Mean Flow and Variability in the Southern Ocean from Altimetry

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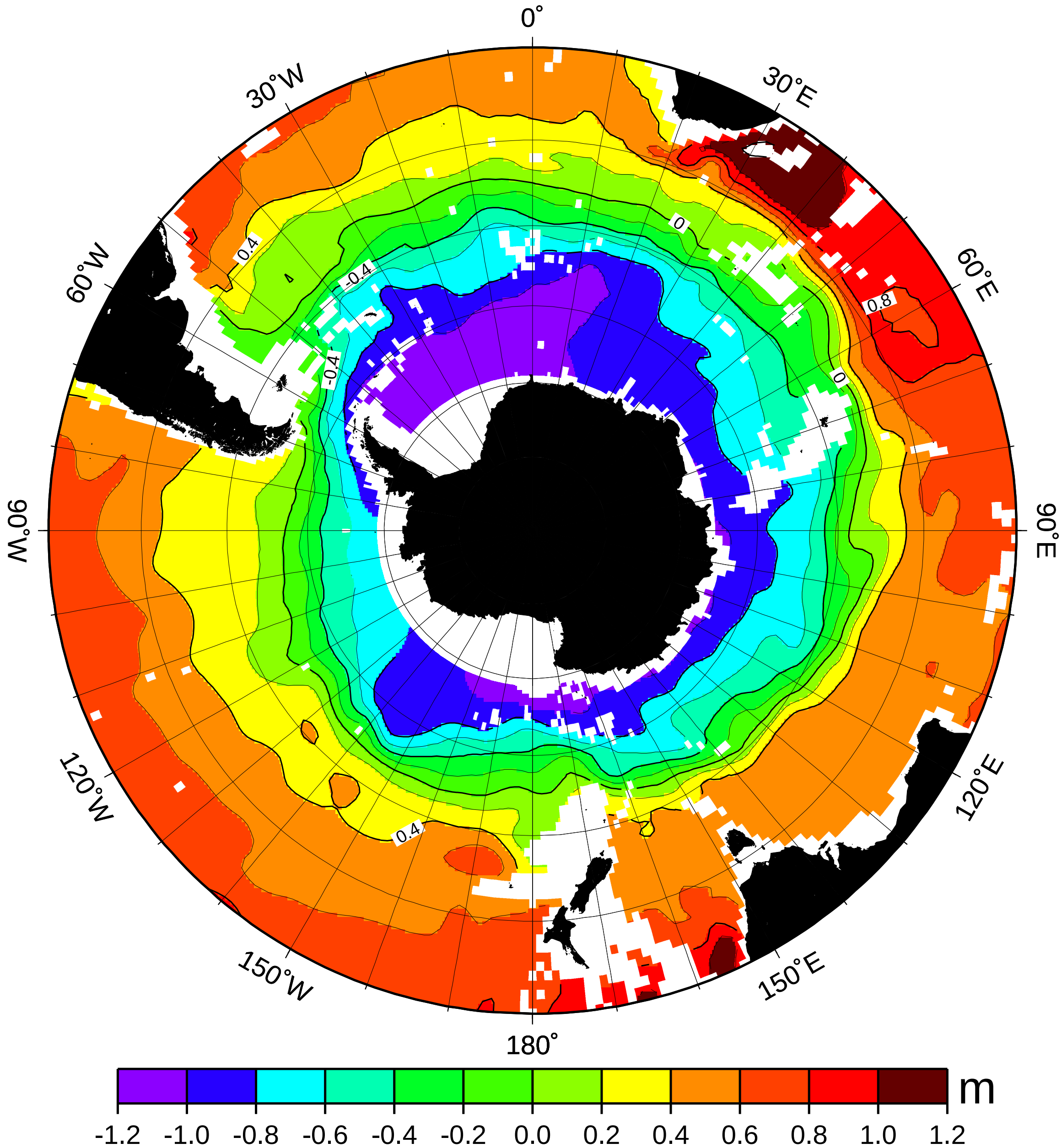
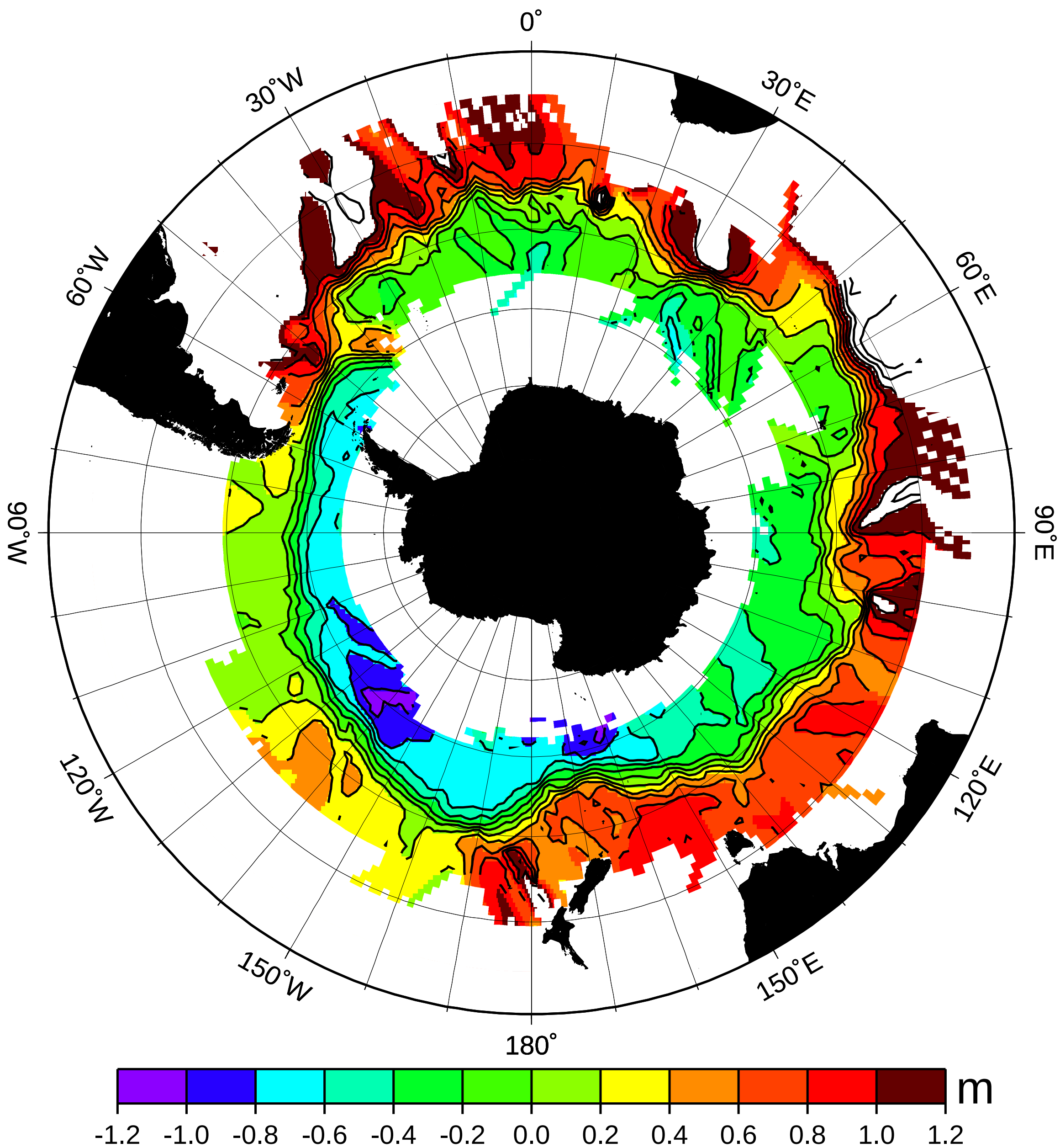
In this poster

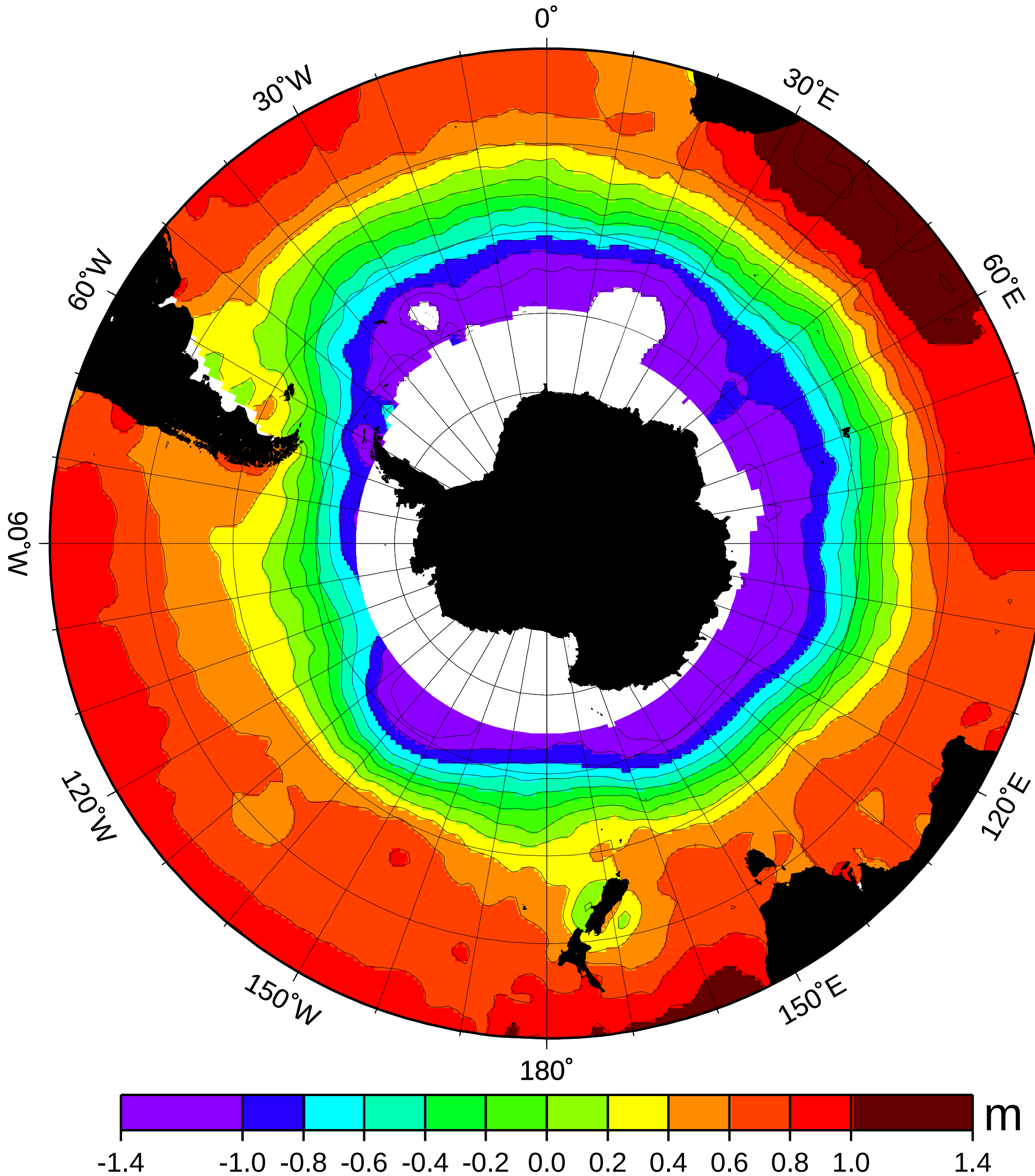
- **Mean Sea Surface Height** from hydrography, geoid models, and reconstruction from Topex variability are compared.
- **Characteristics of variability** are evaluated, using bottom pressure data to assess aliasing and then TOPEX variability to examine EOFs.



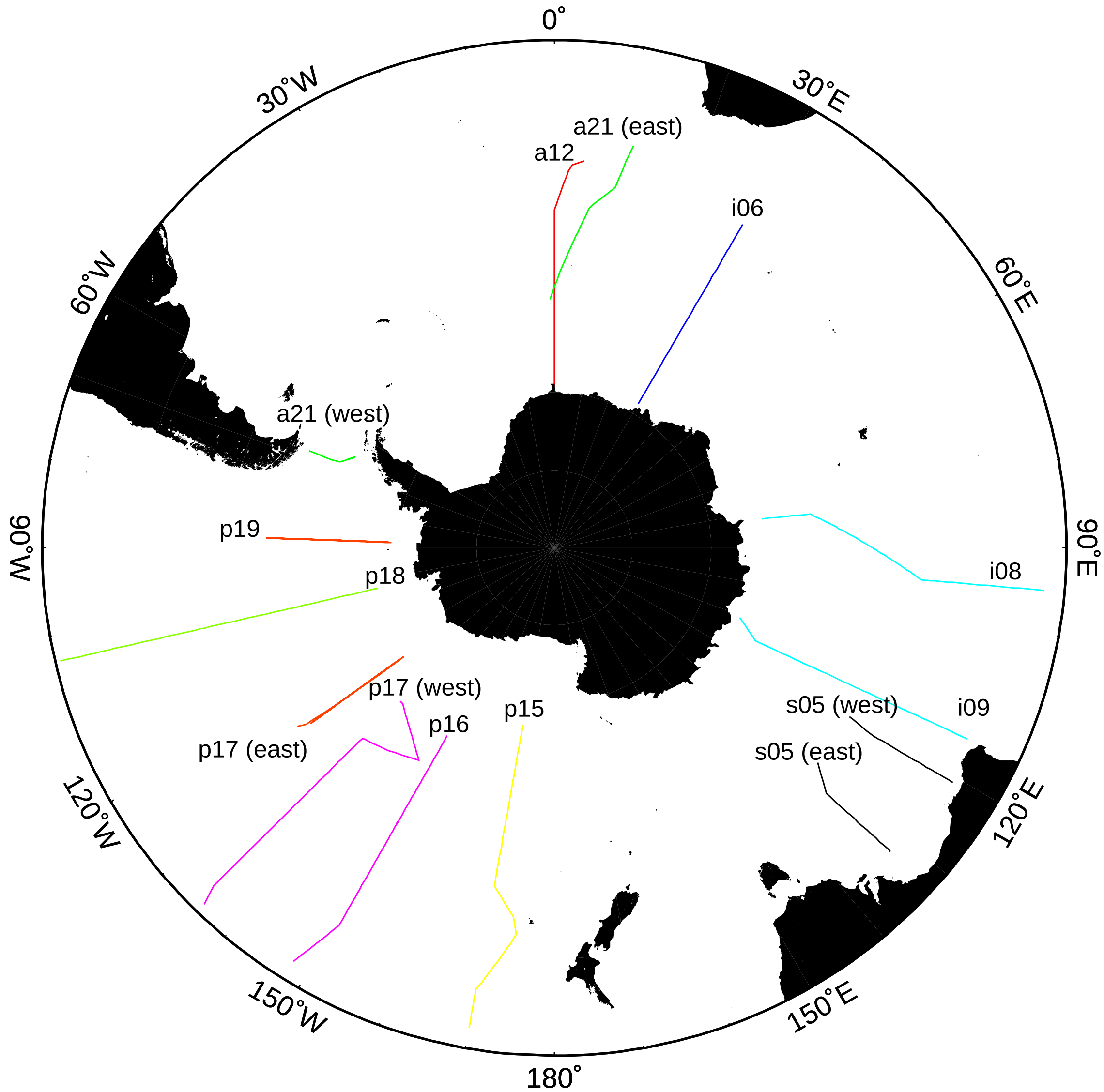
Hydrographic dynamic topography at the ocean surface relative to 2500 m from atlas data (Olbers, et al., 1992).



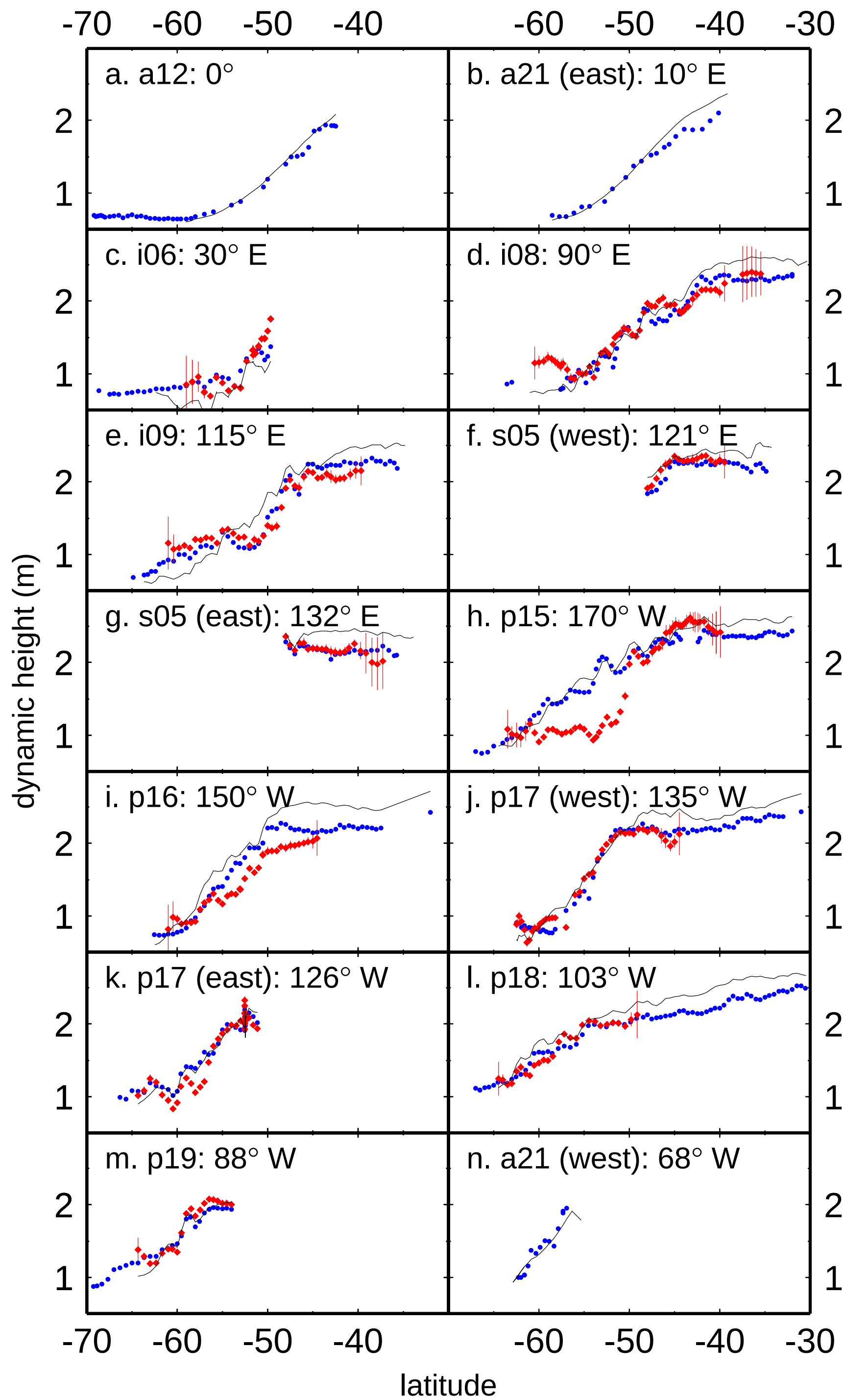
Mean sea surface height reconstructed from TOPEX altimeter measurements, assuming the ACC can be represented by two meandering jets.



EGM96 geoid dynamic topography based on best available geoid models (LeMoine et al., 1997; Koblinsky, personal communication).



WOCE-era hydrographic sections in the Southern Ocean, for which mean sea surface heights have been compared.

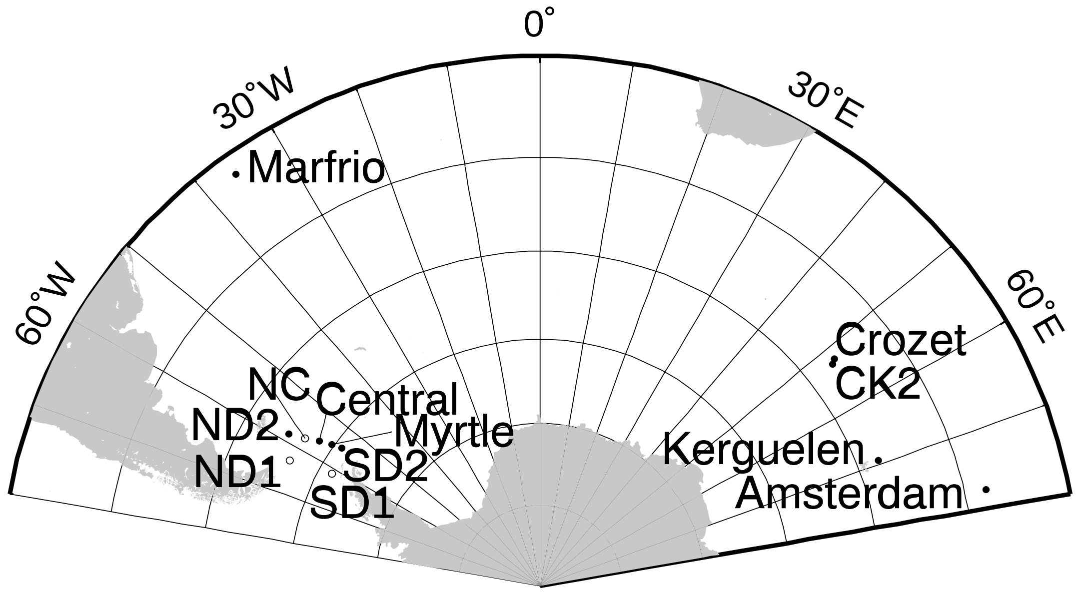


Instantaneous sea surface height compared along hydrographic sections. Black lines are EGM96 plus altimetric variability, blue dots are dynamic height from the WOCE cruises, and red dots are total sea surface height from altimetry.

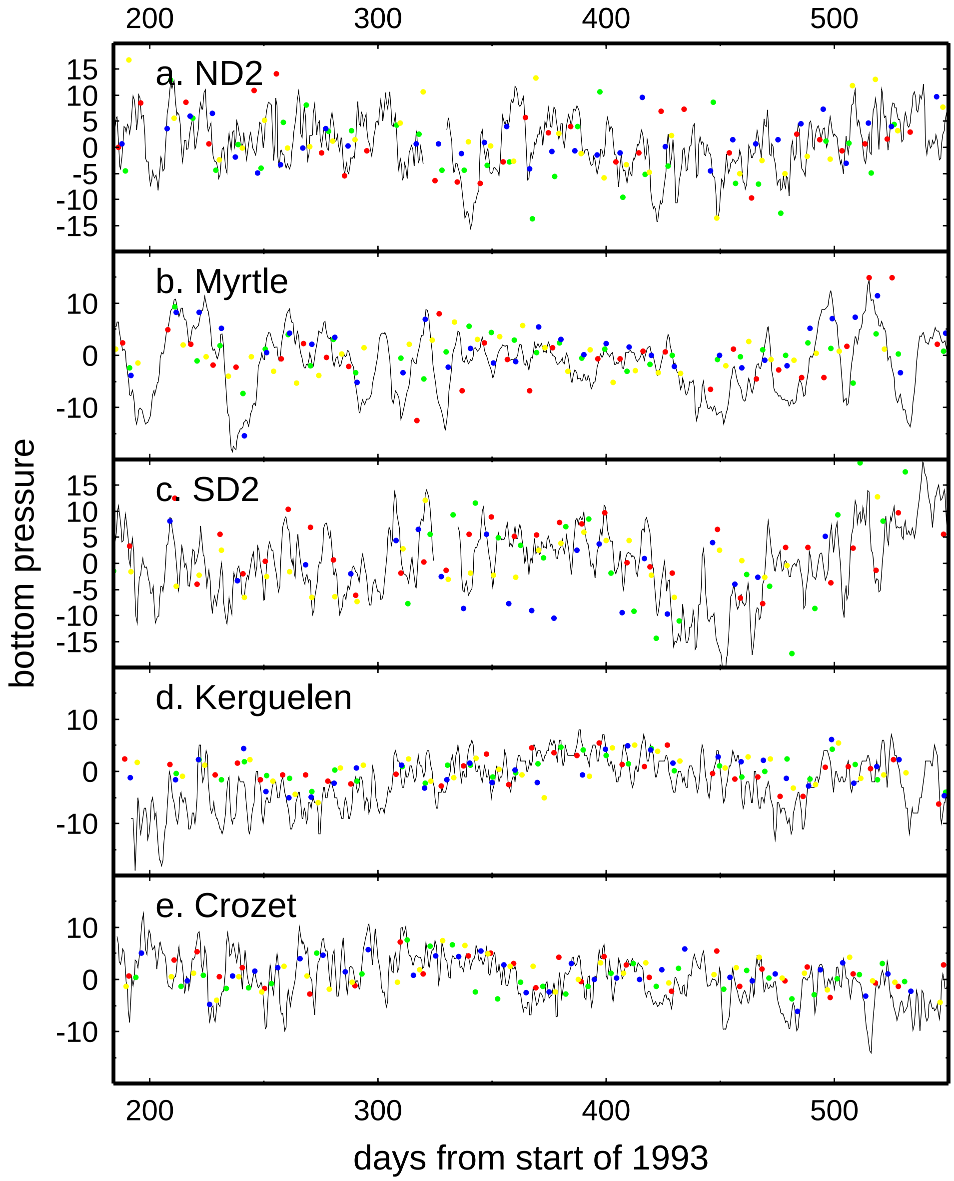
The meandering jet model typically provides a better match to hydrographic dynamic topography over 6 to 12 degree ranges in the core of the ACC, and in some cases is better than the EGM96 geoid at representing the total height difference across the Southern Ocean, as summarized below.

Latitude ranges in which hydrographic dynamic topography is better matched by meandering jet model rather than EGM96 geoid model:

i06	-50 to -44; -59 to -51
i08	-57 to -48
i09	-62 to -39
s05 (west)	-48 to -39
s05 (east)	-48 to -38
p15	-61 to -55; -50 to -46; -46 to -41
p16	-56 to -44
p17 (west)	-62 to -44
p17 (east)	-57 to -51
p18	-64 to -61; -58 to -54; -56 to -49
p19	-64 to -55

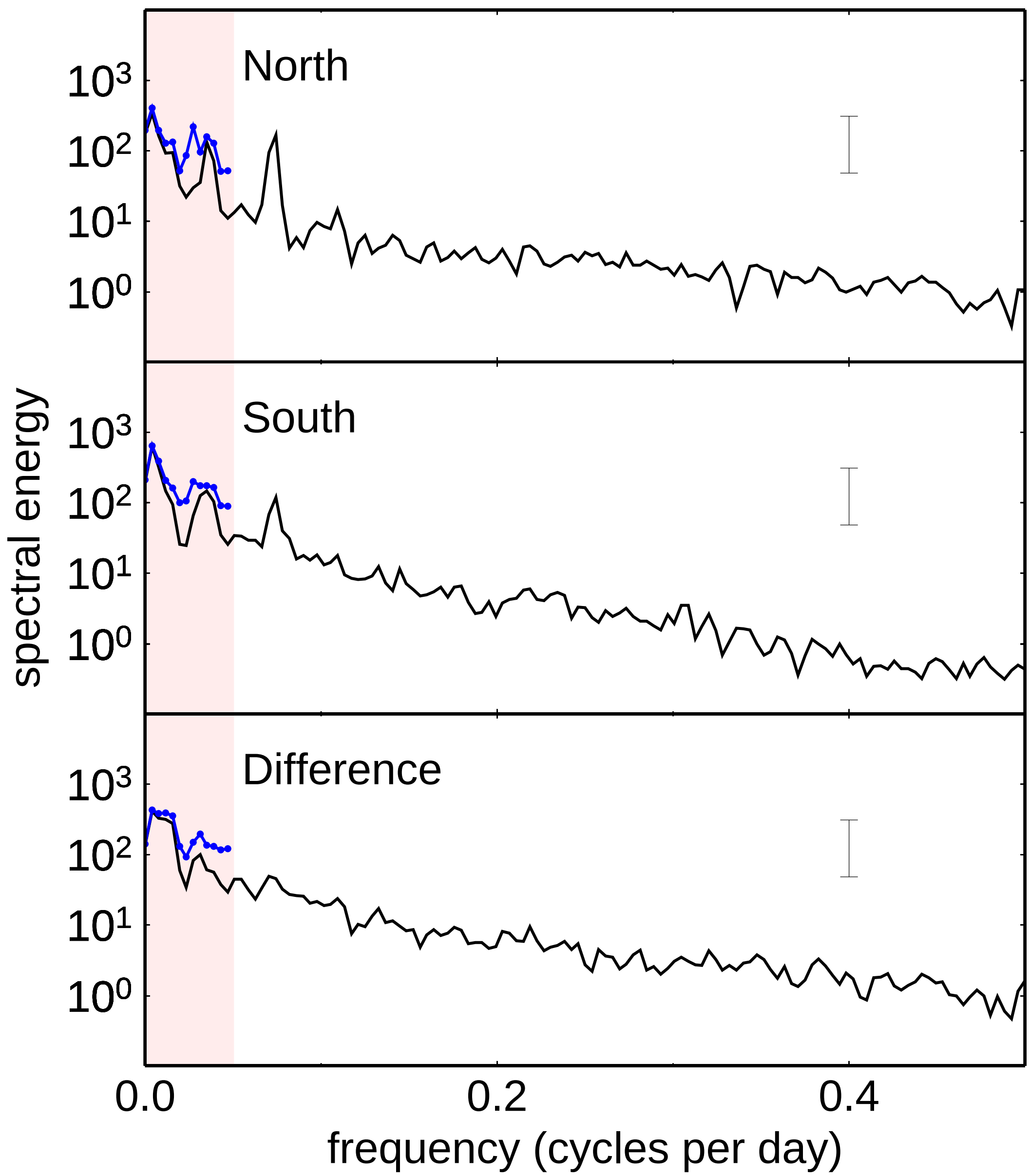


Bottom pressure gauge locations from the Southern Ocean.

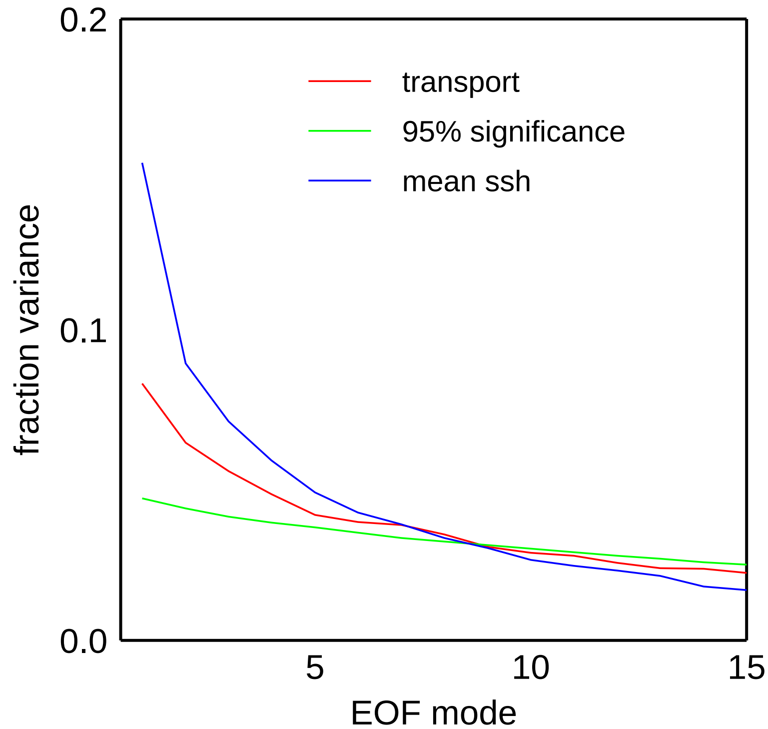


Time series of sea surface height (colored dots) and bottom pressure.

Lagged correlation coefficients (not shown) suggest that surface fluctuations are nearly simultaneous with bottom pressure fluctuations. The surface is more likely to lag the bottom rather than leading it, suggesting that bottom fluctuations represent a fast barotropic response while surface fluctuations represent a superposition of barotropic and slower baroclinic modes.

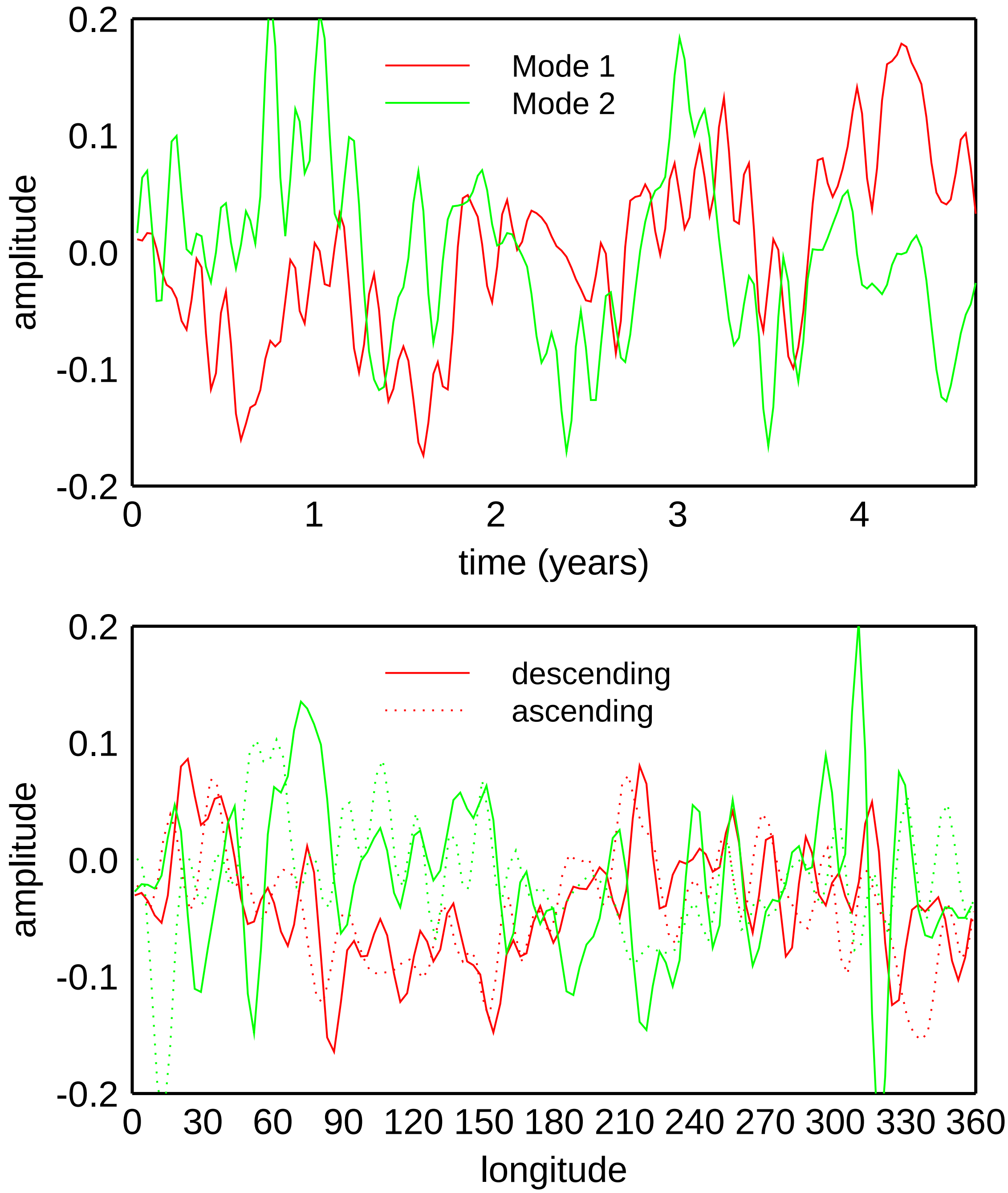


Spectra from the north side of Drake Passage, the south side, and the difference are nearly white. As a result, subsampling at 10-day increments aliases significant amounts of high-frequency energy and biases the spectra. Here aliasing appears less severe for frequencies less than half the Nyquist frequency.

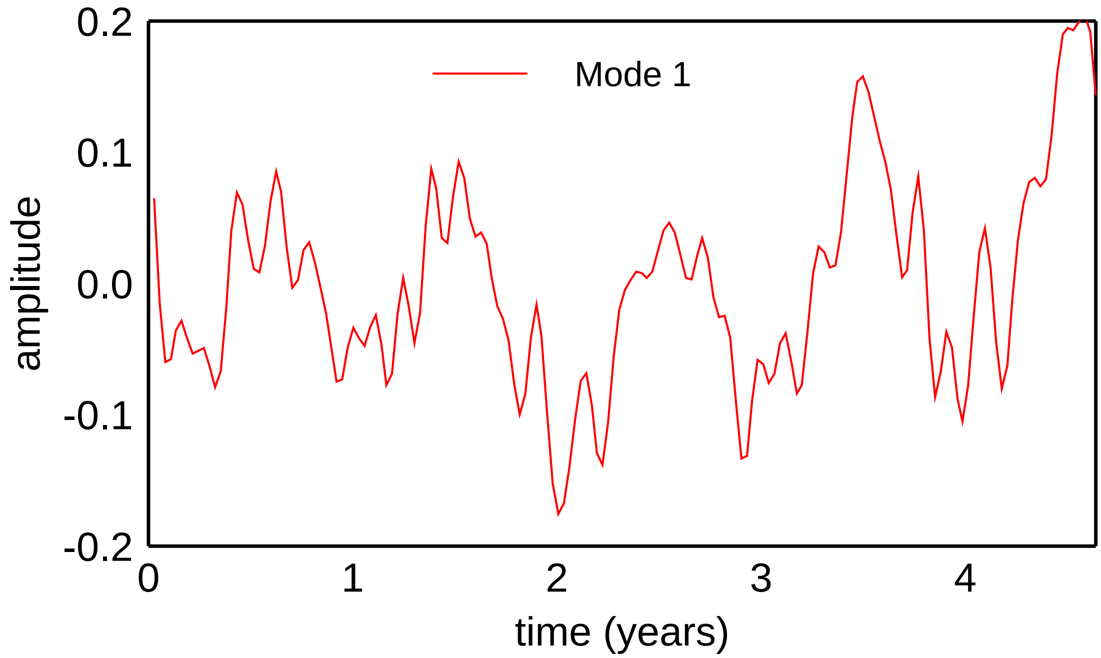


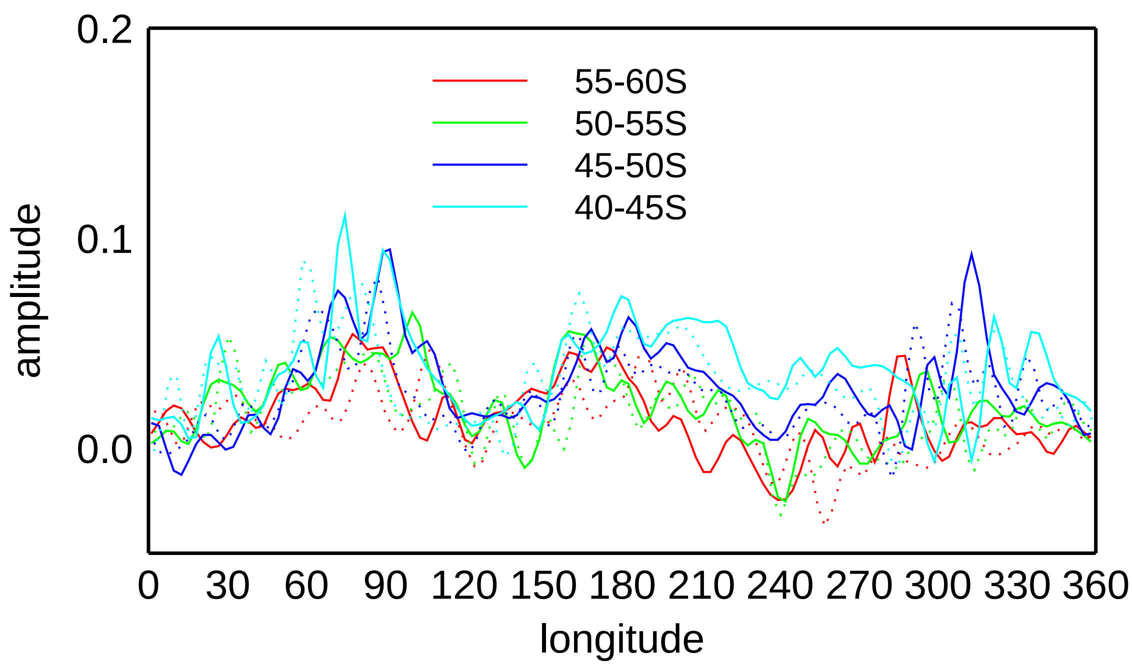
Fraction of variance explained by leading mode Empirical Orthogonal Functions for the ACC show that many modes are required to explain even 50% of the variance. This suggests that the upper ocean does not vary coherently.

Two data records are considered. The first (in red) is ACC surface transport based on the meandering jet model. The first 8 modes are significant compared with random white noise, and together they explain 40% of the variance. The second (in blue) is based on TOPEX sea surface height averaged in 5-degree bins between 40 and 60S.

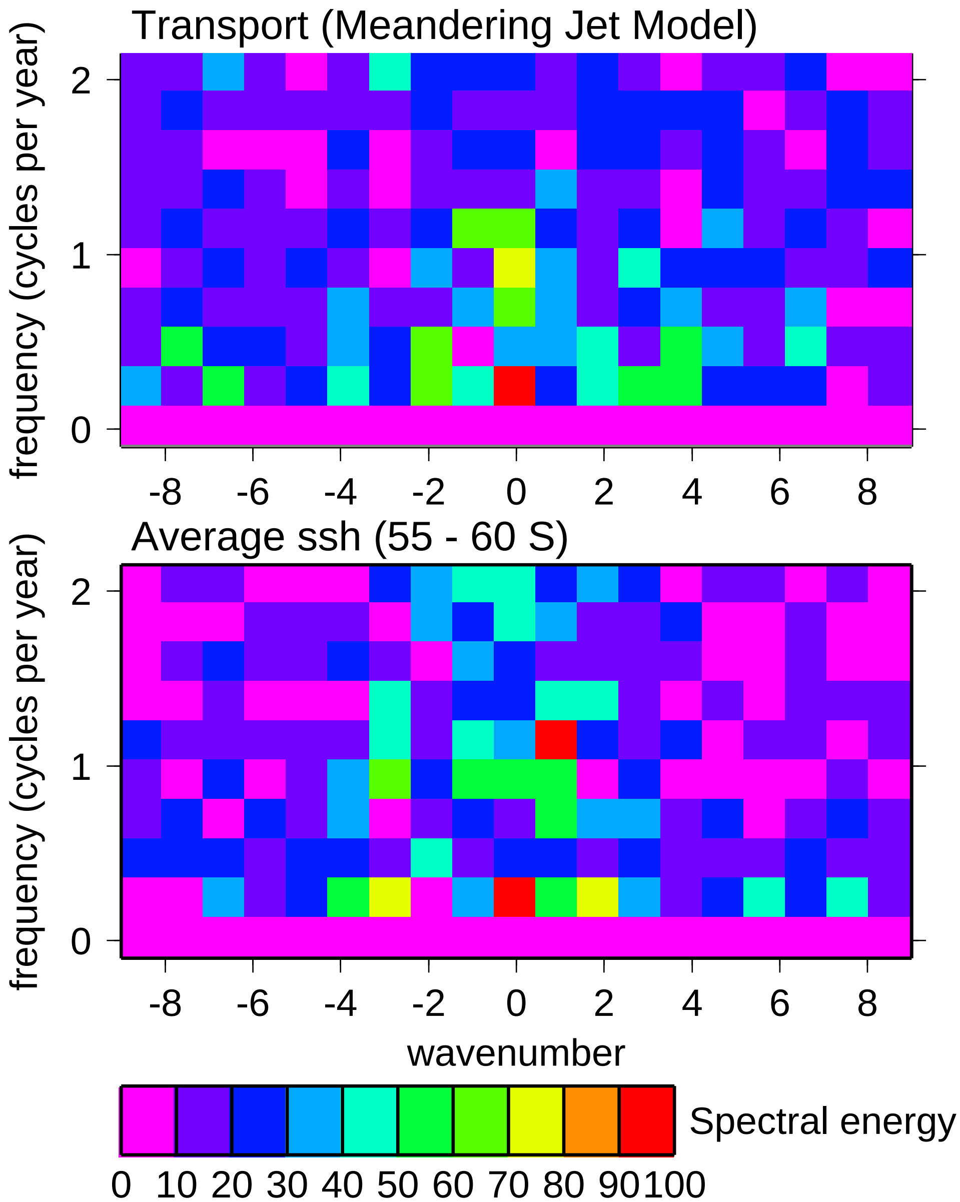


Surface transport EOFs for modes 1 and 2 have spatial and temporal structures dominated by the annual cycle and by wavenumber 1. If the annual cycle is removed, interannual fluctuations in the annual cycle appear to dominate the first EOF.





Sea surface height EOFs for moes 1 and 2 are dominated by the annual cycle with wavenumber 3.



Representative spectra for ascending track data indicate substantial energy at the annual cycle, particularly at wavenumber zero. Removing the annual cycle removes the energy peak at 1 cycle per year, but otherwise does not substantially change the spectra.

The Antarctic Circumpolar Wave is predicted to have wavenumber 2 and a frequency of one cycle per four years. Sea surface height spectra indicate a moderate peak at this frequency/wavenumber combination, but this peak explains only a small fraction of upper ocean variability. “Transport” spectra are more strongly dominated by the annual cycle.

Summary

- Mean sea surface height estimates from hydrography, the EGM96 geoid model, and a meandering jet model differ. The geoid model estimates a larger sea surface height difference across the ACC than might be inferred from hydrography or altimetry alone. The meandering jet model provides a good match to hydrography over approximately 500 km lengthscales.
- Bottom pressure data suggest substantial aliasing of altimeter energy, particularly for frequencies greater than about half the Nyquist frequency N.
- EOFs show non-propagating variability is dominated by the annual cycle.
- Spectra indicate substantial energy at a broad range of frequencies and wavenumbers, including a moderate energy peak that may correspond to the Antarctic Circumpolar Wave.

References

Lemoine, F. G., D. E. Smith, L. Kunz, R. Smith, E. C. Pavlis, N. K. Pavlis, S. M. Klosko, D. S. Chinn, M. H. Torrence, R. G. Williamson, C. M. Cox, K. E. Rachlin, Y. M Wang, S. C. Kenyon, R. Salman, R. Trimmer, R. H. Rapp, and R. S. Nerem, 1997. The Development of the NASA GSFC and NIMA Joint Geopotential Model. *Gravity, Geoid and Marine Geodesy: Int. Assoc. Geodesy Symp.*, **117**, 461–469.

Olbers, D., V. Gouretski, G. Seiß, and J. Schröter, 1992. *Hydrographic Atlas of the Southern Ocean*. Alfred Wegener Inst., Bremerhaven, Germany.