CERFACS

Some critical technical choices for pacemaker experiments

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Goal of the talk and experimental setup

Overall objectives: provide some analyses to help choose objectively the restoring parameters in Atlantic and Pacific pacemaker experiments

Pacemaker experiments :

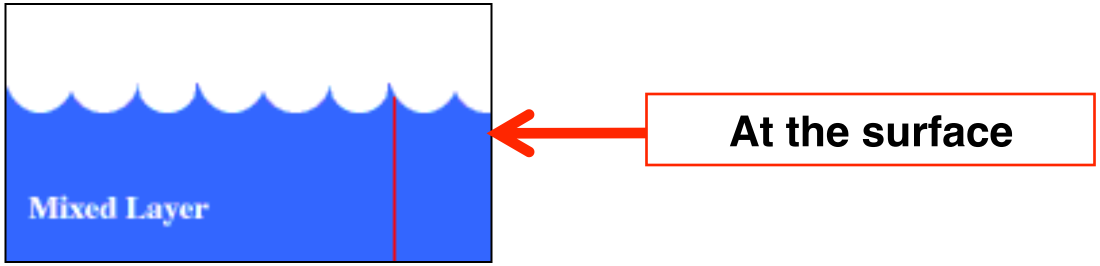
- ✧ **Goal: to constrain the interannual-to-decadal modes of variability of a coupled model to follow the observed fluctuations.**
- ✧ **Investigate :**
  - **(i) the local atmosphere response to the constrained temporal evolution of the SST modes**
  - **(ii) the remote ocean-atmosphere response in the others oceanic basins that are not constrained**

Experimental protocol :

- ✧ **Easy in principle: Add a restoring term over a selected regional domain and set a buffer zone between restored and fully-coupled oceans**
- ✧ **Need some cautious though because :**
  - **(i) the restoring term may create energy imbalance leading to spin-up of the coupled model**
  - **(ii) the restoring term may perturb local ocean dynamics that may remotely perturbed the entire system**

Need to find a set of parameters that perturbs the least the equilibrium and the intrinsic physics of the coupled climate model, while controlling enough the temporal low-frequency changes

The surface restoring



Heat flux:

[illegible]

Nonsolar Heat flux at the surface

Feedback term. SST_{obs}= observations

$\frac{dQ}{dT}$ Feedback coefficient acting as a restoring term

Units: $W/m^2/K$

Fresh water flux:

[illegible]

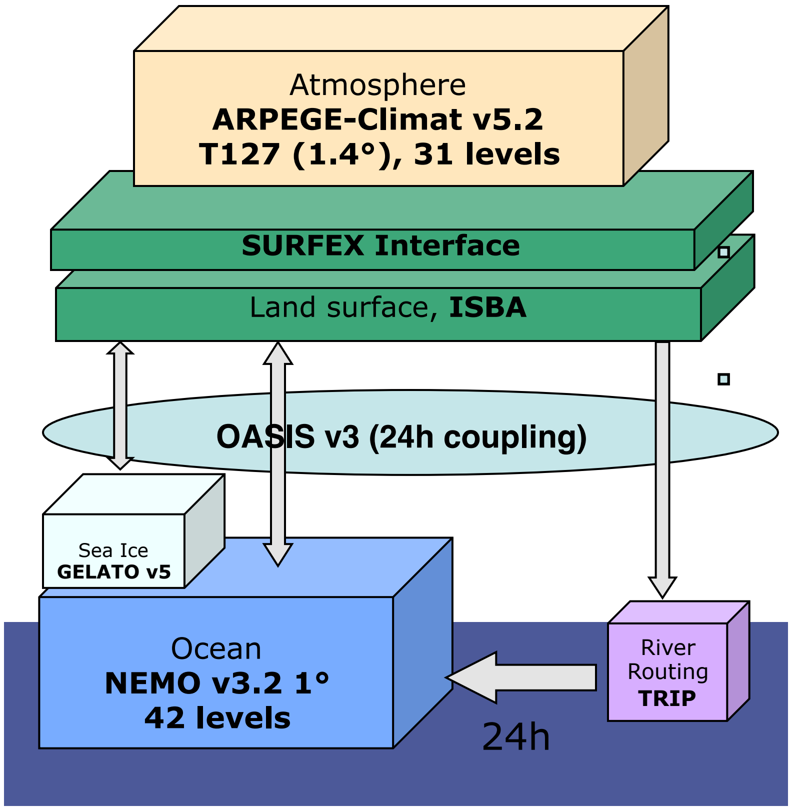
Fresh water budget at the surface

Feedback term. SSS_{obs}= observations

γ_s Coefficient acting as a restoring term

Units: mm/day

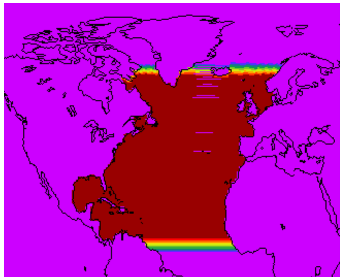
The simulations [1986-2005]



The coupled model = CNRM-CM5 used for CMIP5

Pacemaker branched on Jan 1st, 1986 HISTORICAL run

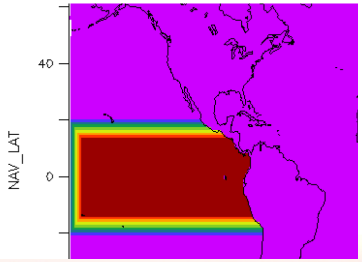
North ATLANTIC pacemaker



0-60°N domain
10 degree buffer zone
no restoring under seaice

3 members with 960 W/m2/K (~2 day restoring)
1 member with 240 W/m2/K (~10 day restoring)
1 member with 120 W/m2/K (~20 day restoring)
3 members with 40 W/m2/K (~2 month restoring)

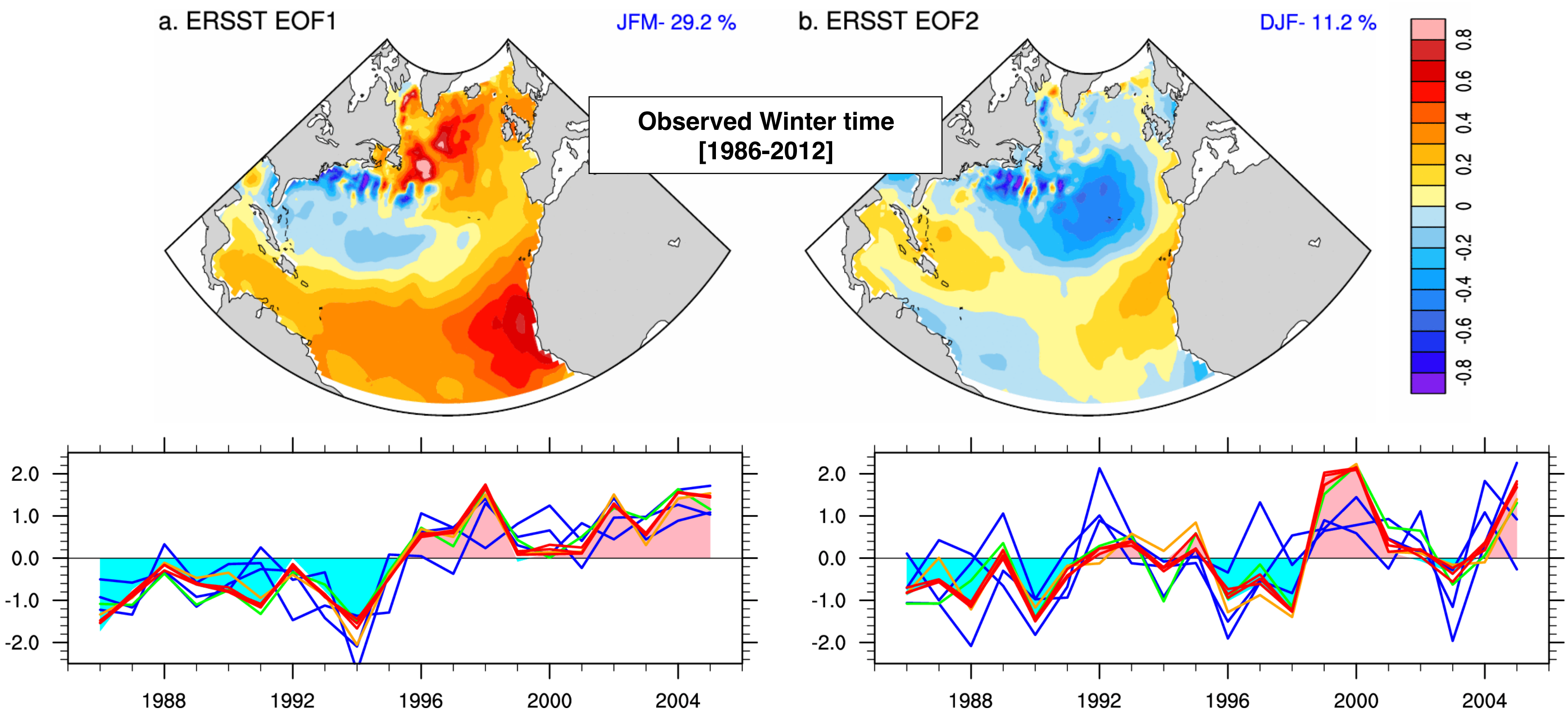
East PACIFIC pacemaker



domain and buffer zone similar to Kosaka and Xie (2013)

1 member for each restoring parameter

The Atlantic experiments (ATL-NUD) : wintertime SST

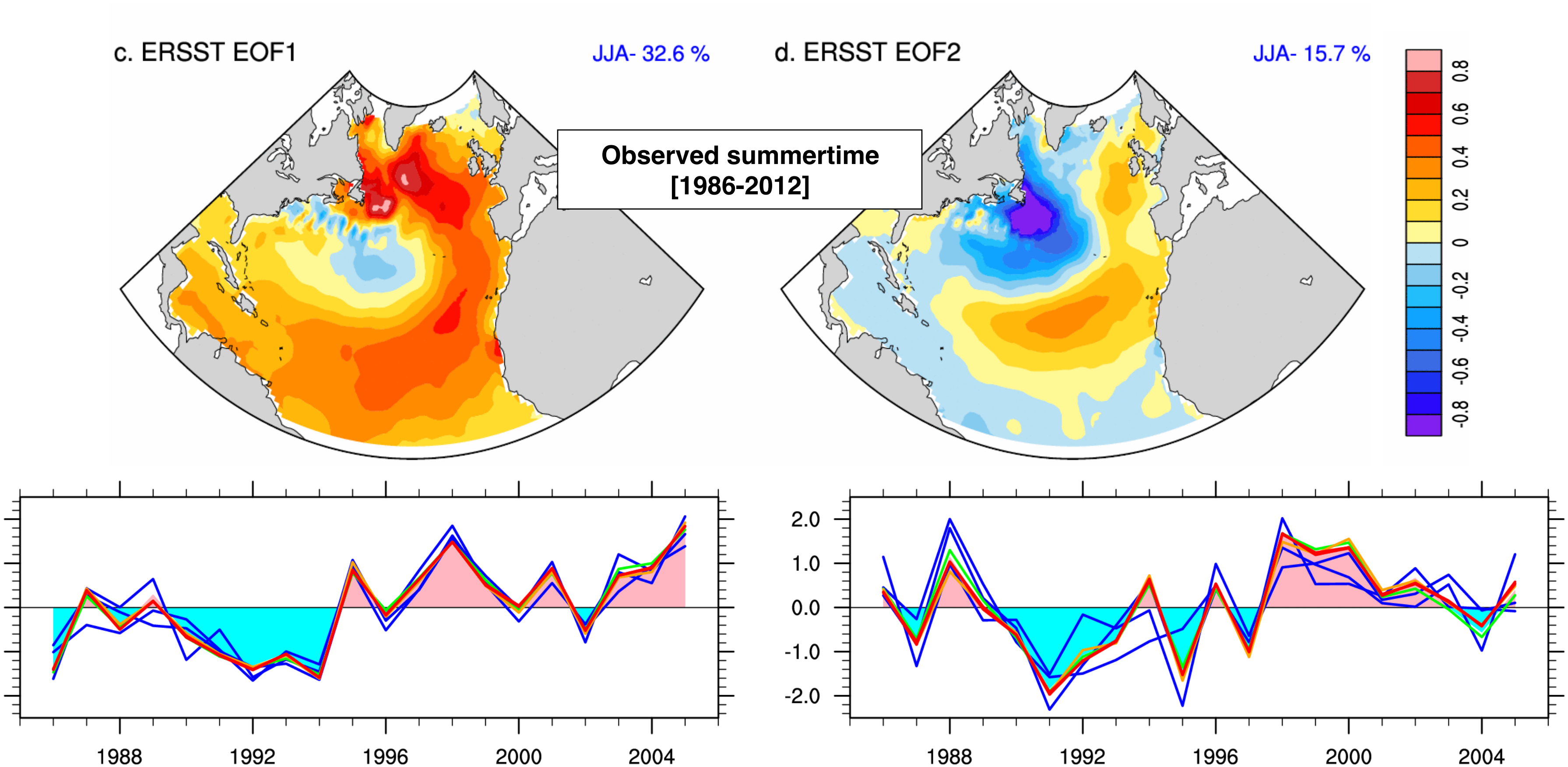


- ✧ **Capture the decadal shift whatever the restoring timescales**
- ✧ **Less constraint for the 40W/m²/K ensemble at interannual timescales**

Corr (Q40)= 0.83/0.73/0.83 --> EM= 0.87
Corr (Q120)= 0.95
Corr (Q240)= 0.97
Corr (Q960)= 0.99/0.99/0.99/ --> EM=0.99

Corr (Q40)= 0.55/0.50/0.65 -->EM=0.72
Corr (Q120)=0.92
Corr (Q240)=0.97
Corr (Q960)=0.98/0.98/0.98 --> EM=0.99

The Atlantic experiments (ATL-NUD) : summertime SST



✧ **Stronger constrain in summer versus winter (shallower seasonal mixed layer)**

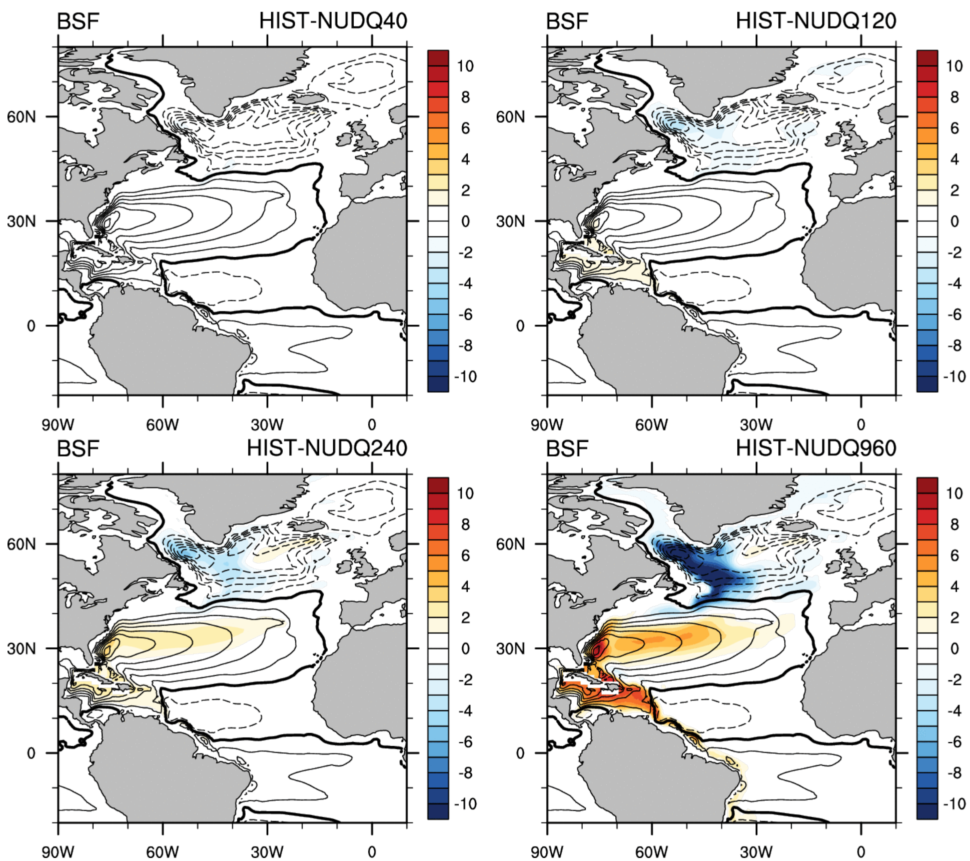
Corr (Q40)= 0.95/0.94/0.95 --> EM=0.98
Corr (Q120)=0.99
Corr (Q240)=0.99
Corr (Q960)= 0.99/0.99/0.99 --> EM= 0.99

Corr (Q40)= 0.93/0.81/0.85 --> EM=0.95
Corr (Q120)=0.99
Corr (Q240)=0.99
Corr (Q960)= 0.99/0.99/0.99 --> EM=0.99

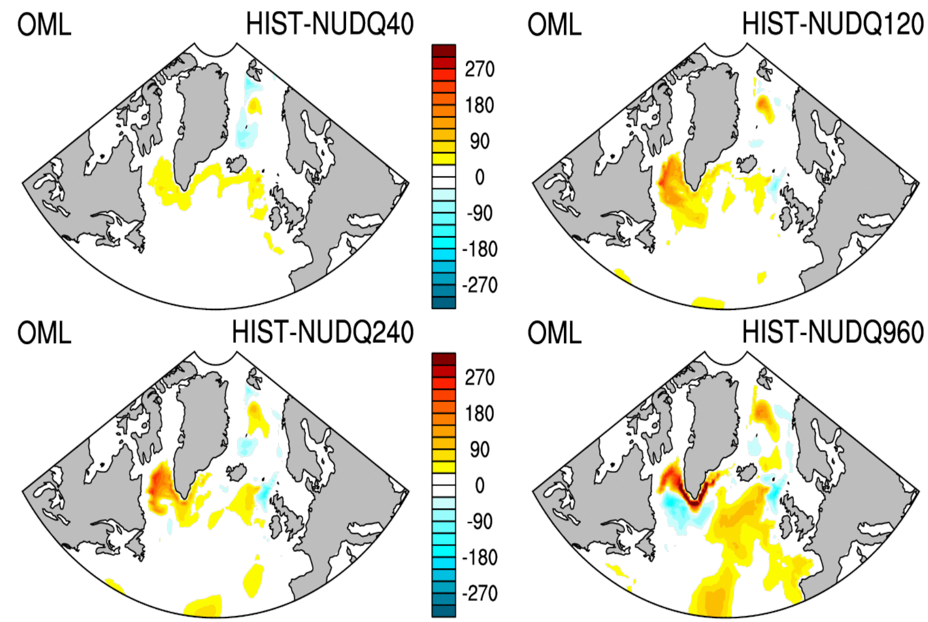
ATL-NUD : horizontal oceanic circulation + MLD

Barotropic Streamfunction

Difference between ATL-NUD and HIST over [1986-2005] (color)

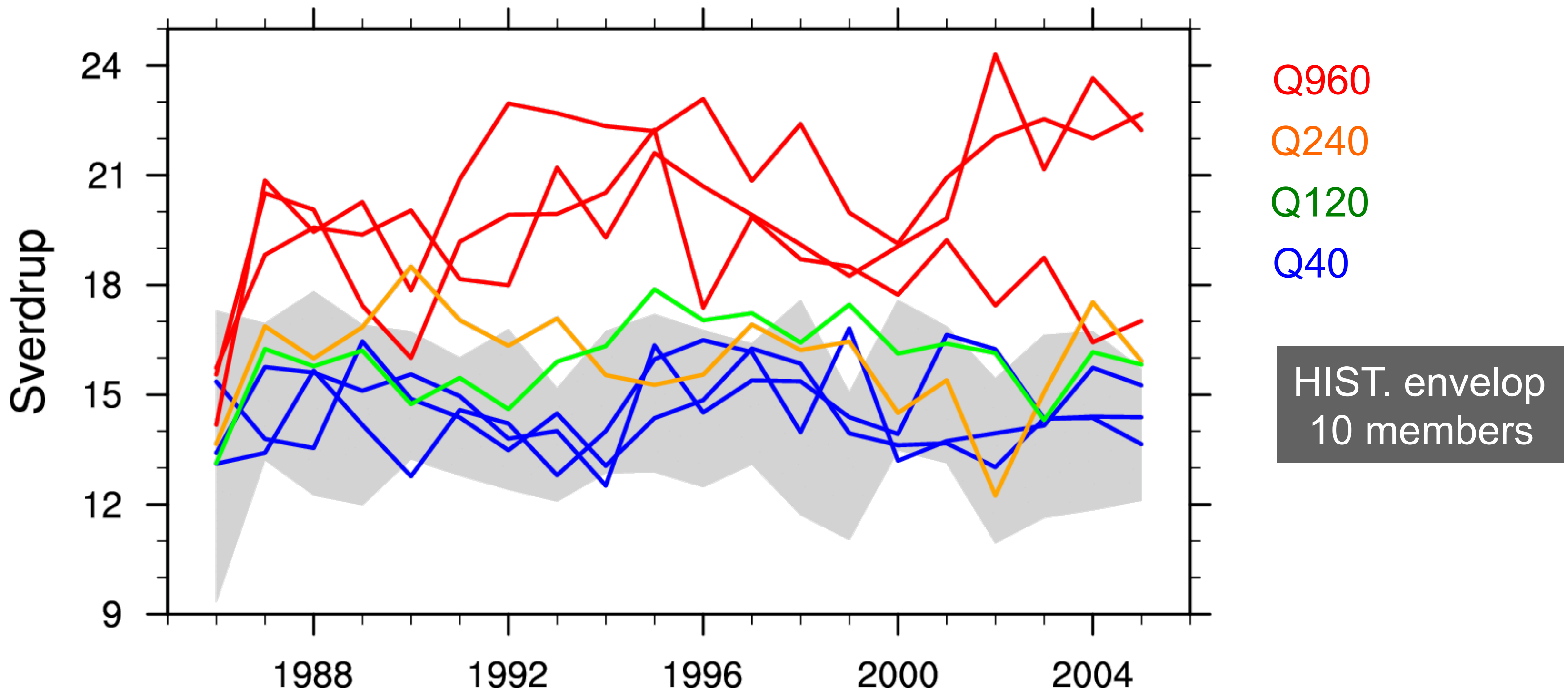


Mixed-layer depth in March



✧ **Spurious effect for Q960 and Q240 restoring values : acceleration of the circulation and plunging of MLD in Labrador Sea, except for Q960 (non physical behavior)**

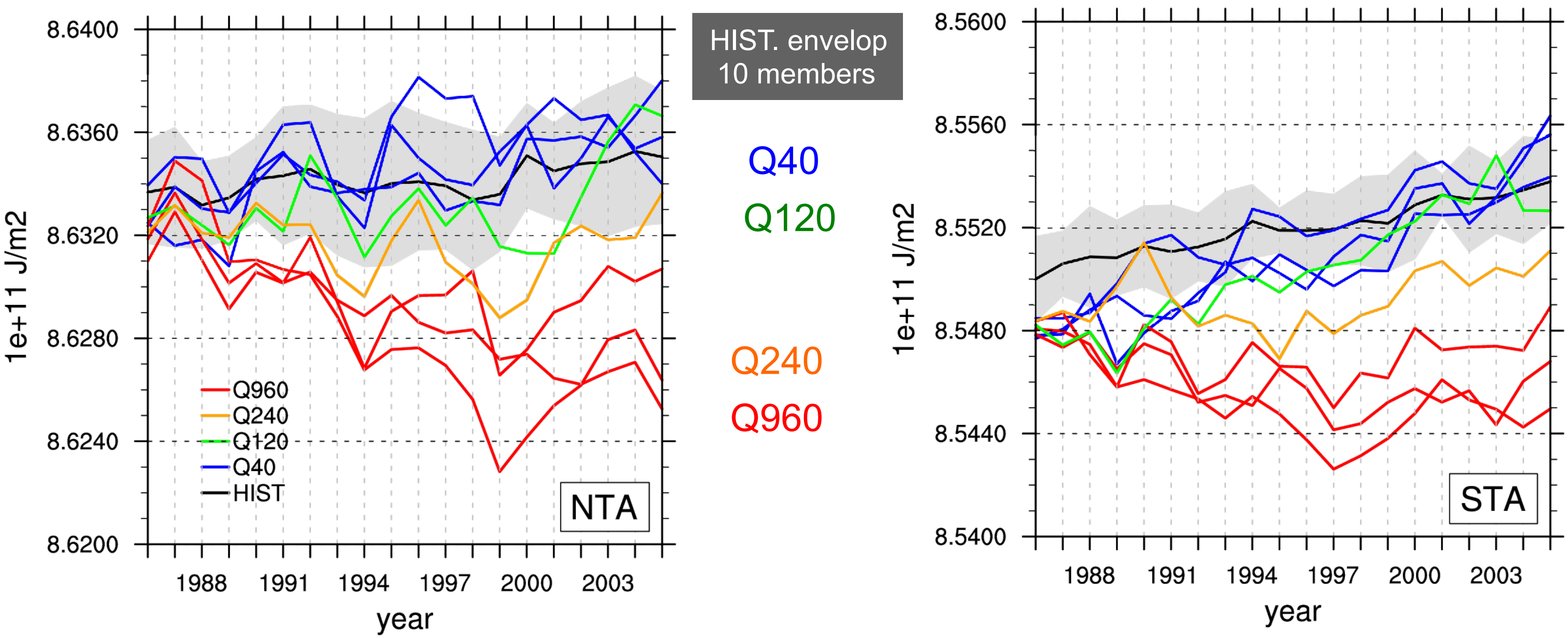
ATL-NUD : AMOC@30N



✧ **Incompatibility between Q960 AMOC and model equilibrium estimated by historical ensemble simulations, Q40 perfectly within the historical range.**

✧ **Who cares, because the model atmosphere only sees the SST?**

ATL-NUD : Heat content

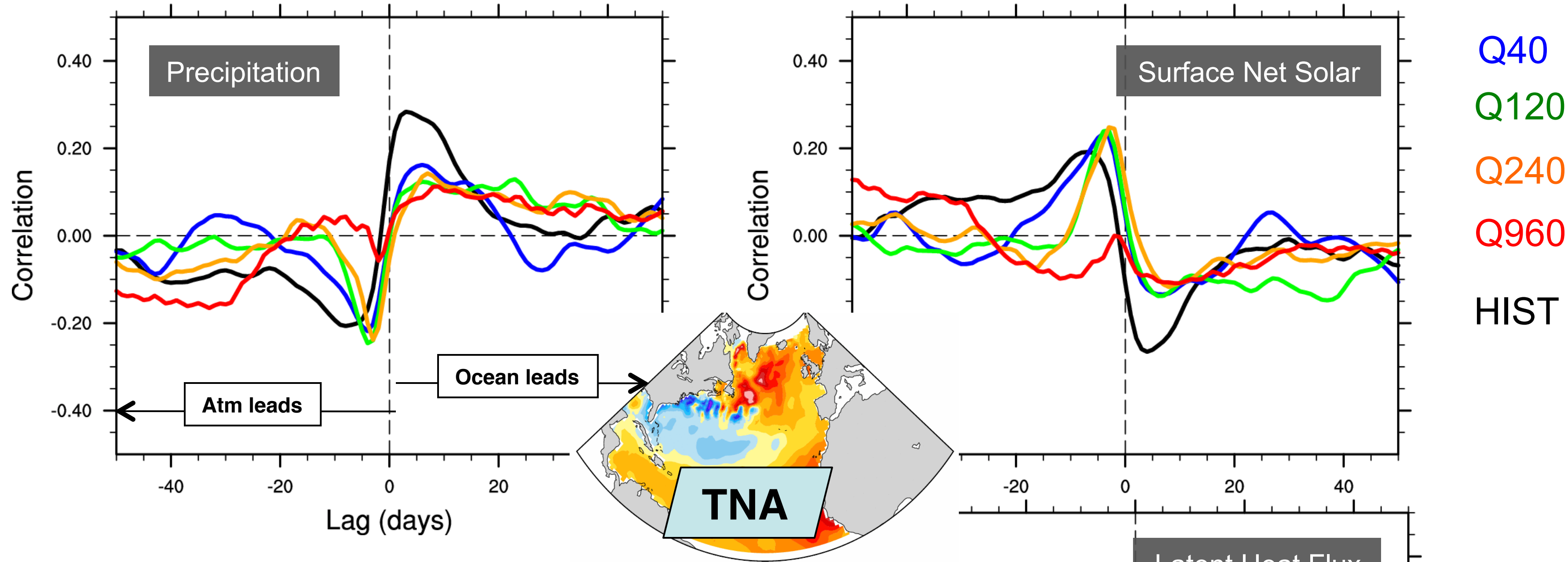


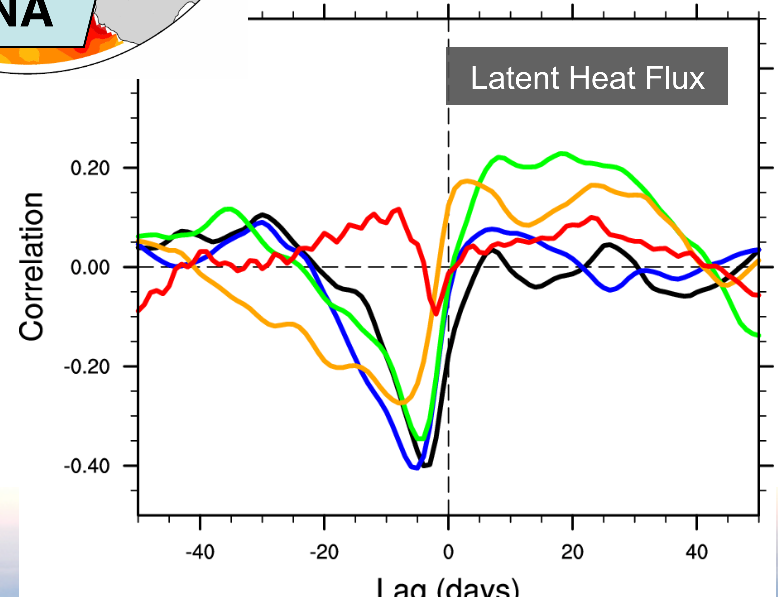
✧ **Adjustment of the Tropical Atlantic Heat Content (reduction of heat storage)**

✧ **Perturbation of the Southern Atlantic basin in Q960 & Q240**

✧ **Could it perturb the entire system through ACC if runs are longer? Can we confidently interpret the remote influence of AMO in the South Atlantic when the response is very much dependant on the choice of parameter of the restoring?**

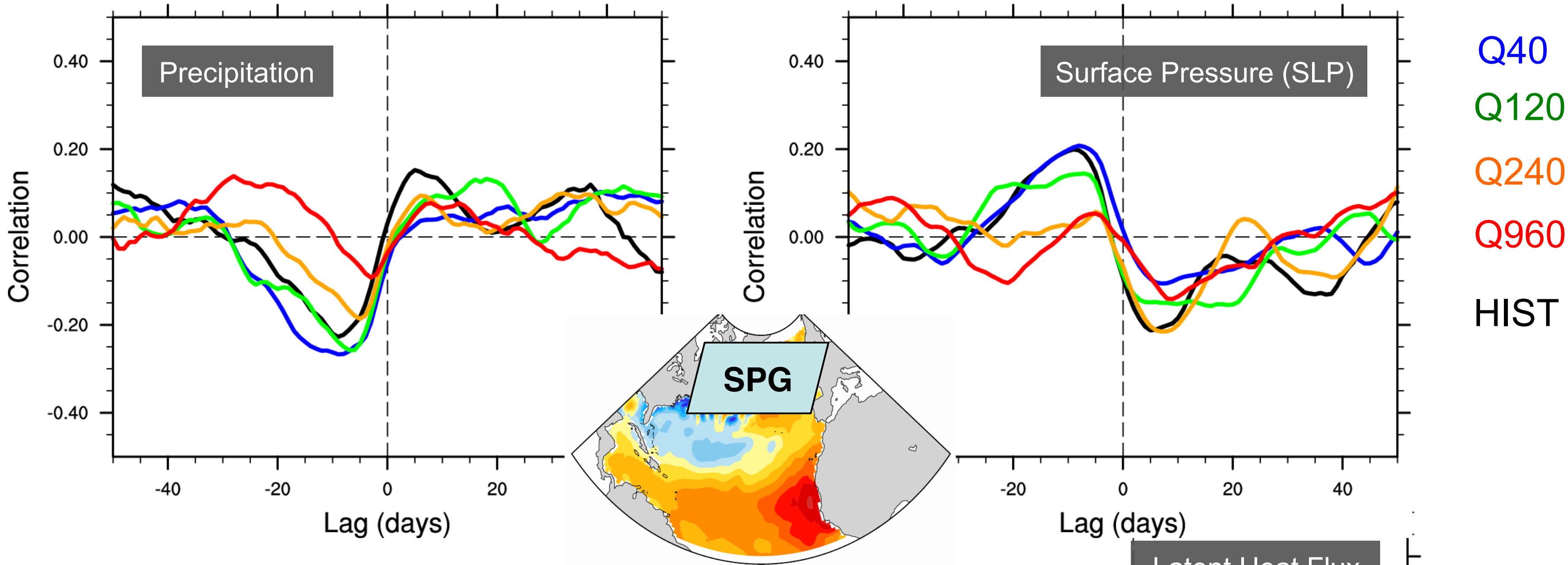
High frequency SST/atmosphere (tropical Atlantic-Summer)

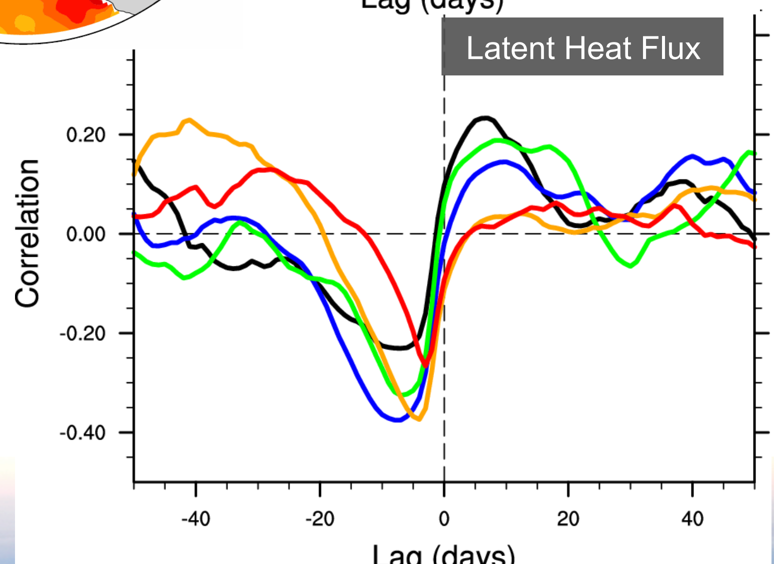




✧ **Perturbation of the Summertime high frequency relationship between SST and surface fields in the tropical North Atlantic**

High frequency SST/atmosphere (Subpolar Gyre-Winter)

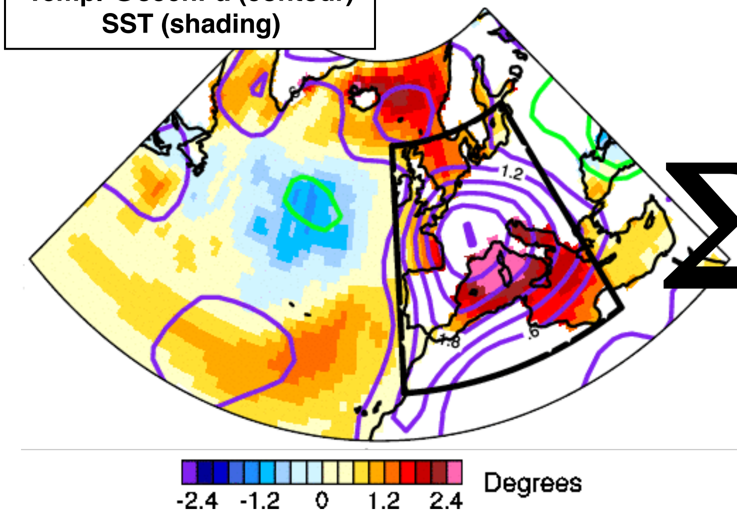




✧ **Perturbation of the Wintertime high frequency relationship between SST and surface fields over the subtropical gyre**

Case studies: the 2003 heat wave (1)

JJA 2003
Temp. @850hPa (contour)
SST (shading)



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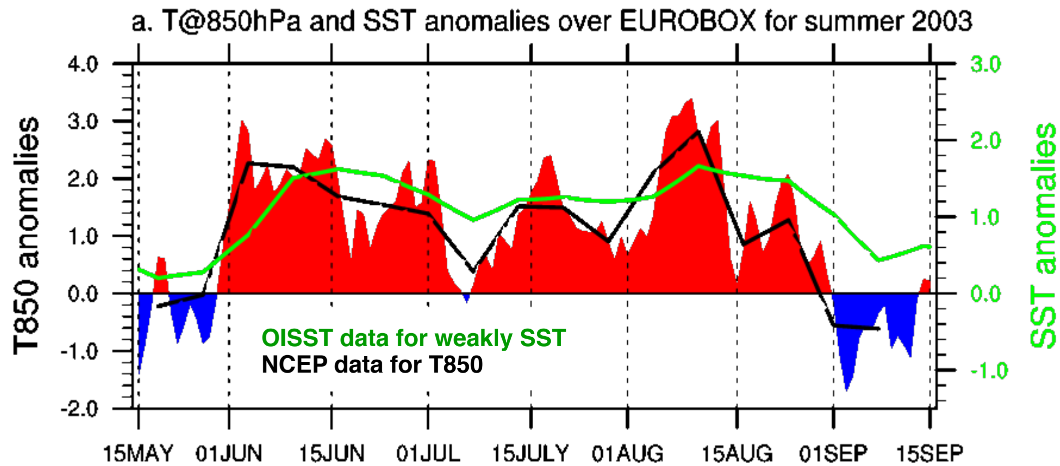
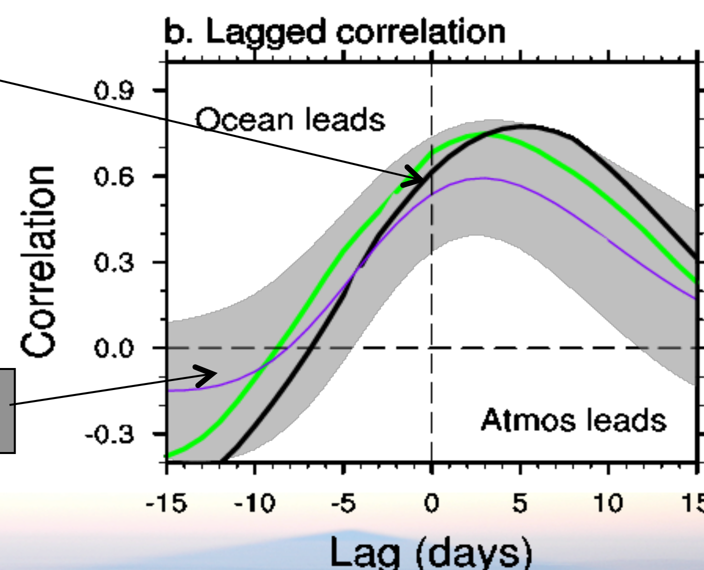


2003

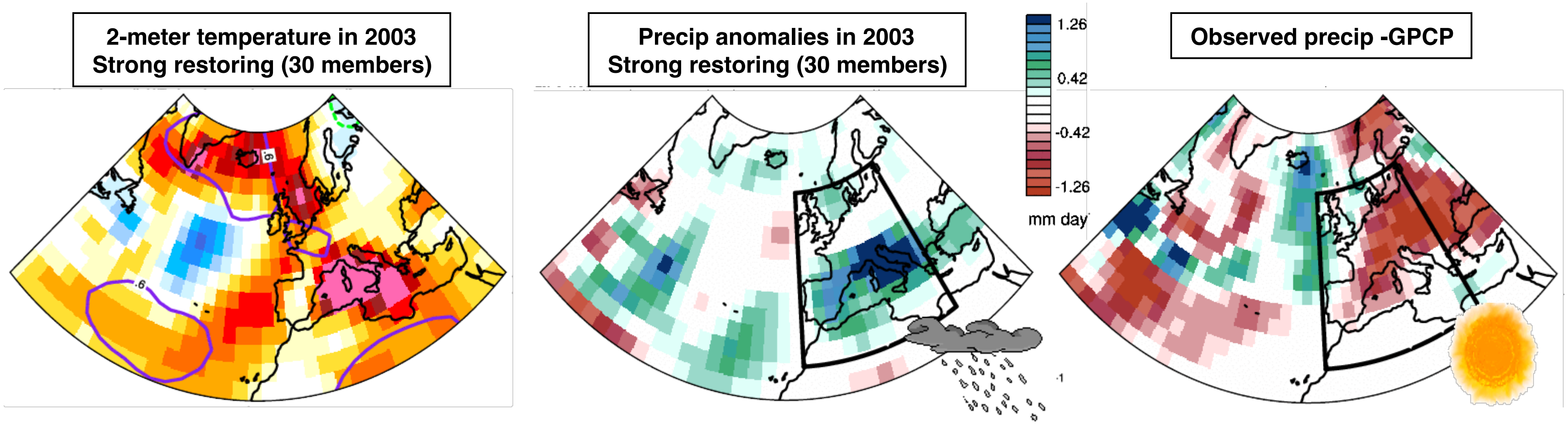


20 summers [1990-2010]

1. Atmosphere acting as a forcing for the SST at interannual timescale

2. 2003 is NOT an exception

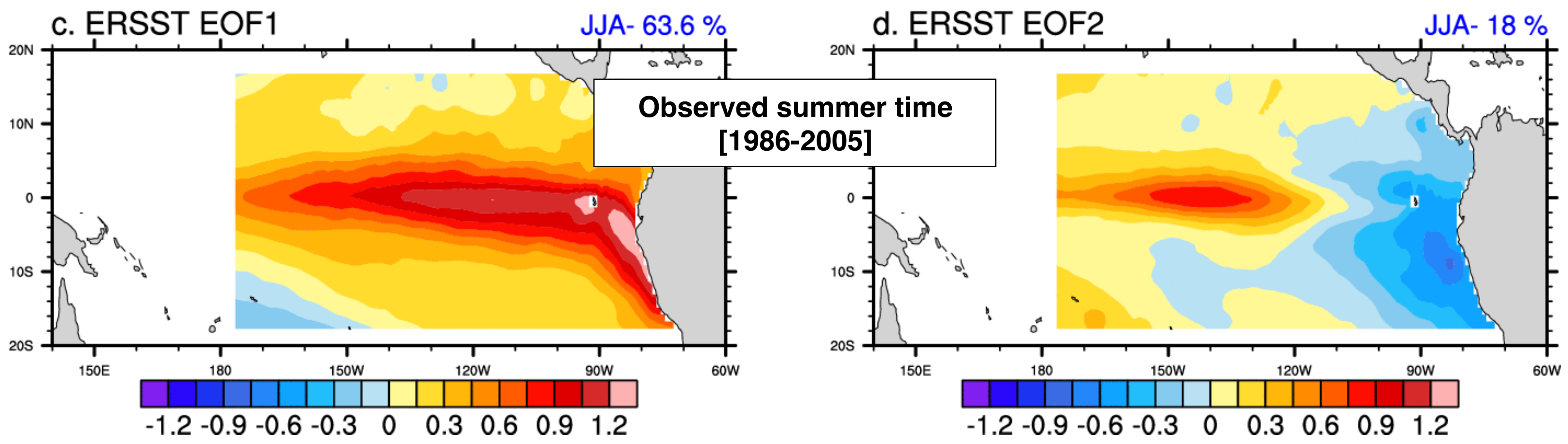
Case studies: the 2003 heat wave (2)

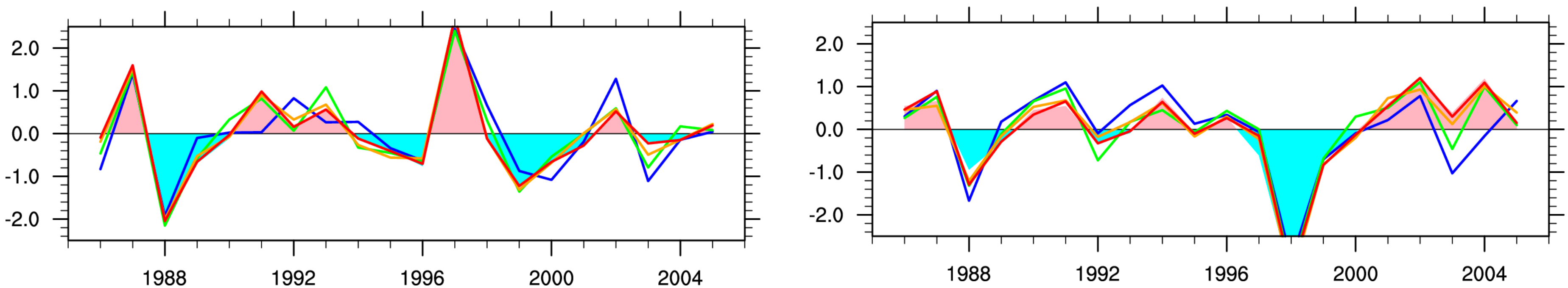


✧ **Strong restoring (very similar to an AMIP simulation) can lead to spurious results at monthly to interannual time scale at midlatitude**

✧ **Advice = choose a restoring term that controls the decadal variability while the rapid ocean-atmosphere interaction is still preserved.**

The Pacific experiments (EPAC-NUD) : summertime SST

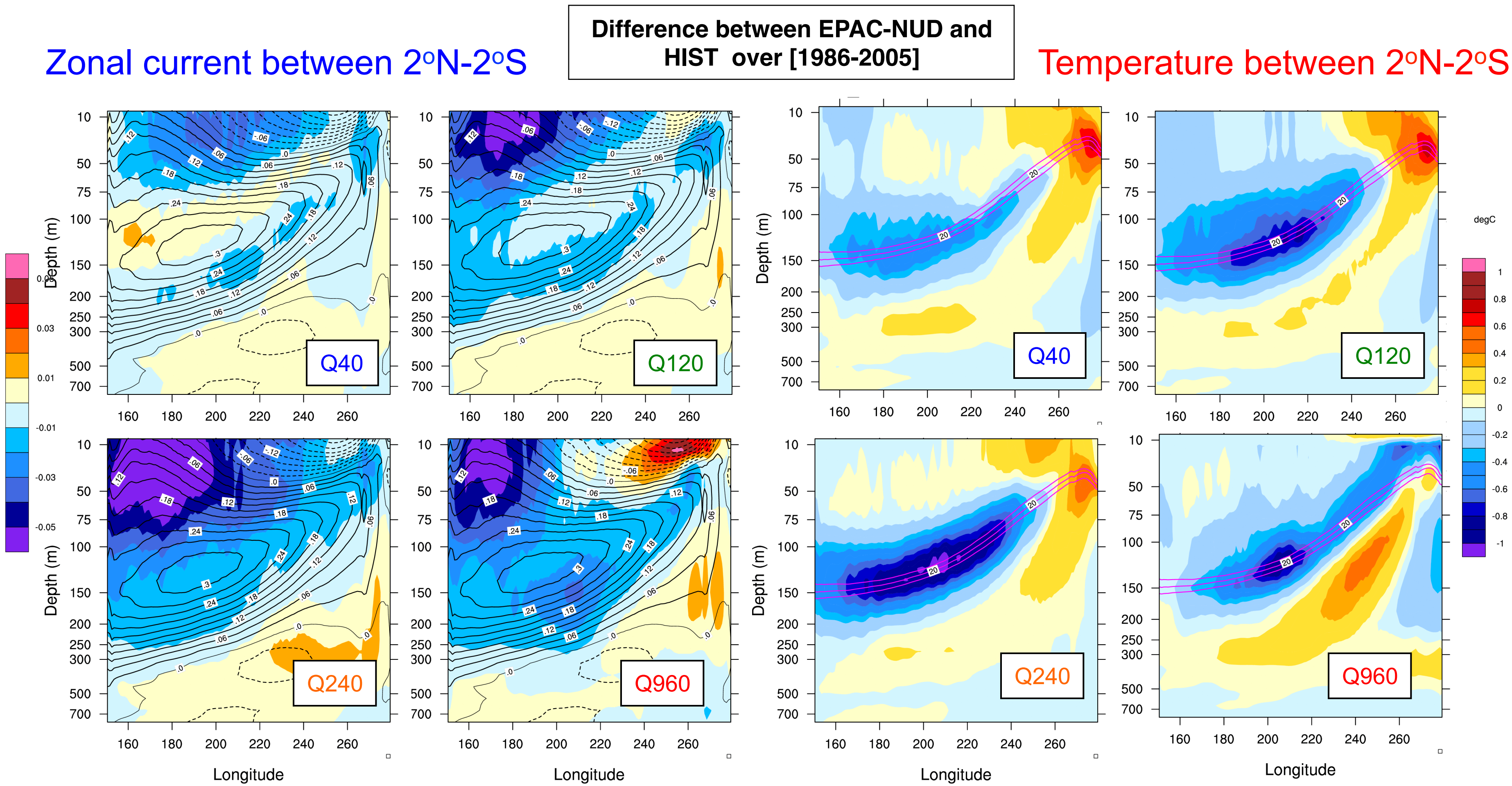




- ✧ **Capture the interannual ENSO events**
- ✧ **Less constraint for the 40W/m²/K ensemble as expected**

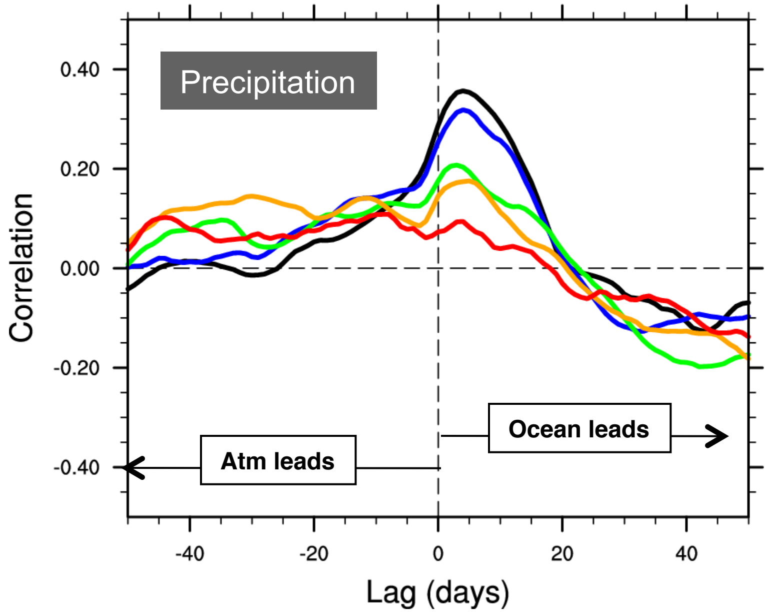
Corr (Q40)=0.87	**Corr (Q40)=0.82**
Corr (Q120)=0.95	**Corr (Q120)=0.94**
Corr (Q240)=0.99	**Corr (Q240)=0.98**
Corr (Q960)=0.99	**Corr (Q960)=0.98**

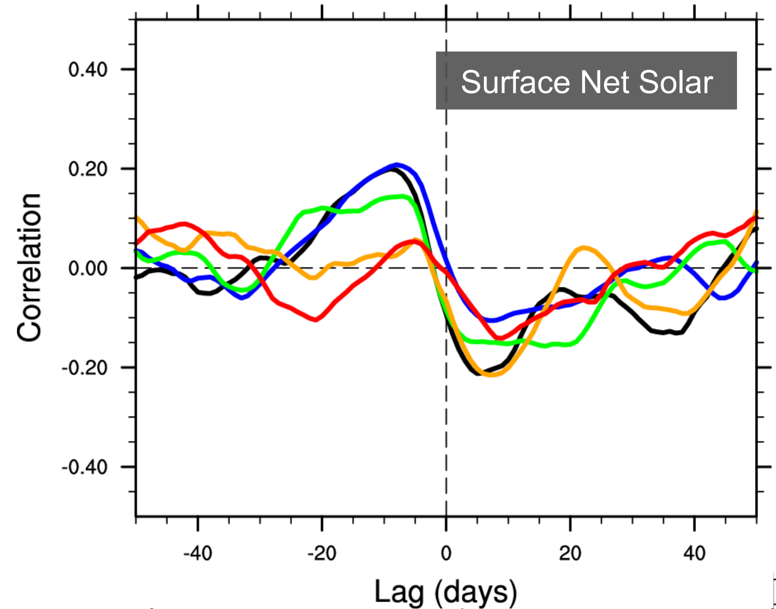
EPAC-NUD : countercurrent and temperature



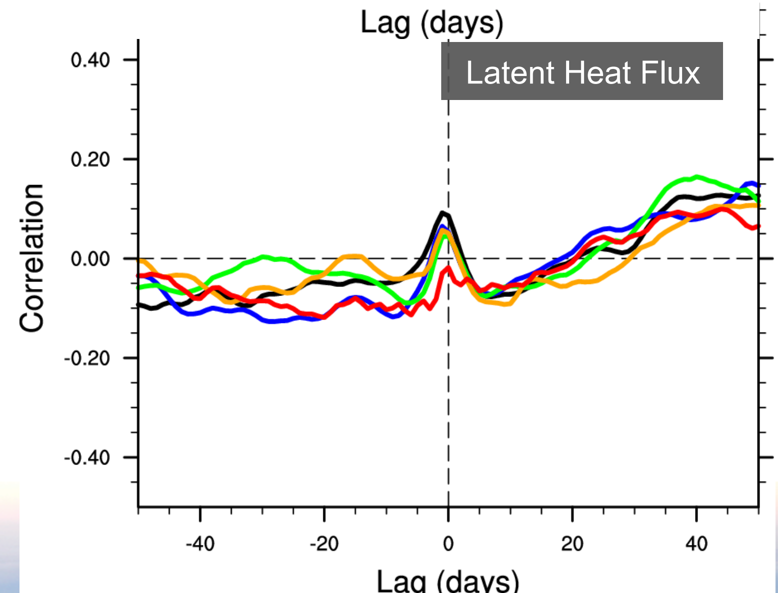
✧ **The strongest restoring, the greatest perturbation of the heat content + dynamics**

High frequency SST/atmosphere (NINO34)



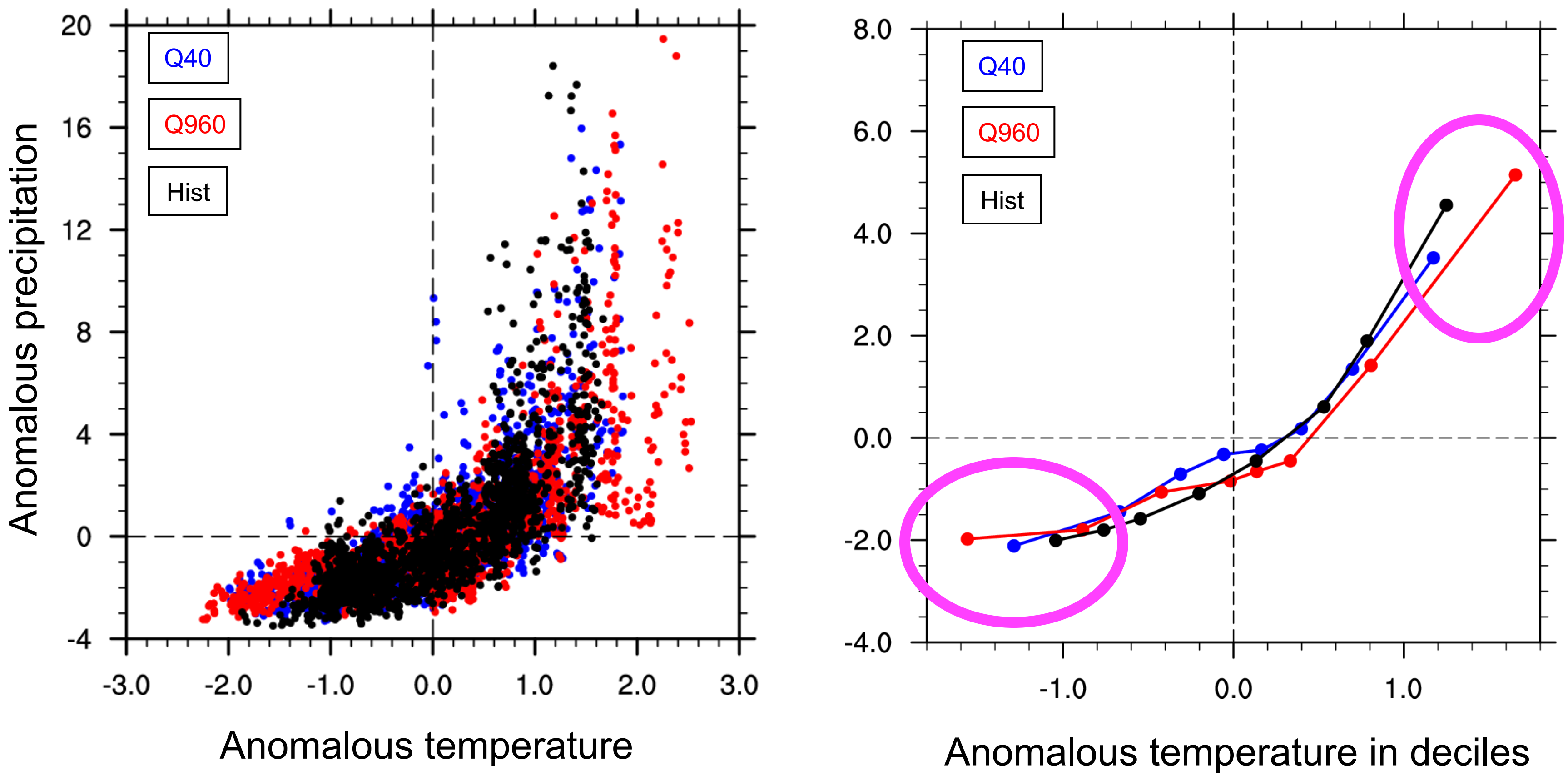


Q40
Q120
Q240
Q960



✧ **Perturbation of the Summertime high frequency relationship between SST and surface fields over the NINO34 domain**

EPAC-NUD : relationship between daily SST and Precip. over Nino34



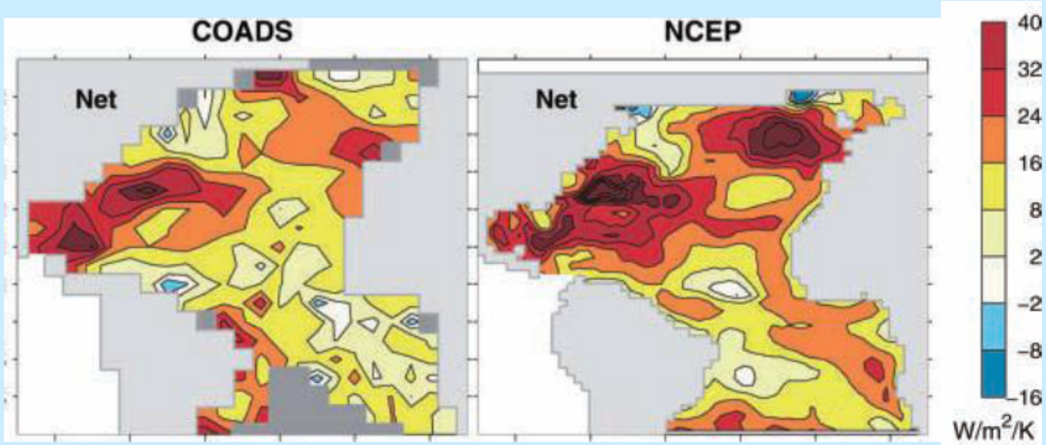
✧ **Weaker restoring allows smoother "digestion" of model biases in terms of variance.**

Some conclusions

✧ **Don't push the button too far for the restoring term!**

✧ **Should be weak enough to respect the high frequency ocean-atmosphere relationship, i.e. ~2-3 weeks as found in e.g. Timlin and Deser (1997), Barnier (1985) etc. while le low-frequency is constrained.**

Estimate of the surface heat flux feedback



Frankignoul and Kestenare 2002

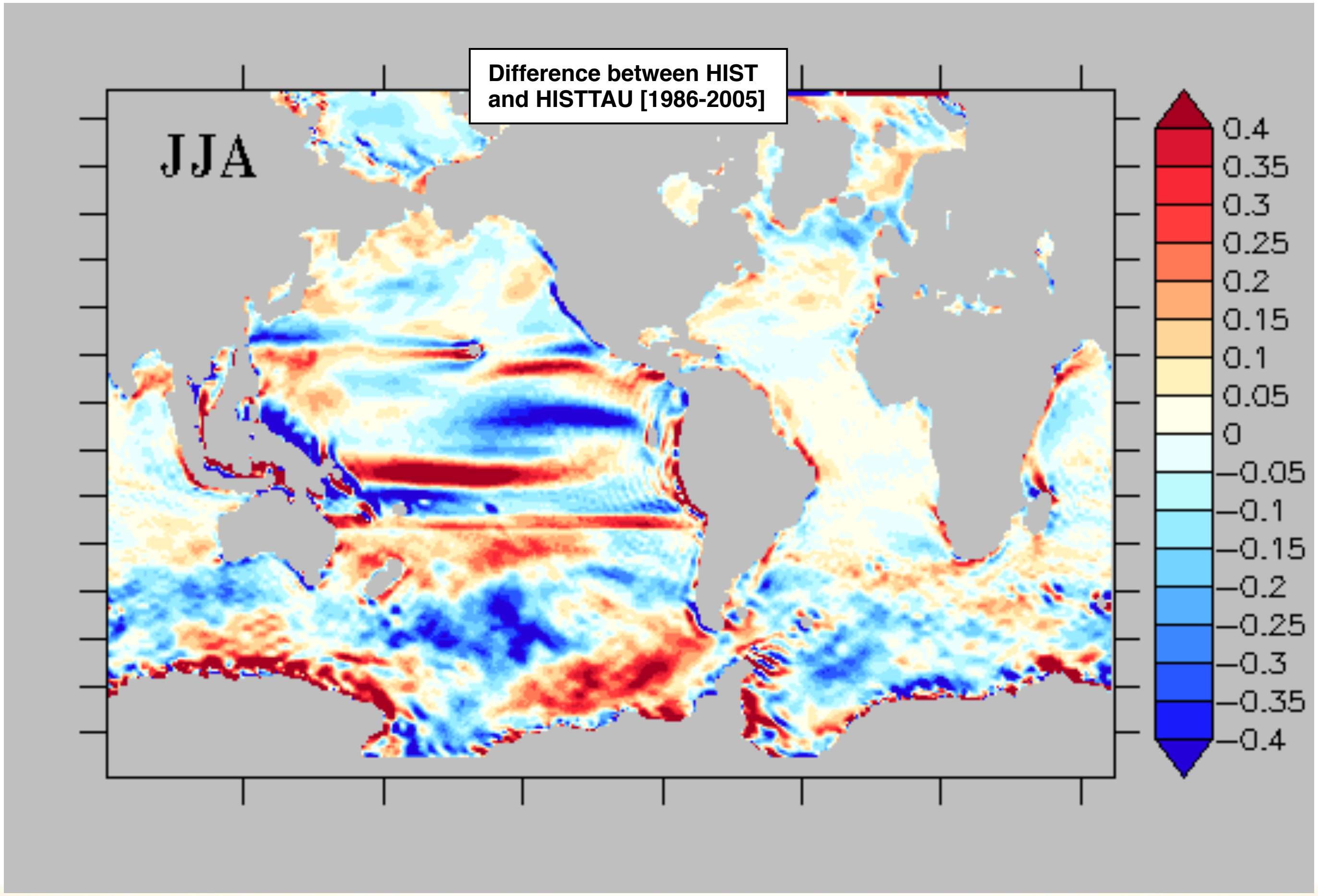
✧ **Anomalous SST restoring is NOT a flux correction term and it should not induce model adjustement.**


Thanks for your attention

Windstress restoring

✧ **ERAI Windstress anomalies restored over the Pacific**

Douville et al (2015)



✧ **Importance of wind curl conservation in the buffer zone --> spurious Ekman pumping**