Deriving ocean surface currents from remote sensing techniques

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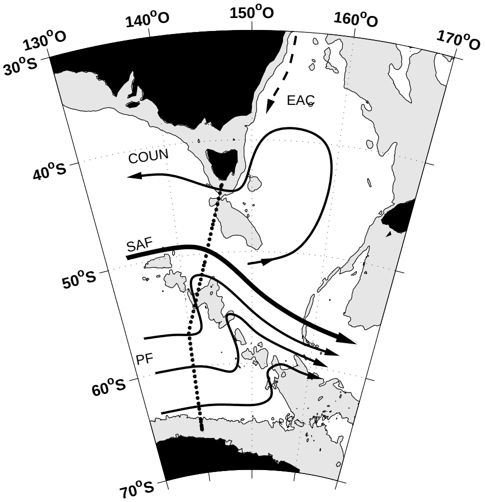
Hamburg, 12.06.2010

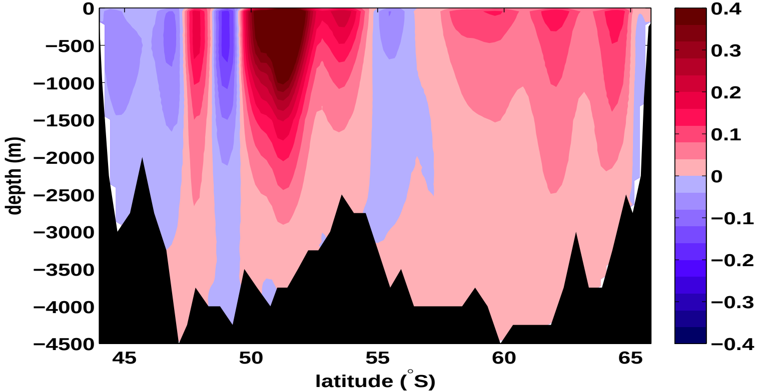
SR3 section



Assimilation:

- temperature
- salt
- velocities

Ocean model result

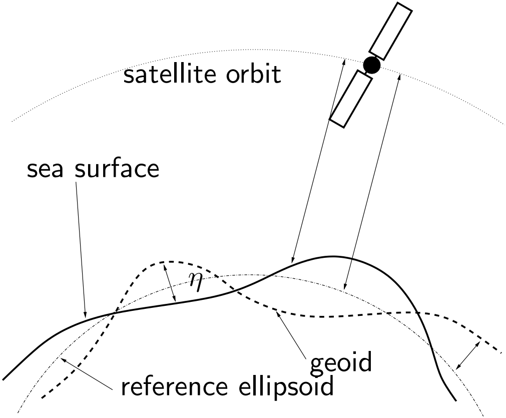


Transport across section: **159 ± 64 Sv**

Formal errors: Inverse of the Hessian of the cost function.

Mean dynamic topography

- geostrophic balance: $\frac{\partial \eta}{\partial \mathbf{x}} = \frac{\mathbf{f}}{\mathbf{g}}\mathbf{v}$ => reference surface velocity
- $\eta = \mathbf{h} - \mathbf{N}$



Problems with the geoid!

- geoid models describe short scales not sufficiently for oceanography
- omission error is generally neglected
  => underestimation of the geoid model error
- "higher" accuracy => larger formal error
- considering omission error => "complete" geoid models

Is it possible to improve the ocean models by assimilating MDT?

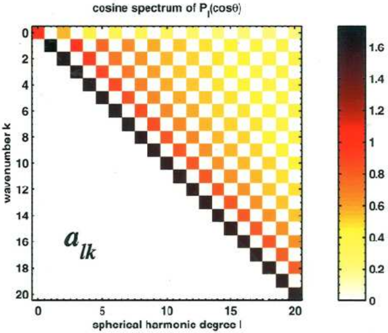
Principle for omission error problems

Homogeneous, isotropic covariance function for geoid model

$$C(\psi) = \sum_{l=0}^{L} p_l P_l(\cos\psi) = \sum_{l=0}^{L} p_l \sum_{k=0}^{l} a_{lk} \cos k\psi = \sum_{k=0}^{L} c_k \cos k\psi$$

with the (Fourier-) coefficients

$$c_k = \sum_{l=k}^{L} p_l a_{lk}$$



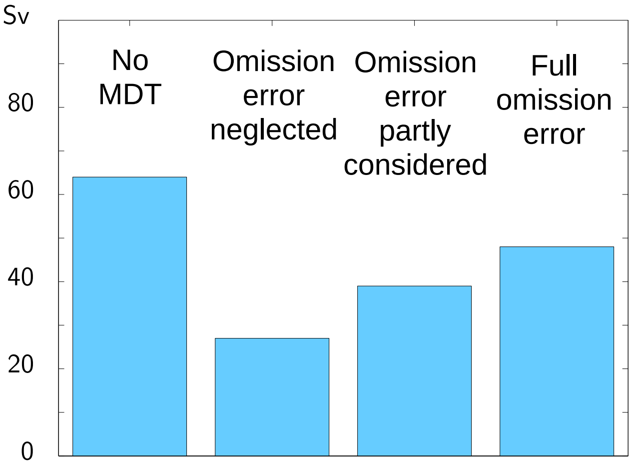
Ocean model parameters

Free to choose:

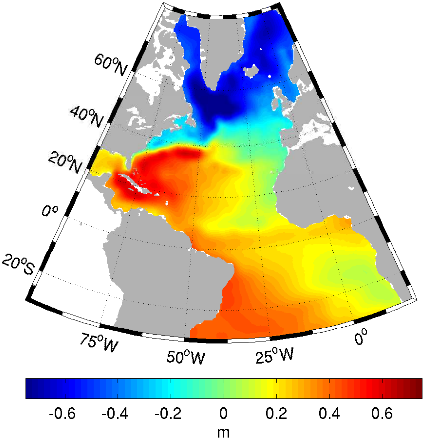
- discretization method
- number of iterations
- bottom (reference) velocities
- roughness parameters
  for salinity, temperature, horizontal velocities
- prior error estimations

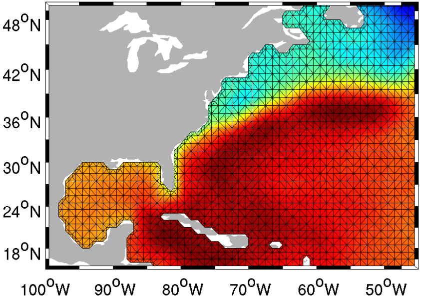
$\rightsquigarrow$ Transport across section: **174 $\pm$ 48 Sv**

Transport error estimates

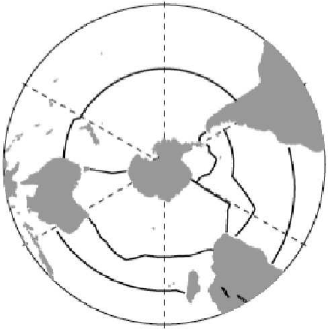


Stationary 3D model: IFEOM





Inverse box model for the Southern Ocean



e.g. Sloyan and Rintoul (2001),
Losch, Sloyan, Schröter and Sneeuw (2002)

Ice drift algorithm

$$\begin{bmatrix} \bar{c}_u \\ \bar{c}_v \end{bmatrix} = \begin{bmatrix} \bar{U} \\ \bar{V} \end{bmatrix} - F \cdot \begin{bmatrix} \cos\theta & -\sin\theta \\ \sin\theta & \cos\theta \end{bmatrix} \begin{bmatrix} \bar{u} \\ \bar{v} \end{bmatrix}$$

Turning angle: $\theta = \arctan\left[\frac{\sum u'V' - \sum v'U'}{\sum u'U' + \sum v'V'}\right]$

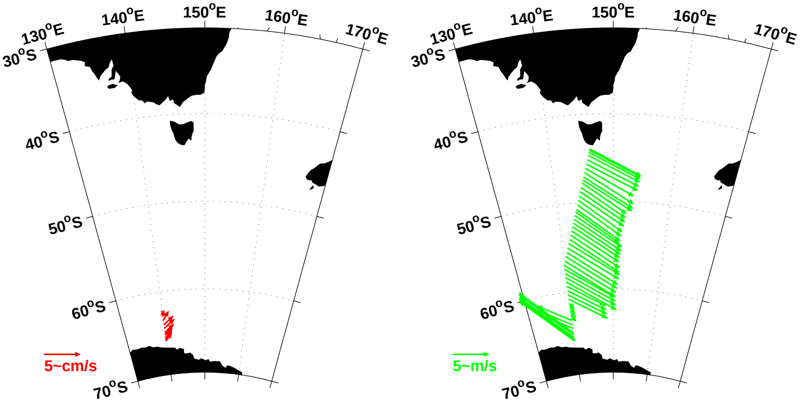
Speed reduction factor:

$$F = \frac{\cos\theta \sum u'U' + \sin\theta \sum v'U' - \sin\theta \sum u'V' + \cos\theta \sum v'V'}{\sum u'^2 + \sum v'^2},$$

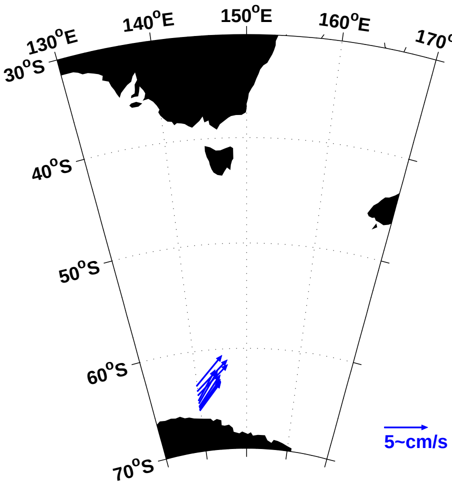
$u' = u - \bar{u}$ etc.

(N. Kimura: Sea Ice Motion in Response to Surface Wind and Ocean Current in the Southern Ocean, JMSJ 2004.)

Ice drift and wind data



Resulting ocean surface currents



Mass transport across section:

173 ± 46 Sv

Summary

Mass transport across section for the 3 cases:

Ocean model only:	**159 ± 64 Sv**
Ocean with dynamic topography:	**174 ± 48 Sv**
Ocean with drifting sea ice:	**173 ± 46 Sv**

Thank you for your attention!

? *Questions* ?