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Imaging of Deep Planetary Interiors from Inter-source Correlations via a Single Seismograph


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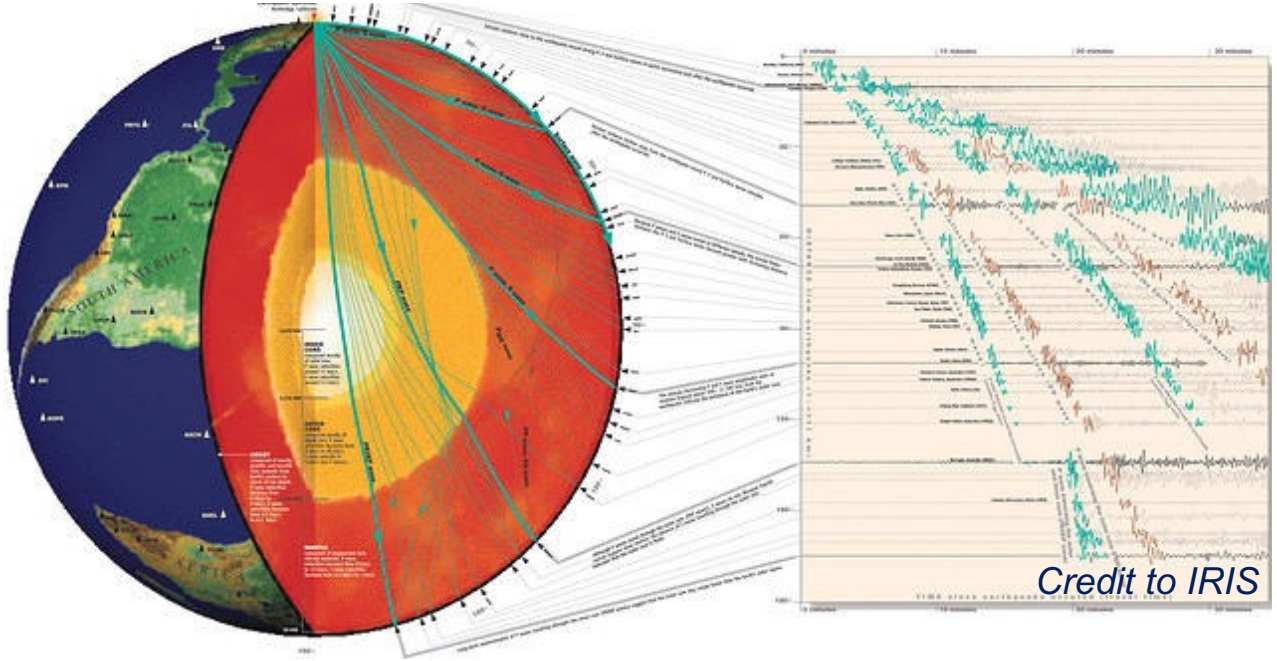
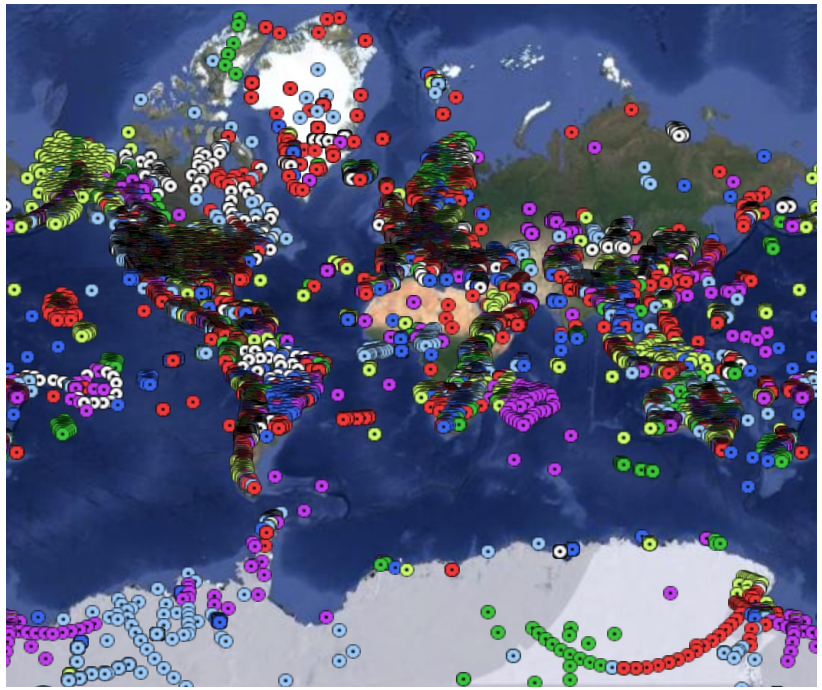
Introduction

- Seismic observations provide direct constraints on the Earth's internal structure, powered by the worldwide proliferation of seismographs.

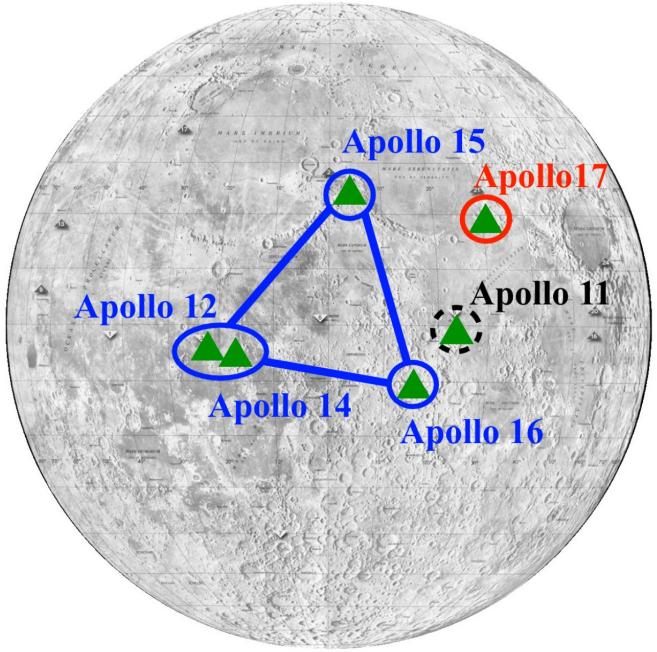




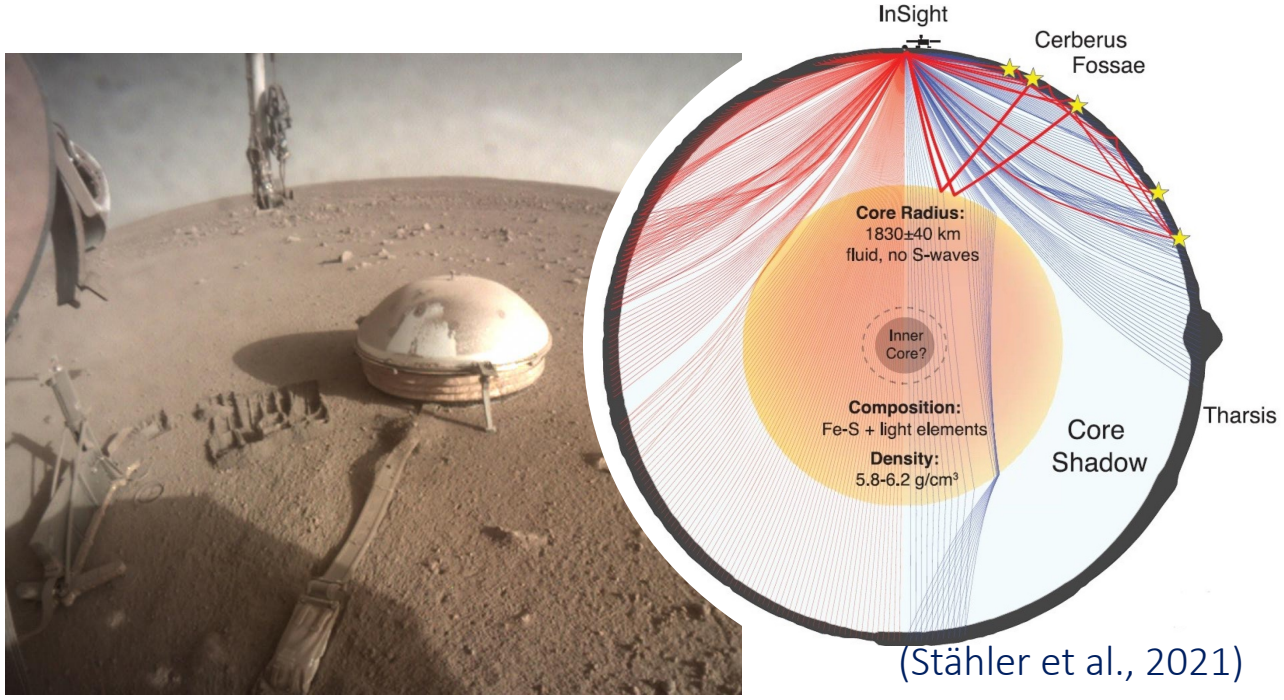
Seismic stations accessible on 19-05-2022 from IRIS

How about a **Single Seismograph**?

- Seismic investigation on **other planets** (e.g., Mars) remains challenging due to limited number of seismographs that are and will be deployed in the foreseeable future.



Apollo stations on the Moon. (*Nunn et al., 2020*)



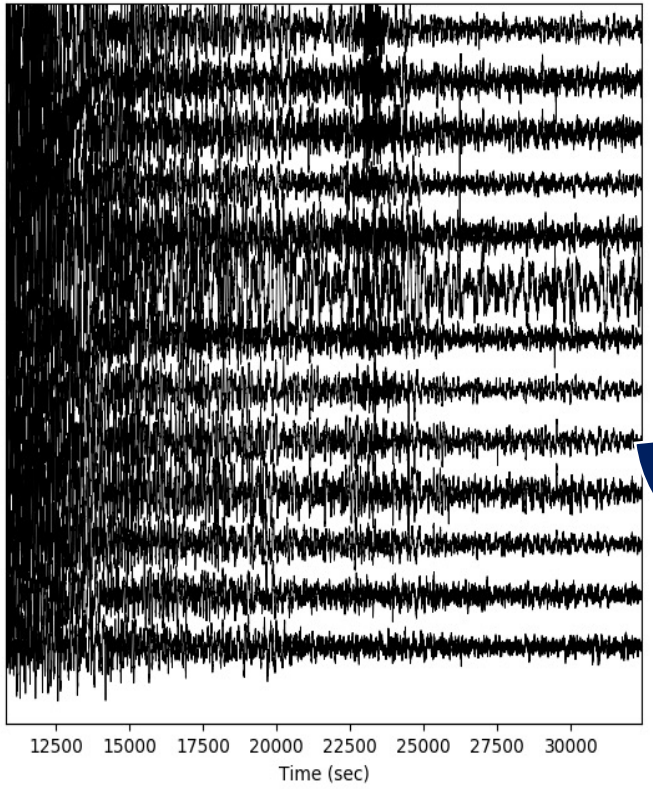
(Stähler et al., 2021)

The InSight SEIS on Mars. (NASA, CNES, their partner agencies and institutions (UKSA, SSO, DLR, JPL, IPGP-CNRS, ETHZ, IC, and MPS-MPG), and the flight operations team at JPL, SISMOC, MSDS, IRIS-DMC, and PDS)

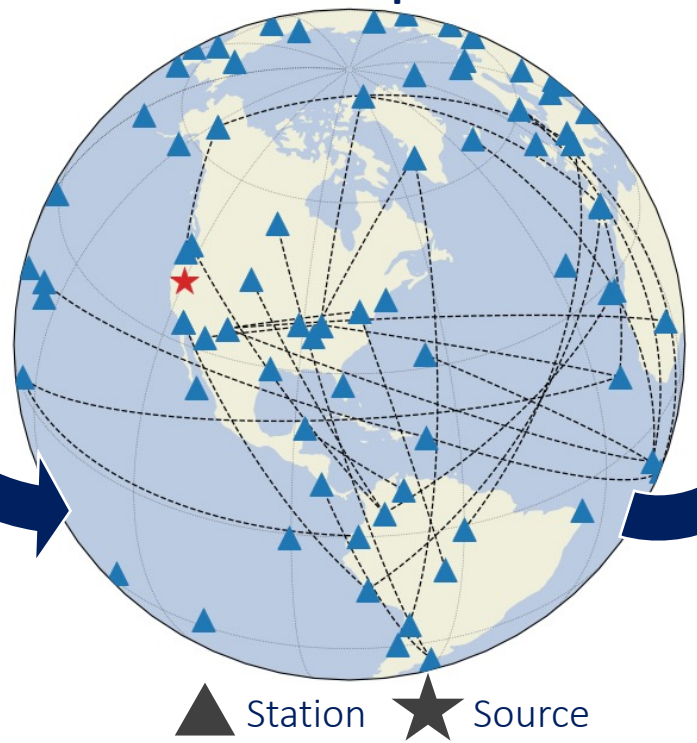
Global Late-Coda Cross-Correlation Approach

Earthquake late coda

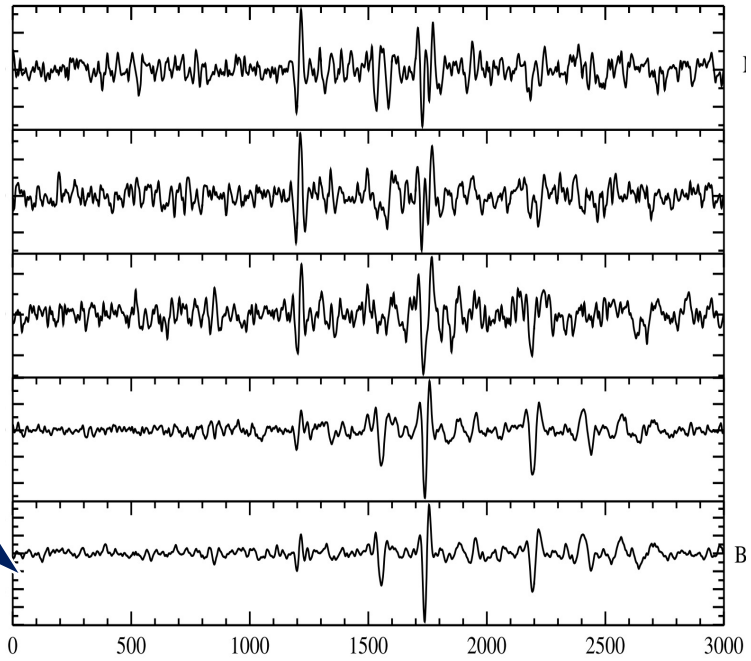
records in 3-10 h after events' origin that seems noisy
but full of deep-traveling energy (reverberations)



Station pairs



Inter-station cross-correlation stacks



(Lin and Tsai, 2013; Nishida, 2013; Boué et al., 2014; Poli et al., 2017; Phạm et al., 2018;... ...)

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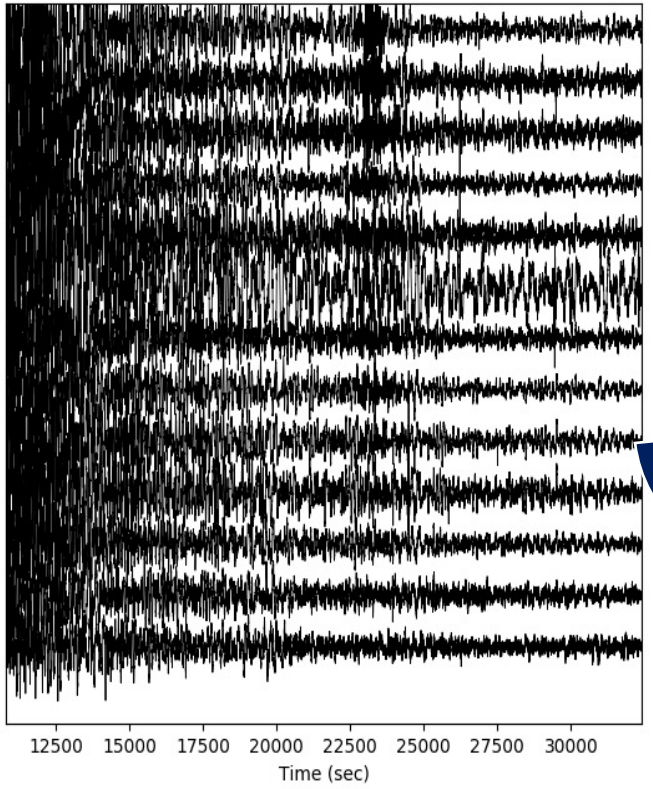

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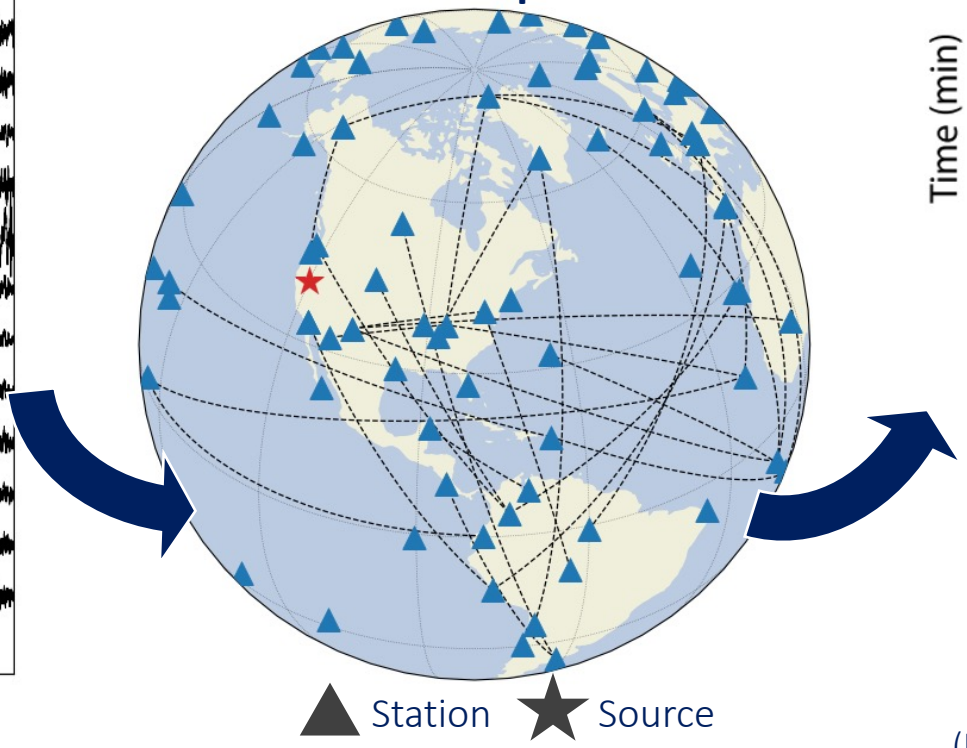

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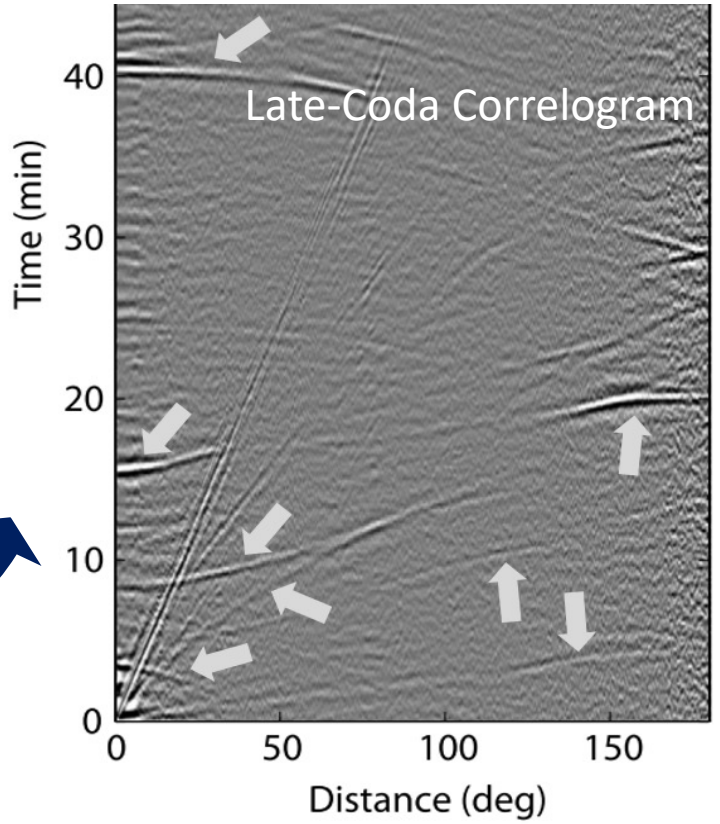

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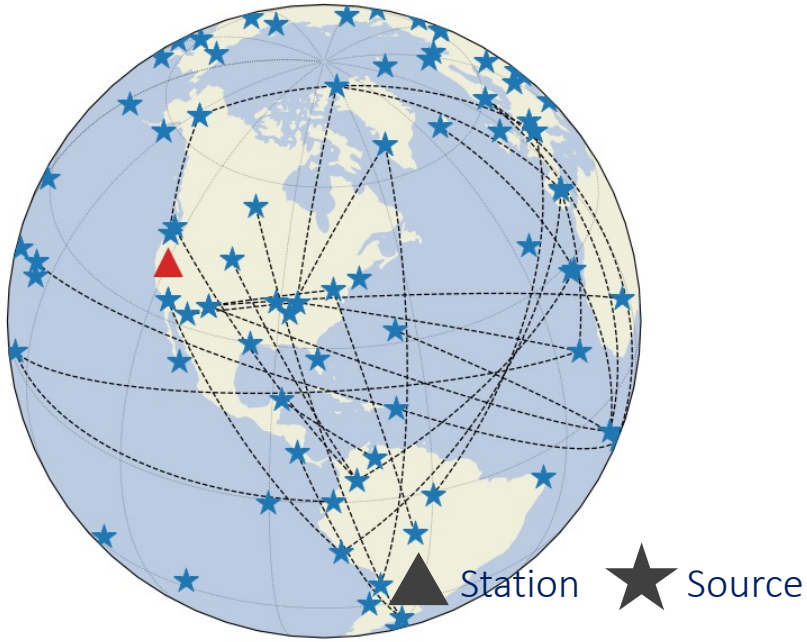
Inter-Source Correlograms

- **Inter-source correlation configurations**



Reciprocal Theorem

$G(t; x_A \rightarrow x_B) = G(t; x_B \rightarrow x_A)$

(Wang and Tkalčić, 2022 in review)

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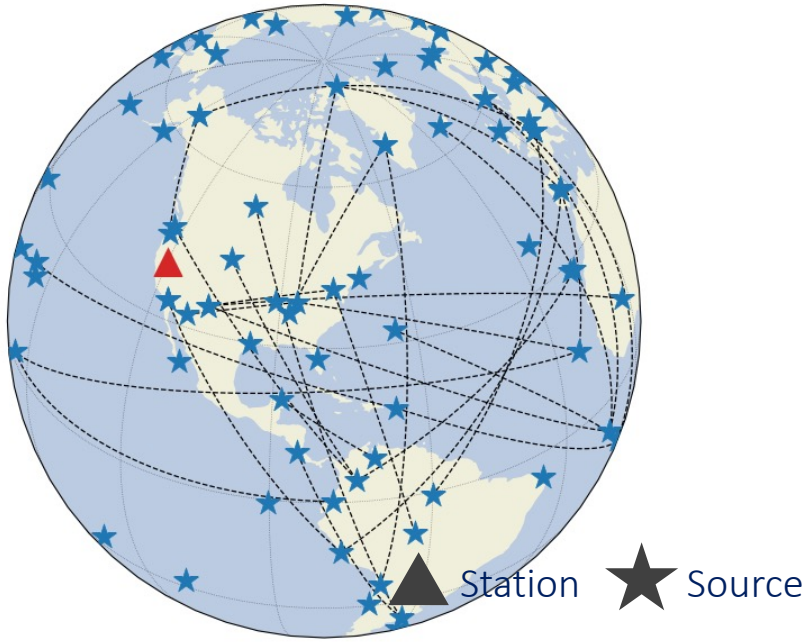

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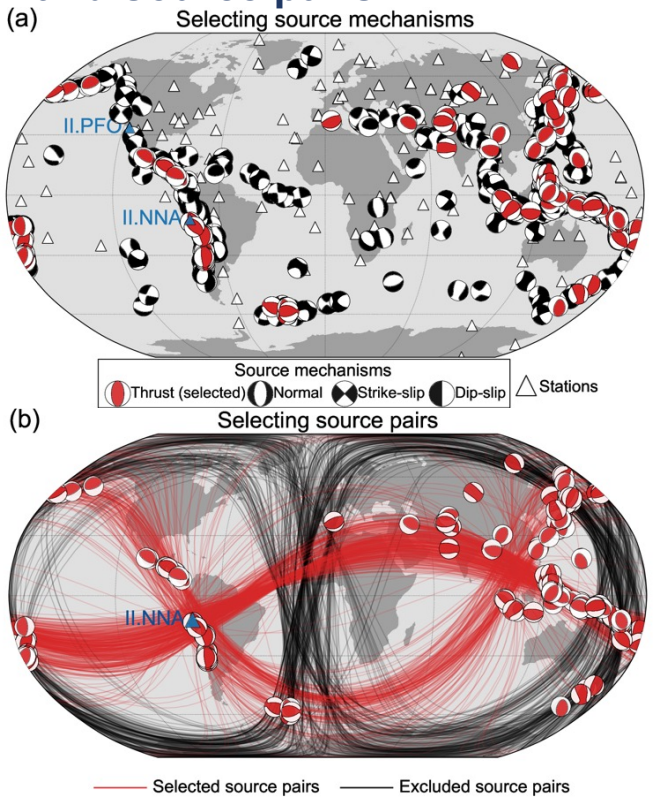
- **Selecting source mechanisms and source pairs**



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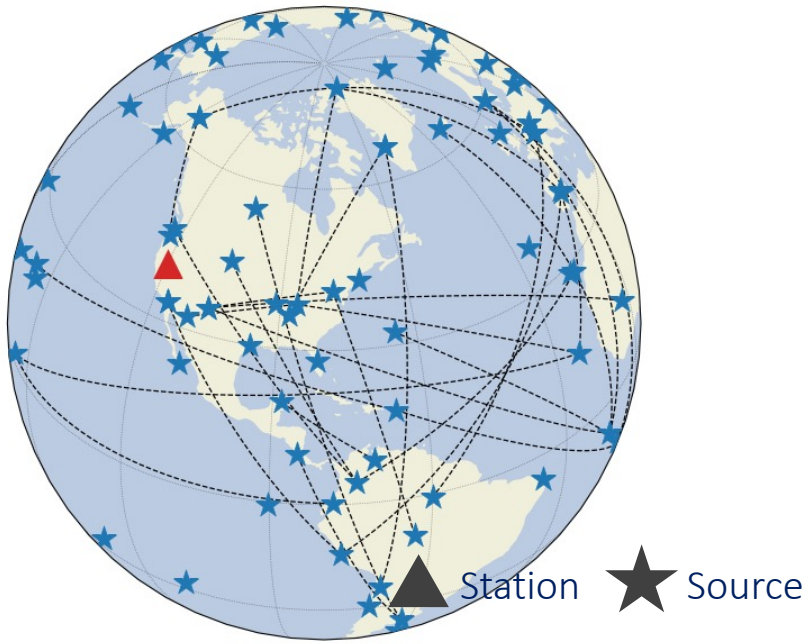

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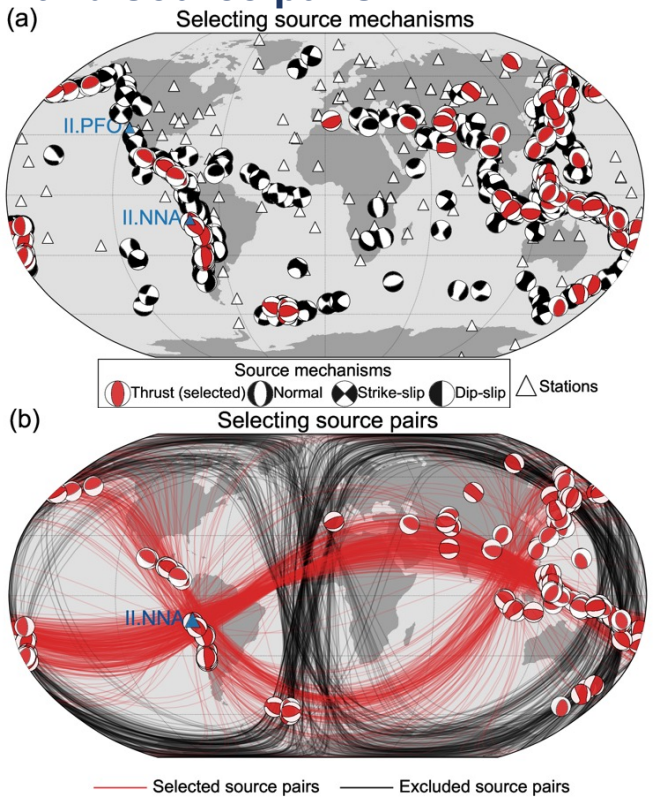
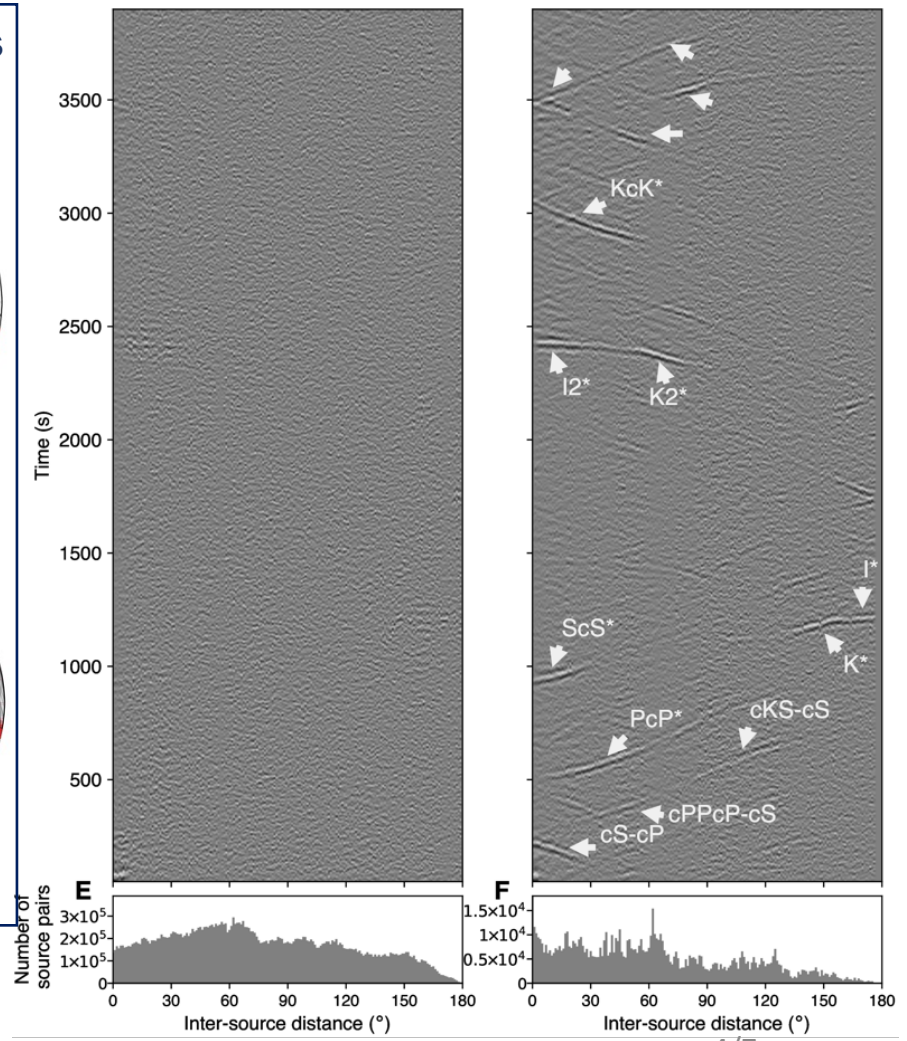


Inter-Source Correlogram Without the Selections

Inter-Source Correlogram With the Selections



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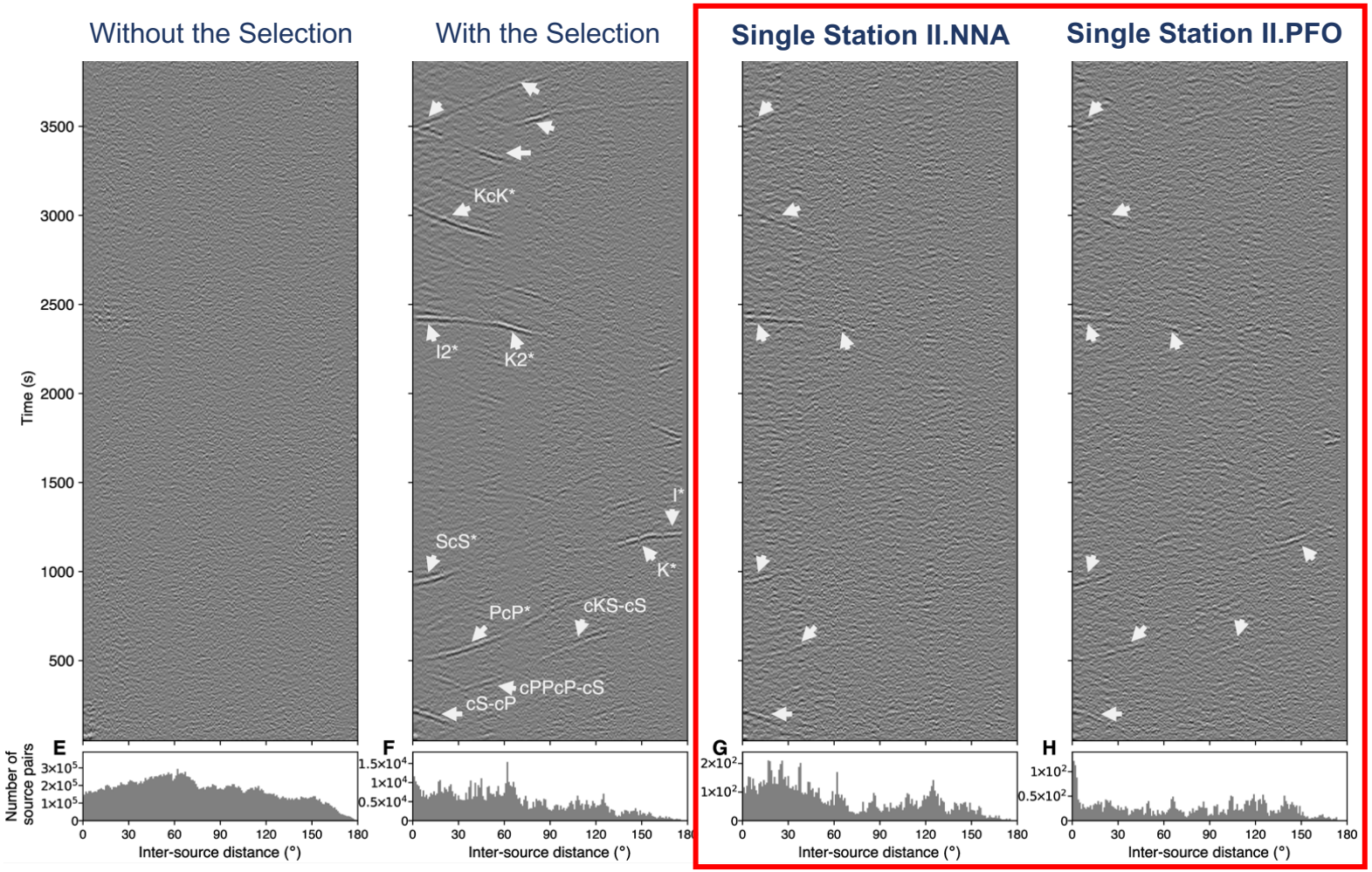
Single-Station Correlograms

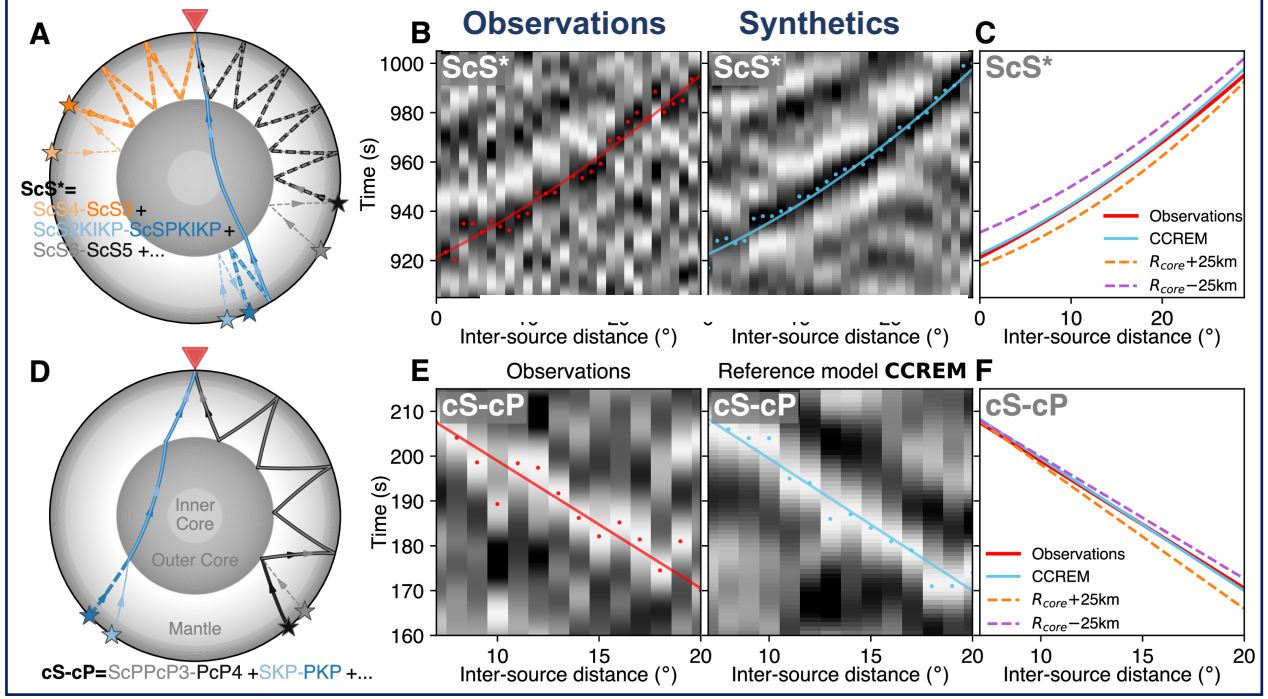


We can use the single-station correlogram:

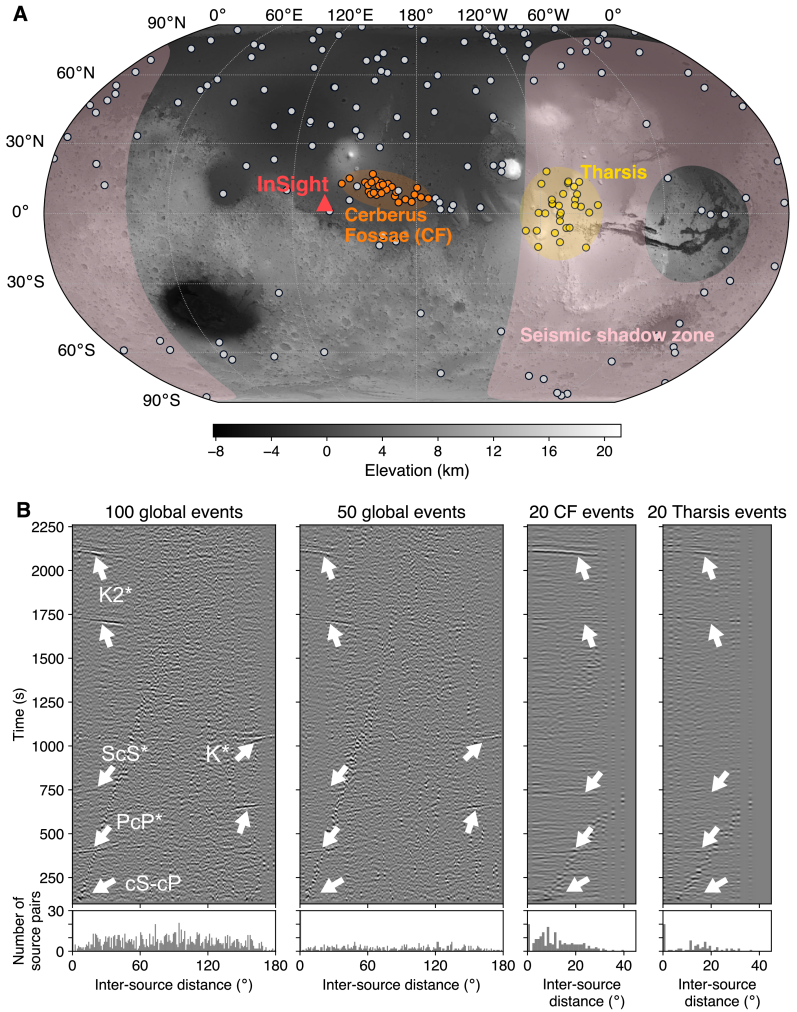
- *the **appearance** of specific correlation features;*
- *the **timing, amplitude, distance-time dependency** of the correlation features;*

Constraining Planetary Interiors with Single-Station Correlograms

- **Scanning for the Earth's core using a single station**



- **Synthetic Marsquake Correlograms**



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Conclusions

- We developed a new and simple procedure to construct **global-scale inter-source correlograms** characterized by many correlation features sensitive to the Earth's and internal planetary structures.
- We demonstrate that **a single station** is sufficient to produce a global correlogram.
- A single-station correlogram can be used to **image the Earth's and deep planetary interiors**.

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Thank you!
Questions and Comments!

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