Toroidal free oscillations recorded with a rotational sensor

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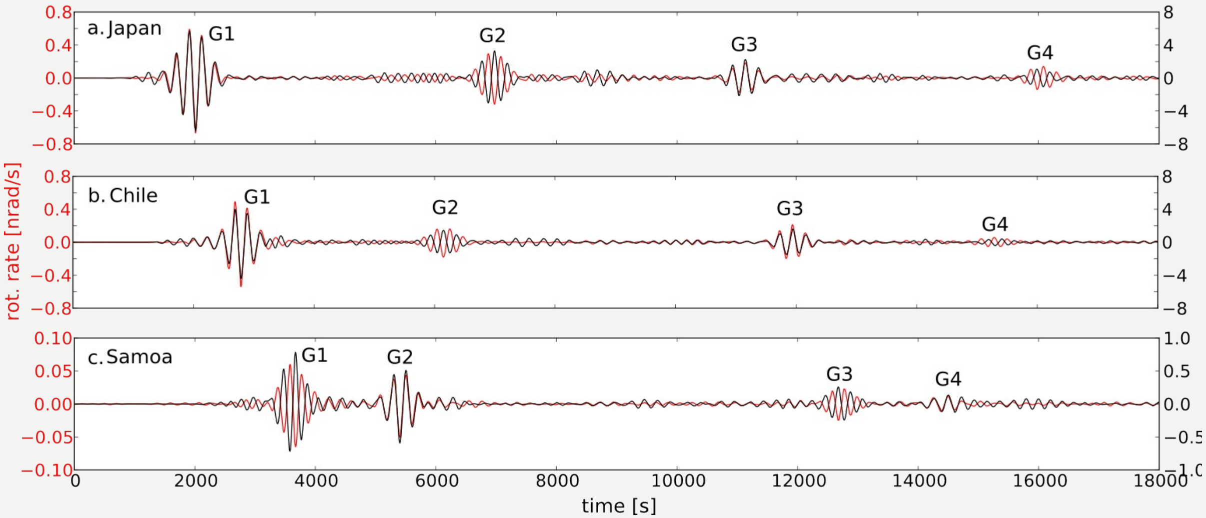
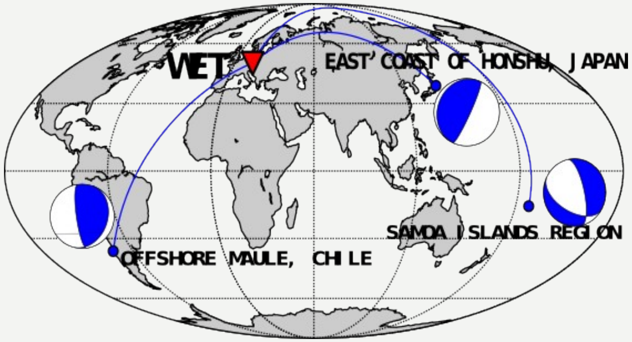
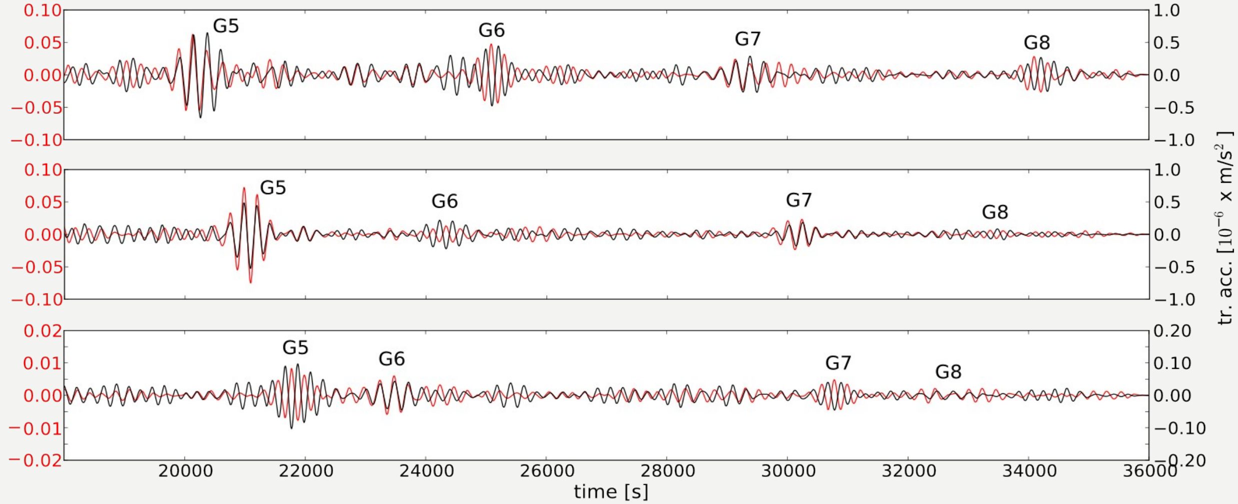
Love wave trains





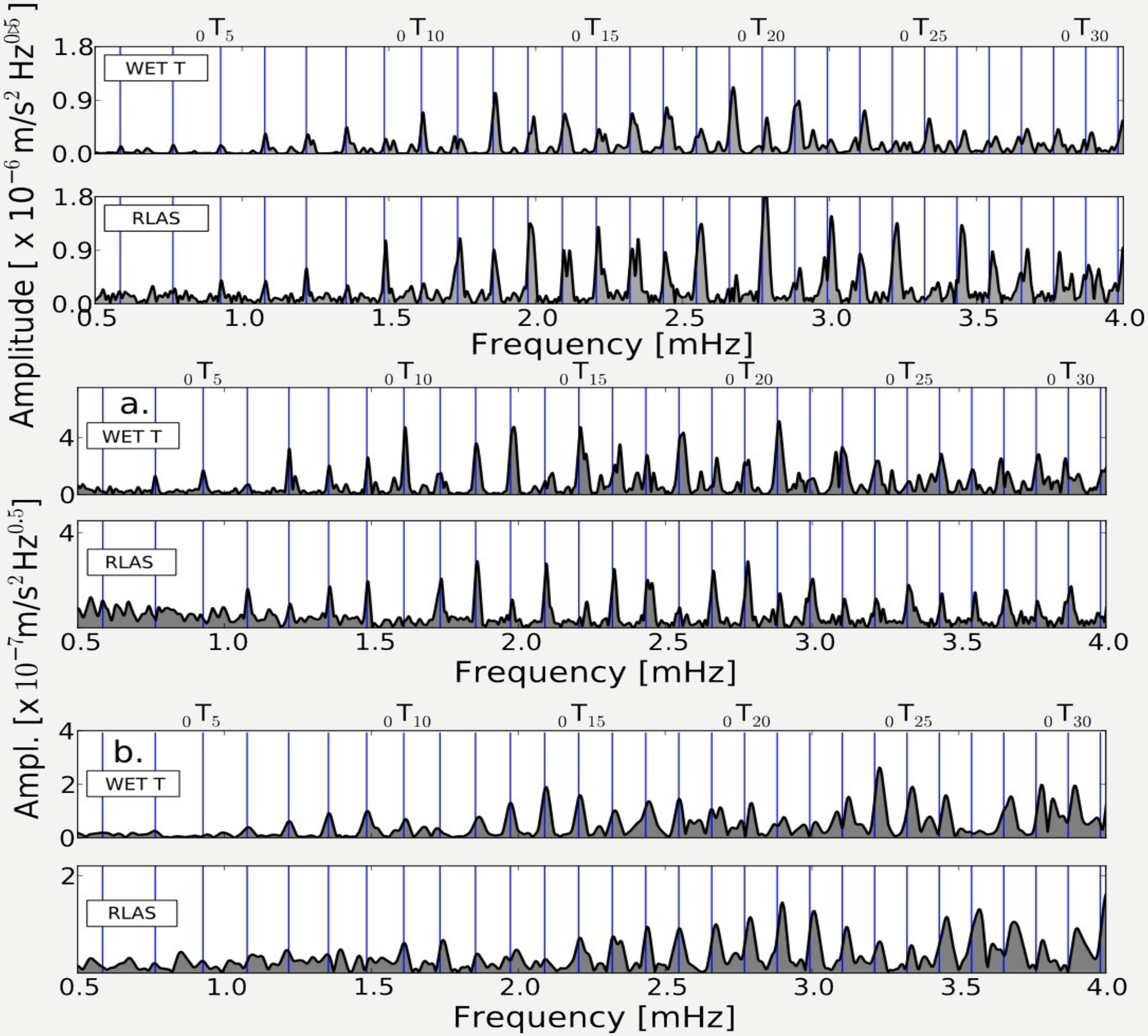


Synthetic calculations with using MINEOS

Bench Marking with HPSYNA

rotation rate – transverse acceleration

Free oscillations induced from rotational motions



Tohoku M9 (2011)

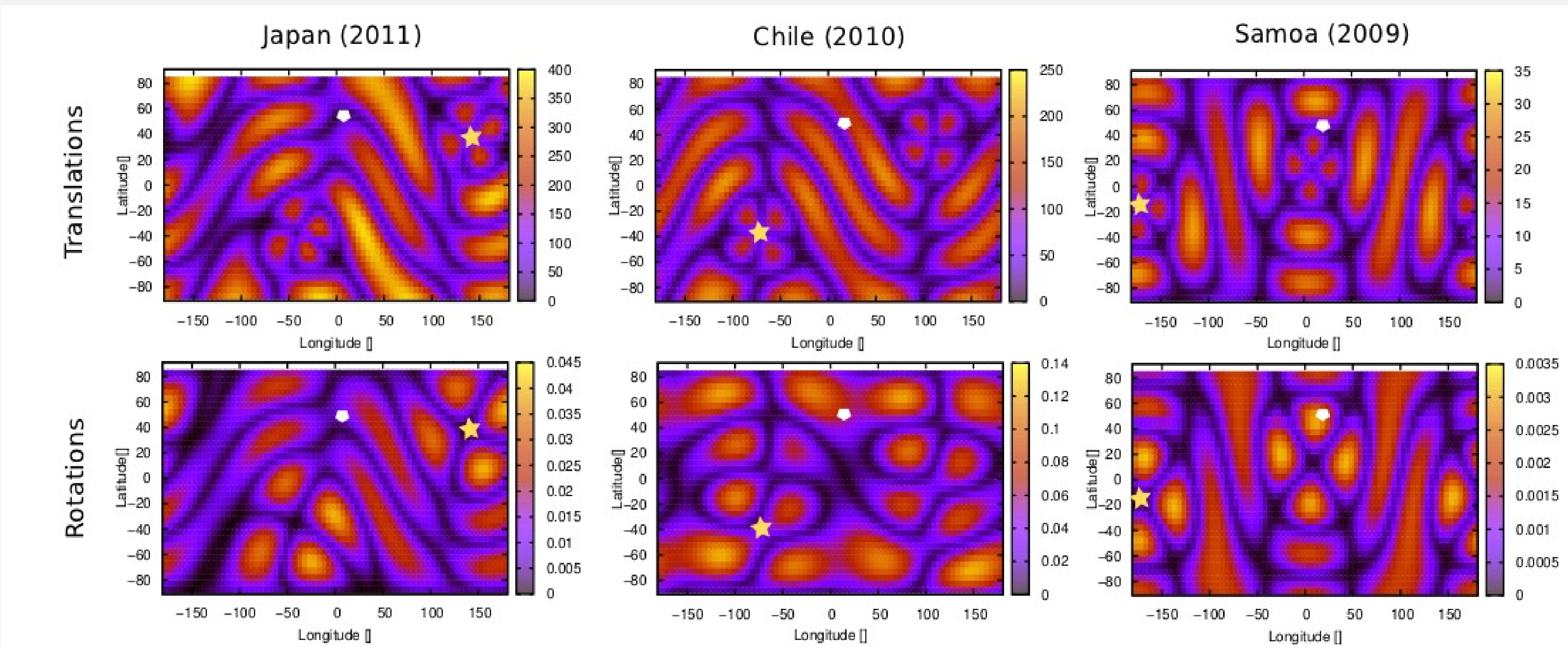
Chile M8.8 (2010)

Samoa M8.2 (2009)

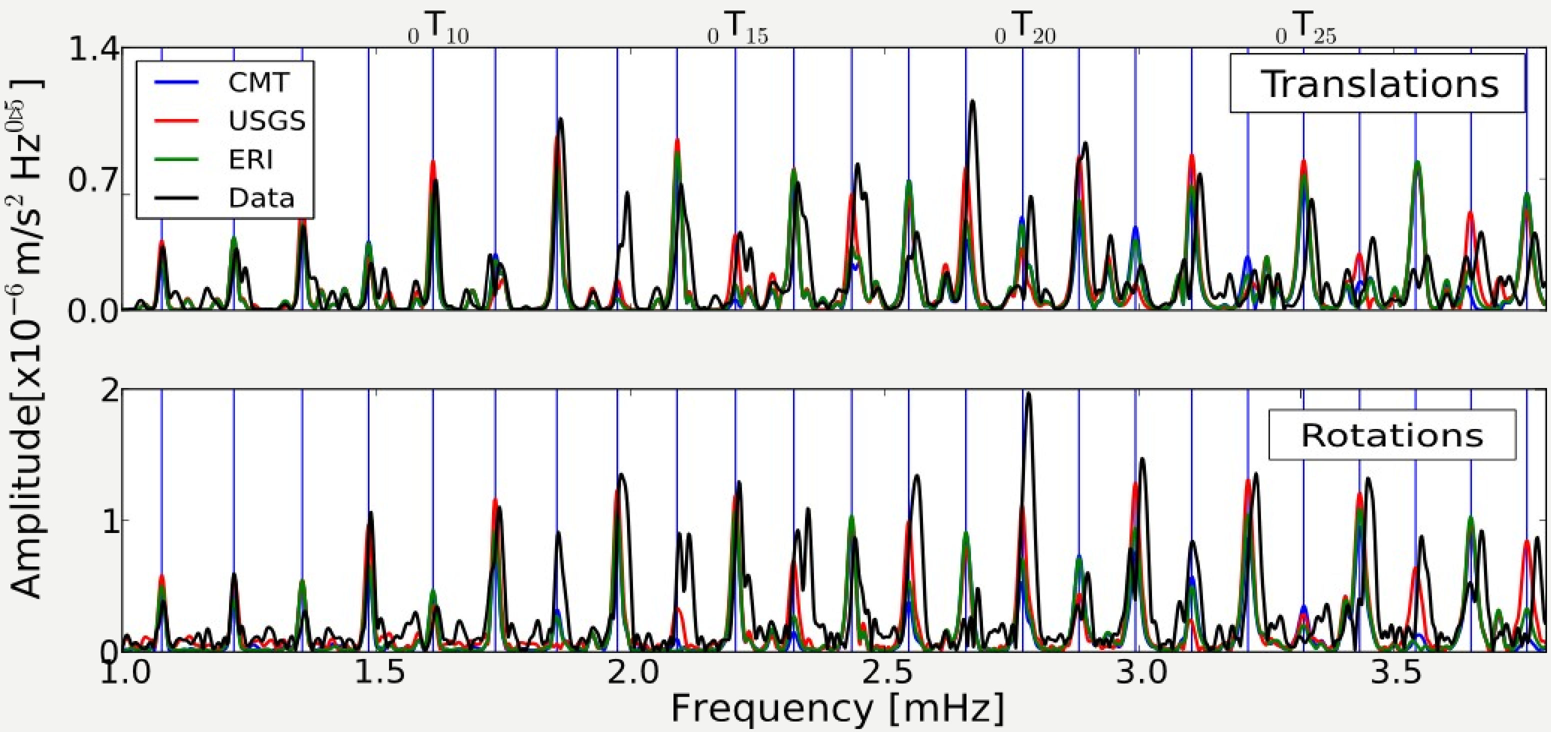
Standing waves for the Tohoku-Oki event.

$$Mode\ {}_0T_5$$

$$\nabla \times \dot{u}\left(x, \omega_l, source\right) \qquad \ddot{u}\left(x, \omega_l, source\right)$$



Source parameters sensitivity



- The misfit is similar for all the source inversion parameters

(~35% for f<1.75 , ~ 60% f>1.75 mHz)

- Same observations hold for the rotational component with similar misfit values

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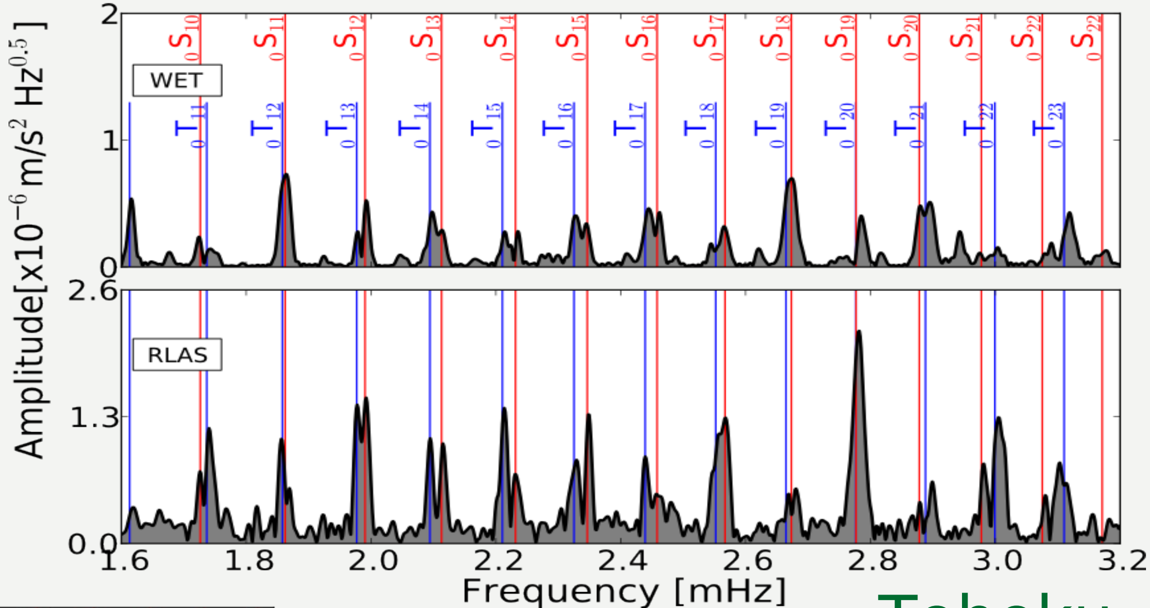
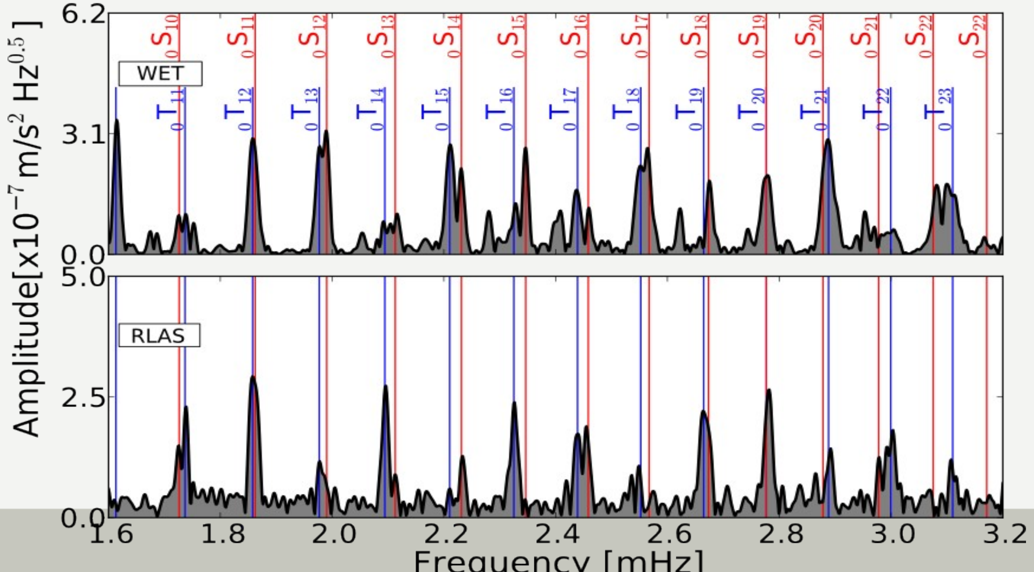
Spheroidal modes in the torsional spectra?

Deviations from SNREI

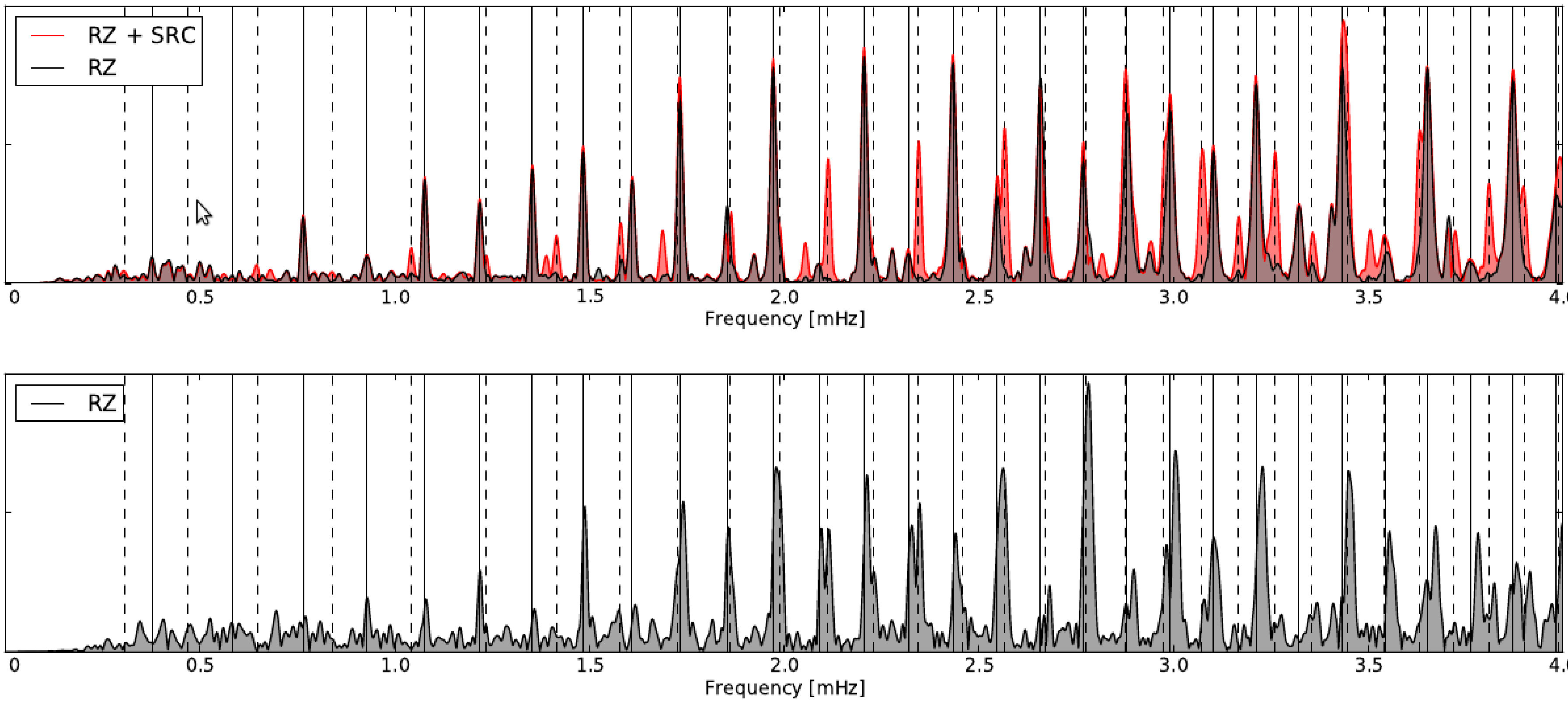


Chile

Tohoku



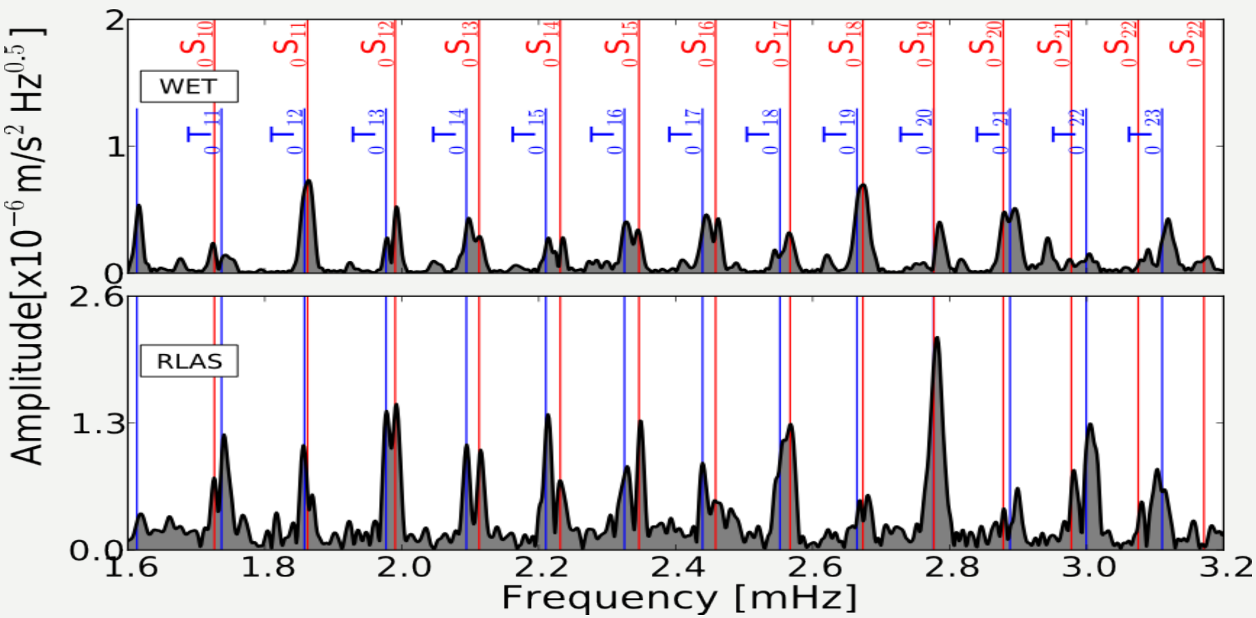
Strain-Rotation coupling



Martin

Coriolis coupling between S and T modes

Deviations from SNREI



Rotation (Coriolis)

Ellipticity

3D

- Modes are no more orthogonal
- Coupling and splitting
- eg. S modes in the horizontal component

How to do that?

Higher **O**rder **P**erturbations **T**heory (HOPT)

Éric Clévéde, Philippe Lognonné

- Alows synthetic seismograms with a wide variety of 3D earth models, The perturbation starts frorm an anelastic non rotating earth.

- The spectrum of an anelastic , dispersive and rotating earth does not depend on the direction of rotation.
-
- Compute the interaction matrices
- Use legendre transform to compute kernels for the 3D structure
- Forbineus rule (no selection rules)
- Inherently take into account focussing and defoccusing effects

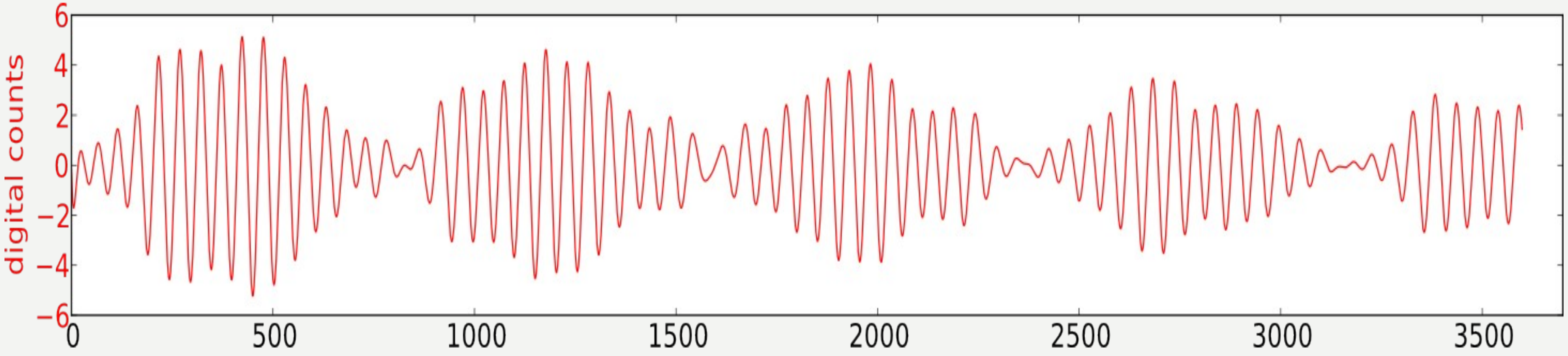
The coplping effects are strongly controled by the Q ratio of interacting modes

The plan …

- Spectra calculations from 1.6 to 3.2 mHz and comparison with data (coriolis Coupling band)
  - Taking into accoun the effects individualy to cuantify how do they affect each obserbable
- Q calculation of the coupled modes .
- Spliting comparative synthetic study.
- Evaluate the sensitivity of the obserbable to different earth models
- Extend synthetic calculations to the other components of rotations.

The first attempt …

Vertical component 10 hours siemogram including cross coupling for fundamental modes between 0 and 1.5 mHz.... to be continue

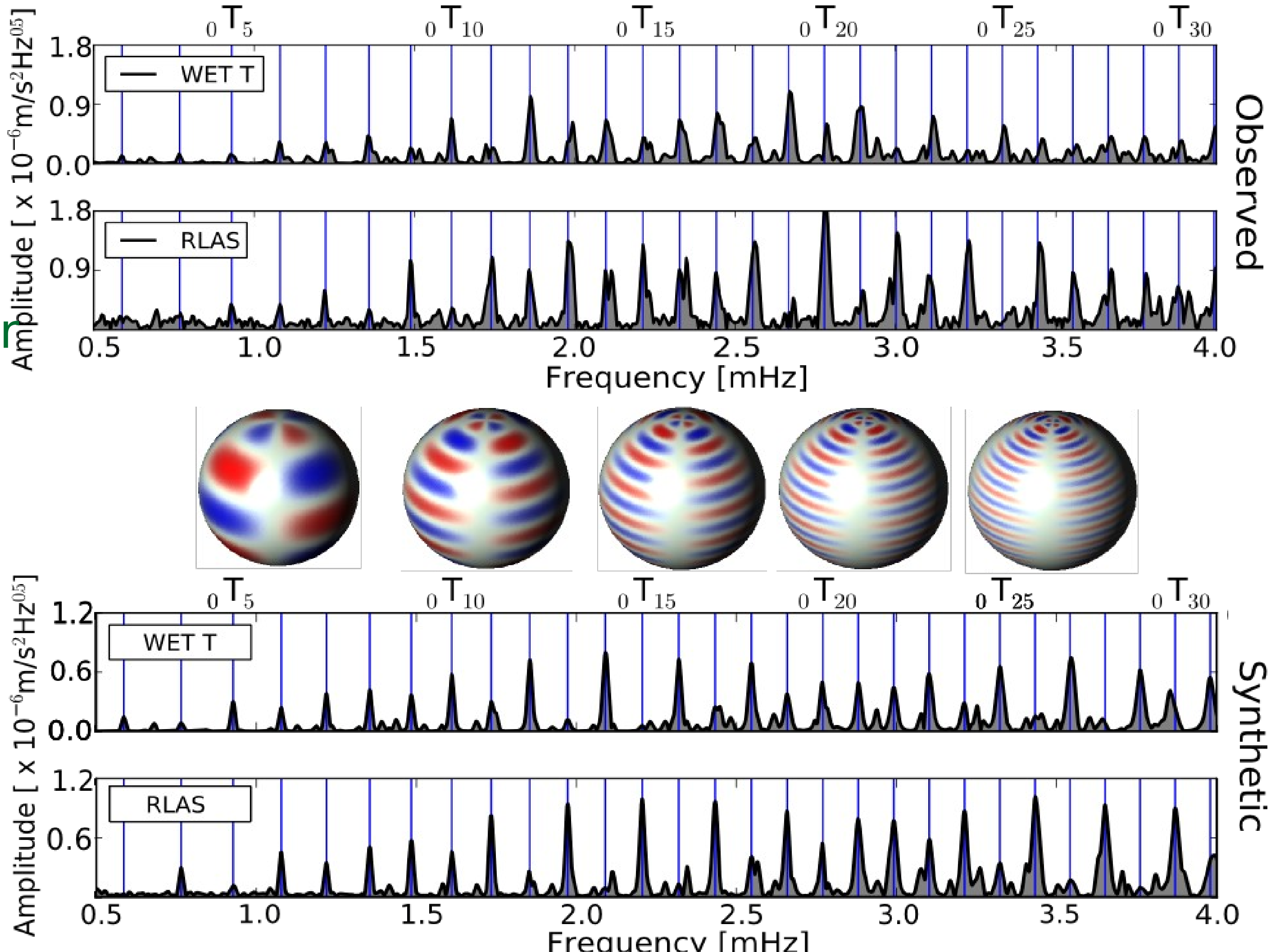


Format used for the inputs is .ah (Iris)... problematic convertion to and from any other thing...

Thank you all!

Any comment,
suggestion(clue) or
question is welcomed

- 36 hr time window
- Comparison with WET
- Hanning taper



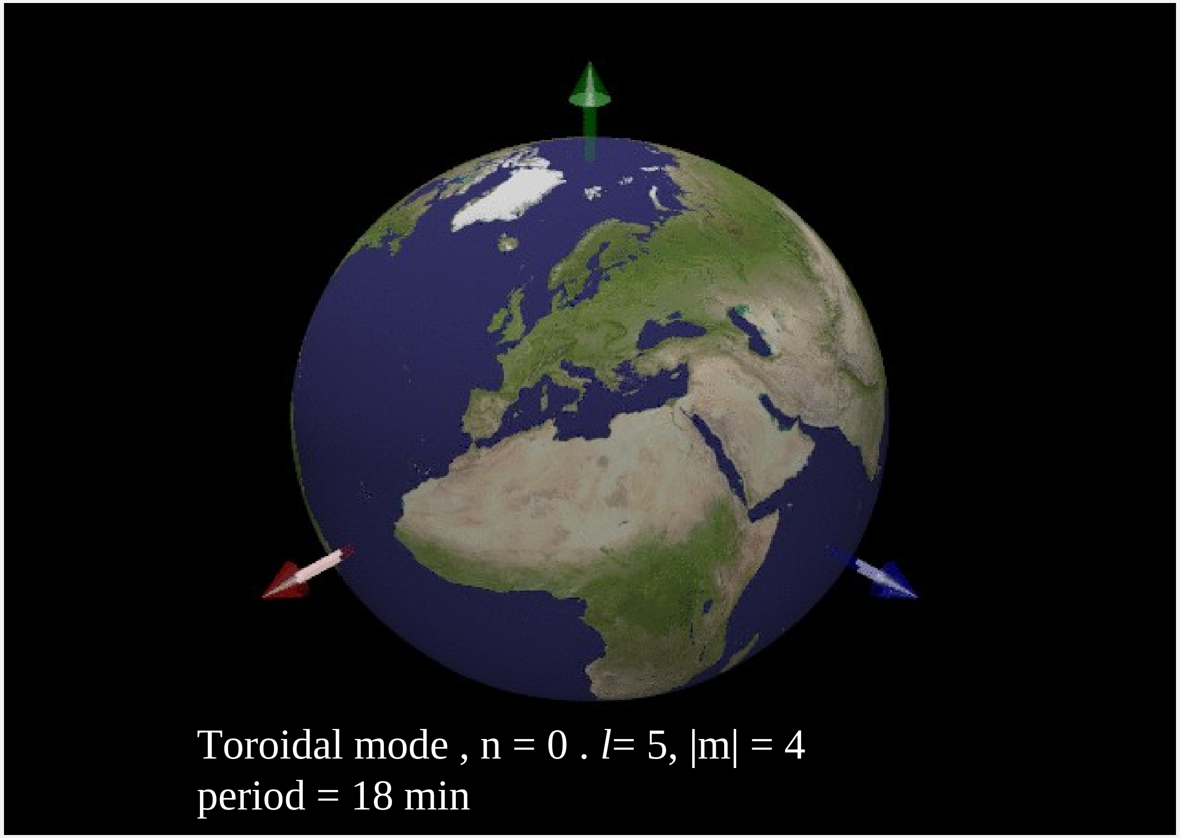
Magnitude 9.1 – Tohoku-Oki, March 11 2011

Earth‘s free oscillations

Periods < 54 min,

Amplitudes < 2-3 cm for M9

Observable weeks to months after great earthquakes.



Source: http://icb.u-bourgogne.fr/nano/MANAPI/saviot/terre/index.en.html

Conclusions

- Ring laser technology has advanced to a sensitivity level that provides an interesting complement to classical seismological instrumentation.
- Ground rotations measurements can be used to put additional constraints on earthquake source properties with sensitivities equivalent to translational measurements.
- Coriolis Coupling between T-S fundamental modes is observed.
- Fundamental differences in the attenuation of the coupled modes is observed with respect to classical observations.
- Observations should be extended to other rotational motion components (tilts, as suggested by Widmer/Scniedrig 2009).

Free Oscillations from horizontal motions

Because at low frequencies ($f < 5$ mHz) horizontal seismometers are limited by tilt noise, there exists the possibility for obtaining superior torsional mode spectra with ring lasers provided that their self noise is further reduced.

Widmer et al., BSSA, 2009