Eddy lifecycles and storm tracks

UNIVERSITY OF LIVERPOOL

Ric Williams[1], Chris Wilson[1,2] and Chris Hughes[2]

1. Department of Earth and Ocean Science, University of Liverpool, U.K.
2. Proudman Oceanography Laboratory, Liverpool, U.K.

Proudman Oceanographic Laboratory
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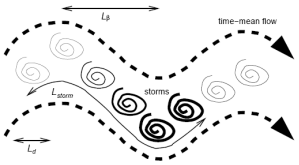
1. Motivation

Eddies have characteristic life cycles:

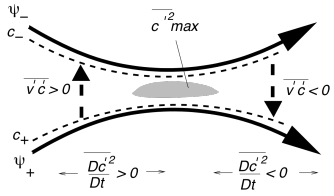
- as tracer variance grows, eddy tracer fluxes are directed down gradient
- as variance decays, eddy tracer fluxes are directed up gradient

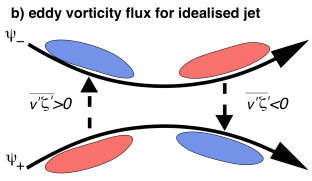


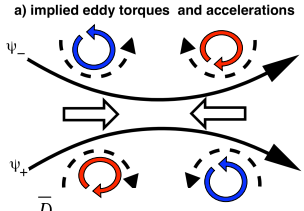
Tracer equation $\frac{\partial C}{\partial t} + \mathbf{u} \bullet \nabla C = F$

Tracer variance $\overline{\frac{D}{Dt}\left(\frac{C'^2}{2}\right)} + \overline{\mathbf{u}'C'} \bullet \nabla \overline{C} = \overline{F'C'}$

Idealized jet







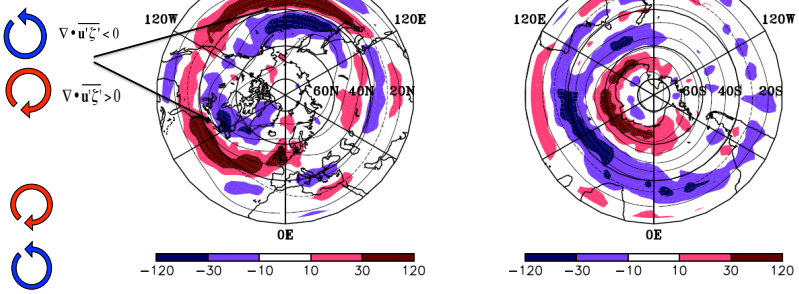
Vorticity equation $\frac{\overline{D}}{Dt}(f+\bar{\zeta}) = -(f+\bar{\zeta})\nabla \bullet \bar{\mathbf{u}} - \nabla \bullet \overline{\mathbf{u}'\zeta'}$

c is a conserved tracer, such as CFCs or potential vorticity

zeta is vorticity

2. Atmospheric Storm tracks

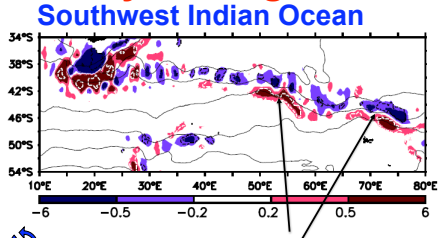
- Eddies grow at the entrance of storm tracks, providing a down-gradient heat flux and an eastward acceleration
- Eddies decay at the exit and downstream of a storm track, providing a westward acceleration, sometimes leading to blocking



Diagnostics of high-pass (<7days) eddy relative vorticity convergence at 250-hPa (10^{-12} s^{-2}) for 1992-2002 from ERA-40

3. Eddy forcing in the Southern Ocean

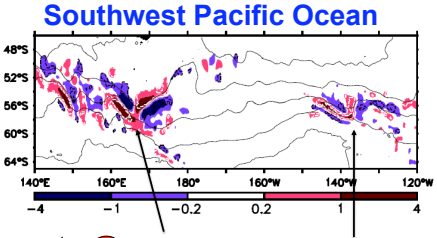
Southwest Indian Ocean



eddies accelerate mean flow eastward
- at about half of planetary forcing

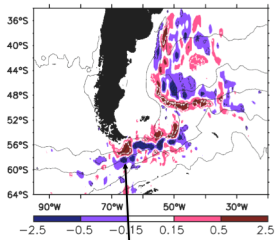
Diagnostics of high-pass (<100 days) eddy relative vorticity convergence (10^{-12} s^{-2}) for 1992-2002 from from altimetry on 1/3° grid.

Southwest Pacific Ocean



eddies accelerate mean flow eastward, then westward
- linked to topography

Drake Passage



deceleration near Drake Passage

Dashed lines denote regions of 90% significance (a Monte Carlo technique where the original data is Fourier transformed, random phase applied, then a new time series constructed, 800 times)

4. Implications

- Eddies provide sequence of down-gradient and up-gradient tracer fluxes;
- Need to consider life cycle of eddies via evolution of tracer variance;
- Expect life cycles of ocean eddies to be reflected in coherent patterns, such as storm tracks.

References:

Williams, R.G., C. Wilson and C.W. Hughes, 2007: Ocean and atmosphere storm tracks: the role of eddy forcing. Journal of Physical Oceanography, 37, 2267-2289.

Also see: Hughes, C.W. and E.R. Ash, 2001: Eddy forcing of the mean flow in the Southern Ocean. J Geophys. Res., 106, 2713-2722.

Wilson, C. and R.G. Williams, 2006: When are eddy tracer fluxes directed down gradient? Journal of Physical Oceanography, 36, 2, 189-201.