J Seismol (2012) 16:571–572
DOI 10.1007/s10950-012-9307-6

Preface to the special issue on "Advances in rotational seismology: instrumentation, theory, observations, and engineering"

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Published online: 10 June 2012

Seismology is no longer based only on the analysis of observations made with classical seismometers measuring translational motions or their time derivatives. More and more observables like strain, rotations, GPS-based measurements and others are used to constrain either the Earth's structure or to understand the nature of seismic sources and observed ground shaking. This special issue focuses on recent developments in the area of rotational seismology and engineering applications.

The analysis of rotational ground motions has recently emerged as a new branch in seismology and earthquake engineering. It does not seem to be common, seismological knowledge that particularly at the Earth's surface, with (almost any) translational ground motion there is an associated rotational ground motion as well. This has several implications: (1) depending on frequency and amplitude range translational seismometer records are contaminated by rotational motions; (2) when both motion types (or additional strain measurements) are available the collocated records contain direct information on subsurface structure; (3) the additional motion components can contribute to the excitation of structures and structures can radiate additional rotational motions and (4) rotational motion observations can help in decomposing seismic wave fields. The neglect of the rotational motion type so far is basically explained with the tremendous difficulty in measuring these motions with high accuracy in the broad frequency band required in seismology. This is also true for strong motion, rotational measurements and their engineering applications, which await adequate records from epicentral areas of major earthquakes. Progress has been made possible with recent developments in rotation sensors, producing the first direct measurements that could be compared with theoretical expectations or used to predict the responses of structures.

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These developments led to the initiation in 2006 of an International Working Group on Rotational Seismology (IWGoRS; www.rotational-seismology.org). In October 2010 the 2nd IWGoRS workshop was held in Prague with around 50 international participants. The contributions presented at this workshop (programme and presentations available on the IWGoRS home page) highlighted the wide range of fields for which measurement of rotational motions are relevant. These include earthquake source physics, the rheology of granular material, theory of wave propagation, seismic tomography, seismic exploration, earthquake engineering, seismic decoupling systems of gravitational wave sensors, strong ground motion, long-period seismology and others.

The primary conclusions of the workshop were that appropriate (portable) rotation sensors that can be used to make substantial observations across a wide range of frequencies and amplitudes are still lacking, limiting the analysis of such data for seismological and other problems. This need is reflected in the contributions to this special issue of several studies of rotation sensor technologies. These are complemented by theoretical studies on non-classical rheologies, the use of rotational ground motions in tomographic inversion, relations between strain and rotation, aspects of rotational motions in earthquake engineering, observations of Earth's free oscillations, ambient rotational seismic noise, comparison with array-derived rotational motions and other topics.

The guest editors would like to thank Prof. Torsten Dahm, Petra van Steebergen and Diana Javinal for their great help in preparing this special issue. We would like to thank the following scientists for their reviews: Felix Bernauer, Alberto Castellani, Alain Cochard, Ramanth Cowsik, Robert Dunn, Victor Eremeyev, Ana Ferreira, Andreas Fichtner, Frantisek Gallovic, Vladimir Graizer, Elena Grekova, Vinay Gupta, Céline Hadziioannou, Klaus Hinzen, Bob Hutt, Elena Ivanova, Erol Kalkan, Bohumil Kasal, Petr Kolinsky, Jan Kozak, Chuck Langston, Chin Jen Lin, Chun-Chi Liu, Jiri Malek, Robert Nigbor, Roberto Paolucci, Adam Ringler, Miguel-Angel Santoyo, Ulrich Schreiber, Roman Teisseyre, Mihailo Trifunac, Alexander Velikoseltsev and Jon-Paul Wells.