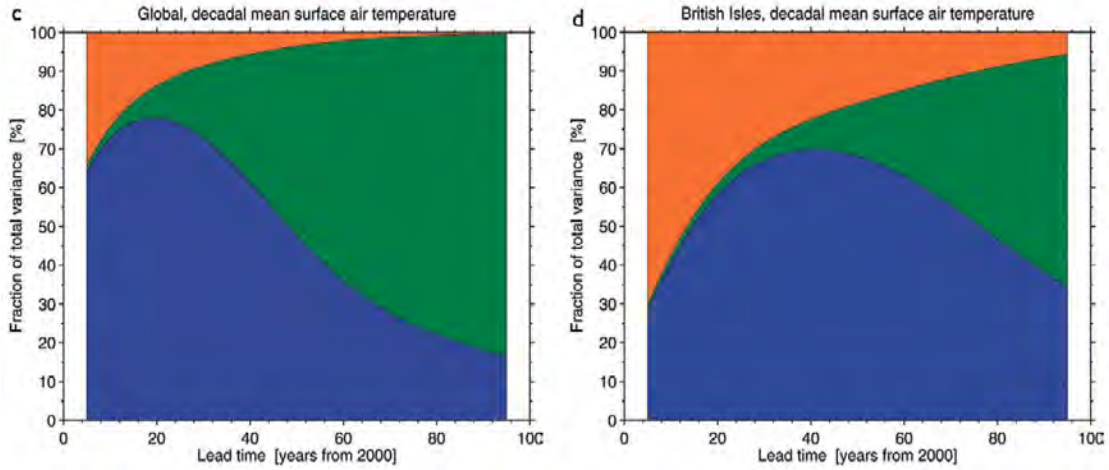
Bilan de 3 ans d'études sur le décennal à IPSL

Juliette Mignot, Didier Swingedouw, Eric Guilyardi

Contribution de Sonia Labetoulle, Aurélie Persechino, Jérome Servonnat, Roland Séférian, Sulagna Ray

Contribution et soutien du pôle de modélisation, Marie-Alice Foujols et Sébastien Denvil

Motivations



- Identifier les sources de prévisibilité multi-annuelle du système couplé, en particulier dans l'océan.
- Développement méthodologiques et techniques autour de IPSL-CM5 (initialisation, ensembles, analyse,…)
- Utiliser des simulations initialisées pour identifier l'origine des biais des modèles

Le décennal à l'IPSL

- Etude des mécanismes de prévisibilité
- Initialisation en surface (SST, SSS, tension de vent)
- Expertise océan forcé
- Etudes en modèle parfait

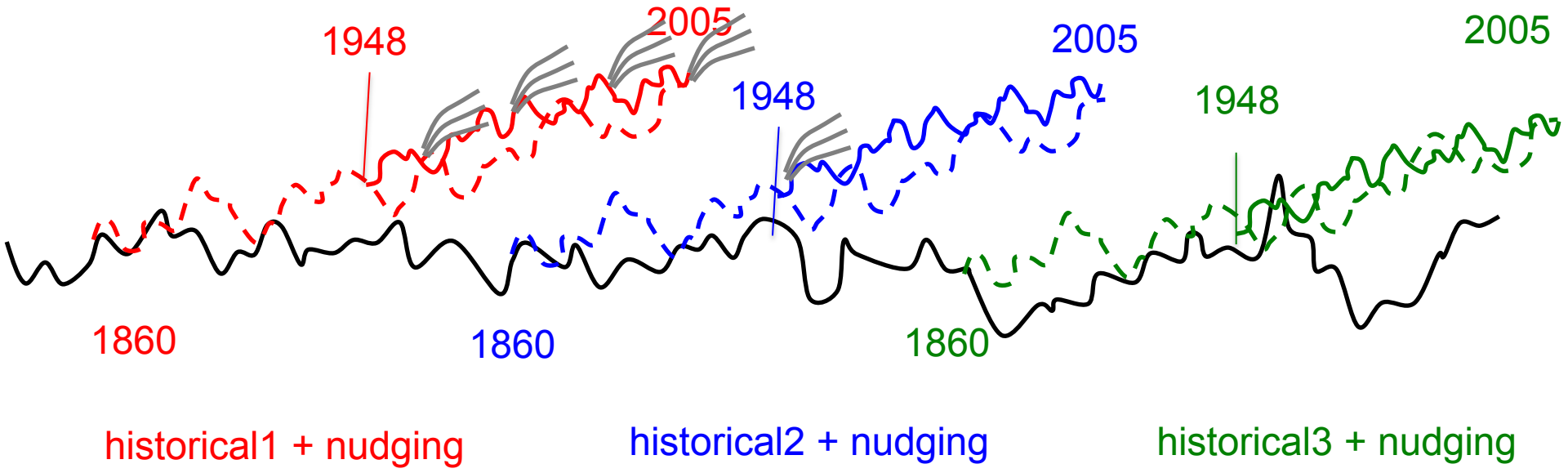
- **Projets**:
  - CMIP5 contribution (soutien ingénieur LOCEAN 2 ans à 50%)
  - EPIDOM, GICC (2011-2013) (2.5 ans postdoc IPSL)
  - En démarrage:
    - Labex IPSL: projet impact du volcanisme (M. Khodri, M. Marchand, 2 ans postdoc)
    - SPECS, FP7, 25 partenaires (3 ans postdoc, 18 mois ingénieur IPSL)

Études scientifiques

- Initialisation and predictability of the AMOC over the last 50 years in a climate model (Swingedouw D., J. Mignot, S. Labetoulle, E. Guilyardi and G. Madec, *Clim. Dyn*. 2012)
- Decadal predictability of the Atlantic Meridional Overturning Circulation and Climate in the IPSLCM5A-LR model (Persechino A., J. Mignot, D. Swingedouw, S. Labetoulle and E. Guilyardi, *Clim Dyn*. 2012)
- Testing different initialisation strategies with surface variables for decadal projections in a perfect model framework (Servonnat J., J. Mignot, E. Guilyardi, D. Swingedouw, R. Séférian, S. Labetoulle, *in prep*)
- Predictability of oceanic primary productivity at decadal time-scale (R. Séférian et al., *in prep)*
- The impact of surface nudging at depth (Ray S. J.Mignot, D. Swingedouw, E. Guilyardi)
- Other predictability studies
  - Evaluation of prediction skill (S. Ray, J. Mignot, D. Swingedouw)
  - African monsoon (A. Gueye, S. Janicot)
  - + contribution a un “comment” dans Science

Projets

- CMIP5 contribution (J. Mignot, S. Labetoulle, D. Swingedouw, E. Guilyardi)
  - IPSL-CM5A-LR



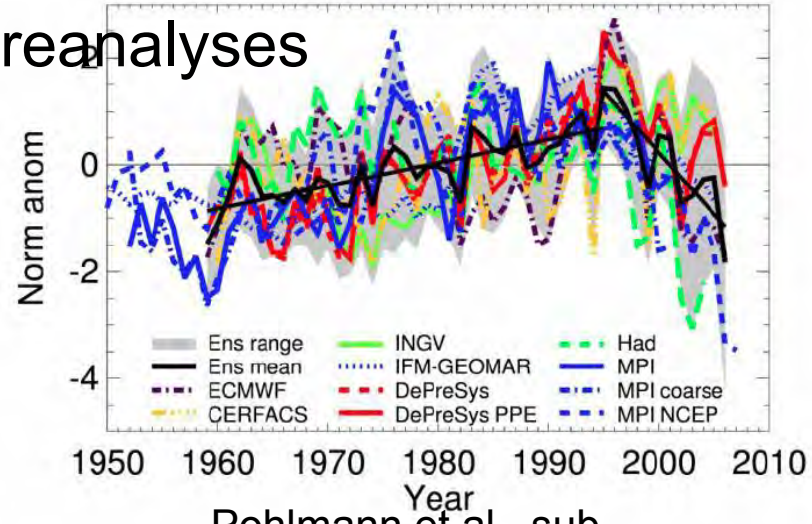
- 2 sets of hindcasts done (6 members), published in ESG
- already in many CMIP5 publications
- 4500 years of run (1000 for CMIP5 + 3500 research simulations)
- 200-300 To of data

AMOC Initialisation

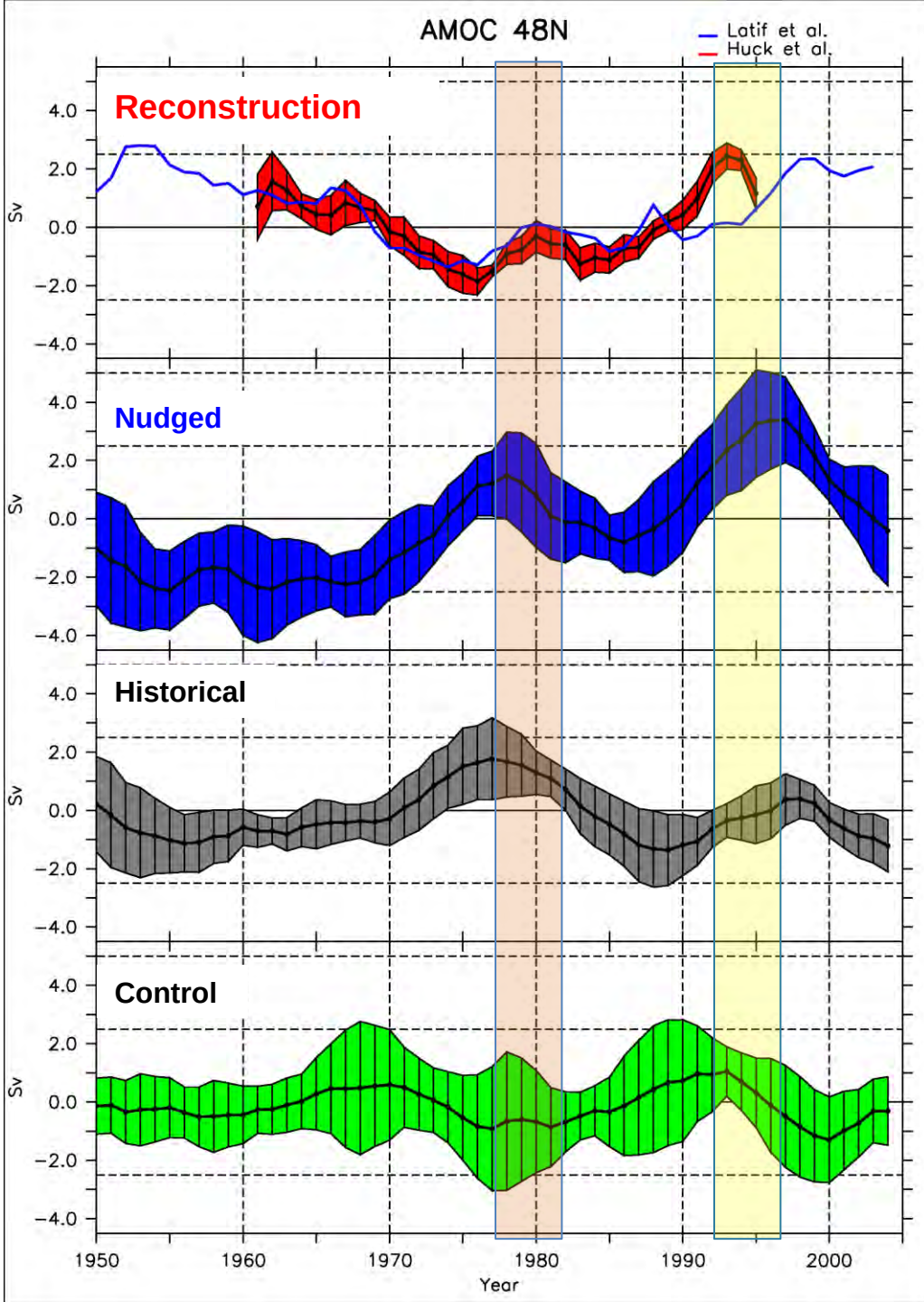
Swingedouw et al. 2012

- Two independant AMOC reconstructions
- Agreement between nudged and reconstructions
- Synchronisation also in the historical simulations

AMOC in reanalyses

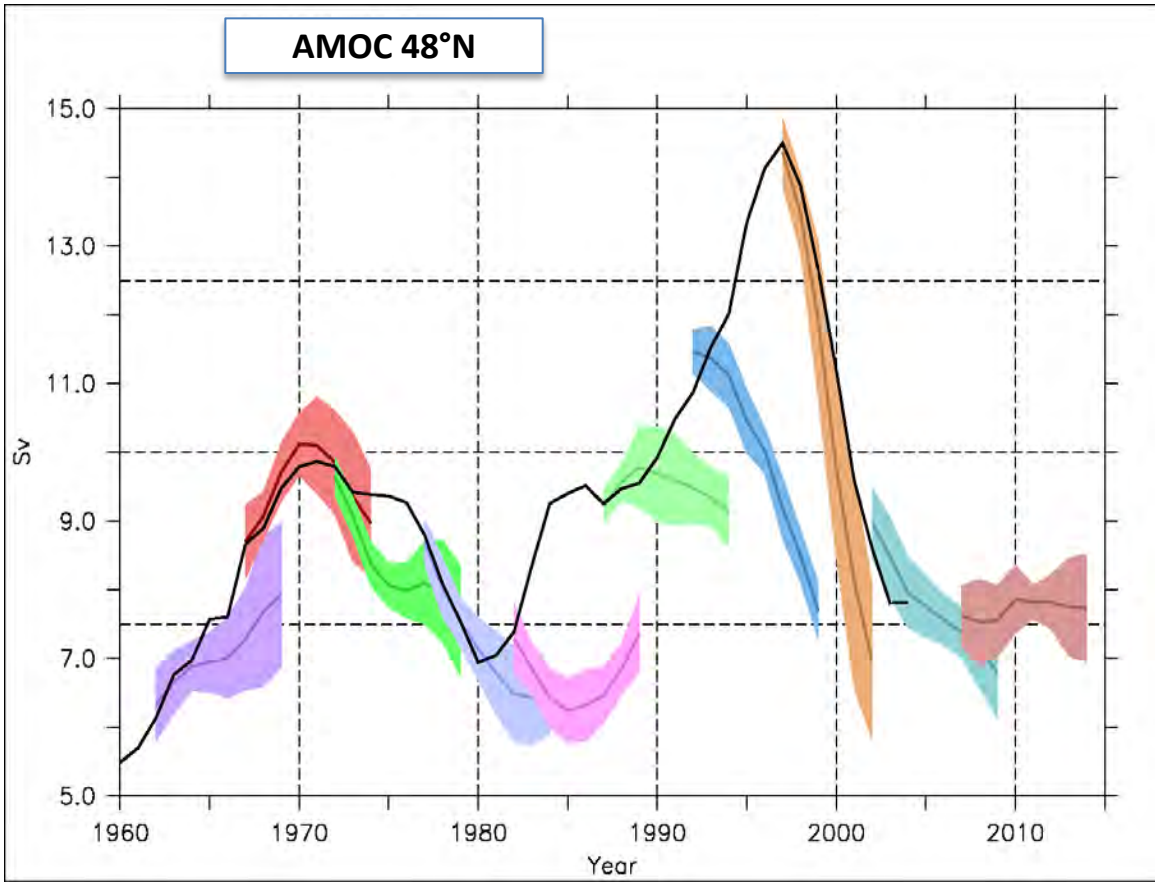


Pohlmann et al., sub.



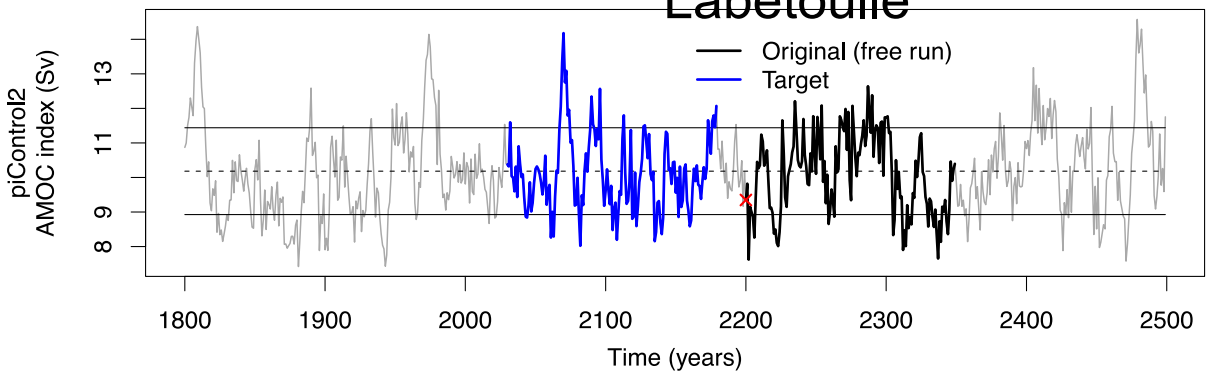
AMOC hindcasts

- Only one member of the nudged ensemble (planned to apply to each)
- 3-members ensemble of free run
- 90's max. missed (effect of persistent NAO?)



Testing different initialisation strategies with surface variables in a perfect model framework

J. Servonnat, J. Mignot, E. Guilyardi, D. Swingedouw, R. Séférian, S. Labetoulle



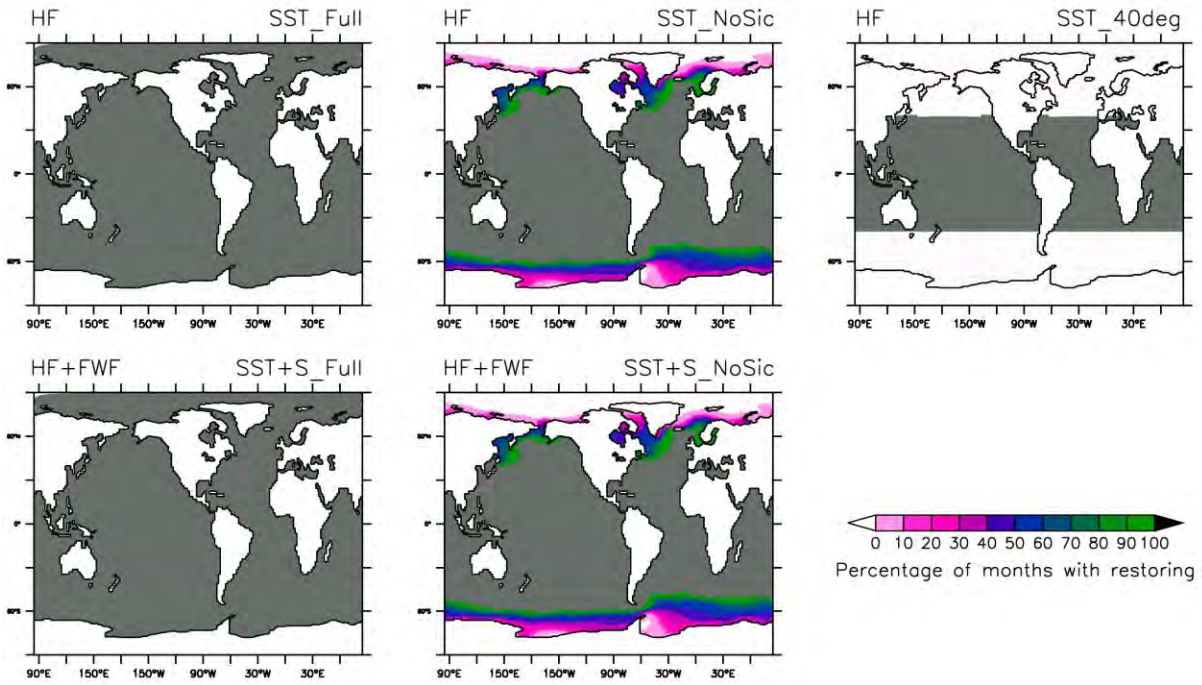
SST and/or SSS nudging, applied on various areas

$$Q_{nudg} = -\gamma_T (T'_{model} - T'_{target})$$

γ_T = 40 W/m²/K

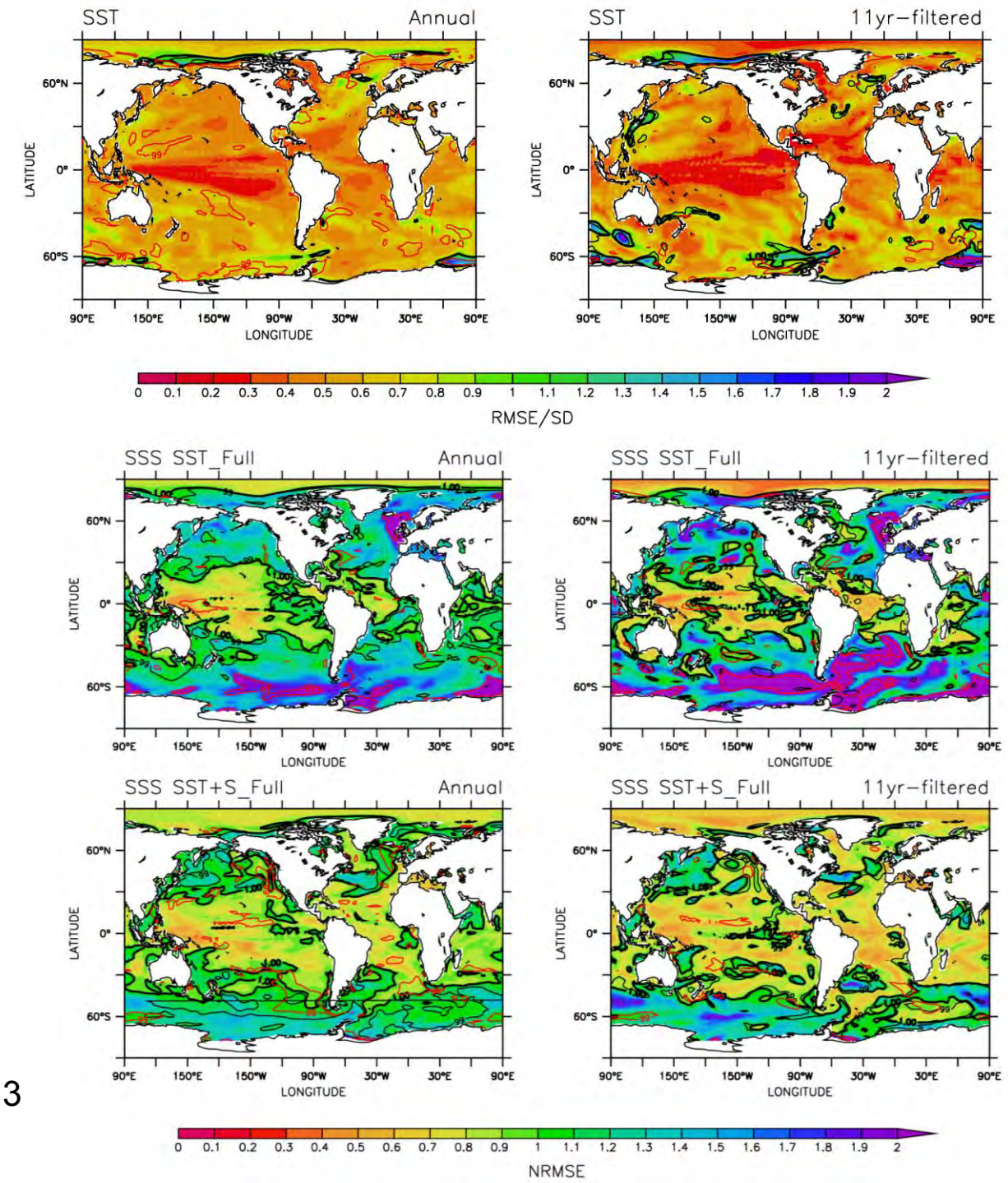
$$F_{nudg} = -\gamma_S (S'_{model} - S'_{target})$$

γ_S = XX mm/day/psu



Surface initialisation

- SST ok
- SSS also in the tropical area even only with SST
- Role of wind initialisation via nudged SST structure

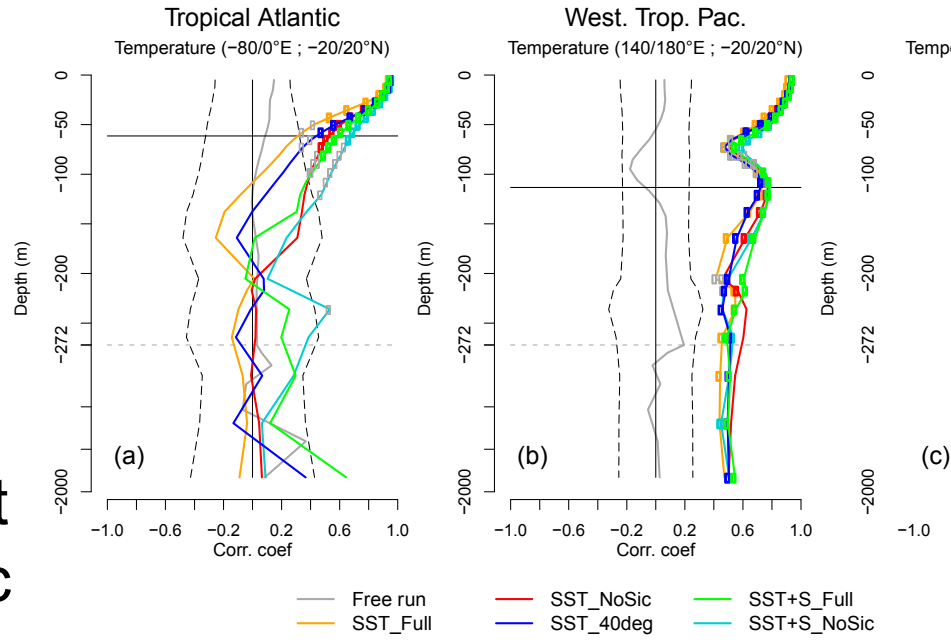


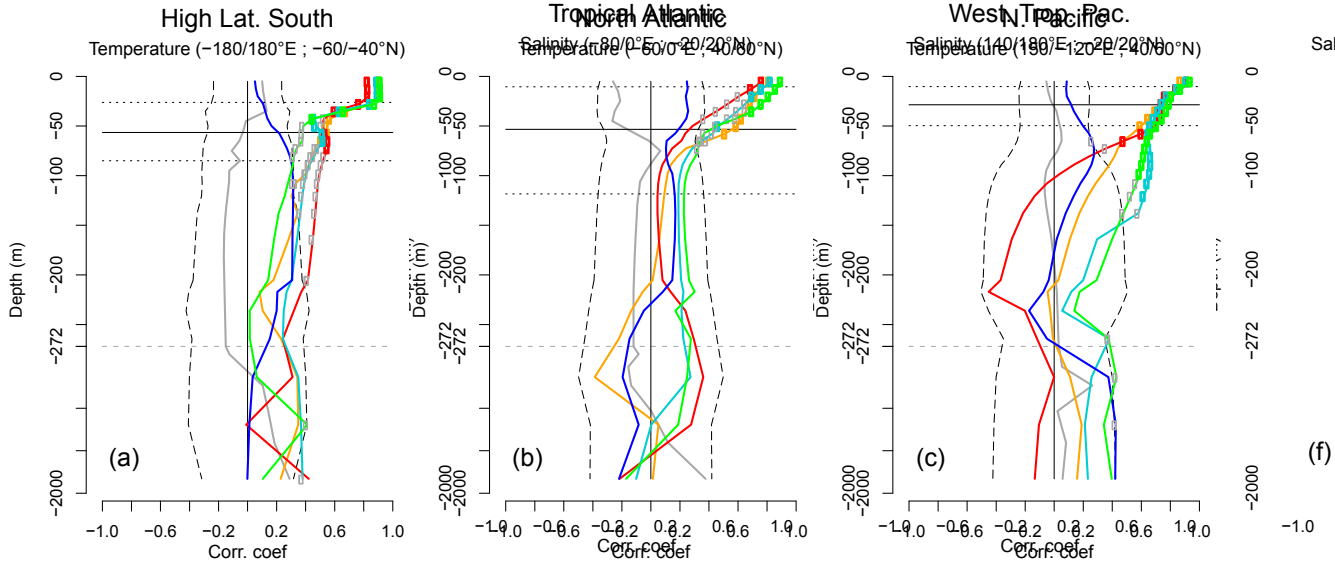
Servonnat et al. 2013

Effect on the subsurface temperature

- Mostly limited to mixed-layer (or thermocline)
- Wind init helps deeper initialisation in tropical Pacific
- SSS nudging helps form right water masses in North pacific

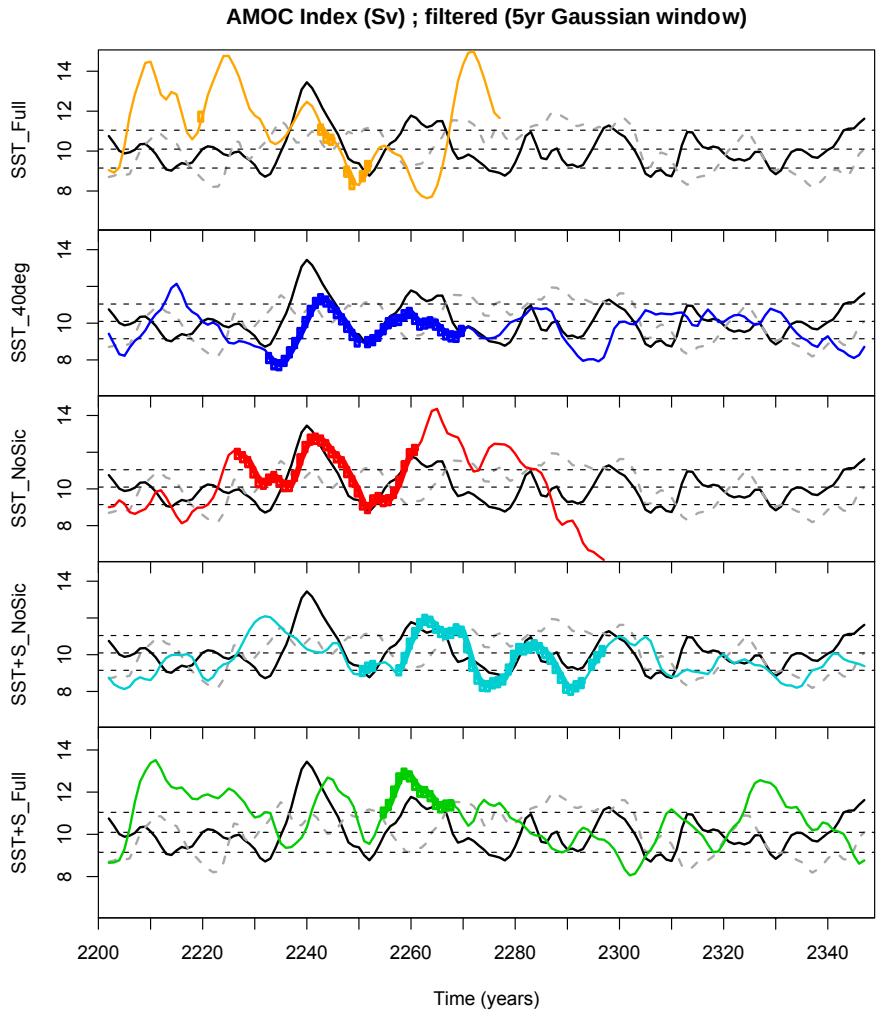
tropical basins



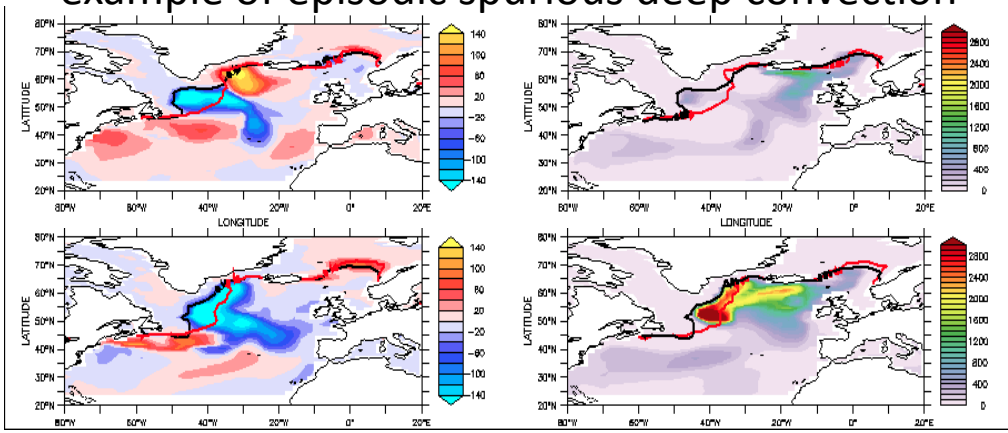


Servonnat et al. 2013

Initialisation of AMOC in a perfect model framework



example of episodic spurious deep convection

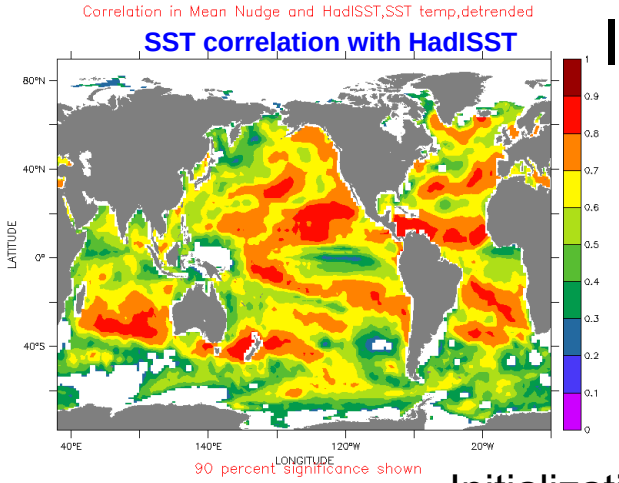


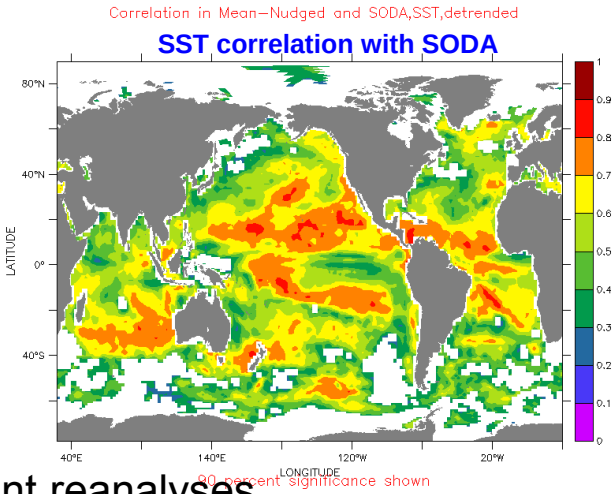
- Initialization of AMOC large events
- Linked to the 20-yr cycle in the North Atlantic in IPSL model
- Sea-ice edge initialisation challenging

Servonnat et al. 2013

Initialization of CMIP5 simulations

Sulagna Ray

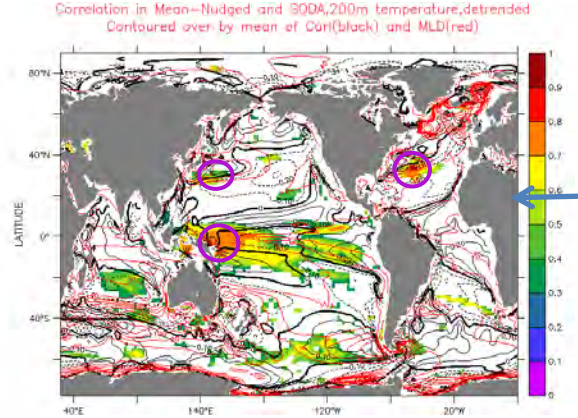




Correlation between the mean of 4 initialized runs and HadISST (left) and SODA (right) showing only 90% significant correlations. Detrended linearly to remove the externally forced component

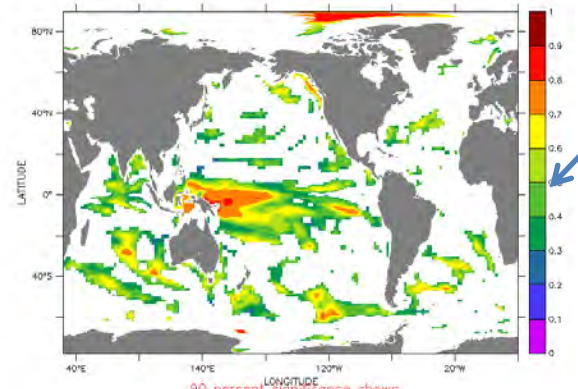
Initialization at depth, compared to different reanalyses

200m depth temperature comparison with SODA

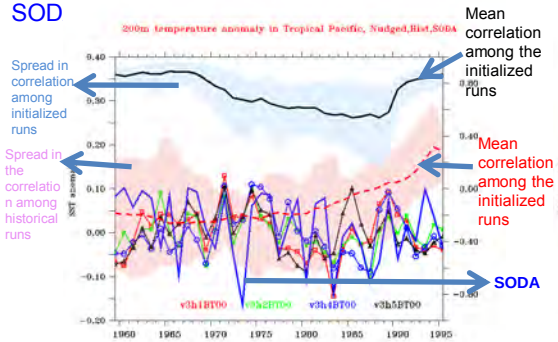


Same as above but for temperature at 200m depth with SODA and ECMWF-ORAS4. Overlaid by the mean mixed layer depth (red contours) and mean of the wind stress curl (black contours). Bold black contour is the zero line for wind stress curl

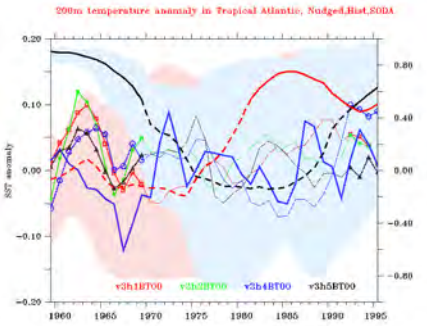
200m depth temperature comparison with ECMWF-ORAS4



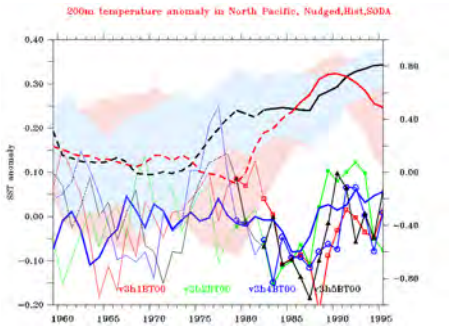
Anomalies and spread in the correlation (20-year window) among the 4 initialized members along with that from historicals, averaged over sub-basins. Anomalies from SOD



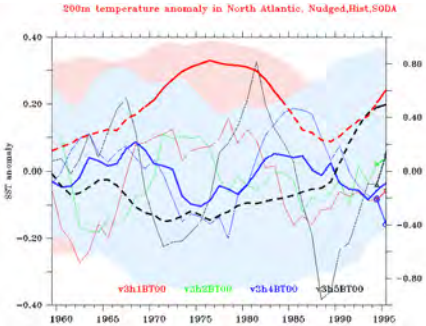
Tropical Pacific (30S:30N)



Tropical Atlantic (30S:30N)



North Pacific (30N:70N)

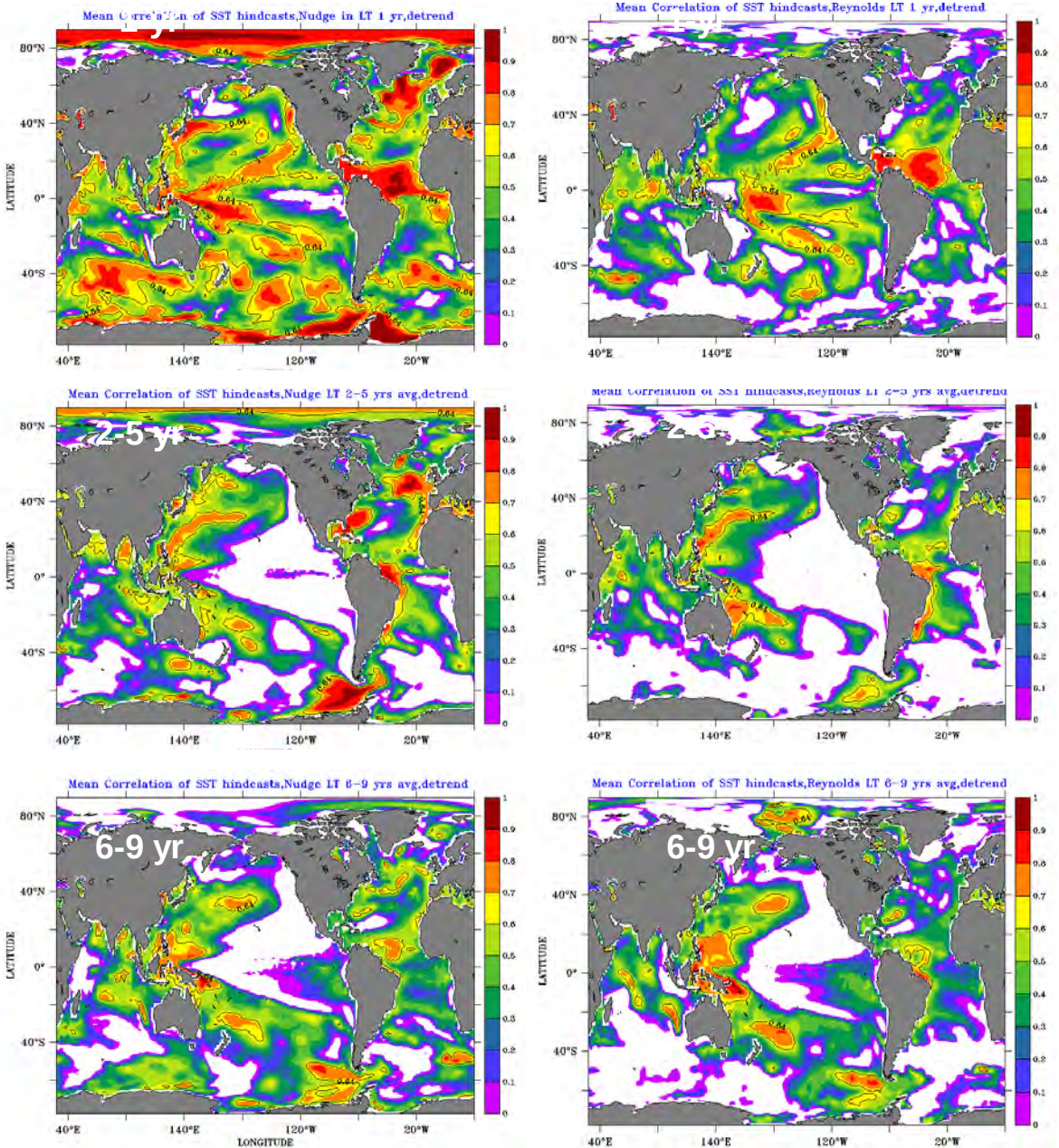


North Atlantic (30N:70N)

Potential and effective SST predictability

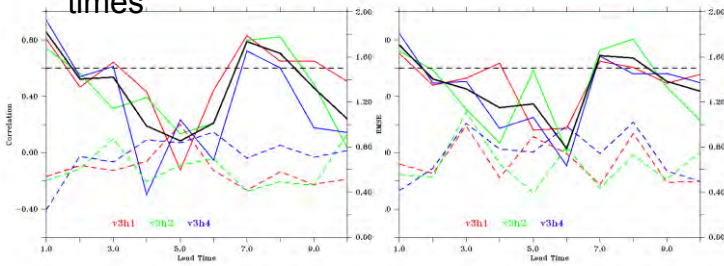
S. Ray

Potential | **Effective**

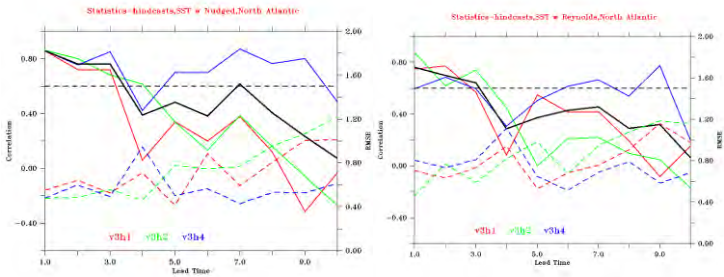


Maps of mean correlation between hindcasts and Initialized runs(potential predictability) and between hindcasts and Reynolds SST (effective predictability). 90% significant correlation shown.

Correlation (line, left axis) and root mean square (dash, right axis) among hindcasts and initialized runs (left column) and Reynolds' SST (right column) at 10 lead times



Tropical Atlantic



North Atlantic

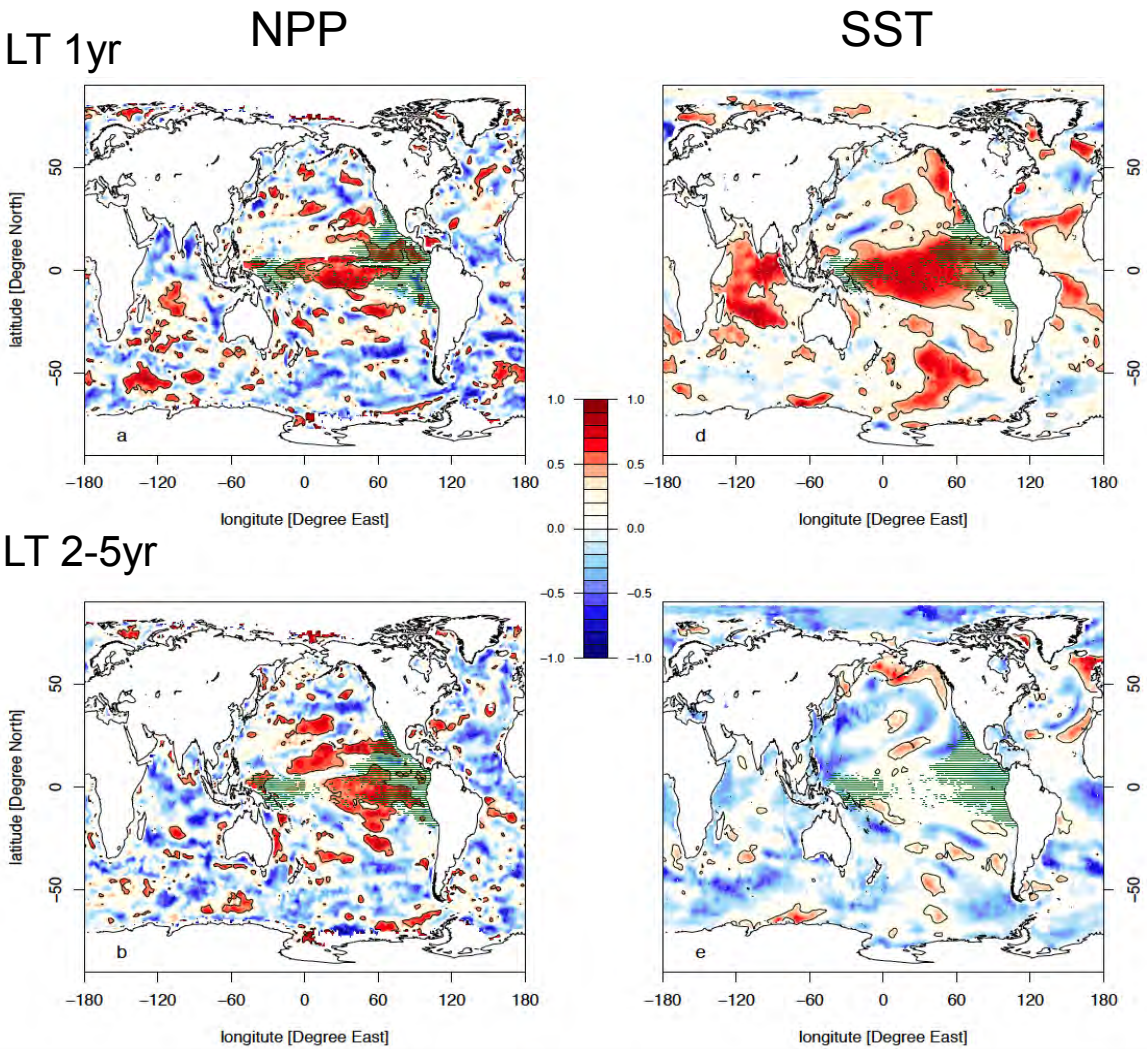
Red, green, blue are from hindcasts launched from different initialized runs. Black is the mean correlation of the three

Predictability of oceanic primary productivity at decadal time-scale

Séférian et al. *in prep.*

- 1989-2011 hindcasts compared to SeaWiFS (1997-2008) and Reynolds
- Better correlation for NPP at lead time 2-5 than for SST!
- Due to correct initialisation of nutriments location
- An impact on fisheries? (green shading)

Correlation Skill score for



Conclusions

- Lancement d'une nouvelle thématique (MISSTERRE, IPSL & Cerfacs)
- Gros travail sur CMIP5
- Bonne production scientifique
- Dynamique internationale
- Pérennisation scripts et méthode -> libGCM

Pour les prochaines étapes:

- Comment initialiser un système couplé et pourquoi (analyse biais ou P…)
- Mécanismes de prévisibilité (variabilité) <> prévision !
  - peu de prévisibilité non forcée en dehors de l'Atlantique Nord
- Fiabilite chaine de calcul CCRT/IDRIS
- Renforcer équipe de permanents, synergies Toulouse-Paris

Stratégie d'initialisation à l'IPSL

Surface nudging only

- ➢ Explore different ways of surface nudging (SST, wind stress, salinity…)

•Less intrusive

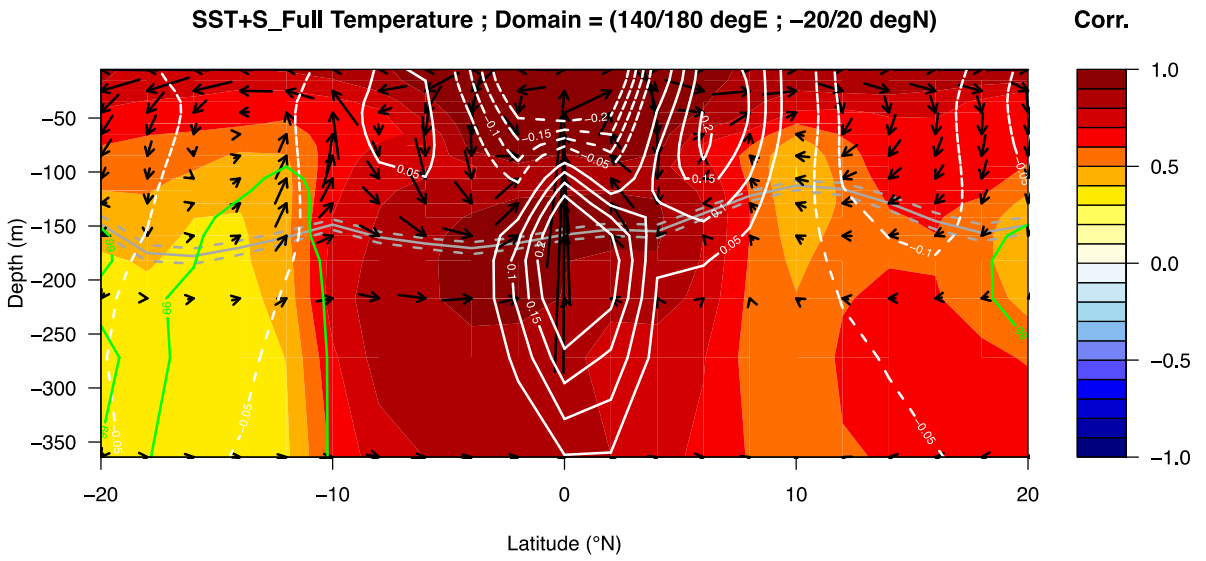
• no clear evidence that 3D init leads to better predictability yet (although probably better *initialisation*)

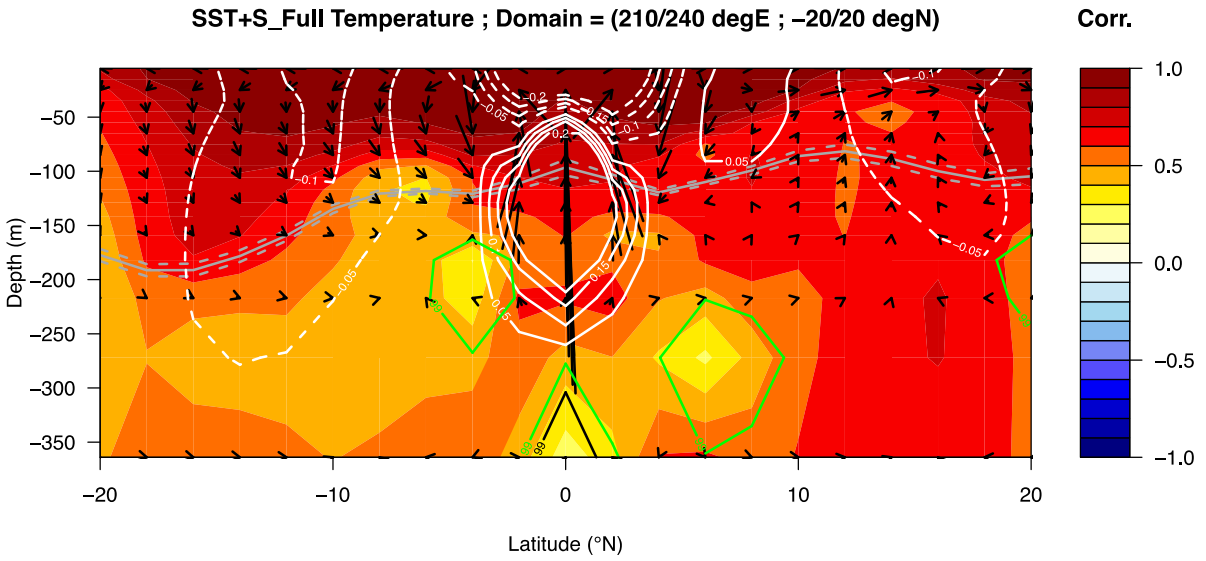
• Benefit from Drakkar NEMO forced OGCM experience (ex. *Barnier et al. 2006*)

Jusqu'à présent: $Q_{nudg} = -\gamma(T'_{model} - T'_{obs})$ $\gamma =$ 40 W/m²/K
SST nudging only

Deeper initialisation?

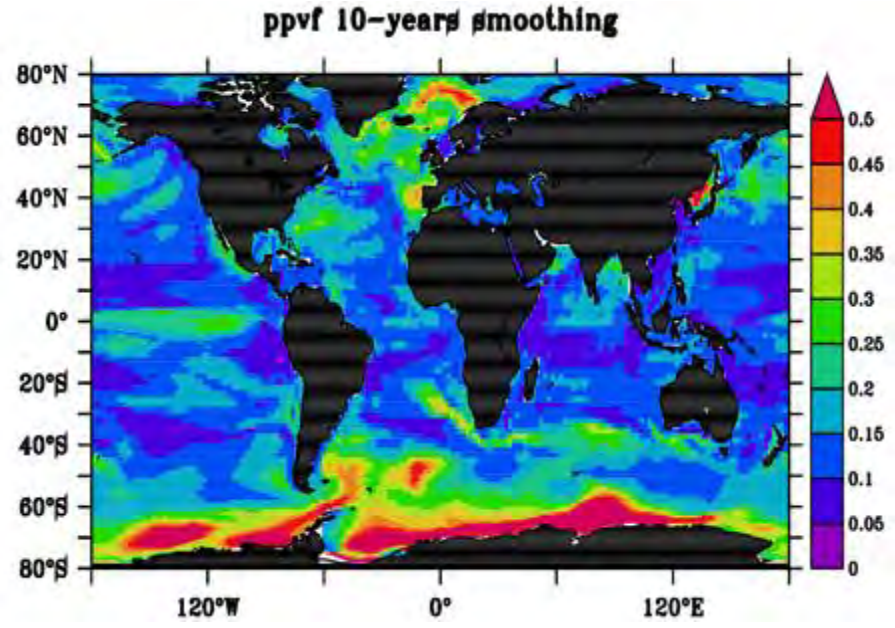
Penetration of the signal through STC
And transport via subsurface zonal current





Predictability of ocean carbon fluxes at decadal time-scale

Séférian, Bopp et



Potential predictability diagnostic (PPVF, Boër et al., 2004)

Perfect Model Approach

Understanding the mechanisms of the decadal predictatibility/variability

Practical predictability diagnostic (e.g., Msadek et al., 2010)