

Low-frequency variations of the large-scale ocean circulation and heat transport in the North Atlantic from 1955-2008 in situ temperature and salinity data

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2008-2009 french project GMMC TOCAD F. Gaillard (PAC EuroArgo)

2007-2008 french project CNRS/INSU/LEFE Reco T. Huck

Goals

- Use of Argo and historical hydrological data for monitoring:
 - ocean properties
 - large-scale ocean circulation and transports



Methodology

- Statistics
- Optimal estimation
- Robust diagnostic model
- Inversion
- Assimilation



First methodological step

Comparison of 3 simple methods for constraining ocean models to temperature and salinity fields:

RD Robust Diagnostic

CT Constant Tracer

PR Short Prognostic

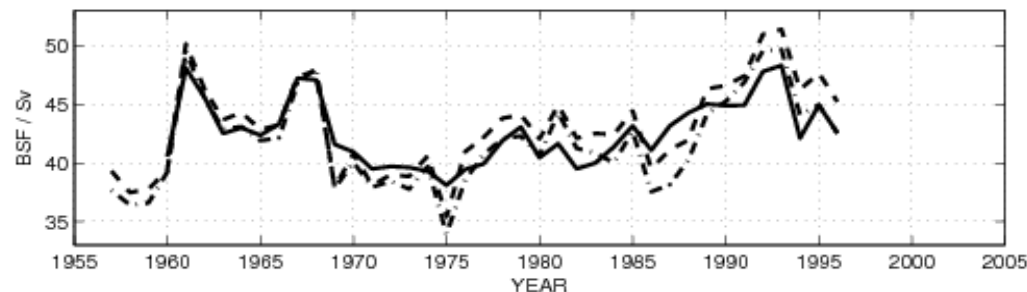
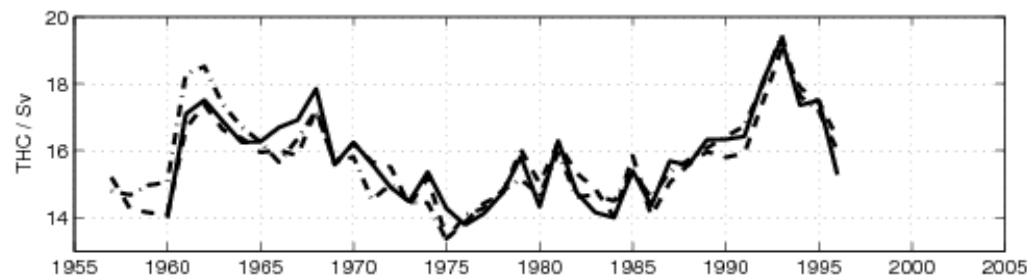
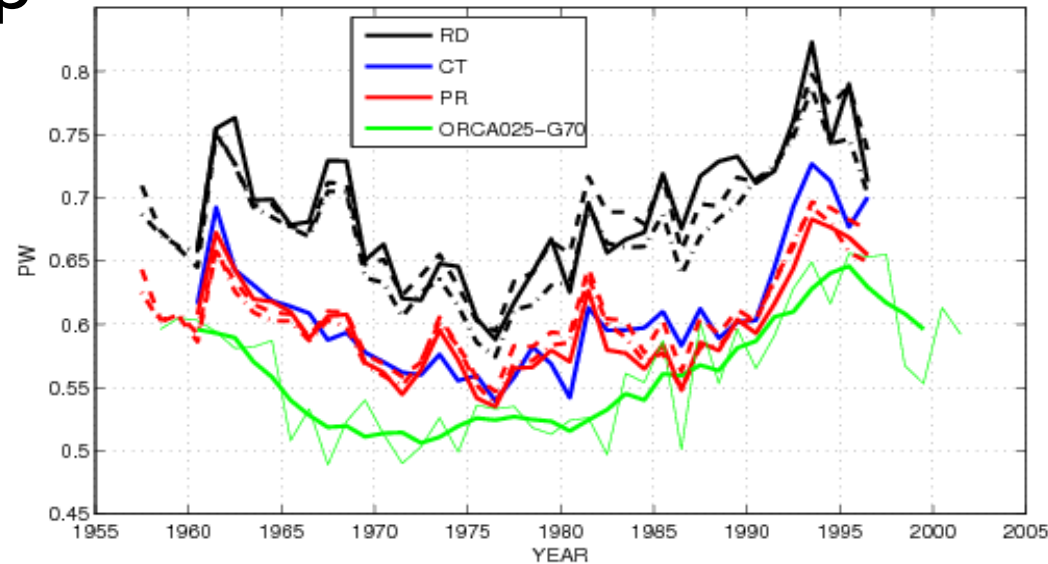
implemented in a $\frac{1}{2}^\circ$ Atlantic configuration with ROMS.

Pentadal TS anomalies from World Ocean Database 2004 (Levitus, NODC) from 1954-1958 to 1994-1998.

Surface forcing from NCEP/ERA40.

Variations of maximum meridional heat transport (MHT), thermohaline circulation (THC) and barotropic streamfunction (BSF) are in phase in the North Atlantic subpolar gyre

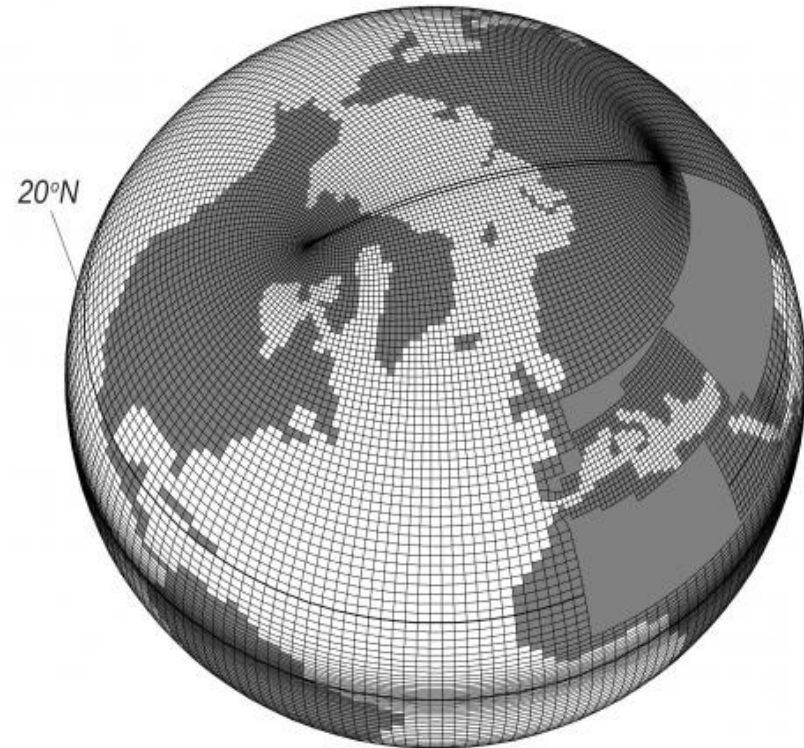
[Huck et al. 2008 GRL]



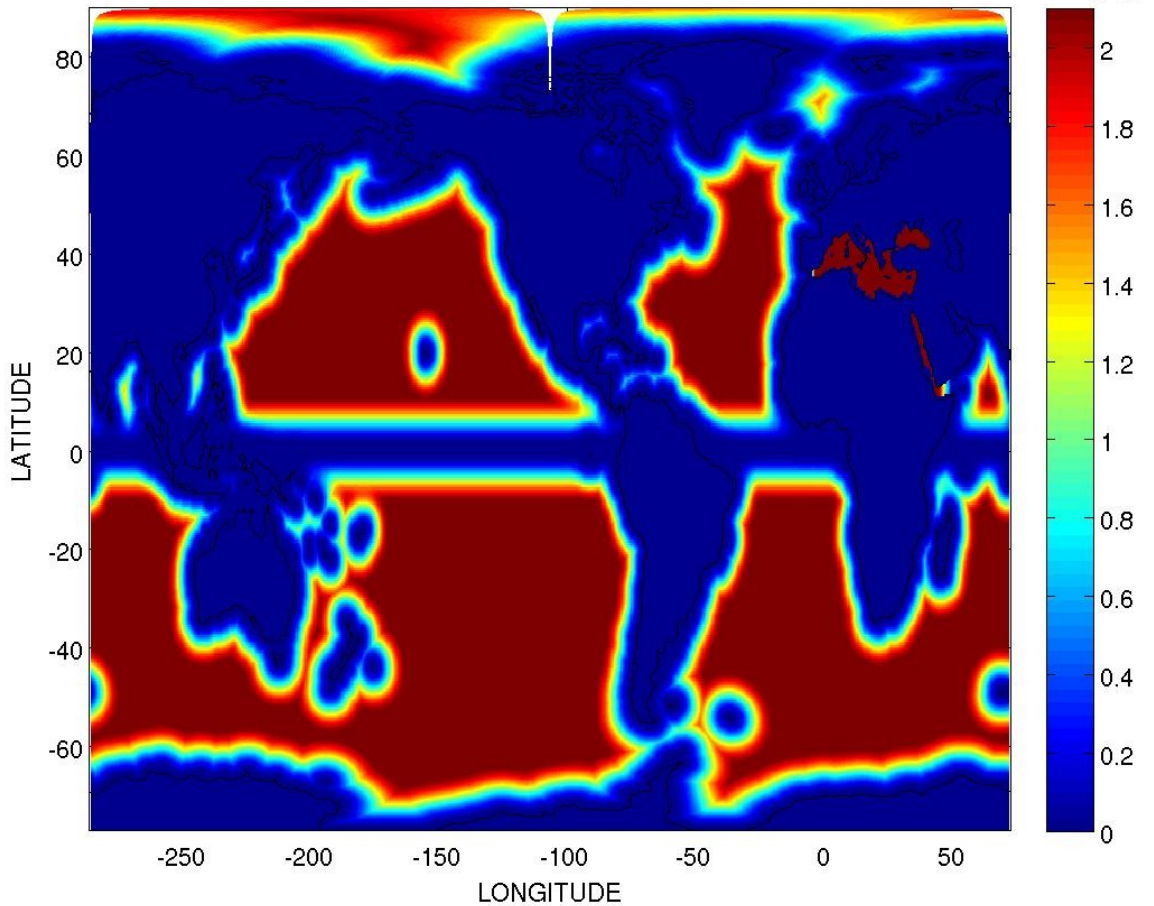
Method

- Ocean General Circulation Model NEMO: global $\frac{1}{2}^\circ$ configuration ORCA05 (Drakkar)
- Atmospheric forcing based on ERA40 reanalysis "DFS4" [Brodeau et al. 2010 OM]
- *robust diagnostic*: 3D restoring with coefficient decreasing with depth and close to bottom and coast [Madec and Imbard 1996 CD]
- temperature/salinity fields for 3D restoring:
 - 1958-96 WOD04 pentadal anomalies 0-3000m + WOA05 seasonal cycle [Levitus et al. 2005; Boyer et al. 2005]
 - 1997-2001 Atlantic: annual fields ARIVO ARRATY1 0-2000m; WOA05 elsewhere
 - 2002-2008 70°S-70°N: monthly fields ARIVO ARRAGL05 0-2000m; WOA05 elsewhere [von Schuckmann et al. 2009 JGR]
- Initial conditions for 1958: 56-60 anomalies

ORCA mesh

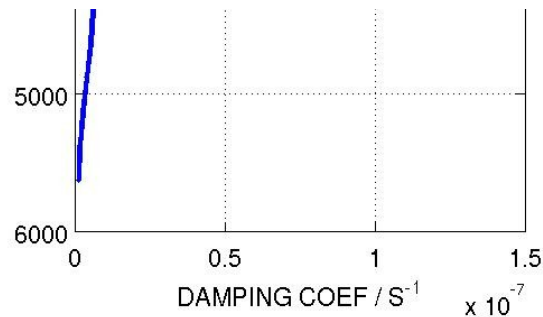
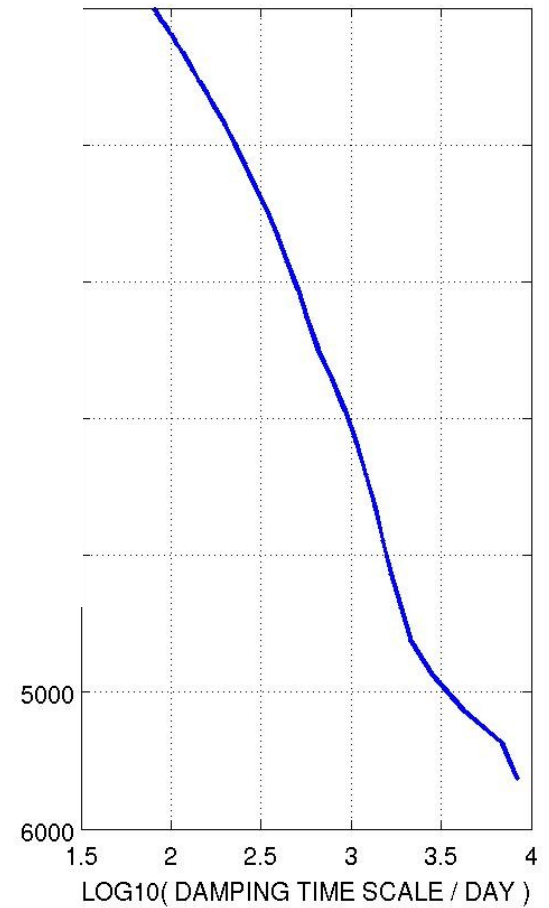


ORCA05-BPB27 DAMPING COEFFICIENT (s^{-1}) $z=94m$

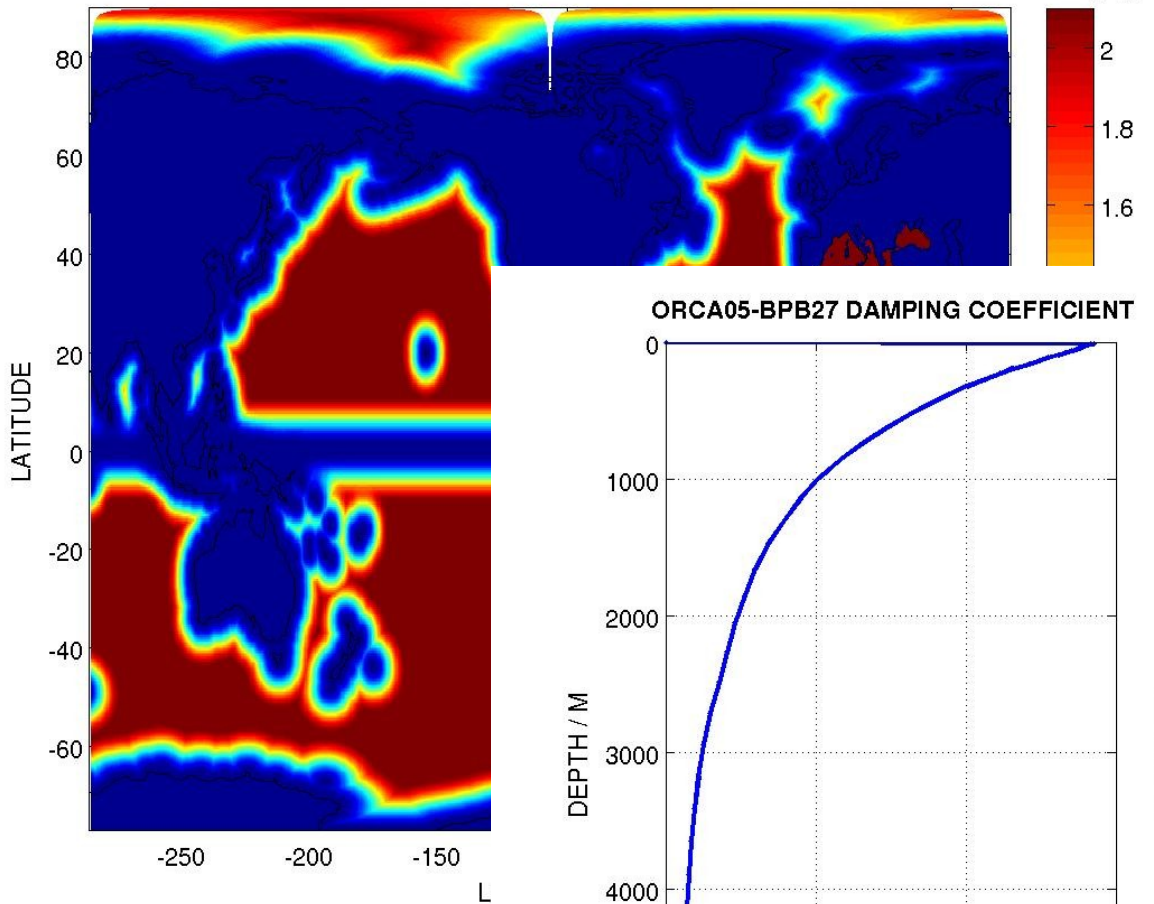


3D restoring coefficient

DAMPING TIME SCALE

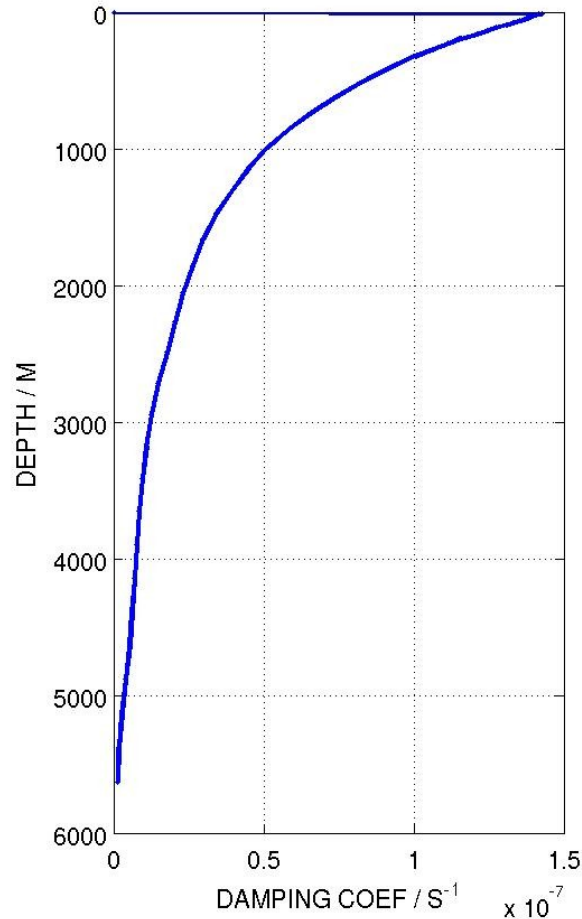


ORCA05-BPB27 DAMPING COEFFICIENT (s^{-1}) $z=94m$

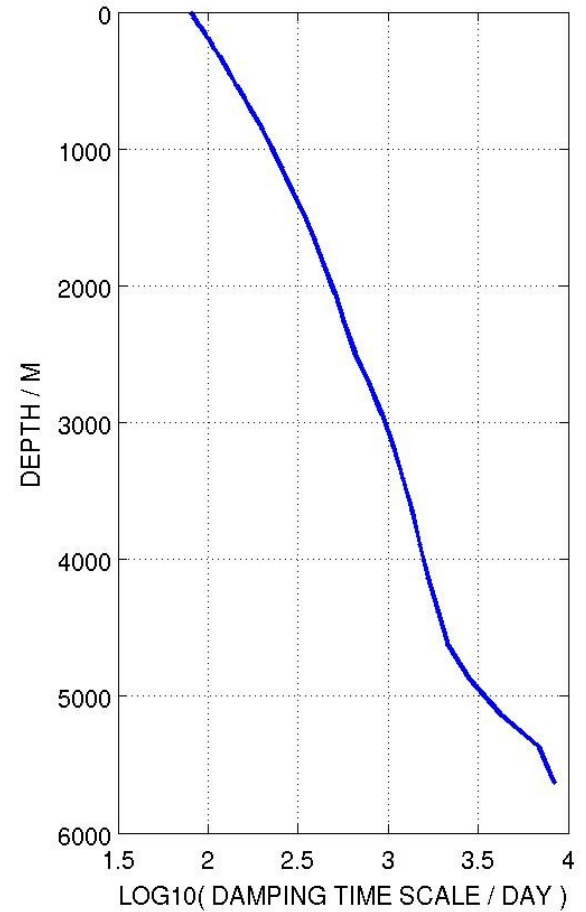


3D restoring coefficient

ORCA05-BPB27 DAMPING COEFFICIENT



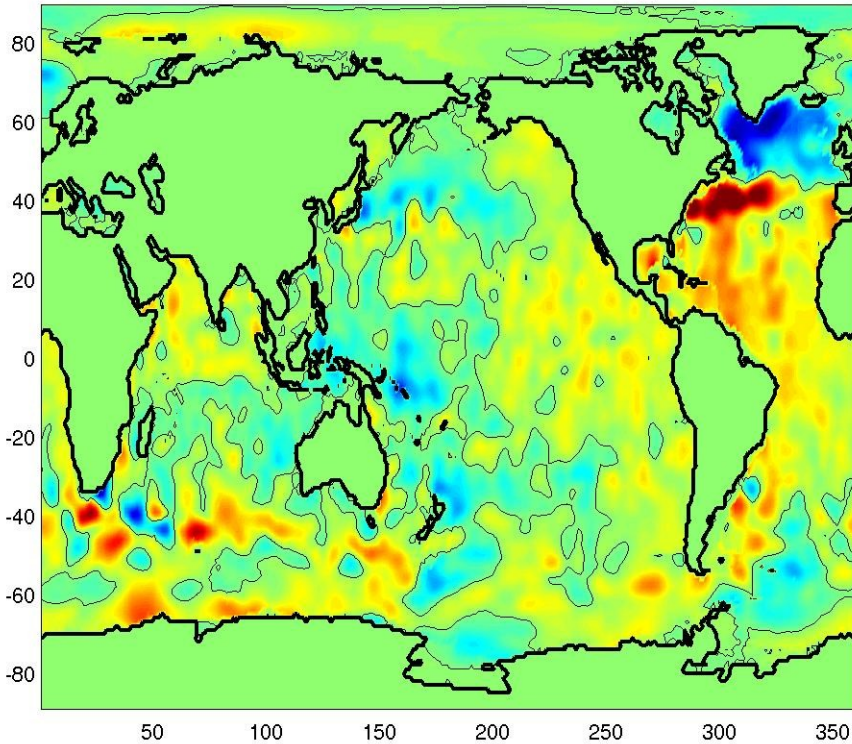
DAMPING TIME SCALE



Heat content trend

PROGNOSTIC:

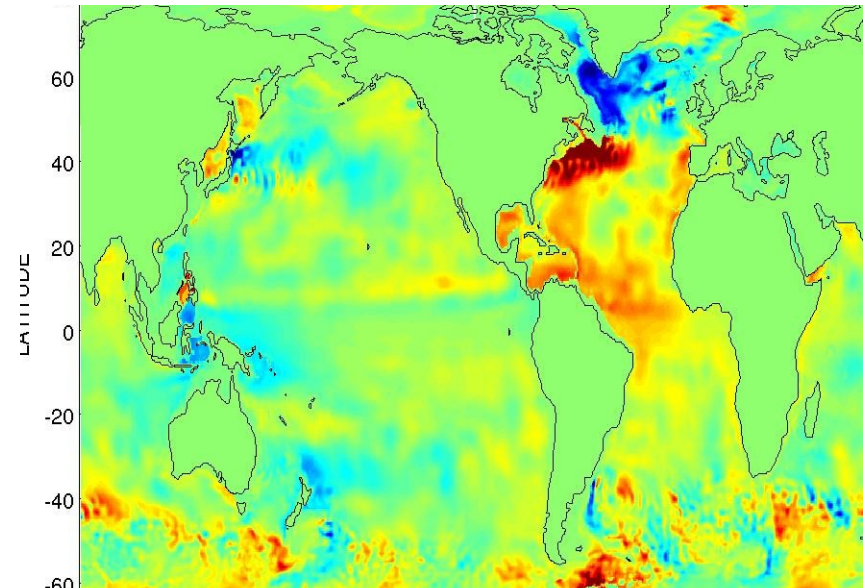
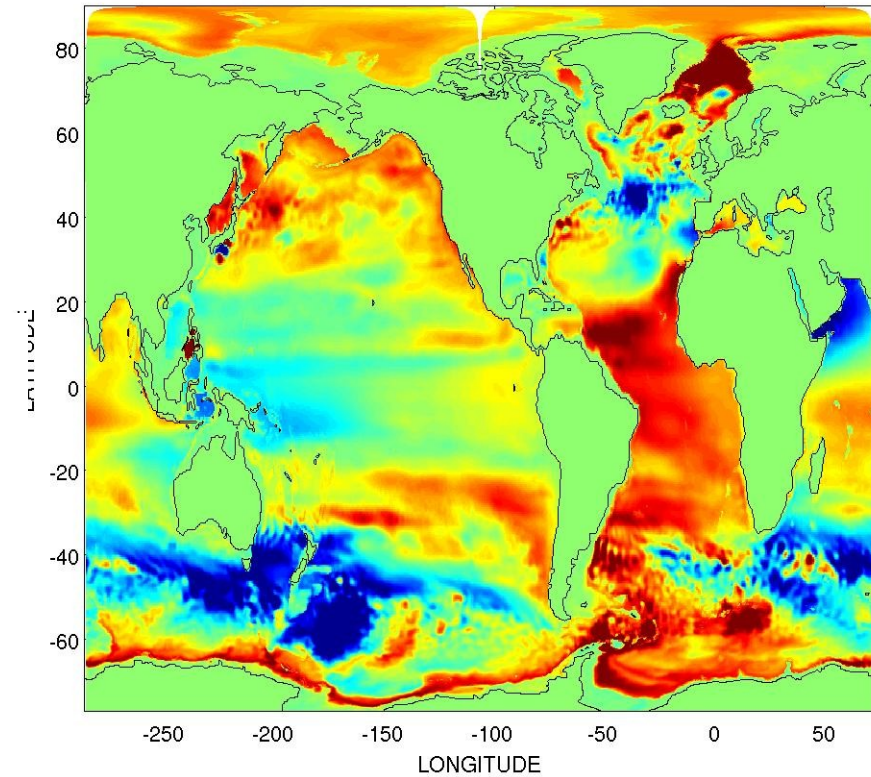
WOD2004 0-3000m HEAT CONTENT TREND 1955-1998 ($\text{J m}^{-2} \text{yr}^{-1}$)

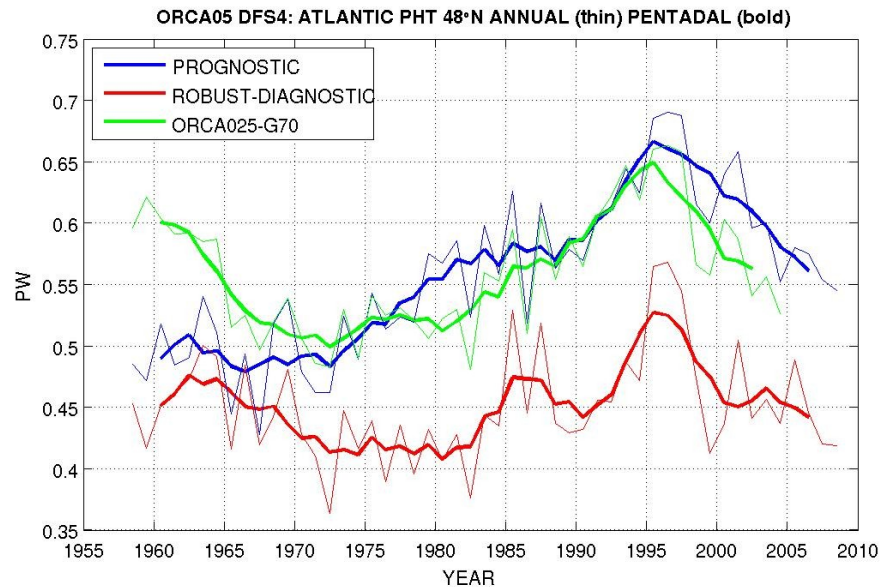
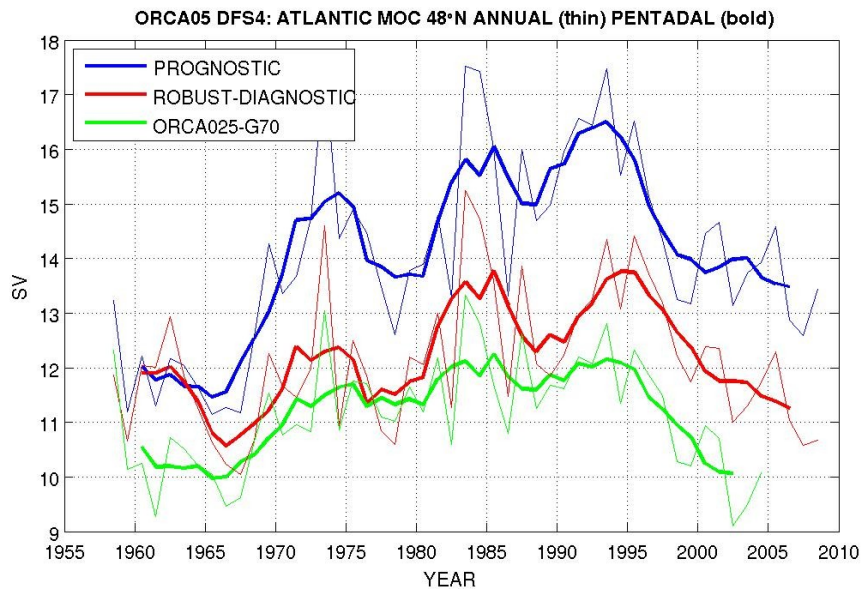


DATA: WOD2004

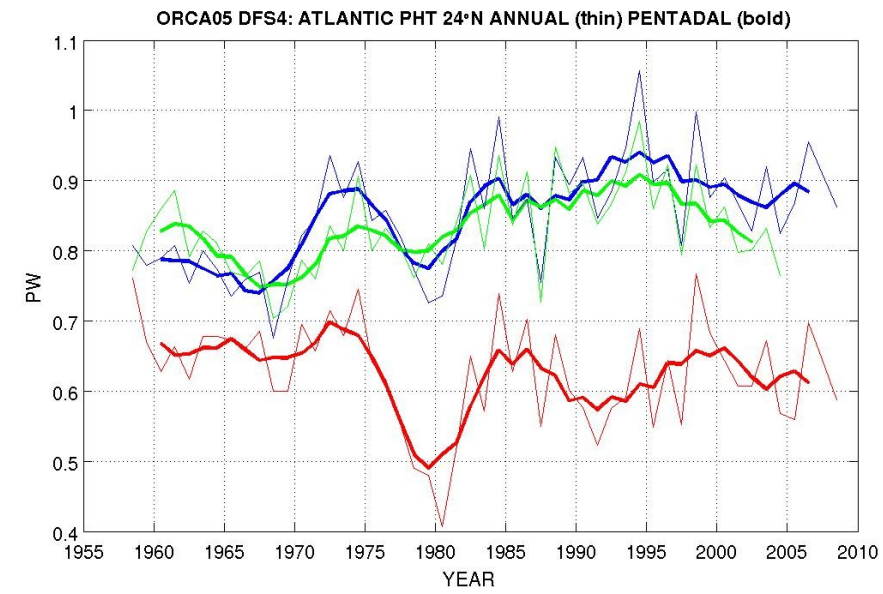
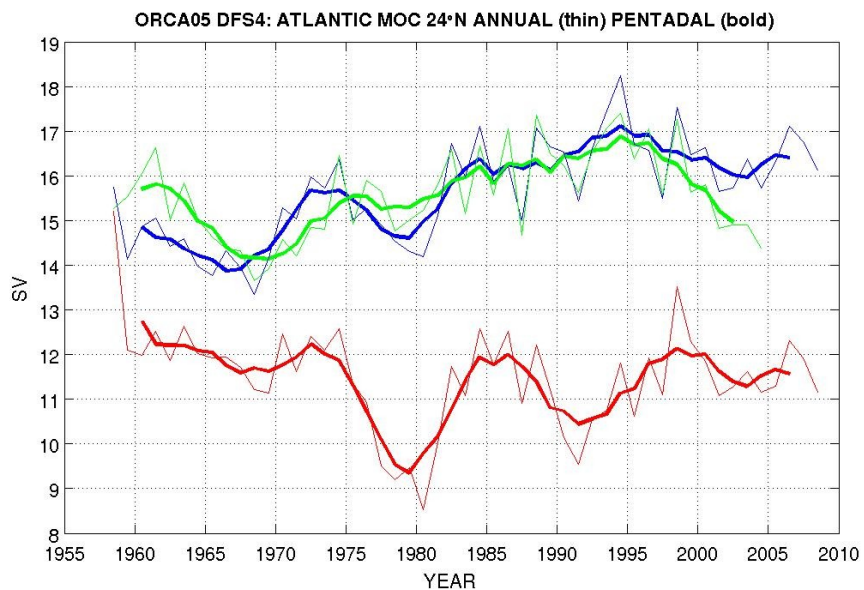
ROBUST DIAGNOSTIC:

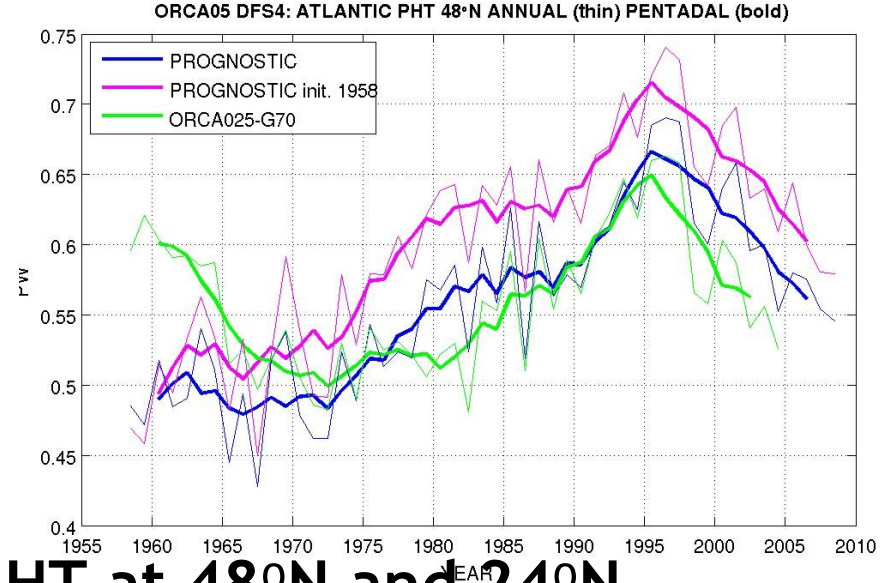
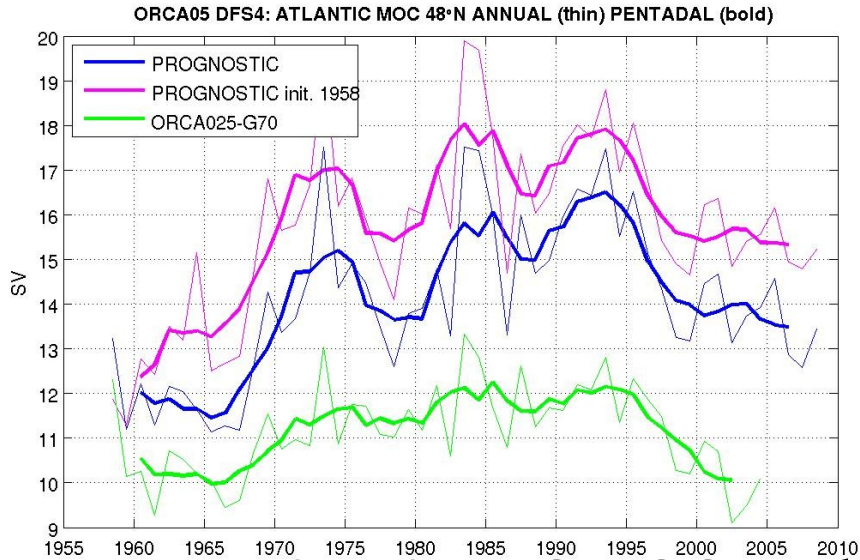
ORCA05-BPB14 HEAT CONTENT 0-3000m TREND 1958-1997 ($\text{J m}^{-2} \text{yr}^{-1}$)





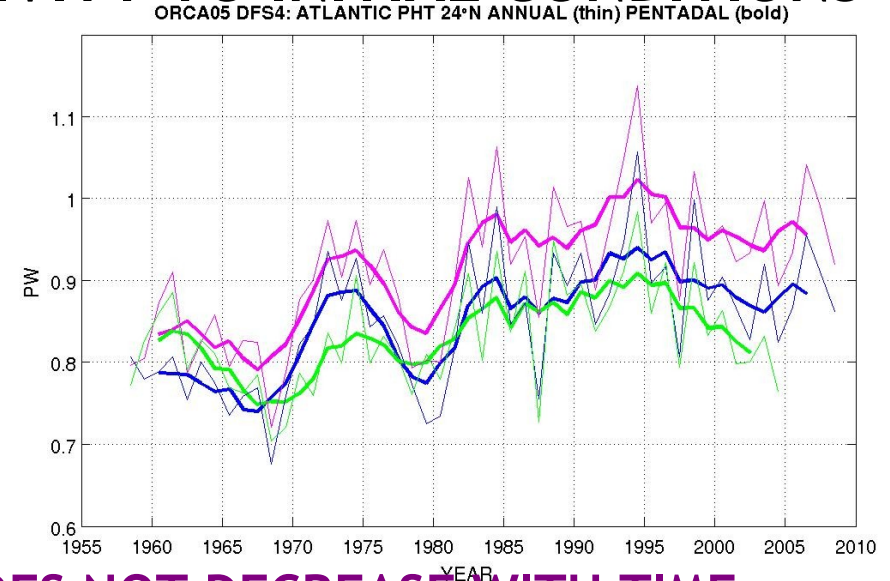
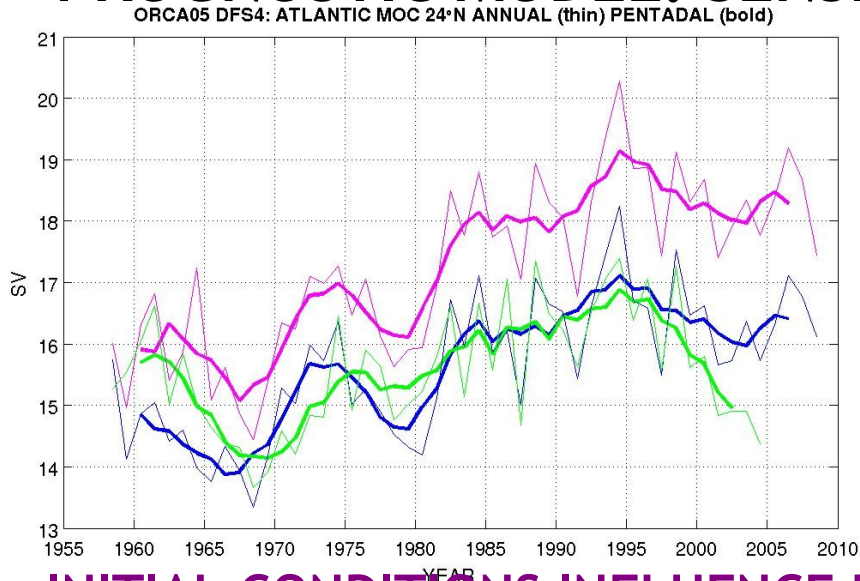
ATLANTIC MOC and MHT at 48°N and 24°N



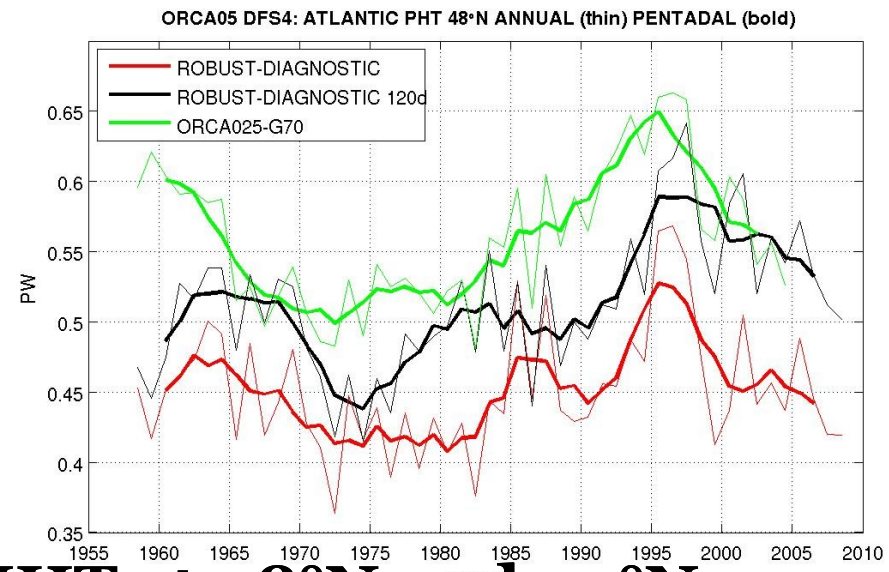
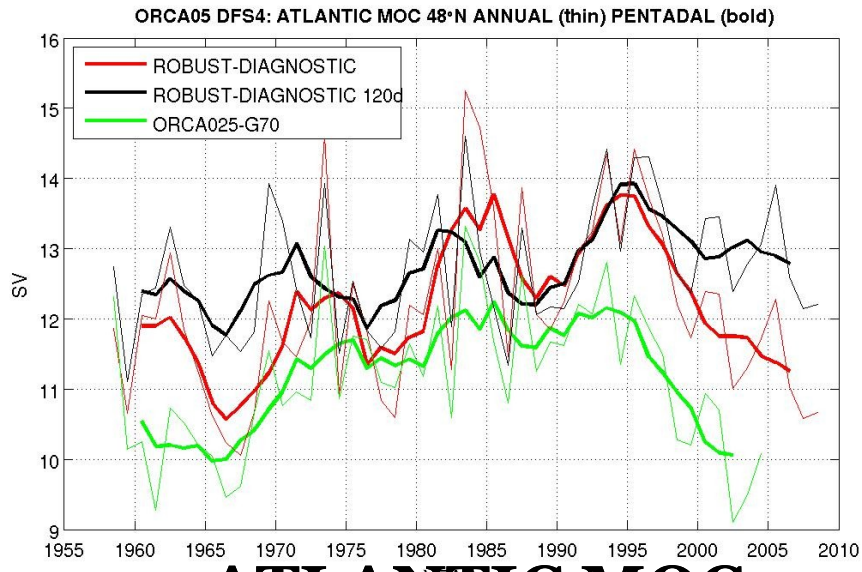


ATLANTIC MOC and MHT at 48°N and 24°N

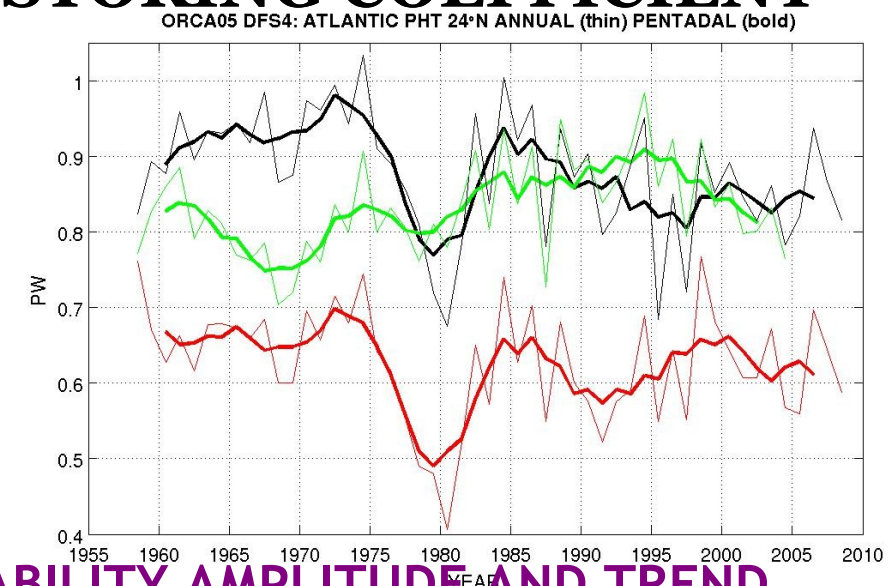
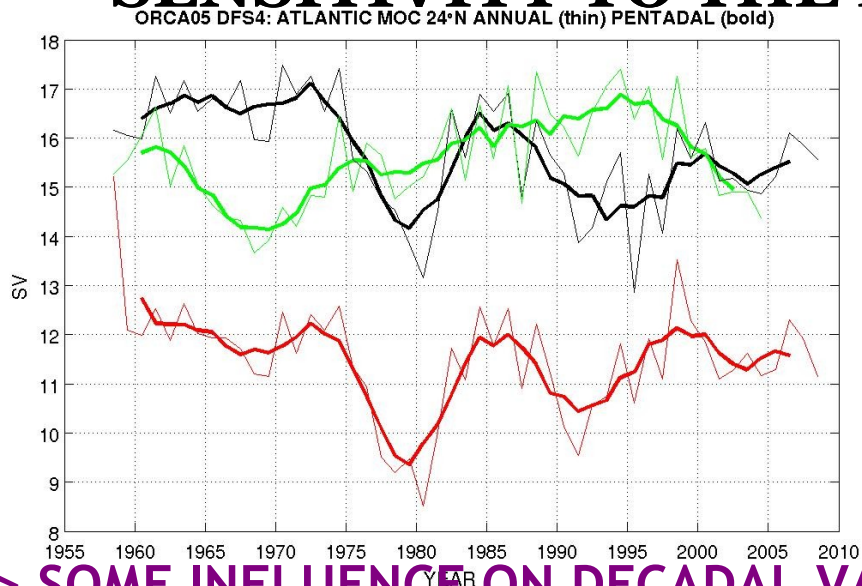
PROGNOSTIC MODEL: SENSITIVITY TO INITIAL CONDITIONS



> INITIAL CONDITIONS INFLUENCE DOES NOT DECREASE WITH TIME



ATLANTIC MOC and MHT at 48°N and 24°N: SENSITIVITY TO THE RESTORING COEFFICIENT



> SOME INFLUENCE ON DECADEAL VARIABILITY AMPLITUDE AND TREND

Conclusion / discussion

(+) Reconstruction of MOC and MHT variations (3 Sv 0.15 PW) associated with the Atlantic Multidecadal Variability (AMO), in relative agreement with prognostic runs: significant reduction of mass and heat transport at 48° N since 1995, opposite to the long-term tendency 1958-2008

(-) Problem/questions

- major influence of model configuration on transports absolute values
- '*spin up*' : prognostic models drift over decades... adjustment vs. response to forcing?
- inhomogeneity of forcing and TS fields over past 50 years...
- influence of hydrology variations below 2000/3000m?

in progress: comparison with hydrology/current measurements on repeated Portugal-Greenland sections Ovide in 2002, 2004, 2006, 2008 and 2010 to estimate the efficiency of the 3D restoring term...