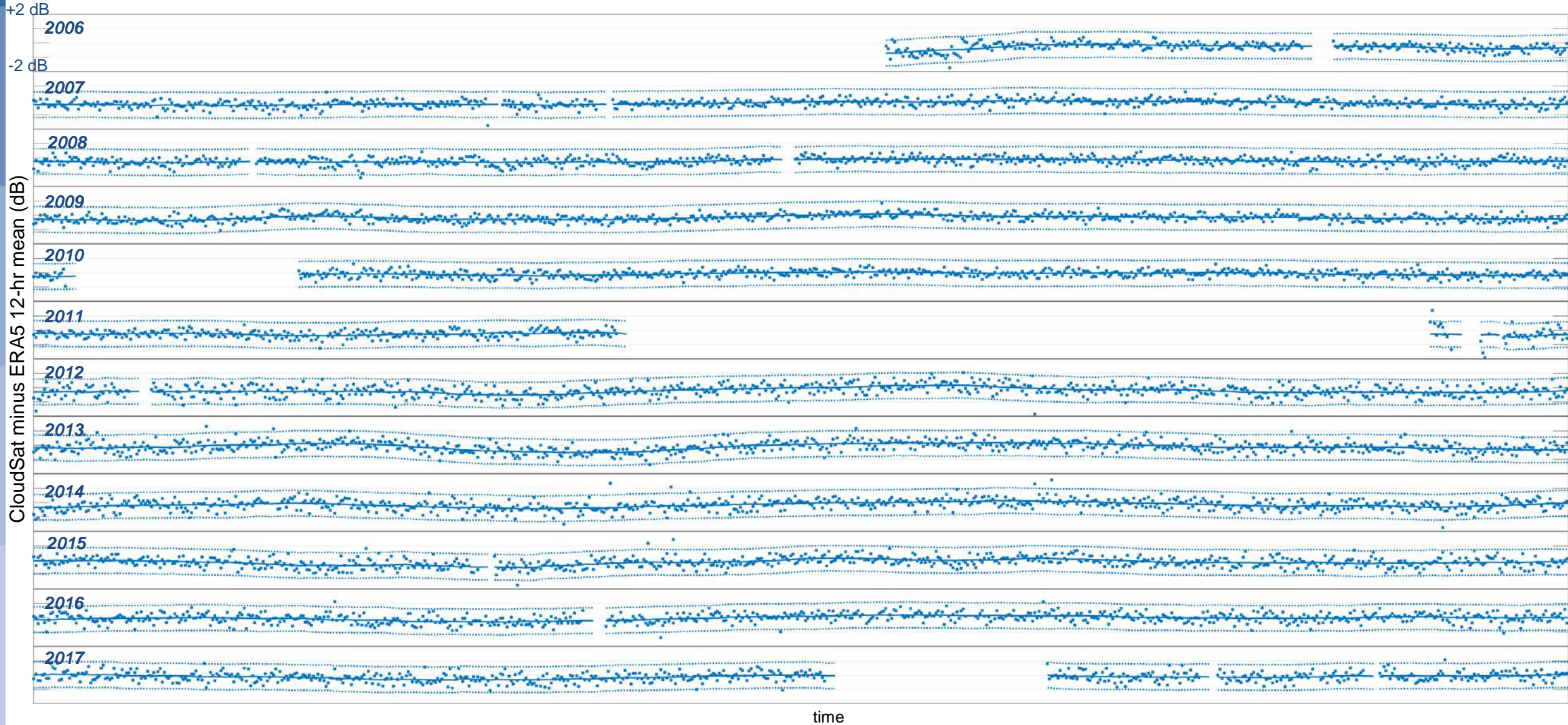


A multi-decadal review of CloudSat and CALIPSO via monitoring against ERA5



EarthCARE pre-launch science and validation workshop, ESA-ESRIN, 14 Nov 2023

Mark Fielding (ECMWF)
Marta Janisková (ECMWF)

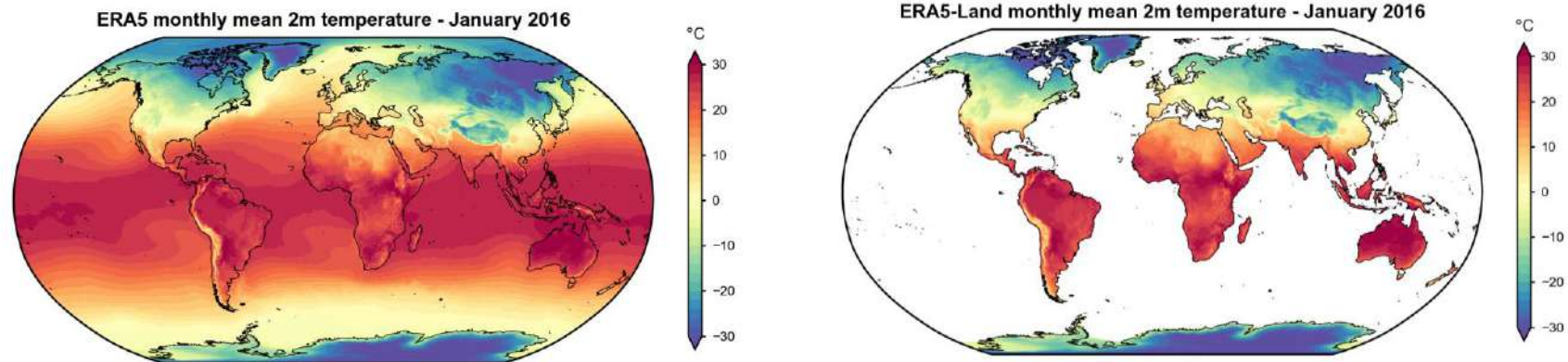


What is ERA5?

“**ERA5** is the fifth generation ECMWF reanalysis for the global climate and weather for the past 8 decades. Data is available from 1940 onwards [**to the present day**]. ERA5 replaces the ERA-Interim reanalysis.”

“Reanalysis combines model data with observations from across the world into a globally complete and consistent dataset **using the laws of physics...**”

“Reanalysis **does not have the constraint of issuing timely forecasts**, so there is more time to collect observations, and when going further back in time, to allow for the ingestion of improved versions of the original observations, which all benefit the quality of the reanalysis product.”



Source: climate.copernicus.eu

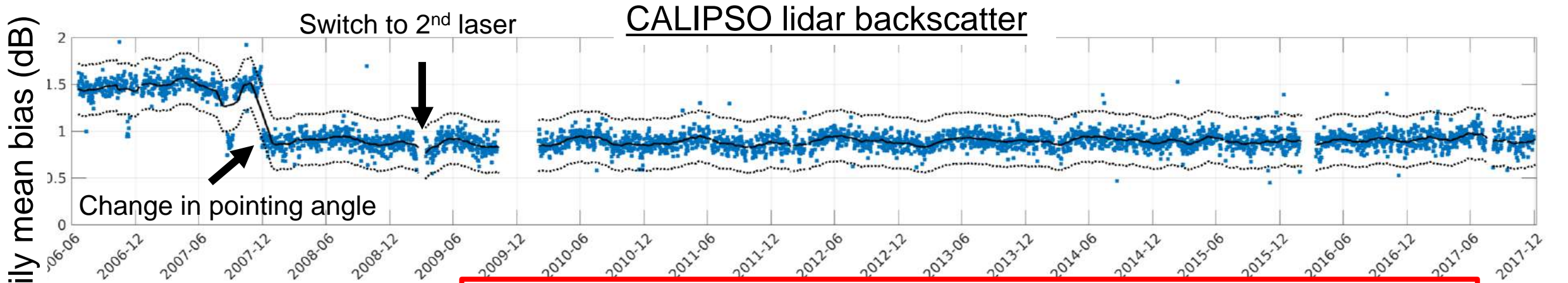
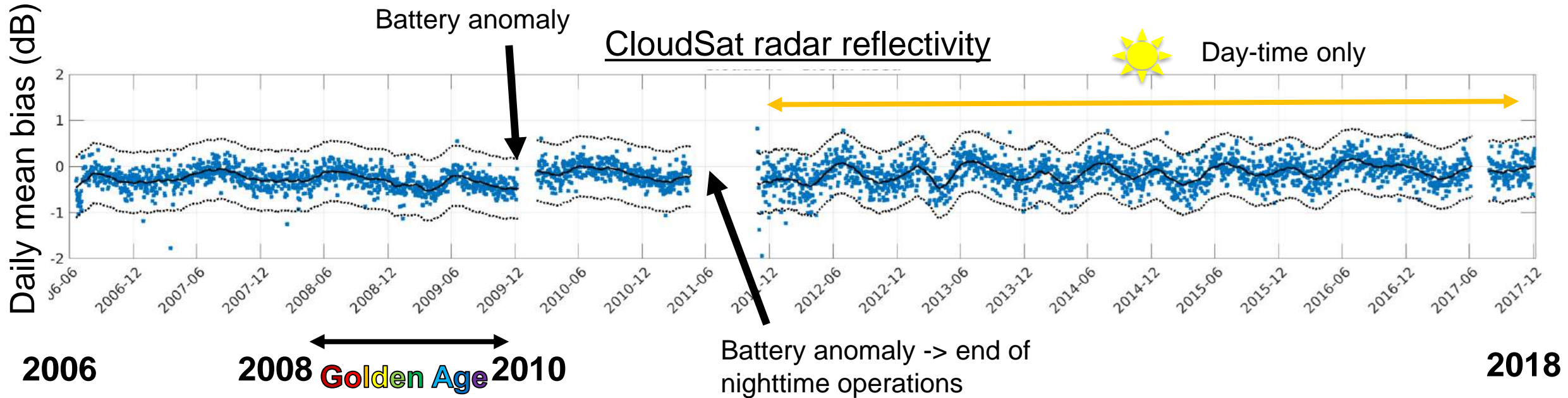
Motivation

- Assess the stability of CloudSat and CALIPSO observations and demonstrate their potential for inclusion in future re-analyses.
- Demonstrate and test monitoring system in preparation for EarthCARE observations.
- Provide a 'stepping stone' for comparison of EarthCARE CPR radar reflectivity with CloudSat.
- Evaluate quality of CloudSat and CALIPSO data for assimilation experiments in more recent observing systems.
- Investigate ERA5 biases in representation of clouds.

Monitoring CloudSat and CALIPSO against ERA5

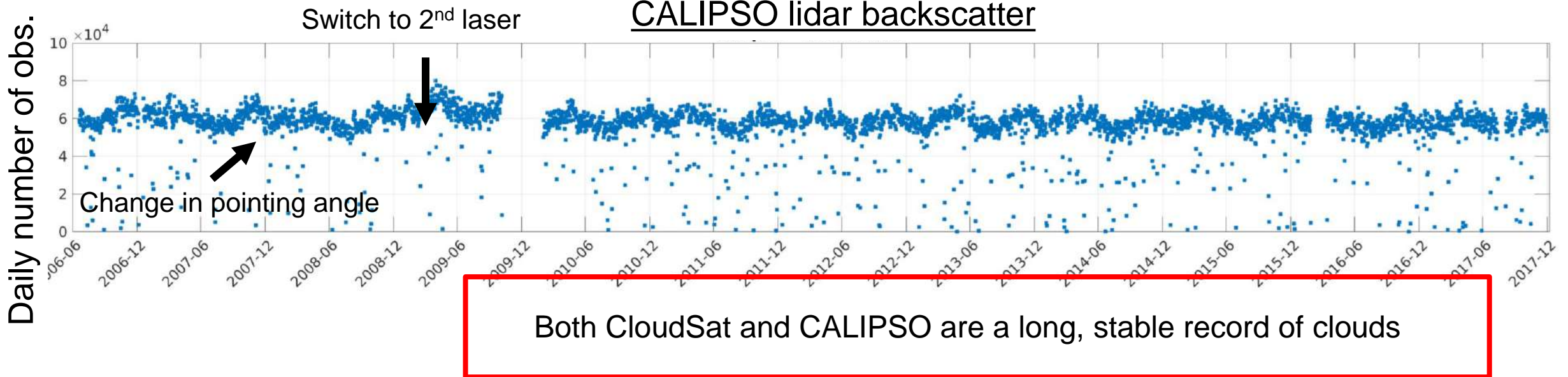
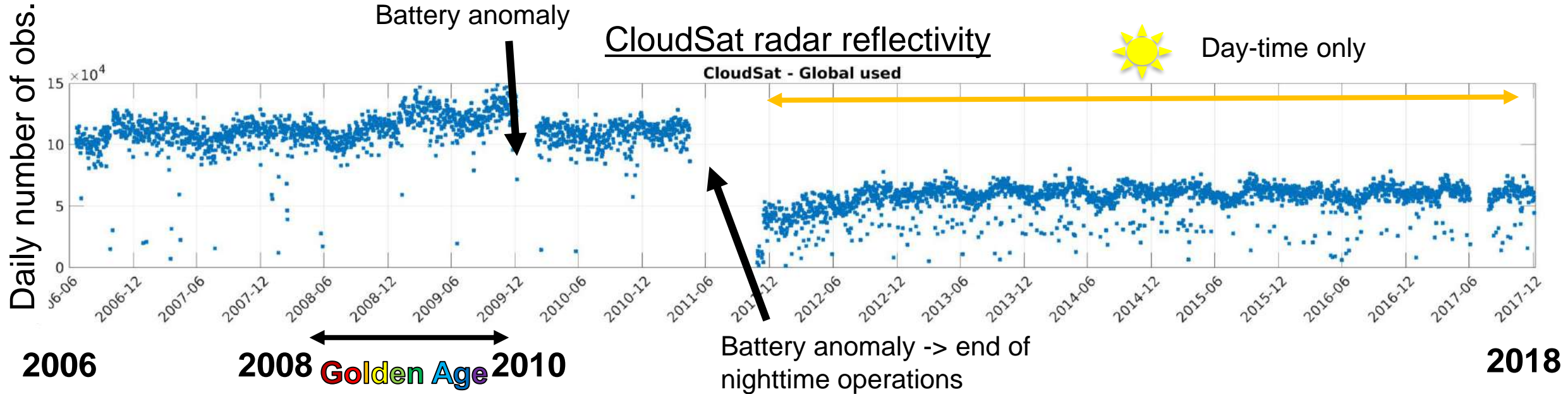
- IFS ‘monitor-only’ experiment using CY48R1 re-initialised with ERA5 model fields using the same horizontal resolution of TL399 spectral truncation (corresponding to ~30 km on a reduced gaussian grid) and 137 vertical levels:
 - Period: 1 June 2006 – 31 December 2017
- Observations of cloud radar reflectivity (at 94 GHz, CloudSat), cloud lidar backscatter (at 532 nm, CALIPSO) horizontally averaged to ERA5 grid.
- Use same observation operator as assimilation (evolved from COSP, now with ‘triple column’ approach*).
- Initial conditions are from ERA5 (CY41R2, operational in 2016), while the 12-hour forecast uses operational cycle (CY48R1).

Monitoring CloudSat and CALIPSO against ERA5 – mean bias

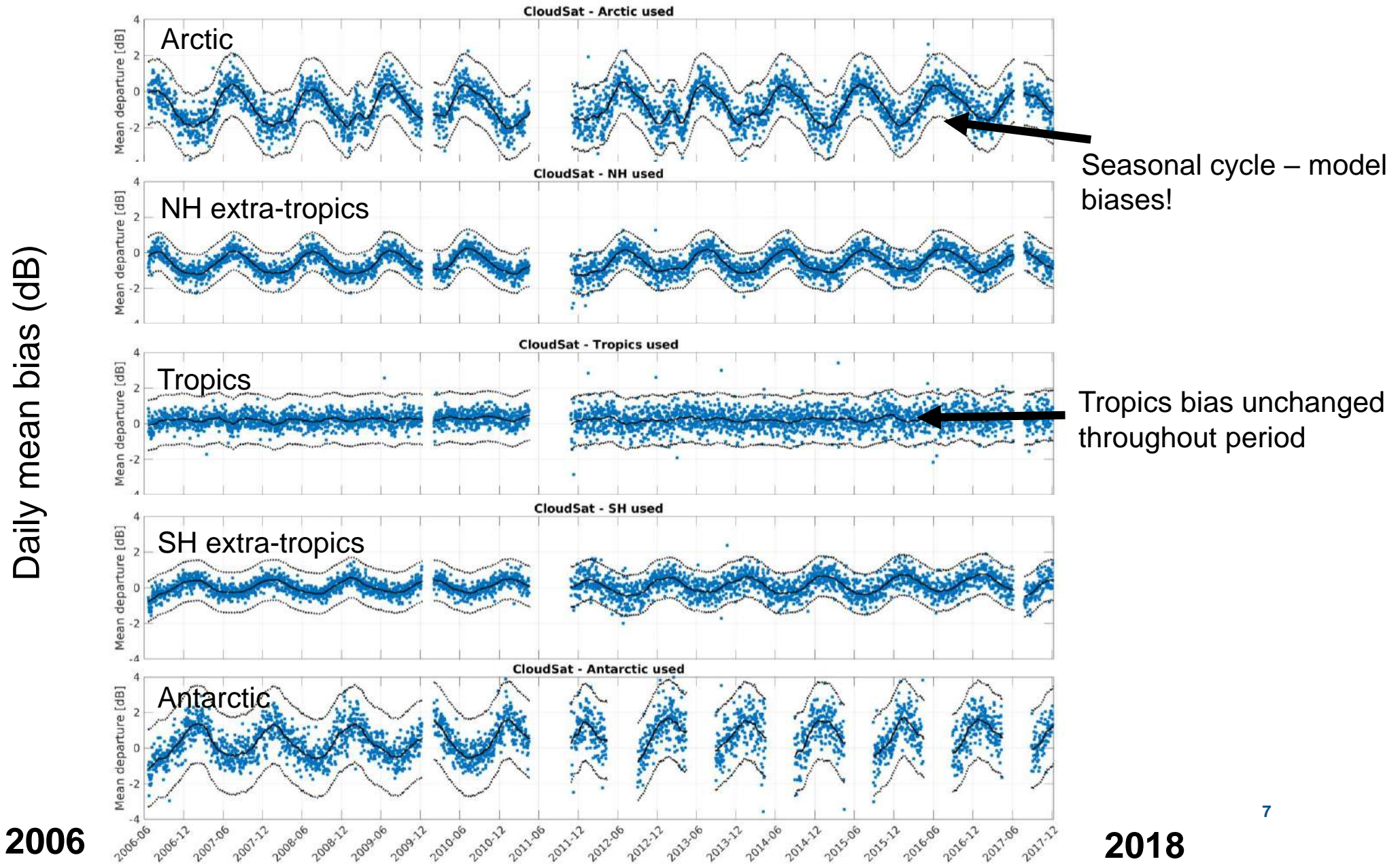


Both CloudSat and CALIPSO are a long, stable record of clouds

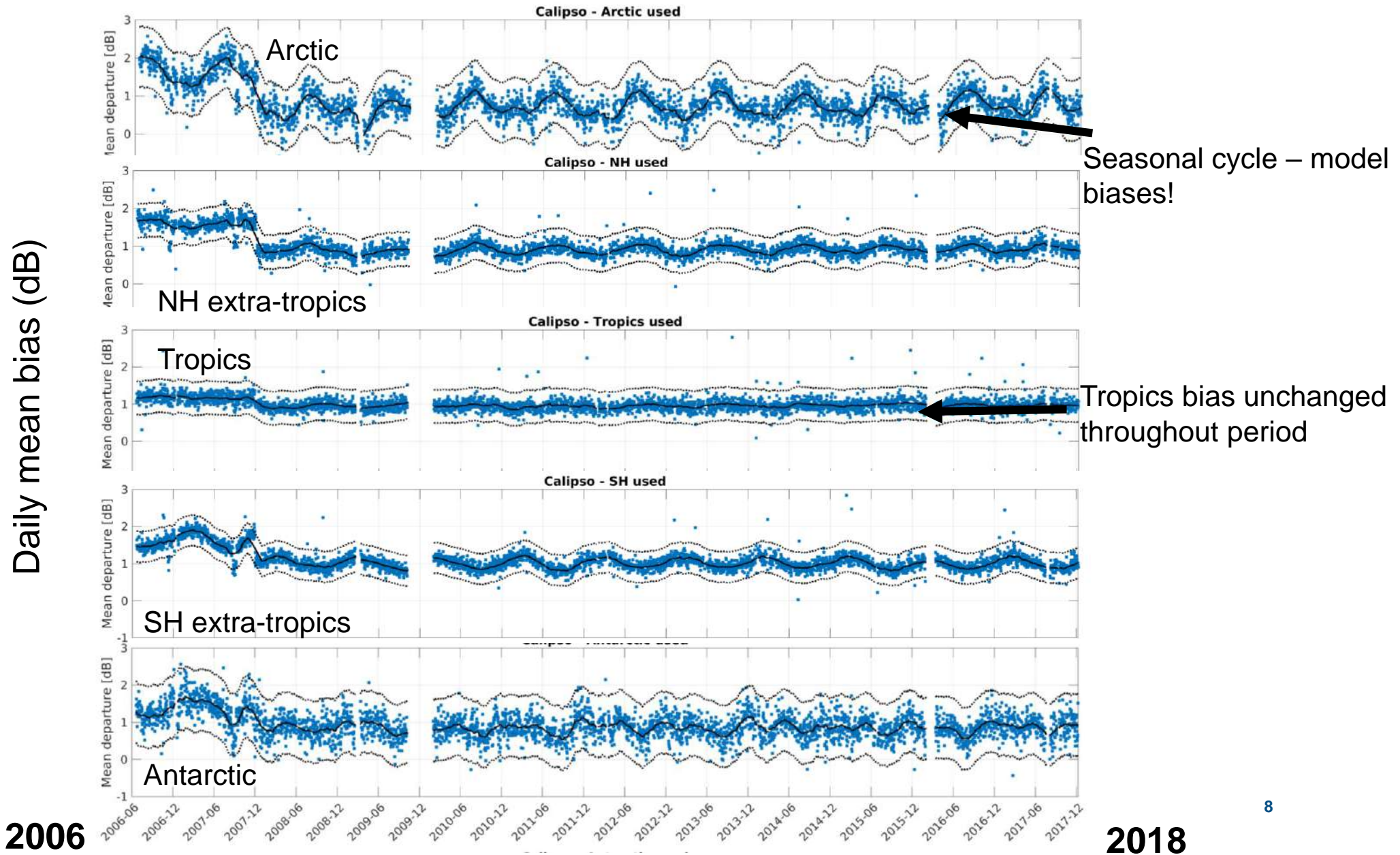
Monitoring CloudSat and CALIPSO against ERA5 – number of obs.



Monitoring regional biases - CloudSat

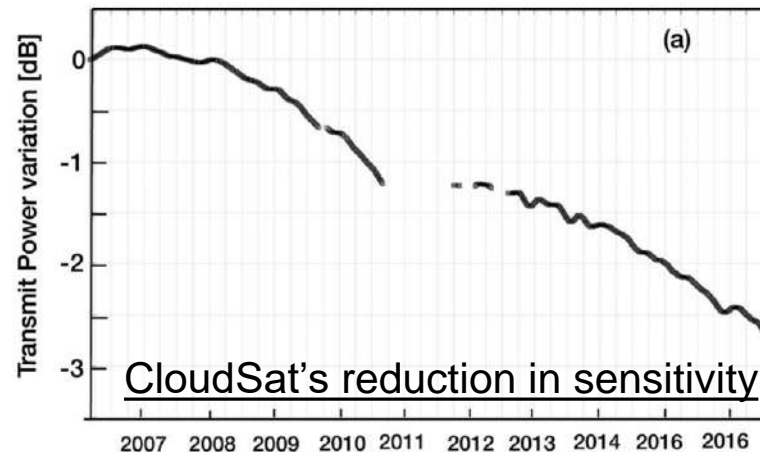


Monitoring regional biases - CALIPSO



Data requirements for reanalysis and data homogenization

- Do the observations cover a significant period?
- Does impact justify additional cost?
- Do the observations have consistent data quality?
- Do the observations impact the mean state? Is bias correction appropriate throughout?

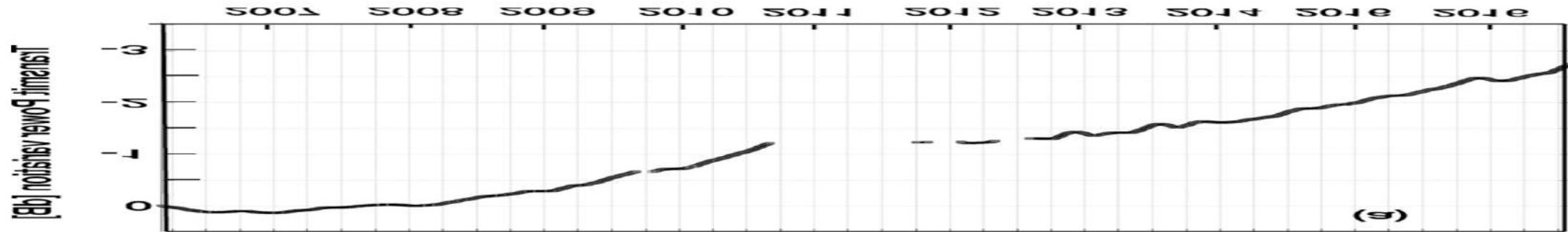
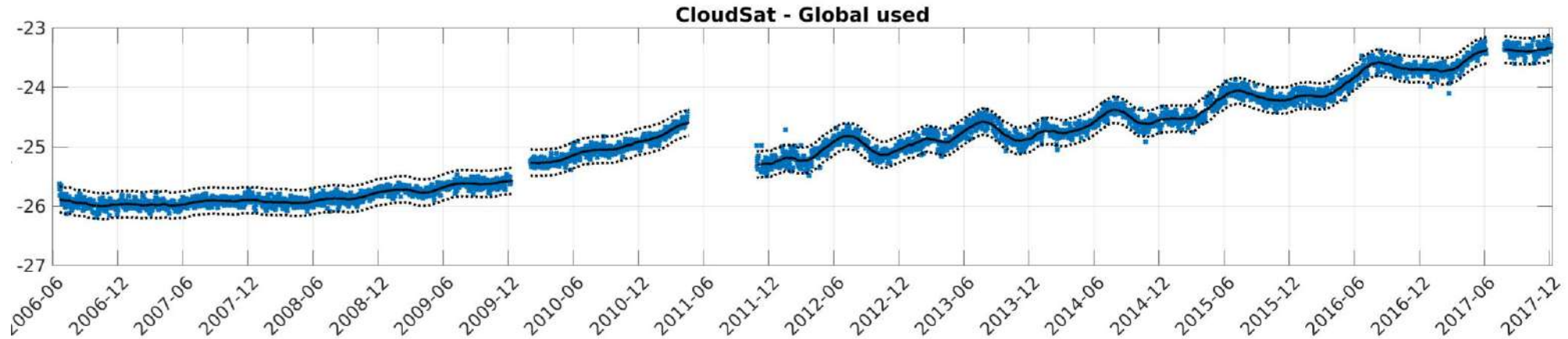


Stephens et al., 2018

**Can we address CloudSat's
reduction in sensitivity and loss of
night-time operations?**

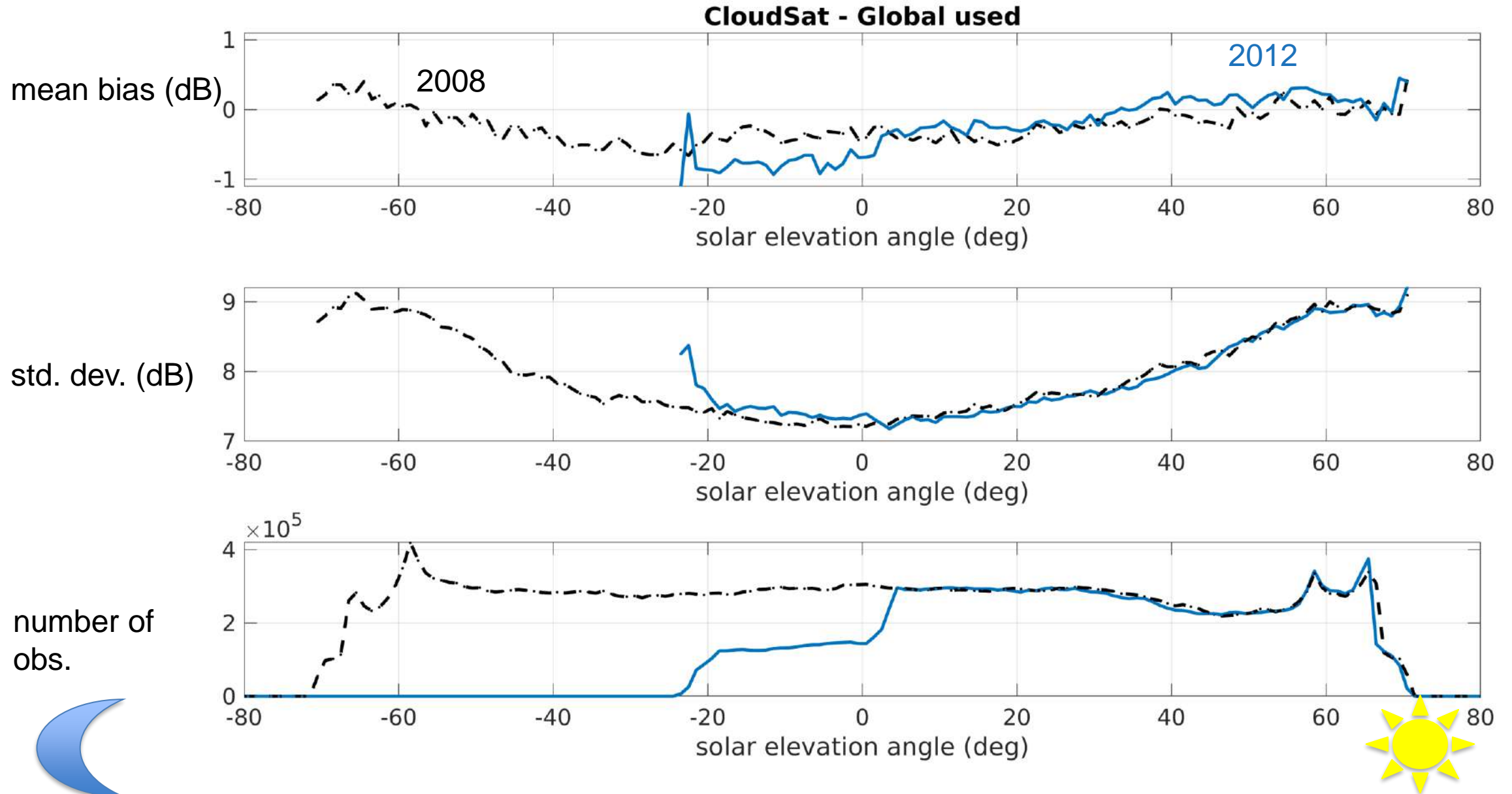
1. Monitoring CloudSat's sensitivity change

First percentile of in-cloud mean Z



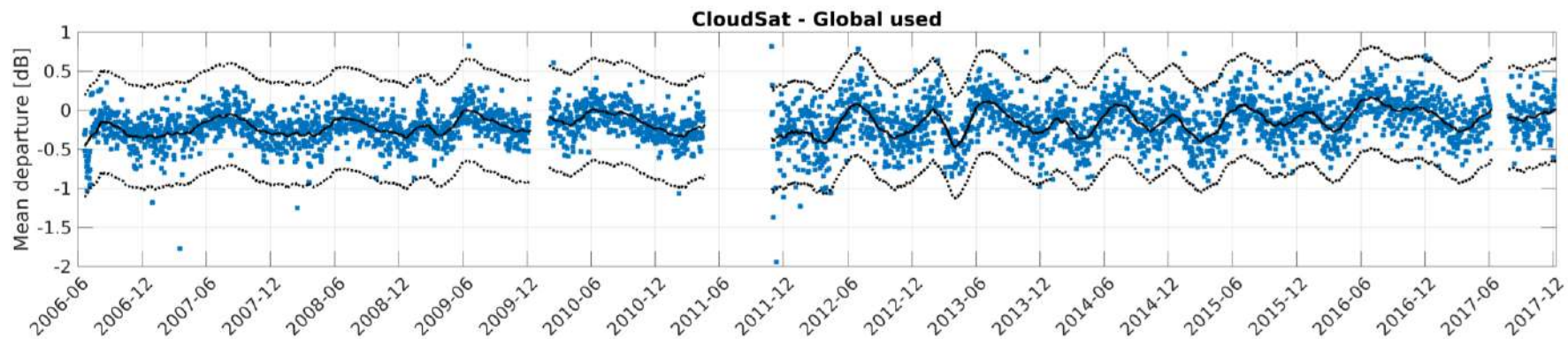
...discard observations below - 24 dBZ

2. Day-time only operations

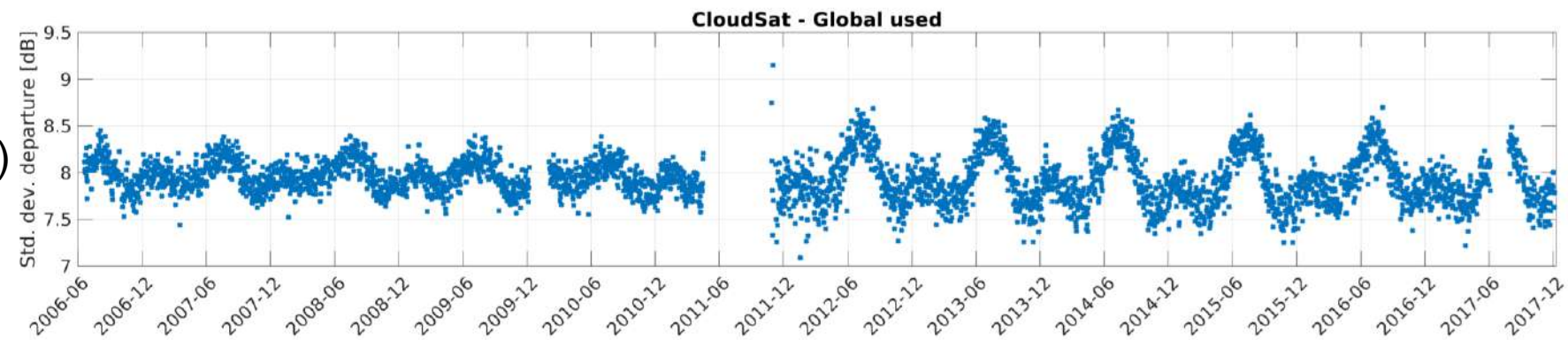


Homogenizing the CloudSat dataset

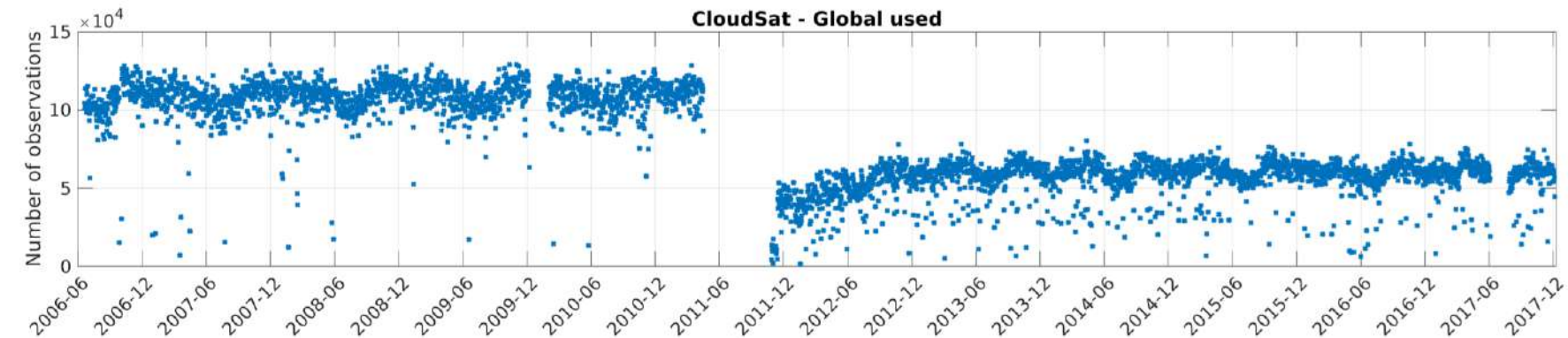
Daily mean bias (dB)



Std. dev. (dB)

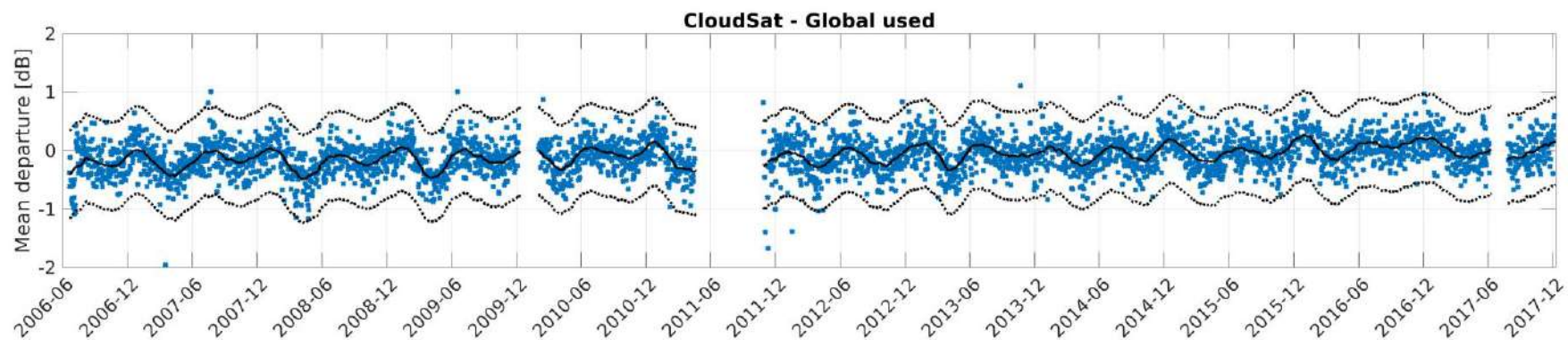


Number of obs.

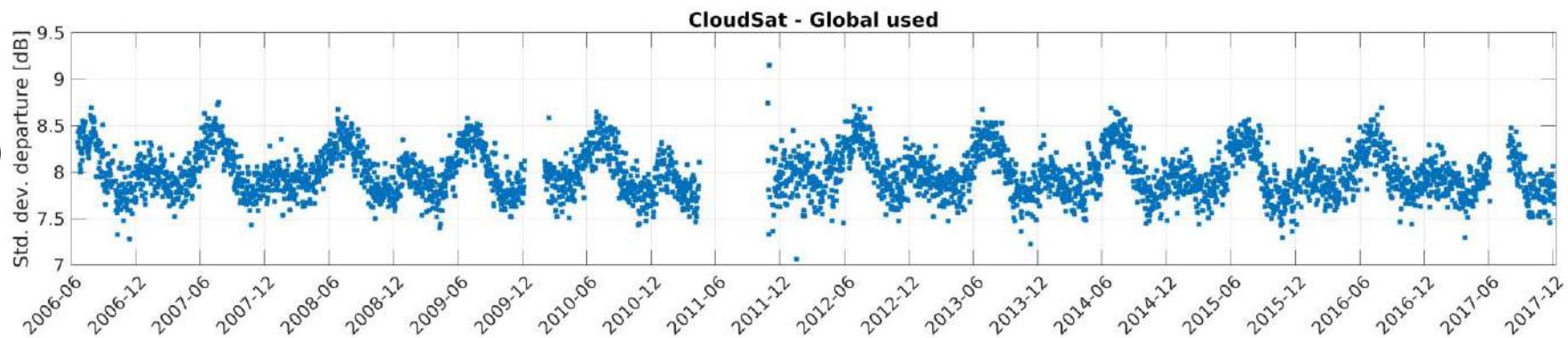


Homogenizing the CloudSat dataset – remove daylight obs.

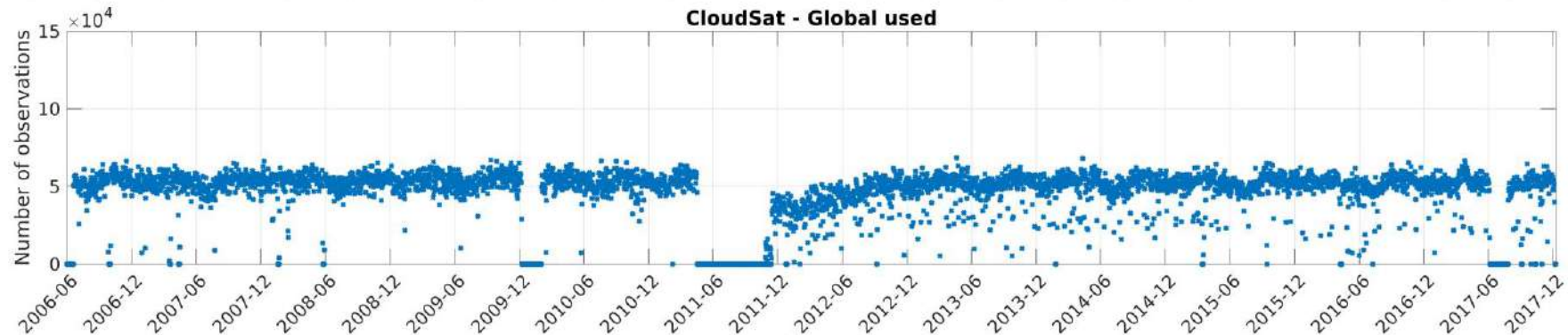
Daily mean bias (dB)



Std. dev. (dB)

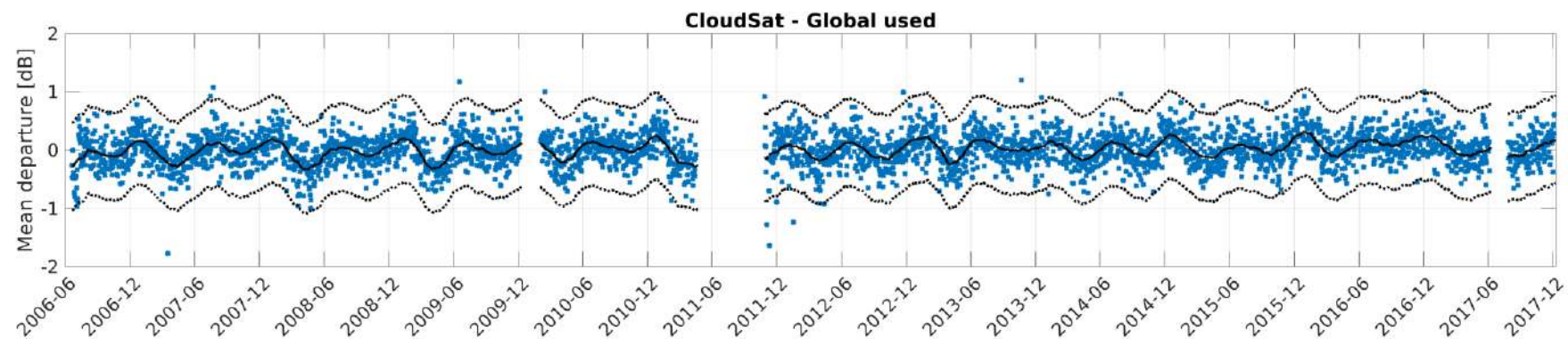


Number of obs.

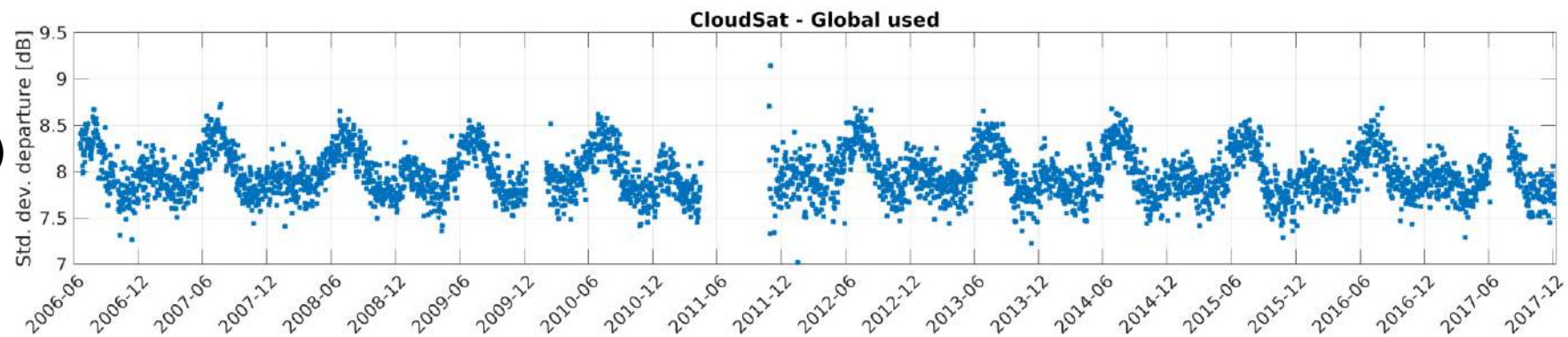


Homogenizing the CloudSat dataset – adjust sensitivity

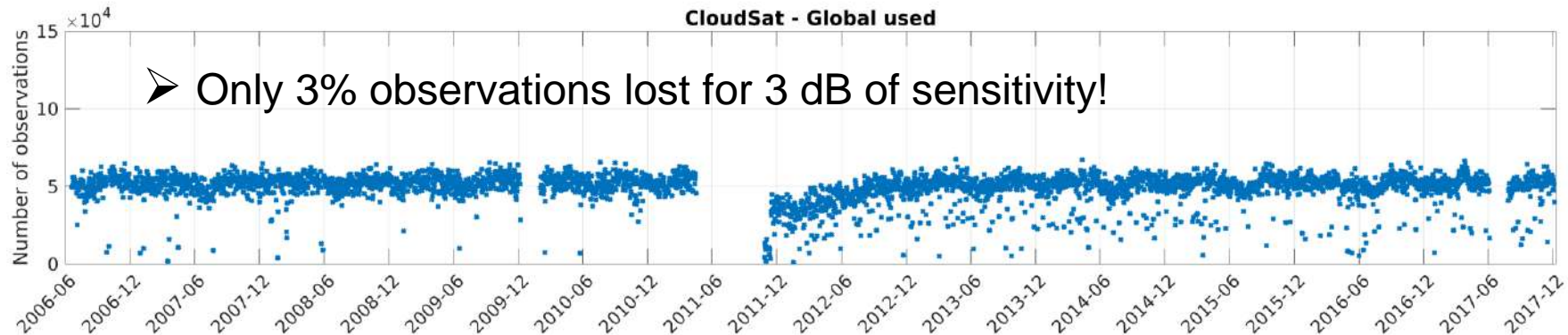
Daily mean bias (dB)



Std. dev. (dB)

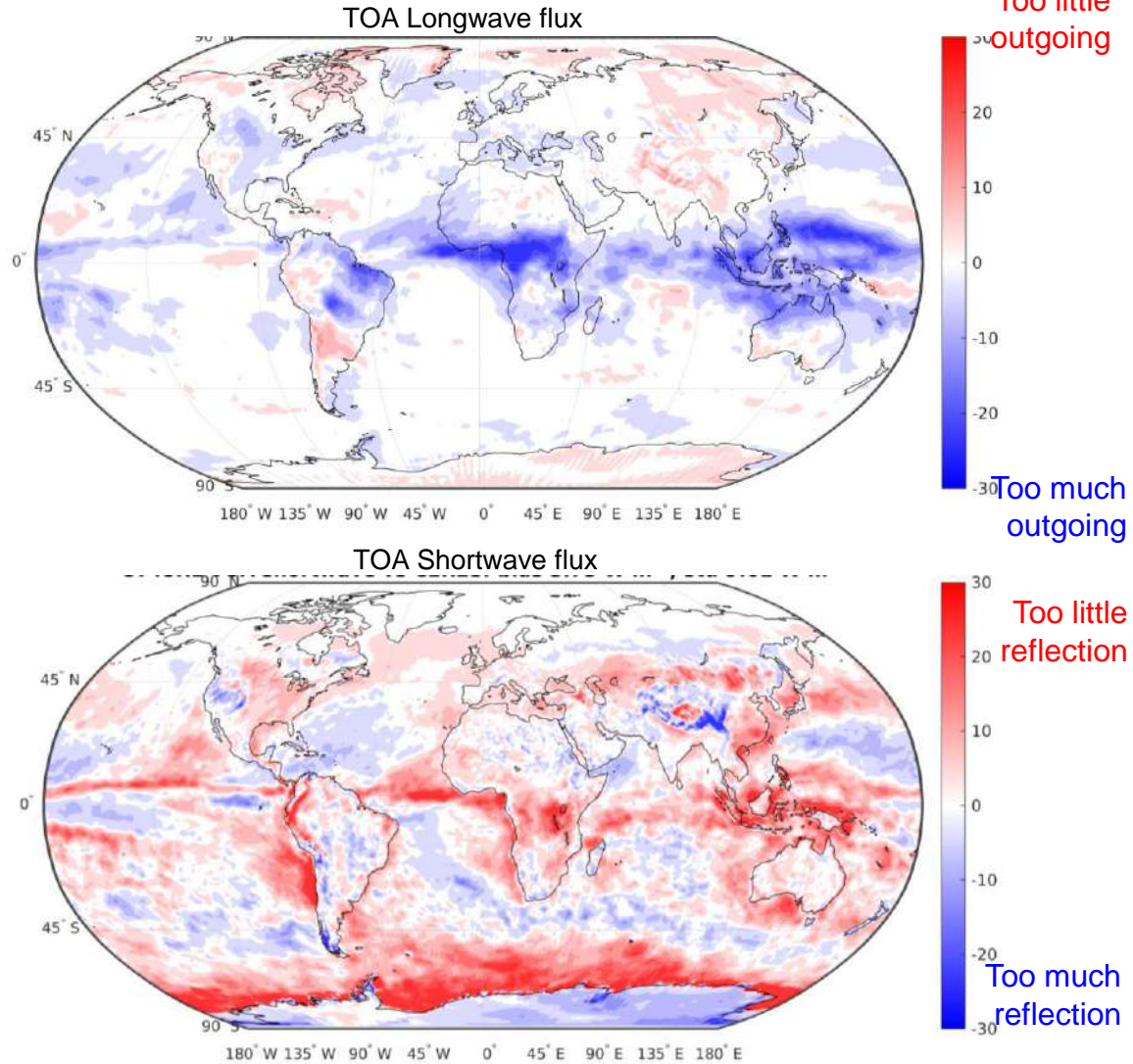


Number of obs.

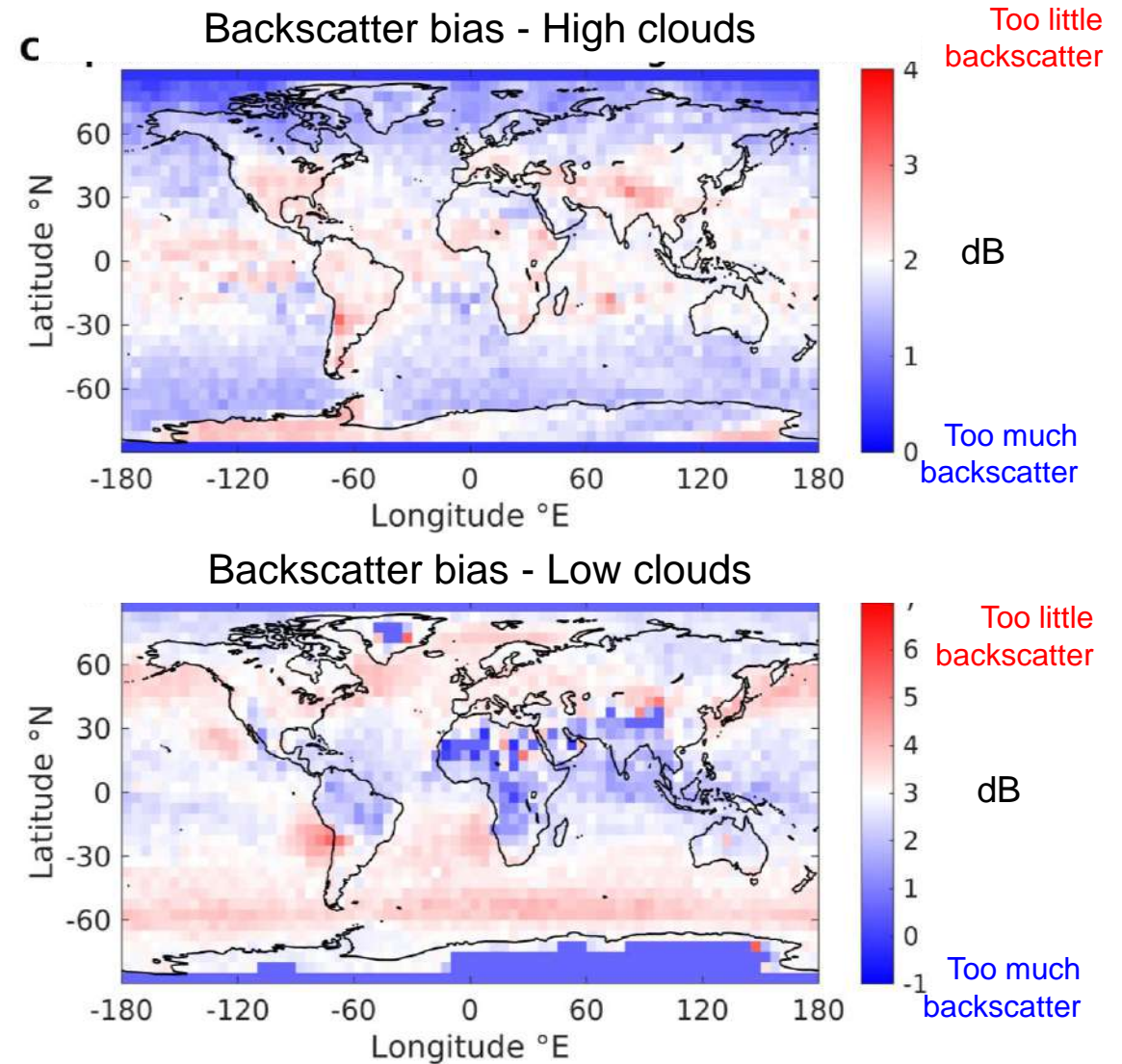


Model biases are waiting to be solved by EarthCARE!

CY48R1 vs CERES

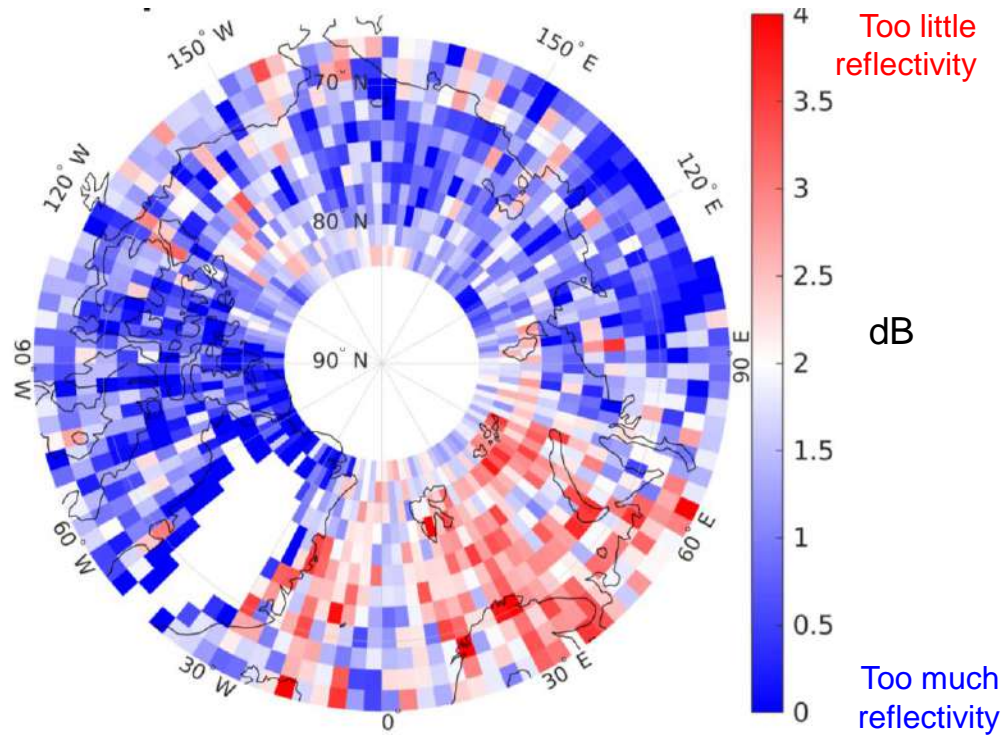


ERA5 vs CALIPSO

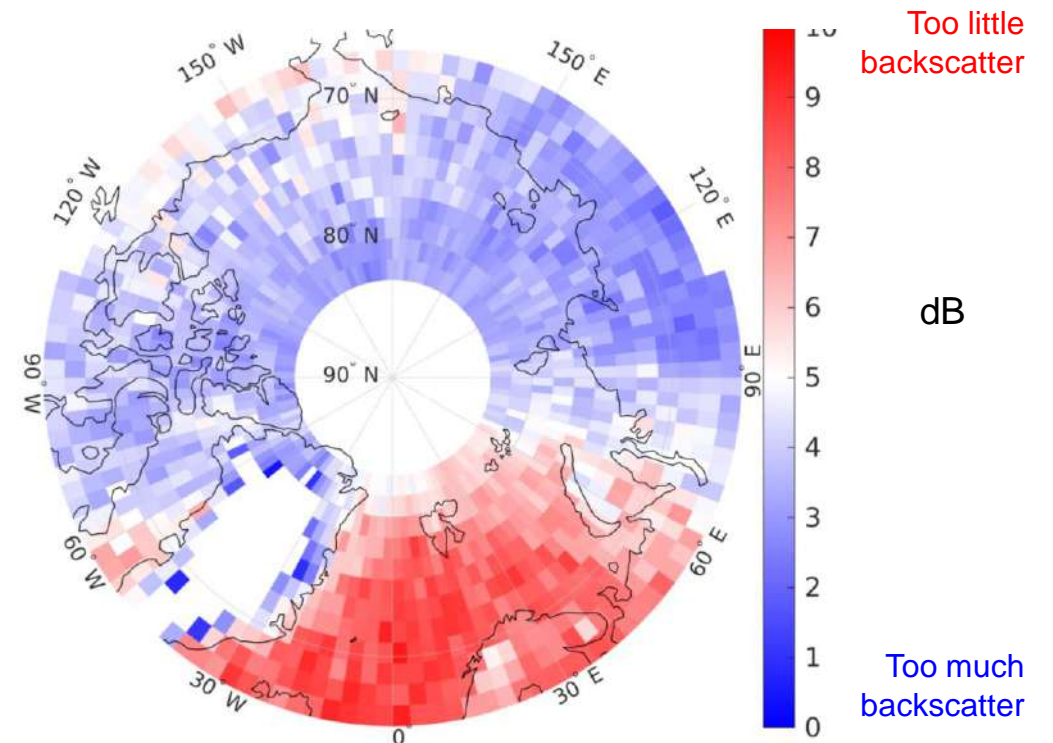


Cold air outbreaks poorly represented – DJF 2010-2016 mean bias low clouds (p>700 hPa)

CloudSat vs ERA5



CALIPSO vs ERA5



Reanalyses need help too!

Summary

- CloudSat and CALIPSO data quality are enviable.
- Monitoring EarthCARE against ERA5 will allow indirect comparison with CloudSat and CALIPSO.
- Datasets are suitable for inclusion in reanalyses – likely too late for ERA6 (deadline < 6 months), further testing required on assimilation impact.
- CloudSat, CALIPSO and EarthCARE earmarked for ERA7 (2030?).
- EarthCARE will be a catalyst for reducing model errors through synergistic active/passive approaches that target compensating biases.