High resolution atmospheric topography key to reduce South Atlantic coastal SST bias

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Introduction

Most coupled general circulation models suffer from severe sea surface temperature (SST) biases in the tropical Atlantic. We have investigated the bias dependency on model resolution and the sources of the biases.

Model: MPI-ESM-1

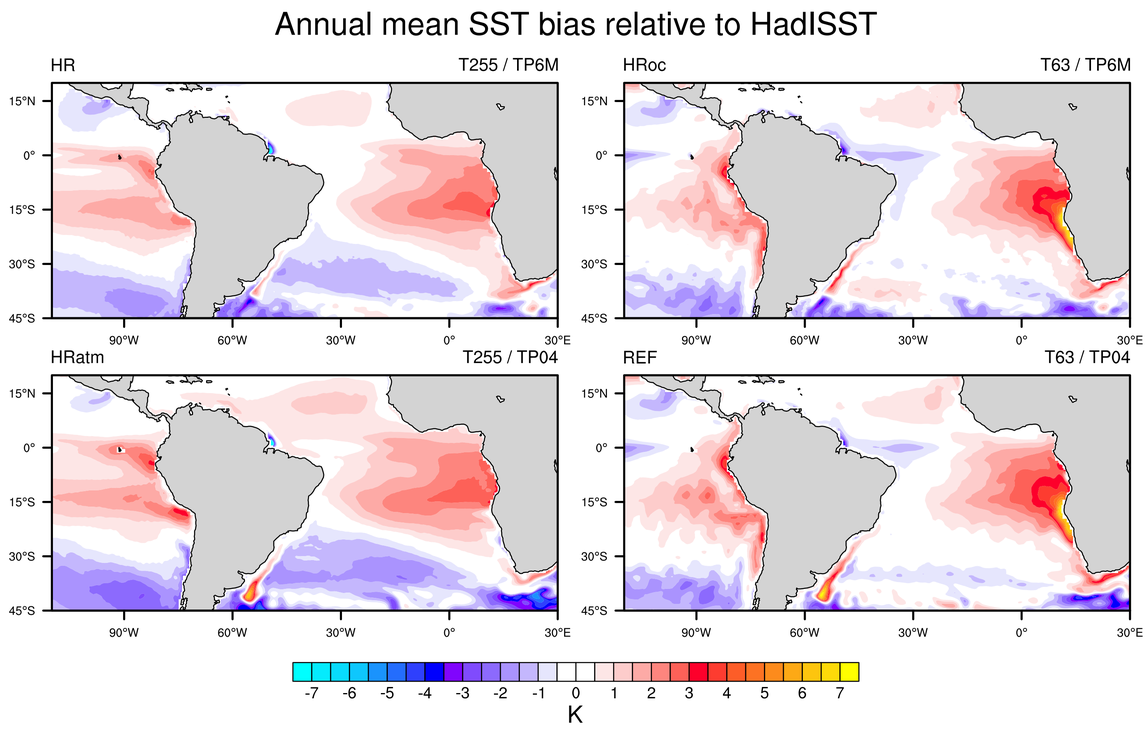
preindustrial control simulation
ECHAM 6.1.06p2
JSBACH 2.01
MPIOM 1.5.1 incl. HAMOCC
OASIS-MCT

	Ocean	Atmosphere
REF	TP04 L40 (~40 km)	T63 L95 (~200 km)
STORM HR	TP6M L40 (~10 km)	T255 L95 (~50 km)
HRoc	TP6M L40	T63 L95
HRatm	TP04 L40	T255 L95

Results

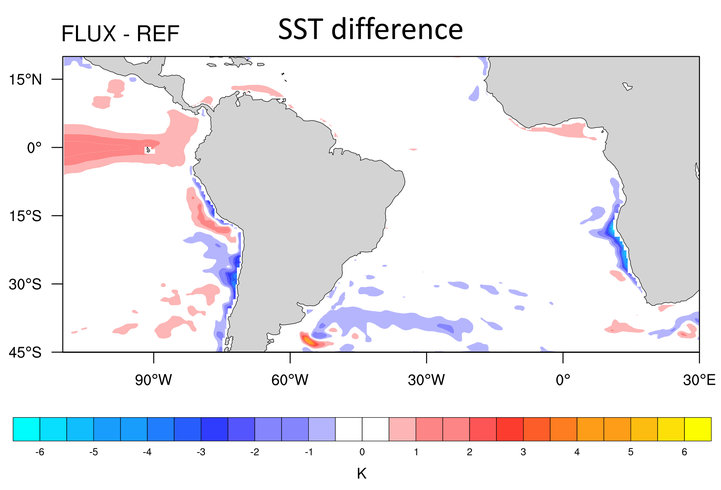
1 Mean state bias

The annual mean SST bias in the south eastern tropical Atlantic is reduced by 50% at high atmospheric resolution.



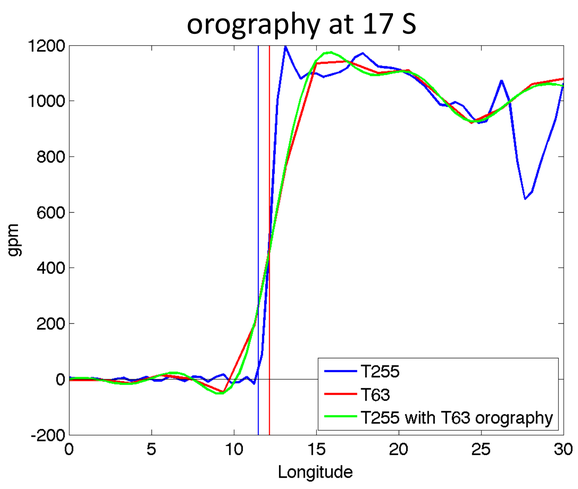
2 Wind bias

Too weak along-shore winds close to the African coast cause the local SST bias. The representation of the wind field is largely improved at T255 atmospheric resolution. Sensitivity experiments in the REF setup with improved surface wind stress (flux correction towards HR) reproduce the reduced SST bias.

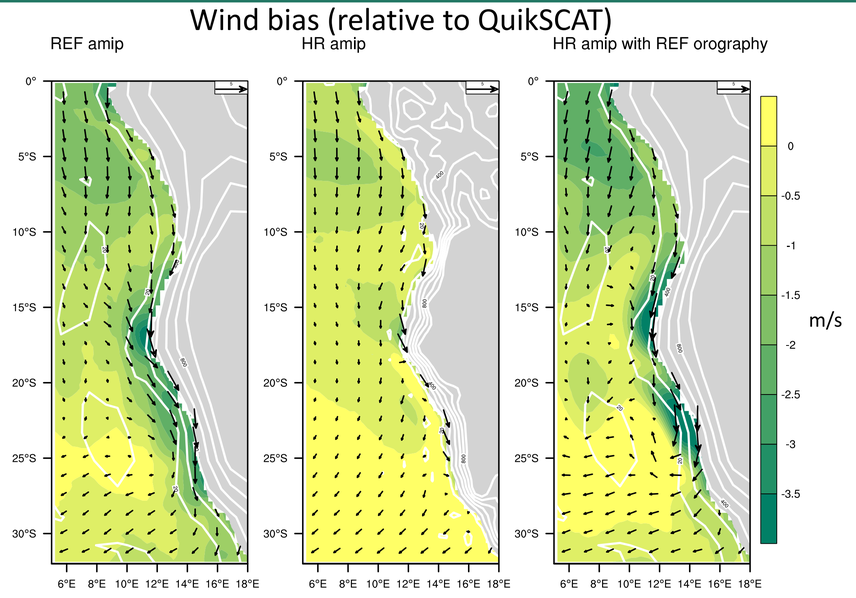


3 Orography

The spectral transformation of the orography leads to artefacts in the model. Strong horizontal gradients in surface elevation are not well represented and the transformation introduces overshooting known as the Gibbs phenomenon.



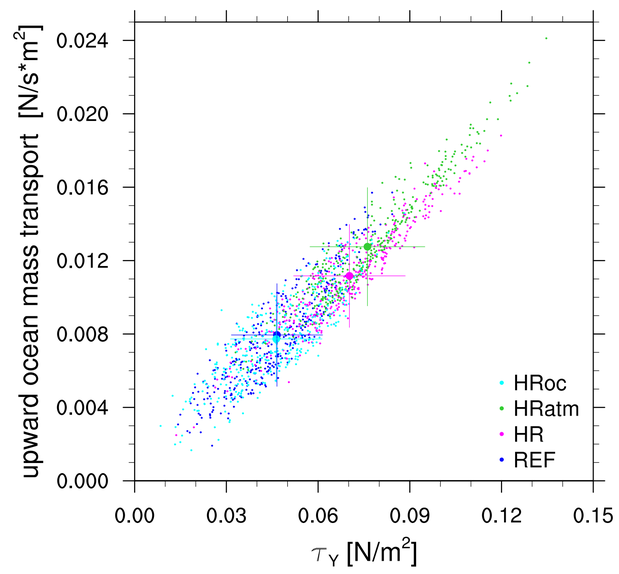
Wind bias (relative to QuikSCAT)



Replacing the orography in a high-resolution atmosphere only simulation with the low resolution T63 atmosphere introduces the bias in the coastal surface winds.

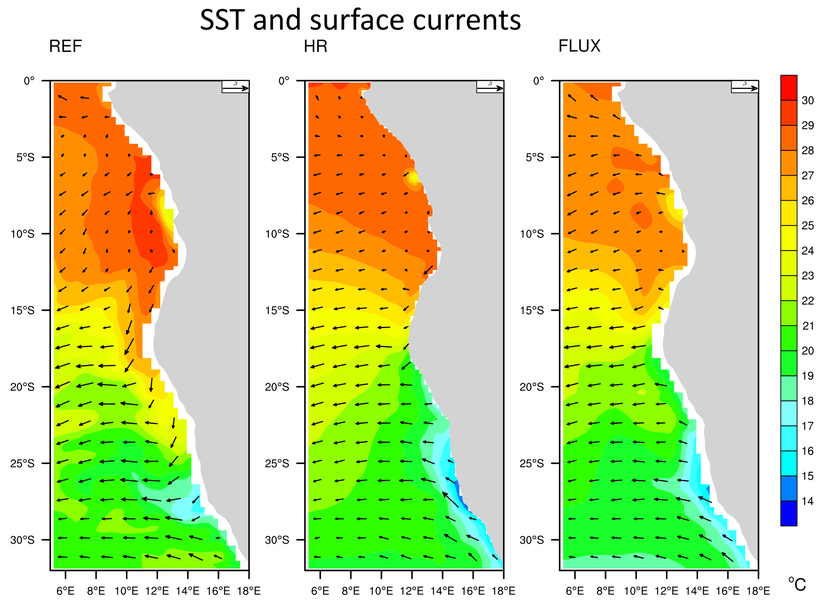
4 Upwelling

Upwelling 1° off the coast is directly proportional to the along-shore wind stress. Due to larger wind stress, experiments with high resolution in the atmosphere simulate stronger coastal upwelling independent from the ocean resolution.



5 Advection

SST and surface currents



The representation of ocean currents, especially the northward Benguela current, depends on the surface wind stress. The northward advection of cold water and a more realistic location of the Angola-Benguela frontal zone reduce the SST bias.

Conclusions

- The coastal SST bias in the south east tropical Atlantic is caused by a surface wind bias
- Higher atmospheric resolution and thus more realistic orography lead to more realistic surface winds and a reduced bias
- Multiple, mostly independent, bias patterns are superimposed to form the bias pattern common to most models

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