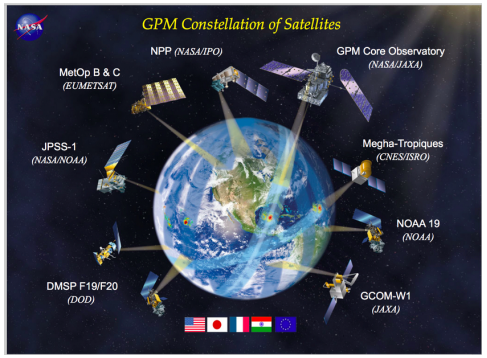
WELCOME TO
NASA APPLIED REMOTE SENSING TRAINING (ARSET)
WEBINAR SERIES

INTRODUCTION TO GLOBAL PRECIPITATION MEASUREMENTS (GPM) DATA AND APPLICATIONS

COURSE DATES: EVERY TUESDAY, MARCH 17, 24, 31
TIME: 8 TO 9 AM AND 1 TO 2 PM EDT

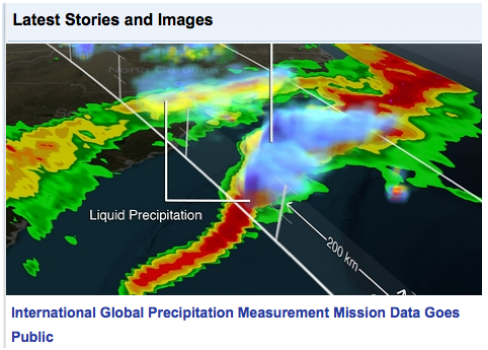
Webinar Outline

Week 1



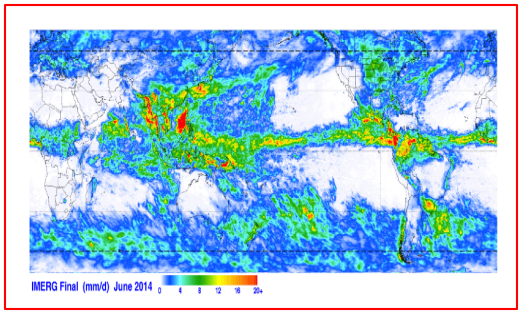
Precipitation Remote Sensing Overview of TRMM and GPM

Week 2



TRMM/GPM Data Products and Data Access Tools

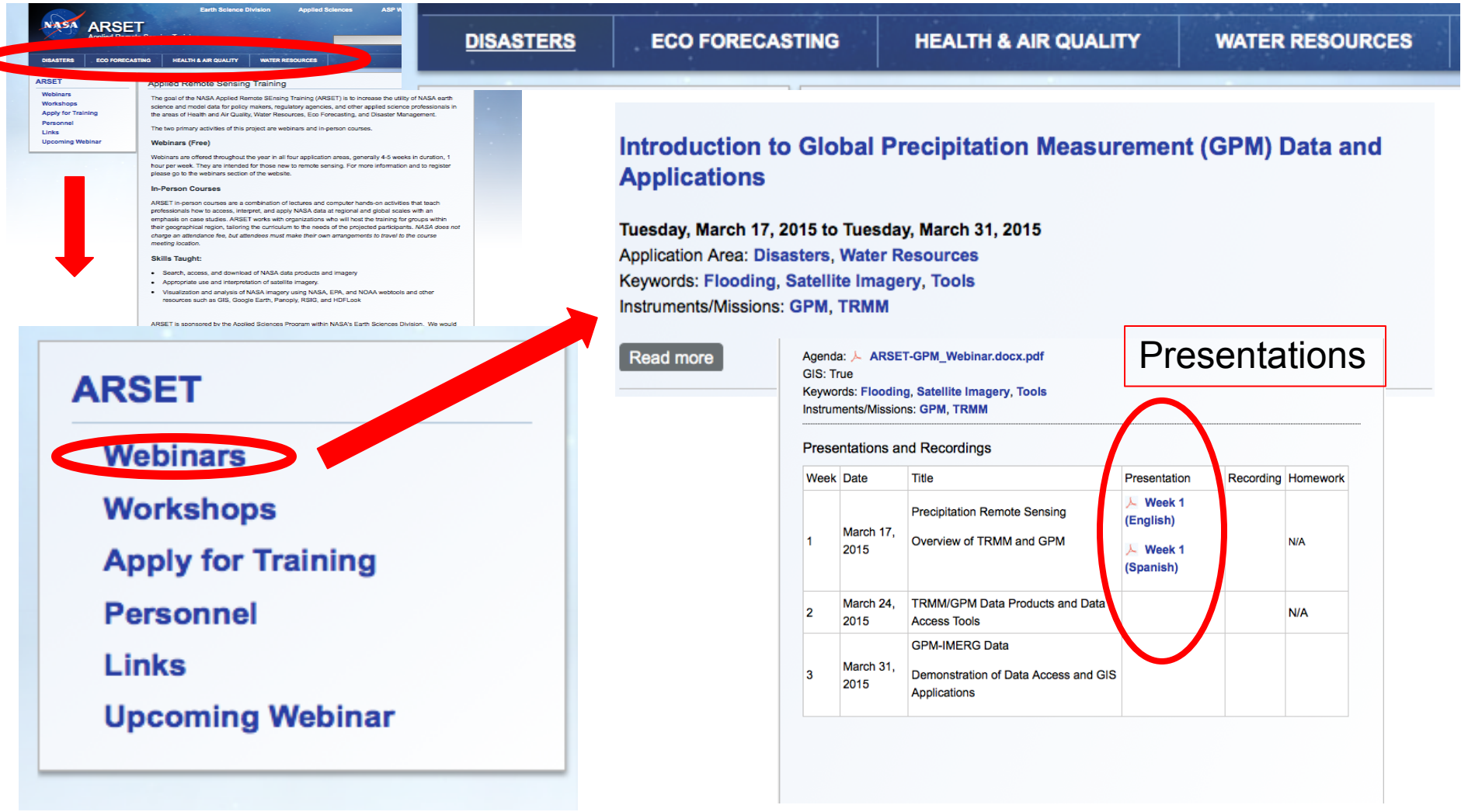
Week 3



GPM-IMERG Data Demonstration of Data Access and GIS Applications

ARSET Webinars Website

http://arset.gsfc.nasa.gov



Review of Weeks 1 & 2

Remote Sensing of Precipitation

- Inferred indirectly from reflected solar radiation and emitted Infrared radiation by clouds **(Passive Remote Sensing)**
- Estimated from microwave radiation emitted or scattered by surface and precipitation particles **(Passive Remote Sensing)**
- Estimated from back-scattered microwave radiation transmitted by radars **(Active Remote Sensing)**

TRMM

One active and two passive rain sensors
*Precipitation Radar (**PR**)*
*TRMM Microwave Imager (**TMI**)*
*Visible and Infrared Scanner (**VIRS**)*

GPM

One active and one passive rain sensors
Dual-frequency *Precipitation Radar (**DPR**)*
*GPM Microwave Imager (**GMI**)*

GPM GMI and DPR Measurements

http://pmm.nasa.gov/GPM

GMI

- Higher frequency channels, not included in TMI, for improved light rain and snow detection
- Higher spatial resolutions
- Reference for constellation radiometers calibration

GPM constellation satellites have revisit times of 1-2 hours over land

DPR

- Higher sensitivity to light rain and snow compared to TRMM-PR
- Better accuracy of measurements
- Better identification of liquid, ice, mixed-phase precipitation particles
- Reference standard for inter-calibration of constellation precipitation measurements

GPM Level-2 and -3 Data Products Information

http://pmm.nasa.gov/data-access/downloads/gpm

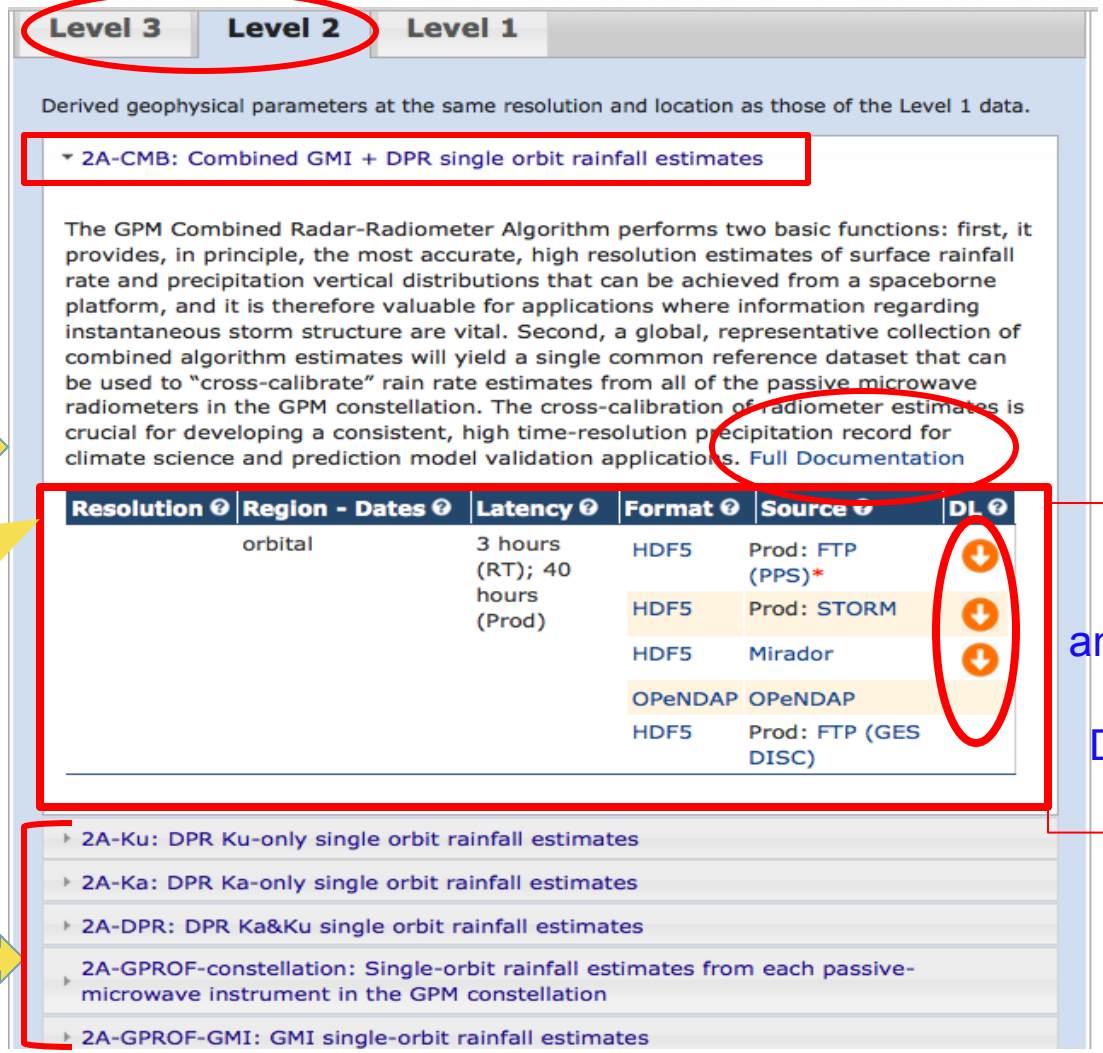
Data Product Name

Data Product Documentation

Data Product Summary

Multiple Data Products Useful for Research and Applications

Multiple Formats and Options for Data Download



Summary of GPM Data Access Tools

Tools	Data Products and Formats	Analysis and/or Visualization	Data Download
Mirador http://mirador.gsfc.nasa.gov	**L1B, L2, and L3 GMI-GPROF** **IMERG Half-hourly, Monthly** Orbital and Gridded Daily, Monthly HDF5, OPenDAP (can be converted to ASCII, Binary, NetCDF)	N/A	Batch Download
Giovanni http://giovanni.gsfc.nasa.gov/giovanni/	**IMERG Half-hourly, Monthly** NetCDF, GeoTIFF, PNG	**Visualization:** Map, Time Series, Scatter Plot Histogram **Analysis:** Time-averaged Maps, Time Series, Scatter Plot, Map Correlations, Vertical Profiles, Time-averaged Differences	Download by Select and Click on Data Files
PPS/STORM https://storm.pps.eosdis.nasa.gov/storm	**L1B and 1C, L2, L3 GMI, DPR, GMI-DPR Combined Data**, Orbital and Gridded Daily, Monthly IMERG Half-hourly, Monthly HDF5, PNG	Map Visualization, Interactive Latitude/Longitude Point Data Value Display	FTP

TMPA: TRMM Multi-satellite Precipitation Analysis
IMERG: Integrated Multi-satellitE Retrievals for GPM

IMERG is conceptually similar to TRMM TMPA, combines GPM GMI/DPR data with the GPM constellation satellites to yield improved spatial/temporal precipitation estimates:

	IMERG	TMPA
Temporal Resolution :	30-minutes	3 hours
Spatial Resolution:	0.1°x0.1°	0.25°x0.25°
Spatial Coverage:	Global 60°S to 60°N	Global 50°S to 50°N

Constellation Satellites:
GCOM-W, DMSP, Megha-Tropiques, MetOp-B, NOAA-N', NPP, NPOESS

Week 3 Agenda

- ***GPM IMERG*** *Guest speaker: Dr. George Huffman (NASA-GSFC)*

- **Case Study: GPM IMERG Precipitation Data for Hurricane Arthur**

  Brock Blevins: Demonstration of IMERG data access from Giovanni-4 and using IMERG in GIS ArcMAP

- **Course Summary**

GPM IMERG

Dr. George Huffman (NASA-GSFC)

george.j.huffman@nasa.gov

Insights on the Day-1
Integrated Multi-satellitE Retrievals for GPM (IMERG) Data Sets

The GPM Multi-Satellite Team

George J. Huffman NASA/GSFC, Chair
David T. Bolvin SSAI and NASA/GSFC
Dan Braithwaite Univ. of California Irvine
Kuolin Hsu Univ. of California Irvine
Robert Joyce Innovim and NOAA/NWS/CPC
Chris Kidd ESSIC and NASA/GSFC
Soroosh Sorooshian Univ. of California Irvine
Pingping Xie NOAA/NWS/CPC

Introduction
IMERG Design
Examples
Validation
Future
Final Comments

1. INTRODUCTION

A diverse, changing, uncoordinated set of input precip estimates

Goal: seek the longest, most detailed record of "global" precip

IMERG is a High-Resolution Precipitation Product

- best snapshot precipitation
- not a Climate Data Record

IMERG is a unified U.S. algorithm that takes advantage of

- KF-CMORPH – NOAA
- PERSIAN-CCS – U.C. Irvine
- TMPA – NASA
- PPS production – NASA

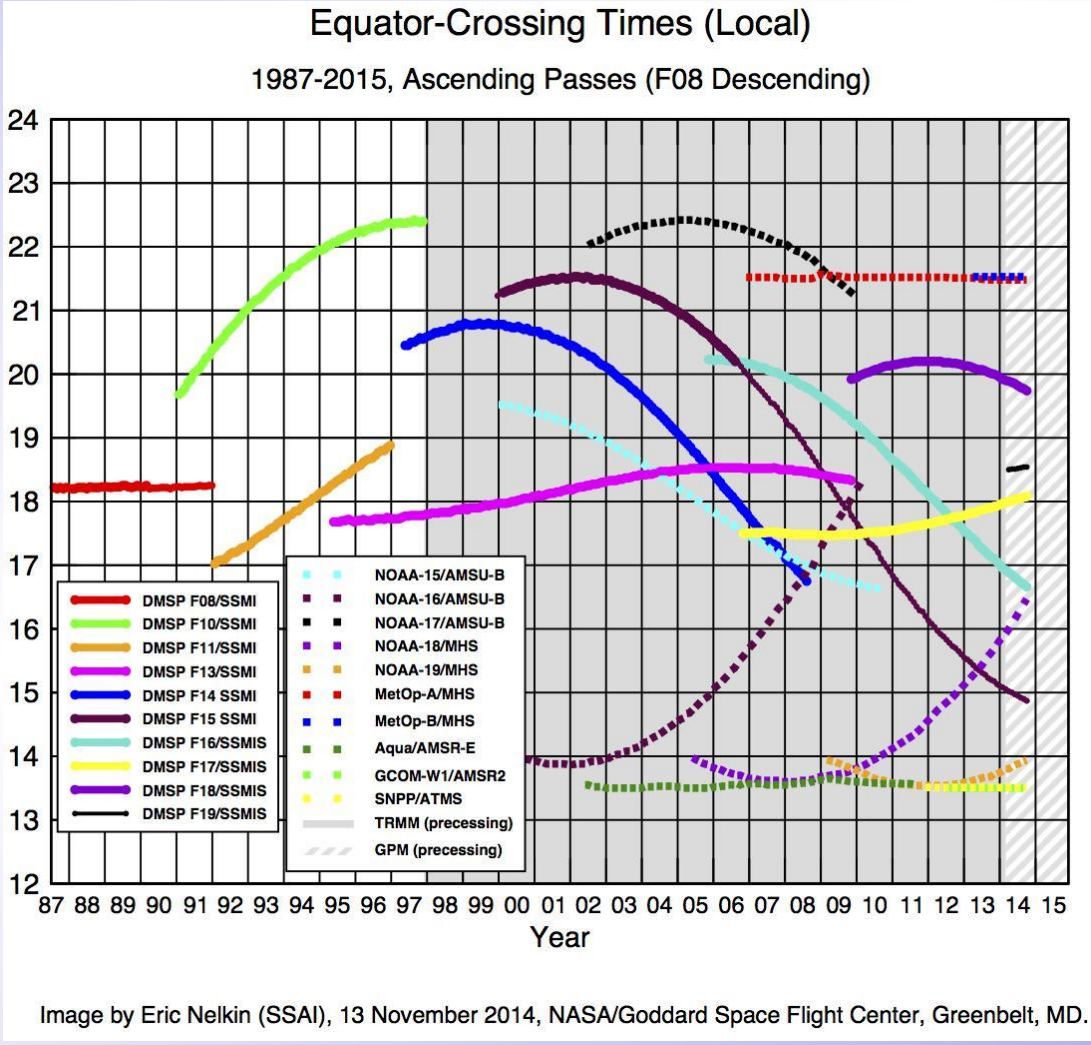


Image by Eric Nelkin (SSAI), 13 November 2014, NASA/Goddard Space Flight Center, Greenbelt, MD.

2. IMERG Data Sets

Multiple runs accommodate different user requirements for latency and accuracy

- "Early" – 4 hours (flash flooding)
- "Late" – 12 hours (crop forecasting)
- "Final" – 3 months (research data)

Time intervals are half-hourly and monthly (Final only)

0.1° global CED grid

- PPS will provide subsetting by parameter and location
- initial release covers 60°N-S

User-oriented services

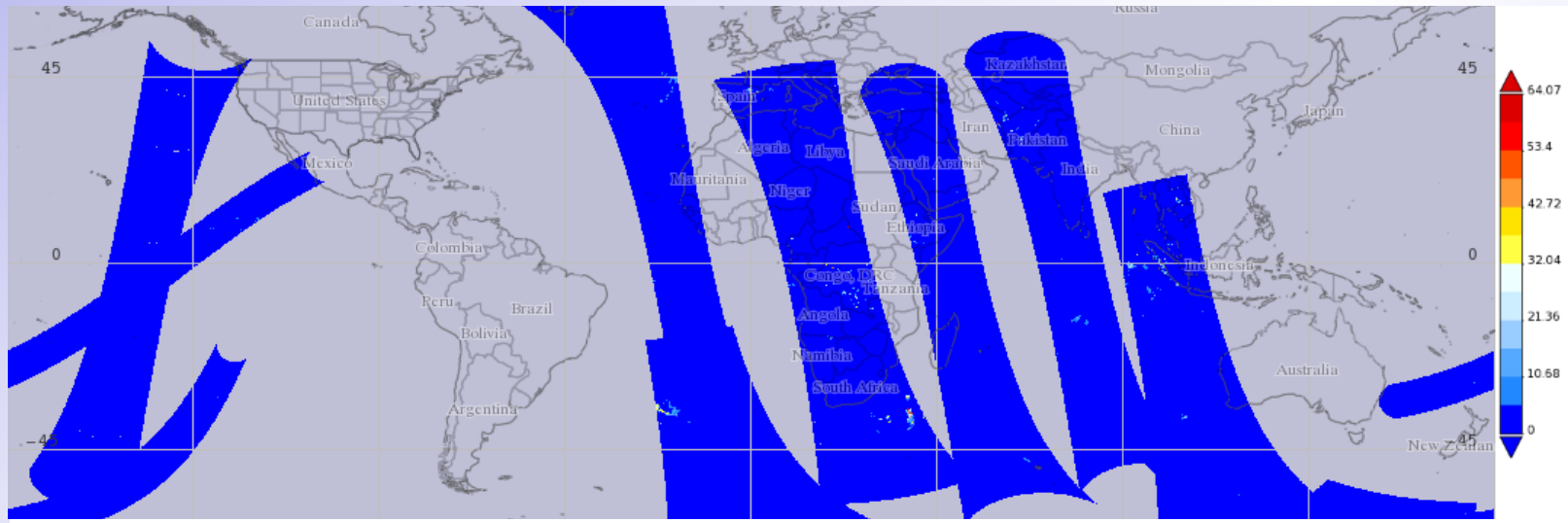
- interactive analysis (GIOVANNNI)
- alternate formats (KMZ, KML, TIFF WRF files, …)
- area averages

	Half-hourly data file (Early, Late, Final)
1	*[multi-sat.] precipitationCal*
2	[multi-sat.] precipitationUncal
3	*[multi-sat. precip] randomError*
4	[PMW] HQprecipitation
5	[PMW] HQprecipSource [identifier]
6	[PMW] HQobservationTime
7	IRprecipitation
8	IRkalmanFilterWeight
9	*probabilityLiquidPrecipitation [phase]*
	Monthly data file (Final)
1	*[sat.-gauge] precipitation*
2	*[sat.-gauge precip] randomError*
3	GaugeRelativeWeighting
4	*probabilityLiquidPrecipitation [phase]*

3. EXAMPLES – Data Fields from IMERG Test Data (1/4)

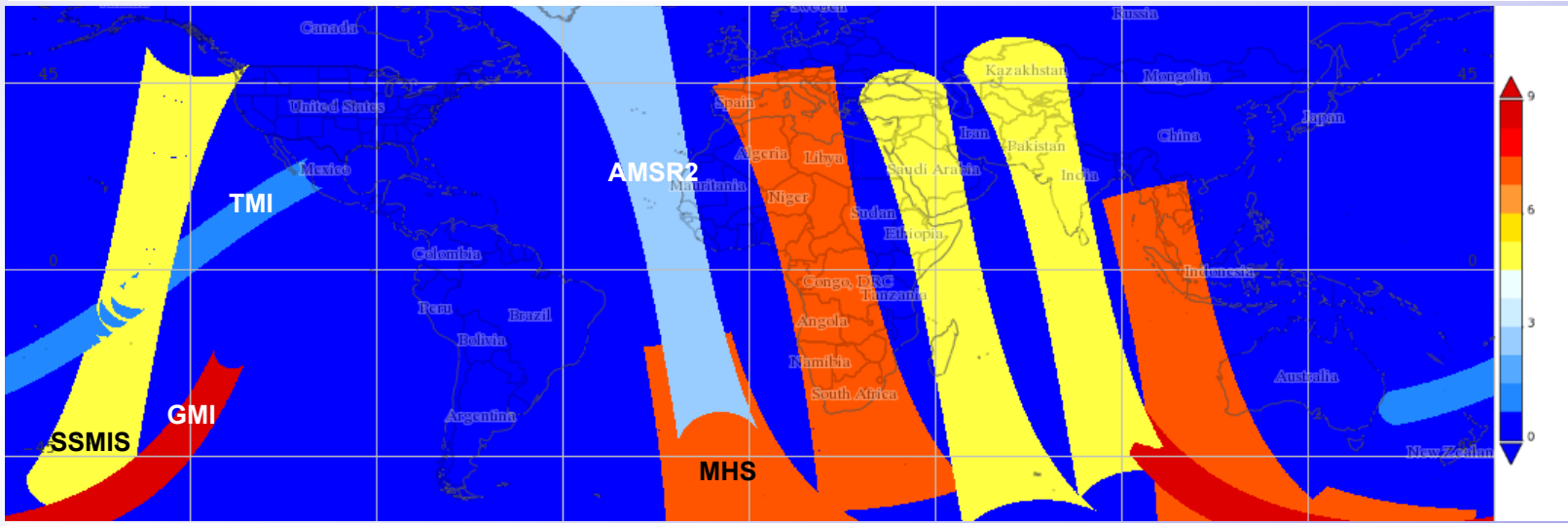
1430-1500Z 3 April 2014

PMW data collected in the half hour



[PMW] HQprecipSource [identifier] (mm/hr)

PMW sensor contributing the data, selected as imager first, then sounder, then closest to center time

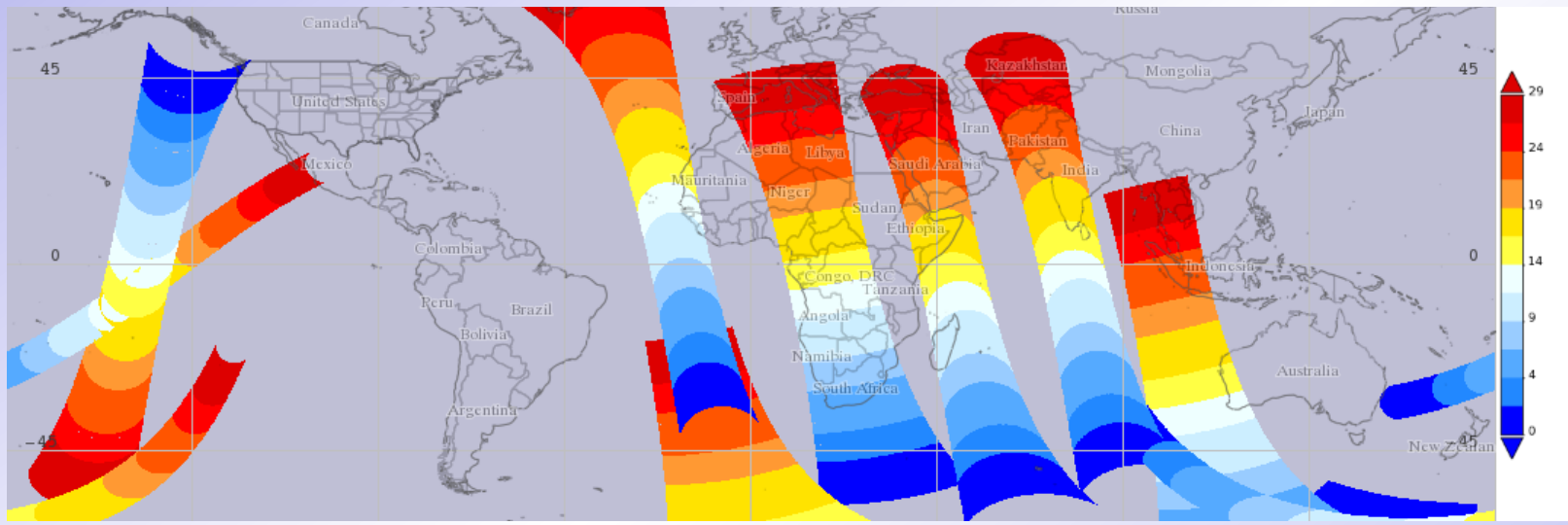


[PMW] HQprecipSource [identifier]

3. EXAMPLES – Data Fields from IMERG Test Data (2/4)

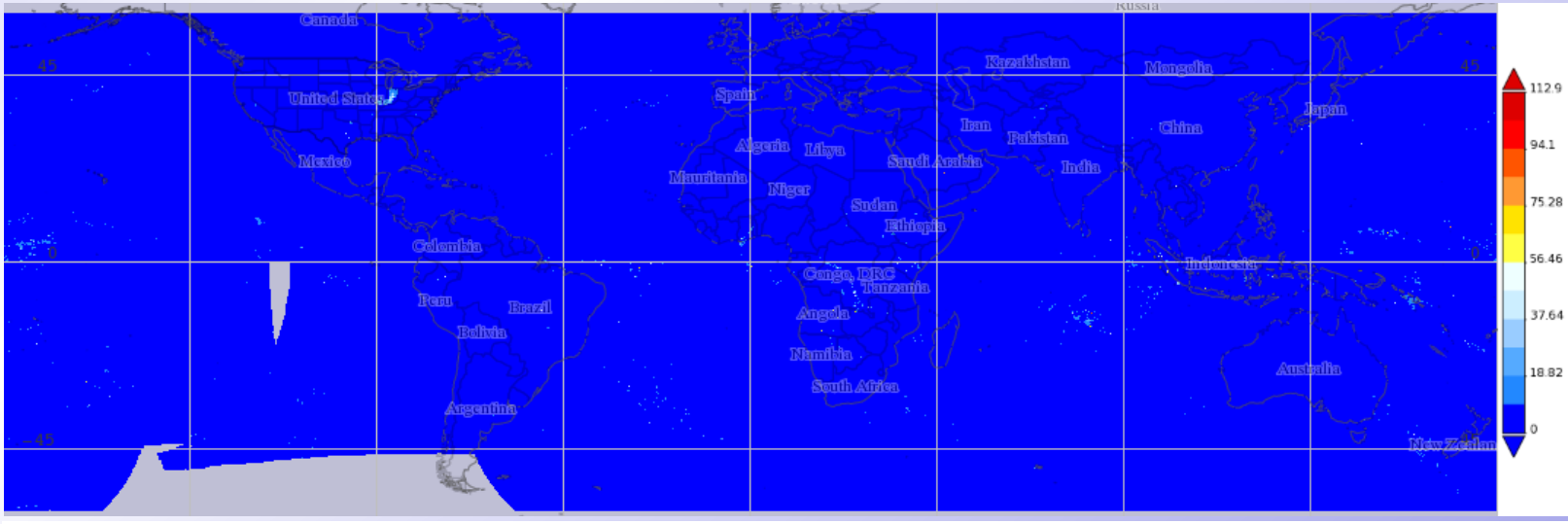
1430-1500Z 3 April 2014

PMW sensor observation time after start of half hour



[PMW] HQobservationTime (min)

precip from merged geo-IR data

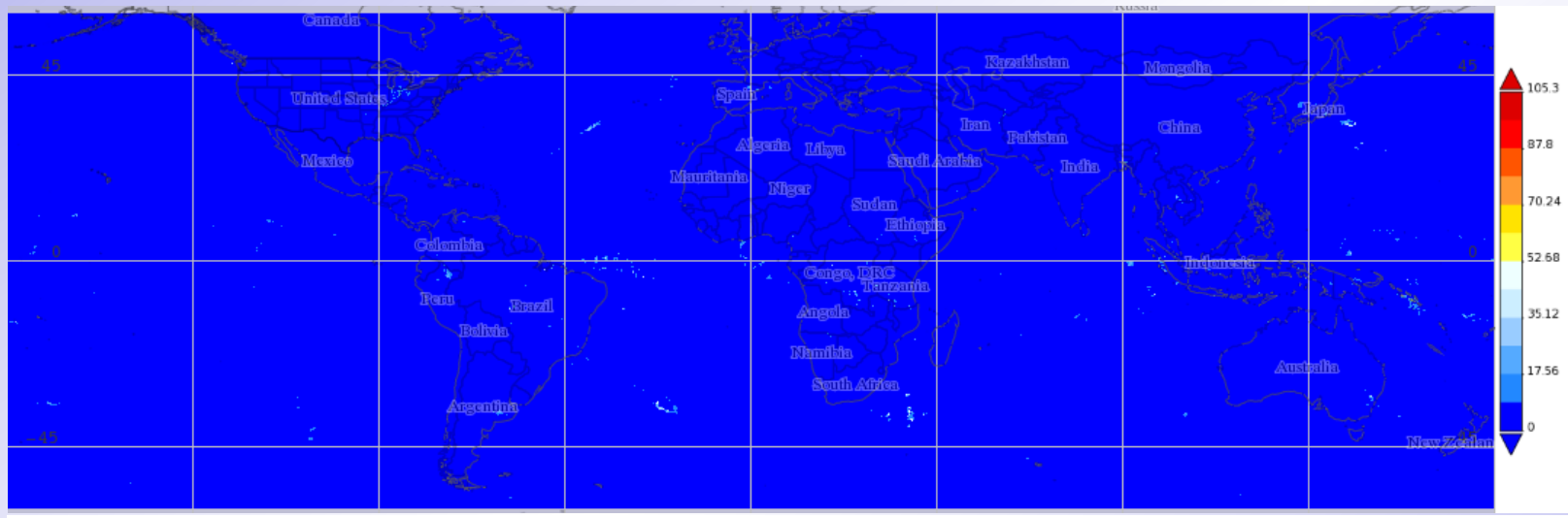


IRprecipitation (mm/hr)

3. EXAMPLES – Data Fields from IMERG Test Data (3/4)

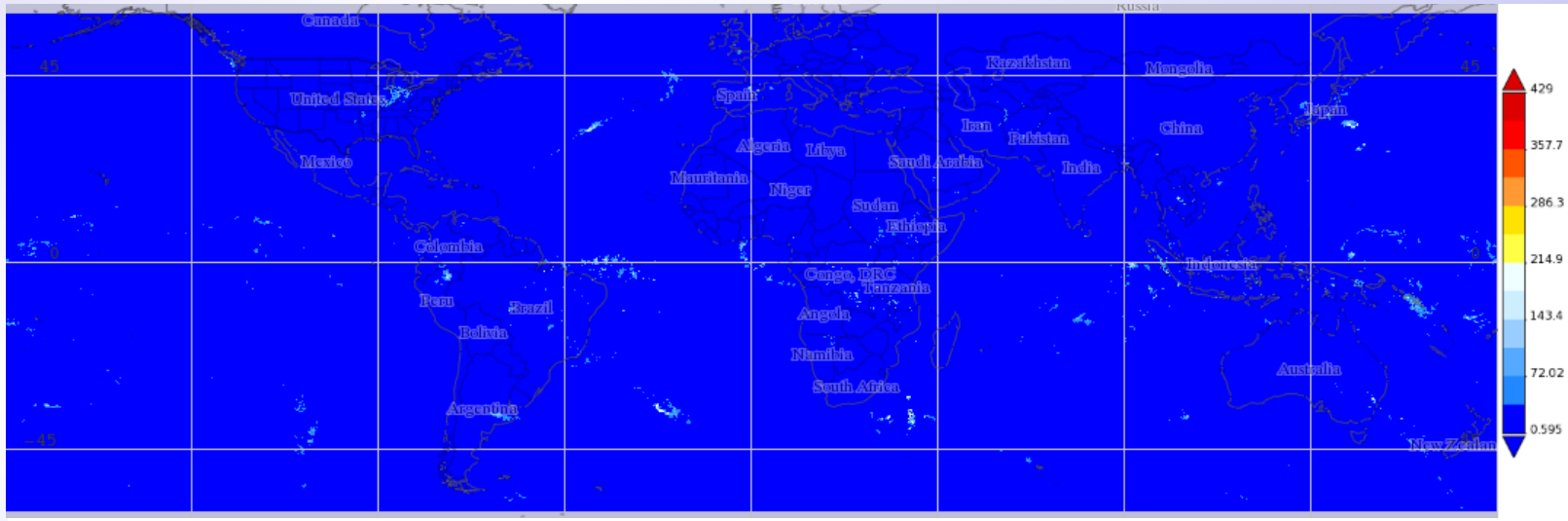
1430-1500Z 3 April 2014

"Final" IMERG field: forward and backward morphed microwave, Kalman filter with IR data; monthly gauge



[multi-sat.] precipitationCal (mm/hr)

estimated random error for the multi-satellite precip

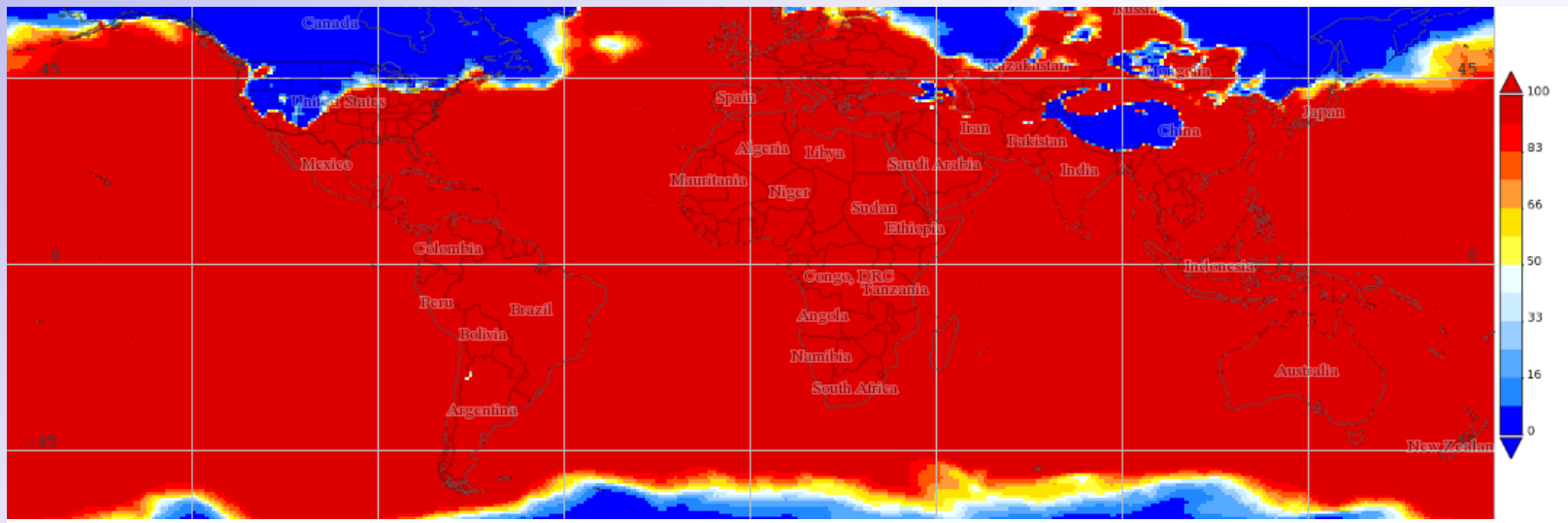


[multi-sat. precip] randomError (mm/hr)

3. EXAMPLES – Data Fields from IMERG Test Data (4/4)

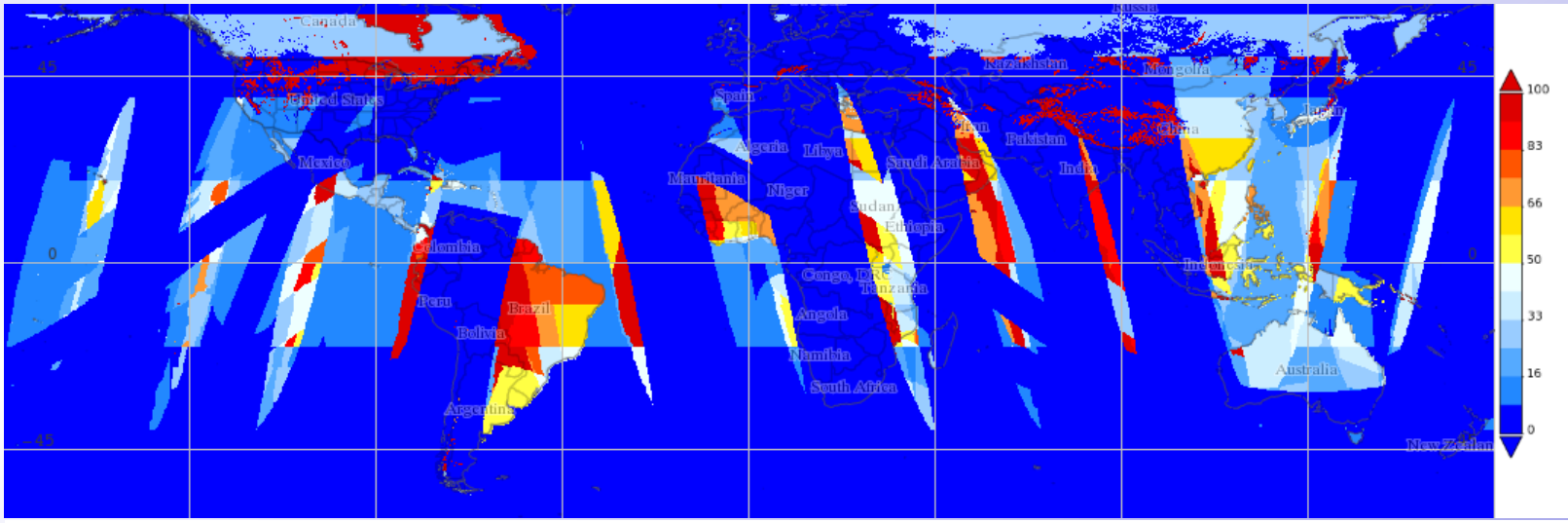
1430-1500Z 3 April 2014

probability that precipitation phase is liquid; diagnostic computed from ancillary data



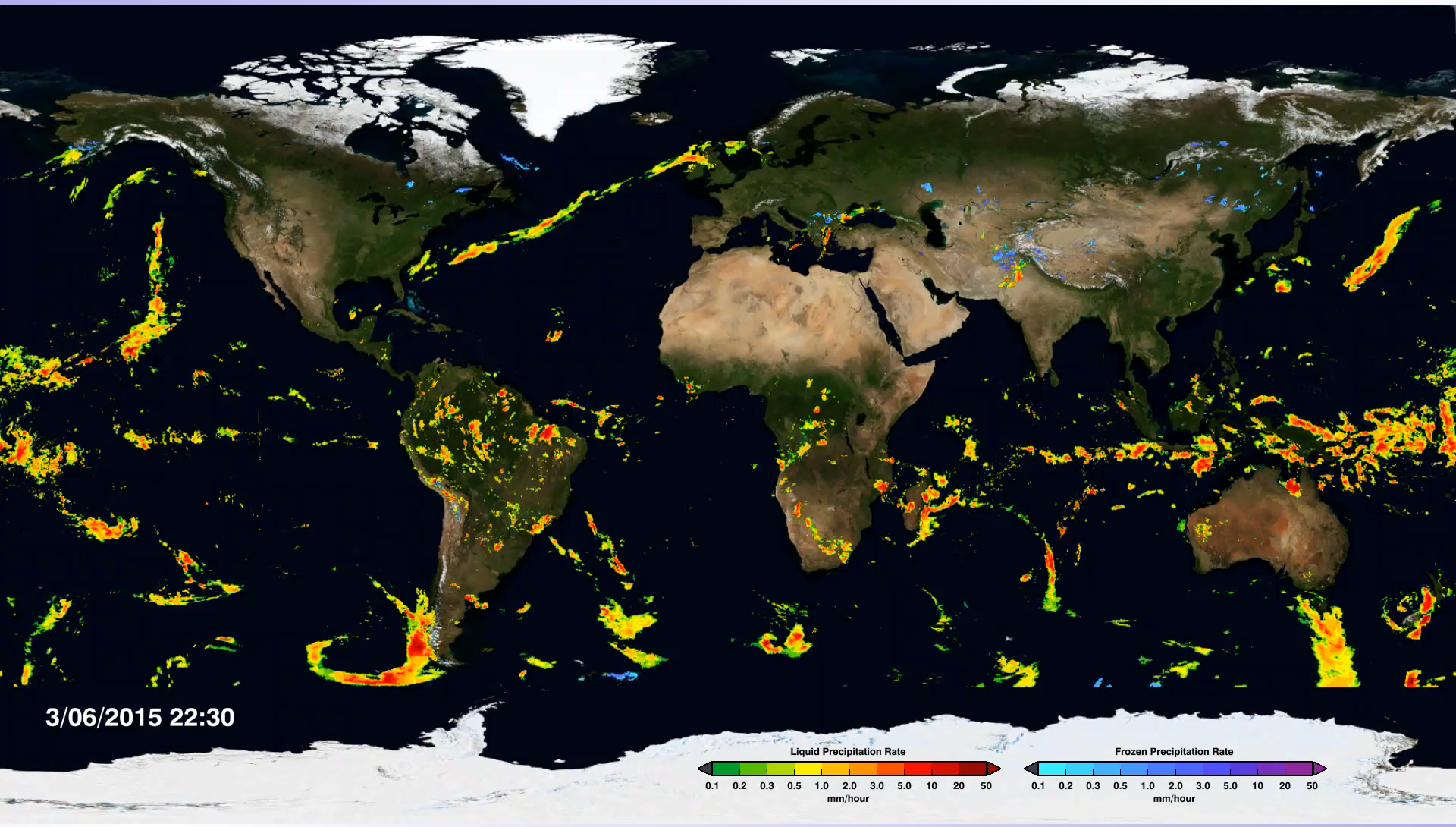
probabilityLiquidPrecipitation [phase] (%)

weighting of IR in the Kalman filter step



IRkalmanFilterWeight (%)

3. EXAMPLES – IMERG Final for 1-3 June 2014



4. VALIDATION – Release Notes

"Day 1 IMERG Final Run Release Notes"

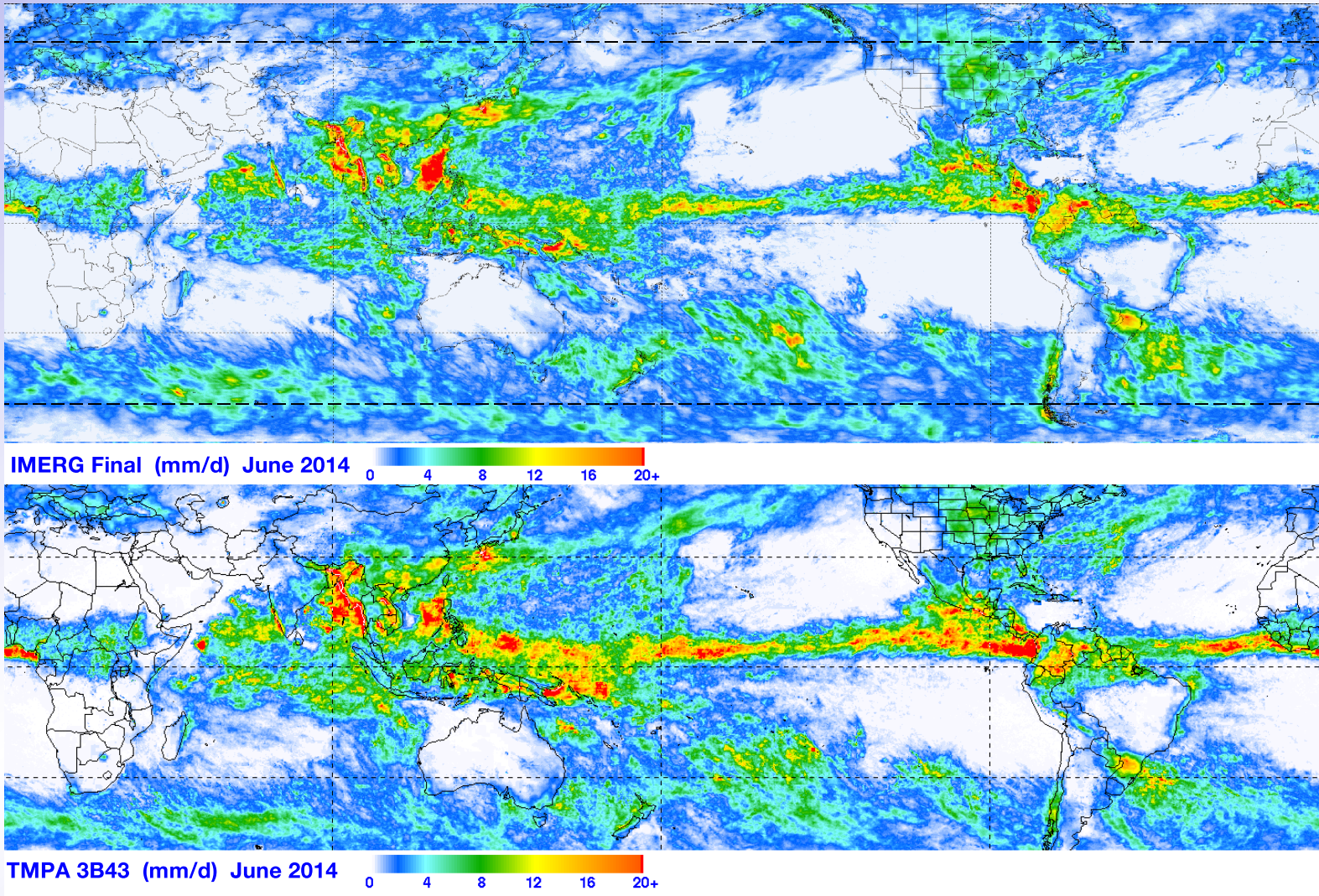
- an introduction and first cut at comparisons
- a living document
- http://pmm.nasa.gov/sites/default/files/document_files/IMERG_FinalRun_Day1_release_notes.pdf
    - this and all documents hot-linked on the IMERG data access page, accessible on the Level 3 tab on http://pmm.nasa.gov/data-access/downloads/gpm
- specific features, problems, behaviors
- effects due to IMERG's structure
- cautions due to the input data
- biggest overall issue is that none of the inputs or IMERG are fully GPM-based

4. VALIDATION – IMERG Final Run vs. 3B43 for June 2014

Same input satellites, different algorithms, different calibrator

Similar features, but not identical

- features (SPCZ)
- bias (ITCZ)



4. VALIDATION – Daily 0.25° IMERG, 3B42, MRMS for 15 June 2014

MRMS = NOAA Multi-Radar Multi-Sensor

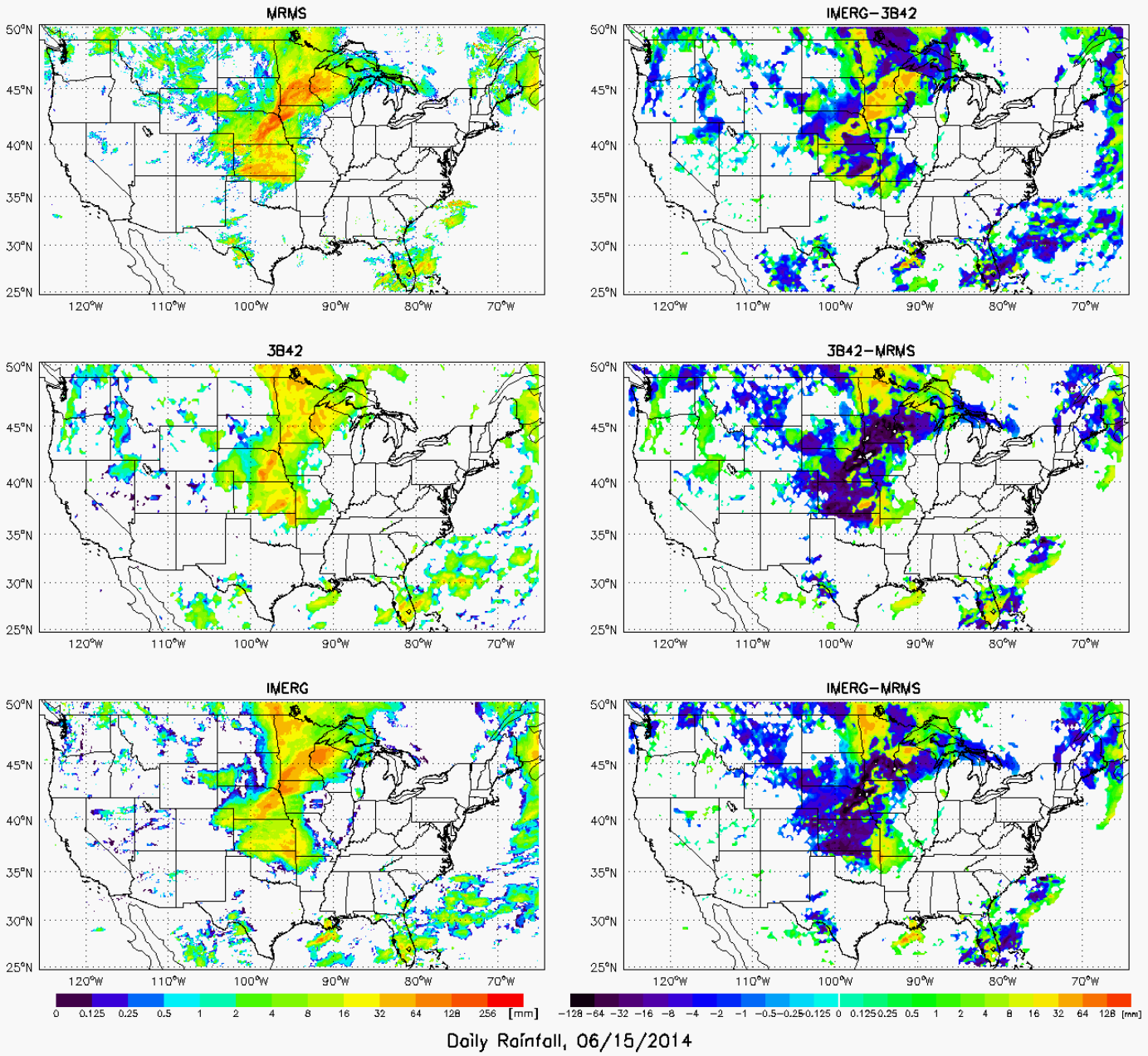
IMERG better

- Wisconsin to Nebraska
- Idaho, Nevada

IMERG worse

- N. Minnesota

Radar stops just off-shore; satellite doesn't



[Courtesy J. Wang (SSAI; NASA/GSFC 612)]

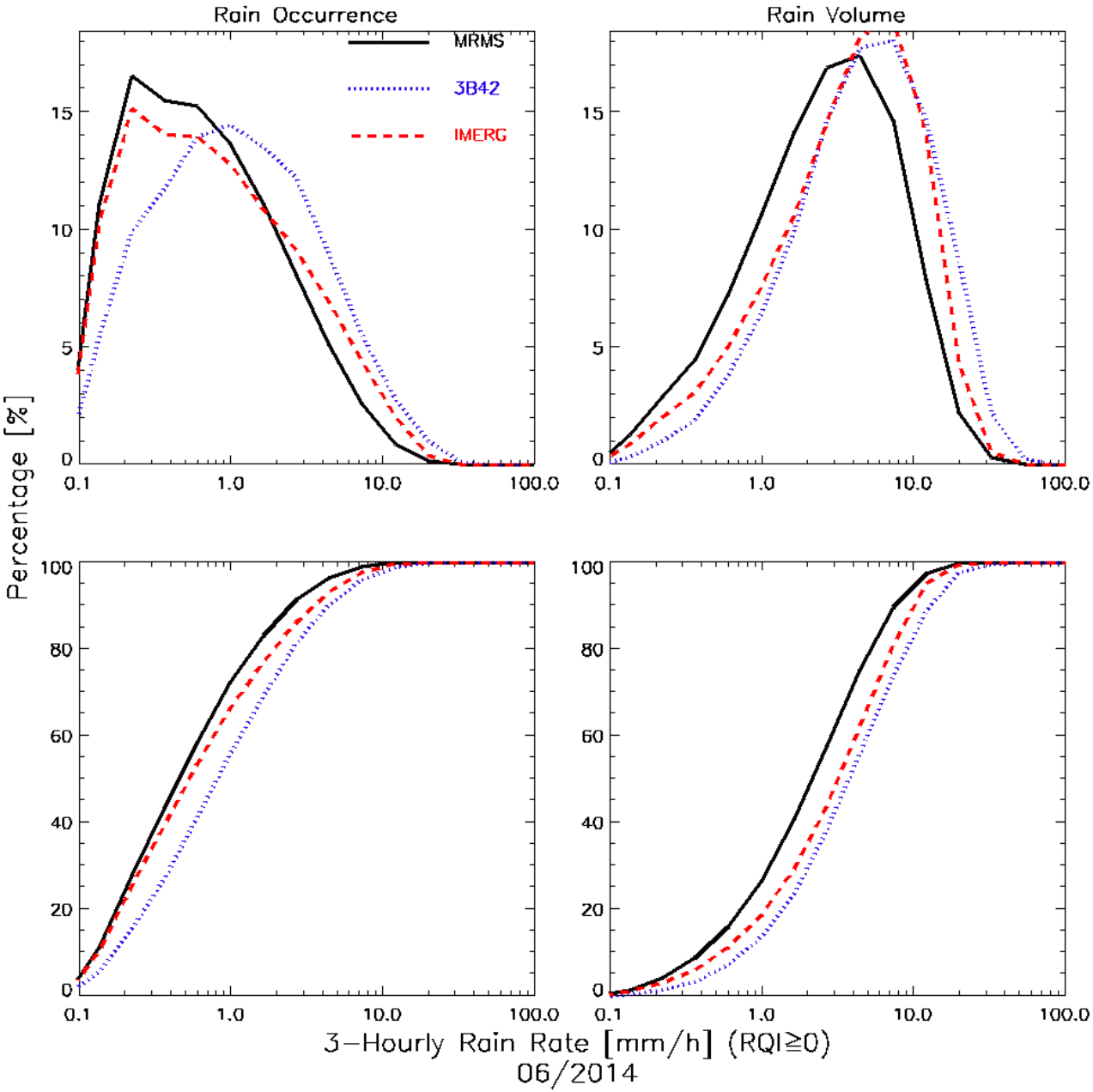
4. VALIDATION – 3-Hourly, 0.25° IMERG, 3B42, MRMS for 15 June 2014

IMERG better than 3B42 for precip occurrence

IMERG performs modestly better for precip volume

Note: Original footprint GPROF retrievals below 0.1 mm/hr are thresholded to zero

- how this affects IMERG depends on the resolution of the input sensor and subsequent averaging (here 0.25°)



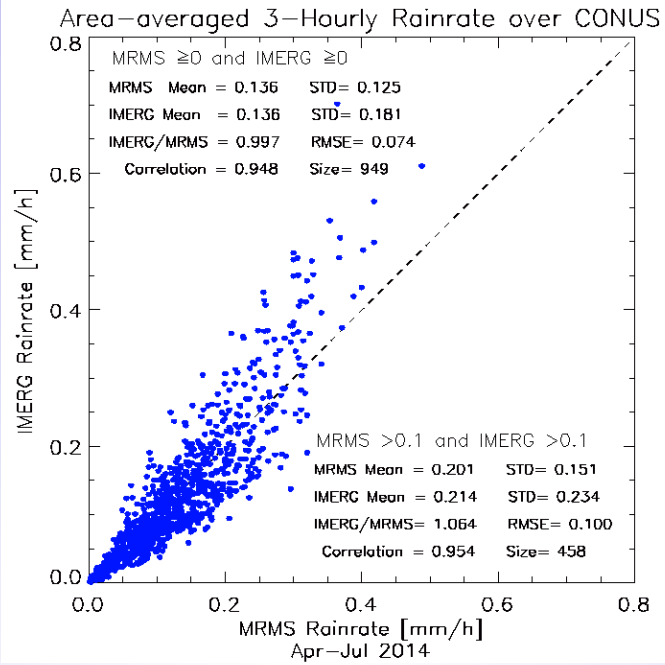
[Courtesy J. Wang (SSAI; NASA/GSFC 612)]

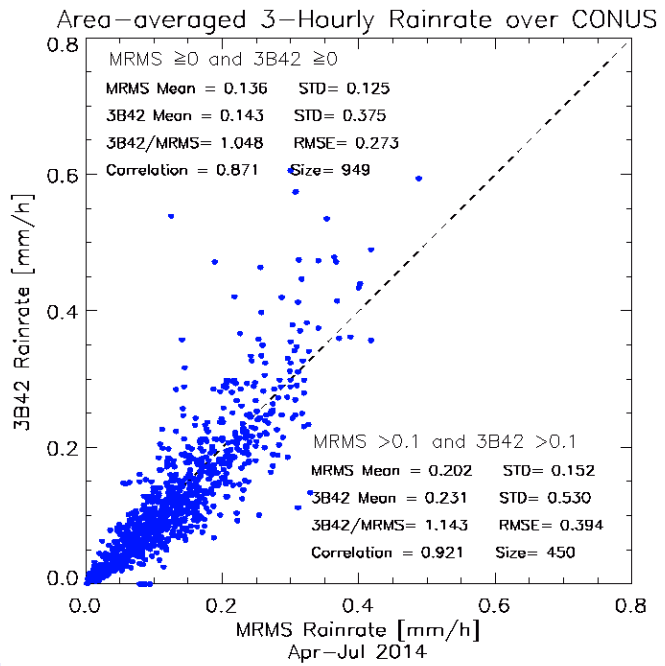
4. VALIDATION – 3-Hourly, CONUS-avg. IMERG, 3B42, MRMS for April–July 2014

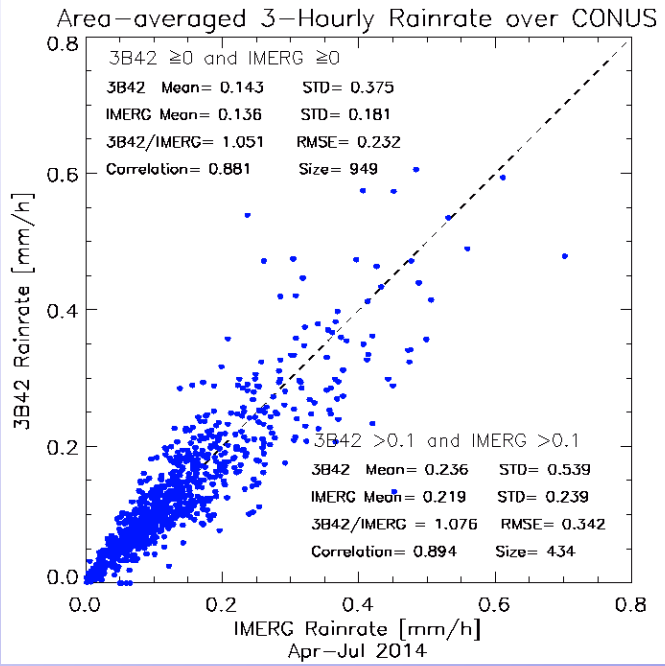
IMERG better for bias and RMSE

IMERG and 3B42 trend high at high rates

At this spatial scale, error is roughly multiplicative







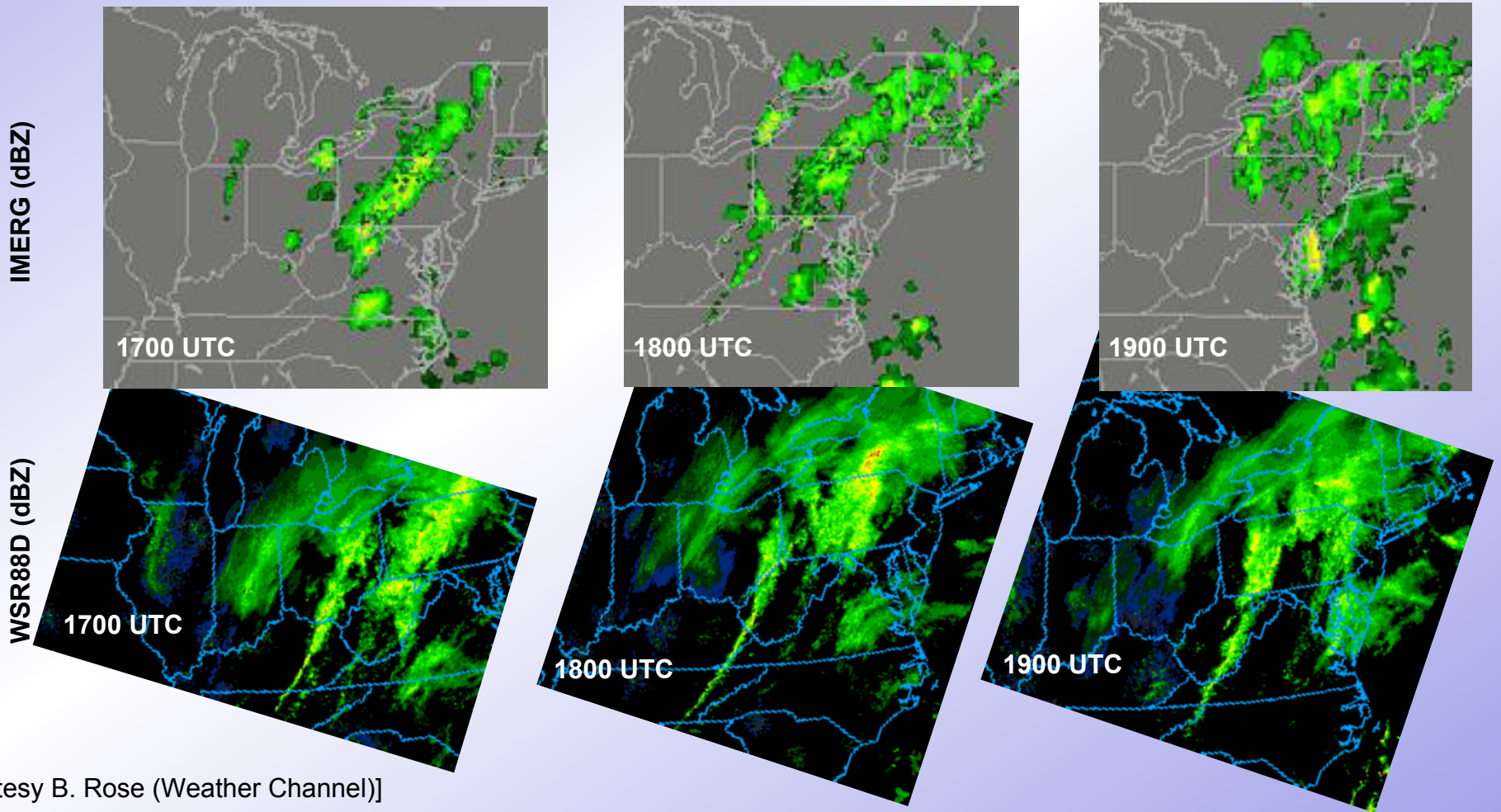
[Courtesy J. Wang (SSAI; NASA/GSFC 612)]

4. VALIDATION – Snow in IMERG, NWS WSR88D, 12 March 2014

IMERG converted to dBZ, WSR88D in dBZ; both original resolution

Hang-back line in radar missing in IMERG

2-5” of snow with near-blizzard conditions at Cleveland, Ohio around 1900 UTC



[Courtesy B. Rose (Weather Channel)]

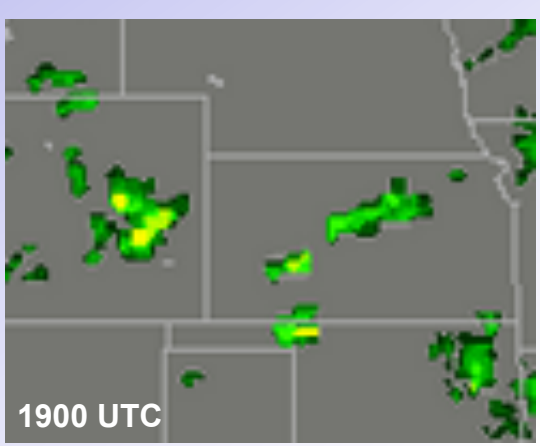
4. VALIDATION – Supercells in IMERG, NWS WSR88D, 22 July 2014

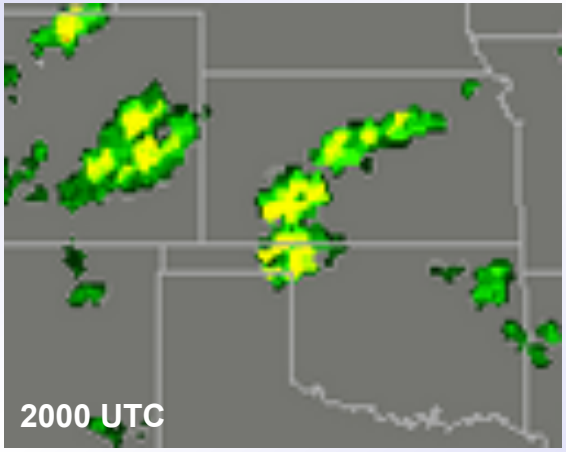
IMERG converted to dBZ, WSR88D in dBZ; both original resolution

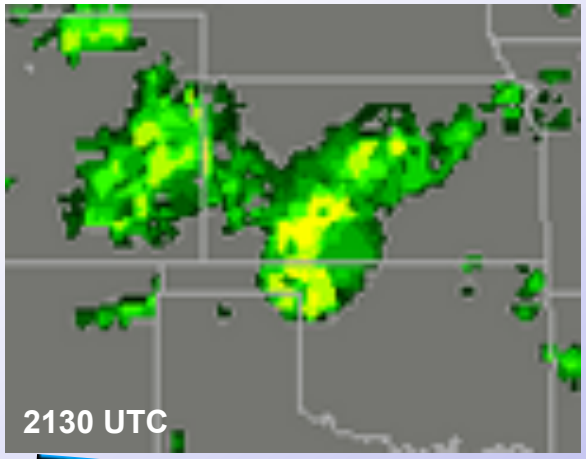
IMERG has good placement of supercells

Anvils more prominent in IMERG, lower maximum values (resolution?)

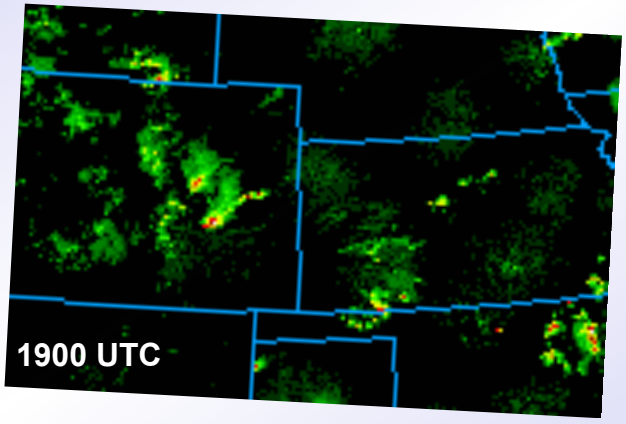
IMERG (dBZ)

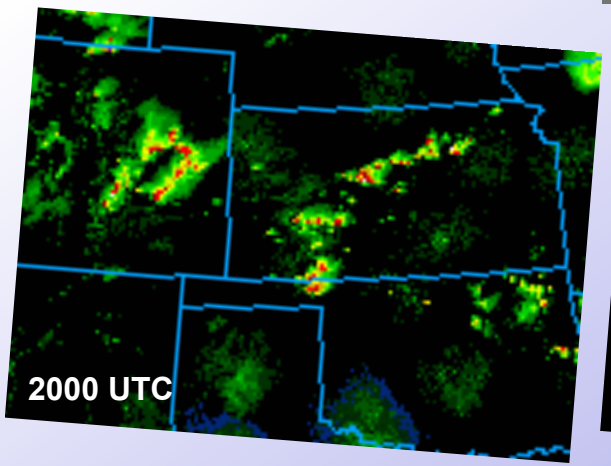


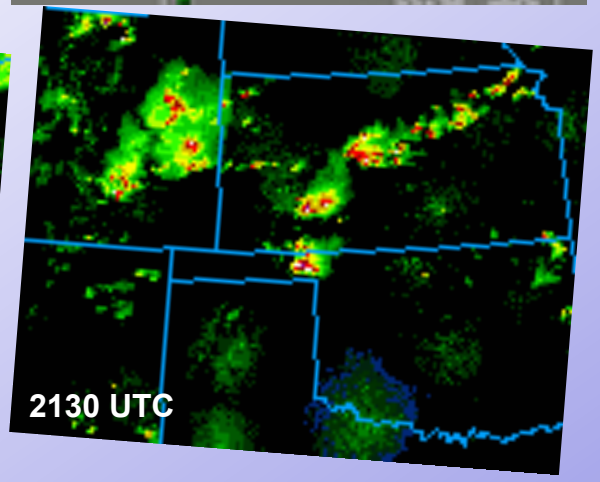




WSR88D (dBZ)







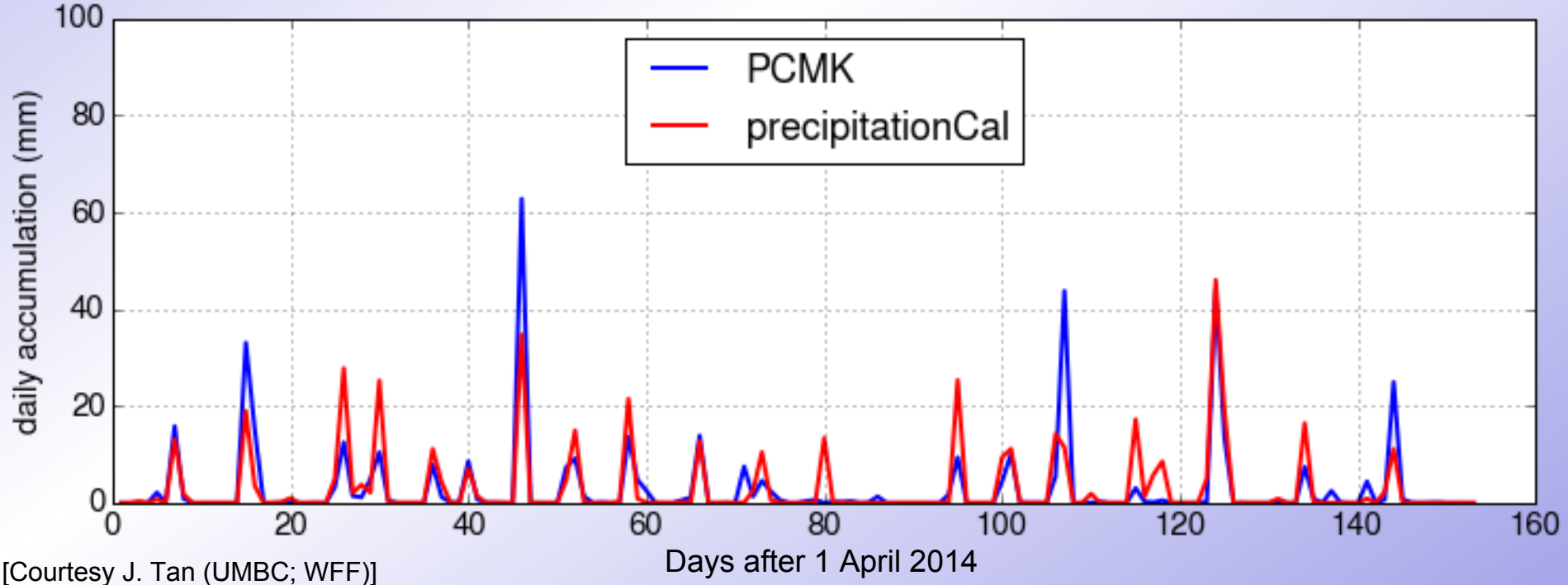
[Courtesy B. Rose (Weather Channel)]

4. VALIDATION – Daily IMERG and Pocamoke Fine-Scale Grid, April-August 2014

23 surface gauges in a 6x5 km region near Wallops Island, Virginia

Excellent correlation for most events (warm season)

Both over- and under-estimates for largest events



[Courtesy J. Tan (UMBC; WFF)]

4. VALIDATION – Half-Hourly IMERG Sources and Pocamoke Fine-Scale Grid, April-August 2014

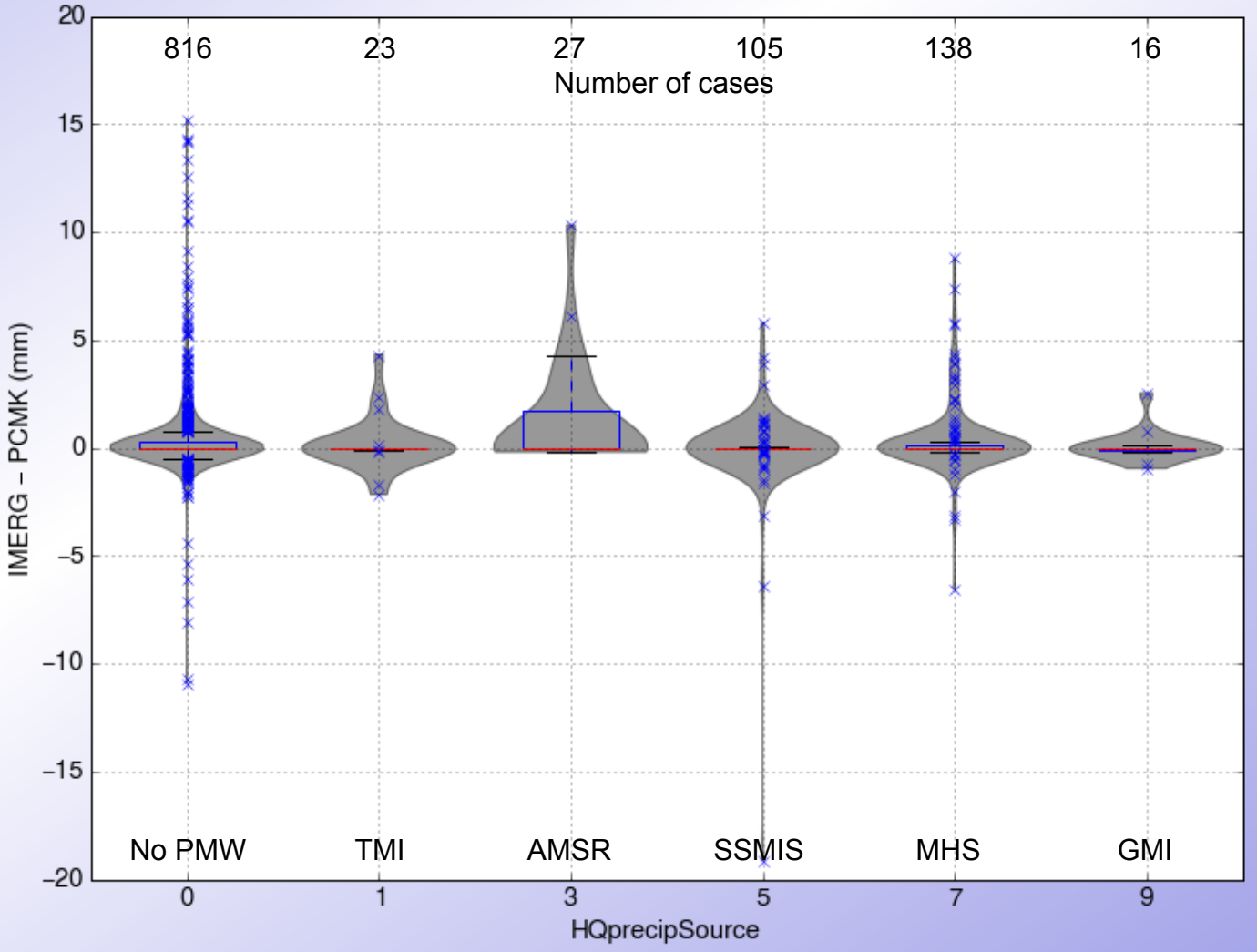
"Violin diagram" for individual sources of the half-hourly IMERG estimates

- width shows relative contribution for each difference bin

GMI is best; AMSR and SSMIS less so

The extra scatter for no-PMW (interpolated) is partly driven by the large number of cases

No-PMW (interpolated) data are competitive with the skill for most of the sensors



[Courtesy J. Tan (UMBC; WFF)]

5. FUTURE – Transitioning from TRMM to GPM

IMERG is becoming available

- Final Run for mid-March to October 2014 (having a fight with November)
- Late Run in Beta Test, starting from 7 March 2015
- Early Run in Alpha Test

Early 2016: first-generation GPM-based IMERG archive, March 2014–present

Early 2017: first-generation TRMM/GPM-based IMERG archive, 1998–present

What happens to TMPA now that the TRMM satellite has run out of fuel?

- TRMM will be shut down in April 2015
- TMI has been useful throughout, but PR products stopped 8 October 2014
- TMPA-RT uses climatological calibration, so continues to run "as is"
- production TMPA partly depends on PR for calibration
  - production switches to climatological calibration with October 2014
  - performance is being scrutinized
  - gauge calibration over land should continue to yield consistent results
  - climatological calibration over ocean is likely to cause a discontinuity
- loss of legacy sounder estimates could raise issues for continuing TMPA

6. FINAL COMMENTS

The U.S. Day-1 GPM multi-satellite precipitation algorithm is constructed as a unified U.S. algorithm

IMERG is becoming available

- Final Run for mid-March to October 2014 (having a fight with November)
- Late Run in Beta Test, starting from 7 March 2015
- Early Run in Alpha Test
- GPM era reprocessed in early 2016
- TRMM-GPM eras reprocessed in early 2017
- TMPA to be run until mid-2017

Even the Day-1 datasets are typically an improvement over TMPA

- There is no substitute for seeing how particular IMERG runs work for your application

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pmm.nasa.gov

Reserve Slides

2. IMERG DESIGN – Processing

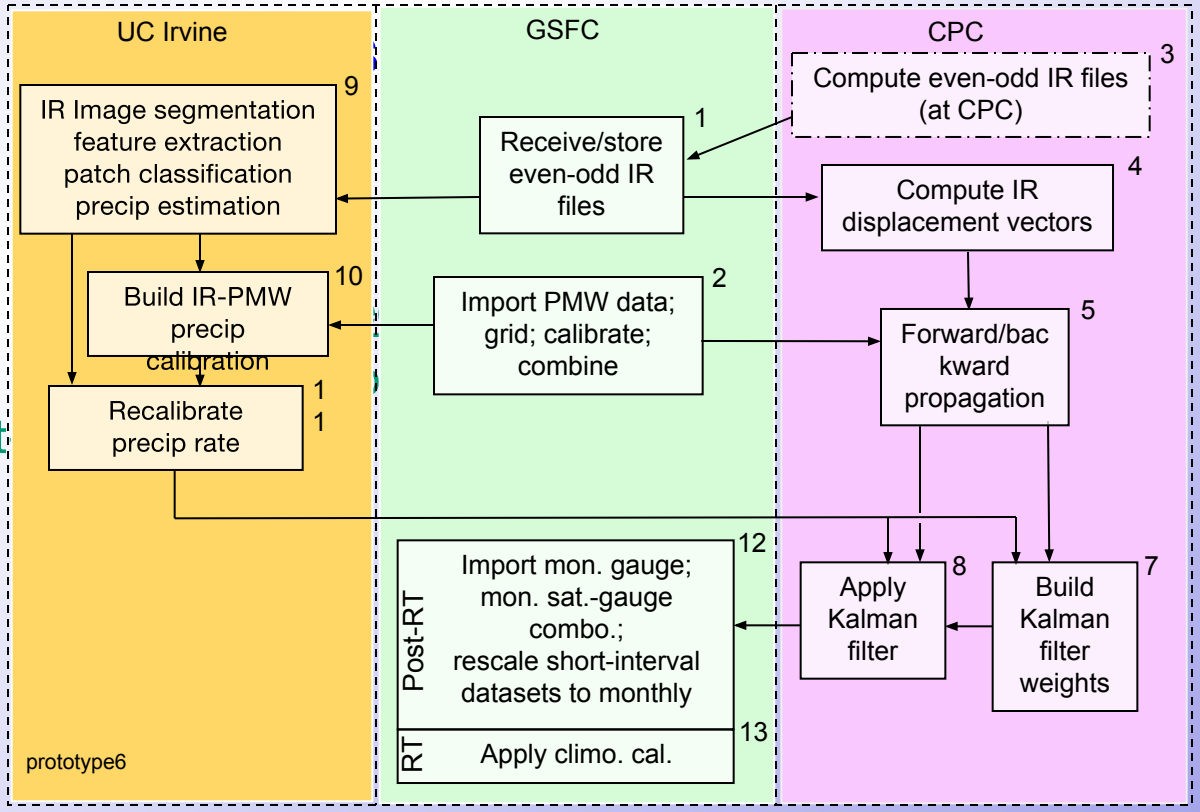
IMERG is a unified U.S. algorithm that takes advantage of

- Kalman Filter CMORPH (lagrangian time interpolation) – NOAA
- PERSIANN with Cloud Classification System (IR) – U.C. Irvine
- TMPA (inter-satellite calibration, gauge combination) – NASA
- all three have received PMM support
- PPS (input data assembly, processing environment) – NASA

The Japanese counterpart is

Institutions are shown for module origins, but

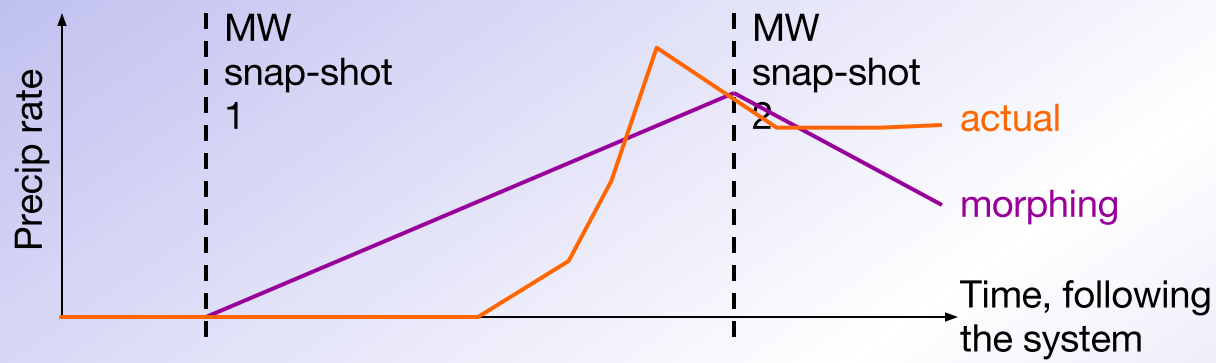
- package will be an
- goal is single code system real and post
- "the devil is in the details"



4. FUTURE – Where do we need help? (1/2)

We need a better treatment for (precipitation system) cloud growth and decay

- current morphing is linear interpolation between microwave snapshots



- how do we use more-frequent GEO data to capture short-interval variations?

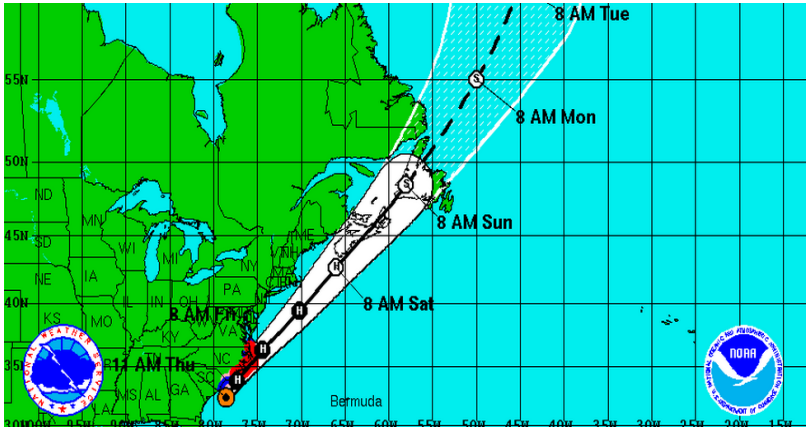
Orographic enhancement and suppression

- that happens in the liquid phase
- is missed by current microwave algorithms
- because they only quantitatively detect solid hydrometeors using scattering channels) over land
- "obvious" choices are hard:
  - compute quantitative results for liquid phase (use emission channels)
  - model moisture convergence and precipitation with ancillary data

Live Demonstration of IMERG Access and GIS Analysis

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

Hurricane Arthur (1-5 July 2014)



Reference, National Hurricane Center (2014, July 2)

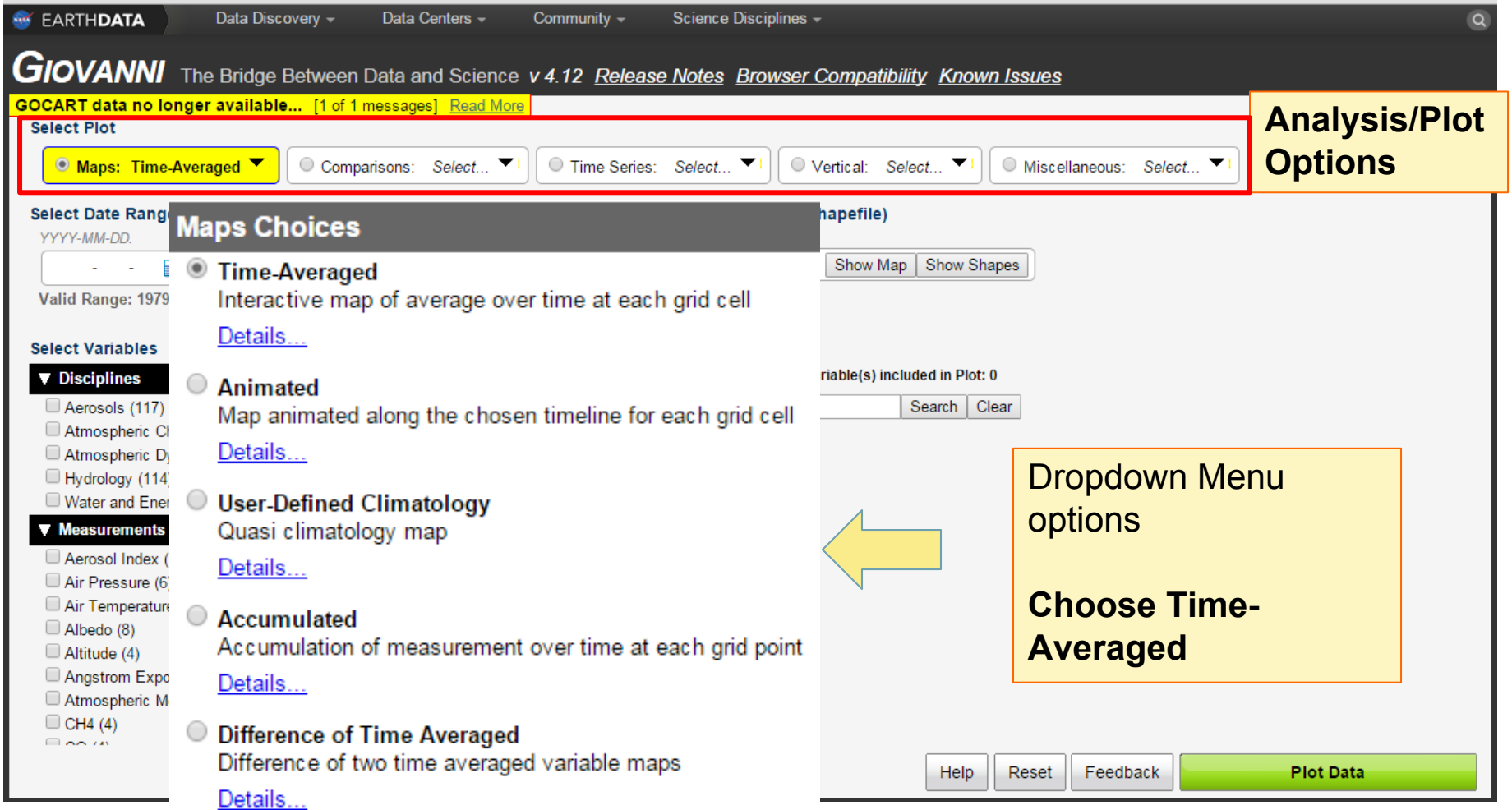
Hurricane Arthur, formed off southern Florida on July 1, 2014, and is moving north toward the Outer Banks on 4th of July.

Arthur continued to move northward to mid- and high-latitudes causing heavy rains over New England and Atlantic Coast of Canada

GPM Data Access - Giovanni Version 4 data portal

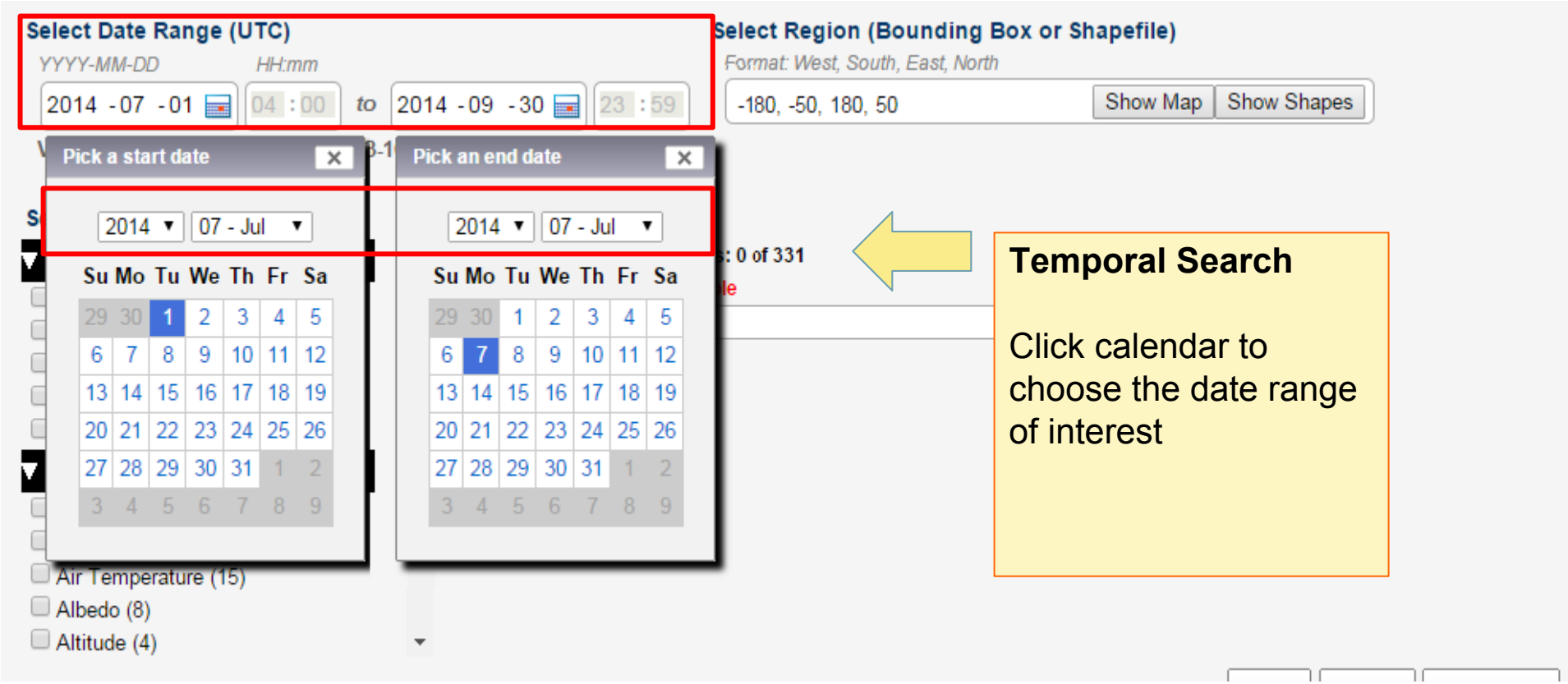
http://giovanni.gsfc.nasa.gov/giovanni/

Giovanni Home page



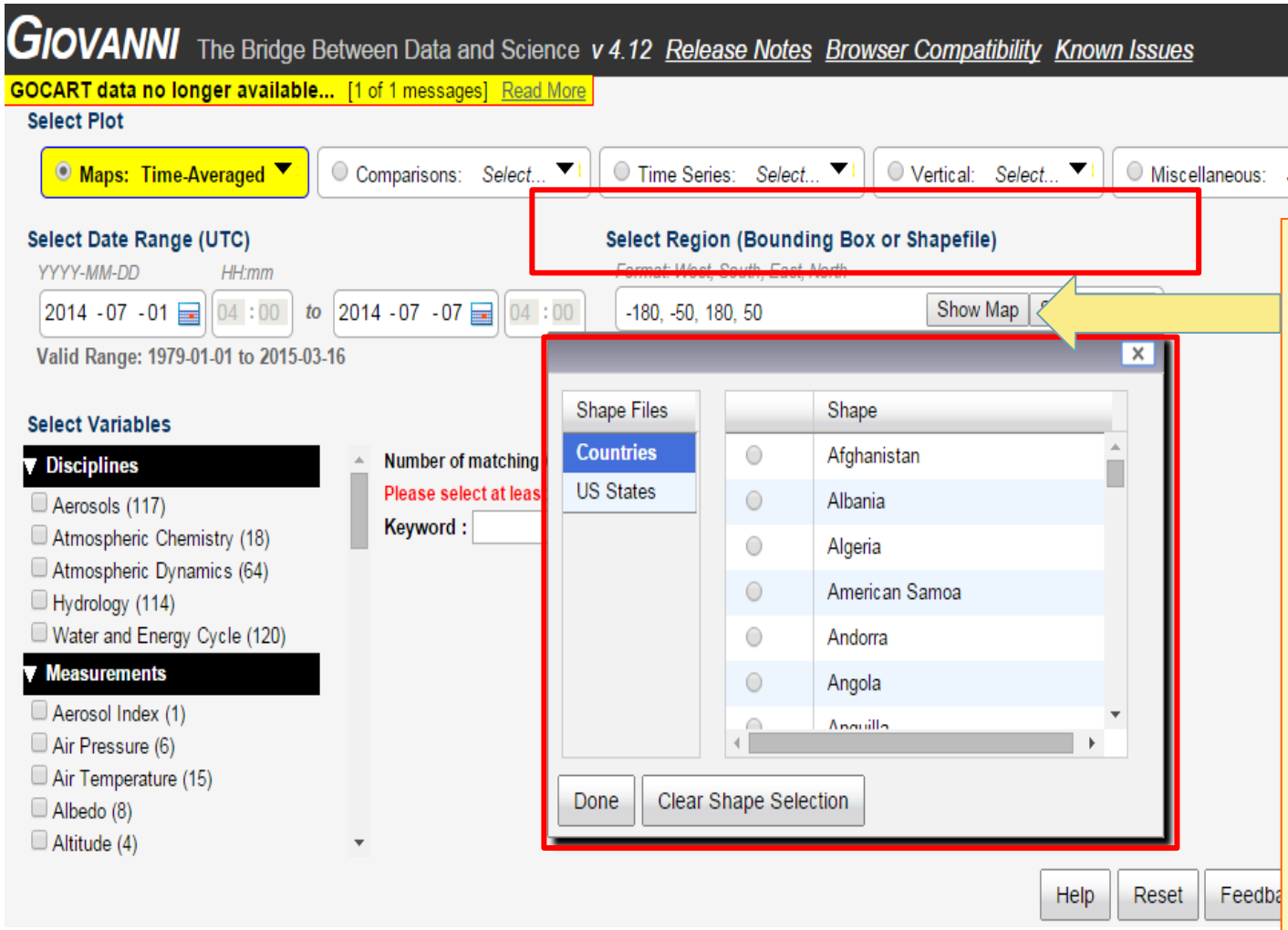
Giovanni Version 4

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



Giovanni Version 4

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



Spatial Search

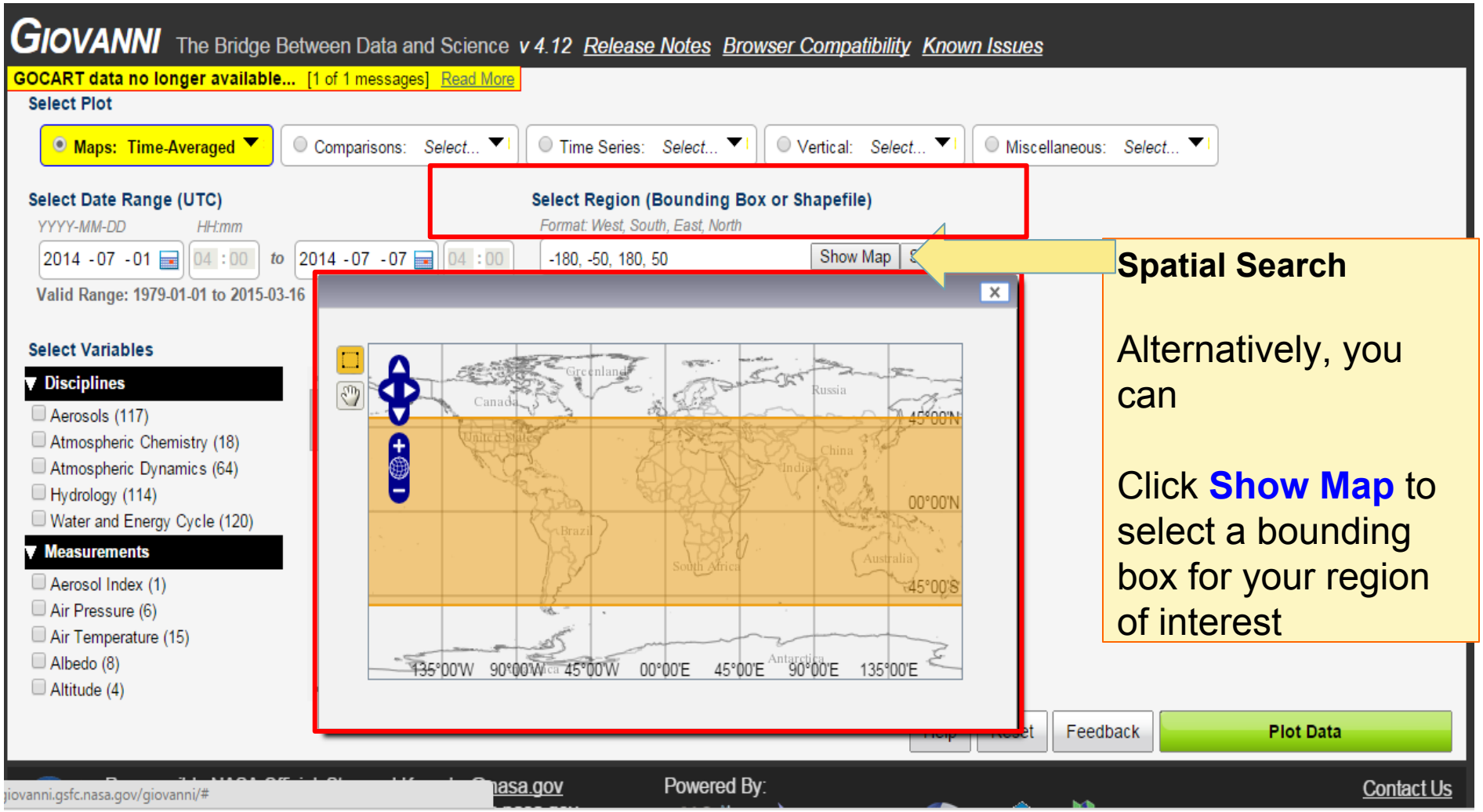
You can manually enter the latitude/longitude of your region

OR

Click **Show Shapes** to select shapefiles for various Countries or US States

Giovanni Version 4

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



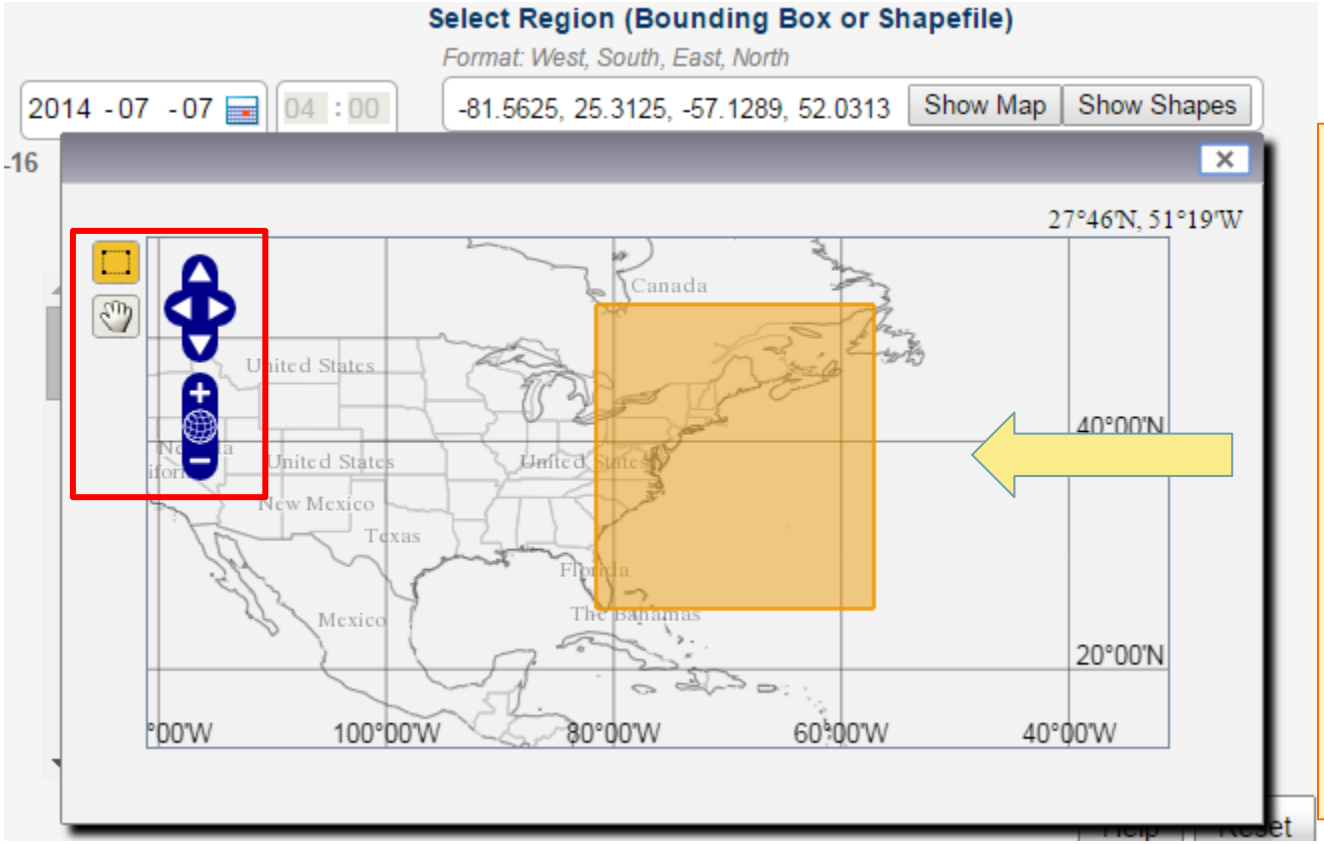
Spatial Search

Alternatively, you can

Click **Show Map** to select a bounding box for your region of interest

Giovanni Version 4

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

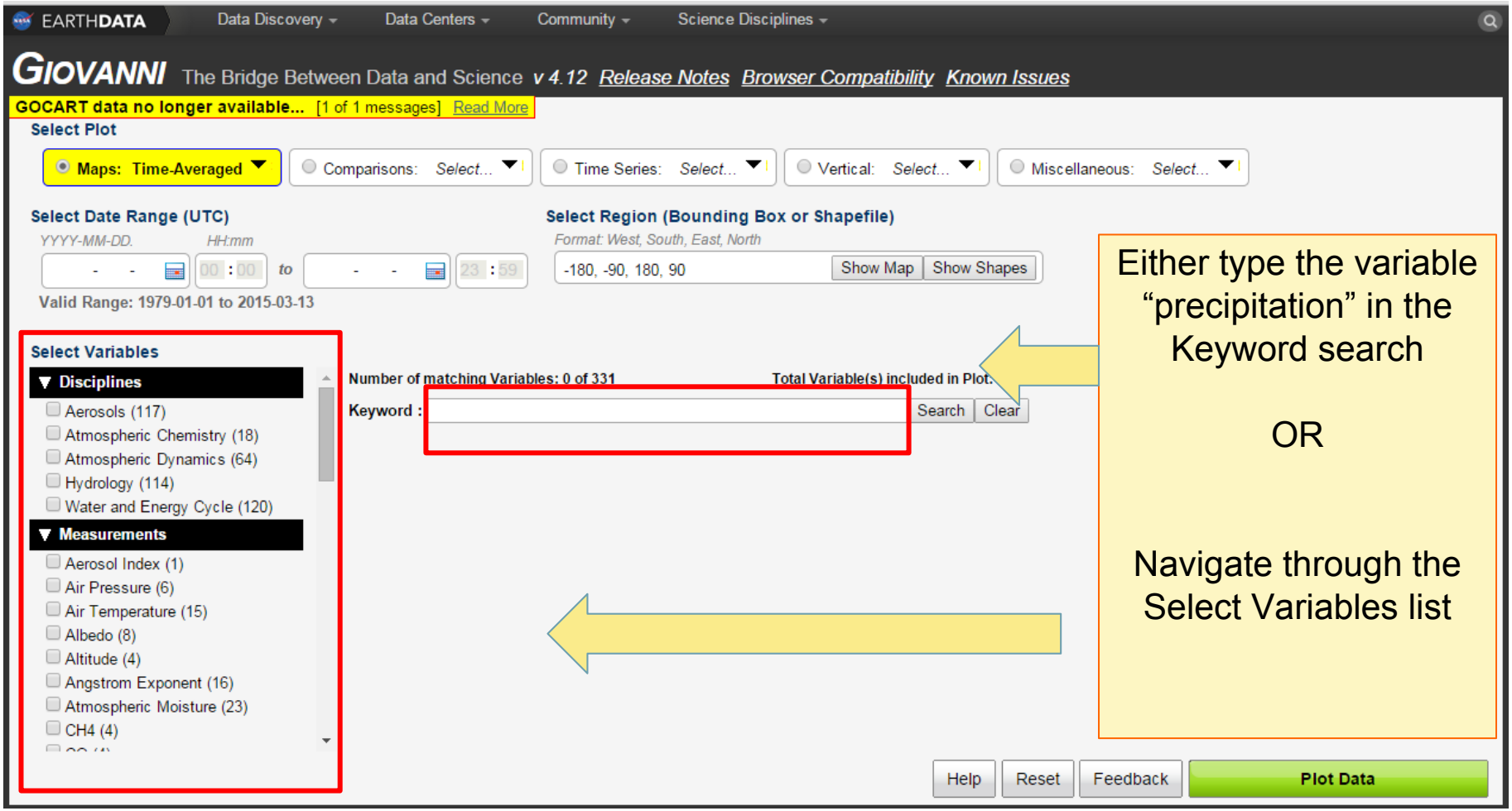


Spatial Search

Using the interactive map tools, zoom into your region of interest and select your bounding box for data retrieval

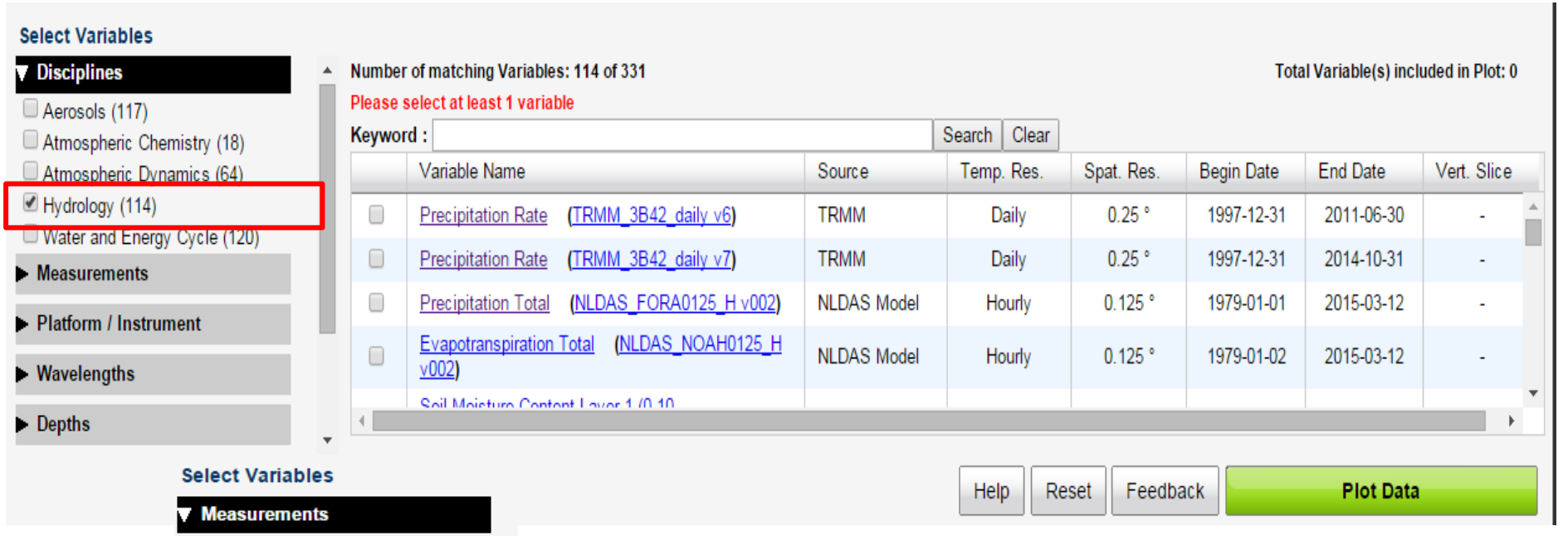
Giovanni Version 4

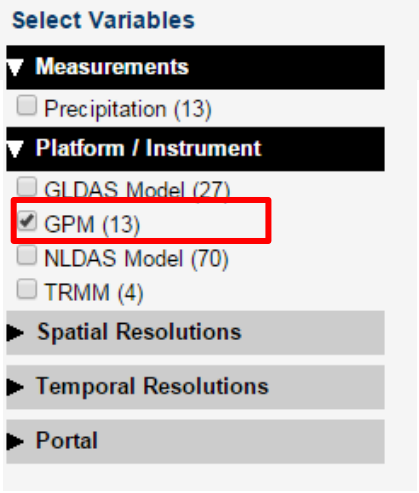
http://giovanni.gsfc.nasa.gov/giovanni/



Giovanni Version 4

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



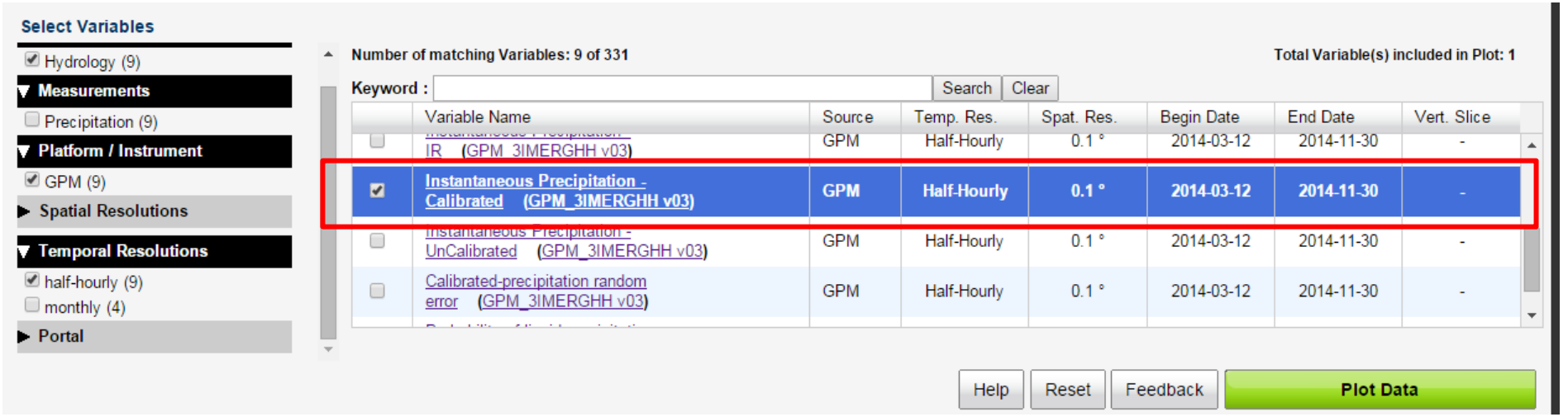


Navigate through the Select Variables list

Check boxes next to the various Disciplines (Hydrology), Measurements (Precipitation), Platform / Instrument **(GPM)** to narrow down your search for the desired variables

Giovanni Version 4

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



Scroll down and select

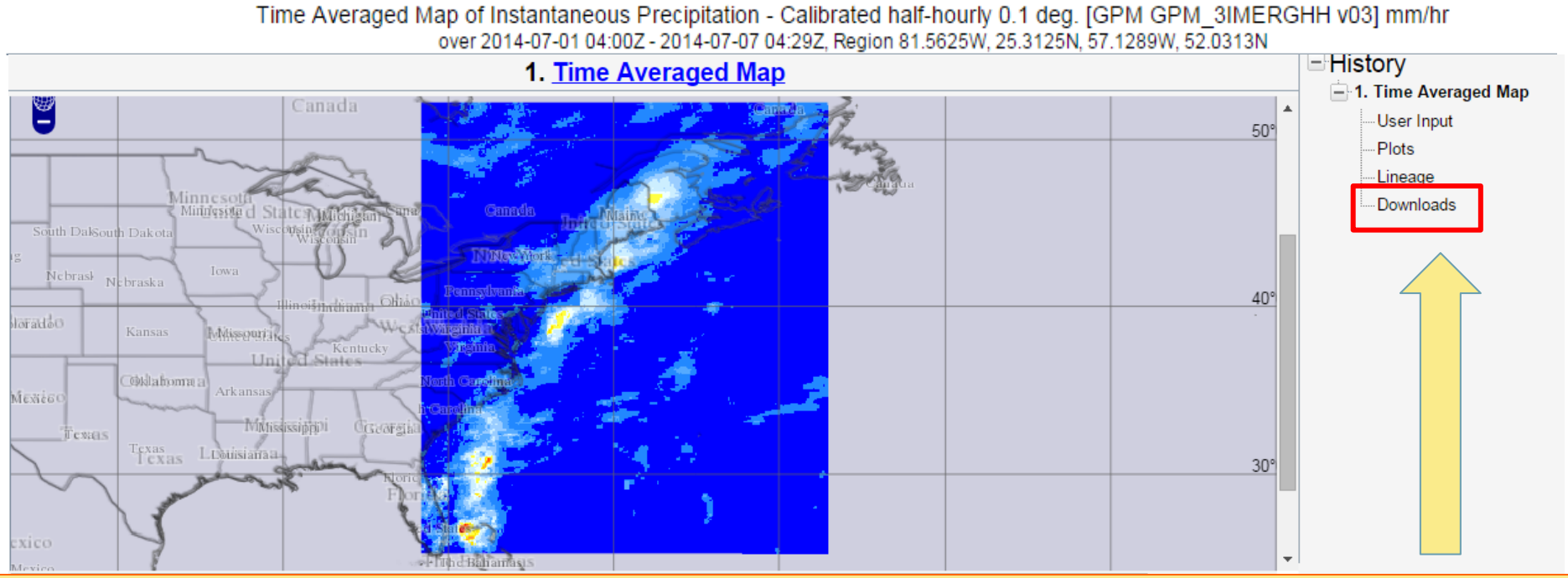
Instantaneous Precipitation - Calibrated (GPM_3IMERGHH v03)
Half-Hourly Temporal Resolution

Click
Plot Data

Giovanni Version 4

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

A Time Averaged Map will be generated with precipitation displayed in mm/hr from July 1, 2017 - July 7, 2014 for our region



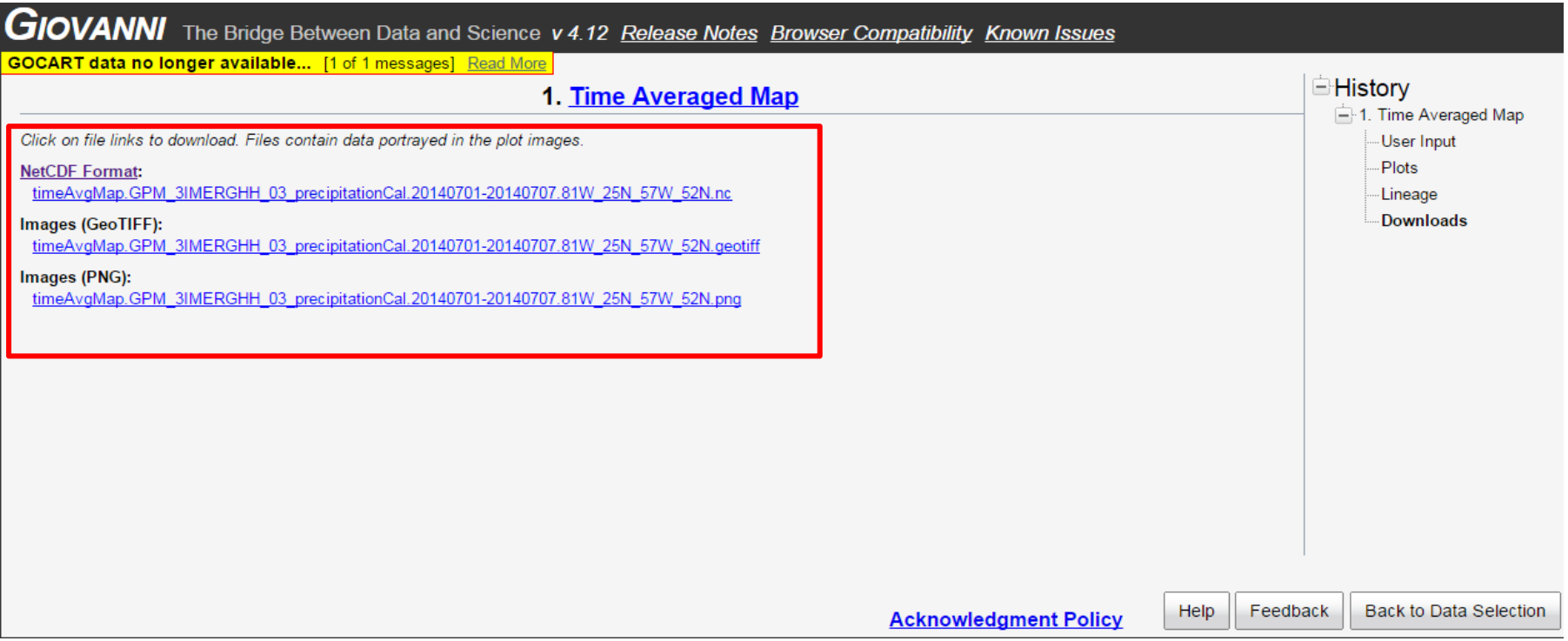
Click Downloads to display links to data files ready for downloading.

You may also use the time averaged map or an animated maps to narrow down specific half-hourly periods to download.

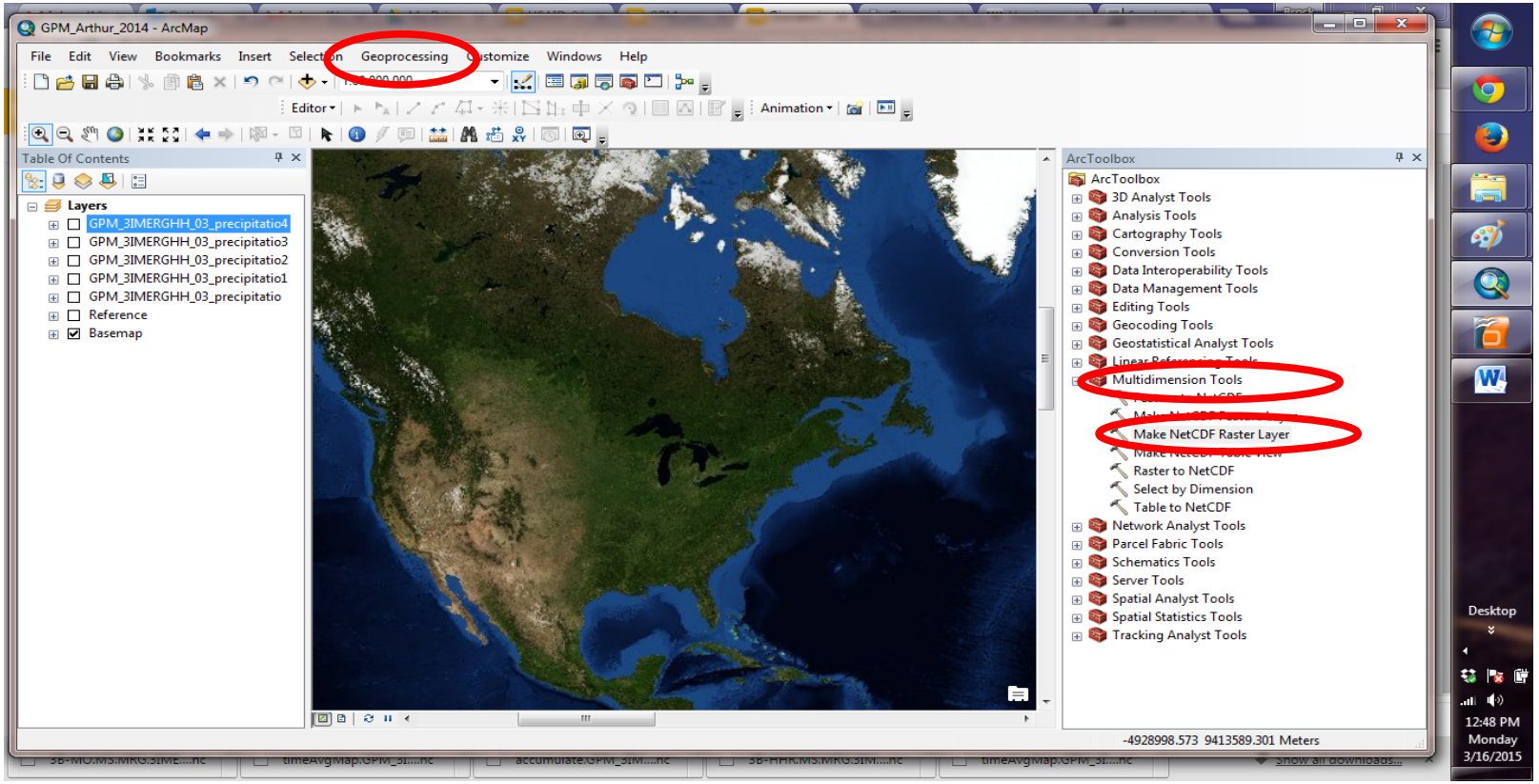
Giovanni Version 4

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

You can download the data files in either NetCDF, GeoTIFF or PNG formats.
NetCDF format is easily imported into ArcMap.
Click the link to download to your desired location on your computer.

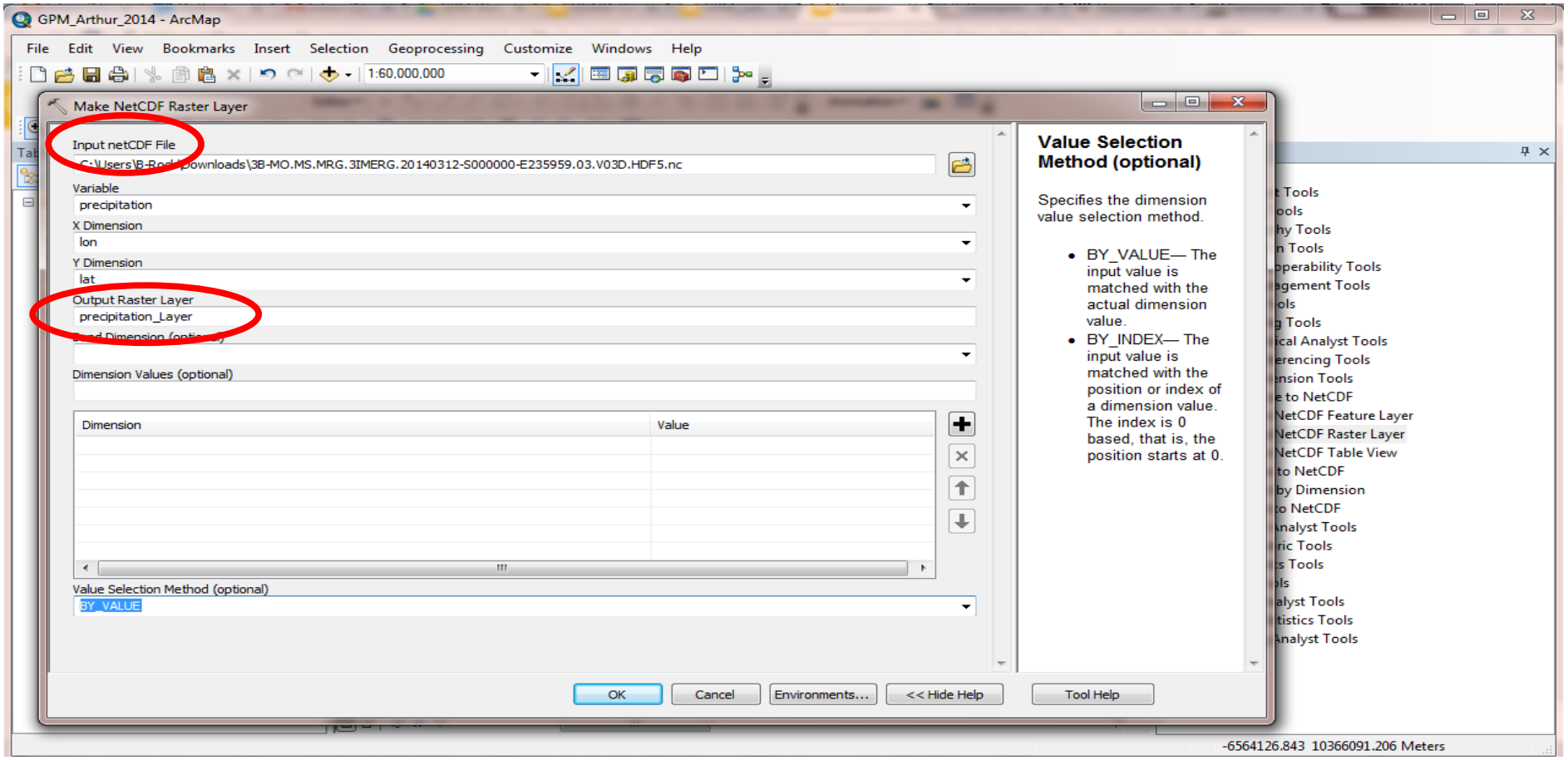


Import into GIS (ArcMAP)



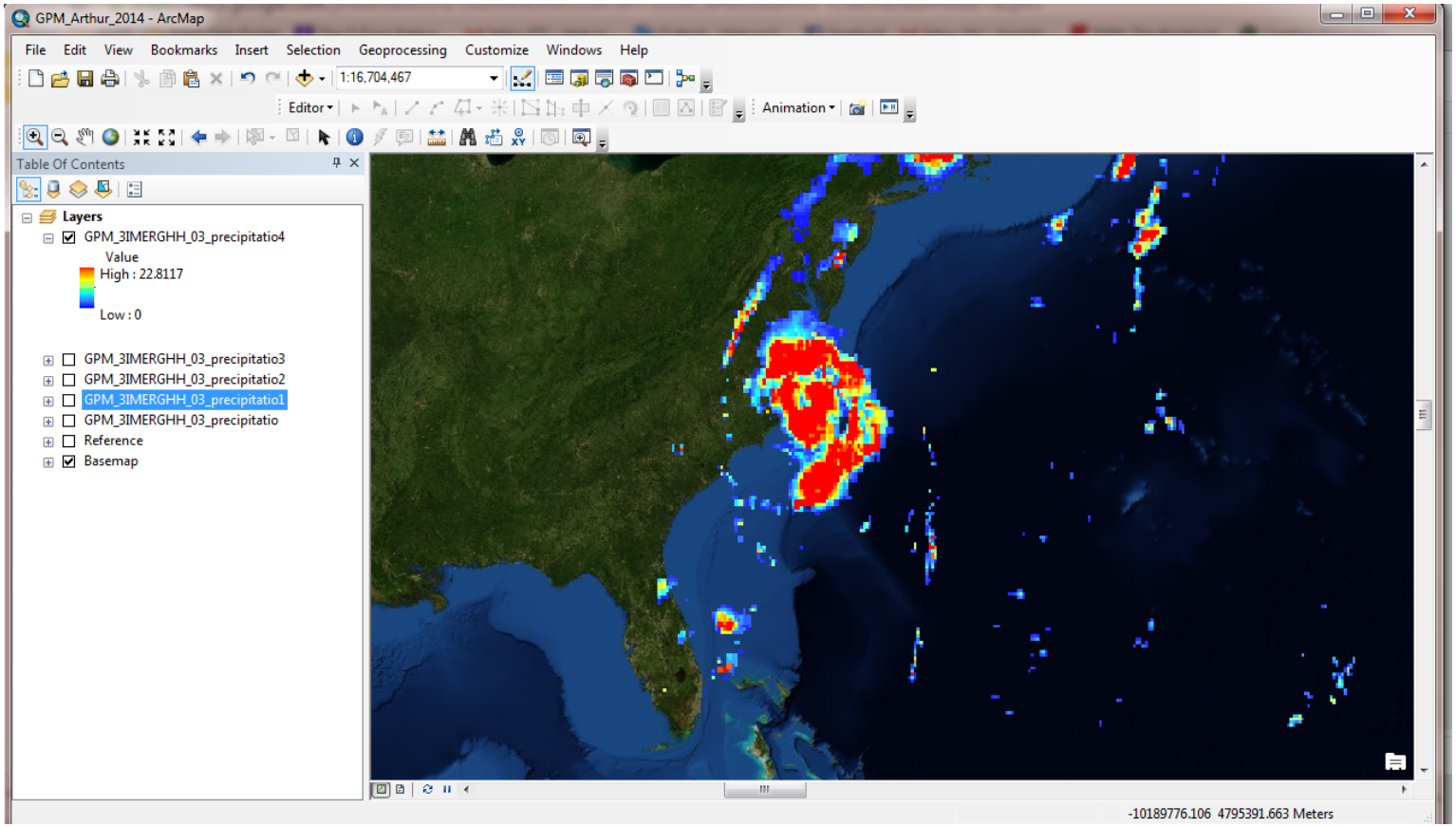
Import TRMM precipitation data - Under the Geoprocessing Tab, Open the ArcToolbox.Open the Multidimensional toolbox, choose the **Make NetCDF Raster Layer tool**

Import into GIS (ArcMAP)



For the input field, **Input netCDF File:** Navigate to and click on the previously downloaded GPM precipitation file. The remaining fields will fill in accordingly, KEEP the default values. You may change the output file name if you choose. Click OK.

Import into GIS (ArcMAP)



The result will be in raster format in ArcMAP. Rater files are ideal for spatial analysis tools

Common GIS Data Layers

Rivers/Basins	USGS HydroSHEDS	http://hydrosheds.cr.usgs.gov/
Population	NASA Socioeconomic Data and Applications Center (SEDAC)	http://sedac.ciesin.columbia.edu/
Elevation	Consortium for Spatial Information (CGIAR-CSI)	http://srtm.csi.cgiar.org/
Reservoirs	NASA Socioeconomic Data and Applications Center (SEDAC)	http://sedac.ciesin.columbia.edu/
Soil Type	ISRIC - World Soil Information	http://www.isric.org/
Dams	NASA Socioeconomic Data and Applications Center (SEDAC)	http://sedac.ciesin.columbia.edu/
Infrastructure	See various local/state/regional GIS data sites	
Land Use	Waterbase	http://www.waterbase.org

Course Summary

NASA Remote Sensing Observations of Precipitation

- Tropical Rainfall Measuring Mission (TRMM) launched in November 1997 and Global Precipitation Measurement (GPM) mission launched in February 2014 provide high-quality precipitation measurements useful for various applications

- GPM Level-2 precipitation from GMI/DPR are available at high resolution **(5 km)** between 65°S to 65° N – 16 orbits per day, no continuous spatial coverage

- Integrated Multi-satellitE Retrievals for GPM (IMERG), using GPM core satellite and constellation satellites, provides **half-hourly, 0.1°x0.1°** precipitation between 60°S to 60°N -- **will be available in near-real time with 4-hour data latency and will extend research quality TRMM Multi-satellite Precipitation Analysis Data useful for climate applications**

- Several web-based tools (PPS/STORM, Mirador, Giovanni) make it easy to access, analyze, visualize, and download freely available GPM and TRMM precipitation products

NASA Remote Sensing Observations of Precipitation Trade Offs

- It is difficult to obtain extremely high spatial and temporal resolution at the same time – *high frequency, high resolution data can not be obtained globally due to sensors' swath widths and satellite orbital configuration*

- Various levels of data from individual sensors and derived data products from multiple sensors and satellites are available in various data formats – **selection depends on the applications**

- Data applications may require additional *in situ* measurements, processing, and analysis

- Regional validation is highly commended

Concluding Remarks

- NASA Applied Sciences Program offers 'research to application' opportunities through competitive grants/proposals program (http://nspires.nasaprs.com/external/)

- NASA DEVELOP program offers opportunities to utilize NASA data products for specific environmental application involving student liaisons (http://develop.larc.nasa.gov/

ARSET can provide advanced on-line and/or in-person trainings focused on specific environmental applications and geographic regions upon request in Air Quality, Land Management, Water Resources and Disasters Management (http://arset.gsfc.nasa.gov/training)

Homework Assignment

Homework Assignment Link
Due by April 30, 2015

Important Information

Who can request the Certificate of Completion?

Those who attended all 3 live sessions and submit the completed homework assignment by April 30, 2015

Send request to Marines Martins for the Certificate
Email: marines.martins@ssaiha.com

Upcoming Training

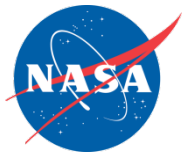
NASA Remote Sensing Observations and Tools for Flood Management

webinar sessions on
June 8, 15, 22, and 29 June 2015

ARSET ListServ

For information on upcoming courses and program updates sign up to the listserv

https://lists.nasa.gov/mailman/listinfo/arset



Thank You!

Amita Mehta

email: amita.v.mehta@nasa.gov