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

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

mean dynamic topogr. = sea surface height - geoid height
\( \eta = h - N \)

Information about the entire water column:
\[
\frac{\partial \eta}{\partial t} + \nabla_z \int u \, dz = E - P
\]

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

\[ C(\psi) = \sum_{l=0}^{L} p_l P_l(\cos \psi) = \sum_{l=0}^{L} p_l \sum_{k=0}^{l} a_{l,k} \cos k\psi = \sum_{k=0}^{L} c_k \cos k\psi \]

with the (Fourier-) coefficients

\[ c_k = \sum_{l=k}^{L} p_l a_{l,k} \]
(after Balmino et al. 1998)
“Identical twin” experiments with a simplified inverse “box” model.

<table>
<thead>
<tr>
<th>$L$</th>
<th>$\delta \phi$</th>
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</thead>
<tbody>
<tr>
<td>0</td>
<td>$8.4 \times 10^6 \text{ m}^3\text{s}^{-1}$</td>
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<tr>
<td>20</td>
<td>$4.0 \times 10^6 \text{ m}^3\text{s}^{-1}$</td>
</tr>
<tr>
<td>70</td>
<td>$1.9 \times 10^6 \text{ m}^3\text{s}^{-1}$</td>
</tr>
<tr>
<td>150</td>
<td>$3.9 \times 10^6 \text{ m}^3\text{s}^{-1}$</td>
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</tbody>
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contradiction!
Fehlerreduktion bei integrierten Volumentransporten