

Short term model errors that lead to errors in the structure of ENSOA

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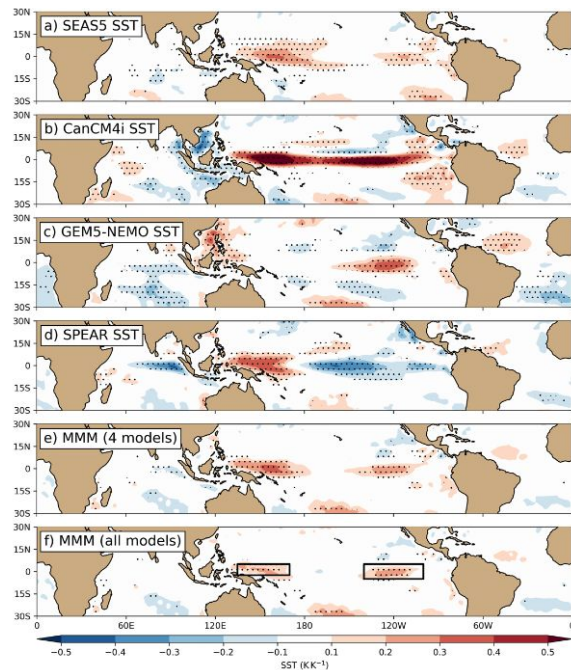
Introduction

A common bias of S2S models is the westward extension of the warm SST anomalies associated with the El Niño/Southern Oscillation (ENSO).

Beverly et al. 2023 shows that all models show ENSO related error of varying degree.

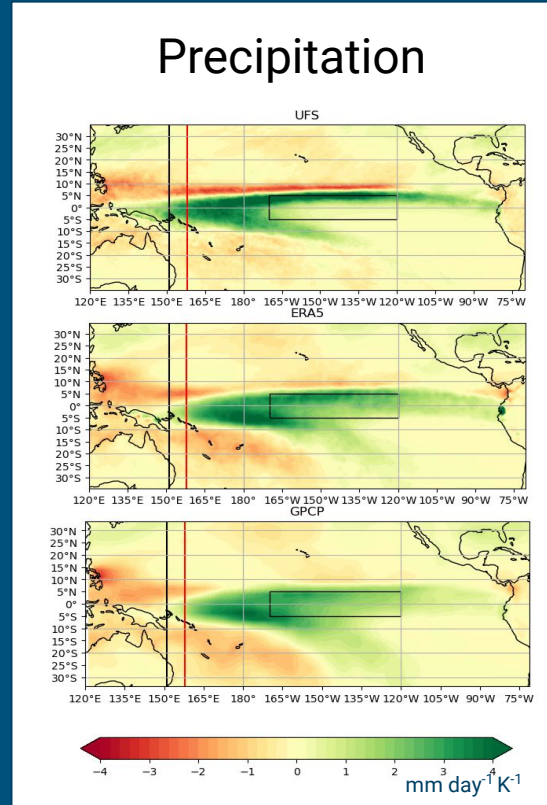
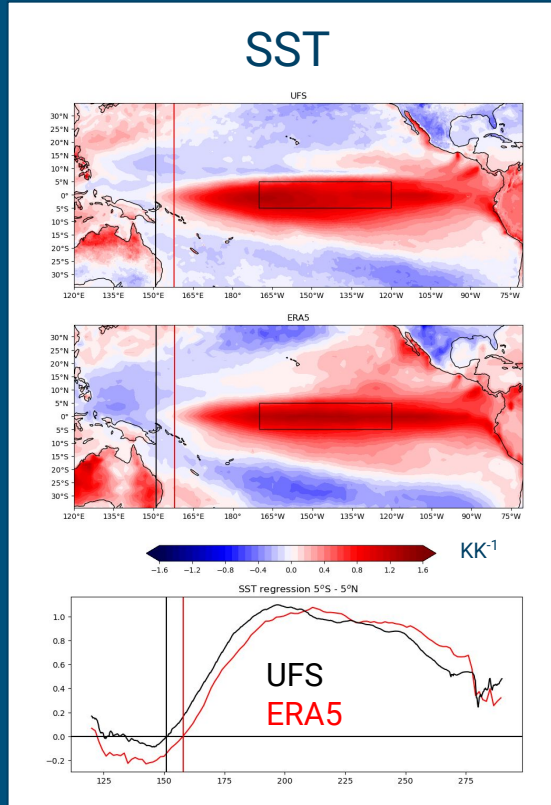
The UFS is no exception to this error.

DJF ENSO related SST error from Oct init.



Taken from Beverly et al. 2023

ENSO-related errors in a 30 year UFS simulation



Both the SST variability and precipitation variability are too far west in the UFS.

But since the background climate has changed, we don't know what to blame

30-year simulation of UFS P8 at 0.25 degrees

Replay Dataset

We have generated 30-years of a coupled replay dataset

The replay is constrained by ERA5 atmospheric variables (T, Qv, O3, U, V, psf) every 6-hours and ORAS5 variables (T, S, U, V, sea-ice concentration, thickness and snow depth)

An analysis increment is computed as the difference between the background forecast and the corresponding analysis, the model is backed up and the increment is applied over a 6-hour window.

Methodology

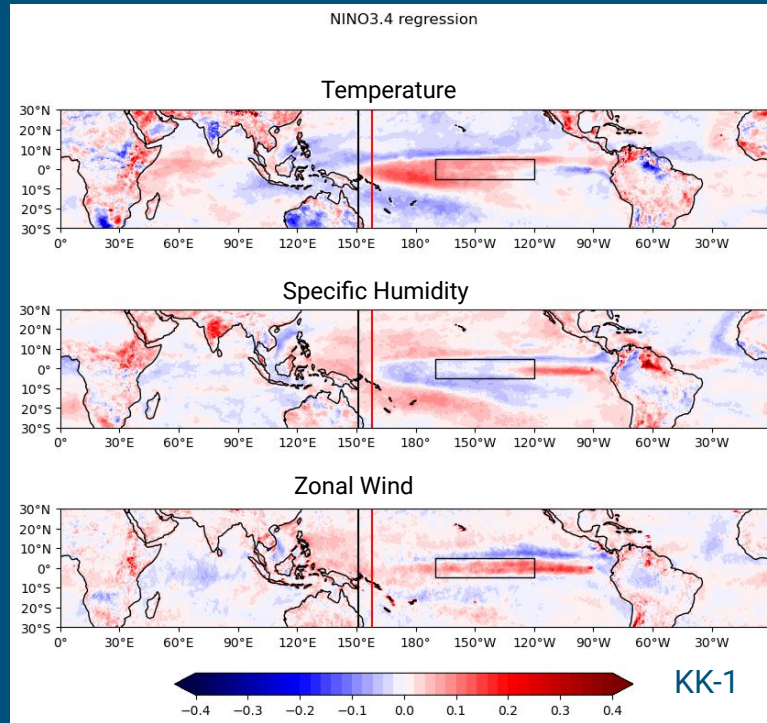
Generate seasonal mean increments for the DJF season over the 30-years

The 30-year mean increment is the climatological bias.

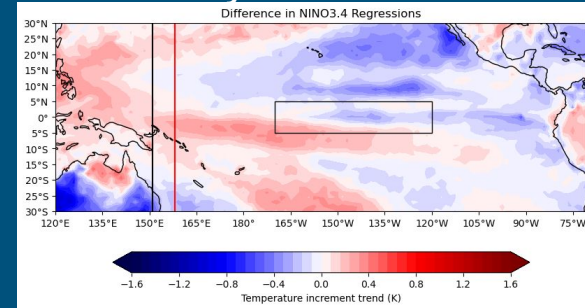
Regress these DJF seasonal mean increments onto the DJF NINO3.4 index
(*ENSO-related error*)

Flip the sign of the increments so the result is bias (forecast - analysis)

lowest atmosphere model level ENSO related errors



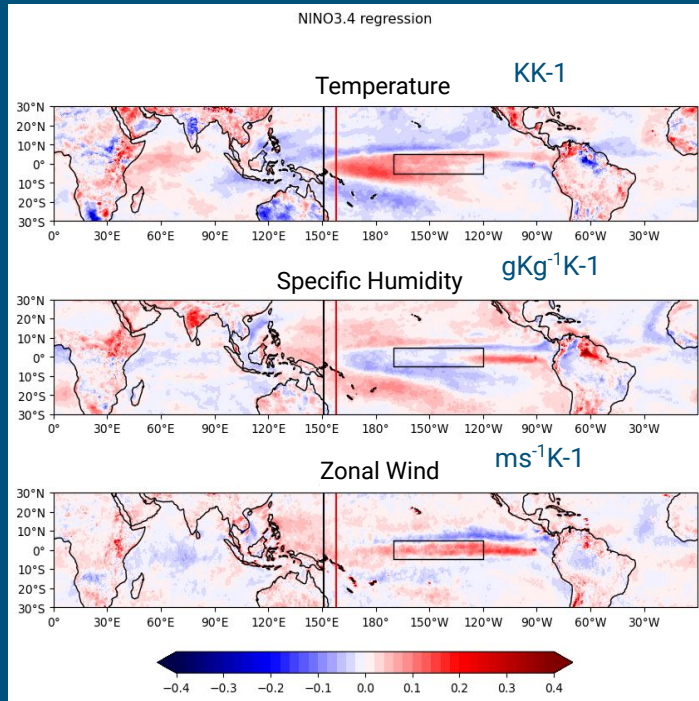
Error in ENSO SST pattern From 30-year simulation



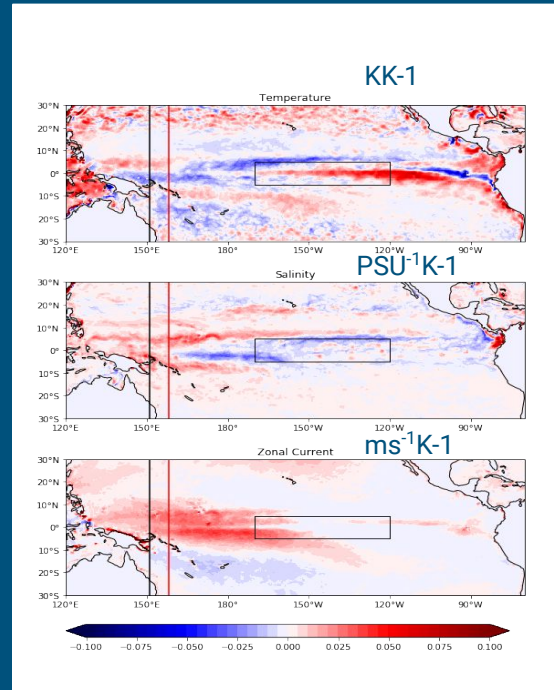
Conditioning the seasonal mean increments on ENSO shows that the model is too warm and dry near the dateline/equator and also has a zonal wind bias right along the equator, which too weak

ENSO related errors continued

Atmosphere errors

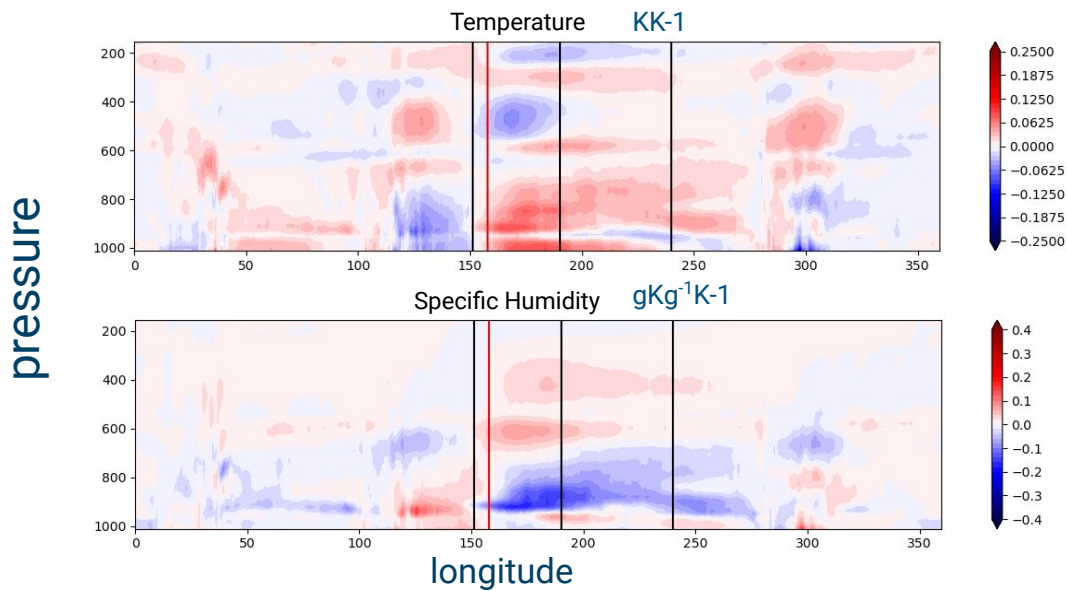


Ocean errors



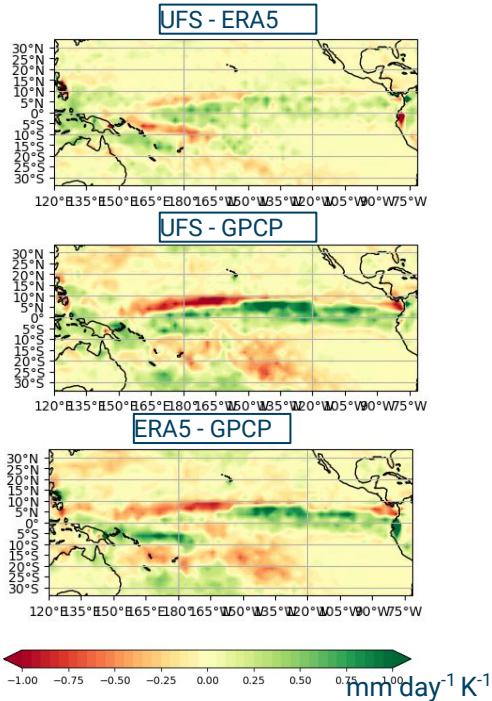
The biases in the ocean have a much different structure and are much smaller.

Cross section along the equator



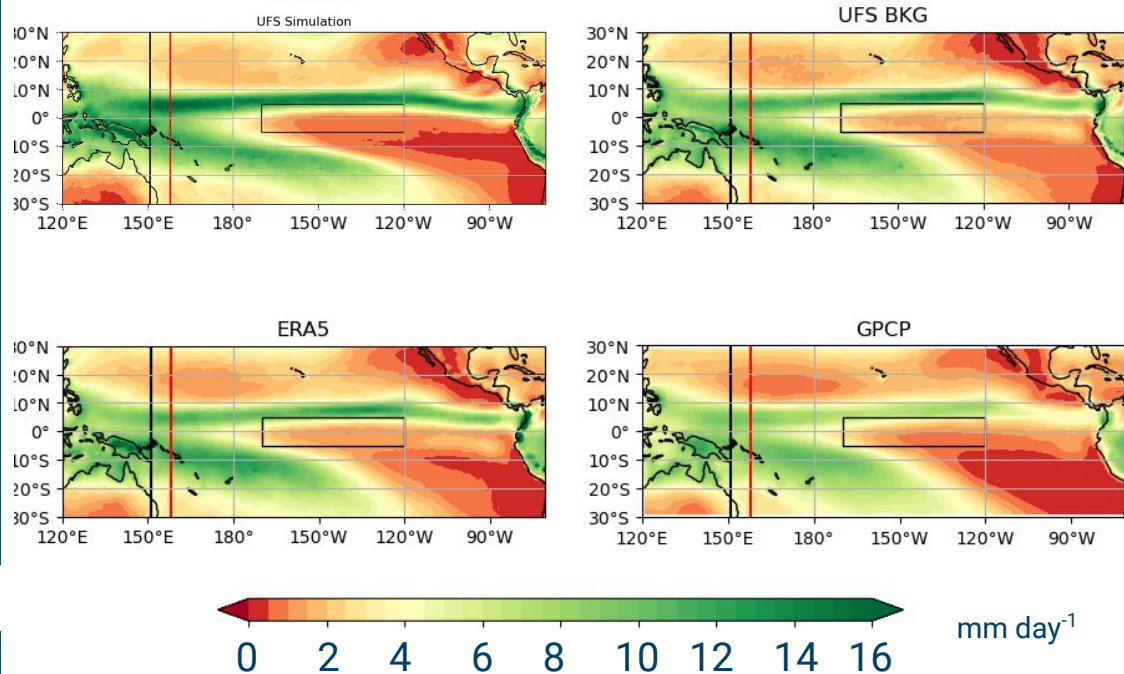
Cross sections along the equator in the atmosphere show the warm/dry bias near the dateline extends above the PBL

ENSO related precipitation errors



When being nudged to ERA-5 the precipitation response near the dateline is too strong. The background forecast is very close to ERA5's precipitation response to ENSO, but but has biases compare to the GPCP observations

DJF Precipitation Climatology



Both the 30-year simulation, and the series of 6-hour forecast and ERA5 show too much precipitation over the warm pool.

Conclusions

The errors in the spatial structure of the UFS's simulated ENSO variability is related to the atmospheric response to the changes in SST near and west of the dateline.

At first glance, the ENSO related errors are much smaller.

The coherent errors in the 6-hour forecast suggest a fast process is behind these errors. Could it just be that the model has too much precipitation over the warmer waters?