Weakening of the Southeastern Tropical Atlantic Interannual Sea Surface Temperature Variability under Global Warming

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Motivation

The Angola-Benguela Area (ABA, 8°E-coast°; 10°S-20°S) is characterized by extreme warm and cold events, the so-called Benguela Niños and Niñas. Remote and local forcings via complex mechanisms are responsible for these events. High resolution coupled models are needed to well represent these events and understand global warming effects on them. Studying the evolution of these events is crucial as they have socio-economic consequences for the southwestern African countries.

The Flexible Ocean and Climate Infrastructure (FOCI)

We use the new FOCI (Matthes et al., 2020) global ocean-atmosphere coupled model (Fig. 1a) at 1/2° ocean resolution (*ORCA05*) with a high resolution nest (70°W-70°; 64°S-10°N) at 1/10° horizontal resolution (*INALT10X*), the atmosphere resolution is everywhere 1.875° (T63L95). To investigate future changes in interannual SST variability we use two ensembles :

– HISTORICAL (1951-2013) with 4 members

– SCENARIO (SSP5 8.5, 2014-2099) with 6 members

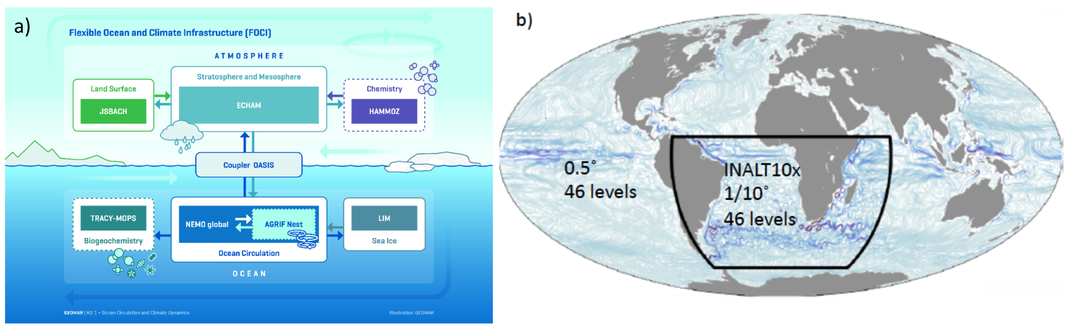

Figure 1: (a) Schematic of the FOCI model. (b) FOCI model grid description.

Results

Simulated change in mean state and variability of SST

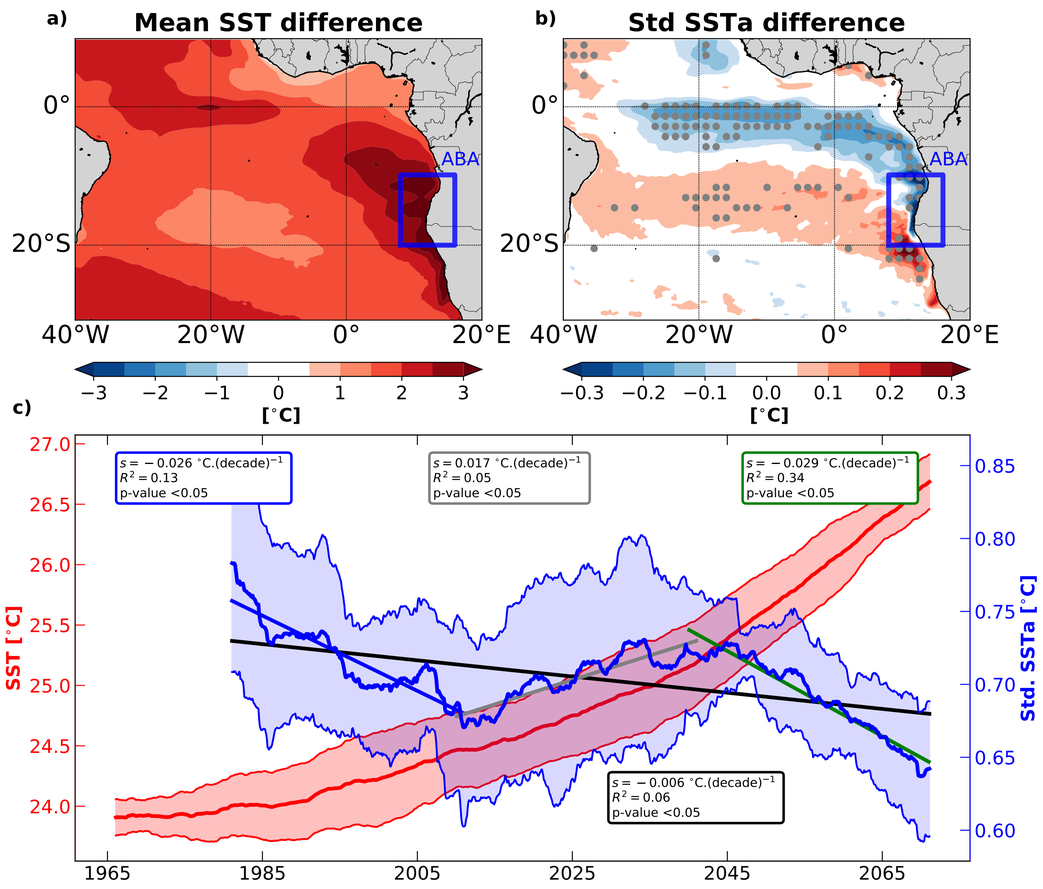

Figure 2: (a) Mean temperature difference, 2070-2099 minus 1970-1999. (b) Difference of the standard deviation of the SSTa, 2070-2099 minus 1970-1999. (c) 30-year running-mean of the standard deviation of the ABA-averaged SST (blue). The red line is the 30-year running-mean of the ABA-averaged SST.The blue and red shadings represent the ensemble spread.

Relative to 1970-1999, during 2070-2099 we find:

– A strong SST increase off the coast of Angola and Namibia, of approximately 3°C (Fig. 2a)

– A reduction of the interannual SST variability in the northern and an increase in the southern ABA (Fig. 2b).

– Overall decreasing trend of the interannual SST variability (-0.006 °C.decade^{-1}) in the ABA, with an intermediate period between 2010 and 2050 with increasing trend (Fig. 2c).

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BANINO Spaces II

Surface/subsurface coupling

The surface/subsurface coupling is known to play an important role in driving interannual SST variability in the ABA.

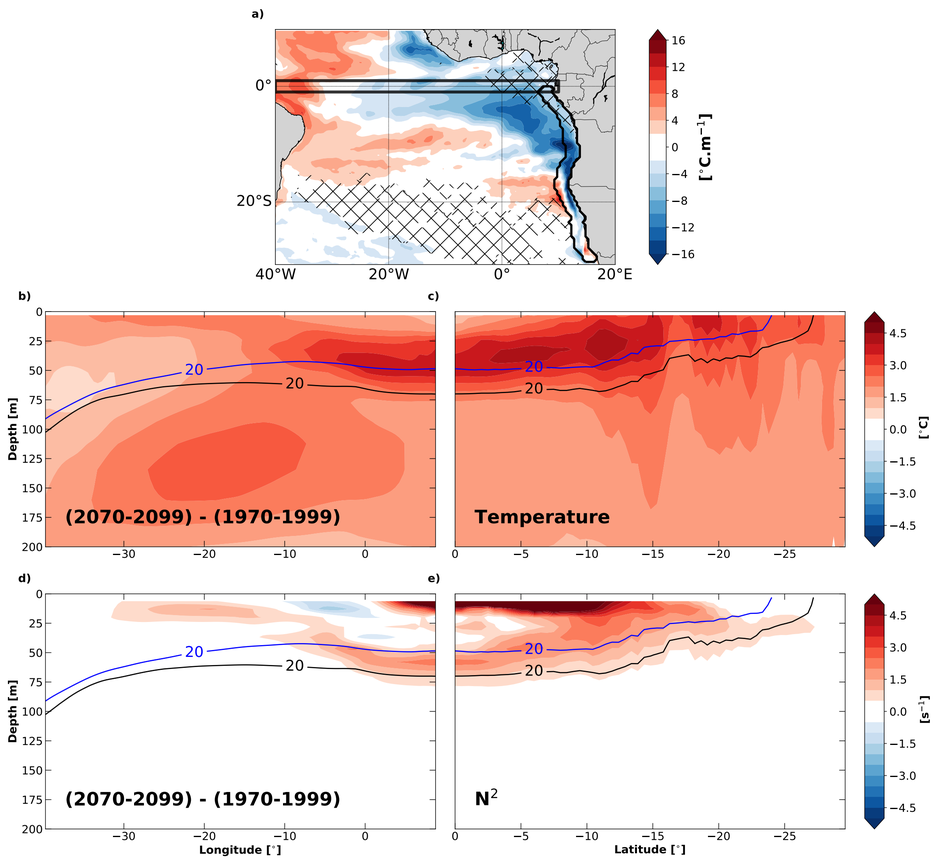

Figure 3: (a) Pointwise regression of the SST anomalies on the SSH anomalies. Hatchings represent the non-significant regressions according to the Student's t-test. Black contours indicate the two sections used for the following plots. Difference of temperature along the equatorial section (b) and along a 2° band along West Africa. (d, e) same as (b, c) but for the Brunt-Vaisala frequency (N^2).

Relative to 1970-1999, during 2070-2099 we observe:

– A reduction of the SST response to thermocline perturbations

– A subsurface warming and increased stratification as well as a deepening of the mean 20°C isotherm depth (Z20)

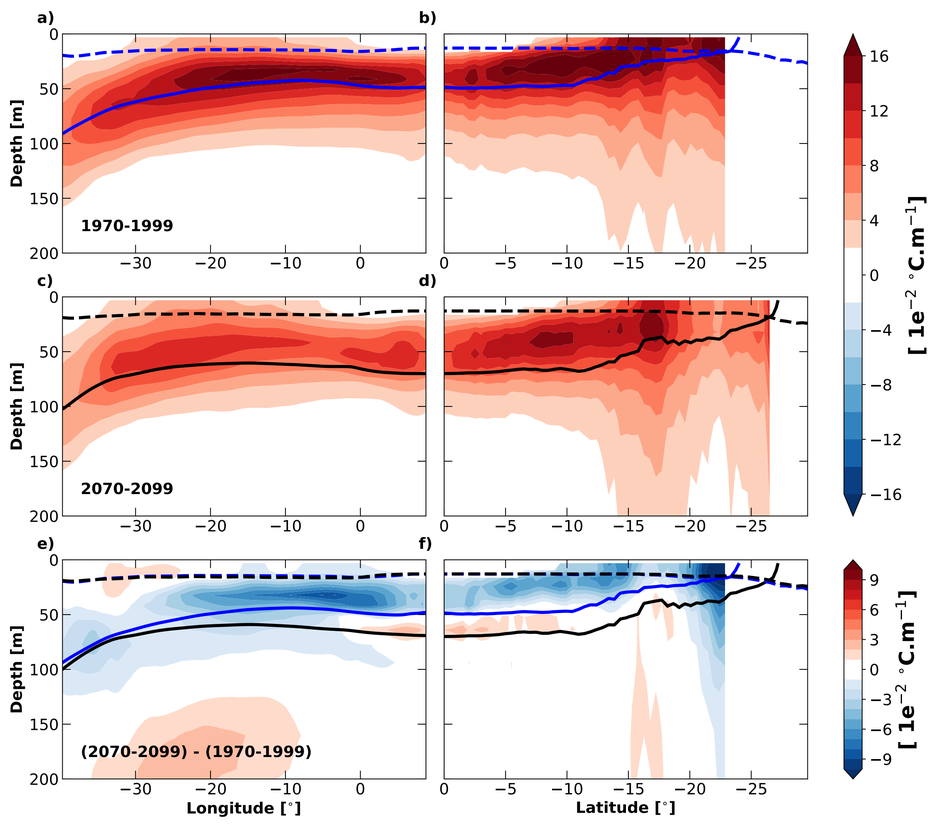

Figure 4: Vertical sections of the regression between temperature and Z20 depth anomalies during 1970-1999 along the equator (40°W- 9°E; 1°S-1°N) (a) and along a 2° band along the West African coast (b). (c, d) same that (a, b) but for the period 2070-2099. (e, f) Difference of the vertical sections, 2070-2099 minus 1970-1999. The blue (black) solid line is the depth of the mean Z20 depth during 1970-1999 (2070-2099). The blue (black) dashed line is the depth of the mean mixed layer depth during 1970-1999 (2070-2099). Displayed values are significant at 95% according to the Student's t-test.

Relative to 1970-1999, during 2070-2099 we found:

– A reduction of the impact of the deepening/shoaling of the Z20 on the temperature due to the deepening of the mean Z20 (Figs. 4e and f).

Conclusions

We use a high resolution coupled ocean-atmosphere model to investigate the impacts of global warming on interannual SST variability in the ABA. So far, we found:

– A reduction of the interannual SST variability in the Angola-Benguela Area.

– Relative to 1970-1999, during 2070-2099 a reduced SST response to the thermocline perturbations which might be due to the strong surface warming.

– The deepening of the Z20 seems to reduce the efficiency of the surface/subsurface feedback.

Acknowledgements

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