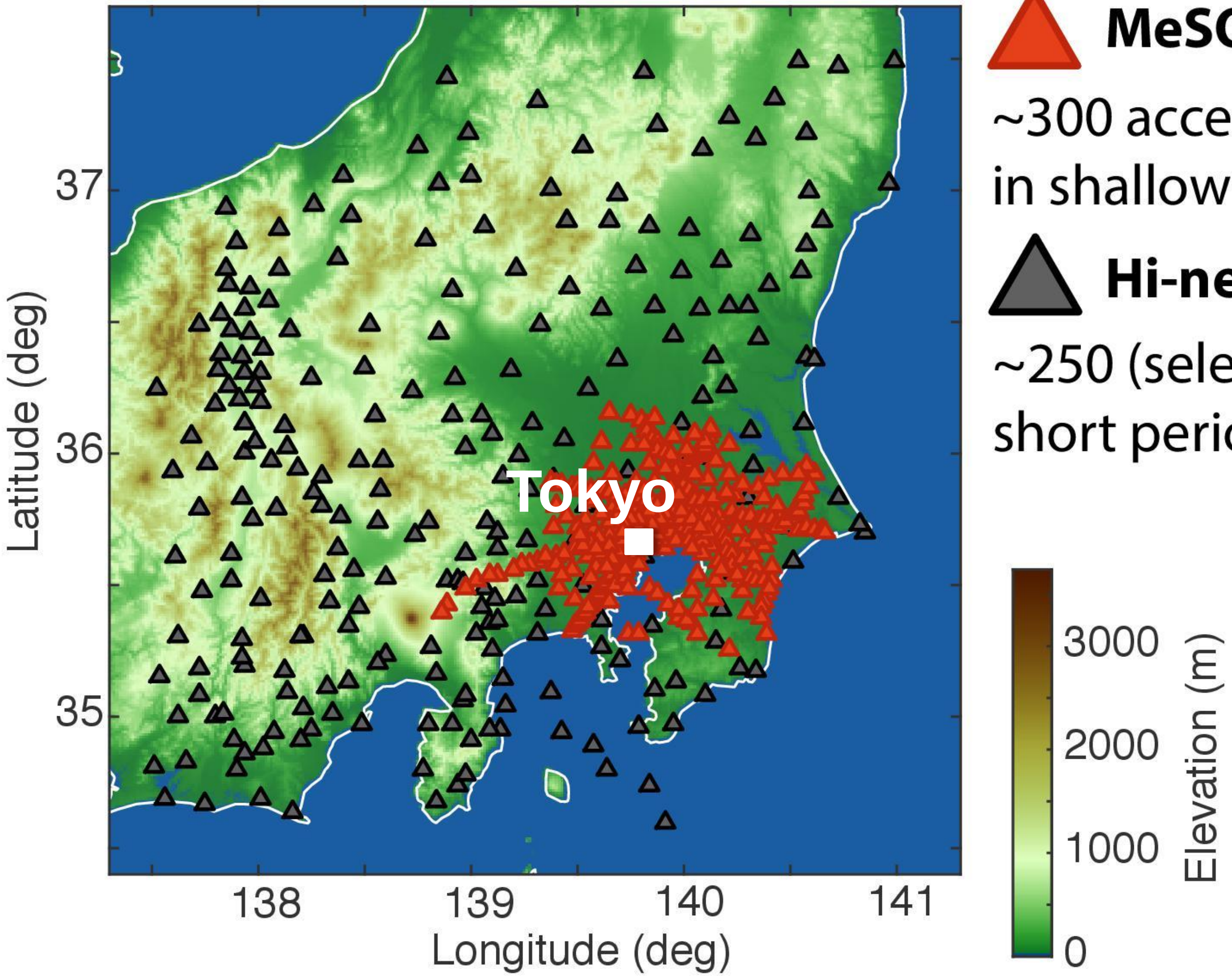
CHARACTERIZING BASIN SCALE WAVEFIELDS USING A DENSE SEISMIC ARRAY

Pierre BOUÉ

Marine DENOLLE
Naoshi HIRATA
Shigeki NAKAGAWA
Greg .C. BEROZA

The Kanto Basin and the MeSO-net



MeSO-net:

~300 accelerometers in shallow boreholes

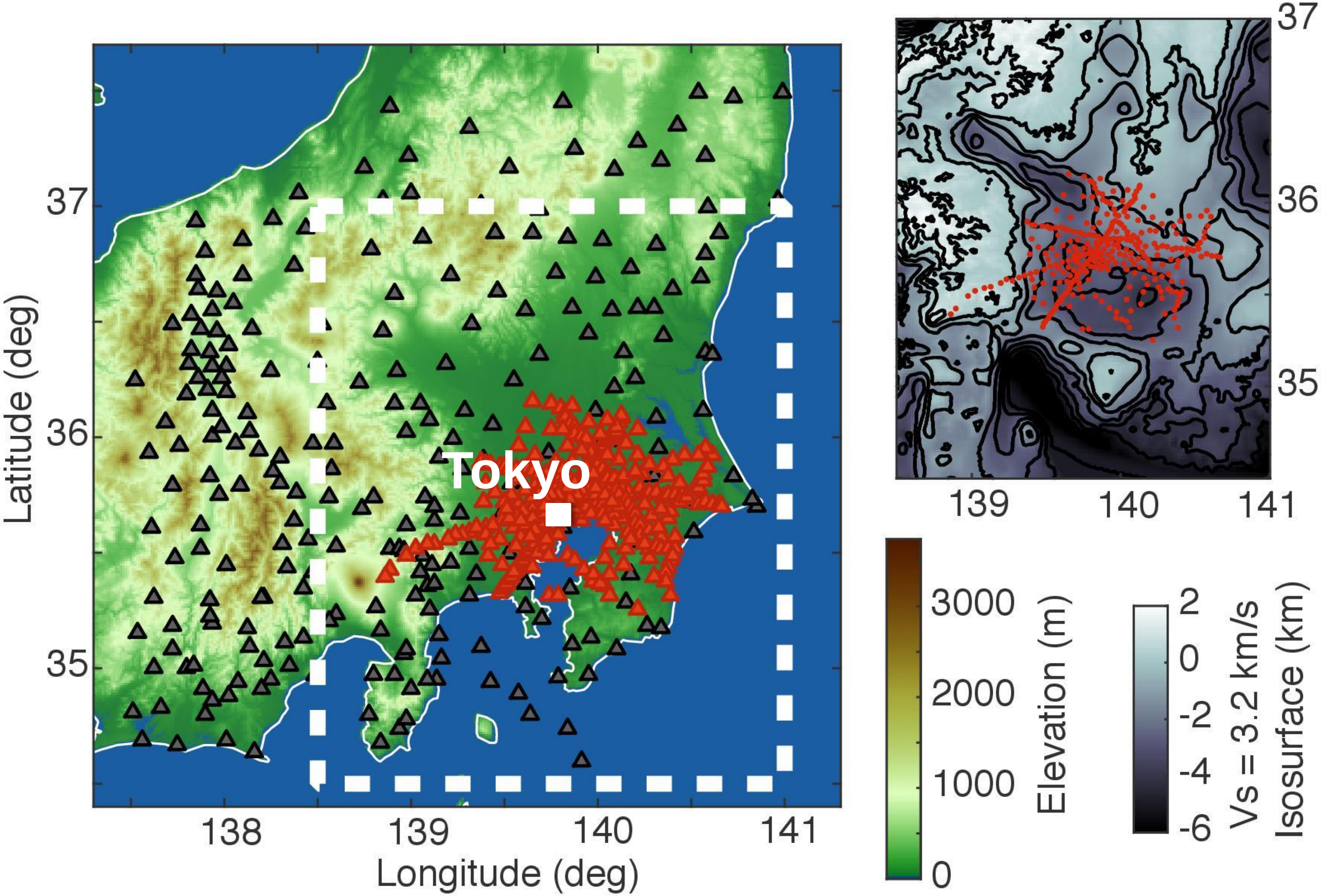
Hi-net:

~250 (selection) short period sensors

One year (2012) of 3-components continuous data

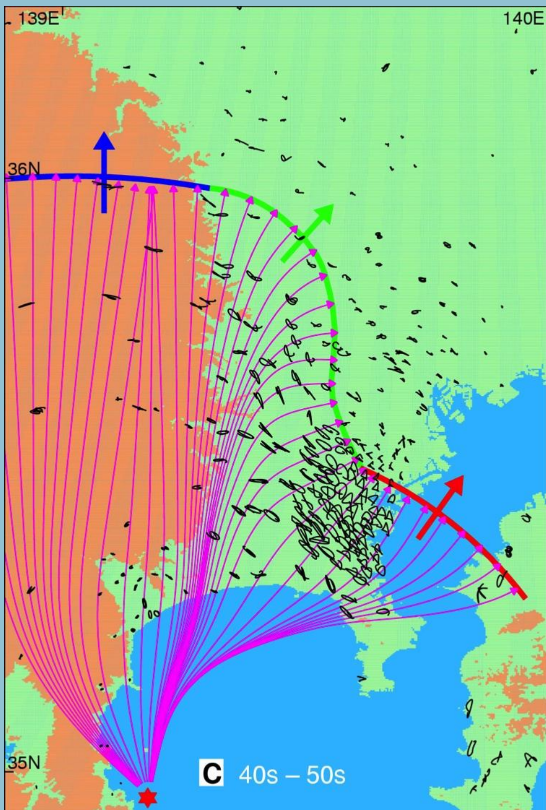
The Kanto Basin and the MeSO-net

A (very) good a priori velocity model (Koketsu et al., 2009)



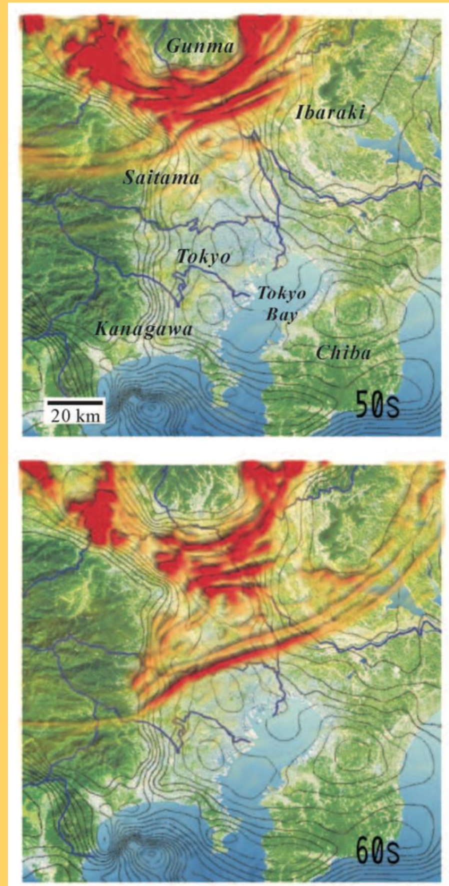
Ground Motion in the Kanto Basin

From Earthquake Data



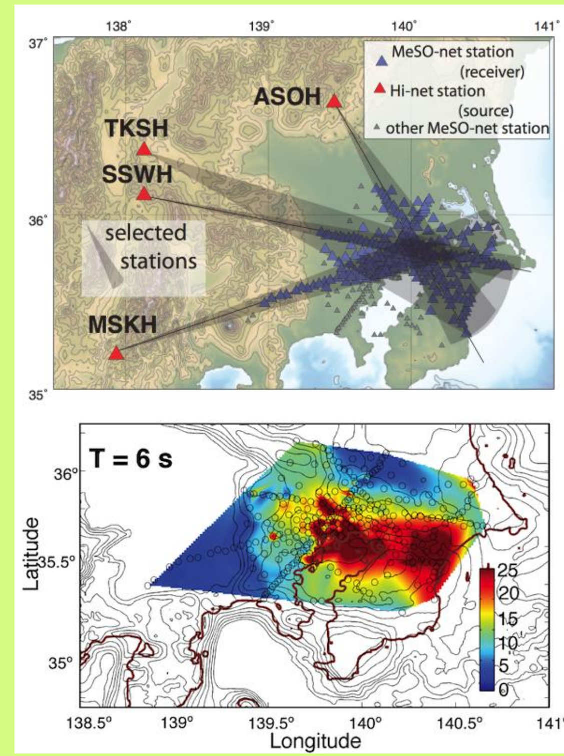
Koketsu & Kikuchi (2000), M5.7 offshore Izu peninsula

From Simulations



Fururuma &Hayakawa (2007), M6.6 Niigata-ken Chuetsu

From Ambient Noise and/or Interferometry

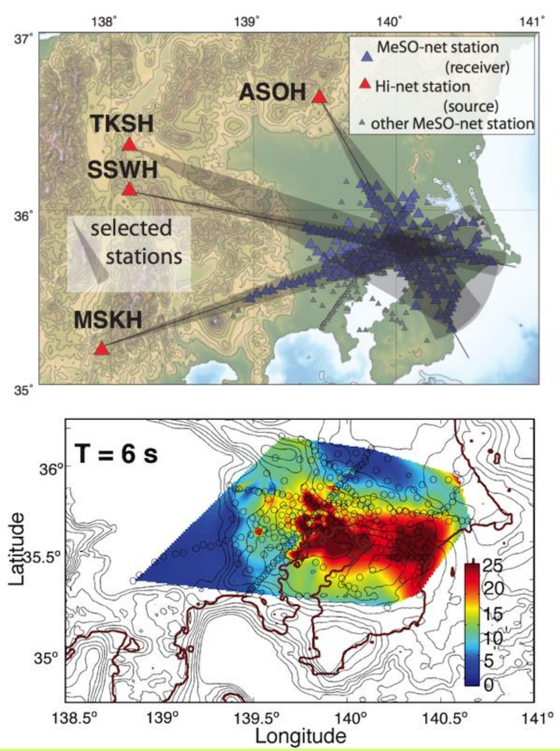


Denolle et al. (2014) Amplification in the basin as a function of basin depth (**<u>Long period</u>**)

Ground Motion in the Kanto Basin From Ambient Noise?

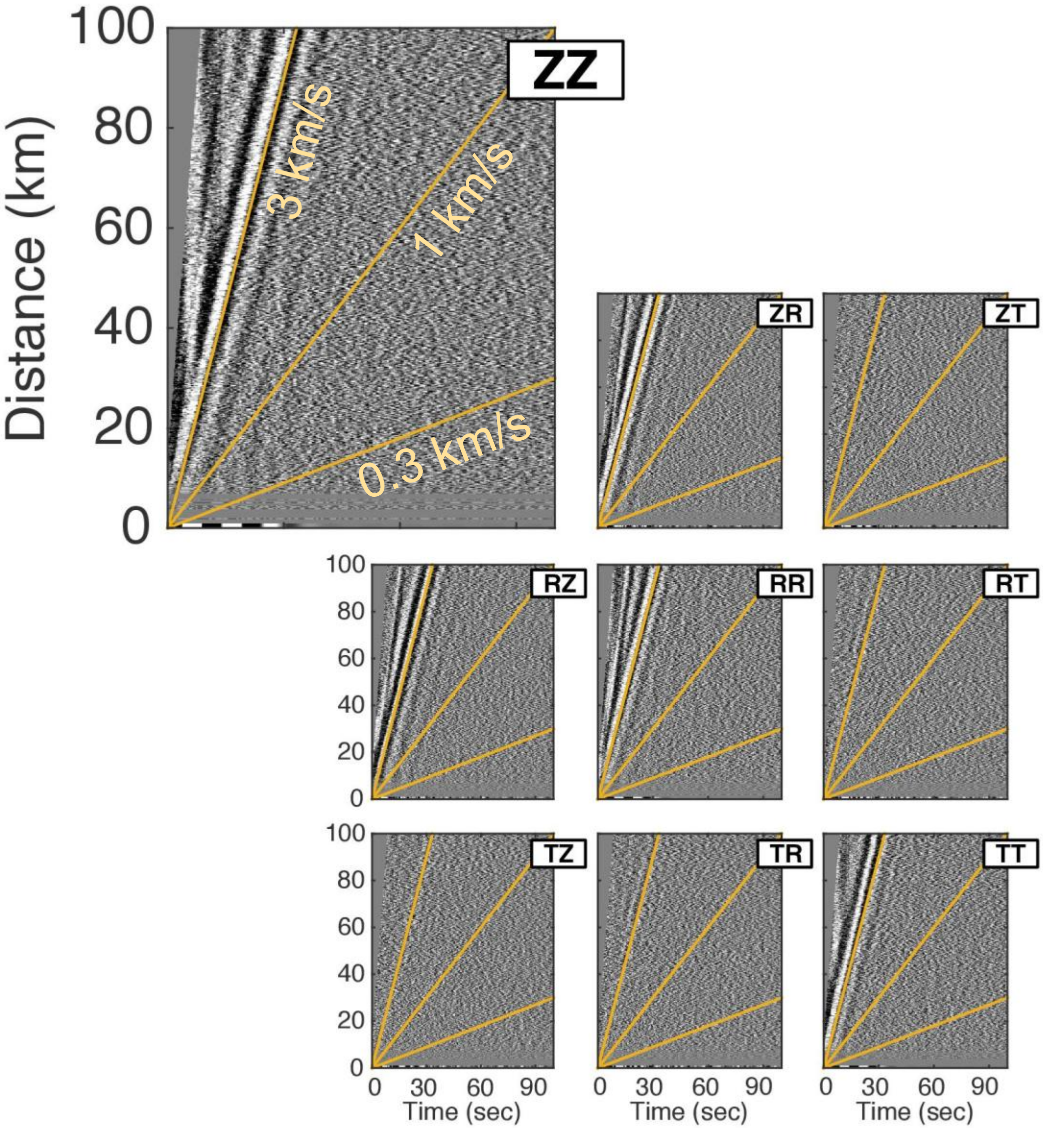
- **Can we extract more than the amplification from reconstructed noise-based Green's function in such heterogeneous medium?**
- Reconstruction of surface wave higher-modes?
  - Savage et al. (2013) in the Canterbury region (NZ)
  - Rivet et al. (2015) in the valley of Mexico
- Complex dispersion pattern?
- Basin edge effects?

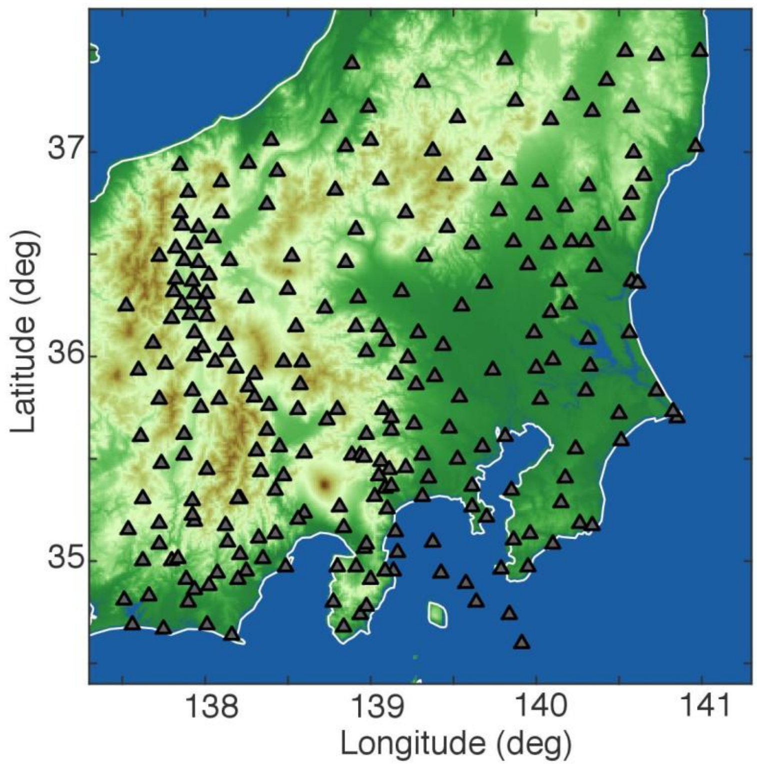
From Ambient Noise and/or Interferometry



Denolle et al. (2014)
Amplification in the basin as a function of basin depth (**<u>Long period</u>**)

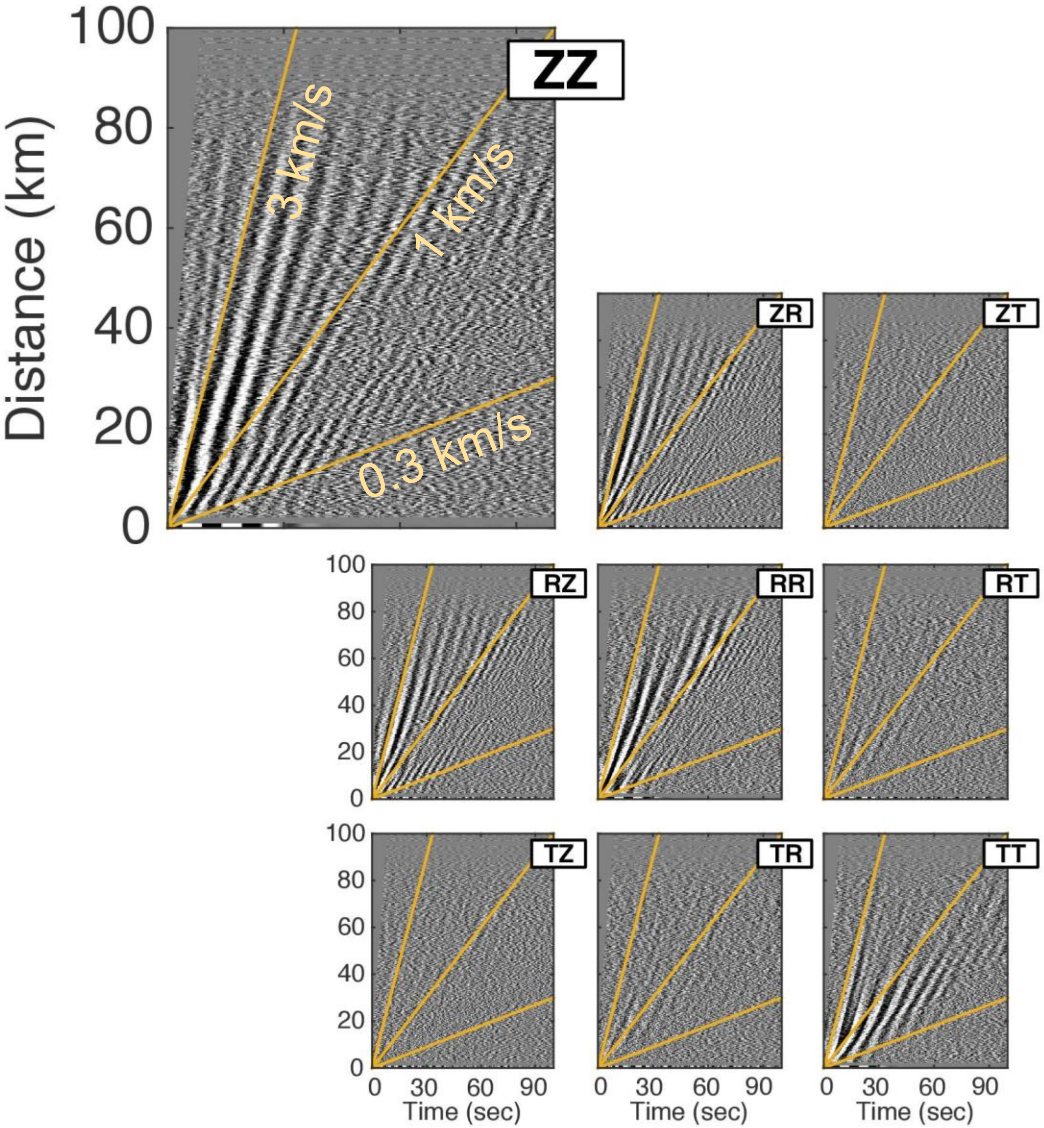
Averaged Correlation Tensor
Hi-net Only

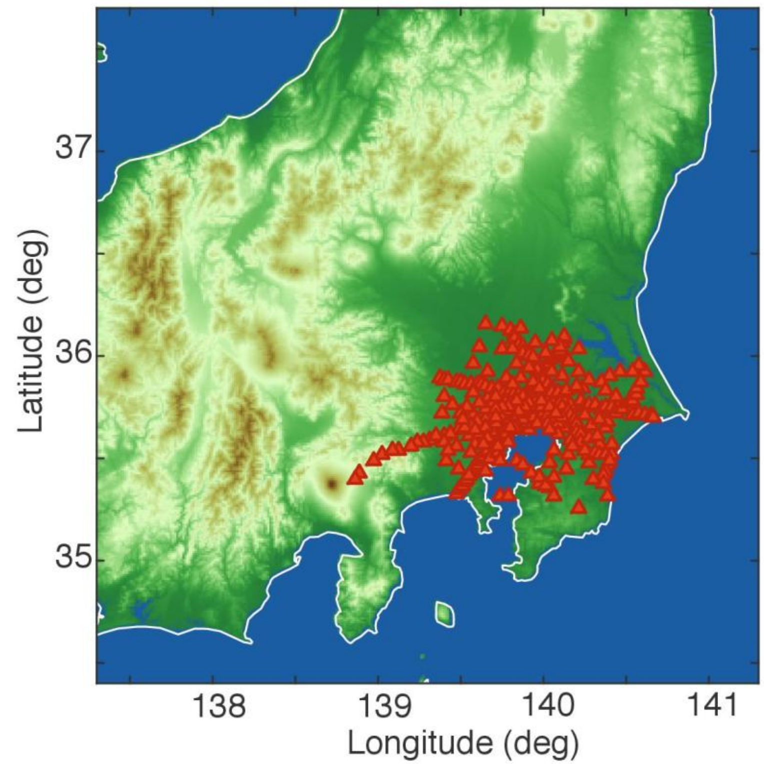




- **Filter [1,10]s**
- **Rayleigh wave (ZZ,RR,ZR,RZ)**
- **Love wave (TT)**
- **Low dispersion (~3 km/s)**

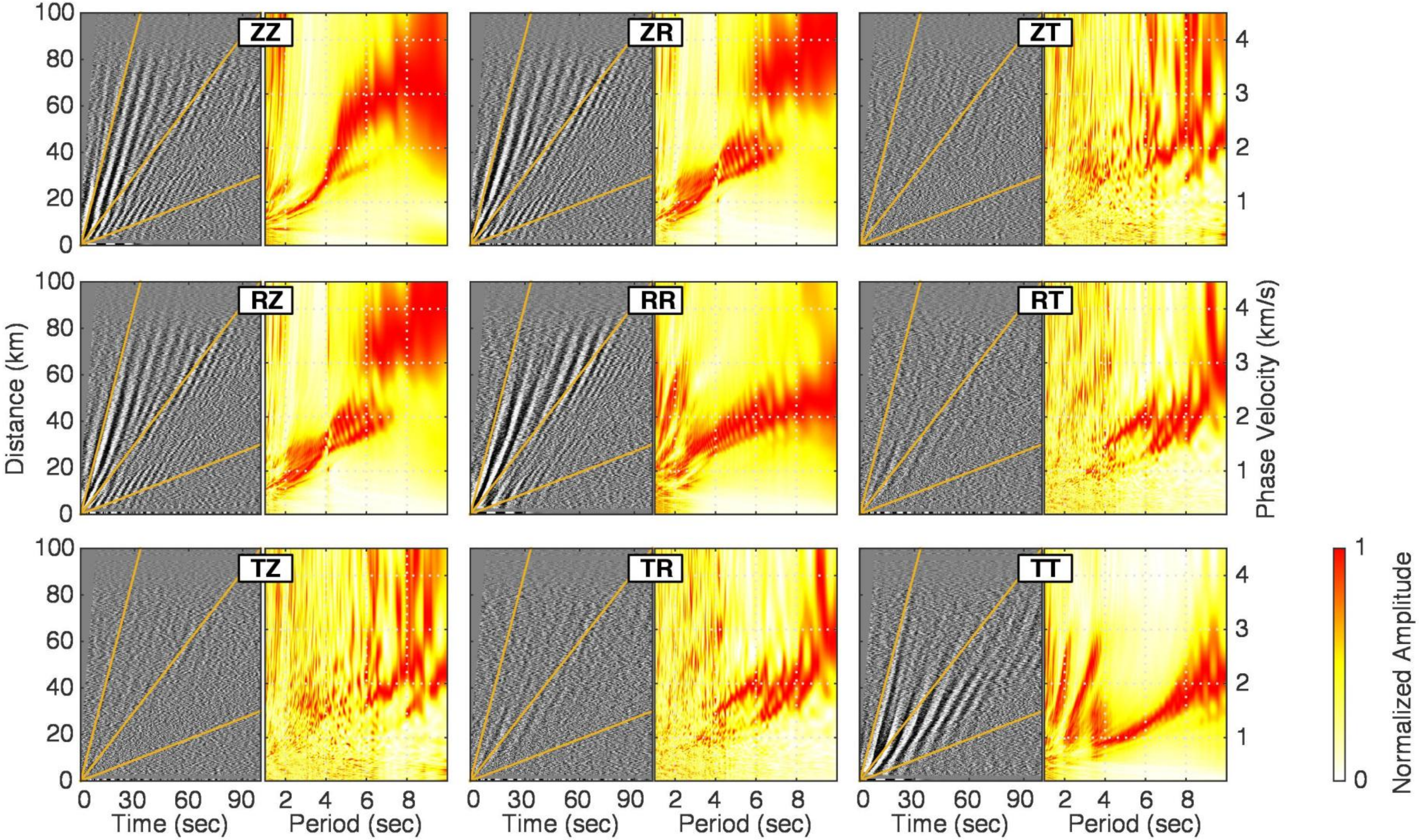
Averaged Correlation Tensor MeSO-net Only



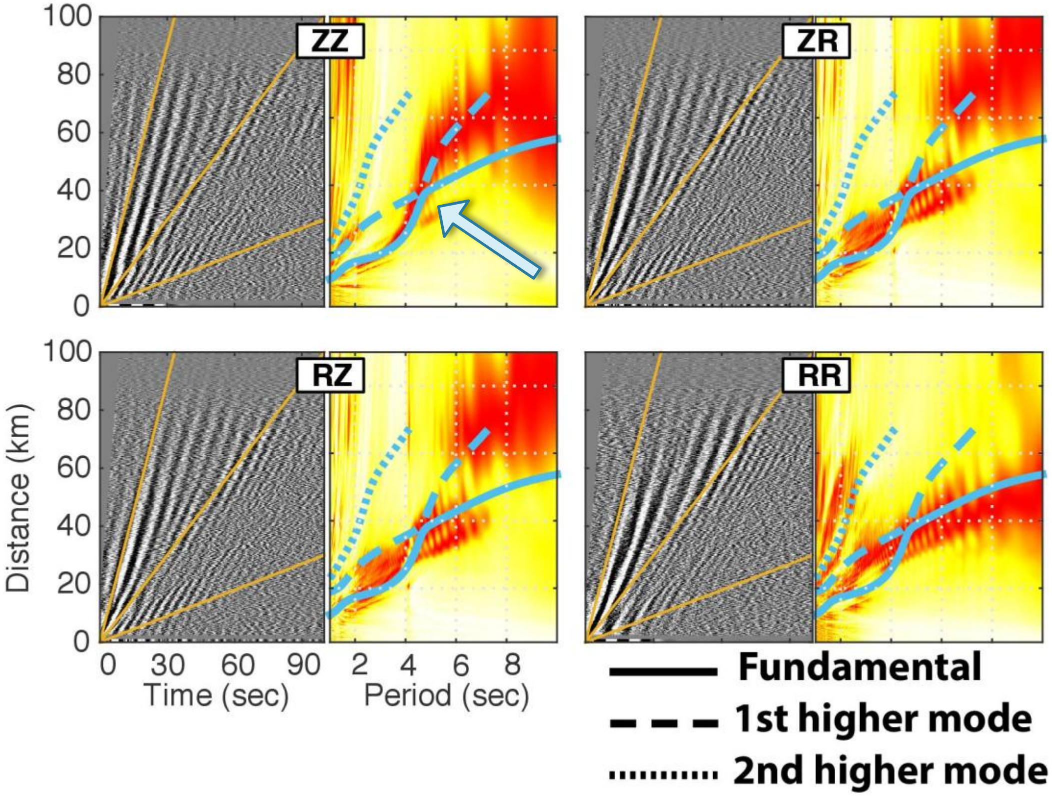


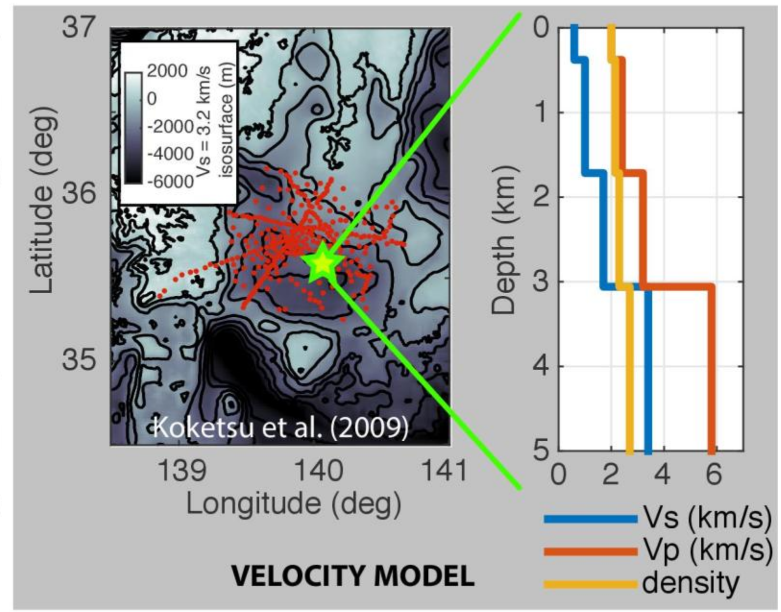
- **Filter [1,10]s**
- **Rayleigh waves (ZZ,RR,ZR,RZ)**
- **Love waves (TT)**
- **Strong dispersion between 300 m/s and ~3 km/s**

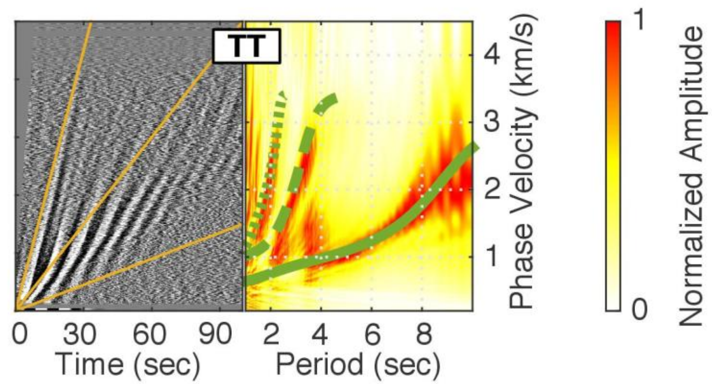
Averaged Correlation Tensor Observed Dispersion



Averaged Correlation Tensor Theoretical Dispersion

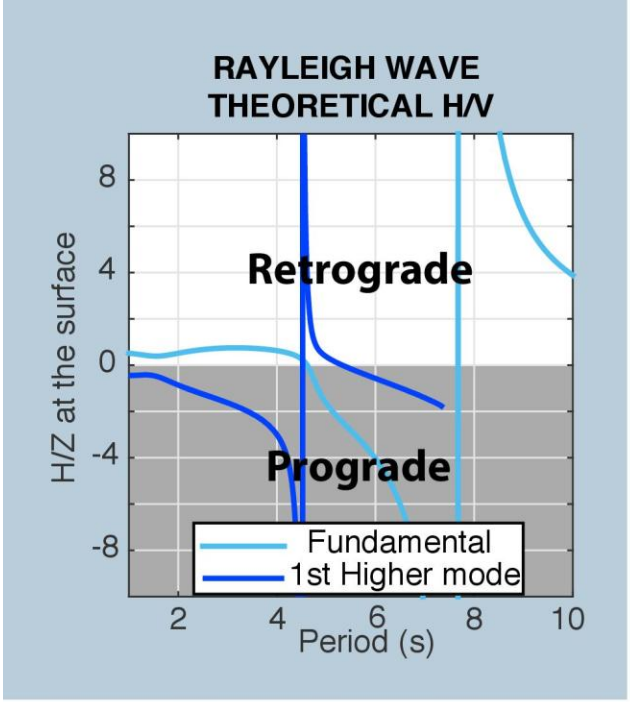






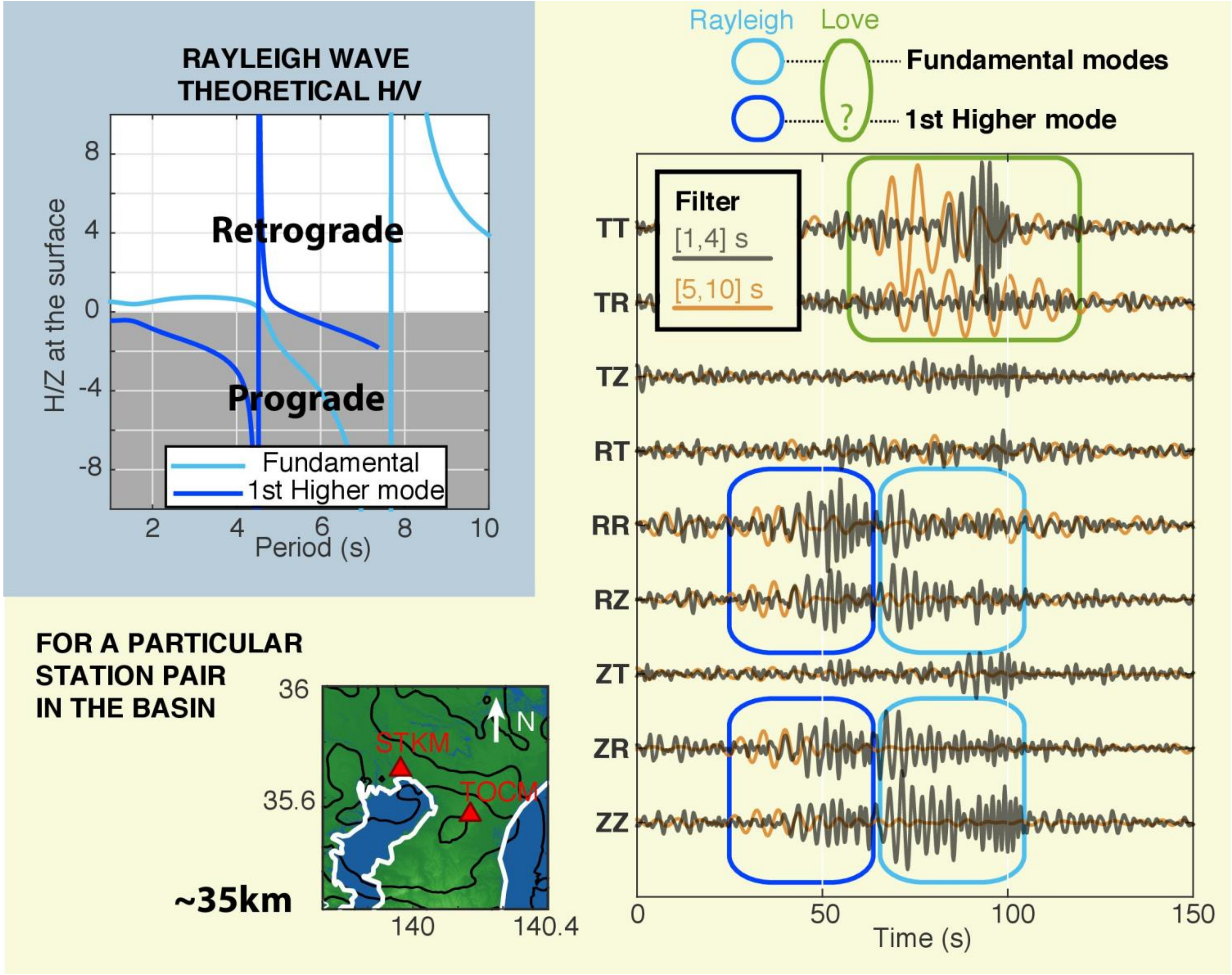
- Rayleigh waves
  - Mode 0,1… and 2?
  - Osculation point at ~4.7s
- Love wave
  - First 3 modes

Particle Motion Analysis Prograde Vs Retrograde

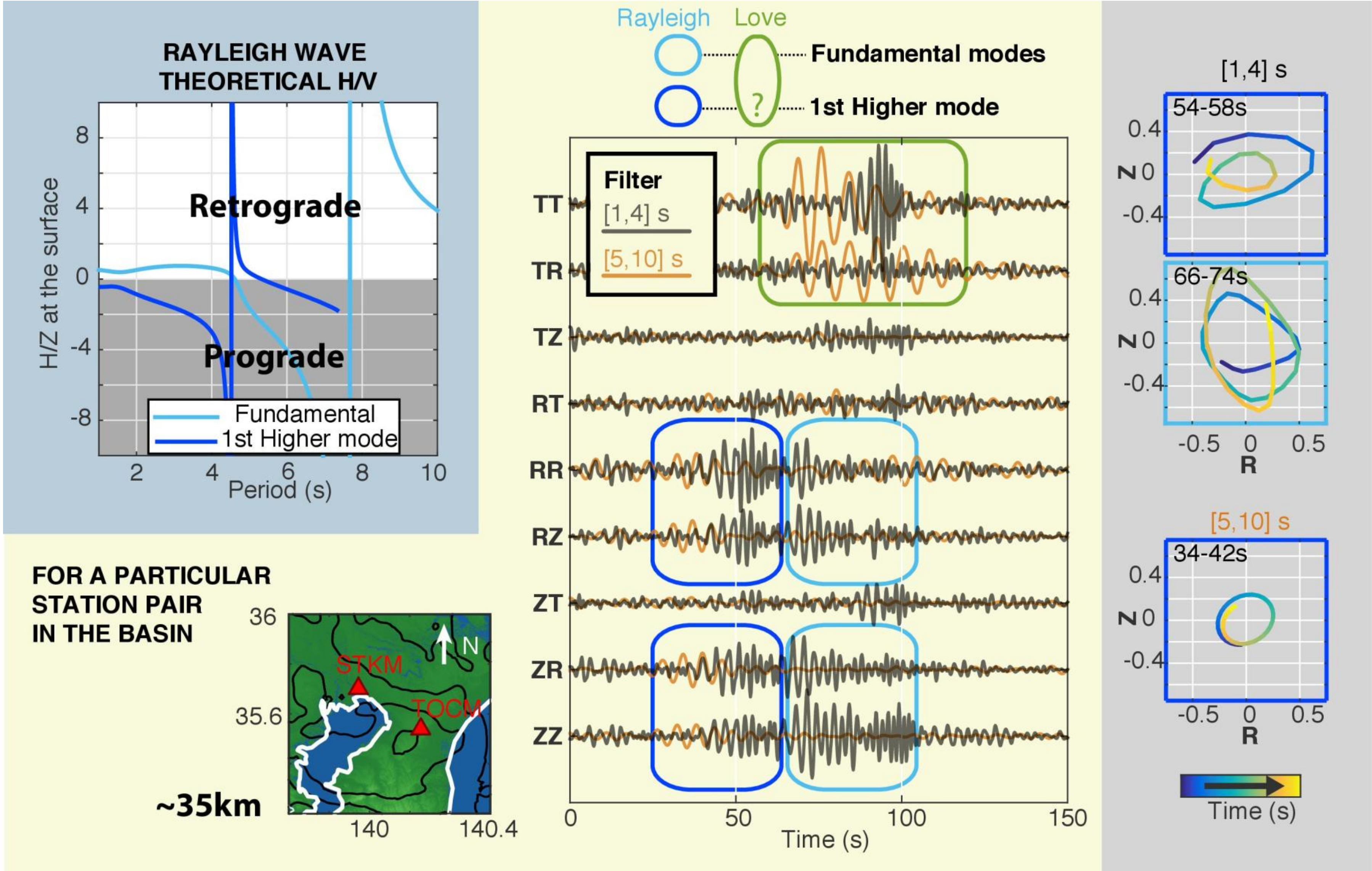


- **Computed from the eigenfunctions at the surface**
- **Identification of the 1st higher mode Rayleigh wave in the data?**

Particle Motion Analysis Prograde Vs Retrograde

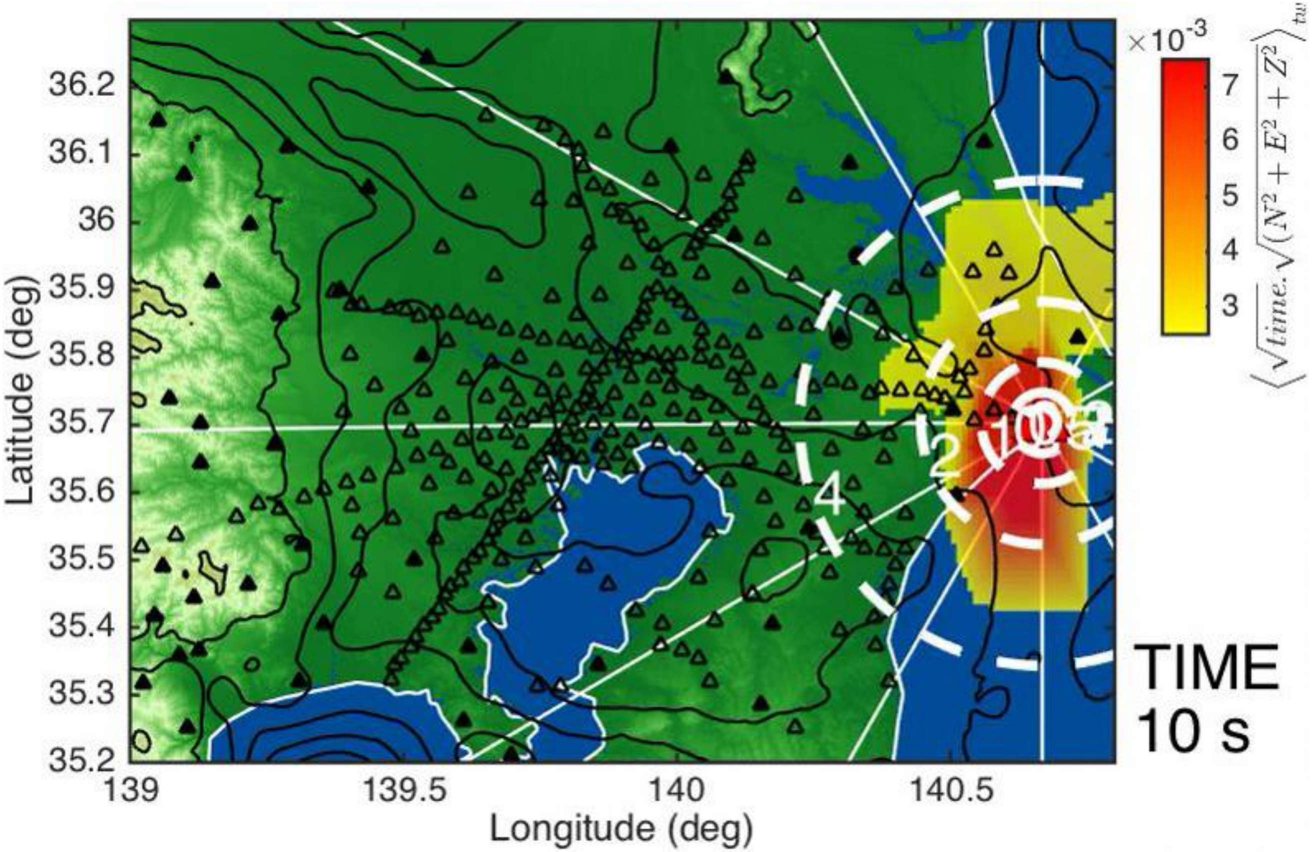


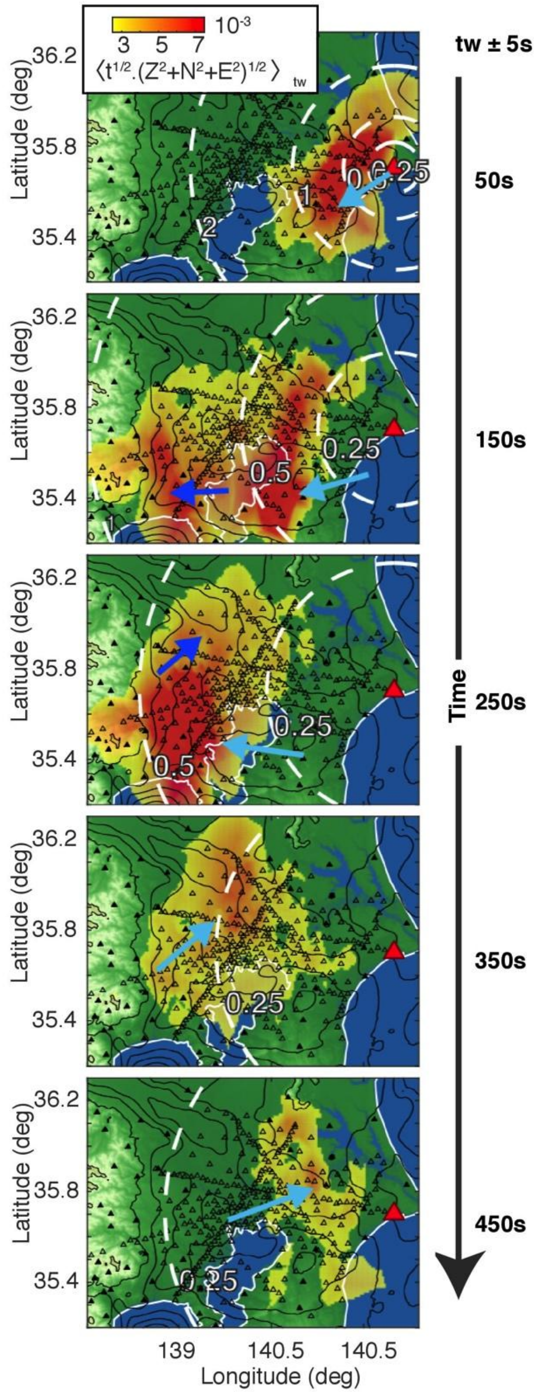
Particle Motion Analysis Prograde Vs Retrograde



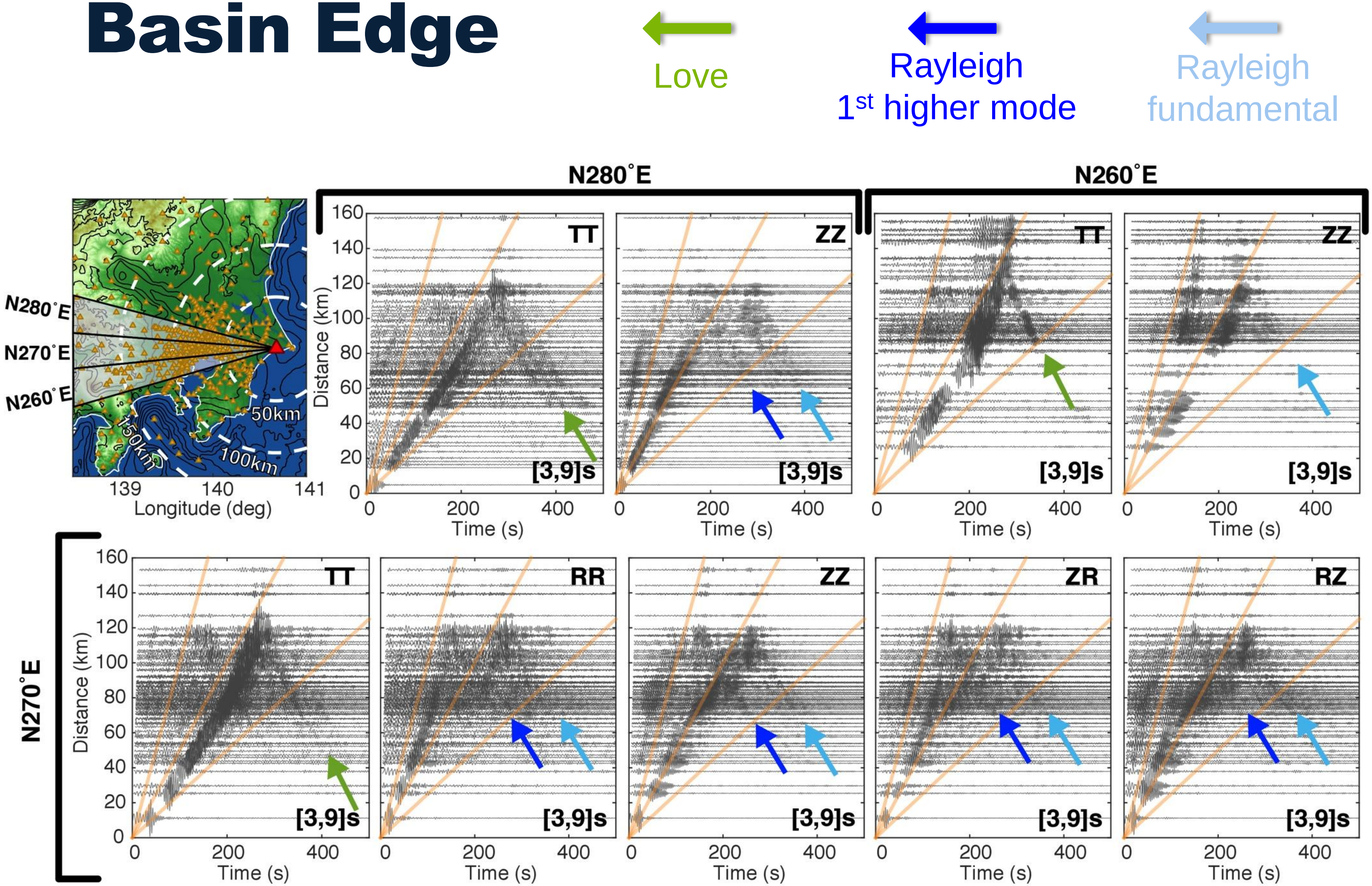
Propagation Across the Basin

- Example for a radial excitation
- Fundamental and 1st higher mode
- Bending and reflection

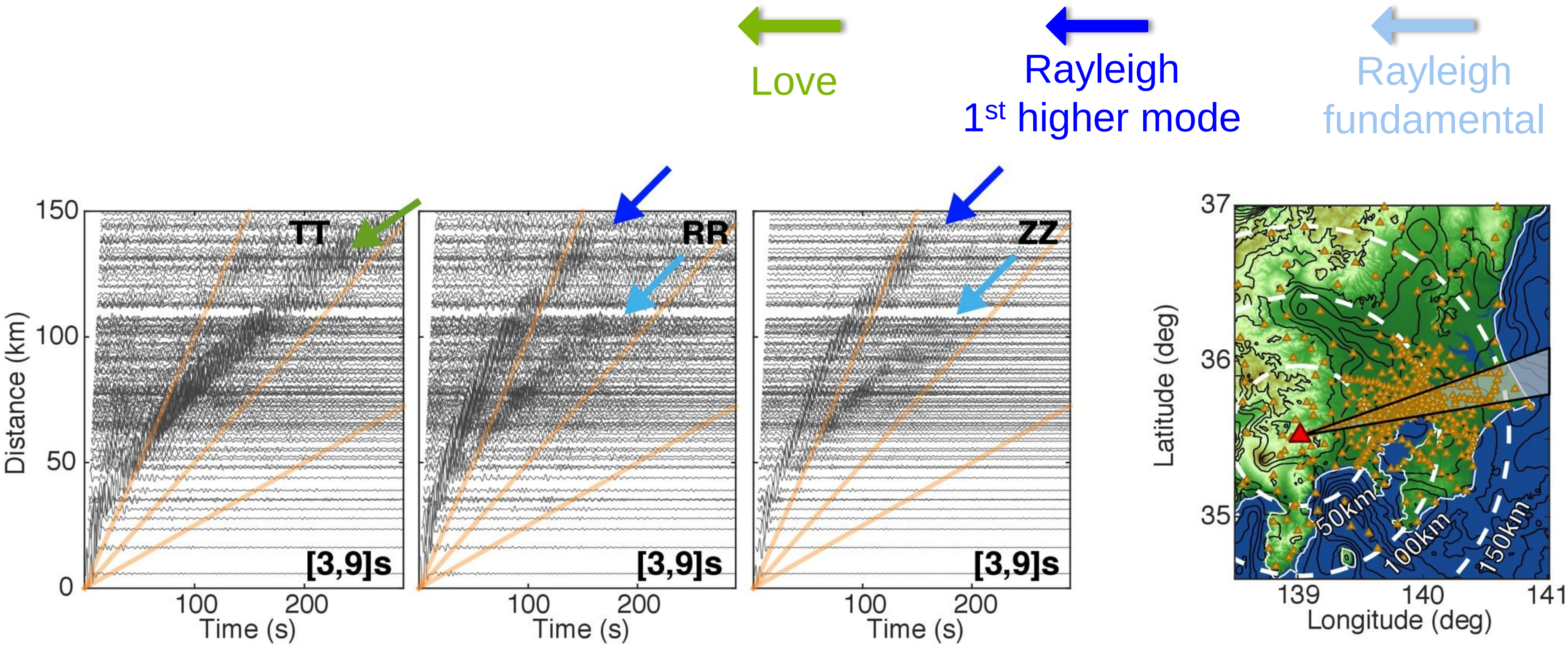




Reflected Surface Waves at the Basin Edge



Transmitted Surface Waves Inside the Basin



- **For a Virtual source outside the Basin**
- **Transmission of both Love and Rayleigh waves**
- **Excitation of the first higher-mode Rayleigh wave at the basin edge**

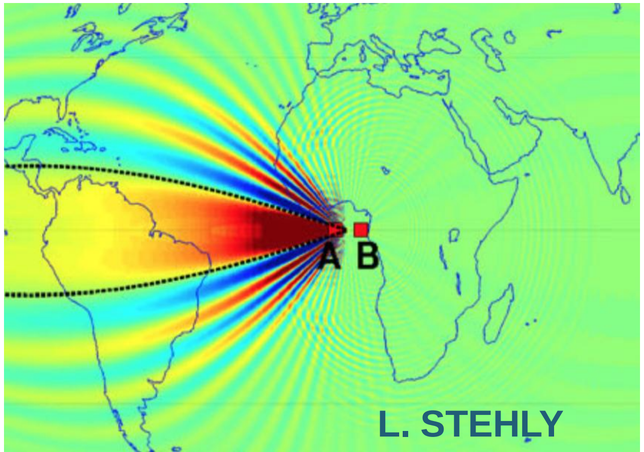
C3-like Kernels

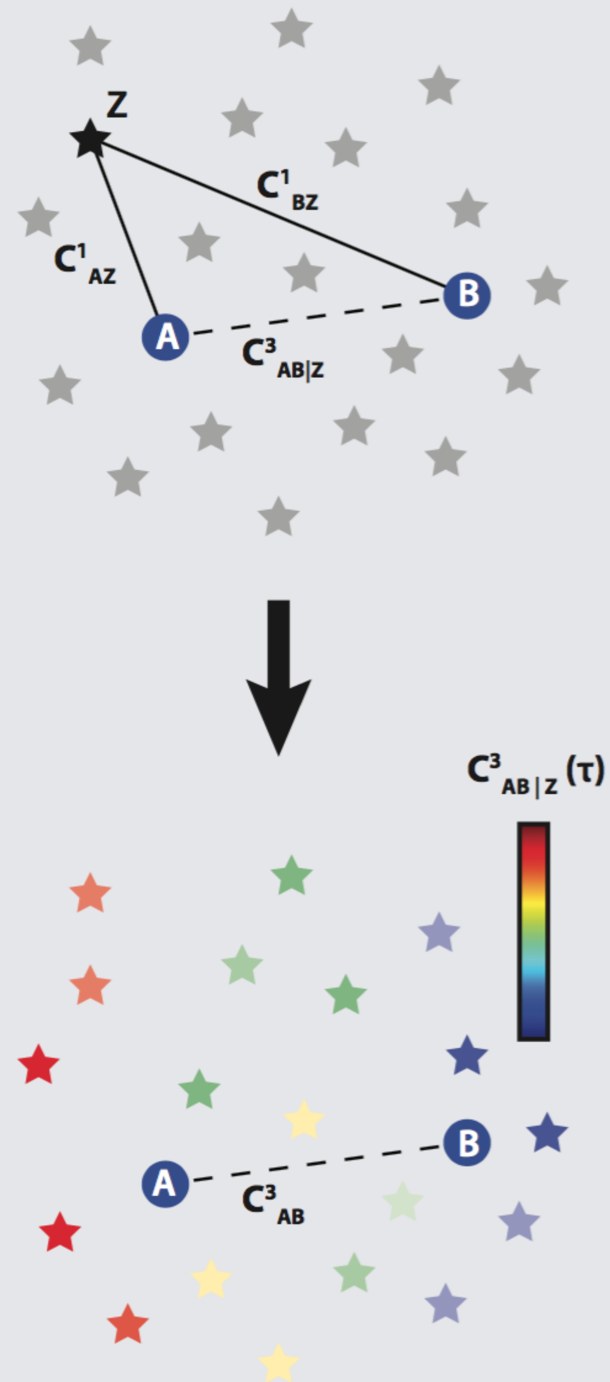
- An other way to observe the wavefield

- Recipe:
  - Two stations as receivers (A-B)
  - A backbone array as virtual sources (Z) using noise correlations (C^1)

  - Correlation of correlations (C^3-like) using <u>both ballistic and coda parts</u>

- Result:
  Map the contribution of each virtual source Z to the C^3_{AB} at a given time τ

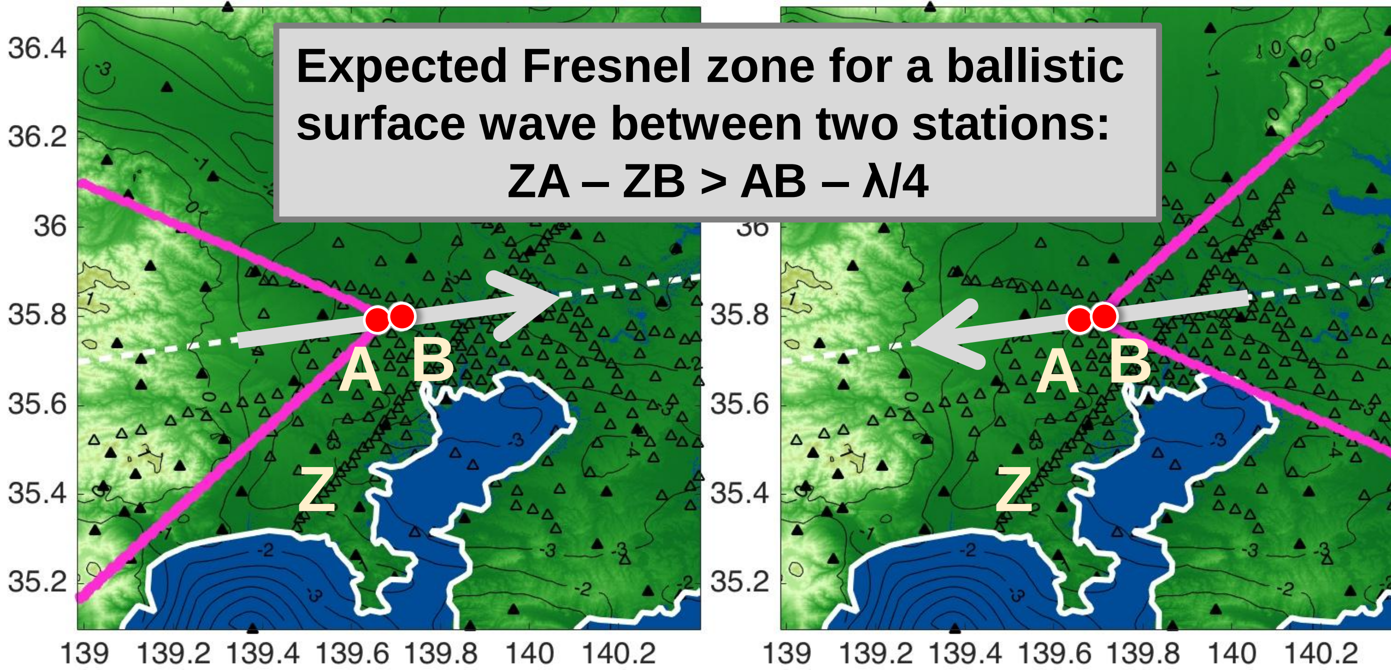


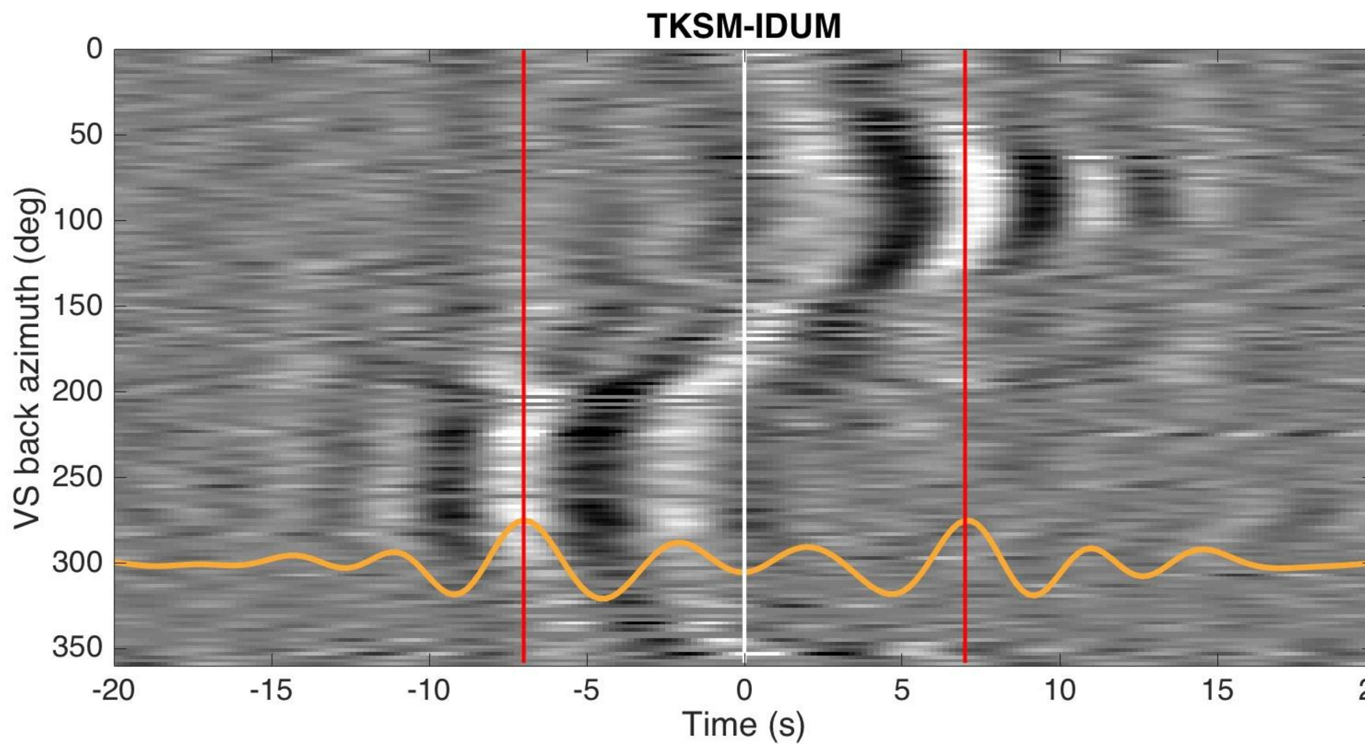


Kernel 3-9s

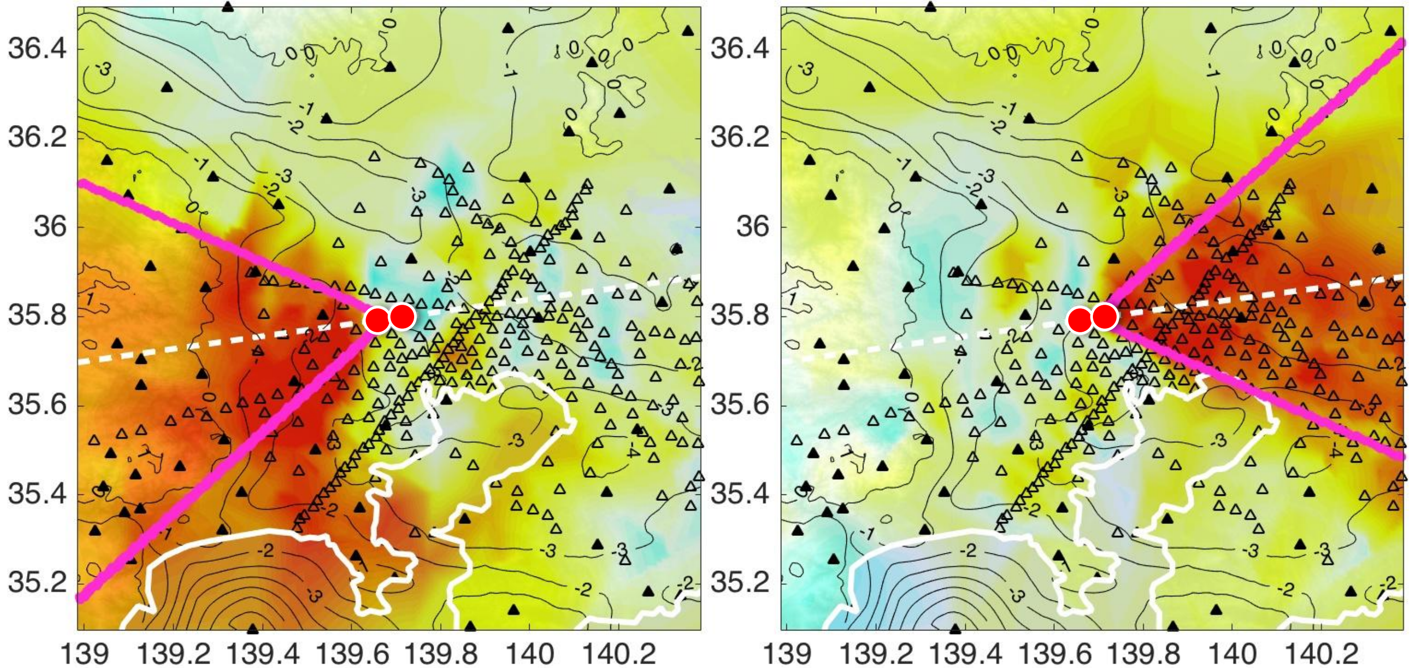
- Comparing theoretical and empirical Fresnel zones

- One C^3 for each virtual source



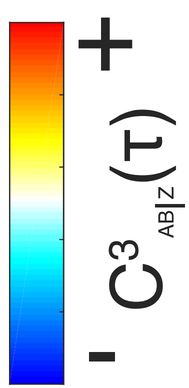


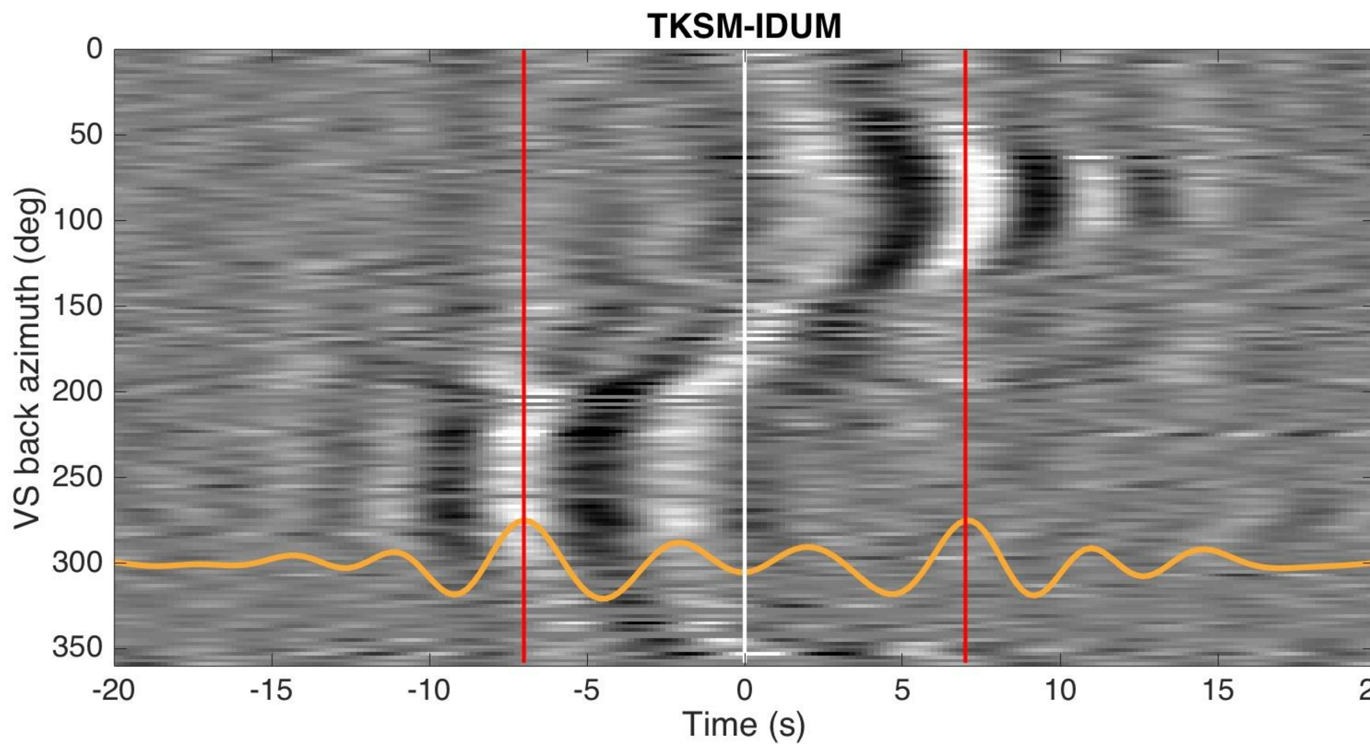
Kernel 3-9s



- Comparing theoretical and empirical Fresnel zones

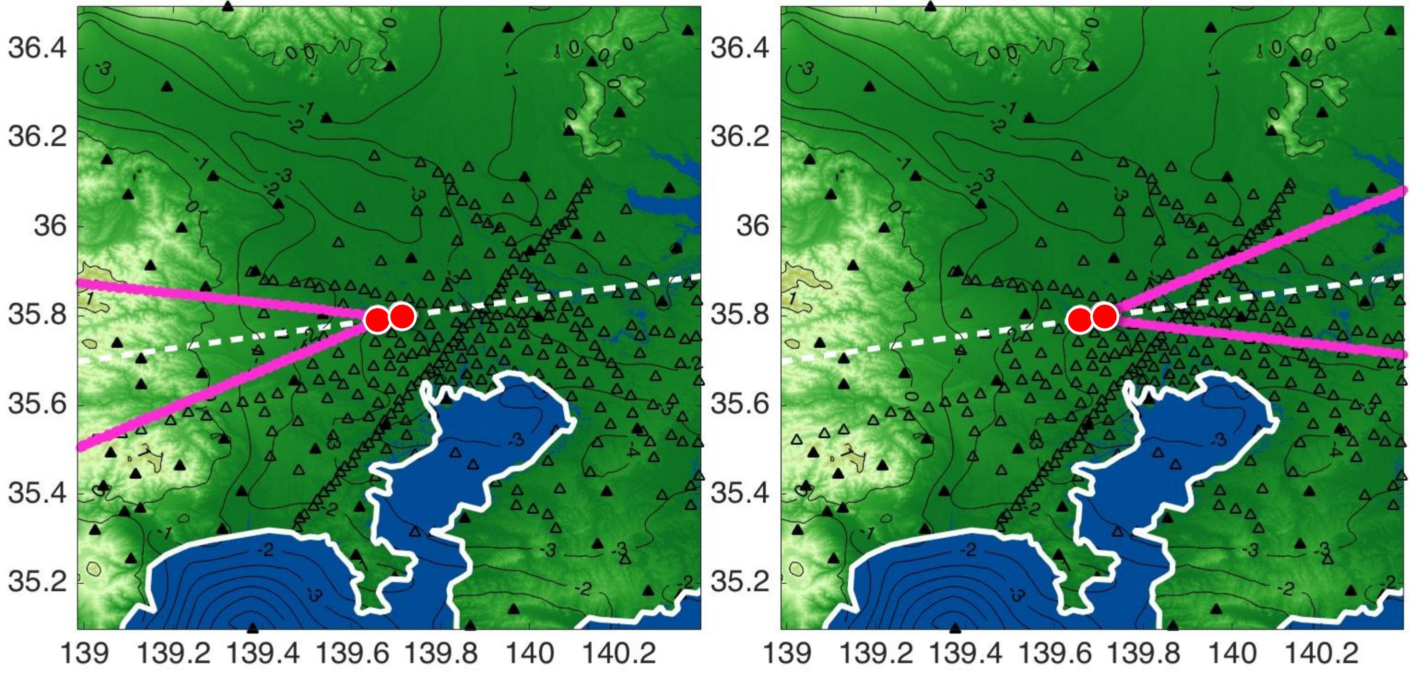
- One C^3 for each virtual source



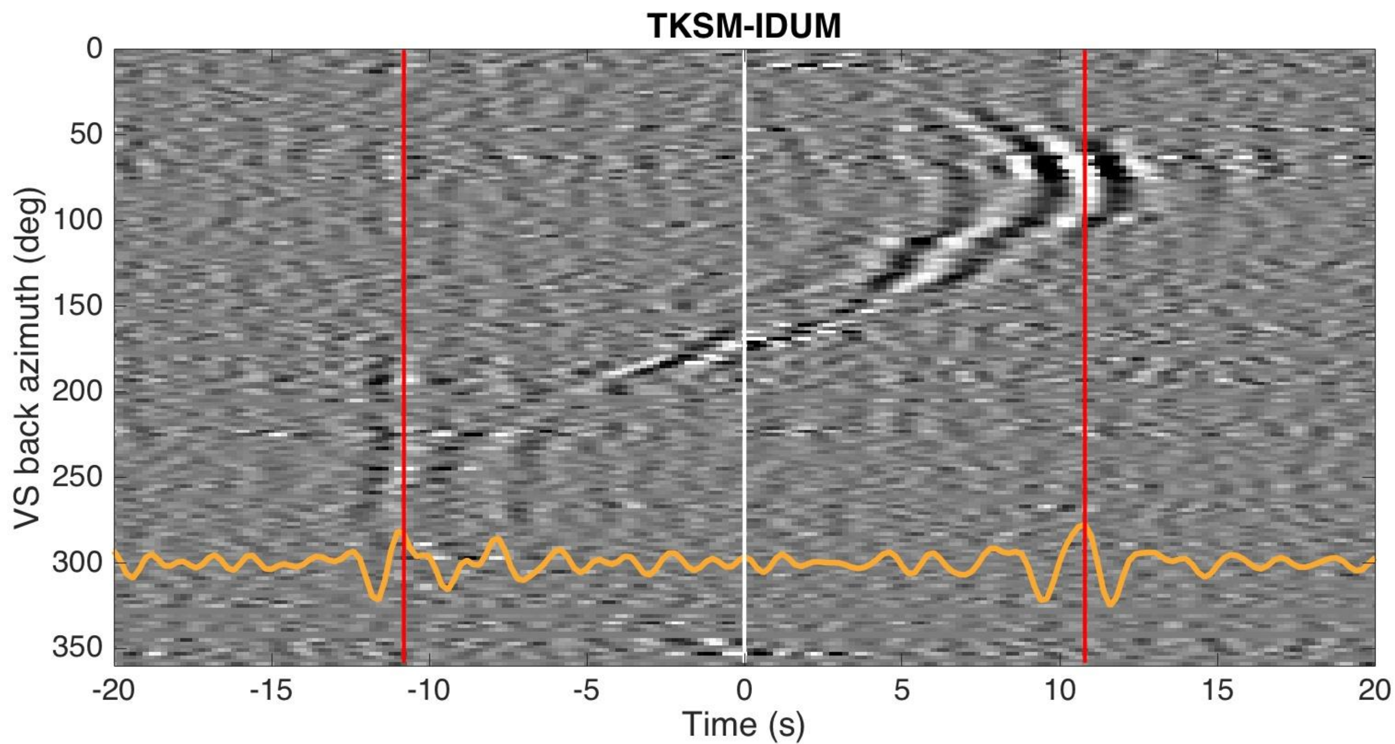


Kernel 1-3s

- Comparing theoretical and empirical Fresnel zones

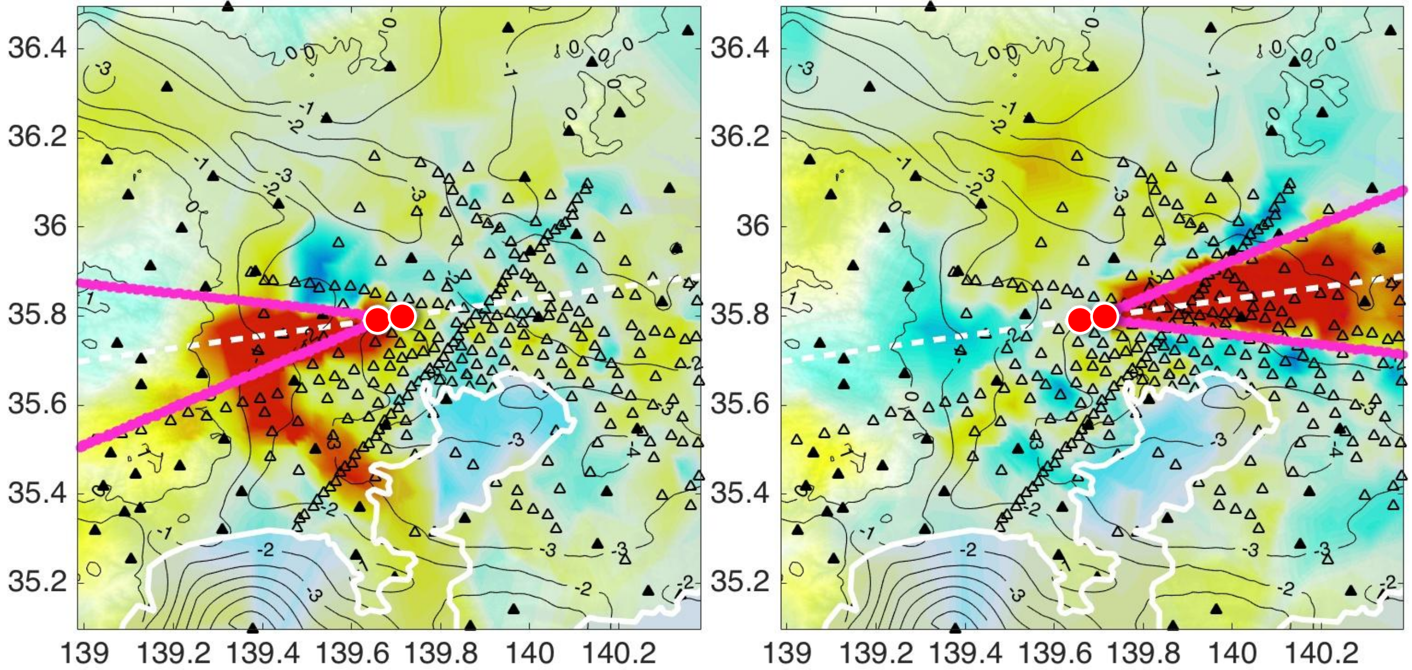


- One C^3 for each virtual source

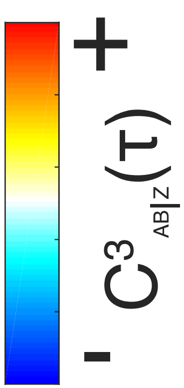


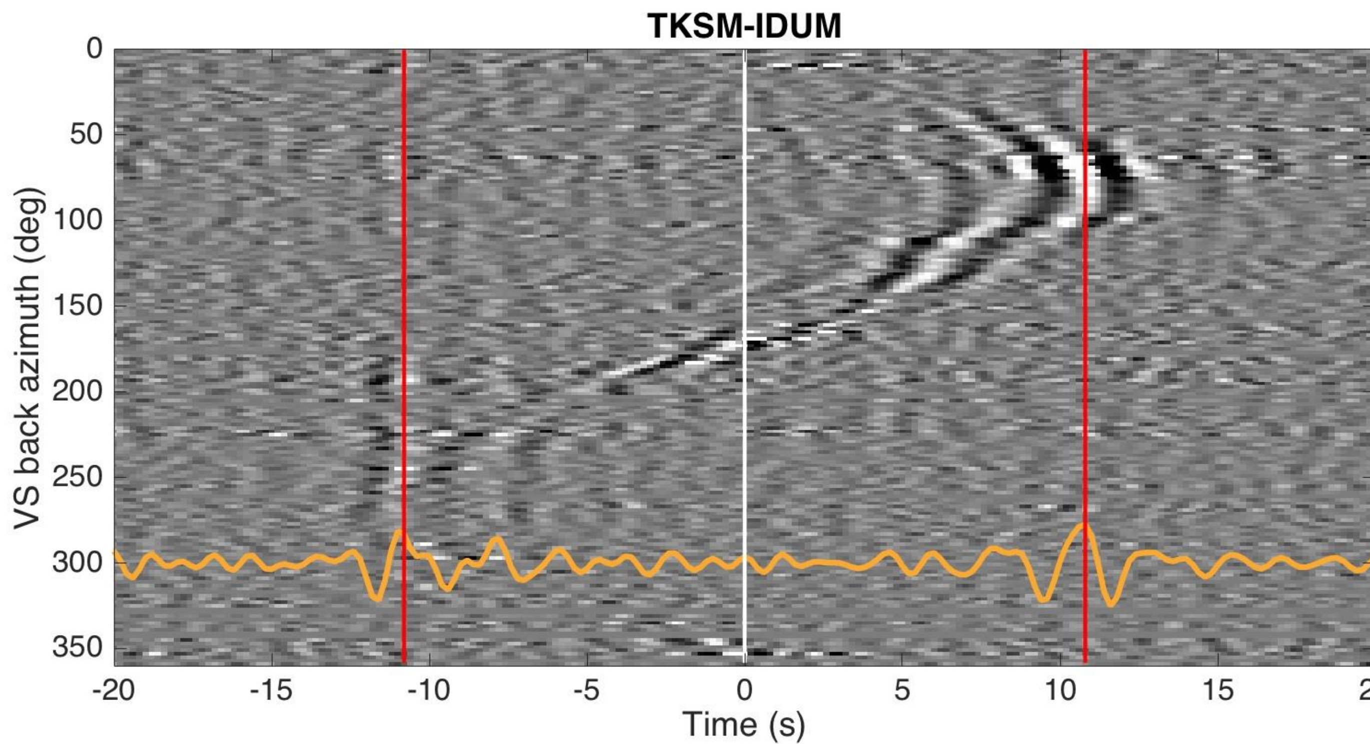
Kernel 1-3s

- Comparing theoretical and empirical Fresnel zones



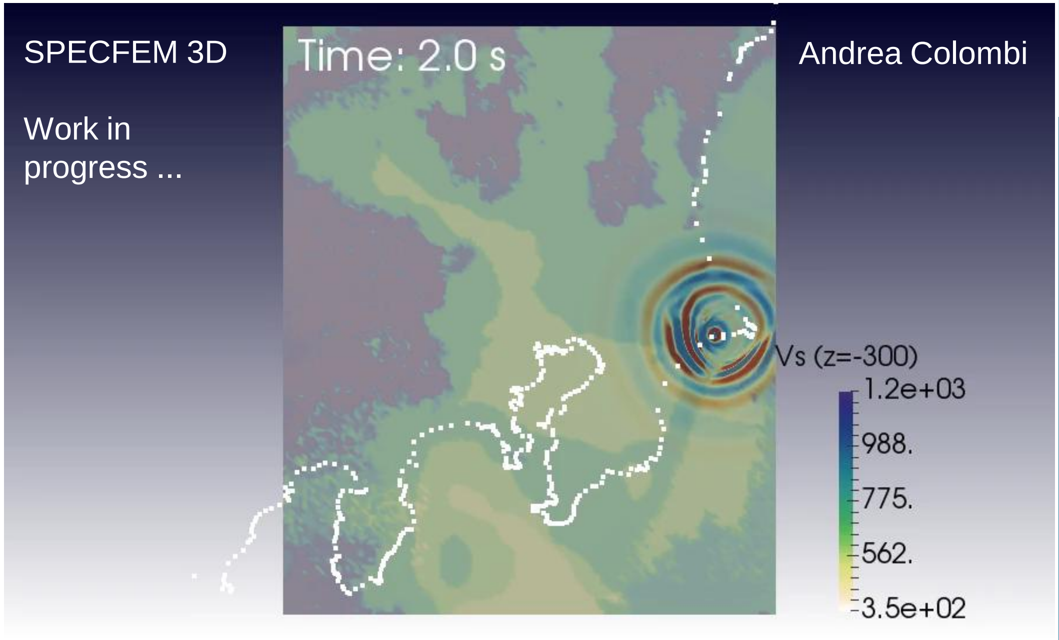
- One C^3 for each virtual source





Conclusions

- **Ambient noise correlation functions catch complex propagation features in the Kanto basin**
  - **Higher-mode surface waves following the basin shape**
  - **Reflections of surface waves (West of Tokyo)**
  - **Higher mode excitation at the basin edge**
- **It can be used both for high resolution imaging and ground motion prediction (At least up to 1s)**
  - **Ambient noise Imaging Vs. Simulation …**
  - **Migration to map the basin edge reflector …**

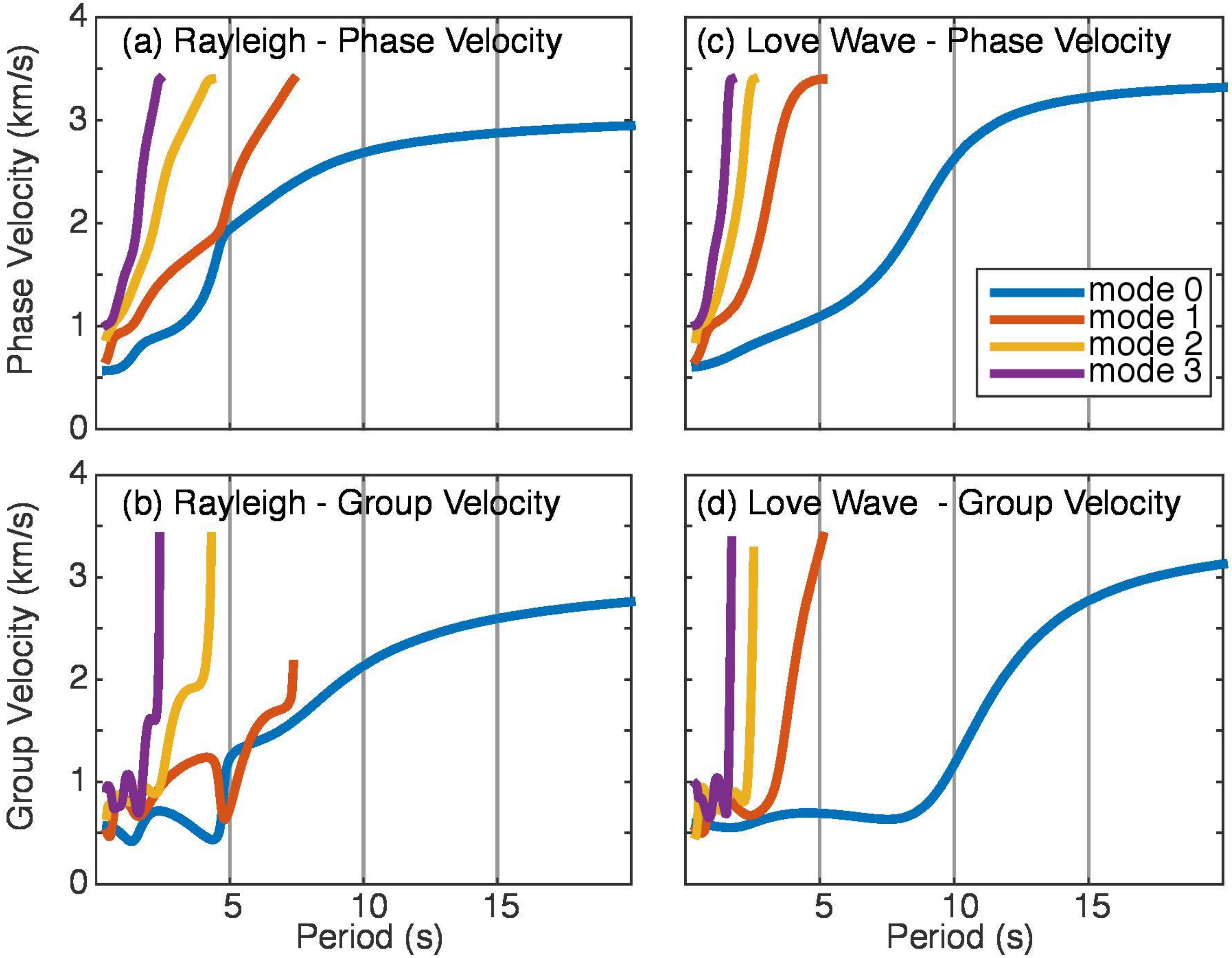


Geophysical Journal International

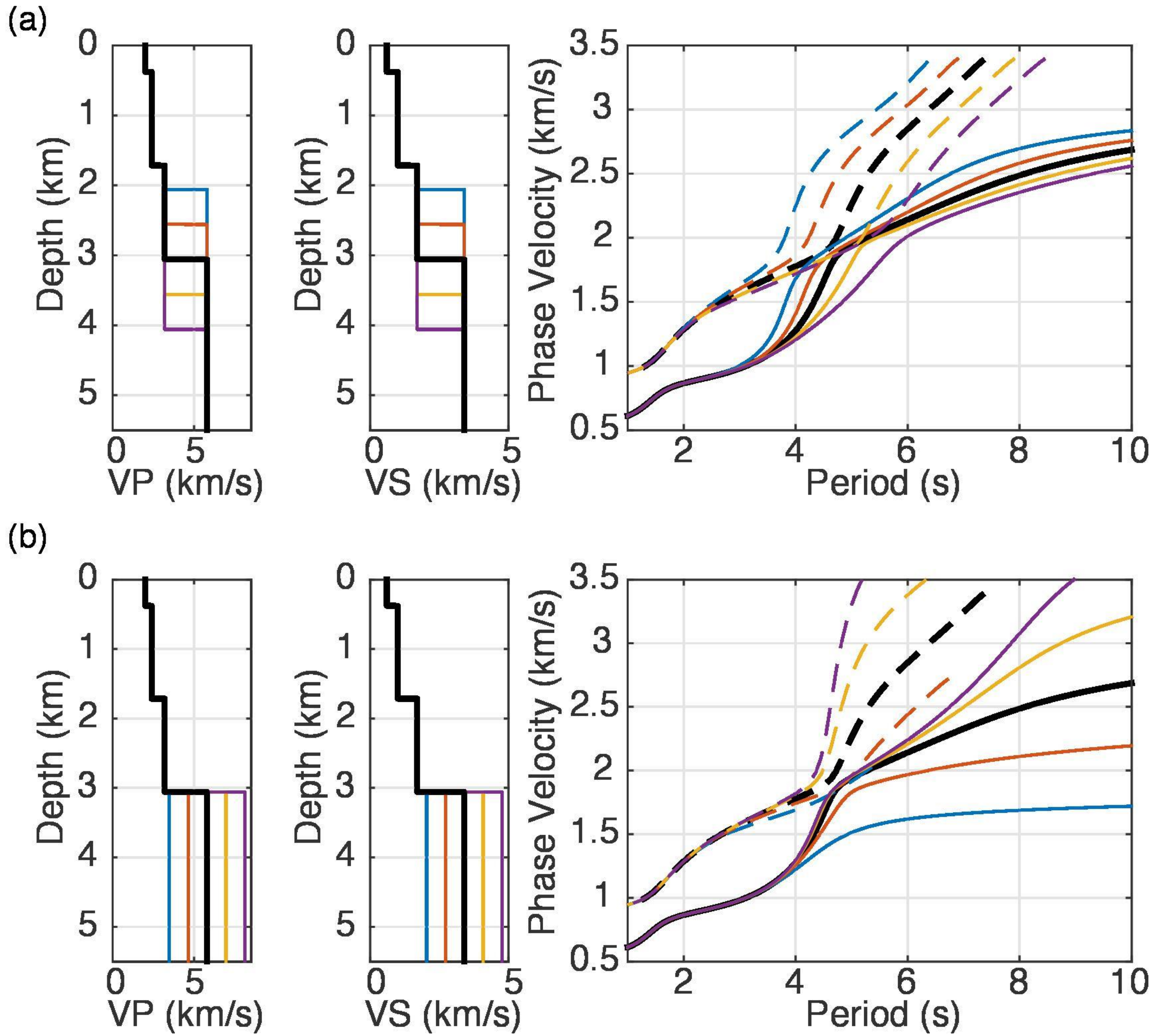
Geophys. J. Int. (2016) **206,** 1261–1272
doi: 10.1093/gji/ggw205
Advance Access publication 2016 June 6
GJI Seismology

Beyond basin resonance: characterizing wave propagation using a dense array and the ambient seismic field

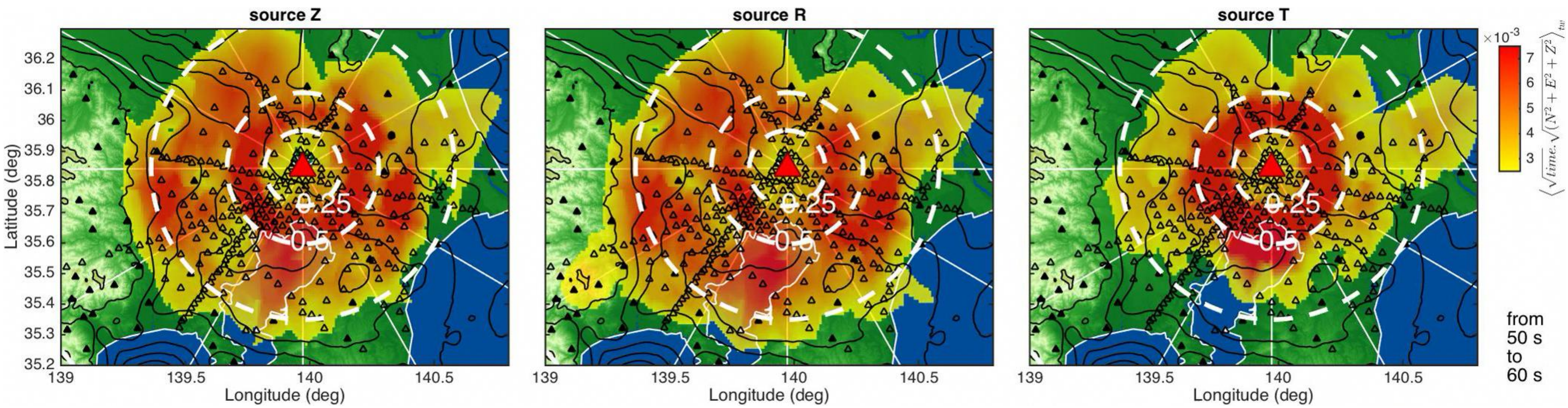
A1 - Theoretical Dispersion in the 3km Deep Basin



A2 – Osculation Point



A3 - Propagation from the Array Center



A4 - Reflected Surface Waves Inside a Caldera