CERFACS

CENTRE EUROPÉEN DE RECHERCHE ET DE FORMATION AVANCÉE EN CALCUL SCIENTIFIQUE

5th Climate Europe Webminar

Model drift analysis to understand the causes of systematic errors in climate prediction systems

Emilia Sanchez-Gomez
Katerina Goubanova and collaborators

climateurope
Linking science and society

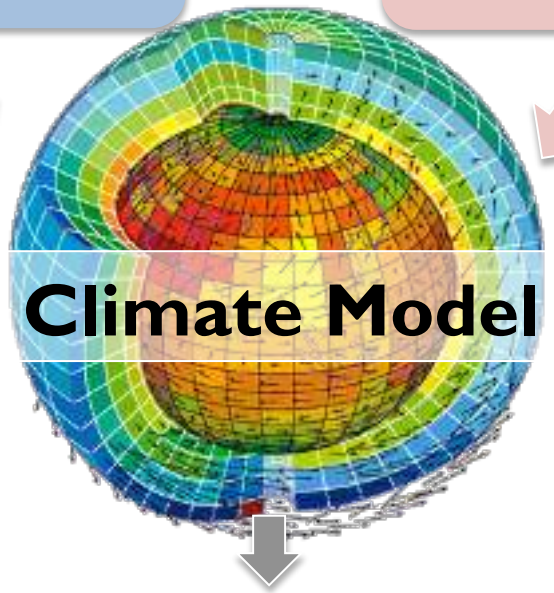
Climate Prediction System

Initial conditions

Observations
Ocean, atmosphere, land, sea-ice

Boundary conditions

External forcings
GHG, Volcanoes, aerosols, solar



Perturbing

Ensembles

simulations

Drift correction

Forecast verification
skill

Forecast Products
downscaling

Climate Prediction System

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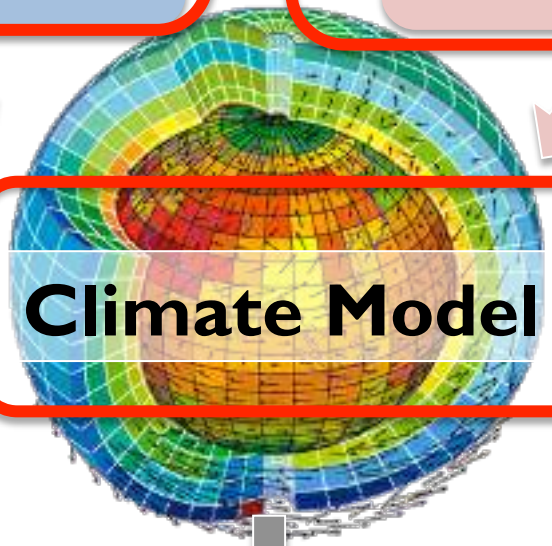

Climate Model

Uncertainties affecting forecast performance

Forecast verification
skill

Forecast Products
downscaling

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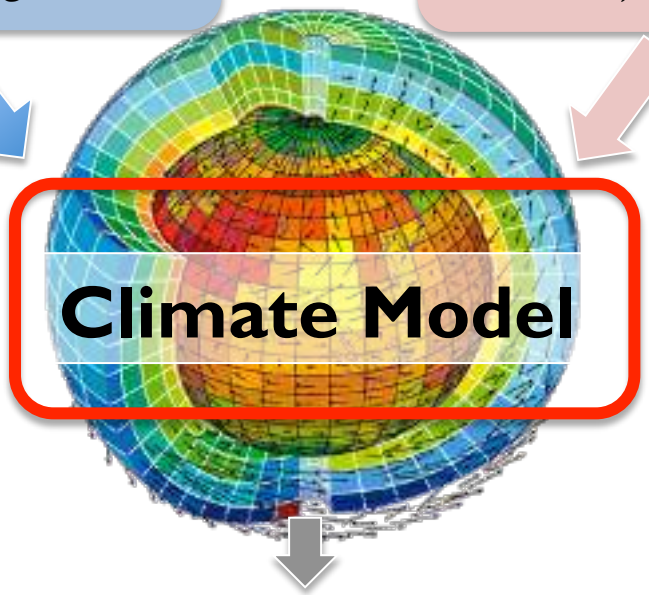

Perturbing

Ensembles

simulations

Drift correction

Forecast verification
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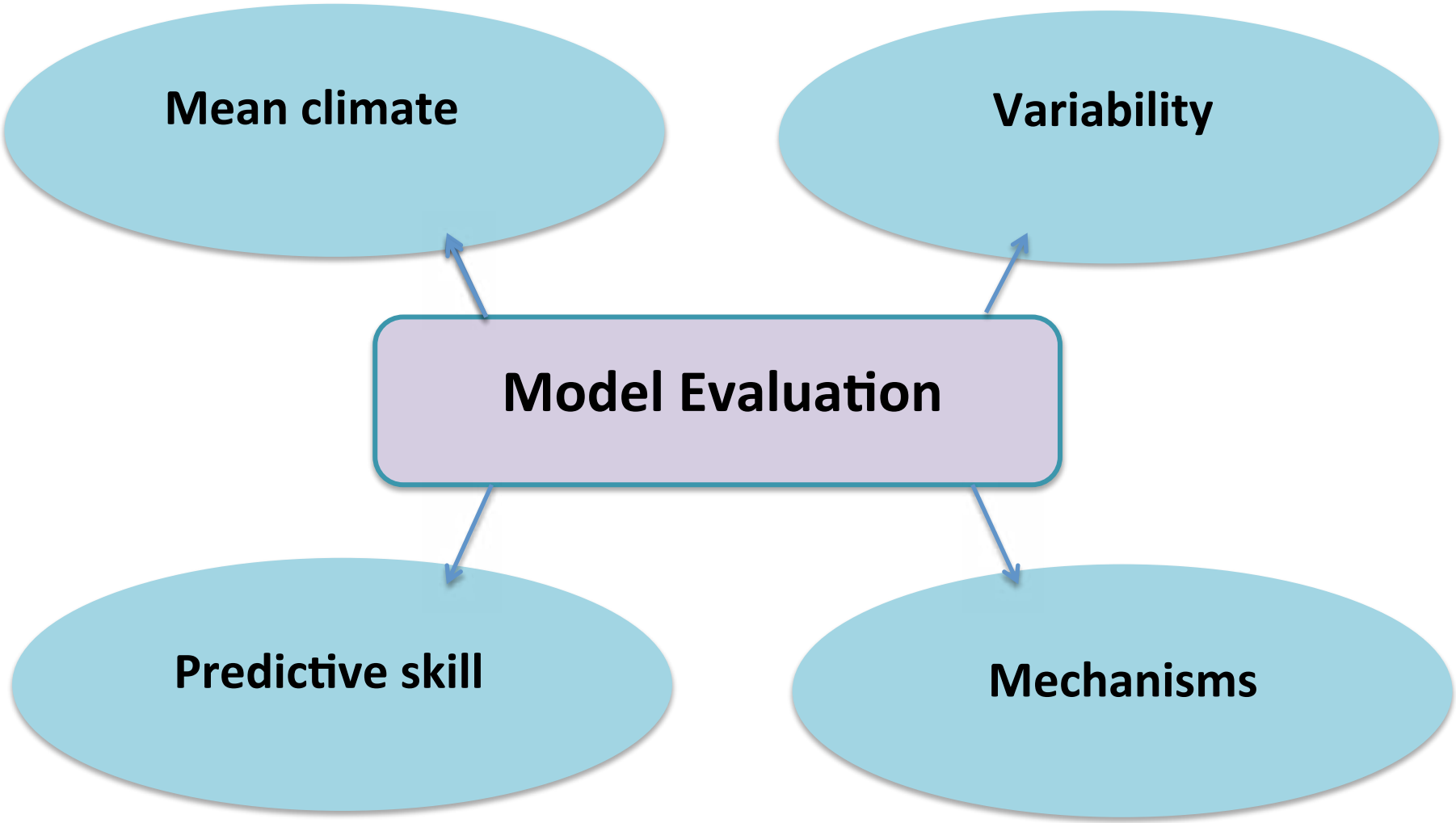
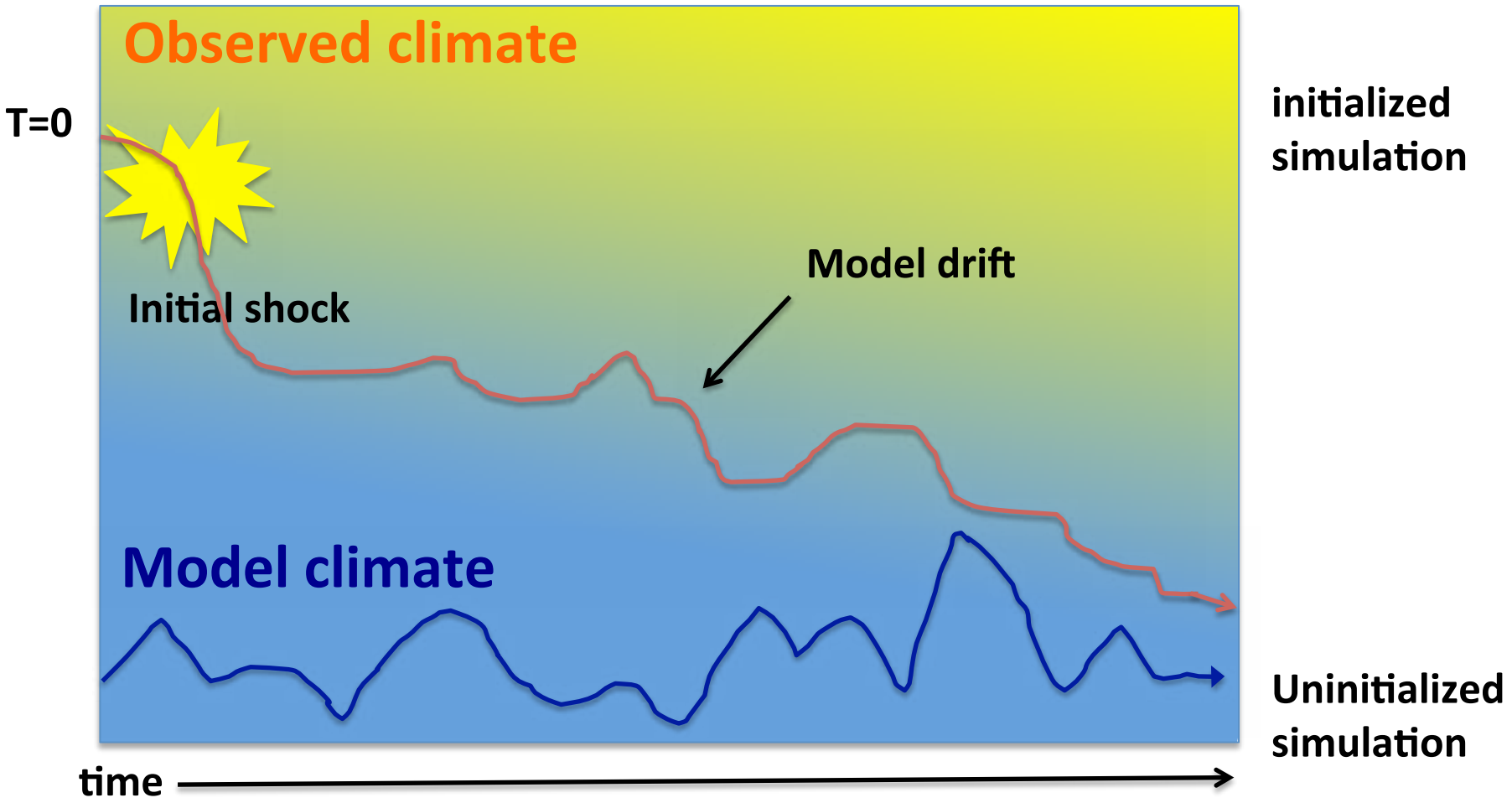
Evaluation of climate models



Drift Analysis to understand model biases



The **model drift** *is the sequence of physical processes by which model adjust to its* <u>*equilibrium state or attractor*</u>

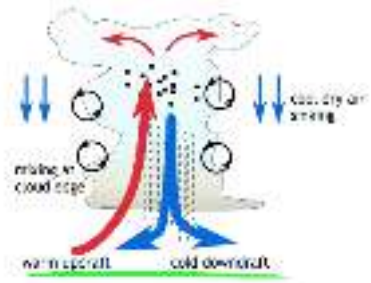
Drift Analysis to understand model biases

The drift (or bias adjustment) analysis depends on the spatial and timescales considered in the physical problem:

- Fast atmospheric processes (convective processes, clouds)

hours to days

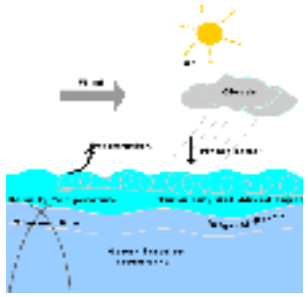
Transpose-AMIP protocol



- Ocean subsurface (mixing processes)

days to months

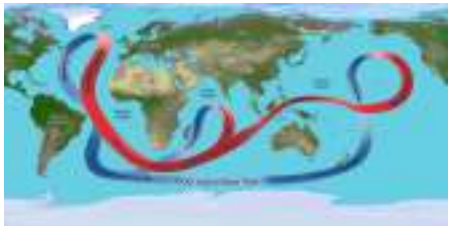
Seasonal forecast



- Deep ocean circulation and gyres

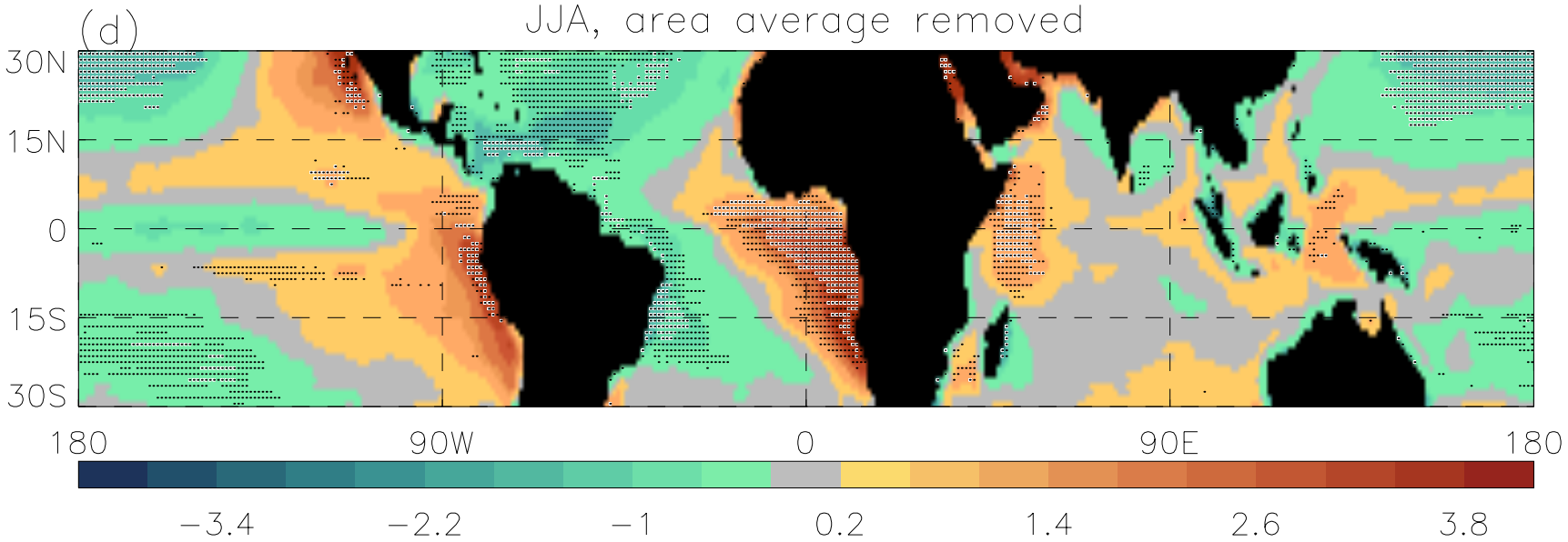
years, decades

Decadal forecast



Understanding climate model biases

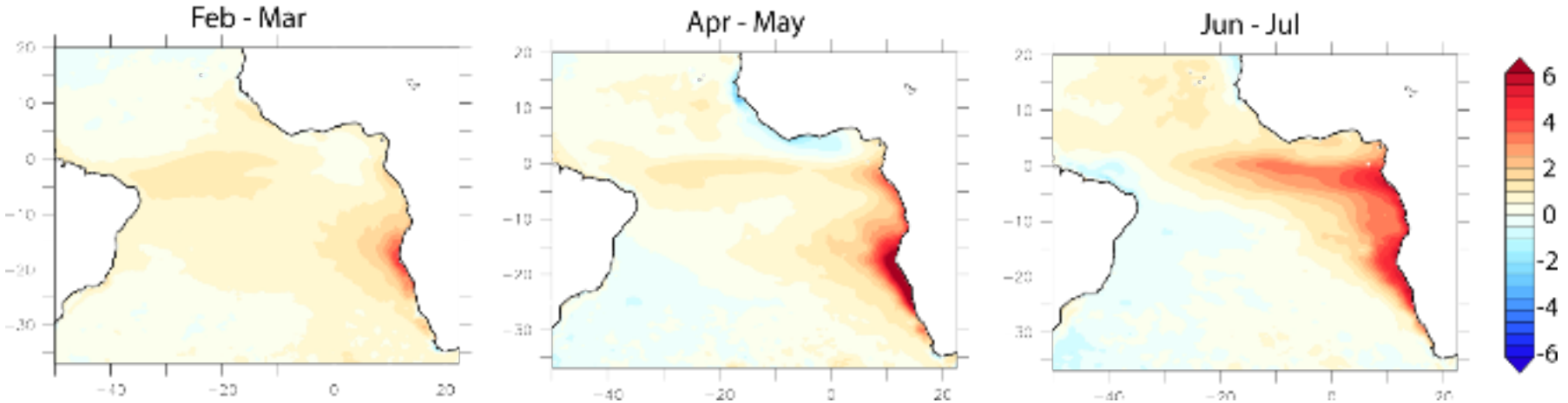
Coupled models continue to suffer from severe equatorial SST biases over the **Tropical Atlantic**



SST bias in the Tropical Oceans (from Toniazzo and Woolnough, 2013)
Data: CMIP5

What is the origin of SST biases in the SouthEastern Tropical Atlantic (SETA)?

Drift Analysis to understand model biases



2-months averaged evolution of the SST bias with respect to GLORYS2v3

❑ Model:

CNRM-CM : **ARPEGE (~50km)** (T359L31) and **NEMO ~0.25⁰** (ORCA025L75)

❑ Seasonal forecast:

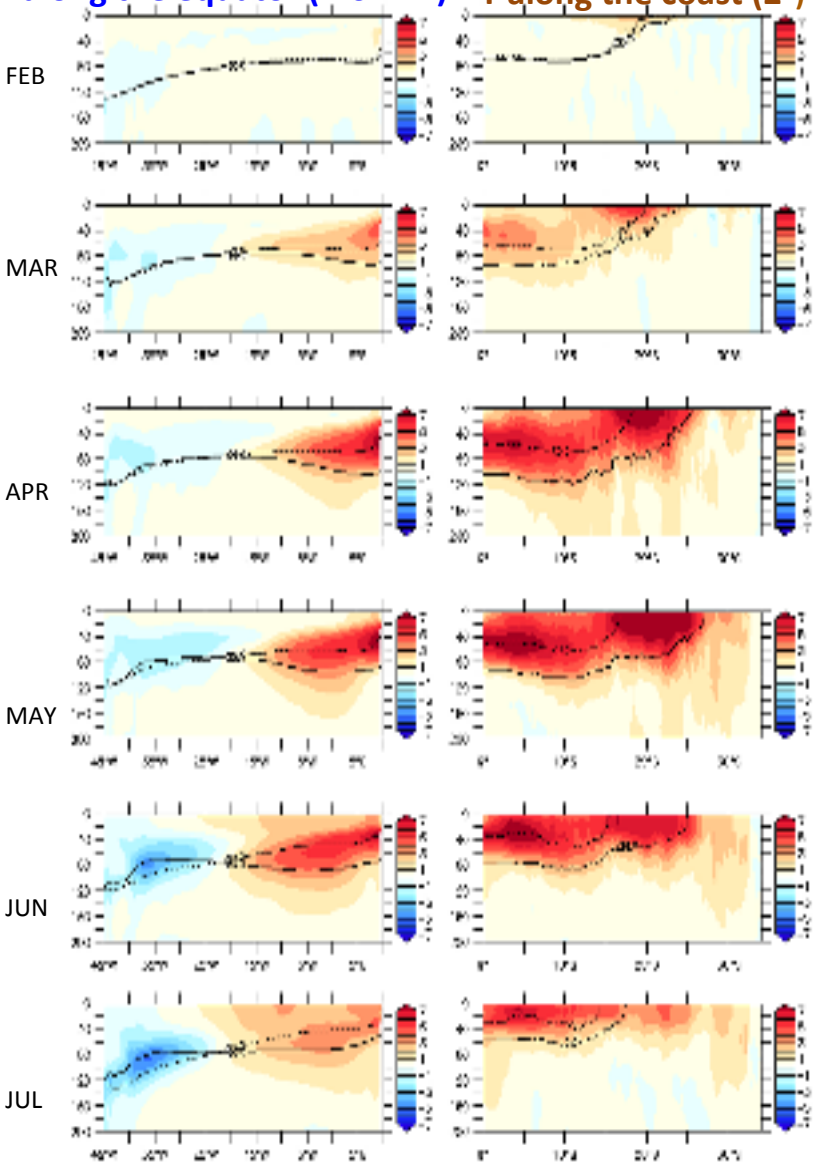
- Initialization from ERAI and GLORYS2v3
- Start date: 1 February
- 10 years: 2000-2009
- Three-members, 6 months lead time

Goubanova et al. 2017 (in prep.)

Drift of ocean subsurface temperature

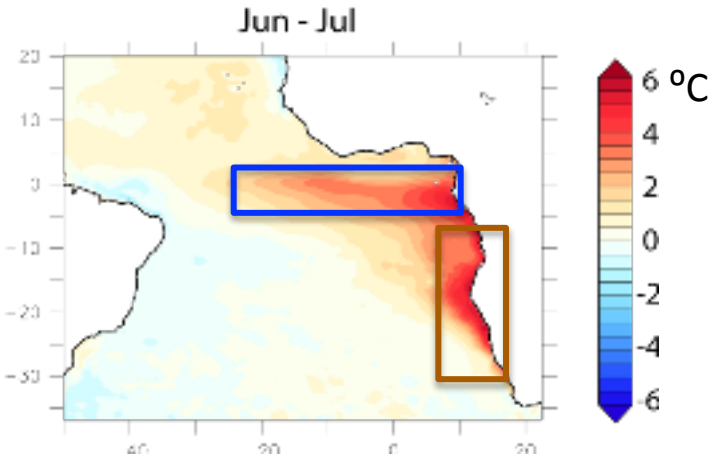
T along the equator (2°S-2°N)

T along the coast (2°)



Isotherme 20°C in the model

Isotherme 20°C in GLORYS2v3



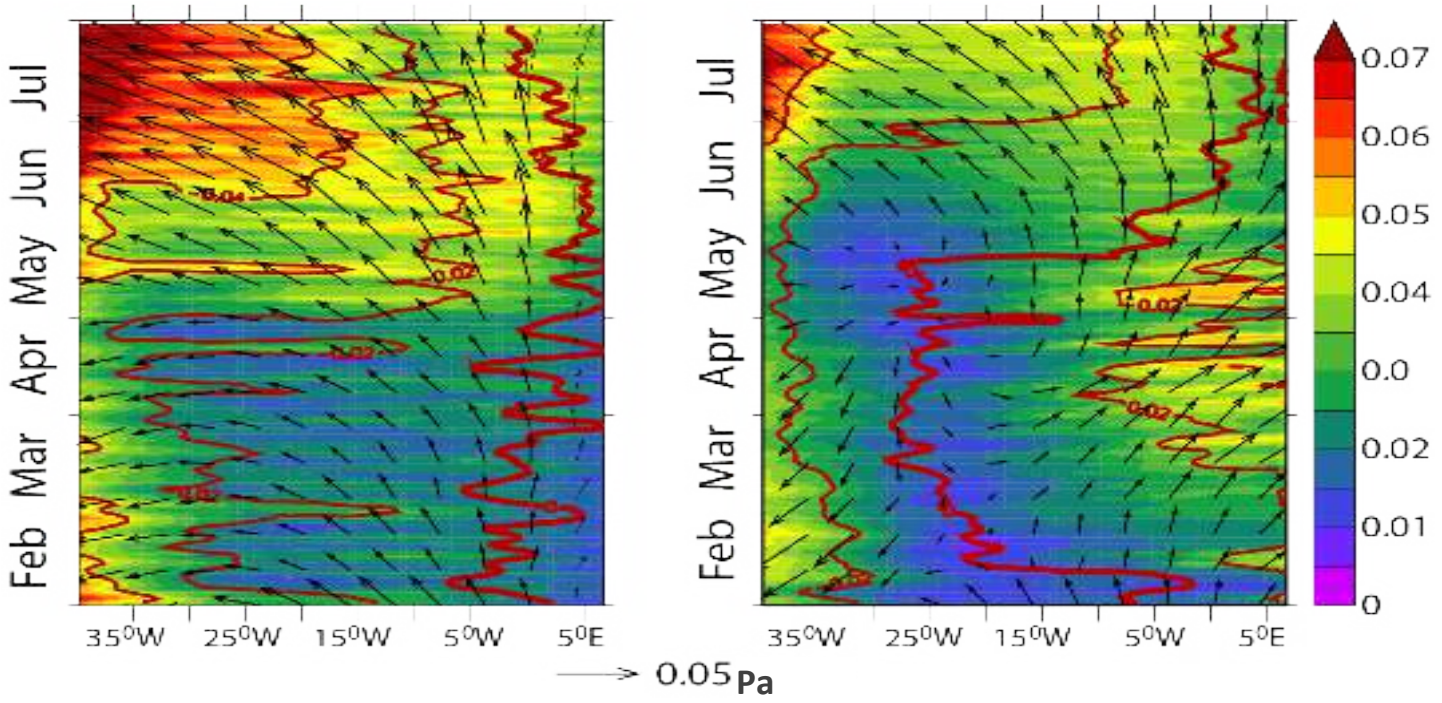
Goubanova et al. 2017 (in prep.)

Drift in wind stress

Mean evolution of the equatorial wind stress (2°S- 2°N)

ERAI

CNRM-CM Model



Shading : wind stress amplitude
Vector: wind stress vector
Contour: zonal wind stress

Goubanova et al. 2017 (in prep.)

Drift in wind stress

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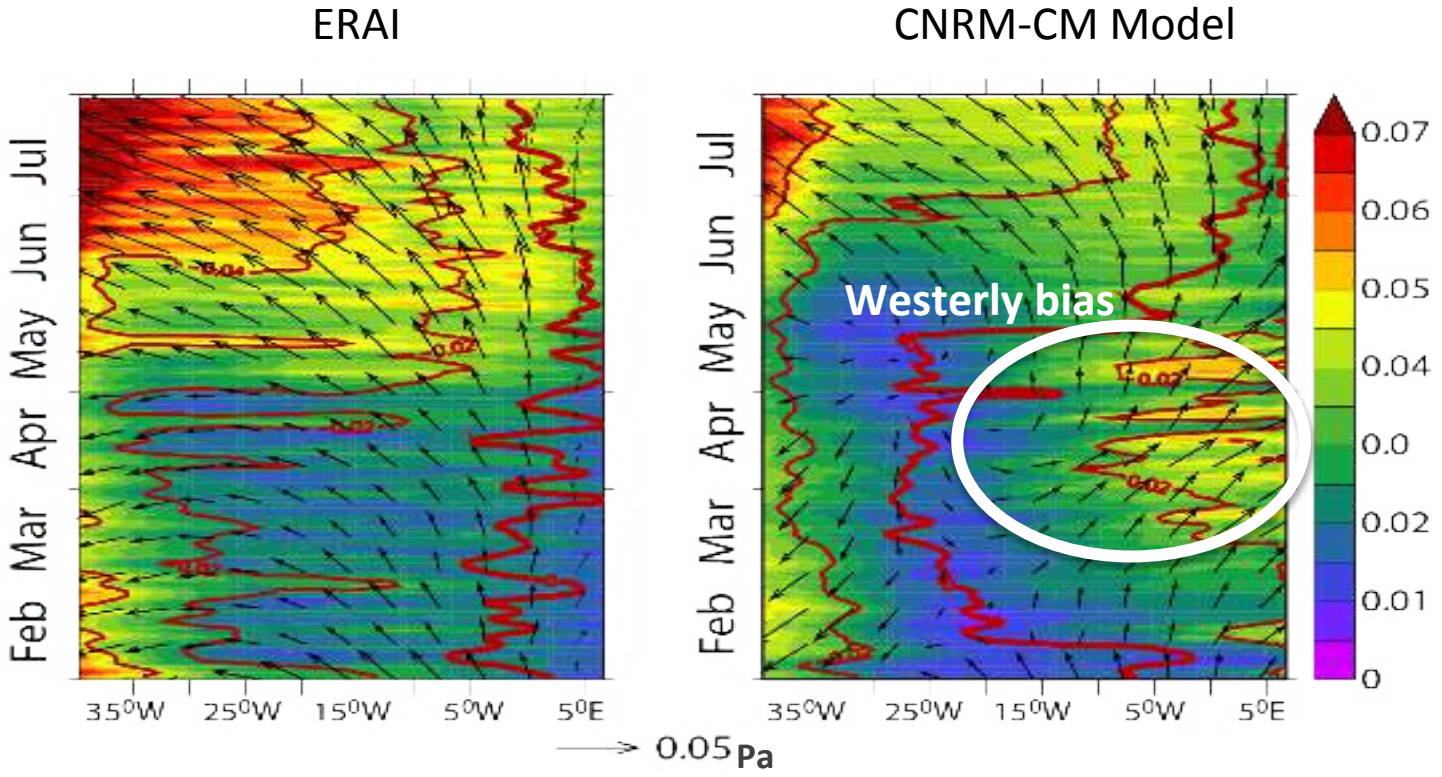

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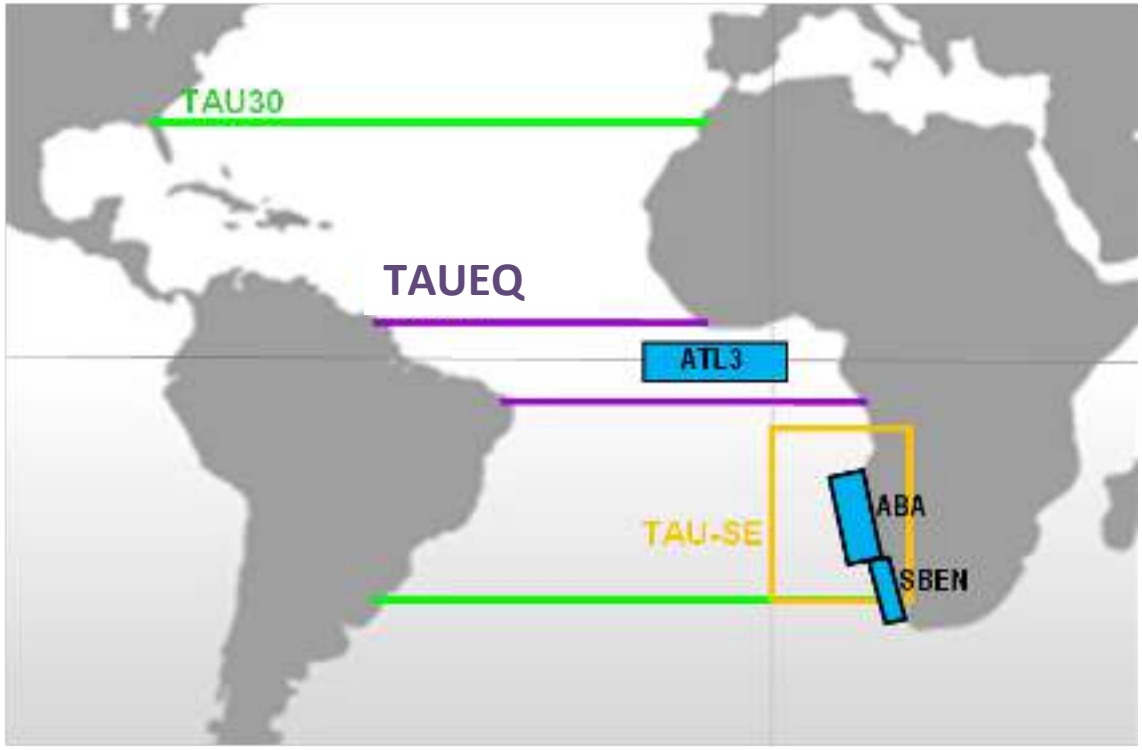
Goubanova et al. 2017 (in prep.)

Sensitivity experiments



TAUEQ : Seasonal forecast experiment with wind stress replacement (ERAI) at the equator

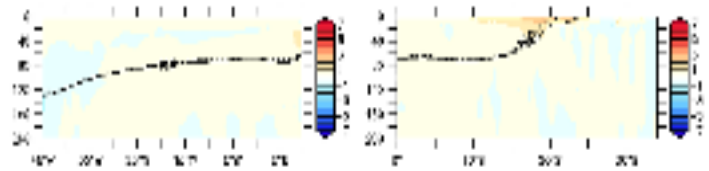
Goubanova et al. 2017 (in prep.)

Sensitivity experiments

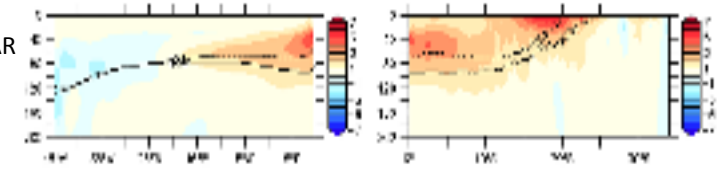
CONTROL

Theta along the equator (2°S-2°N) Theta along the coast (2°)

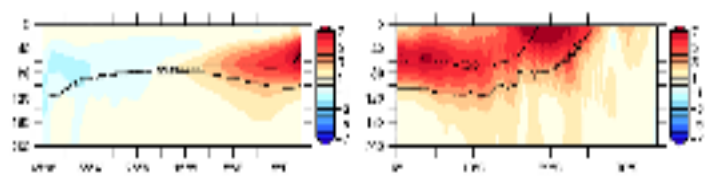
FEB



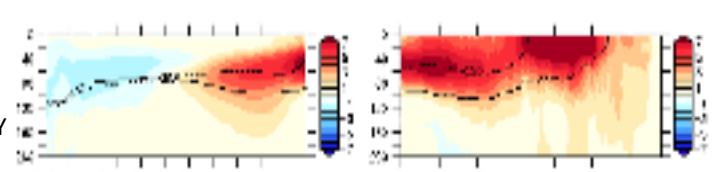
MAR



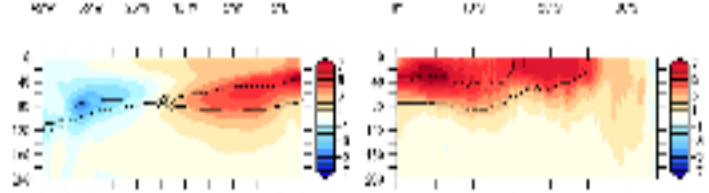
APR



MAY



JUN



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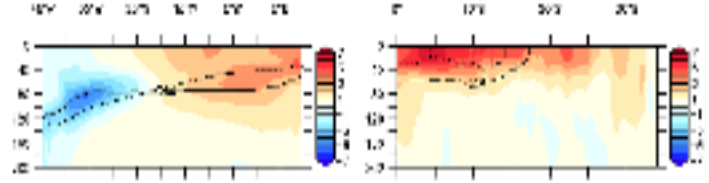
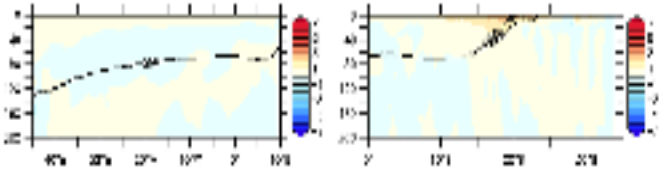


TAUEQ

Theta along the equator (2°S-2°N) Theta along the coast (2°)

FEB



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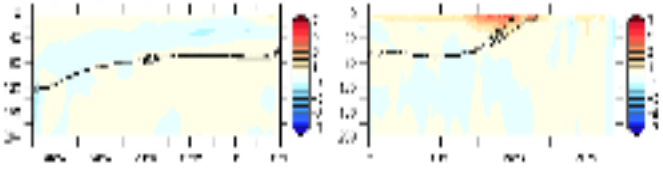

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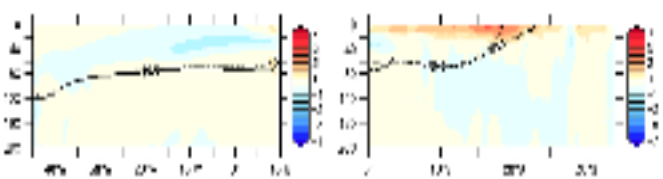

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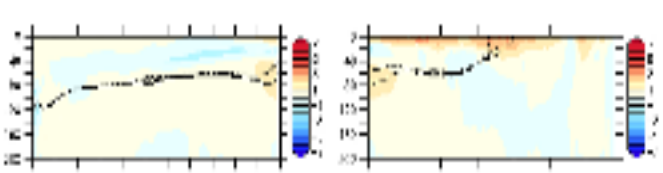

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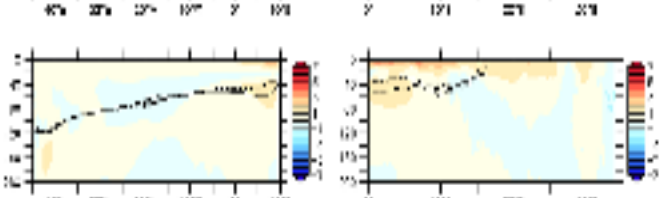

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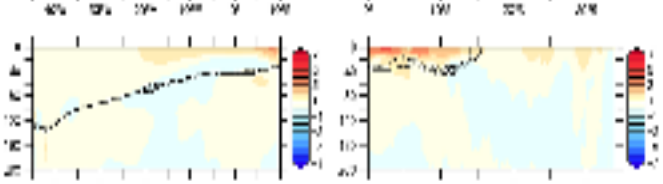

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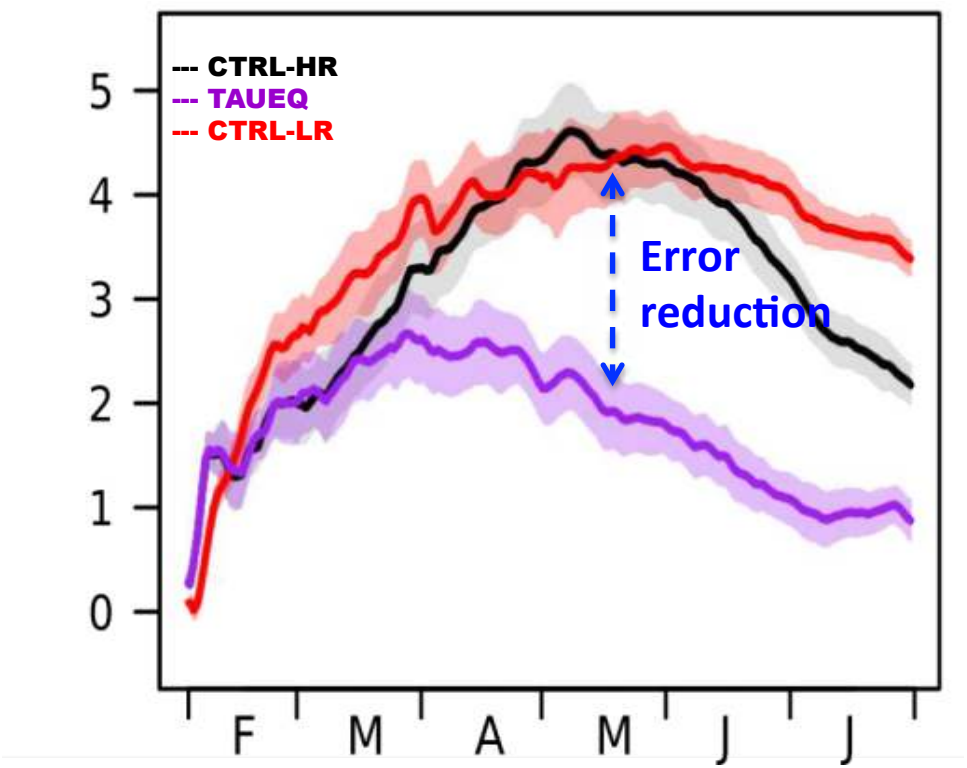
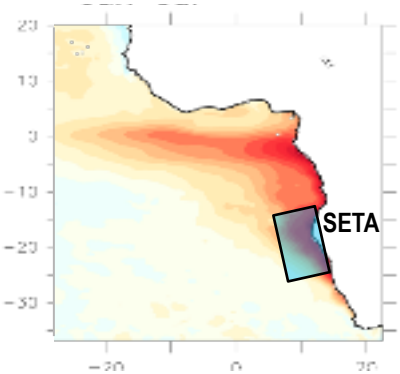
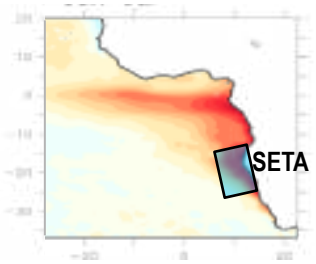




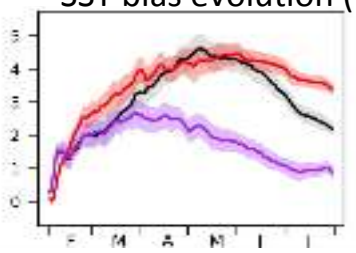
SST bias daily evolution over the SETA (°C):

- **Remote forcing from the equator contributes to ~50% of warm SETA SST** bias in CNRM-CM model

Physical analysis SST biases in SETA



SST bias evolution (°C)

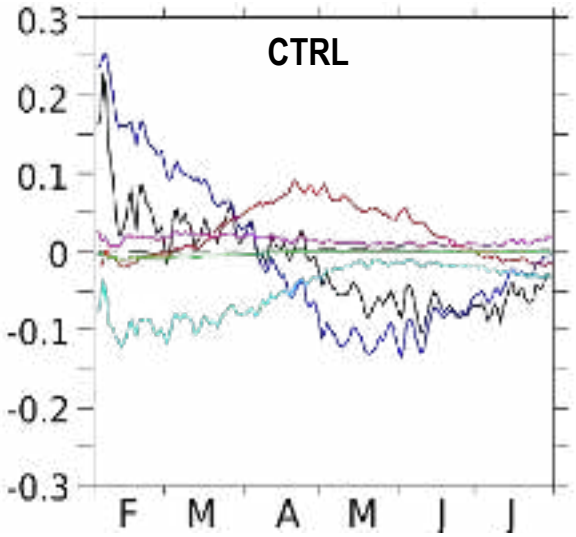


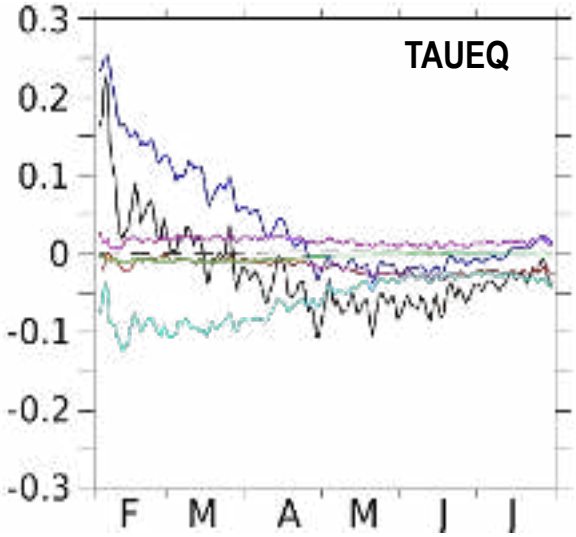
CTRL-HR
CTRL-LR
TAUEQ

Mixed-layer temperature tendency terms

TemperRATE = XY_Adv + Z_Adv + Atm.FORC + Vert.DIFF + ENTR + Res

°C/day





RATE
XY-Adv
Z-Adv
FORC
DIFF
ENTR

CTRL: Spurious particular warm horizontal advection
TAUEQ: warm horizontal advection disappears

Conclusions

❑ **Usefulness of drift analysis in Climate Prediction Systems to understand the origin of model systematic biases**

(Toniazzo and Woolnough 2013; Vanniere et al. 2013,2014; Sanchez-Gomez et al. 2016; Goubanova et al. (in prep))

❑ **Case study: Tropical Atlantic SST bias**

- **Seasonal forecasts CNRM-CM model**
- **Analysis of the drift to understand SST bias in the SETA region**

✓ 50% of SST bias can be explained by spurious warm advection from the equator, due to atmospheric biases (equatorial westerly wind bias).

✓ Transpose-AMIP analysis shows that atmospheric westerly bias develop very fast (within the first 5 days) (Roehrig et al.)