# SST bias development in the Tropical Atlantic in PREFACE coordinated experiments

*A. Voldoire*[1], *T. Demissie*[2], *A.-L. Deppenmeier*[3], *E. Exarchou*[4], *C. Frauen*[1], *K. Goubanova*[5], *N. Keenlyside*[6], *S. Koseki*[6], *C. Prodhomme*[4], *E. Sanchez-Gomez*[5], *M.-L. Shen*[2], *J. Shonk*[7], *T. Toniazzo*[2], *A.-K. Traoré*[8]

[1]*CNRM, France,*
[2]*UniRes, Norway,*
[3]*Wageningen University, The Netherlands,*
[4]*Barcelona Supercomputing Center, Spain,*
[5]*CERFACS, France,*
[6]*Bergen University, Norway,*
[7]*Reading University, UK,*
[8]*LMD/IPSL, France.*

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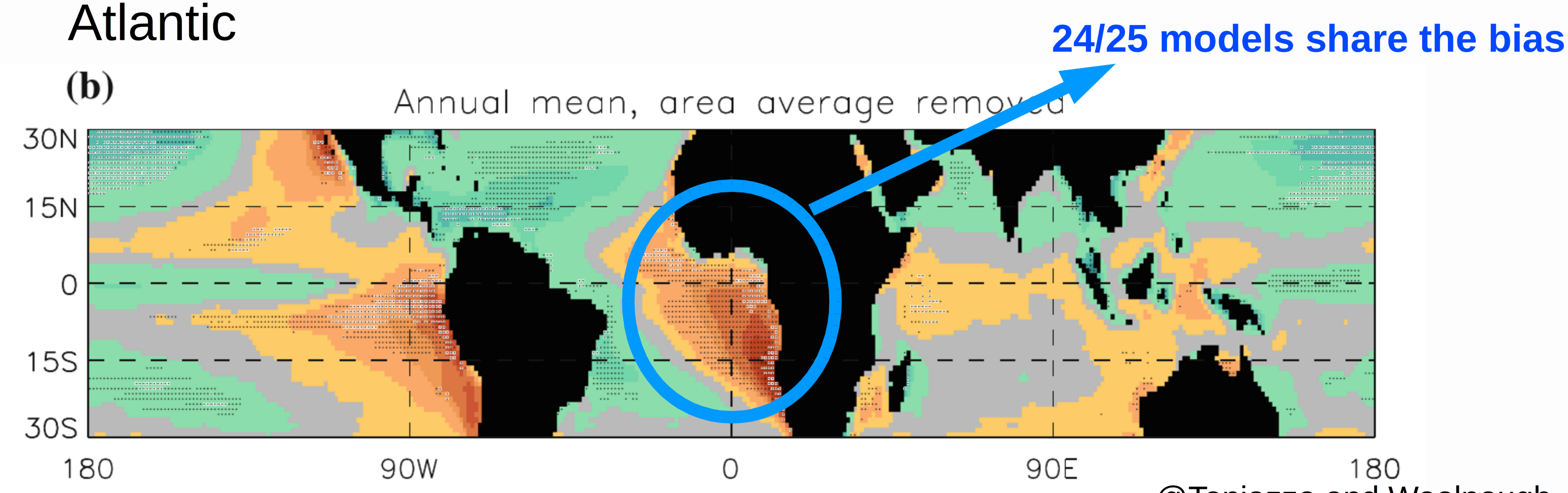
# Motivation

- A large warm bias in the CMIP5 climate models in the tropical Atlantic



@Toniazzo and Woolnough, 2014

- Several studies have pointed out the role of the wind stress biases in driving the SST bias (Ding et al., 2015, Richter et al., 2014, Small et al., 2015)

# Motivation

- The SST bias settle within several weeks to several months in CMIP5 decadal hindcasts in the tropical Atlantic (Toniazzo and Woolnough, 2014, Voldoire et al., 2014)

  → Analyse the way models are drifting to tackle the sources of SST bias

  → A cheap framework to run sensitivity studies

- Key questions :
  - Are all models drifting the same way?
  - What is the role of the wind biases in driving the SST drift?

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# Models involved

- Cerfacs :
  CNRM-CM5.1-HR NEMO1/4° L75 / ARPEGE-Climat T359L31
- IPSL :
  IPSL-CM NEMO2° L31 / LMDZ 2,5°x1,2° L79
- MF-CNRM :
  CNRM-CM5.2-LR NEMO1° L42 / ARPEGE-Climat T127 L31
- UREAD :
  ECWMF-S4 NEMO1° L42 / IFS T255 L91
- UniRes/Uib :
  NorCPM MICOM 1° L53 / CAM4 2° L27
- WU/BSC :
  EC-Earth 3.1 NEMO1° L46 / IFS T255 L91

Initialisation : all initialized from ORAS4 except NorCPM and CNRM-CM5.1-HR.

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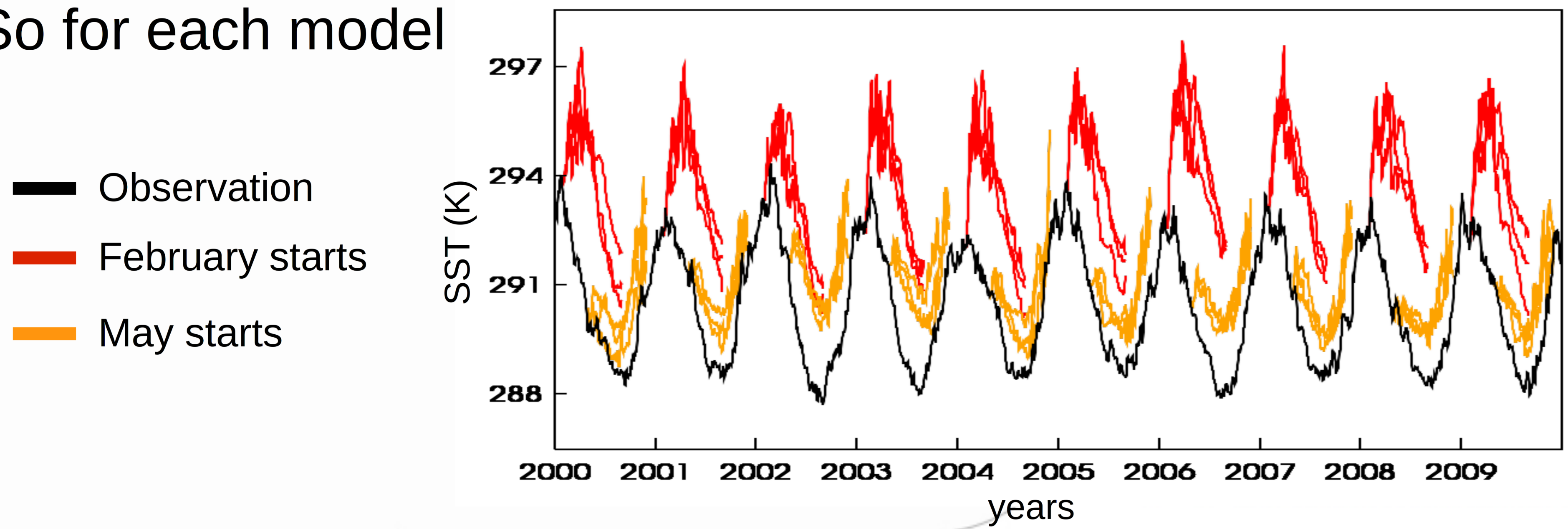
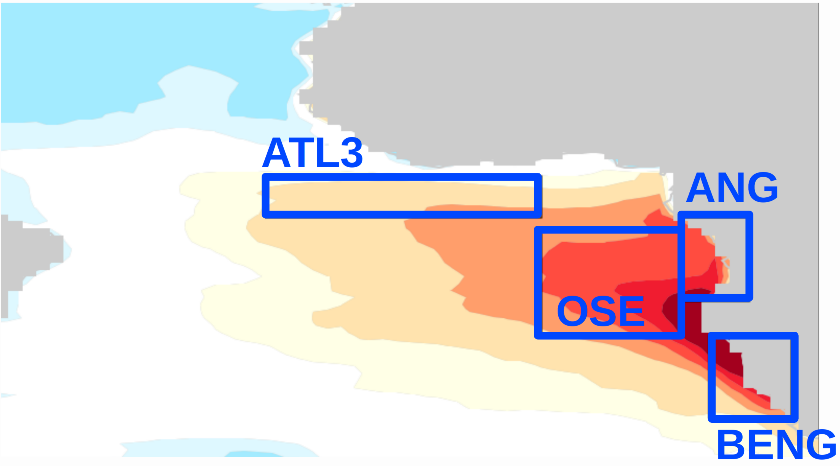
# Control experiment setup

- 2 start dates : May and February (most interesting dates to deal with the spring cooling)
- Initialisation full-field (or as close as possible)
- 10 years 2000-2009
- At least 3 members (differences in the atmospheric state)
- At least 4 months long (but generally 6 months have been provided)
- So for each model



# Analysis strategy

- For this presentation 4 regions have been considered :

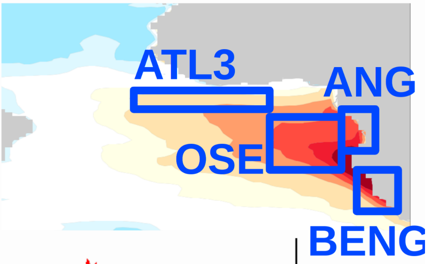


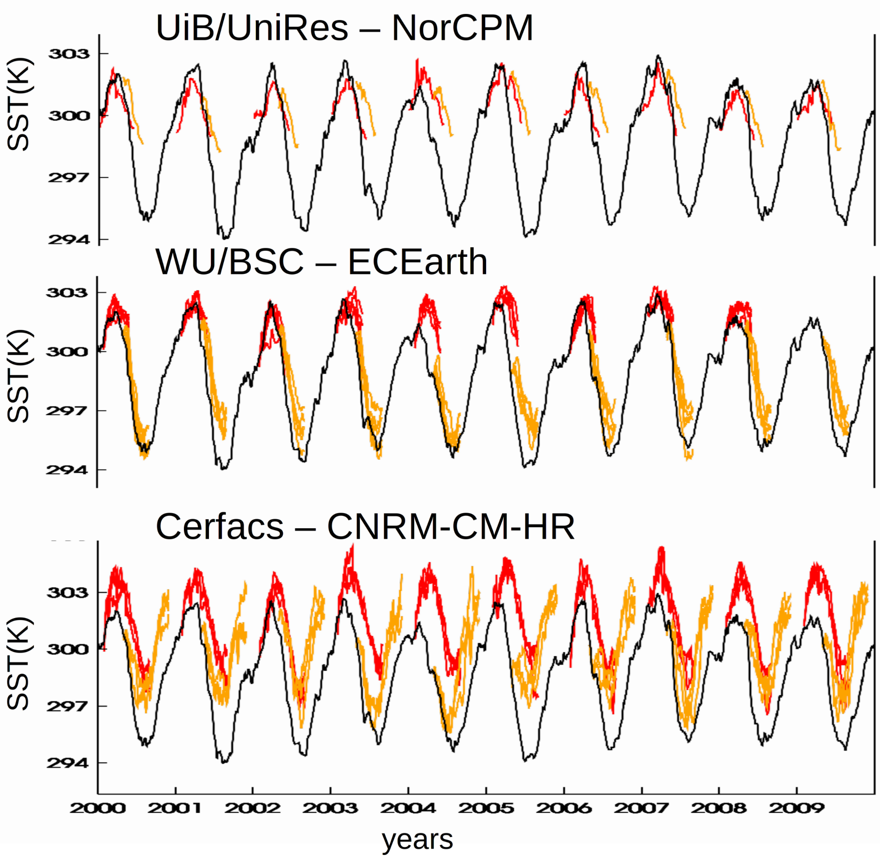

→ Similar drift in all 4 regions? in all models?

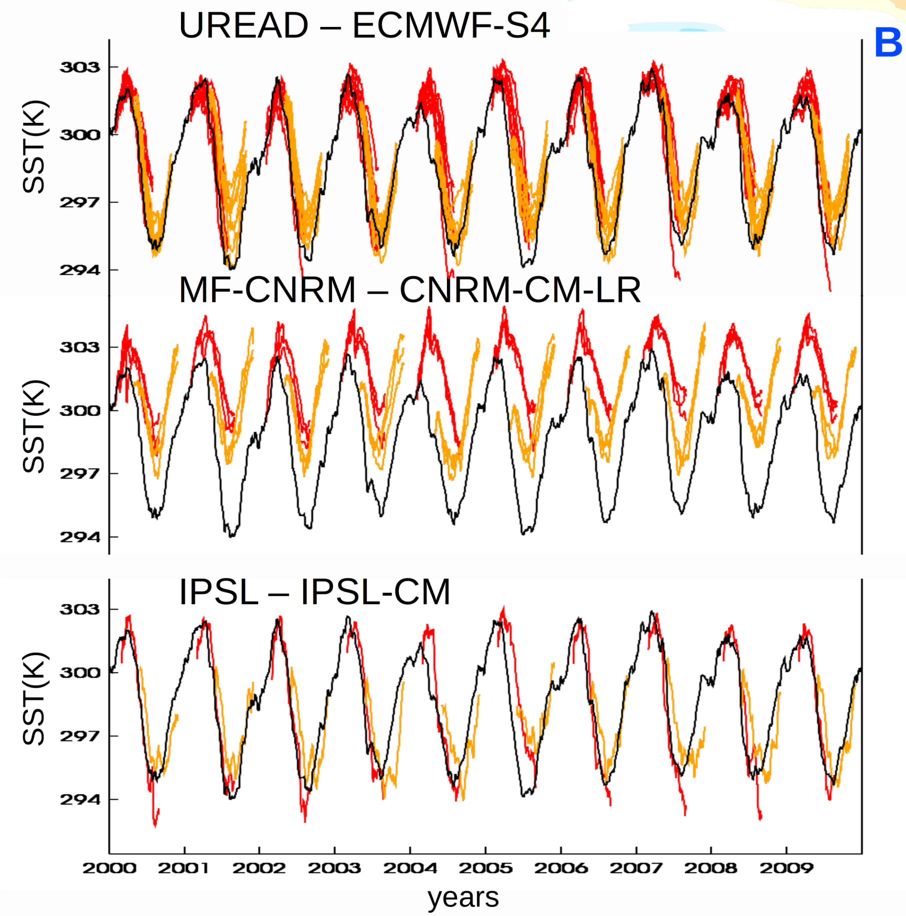
# Control experiment

## Spread across years versus ensemble members

*Example of SST (K) over the ANG box*



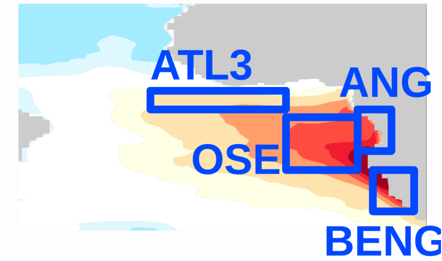

- Drift more different between years than between members

- The drift is very robust over this region (and over the other regions studied here)

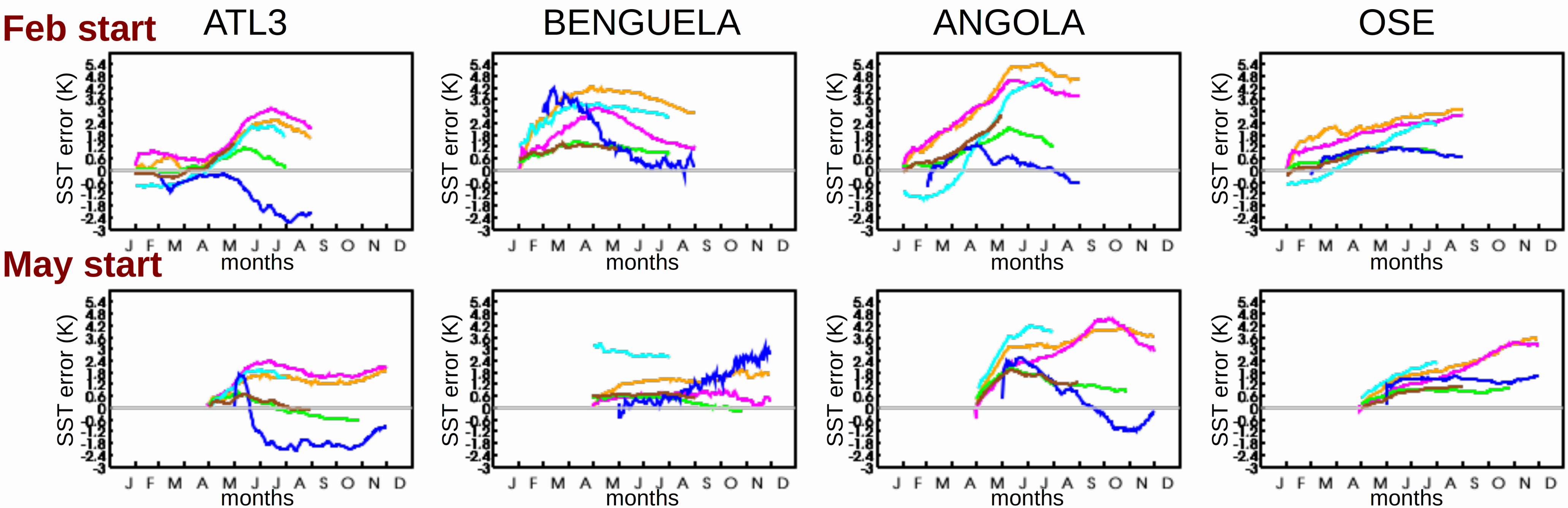
→ Focus on the **mean drift by averaging over years and members**

# Control experiment

## SST drift

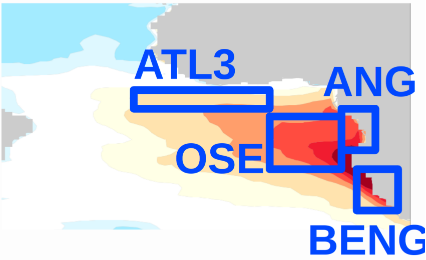



*SST error (K) to ORA-S4*

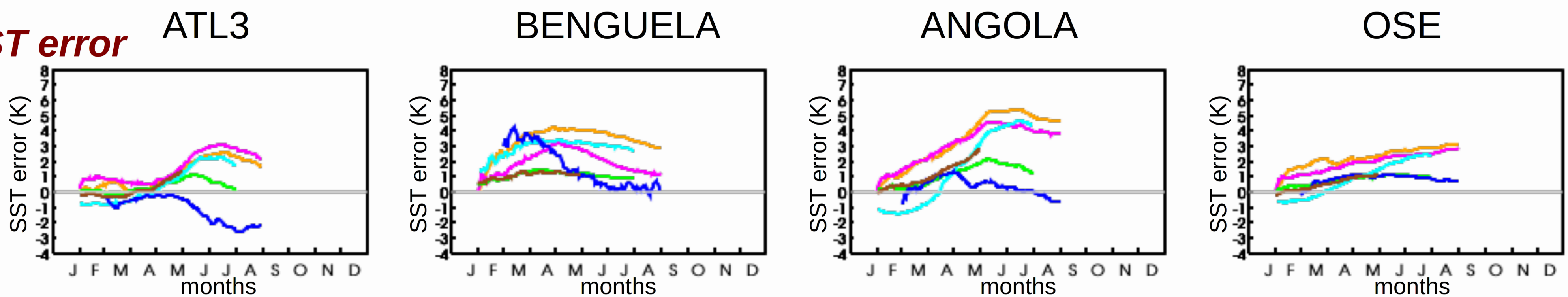



- larger drift for February starts over coastal regions
- over OSE the drift seems to depend less on the start date and on the model → very robust bias
- over ATL3 small drift the first months for February starts in all models
- IPSL has a cold drift over ATL3
- WU/BSC and UREAD model drift less particularly over BENGUELA
- MF-CNRM and Cerfacs (same model, different resolution) often similar drift, except over BENGUELA where it is stronger at low resolution

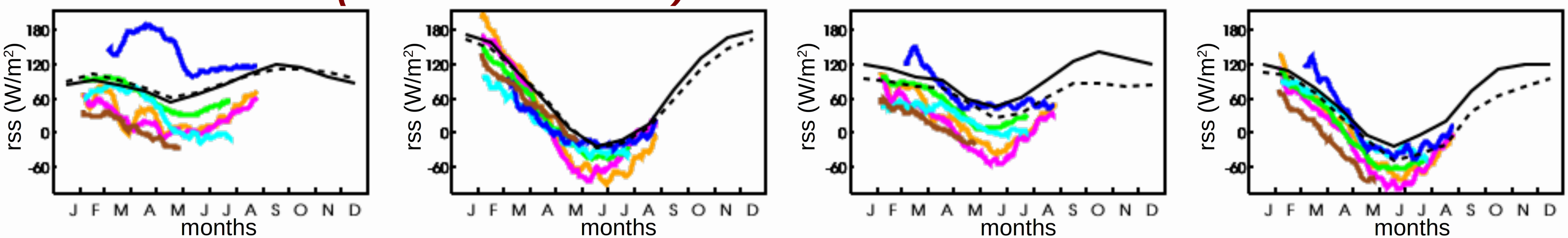
# Control experiment
## Heat fluxes

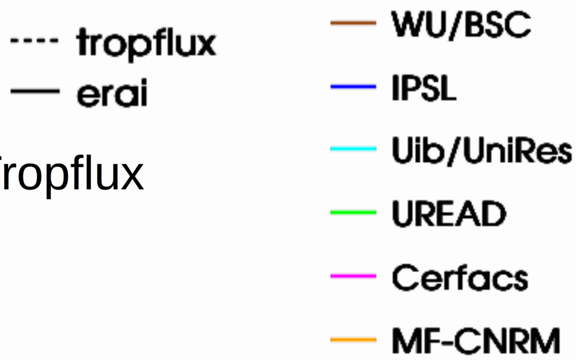



***SST error***




***Net surface heat flux (H + LE + SW + LW)***

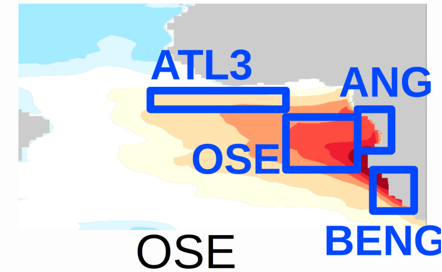


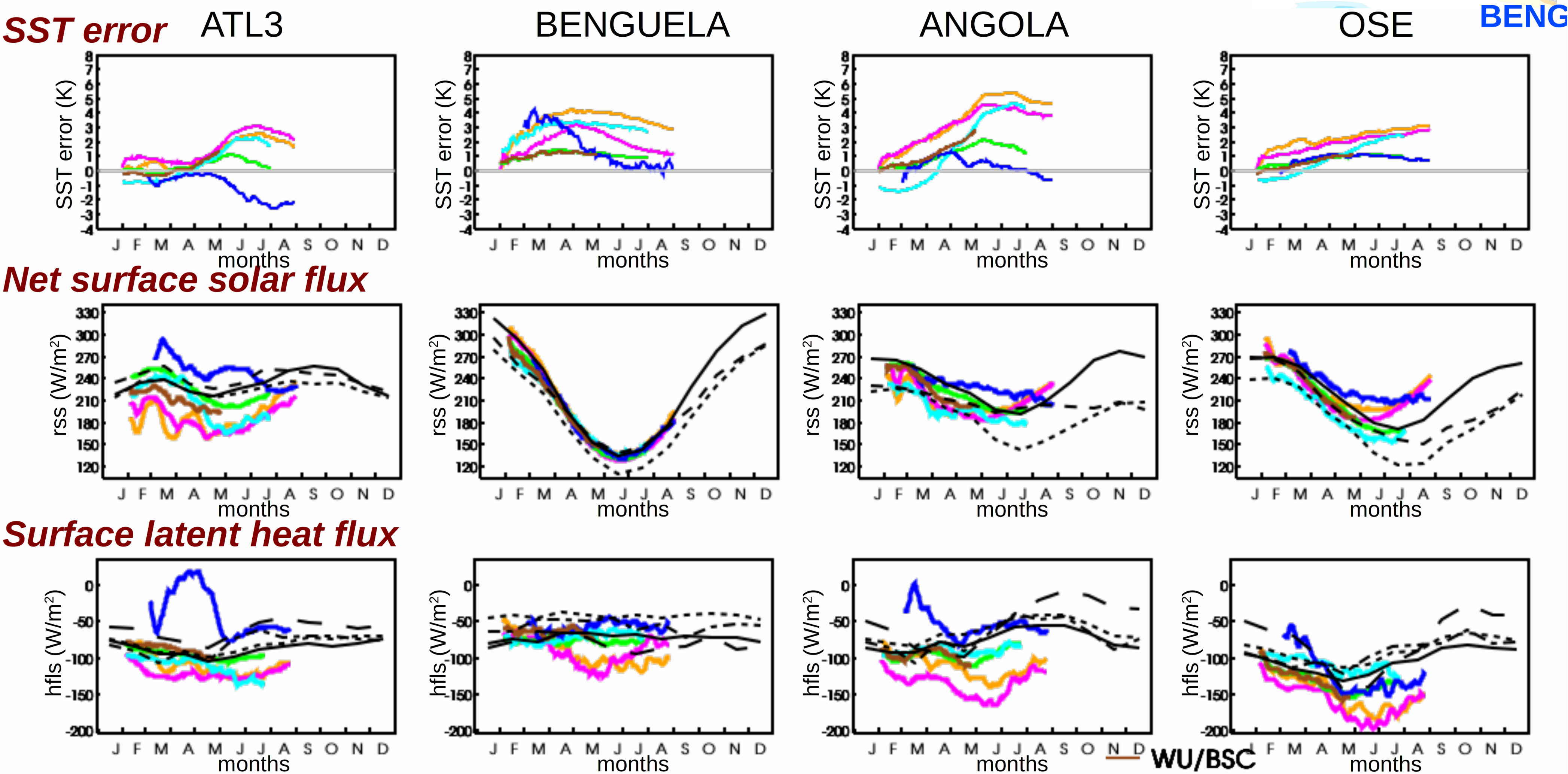




- Surface net heat flux are generally weaker than estimates from Tropflux and Era-Interim
- needs to be confirmed by comparison with other products

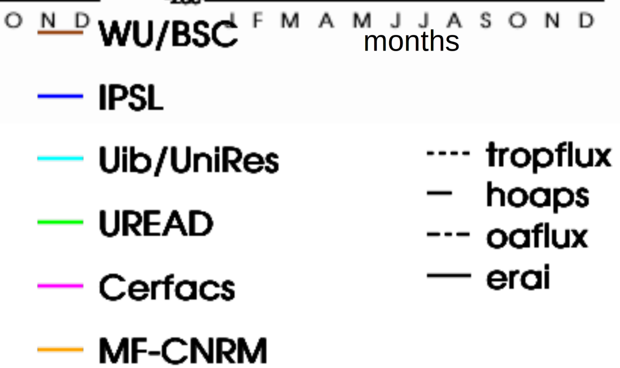
# Control experiment

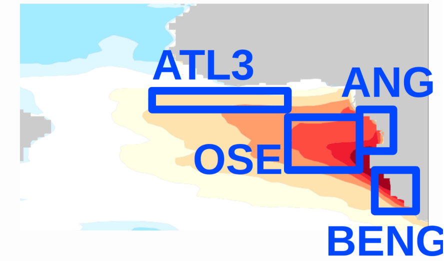
## Heat fluxes




- Surface net solar flux underestimated over ATL3, in excess over OSE in summer
- Latent heat flux generally stronger than observed thus cannot explain a warm bias





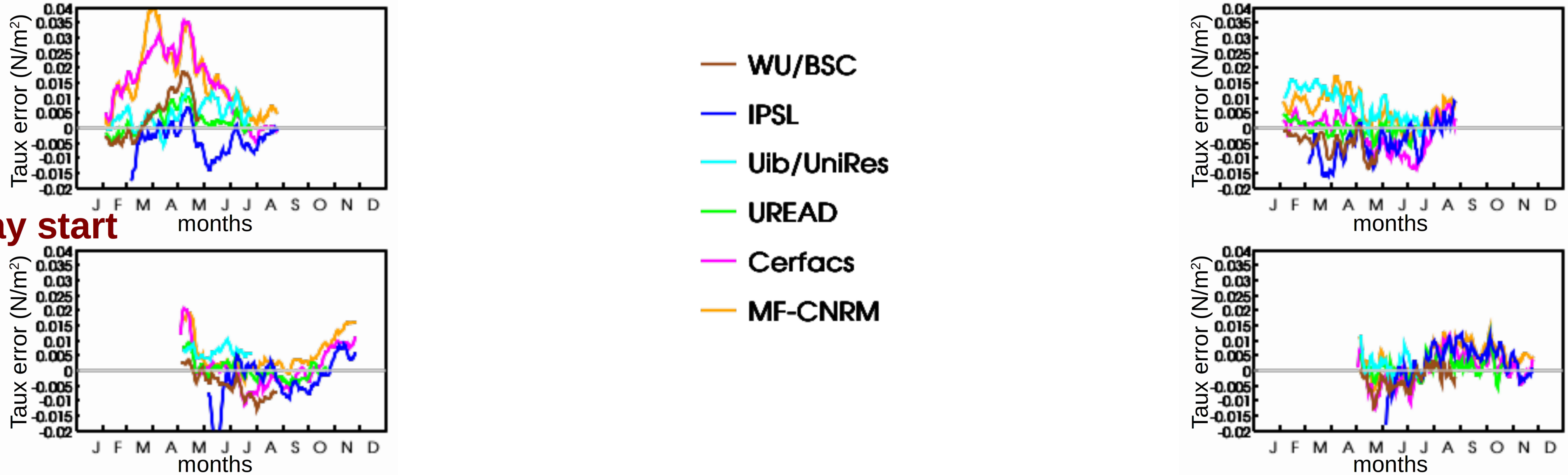

# Control experiment

## Zonal wind stress error development

*Zonal wind stress error ($N/m^2$) to ERA-Interim*

**Feb start** ATL3 OSE

**May start**




- Cerfacs,MF-CNRM and Uib/UniRes have a large westerly bias in spring

- The zonal wind bias appears to be an issue mainly for february starts.

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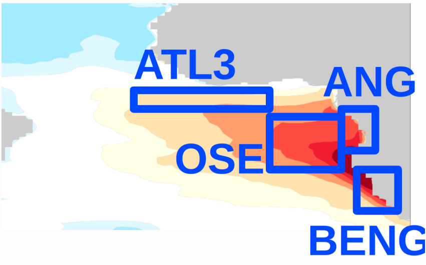
# Control experiment

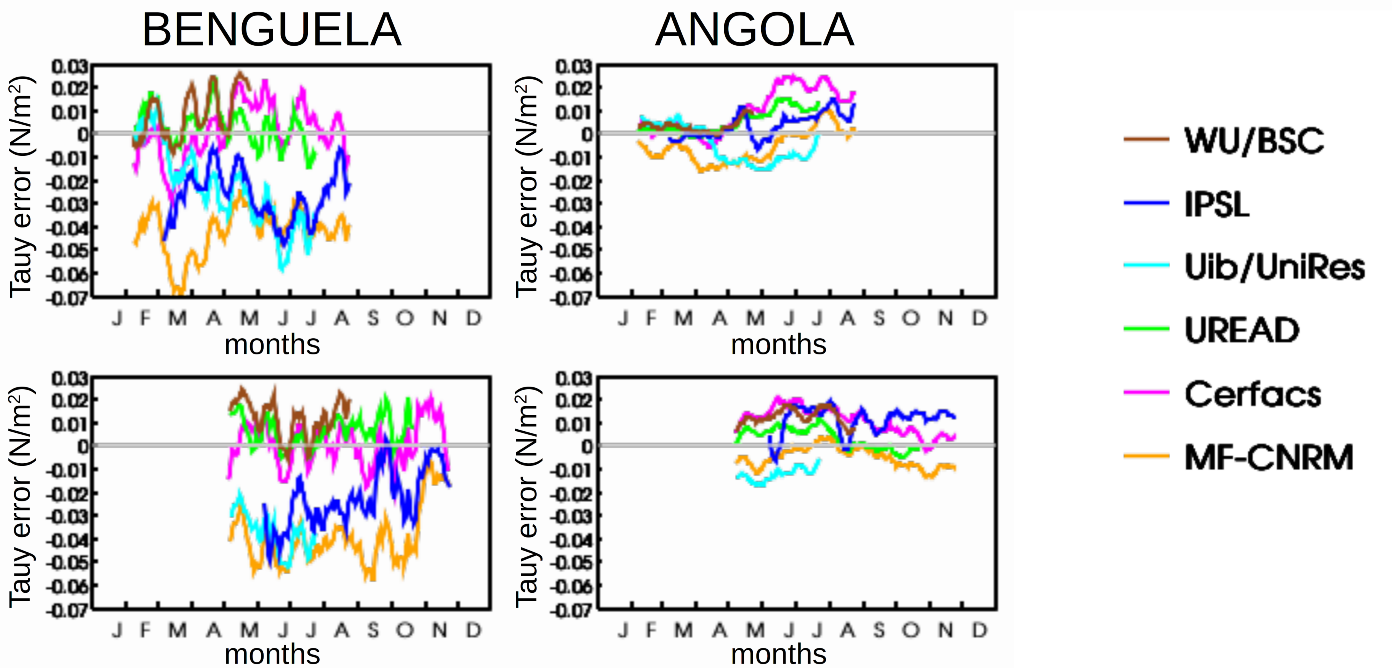
## Meridional wind stress error development




*Meriodional wind stress error (N/m$^2$) to ERA-Interim*

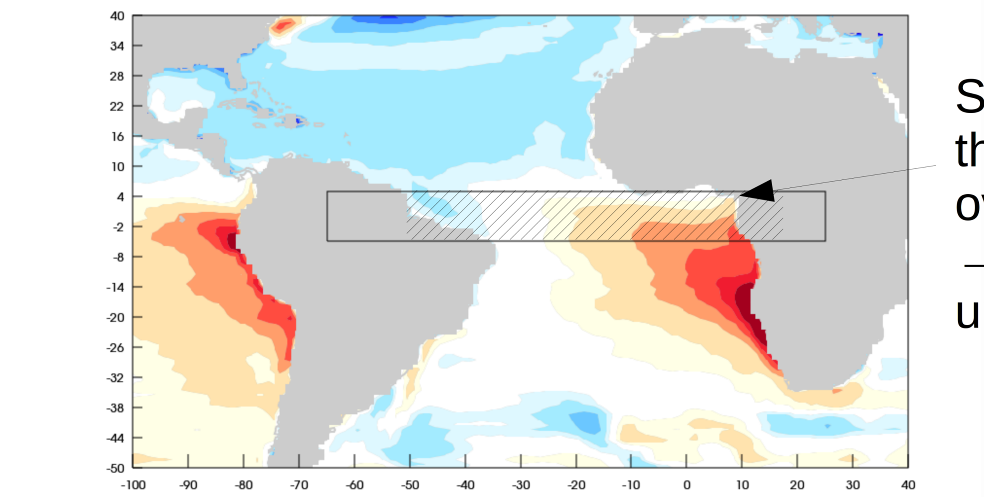
**Feb start**

**May start**

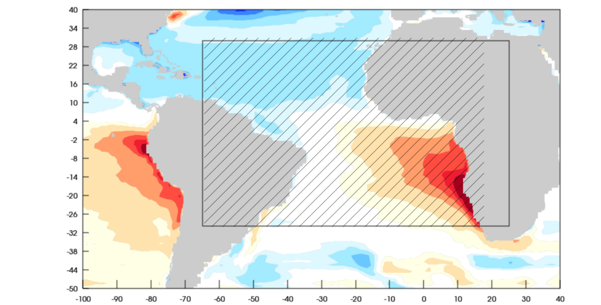


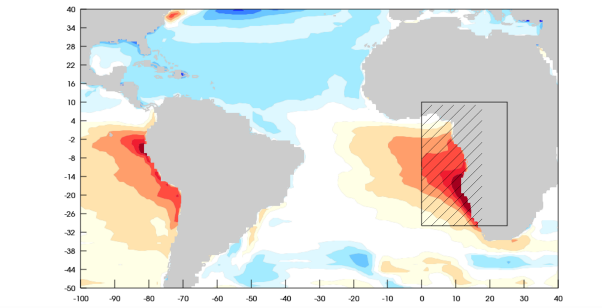

- Larger meridional wind stress errors over BENGUELA than over ANGOLA
- Sign of the error is model dependent over both coastal regions.

# Sensitivity experiments design




Simulated atmosperic wind stress is replaced by the Era-Interim wind stress in the ocean model over the hatched region
→ in the hatched box, momentum fluxes are uncoupled, heat fluxes are coupled

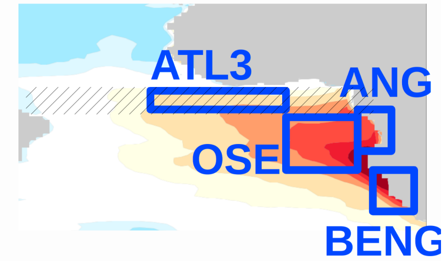




| Name | Domain of wind stress replacement |
|---|---|
| TAUEQ | 5S-5N |
| TAU30 | 30S-30N |
| TAUBE | 30S-10S East of 0°E |

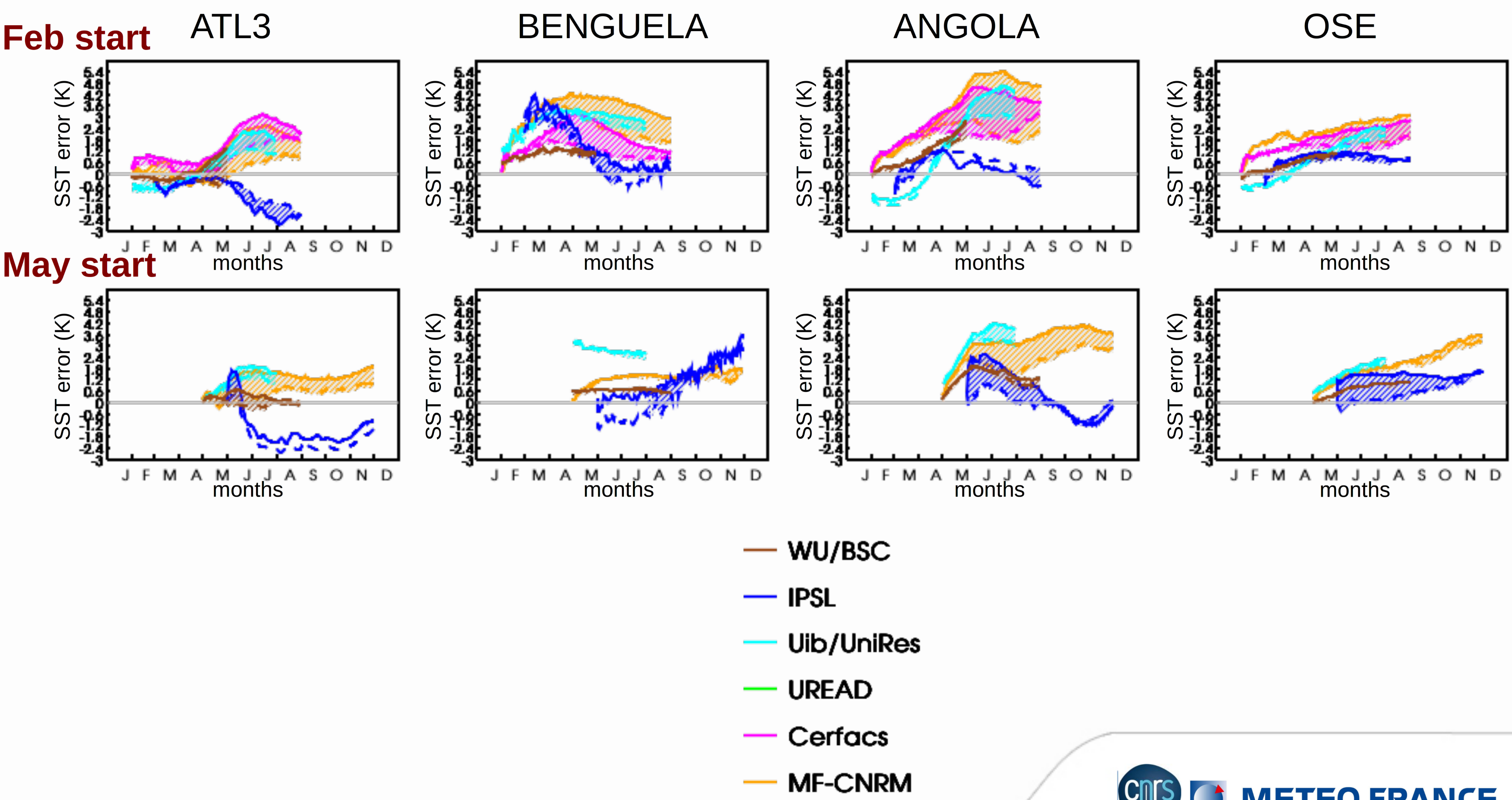
# TAUEQ sensitivity experiment

## Impact on the SST drift



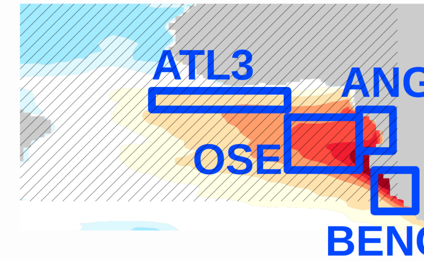

*SST error (K) to the respective initialisation product*

Control    TAUEQ    Error reduced in TAUEQ



# TAU30 sensitivity experiment

## Impact on the SST drift



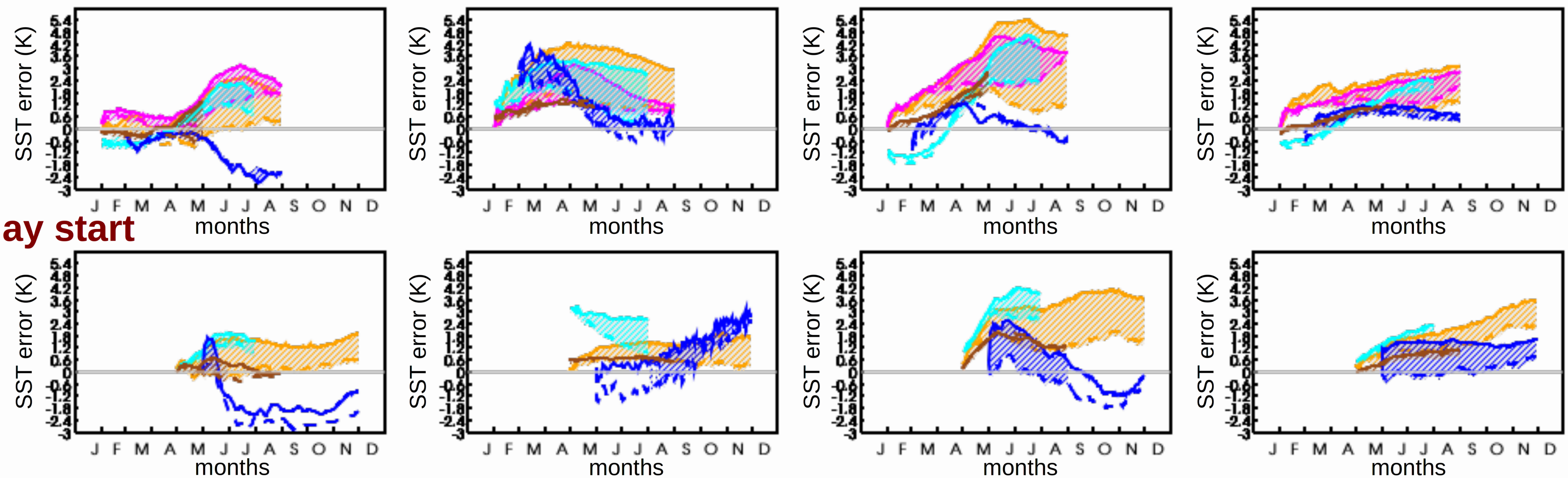

*SST error (K) to the respective initialisation product*

Control TAU30 Error reduced in TAU30

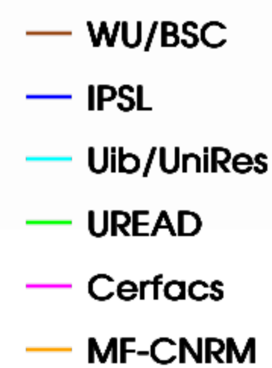
**Feb start**

ATL3 BENGUELA ANGOLA OSE

**May start**

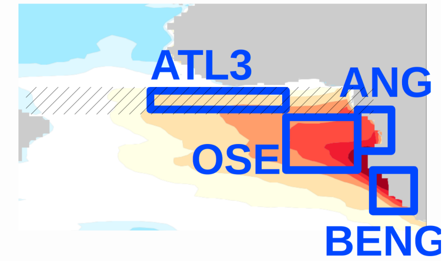



- Impact of wind correction over all regions and for all models
- Summer bias reduced over ATL3 for 4 models for February starts
- Bias reduced from the start over BENGUELA for 4 models
- Large bias reduction over ANGOLA for several models in summer



# TAUEQ sensitivity experiment

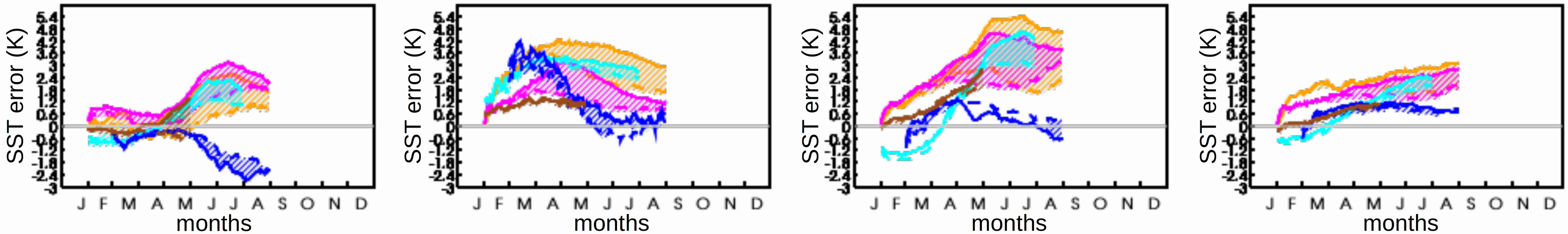
## Impact on the SST drift



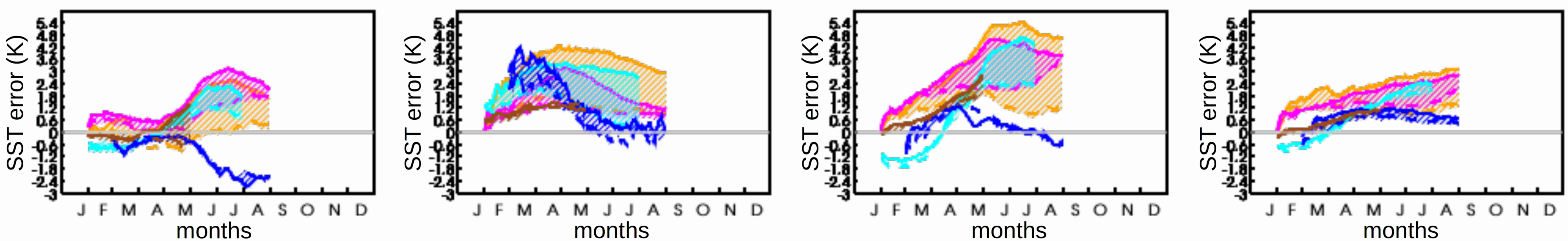

*SST error (K) to the respective initialisation product*

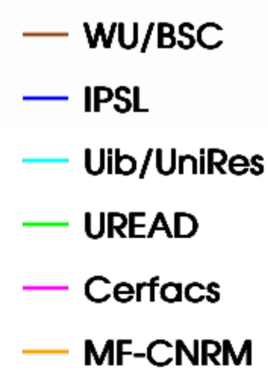
Control TAUEQ Error reduced in TAUEQ

**Feb start** ATL3 BENGUELA ANGOLA OSE




**TAU30**



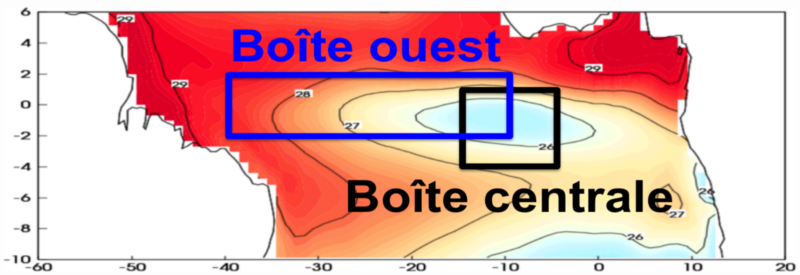




- Wind correction over the Equator impacts SSTs over all 4 domains
- SST error reduction of the same magnitude over OSE even if the wind correction is only applied over the Equator.

# Interannual variability
## Role of the wind

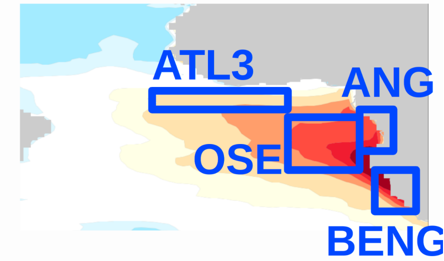
Planton et al. (*under revision*) proposed a robust classification of cold/warm equatorial cold tongue events based on Richter et al. (2013)
→ Does the role of wind hold in the sensitivity experiments?

| Cold events | Warm events |
|---|---|
| 1983 | 1988 |
| 1992 | 1991 |
| 1997 | 1995 |
| 2004 | 1996 |
| 2005 | 1999 |



# Cold events 2004-2005

## Impact of the wind forcing

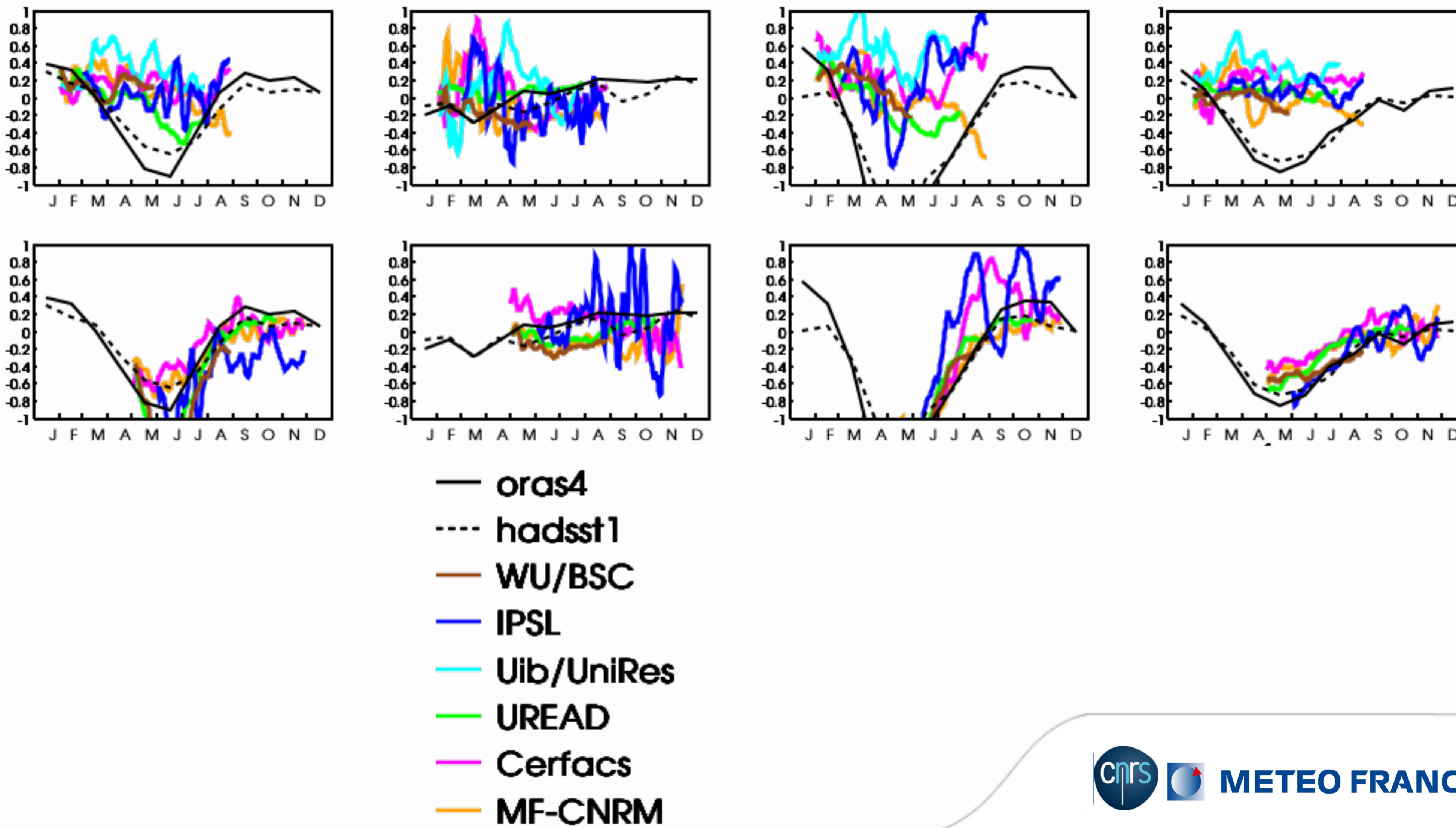



*[2004-2005] SST – [2000-2009] SST*

*i.e. cold years SST – mean SST*

ATL3 BENGUELA ANGOLA OSE

**CTRL**

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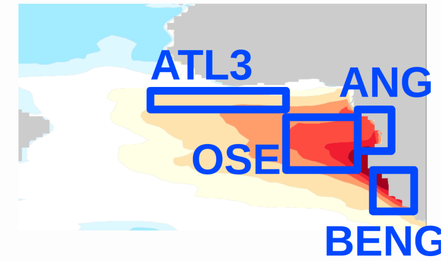
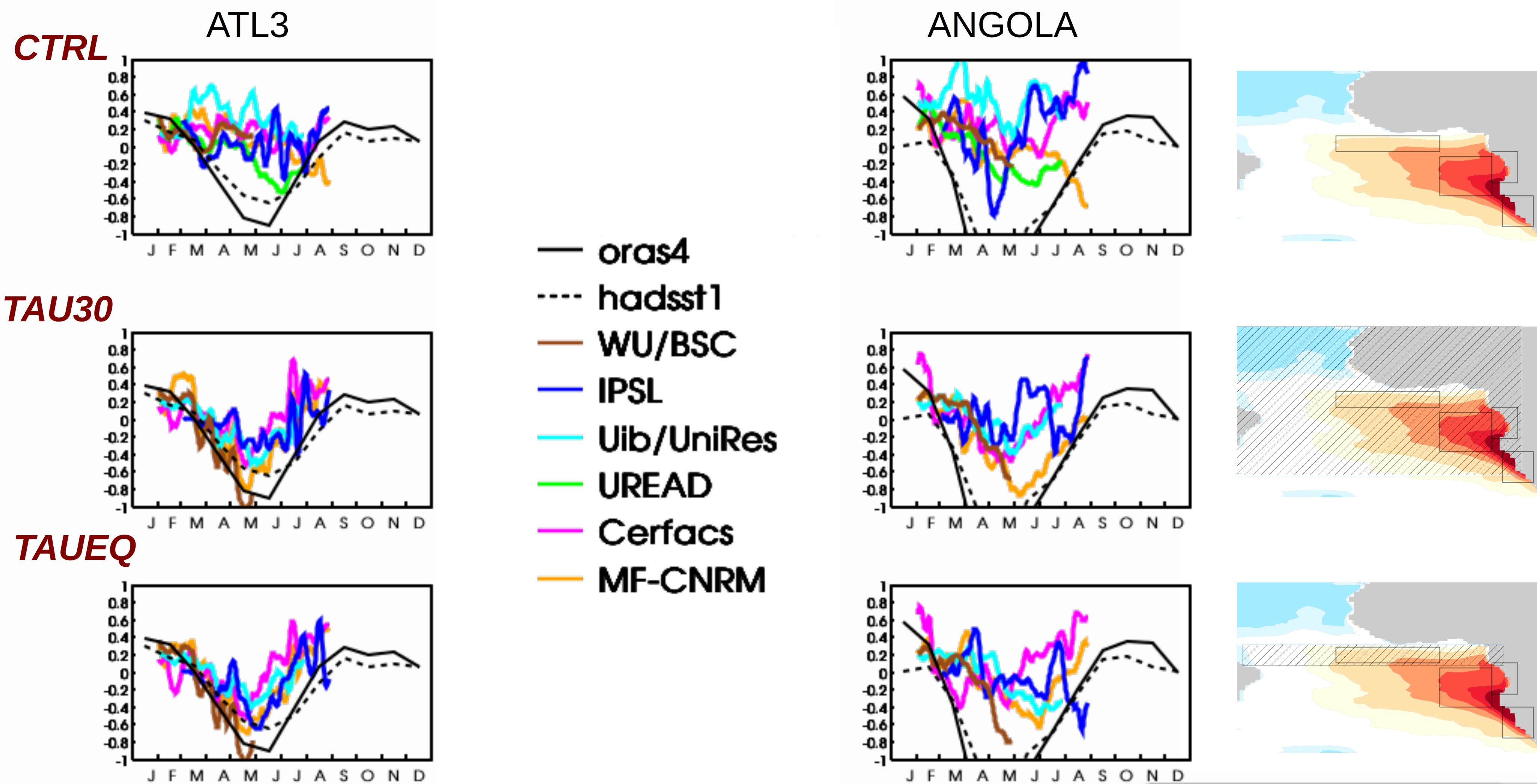
# Cold events 2004-2005

## Impact of the wind forcing




*[2004-2005] SST – [2000-2009] SST*
*i.e. cold years SST – mean SST*

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# Conclusion

- Work in progress, not all data available (mixed layer depth, equilibrium state)
- Warm bias develops slowly over OSE for all models
- Warm bias develops in spring over ATL3 for 5 models
- Drift model dependent over coastal regions
- Surface non solar heat fluxes compensate for the SST bias
- Equatorial wind stress replacement reduce the SST bias locally and in remote regions
- Wind is confirmed as a driver of the interannual variability

Thank you for your attention!

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