Combining mean dynamic topography (MDT) and steady-state ocean models

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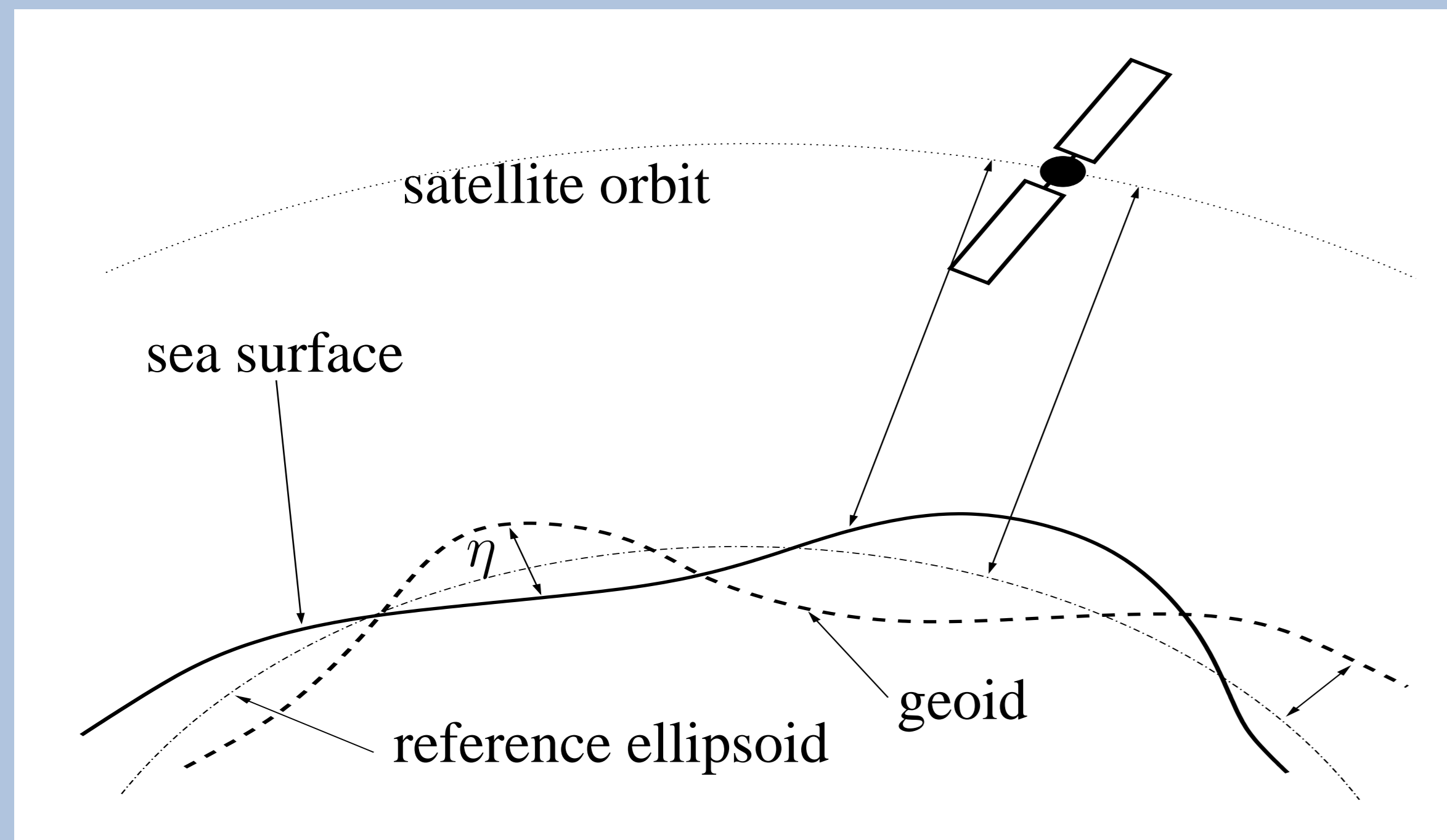Email: grit.freiwald@awi.de

1 Mean dynamic topography modeling

Mean dynamic topography (MDT) η is the departure of the sea surface from the geoid. The geostrophic relation balance

$$v = \frac{g}{f}\frac{\partial \eta}{\partial x}$$

is used for deriving ocean surface velocities v. These can be assimilated into inverse ocean models.

Mean dynamic topography (MDT)

Common problems of MDT models are the different scales, accuracies and basis functions of altimetry data and geoid data.

These issues are avoided by combining the normal equations directly. The MDT is calculated on the ocean model grid and no additional smoothing of the MDT is required.

A stochastic model accounts for the omission error in the respective frequency domains.

A full MDT error covariance matrix is also estimated.
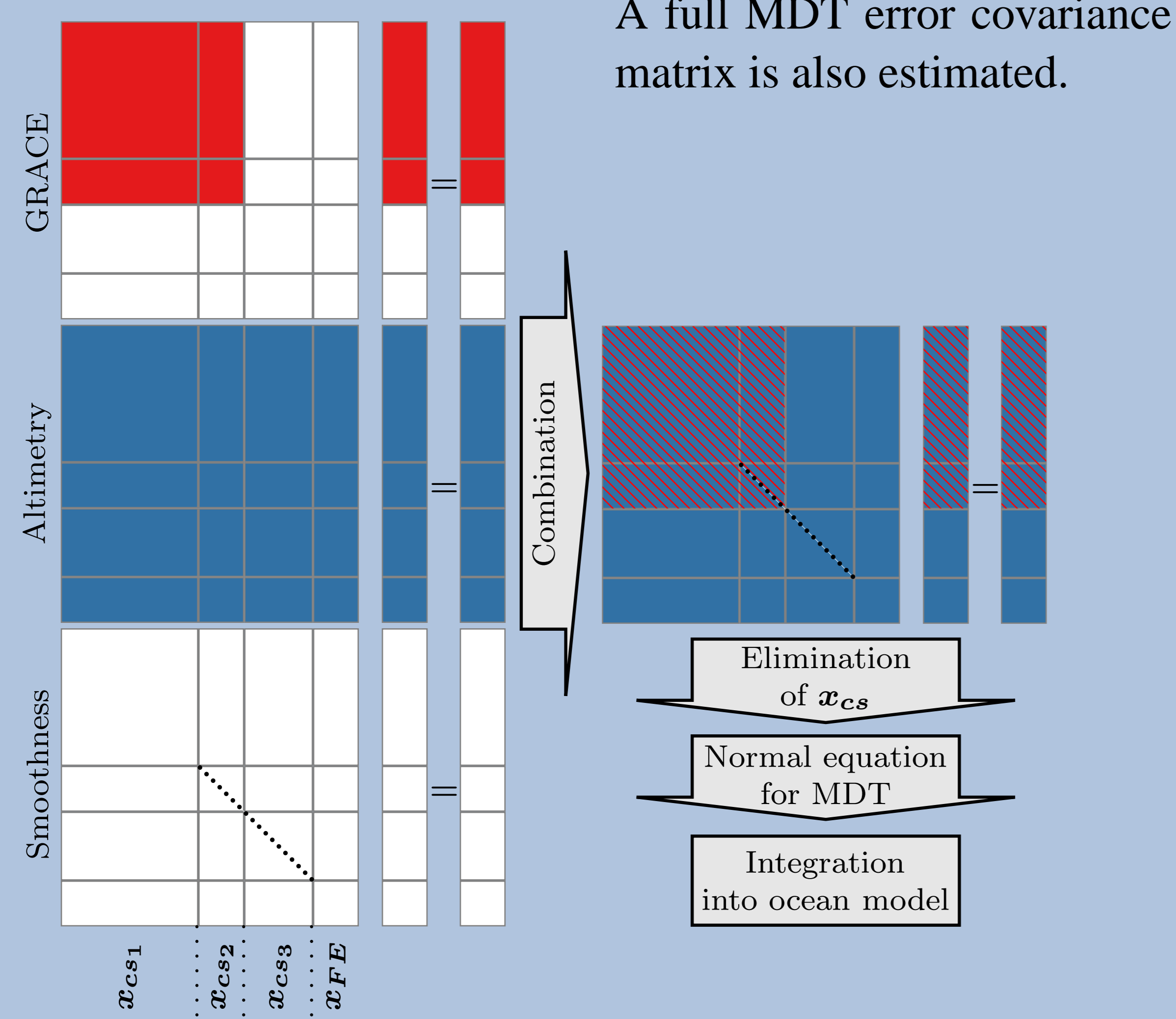
Frequency domains of observations and parametrization

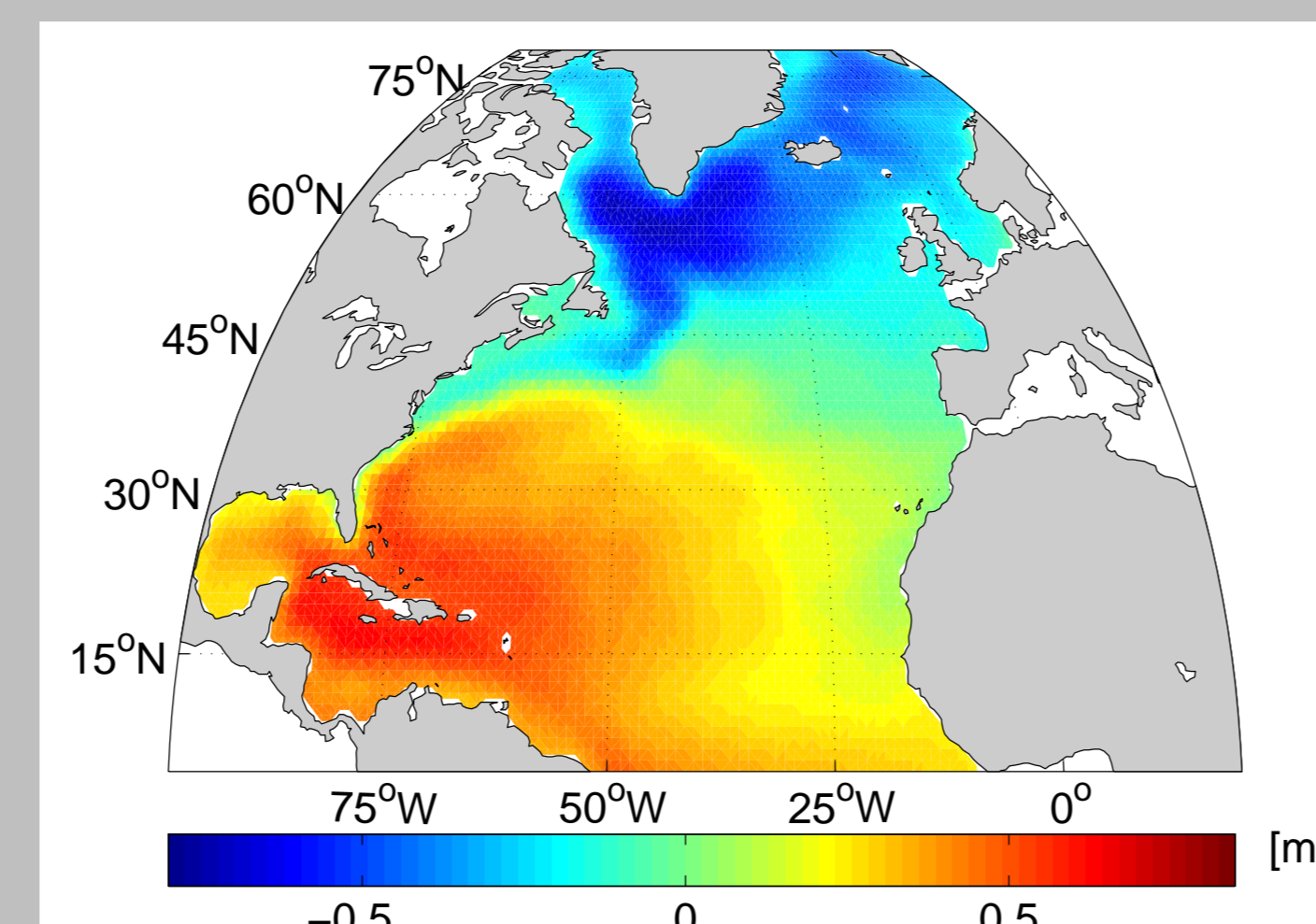The picture shows the geodetic Rifugio MDT from section 1 before modification by the any ocean model.

The Rifugio MDT is now combined with the ocean model IFEOM.

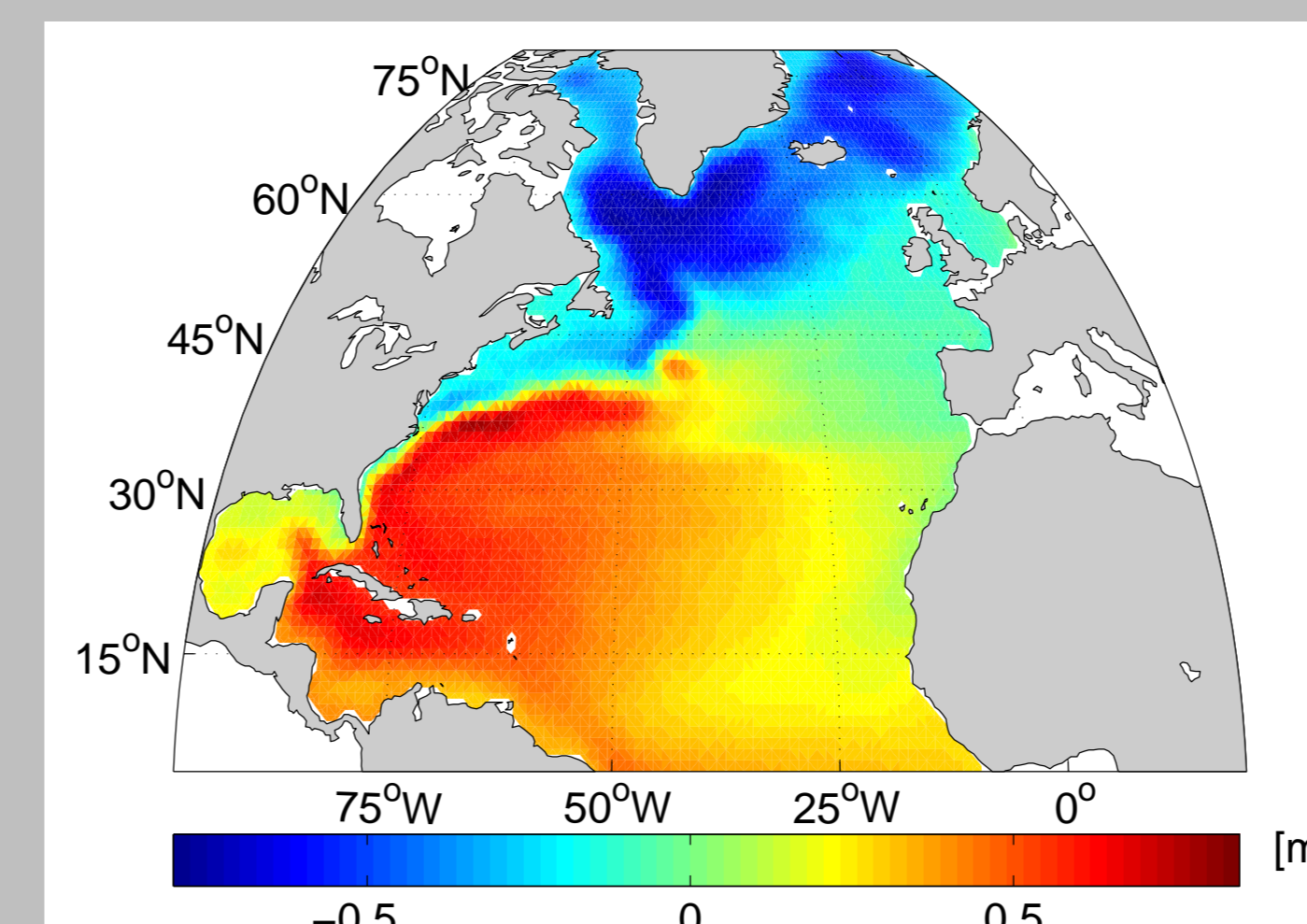The inverse error covariance matrices are used for weighting the data.

3 Inverse 3D ocean model: IFEOM

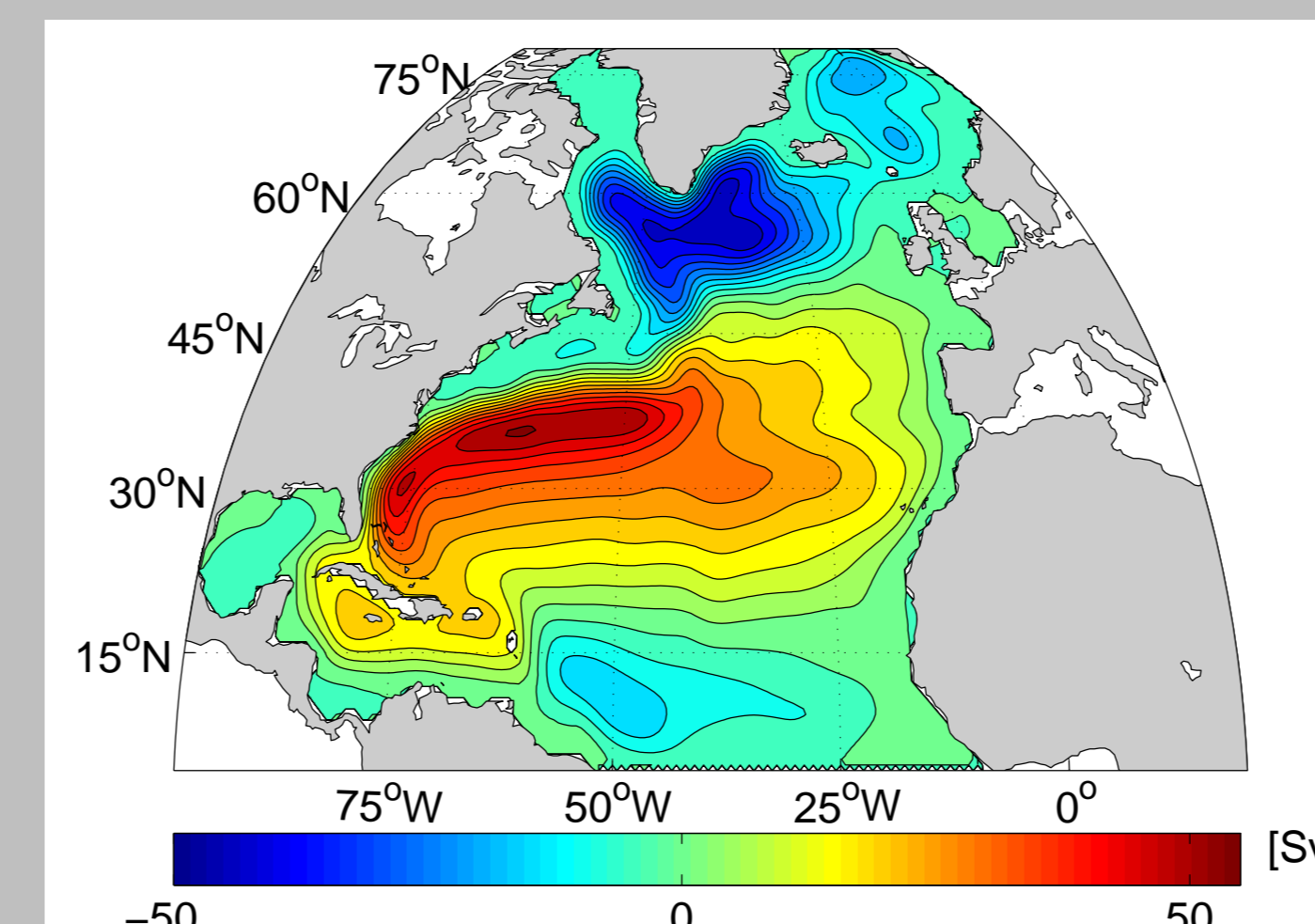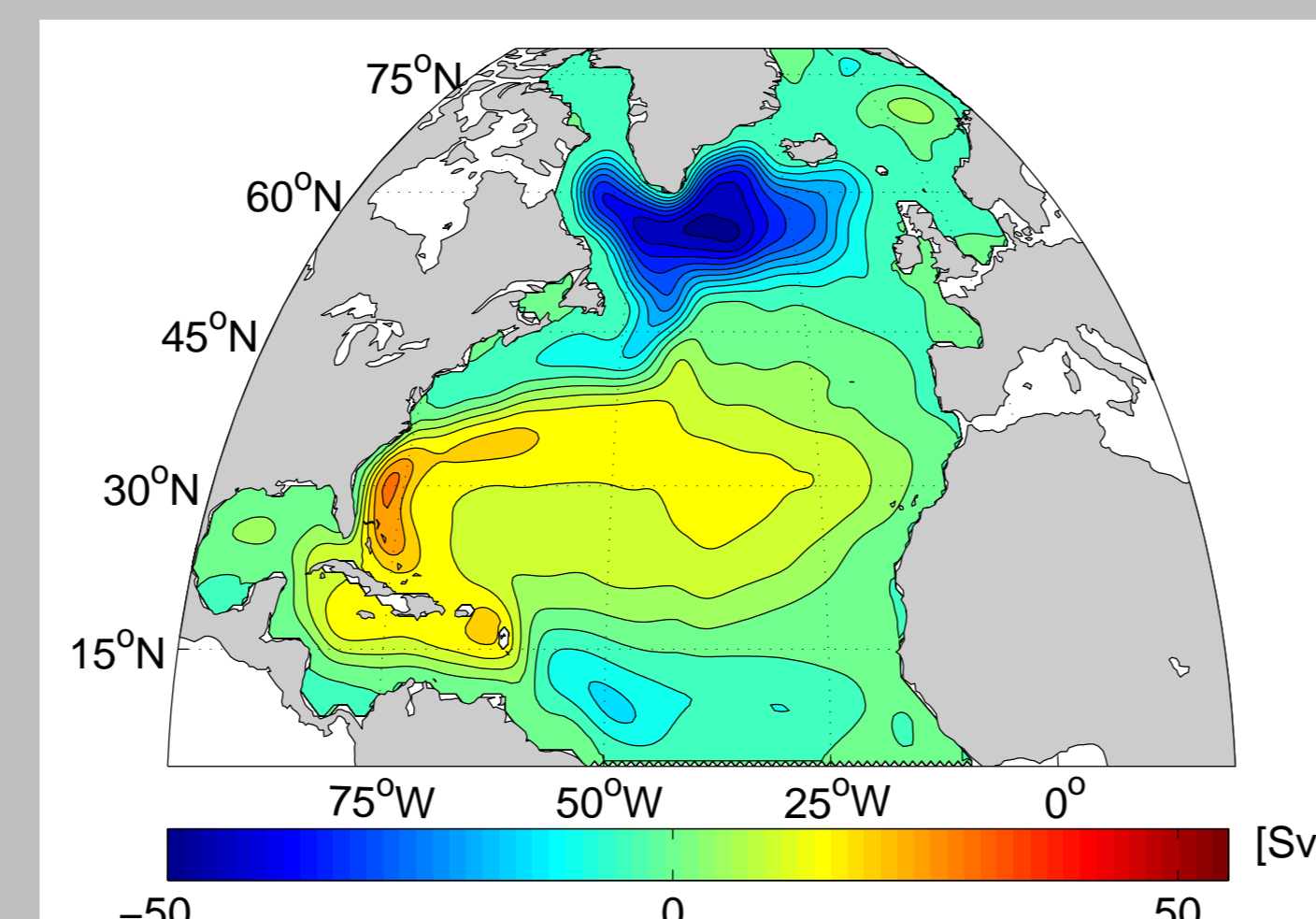IFEOM is a 3D Finite Element model for the North Atlantic ocean.
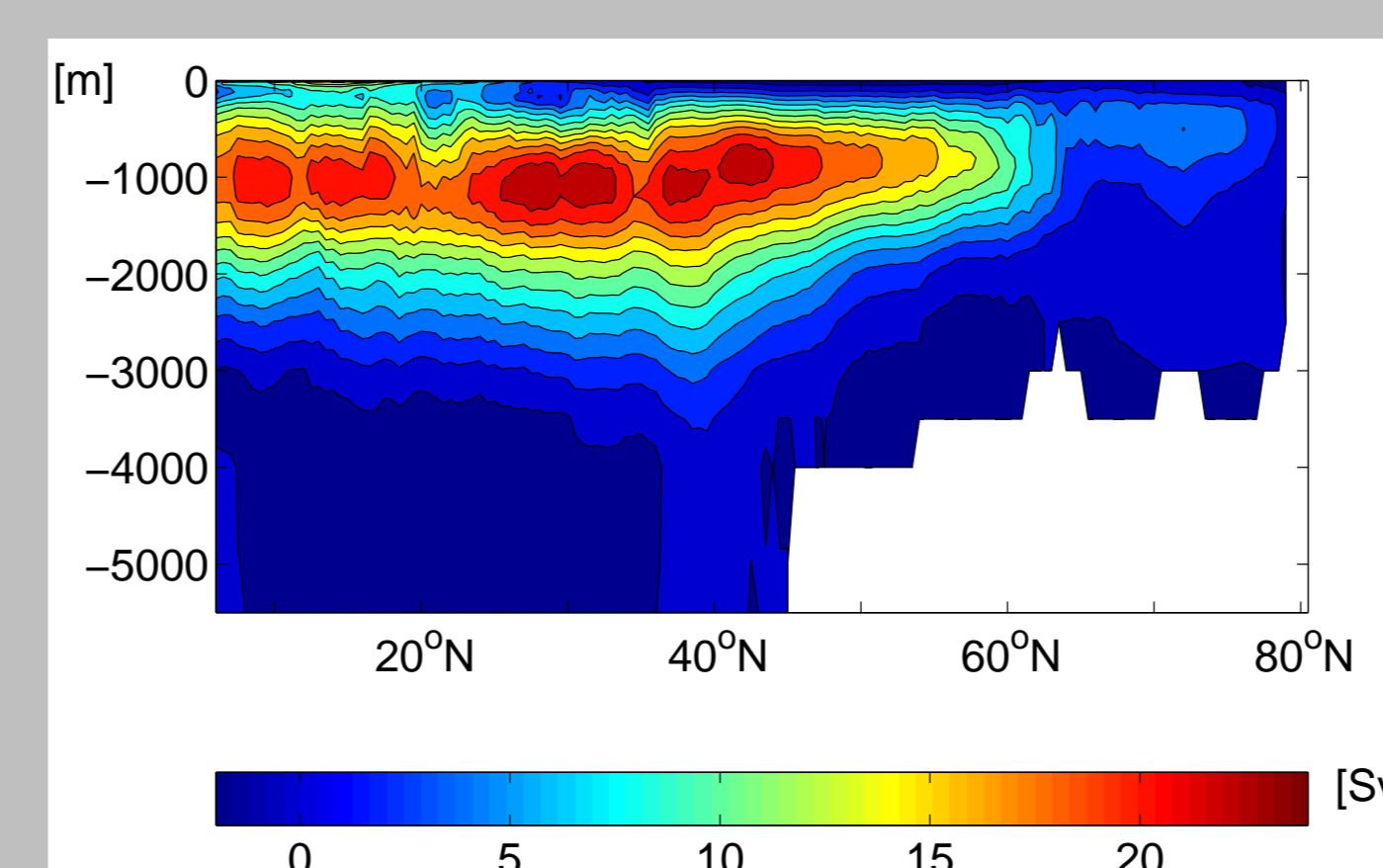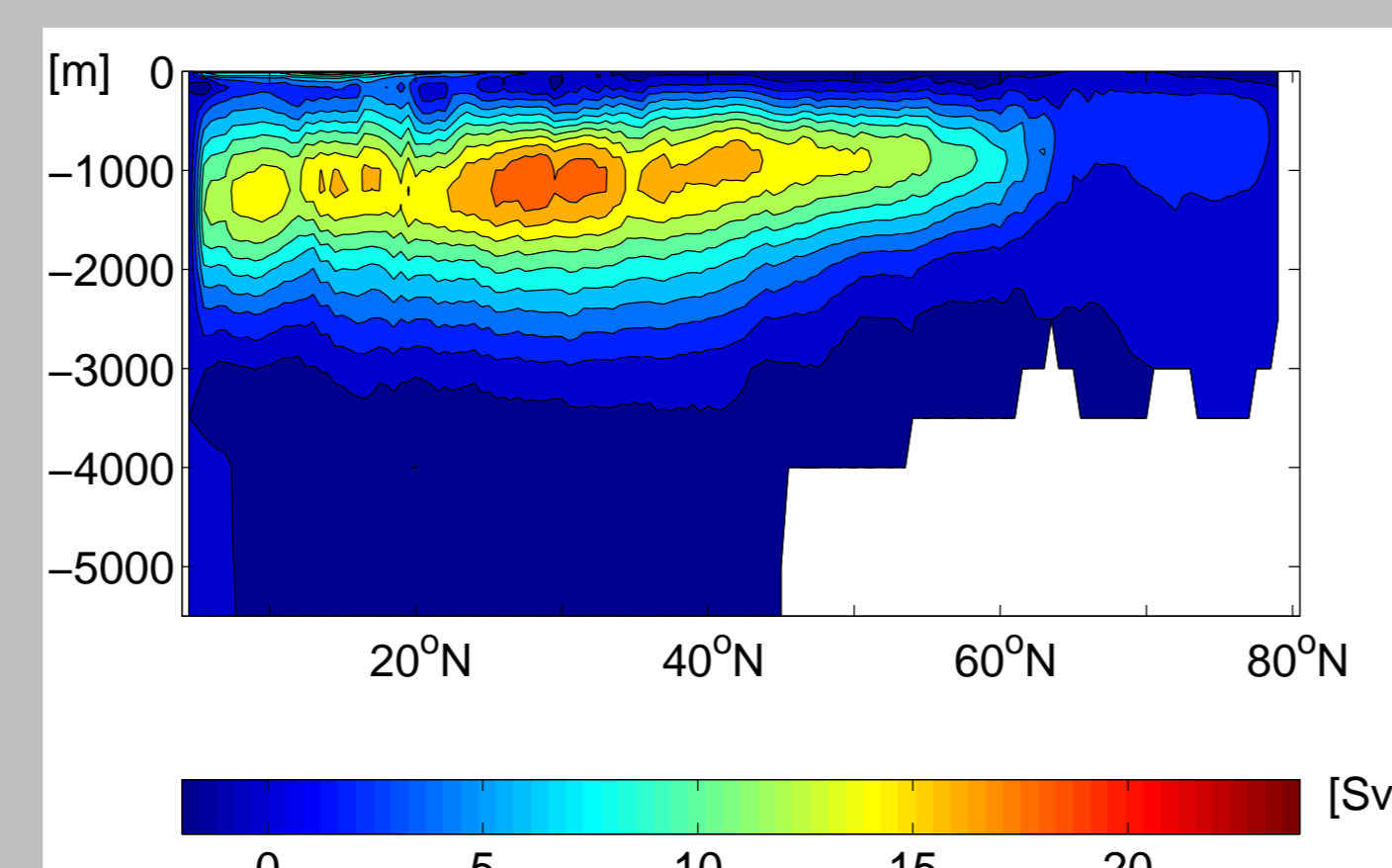
Without Rifugio MDT:

With Rifugio MDT:

Resulting IFEOM MDT.

IFEOM barotropic stream function.

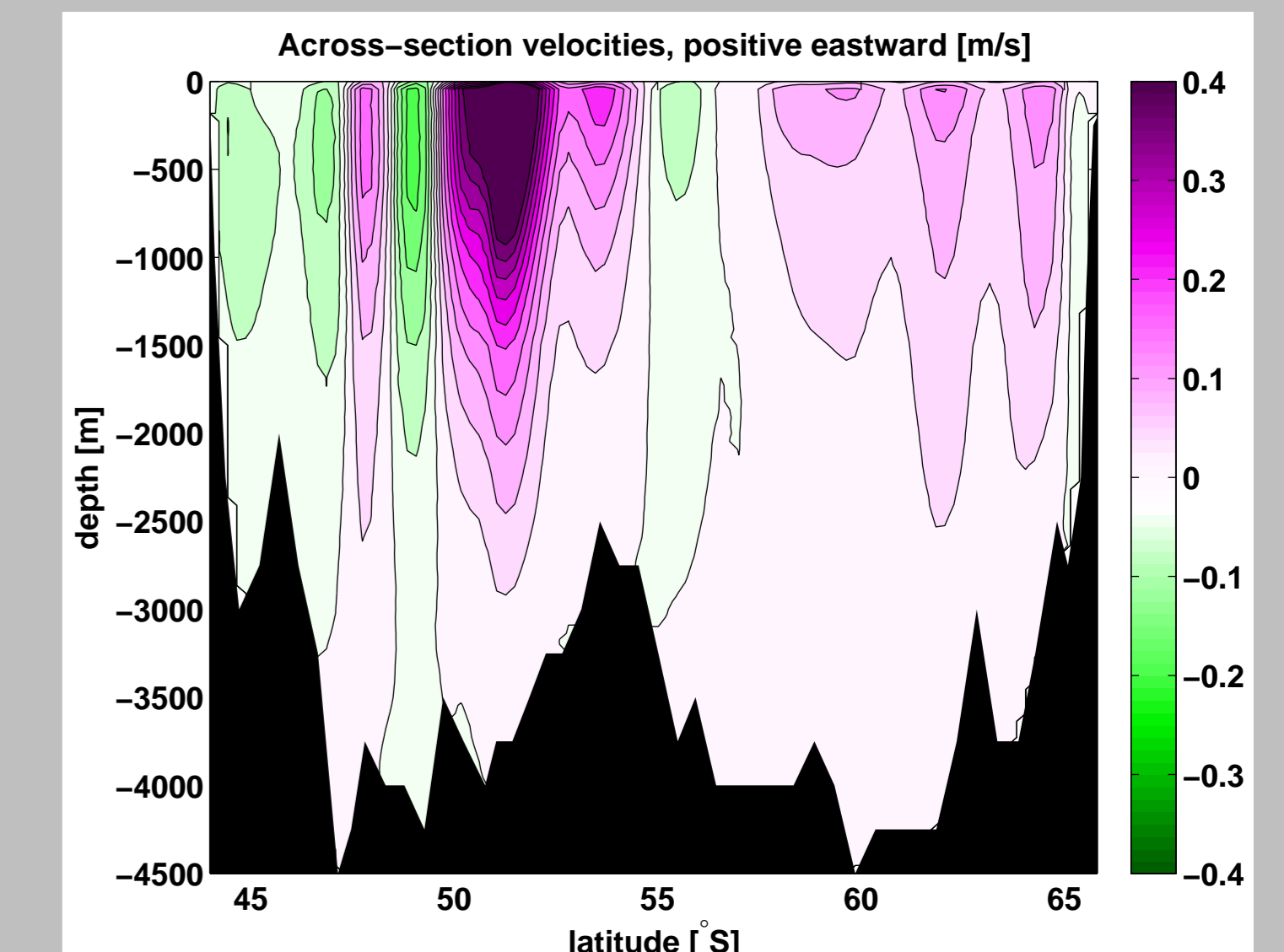IFEOM meridional overturning circulation (MOC).

2 Inverse 2D ocean model: FEMSECT

FEMSECT describes a 2D section from Tasmania to Antarctica.

The full combined Rifugio approach is not applicable to a 2D section model. However, the effects of different omission error models are studied.

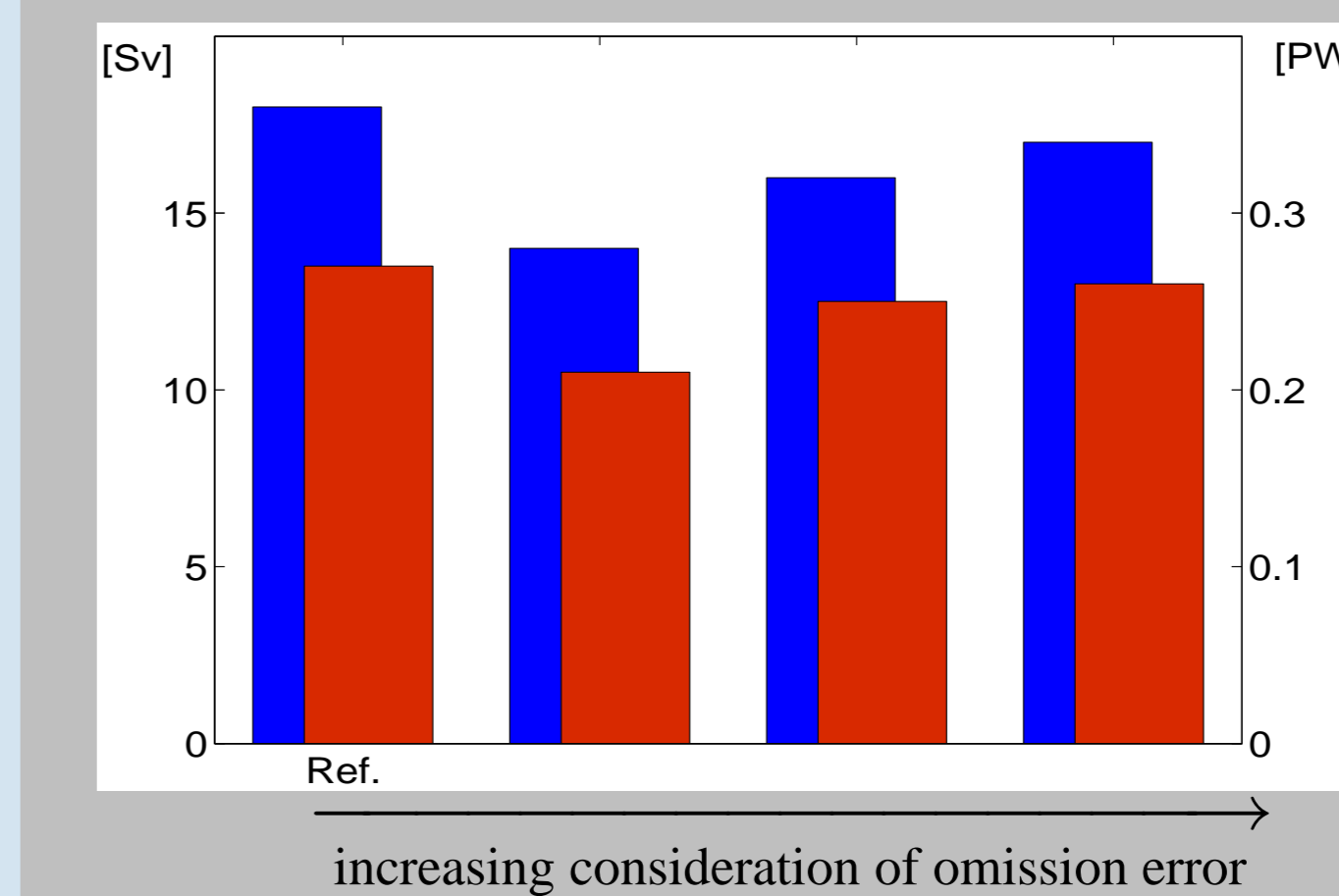Across-section velocities, positive eastward [m/s]
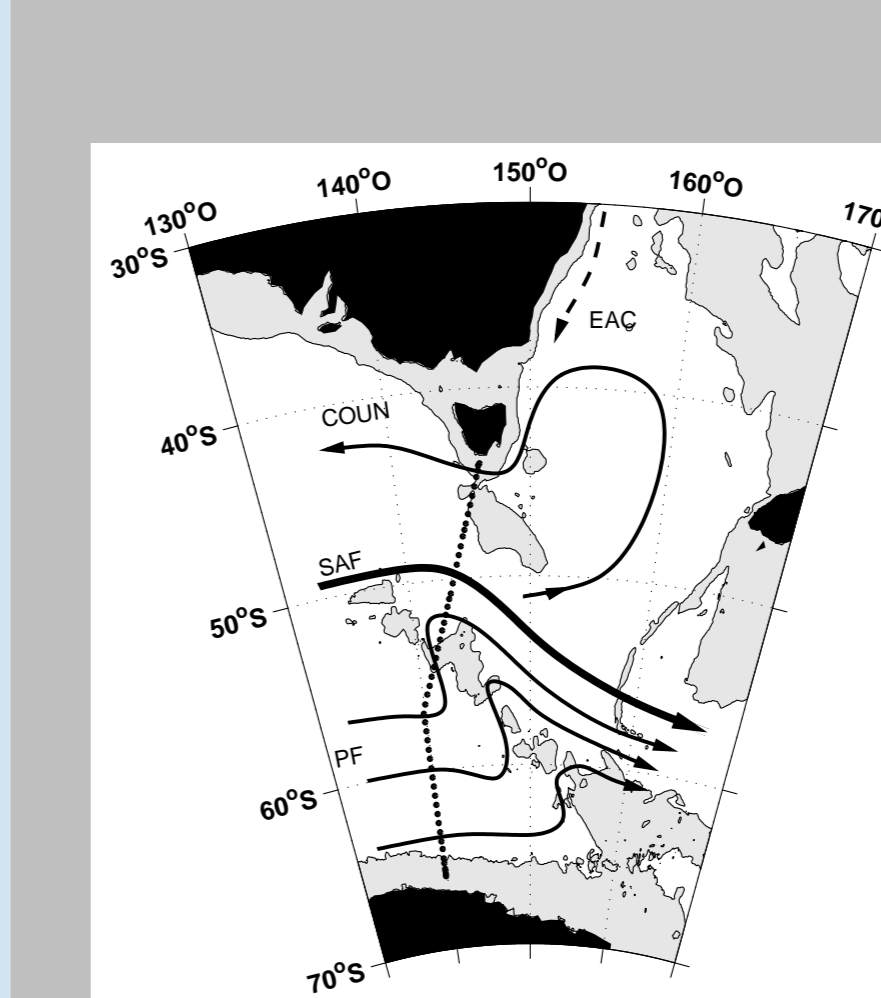
Section location.

Velocity profile across the section.

The velocity profile across the section is already well represented without additional MDT information. When MDT is included, the transport error estimates change.

FEMSECT transport errors:

increasing consideration of omission error

Final transports across section:
Mass: **159 ± 17 Sv**
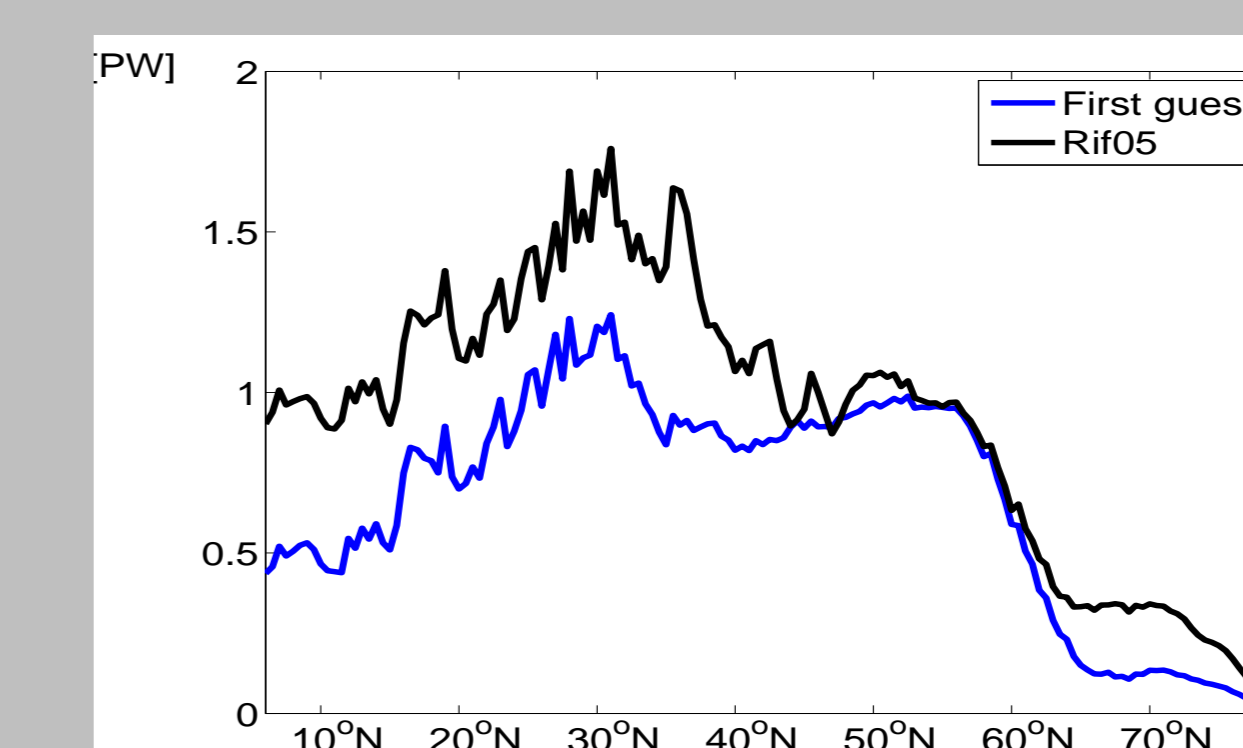Heat: **1.91 ± 0.26 PW**

4 Results

FEMSECT:

● Additional MDT information reduces the transport error.

● Neglecting the omission error underestimates the true error.

IFEOM:

● Model-data deviations are consistent with error estimates.

● Estimation of posterior errors is not straightforward and a subject for further research.

● The geodetic MDT is improved by the ocean model.

● The ocean model is improved by the new MDT:
  – more detailed current structure
  – steeper temperature gradients
  – more realistic MOC
  – increased heat transports

IFEOM heat transports.