MyScience Cruise

Causes for temperature variability of Antarctic Bottom Water in the Vema Channel

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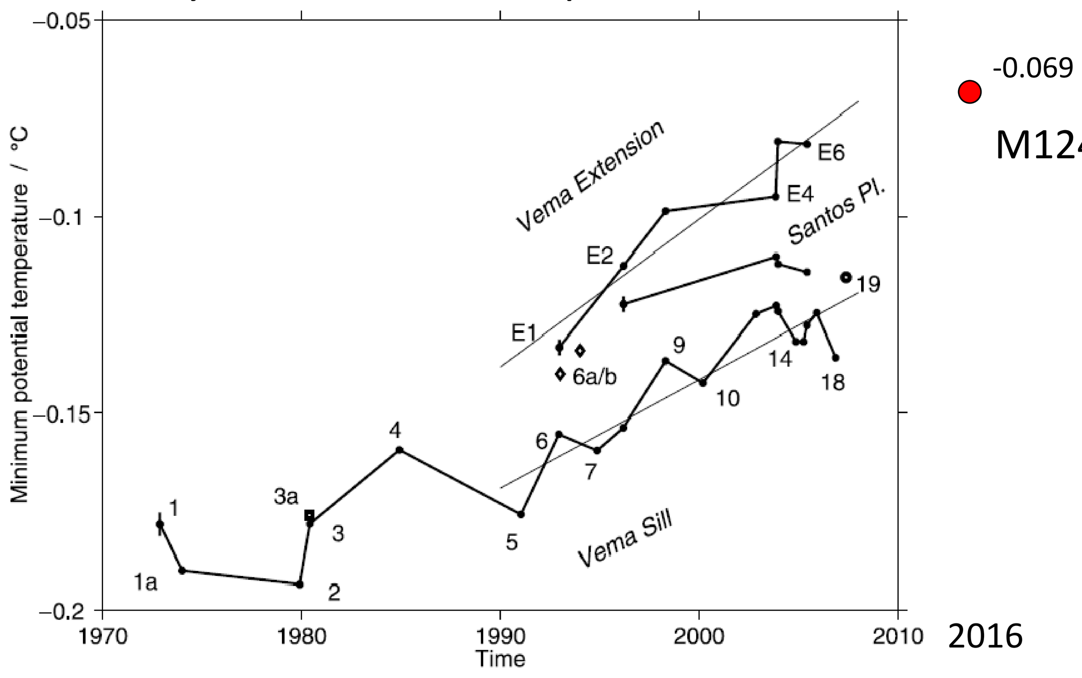
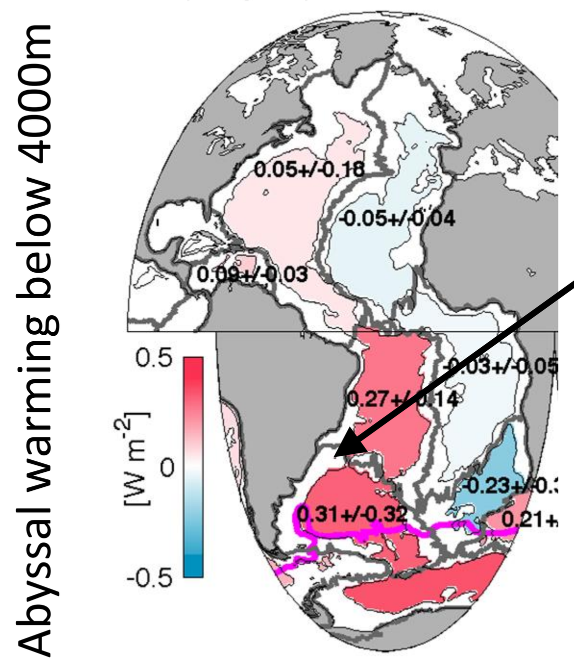
Introduction

The abyssal ocean is warming as a response to climate change [1]. The coldest and most dense water is the Antarctic Bottom Water (AABW) with a potential temperature of < 2°C [2]. In the western South Atlantic it spreads northward from the Argentine Basin to the Brazil Basin. The coldest AABW flows therefore through the Vema Channel which has a sill depth of over 4800m at ~31°S, ~ 39°W [3]. Since the 1970's a decadal warming trend of the coldest Antarctic Bottom Water has been observed in the Vema Channel and Vema Extension [2]. This study will investigate the short and long term variability in observed temperature and attribute it to tides and topographic waves.



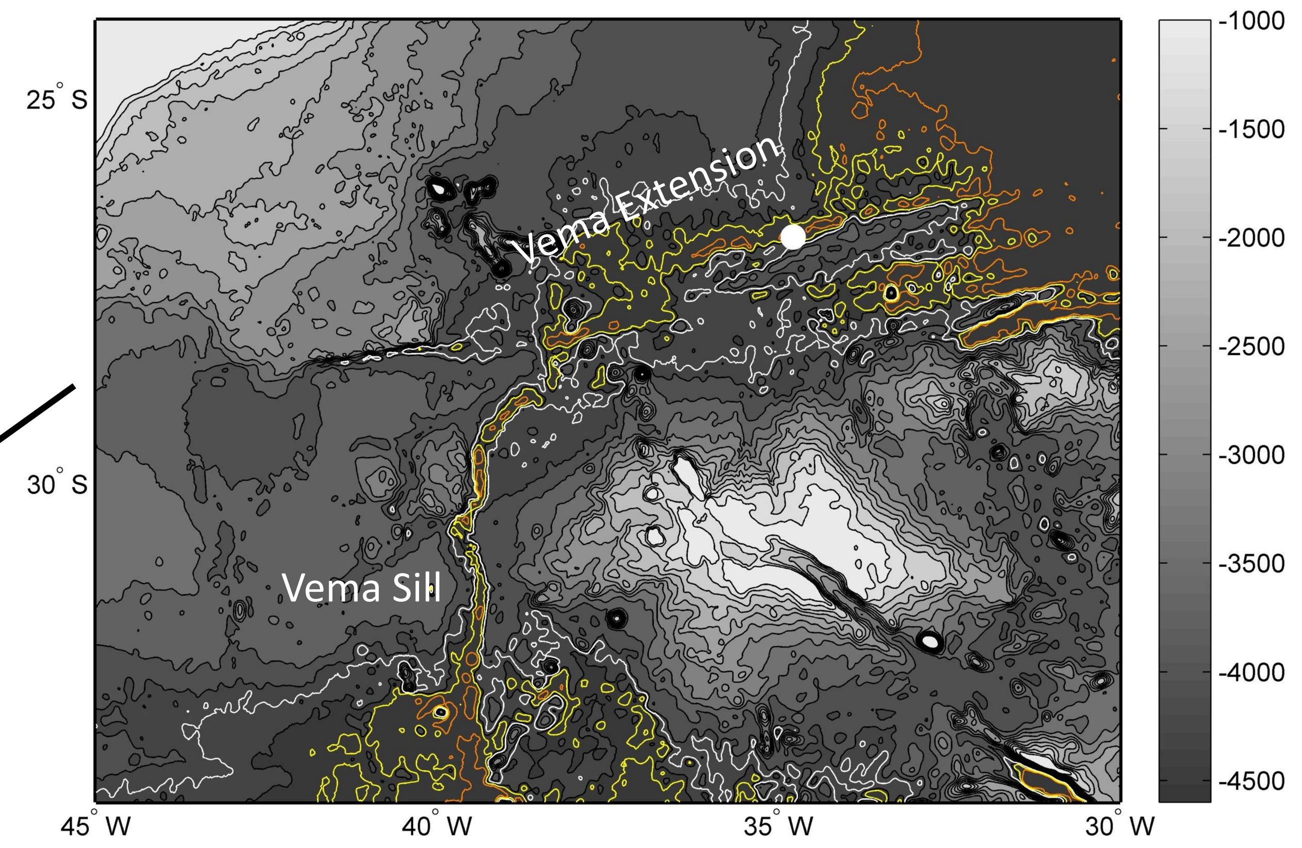
Zenk & Morozov, 2007



Purkey & Johnson, 2010

Data: CTD and current meters in the Vema Channel

The mooring V349/K3 in the Vema Extension measured speed and direction of velocity as well as temperature from 19.12.1992 to 4.04.1995 every two hours. The three current meters were placed at depth of 997 m, 4352 m (white isoline) and 4849 m. The distance from this the mooring to CTD M22_53 was 2.3 km.



The CTD casts measured Conductivity, Temperature and Pressure for the whole water column down to 4762 m.
CTD cast M22_53 was performed on 18.12. 1992 and cast M124_13 on 15.03.2016.
The distance between the CTD stations was 56m.

Method

The frequency of **topographic Rossby Waves** with a large horizontal wave number was calculated using

$$\omega = \Gamma N \sin\theta \quad (1)$$

with Γ representing the topographic slope at the location of the mooring V349/K3, N the Brunt-Väisälä frequency of the water column deeper than 4000m from CTD cast M22_53 and θ the angle between the wave number vector and upslope [4].
For motions up and down the slope ($\theta = \pi/2$) the highest frequencies occur, so (1) becomes

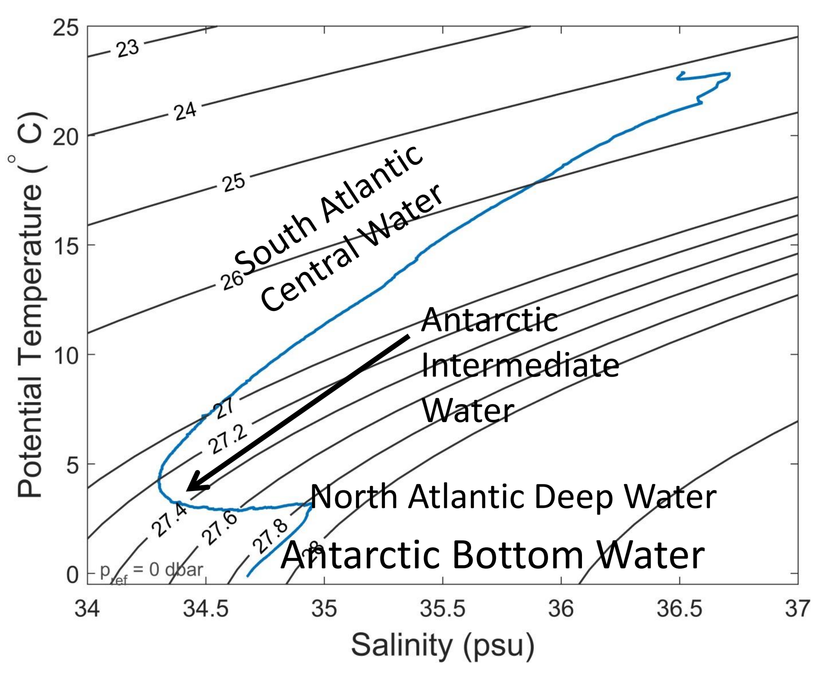
$$f = 2\pi / \Gamma N \quad (2)$$

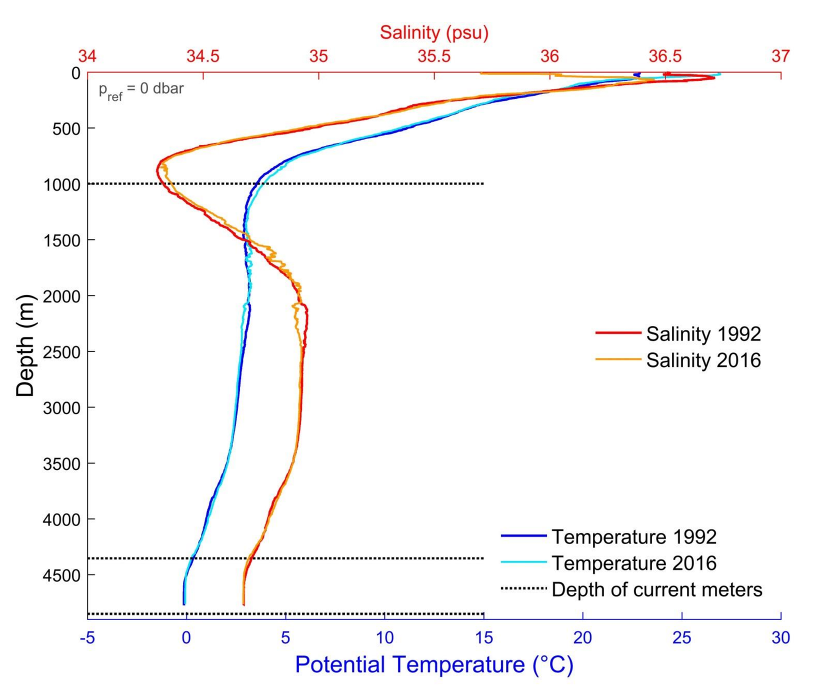
In the observed location in the Vema Channel with Γ ≈ 3.2-5.5*10^-2 and N ≈ 1.2*10^-3 the frequency of topographic Rossby waves is **f ≈ 26-45 hours.**

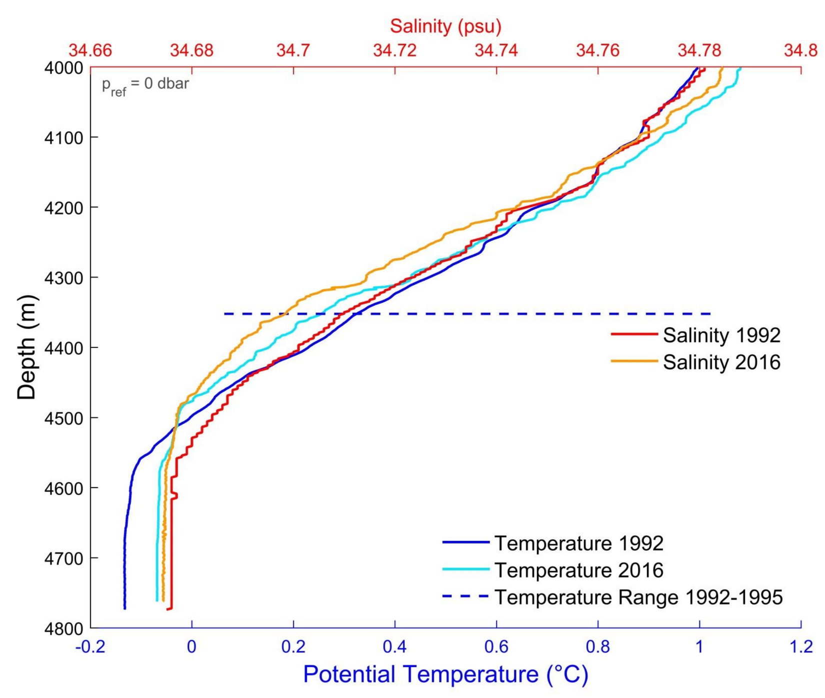
The frequency of **inertial oscillation** is f = 2*Ω*sin(latitude) ≈ **26.48 hours.**

The **spectral analysis of the tides** was done with the Matlab toolbox t_tide [5].

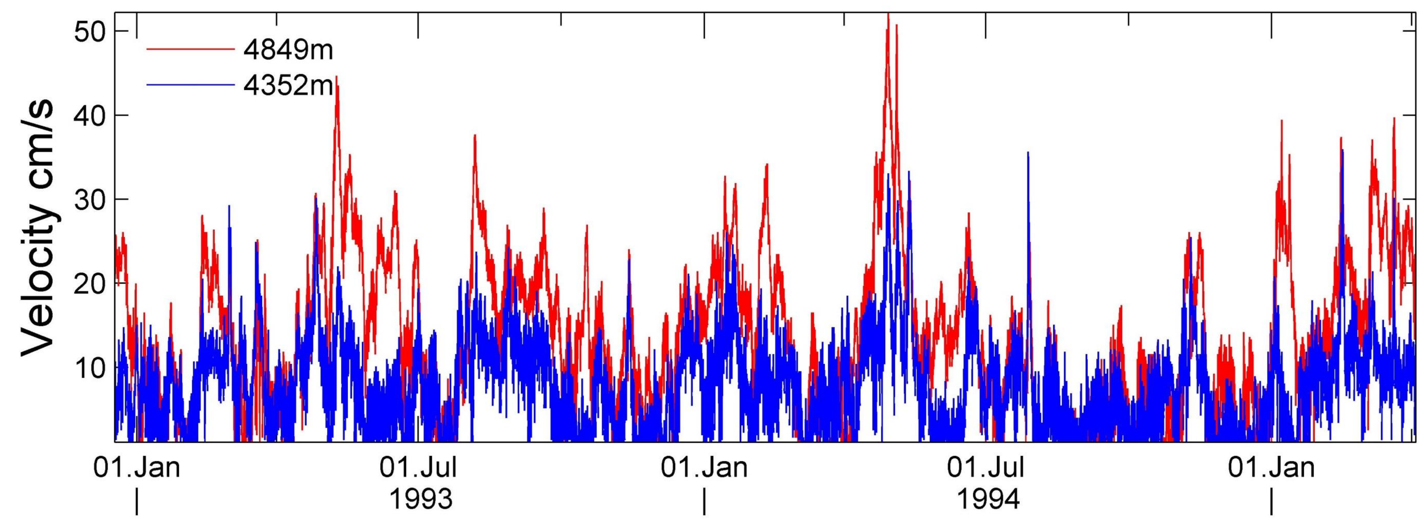
CTD: temperature and salinity

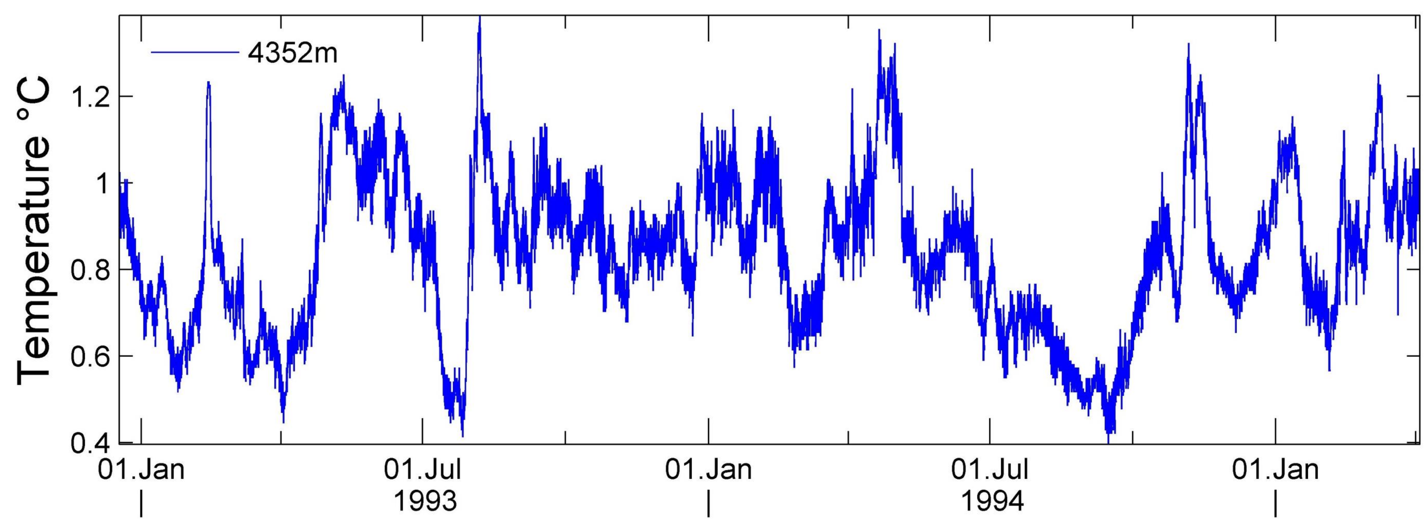




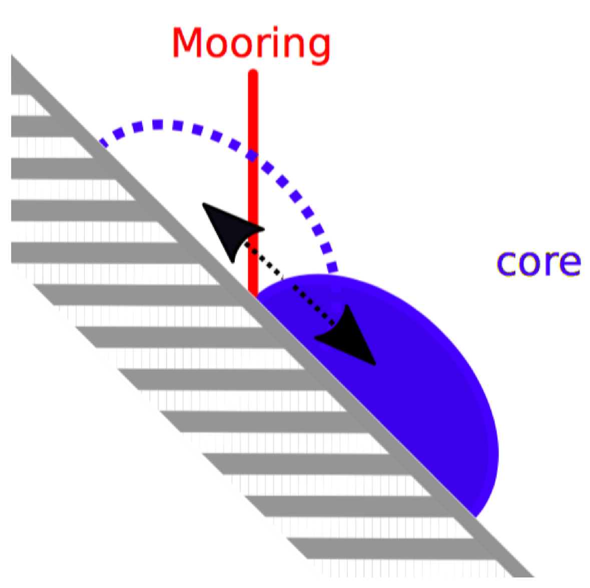


Mooring: velocity and temperature

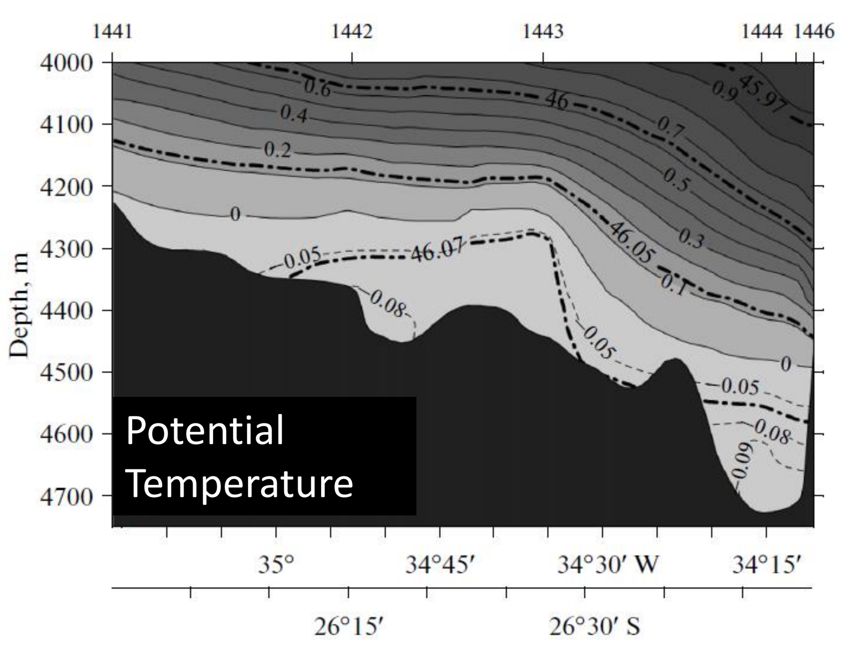




- mean velocity: ≈ 7.8 cm/s at 4352m and ≈ 13.7 cm/s at 4849m
- mean in situ temperature: ≈ 0.84 °C at 4352m
- co-variability of velocity and temperature because of a horizontal and vertical temperature gradient and the core moving up and down the slope

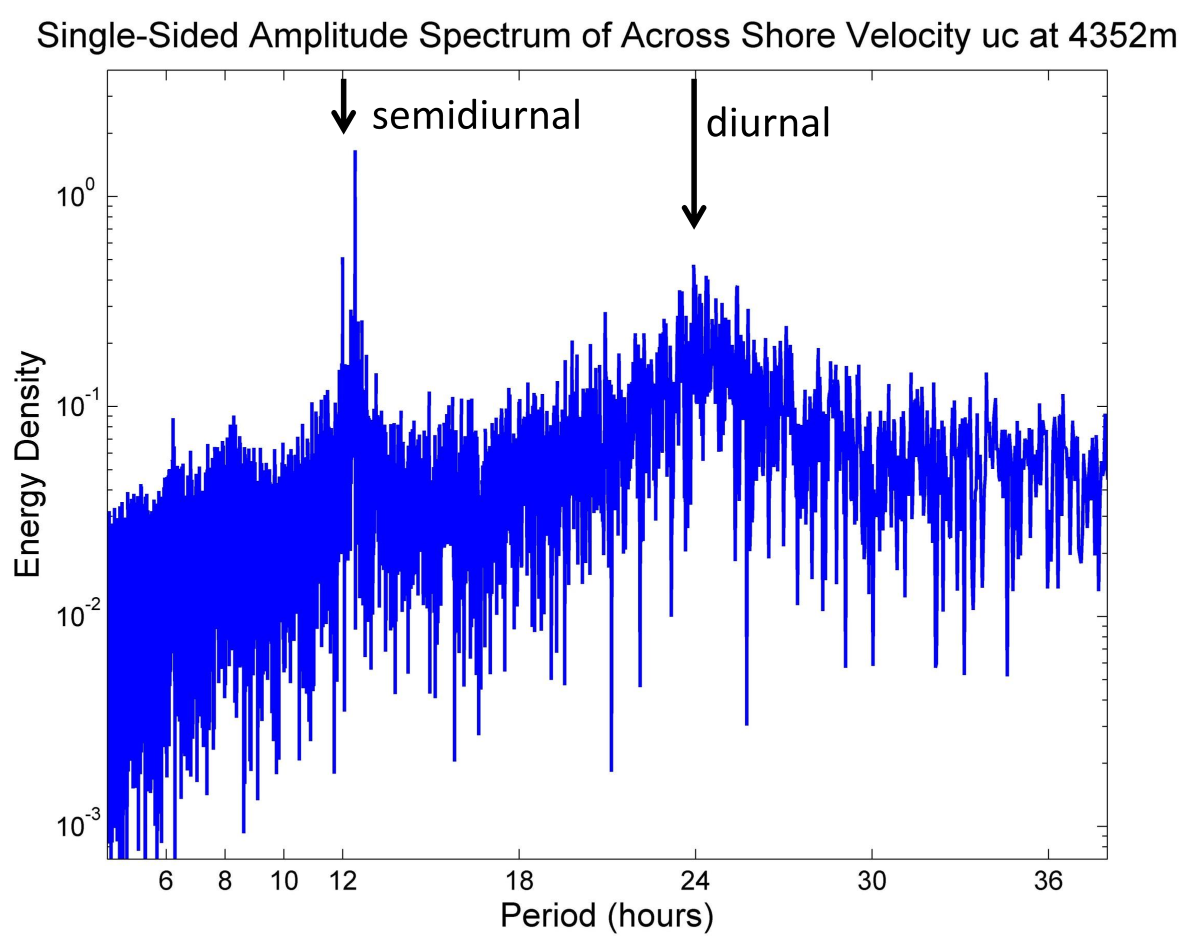


Baumann, personal communication



Tarakanov et al., 2015

Spectral Analysis



Tide	f (1/h)	T	snr of vc *	snr of uc
SA	0.0001141	365.18 d	210	---
SSA	0.0002282	182.59 d	17	12
MM	0.0015122	27.55 d	56	45
O1	0.0387307	25.82 h	9.8	---
S1	0.0416667	24.00 h	5.3	13
K1	0.0417807	23.93 h	----	18
M2	0.0805114	12.42 h	47	290
S2	0.0833333	12.00	---	31

* serial number (snr) indicates importance of tide, vc is along shore velocity and uc is across shore velocity at 4352m

Summary and Conclusion

- long term variability: Antarctic Bottom Water temperature continues to rise at ≈ 3.75mK/yr
- short term variability:
  - tides influence AABW temperature
  - tides, inertial oscillation and topographic waves are within the same range of frequency

References
[1] Purkey, S. & Johnson, G. C. Warming of Global Abyssal and Deep Southern Ocean Waters between the 1990s and 2000s: Contributions to Global Heat and Sea Level Rise Budgets. (2010).
[2] Zenk, W. & Morozov, E. Decadal warming of the coldest Antarctic Bottom Water flow through the Vema Channel. (2007).
[3] Zenk, W., Morozov, E. & Müller, T. Vema Channel: Antarctic bottom water temperatures continue to rise. (2003).
[4] Thompson, R., Luyten, J. Evidence for bottom-trapped topographic Rossby waves from single moorings. (1975).
[5] Pawlowicz, R., Beardsley, B. & Lentz, S. Classical Tidal Harmonic Analysis Including Error Estimates in MATLAB using T_TIDE.(2002).
[6] Tarakanov, R. & Morozov, E., Flow of Antarctic Bottom Water at the Output of the Vema Channel. (2015).

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