GOES Climate Activity at NESDIS

(formerly: The Growing use of GEO Satellites for Supporting Solar Energy Applications)

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NOAA
National Environmental Satellite, Data, and Information Service

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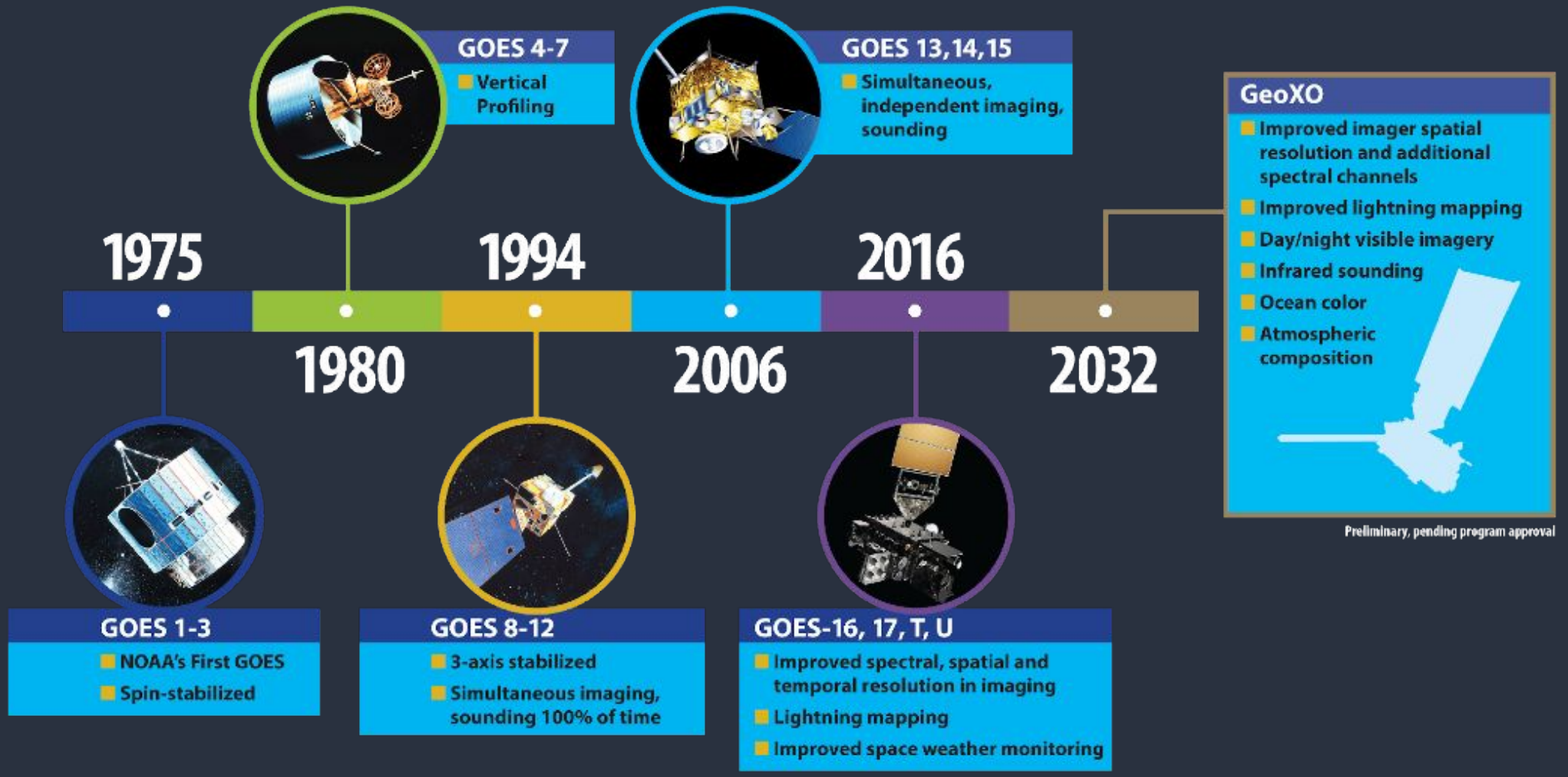
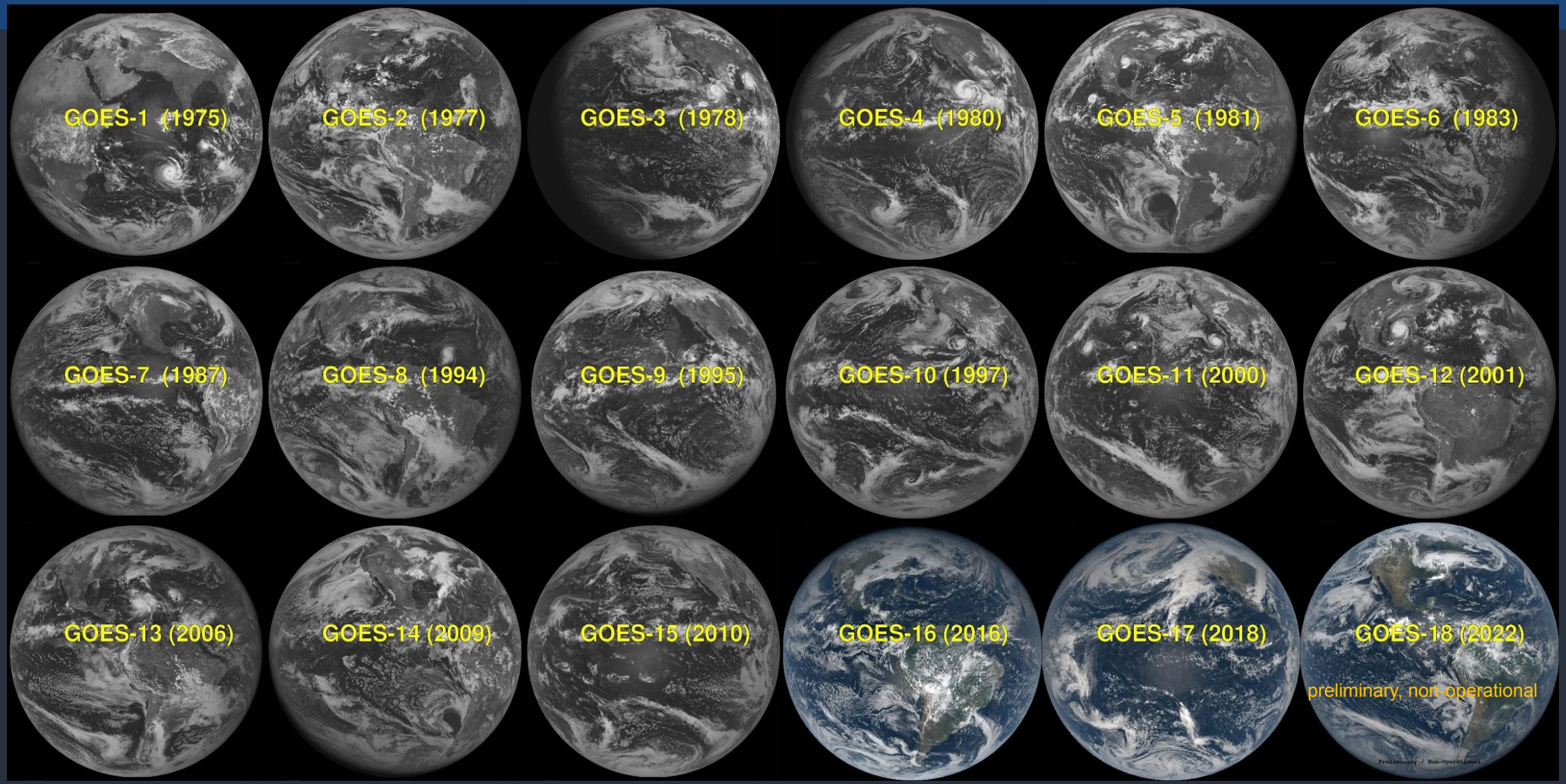
Takeaways

- GOES is an emerging source of Fundamental Climate Records (FCDRS) including solar reflectance applications.
  - Several projects funded by NESDIS are improving older GOES data (1975-2020)
- An International project (ISCCP-NG) is underway to make a useful GEO-RING data set for clouds and other applications from the new era of geostationary data.
- The next installment of GOES (GeoXO) will bring new sensors and a better imager

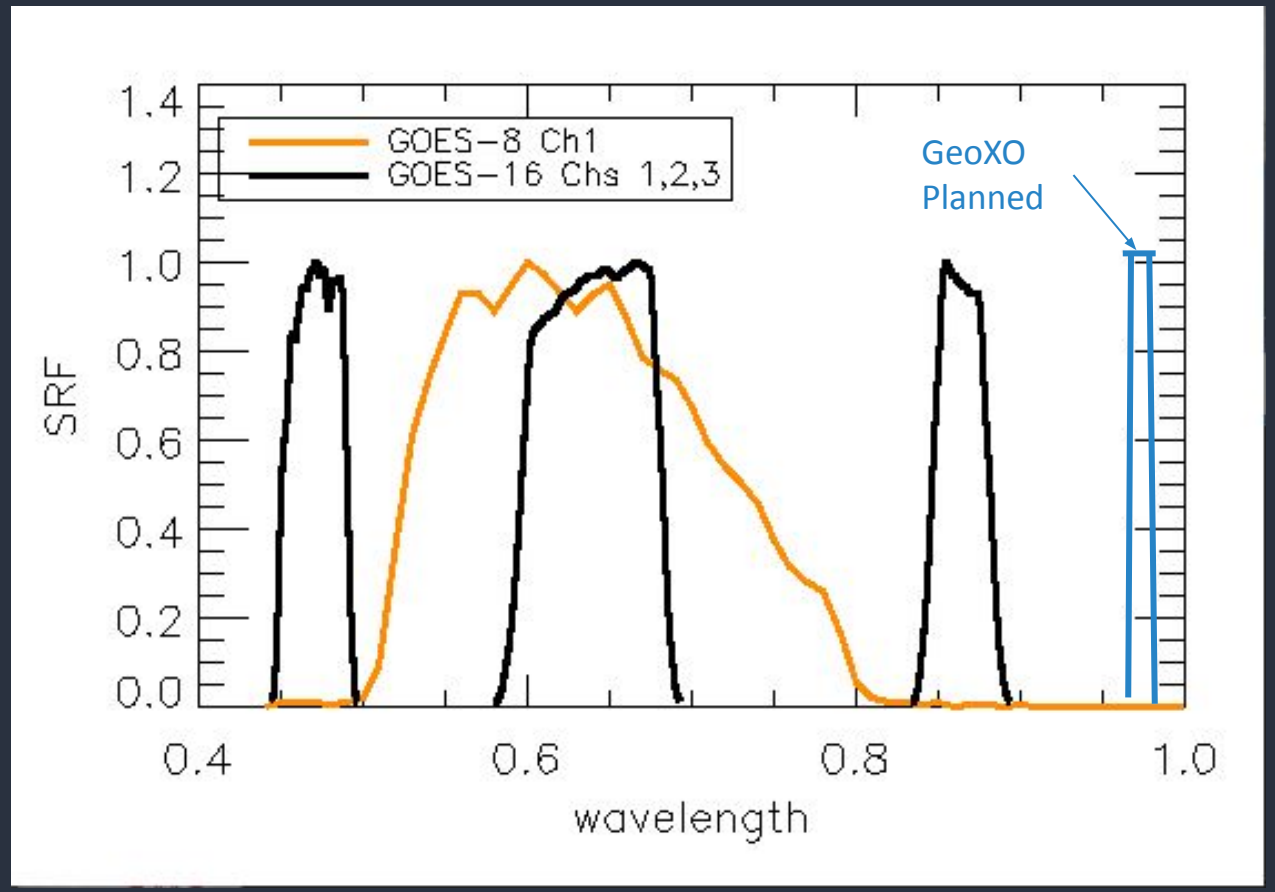
Generations of Geostationary Operational Environmental Satellites





Welcome GOES-18!

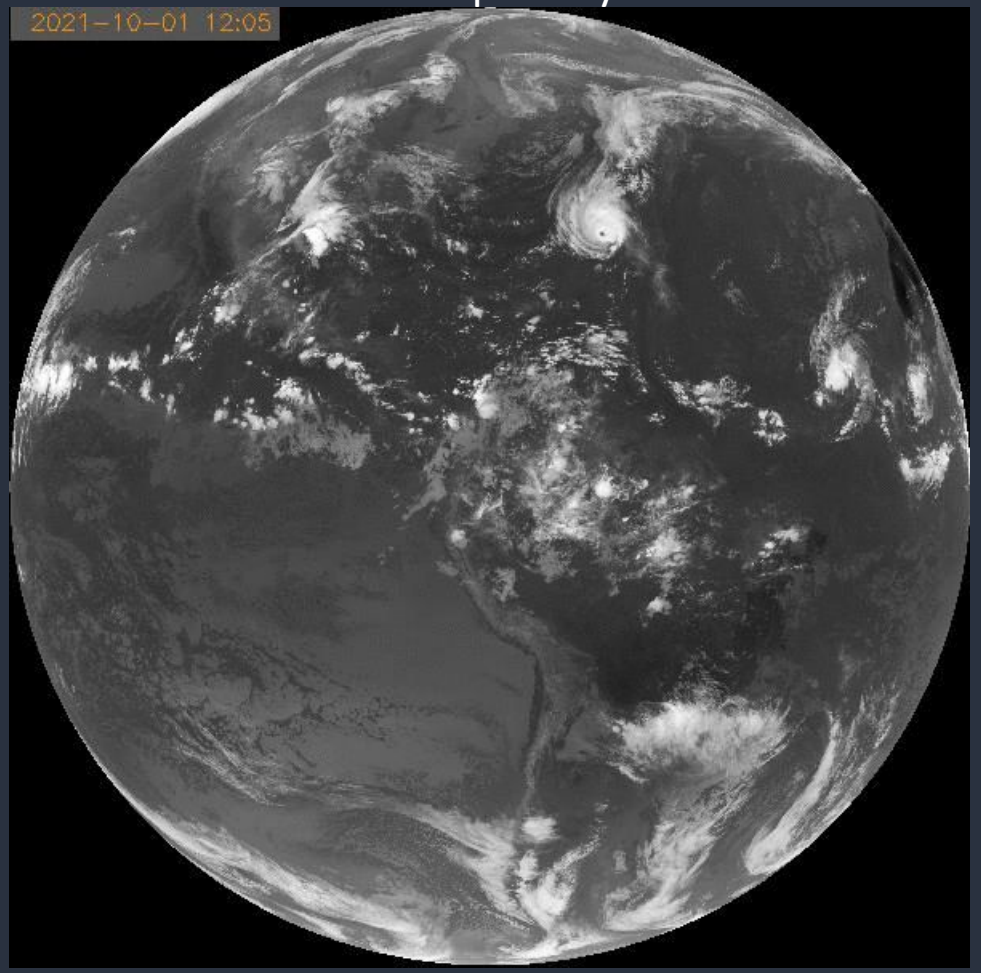
Spectral and Spatial Evolution of the GOES Imagers



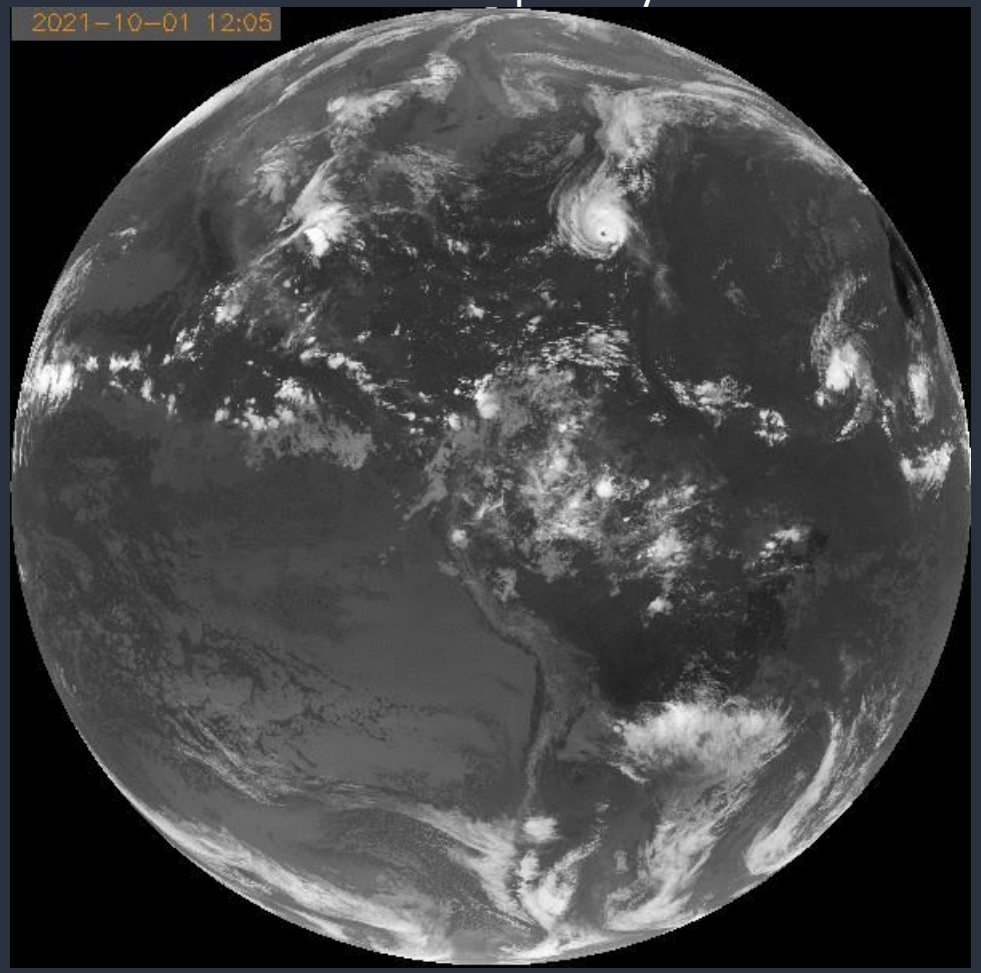
Current GEO Imagers are providing MODIS like capabilities (spectral and spatial) at a 10 minute cadence.

Temporal Evolution of the GOES Imagers

12 hours of 3 hrly Full Disk Scans prior to GOES-R
8 per day



12 hours of 10 minute Full Disk Scans GOES-R and GeoXO
144 per day



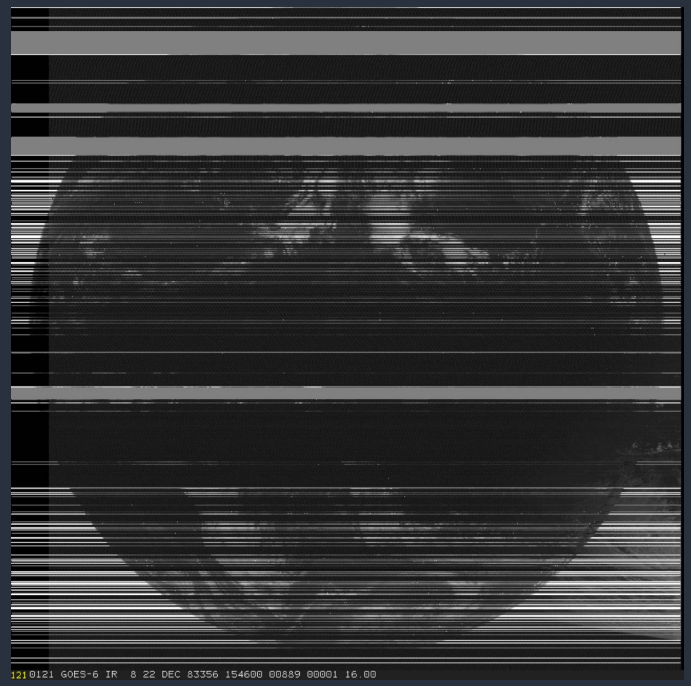
Plans for SMS 1&2, GOES 1-7 and GOES 8-15

- NESDIS is working with EUMETSAT to improve the Geostationary Imager Climate Data Records prior to GOES-R.
- NESDIS will use a EUMETSAT tool to apply a standard QC and to reformat into a modern netcdf format.
- NESDIS is also funding a data rescue of SMS 1-2 and GOES 1-7 at UW/SSEC/CIMSS.
- NESDIS is also developing radiometric and geolocation correction techniques.
- In the end, recalibrated and QCed GOES imager data from 1975(?) - present should be in a publicly accessible cloud resource in netcdf.

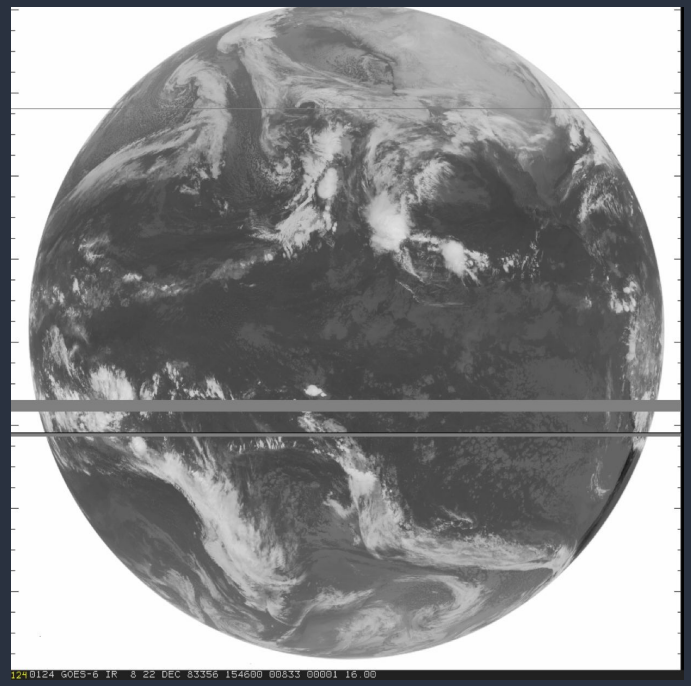
SMS 1,2 & GOES 1 - 7 Data Rescue

Funded by NESDIS
GOES-R Program

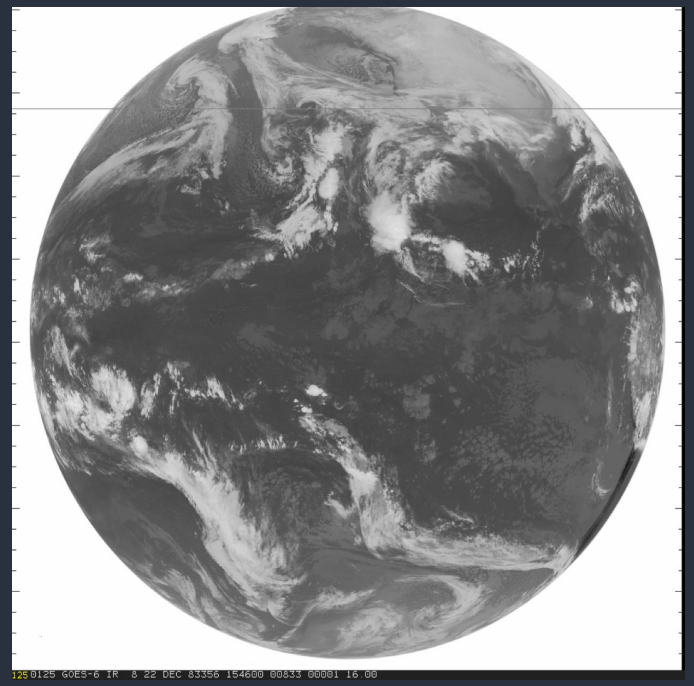
Example of the recovery of a GOES-6 Scene



The original image as archived at SSEC.



First step of reprocessing filled in gaps of the image using a ‘smart’ recognition of the sync bits, creating a more complete full disk.

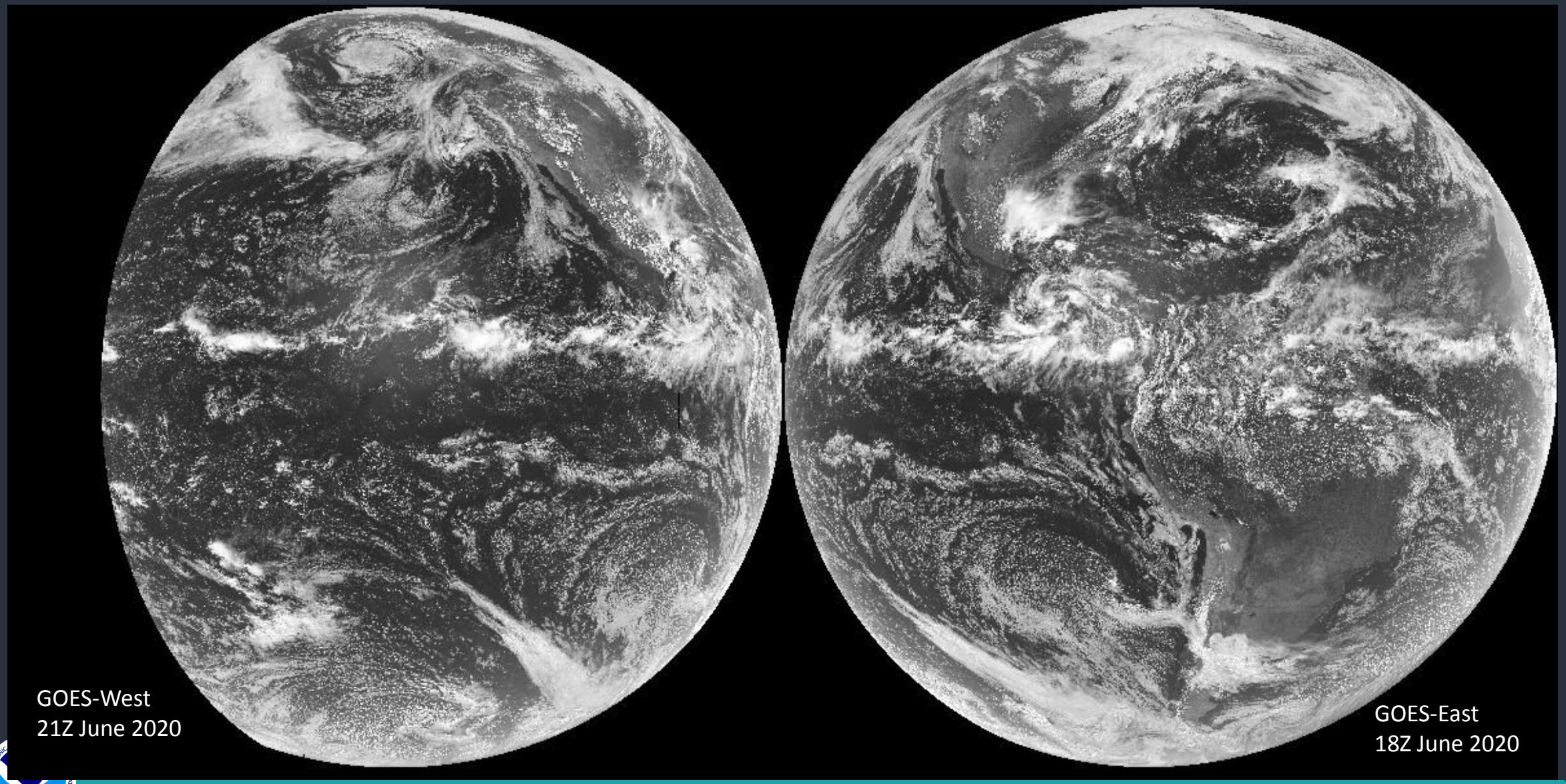


By combining data from multiple reads of the same file from the Sony U-matic tape, the complete full disk can be reconstructed (data is not filled or interpolated. It is a complete scan from observed data).

Recalibrating the GOES 8-15 Visible Channel

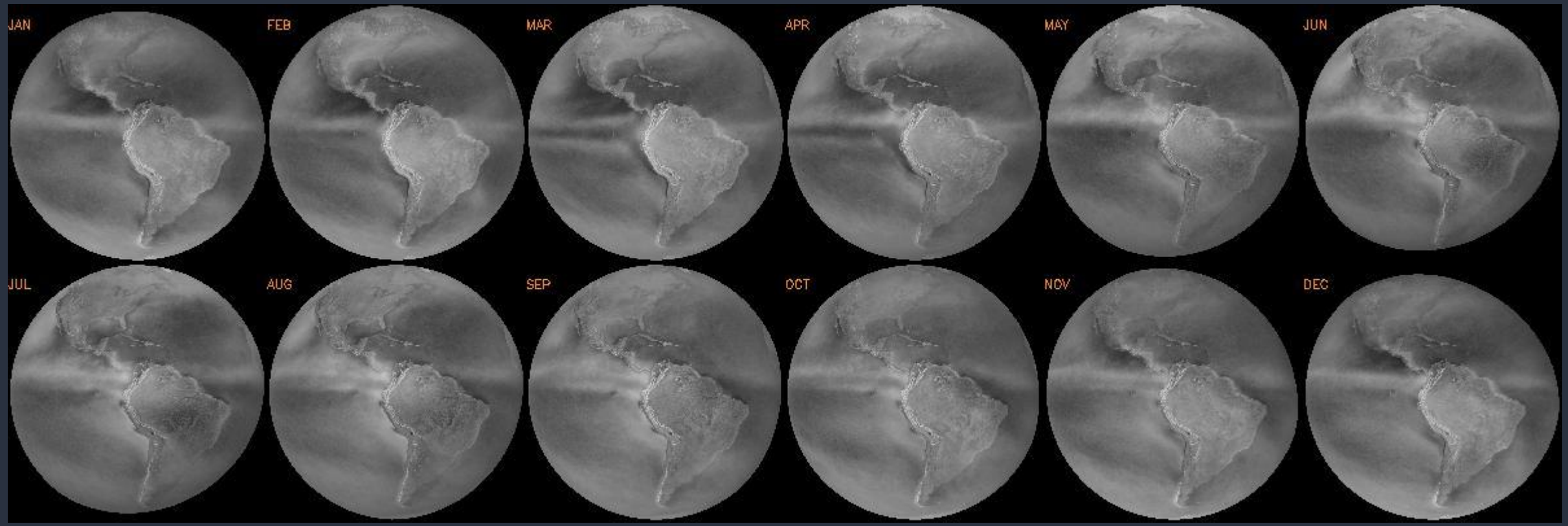
- Prior to GOES-R, there was no on-board calibration for the visible channel.
- Many techniques have been developed using deserts, ray-traced MODIS, DCC…
- We developed a technique that tied old GOES to GOES-R and would work before the era of well-calibrated reference sensors (ie MODIS).
- Assumes that the integrated monthly full-disk scaled radiances are constant when viewed at the same time of day and at the same location.
- We did this for the full disk images closest to local noon (West = 21Z and East = 18Z).

GOES West and East Noon Full-Disk Visible Refl.



Stability of Noon Full-Disk Visible Refl.

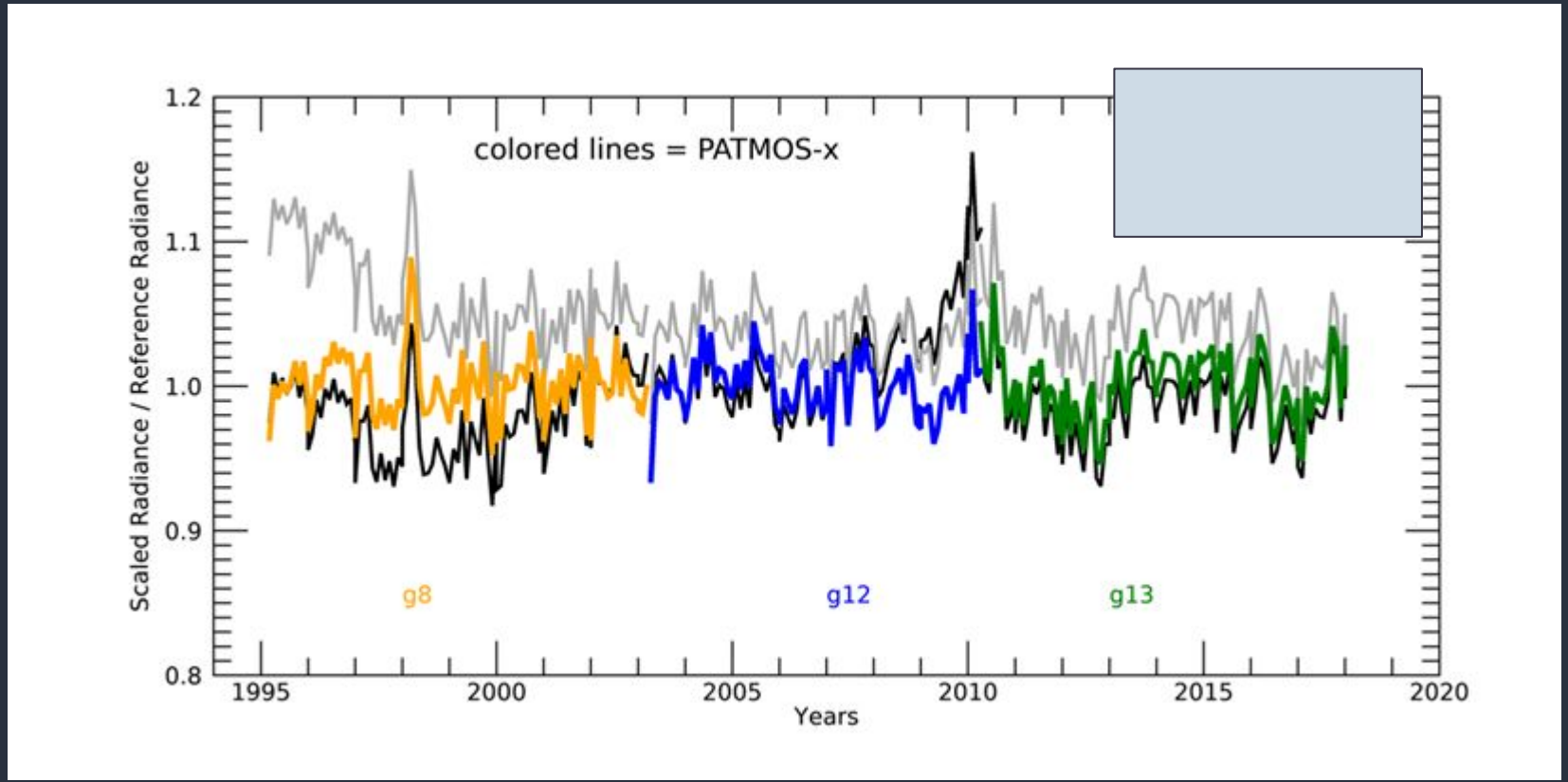
Monthly means from 2018 to 2021 of GOES-16 (East) Visible (0.65 um) Full Disk Reflectances.



If the planetary albedo is sufficiently stable, one could argue it would be stable over the 1/6th of the globe viewed by any GEO satellite. The time mean full-disk reflectances show a very consistent pattern and value. This offers a very simple calibration target for previous generations of GOES that lacked on-board calibration.

Annual Stability

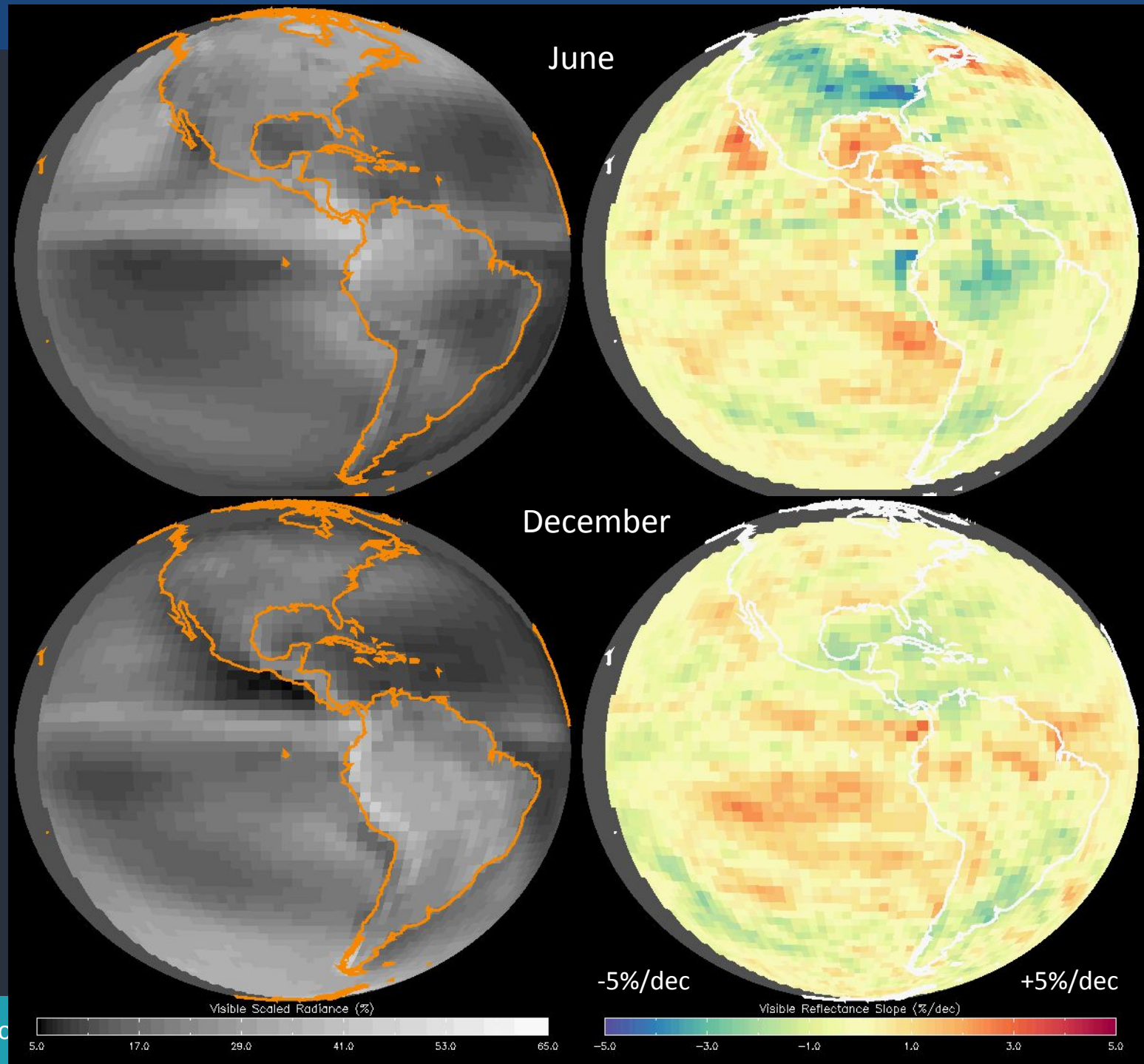
- Figure shows the mean full-disk scaled radiance divided by the GOES-R Reference value.
- Standard deviation is less than 2.5%.
- Annual deviations are due to natural variations.
- Biases with NESDIS Ops and NASA CERES Ed4 are shown.
- Hope is to be able to use this method by to 1980 and on the GEO-RING.



Studies have shown the SW TOA FLUX UP has decreased by 1 W/M2 from 2000 to 2020. Given that mean SW TOA FLUX UP is 100 W/m2, this would be a 1% drop and would a 1% trend in the above figure (drop of one tick mark). Not negligible but not a driver. Solar variability also ignored.

Regional Trends in 18Z Reflectance (1996 -2021)

- Calibration guarantees a lack of any significant trend over full-disk.
- Regional trends exist and shown here for June (top) and December (bottom).
- Due to consistency of viewing geometry, GEO radiometric observations are useful CDRs themselves.
- Need to attribute these regional changes to cloud properties.



GeoXO Constellation

(Preliminary, pending program approval)

GEO-West

Visible/Infrared Imager
Lightning Mapper
Ocean Color

GEO-Central

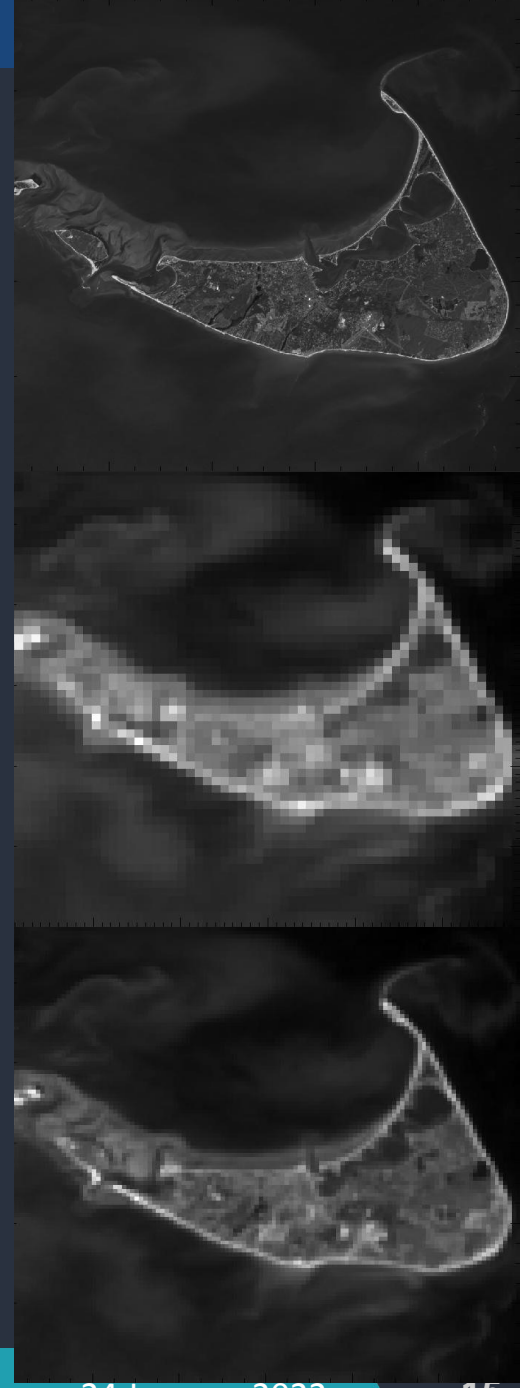
Hyperspectral Infrared Sounder
Atmospheric Composition
Partner Payload

GEO-East

Visible/Infrared Imager
Lightning Mapper
Ocean Color

GeoXO Imager (GXI)

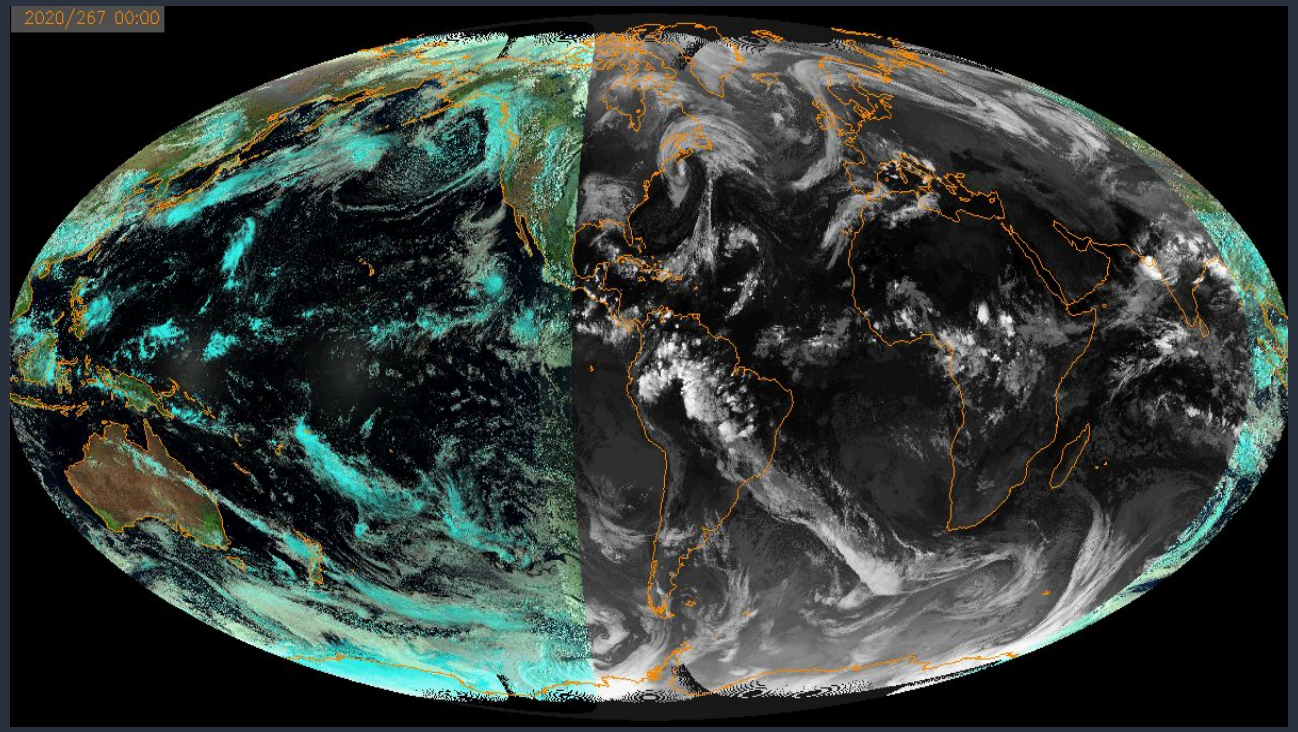
- GeoXO/GXI will replace the GOES-R/ABI
- GXI will be an incremental improvement over ABI
  - A new nir h2o channel at 0.94 µm
  - a new ir h2o channel at 5.15 µm
  - a higher resolution (1km) 3.9 µm channel
  - a higher resolution (~1km) 10.4 µm channel
  - a higher resolution (0.25km) 0.65 µm channel
- Temporal resolution will remain similar to ABI (10 min Full-Disk + CONUS + Meso).
- GeoXO is also exploring a low-light imaging band (similar to VIIRS DNB) hosted on another sensor (including GXI)



ISCCP-NG

Not only GOES (USA) has improved by the world is encircled by a GEO-RING of advanced imagers.

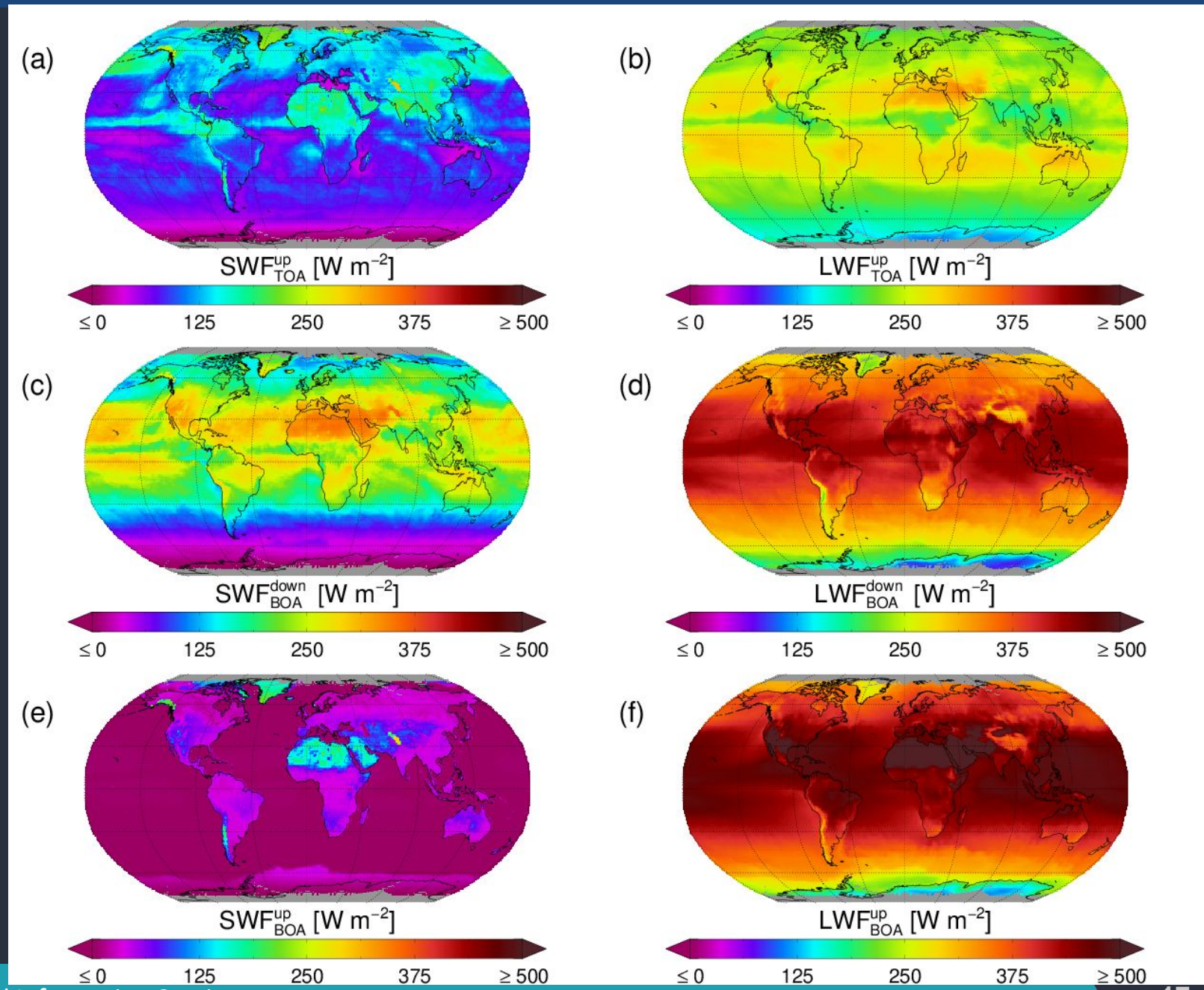
- ISCCP-NG attempts to reformulate an ISCCP on the next generation of geostationary imagers. Started by GEWEX and connected to CGMS and GSICS.
- New imagers offer roughly 12 common channels with resolutions of 2km and a full-disk scanning cadence of 10 minutes. (ISCCP was 2chan 3hrly)
- ISCCP-NG has made preliminary Level-1 Gridded (L1g) that combines current geo-data from 2020. Planned start date is when MTG FCI becomes operational (2024?).
- Current plans are for reducing data to 30 min and 0.5deg and no spectral thinning. (flexible)
- Groups are confirming L1G is suitable for Cloud L2.



Grab sample data and source code (via git) at cimss.ssec.wisc.edu/isccp-ng

Radiative Fluxes From ISCCP-NG

- Martin Stengel (DWD) has applied the ESA CCI Cloud and Radiative Flux algorithms to ISCCP-NG L1G.
- Results agree with their official product.
- This shows a mean for July 2020.
- ISCCP-NG should provide the capability of 30-min 5 km data.
- Is that useful for the radiative flux community?



Conclusions

- Work is being by NESDIS and EUMETSAT to make the GOES Record into a FCDR and accessible to the whole community in a modern format in a cloud-based service.
- To support this effort, a new calibration method has been developed to apply the GOES-R Visible Calibration to the GOES 8-15 record.
- These efforts should make GOES FCDRs from 1975 to 2050(?).
- ISCCP-NG is pioneering a new way to provide easy access of the advanced capabilities of current geostationary imagers to the climate community.
- NESDIS is planning its next GOES Series (GeoXO) which bring new sensors to the GOES Community.

The End, Thank you!

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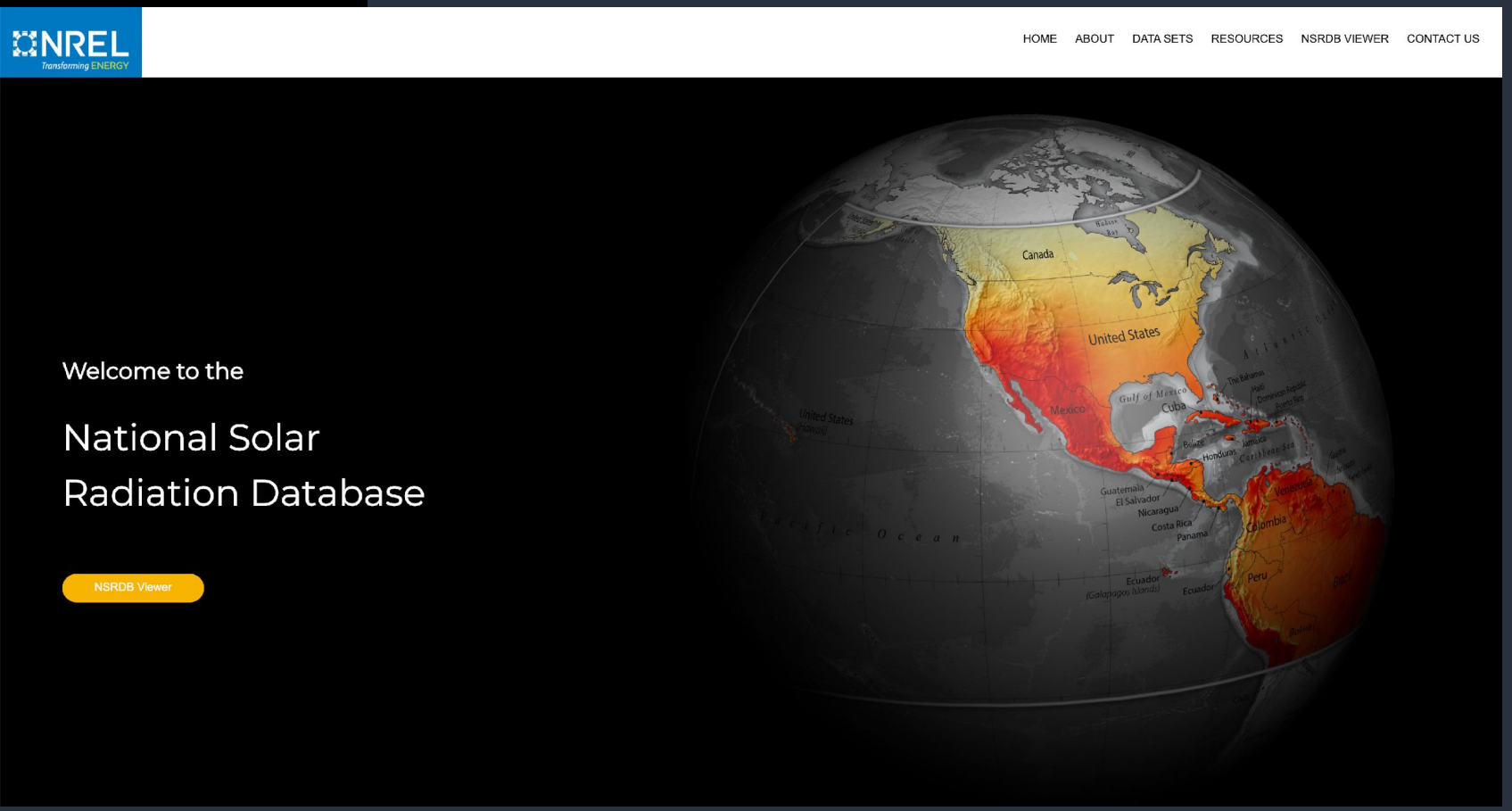

The NSRDB is one of the most accessed public datasets providing a serially complete collection of solar energy and meteorological data, including the three most common measurements of solar radiation: GHI, DNI, and DHI, which have been collected over the United States and a growing list of international locations with high temporal (30 minutes) and spatial (4 km) resolutions to accurately represent the global and regional solar radiation climates.

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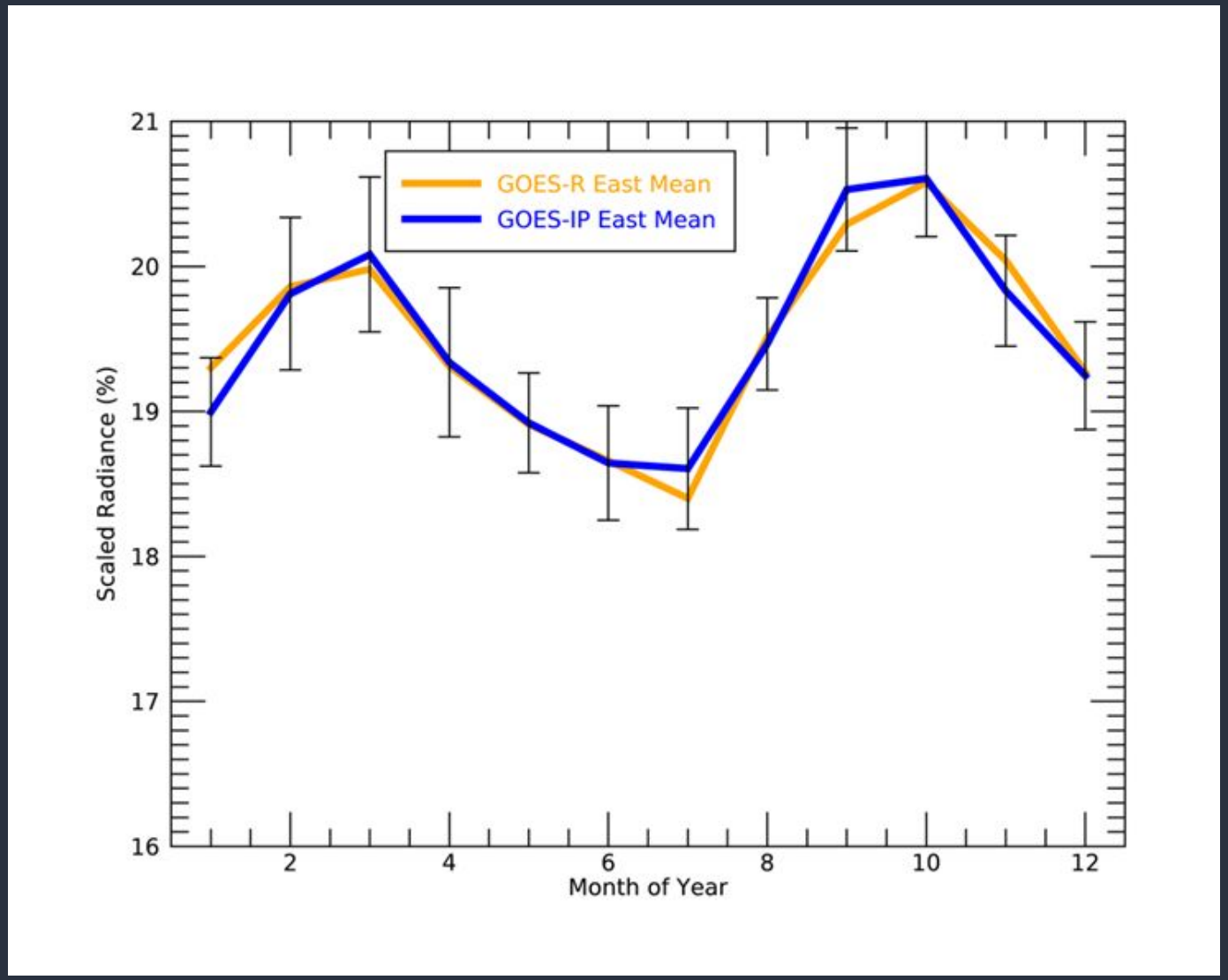
Stability of the Annual Cycle in Full Disk Refl.

- Annual cycle in the mean full-disk scaled radiance is very stable (monthly standard deviation < 1%) on a signal with a magnitude of about 20%.
- Scaled radiance is the reflectance without the sun angle correction.
- GOES-IP cycle comes from 1995 to 2018.



GXI – Improvements over ABI

	Center Wavelength (μm)	50% Bandwidth (μm)	Nadir Pixel Size (km)	SNR/NEdT**
	0.47	0.04	0.5 (TBR)	250 (TBR)
	0.64	0.1	0.25***	125
	0.865	0.039	0.5 (TBR)	150 (TBR)
	0.91	0.02	1.0 (TBR)	300
	1.378	0.015	2.0	300
	1.61	0.06	1.0	300
	2.25	0.05	1.0 (TBR)	200 (TBR)
	3.9*	0.2	1.0	0.15 (TBR)
	5.15	0.2	1.0	0.15
	6.185	0.83	2.0	0.1
	6.95	0.4	1.0**** (TBR)	0.15 (TBR)
	7.34	0.2	2.0	0.1
	8.50	0.4	2.0	0.1
	9.61	0.38	2.0	0.1
	10.35	0.5	1.0**** (TBR)	0.1
	11.20	0.8	2.0	0.1
	12.30	1.0	2.0	0.1
	13.30	0.6	2.0	0.3

Finer resolution 0.65um channel

0.91 μm water vapor absorption channel similar to EUMETSAT's FCI instrument

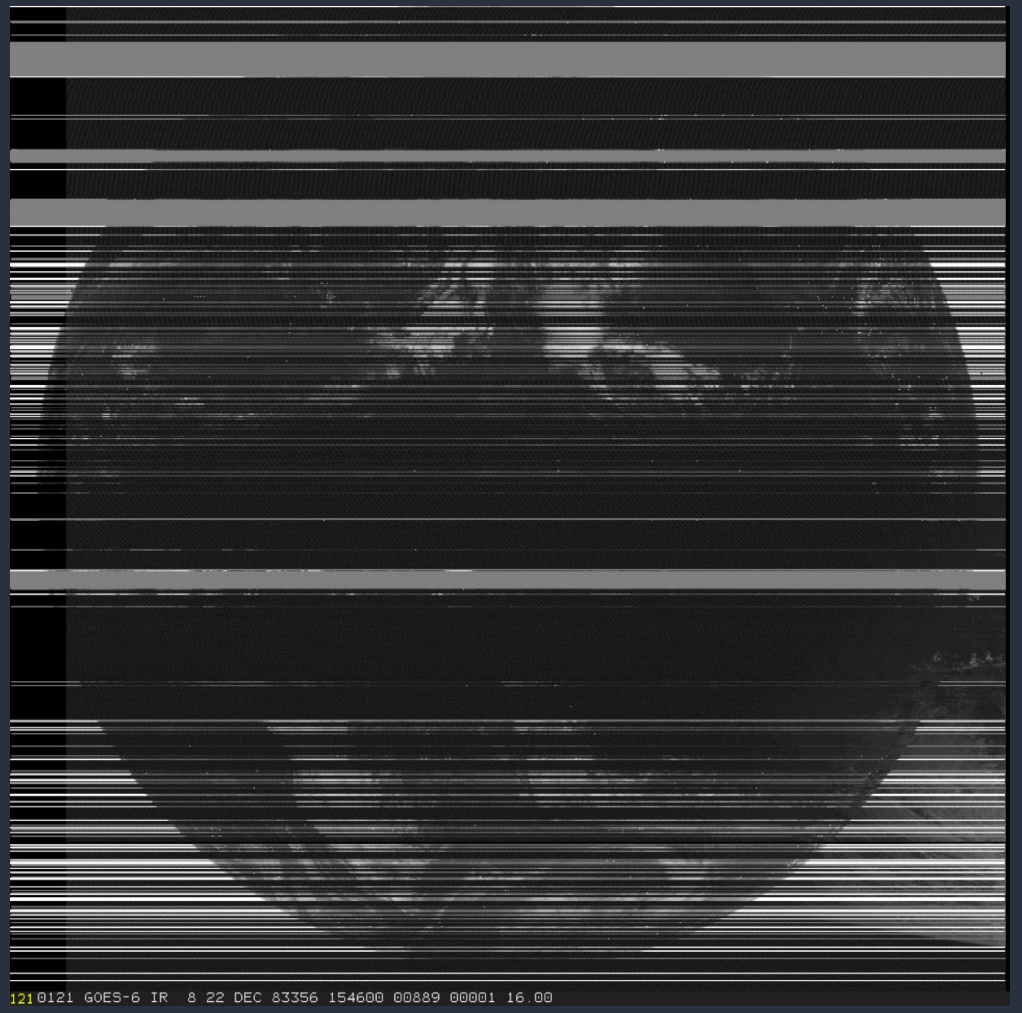
Improved resolution of the 3.9 μm will allow for improved fire detection

New IR "very low level" water vapor absorption channel near 5.15 μm

Potentially higher spatial resolution on some existing IR channels.

SMS 1,2 & GOES 1 - 7

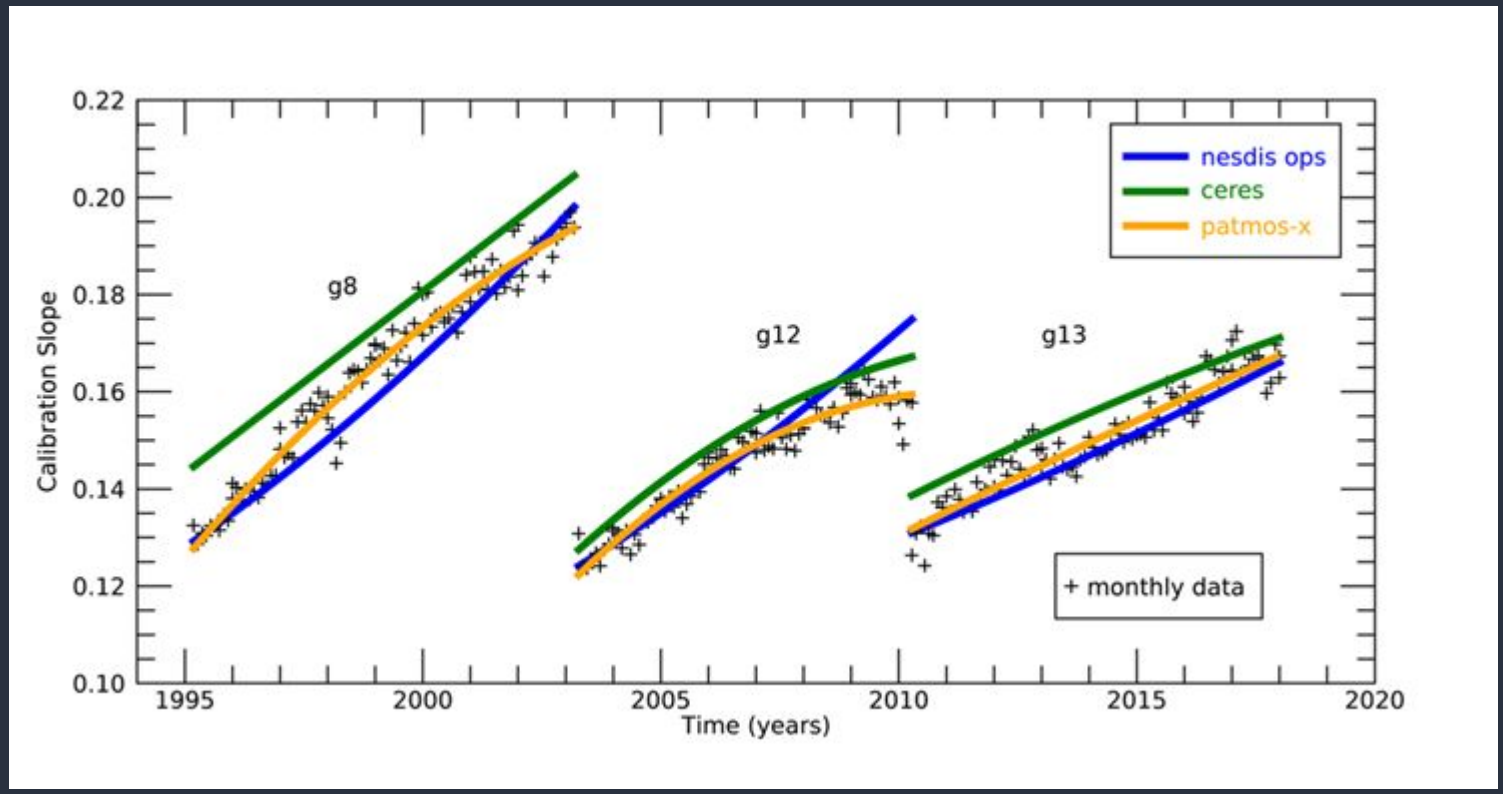
- Raw SMS and GOES 1-7 data are stored at SSEC (and in CLASS) in MODE A/AA/AAA format that were originally stored on Sony U-matic tapes.
- The process for reading data from these tapes was not stable and resulted in several issues.
- The mode A data (which comprises about 40% of the record) were recently reprocessed at SSEC by Jerry Robaidek, David Santek and Dan Forrester.
- The work included developing ‘smart’ decoders that detected errors in sync patterns.
- This resulted in restoring missing data to complete full disk images. Also, noisy images were re-rendered to produce noise-free images.



An Example of bad data from tapes at UW/SSEC.

Using GOES-R Full-Disk Refl as Calibration Target.

- The GOES-R series has on-board calibration for the first time in the history of GOES.
- This allows us to use the GOES-R mean full-disk 0.65um reflectances as a calibration target.
- We can use this target for any previous GOES satellite that viewed the full-disk from a similar location and time of day.
- For this study, we chose the noon full-disk images (East = 18Z and West = 21Z).
- Image shows our calibration (patmos-x) for GOES-East (1995-2019). Fit standard error < 3%.
- Also shown are comparison to NASA Langley CERES Ed4 and NESDIS Operations. Both of these techniques are more complicated.



This technique is applicable to all GOES data back to 1970s.