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Modeling wind-induced seismic signals in Antarctica.

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Introduction

Cryospheric seismicity reflects a variety of dynamic glacial processes, ranging from ocean-ice interactions to long-term climate change responses. It encompass various types of sources, including crevasses formation, iceberg calving, basal shear motion, glacier hydraulics, and englacial fracture development, covering several decades:$10^{-3} - 10^{2}$Hz. Another seismic source is the wind blowing on surface inhomogeneities, such as the sastrugi (wavelike ridges of hard snow), which can produce firn-trapped surface wave resonant signals of ≥ 5Hz in the immediate subsurface, ≤ 5m. The Criosfera-I (C-I) is a prismatic body $6.3 \times 2.6 \times 2.6\,\text{m}^3$, weighting ≤ 3 ton, held 1.5 m above the surface by four stilts. The C-I is the main landmark at the fieldwork site at (84°S, 79°W), anchored with steel cables to the snow. The C-I has four wind turbines and an automatic weather station mounted on its top, fixtures affecting the dynamic response of the prismatic body. By its size and stance the C-I is by far the main obstacle to the wind and, most probably the main wind-induced seismic source.

Method and/or Theory

In this work we apply the finite difference method to understand the wave propagation through the ice cover in the region, which has a strong density gradient, especially in the first 40 m of the firn layer, which reaches 100 m, as revealled by a borehole dug at the site. Based on the ice density profile from the borehole and empirical relations of seismic wave velocities in firn, it is possible to estimate $v_p = 600$ m/s and $v_s = 200$ m/s, increasing with depth to $v_p = 3900$ m/s and $v_s = 2000$ m/s beyond the firn, into the main ice body. The near-surface strong velocity gradient complicates both the body wave propagation, as they refract continuously, and strongly affects the dispersion of the dominant surface waves. The numerical model allow us to weigh on important parameters on frequency and wavenumber filtering, to separate the surface from the body waves. Those parameters will be applyed on the field seismic data in order to both mark the firn-ice transition and eventually obtain a spot estimate for the aggregate local ice cover.

Results and Conclusions

There were two seismic field campaigns during the Summers of 2018/19 and 2019/20 with three collinear profiles spaning over 372 m, due S from the C-I. Seismic traces were decimated and filtered to yield a useful frequency range of 10–250 Hz. Overall it was a quiet place, apart of the electromagnetic 60 Hz line and its even harmonics. Winds reached wind force 6 on the Beaufort Scale, with gusts ≤ 12 m/s. The adaptative multitaper method showed the signal had important spectral lines at 6, 17, 34 and 212 Hz. A band-passed version of the signal at [5, 45] Hz showed a modulation probably associated with the module's vibration modes excited by the wind.