GEO imager's IR channel bias monitoring at ECMWF

GSICS IR group Web meeting – 21 July 2022

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Thanks to

EUMETSAT Fellowship

Tony McNally, Chris Burrows, Cristina Lupu, Mohamed Dahoui, Marco Matricardi, Kirsti Salonen (ECMWF)

Tim Hewison, Arthur de Smet (EUMETSAT)

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

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ECMWF

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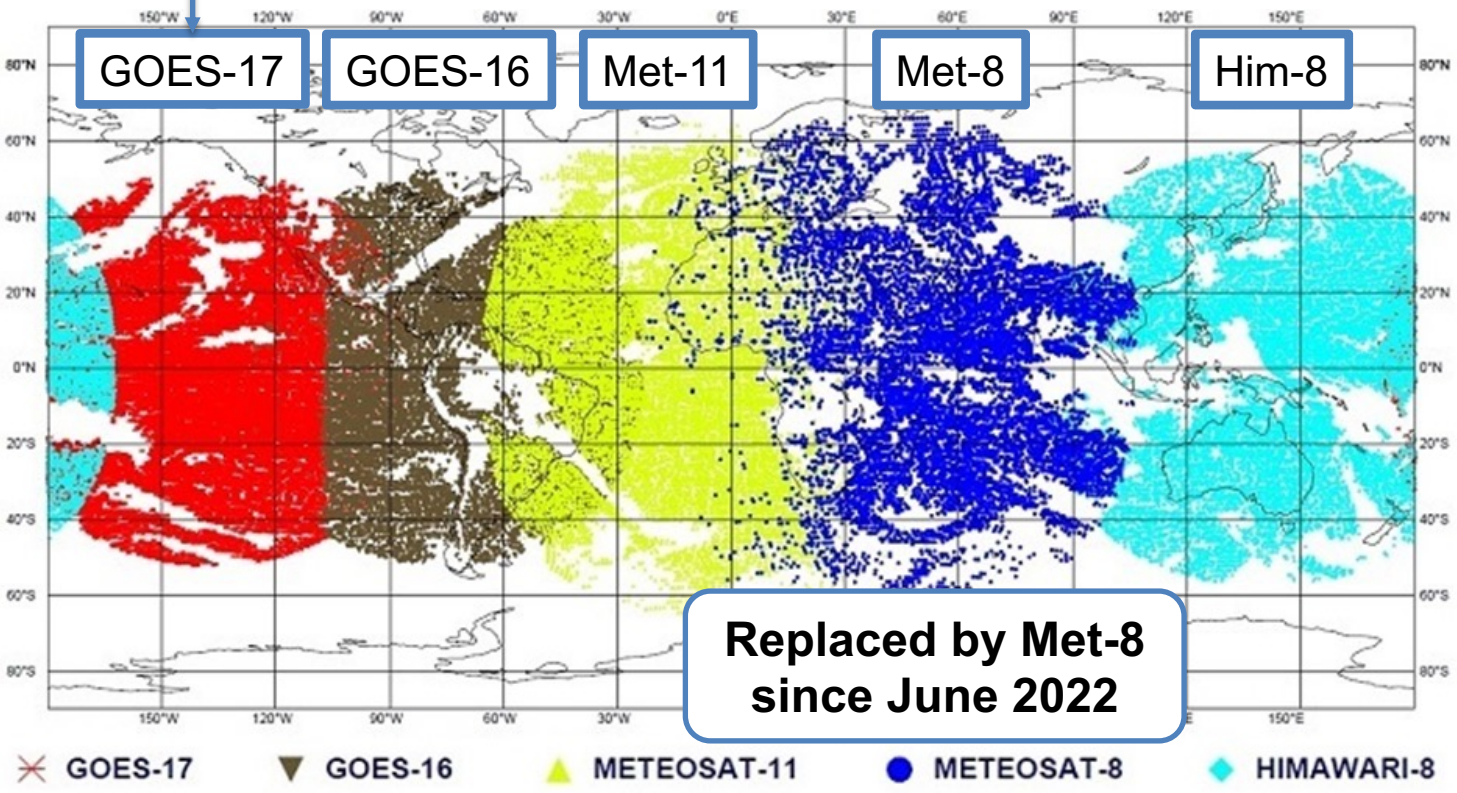
Part I: Further exploiting GEO Window Channel radiance observations

Part II: Met-9 take over Met-8 for the IODC

Part I: Further exploiting GEO Window Channel radiance observations

Geostationary radiances observations currently used in operations at ECMWF



Data coverage for geostationary radiances used at ECMWF from 21 UTC on 8 February 2022 to 3 UTC on 9 February 2022

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

Sat.	Met-11	Met-8	Him-8	GOES-16	GOES-17
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.**

- 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

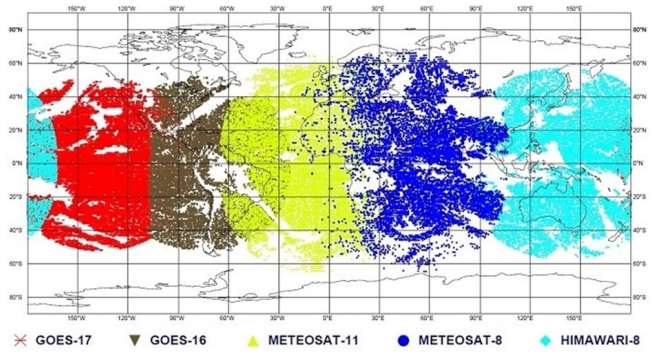
GEO Window Channels are similar but with differences

Different instruments

Different products

Satellite	Met-11	Met-8	Him-8	GOES-16	GOES-17
Instrument	SEVIRI		AHI	ABI	
Product	ASR		CSR	CSR	
Longitude	0.3°W	41.5°E	140.7°E	75.2°W	137.2°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

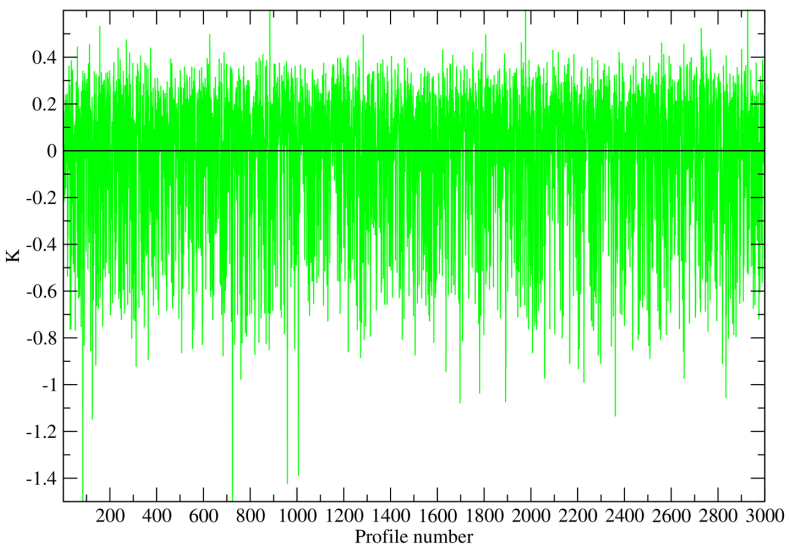
How do the GEO Window Channel differences translate into radiance space

Marco Matricardi

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

SEVIRI - ABI

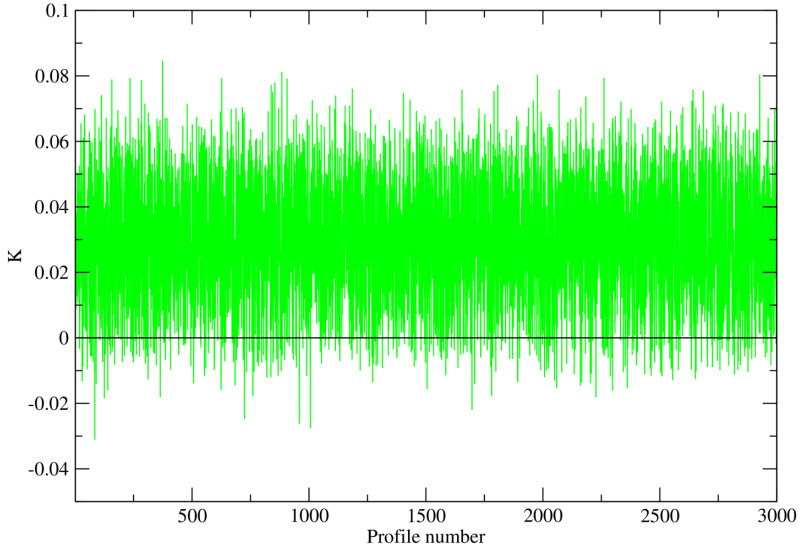
METEOSAT-11 minus GOES-16



< 1.0K

ABI - ABI

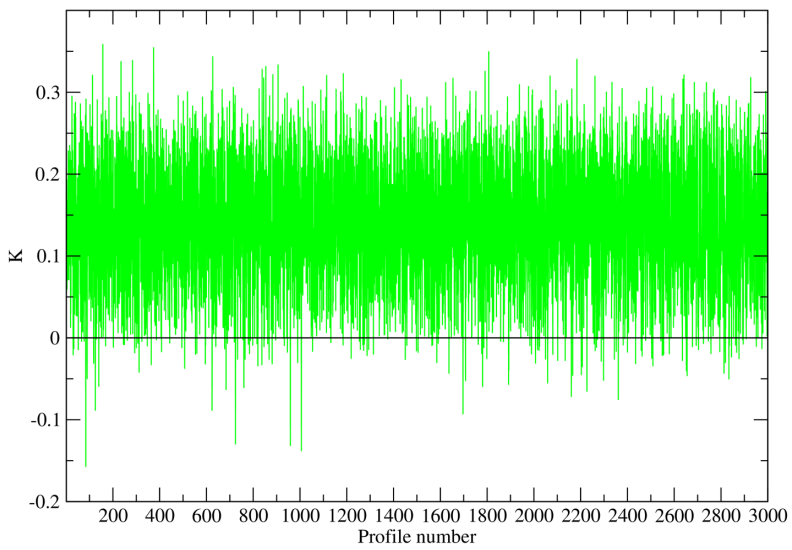
GOES-16 minus GOES-17



< 0.1K

AHI - ABI

HIMAWARI-8 minus GOES-16



< 0.3K

Radiance differences are due solely to differences between sensors

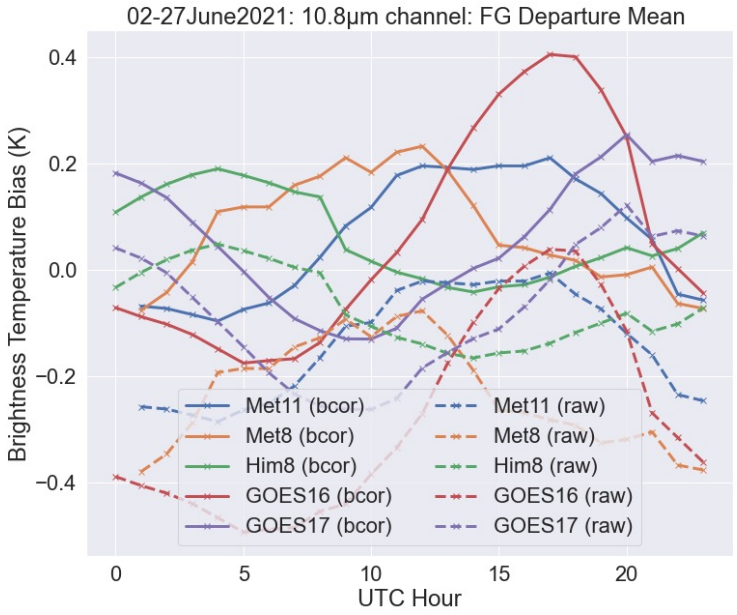
GEO Window Channel monitoring

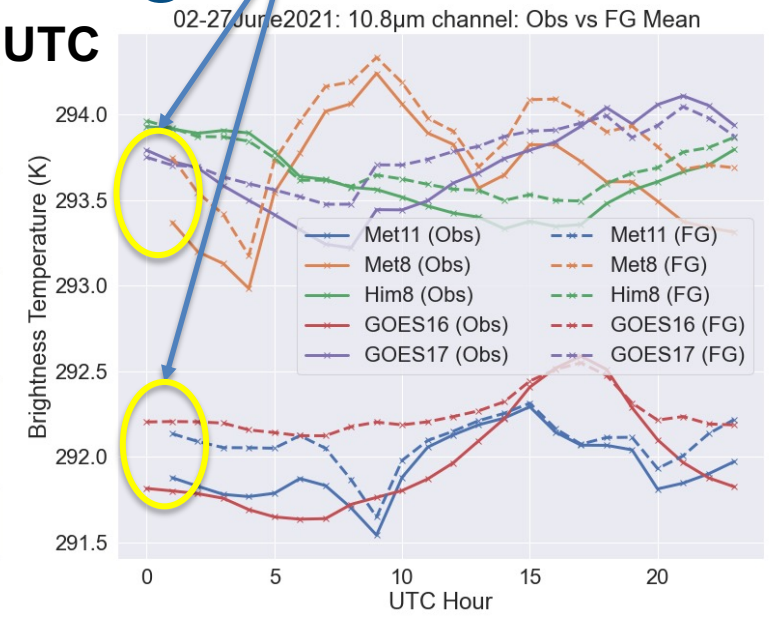
00 UTC missing for Met-11 & Met-8

Solar time is preferred for comparisons

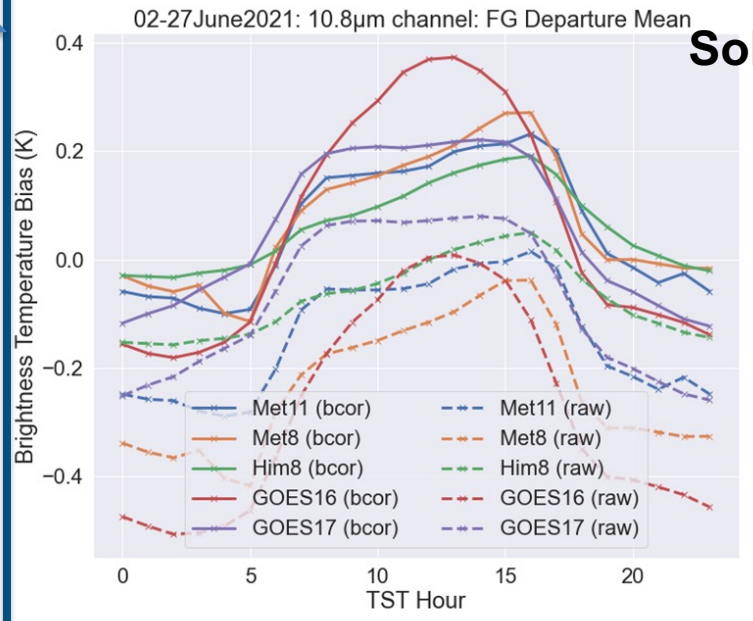
Bias correction has no effect over the diurnal cycle

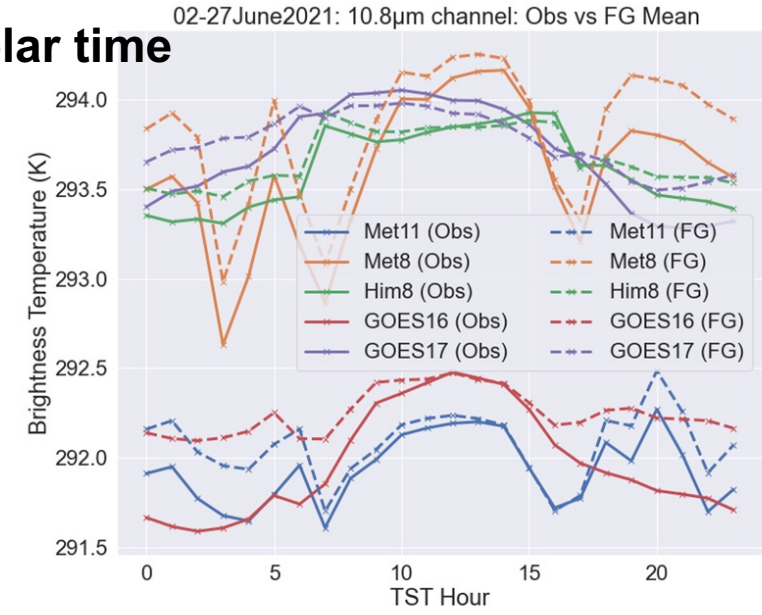
UTC





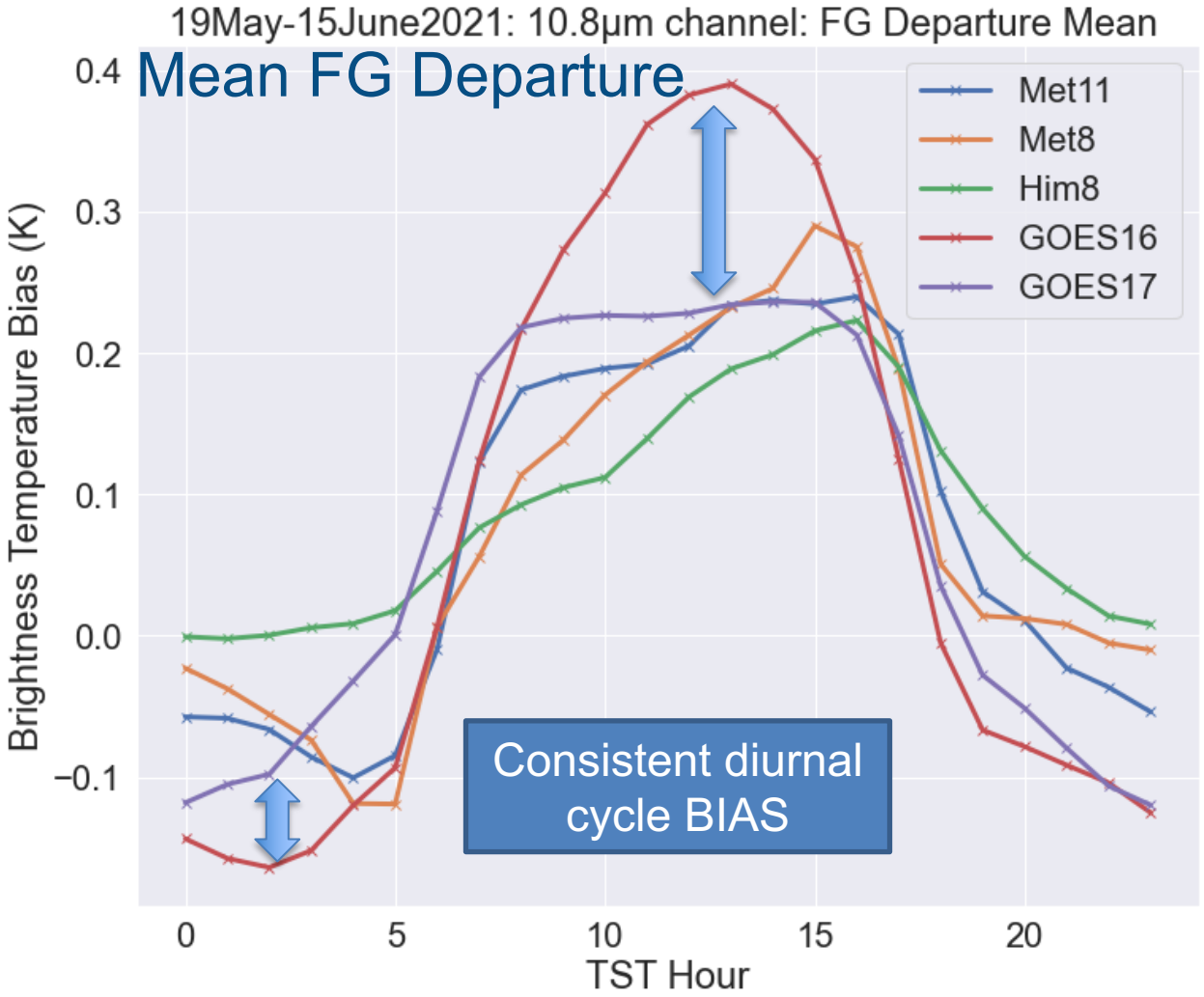
Solar time





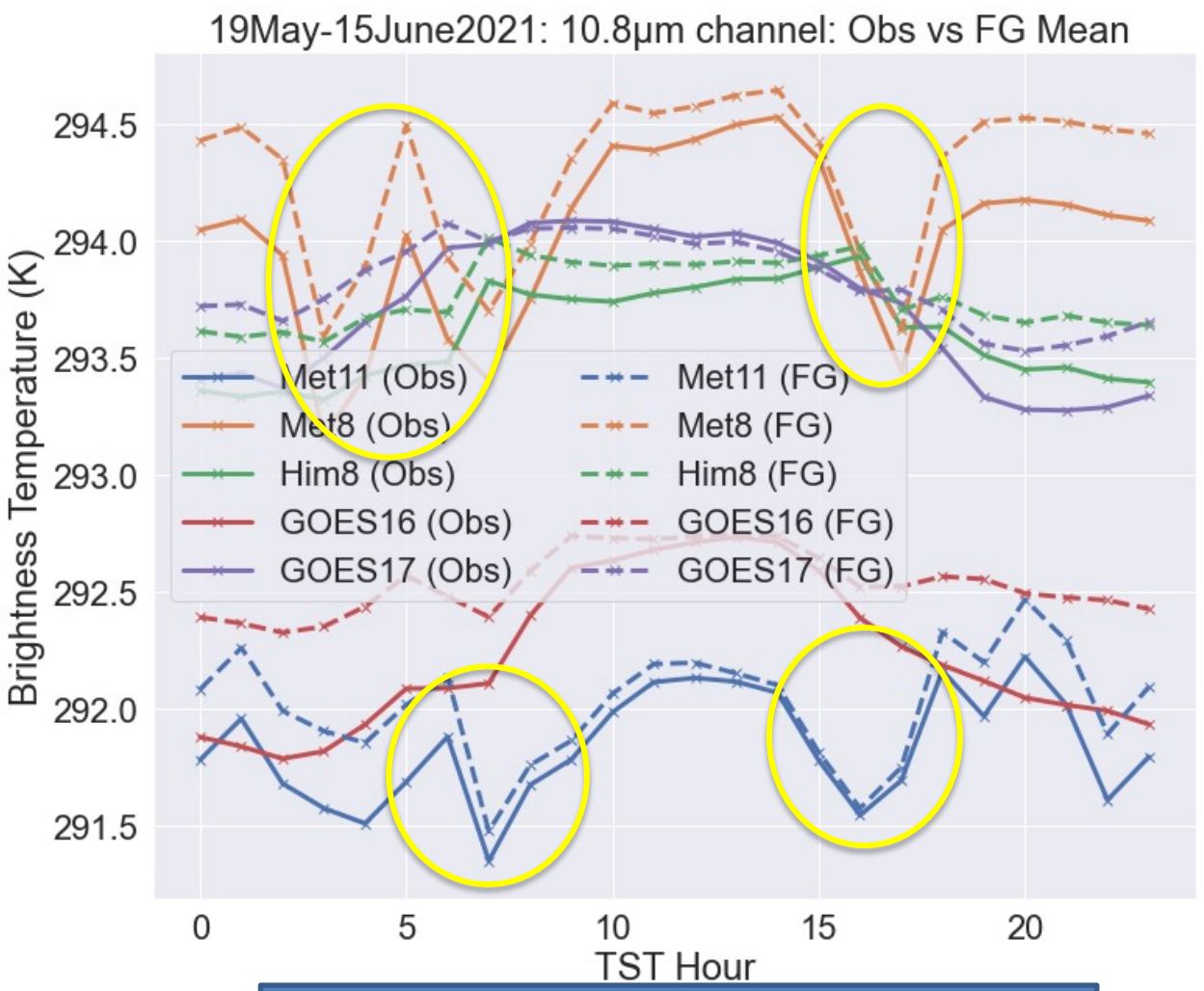
GEO Window Channel monitoring

Mean FG Departure



Discrepancies shown in GOES-16 vs GOES-17

Mean Obs vs FG



Obs&FG BT jumpiness at sunrise and sunset for both Met-8 and Met-11 ASR
Not seen for G16,G17,Him-8 CSR

EUMETSAT changes to SEVIRI Met-11 & Met-8 (21 July)

1. ***incorrect observation times***. *The reported times are* ***15 minutes too late***
2. ***improvement in the temporal resolution of the Radiative Transfer Model*** *(RTM) calculations. This* ***will especially improve the identification of cloudy and clear-sky pixels in dawn and dusk areas***

Before

```
netview/GEO >odbsql -q "select time,timeslot,count(*)
        where reportype=4023" -i MFB_0001_LWDA_20210721_geos.odb
      time@hdr  timeslot@timeslot_index       count(1)
000 2021-07-22 18:06:40 (I) SELECT has aggregated and non-aggregated results
         10000                         9 9052.0000000000000000
         20000                        11 8934.0000000000000000
         30000                        13 8754.0000000000000000
         40000                        15 8849.0000000000000000
         50000                        17 8497.0000000000000000
         60000                        19 8135.0000000000000000
         70000                        21 7345.0000000000000000
         80000                        23 7047.0000000000000000
         90000                        25 6565.0000000000000000
        220000                         3 9005.0000000000000000
        230000                         5 9155.0000000000000000
000 2021-07-22 18:06:41 (I) Matching row(s): 11 out of 867,967
000 2021-07-22 18:06:41 (I) Skips: 776,629
000 2021-07-22 18:06:41 (I) Execute: 0.93696 second elapsed, 0.936845 second cpu
```

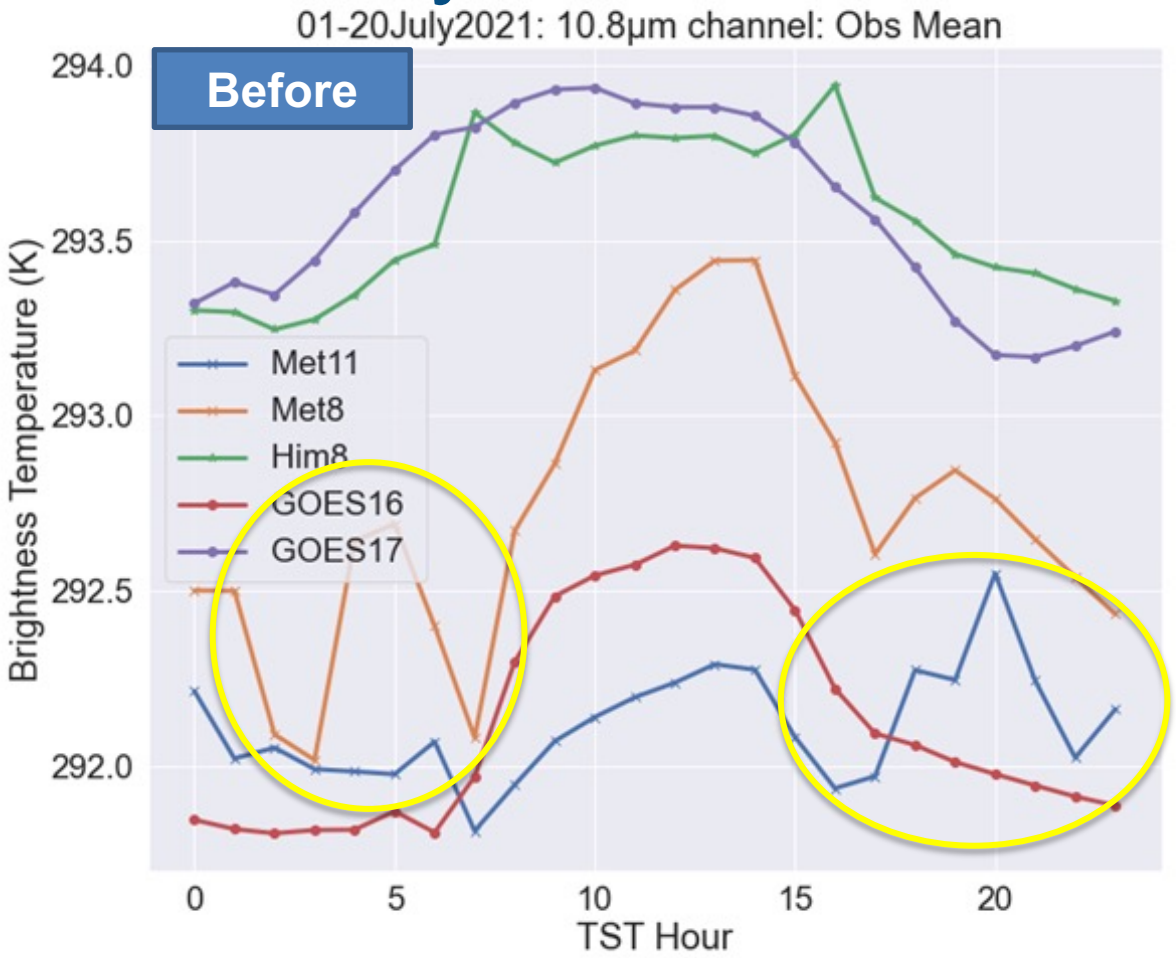
After

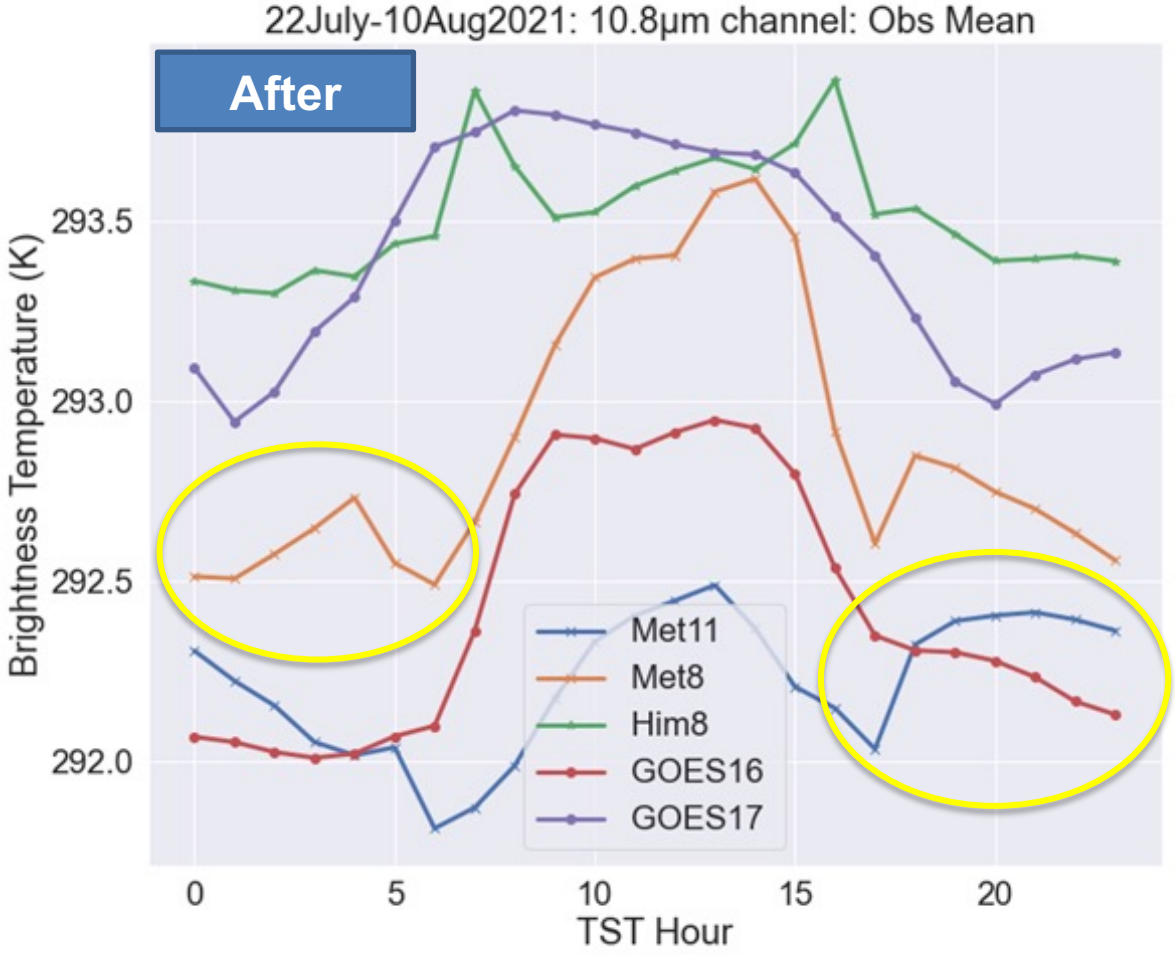
```
netview/GEO >odbsql -q "select time,timeslot,count(*)
e reportype=4023" -i MFB_0001_LWDA_20210722_geos.odb
      time@hdr  timeslot@timeslot_index       count(1)
000 2021-07-22 18:06:48 (I) SELECT has aggregated and non-aggregated results
          4500                         8 8807.0000000000000000
         14500                        10 8657.0000000000000000
         24500                        12 8417.0000000000000000
         34500                        14 8517.0000000000000000
         44500                        16 8303.0000000000000000
         54500                        18 7961.0000000000000000
         64500                        20 7063.0000000000000000
         74500                        22 6884.0000000000000000
         84500                        24 6455.0000000000000000
        214500                         2 9040.0000000000000000
        224500                         4 9116.0000000000000000
        234500                         6 8989.0000000000000000
000 2021-07-22 18:06:49 (I) Matching row(s): 12 out of 815,275
000 2021-07-22 18:06:49 (I) Skips: 717,066
000 2021-07-22 18:06:49 (I) Execute: 0.946554 second elapsed, 0.945681 second cpu
```

Benefits:

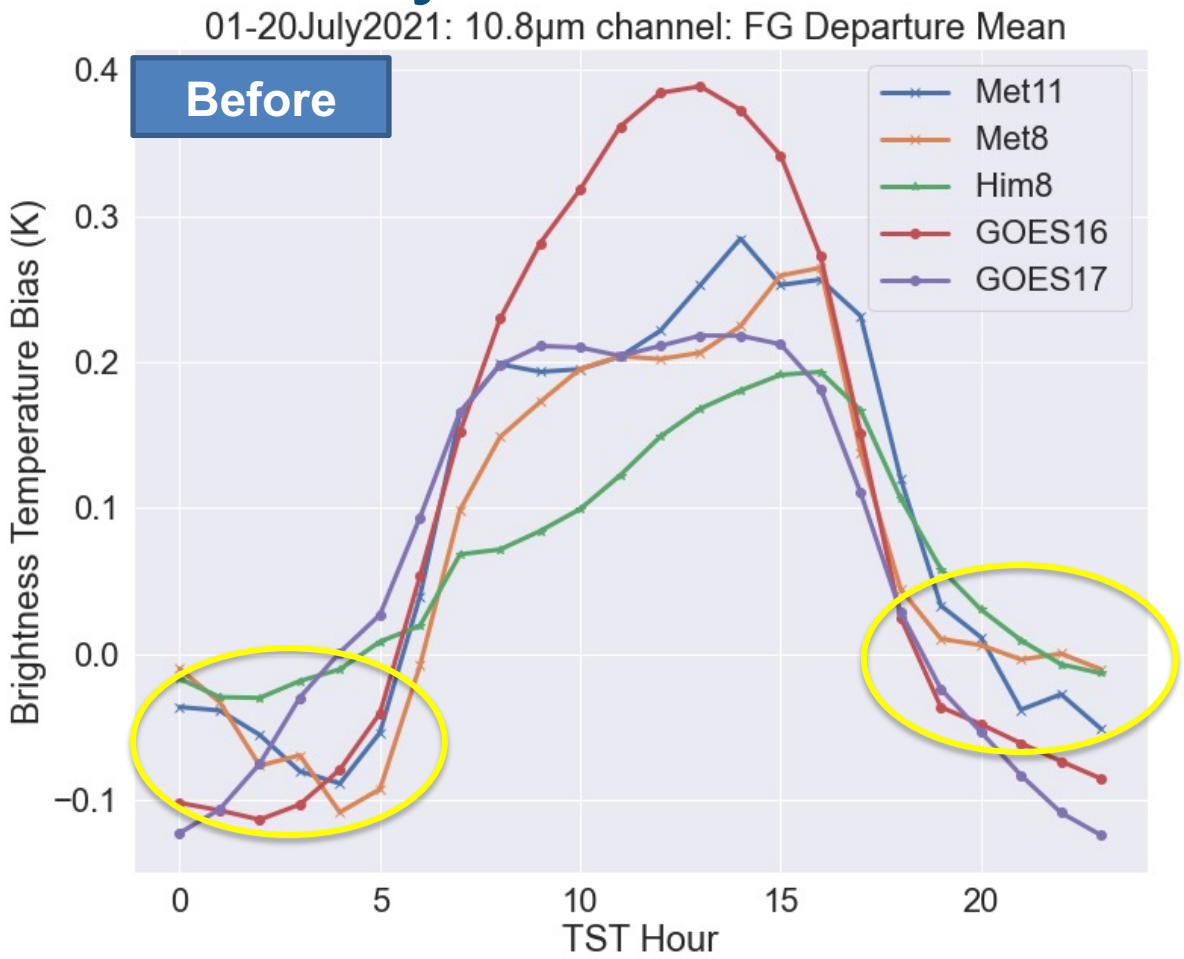
- Having **1h extra of observations** (before only 23 hours)
- **More accurate observation time**: Temporal shift of 15 minutes of all observations -> timeslot shift of 30min
- **Improved temporal resolution in the RTM calculations**

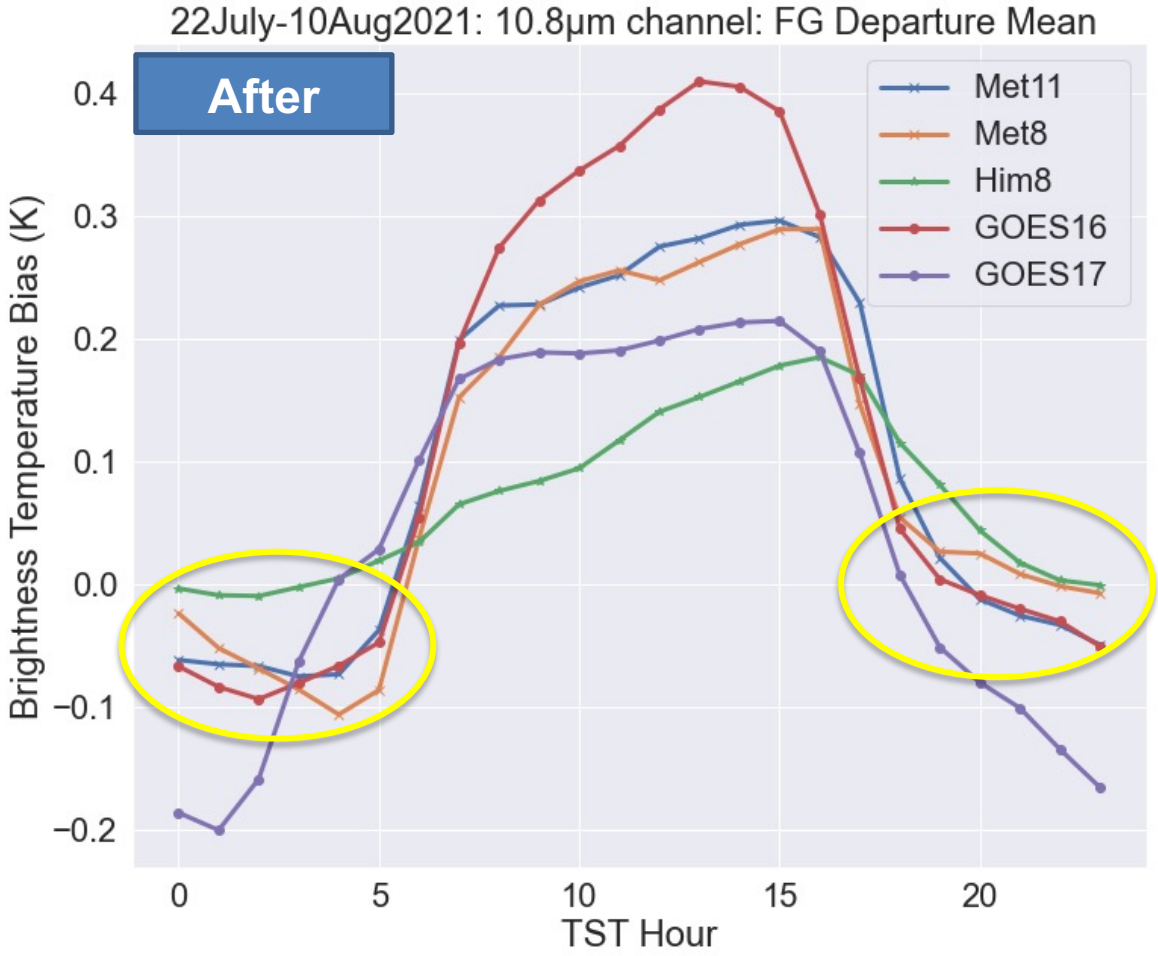
Reduced jumpiness in the observations at dawn and dusk following EUMETSAT changes to Met-11 & Met-8 on 21 July 2021





Reduced jumpiness in the FG departures at dawn and dusk following EUMETSAT changes to Met-11 & Met-8 on 21 July 2021





EUMETSAT changes to SEVIRI Met-11 & Met-8 (21 July)

What are the changes to the temporal resolution of the RTM?

Arthur de Smet (EUMETSAT):

*We **used to run the RTM every 6 hours**, generating RTM tables for 00, 06, 12, and 18 UTC.*
The individual products relied on a linear temporal interpolation between these 4 validity times.
*We **now run the RTM every 15 minutes**, so for every image time. We don't need temporal interpolations anymore.*
*The **impact** on the products **is in general small**, but is **larger**:*

- *the further away the product time is from the two closest validity times.*
- *in **dawn and dusk** cases, where the temporal changes in surface parameters are largest.*

The main input to the RTM are the forecast data from the ECMWF. We are still using the forecasts with validity times of 00, 06, 12, and 18 UTC.
*We **plan to move to 3 hours forecast data** at the end of this year. We reckon that this **will result in further improvements** to our products.*

There is still scope for further improvement of SEVIRI in the near future

Coastlines pixels are subject to inconsistencies in Land or Sea classification between the observation and the model

Observation based Land Sea Mask is currently not provided, so we need to rely only on model based information

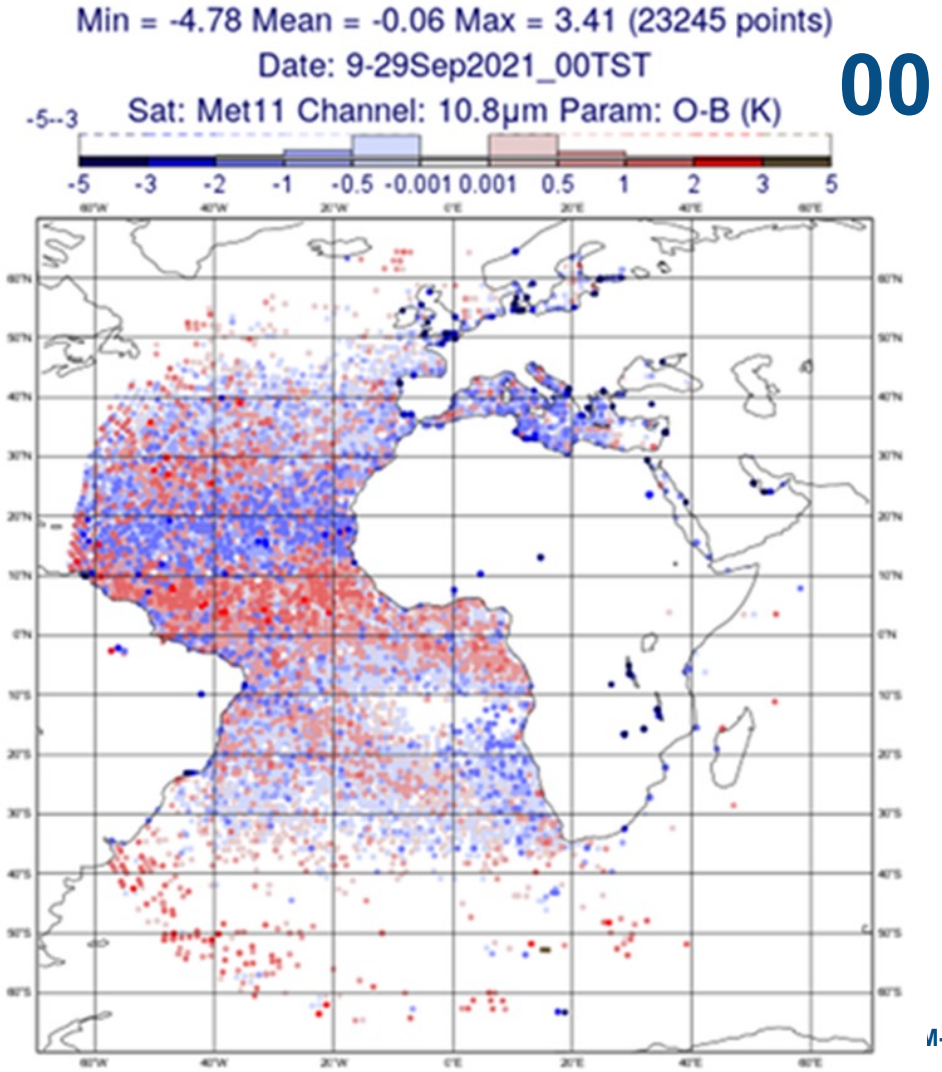
A solution to tackle to a large extend this issue has been proposed.

It is easy to implement but not perfect.

Large CSR footprint can still result in mixed land/sea scenes even though the LSM flag in the blacklist says the grid box is fully sea

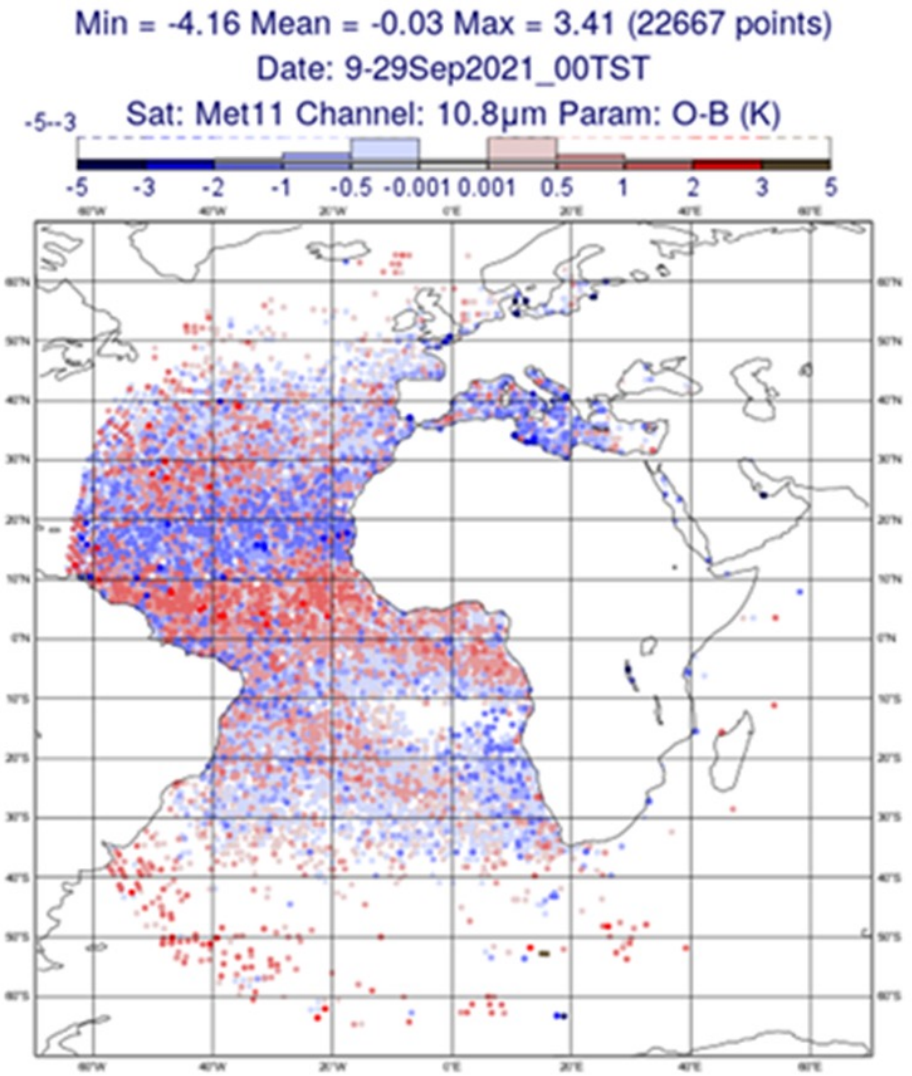
Coastline pixels with large departures can be removed by applying a more stringent Land Sea Mask filtering

Operational Configuration (lsm<0.5)



00 TST

Removing model coastlines (lsm=0)



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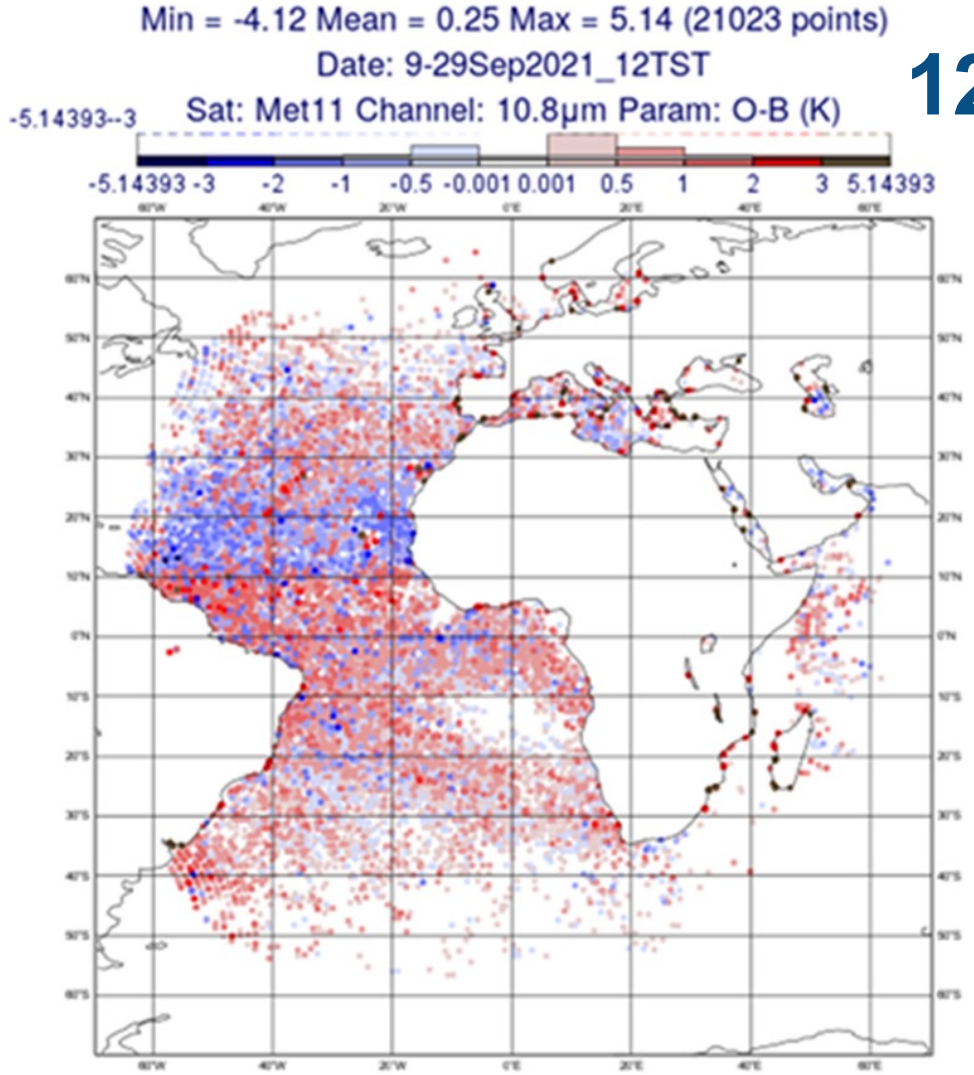
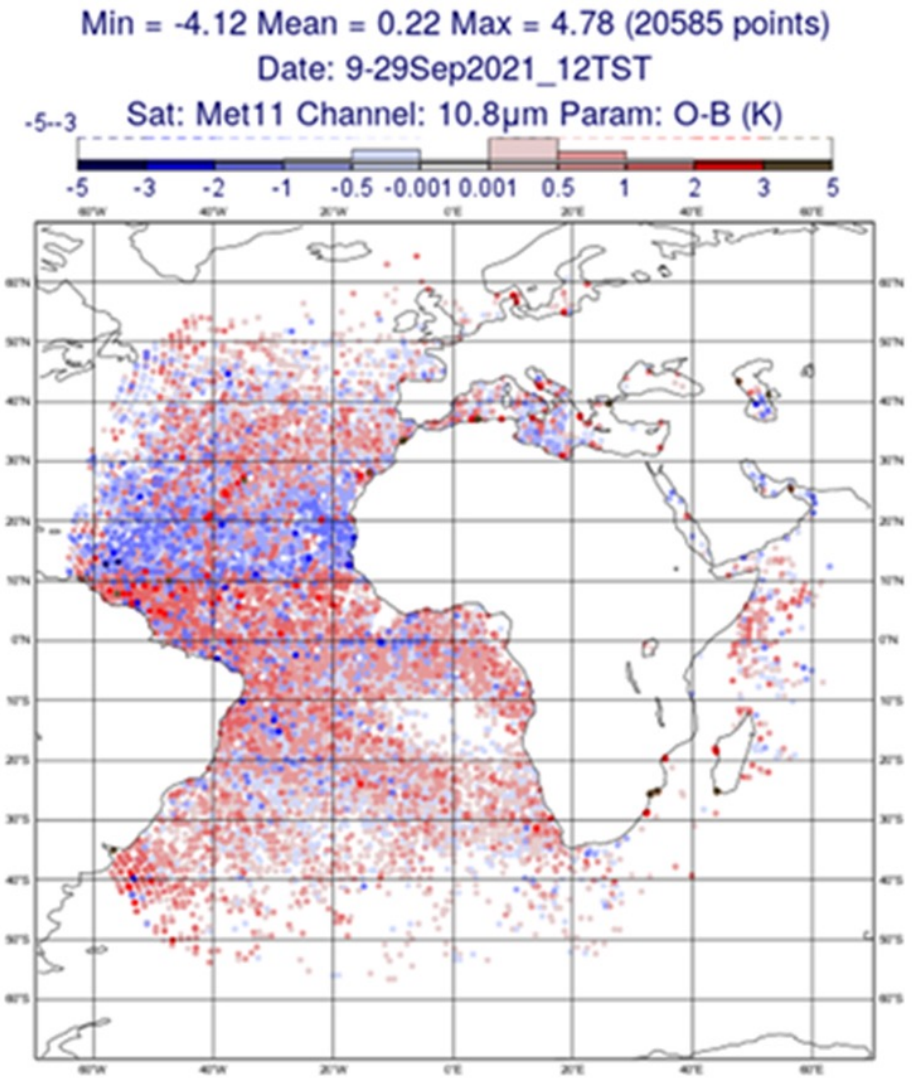


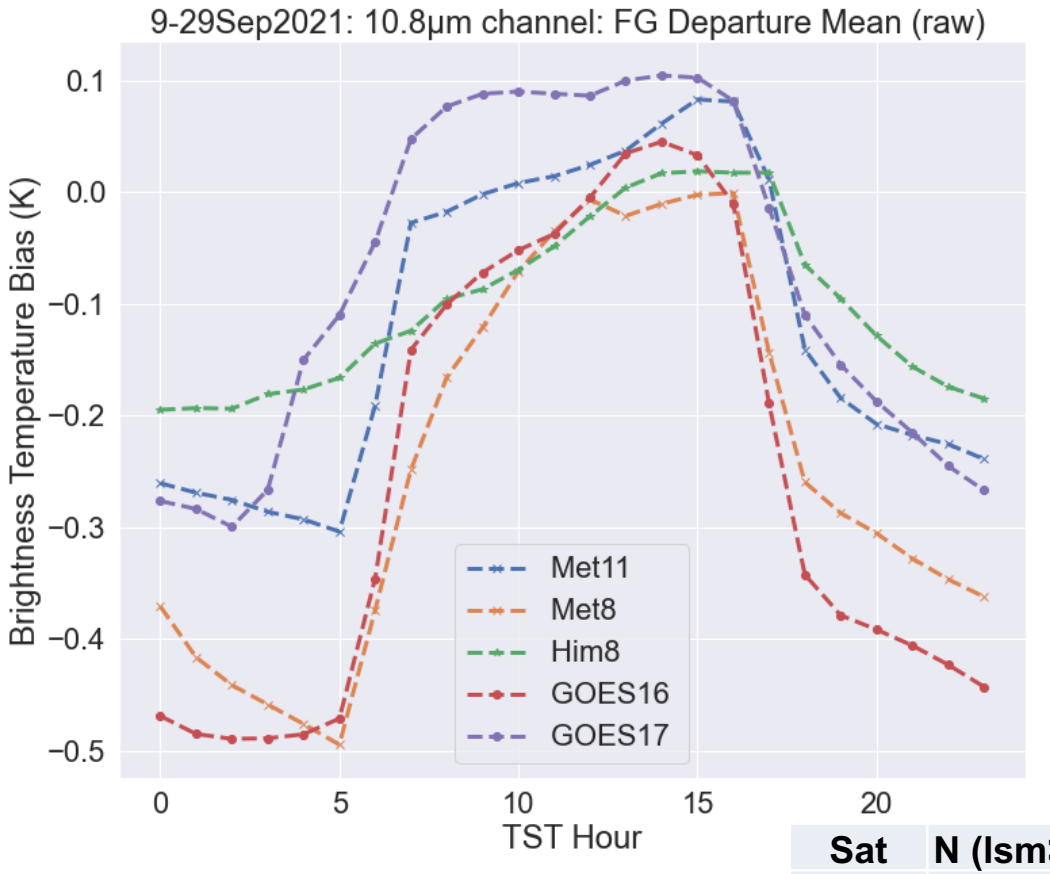
12 TST

Removing model coastlines (lsm=0)

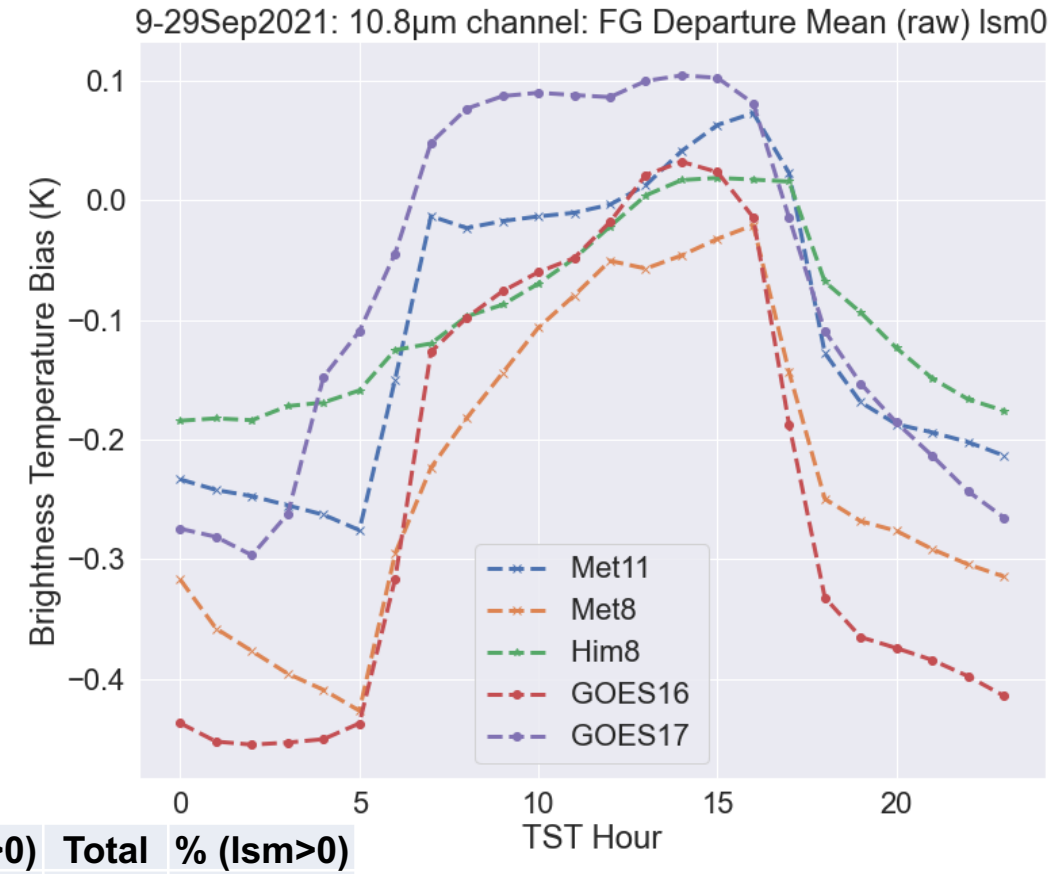


Slight reduction of window channel diurnal cycle amplitude by removing model coastlines

Operational Configuration (lsm<0.5)

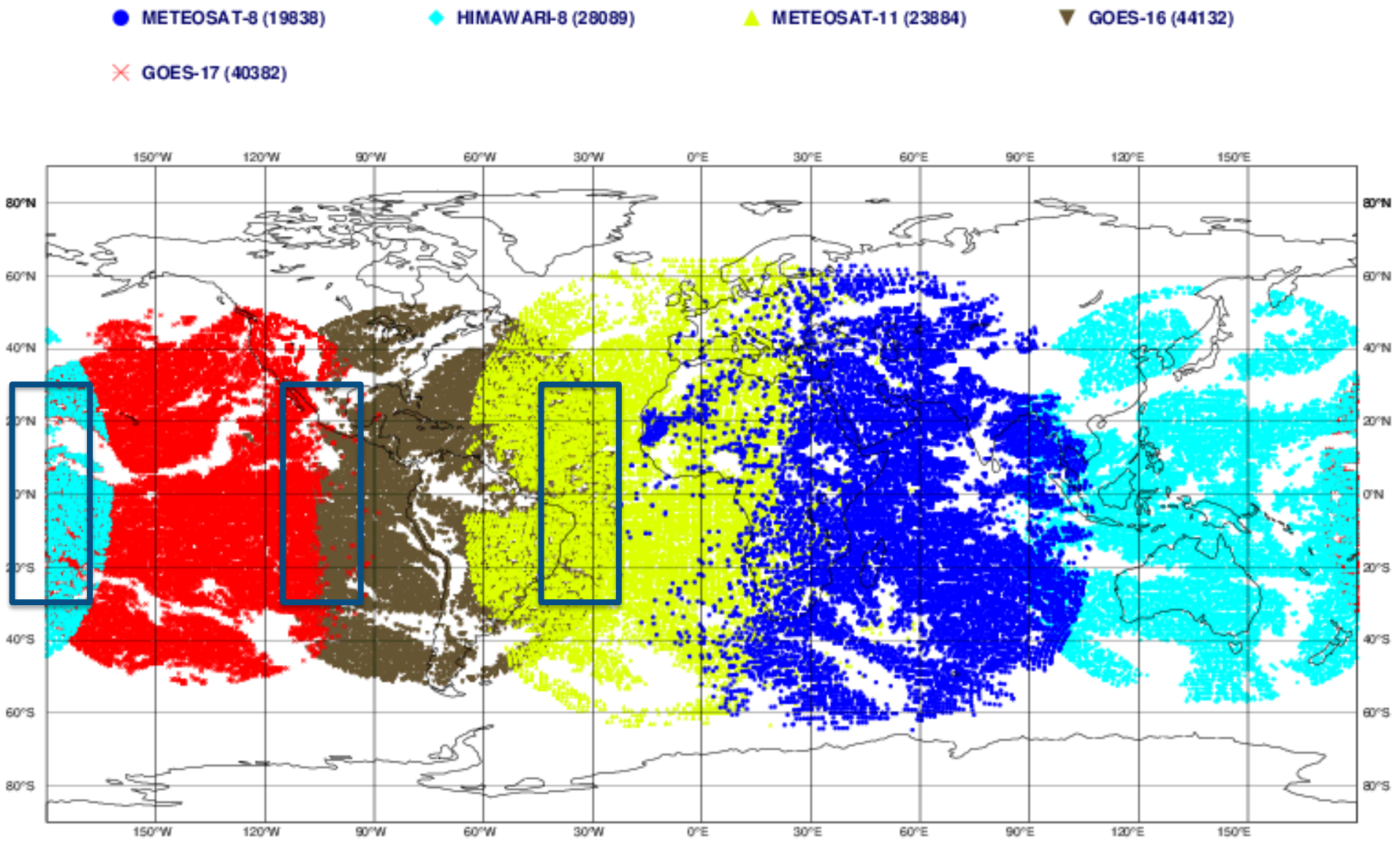


Removing model coastlines (lsm=0)



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%**

GEOS Intercomparison in overlap region



Satellites with same instrument are thinned together

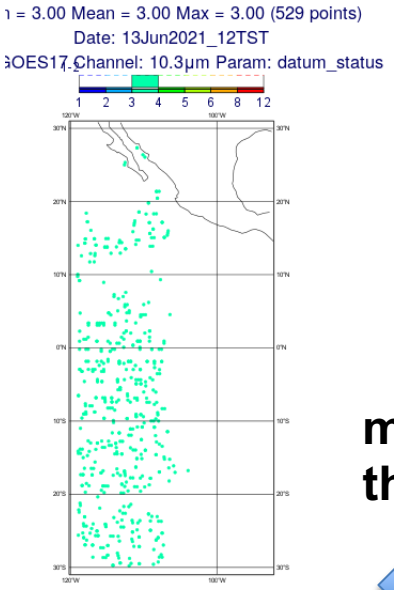
datum_status

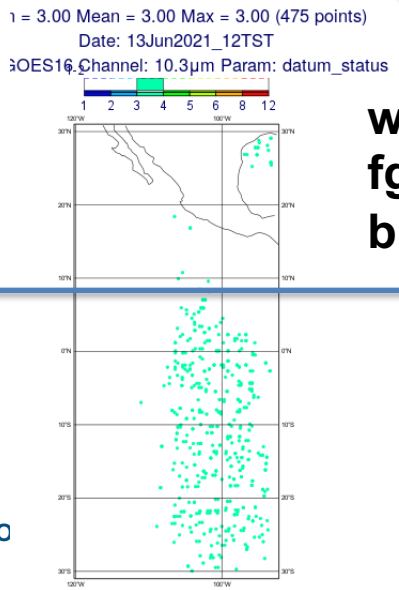
datum_ status	meaning
1	active
2	passive
4	rejected
8	blacklisted
3	active&passive
6	passive&rejected
12	blacklisted&rejected

GOES-17

GOES-16

(3) ~ MFB

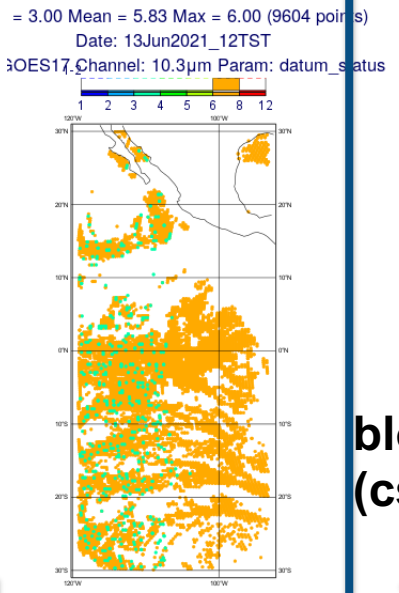


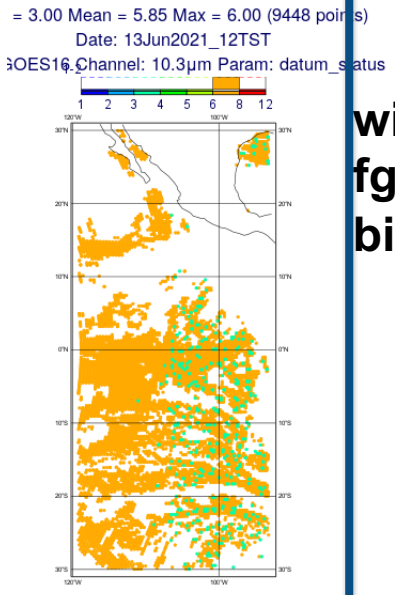


mainly thinning

with a few fgdep too big

(3,6)



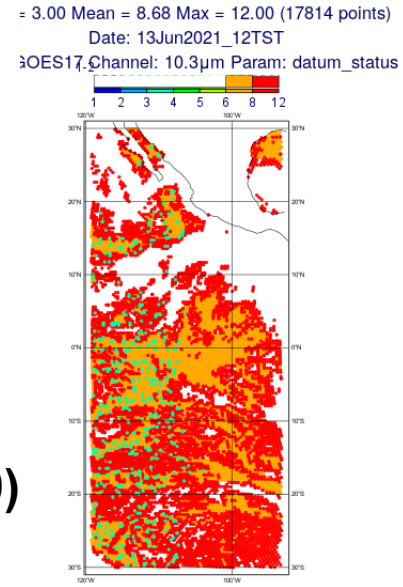


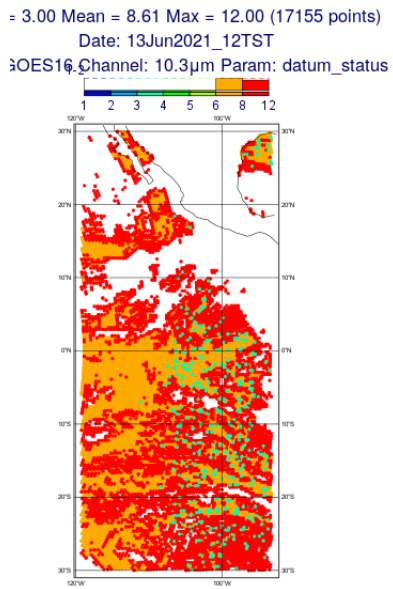
blocklist: (csr_pclear<70)

with most of fgdep too big

12 TST

(3,6,12)





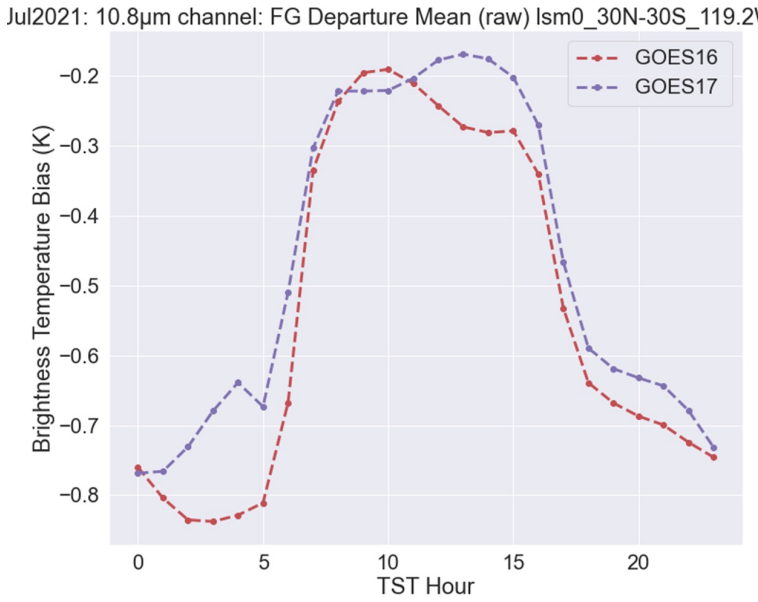
Data before thinning is used in this intercomparison

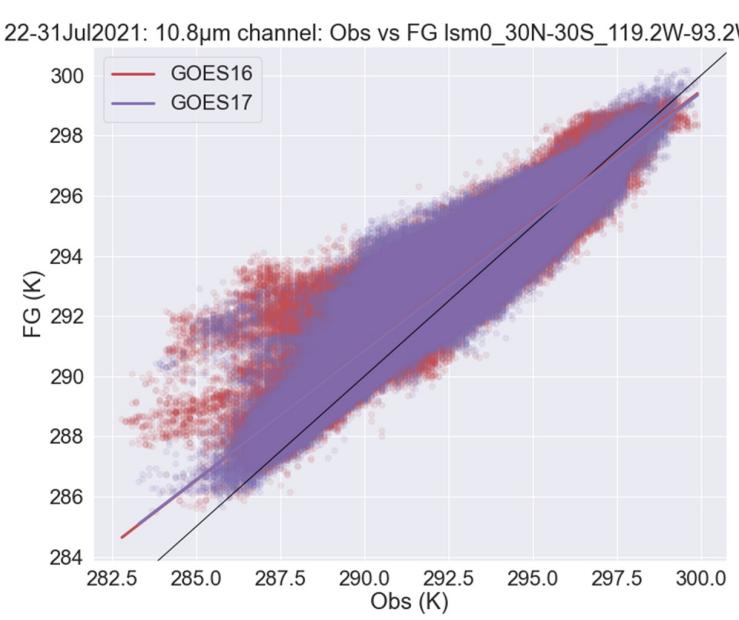
ECMWF EURO

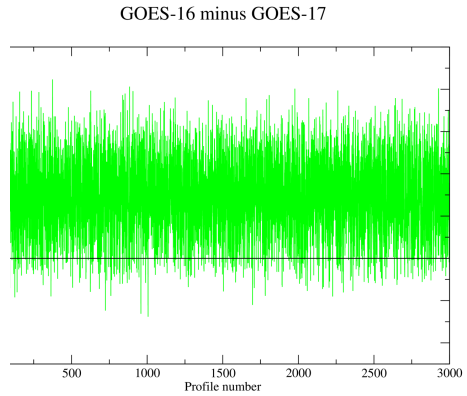
Intercomparison in overlap region: GOES-16 vs -17

10 days

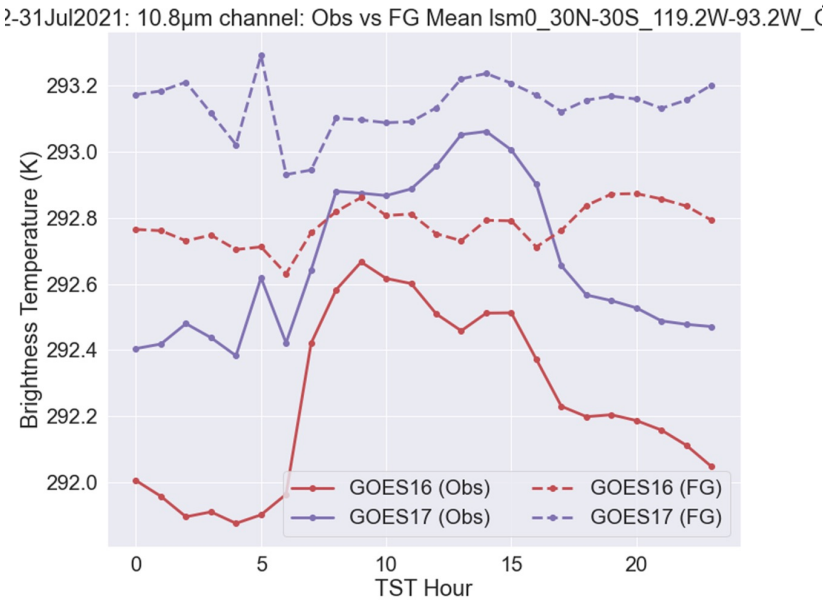
lsm=0.0

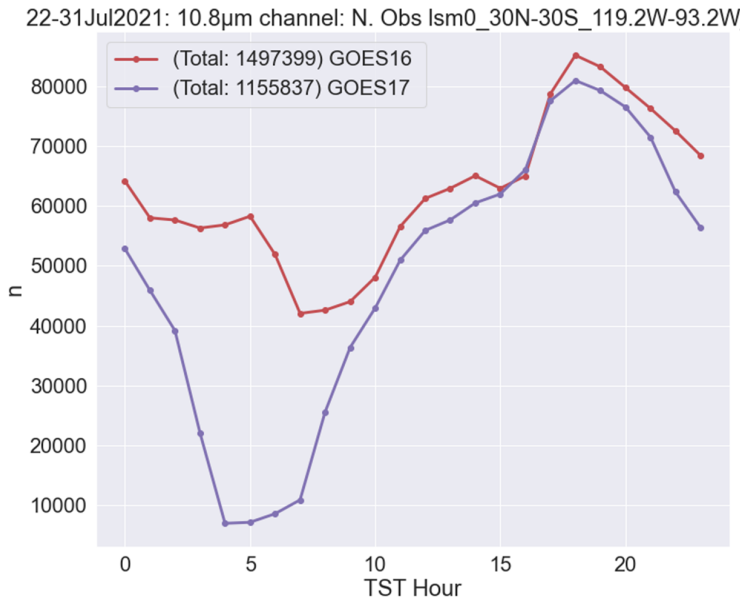






< 0.1K

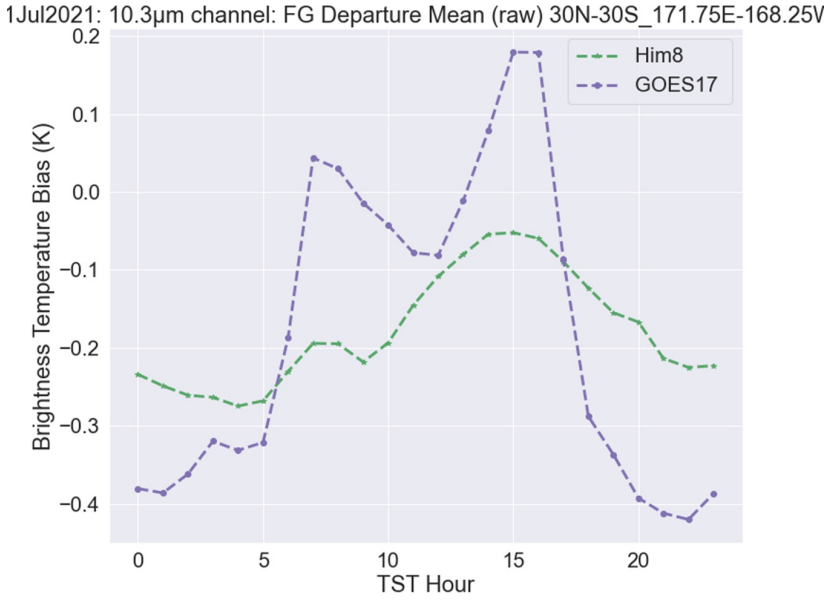


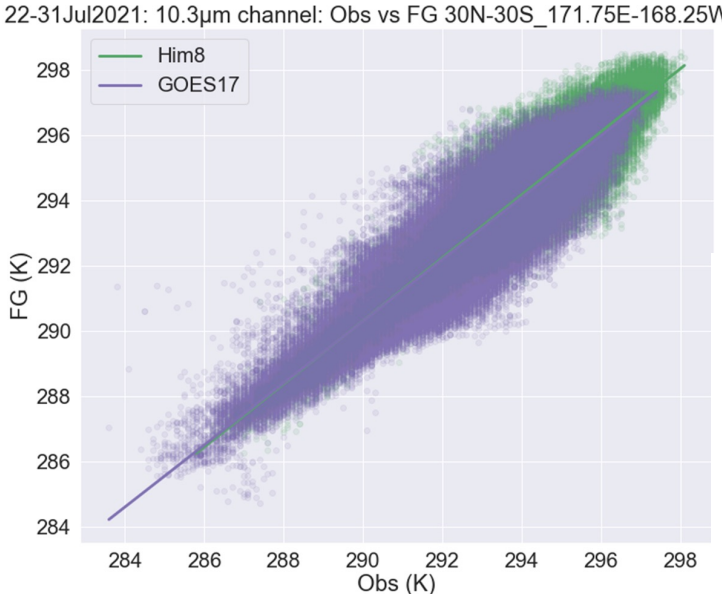


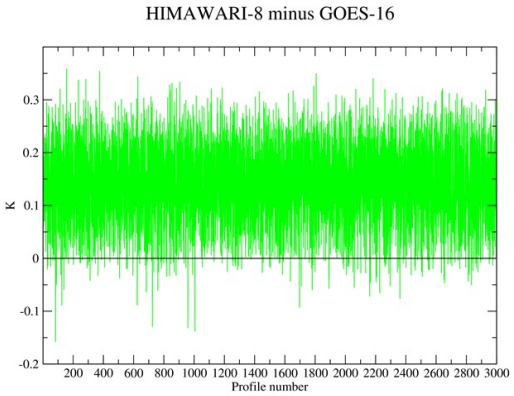
< 0.4 K

Intercomparison in overlap region: GOES-17 vs Him8

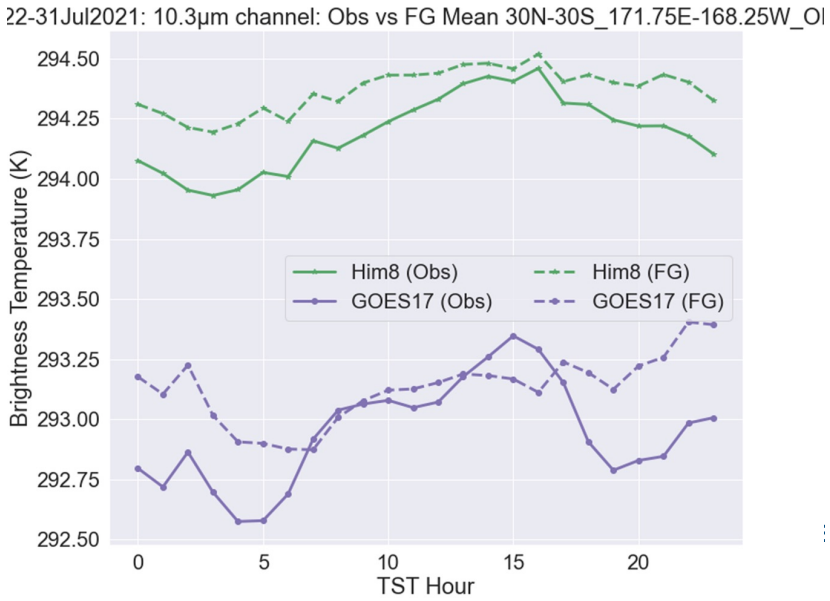
10 days

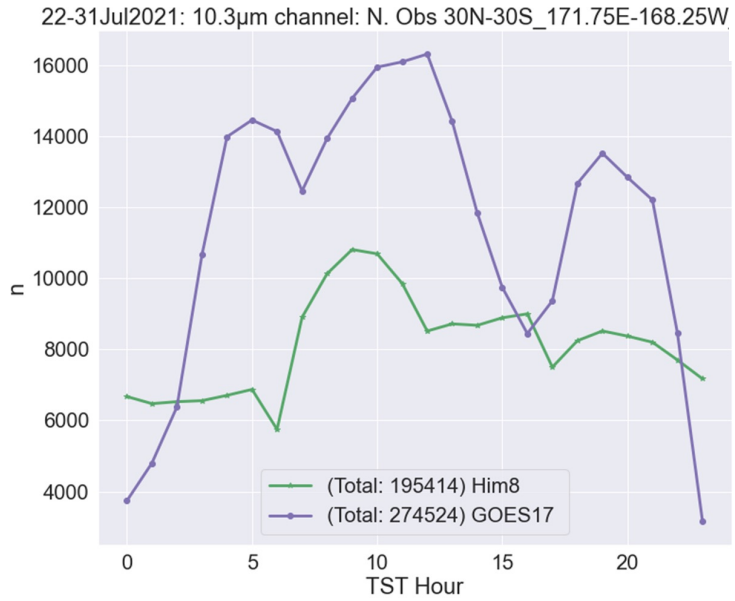






< 0.3K

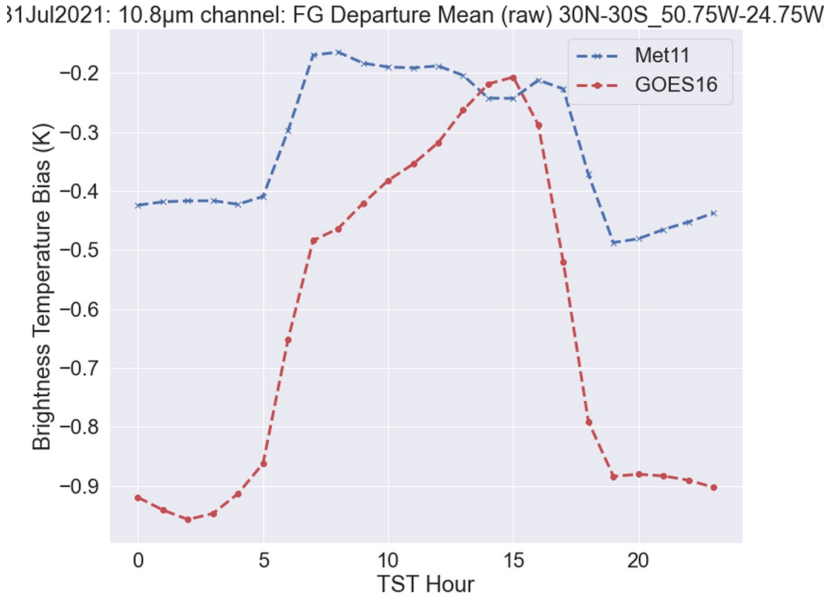


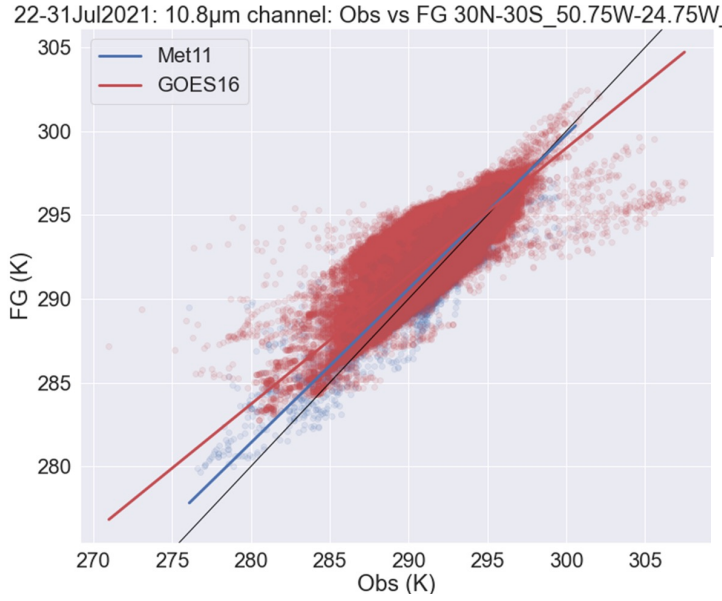


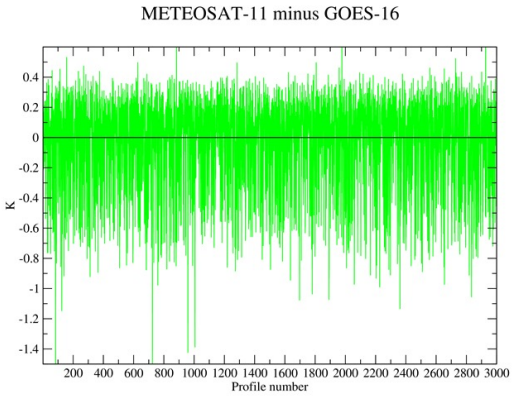
~ 1 K

Intercomparison in overlap region: GOES-16 vs Met11

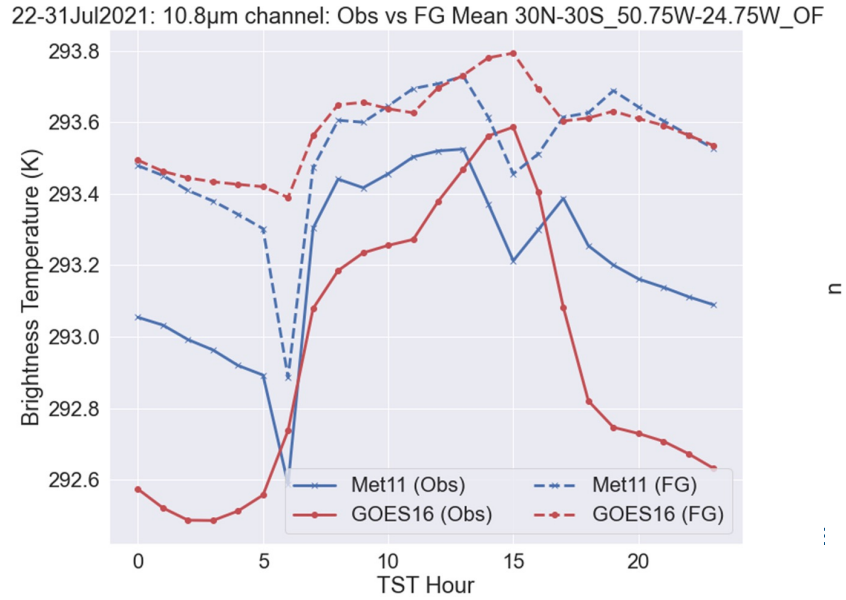
10 days



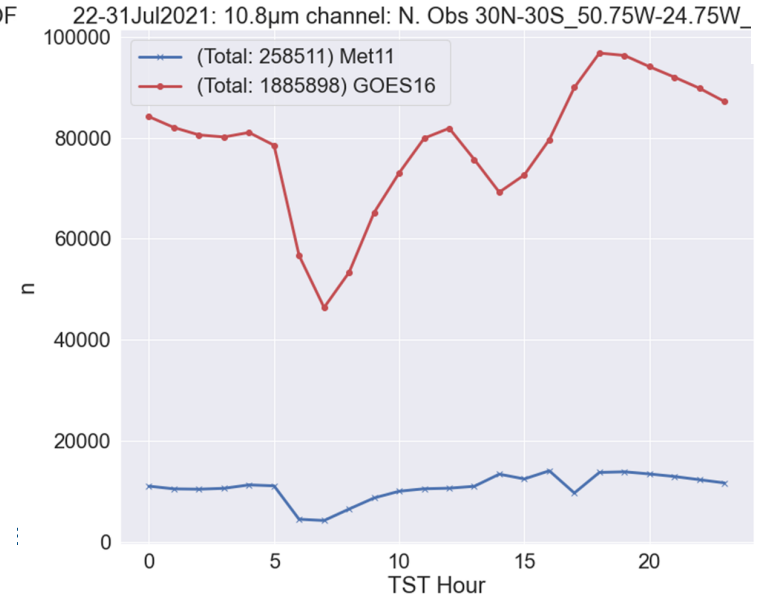




< 1.0 K



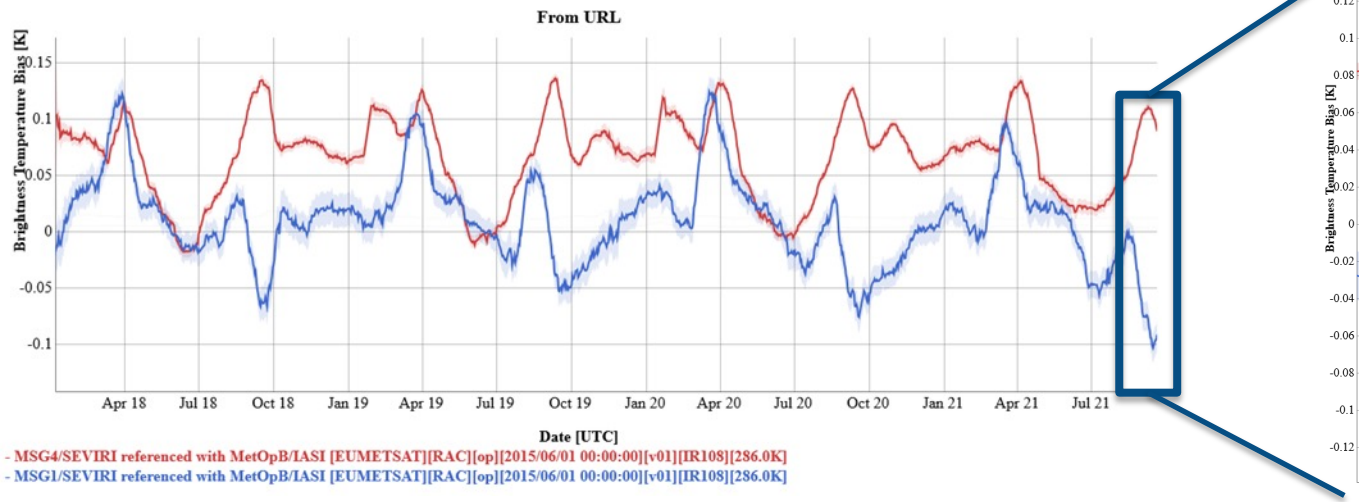
~ 0.5 K

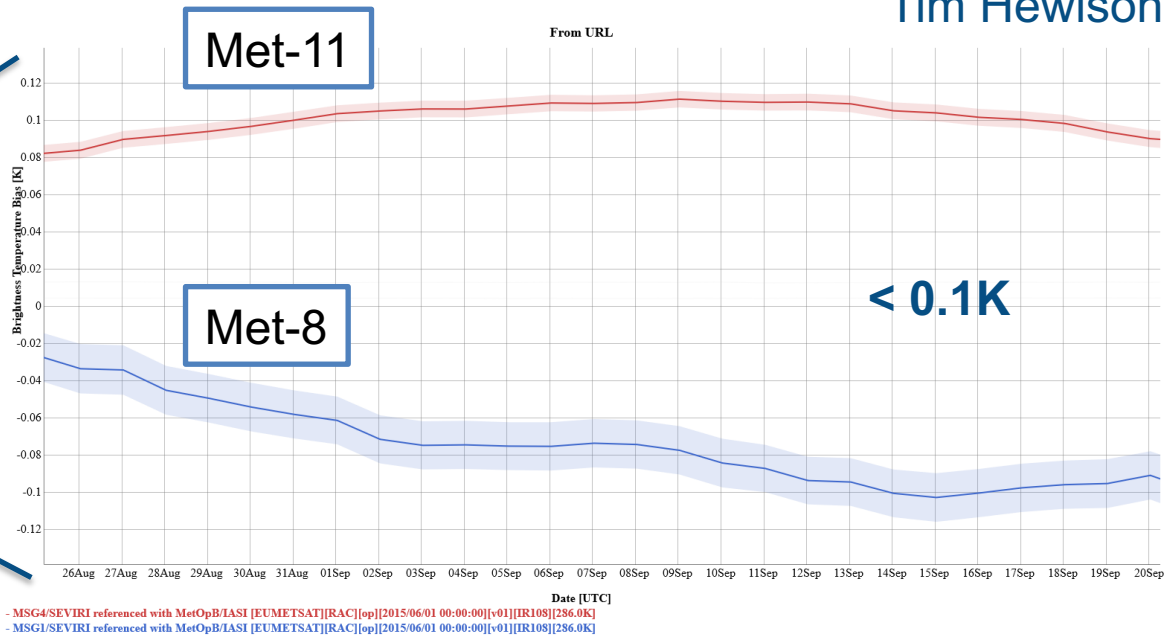


Intercomparison of Met-11/-8 with IASI (night values)

[GSICS Plotting Tool]

Tim Hewison





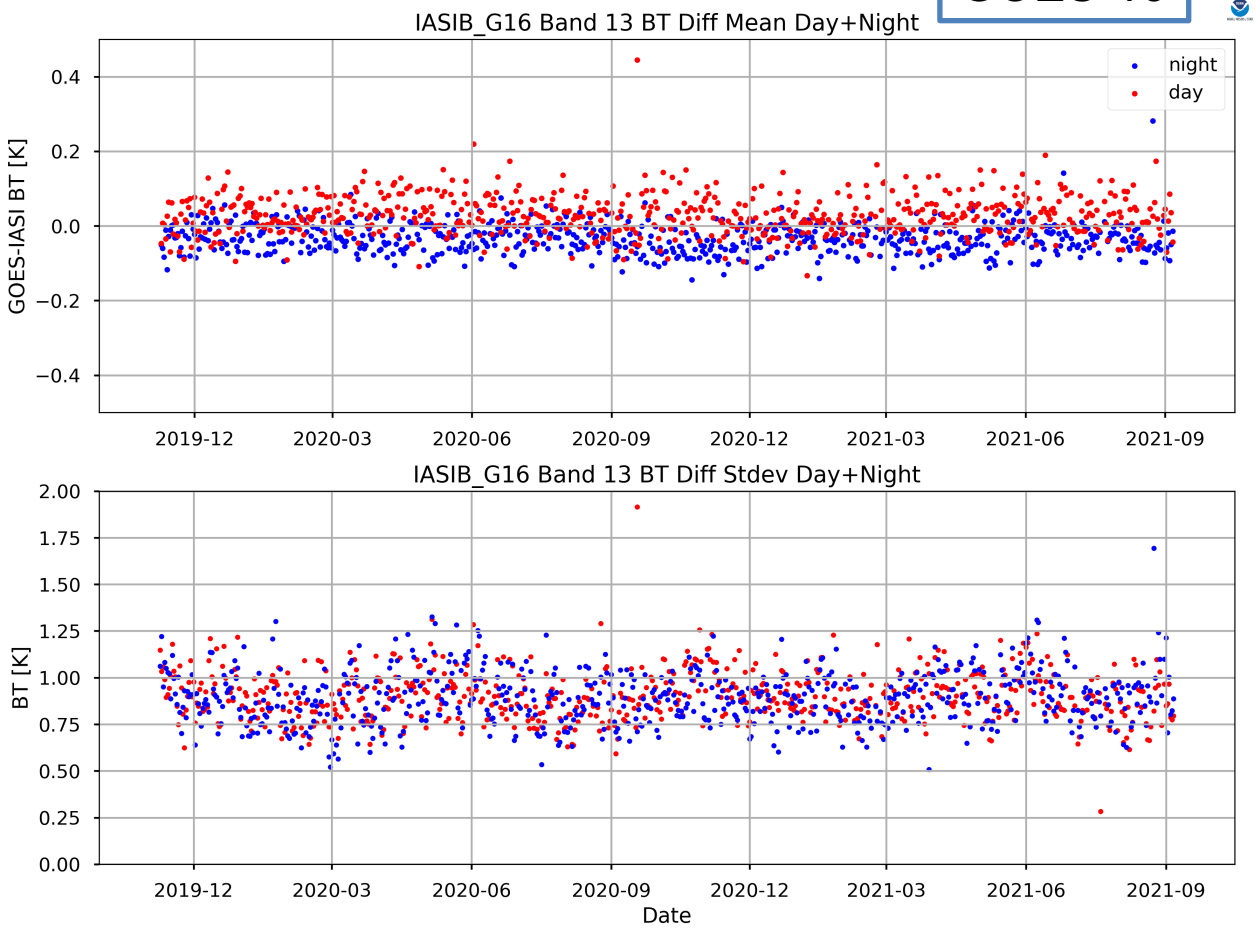
EUMETSAT does not process IASI intercomparison during daytime

- No diurnal cycle is expected in the calibration for SEVIRI outside eclipse season, due to its spin-stabilisation.
- The other GEOs are 3-axis stabilised, so would be more subject to (very small) diurnal variations.

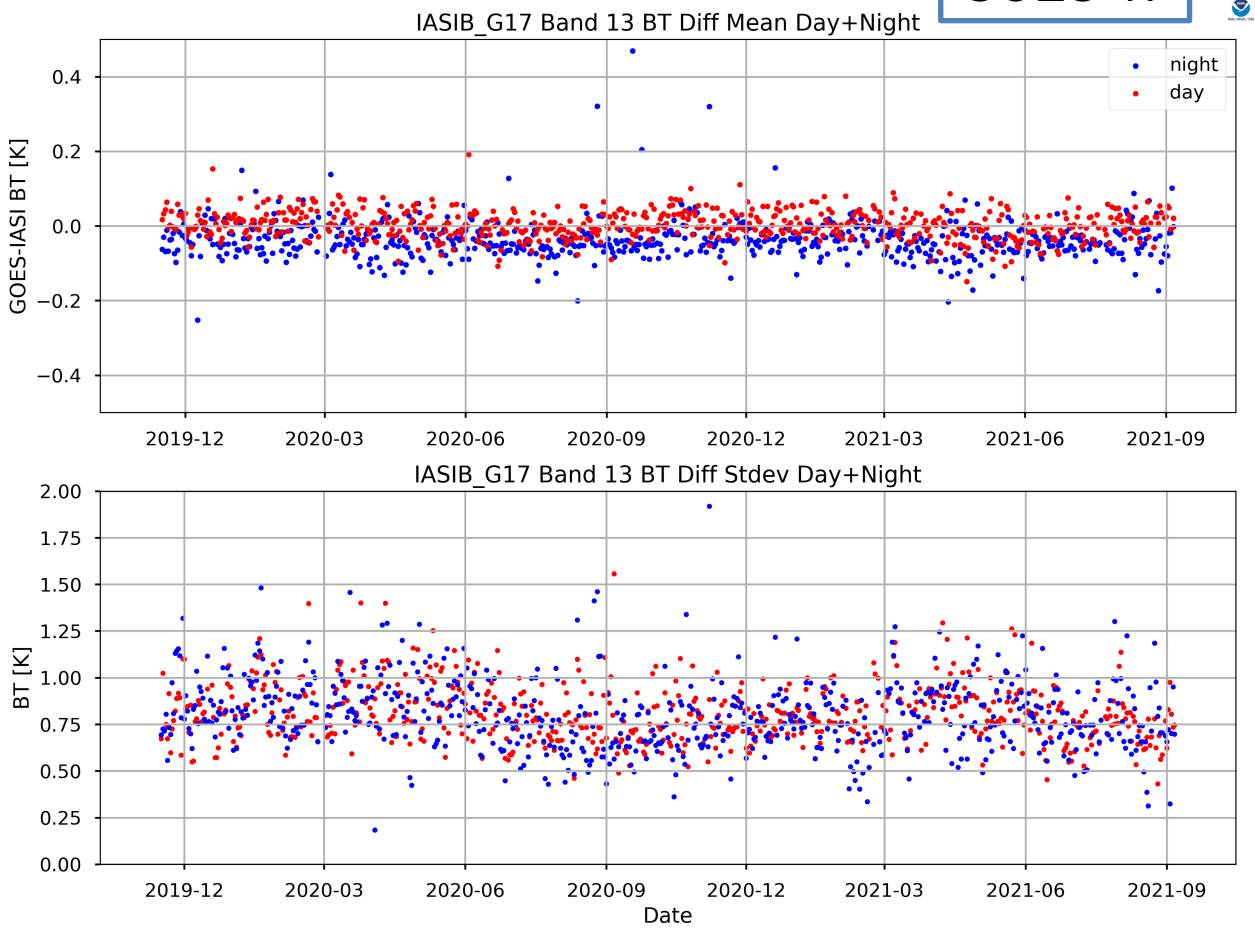
Intercomparison of GOES-16/-17 with IASI (day+night)

https://www.star.nesdis.noaa.gov/icvs/GSICS.php

GOES-16



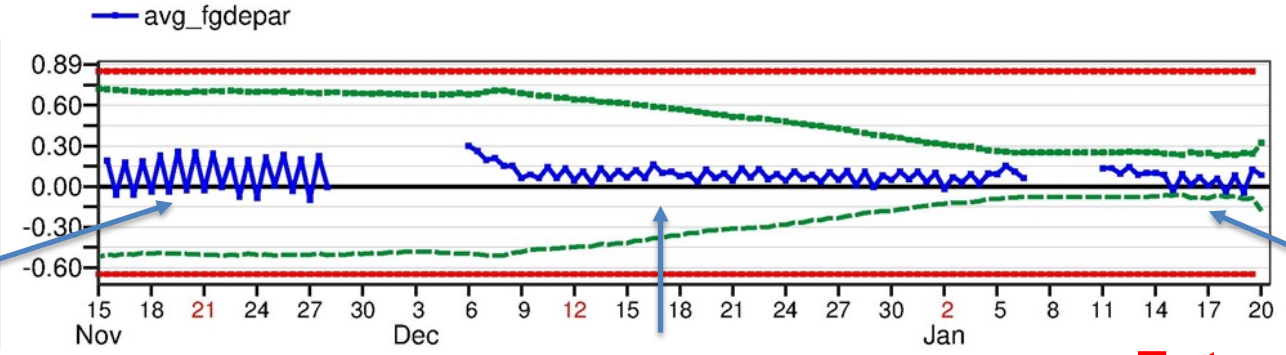
GOES-17



< 0.1K

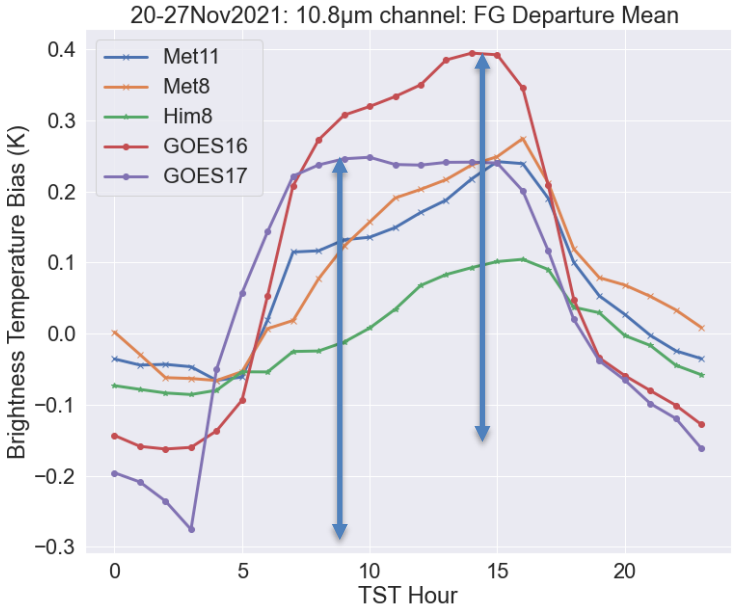
GOES-16/-17 Enterprise Cloud Mask greatly reduce the Window Channel diurnal cycle amplitude over Sea

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

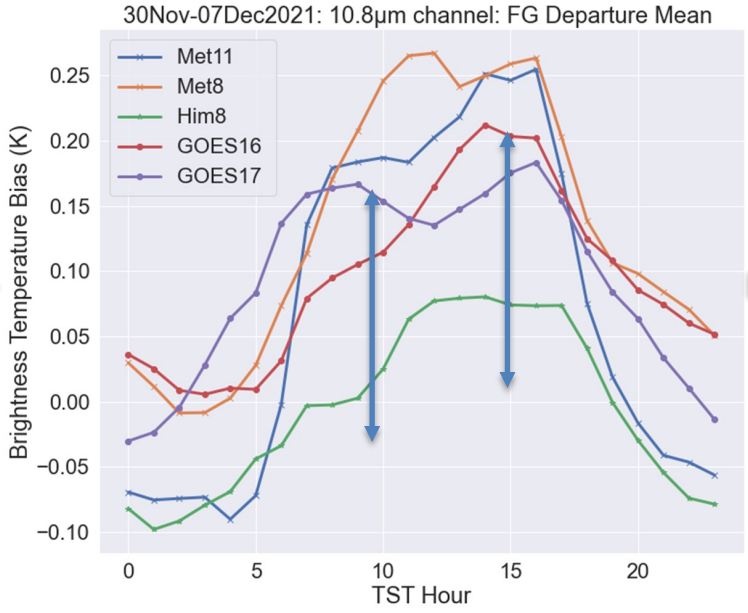


NOAA changed GOES-16 from v2r0 to v2r1 on 6Jan2022

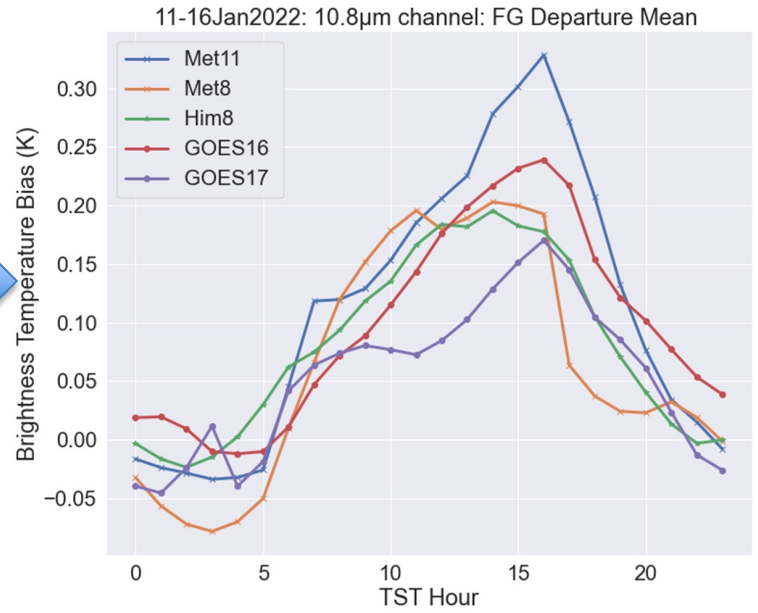
Baseline



Enterprise



Enterprise GOES-16 r0 -> r1

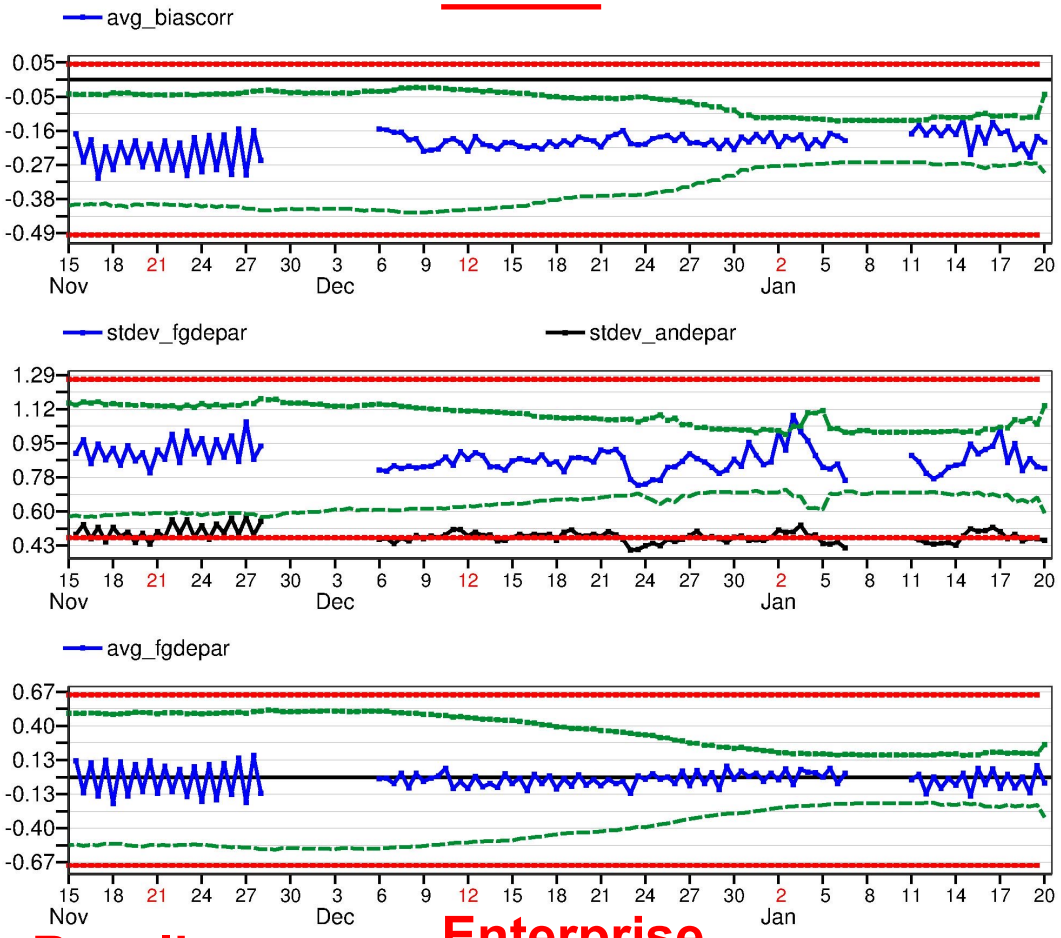


Diurnal cycle amplitude in the Window Channel **reduced from 0.5 K to 0.2 K** for both GOES-16/17

Smoother diurnal cycle for GOES-16

Enterprise Cloud Mask reduced error and BIAS for GOES-16 Window Channel – with benefits also for WV7.4

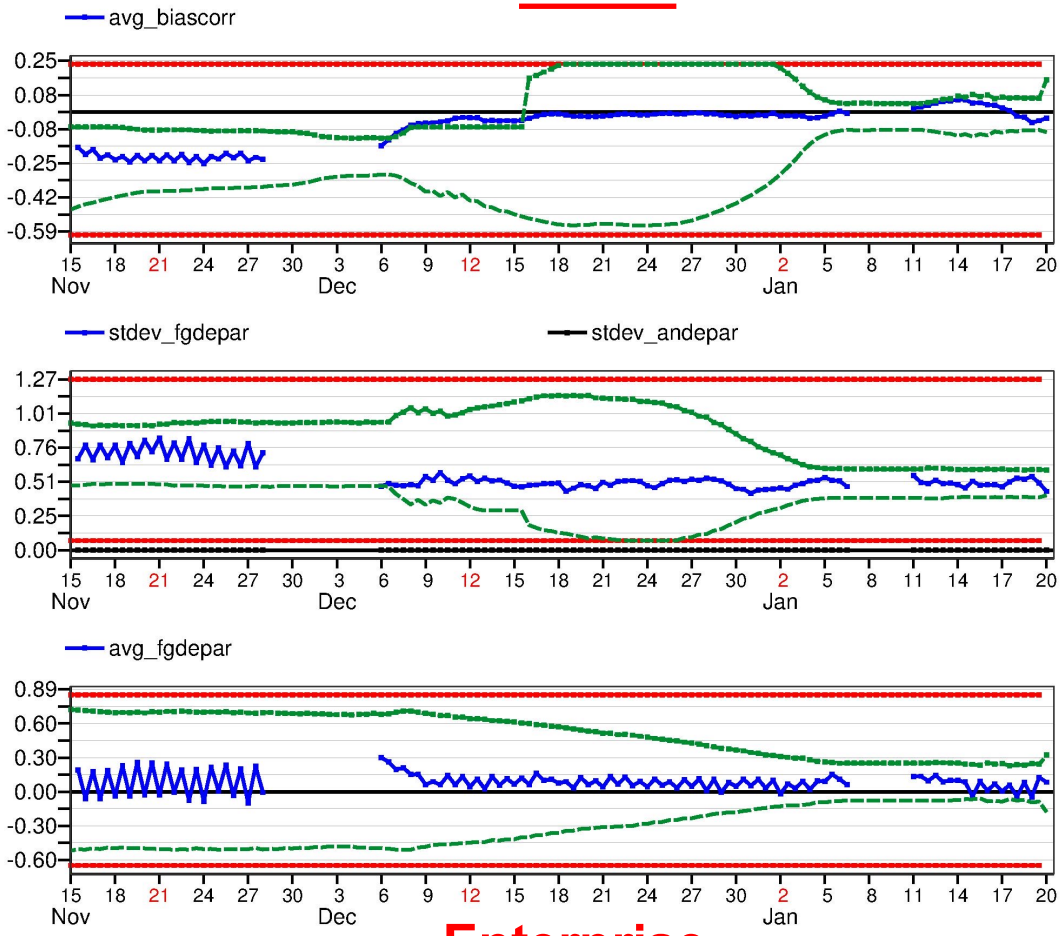
WV7.4



Baseline

Enterprise

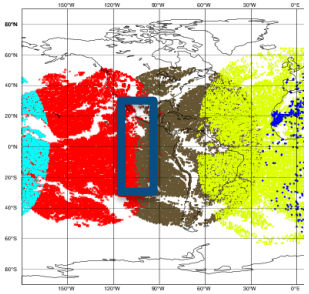
IR10.3

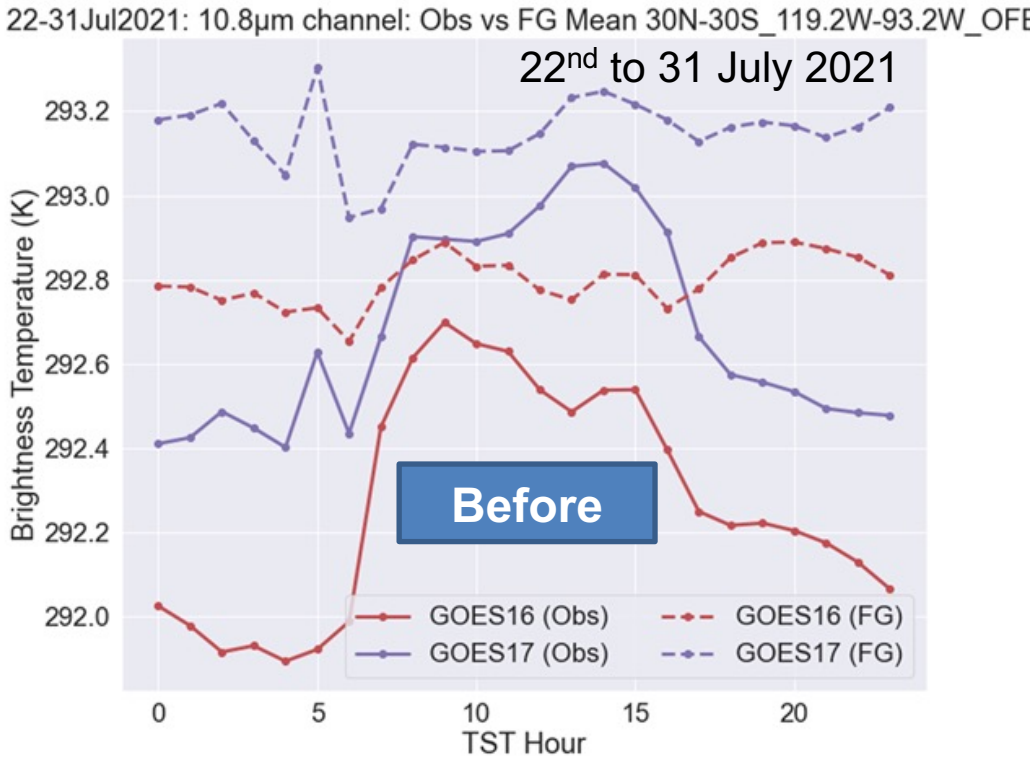


Baseline

Enterprise

Better agreement of GOES-16/-17 in overlap region thanks to the Enterprise Cloud Mask

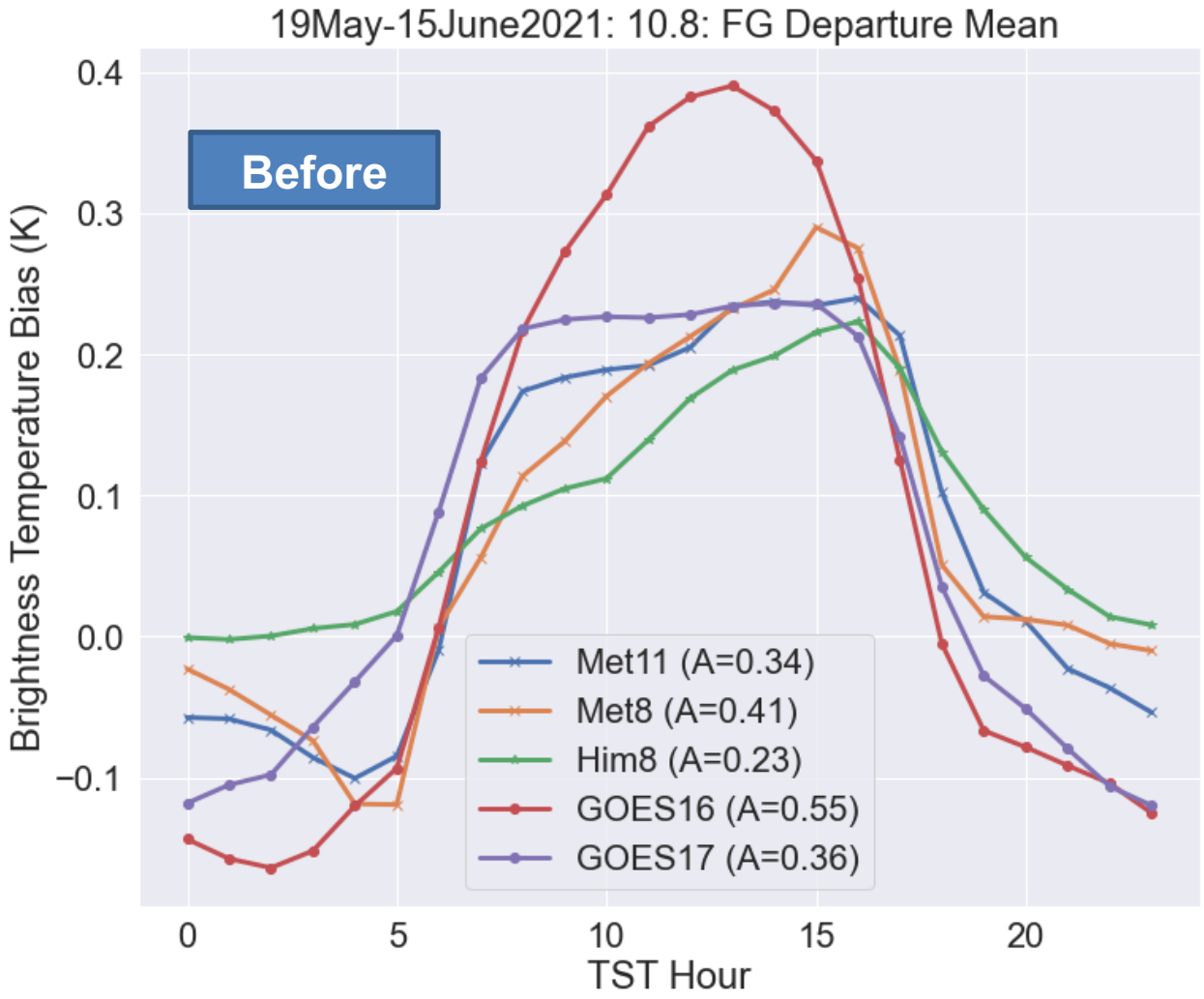


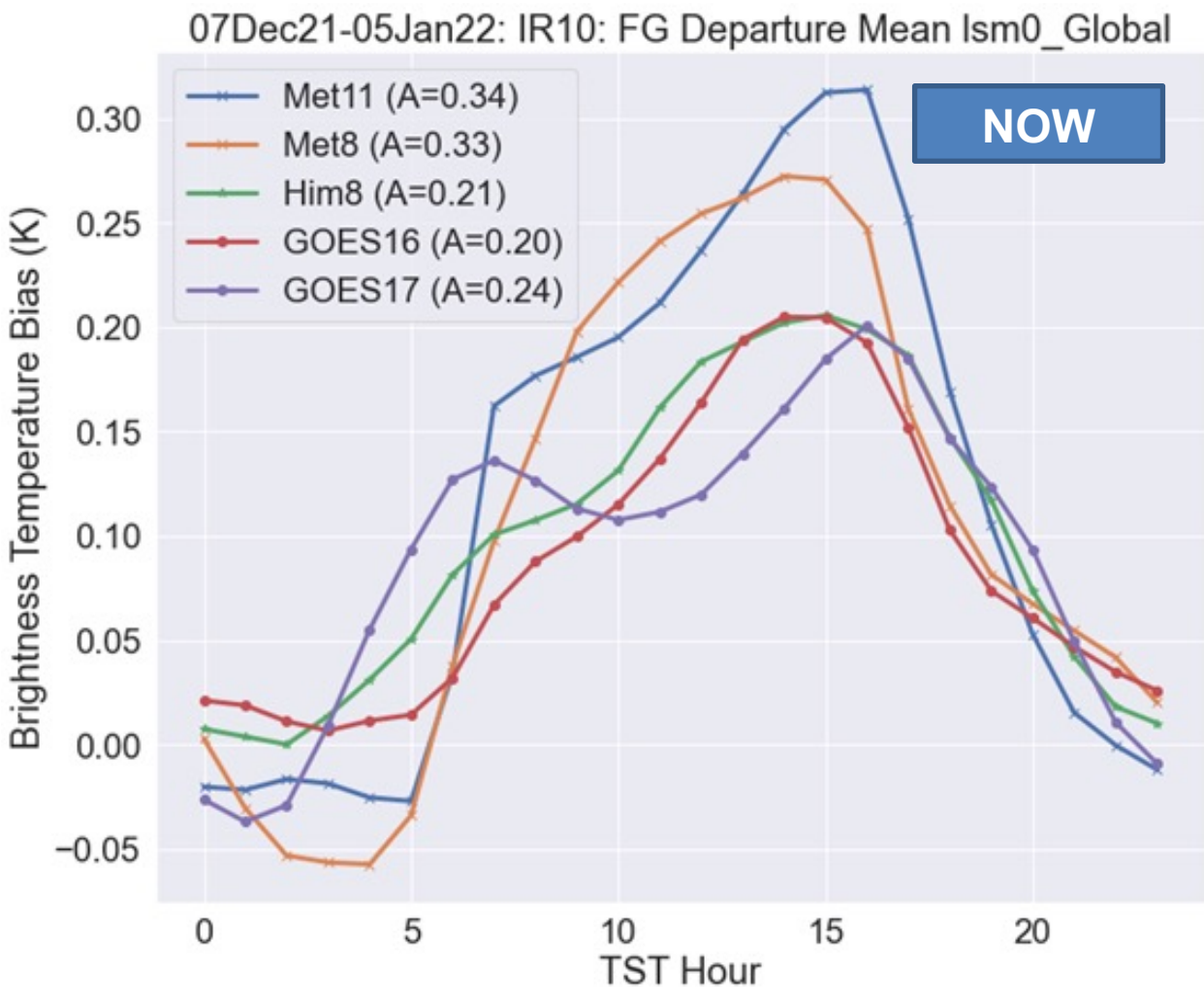


After two recent updates involving the GOES and originating at the data provider:

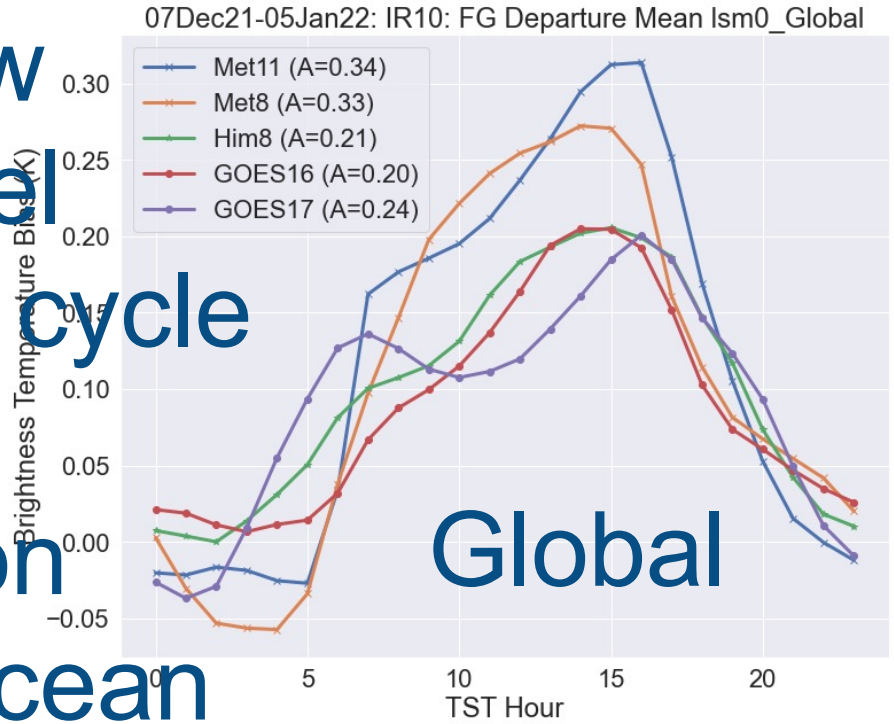
- ***GOES-16 and GOES-17 observations exhibits a reduced diurnal cycle variation***
- ***GOES-16 and GOES-17 have much closer observation values (difference reduced from 0.4 K to 0.2 K)***
- ***GOES-16 now displays a warmer value of up to 0.2 K compared to GOES-17.***

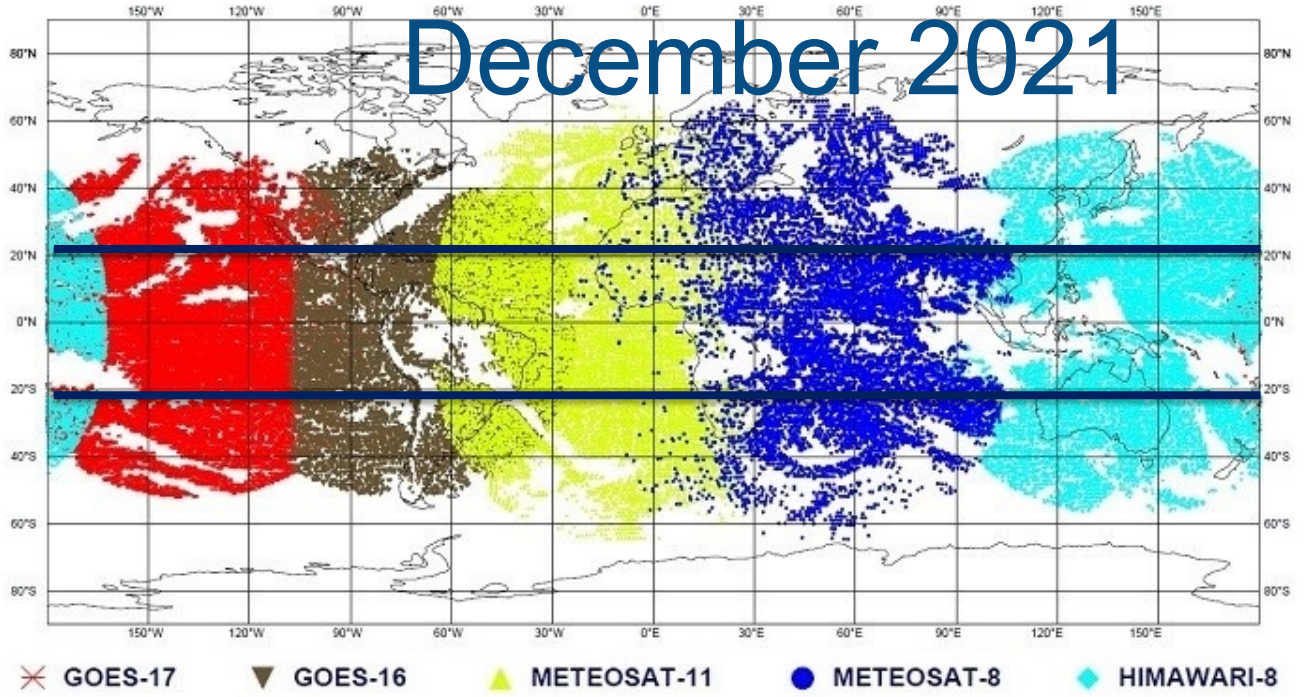
Window Channel cumulative benefit of last year operational changes

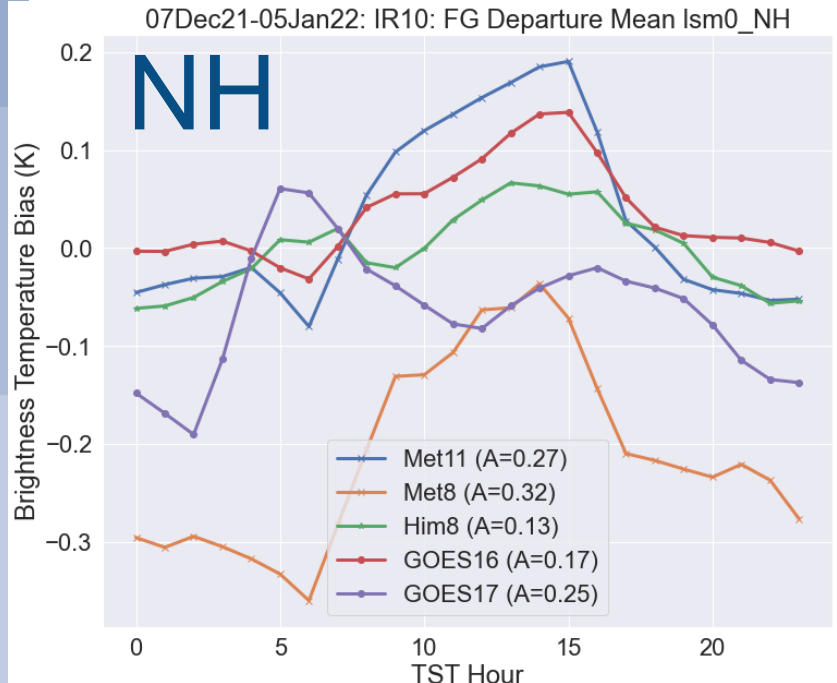


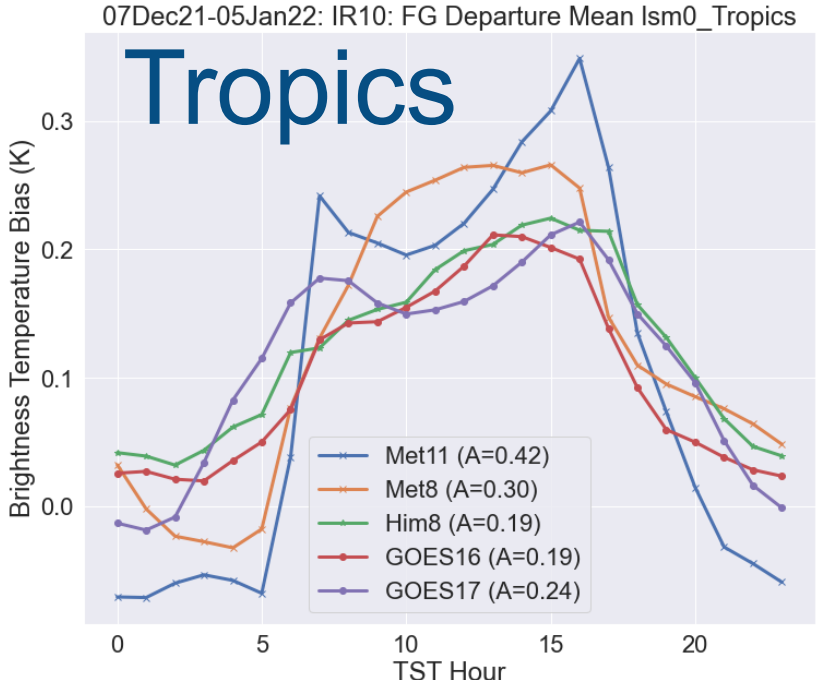


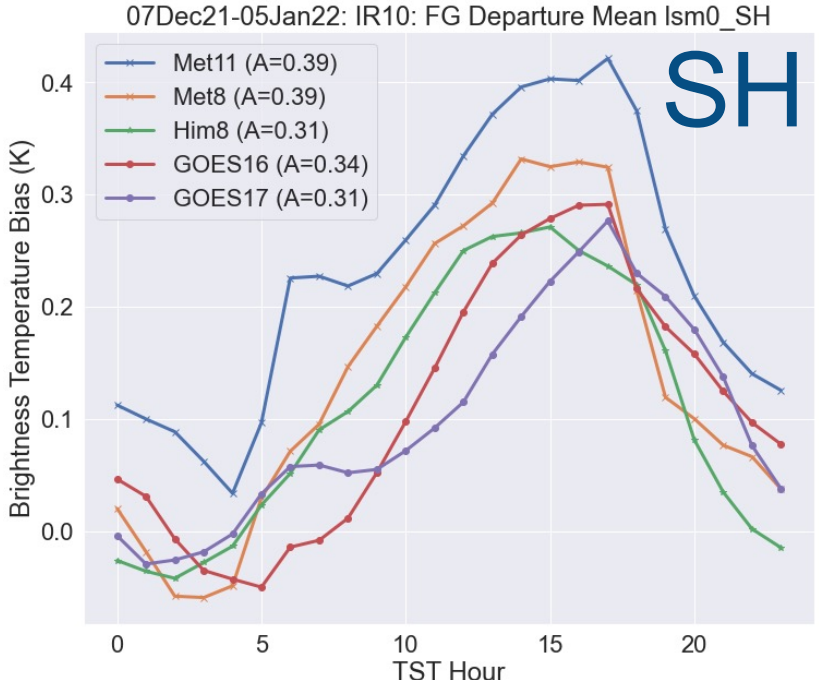
Window Channel diurnal cycle zonal variation over Ocean



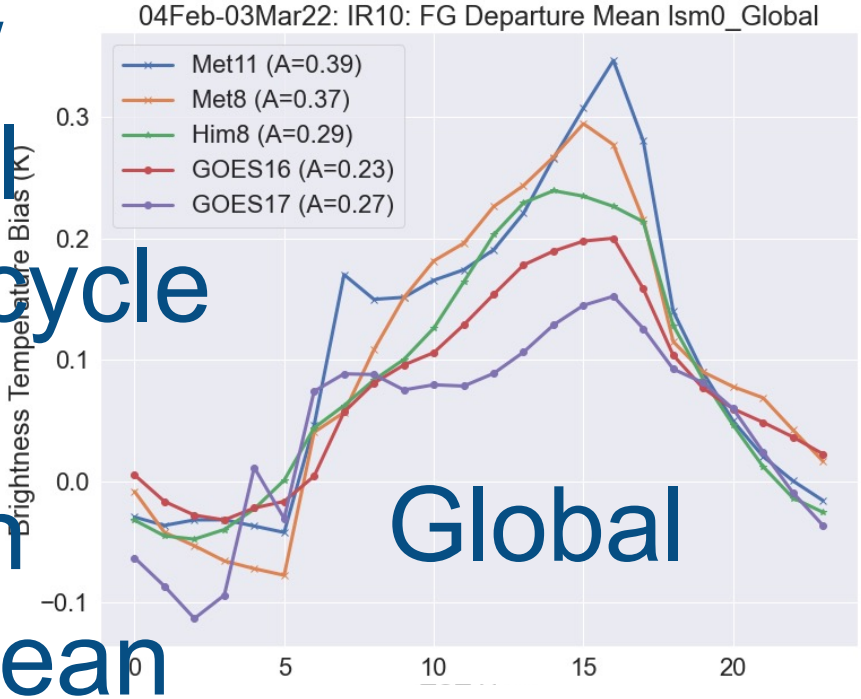


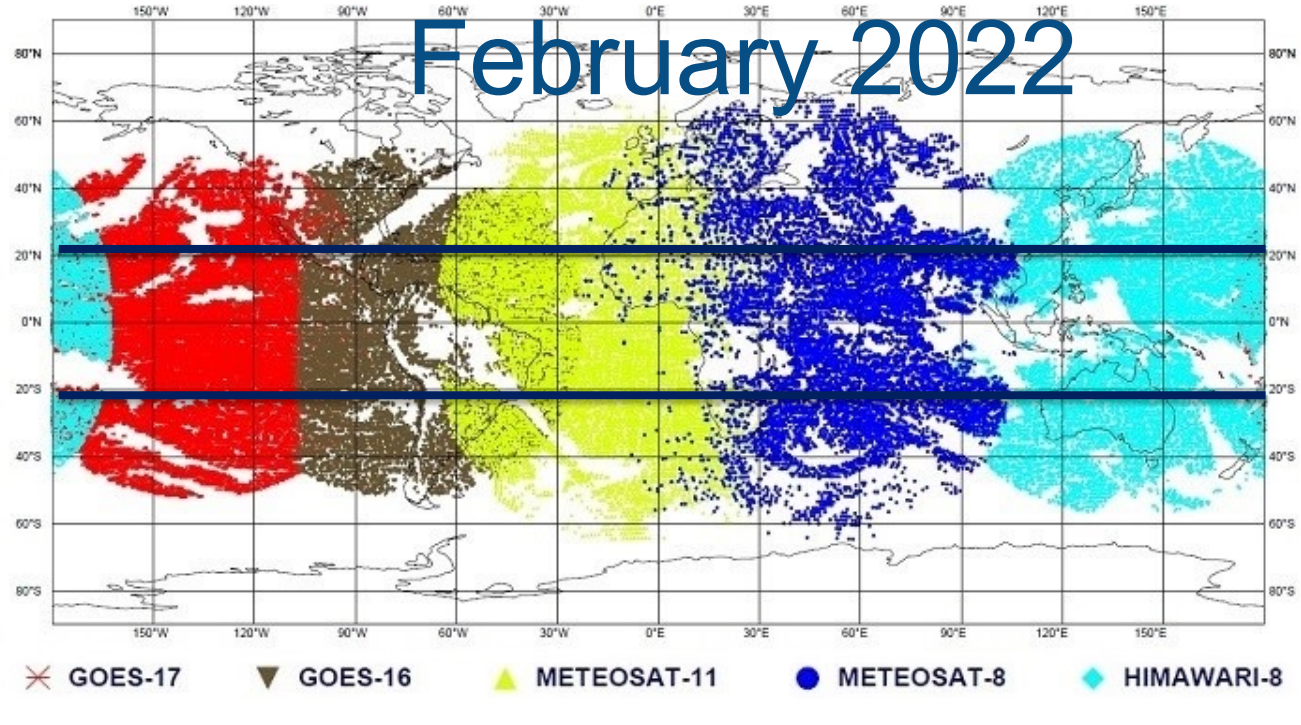


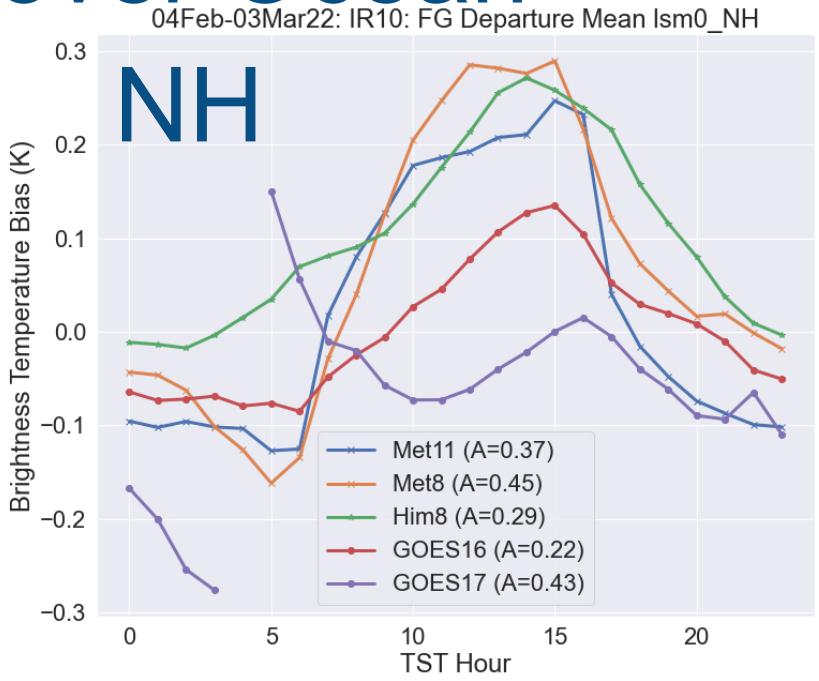


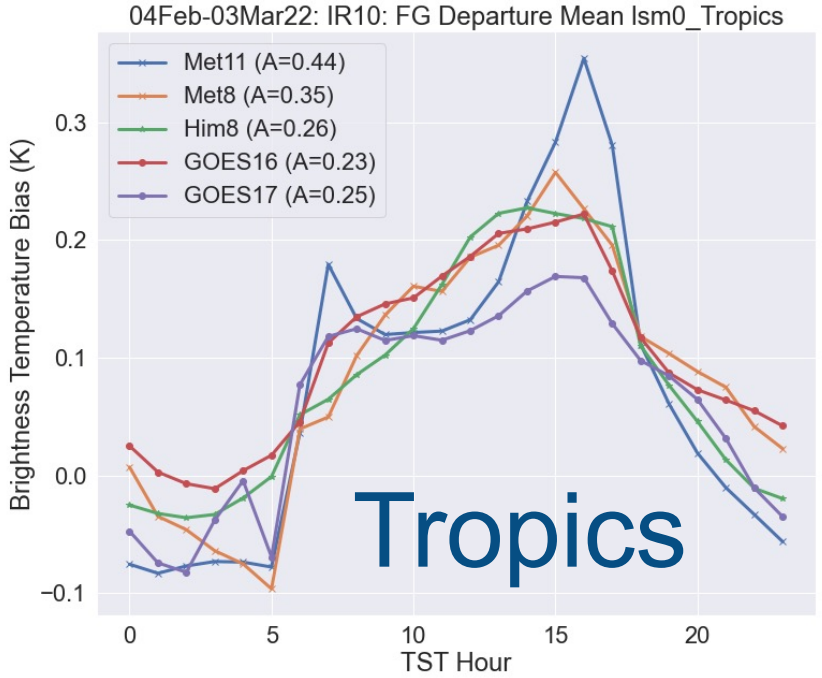


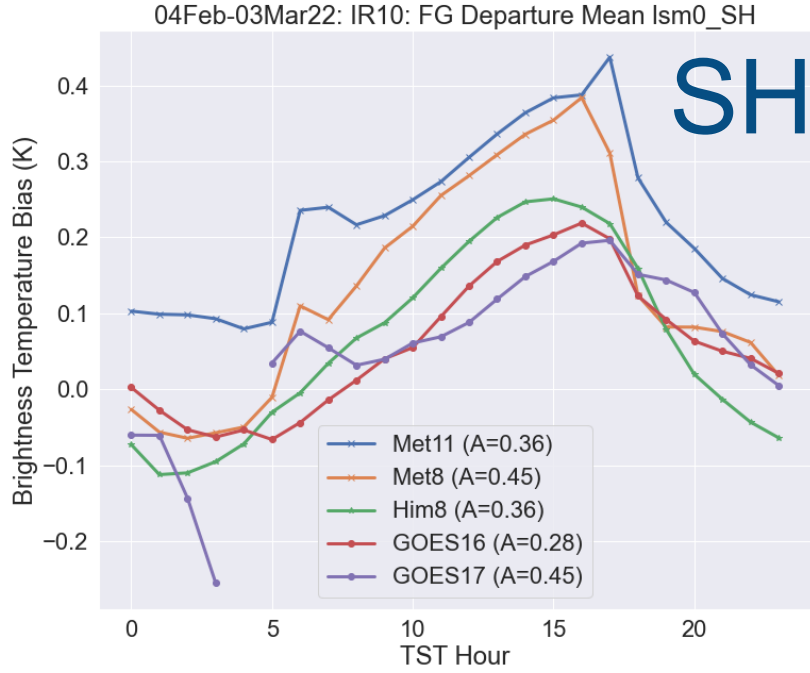
Window Channel diurnal cycle zonal variation over Ocean





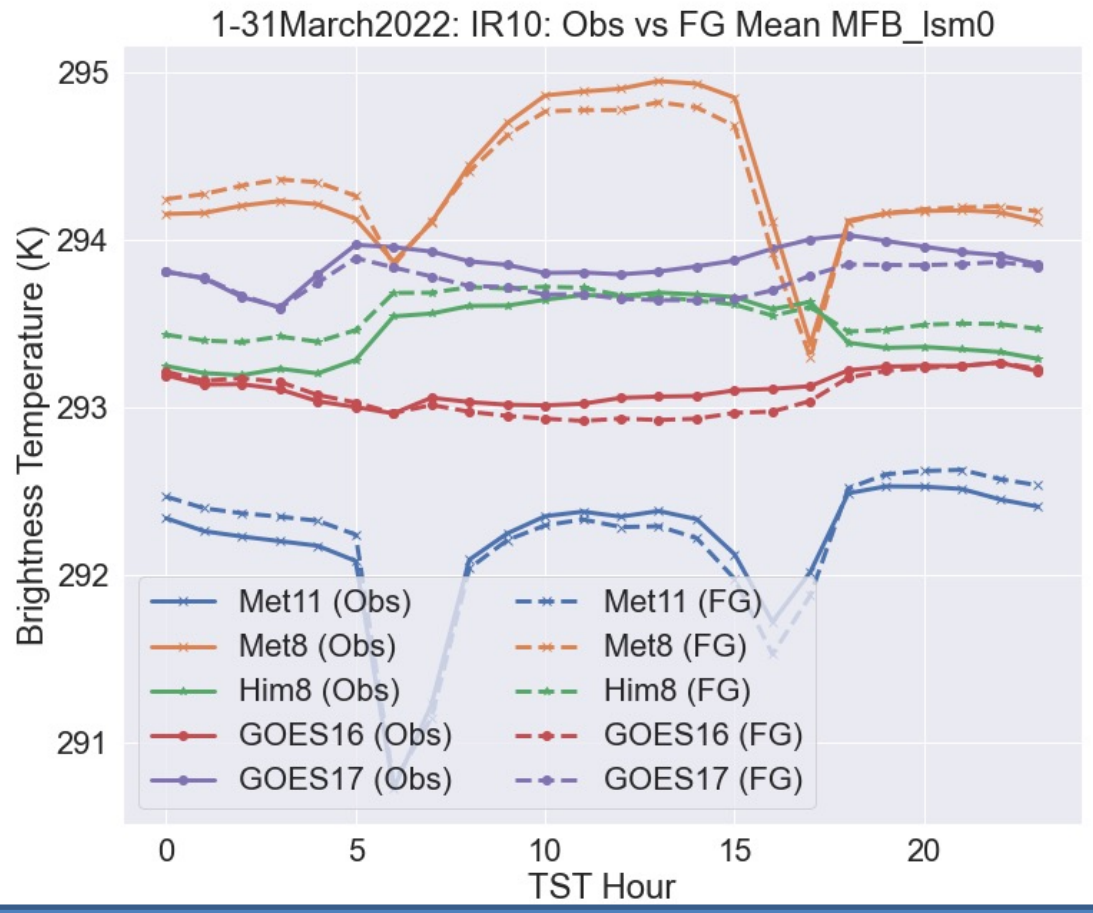




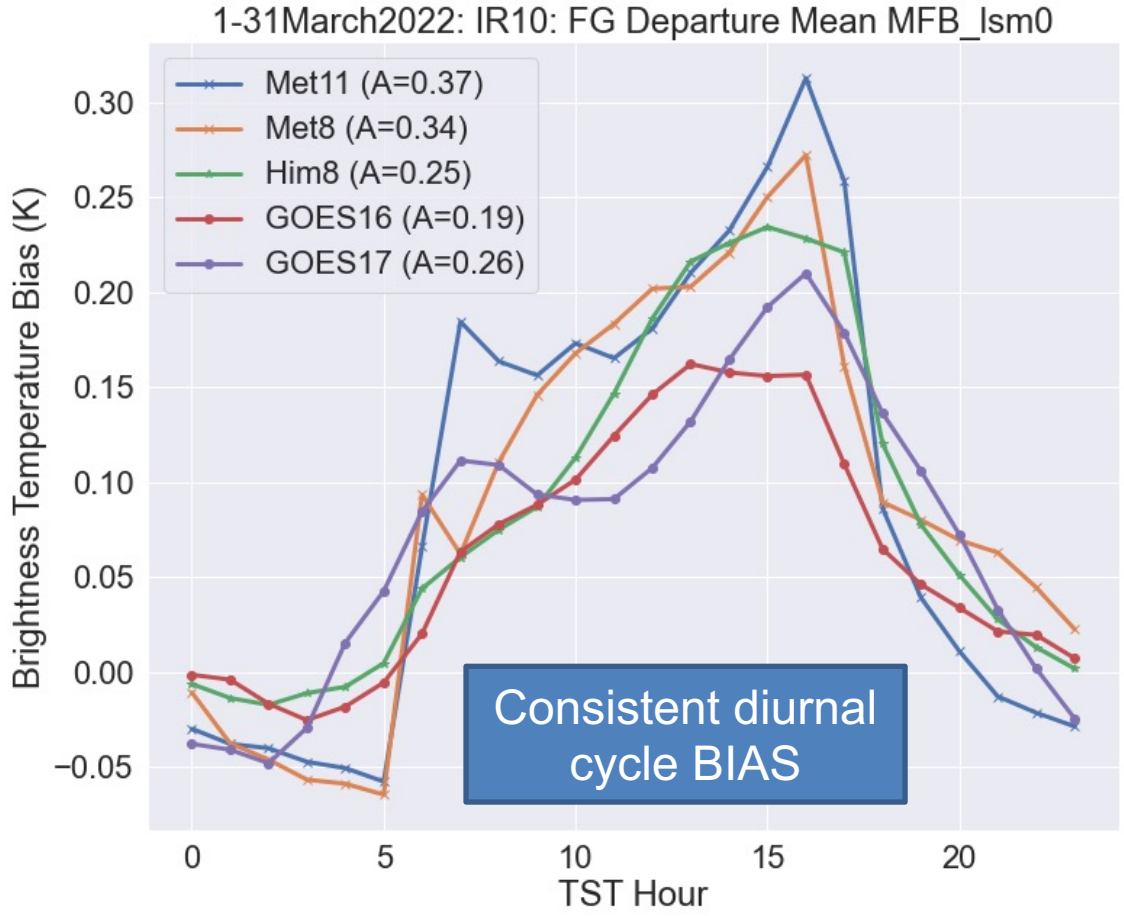


5 GEO Window Channel monitoring in operations show a consistent diurnal cycle bias over **ocean** (March 2022)

Mean Obs vs FG



Mean FG Departure



Obs are warmer daytime and cooler night-time than FG

Conclusions

- GEO window channels are a critical and unique source of information for NWP model improvement. In this study we are making good progress disentangling the various sources of bias (observation, RT, model). Last year EUMETSAT and NOAA have introduced several operational changes for METEOSAT and GOES which improve the quality of geostationary window channel radiances.

- Window channel radiances observed by different GEO instruments have different statistical characteristics (due to varying spectral response and systematic aspects of the underlying surface that they are exposed to). However, when these differences are taken in to account, the 5 available GEO sensors are consistent and suggest a model bias in the ECMWF diurnal cycle of ocean skin temperature.

- If the above changes (up to 0.3K) are confirmed as a systematic model problem (in collaboration with ECMWF model experts) this could prove extremely significant as the ocean surface temperature (SST) is an important driver of NWP forecast skill.

Part II: Met-9 take over Met-8 for the IODC

Timeline of transition from Met-8 to Met-9 for the IODC

https://www.eumetsat.int/meteosat-9-takes-over-IODC-service)

10 May 2022

Parallel stream of Met-9 ASR data is made available

19 May 2022

Starts passive monitoring of Met-9 ASR in operations

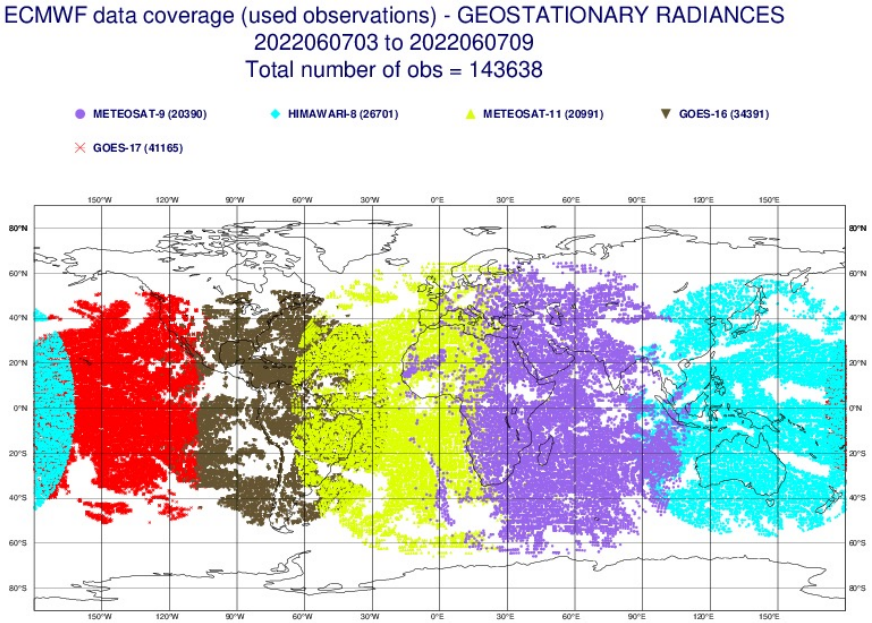
1 June 2022

Stop ingestion of Met-8 ASR in operations

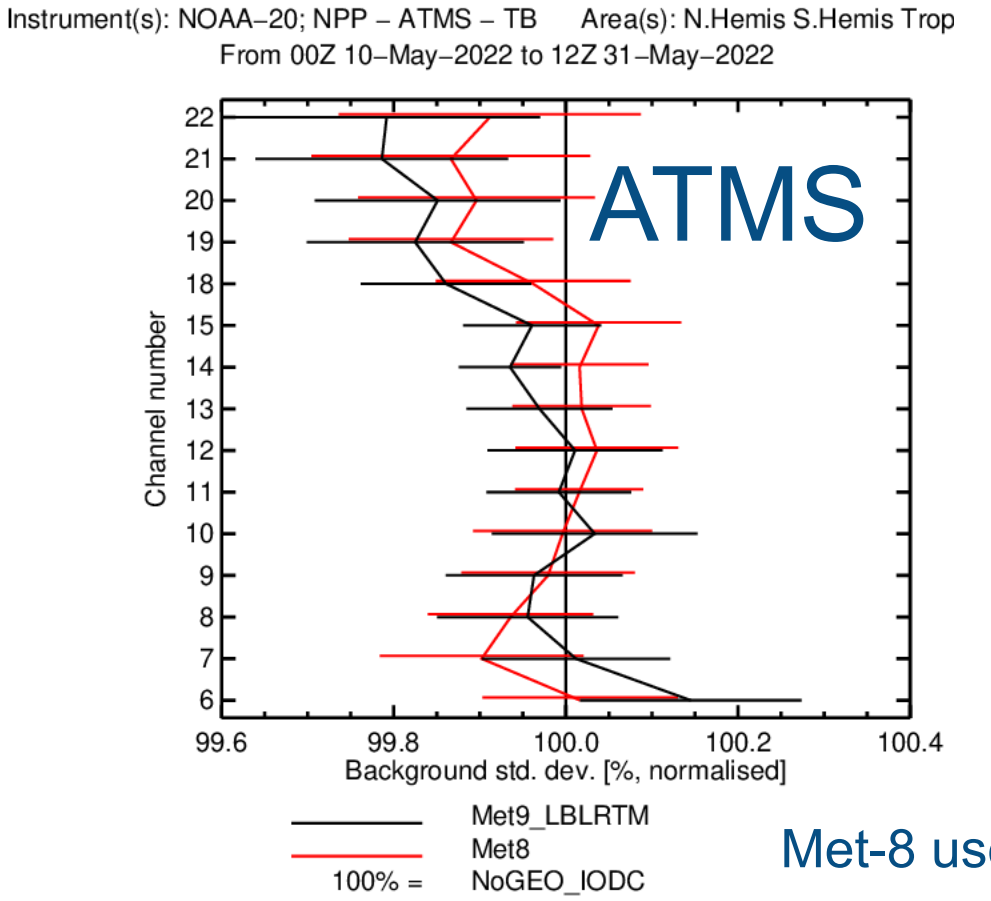
Meteosat-9 took over Meteosat-8 as the prime satellite for Indian Ocean Data Coverage (IODC) service

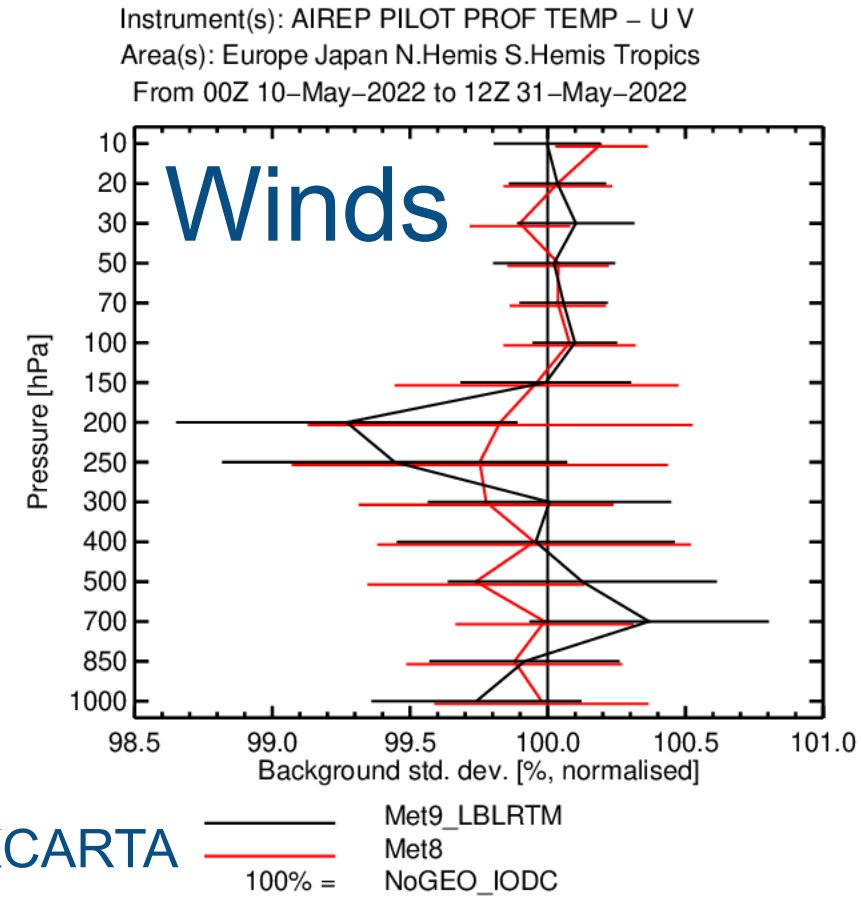
7 June 2022

Starts active assimilation of Met-9 ASR in operations



Fit to observations of Met-9 vs Met-8 (10-31 May 2022)

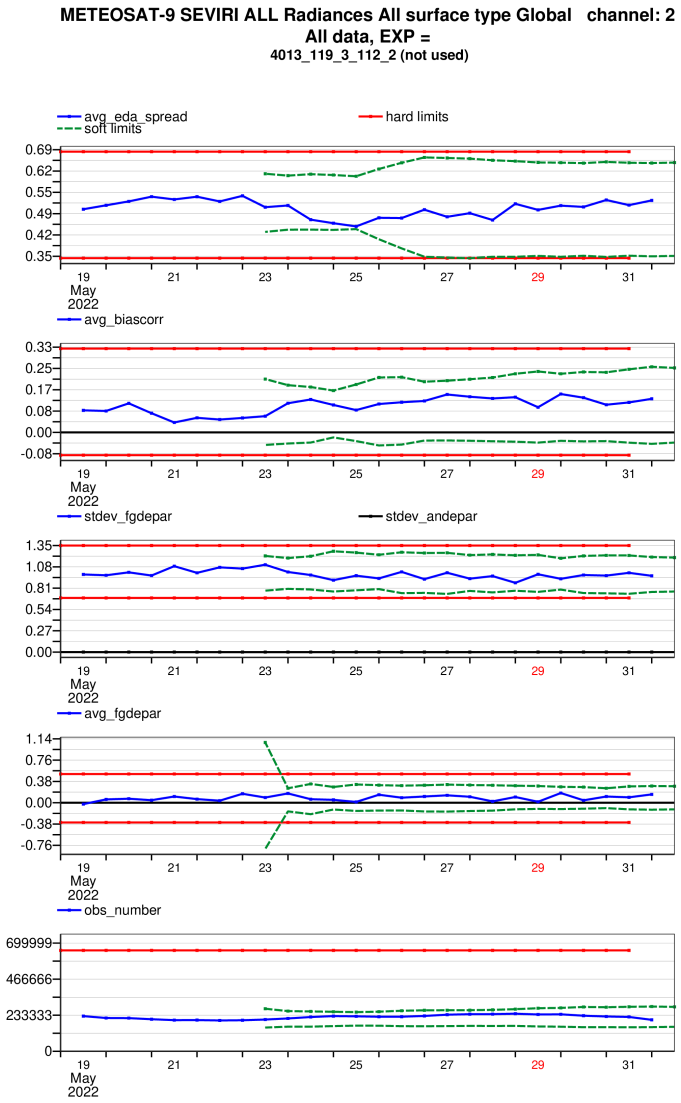


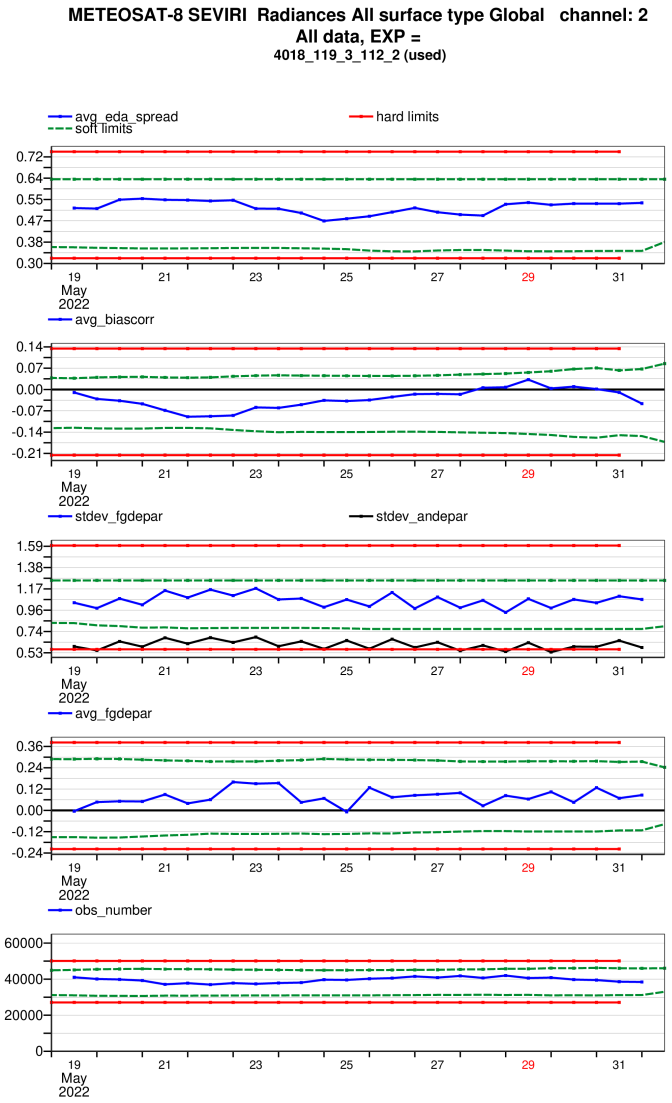


Met-8 used KCARTA

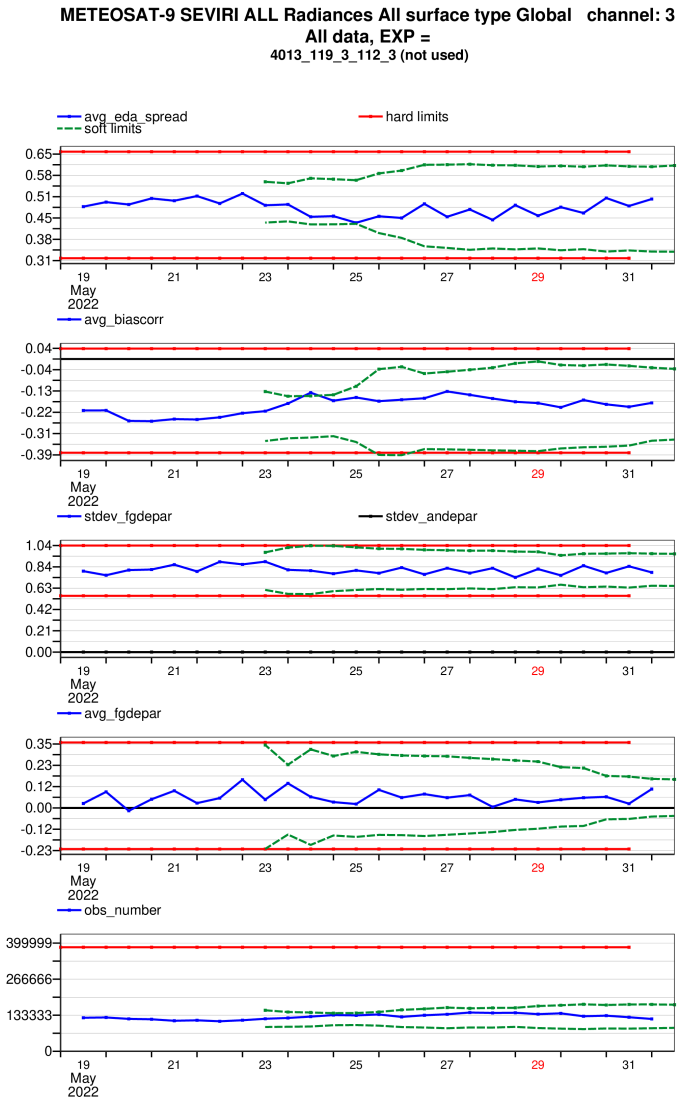
Met-9 with LBLRTM based RT coefficients presents an improved fit to ATMS and further improves the fit to winds in the upper troposphere when compared to Met-8

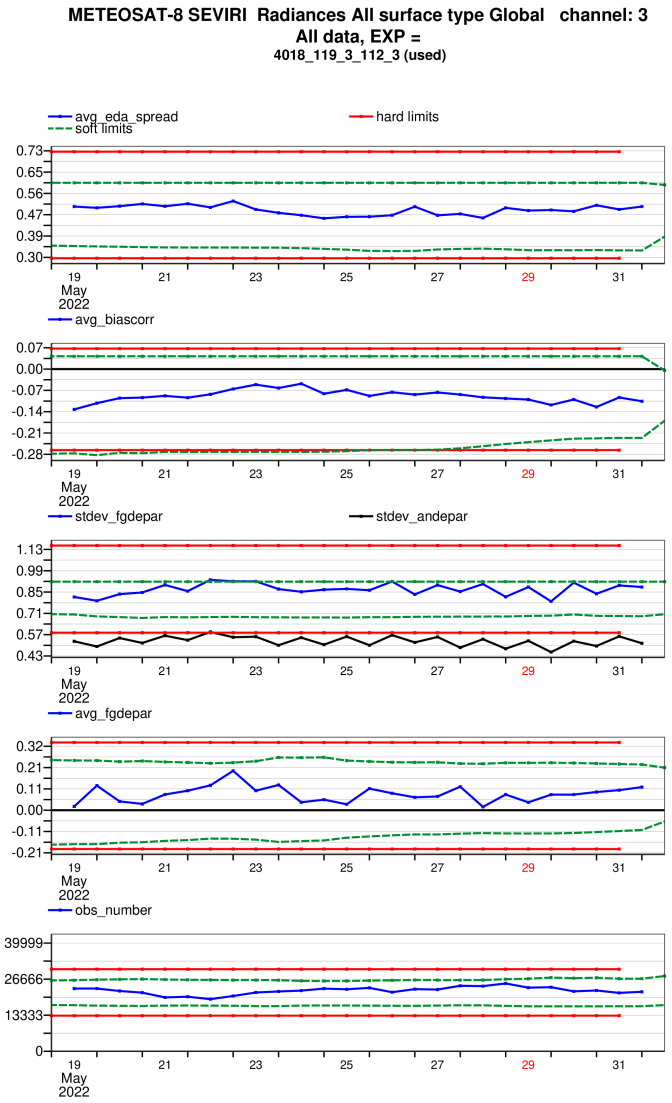
Met-9 vs Met-8 monitoring in operations (WV6.2)



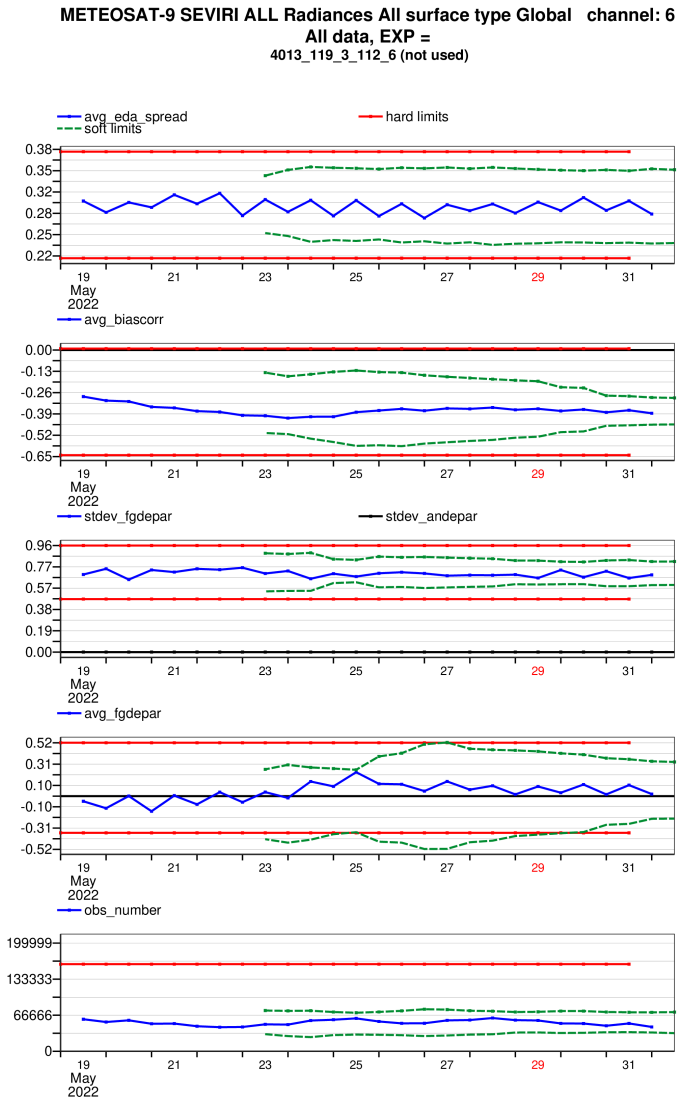


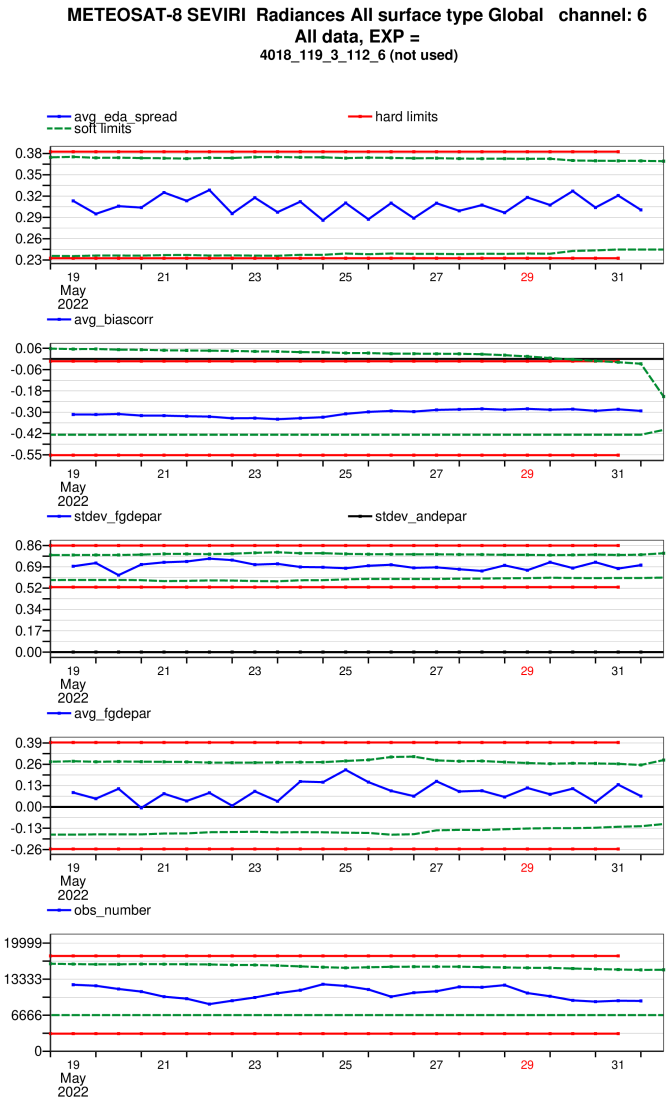
Met-9 vs Met-8 monitoring in operations (WV7.3)



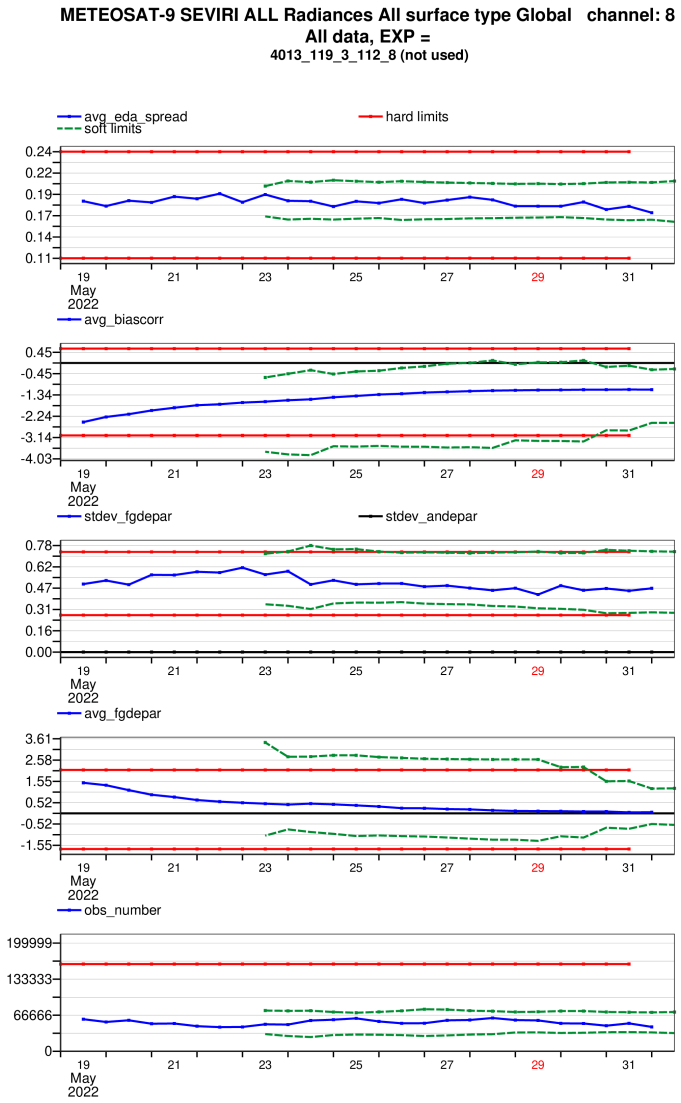


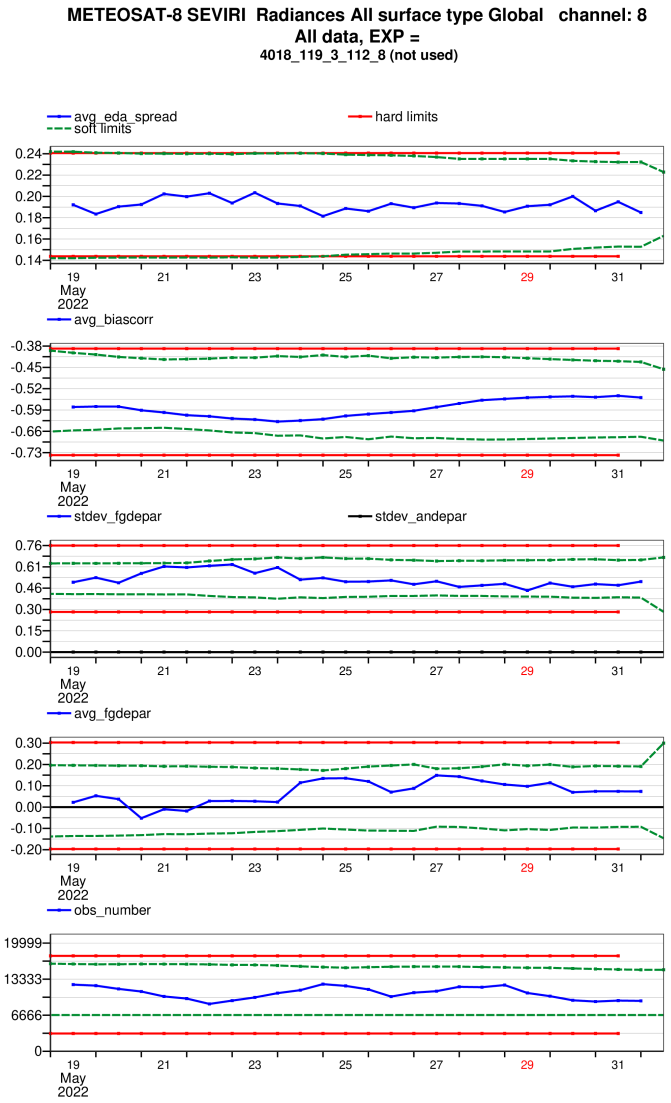
Met-9 vs Met-8 monitoring in operations (IR10.8)





Met-9 vs Met-8 monitoring in operations (IR13.4)





Conclusions

- Met-9 and Met-8 have been intercompared while parallel data was available (second half of May 2022). Operational monitoring statistics show comparable results.

- At ECMWF, the assimilation of Met-9 All-Sky Radiances (ASR) was tested offline prior to its integration in IFS operations, together with a new set of radiative transfer (RT) coefficients based on LBLRTM, for consistency with the other 4 geostationary satellites (note that Met-8 was the only GEO instrument using RT coefficients based on KCARTA).

- Met-9 results are consistent with those of Met-8, illustrating the benefit of the assimilation of geostationary infrared radiances over the Indian Ocean. Met-9 with LBLRTM based RT coefficients presents an improved fit to ATMS and further improves the fit to winds in the upper troposphere when compared to Met-8.

Thanks for your time

Any questions?

samuel.quesada@ecmwf.int