

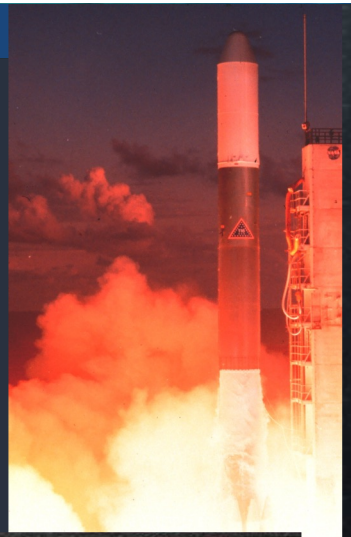
NOAA/NESDIS Progress on a GOES Fundamental Climate Data Record

Session 4B GEO Special Topics
Monday January, 13 2025 4:45-5:00 Room 357

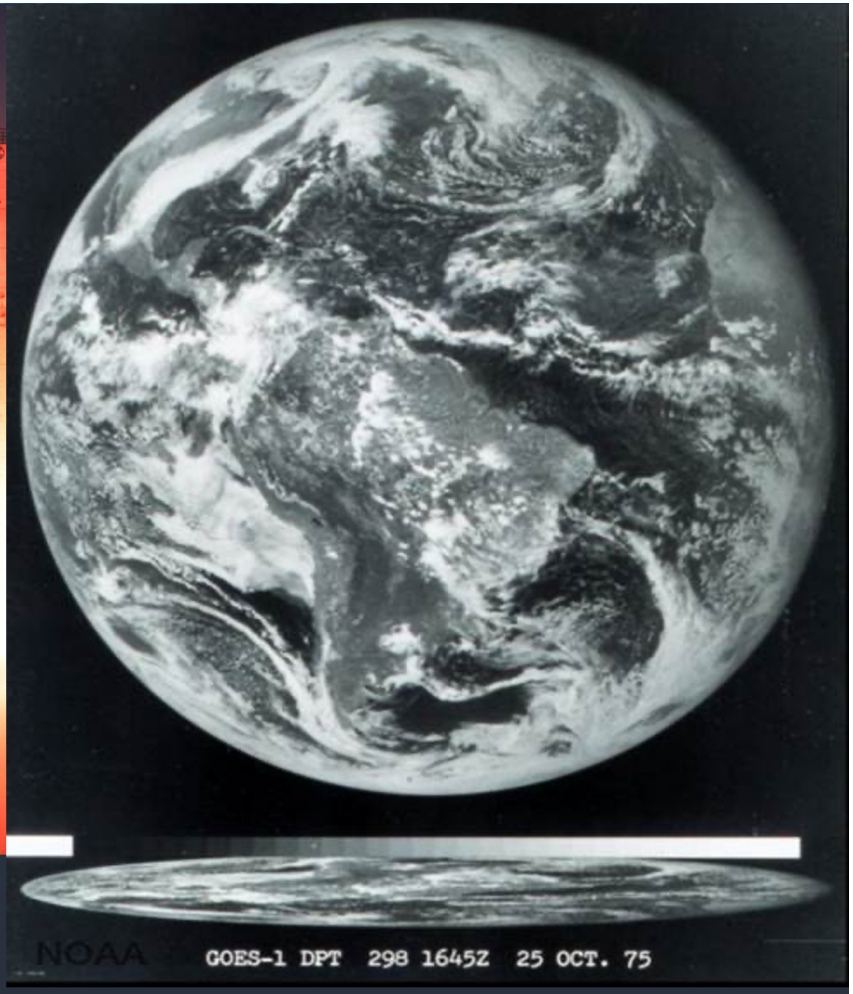
NOAA
National Environmental Satellite, Data, and Information Service

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Steve Wanzong, Jerrold Robaidek, Dave Santek UW-CIMSS
Ken Knapp and Jessica Mathews, NOAA/NESDIS/NCEI
Dan Lindsey NOAA/NESDIS/GEO GOES-R Program Scientist

Happy 50th Birthday GOES







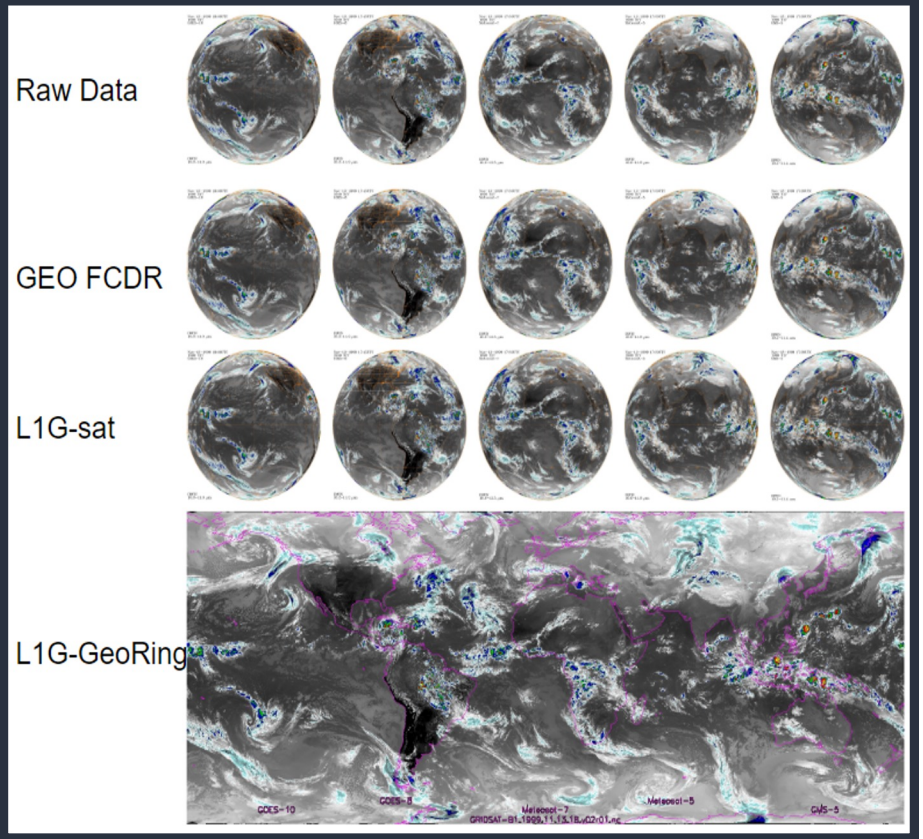
Outline

1. Motivation
2. Data Rescue, Missing Navigation and Archive Update
3. Recalibrating the GOES 1-7 VIS Channel using GOES-R ABI
4. Integration of GVAR (GOES 8-15) into the GEO-RING
5. GOES-R ABI Reprocessing
6. A new GEO-RING for the current geostationary imagers (ISCCP-NG)

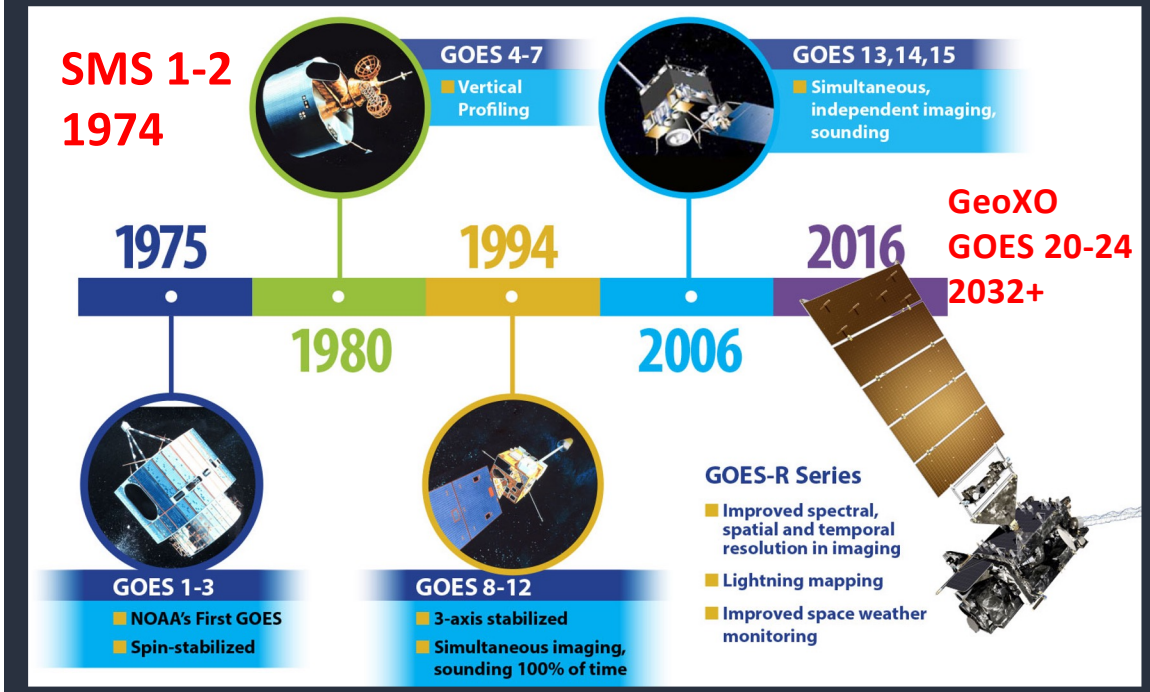
1. Motivation

- NESDIS and other agencies have invested billions of USD into the GOES program but not much has been invested in GOES as a climate resource.
- EUMETSAT and NESDIS initiated a bilateral activity to create a new GEO-RING based on improved GEO imager FCDRs. Most of our work is getting the Raw GOES data in shape for GEO FCDR
- The NESDIS GEO record needs substantial effort
  - Corrupted Data & Archaic Formats
  - Missing or Bad Navigation & Poor Calibration
- These NESDIS (and CIMSS) efforts build off of past efforts like ISCCP, CERES, GRIDSAT, GeoNEX and others.
- This talk will explain the NESDIS efforts to fulfill its commitment to making GOES FCDRs.

strategy for GEO-RING



GOES Imager History

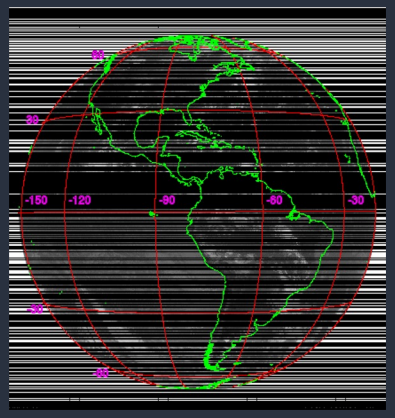


	Instr	Full Disk (min)	VIS Res (km)	IR Res (km)	# Chans (km)
SMS 1-2, GOES 1-3	VISSR	30	1	7	2
GOES 4-7	VAS	30	1	7	2 + sounding
GOES 8-15	IMAGER	180, 30 (partial)	1	4	5
GOES 16-19	ABI	10 - 15 min	0.5	2	16
GOES 20-24	GXI	10 min	0.25	1-2	18

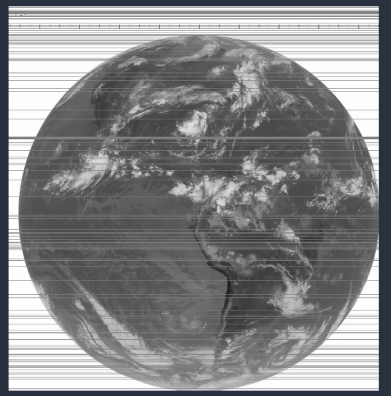
2. Data Rescue, Missing Navigation and Archive Update

Approach: SMS/GOES data rescue (1978-1996)

- Lines deleted/added: Caused by multiple/bad sync or ground station send errors, sometimes resulted in multiple images in one index.
- Bit slip: Bits inserted between sync and type blocks and/or data, probably from when U-matic was first recorded, or may have happened during playback.
- Fixed type: IR (0) or VIS (1-8) incorrect, sometimes due to bit slip or multiple/bad sync.
- Fixed line number: Line number was changed, caused by bit error.
- Framing Error: IR data block size was incorrect.



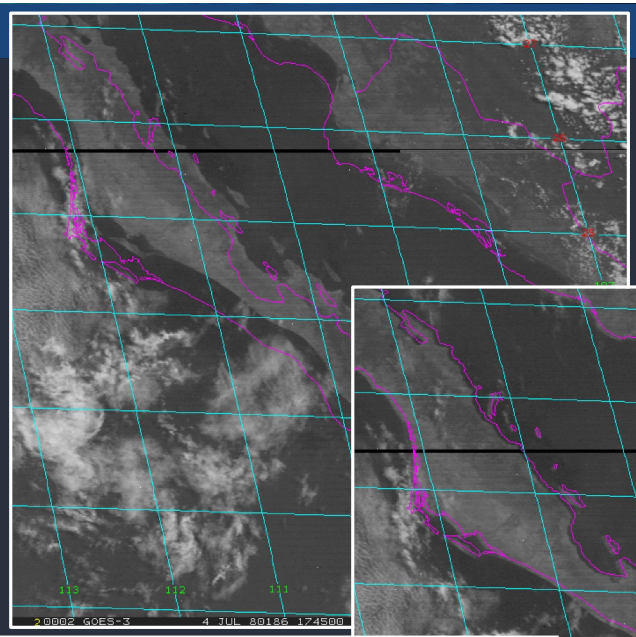
NOAA CLASS
GOES-5 IR 1981-08-17
15:30 UTC

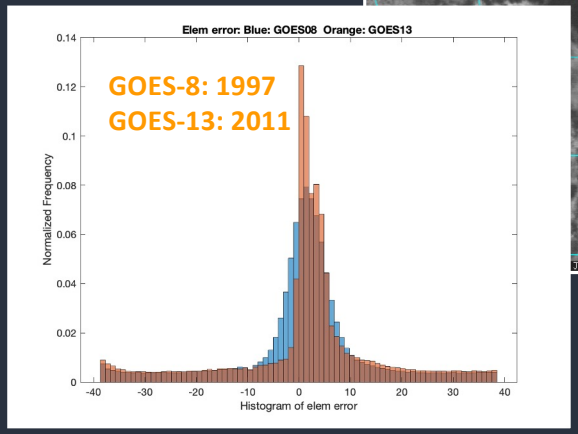


SSEC reprocessed
GOES-5 IR 1981-08-17
15:30 UTC

Improving Navigation: The McIDAS AUTONAV Process

- One–time step: Identify landmarks and extract from satellite image(s)
- Run AUTOLM on other satellite images, which determines the errors in the landmark locations
- Run NVUP to update the navigation orbit and attitude parameters to minimize the errors in the location of landmarks in the other satellite images
- Backup slides show more details on approach and results.
- A more general navigation fix will be pursued with Jim Carr





Note: Autonav, Autolm, Nvup use McIDAS-X

Status of Raw Data Rescue and Transfer

Data Rescue:

- ❑ Total recovered images for all modes is over 19,200 (~400 days)
- ❑ Filtering duplicate files reduced GOES 1-7 from ~115 TB to ~89TB

Navigation:

- ❑ Missing Navigation: ~42,244 images (~2.4 years)
- ❑ **36,206** images had "first guess" (~2.1 years)
- ❑ 6,000 images remain un-navigated

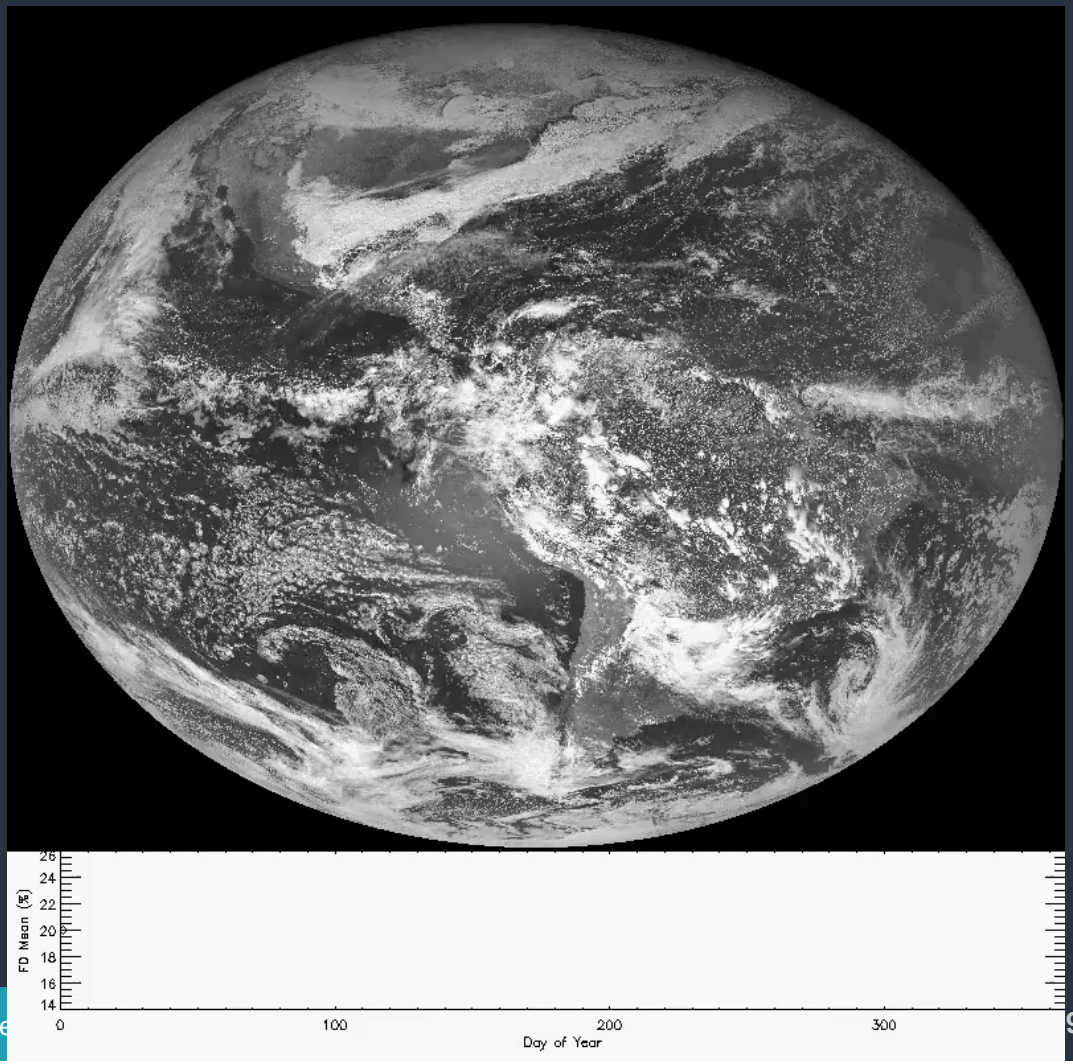
Transfer:

- ❑ Mode A transfer is being done now (~309,000 image times)
- ❑ Followed by Mode AAA (~353,500) estimated 2+ months
- ❑ Followed by Mode AA (~50,900) estimated less than 1 month
- ❑ Some "Outlier" images may be held back that fail pre-transfer QC
- ❑ 1974 mode A navigated with AUTONAV (early 2025)

3. Recalibrating the GOES 1-7 VIS Channel using GOES-R ABI

- Heidinger et al. (2022) showed that GOES-R ABI's calibration could be transferred to GOES 8-15.
- This technique works for any GOES in the E/W position and we have applied it to GOES 1-7.
- Results are less certain for GOES 1-7 then GOES 8-15. (next slide).
- This technique should complement and fill-in gaps from the other sources (Inamdar and Knapp, 2015).

Mean Full Disk Reflectance is Stable



GOES VISIBLE CALIBRATION

- Each GOES Generation is color coded.
  Slope equation: $S(t) = S_o*(100 + a*t + b*t^2) / 100$

- GOES 8-15 (1994-2018) was done earlier in Heidinger et al., (2022). No data for GOES-14 in the E/W position.

- Compared to GOES 8-15, GOES 1-7 is both noisier, has more artifacts, less bit depth and is missing more images. We forced a linear fit due to short durations.

- For these reasons, RMS is bigger

- Work continues on:
  - GOES-1 was never in the GOES E/W position (supporting GATE)
  - GOES 6 & 7 drifted back and forth between the E/W positions.

VISSR

VAS

GVAR IMAGER

GVAR IMAGER

Satellite	S_o	a	b	RMS(%)
GOES-1	—-	—---	—--	—--
GOES-2	0.106	5.59	0.00	4.46
GOES-3	0.103	6.56	0.0	4.55
GOES-4	0.115	0.329	0.0	4.48
GOES-5	0.103	-1.95	0.0	5.42
GOES-6	0.111	3.31	0.00	9.58
GOES-7	0.112	7.33	0.00	6.68
GOES-8	0.130	8.24	-0.25	2.0
GOES-9	0.120	-2.45	1.41	3.5
GOES-10	0.132	7.02	-0.28	3.2
GOES-11	0.127	4.86	-0.05	3.3
GOES-12	0.122	7.71	-0.47	1.8
GOES-13	0.132	3.57	-0.014	2.1
GOES-14	—-	—---	—---	—---
GOES-15	0.127	3.40	0.9	3.1

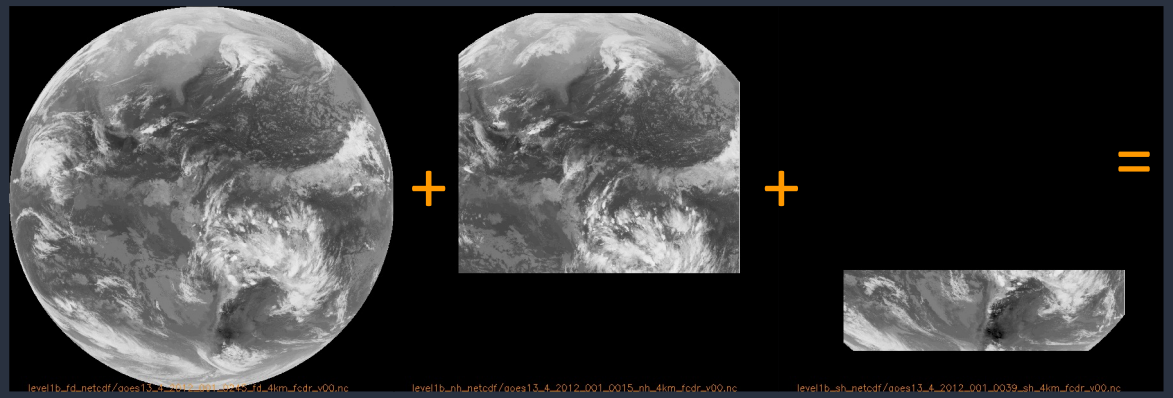
4. Integrating GVAR L1g Sat into GEO-RING: Making Consistent 30 min "Full" Disk

Unlike previous geostationary satellites, GOES 8-15 made observations in several domains to optimize temporal coverage over the USA.

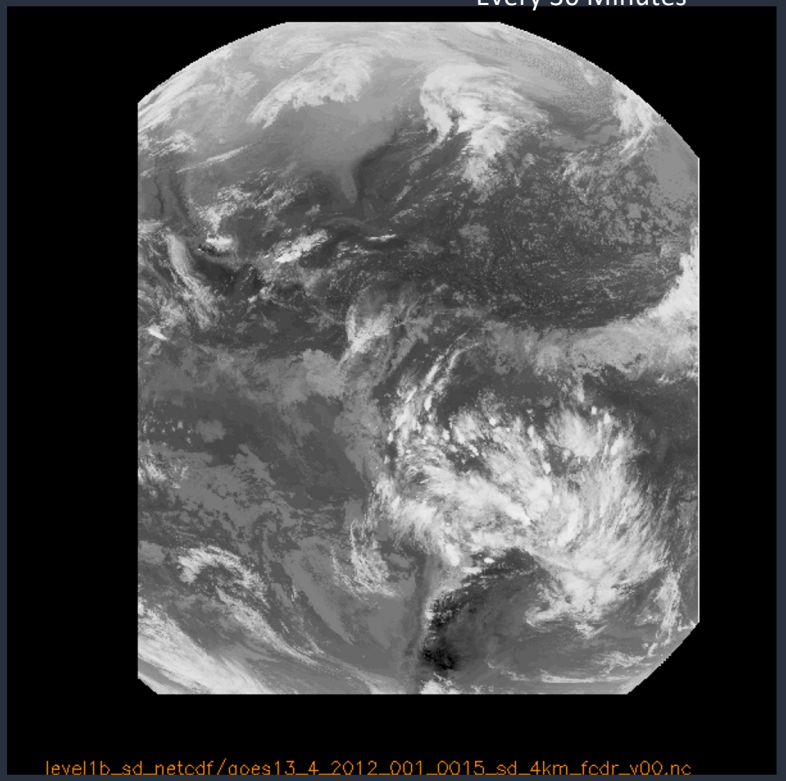
Full Disk
Every 3 hours

Northern Hemisphere
Every 30 Minutes

Southern Hemisphere
Every 30 Minutes



Stitched Full Disk
Every 30 Minutes

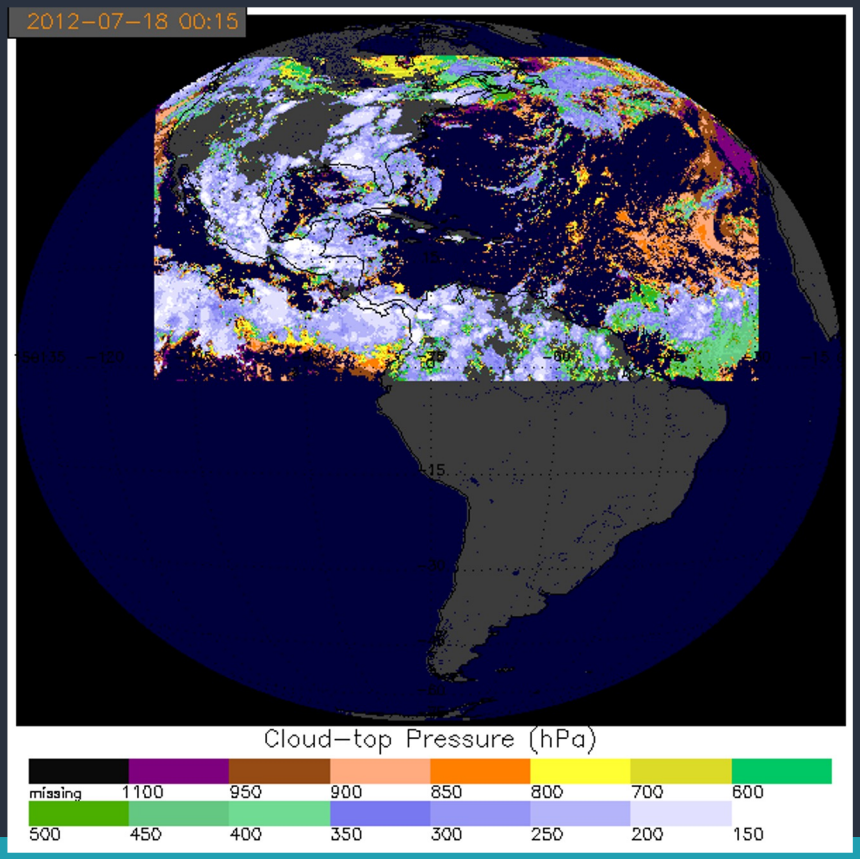


- CONUS domains every 15 minutes are ignored.
- GOES 1- 7 provided full disks every 30 min.
- Use 4km fixed grid from L3Harris 4km GOES-R products.
- VIS is provided at 1 and 4km.
- Example netcdf data is at http://tyr.ssec.wisc.edu/goes_gvar_fcdr/

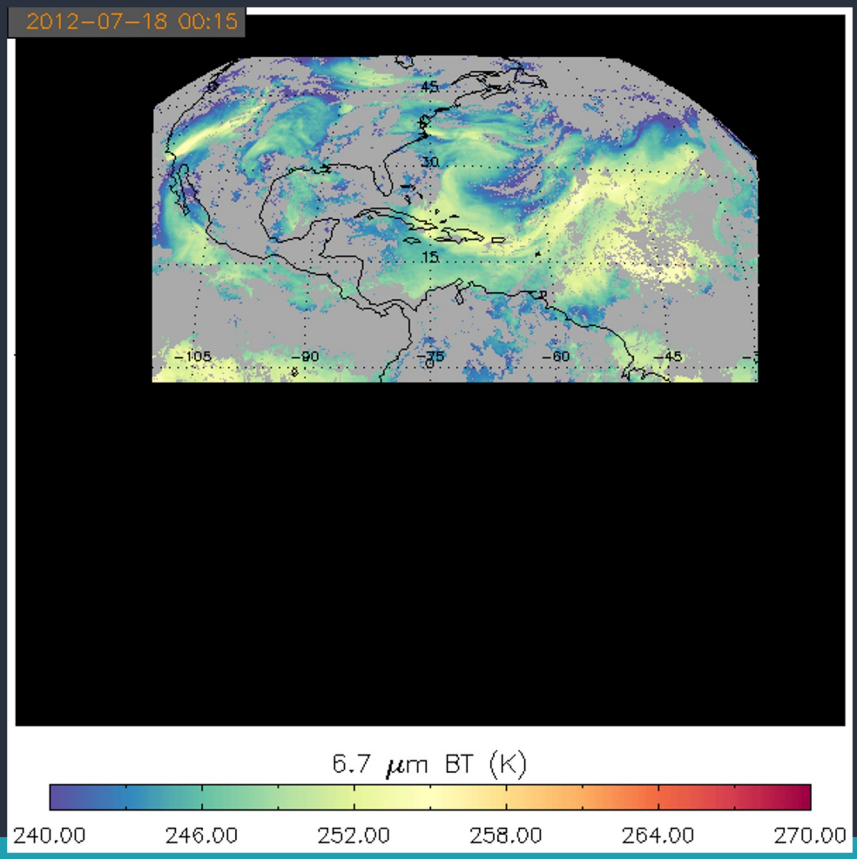
Application of GOES 8-15 L1g Sat to Cloud ECVs

CLAVR-x can process these GOES netcdf files. Here we show cloud detection and pressure. Validation with CALIOP shows same level of performance with original GOES GVAR processing. 30 min "stitched" disk for day 200 year 2012.

cloud top pressure



cloud masked 6.7 µm BT (K)



5. GOES-R ABI L1b Reprocessing

Goal: Reprocess the GOES-16 and -17 ABI L1b record to improve calibration, fix many missing images or image segments, and add some enhancements

Enhancements:

1. Limb Pixels

Same array size as operational data, but include off-Earth radiances

2. Pixel Timestamps

Introduces the ability for users to determine collection time of individual L1b pixels

3. GSICS Calibration Coefficients

Enables interoperability with GSICS partners

Status:

All of GOES-16 reprocessing is complete and a beta release will soon be available via NODD

Image from an example ABI L1b data currently in the NOAA archive

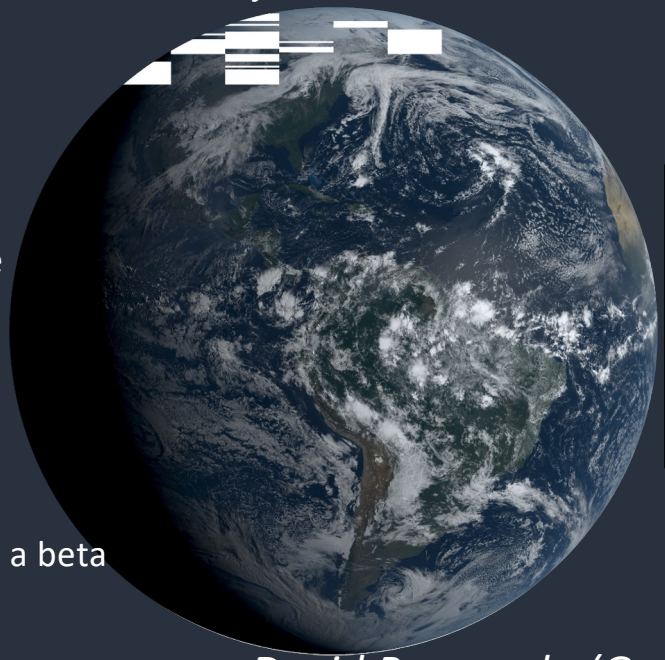
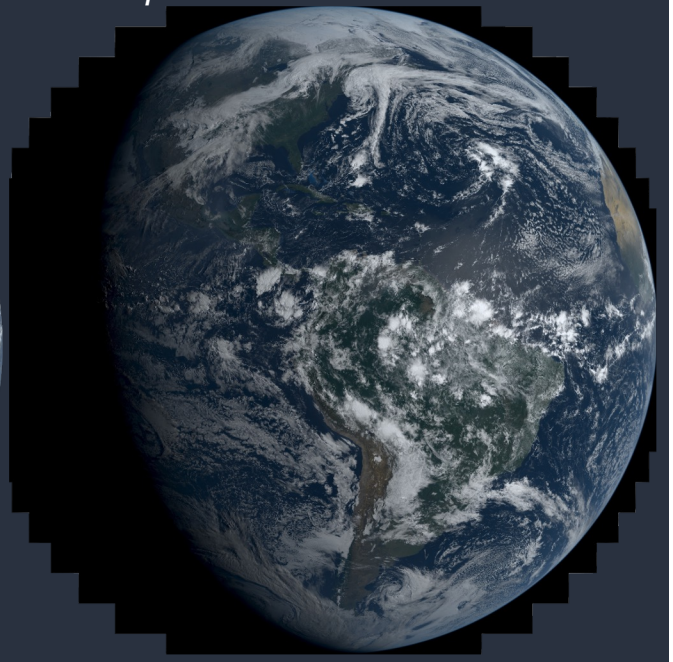


Image from corresponding reprocessed ABI L1b data

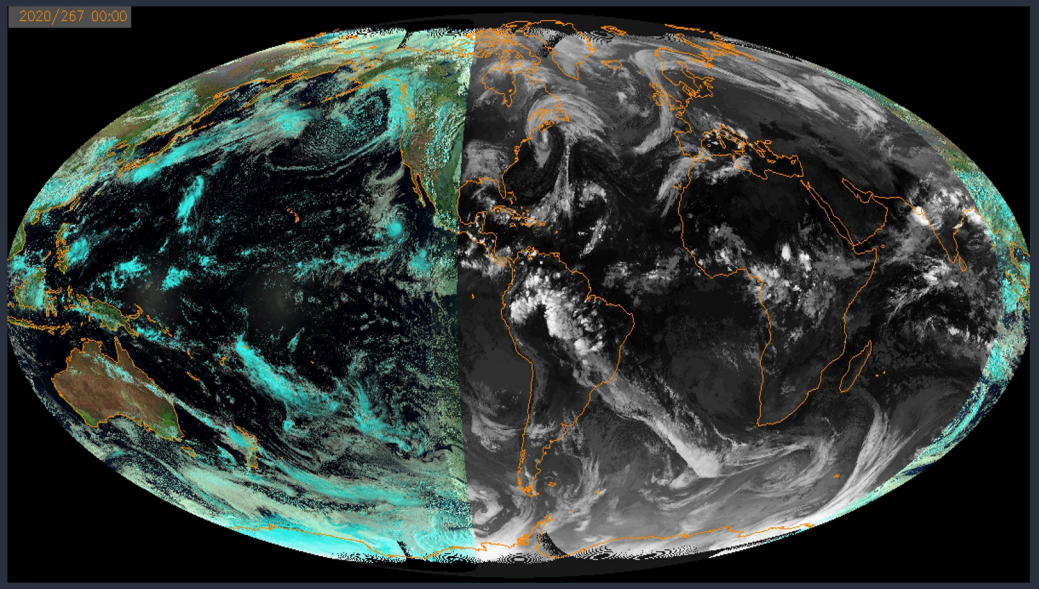


David Pogorzala (GeoThinkTank) 3A.4 Monday 2:30

6. New GEO-RING: ISCCP-NG

GOES FCDRs are critical for success of the GEO-RING

- 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

Summary

- NESDIS and CIMSS is finishing its data rescue activities for SMS and GOES 1-7. Rescued data with navigation is being moved to the NOAA cloud archive for access by EUMETSAT and others.
- NESDIS is extending a GOES-R ABI based calibration to GOES 1-7.
- NESDIS is testing making GOES 8-15 L1g Sat data for future inclusion in a 30 minute GEO-RING.



Do you have the SMS and GOES-13 Spectral Response Functions?

We need them!

andrew.heidinger@noaa.gov

The End, Thank you!

andrew.heidinger@noaa.gov

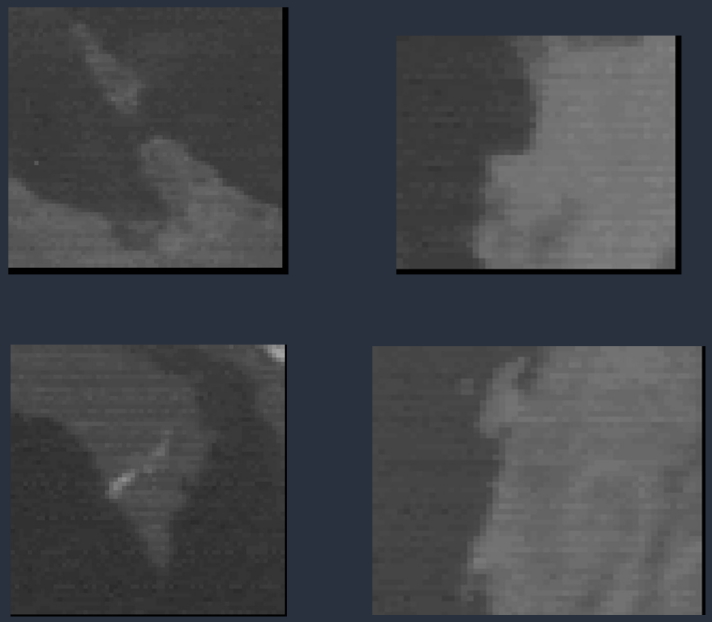


Backup

Improving Navigation: The McIDAS AUTONAV Process

- One–time step: Identify landmarks and extract from satellite image(s)
- Run AUTOLM on other satellite images, which determines the errors in the landmark locations
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Sample LandMarks from GOES VISSR



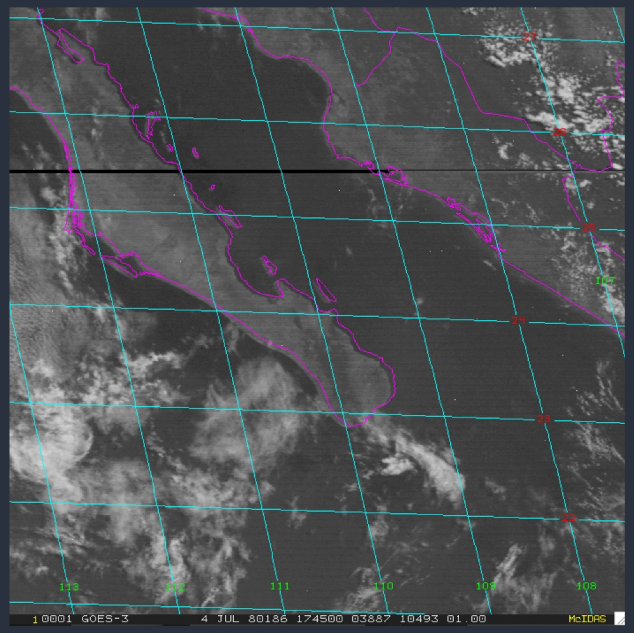
Note: Autonav, Autolm, Nvup use McIDAS-X

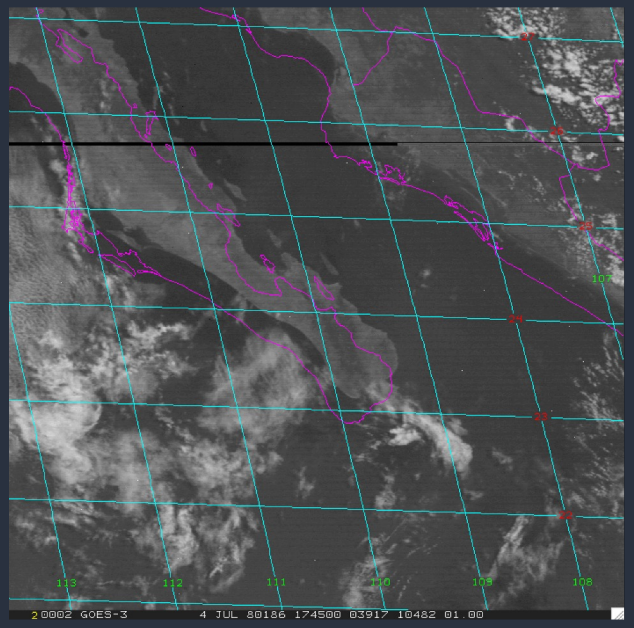
AUTONAV Verification

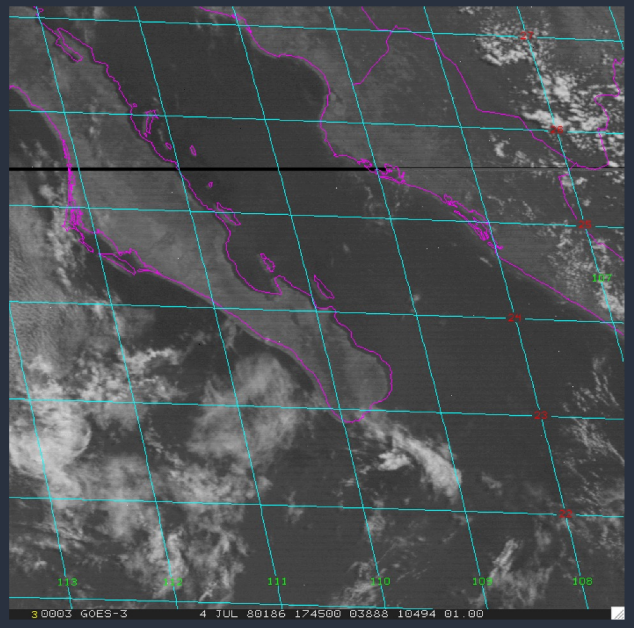
GOES-3 image on 04 July 1980 at 17:45 UTC

Pretend we have no navigation and simulate first guess orbit parameters (*as we would for images with no navigation*)

After AUTONAV, Navigation is similar to original image

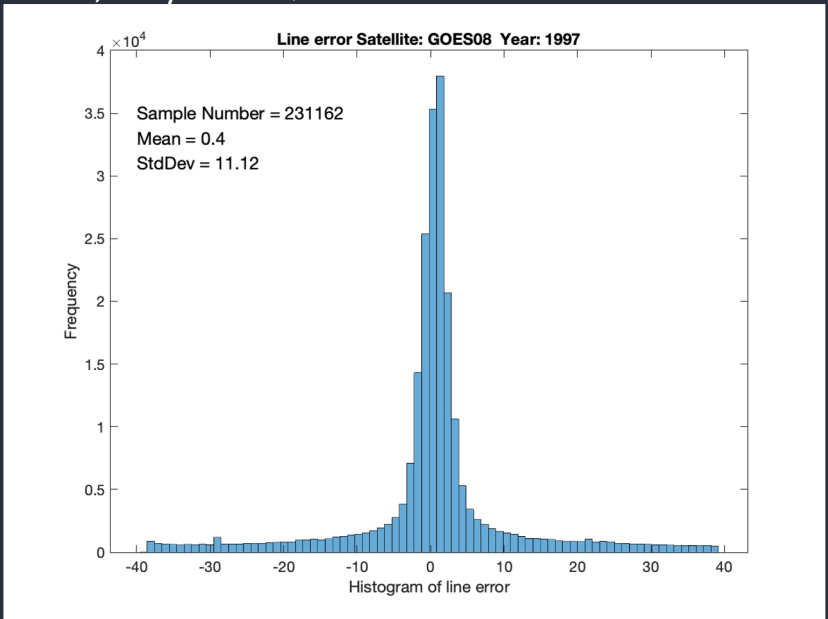


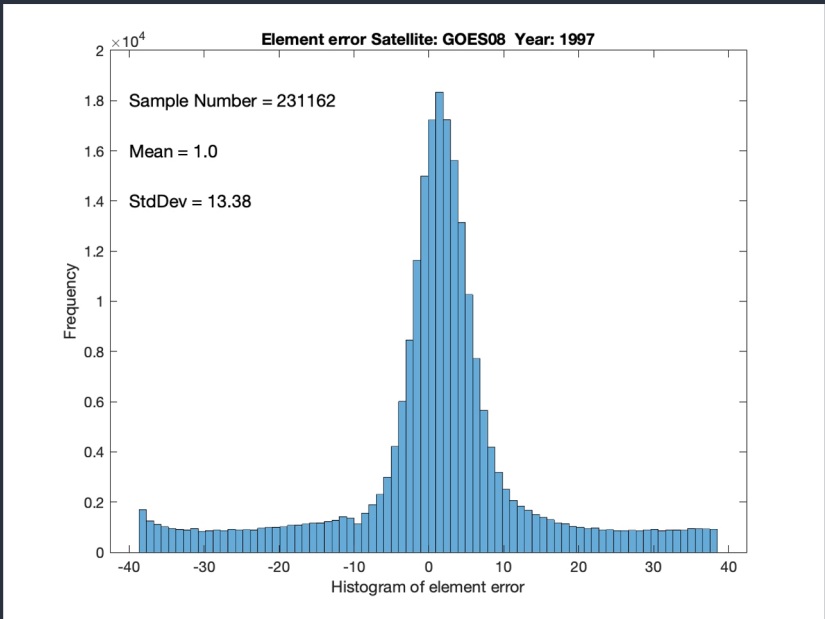




Evaluating GOES GVAR Geolocation

Components of the AUTONAV system are being used to evaluate geolocation errors in the GOES GVAR record. Two years (GOES-8: 1997 and GOES-13: 2011) were selected to prototype the processing and data analysis. Landmarks extracted from the NASA Blue Marble were used to measure line and element displacements in features (e.g., island, coastlines) in full resolution GVAR visible images. These are initial results; very little QC.

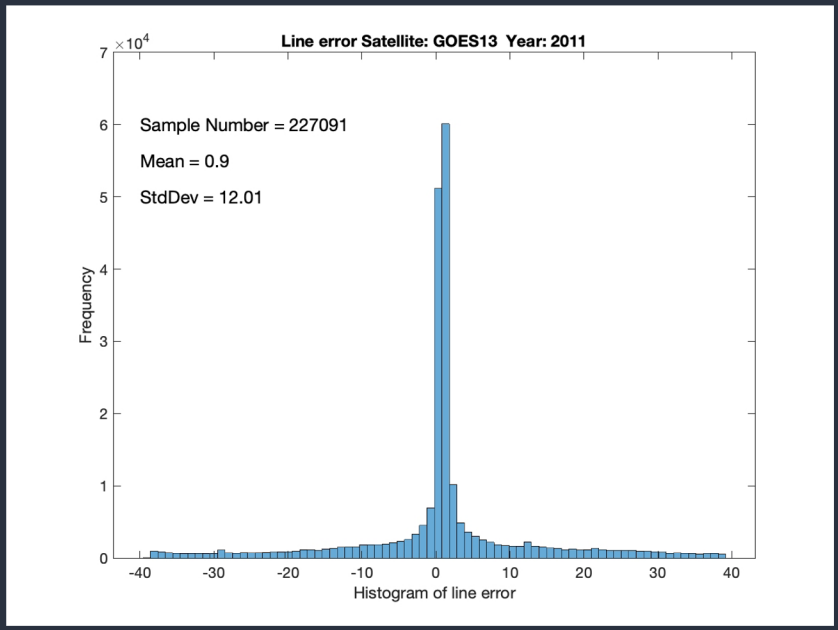


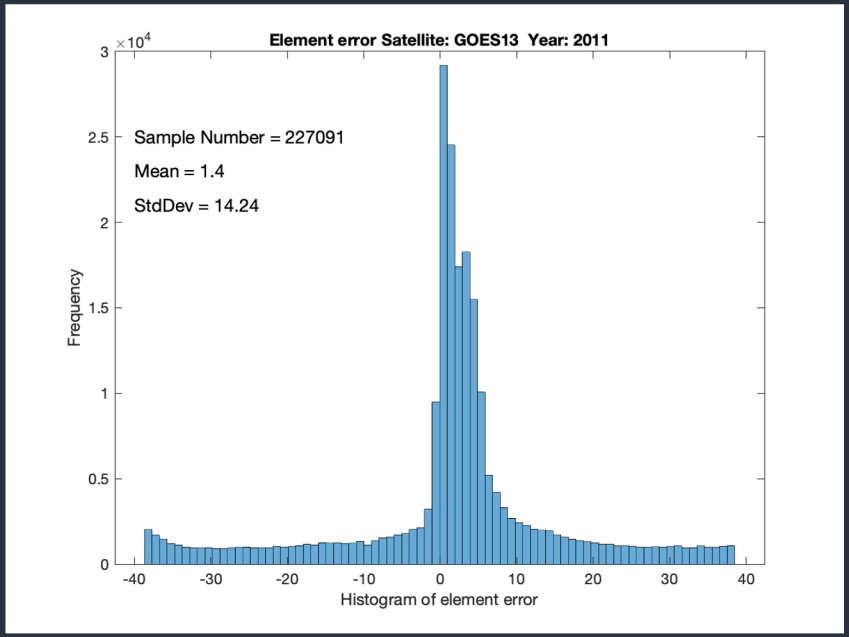


GOES-8 1997: Line Error Element Error

Evaluating GOES GVAR Geolocation

A second example is from GOES-13 during 2011. The overall stats (mean, standard deviation) are similar to the GOES-8 example, however the distributions are narrower than GOES-8, indicating a higher quality geolocation in GOES-13. This is expected as the GOES-N to -P series had an improved INR (Image Navigation and Registration) as compared to the earlier GVAR series.

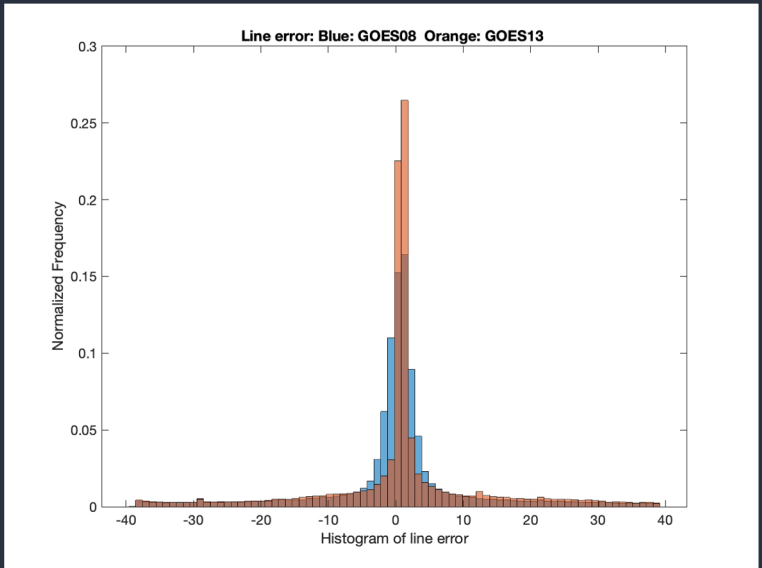




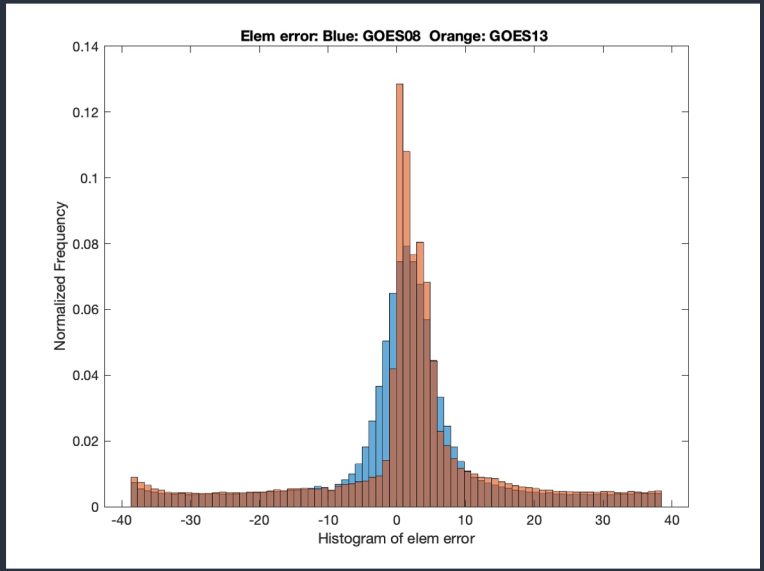
GOES-13 2011: Line Error Element Error

Evaluating GOES GVAR Geolocation

Similar plots as the previous two slides, but overlaid together and normalized. GOES-8 (blue) and -13 (orange) line and element error, depicted as normalized histograms. GOES-13 has a narrower distribution for both line and element errors, as compared to GOES-8. For example, the two highest peaks in the GOES-13 line error account for about 47% of the data, while it's only 30% for GOES-8.



Line Error



Element Error

3. Recalibrating the GOES 4-7 VIS Channel using GOES-R ABI

- Our goal is to add the FD reference calibration approach (**Heidinger et al, 2022**) to those shown in **Inandar and Knapp (2015).**
- GOES 4-7 store the visible counts as the square-root of the observed 8 bits count, reduced to 6 bits. (common to most geo imagers in 1980's and 1990s). Binary Format (Mode-A, AA, AAA).
- We converted to linear counts and did sum over the full-disk to compare to GOES-R reference.

$$C_{lin} = (C_{raw})^2/64$$

- No SBAF was applied.
- We compare our results to those from NASA Langley CERES and ISCCP - others coming.
- A complicating factor is the meridional movement of GOES-6 and 7 during their life.
- Our slope, using the **PATMOS-x** formulation, compared to **NASA CERES:**

$$S_{patmosx} = S_{nasa} * (6400/E)$$

where E is the in-band solar flux.

