Mixed Layer Processes in the Labrador Sea from a High Resolution Atlantic and Pan-Arctic Ocean-ice Model Configuration (ANHA12)

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GEOTRACES VITALS

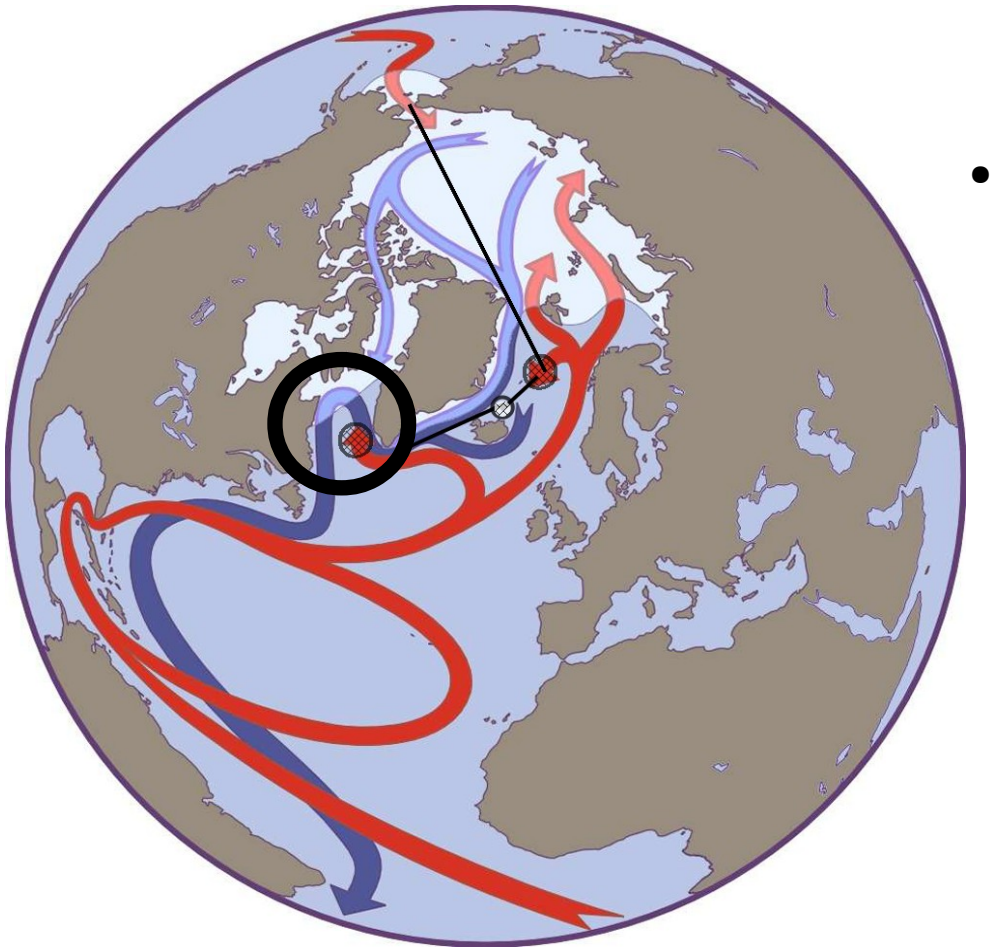
NSERC CRSNG People. Discovery. Innovation.

Outline

- **Background**
- **Model configuration and experiment**
- **Results**
  - simulated seasonal and inter-annual MLD in Labrador Sea
  - surface fluxes and MLD
  - cross section flux and MLD
- **Summary**

Labrador Sea

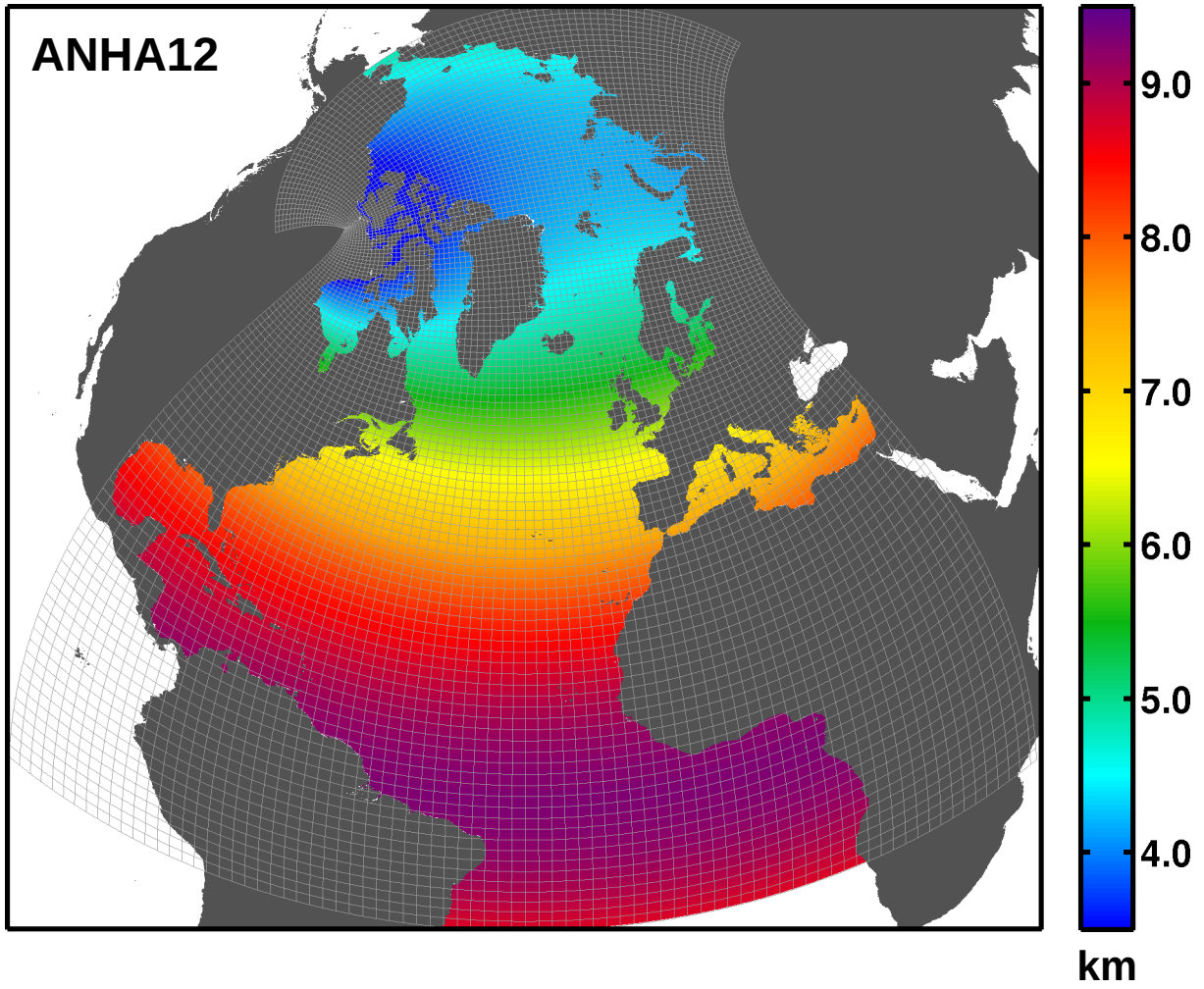
-- a vital element of climate system



Holloway and Proshutinsky 2007

- **Receiving Arctic Ocean outflows**
  - Canadian Arctic Archipelago
  - Fram Strait
- **Deep convection site**
  - deep water ventilated
  - gas exchanges
  - heat and freshwater

Model Configuration



Model : NEMO 3.4
LIM2 + EVP

Resolution : 1/12 degree

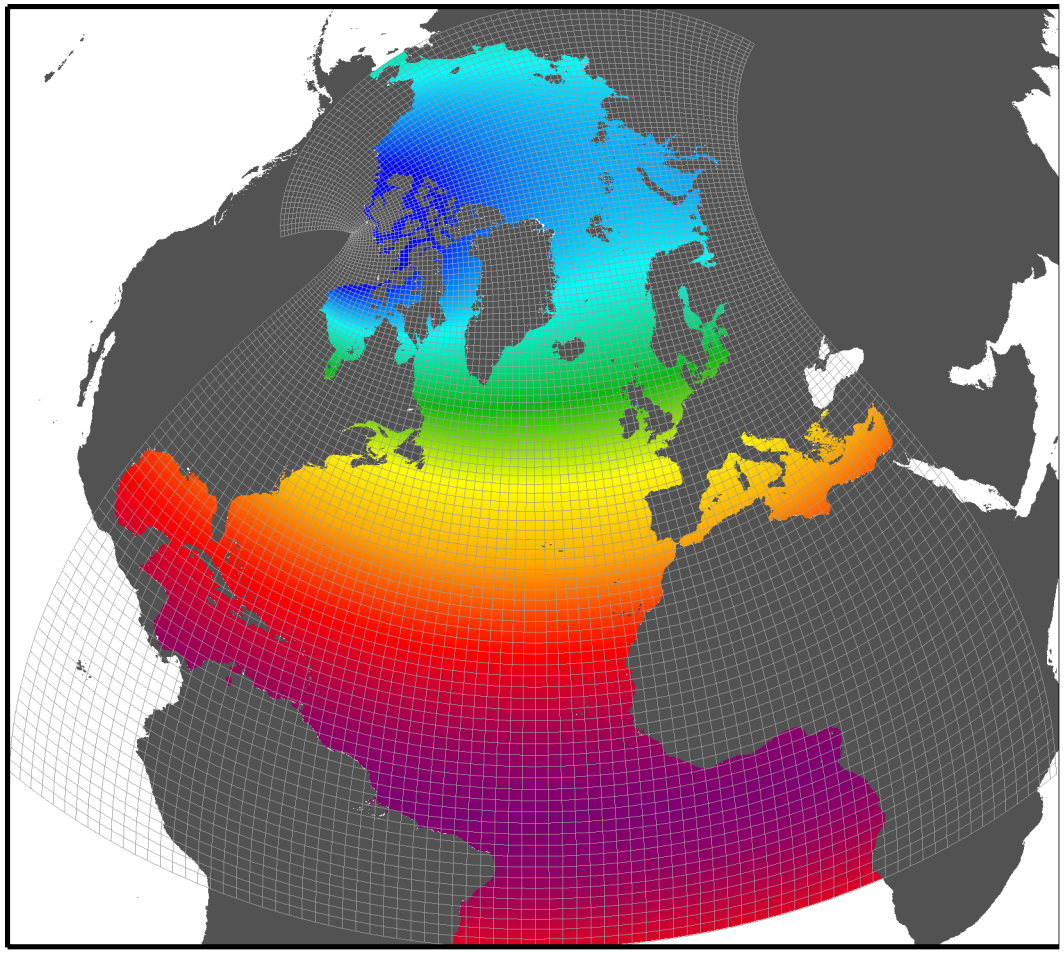
Mesh : 1632 x 2400

50 levels

LS : ~ 5km

ANHA: Arctic and Northern Hemisphere Atlantic

Experiment Setup



Initialization:

3D T, S, U and V (GLORYS1v1, Jan02)
Sea Ice

Atmospheric forcing (CGRF, hourly):

T2, Q2, U10, V10
Precipitation
Radiation (SW & LW)

Snow: CORE2 (IA)
Runoff: Dai and Trenberth climatology

OBC:
U, V, T and S (GLORYS1v1)

NO temperature & salinity restoring

Jan 2002 – 2008 -- > 2010

CGRF: CMC GDPS reforecasts
GDPS: Global Deterministic Prediction System

CMC: Canadian Meteorological Centre
GLORYS: GLobal Ocean ReanalYses and Simulations

Simulated Fields in the Labrador Sea

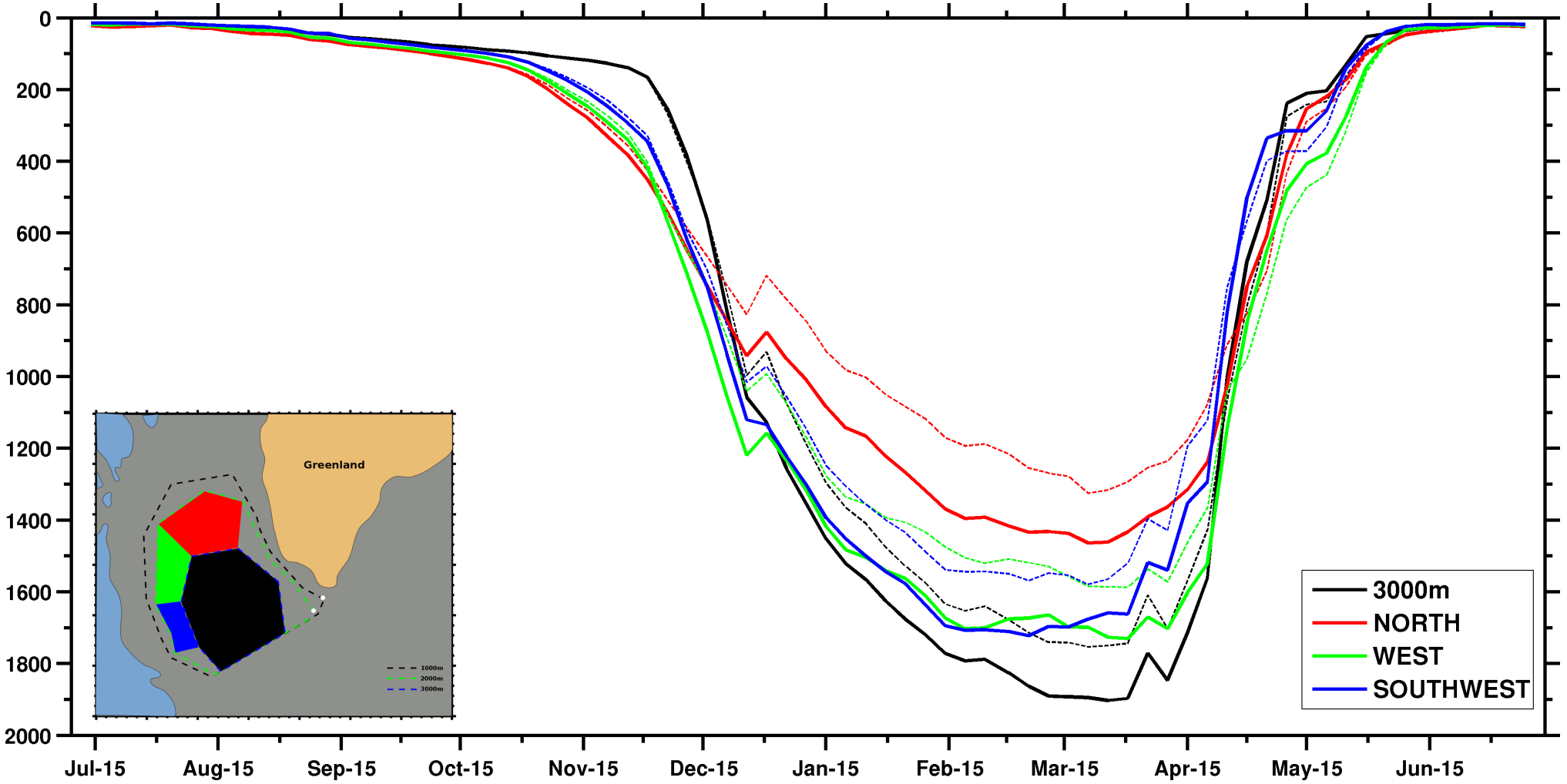
- Ice concentration
- Ice thickness
- Mixed layer depth (MLD)
- Ocean current (speed) at 55m

Result I:

Labrador Sea Mixed Layer Depth

- Seasonal cycle
- Inter-annual variability

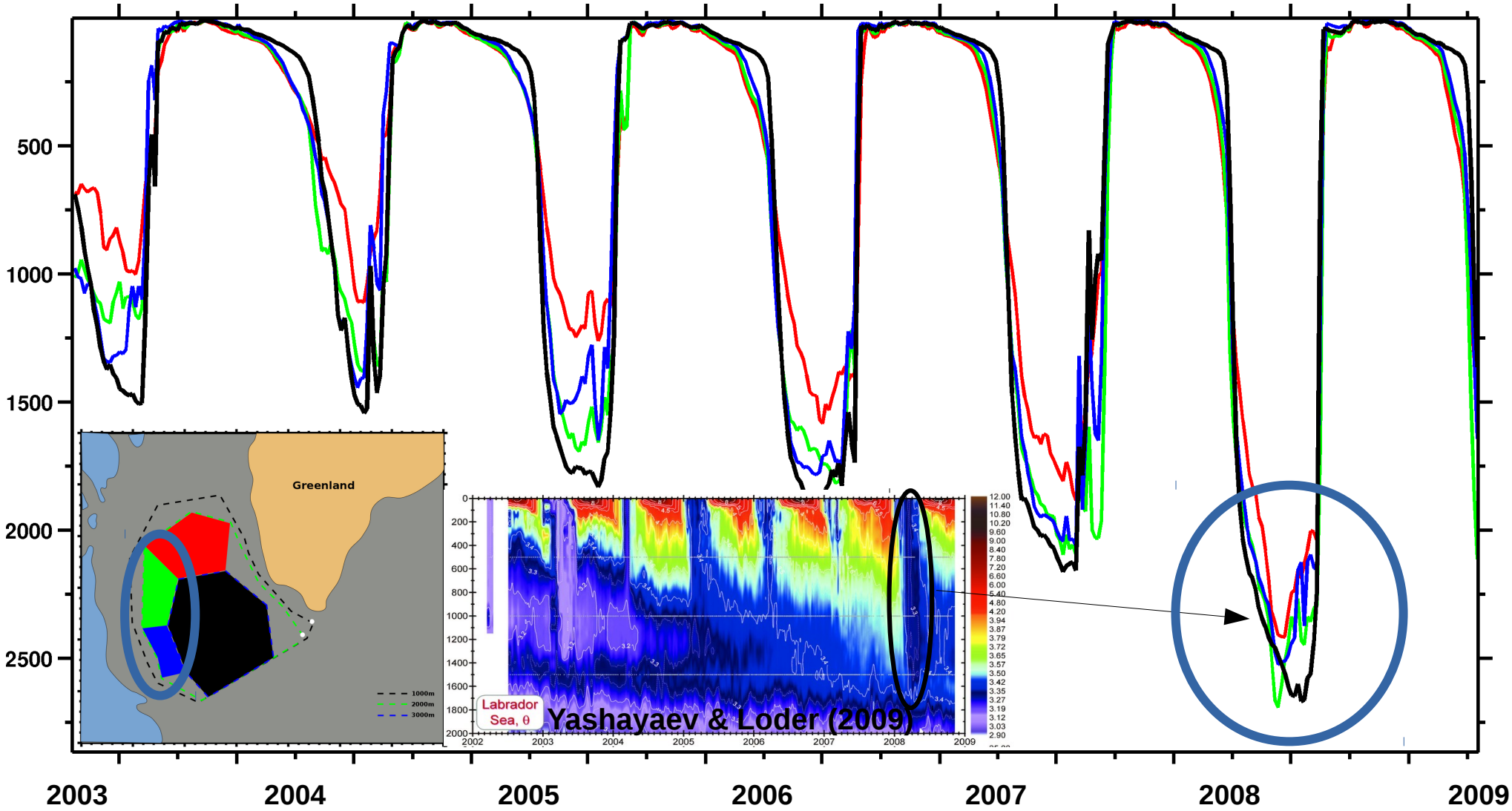
MLD Seasonal Cycle



- Nov ~ Dec --> Mar ~ Apr --> the mid of May
- re-stratification process: ~ 1 month
- north --> south, shelf --> interior

MLD: 0.01 kg m^{-3}
solid lines : 2003 – 2008
dotted lines: 2003 – 2007

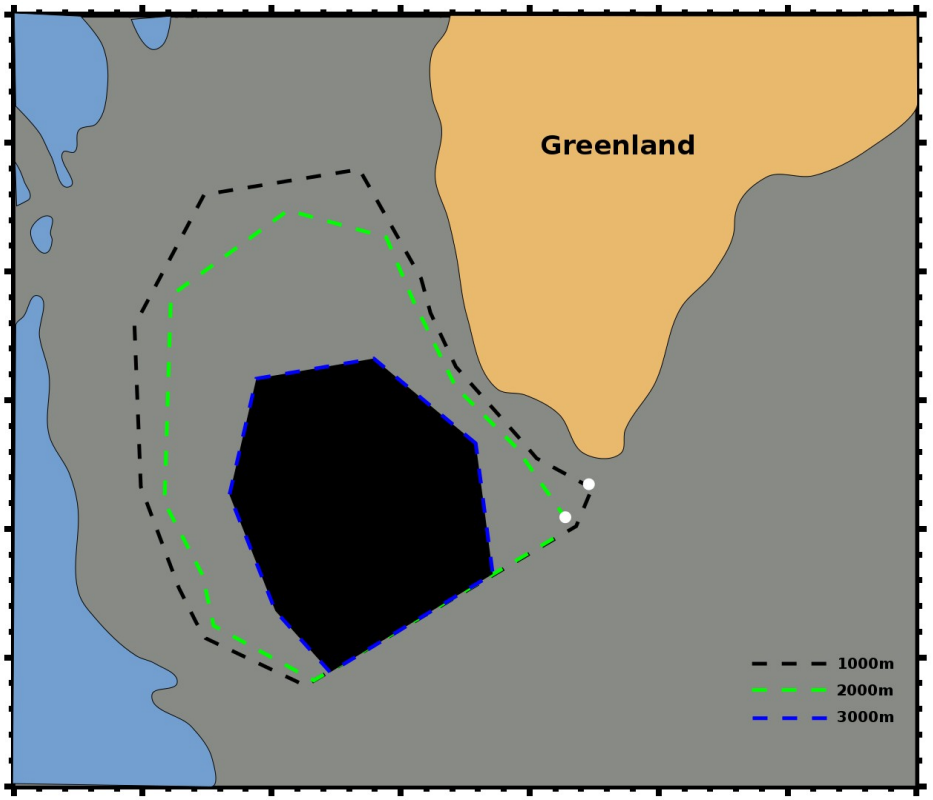
MLD Inter-annual Variability



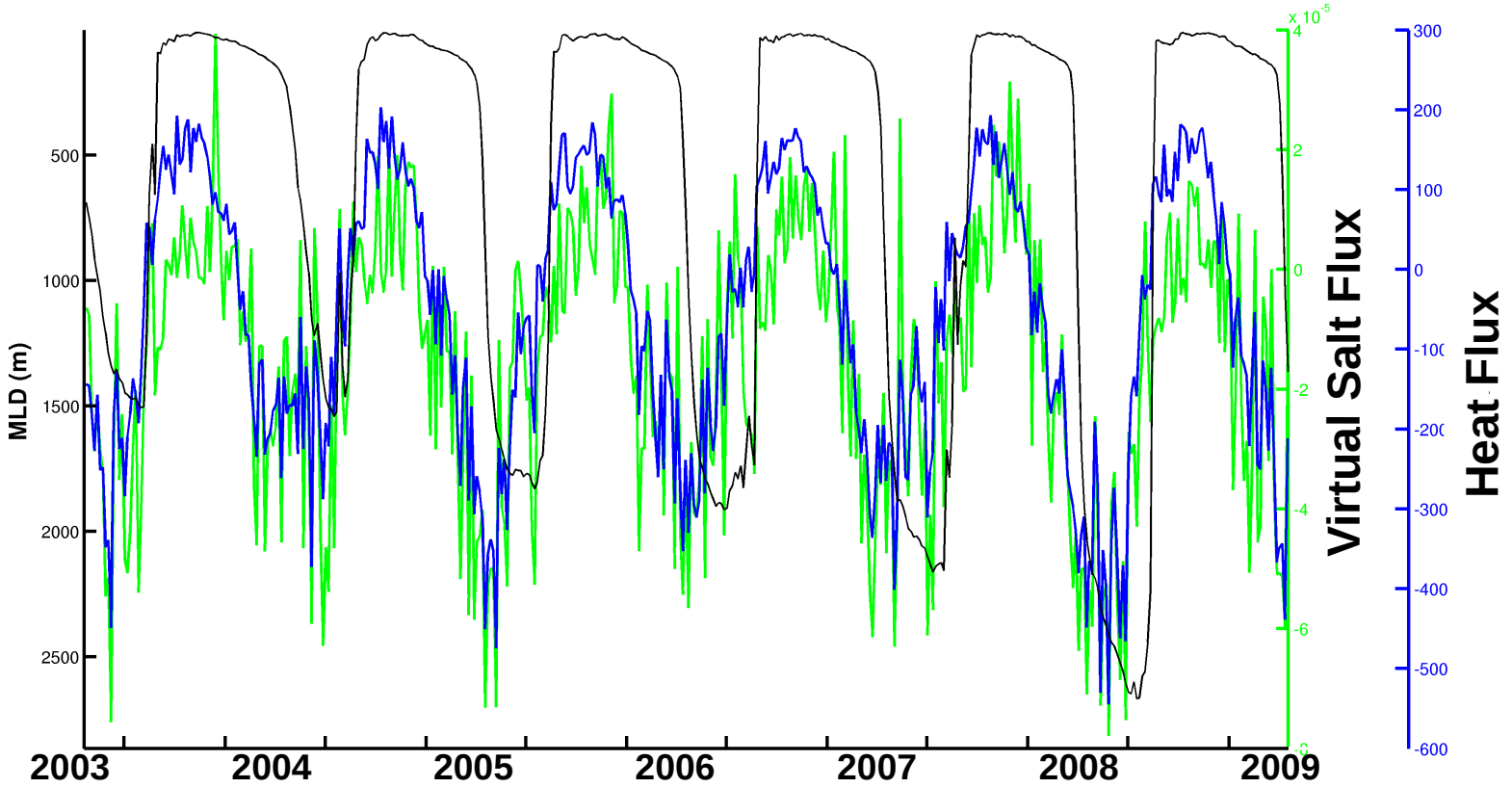
Yashayaev, I., and J. W. Loder (2009), Enhanced production of Labrador Sea Water in 2008, Geophys. Res. Lett., 36, L01606, doi:10.1029/2008GL036162.

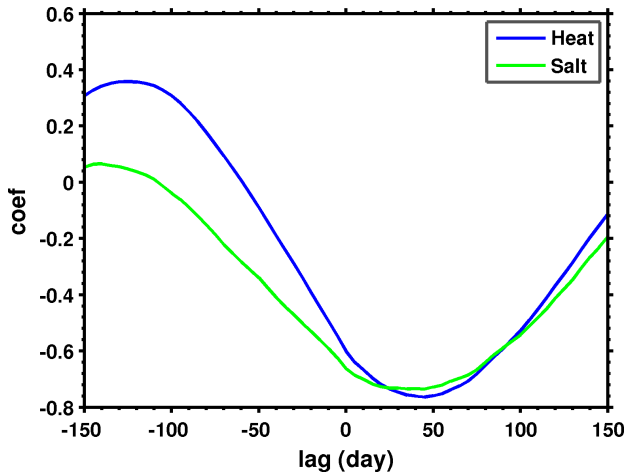
Result II:

Surface Fluxes and MLD



MLD and Surface Fluxes



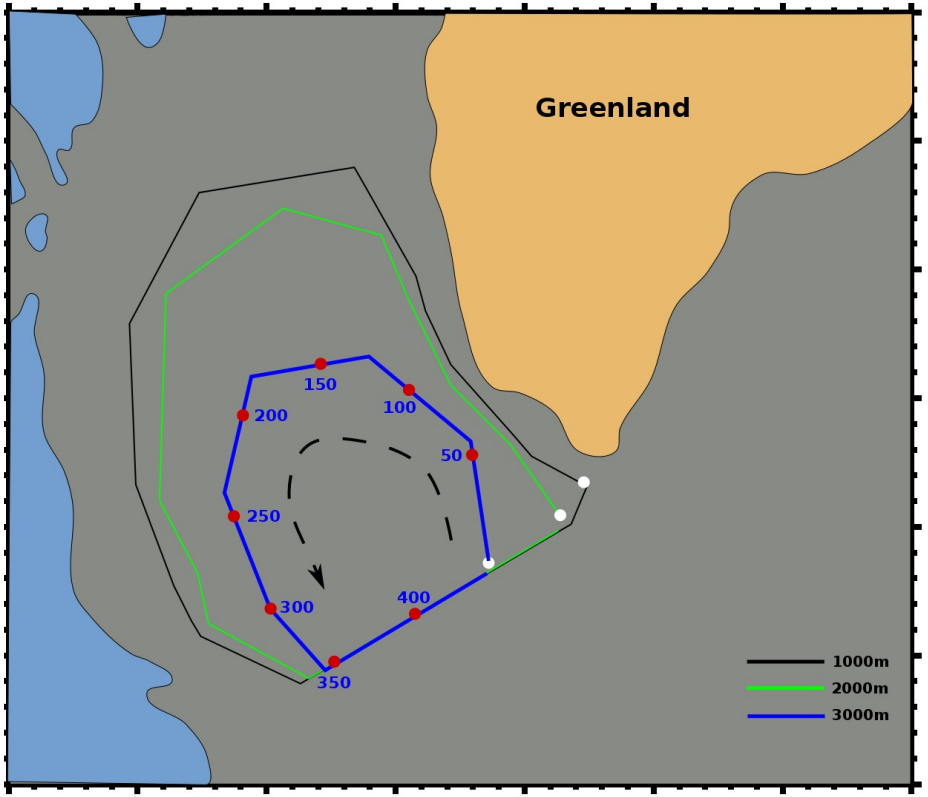


- heat loss & SSS increase during deep convection
- highly correlated
- fluxes lead MLD change by ~ 1.5 months

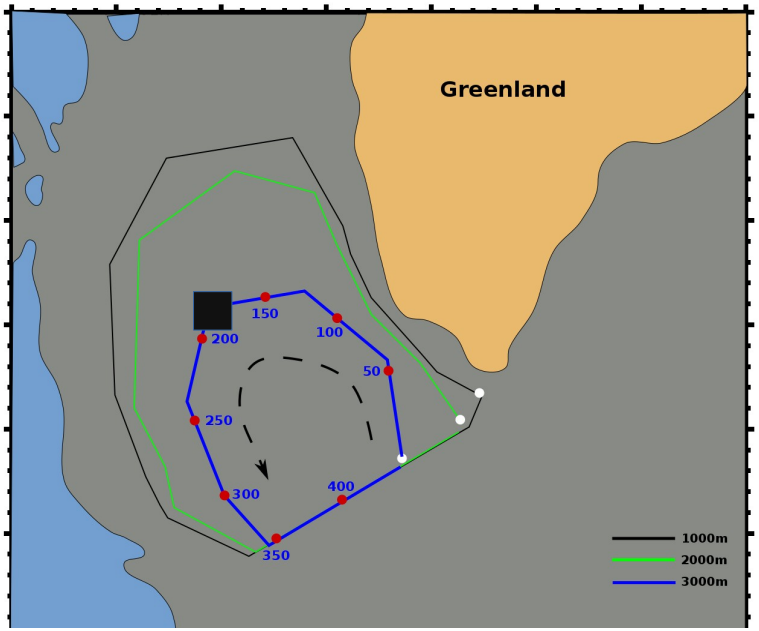
Downward heat flux: positive ==> into ocean

Result III:

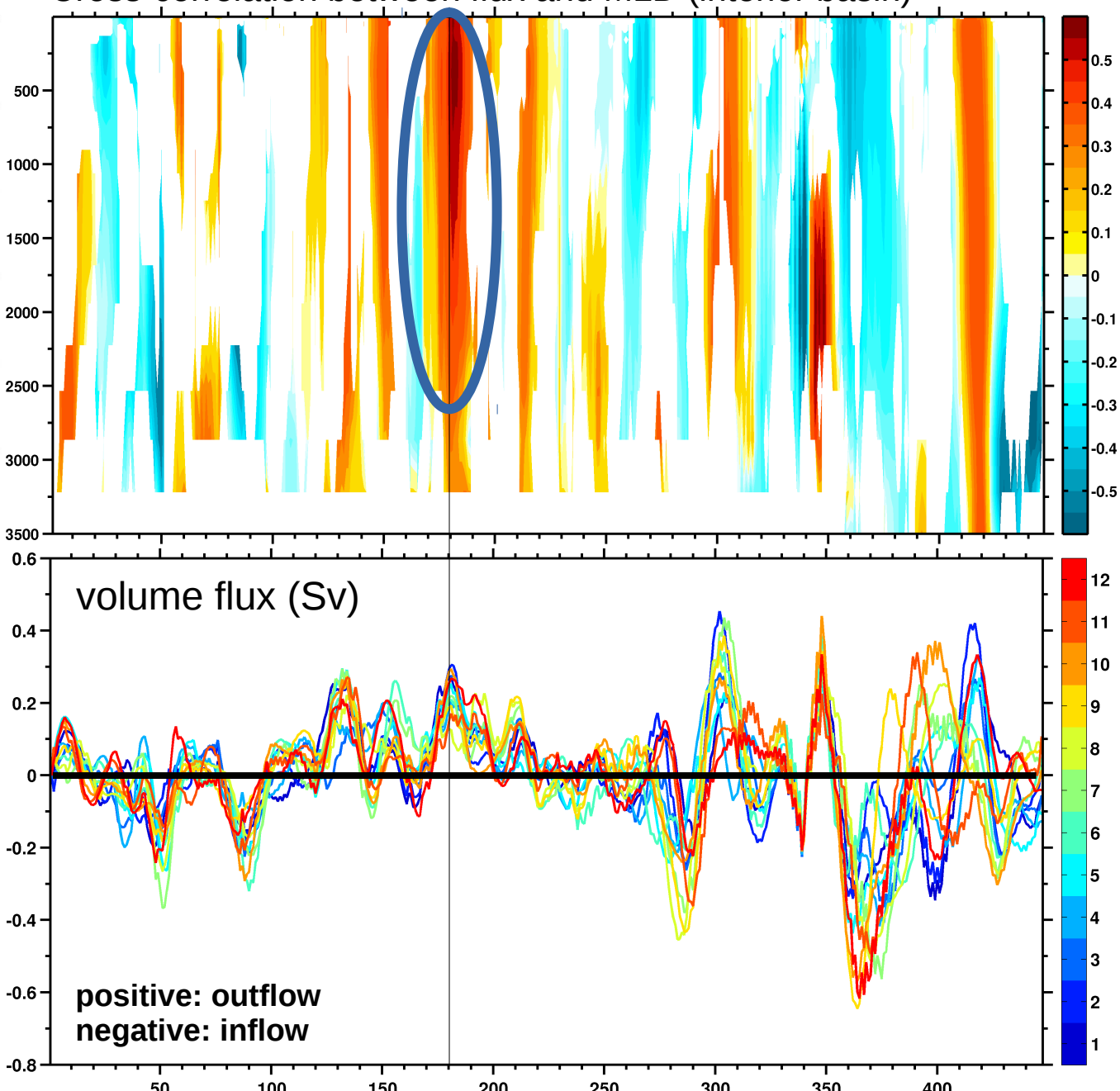
Cross Section Flux and MLD



MLD and Cross Section Volume Flux



Cross-correlation between flux and MLD (interior basin)



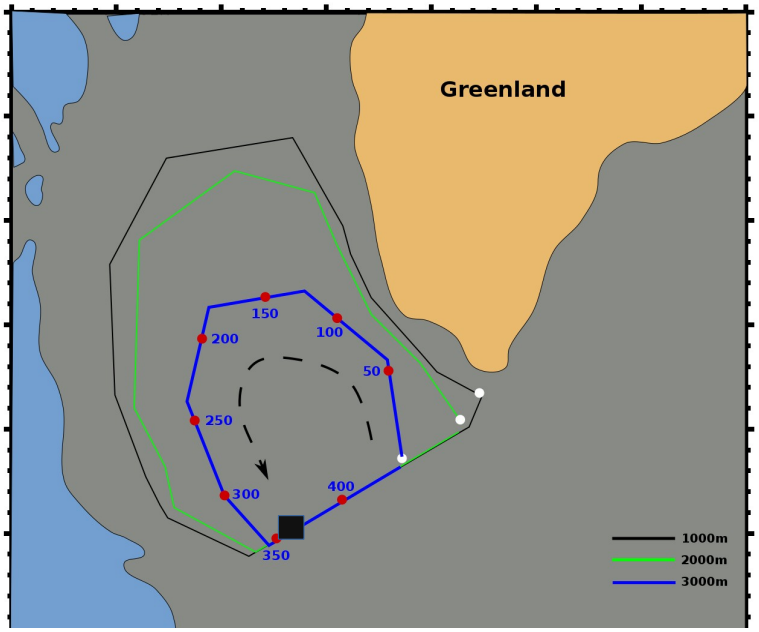
R > 0, flux is leading

Larger outflow

Deeper MLD

Less buoyancy into the interior

MLD and Cross Section Volume Flux



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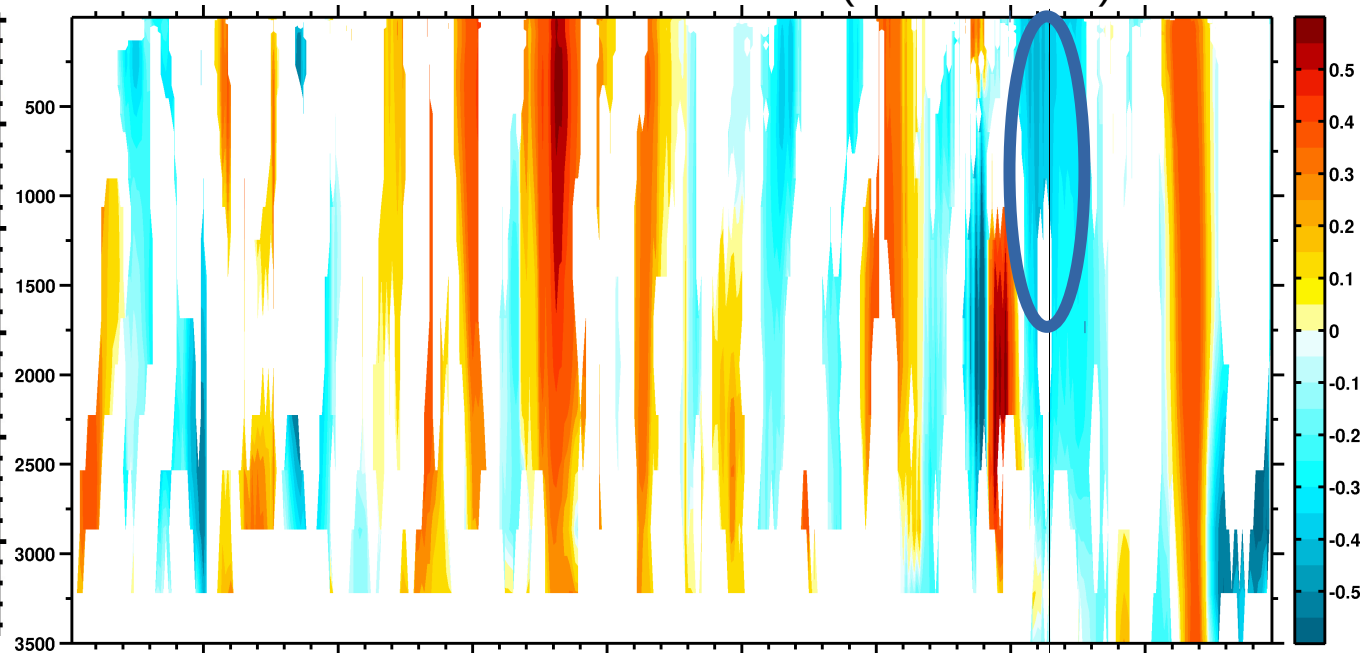
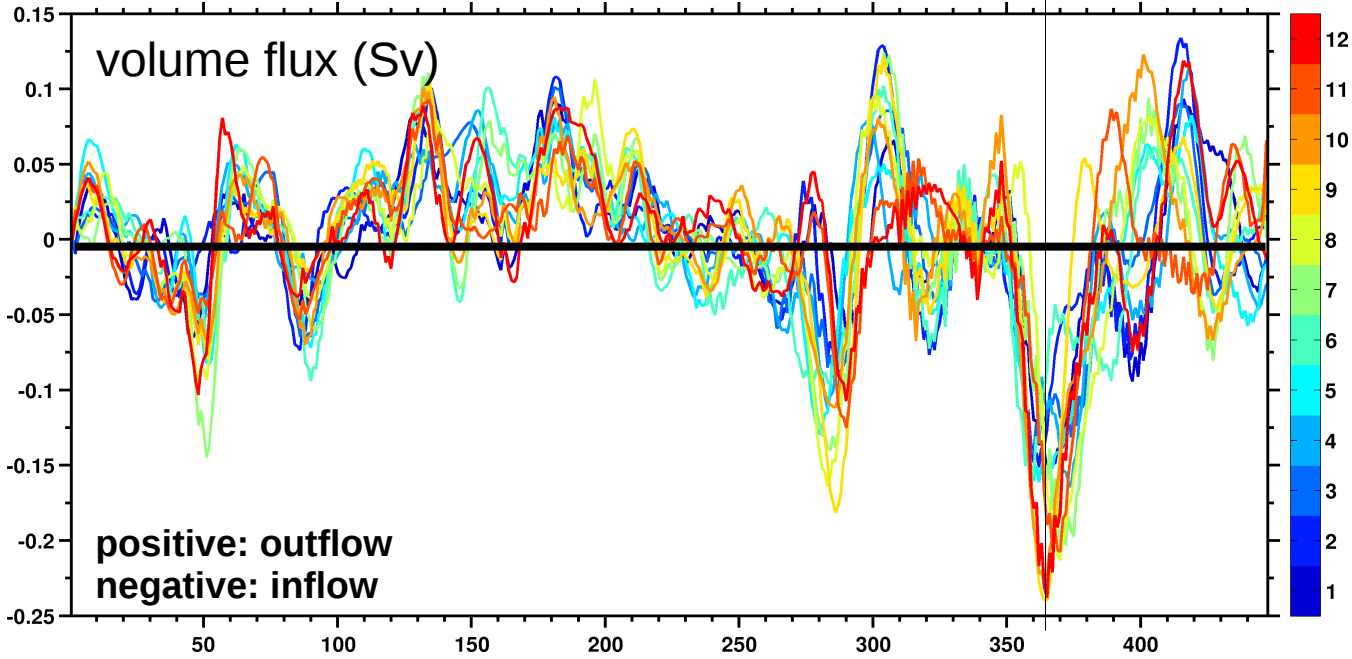


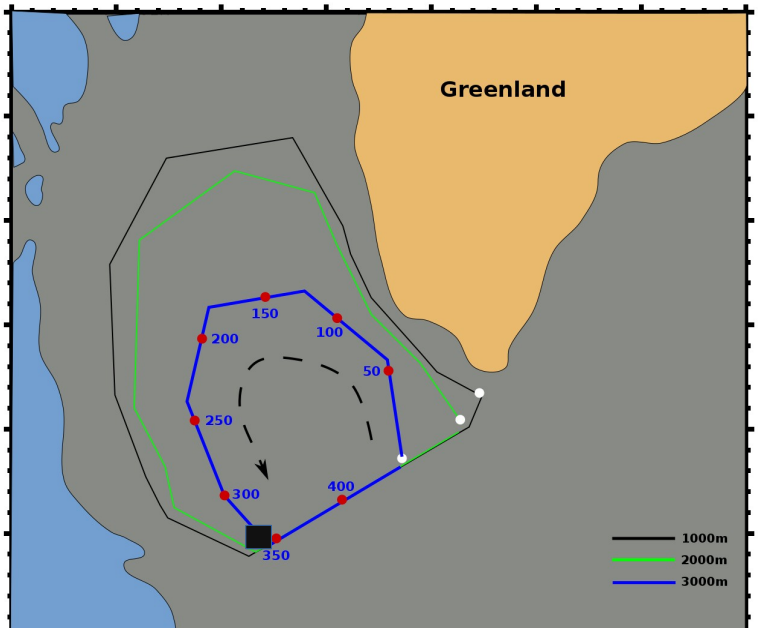


R < 0, flux is leading

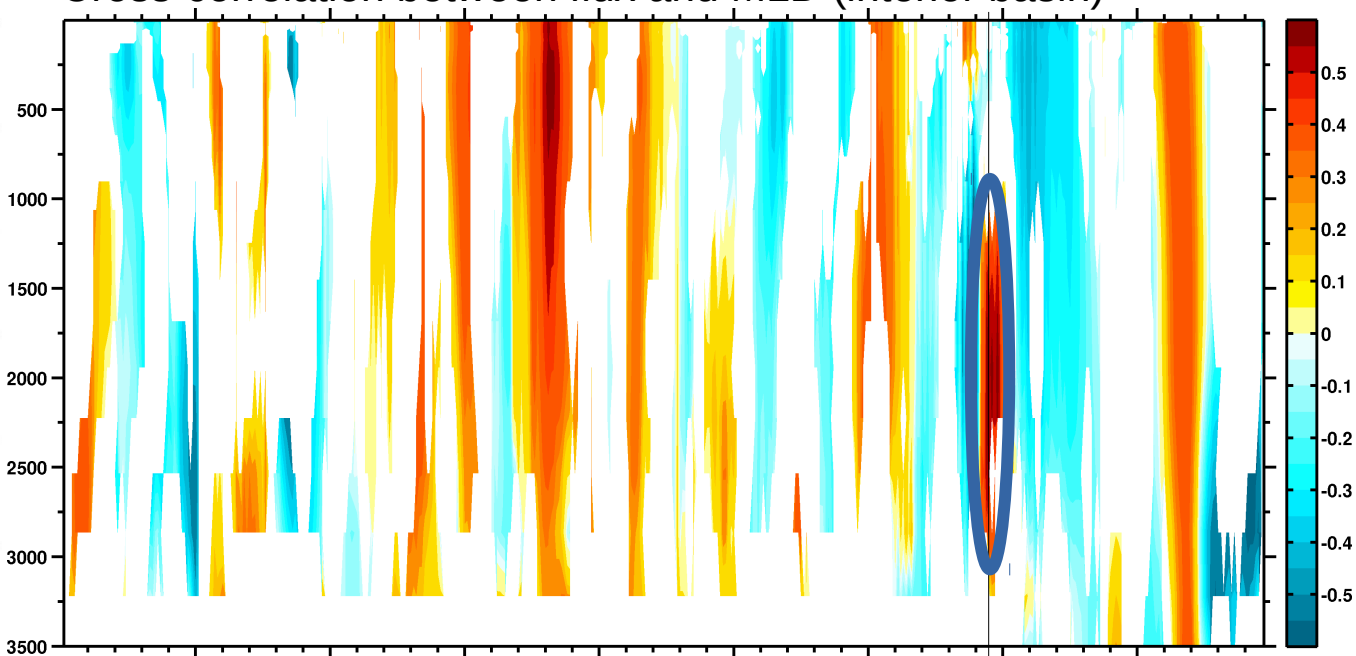
Larger inflow

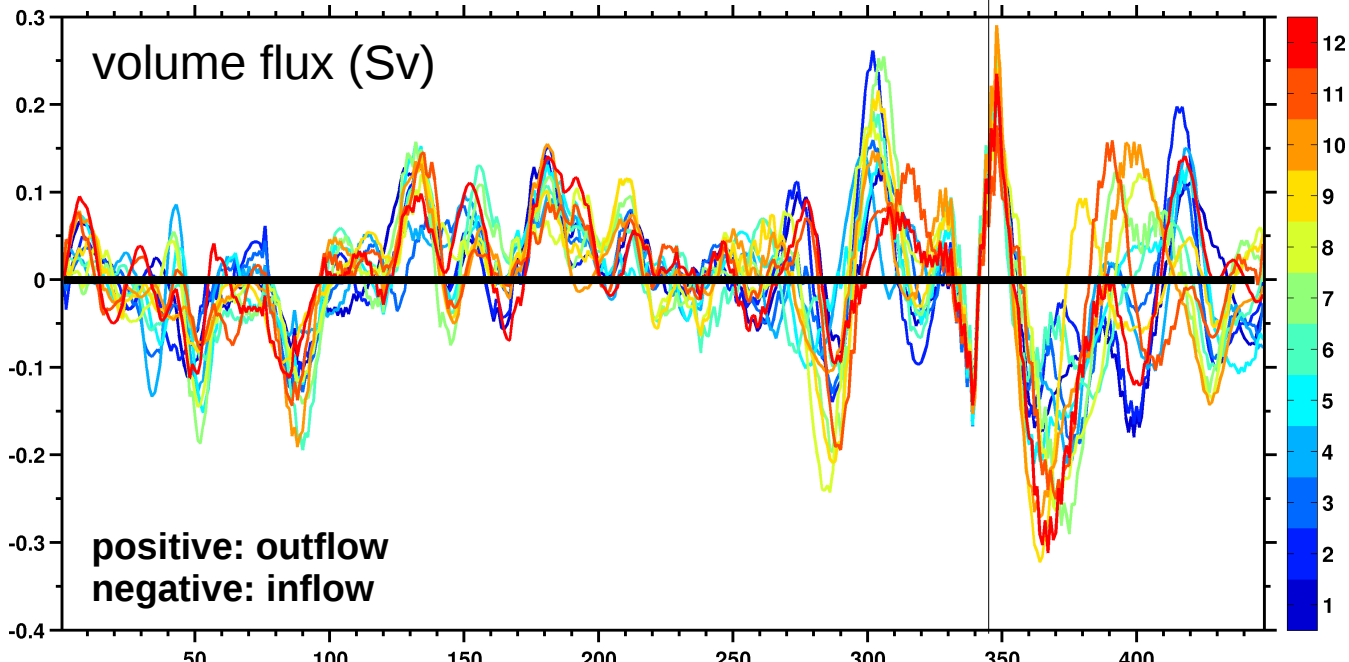
Deeper MLD

MLD and Cross Section Volume Flux



Cross-correlation between flux and MLD (interior basin)



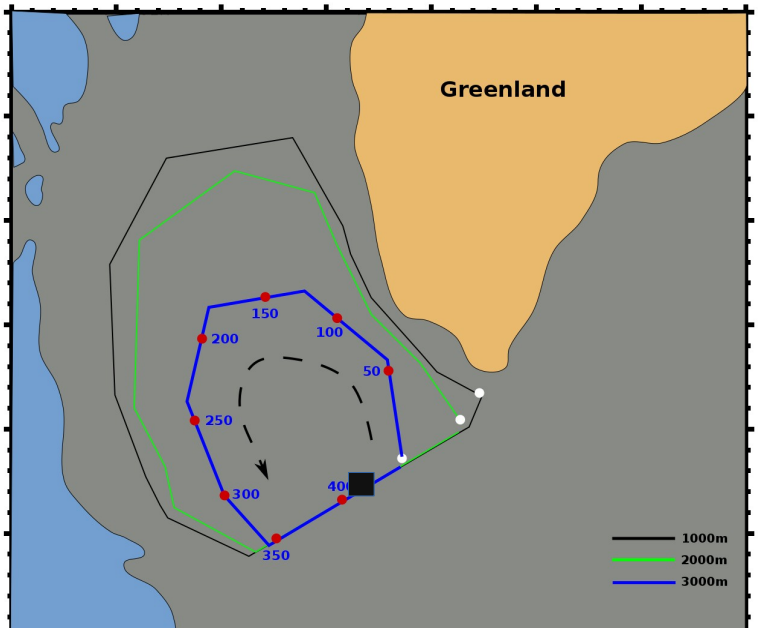


R > 0, MLD is leading

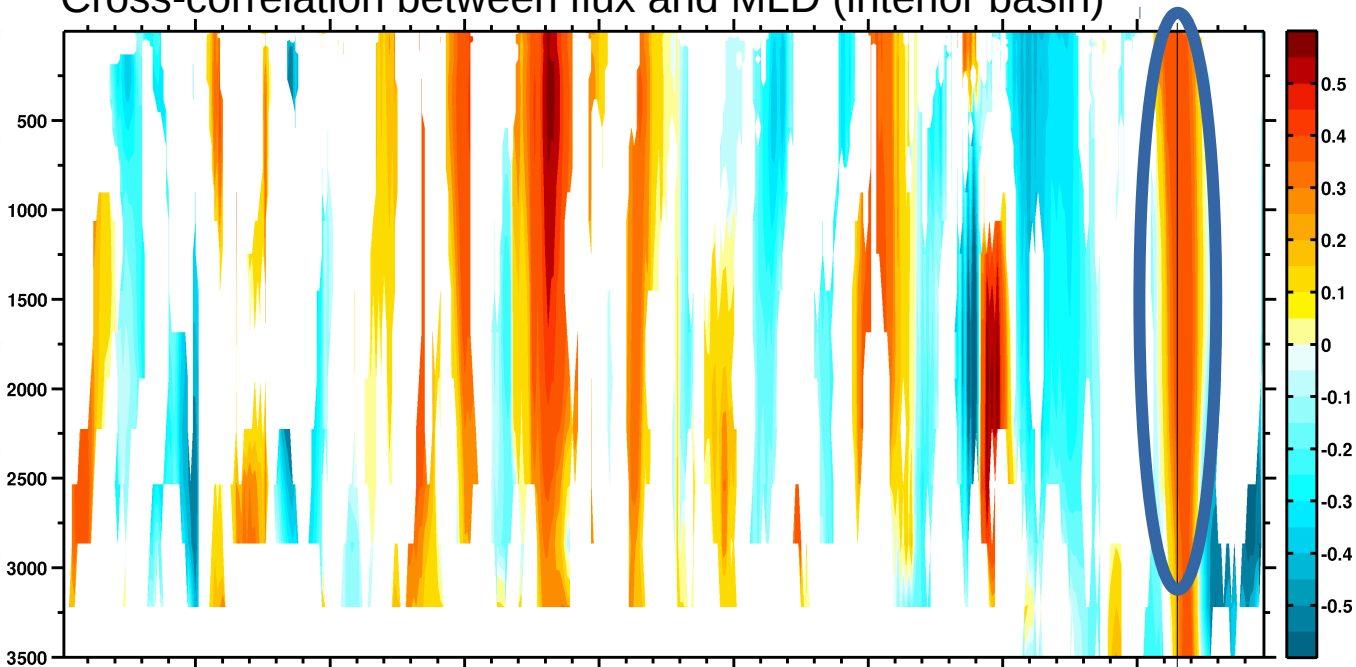
Deeper MLD

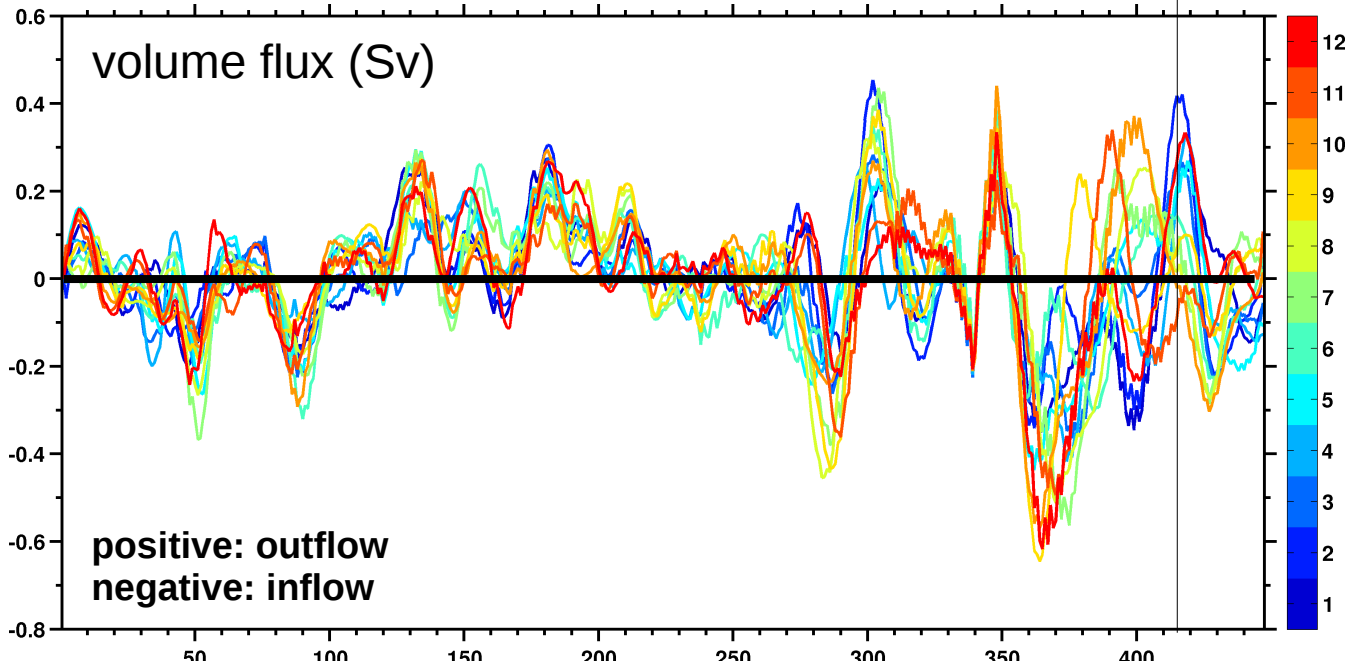
Larger outflow

MLD and Cross Section Volume Flux



Cross-correlation between flux and MLD (interior basin)





R > 0, MLD is leading

Deeper MLD

Larger outflow

Summary

- **MLD in the Labrador Sea**
  - from the end of November to the mid of next May
  - starts deepening on shelf from the north to south and interior
  - re-stratification is much faster than the development process
- **MLD variability in the deep basin (>3000m)**
  - highly related to the surface heat and virtual salt fluxes
  - surface fluxes lead MLD change by ~ 1.5 months
  - relation between the cross section transport and MLD varies by location
    - less buoyancy input from the north or larger upper layer inflow from the south leads to a deeper MLD
    - deeper MLD leads to larger outflow to the south