Towards a fuller exploitation of the window channel from geostationary satellites in NWP

ITSC-24 – 16 March 2023

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Thanks to

EUMETSAT Fellowship Program

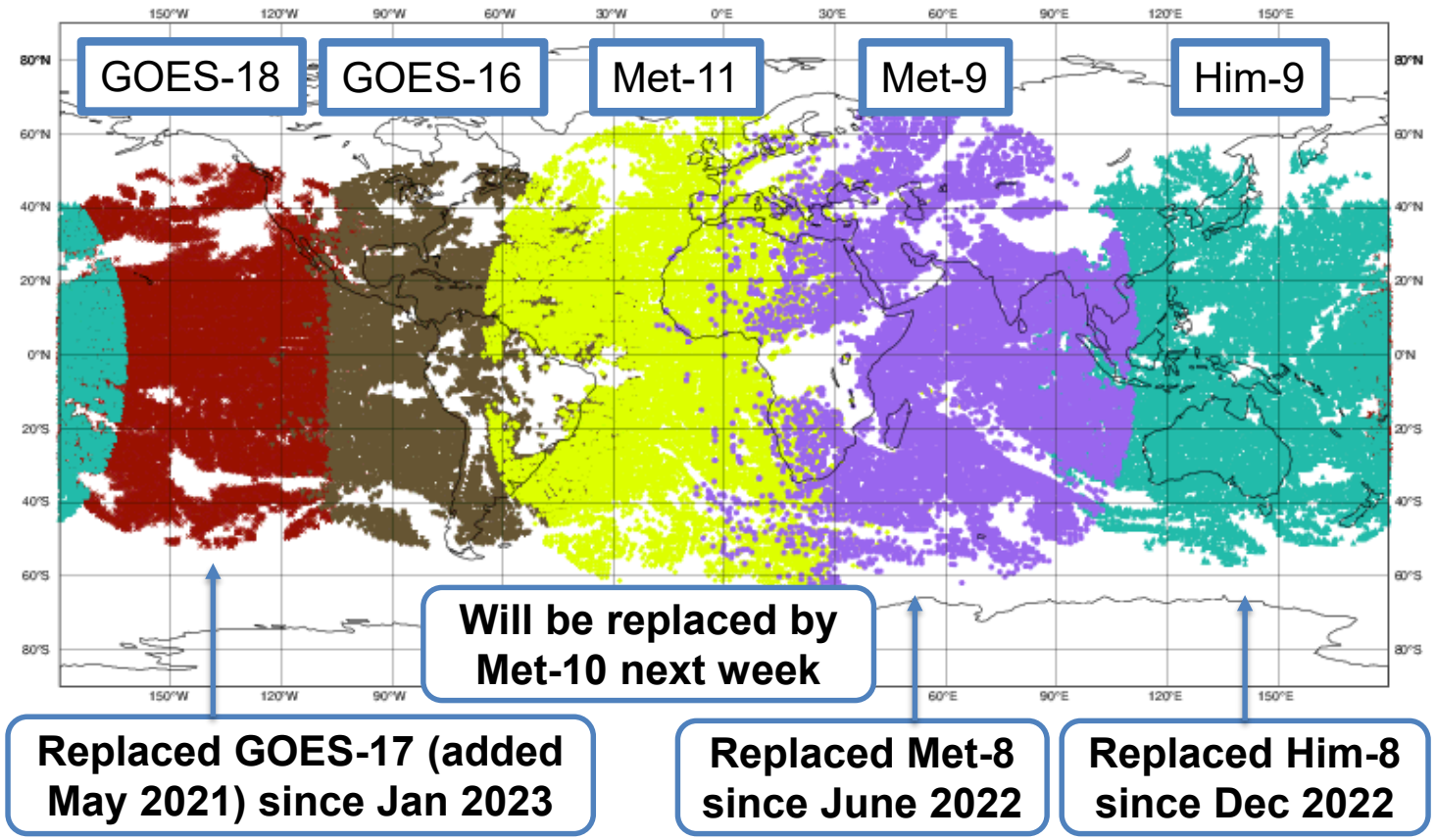
Cristina Lupu, Marco Matricardi, Kirsti Salonen, Mohamed Dahoui (ECMWF)

Tim Hewison, Mounir Lekouara, Johan Strandgren, Arthur de Smet (EUMETSAT)

AK Sharma, Andrew Heidinger, Sharon Nebuda, Thomas King, Donna McNamara, Qiang Zhao (NOAA/NESDIS)

ECMWF

Geostationary radiances observations currently used in operations at ECMWF



Data coverage for geostationary radiances used at ECMWF from 21 UTC on 13 March to 3 UTC on 14 March 2023

Currently only water vapour channels are assimilated, with the **window channel** used as an additional QC check for cloud contamination.

Sat.	Met-11	Met-9	Him-9	GOES-16	GOES-18
Instrum.	SEVIRI		AHI	ABI	
Product	ASR		CSR		
Active	6.25µm		6.25µm	6.15µm	
			6.95µm	7.00µm	
	7.35µm		7.35µm	7.40µm	
Passive	**10.8µm**		**10.45µm**	**10.30µm**	
	13.4µm				

Why is important to Maximise the Exploitation of Window Channel Radiance Observations from GEO

- Quantifying the surface emission in a scene (with the window channel) assists **vertical localisation** and accuracy of the humidity information extracted from the two water vapour channels above.
- The GEO window channel is the only source of information to constrain the full **diurnal cycle of skin temperature** in the 4D-Var analysis.
- The GEO window channel will play a key role in the ECMWF **coupled SST analysis.**

Tuesday 21 March 2023		
8:30– 9:40 Session 13: Earth System Approach		Oral presentation
13.03	Tracy Scanlon	Further exploiting MW and IR radiances through extracting and using ocean skin temperature information in a coupled ocean-atmosphere system

- Later it will be used to similarly constrain land surface temperature (LST) in a **coupled land data assimilation**.
- **MTG-IRS** will provide hundreds of surface sensitive channels so we need to gain experience in their exploitation

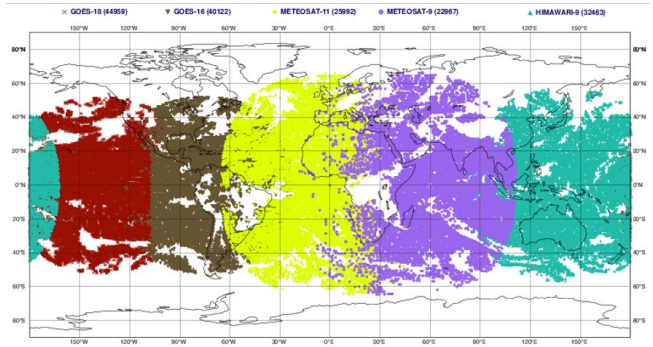
GEO Window Channels are similar but with differences

Different instruments

Different products

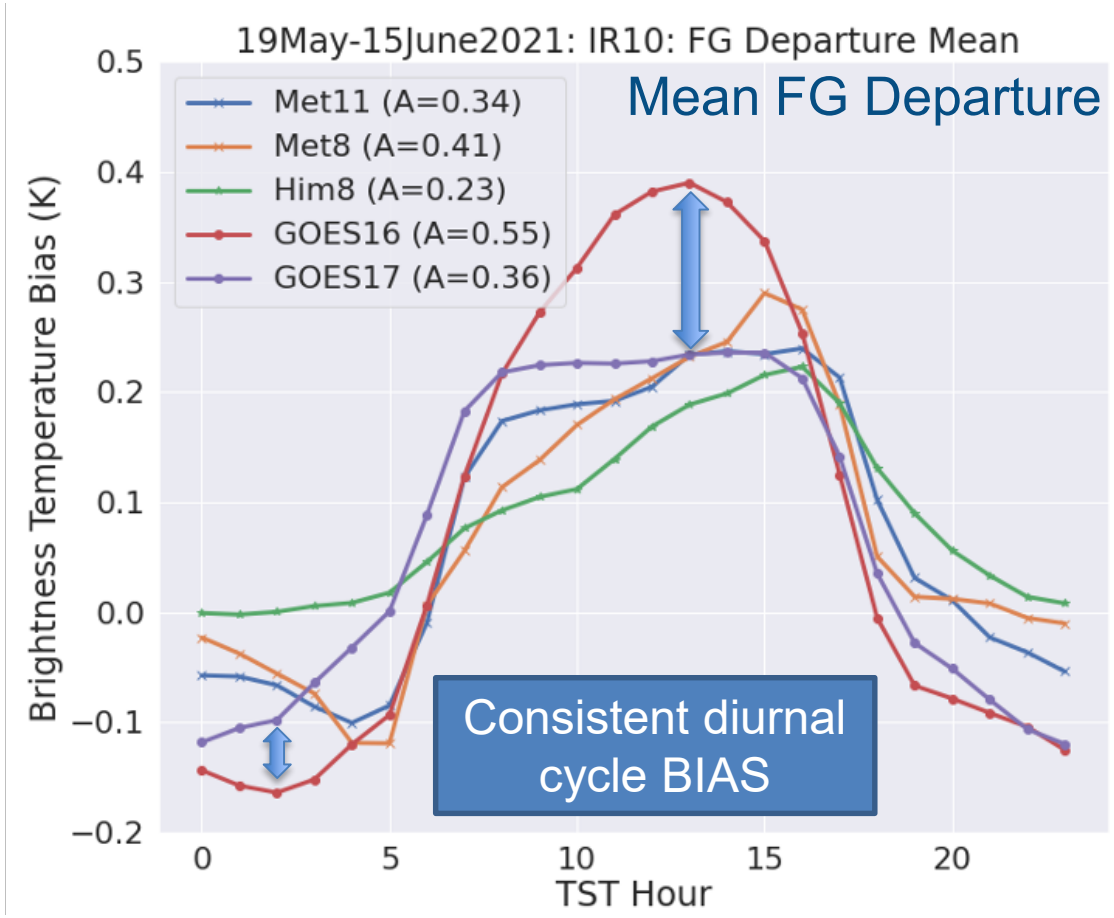
Satellite	Met-11	Met-9	Him-9	GOES-16	GOES-18
Instrument	SEVIRI		AHI	ABI	
Product	ASR		CSR	CSR	
Longitude	0.3°W	41.5°E	140.7°E	75.2°W	137.0°W
Central Wavelength	10.8 µm		10.45 µm	10.30 µm	
Spectral interval (99% encircled energy)	1.0 µm		0.3 µm	0.5 µm	
SNR or NEΔT	0.25 K @ 300 K		≤ 0.1 K @ 300 K	0.1 K @ 300 K	

Looking at different regions (oceans)

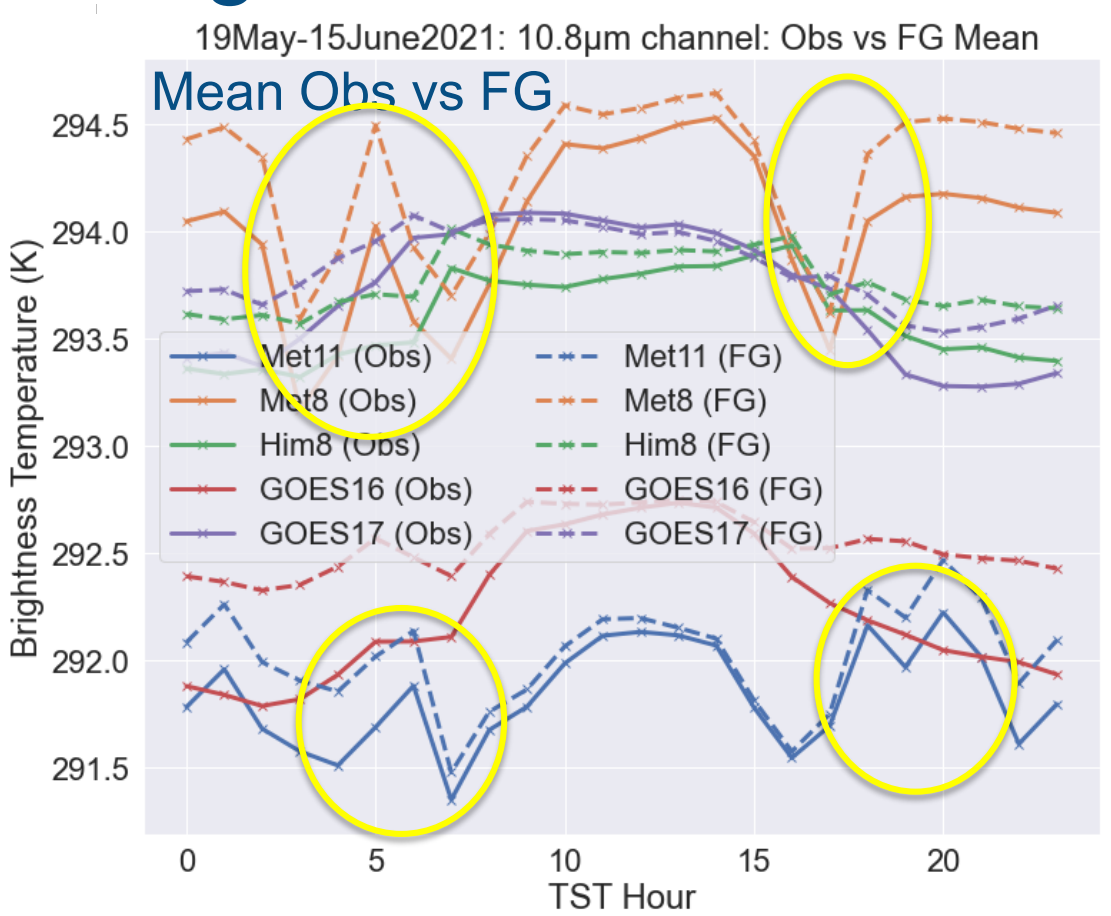


Different spectral characteristics

GEO Window Channel monitoring



Discrepancies shown in GOES-16 vs GOES-17



Met-11/-8 obs jumpiness at sunrise and sunset

How to disentangle the various sources of bias (RT, observation, model) ?

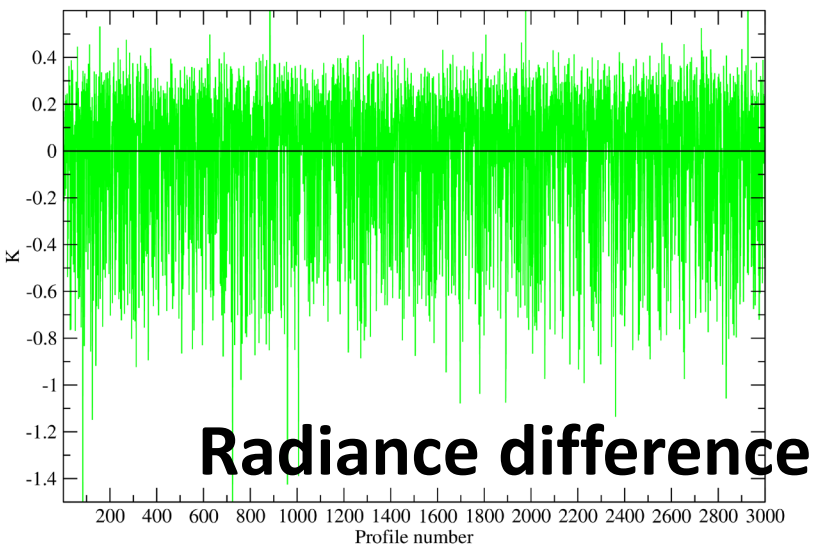
How do the GEO Window Channel differences translate into radiance space

Marco Matricardi

Used 3000 vertical profiles and surface conditions from our 137-level forecasting model to simulate GEO observations with RTTOV

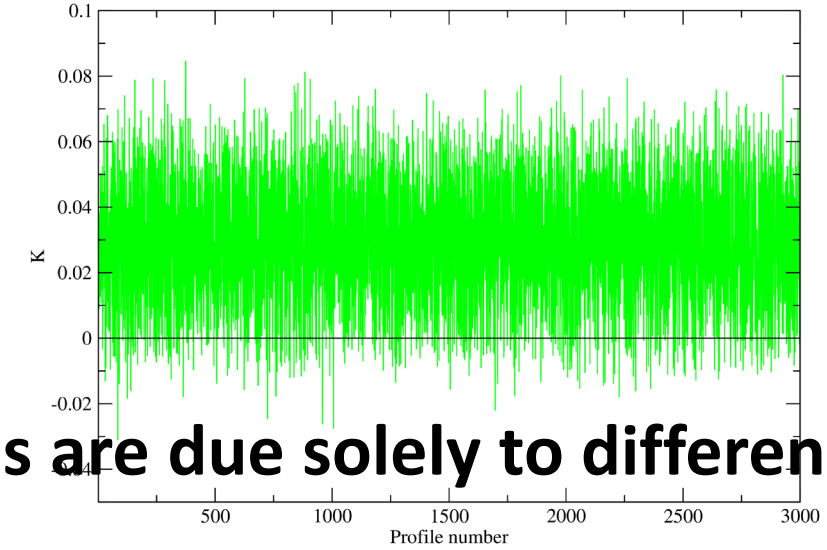
SEVIRI - ABI

METEOSAT-11 minus GOES-16



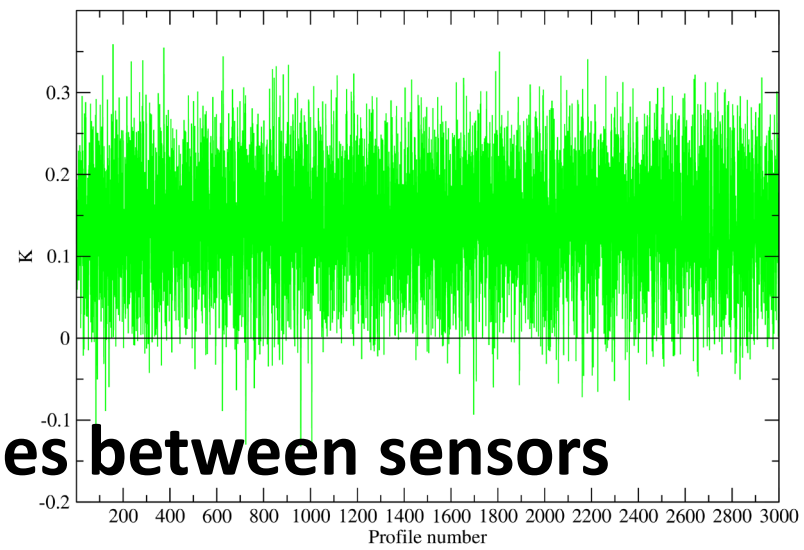
ABI - ABI

GOES-16 minus GOES-17



AHI - ABI

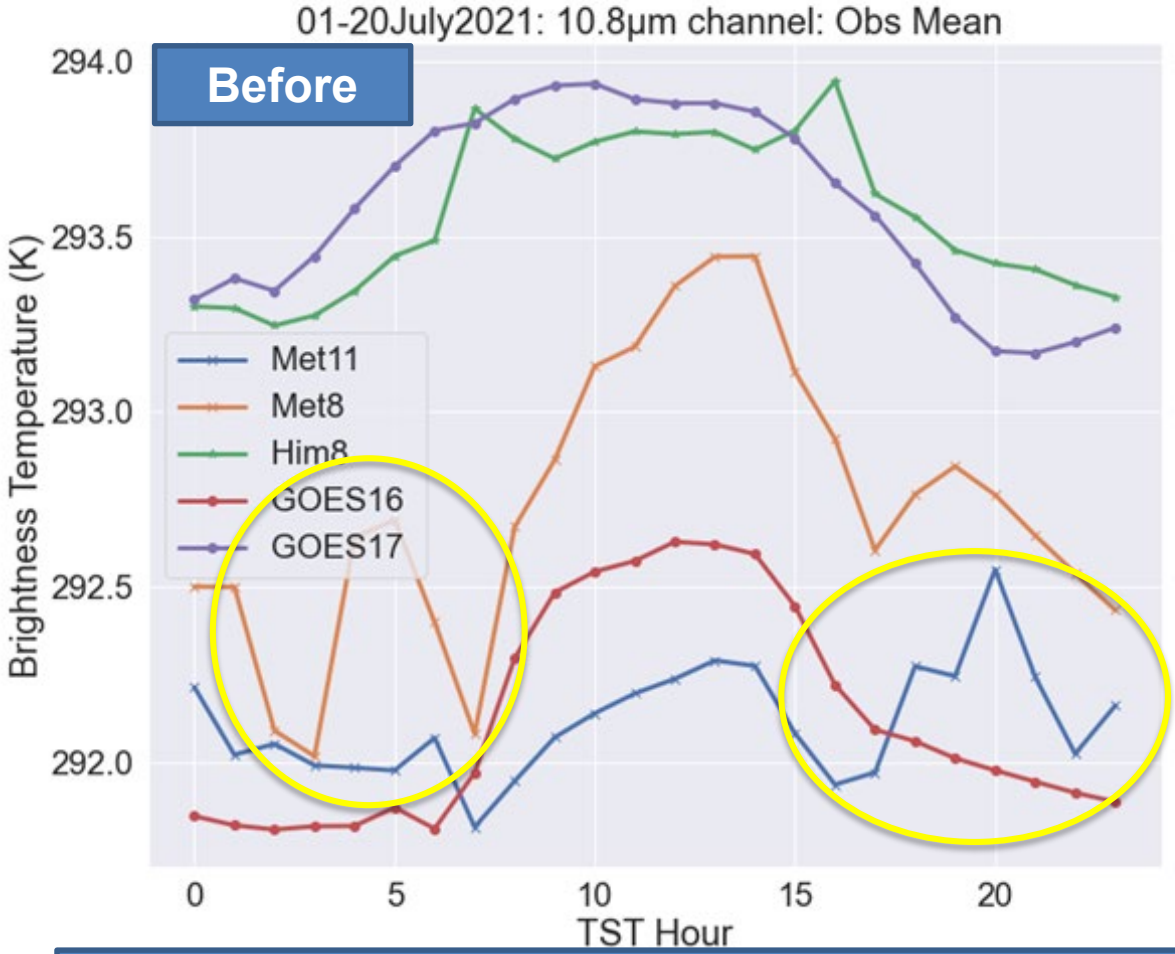
HIMAWARI-8 minus GOES-16

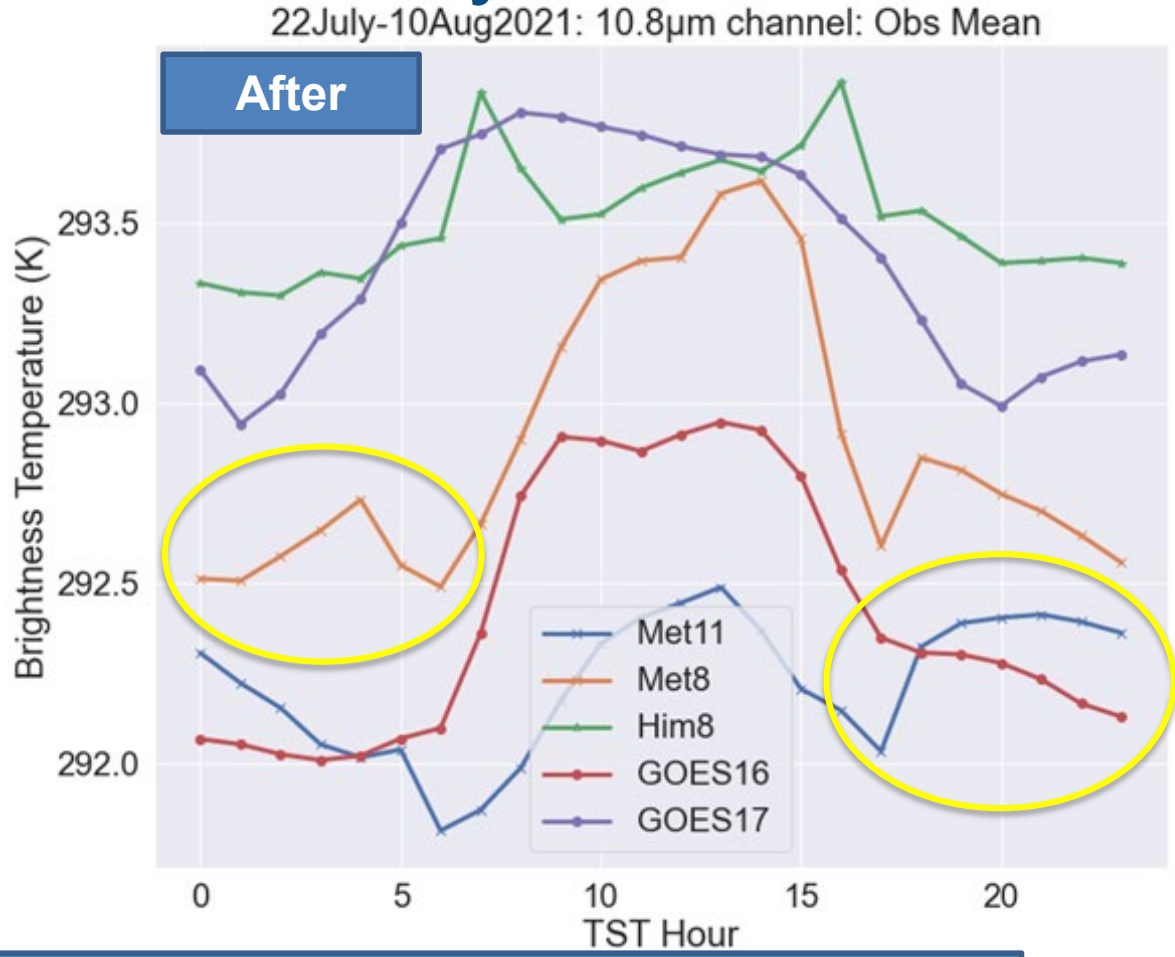


Radiance differences are due solely to differences between sensors

The radiative transfer model can correctly simulate the GEO Window channel observations and is not responsible for the diurnal cycle of the bias

Reduced jumpiness in the observations at dawn and dusk following EUMETSAT increased temporal resolution of the RTM to Met-11 & Met-8 on 21 July 2021



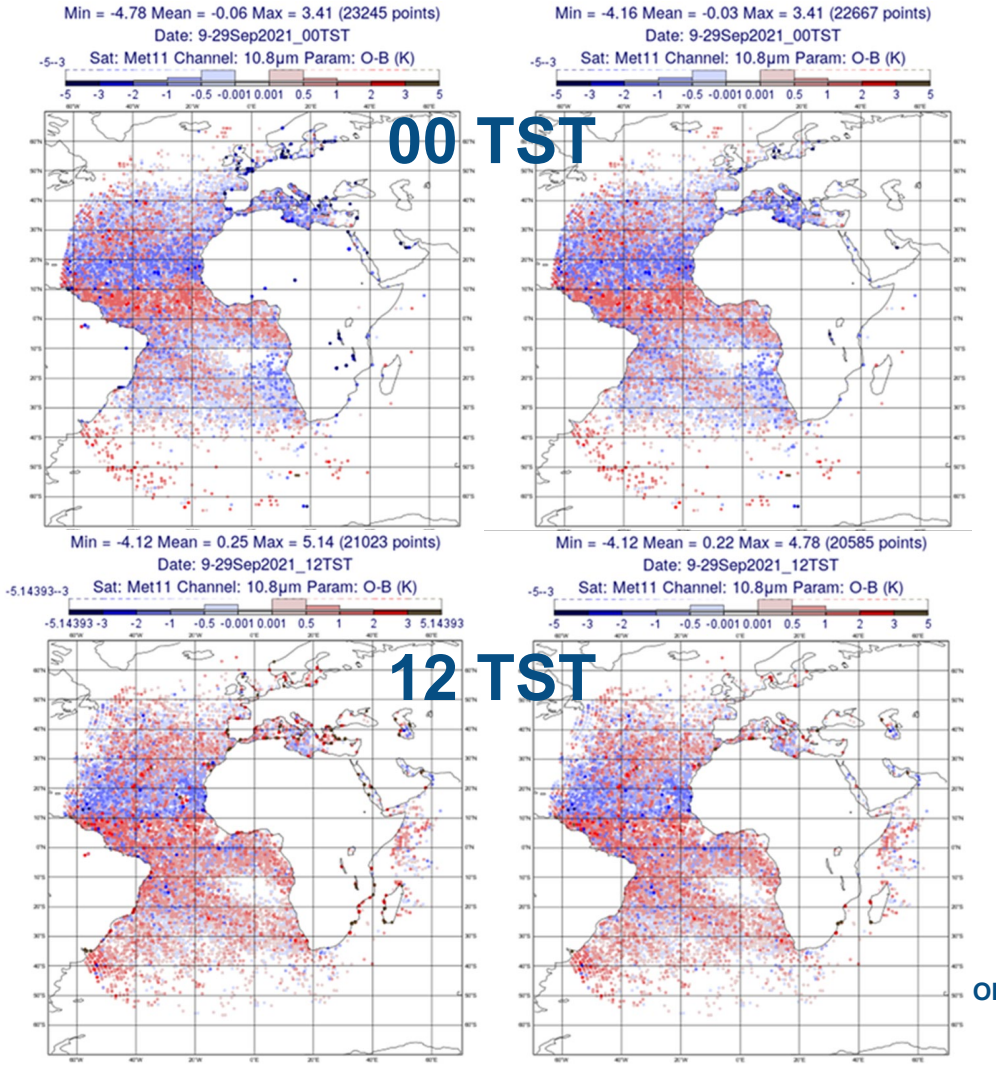


There is still scope for further improvement of SEVIRI in the near future, when moving from 6h to 3h forecast as input data (Arthur de Smet)

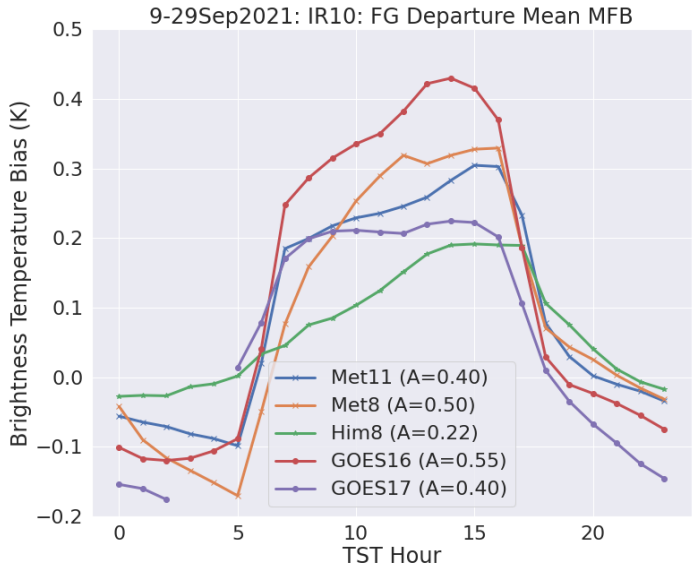
Coastline pixels with large departures can be removed by applying a more stringent Land Sea Mask filtering

Operational Config (lsm<0.5)

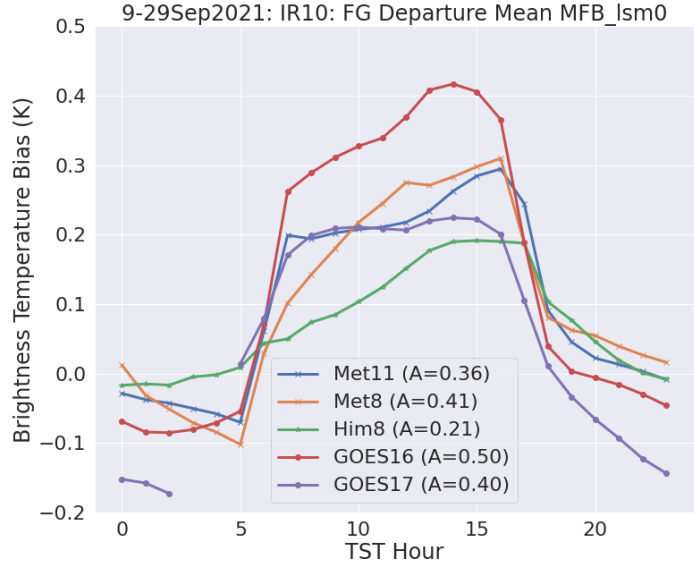
Removing coastlines (lsm=0.0)



Operational Config (lsm<0.5)



Removing coastlines (lsm=0.0)

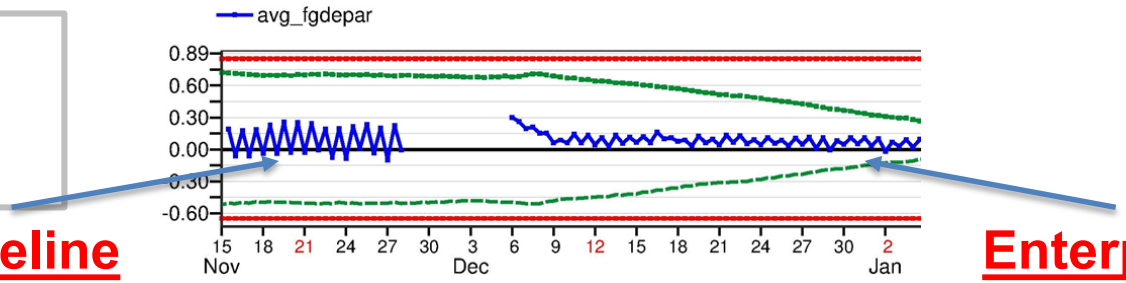


Sat	N (lsm>0)	Total	% (lsm>0)
Met-11	11624	496483	**2.34%**
Met-8	12633	327369	**3.86%**
Him-8	1188	687847	**0.17%**
GOES-16	28342	1282955	**2.21%**
GOES-17	1949	1800355	**0.11%**

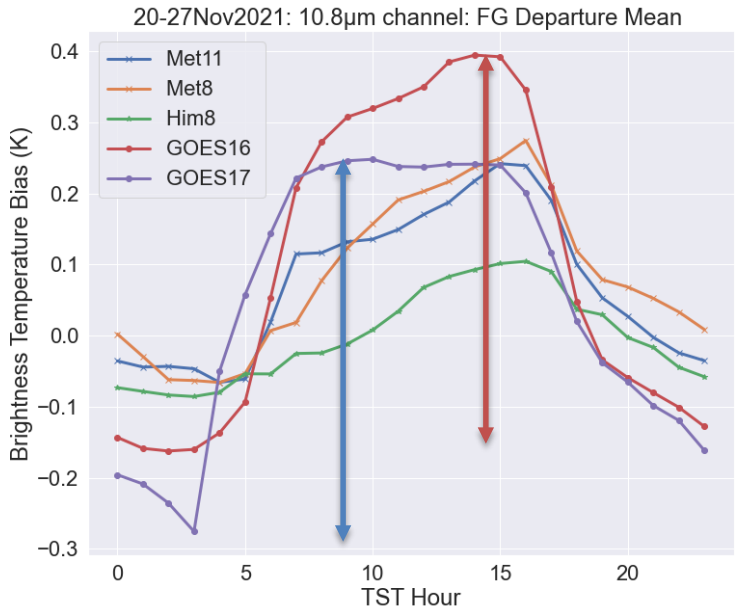
Slight reduction of the window channel diurnal cycle amplitude by removing model coastlines

GOES-16/-17 Enterprise Cloud Mask greatly reduce the Window Channel diurnal cycle amplitude over Ocean

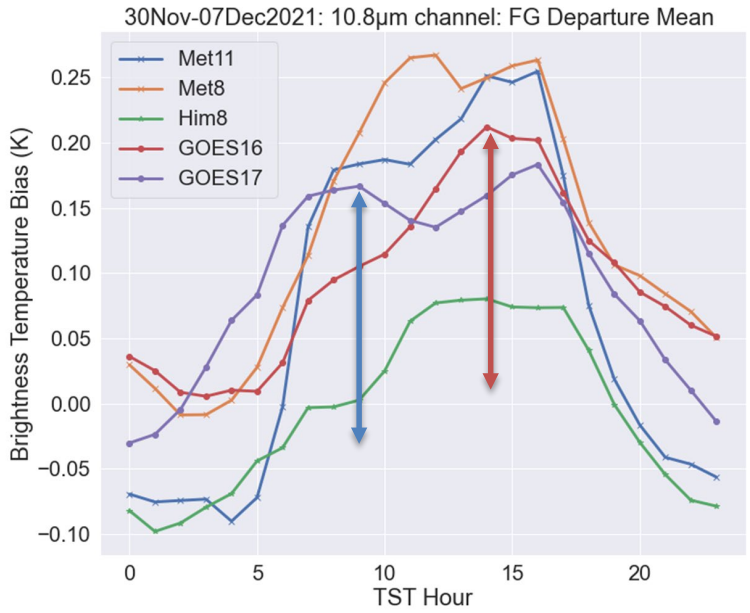
NOAA changed their Cloud Mask processing from Baseline to Enterprise on 29Nov2021 19UTC



Baseline

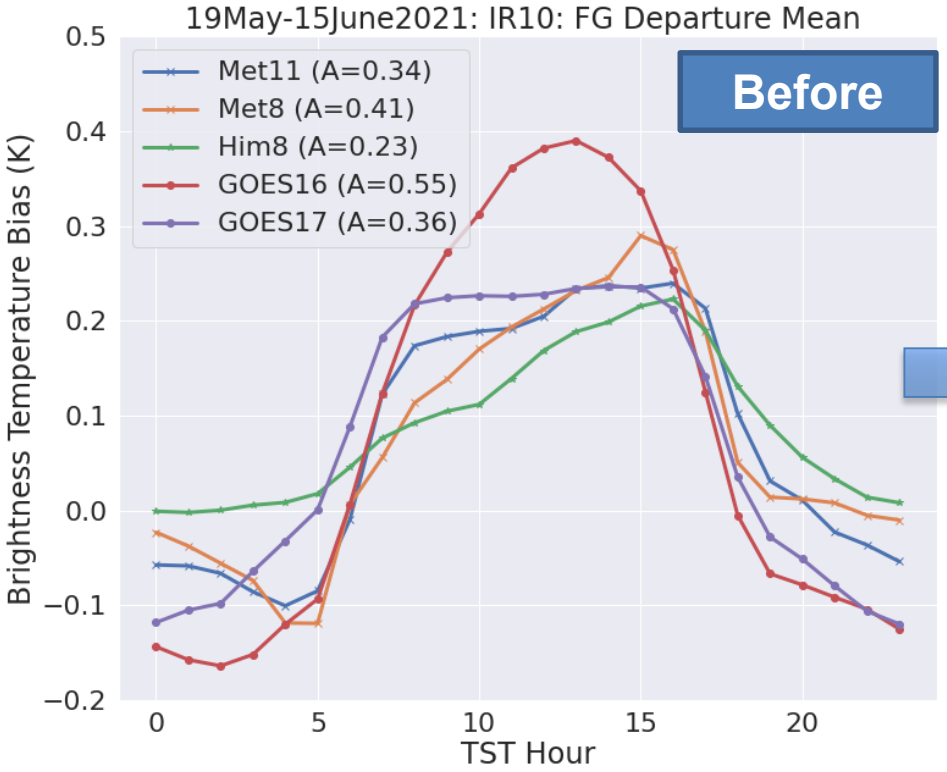


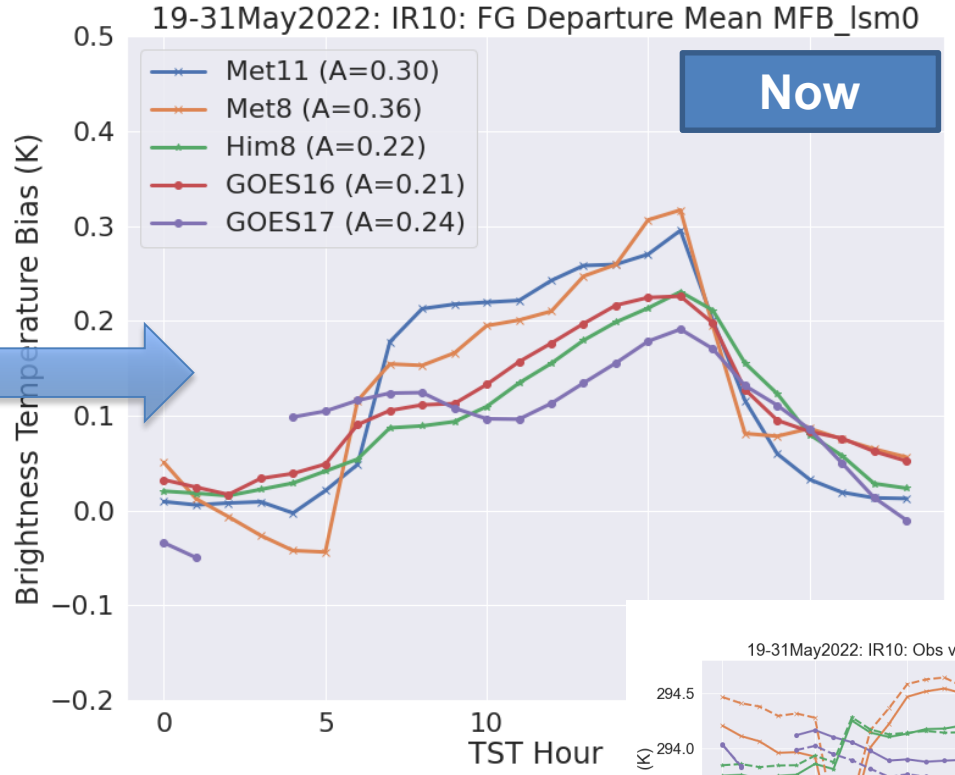
Enterprise



Diurnal cycle amplitude in the Window Channel **reduced from 0.5 K to 0.2 K** for both GOES-16/17

GEO Window Channel observations have benefitted of a year of operational changes and research but are reaching a saturation point – time to improve the model



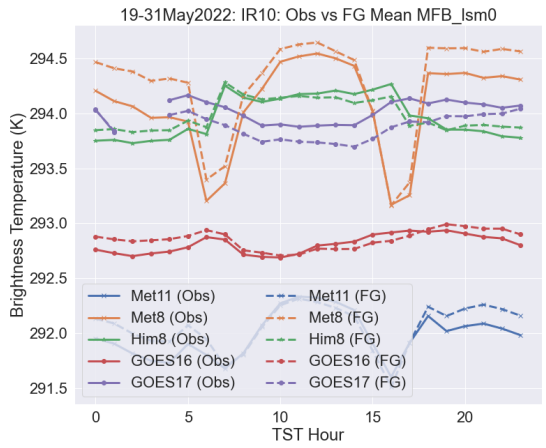


Diurnal cycle amplitude in the Window Channel **reduced up to more than 50%** for the GOES.

Smaller reduction for the Meteosats.

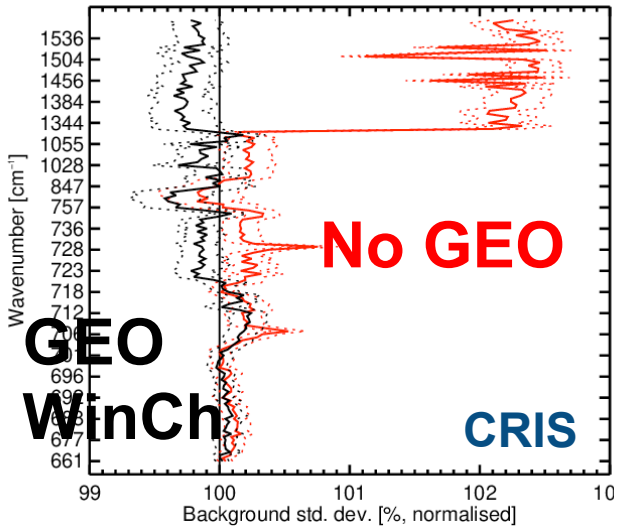
Smallest benefit for Himawari.

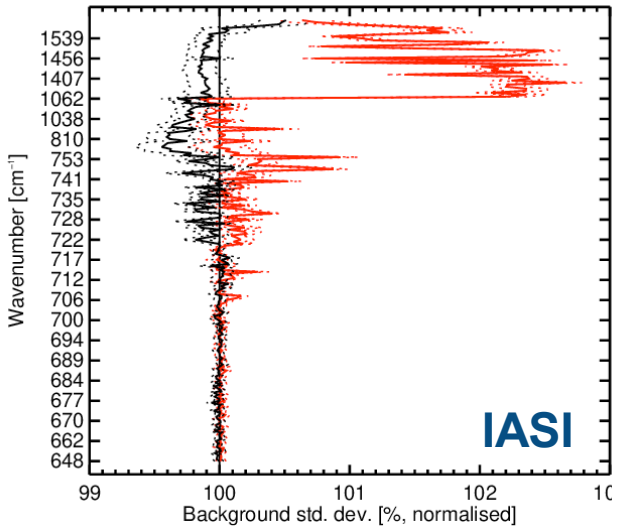
SEVIRI observations could still be improved … or just wait for FCI

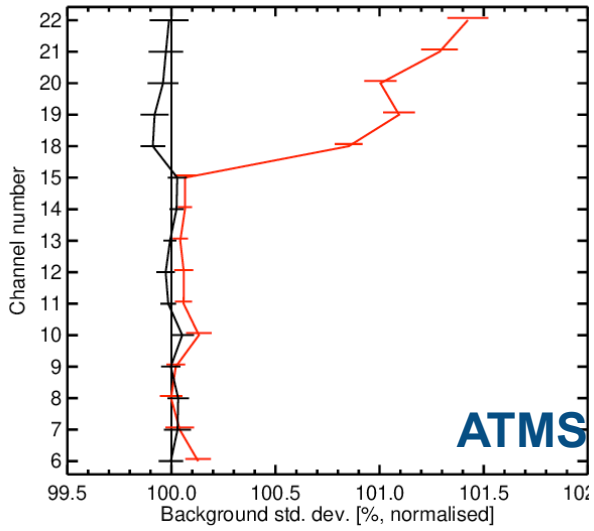


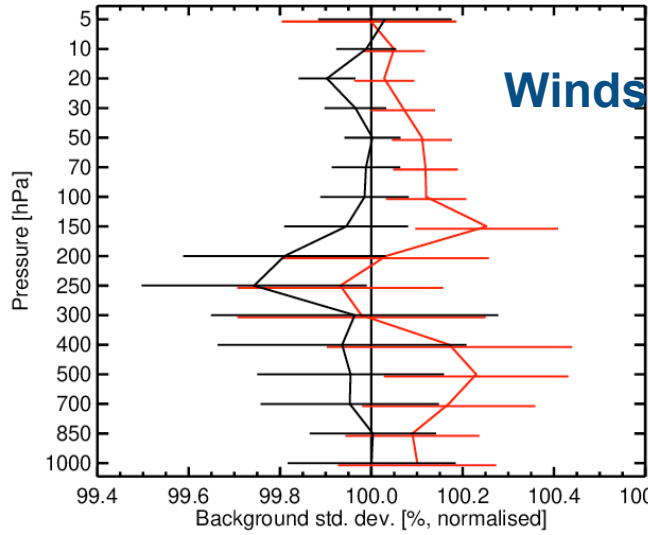
Assimilation of the GEO Window Channel (in the current context – CY47R3) further improves operational GEO assimilation

Operations





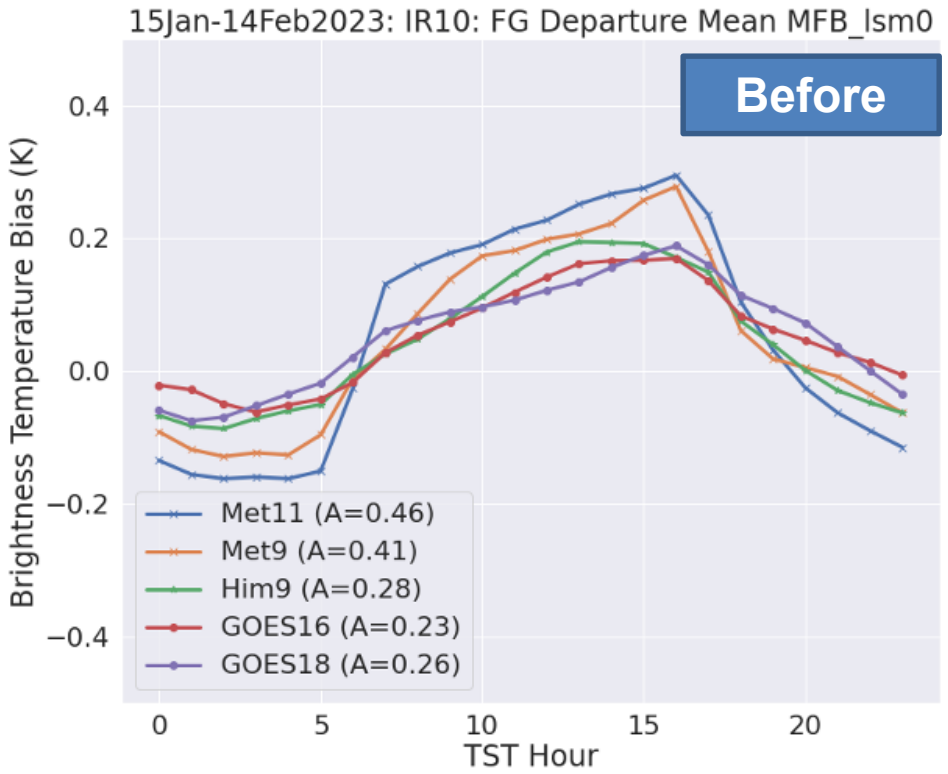




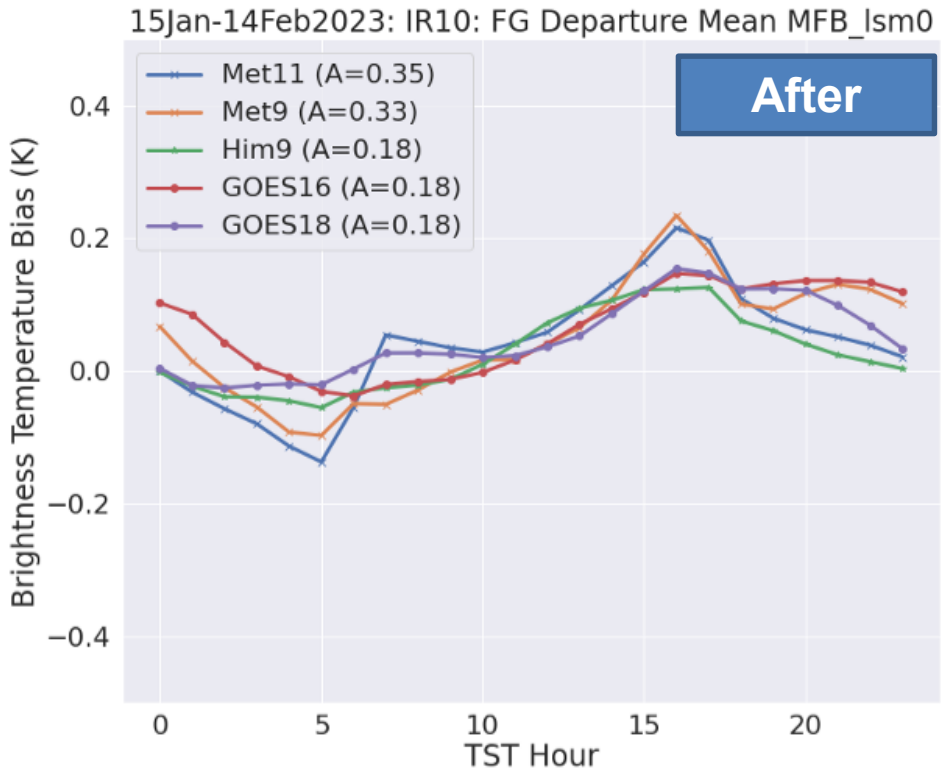
Preliminary Experiment (1 March – 31 May 2022)
There is still scope for further improvement

Bias correcting the GEO Window Channel observations for solar zenith angle removes the solar signature from the diurnal cycle leaving the surface temperature cycle

Preliminary Result based on CY48R1 (just out of the oven) – Still needs to be better understood



Bias Correction for SolZen



Conclusions

- Initially, we had a large systematic diurnal mismatch between the model and the GEO data
- With improvements made by data providers (improved cloud masking applied to the data and increased temporal resolution of the RTM calculations) and more stringent pixel selection the amplitude of the diurnal cycle is reduced
- In the current context, assimilation experiments including the GEO Window Channel show positive improvement
- The remaining bias is still important and likely a diurnal error in the model that should be investigated.
- This could prove extremely significant as the ocean surface temperature (SST) is an important driver of NWP forecast skill

Thanks for your time

Any questions?

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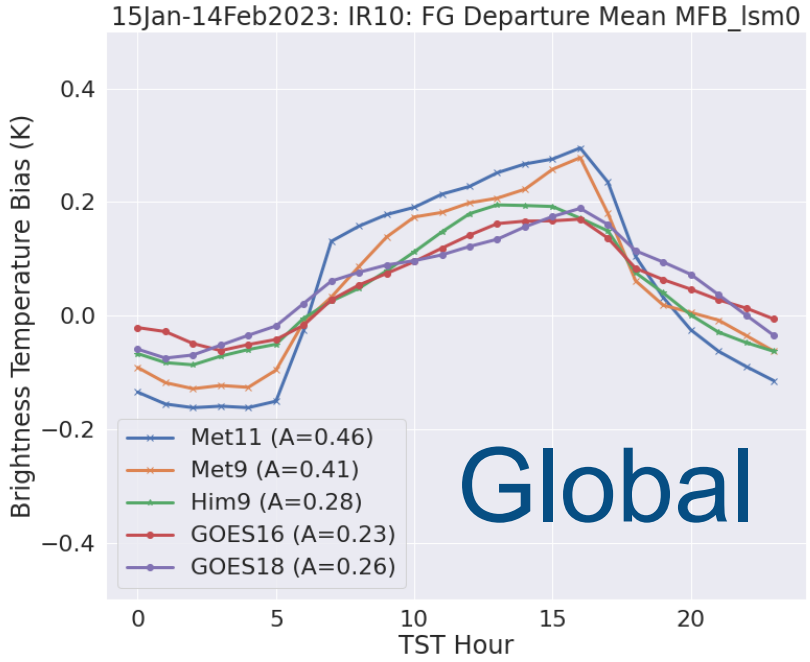
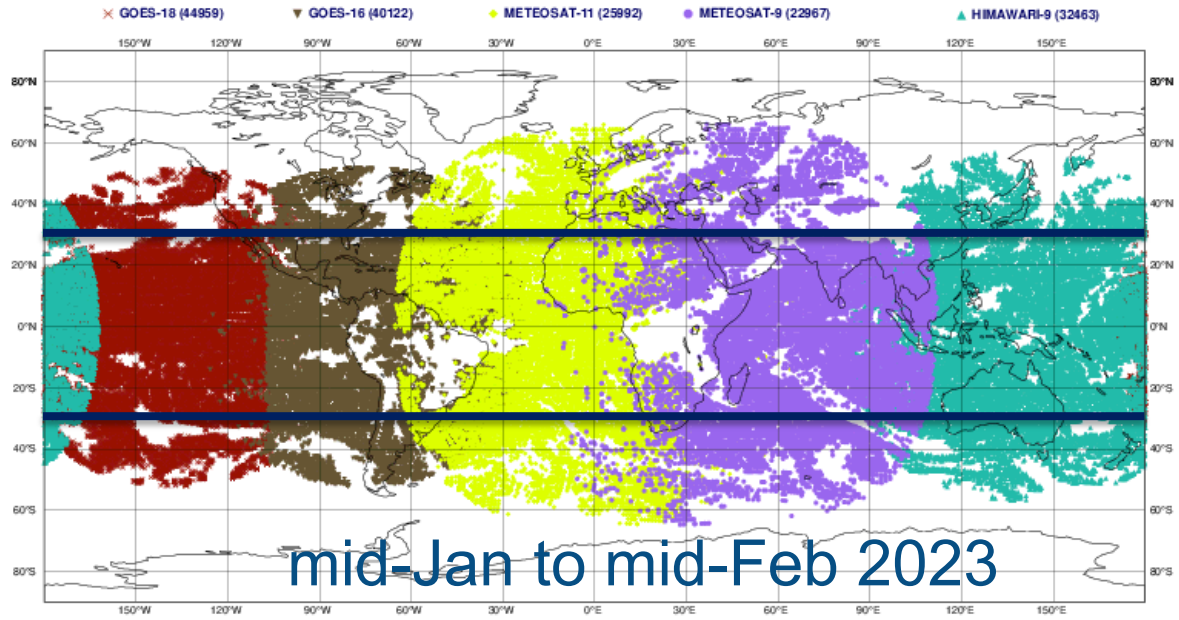
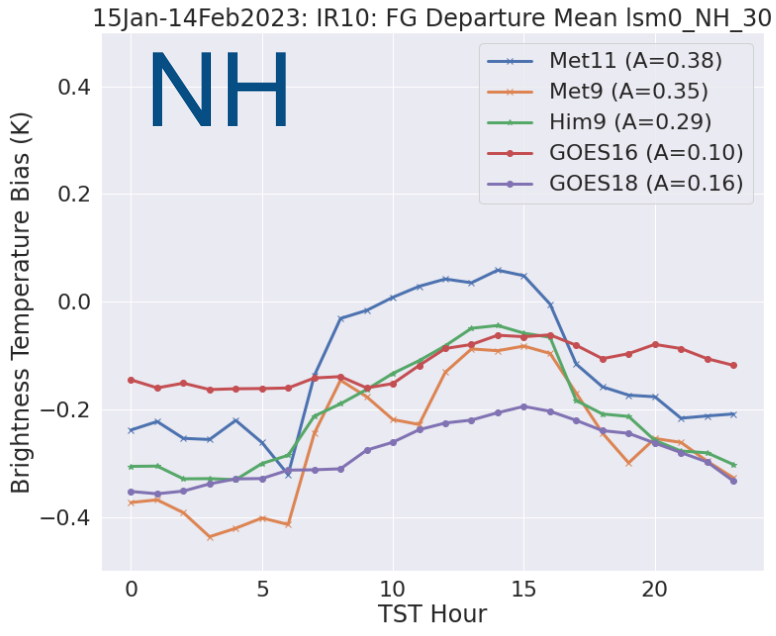
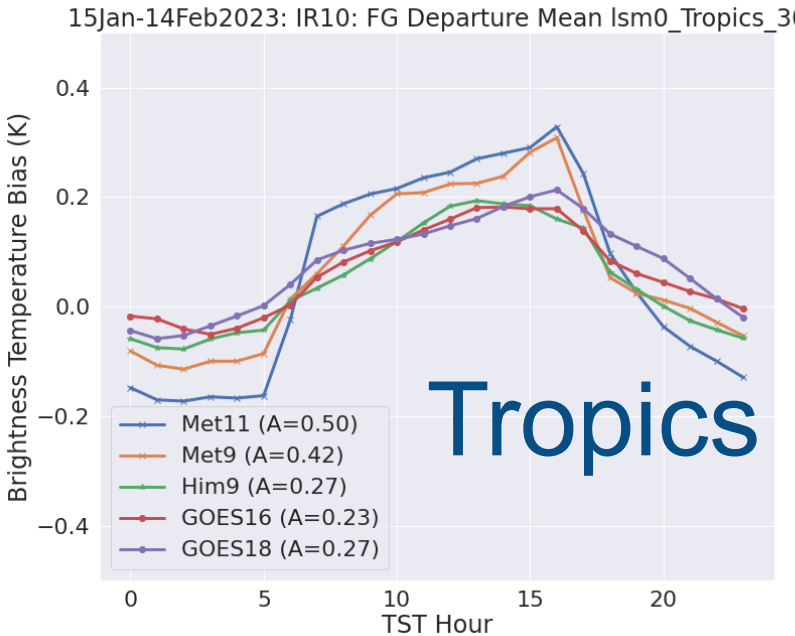
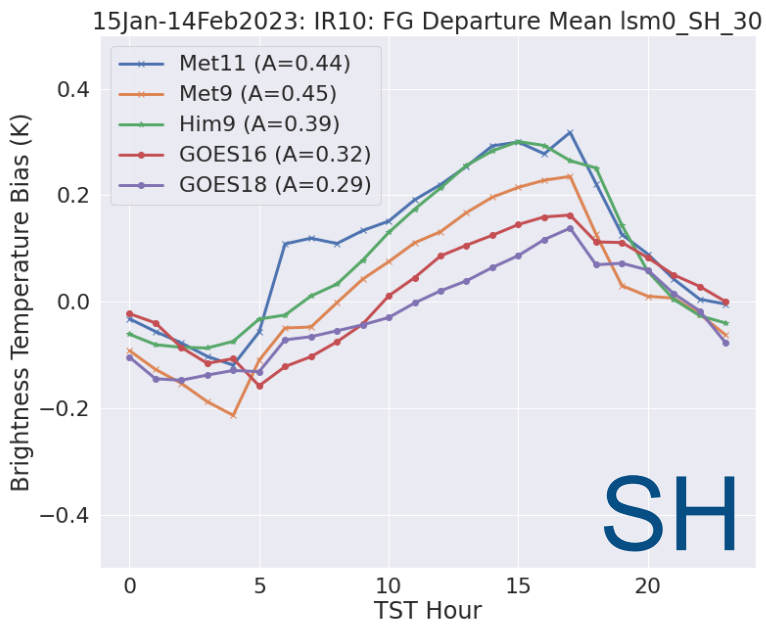
Window Channel diurnal cycle zonal variation over Ocean



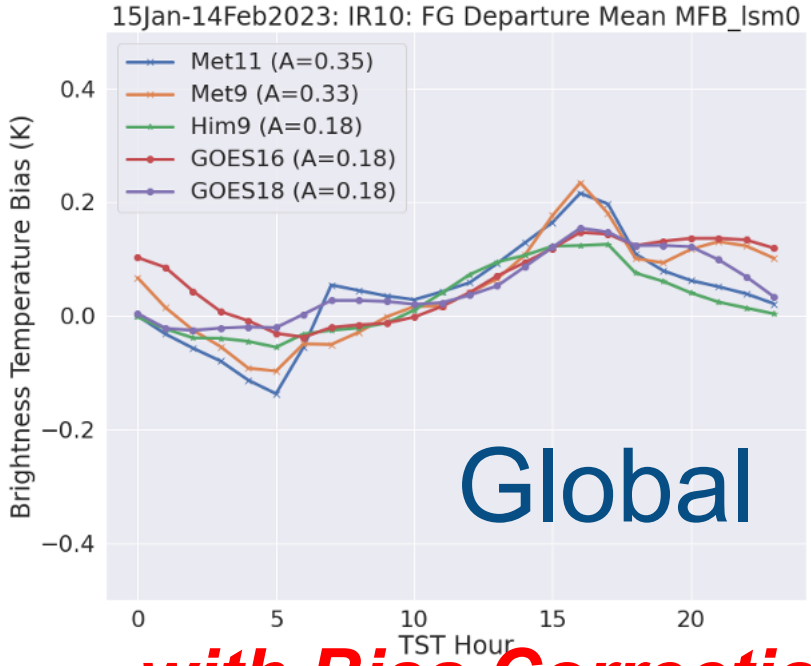


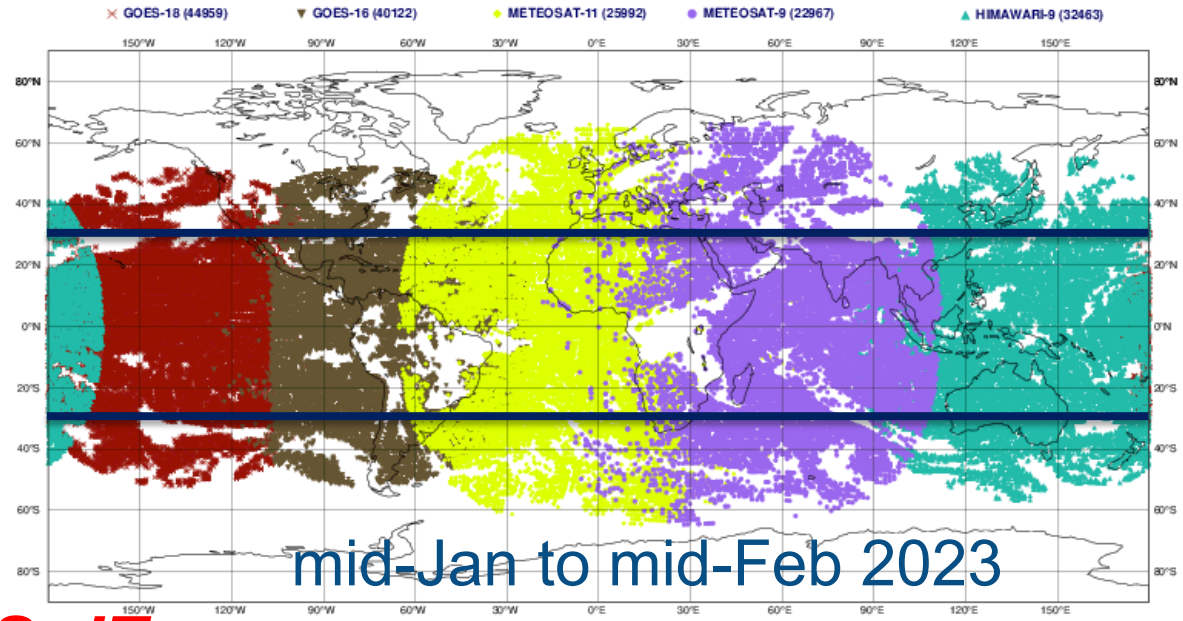






Window Channel diurnal cycle zonal variation over Ocean …





… with Bias Correction for SolZen