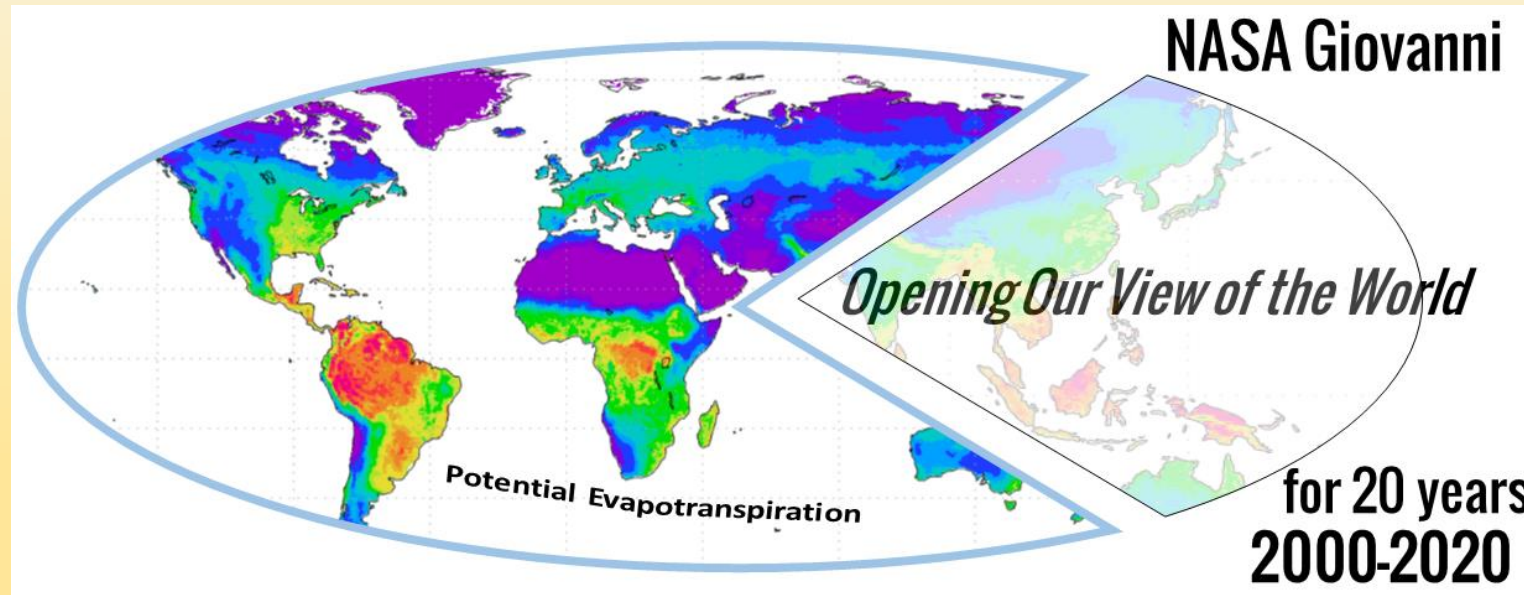




# Giovanni at 20: *Consistency and Persistency* in Making Earth Remote Sensing Data Available (and **Useful**) to the Earth Science Community

**Session IN002**  
Developing Innovative  
Tools and Services  
to Enable Data Use  
Across Broad User  
Communities I

AGU Fall Meeting  
2020



James G. Acker (NASA GES DISC; ADNET Systems), Zhong Liu (NASA GES DISC; CSISS, George Mason University), Jennifer C. Wei (NASA GSFC), Dave L. Meyer (NASA GSFC), Angela Li (NASA GSFC), Mahabal Hegde (NASA GES DISC; ADNET Systems), Chung-Lin Shie (NASA GSFC), and the Giovanni Development Team

Since its creation in the year 2000, the NASA Geospatial Interactive Online Visualization ANd aNalysis Infrastructure (Giovanni) has been an exemplar of how to provide remotely-sensed satellite data and related Earth science datasets to a broad and globally diverse researcher community.

The “original” Giovanni was conceived by Dr. Gregory Leptoukh and built by Zhong Liu and colleagues, for the Tropical Rainfall Measuring Mission (TRMM). It was named the “TRMM Online Visualization and Analysis System” (TOVAS). A subsequent version for Moderate Resolution Imaging Spectroradiometer (MODIS) data was named MOVAS. With the addition of more data, the system became NASA Giovanni – the Geospatial Interactive Online Visualization ANd ANalysis Infrastructure.



Don't miss the Leptoukh Lecture on December 10, given by Erin Robinson, ESIP.

Giovanni was “born” in a period when the remarkable potential of the World Wide Web to enhance and facilitate data access, data distribution, and data analysis was just being recognized.

The traditional 1990’s model of a NASA Distributed Active Archive Center (DAAC) was a system that received data requests from users, put these requests on media or very early electronic transfer protocols, and sent the data to the user. The user was left to their own devices and software to read, store, process, and analyze the data.

Giovanni was conceived as a system with these aspects:

- A Web-based tool allowing data access, without requiring additional software for data processing.
- A simple and intuitive graphical user interface (GUI).
- The ability to generate graphic images and plots, and also provide data download capability.
- Deliver both graphic visualization and corresponding output data quickly.
- Users should still be able to access the original data easily.
- Use ‘community-accepted’ software packages for the analysis of the data.

One of the early adopters of Giovanni, a researcher from Chile, said that Giovanni “democratized” the use of NASA Earth science data by markedly expanding the user community.

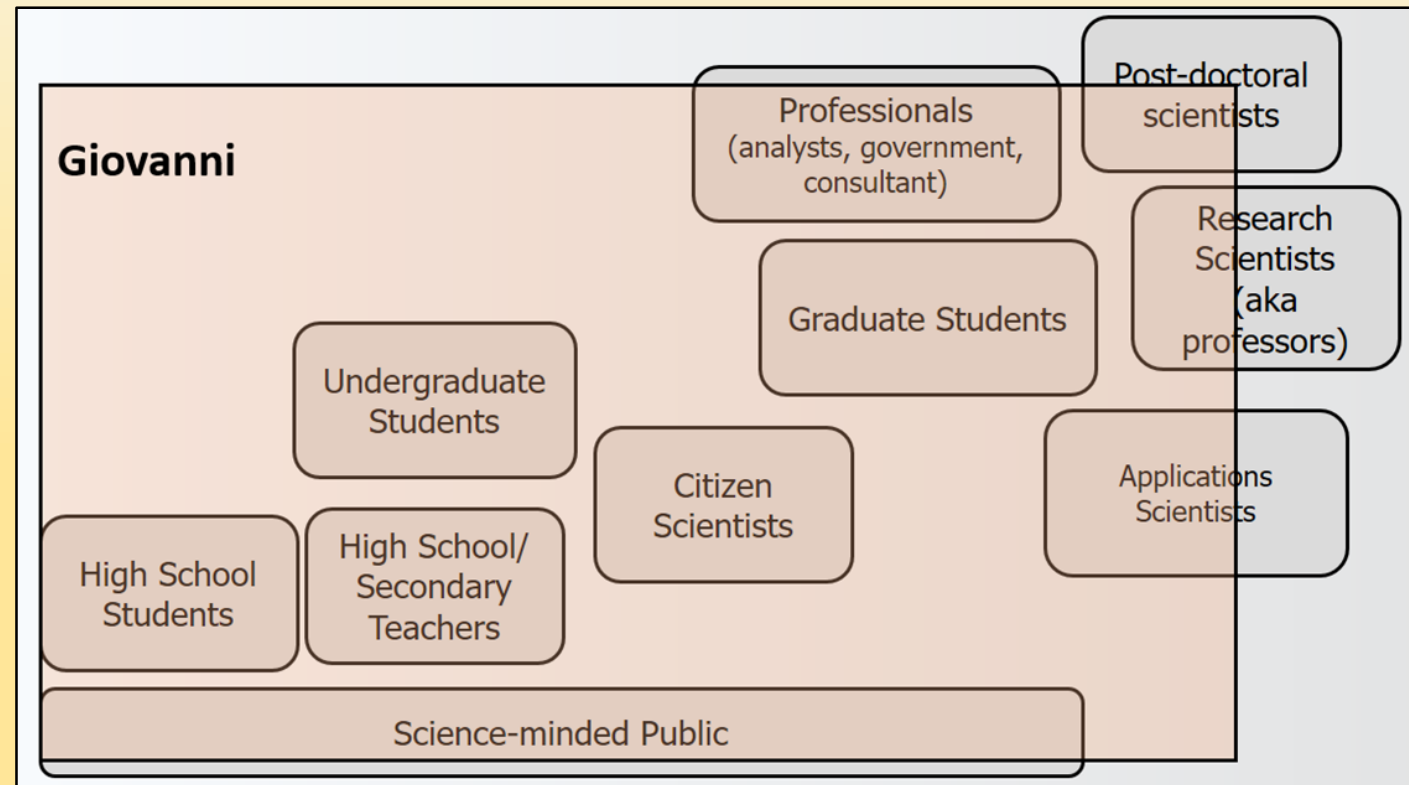
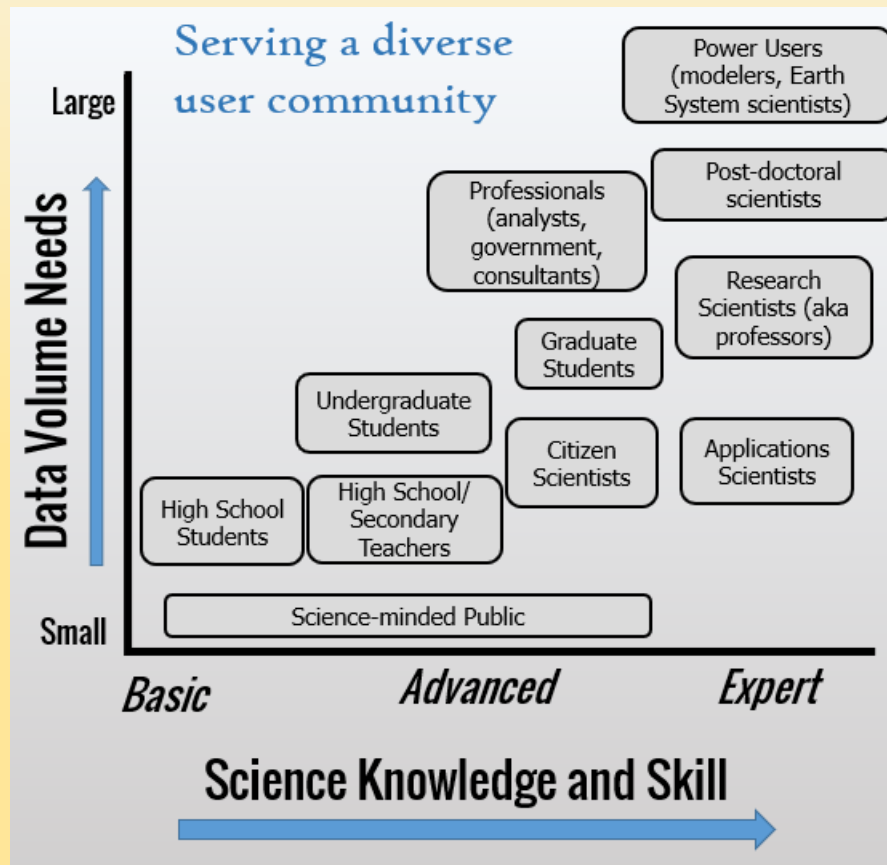
Via Giovanni, NASA data could be used by researchers other than scientists familiar with remote sensing, which had been the province of academic or private researchers with sufficient computational resources and staff to process and analyze the data.

Now, users could access and analyze the data available in Giovanni with minimal prior investments required for either the necessary infrastructure or the technological know-how for data usage. Users could quickly get started doing what they wanted to do most – research!

Over the 20 years of Giovanni's existence, the system has progressed to keep pace with the remarkable expansion of data available from NASA missions and models; much larger datasets in both volume and data variable diversity; and much faster computational speed and analytical variety.

In the following, Giovanni's history, current capabilities, and future prospects will be described.

One of the hallmarks of Giovanni system usage is that it is common to see practitioners of many branches of science – particularly those in fields *not* traditionally associated with remote-sensing data, such as animal behavior and public health – both accessing and employing datasets which the system provides. This usage pattern is attested to by the diversity of published science citing Giovanni.



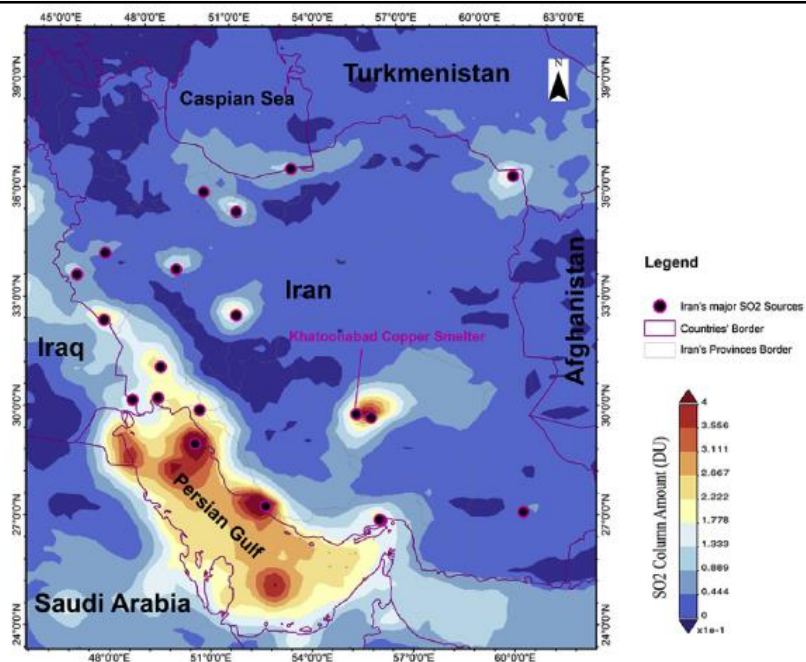


Fig. 1. Location of Iran's major SO<sub>2</sub> emission Sources coupled with the time-averaged map of SO<sub>2</sub> column amount in Planetary boundary layer (PBL) over 2005–2016 acquired from Ozone Monitoring Instrument (OMI).

Salmabadi, H. and Saedi, M. (2019) Monitoring of SO<sub>2</sub> column concentration over Iran using satellite-based observations during 2005-2016. *Pollution*, **5(2)**, 257-268, doi:10.22059/poll.2018.260252.463.



Serrano, M.A., Cañada, J. and Moreno, J.C. (2013) Erythemal ultraviolet solar radiation doses received by young skiers. *Photochemical and Photobiological Sciences*, doi:10.1039/C3PP50154J.

## Southern giant petrel

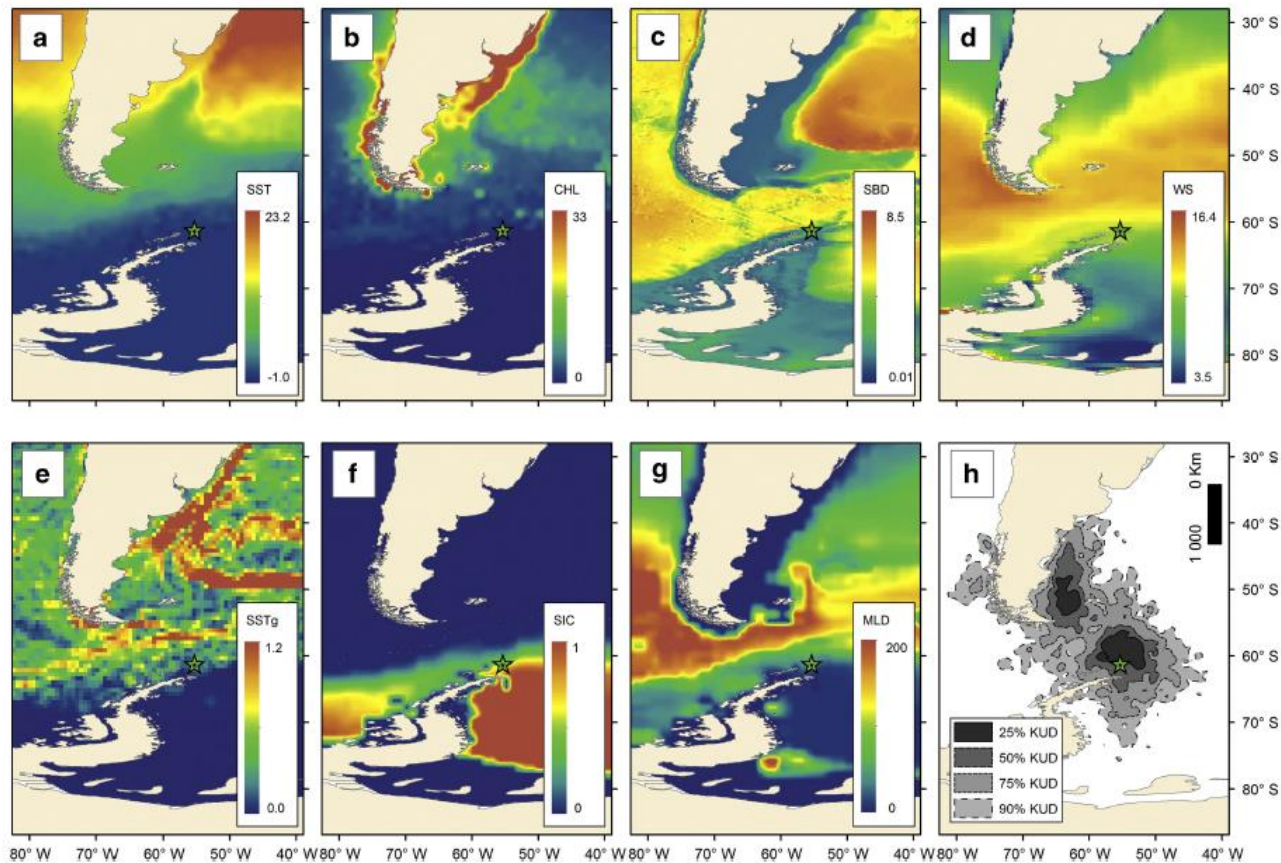
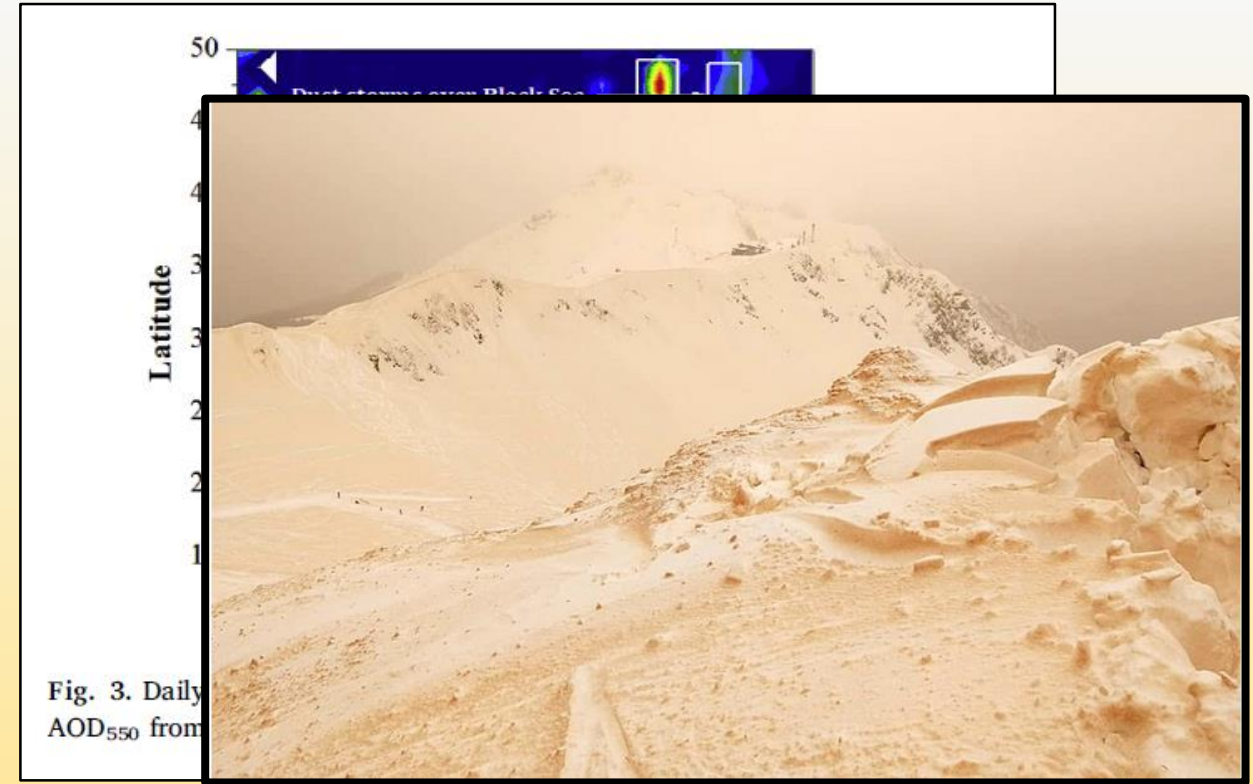


Fig. 1. Environmental variables used in this study. a. Sea surface temperature, SST ( $^{\circ}\text{C}$ ). b. Chlorophyll *a* concentration, CHL ( $\text{mg m}^{-3}$ ). c. Sea bed depth, SBD (km). d. Surface wind speed, WS ( $\text{m s}^{-1}$ ). e. Sea surface temperature gradient, SSTg ( $^{\circ}\text{C}$ ). f. Sea ice cover, SIC (proportion). g. Mixed layer depth, MLD (m). Non-breeding distribution (h) of all the tracked southern giant petrels breeding at Stinker Point, Elephant Island (star) measured as kernel usage density (KUD); for sex-level KUD see Krüger *et al.* (2017).

Krüger, L., Paiva, V.H., Finger, J.V.G., Petersen, E., Xavier, J., Petry, M.V., and Ramos, J.A. (2018) Intra-population variability of the non-breeding distribution of southern giant petrels *Macronectes giganteus* is mediated by individual body size. *Antarctic Science*, **30(5)**, 271-277, doi:10.1017/S0954102018000238.



Patterson, S., Drewe, J.A., Pfeiffer, D.U., and Clutton-Brock, T.H. (2017) Social and environmental factors affect tuberculosis related mortality in wild meerkats. *Journal of Animal Ecology*, **86**, 442–450, doi: 10.1111/1365-2656.12649.



Kaskaoutis, D.G., Dumka, U.C., Rashki, A., Psiloglou, B.E., Gavriil, A., Mofidi, A., Petrinoli, K., Karagiannis, D., and Kambezidis, H.D. (2019) Analysis of intense dust storms over the eastern Mediterranean in March 2018: Impact on radiative forcing and Athens air quality. *Atmospheric Environment*, **209**, 23-39, doi:10.1016/j.atmosenv.2019.04.025.

This year will mark the *8<sup>th</sup> consecutive year* that the number of peer-reviewed journal publications citing Giovanni will exceed 200.

Though the publications appearing in November and December have not been counted yet, it is possible that this year will exceed the previous maximum of 234 journal publications.

The global usage of the system indicates that Giovanni continues to enable simple access to, and analysis of, NASA Earth science data.

Giovanni has evolved through several versions, each of which increased analytical and visualization options while also enhancing ease-of-use.

## TRMM Online Visualization and Analysis System

# TOVAS

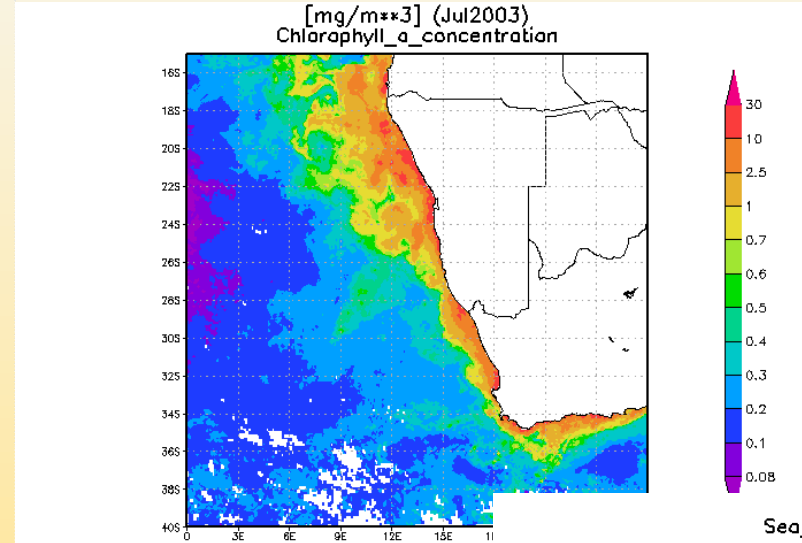
### Rainfall Data for a Few Mouse Clicks

**The Power of Simplicity**

TOVAS makes TRMM and other gridded precipitation data available in a format that anyone can learn to use within minutes, and puts them to work productively for research or applications. In just a few mouse clicks, one can easily obtain precipitation information from around the world. Try it! <http://lake.nascom.nasa.gov/tovas/>

The screenshot shows the TOVAS web interface with the following elements:

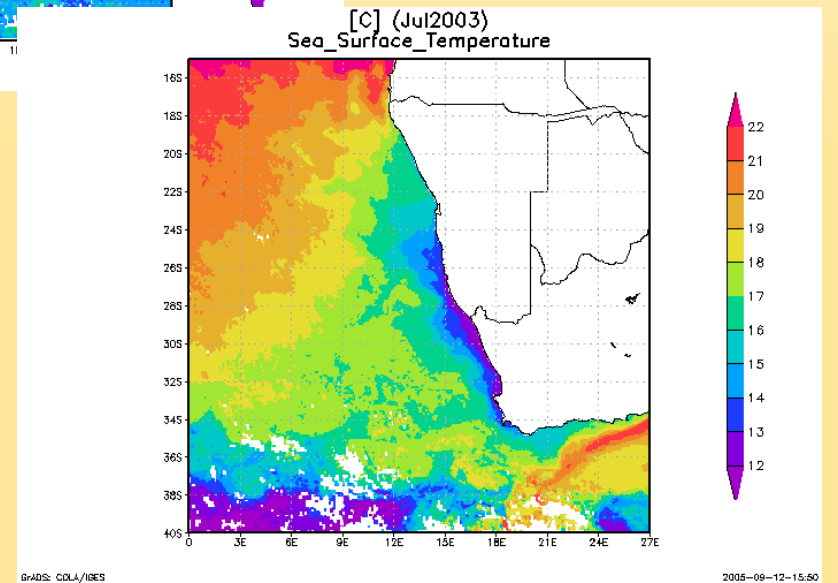
- Search Parameters:** West Longitude: 530.0, East Longitude: 580.0, North Latitude: 40.0, South Latitude: 40.0.
- Parameter:** Accumulated Rainfall.
- Color Level Option:** Pre-defined, Dynamic, or Customized (Min/Max).
- Plot type:** Area Plot.
- Begin date:** 2003-12-01, End date: 2003-12-31.
- Data Description:** TRMM Level-3 Daily 1° x 1° Rainfall Data Product 3B42.
- Visualizations:** Rainfall Map, Hovmöller Diagram, Time Series, and Animation (Hurricane Isabel).



Benguela  
Upwelling  
Zone

Chlorophyll  
concentration  
from SeaWiFS

Sea surface  
temperature  
from  
MODIS-Aqua



# Giovanni – 3

Select Area of Interest

Select Display (info, unit)

Select Parameters

Select Time Period

Select Plot type

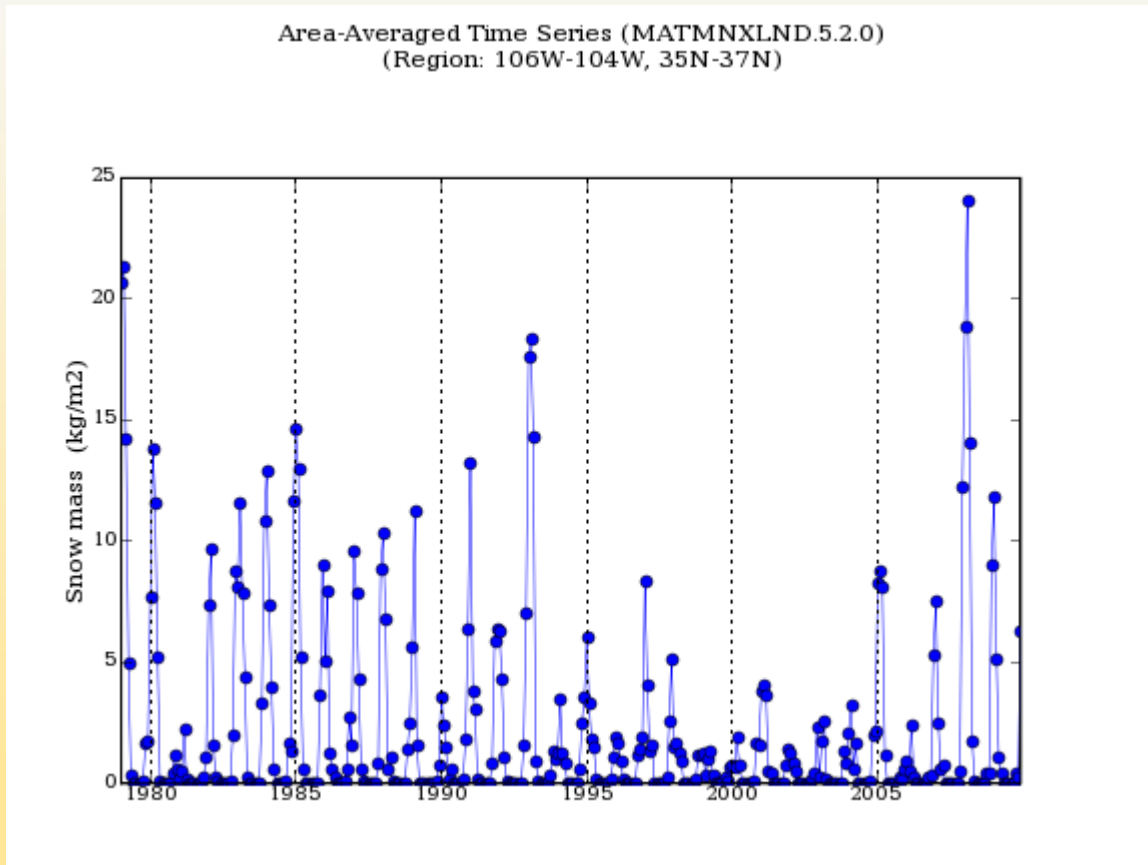
Generate Visualization

The screenshot shows the Giovanni Air Quality web interface. At the top, it displays the NASA logo and the title "Giovanni Air Quality". Below this, there is a section for "EPA AIRNOW PM2.5, MODIS and OMI Measurements for Air Quality Applications". The main content area is divided into several sections: "Spatial", "Parameters", "Temporal", and "Select Visualization".

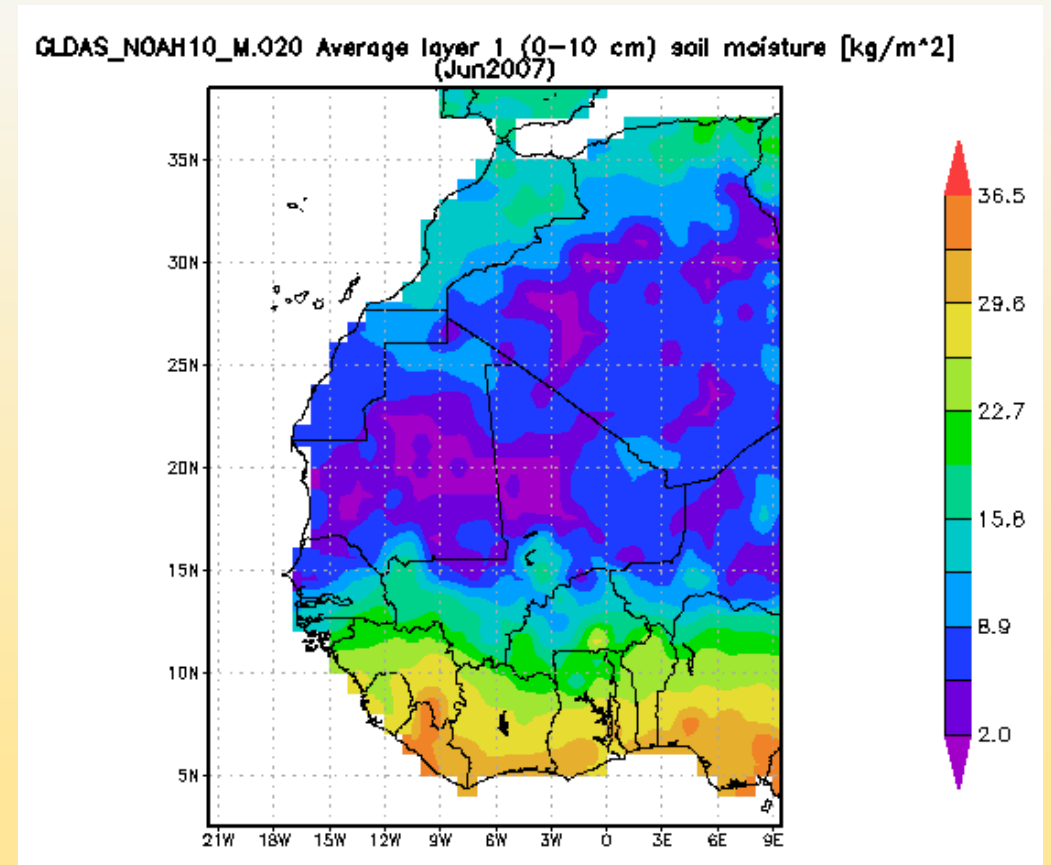
- Spatial:** A map of the United States with a red rectangular box highlighting a region in the western part of the country. Below the map are input fields for "West", "North", "South", and "East" coordinates, along with a "Update" button.
- Parameters:** A list of parameters with checkboxes. The "Parameters" section is highlighted with an orange box. The "Display" section is highlighted with a blue circle. The "Parameters" list includes "Fine Particulate Matter - PM2.5", "Aerosol Optical Depth at 550 nm", "Aerosol Small Mode Optical Depth", "Cloud Optical Depth - Total (QA-w)", "Cloud Top Pressure (Day only)", and "Cloud Top Temperature (Day only)".
- Temporal:** Input fields for "Begin Date" and "End Date", each with dropdown menus for Year, Month, and Day, and a "Date" label.
- Select Visualization:** A dropdown menu showing "Lat-Lon map, Time-averaged".

Annotations include red arrows pointing to the "Spatial" map and "Parameters" list, a blue arrow pointing to the "Display" section, a green arrow pointing to the "Temporal" section, and a blue arrow pointing to the "Select Visualization" dropdown. A blue circle highlights the "Display" section, and an orange box highlights the "Parameters" list.

- Animation
- Overlay of Lat-Lon Maps
- Latitude-Time Hovmoller Diagram
- Longitude-Time Hovmoller Diagram
- Lat-Lon map, Time-averaged
- Correlation map
- Lat-Lon map of time-averaged differences
- Scatter plot
- Scatter plot, Time-averaged
- Time series
- Time series, Area-averaged differences
- Time series, Area statistics
- Correlation map



Time-series plot of monthly snow mass in central New Mexico, 1979-2009, with Modern-Era Retrospective analysis for Research and Applications (MERRA) data.



Map of monthly surface soil moisture from the Global Land Data Assimilation System (GLDAS), June 2007.

# Giovanni Version 4.34 User Interface

The screenshot shows the Giovanni Version 4.34 User Interface. The header includes the logo "GIOVANNI" and the tagline "The Bridge Between Data and Science v 4.34". Navigation links for "Feedback", "Help", and "Login" are in the top right.

Key sections are highlighted with colored boxes:

- Plot / Map Selection:** A dropdown menu showing "Time Averaged Map".
- Time Range Selection:** A date range selector for "Select Date Range (UTC)" with fields for "YYYY - MM - dd" and "HH : MM", and a "Valid Range: 1948-01-01 to 2020-05-22" note.
- Region-of-Interest Selection:** A text input field for "Select Region (Bounding Box or Shape)" containing "-180, -90, 180, 90".
- Variable Selection (Faceted or Keyword Search):** A large section for "Select Variables" with a list of categories (Observations, Disciplines, Measurements, Platform / Instrument) and a search bar.

At the bottom, there is a footer with the NASA logo, contact information for Angela Li and M. Hegde, and a navigation bar with "Reset" and "Plot Data" buttons.

**GIOVANNI**

The Bridge Between Data and Science v 4.34

[Feedback](#) [Help](#) [Login](#)

**Select Plot**

Time Averaged Map

**Select Date Range (UTC)**

YYYY - MM - dd HH : MM to YYYY - MM - dd HH : MM

Valid Range: 1948-01-01 to 2020-05-22

**Select Region (Bounding Box or Shape)**

-180, -90, 180, 90



**Select Variables**

**Observations**

- Model (1219)
- Observation (762)

**Disciplines**

- Aerosols (218)
- Atmospheric Chemistry (117)
- Atmospheric Dynamics (549)
- Cryosphere (16)
- Hydrology (867)
- Ocean Biology (167)
- Oceanography (193)
- Water and Energy Cycle (957)

**Measurements**

**Platform / Instrument**

Number of matching Variables: 0 of 1981

Total Variable(s) included in Plot: 0

Keyword :

Search

Clear

Plot / Map Selection

Time Range Selection

Region-of-Interest Selection

Variable Selection (Faceted or Keyword Search)



Responsible NASA Official: [Angela Li](#)  
Web Curator: [M. Hegde](#)

[Privacy](#)

Powered By

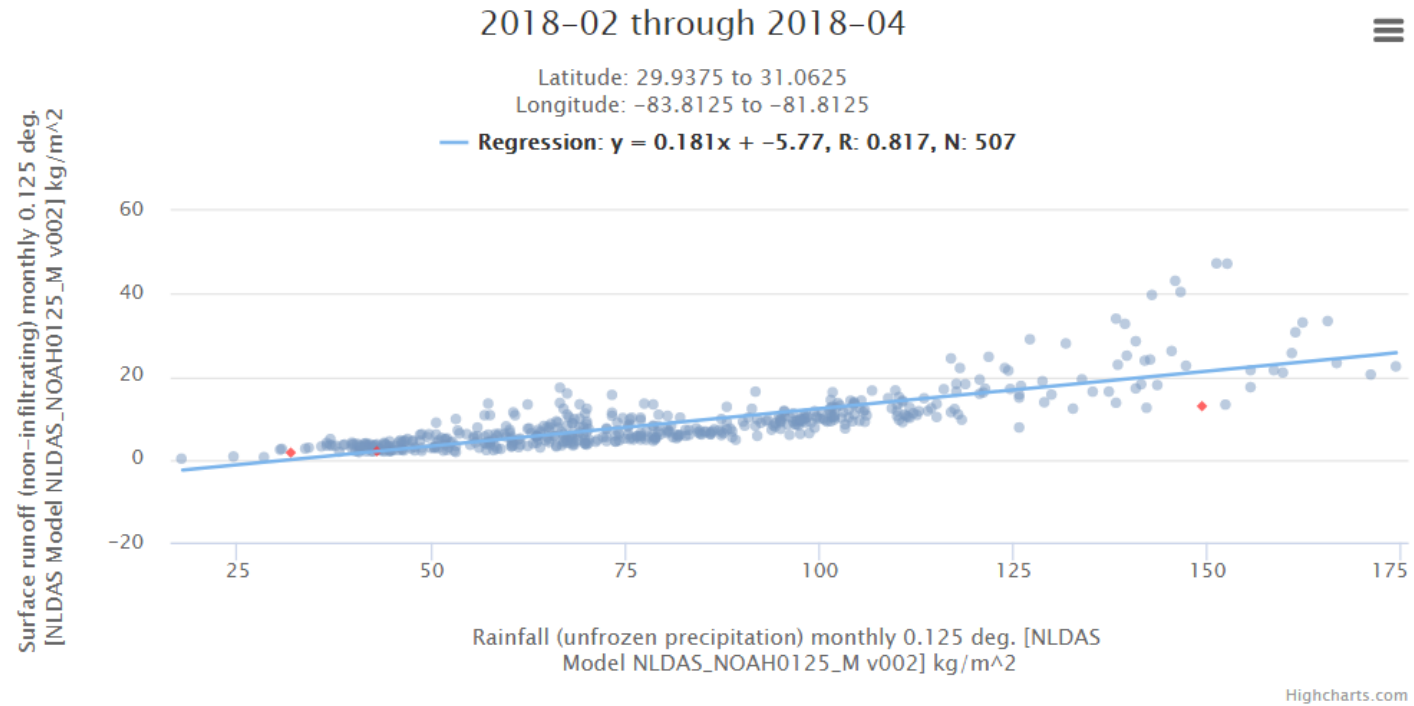
[Contact Us](#)

Reset

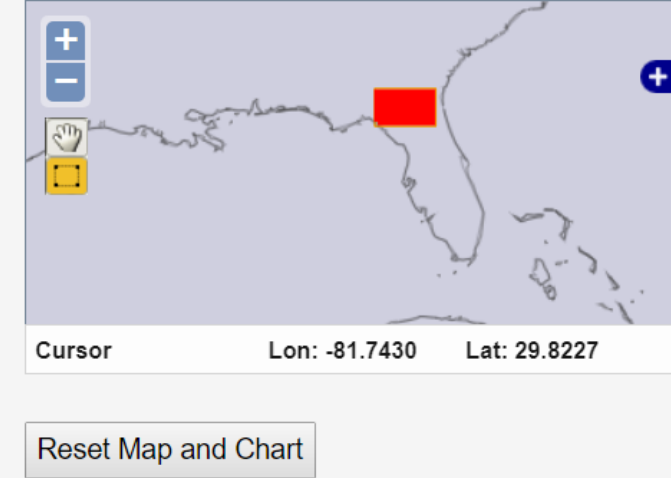
Plot Data

# Interactive Scatter Plot

Drag bounding box on plot to subset data



Drag bounding box on map to subset data



Information resources supporting Giovanni from the Goddard Earth Sciences Data and Information Services Center (GES DISC), which hosts the system, start with basic mapping and plotting functions and extend to “How-to” recipes demonstrating interusability with other data analysis systems and software.

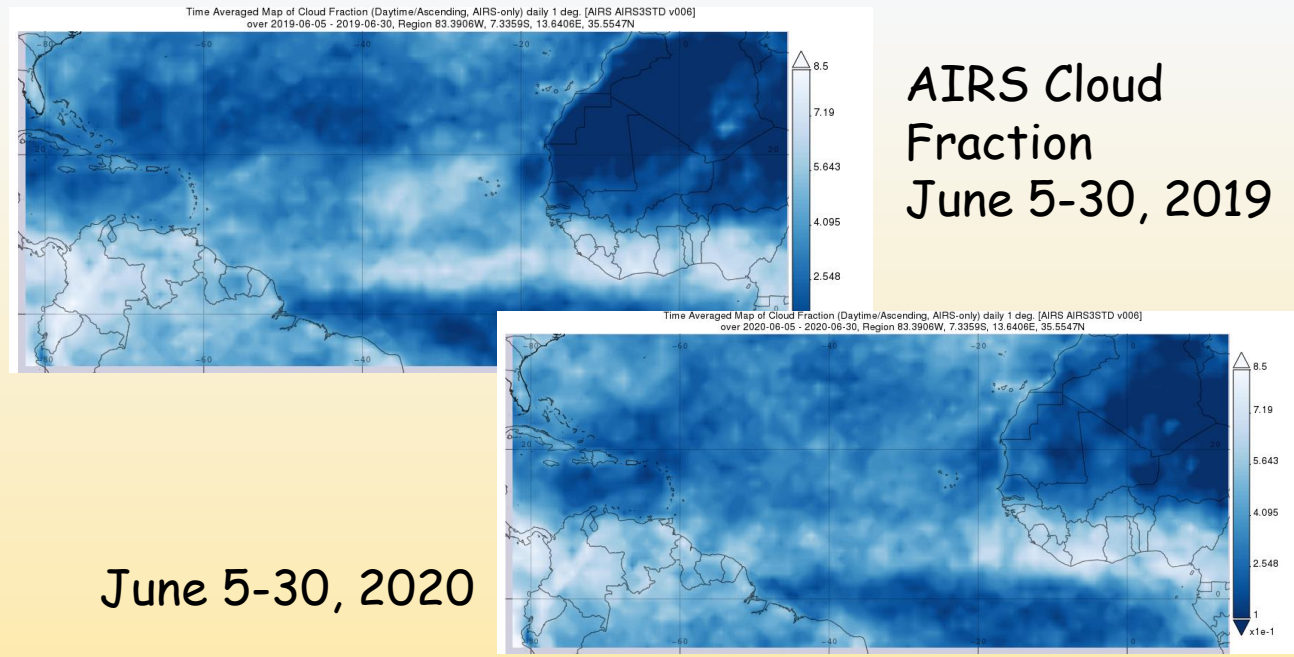
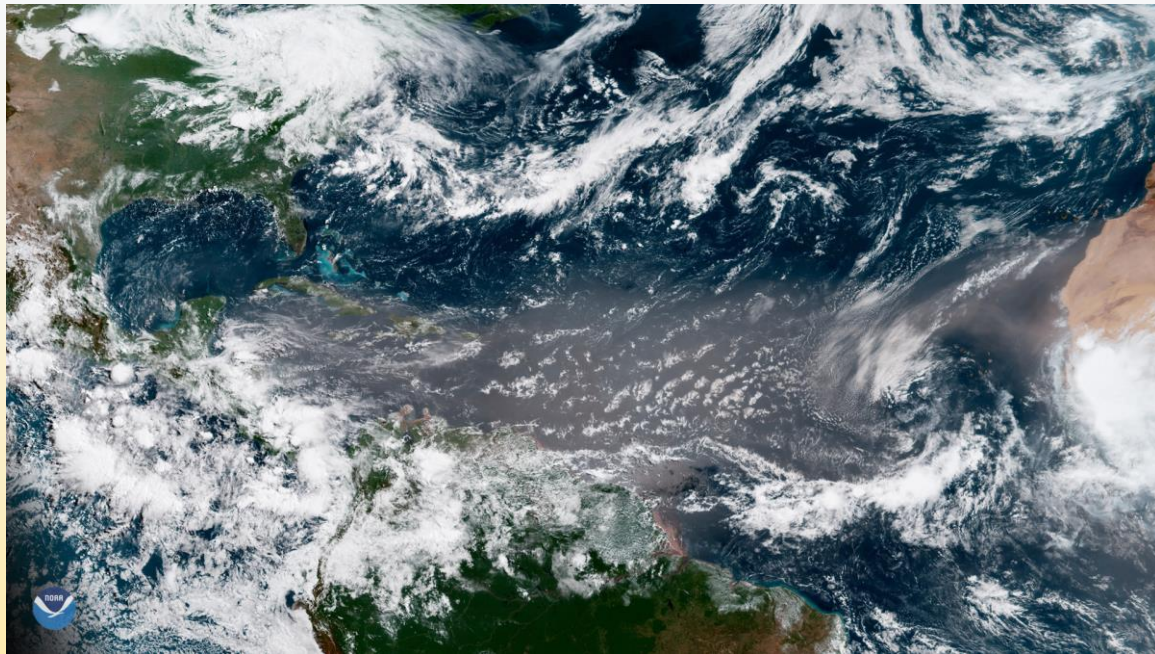
[View How-To's](#)



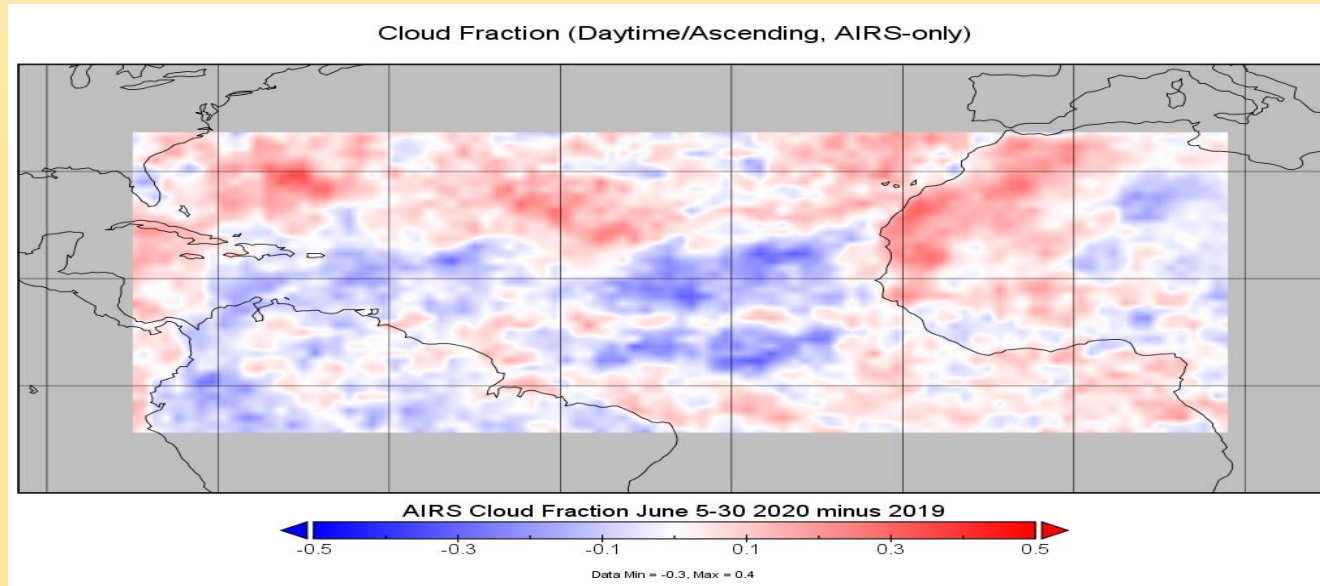
## How to Create Difference Maps with Giovanni and Panoply: Creating Quantified ASCII Text Difference Map Output with Giovanni, Panoply, and Excel

### Overview:

This data recipe demonstrates two procedures. The first procedure is creating a difference map image with NetCDF output (two data files) from Giovanni and the NASA Panoply data visualization package. The second procedure employs the two data files used for the difference map and Excel, along with an Excel macro, to provide quantified difference map data in the form of lat-lon-data value ASCII text triads.

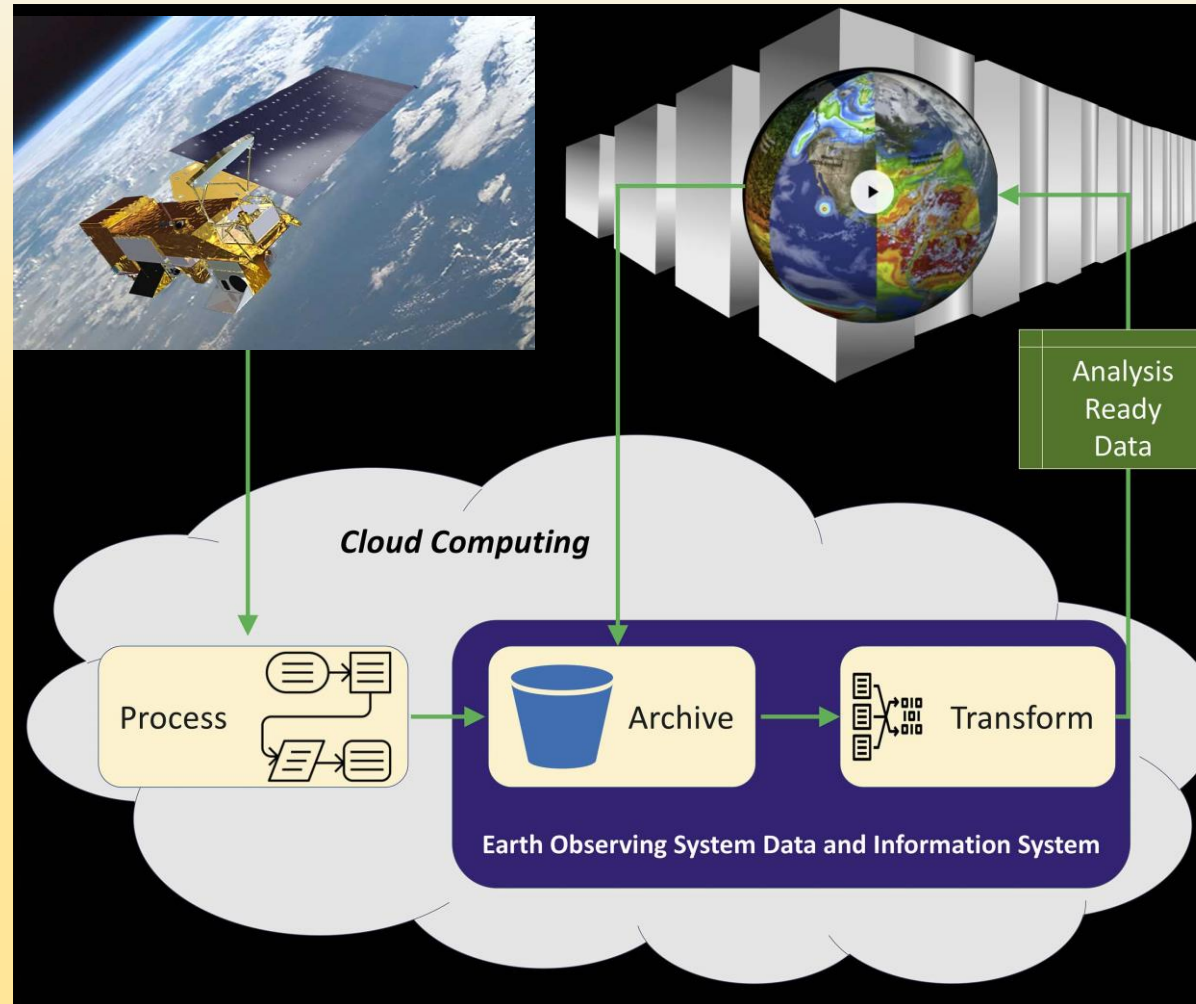


## Sahara Dust Outbreak June 2020



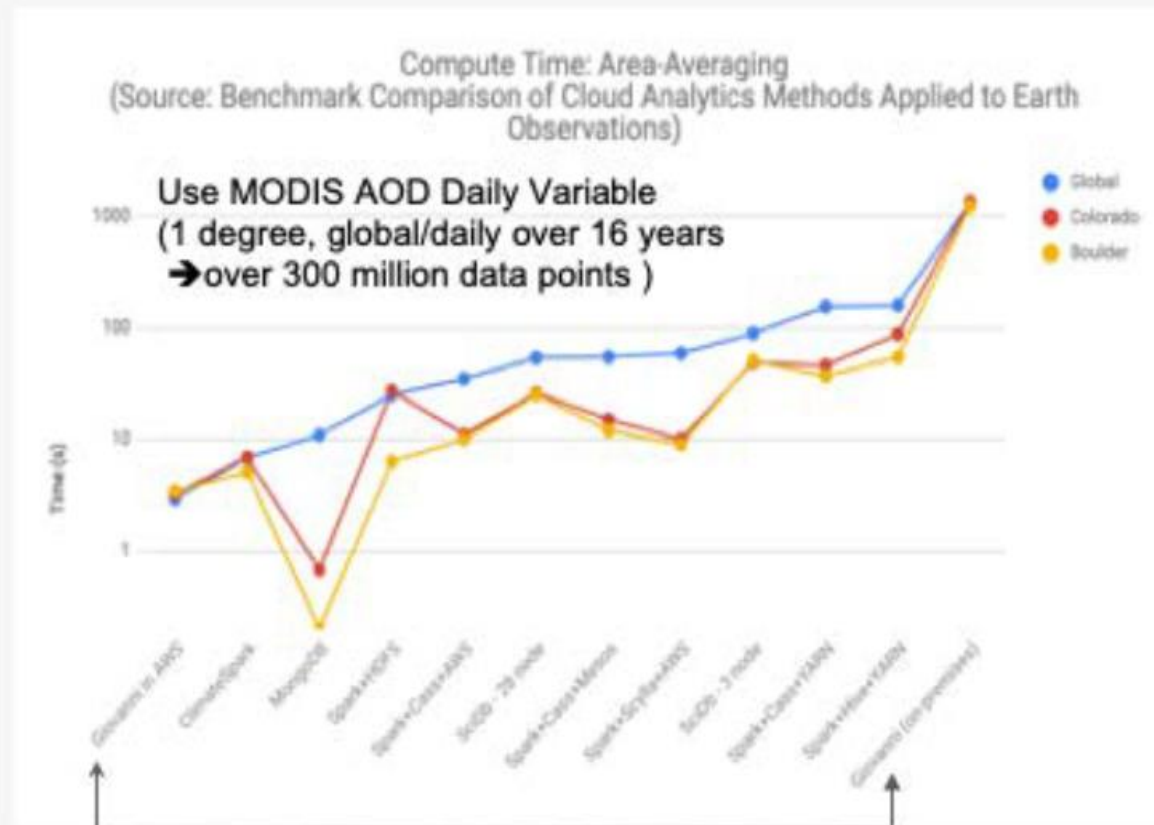
The difference map shows the reduction in cloud cover in 2020 compared to 2019, likely due to the low humidity in the Saharan Air Layer associated with the dust outbreak.

Giovanni is now being developed for use in a cloud computing environment, potentially expanding datasets the system can be applied to, and also improving performance for data having high spatial and temporal resolution.





# Giovanni in the Cloud Performance Benchmark



Improvement of cloud version over current Giovanni

## Highlights

- ❑ Achieved close to fixed-cost (per request) both in clock time and dollar amount
- ❑ **Extreme reduction** in compute cost: < \$5 per month for a service which is a cause of frequent server overloading.
- ❑ **Portable** Cloud-based data store
- ❑ Certain computationally intensive services saw a **500x** increase in performance (from 1.5 hours to 11 seconds)

# Multi-dataset examination of derecho events associated with mesoscale convective phenomena in the summer of 2020



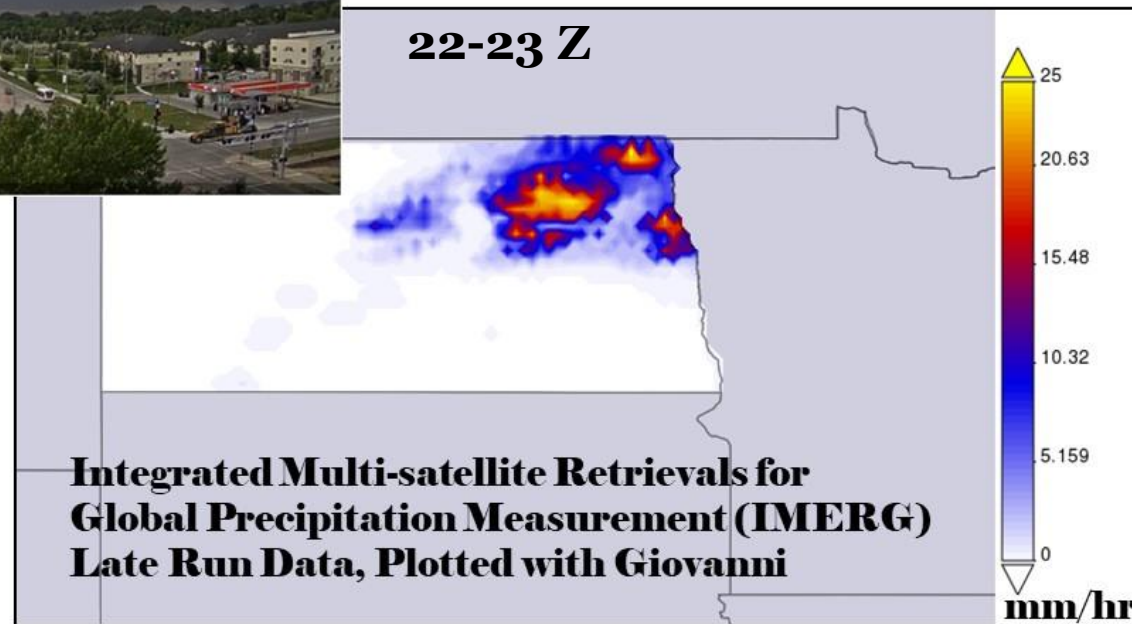
**Grand Forks,  
North Dakota**

**July 17, 2020**

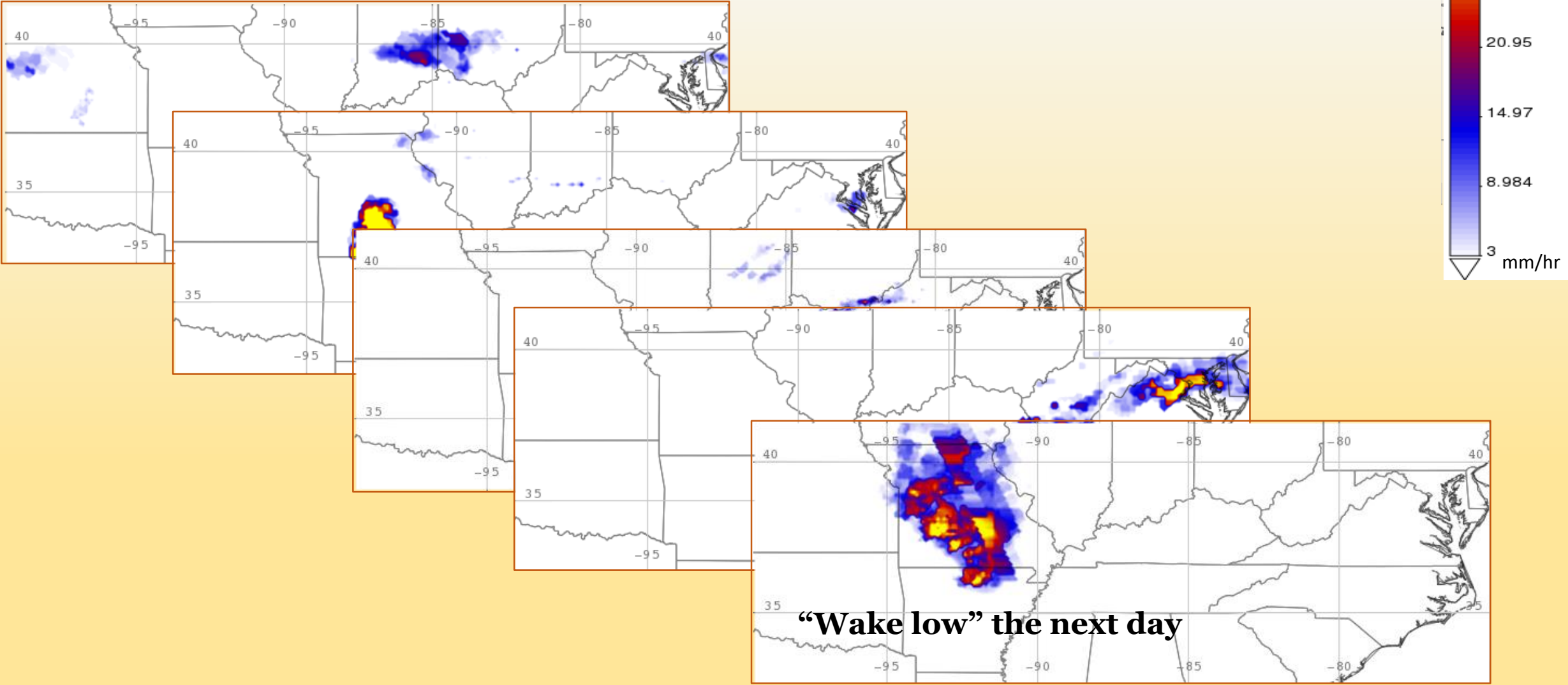


"Independence Day" (1996) – not an actual invasion

**22-23 Z**

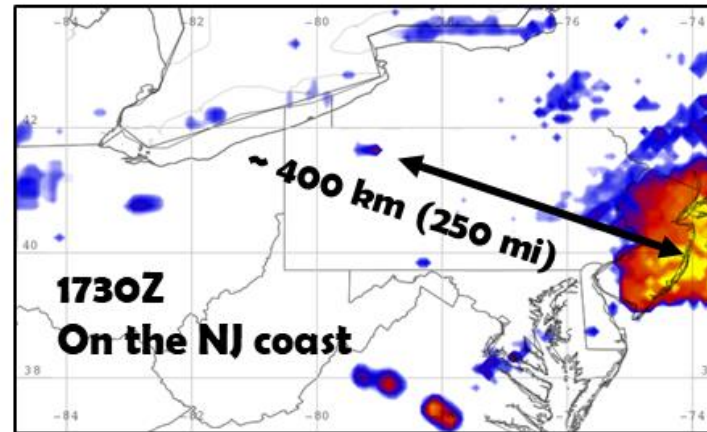
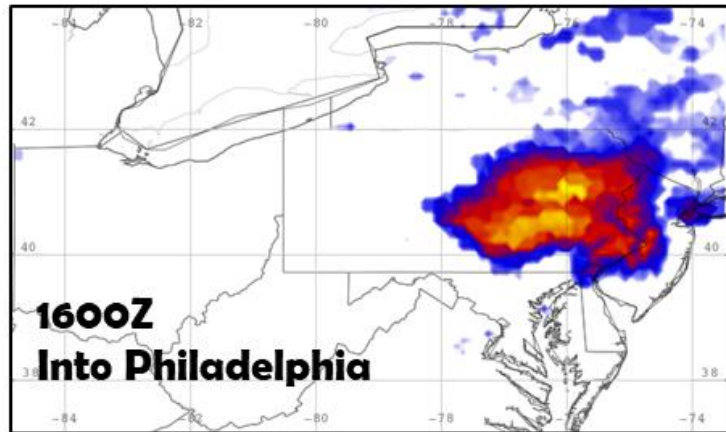
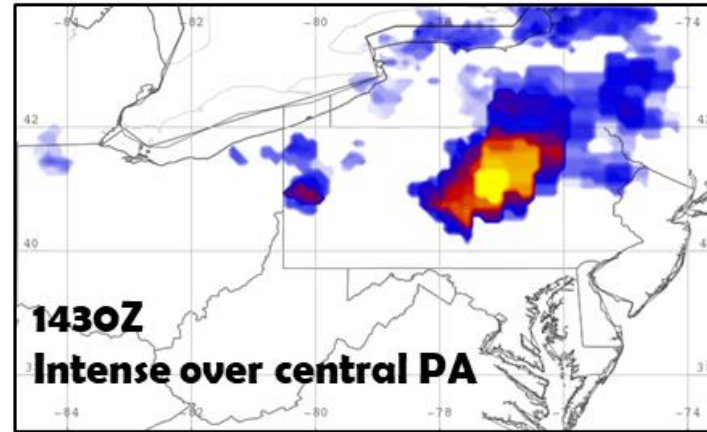
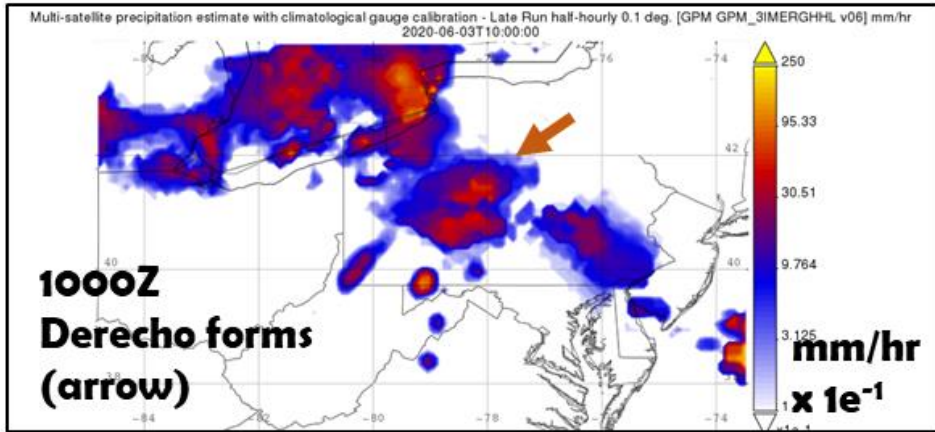


# “Nashville” derecho, May 4, 2020



# “Pennsylvania” derecho, June 3, 2020

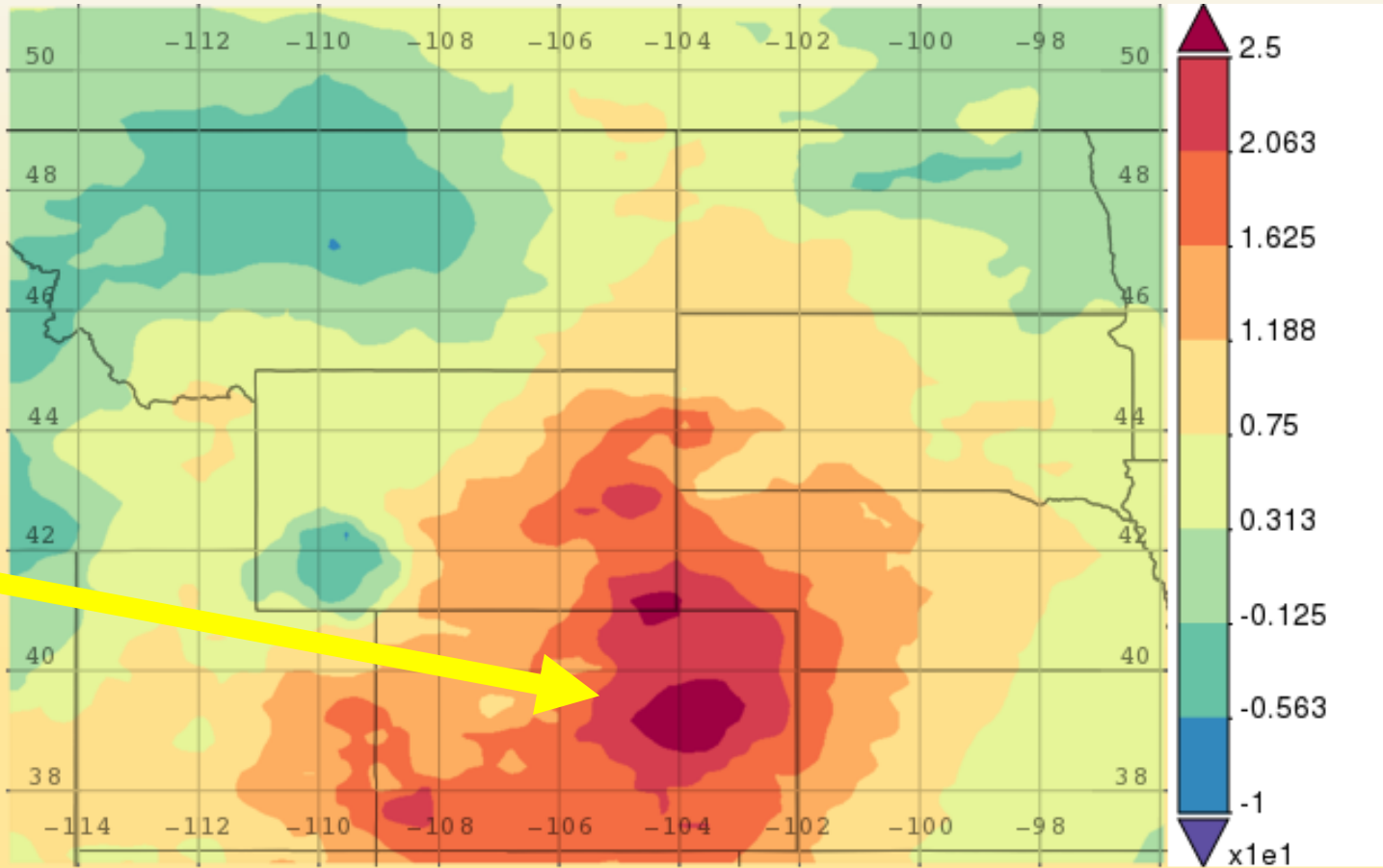
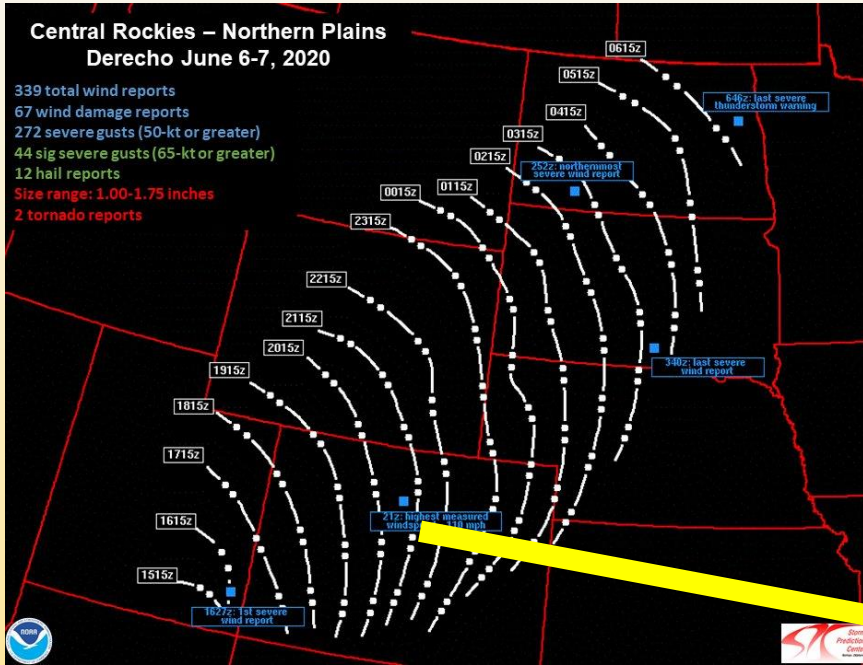
## Scenes from a derecho: June 3, 2020 – IMERG “Late Run” data in Giovanni



**IMERG:**

Interactive  
Multi-satellite  
Retrievals for  
Global  
Precipitation  
Measurement  
(GPM)

# “Western” derecho, June 6-7, 2020



Approximate position of the derecho edge over time. The arrow connects where the highest wind speed was reported (110 mph) to the corresponding location on the Giovanni map.

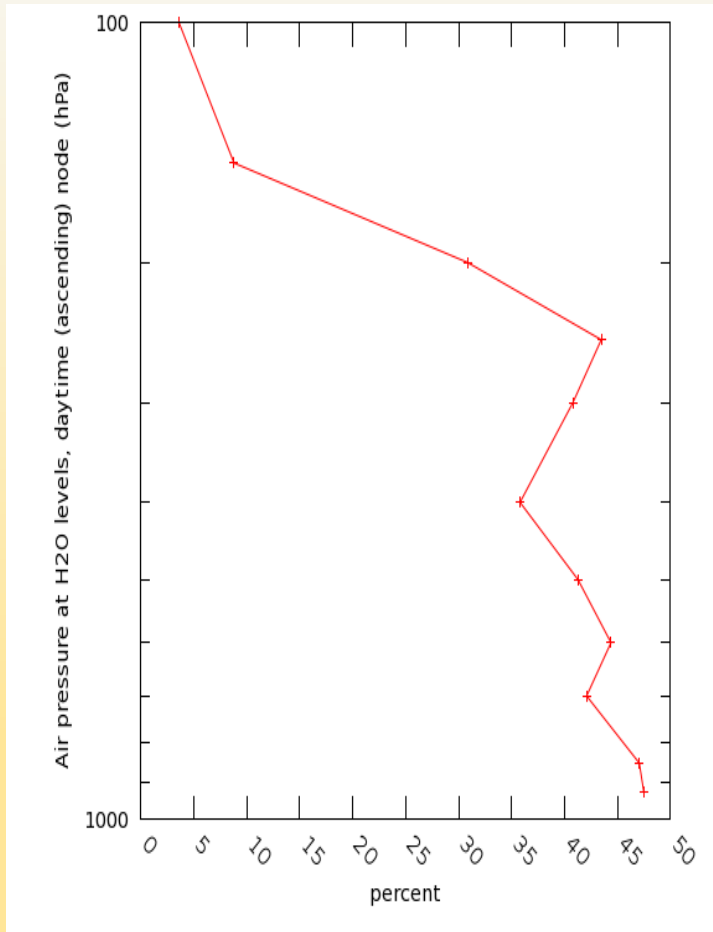
Hourly wind speed data – NARR hybrid level meridional wind from North American Land Data Assimilation System, 18Z, June 6, 2020.

# North Dakota – Minnesota – Wisconsin derecho, July 17, 2020

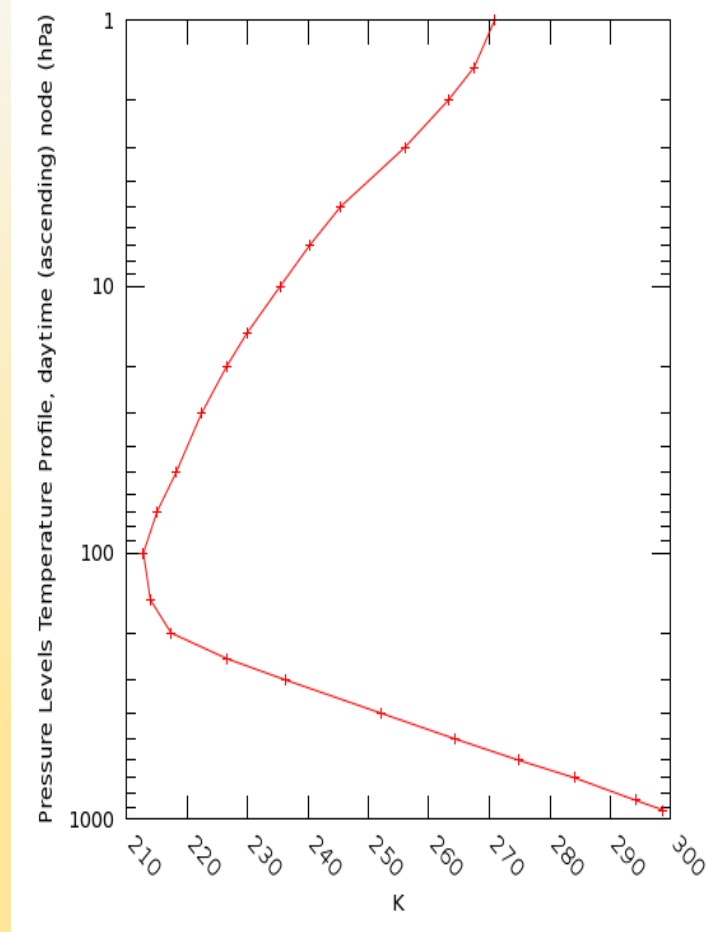
## Screen captures from the University of North Dakota - Grand Forks Skycam



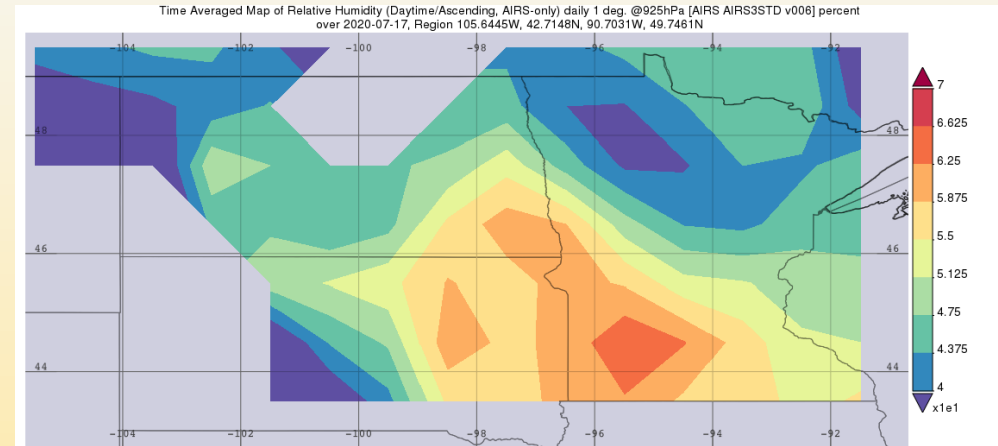
# North Dakota – Minnesota – Wisconsin derecho, July 17, 2020: Atmospheric conditions



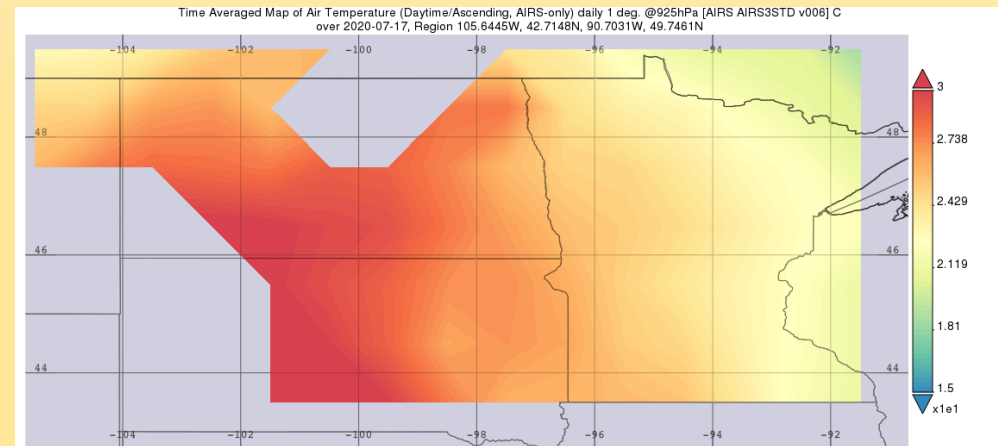
**AIRS Relative Humidity Profile**



**AIRS Temperature Profile**



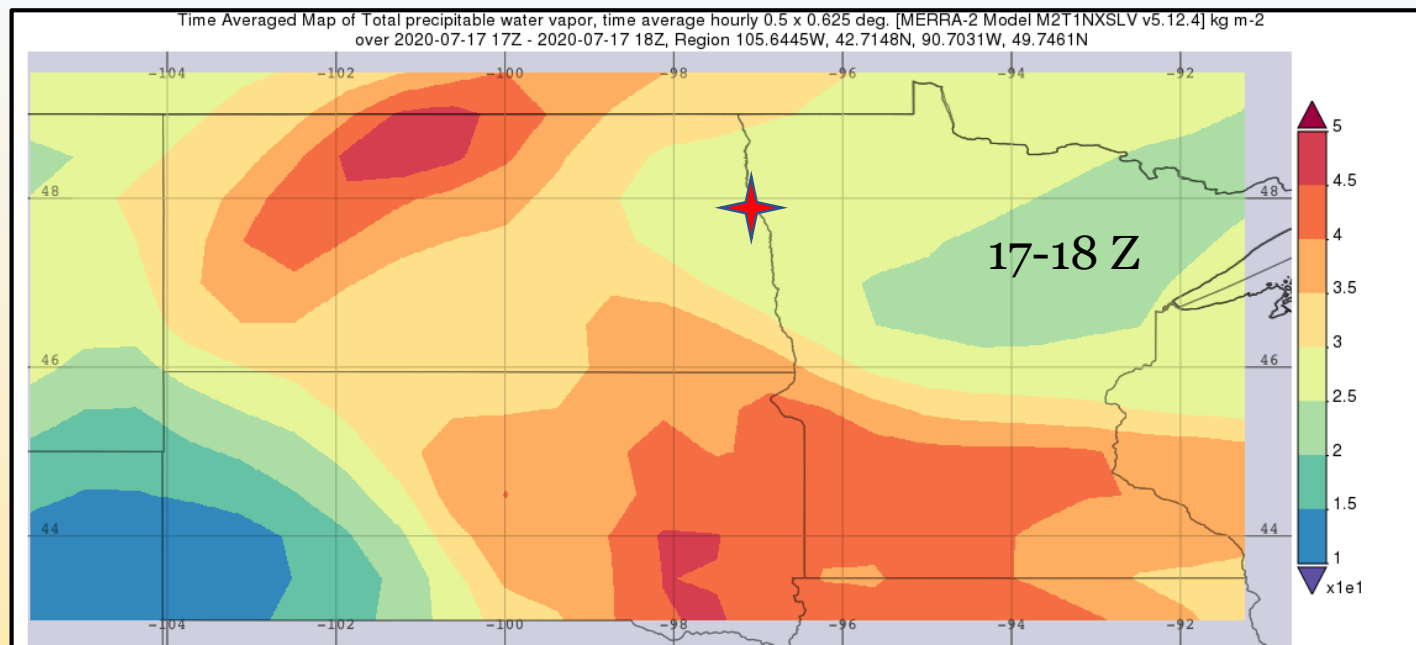
**AIRS Relative Humidity, 925 hPa**  
Color scale 40-70%



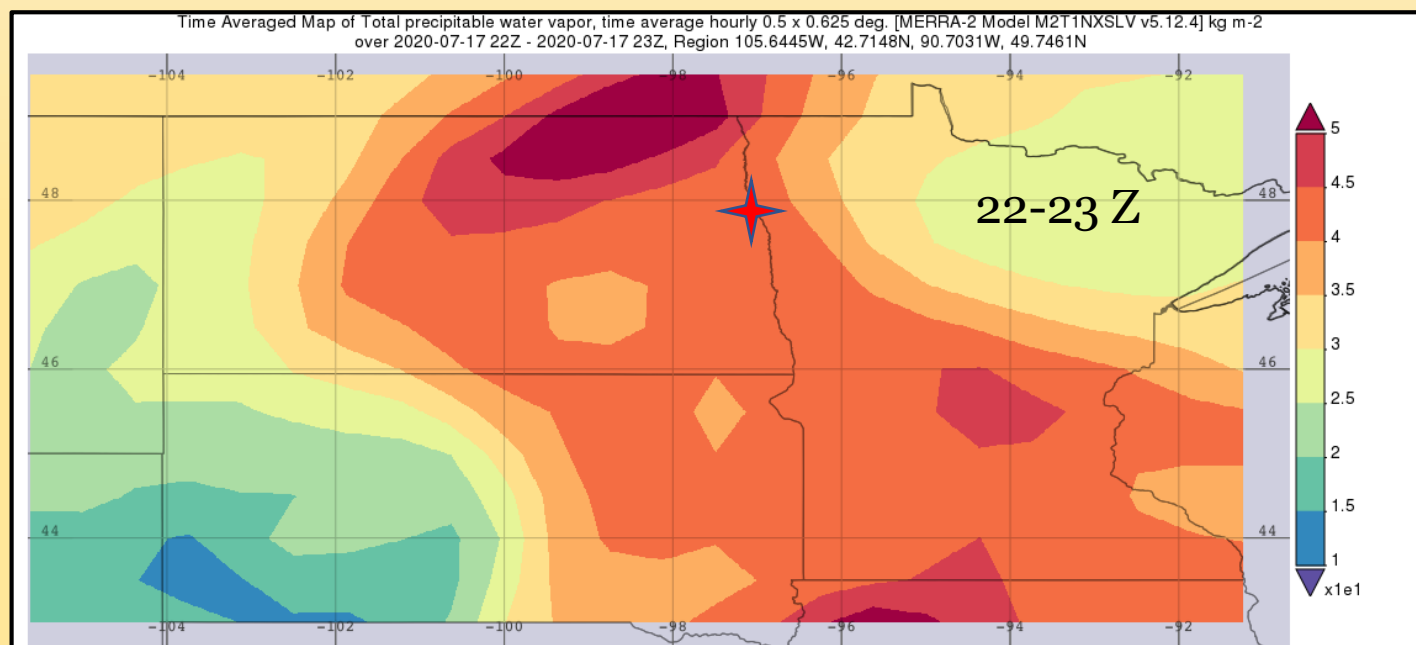
**AIRS Air Temperature, 925 hPa**  
Color scale 15-30 degrees C

North Dakota –  
Minnesota –  
Wisconsin  
derecho, July  
17, 2020:

Precipitable  
water from  
MERRA-2  
Hourly Data

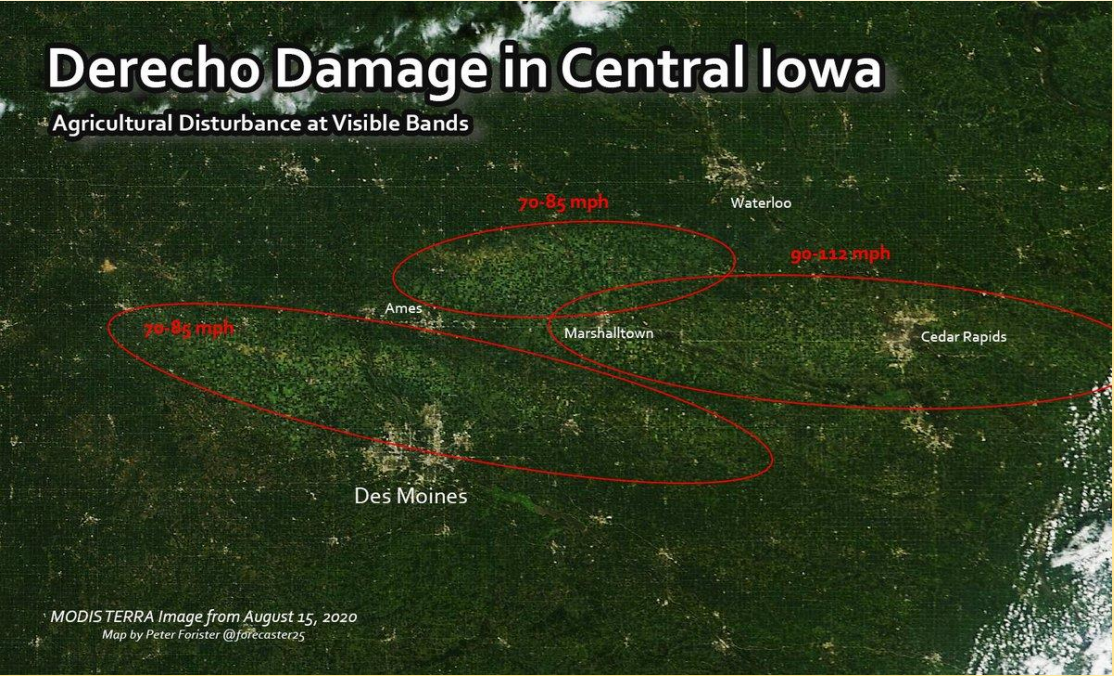
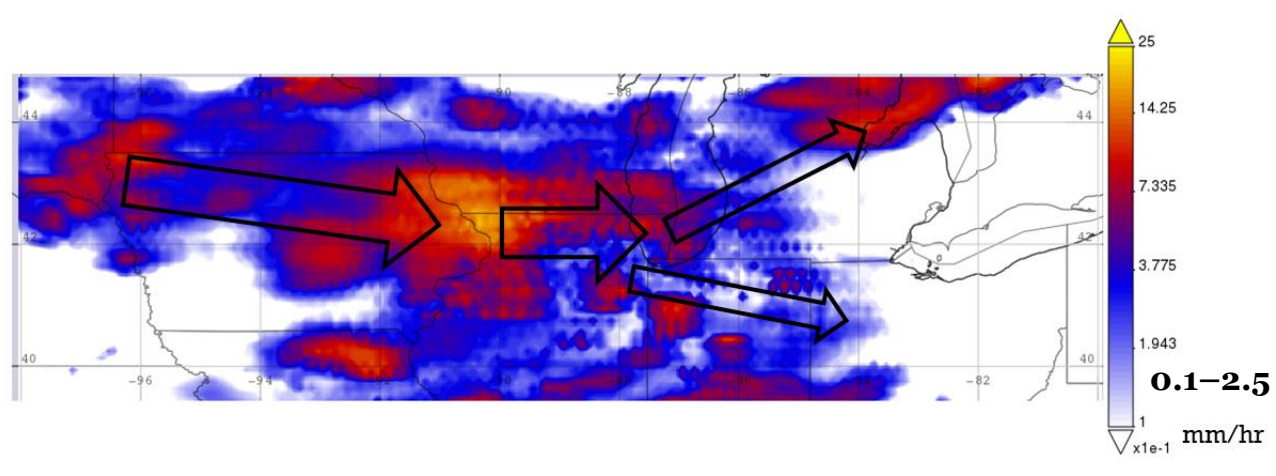
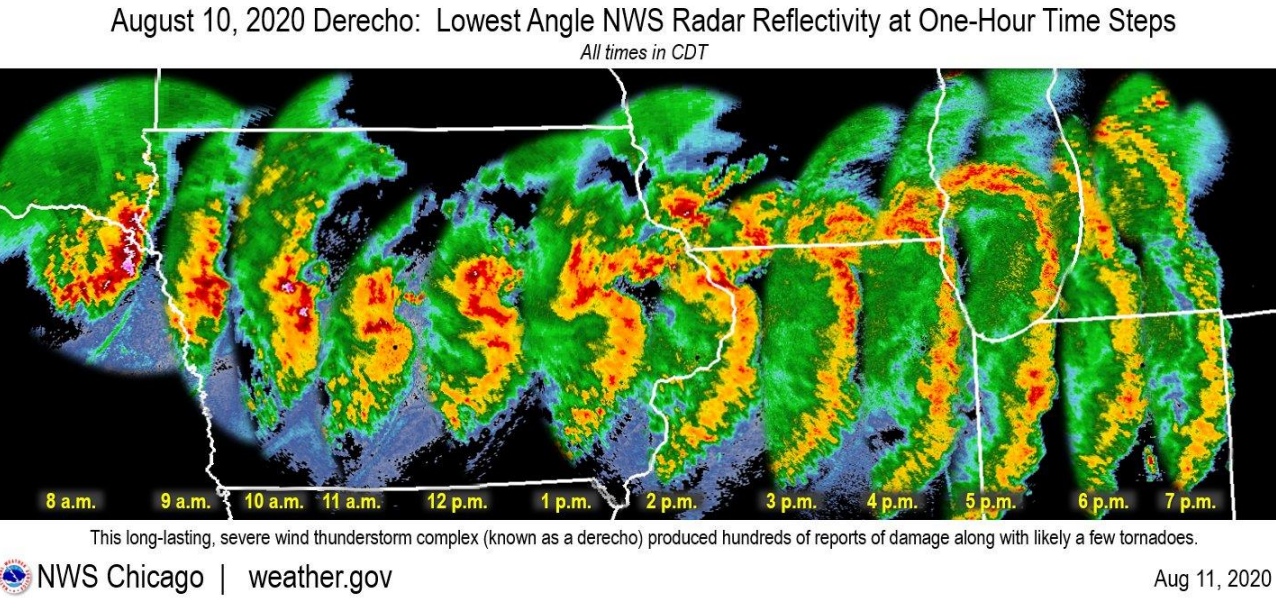


  
Grand Forks



Color scale  
10-50  
kg/m<sup>2</sup>

# The Iowa “flat corn” derecho of August 10-11, 2020 – the most costly thunderstorm in U.S. history



MODIS-Terra image from August 15, 2020

From its earliest version to its current state, Giovanni has been a pioneering technology utilizing NASA Earth science data with the power of online data access and visualization.

This presentation can only briefly mention examples of how Giovanni has been used and what it can do. We invite you to the GES DISC home page and social media to learn more about it and to follow the system's continuing evolution.

<https://disc.gsfc.nasa.gov>

<https://giovanni.gsfc.nasa.gov>



So when everything is changing and you don't know where to start,  
start with Giovanni.

*Thanks for watching this presentation!*