On the Use of Geostationary Imagers as Transfer Radiometers to Inter-calibrate CERES Broadband Radiometers

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Fall 2026 CERES science team meeting

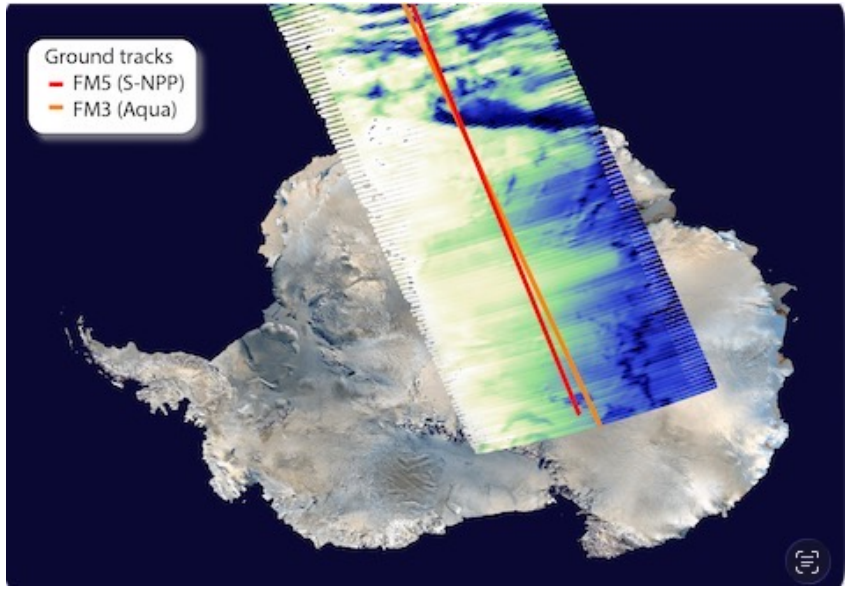
October 27-29, 2026

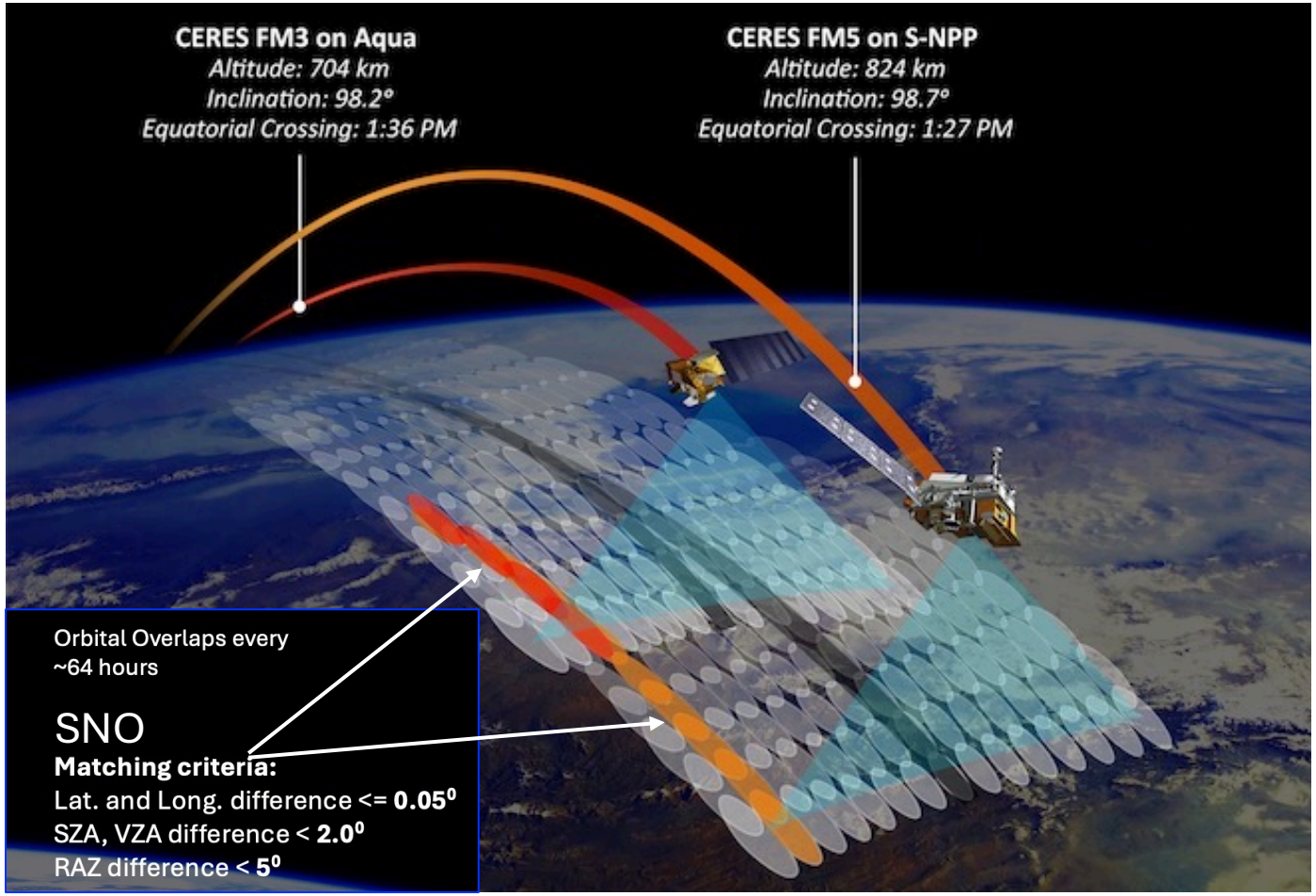
NASA-Langley, Hampton, VA

Background

- The CERES instruments onboard the Terra, Aqua, SNPP and NOAA20 satellites are inter-calibrated to provide consistent, seamless and continuous 26-year record of TOA flux products.

- Inter-calibrate use Aqua/SNPP and Aqua/NOAA20 SNOs where the ground tracks overlap

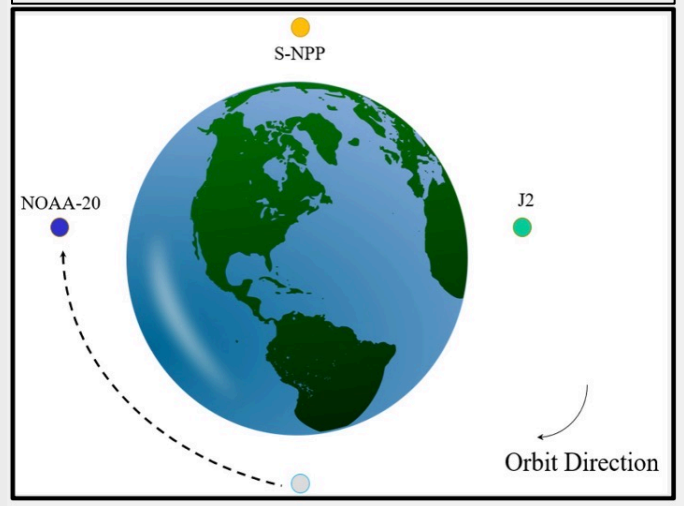


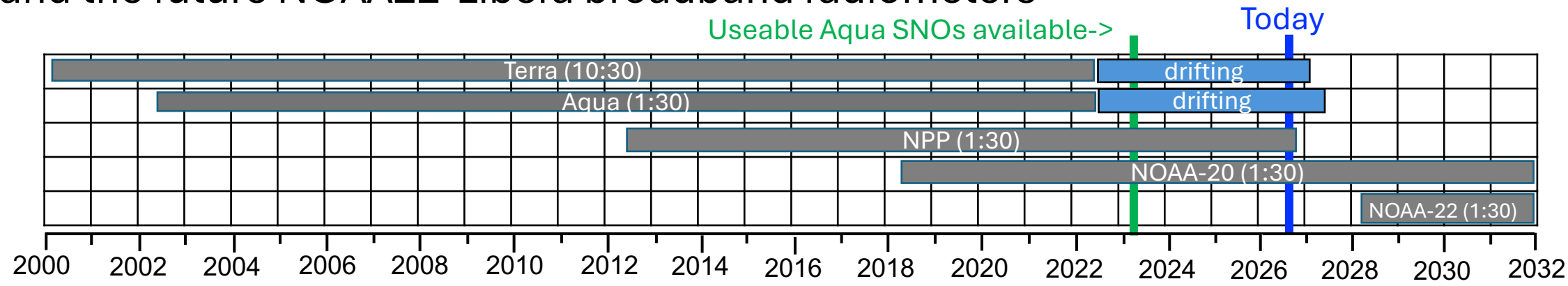


Motivation

- The NOAA20-CERES and the future NOAA22-Libera will need to be inter-calibrated
  - They will be in the same 16-day repeat cycle orbit but spaced 4-days apart preventing nearly any coincident SNOs
- SNPP (Nov 2026), Terra (Jan 2027), and Aqua (mid 2027), will be decommissioned before NOAA-22 becomes operational in early 2028
- As a proof of concept, inter-calibrate NOAA20-CERES and SNPP-CERES using geostationary imagers (GEOs) as transfer radiometers as a proxy for the NOAA20-CERES and the future NOAA22-Libera broadband radiometers

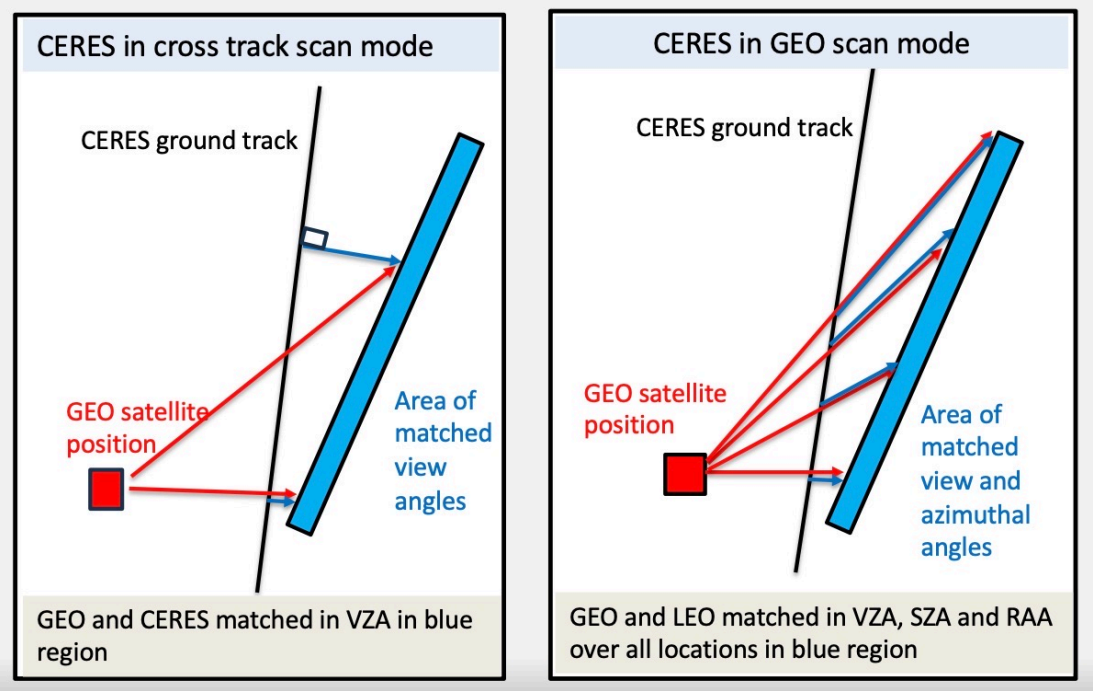
Satellite spacing in orbit.





Rotate CERES instrument scan to align with GEO

- The CERES instrument can be rotated in azimuth to align with the GEO scanning so that the CERES and GEO view and azimuth angles are matched

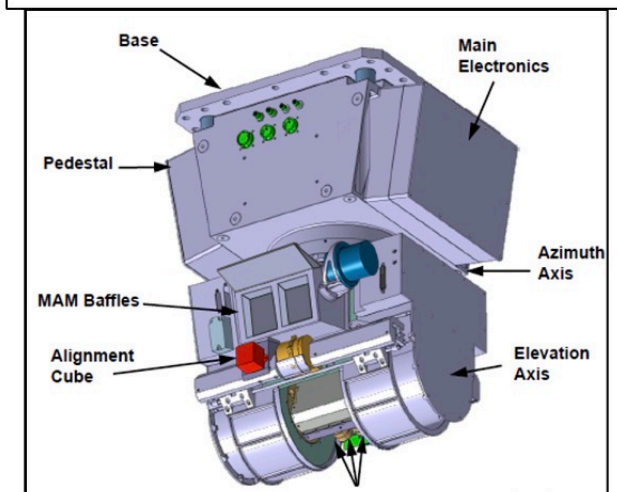


- The NOAA-20/GEO matched angular distribution spatial track is identical to the 4-day later SNPP/GEO track

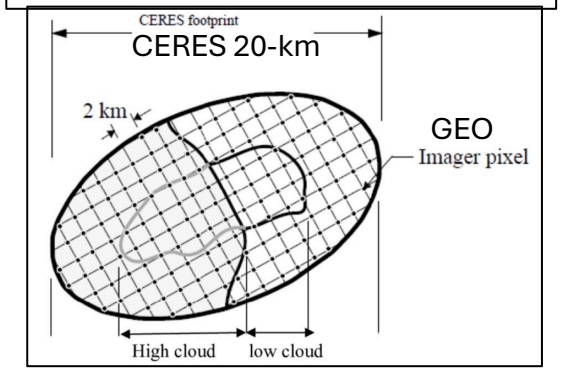
CERES inter-calibration approach

- The CERES instrument has 3-channels, a total wavelength (no filter), a shortwave (SW), and window (NPP) or longwave channel (NOAA20)
  - The CERES daytime SW radiance is from the SW channel
  - The CERES nighttime LW radiance is from the TOTAL channel
  - The CERES daytime LW radiance is from the TOTAL - SW channels
- The GEO pixel radiances are aggregated into the CERES footprint weighted by the CERES point spread function
- The GEO/CERES time match is within 5 minutes
- The GEO imagers scan a full disk image every 10 minutes.

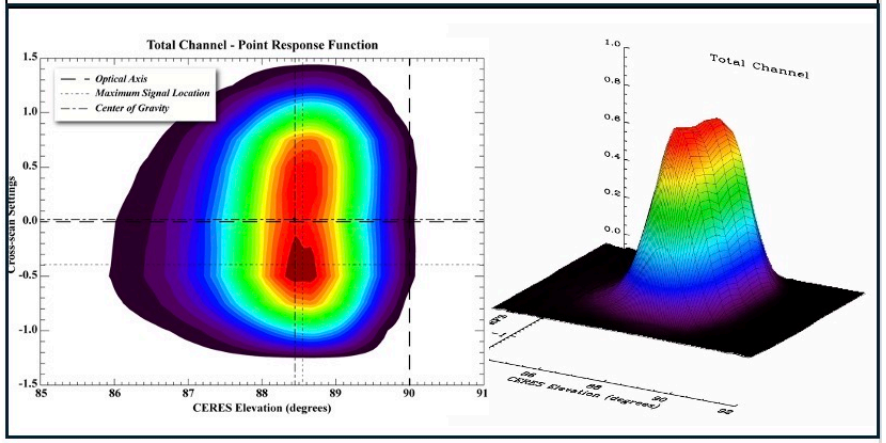
CERES instrument



CERES/GEO spatial view

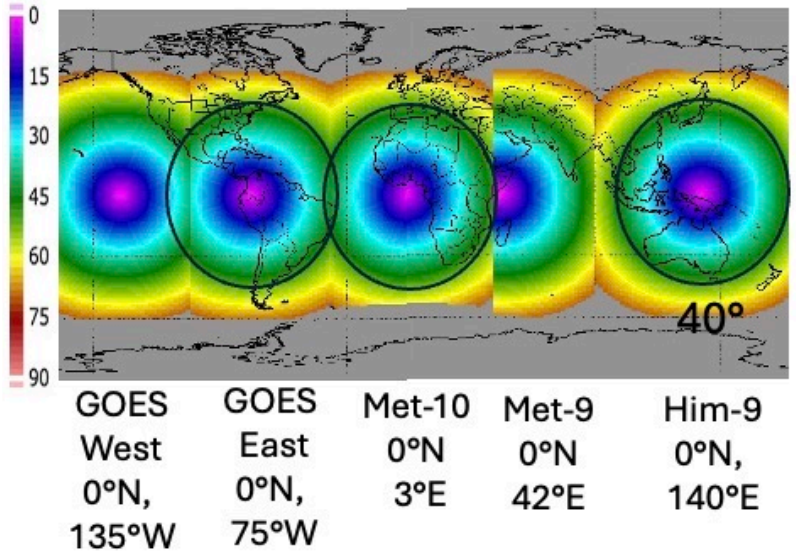


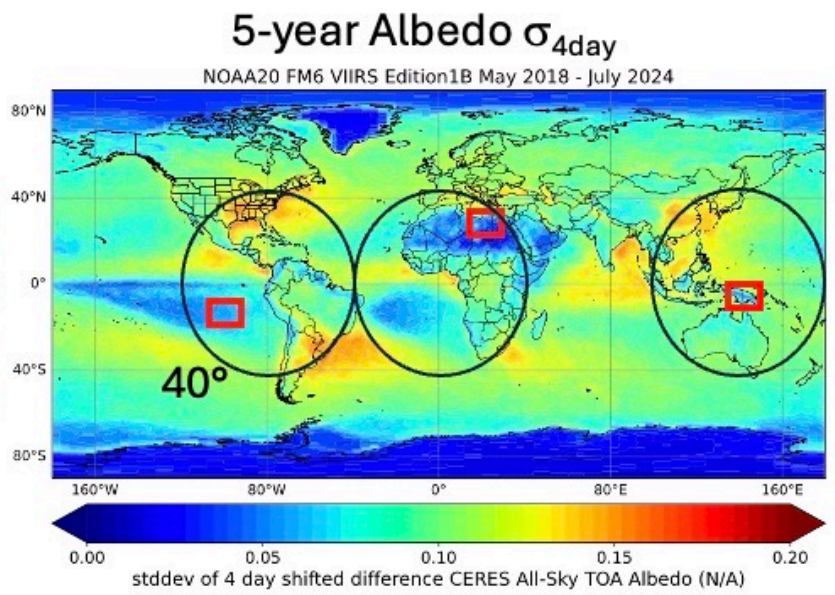
CERES point spread function

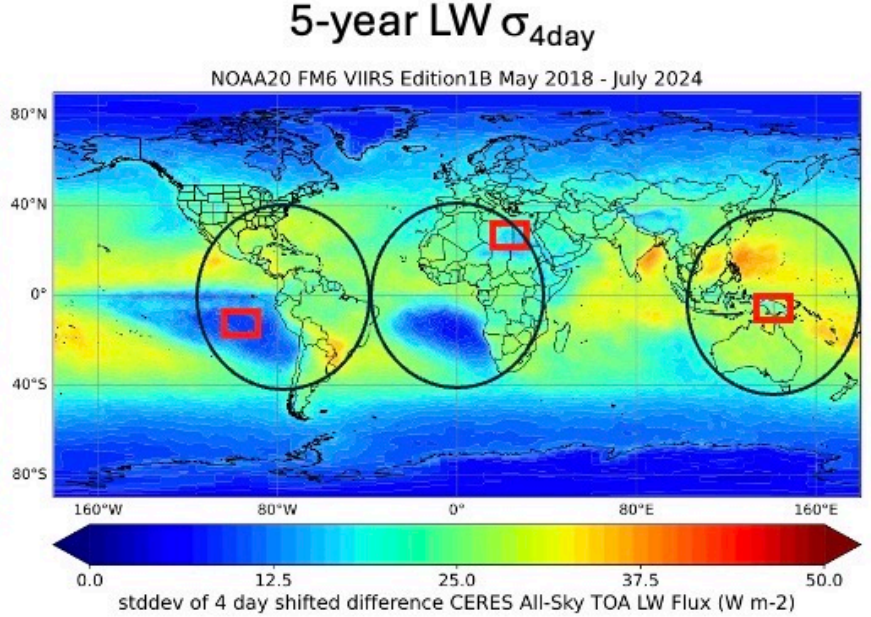


Site Selection

- Find sites with repeatable 4-day albedo and LW scene conditions over the year
- The site must be within a 40° view zenith angle of a GEO
- Two SW channel daytime sites were selected
  - Sahara Desert, Indonesian Deep Convection
- One TOTAL channel nighttime site was selected
  - Peruvian Stratus

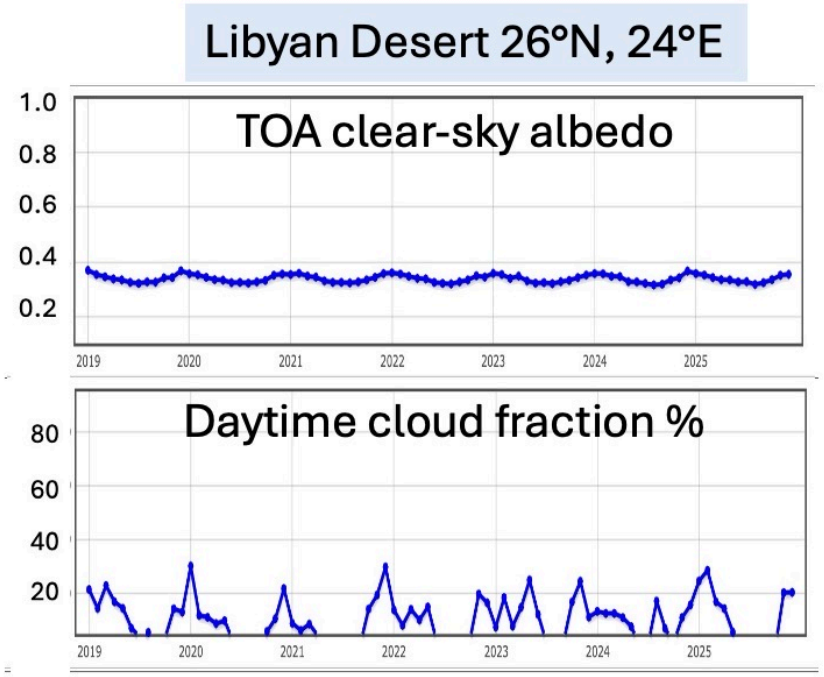


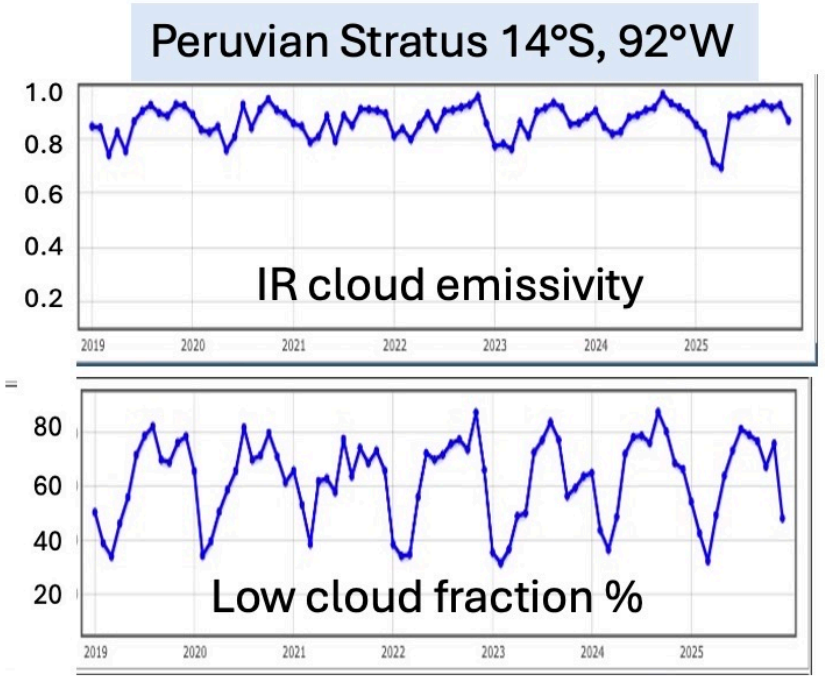


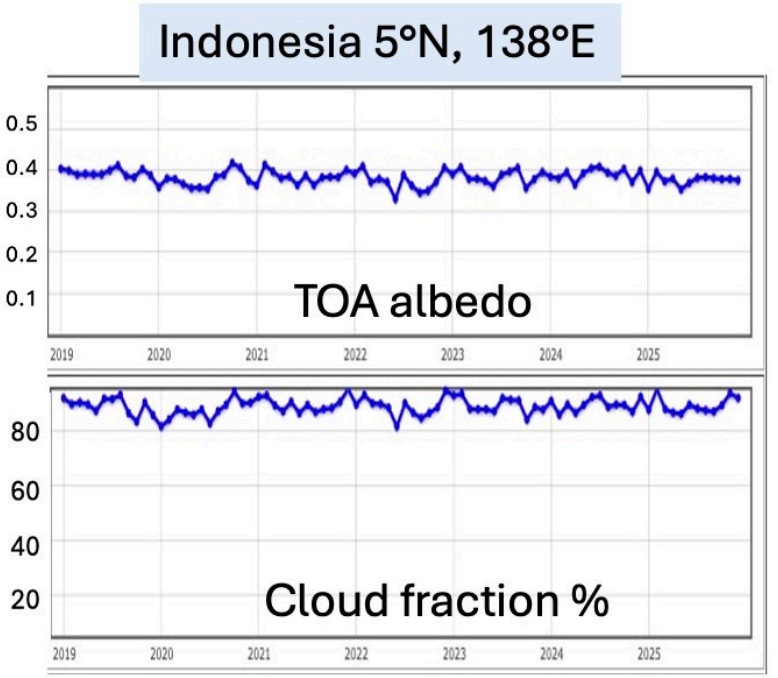


Site Characteristics

- SW bright clear-sky desert with little cloud cover,
  - The Libyan desert has <10% summer cloud cover and an albedo ~ 0.35
- SW persistent deep convective cloudy region,
  - The Indonesian Papua Island has a cloud fraction ~90% and an all-sky albedo of 0.35
- LW nighttime persistent stratus region
  - The Peruvian stratus has ~80% low cloud, outside of winter, with an IR emissivity of 0.95

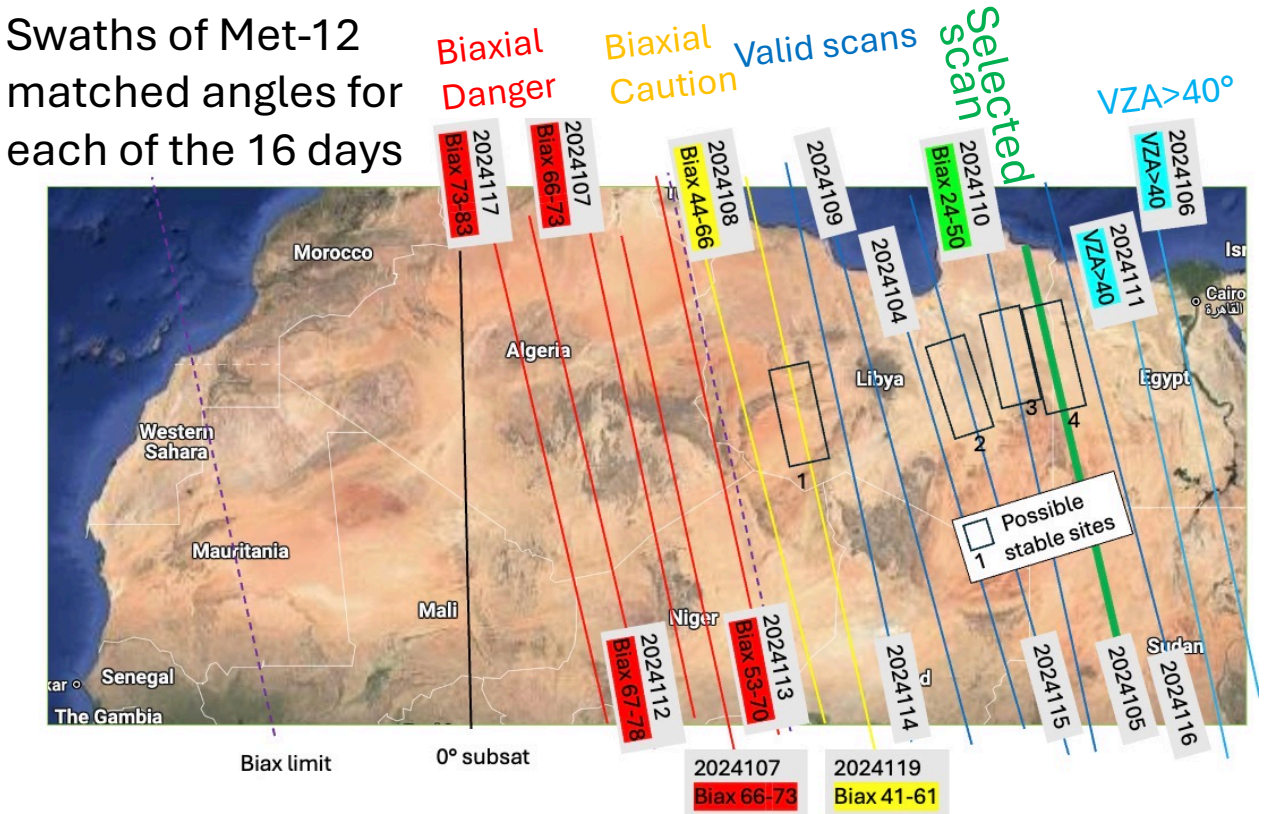






Orbit selection over Sahara site

- Plot the angle matched swaths that are within 2° VZA and 5° RAZ for each 16-day repeat cycle day. Pick the best Sahara stable site (Libya-4, sand dunes)
- Avoid sites where the GEO or biaxial scan occurs in the satellite direction of motion to avoid optical contamination



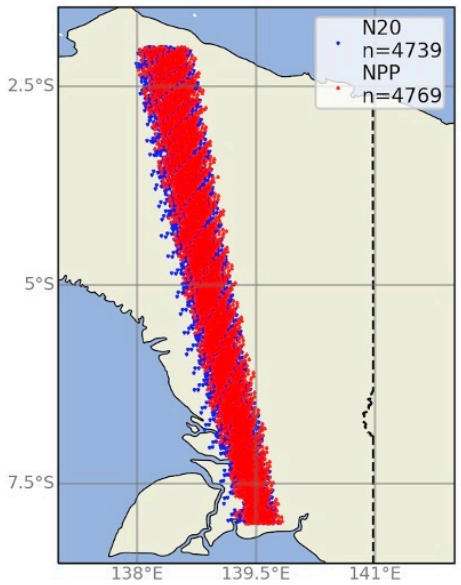
Schedule and GEOscan consistency

- Verify that the NPP and N20 GEOscan footprint swaths (within 2° ΔVZA, and 5° ΔRAZ) are spatially overlapping over the site

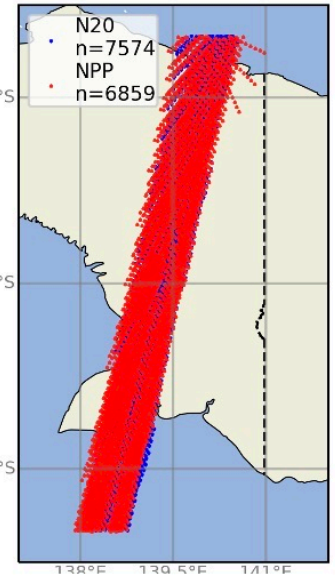
Daily Schedule

	NOAA20				NPP		
	Date	DoY	Event		Date	DoY	Event
					4/21/25	*111*	*Sahara test*
	5/5/25	*125*	*Papua*		*5/9/25*	*129*	*Papua*
	5/21/25	141	Papua		5/25/25	145	Papua
	6/4/25	155	Sahara		6/8/25	159	Sahara
	6/6/25	157	Papua		6/10/25	161	Papua
	6/20/25	171	Sahara		6/24/25	175	Sahara
	6/22/25	173	Papua		6/26/25	177	Papua
	6/26/25	177	Night	Peru	6/30/25	181	Night

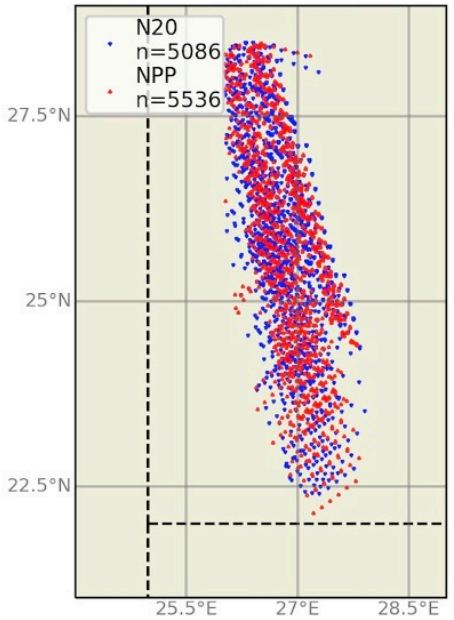
Papua-Day



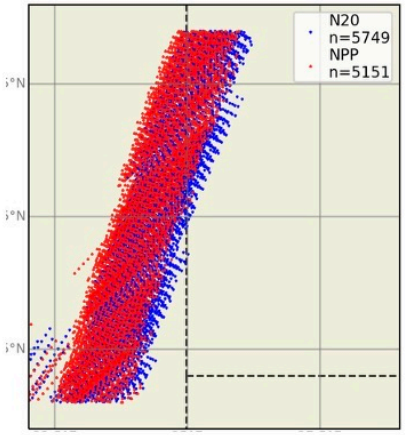
Papua-Night



Libya-Day

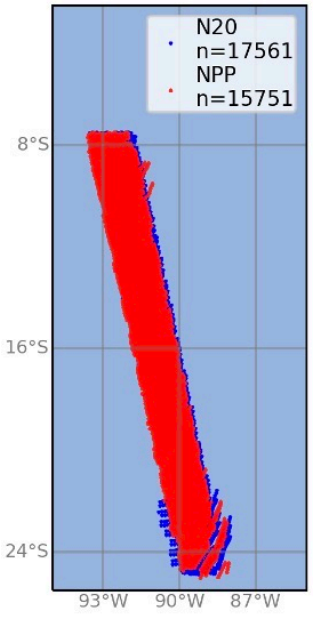


Libya-Night

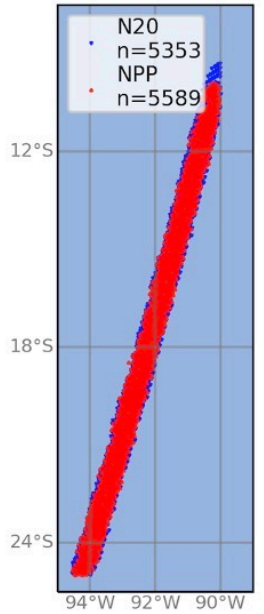


Footprints
NPP NOAA20

Peru-Day



Peru-Night



NOAA20 and NPP SW comparison Sahara Desert

Compute MET12-SW(N20)$_{pred}$

Regress N20-CERES Rad$_{obs}$
with (GEO) Met-12 band counts or radiance

MET12-SW(N20)$_{pred}$ = a0 + a1*Met12cnt

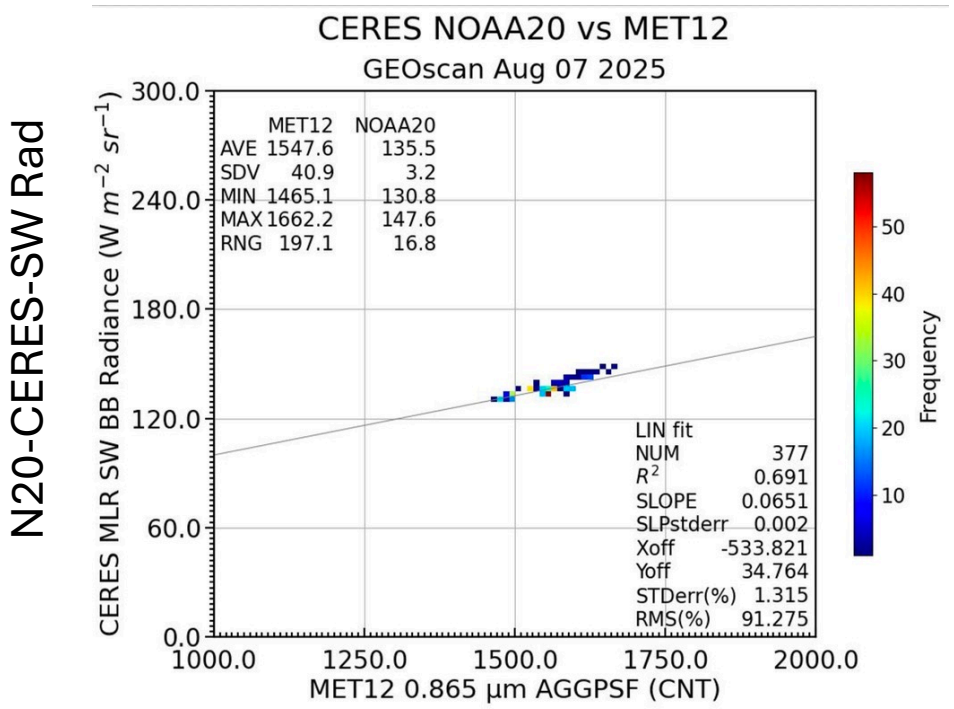
4 days later

GEO imager calibration assumed to be stable over 4-days

Compute N20 – NPP CERES SW bias

Regress MET12-SW(N20)$_{pred}$
with NPP-CERES Rad$_{obs}$

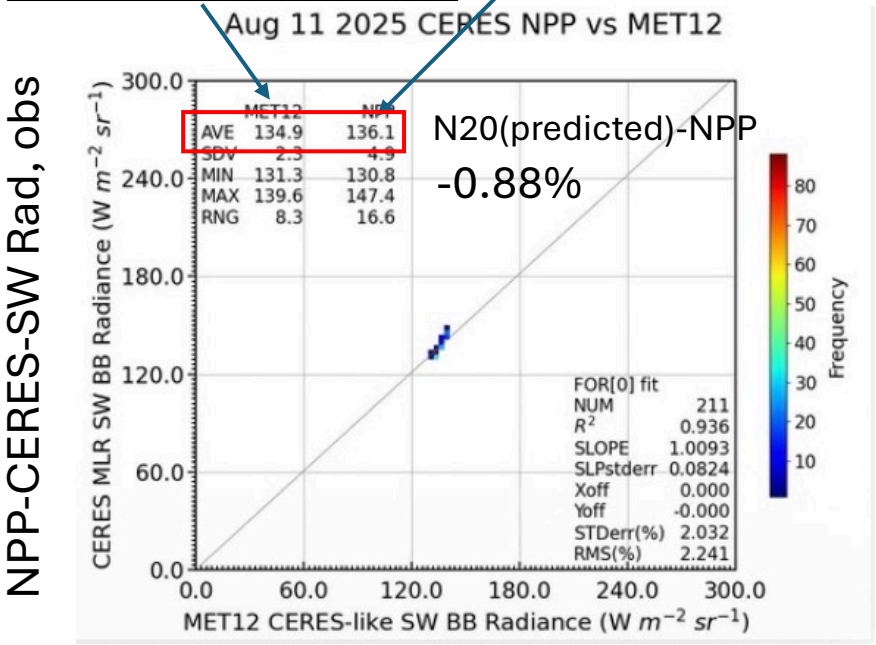
MET12-SW(N20)$_{pred}$ — NPP-CERES-SW



Met-12 0.86µm count

The Met-12 predicted NOAA20 radiance

The NPP observed radiance



MET12-SW(N20)$_{pred}$

Sahara N20-NPP SW bias and uncertainty

Number of events->

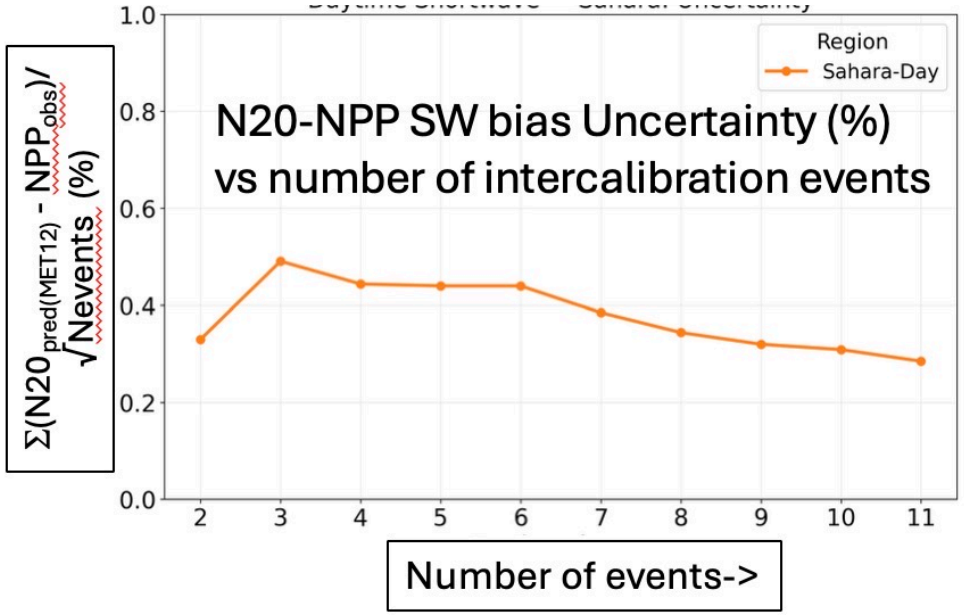
N20 date (NPP +4 days)		NPPobs npp (Wm-2sr-1)	N20pred pred (Wm-2sr-1)	N20pred - NPPobs pred-npp (Wm-2sr-1)
20250604	sahara	138.54	139.00	0.464874108
20250620	sahara	136.21	137.58	1.372806635
20250722	sahara	136.17	135.24	-0.938929264
20250807	sahara	136.07	134.87	-1.206765171
20250823	sahara	135.02	136.82	1.795468525
20250908	sahara	133.64	131.88	-1.762812849
20251026	sahara	111.33	111.73	0.401832491
20251111	sahara	106.82	107.26	0.445606797
20251127	sahara	104.30	103.50	-0.794757116
20251213	sahara	101.34	100.05	-1.288378957
20251229	sahara	104.92	104.35	-0.567790498

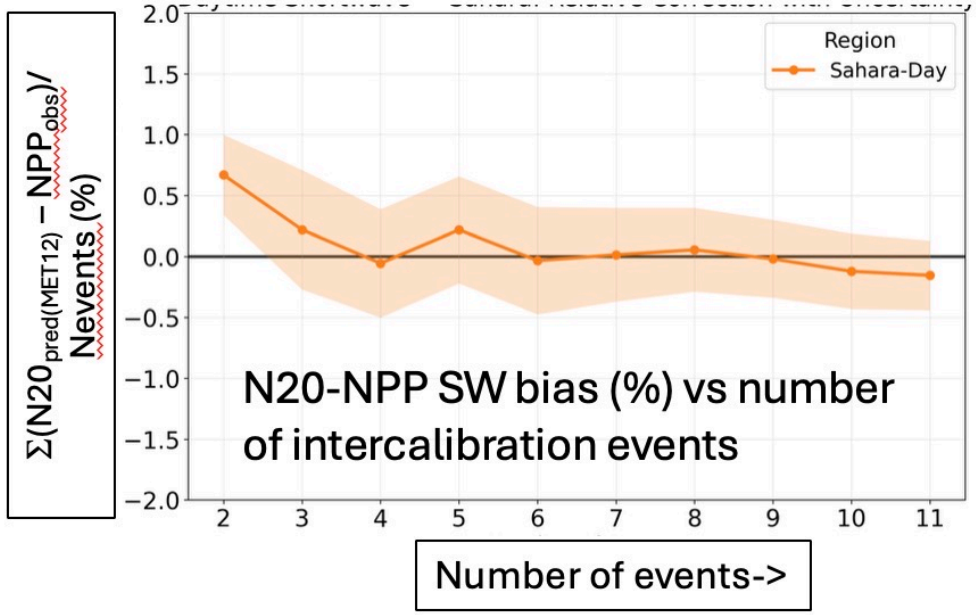
Table of N20-NPP event SW biases

The N20-NPP SW bias uncertainty will decrease with additional events.

The number of GEOscan events needed is dependent on the uncertainty required for scaling

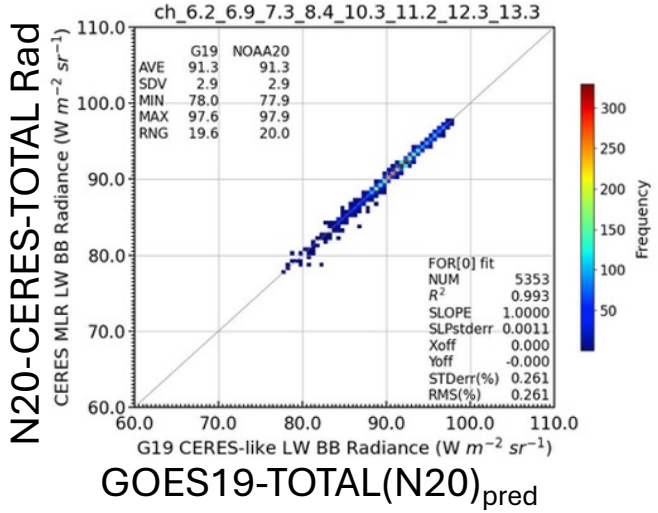
The N20 – NPP SW bias is anticipated to be near zero, since the they were radiometrically scaled using Aqua





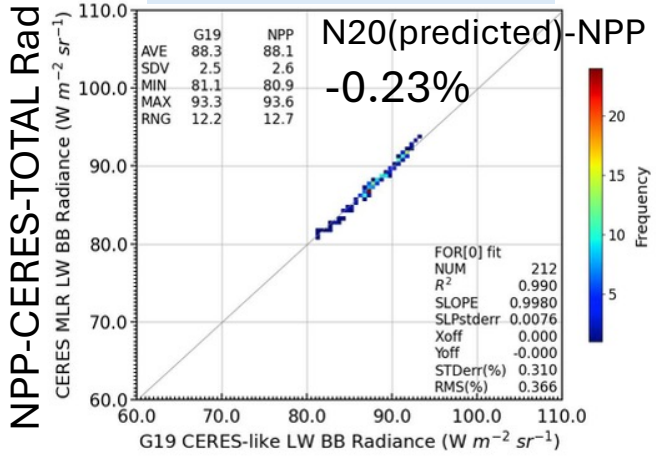
NOAA20 and NPP TOTAL comparison Peru Night

- For GEO IR narrowband to LW broadband use all available GOES-19 IR channels
- To ensure the N20 LW dynamic range encompasses the NPP event range, aggregate all N20 event footprints
- The GEO IR calibration is tied to the onboard blackbody and is assumed to be stable
- A cirrus footprint filter (10.4 - 12.3 BTD < 3 K) was applied to all footprints ensure a stratus scene

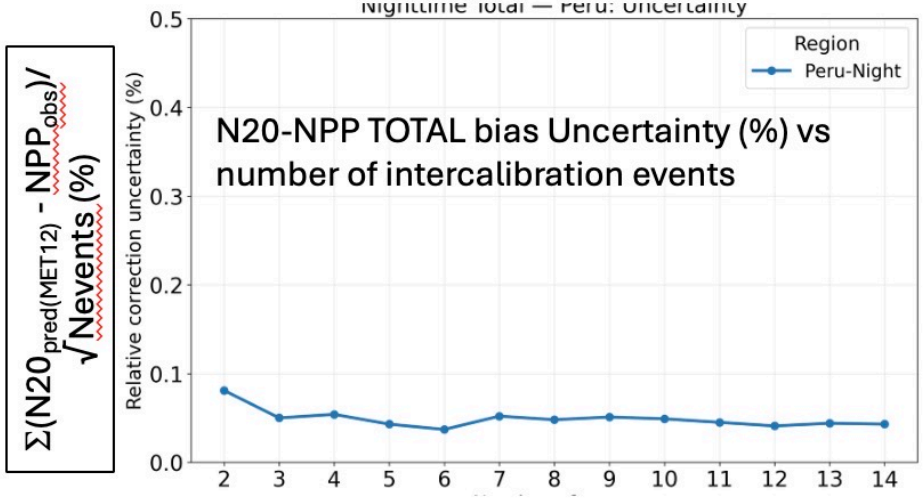


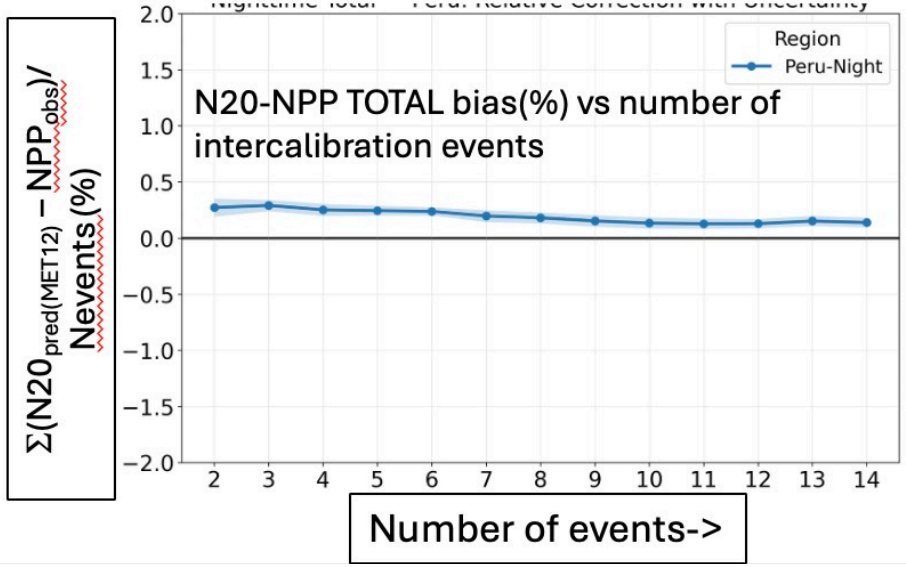
GOES19-TOTAL(N20)$_{pred}$

4-days later

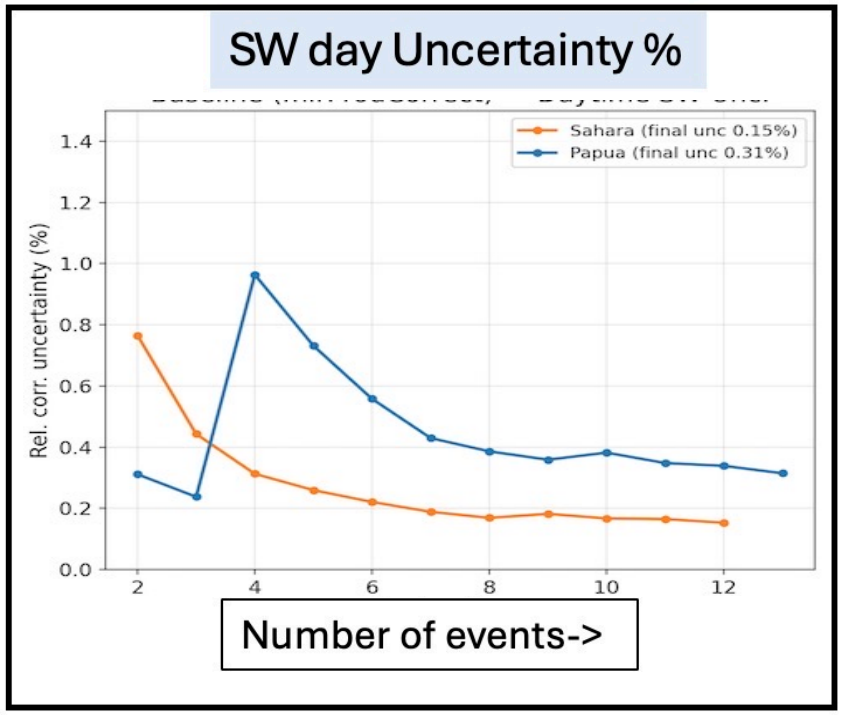


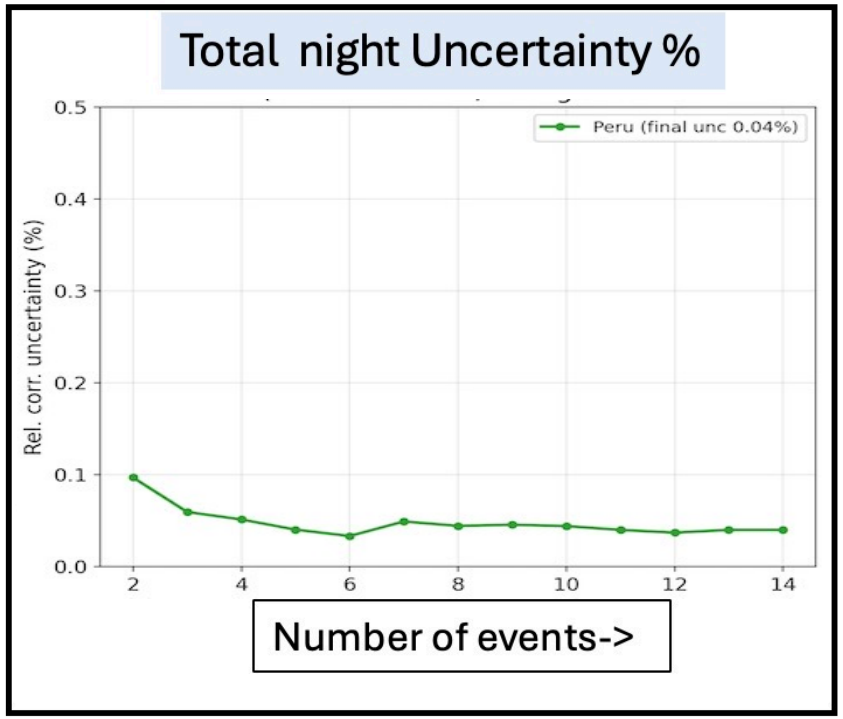
GOES19-TOTAL(N20)$_{pred}$

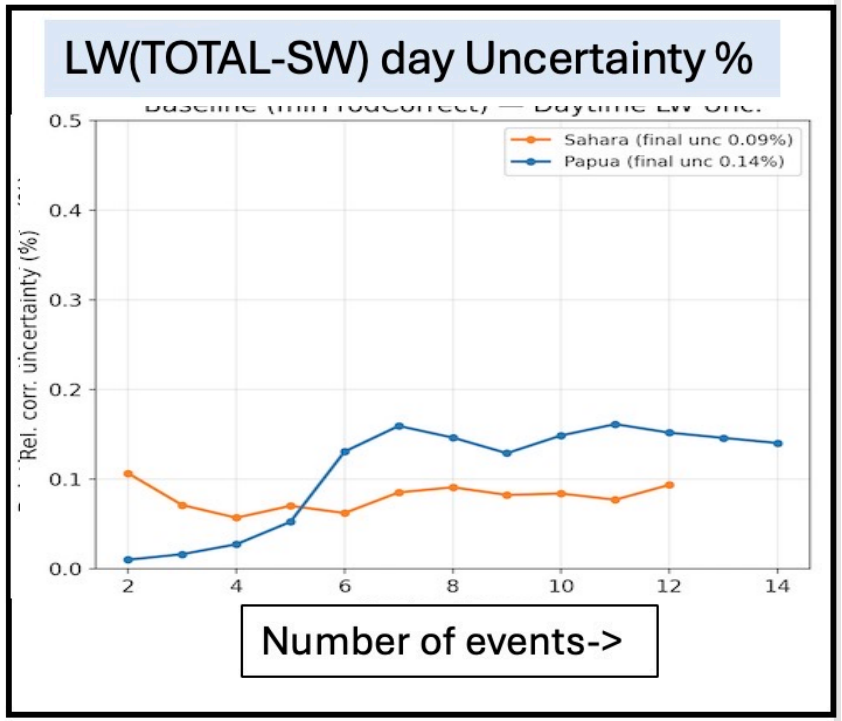




N20-NPP site uncertainty vs number of intercalibration events



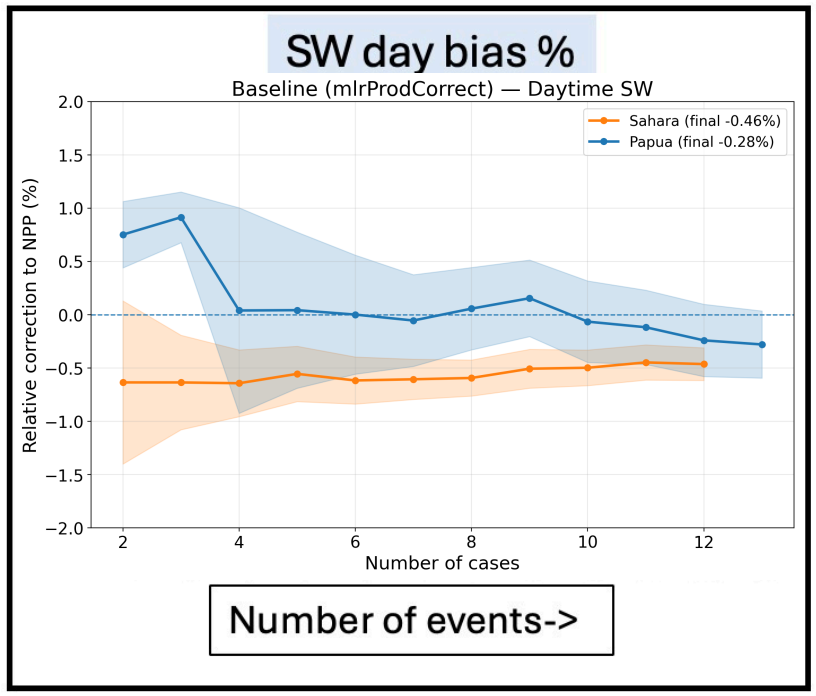


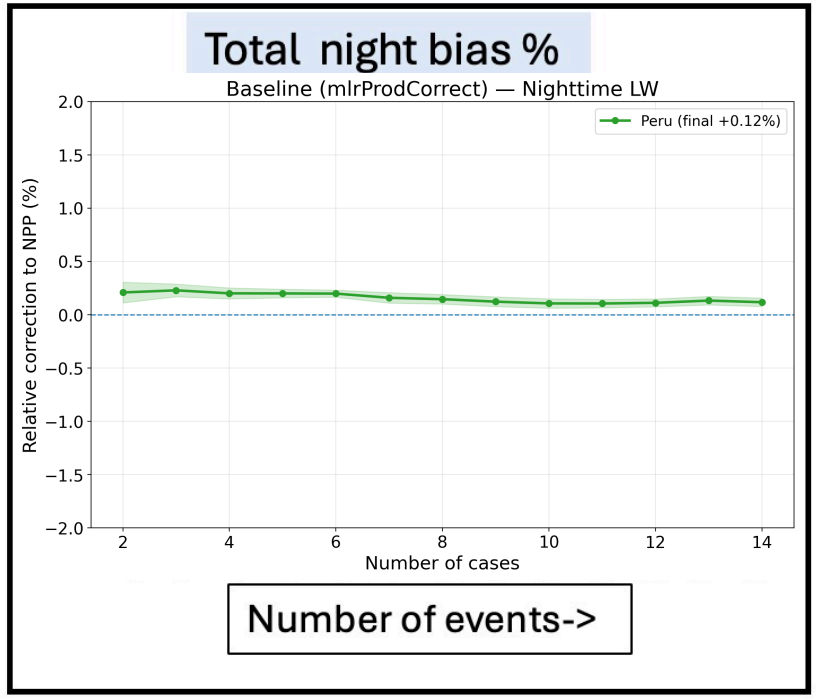


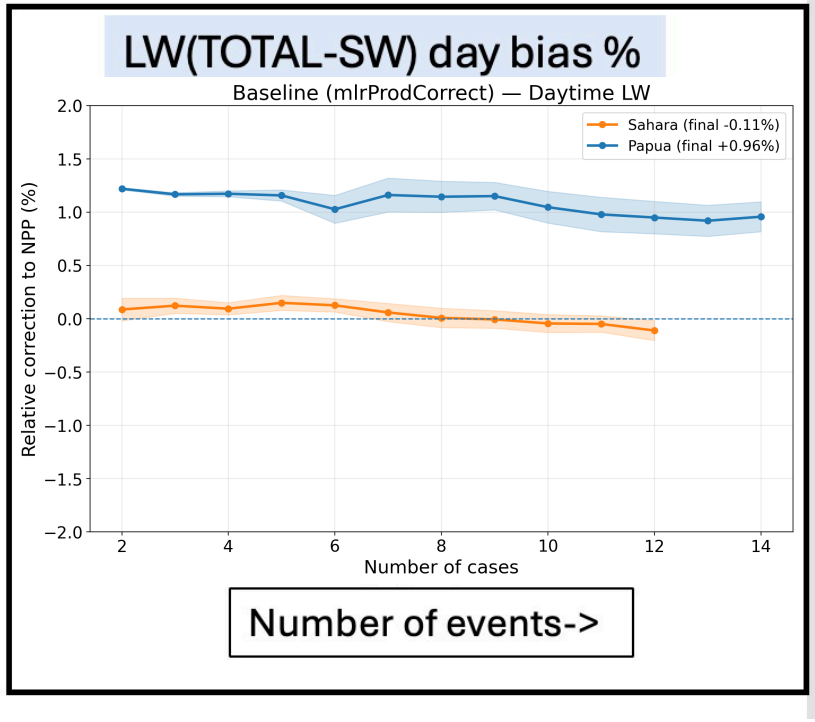
- Typically, a minimum of 4-months or 8 events of GEOscan is needed before the uncertainty starts to level off
- The SW and TOTAL channel GEOscan uncertainty are within 0.35% and 0.1%

N20-NPP site bias vs number of intercalibration events

- The N20-NPP channel radiance biases are a combination of the Ed4 CERES instrument intercalibration and GEOscan algorithm uncertainty
- The N20-NPP SW and TOTAL channel biases are within 0.5% and 0.1%, respectively

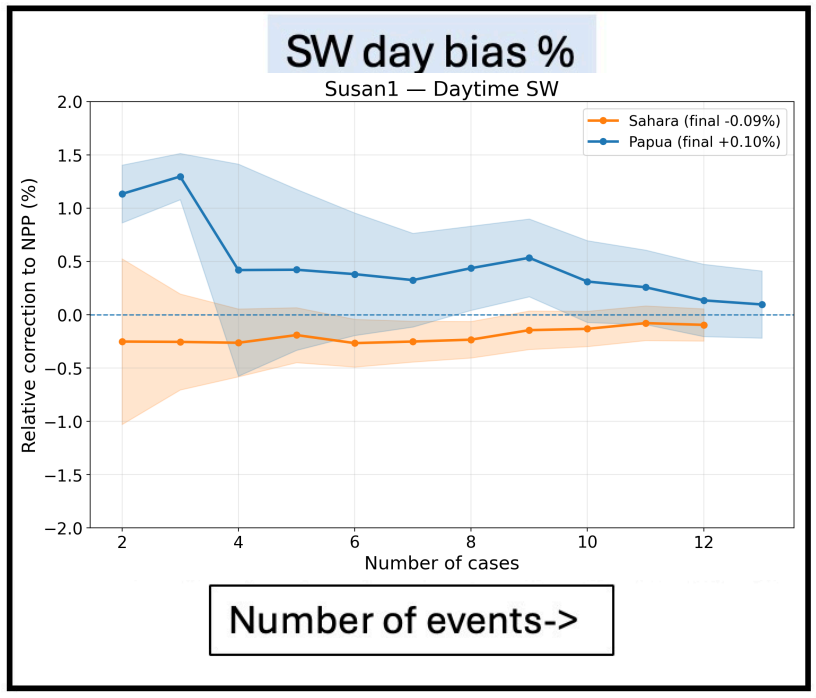


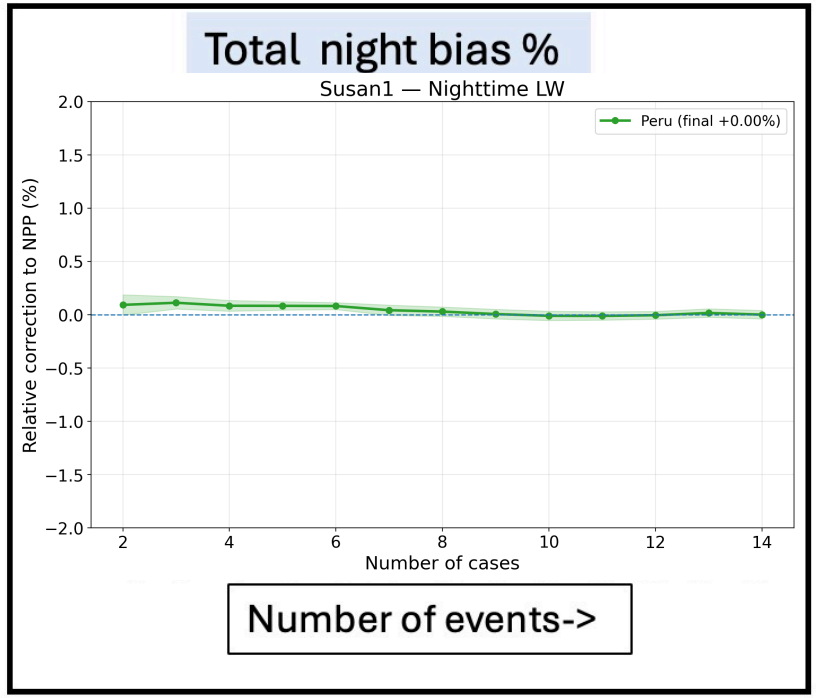


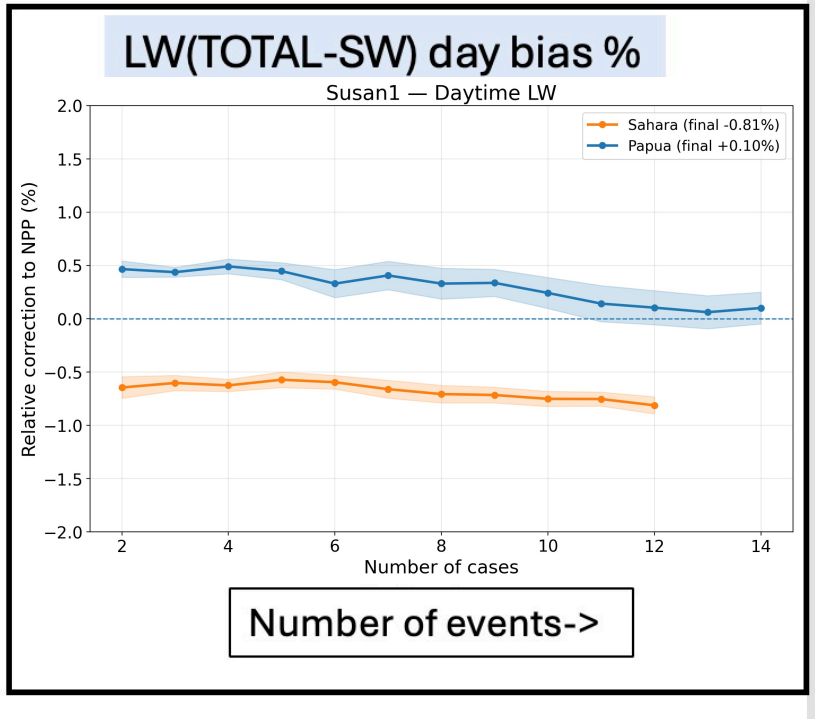


N20-NPP site bias vs number of intercalibration events

- Here the total channel gain was adjusted to provide a zero bias
- The SW channel gain was adjusted based on the Sahara and Papua biases weighted by the inverse of the square of the uncertainty

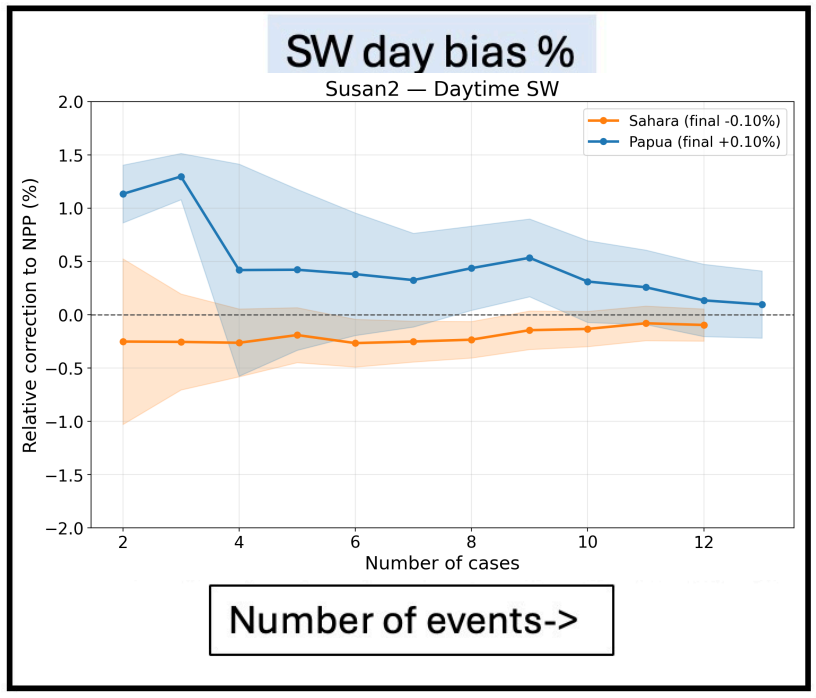


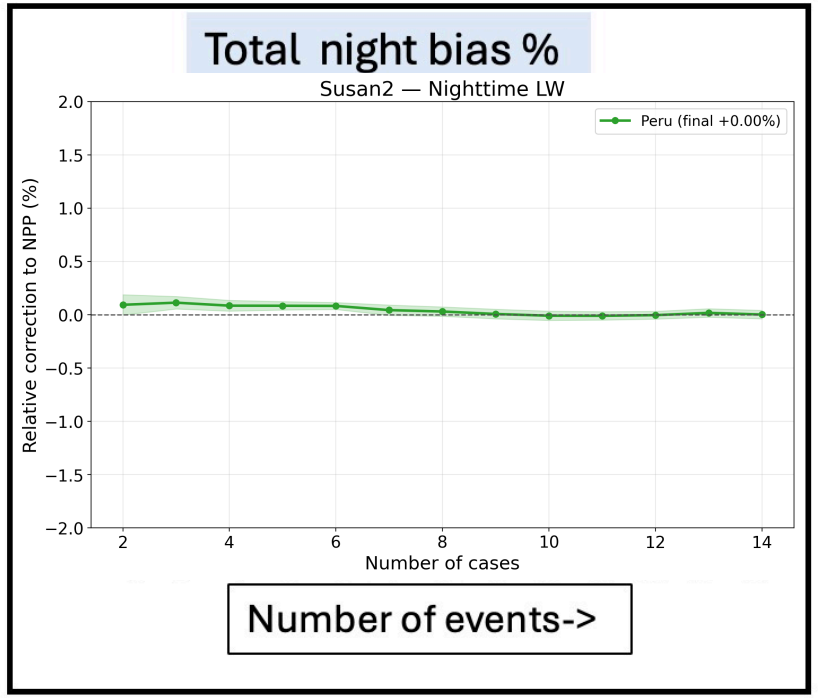


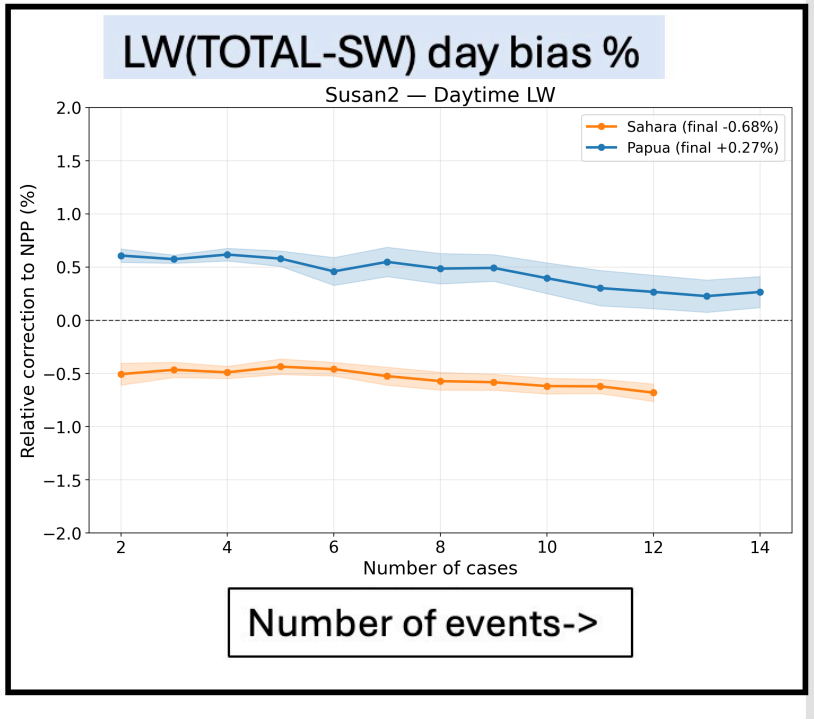


N20-NPP site bias vs number of intercalibration events

- This slide includes the adjustment of the LW part of the TOTAL channel
- The next adjust the SW part of the TOTAL channel







Conclusions

- The GEOscan methodology demonstrated that NPP and NOAA-20 CERES can be intercalibrated without SNOs
  - A minimum of 4-months (8 events) of GEOscan is needed before the uncertainty starts to level off
  - Daytime SW channel within 0.35% uncertainty
  - Nighttime TOTAL channel within 0.1% uncertainty
- The GEOscan methodology provides a way of inter-calibrating NOAA-20 CERES with the future NOAA-22 Libera channel radiances
- CLARREO radiances will be helpful for inter-calibrating the N20-CERES and NOAA22-Libera SW channel radiances