Impact of Mesoscale Eddies on the Vertical Nitrate Flux in the Gulf Stream Region

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1. Summary

- A high-resolution 25-year simulation is performed in Gulf Stream (GS) region using a coupled physical-biological model.
- A large sample of mesoscale eddies are detected and tracked, and the eddy-centric composites are created.
- The long-term averaged contribution of cyclonic eddies (CEs) and anticyclonic eddies (ACEs) to the vertical NO_3 flux into the euphotic zone (Z_{eu}) are both positive.
- The eddy-wind-interaction-induced Ekman pumping is likely the dominant mechanism for the enhanced NO_3 flux at Z_{eu} in ACEs.

2. Numerical Model

- Physical model: ROMS over Northwest Atlantic (NWA) with 7km horizontal resolution and 40 vertical levels
- Biogeochemical model: NOAA/GFDL's Carbon, Ocean, Biogeochemistry and Lower Trophics (COBALT) model

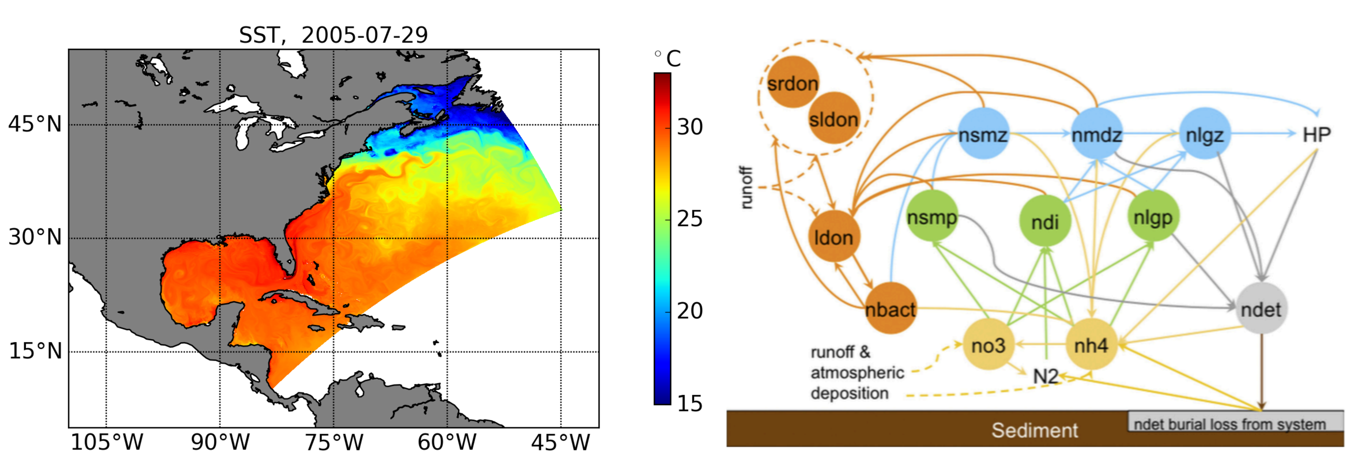


Fig 1. (Left) A snapshot of SST from ROMS-COBALT simulation. (Right) Schematic of N-based state variables in COBALT [Stock et al.,2014b].

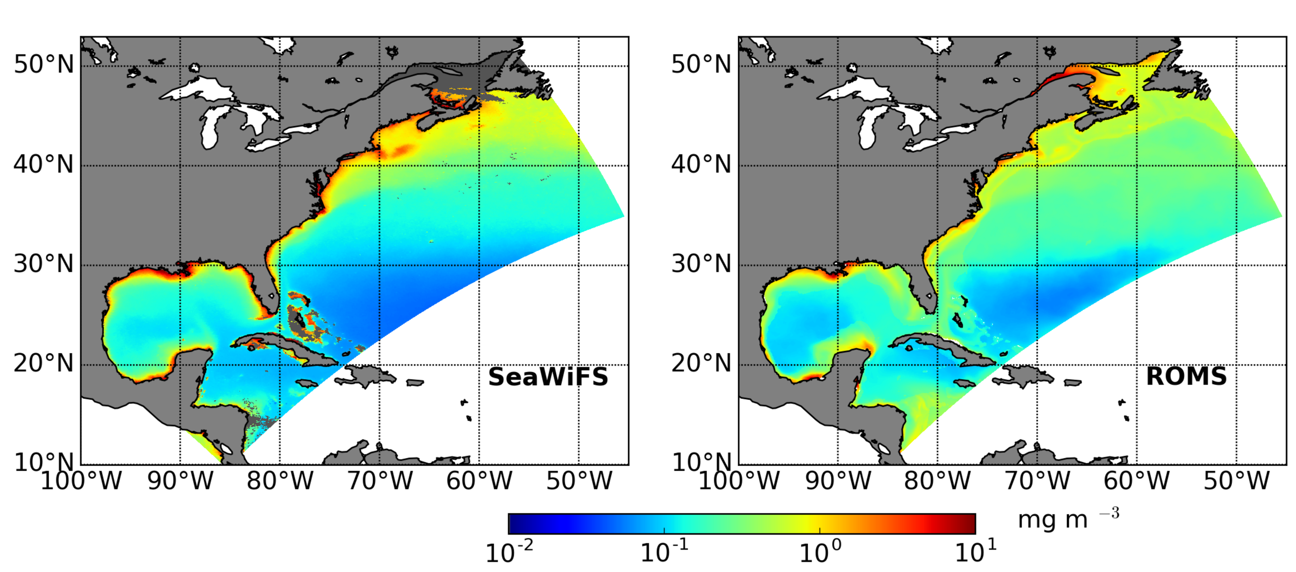


Fig 2. Mean surface chl from (left) SeaWiFS during 1998-2007 and (right) coupled ROMS-COBALT simulation during 1983-2007.

3. Eddy Detection and Tracking

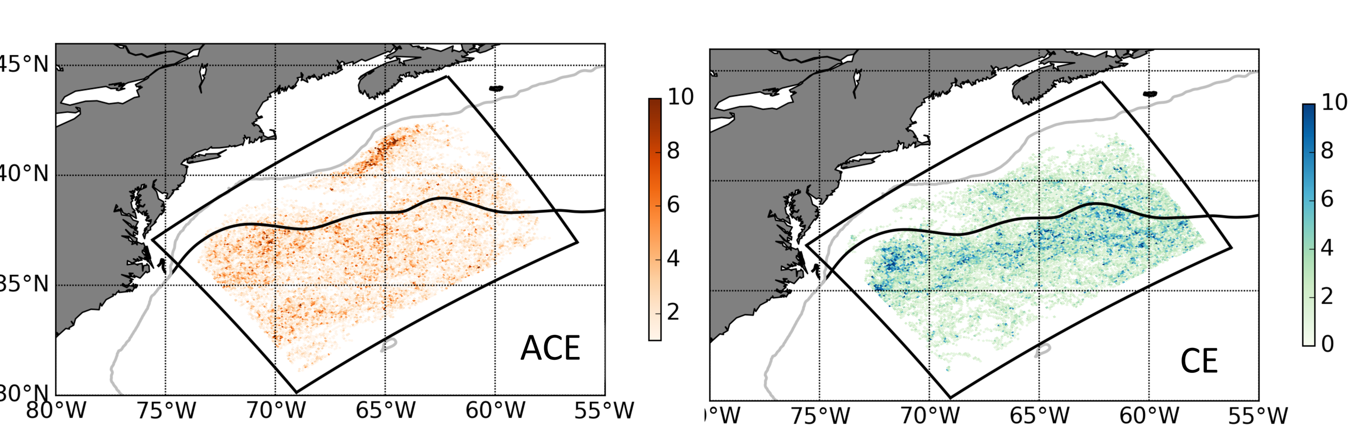


Fig 3. ACE and CE occurrence during 1983–2007. Black curve is the mean GS pathway and grey contour is the 1000m isobath.

Table 1. Eddy properties with standard deviations in parentheses.

	Number		Duration (days)	Radius (km)	Distance (km)
	Total	Per year			
ACE	740	30 (5.5)	31 (7.5)	81 (27.7)	167 (39.6)
CE	612	24 (5.3)	46 (20.63)	88 (21.2)	193 (72.1)

4. Eddy Composites

Hydrography

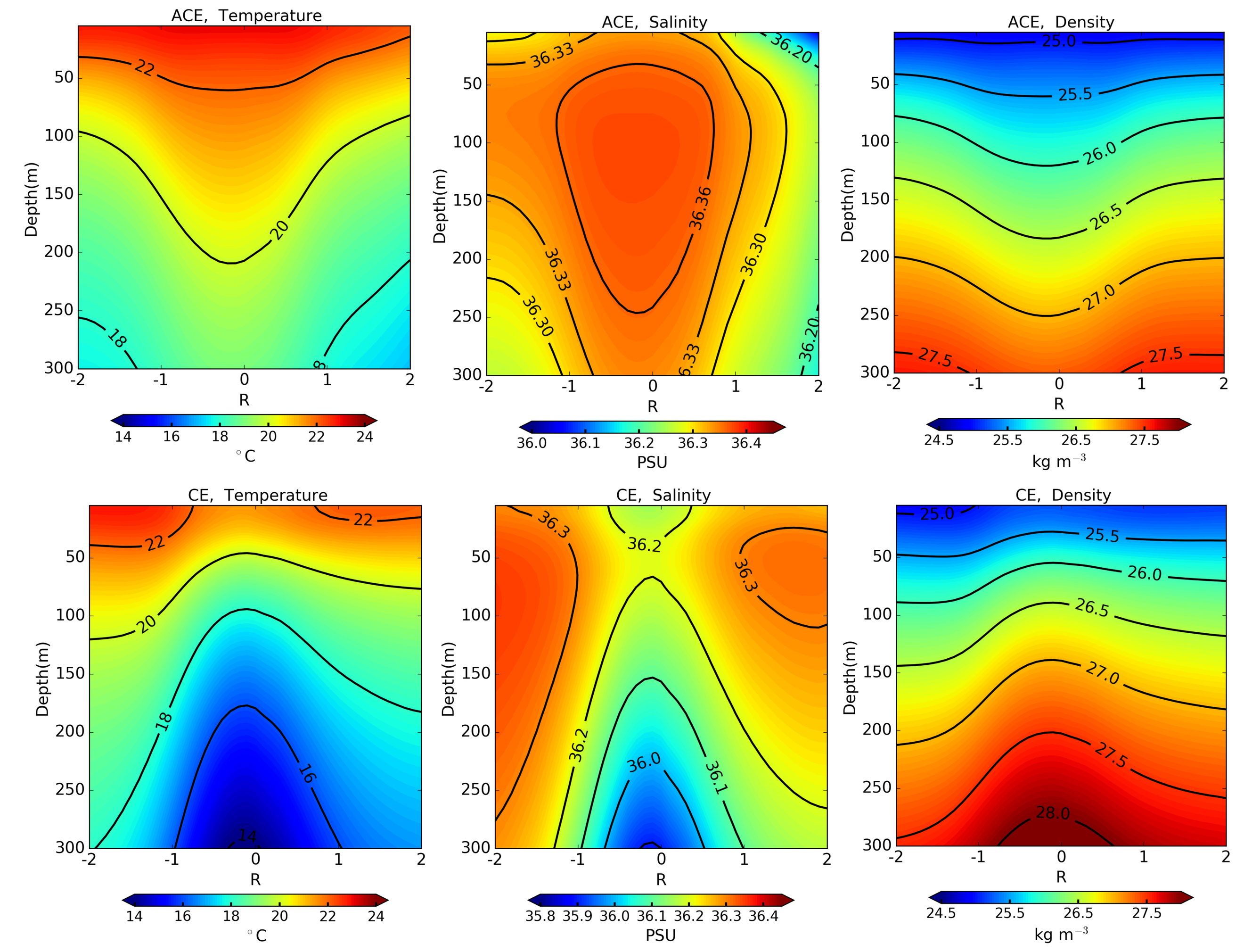


Fig 4. Composites of temperature, salinity and potential density in (upper) ACE and (lower) CE along the vertical-latitudinal transect across the eddy center. x-axis is the normalized radius; negative (positive) means south (north).

Nitrate

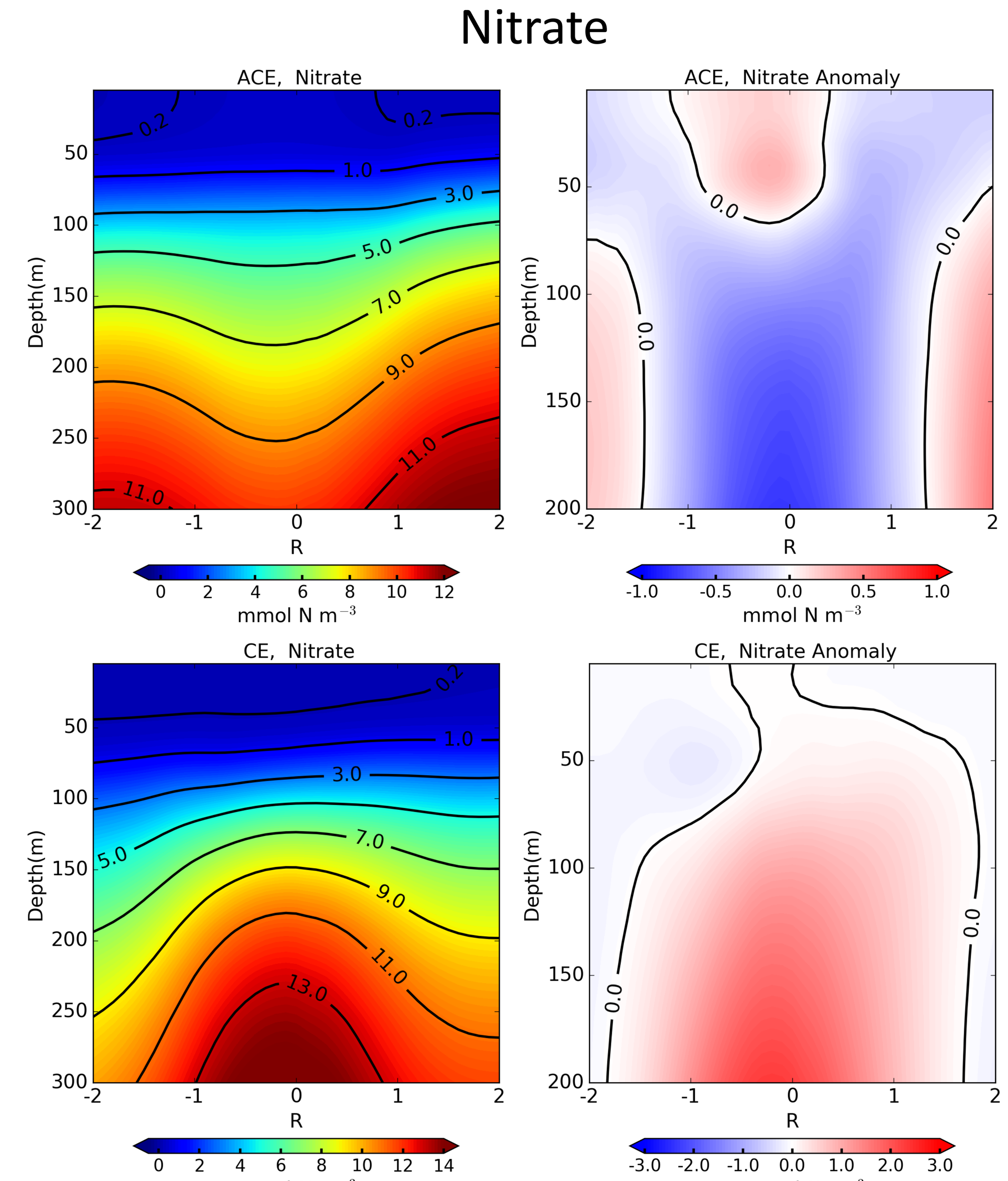


Fig 5. Composites of NO_3 and its anomalies for (upper) ACE and (lower) CE. NO_3 anomalies are derived by subtracting the annual average from the daily field.

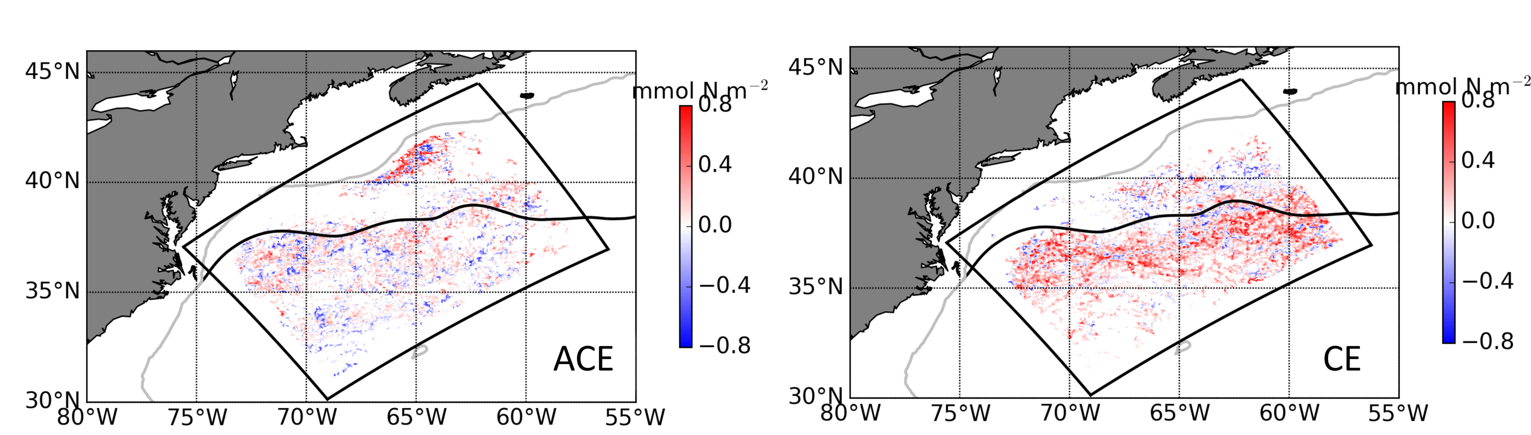


Fig 6. Vertical-integrated NO_3 anomalies for all (left) ACEs and (right) CEs above Z_{eu}.

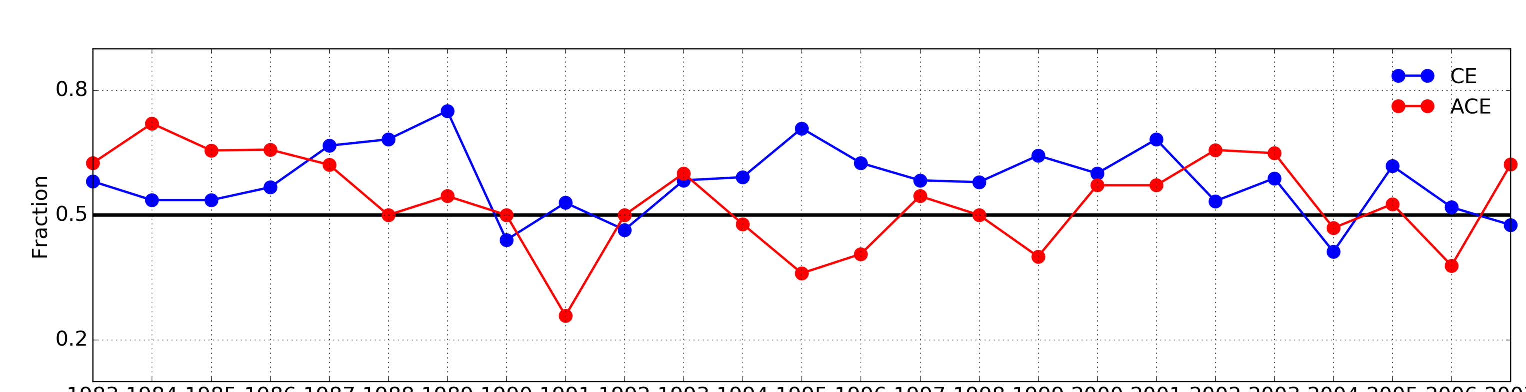
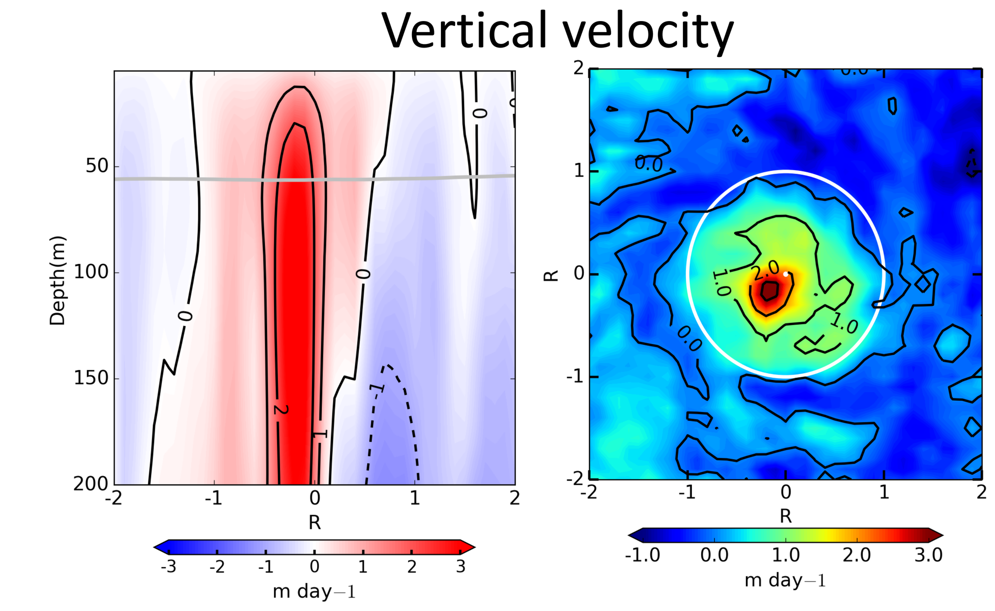


Fig 7. Fraction of ACEs (red) and CEs (blue) with positive NO_3 anomalies above Z_{eu}.

5. Mechanism

Vertical velocity



Vertical mixing coefficient

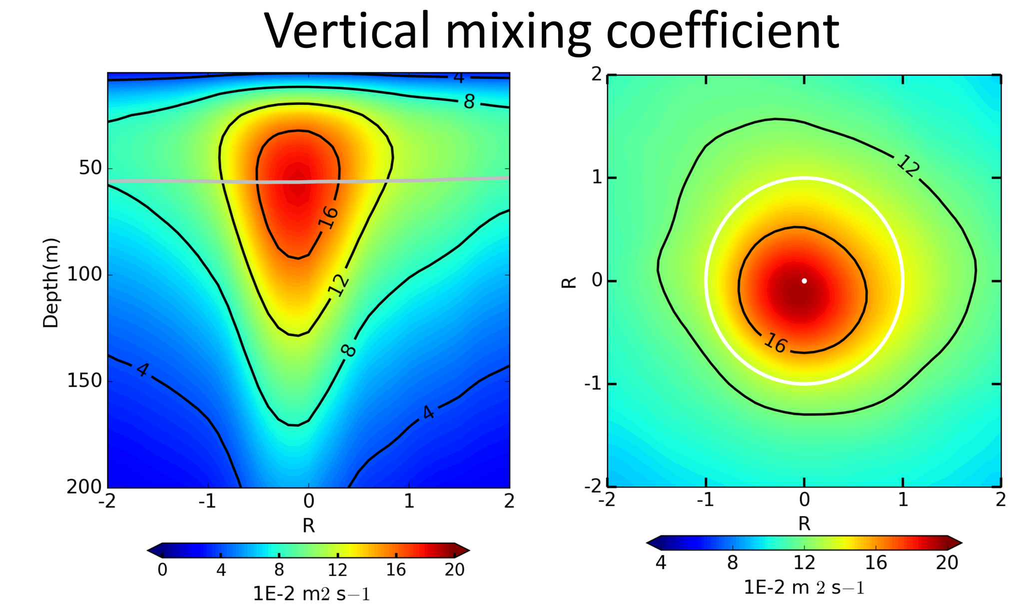


Fig 8. Composites of vertical velocity and mixing coefficient (left) along the latitudinal transect across the eddy center and (right) on the horizontal plan Z_{eu} in ACE.

Vertical fluxes at Z_{eu}

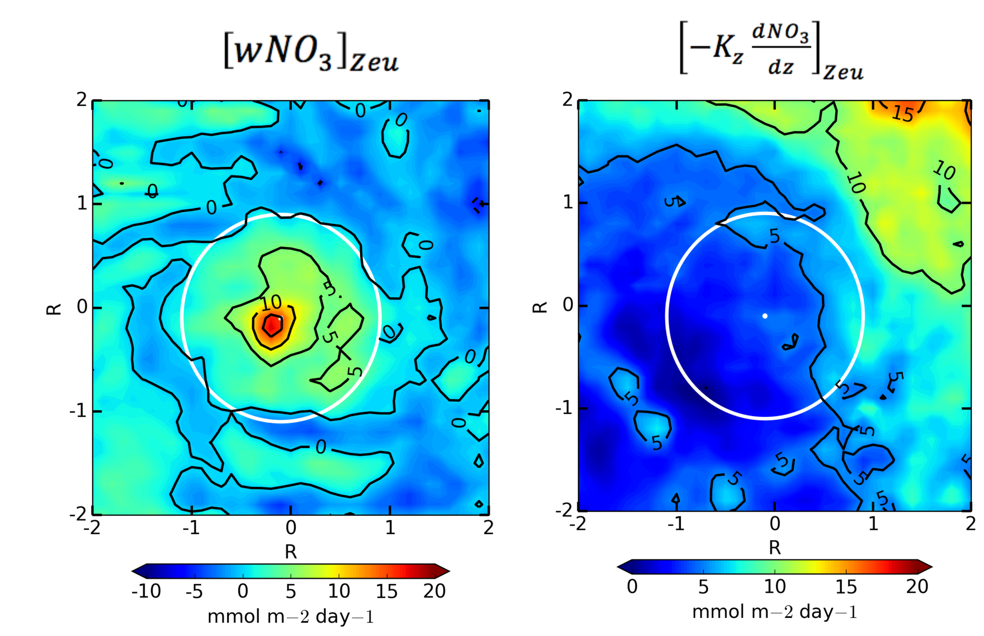
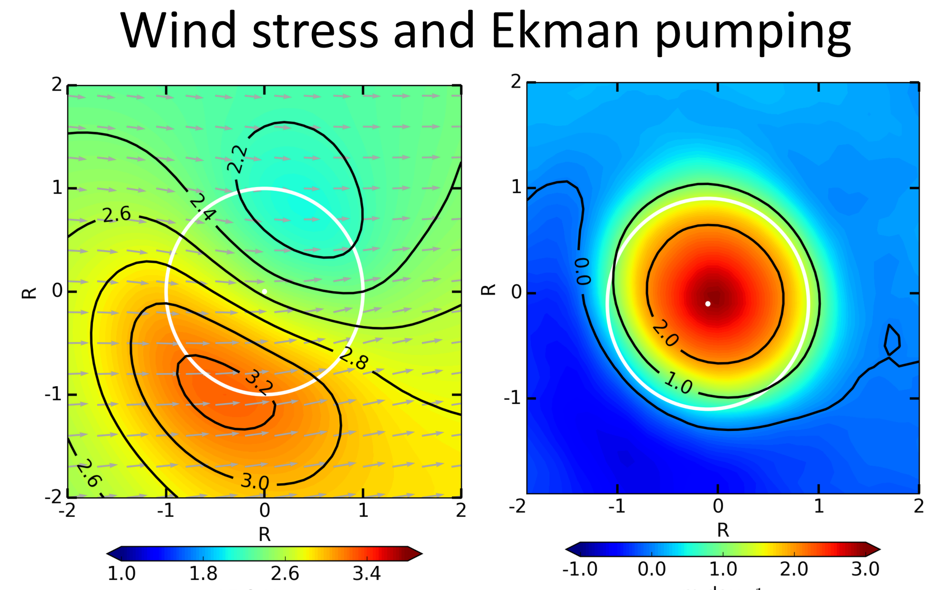


Fig 9. Vertical NO_3 flux driven by (left) vertical advection and (right) vertical mixing at Z_{eu} in ACE.

Wind stress and Ekman pumping



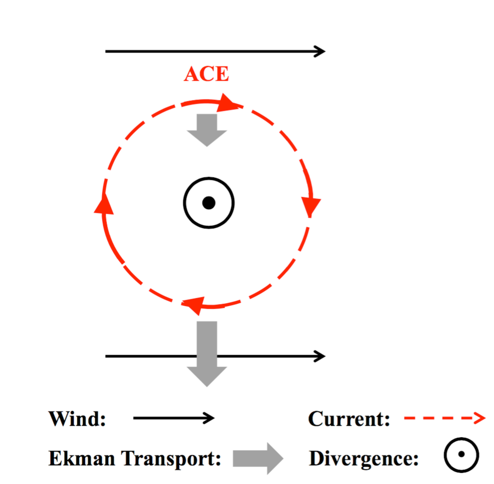


Fig 10. (Upper) Wind stress over ACE and the Ekman pumping velocity w_E. (Left) Schematic of the wind-current-interaction-induced Ekman pumping.

6. Reference

- Stock, C.A., J.P. Dunne, and J.G. John (2014b), Global-scale carbon and energy flows through the marine planktonic food web: an analysis with a coupled physical-biological model, Prog Oceanogr., 120, 1–28.
- Kang, D., and E. N. Curchitser (2013), Gulf Stream eddy characteristics in a high-resolution ocean model, J. Geophys. Res. Oceans, 118, 4474–4487
- McGillicuddy, D., et al. (2007), Eddy/wind interactions stimulate extraordinary mid-ocean plankton blooms, Science, 316(5827), 1021.