

Enhanced vertical atmosphere resolution improves climate model simulation of tropical Atlantic SST and interannual variability

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OS1.7: Tropical & Subtropical Ocean Circulation,
Equatorial to Mid-Latitude Air-Sea Interactions

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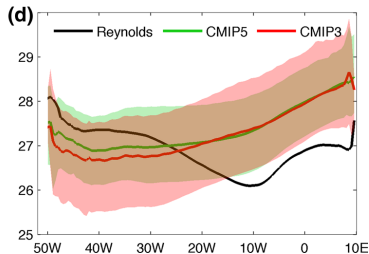
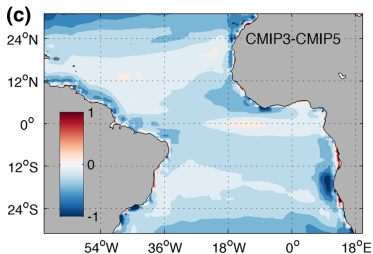
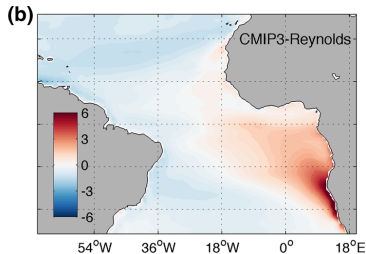
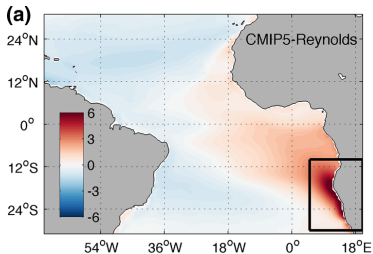
GEOMAR Helmholtz Centre for Ocean Research Kiel, Germany



Tropical Atlantic SST bias

in CMIP 3 & 5

Enhanced Vertical
Atmosphere
Resolution Improves
Climate Model
Simulation
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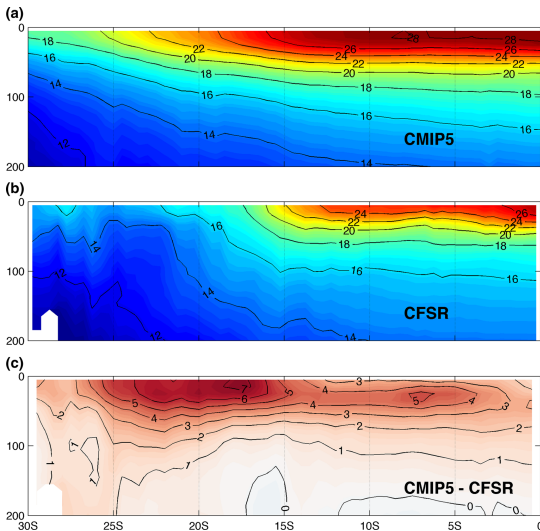


1 Motivation

- Model
- SST
- Precipitation
- Equator
- Benguela Region
- Variability
- Summary

Subsurface temperature bias

1° wide band along the coast



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Model

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Equator

Benguela Region

Variability

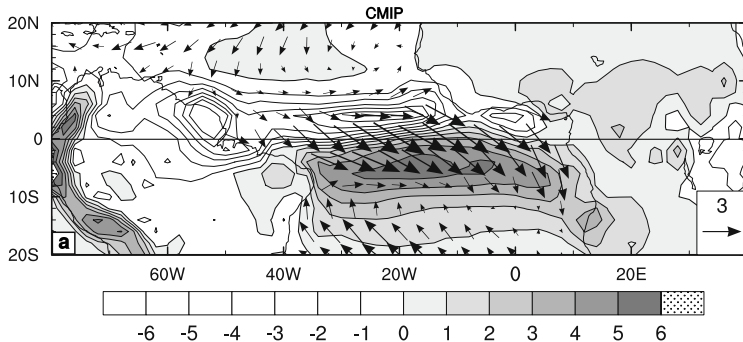
Summary

Atmospheric biases

March-May, CMIP3

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Contours: precipitation bias (mm/day), Vectors: surface wind bias (m/s)

[Richter & Xie 2008]

3 Motivation

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Summary

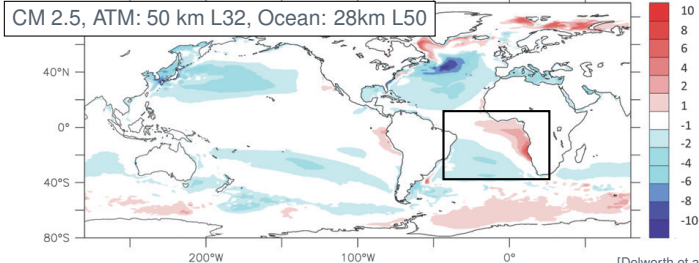
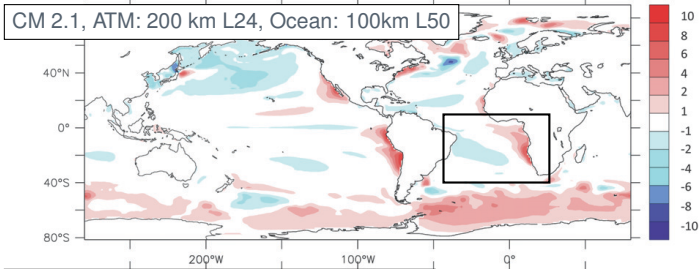
Higher model resolution

Annual mean SST bias

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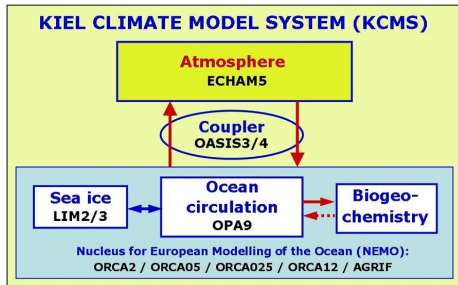
4 Motivation

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ORCA2

- ▶ $2^{\circ} \times 2^{\circ}$
- ▶ latitudinal refinement
- ▶ 31 levels
- ▶ No changes



[Park et al. 2009]

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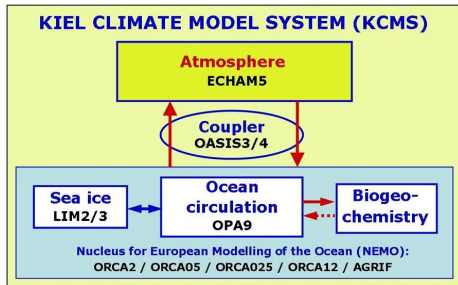
Benguela Region

Variability

Summary

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[Park et al. 2009]

ECHAM5

- ▶ T42 (2.8°, ~300km) L31 / L62 LR / LR_V

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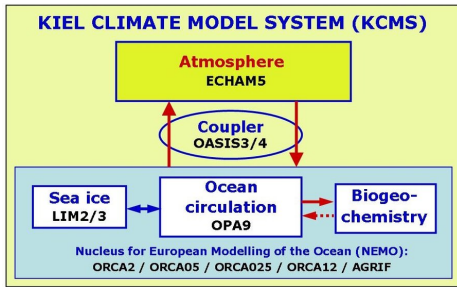
Benguela Region

Variability

Summary

ORCA2

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[Park et al. 2009]

ECHAM5

- | | | | |
|--------|-------------------------|-----------|-----------|
| ▶ T42 | (2.8° , ~300km) | L31 / L62 | LR / LR_V |
| ▶ T159 | (0.75° , ~80km) | L31 / L62 | HR / HR_V |

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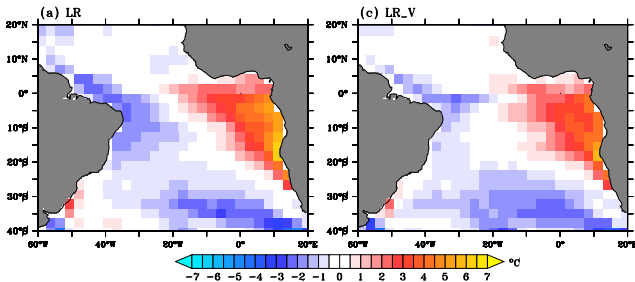
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Variability

Summary

SST bias

July-September [JAS]



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Precipitation

Equator

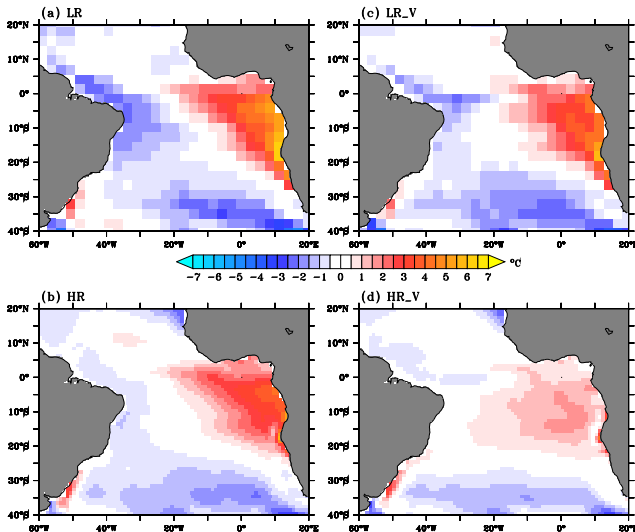
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SST bias

July-September [JAS]



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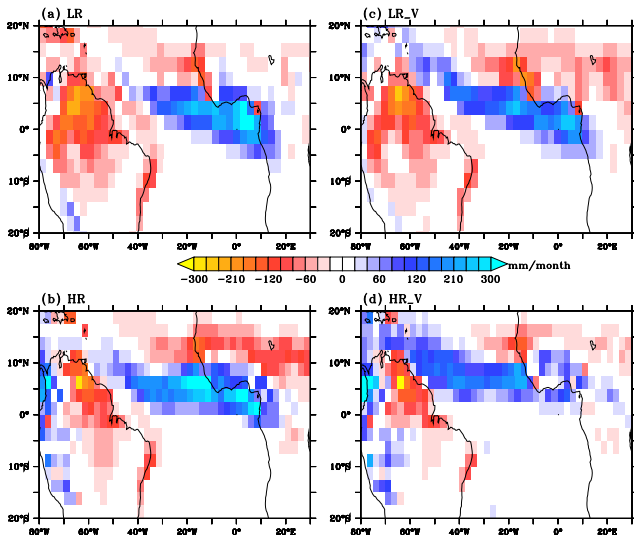
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Variability

Summary

Total Precipitation bias

JAS



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7 Precipitation

Equator

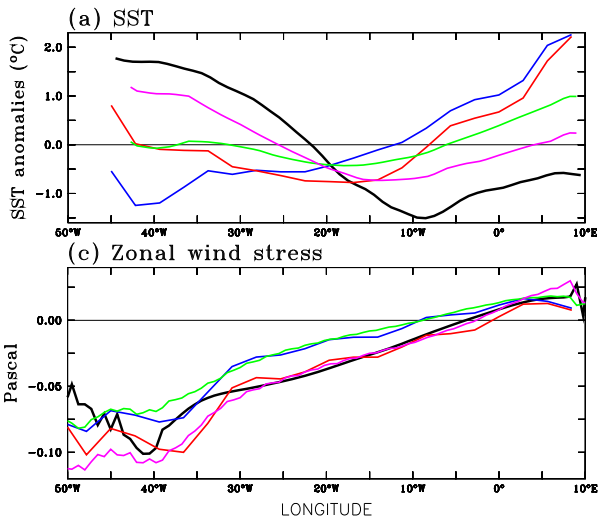
Benguela Region

Variability

Summary

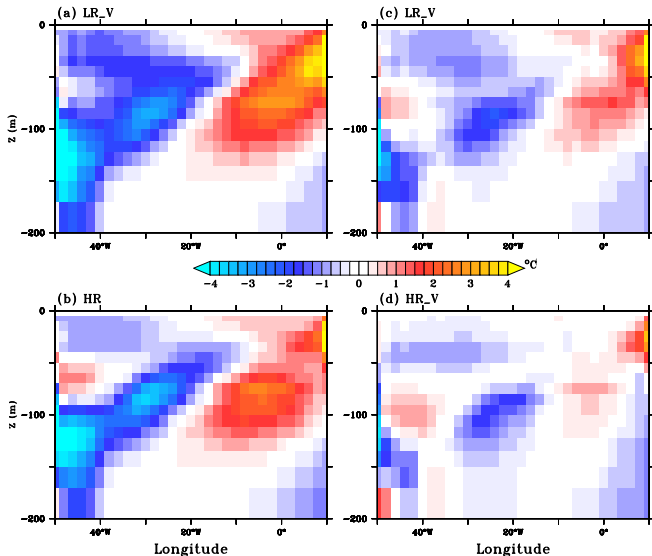
Zonal section along the equator

3° S-3° N, JAS



Temperature bias

5° S-5° N, annual average



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9 Equator

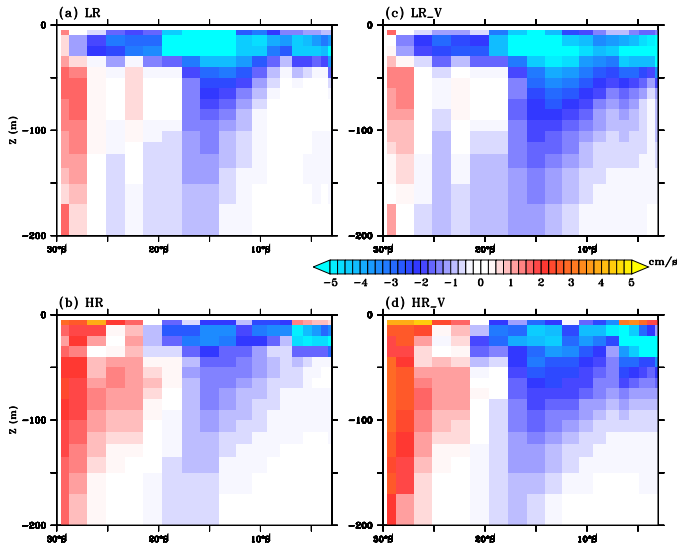
Benguela Region

Variability

Summary

Meridional velocity

Zonally averaged over 3 gridpoints from the coast, annual average



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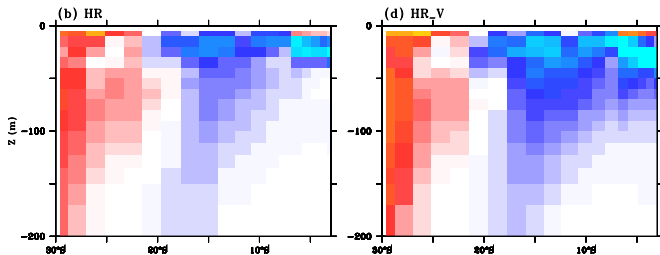
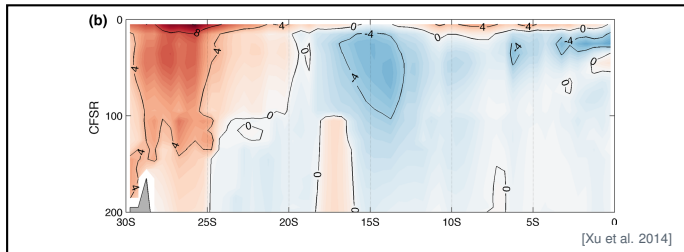
Precipitation

Equator

10 Benguela Region

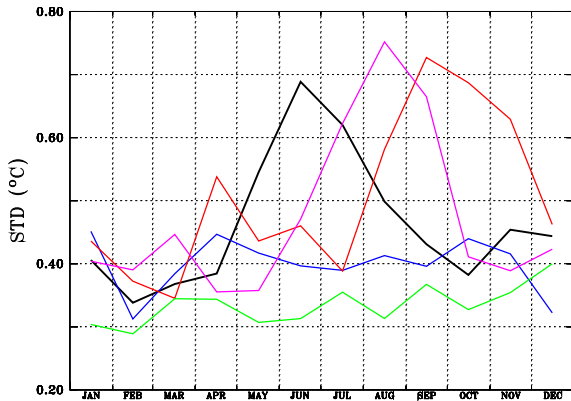
Variability

Summary



Interannual variability

Standard deviation of SST in ATL3 (20° W-0° E, 3° S-3° N)



HadISST LR LR_V HR HR_V

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Regression ATL3 index on SST

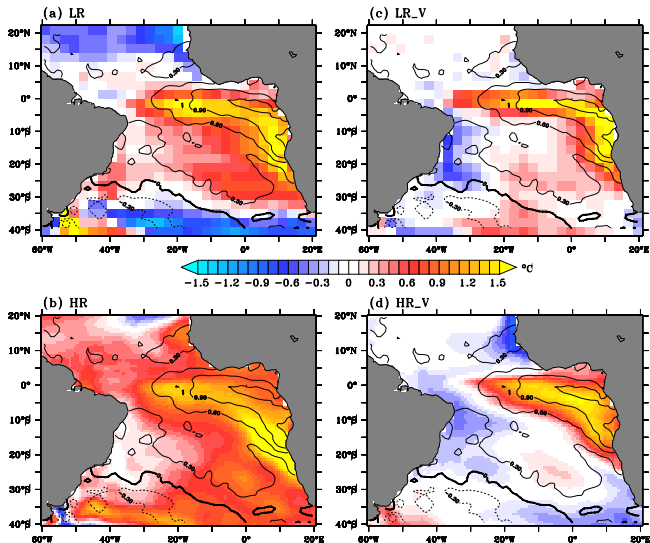
JAS, Contours: HadISST, Shading: bias

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Summary



- ▶ Increased atmospheric **horizontal** resolution reduces Tropical Atlantic SST bias (T42->T159)
- ▶ Spatial bias pattern remains

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13 Summary

- ▶ Increased atmospheric **horizontal** resolution reduces Tropical Atlantic SST bias (T42->T159)
- ▶ Spatial bias pattern remains

- ▶ **High** resolution in both the **horizontal** and **vertical** strongly reduced biases in the Tropical Atlantic (T159 L62)
- ▶ Improved mean state in the ocean and the atmosphere
- ▶ Improved interannual variability

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13 Summary

- ▶ Increased atmospheric **horizontal** resolution reduces Tropical Atlantic SST bias (T42->T159)
- ▶ Spatial bias pattern remains
- ▶ **High** resolution in both the **horizontal** and **vertical** strongly reduced biases in the Tropical Atlantic (T159 L62)
- ▶ Improved mean state in the ocean and the atmosphere
- ▶ Improved interannual variability
- ▶ Consistent choice of horizontal and vertical resolution!

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Thank you for your attention!

Harlaß, J., Latif, M., Park, W. (2015). *Improving Climate Model Simulation of Tropical Atlantic Sea Surface Temperature: The Importance of Enhanced Vertical Atmosphere Model Resolution*, Geophys. Res. Lett., 42, doi:10.1002/2015GL063310

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Richter, I., & Xie, S.-P. (2008). *On the origin of equatorial Atlantic biases in coupled general circulation models*. *Climate Dynamics*, 31(5), 587–598. doi:10.1007/s00382-008-0364-z

Xu, Z., Chang, P., Richter, I., ... (2014). *Diagnosing southeast tropical Atlantic SST and ocean circulation biases in the CMIP5 ensemble*. *Climate Dynamics*, 43(11), 3123–3145. doi:10.1007/s00382-014-2247-9

