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University of Wisconsin –  
Madison

CSPP Users' Group  
Meeting, Darmstadt,  
Germany, 20 May 2026

# CSPP POLAR2GRID AND GEO2GRID IMAGE CREATION SOFTWARE





# DAVID HOESE - SOFTWARE ENGINEER

Dave is part of the Pytroll team. Pytroll is an easy to use, modular, free and open source python framework for the processing of earth observation satellite data.





# PURPOSE

## **Make it easy to create high quality images.**

- Open source reprojection software packages supporting Linux OS for Polar Orbiter and Geostationary Meteorological satellite data.
- Originally designed as a tool that can run at polar orbiter direct broadcast antenna sites to create AWIPS NetCDF-3 from S-NPP VIIRS SDR files in near-real-time – funding through JPSS project, Polar2Grid.
- Extended the use cases to include more instruments, spectral bands, products and output data formats.
- Popularity led to support of the Geostationary Imagers – Geo2Grid
- Funding through NOAA





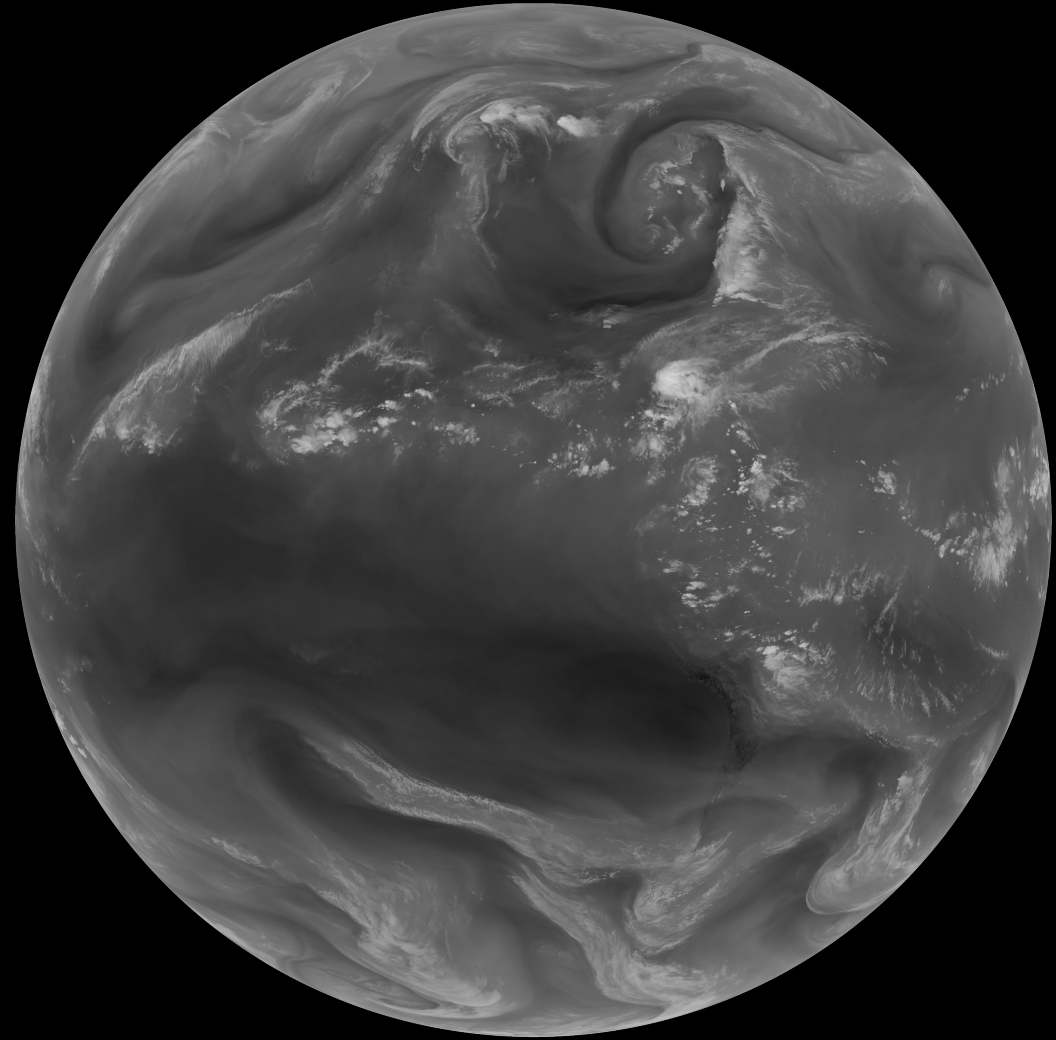
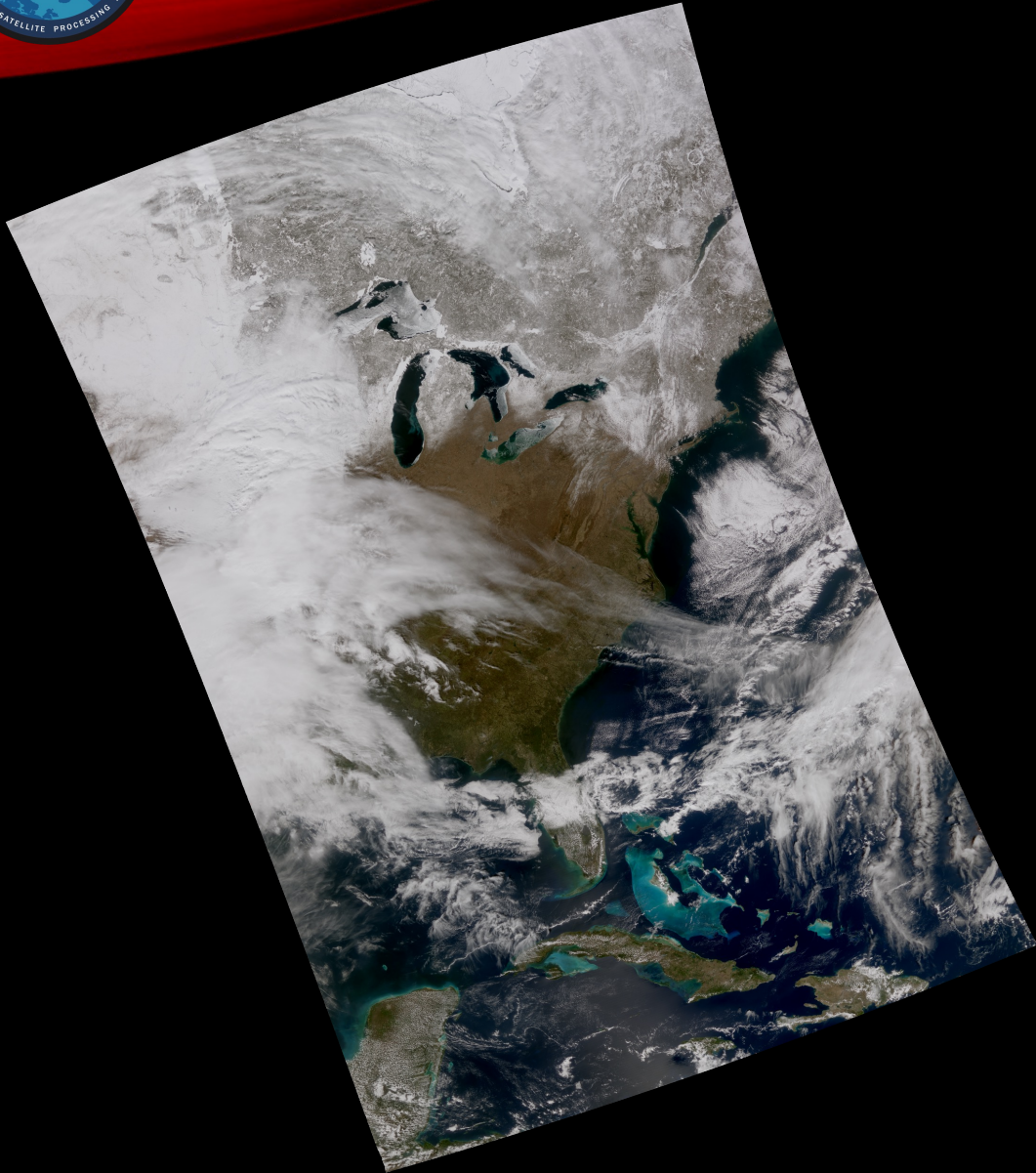
# FREE DISTRIBUTION

- Polar2Grid is distributed as part of the Community Satellite Processing Package for Low Earth Orbiter Satellites (CSPP LEO)
  - <https://cimss.ssec.wisc.edu/cspp/>
- Geo2Grid is distributed as part of the Community Satellite Processing Package for Geostationary Satellites (CSPP Geo)
  - <https://cimss.ssec.wisc.edu/csppgeo/>
- Installation
  - Download a tarball (either [CSPP\\_POLAR2GRID\\_V3.2.tar.gz](https://cimss.ssec.wisc.edu/cspp/polar2grid/v3.2/) or [CSPP\\_GEO2GRID\\_V1.3.tar.gz](https://cimss.ssec.wisc.edu/cspp/geo2grid/v1.3/) )
  - Unpack the tarball on your Linux server
  - Set an environment variable (export GEO2GRID\_HOME=/path/to/geo2grid\_v\_1\_3)





# SHOULDN'T THIS BE EASY?





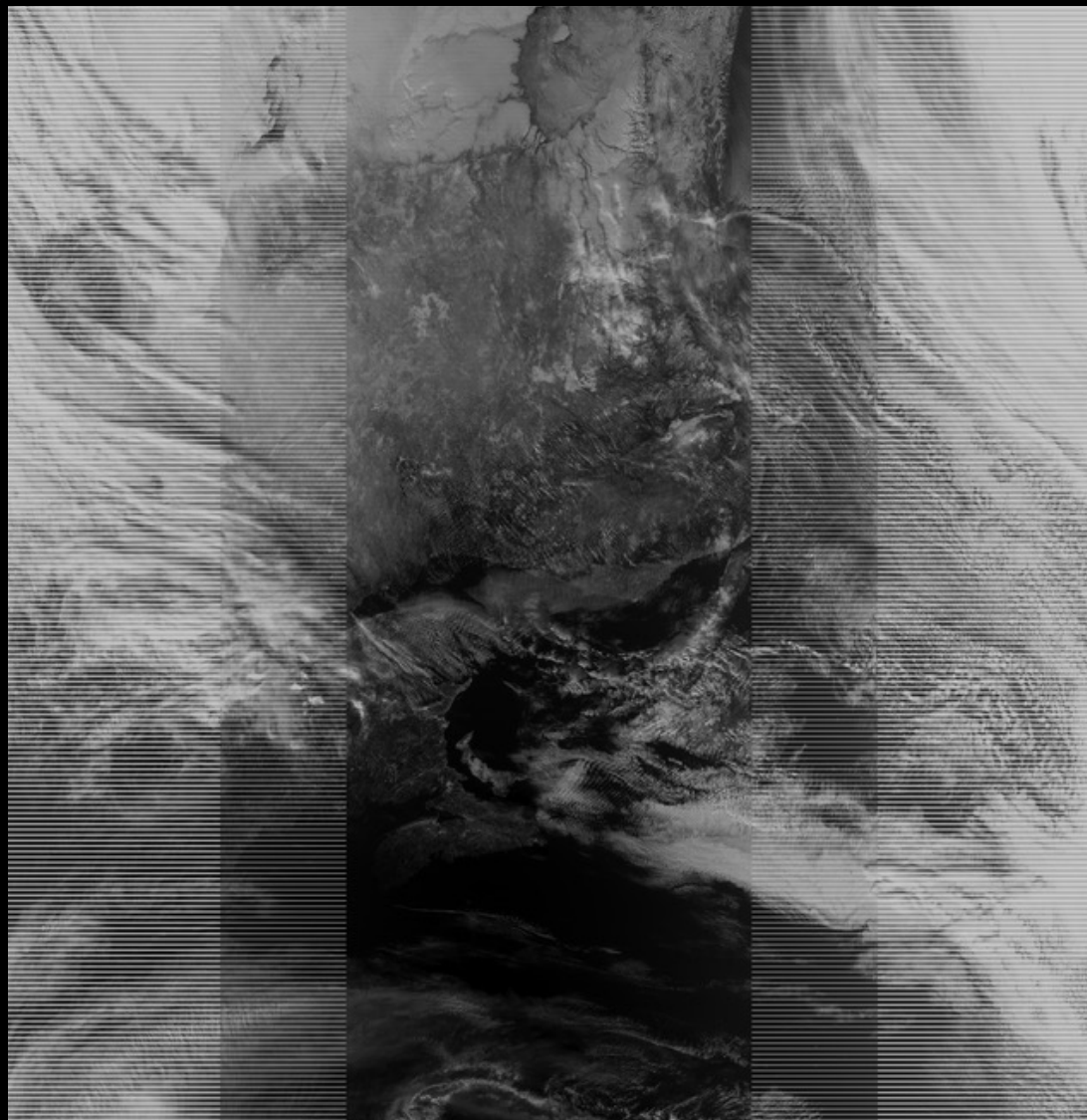
# COMPLICATIONS

- Input data formats (HDF4, HDF5, NetCDF3, Binary, ...)
- Data storage characteristics
  - Calibration
  - Geolocation
  - Science products
- Swath type
  - Satellite Projection
- Output Formats
  - What tools are used to display the end products?





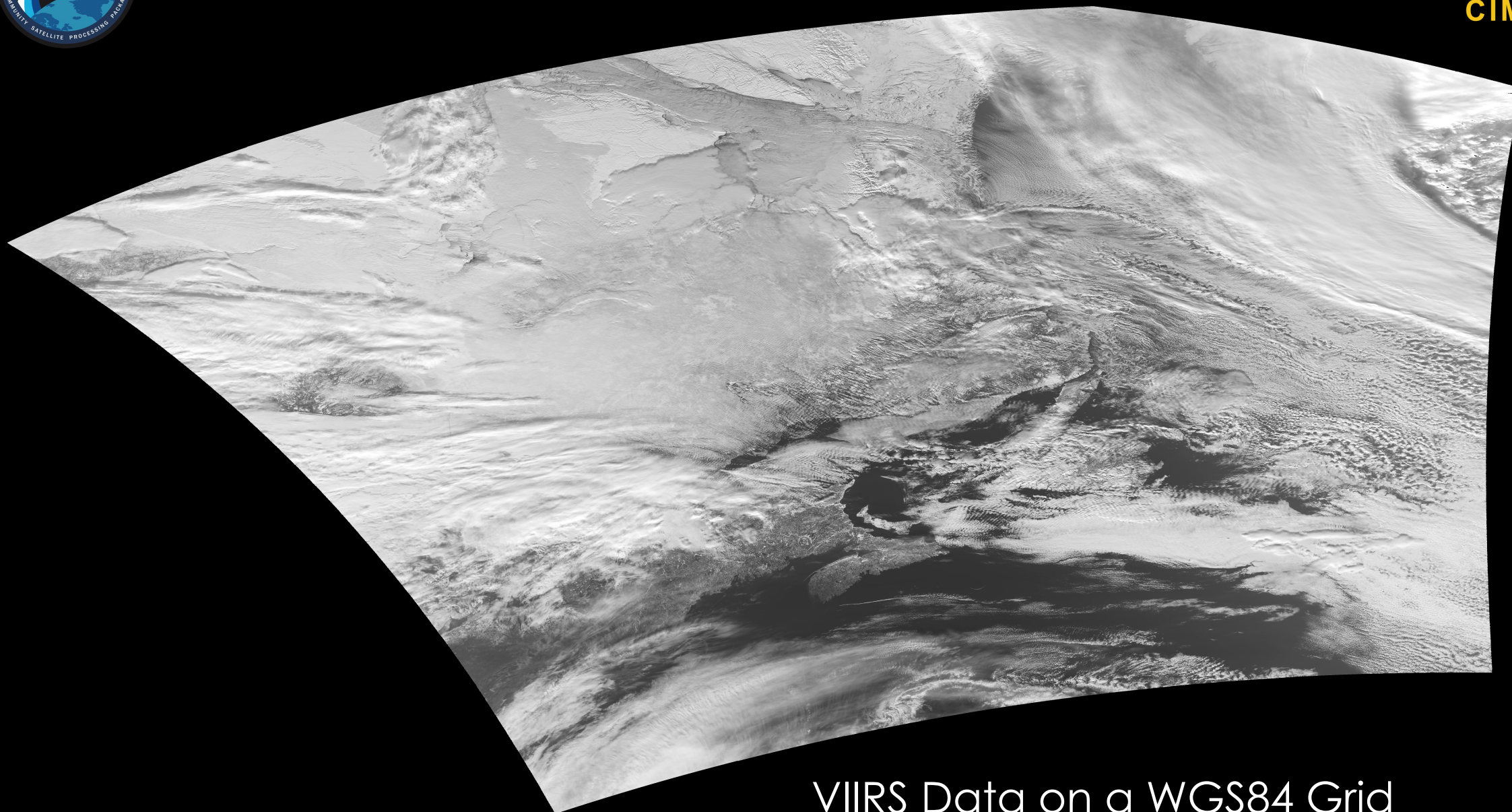
# VIIRS DATA EXAMPLE



VIIRS Data Segment in Satellite Projection



# VIIRS DATA EXAMPLE

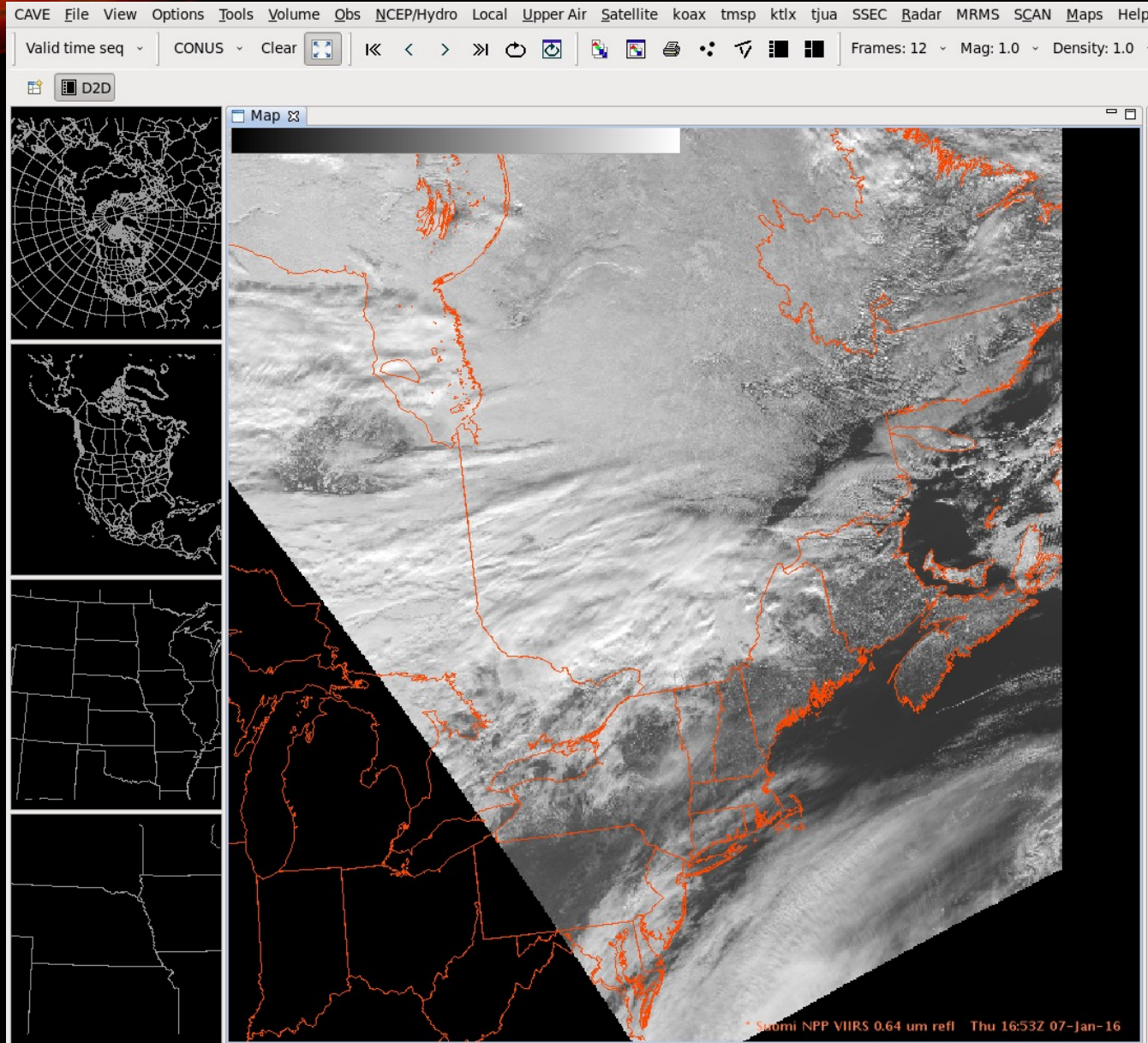


VIIRS Data on a WGS84 Grid





# VIIRS DATA EXAMPLE

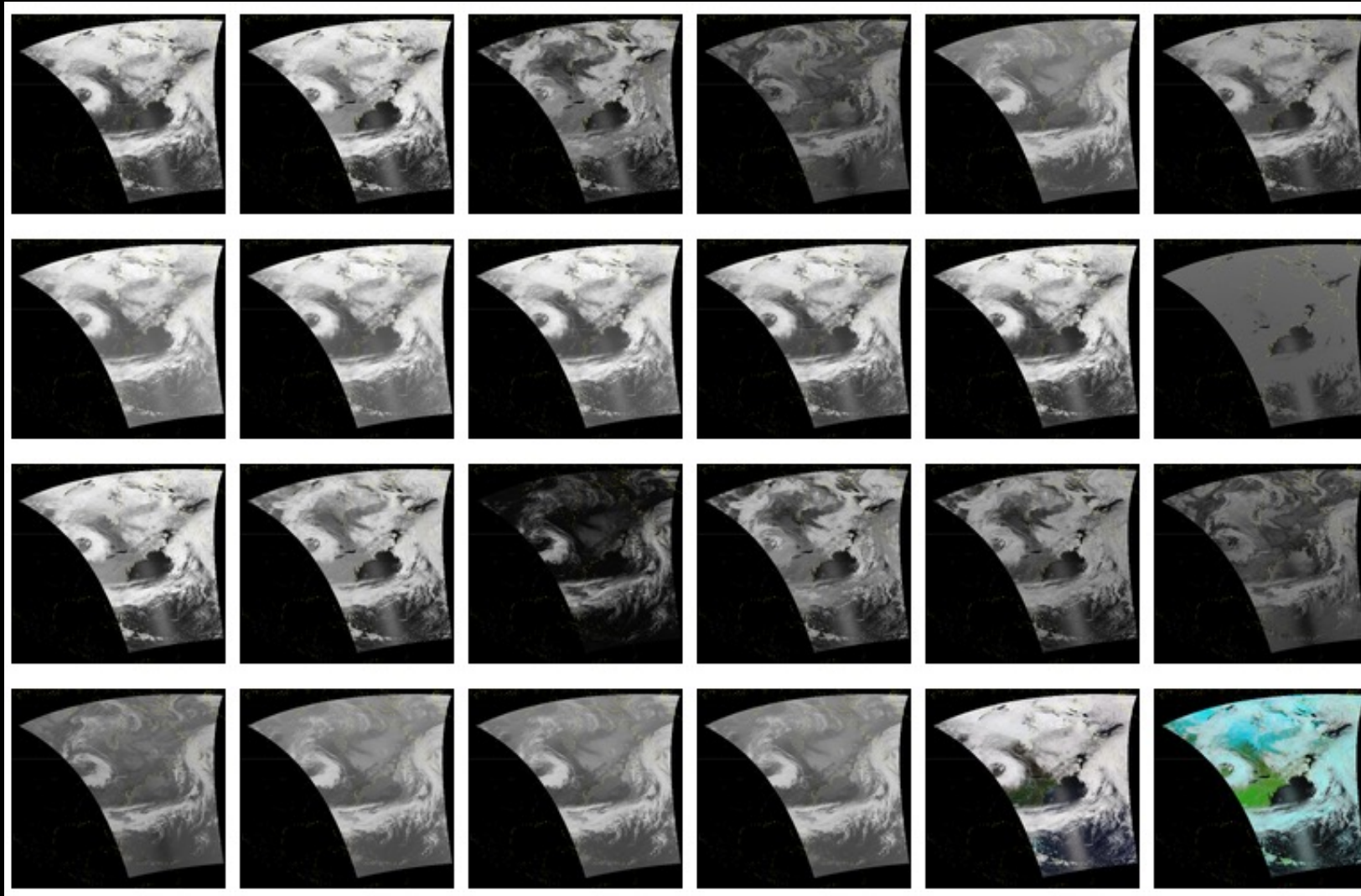


Grid to Output Format (AWIPS NetCDF)



# POLAR2GRID AND GEO2GRID MAKE IT EASY

- Simple Bash Shell Script interface to underlying Python
- `polar2grid.sh -r viirs_sdr -w geotiff -f /path_to_data`

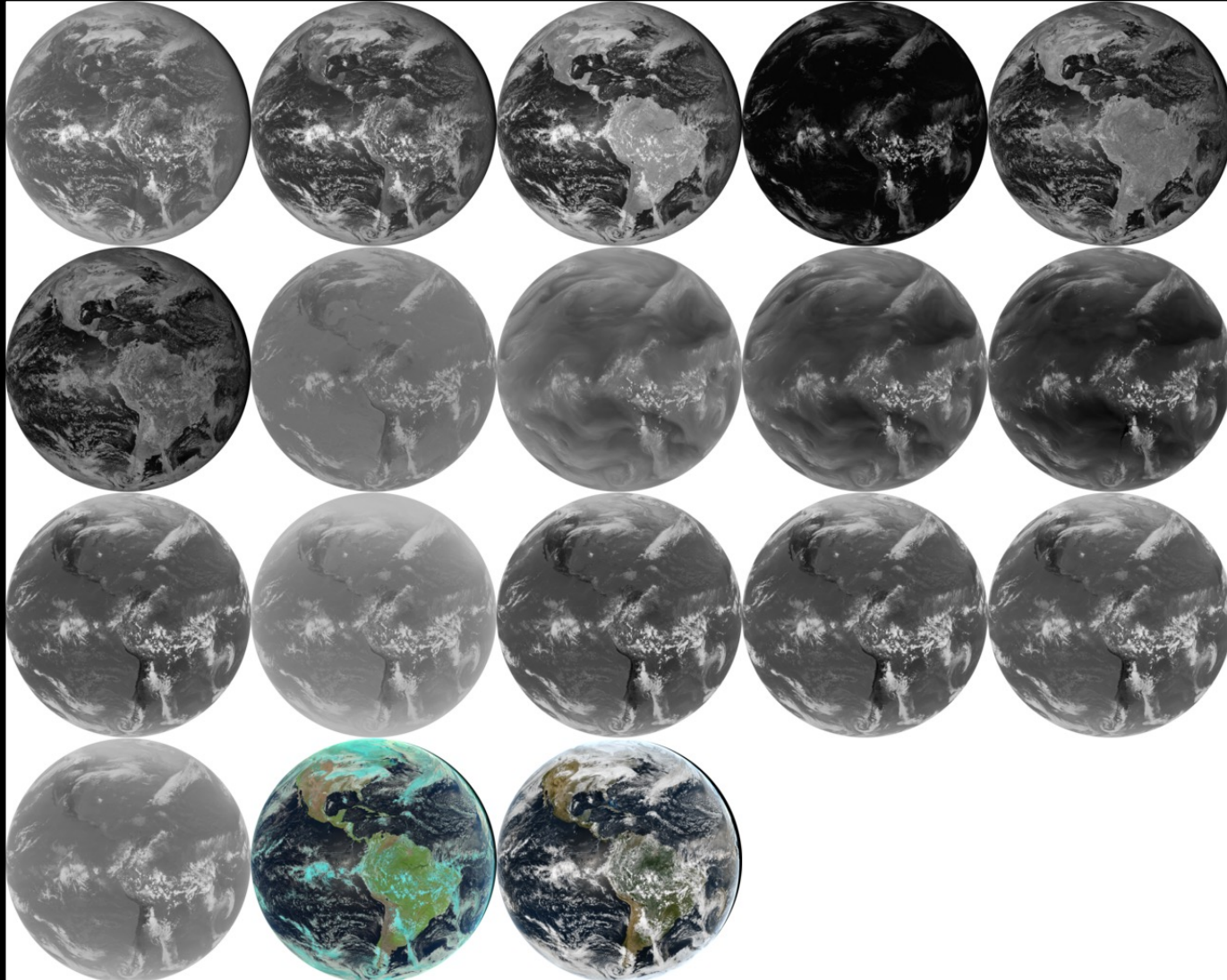


NOAA-21 Direct  
Broadcast overpass  
May 12, 2026  
17:23 UTC



# POLAR2GRID AND GEO2GRID MAKE IT EASY

- Simple Bash Shell Script interface to Python – Pytroll Satpy libraries
- `geo2grid.sh -r abi_l1b -w geotiff -f /path_to_data`



GOES-19 ABI  
GRB  
3 March 2026



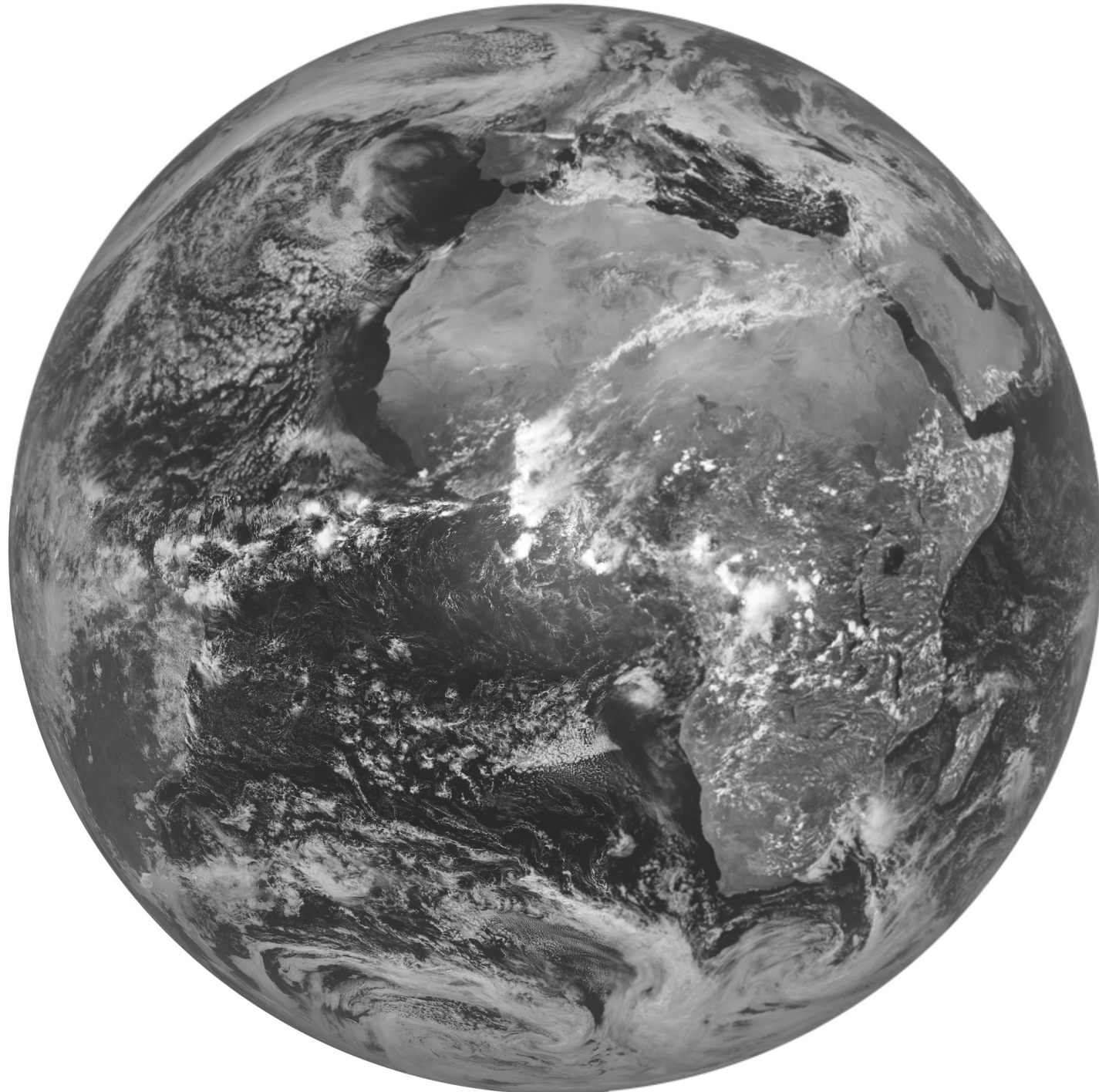


# METEOSAT -12 FCI EXAMPLE

## • Simple Output Product Selection

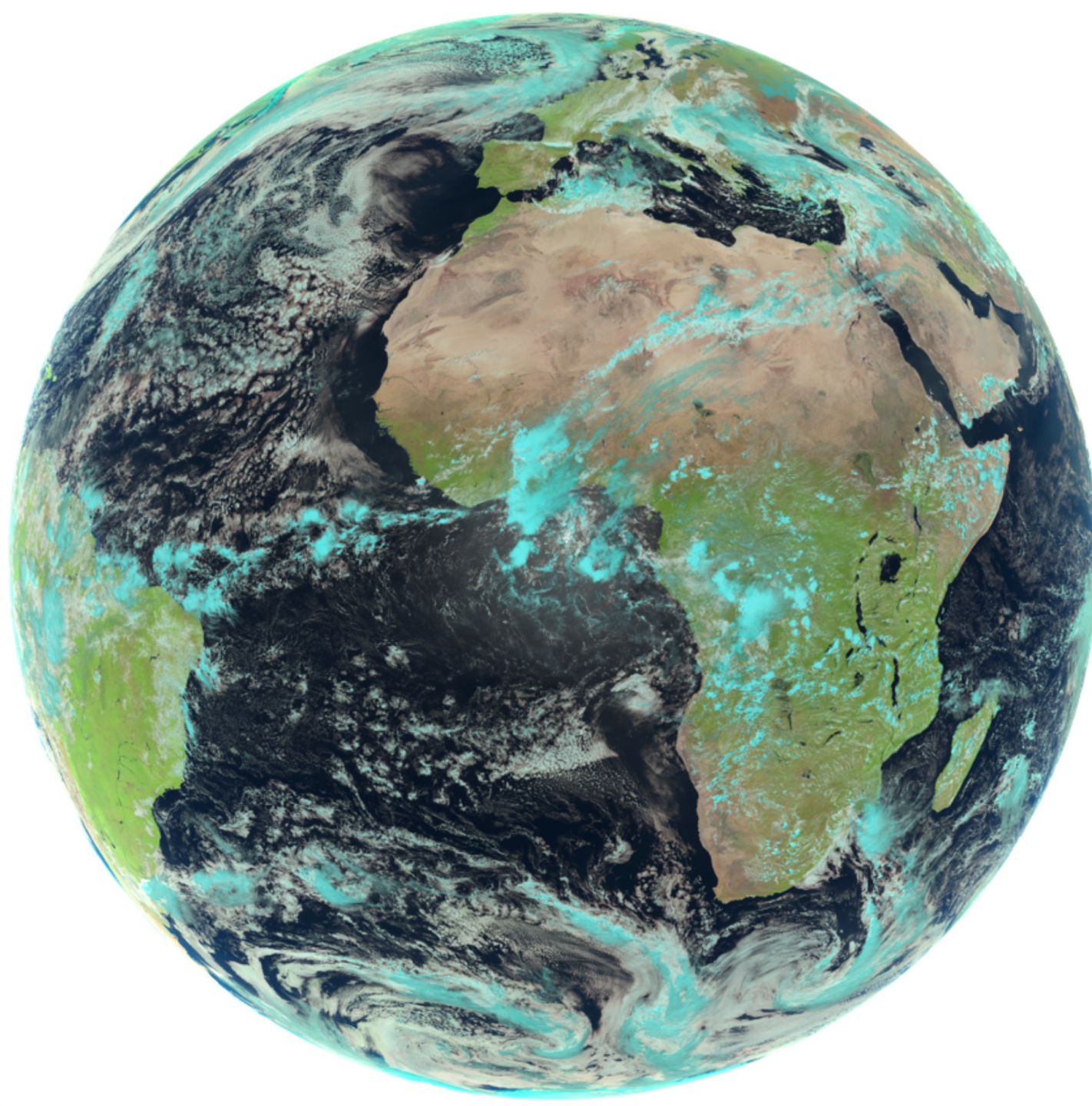
- `geo2grid.sh -r fci_l1c_nc -w geotiff -p vis_06 natural_color -f /path_to_data`
- `polar2grid -r viirs_sdr -w geotiff -p i01 m16 true_color -f /path_to_data`
- **True color and Natural color RGB creation includes these processes:**
  - Atmospheric Correction
  - Sharpening to highest band resolution
  - Creation of the green band if necessary (ie., ABI)
  - Division by  $\cos \theta$  (create reflectance)





FCI .6 micron  
Reflectances  
12 UTC  
29 March 2026





FCI False Color  
RGB Image  
12 UTC  
29 March 2026





# DEFINING A GRID/PROJECTION

- **Predefined Grids**

- **wgs84\_fit** – **Default for polar2grid.** Platte Carrée projection .0057 degree (mid latitudes  $\approx$ 600m) resolution.
- Lambert Conic Conformal (LCC) 1km predefined continental grids:
  - **lcc\_na** - North America
  - **lcc\_south\_africa** - South Africa
  - **lcc\_sa** - South America
  - **lcc\_aus** - Australia
  - **lcc\_eu** - Europe and North Africa
  - **lcc\_asia** - Asia

```
polar2grid.sh -r viirs_sdr -w gtiff -g lcc_na -f /path_to_files
```



# DEFINE YOUR OWN GRID

**A script is provided to help users define a grid over a specified region**

```
p2g_grid_helper.sh [-p PROJ_STR] grid_name  
  center_longitude center_latitude pixel_size_x  
  pixel_size_y grid_width grid_height
```

```
p2g_grid_helper.sh Germany 9.95 51.15 500 500 1500 1500  
> my_fci_grid.yaml
```

```
germany:  
  projection:  
    proj: lcc  
    lat_1: 51.15  
    lat_0: 51.15  
    lon_0: 9.95  
    datum: WGS84  
    units: m  
    no_defs: null  
    type: crs  
  shape:  
    height: 1500  
    width: 1500  
  center:  
    x: 9.95  
    y: 51.15  
    units: degrees  
  resolution:  
    dx: 500.0  
    dy: 500.0
```





# USER DEFINED GRIDS

Provide the configuration file, along with the grid name (more than one grid can exist in a configuration yaml file), to a `polar2grid.sh` or `geo2grid.sh` command

```
geo2grid.sh -r fci_l1c_nc -w geotiff --grid-configs  
/data/local_grids/my_fci_grid.yaml -g germany --num-workers 8 -f  
/data_dir/*_N_JLS_O_0036*
```





# METEOSAT-12 FCI

True color image  
2 May 2026  
12 UTC  
Centered on  
Darmstadt Germany





# ADD BOUNDARIES AND COLOR TABLES

add\_coastlines.sh script has many, many different options that allow users to control what kind of map overlays they want to use, along with positioning and annotating of color tables.

```
add_coastlines.sh METEOSAT-12_FCI_true_color_20260502_115000_germany.tif  
--add-coastlines --coastlines-resolution f --coastlines-level 6 --coastlines-outline  
black --add-borders
```



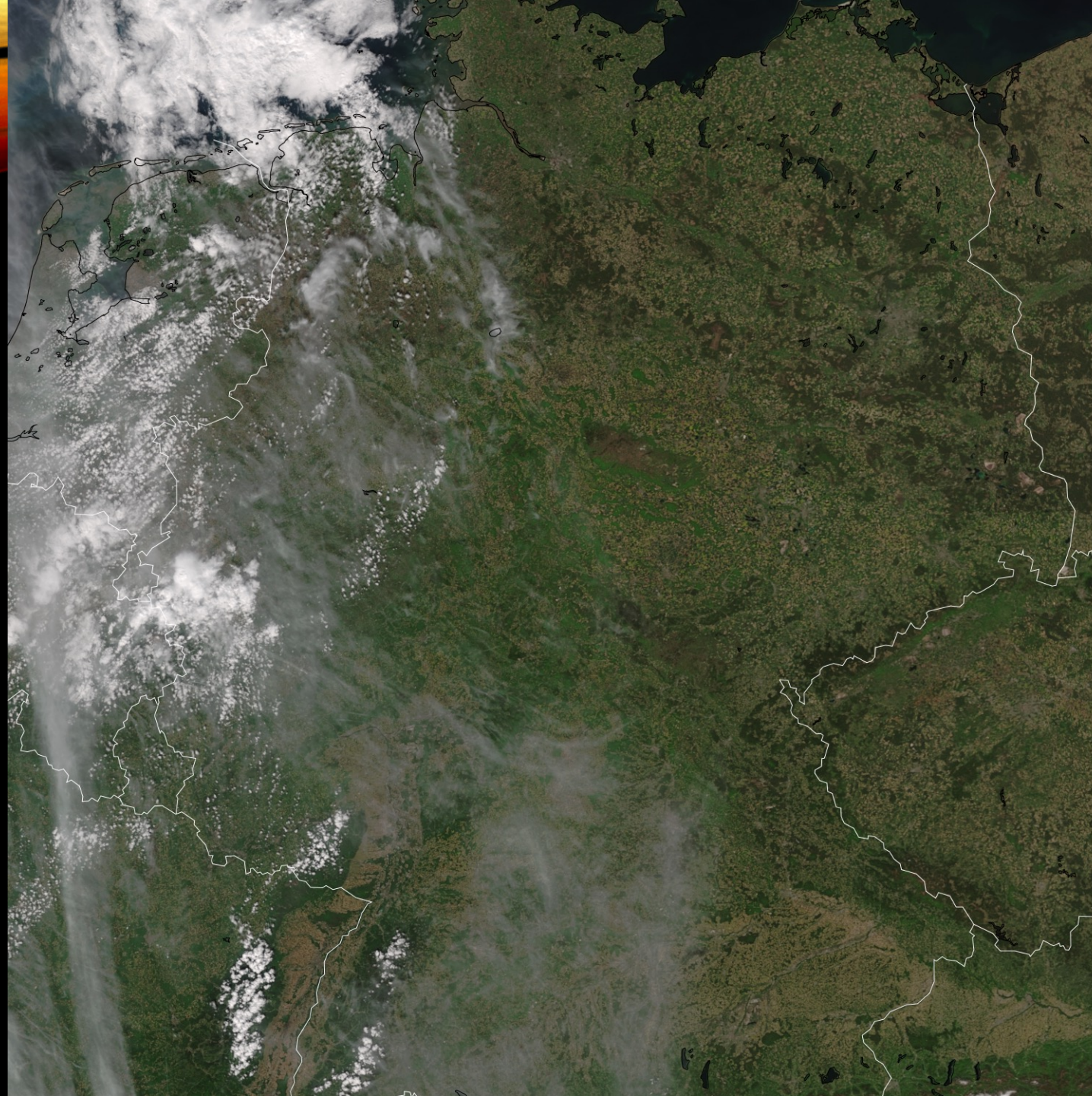
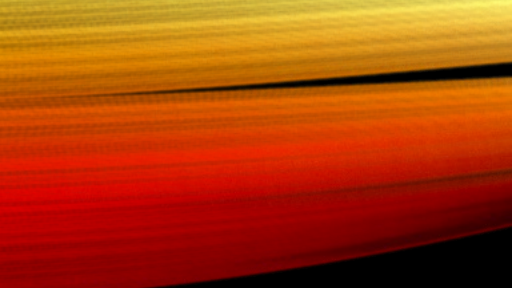


# USER DEFINED GRIDS

In the same way, I can use this grid in a polar2grid.sh command. In this case, I am using the JPSS Amazon Marketplace as the source of my data, so that I do not have to have the data locally. More work will be done to make this easier with future Polar2Grid releases.

```
polar2grid.sh -r viirs_sdr -w geotiff -p true_color --num-workers 8 --grid-configs  
/data/local_grids/my_fci_grid.yaml -g germany -f s3://noaa-nesdis-n21-  
pds/VIIRS-I1-SDR/2026/05/02/SVI01_j02_d20260502_t121{3,4,5,6,7,8,9}*.h5  
s3://noaa-nesdis-n21-pds/VIIRS-M{3,4,5}-  
SDR/2026/05/02/SVM0{3,4,5}_j02_d20260502_t121{3,4,5,6,7,8,9}*.h5 s3://noaa-  
nesdis-n21-pds/VIIRS-{IMG,MOD}-GEO-  
TC/2026/05/02/G{I,M}TCO_j02_d20260502_t121{3,4,5,6,7,8,9}*.h5
```





# NOAA-21 VIIRS

True color image  
2 May 2026  
12:13UTC  
Centered on  
Darmstadt Germany





# METEOSAT-12 FCI

True color image  
2 May 2026  
11:50 UTC  
Centered on  
Darmstadt Germany





# EFFICIENT PROCESSING

- Very Good Performance
  - disk and xarray libraries used
- Timing benchmarks done
  - Execution times taken for the creation of all bands plus true and natural color RGB imagery.
  - Users can control how many processors they use:

Example: `polar2grid.sh -r viirs_sdr -w geotiff --num-workers 8 -f ....`

<b>Geo2Grid Version</b>	<b>ABI Full Disk Sector</b>	<b>CONUS Sector</b>
Version 1.3	2m40s	40s
<b>Polar2Grid Version</b>	<b>10 granule Daytime VIIRS Overpass - All Bands plus True and False Color RGB products</b> <b>Execution Times</b>	
Version 3.2	4m23s	





# POLAR2GRID



# POLAR2GRID CURRENT CAPABILITIES

VERSION 3.2

## Polar Satellite Sensors (SDR/Level 1)

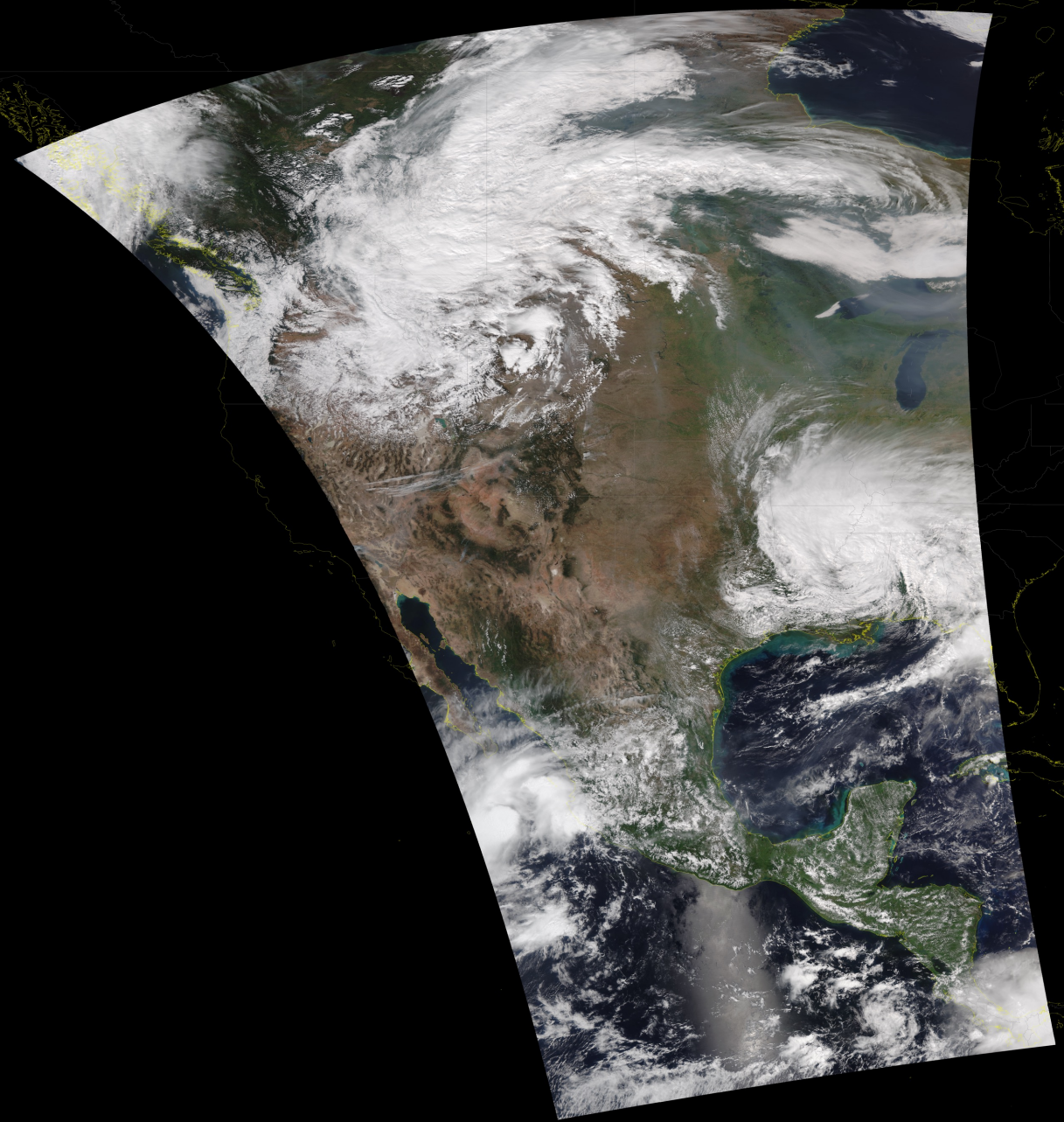
- VIIRS – NOAA-21, NOAA-20, S-NPP
- AVHRR - Metop-B, C
- MODIS - Aqua and Terra
- ATMS – Limb Corrected NOAA-21, NOAA-20 and S-NPP
- AMSR-2 – GCOMW-1
- ESA Arctic Weather Satellite (AWS) Microwave Radiometer (MWR)
- FY3-D MERSI-2
- FY3-E MERSI-LL

## CSPP LEO Science Products

- VIIRS Environmental Data Records (EDRs)
  - Aerosol Optical Depth, Cloud Properties, Surface Reflectance, Vegetation Indices (NDVI,EVI),
- ACSPO EDR SSTs from VIIRS, MODIS, AVHRR
- MiRS Microwave Retrievals from ATMS, AMSU, and MHS
- HEAP NUCAPS Retrievals from CrIS/ATMS, IASI/AMSU
- VIIRS Active Fires with overlays
- AMSR2 GAASP Level 2 Products

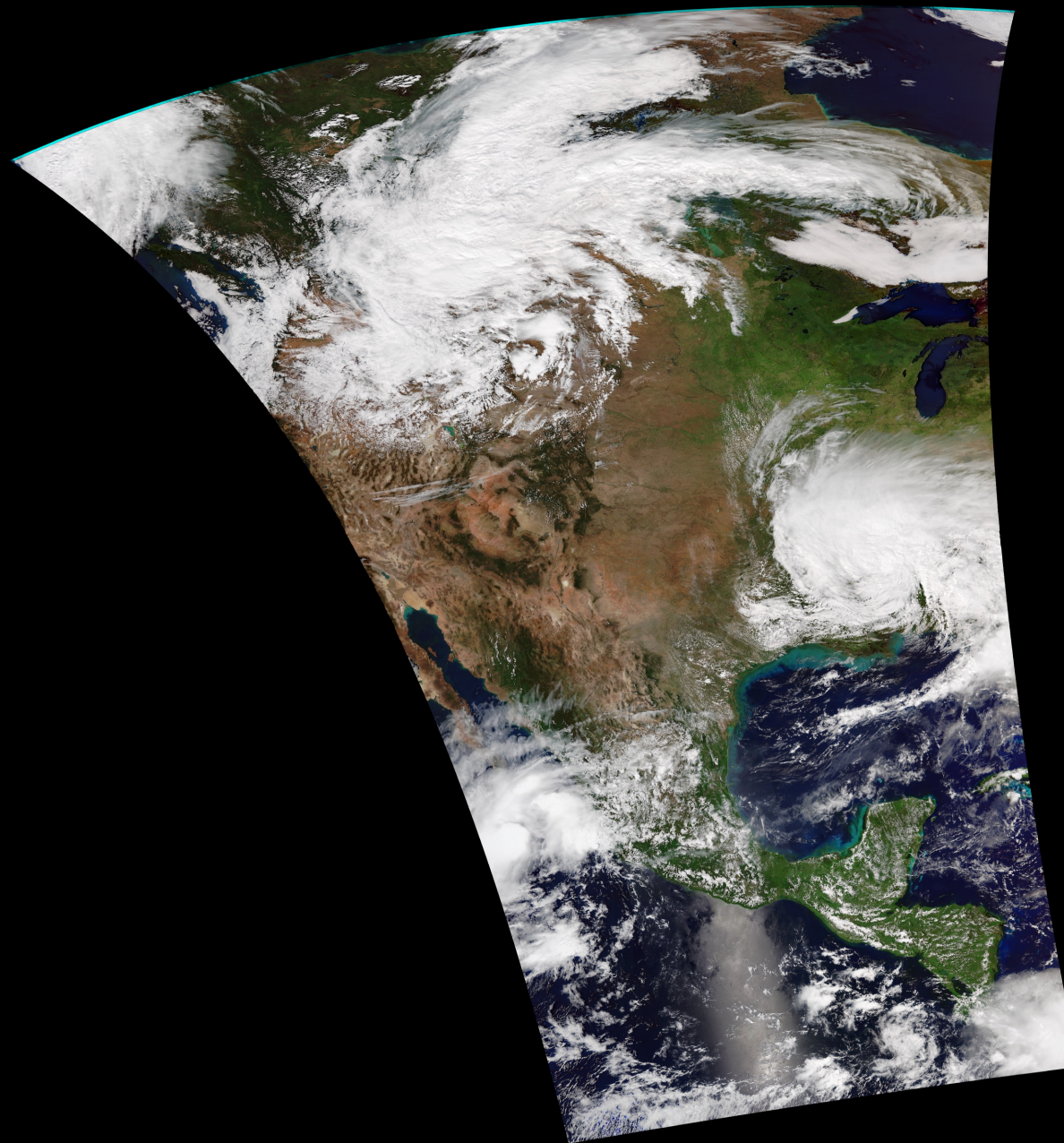


Polar2Grid True color image  
produced in near-real-time  
NOAA-20 VIIRS  
12 September 2024  
19:30 UTC

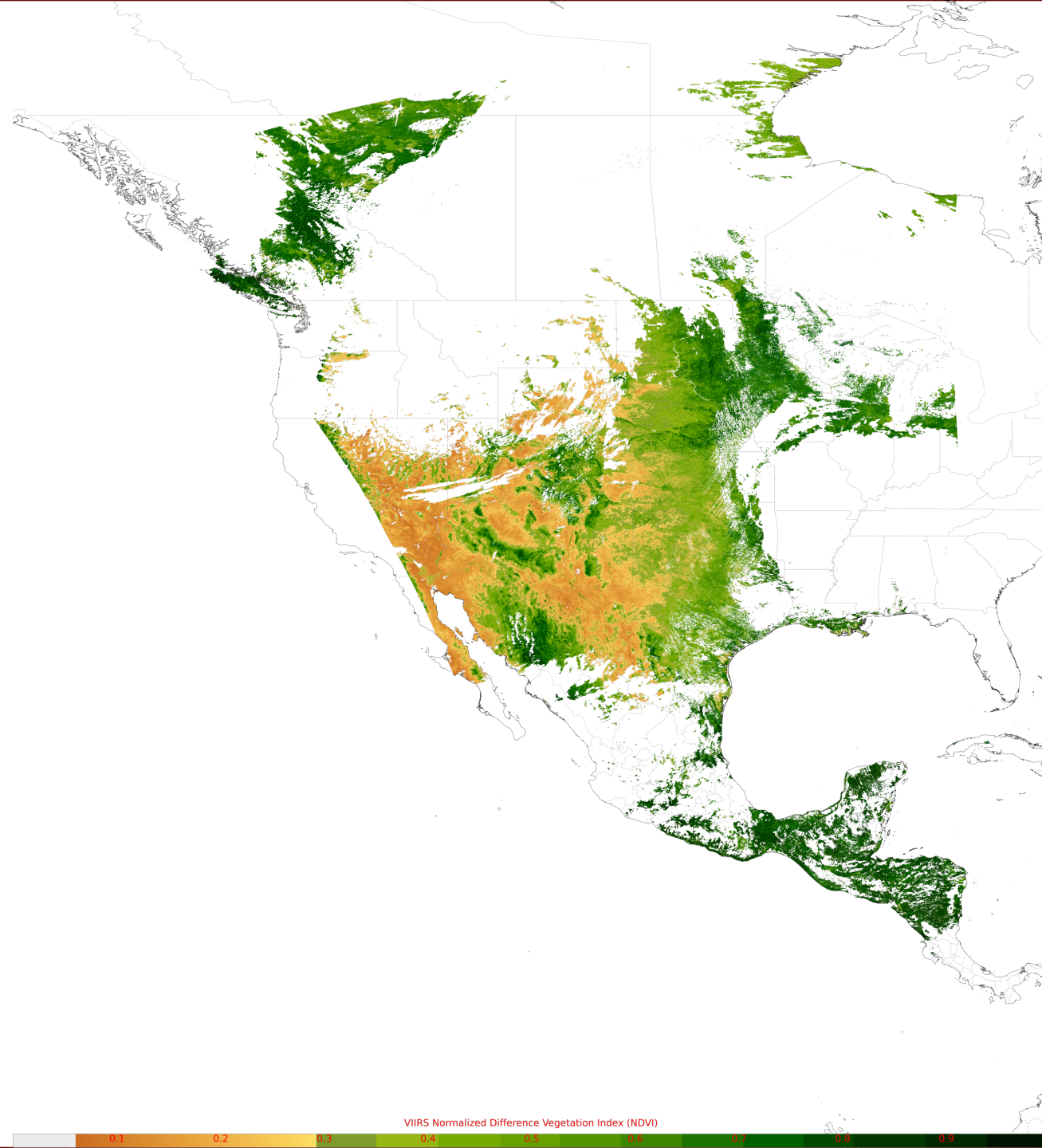




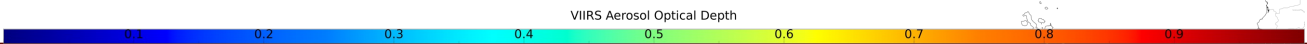
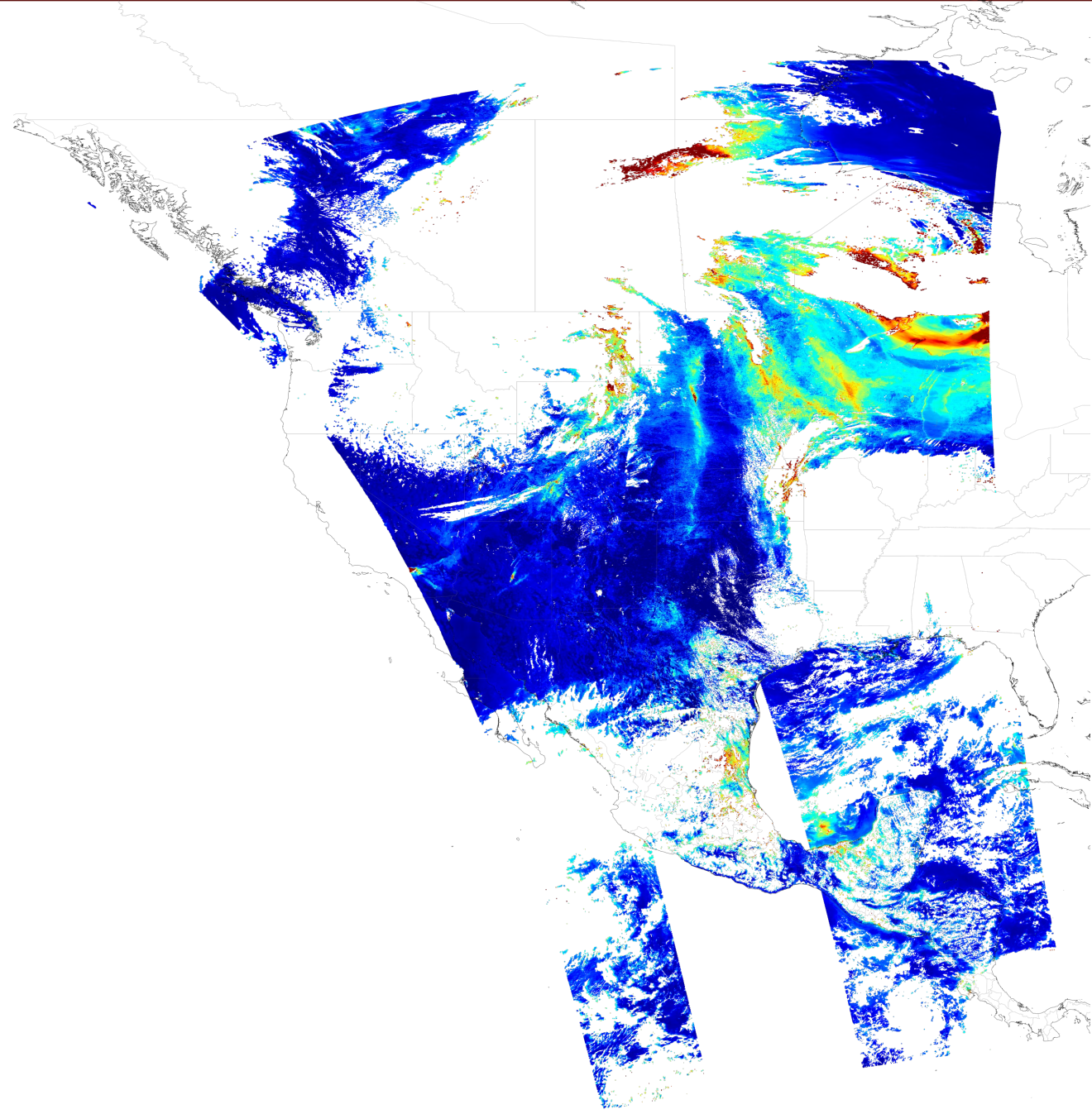
Polar2Grid True color image  
produced from the Surface  
Reflectance product in  
near-real-time  
NOAA-20 VIIRS  
12 September 2024  
19:30 UTC



Polar2Grid NDVI  
Image created from  
the VIIRS Surface  
Reflectance EDR  
in near-real-time  
NOAA-20 VIIRS  
12 September 2024  
19:30 UTC

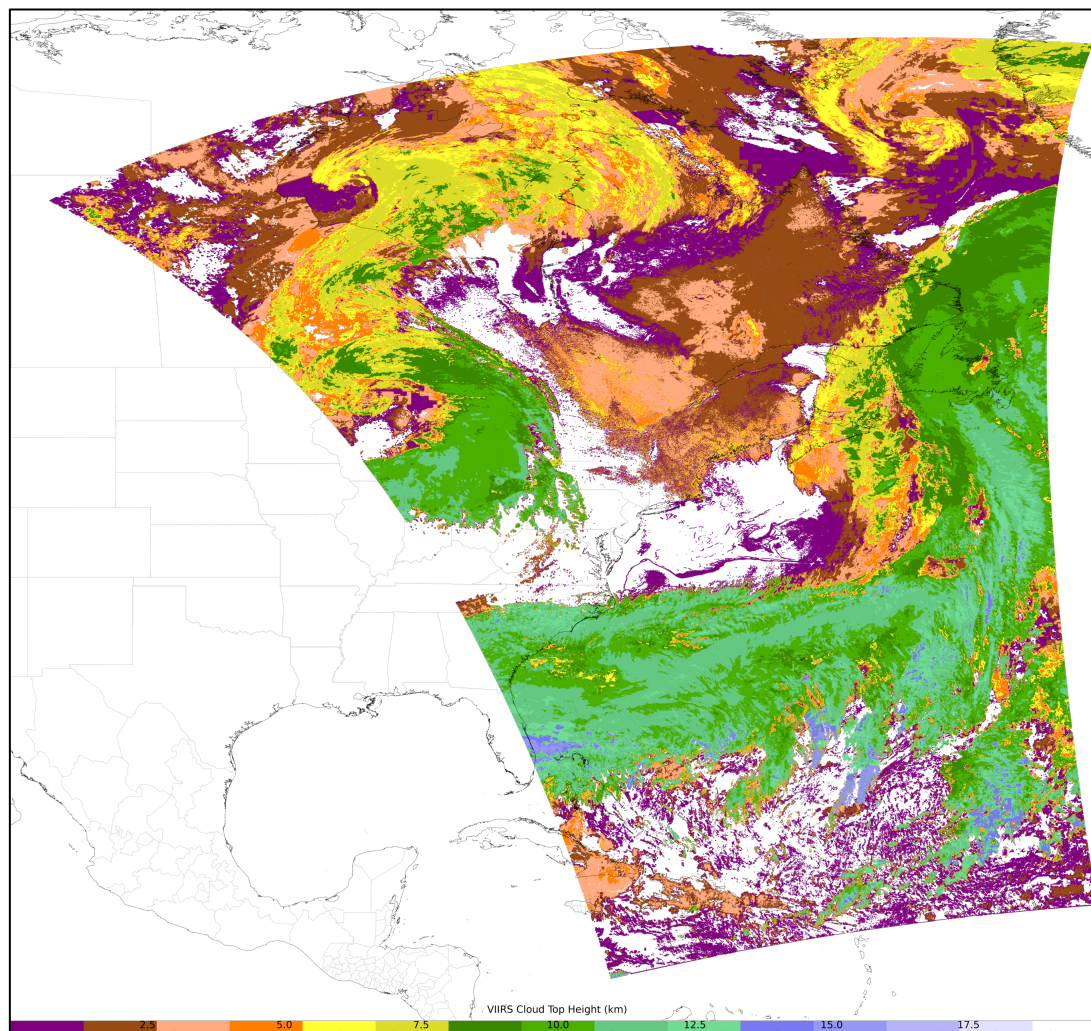
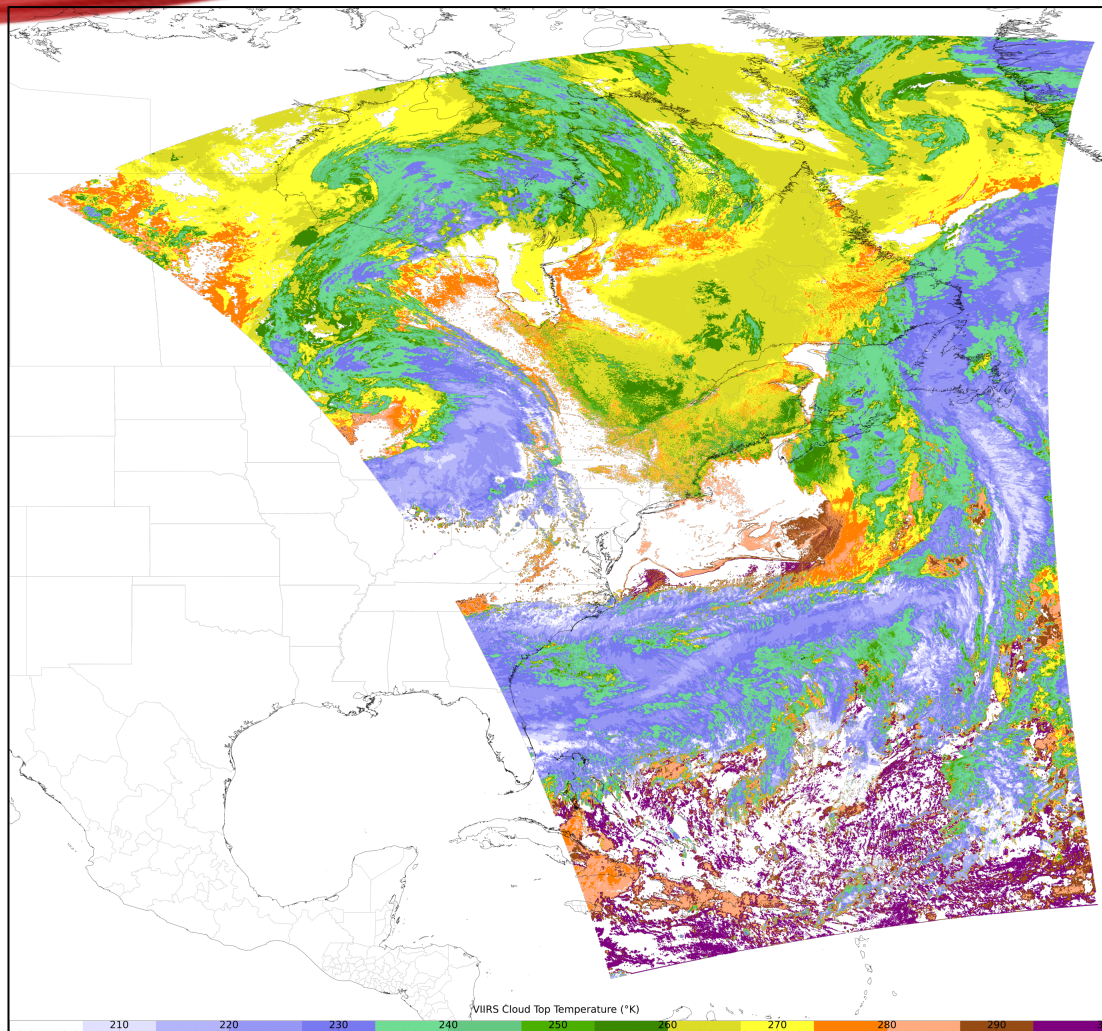


Polar2Grid Aerosol  
Optical Depth (AOD)  
Image created from  
The VIIRS AOD EDR  
in near-real-time  
NOAA-20 VIIRS  
12 September 2024  
19:30 UTC



# POLAR2GRID VIIRS CLOUD PRODUCT EDR EXAMPLES

```
polar2grid.sh -r viirs_edr -w geotiff -p CldTopTemp CldTopHght -f /path_to_edrs
```



NOAA-21 VIIRS Products 12 May 2026 17:23 UTC  
See polar2grid documentation for overlay examples



# POLAR2GRID DOCUMENTATION

## HTTPS://WWW.SSEC.WISC.EDU/SOFTWARE/POLAR2GRID/



**Polar2Grid**

Search  Go

### Navigation

- [1. Introduction](#)
  - [2. Installation](#)
  - [3. Polar2Grid Basics](#)
  - [4. Readers](#)
  - [5. Remapping](#)
  - [6. Writers](#)
  - [7. Utility Scripts](#)
  - [8. Verifying your Polar2Grid Installation](#)
  - [9. Examples](#)
  - [10. Grids](#)
  - [11. Custom Grids](#)
  - [12. Image Processing Techniques](#)
- Additional Details
- [1. Developer's Guide](#)
  - [2. Release Notes](#)
  - [3. Enhancements](#)
  - [4. Scaling of the VIIRS Day/Night Band in Polar2Grid](#)

## Polar2Grid

Polar2Grid is a set of command line tools for extracting data from earth-observing satellite instrument files, remapping it to uniform grids if needed, and writing that gridded data to a new file format. It provides an easy way to create high quality projected images. Polar2Grid was created by scientists and software developers at the [SSEC](#). It is distributed as part of the [CSPP LEO](#) project for processing of data received via direct broadcast antennas. Although Polar2Grid was created to serve the direct broadcast community, it can be used on most archived data files.

The features provided by Polar2Grid are accessible via bash scripts and binary command line tools. This is meant to give scientists an easy way to use and access features that typically involve complicated programming interfaces. Linux terminal commands included in these instructions assume the bash shell is used.

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[GitHub Repository](#)

[CSPP LEO Forum](#)

- [1. Introduction](#)
- [2. Installation](#)
- [3. Polar2Grid Basics](#)
- [4. Readers](#)
- [5. Remapping](#)
- [6. Writers](#)
- [7. Utility Scripts](#)
- [8. Verifying your Polar2Grid Installation](#)
- [9. Examples](#)
- [10. Grids](#)
- [11. Custom Grids](#)
- [12. Image Processing Techniques](#)

## 9. Examples

- [9.1. Creating VIIRS SDR GeoTIFF Files](#)
- [9.2. Creating MODIS AWIPS Compatible Files](#)
- [9.3. Creating ACSP0 SST Reprojections](#)
- [9.4. Creating VIIRS Land and Atmosphere Product Images](#)
- [9.5. Creating AMSR2 Reprojections](#)
- [9.6. Creating AMSR2 GAASP Product Reprojections](#)
- [9.7. Working with Data from the JPSS AWS Marketplace](#)



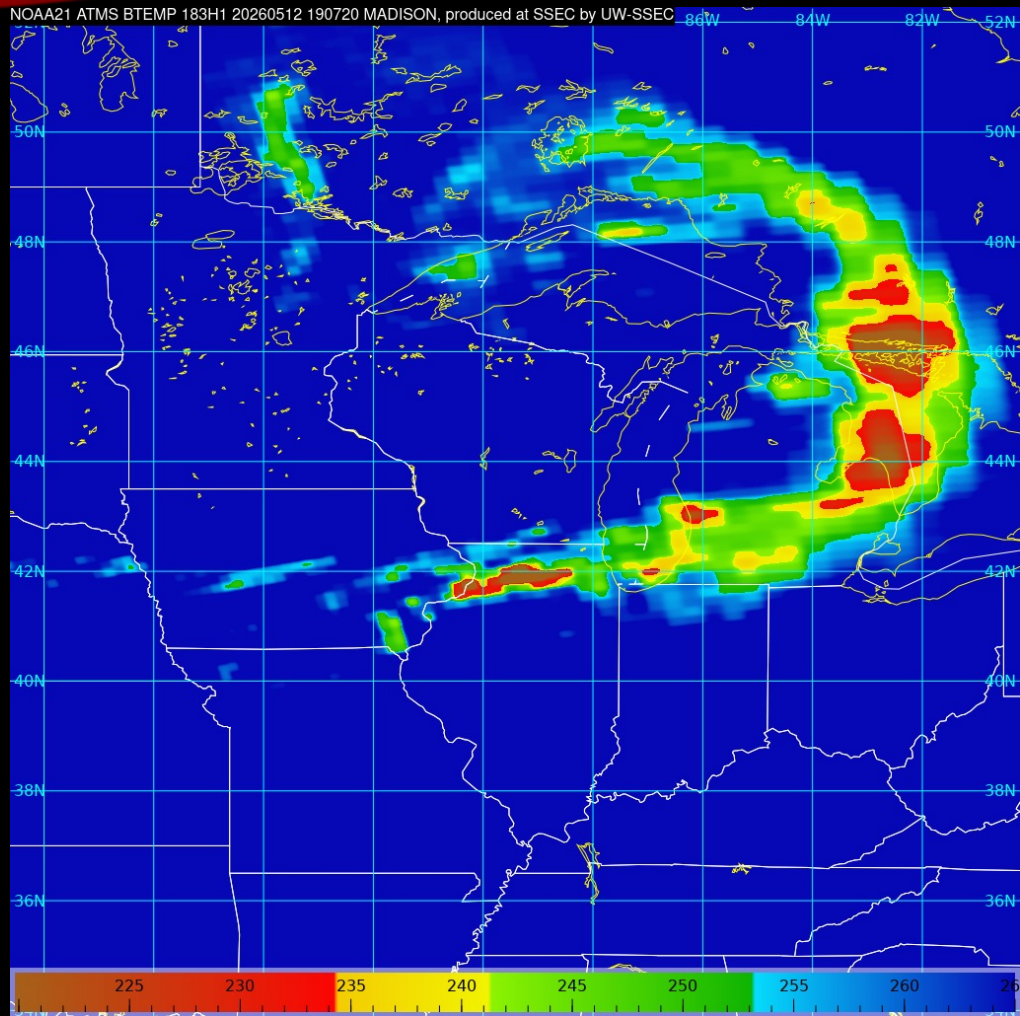


# EXAMPLE APPLICATIONS

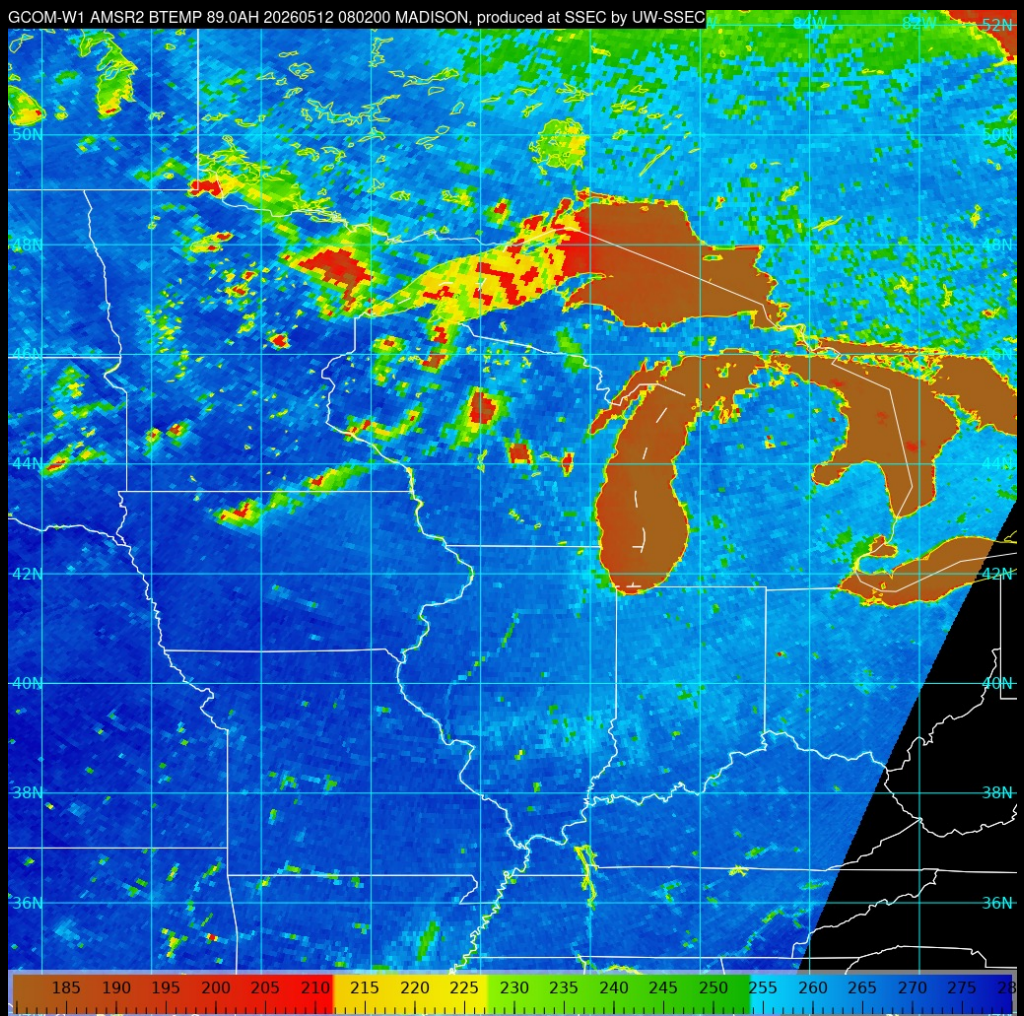




# APPLICATIONS



AMSR2 183h1 GHz 12 May 2026



AMSR2 89.0 GHz 12 May 2026



# TYPHOON SINLAKU APRIL 11, 2026 FACEBOOK LIVE BROADCAST BY GUAM NATIONAL WEATHER SERVICE

- Public Briefing Live Broadcast done via Facebook by Brandon Aydlett, Meteorologist in Charge (MIC) at the National Weather Service Forecast Office in Guam

The following is a 1 minute segment of that briefing. The full recording is available at

<https://www.facebook.com/NWSGuam/videos/1499301111709875/>

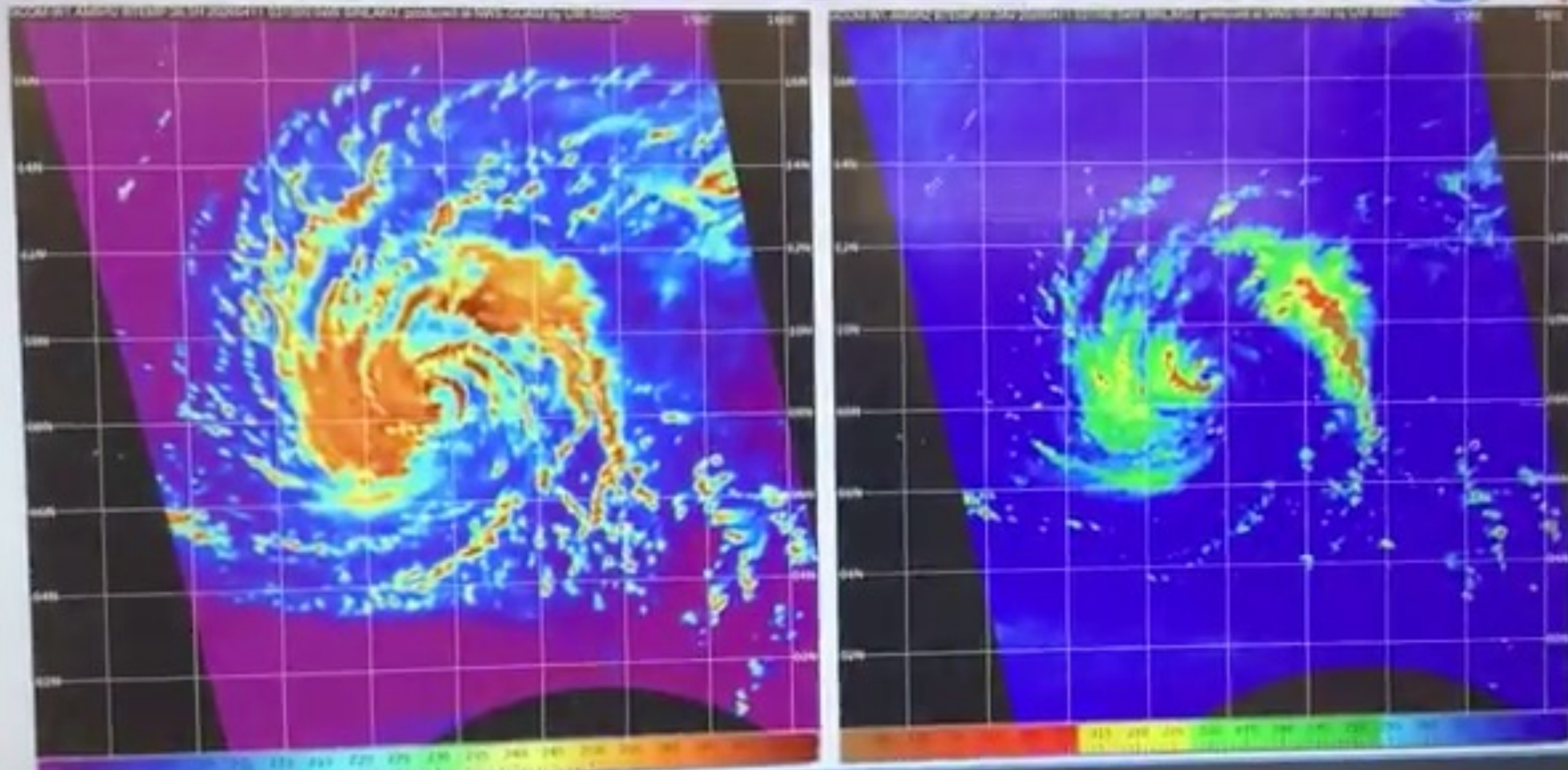
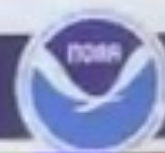
AMSR2 imagery created using CSPP Polar2Grid with customized NRL enhancements

Full Video Available at:

<https://www.facebook.com/NWSGuam/videos/1499301111709875/>



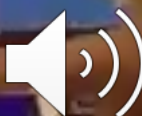
# TY Sinlaku (04W): AMSR2 Microwave Data – 11/03Z



NATIONAL WEATHER SERVICE  
Protecting Lives and Property for 150 Years

Building a Weather-Ready Nation | 1

Promethean





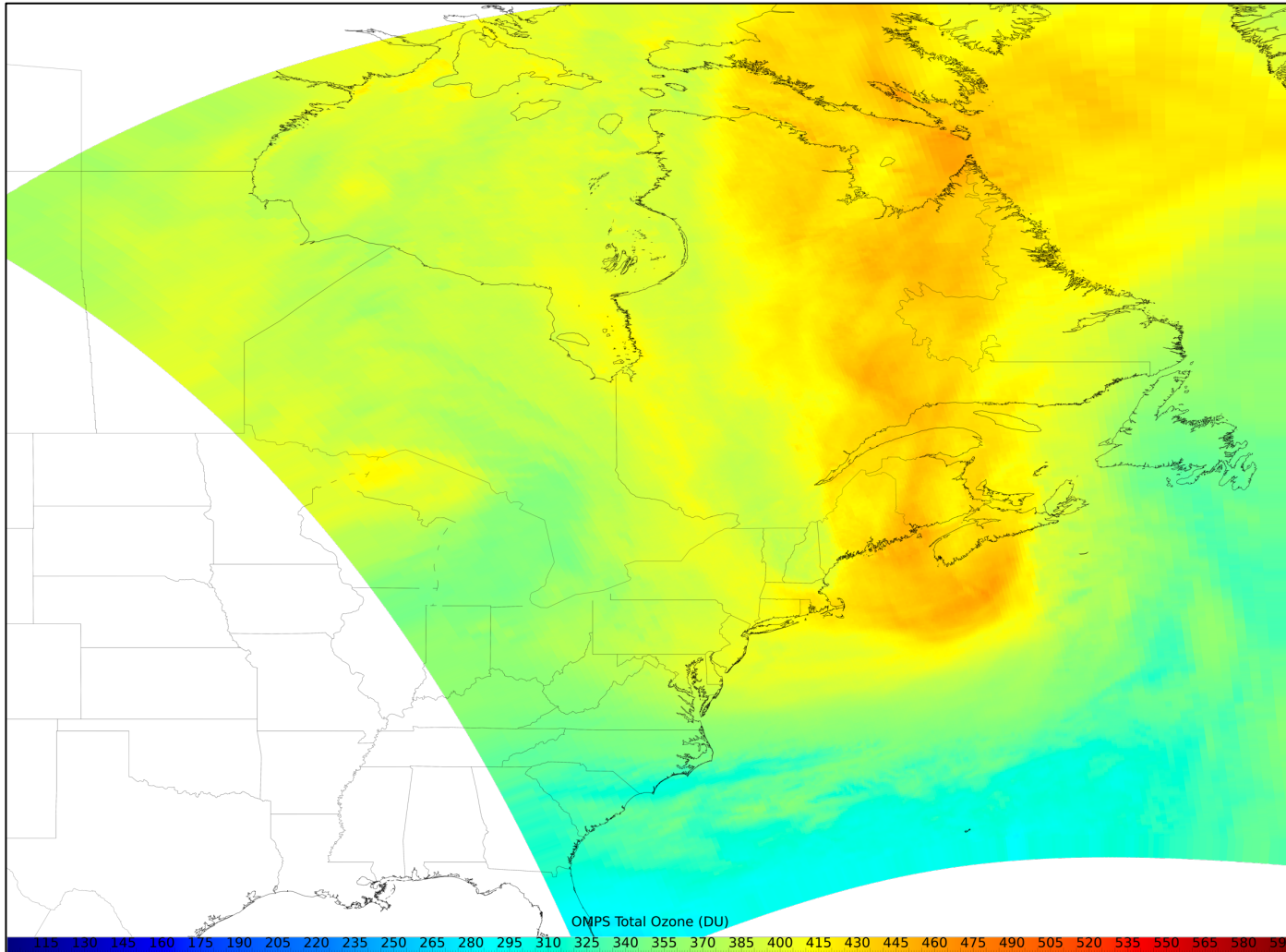
# WHAT ARE WE WORKING ON?

- Polar2Grid Version 3.3
  - Additional VIIRS EDR support
    - VIIRS Cryosphere products
    - Additional VIIRS RGBs supported
    - OMPS Level 2 support – including Total Ozone
    - Improving use of JPSS Marketplace data directly
    - Optimizations
    - Bug fixes





# OMPS LEVEL 2 EXAMPLE



```
polar2grid.sh -r  
omps_edr -w geotiff -p  
ColumnAmountO3 -f  
/path_to_edrs
```

NOAA-21  
OMPS Total Ozone  
12 May 2026  
17:28 UTC





# GEO2GRID

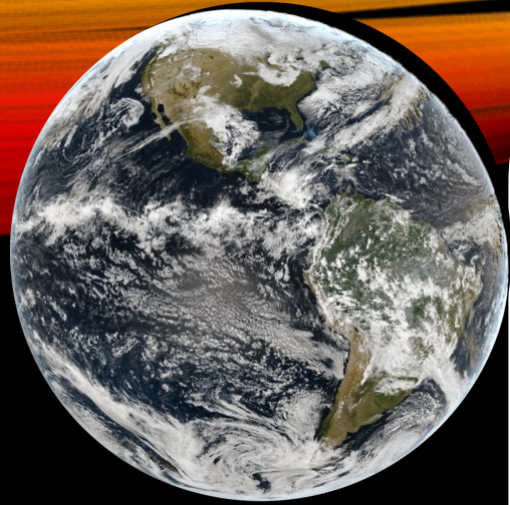


# GEO2GRID CURRENT CAPABILITIES

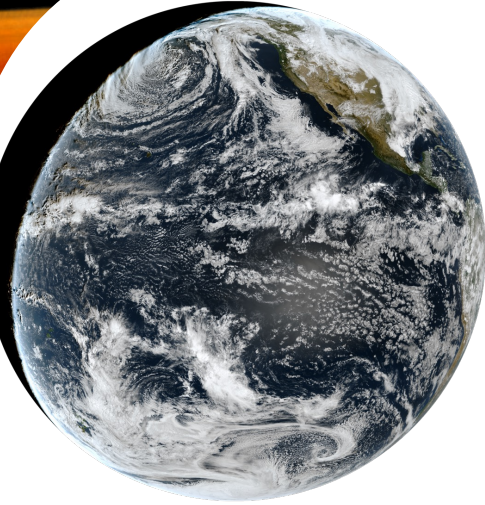
VERSION 1.3

- GOES-16, 17, 18, 19: Advanced Baseline Imager (ABI)
  - All Bands plus true and natural color
  - All Sectors and Modes
- Himawari-8, 9: Advanced Himawari Imager (AHI) (both HSD and HimawariCast formats)
  - All Bands plus true and natural color
- GEO-KOMPSAT-2A: Advanced Meteorological Imager (AMI)
  - All Bands plus true and natural color
- FY-4A, 4B: Advanced Geostationary Radiation Imager (AGRI)
  - All Bands plus true and natural color
- Meteosat-12: Flexible Combined Imager (FCI)
  - All Bands plus true and natural color
- ABI Atmosphere Products
  - Cloud Top Temperature, Cloud Top Height, Cloud Top Pressure, Cloud Phase, Aerosol Optical Depth (AOD) and Fog/Low Stratus (FLS), Land Surface Temperature
- GOES Gridded Geostationary Lightning Mapper (GLM) Products
  - Flash Extent Density, Group Extent Density, Flash Centroid Density, Group Centroid Density, Average Flash Area, Minimum Flash Area, Average Group Area, Total Energy

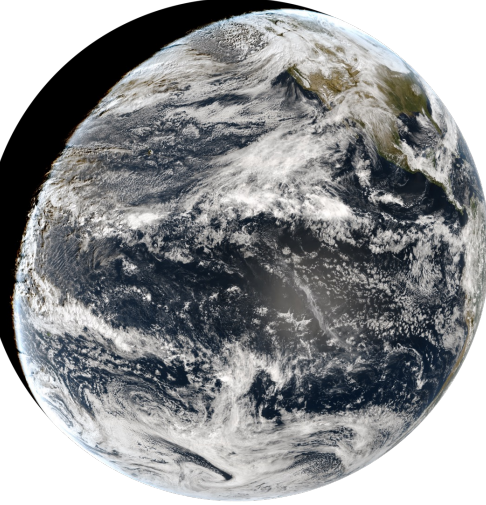




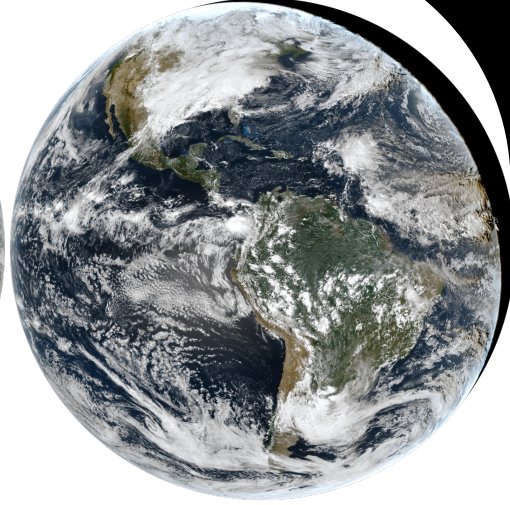
**GOES-19 ABI**



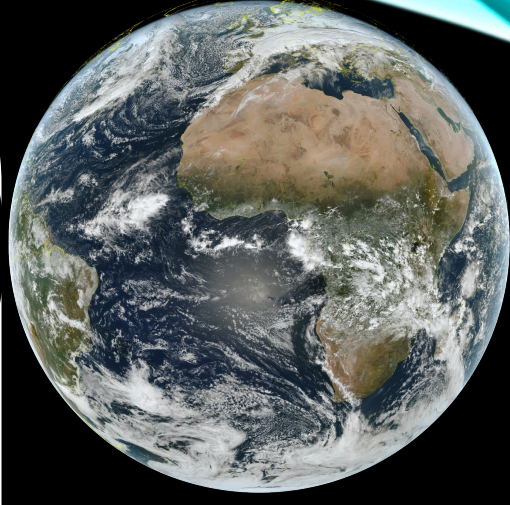
**GOES-18 ABI**



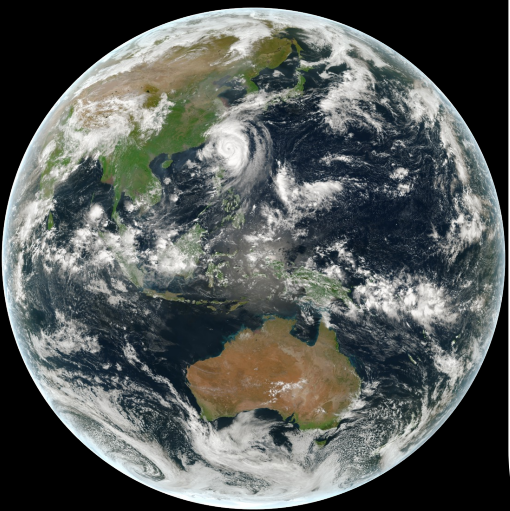
**GOES-17 ABI**



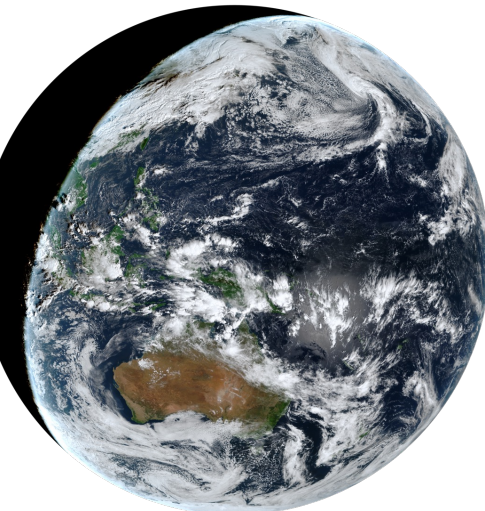
**GOES-16 ABI**



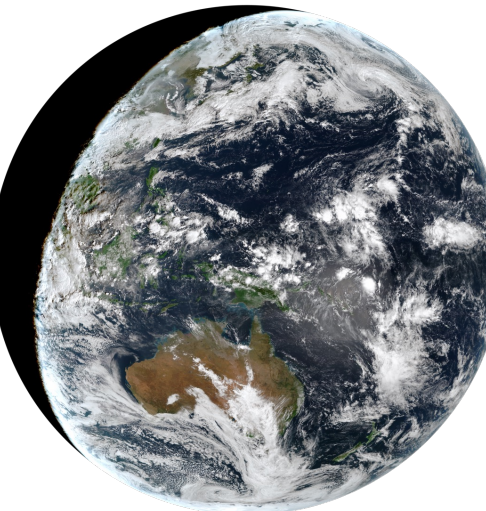
**Meteosat-12 FCI**



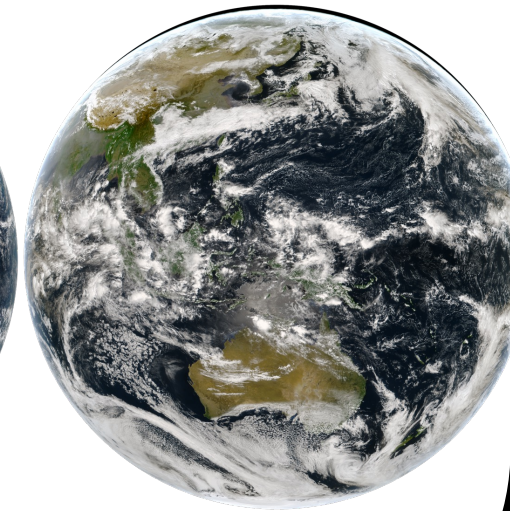
**GK-2A AMI**



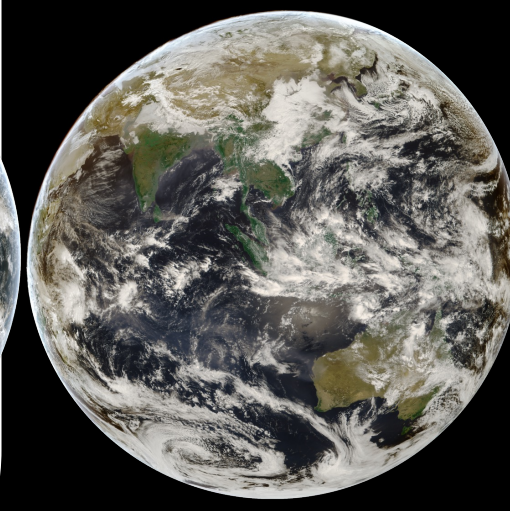
**Himawari-9 AHI**



**Himawari-8 AHI**



**FY-4A AGRI**



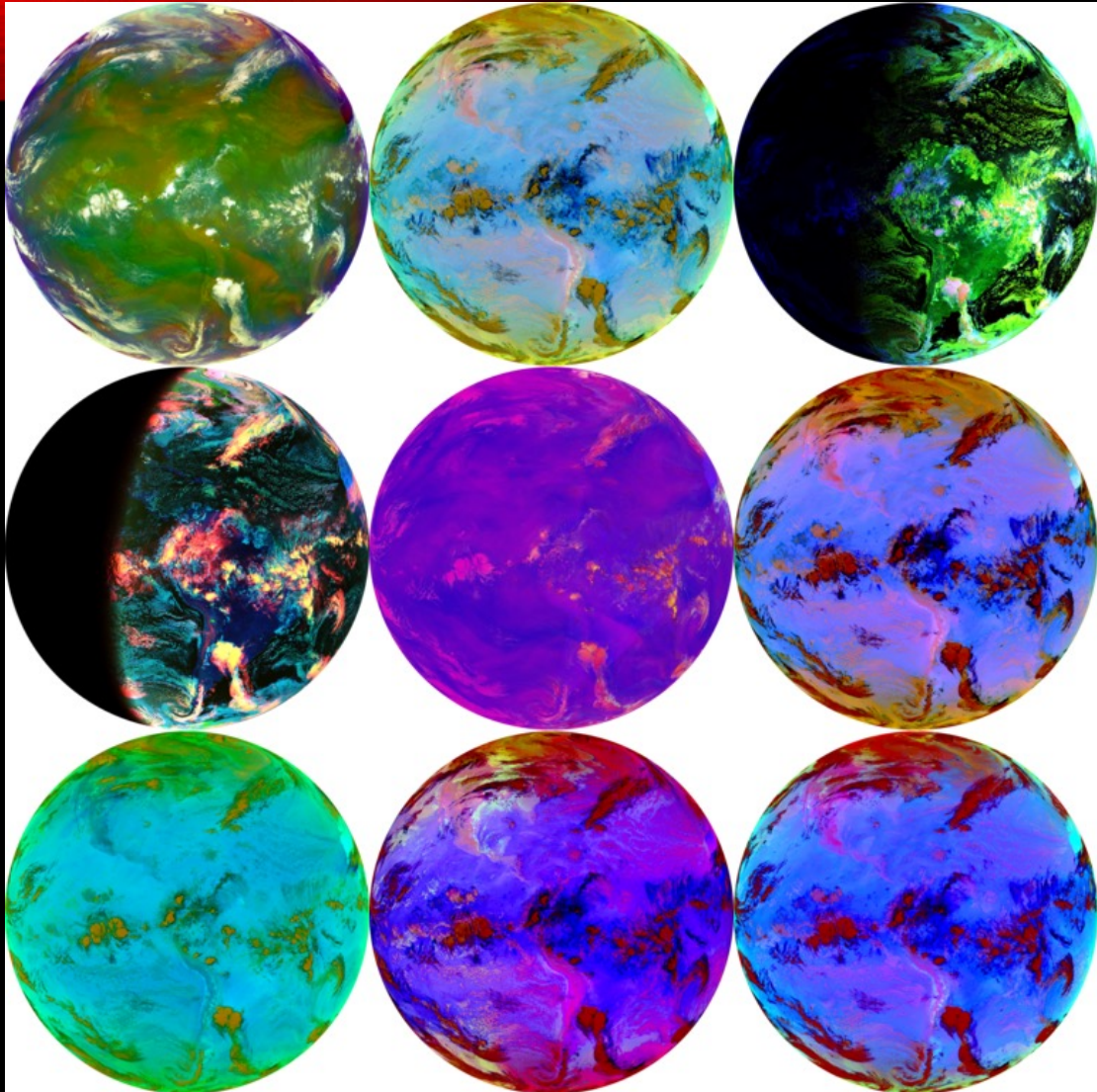
**FY-4B AHI**

# GEO2GRID CURRENT CAPABILITIES

VERSION 1.3

- Now supports a number of new ABI RGBs
  - Airmass
  - Nighttime Microphysics
  - Day Cloud Type
  - Day Severe Storms
  - Ash
  - Dust
  - Volcanic Emissions
  - Day Blowing Snow
  - Fog



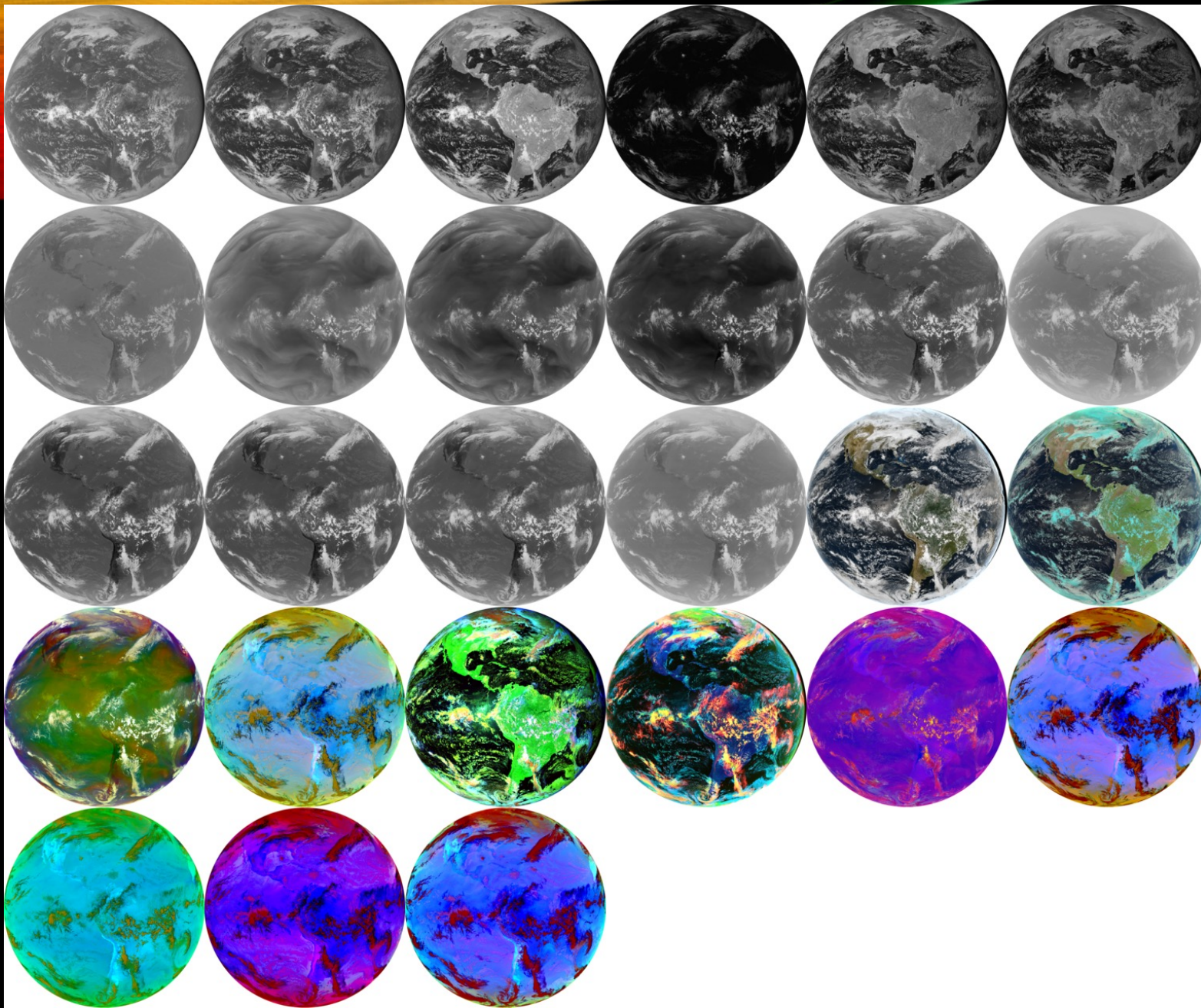


# GOES-19 NEW ABI RGBS

GOES-19 ABI  
GRB  
3 March 2026

```
geo2grid.sh -r abi_l1b -w geotiff -p fog airmass ash dust  
night_microphysics day_cloud_type day_severe_storms  
volcanic_emissions day_blowing_snow -f path_to_data
```





Montage of complete compliment  
Of GOES-19 ABI reflectance,  
Brightness temperature and  
RGB images

GOES-19 ABI  
GRB  
3 MARCH 2026

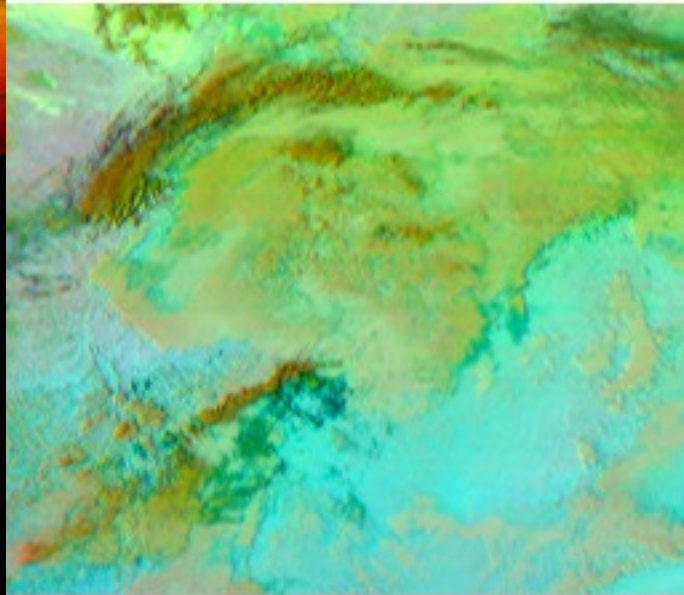




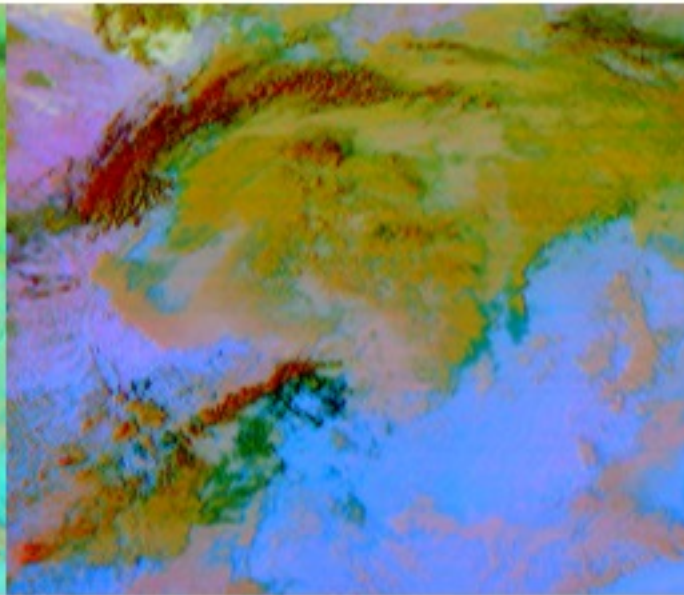
# CUT OUTS

- **Areal Cut Outs (Subsets) – Geo2Grid only**
  - **Define a region by using lat/lon boundaries in the geo2grid.sh command itself. Possible because Geostationary Imagers are on a fixed grid.**
    - `geo2grid.sh -r agri_fy4a_l1 -w geotiff --ll-bbox 100 20 120 40 -p ash dust fog true_color -f /data/test_data/agri4a/0400/*.HDF`

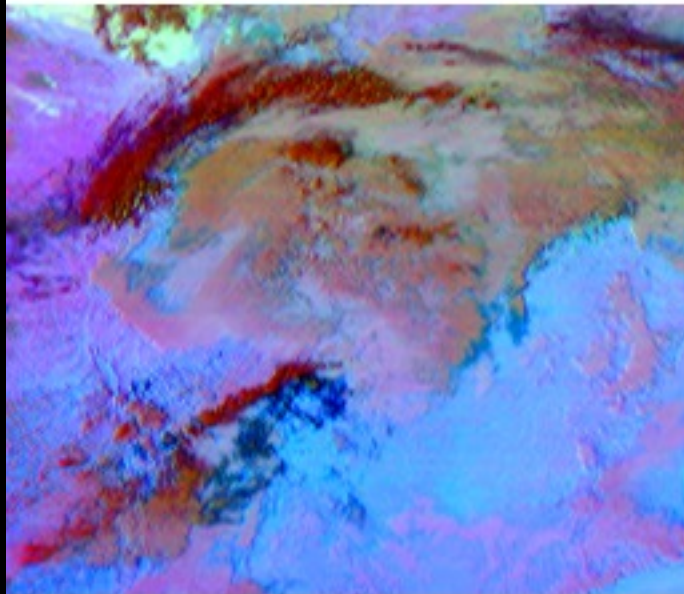




Ash RGB



Dust RGB



Fog RGB



True Color RGB

FY-4A  
RGBs

Cutout  
20240116  
0400 UTC

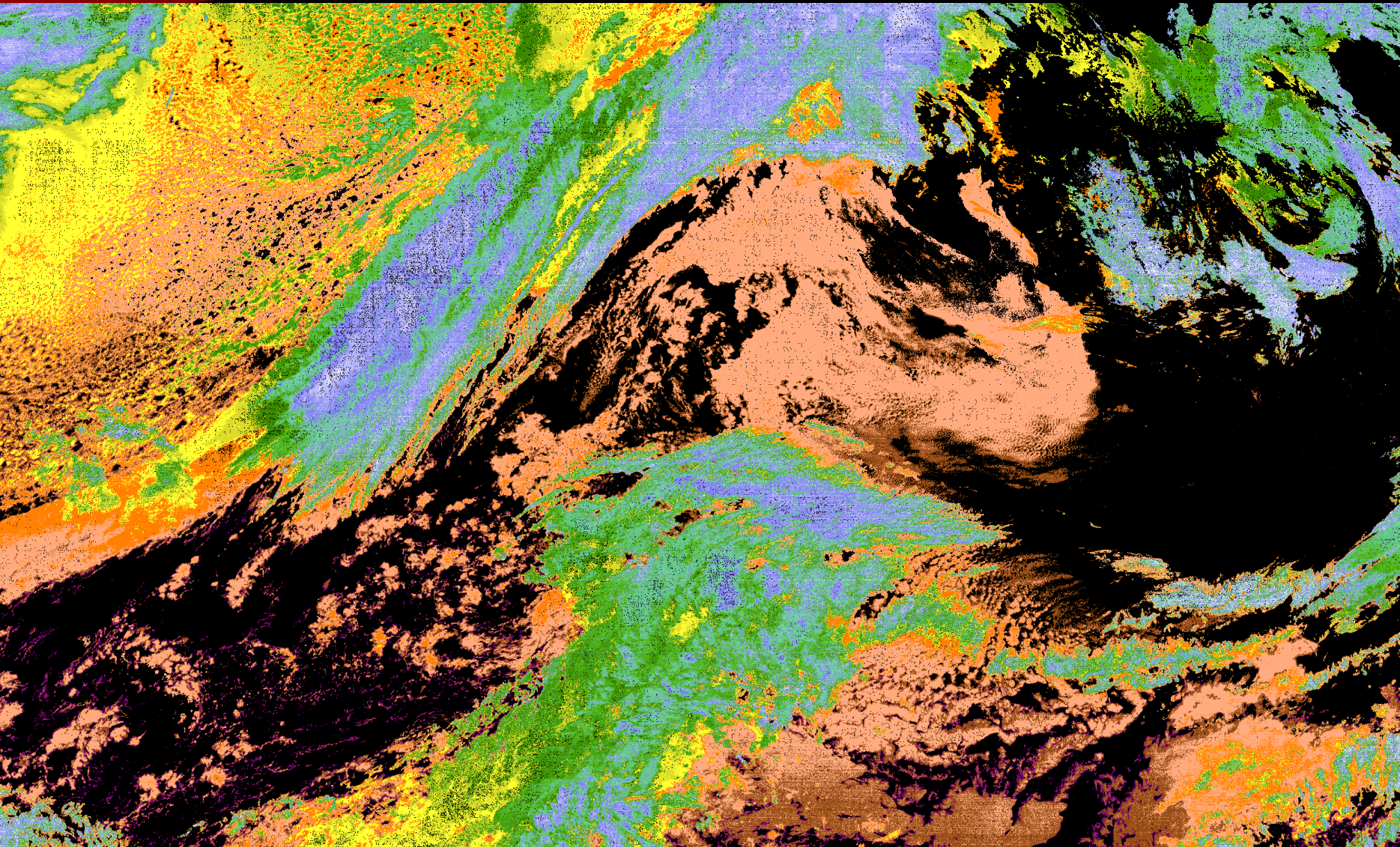




# PRODUCTS



# ABI AIT PRODUCT SUPPORT

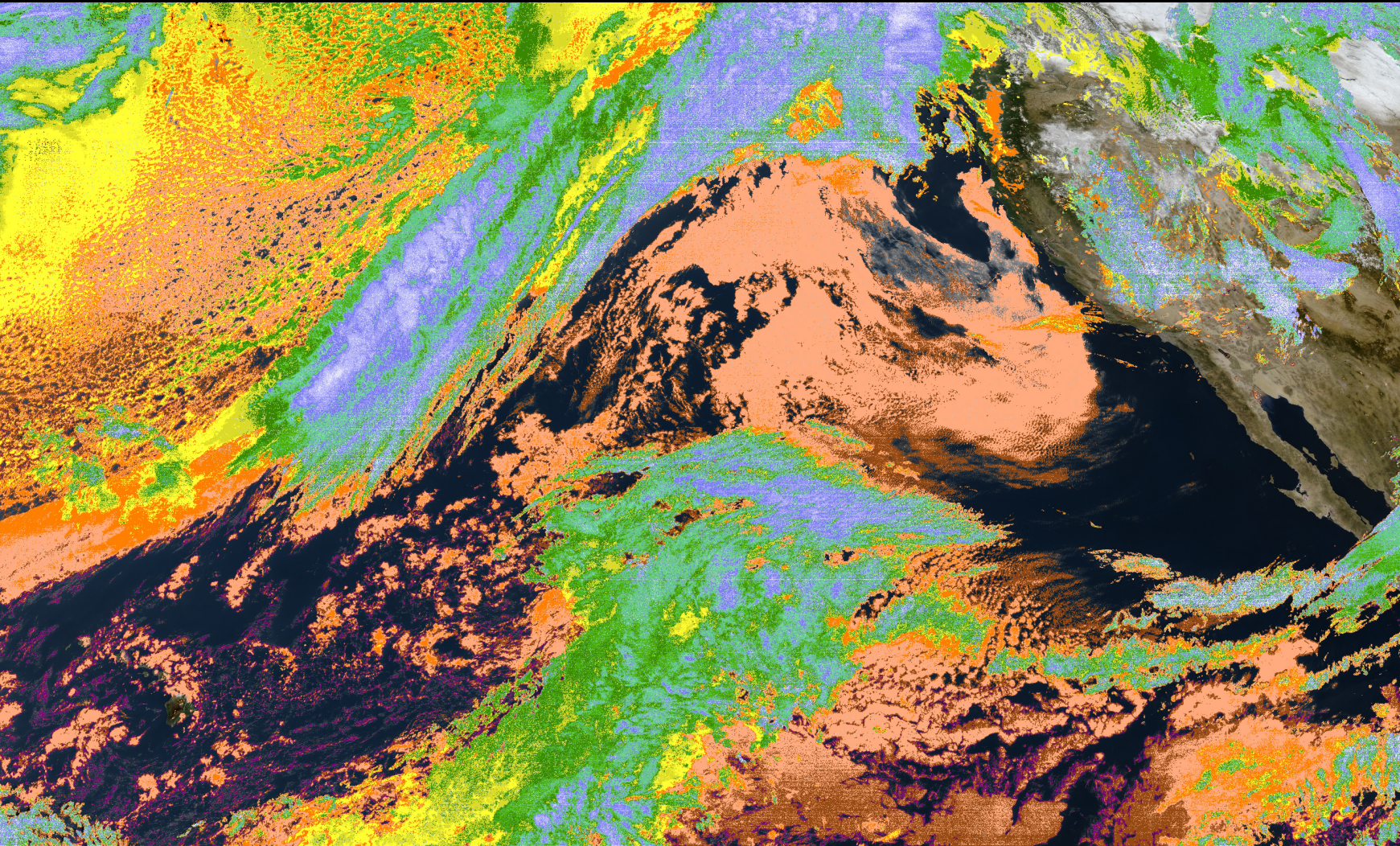


Cloud Top Temperature

```
geo2grid.sh -r abi_l2_nc  
-w geotiff -p TEMP -f  
CG_ABI-L2-ACHTC-  
M6_G17_s2022327183117  
2_e20223271833556_c20  
223271834370.nc
```



# OVERLAY CAPABILITIES

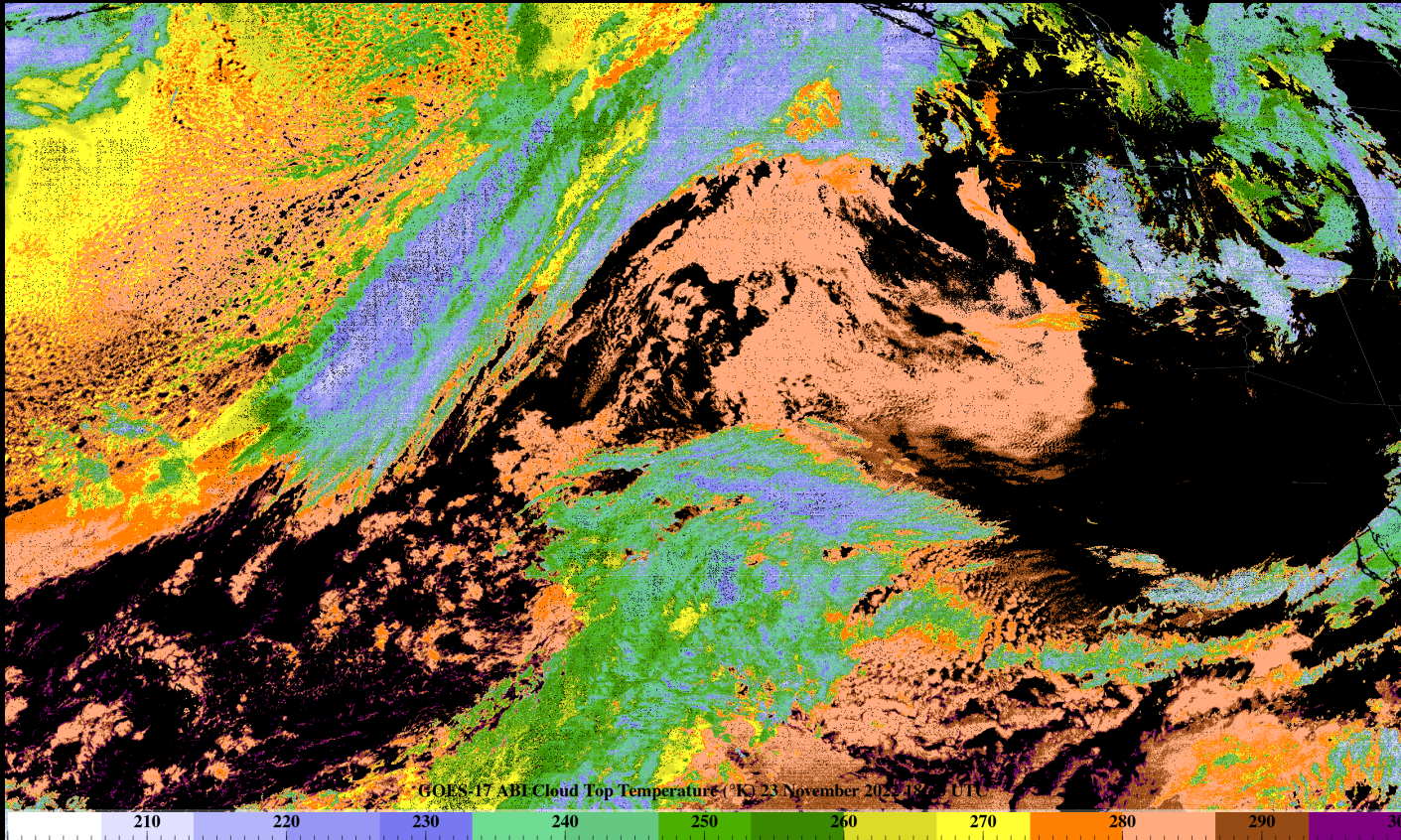


ABI Cloud Top Temperature  
overlaid on a true color image

```
overlay.sh GOES-  
17_ABI_RadC_true_color_20221  
123_183117_GOES-West.tif  
GOES-  
17_ABI_TEMP_20221123_183117  
_GOES-West.tif  
goes17_overlay_true_color_clo  
ud_temperature.tif
```



# ADDING BORDERS AND COLORTABLE



```
add_coastlines.sh GOES-17_ABI_TEMP_20221123_183117_GOES-West.tif --add-colorbar --colorbar-text-color="black" --colorbar-title="GOES-17 ABI Cloud Top Temperature (°K) 23 November 2022 18:30 UTC" --add-coastlines --coastlines-outline "black" --coastlines-level 1 --coastlines-resolution=i --add-borders --borders-level 2 --borders-outline gray --coastlines-width 2 --colorbar-tick-marks 10 -o my_goes17_abi_ctt.png
```





# CREATING ANIMATIONS

- Geo2Grid includes an example section to help with creating animations.  
[https://www.ssec.wisc.edu/software/geo2grid/examples/creating\\_animations\\_example.html](https://www.ssec.wisc.edu/software/geo2grid/examples/creating_animations_example.html)

## Navigation

- [1. Introduction](#)
- [2. Installation](#)
- [3. Geo2Grid Basics](#)
- [4. Readers](#)
- [5. Composites](#)
- [6. Remapping](#)
- [7. Writers](#)
- [8. Utility Scripts](#)
- [9. Verifying your Geo2Grid Installation](#)
- [10. Examples](#)
- [11. Data Access](#)
- [12. Grids](#)
- [13. Custom Grids](#)
- [14. Image Processing](#)

## 10.4. Using Geo2Grid to Create Animations

The advantage of Geostationary Satellites is the temporal resolution of the observations. Geo2Grid offers an easy interface for creating animations from Geo2Grid GeoTIFF and PNG files. The following example demonstrates how Geo2Grid software can be used to create an animation of files from a latitude/longitude subset of GOES-19 ABI Mesoscale Sector images centered over Hurricane Melissa in October 2025.

Create a series of GOES-19 ABI GeoTIFF files from a time sequence of data. In the bash shell script example below, I use the ABI MESO Sector 1, Band 1 files to search for files that are available from October 28, 2025, limiting the search to files with an hour prefix of 15, 16, 17, or 18. These files were produced at 1 minute resolution. I then create true color images from all time periods that are available.

```
#!/bin/bash

# Example script for using Geo2Grid Version 1.3 to create an MP4 ani

# Set GEO2GRID environment variables

export GEO2GRID_HOME=/home/g2g/geo2grid_v_1_3
export PATH=$PATH:$GEO2GRID_HOME/bin

# Get input list of available files/times based upon ABI Band 1 files

ls -l /data/abi19/20251028/OR_ABI-L1b-RadM1-M6C01_G19_s2025301{15,16,
```





# HURRICANE MELISSA

## 1 MINUTE DATA

15:00 UTC – 18:59 UTC

28 October 2025

239 images Second set with GLM flash extent density overlay

Animations made with `gtiff2mp4.sh` script.

`gtiff2mp4.sh GOES19_ABI_Hurricane_Melissa.mp4 *true_color*.png`





**Hurricane Melissa Landfall on Jamaica  
GOES ABI true color  
28 October 2025**





**Hurricane Melissa Landfall on Jamaica  
GOES ABI true color w/lightning overlay  
28 October 2025**



# GEO2GRID UTILITY - RESEARCH

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Joint International Conference Geospatial Asia-Europe 2021 and GeoAdvances 2021, 5-6 October 2021, online

## MODELLING THE CHLOROPHYLL-A CONCENTRATION OF LAGUNA LAKE USING HIMAWARI-8 SATELLITE IMAGERY AND MACHINE LEARNING ALGORITHMS FOR NEAR REAL TIME MONITORING

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Commission 4, WG 7

**KEY WORDS:** Laguna Lake, Chlorophyll-a Concentration, Himawari-8, Machine Learning, C2RCC.

- Martinez, E. R. G., et al. "Modelling the Chlorophyll-a Concentration of Laguna Lake Using Himawari-8 Satellite Imagery and Machine Learning Algorithms for Near Real Time Monitoring." *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences* 46 (2022): 211-214.

**Preparation of Satellite Imagery Data** The methodology begins with the processing of Himawari-8 image data provided by the Japan Aerospace Exploration Agency dating back to October 2019. Specifically, 4 Himawari-8 raster images and 1 Sentinel-3 raster image were obtained from 09:10 to 10:10 on 9 October 2019, when cloud cover was low. The raster images were first converted into a GeoTIFF format using the **geo2grid** plugin. This plugin is a set of command line tools for mapping satellite instrument files to uniform grids for further processing (Space Science and Engineering Center University of Wisconsin - Madison, n.d.). Chl-a concentration map was generated using Sentinel-3 OLCI Level-1 data from the Copernicus Open Access Hub as input to the Case 2 Regional Coast Colour (C2RCC) processor. This processor is a set of neural networks trained on simulated top-of-atmosphere reflectance which produces inherent optical properties (IOPs), Chl-a, total suspended matter (TSM), and yellow substance maps (NASA SeaDAS, n.d.). Through Kriging interpolation, the different bands were interpolated to a spatial resolution of 0.5 km to resolve differences in spatial resolution. This is followed by the radiometric correction, resampling, and filtering of the Himawari-8 bands to exclude cloud contaminated pixels. Finally, the bands are stacked into one raster image file.





THANK YOU

