P1.11 A WEB BASED TOOL FOR VISUALIZATION AND ANALYSIS OF ATMOSPHERIC COMPOSITION DATA

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1. INTRODUCTION

The NASA Goddard Earth Sciences Data and Information Services Center (GES DISC) has developed Giovanni, a web-based service for the visualization and analysis of its atmospheric composition data sets. Giovanni allows on-line interactive data exploration, analysis, and downloading of subsetted data from multiple sensors independent of the underlying file format. Currently, several Giovanni instances have been developed to support satellite data from: 1) Aura MLS (profiles of ozone, trace gases, water vapor, temperature, and geopotential height); 2) UARS HALOE (profiles of ozone, trace gases, water vapor, temperature, and aerosol extinction); 3) TOMS and Aura OMI (column ozone, aerosol index, effective surface reflectivity); 4) AIRS (column ozone, and vertical profiles of water vapor, relative humidity, temperature, geopotential height, etc.); 5) Aqua and Terra MODIS (aerosols, clouds, and water vapor). For more information see http://acdisc.gsfc.nasa.gov/.

2. GIOVANNI OVERVIEW

Giovanni, or the GES DISC On-line Visualization and Analysis Infrastructure is a web-based tool designed to make it easier for science users to quickly explore various data sets from different satellite based instruments. The user could then save the resulting plots, graphs and tables, and use them in their studies. A new feature in Giovanni allows a user to first preview the data online, and then using this information decide on downloading the original data subsetted by the users criteria to their desktop computer. This alleviates the need of the user having to download huge volumes of data or learning how to read various file formats. Giovanni was also designed to be easily configurable, extensible, and portable; it currently runs on SGI, Linux, and Sun platforms.

At its core, Giovanni consists of HTML and CGI scripts written in Perl, Grid Analysis and Display System (GrADS) scripts, and one or more GrADS-DODS (Distributed Oceanographic Data System, now OPeNDAP) Servers (GDS) running on remote machines hosting GrADS readable data files. Additionally, an image map Java applet allows users to select a spatial region that the user can focus on. Currently, the GES DISC hosts several instances of Giovanni for its atmospheric composition, atmospheric dynamics, precipitation, and ocean data sets. Giovanni uses area weighted averaging for its spatial and time average plots.

The atmospheric composition Giovanni instances include data from TOMS and Aura OMI, Aura MLS, UARS HALOE, AIRS, and Aqua and Terra MODIS. For a list of the geophysical parameters measured by

3. TOMS AND OMI OZONE

The Total Ozone Mapping Spectrometer (TOMS) on Nimbus-7 (Nov. 1978 – May 1993) and Earth Probe (July 1996 – present) data represent the primary long-term (for more than 25 years), continuous record of satellite-based observations available for use in monitoring global and regional trends in total ozone. TOMS also provides measurements of tropospheric aerosols volcanic SO_2, ultraviolet irradiance, erythemal UV exposure, and effective reflectivity from the Earth's surface and clouds. The spatial resolution of TOMS is about 50 x 50 km at nadir. The version 8 TOMS data are available from the GES DISC.

The Ozone Measuring Instrument (OMI) aboard the Earth Observing System (EOS) Aura spacecraft (launched July 2004) employs hyperspectral imaging to observe solar backscatter radiation in the ultraviolet (270 - 380 nm) and visible (350 - 500 nm). OMI measures column

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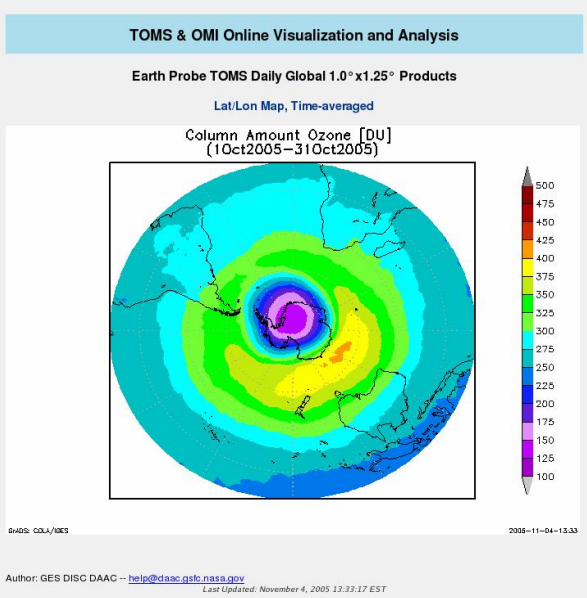

Figure 1 TOMS EP column ozone data averaged for the month of October 2005 over the southern hemisphere.

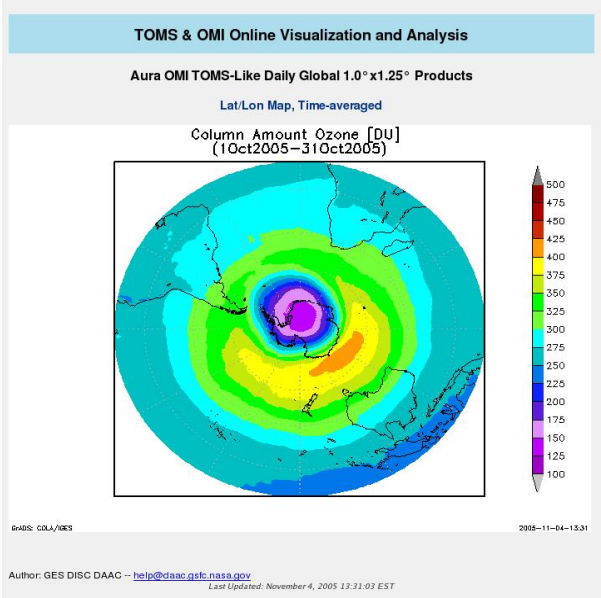

Figure 2 OMI column ozone data averaged for the month of October 2005 over the southern hemisphere. Compare TOMS-EP in figure 1.

amounts of ozone, NO_2, SO_2, BrO, HCHO, OClO, and ozone profiles, as well as UV-B radiation at the surface, aerosol and cloud properties. Spatial resolution at nadir is 13 x 24 km for nominal observations, and can be zoomed to 13 x 8 km for detecting small-scale sources. Currently, only the column ozone product (OMTO3) based on the TOMS version 8 algorithm is available to the public. The other products will be made available in the near future.

The Giovanni instance for TOMS Nimbus-7 and Earth Probe uses the version 8 level 3 gridded 1.25° x 1.0° data. The OMI data are from the gridded 1.25° x 1.0° TOMS-like product derived from the level 2 OMTO3 data. A Java map applet allows users to select a spatial region for plotting time averaged area maps using different projections, time series, Hovmoller lat vs time or lon vs. time for column ozone, aerosol index, effective reflectivity, or erythemal UV (not available in OMI). Users can also run animations for these parameters, or dump the data to an ASCII output file. In figure 1 we show TOMS EP data averaged for the month of October 2005 over the southern hemisphere (peak ozone minimum) with that from OMI in figure 2.

In the future, OMI Level 2G daily products consisting of data from 15 orbits that are binned onto a 0.25 ^{o} x 0.25^{o} global grid will be made available through Giovanni. Users will be able to generate OMI gridded products from this L2G product as well as get its spatial and parameter subset.

4. MLS TRACE GASES

The Microwave Limb Sounder (MLS) aboard Aura (launched July 2004) measures microwave emissions from the Earth's limb at 118, 190, 240 and 640 GHz, and 2.5 THz. Since then it has been providing global daily measurements of vertical profiles of ozone and various trace gases (BrO, ClO, CO, H2O, HCl, HCN, HOCl, HO_2, N2O, OH, and SO_2), temperature, relative humidity with respect to ice, cirrus ice, and geopotential height. The vertical resolution of these data is about 3 km, and the spatial coverage is near global (-82 to +82 latitude), with each profile spaced 1.5° (about 165 km) along the orbit track. The first public release of MLS data (version 1.51) was in February 2005.

The GES DISC has implemented an instance of Giovanni for MLS that allows users to view vertical profile plots of the level 2 MLS data or output the data to an ASCII text file. The interface allows one to select a point on a map, and the three nearest profiles are then displayed. The data values are filtered for good quality, and only data points with precision within ±1 sigma. MLS Giovanni also only displays data within the MLS team recommended vertical pressure ranges. Figure 3 shows an example MLS vertical profile plot from Giovanni.

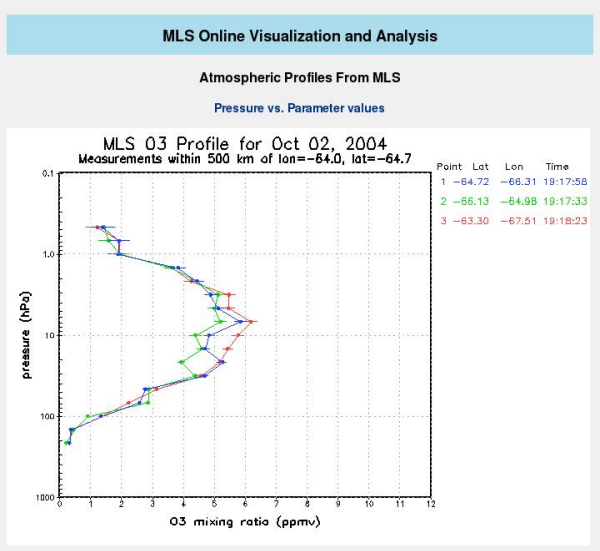

Figure 3 MLS ozone profiles with overpass closest to Palmer Station in Antarctica for Oct. 2, 2004. Data points have been screened for good quality and include estimated uncertainties.

5. UARS HALOE TRACE GASES

The Halogen Occultation Experiment (HALOE) on the Upper Atmosphere Research Satellite (UARS) has operated flawlessly since its activation on October 11, 1991. HALOE uses the principal of satellite solar occultation to measure profiles of solar attenuation by the atmosphere's limb, as the sun rises or sets relative to the spacecraft, 15 profiles each in two narrow latitude bands. The progression of measurement latitude bands with time provides near global coverage over periods of 3-4 weeks. HALOE measures vertical profiles of atmospheric O_3, HCl, HF, CH_4, H_2O, NO, NO_2, aerosol extinction at 4 bands, and temperature. Vertical resolution is about 1.6 km.

The HALOE Giovanni instance provides users with the ability to display vertical profile plots of selected sunrise and sunset events from the version 19 level 2 data along with standard deviations. The data can be plotted with the y-axis as pressure in hPa or altitude in km. A map on the user interface shows the location of each sunrise and sunset event. The data can also be output to an ASCII text file to the users desktop computer. See figure 4 for an example of HALOE Giovanni.

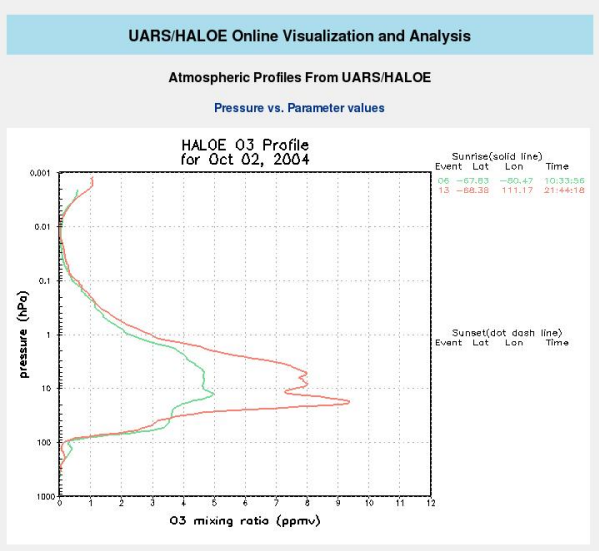

Figure 4 UARS HALOE vertical profiles showing variations in ozone in the Antarctic for Oct. 2, 2004. The green line shows a region of low ozone (closest to the MLS profiles in figure 3), while the orange line shows a region of high ozone. Both profiles are at the same latitude band.

6. AIRS ATMOSPHERIC PROFILES

The Atmospheric Infrared Sounder (AIRS) on the EOS Aqua spacecraft is a hyperspectral instrument that measures radiation in the 3.74 to 15.4 micron spectral region. The spatial resolution of the instrument is about 15 x 15 km at nadir. AIRS measurements, together with the Aqua AMSU-A and HSB instruments, are used to derive the geophysical parameters of surface and atmospheric temperature, water vapor, relative humidity, geopotential height and column ozone. The vertical profiles are retrieved on 28 layers from about 1100 up to 0.1 hPa with a resolution of 1 km. The AIRS instrument has been acquiring data since August 2002.

The AIRS Giovanni instance uses the version 4 level 3 gridded 1° x 1° resolution data as input for displaying time averaged area maps on different projections, time series, vertical profiles, zonal or meridional cross sections, or Hovmoller lat vs time and lon vs time plots. Users can also create animations or dump the data to ASCII files. The interface allows the user to select the vertical layers to display for the parameter on the ascending (daytime) or descending (nighttime) portion of the orbits.

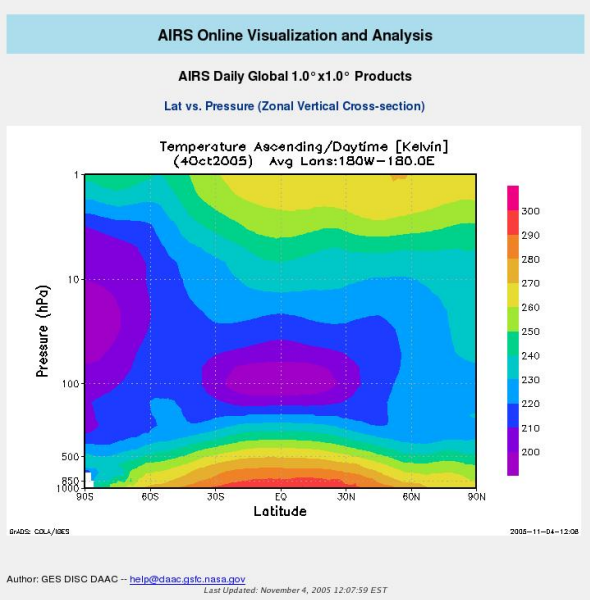

Figure 5 AIRS daytime temperature profiles that have been zonally averaged.

7. MODIS ATMOSPHERIC PARAMETERS

The Moderate Resolution Imaging Spectrometer provides images of land, ocean and atmosphere in 36 spectral bands (from 0.4μm to 14.5μm) with spatial resolutions of 250m (bands 1-2), 500m (bands 3-7) and 1000m (bands 8-36). Two MODIS instruments are in orbit, the first on the EOS flagship Terra (morning equator crossing) spacecraft and the other on the EOS Aqua (afternoon equator crossing) satellite. MODIS Terra has been operational since Dec. 1999, while MODIS Aqua has been acquiring data from Aug 2002. The GES DISC archives MODIS level 1B radiance and level 2 and 3 atmosphere products.

The Giovanni instance for MODIS data allows users to display time averaged area maps on different map projections, time series, Hovmoller lat vs time and lon vs time plots. Users can also create animations or dump the data to ASCII files. Correlation plots can be made through Giovanni comparing data between MODIS Aqua and MODIS Terra or with GOCART model data. See figure 6 for an example of comparing MODIS Terra cloud fraction data with MODIS Aqua.

A new Giovanni feature allows users to preview the data within a session, and use this information to decide to download the original data to their site. Using the selected geophysical parameter, spatial region and time range criteria, the original data files will be subsetted on-the-fly during FTP download. The user can then continue studying the data in more detail on their local machine using their own preferred software package.

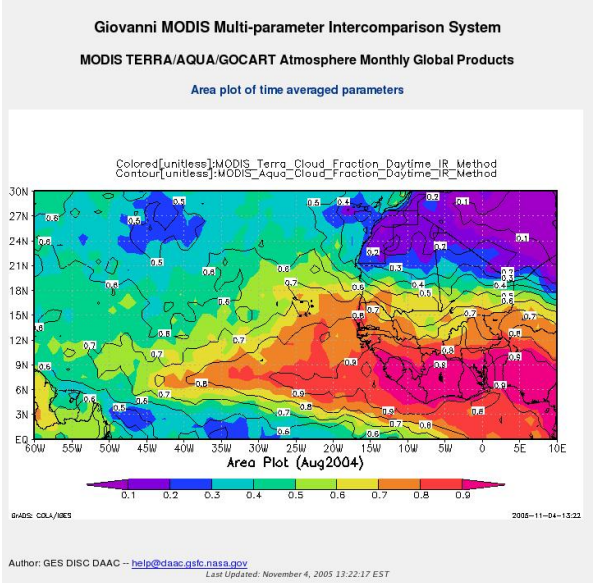

Figure 6 Difference map of Aqua versus Terra MODIS Cloud Fraction over the intertropical convergence zone in August 2004. Please note MODIS Aqua crosses the region about 1:30 PM, whereas MODIS Terra crosses the region around 10:30 AM when there is less cloud development.

8. FUTURE PLANS

Various intercomparison options will be employed allowing users to compare data from one instrument against another. For OMI the GES DISC is working on implementing the Level 2G product with the ability to process it into user-defined global gridded products suitable for Giovanni. AIRS daily products will be added in the future too. The GES DISC also plans to include more data sets from other instruments to its atmospheric chemistry suite of Giovanni instances. Please see http://acdisc.gsfc.nasa.gov/ for the latest information on the atmospheric composition instances of Giovanni.

9. ACKNOWLEDGMENT

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10. REFERENCES

G. Leptoukh, S. Kempler, I. Gerasimov, S. Ahmad, J.Johnson, 2005, "Goddard Atmospheric Composition Data Center: Aura Data and Services in One Place," IGARRS'05, Proceedings