Detection of Seismic Events originating from Europa's Silicate Interior: Implications for constraining interior dynamics

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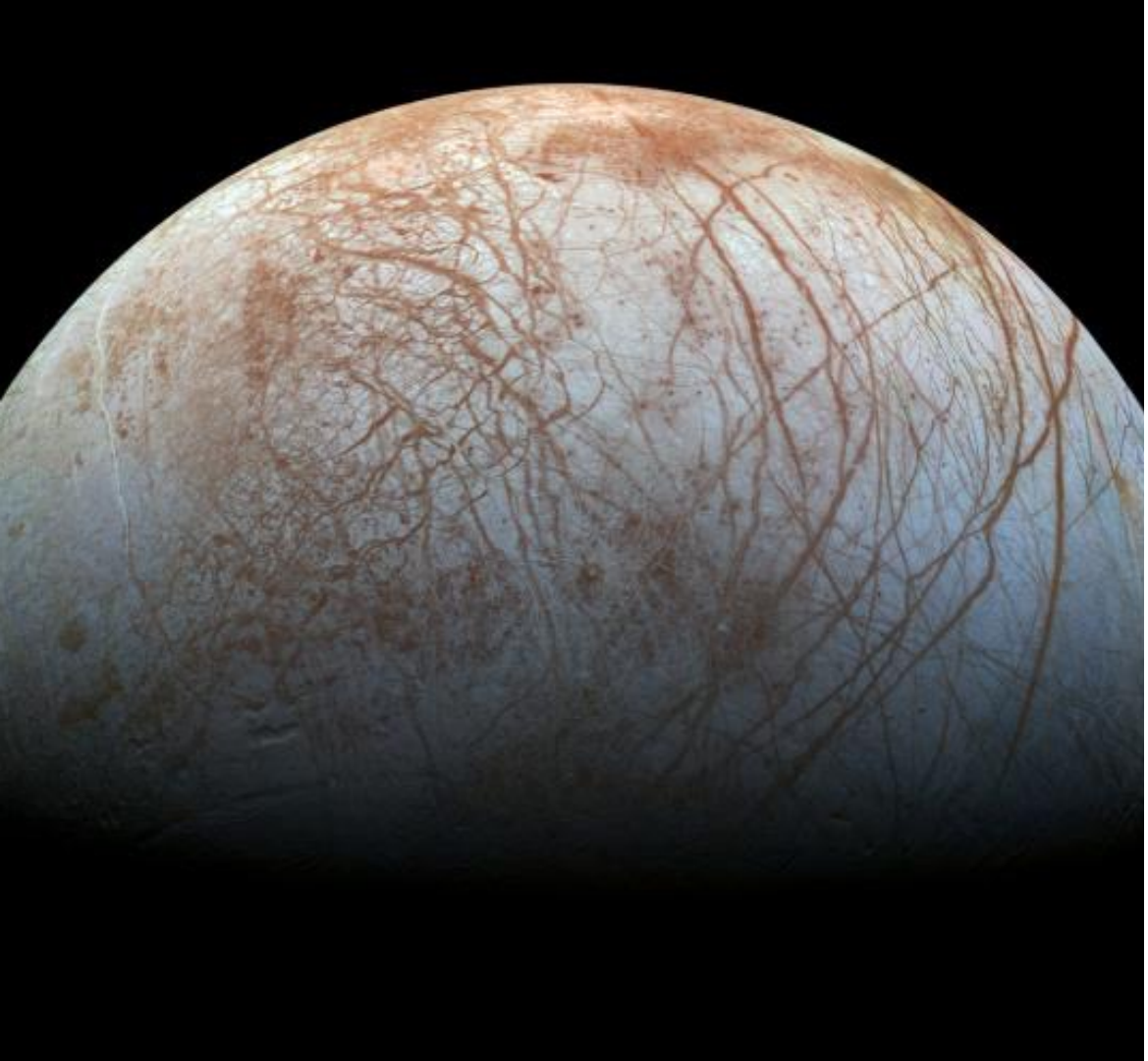
Abstract

Here we explore the detection limits of a seismic event originating from Europa's silicate interior. Such an event could be used to constrain the tectonic regime, rheology, and internal dynamics of Europa's deep interior. We use PlanetProfile to generate interior structure models of Europa with ice shell ranging from 5-50 km in thickness. We then use the models as inputs for AxiSEM and InstaSeis to generate a database of seismograms. Realistic noise is added using the approach of Panning et al. 2018. We show that a deep event (depth 155km) would produce seismic signals 1/10- 1/75 the amplitude of shallow (depth 3km) events. Thinner ice shells allow for more ground motion, and thus, a seismometer could detect a smaller magnitude event than if the ice shell was thick. A Mw 3.5 could overcome background noise, but a Mw 4.5 or greater is necessary to be detectable by even the most sensitive seismic instrumentation. A Mw 5.0 or greater is likely needed to be seen by a seismometer on Europa's surface. Constraining deep seismicity would allow for better constraints on the deep internal structure and dynamics of Europa.



Detection of Seismic Events originating from Europa's Silicate Interior: Implications for constraining interior dynamics

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Background: Europa Seismicity

- Signs of current geologic activity
- Tidal forces likely induce seismic activity
- Could point to ice shell dynamics

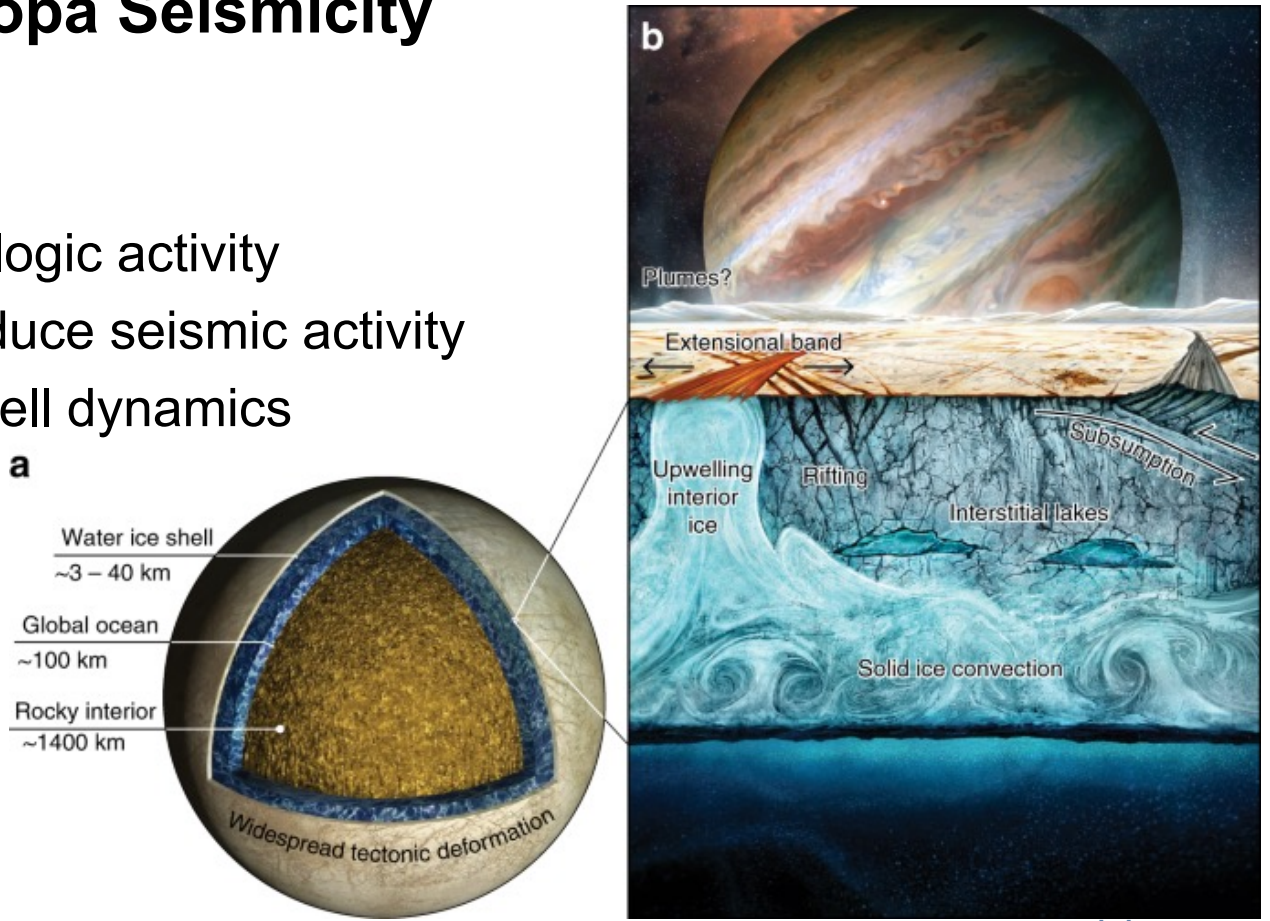


Image credit: Howell and Pappalardo 2020

Implications for Deep Seismicity

- Hydrothermal systems?
- Volcanic activity?
- Geologic activity?

- Water-rock interactions
- Energy availability
- Habitable environments

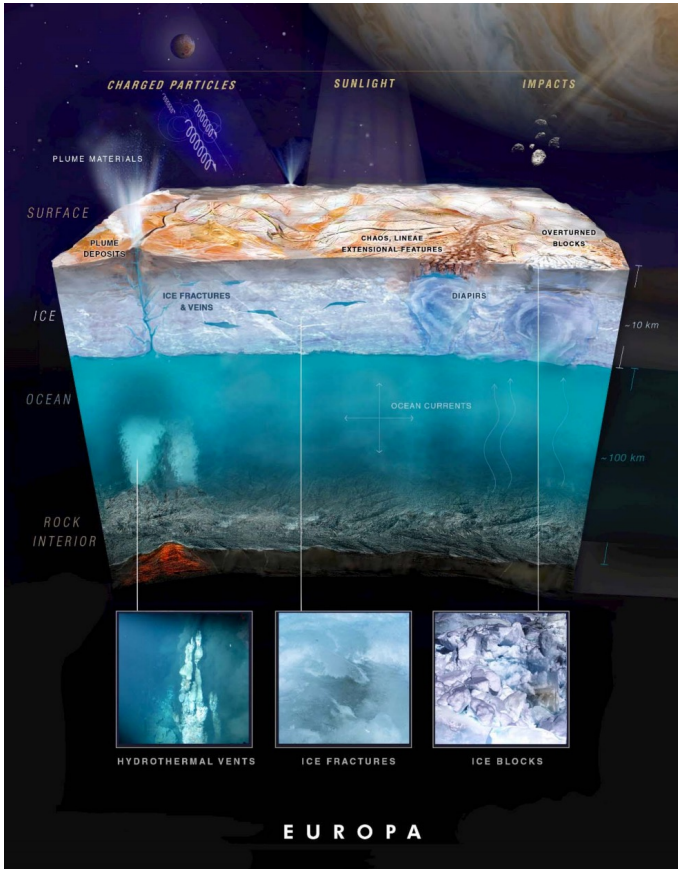
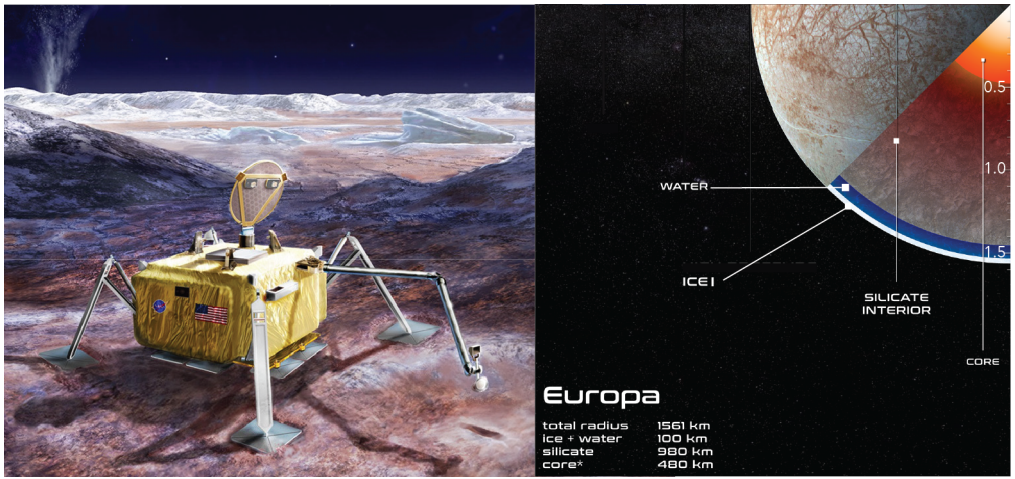


Image credit: NASA/JPL

Background: Deep Interior

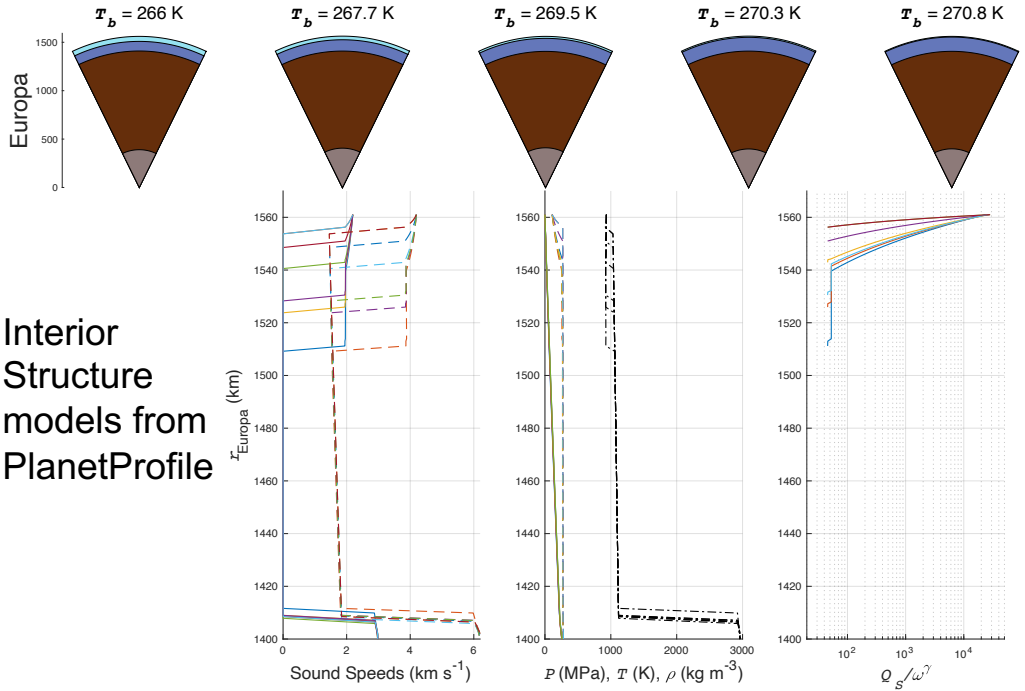
- Apollo seismometers recorded deep moonquakes from tidal forces
- Volcanic/hydrothermal activity has been theorized
- Geologic/tectonic state is unknown

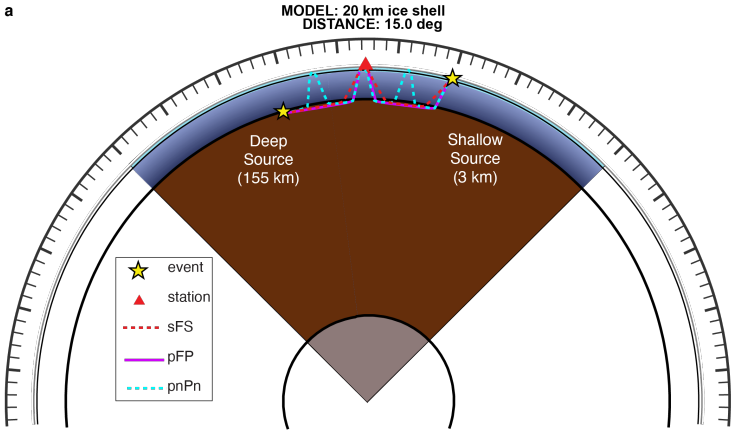


Methods

Let's see what what we can see

Interior Structure models from PlanetProfile

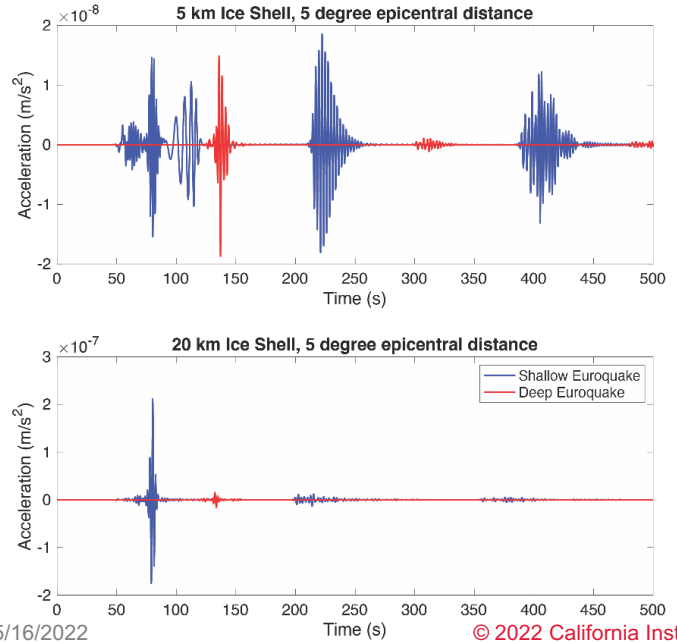


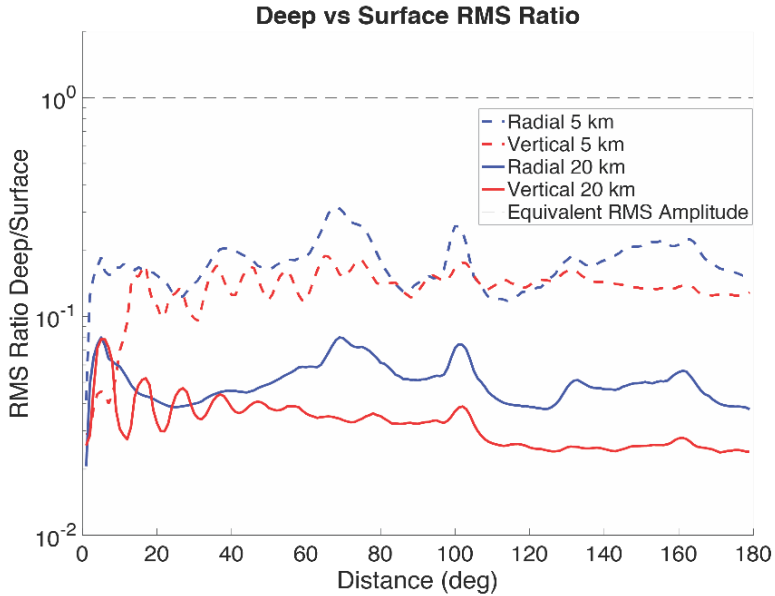


Waveforms from Instaseis and AxiSEM

Surface vs Deep Waveforms

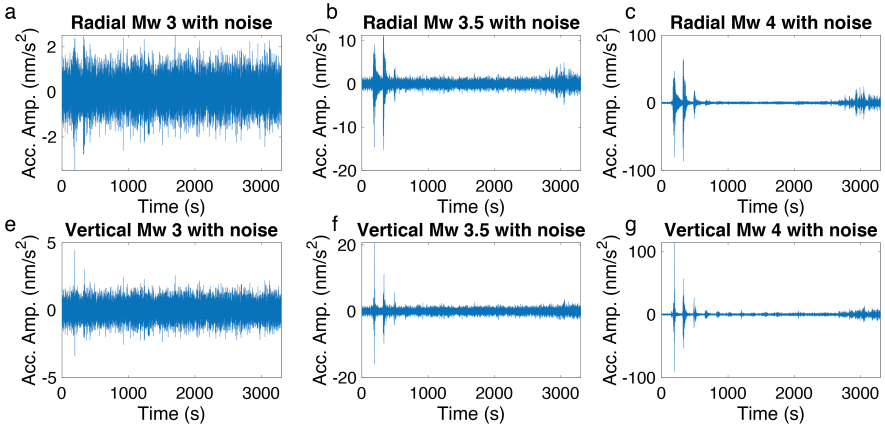
- Compare ground motion from 3 km deep event (shallow) and 155 km (deep)



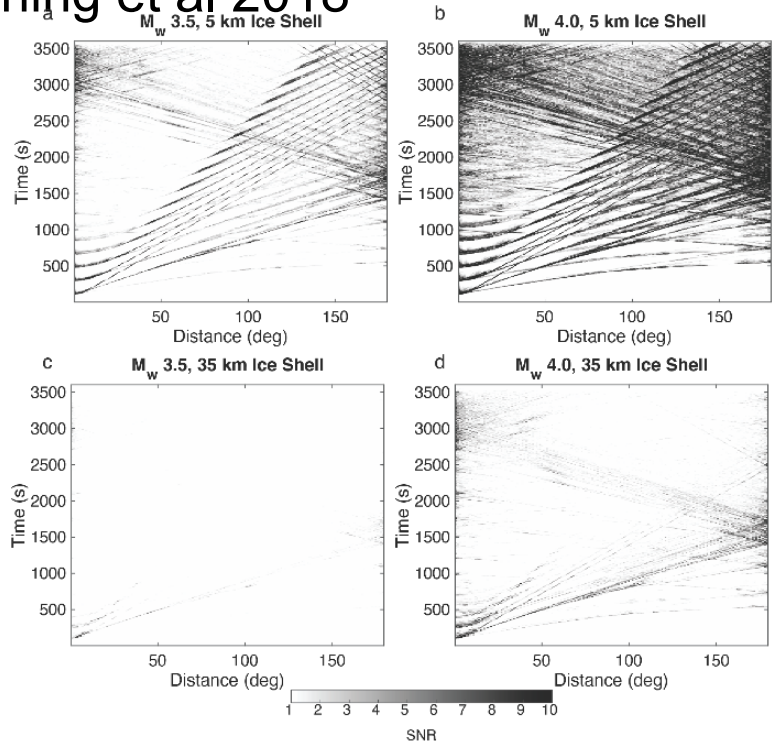


Signal-to-Noise Ratios

Background noise uses approach of Panning et al 2018



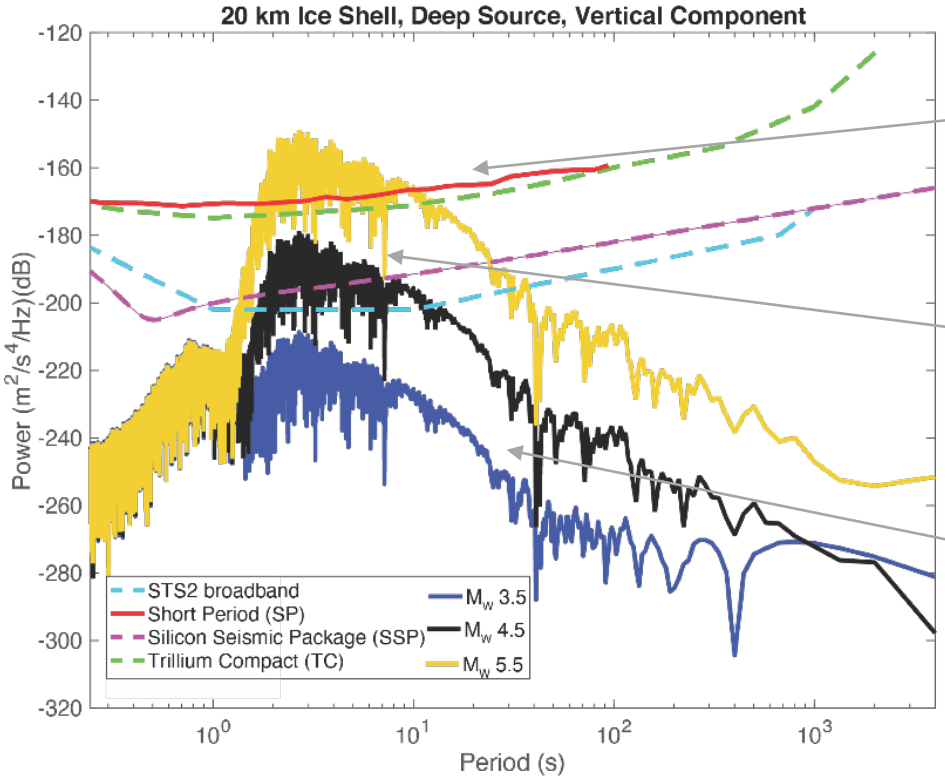
10 km ice shell



SNR depends on ice shell thickness

Instrument limits

What can we detect and see?



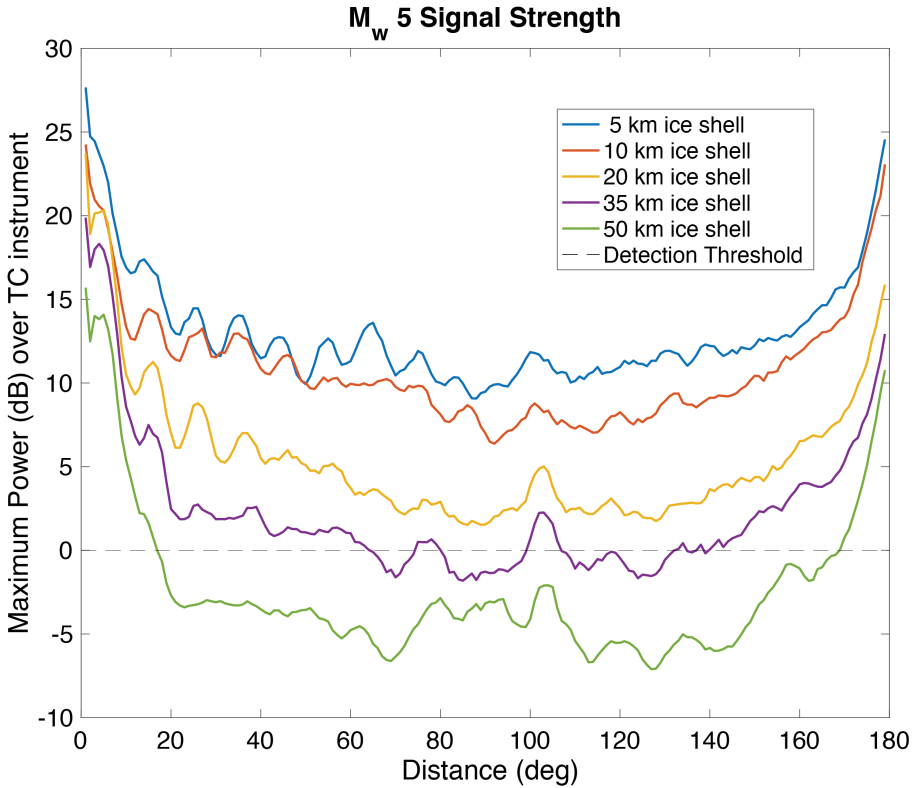
Detectable by any instrument

Detectable by sensitive instruments

Not detectable

Ice Shell Thickness Effects

Measures maximum difference between event power and detection threshold



Mw 5.0 could be seen at any distance if ice shell is <35 km

Thicker ice shells need stronger ground motion or a nearby event

Summary

Link to pre-print

SCAN ME

- Without instrument limits: Mw 3.5
- With sensitive instruments: Mw 4.0
- With less-sensitive instruments: Mw 5.0
- Thicker ice shells increase minimum magnitude

- **Lack of detection could be from instrument limits, not Europa**

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