D15

The Influence of High Frequency Atmospheric Forcing on Ocean Circulation

UNIVERSITY OF ALBERTA
FACULTY OF SCIENCE
Department of Earth & Atmospheric Sciences

Amber M. Holdsworth and Paul G. Myers

University of Alberta Department of Earth and Atmospheric Sciences

Motivation

Examples of *high frequency forcing*: storms, barrier winds, cold air outbreaks, polar lows, topographic jets

- short time scale events can enhance air-sea heat exchange
  - -> Trigger deep or intermediate convection
    1. nutrient distribution and chemical exchange [1]
    2. Atlantic Meridional Overturning Circulation (AMOC) [2]
  - -> we examine the response of the *Labrador Sea*
- as the climate warms storms are predicted to increase [3]
  - -> We must be able to predict the oceanic response

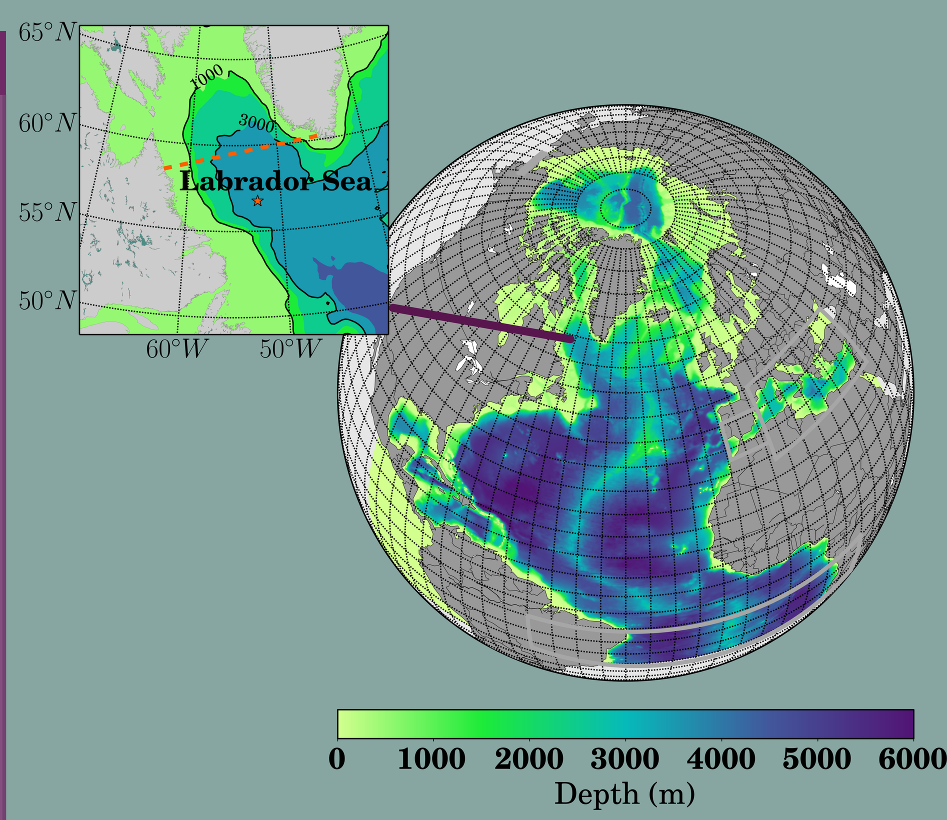

Fig.1. Bathymetry over the domain of ANHA4. Buffer zones are light gray.

Ocean-Ice Model

- NEMO -Nucleus for European Modeling of the Ocean [4]
- Arctic Northern Hemisphere Atlantic Configuration
- CICE -Los Alamos Sea ice model
- 1/4° grid
- 50 vertical levels

Method

- we filtered the wind and temperature fields
- time scales less than one week were removed using a moving average filter [5]

Atmospheric Forcing

- CGRF-Canadian Meteorological Centre's Global Deterministic Prediction System [6]
- hourly atmospheric data
- Resolution:
  0.45° longitude
  0.3° latitude
- model forecasts from operational analysis
- 2002-2010

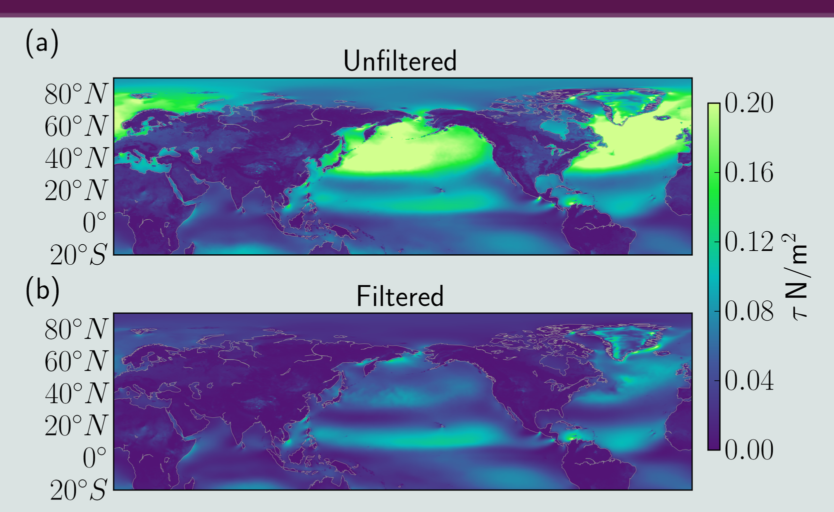

Fig.2. Average wind stress curl (JFM).

The Labrador Sea

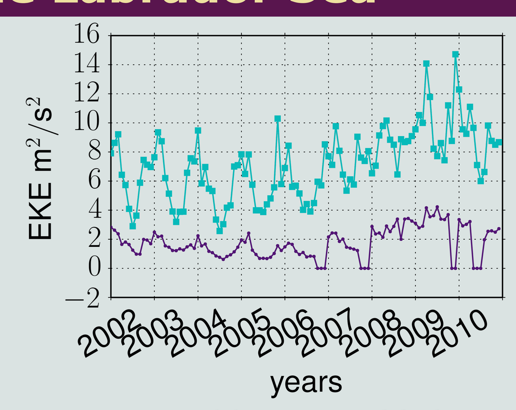

Fig.3. Monthly mean eddy kinetic energy.

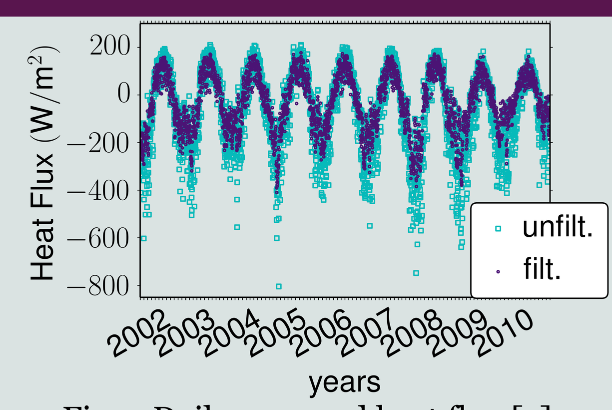

Fig.4. Daily averaged heat flux [7].

- we averaged the heat flux, EKE and Mixed Layer Depths within the 3000 m isobath of the Labrador Sea (<-44°W)
- Convective Energy is the amount of energy required to mix the column to a depth h [8]

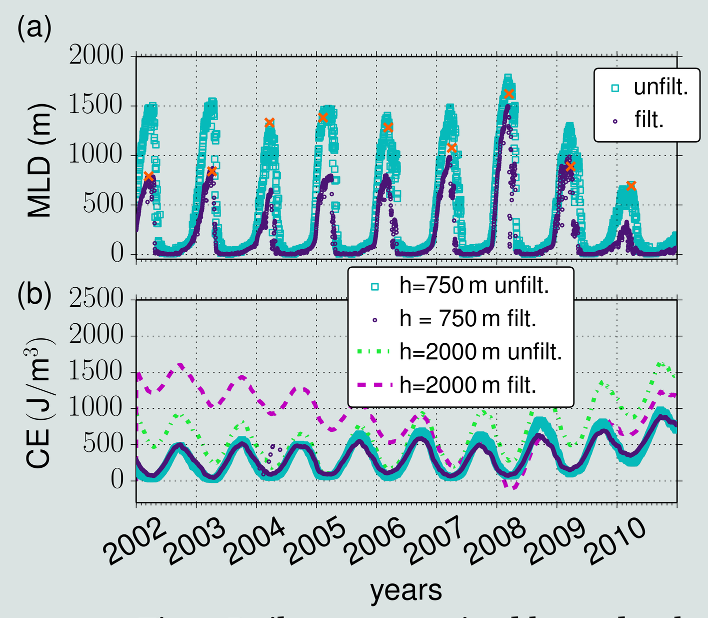

Fig.5. Daily average mixed layer depth and convective energy [8].

Ocean Circulation

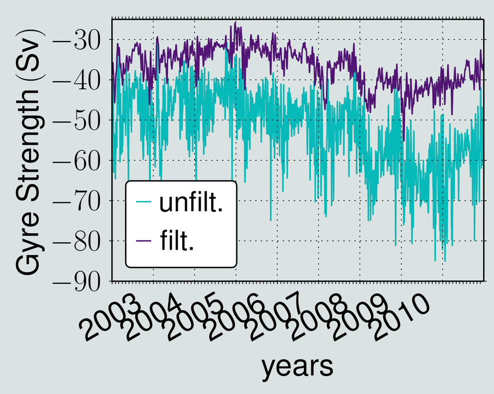

Fig 6. Maximum Strength of the Subpolar Gyre computed from the barotropic stream function along the orange line in Fig.1.

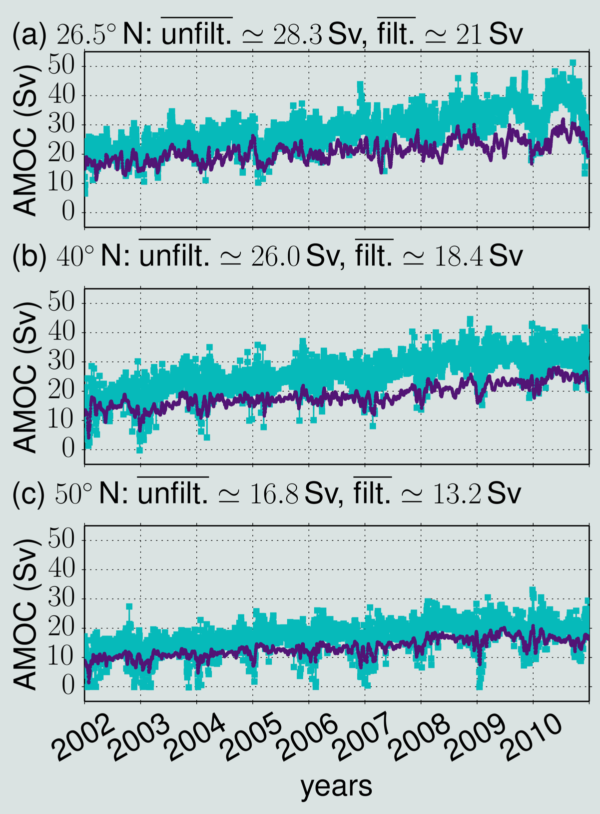

Fig.7. Daily maximum AMOC. Selected latitudes and mean values are shown above each panel.

RAPID = 18.75 +/- 4.8 Sv
unfilt. = 27.84 +/- 4.3 Sv
filt. = 20.47 +/- 2.5 Sv

tab.1. Mean and standard deviation of the AMOC at 26.5 N (02/04/04-10/04/8) [9].

Conclusions

The effects of removing high frequency forcing

Circulation of the North Atlantic

- decreased the EKE by 75%
- decrease the circulation of the Atlantic by about 20%
- eliminated fluctuations in the AMOC and sub-polar gyre

Convection in the Labrador Sea

- MLD decreased by 20% in cold years
- MLD decreased by as much as 110% relatively warm years

Future Directions

- removal of particular storm tracks in atmospheric forcing data
  -> removal of synoptic vs. mesoscale
- how does high frequency forcing effect sub-surface processes?

Wavelet Power Spectrum of Filtered Data

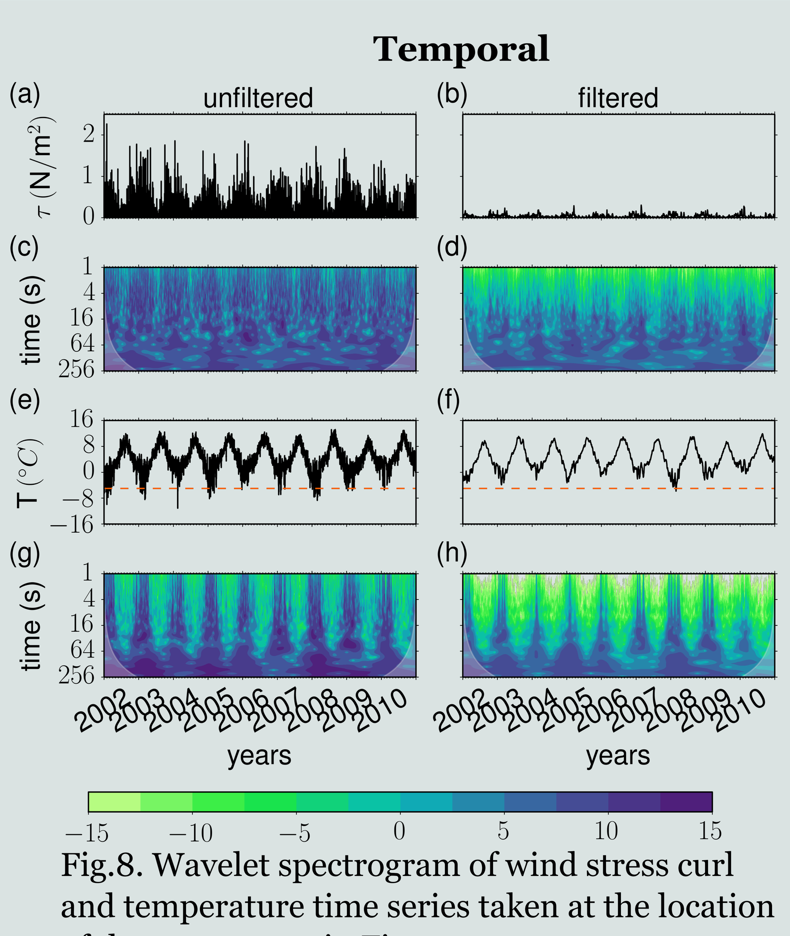

Fig.8. Wavelet spectrogram of wind stress curl and temperature time series taken at the location of the orange star in Fig.1.

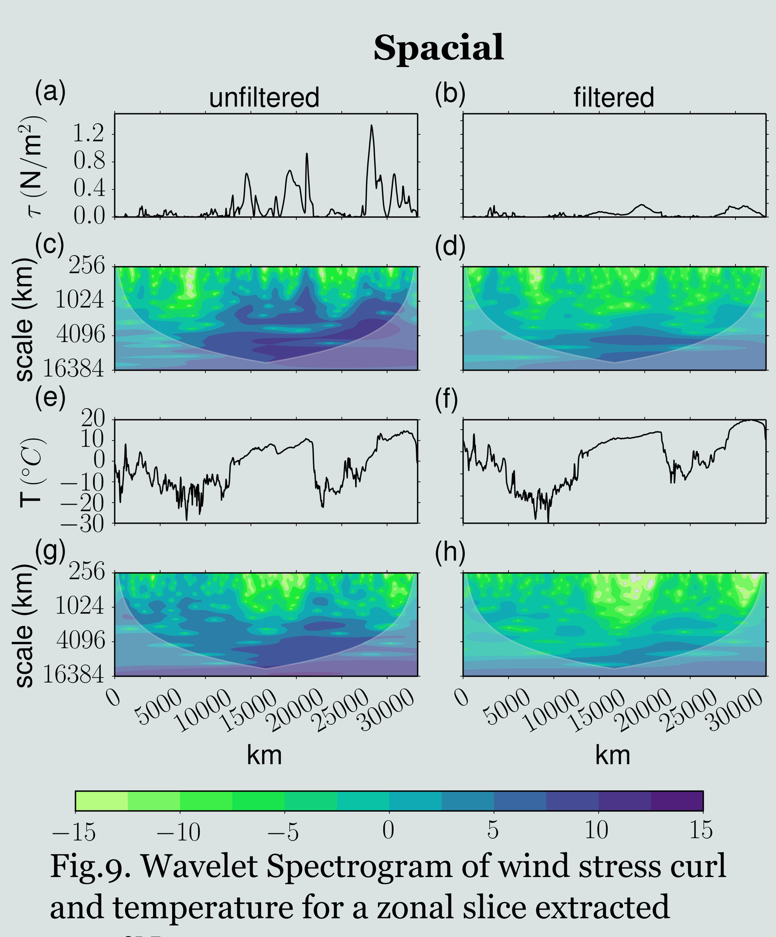

Fig.9. Wavelet Spectrogram of wind stress curl and temperature for a zonal slice extracted at 45°N.

References

[1] Azetsu-Scott, K., Jones, E. P., Yashayaev, I., & Gershey, R. M. (2003). Time series study of CFC concentrations in the Labrador Sea during deep and shallow convection regimes (1991–2000). Journal of Geophysical Research: Oceans (1978–2012), 108 (C11).

[2] Kuhlbrodt, T., Griesel, A., Montoya, M., Levermann, A., Hofmann, M., & Rahmstorf, S. (2007). On the driving processes of the Atlantic Meridional Overturning Circulation. Reviews of Geophysics, 45 (2).

[3] Zahn, M., & von Storch, H. (2010). Decreased frequency of North Atlantic polar lows associated with future climate warming. Nature, 467 (7313), 309-312.

[4] Madec, G. (2008). NEMO reference manual, ocean dynamic component: NEMO-OPA. Note du Pole de modelisation, Institut Pierre Simon Laplace, Technical Report, 27.

[5] Eskridge, R. E., Ku, J. Y., Rao, S. T., Porter, P. S., & Zurbenko, I. G. (1997). Separating different scales of motion in time series of meteorological variables. Bulletin of the American Meteorological Society, 78(7), 1473-1483.

[6] Smith, G. C., Roy, F., Mann, P., Dupont, F., Brasnett, B., Lemieux, J. F., ... & Bélair, S. (2014). A new atmospheric dataset for forcing ice–ocean models: Evaluation of reforecasts using the Canadian global deterministic prediction system. Quarterly Journal of the Royal Meteorological Society, 140 (680), 881-894.

[7] Large, W. G., & Yeager, S. G. (2009). The global climatology of an interannually varying air–sea flux data set. Climate Dynamics, 33(2-3), 341-364.

[8] Bailey, D. A., Rhines, P. B., & Häkkinen, S. (2005). Formation and pathways of North Atlantic Deep Water in a coupled ice–ocean model of the Arctic–North Atlantic Oceans. Climate dynamics, 25(5), 497-516.

[9] Rayner, D., Hirschi, J. J. M., Kanzow, T., Johns, W. E., Wright, P. G., Frajka-Williams, E., ... & Cunningham, S. A. (2011). Monitoring the Atlantic Meridional Overturning Circulation. Deep Sea Research Part II: Topical Studies in Oceanography, 58(17), 1744-1753.

NSERC CRSNG

VITALS- Ventilation Interactions and Transports Across the Labrador Sea

*aholdswo@ualberta.ca