Predicted Detection rates of Regional-scale Meteorite Impacts on Mars with the InSight Short-period Seismometer

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InSight Mission

- Due to Launch in Spring 2018, Landing in late 2018
- Primary Mission Lifetime: 2 years (1 Martian year)
- SEIS experiment includes 3-component broadband seismometer (SEIS VBB), and short-period seismometer (SEIS SP)
- One possible source of seismic waves are impacts

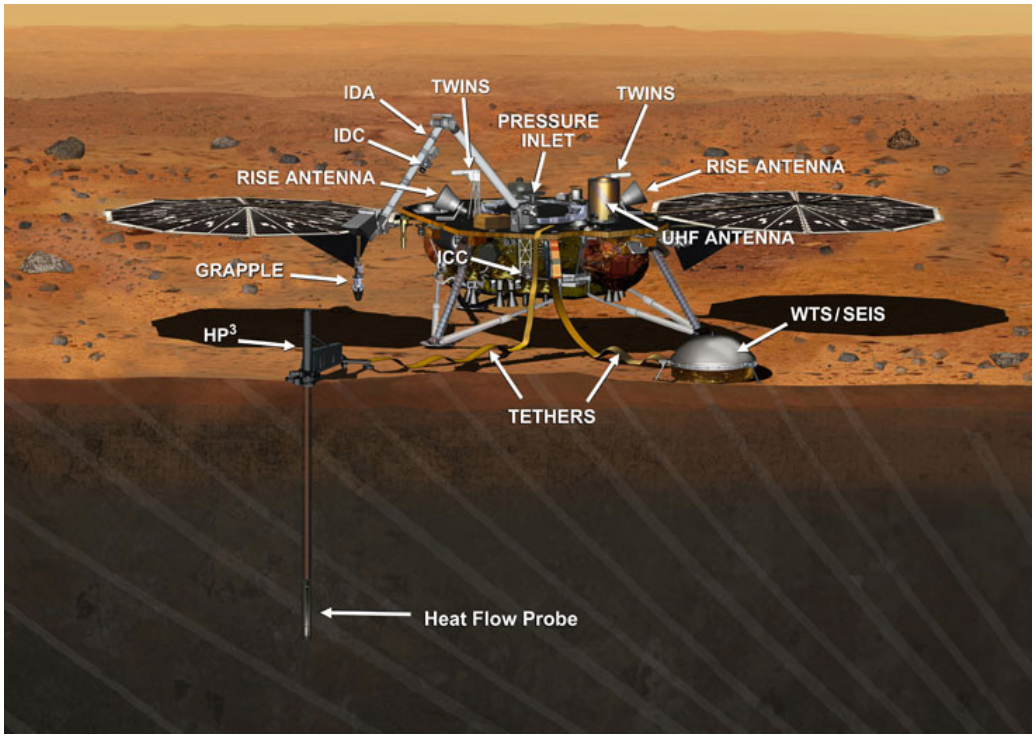
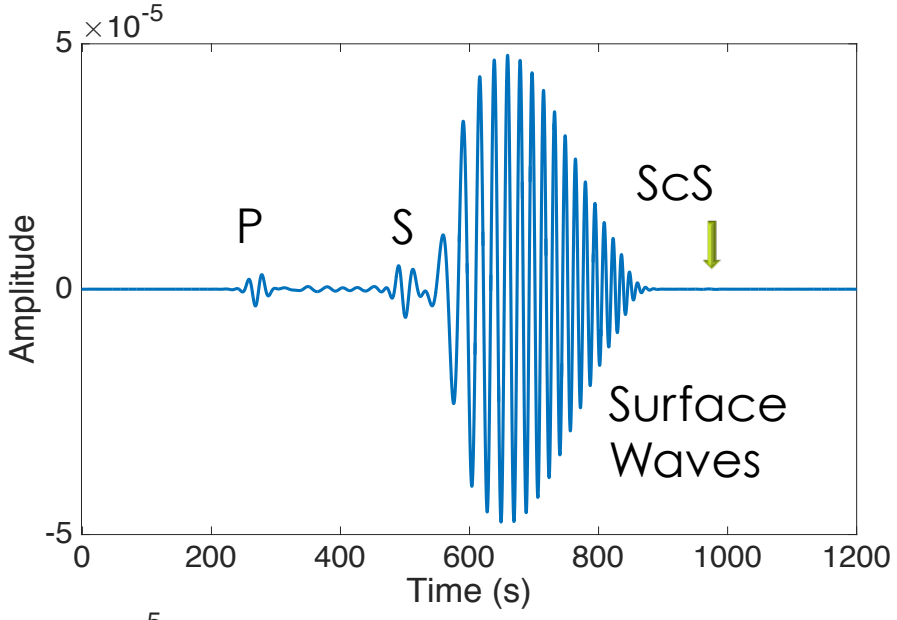
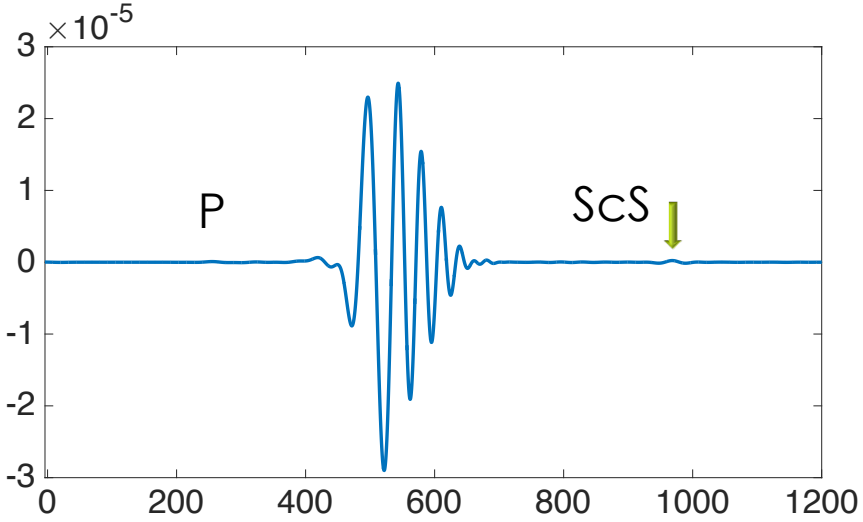


Image Credit: NASA/JPL

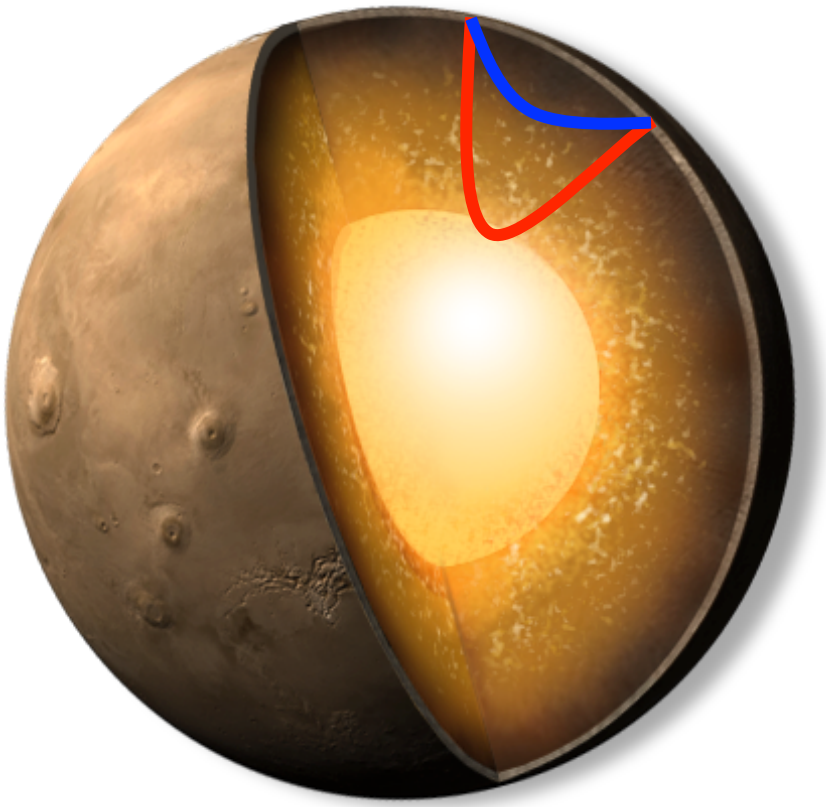
Seismic Waves





- Surface Waves
  - Love Waves: Travel Faster than Rayleigh. Require slower layer on top of a faster layer. Shear Waves
  - Rayleigh Waves: Have both Compressional and Shear Waves
- Body Waves
  - P waves: Arrive first (Primary Waves). Compressional Waves
  - S waves: Shear Waves
  - ScS: Core reflected phase of S

Core Reflected Phases



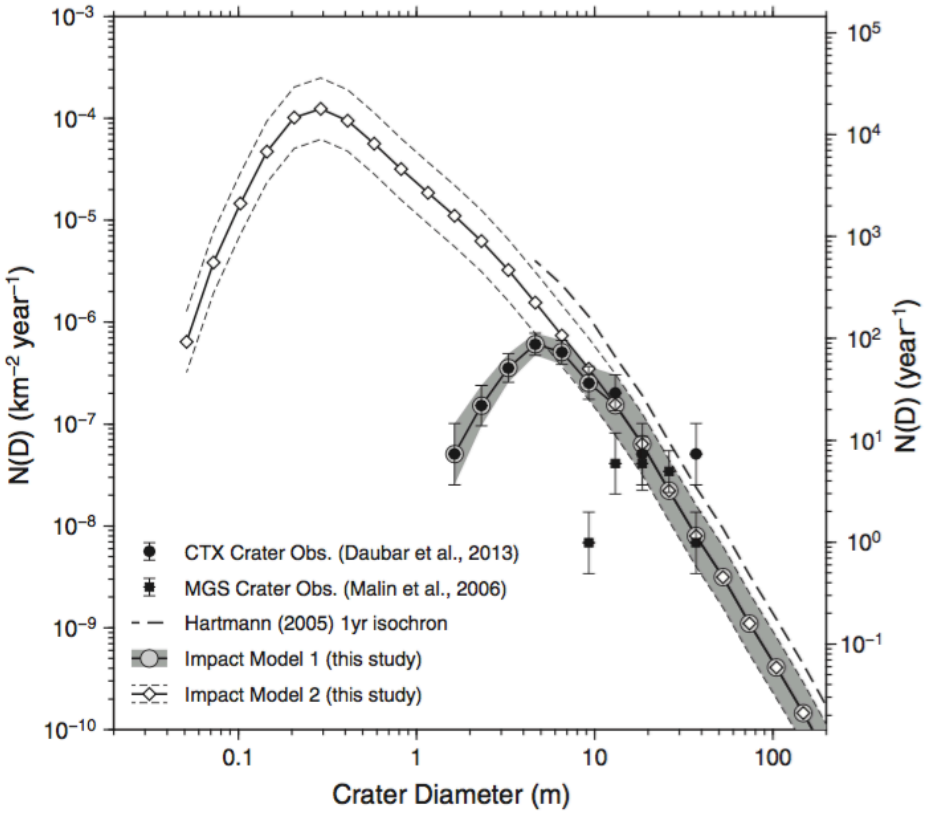
- ScS: Shear wave that reflects off the outer core
- S waves loose energy when they reflect
- Amplitude of ScS is smaller than S's, but depends on the distance
- Smaller amplitude reduces detectability

Goals of Teanby's Paper and My Project

- Teanby used SEIS SP to look at the detectability of Surface Waves, but also S and P waves
- Found about 1-3 impacts should be detected
- How does SEIS VBB compare to SEIS SP?
- Are impacts energetic enough to cause detectable core reflected phases?

Impact Size and Rates

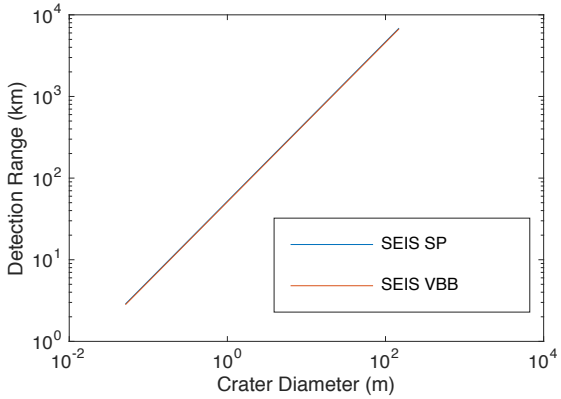
- Impact Model 1: Lower Bound of Present-Day Crater Production using Daubar et al. (2013)
- Impact Model 2: Attempted Best Guess at Present-Day Crater Production

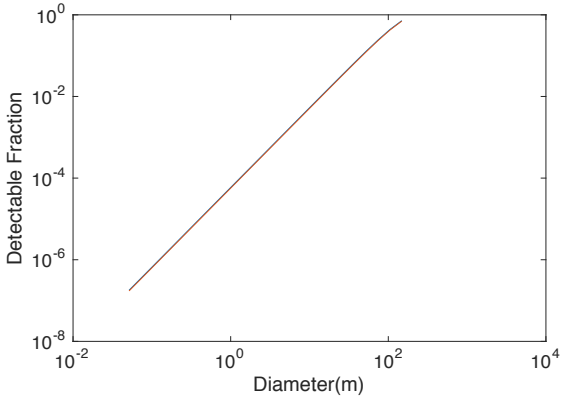


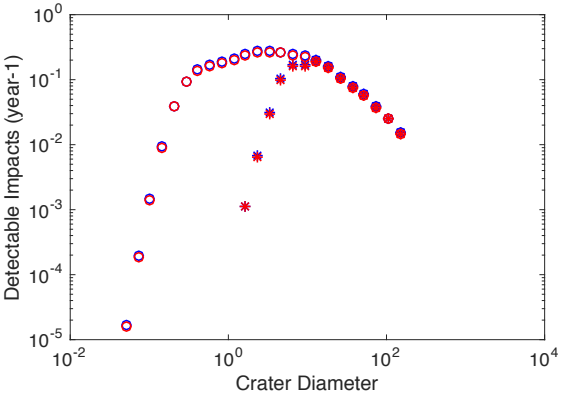
Maximum Detection Distance and Detection Rate

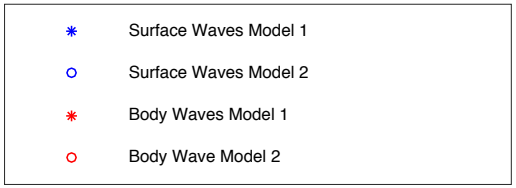
- Detectable distance from source of an impact depends on
  - The detectability, power spectral noise of the seismometer
  - Size of Impact-> Crater Diameter->Energy Released
  - Attenuation of Seismic Waves
- Fractional area of Mars
  - Function of Xmax/Rmars
- The detection rate of a given diameter:
  - The Functional area * Number of Impacts in a year

Comparing SEIS SP to SEIS VBB



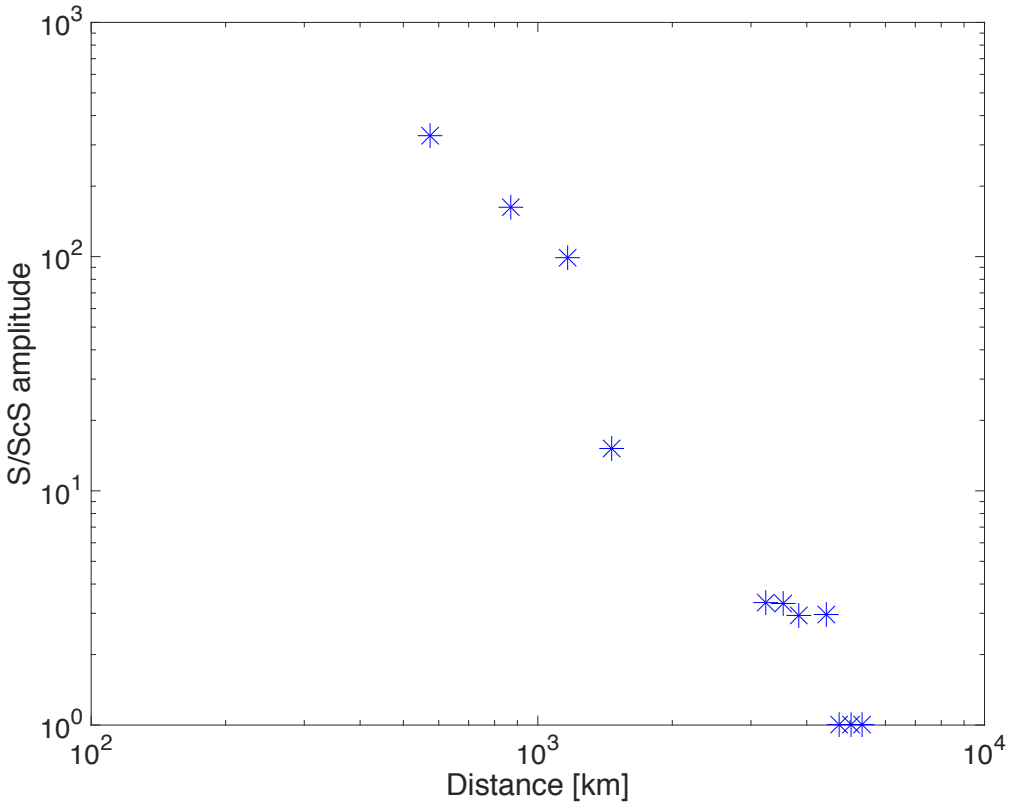






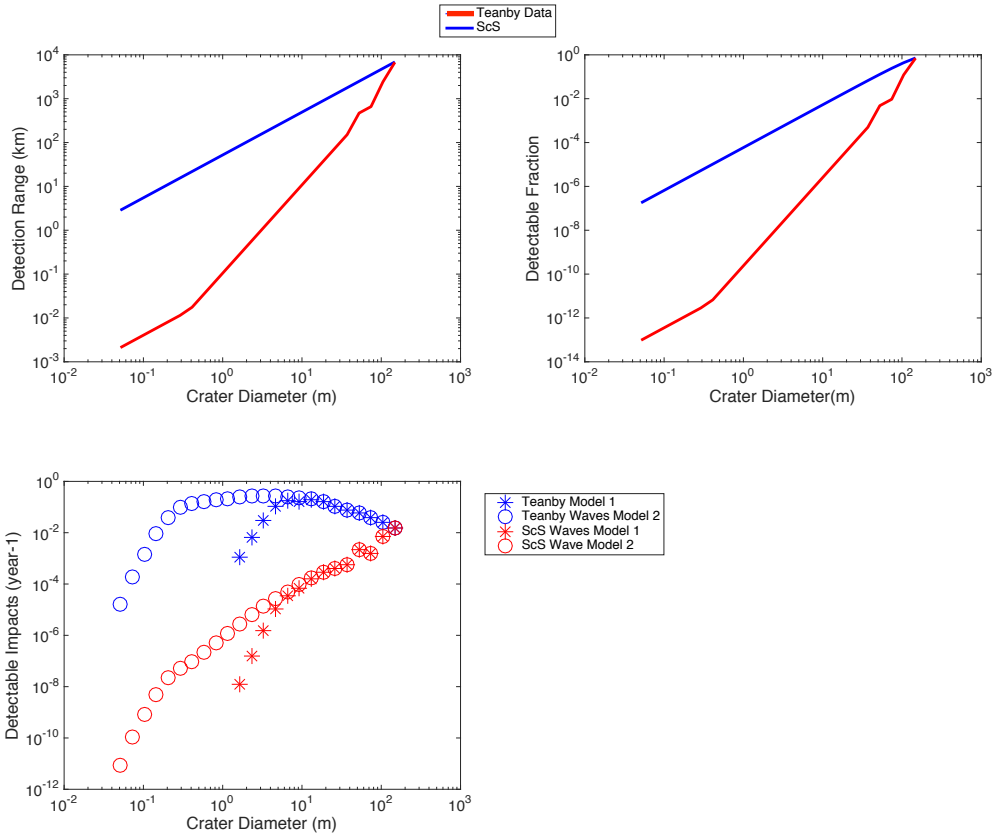
- Very little difference between SEIS SP and SEIS VBB detection rates
- SEIS SP's Detectable Impacts per year are 2.4-3.8% higher than SEIS VBB's

Comparing S to ScS



- For distances less than 100 km, S amplitude is about 100,000 greater than ScS
- Ratio decreases until a distance of about 5300 km where S and ScS merge into one wave

Detectability of Core Reflected Phases



- Detection Range is reduced by 3 orders of magnitude for smaller craters
- Detectable Fraction Reduced by about 6 orders of magnitude
- No. of Detectable Impacts is reduced by a factor of 500

Conclusions

- 1-3 Body and Surface Waves could be observed in 1 year
- 0.2-0.6% chance core reflected phases will be observed in a 1 year time span
- Impacts will be useful for constraining the crust and upper mantle, but will be unable to survey the deep interior
- Reducing uncertainty in crust and upper mantle, reduces uncertainty in deep interior when it can be sampled.