Using covariability between the surface temperature and salinity to understand the mechanism acting on different time and spatial scales

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Motivation

- The SST tripole pattern is due to atmospheric forcing.
- Some think that ocean dynamics become important at longer timescales (e.g., the AMV is forced by the ocean).
- SST/SSS relationships can shed light onto the role of atmospheric forcing and ocean dynamics in setting SST.

Conclusions

1) Temperature and salinity in most of the subpolar North Atlantic are in phase, with strongest relationships and low frequencies and subsurface depths, indicating the role of ocean dynamics (Figures 1 and 2).
2) SST and SSS are out of phase at the surface at high frequencies, specifically in the eastern subpolar gyre (Figures 2 and 3).
3) Anticorrelation between SST and SSS in the eastern subpolar gyre is due to high frequency wind forcing induced by the NAO, namely via Ekman transports that act on the mean SSS field (Figures 4 and 5).

Correlations between Temperature and Salinity in the North Atlantic

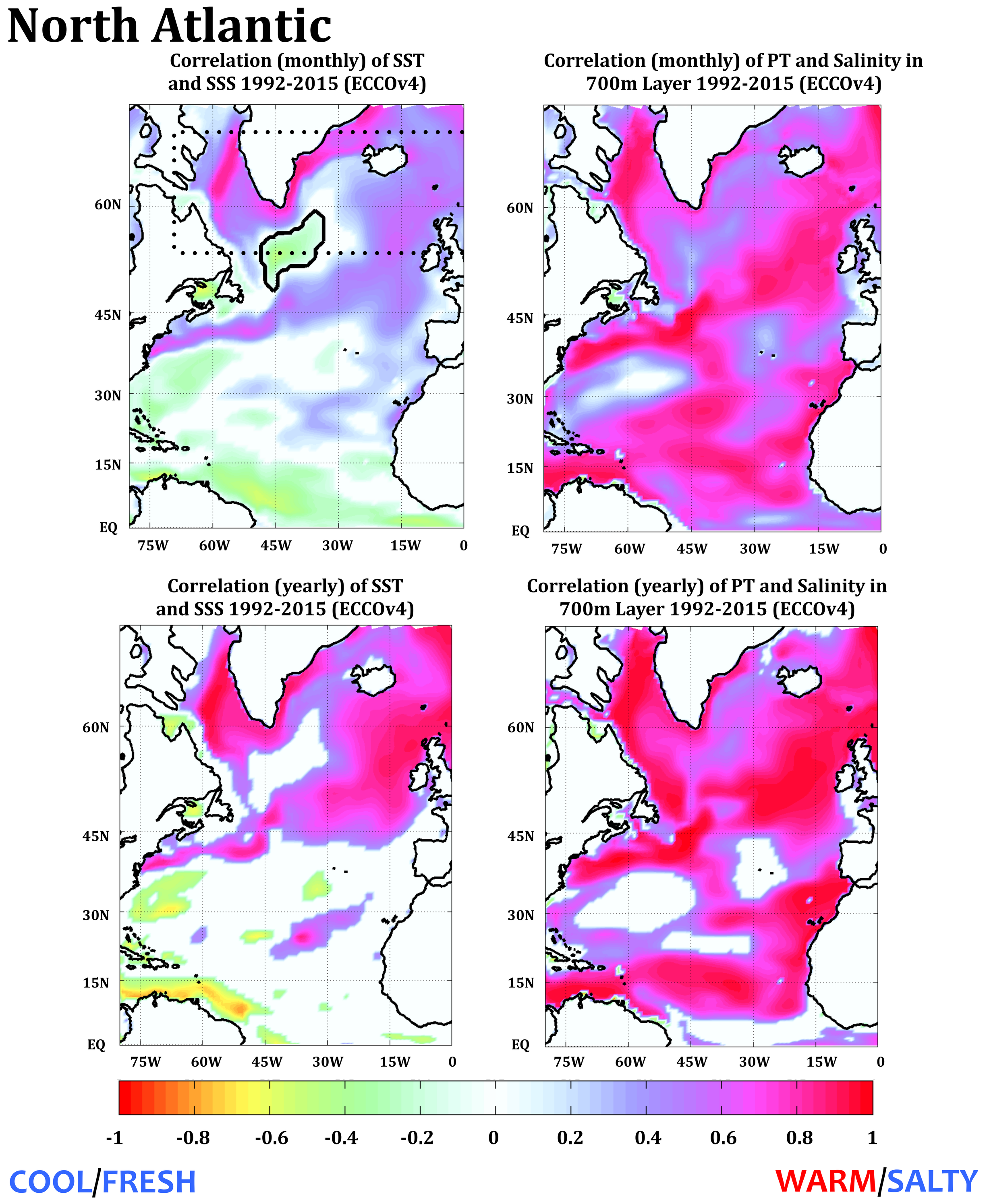

Figure 1: Point wise correlations between sea surface (left) and ~700m layer (right) potential temperature and salinity for monthly (upper panel) and annual mean (lower panel) data from ECCOv4. The dotted box illustrates the mask used in Figure (2) to compute the coherence plots. The black contour shows an area of negative correlation that is of interest.

Ocean State Estimate

Estimating the Circulation and Climate of the Ocean (ECCOv4), uses release 3 (1992-2015)

- MITgcm least squares fit to observations using adjoint (4D-Var)
- Fit achieved by adjusting initial conditions, forcing, and model parameters.
- First guess atmospheric forcing provided by ERA-Interim
- Ocean data include: Argo, CTDs, XBTs, mooring arrays, satellite SST, satellite altimetry
- Nominal 1° resolution with equatorial refinement, 50 vertical levels. (Forget et al, 2015)

Origin of correlations in the North Atlantic basin

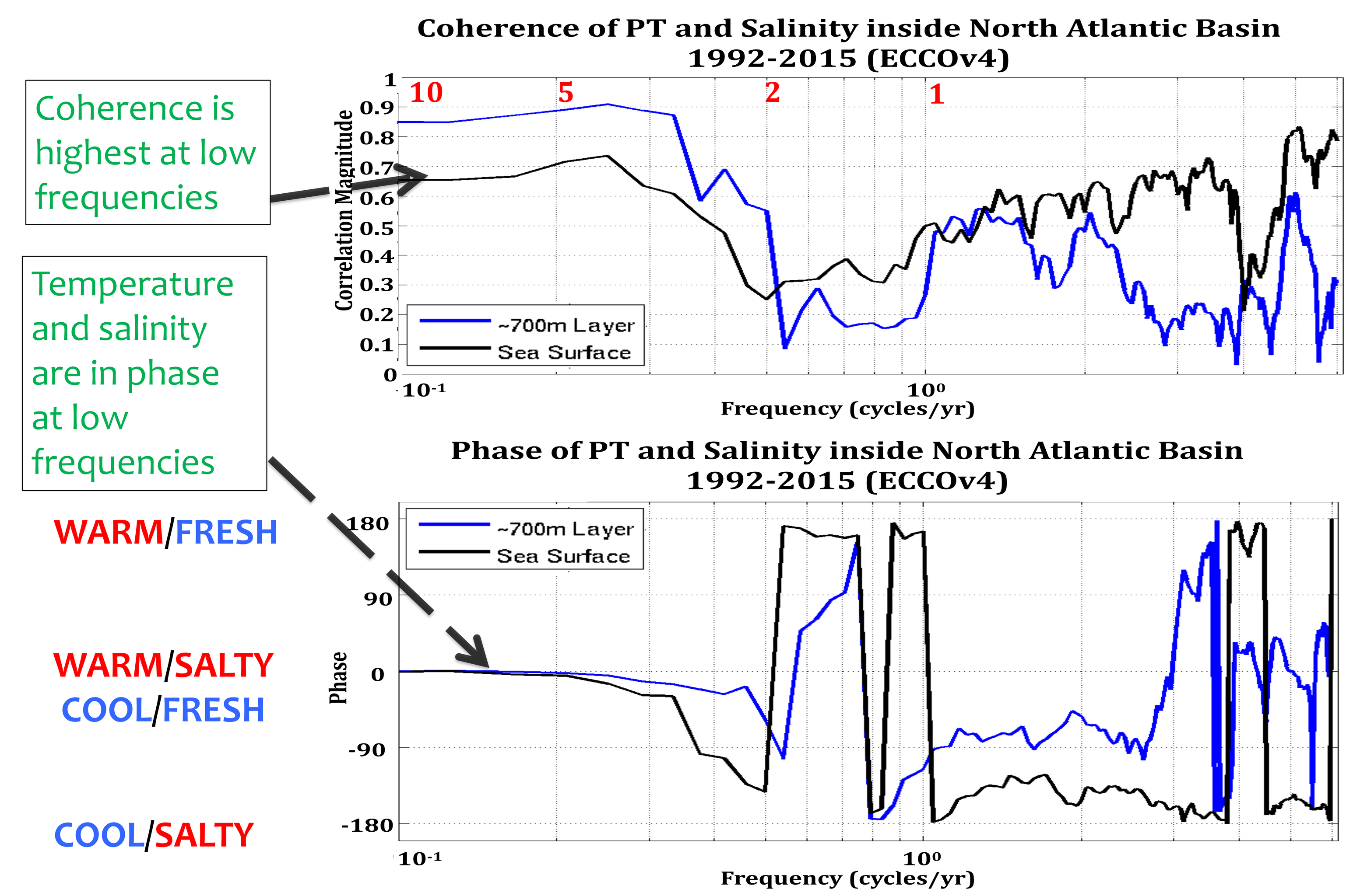

Figure 2: Coherence plots (upper) of normalized, deseasonalized potential temperature and salinity for the sea surface and ~700m layer regionally averaged over the subpolar North Atlantic. Mask is shown in Figure (1). Phase plots (lower) associated with the coherence plots above.

Origin of the negative correlation between SST and SSS

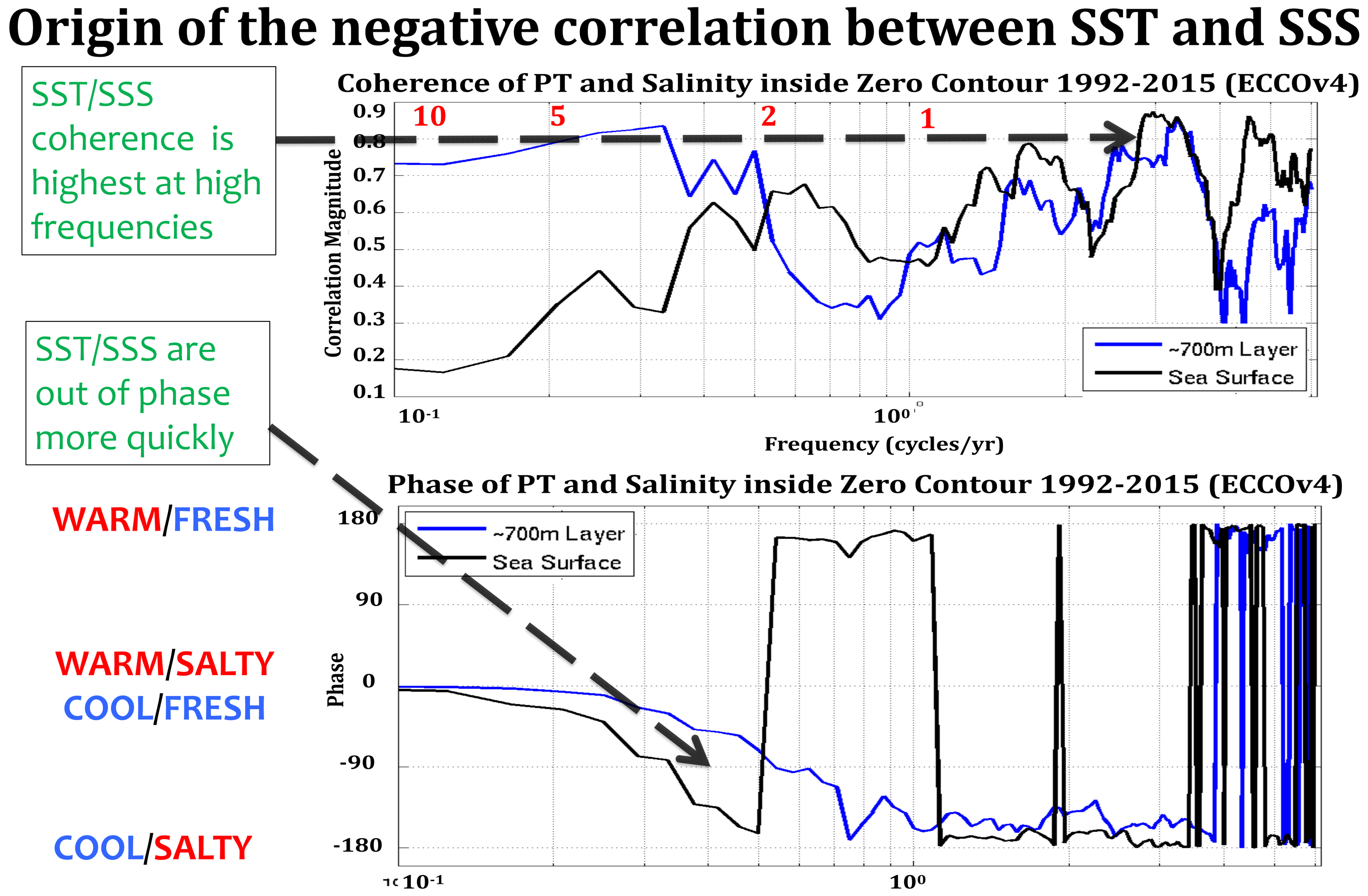

Figure 3: Coherence plots (upper) of normalized, deseasonalized potential temperature and salinity for the sea surface and ~700m layer averaged over the black contour shown in Figure (1). Phase plots (lower) associated with the coherence plots above.

Is the NAO causing the negative correlation between SST and SSS?

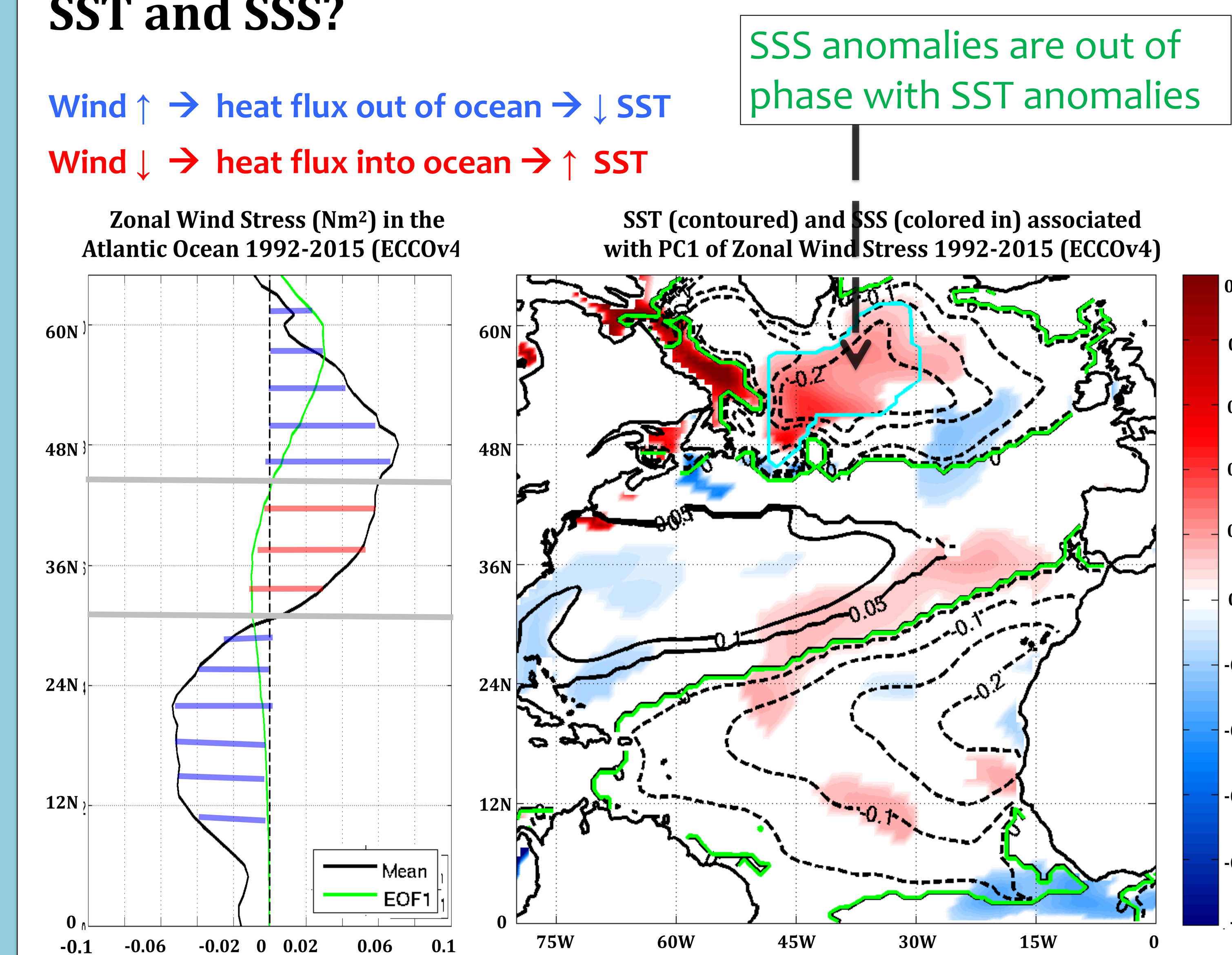

Figure 4: an EOF analysis was performed on zonal wind. Plot on the left shows the mean zonal wind stress in ECCOv4 and the mean zonal wind stress from EOF1 in the North Atlantic basin. EOF1 explains 40.5% of the variance. The first PC of wind stress was projected onto the SST (contoured) and SSS (colored in) field, pictured on the right.

How do the winds force SSS anomalies?

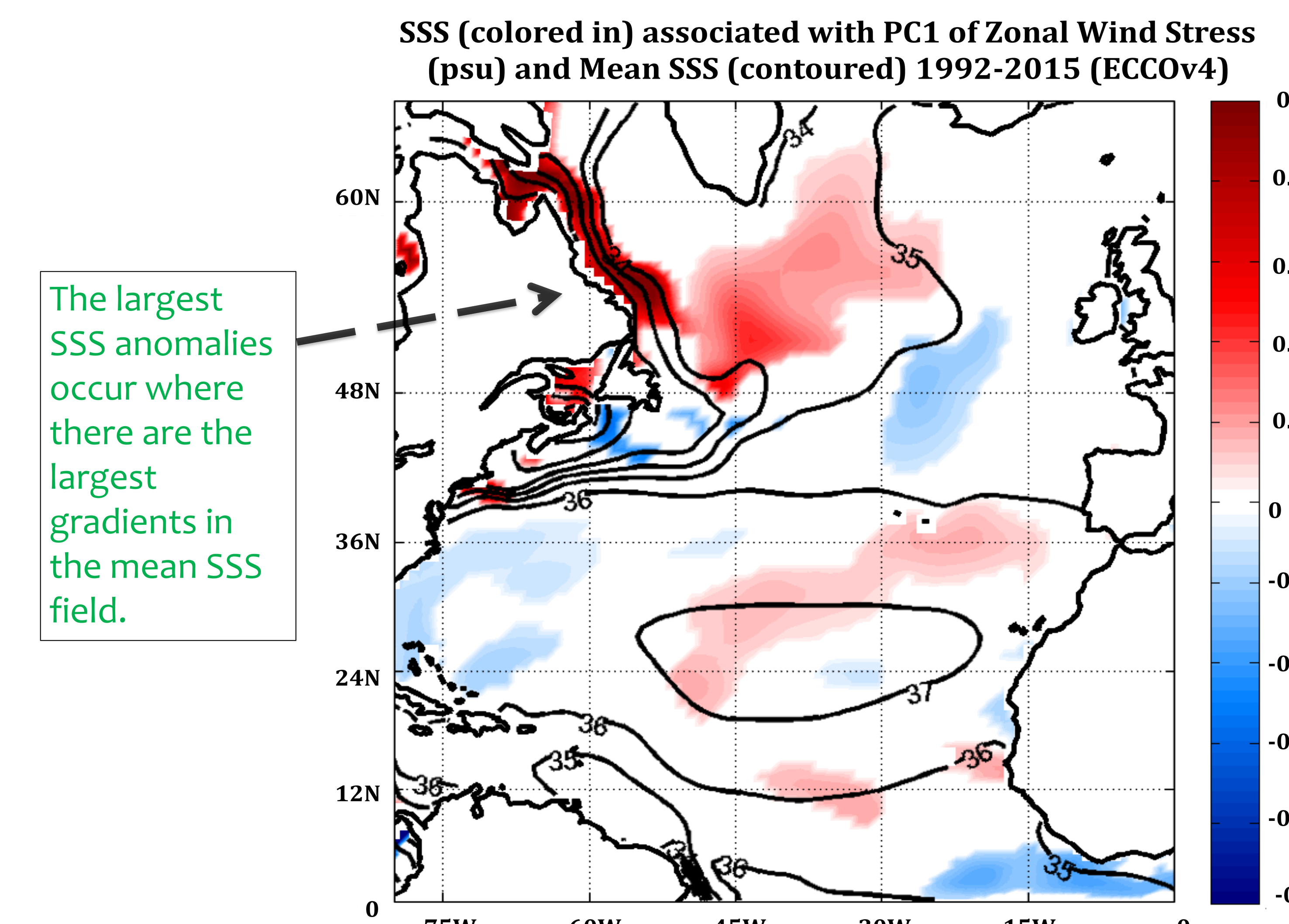

Figure 5: SSS associated with PC1 of zonal wind stress with the mean SSS field contoured over the anomaly to illustrate Ekman transport anomalies.

References

1. Forget, G., J. M. Campin, P. Heimbach, C. N. Hill, R. M. Ponte, and C. Wunsch (2015), ECCO version 4: an integrated framework for non-linear inverse modeling and global ocean state estimation, Geosci. Model Dev. Discuss., 8(5), 3653–3743.
2. Fukumori, I., P. Heimbach, R. M. Ponte, and C. Wunsch (2018), A dynamically consistent, multi-variable ocean climatology, Bulletin of the American Meteorological Society, 0(0), null, doi:10.1175/BAMS-D-17-0213.1, in press.