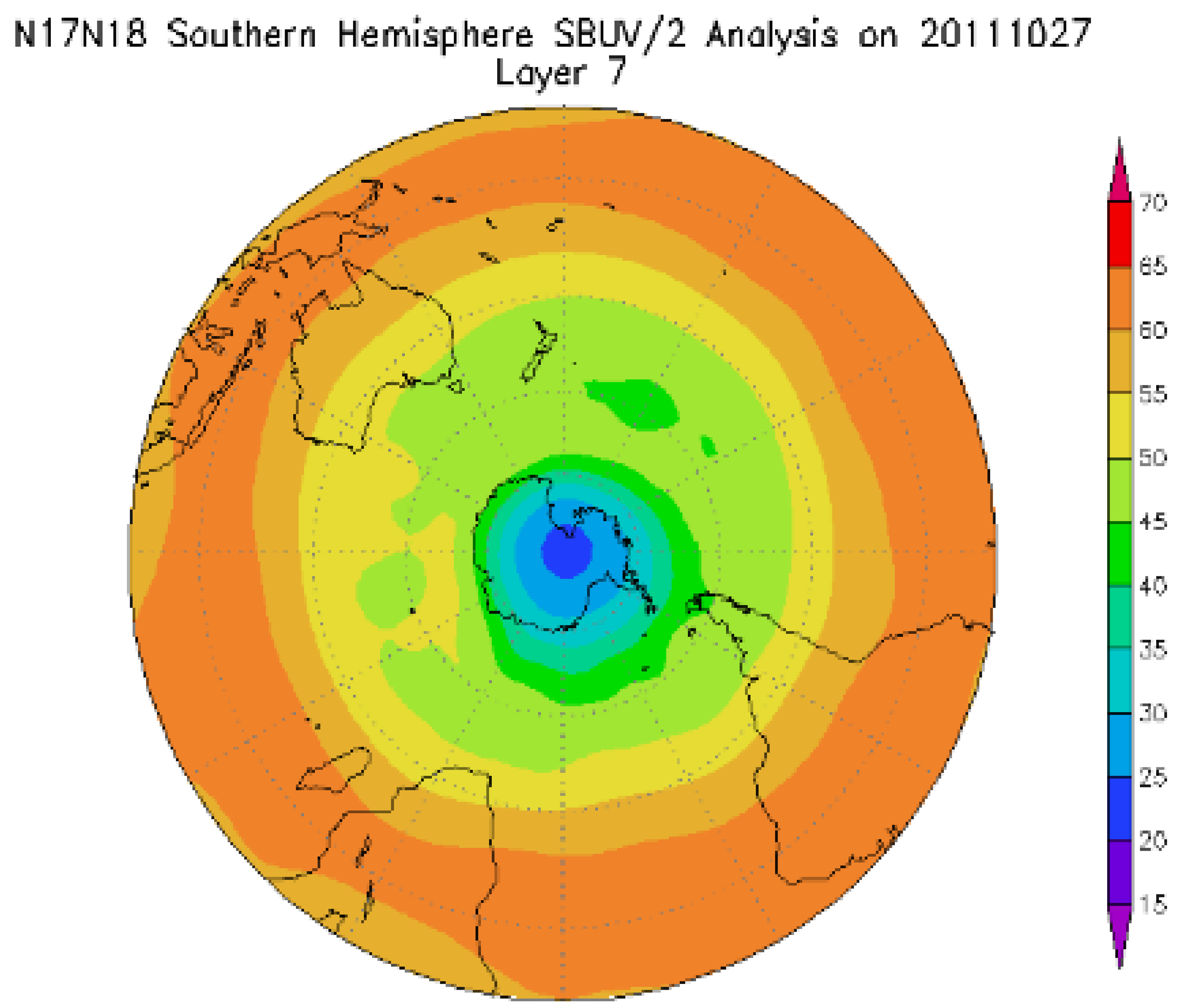
Layer 5



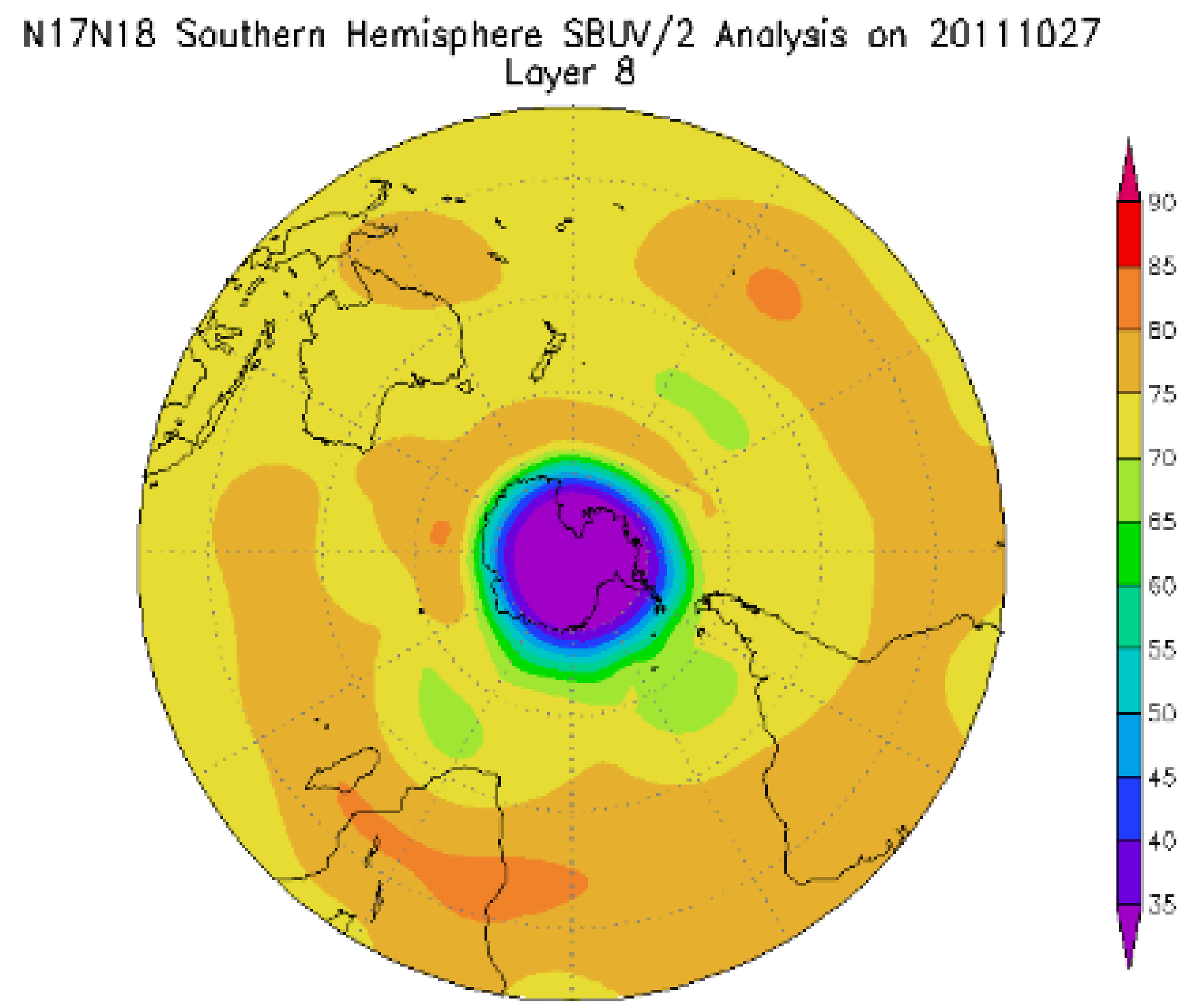
Layer 6



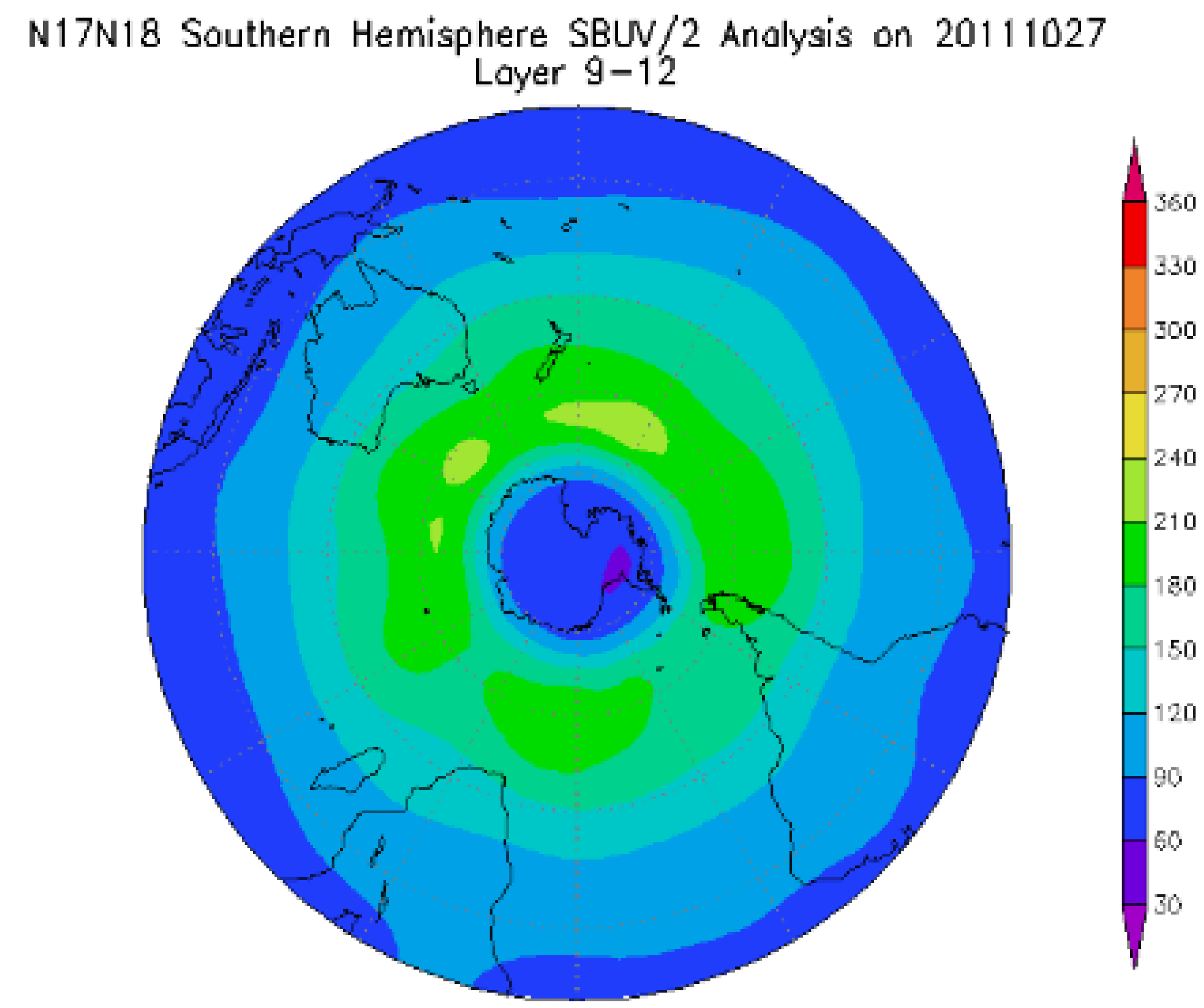
Layer 7



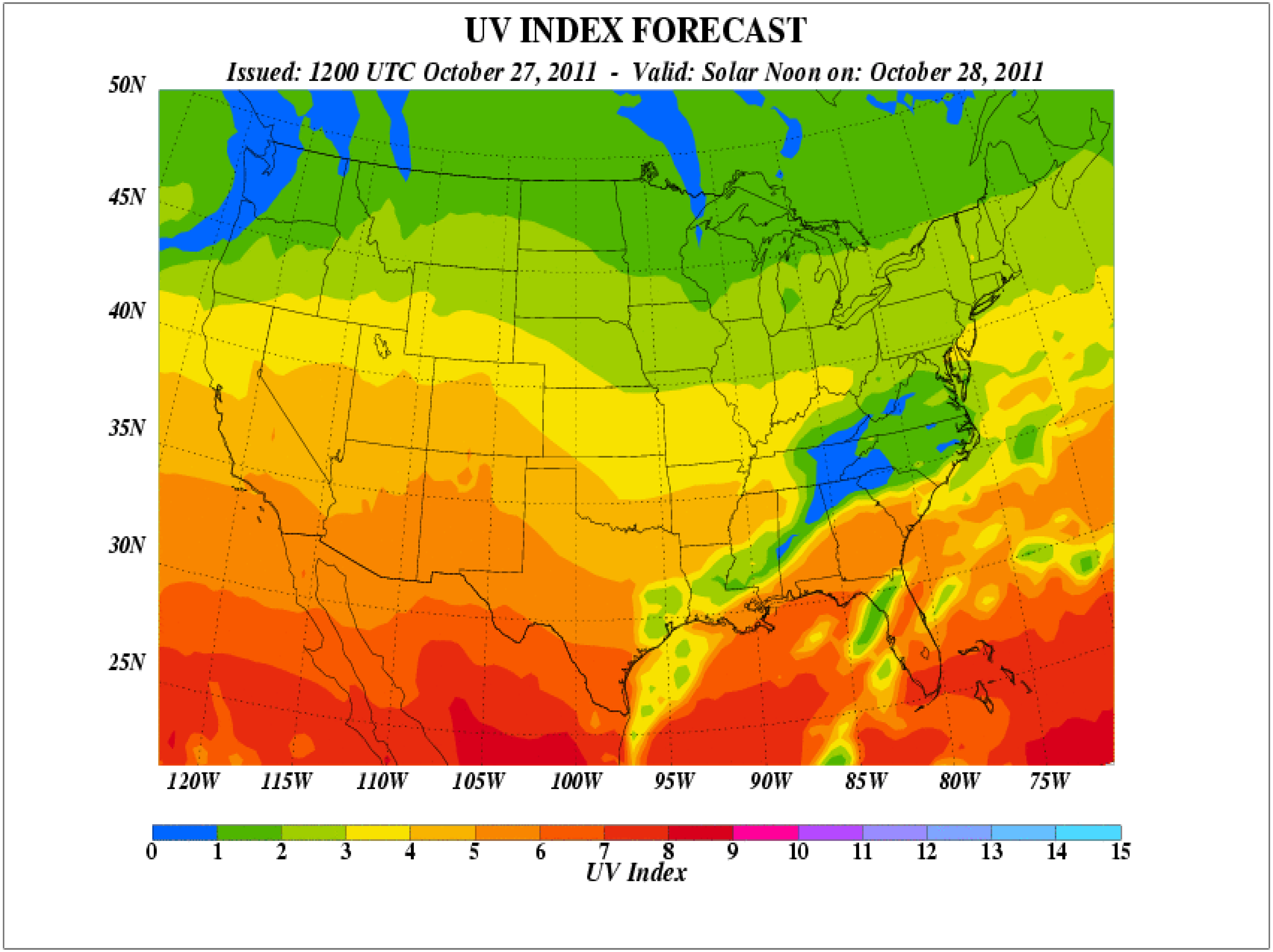
Layer 8



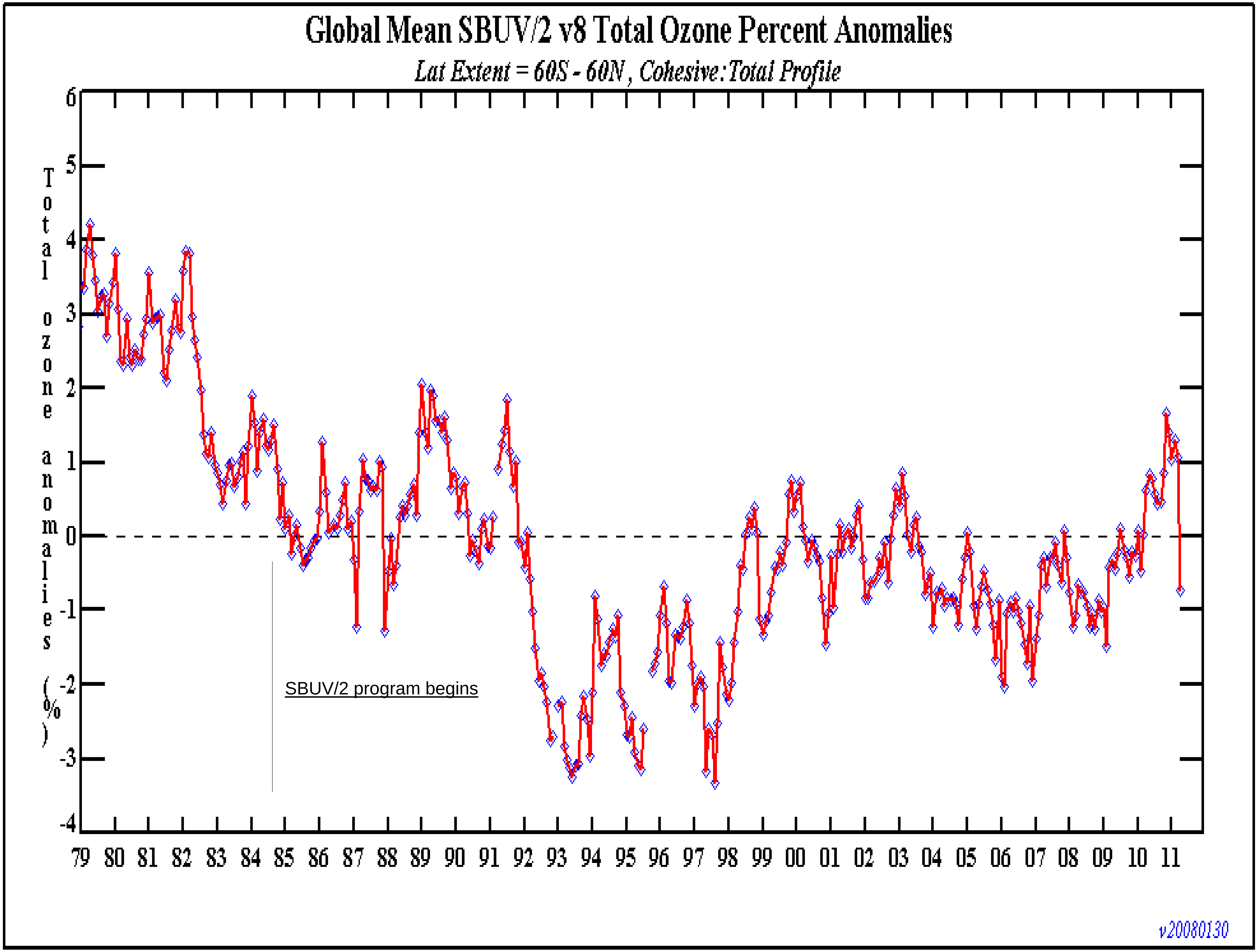
Layer 9-12



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



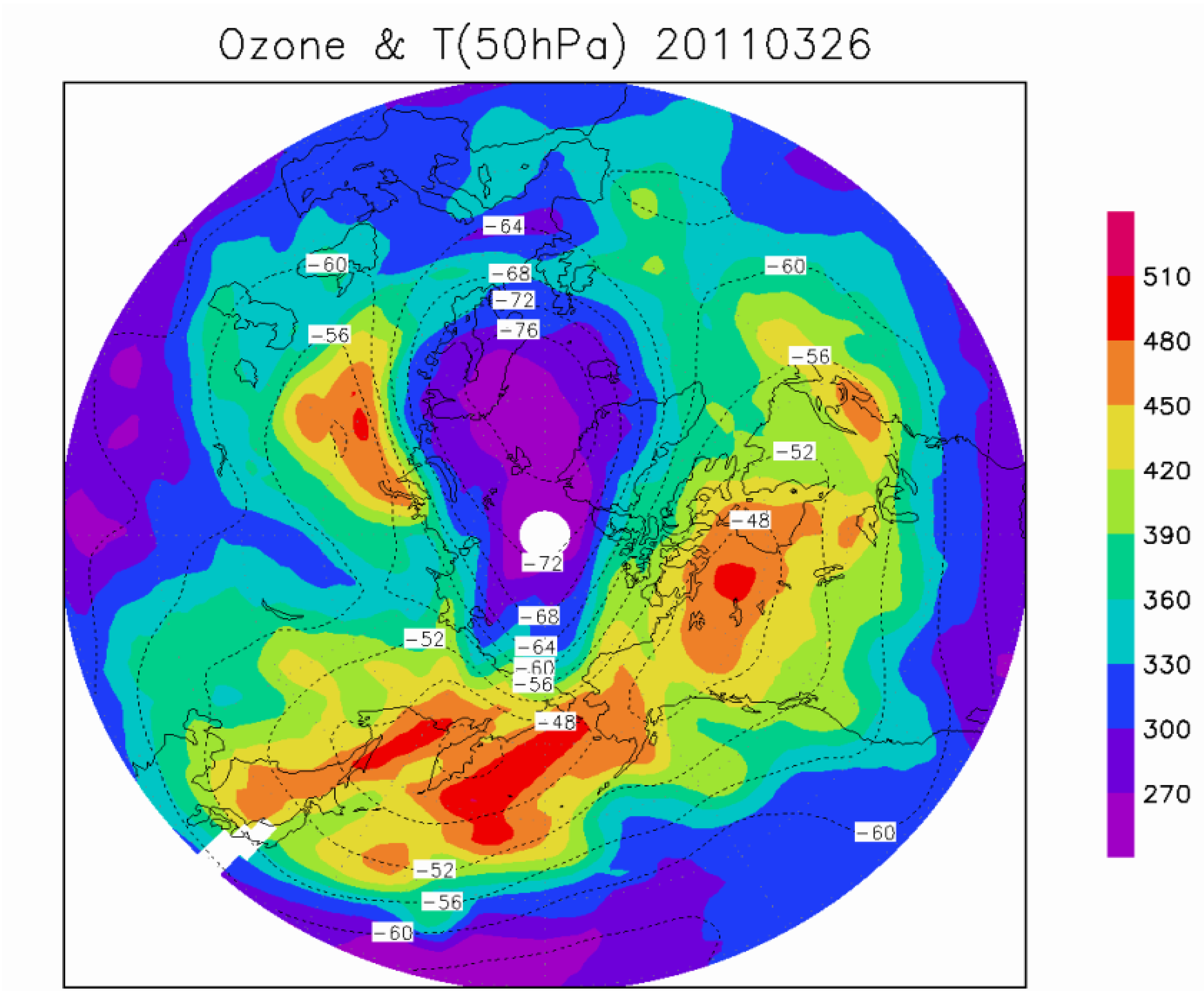
UV Index forecast derived by using SBUV/2 ozone information



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.

TOU and 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 estimates. 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.

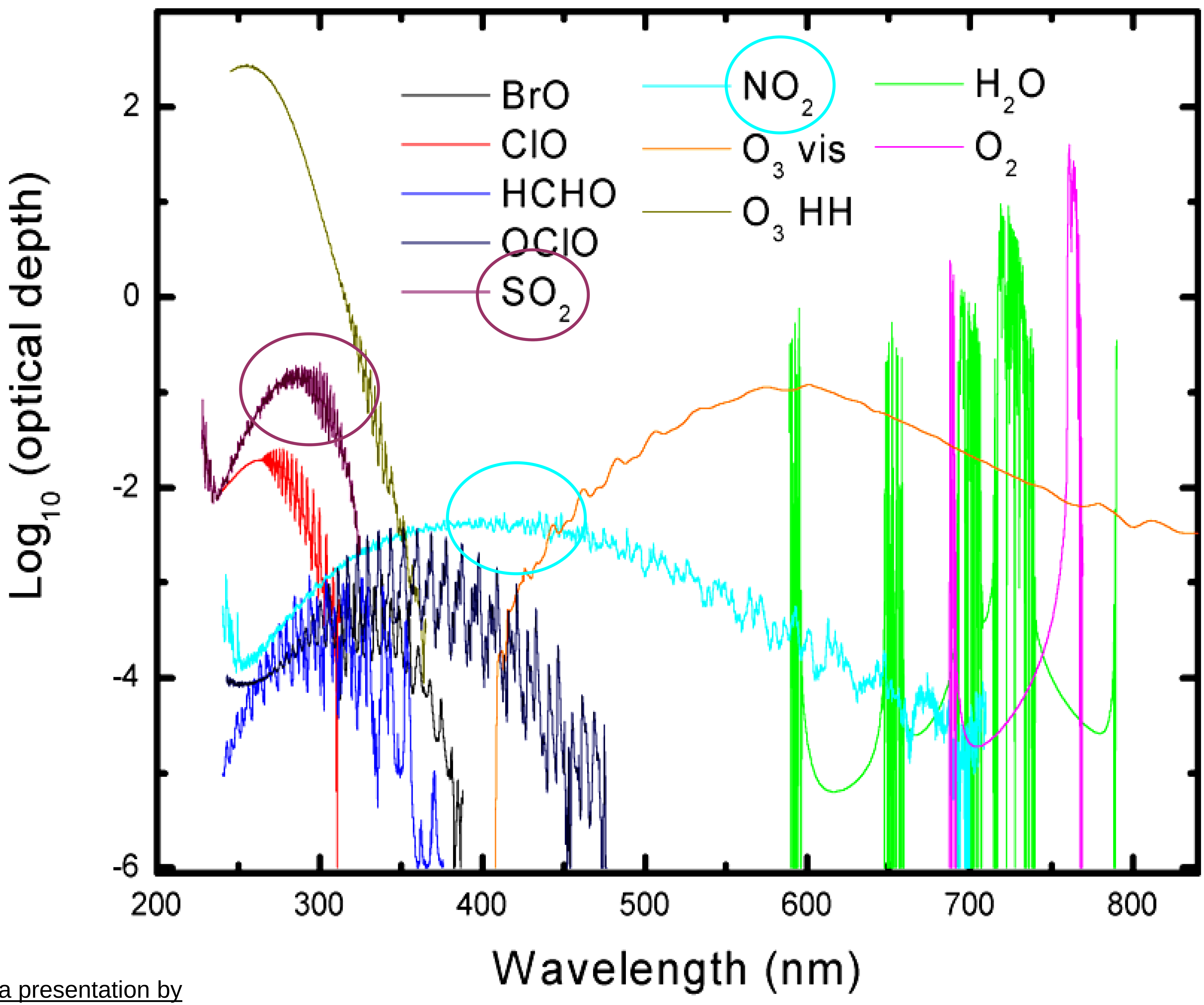


Composite of TOU total column ozone in DU with an overlay of contour lines for temperatures at 50 hPa in ºC for the Arctic, March 26, 2011.

GOME-2

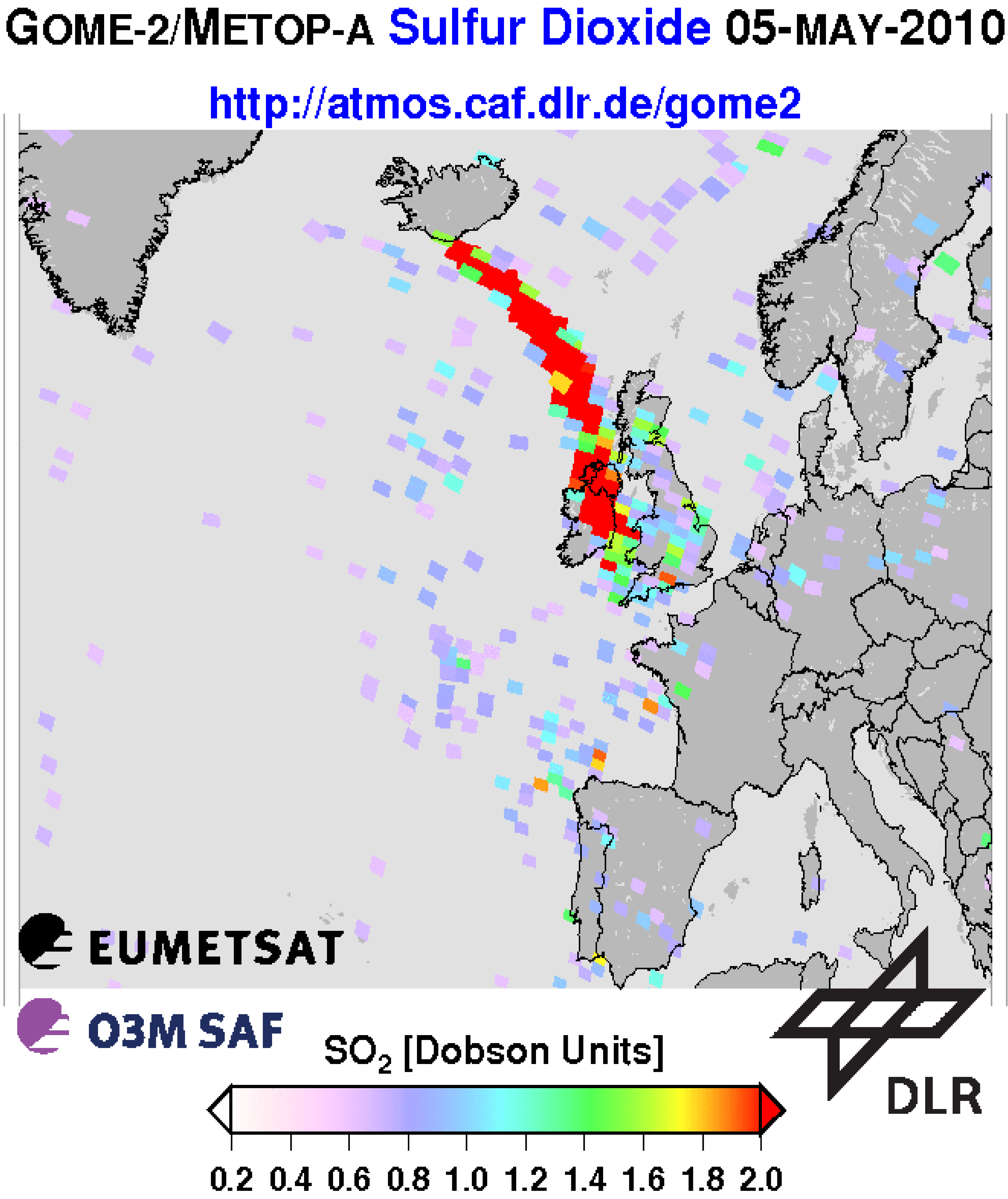
The European Organisation for the Exploitation of Meteorological Satellites (EuMetSat) is flying the MetOP series of Meteorological Operational Polar satellites. MetOP-A, was launched in October 2006; MetOP-B, is scheduled for launch early this year, and MetOP-C will follow in 2017. These satellites 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.

Optical Depths for Typical GOME Measurement Geometry

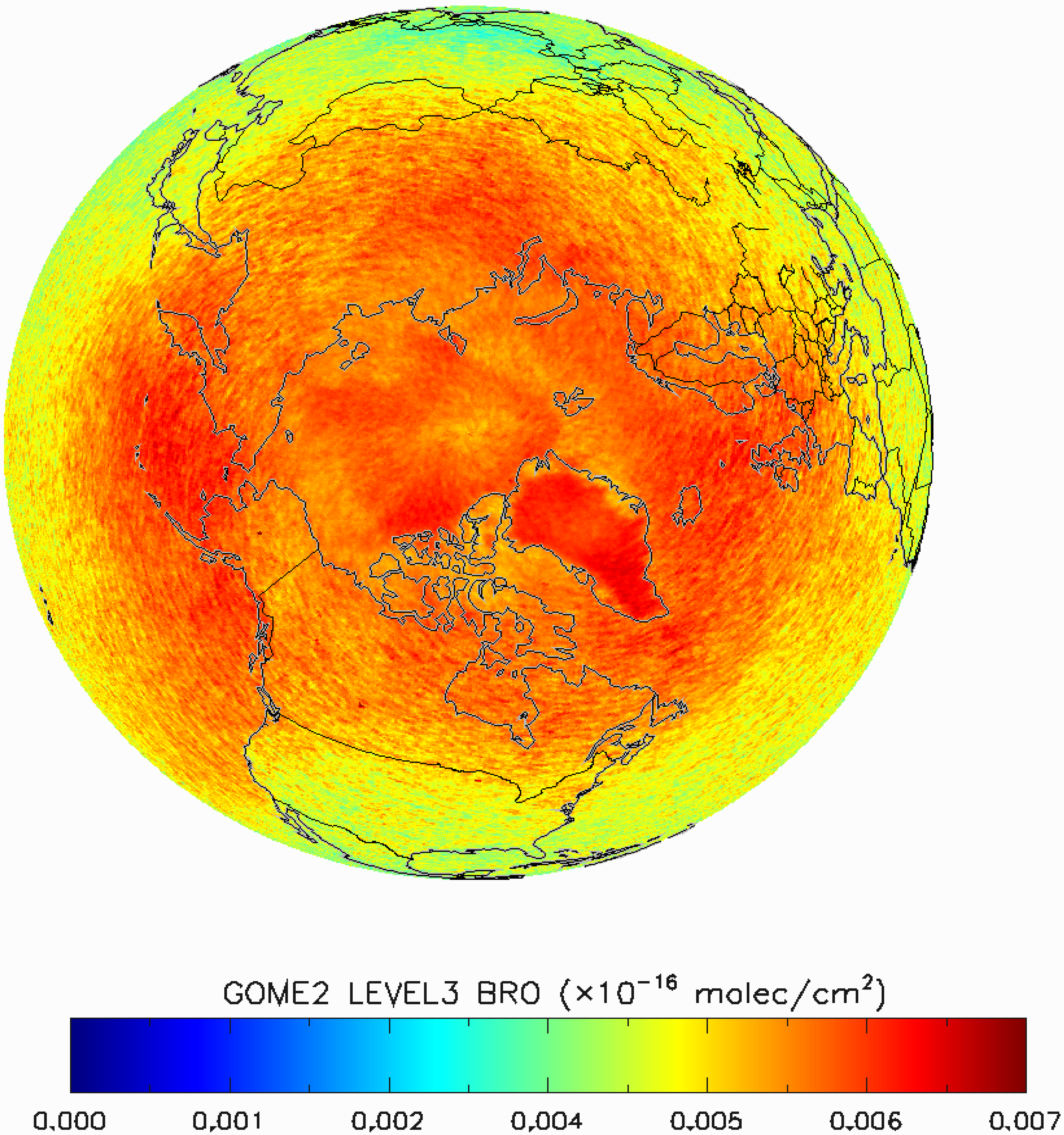


From a presentation by

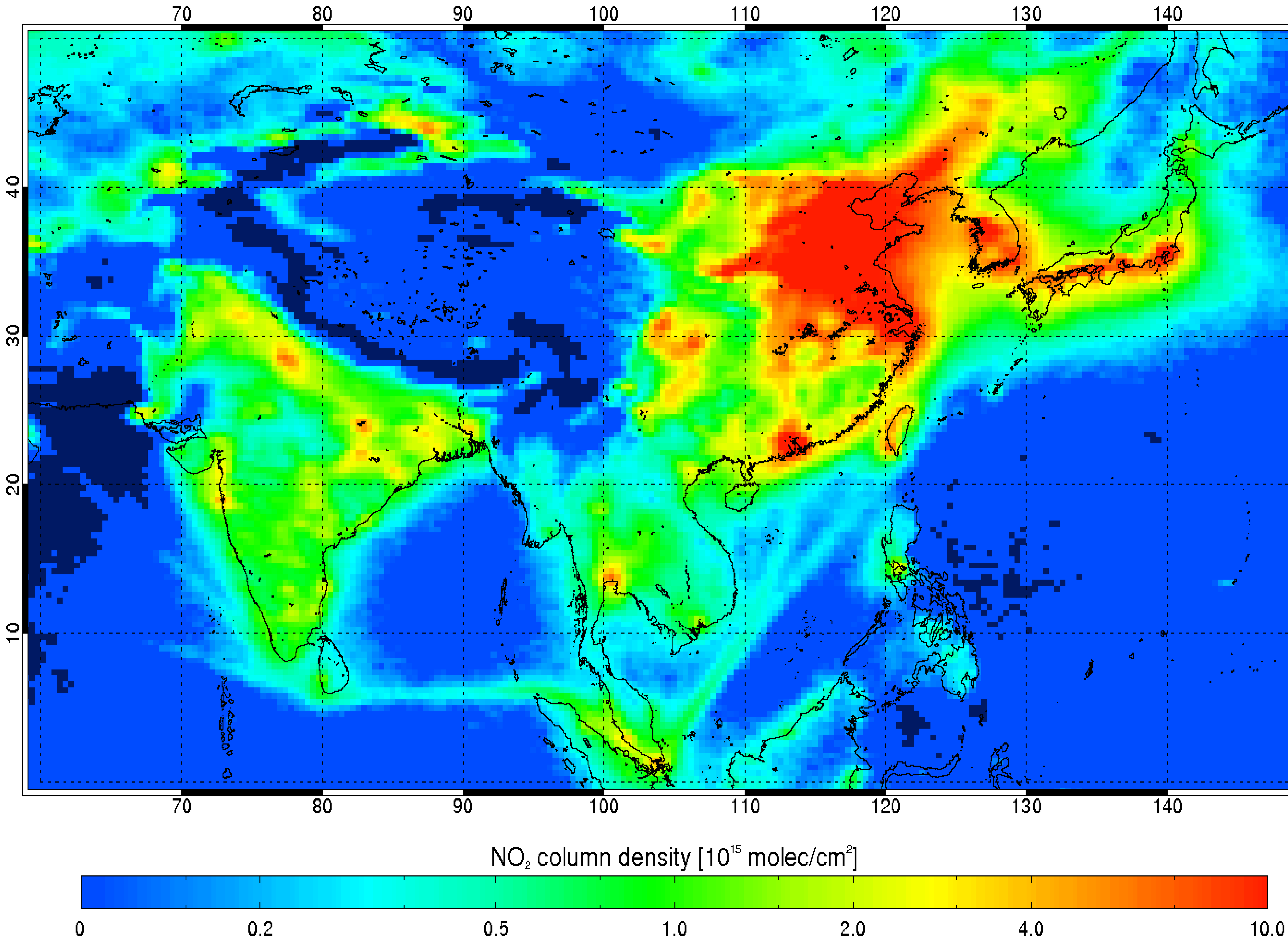
Kelly Chance, et al., Harvard-Smithsonian Center for Astrophysics



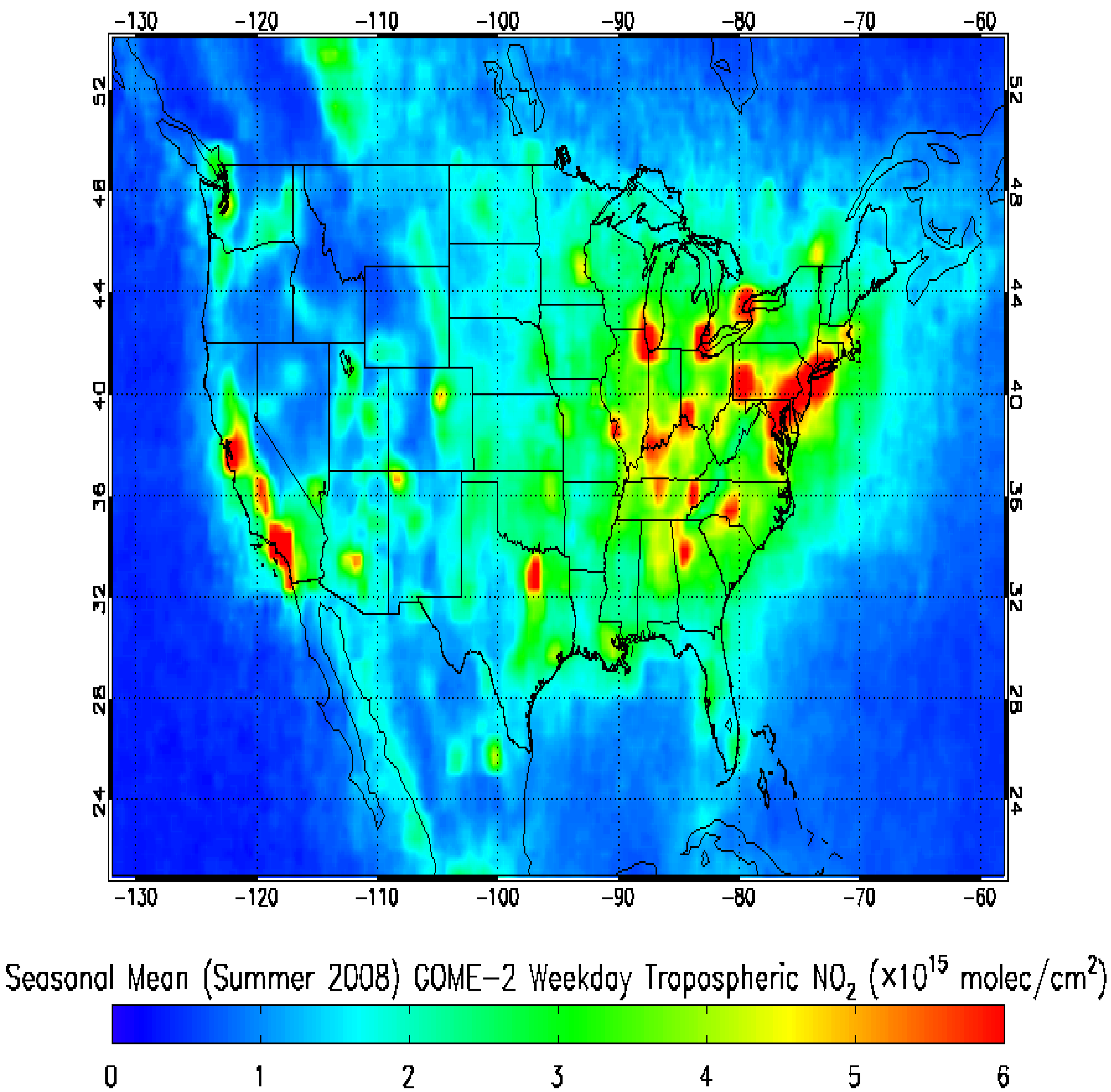
GOME-2 SO2 column amounts for an Icelandic eruption.

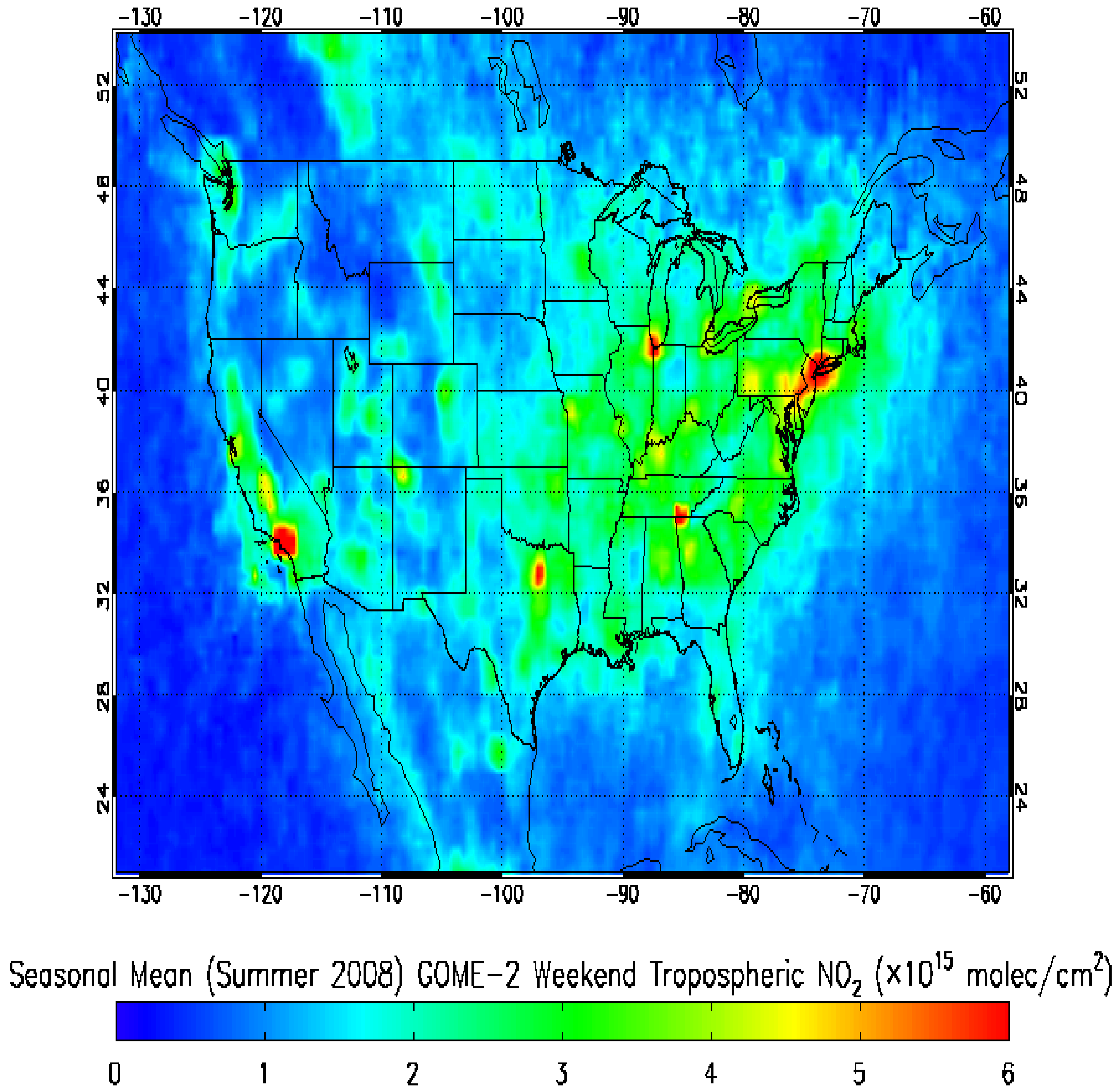


Monthly average total column BrO estimates from MetOP-A GOME-2 measurements for August 2010.



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





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

OMPS Nadir

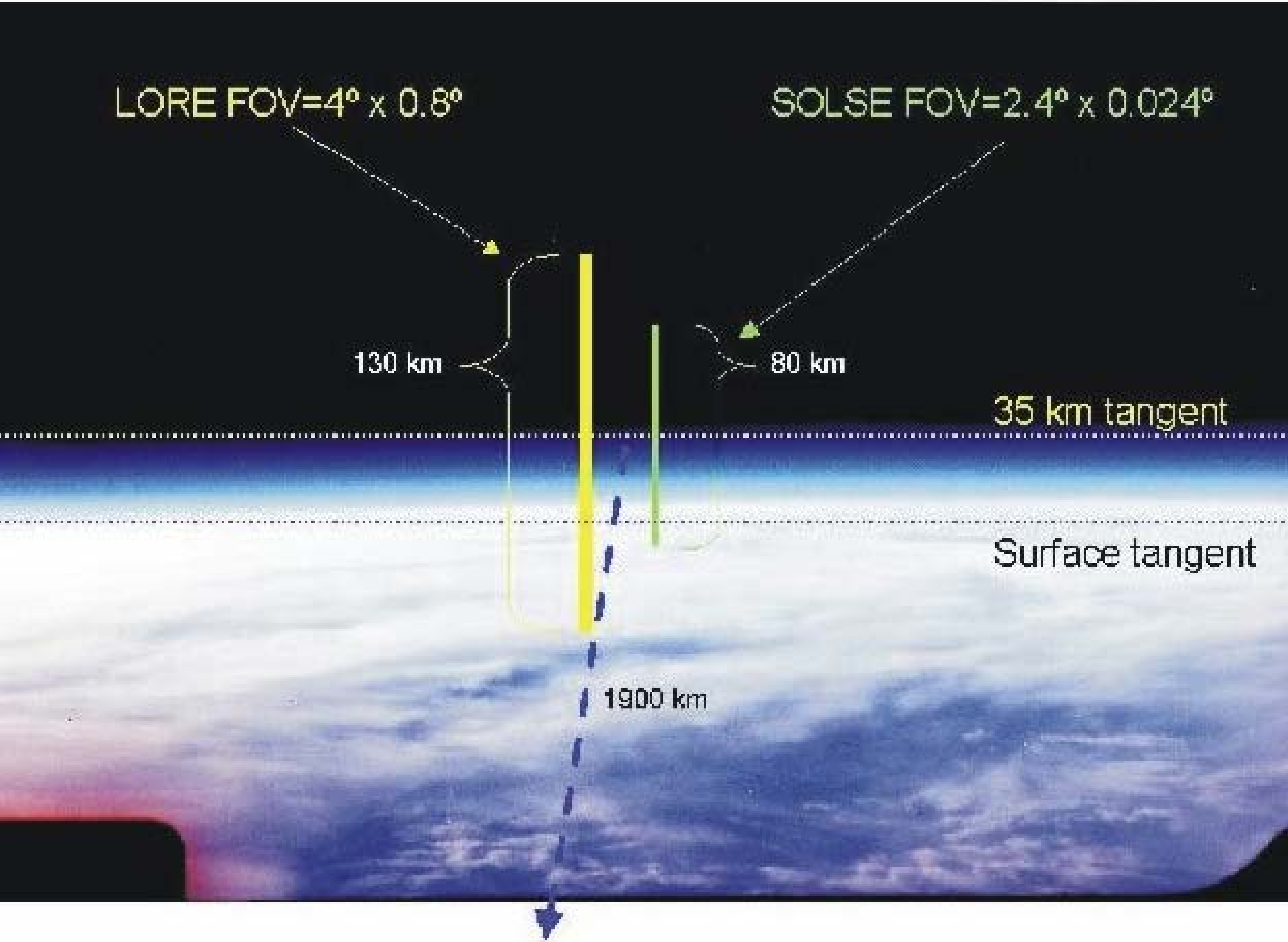
NOAA and NASA have just launched the NPP satellite, the first US component of the Joint Polar Satellite System (JPSS). Two more launches are planned, with J1 in 2016 and J2 in 2021. The NPP satellite carries a three-instrument suite of ozone sensors, the Ozone Mapping and Profiler Suite (OMPS).

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 SO_2.

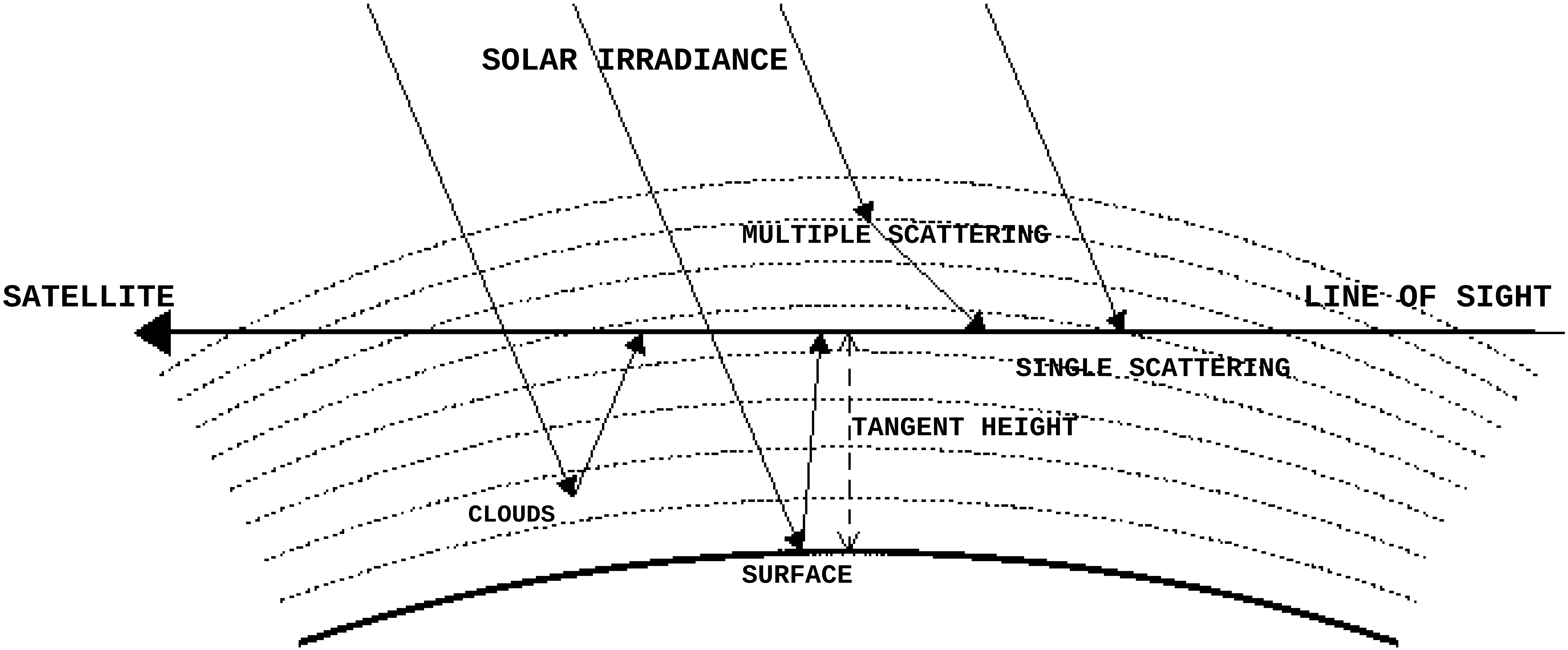
OMPS Limb

The OMPS on NPP and on J2 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.

NASA Space Shuttle View of Limb Scatter Observations

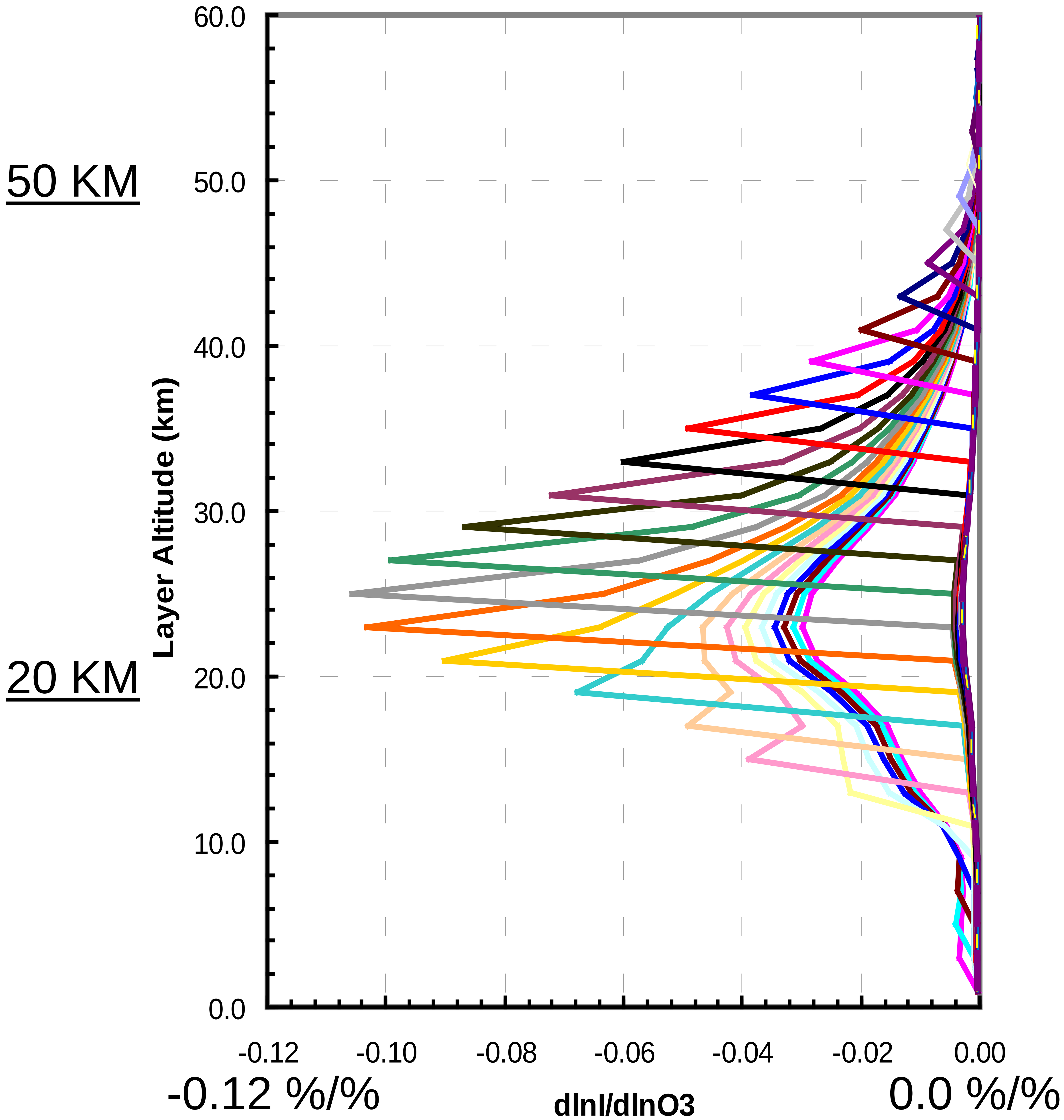


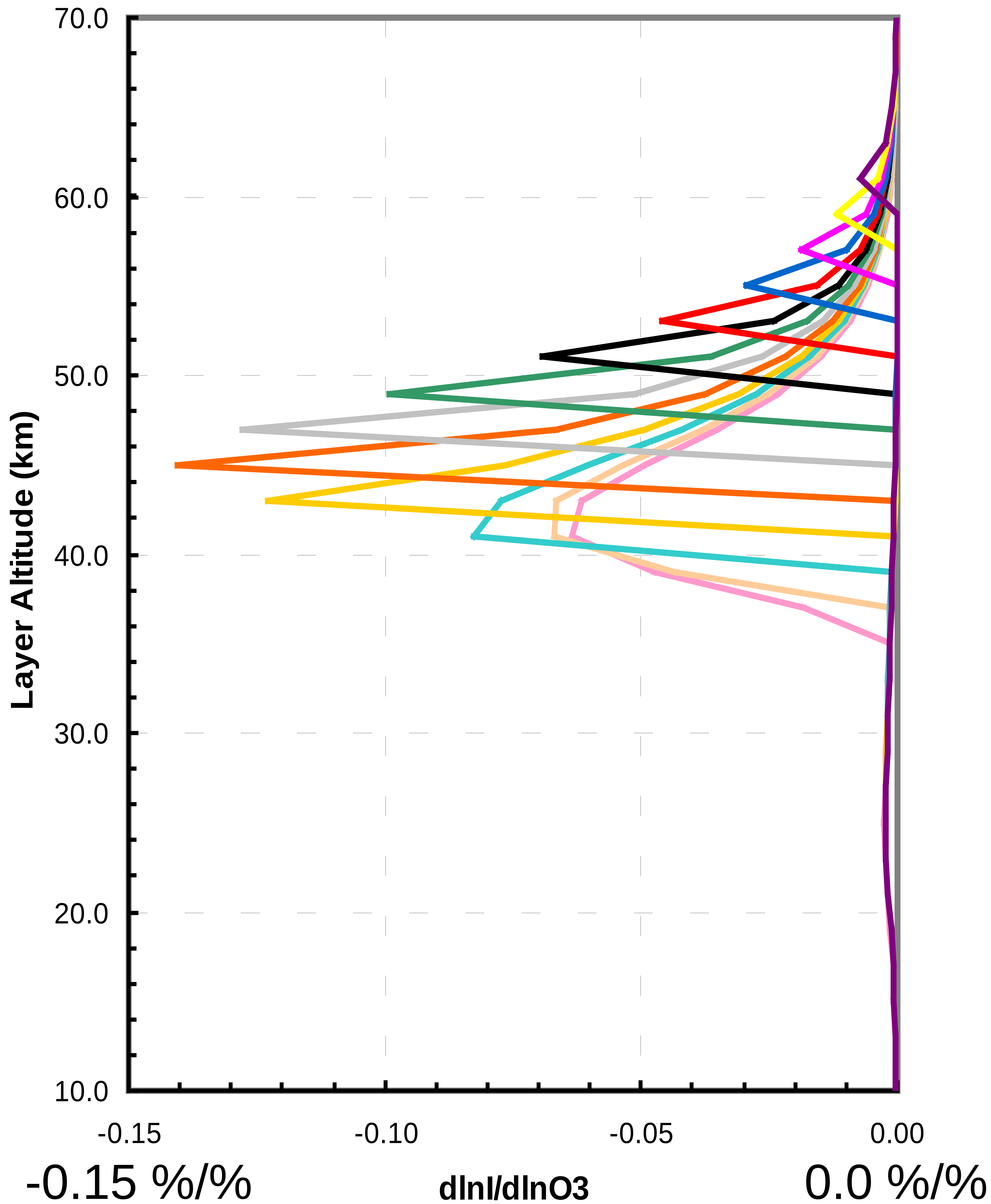
Limb Scatter Schematic



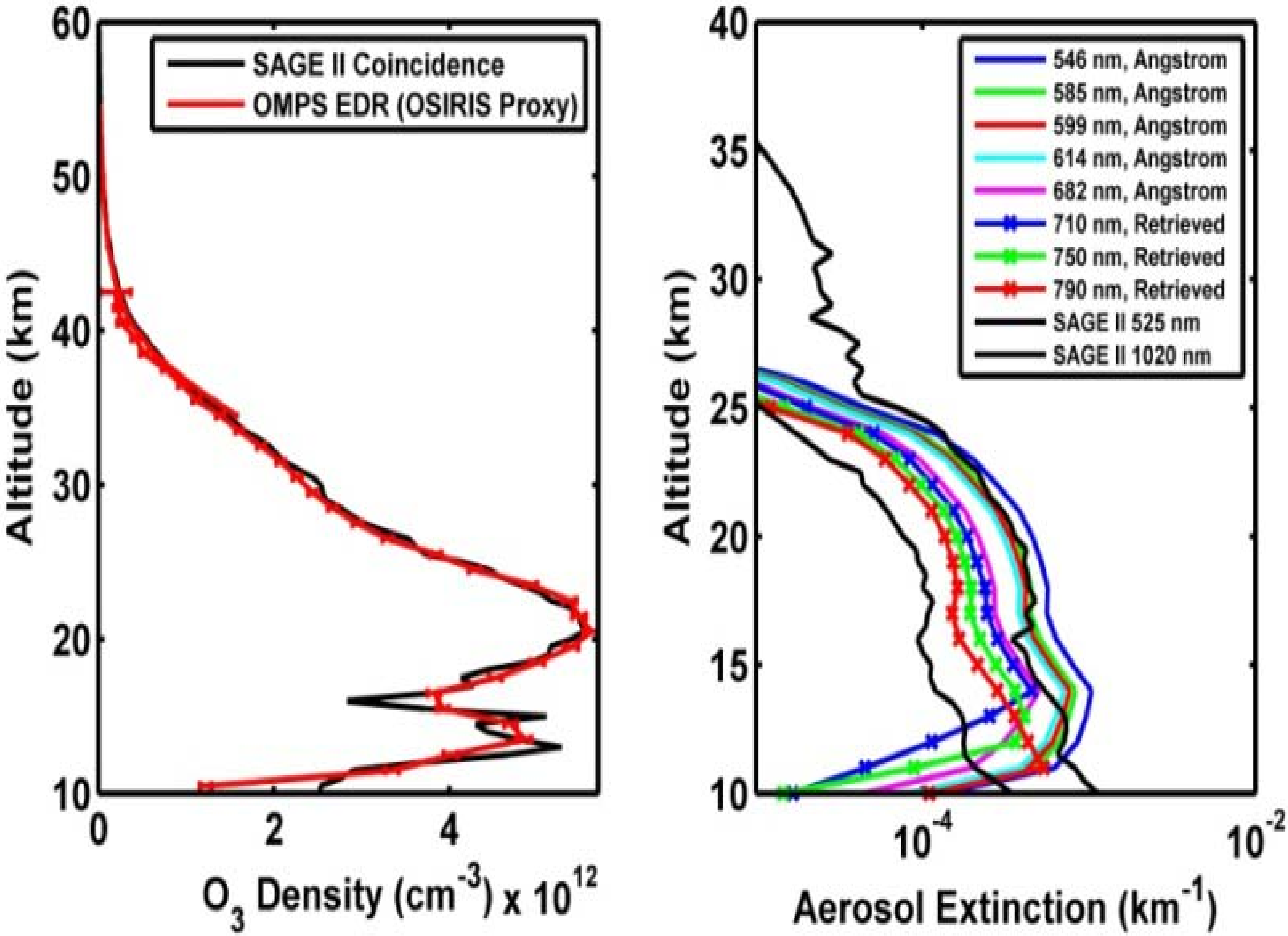
Notice that contributions from the layer at the tangent height will be accentuated both due to geometry and by an increase in scatterers.

Sensitivity of channel limb radiances to layer ozone changes for 1-km layers for a 40º SZA and mid-latitude 325-DU profile. Each curve gives the ratio of changes in the limb radiance for a given tangent height to changes in the ozone amounts as a function of altitude. The changes in the natural log of both quantities are used to give a % radiance change per % ozone change interpretation to the results. The curves give radiances for observation tangent heights spaced out every 2 km.





The plot on the left is for the 600-nm channel. The grey curve with the highest peak is for the 25-km tangent height case. The plot on the right is for the 305-nm channel. The orange curve with the highest peak is for the 45-km tangent height case.



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