CLIVAR-PIRATA-PREFACE TROPICAL ATLANTIC VARIABILITY CONFERENCE
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On the possible sources of southeastern Atlantic warm bias

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MOTIVATION

To explore the role in the generation of the SST bias in the Southern Atlantic:

- Of the ocean
- Of the atmosphere (SAA role)
- Of ocean-atmosphere coupling
- Of the atmospheric and ocean model resolution

THE TOOLS

THE REGIONALY COUPLED MODEL ROM

•**Components**:

- The **RE**gional atmospheric **MO**del **REMO**

- Global ocean model **MPIOM** (increased resolution in the Atlantic).

-The models are coupled in the common region via **OASIS** coupler.

• **Adventages**

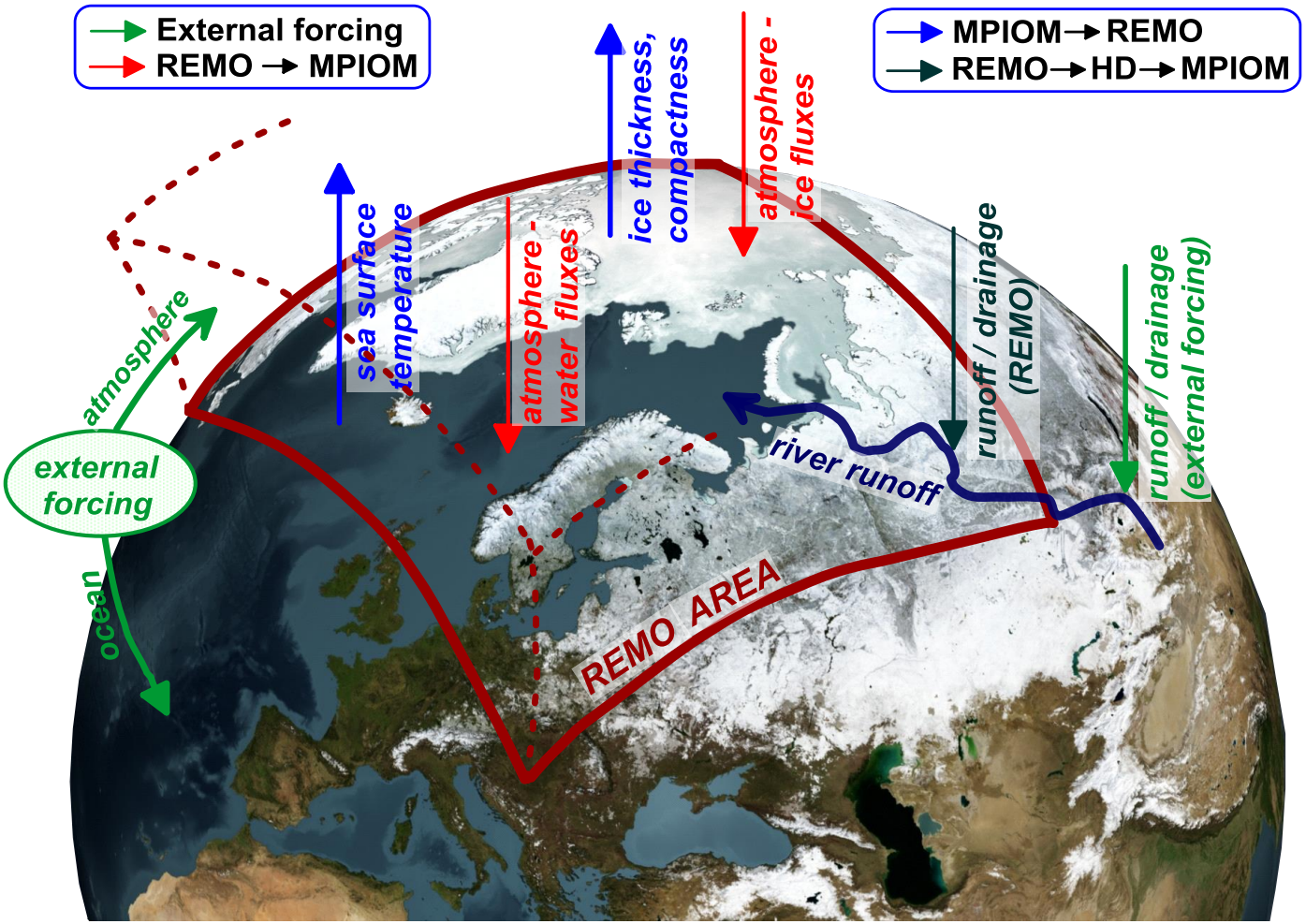
- Higher resolution in the region of interest for both the atmosphere and the ocean

-Ocean developes a consistent global circulation

- Climate close to the boundaries of the regional atmosphere is strongly influenced by external forcing

- Inside the atmospheric domain a own climate is developed

THE REGIONALY COUPLED MODEL ROM (Sein et al, 2015)



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THE GLOBAL COUPLED MODEL AWI-CM

- **Components:**

- Global spectral atmospheric model ECHAM6

- Global **F**inite **E**lement **S**ea **I**ce-**O**cean **M**odel FESOM (increased resolution where needed: Rossby radius and eddie activity, coast, etc).

- **OASIS** coupler.

- **Adventages**

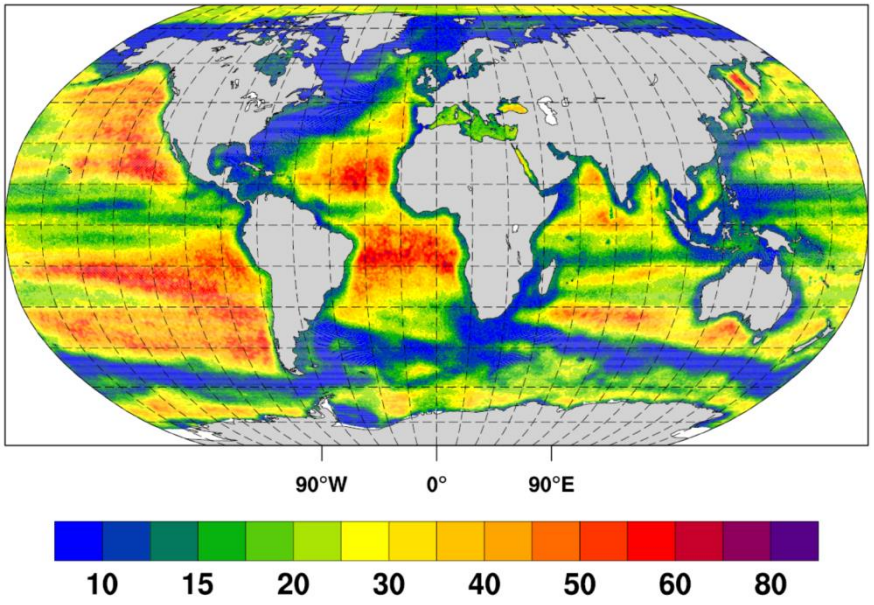
- FESOM has high resolution in dynamically active regions; in other regions such as subtropical regions low resolution to save computing time

- The Aghulas leackage is well resolved.

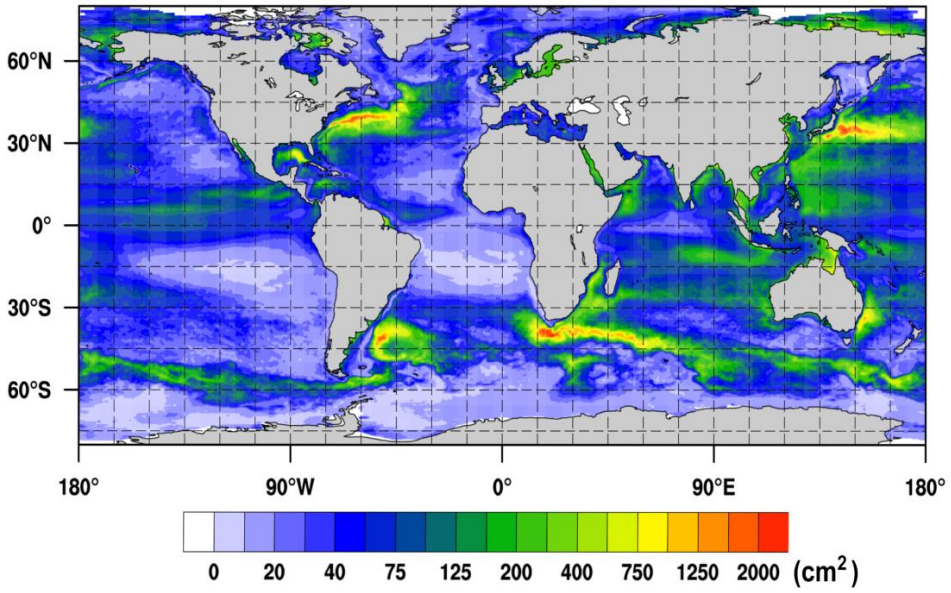
- Consistent oceanic and atmospheric global circulation

Example FESOM setup: based on eddies activity

FESOM mesh



Eddie activity (from AVISO SSH)



Sein et al, 2016

THE GLOBAL COUPLED MODEL AWI-CM

- **Components:**

- Global spectral atmospheric model ECHAM6
- Global finite element sea ice-ocean model FESOM (increased resolution according to Rossby radius and eddie activity, coast).
- **OASIS** coupler.

- **Adventages**

- FESOM has high resolution in dynamically active regions; in other regions such as subtropical regions low resolution to save computing time
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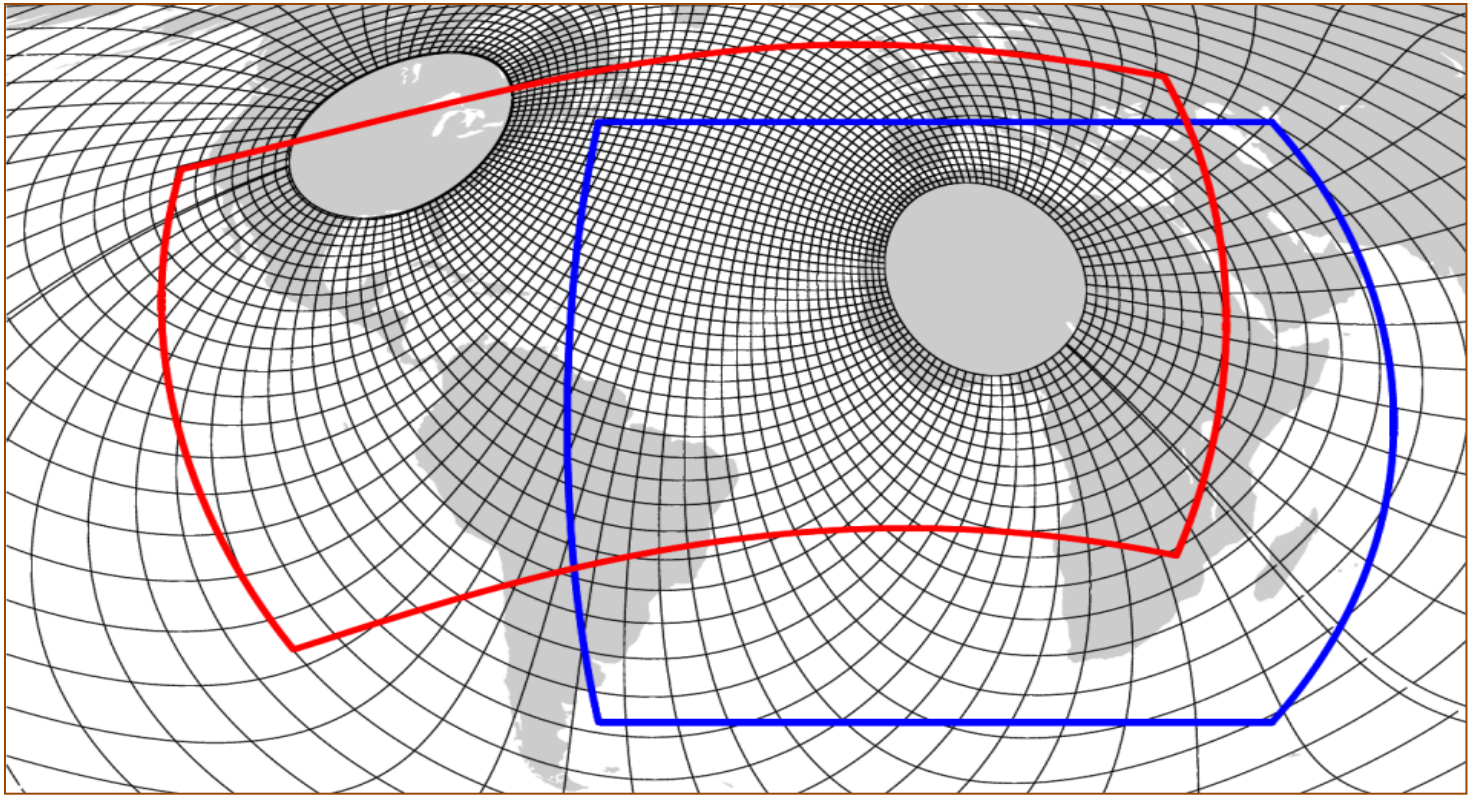
EXPERIMENTS

ROM forced by ERA40: two atm. domains



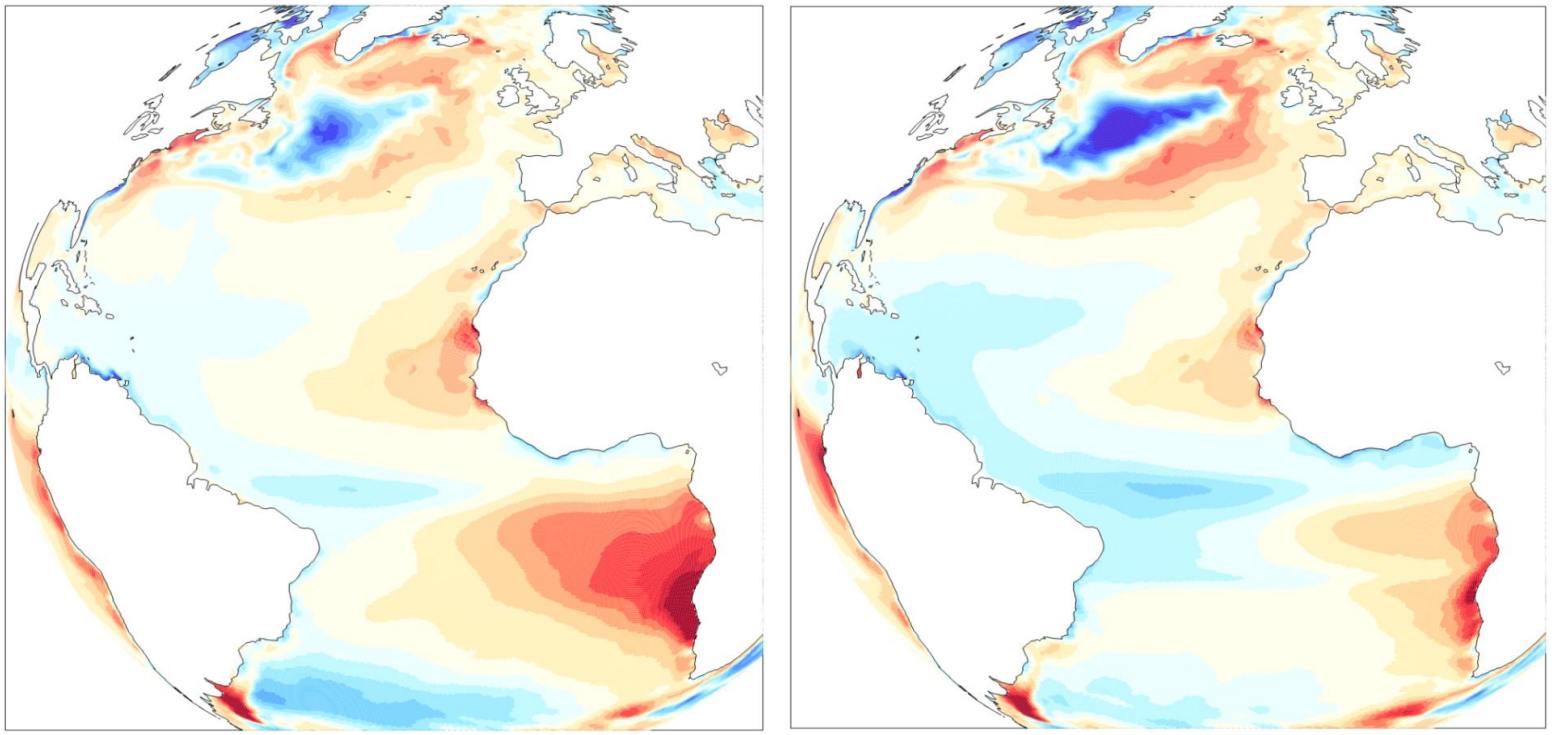
AFR includes the SAA . **NAT** excludes its core and southern part. **TR04** MPIOM is global

MEAN SST BIAS (1980-1999)

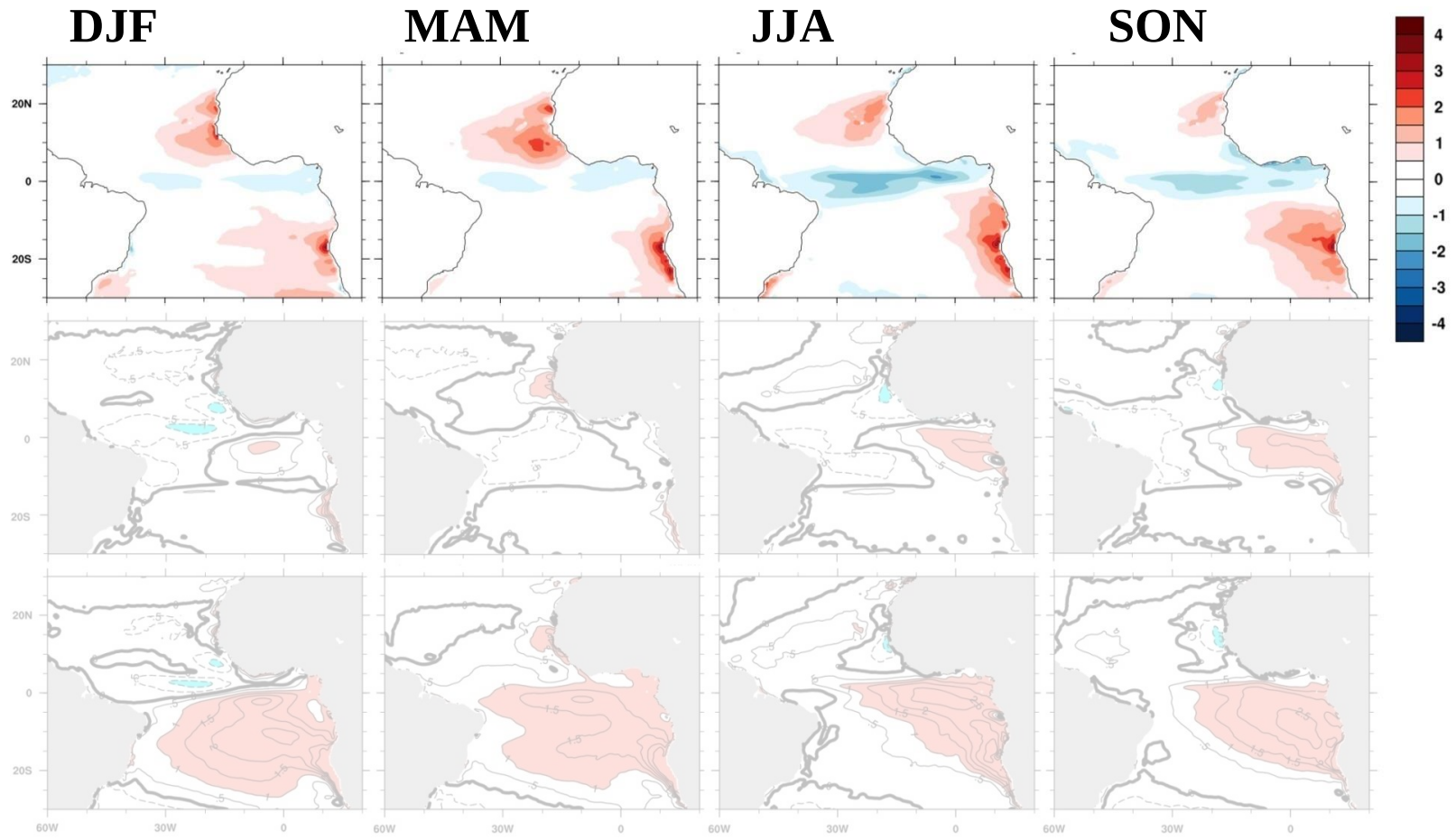
With the same parameterizations, NAT has less biases

AFR 50 km

NAT 50 km



ERA40 forced MPIOM has its own biases

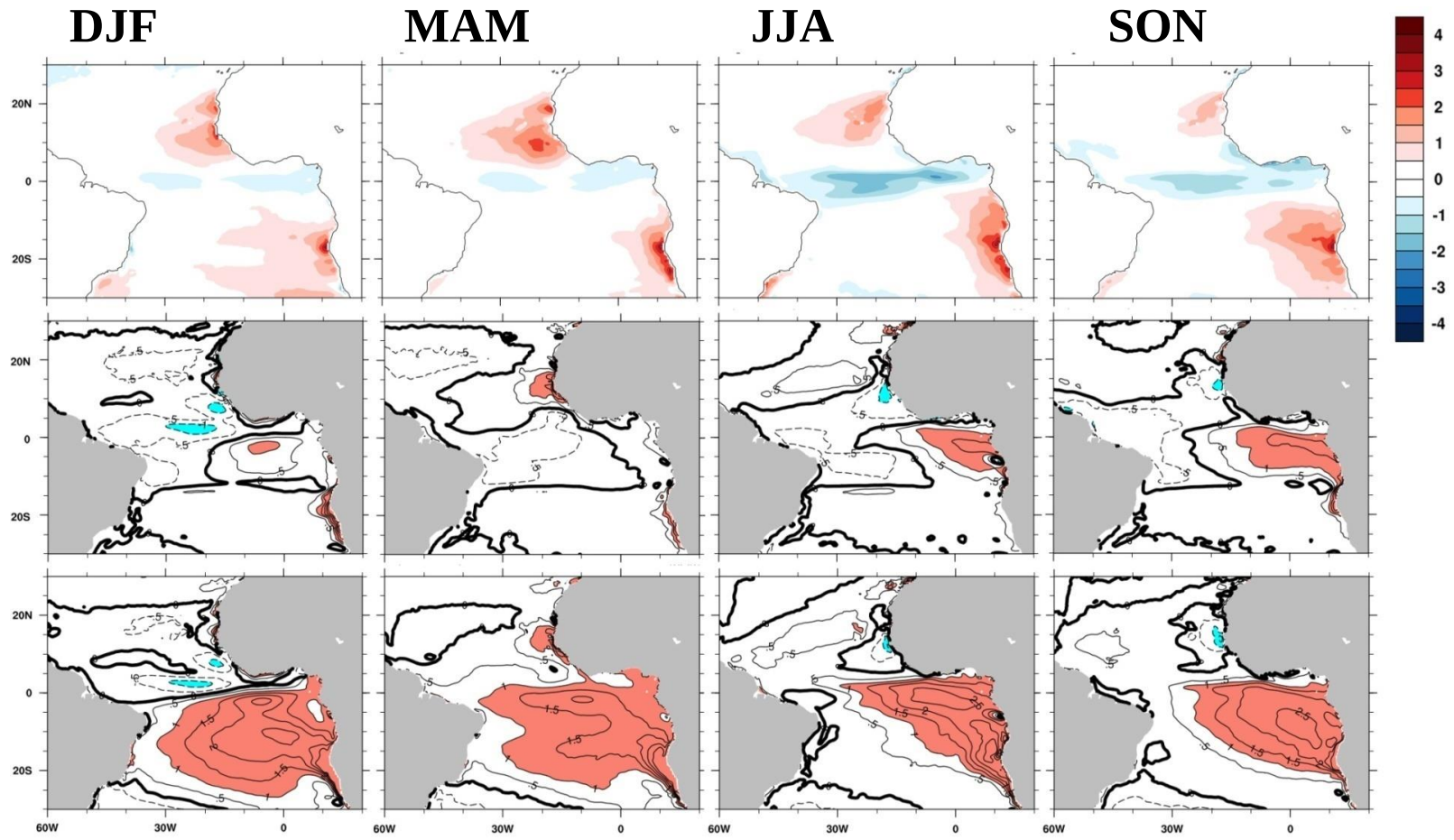


TR04: Cold bias in the equatorial strip and warm biases offshore of Africa.

NAT50: Colder bias reinforced in western equator, warmer bias in the east

AFR50: Coastal biases in the southern TA to the east and the north.

SST biases are modifed by the coupling



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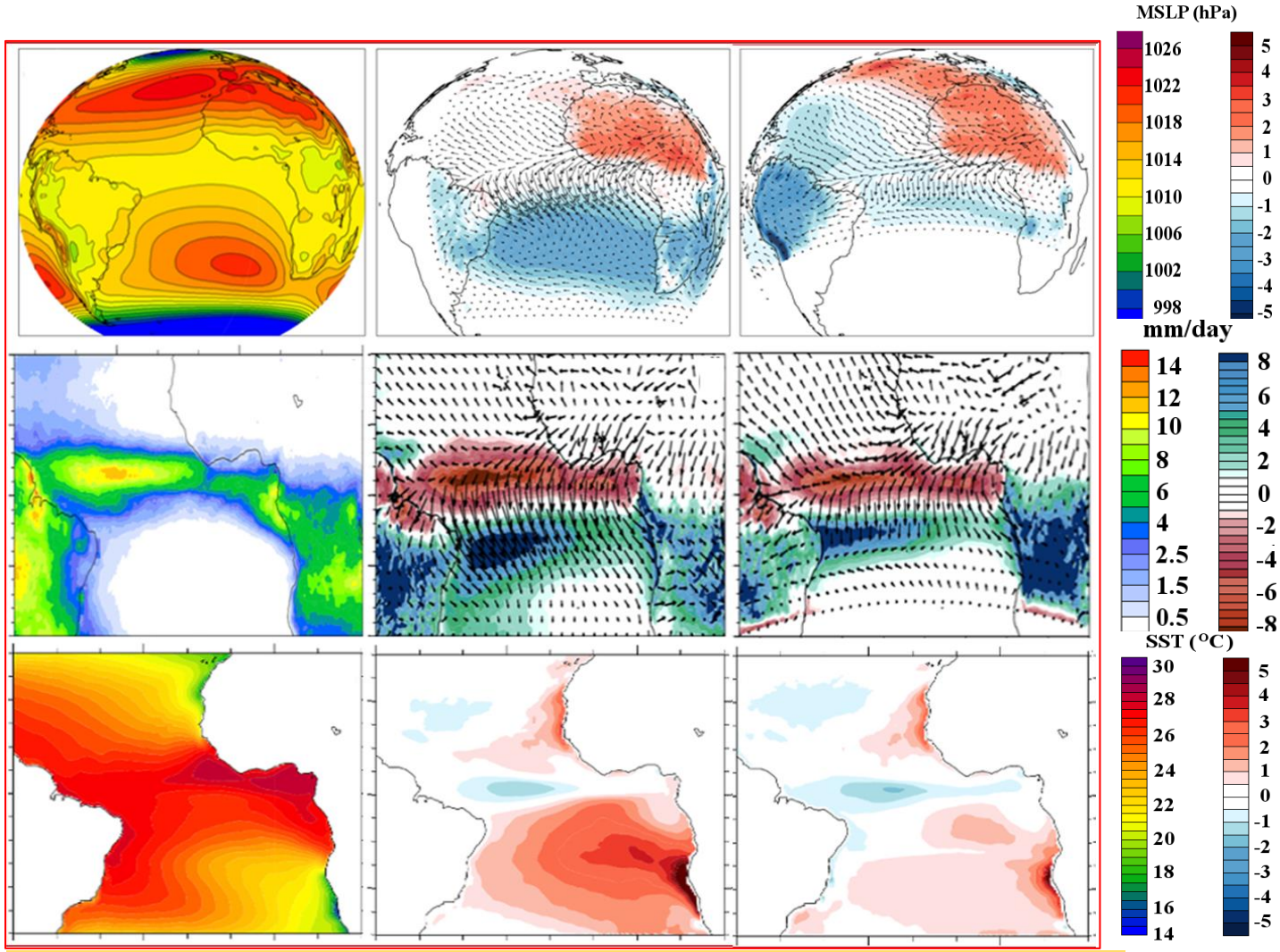
DJF ATMOSPHERIC BIASES

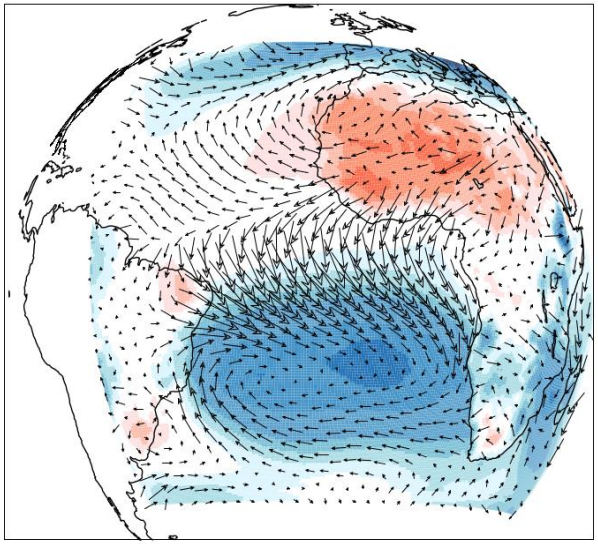


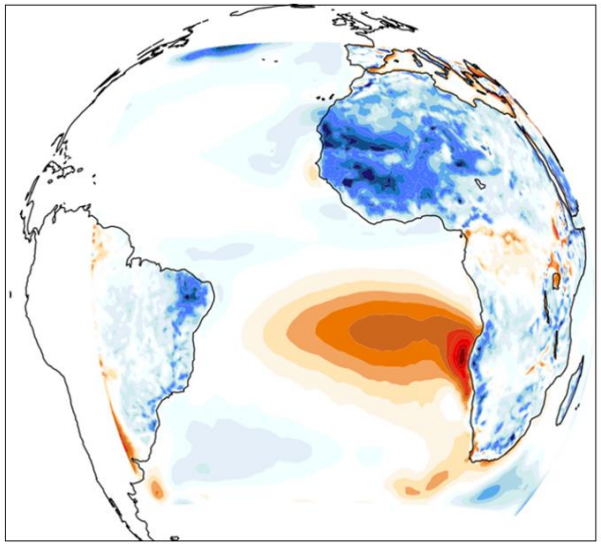
Coupling can improve the simulation: MIKLIP FORCING (DJF)

MSLP

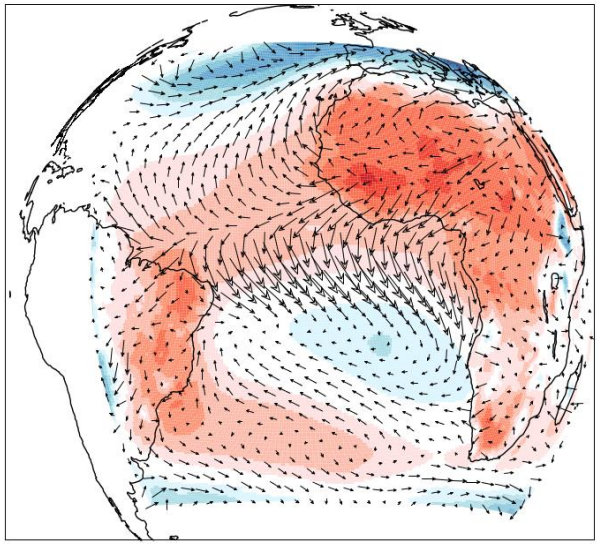
T2M

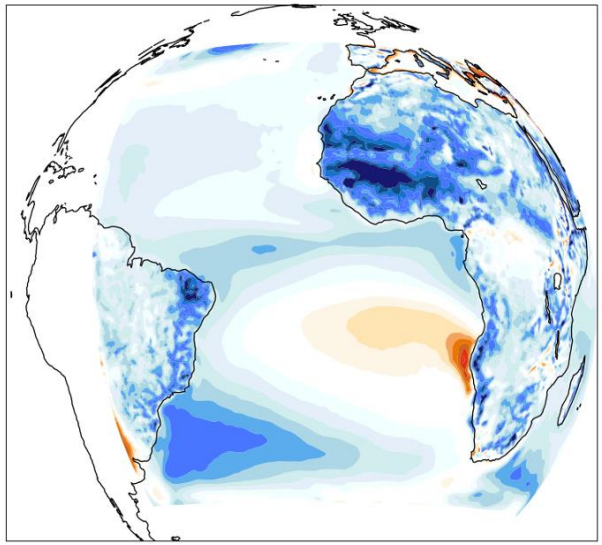
AFR50 uncoupled





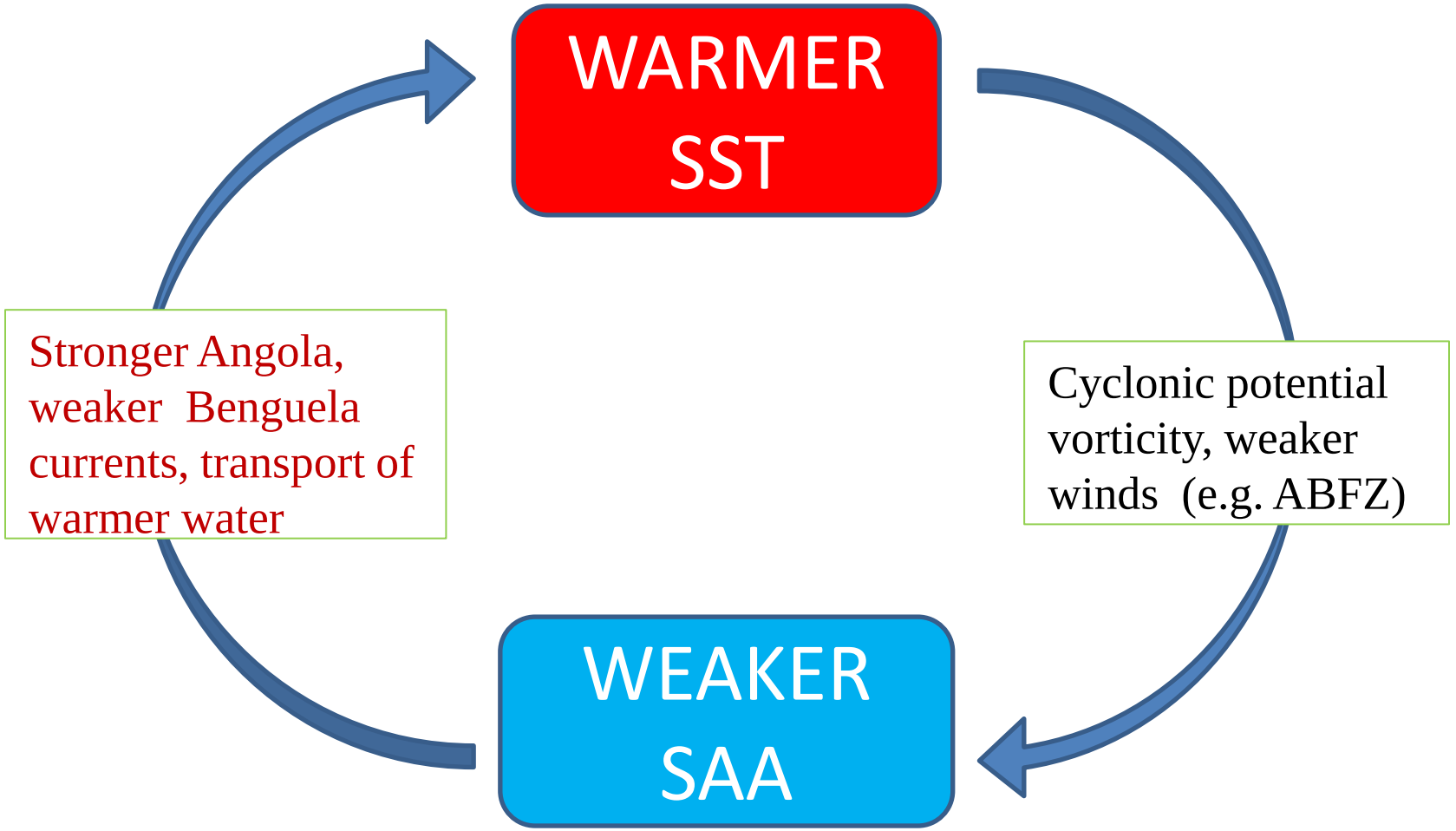
AFR50 coupled





POSSIBLE MECHANISM (DJF)

Cabos et al, 2016



POSSIBLE MECHANISM

- **Austral summer**

A weaker SAA cause a strong southward flow and a weaker northward flux of cool water along the South African coast and less upwelling and mixing, warming the water in the upwelling region. The transport of this anomalous warm water by the South Equatorial current, results also in a net warming in the interior ocean and a warmer equatorial countercurrent. In turn, the atmosphere responds to warm SST bias by creating cyclonic potential vorticity, weakening the SAA.

- **Austral winter**

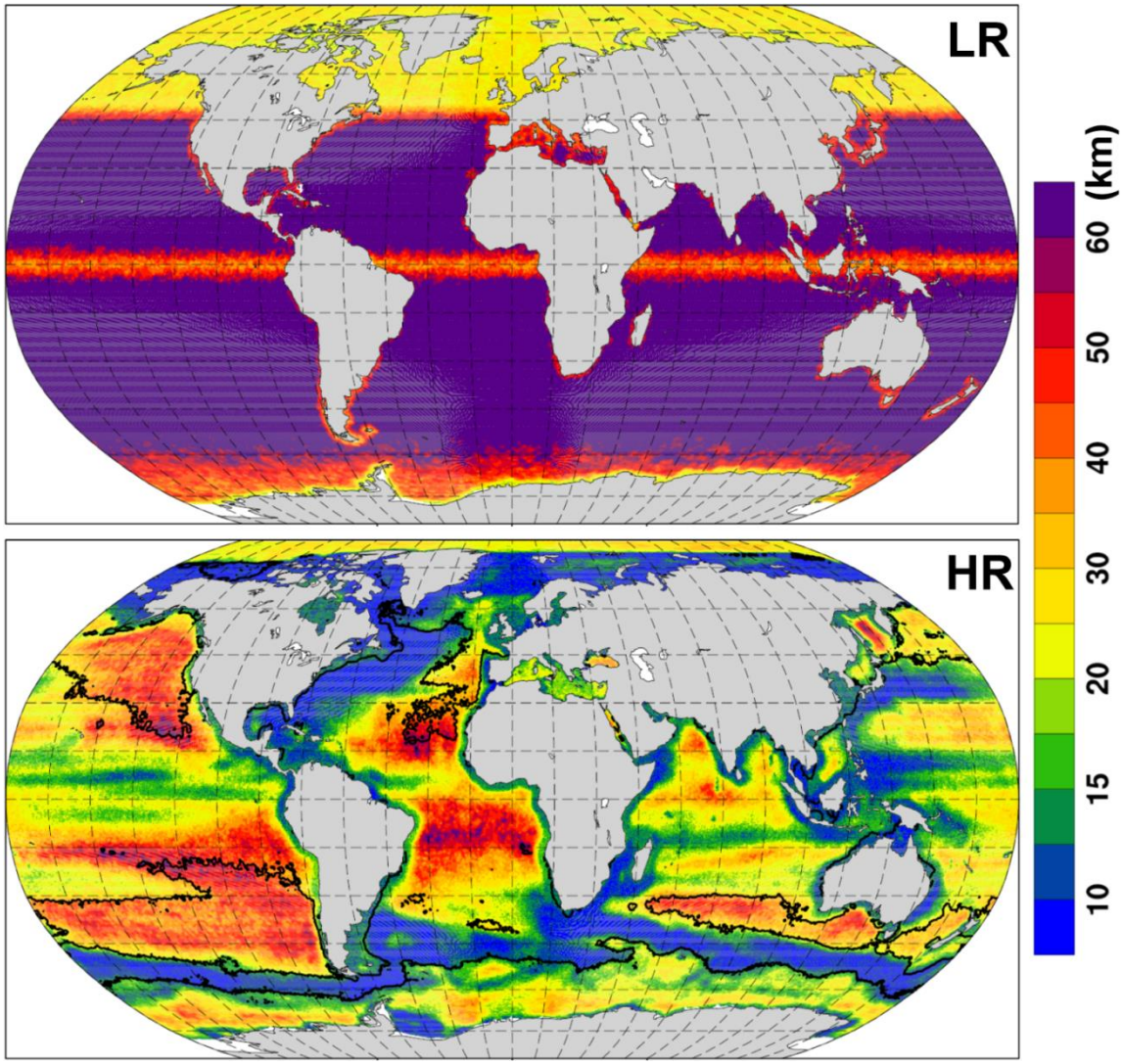
Coupling influences the JJA biases indirectly, through changes in the simulated thermocline depth. In JJA, when the upwelling is stronger, the deeper thermocline makes the upwelled water warmer, contributing to the strong positive bias. The AFR simulations have a deeper thermocline in the ABFZ region.

FESOM, Mesh refinement

- Oceanic fronts
- Regions of eddies activity
- Deep water production
- Polar regions (sea ice)
- Straits
- Rossby radius (?)
- ???

JAMES, 2016

High and Low resolution setups



LR: ECHAM6-T63L95
HR: ECHAM6-T127L95

HiResMIP protocol:

Initialisation: EN4 1950-1954

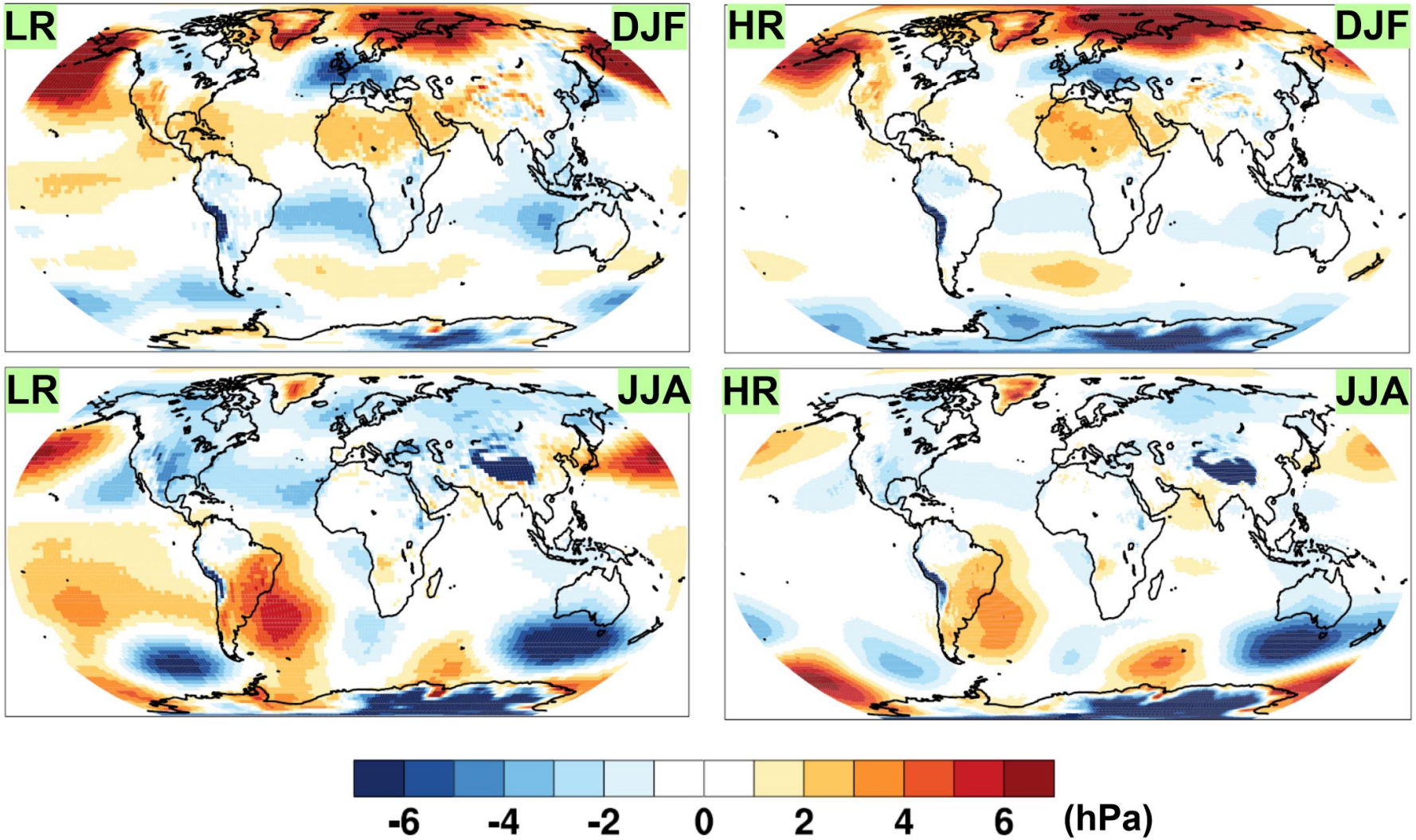
Ocean spin-up 5 years

Coupled spin-up 50 years with constant 1950 forcing

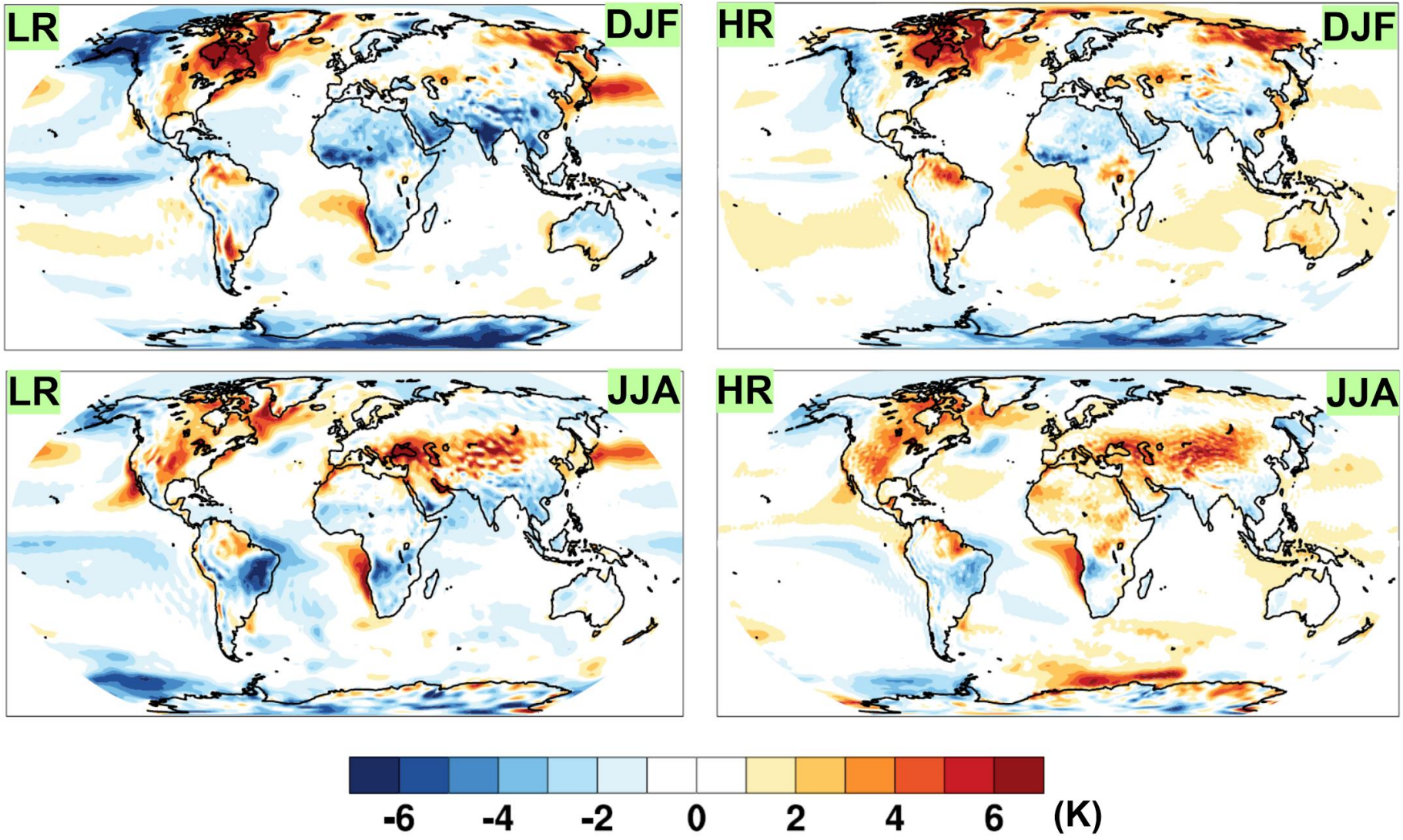
Scenario (RCP8.5) and control (1950) runs for the next 100 years (1951-2050)

HR grid: function variability of sea surface hight, sea ice extent and mixed layer depth (Sein et al. 2016, JAMES)

Mean (1980-2000) Sea Level Pressure bias. Model – ERA-Int.



Mean (1980-2000) 2m Temperature bias. Model – ERA-Int.



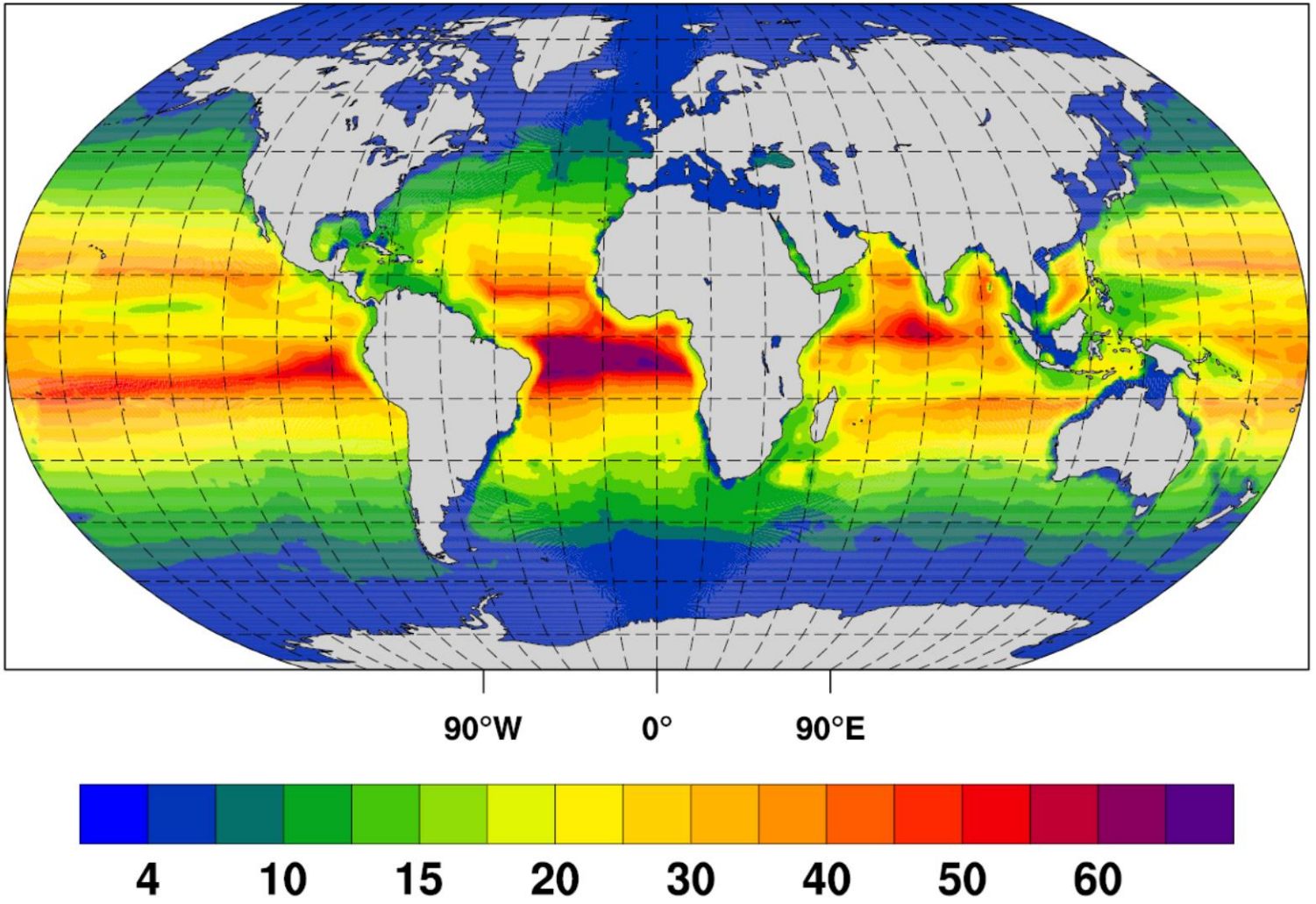
CONCLUSSIONS

- With two different regionally coupled domains we study the impact of the SAA on the Tropical Atlantic seasonal cycle
- Stronger SST biases are associated to a weaker SAA
- In DJF, a feedback that involves the ocean transport and the SAA seem to influence the SST biases
- In JJA, a too deep thermocline seems to be the most important factor for the biases
- A higher horizontal resolution improves the biases in AWI-EC
- The mechanism seem to be confirmed by the AWI-EC simulations (better Aghulas leakage)

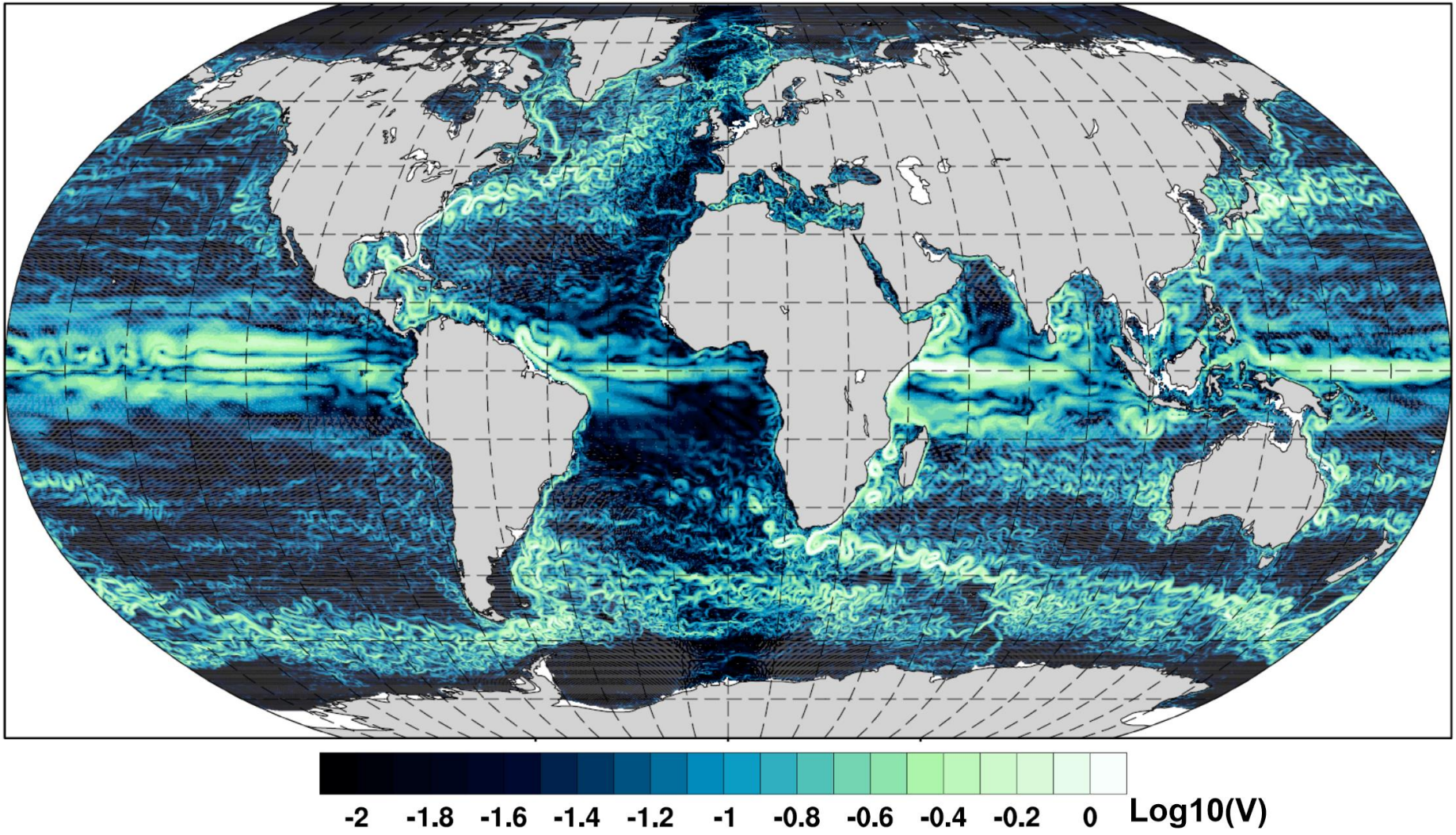
OUTLOOK

ECHAM T255 + FESOM Frontier mesh

FESOM Frontier mesh (5M surface nodes)
Resolution = Max(Min(Rossby radius, Ocean variability), 4km)



50m ocean velocity snapshot. Frontier mesh.



Regional coupling

- **ROM**:

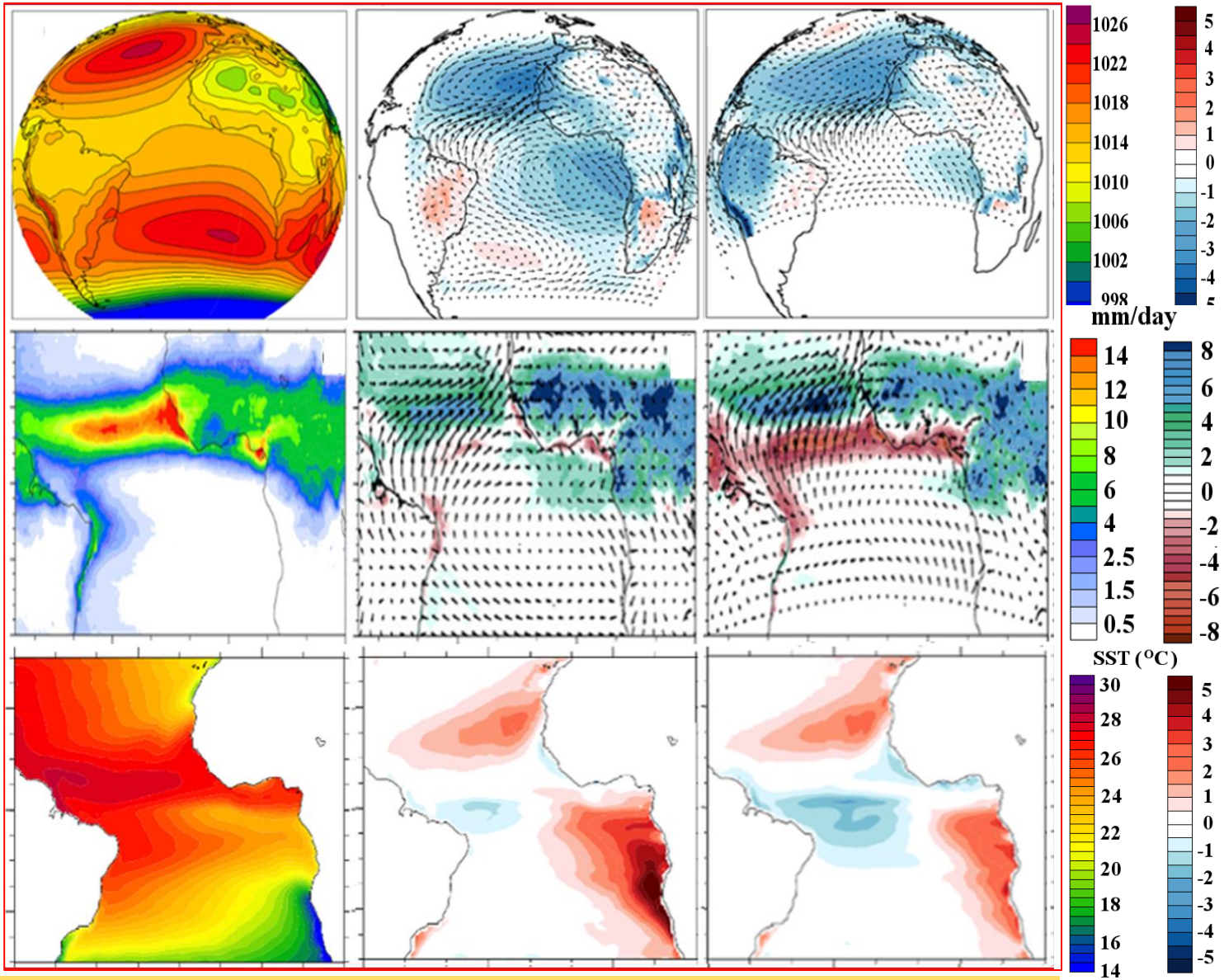
1. AFR domain with (ERAI forcing):
- 25 km REMO and current MPIOM setup (~ 20 km)
- 50 km REMO and higer resolution MPIOM (~ 5 km)
- 25 km REMO and and higer resolution MPIOM (~ 5 km)
2. Ensemble simulations to identify the predictability of the coupled system.
3. Development of coupled domain placemment strategy for a better identification of the sources of variability and predictability in the region

- **New regionally coupled model**:

FESOM + REMO

THANKS FOR YOUR ATTENTION!!

JJA BIASES



OBSERVED AFR BIAS NAT BIAS

Sea Ice thickness January snapshot.
Frontier mesh.