Bottom Currents and Cyclogenesis in Drake Passage

T. Chereskin, K. Donohue, R. Watts, K. Tracey, Y. Firing, and A. Cutting
cDrake goals

Quantify transport & dynamics of the Antarctic Circumpolar Current for 4 years (2007-2011)

- Transport line to determine the horizontal and vertical structure of the time-varying transport.
- Local dynamics array (LDA) to describe the mesoscale eddy field and to quantify the vertical transfer of ACC momentum.
CPIES: current and pressure recording inverted echo sounder

Measures bottom current (50 m off bottom).

Emits 12kHz sound pulses. Measures round trip travel times of acoustic pulses to sea surface and back.

Measures bottom pressure.
cDrake Timeline

Deployment (Nov/Dec 2007) & Recovery (Nov/Dec 2011) cruises

A CPIES array yields daily maps of upper and deep streamfunction.

Look-up tables interpret acoustic travel times as geopotential height (0 referenced to 5000 dbar).

2-D arrays of CPIES estimate horizontal gradients of geopotential to calculate geostrophic velocities.

Velocity profiles are referenced by measured near-bottom currents.

Bottom pressures are leveled using time-mean near-bottom currents.
Bottom Currents and the Antarctic Circumpolar Current

- ACC is a deep reaching current, strongly influenced by topography.
- Bottom torques thought to balance wind stress and wind stress curl that drives the ACC and sets its transport.
- Deep jets make direct observations difficult.
Recent Observations of ACC Bottom Currents

- Instantaneous bottom velocities in the range 4-20 cm/s eastward (Donohue et al., 2001; Cunningham et al., 2003).

- Mean speeds 2-6 cm/s eastward observed in AUSSAF and SAFDE (Phillips and Rintoul, 2000; Meinen et al., 2002).

- Transient eddies can have much larger currents - peak speeds observed in SAFDE were ~30 cm/s.
Record-length (~1 yr) mean currents (50-m above bottom) and standard deviation ellipses

Northern Drake Passage:

Means exceed 10 cm/s at 15 sites. Directions not aligned with surface flow.

Southern Drake Passage:

Mean bottom flow near PF ~5-8 cm/s Directions aligned with the front.

[Mean SAF & PF streamlines identified from altimetry (Lenn et al., JPO 2007)]
Mean (1999-2009) surface EKE from altimetry

Mean (2007-2008) surface EKE from altimetry

Mean (2007-2008) bottom EKE from mapped currents and pressures from cDrake

I/6 degree, 42 levels, MITgcm, assimilation (altimetry; ARGO)

SOSE mean bottom currents (100-m above bottom) and 3500 m pressure anomaly

Courtesy of Matthew Mazloff
SAF/PF meanders and deep cyclogenesis

[Map showing SAF and PF meanders with dates and locations]
Conclusions

- Velocity variance is largest in northern Drake Passage, both at the surface and the bottom.
- Year-long-mean bottom currents between the SAF and PF exceed 10 cm/s, and the direction is not parallel with the surface flow.
- Multiple bottom current events, with peak speeds of 70 cm/s, last for 10 days or more and are correlated between sites separated by 45 km.
- Events indicate deep cyclogenesis occurs in the high EKE zone between the SAF and the PF.
Future Work

- Daily maps of all fields with mesoscale resolution and a separation of the barotropic and baroclinic components.
- Partitioning of ACC transport and transport variability.
- Along-stream momentum and vorticity balance.
- Eddy-mean exchange of momentum and energy.
Hourly time series during eddy event

Peak pressure anomaly of 0.5 dbar

Peak speeds of 60 cm/s
Daily EKE averaged over the LDA

5 events over year

Peak “event” EKE > 350 cm² s⁻²
cDrake southbound, 2007/11/16–2007/11/21

OA velocity at 150 m (vectors)
Streamfunction height in cm (color)

cDrake northbound, 24 Nov to 2 Dec 2007

OA velocity at 150 m (vectors)
Streamfunction height in cm (color)
Figure 1: Mean and standard deviation ellipses from CPIES velocity. Recovered data are indicated in red.