Impact of major earthquakes on variations of Earth rotation

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Motivation

Excitation functions:

$$\psi = 1.61(\Delta I_{xz} + i\Delta I_{yz})/(C - A)$$
$$\psi_3 = -\Delta I_{zz}/C_m$$

where $\psi(t) = \psi_x(t) + i\psi_y(t)$ and $\psi_3 = -\Delta LOD/LOD$

Xu et al. 2014

$\Psi(t)$: excitation function of polar motion
$\Psi_3(t)$: excitation function of ΔLOD
ΔI_{xz}, ΔI_{yz}, ΔI_{zz}: perturbations of inertia moment components
C, A: polar and equatiorial moments of inertia
($C = 8.0438 \times 10^{37}$ kg m^2 and $A = 8.0177 \times 10^{37}$ kg m^2)
C_m: mantle axial moment
($C_m = 7.1236 \times 10^{37}$ kg m^2)

- Tidal friction causes significantly increased seismicity around ± 45° latitudes through the variation of flattening

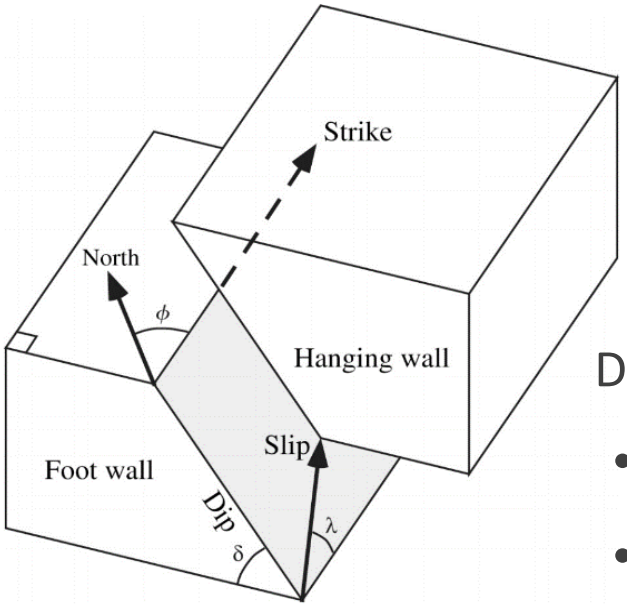
Applied formulation

Xu et al. 2014: Formulation of coseismic changes in Earth rotation and low-degree gravity field based on the spherical Earth dislocation theory

- Location of the event (latitude, longitude, depth)
- Focal mechanism (strike, dip, slip)
- Moment magnitude (Mw)

→

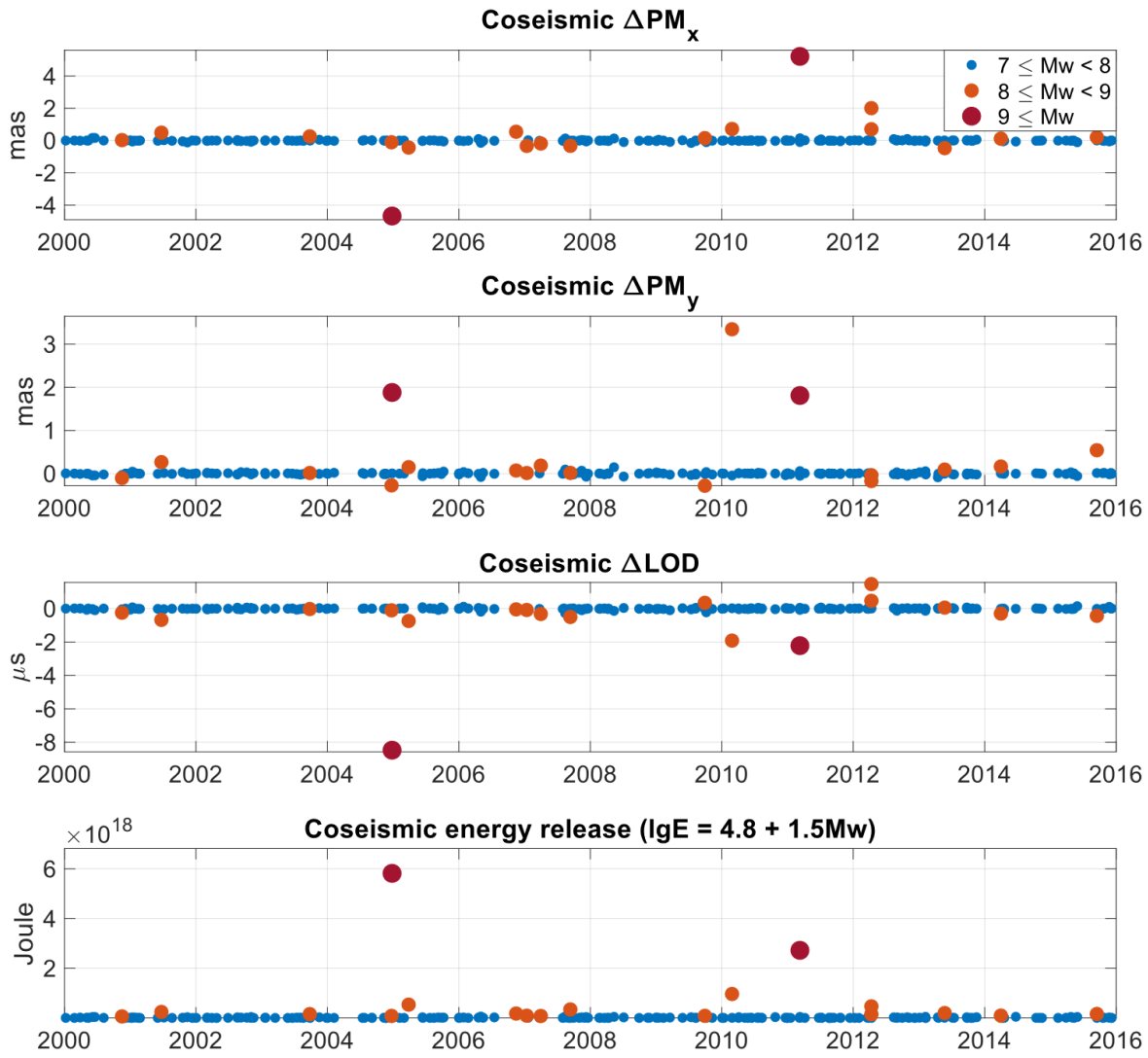
- Coseismic changes in ΔLOD and Polar Motion



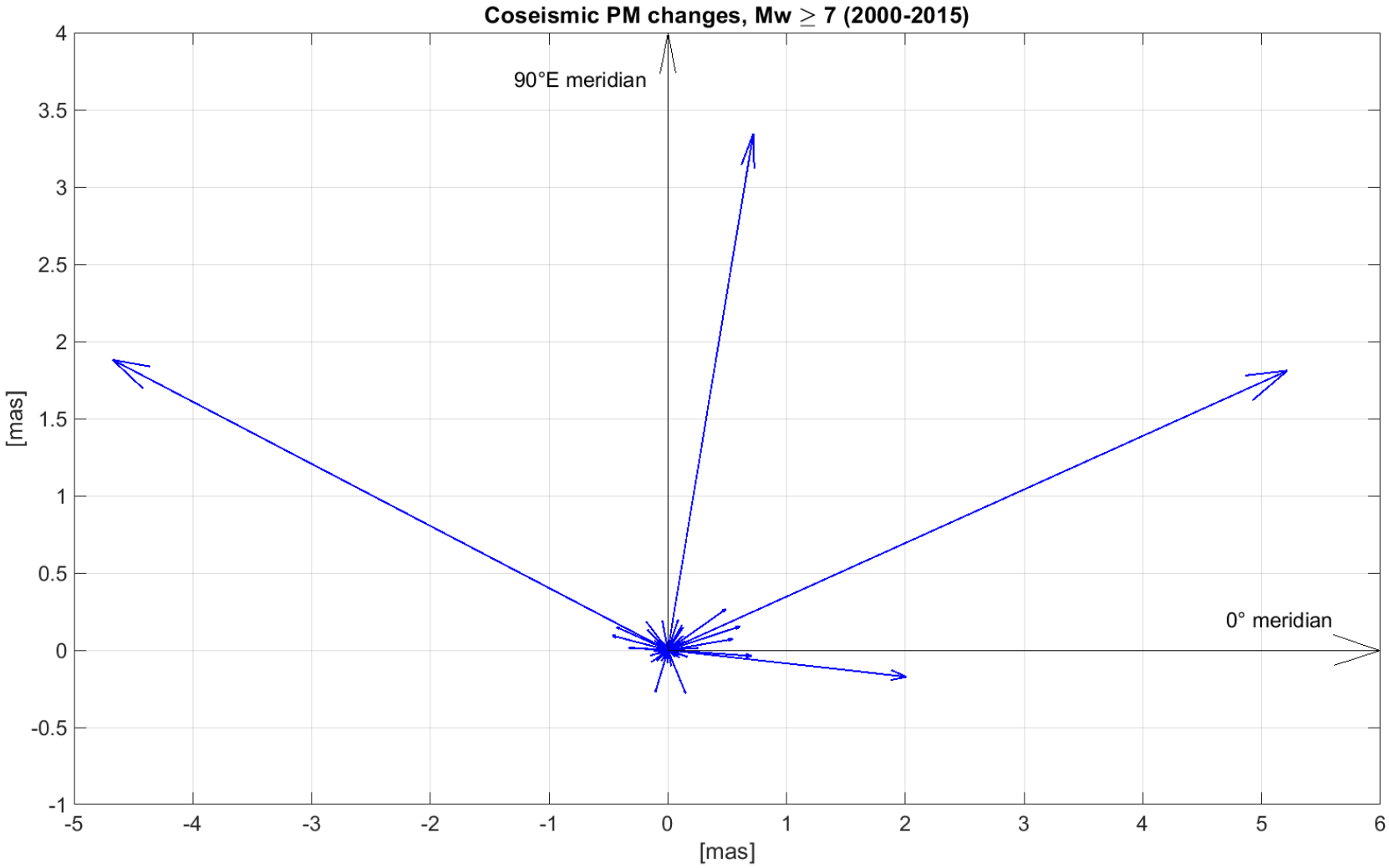
Data:

- Preliminary Reference Earth Model (PREM)
- ISC-GEM Catalogue (version 6.0, 2019-05-07)

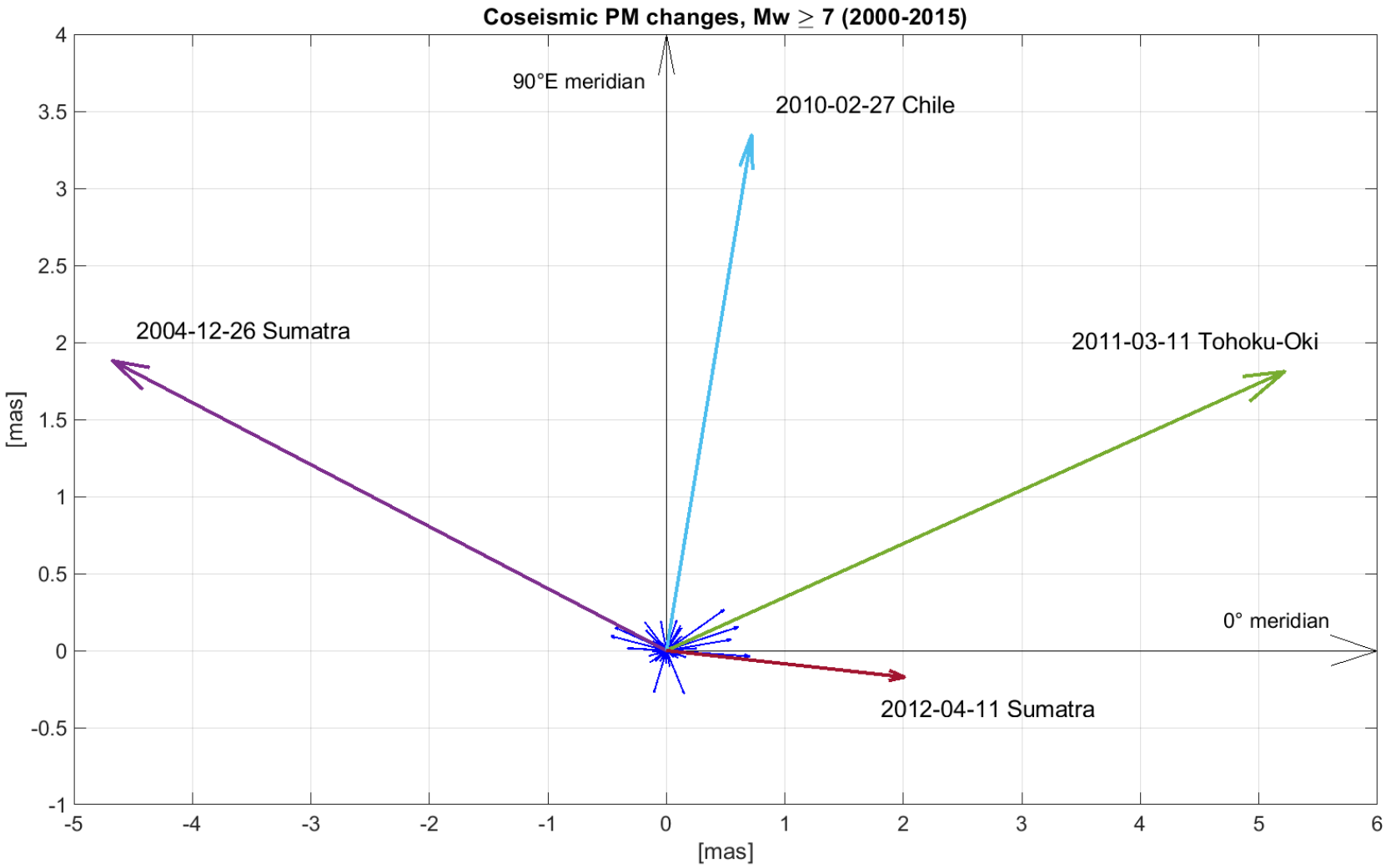
Variations in ERP due to earthquakes



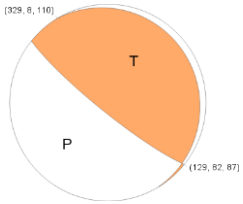
Variations in ERP due to earthquakes



Variations in ERP due to earthquakes



Major earthquakes (2000-2016)

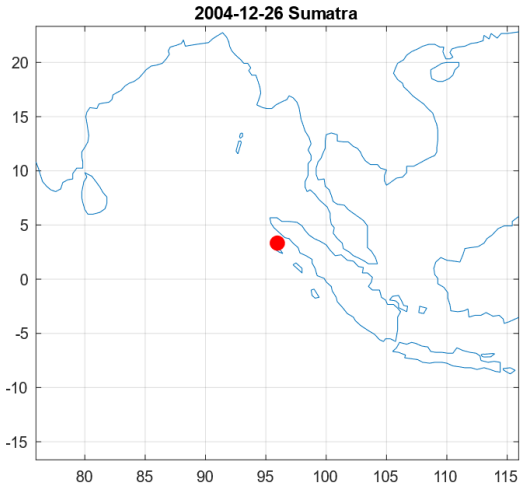


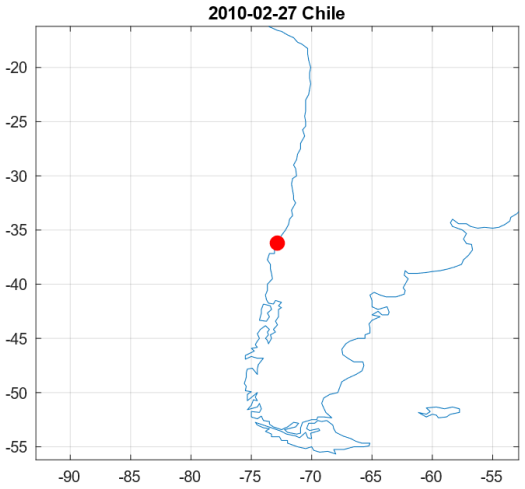
Mw = 9.3

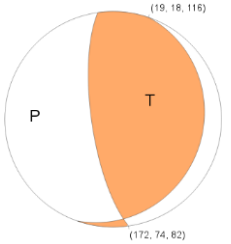
ΔLOD = -8.473 µs

ΔPMx = -4.675 mas

ΔPMy = 1.880 mas





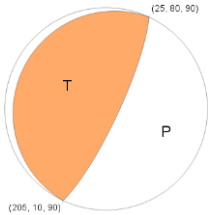


Mw = 8.9

ΔLOD = -1.916 µs

ΔPMx = 0.720 mas

ΔPMy = 3.346 mas

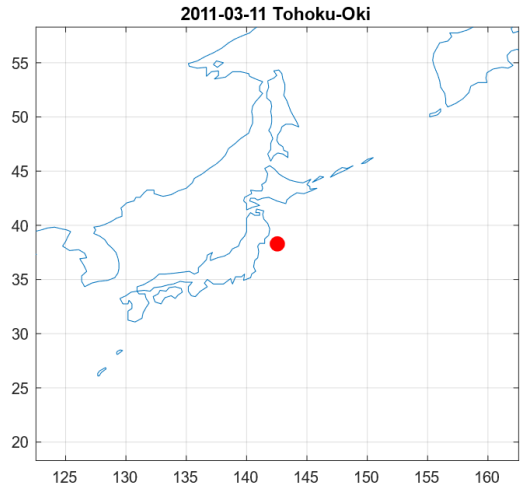


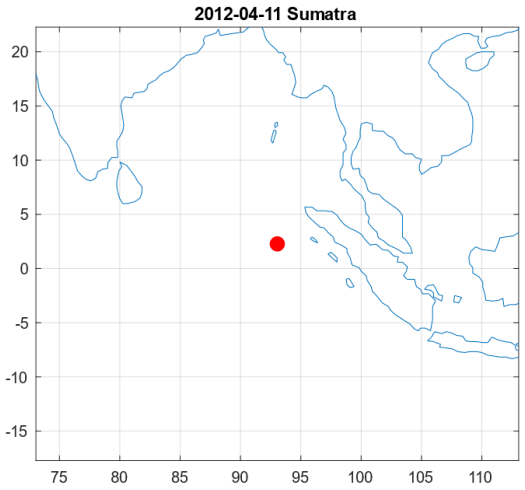
Mw = 9.1

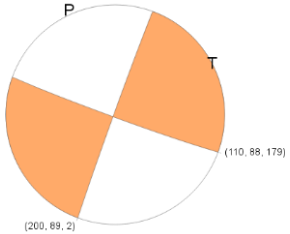
ΔLOD = -2.217 µs

ΔPMx = 5.217 mas

ΔPMy = 1.810 mas







Mw = 9.3

ΔLOD = 2.009 µs

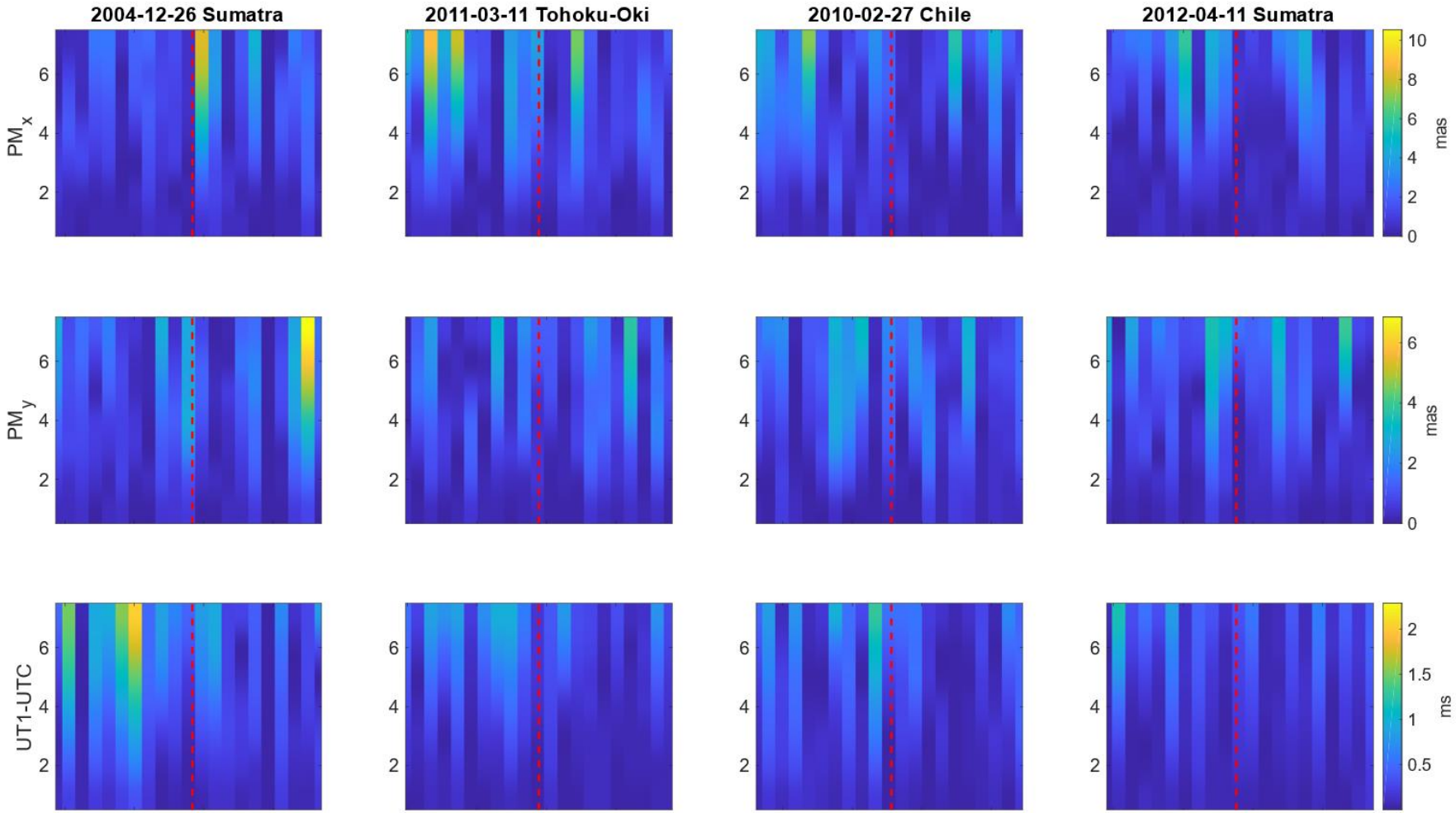
ΔPMx = 2.009 mas

ΔPMy = -0.173 mas

1st Approach: Prediction errors (IERS)

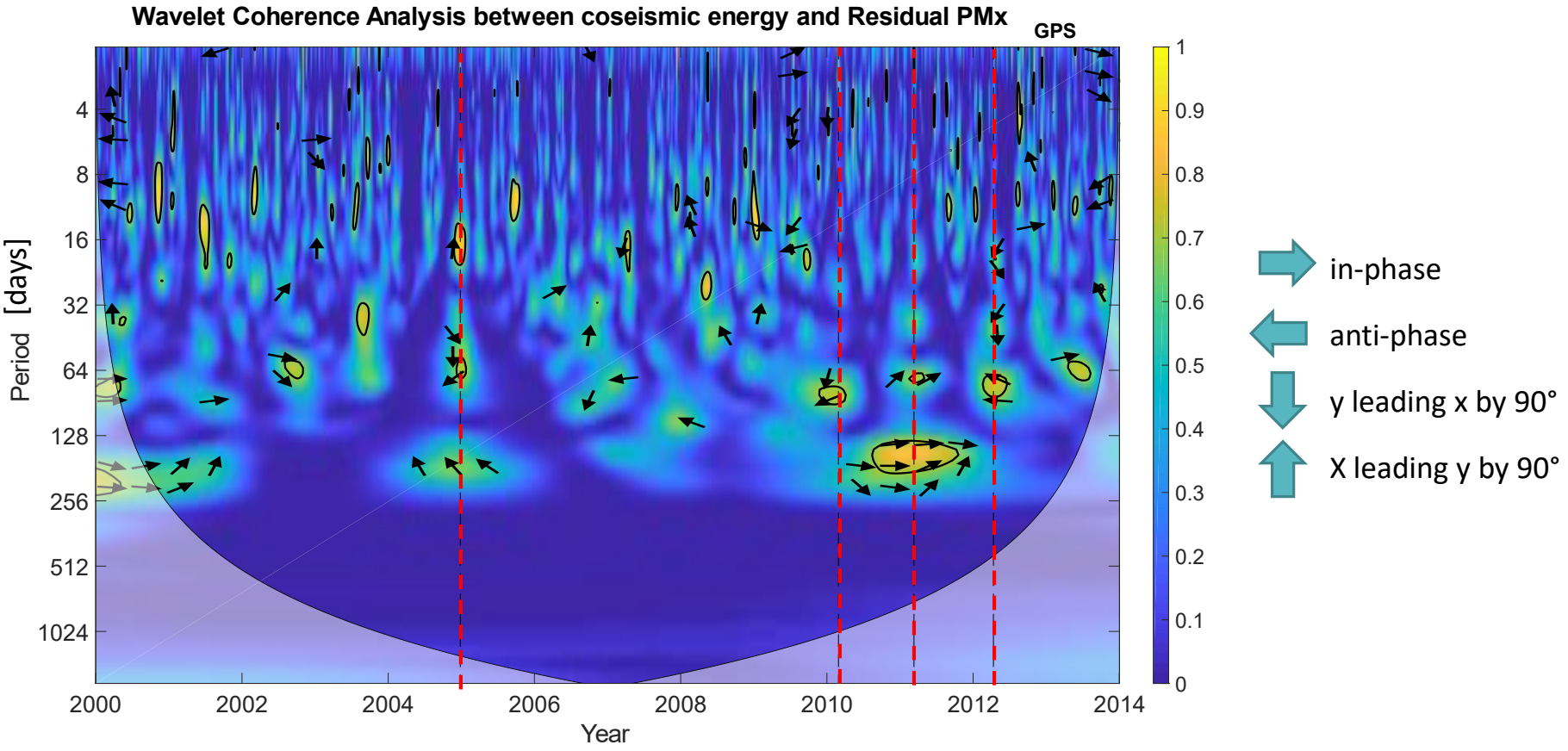
Data: IERS Bulletin A and C04

$$\varepsilon_{pred} = |x_{BulletinA} - x_{C04}|$$



2nd Approach: GPS observations residuals

Data: IGS input for the ITRF2014



Wavelet coherence is a measure of the correlation between two signals.

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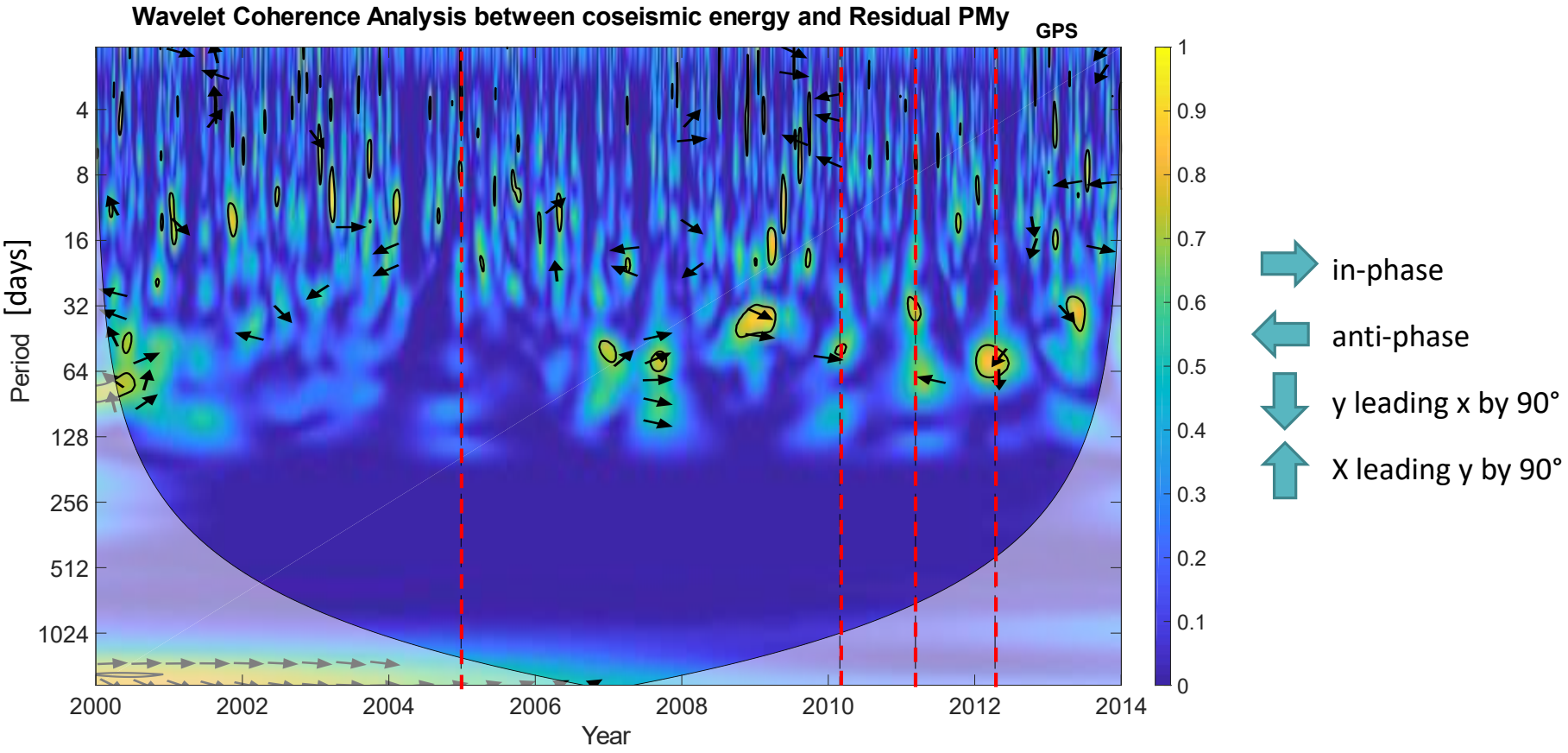

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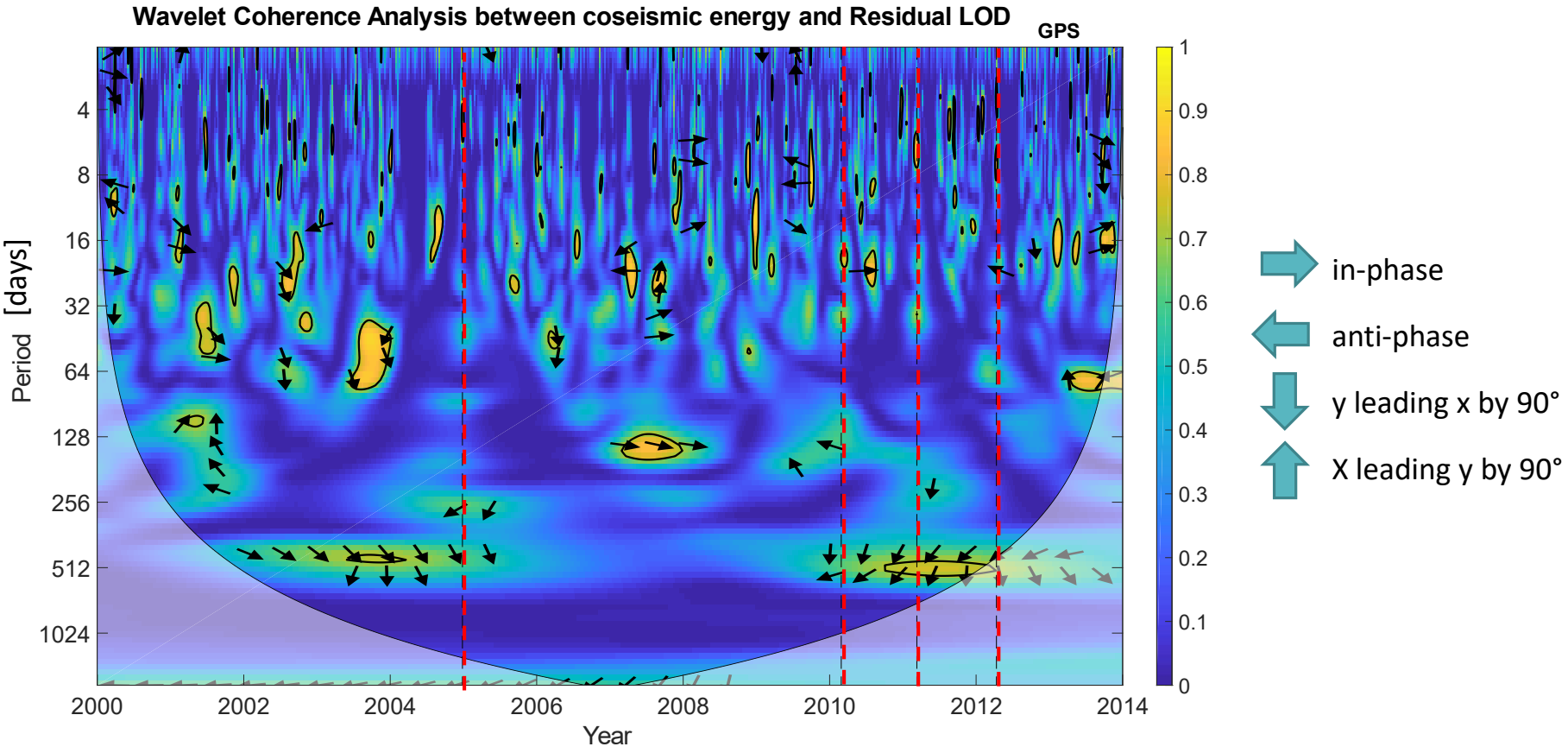

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Conclusions, Outlook

- **Prediction errors**
  - No convincing evidence of seismic activity, but theory shows otherwise
    - *The energy of earthquakes could also propagate into other processes, not just Earth rotation (e.g. changing the center of mass by such a small value that would be impossible to measure)*

→ analyse prediction with daily resolution

→ for testing the formulation, compute the parameters for the maximal effect of coseismic changes

- **GPS residuals**
  - Polar Motion shows high correlations at the epochs of large earthquakes, but not just at the epoch of large events
  - LOD on the other hand shows long term relationship between the two processes

→ study Polar Motion phase and amplitude values instead of cartesian coordinates (episodic changes should be more visible in phase data)

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Thank you for your attention!

Acknowledgements

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References

Xu, C., Sun, W., and Chao, B. Fong (2014), Formulation of coseismic changes in Earth rotation and low-degree gravity field based on the spherical Earth dislocation theory, *J. Geophys. Res. Solid Earth*, 119, 9031– 9041, doi:10.1002/2014JB011328.

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