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

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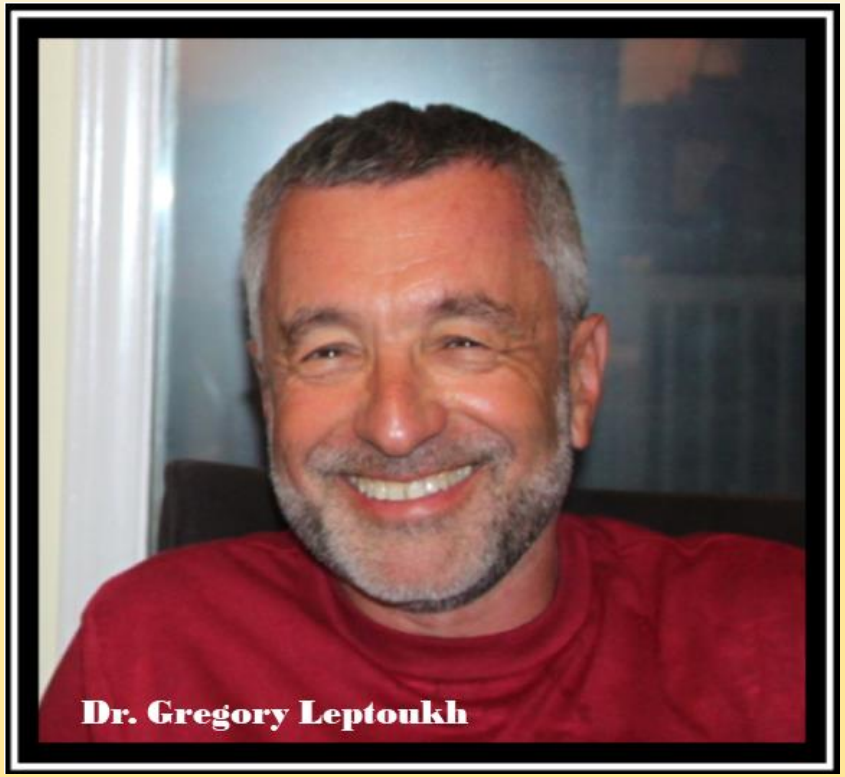
NASA Goddard Earth Sciences Data and Information Services Center

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.

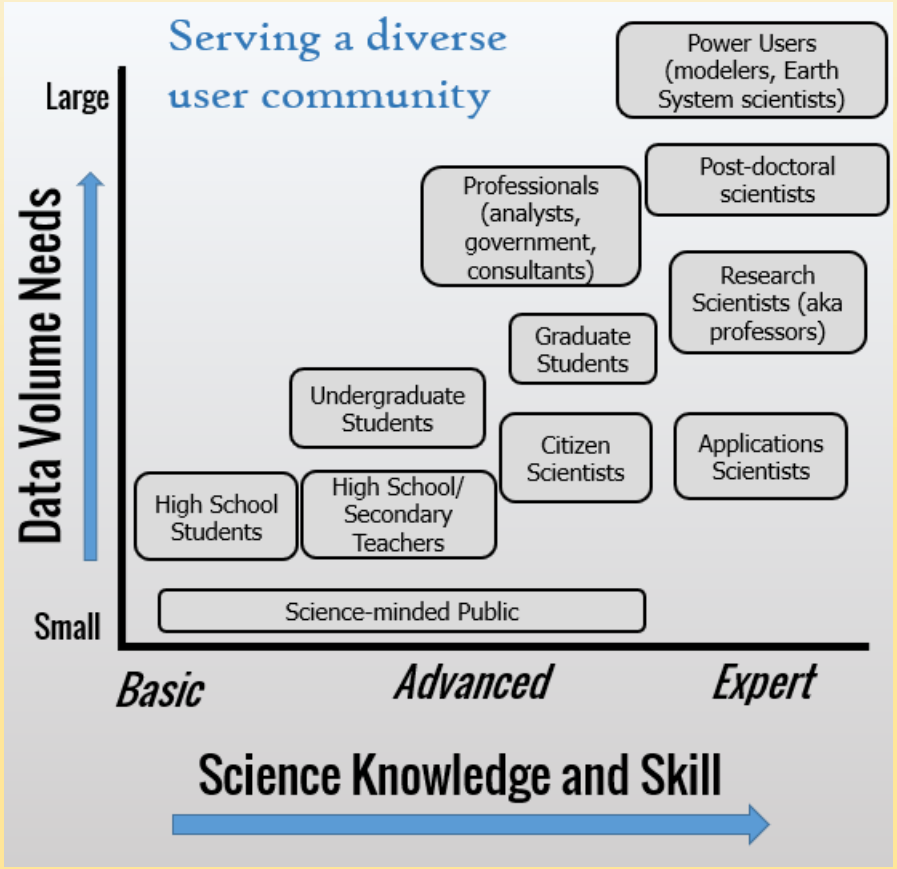
Via Giovanni, NASA data could be used by researchers other than scientists familiar with remote sensing, which had been the province of academic or private researchers with sufficient computational resources and staff to process and analyze the data.

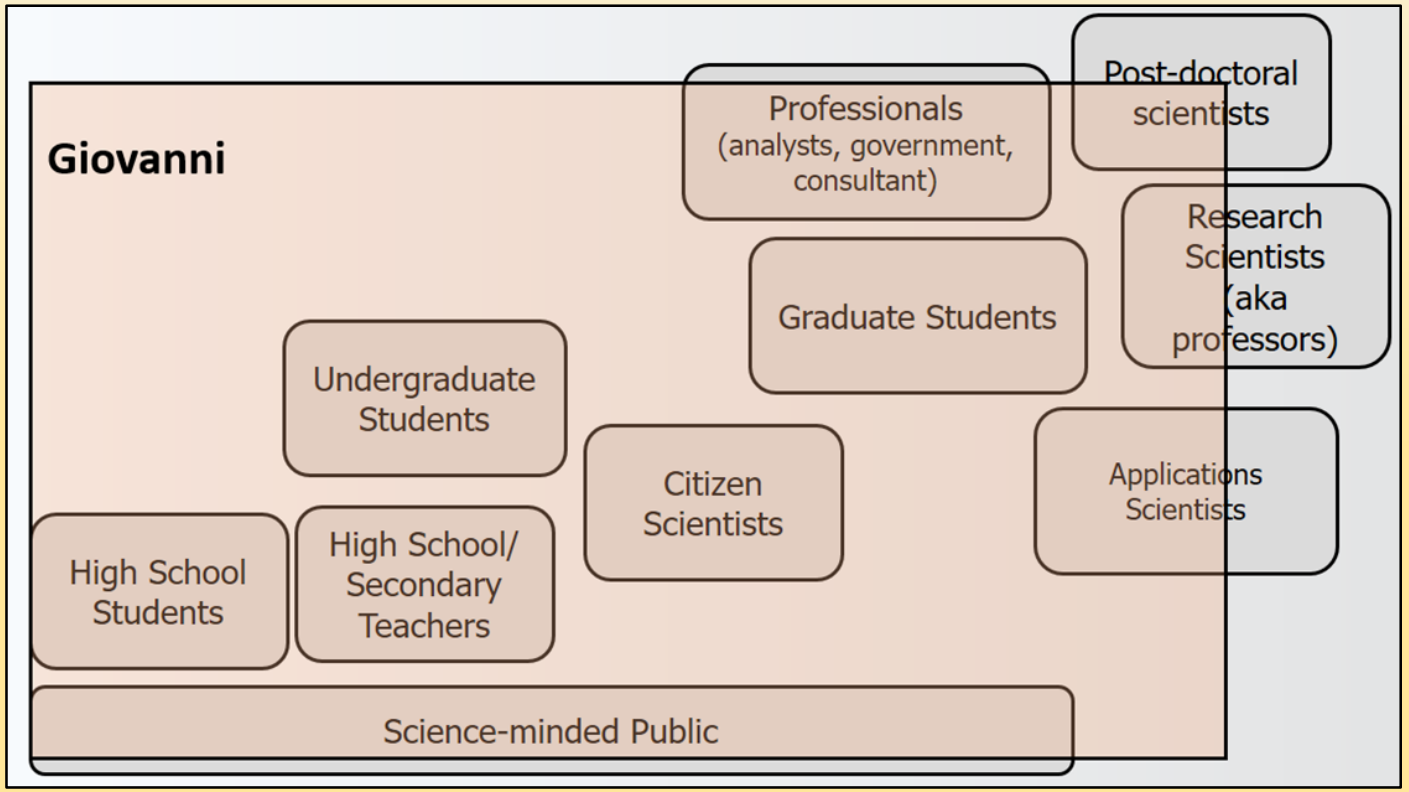
Now, users could access and analyze the data available in Giovanni with minimal prior investments required for either the necessary infrastructure or the technological know-how for data usage. Users could quickly get started doing what they wanted to do most – research!

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.





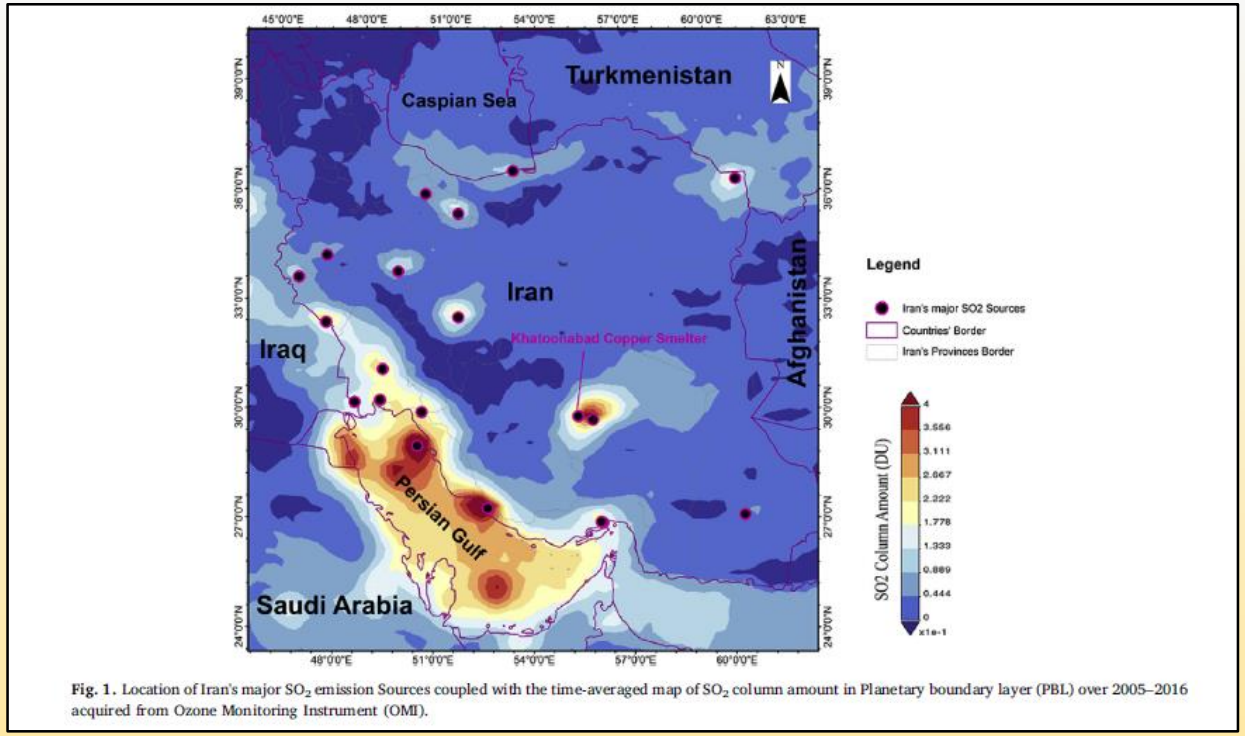


Fig. 1. Location of Iran's major SO_2 emission Sources coupled with the time-averaged map of SO_2 column amount in Planetary boundary layer (PBL) over 2005–2016 acquired from Ozone Monitoring Instrument (OMI).

Salmabadi, H. and Saeedi, M. (2019) Monitoring of SO_2 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.

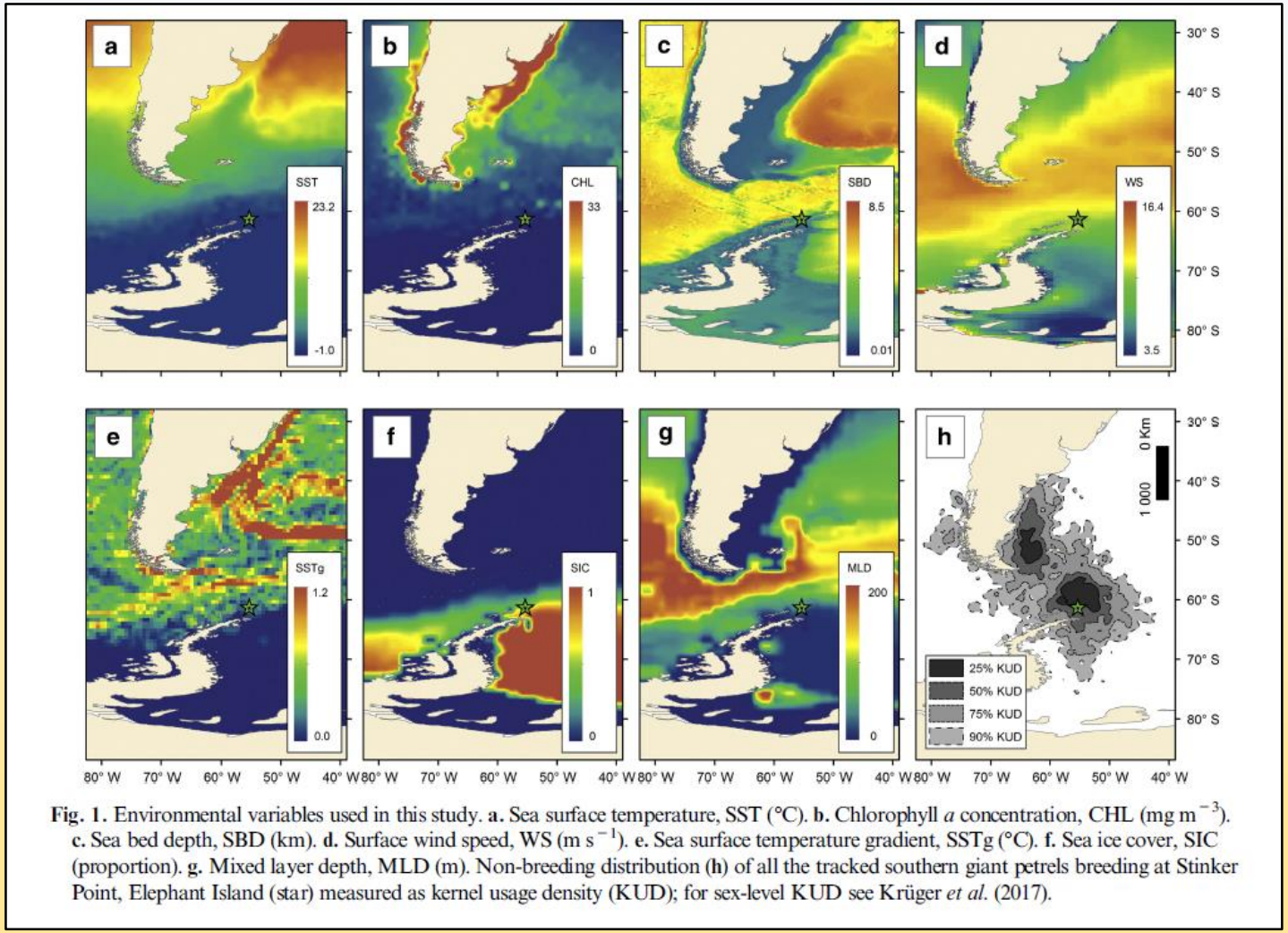
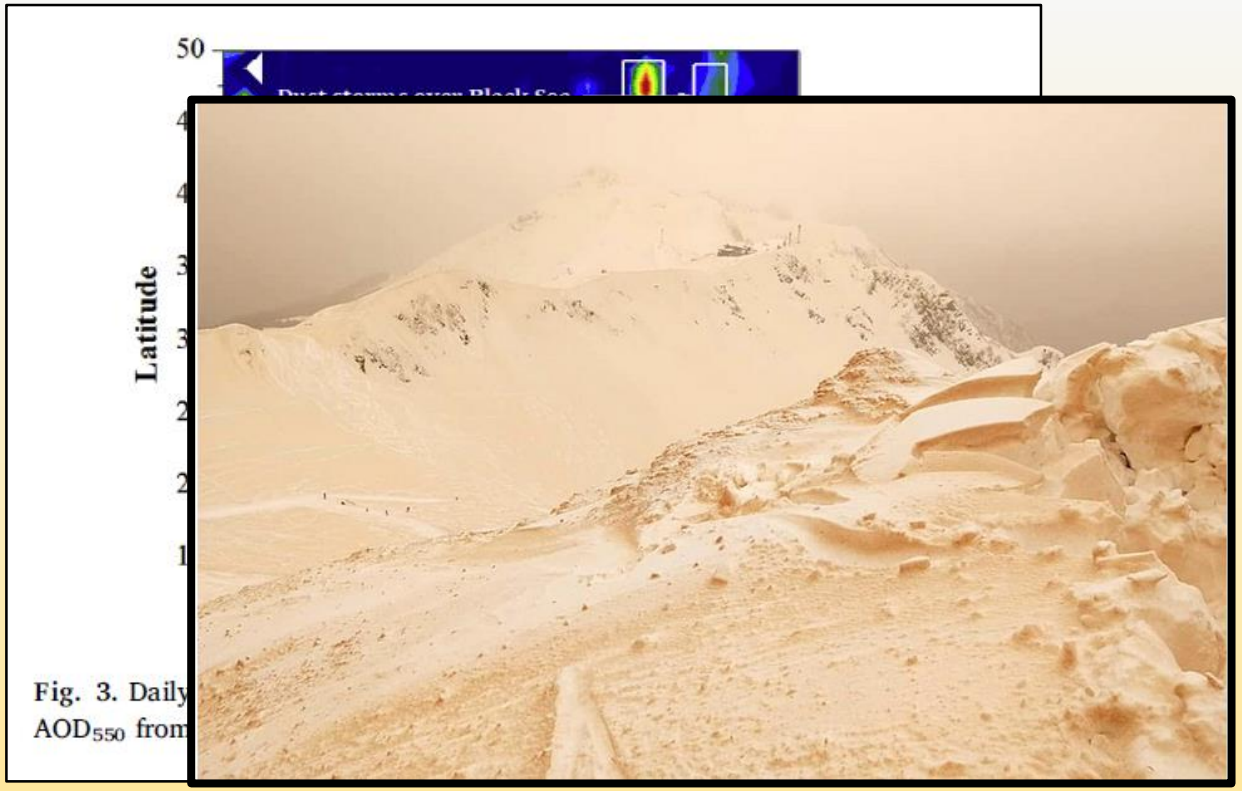


Fig. 1. Environmental variables used in this study. **a.** Sea surface temperature, SST (°C). **b.** Chlorophyll *a* concentration, CHL (mg m^{-3}). **c.** Sea bed depth, SBD (km). **d.** Surface wind speed, WS (m s^{-1}). **e.** Sea surface temperature gradient, SSTg (°C). **f.** Sea ice cover, SIC (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).

Southern giant petrel

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.

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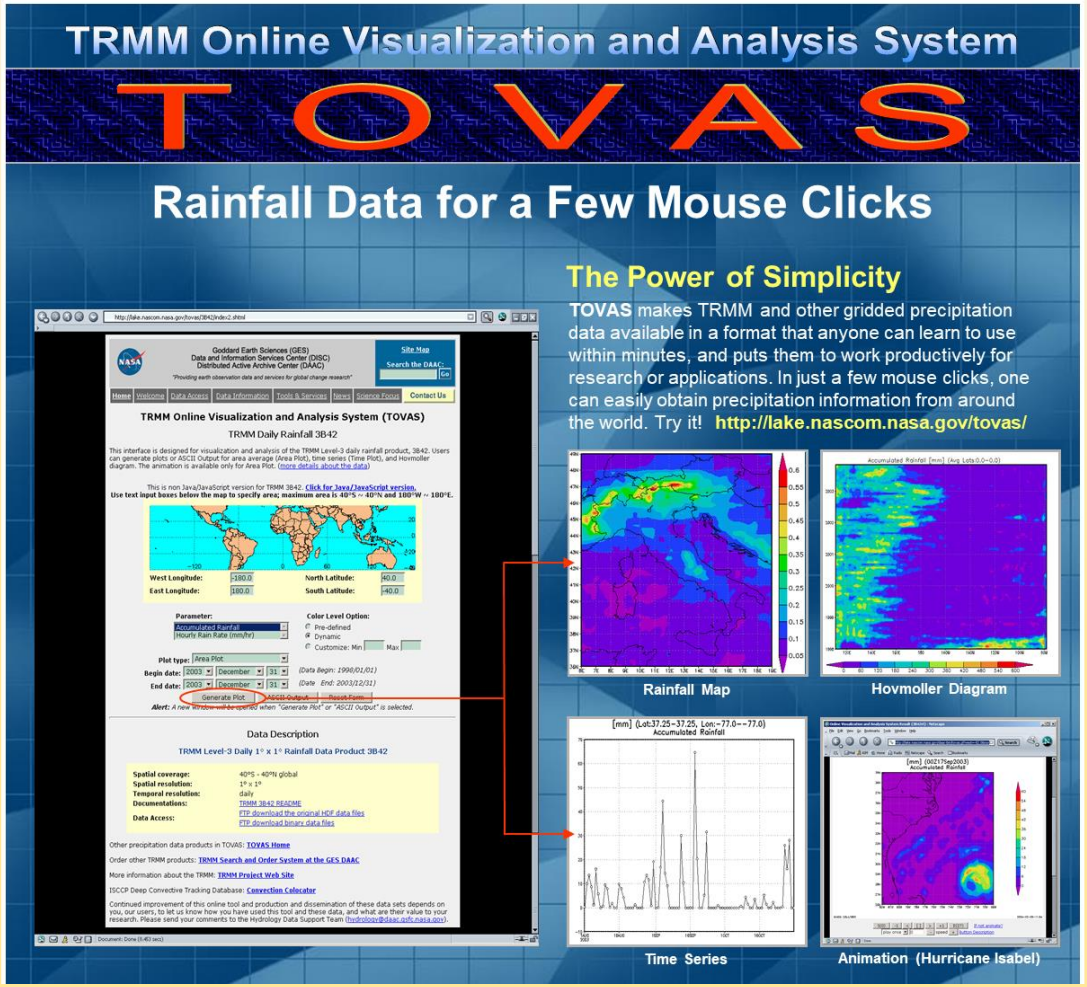
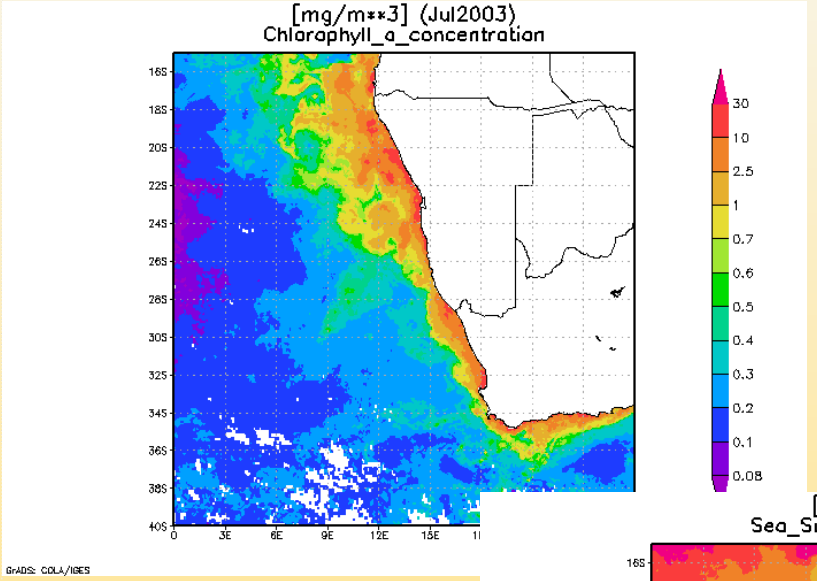
This year will mark the *8th consecutive year* that the number of peer-reviewed journal publications citing Giovanni will exceed 200.

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.

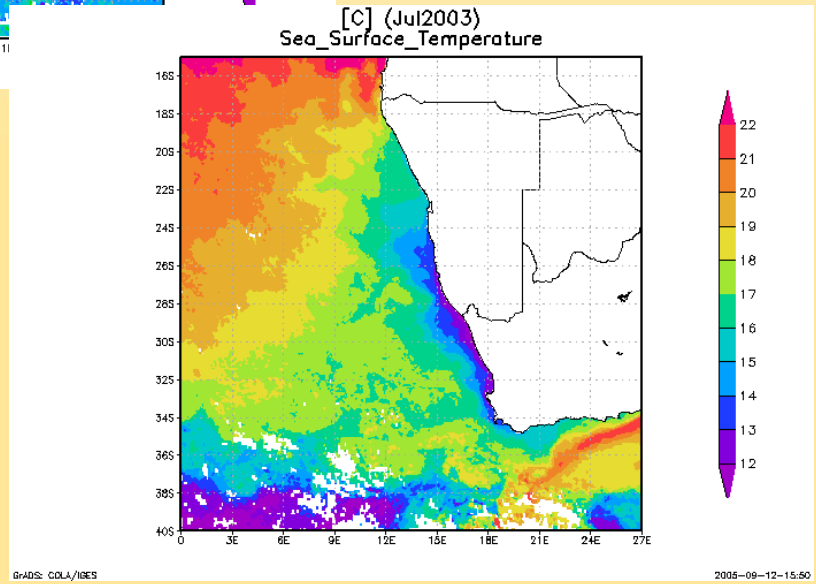




Benguela Upwelling Zone

Chlorophyll concentration from SeaWiFS

Sea surface temperature from MODIS-Aqua



Giovanni – 3

Select Area of Interest

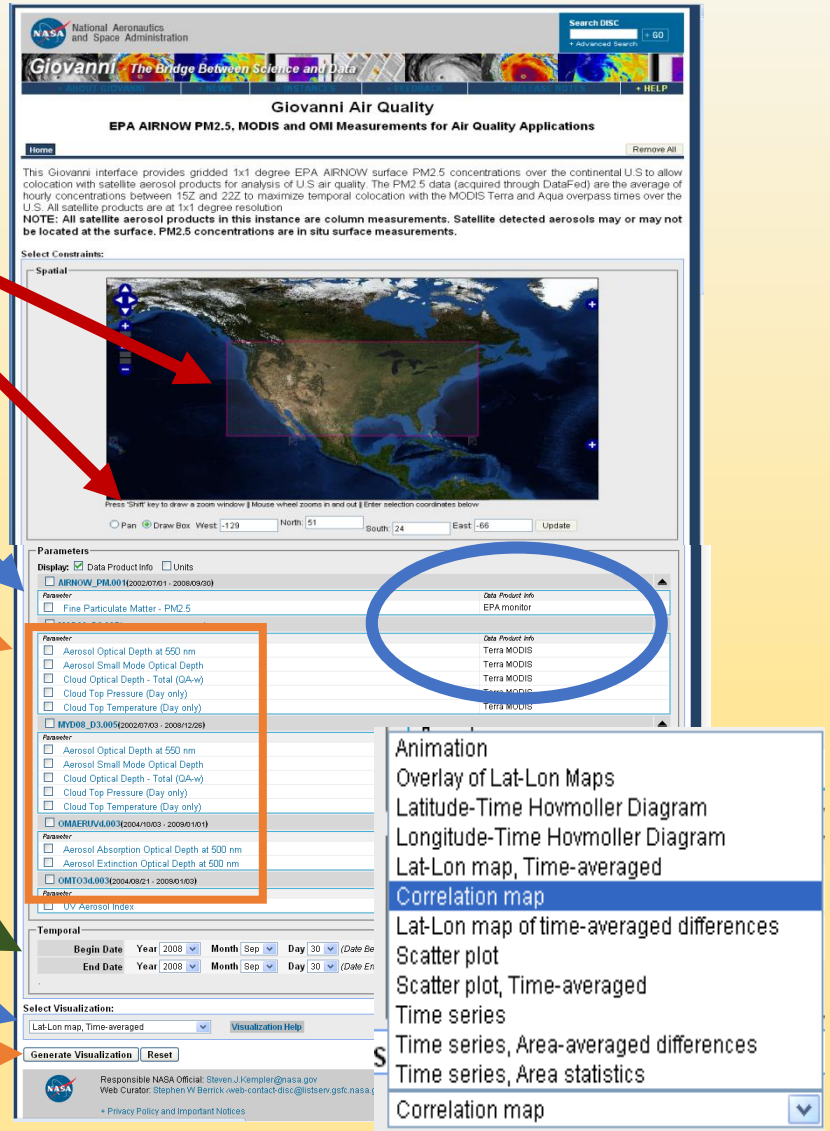
Select Display (info, unit)

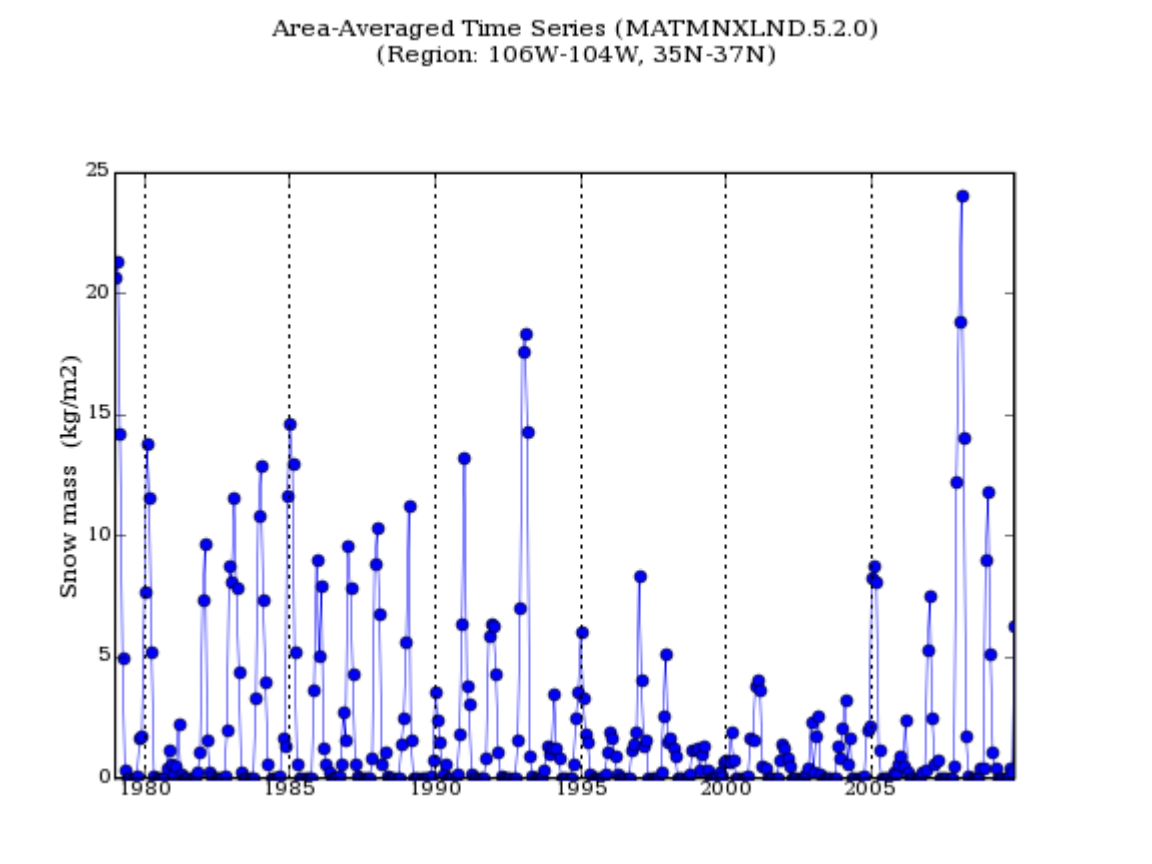
Select Parameters

Select Time Period

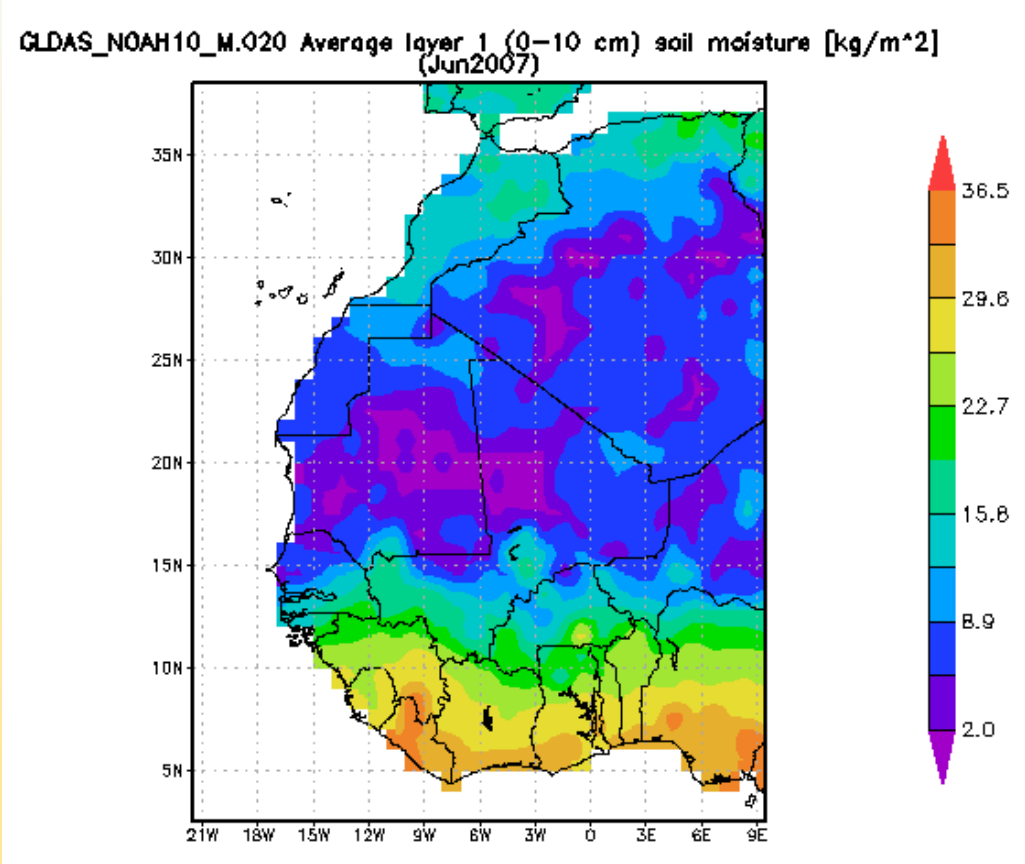
Select Plot type

Generate Visualization



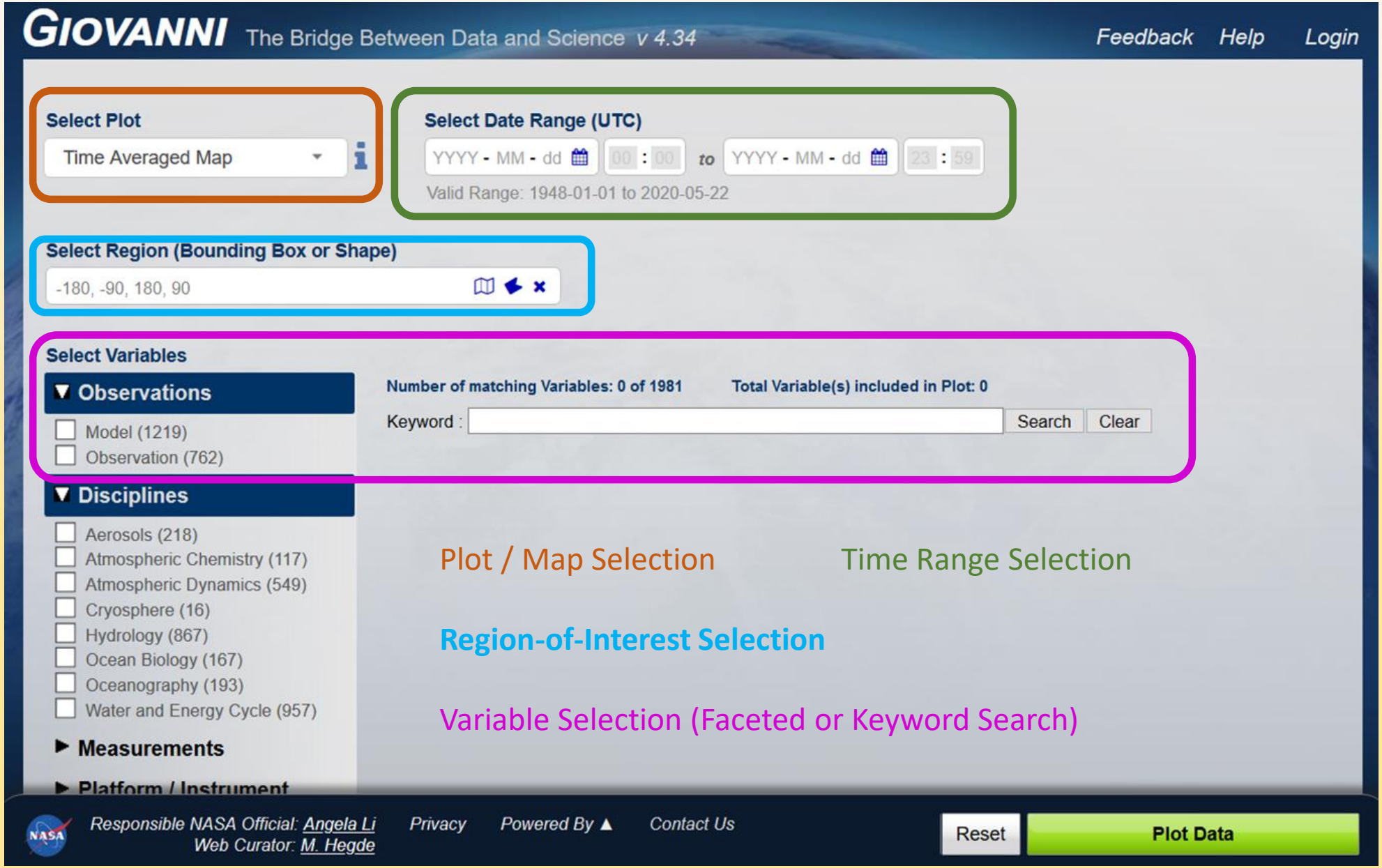


Time-series plot of monthly snow mass in central New Mexico, 1979-2009, with Modern-Era Retrospective analysis for Research and Applications (MERRA) data.



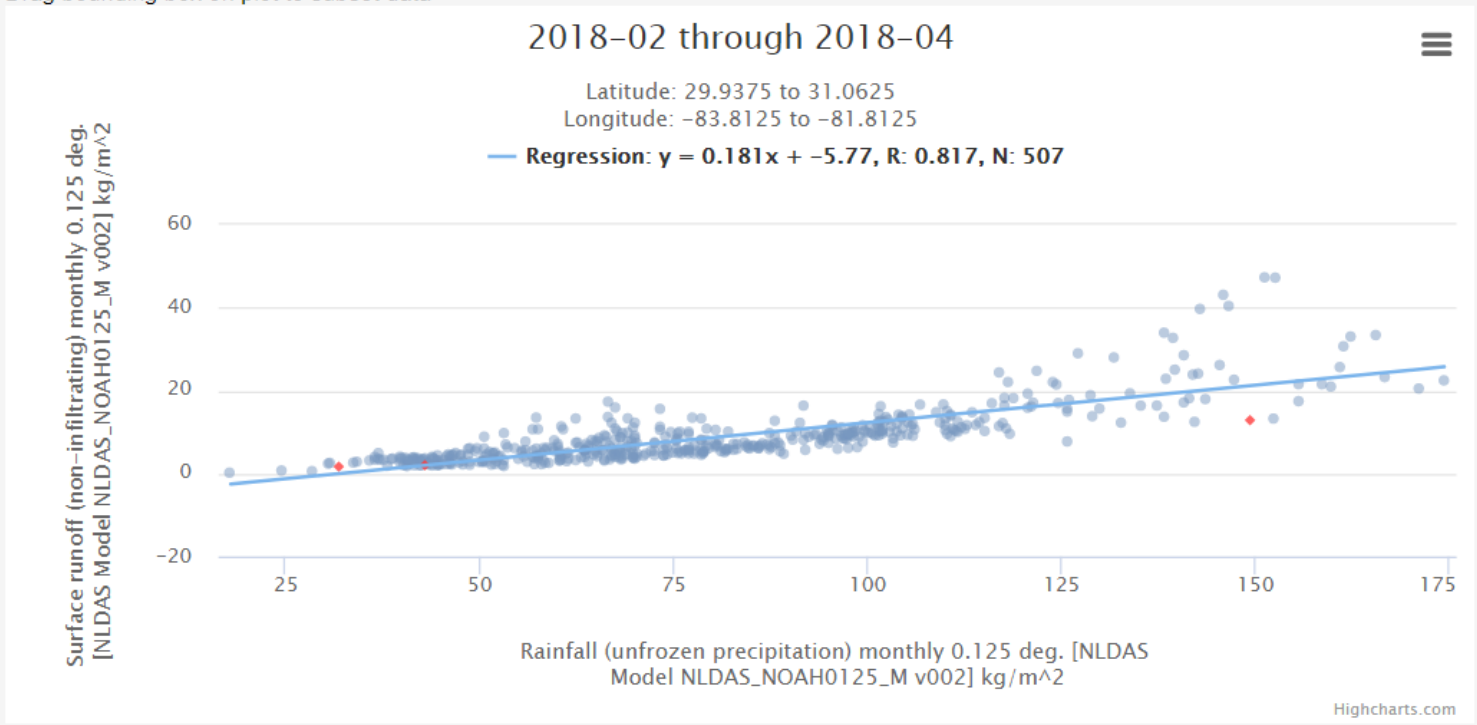
Map of monthly surface soil moisture from the Global Land Data Assimilation System (GLDAS), June 2007.

Giovanni Version 4.34 User Interface

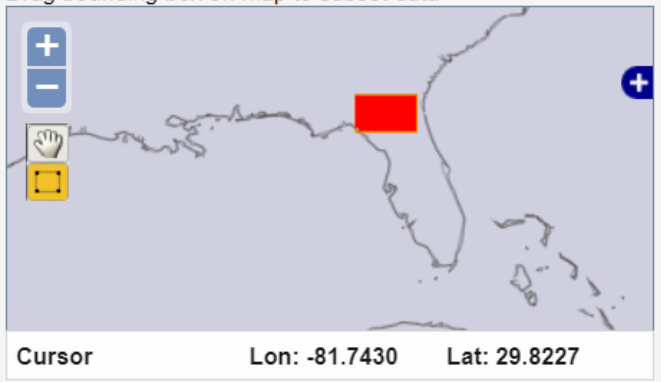


Interactive Scatter Plot

Drag bounding box on plot to subset data

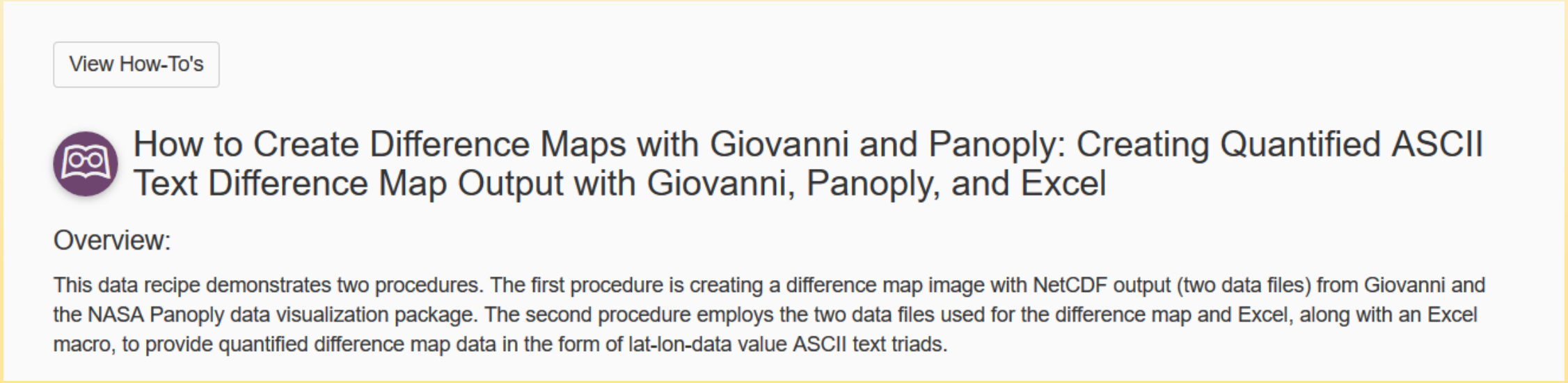


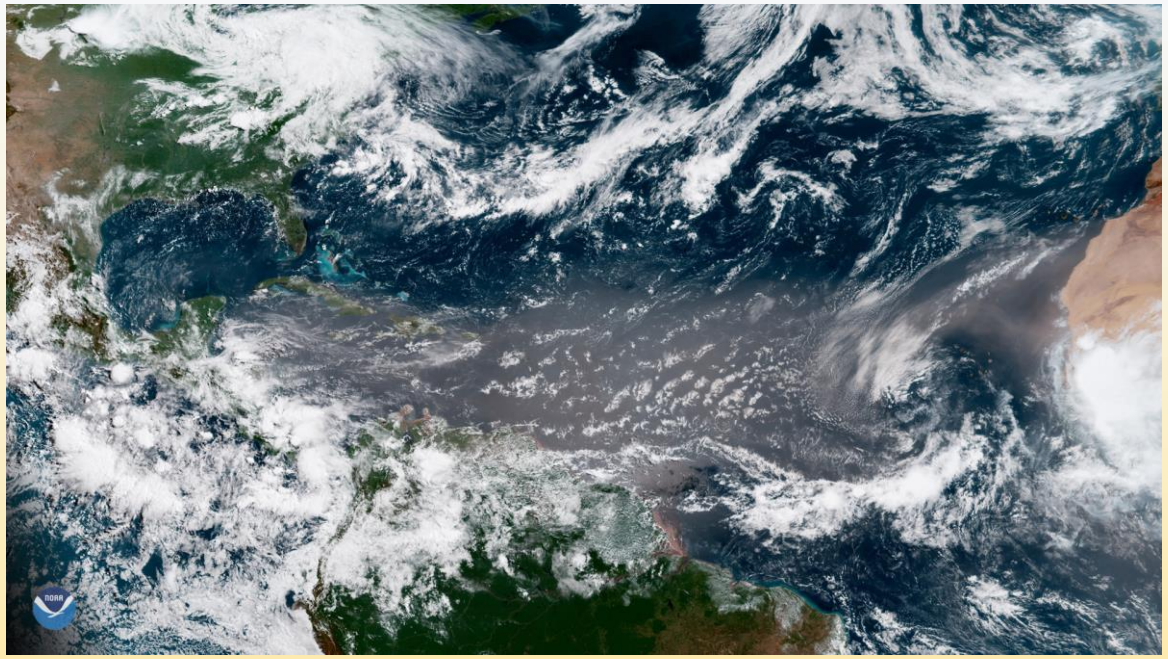
Drag bounding box on map to subset data

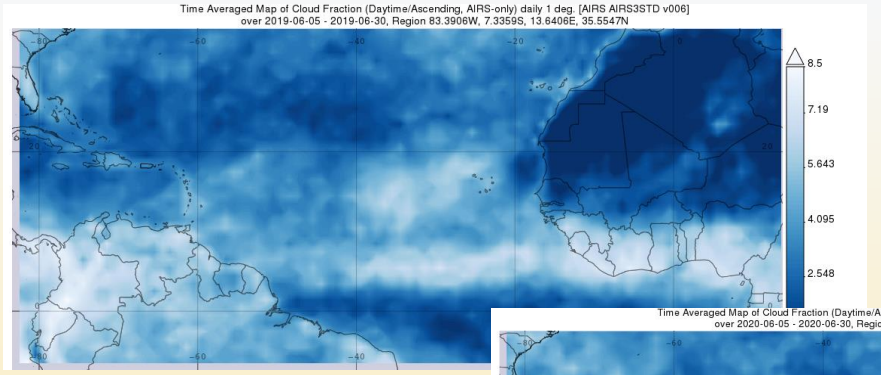


Reset Map and Chart

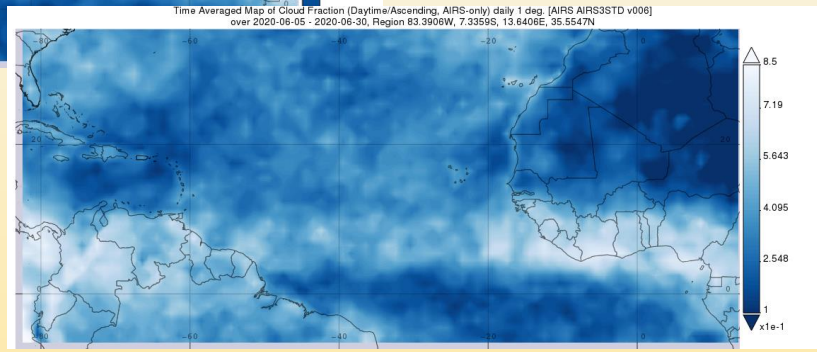
Information resources supporting Giovanni from the Goddard Earth Sciences Data and Information Services Center (GES DISC), which hosts the system, start with basic mapping and plotting functions and extend to “How-to” recipes demonstrating interusability with other data analysis systems and software.





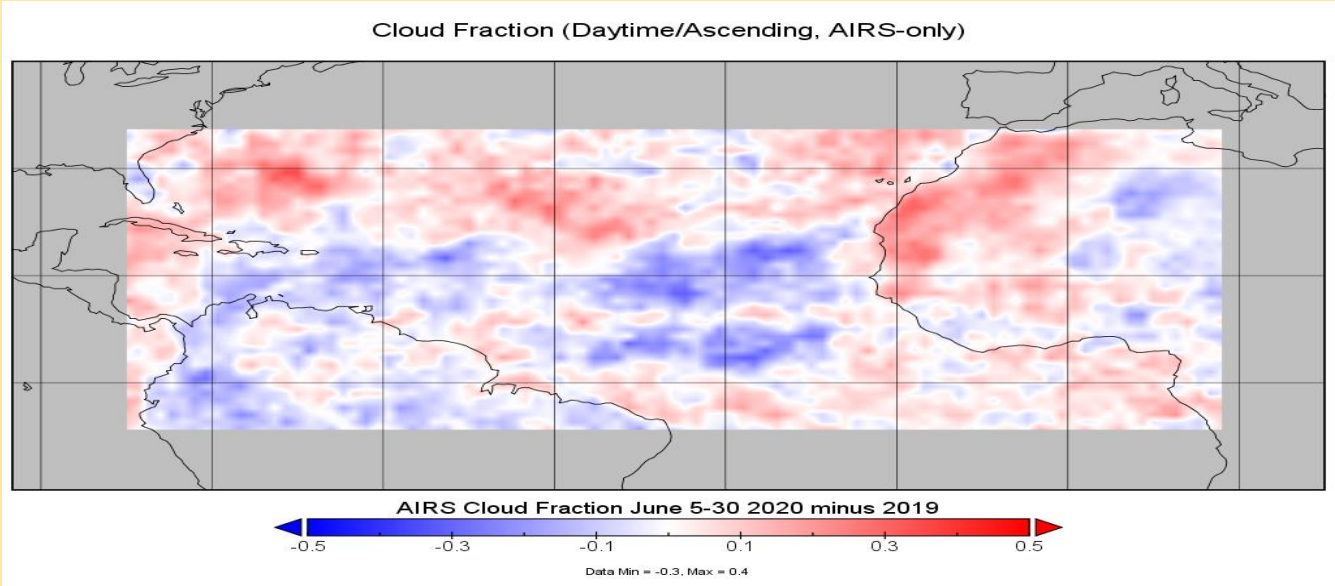


AIRS Cloud Fraction
June 5-30, 2019



June 5-30, 2020

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.

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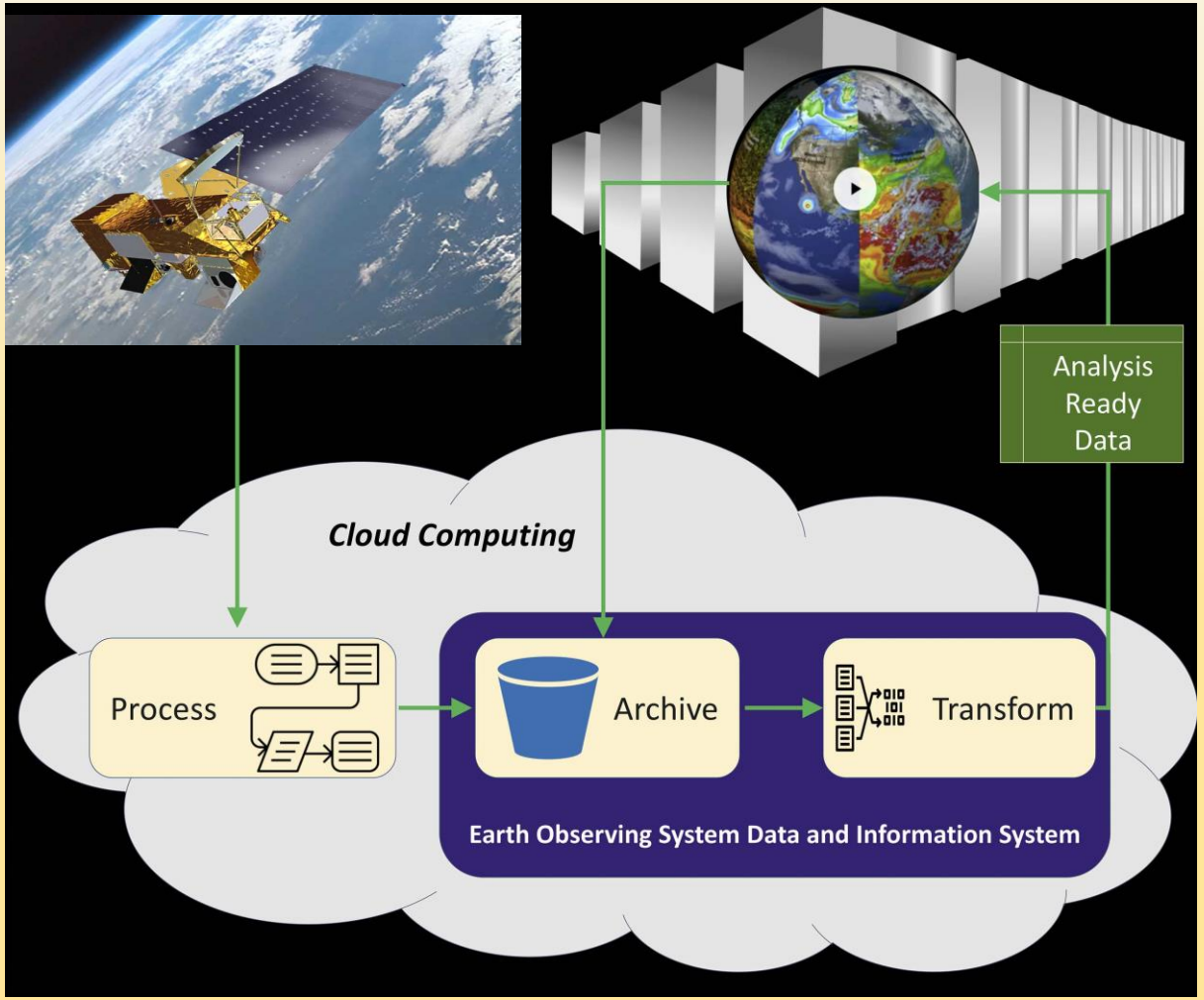
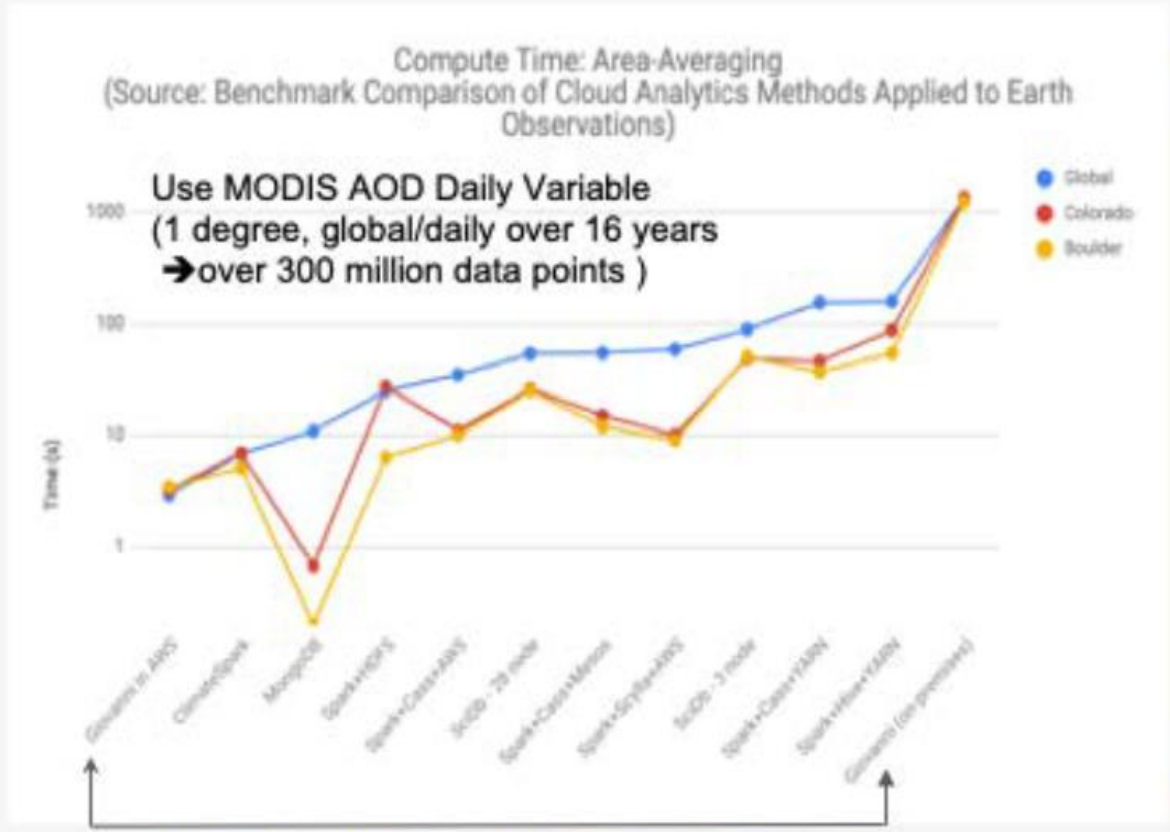
Giovanni is now being developed for use in a cloud computing environment, potentially expanding datasets the system can be applied to, and also improving performance for data having high spatial and temporal resolution.



Giovanni in the Cloud Performance Benchmark

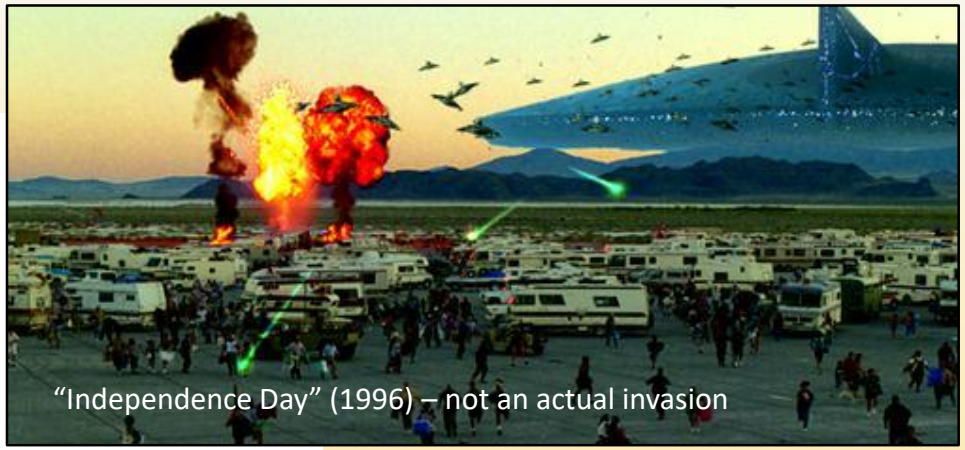


Improvement of cloud version over current Giovanni

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)

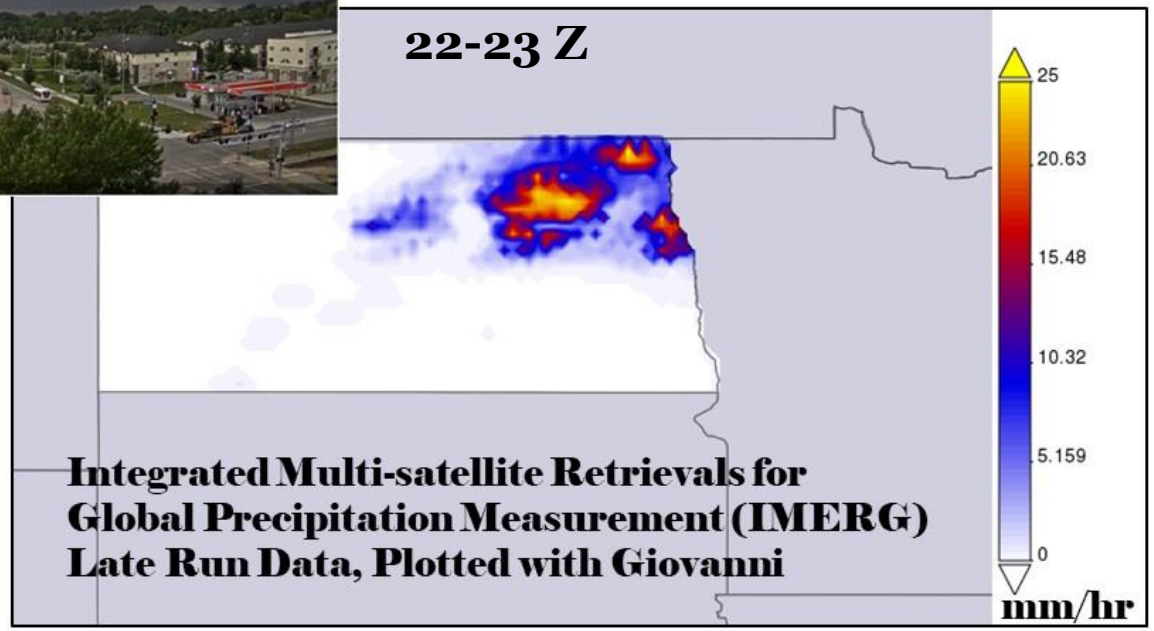
Multi-dataset examination of derecho events associated with mesoscale convective phenomena in the summer of 2020



Grand Forks, North Dakota

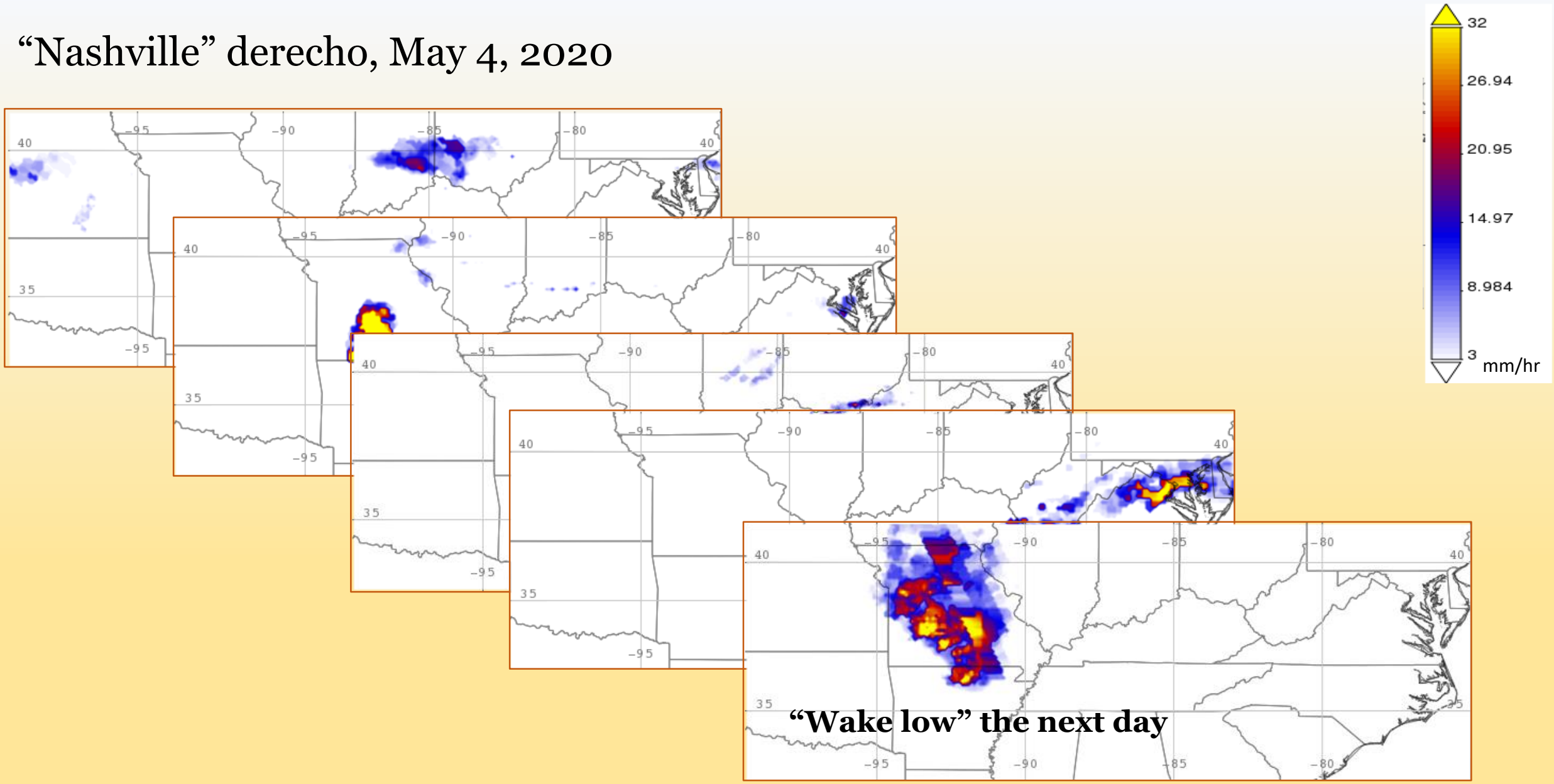
July 17, 2020

22-23 Z



Integrated Multi-satellite Retrievals for Global Precipitation Measurement (IMERG) Late Run Data, Plotted with Giovanni

“Nashville” derecho, May 4, 2020



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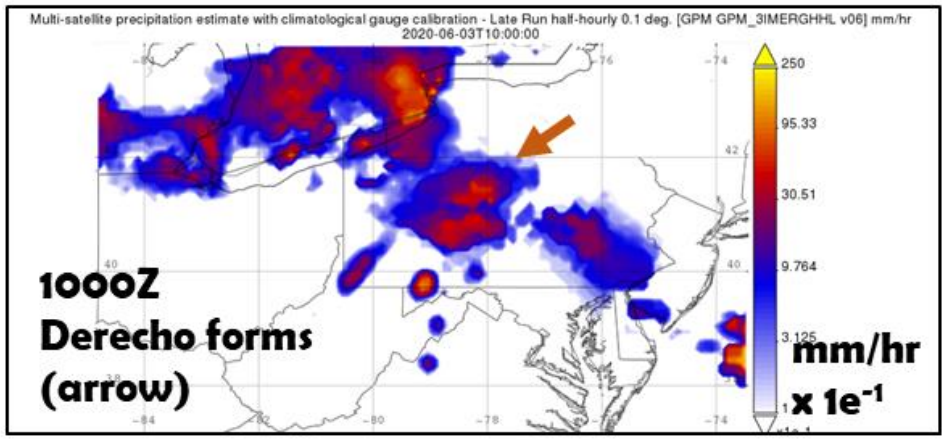
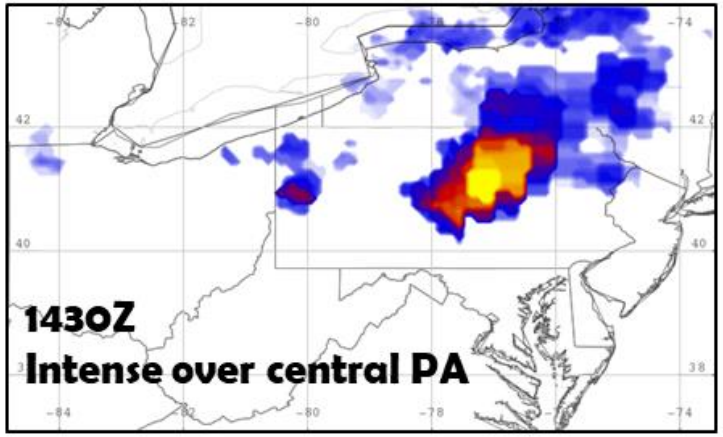
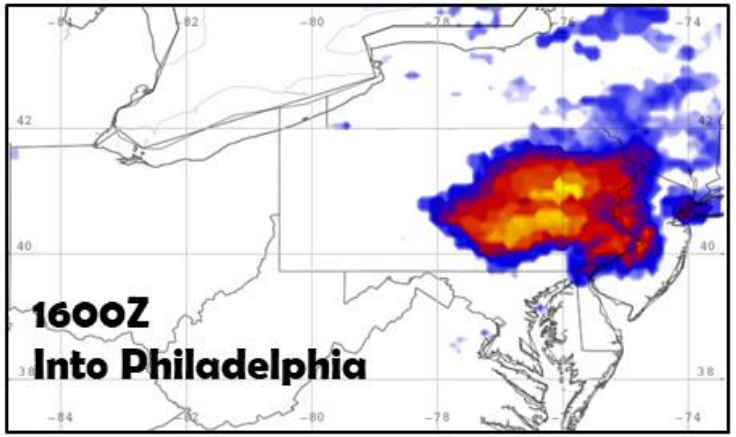
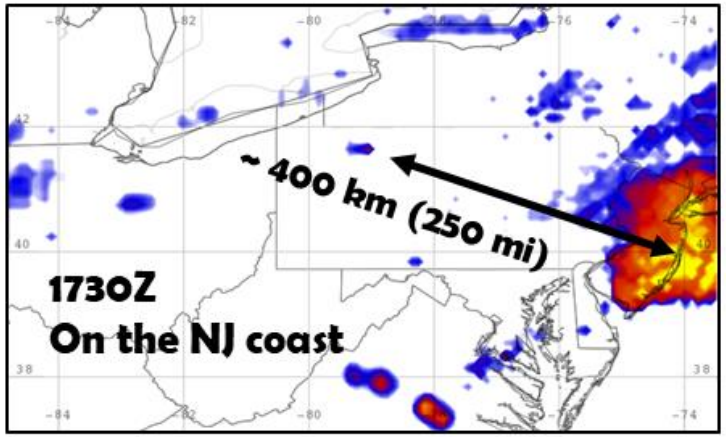
“Pennsylvania” derecho, June 3, 2020

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





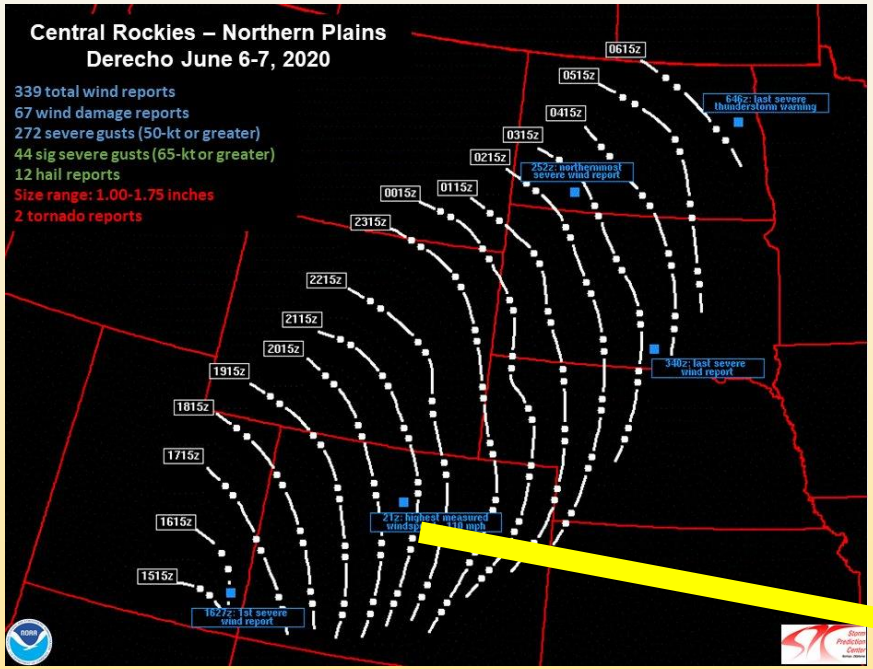




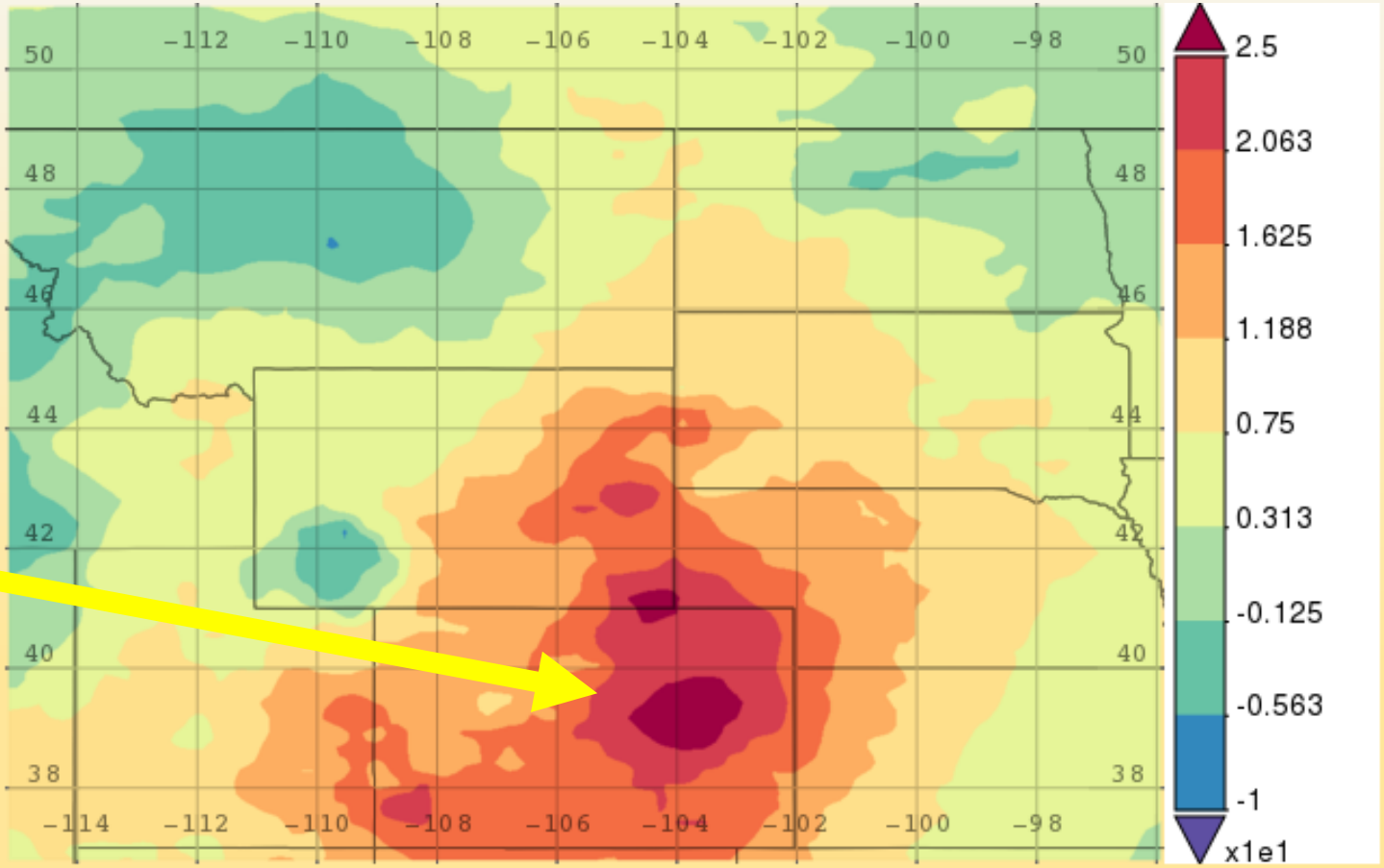
IMERG:

Interactive
Multi-satellit**E**
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

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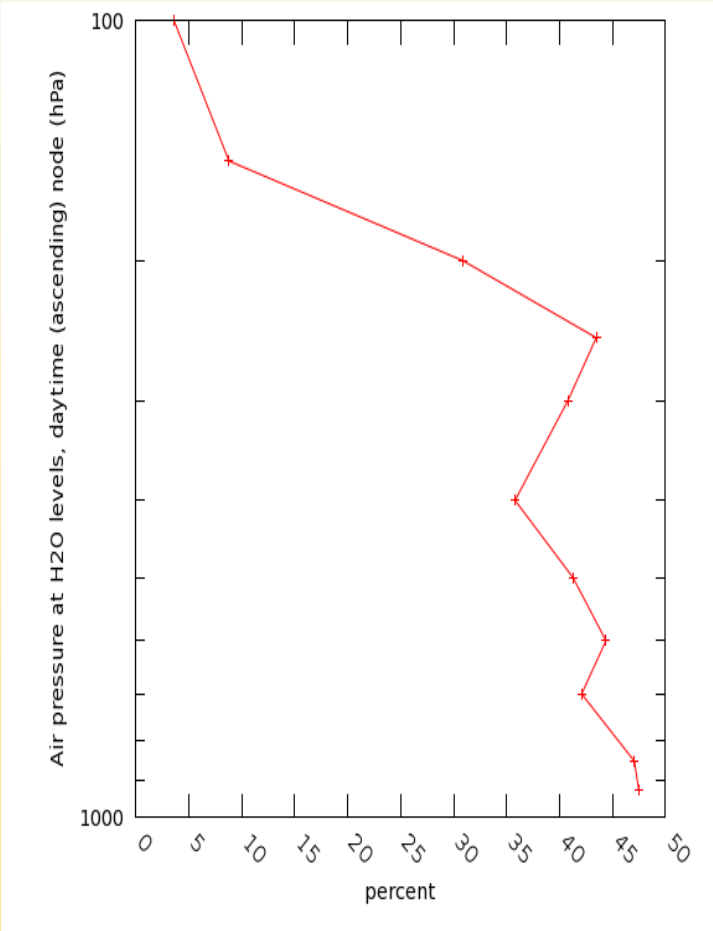
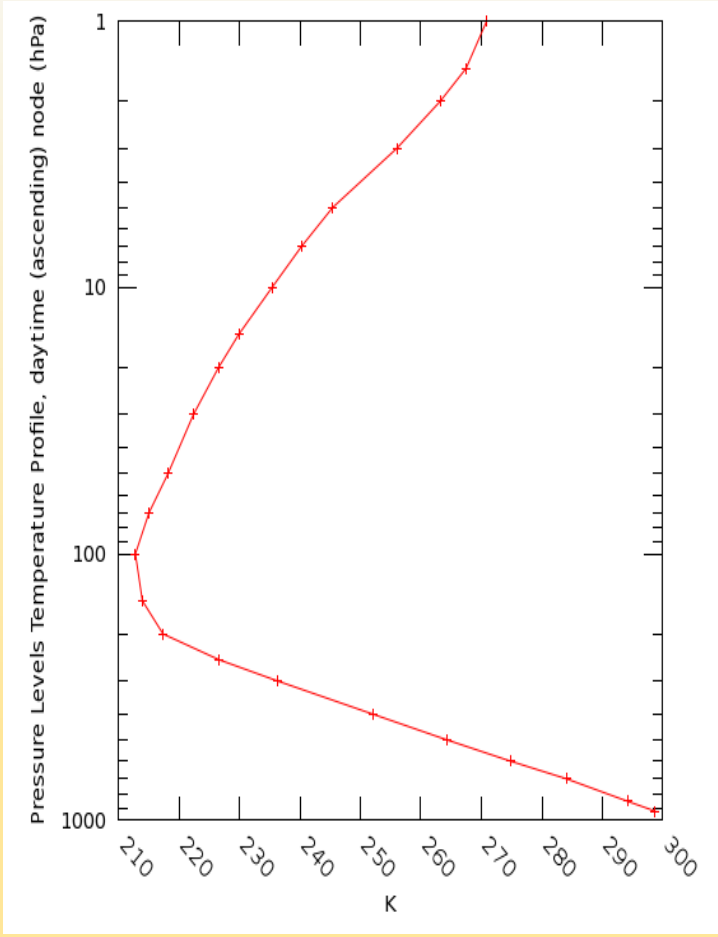
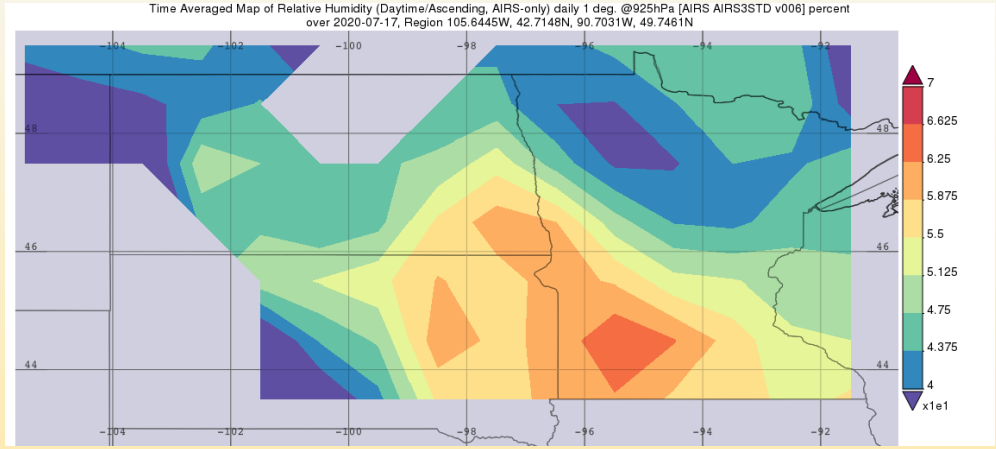
North Dakota – Minnesota – Wisconsin derecho, July 17, 2020: Atmospheric conditions



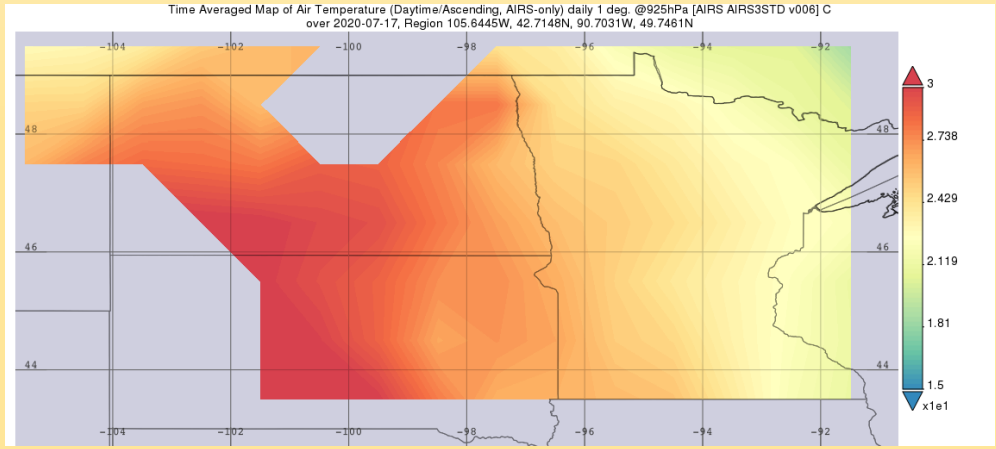
AIRS Relative Humidity Profile



AIRS Temperature Profile



AIRS Relative Humidity, 925 hPA
Color scale 40-70%



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

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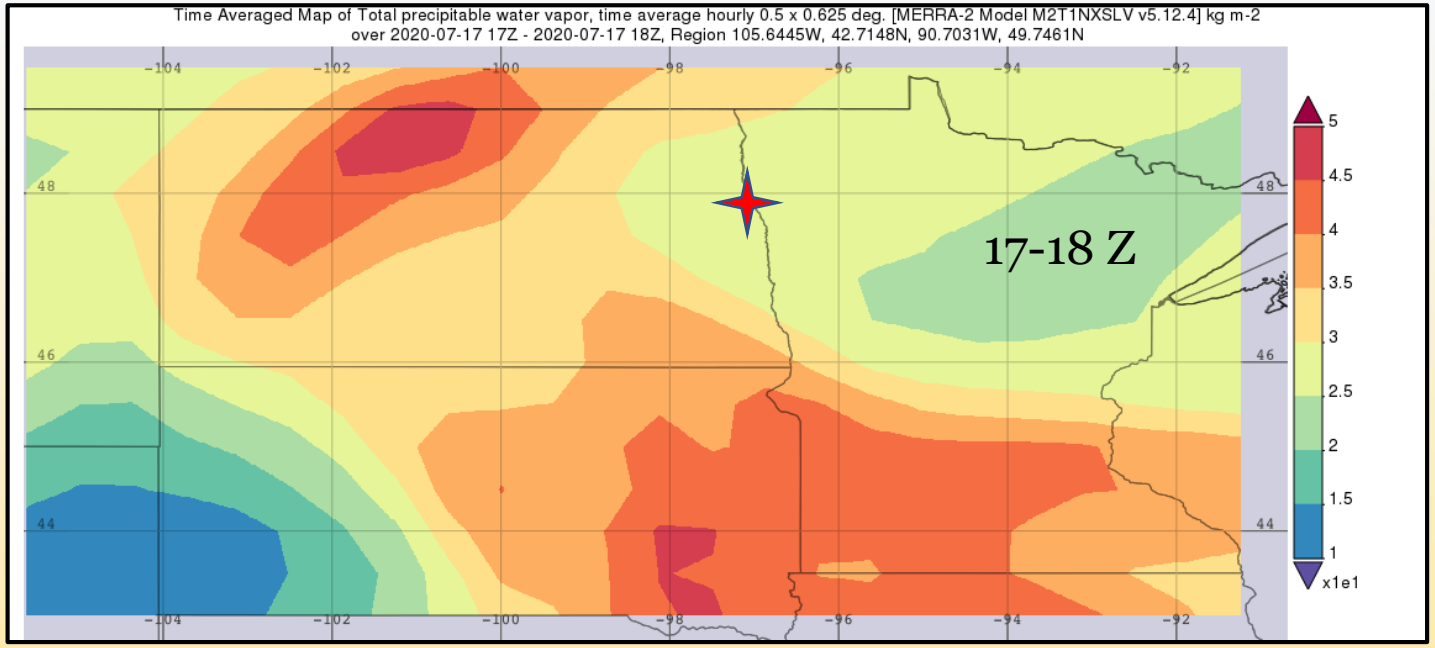
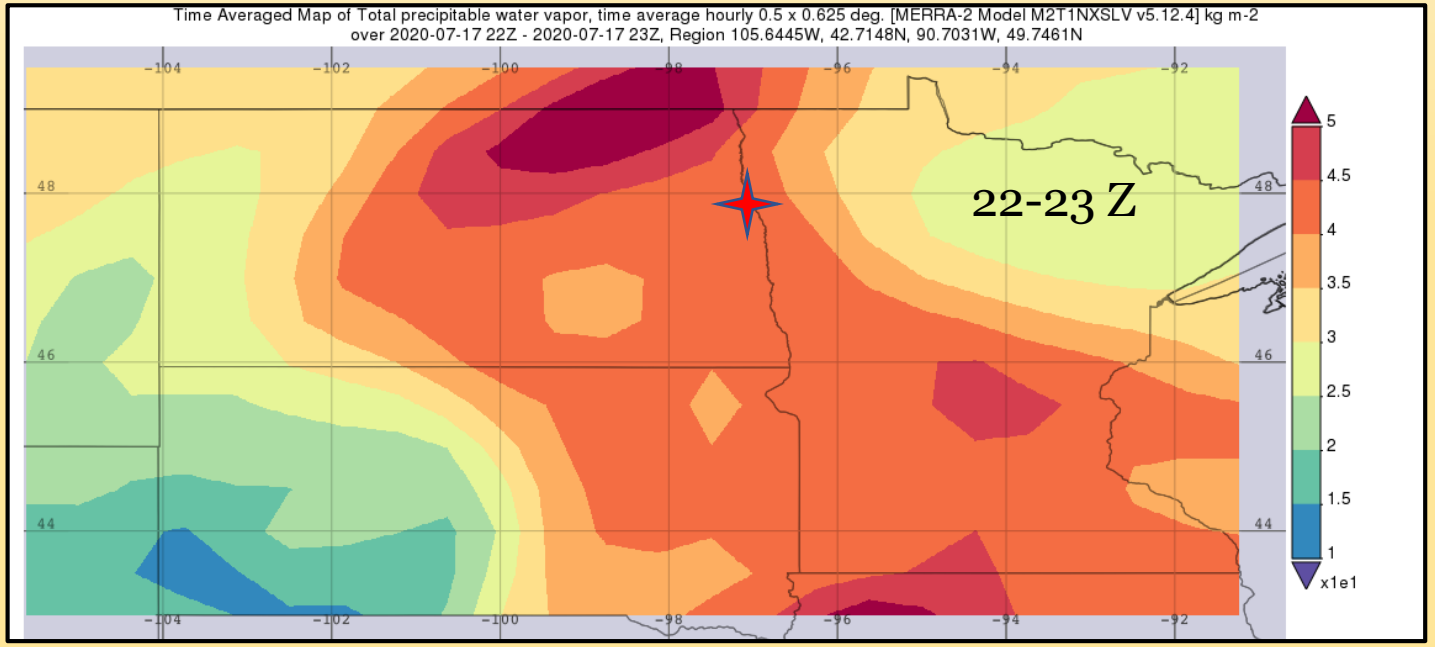
North Dakota – Minnesota – Wisconsin derecho, July 17, 2020:

Precipitable water from MERRA-2 Hourly Data





Grand Forks

Color scale 10-50 kg/m²

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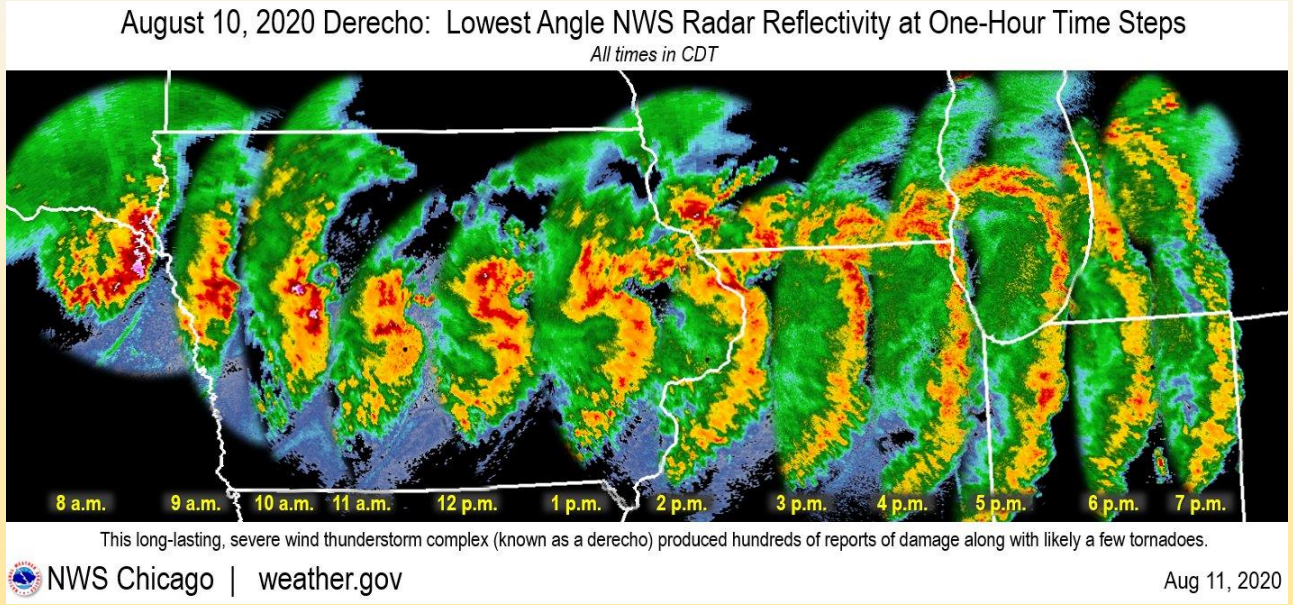
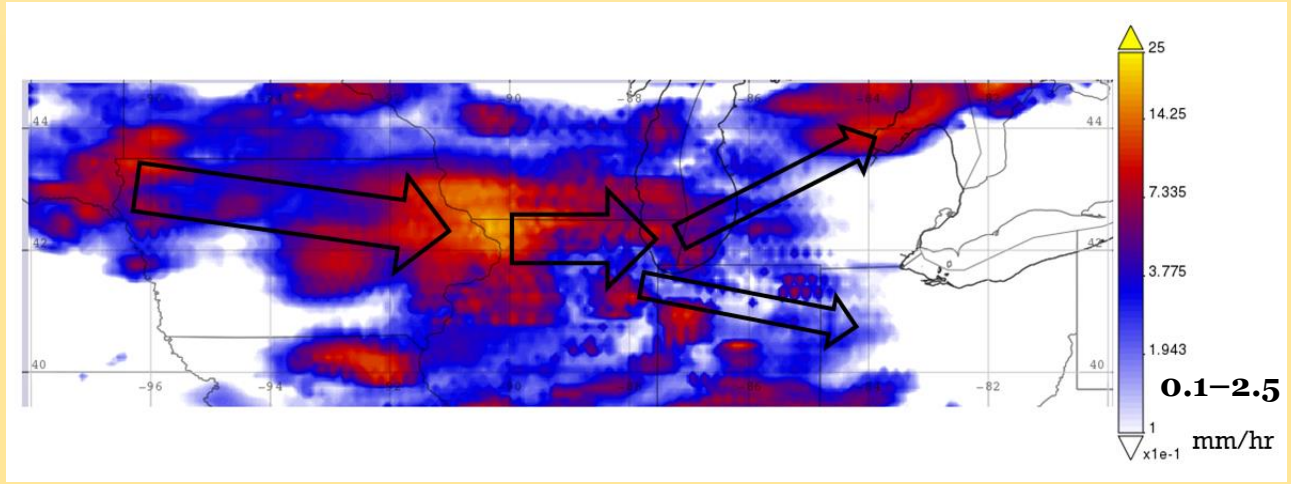
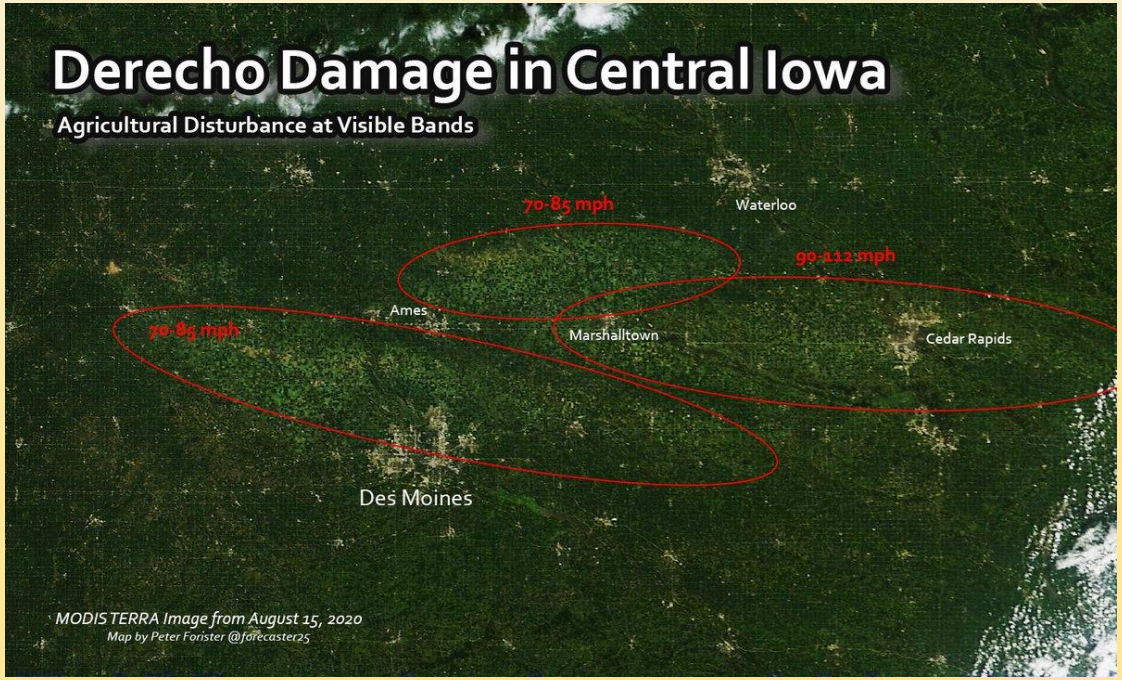
The Iowa “flat corn” derecho of August 10-11, 2020 – the most costly thunderstorm in U.S. history







MODIS-Terra image from August 15, 2020

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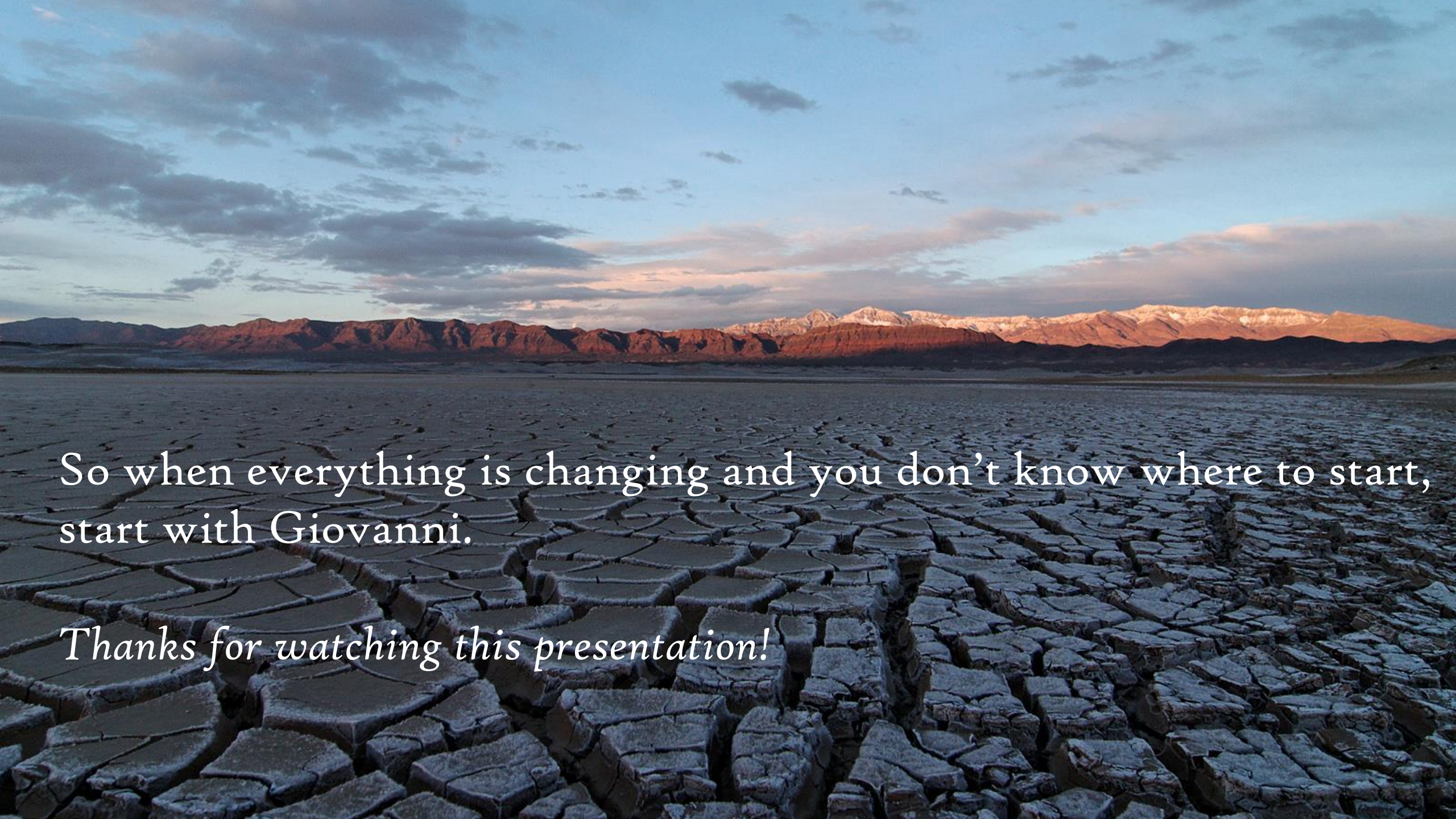
From its earliest version to its current state, Giovanni has been a pioneering technology utilizing NASA Earth science data with the power of online data access and visualization.

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!