Bottom Currents and Cyclogenesis in Drake Passage

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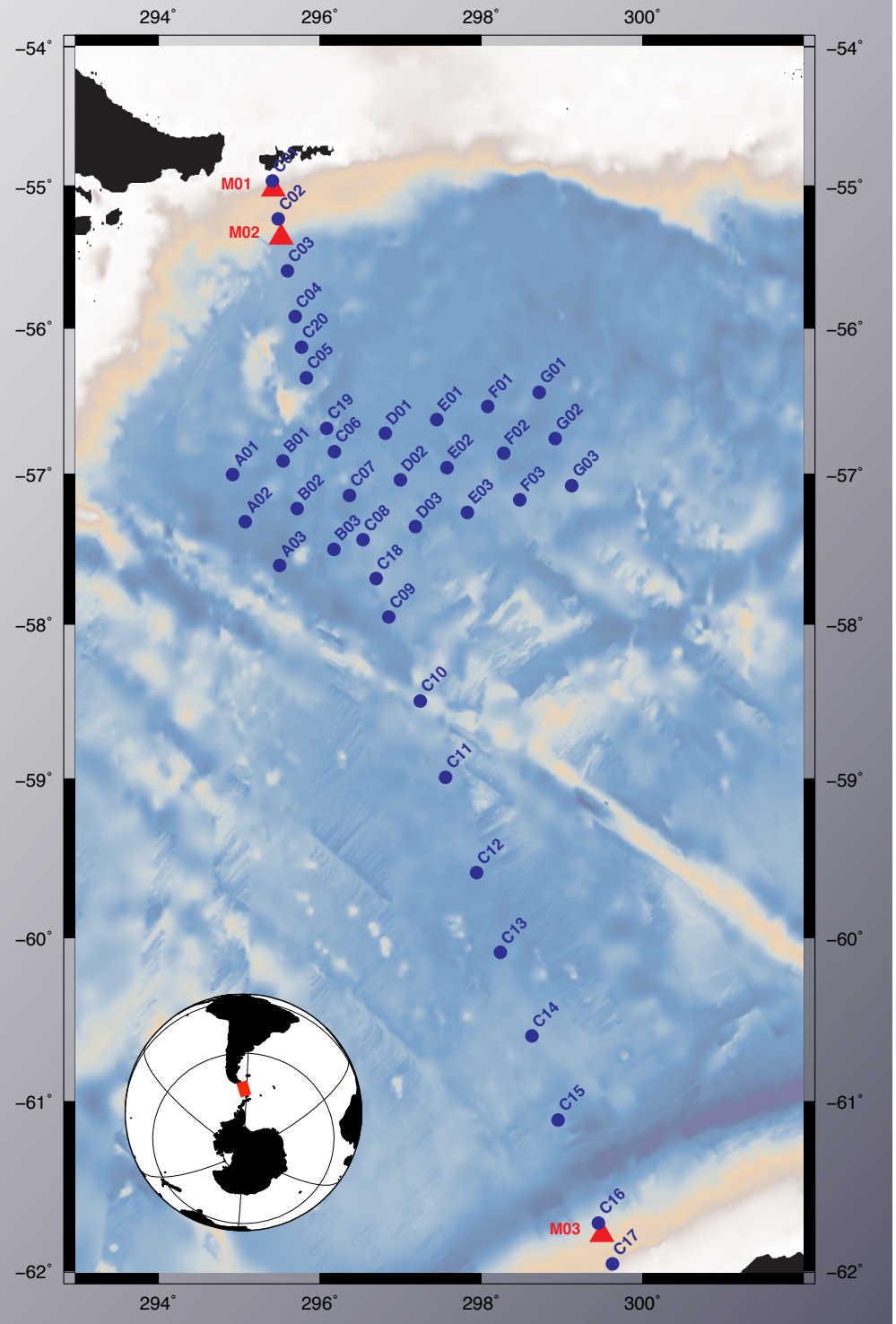
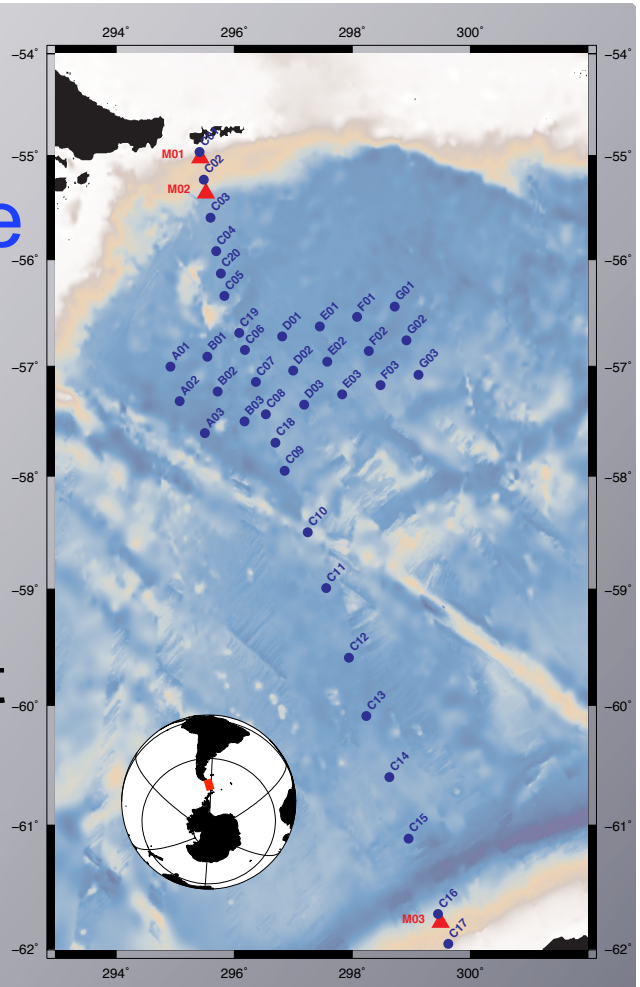
cDrake goals

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

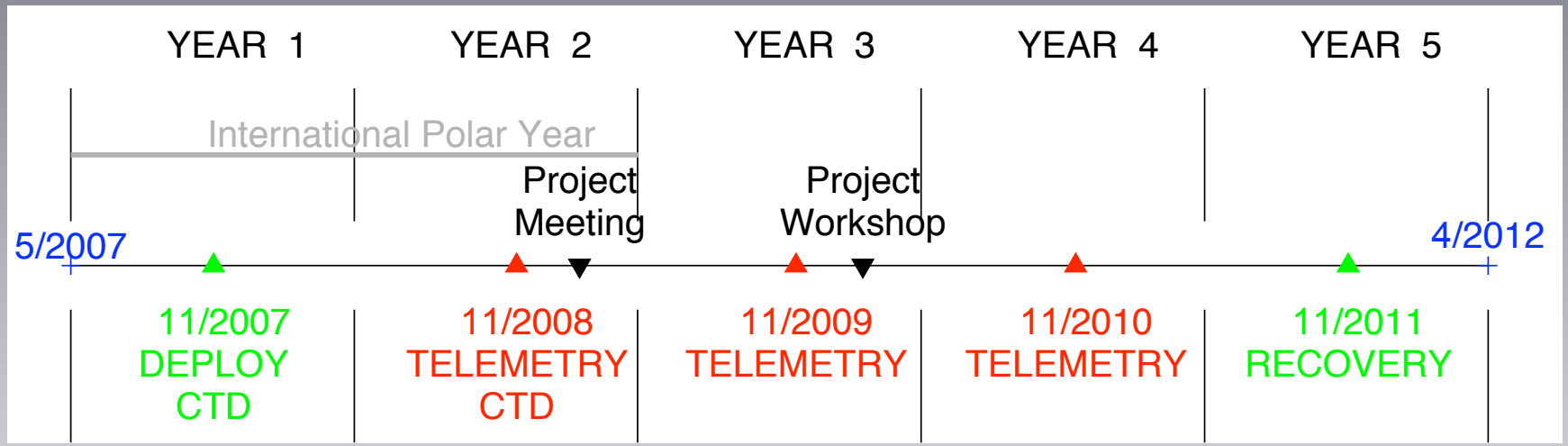


Measures bottom current (50 m off bottom).

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

Measures bottom pressure.

cDrakeTimeline



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

Annual Telemetry cruises (Nov/Dec 2008, 2009, 2010)

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.

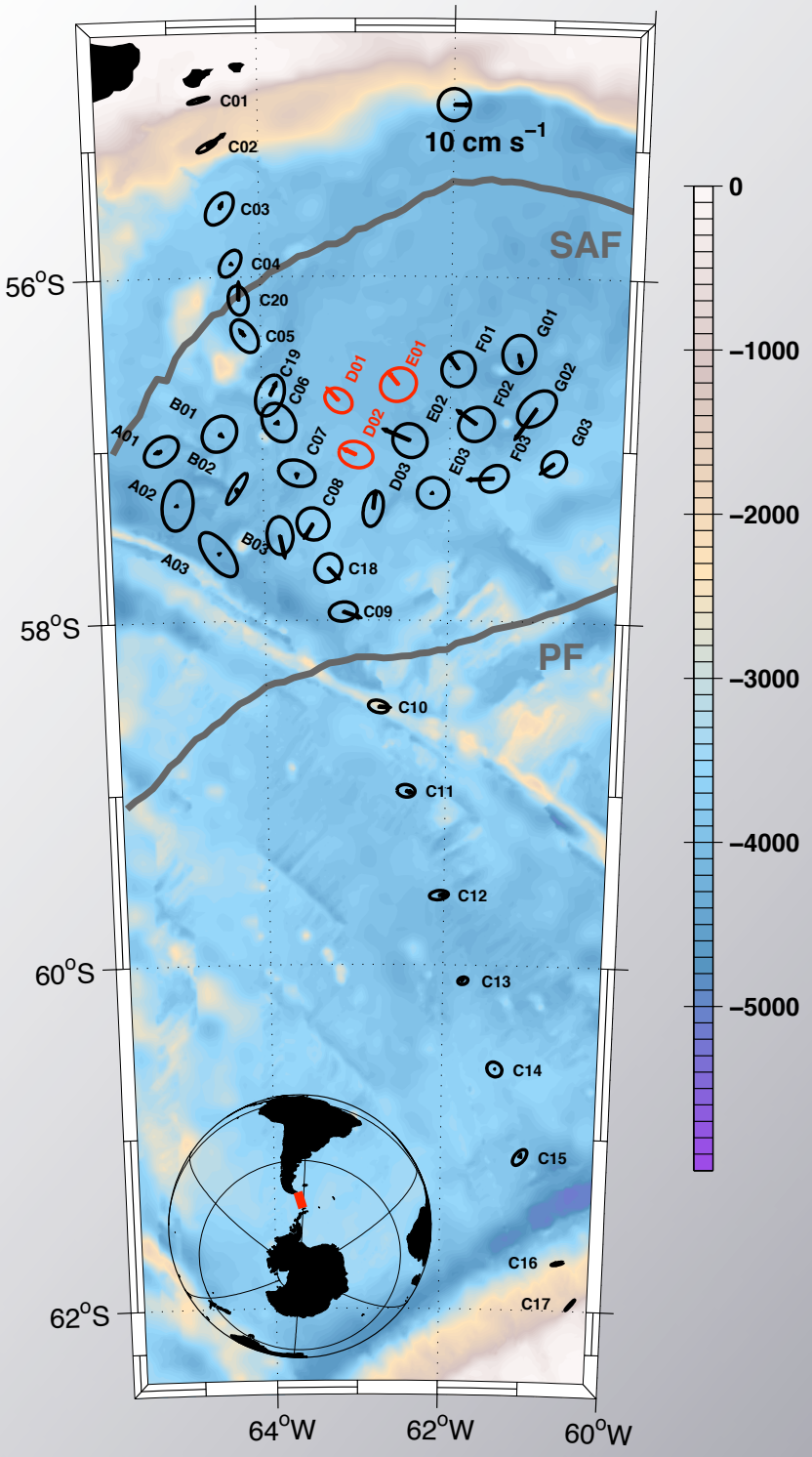
Bottom pressures are leveled using time-mean near-bottom currents.

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:

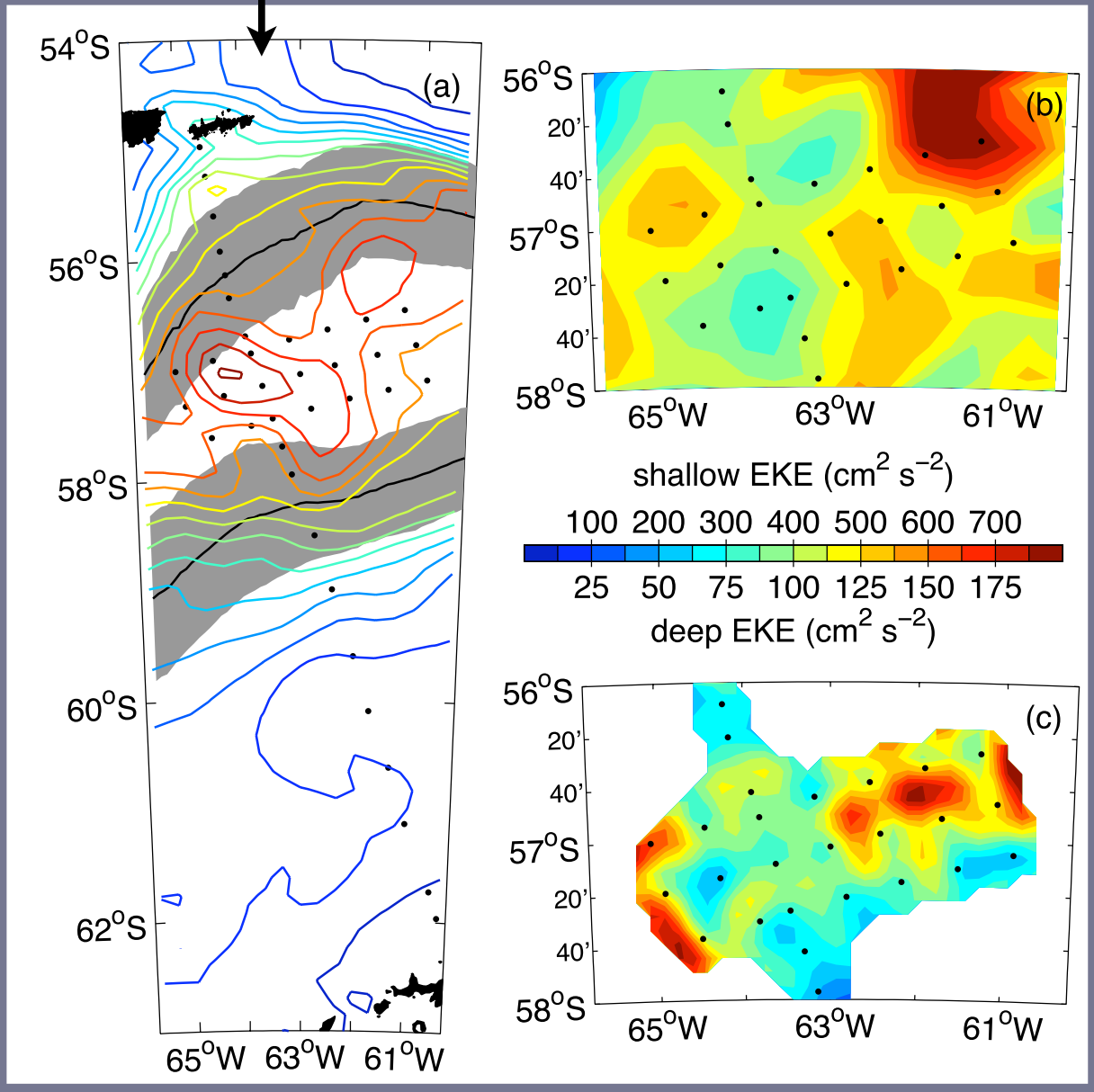
Means exceed 10 cm/s at 15 sites.
Directions not aligned with surface flow.

Southern Drake Passage:

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

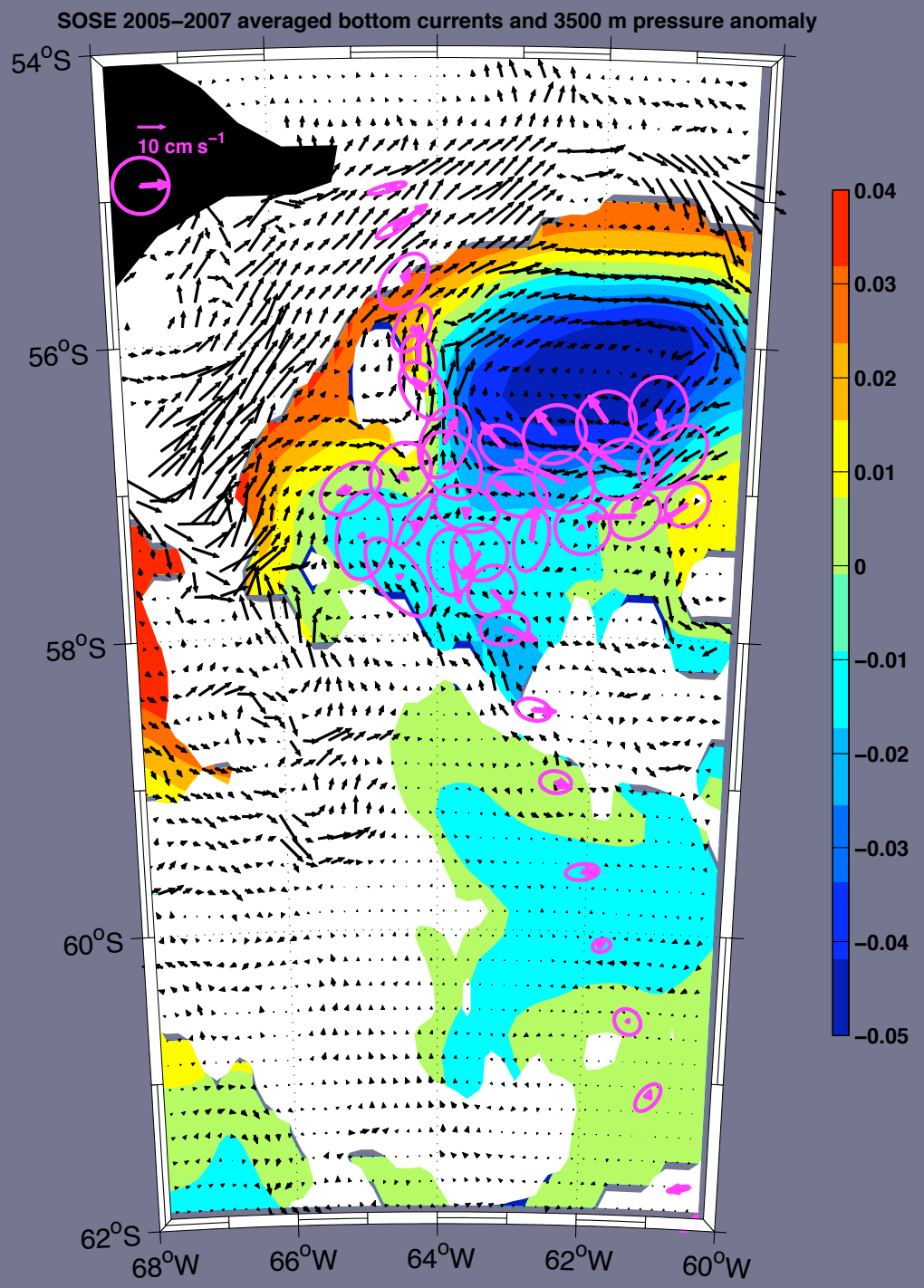
[Mean SAF & PF streamlines identified from altimetry (Lenn et al., JPO 2007)]

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

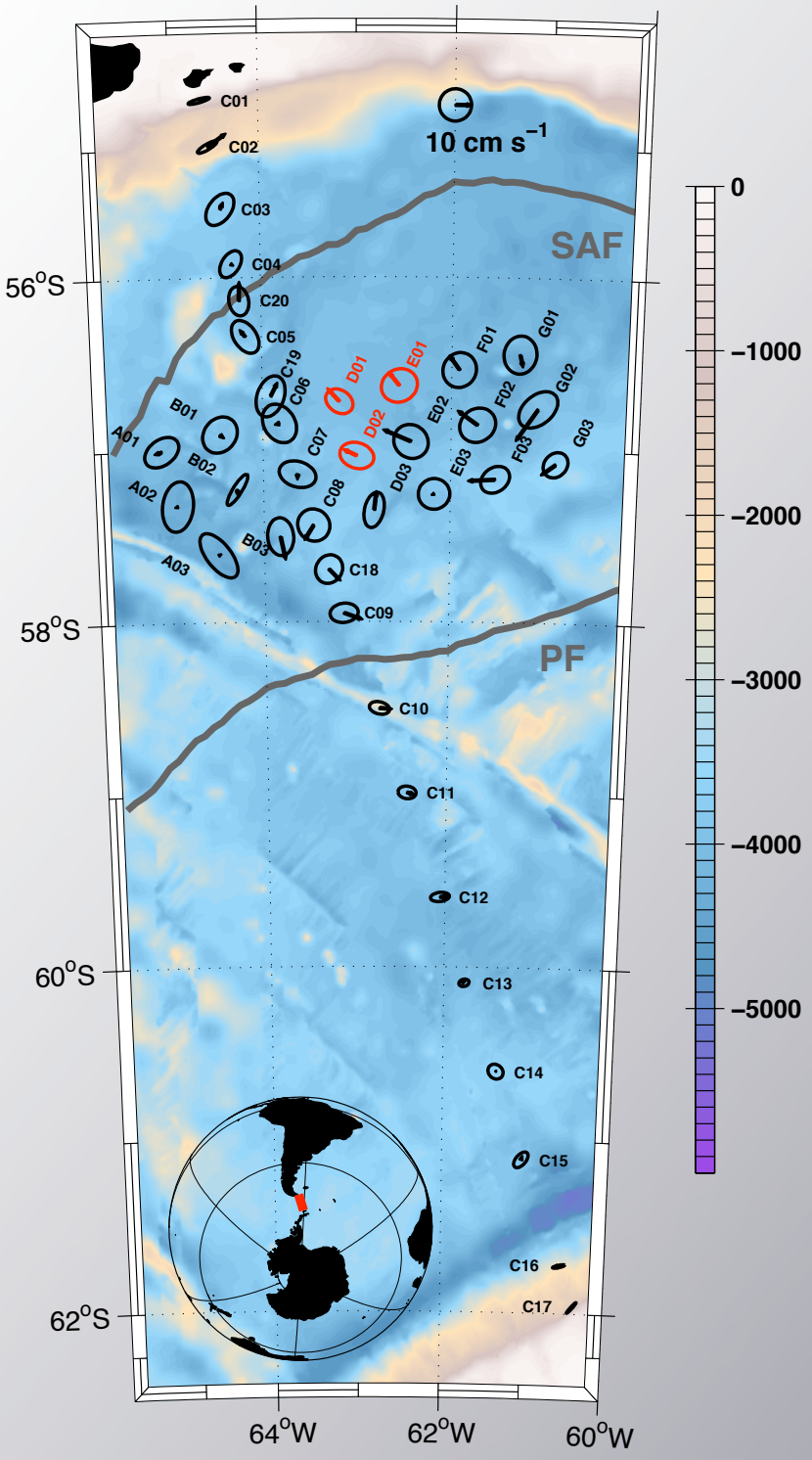


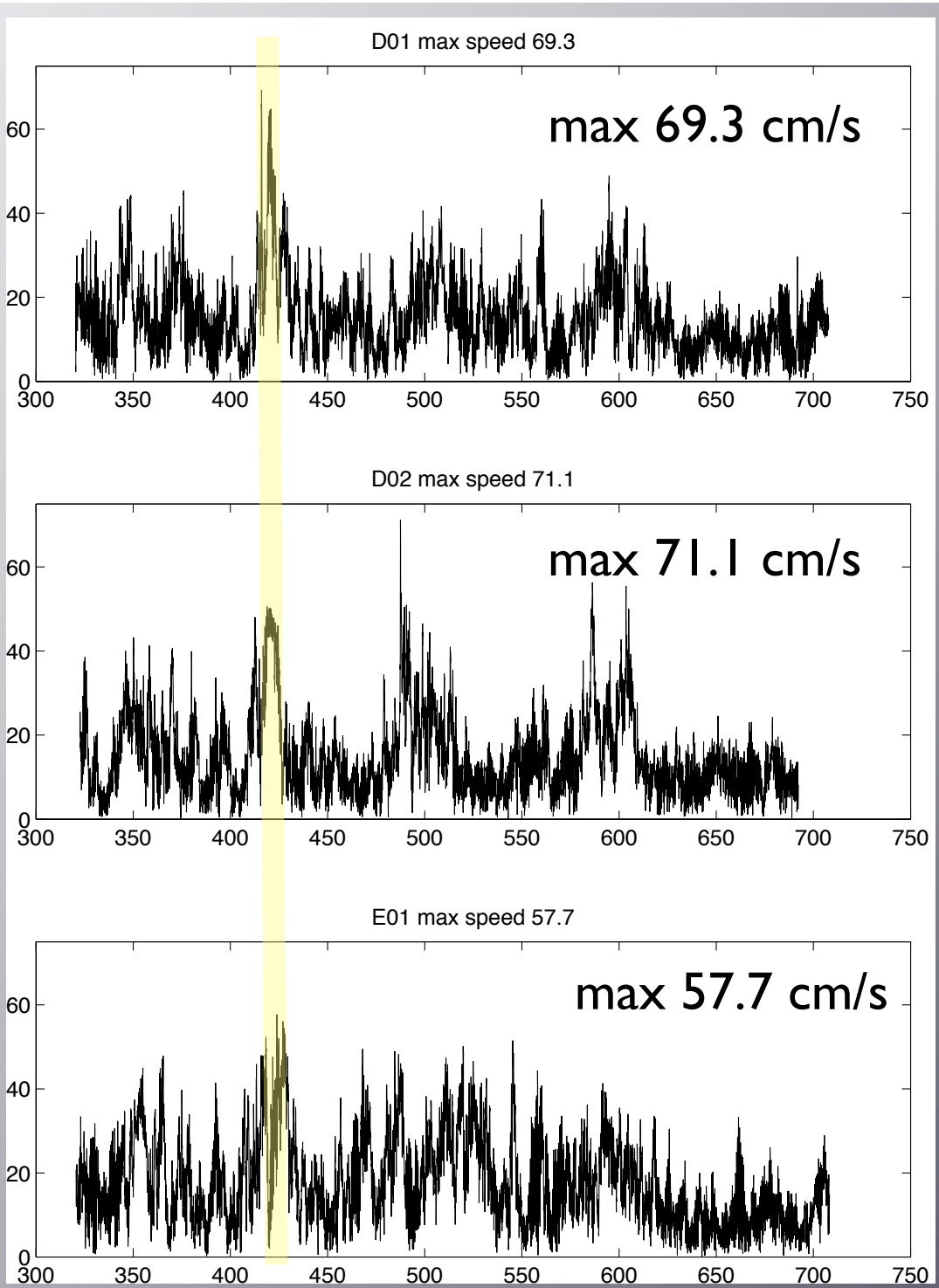
Southern Ocean State Estimate (SOSE) 2005-2007

1/6 degree, 42 levels, MITgcm, assimilation (altimetry; ARGO)

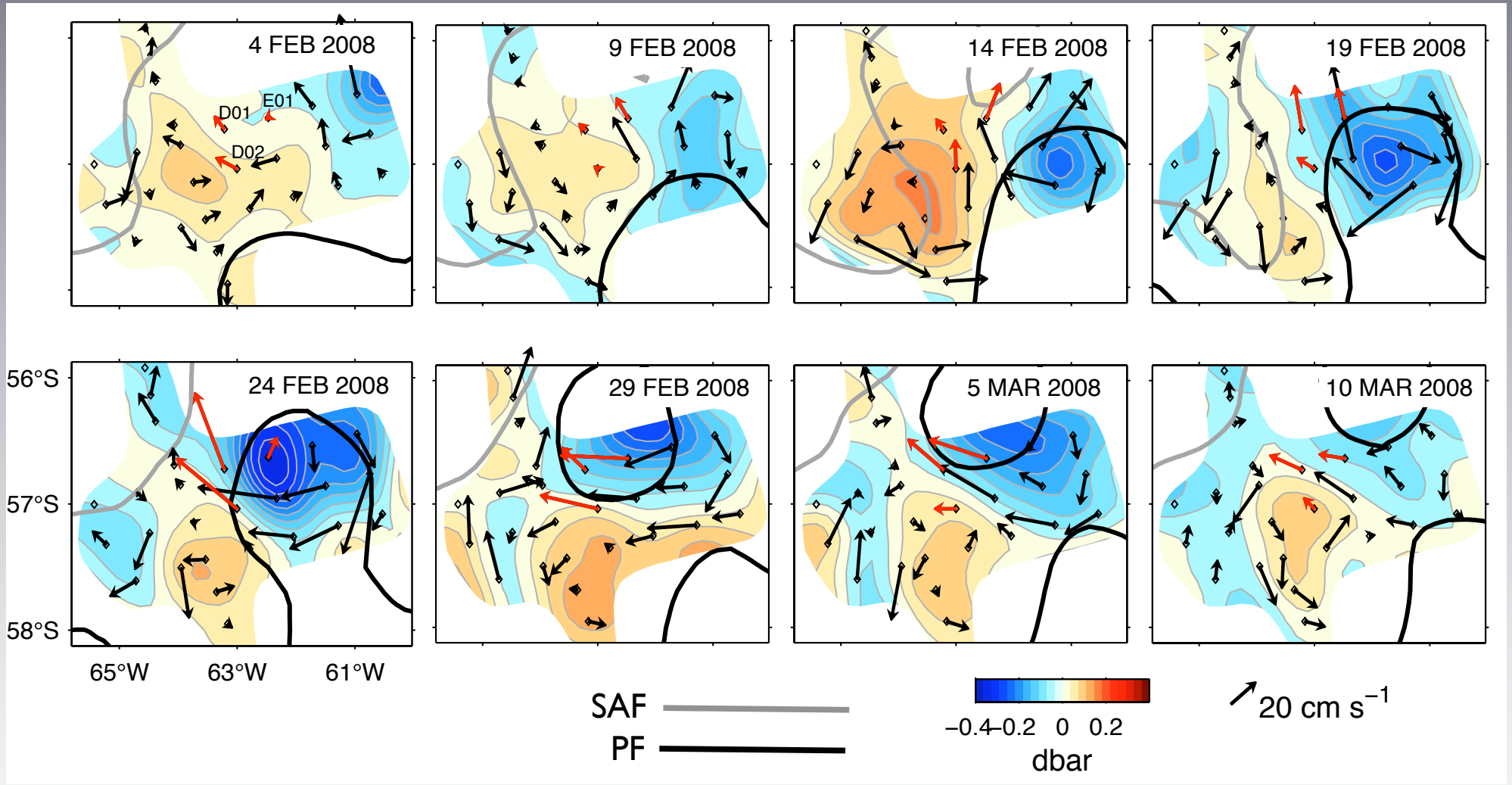
SOSE mean bottom currents (100-m above bottome) and 3500 m pressure anomaly

Courtesy of Matthew Mazloff


10 cm s^{-1}
SAF
PF
C01
C02
C03
C04
C20
C05
C19
C06
C07
C08
C09
C10
C11
C12
C13
C14
C15
C16
C17
C18
A01
A02
A03
B01
B02
B03
D01
D02
D03
E01
E02
E03
F01
F02
F03
G01
G02
G03
56°S
58°S
60°S
62°S
64°W
62°W
60°W
0
−1000
−2000
−3000
−4000
−5000


D01 max speed 69.3
max 69.3 cm/s
D02 max speed 71.1
max 71.1 cm/s
E01 max speed 57.7
max 57.7 cm/s
0
20
40
60
300
350
400
450
500
550
600
650
700
750

SAF/PF meanders and deep cyclogenesis



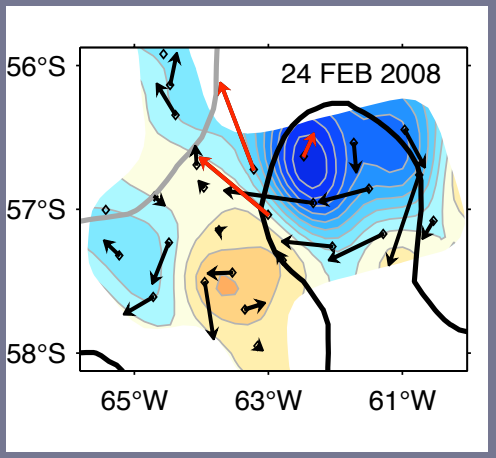
Conclusions

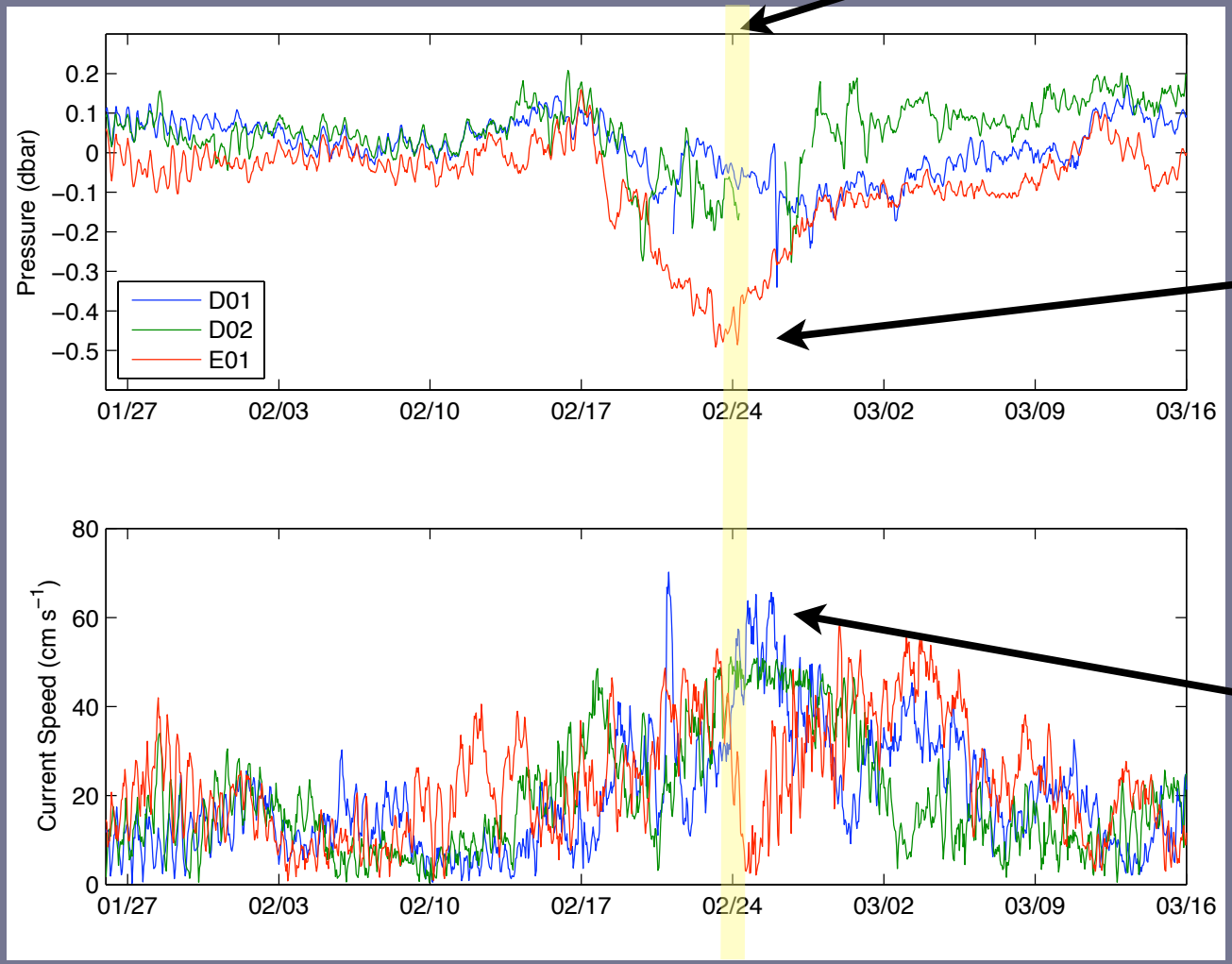
- Velocity variance is largest in northern Drake Passage, both at the surface and the bottom.
- Year-long-mean bottom currents between the SAF and PF exceed 10 cm/s, and the direction is not parallel with the surface flow.
- Multiple bottom current events, with peak speeds of 70 cm/s, last for 10 days 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





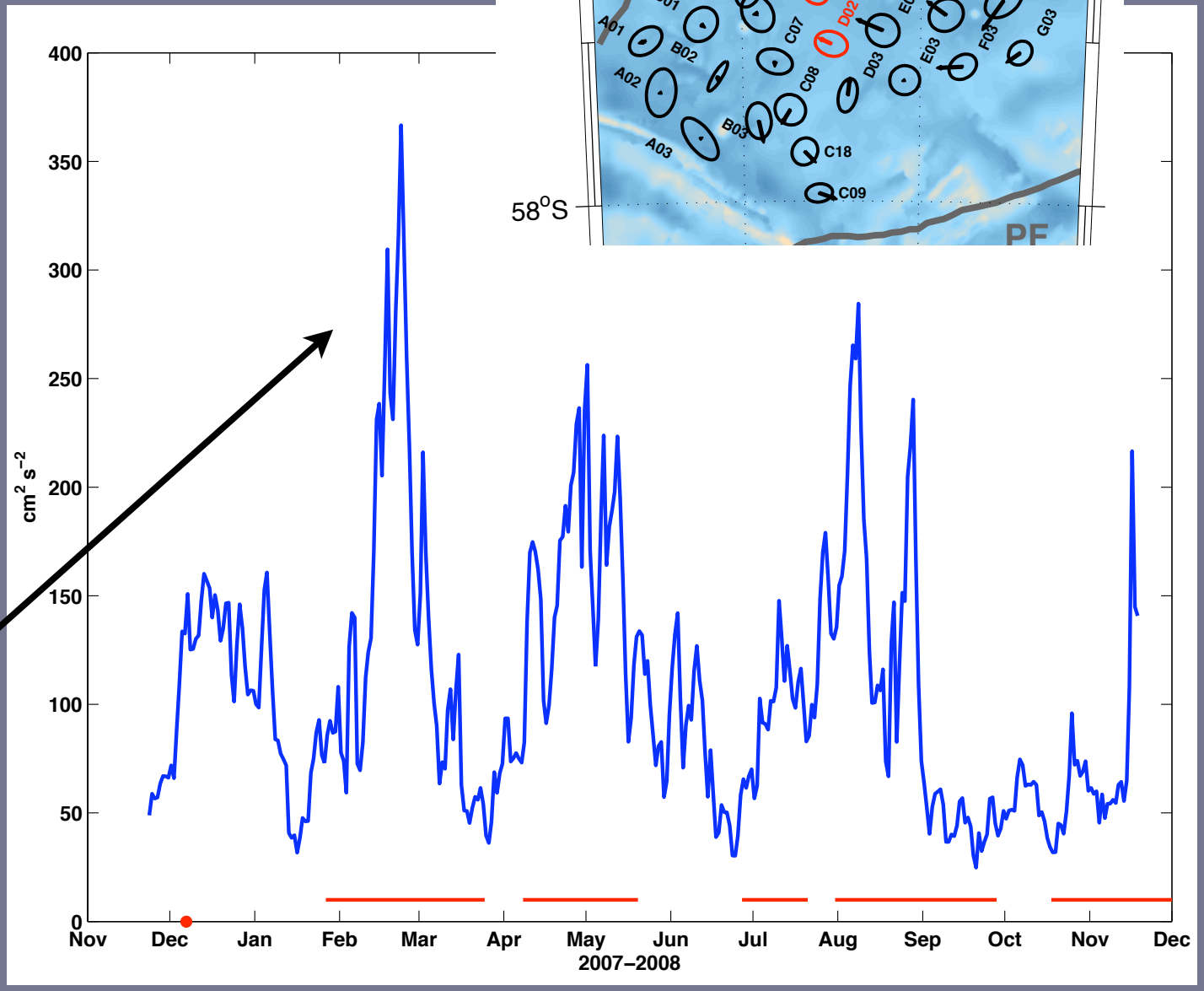
Peak pressure anomaly of 0.5 dbar

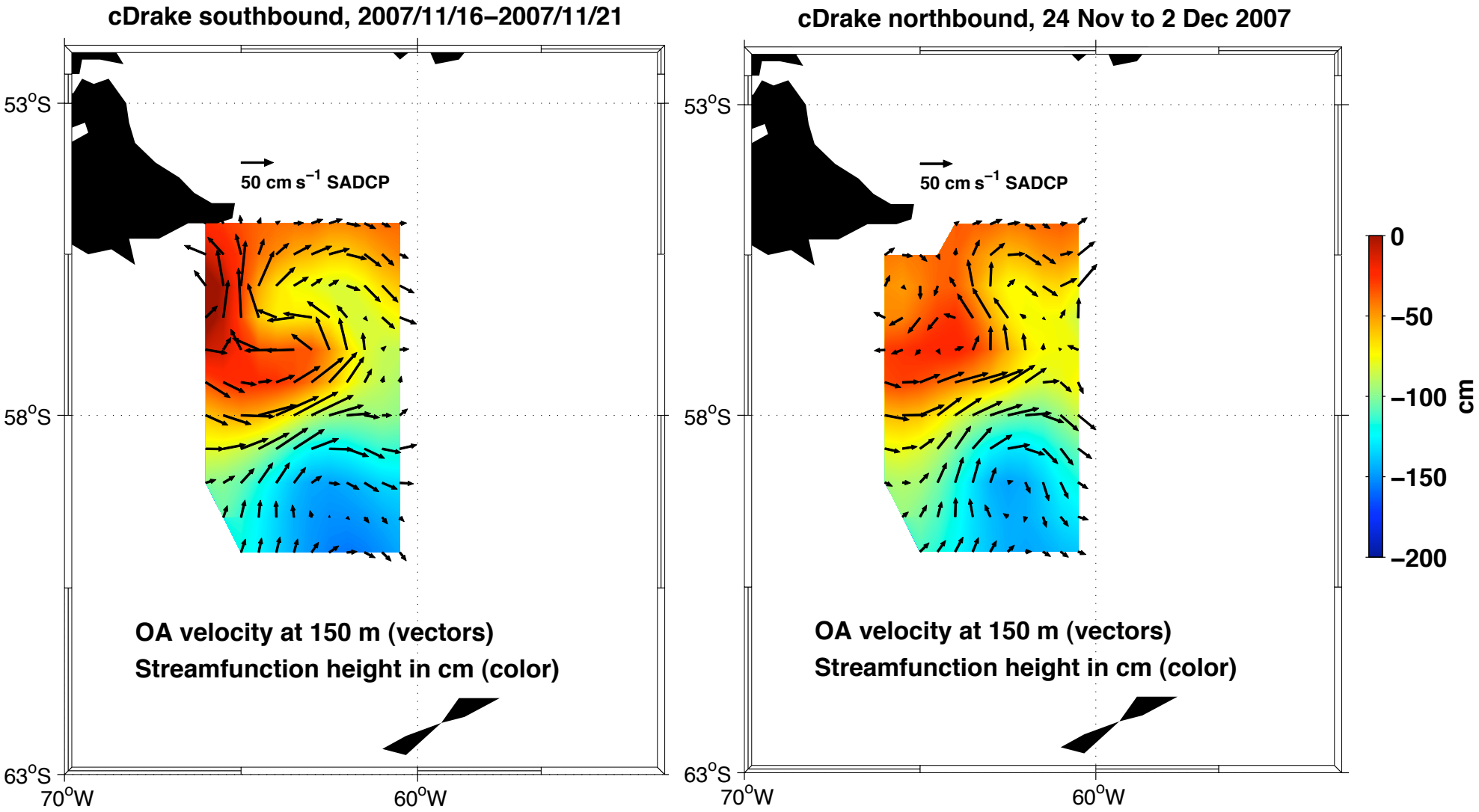
Peak speeds of 60 cm/s

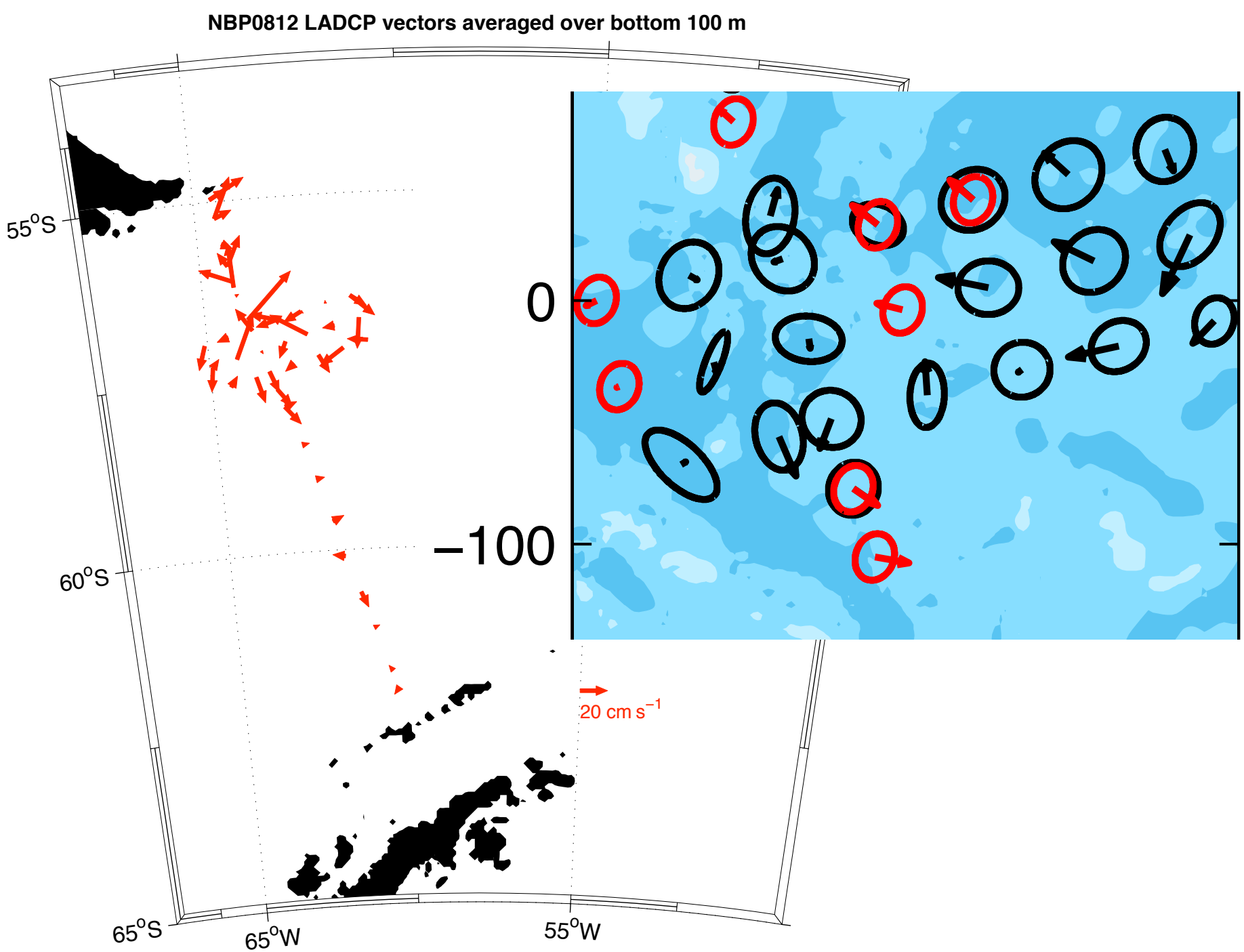
Daily EKE averaged over the LDA

5 events over year

Peak "event" EKE > 350 $cm^2 s^2$




cDrake southbound, 2007/11/16–2007/11/21
cDrake northbound, 24 Nov to 2 Dec 2007
50 cm s−1 SADCP
OA velocity at 150 m (vectors)
Streamfunction height in cm (color)
53°S
58°S
63°S
70°W
60°W
0
−50
−100
−150
−200
cm


NBP0812 LADCP vectors averaged over bottom 100 m
55°S
60°S
65°S
65°W
55°W
0
−100
20 cm s−1