# Towards Decadal Prediction with CCSM4

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December 11, 2009

Outline

I. Intro -- the experience with CCSM3.5

II. The Initial Conditions -- ocean, ocean-ice, and Data Assimilation Research Testbed (DART) hindcast runs
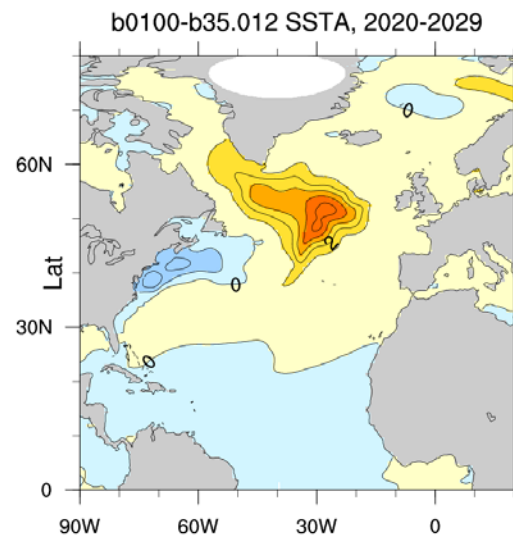
I. Short & Long-term plans

CCSM3.5 Fully-Coupled Decadal Prediction Runs

Max Atlantic MOC (Eulerian)

b35.012
g3_5_19.11
b0100
b0105
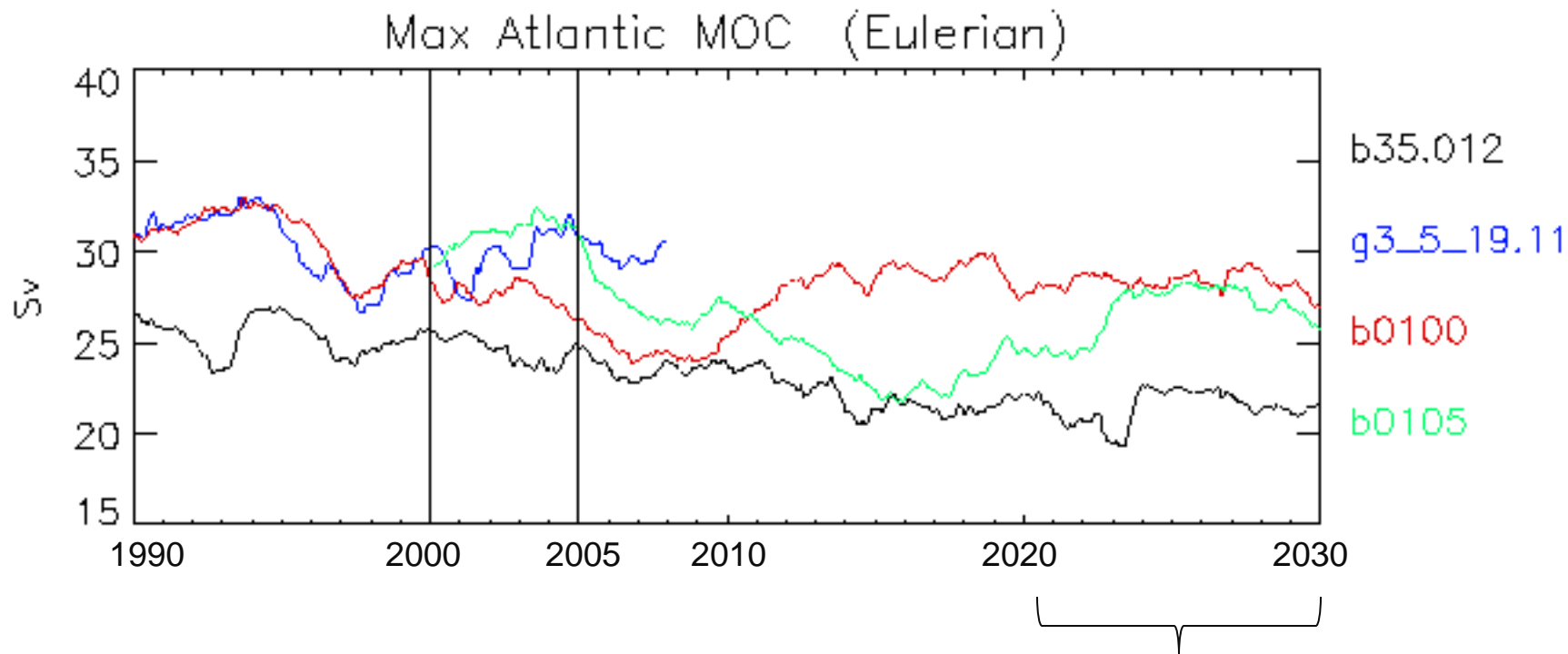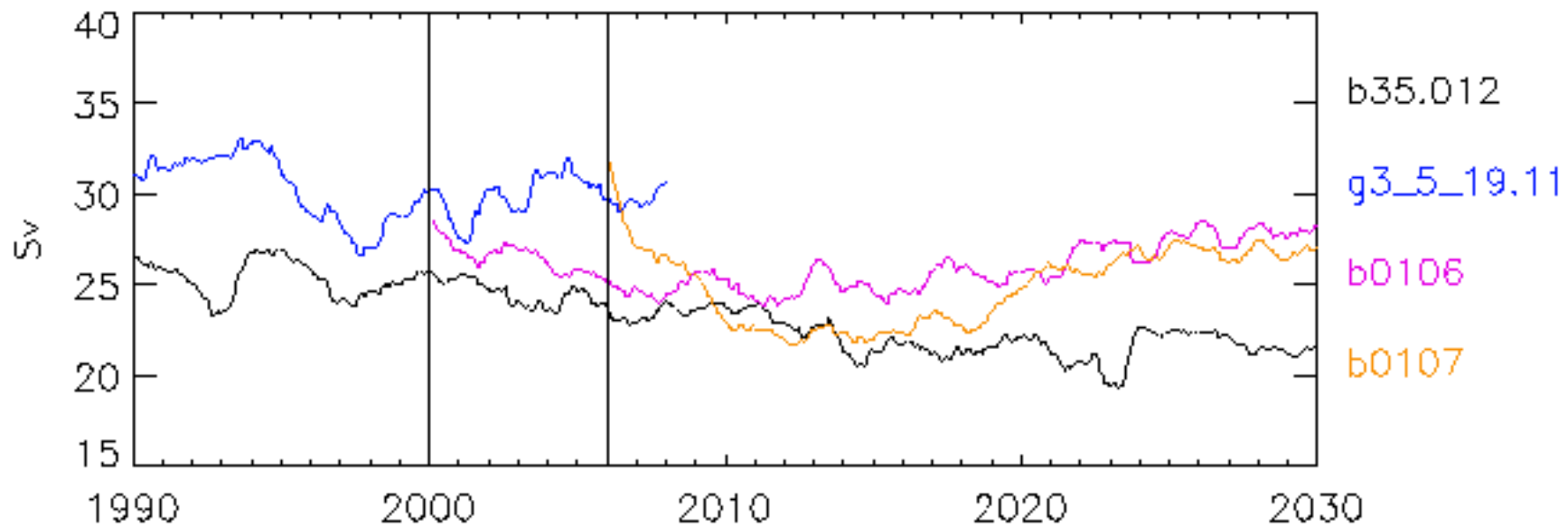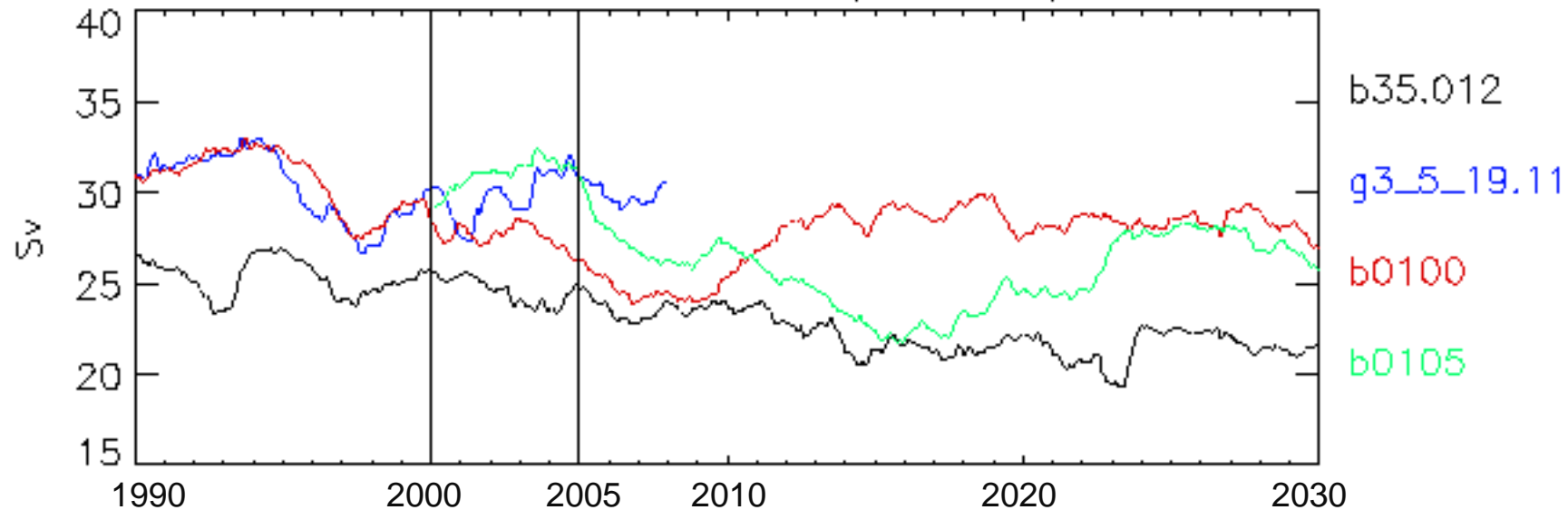
b35.012: CCSM3.5 fully coupled 1870-2030

g3_5_19.11: CCSM3.5 ocean-ice coupled hindcast (1949-2006)

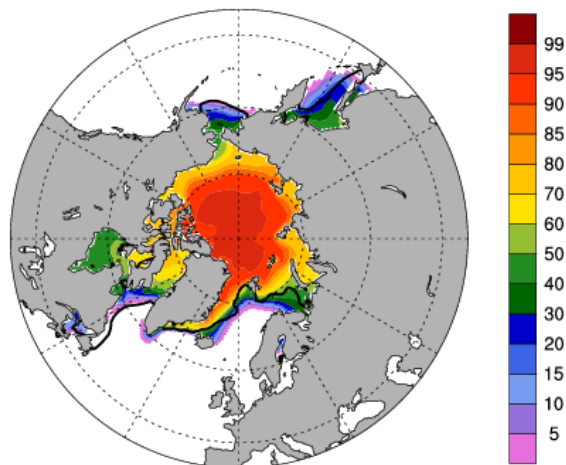**b0100**: branched from (1) at 1980, nudged to (2) from 1980 through 1999 (τ = 40 day)

b0100-b35.012 SSTA, 2020-2029

CCSM3.5 Fully-Coupled Decadal Prediction Runs

CCSM3.5 Fully-Coupled Decadal Prediction Runs
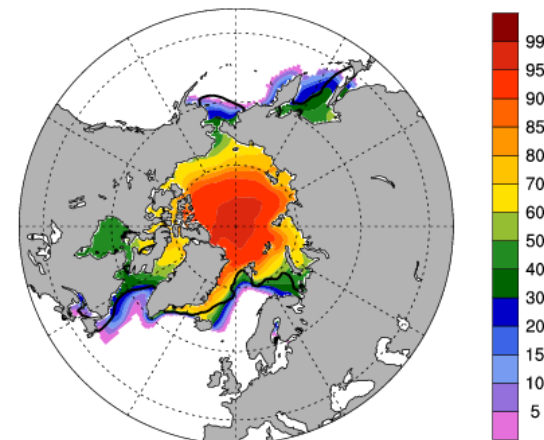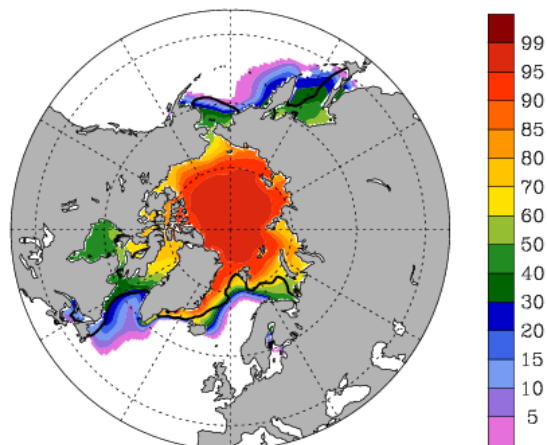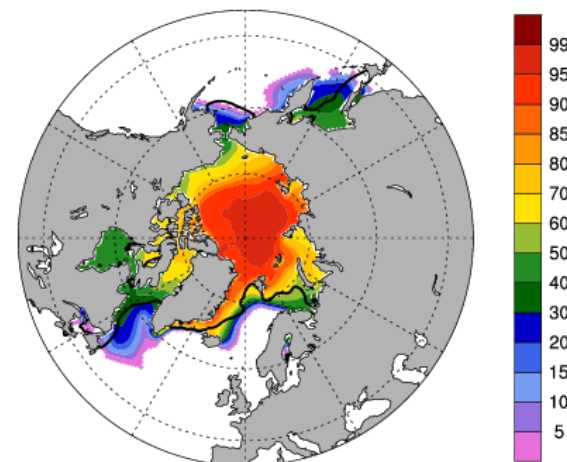
nudged

CNTRL

CCSM3.5 Fully-Coupled Decadal Prediction Runs

1980-1999   2020-2029

nudged

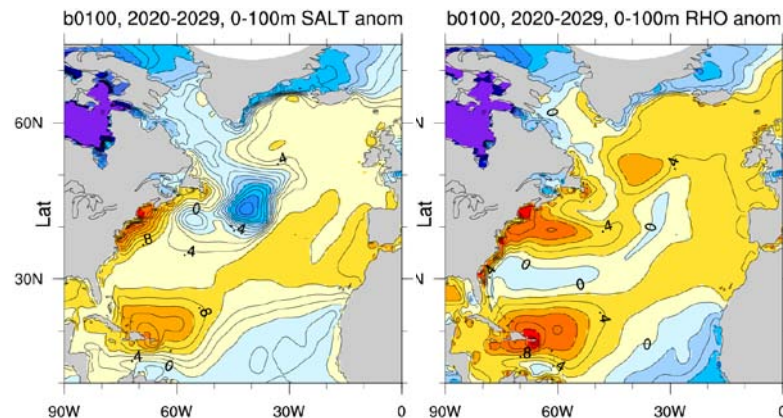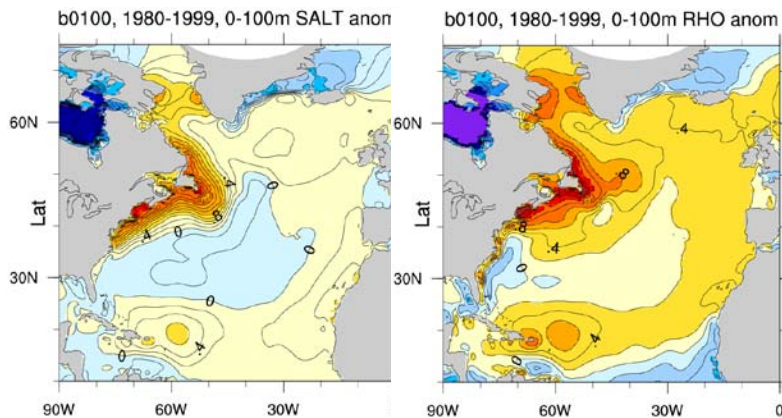| b0100, 1980-1999, 0-100m SALT anom | b0100, 1980-1999, 0-100m RHO anom | b0100, 2020-2029, 0-100m SALT anom | b0100, 2020-2029, 0-100m RHO anom |

S'   σ'   S'   σ'

CNTRL

| b35.012, 1980-1999, 0-100m SALT anom | b35.012, 1980-1999, 0-100m RHO anom | b35.012, 2020-2029, 0-100m SALT anom | b35.012, 2020-2029, 0-100m RHO anom |

CCSM3.5 Fully-Coupled Decadal Prediction Runs

Max Atlantic MOC (Eulerian)
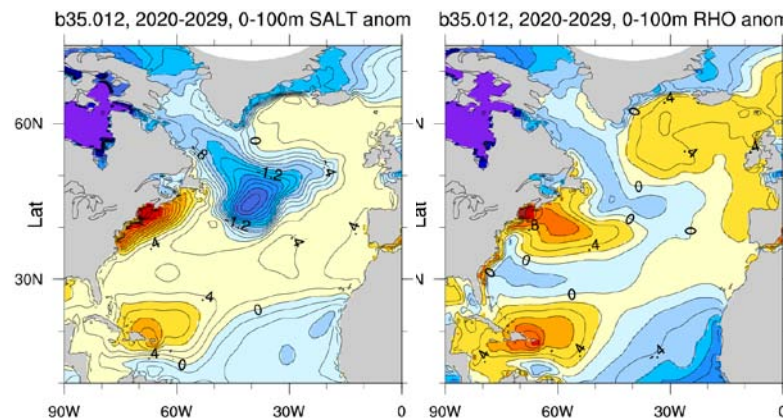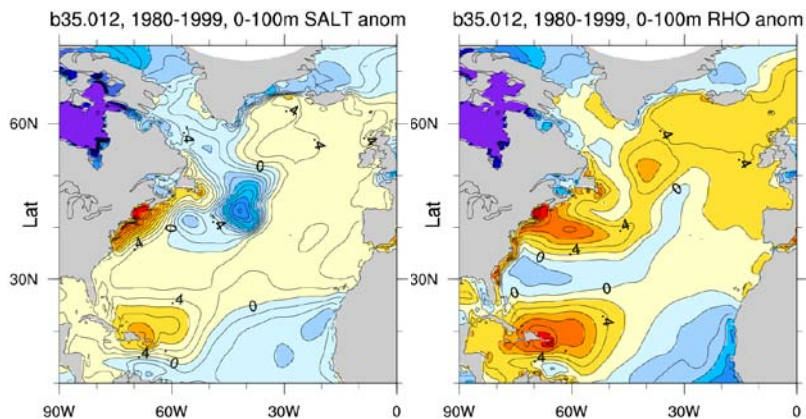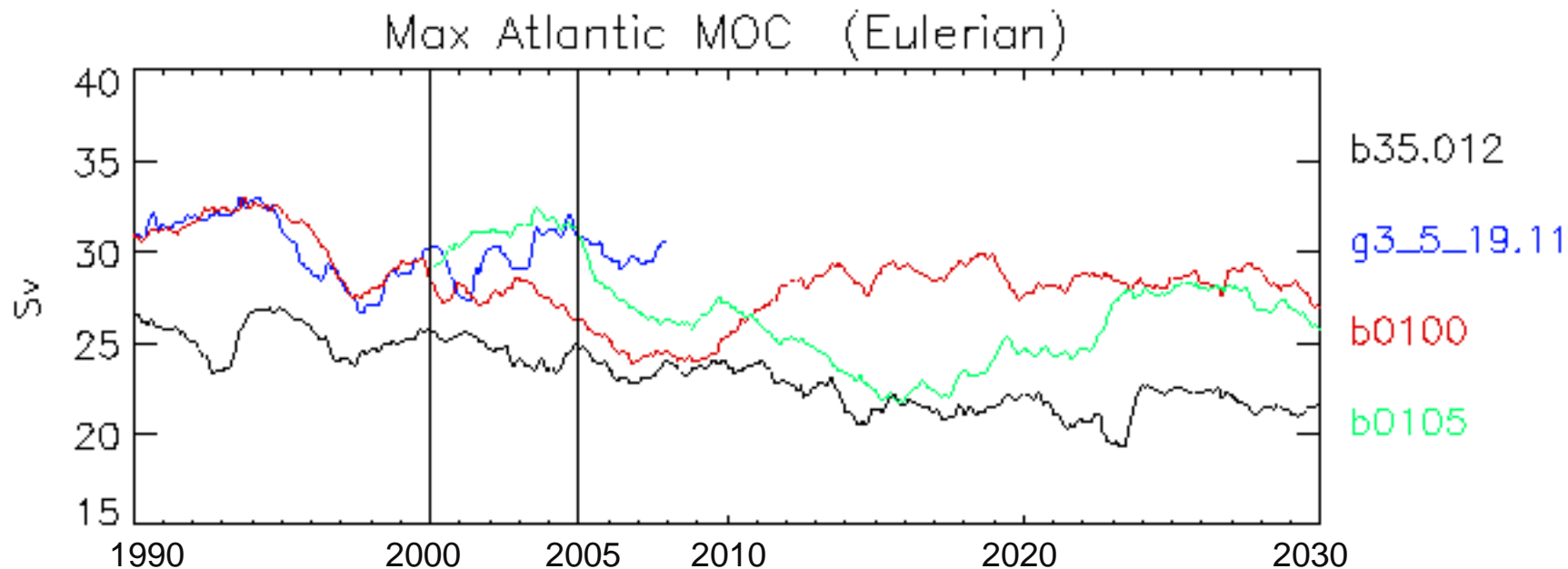
b35.012   cold/fresh/light Lab Sea; warm/salty/dense Irminger Sea

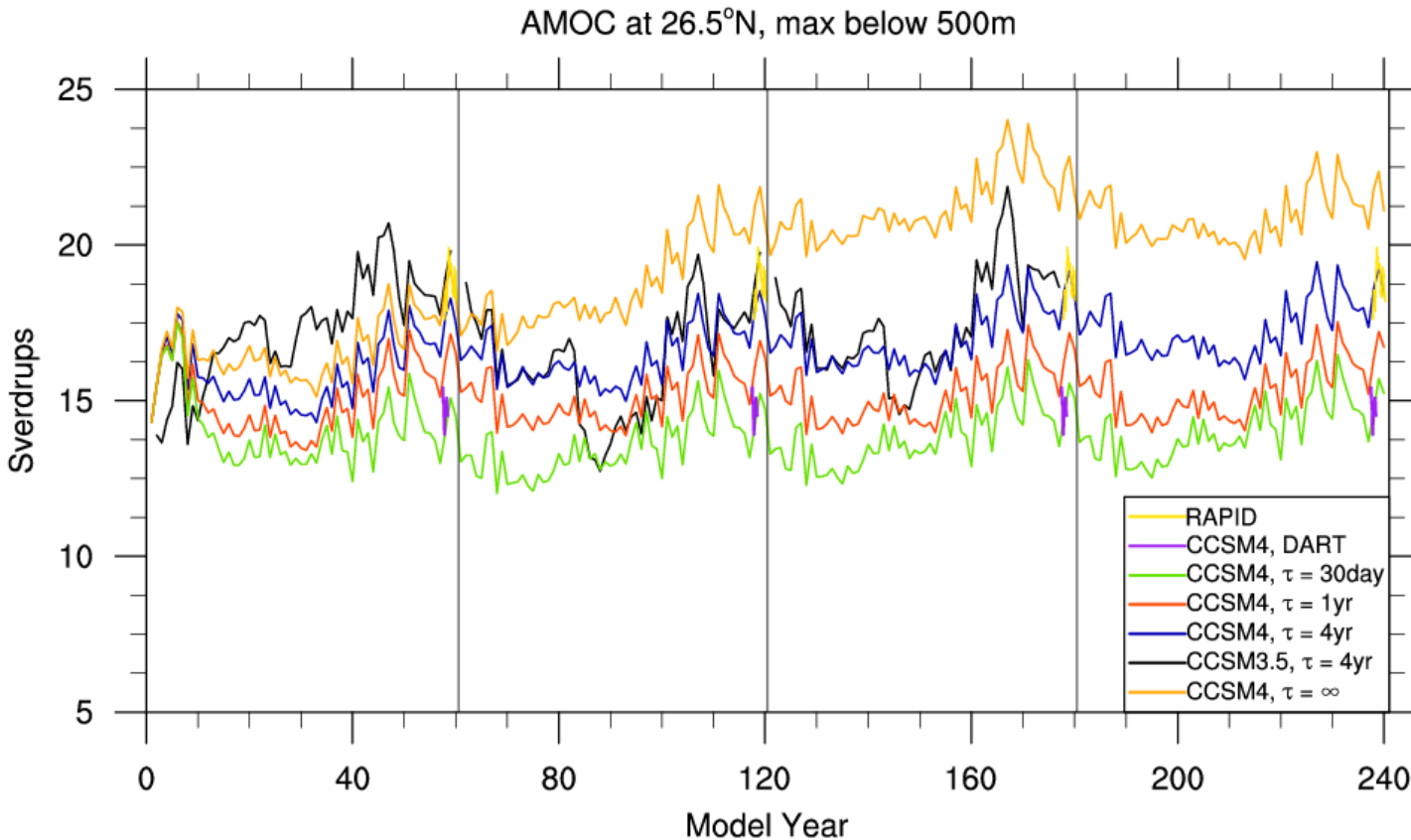➔ deep convection in Irminger Sea only throughout

b0100   pre-2000: warm/salty/dense Lab Sea; warm/salty/dense Irminger Sea

post-2000: cold/fresh/light Lab Sea; warm/saltier/denser Irminger Sea

➔ deep convection transitions out of LAB and becomes stronger in Irminger

I.   Intro – the experience with CCSM3.5

- Large transients due to major discrepancy between the ocean ic biases and the coupled model preferred biases

- Expect Atlantic upperocean salinity/density bias in ocean ic to "dial in" AMOC strength

CCSM4 Hindcast Integrations

AMOC at 26.5°N, max below 500m

Legend:
- RAPID
- CCSM4, DART
- CCSM4, τ = 30day
- CCSM4, τ = 1yr
- CCSM4, τ = 4yr
- CCSM3.5, τ = 4yr
- CCSM4, τ = ∞

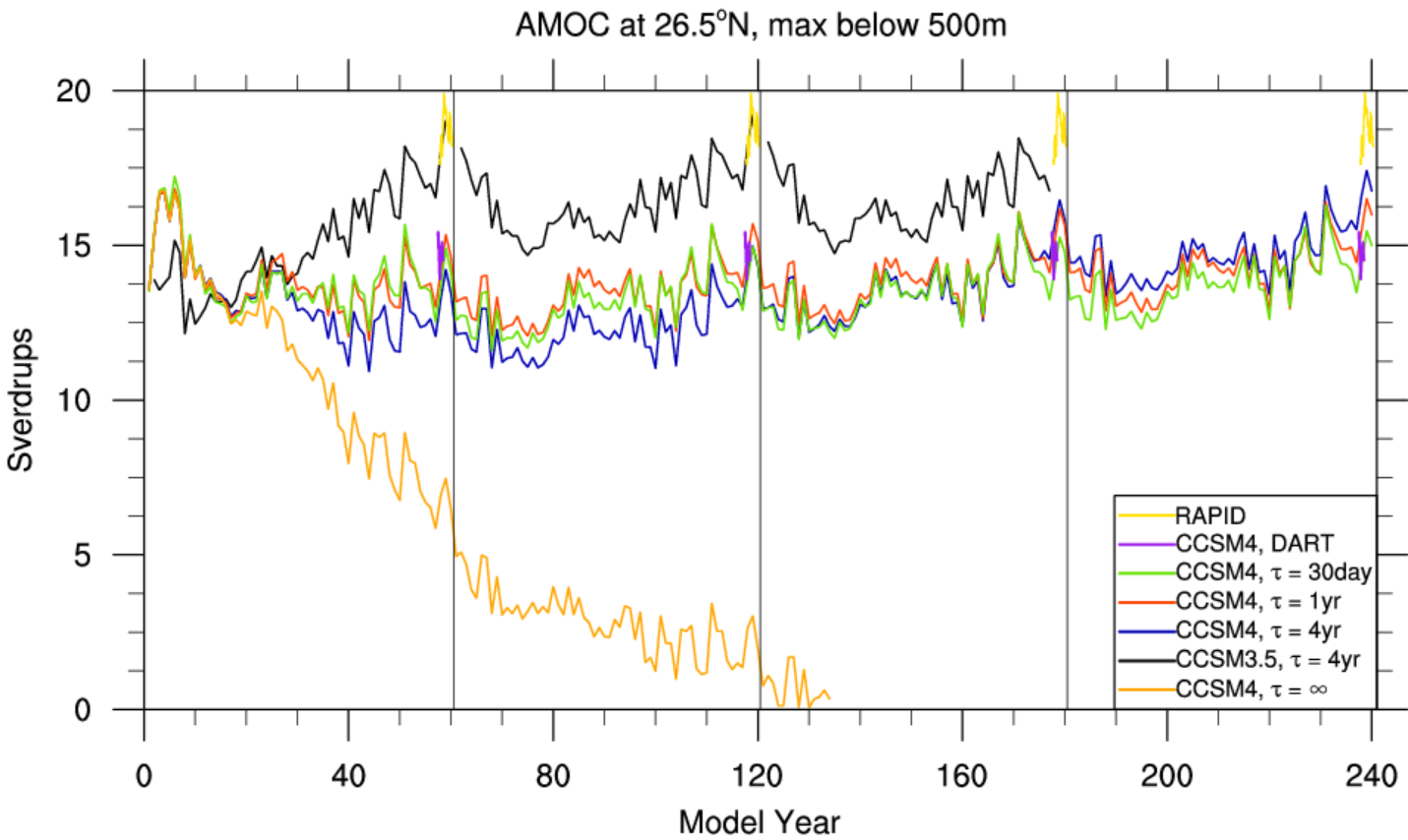Axis labels: Sverdrups (y-axis), Model Year (x-axis)

- DART: ensemble mean of 23-member 1998-1999 ocean-only hindcast

(assimilating WOD daily T,S)

Thanks Peta-Apps!

CCSM4 Hindcast Integrations

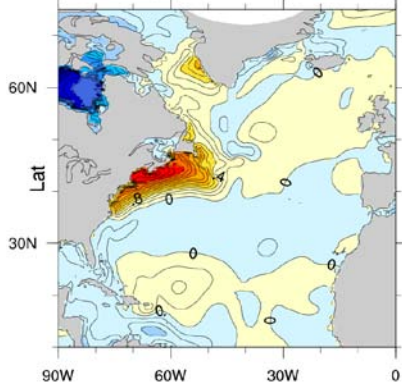Ocean-only

AMOC at 26.5°N, max below 500m

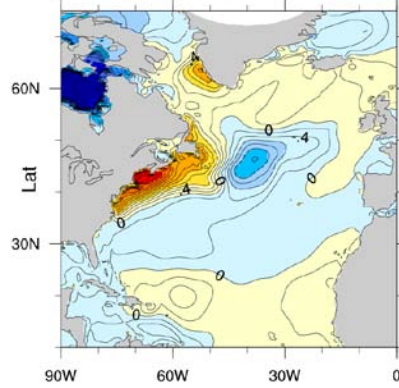Monthly AMOC at 26.5°N, max below 500m
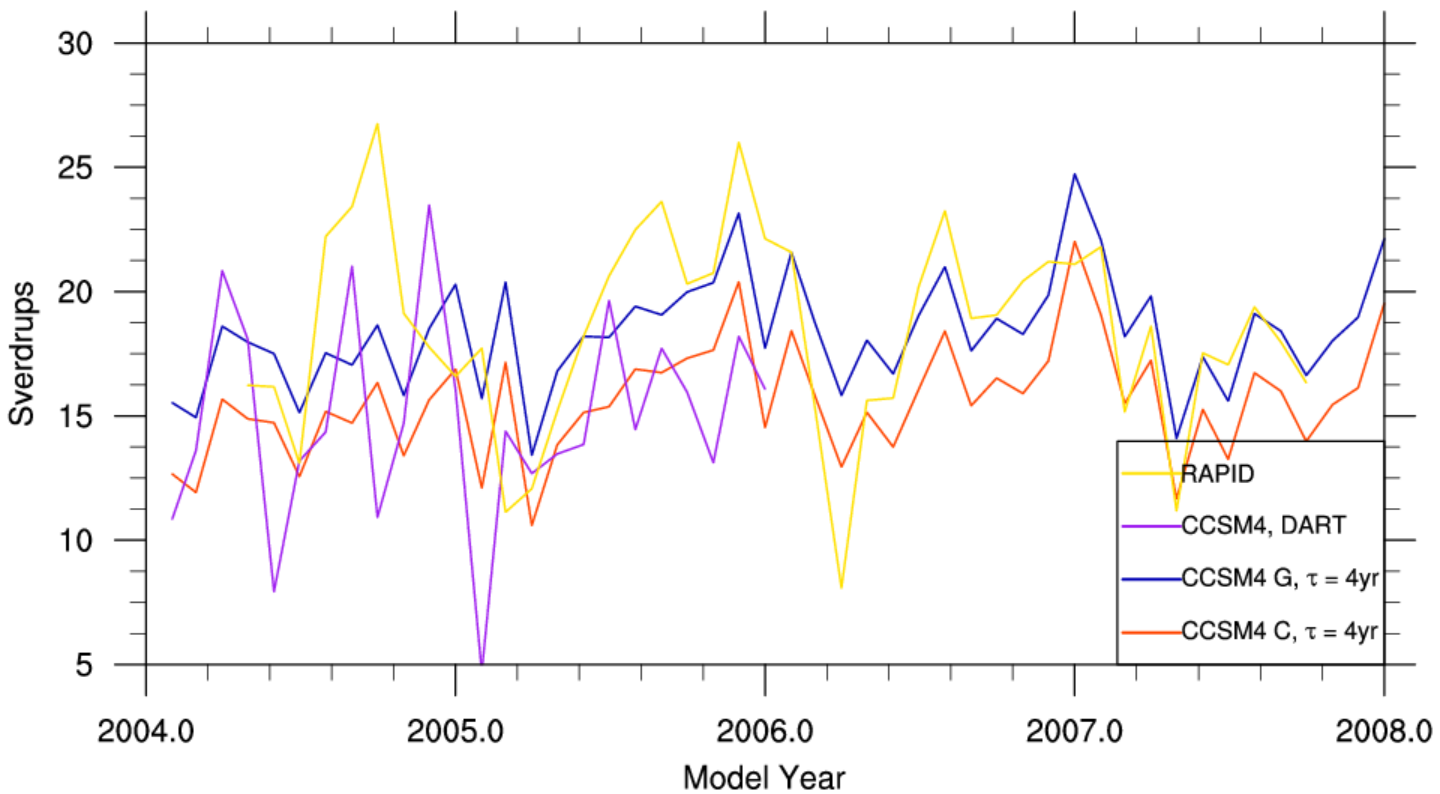
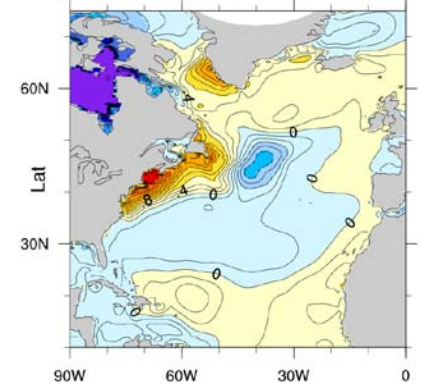- AMOC strength scales with subpolar gyre density (salinity):
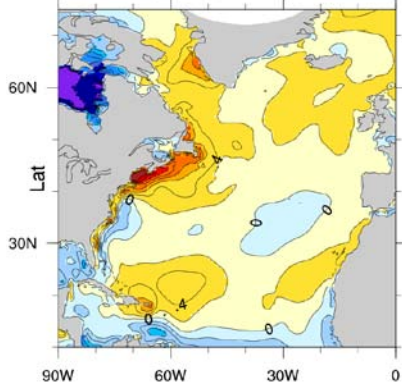

dart.005.6, 1999, 0-100m SALT anom

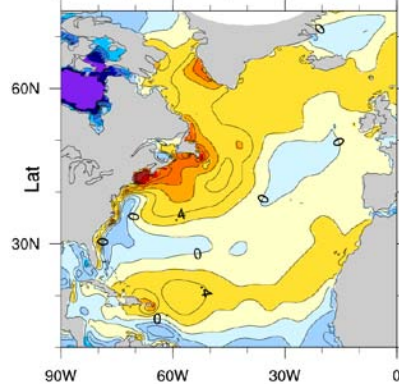g.b29.01, 1980-1999, 0-100m SALT anom

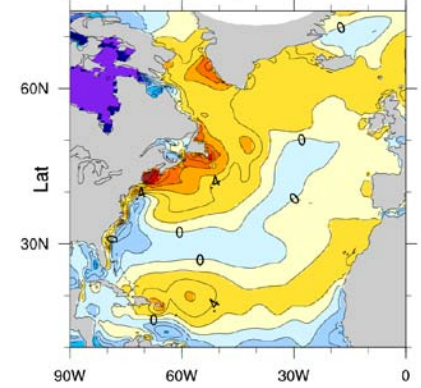g.b29.04, 1980-1999, 0-100m SALT anom

dart.005.6, 1999, 0-100m RHO anom

g.b29.01, 1980-1999, 0-100m RHO anom

g.b29.04, 1980-1999, 0-100m RHO anom

Stronger AMOC

- CCSM4 POP needs this magnitude positive S' and σ' needed to match observed AMOC

• Positive Mixed Boundary Condition feedbacks which amplify warm,salty NATL biases are weaker in CCSM4 than CCSM3.5 due to:

- • POP: Overflow parameterization
- • POP: Horizontally-varying background diffusivity
- • POP: Submesoscale mixing parameterization
- • CICE: delta-Eddington shortwave transfer, melt ponds, aerosols

• As a result, ocean-ice hindcast ice distribution is more compatible with OBS and the fully coupled CCSM4 ➔ Good news for decadal prediction
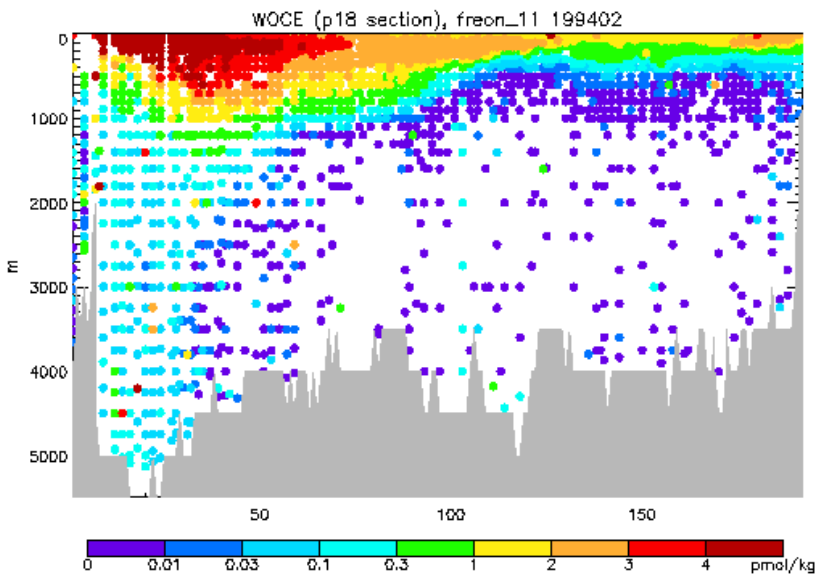

Case g.b29.01
ANN Mean   Years 0231-0240
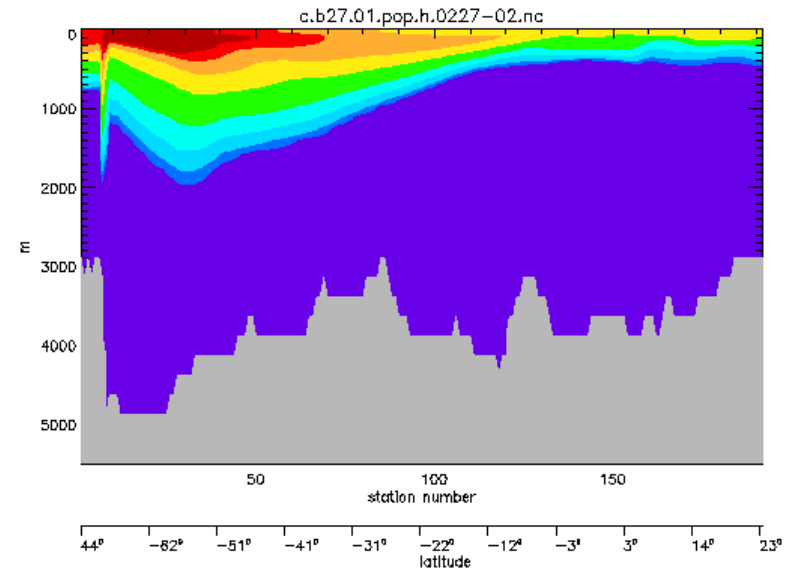ice area (aggregate)   %
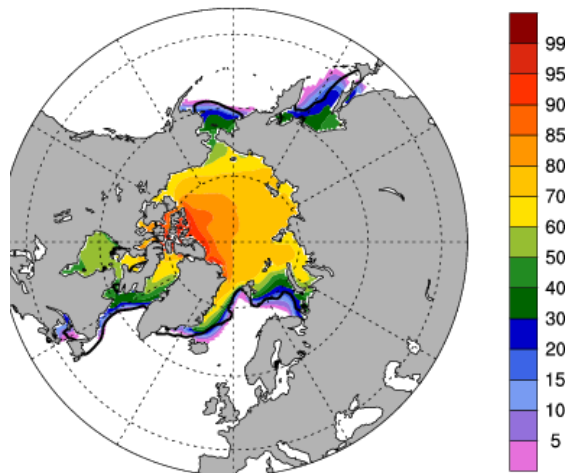
Case b40.20th.track1.1deg.002a
ANN Mean   Years 1985-2004
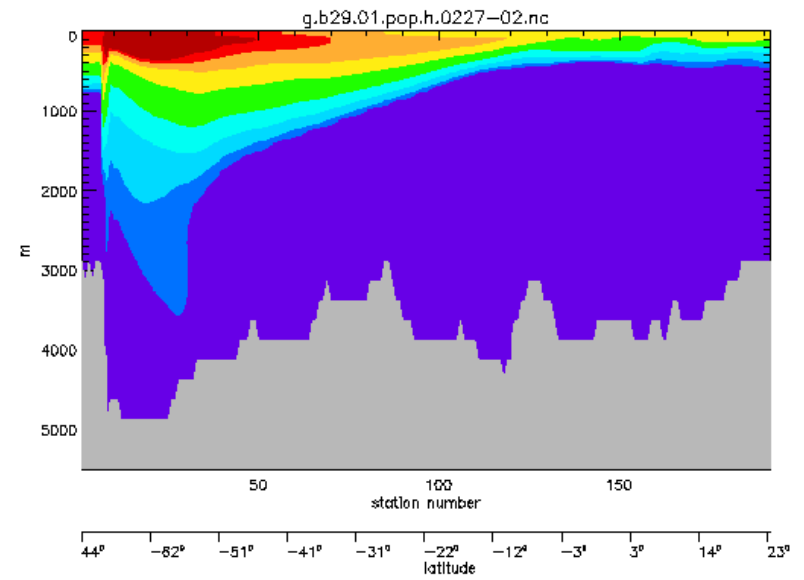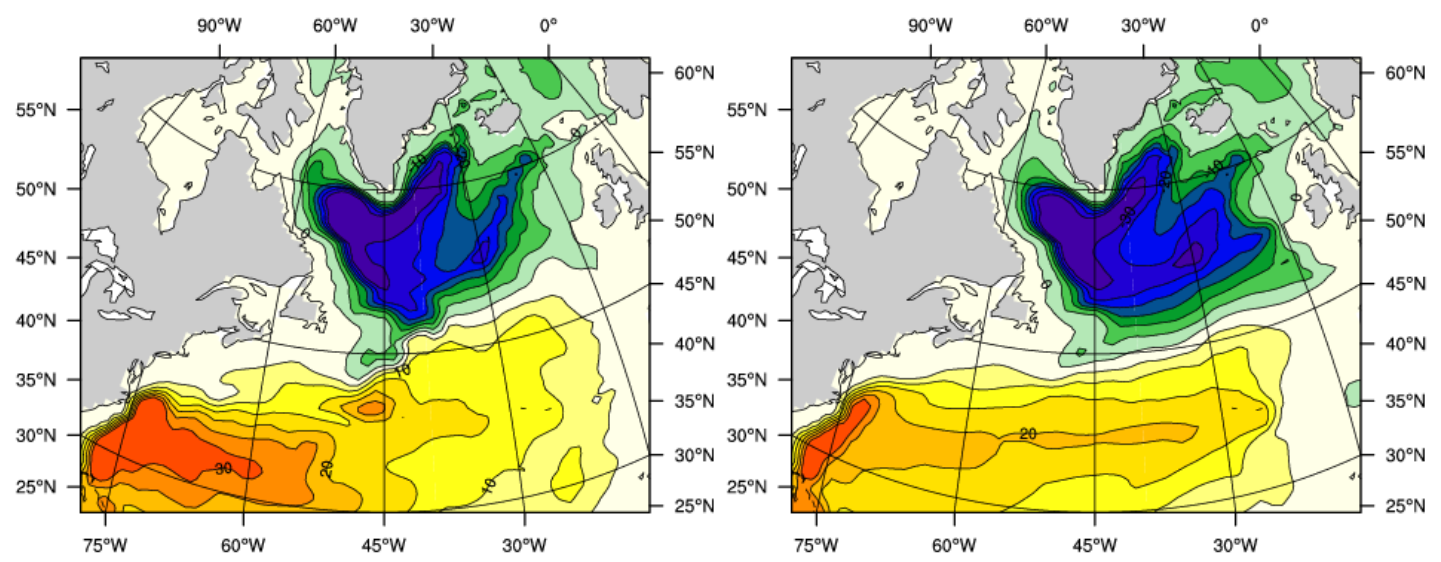ice area (aggregate)   %
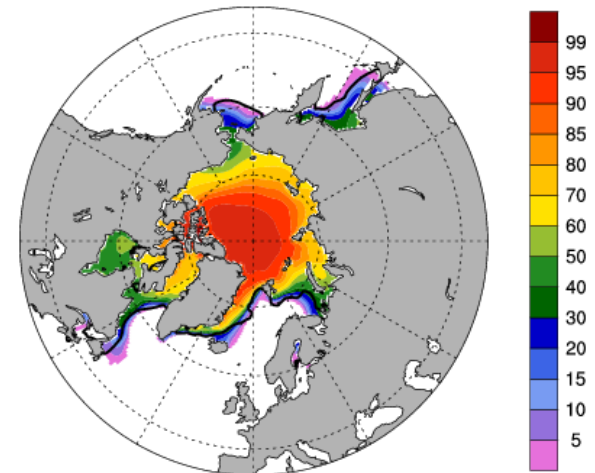
Ocean-only

CFC-11, WOCE P18
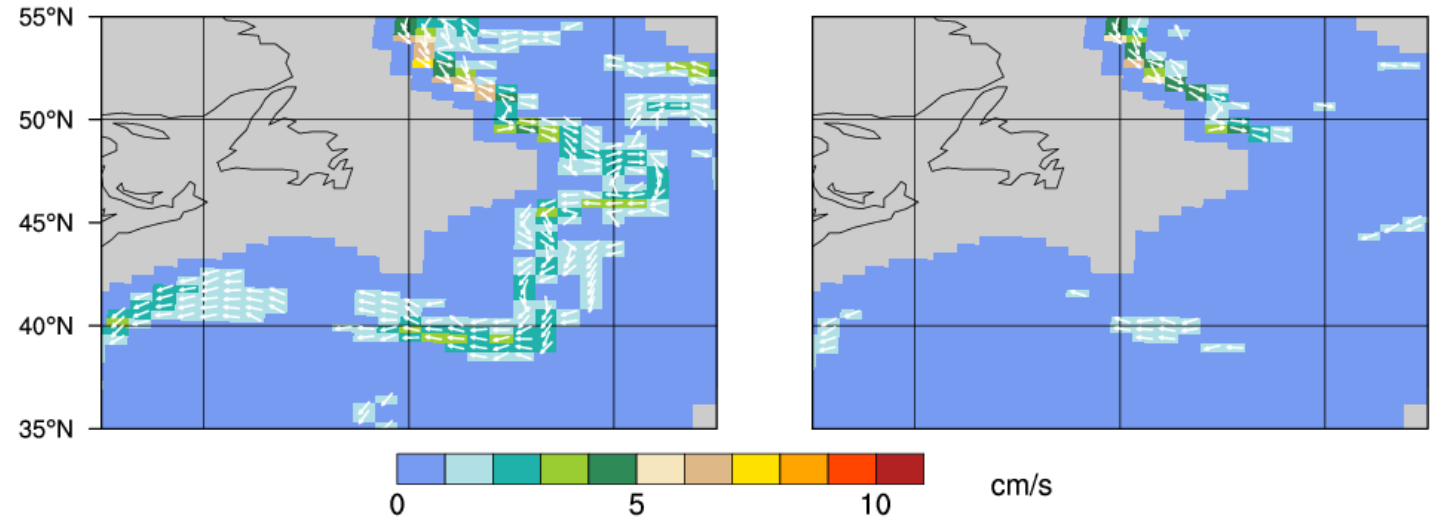
Ocean-ice
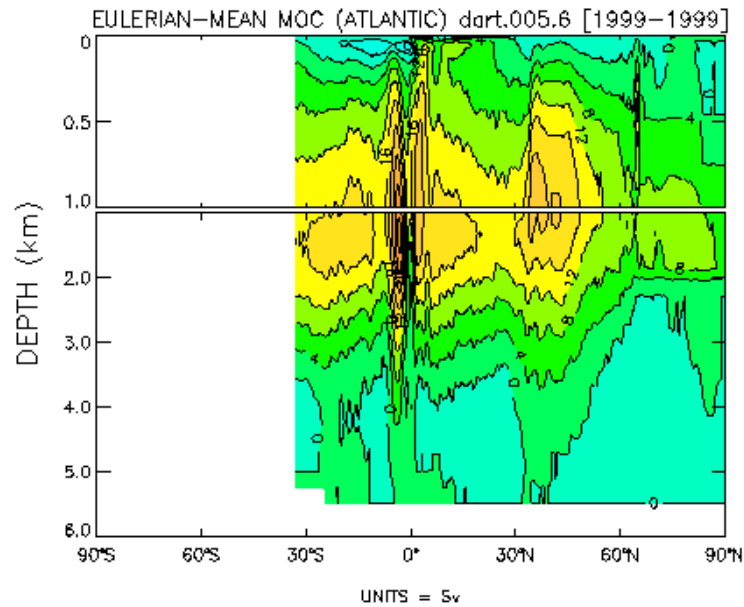
1999

BSF

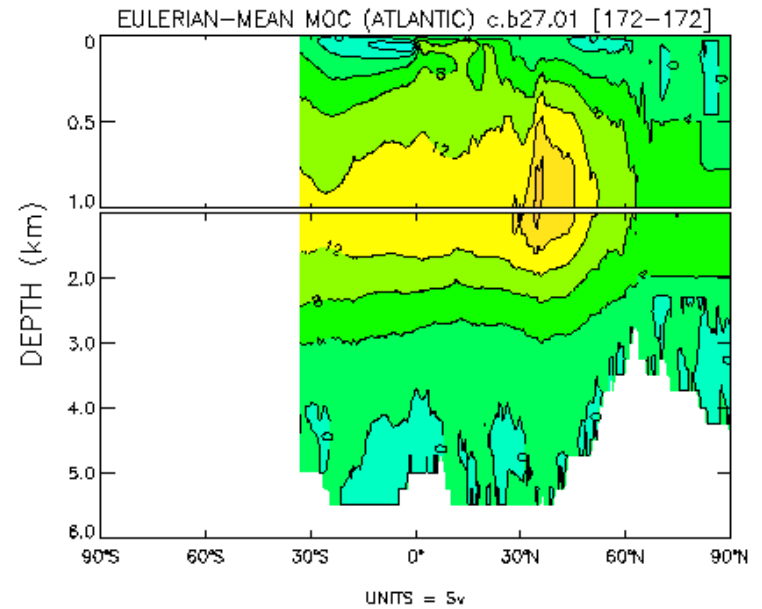**DWBC**

(3000m)

ocean hindcast w/ DART   ocean hindcast

1999

ocean hindcast w/ DART   ocean hindcast

Short Term Plan

✓ Generate 2000 ic's for ocn (& ice) from best CORE2 hindcast (CCSM4, ocean-ice, т = 4 yr)

✓ Generate 2000 ic's for ocn from a DART hindcast ensemble (1998-1999, ocean only)

o Generate 2000 ic's for atm & lnd from a 1990-2000 AMIP-style run using surface BC's from CORE2 hindcast (~days)

o 2000-2005 20th Cent projection tests using various ic's (~weeks):

   1. HINDCAST/AMIP :
      ocn & ice (weak restored ocean-ice hindcast), atm (AMIP), lnd (AMIP)

   2. DART/AMIP :
      ocn (DART hindcast), ice (strong restored ocean-ice hindcast), atm (AMIP), lnd (AMIP)

   3. HINDCAST/20C :
      ocn & ice (weak restored ocean-ice hindcast), atm (20thC), lnd (20thC)

   4. DART/20C :
      ocn (DART hindcast), ice (strong restored ocean-ice hindcast), atm (20thC), lnd (20thC)
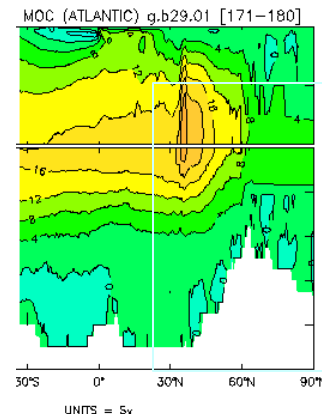
Longer Term Plans/Ideas

o   Generate 2000 ic's for ocn from an ocean-only DART hindcast ensemble, forced with output from an ensemble of data-assimilated CAM runs (~weeks)

?   Generate 2000 ic's for ocn/ice from an ocean-ice coupled DART hindcast ensemble, forced with CORE2 or CAM DA ensemble

?   Generate 2000 ic's for ocn/ice/atm/lnd from a fully coupled 20th Cent run with ocean data assimilation (ocn = DART ensemble)

?   Generate 2000 ic's for ocn/ice/atm/lnd from a fully coupled 20th Cent run with multi-model data assimilation (atm, ocn = DART ensembles)

o   CMIP5 fully-coupled CCSM4 decadal projections* (~months-year):
   I.   10-year hindcast & prediction ensembles initialized at 1970, 1975, 1980, …, 2005
   II.   30-year hindcast & prediction ensembles initialized at 1960, 1980, 2005
   III. 10-year prediction ensembles initialized at 2001, 2002, …, 2009

   *Taylor, Stouffer, and Meehl, 2008: "A Summary of the CMIP5 Experiment Design", WCRP   Working Group on Coupled Modelling

AMOC, max below 500m, north of 28N
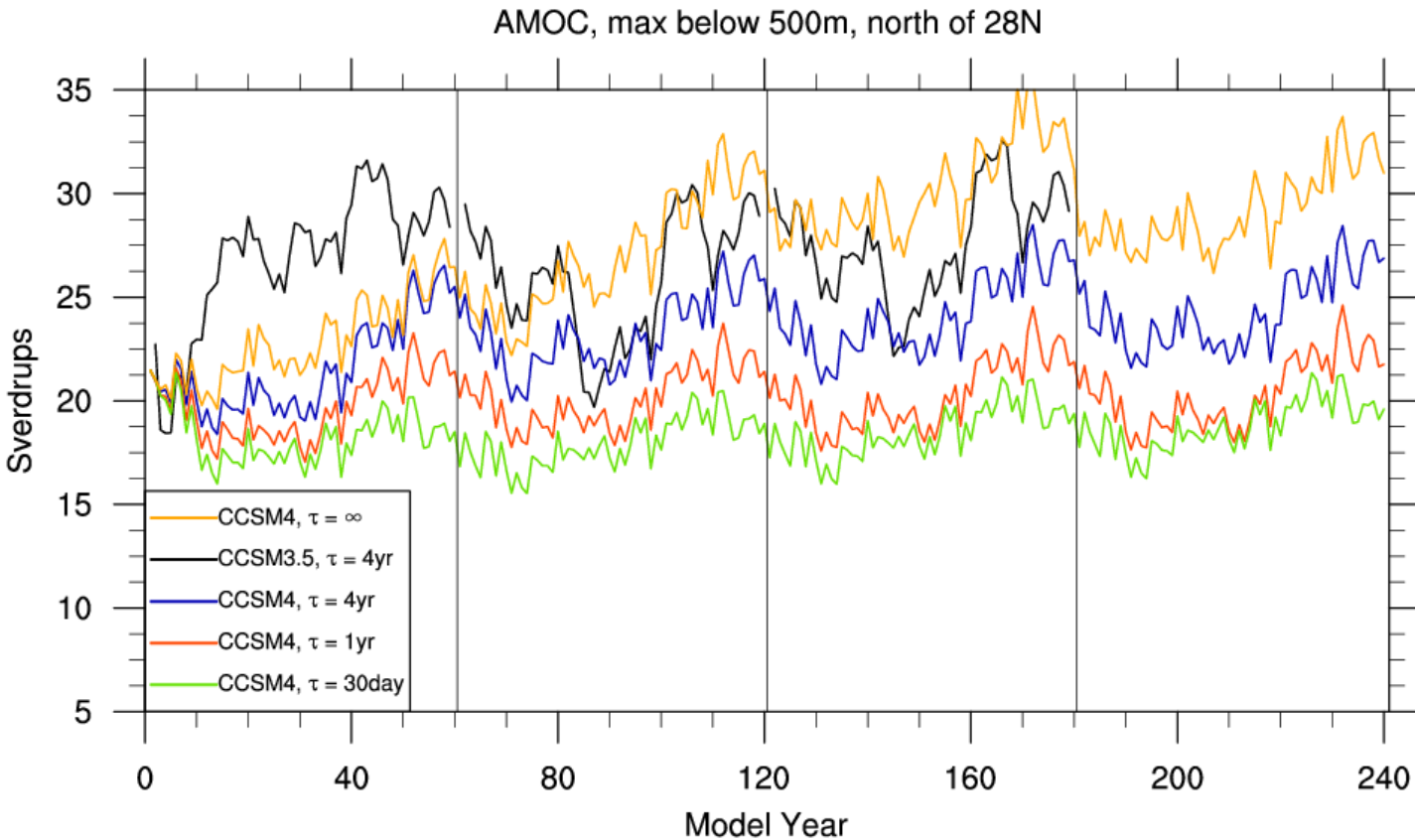
Major differences between **black** and **blue** :
- POP: Overflow parameterization
- POP: Horizontally-varying background diffusivity
- POP: Submesoscale mixing parameterization
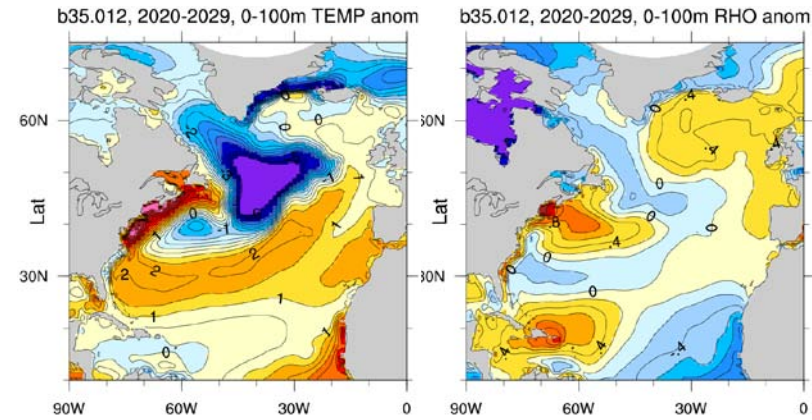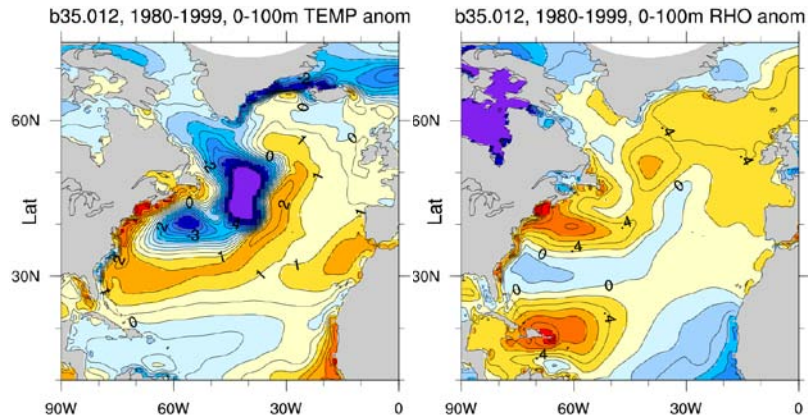- CICE: delta-Eddington shortwave transfer, melt ponds, aerosols

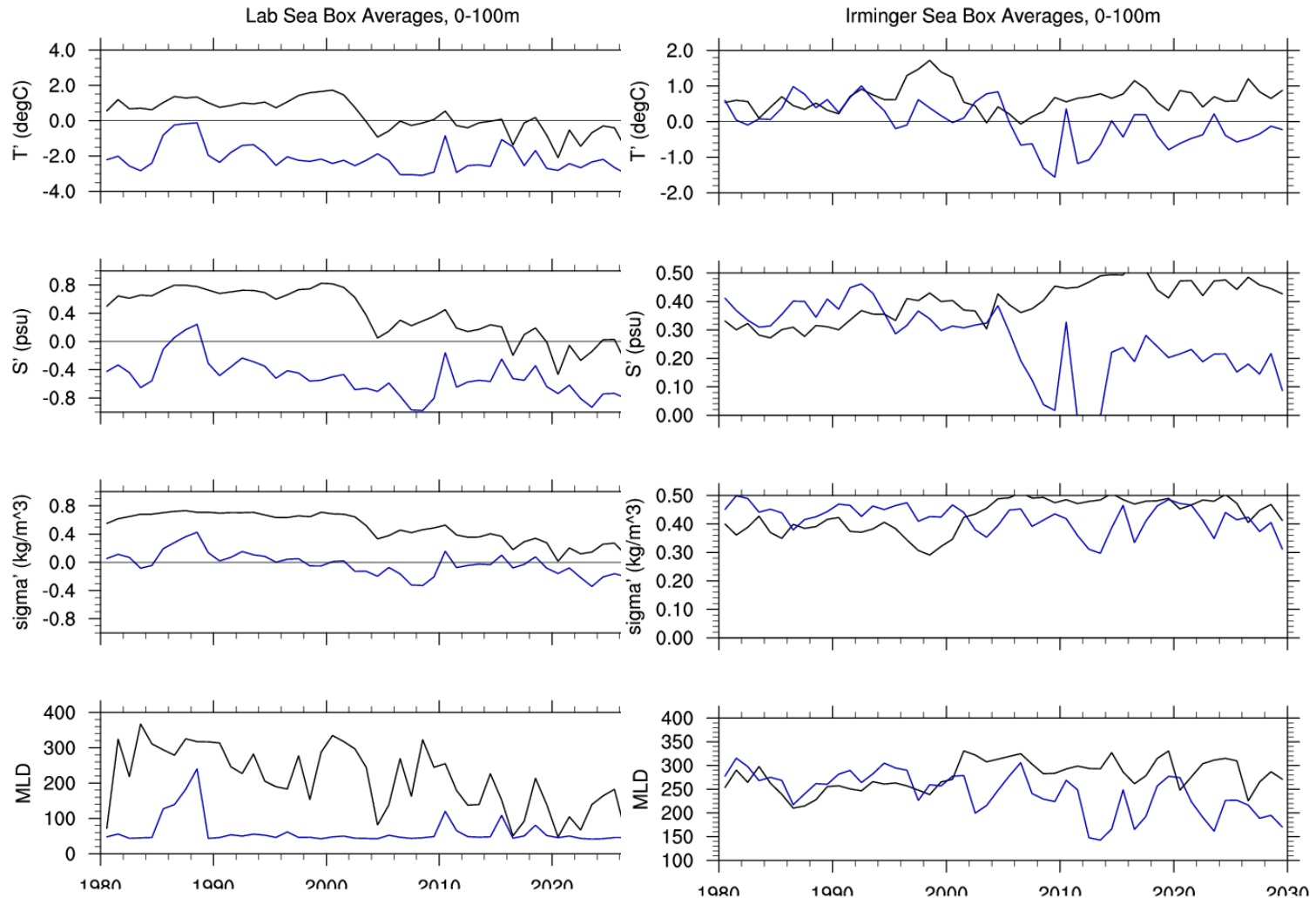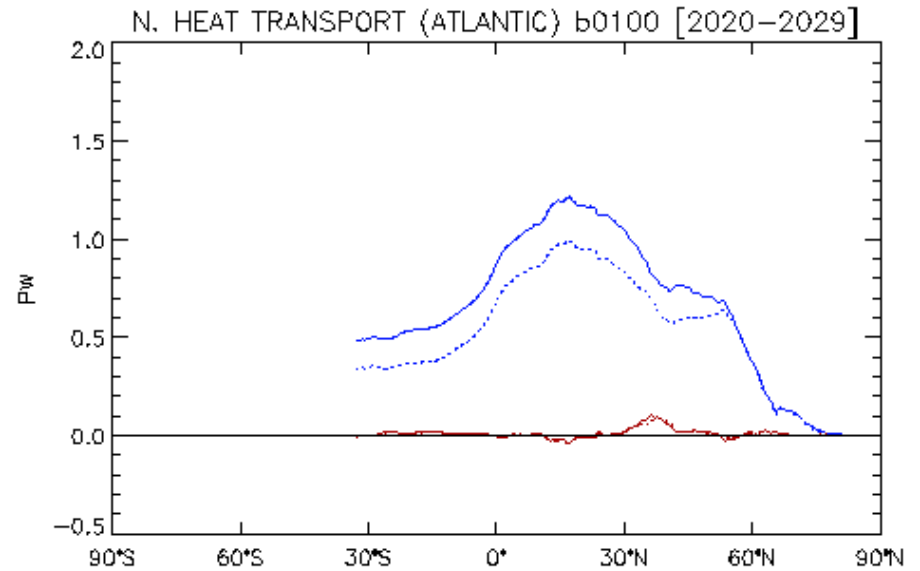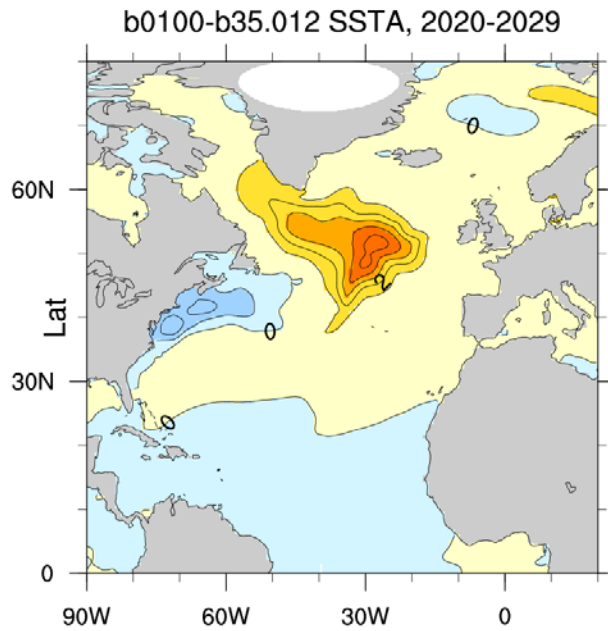# CCSM3.5 Fully-Coupled Decadal Prediction Runs

nudged

CNTRL

CCSM3.5 Fully-Coupled Decadal Prediction Runs

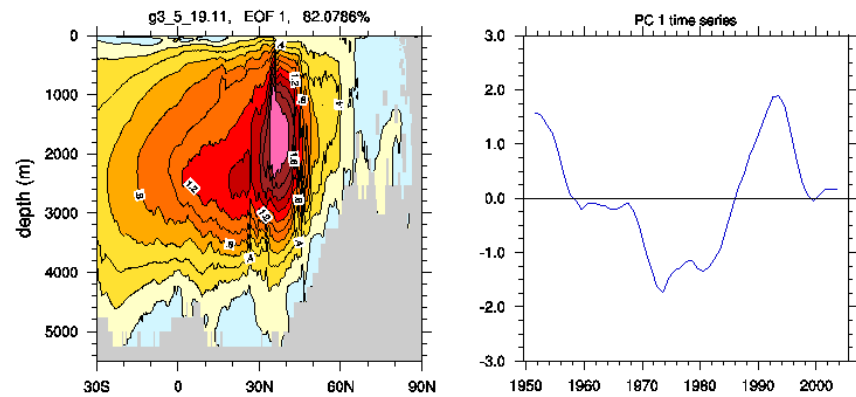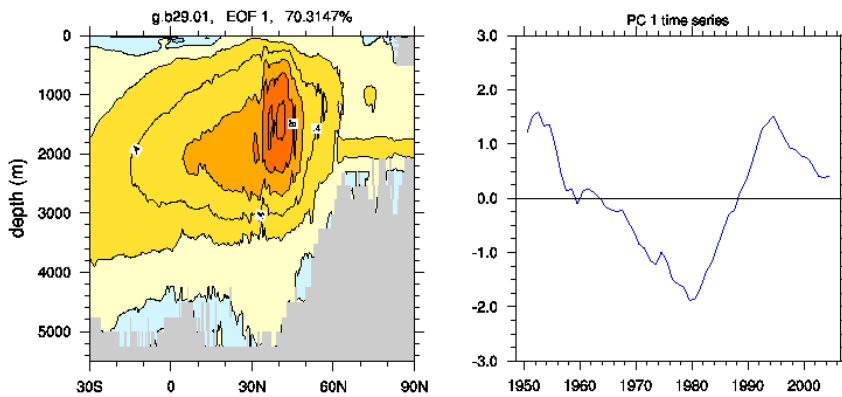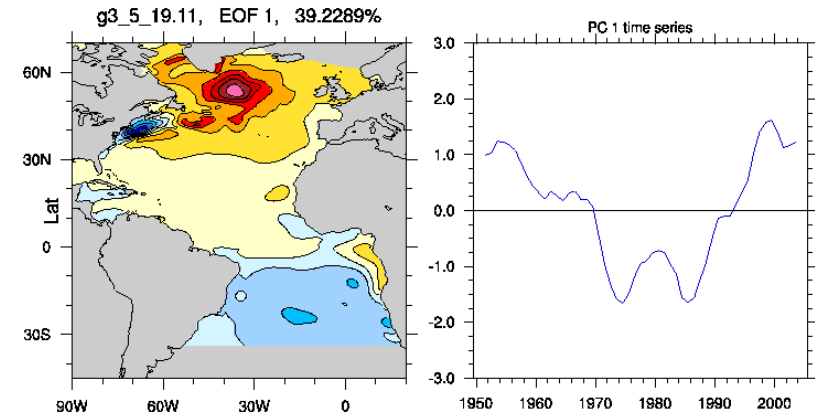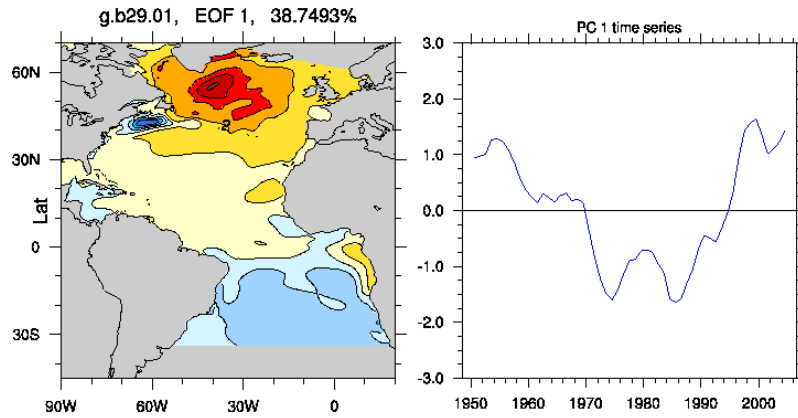Lab Sea Box Averages, 0-100m
Irminger Sea Box Averages, 0-100m
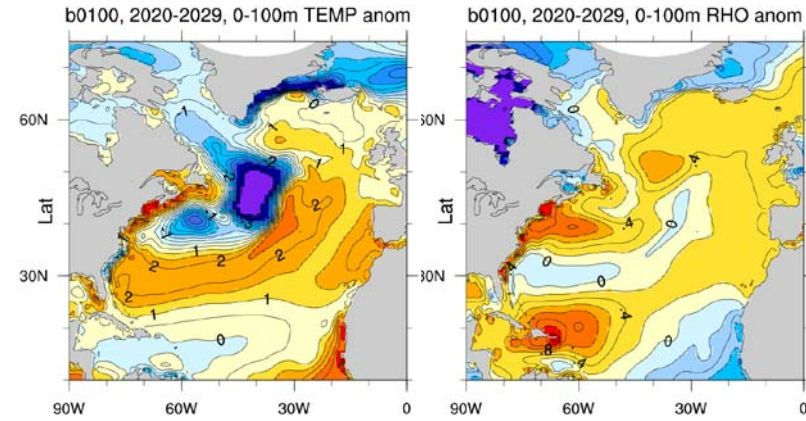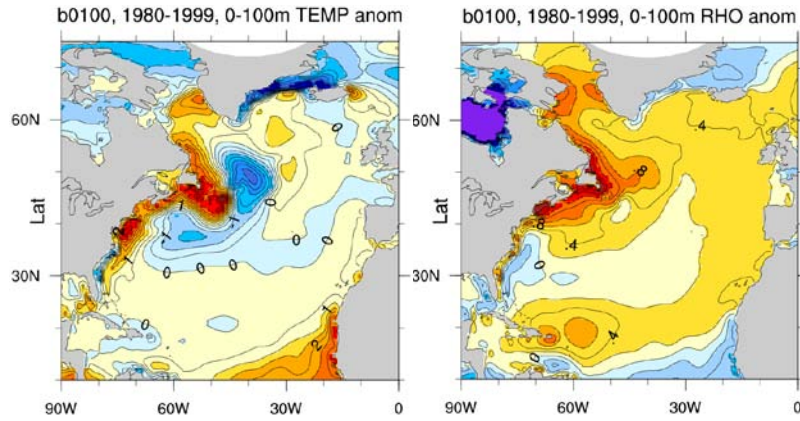
Exploring MOC initialization for future projection runs

b0100-b35.012 SSTA, 2020-2029

N. HEAT TRANSPORT (ATLANTIC) b0100 [2020-2029]

➔ expect ocean/ice initialization to be (the?) key factor in projections of future North Atlantic climate using fully coupled CCSM4

OBS SST
EOF1
"AMO"

HADOI-SST, EOF 1, 45.1214%

PC 1 time series

SST
EOF1

AMOC
EOF1

g.b29.01, EOF 1, 38.7493%

g3_5_19.11, EOF 1, 39.2289%

g.b29.01, EOF 1, 70.3147%

g3_5_19.11, EOF 1, 82.0786%

PC 1 time series

CCSM4 Ocean-ice τ = 4yr

CCSM3.5 Ocean-ice τ = 4yr