Sea Swell induced motion of Ross Ice Shelf: One Year of Storm Events and induced motion.

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It has been shown that storm events in the far field, e.g., in the tropics, and as far away as the high latitudes of the opposite hemisphere, are observable in seismic signals recorded on icebergs and ice shelves as well as at long-term land-based seismic stations (MacAyeal et al., in press; and Wadhams et al., 1983). Previous studies have observed the motion and induced stresses on small tabular icebergs and have suggested that sea swell is a mechanism capable of breaking up icebergs (Wadhams et al., 1983; Holdsworth and Glynn, 1978).

This study presents data collected using a broad-band seismometer installed on the Ross Ice Sheet. The seismometer location, called Nascent Iceberg, is expected to calve and become another large tabular iceberg as a result of a large rift that currently is propagating parallel to the icefront, about 30 km back. We describe the motion of the ice shelf during the 2004 and 2005 austral summer, and correlate the observed motion to size, duration and distance of far-field storm events.

Objectives

- Quantify the impact of Sea Swell from storms in the near and far fields.
  - Examine temporal and spatial distribution of event sources.
  - Correlate storm intensity and distance with motion induced in the iceberg.

Are the Calving Margins in Antarctica Sensitive to Ocean Swell from away Storms?
- If so, then a new climate teleconnection exits.

- Explore One year of Seismic Data.
- Assess the impact of storms on the calving of B-15.

Acknowledgments

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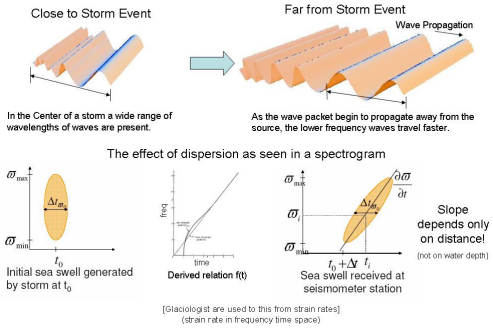
Dispersive Gravity Waves



Overview of Data Presented

Seismic Data

- Seismic Data was recorded at Nascent iceberg on the Ross Ice Shelf using a Guralp 40T broadband seismometer with a photo-voltaic power supply.
- The seismometer's instrument response has been removed, all data shown is actual displacement measured.

Sea Level Pressure (SLP): NCEP Reanalysis Data

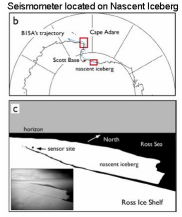
Surface pressure is class "B" reanalysis data and is characterized as being "partially defined by observations but also strongly influenced by the model characteristics".

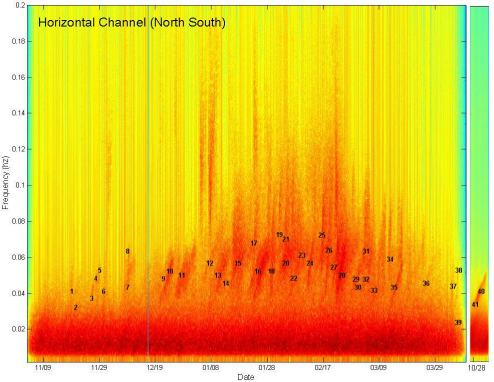
Wave Height: NOAA's wavewatch III

Wavewatch III uses NCEP's Medium Range Forecast model as input to generate the wave height model. Broadly speaking, surface wind intensity and duration is used to calculate fetch, and then wave height.

NOAA WAVEWATCH III

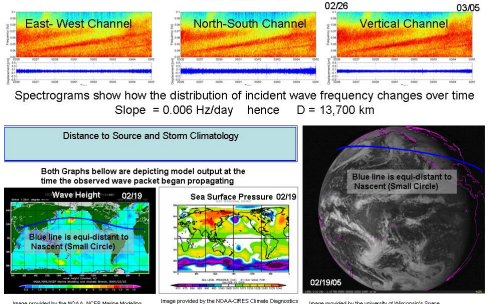
Seismometer located on Nascent Iceberg



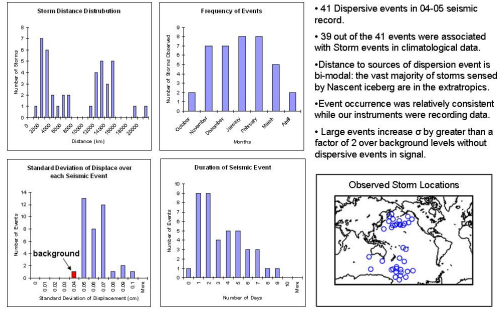


Example of Storm Event Log Entry

Event 29

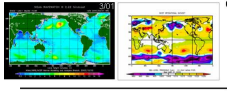


Basic Data Statistics

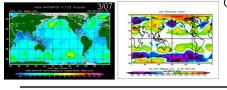


- 41 Dispersive events in 04-05 seismic record.
- 39 out of the 41 events were associated with Storm events in climatological data.
- Distance to sources of dispersion event is bi-modal: the vast majority of storms sensed by Nascent iceberg are in the extratropics.
- Event occurrence was relatively consistent while our instruments were recording data.
- Large events increase σ by greater than a factor of 2 over background levels without dispersive events in signal.

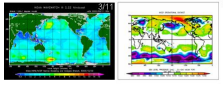
Weather Prior to Calving of B-15, March 17th, 2000



Compare to event 40
Estimated wave (0.04 Hz) arrival time at B-15: 3/09/2000
Estimated Duration of seismic event on B-15: 5 Days
Comparable storm produces sustained displacement of: 0.05 cm



Compare to event 29
Estimated wave (0.04 Hz) arrival time at B-15: 3/15/2000
Estimated Duration of seismic event on B-15: 7 days
Comparable storm produces sustained displacement of: 0.06 cm

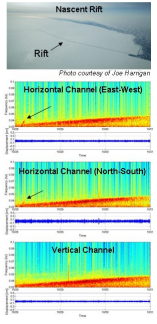


Compare to event 37
Estimated wave (0.04 Hz) arrival time at B-15: 3/13/2000
Estimated Duration of seismic event on B-15: 1 - 2 days
Comparable storm produces sustained displacement of: 0.06 cm

Conclusion
From 3/09 until it calved on 3/17, B-15 probably experienced significant wave action comparable to some of the most intense recorded at Nascent during the 04-05 field season.

Aside: Could Nascent's Rift act as a Wave Guide?

- On October 28th 2005 the seismometer on nascent recorded a dispersive wave on only the 2 horizontal Channels, (arrow; superimposed on larger, more distant signal).
- This dispersive wave was from a very local source; <500 km.
- The rift is ~ 50 km long and the seismometer is located ~ 10 km from the tip of the rift.
- If the source was to the station's east, then it is plausible that the rift acted as a wave guide: intensifying the effect of the wave in the horizontal plane, while minimizing its effect in the vertical.
- Further research efforts will investigate approximately 17 other events which occur in only one or two of the channels, many of these events were not of the dispersive nature, but may provide further insight into sea-ice shelf dynamics



Conclusions & Future Work

- Weather as far away as the Gulf of Alaska causes increase in the magnitude of the oscillation of the Ross Ice Shelf. Gravity waves from storms are observed in seismic signals recorded on the Ross Ice Shelf.
- 41 total dispersive events were recorded on a broad band seismometer from November 2004 to April 2005 and also October 27th, 2005 to November 5th, 2005.
- 39 of those events have been link to storms in the Pacific Ocean
- During the week prior to the Calving of B15, it is likely that there were increases in the amplitude of oscillations in the 0.03 -0.07 Hz range due to the arrival of gravity waves from storms in the North Pacific.
- Future work will extend the event log to include both body and surface waves as well as higher frequency events visible in spectrograms shown here (0.08 to 0.2 Hz). Additionally we plan to use a finite-element model of the structural mechanics of an ice-shelf rift and analyze the stress regime along the rift as it's subject to various types of incident ocean waves.

References
Holdsworth, G., and J. Glynn (1978), Iceberg calving from floating glaciers by a vibrating mechanism, Nature, 274, 464–466.
Kalnay, E. and Coauthors, 1996: The NCEP/NCAR Reanalysis 40-year Project. Bull. Amer. Meteor. Soc., 77, 437-471.
MacAyeal, D. R., et al. (2006), Transoceanic wave propagation links iceberg calving margins of Antarctica with storms in tropics and Northern Hemisphere, Geophys. Res. Lett., 33, L17502

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Event Log (41 storm events)