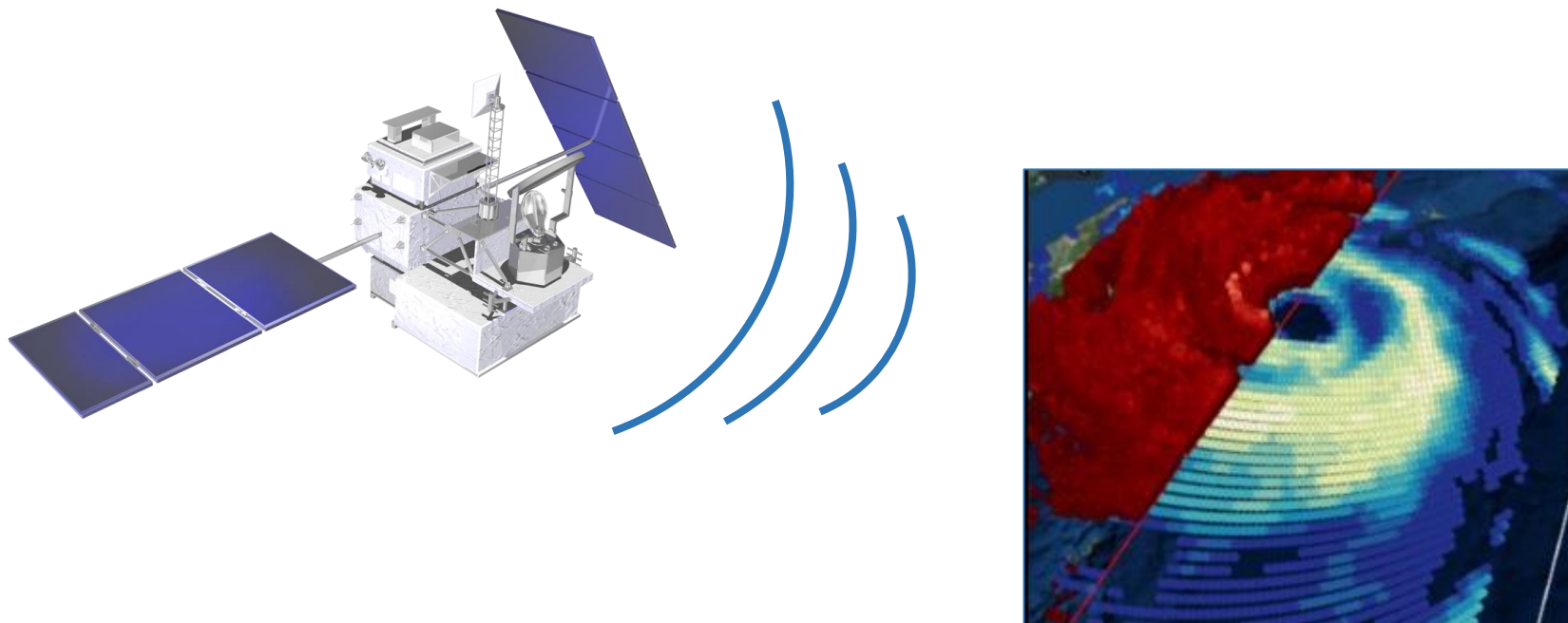
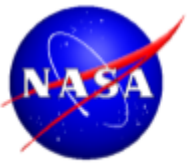


Weather from 250 Miles Up: Visualizing Precipitation Satellite Data (and Other Weather Applications) using CesiumJS



August 16, 2017

***Matt Lammers (matthew.r.lammers@nasa.gov)
Senior Science Data Visualization Analyst/Software Engineer***

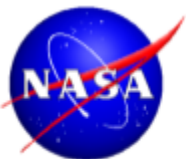


Who Am I?



I maintain the STORM data portal for Global Precipitation Measurement (GPM) Mission satellite data at NASA Goddard





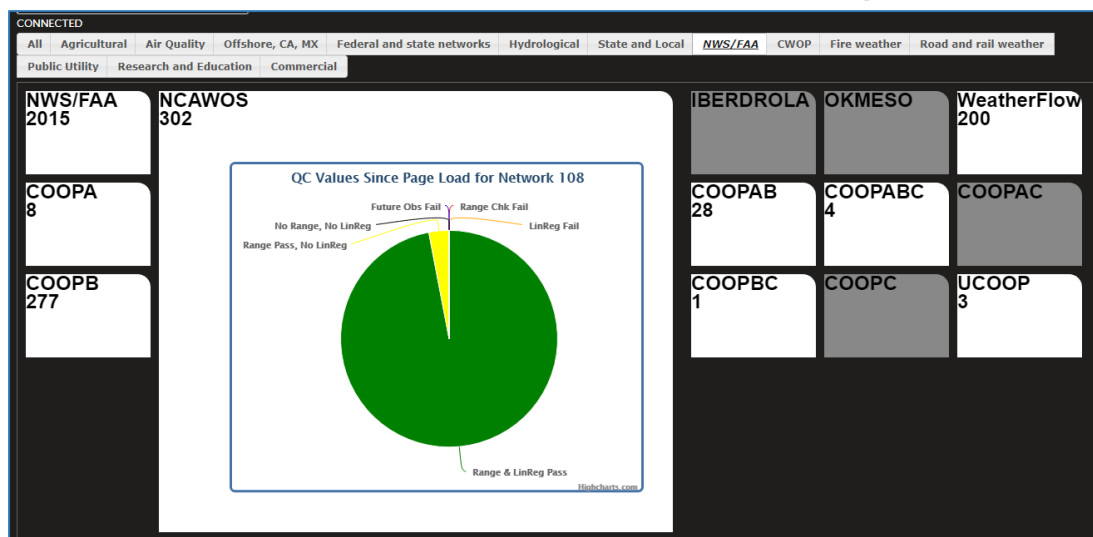
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Before this I worked at MesoWest (University of Utah) building APIs and visualizations using surface weather observations





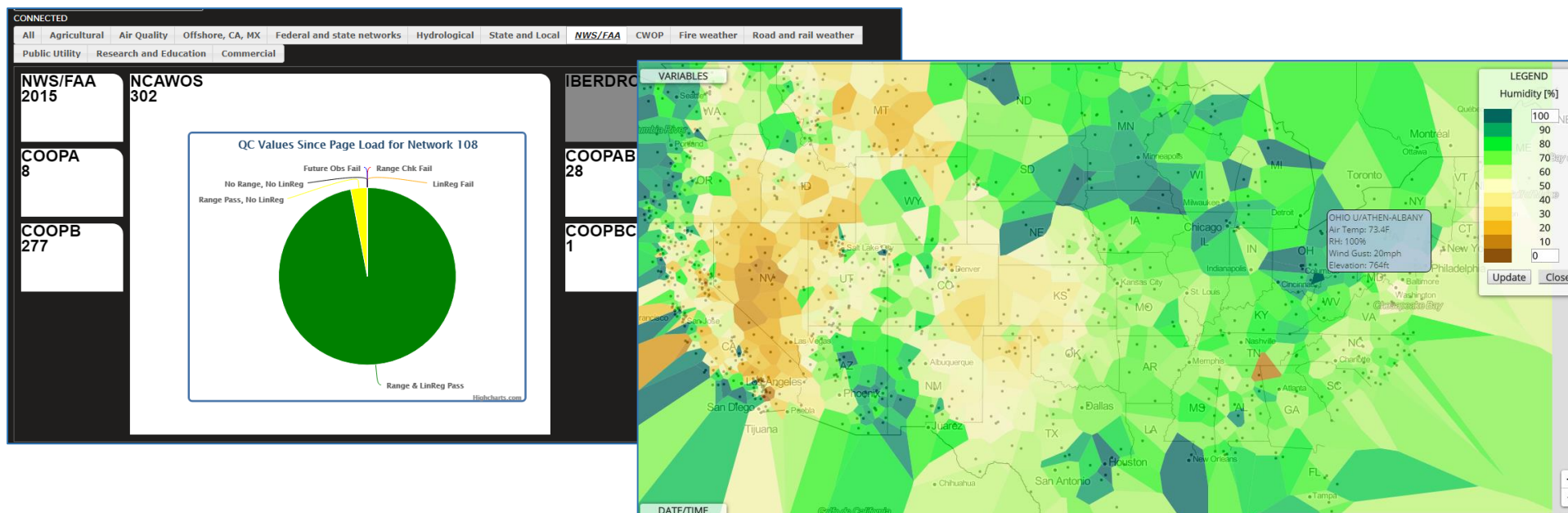
Who Am I?

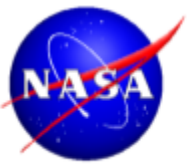


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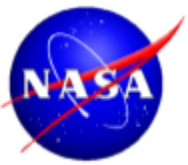


What Data Do I Use?



HDF5 files from low-Earth orbit microwave imager/sounders and radars





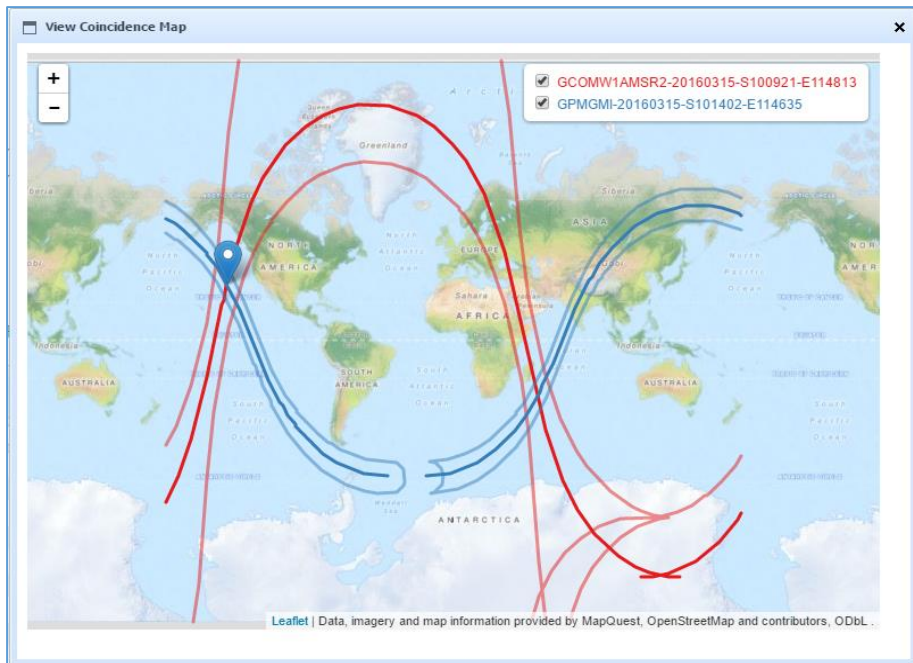
What Data Do I Use?



HDF5 files from low-Earth orbit microwave imager/sounders and radars



Most of the time, the data are stored by the swath

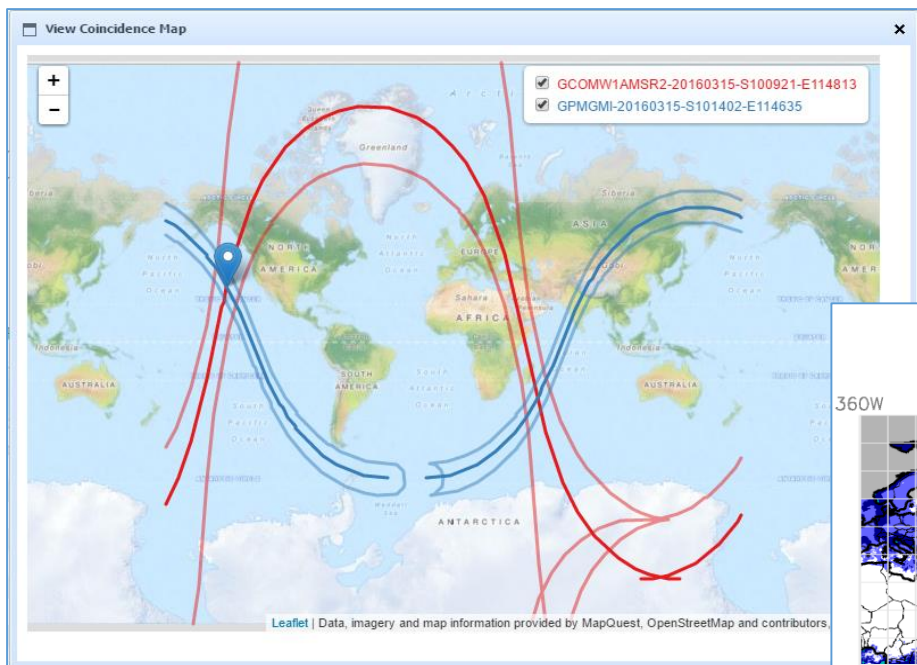




What Data Do I Use?

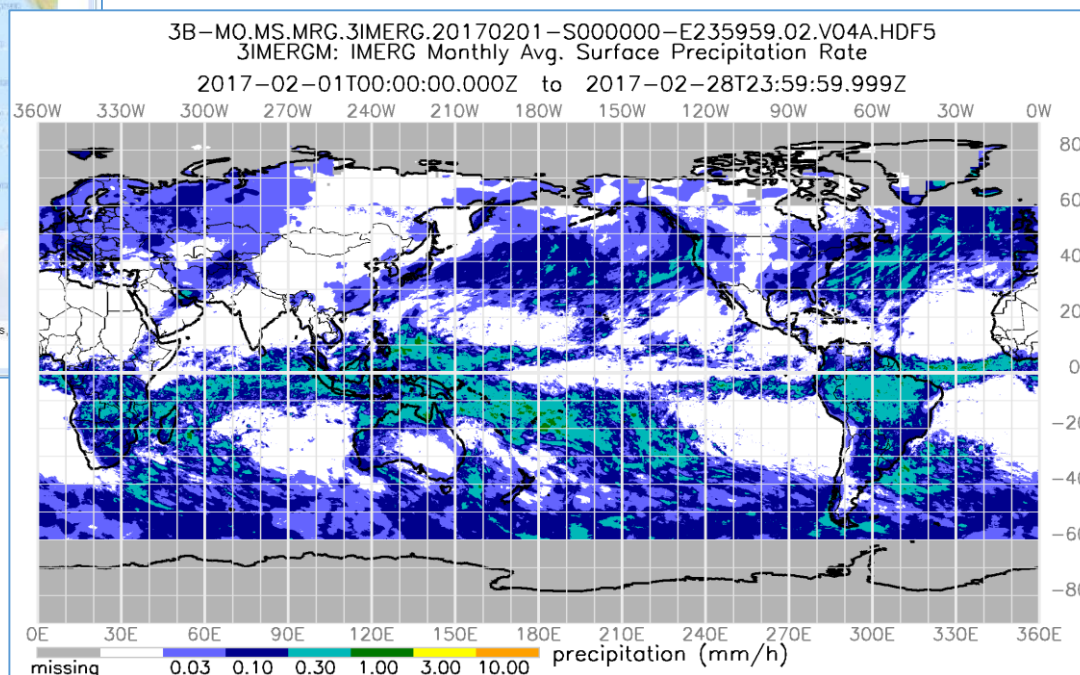


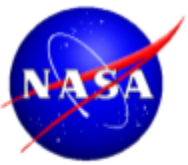
HDF5 files from low-Earth orbit microwave imager/sounders and radars



Most of the time, the data are stored by the swath

Sometimes it's on a latitude-longitude grid





What Data Do I Use?



National Aeronautics and Space Administration

GPM NRT Viewer

Product: DPR Level 2

Variable: Precipitation Rate

Time: 20

Show Legend

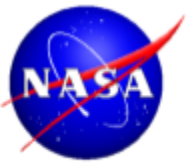
Scale
All values in mm/hr

Color	Range
Yellow	>34.0
Light Green	21.0-34.0
Green	13.0-21.0
Light Blue	8.0-13.0
Teal	5.0-8.0
Blue	3.0-5.0
Dark Blue	2.0-3.0
Very Dark Blue	1.0-2.0
Black	0.01-1.0
Grey	0-0.01

Close

Variables include **brightness**, **temperature**, **reflectivity**, **precipitation phase**, and **precipitation rate**.

Some demos I will be showing also include model output of wind speed and reflectivity, as well as modeled tracers of air quality.

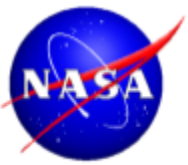


What Tool Do I Use?



CesiumJS!

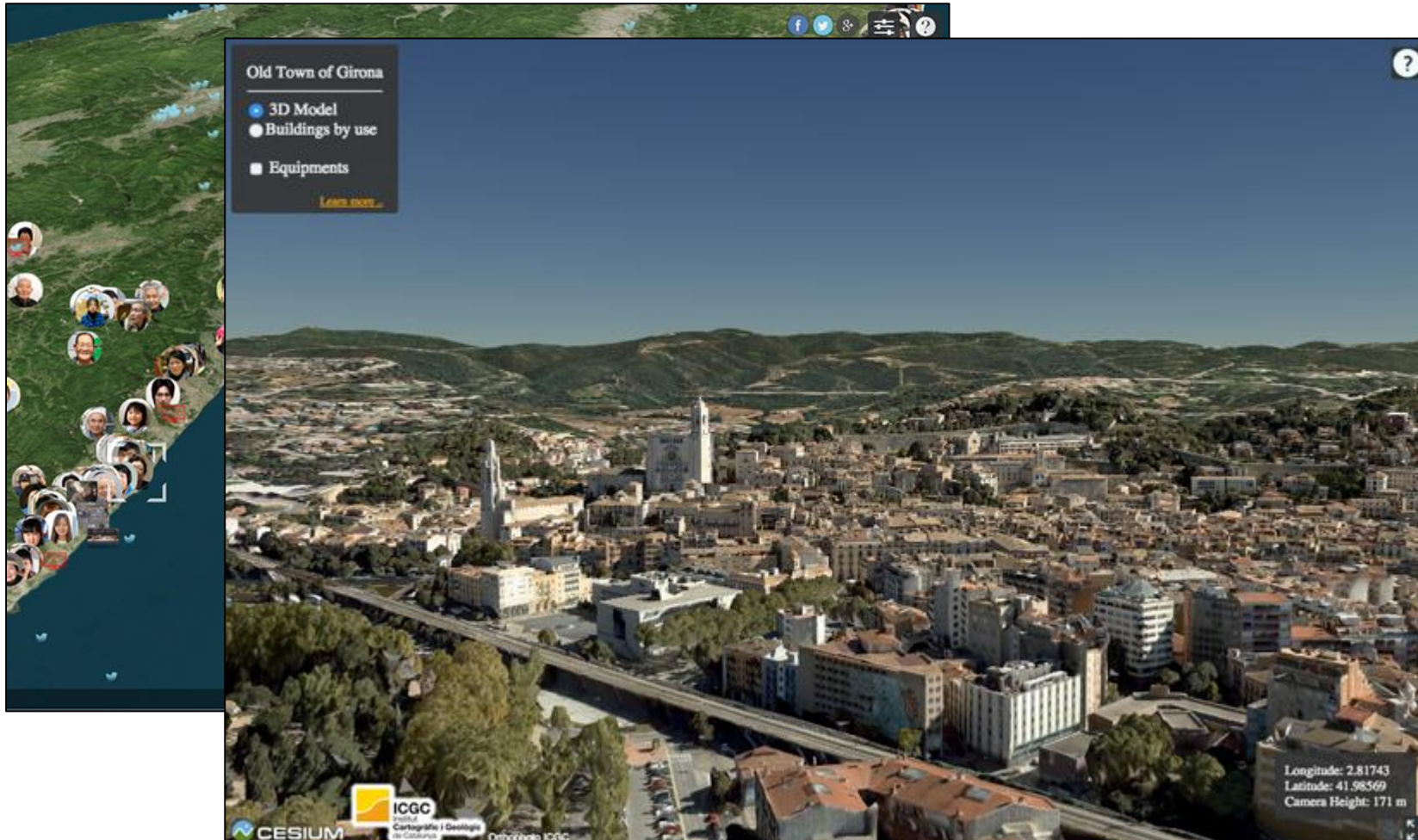


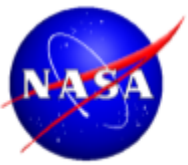


What Tool Do I Use?



CesiumJS!

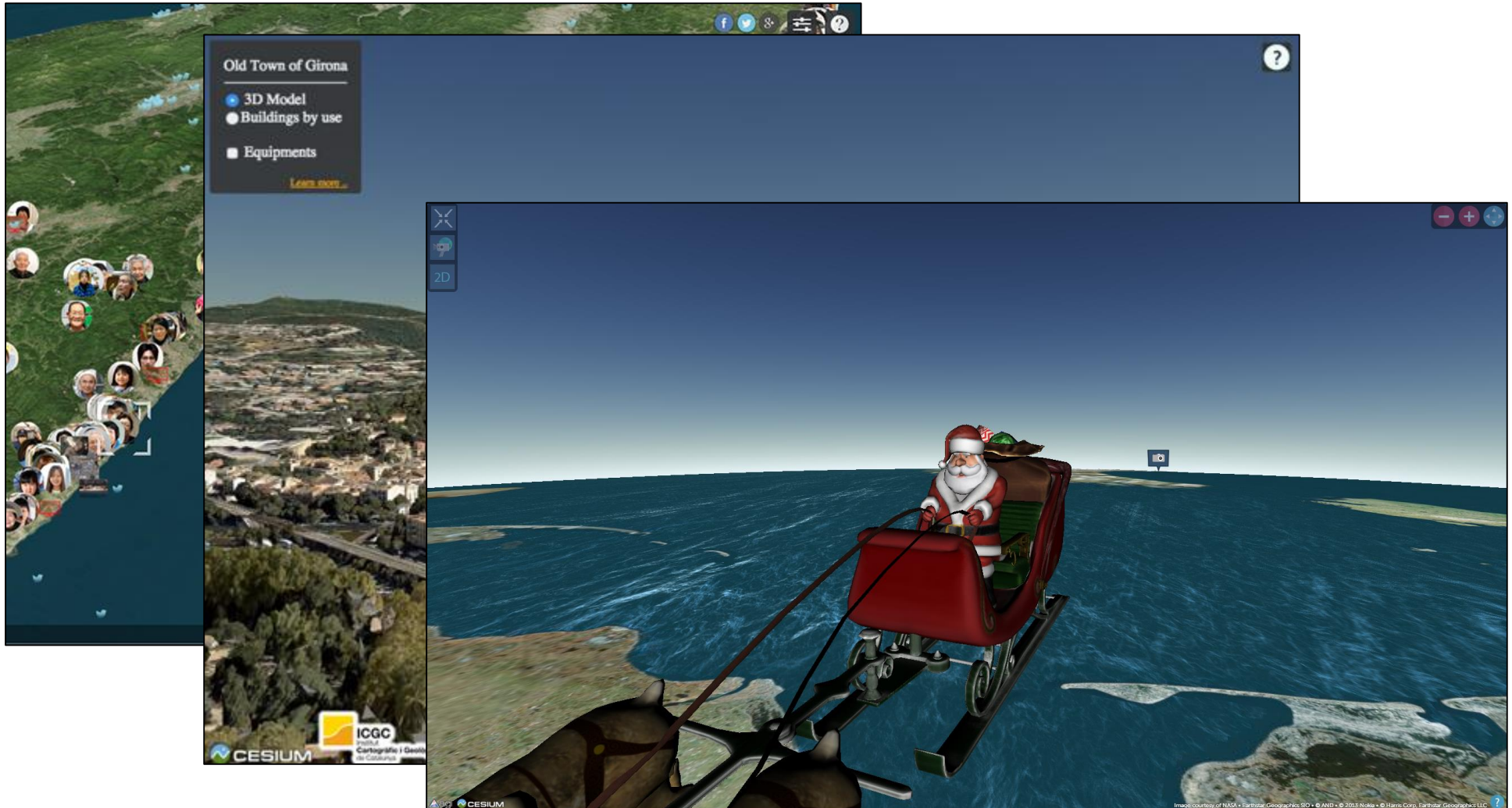




What Tool Do I Use?



CesiumJS!

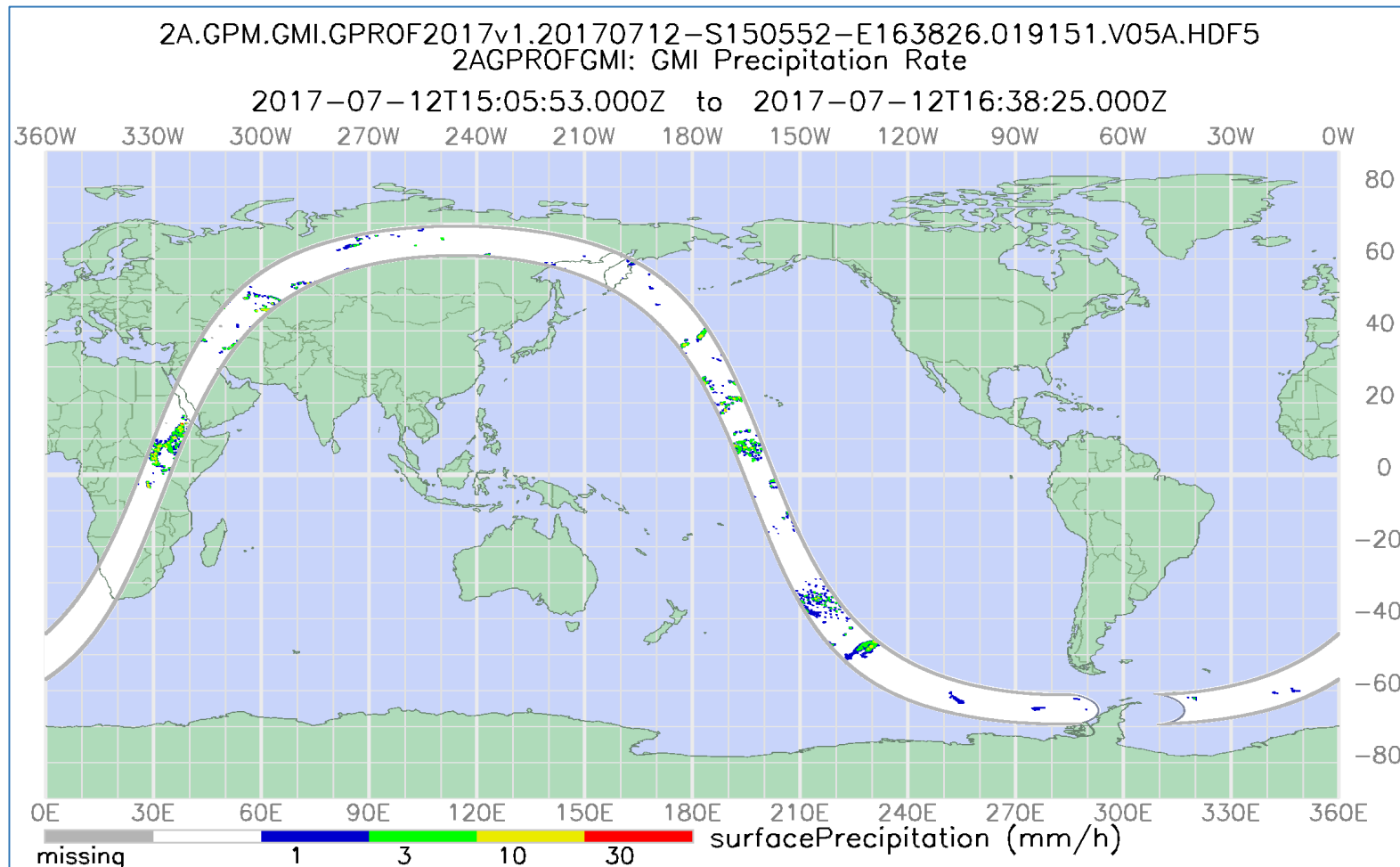


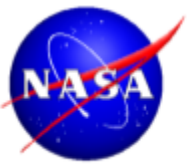


What Motivates This Work?



When I came to NASA, project scientists were making decisions about data acquisition based on static images.

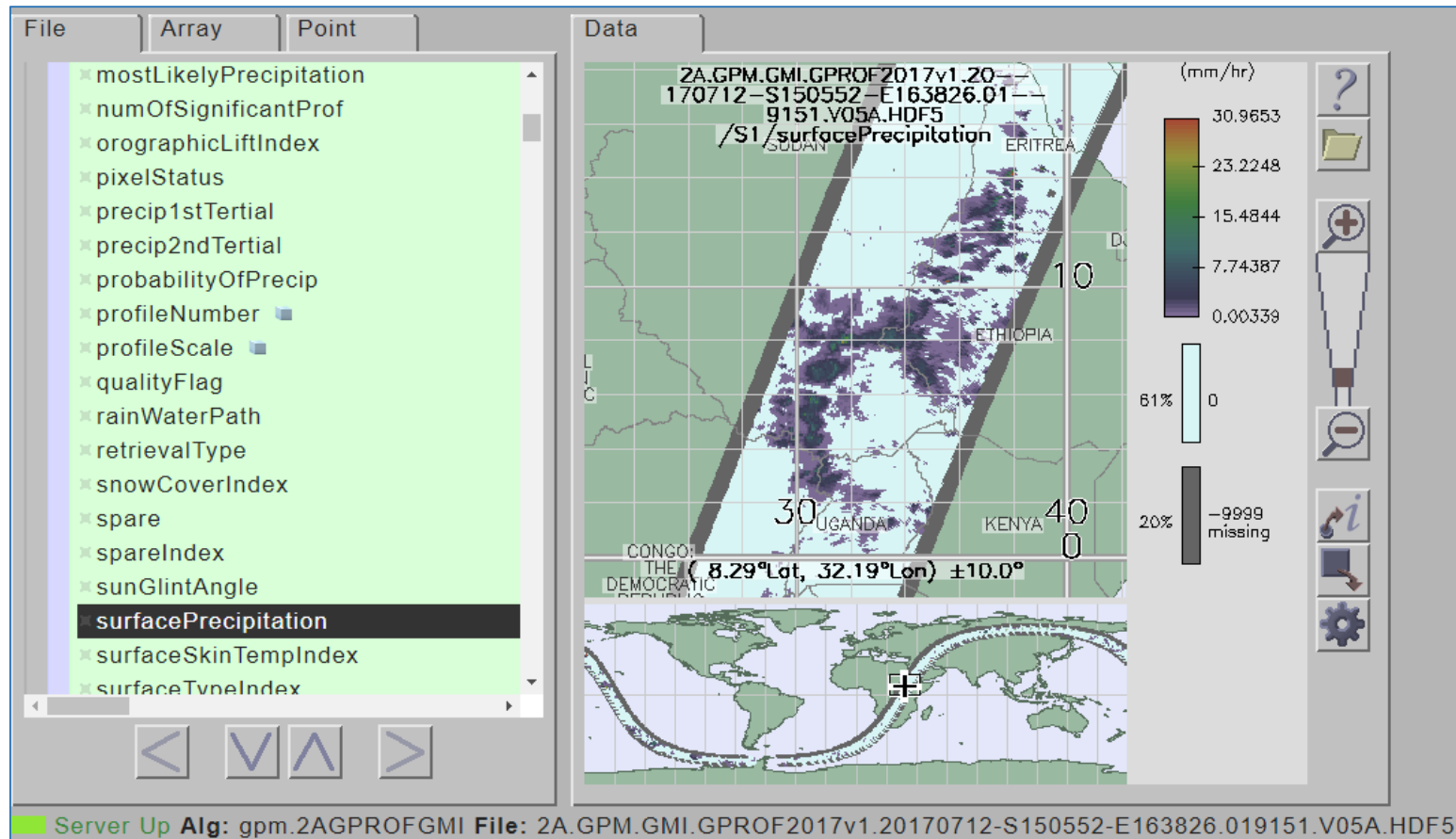




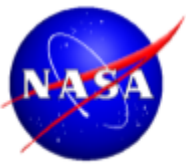
What Motivates This Work?



Files could be ingested into THOR data viewer tool, but visualization was limited to two dimensions.



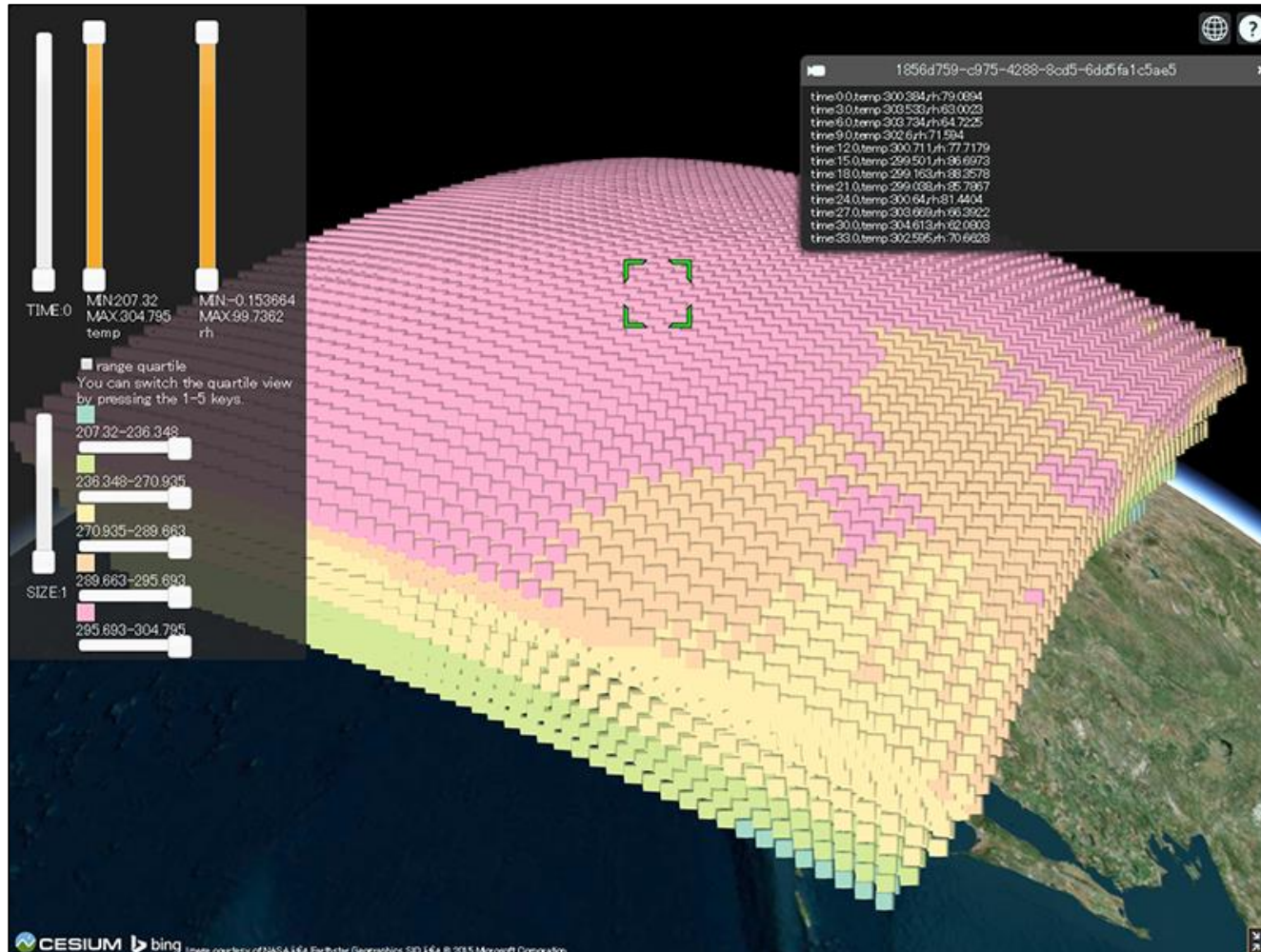
With Near Real Time data, they had no ability to preview files.

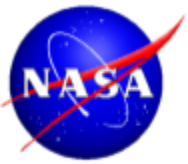


What Motivates This Work?



One day, I saw this demo in the Cesium showcase...

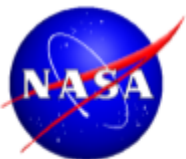




What Motivates This Work?



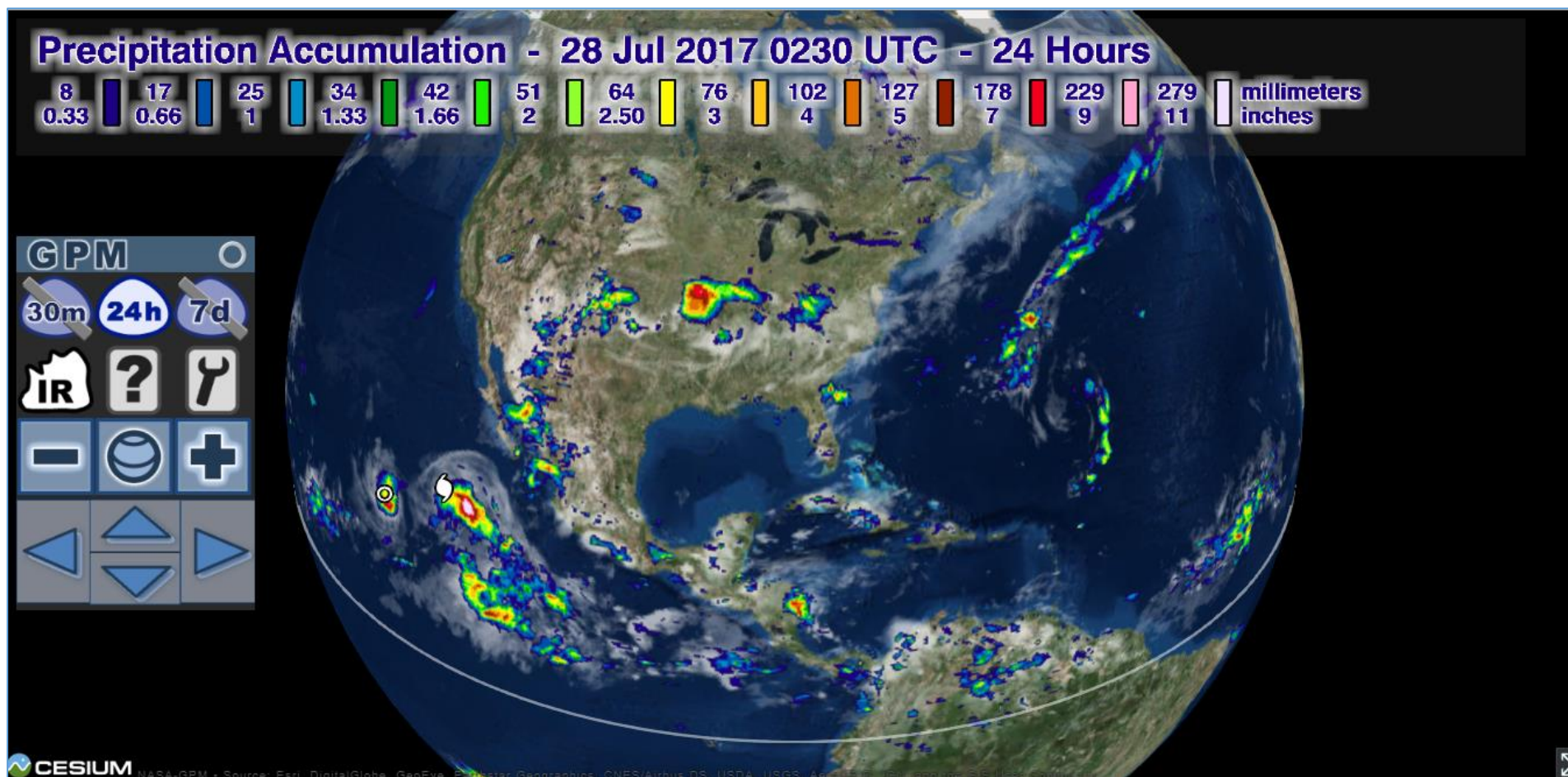
If Cesium could handle weather model data like that, I could use the same principles to display precipitation satellite information.

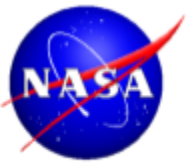


What Motivates This Work?

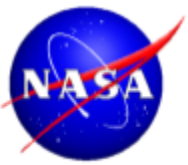


One approach is to use image tiles, which remains 2D, but can still be placed on a 3D globe.

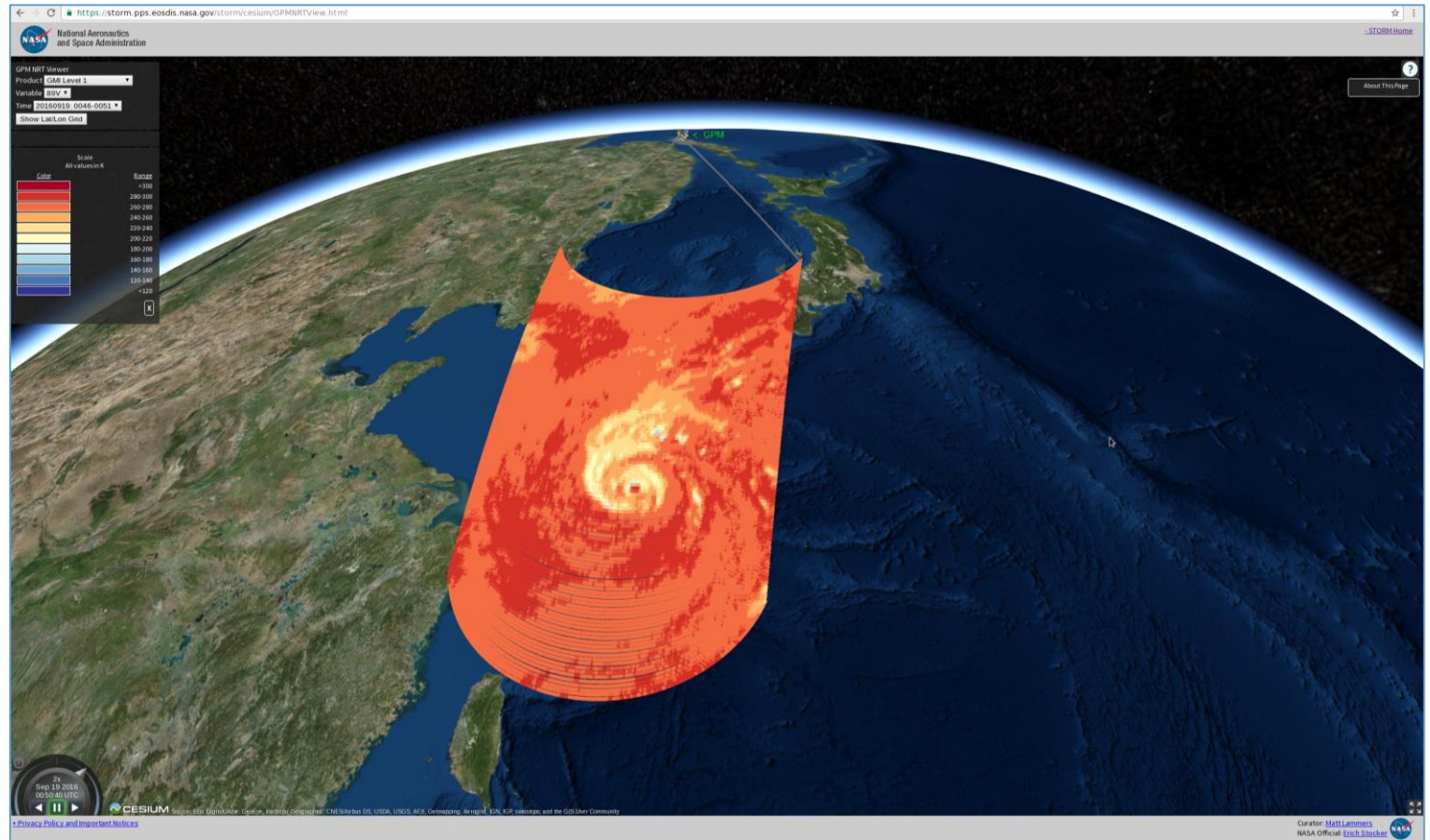


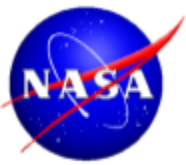


So where did I start? Near Real Time Data...
[https://storm.pps.eosdis.nasa.gov/storm/
cesium/GPMNRTView.html](https://storm.pps.eosdis.nasa.gov/storm/cesium/GPMNRTView.html)

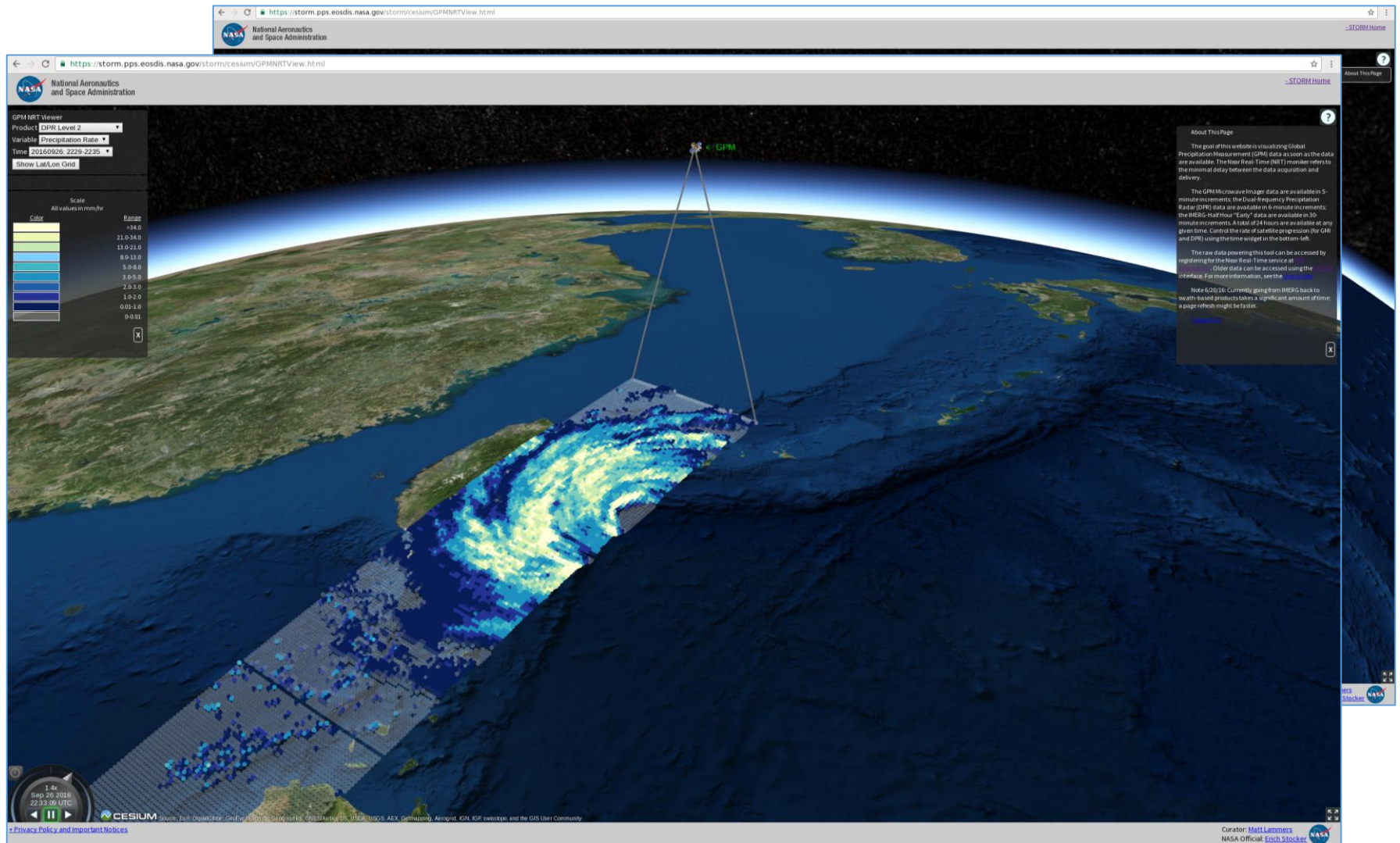


GPM Near Real Time Viewer





GPM Near Real Time Viewer





GPM Near Real Time Viewer



Product: GPROF (GMI Level 2)
Variable: Precipitation Rate
Time: 20101003_2011-2016
Show Lat/Lon Grid

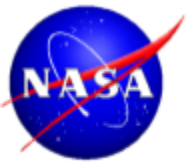
Color	Range
Yellow	> 14.0
Light Green	21.0-34.0
Green	13.0-21.0
Light Blue	6.0-13.0
Blue	3.0-6.0
Dark Blue	1.0-3.0
Very Dark Blue	0.0-1.0

Scale: All values in mm/hr

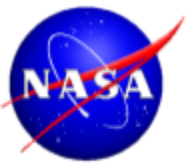
Curator: Matt Lammers
NASA Official: Erich Stocker



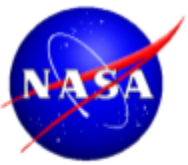
-
- Post-Processed HDF5 into CZML (Cesium Markup Language), storing a rolling 24 hours of data



- Post-Processed HDF5 into CZML (Cesium Markup Language), storing a rolling 24 hours of data
- Each 5-/6-minute segment is stored as a series of points that are time dynamic. Cesium interpolates between the points and colors to present smooth transitions.



- Post-Processed HDF5 into CZML (Cesium Markup Language), storing a rolling 24 hours of data
- Each 5-/6-minute segment is stored as a series of points that are time dynamic. Cesium interpolates between the points and colors to present smooth transitions.
- Each scan time, the point positions/colors are dumped out and stored as the satellite and time dynamic points move forward. These dumped points are erased after 15 minutes of scan.



GPM Near Real Time Viewer



A close-up to illustrate how this process works...

National Aeronautics and Space Administration

-STORM Home

GPM NRT Viewer

Product: GPROF (GMI Level 2)

Variable: Precipitation Rate

Time: 20170807: 0306-0311

Show Lat/Lon Grid

Scale: All values in mm/hr

Color	Range
>34.0	>34.0
21.0-34.0	21.0-34.0
13.0-21.0	13.0-21.0
8.0-13.0	8.0-13.0
5.0-8.0	5.0-8.0
3.0-5.0	3.0-5.0
2.0-3.0	2.0-3.0
1.0-2.0	1.0-2.0
0.01-1.0	0.01-1.0
0-0.01	0-0.01

Close

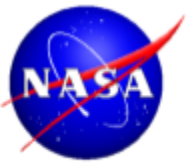
Aug 7 2017
03:08:12 UTC

CESIUM

NASA/JAXA - Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

+ Privacy Policy and Important Notices

Curator: [Matt Lammers](#)
NASA Official: [Erich Stocker](#)



STORM Virtual Globe



Moving on to “production” data, and STORM Virtual
Globe

<https://storm.pps.eosdis.nasa.gov/storm/data/Service.jsp?serviceName=Order>



STORM Virtual Globe



BEFORE:

Search Results [?](#)

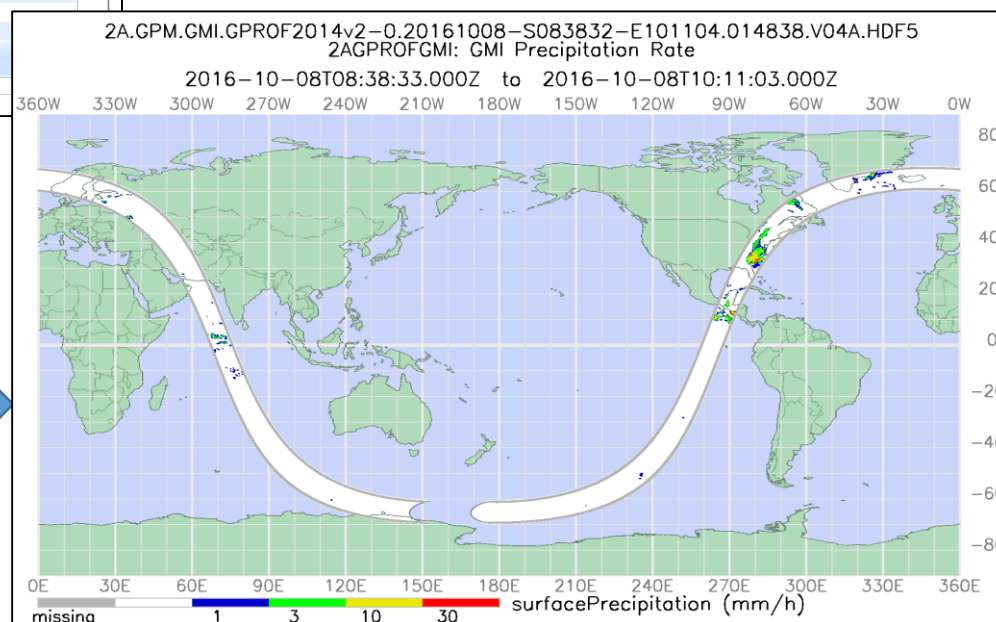
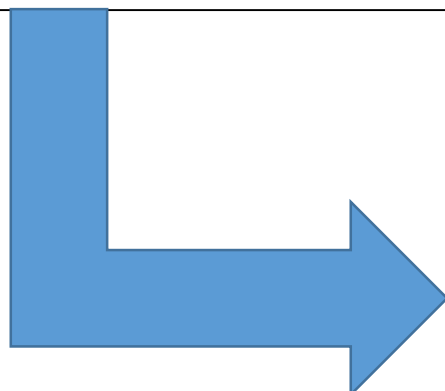
Required for Order Submission

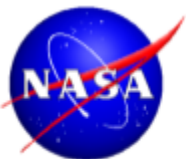
Left click on the header to sort columns. Right click to view additional info (file name, satellite, instrument, format and version).

Select	Data Type	Algorithm	Download / View	Start Time	Stop Time	Orbit #	Format
<input type="checkbox"/>	2A	2AGPROFG		2016-10-09 00:04:04	2016-10-09 01:36:36	14848	hdf5
<input type="checkbox"/>	2A	2AGPROFG		2016-10-09 01:36:37	2016-10-09 03:09:09	14849	hdf5
<input type="checkbox"/>	2A	2AGPROFG		2016-10-09 03:09:10	2016-10-09 04:41:42	14850	hdf5
<input type="checkbox"/>	2A	2AGPROFG		2016-10-09 04:41:43	2016-10-09 06:14:15	14851	hdf5
<input type="checkbox"/>	2A	2AGPROFG		2016-10-09 06:14:16	2016-10-09 07:46:48	14852	hdf5
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<input type="checkbox"/>	2A	2AGPROFG		2016-10-09 09:19:22	2016-10-09 10:51:54	14854	hdf5
<input type="checkbox"/>	2A	2AGPROFG		2016-10-09 10:51:55	2016-10-09 12:24:27	14855	hdf5
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Total Granules selected: 0

1 2 3 Records from 33 to 48 of 48





STORM Virtual Globe



AFTER:

Search Results ▼

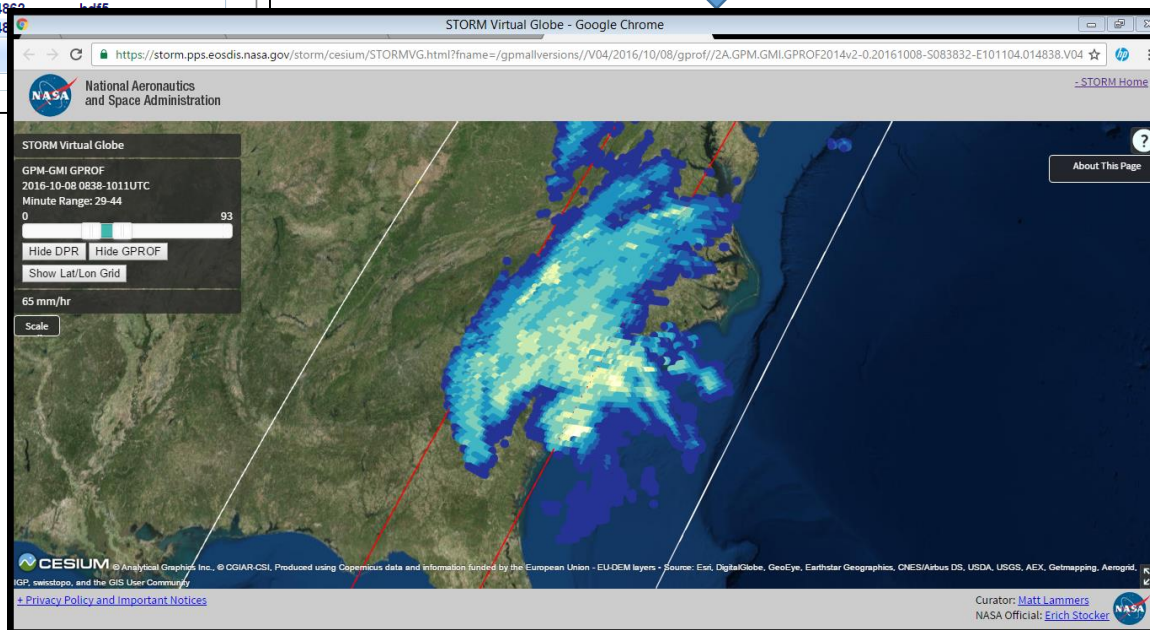
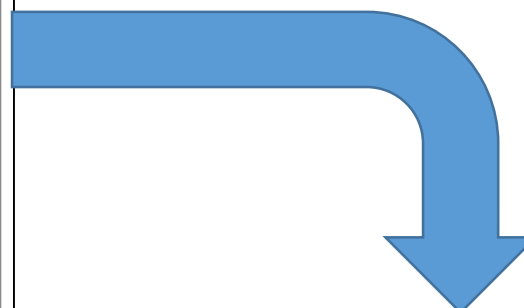
Required for Order Submission

Left click on the header to sort columns. Right click to view additional info (file name, satellite, instrument, format and version).

Select	Data Type ^A	Algorithm	Download / View [Ⓞ]	Start Time	Stop Time	Orbit #	Format
<input type="checkbox"/>	2A	2AGPROFG		2016-10-09 00:04:04	2016-10-09 01:36:36	14848	hdf5
<input type="checkbox"/>	2A	2AGPROFG		2016-10-09 01:36:37	2016-10-09 03:09:09	14849	hdf5
<input type="checkbox"/>	2A	2AGPROFG		2016-10-09 03:09:10	2016-10-09 04:41:42	14850	hdf5
<input type="checkbox"/>	2A	2AGPROFG		2016-10-09 04:41:43	2016-10-09 06:14:15	14851	hdf5
<input type="checkbox"/>	2A	2AGPROFG		2016-10-09 06:14:16	2016-10-09 07:46:48	14852	hdf5
<input type="checkbox"/>	2A	2AGPROFG		2016-10-09 07:46:49	2016-10-09 09:19:21	14853	hdf5
<input type="checkbox"/>	2A	2AGPROFG		2016-10-09 09:19:22	2016-10-09 10:51:54	14854	hdf5
<input type="checkbox"/>	2A	2AGPROFG		2016-10-09 10:51:55	2016-10-09 12:24:27	14855	hdf5
<input type="checkbox"/>	2A	2AGPROFG		2016-10-09 12:24:28	2016-10-09 13:57:00	14856	hdf5
<input type="checkbox"/>	2A	2AGPROFG		2016-10-09 13:57:01	2016-10-09 15:29:33	14857	hdf5
<input type="checkbox"/>	2A	2AGPROFG		2016-10-09 15:29:34	2016-10-09 17:02:06	14858	hdf5
<input type="checkbox"/>	2A	2AGPROFG		2016-10-09 17:02:07	2016-10-09 18:34:39	14859	hdf5
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<input type="checkbox"/>	2A	2AGPROFG		2016-10-09 21:39:47	2016-10-09 23:12:19	14862	hdf5
<input type="checkbox"/>	2A	2AGPROFG		2016-10-09 23:12:20	2016-10-10 00:44:52	14863	hdf5

Total Granules selected: 0

1 2 3 Records from 33 to 48 of 48

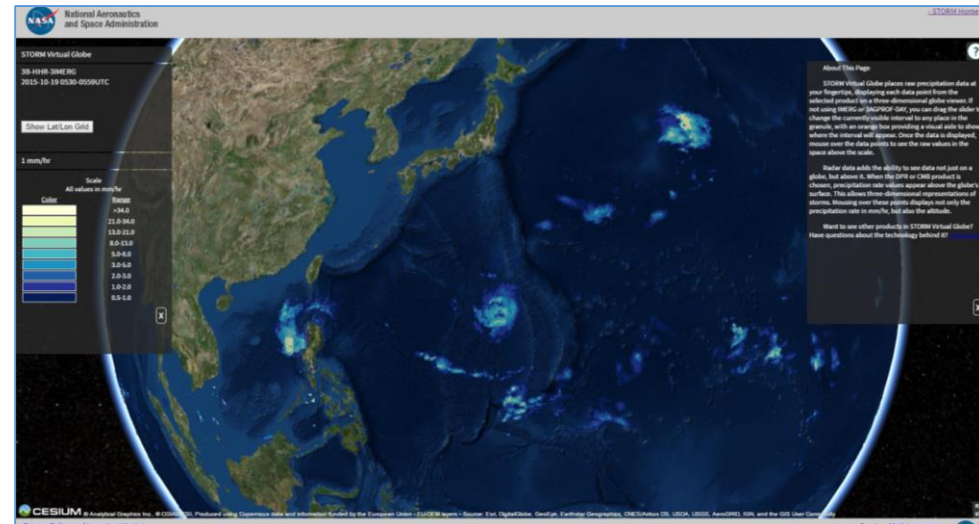
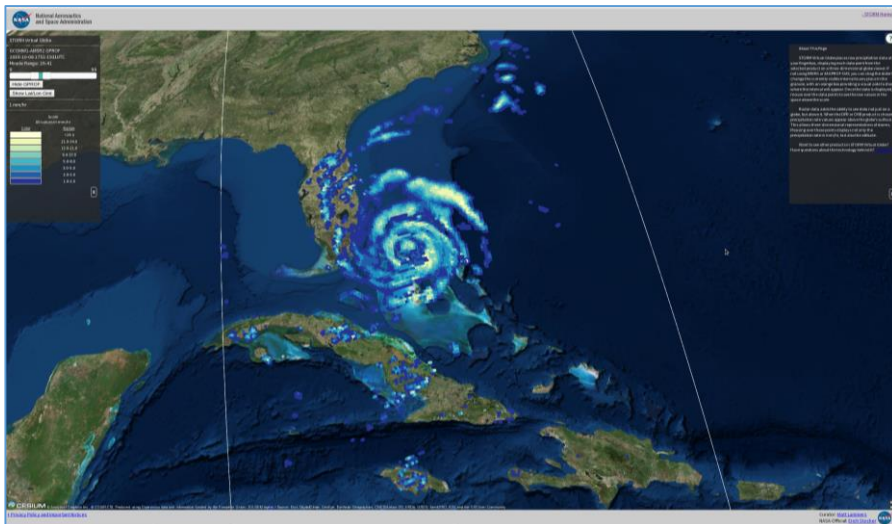
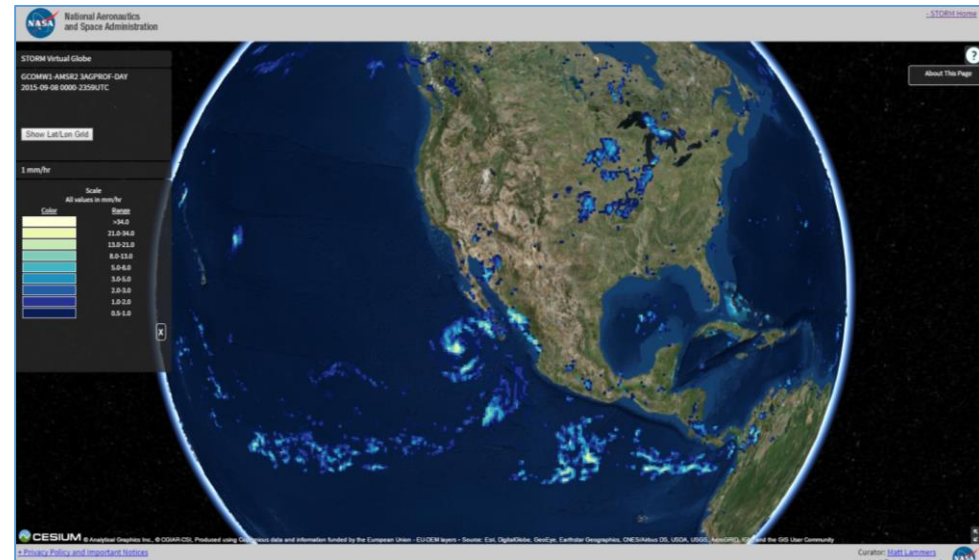
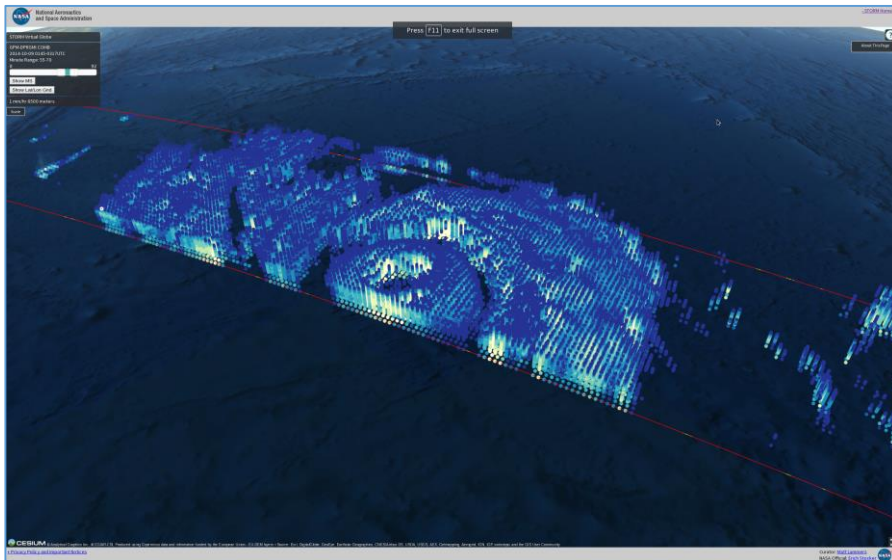




STORM Virtual Globe



29 Products Available

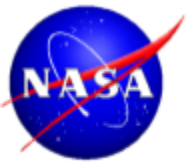




STORM Virtual Globe



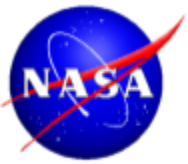
-
- AJAX Request sent to Java Apache Tomcat server, which pulls in the HDF5 file
 - Java code converts the relevant data to JSON
 - JavaScript parses the JSON and loops through it, generating CesiumJS PointPrimitives



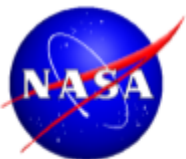
STORM Virtual Globe



-
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 - Gridded, swath, and 3D data are all treated the same



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- Java code converts the relevant data to JSON
- JavaScript parses the JSON and loops through it, generating CesiumJS PointPrimitives
- Gridded, swath, and 3D data are all treated the same
- Only 15 minutes of swath data allowed at a time to avoid overloading Cesium



STORM Virtual Globe



Need Help?

- Click on for context specific help.
- [STORM User Guide](#)
- [Help Desk](#)

Number of granules 23

Search Results

Required for Order Submission

Left click on the header to sort columns. Right click to view additional info (file name, satellite, instrument, format and version).

Select	Data Type	Algorithm	Download / View	Start Time	Stop Time	Orbit #	Format
<input type="checkbox"/>							
<input type="checkbox"/>	2A	2AGPROFAMSR		2017-08-01 02:44:36	2017-08-01 04:23:28	27692	hdf5
<input type="checkbox"/>	2A	2AGPROFAMSR		2017-08-01 04:23:29	2017-08-01 06:02:21	27693	hdf5
<input type="checkbox"/>	2A	2AGPROFAMSR		2017-08-01 15:55:40	2017-08-01 17:34:32	27700	hdf5
<input type="checkbox"/>	2A	2AGPROFAMSR		2017-08-02 03:27:52	2017-08-02 05:06:44	27707	hdf5
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<input type="checkbox"/>	2A	2AGPROFAMSR		2017-08-04 16:26:35	2017-08-04 18:05:27	27744	hdf5
<input type="checkbox"/>	2A	2AGPROFAMSR		2017-08-05 03:58:46	2017-08-05 05:37:38	27751	hdf5
<input type="checkbox"/>	2A	2AGPROFAMSR		2017-08-05 15:30:58	2017-08-05 17:09:50	27758	hdf5
<input type="checkbox"/>	2A	2AGPROFAMSR		2017-08-06 03:03:09	2017-08-06 04:42:01	27765	hdf5
<input type="checkbox"/>	2A	2AGPROFAMSR		2017-08-06 14:35:21	2017-08-06 16:14:13	27772	hdf5

Total Granules selected: 0

1 2 Records from 1 to 16 of 23

[Submit Request](#) [Clear Form](#)

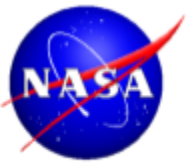
SECURITY

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+ [Privacy Policy and Important Notices](#)



Curator: Matthew Lammers
NASA Official: Erich Stocker, Code 610.2, NASA/GSFC
Last Updated: 8/18/2015



STORM Event Viewer



What about really important, high impact events?

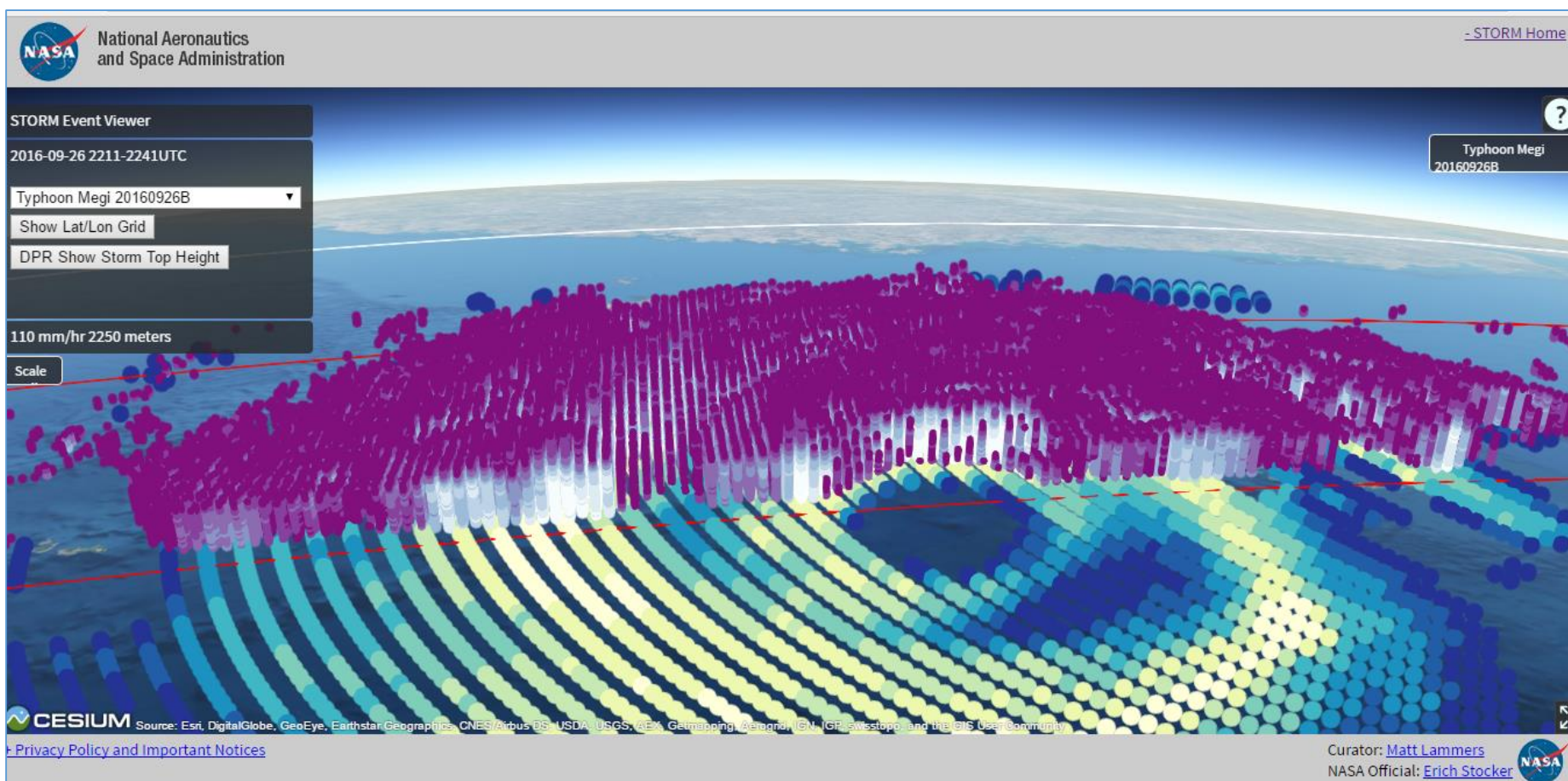
<https://storm.pps.eosdis.nasa.gov/storm/cesium/EventViewer.html>

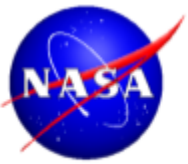


STORM Event Viewer



With tens of thousands of GPM orbits, isolating the ones that contain high-impact events is a priority.





STORM Event Viewer



Three ways “Events” get selected:



STORM Event Viewer



Three ways "Events" get selected:

- I performed a massive survey collocating GPM overflights with tropical cyclones

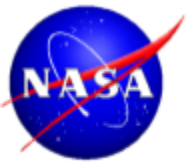


STORM Event Viewer



Three ways "Events" get selected:

- I performed a massive survey collocating GPM overflights with tropical cyclones
- I see events occurring in the NRT Viewer and isolate them for preservation in the Event Viewer



Three ways "Events" get selected:

- I performed a massive survey collocating GPM overflights with tropical cyclones
- I see events occurring in the NRT Viewer and isolate them for preservation in the Event Viewer
- A researcher or project member requests a specific case get highlighted for a press release or to feature in a presentation



STORM Event Viewer



Latest Event: Hurricane Franklin 8/9/17

NASA National Aeronautics and Space Administration - STORM Home

STORM Event Viewer

Franklin
2017-08-09 1611-1641UTC

Events

Show Lat/Lon Grid

DPR Show Storm Top Height

4 mm/hr

Scale
All values in mm/hr
GMI | DPR

Color	Range	Color
	>34.0	
	21.0-34.0	
	13.0-21.0	
	8.0-13.0	
	5.0-8.0	
	3.0-5.0	
	2.0-3.0	
	1.0-2.0	
	0.5-1.0	

Close

Franklin 20170809B

Approaching hurricane force, Franklin has sustained winds around 60 knots near the center, as observed by the Hurricane Hunters. The storm appears lopsided, with dry air impinging on the northwestern side, while the southeastern side features intense rainfall, observed by GMI. DPR shows a tall cell (above 16km) in the eye wall, with deep convection in outer bands as well. The storm is expected to continue intensifying into a Category 1 storm before it makes landfall on the Mexican coast less than 24 hours from now.

Want to see other events in STORM Event Viewer? Have questions about the technology behind it? [Learn More](#)

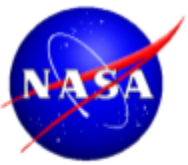
The Dual-frequency Precipitation Radar and GPM Microwave Imager data are products of a joint mission between NASA and JAXA. If you are interested in the data, it is accessible through the [data](#) ordering interface.

Close

CESIUM NASA/JAXA • Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS/AeroGRID, IGN, and the GIS User Community

[+ Privacy Policy and Important Notices](#)

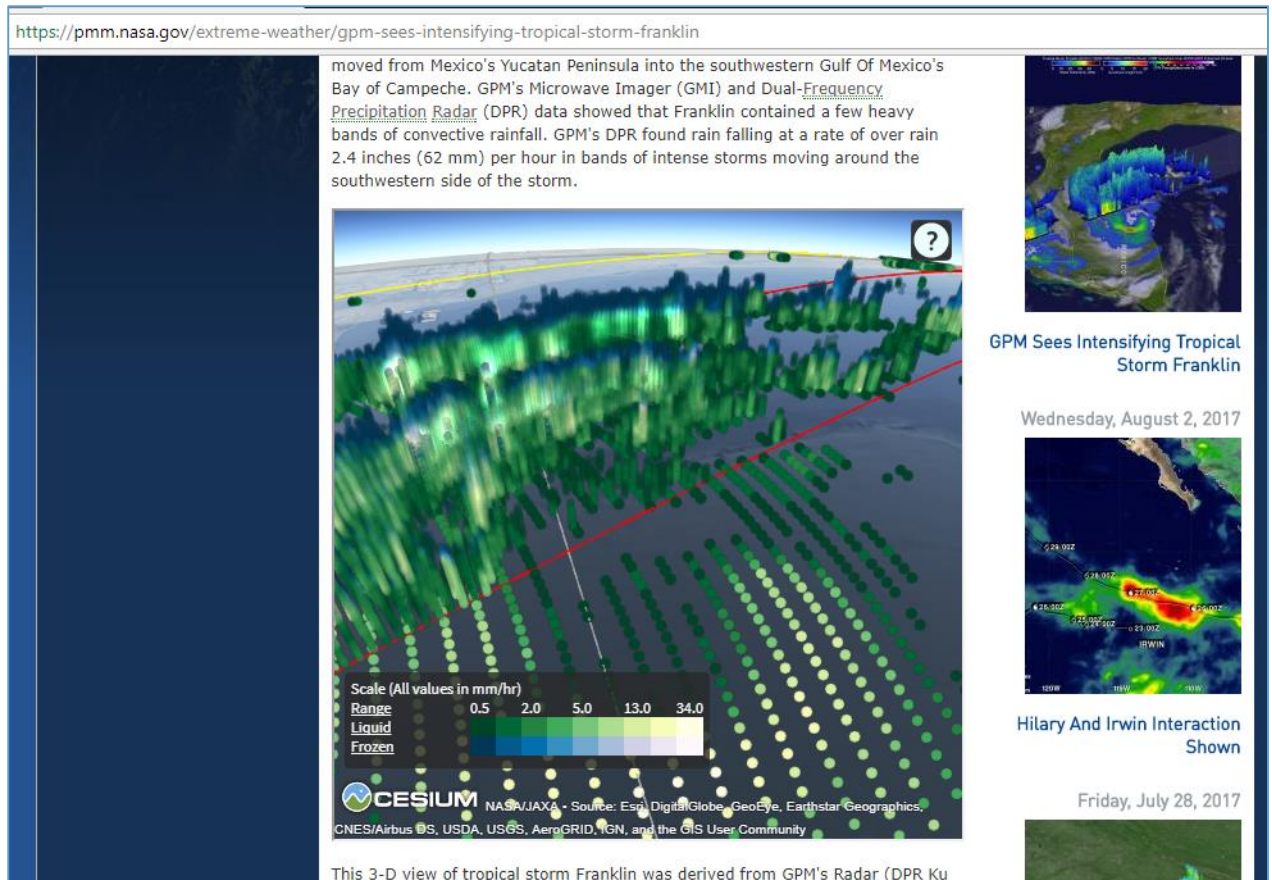
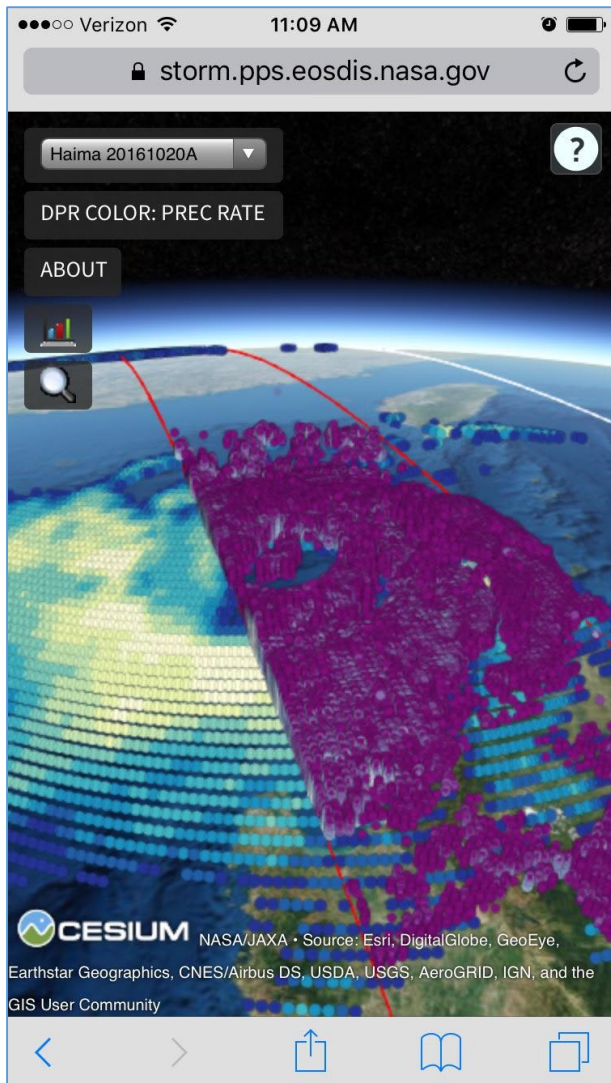
Curator: [Matt Lammers](#)
NASA Official: [Erich Stocker](#)

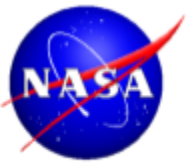


STORM Event Viewer



Mobile Version (EVMini) and Embeddable Version (EVMicro)





Other Demos



Where else has this CesiumJS journey taken me?



Other Demos



High-Resolution Weather Model Output

<https://storm.pps.eosdis.nasa.gov/storm/cesium/HWRF.html>

NASA National Aeronautics and Space Administration

STORM VG HWRF Demo

Super Typhoon Nepartak
7 July 2016, 06 UTC Run Hour: 03

Time Controls:

Visibility Controls:

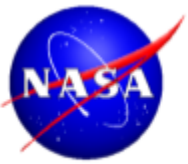
34 dBZ 10777 meters

Color	Range
Yellow	>55.0
Light Green	52.5-55.0
Green	50.0-52.5
Light Blue	47.5-50.0
Blue	45.0-47.5
Dark Blue	42.5-45.0
Very Dark Blue	40.0-42.5
Dark Purple	35.0-40.0
Black	30.0-35.0

Scale
All values in dBZ

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community • © Analytical Graphics Inc. • © CGIAR-CSI, Produced using Copernicus data and information funded by the European Union - E

Curator: [Matt Lammers](#)
NASA Official: [Erich Stocker](#)

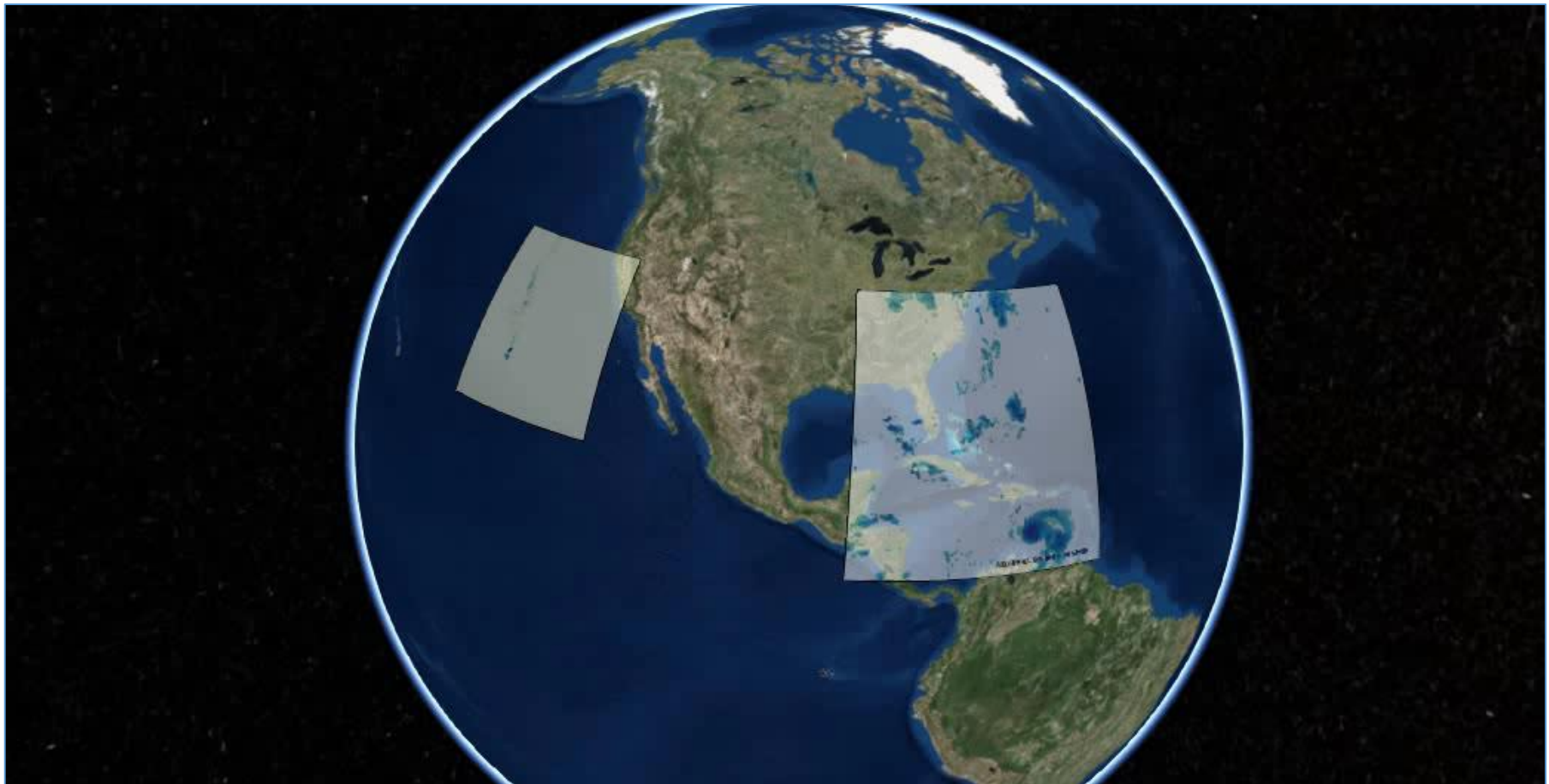


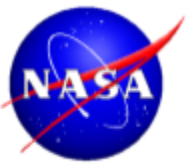
Other Demos



Generating Videos from Gridded Data and Previewing Them on the Globe

<https://storm.pps.eosdis.nasa.gov/storm/cesium/VidTest.html>





Other Demos



Animating Modeled Particle Transport





Final Remark

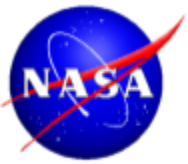


This is just scraping the surface of what can be done with remote sensing and other atmospheric data in CesiumJS. It is on this generation (and future generations) of researchers to leverage innovative tools to make scientific investigation easier to perform and results easier to share online with colleagues and the public.



...THANK YOU!

matthew.r.lammers@nasa.gov



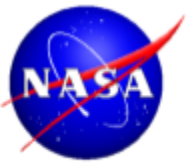
Oh Yeah!

Demos and Discussions
Tomorrow (Thursday) at
Noon at the CesiumJS
Booth

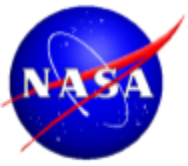


...THANK YOU!

matthew.r.lammers@nasa.gov



Extra Slides...



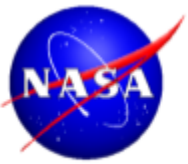
Who Am I?



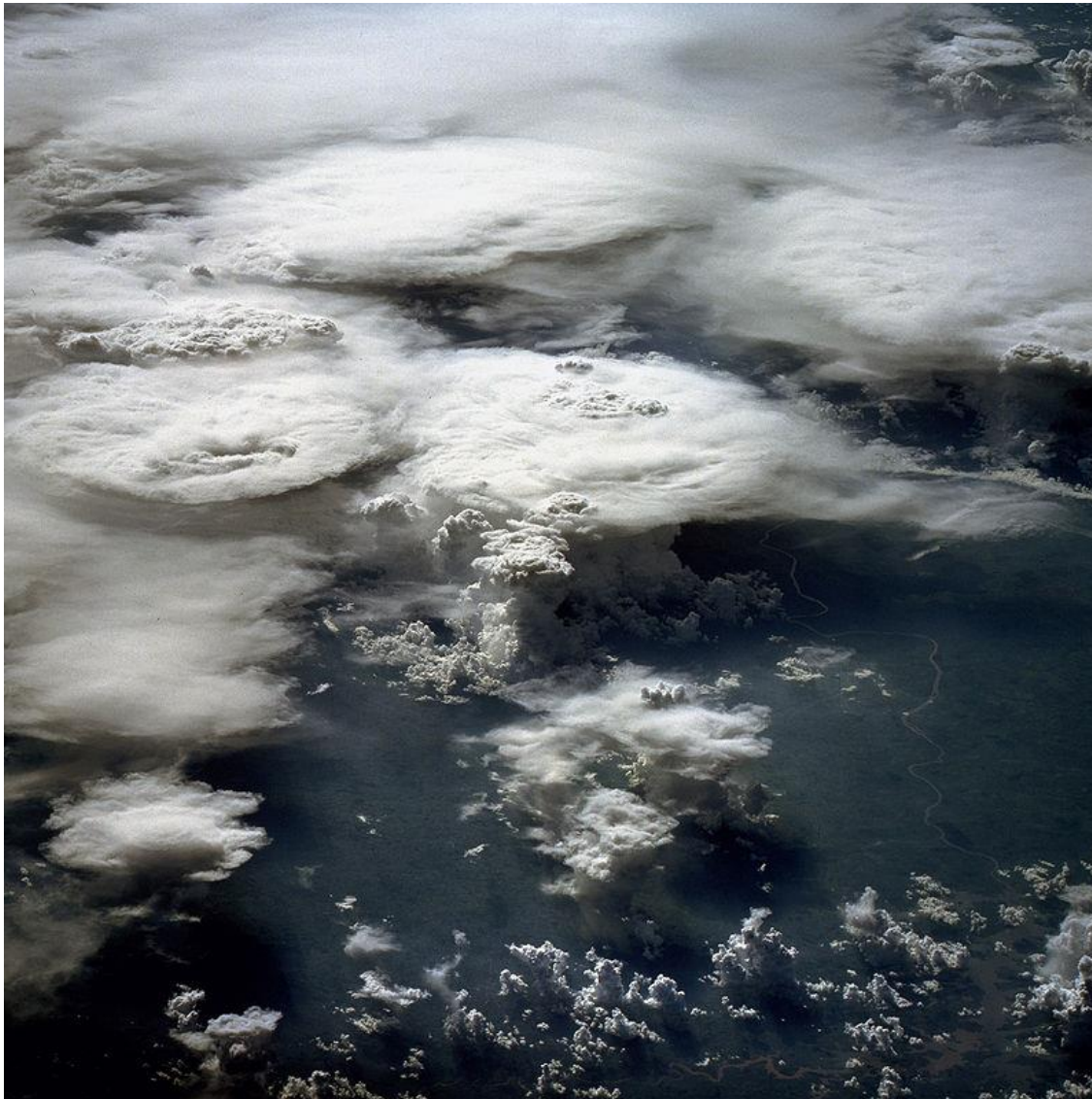
Then, I saw weather from the ground



By Taken byfir0002 | flagstaffotos.com.auCanon 20D + Canon 17-40mm f/4 L - Own work, GFDL 1.2, <https://commons.wikimedia.org/w/index.php?curid=893031>

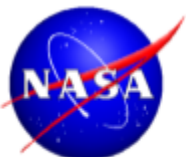


Who Am I?



Now,
I see it from space

By NASA - <http://eol.jsc.nasa.gov/sseop/EFS/photoinfo.pl?PHOTO=STS41B-41-2347>, Public Domain,
<https://commons.wikimedia.org/w/index.php?curid=1975689>



Other Demos



High-Resolution Weather Model Output

https://storm.pps.eosdis.nasa.gov/storm/cesium/HWRF_v2.html

NASA National Aeronautics and Space Administration

STORM VG HWRF Demo

Hurricane Sylvester
27 July 2016, 06 UTC Run Hour: 00

- 500 hPa
- 700 hPa
- 850 hPa
- 10 meters

Time Controls:

Scale
All values in m/s

Color	Range
	>70.0 (Cat 5)
	64.0-70.0 (Cat 4)
	58.0-64.0 (Cat 4)
	53.0-58.0 (Cat 3)
	49.0-53.0 (Cat 3)
	46.0-49.0 (Cat 2)
	42.0-46.0 (Cat 2)
	32.0-42.0 (Cat 1)
	18.0-32.0 (TS)

CESIUM Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

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Curator: [Matt Lammers](#)
NASA Official: [Erich Stocker](#)