No 116

TEMPORAL VARIABILITY OF SURFACE EDDY DIFFUSIVITIES FROM ALTIMETRY

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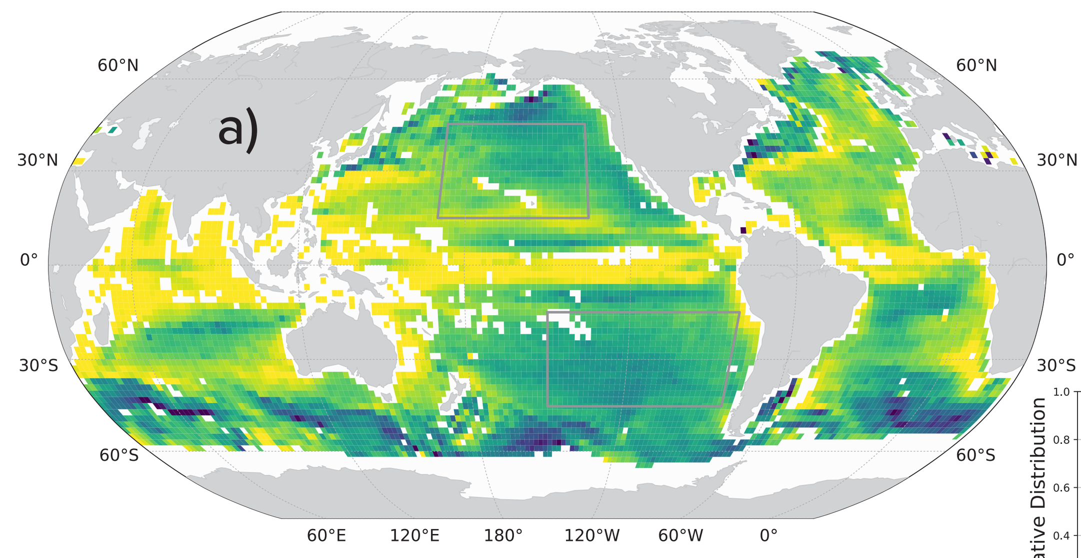
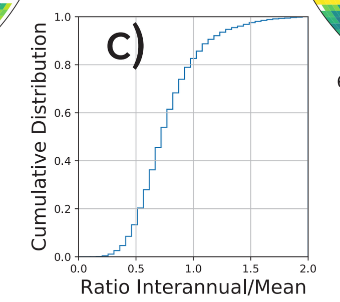
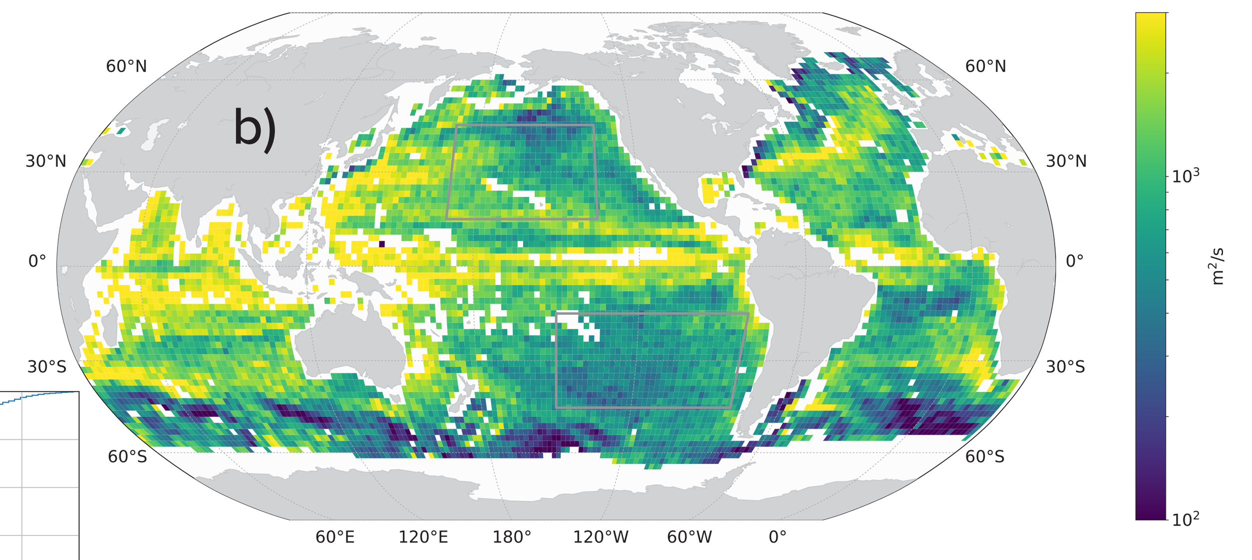
Average Surface Diffusivity





Interannual Range



Mean Surface Diffusivities and Interannual Range || a) Map of mean surface diffusivities (K_{min}, see Methods) **b)** Map of interannual range of surface diffusivities (difference between 15th and 85th percentile of annual averaged data) **c)** Cumulative Distribution of the ratio of interannual variability (Fig. b) over mean diffusivity (Fig. a)

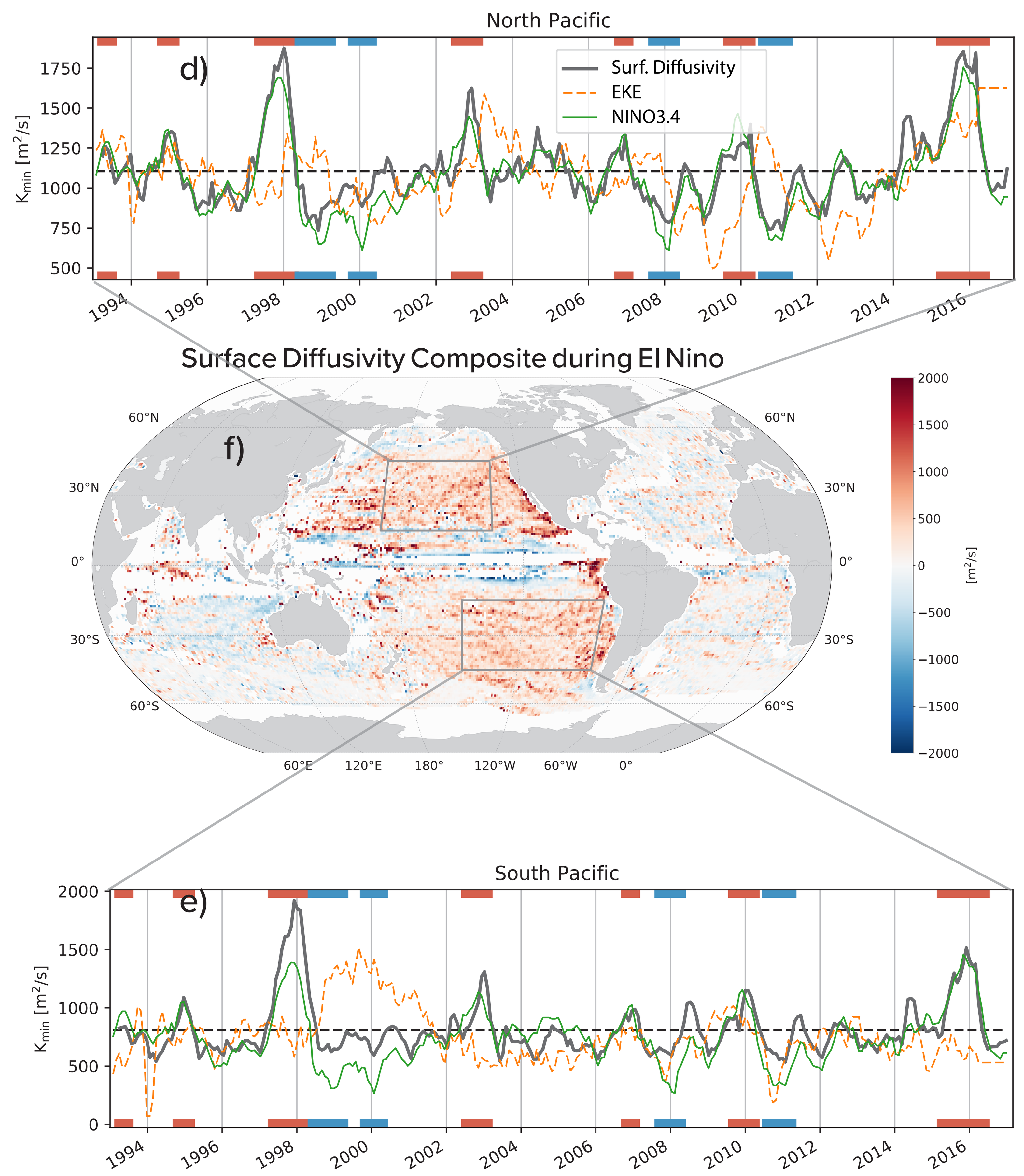
INTRO

Lateral eddy diffusivities are important for the oceanic distribution and uptake of various tracers (heat, carbon, nutrients and others) (e.g. Gnanadesikan et al. 2015)

The global ocean circulation is highly sensitive to the value of lateral diffusivity used in global climate models (Marshall et al. 2017)

Most state of the art climate models use a constant diffusive transfer coefficent. However, high spatial variability is suggested globally (Abernathey and Marshall 2013, Cole et al. 2015) and regional studies indicate temporal variability as well (Busecke et al. 2017).

How important is the temporal variability of surface eddy diffusivity globally?



Surface Diffusivities and ENSO || d-e) Time series of surface diffusivites (black line), NINO3.4 index (green line, normalized for comparison) and Eddy Kinetic Energy (orange line, normalized for comparison) for the boxes indicated on map. **f)** Map of surface diffusivities composited during high NINO3.4 episodes (marked by red blocks in Fig d+e)

KEY FINDINGS

Surface diffusivities vary by more then half of the local mean over 80% of the global ocean.

Variability seems to be connected to large scale climate fluctuations. Surface diffusivities in the Pacific show a marked increase during positive ENSO periods.

The temporal variability in the Pacific does not only seem to be related to the changes in the EKE

DISCUSSION

The results suggest that surface diffusivities are modulated by large scale climate fluctuations.

This could represent a climate feedback mechanism not currently accounted for in global climate models.

Since the changes in EKE do not explain the enhanced surface diffusivities during positive ENSO events, we will explore the effect of time variable large scale flow in supressing diffusivities using modified mixing length theory (Ferrari and Nikurashin 2010, Klocker and Abernathey 2014)

Future work will investigate if these changes are coherent below the surface - where isopycnal eddy mixing implies vertical tracer transports due to the mean tilt of isopycnal surfaces.

Literature

Abernathey, R. P., & Marshall, J. (2013). Global surface eddy diffusivities derived from satellite altimetry. Journal of Geophysical Research: Oceans, 118(2), 901–916.

Busecke, J., Abernathey, R. P., & Gordon, A. (2017). Lateral Eddy Mixing in the subtropical salinity maxima of the global Ocean. Journal of Physical Oceanography.

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Klocker, A., & Abernathey, R. P. (2014). Global patterns of mesoscale eddy properties and diffusivities. Journal of Physical Oceanography.

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METHODS

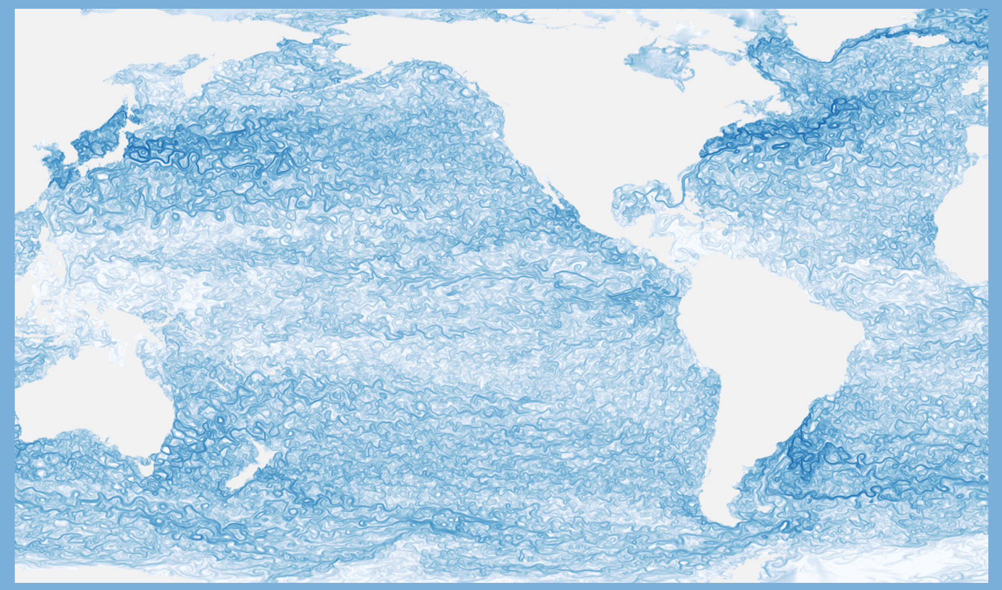
Passive tracer fields advected by observed geostrophic velocities from altimetry (AVISO)

Advection-Diffusion equation solved on 1/10° grid using MITgcm

Velocities are divergence corrected but correction is small away from the equator and the coast

Results are sensitive to velocity field not the small scale diffusivity

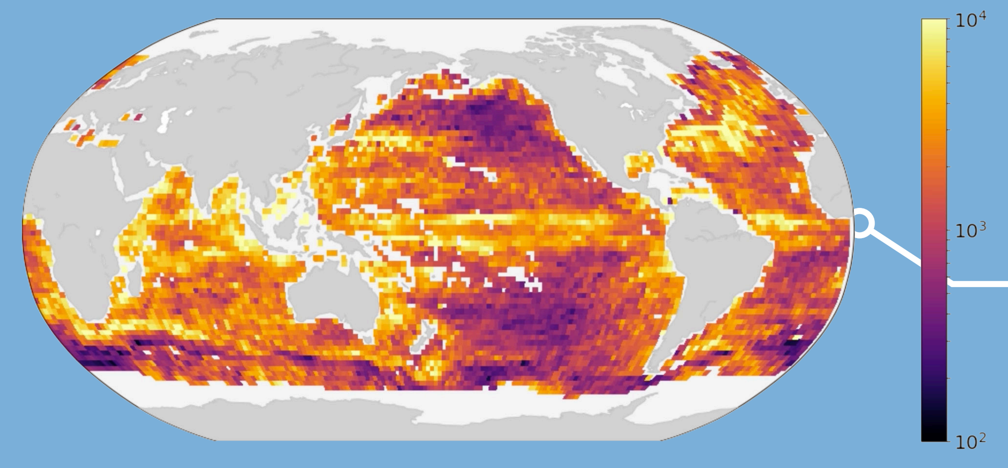
Snapshot of surface tracer gradient magnitude



Calculate Osborn-Cox Diffusivity

Aggregated over 2° x 2° x 30 days

Snapshot of surface diffusivity for single initial conditon [m²/s]

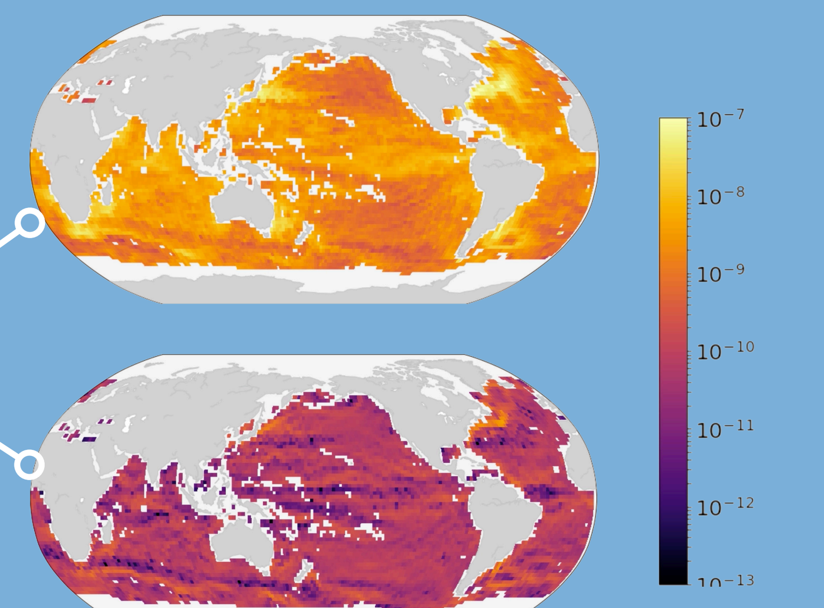


OSBORN-COX DIFFUSIVITY

$$K_{OC} = \kappa \frac{\overline{|\nabla q'|^2}}{|\nabla \overline{q}|^2}$$

The Osborn-Cox Diffusivity quantifies the destruction of small scale variance (due to stirring) by irreversible mixing

Illustration of Numerator and Denominator of Osborn-Cox Diffusivity [m²/s]



A scalar diffusivity is calculated for several initial conditions and the minimum diffusivity (K_{min}) is assumed to represent the minor axis of the surface diffusivity tensor, particulary relevant to cross frontal mixing and the identification of mixing barriers.

All results above show K_{min}