Decadal prediction studies at IPSL

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Overview of activities

• Initialisation of coupled system (J. Servonnat, D. Swingedouw, E. Guilyardi, J. Mignot)
  • Surface nudging/forcing
  • Perfect model studies (SST, SSS, wind stress - sea-ice, ...)

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

• Mechanisms for MOC predictability, potential predictability evaluation (D. Swingedouw, A. Persechino, E. Guilyardi, J. Mignot)

• Other predictability studies
  • Ocean biogeochemistry (R. Séférian, L. Bopp)
  • African monsoon (A. Gueye, S. Janicot)

• Seasonal in tropics (B. Vannière, E. Guilyardi)
  • Understand model initial drift
IPSLS-CM5 Earth System Model plateform

Biogeochemistry models

Carbon & CO₂ (Orchidée, Pisces)

Physical models

- Atmosphere (LMDZ)
- Land surf. (Orchidée)
- Coupler (OASIS)
- Ocean (Nemo)
- Sea-ice (LIM)

Natural and anthropogenic perturbations

- CO₂ emissions
- Other gas
- Land use
- Solar irradiance
- Volcanic aerosols

ORCA2

LR: 96 x 95 x L39
MR: 144x142x39

>1000 yrs piControl
5 members historical simulations  http://forge.ipsl.jussieu.fr/igcmg
Atlantic meridional overturning circulation

Atlan+ meridional overturning circulation

Atlantic MOC

Mean: 10.3 Sv

Atlantic MOC maximum

winter mixed layer depth maximum

max(AMOC) autocorrelation

lag (years)
A 20-yr coupled ocean atmosphere sea-ice mode in the subpolar North Atlantic in IPSLCM5A

\[\text{Labrador SST + SSS +} \quad 0 \text{ yrs (0.4)}
\]

\[\text{Wind stress + GIN} \quad 0 \text{ yrs (0.4)}
\]

\[\text{EGC +} \quad 3 \text{ yrs (0.6)}
\]

\[\text{Sea-ice cover - GIN} \quad 9 \text{ yrs (0.3)}
\]

\[\text{West SST + SSS +} \quad 4 \text{ yrs (0.6)}
\]

\[\text{GIN SST + SSS +} \quad 7 \text{ yrs (0.5)}
\]

\[\text{AMOC} \quad 3 \text{ yrs (0.3)}
\]

**Fig. 1.** Mean Atlantic MSF for the studied period.

**Fig. 11.** Schematic vue of the whole mechanism. Estimated time lags (and correlations) are indicated.

Escudier, Mignot and Swingedouw, in prep.
A 20-yr coupled ocean atmosphere sea-ice mode in the subpolar North Atlantic in IPSLCM5A

Escudier, Mignot and Swingedouw, in prep.

FIG. 11. Schematic vue of the whole mechanism. Estimated time lags (and correlations) are indicated.
A 20-yr coupled ocean atmosphere sea-ice mode in the subpolar North Atlantic in IPSLCM5A

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Escudier, Mignot and Swingedouw, in prep.
Consequences for potential predictability at decadal timescales?
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- Labrador Sea SSS = 7-10 years predictor of the AMOC
- EGC = more than 10 years predictor

Persechino, Mignot, Swingedouw, Labetoulle, Guilyardi, in prep.
CMIP5 near term exercise at IPSL
CMIP5 near term at IPSL: strategy
CMIP5 near term at IPSL: strategy

historical1
historical2
historical3

1860
2005
piControl
CMIP5 near term at IPSL: strategy

surface restoring

\[ Q_{nudg} = -\gamma (T'_{\text{model}} - T'_{\text{obs}}) \]
\[ \gamma = 40 \text{ W/m}^2/\text{K} \]

- 3 initialized simulations from 3 members of the ensemble of historical simulations (long term)
CMIP5 near term at IPSL: strategy

Strategy:

3 free runs with perturbed initial conditions started from 31 dec 1960, 1965, ... 2005

Initial perturbation: spatial white noise on SST
CMIP5 near term at IPSL: status

1st set hindcasts done - 90%
2nd set in the machine – 50%
First results on AMOC initialisation
AMOC Initialisation

- 5-members ensemble of nudged simulations and control-historical ones
- 5-members historical simulations as control
AMOC Initialisation

- Reconstruction of the AMOC using NODC hydrographic data (Huck et al. 2008)
- 5-members ensemble of nudged simulations and control-historical ones
- 5-members historical simulations as control

Pohlmann et al 2010
Convection sites response

- Two pics around 5 years before each AMOC max.
- Driven by density at surface, coming from salinity mainly and a slight contribution from SST
- How is SSS initialized?
Mechanisms

⇒ GIN seas SST
⇒ GIN seas ice cover
⇒ Wind stress
⇒ EGC
⇒ SSS Labrador Sea
⇒ CV sites
⇒ AMOC
Mechanisms

$\Rightarrow$ HadISST

GSAs!
(1970, 82, 90 Sundby & Drinkwater 2007)
first hindcasts results
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?)
Correlations CTRL avec OBS

SST lead time 1 yr

SST lead time 2-6 yrs

SST lead time 6-10 yrs

Hindcasts / Reynolds

Free historical / Reynolds

Global average removed
Conclusions

• In IPSLCM5, AMOC predictability strongly linked to a multidecadal mode of variability
• AMOC initialisation also linked to this mode. Surprising agreement with data given the biases in the North Atlantic in the IPSL-CM5 model?
  - not inconsistent with GSAs
  - initialised after 30 years using only Reynolds SST
• 1st set of decadal predictions with IPSLCM5A is on the way
• Evaluation of the predictive skill under investigation.
• Some issue about the 1991 starting date

  to be continued...
Future work

use perfect model approach to gain insight into initialization strategy
- add compensating freshwater flux to compensate temperature anomalies
- initialization through wind (3D atmosphere)
surface temperature  lead time 1 yr

correlation hindcasts / nudged run

correlation free historical run / nudged run
surface temperature

lead time 2-4 yrs

lead time 5-9 yrs

hindcasts / nudged run

free historical run / nudged run
Why do we miss the 1990s peak?
Hindcasts

AMOC 48°N

AMOC max

Pac. HT 20°N

Atl. HT 20°N
Air-sea ice interactions in 1978-80

Nudged simulations
Air-sea ice interactions in 1967-69
Propagation of SST anomalies

⇒ We follow the minimum of SST along the gyre
⇒ 8 years between Labrador and GIN
⇒ True in the model (known)
⇒ And in the Reynolds data!
Simulating ocean carbon fluxes at decadal time-scale need online simulations

Séférian, Bopp et al.

North Atlantic (45-75°N) carbon uptake Wavelet Analysis on preindustrial simulation (1000 years)

Offline simulation
Biogeochemical model
forced by monthly means

Online simulation
Biogeochemical model
Embedded in coupled climate model

No Signal at decadal time-scale

Signal at decadal time-scale
Predictability of ocean carbon fluxes at decadal time-scale

Séférian, Bopp et al.

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

Perfect Model Approach
Understanding the mechanisms of the decadal predictability/variability

Practical predictability diagnostic (e.g., Msadek et al., 2010)
AMOC maximum in IPSLCM5A control simulations

96x96x39 piControl2
Mean=10.3 Sv

144x142x39 piControlMR1
Mean=12.5 Sv