



GEOS-5 system developments for decadal climate prediction

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The GEOS-5 AOGCM for CMIP5

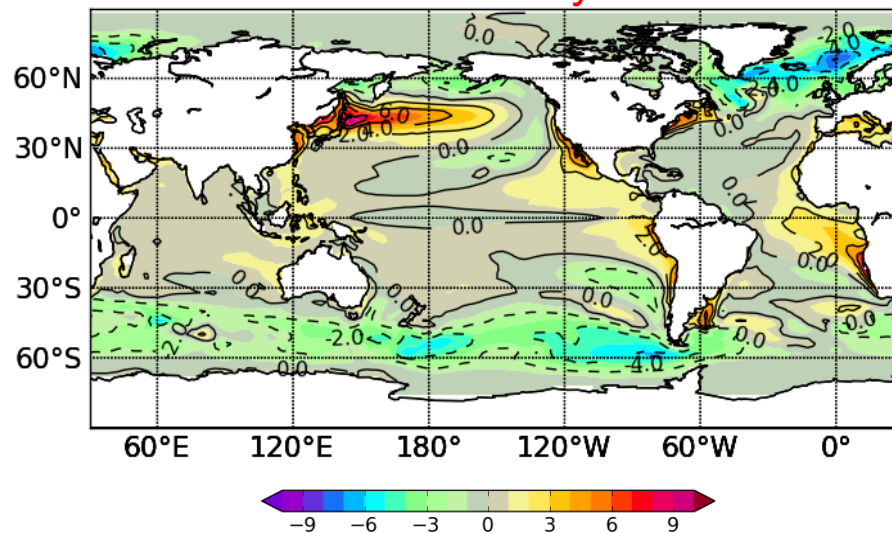
GEOS-5 AGCM	<ul style="list-style-type: none"> ➤ 2° lat. x 2.5° lon. X 72L ➤ surface to 0.01hPa ➤ Finite Volume Dynamical Core ➤ RAS convection scheme with stochastic Tokioka ➤ Bacmeister et al. prognostic clouds ➤ Chou-Suarez radiation ➤ Louis and Lock PBL schemes ➤ Monin-Obhukov type surface turbulence scheme ➤ Catchment Land Surface Model ➤ CMIP5 prescribed forcings 	<p>Lin et al. (2004) Bacmeister et al. (2006) Moorthi and Suarez (1992) Lock et al. (2000) Louis (1982) Chou and Suarez (1999) Chou et al. (2001) Koster et al. (2000)</p>
GOCART Aerosols	<ul style="list-style-type: none"> ➤ Dust: 5 bins ➤ Sea-salt: 5 bins ➤ Organic carbon: hydrophobic & hydrophilic tracers ➤ Black carbon: hydrophobic & hydrophilic tracers ➤ Sulfates: SO₂, SO₄, DMS, MSA 	<p>Colarco et al. (2010)</p>
OGCM: MOM4	<ul style="list-style-type: none"> ➤ MOM4p1 ➤ 1/2° lat. x 1/2° lon. with 1/4° equatorial refinement ➤ 40 vertical levels ➤ Tripolar grid ➤ z coord; conservative temp., KPP+tidal mixing 	<p>Griffies et al. (2004) Large et al. (1994)</p>
CICE v4.1	<ul style="list-style-type: none"> ➤ Sea-ice thermodynamics ➤ Sea-ice dynamics and advection ➤ Ridging parameterization 	<p>Hunke and Lipscomb (2010)</p>

Air-sea coupling interval: 30 minutes

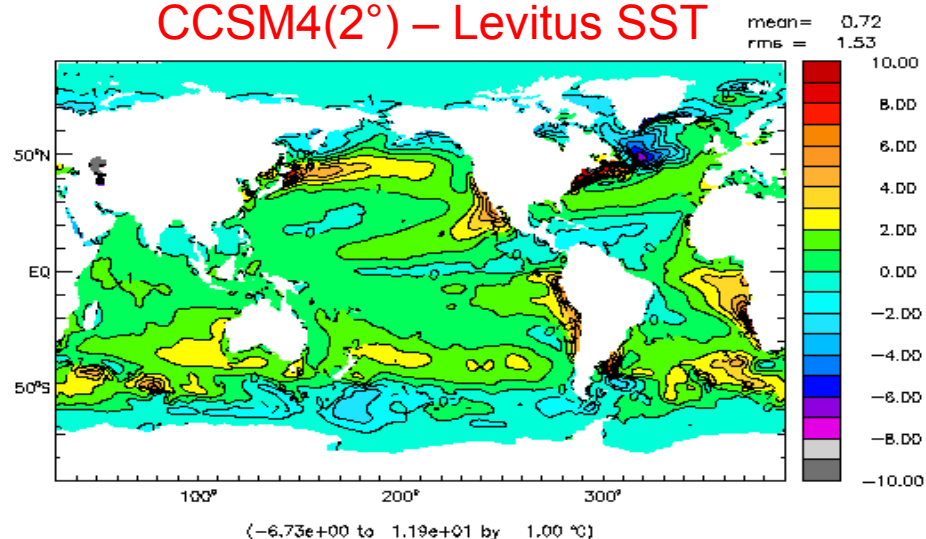
Annual Mean Model Bias

mean: -0.07
std: 1.86

GEOS-5 – Reynolds SST

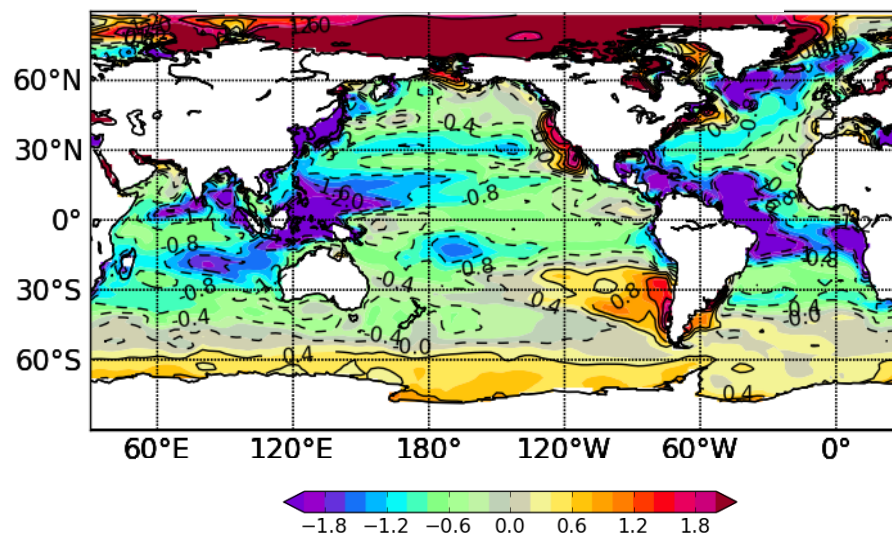


CCSM4(2°) – Levitus SST

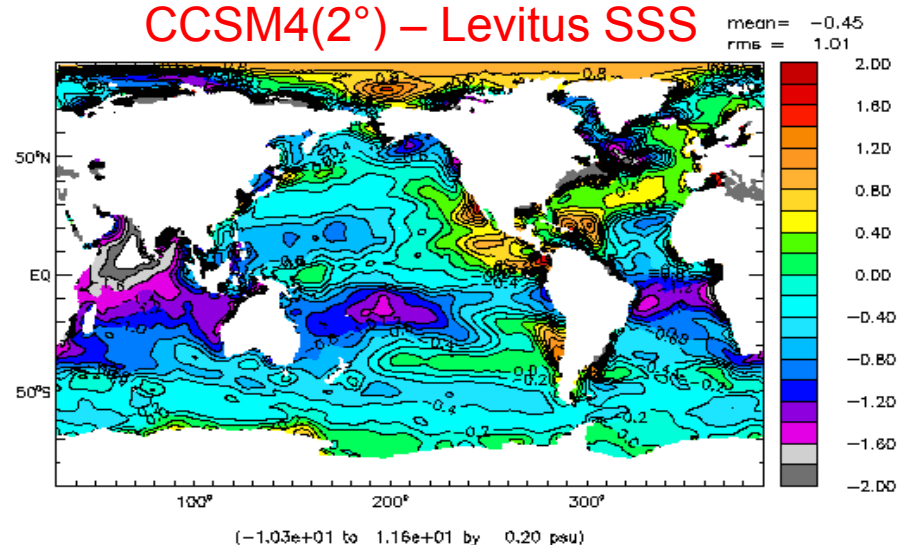


mean: -0.44
std: 1.75

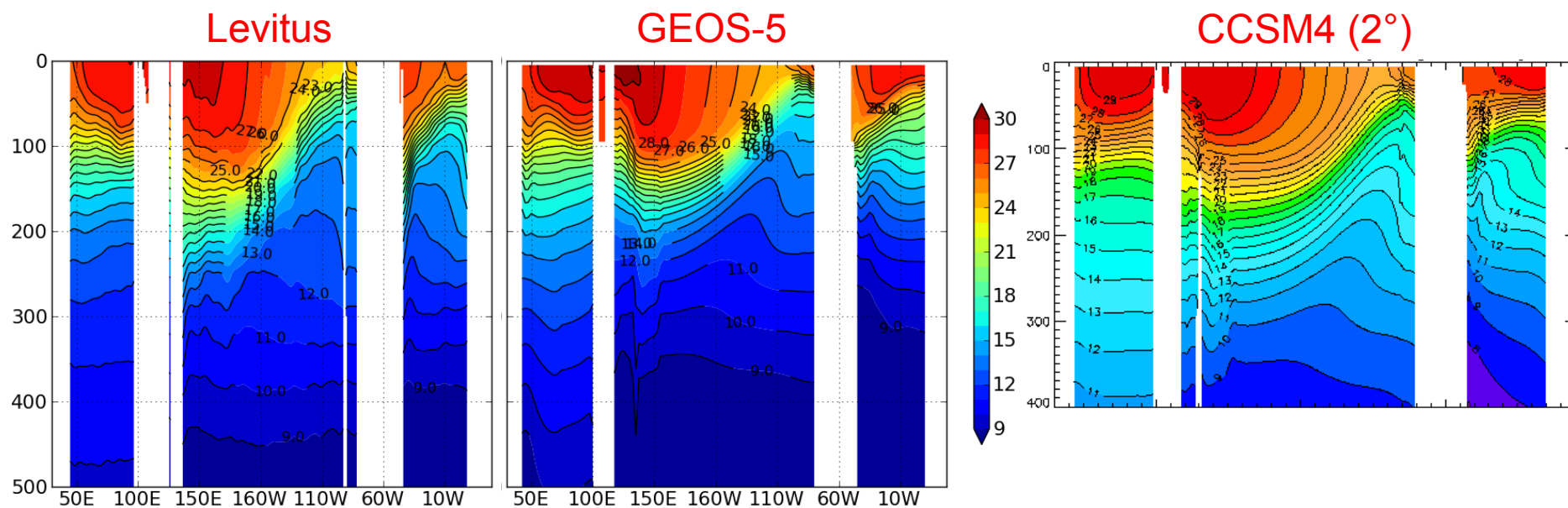
GEOS-5 – Levitus SSS



CCSM4(2°) – Levitus SSS

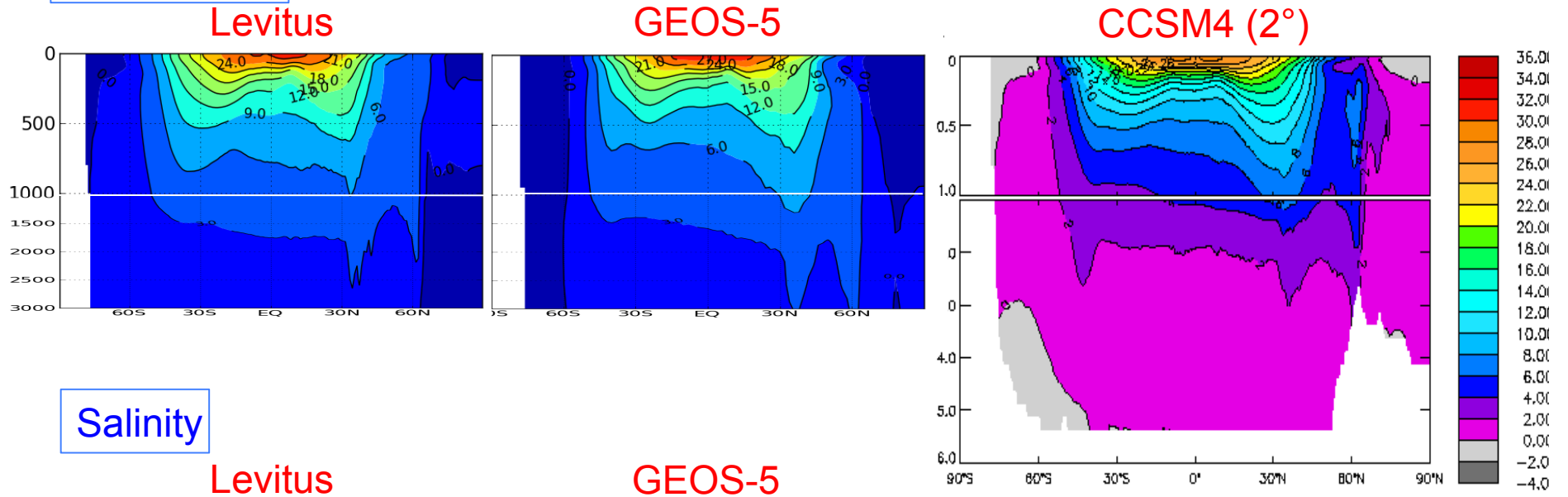


Annual Mean Equatorial Temperature

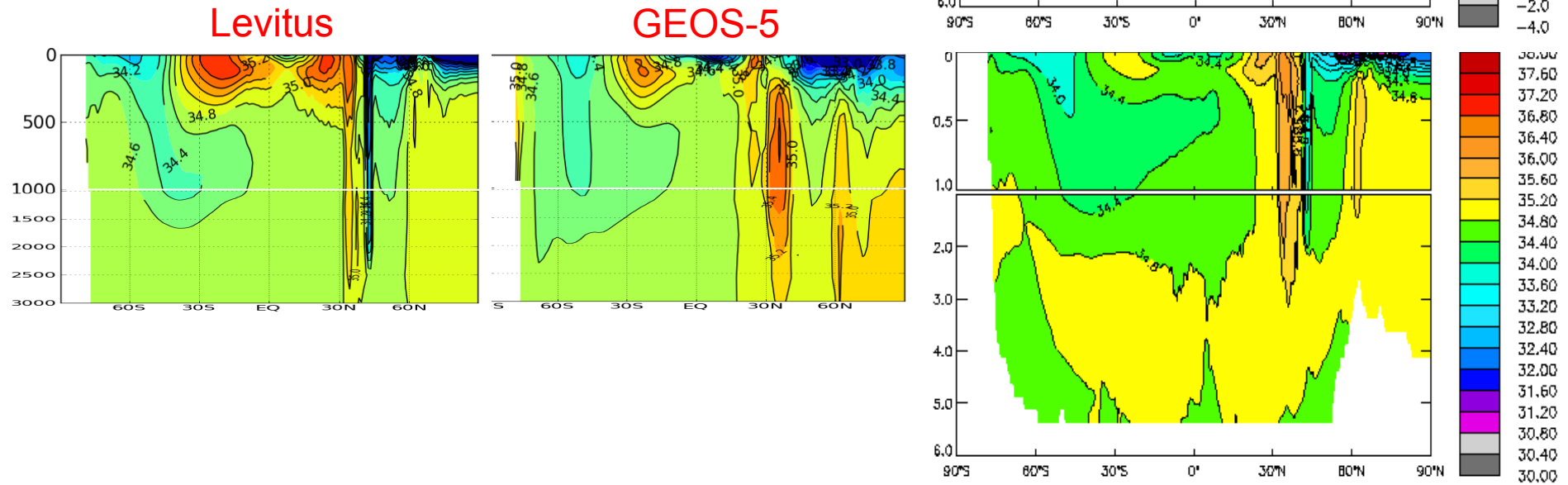


Annual Zonal Mean Structure

Temperature

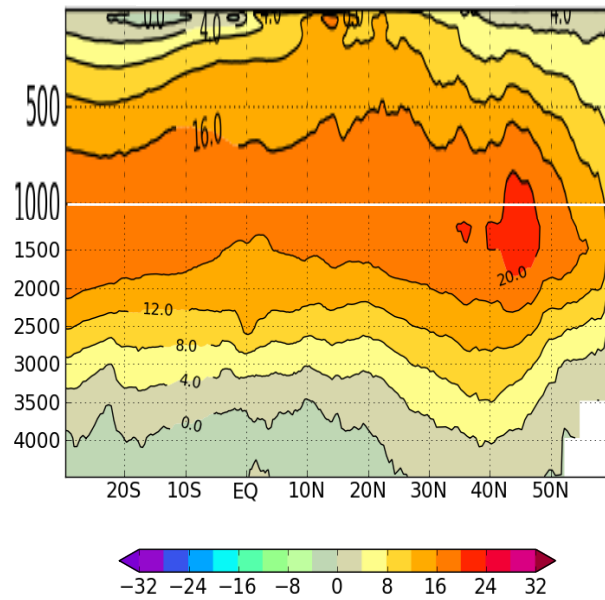


Salinity

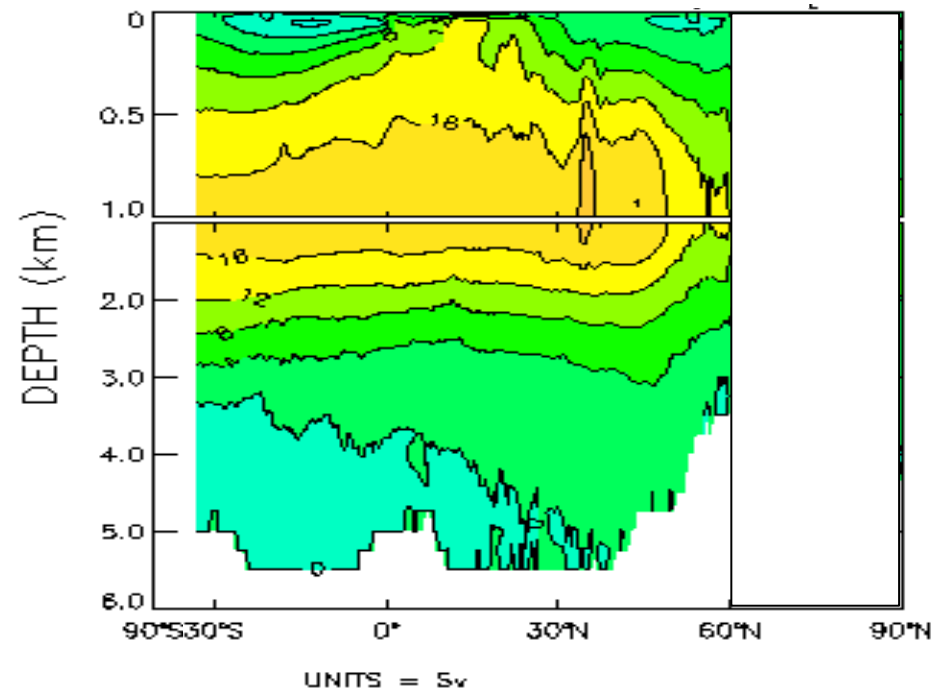


AMOC

GEOS-5



CCSM4 (2°)





Coupled A-L-O-S initialization of decadal predictions

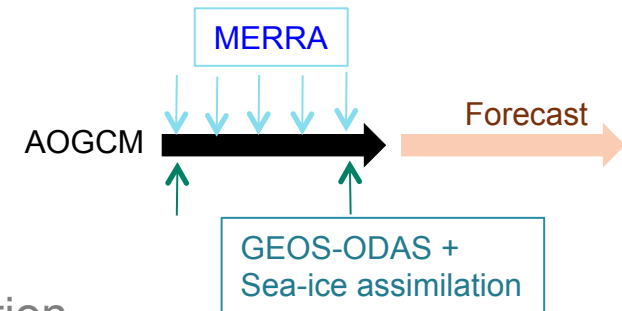
Atmosphere constrained by MERRA every 6 hours

- Precipitation rescaled to GPCP for LSM

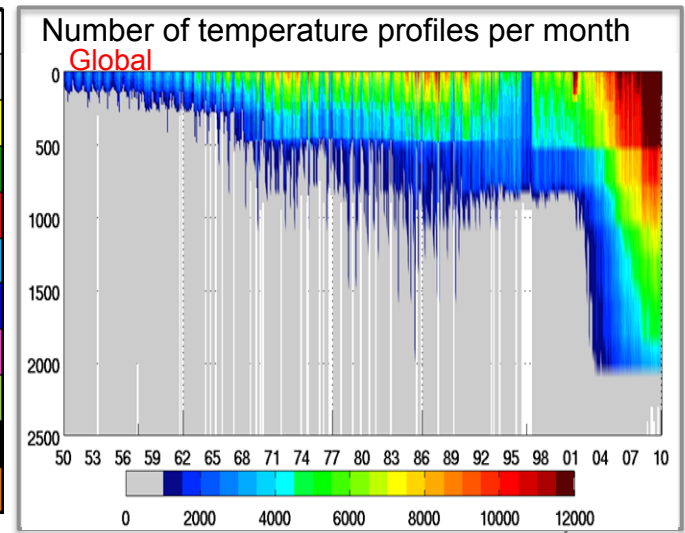
Ocean: daily assimilation

- Ensemble Optimal Interpolation (EnOI)
- State dependent localization based on density
- 1960 to present

Sea-ice: daily assimilation of sea-ice concentration used to constrain mixed layer temperature and salinity



1950's	1960's	1970's	1978	1979	1980	1982	1984	1986	1988	1990	1992	1994	1996	1998	2000	2002	2004	2006	2008	2010
Levitus T and S (5% of global profiles, randomly chosen)																				
CMIP AICE				NSIDC AICE																
CTD T and S																				
XBT T and S (Temperature profiles corrected à la Levitus; synthetic salinity profiles)																				
CMIP SST						Reynolds SST														
					TAO T and S (Synthetic salinity profiles)															
															SLA from Topex, Jason-1 and Jason-2					
														Argo T & S						
														PIRATA T and S						
																	RAMA T and S			

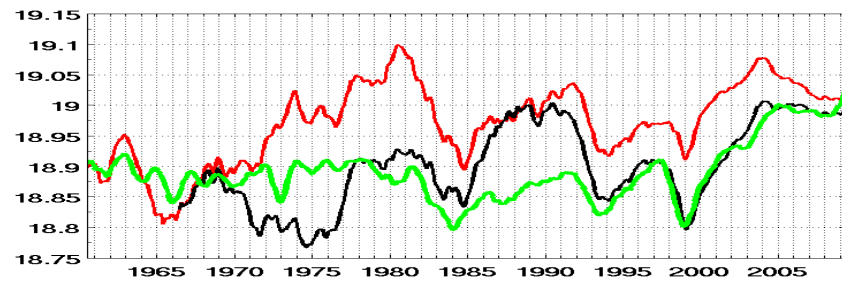


Tav 300m

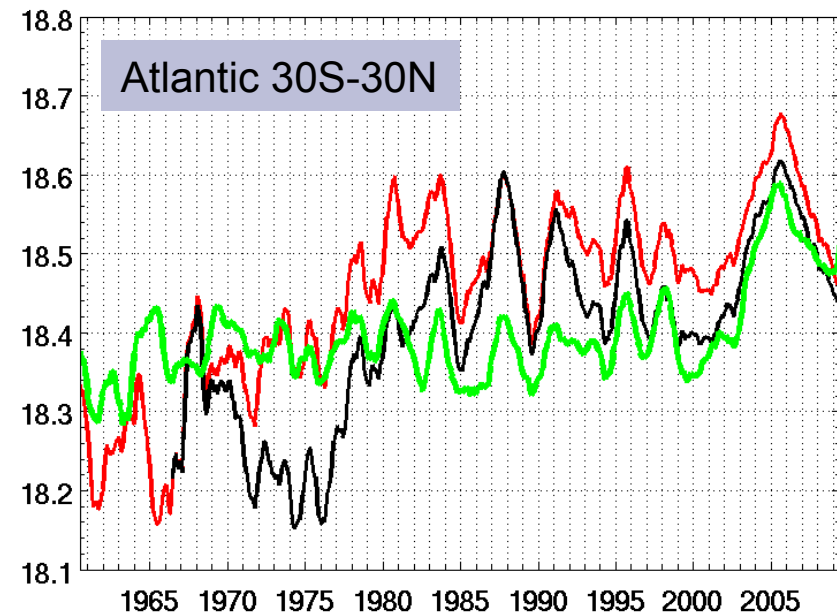
— En3 UnCorrected
— En3 Corrected
— GMAO

*EN3 data and analyses courtesy of
Simon Good, UKMO*

Global 30S-30N

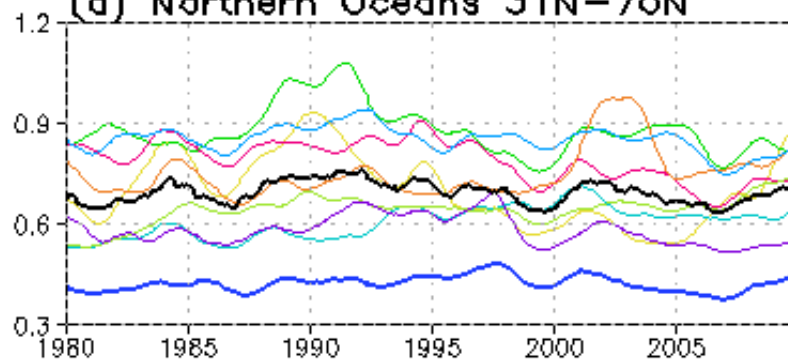


Atlantic 30S-30N

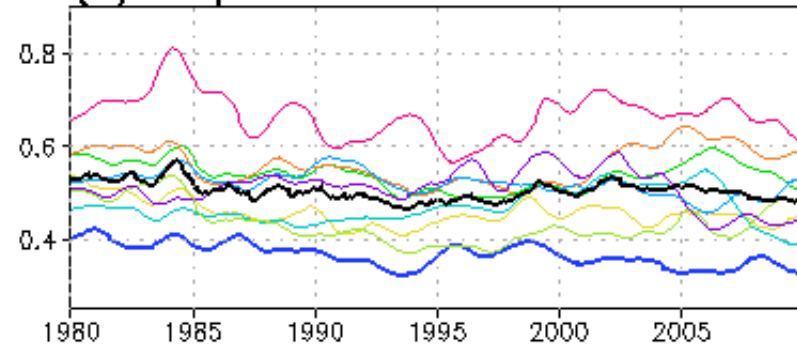


From Yan Xue: RMSD of ocean analyses from EN3 (uncorrected)

(d) Northern Oceans 31N-70N

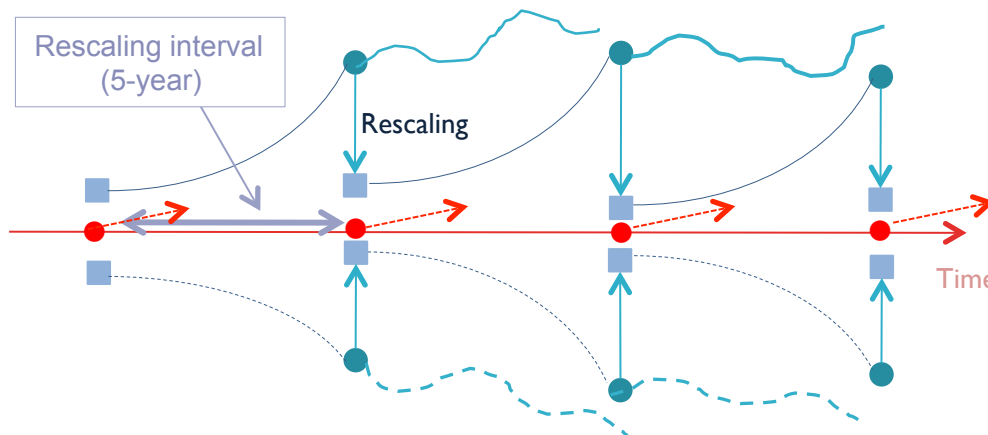


(c) Trop. Atlantic 30S-30N

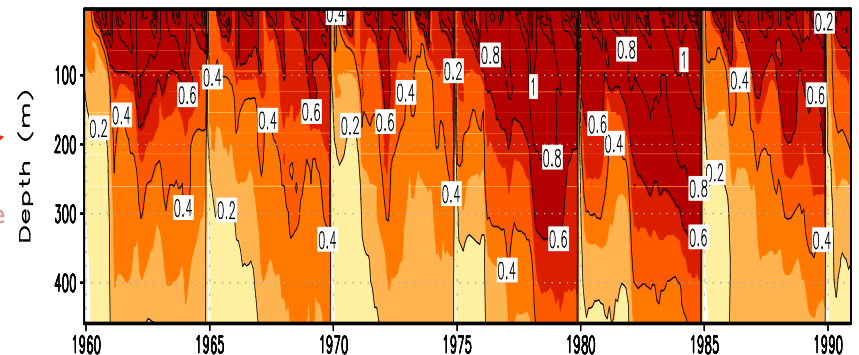


Generation of Ensemble Perturbations

- Method : **Two-sided breeding**
- Norm variable : **HC500 (Averaged Temperature 0-500m)**
- Norm Regions : **Atlantic ocean (100W-20E, 20N-70N)**
- Initial BV magnitude : **Reduced to 10% of natural variability**
- Rescaling Interval : **5 years**
- Period : **Jan. 1954 – Dec. 2010**



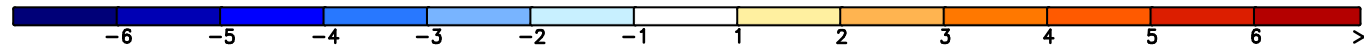
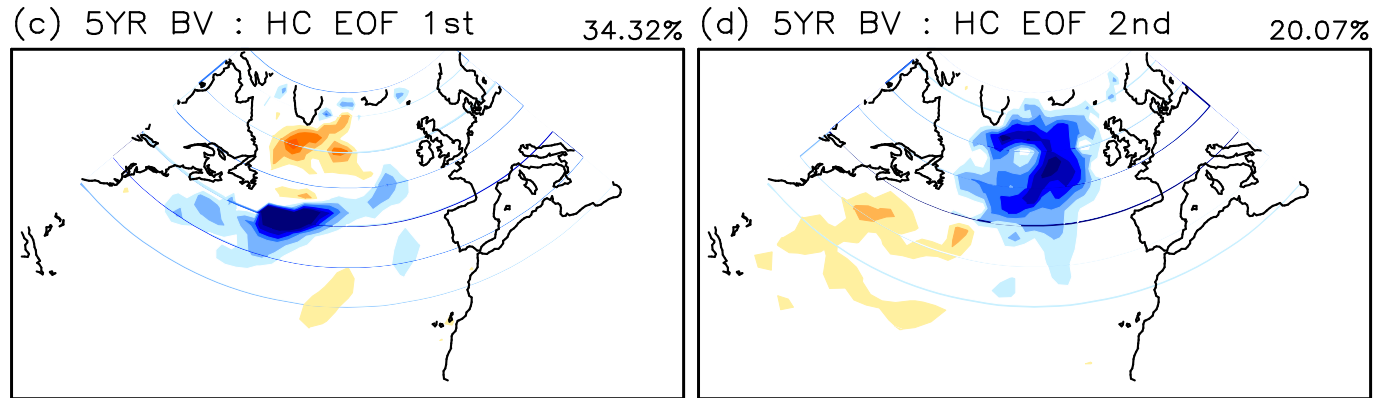
RMS difference between BVs over the Atlantic



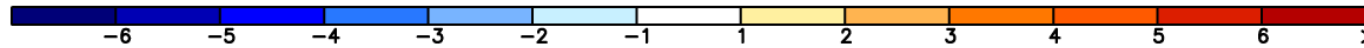
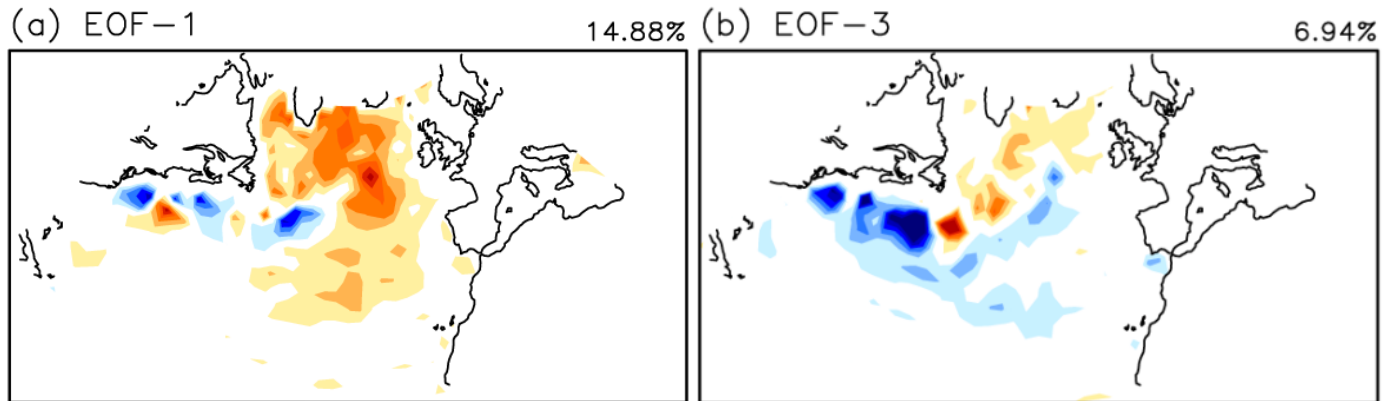
- IC: A-L-O-S Reanalyses
- Bred Vectors
- Perturbation from BV

EOFs of HC500

Bred
Vectors

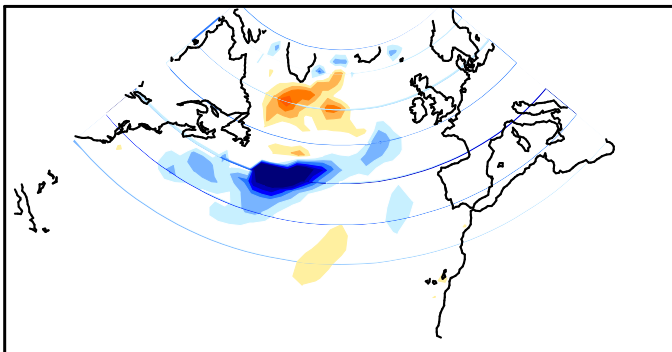


Ocean
Analysis



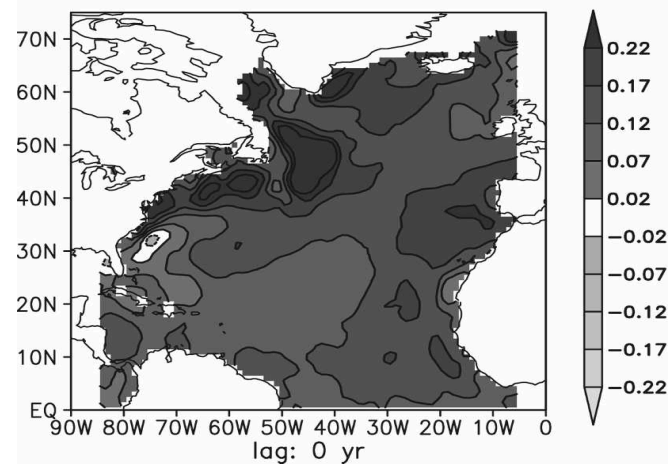
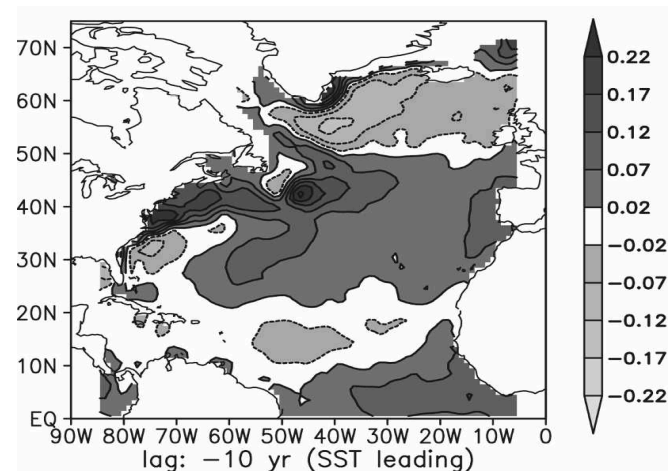
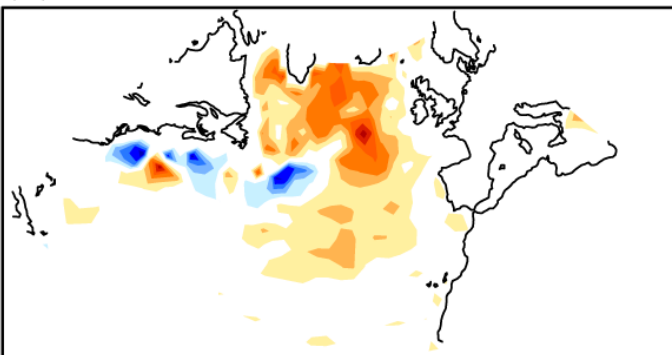
Bred Vectors

(c) 5YR BV : HC EOF 1st 34.32%



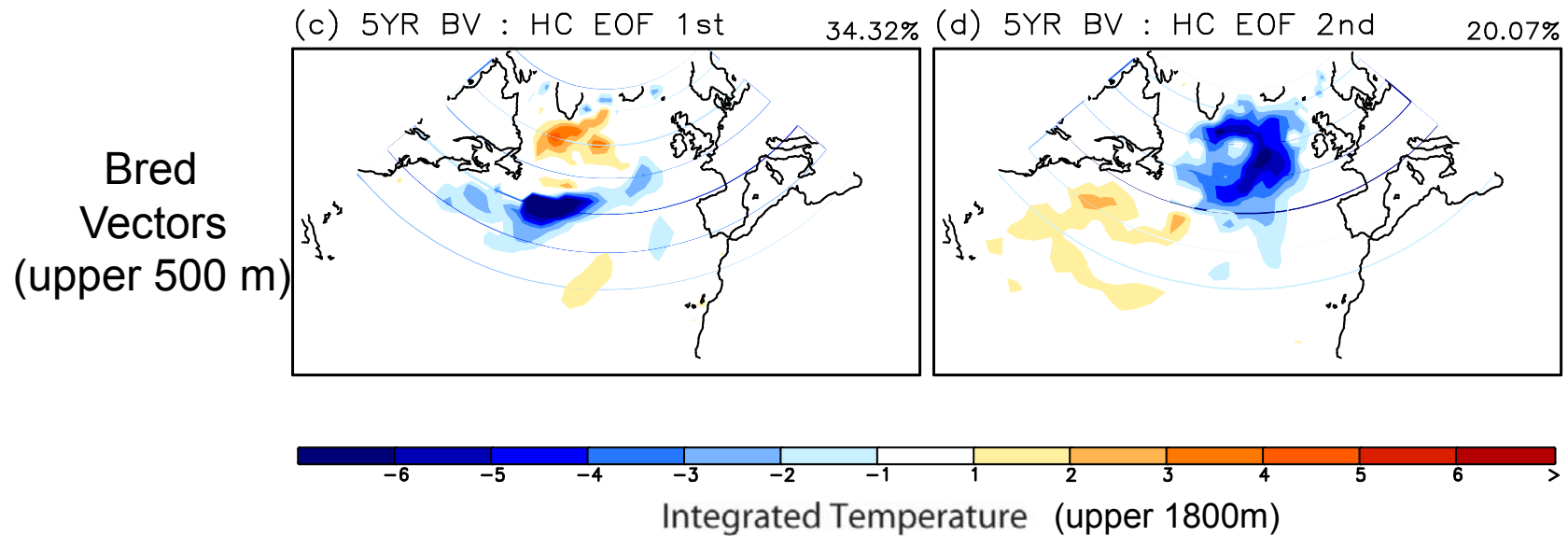
Ocean Analysis

(a) EOF-1 14.88%

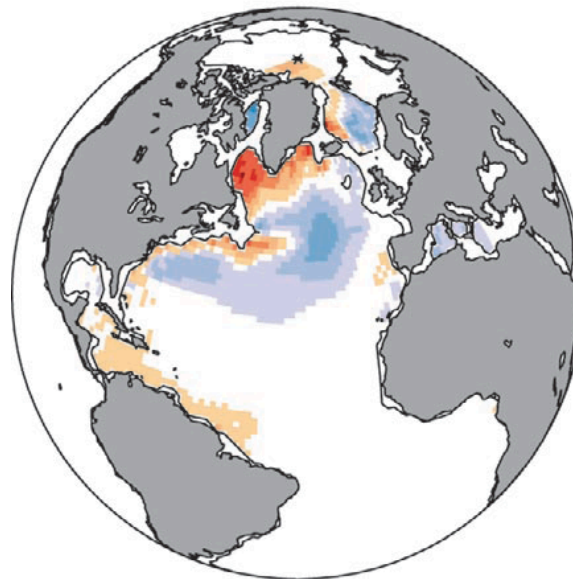


Lagged regression of SST anomaly (from HadISST1.1 1870–2004) on the *multidecadal* reconstruction of the North Atlantic basin-average SST anomaly. Units are °C per standard deviation of the latter time series *from Alvarez-Garcia et al. 2008*

Leading BV modes and optimal perturbation



Optimal perturbation
from the HadCM3
model (Hawkins and
Sutton 2009)

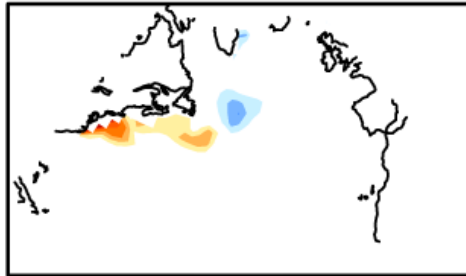


GEOS-5 Decadal Climate Predictions an early look...

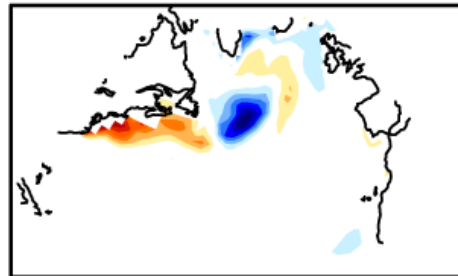
- Forecast period : 5 years
- Initialization from 1 December
- Number of hindcasts : 9 (every 5 year from Dec. 1959)
- Number of ensemble members : 2 (+/- pair of 5yr BVs)
- Validating observations : GEOS Ocean Reanalysis
- **No Volcanic emissions**

Climatological Drift - Annual Mean HC500

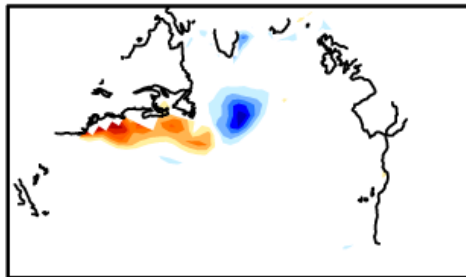
(a) 1yr Lead Forecast



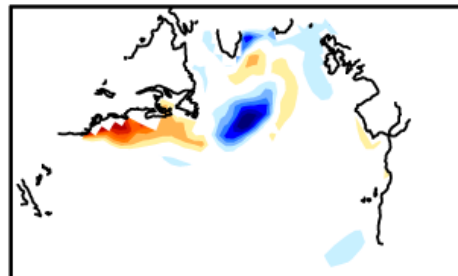
(c) 3yr Lead Forecast



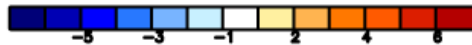
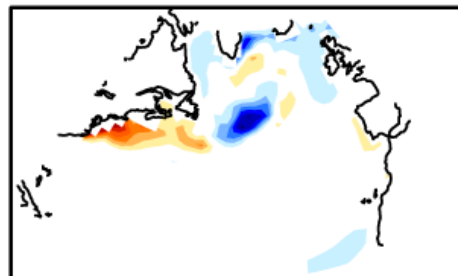
(b) 2yr Lead Forecast



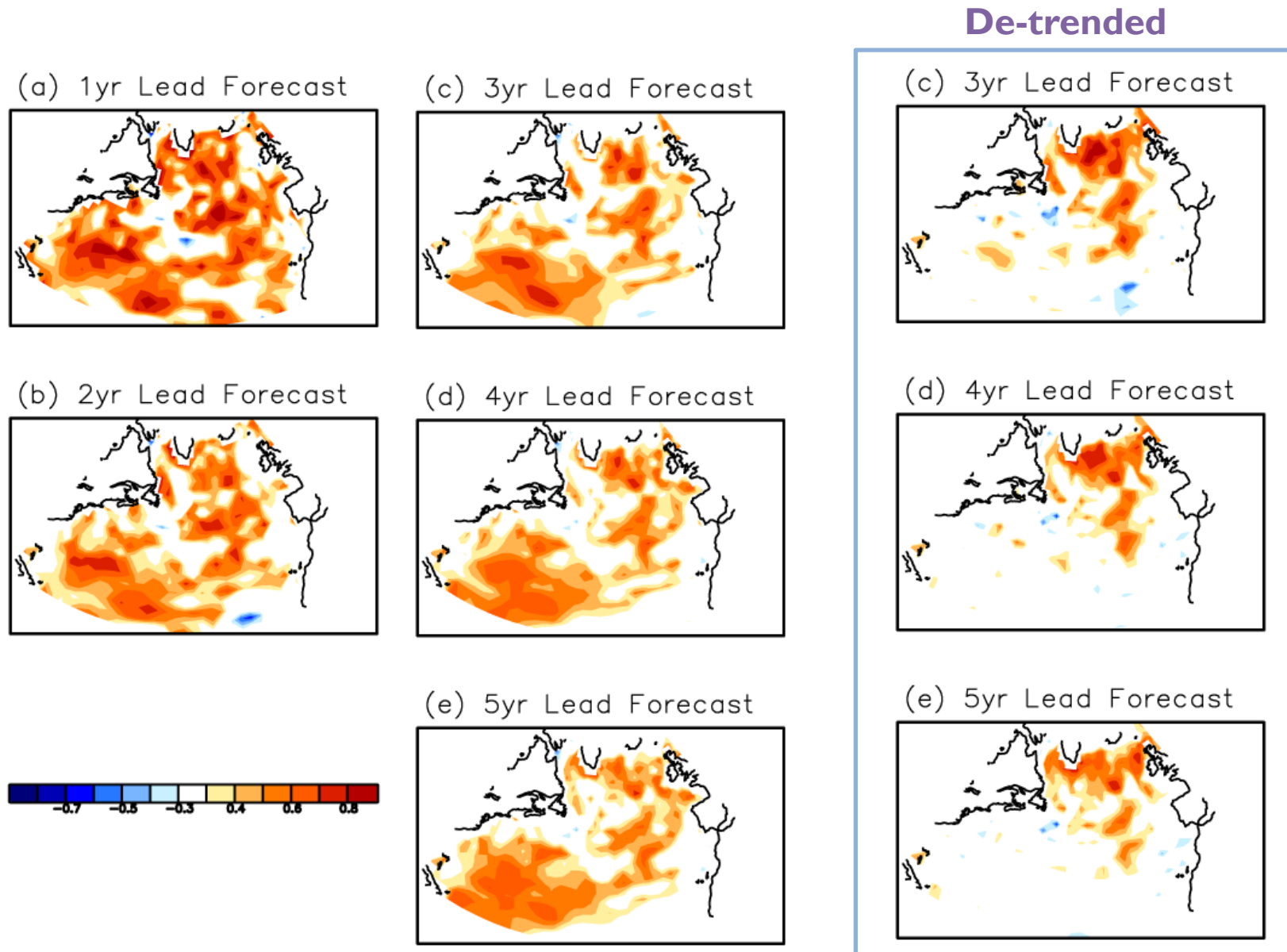
(d) 4yr Lead Forecast



(e) 5yr Lead Forecast



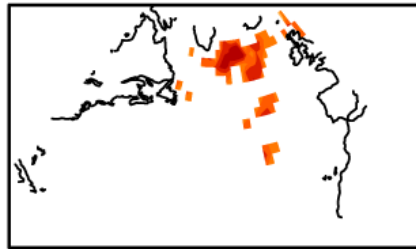
ACC for Annual Mean Forecast HC500



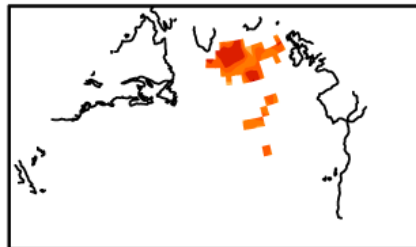
ACC for Annual Mean Forecast HC500

Dynamical Prediction

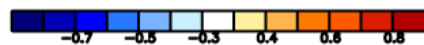
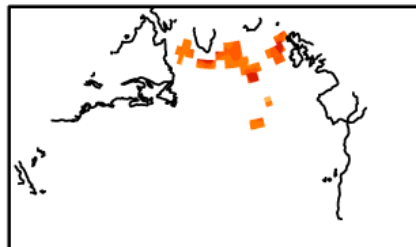
(c) 3yr Lead Forecast



(d) 4yr Lead Forecast

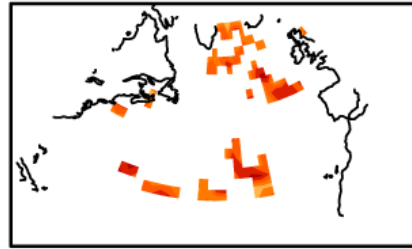


(e) 5yr Lead Forecast

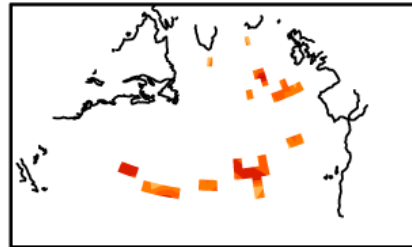


Persistence forecast

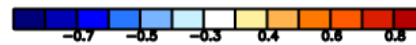
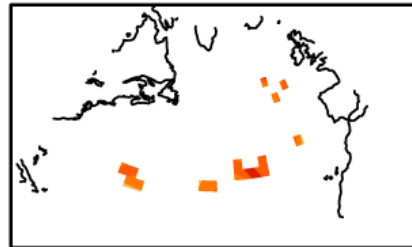
(c) 3yr Lead Forecast



(d) 4yr Lead Forecast

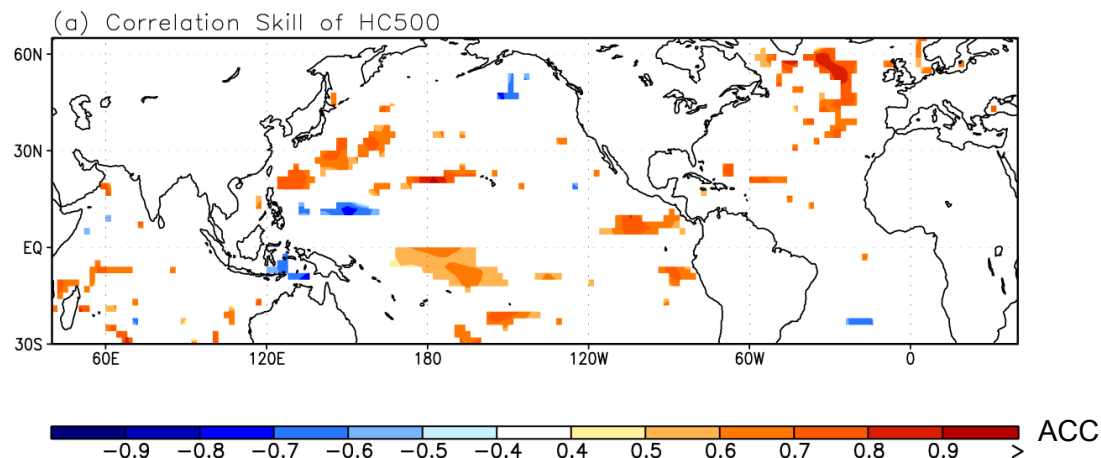


(e) 5yr Lead Forecast



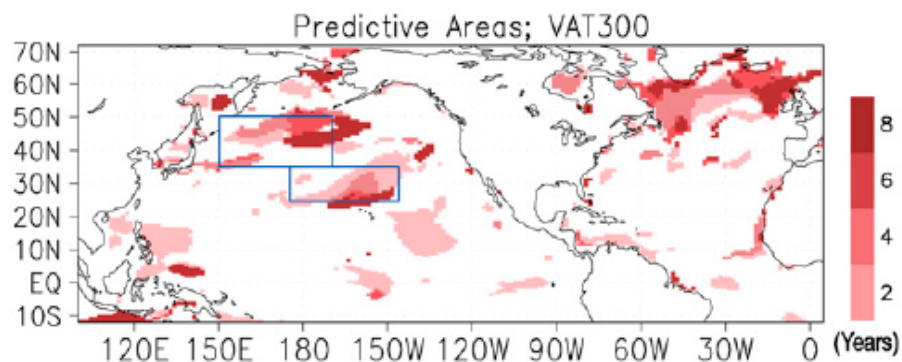
Forecast skill of upper ocean heat content

GMAO
HC500
5-yr average



JAMSTEC
HC300

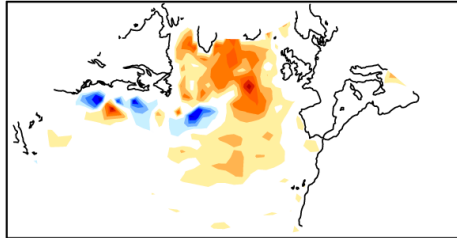
From Mochizuki et al 2010



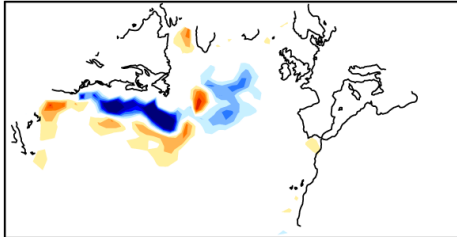
* 90% significance level masking

HC500

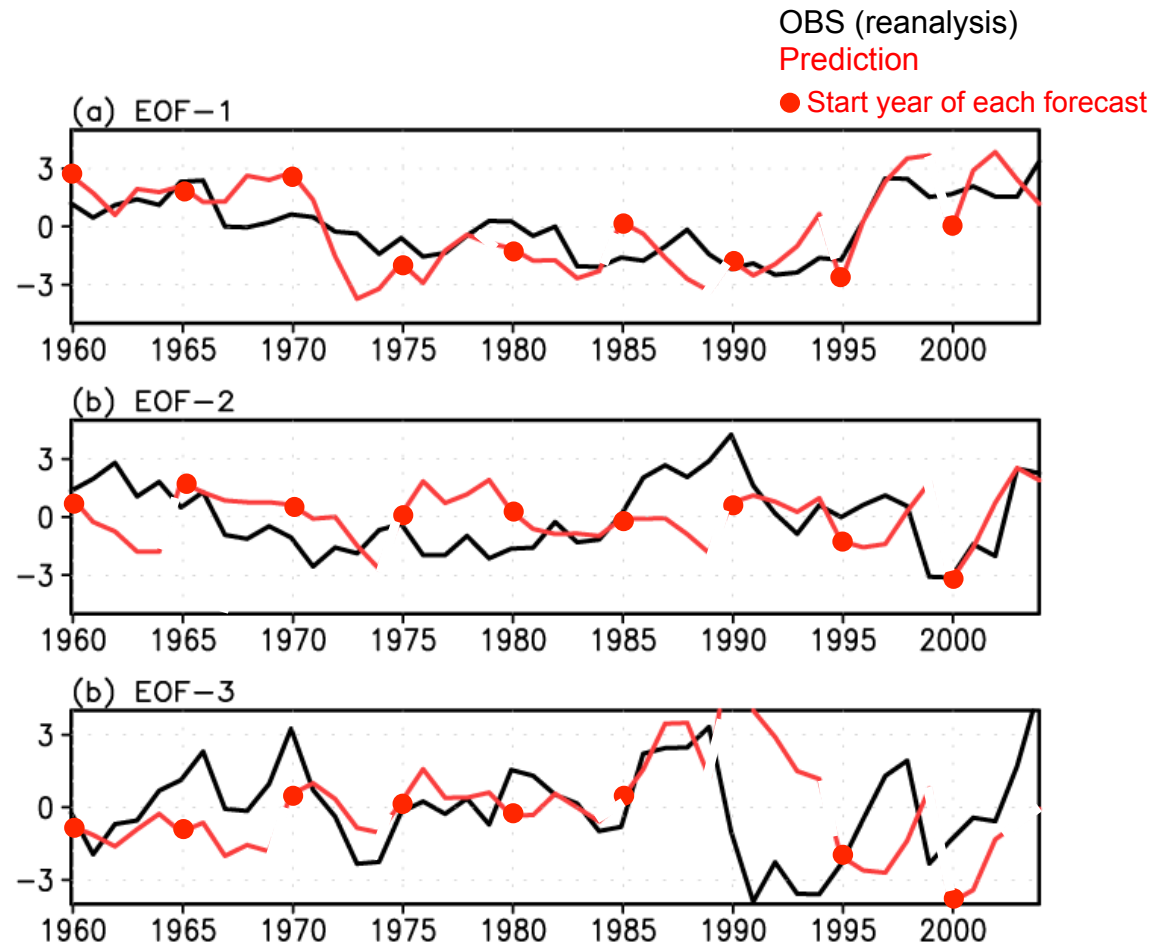
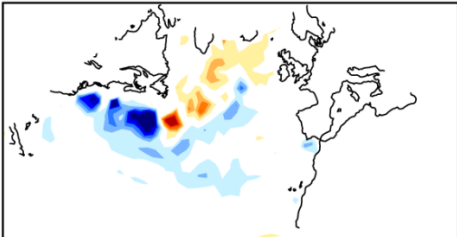
(a) EOF-1 14.88%



(b) EOF-2 10.18%



(b) EOF-3 6.94%



Summary

- GEOS-5 AOGCM performance similar to CCSM4, some deficiencies in high latitudes
- Early look at decadal prediction results from BV generation runs indicate some (?) predictable signal of variability over the subpolar North Atlantic
- Decadal prediction ensemble suite – central (unperturbed) prediction and more ensemble members (re-bred BV, atmospheric perturbation only) have just started
- Output to be served on the ESG node at GSFC; output is CMOR2-ready