CSPP Geo Status and Plans

Graeme Martin, Liam Gumley, Nick Bearson, Jessica Braun, Geoff Cureton, Alan De Smet, Ray Garcia, Dave Hoese, Tommy Jasmin, Scott Lindstrom, Eva Schiffer, Kathy Strabala, Jenny Witt

University of Wisconsin – Madison, Space Science & Engineering Center (SSEC) /
Cooperative Institute for Meteorological Satellite Studies (CIMSS)

CSPP Users' Group Meeting
22 June 2022
Madison, Wisconsin, USA

Outline

- Project Overview

- CSPP Geo Users

- Software Packages

- GeoSphere Website and Cloud Demonstration

Project Overview

- Before the launch of GOES-16, it was recognized that users would need a way to process raw data received from GOES-R series satellites, and generate higher level products

- In 2014, the Community Satellite Package for Geostationary Data (CSPP Geo) was started at the University of Wisconsin, modeled after CSPP (LEO)

- Initially an ingestor package was prototyped and distributed, to help users to build GOES-R reception and processing systems

- Later, science code written by the GOES-R Algorithm Working Group was developed into software packages to generate higher-level geophysical products

- Additional software has since been developed to generate imagery and other higher-level products

- Supported missions: **GOES-16/17/18, Himawari-8, legacy GOES-13/15**
  - **Coming soon: GK2A, FY4A**

- The project is mainly funded by the NOAA GOES-R Program Office

Direct Broadcast Receiving System

CSPP Geo Software → Data Products
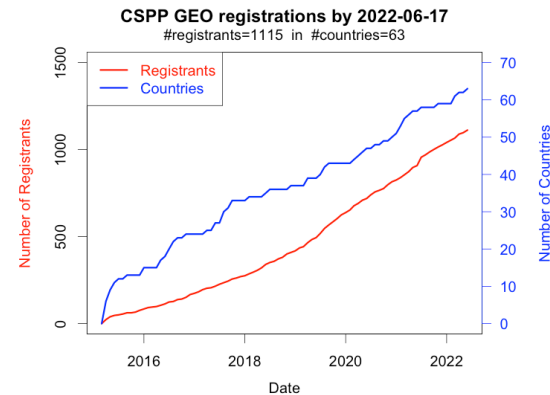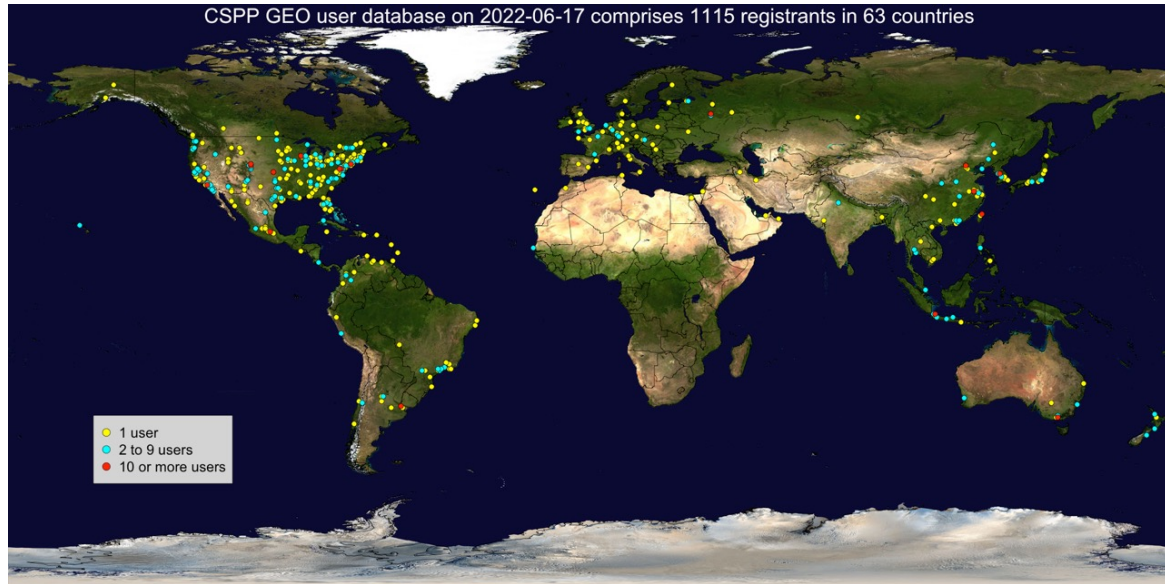
CSPP Geo Software
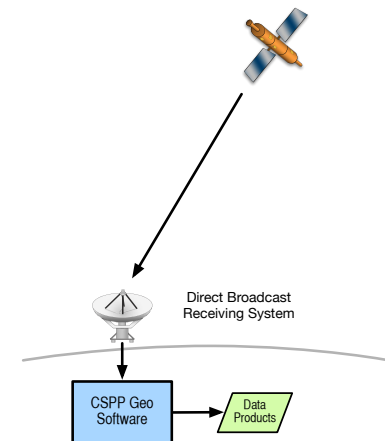
- The software / support model is similar to CSPP LEO
  - Self-contained binary packages built for Linux
  - Products are generally NetCDF files or GeoTiffs
  - Quicklooks image generation is supported
  - All software is free to download and use
  - Users have access to the CSPP team for software support
- Some unique capabilities and challenges exist with Geo
  - The data stream is always on
  - Much higher temporal refresh
  - Parallel processing is required to keep up with the data
- The target platform for new releases is CentOS7 (end of life June 30 2024)
  - New releases will also be tested on Rocky Linux 8
- Dynamic ancillary data required for Level 2 processing is acquired at the UW and staged for download
 - A second, offsite ancillary data server has been stood up

Users

- CSPP Geo software is used at half of all GRB receiving stations around the world (as of early 2018, per GRB User Group survey)

- Users include NOAA, NASA, international meteorological agencies, receiving station vendors, data and weather service providers, and the university and research community

- In 2019, NWS transitioned to CSPP Geo software at their 8 sites receiving GRB and HimawariCast data. 8x5 support is provided under sub-contract with IBSS.

- User briefings are provided via the GRB User Group, at the CSPP Users' Group Meeting, and at conferences

- Direct user support is provided via email

- A user forum as a second user support channel and to disseminate information

CSPP GEO user database on 2022-06-17 comprises 1115 registrants in 63 countries

- 1 user
- 2 to 9 users
- 10 or more users

CSPP GEO registrations by 2022-06-17
#registrants=1115 in #countries=63

Registrants
Countries

GRB Software Package

- Users who are within the GOES-East (16) or GOES-West (17) satellite footprint can receive data via the GOES Rebroadcast (GRB) stream

- Data from all on-board instruments is included, at full resolution
  - Advanced Baseline Imager (ABI)
  - Geostationary Lightning Mapper (GLM)
  - Solar Ultraviolet Imager (SUVI)
  - Space Environment In-Situ Suite (SEISS)
  - Extreme Ultraviolet and X-ray Irradiance Sensors (EXIS)
  - Magnetometer (MAG)

- The data is first processed at the ground system to L1B (or L2+ in the case of GLM), then rebroadcast via the satellite

- By running the CSPP Geo GRB software package, users can reconstruct those products locally, with very low latency

- The software runs as a server, reading raw CCSDS data from two sockets, extracting payloads and decompressing datasets
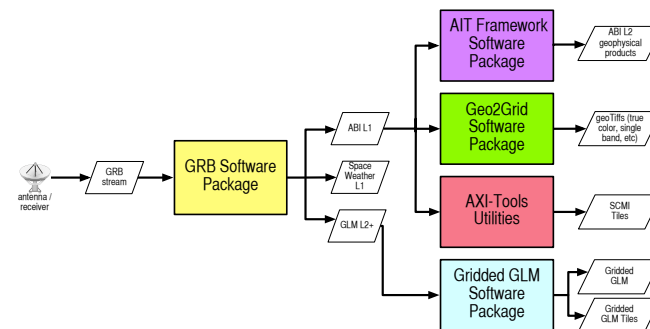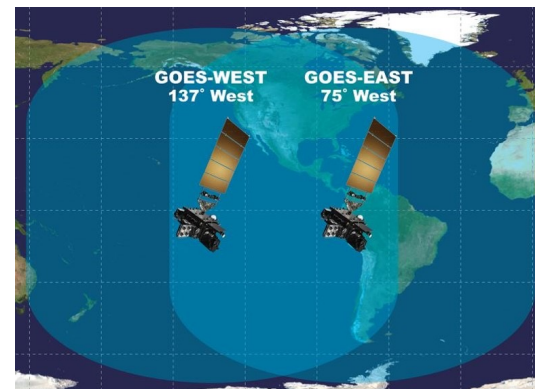
GRB Package – Recent Software Releases

Since the last CSPP User Group Meeting (2019)

➢5 releases of the GRB package

➢This includes 3 releases in connection with GOES-R ground system changes, to avoid user impacts

Release Date	Version	Description
Aug 2019	GRB v1.0.21	Updates to improve product yield when upstream data frames are lost and the addition of an experimental configuration file to process either GOES-16 or GOES-17
Nov 2019	GRB v1.0.23	Updates to support the DO.08.01 change to the ground system to allow continued processing of MAG, SEISS and SUVI products
Dec 2020	GRB v1.0.24	Updates to improve the default delay to wait for data after metadata and bug fixes.
Feb 2021	GRB v1.0.25	Fixes to quality variables in EXIS EUV and SUVI products
Aug 2021	GRB v1.0.26	Updates to support the DO 09.05.01 change to the ground system to allow continued processing of SEISS SGPS products

GOES-18 Support in the GRB Package

- GOES-18 was successfully launched on Mar 1, 2022
  - GOES-18 has an improved cooling system and improved magnetometer design
  - GOES-18 has been drifted to an orbit near GOES-17 at the GOES-West position
  - Scheduled to replace GOES-17 as the operational GOES-West satellite on an accelerated schedule, due to cooling issues affecting GOES-17 ABI
- An "interleaved" GOES-West GRB data stream is planned as an interim solution, which will contain ABI data from GOES-18 and other instrument data from GOES-17 during heating periods
  - Interleaving is scheduled to go live in the GOES-West GRB stream on Aug 1, 2022
  - The data will continue to be relayed by GOES-17
- Interleaving was successfully demonstrated during GOES-18 post launch testing, and the CSPP Geo GRB package successfully processed interleaved data
- For users who are currently processing the GOES-West stream using the current version of the GRB package (1.0.26), no software or configuration updates will be needed to process interleaved data or to generate GOES-18 products
- When GOES-18 becomes operational as GOES-West (currently scheduled for Jan 2023), a configuration change to GRB v1.0.26 will be needed.
  - However, a software update is planned for late summer / early fall 2022 that will allow processing of data transmitted via any GOES-R satellite without a configuration change
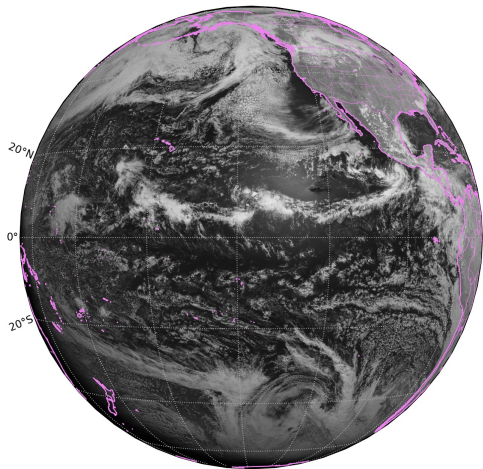
Three Advanced Baseline Imagers in Geostationary Orbit
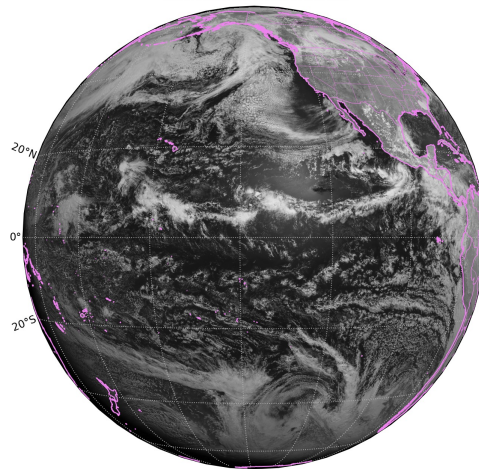# 2022-06-14 1950z

GOES-17
137.2° West

GOES-18
136.8° West

GOES-16
75.2° West

GOES-17, ABI L1 Reflectance (Band 3)
from 2022-06-14 19:50:32.1Z

GOES-18, ABI L1 Reflectance (Band 3)
from 2022-06-14 19:50:20.6Z
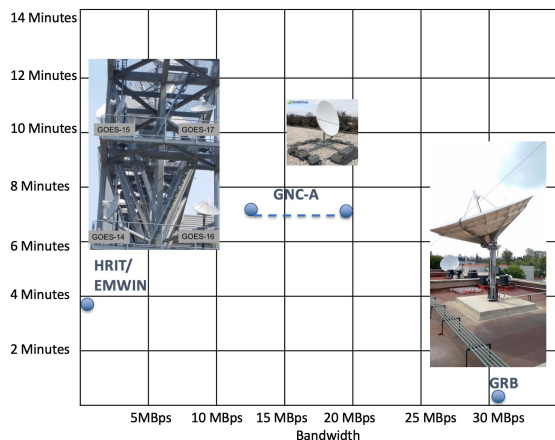
GOES-16, ABI L1 Reflectance (Band 3)
from 2022-06-14 19:50:20.6Z

CSPP ABI Quicklooks v0.8.

Data created by CSPP Geo GRB v1.0.26. Plotted using CSPP ABI Quicklooks v0.8.
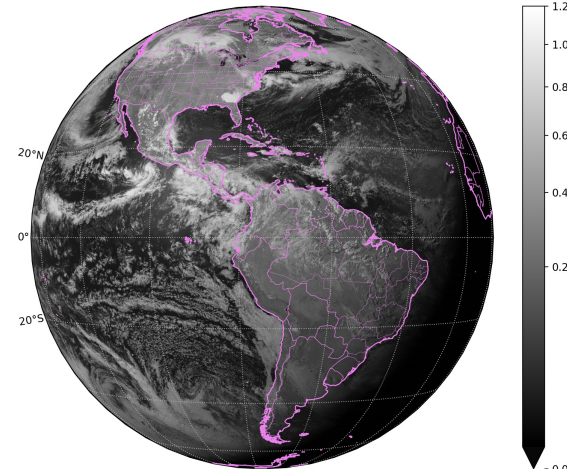
Plotted using CSPP ABI Quicklooks v0.8.

"Quicklook" images created with CSPP Geo GRB package

Product Latencies

Antenna-based options to receive GOES-R data

Jim McNitt, NOAA

Observed GRB product latencies, in seconds

ABI CONUS	mean:	8.1	median:	8.3	max:	11.4	min:	3.5
ABI Full Disk	mean:	8.1	median:	7.9	max:	12.8	min:	4.1
ABI Mesoscale	mean:	6.4	median:	5.8	max:	12.3	min:	4.0
EXIS	mean:	6.9	median:	7.3	max:	11.2	min:	2.5
GLM	mean:	5.0	median:	4.1	max:	8.8	min:	2.9
MAG	mean:	2.5	median:	2.5	max:	2.9	min:	2.4
SEISS	mean:	5.6	median:	3.2	max:	67.2	min:	2.9
SUVI	mean:	32.2	median:	32.8	max:	34.4	min:	30.4

- Statistics are based on ~20mins of GOES-16 GRB data received on SSEC's antenna
- Latencies are measured from observation end time to product file completion time on GRB receiving system

The AIT Framework Level 2 Software Package

- Further processes ABI data to generate Level 2 geophysical products, using research versions of the GOES-R product algorithms that were developed under Algorithm Working Group

- Core processing software is developed and maintained by the ASSISTT group at NOAA STAR

- Product algorithm updates flow from the science teams to ASSISTT, and then to the Ground System and CSPP Geo

- CSPP Geo "production" releases are done in sync with equivalent capabilities in the ground system

- CSPP Geo "beta" releases may contain preliminary and capabilities that are not yet in the operational products

- **AIT Framework v1.0** is the current production release and generates a subset of the GOES-R Baseline products
  - Software, documentation and test data are available from the CSPP Geo website
  - v1.0.36 patch was released in July 2021 to address processing failures following a ground system update

GOES-16, ABI L2+ Cloud Top Height from 2019-05-27 18:01:37.8Z

GOES-16, ABI L2+ Land Surface (Skin) Temperature from 2019-05-27 18:01:37.8Z
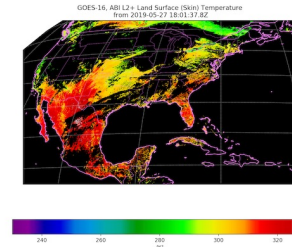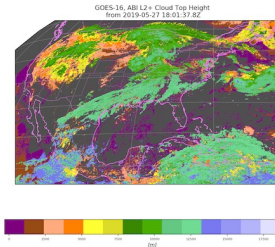
Version 1.0 products:

| Aerosol Detection: Smoke and Dust |
|---|
| Aerosol Optical Depth |
| Clear Sky Masks |
| Cloud and Moisture Imagery |
| Cloud Optical Depth (day/night) |
| Cloud Particle Size Distribution (day/night) |
| Cloud Top Height |
| Cloud Top Phase |
| Cloud Top Pressure |
| Cloud Top Temperature |
| Land Surface Temperature (Skin) |

AIT Framework v2 Beta

- **AITF Version 2.0:** an initial beta was released on Jan 13, 2022
  - Beta products should be considered preliminary / non-operational
  - Added products: Derived Motion Winds, Low Cloud and Fog
  - GOES-17 support for a subset of products
  - Transition from baseline to enterprise algorithms: first major science upgrade since the original GOES-16 algorithms
  - Migration to new core processing software (Framework v2)
  - Various bug fixes and minor improvements
- Feedback to csppgeo.issues@ssec.wisc.edu is encouraged

Product / Set	AITF v1.0	AITF v2.0 (beta status)
Aerosol Detection: Smoke and Dust	baseline, G16	enterprise, G16
Aerosol Optical Depth	baseline, G16	enterprise, G16
Clear Sky Masks	baseline, G16	enterprise, G16/17
Cloud and Moisture Imagery	baseline, G16	enterprise, G16/17
Cloud Optical Depth (day/night)	baseline, G16	enterprise, G16
Cloud Particle Size Distribution (day/night)	baseline, G16	enterprise, G16
Cloud Top Height	baseline, G16	enterprise, G16/17
Cloud Top Phase	baseline, G16	enterprise, G16/17
Cloud Top Pressure	baseline, G16	enterprise, G16/17
Cloud Top Temperature	baseline, G16	enterprise, G16/17
Land Surface Temperature (Skin)	baseline, G16	enterprise, G16
Low Cloud and Fog	N/A	enterprise, G16
Derived Motion Winds	N/A	enterprise, G16/17

AIT Framework Performance Testing

- Extensive performance testing was done following the v2.0 beta release

- It was found that the full set of v2 products could be generated on a machine matching the v1 recommended spec
  - This includes all products, for all timesteps and all domains (Full Disk, CONUS, Meso1 and Meso2)
  - High-res winds was included, though it had been turned off by default in the beta release

- System resource utilization and job run times were found to be stable over time

- However, there is very little margin, with disk utilization identified as the main bottleneck
  - Recommended mitigation: use of RAM Disk for intermediate and final products. An example will be included with the v2.1 beta release documentation

- An additional recommendation is to run winds as a separate processing job, to prevent longer processing times from affecting latencies of other products
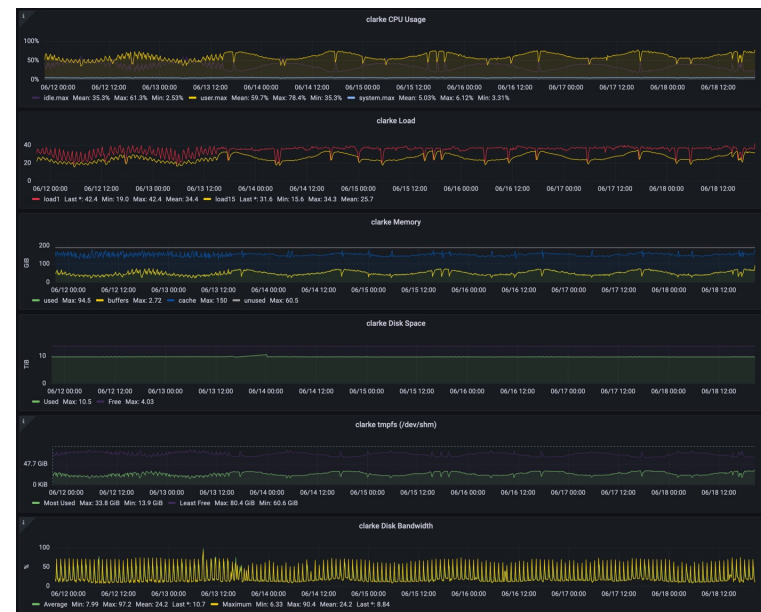
AIT Framework upcoming releases

AITF v2.1 beta release planned for mid-July (before GOES-West interleaving begins)

- Preliminary support for GOES-18
- Latest science updates including changes to cloud products, winds
- Bug fixes and improvements coming from beta tester feedback
- Quicklooks improvements

AITF v2.1 production release planned to sync with the equivalent algorithm upgrades in the ground system, currently Feb 2023

- The latest G18 processing updates and science updates from the GOES-R science teams
- Bug fixes and improvements coming from beta tester feedback
- Offsite ancillary server failover

AITF v3

- Planned capabilities: added products, GOES-18 updates, science upgrades
- Initial beta planned for June 2023

Additional products planned for AITF v3:

Sounding products
Total Precipitable Water (TPW)
Derived Stability Indices
Legacy Vertical Moisture Profile
Legacy Vertical Temperature Profile
Rainfall Rate
Cloud Cover Layers

Geo2Grid Software Package

- Generates high quality imagery and animations from GOES-16 and GOES-17 ABI and Himawari AHI data
  - "composite RGB" images (true color, natural color, airmass, ash, dust, fog, night microphysics)
  - single-band images
- Formats: geo-tiff and PNG with coastlines
- Uses open source "satpy" plotting library
- Allows remapping and custom grids (projections, resolutions and coverage)
- **Geo2Grid v1.0.2** is currently available on the CSPP Geo website
- **Geo2Grid v1.1** is planned for release in Summer 2022
  - ABI Level 2 Product Images (Cloud Top Height, Cloud Top Temperature)
  - Gridded GLM product images + overlays
  - New Instruments supported (provisional GOES-18, GEO-KOMSAT-2 AMI, FY-4 AGRI)
  - Bug fixes and performance improvements
- Interested in beta testing v1.1? Contact csppgeo.issues@ssec.wisc.edu
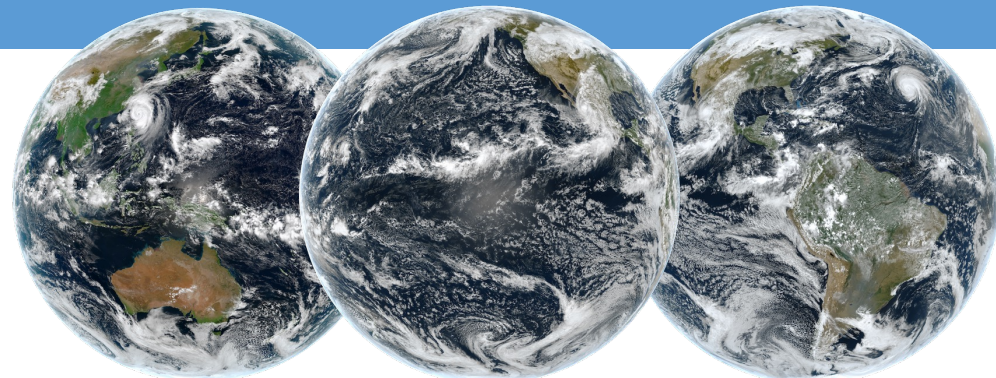
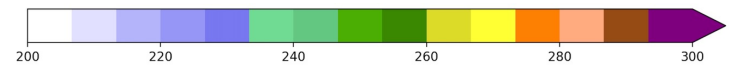Himawari-8 AHI   GOES-17 ABI   GOES-16 ABI
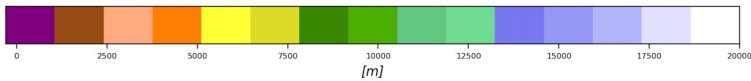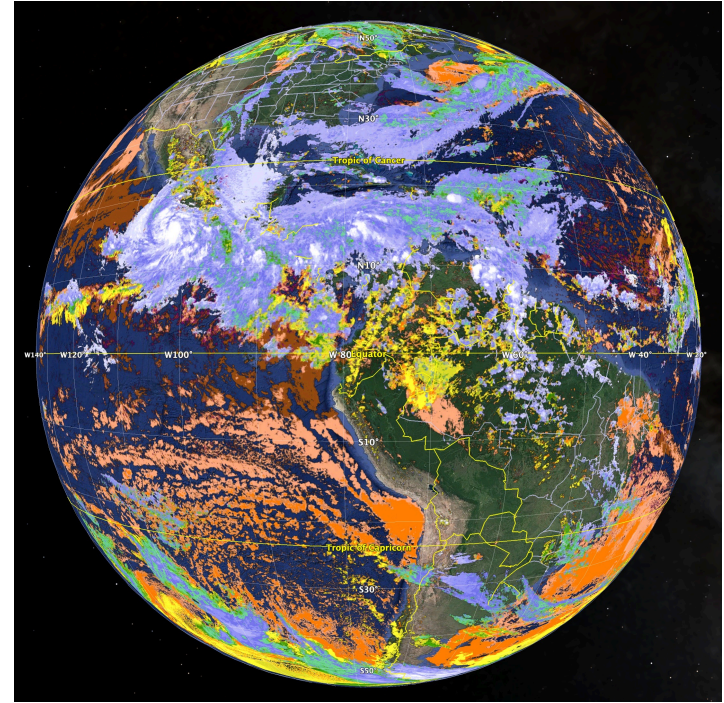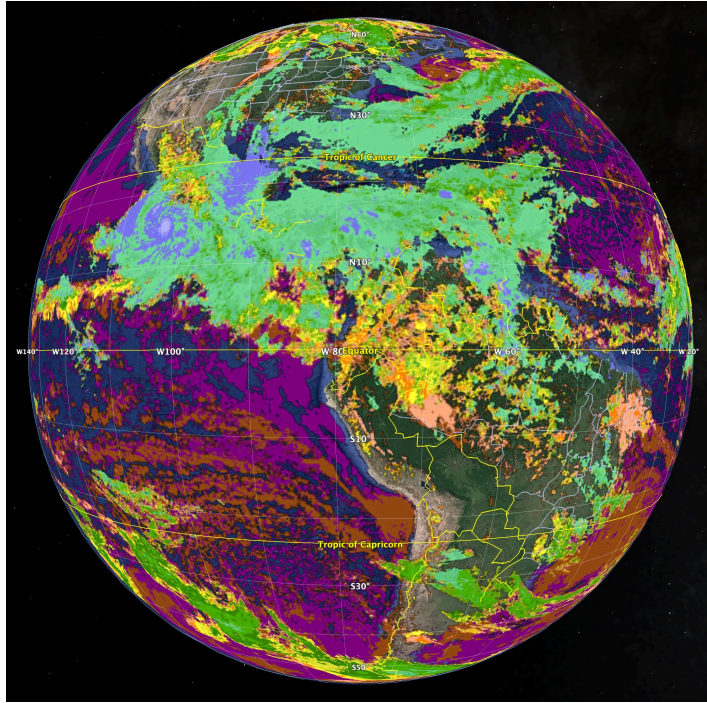
FY-4 AGRI   GK-2A AMI   GOES-18 ABI
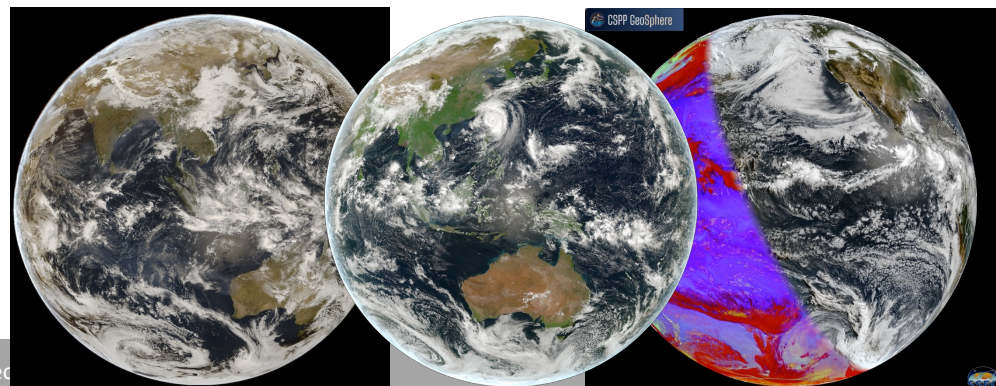
Coming soon: Level 2 products in Geo2Grid!

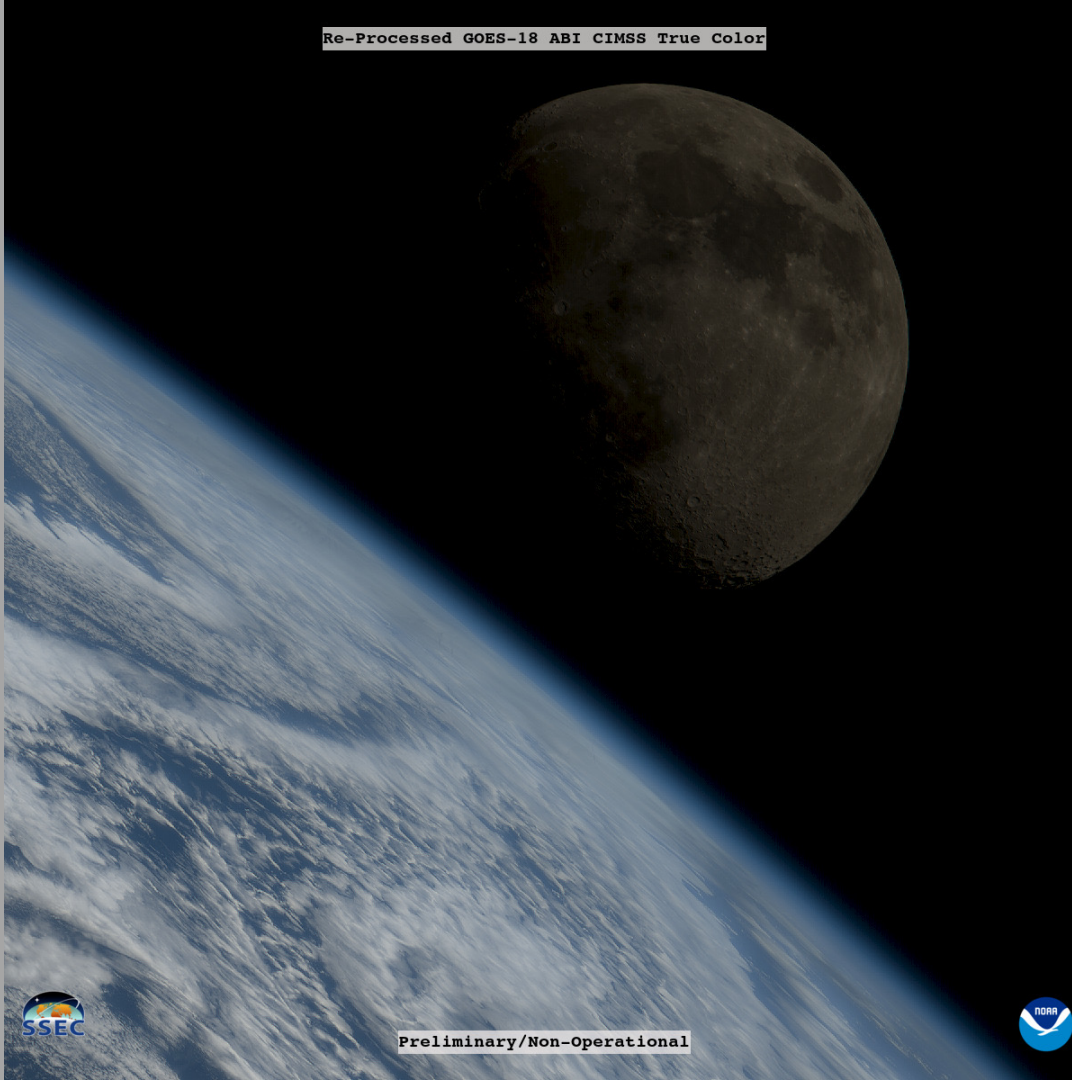Cloud Top Height GOES-16 ABI, 2022-06-15 2000z Cloud Top Temperature

Tim Schmit

Preliminary/Non-Operational

Gridded GLM Software Package

- Underlying software was created by Eric Bruning, and is being developed into an operational product by Scott Rudlosky

- Generates new GLM products that are on the ABI grid and aggregated at 1-minute intervals
  - Minimum Flash Area
  - Flash Extent Density
  - Total Optical Energy

- Recovers spatial extent information that is not in the L2+ (via GRB) product

- Can create AWIPS-compatible tiles

- An initial v1 beta version of the Gridded GLM software package was released in March 2021

- v1 production release planned for July 2022
  - GOES-18 support
  - Multiprocessing
  - Better input handling for large data processing
  - Performance improvements & bugfixes
  - Users' Guide

- Future releases will add new capabilities coming from the science team and incorporate feedback from beta testers
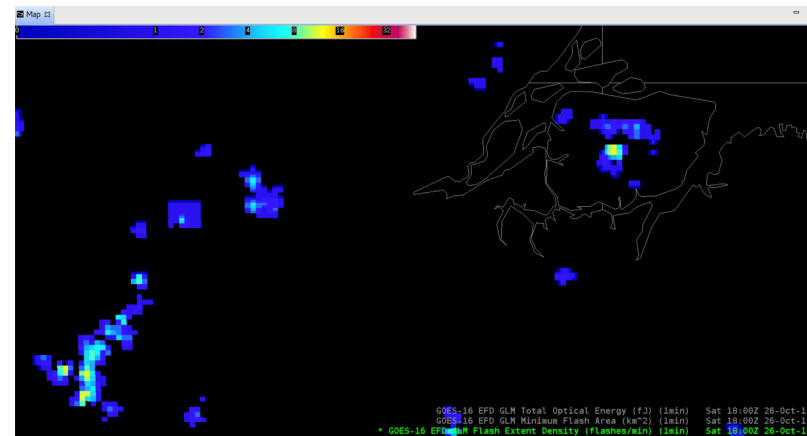
Related poster: "CSPP Geo Gridded GLM" by Nick Bearson

GOES-16 ABI true color / Gridded GLM overlay, 2022-06-15 2000z
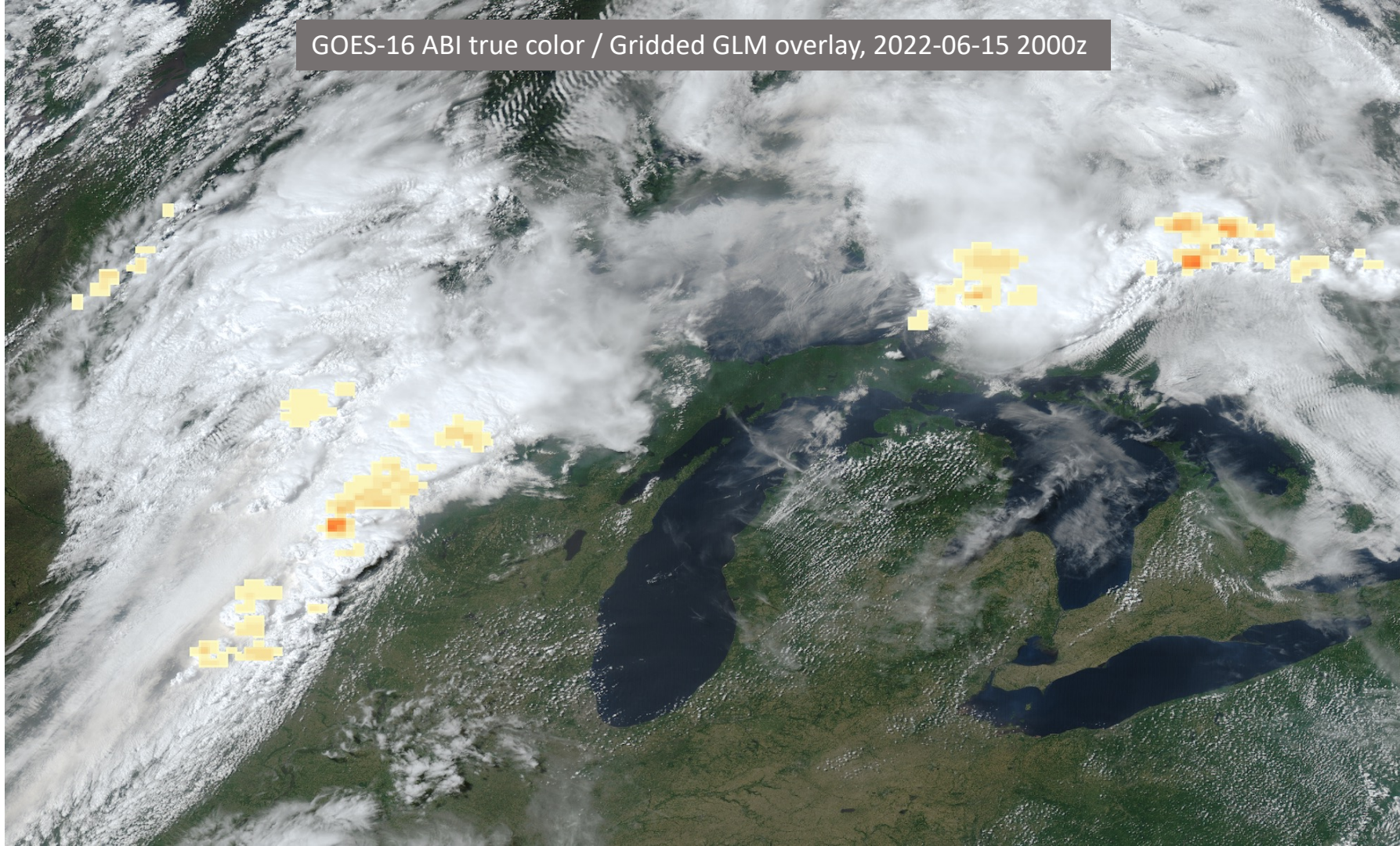
GOES-16 ABI true color / Gridded GLM overlay, 2022-06-15 2000z

Created with Geo2Grid v1.1 beta

```
geo2grid.sh -r abi_l1b -w geotiff -f OR_ABI-L1b-RadF-M6C* -p true_color

geo2grid.sh -r glm_l2 -w geotiff -p flash_extent_density -f glm-20221662000/CG_GLM-L2-GLMF-
M3_G16_s20221662000000_e20221662001000_c20221671514250.nc

overlay.sh GOES-16_ABI_RadF_true_color_20220615_200020_GOES-East.tif GOES-
16_GLM_flash_extent_density_20220615_200000_GOES-East.tif GOES-16_ABI-
GLM_true_color_flash_extent_density_20220615_200020_GOES-East.tif
```

GEOCAT Level 2 Software Package for Himawari AHI

- The Geostationary Cloud Algorithm Testbed (GEOCAT) was developed by NOAA Scientist Mike Pavolonis for GOES-R algorithm development

- The CSPP Geo package supports Himawari-8 AHI. Legacy GOES-13 and GOES-15 are also supported

- Products are generated by research versions of GOES-R algorithms that have been updated and adapted for AHI

- v1.0 beta was released in Fall 2016

- JMA has announced plans to switch from Himawari-8 to Himawari-9 in ~December 2022

- A CSPP Geo GEOCAT release is planned for late 2022 that will add support for Himawari-9

HimawariCast reception area
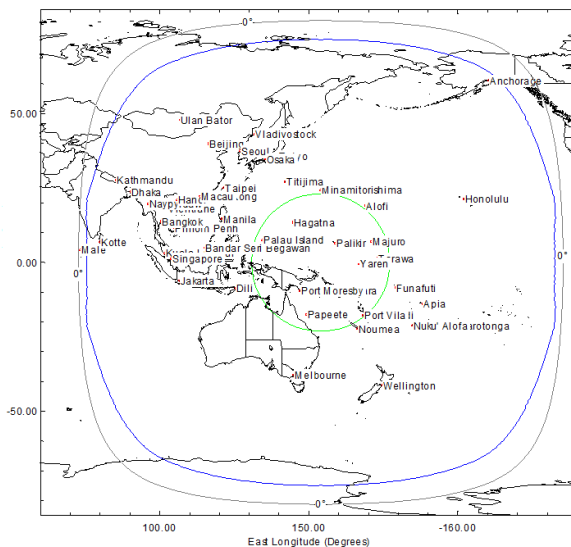
- 1.8 mΦ (16.5 dB/K)
- 2.4 mΦ (19.6 dB/K)

JMA

Initial set of products:

Initial set of products:
Cloud and Moisture Imagery
Clear Sky Masks
Cloud Phase
Cloud Type
Cloud Top Height
Cloud Top Pressure
Cloud Top Temperature
Cloud Optical Depth (day/night)
Cloud Particle Size Distribution (day/night)
Cloud Liquid Water Path (day/night)
Cloud Ice Water Path (day/night)
Low Cloud and Fog

AXI-Tools

- AXI-Tools is a collection of utilities for ABI and AHI data format conversion and manipulation

- Generates tiled / SCMI products from ABI and AHI radiances

- Creates ABI CMI product in mission-standard format

- Used by NWS to load AHI data into AWIPS

- Relies on open-source Himawari and GOES-R ingest libraries maintained at UW

- Source and documentation: http://sift.ssec.wisc.edu/axi-tools-package/

- Updates are in progress for GOES-18 and Himawari-9 support
  - A patch will be released in July 2022 for GOES-18 tiling / AWIPS compatibility
  - A release is planned for late Fall 2022 for Himawari-9
  - Note that the satellite cannot be determined from the Himawari-9 HRIT data stream, and thus a user override may be needed
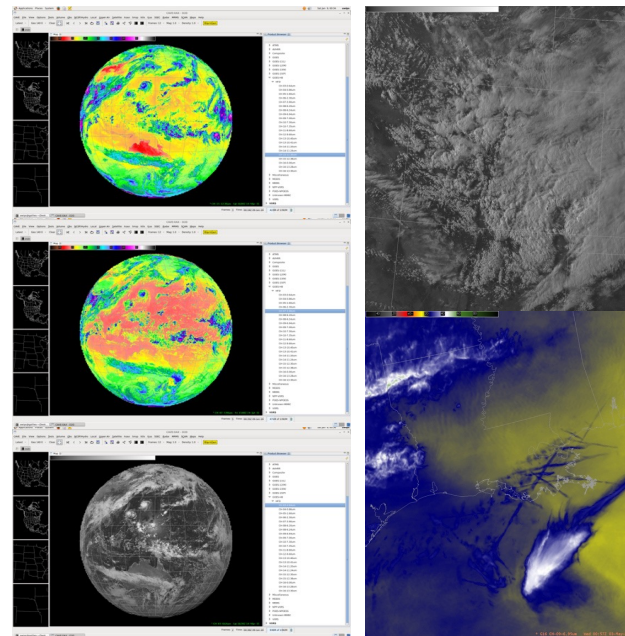

AHI and GRB data converted and loaded in AWIPS2

ABI Flood Mapping

ABI Flood Map 20180816 17:05(UTC)

ABI Composited Flood Map 20180816

- Sanmei Li at George Mason University has developed software that retrieves flooding extent, using VIIRS and ABI data

- A VIIRS Flood Mapping package is currently available via CSPP LEO

- The VIIRS product has the advantage of higher spatial resolution, while the ABI product has the advantage of higher temporal refresh and cloud clearing

- An initial beta version of an ABI Flood Mapping package in CSPP Geo is planned for release in Summer 2022

- The beta will support GOES-16 and 17, with a potential update for GOES-18 in 2023
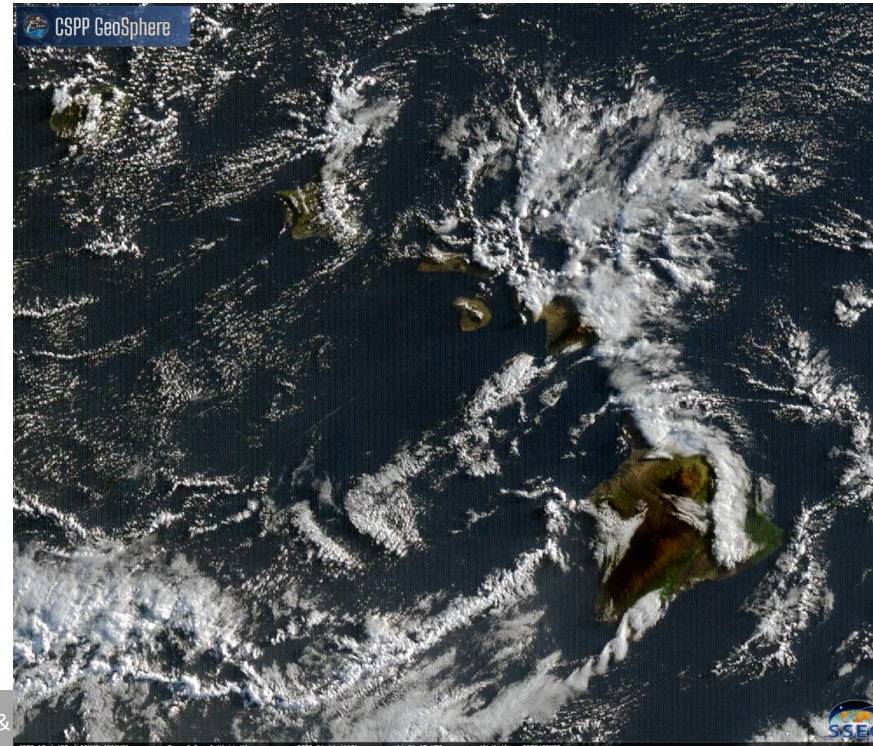
Sanmei Li
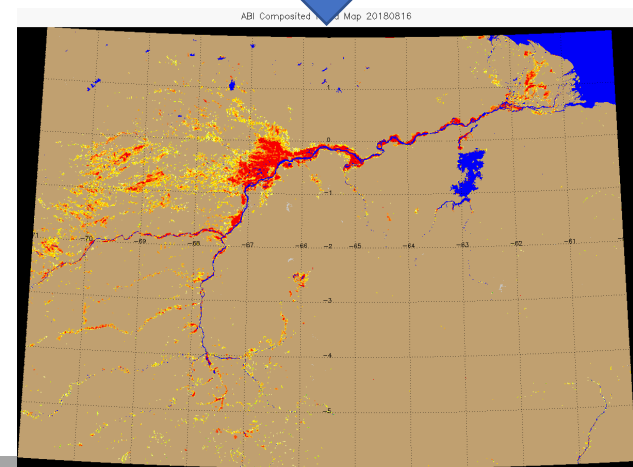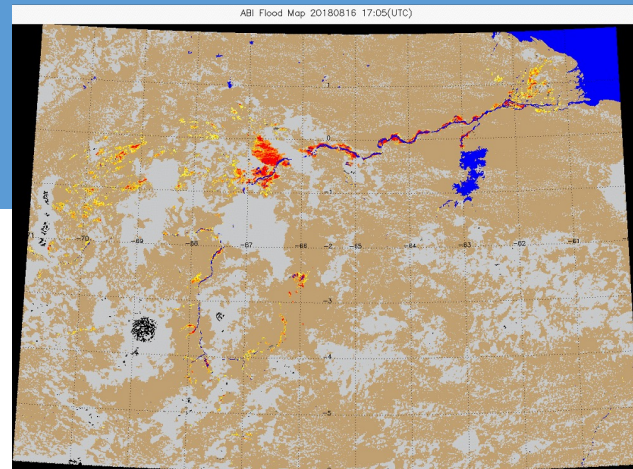
Geosphere website and cloud computing demonstration

- Under SSEC funding, the CSPP GeoSphere website was developed that displays live GOES-16 imagery created with Geo2Grid

- The data is acquired on an antenna at SSEC and processed in a containerized CSPP Geo software chain running on local cloud-equivalent infrastructure

- The full processing chain has been demonstrated in Google Cloud and Amazon Web Services, running on live GRB data

- The website is interactive and tile-based (Google Maps-like), and displays data with very low latency

- Currently support for GOES-17/18 is being added, as well as additional RGB images, and image/video save capability

https://geosphere.ssec.wisc.edu

Related talk: "CSPP Geosphere: Transforming Packets to Interactive Imagery in a Cloud Environment" by Dave Hoese, Thurs 10AM

GOES-18 true color created with Geo2Grid, from data acquired during GOES-18 post-launch interleave test

CSPP Geo Status &

For more information...

CSPP Geo Team

Names in purple are present at meeting

Nick Bearson	GRB, Gridded GLM and Flood Mapping packages
Jessica Braun	User support, documentation, testing
Geoff Cureton	GEOCAT & AIT Framework packages
Alan DeSmet	AIT Framework package
Ray Garcia	Himawari ingest, AXI Tools, AIT Framework package
Liam Gumley	Principal Investigator
Dave Hoese	Geo2Grid package
Tommy Jasmin	GRB package
Scott Lindstrom	Gridded GLM package
Graeme Martin	Project Manager
Eva Schiffer	Quicklooks
Kathy Strabala	Geo2Grid package, ancillary
Jenny Witt	Testing, automation

- Website:
https://cimss.ssec.wisc.edu/csppgeo/

- User Support:
csppgeo.issues@ssec.wisc.edu

Backup slides

CSPP Geo Status & Plans

Tracking interface

- GOES-R series instrument data is continuously streamed to the Ground System, calibrated and navigated, and transmitted to users via GRB

- The GRB package writes data as it is received, and offers a "tracking" interface to allow ABI data to be used before a dataset is complete

- By following the tracking interface, a user can utilize ABI data at the start of the scan pattern (far north) sooner, potentially shaving minutes off latency
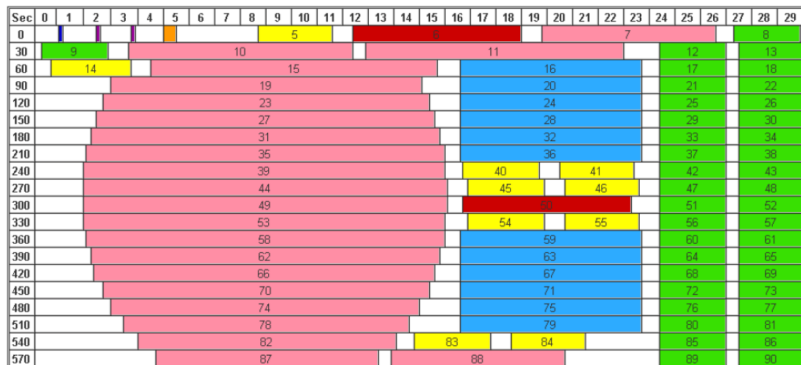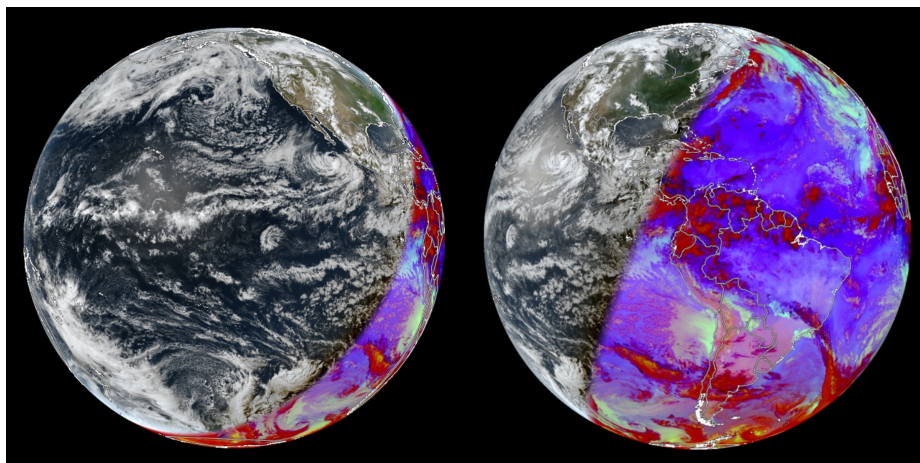
GOES-West   GOES-East

Figure 7.1.1-3   ABI Mode 6 Timeline