RIFUGIO
- Rigorous Fusion of Gravity Field into Stationary Ocean Models

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Project idea

- combine complete geoid models as developed by project partners at IGG-GT with altimetry to obtain mean dynamic topography (MDT)
- use simple stationary ocean models to test this MDT

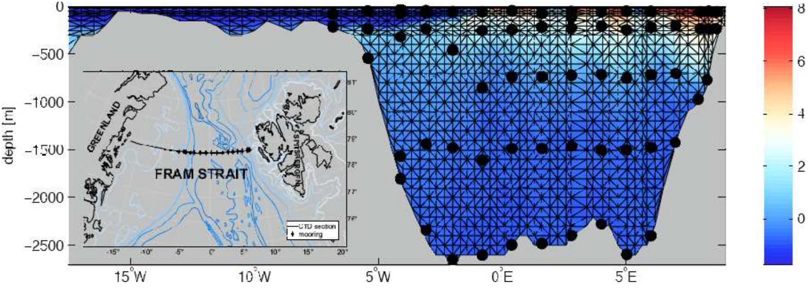
Why stationary ocean models?

- Pro:
  - compact and fast
  - many integrations possible
  - realistic solutions for present application with stationary geoid model and MDT
- Contra:
  - simplified physics, restricted application
  - adjustment processes not represented

We will use ...

- a geostrophic (diagnostic) section model (FEMSECT)
- a geostrophic box inverse model (Bernadette Sloyan)
- stationary 3D circulation model IFEOM (Dimitry Sidorenko)

Section model FEMSECT

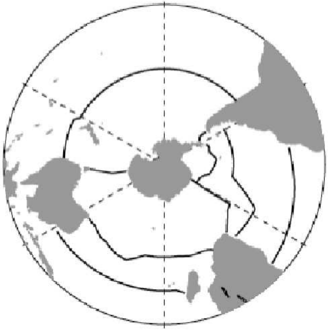


Thermal wind equation with reference velocity problem

$$f\frac{\partial v_g}{\partial z} = -\frac{g}{\rho}\left(\frac{\partial \rho}{\partial x}\right)_p$$

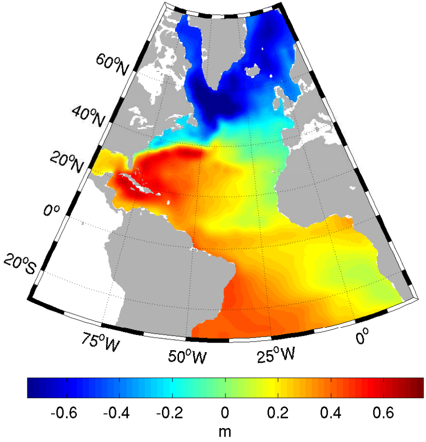
(Losch, Sidorenko, Beszczynska-Möller 2006)

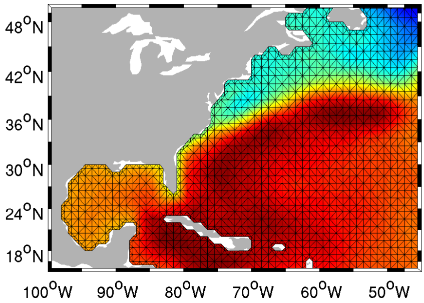
Inverse box model for the Southern Ocean



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

Stationary 3D model: IFEOM



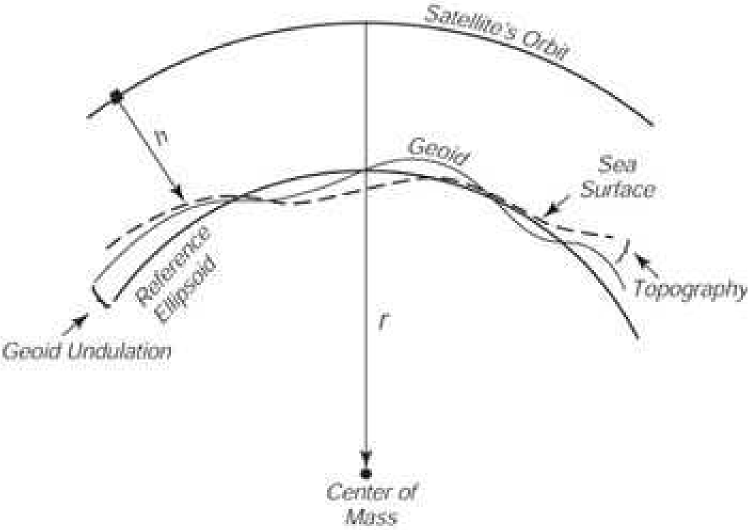


Stationary 3D model: IFEOM

$$
\begin{aligned}
f \times \vec{u} - \nabla \cdot A_h \nabla \vec{u} + \frac{1}{\rho} \nabla p &= 0 \\
\nabla \cdot \vec{u} + \partial_z w &= 0 \\
\nabla_3 \cdot [(\vec{u}, w) T] - \nabla_3 \cdot K \nabla_3 T &= \epsilon_T \\
\nabla_3 \cdot [(\vec{u}, w) S] - \nabla_3 \cdot K \nabla_3 S &= \epsilon_S
\end{aligned}
$$

Dimitry Sidorenko et al (2006)

mean dynamic topogr. = sea surface height - geoid height



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MDT = Altimetry - Geoid

- $\eta = h - N$
- information about the entire water column:
  $\frac{\partial \eta}{\partial t} + \nabla_z \int \mathbf{u} \, dz = E - P$
- geostrophic balance: $g \frac{\partial \eta}{\partial x} = fv$ solves the reference velocity problems of geostrophic models with thermal wind equations
- but: requires filtering before $h - N$ is useful for oceanography

Omission error

- different representations of geoid models and ocean model can lead to an underestimation of the geoid model error
- $C_{MDT} = C_{SSH} + C_N \quad \text{with} \quad C_N = C_L + C_{om}$

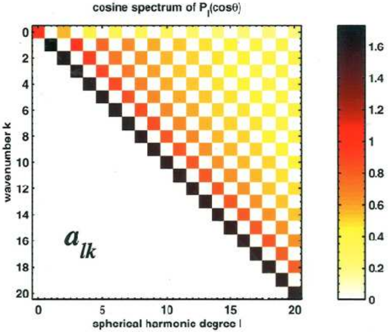
Principle for omission error problems

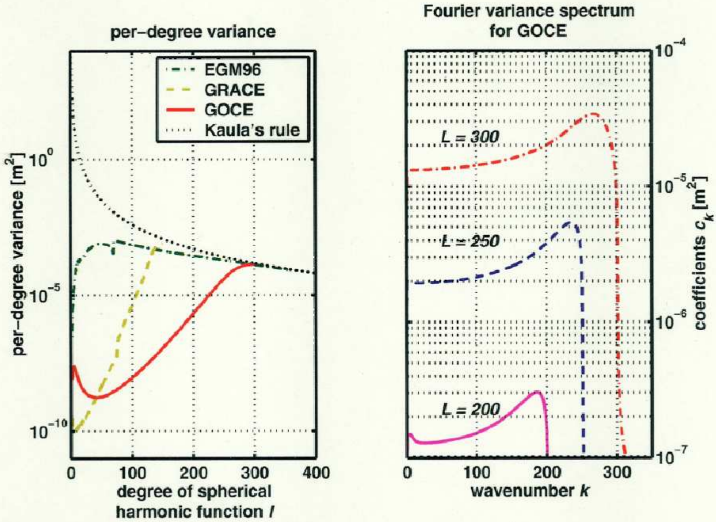
Homogeneous, isotropic covariance function for geoid model, representation in Legendre and trigonometric functions

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

with the (Fourier-) coefficients

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





(after Balmino et al. 1998)

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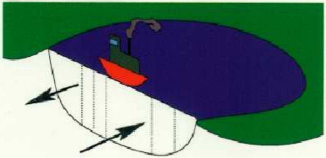
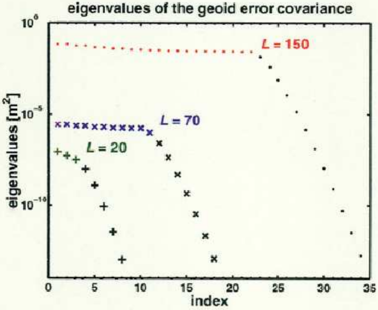
Idealized section model

"Identical twin" experiments with a simplified inverse "box" model





L	$\delta\phi$
0	$8.4 \times 10^6\ \mathrm{m^3s^{-1}}$
20	$4.0 \times 10^6\ \mathrm{m^3s^{-1}}$
70	$1.9 \times 10^6\ \mathrm{m^3s^{-1}}$
150	$3.9 \times 10^6\ \mathrm{m^3s^{-1}}$
	contradiction!

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Error reducion for integrated volume transports