Data Visualization and Analysis for Climate Studies Using NASA Giovanni Online System

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Introduction

With many global earth observation systems and missions, focused on climate systems, and the associated large volumes of observational data available for exploring and explaining how climate is changing and why, there is an urgent need for climate services. Giovanni, the NASA GES DISC Interactive Online Visualization ANd ANalysis Infrastructure, is a simple-to-use yet powerful tool for analysing these data for research on global warming and climate change, as well as for applications to weather, air quality, agriculture, and water resources.

Giovanni Capabilities

Input Data Formats: HDF4, HDF5, NetCDF, and binary
Input Data Types: Gridded, Swath
Data Access Methods: FTP, HTTP, WCS, OPeNDAP, and GDS
Giovanni User Access Methods: Web GUI, WCS, and WMS
Visualization and Analysis Types:

Single Parameter:
- Curtain Along Swath
- Swath Strip Plot
- Lat-Lon Map, Time-averaged
- Time Series, Area-averaged
- Time-Lat Hovmoller, Longitude-Averaged
- Time-Lon Hovmoller, Latitude-average
- Cross Map, Lat-Pressure, Time-Lon-averaged
- Cross Map, Lon-Pressure, Time-Lat-averaged
- Cross Map, Time-Pressure, Time-Area-averaged
- Vertical Profile
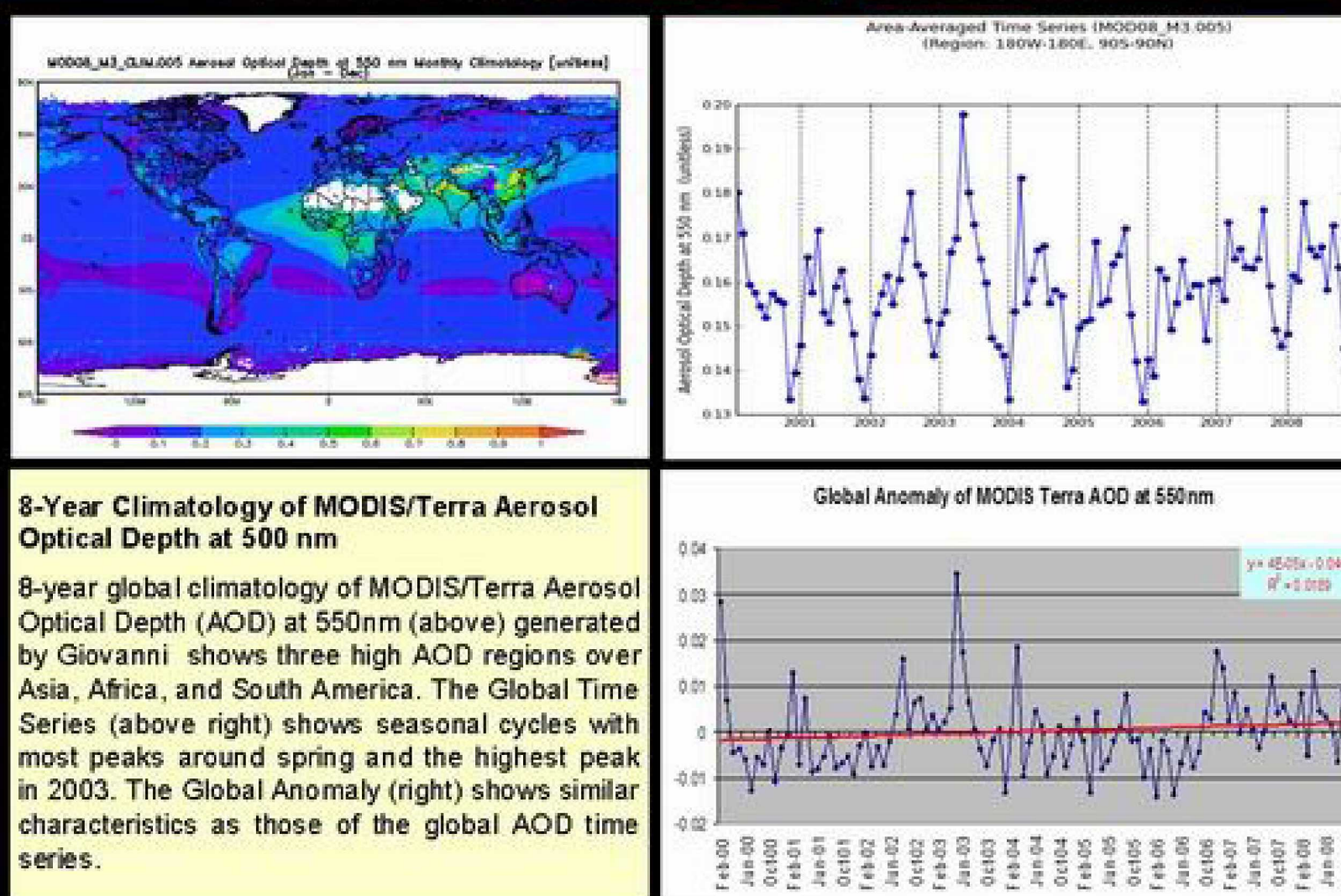- Climatology and Anomaly Analysis

Multi-Parameters:
- Correlation Map
- Scatter
- Difference of Lat-Lon Maps
- Overlay of Lat-Lon Map
- Overlay of Vertical Profile
- Difference of Time Series
- Line Plot overlay on Curtain

Data Output Formats
- **Image:** gif, png, animation, KMZ (ready for displaying on Google Earth)
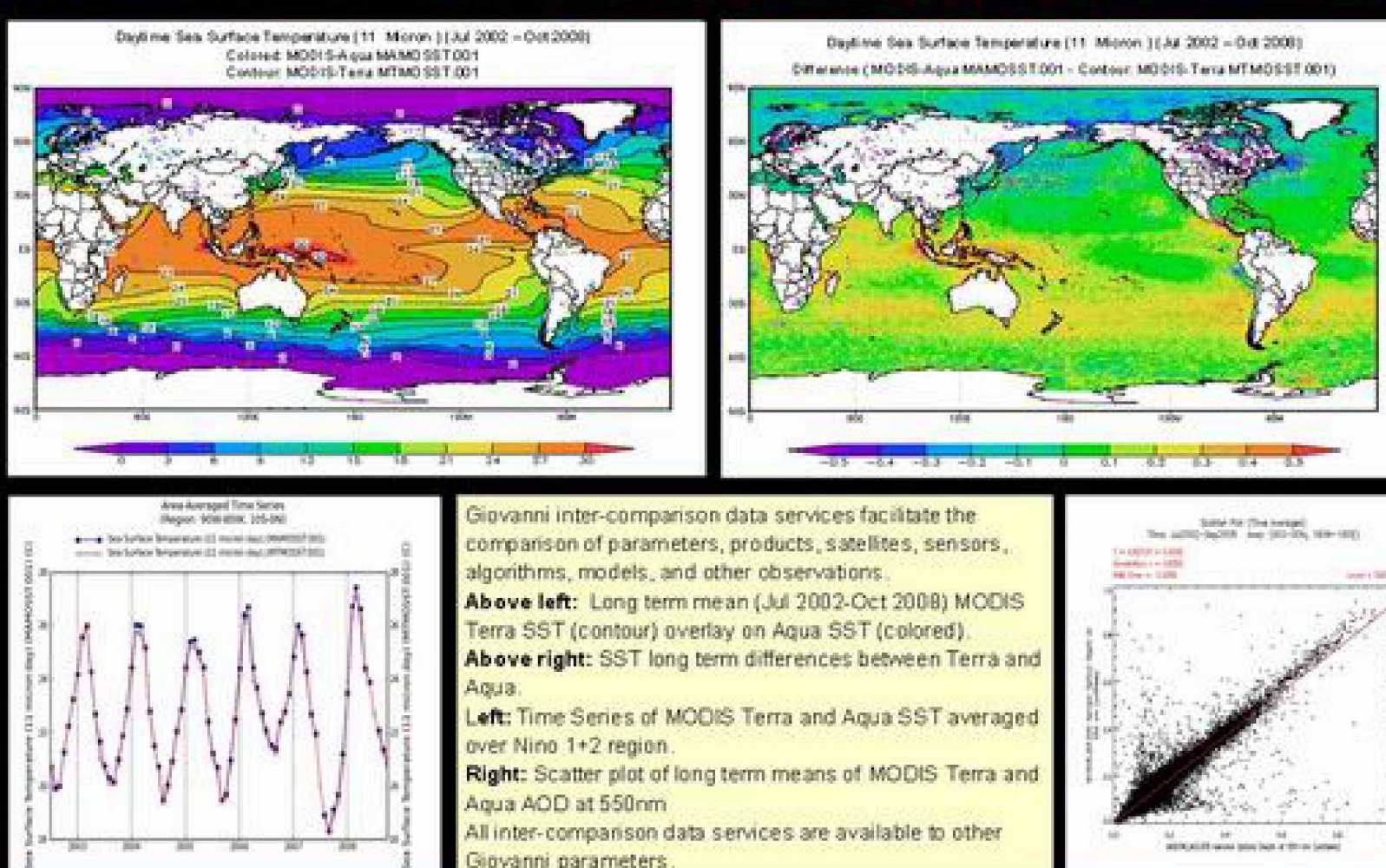- **Data:** HDF4, NetCDF, ASCII

Work Flow status, Data Lineage, Data Download, Documentation, and more.

24 Giovanni Instances with focus on different disciplines

###	Instance	Title: Subtitle
1	aerosol_daily	Daily Aerosol Optical Thickness Measurement and Model Comparison:Beta Version
2	aerosol_monthly	Monthly MODIS-GOCART Aerosol Optical Thickness Intercomparison:Beta Version
3	Air_Quality	Giovanni Air Quality :EPA AIRNOW PM2.5
4	AIRS_Level3Daily	AIRS Online Visualization and Analysis:AIRS Global 1.0° x 1.0° Daily Level-3 Products
5	AIRS_Level3Month	AIRS Online Visualization and Analysis:AIRS Global 1.0° x 1.0° Monthly Level-3 Products
6	cltrain	A-Train Along CloudSat Track Instance:CloudSat
7	hirdls	HIRDLS/Aura Online Visualization and Analysis System:Level 2 Vertical Profiles
8	MERRA_MONTH_2D	MERRA Monthly 2D Data Collections:
9	MERRA_MONTH_3D	MERRA Monthly 3D Data Collections:
10	MISR_Daily_L3	MISR Daily Level-3 Data:Daily Global 0.5 x 0.5 Degree Aerosol Product
11	MISR_Monthly_L3	MISR Monthly Level-3 Data:Monthly Global 0.5 x 0.5 Degree Aerosol Product
12	mls	MLS/Aura Online Visualization and Analysis System:Version 2.2 Vertical Profiles
13	MODIS_DAILY_L3	MODIS Terra and Aqua Daily Level-3 Data:Atmosphere Daily Global 1X1 Degree Products
14	MODIS_MONTHLY_L3	MODIS Terra and Aqua Monthly Level-3 Data:Atmosphere Monthly Global 1X1 Degree Products
15	neespi	NEESPI Experimental Instance:Northern Eurasia Earth Science Partnership Initiative Monthly Products
16	neespi_daily	NEESPI Experimental Instance:Northern Eurasia Earth Science Partnership Initiative Daily Products
17	ocean_model	Ocean Color Radiometry Online Visualization and Analysis:NOBM Assimilated Monthly Global Products
18	ocean_model_day	Ocean Color Radiometry Online Visualization and Analysis:NOBM Assimilated Daily Global Products
19	ocean_month	Ocean Color Radiometry Online Visualization and Analysis:Global Monthly Products
20	omi	OMI/Aura L3 Online Visualization and Analysis:Daily Level 3 Global Gridded Products
21	omil2g	OMI/Aura L2G Online Visualization and Analysis: «BETA» Daily Level 2G Global Binned Products «BETA»
22	toms	TOMS Online Visualization and Analysis:Daily Level 3 Global Gridded Products
23	TRMM_3-Hourly	TRMM Online Visualization and Analysis System (TOVAS):3-hourly TRMM and Other Rainfall Estimate (3B42 V6)
24	TRMM_Monthly	TRMM Online Visualization and Analysis System (TOVAS):TRMM Level-3 Monthly Products.

Data Set	Temporal Coverage	Length (Yrs)
Willmott & Matsuura Precip	Jan 1950 – Dec 1999	50
GPCP[1] – Precipitation	Jan 1979 – Present	30
GPCC[2] – Precipitation	Jan 1986 – Present	22
MERRA (Model)	Jan 1979 – Dec 1999	20
TRMM	Jan 1998 – Present	11
SeaWiFS	Jul 1997 – Present	11
TOMS/Earth Probe	Jul 1996 – Dec 2005	10
MODIS/Terra	Feb 2000 – Present	9
MISR/Terra	Feb 2000 – Present	9
AMSRE	Jan 2003 – Present	8
MODIS/Aqua	Jul 2002 – Present	7
AIRS/Aqua	Aug 2002 – Present	7
EPA PM2.5	Jul 2002 – Present	7
GOCART (Model)	Jan 2000 – Dec 2006	6
TOMS/Nimbus-7	Nov 1978 – May 1993	5
OMI	Aug 2004 – Present	4

Currently, there are 130 NASA Earth Science data products and more than 1000 parameters registered in Giovanni. These products and parameters are included in 24 instances (GUI Interface pages), with focus on different disciplines, such as Atmospheric Dynamics, Atmospheric Composition, Air Quality, Hydrology, Precipitation, Aerosol, Cloud, Oceans, etc. Many data products have long time records. The table to the left lists some Giovanni gridded products with data coverage length longer than four years. Most of these data products continue to present. With these long data records, Giovanni can facilitate climate studies.

[1]GPCP - Global Precipitation Climatology Project
[2]GPCC - Global Precipitation Climatology Center

Global Climate Viewed by Giovanni

8-Year Climatology of MODIS/Terra Aerosol Optical Depth at 500 nm

8-year global climatology of MODIS/Terra Aerosol Optical Depth (AOD) at 550nm (above) generated by Giovanni shows three high AOD regions over Asia, Africa, and South America. The Global Time Series (above right) shows seasonal cycles with most peaks around spring and the highest peak in 2003. The Global Anomaly (right) shows similar characteristics as those of the global AOD time series.

Similarly, Giovanni can generate long term mean, annual mean, seasonal mean, time series, Hovmöller diagram, and anomaly for any other Giovanni parameters. Giovanni provides HDF, NetCDF, and ASCII outputs, which can facilitate further studies on these data by users. For example, the Global Anomaly AOD Time Series (above right) was generated by Excel using the ASCII data downloaded from the Giovanni result page. New options, such as Running Mean, Trend, Zonal Mean, Bar Graph, etc. are planned to become available in upcoming Giovanni releases.
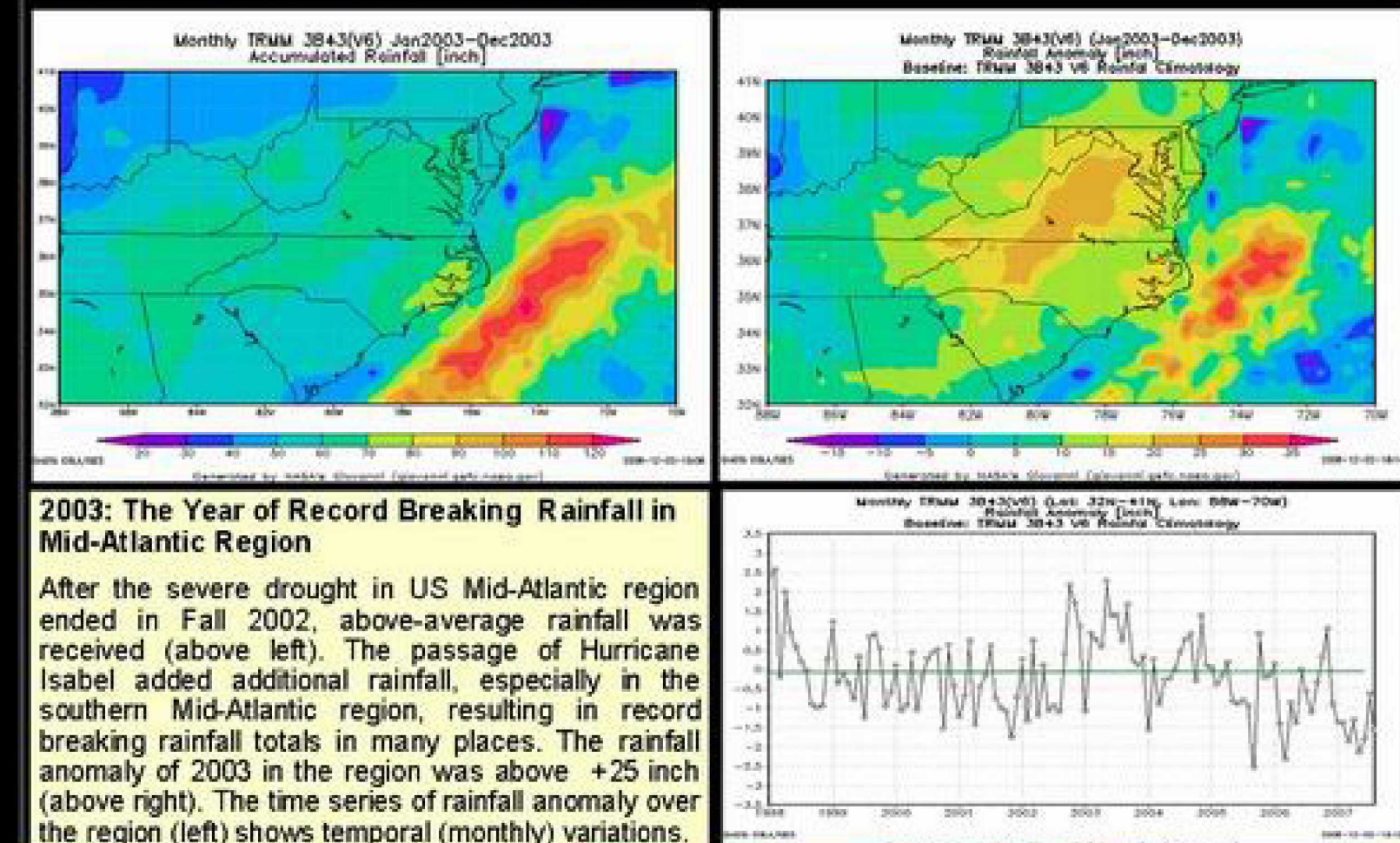
Climatology Inter-comparison by Giovanni

Giovanni inter-comparison data services facilitate the comparison of parameters, products, satellites, sensors, algorithms, models, and other observations.
Above left: Long term mean (Jul 2002-Oct 2008) MODIS Terra SST (contour) overlay on Aqua SST (colored).
Above right: SST long term differences between Terra and Aqua.
Left: Time Series of MODIS Terra and Aqua SST averaged over Nino 1+2 region.
Right: Scatter plot of long term means of MODIS Terra and Aqua AOD at 550nm
All inter-comparison data services are available to other Giovanni parameters.

Long term (Sep 2002 – Nov 2008) mean of AIRS Total Column Ozone, CO, and Water Vapor
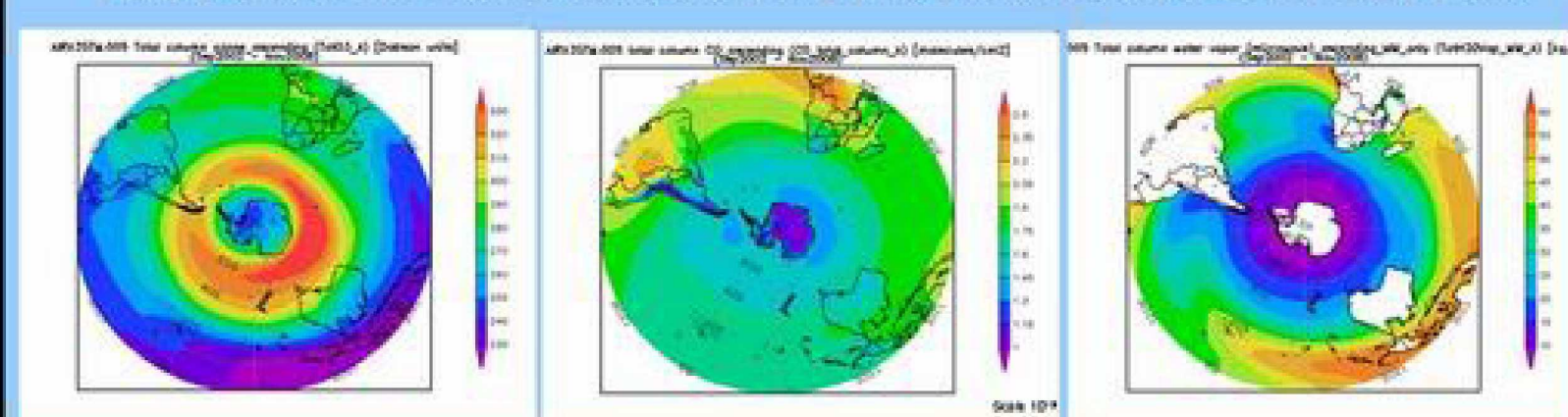
Reginal Climate Studies with Giovanni
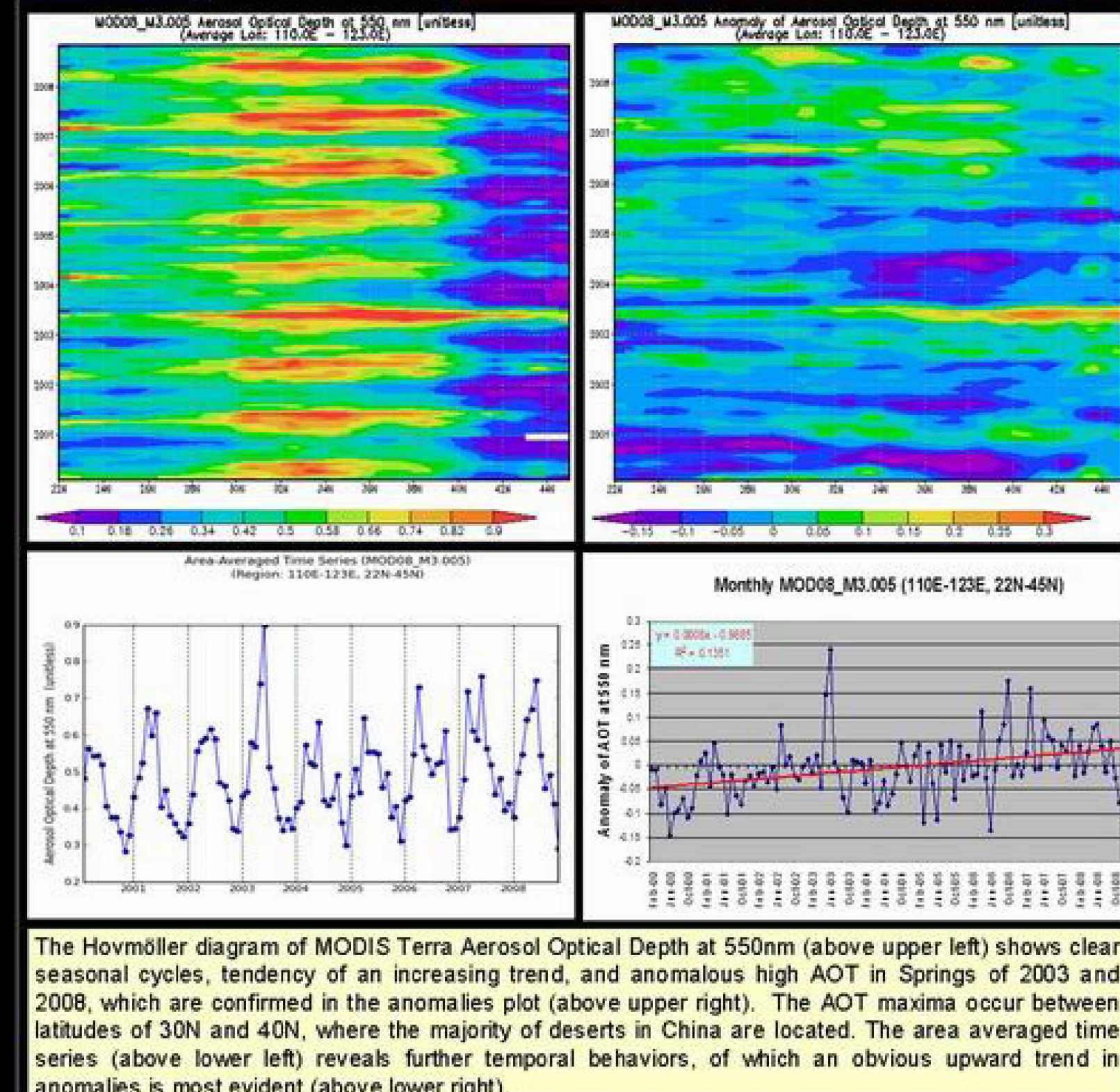
The Hovmöller diagram of MODIS Terra Aerosol Optical Depth at 550nm (above upper left) shows clear seasonal cycles, tendency of an increasing trend, and anomalous high AOT in Springs of 2003 and 2008, which are confirmed in the anomalies plot (above upper right). The AOT maxima occur between latitudes of 30N and 40N, where the majority of deserts in China are located. The area averaged time series (above lower left) reveals further temporal behaviors, of which an obvious upward trend in anomalies is most evident (above lower right).

2003: The Year of Record Breaking Rainfall in Mid-Atlantic Region

After the severe drought in US Mid-Atlantic region ended in Fall 2002, above-average rainfall was received (above left). The passage of Hurricane Isabel added additional rainfall, especially in the southern Mid-Atlantic region, resulting in record breaking rainfall totals in many places. The rainfall anomaly of 2003 in the region was above +25 inch (above right). The time series of rainfall anomaly over the region (left) shows temporal (monthly) variations.

Conclusions

Giovanni is an online data system with a remarkable and proven capability for data exploration, basic research, and exemplary data visualization, available for data from many different NASA Earth observation missions. With these long-term and widely available data sets, including parameters such as temperature, precipitation, and greenhouse gases, Giovanni provides capabilities to facilitate climate change and global warming research. Giovanni has proven to be a highly successful and popular climate services infrastructure that is significantly contributing to the study of global warming and climate change and the consequential environmental issues that affect all of us on this planet.

Giovanni URL: http://Giovanni.gsfc.nasa.gov