

The power of higher-order cross-correlations (C^3) to image the Earth from the crust to the core

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CARGÈSE, JUNE 2017

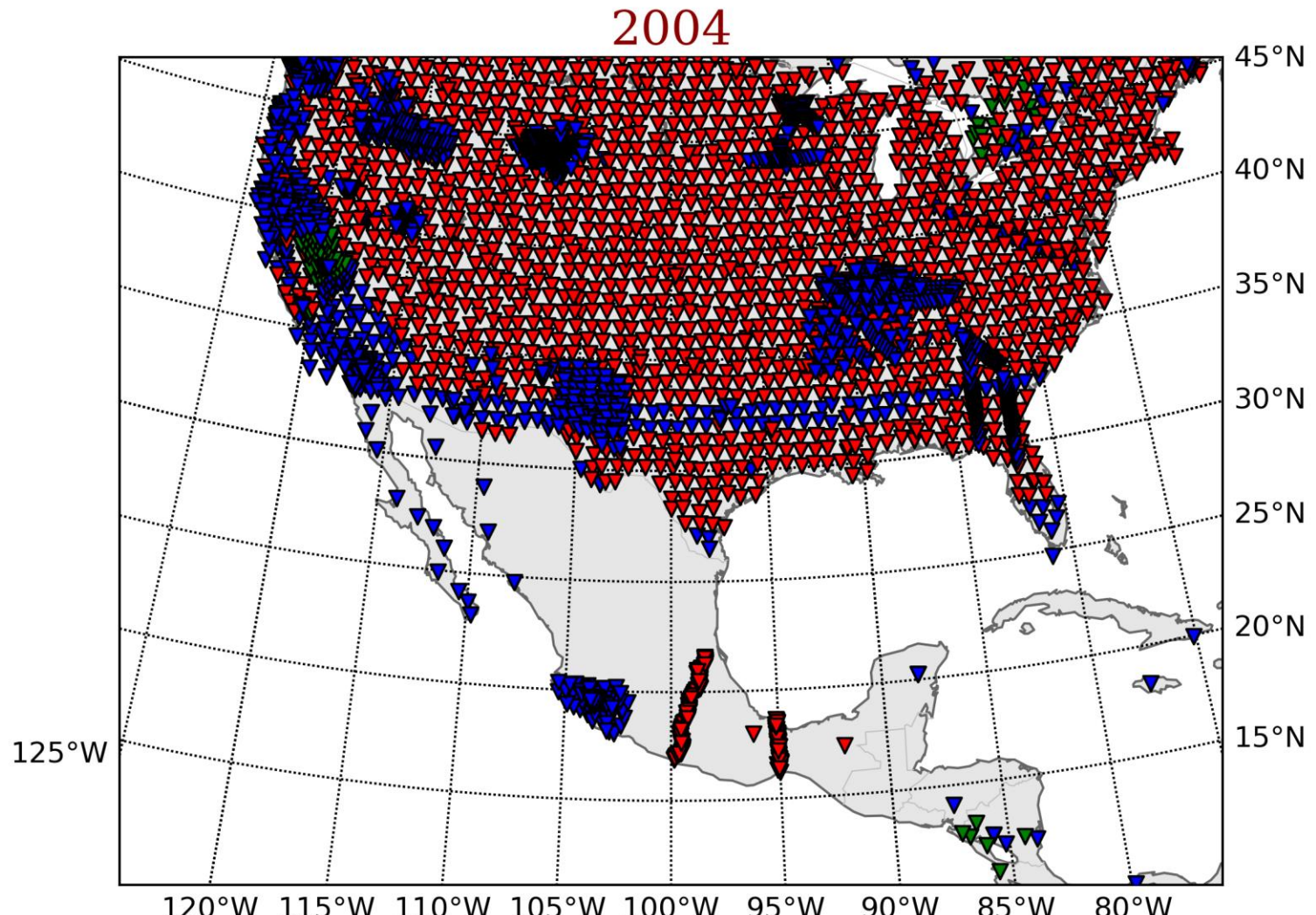
Stanford
EARTH



Motivations:

Station distribution in north America

Higher-order cross-correlation to bridge in space and time all the networks



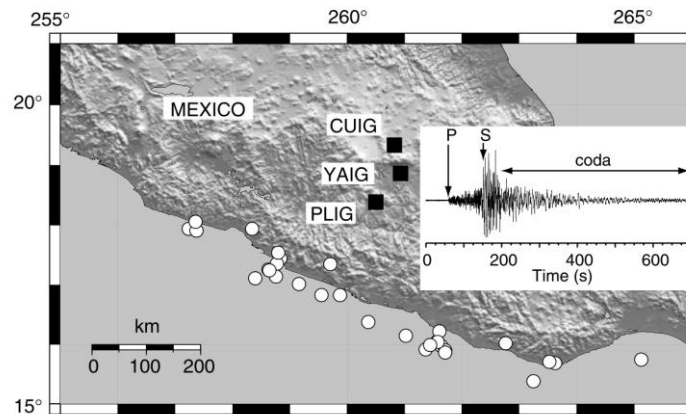
What is C³?

Back to 2003:

Coda interferometry

Long-range correlations in the **diffuse** seismic coda

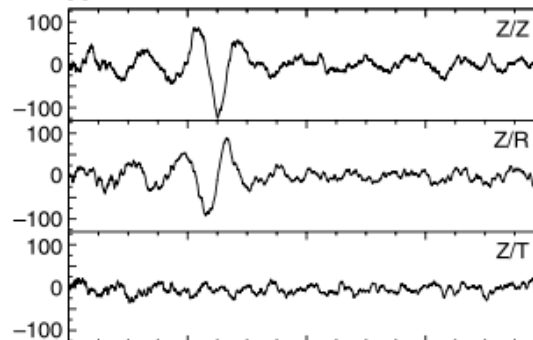
- The **coda** of earthquakes



Campillo & Paul, 2003



A Stacks of cross-correlations in the coda



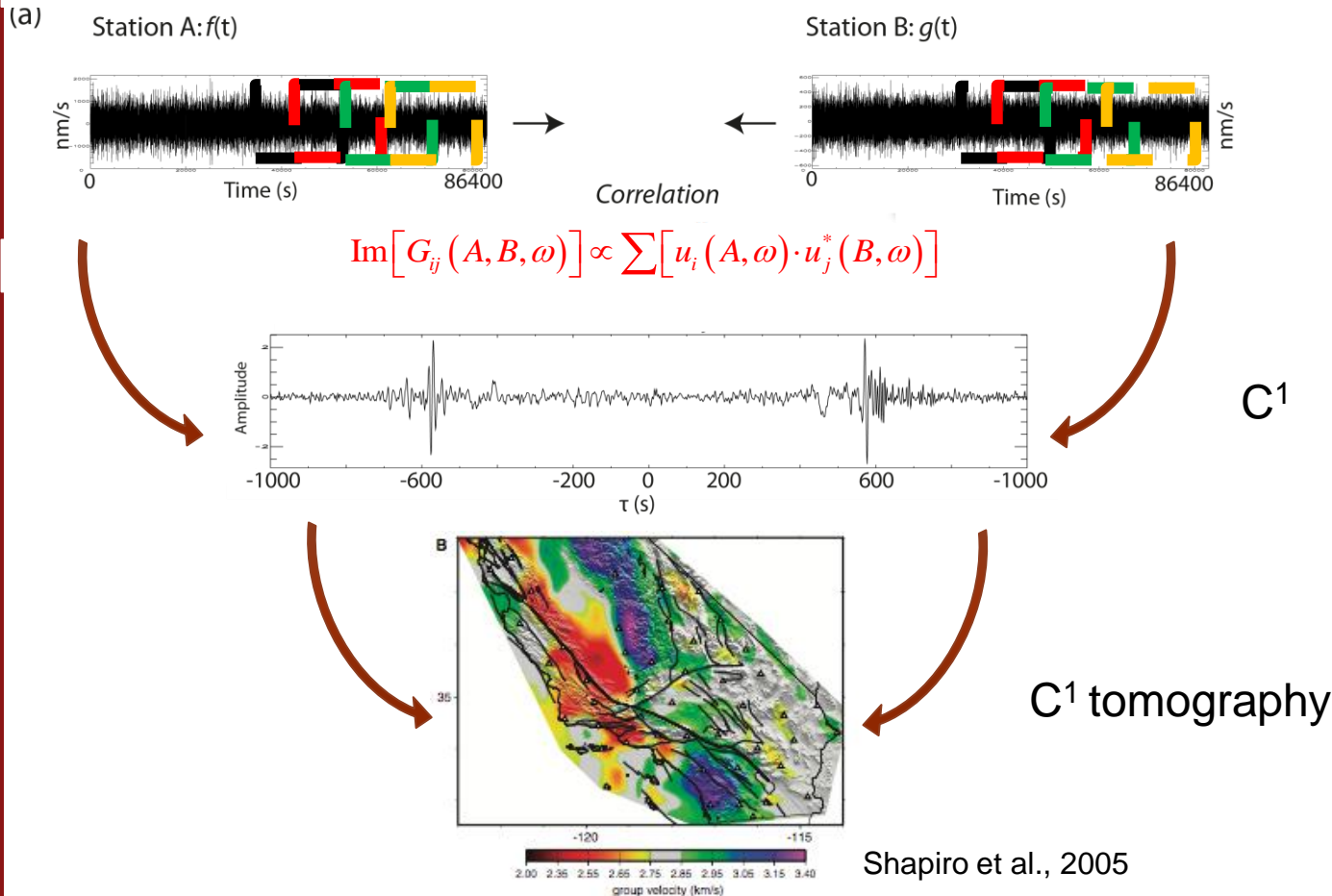
Ambient field interferometry

Back to 2004:

It appeared that **two** kinds of seismic records can be considered as representative of a diffuse field:

- The **coda** of earthquakes.
- Long-time records of **ambient seismic field**.

Emergence of broadband Rayleigh waves from correlations of the seismic **ambient noise**, Shapiro & Campillo 2004

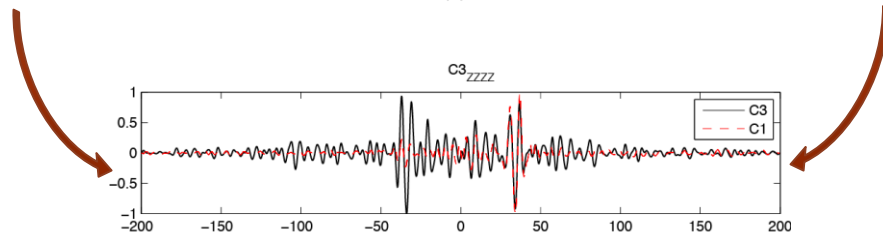
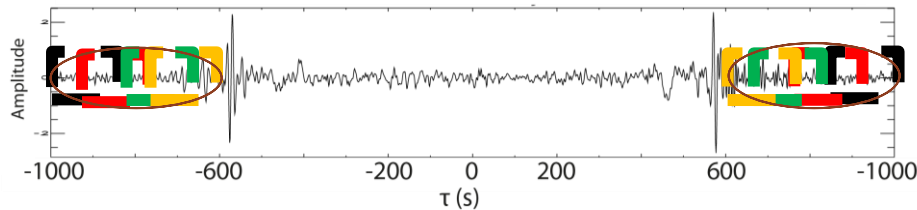


What is C^3 ?

Back to 2008:

It appeared that **three** kinds of seismic records can be considered as representative of a diffuse field:

- The **coda** of earthquakes.
- Long-time records of **ambient seismic field**.
- The **coda** of the C^1 .



C^3

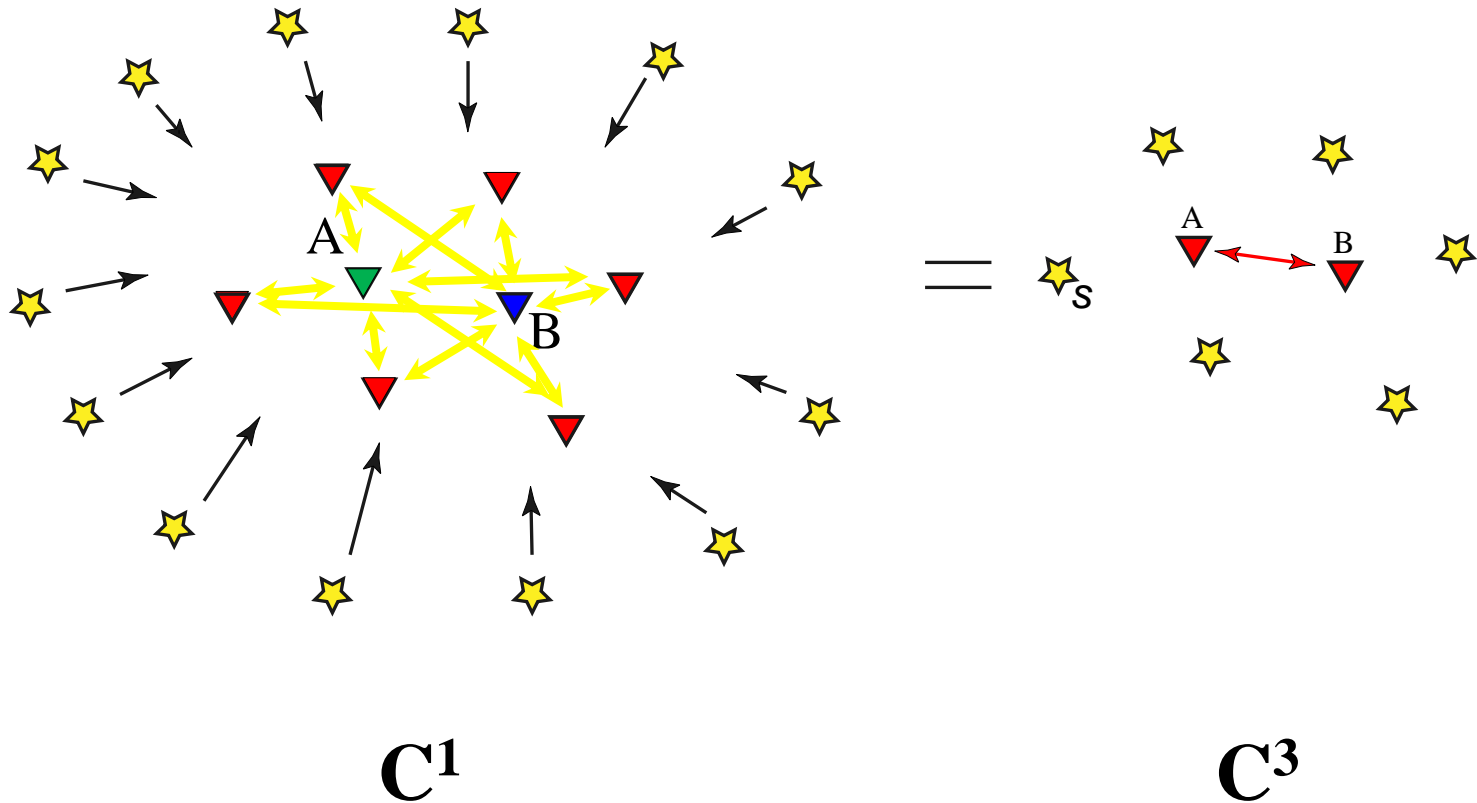
Correlation of **Coda** of **Correlations**

Stehly et al., 2008

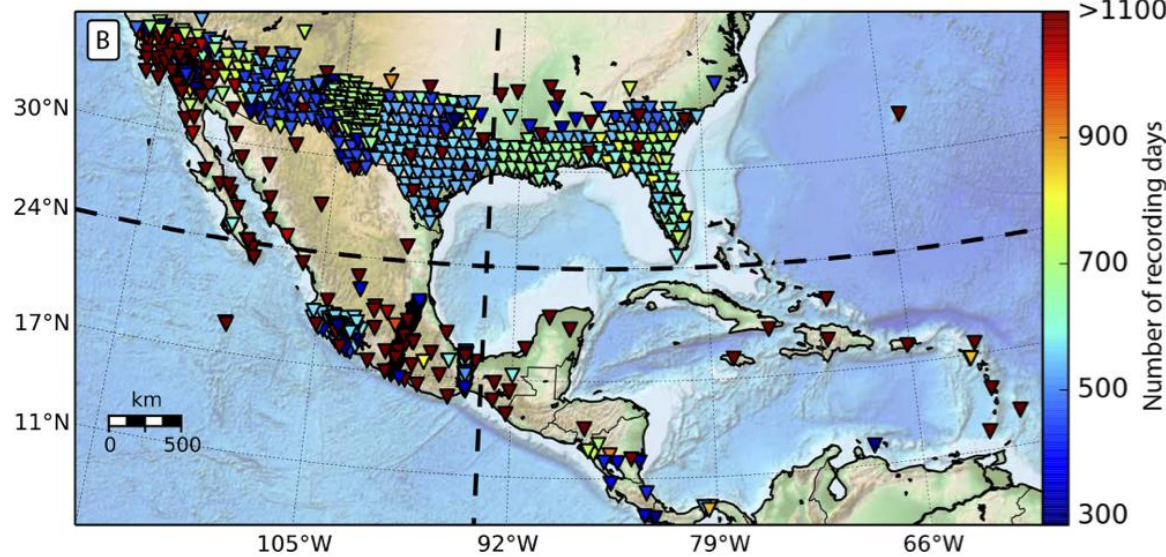
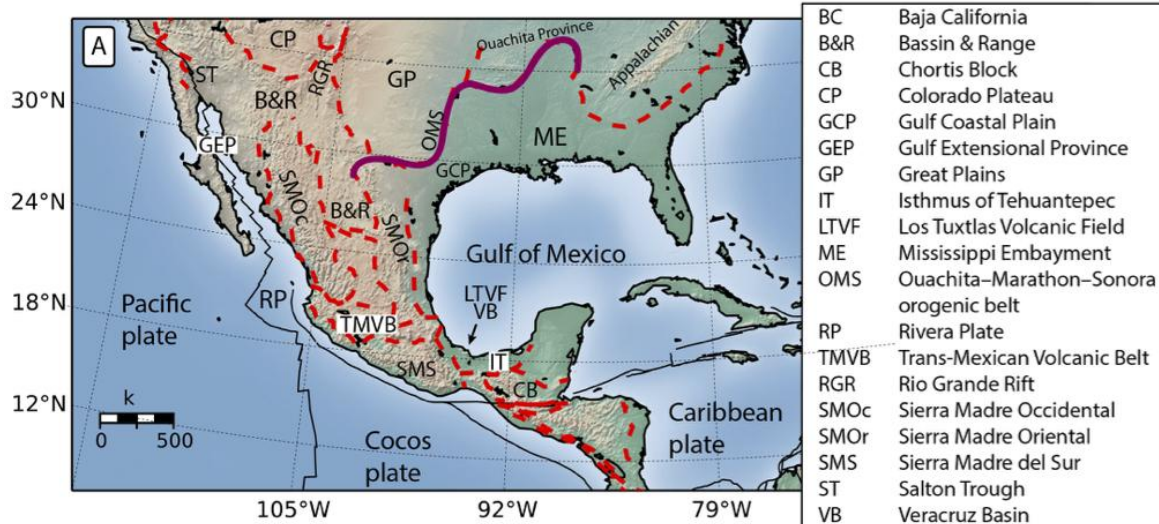
C³ in practice

Bridging seismic networks in time and space

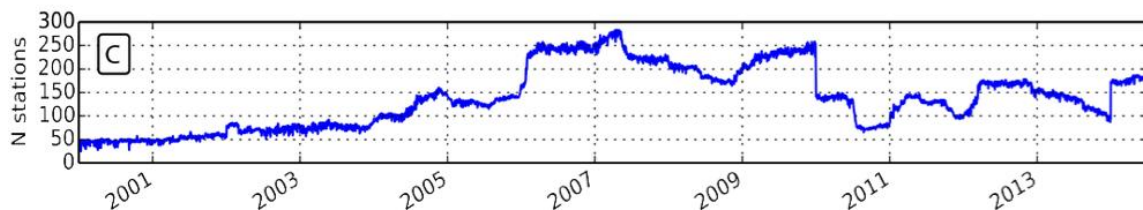
Noise sources

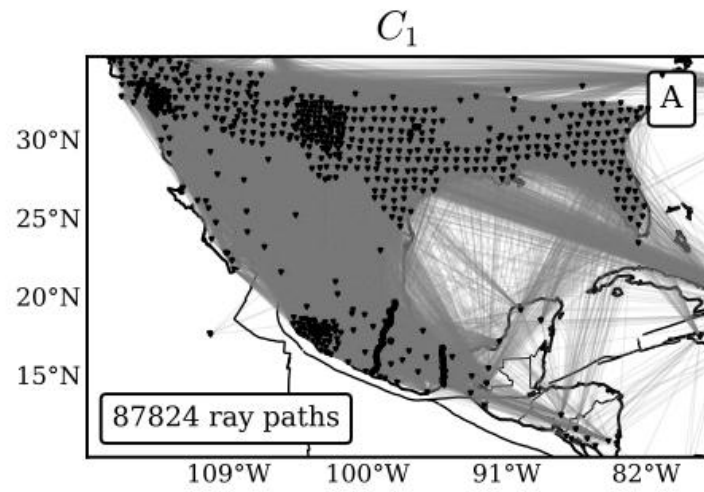


Application to Mexico

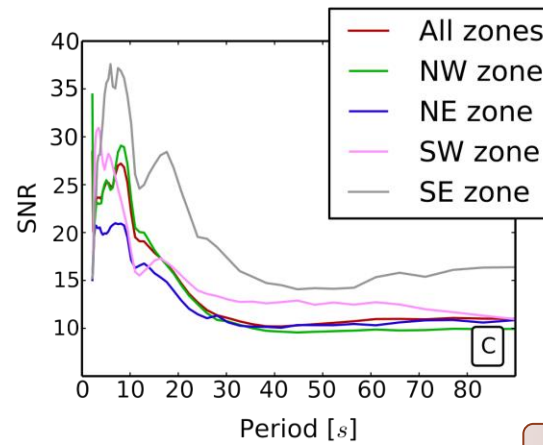
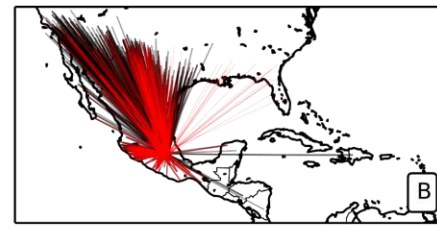
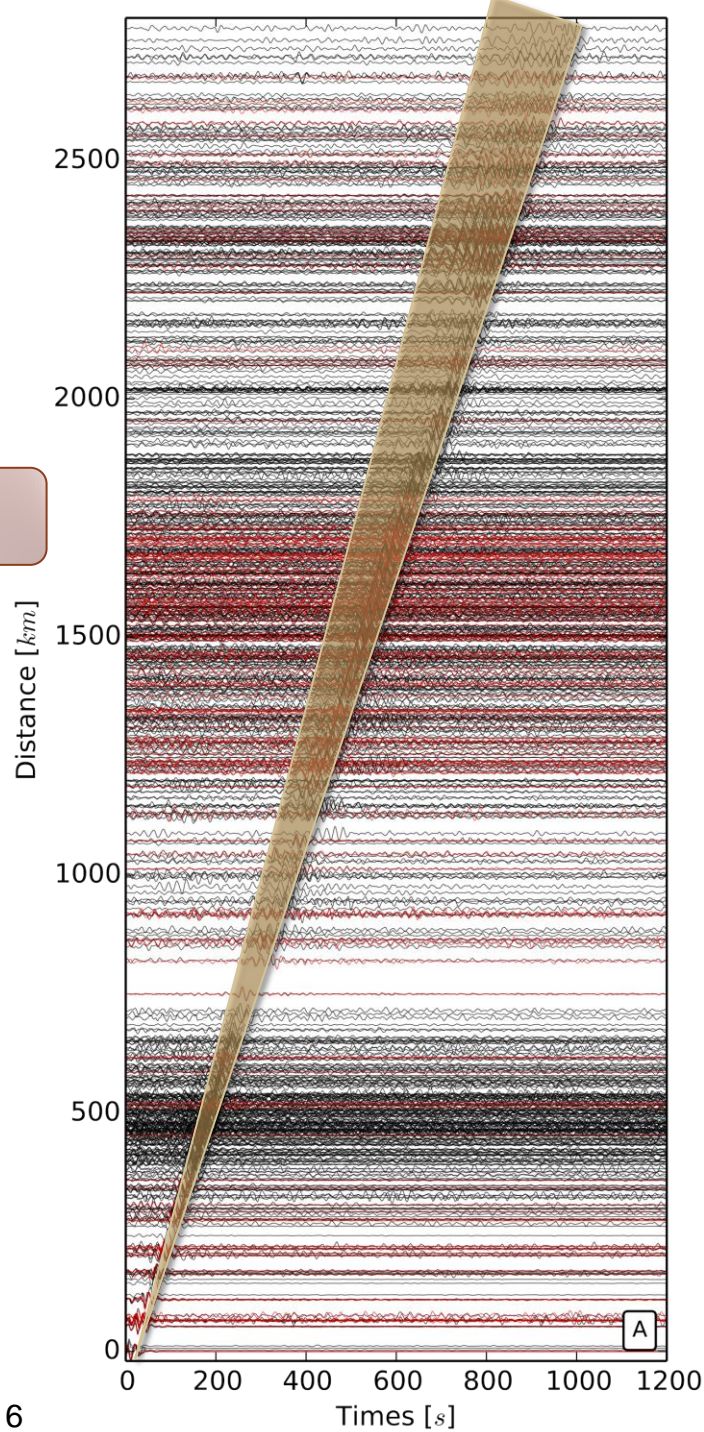


14 years of data | > 900 Z sta to compute the C^1

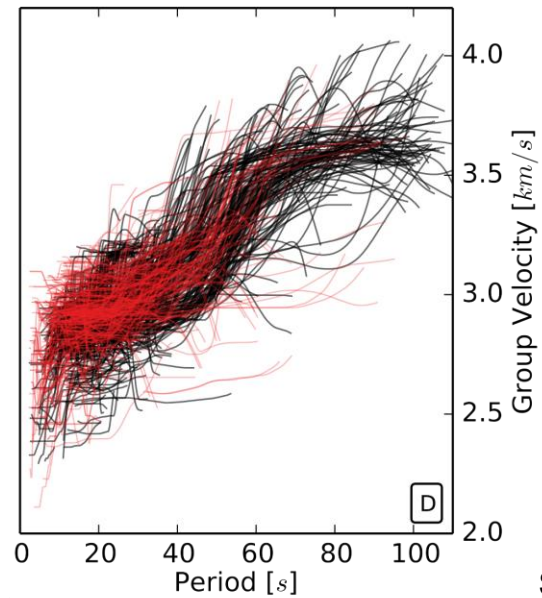




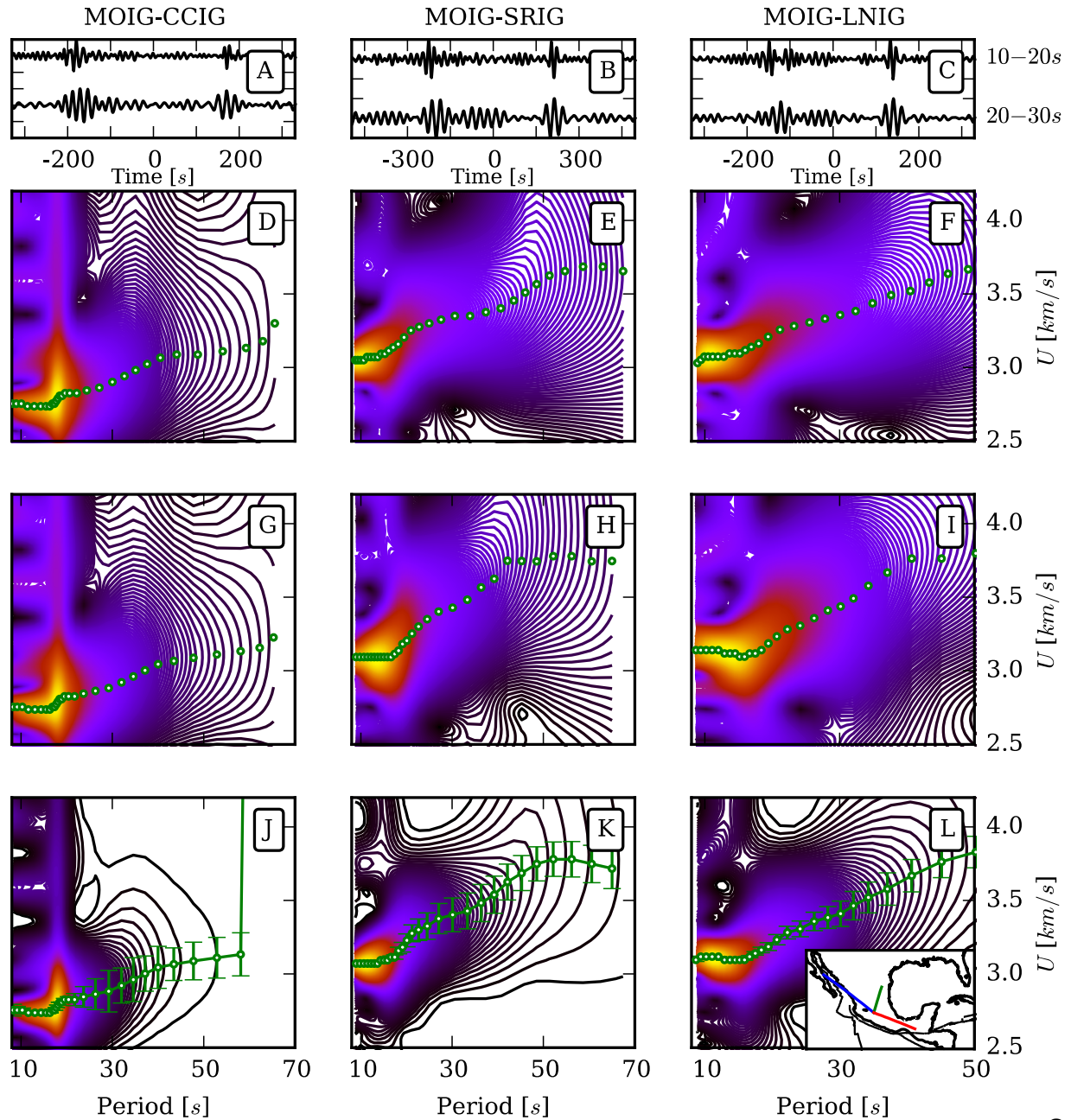
Correlations



FTAN



FTAN



Velocity model (Rayleigh group)

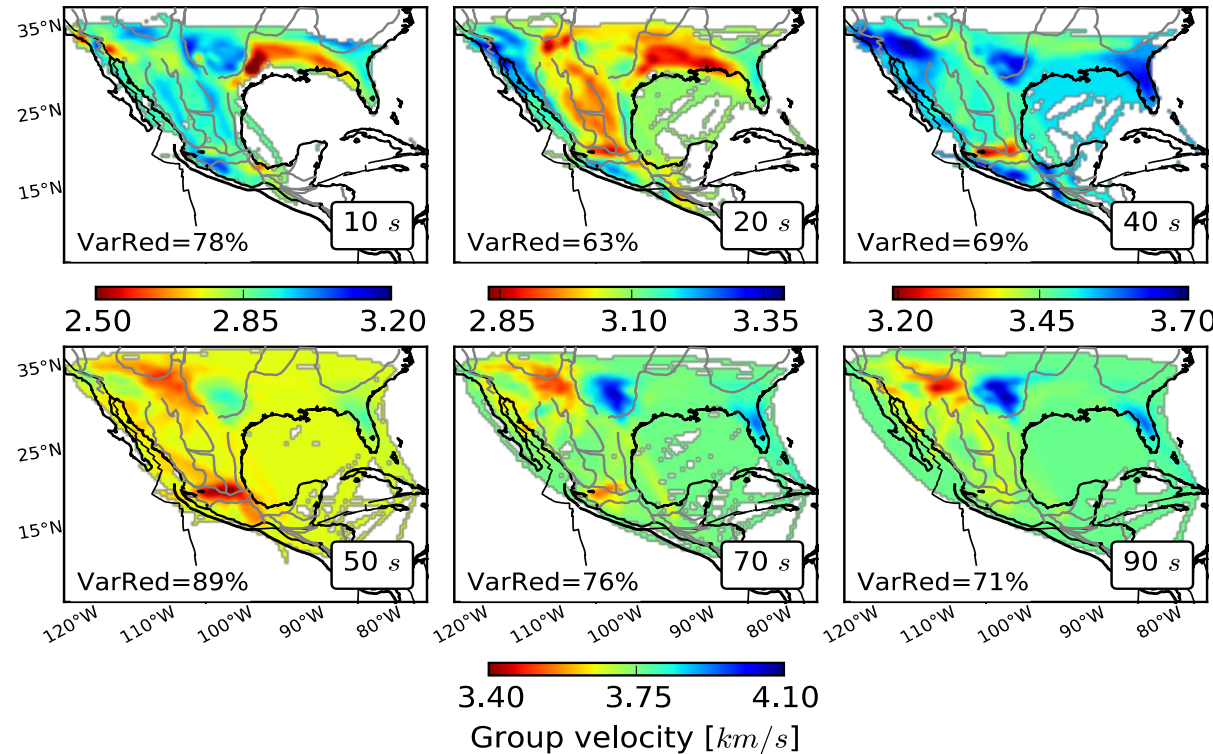
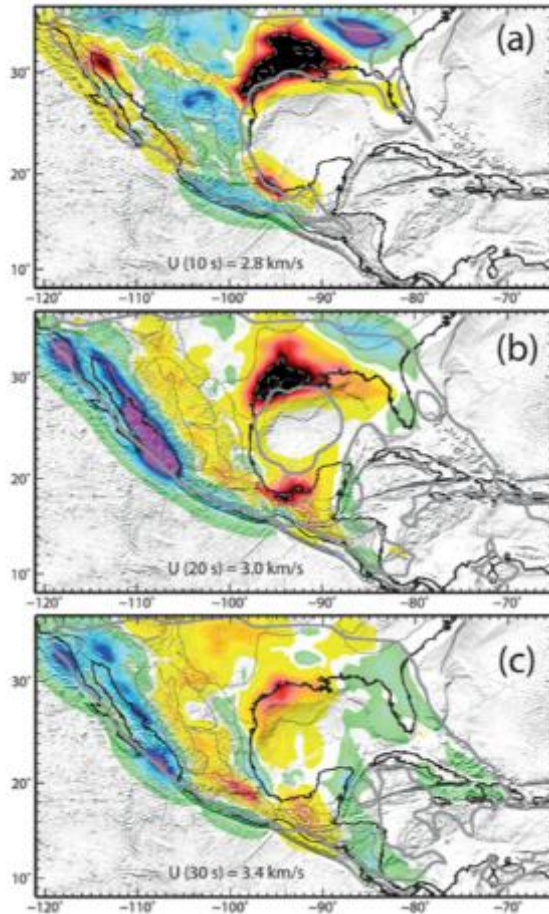
Tomographic inversion

Gaite et al., 2012; 2015

Spica et al., 2016

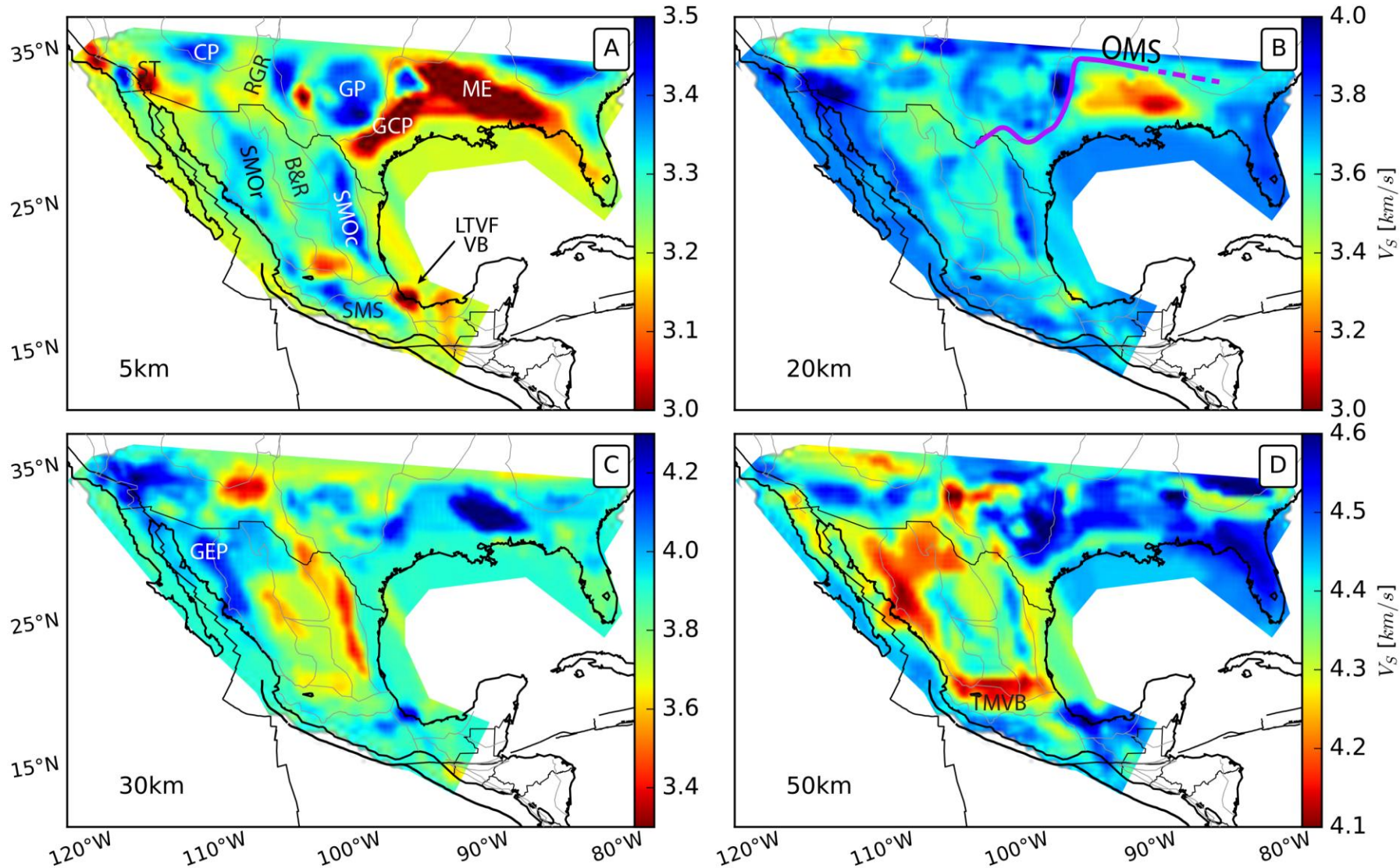
$2^\circ \times 2^\circ \sim 200 \text{ km}^2$

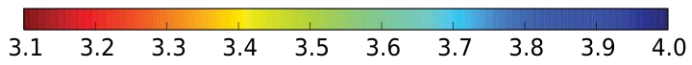
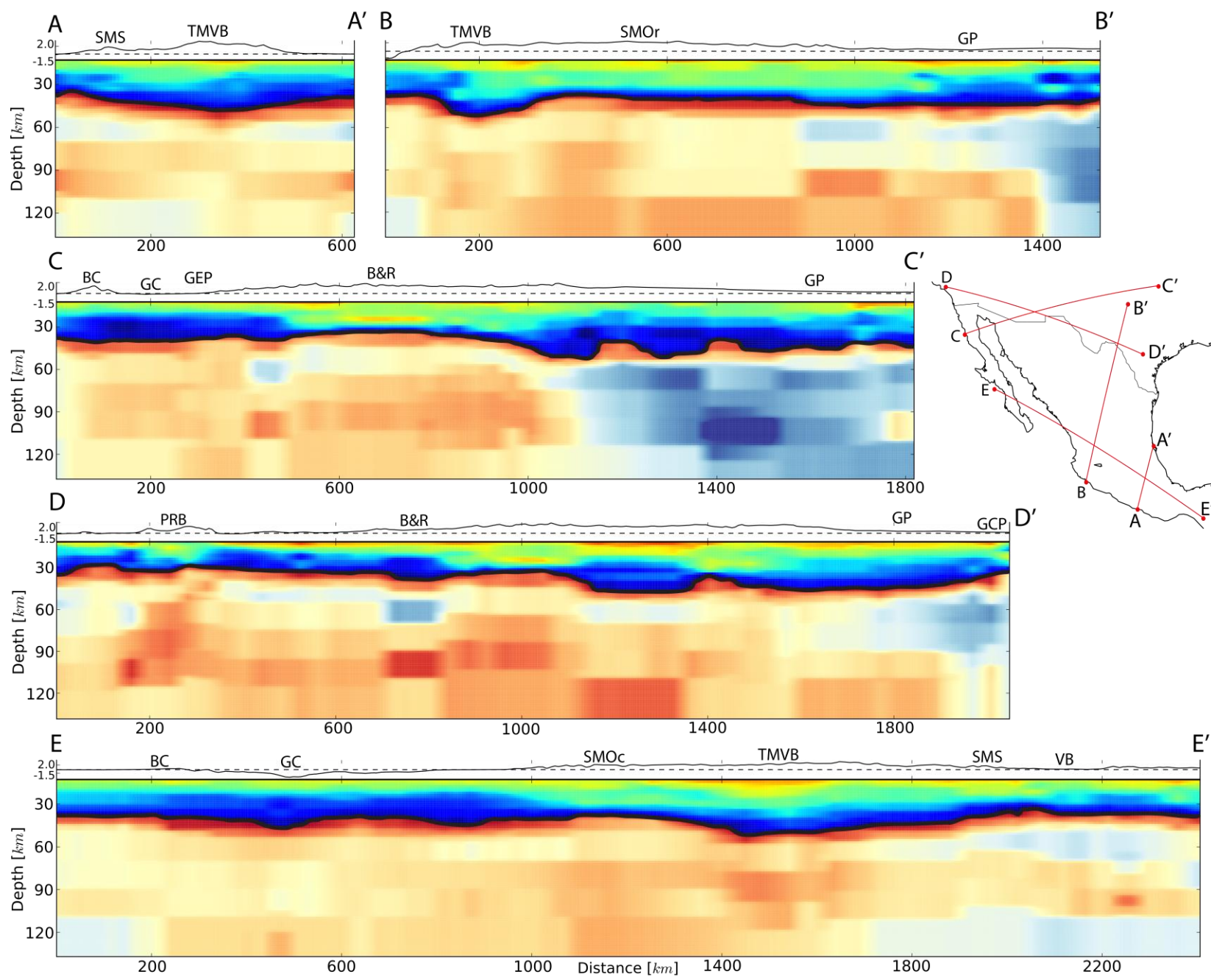
$0.4^\circ \times 0.4^\circ \sim 40 \text{ km}^2$



High-resolution tomography of Mexico and South US

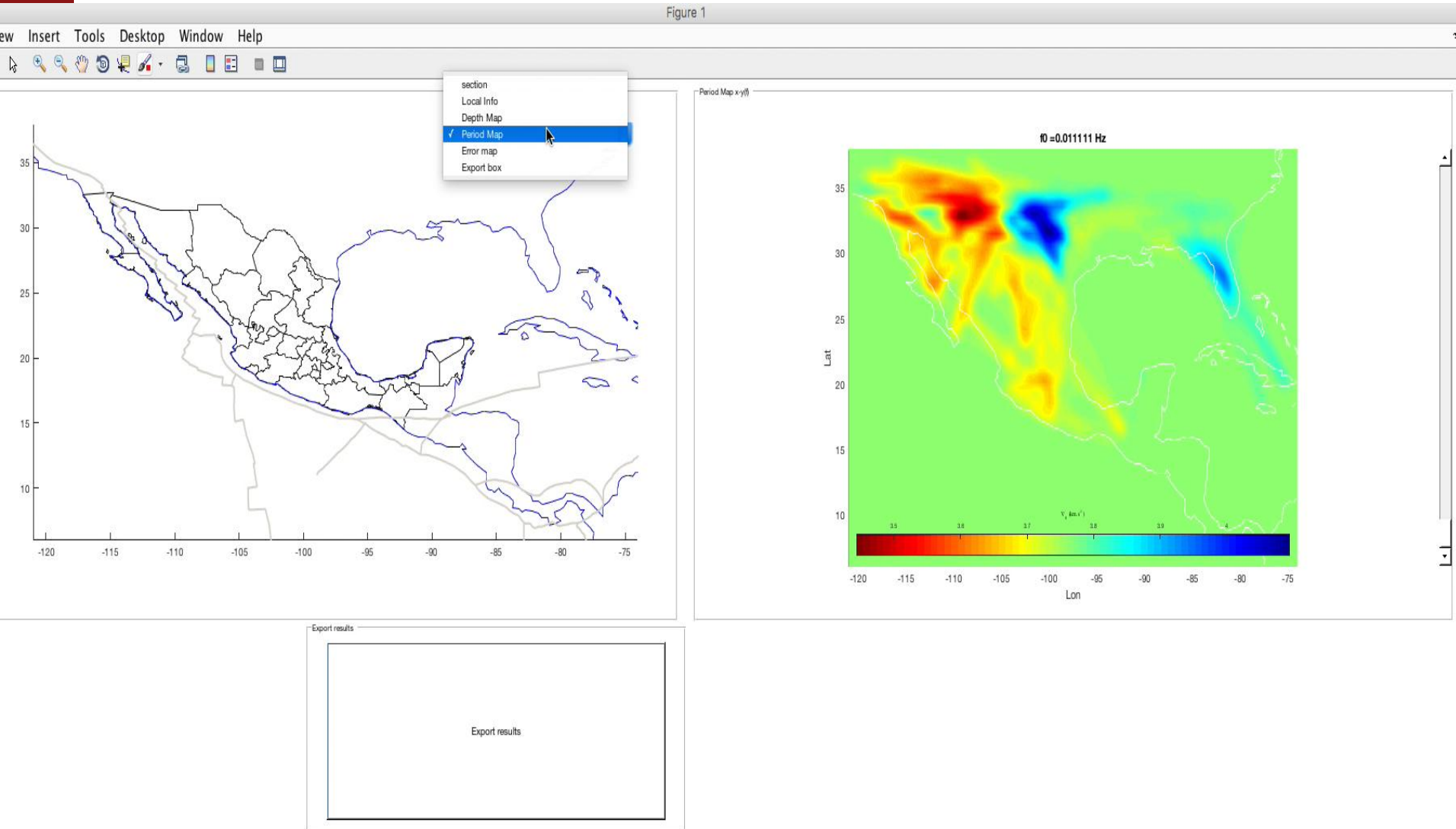
1D inversion and
3D model



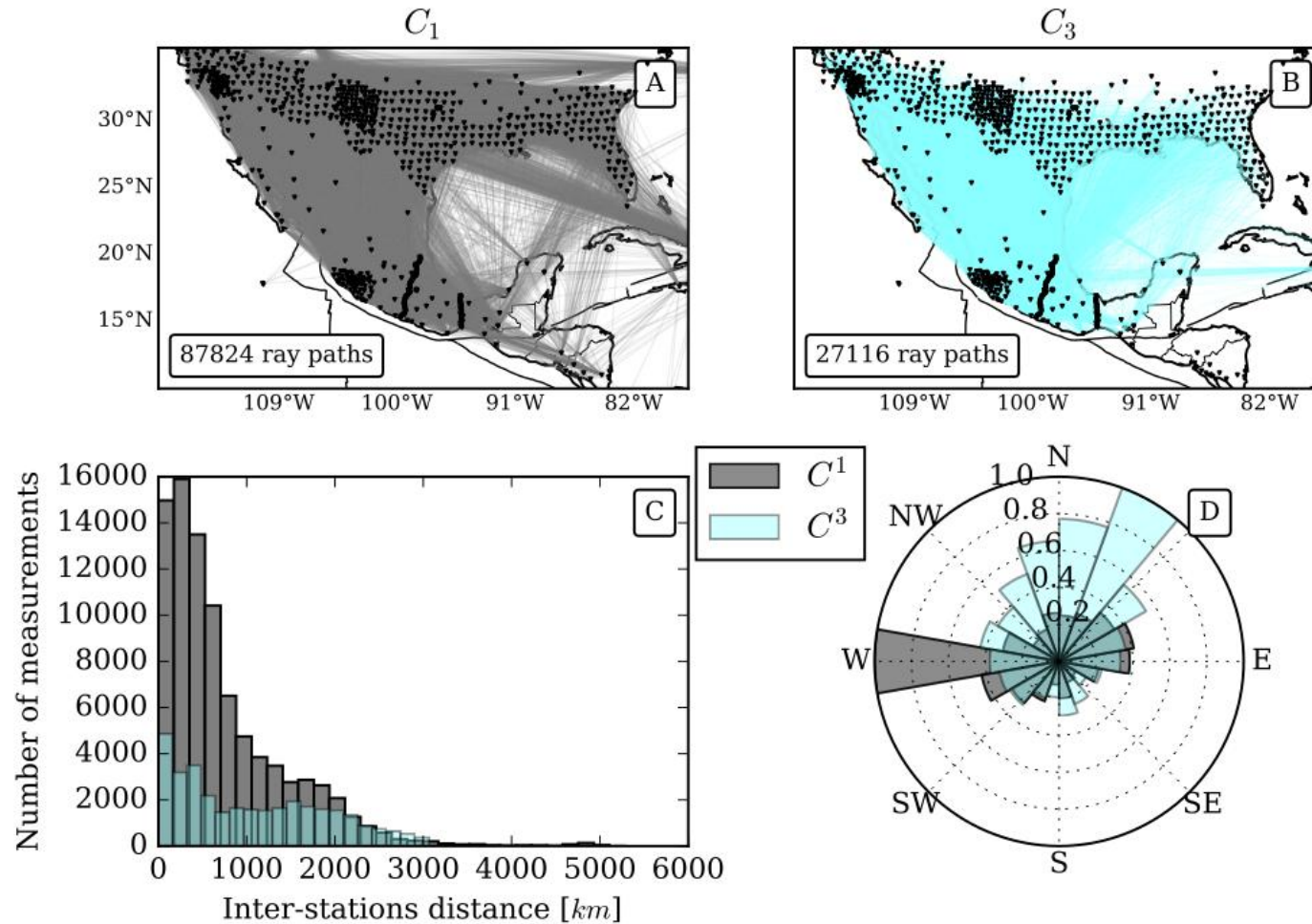


Tool to explore the models

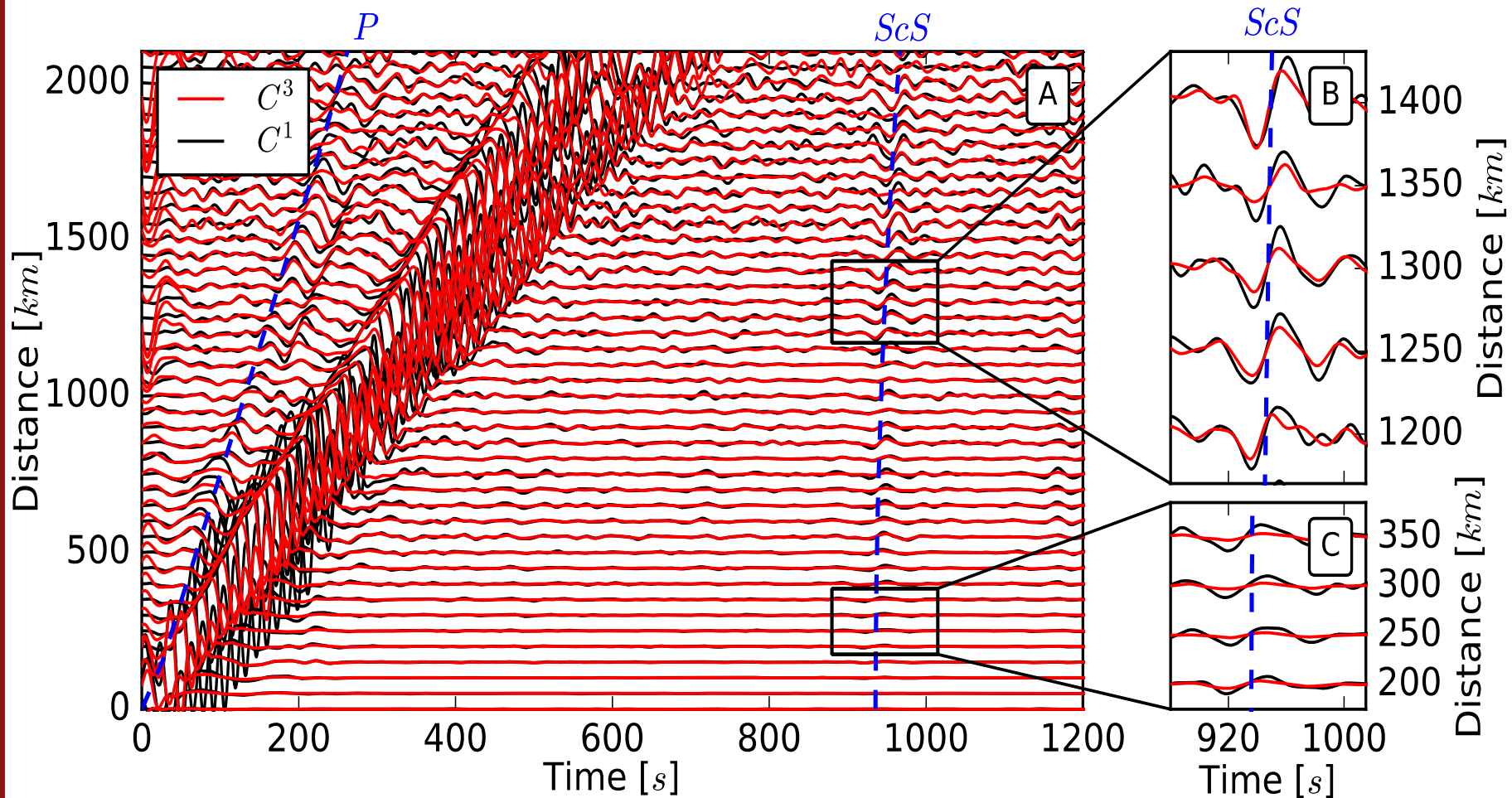
<http://www.igum.unam.mx/mperton/MexTomo/>



Body waves in C^3 ?

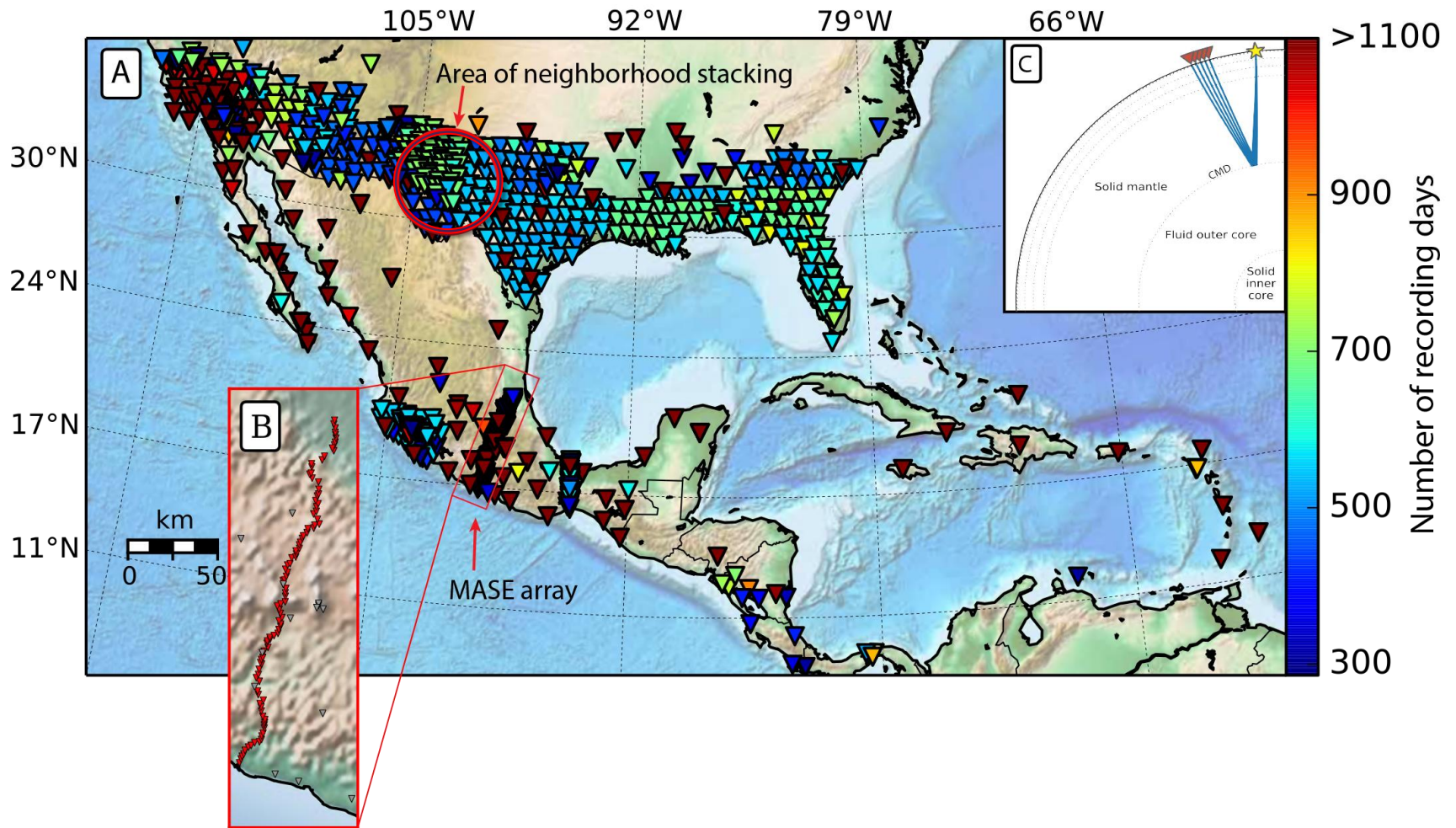


50 km bin stacks



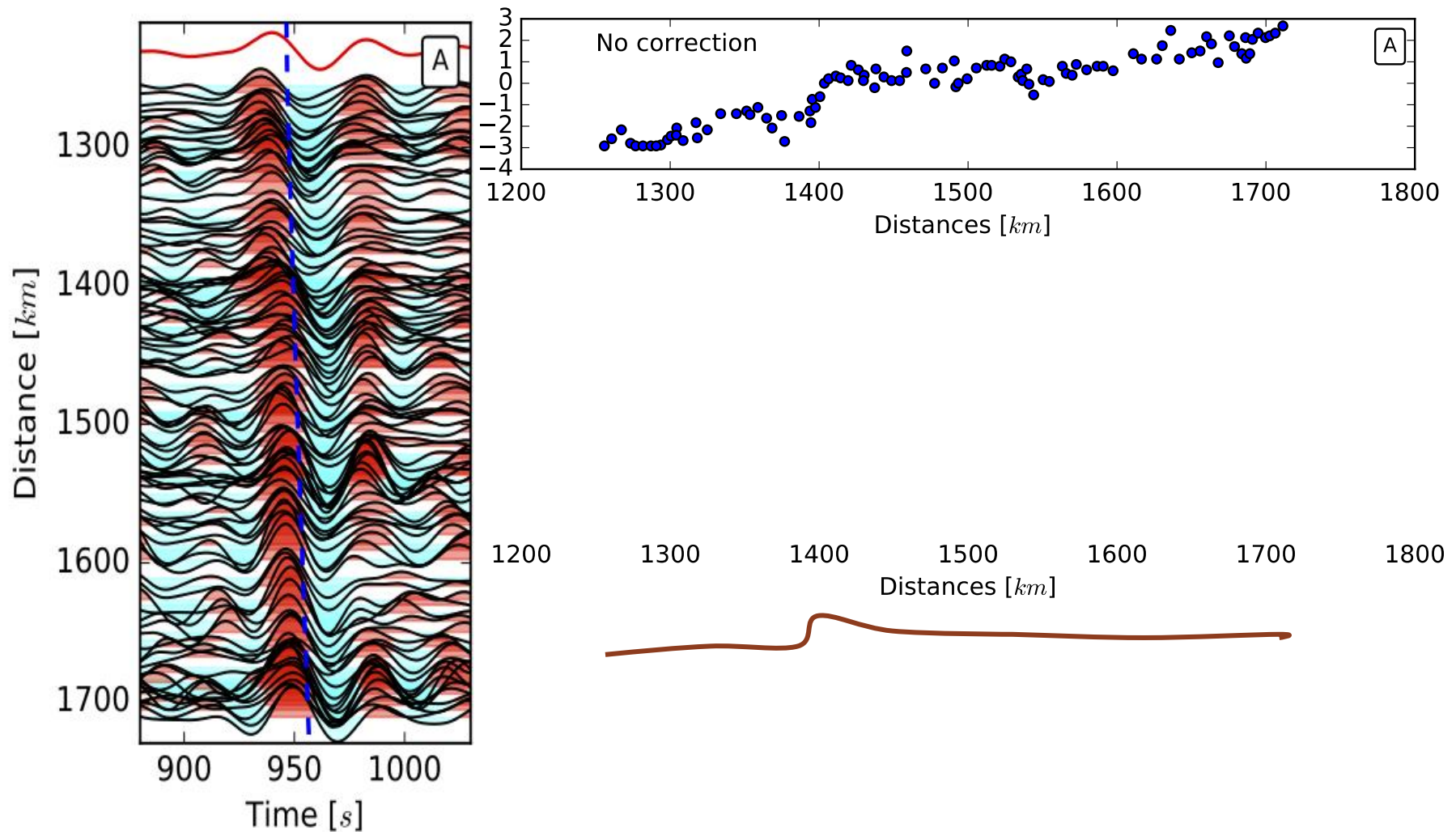
- Thousands of C^n stacked
- All azimuths

Same problem as before:
only few stations in Mexico...

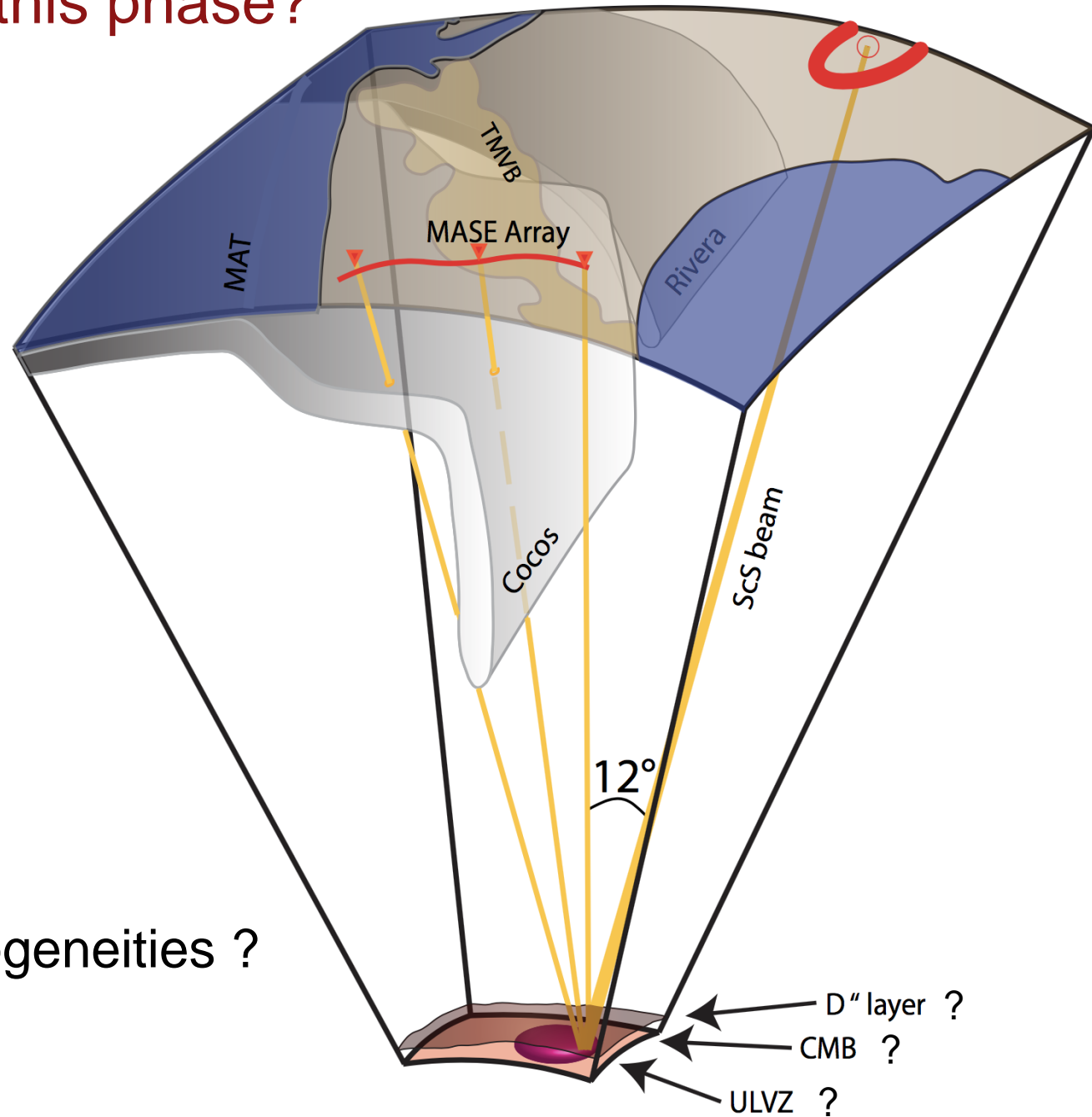


Relative time delay analysis

Removing Radial heterogeneities



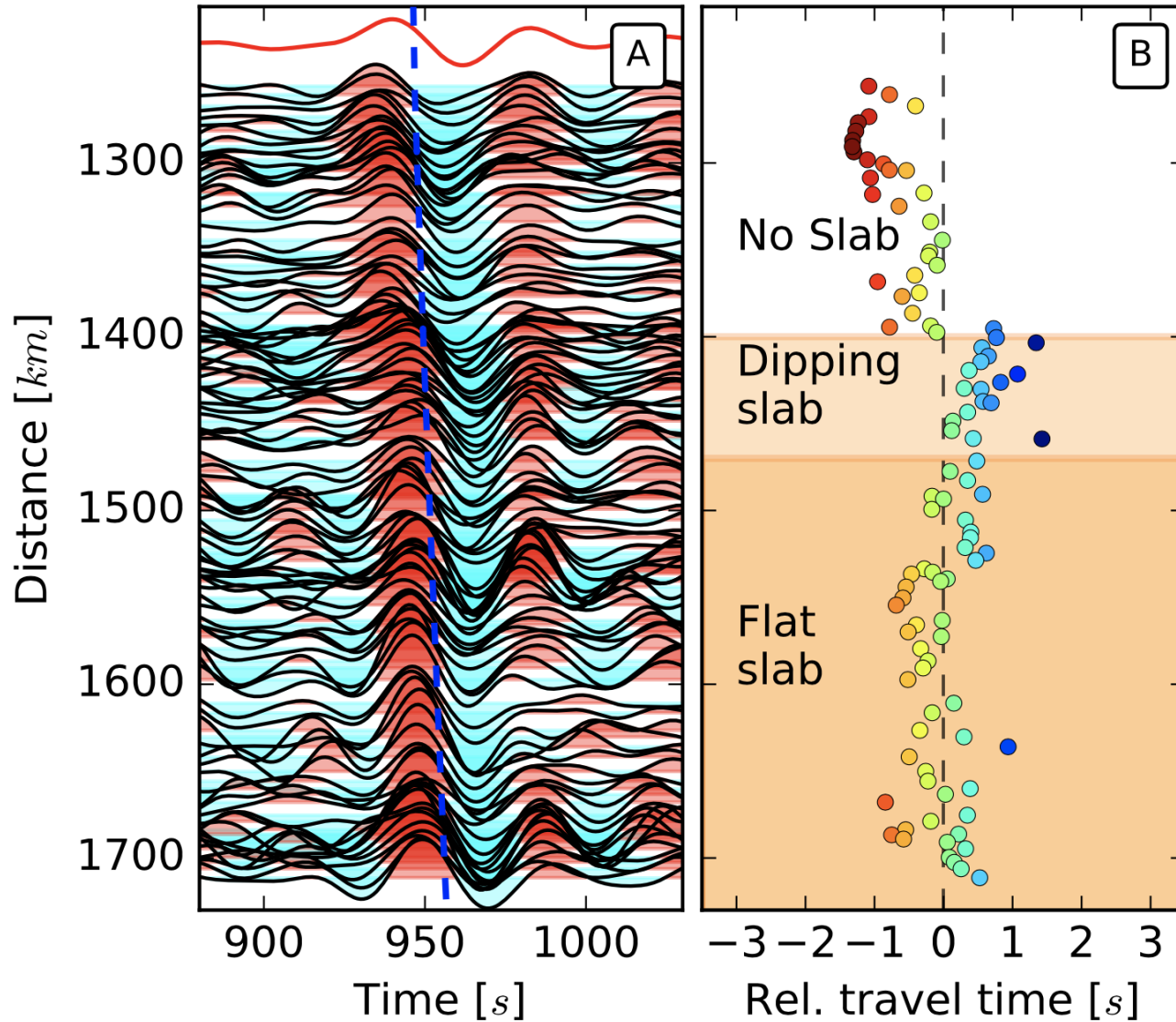
What affects this phase?



Horizontal heterogeneities ?

Spica et al., in review

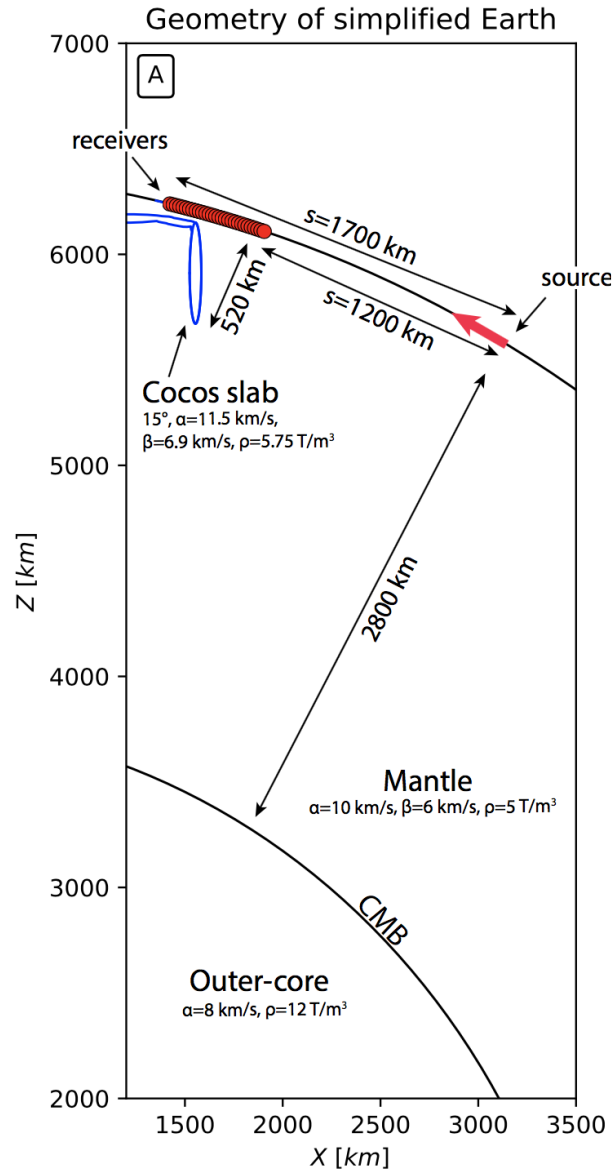
The oceanic slab seems to have an effect on travel-time measurements...



How to confirm it?



Indirect Boundary Element Method to simulate elastic wave propagation in a 2-D piecewise homogeneous domain (Pertou & Sánchez-Sesma, 2016)

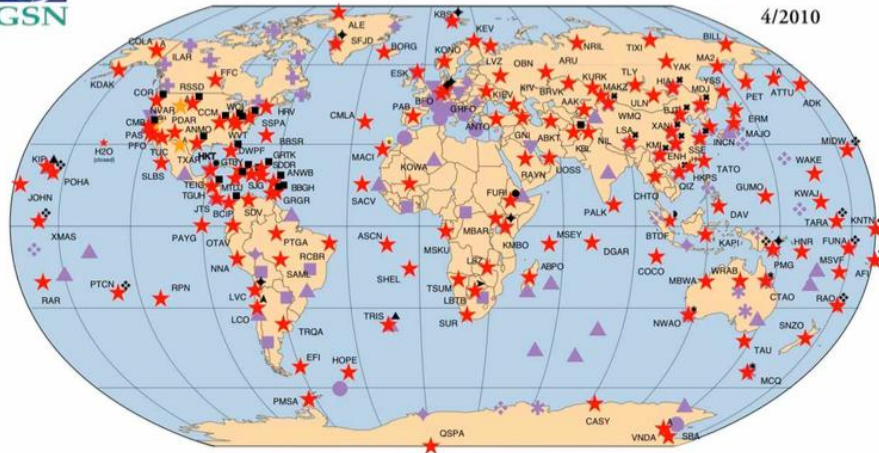


Some conclusions



GLOBAL SEISMOGRAPHIC NETWORK
& INTERNATIONAL FEDERATION OF DIGITAL SEISMOGRAPHIC NETWORKS

4/2010



- Thousands of permanent seismometers are operating continuously
- Some temporary networks regroup tens and hundreds of thousands of instruments
- Waiting to be used as one single array...



Thank you

