Investigating the relationship between volume transport and sea surface height in the Agulhas Current using the Hybrid Coordinate Ocean Model.

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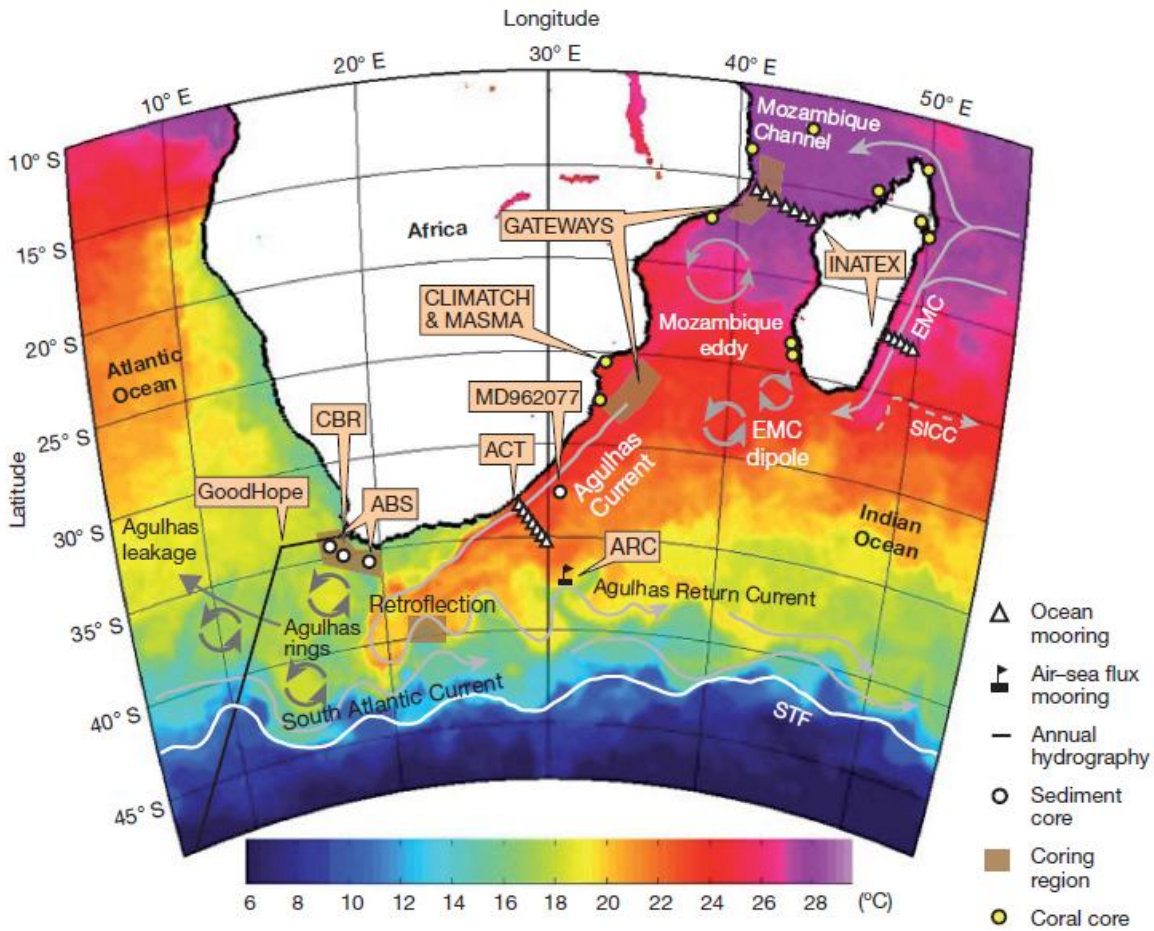
NRF National Research Foundation | SAEON South African Environmental Observation Network

Nansen-Tutu Centre for Marine Environmental Research

The Agulhas Current System

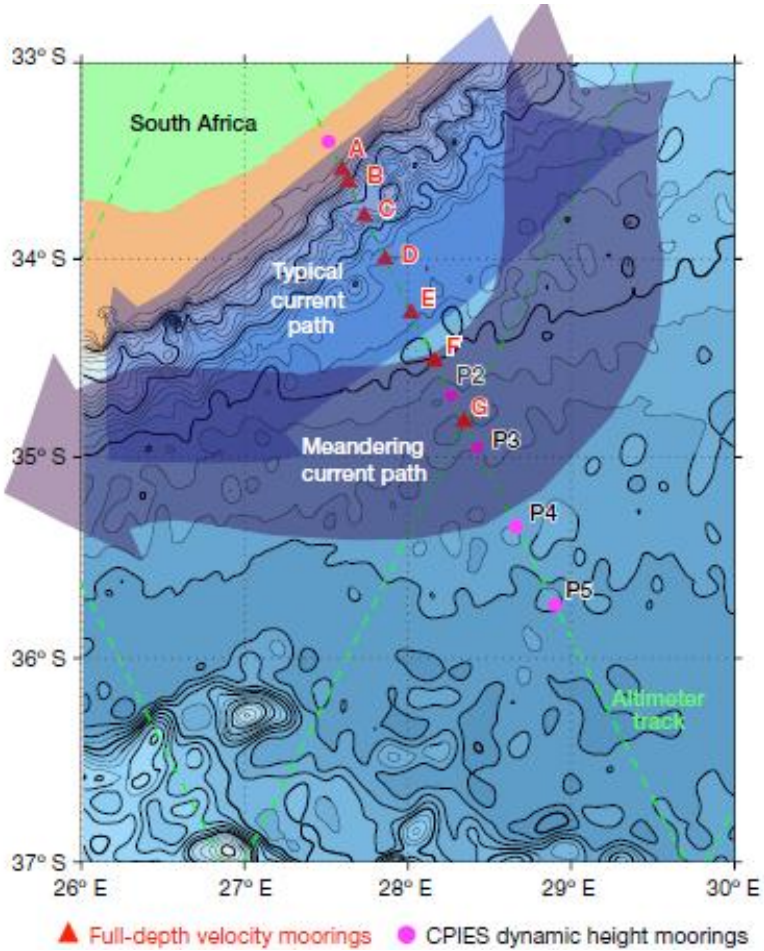


Beal, L.M., De Ruijter, W.P., Biastoch, A. and Zahn, R., 2011. On the role of the Agulhas system in ocean circulation and climate. *Nature*, *472*(7344), pp.429-436.

The Agulhas Current Time-series Experiment (ACT)

Phase 1: Mooring array deployed from 2010- 2013, 34°S. Calculated two transports, one of the fixed current (***Tbox***) and another taking into account the current meanders (***Tjet***).

Phase 2: Altimeter Proxy based on the linear relationship between along-track SSH and transport, with the objective to estimate 22-years of Agulhas Current transport.



Project funded by USA NSF

Beal, L.M. and Elipot, S., 2016. Broadening not strengthening of the Agulhas Current since the early 1990s. *Nature*, *540*(7634), pp.570-573.

Beal, L.M., Elipot, S., Houk, A. and Leber, G.M., 2015. Capturing the transport variability of a western boundary jet: Results from the Agulhas Current Time-Series Experiment (ACT). *Journal of Physical Oceanography*, *45*(5), pp.1302-1324.

Objectives

- Perform a linear regression analysis between model transport and model SSH for ACT in-situ period (2010-2013) using the Hybrid Coordinate Ocean Model (HYCOM).

- The proxy is based on the assumption that a 3-year linear relationship between SSH slope and volume transport is applicable over longer time periods.

- Using the HYCOM model we can quantify the depth variability for longer time periods and estimate the resultant impact on the predictions made by the proxy.

- After creating the proxy, test the sensitivity of the transport proxy to the time period of observations (i.e. how many years of *in situ* observations are optimal to create an accurate proxy of Agulhas Current transport.

Glossary

Tx- Vertically integrated velocity i.e. net transport per unit distance ($m^2.s^{-1}$),

Txsw- Vertically integrated southwest velocity i.e. southwest transport per unit distance ($m^2.s^{-1}$).

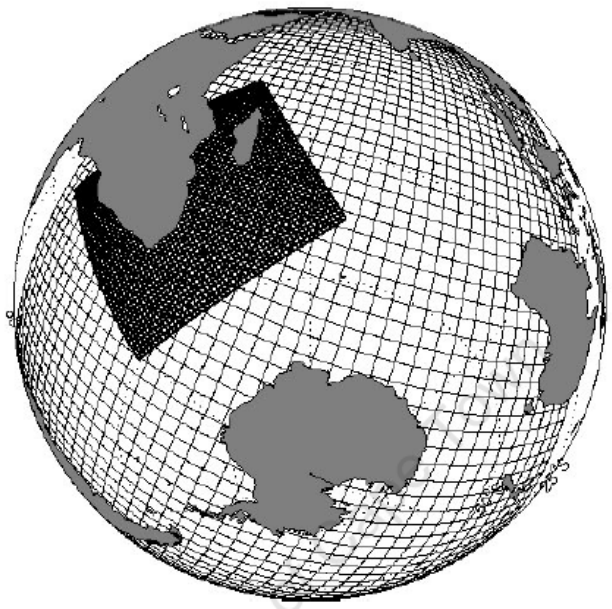
Tbox: Net transport based on the fixed 3yr-mean width of Agulhas Current ($m^3.s^{-1}$).

Tjet: Southwestward transport of the meandering current ($m^3.s^{-1}$).

Development period- 3-year *in situ* period over which the proxy was build (2010-2013).

The Hybrid Coordinate Ocean Model (HYCOM)

- The model output is based on the nested configuration of the basin-scale INDIA model providing boundary conditions to the regional model AGULHAS (1/10°).
- 30 vertical hybrid layers
- GEBCO 1’ bathymetry
- ERA-interim reanalysis data (1/4°)
- Model output: 1980-2014 (weekly)



Regression models between SSH slope and Tx & Txsw.

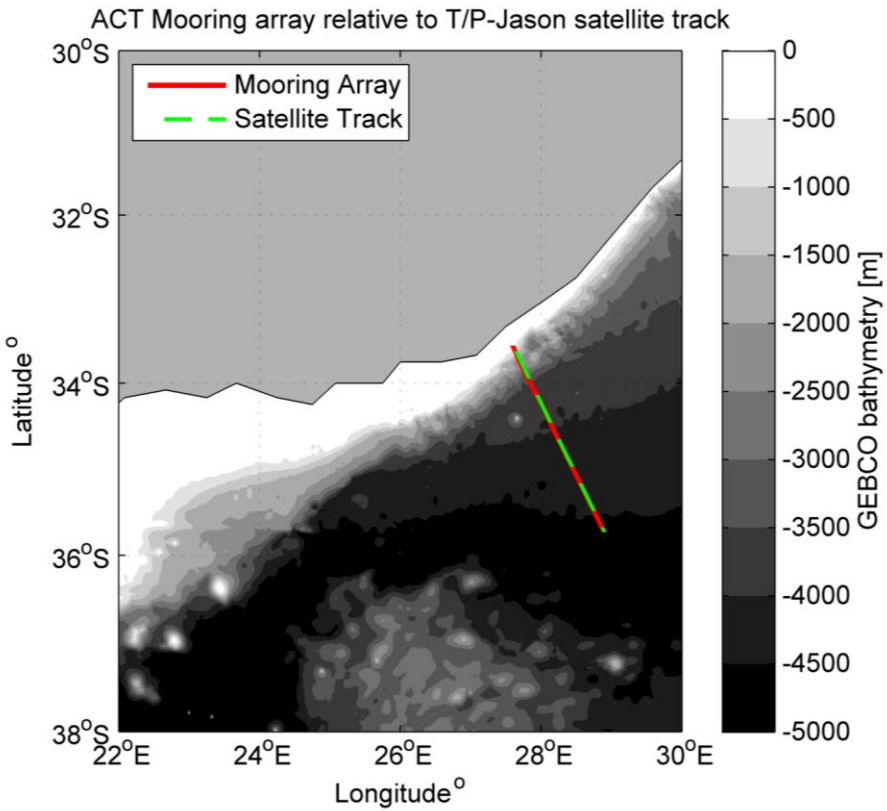
9 linear regression models, one for each mooring for 3-years (2010-2013):

1. Extract barotropic velocity at each mooring from the HYCOM velocity field.

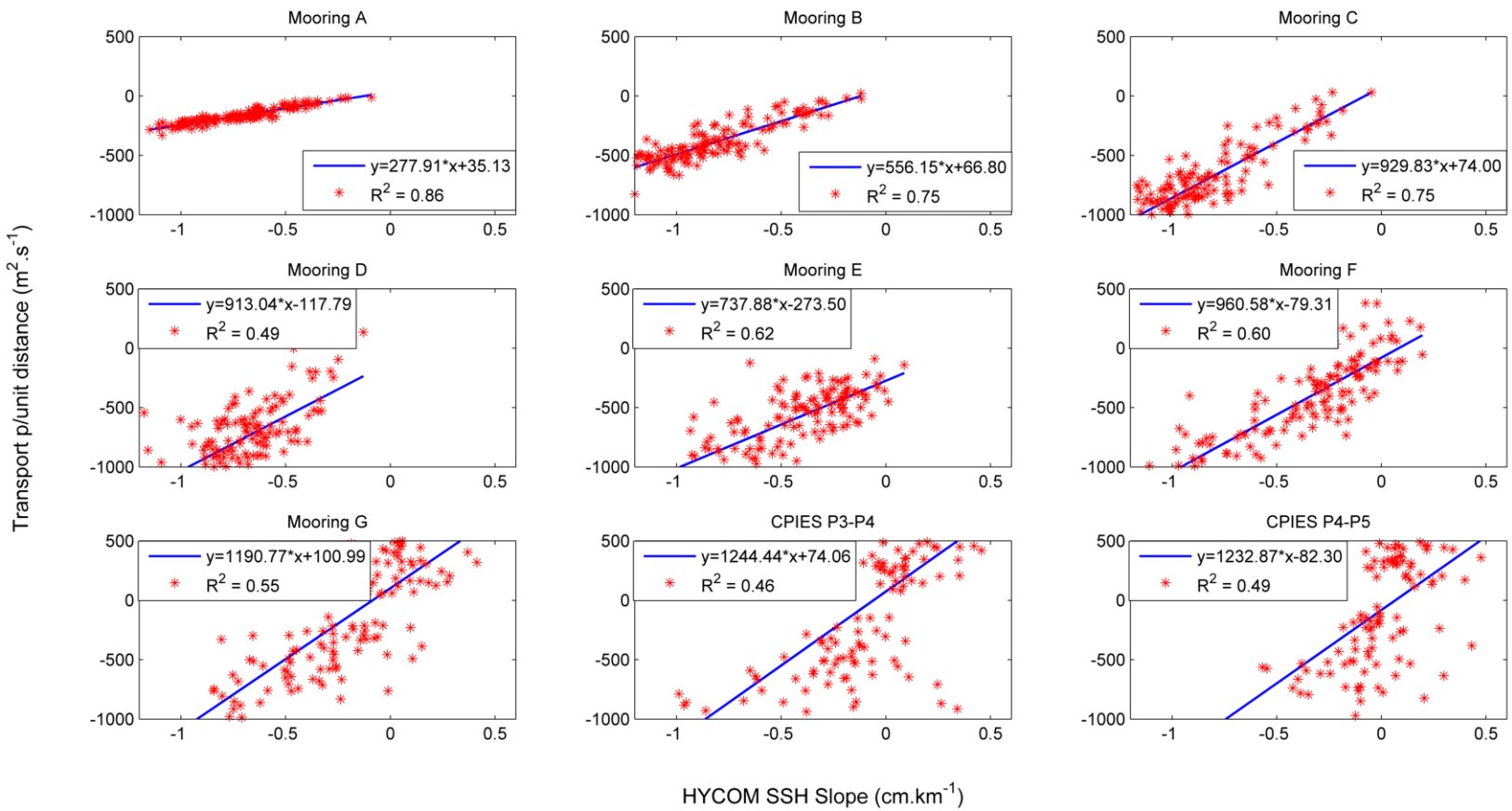
2. Interpolate SSH model data onto the positions of the T/P-Jason satellite track 96, overlapping the array.

3. Calculate SSH slope, by selecting the length scale that permits a maximum correlation with the corresponding mooring transport (Tx).

4. Build regression models for net transport (Tbox) and jet transport (Tjet).

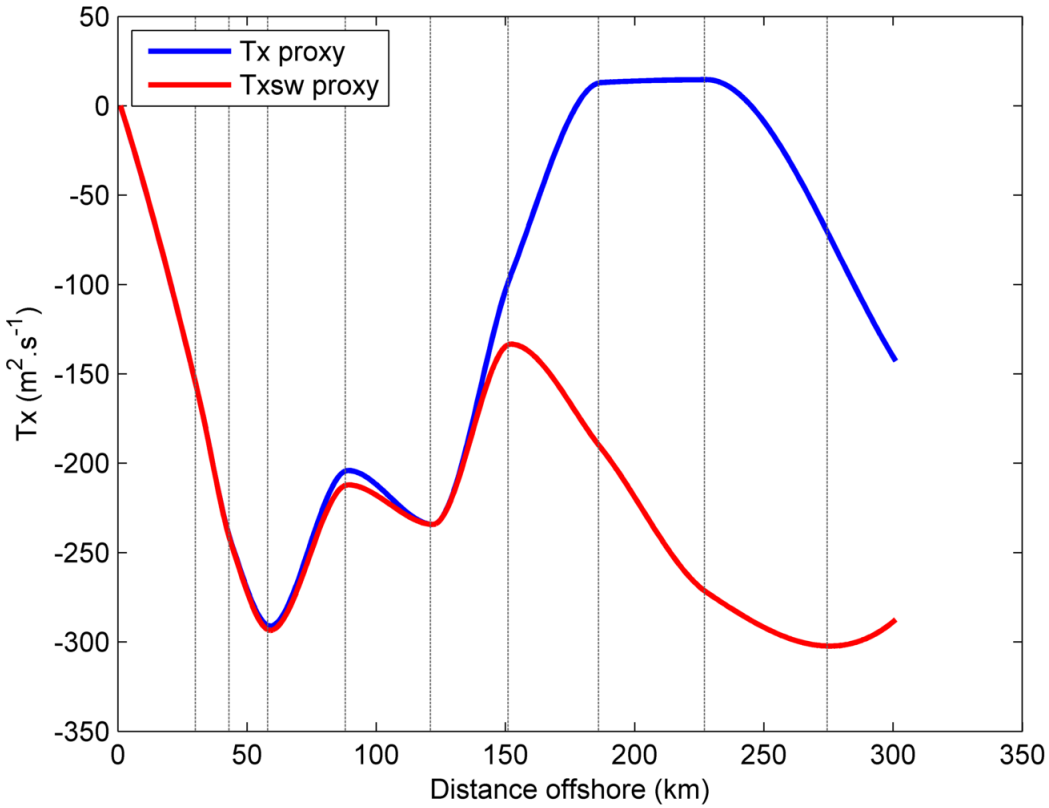


Net transport (Tx)



P values <10^{-3}, significant at 95% confidence interval.

Transport calculation method



Tx and Txsw estimates at the 1st model timestep.

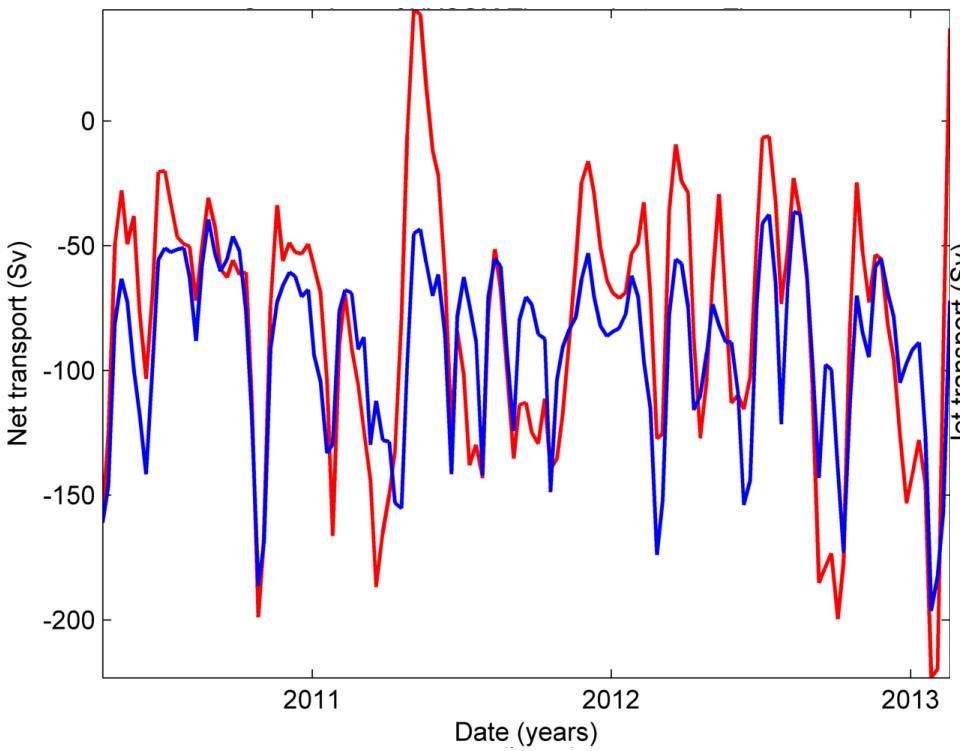
Applied Beal & Elipot, 2016 transport algorithm to calculate Tbox and Tjet.

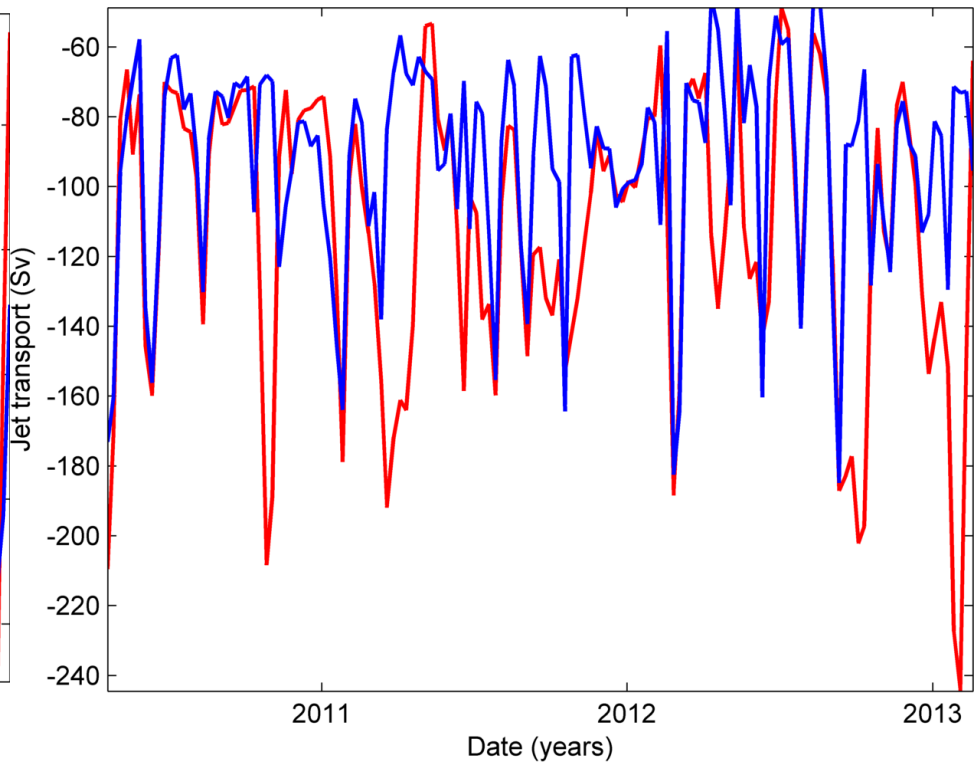
Fit interpolating polynomial to obtain Tx & Txsw estimates a 1km intervals from 0-300km offshore.

Tbox: Integrate Tx to 3-year mean width of the current.

Tjet: Use Tx to determine the position of the jet, then integrate Txsw horizontally to the jet width.

Proxy vs. Model

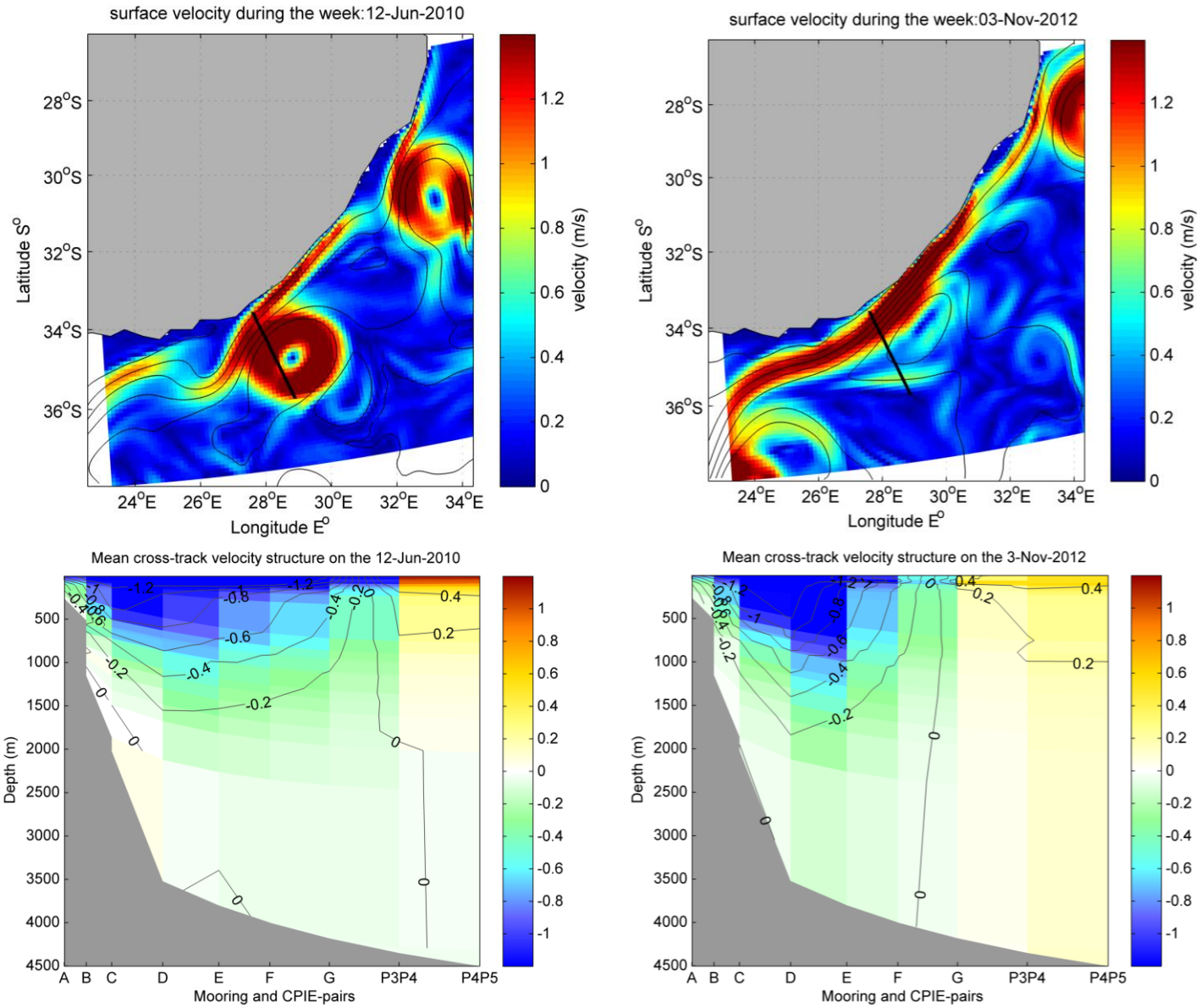




Model Tbox: -84 ± 47 Sv
Proxy Tbox: - 87.21 ± 34 Sv
Correlation: r=0.72, rms= 33 Sv

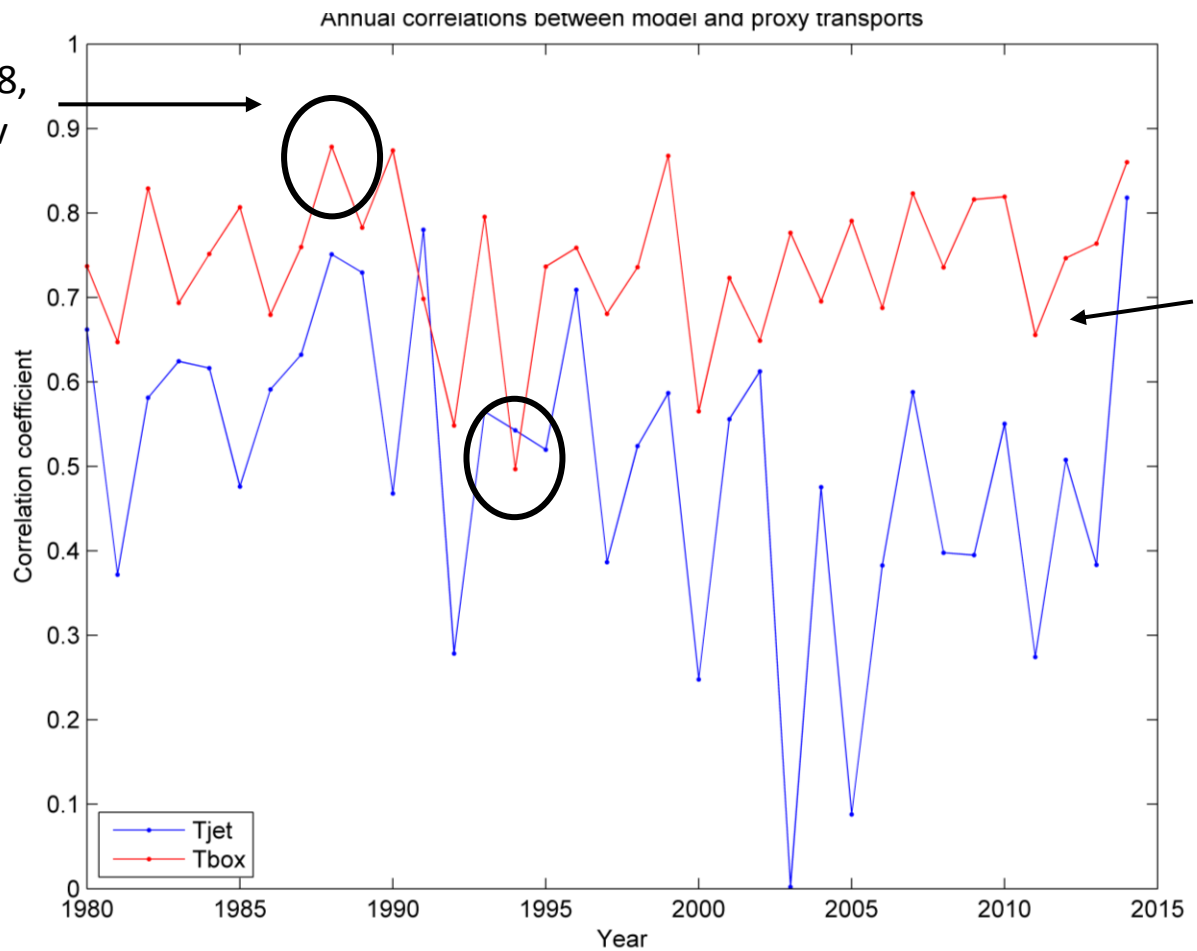
Model Tjet: -110 ± 38 Sv
Proxy Tjet: - 92 ± 31 Sv
Correlation: r=0.51, rms= 39 Sv

Meandering current vs non-meandering current…



Annual Correlations

1988: r=0.88,
rmse= 23 Sv

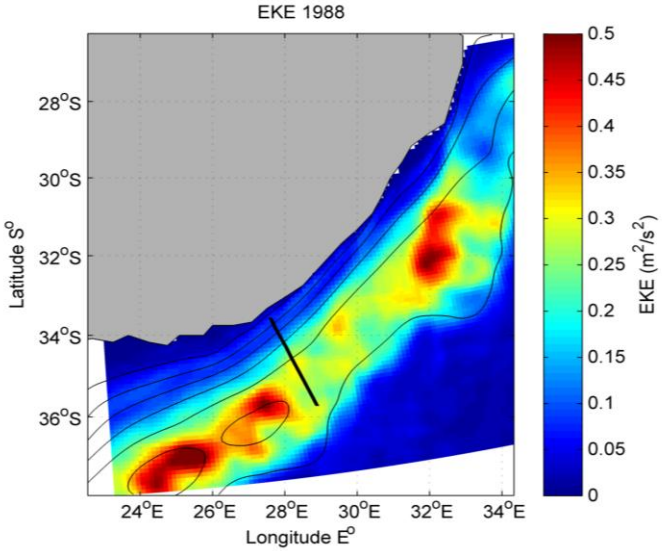


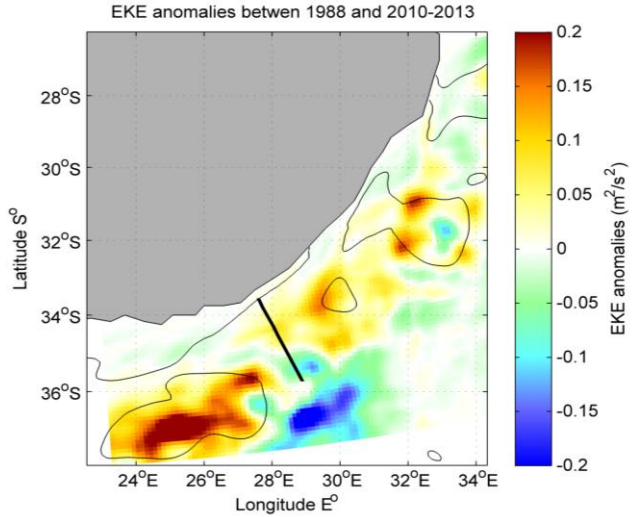
1994: r=0.50
rmse=28 Sv

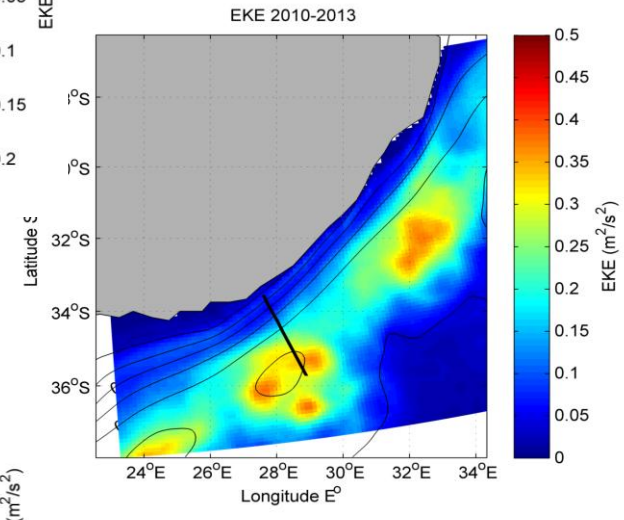
* P-values < 10^{-3}

How does the current structure look like during the highest & lowest correlated years?

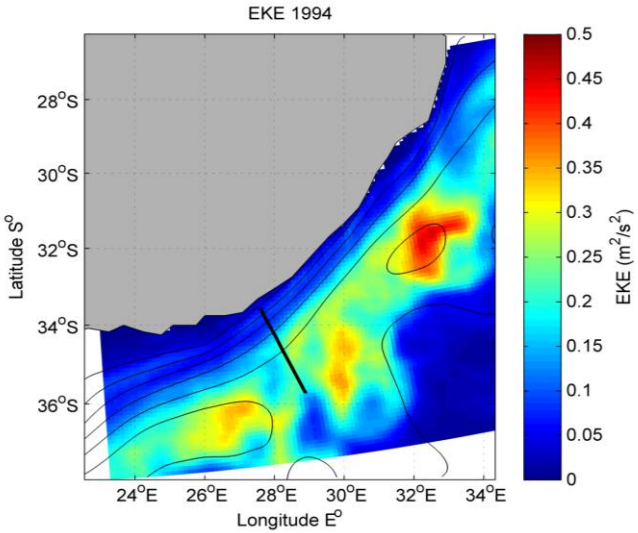
Highest correlated year: 1988

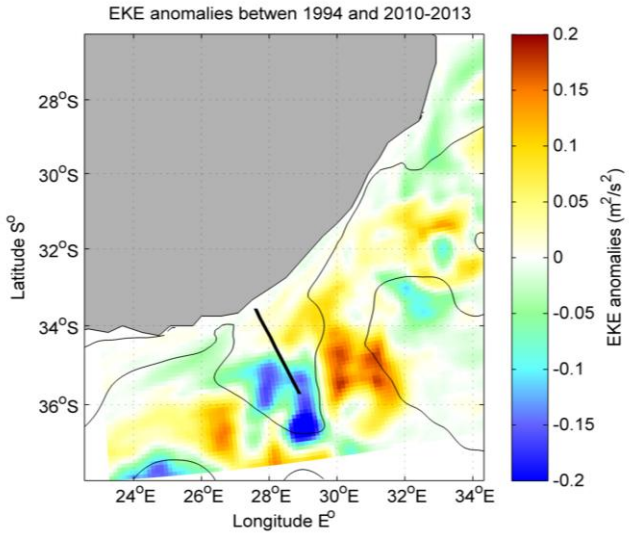




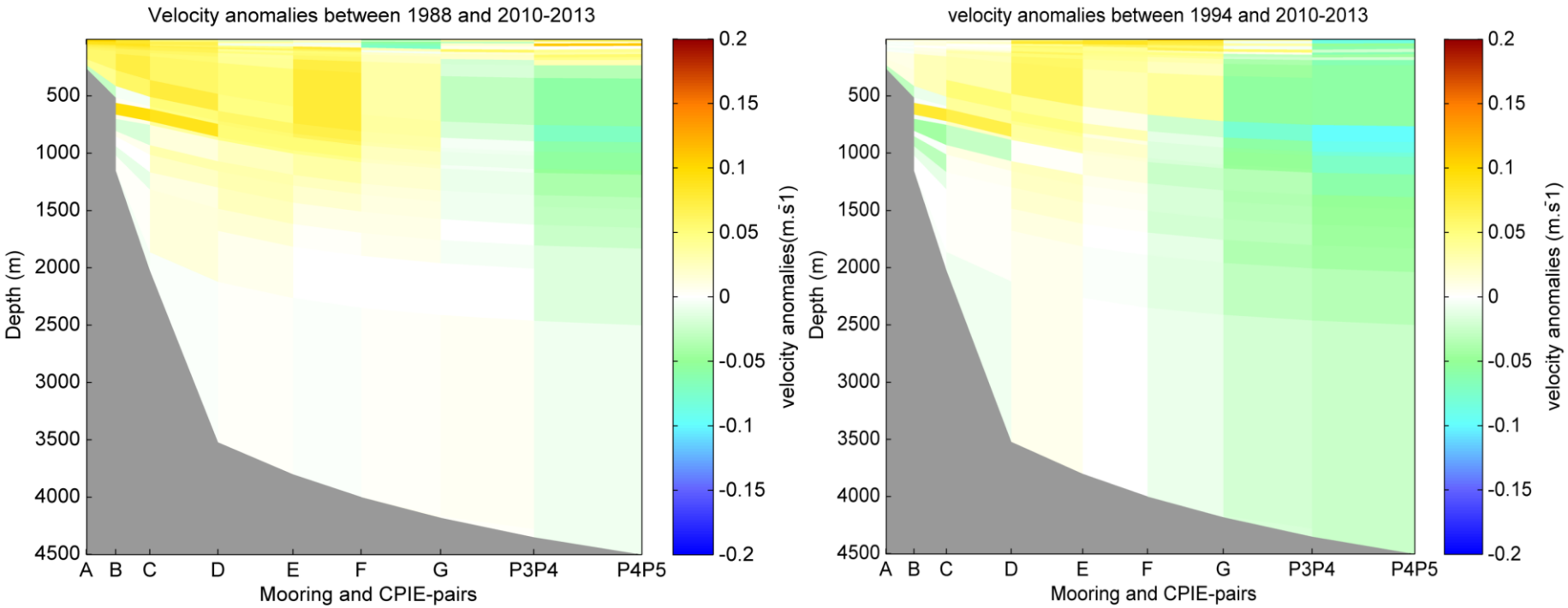


Lowest correlated year: 1994



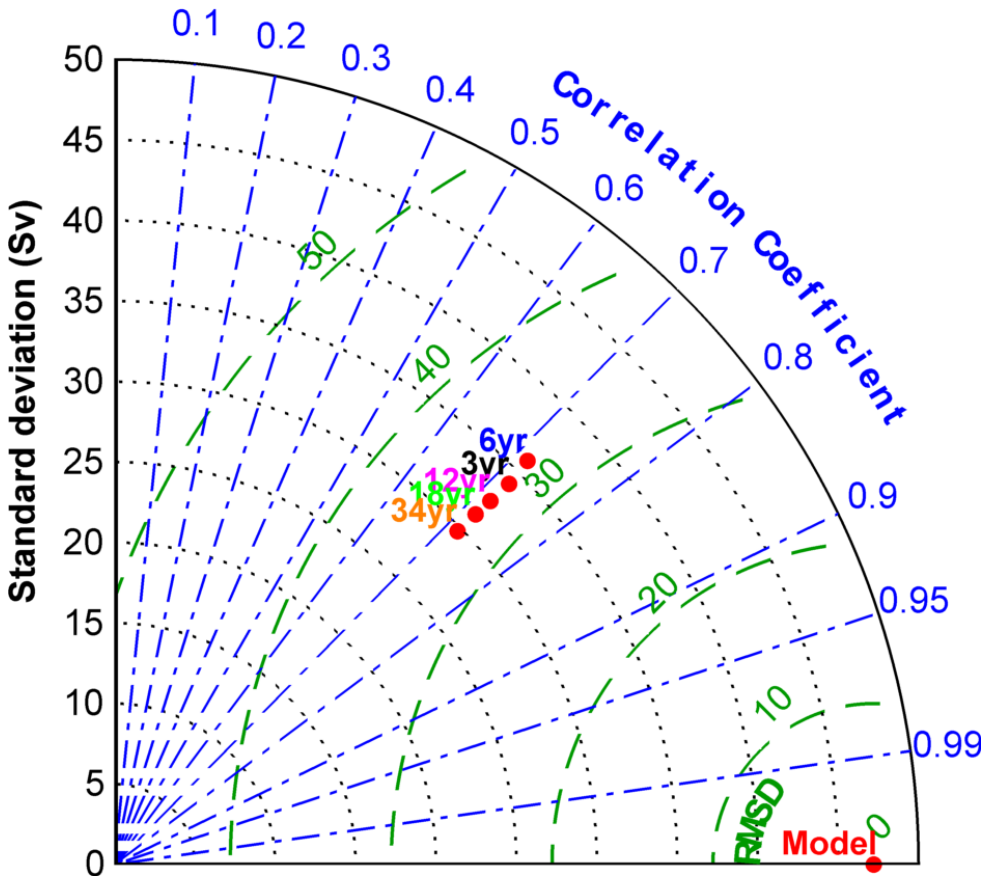


What does the cross-track velocity structure show?



Cross-track velocity anomalies between highest (left) and lowest (right) correlated years relative to the cross-track velocity profile during the development period (2010-2013).

Does the proxy depend on the length of the development period?



Taylor diagram showing the statistics of the transport proxies developed over 3, 6, 12, 18 and 34 years.

	STD	RMSE	CORR
MODEL	47.23	0	1
3-yr	34.09	32.76	0.7202
6-yr	35.91	33.04	0.7156
12-yr	32.51	32.83	0.7193
18-yr	31.28	32.95	0.7184
34-yr	29.74	33.14	0.7177

Conclusions

- The Agulhas Current transport proxy method is best suited to estimate the net transport, rather than the southwest jet transport.
- The net transport proxy is unable to represent all of the variability in the Agulhas Current (r=0.72). How can we improve the proxy?
- Offshore current meanders as a consequence of frequently impinging eddies reduced the correlation of the transport proxy.
- This modelling study suggests a 3-year development period is sufficient to estimate a linear relationship between SSH slope and volume transport and is thus applicable over longer time periods.

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Southwest transport (Txsw)