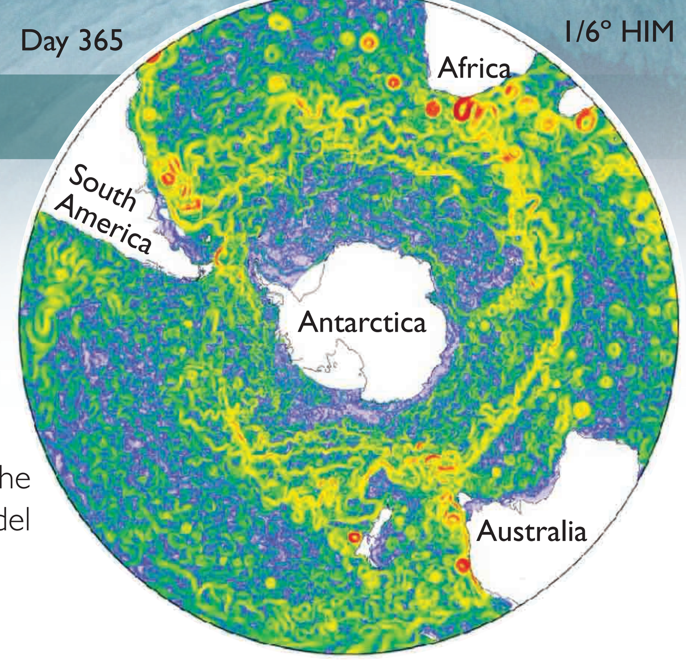
An estimate of

Lagrangian eddy statistics and diffusion in the mixed layer of the Southern Ocean

J.B. Sallée[1] • K. Speer[2] • R. Morrow[3] • R. Lumpkin[4]

Introduction

Mesoscale eddies mix tracers and transport mass in the ocean: affects the large-scale circulation, so is fundamental for climate studies (models or data).



Snapshot of surface velocity from the high resolution 1/6 HIM model

Need to estimate the eddy impact!

Diffusion

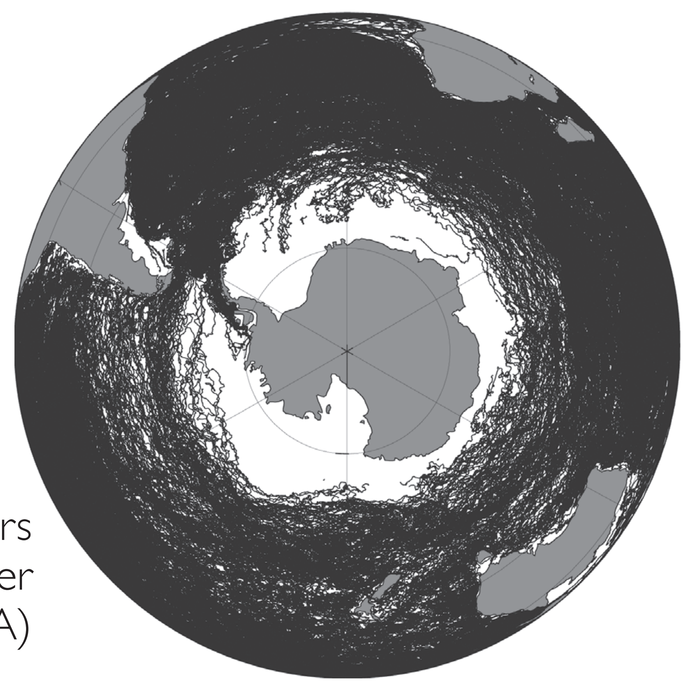
Difficulties in observing the eddy impact with data on a large scale.

→ We parameterize mixing and eddy-induced flux through an eddy diffusion coefficient.

Problem: calculating oceanic eddy diffusion.

We can calculate eddy diffusion coefficients based on Lagrangian data statistics (eg Taylor, 1921; Davis, 1991)

But: a statistical approach needs lots of Lagrangian data!



We use 10 years of Lagrangian drifters trajectories form the Global Drifter Program (AOML/NOAA)

Framework

Statistical calculation (Taylor, 1921):

1) Dispersion: $\langle x'^2(t) \rangle$. *Ensemble mean*

2) Diffusivity is the time derivative of dispersion

Effective diffusivity: $\kappa_{xx} = \frac{1}{2}\frac{d}{dt}\langle x'^2 \rangle$,or: $\kappa_{xx} \approx u_{rms}^2 T_u$.

Where Tu is the Lagrangian timescale, related to the velocity autocorrelation function, R. Finally:

$$K^{(1)} \equiv u_{rms}^2 \int_0^t R(\tau)d\tau$$

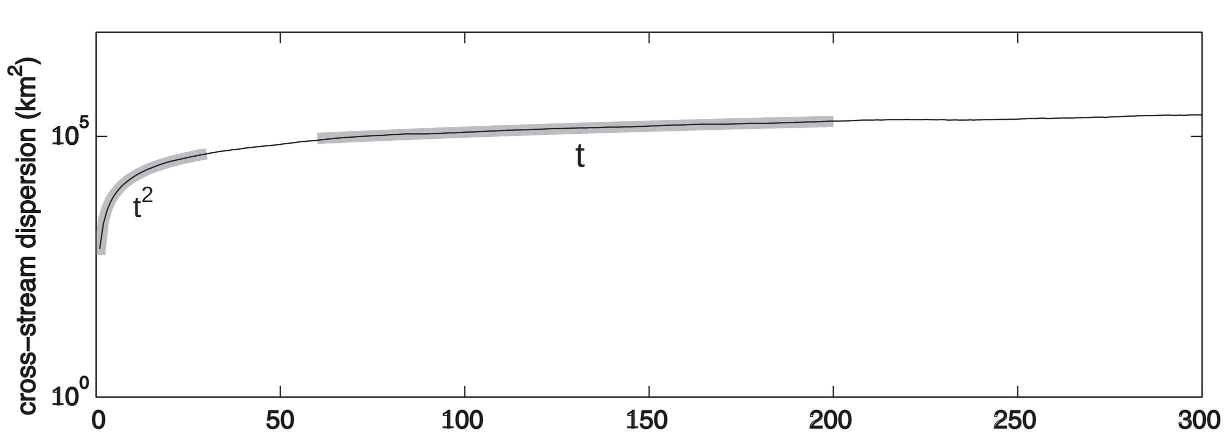
Results

1) Dispersion:

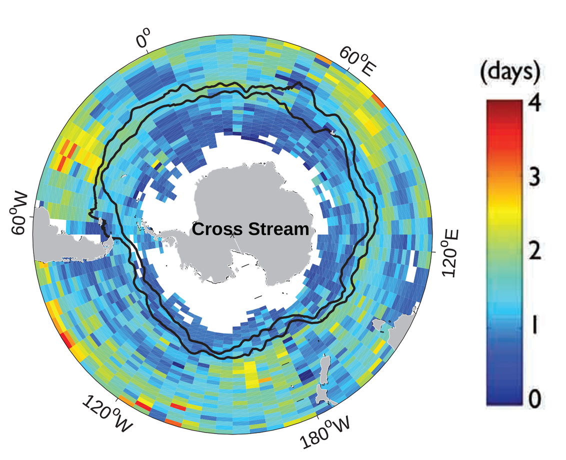
2 regimes:

Quadratic grows in early days

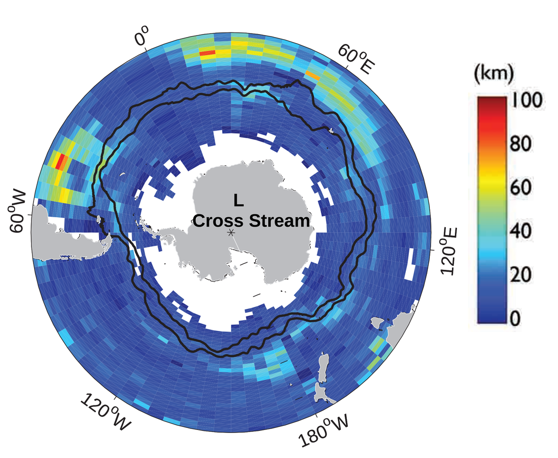
Linear grows from the ~70 days



2) Length and Time scales:

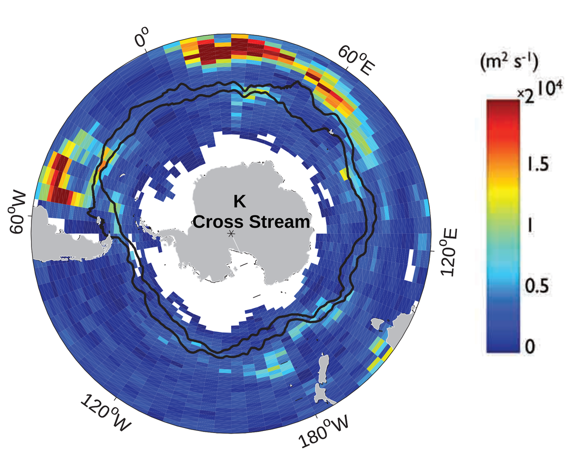


Lagrangian eddy time-scales (days)



Lagrangian eddy space-scales (km)

3) Diffusion:



K from fit to averaged autocorrelation in each bin

1. Large regional variability
2. Very diffusive in the Western Boundary currents
3. Very diffusive when ACC interact with bathymetry

Simulated drifters

In order to separate the processes responsible for the diffusion, we simulate idealized drifter trajectories and recompute the diffusion from them.

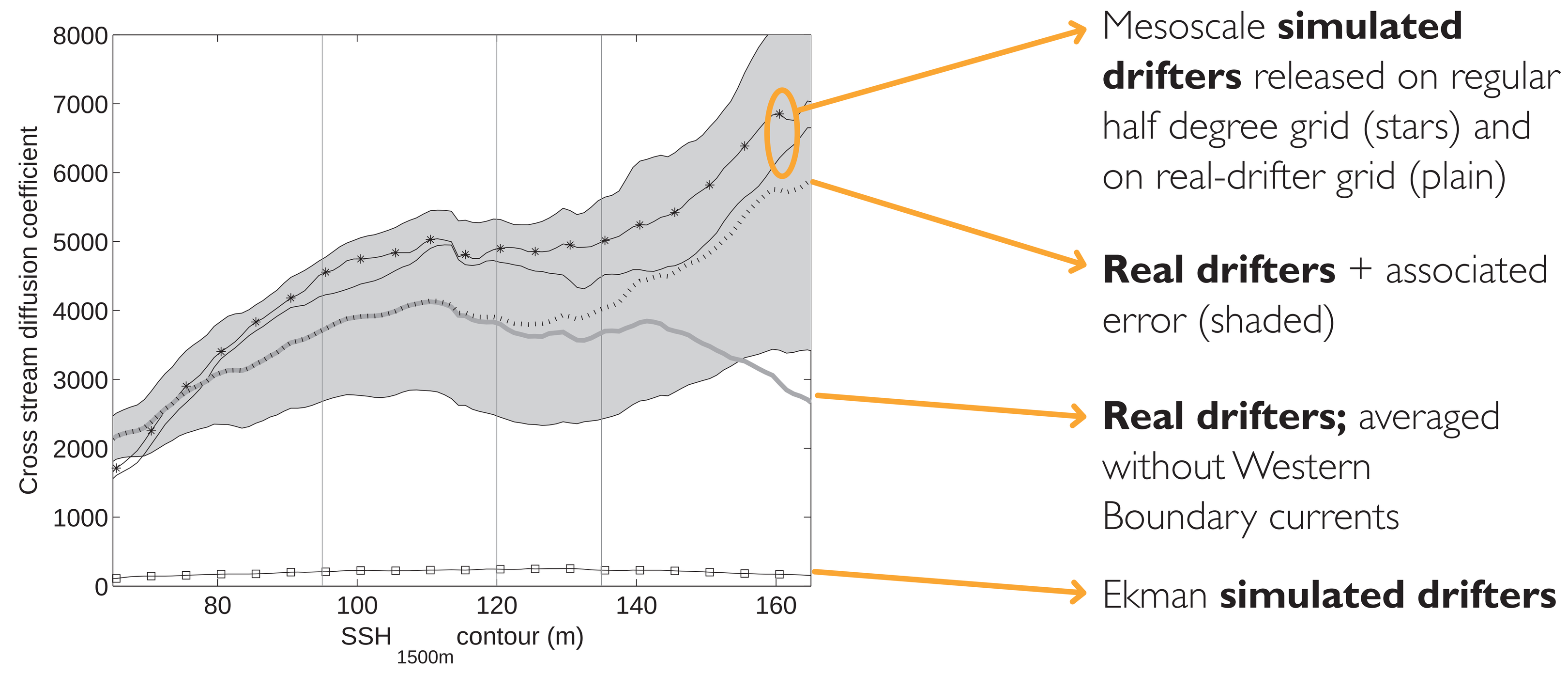
3 simulations:

1. Geostrophic mesoscale only → *Altimetry*
2. Geostrophic mean+mesoscale → *Altimetry + Argo*
3. Ekman only → *QuickScat satellite winds*

Satellite altimetry allow us to isolate the mesoscale component of the diffusion.

Along-stream average picture

Cross-Stream Diffusion



- Higher values than tracer study by Marshall *et al.* (2006). But local tracer studies are consistent with local peaks of diffusion similar to this study (Schuckburg *et al.*, 2008)
- Consistent values with Gulf Stream or Kurushio calculations from GDP drifters.
- Mesoscale geostrophic eddy contribution dominates; Ekman contribution is weak.

Parameterization

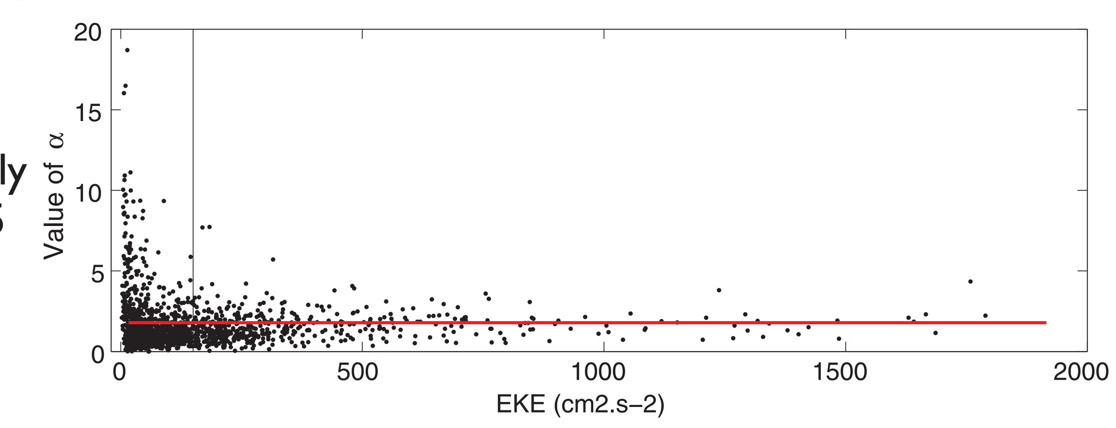
Heavy calculation that require a lot of drifters

→ Can we parameterize the diffusion coefficient from satellite product?

Parametrisation: $K_u = C.\sqrt{(EKE)}.L_d$ (Stammer, 1996)

Problem: Is there a unique C?

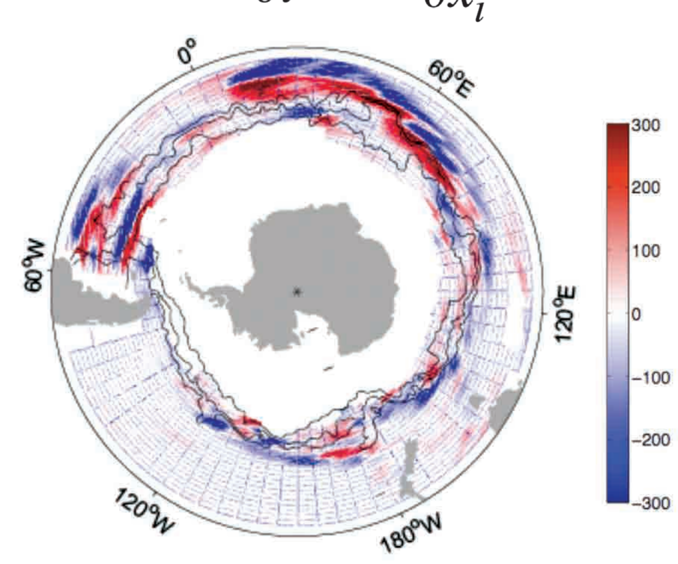
A single coefficient exists only for EKE≥150 cm².s⁻² : C=1.35



Applications: heat diffusion and mass transport in the surface layer

1) Annual mean heat diffusion (W.m-2) in the mixed layer

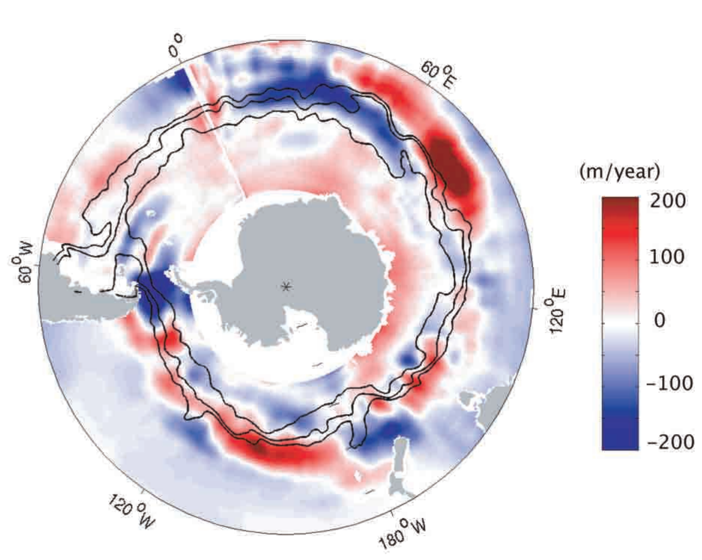
$$\rho c_p \frac{\partial T}{\partial t} = \kappa \frac{\partial^2 T}{\partial x_i^2}$$



Sallee *et al.*, Eddy heat diffusion and Subantarctic Mode Water formation, Geophys. Res. Lett., 2008, 35, L05607

2) Annual mean eddy-induced vertical velocity (m.yr-1)

$$S_{eddy} = \nabla[\kappa.\mathbf{s}]_{z=H_{max}}$$



Sallee *et al.*, Southern Ocean thermocline ventilation, in preparation.

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Florida State University

Further information
contact: jean-baptiste.sallee@csiro.au
CSIRO Marine and Atmospheric Research
GPO Box 1538 Hobart, Tasmania 7001, Australia
www.csiro.au

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