Currents and Mixing in the Southern Ocean

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- Where might AVISO gridded fields fall short?
- What are length and time scales for Southern Ocean variability?
- How well can we line up biology and physics? SST, color, and altimetry
Why can’t we stick to AVISO gridded fields?

• For most purposes AVISO fields are great.
  — Basin modes in south Pacific (with Wilbert Weijer)
  — Geostrophic advection in Drake Passage (with Marina Frants)
  — Kelvin wave propagation along Indonesian Archipelago (with Kyla Drushka)

• Problems with gridded AVISO fields:
  — Higher moment statistics: skewness and kurtosis
  — Small-scale filamented features
Finding Frontal Features in the Ocean: Skewness

Thompson and Demirov, JGR, 2006
Skewness and Frontal Features

Thompson and Demirov, JGR, 2006
Finding Frontal Features in the Ocean: Skewness

Gille and Sura, in preparation, 2008
Skewness: Agulhas Retroflection

Thompson and Demirov, JGR, 2006
Skewness: Along Track versus Gridded Data

Gille and Sura, in preparation, 2008
Skewness: Key Issues

- Skewness serves as diagnostic for frontal position.
- Higher statistical moments also relevant for assessing impact of rare eddies versus smooth background flow.
- Mapping is like averaging. Central limit theorem implies mapped fields will be more Gaussian than raw data.
- Swath data with comparable accuracy/smoothing at all points will allow us to make better use of higher moment statistics in diagnosing eddy processes.
Eddies in the Southern Ocean: Small Rossby Radius

Rossby radius data from Chelton et al., JPO, 1998
Ocean Color: Isolated Regions of High Productivity

- Southern Ocean is usually classed as a high nutrient/low chlorophyll region.
- Biological productivity appears linked to iron input (Martin, 1990).
- Oceanic CO$_2$ uptake linked to variations in productivity.

Moore and Abbott, JGR, 2000
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Eddies and Mixing: The “Blue Water Zone”

Kahru et al., GRL, 2007
Bathymetry Steers Biological Productivity?

Water Mass Analysis Suggests Filamented Flow

Frants et al., in preparation, 2008: Optimal Multiparameter Analysis for Mixed-Layer
Chlorophyll shows cyclonic and anticyclonic eddies

26-30 January 2005: Kahru et al., GRL, 2007
Chlorophyll and SST in Southern Drake Passage

28 January 2004. Anticyclonic eddy diameter \(\sim 220 \text{ km}\); Filaments \(< 20 \text{ km}\)

Kahru et al., GRL, 2007
Chlorophyll and SST and dynamic topography

28 January 2004. Eddy diameter $\sim 220$ km; Filaments $< 20$ km

Kahru et al., GRL, 2007, AVISO mean sea surface height
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Kahru et al., GRL, 2007, AVISO mean sea surface height

- Temperature within eddy (5\(^\circ\)C) also found along northern edge of front.
- Dynamic height range from region containing eddy to front is about 20 cm.
1 January 2006. Eddy diameter $\sim 100$ km; Filaments $< 20$ km

Kahru et al., GRL, 2007
SST Cyclonic Eddies and Altimetry

SST 1 January 2006
Kahru et al., GRL, 2007

28 Dec. 2005 mean SSH
AVISO

4 Jan 2006 mean SSH
AVISO
SST Cyclonic Eddies and Altimetry

SST 1 January 2006
Kahru et al., GRL, 2007

28 Dec. 2005 mean SSH
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4 Jan 2006 mean SSH
AVISO
What brings iron to southern Drake Passage?

Kahru et al., 2007:
- Suggest possibility of eddy-induced upwelling in cyclonic eddies.
- Correlate rms negative sea-level anomaly with chl-a (for September/October).

Frants et al., in prep:
- Suggest displacements of 19 cm dynamic height contour indicate off-shore iron advection (for November, December, January).
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- Existing altimeter data not sufficient to distinguish eddy upwelling from off-shore advection.
- Neither hypothesis explains persistent February and March bloom.
Summary

• What new dynamics can we study with O(10) km resolution SSH? *Processes governing iron supply to Southern Ocean depend on small scale structures and are not well observed.*

• How large an SSH signal would those dynamics produce? 20 cm??

• What is the desired highest spatial resolution? 10 km

• What is the desired precision? 5-10 cm

• Spatial coverage vs temporal coverage? *Physics would benefit from either. Bathymetry matters, so could be a reason to pursue full spatial coverage.*

• Other signals that might interfere? *On shelf, tides. At southern edge of domain, seasonal ice.*

• Complementary measurements? *Color and SST. Because of persistent cloud cover, microwave SST would be ideal, if resolution could be improved.*
Extra Discussion Material
CROZet natural iron bloom and Export experiment (CROZEX)

Kerguelen Ocean and Plateau compared Study (KEOPS)

SeaWiFS. http://www.obs-vlfr.fr/proof/vt/op/ec/keops/keo_obj_context.htm
- Where do existing gridded fields fall short?
- What are length scales of variability?
- What are time scales of variability?
- How big is sea surface height gradient for relevant features?