Variational bias correction of Sea Surface Temperature observations

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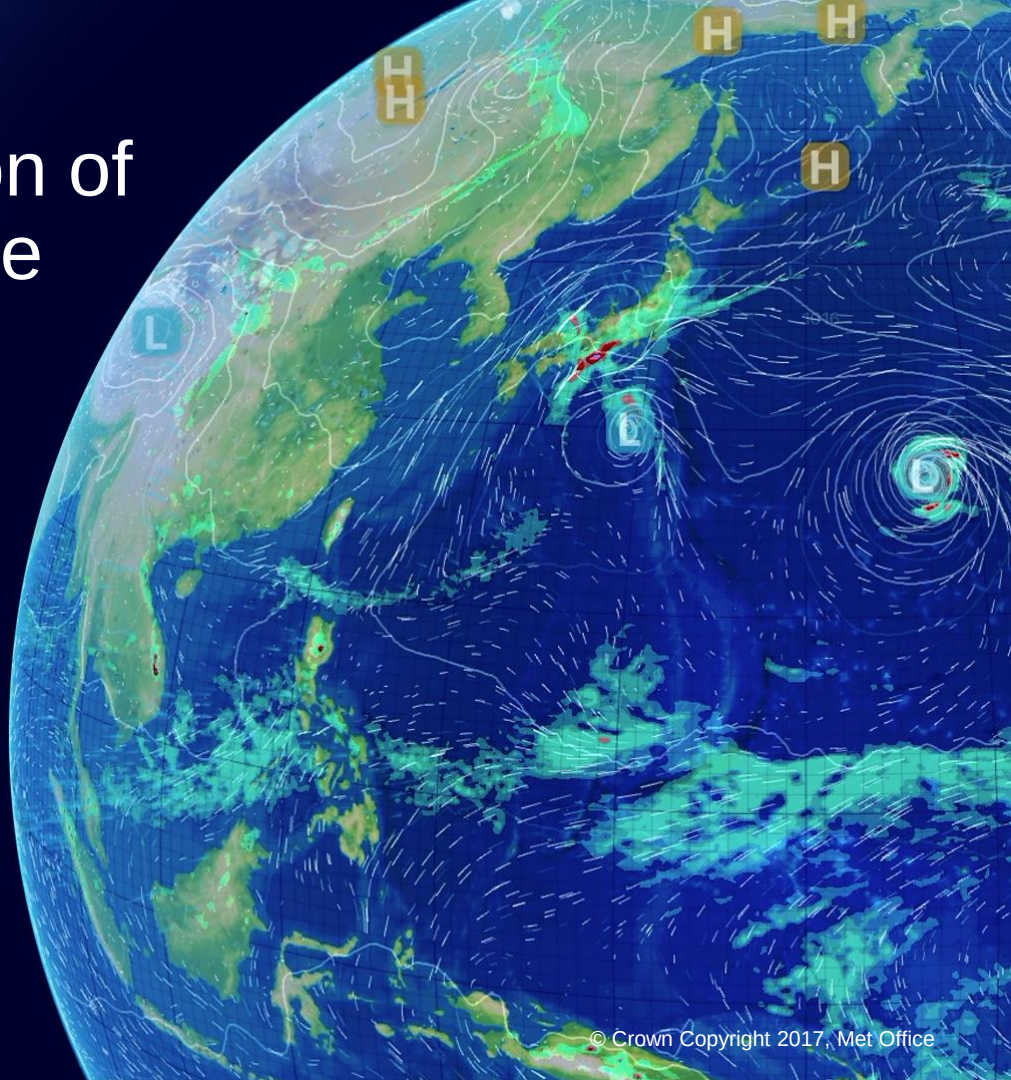


Introduction

Over the last few years we have been developing a new system for bias correcting SSTs

The purpose of this work is to:

- Replace the ‘offline’ bias correction scheme we have been using with something better.
- Produce a bias correction scheme that can be used in the early satellite period when there were few high quality ‘unbiased’ reference data.

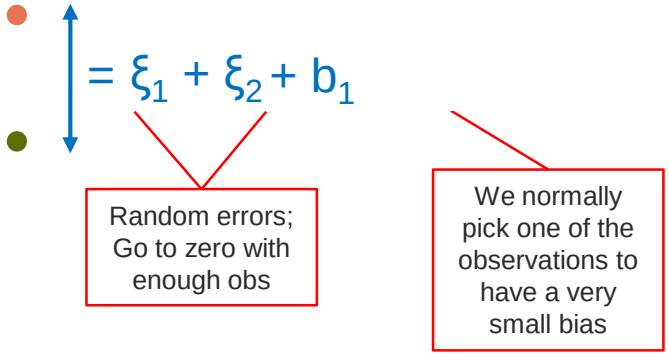
Our solution has been to create a scheme that combines observation minus model differences with “observations-of-bias”.

This is a type of variational bias correction scheme

Obs Bias correction basics

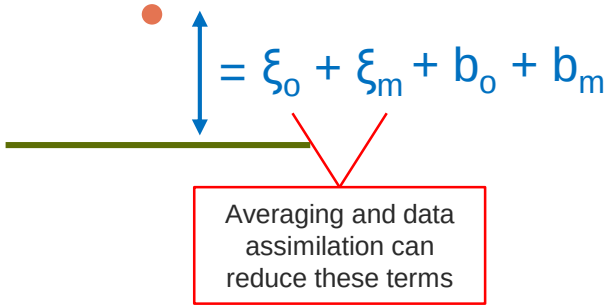
There are two ways to get information about the obs bias:

1. The difference between two observations of the same thing. We refer to these as observations-of-bias



Advantage: gives a 'direct' measurement of the observation bias.
Disadvantage: Requires significant numbers of 'unbiased' observations.

2. The difference between observations and a model of the same thing.



Advantages: 1. Does not require 'unbiased' observations
2. Can be directly incorporated into data assimilation schemes
Disadvantage: Cannot separate observation and model bias

There are 4 possibilities

1. Do no bias correction
If you 'know' the bias is negligible this is the sensible choice.

2. Bias correct using observations-of-bias
ice has done things.

All possibilities can be tuned in various ways.

3. Bias correct u ifferences.
This can be done using a modified form of the variational assimilation equations,
and is often called a variational bias correction method.

Note that high quality reference observations can still be assimilated as normal obs.

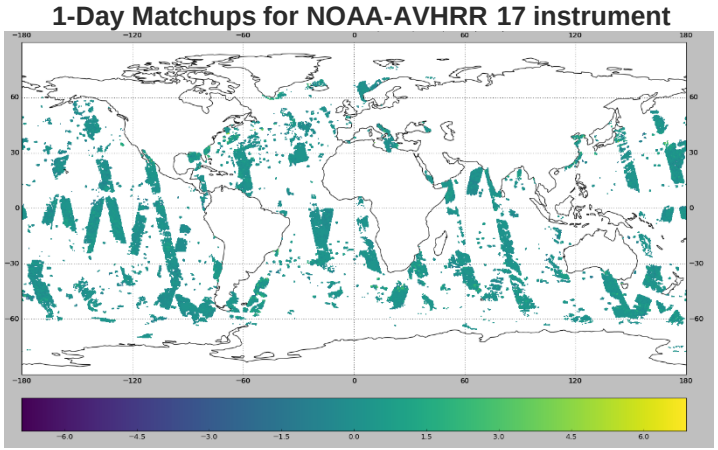
3. Bias correct using using observations-of-bias and observations model (analysis) differences.
This is the new method we are implementing in our operational systems.

Observations-of-Bias

Observations-of-bias are the differences between co-located standard observations and assumed ‘un-biased’ reference data.

Their accuracy and quality depend on the matchup criteria used – We use 6 hours and 50km.

To prevent cross correlations between observations and observations-of-bias. All observations that are used to calculate the observations-of-bias are NOT assimilated as normal observations.



The number of co-located observations varies depending on the settings. For our experiments it was ~15% of the biased data and ~70% of the reference data

Tests using the Lorenz-63 system

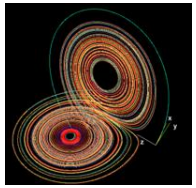


Image from Wikipedia
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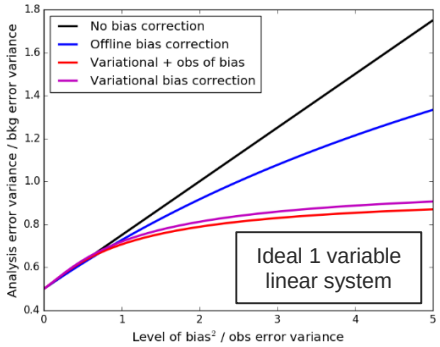
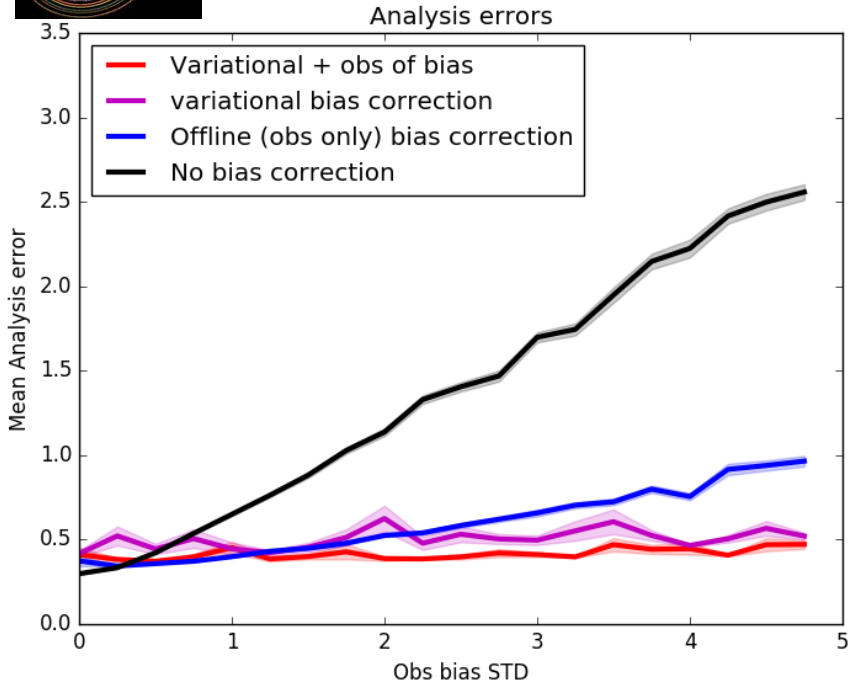
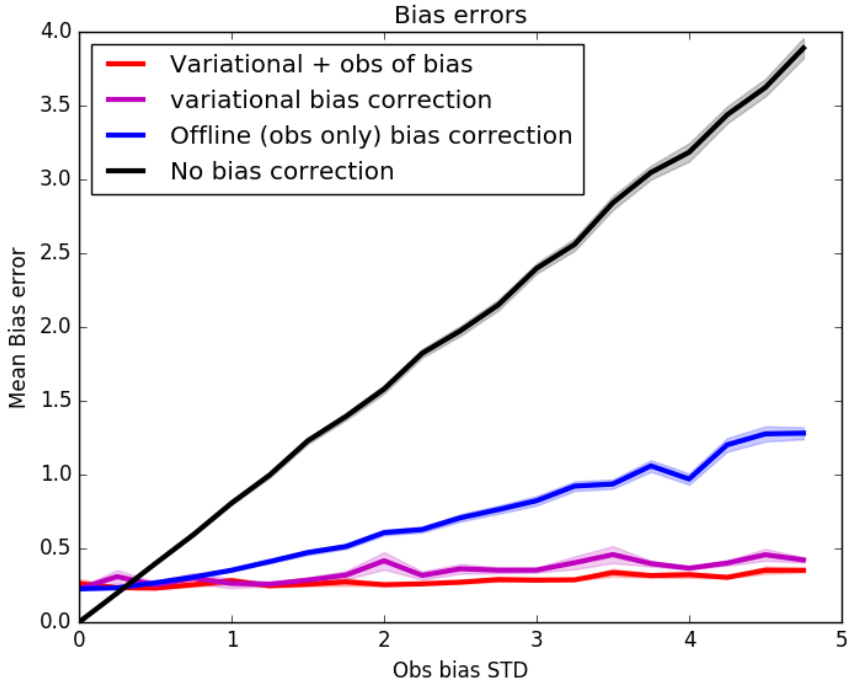






Results from a 3 year reanalysis

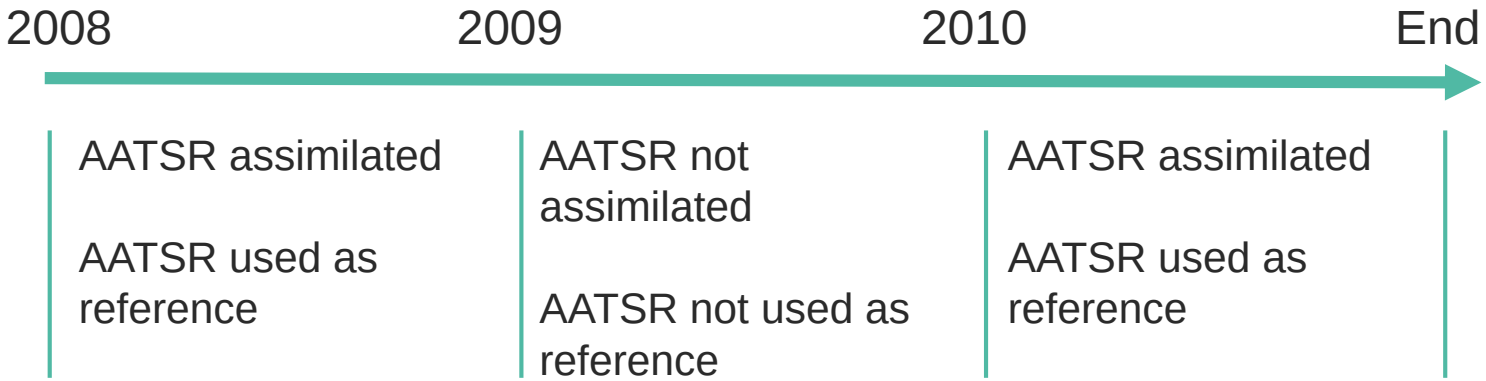
To test the bias correction scheme we ran four 3 year experiments (2008-2010):

NO_COR_GCM:- No bias correction, all observations assimilated directly

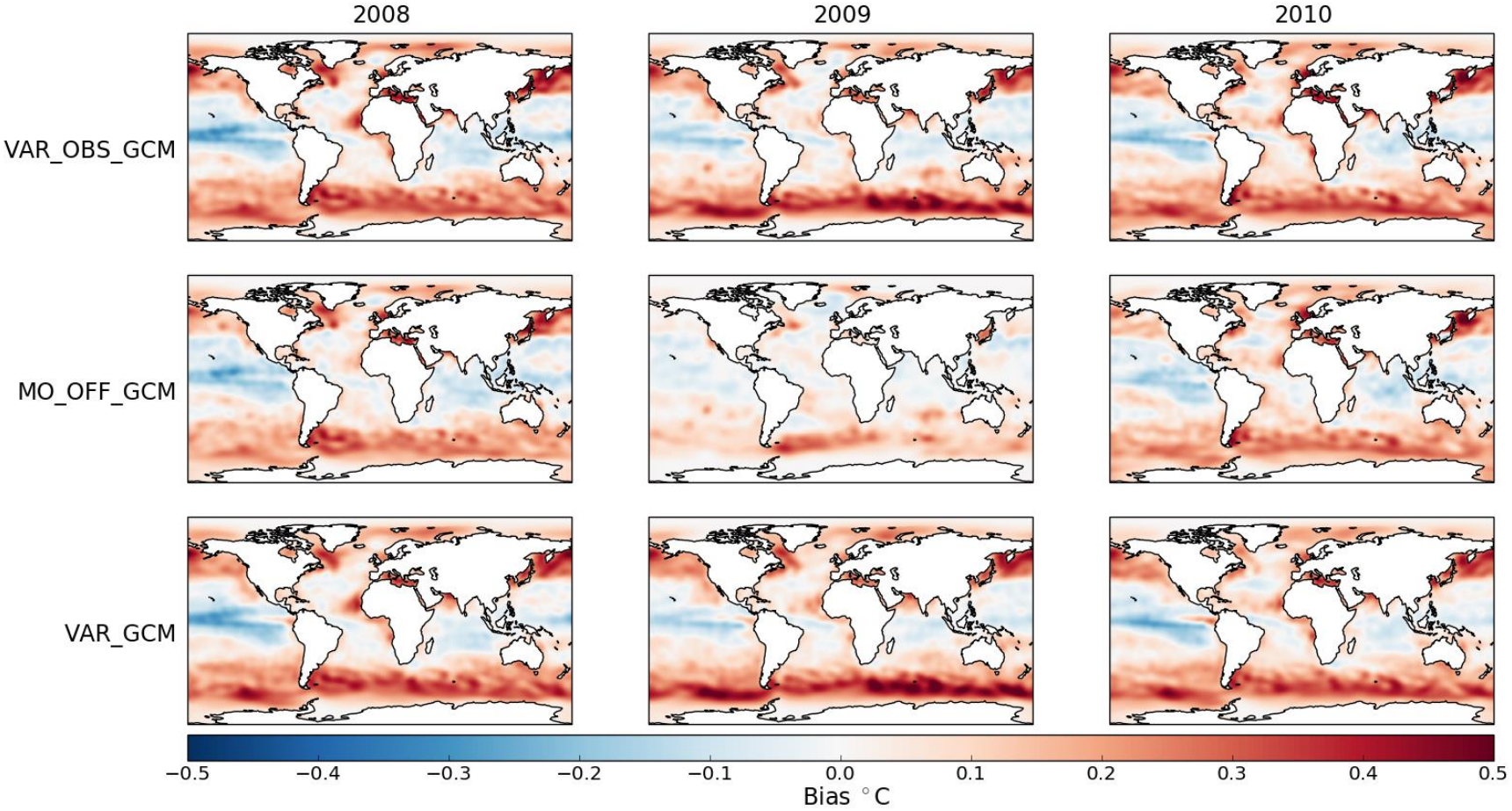
VAR_GCM:- Variational bias correction, only obs-model differences used.

MO_OBS_GCM:- Offline bias correction using just the observations-of-bias (similar to old Met Office system)

VAR_OBS_GCM:- Variational bias correction including both observations-of-bias and observation – model differences



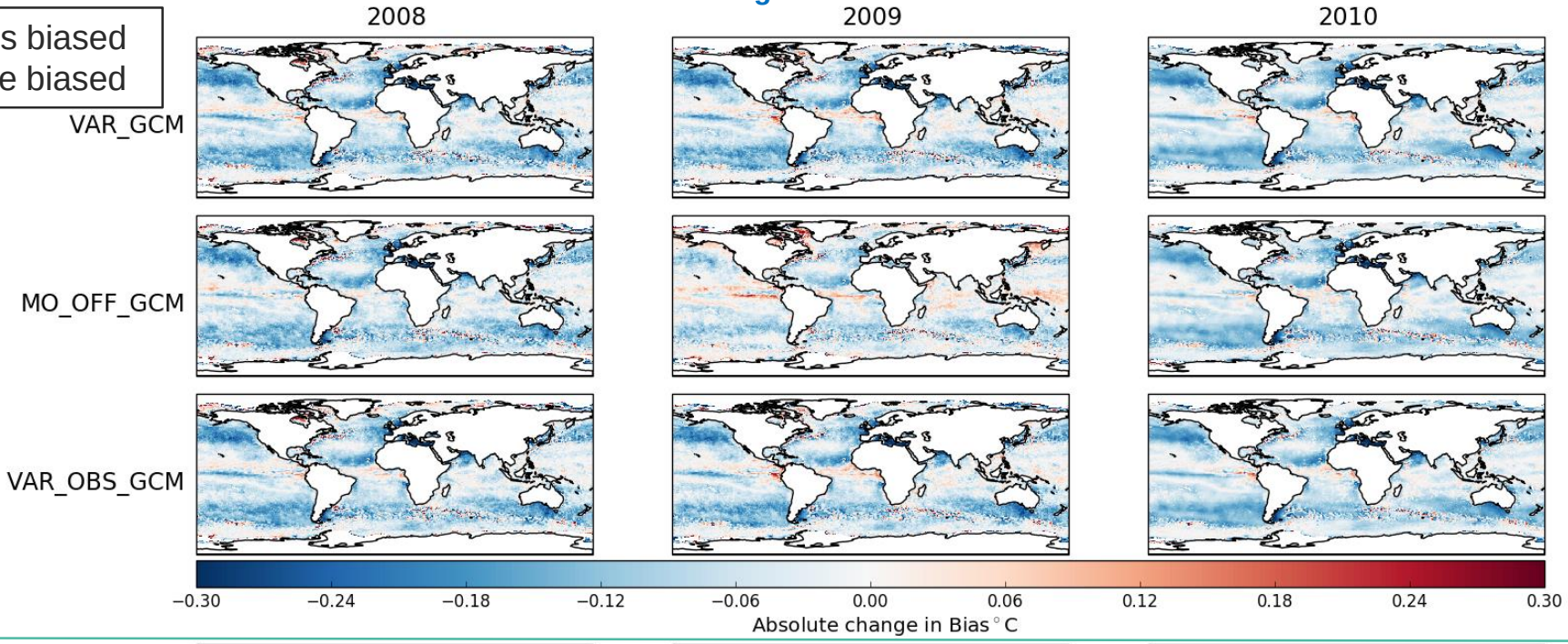
Mean Bias fields - AMSRE



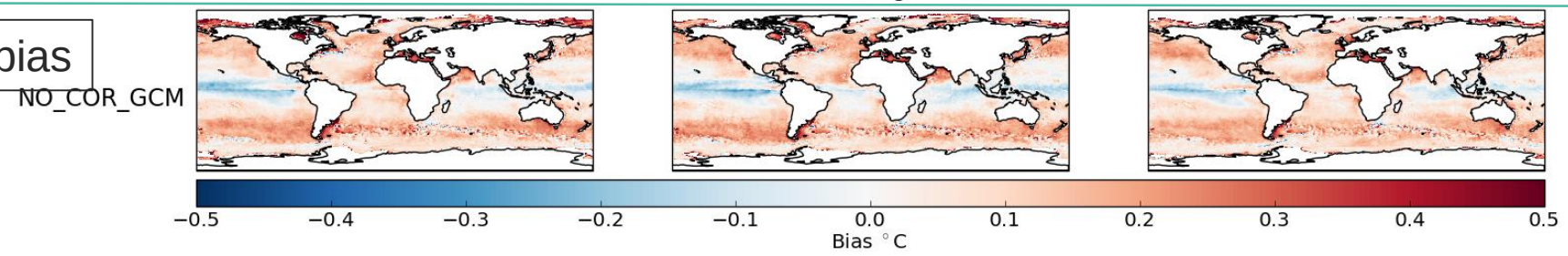
Change in absolute bias AMSRE (1° Bins)

Statistics are from observations – background values.

Blue:- less biased
Red: More biased



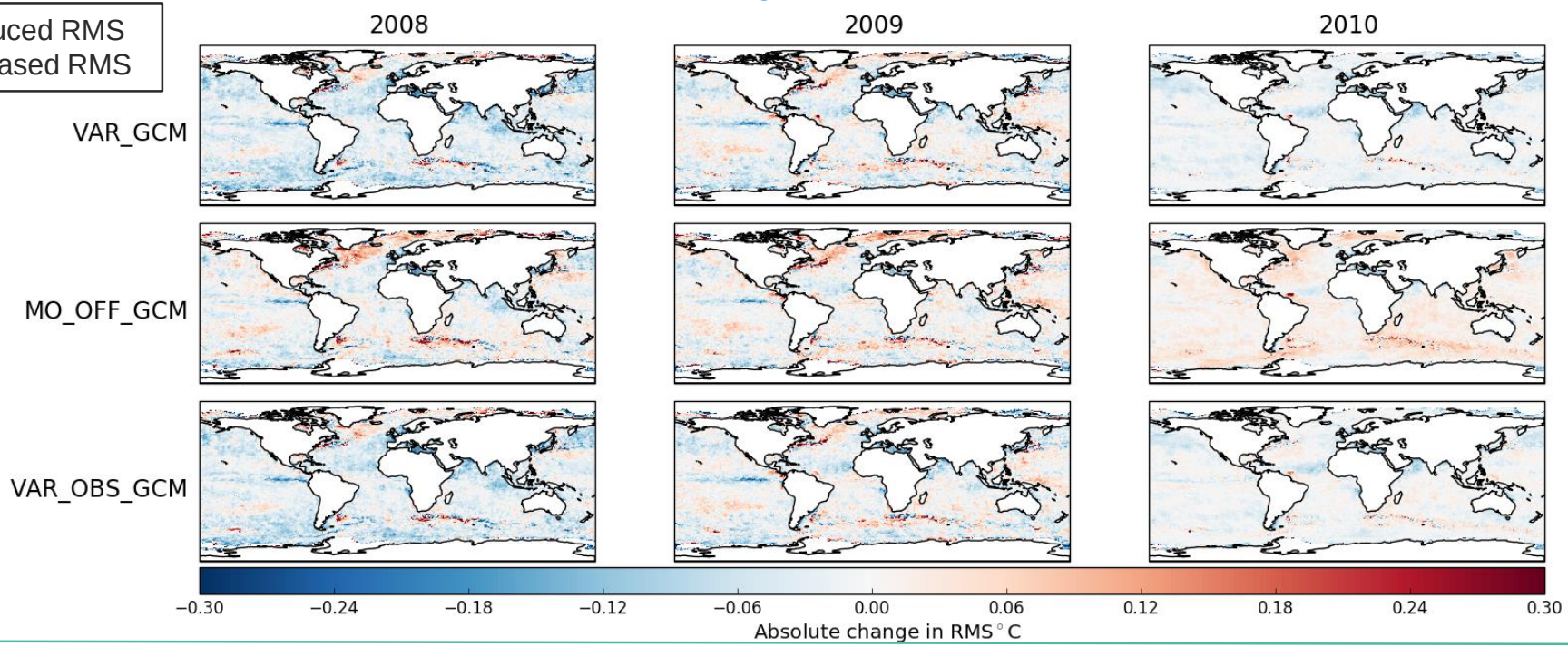
Actual bias



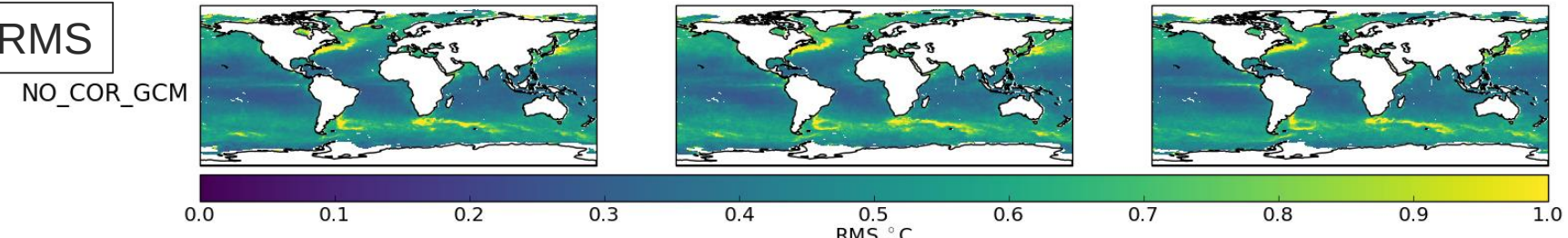
Change in RMS for AMSRE (1° Bins)

Statistics are from observations – background values.

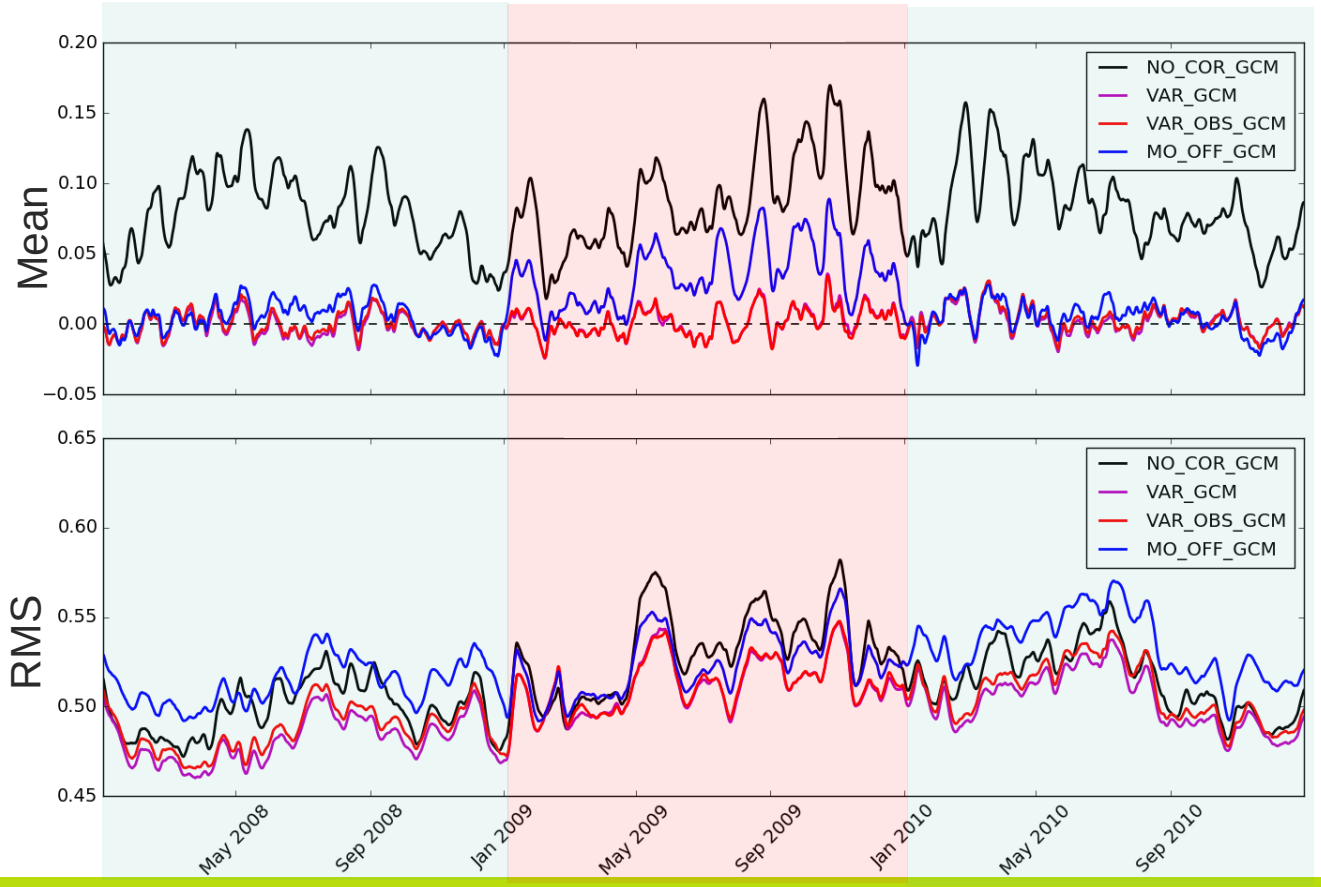
Blue: Reduced RMS
Red: Increased RMS



Actual RMS



Global Obs minus Bkg for AMSRE



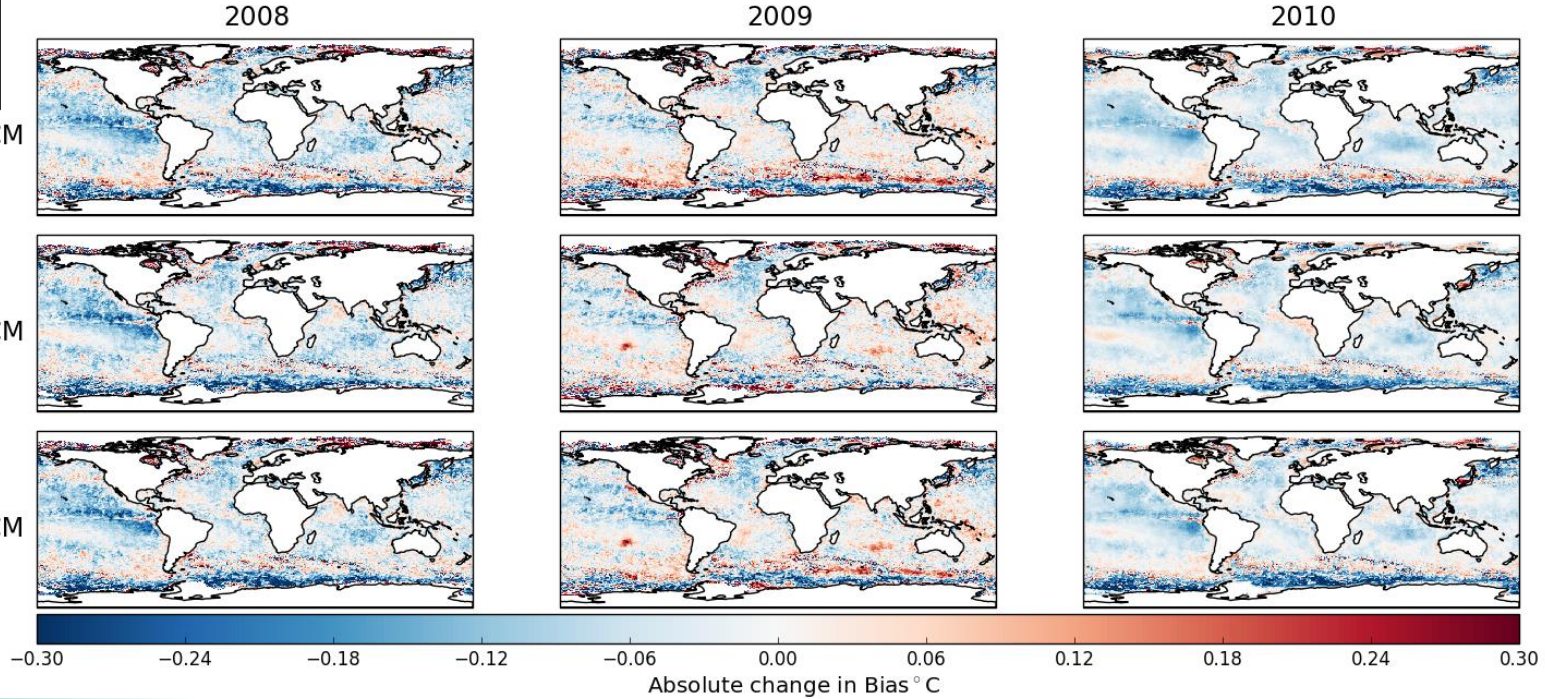
AATSR Data used as reference

AATSR Data not used as reference,

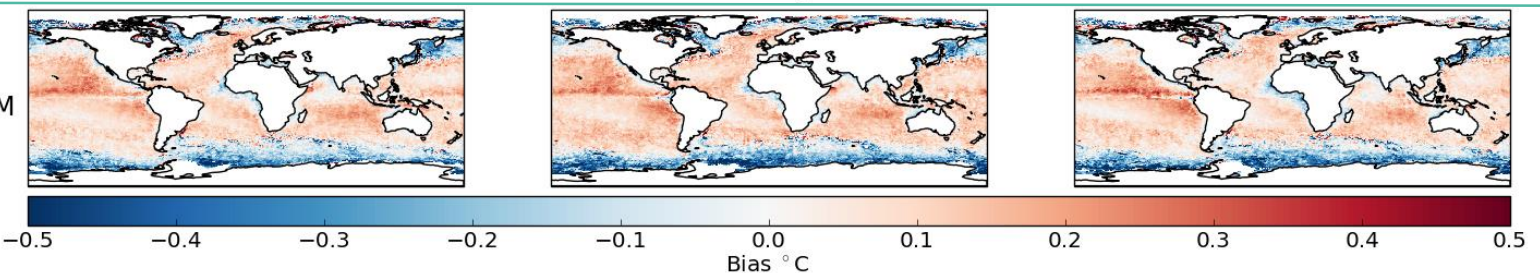
Change in absolute bias AATSR (1° Bins)

Statistics are from observations – background values.

Blue:- less biased
Red: More biased



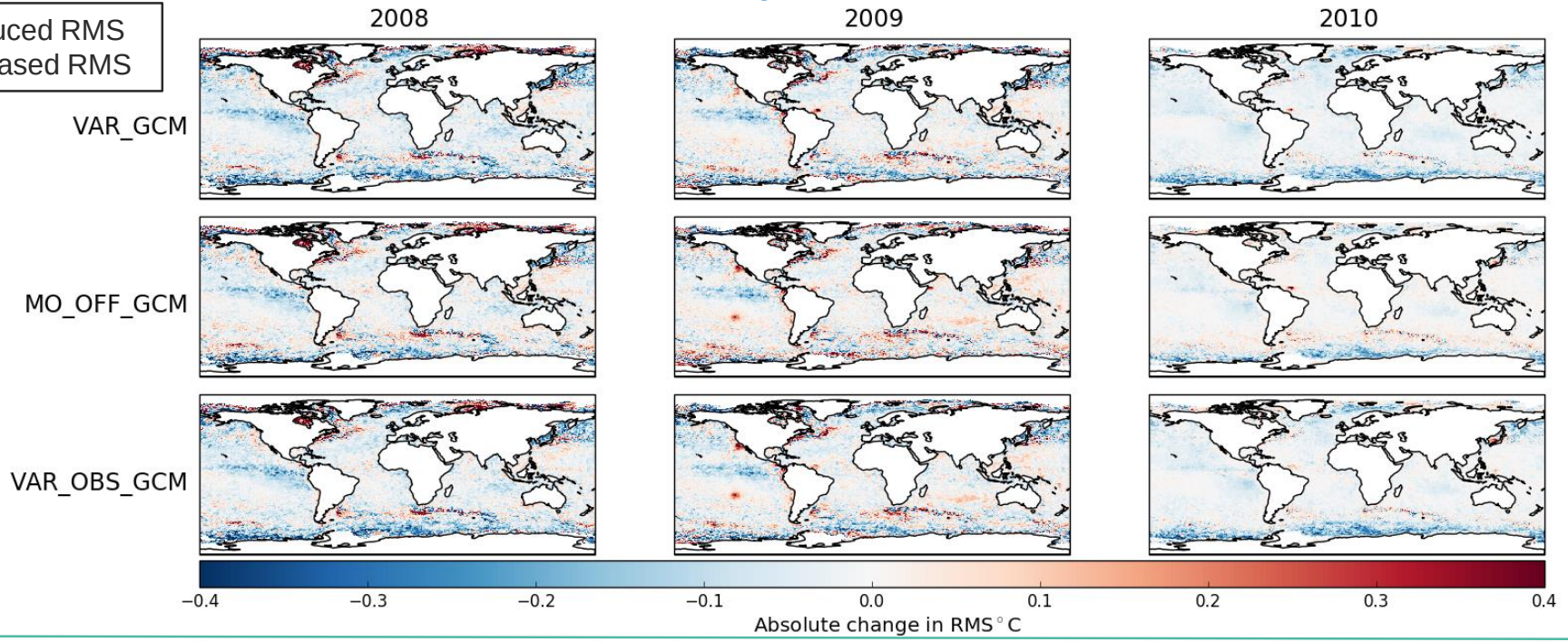
Actual bias



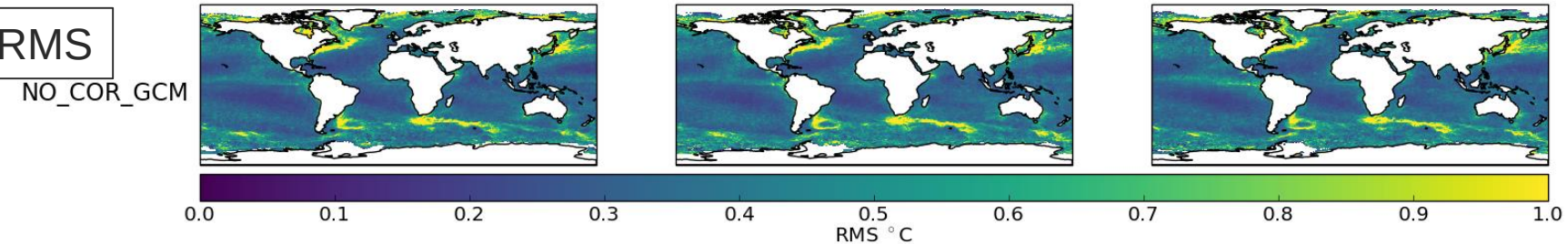
Change in RMS for AATSR (1° Bins)

Statistics are from observations – background values.

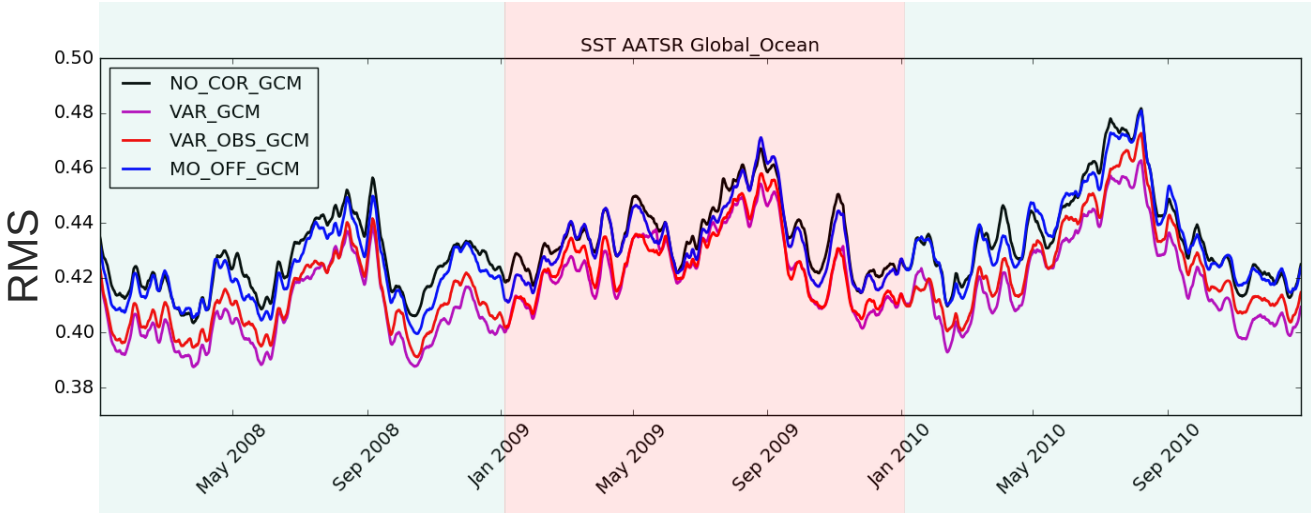
Blue: Reduced RMS
Red: Increased RMS



Actual RMS



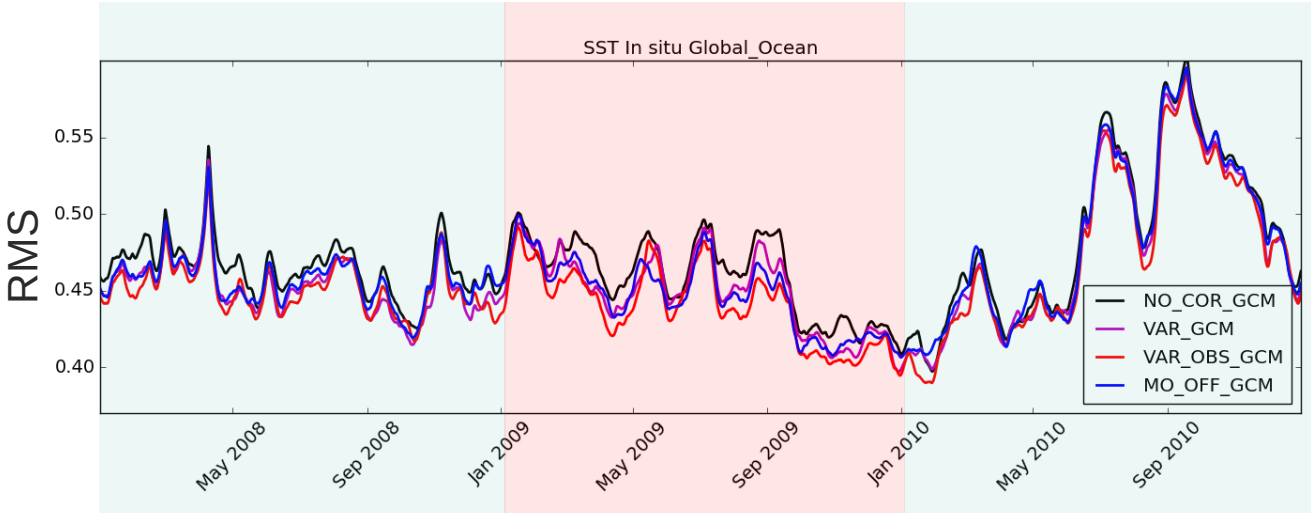
Global Obs minus Bkg for AATSR



AATSR Data assimilated, These are the stats from the observation minus background (i.e. from 1 day forecast)

AATSR Data not assimilated,

Global Obs minus Bkg for In-situ data



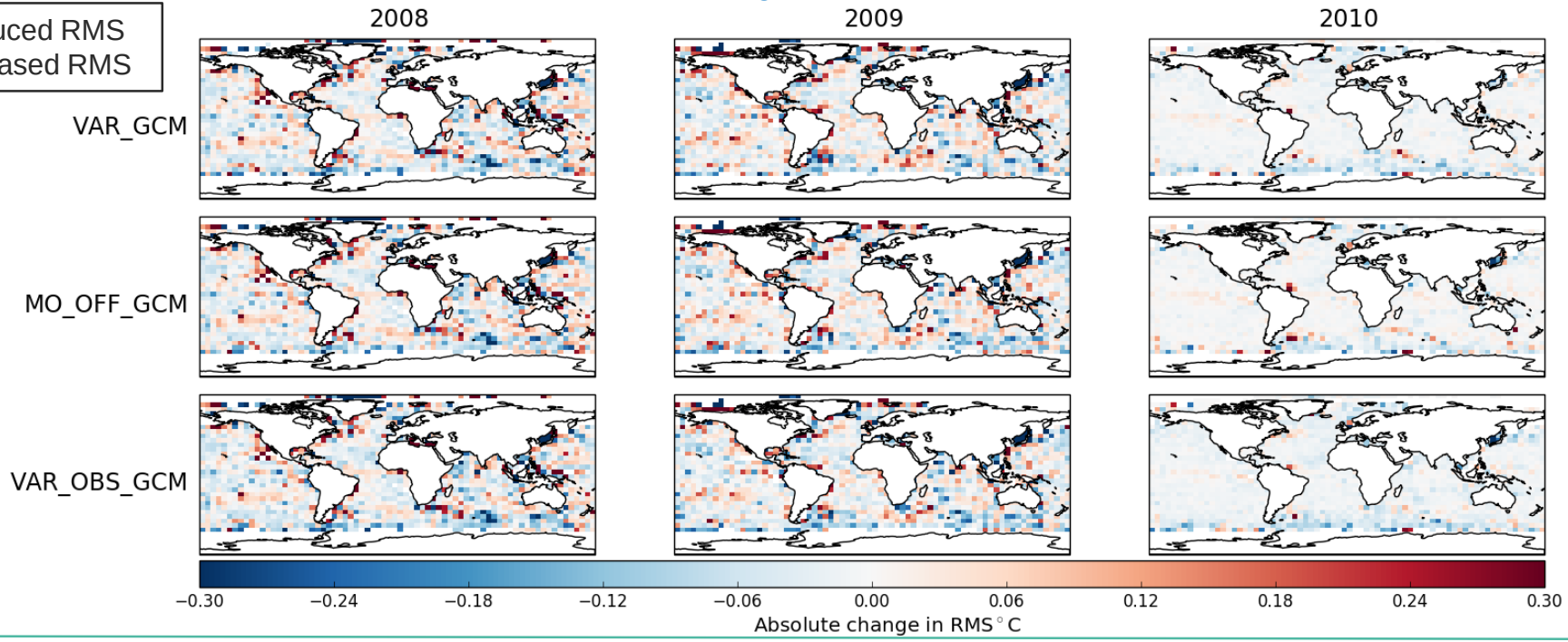
AATSR Data assimilated, These are the stats from the observation minus background (i.e. from 1 day forecast)

AATSR Data not assimilated,

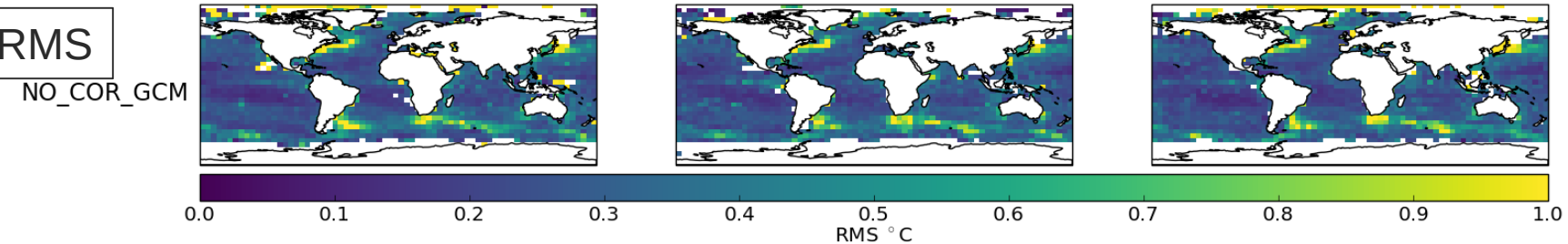
Change in RMS for In-situ (1° Bins)

Statistics are from observations – background values.

Blue: Reduced RMS
Red: Increased RMS



Actual RMS



Summary

- We have developed a variational methodology for observation bias correction that incorporates observations-of-bias.

- Testing the bias correction scheme using the Lorenz 63 system showed a clear benefit over other systems, except when the bias was very small.

- Results when using a realistic ocean model showed that:
  - Bias correction makes biased data more consistent with the model.
  - Compared to an observations-of-bias only scheme, observation-model bias correction methods produce more consistent bias fields between periods with plentiful observations-of-bias and periods with few observations-of-bias.
  - Our bias correction scheme with observations-of-bias produced smaller RMS differences with respect to in-situ data than the other schemes. Although the differences were small.