Giovanni: A Vital Tool Enabling Rapid and Accurate Climate Data Analysis for Evaluation, Assessment, and Research

http://giovanni.gsfc.nasa.gov/

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ABSTRACT

The Goddard Earth Sciences Data and Information Services Center (GES DISC) has created the GES DISC Interactive Online Visualization and ANalysis Infrastructure, Giovanni, to enable Web-based analysis of several NASA remote-sensing climate data sets. Giovanni was conceived as a research tool to increase the usability of climate data sets, but it can also be used to evaluate climate data for purposes of overview and site assessment, trend detection, anomaly detection, and identification of significant events and potential hazards. The simplicity of Giovanni allows users unfamiliar with the scientific and technical details of Earth remote sensing to utilize climate data for the purposes of short-term and long-term decision making, and the determination of future research needs.

Giovanni features a simple user interface allowing rapid access to data, establishment of spatial and temporal criteria, and a variety of output options. The data analysis engine provides rapid statistical analyses and generation of area average plots, time plots, Hovmöller latitude vs. time and longitude vs. time plots, vertical profiles, data set intercomparisons, and anomaly analysis. Giovanni has been applied to several different climate data sets, including precipitation, atmospheric chemistry, ocean color, and sea surface temperature.

Giovanni currently includes data from:

MODIS
atmospheric products:
aerosol parameters, cloud parameters, water vapor
ocean products:
chlorophyll, sea surface radiance, diffuse attenuation coefficient, and aerosol parameters

TRMM
precipitation rate, cloud latent heat, cloud liquid water

SeaWiFS
chlorophyll, sea surface radiance, diffuse attenuation coefficient, and aerosol parameters

MLS
ozone, temperature, water vapor, NOx, ClO, CO, HCN, OH, relative humidity

AIRS
temperature, water vapor, geopotential height, relative humidity

HALOE
ozone, NOx, HCL, HF, CH4, water vapor, temperature

TOMS
column ozone, UV aerosol index, UV irradiance

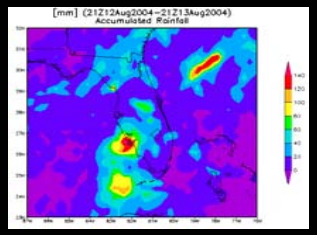
OMI
column ozone, UV aerosol index, surface reflectivity

Giovanni analytical capabilities include:

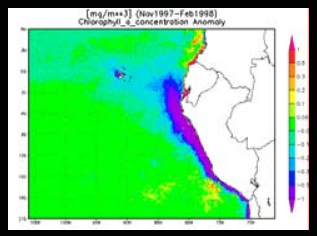
- multi-parameter intercomparison;
- climatological anomaly generation;
- area average plots;
- time-series generation;
- latitude vs. time and longitude vs. time plots
- profile display

Examples of Giovanni climate data analyses

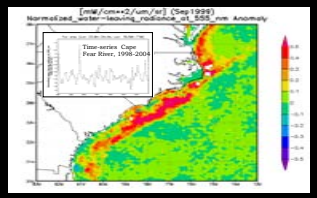
a. TRMM rainfall – Hurricane Charley (August 2004)



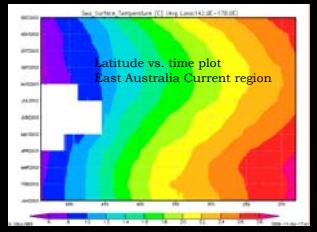
b. SeaWiFS chlorophyll anomaly – 1997-1998 El Niño



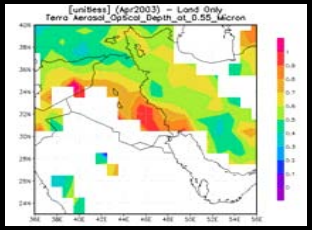
c. SeaWiFS sea surface radiance anomaly Hurricane Floyd (September 1999)



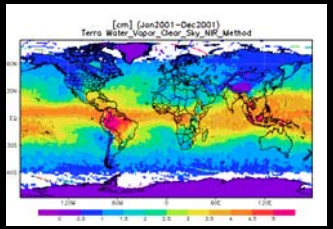
d. MODIS sea surface temperature – Southern Ocean, 2003



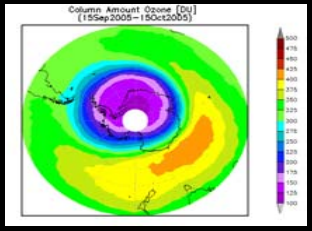
e. MODIS aerosol optical depth – Middle East, April 2003



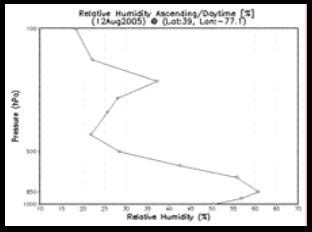
f. MODIS water vapor, clear sky, 2001



g. Earth Probe TOMS – column ozone, September 15 – October 15, 2005



h. AIRS relative humidity – over Washington DC, August 12, 2005



Use of Giovanni for climate science in support of decision making

Overview and site assessment: A multitude of NASA climate data sets can be easily accessed and visualized with Giovanni's suite of analytical capabilities. These capabilities allow rapid evaluation and compilation of applicable climate data for the globe, large regions, or local research sites. Using Giovanni, researchers can create a data catalog covering climate data available for a given site, augmented with high-quality graphics that illustrate the data types and the informational content that can be derived from each. Example (a) demonstrates the use of Tropical Rainfall Measuring Mission (TRMM) precipitation data, highlighting the accumulated rainfall from Hurricane Charley in 2004 over Florida. Example (d) shows a Hovmöller plot of the annual variability of sea surface temperature in the East Australian Current region. This valuable capability considerably simplifies the data search and acquisition process. In this capacity, Giovanni facilitates the determination of how available remotely-sensed climate data can best be utilized to address specific research questions relevant to topics and areas of interest.

Trend detection: Giovanni's analytical capabilities allow the rapid creation of time-series analyses. These time-series can be utilized to evaluate the potential presence of absence of trends in climate data sets relevant to climate change or to regional or local environmental alteration. The inset figure in example (c) shows a time-series of SeaWiFS normalized water-leaving radiance at 555nm (nLw555) for the Cape Fear River outlet on the coast of North Carolina. nLw555 is related to the concentration of particulate matter in surface waters. This time-series shows the Hurricane Floyd event (see below), and a possible increasing trend near the end of the record.

Anomaly detection: If a climate data set is of sufficient duration, Giovanni can be used to provide climatological anomaly analysis. Examples (b) and (c) demonstrate this capability. Example (b) shows the suppression of upwelling-induced productivity in the Peru Current during the 1997-1998 El Niño event. Example (c) shows the nLw555 anomaly caused by turbidity due to the passage of Hurricane Floyd in 1999.

Significant events: Giovanni is a highly useful system for the evaluation of data covering significant climate events, for the investigation of event genesis and for future predictive capability. Example (e) shows the aerosol optical depth (AOD) over Iraq in April 2003, where the highest AOD values were associated with the powerful sandstorm that interfered with military operations during Operation Desert Storm. Examples (a), (b), and (c) also depict significant events.

Potential hazards: Example (g) demonstrates the use of Giovanni to evaluate potential hazards, in this case the potential of elevated exposure to ultraviolet radiation due to the presence of the annual Antarctic depleted ozone concentration "hole". Reduced values of ozone are seen over the southern end of South America. Previous examples also show the potential use of Giovanni for flood (a), sand and dust storm (e), and hazardous algal bloom detection (c).

Short-term and long-term decision-making: The examples shown here are only a small subset of the full range of Giovanni capabilities. Example (f) shows Giovanni's ability to create and display a global average visualization for climate data, in this case atmospheric water vapor from MODIS for the year 2001. Example (h) shows a more specific case, a local relative humidity profile from AIRS for a humid summer day in Washington, DC. As new data sets (and additional data for existing data sets) are added to Giovanni, the capability of Giovanni to inform climate science continues to increase.

Giovanni can function as an online data laboratory, enabling the initiation and continuation of climate research inquiries. Furthermore, although Giovanni is frequently utilized by scientists with in-depth knowledge of complex climate processes, the simplicity of Giovanni operations also allows non-science users to create informative, research-quality data analyses for reports and presentations, and to contribute to assessments for policy-making, planning, and monitoring. Giovanni's progression is continuing to increase its value as a vital tool for rapid and accurate climate data analysis.

Future directions and capabilities for Giovanni

In addition to the existing analytical capabilities described above, future development of Giovanni will make it increasingly useful as a front-end application for access to full-content, high-resolution climate data. Giovanni is being modified so that users can utilize the spatial region, temporal period, and data parameter specification engine to subset online data sets at the GES DISC. Users will therefore be able to combine data analysis and visualization with data acquisition, accelerating and simplifying data access, and reducing the need for "secondary" data processing to create interest-specific data sets. Giovanni developers are also examining the creation of different data output formats, the addition of data with higher spatial and temporal resolution, and alternative data plotting options. All of these capabilities will increase the applicability of Giovanni to climate science questions as climate events and climate trends increasingly impact the activities of humanity.