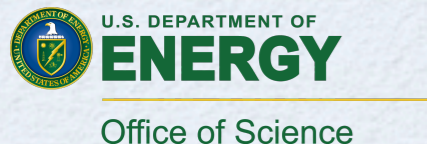


Ultra High Resolution Global Climate Simulations to Explore and Quantify Predictive Skill for Climate Means, Variability and Extremes

Kate Evans (ORNL), Mat Maltrud (LANL), Julie McClean (SIO),
Caroline Papadopoulos (SIO), Milena Veneziani (LANL),
Marcia Branstetter (ORNL), Elena Yulaeva (SIO)

James Hack (ORNL), Phil Jones (LANL), Mark Taylor (SNL)
Bill Collins (LBNL), Dave Bader (LLNL)

Ocean Model Working Group, January 2013



Project Goals

- Test hypothesis that higher resolution models are needed
 - 📌 to include explicit simulation of non-linear phenomena and interactions on the small scale that have feedbacks on large scale climate features
 - 📌 to provide accurate and explicit simulations of local to regional scale phenomena, including low-probability, high-impact hydrological events

Experimental Plan and Status

- T341 experiments

- 📌 T341 / 0.1° POP-CICE preindustrial (CAM4 physics): 43 years completed

- CAM-SE experiments

- 📌 0.25° / 0.1° POP-CICE preindustrial (CAM4 physics): evaluated against T341

- 📌 CAM-SE used for all future work, including ensemble of late 20th century / early 21st century transients

- T85 experiments for comparison

- 📌 T85 / 1° POP-CICE preindustrial for comparison to “standard” CCSM 4 release

- 📌 Ensemble of late 20th century / early 21st century transients to test initialization strategy

- Initial state exploration, sensitivity

- 📌 0.1° forced POP-CICE, 23 years completed. To be used for initialization of high resolution present day transients

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High resolution fully-coupled simulations with T341 atmosphere and 0.1° POP/CICE

Milena Veneziani and Mat Maltrud

Los Alamos National Laboratory

Ocean Model Working Group, January 2013

LA-UR-13-20369

Configuration

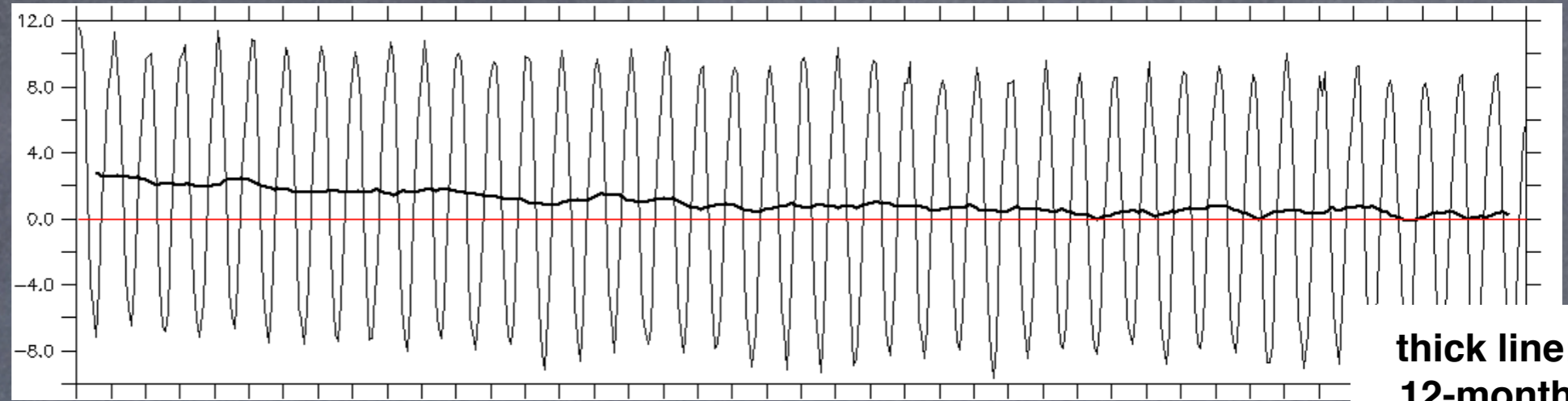
- Pre-industrial conditions
- T341 CAM-EU (~30 km resolution) with initial condition from year 10 of CAM/CLM run from Kate Evans
- 1/10° tripole POP/CICE with initial condition from year 1 of POP/CICE run from Julie McClean
- 1/4° FV grid for CLM with initial condition from year 9 of CAM/CLM run from Kate Evans
- Simulations carried out at NERSC and Oak Ridge Computing Facility

Key changes in the initial set-up

- Change **coupling interval** from 2 to 6 hours: high frequency coupling seemed to excite strong inertial motions that led to excessive sea-ice coverage
- Change the parameterization scheme of solar radiation fluxes over sea-ice from default with prescribed albedo to **Delta-Eddington parameterization**

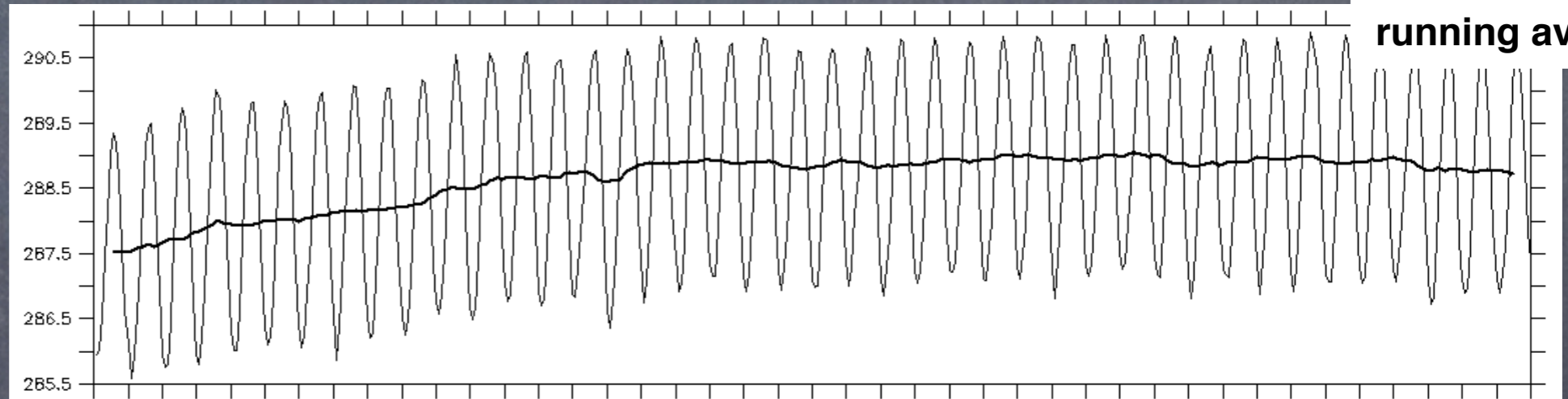
Atmosphere-Ocean adjustment

Top of atmosphere
radiation balance:
incoming SW -
outgoing LW [W/m^2]

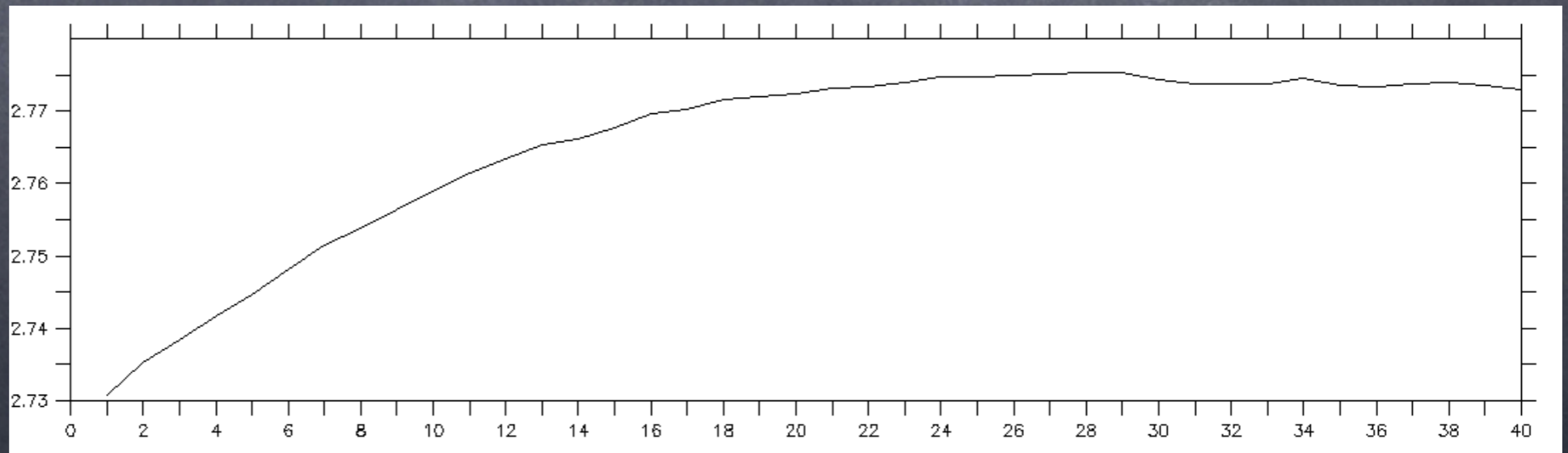


thick line:
12-month
running avg

Global average
surface air
temperature [K]

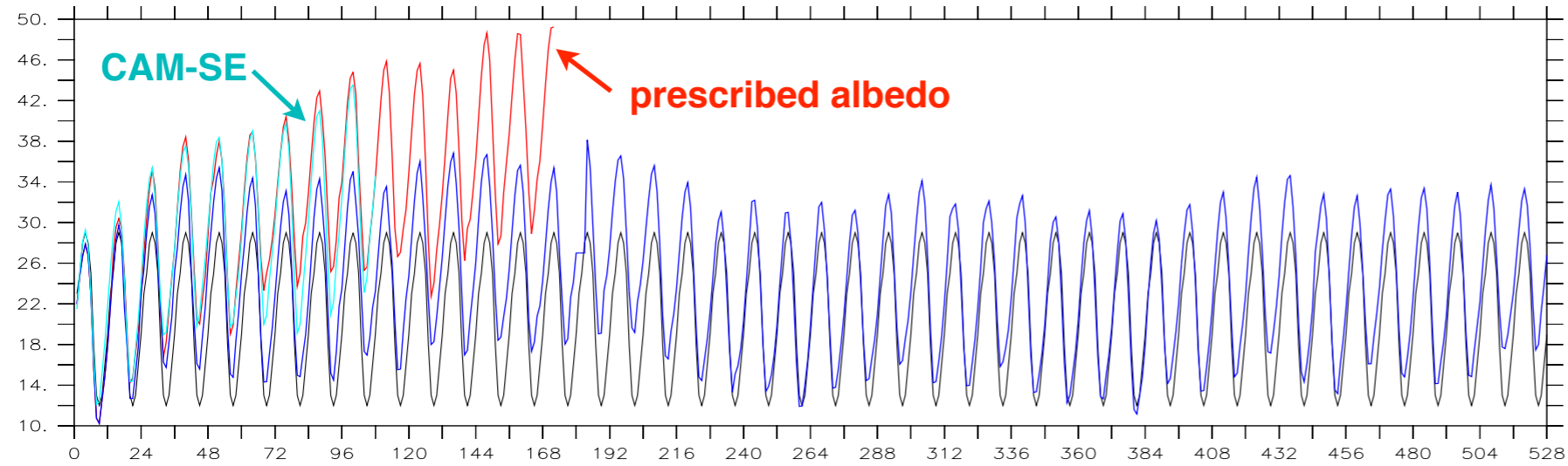


Annual volume
averaged ocean
temperature [$^{\circ}\text{C}$]

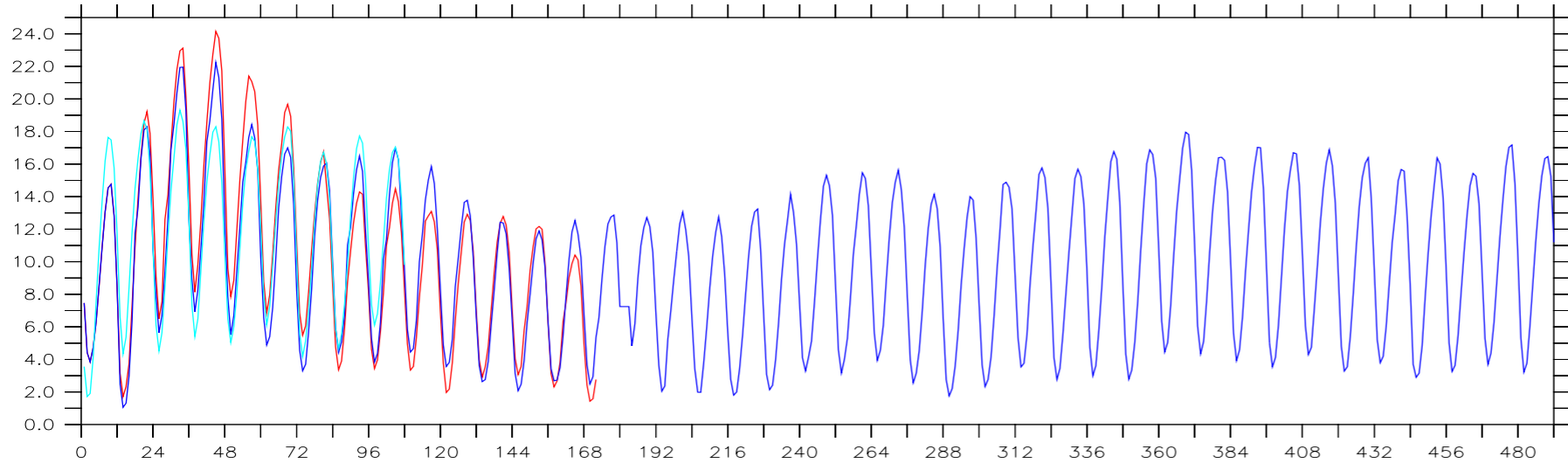


Sea-ice volume

Northern Hemisphere



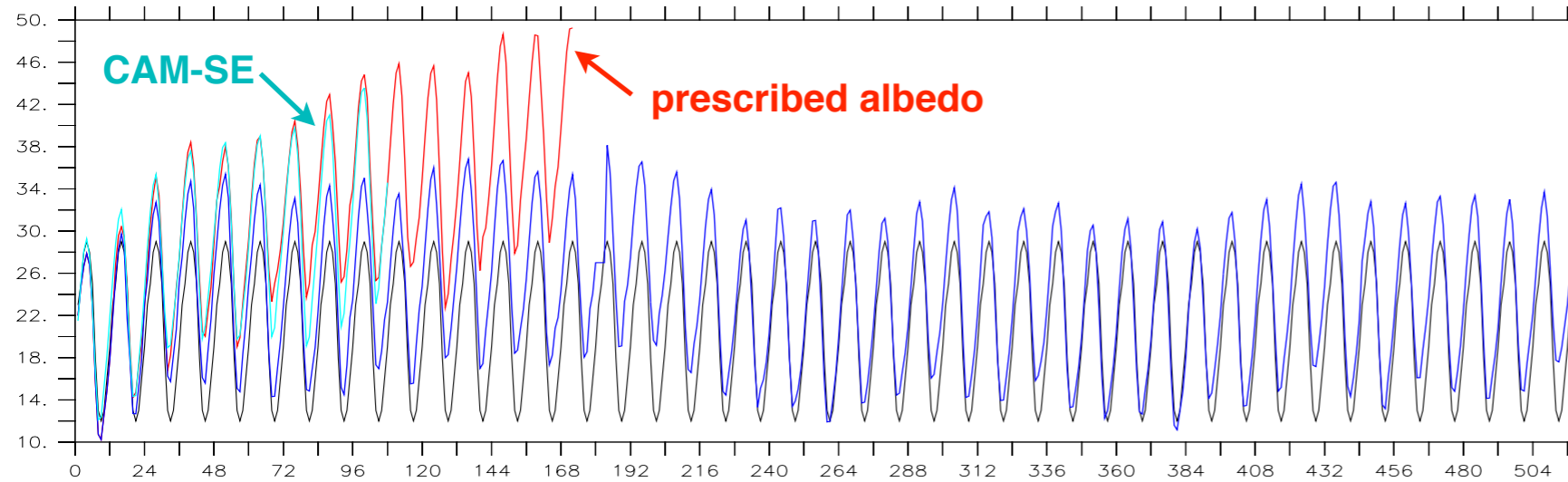
Southern Hemisphere



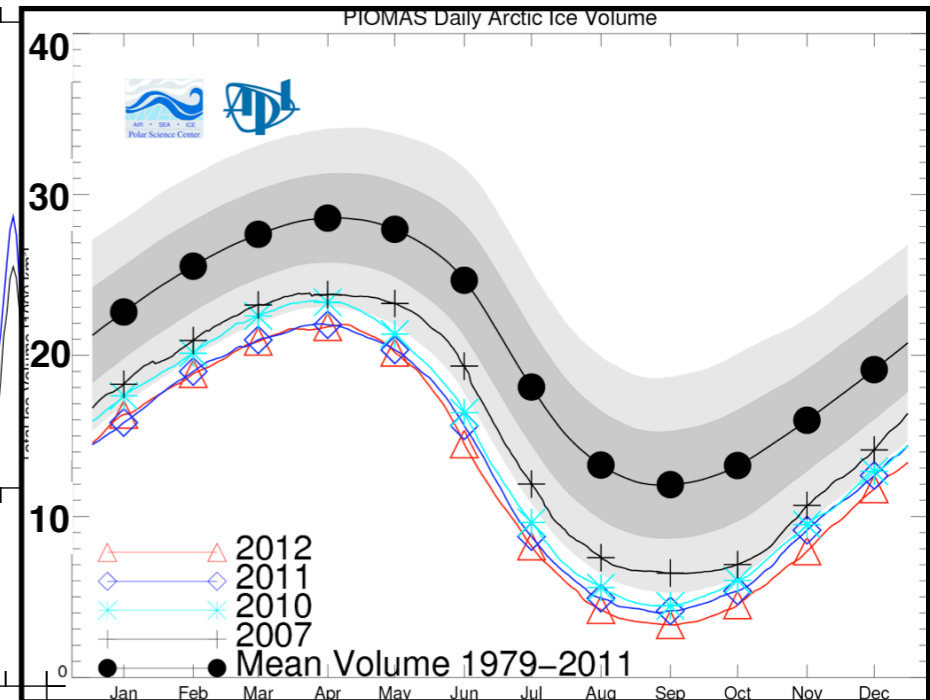
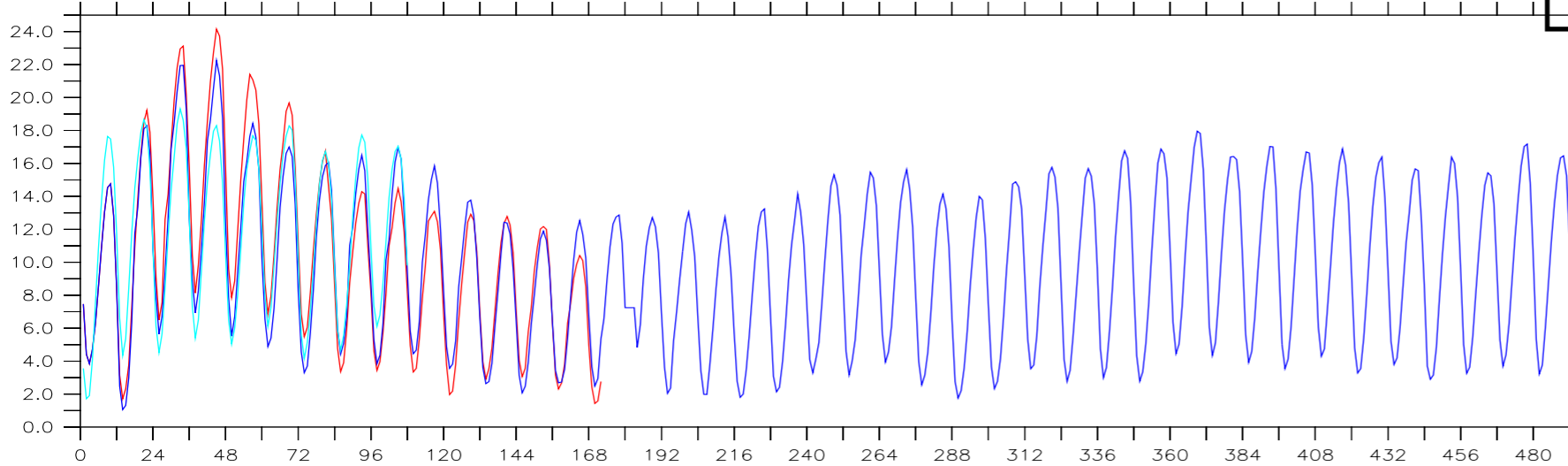
Sea-ice volume

PIOMAS Arctic Ice Volume (1979-2011)

Northern Hemisphere



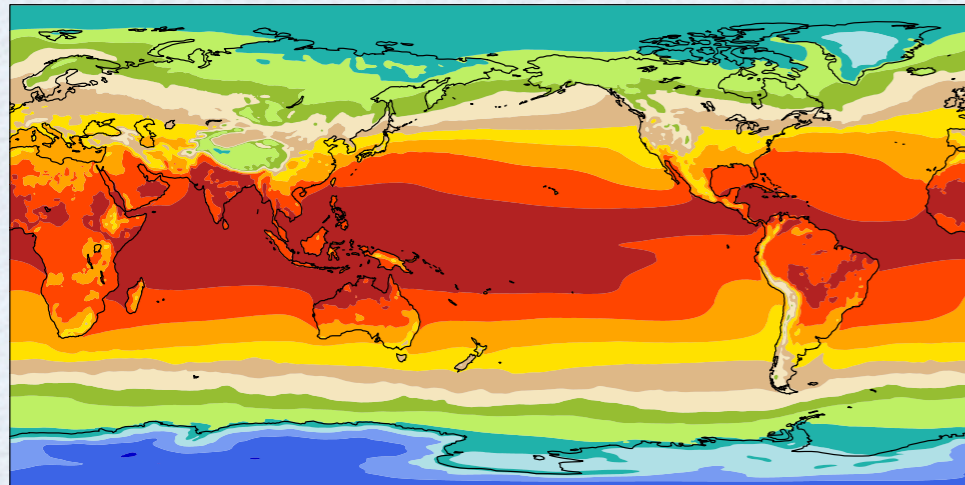
Southern Hemisphere



source: <http://psc.apl.washington.edu/wordpress/research/projects/arctic-sea-ice-volume-anomaly/>

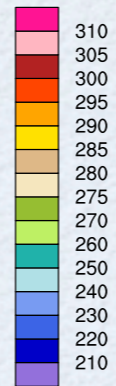
2m air temperature

model yrs 34-43

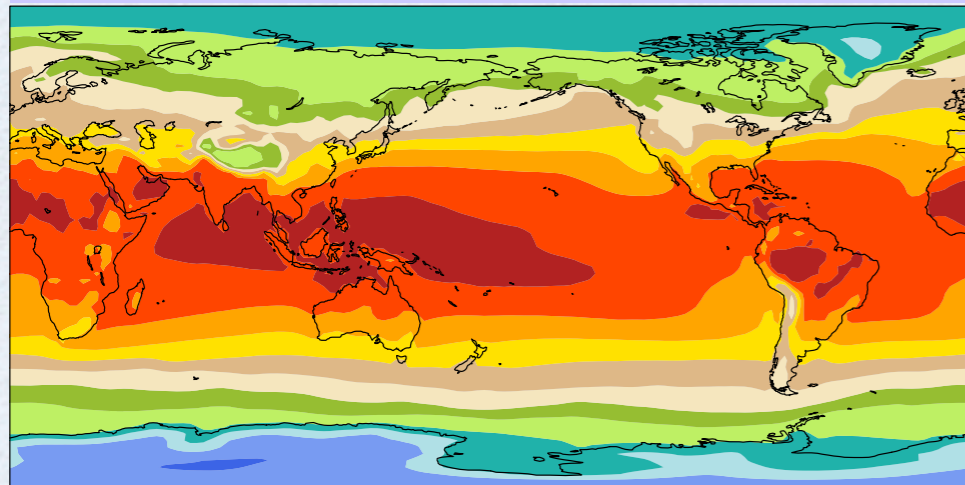


ANN

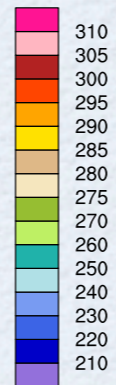
Min = 219.03 Max = 304.73



JRA25



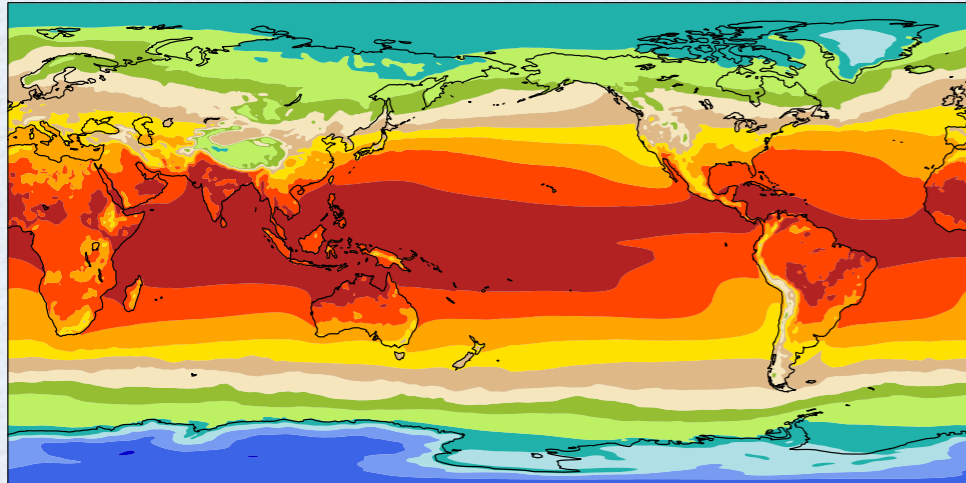
Min = 229.00 Max = 303.13



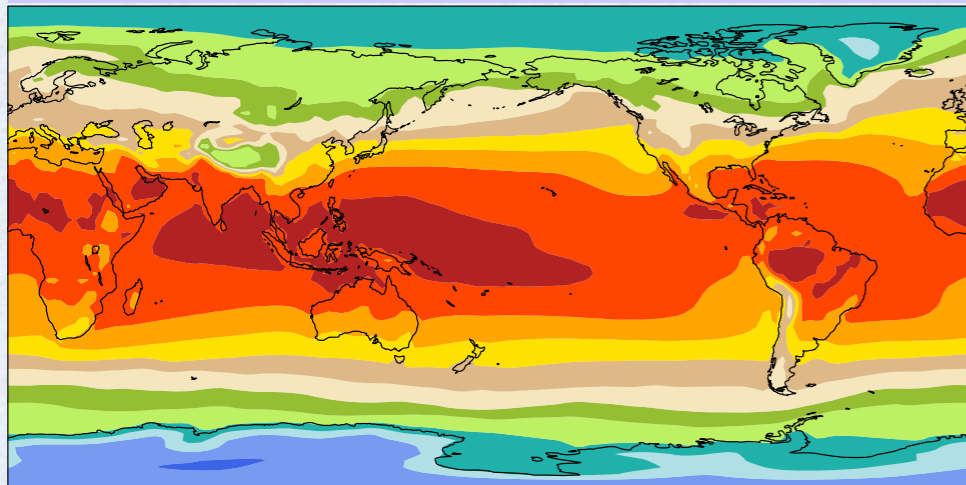
courtesy of Marcia Branstetter

2m air temperature

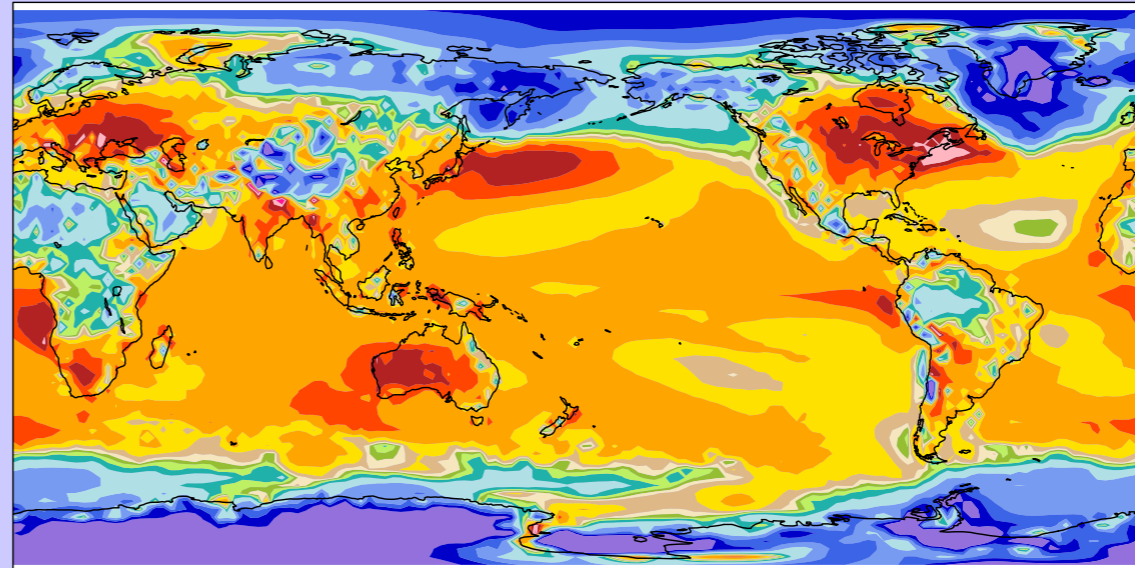
model yrs 34-43



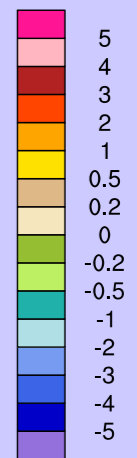
JRA25



model-JRA25



Min = -11.54 Max = 6.74

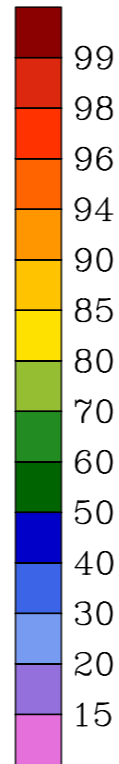
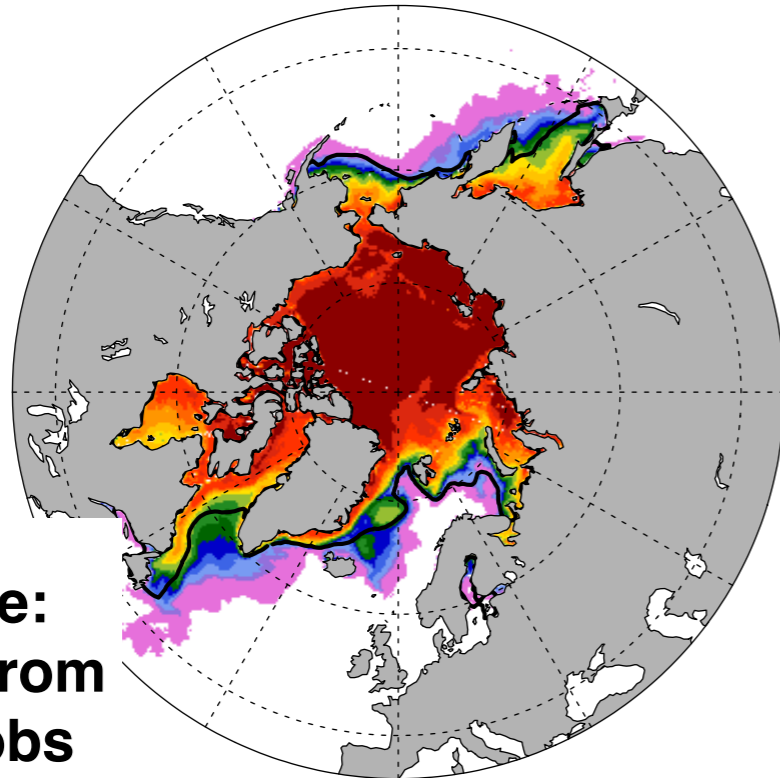


- polar cold bias $> 2^\circ$
- tropical warm bias of $1-3^\circ$

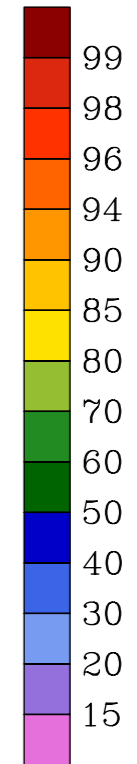
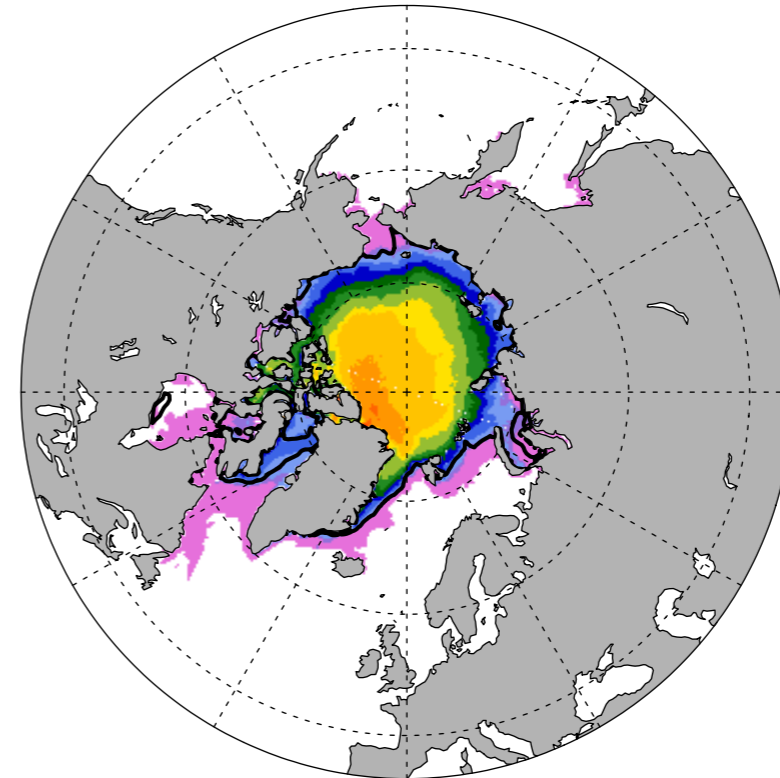
courtesy of Marcia Branstetter

Sea-ice area (%)

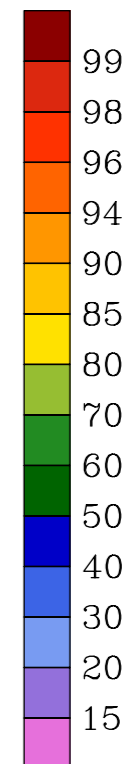
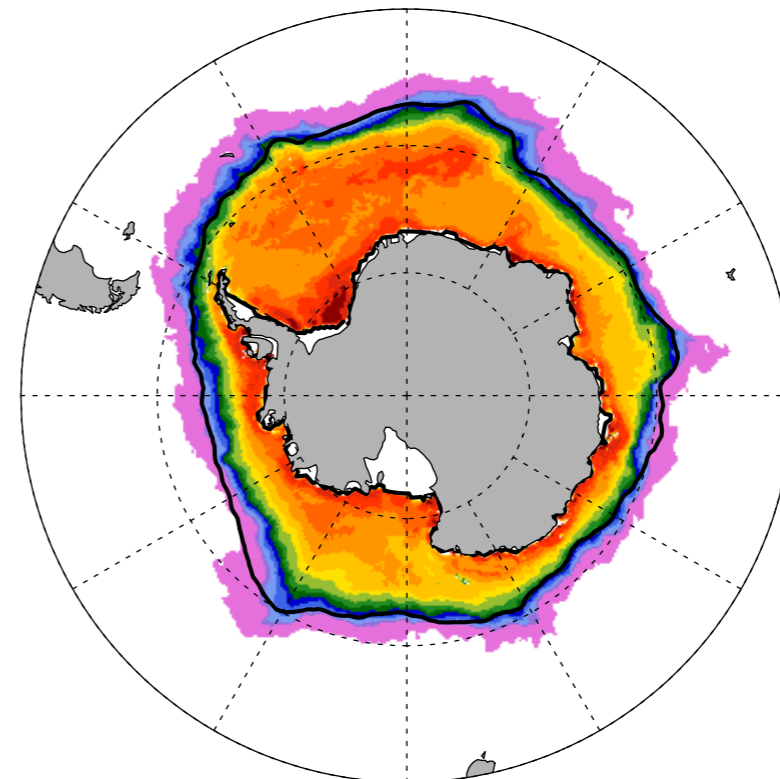
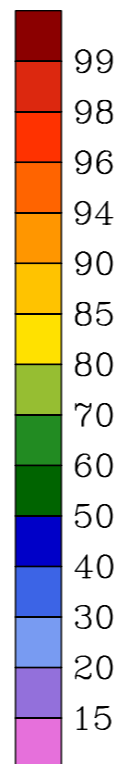
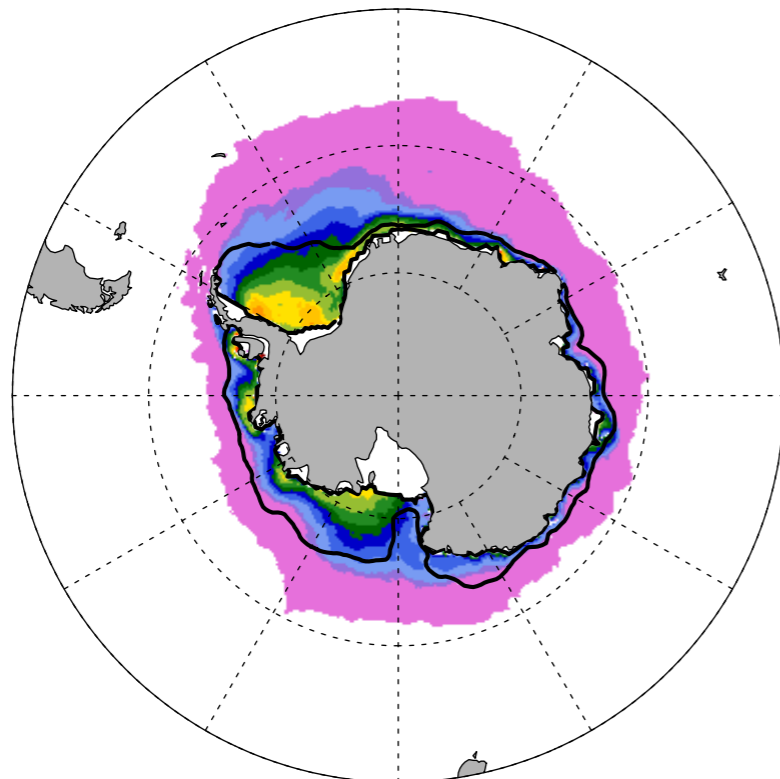
**black line:
15% area from
satellite obs
(1979-2000)**



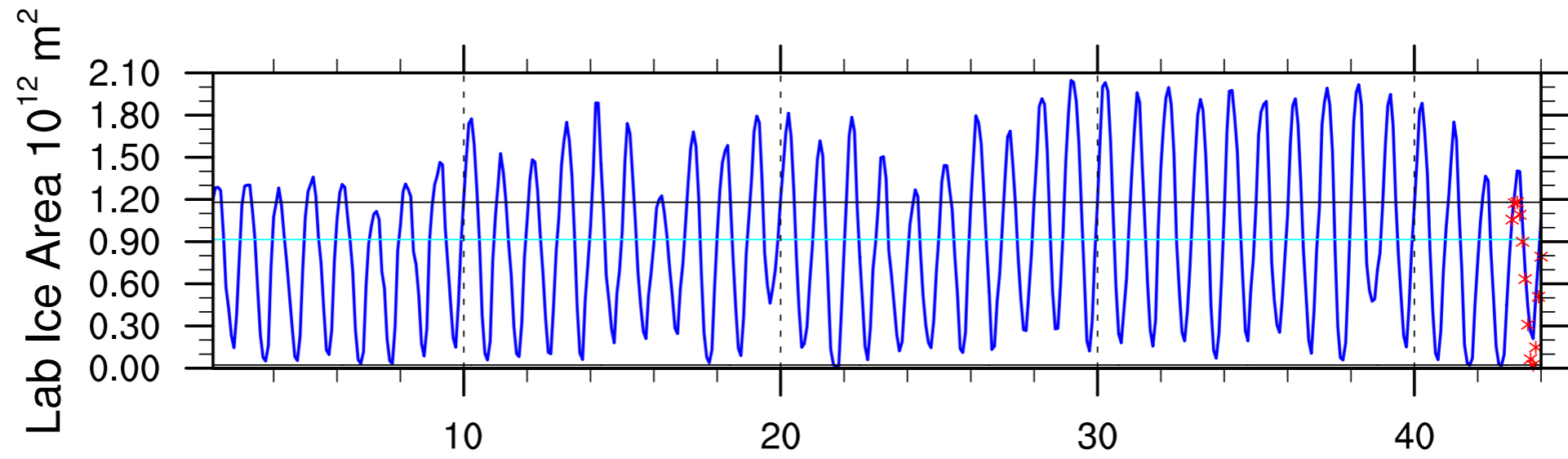
Jan-Feb-Mar



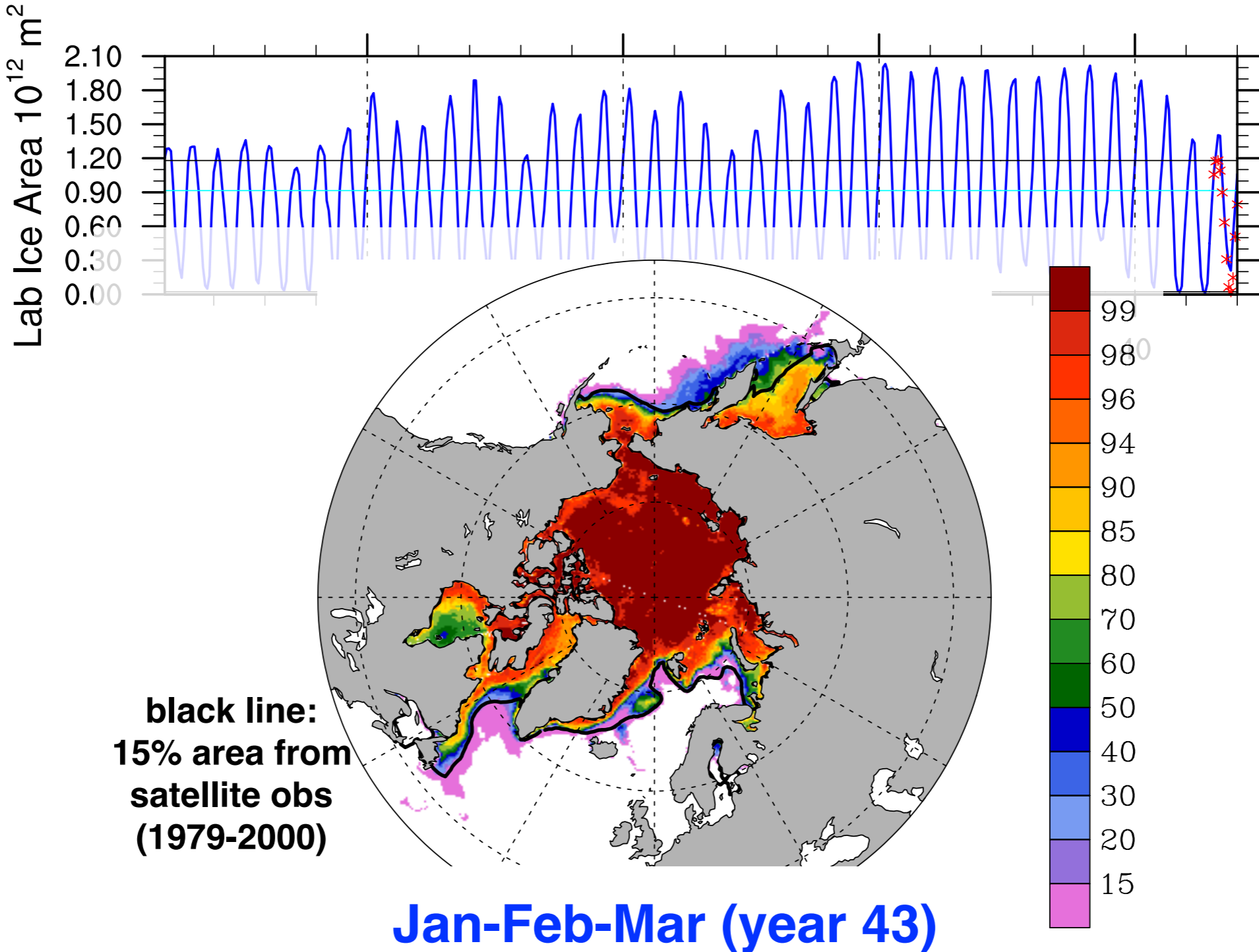
Jul-Aug-Sep



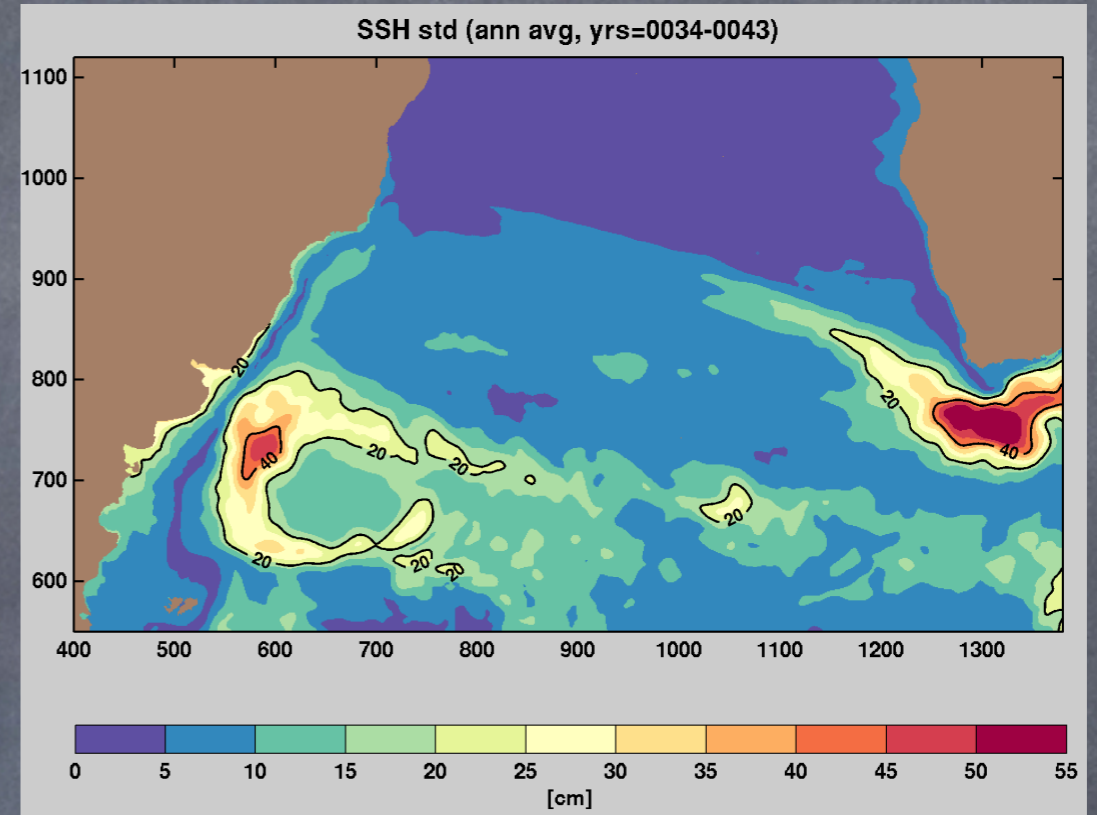
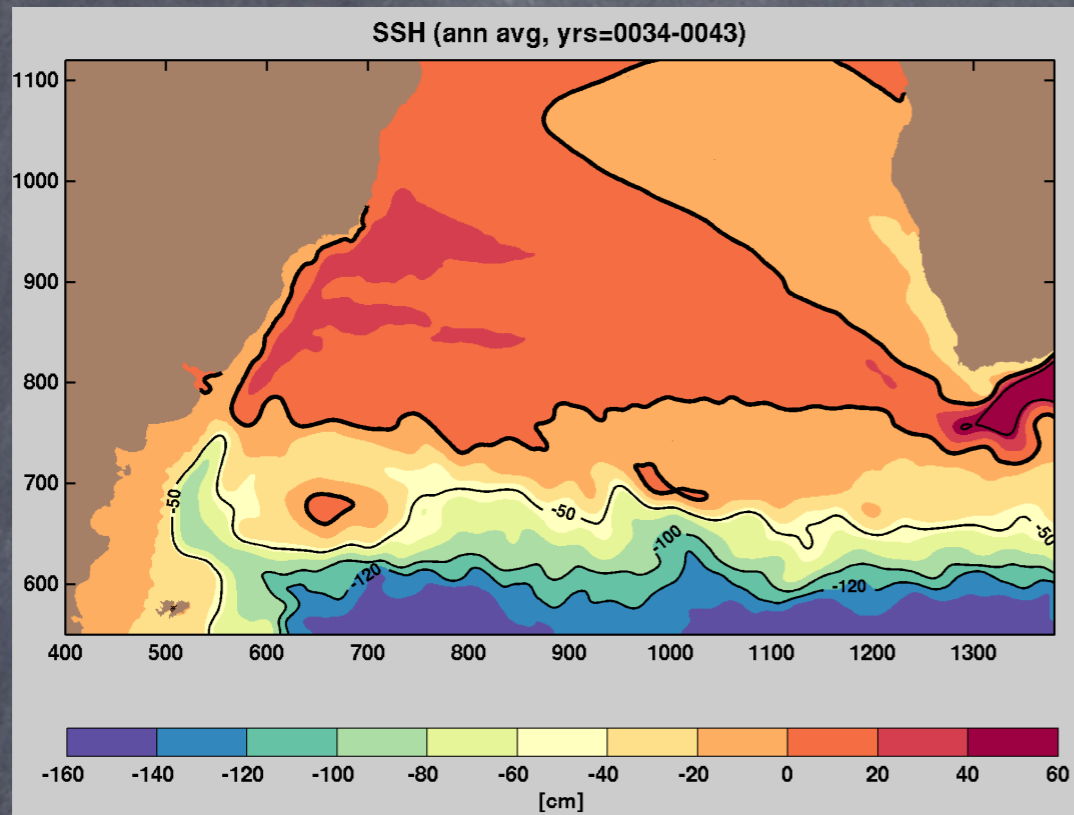
Ice changes in the Labrador Sea



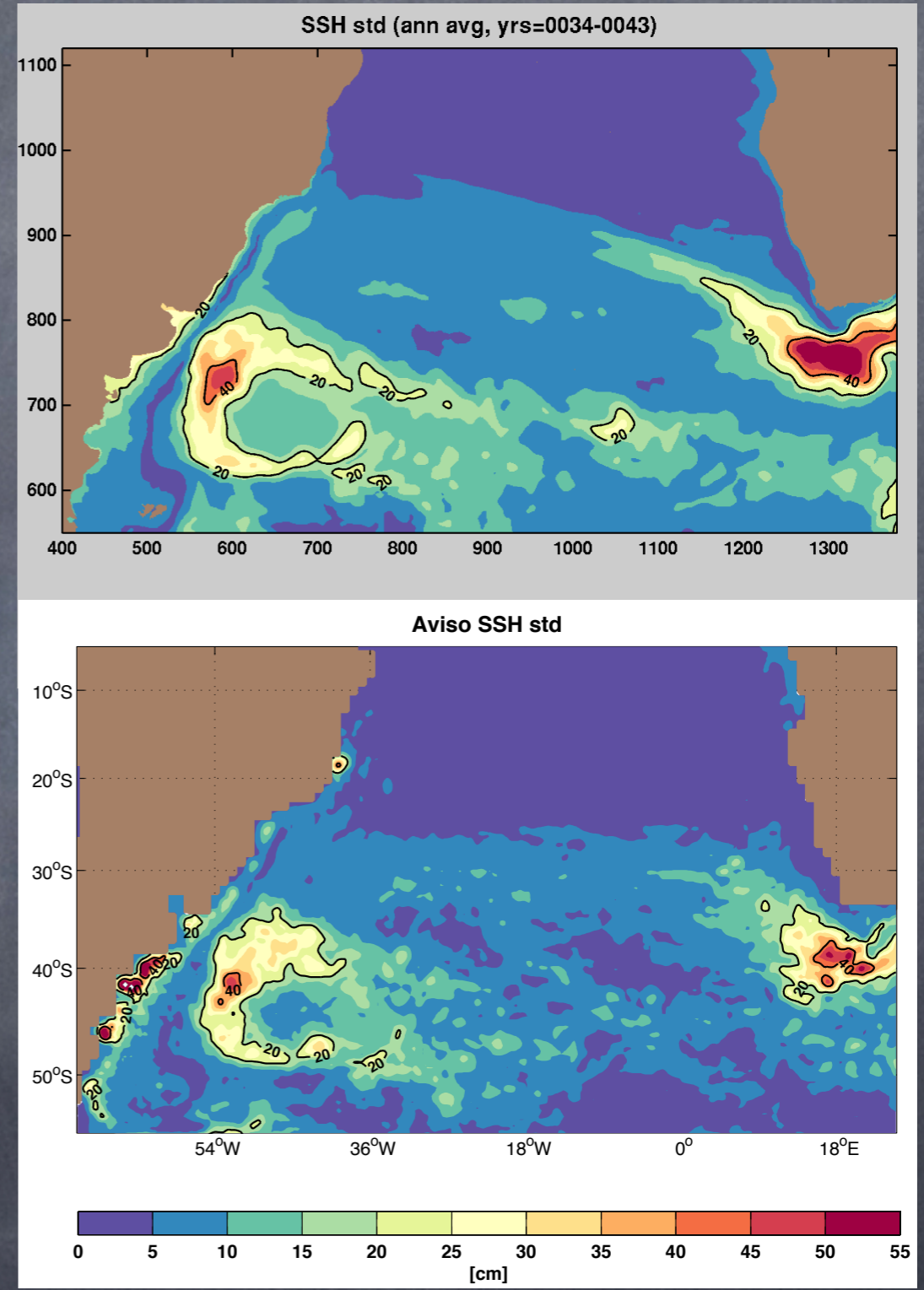
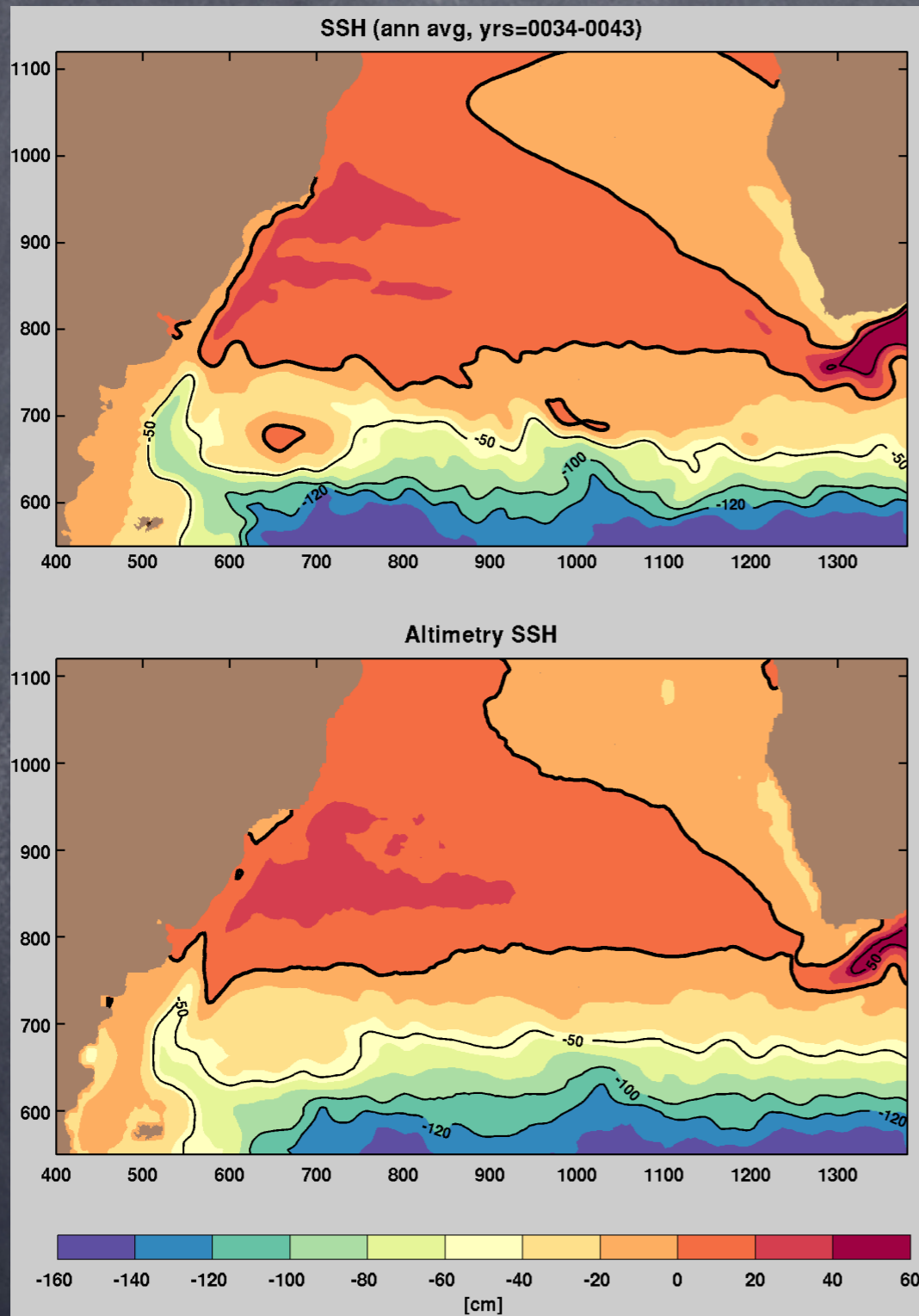
Ice changes in the Labrador Sea



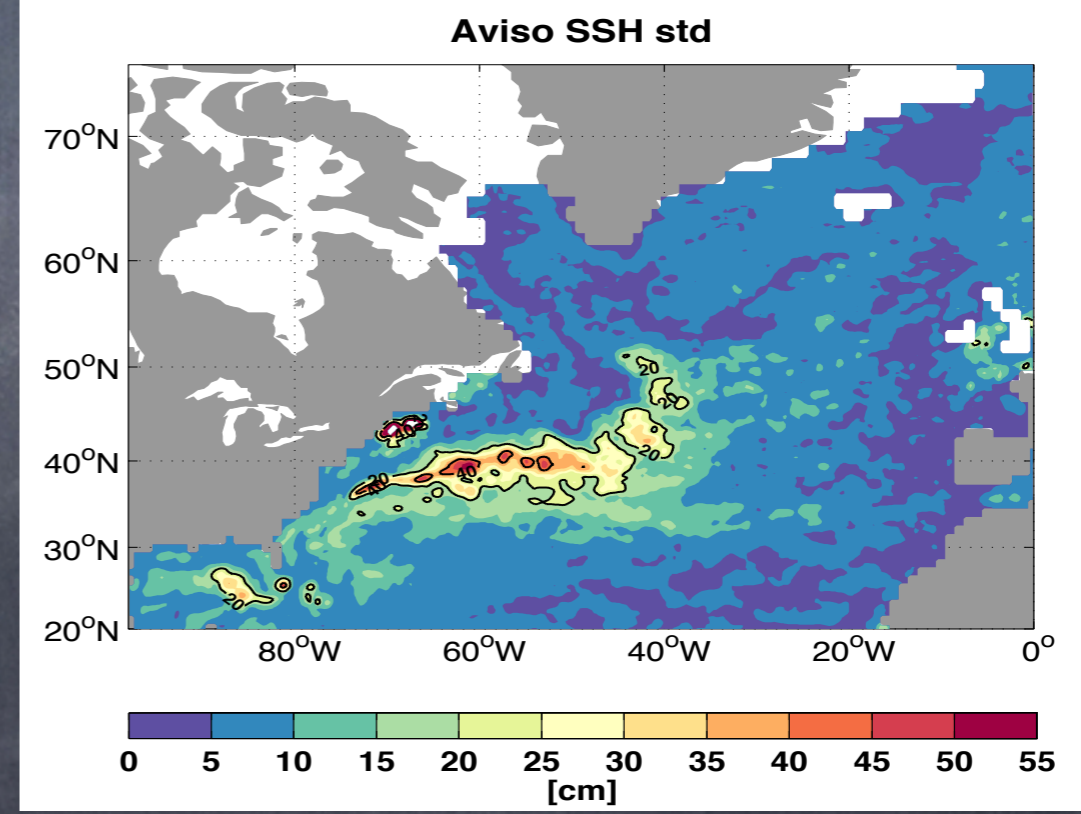
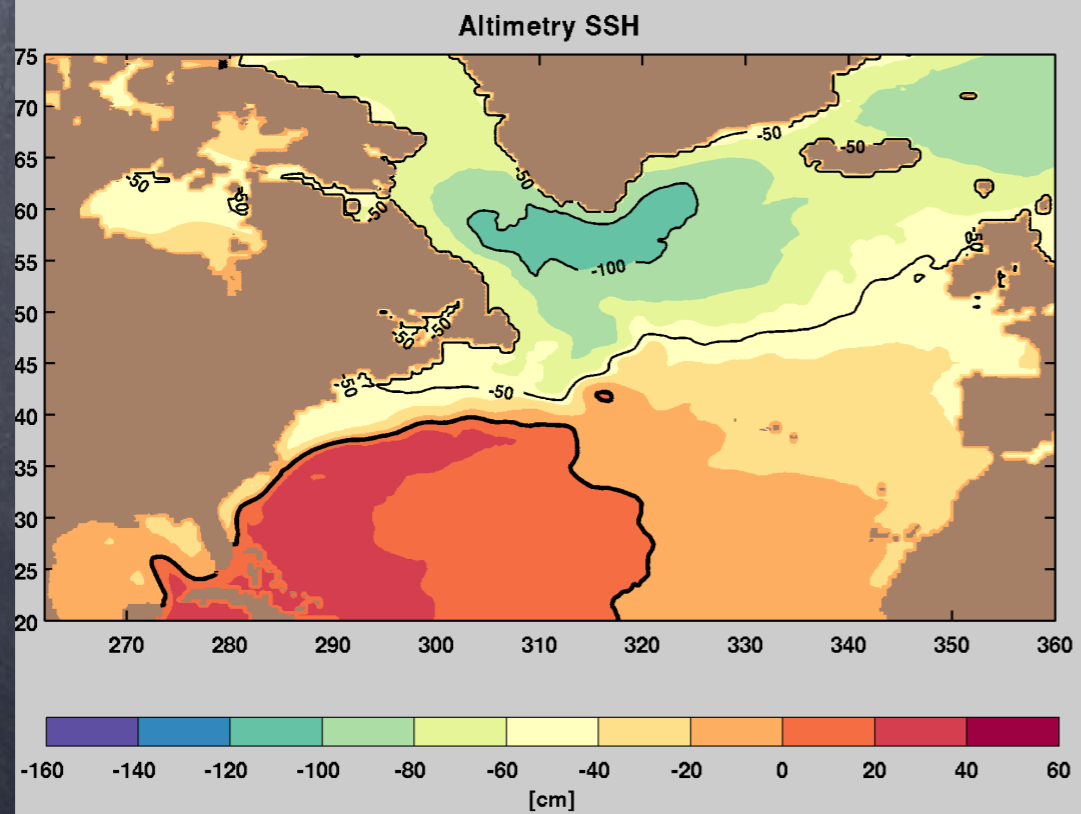
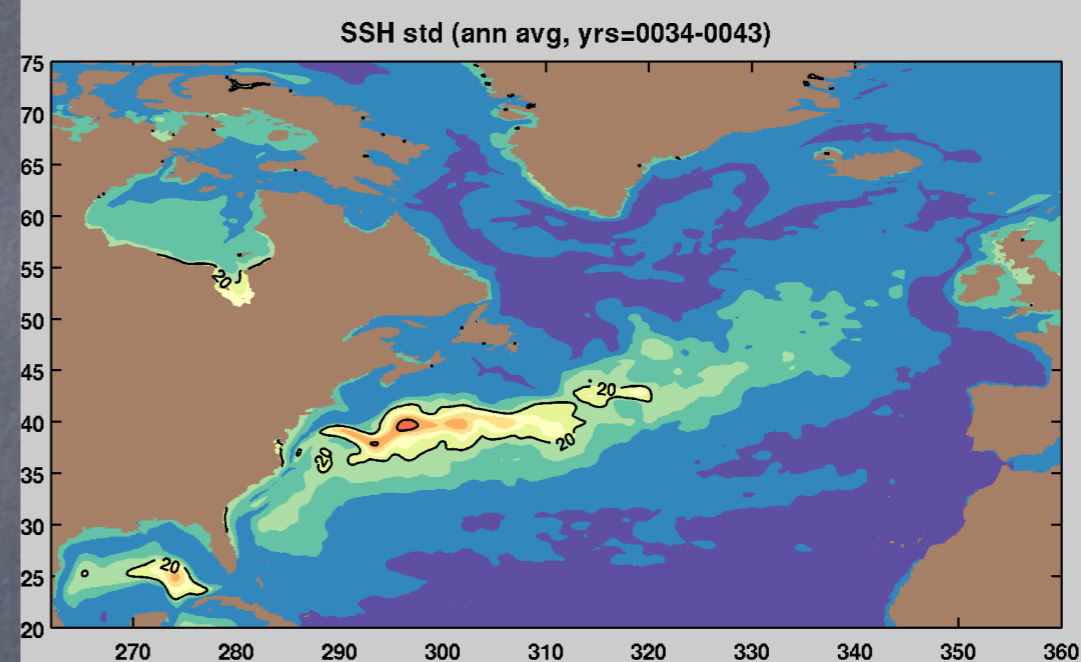
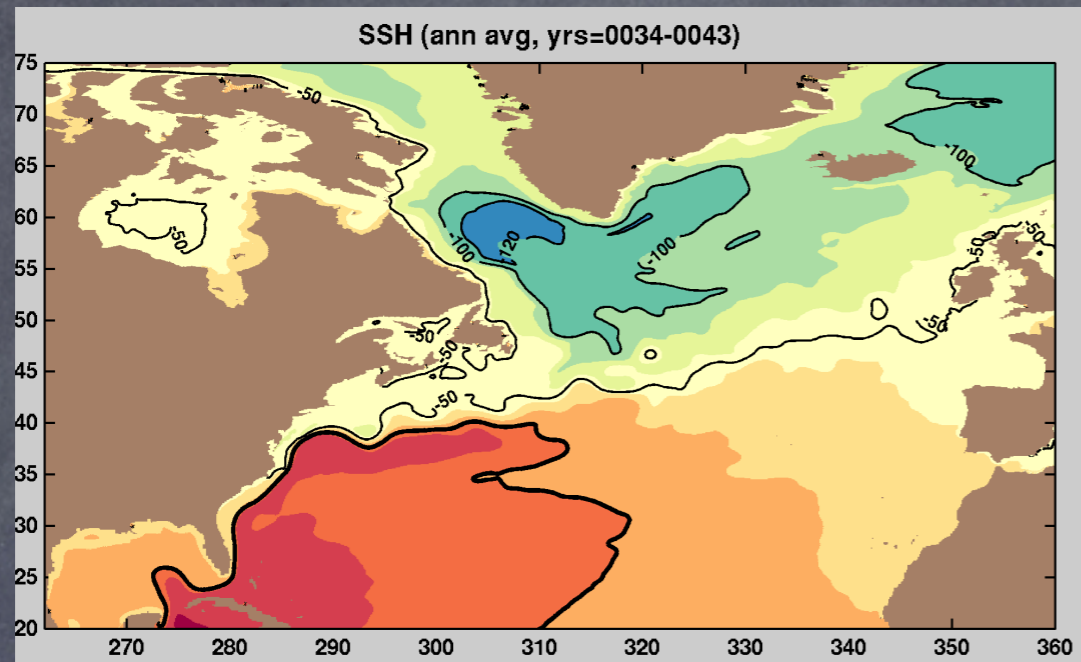
Let's look at the ocean: South Atlantic



Let's look at the ocean: South Atlantic

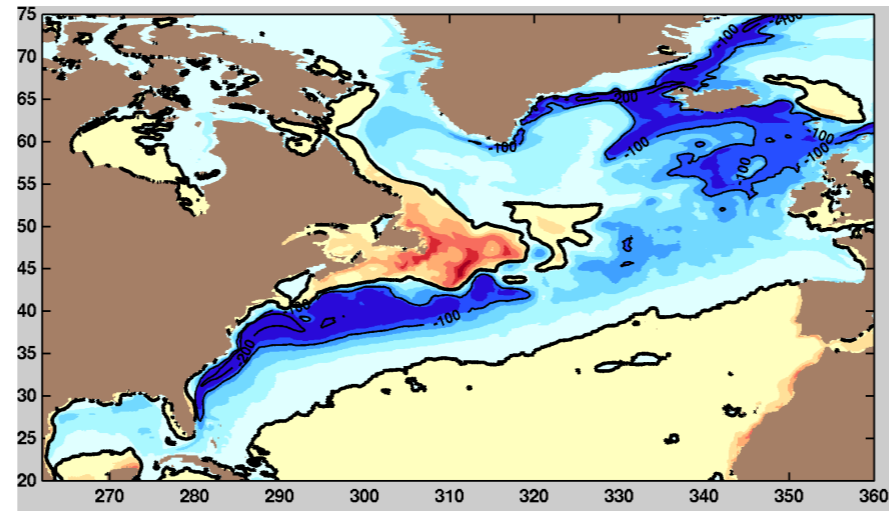
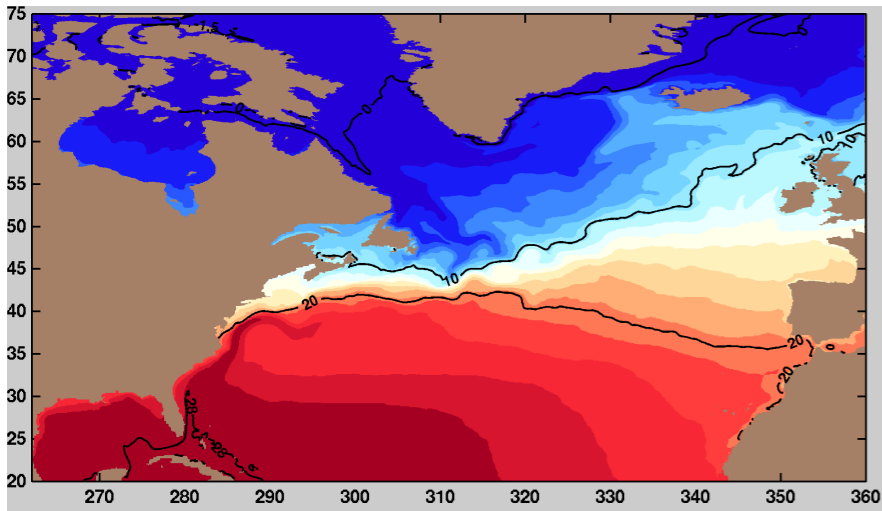


North Atlantic



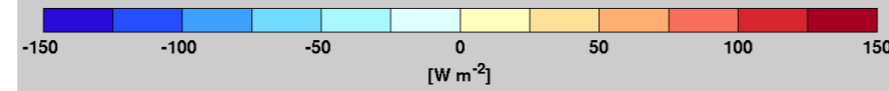
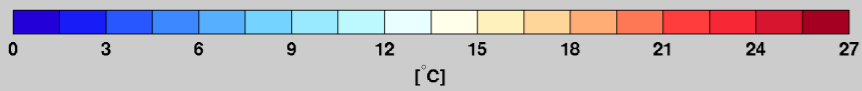
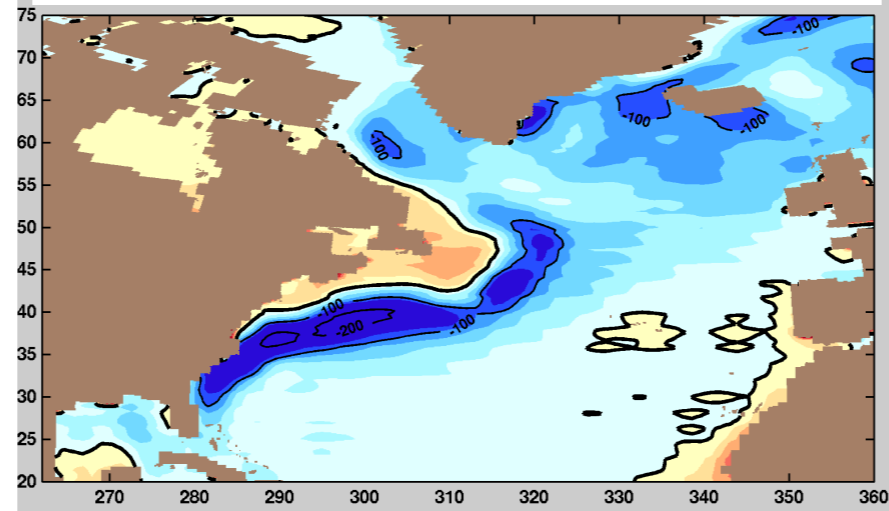
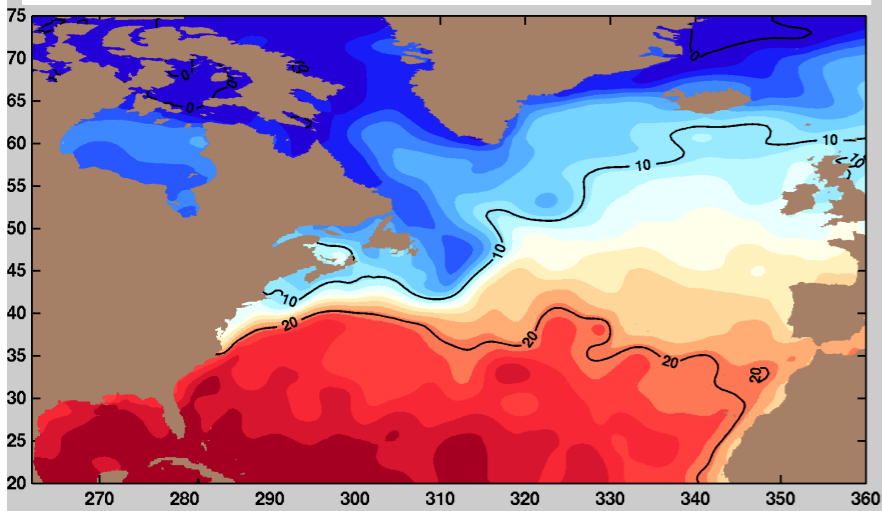
model SST (yrs 34-43)

Surface heat flux (yrs 34-43)



WOCE SST

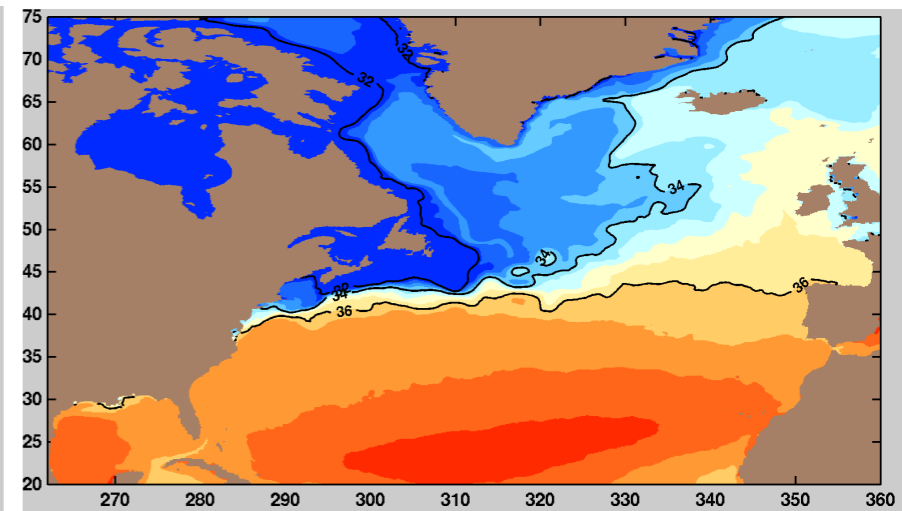
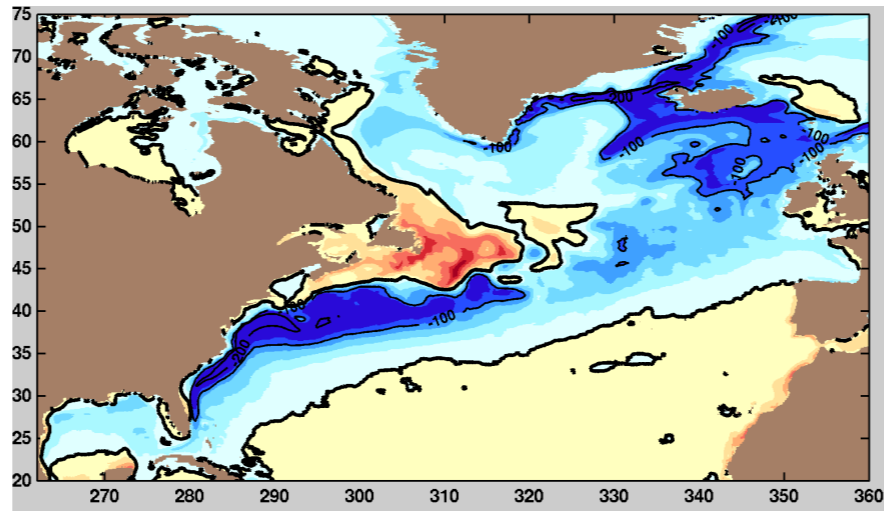
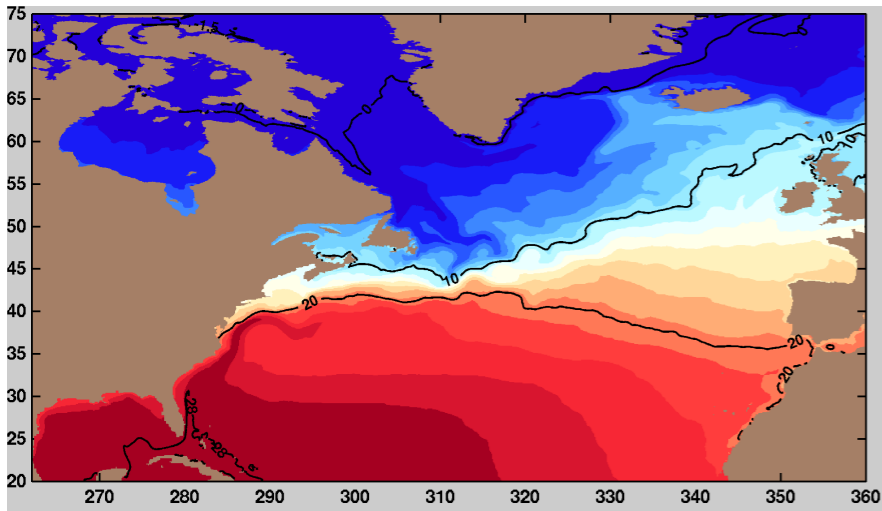
Surface heat flux (CORE data)



model SST (yrs 34-43)

Surface heat flux (yrs 34-43)

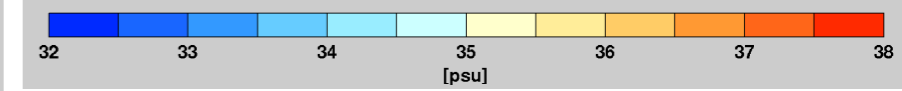
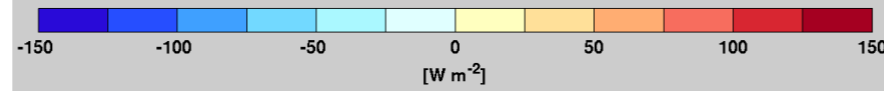
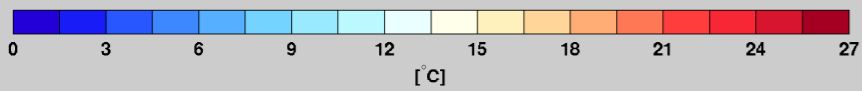
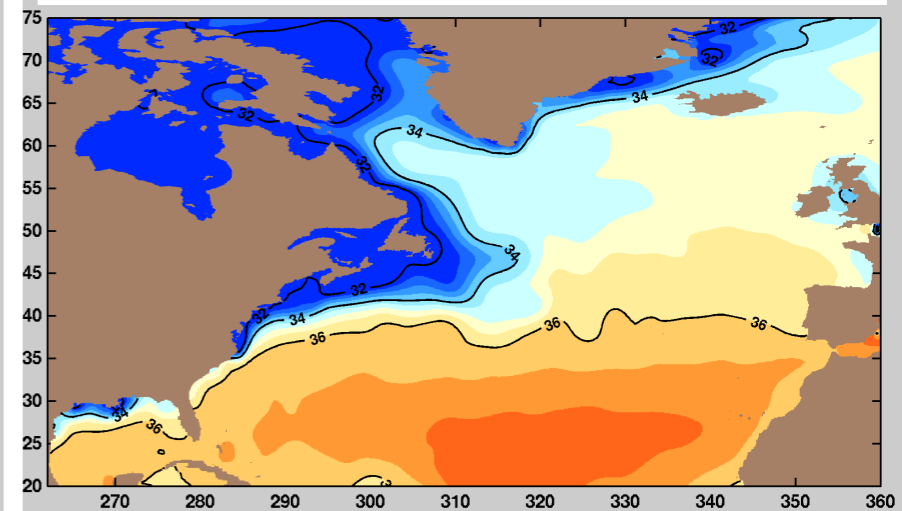
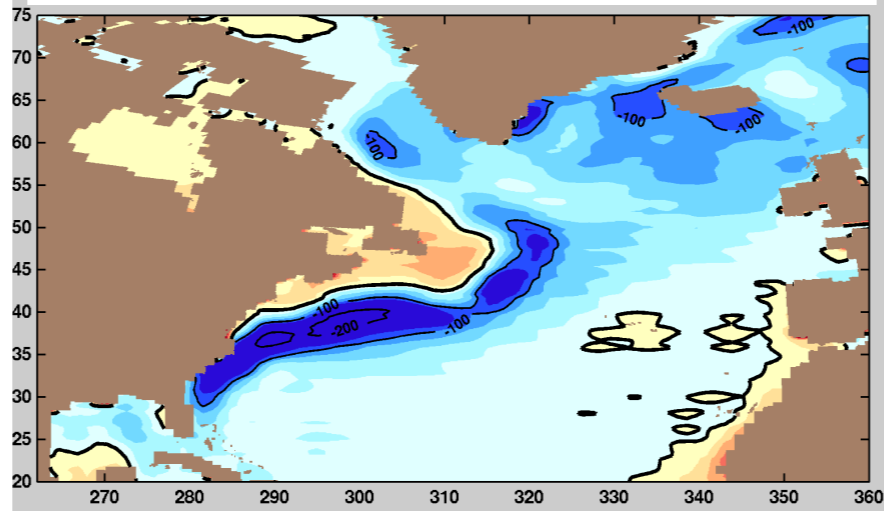
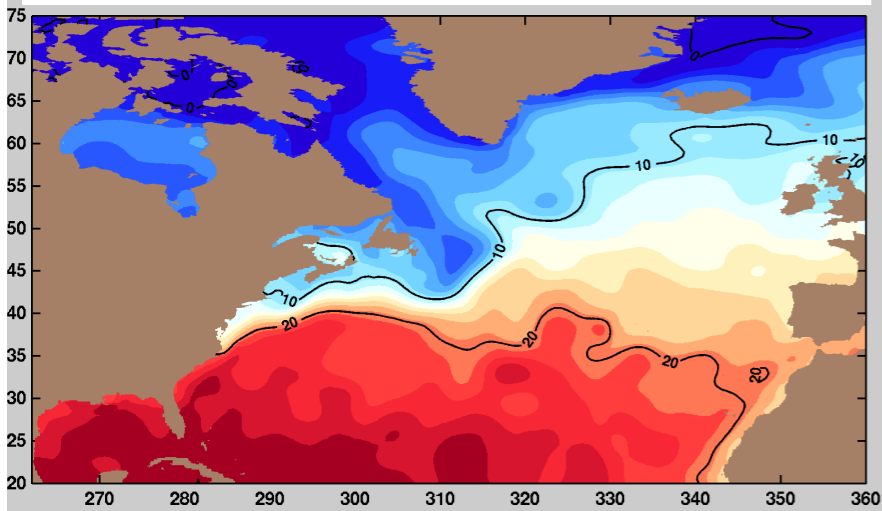
SSS (yrs 34-43)



WOCE SST

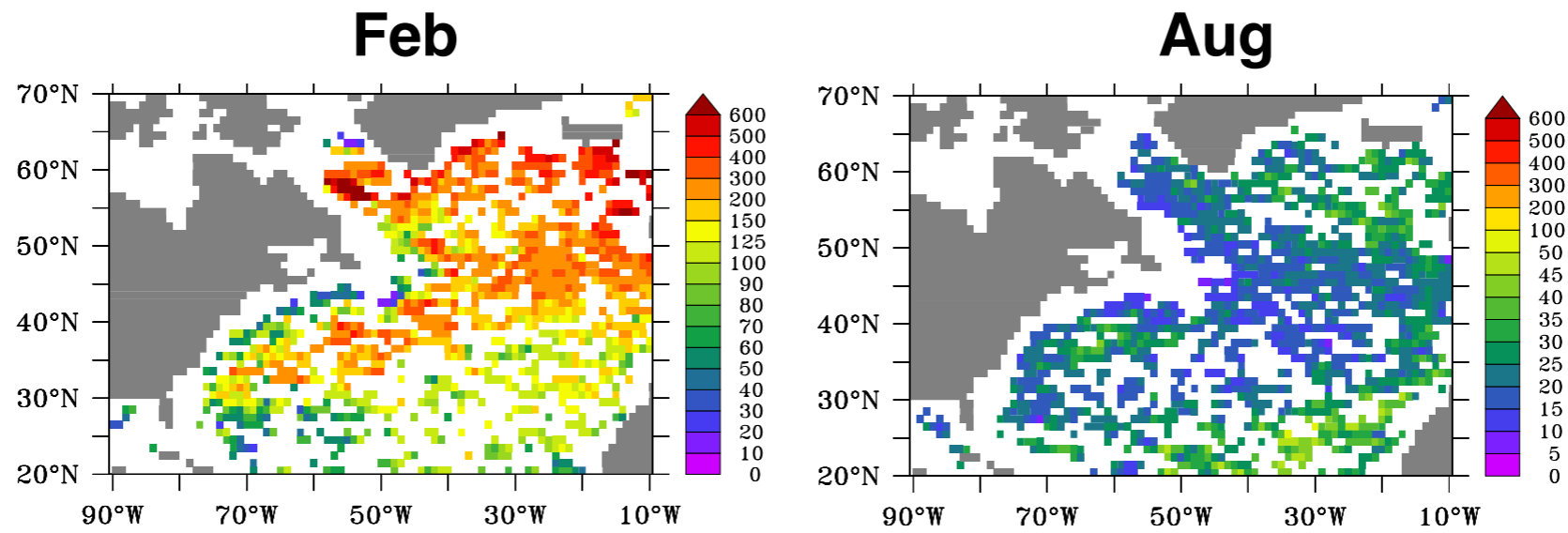
Surface heat flux (CORE data)

WOCE SSS

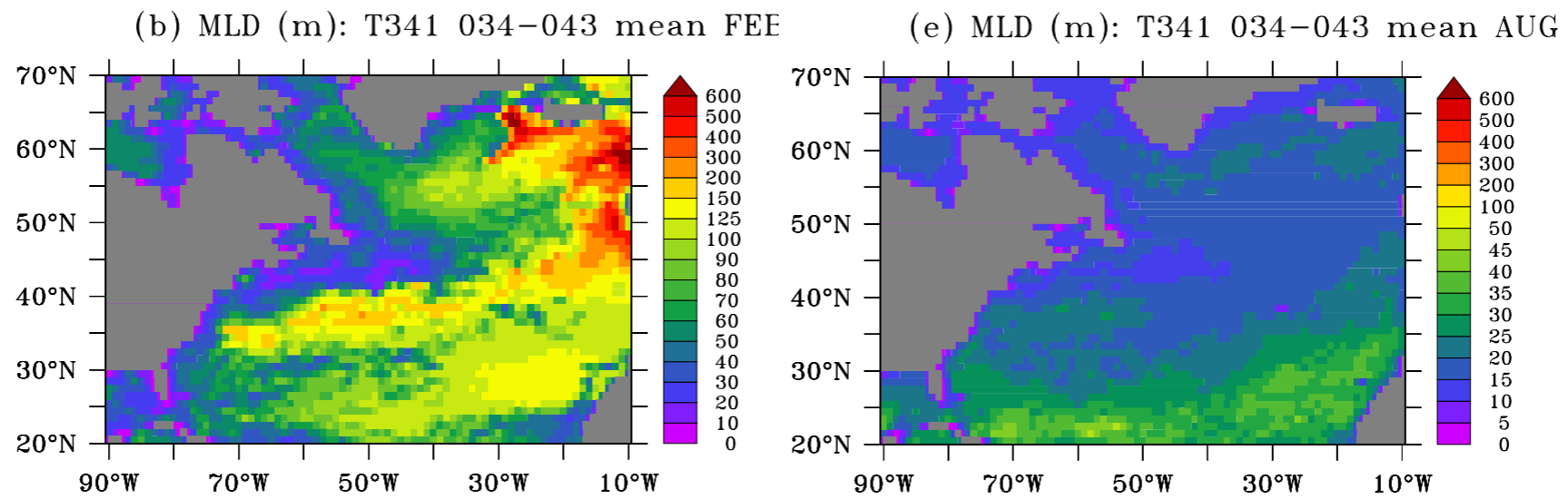


North Atlantic mixed layer depth

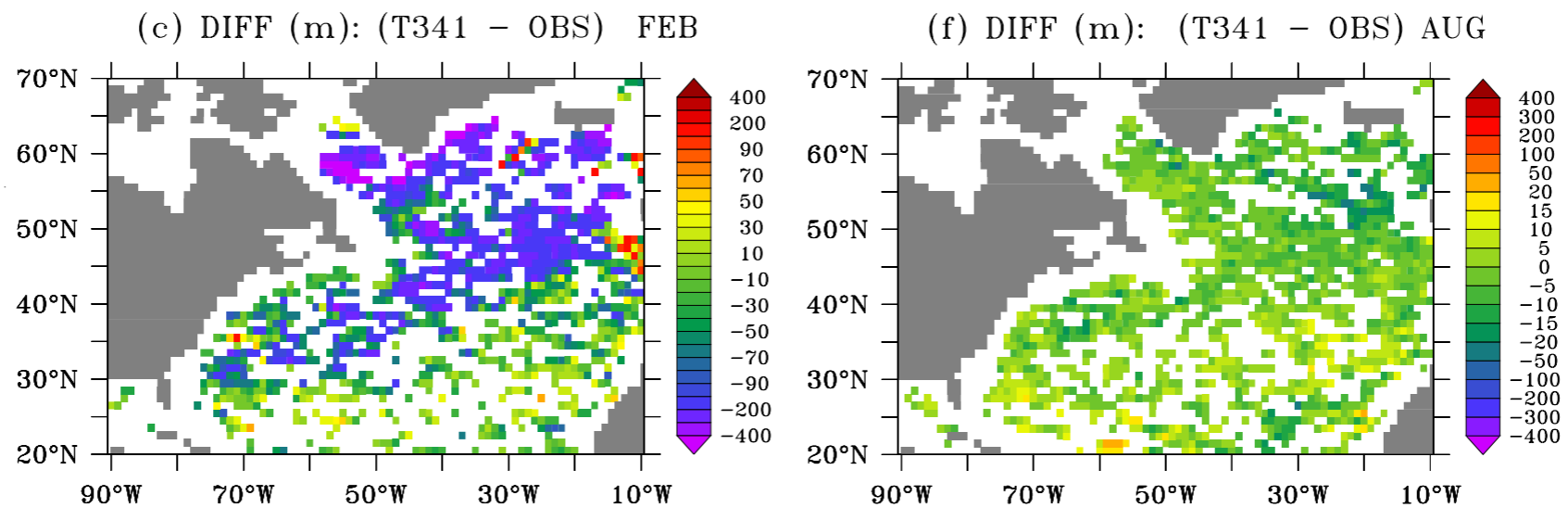
ARGO data



model (yrs
34-43)



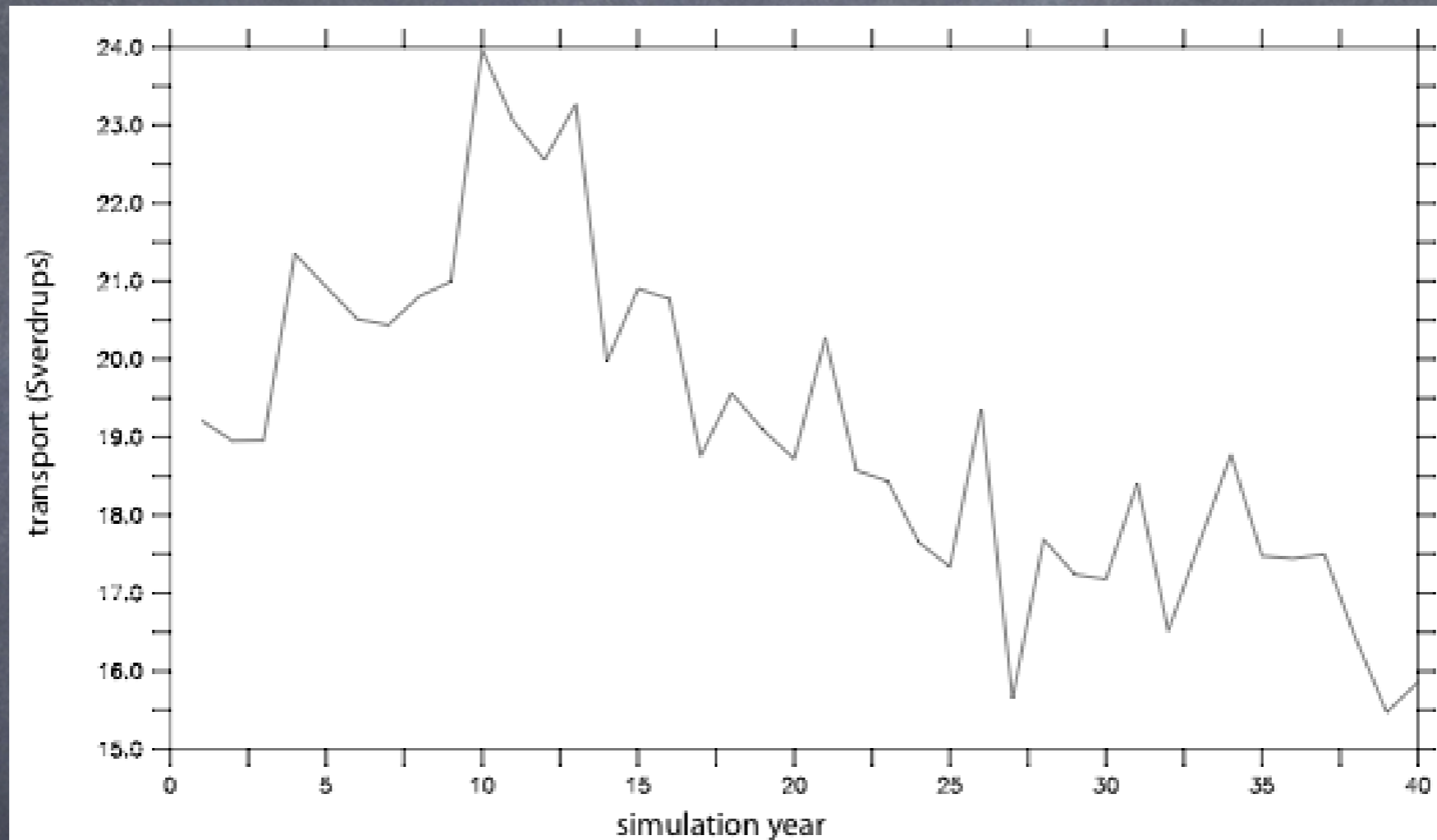
model - data



courtesy of
Elena Yulaeva

Atlantic Meridional Overturning

Maximum between 25°-45°N and 500-1500 m



Accomplishments and future work

- High resolution fully coupled simulation with reasonable sea-ice coverage: this took a lot of preliminary work!

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- Sea-ice coverage: possibly related to atmosphere cold polar bias.
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 - 📌 Learn more about its decadal scale cycle

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- Sea-ice coverage: possibly related to atmosphere cold polar bias.
 - 📌 Investigate results of late 20th century simulations
 - 📌 Learn more about its decadal scale cycle
- Gulf Stream/NAC path: an issue of high res coupled simulations.
 - 📌 How much does it influence Labrador Sea convection and deep water formation?
 - 📌 Is LS convection also affected by sea-ice and how much?
 - 📌 Do things improve if momentum stress does not account for surface ocean velocity?