An Event Database for Rotational Seismology

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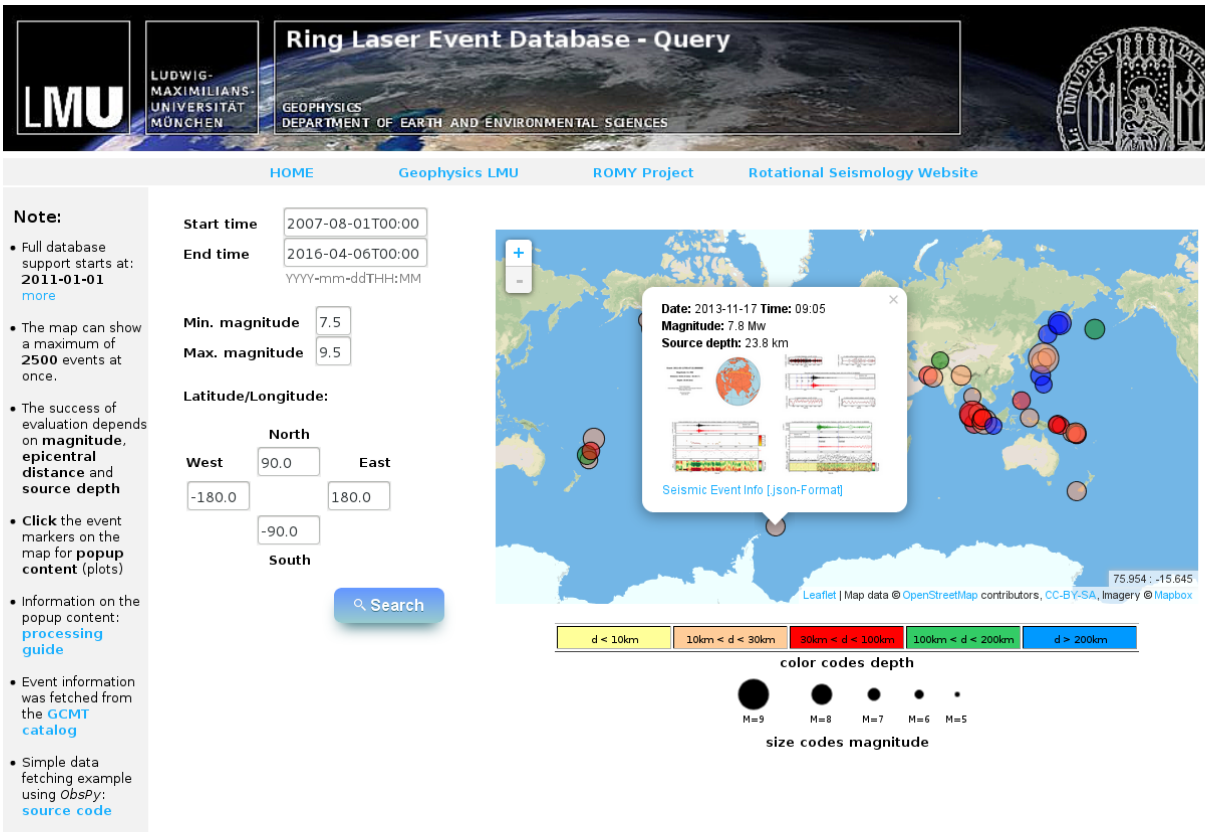
Introduction/Motivation:

- Why rotational measurements?
- Summary of related previous studies: Igel et al. (2005 & 2007), Hadziioannou et al. (2012), …
- Intention of the project:
  - ➢ make processed data publicly available → browse waveforms and parameters by events
  - ➢ present guides and python (open access) source-code examples to download ring laser waveforms → teaching by ipython notebooks!?
  - ➢ Provide meta-data (peak-values, SNRs, ...) to public which can be processed by openly

Database:

- Currently running data of one station: Wettzell
  → short station description (not too specific!): G-Ring, Broadband seismometer
  → Aim: include waveforms from PFO, Christchurch, Gran Sasso?, FFB
- Features:
  - ➢ GCMT catalog
  - ➢ Download example code
  - ➢ Search parameters
  - ➢ Map
  - ➢ Popup-Menue
  - ➢ Event availability notes (Which events are available?)



Processing (Using Obspy mainly)

1. Check for new events: (daily automatic updates)
   → Checks GCMT-catalog for new events (Moment magnitude catalog): usually Mw >4.5

2. Download raw Ring laser and broadband seismometer waveforms according to fetched event origin time (from event-xml)

3. Preprocessing split in 3 categories according to epicentral distance:
   Table 1:

	Distance range	Lowpass cutoff	Resampling decimation factor	Cross-correlation window lenght
close	0 <= d <= 3°	4 Hz	2	3 s
local	3° < d <= 10°	2 Hz	2	5 s
tele	d > 10°	1 Hz	4	120 s

4. Remove instrument response of seismometer recordings (velocity) → [nm/s] and adjust sensitivity of ring laser to [nrad/s], deviate acceleration [nm/s²] from seismometer velocity

5. Filter according to table 1

6. Phase velocity and Backazimuth estimation:

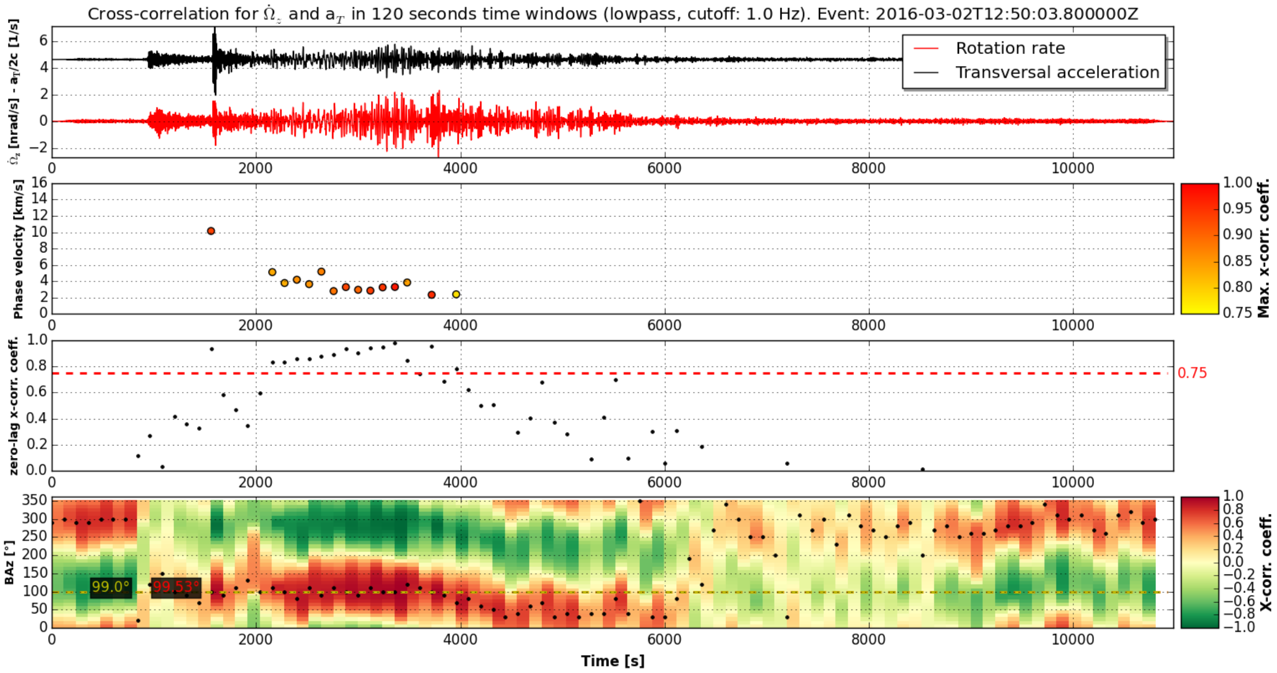
   a) Love wave phase velocities:
   - Rotate seismometer's accelerations from North-East to Radial-Transverse to match the ring laser rotation rate phase. Use theoretical Baz from source receiver geometry!
   - Split the signal traces into subwindows (length according to table 1) and for each subwindow apply cross-correlation between vertical rotation rate and transverse acceleration → check the coherence of the two recorded waveforms
   - For threshold of 75% correlation between the vert. rot. rate and transv. acc. determine phase velocity for the particular time windows that pass this requirement:

$$v_{ph} = \frac{1}{2} \cdot \frac{a_t}{\dot{\Omega}_z}$$

     using peak values of a_t and Ω_z in the time windows.
   - Ideally obtain an impression of the dispersive character of Love waves right away, by looking at the temporal evolution of the phase velocity

   b) Backazimuth estimation:
   - Analogous to before: split traces into subwindows.
   - For each window estimate the direction of the rotational signal by a grid search optimization algorith:
   - The algorithm checks the correlation between horizontal acceleration and vert. rotation rate by rotating the N-E components in 1°-steps
     → the correlation ismaximum when the rotation angle is equal to best-fitting backazimuth, which is naturally the theoretical Baz
   - For the final estimated BAz value only subwindows that reach 90% max. correlation are considered. The corresponding BAz values is an average over these windows.

- The conformity of theoretical and estimated BAz is a measure for the conformity of the two recorded measurands (rotation rate, transv. acc.) and thus for the resolution quality of the two instruments.



Conclusions

- Inclusion of other ring lasers (PFO, Christchurch, FFB, Gan Sasso?) in future
- Statistical evaluations:
  - Magnitude scale based on rotational ground motions (Love waves)
  - Local, one-station tomography
  - Analysis of azimuthal effects
- …

References

- Igel et al. (2005): “Rotational motions induced by …”
- Igel et al. (2007): “Broad band observations of earth …”
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- Schreiber et al. (2003): “New applications of very large ring lasers”
- Kurrle et al. (2010): “Can we estimate local Love wave dispersion properties ...”
- Krischer et al. (2015): “Obspy: a bridge for seismology ...”
- Megies et al. (2011): “Obspy – What can it do for data centers ...”
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