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Current Topics on Deformation Monitoring and Modelling, Geodynamics and Natural Hazards: Introduction

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The term natural hazard includes a wide range of diverse physical processes. A non-exhaustive list should include geophysical (e.g., earthquakes, tsunamis, landslides, volcanic eruptions); hydrological (e.g., floods, droughts); shallow processes (e.g., ground subsidence and collapse); atmospheric (e.g., cyclones, tornadoes, hail, lighting); and biophysical (e.g., wildfires) (Gill and Malamud 2014). In this book (should be topical issue), we emphasize the geophysical and shallow processes natural hazards, although the concept is larger by definition. In particular over the last decades, the investigation on natural hazards has greatly advanced by the widespread use of technology and influx of ideas from multiple earth sciences and related disciplines. In this regard, a current revision of advances in the field of monitoring and modelling of surface deformation processes and, in general geodynamics, with emphasis on the natural hazards was a clear necessity.

In 2013 at the 13th congress of the International Association of Mathematical Geology, we envisioned a special session dedicated to the most recent advances in the study of the Natural Hazards with emphasis on the use of modern geodetic techniques. Based on the positive experience, we proposed to Springer-Birkhäuser, the edition of a topical issue. The current book (should be issue) represents selected papers presented at the session "Deformation modelling, Geodynamics and Natural Hazards", chaired by José Fernández and Pablo J. González. We, the editors, are greatly indebted to Dr. José Fernández for the help during the organization of the session and the early stages of completion of the current issue. Our main duty was to help the discussion and foster the dissemination of the latest trends in leading problems on geodynamics and natural hazards.

Reducing the risk associated with the natural hazards related to earthquakes, volcanic eruptions, land subsidence or landslides is one of the most challenging problems confronting the Earth Science community. For example, earthquakes release accumulated elastic strain energy, radiating energy from an expanding rupture surface area. The growing process is poorly known and the accumulation of energy is slow enough to be difficult to capture. Ground deformation is a powerful tool to investigate such complex and challenging processes, with the aim of not only qualitative assessment, but model it for a deeper understanding, leading eventually to future forecast of hazardous activities. This topical issue represents an attempt to compile a broad view on current topics on the use of geodetic data, enhanced with other techniques to capture the inner working of Geodynamics and Natural Hazard processes. The book consists of 14 chapters grouped in 3 main topics: near-surface; structures and seismotectonics; and volcanic processes.

In many instances, natural and anthropogenic geohazards overlap, indicating different processes; of particular interest due to its prevalence is the occurrence of landslide and land subsidence phenomena. In

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this topical issue, we start by grouping a large set of studies illustrating examples ranging from observational to numerical modelling approaches of near-surface processes. Near-surface hazards are receiving large attention due to its impact on safety of human settlements and infrastructures. In Cigna et al. the Great London (UK) area has been imaged and analysed using radar interferometry within the PanGeo project. Ground motion estimates and geological data were combined to generate a catalogue of geohazards ranging from compaction of river thames fluvial deposits, slope instabilities, land subsidence due to groundwater management and aquifer changes, and geotechnical works such as subway and electricity tunnelling. In the next paper, displacement estimates derived from the application of Permanent Scatterers (PS). Interferometry to ERS (1992–2000) and ENVISAT (2002–2005) images have been integrated with in situ geological information in the City of Roma to produce a Ground Stability Layer (GSL). The GSL identifies in Rome numerous polygons enclosing areas where geohazards have been pointed out by PS data and/or in situ surveys, including: landslides, collapsible grounds, compressible grounds, groundwater abstraction, mining, made (What is made Ground?) ground, tectonic movements, volcanic inflation/deflation. The following paper (perhaps give the name of the first author?) is dedicated to an application of conventional and advanced DInSAR to detect mining subsidence in the Upper Silesian Coal Basin (Southern Poland) exploiting multi-sensor SAR imaginary. Conventional DInSAR from ALOS-PALSAR and TerraSAR-X images was used to detect the fastest displacements and to monitor the underground mining front in a period of several months. Advanced DInSAR analysis (PSInSAR and SqueeSAR) from ERS, ENVISAT and TerraSAR-X imaginary was useful to detect residual displacement around the subsidence bowl even after the closure of the mines.

Bianchini et al. use C- and X-band radar Persistent Scatterer Interferometry to evaluate the spatial and temporal movements on a known landslide. This paper contains a wealth of in situ field measurements that validate and support the spaceborne motion data. The paper addresses the complex issue of delineating and identifying the most active unstable areas to help risk-mitigation measures. The San Fratello landslide test case provides an ideal place to test the technology and assess the potential for future sliding events, similar to the February 2010. With the initiation of such large datasets, the logical next step is to improve existing modelling approaches. In Castaldo et al. an inverse numerical modelling of slow landslides is performed from advanced DInSAR time series derived from 20 years of ERS-1/2 and ENVISAT satellite acquisitions. The proposed methodology allows for automatically searching the physical parameters that characterize the landslide behaviour. This approach is validated on the slow Ivancich landslide (Assisi, central Italy), which behaviour is simulated through a two-dimensional time-dependent finite element model. Comparison between the model results and DInSAR measurements and in situ data reveals that the creep model is suitable to describe the kinematic (not kinematical) evolution of the landslide. To conclude with near-surface processes section (land subsidence and landslides), Notti et al. proposed a set of low-level user-oriented indexes to interpret multi-temporal Differential Synthetic Aperture Radar (SAR) Interferometry (DInSAR and PSI).

In the present volume, contributions broadly relevant to the different geodesy branches as gravimetric and ground deformation measurements in A variety of geodynamic contexts were enclosed. In the case of large regional low-rate subsidence phenomenon, Camacho et al. present a new methodological work to adapt a published inversion approach (growth method) to the case of an alluvial valley (sedimentary stratification, with density increase downward). More specifically, the paper presents a gravimetric study of the low Andarax valley that is an alluvial basin, close to its river mouth, is located in the extreme south of the province of Almería. In an additional study, Conejo-Martín et al. proposed a novel methodology to determine the electromagnetic velocity of the ground due to a combination of LIDAR Digital Terrain Model with Ground Penetrating Radar profiles. This technique is suitable for use in shallow underground spaces with access from surface, as other natural cavities, archaeological cavities, sewerage systems, drainpipes, etc. It has been applied over some cavities used for underground wine cellars in Atauta (Soria, Spain), and allowed the correct

detection of the inner structures of cavities in high resolution and with great accuracy.

At higher sampling rates, the ground deformation is better characterized by seismological methods. In this topical issue, three papers are dedicated to understand Natural Hazards with emphasis in seismotectonic aspects. Induced and natural seismicity is a research subject with profound societal implications. There is a clear gap about different studied regions with much of the current research focused on the US and European cases, but Sarychikhina et al. present a study on ground deformation and seismicity with the aim to separate the origin of the observed seismicity in Mexicali Valley, Mexico. Levelling surveys, radar interferometry and seismic catalogues illustrate a complex setting where active tectonics and human activity interact. Untangling the contributions from the fluid extraction at the Cerro Prieto geothermal field and activity along tectonic faults ensures future research in this area, exploiting spaceborne and ground-based instruments (tiltmeters and creepmeters). Jiménez et al. faced the challenge to determine useful earthquake sources and attenuation parameters around the Itoiz dam, the hydrological infrastructure in Northern Spain, using low magnitude events. Novel inverse methods allow the authors to obtain estimates of moments, source radii and stress drops. Empirical and theoretical relationships show a good agreement between moment and magnitude. Evaluation of seismic activity around Itoiz is a relevant case due to the observed correlation with the water-level variations. Finally, Carmona et al. embrace the identification of internal waves on smaller ocean basins. The authors take advantage of the special setting of the Northern Moroccan seismicity and a dense seismological network in Southern Spain (the Red Sísmica de Andalucía) to record late seismic arrivals. Those late arrivals decayed in amplitude with distance from the coast and have relatively constant delays of 85 s with respect to the P-wave. Those evidences suggested that T-waves were responsible for the late arrivals, usually observed in large oceanic basins. This study shows the first evidence of such waves in a small closed sea, such as the Alboran Sea.

In volcanic context, three contributions were enclosed in the volume. Fernández et al. present an overview of geodetic volcano research in the Canary Islands (Spain). (No: is proposed). The authors describe the research in volcano geodetic monitoring carried out in the Canary Islands and the results obtained and consider for each epoch the two main constraints existing: the level of volcanic activity in the archipelago and the limitations of the techniques available at the time. The second enclosed contribution is relevant to the ground deformation prior to the 2010 eruption of Mt. Sinabung. In particular, González et al. used differential interferometric synthetic aperture radar (DInSAR) obtained from Japanese ALOS-PALSAR radar imagery, between 05 January 2007 and 31 August 2010. InSAR time series processing results detected significant ground deformation (subsidence) at several locations in the Karo plateau, and uplift at the summit area of Mt. Sinabung of hydrothermal origin preceding a phreatic eruption. D'Auria et al. proposed a novel approach to retrieve the full stress field based on ground deformation and seismological estimates. The inversion of the surface ground deformation independently, is consistent with a planar crack source, located at a depth of about 2.56 (perhaps just 2.5, this could not be given with such detail?) km underneath the centre of the caldera. The addition of regional background stress field helped to delineate the full stress field into a variable component (of volcanic origin) and a weak NNE-SSW extension due to constant tectonic forces. This methodology highlights the resolving power of the joint use of seismological and geodetic data for volcano monitoring.

This monographic topical issue does not thematically exhaust all directions that have been taken by the earth science community to understand the Natural Hazards and Geodynamics. However, it does provide an essential view of significant issues in the observation and modelling of geophysical, geodetic and shallow hazardous processes, which should prompt further research and interpretations from the current trend of multidisciplinary approaches.

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