Constituents of sea surface height variability in Drake Passage

IT35M-04

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Introduction

The cDrake Array

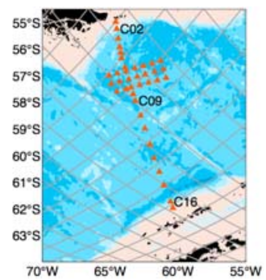
- Transport line and local dynamics array.
- 4-year deployment started in 2007.
- Data collected annually via acoustic telemetry.

Motivation

- Goals of cDrake:
  - Evaluate the momentum and vorticity budgets.
  - Determine the spatial structure of the time varying transport.
  - Provide guidance for future monitoring systems.
  - Validate circulation and climate models.
- Satellite altimetry will play a role in future ACC monitoring.
  - What components of sea surface height anomaly (SSHA) contribute to total SSHA?
  - What is the spectral content of SSHA?

▲ 38 current and pressure recording inverted echo sounders (CPIES)

— Jason-2 altimeter ground tracks



Methods

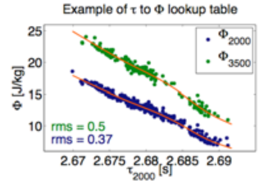
Constituents of SSHA

Steric	Mass-loading
$\eta_s = \Phi_{0\text{-bottom}}/g$	$\eta_{ml} = P/(\rho g)$
Measured by the IES	Measured by the bottom pressure gauge
Meandering ACC jets	Deep eddies or large-scale barotropic signals

Converting CPIES measurements to SSHA

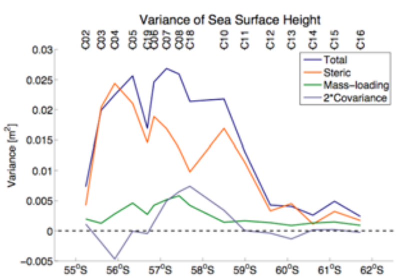
- The IES travel time measurement is converted to geopotential using a lookup table created from historical hydrography. Computed relative to instrument depth, and then the mean is removed.
  - Estimated 4 cm error in steric component of SSHA.
- Bottom-pressure anomaly measurement is detided and dedrifted.
  - Estimated < 1 cm error in mass-loading component of SSHA.

Example of τ to Φ lookup table

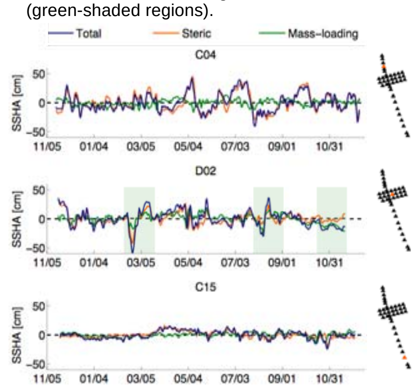


SSH Analysis Results

- Variance in northern Drake Passage is 5 times higher than in southern Drake Passage.
- Mass-loading component exceeds 40% of total variance in southern Drake Passage.



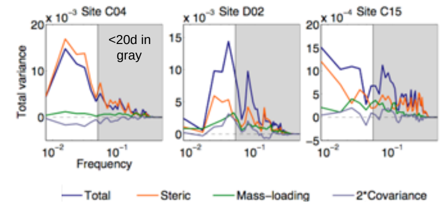
- Steric and mass-loading are uncorrelated except during events of deep cyclogenesis.
- At times the mass-loading exceeds 30% of total (green-shaded regions).



Aliasing

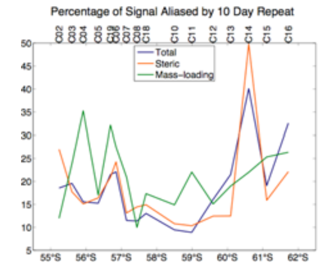
Spectral content

- In northern Drake Passage, low-frequency signals are mainly steric.
- In southern Drake Passage, mass-loading SSHA is comparable to the steric component in the 1/60 to 1/9 cpd day band.



Relation to altimetric sampling

- The Nyquist frequency of the Jason-2 altimeter is 1/20 cpd.
- The percent variance found in the cDrake records that is greater than 1/20 cpd exceeds 20% within the local dynamics array and on the southern end of the transport line.
- Typical altimeter processing uses a barotropic model to remove high frequency mass-loading SSHA, but it doesn't address the aliasing in the steric signal.



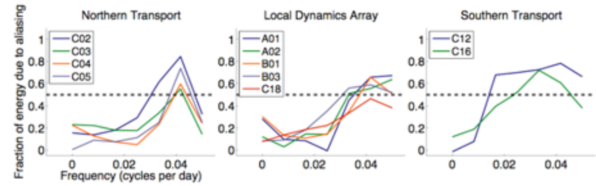
Aliased energy

- Using hourly records from recovered instruments, the aliased energy can be examined as a function of frequency as in Gille & Hughes (2001). The figure below shows:

$$1 - \left(\frac{E(f)}{E_{subsampled}(f)}\right)$$

where $0 < f < 1/20$ cpd.

- The fraction of energy due to aliasing exceeds 0.5 at most sites at 1/25 cpd.
- Gille & Hughes (2001) found similar aliasing ratios for just the mass-loading constituent of SSHA.



Conclusions

- Both steric and mass-loading signals contribute significantly to total SSHA.
  - Ocean forecast or climate models that assimilate SSHA as a purely steric signal in Drake Passage will be flawed.
- Satellite altimeters with Nyquist frequency 1/20 cpd alias a significant portion of energy in both components of SSHA.
- Future work will include analysis of AVISO dynamic atmospheric correction.

References

- Gille, S. T., and C. W. Hughes (2001), Aliasing of high-frequency variability by altimetry: Evaluation from bottom pressure recorders, *Geophys. Res. Lett., 28* (9), 1755-1758.

Acknowledgements

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