NEROGRAV
New Refined Observations of Climate Change from Spaceborne Gravity Missions

GRACE FOLLOW-ON

Connecting NADW transports to OBP variations with the high-resolution ocean model VIKING20X

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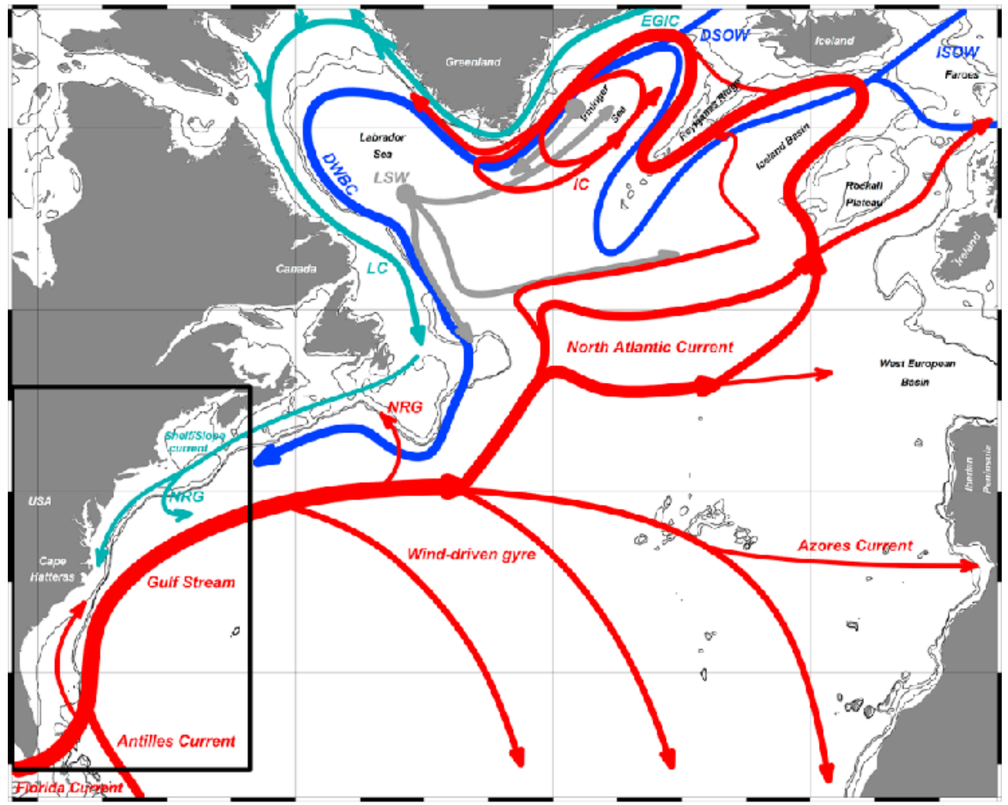
Connection Meridional Transport and OBP

Major AMOC Components



[1] Little et al. (2019), 10.1029/2019JC015152

For Geostrophic Currents:

Meridional Transport

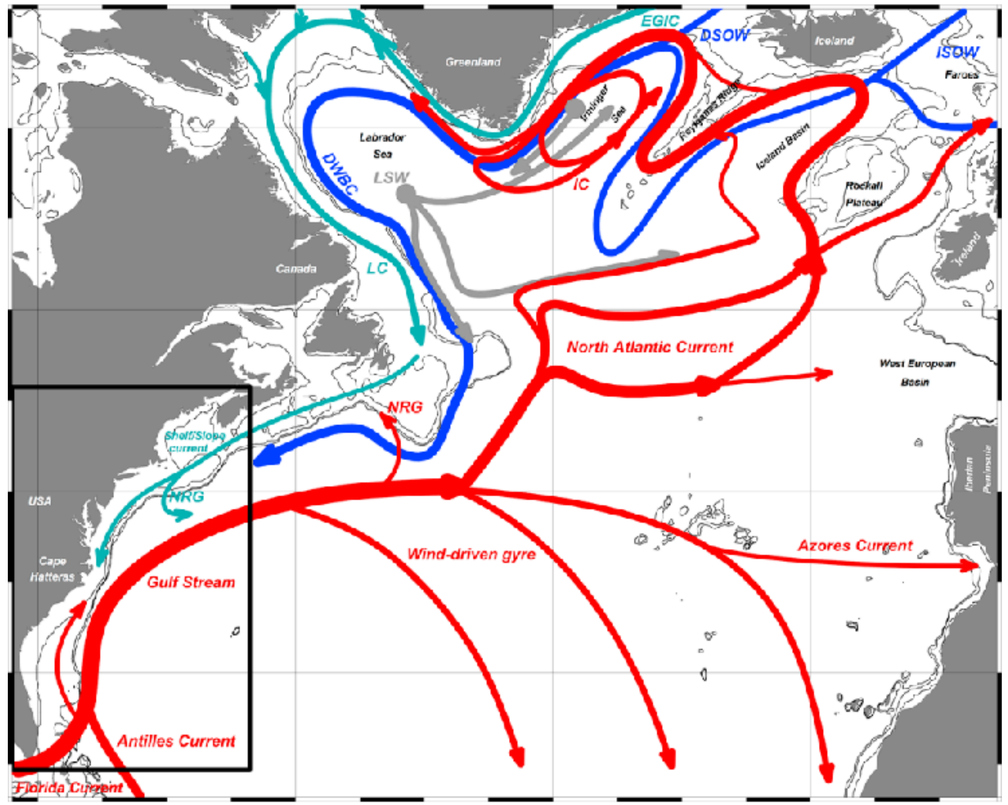
Easter / Western Boundary Pressure

$$T(y,z) = \frac{p_E - p_W}{f\,\rho_0}$$

Most of the variations are found at the western boundary!

Connection Meridional Transport and OBP

Major AMOC Components



[1] Little et al. (2019), 10.1029/2019JC015152

For Geostrophic Currents:

Western Boundary Pressure

Meridional Transport

$$T(y,z) \approx -\frac{p_W}{f\rho_0}$$

Most of the variations are found at the western boundary!

Ocean Model VIKING20X

Test the connection in a high-resolution ocean model: VIKING20X

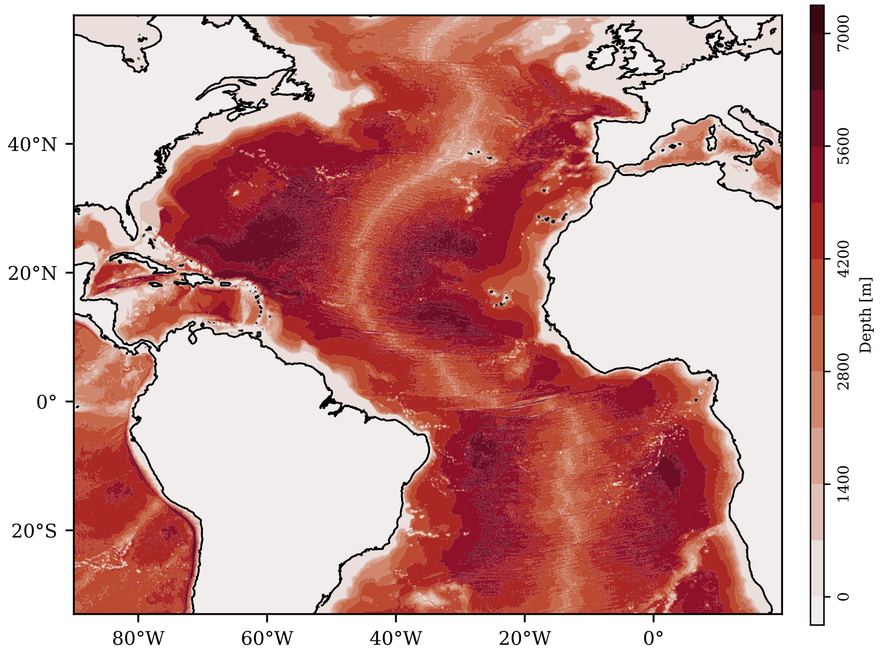
VIKING20X:

- Ocean model with high-res nest for the Atlantic
- Provided by GEOMAR
- AMOC representation well assessed by Biastoch et al. (2021) (10.5194/os-17-1177-2021)
- Access to OBP and meridional transports

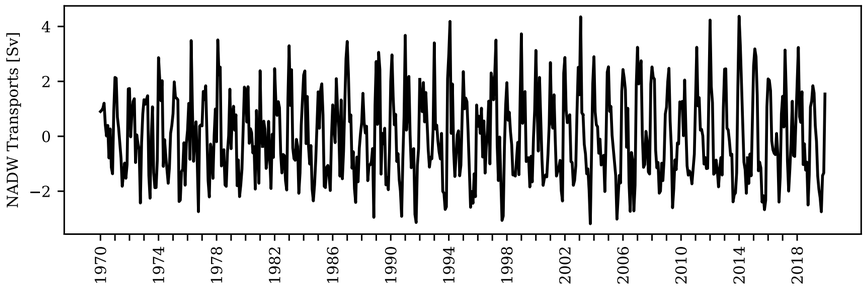
NADW:

- Considering transports between 1000 - 3000m depth from 25°N - 40°N
- High-pass filtered up to 5 years

VIKING20X Nested Region

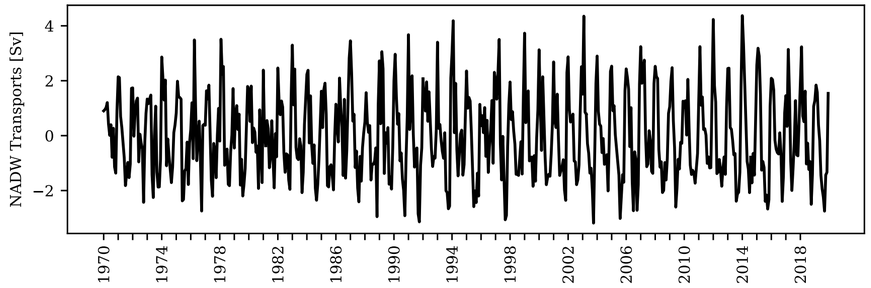


VIKING20X NADW Model Transports

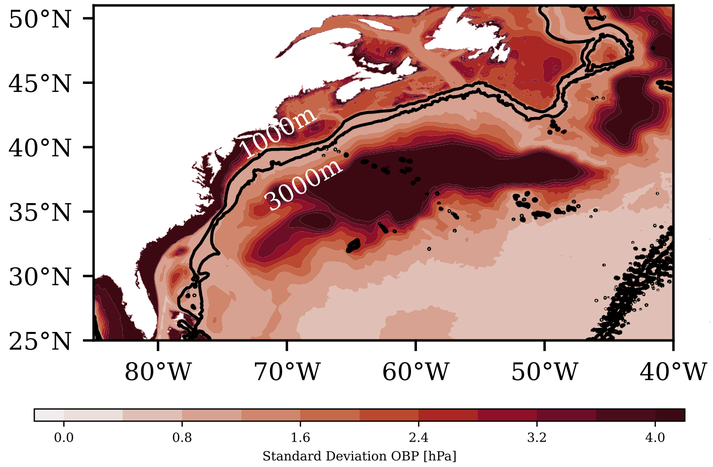


Correlation of NADW & OBP

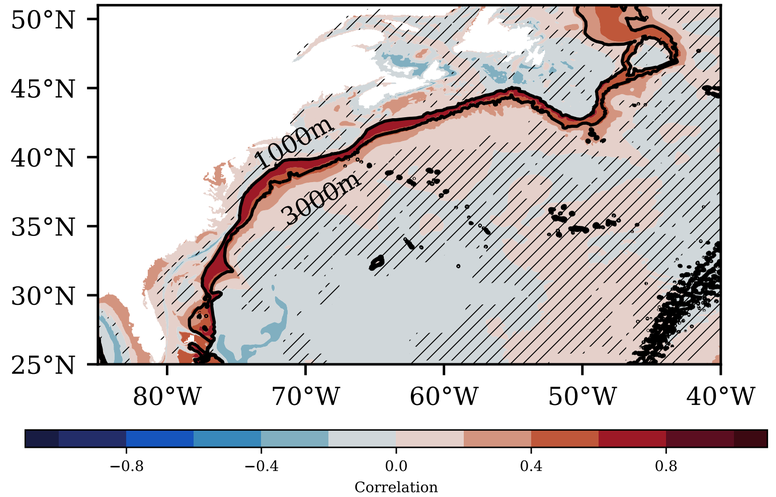
VIKING20X NADW Model Transports



OBP Variability Western Atlantic

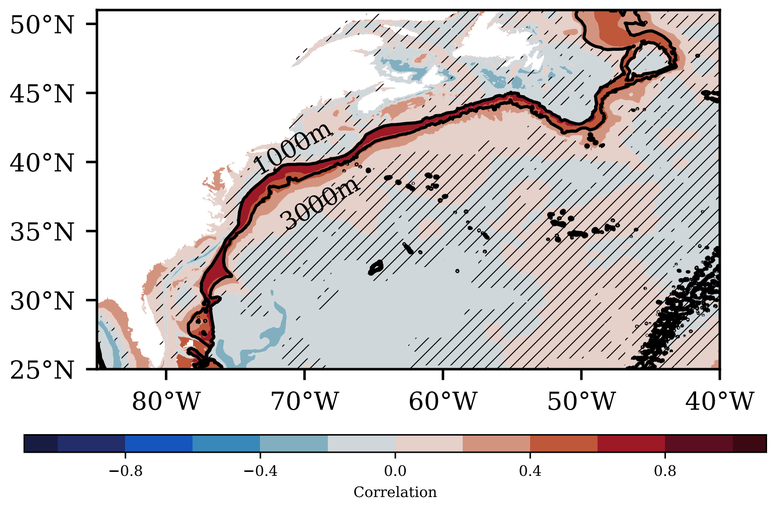


Correlation

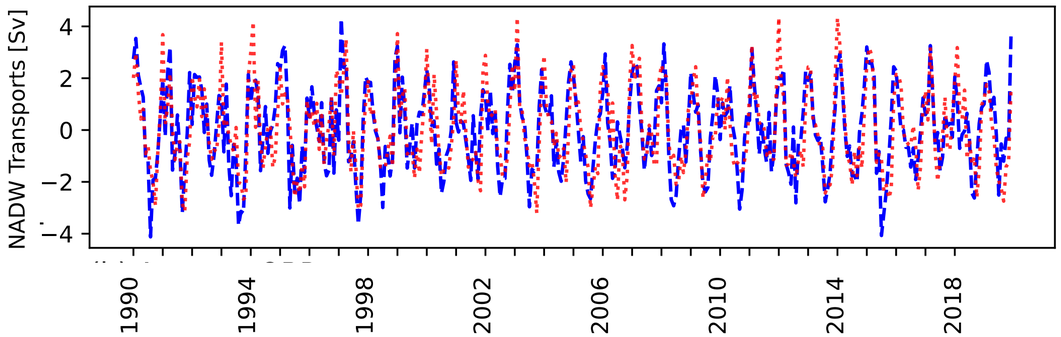


Reconstructing Transport Anomalies from OBP

Correlation



Reconstructed Transports



True Model Transports

OBP Reconstruction

$$T(y,z) \approx -\frac{p_W}{f\rho_0}$$

$$T_{\mathrm{NADW}} \approx -\int_{3000\ \mathrm{m}}^{1000\ \mathrm{m}} \frac{p_W(y,z)}{f\rho_0}\mathrm{d}z$$

- Integration possible given high resolution of VIKING20X
- Compare OBP-derived NADW transports to true model transport anomalies:
  - Correlation: 0.76
  - RMSE: 1.13 Sv

Reconstructing Transport Anomalies from OBP

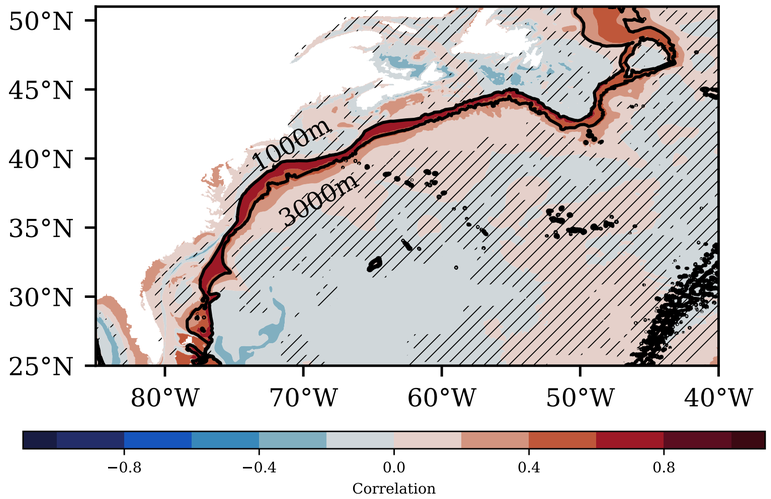
- Average OBP in region of continental slope (1000 - 3000m)
- Calculate scaling factor through regression to model transports

- Compare OBP-derived NADW transports to true model transport anomalies:
  - Correlation: 0.74
  - RMSE: 1.47 Sv

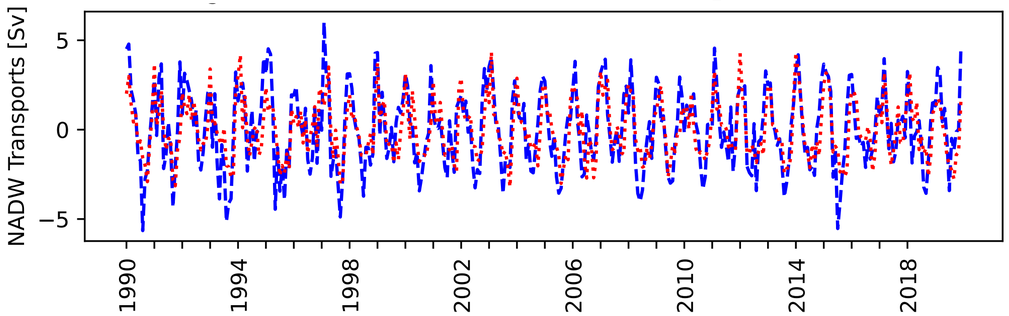
NADW transport anomalies *can* be reconstructed from the average OBP along the continental slope.

From satellite gravimetry ?

Correlation



Reconstructed Transports

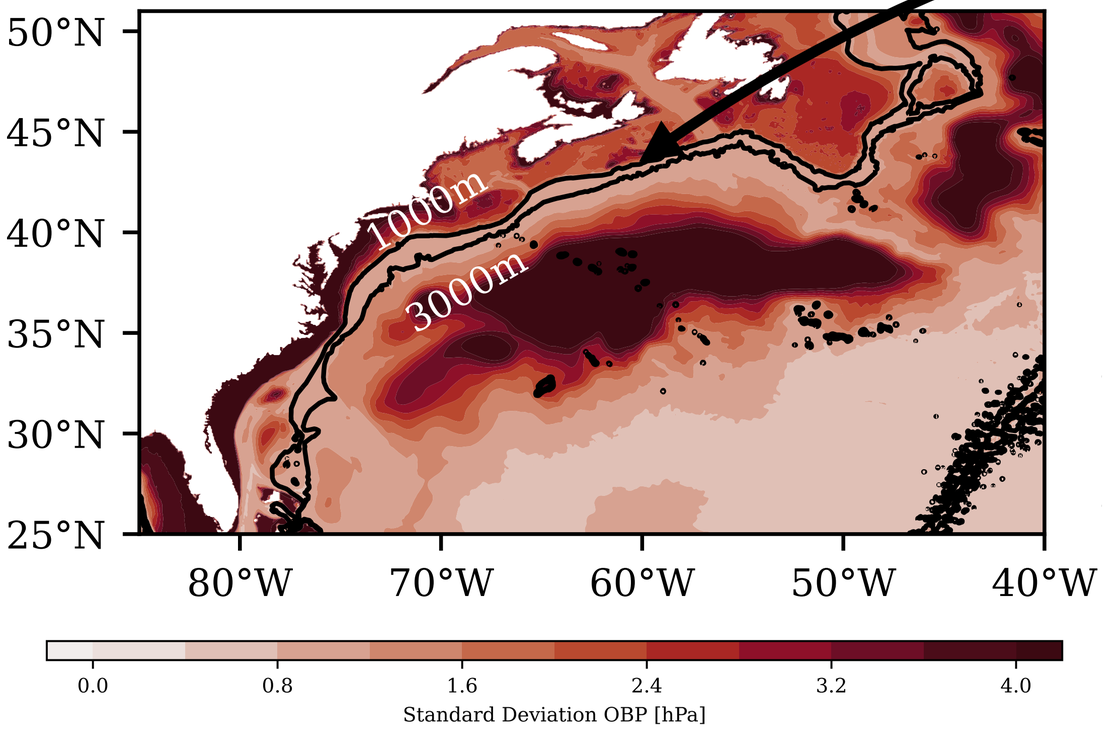


True Model Transports

OBP Reconstruction

Reconstructing Transport Anomalies from OBP

OBP Variability Western Atlantic



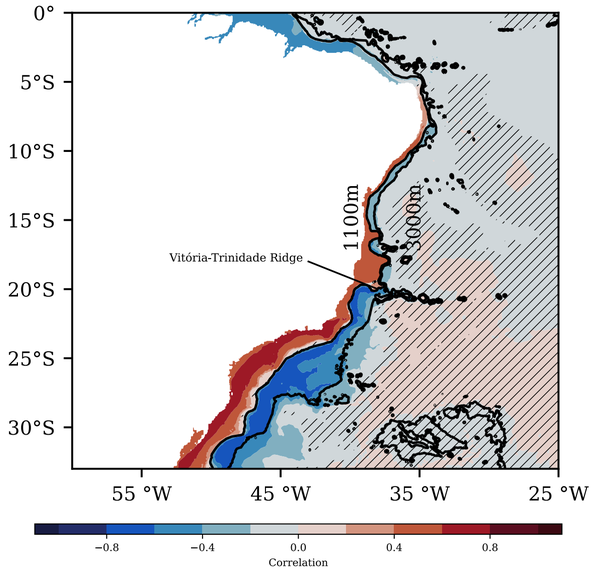
Target Signal

- OBP along the continental slope is very confined
- Amplitude of about 1 hPa, i.e. 1 cm EWH
- Surrounded by larger anomalies in deep ocean and on the shelf
- Future gravity mission constellations (MAGIC) may resolve target region
- Might need specialised assessment

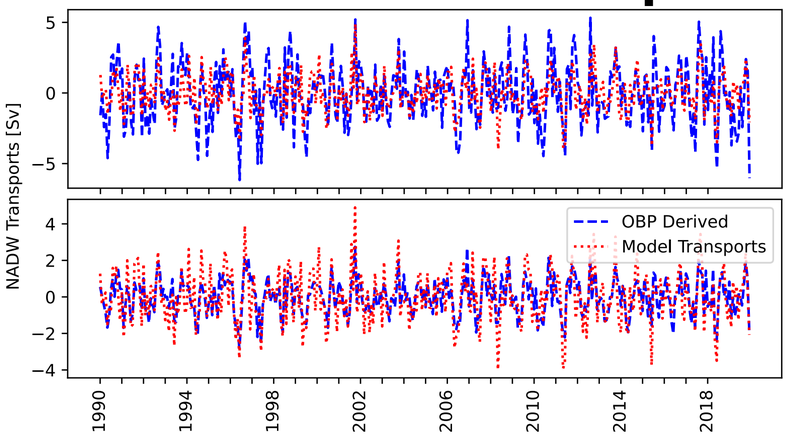
Well-defined target signal should be implemented in future mission simulation studies.

South Atlantic

Correlation NADW & OBP



Reconstructed Transports



Slope only

Slope & Shelf

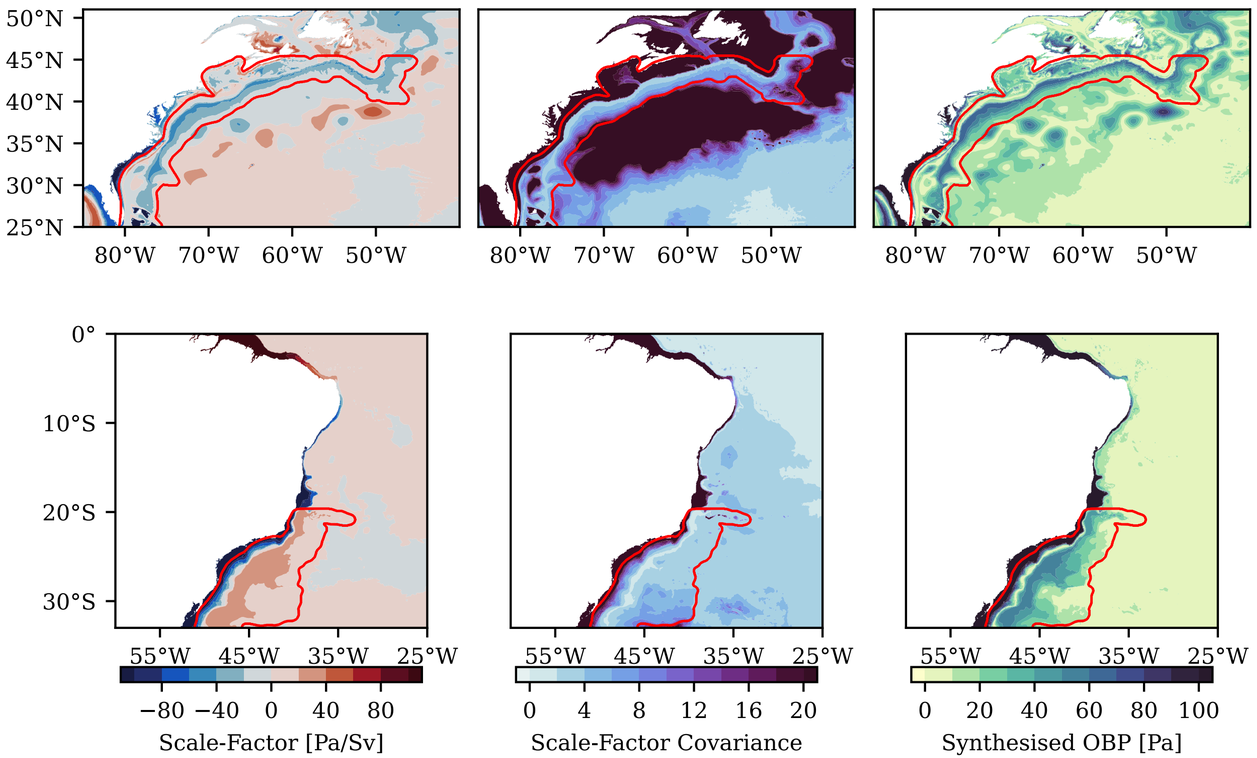
- Similar assessment for South Atlantic between 20°S - 33°S
- Slightly more complex due to different overturning structure
- OBP signals from shelf region can help in transport estimation
- Compare OBP-derived NADW transports to true model transport anomalies:
  - Correlation: 0.72
  - RMSE: 0.97 Sv
- South Atlantic OBP signatures to be included in ESA ESM as well

Synthetic Transport-Related OBP Signals

- OBP Signals for ESA ESM should:
  - Contain only transport-related signals (clean target signal)
  - Realistic Amplitude
  - Cover continental slope as well as shelf
- 'Raw' VIKING20X OBP data contains 'noise'

  -> Create synthetic OBP data through regression

- Fit model transport time-series to OBP at each grid point and derive constant scaling field
- Scaling field multiplied with model transport gives synthetic OBP signals containing only transport signals
- Select region of interest



Summary & Next Steps

- Provide OBP signals related to overturning for satellite simulation studies
- Use VIKING20X ocean model data
- Model transports can be reconstructed using average OBP with correlation above 0.7
- Create synthetic transport-related OBP data for in ESA ESM

- Finalise synthetic OBP data (filtering to prevent Gibbs effects)
- Transformation into ESA ESM format
- Publication
- Explore OBP signatures of other deep ocean transports (such as Antarctic Bottom Water)
- **Feedback welcome!**