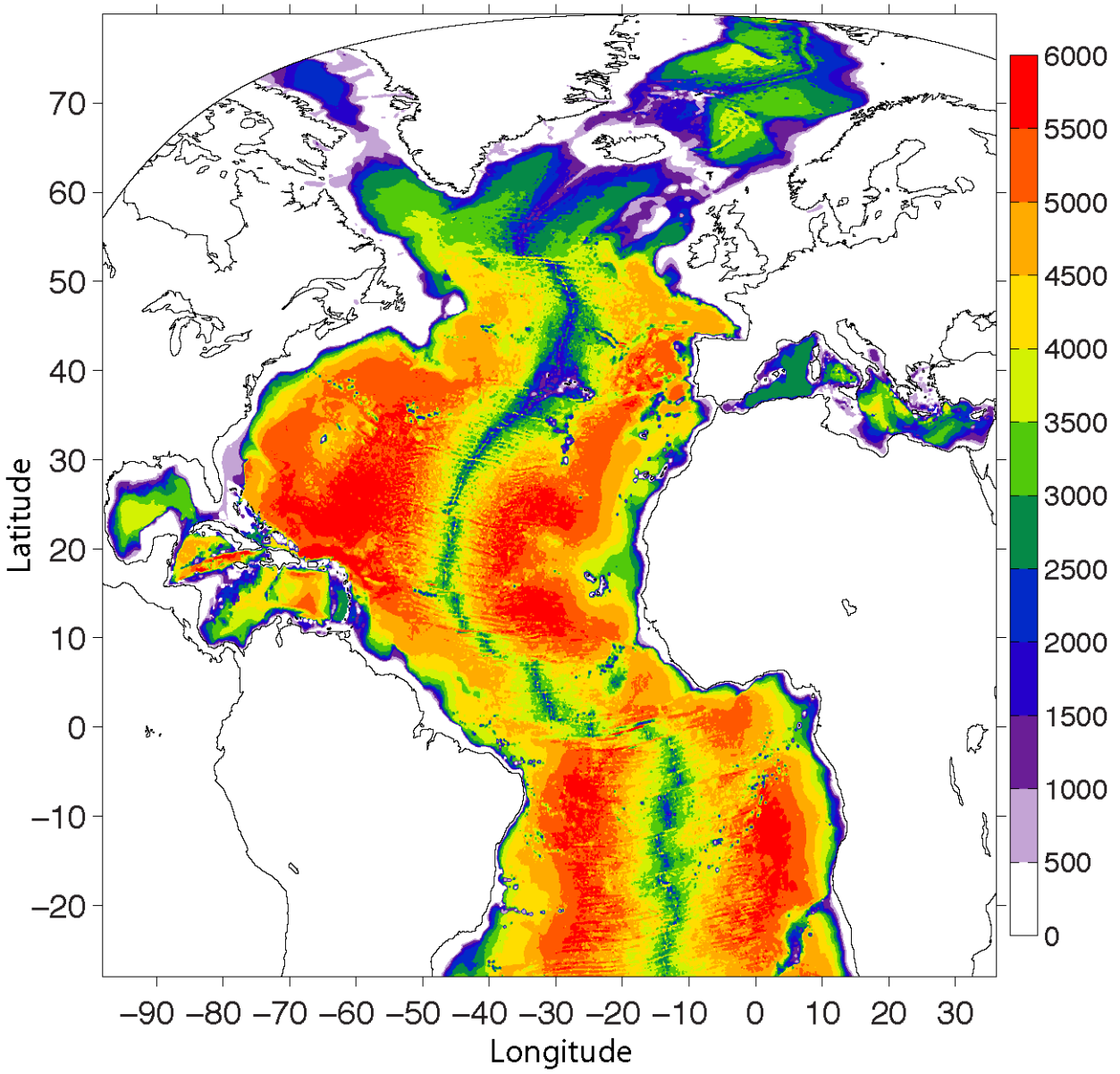
1/50° North Atlantic Modeling with HYCOM

Eric Chassignet and Xiaobiao Xu
Florida State University

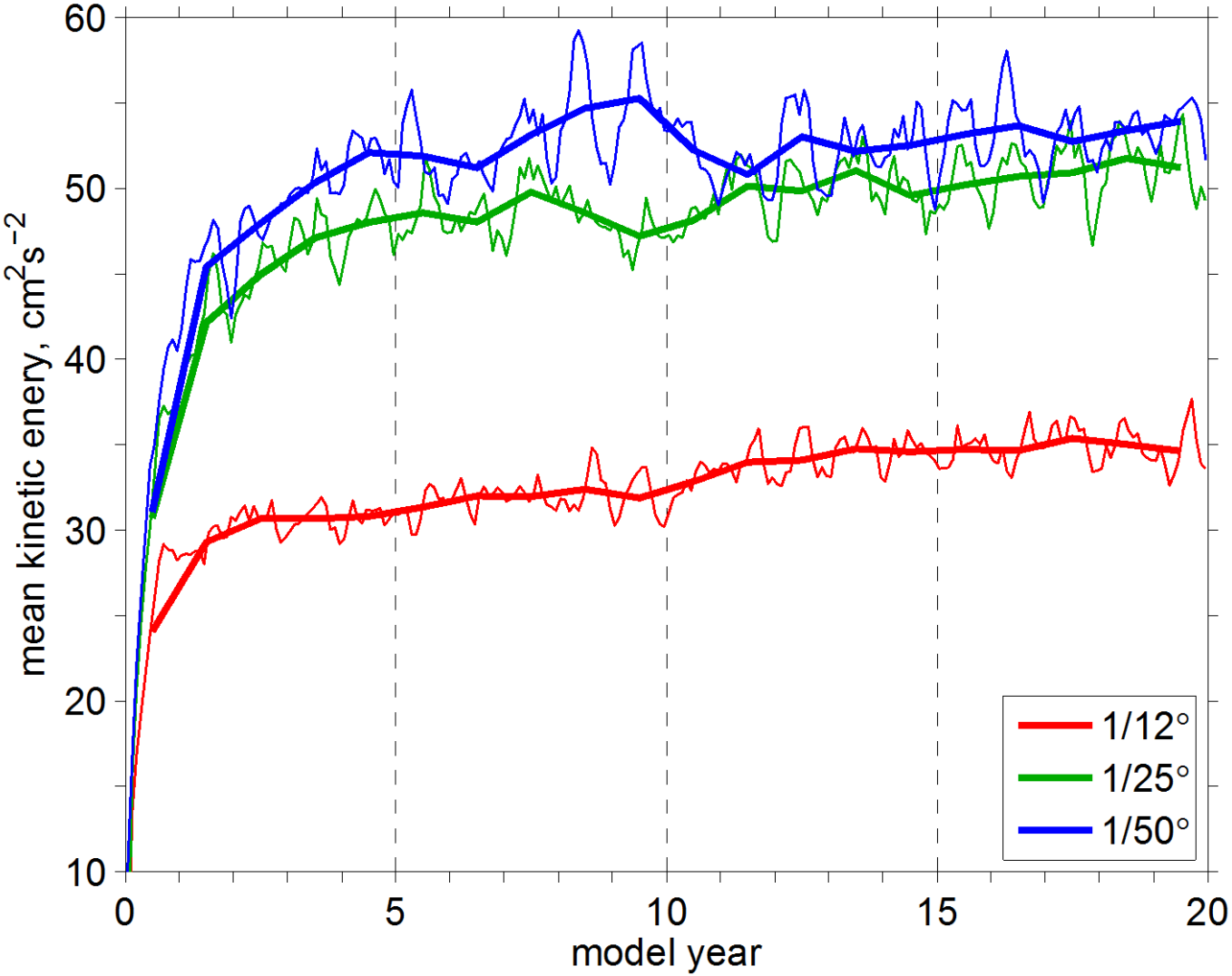
- Identical configuration including topography
- Viscosity as a function of grid spacing (1/12° and 1/25°)
- Same viscosity for 1/25° and 1/50°



Horizontal resolution

- Do we have convergence?
- When do we stop?
- When is the solution “good enough”?

MKE Atlantic simulation spinup



Domain averaged kinetic energy of monthly mean flow (thin) and 12-month averages (thick)

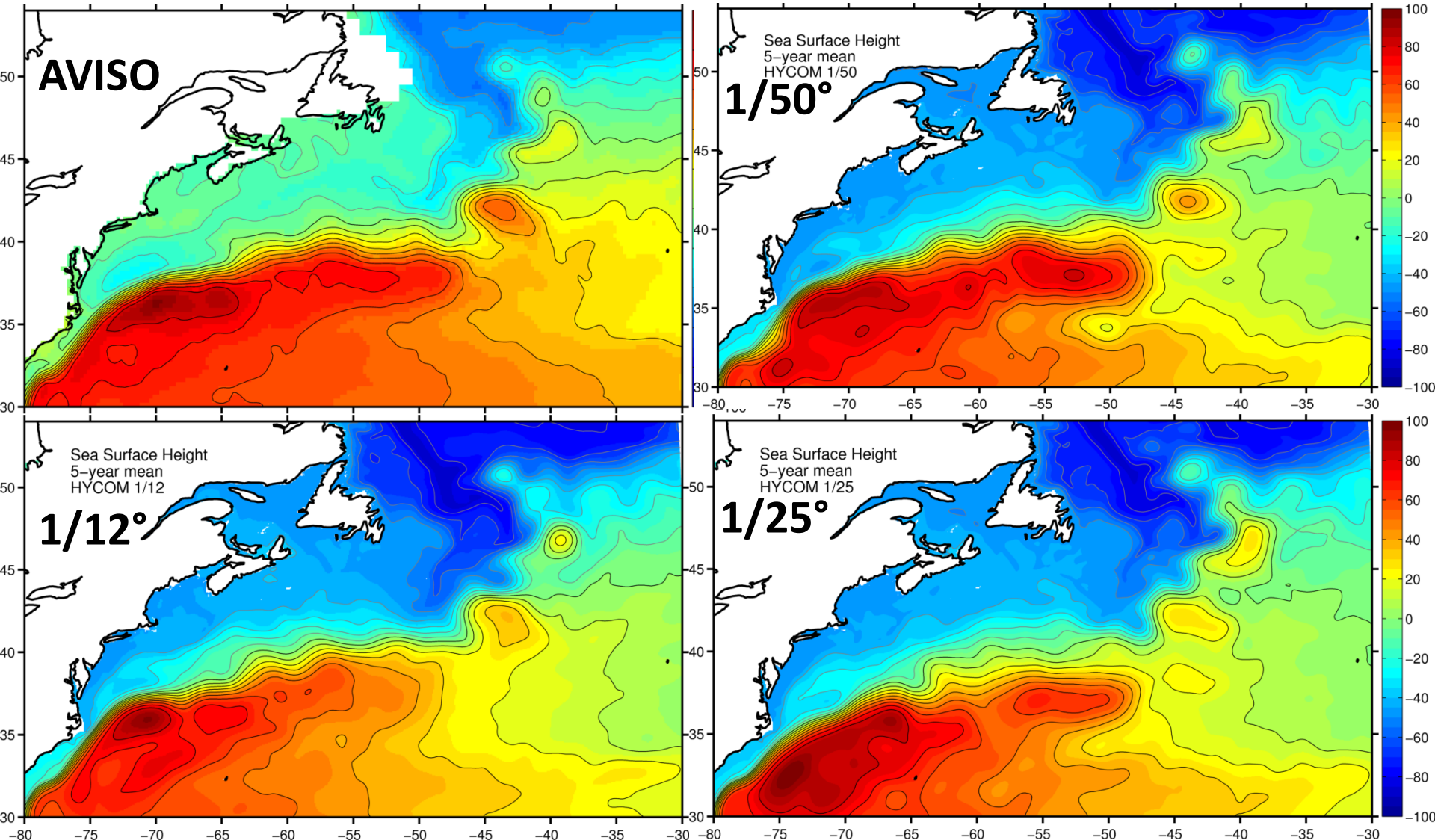
Movies

Vorticity

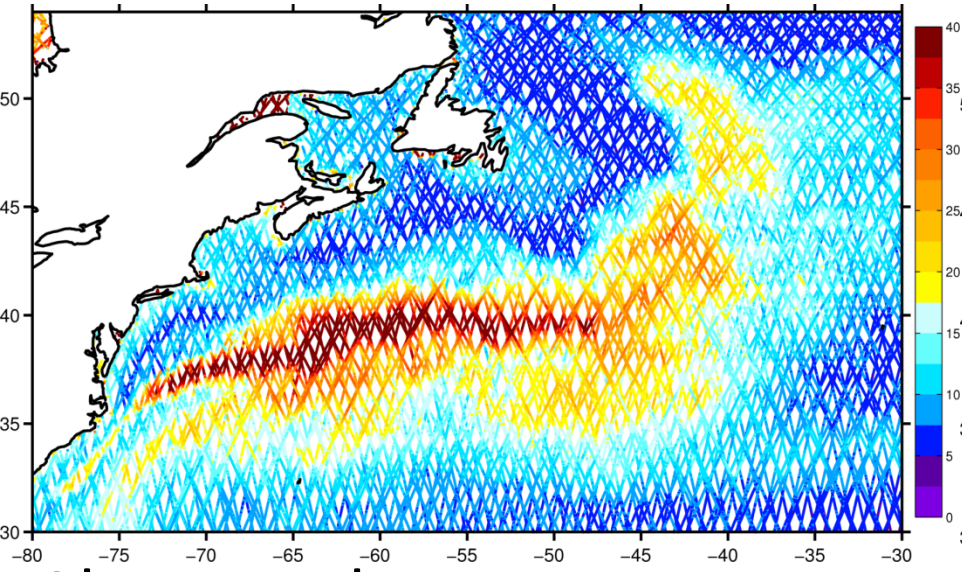
SSH

SST

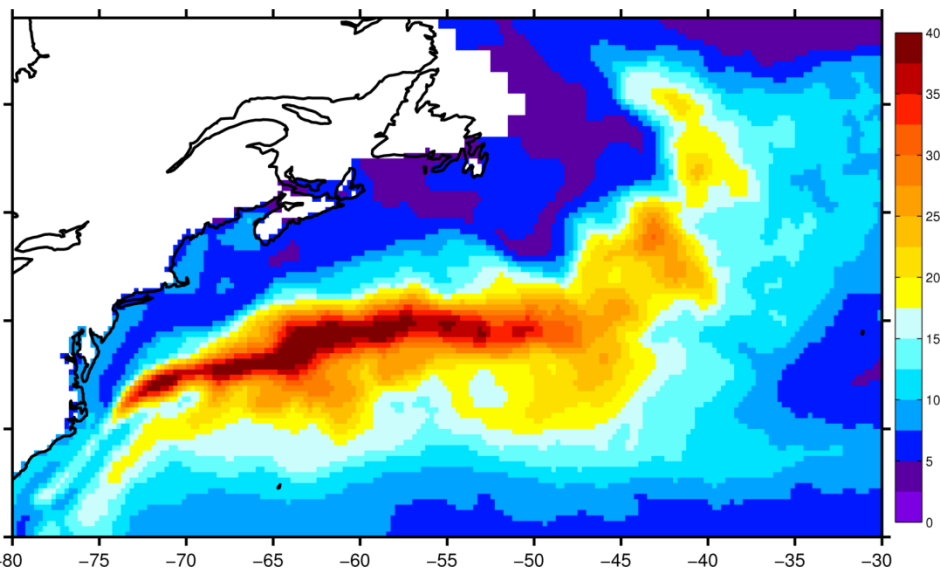
Mean SSH (Years 16-20)



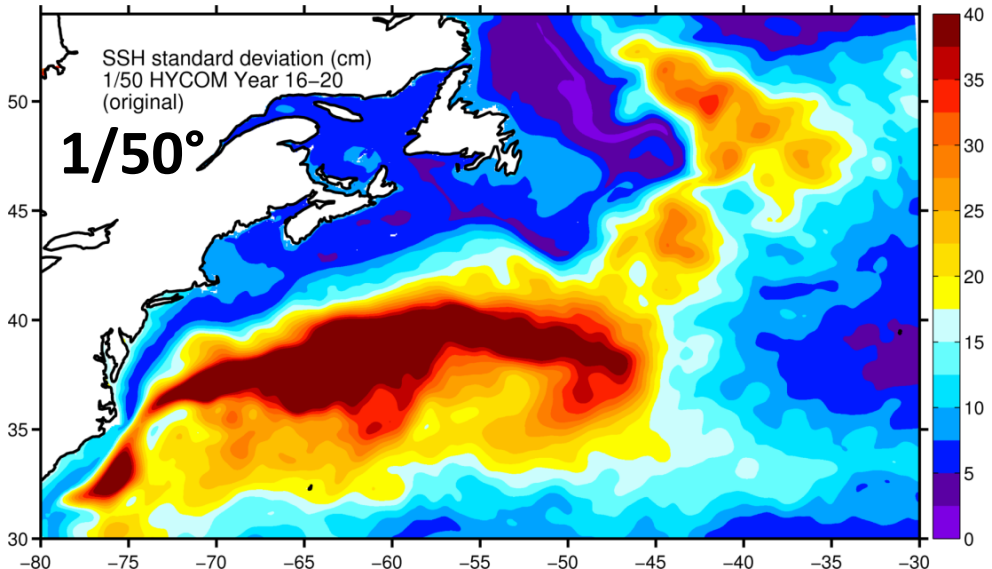
SSH variability (RMS)



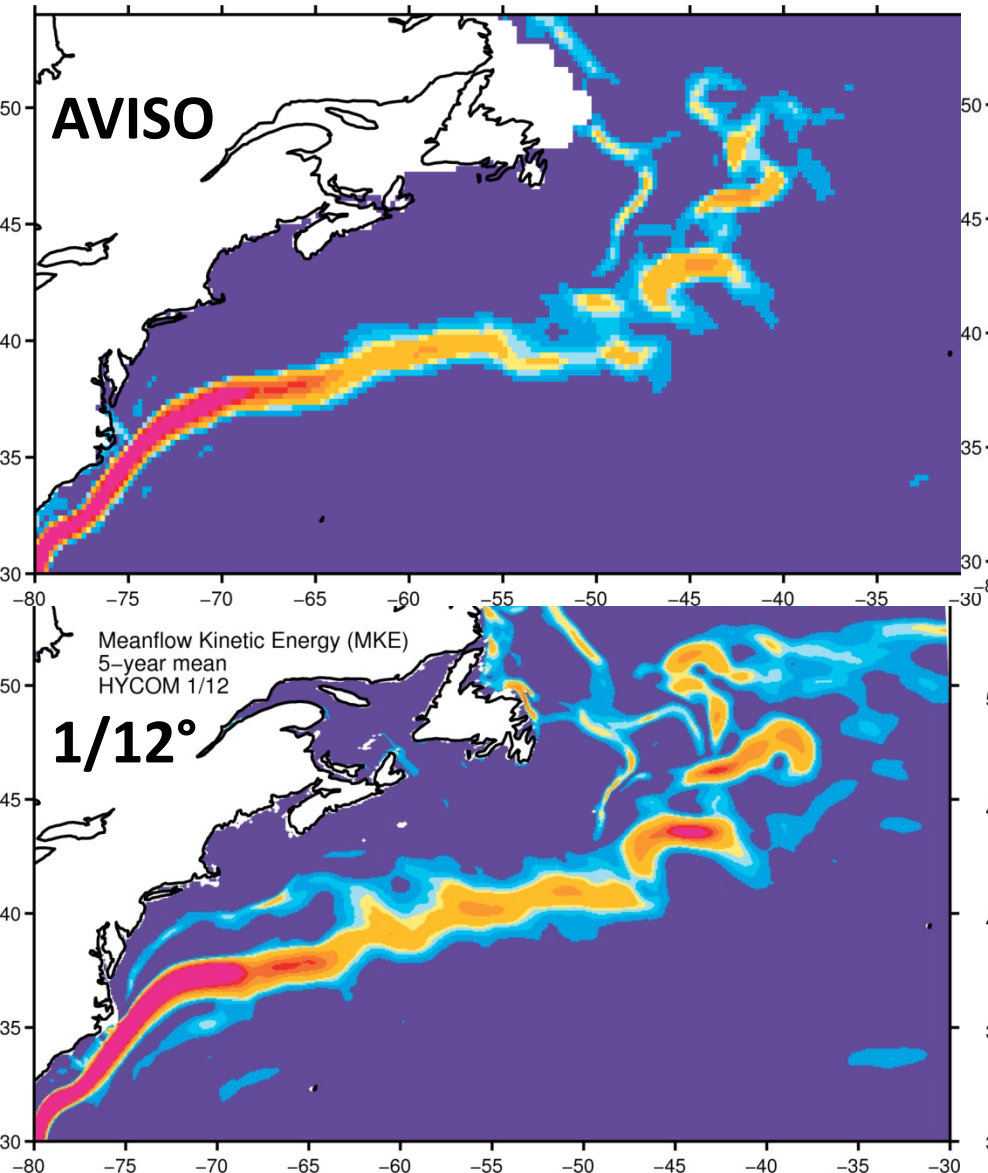
Along-track (Courtesy G. Jacobs, NRL)

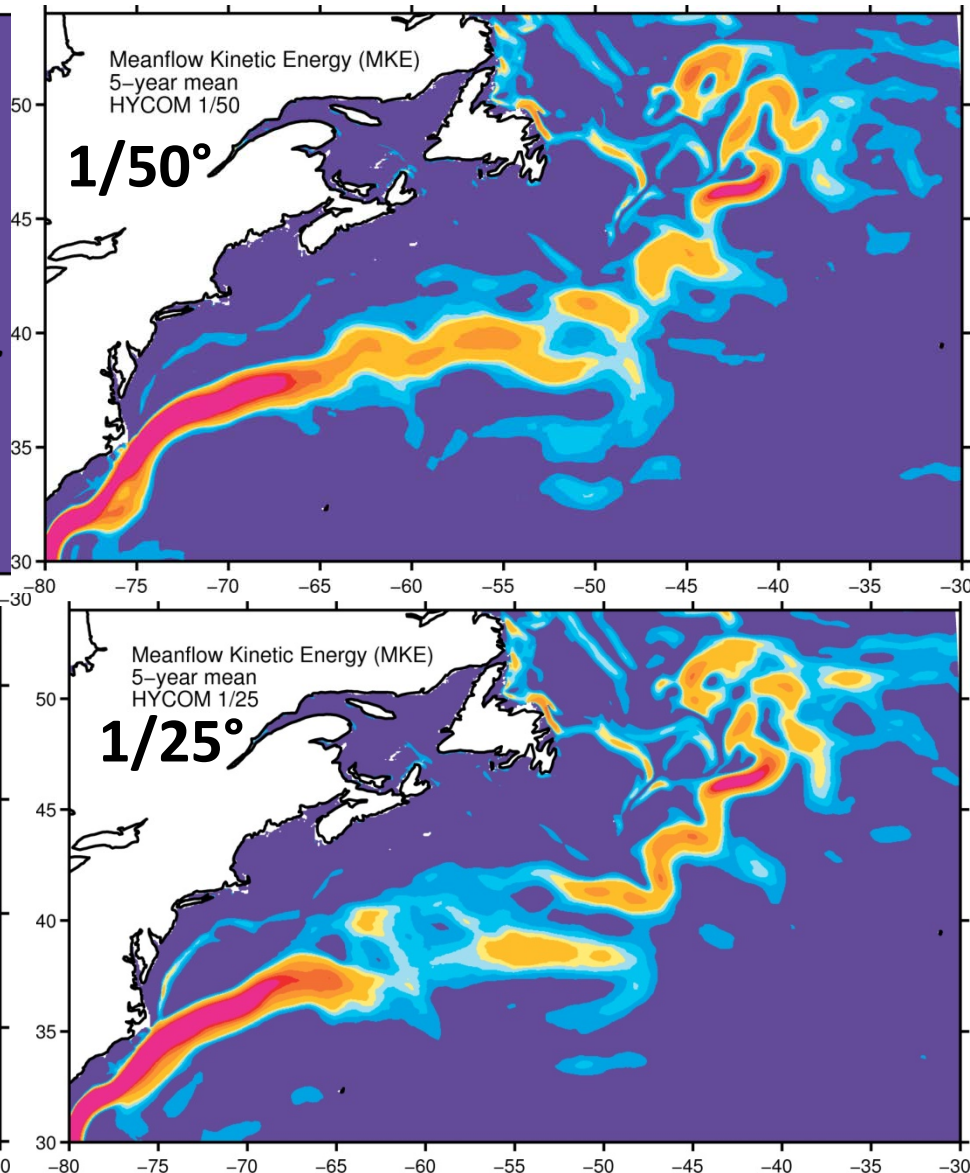


AVISO (¼° resolution)

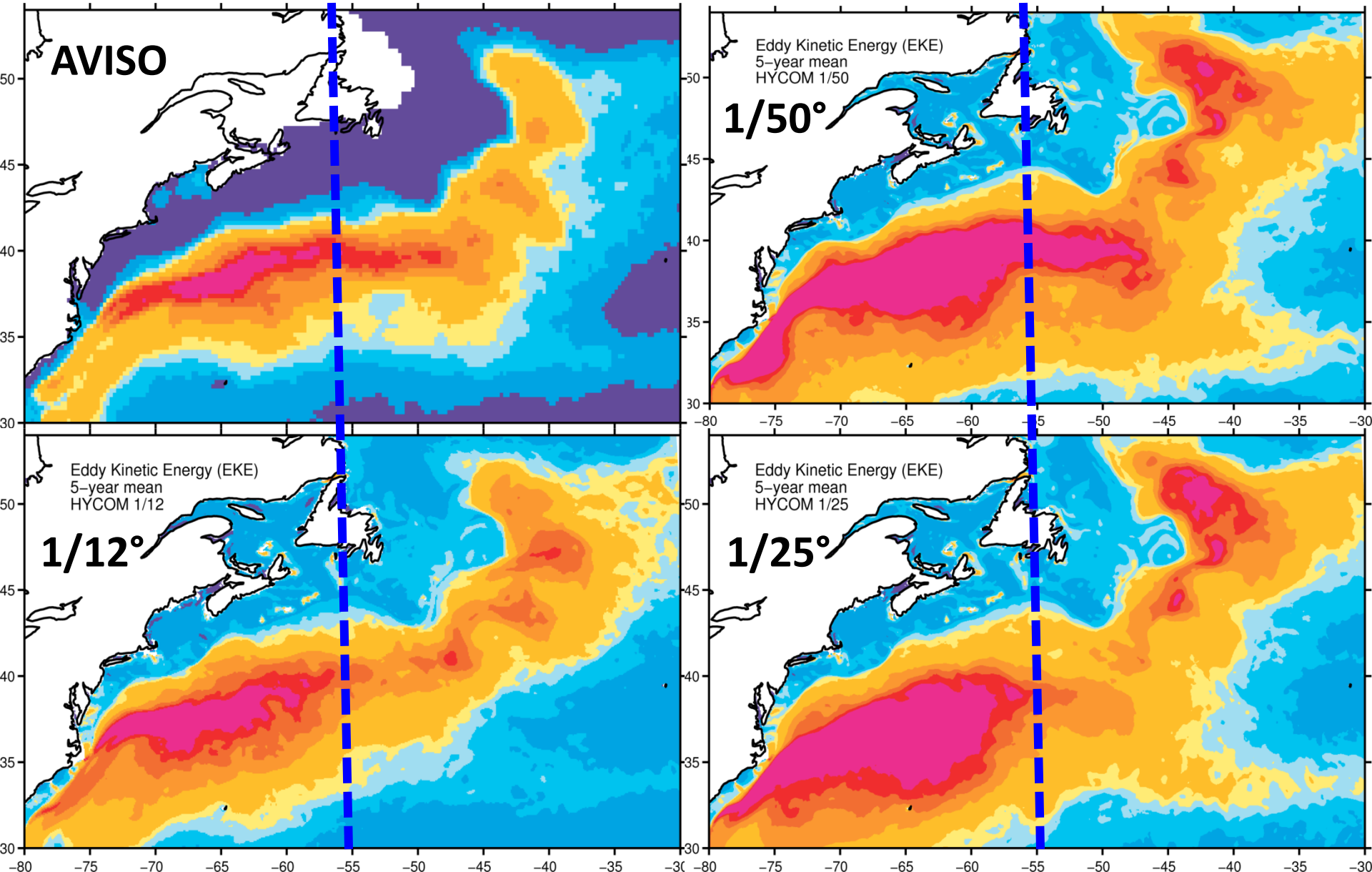


Mean Kinetic Energy (Years 16-20)



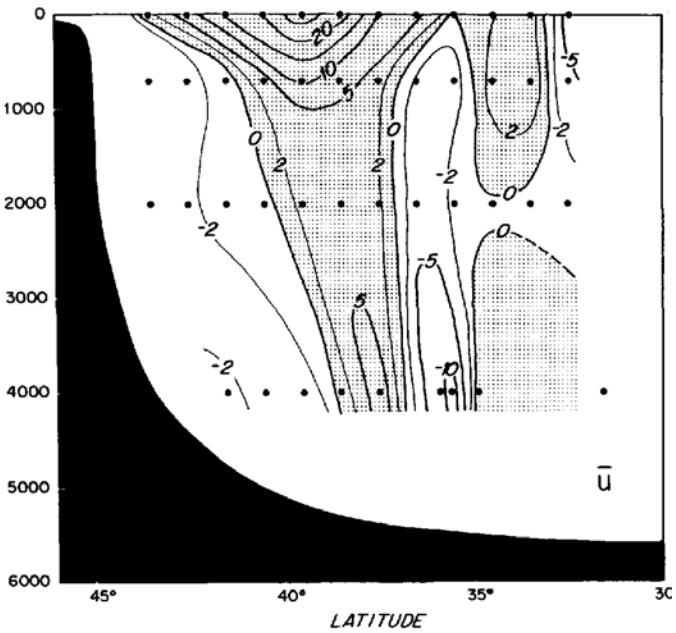


Mean Eddy Kinetic Energy (Years 16-20)

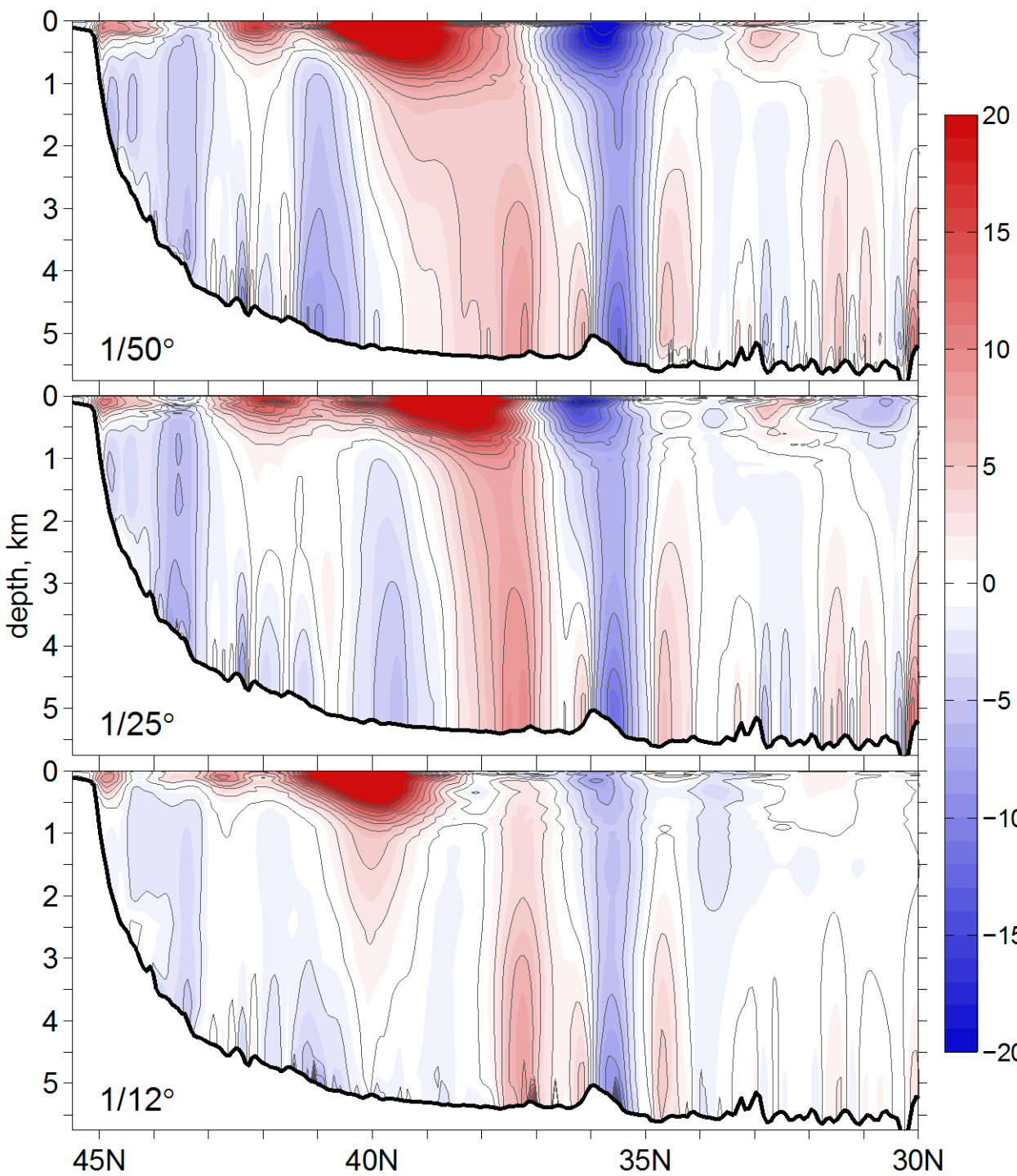


Mean zonal velocity at 55°W

(Richardson, 1985)

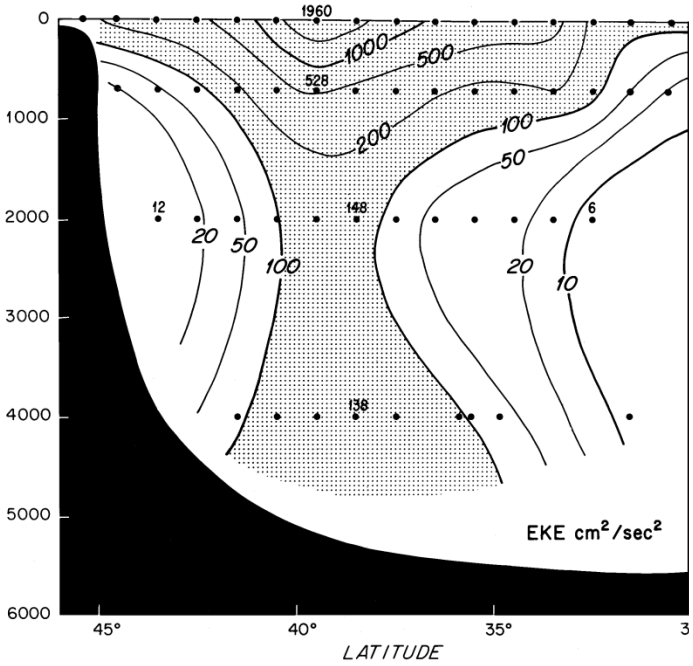


Years 16-20

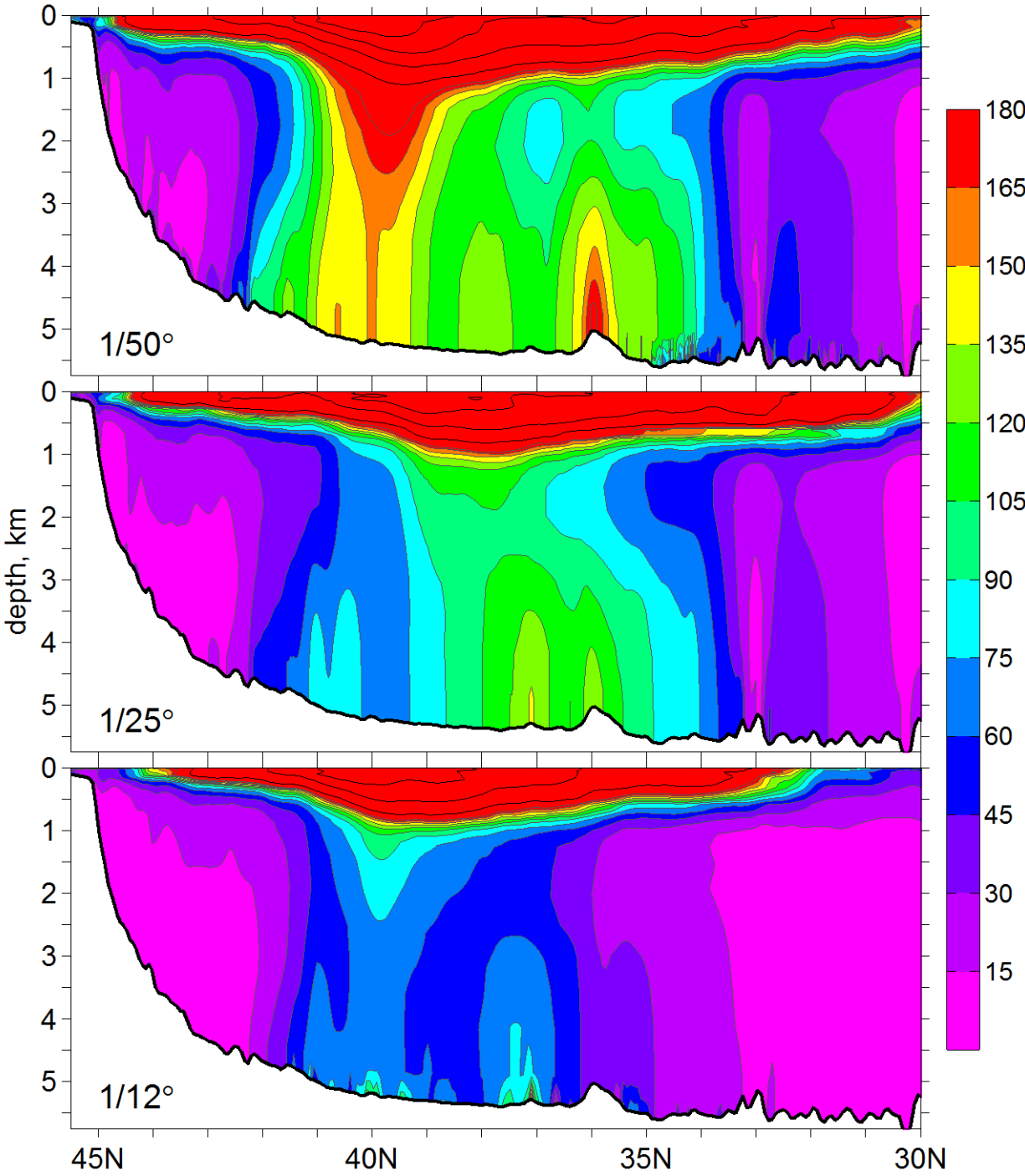


Mean Eddy Kinetic Energy at 55°W

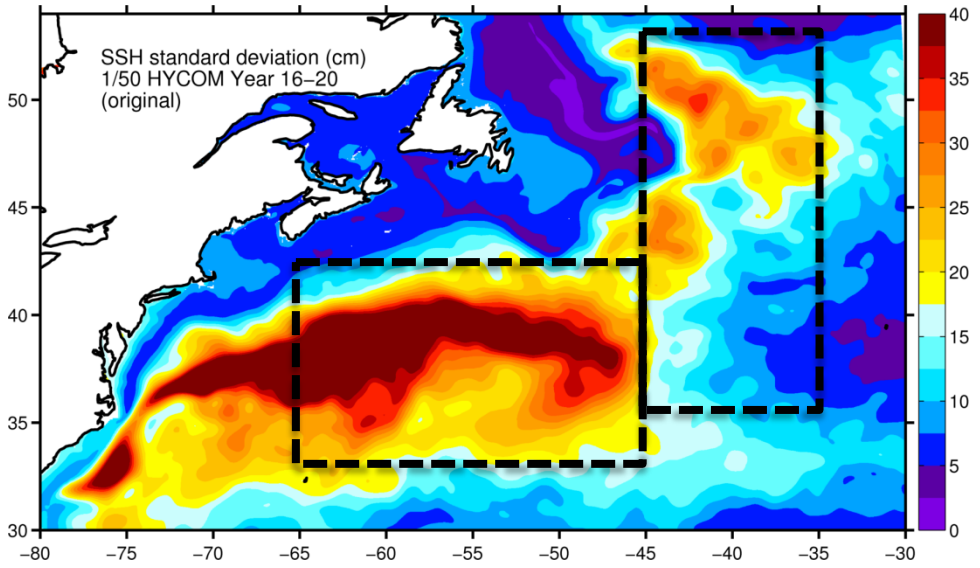
(Richardson, 1985)

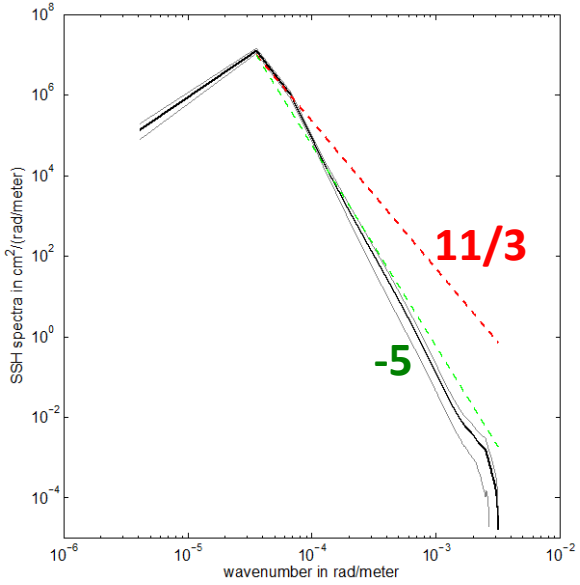


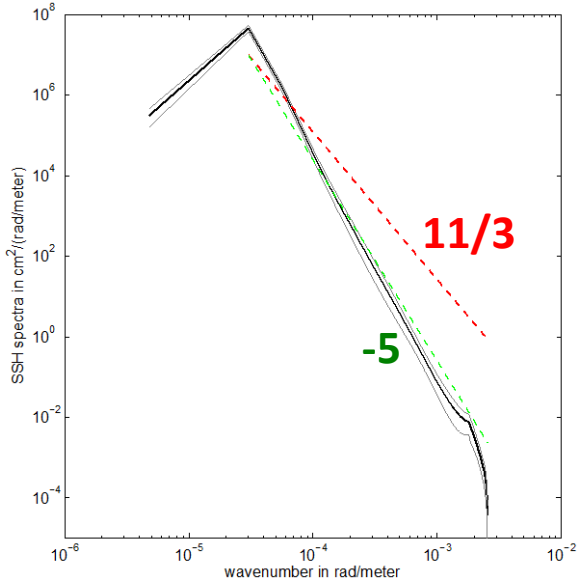
Years 16-20



SSH wave number spectra





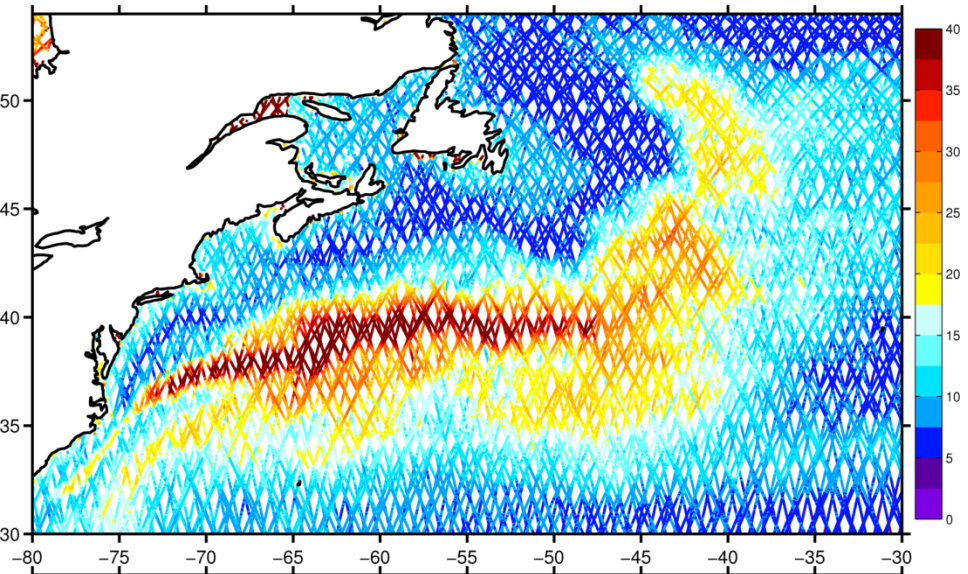


Both the Gulf Stream and North Atlantic Current regions both have a SSH spectra slope of -5, which is consistent with quasigeostrophic (QG) turbulence theory. (-11/3, is surface quasigeostrophic).

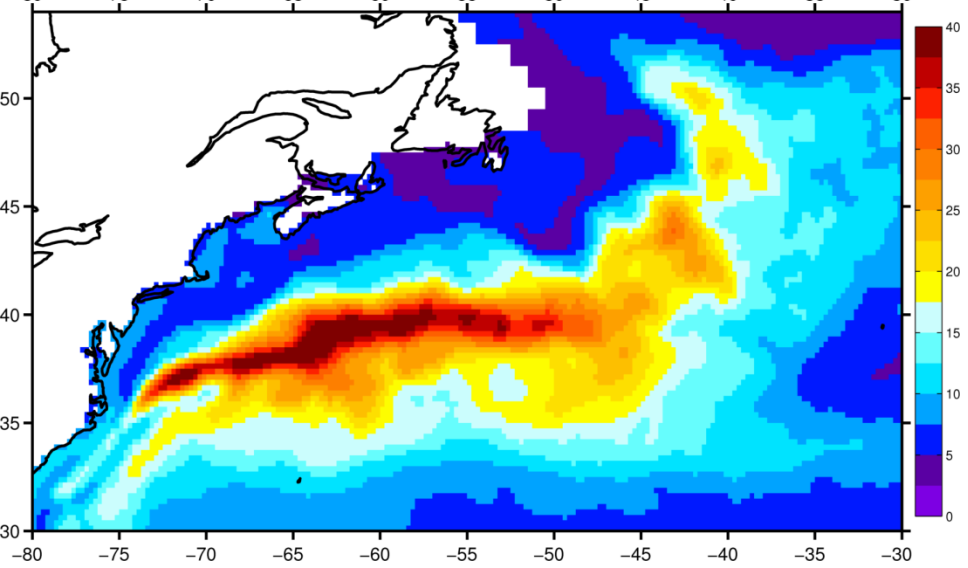
SSH spectra based on altimetry data typically have a slope of about -4 in the western boundary region. Wang et al. (2010-JPO) based on Oleander ADCP data, found -5 for SSH spectran the Gulf Stream near 65W.

How representative is altimetry of SSH variability and EKE?

Observed SSH variability

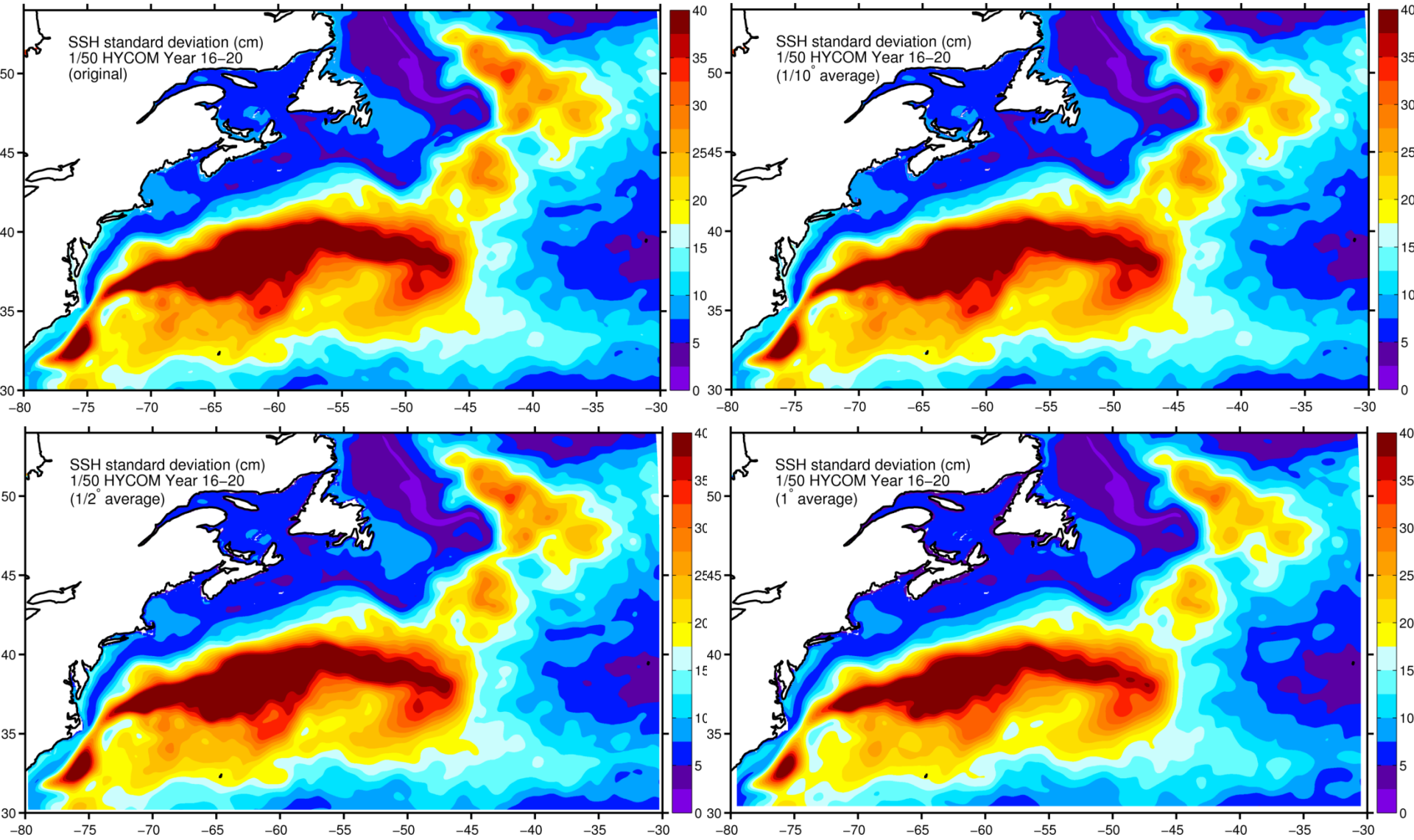


Along-track
(Courtesy G. Jacobs, NRL)

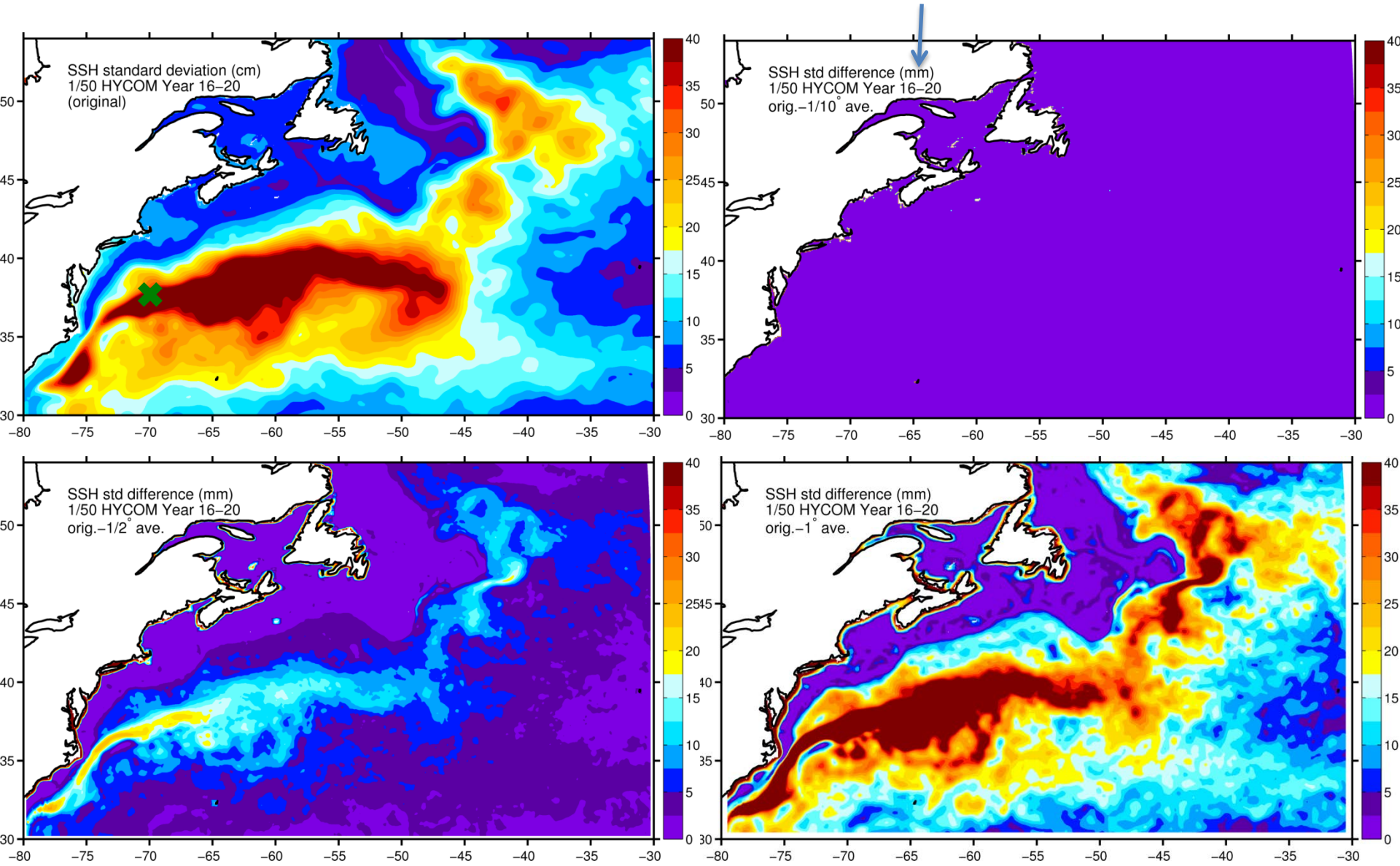


AVISO (¼° resolution)

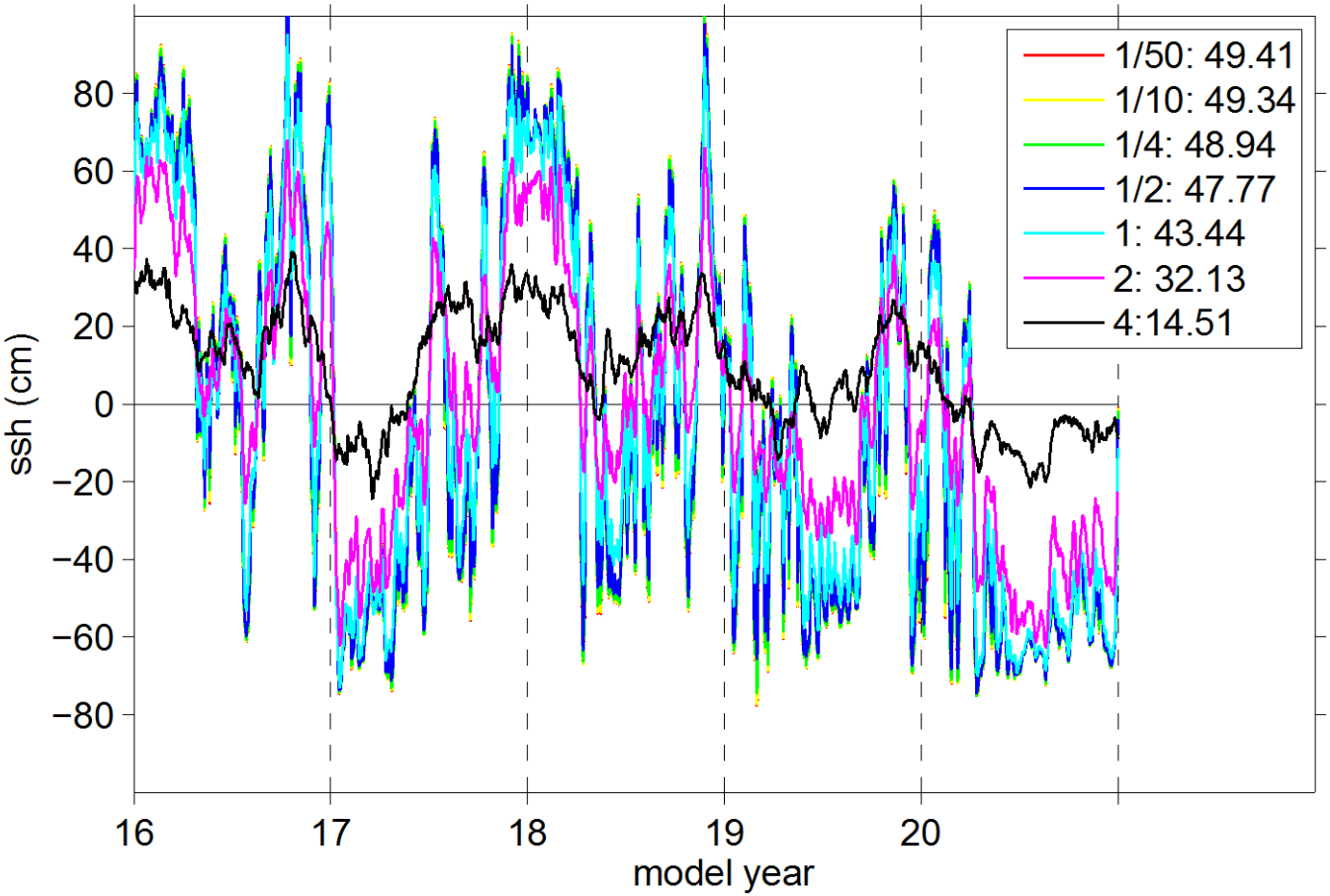
Impact of averaging on SSH rms



Impact of averaging on SSH rms

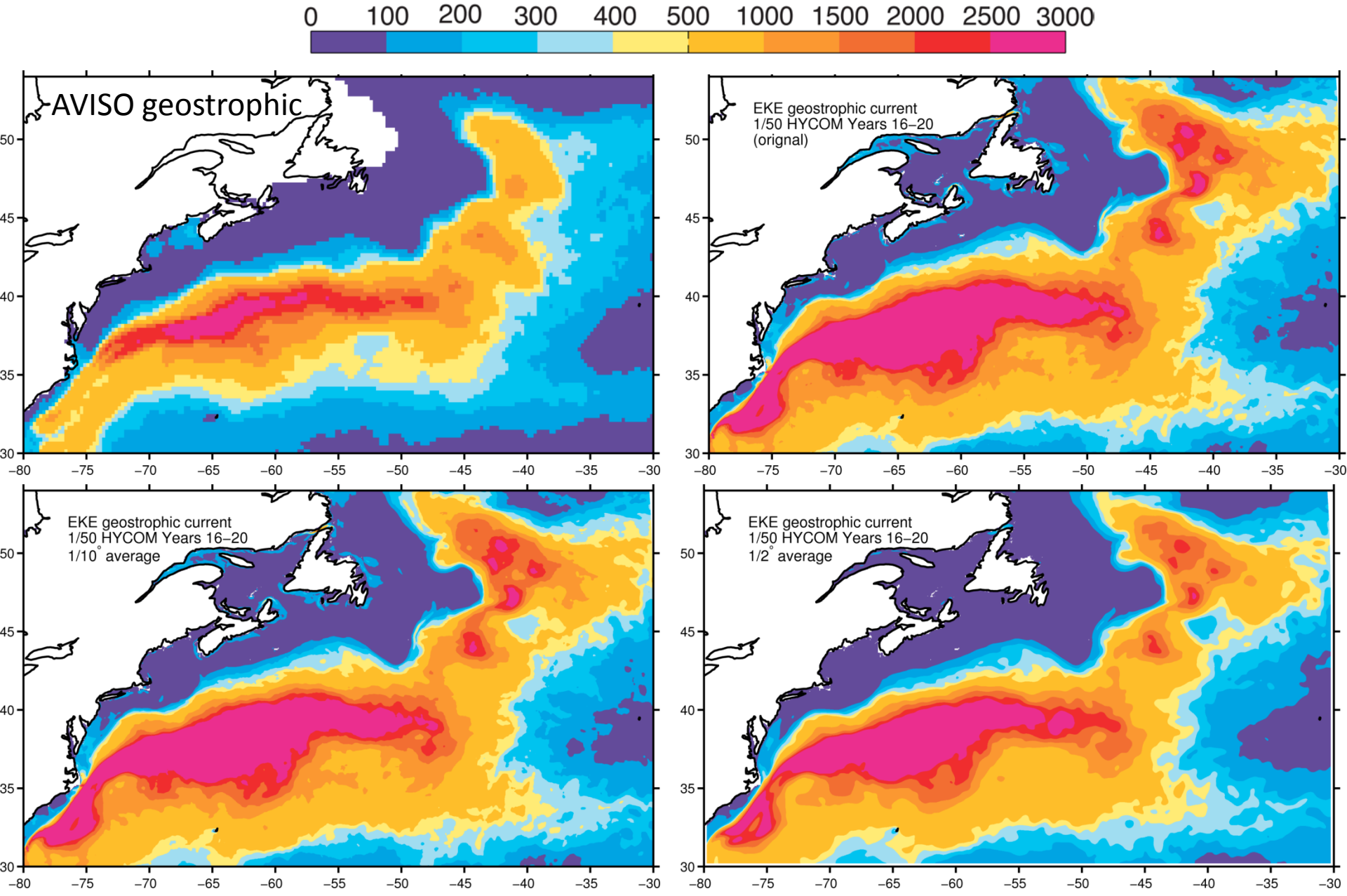


Impact of averaging on SSH rms



Variation of SSH at one point (70W,37.5N) with spatial averaging scale up to 4x4 degree, the decrease of the standard deviation (in cm) becomes notable after about 1 averaging.

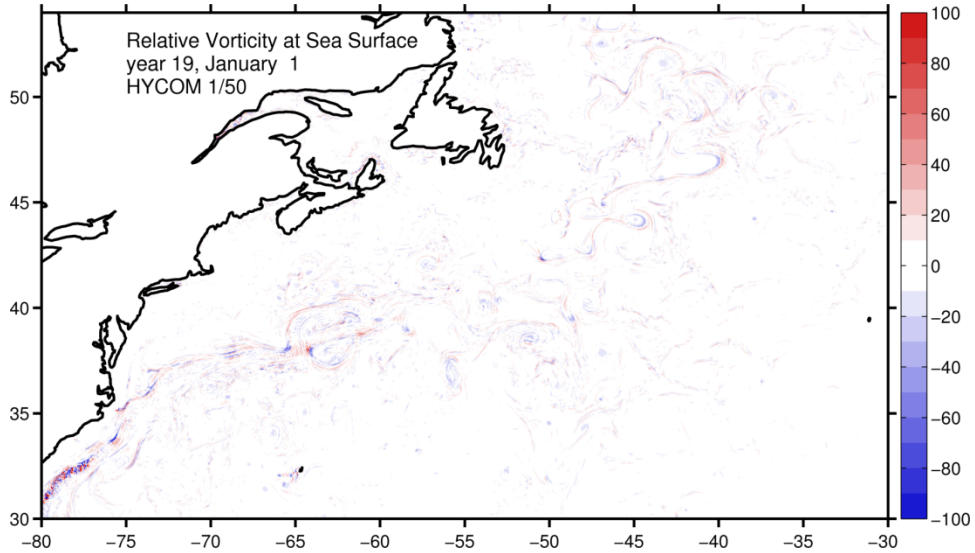
Impact of averaging on EKE



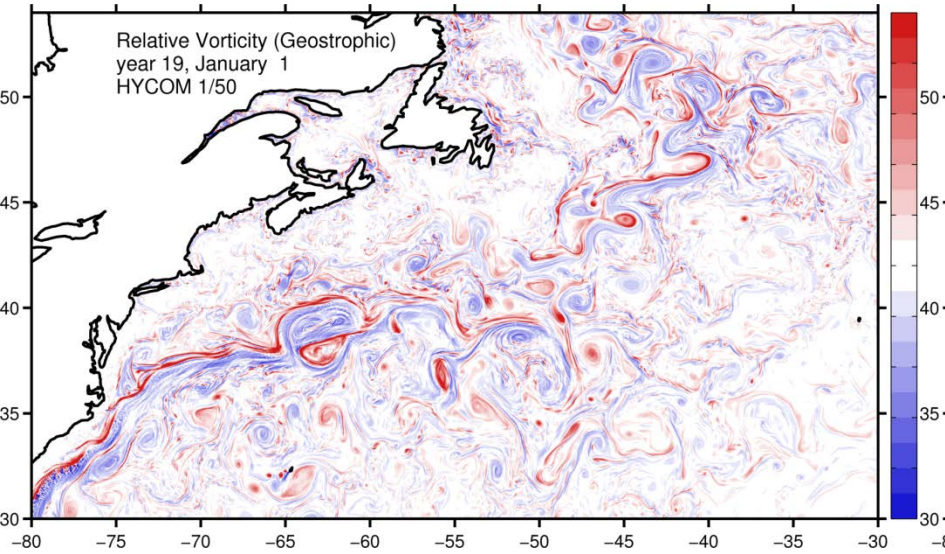
Does not take into account tracks' spacing and OI impact – see R. Morrow's talk – could be significant.

How important is ageostrophy when computing EKE?

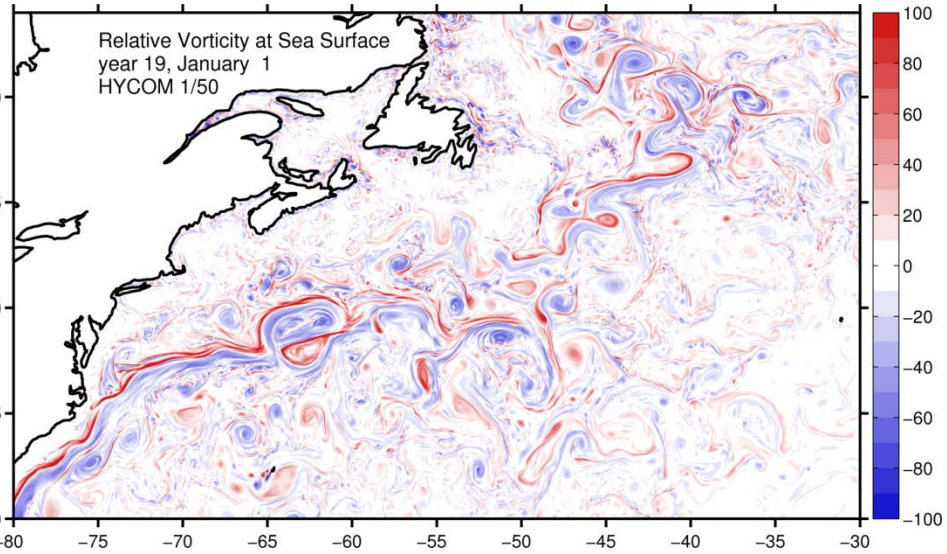
Vorticity snapshot (total minus geostrophic)



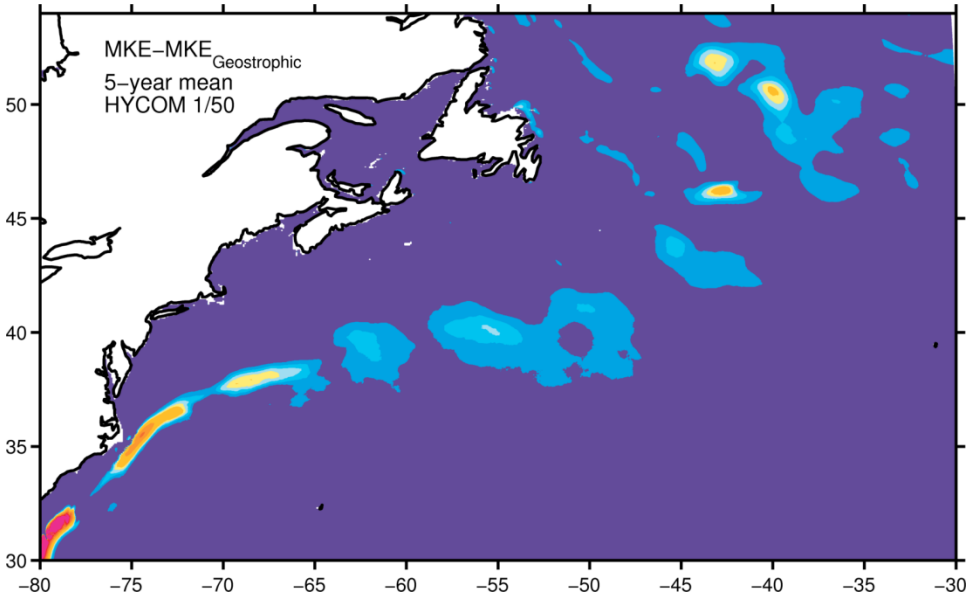
Geostrophic surface vorticity



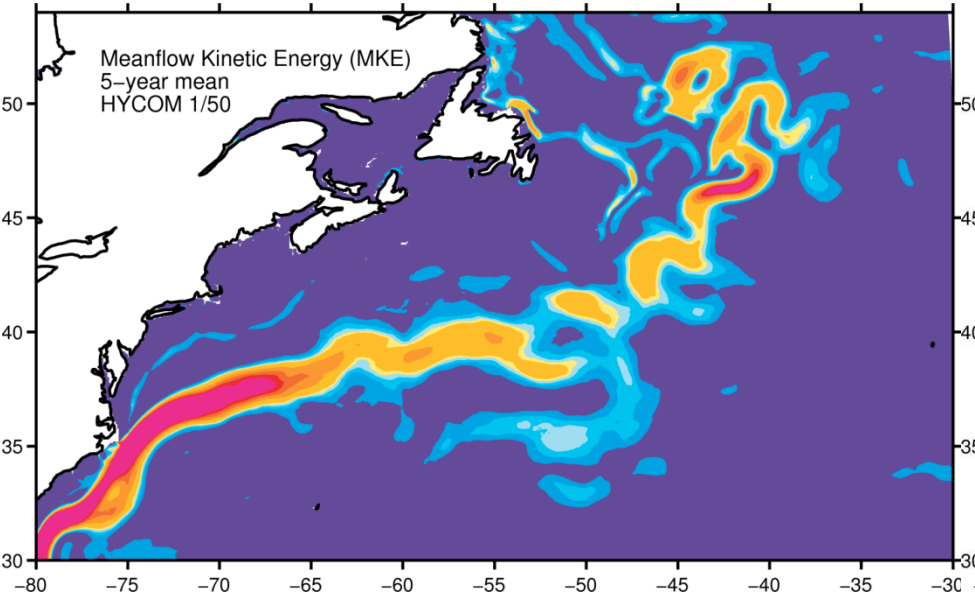
Total surface vorticity



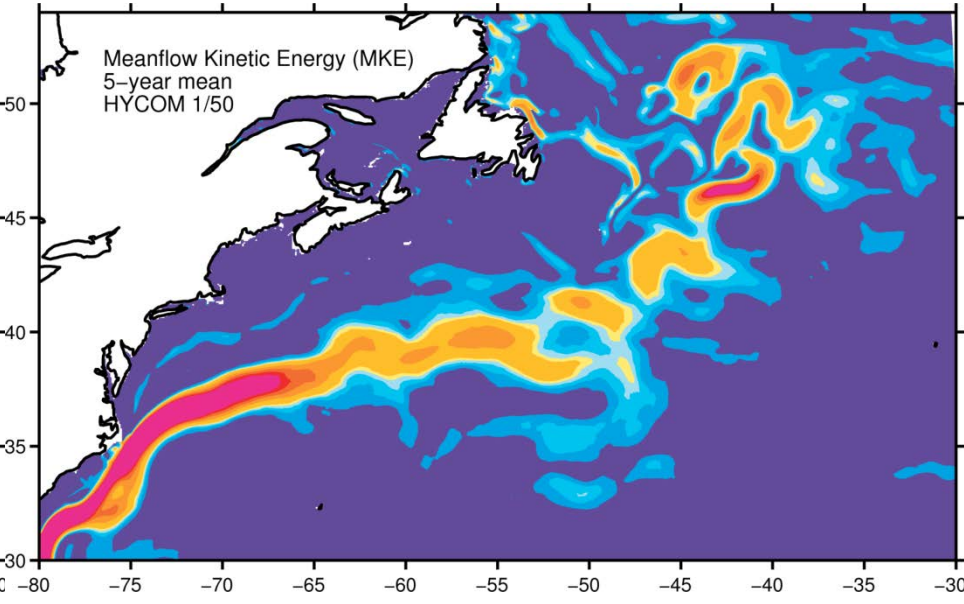
Mean Kinetic Energy (total minus geostrophic) Years 16-20)



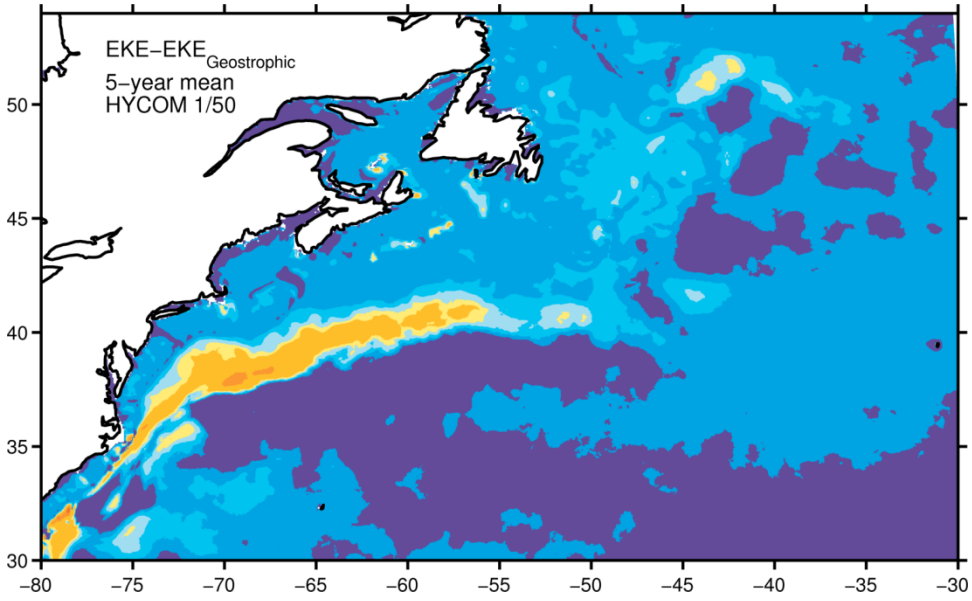
Geostrophic surface MKE



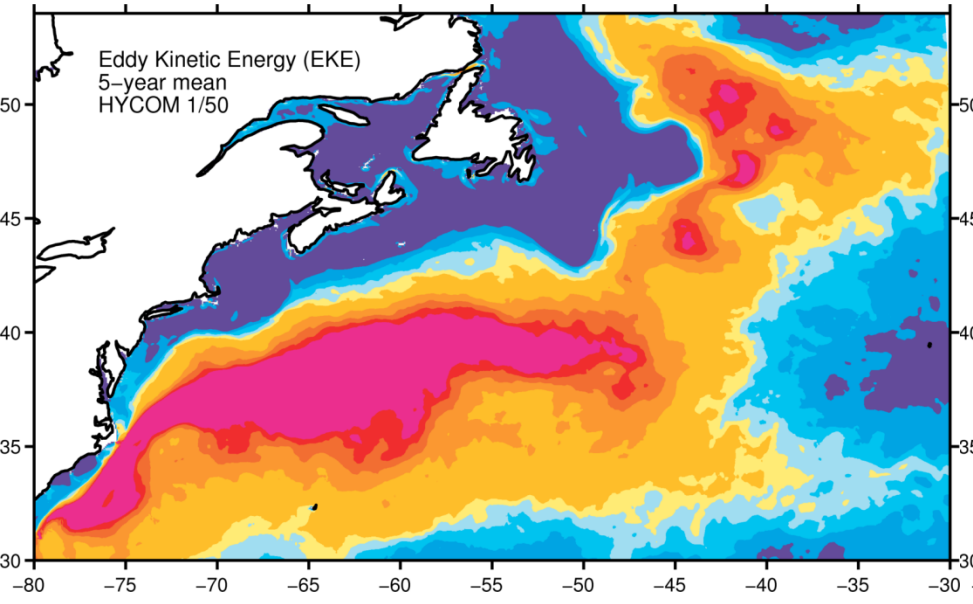
Total surface MKE



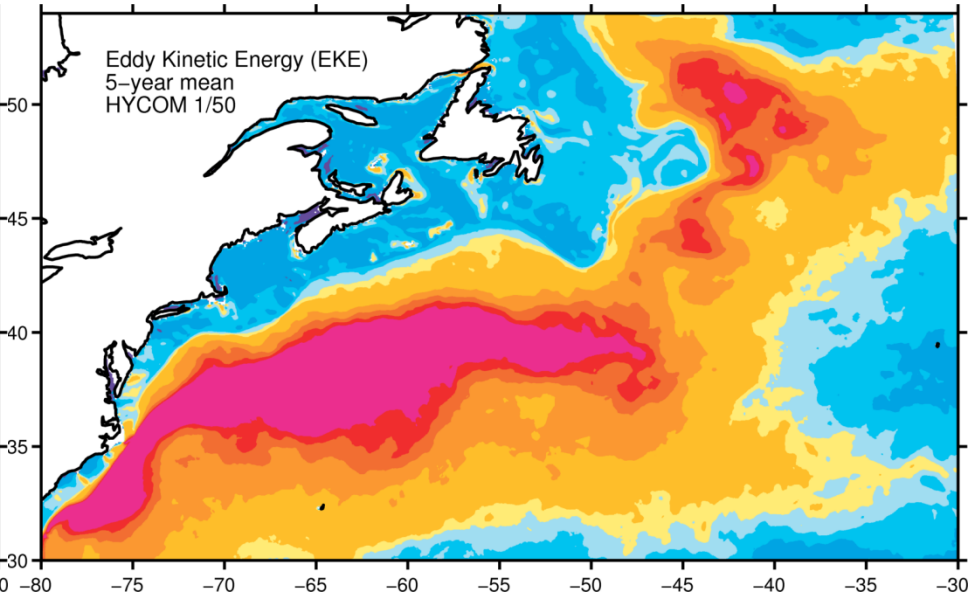
Eddy Kinetic Energy (total minus geostrophic) Years 16-20



Geostrophic surface EKE



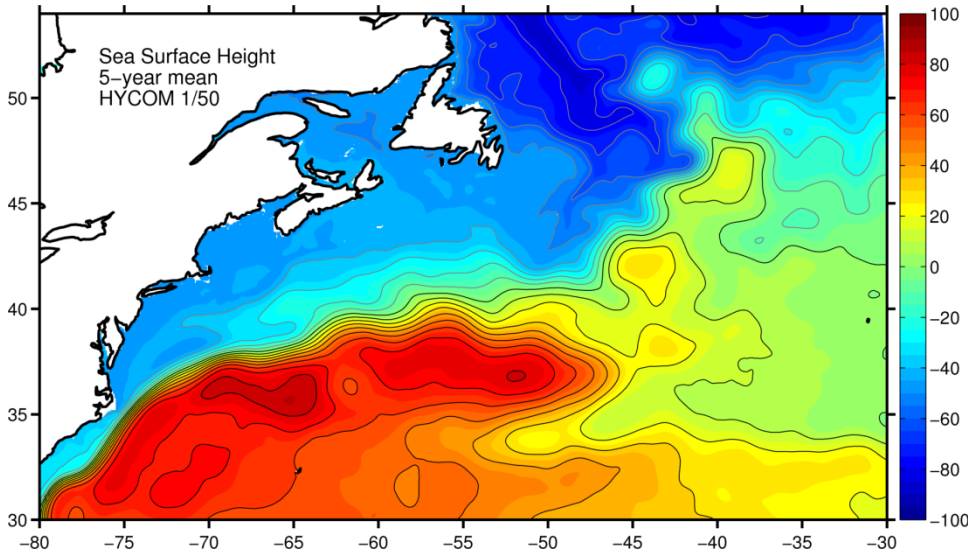
Total surface EKE



Mean SSH

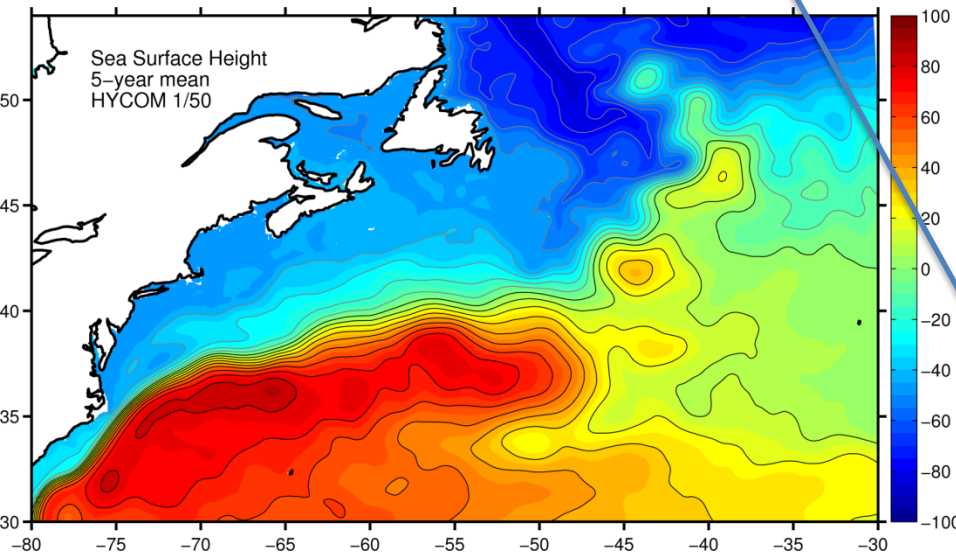
Sensitivity to topographic features: Charleston Bump

Years 11-15

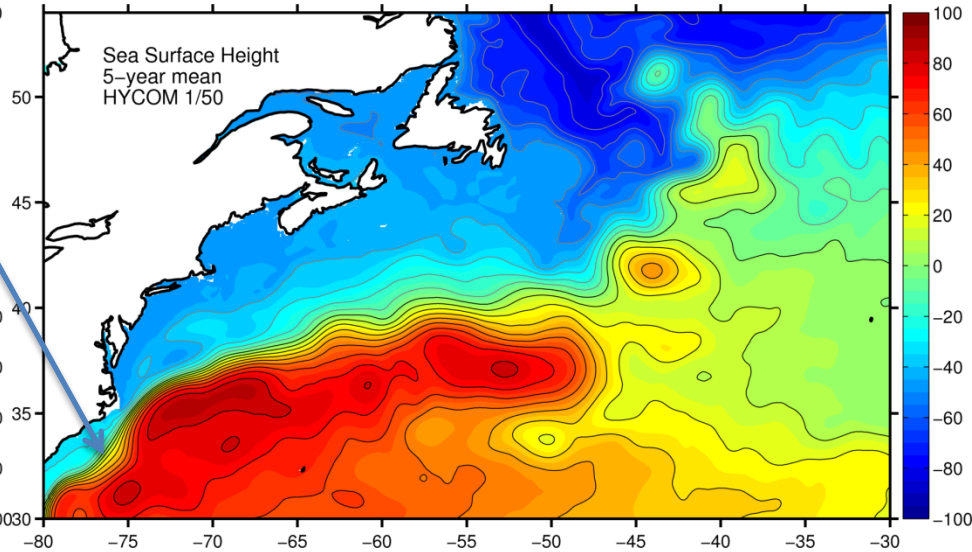


Upstream separation (present in the last two years, but some instances in year 3)

Years 14-18

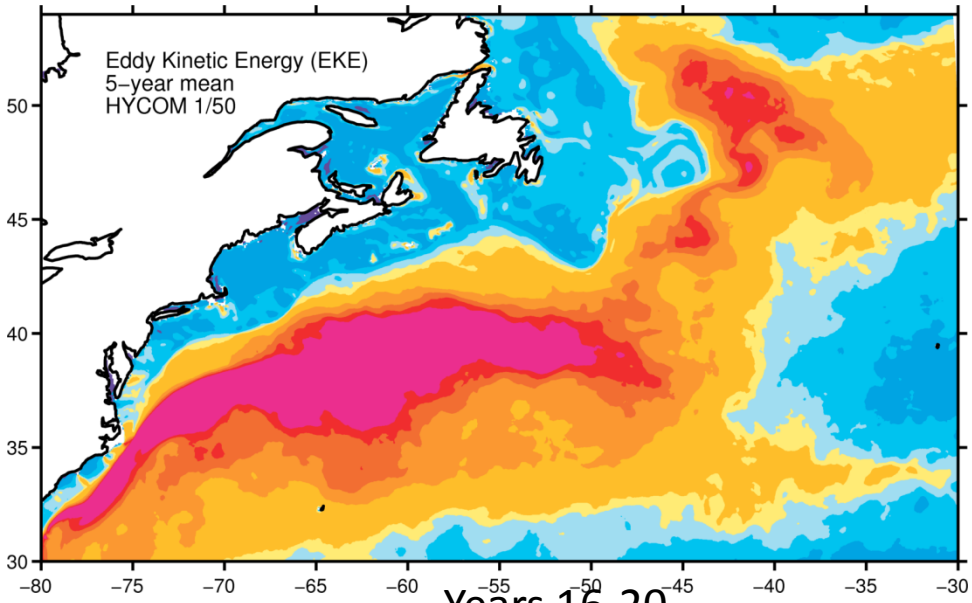


Years 16-20



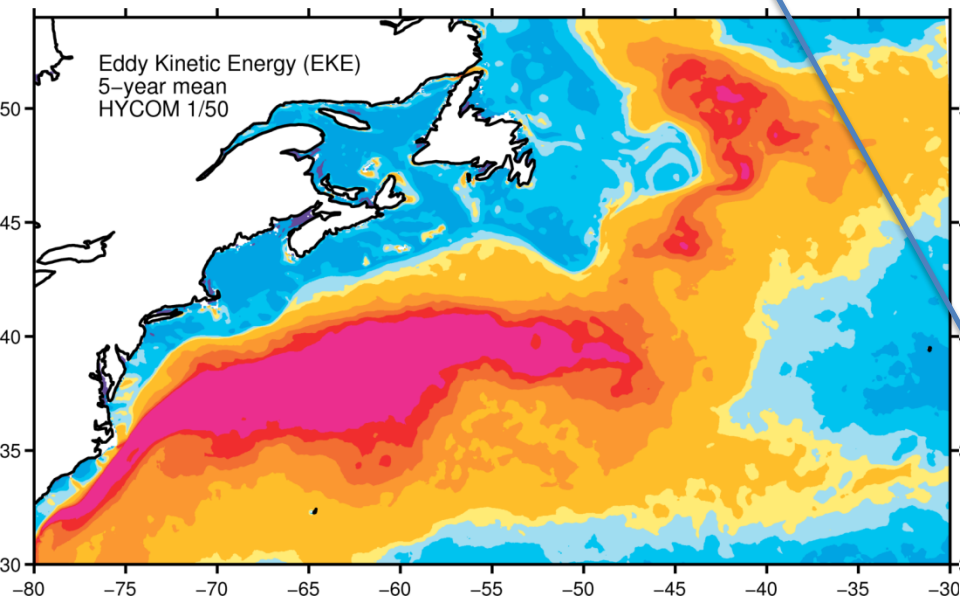
EKE

Years 11-15

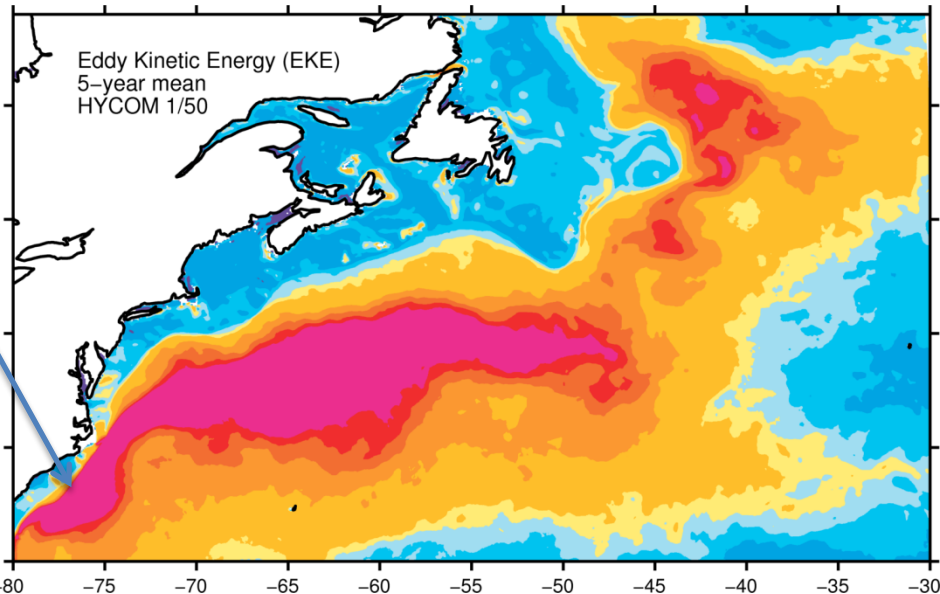


Upstream separation

Years 14-18



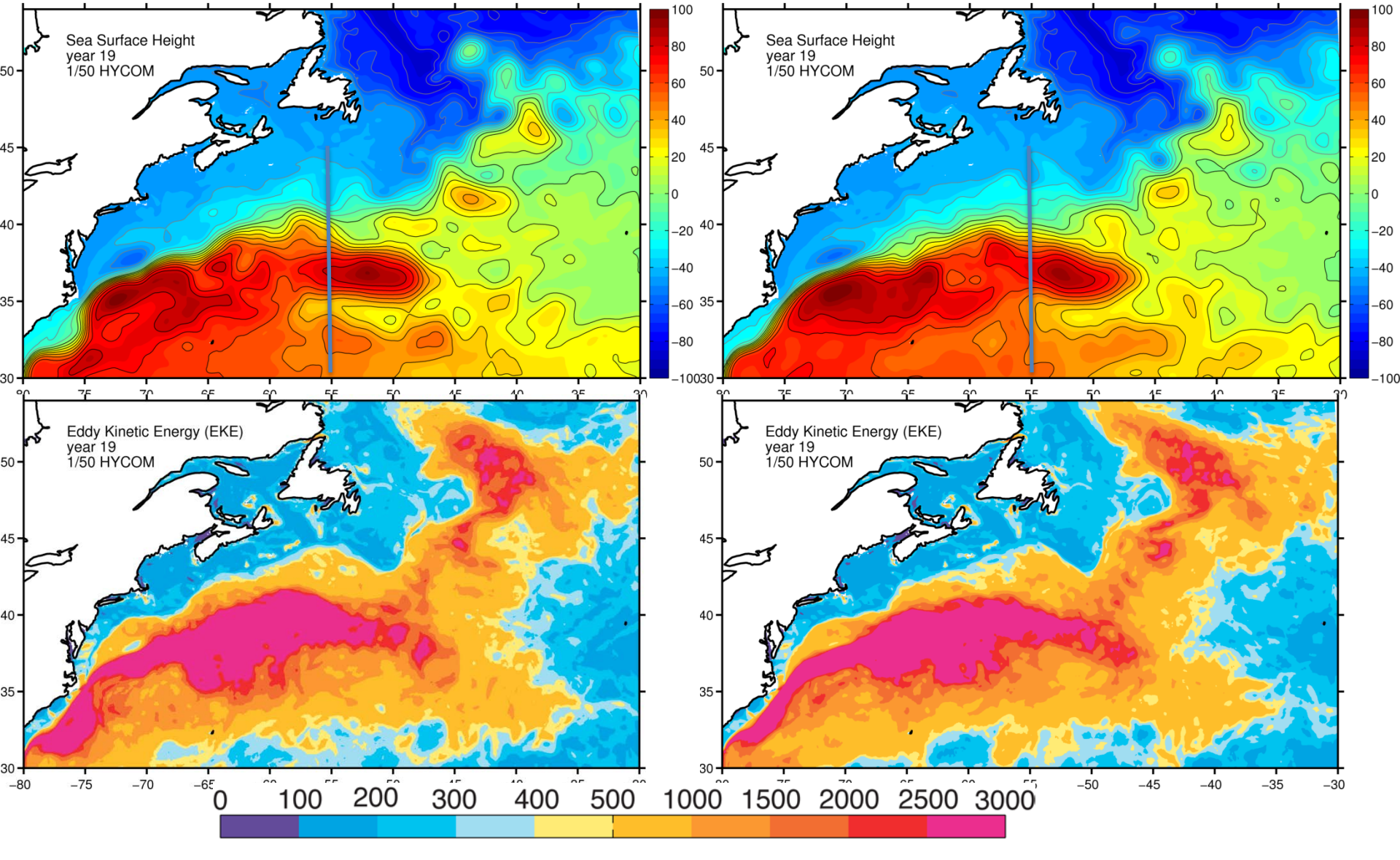
Years 16-20



Impact of increasing C_D by 25% (for 1 year)

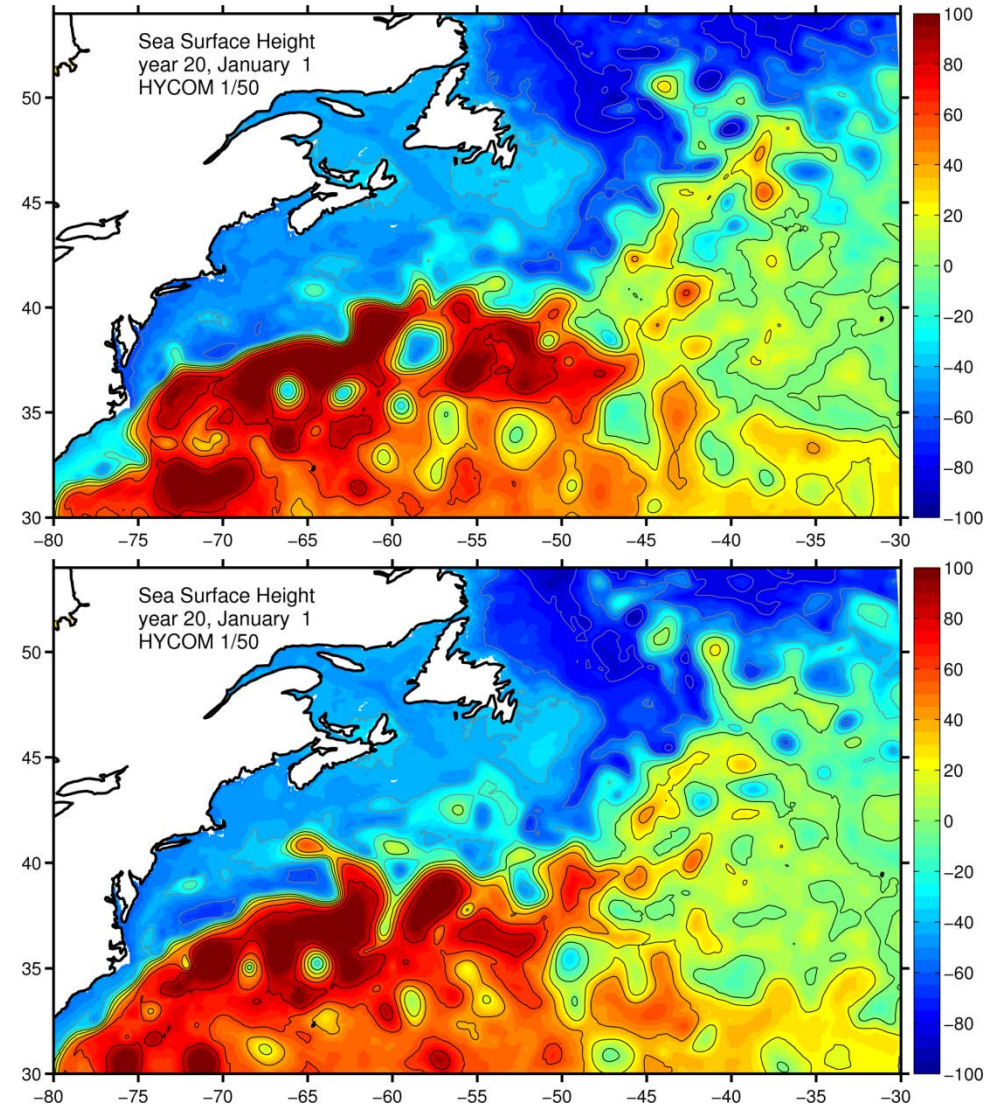
C_D=1.0E-3

C_D=1.25E-3

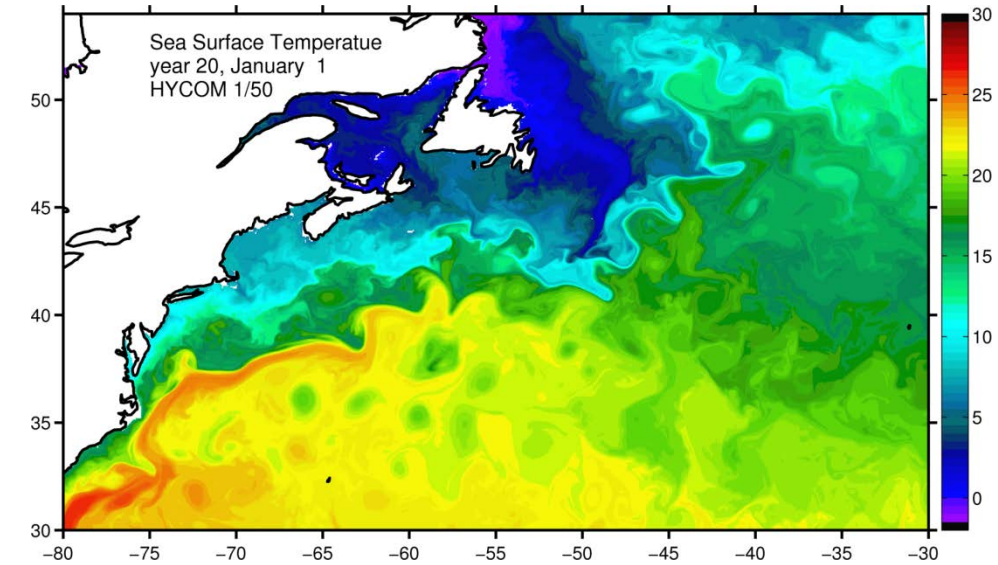


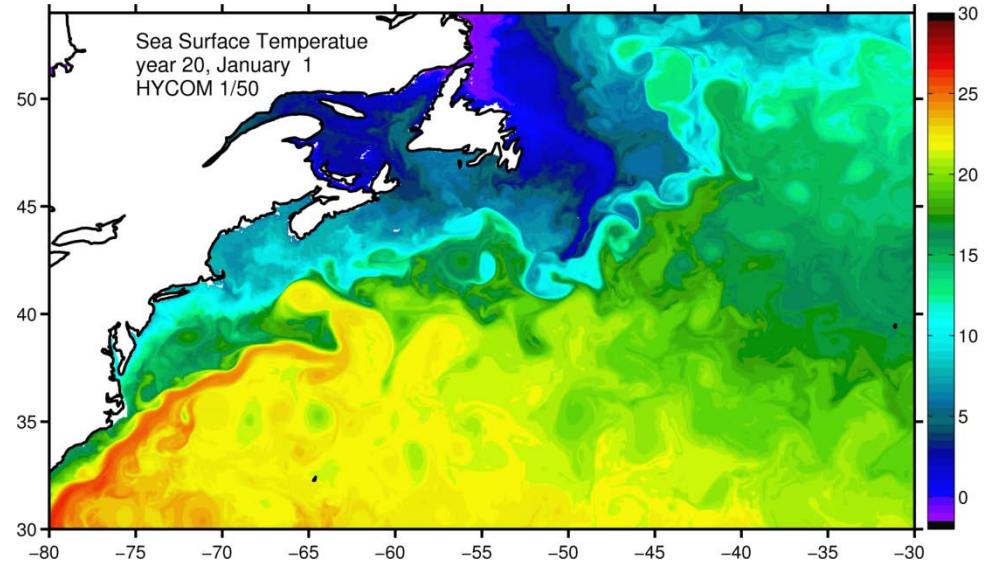
Sensitivity to bottom drag

(Chassignet and Garraffo, 2001)

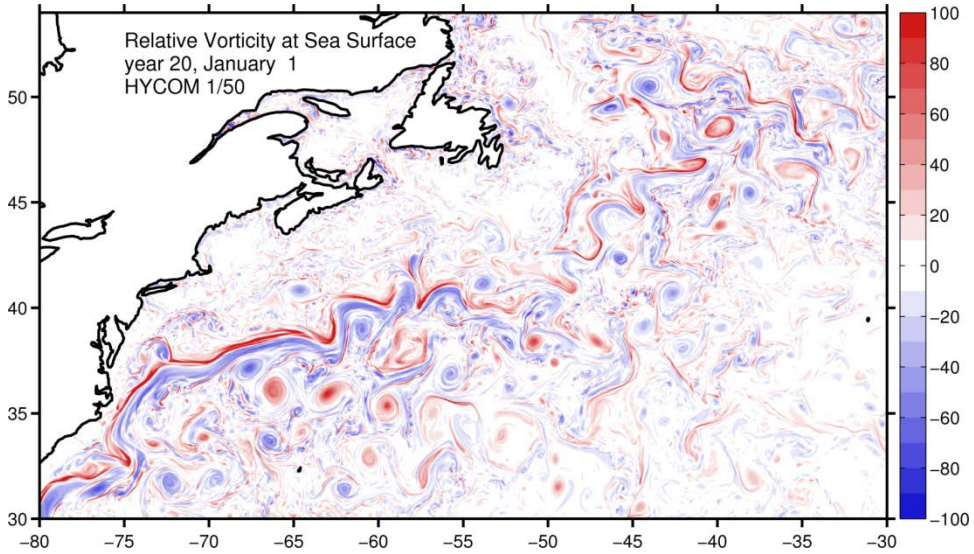


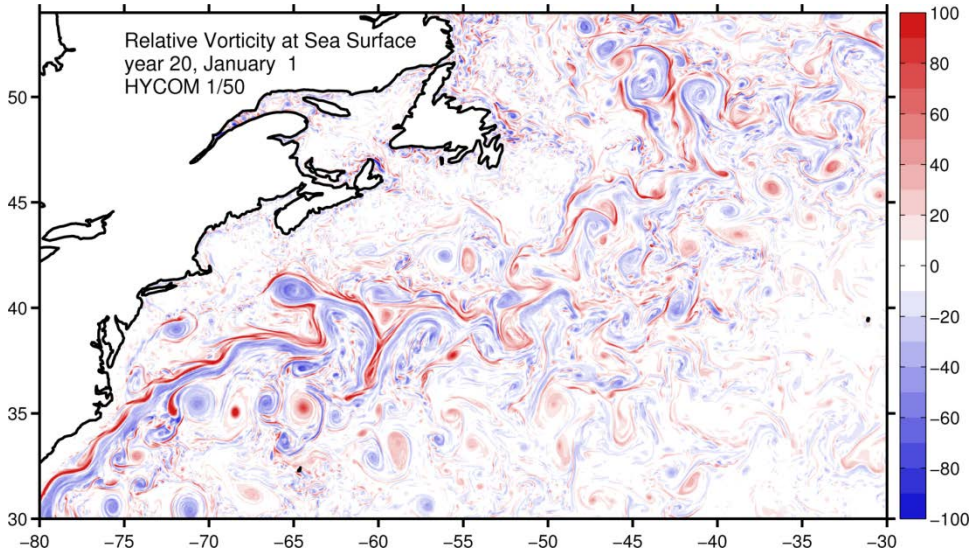
New experiment with 25% higher C_d after 1 year (year 19)





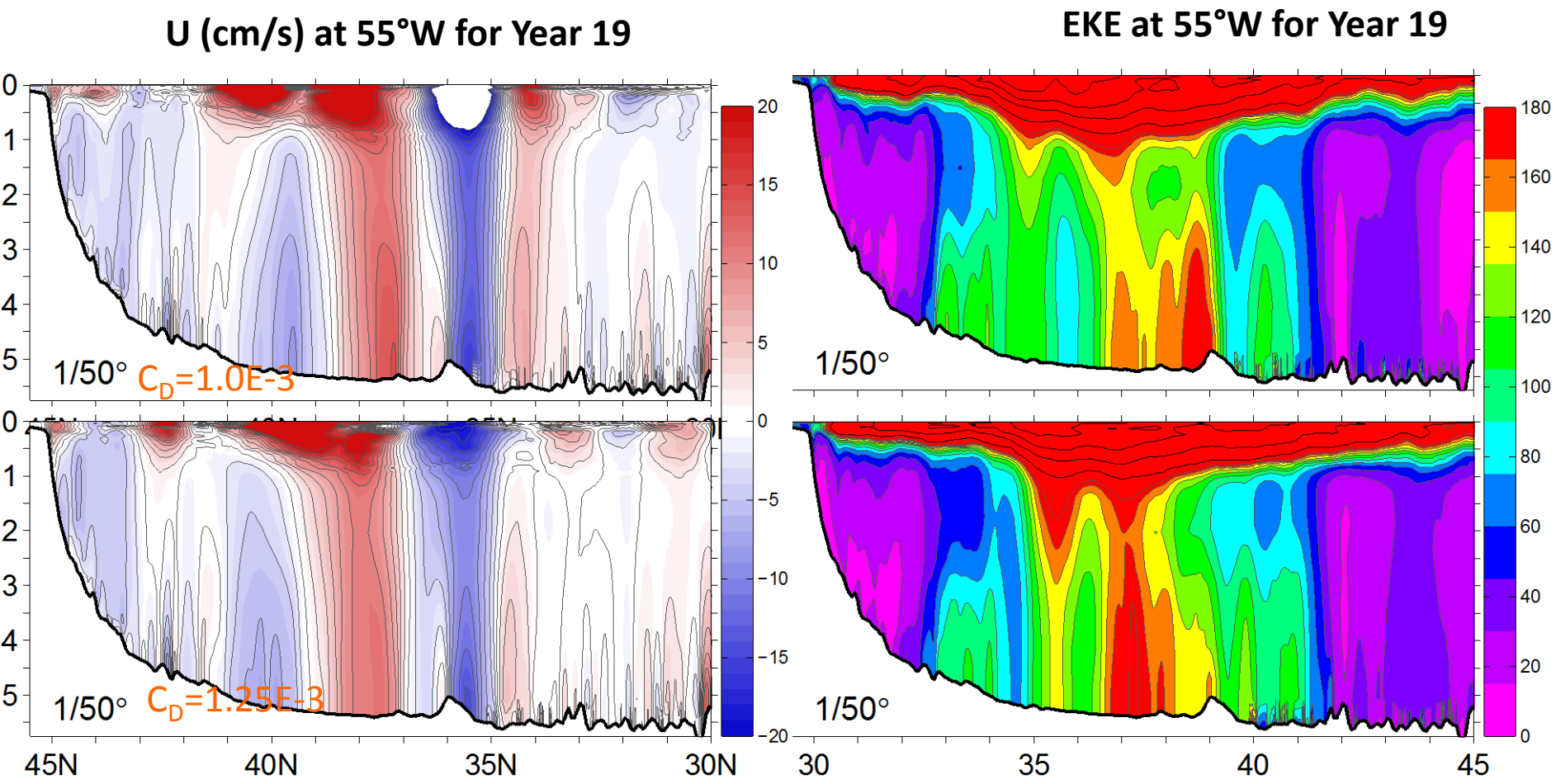
Same comparison in SST





Same comparison in surface relative vorticity (10^{-6} s^{-1})

Impact of increasing C_D by 25%



Higher bottom drag results in reduction of mean flow, but the EKE is not lower (but slight higher in some areas)

Summary

- Significant improvement in Gulf Stream model representation at 1/50°
- May be more energetic than observed
- May require fine tuning (subgrid scale parameterizations, bottom drag)
- Have not yet looked elsewhere in the model. Do we see improvements elsewhere?
- Is this “good enough”?

Questions?