Example utilizations of simulation and assimilation residuals

Arctic Halocline

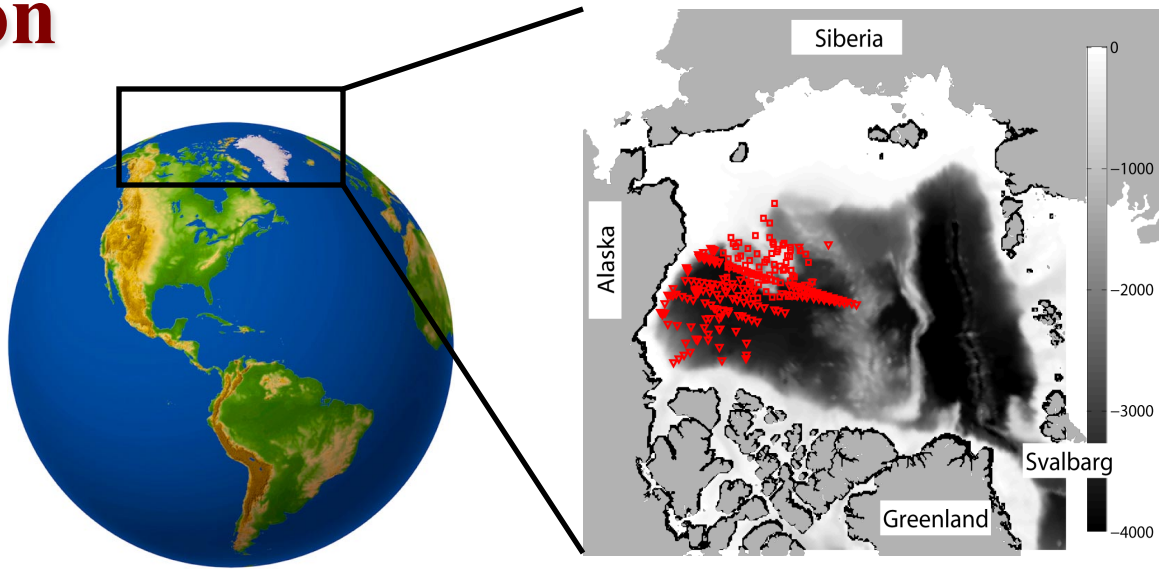
Tides and Antarctic Slope Front

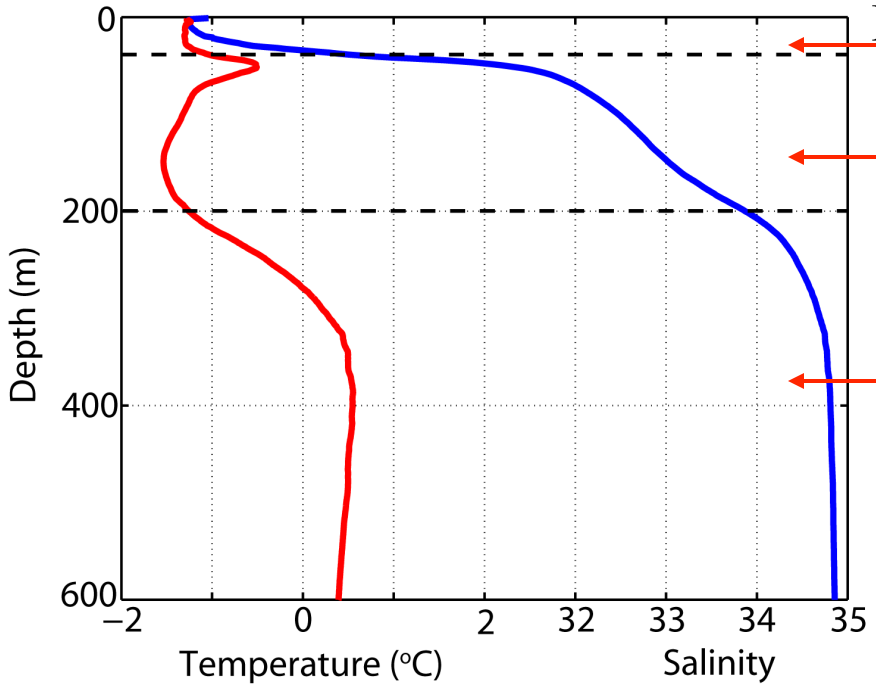
Atlantic waters entering Arctic Ocean

Example 1: Improved representation of Arctic halocline in ocean-ice models

- An Nguyen, et al.: Improved modeling of the Arctic halocline with a sub-grid-scale brine rejection parameterization. J. Geophys. Res., 2009.
- A. Nguyen, et al.: Arctic ice-ocean simulation with optimized model parameters: approach and assessment. J. Geophys. Res., 2011.
- A. Nguyen, et al.: Source and pathway of the Western Arctic upper halocline in a data-constrained coupled ocean and sea ice model. J. Phys. Oceanogr., 2012.

Introduction





Mixed layer

Halocline

Atlantic Water

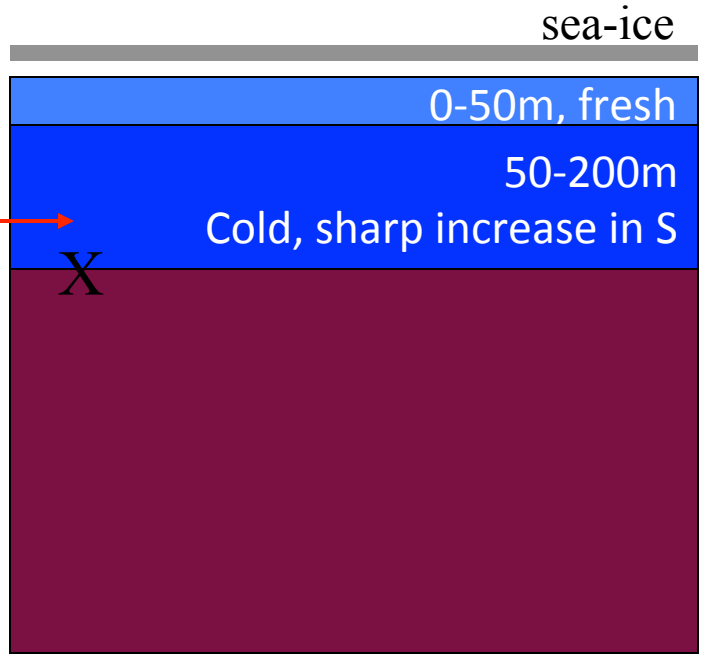
0-50m, fresh

50-200m
Cold, sharp increase in S

> 200m
Warm
Salty

Introduction

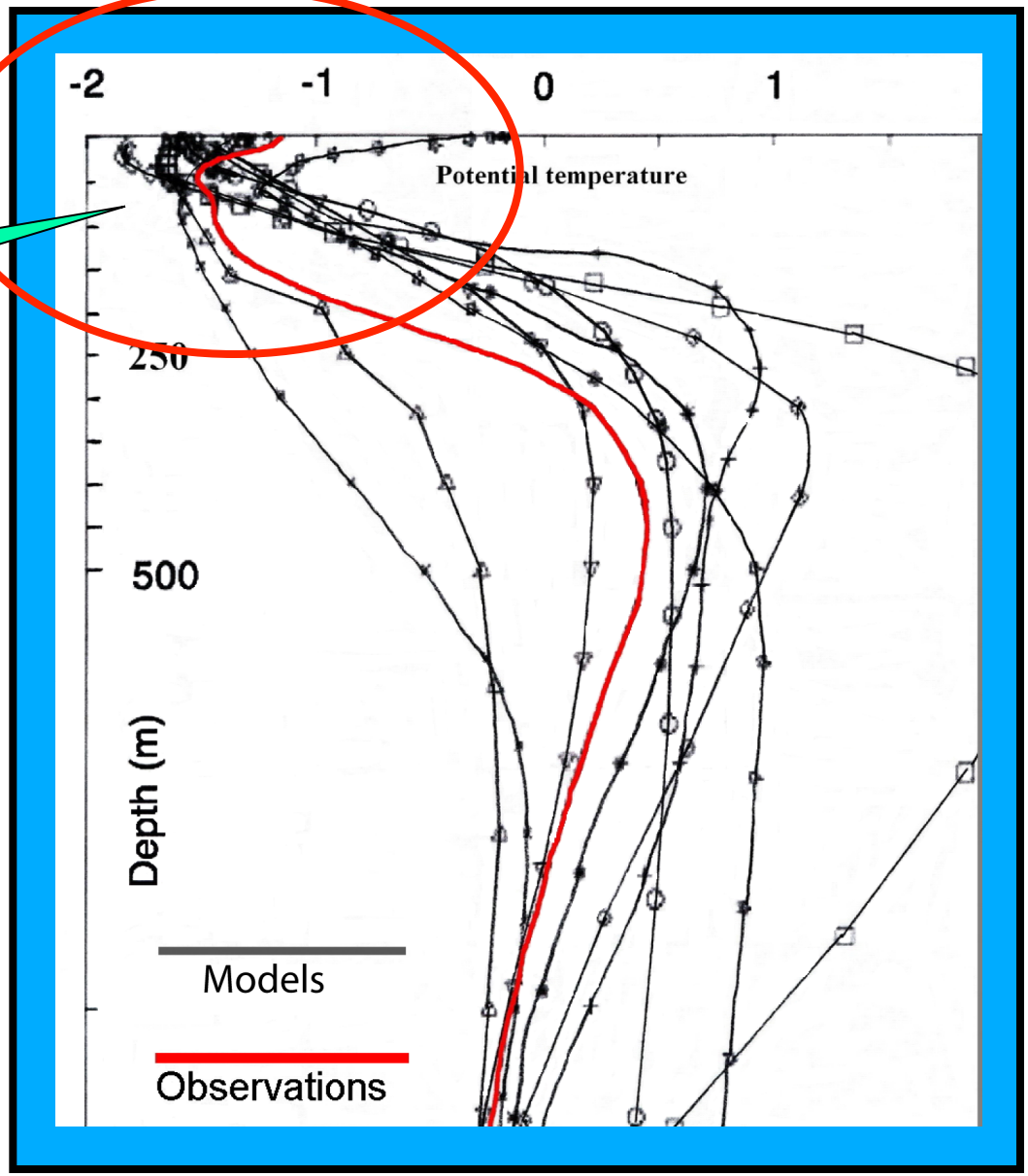
The Halocline:



- **Insulator → prevents sea-ice melting**
- **Important to sea-ice stability**

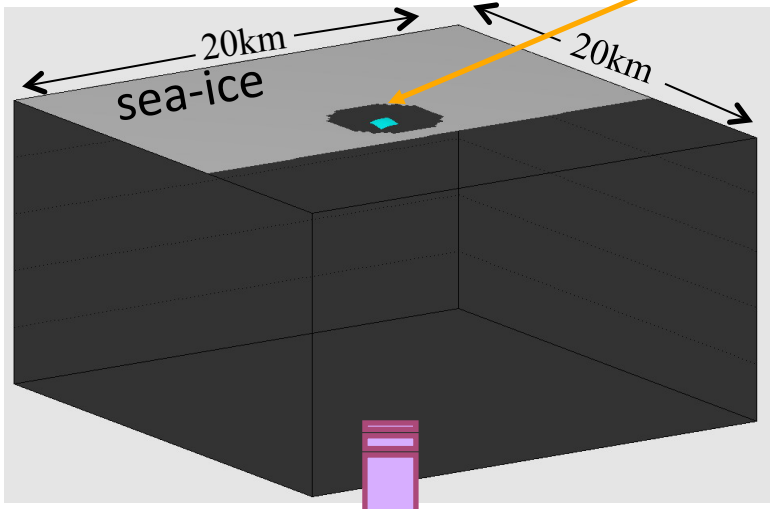
Current State-of-the-Art Models:

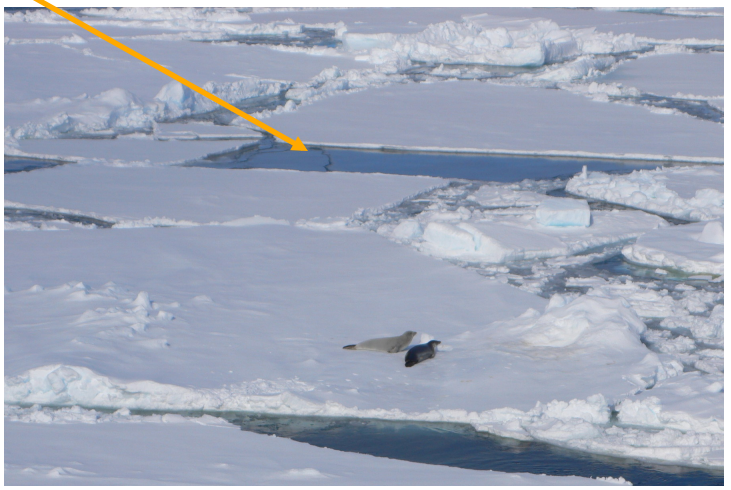
Halocline missing

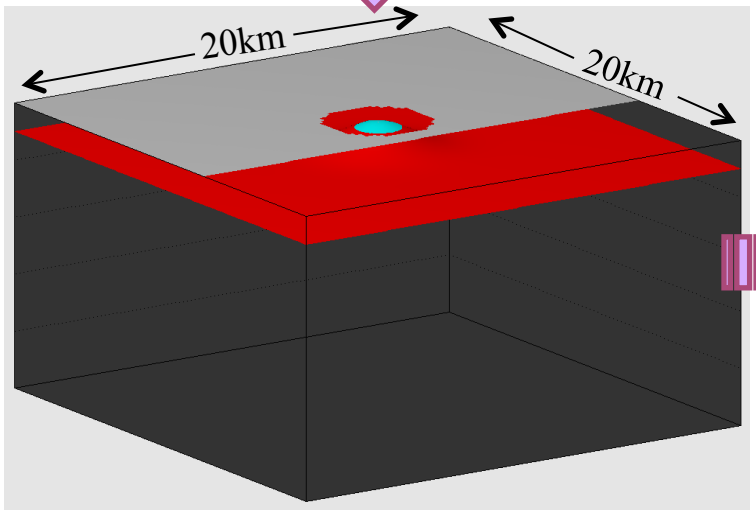


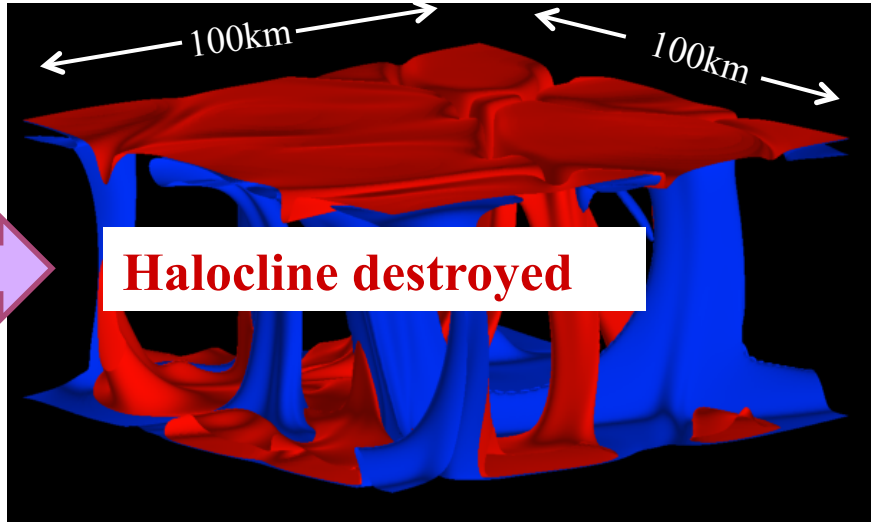
Problem: resolution

rejected salt



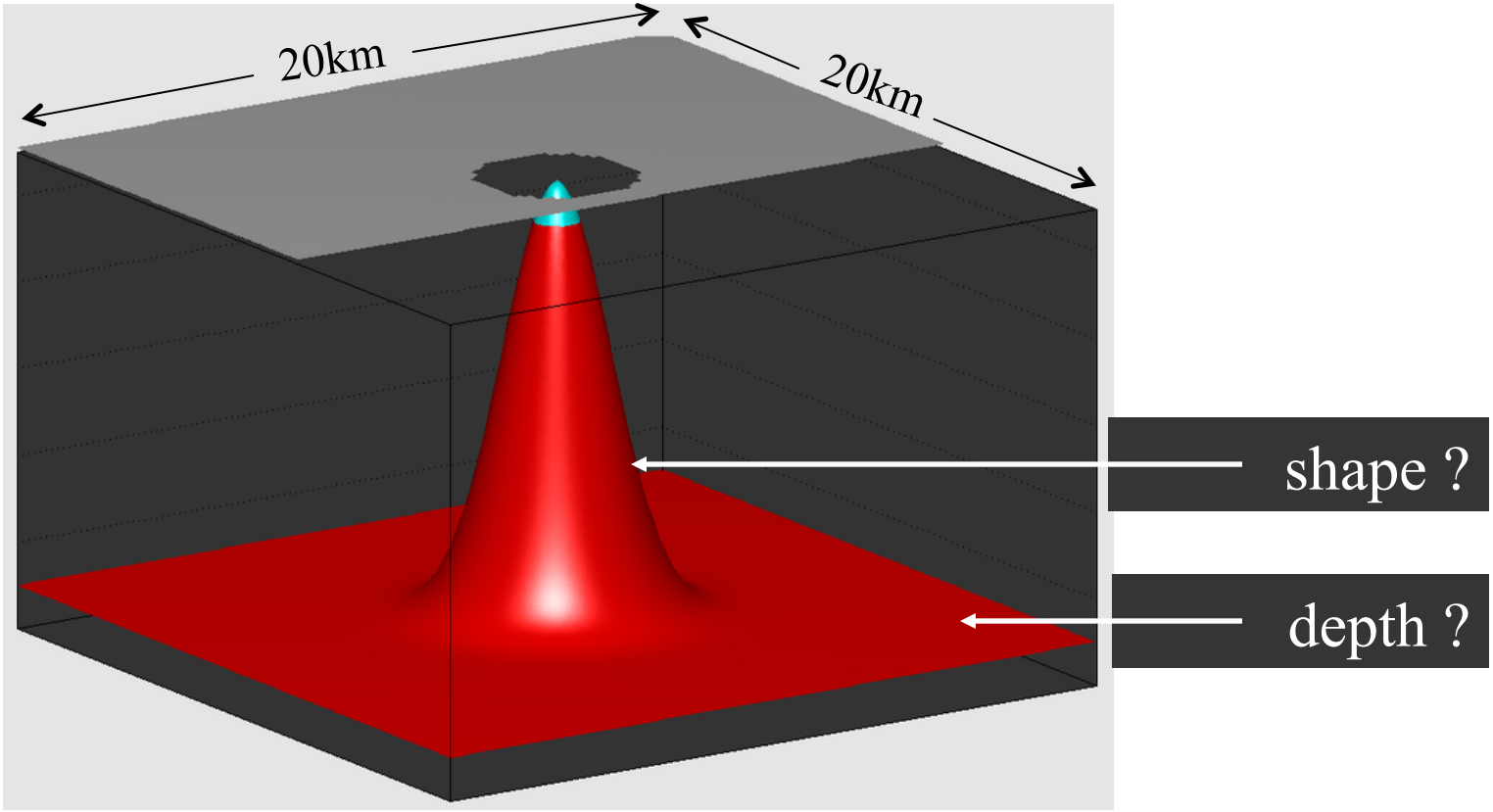




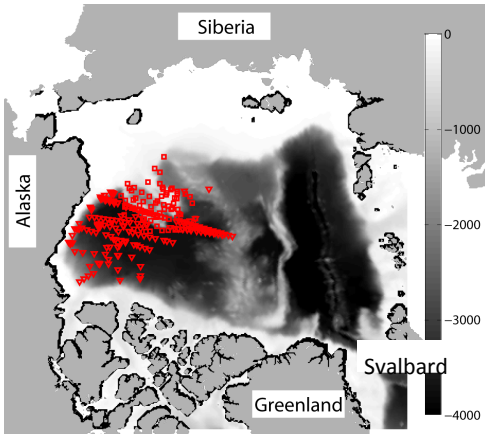


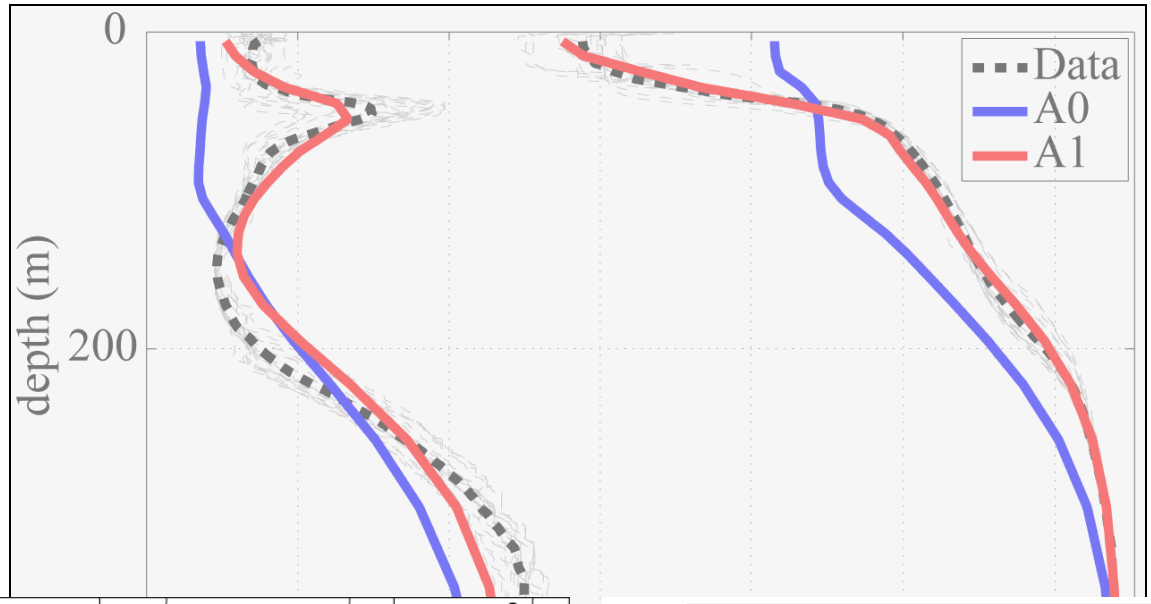
Hypothesis: **Sub-grid-scale Salt Rejection**

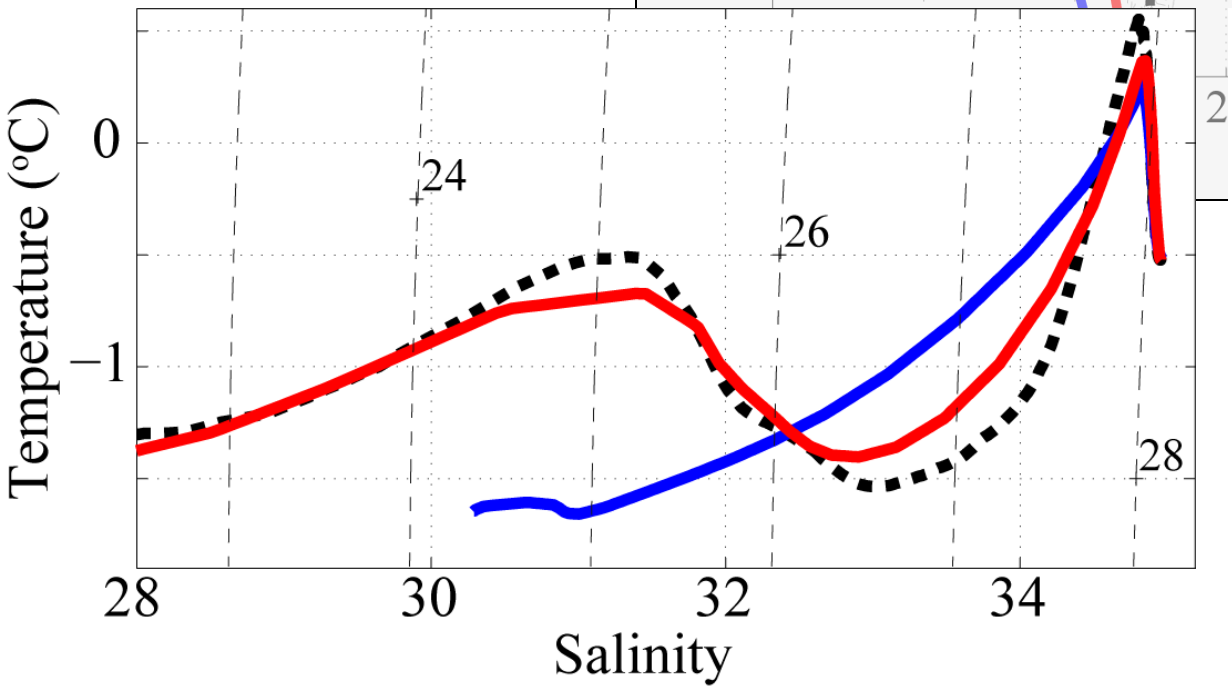
(less than 20km)

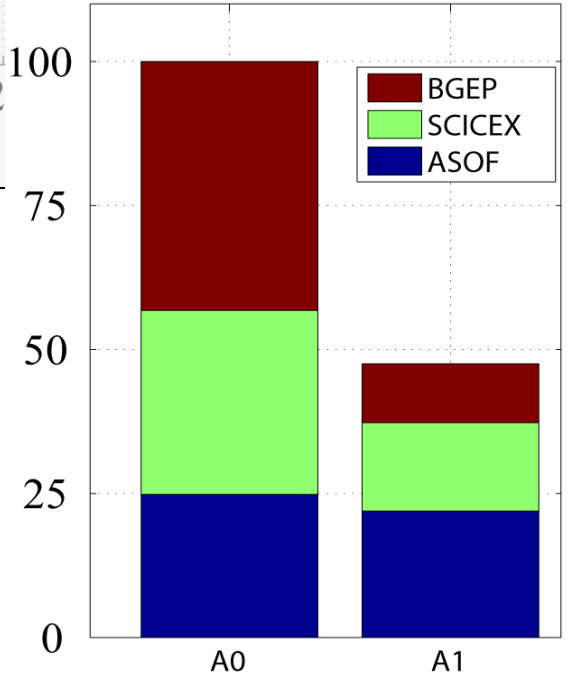


Arctic ocean hydrography









Example 2: Improved representation of Antarctic Slope Front in ocean-ice models

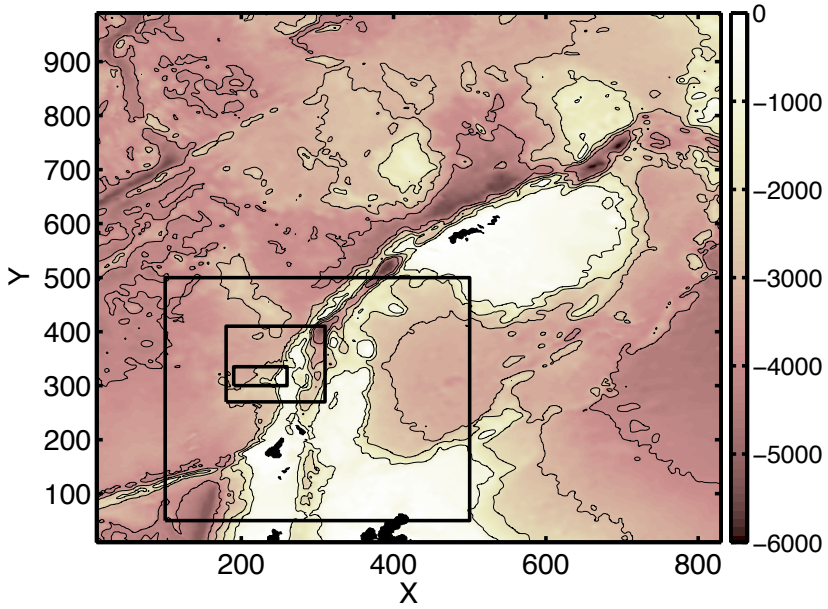
- Maria del Mar Flexas, et al.: Role of tides on the presence of the Antarctic Slope Front at the tip of the Antarctic Peninsula. In preparation.

Motivation

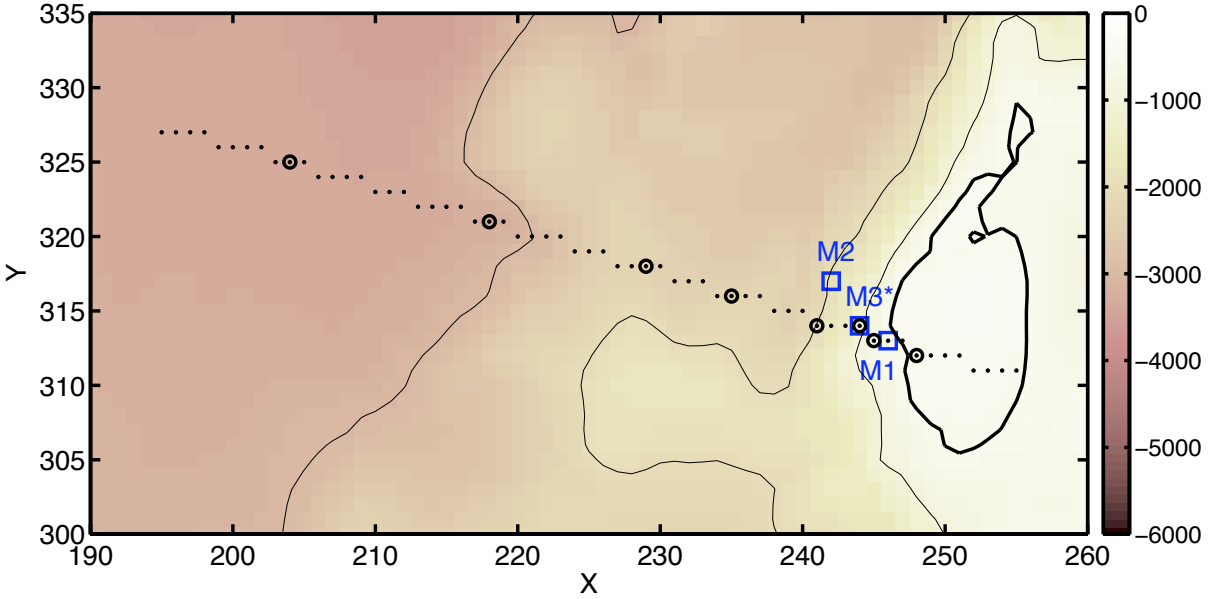
- The Antarctic Slope Front (ASF) is a fundamental component of the MOC.
- It is a highly variable structure. Open questions include the generation of the ASF – e.g., role of winds explored by Steward et al.
- It often has a characteristic V-shape caused by the presence of dense shelf water.
- It is particularly relevant in the Scotia Sea because of its role on ventilating intermediate depths of the ACC.

- In 2009 we placed two moorings over the southern slope of the Scotia Sea to study intermediate water ventilation
- The data showed significant fortnightly signal down to 1800 m deep, with currents of up to 40 cm/s, for which there was no clear explanation

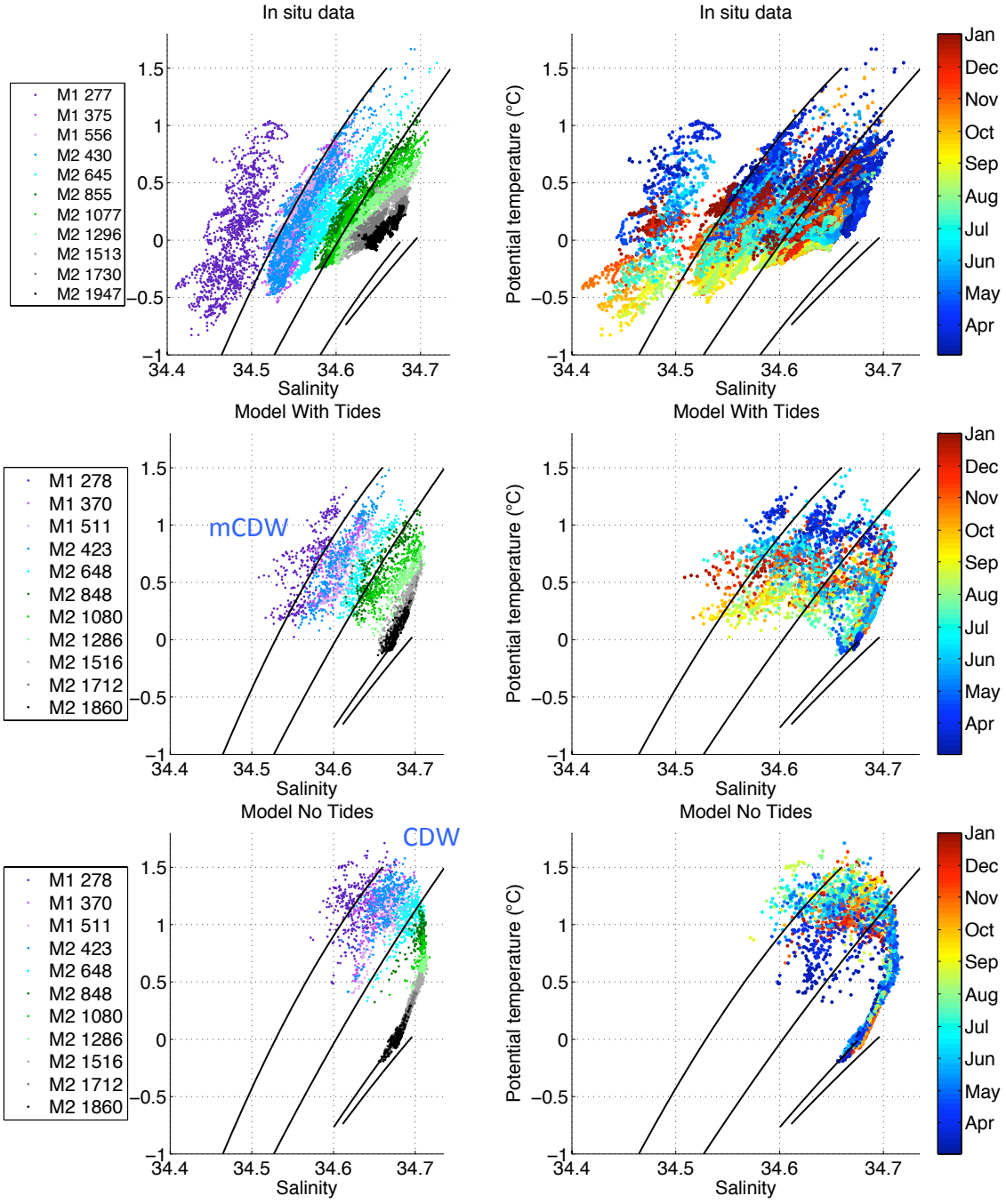
- Tides are known for moving water onshore/offshore
- But in order to explain our observations we need a modification of the density gradients!
- As an example, the role of tides in other areas (e.g., in the Ross Sea) involves dense gravity currents flowing along the bottom of the slope…



Bathymetry of the Scotia Sea (SW Atlantic) model domain in the cubesphere projection. Black contours show 1000, 2000, 3000 and 4000-m isobaths.



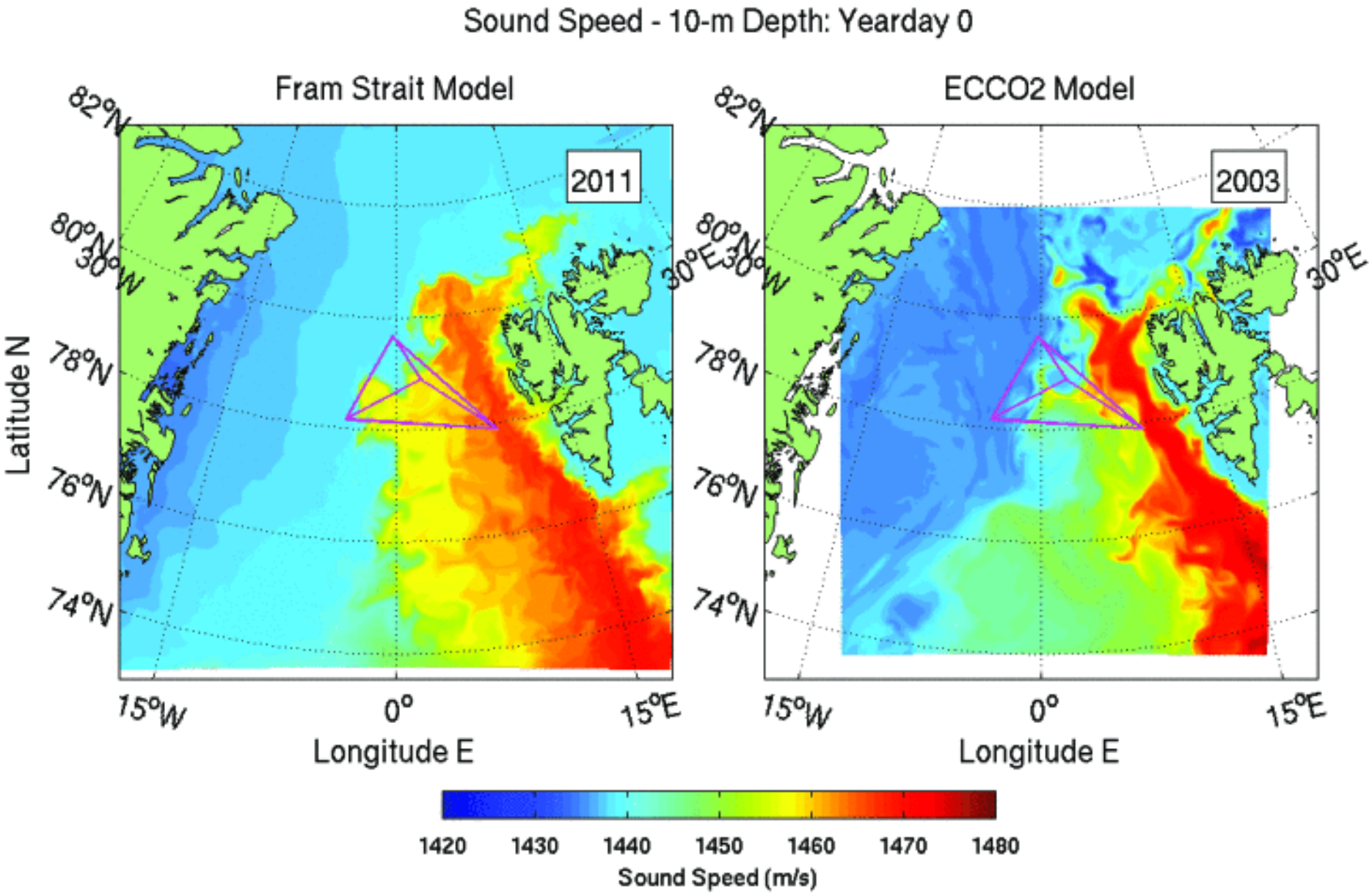
Black circles indicate approximate CTD stations performed in 2009, 2010, 2012 and 2013. Small black dots indicate grid nodes along the approximate hydrographic section. Blue squares indicate mooring locations for M1 at 550 m, M3* at 1100 m, and M2 at 1900 m


In situ data
M1 277
M1 375
M1 556
M2 430
M2 645
M2 855
M2 1077
M2 1296
M2 1513
M2 1730
M2 1947
Salinity
Potential temperature (°C)
Jan
Dec
Nov
Oct
Sep
Aug
Jul
Jun
May
Apr
Model With Tides
M1 278
M1 370
M1 511
M2 423
M2 648
M2 848
M2 1080
M2 1286
M2 1516
M2 1712
M2 1860
mCDW
Model No Tides
CDW

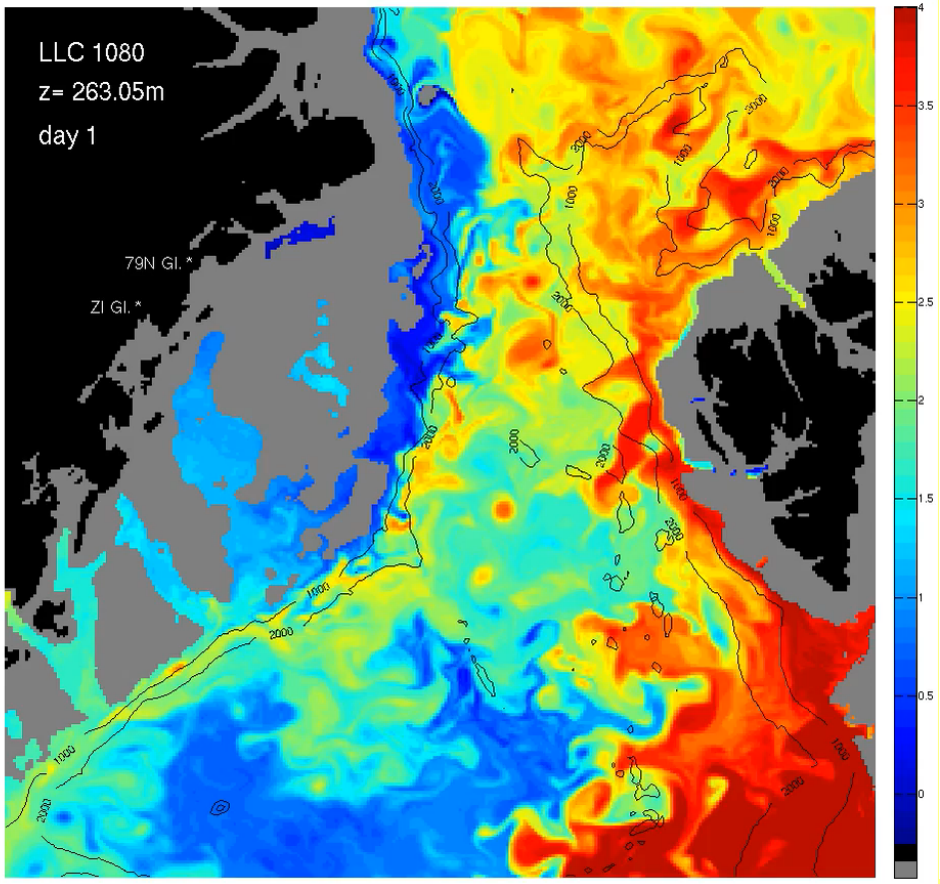
Example 3: Improved representation in ocean-ice models of warm Atlantic waters entering Arctic Ocean

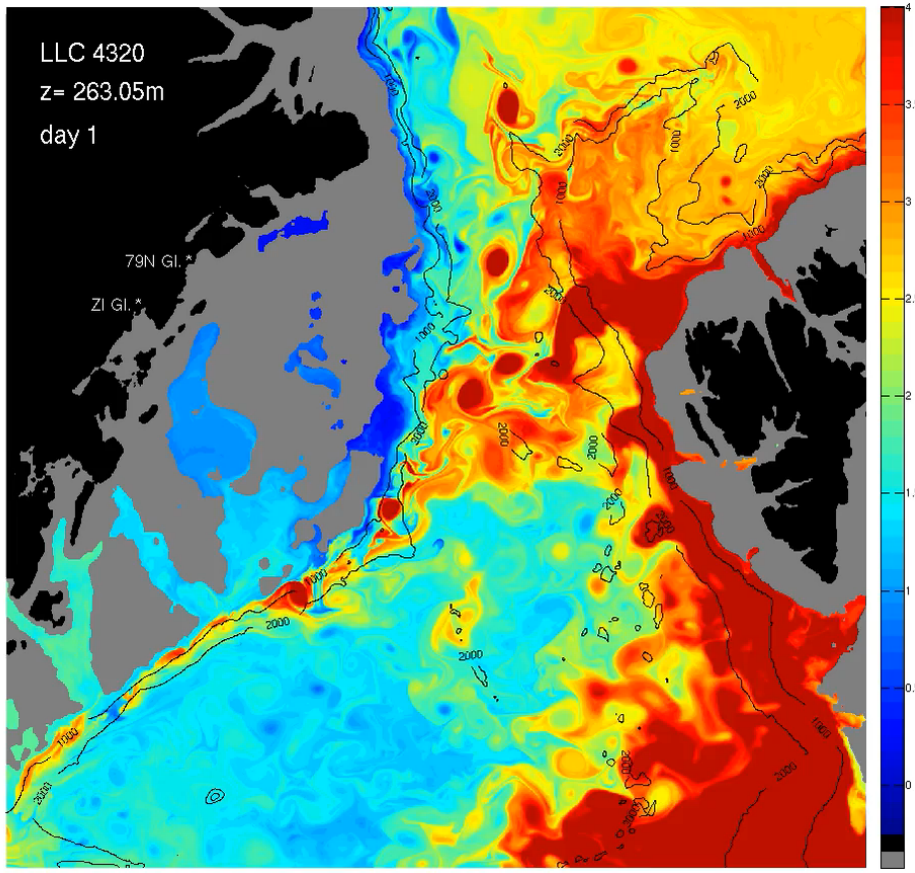
- A. Nguyen, et al.: Arctic ice-ocean simulation with optimized model parameters: approach and assessment. J. Geophys. Res., 2011.
- Optimization above used model configuration with 18-km horizontal grid spacing.
- As we increased resolution to 9 and 4.5-km grid spacing, Arctic Ocean Atlantic layer warmed.
- Why – and how to fix?

West Spitsbergen and East Greenland Currents in simulations with 2.8 and 4.9 km horizontal grid spacing (Brian Dushaw)



West Spitsbergen and East Greenland Currents in simulations with 4 and 1 km horizontal grid spacing (Ian Fenty)





Model output is extracted from global, highly instrumented, ocean-ice-tides simulations

Key challenges and opportunities

- Innovations, increments, and residuals include a lot of information about model biases caused by problematic representation of subgrid scale processes and boundary condition errors.
- Future **Climate Process and Modeling Teams (CPT)** can and should be more directly motivated by innovations, increments, and residuals of current crop of ocean data-assimilating models.
- Can US CLIVAR help facilitate this?