Accessing NASA GES DISC Data for Flood Analyses

Flooding in Pakistan, August 28, 2022

Landsat 9 image

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Why are floods studied?

Floods —
are likely the most dangerous weather-related hazard known, in terms of endangerment to human lives, loss and destruction of land and property, and economic damage to infrastructure.

Floods —
are caused by different combinations of global and regional climate, geography, and weather patterns.

Floods —
can be studied using hydrological, meteorological, and socioeconomic variables, allowing insight into causes and effects, and informing post-disaster assessments.

Floods —
are likely increasing in both severity and frequency due to climate change, which is increasingly impacting vulnerable populations.

Flood Modes

Mode 1: Seasonal flooding

Characteristics:

- Areal Coverage: Regional / watershed scale
- Associated with: Rivers and lakes
- Temporal Duration: Weeks to months
- Causes: Seasonal change (warming, ice and snow melt, soil saturation, evapotranspiration)
- Aggravating factors: Erosion, channelization, climate changes (including shift in spring temperature increase, heavier precipitation in winter)

Comparison of Landsat images acquired March 20, 2018, and March 20, 2019, showing the effects of an intense late-winter storm and snowmelt, which caused severe flooding in the Midwest in 2019. The image shows the flood of the Missouri River adjacent to Offutt Air Force Base, south of Omaha, Nebraska. This event is examined with data available from the GES DISC in the News article "The 'Bomb Cyclone' and Midwest Flood of March 2019".

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Flood Modes

Mode 2: Coastal flooding

Characteristics:

- Areal Coverage: Regional / land adjacent to coast
- Associated with: Oceans / bays / large lakes
- Temporal Duration: Days to weeks
- Causes: Large storm systems (tropical storms and hurricanes, nor'easters, monsoons), high tides, seiches
- Aggravating factors: Sea level rise, coastal subsidence, climate changes (including more intense storms, storm track and movement), coastal infrastructure

Coastal flooding effects of Hurricane Florence on the North Carolina coast, September 2018 (Landsat 8). Featured in the GES DISC News article "Using NLDAS data to examine Hurricane Florence's record rainfall and its effects on the Carolinas"

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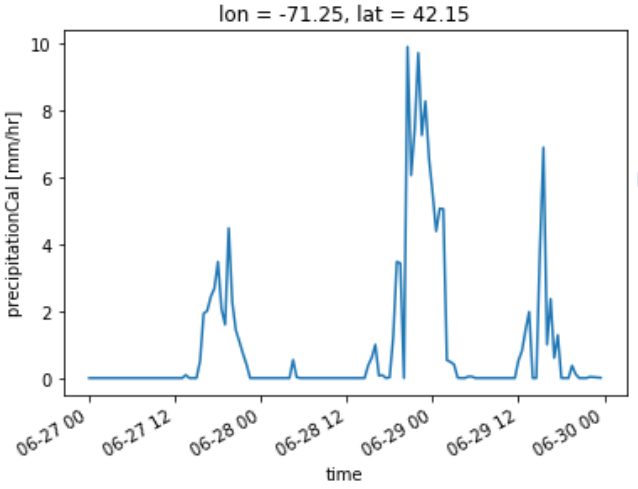
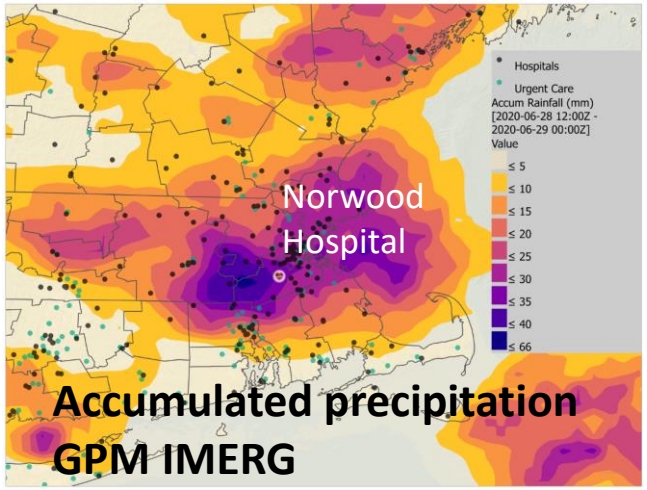
Flood Modes



Mode 3: Flash flooding

Characteristics:

- Areal Coverage: City / county / valley
- Associated with: Streams / dry courses / mountains
- Temporal Duration: Hours to days
- Causes: Severe storms, monsoon rains, landslides, volcanic activity, natural or artificial dam failure
- Aggravating factors: Impermeable surfaces, inadequate infrastructure, geography, climate changes (including heavier rainfall extremes, glacial melt), geography



Accumulated precipitation GPM IMERG

Image courtesy of Norwood Hospital

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NASA GES DISC Data Resources for Flood Studies

The NASA GES DISC archives both precipitation data and hydrological data that are useful for studying the causes and impacts of floods.

Precipitation data are available from these datasets:

- **I**ntegrated **M**ulti-satellit**E** **R**etrievals for **G**lobal Precipitation Measurement (**IMERG**)
- **G**lobal **P**recipitation **C**limatology **P**roject (**GPCP**)
- **M**odern-**E**ra **R**etrospective analysis for **R**esearch and **A**pplications version 2 (**MERRA-2**)
- **G**lobal and **N**orth American **L**and **D**ata **A**ssimilation **S**ystem (**GLDAS/NLDAS**)

Merged IR data allows examination of storm systems.

GLDAS and NLDAS also have a large variety of hydrological data variables, including surface and subsurface runoff, soil moisture, snow depth and snow melt, evaporation, and evapotranspiration.

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What characteristics of the data, and which variables, are useful for studying each of the flood modes?

Studying the Flood Modes

Seasonal Flooding

Temporal resolution: *Monthly, Daily*
Areal coverage: *Regional to continental scale*
Time period: *Annual to decadal*

Astronaut photograph of glacial meltwater flood in Greenland, a region strongly affected by global warming.

<u>Data Variables:</u>

Precipitation (rainfall, accumulated rainfall), snow depth, snowmelt, runoff, soil moisture, surface temperature, ground temperature, evaporation

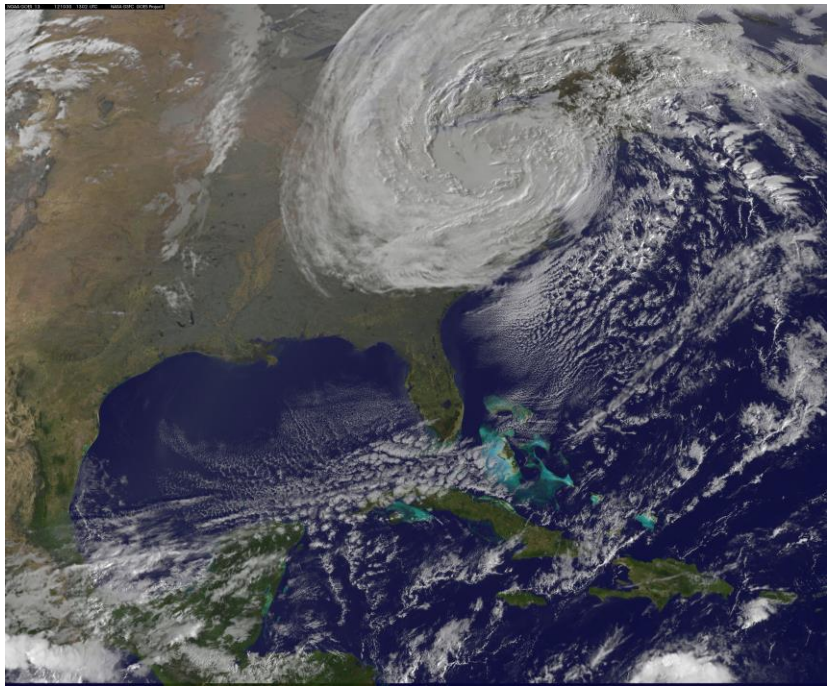
Monthly Data Products

Source	Product Name	Variable name	Resolution	Coverage
MERRA-2	M2SMNXEDI	Extreme precipitation indices for flood (RX5Day, RX1Day, R99p, R95p, R90p, CWD)	Monthly, 0.625x0.5 deg	1980.01 - global
MERRA-2	M2TMNXFLX	Total precipitation (**PRECTOTCORR**)	Monthly, 0.625x0.5 deg	1980.01 - global
IMERG	GPM_3IMERGM	precipitation, randomError	Monthly, 0.1 deg.	2000.06 - Global
GPCP	GPCPMON	combined satellite-gauge precipitation, combined satellite-gauge precipitation random error	Monthly, 0.5 deg.	1983.01 - Global
NLDAS	NLDAS_NOAH0125_M_2.0	Frozen precipitation, Liquid precipitation (rainfall), Surface runoff, Subsurface runoff, Snowmelt, Snow depth, Soil moisture (various depths), Root zone soil moisture, Potential Evapotranspiration, Evaporation, Streamflow	Monthly, 0.125 deg.	1979.01 – North America
NLDAS	NLDAS_MOS0125_M_2.0	Frozen precipitation, Liquid precipitation, Total evapotranspiration, Surface runoff, Subsurface runoff, Snowmelt, Snow depth, Soil moisture (various depths),Transpiration, Evaporation, Streamflow	Monthly, 0.125 deg.	1979.01 – North America
NLDAS	NLDAS_VIC0125_M_2.0	Frozen precipitation, liquid precipitation, Total evapotranspiration, Surface runoff, Subsurface runoff, Snowmelt, Snow depth, Soil moisture (various depths), Root zone soil moisture, Transpiration, Streamflow	Monthly, 0.125 deg	1979.01 – North America
GLDAS	GLDAS_CLSM10_M_2.1	Total precipitation rate, Snow precipitation rate, Rain precipitation rate, Evapotranspiration, Storm surface runoff, Baseflow-groundwater runoff, Snow melt, Snow depth, Root zone soil moisture, Surface soil moisture, Transpiration	Monthly, 1.0 degree	2000.01 - Global
GLDAS	GLDAS_NOAH025_M_2.1 GLDAS_NOAH10_M_2.1	Snow precipitation rate, Rain precipitation rate, Evapotranspiration, Storm surface runoff, Baseflow-groundwater runoff, Snow melt, Snow depth, Soil moisture (various depths), Evaporation, Transpiration, Total precipitation rate, Root zone soil moisture	Monthly, 0.25 degree, 1.0 degree	2000.01 - Global
GLDAS	GLDAS_VIC10_M_2.1	Snow precipitation rate, Rain precipitation rate, Evapotranspiration, Storm surface runoff, Baseflow-groundwater runoff, Snow melt, Snow depth, Soil moisture (various depths), Transpiration, Evaporation, Root zone soil moisture, Total precipitation rate	Monthly, 1.0 degree	2000.01 - Global

Studying the Flood Modes

Coastal Flooding

Temporal resolution: *Daily*
Areal coverage: *Regional to local scale*
Time period: *Annual, monthly*
(annual / decadal for trend analysis)



GOES image of Hurricane Sandy (October 30, 2012). Sandy was one of the most expensive storm events in U.S. history.

<u>Data Variables:</u>

Precipitation (rainfall, accumulated rainfall), wind speed, wind direction, soil moisture, surface temperature, humidity

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Daily Data Products

Source	Product Name	Variable name	Resolution	Coverage
MERRA-2	M2SDNXSLV	Maximum precipitation rate during the period (TPRECMAX)	Daily, 0.625x0.5 deg	1980.01 - global
IMERG	GPM_3IMERGDF	precipitationCal, randomError	Daily, 0.1 deg	2000.06- global
IMERG	GPM_3IMERGDE	precipitationCal, randomError	Daily, 0.1 deg.	2000.06 - Global
IMERG	GPM_3IMERGDL	precipitationCal, randomError	Daily, 0.1 deg	2000.06 - Global
GPCP	GPCPDAY	combined satellite-gauge precipitation, combined satellite-gauge precipitation random error	Daily, 0.5 deg.	1983.01 - Global
GLDAS	GLDAS_CLSM025_DA1_D_2.2	Evaporation, Evapotranspiration, Storm surface runoff, Baseflow-groundwater runoff, Snow melt, Snow depth, Soil moisture, Transpiration	Daiily, 0.25 degree	2000.01 - Global

Studying the Flood Modes

Flash Flooding

Temporal resolution: *Daily, 3-hourly, hourly*
Areal coverage: *Watershed and local scale*
Time period: *Monthly, daily*
(annual/ decadal for trend analysis)

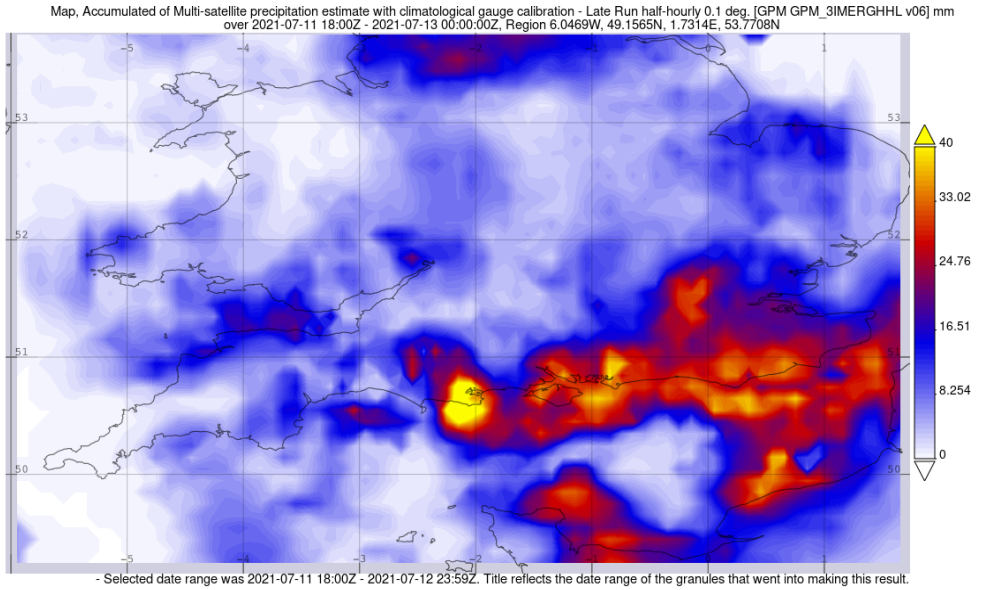

Image of IMERG accumulated rainfall data created with NASA Giovanni for rain and flash flood event in southern England and London, July 11-13, 2021, from the News article "Heavy rains lead to London floods".

Data Variables:

Precipitation (rainfall, accumulated rainfall), wind speed, wind direction, soil moisture, surface temperature, humidity

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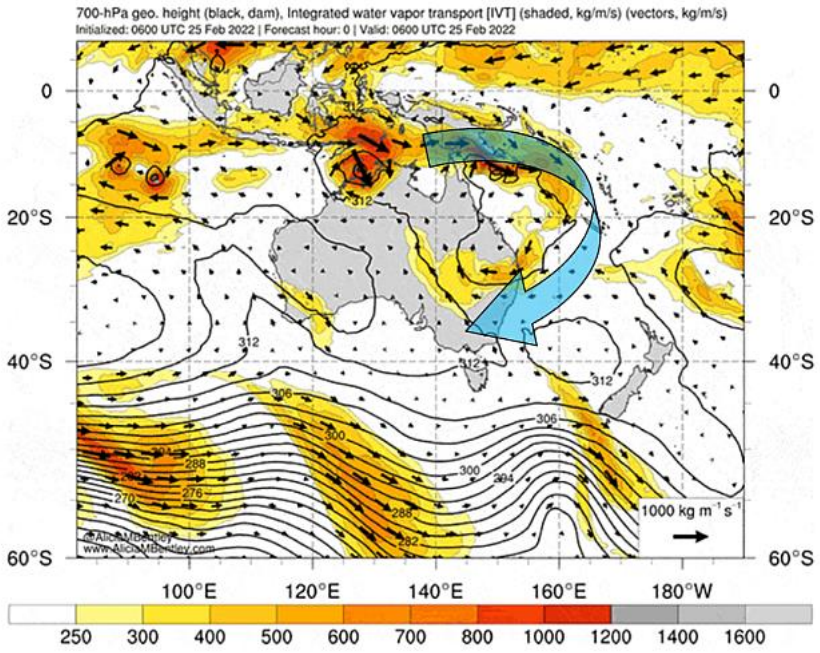
3-Hourly, Hourly, and Half-Hourly Data Products

Source	Product Name	Variable name	Resolution	Coverage
MERRA-2	M2T1NXFLX	Total precipitation (PRECTOTCORR)	Hourly,.625x 0.5 deg	1980.01 - global
IMERG	GPM_3IMERGHH	precipitationCal, randomError	Half-hourly, 0.1 deg.	2000.06 - Global
IMERG	GPM_3IMERGHHE	precipitationCal, randomError	Half-hourly, 0.1 deg.	2000.06 - Global
IMERG	GPM_3IMERGHHL	precipitationCal, randomError	Half-hourly, 0.1 deg	2000.06 - Global
NLDAS	NLDAS_NOAH0125_H_2.0	Frozen precipitation, Liquid precipitation (rainfall), Surface runoff, Subsurface runoff, Snowmelt, Snow depth, Soil moisture (various depths), Root zone soil moisture, Potential Evapotranspiration, Evaporation, Streamflow	Hourly, 0.125 deg.	1979.01 – North America
NLDAS	NLDAS_MOS0125_H_2.0	Frozen precipitation, Liquid precipitation, Total evapotranspiration, Surface runoff, Subsurface runoff, Snowmelt, Snow depth, Soil moisture (various depths),Transpiration, Evaporation, Streamflow	Hourly, 0.125 deg.	1979.01 – North America
NLDAS	NLDAS_VIC0125_H_2.0	Frozen precipitation, liquid precipitation, Total evapotranspiration, Surface runoff, Subsurface runoff, Snowmelt, Snow depth, Soil moisture (various depths), Root zone soil moisture, Transpiration, Streamflow	Hourly, 0.125 deg	1979.01 – North America
GLDAS	GLDAS_CLSM10_3H_2.1	Total precipitation rate, Snow precipitation rate, Rain precipitation rate, Evapotranspiration, Storm surface runoff, Baseflow-groundwater runoff, Snow melt, Snow depth, Root zone soil moisture, Surface soil moisture, Transpiration	3-Hourly, 1.0 degree	2000.01 - Global
GLDAS	GLDAS_NOAH025_3H_2.1 GLDAS_NOAH10_3H_2.1	Snow precipitation rate, Rain precipitation rate, Evapotranspiration, Storm surface runoff, Baseflow-groundwater runoff, Snow melt, Snow depth, Soil moisture (various depths), Evaporation, Transpiration, Total precipitation rate, Root zone soil moisture	3-Hourly, 0.25 degree, 1.0 degree	2000.01 - Global
GLDAS	GLDAS_VIC10_3H_2.1	Snow precipitation rate, Rain precipitation rate, Evapotranspiration, Storm surface runoff, Baseflow-groundwater runoff, Snow melt, Snow depth, Soil moisture (various depths), Transpiration, Evaporation, Root zone soil moisture, Total precipitation rate	3-Hourly, 1.0 degree	2000.01 - Global

Demonstration: Flood Event Use Case

Brisbane, Australia flooding, February 2022

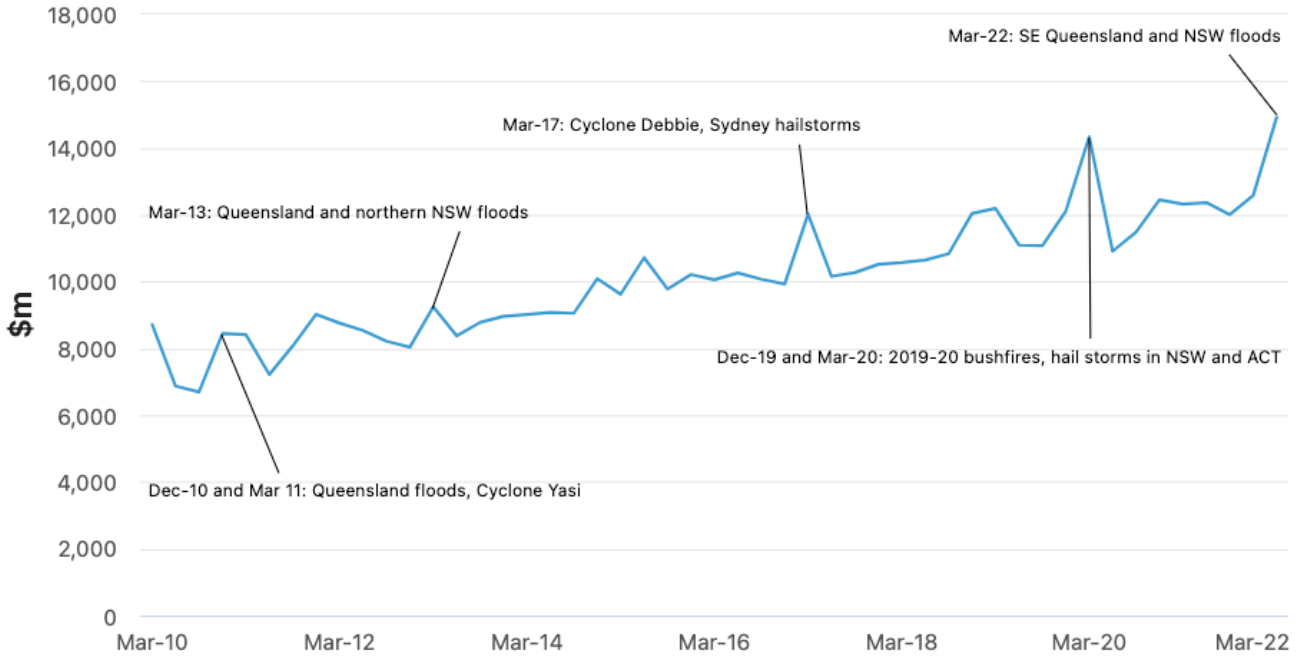


Forecast map of integrated water vapor transport for February 25, created by Alicia Bentley. From the GES DISC News article "Precipitation data provides a detailed view of extraordinary rainfall event in Australia"

In February 2022, atmospheric circulation caused an air mass laden with a large amount of water vapor to move from over the warm ocean waters north of Australia to the eastern coast, as shown by the blue arrow. This circulation caused a “train” of storms dropping heavy rainfall to move over Brisbane, Australia for several days. The massive rainfall created extraordinary flash floods in and near Brisbane. Following this event, the train of storms eased to the south, causing flooding rainfall in Sydney and environs.

Darker orange and red indicates higher amounts of water vapor.

Studying Precipitation Trends



[Australian Bureau of Statistics]

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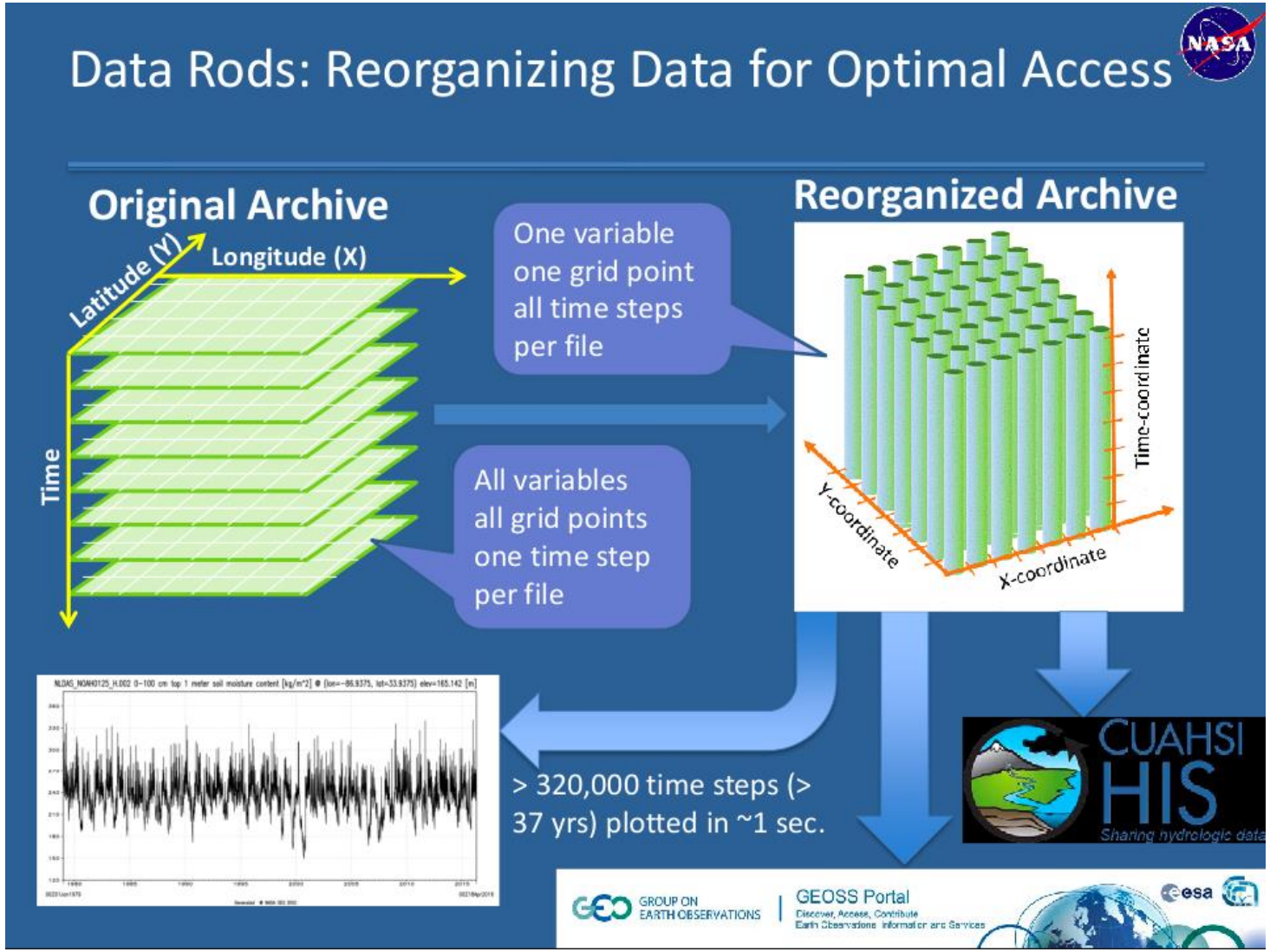
Hydrology Data Rods



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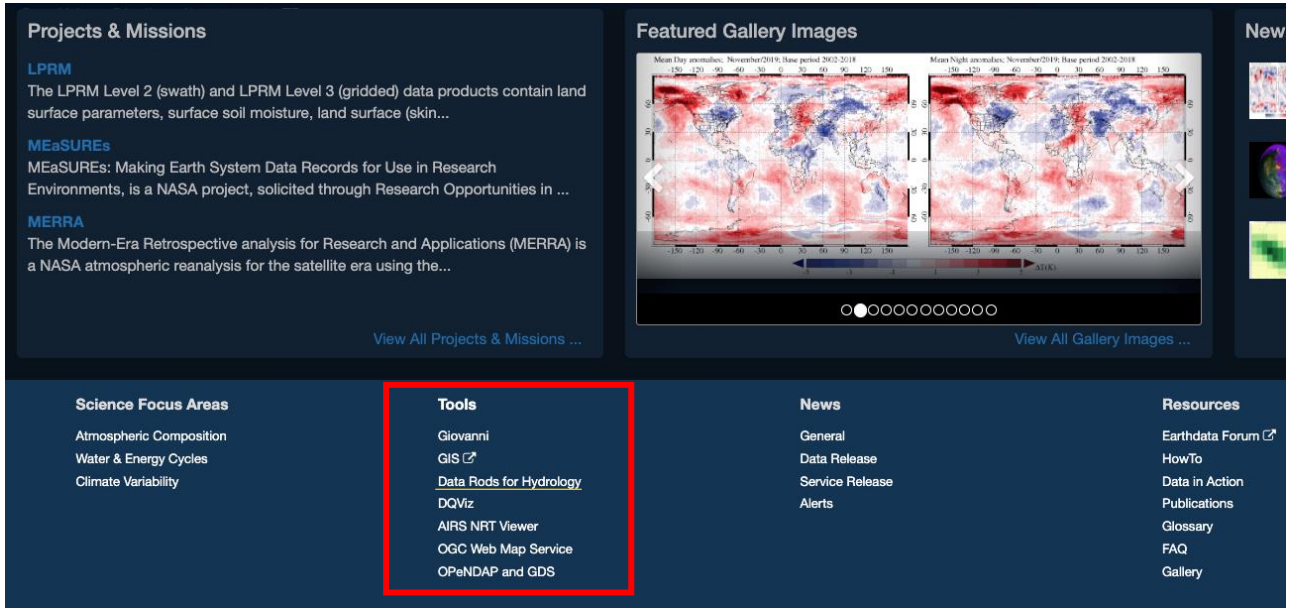
Hydrology Data Rods



GLDAS Noah Land Surface Model L4 3 hourly 0.25 x 0.25 degree V2.1 (GLDAS_NOAH025_3H)

*GLDAS version 2.1 data products have been reprocessed (as of January 31, 2020). After consultation with the GLDAS scientist and data producer, we are temporarily maintaining the access to the existing GLDAS_NOAH025_3H_2.1 data rods files. Once the data rods files for the reprocessed GLDAS version 2.1 have been generated, they will replace these existing files. In the interim, please be aware that, though these GLDAS version 2.1 data rods files were derived from the pre-reprocessed GLDAS 2.1 data, the data accessible via the *GLDAS 2.1 landing page* are of the recently reprocessed GLDAS 2.1 version.

** UPDATE (4/22/20, Earth Day) - We have begun regenerating the data rods files for the reprocessed GLDAS version 2.1. We expect this process to take 1-2 months and will update this message when all the data rods files have been regenerated.

*** UPDATE (5/18/20) – We have finished regenerating the GLDAS 2.1 data rods to use the reprocessed GLDAS 2.1 data. All GLDAS 2.1 access points at the GES DISC are now providing the same version.

Qsb_acc	Baseflow-groundwater runoff	kg/m^2	plot	asc2
Rainf_f_tavg	Total precipitation rate	kg/m^2/s	plot	asc2
Rainf_tavg	Rain precipitation rate	kg/m^2/s	plot	asc2
RootMoist_inst	Root zone soil moisture	kg/m^2	plot	asc2
Snowf_tavg	Snow precipitation rate	kg/m^2/s	plot	asc2
SoilMoi0_10cm_inst	Soil moisture content (0-10 cm underground)	kg/m^2	plot	asc2
SoilMoi10_40cm_inst	Soil moisture content (10-40 cm underground)	kg/m^2	plot	asc2
SoilMoi40_100cm_inst	Soil moisture content (40-100 cm underground)	kg/m^2	plot	asc2
SoilMoi100_200cm_inst	Soil moisture content (100-200 cm	kg/m^2	plot	asc2

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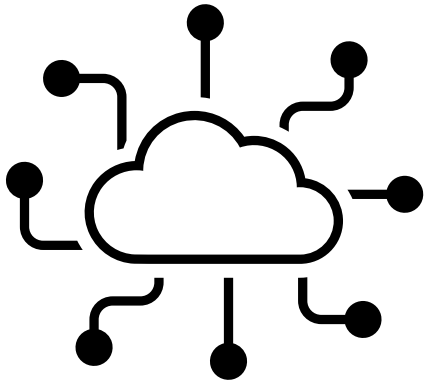
Accessing Hydrology Time Series Data



pandas

matplotlib

Hydrology Data Rods API

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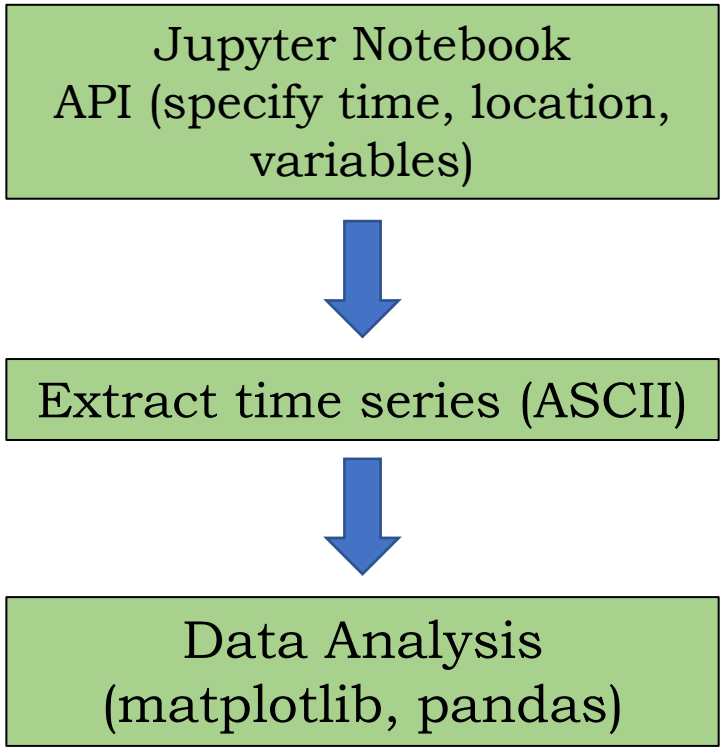
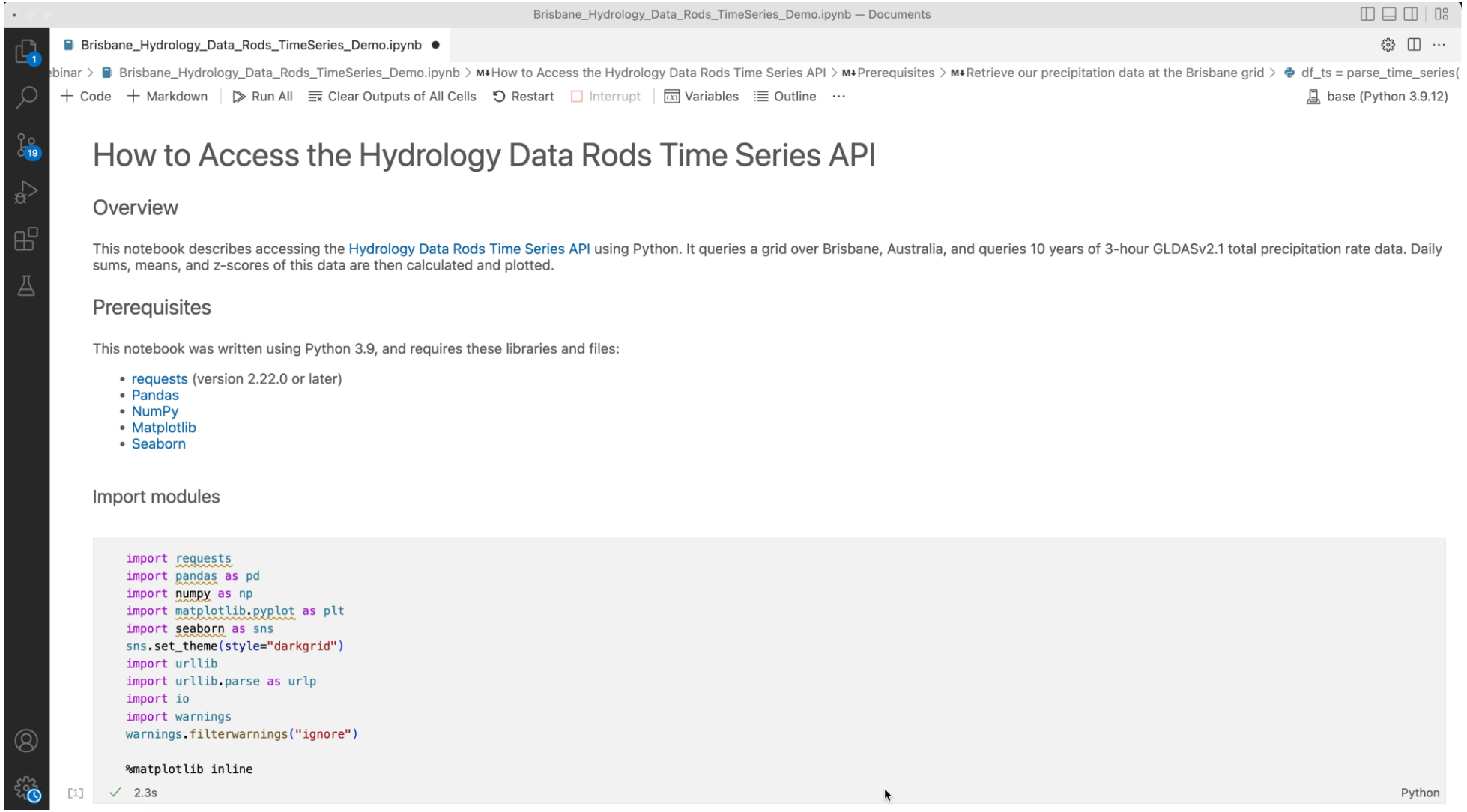
Jupyter Notebook Demonstration

- **Generate Time Series over Brisbane Grid**

- **Variables**
  - Total Precipitation Rate: (GLDAS2:GLDAS_NOAH025_3H_v2.1:Rainf_f_tavg)
    - 3-hourly
- **Time**
  - 2012-06-01 - 2022-05-31



Jupyter Notebook Demonstration



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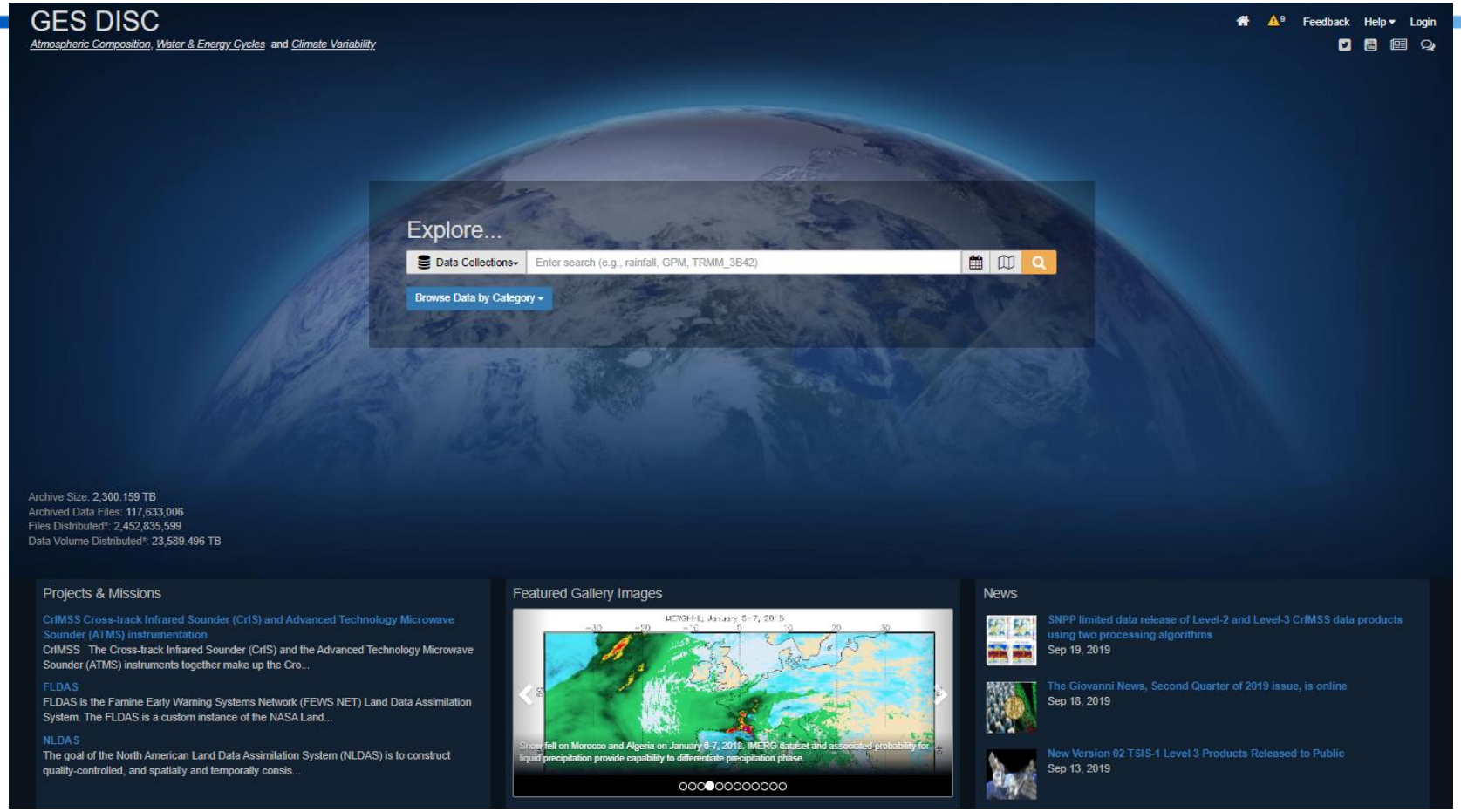
Data Search and Access at the GES DISC



The GES DISC provides access to numerous datasets from NASA remote-sensing missions and related Earth science models. Datasets can be searched for using keywords, and mission or dataset names.

Descriptive documentation is provided for every dataset on individual dataset landing pages.

Data can be ordered using tools developed by the GES DISC, enabling temporal and spatial subsetting for many Level 2 and Level 3 data products.

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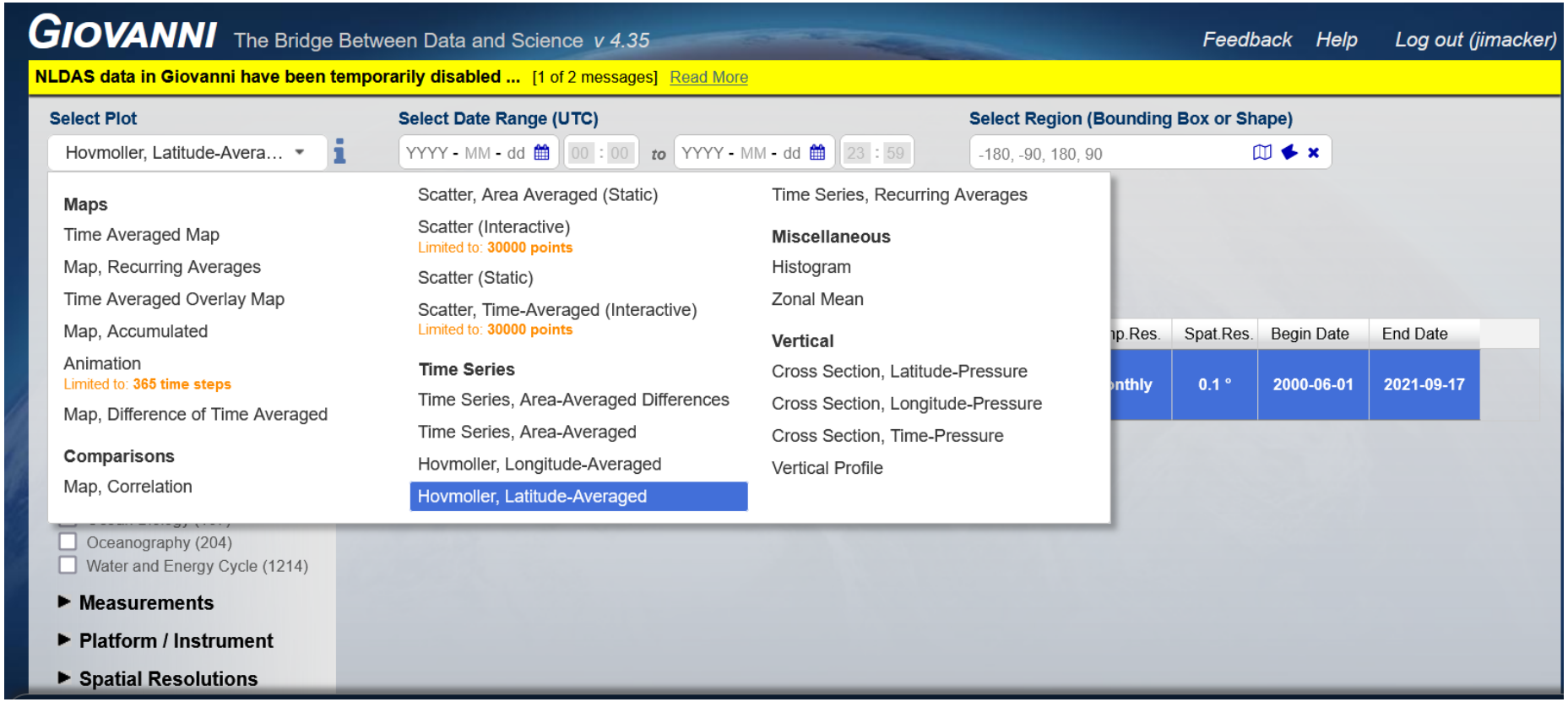
Analytical Capabilities of NASA Giovanni for Flood Research



In addition to time-series analysis, the Giovanni system provides other analytical capabilities, including time-averaged maps for selected time intervals and areas, including major river watersheds; correlation maps; maps of accumulated variables for specific time intervals, such as accumulated rainfall; Hovmöller plots; and atmospheric vertical profiles.

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Data Collections for Flood Analyses

Search links

Precipitation (Rainfall rate, Accumulated Rainfall)	IMERG: https://disc.gsfc.nasa.gov/datasets?keywords=IMERG GPCP: https://disc.gsfc.nasa.gov/datasets?keywords=GPCP
Precipitation, runoff, snow depth, snowmelt, soil moisture, evaporation, evapotranspiration	GLDAS: https://disc.gsfc.nasa.gov/datasets?keywords=GLDAS NLDAS: https://disc.gsfc.nasa.gov/datasets?keywords=NLDAS
Surface temperature, atmospheric temperature, water vapor	AIRS: https://disc.gsfc.nasa.gov/datasets?keywords=AIRS
Precipitation, windspeed, wind direction, water vapor, humidity, pressure	MERRA-2: https://disc.gsfc.nasa.gov/datasets?keywords=MERRA-2
Cloud temperature	Merged IR: https://disc.gsfc.nasa.gov/datasets/GPM_MERGIR_1/summary

Data Collections for Flood Analyses – MERRA-2

Source	Product Name	Variable name	Resolution	Coverage	Processing Level, Data Type	Data Access
MERRA-2	M2SMNXEDI	Extreme precipitation indices for flood (RX5Day, RX1Day, R99p, R95p, R90p, CWD)	Monthly, 0.625x0.5 deg	1980.01 - global	Level 4, grid	Get Data
MERRA-2	M2TMNXFLX	Total precipitation (PRECTOTCORR)	Monthly, 0.625x0.5 deg	1980.01 - global	Level 4, grid	Get Data
MERRA-2	M2SDNXSLV	Maximum precipitation rate during the period (TPRECMAX)	Daily, 0.625x0.5 deg	1980.01.01 - global	Level 4, grid	Get Data
MERRA-2	M2T1NXFLX	Total precipitation (PRECTOTCORR)	Hourly, 0.625x0.5 deg	1980.01.01 - global	Level 4, grid	Get Data

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Data Collections for Flood Analyses -- NLDAS/GLDAS

Source	Product Name	Resolution	Coverage	Variables
NLDAS	NLDAS_NOAH0125_H_2.0	Hourly, 0.125 deg	1979.01 - North America	Frozen precipitation, Liquid precipitation (rainfall), Surface runoff, Subsurface runoff, Snowmelt, Snow depth, Soil moisture (various depths), Root zone soil moisture, Potential Evapotranspiration, Evaporation, Streamflow
NLDAS	NLDAS_NOAH0125_M_2.0	Monthly, 0.125 deg	1979.01- North America	
NLDAS	NLDAS_MOS0125_H_2.0	Hourly, 0.125 deg	1979.01 - North America	Frozen precipitation, Liquid precipitation, Total evapotranspiration, Surface runoff, Subsurface runoff, Snowmelt, Snow depth, Soil moisture (various depths),Transpiration, Evaporation, Streamflow
NLDAS	NLDAS_MOS0125_M_2.0	Monthly, 0.125 deg	1979.01 - North America	
NLDAS	NLDAS_VIC0125_H_2.0	Hourly, 0.125 deg	1979.01 - North America	Frozen precipitation, Liquid precipitation, Total evapotranspiration, Surface runoff, Subsurface runoff, Snowmelt, Snow depth, Soil moisture (various depths), Root zone soil moisture, Transpiration, Streamflow
NLDAS	NLDAS_VIC0125_M_2.0	Monthly, 0.125 deg	1979.01 - North America	
GLDAS	GLDAS_CLSM10_3H_2.1	3-hourly, 1.0-degree	2000.01 - Global	Total precipitation rate, Snow precipitation rate, Rain precipitation rate, Evapotranspiration, Storm surface runoff, Baseflow-groundwater runoff, Snow melt, Snow depth, Root zone soil moisture, Surface soil moisture, Transpiration
GLDAS	GLDAS_CLSM10_M_2.1	Monthly, 1.0-degree	2000.01 - Global	
GLDAS	GLDAS_NOAH025_3H_2.1 GLDAS_NOAH10_3H_2.1	3-hourly, 0.25 degree, 1.0-degree	2000.01 - Global	Snow precipitation rate, Rain precipitation rate, Evapotranspiration, Storm surface runoff, Baseflow-groundwater runoff, Snow melt, Snow depth, Soil moisture (various depths), Evaporation, Transpiration, Total precipitation rate, Root zone soil moisture
GLDAS	GLDAS_NOAH025_M_2.1 GLDAS_NOAH10_M_2.1	Monthly, 0.25 degree, 1.0-degree	2000.01 - Global	
GLDAS	GLDAS_VIC10_3H_2.1	3-hourly, 1.0 degree	2000.01 - Global	Snow precipitation rate, Rain precipitation rate, Evapotranspiration, Storm surface runoff, Baseflow-groundwater runoff, Snow melt, Snow depth, Soil moisture (various depths), Transpiration, Evaporation, Root zone soil moisture, Total precipitation rate
GLDAS	GLDAS_VIC10_M_2.1	Monthly, 1.0 degree	2000.01 - Global	
GLDAS	GLDAS_CLSM025_DA1_D_2.2	Daily, 0.25 degree	2003.02.01 - Global	Evaporation, Evapotranspiration, Storm surface runoff, Baseflow-groundwater runoff, Snow melt, Snow depth, Soil moisture, Transpiration

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Gray rows are popular products

Data Collections for Flood Analyses – IMERG & GPCP

Note: The TRMM Multi-satellite Precipitation Analysis (TMPA) data collection has been superseded by the IMERG data collection.

Source	Product Name	Resolution	Coverage	Variables
IMERG	GPM_3IMERGHH	Half-hourly, 0.1 deg.	2000.06.01 - Global	precipitationCal, randomError
IMERG	GPM_3IMERGDF	Daily, 0.1 deg.	2000.06.01 - Global	precipitationCal, randomError
IMERG	GPM_3IMERGM	Monthly, 0.1 deg.	2000.06 - Global	precipitation, randomError
IMERG	GPM_3IMERGHHE	Half-hourly, 0.1 deg.	2000.06.01 - Global	precipitationCal, randomError
IMERG	GPM_3IMERGDE	Daily, 0.1 deg.	2000.06.01 - Global	precipitationCal, randomError
IMERG	GPM_3IMERGHHL	Half-hourly, 0.1 deg.	2000.06.01 - Global	precipitationCal, randomError
IMERG	GPM_3IMERGDL	Daily, 0.1 deg.	2000.06.01 - Global	precipitationCal, randomError
GPCP	GPCPDAY	Daily, 0.5 deg.	2000.06.01 - Global	precip
GPCP	GPCPMON	Monthly, 0.5 deg.	1983.01 - Global	combined satellite-gauge precipitation, combined satellite-gauge precipitation random error

Acknowledgments

We wish to thank our colleagues Xiaohua Pan, Ashley Heath, Zhong Liu, and Christine Smit for their assistance with the content of this presentation.

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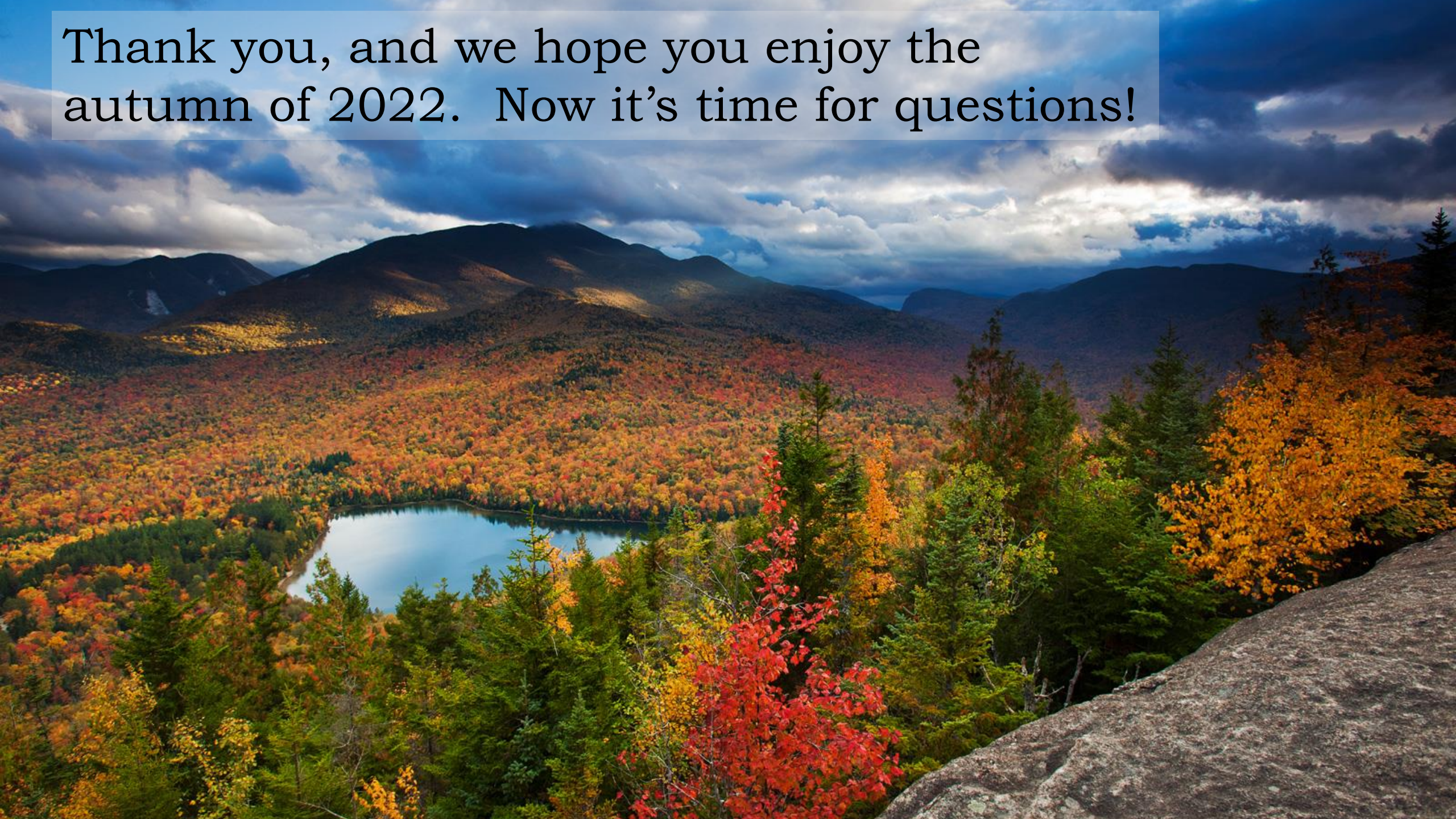
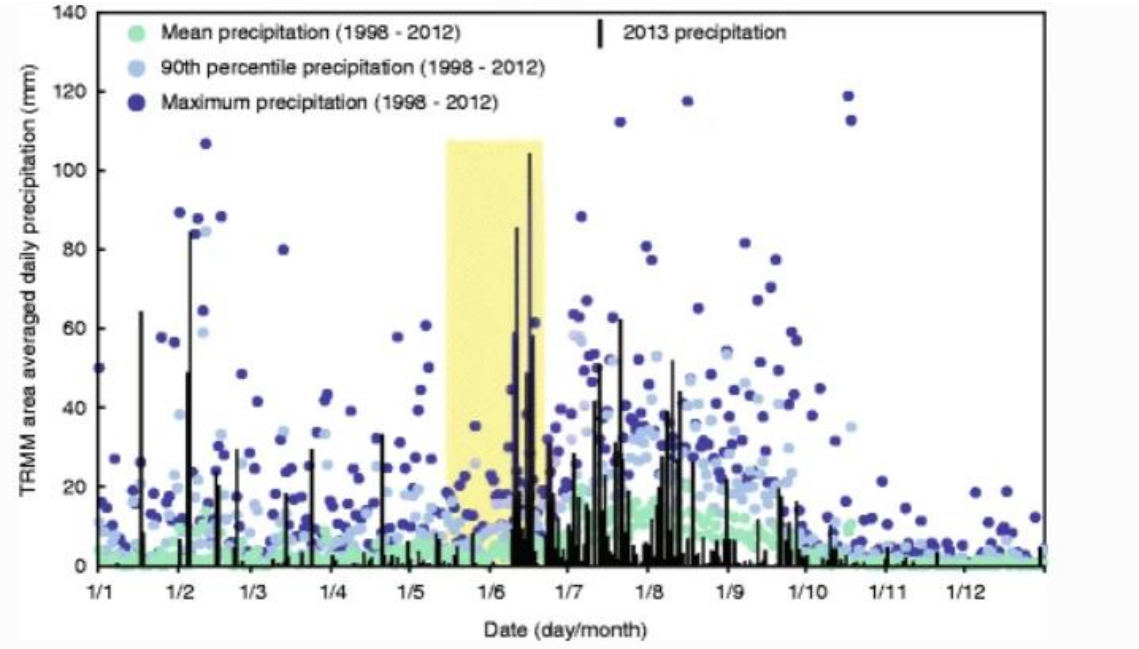
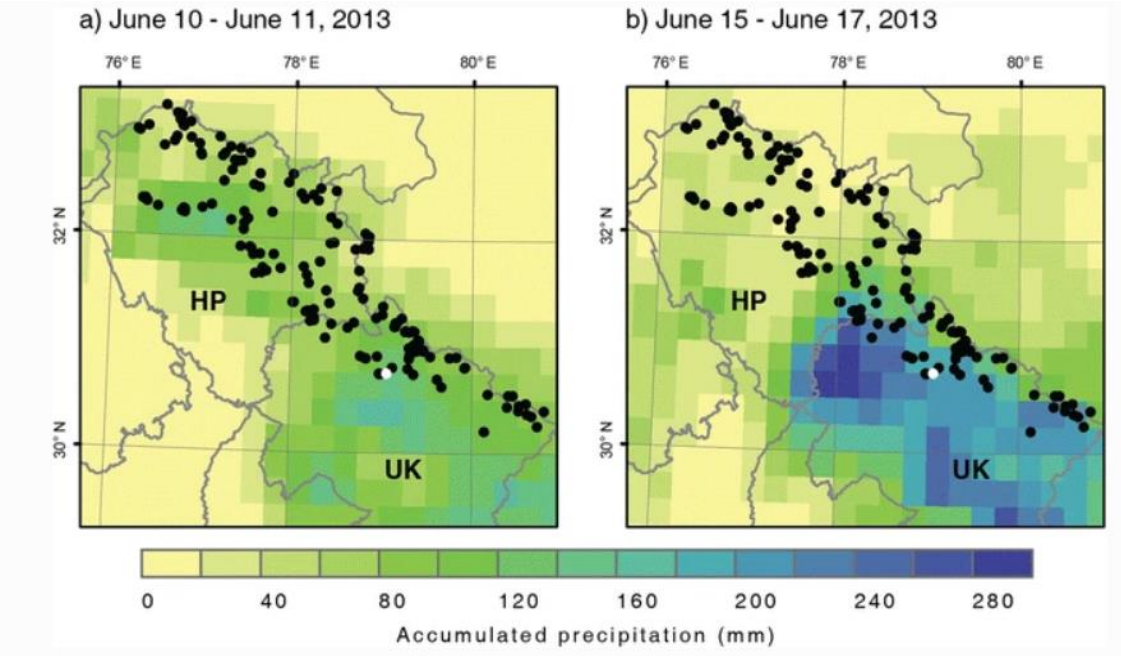

Thank you, and we hope you enjoy the autumn of 2022. Now it's time for questions!

Supplemental slide

Figures from the paper "Allen, S.K., Rastner, P., Arora, M. *et al.* Lake outburst and debris flow disaster at Kedarnath, June 2013: hydrometeorological triggering and topographic predisposition. *Landslides* **13**, 1479–1491 (2016). https://doi.org/10.1007/s10346-015-0584-3





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