Ocean Hindcast Solutions and an Assessment of Their Use in Initialization of CESM Decadal Prediction Experiments

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OUTLINE

Part I: Coordinated Ocean – ice Reference Experiments phase II (CORE-II; hindcast simulations)

Atlantic meridional overturning circulation (AMOC)

Part II: Assessment of prediction skill in hindcast- vs. assimilation-initialized CESM decadal prediction experiments

Sea surface temperature (SST)

Summary

CORE-II

An experimental protocol for ocean – ice coupled simulations forced with inter-annually varying atmospheric data sets for the 1948-2007 period (Large and Yeager 2009). This effort is coordinated by the CLIVAR Working Group on Ocean Model Development (WGOMD).

These hindcast simulations provide a framework for

- evaluation, understanding, and improvement of ocean models,
- investigation of mechanisms for seasonal, inter-annual, and decadal variability,
- evaluation of robustness of mechanisms across models,
- complementing data assimilation in bridging observations and modeling and in providing ocean initial conditions for climate prediction simulations.

The CORE datasets are periodically updated (currently through 2009) and collaboratively supported by NCAR and GFDL. They can be accessed via

-WGOMD CORE web pages

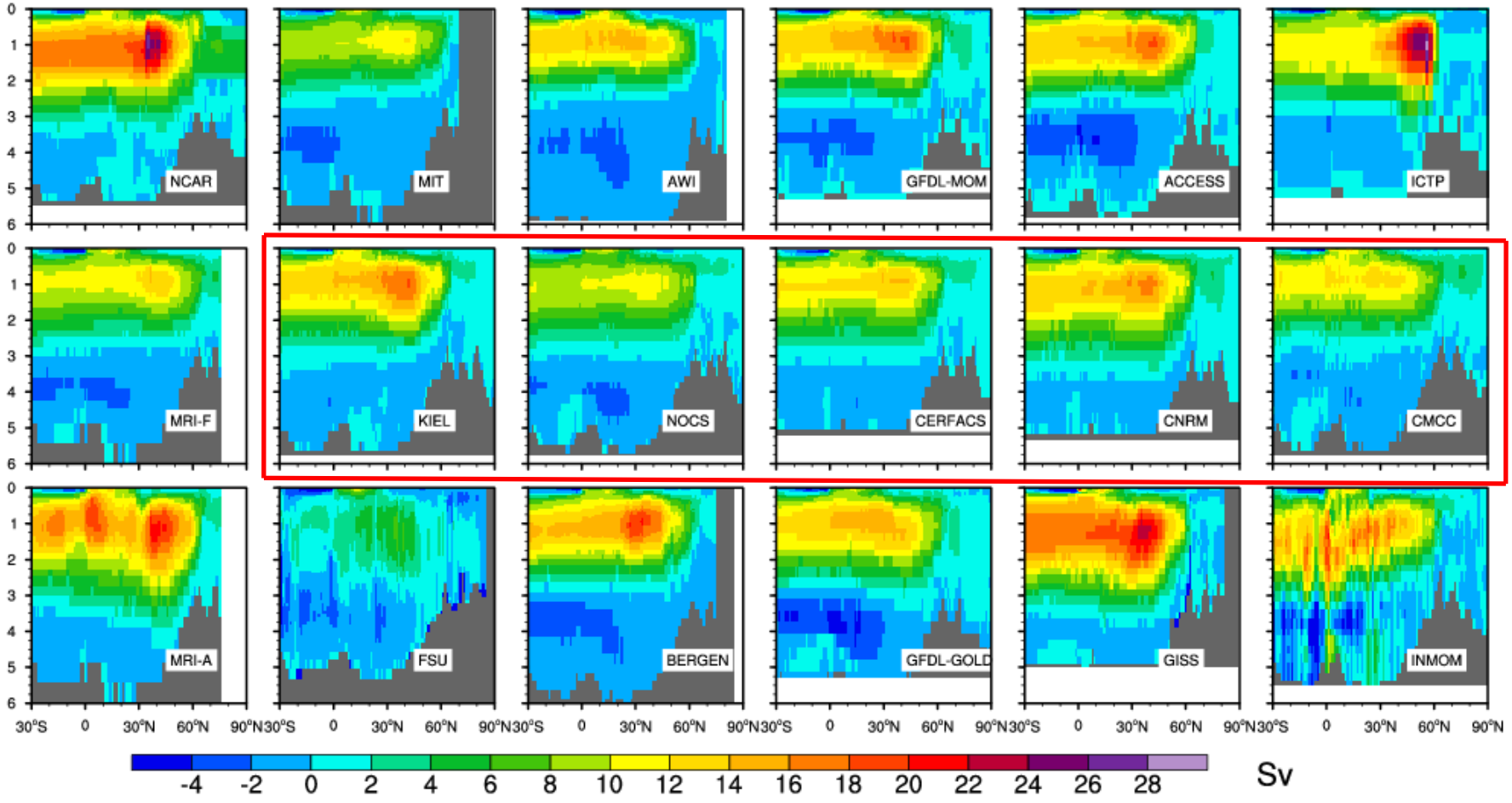
-http://data1.gfdl.noaa.gov/nomads/forms/core.html

Participating groups (18 models):

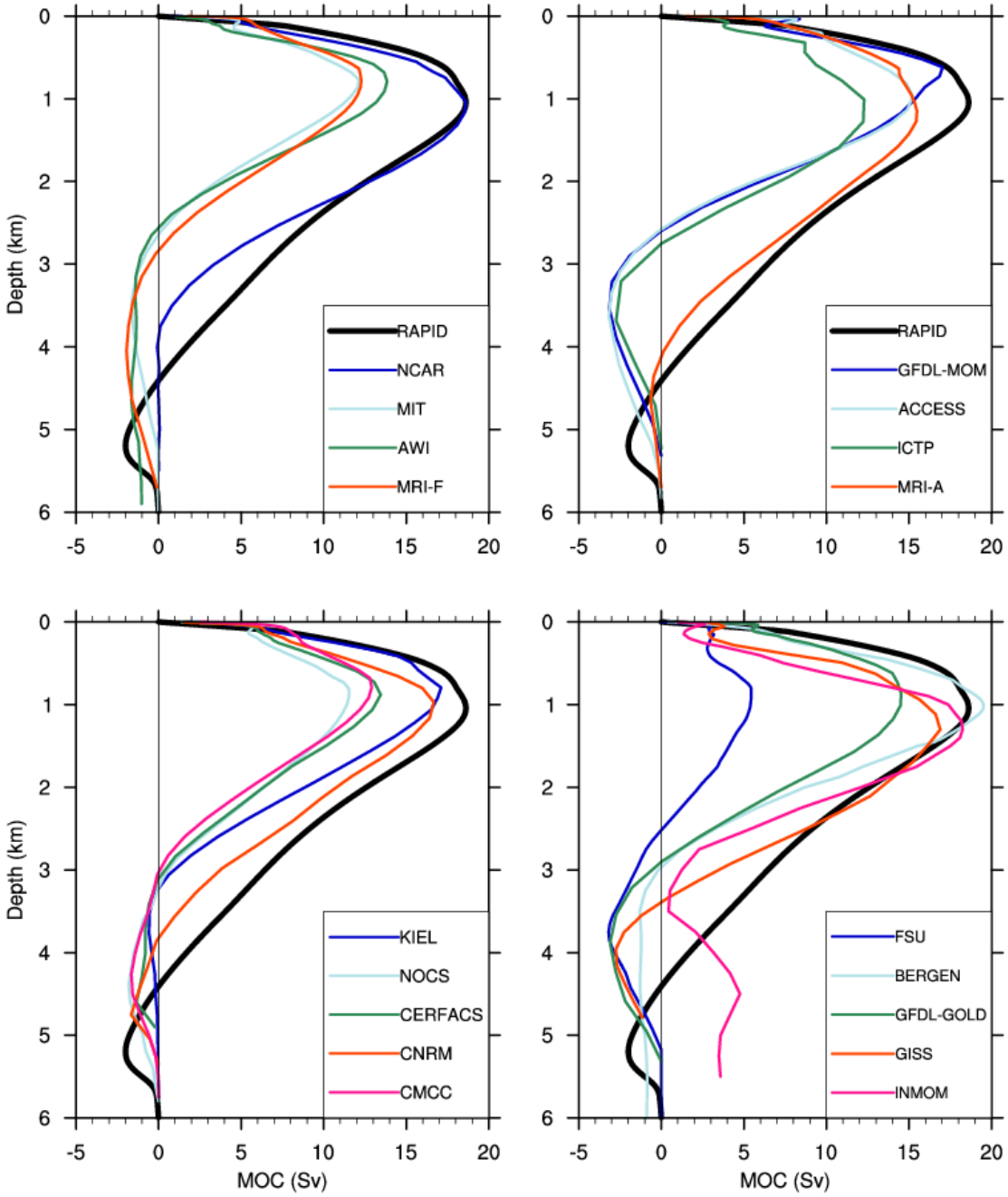
- Australia: CSIRO (ACCESS)
- France: CERFACS, CNRM
- Germany: AWI, IfM-GEOMAR (KIEL)
- Italy: CMCC, ICTP
- Japan: MRI (free, DA)
- Norway: U. Bergen
- Russia: RAS (INMOM)
- UK: NOCS
- USA: FSU, GFDL-GOLD, GFDL-MOM, MIT, NASA GISS, NCAR

Level, isopycnal, hybrid, mass, and sigma coordinates; unstructured finite element ocean model; mostly nominal 1° resolution

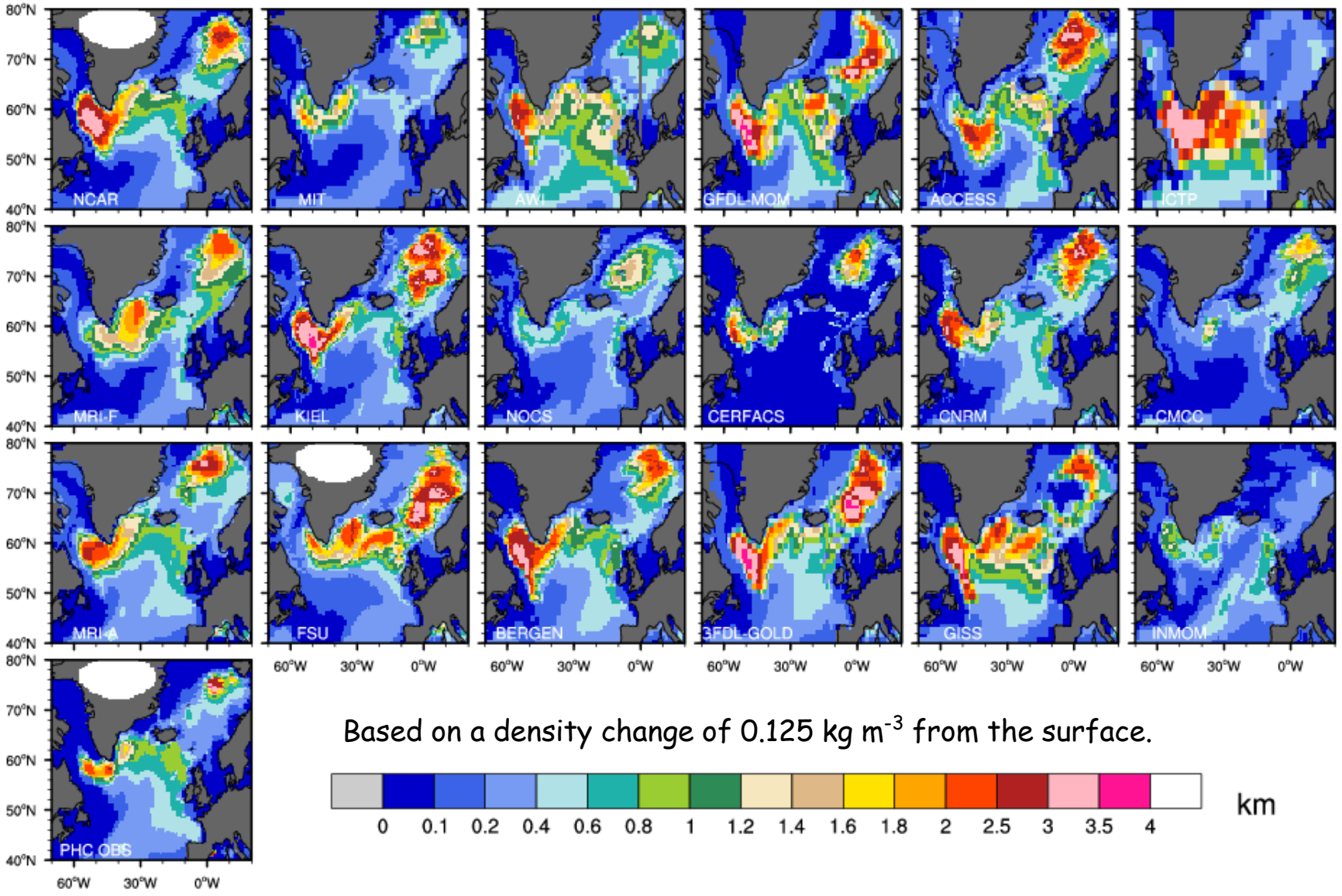
AMOC Mean (1988-2007) in Depth Space



AMOC at 26.5°N (2004-2007)



March-Mean Mixed Layer Depth (1988-2007)

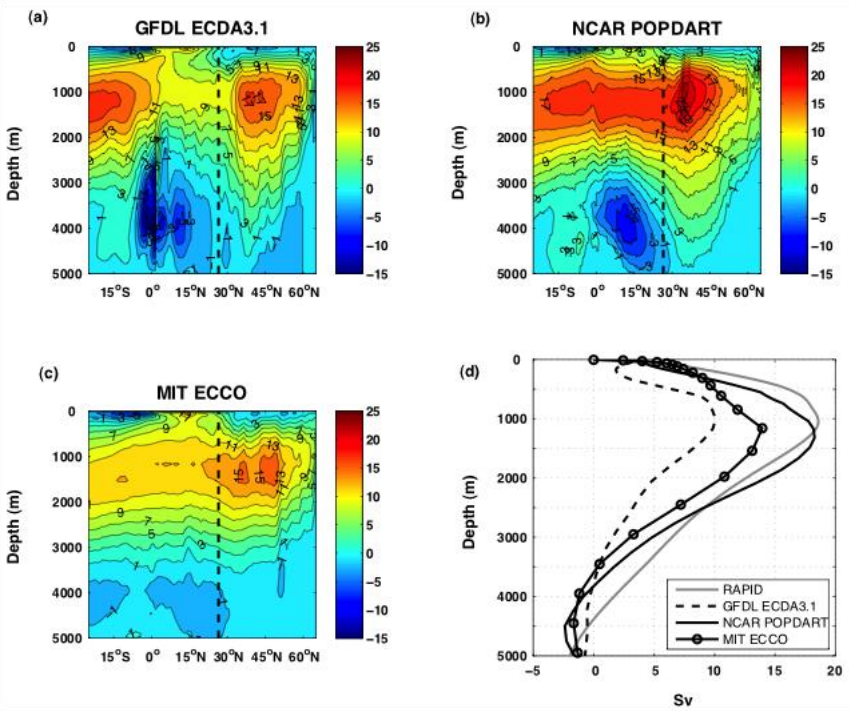


Ocean Initialization in CESM Decadal Prediction Experiments

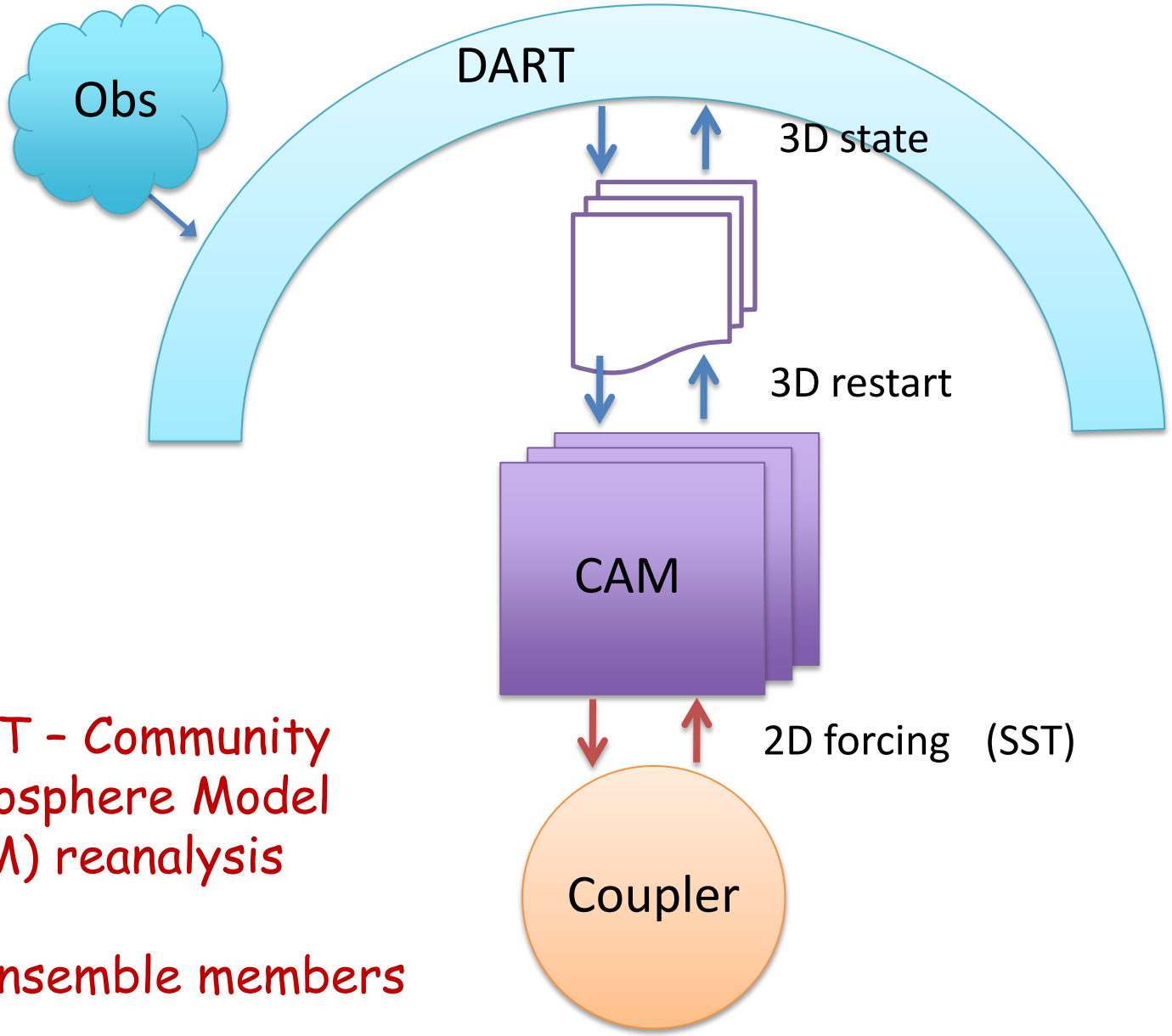
Two methods:

1. Hindcast solutions from CORE-II,
2. States obtained from CESM-DART loosely coupled data assimilation framework.

AMOC

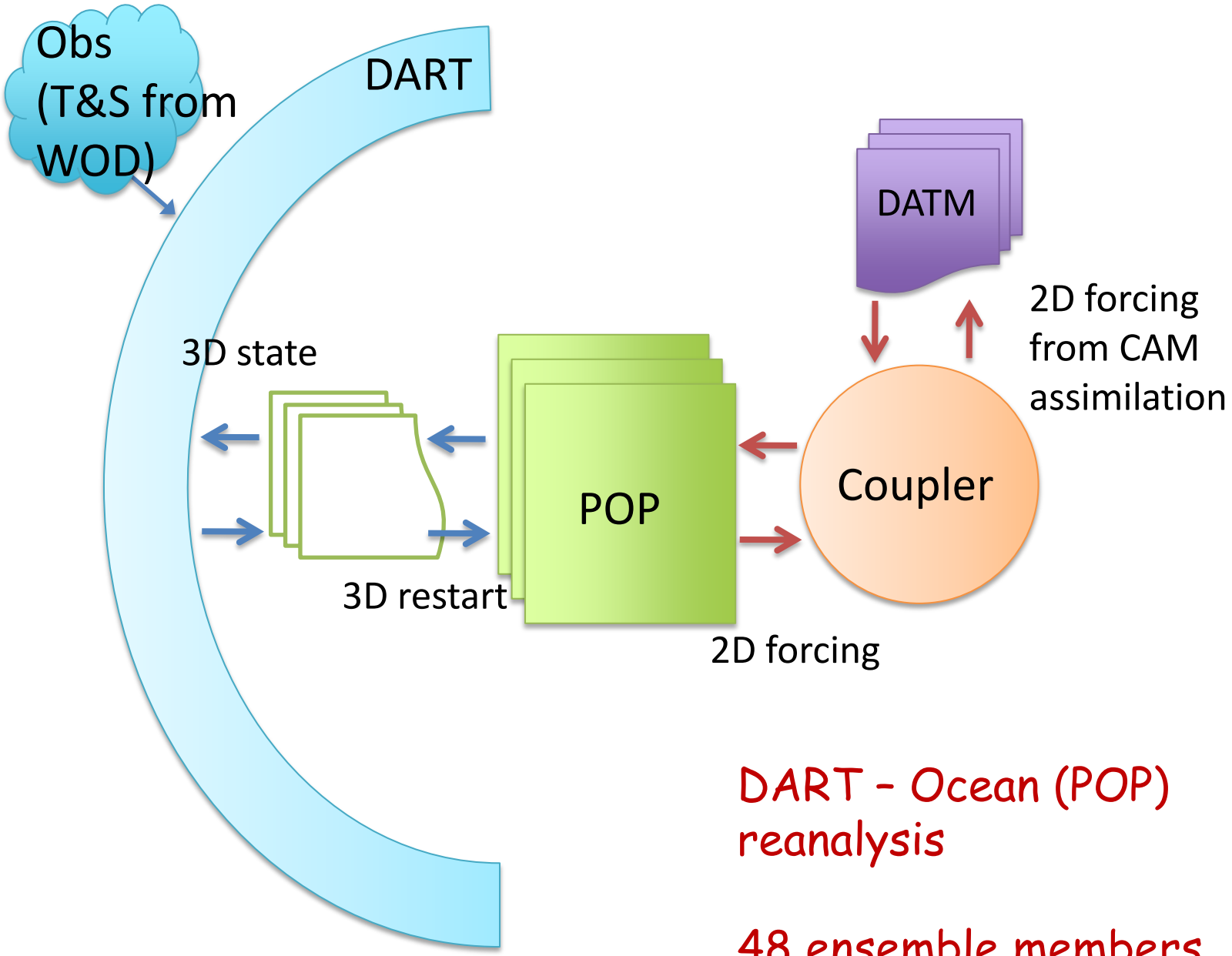


DART: Data Assimilation Research Testbed



DART – Community Atmosphere Model (CAM) reanalysis

80 ensemble members



DART – Ocean (POP) reanalysis

48 ensemble members

Summary of component initialization:

ocean	sea-ice	atm / land
CORE-II	CORE-II	uninitialized (AMIP)
DART	CORE-II	uninitialized (AMIP)

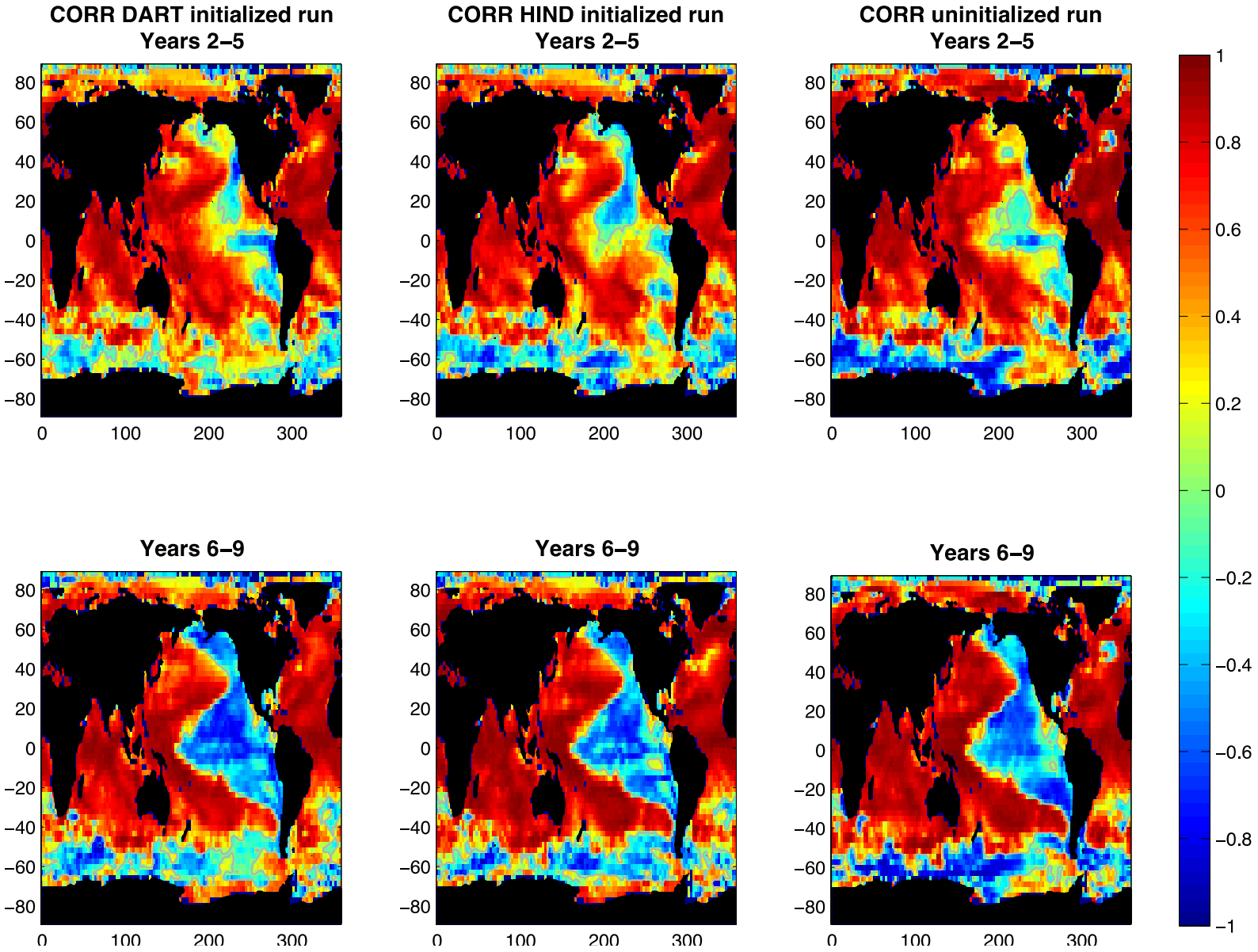
Ensemble generation for decadal prediction experiments:

initialized with	ocean / sea-ice	atm / land
CORE-II	single member	staggered start dates
DART	ensemble assimilation	single member

- Nominal 1° horizontal resolution versions of all component models,
- Full field initialization,
- Start dates follow the CMIP5 protocol:

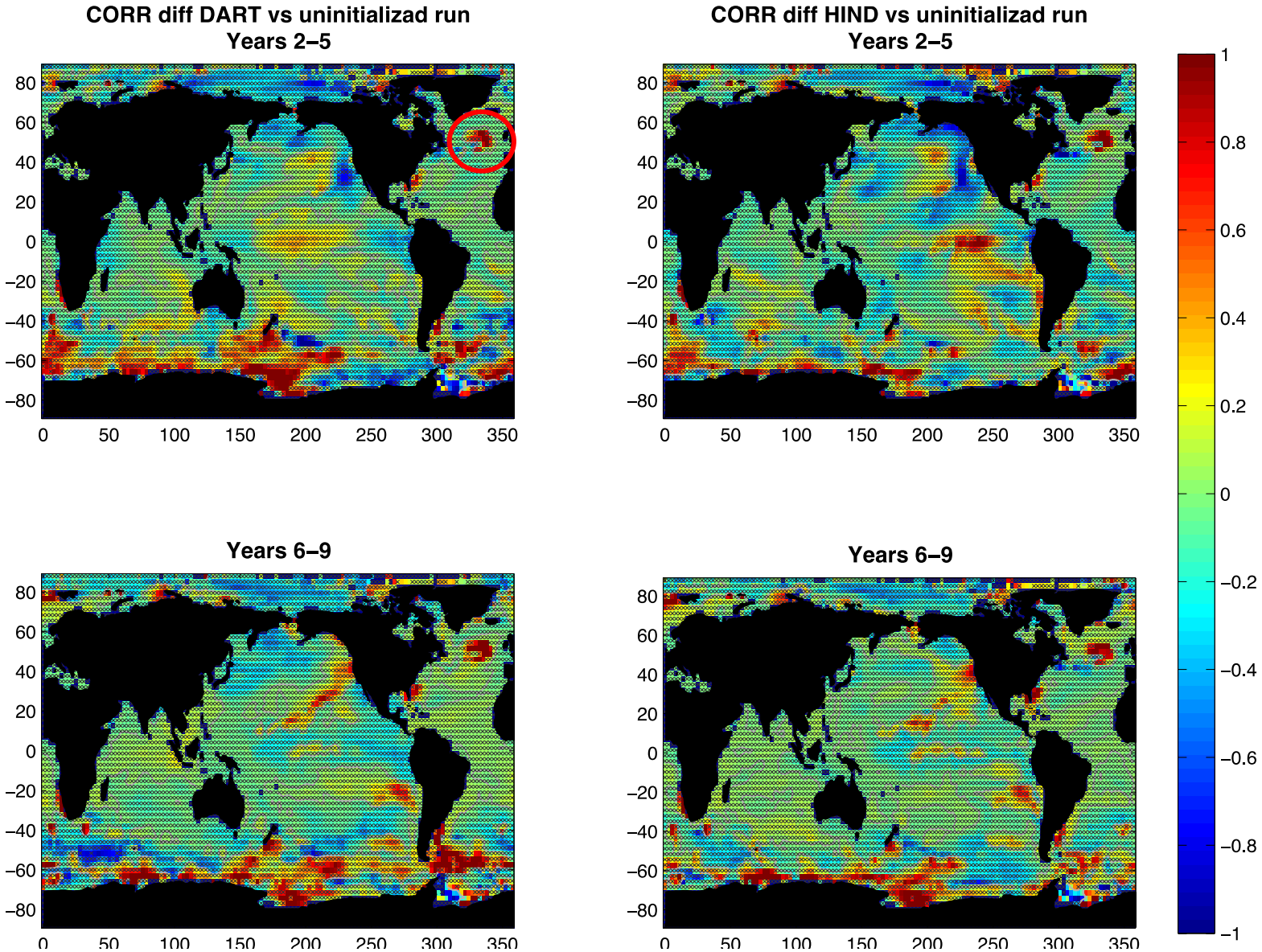
  1960 for CORE-II; 1975 for DART
- Analysis period is 1975-2010,
- 10-member ensembles.

SST Anomaly Correlations at 2-5 and 6-9 Year Lead Times

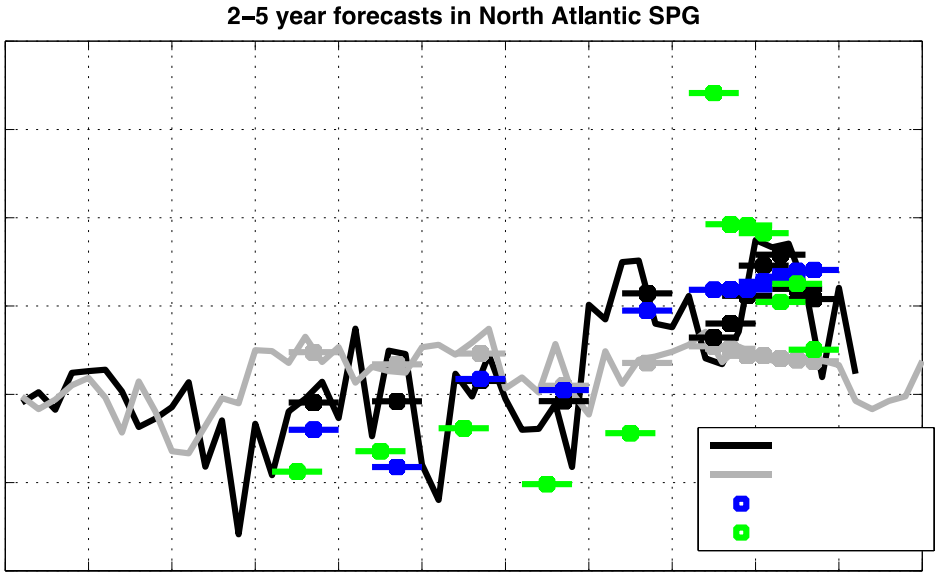


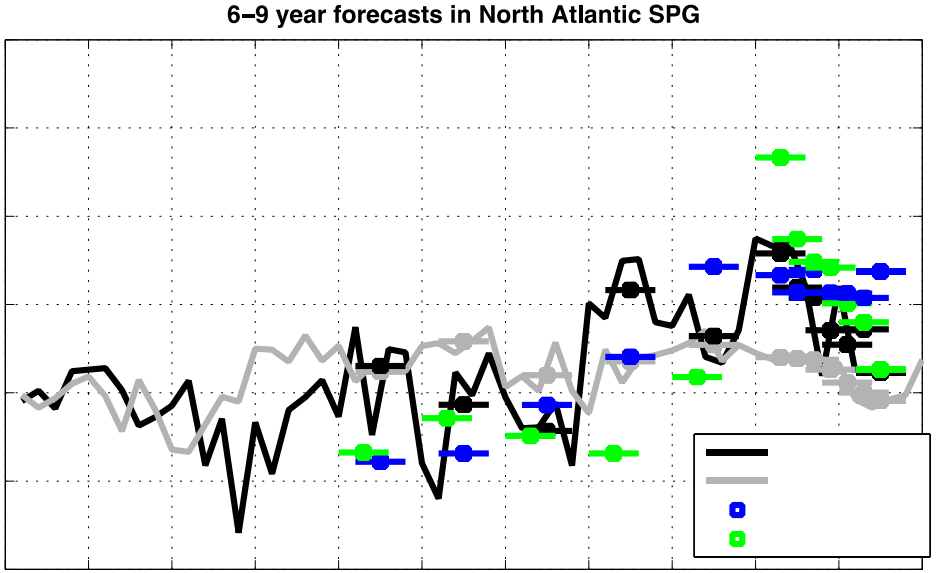
HIND = CORE-II

SST Anomaly Correlation Differences



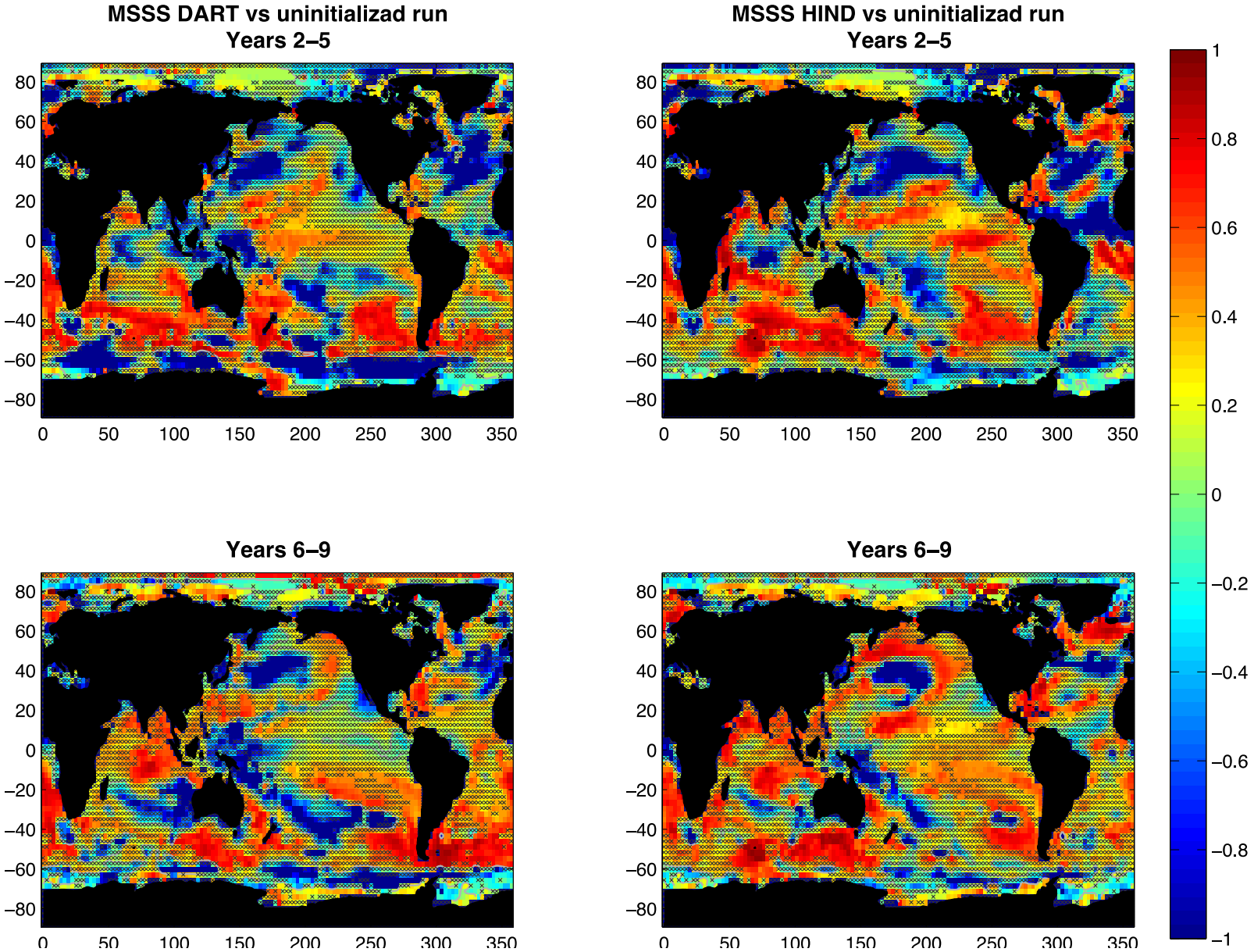
SST Forecasts (°C)

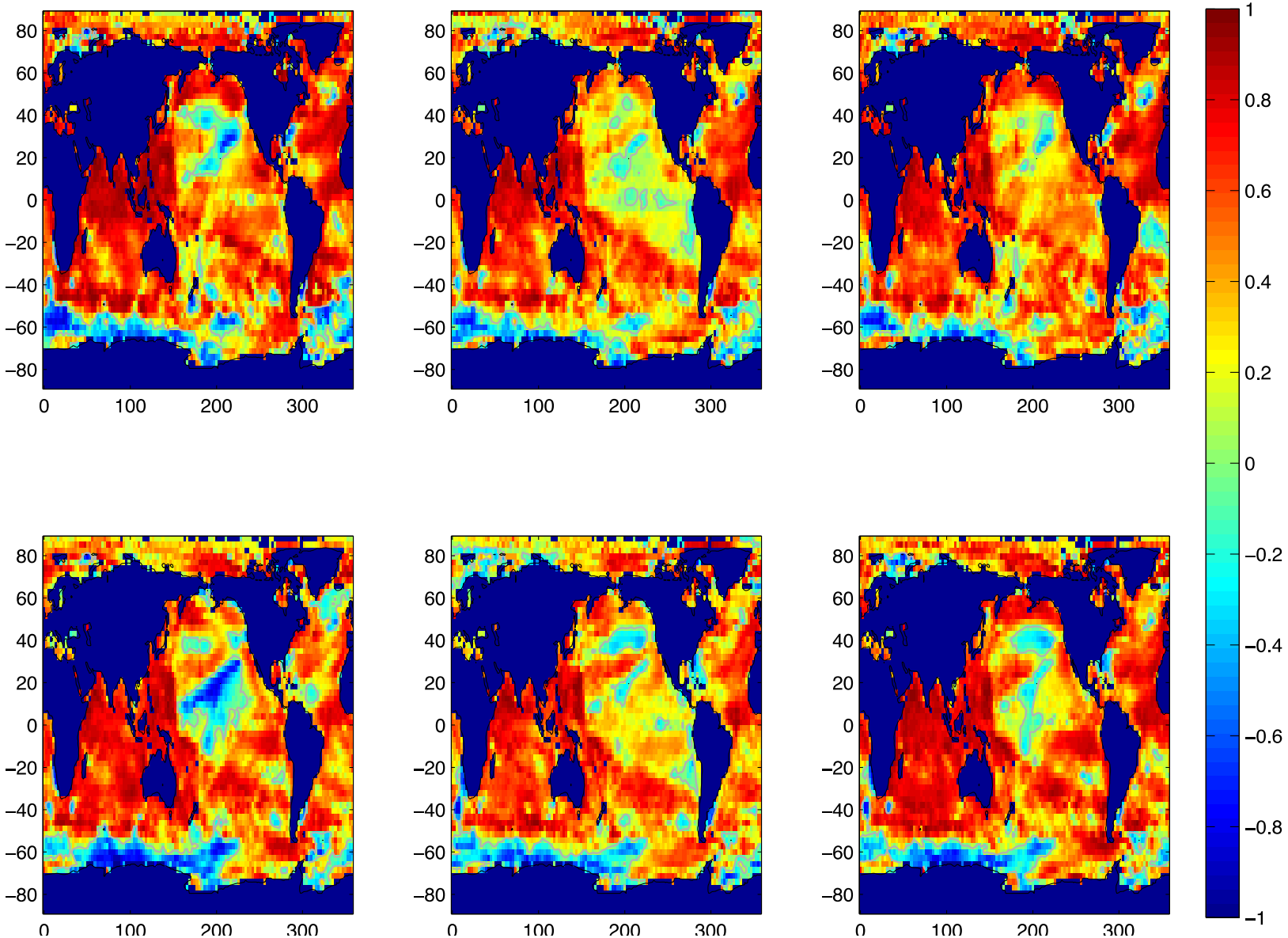




SUMMARY

- Ocean – sea-ice experiments forced with common atmospheric data sets produce significantly different mean states, with implications for initialization of decadal prediction experiments.
- CESM decadal prediction experiments initialized from hindcast and assimilation solutions show similar skills.
- Skill due to initialization appears to be confined to only a few regions, e.g., North Atlantic.


MSSS DART vs uninitializad run
Years 2–5
MSSS HIND vs uninitializad run
Years 2–5
Years 6–9
Years 6–9
80
60
40
20
0
−20
−40
−60
−80
0
50
100
150
200
250
300
350
1
0.8
0.6
0.4
0.2
0
−0.2
−0.4
−0.6
−0.8
−1


80
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0
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0.4
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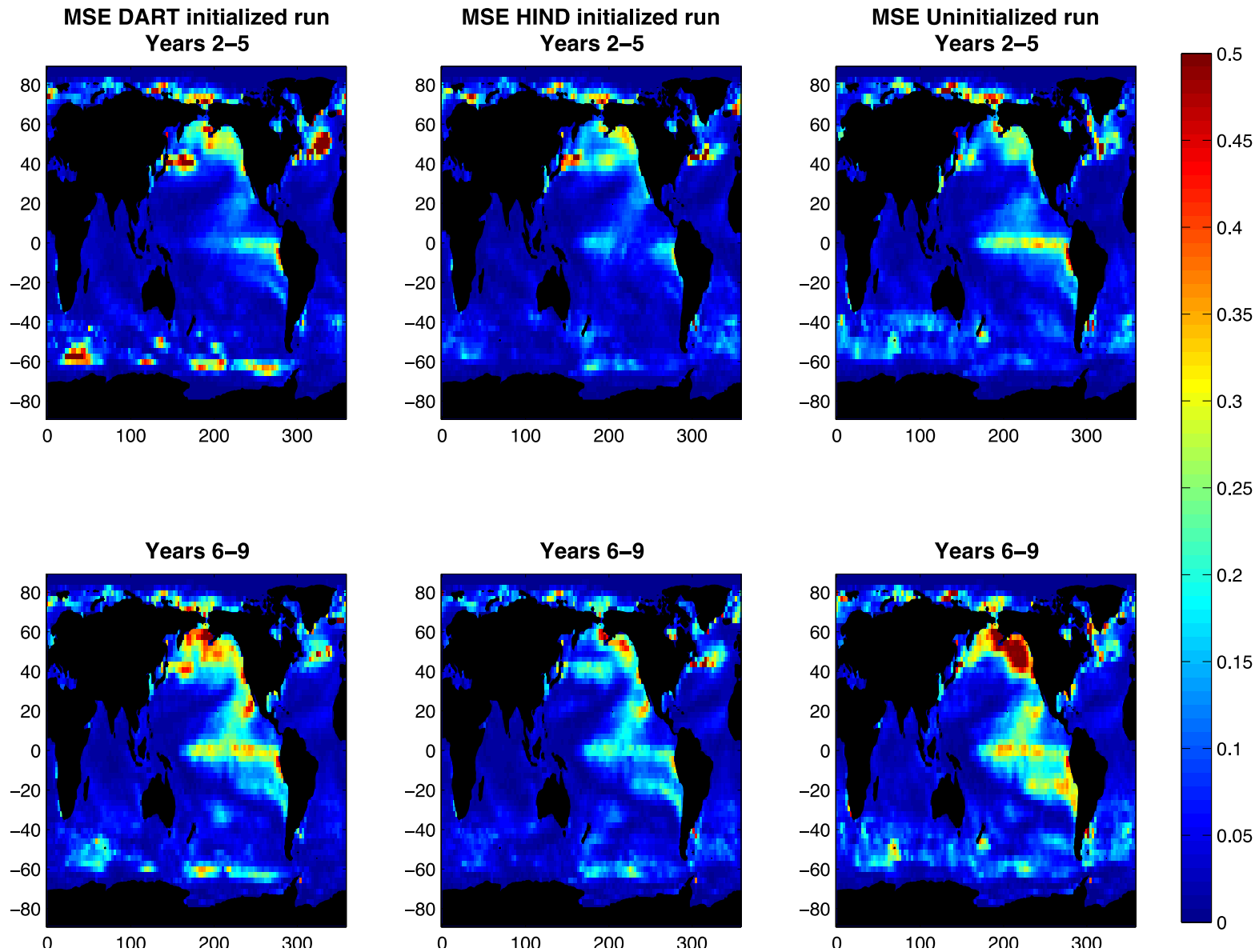
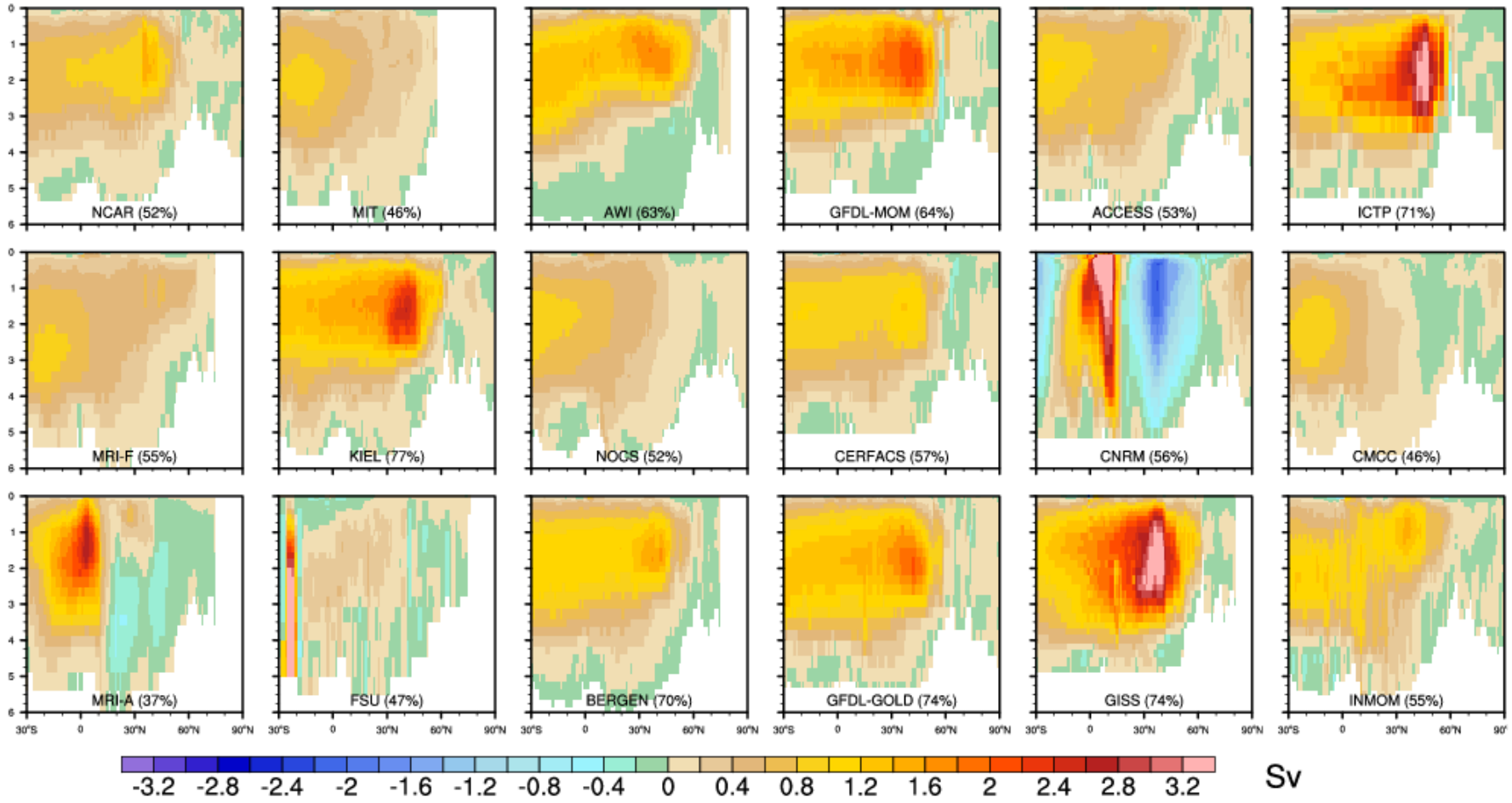
0
−0.2
−0.4
−0.6
−0.8
−1


MSE DART initialized run
Years 2–5
MSE HIND initialized run
Years 2–5
MSE Uninitialized run
Years 2–5
Years 6–9
Years 6–9
Years 6–9
80
60
40
20
0
−20
−40
−60
−80
0
100
200
300
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0

AMOC EOF1


NCAR (52%)
MIT (46%)
AWI (63%)
GFDL-MOM (64%)
ACCESS (53%)
ICTP (71%)
MRI-F (55%)
KIEL (77%)
NOCS (52%)
CERFACS (57%)
CNRM (56%)
CMCC (46%)
MRI-A (37%)
FSU (47%)
BERGEN (70%)
GFDL-GOLD (74%)
GISS (74%)
INMOM (55%)
30°S
0
30°N
60°N
90°N
-3.2 -2.8 -2.4 -2 -1.6 -1.2 -0.8 -0.4 0 0.4 0.8 1.2 1.6 2 2.4 2.8 3.2
Sv