CESM1: Ocean response to Arctic Sea Ice Loss (preliminary!)

Laura Landrum

Marika Holland

The National Center for Atmospheric Research
NCAR
managed by UCAR to serve the community
sponsored by NSF

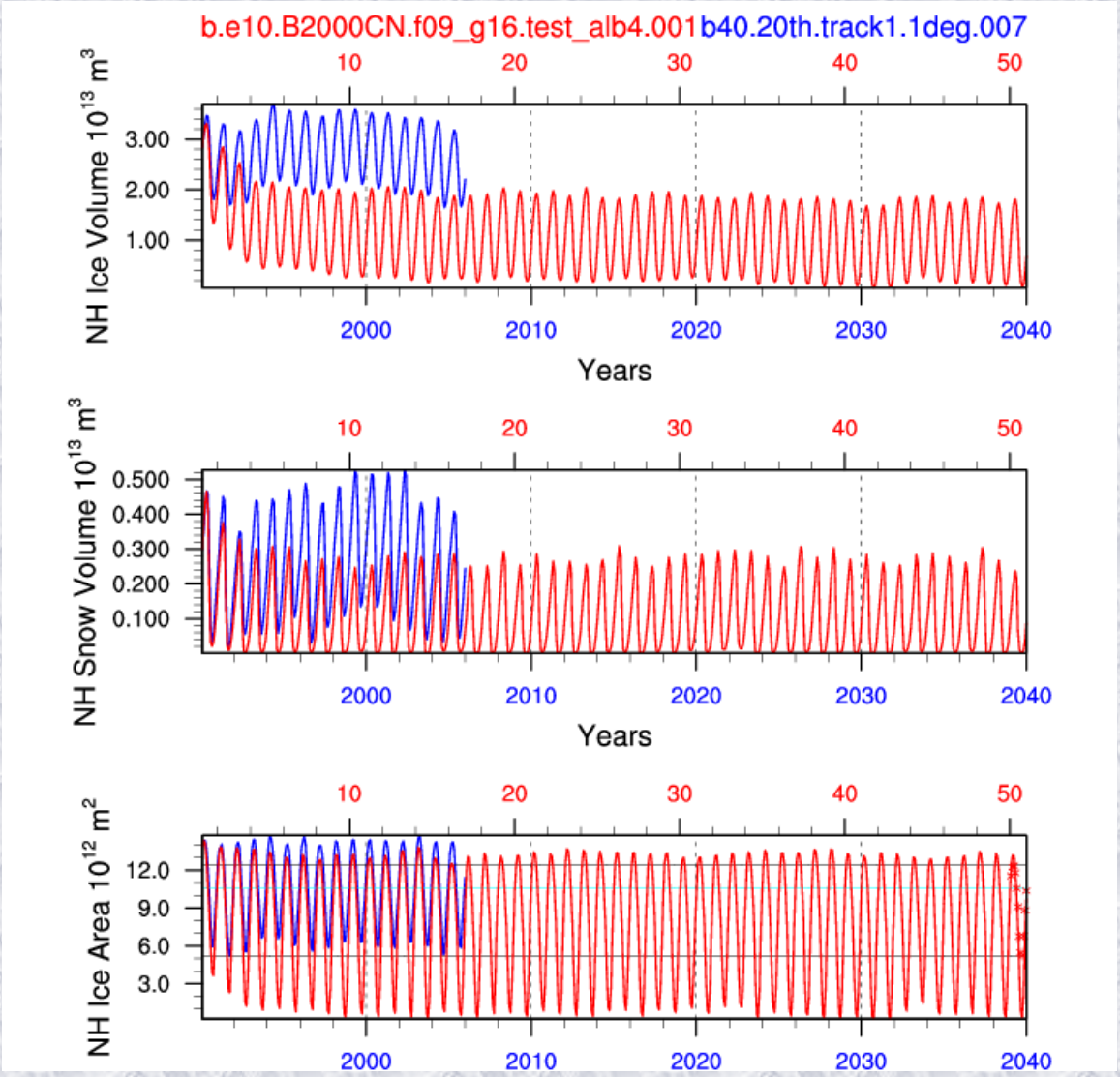
Background

- Experiments with CCSM3 (prescribed sea ice and SSTs) suggest that most of high-latitude warming response to GHG forcing at end of 20th C is due to Arctic sea ice loss (Deser et al., 2010)
- Clara Deser and Bob Tomas - currently investigating atm response in CAM4 to Arctic sea ice loss (very similar to CAM3 – talk on Wednesday)
- Goal: to explore the oceanic response in CESM1 to ice-free summer Arctic conditions separate from greenhouse gas forcings

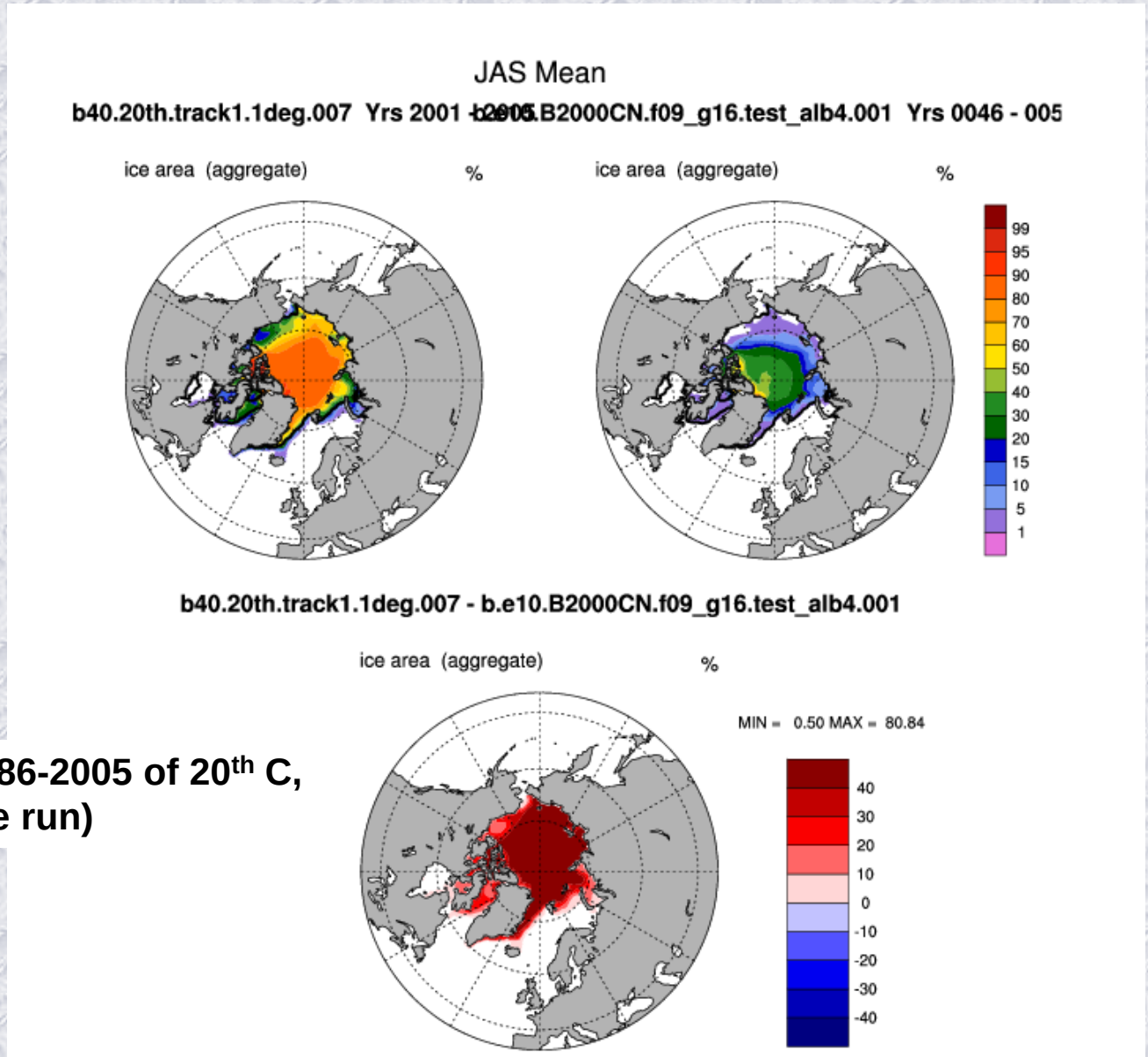
Model set-up

- CESM1 fully coupled (atm-ocn-lnd-ice)
- Change radiative parameters in sea ice model such that Arctic goes ice free most summers
- Initialized from 20th C CMIP5 ensemble member (b40.20thC.track1.1deg.007) in simulation year 1990
- Run at constant 2000 conditions
- Currently have 50 yrs of simulation; plan on continuing for another ~50 yrs

Arctic sea ice loss: 1st 50 yrs

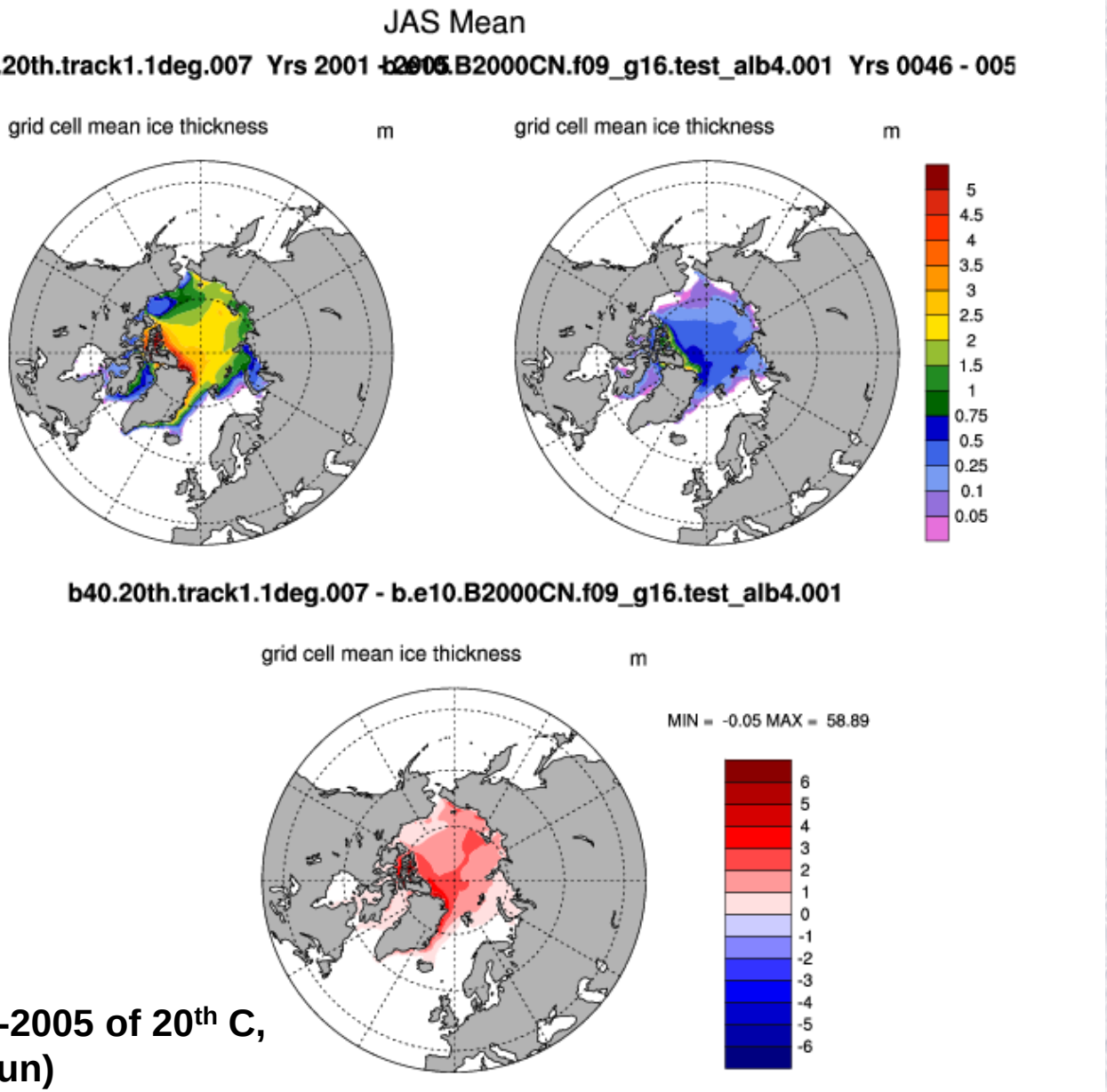


Arctic sea ice loss: 1st 50 yrs



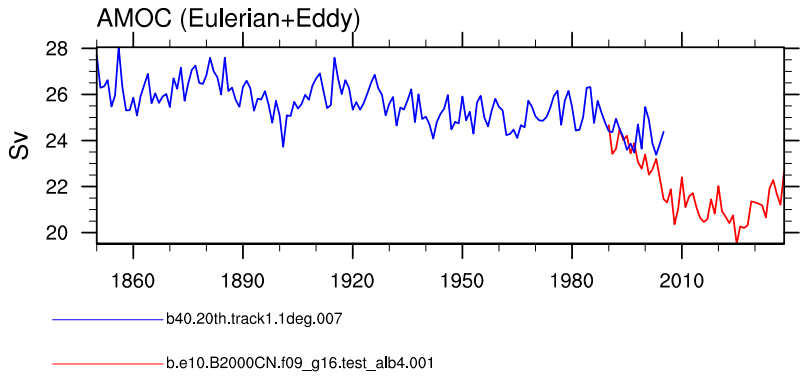
20 yr means (1986-2005 of 20th C, 31-49 of Ice-Free run)

Arctic sea ice loss: 1st 50 yrs



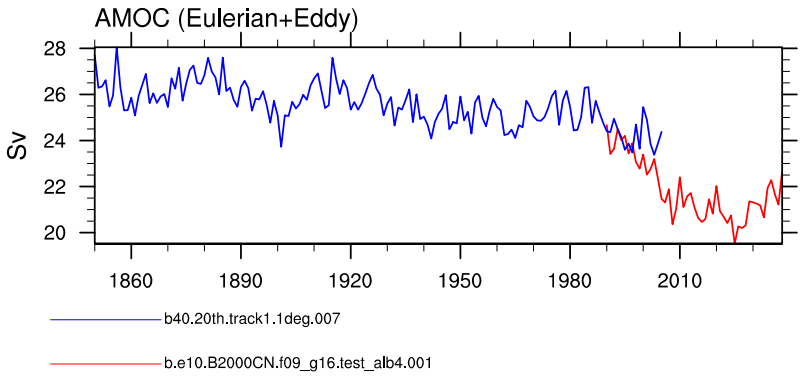
20 yr means (1986-2005 of 20th C, 31-49 of Ice-Free run)

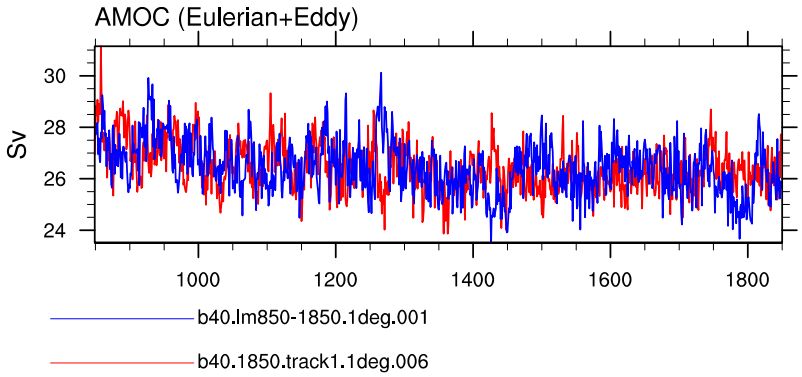
Ocean Response: Atl MOC



Ocean Response: Atl MOC

Model run (yrs)	AMOC in Sv
Ice Free summer Arctic (1-49)	21.8
CCSM4 20th C 007 (1986-2005)	24.4
CCSM4 20th C 007 (1850-2005)	25.6
CCSM4 1850 control run (700-1299)	25.8 (0.51 Sv^2)
CCSM4 Last Millennium (850-1850)	26.4 (1.1 Sv^2)



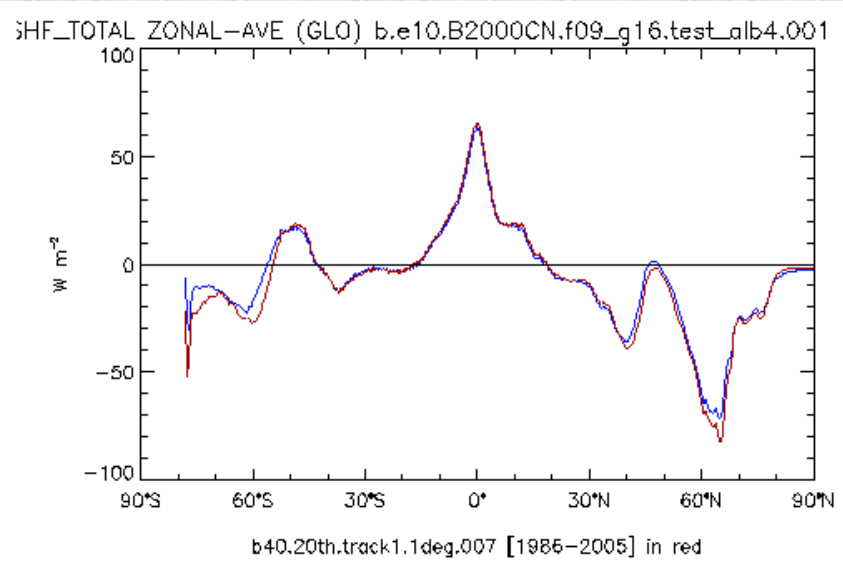


September Ice-Free Arctic ➔immediate, significant decrease in the AMOC

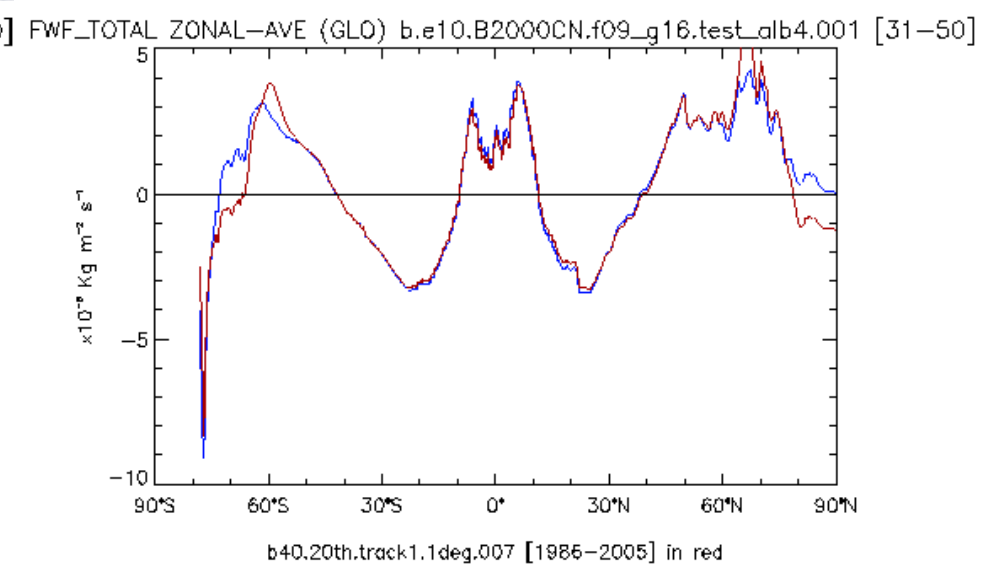
For more background information on the AMOC in CCSM4 see Danabasoglu et al. special issue paper

September Ice-Free Arctic ➔immediate, significant decrease in the AMOC

- Fluxes: surface heat and freshwater

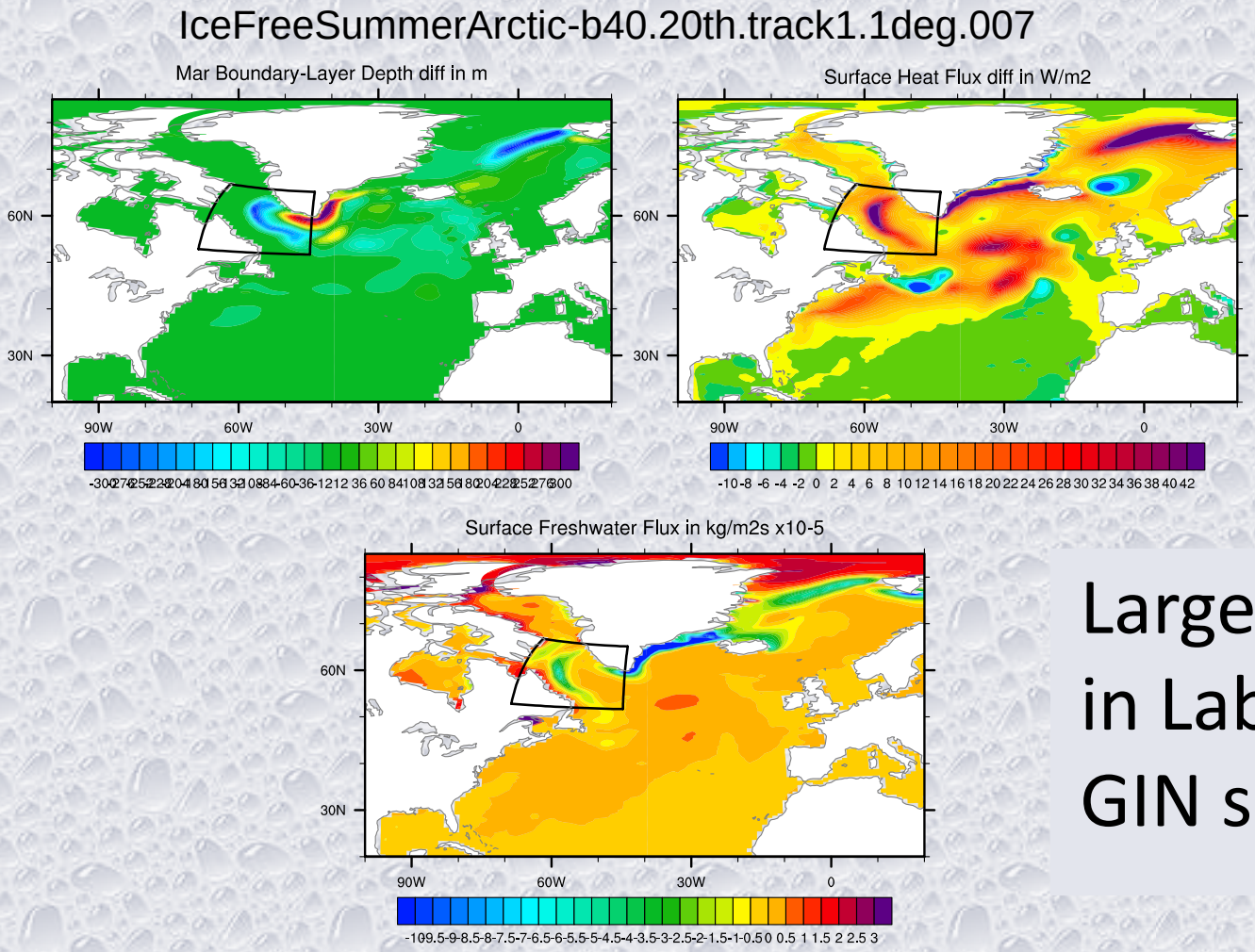


Total (zonal avg) SHF



Total (zonal avg) SFWF

Surface changes: Boundary Layer depth, heat and freshwater fluxes



Largest changes in Labrador and GIN sea regions

Regional Heat and Freshwater budgets: Labrador Sea

Calculate heat and salt budgets (regionally and over a specified depth) as tracer equations:

Ten + adv = Surface flux + diffusive

- Ten = tendency: annual change
- Advective components (mean, meso- and sub-mesoscale) calculated monthly and totaled for year
- Diffusive term calculated as a residual

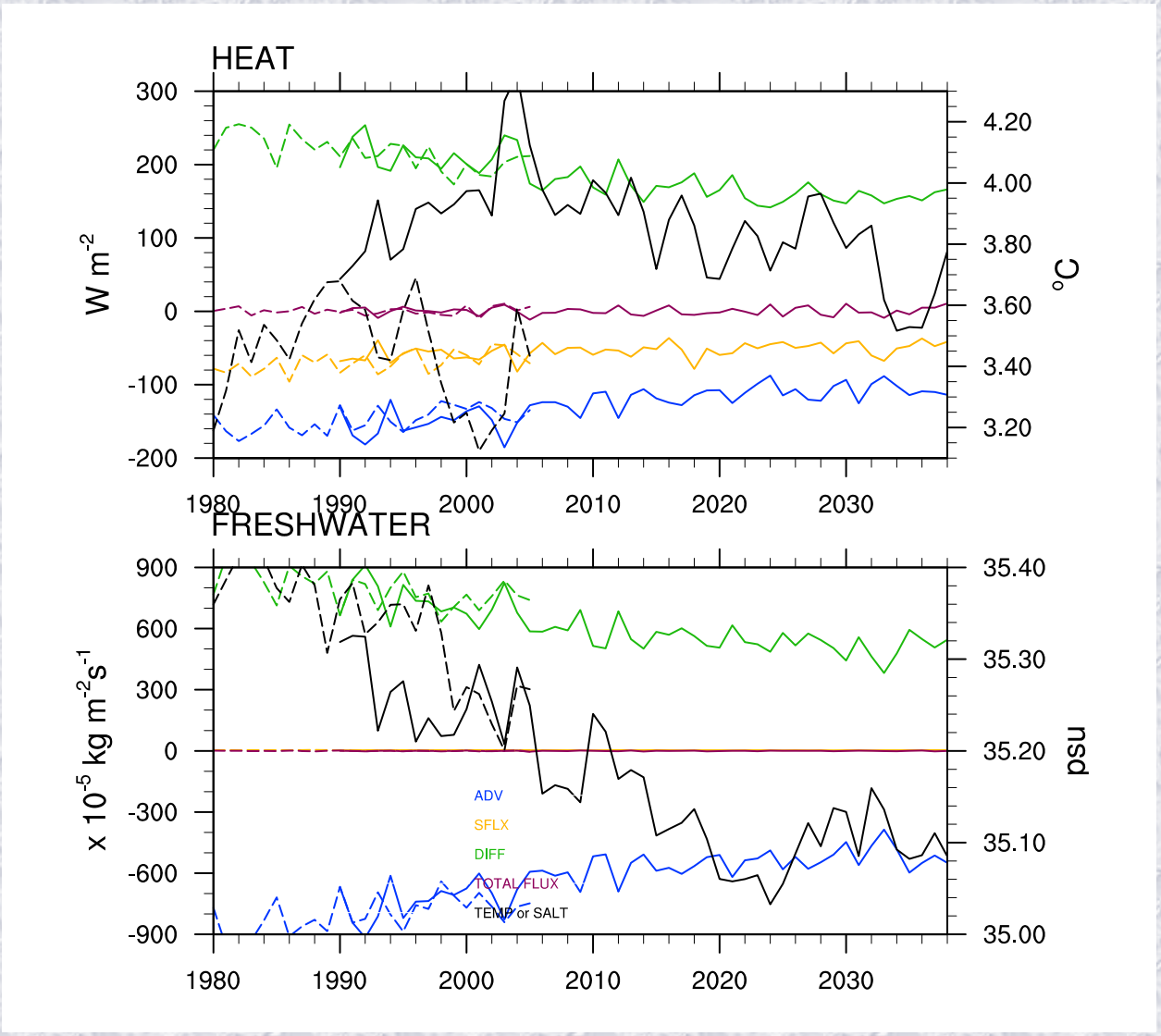
Units:

- Heat (W/m^2)
- Freshwater (kg/m^2s)

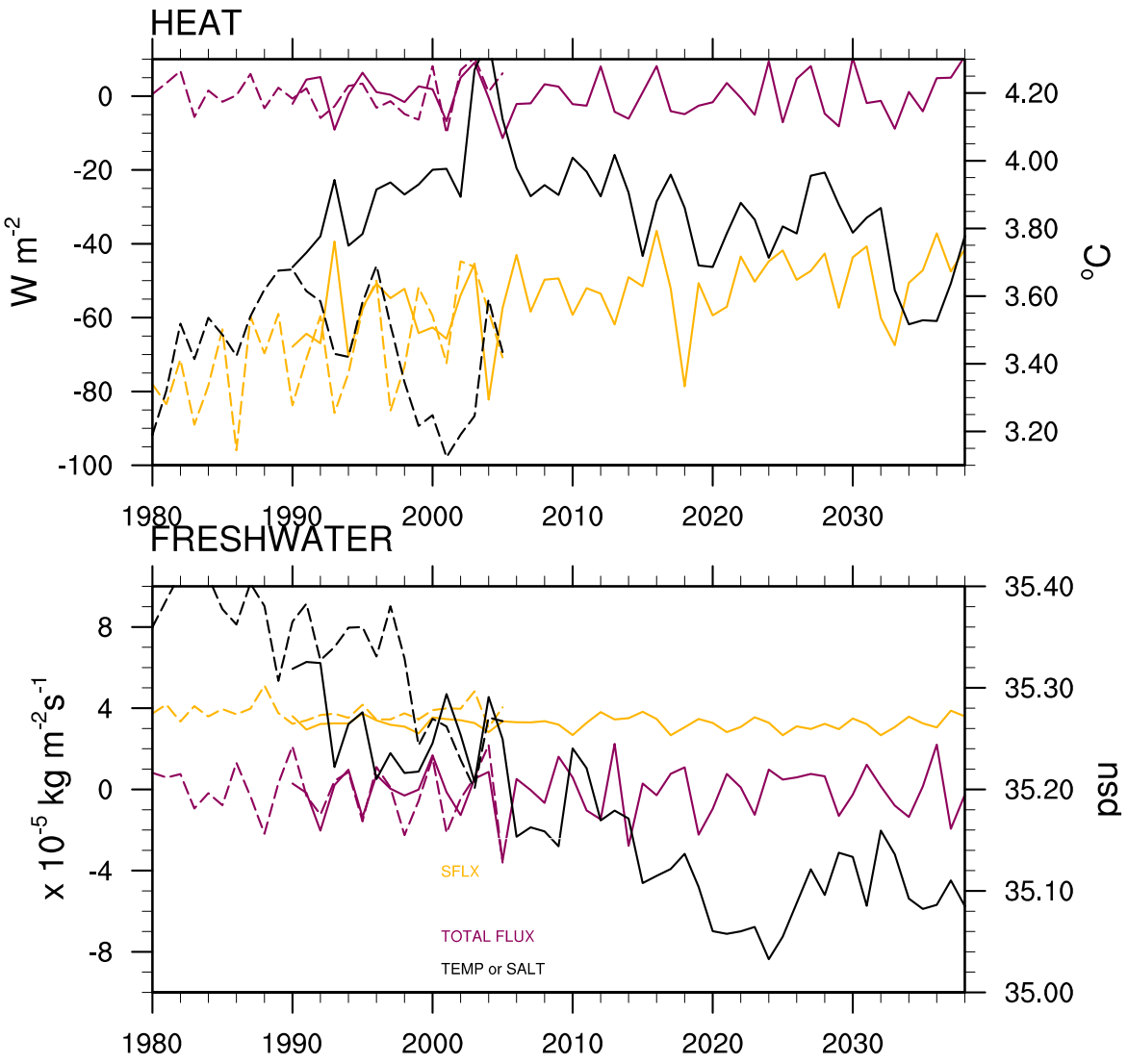
First round: surface to 200m

NESL

Regional Heat and Freshwater budgets: Labrador Sea



Regional Heat and Freshwater budgets: Labrador Sea



NESL

Summary

- CESM studies aimed at understanding effects of Arctic Sea Ice loss on climate
- Have 50 yrs of a fully coupled run with summer ice-free arctic conditions – anticipate another 50 yrs
- Ocean response: rapid, large decrease in AMOC
- Looking into changes in Surface fluxes of heat and freshwater in North Atlantic and AMOC

This work is supported by the National Science Foundation Office of Polar Programs