Measuring Wave-Induced Vibrations on the Ross Ice Shelf

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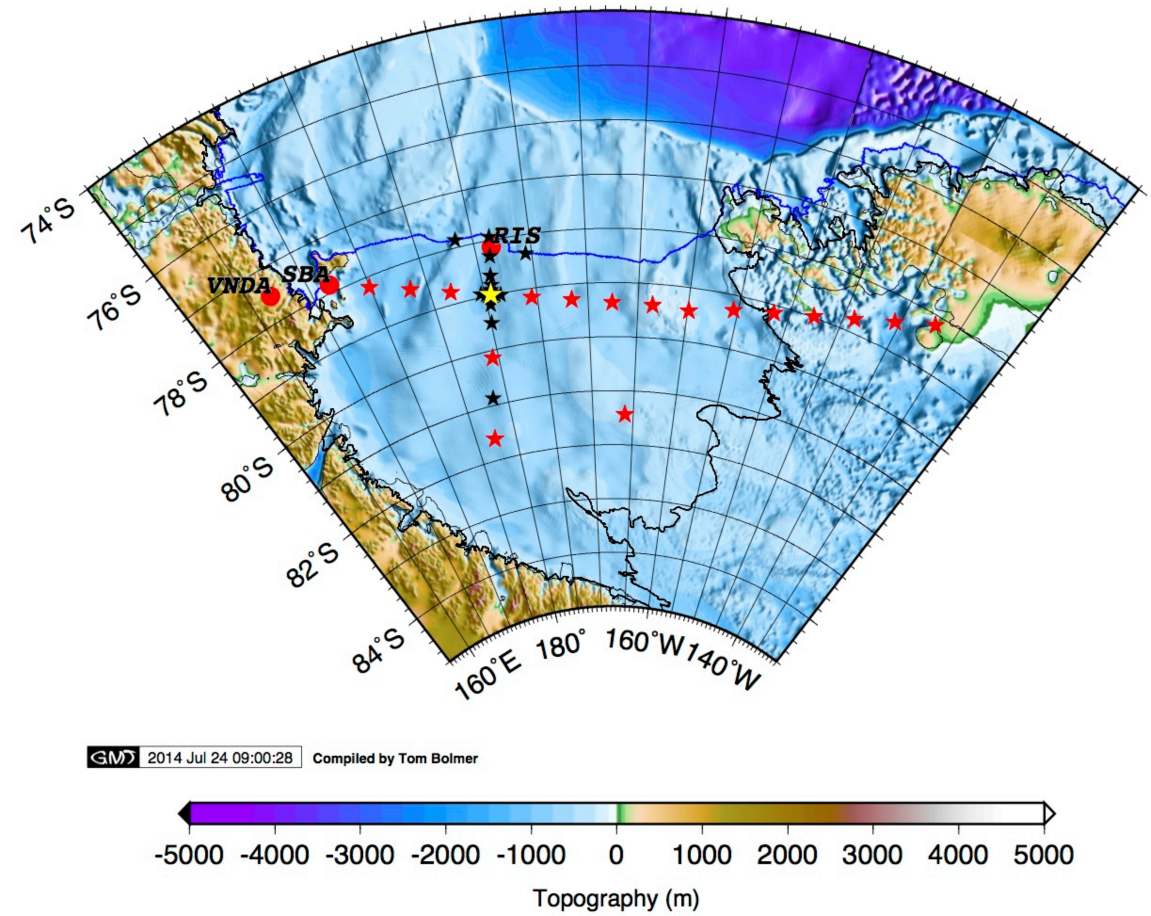
Ocean gravity waves are dynamic elements of the global ocean environment, affected by ocean warming and changes in ocean and atmospheric circulation patterns. Their evolution may thus drive changes in ice-shelf stability by both mechanical interactions, and potentially increased basal melting. The resulting weakening of the RIS will likely cause decreased buttressing of land ice and result in increased rates of ice flow to the Ross Sea, which in turn feed back on sea level rise.

Long-period oceanic infragravity (IG) waves (ca. [250, 50] s period) are generated along continental coastlines by nonlinear wave interactions of storm-forced shoreward propagating ocean swell. Seismic observations on the Ross Ice Shelf (RIS) show that free IG waves generated along the Pacific coast of North America propagate transoceanically to Antarctica, where they induce a much higher amplitude ice shelf response than ocean swell (ca. [30, 12] s period). Additionally, unlike swell, IG waves are not significantly damped by sea ice, and thus impact the ice shelf throughout the year.

Signal propagation across ice shelves depends on ice shelf and sub-shelf water cavity geometry as well as ice shelf physical properties (e.g. structure, thickness, crevasse density and orientation). The vibration response of the RIS varies with season and with the frequency and amplitude of the gravity-wave forcing. A 16 station broadband seismometer array (Dynamic Response of the Ross Ice Shelf to Wave-Induced Vibrations, DRRISWIV, I-348) across the RIS (in conjunction with the Wiens et al. earth structure 18 station array, G-089) will be deployed during November 2014 to study the response of the RIS to swell and IG wave impacts continuously for two years, measuring seasonal changes in ice shelf properties. Field observations and numerical simulations will reveal how wave–induced vibrations on ice shelves in general, and the RIS in particular, can be used (1) to infer spatial and temporal variability of ice shelf mechanical properties, (2) to infer bulk elastic properties from signal propagation characteristics, and (3) to determine whether the RIS response to IG wave forcing observed distant from the front propagates as elastic stress waves from the front or is continuously “locally” generated by IG wave energy propagating within the RIS sub-shelf water cavity. Emphasis will be placed on observation and modeling of the RIS response to IG wave forcing at periods from 75 to 300 s, as these waves constitute a potentially significant and deeply penetrating forcing mechanism contributing to rift expansion and potentially to ice shelf fragmentation.



Station location map for the 16 broadband seismic station array (black stars). Also shown are the 18 Wiens et al. RIS earth structure project (G-089) broadband stations (red stars) to be deployed jointly from a base camp located near RS04 (yellow star). Locations of permanent Global Seismic Network (GSN) seismic stations VNDA and SBA and the McAyeal et al. 2005-06 broadband station RIS are indicated by red circles.