EARTH OBSERVATIONS FOR GEOHAZARD MONITORING AND RISK ASSESSMENT

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List of Principal Investigators (PIs)

Topic Nr.	PIs	Title
32244_1	*Prof. Zhenhong Li,* *Prof. Jingfa Zhang*	***Active Faults and Seismic Risk Assessment in China***
32244_2	*Prof. Jan-Peter Muller,* *Prof. Qiming Zeng*	***Understanding Landslide hazards in the Three Gorges, China and landslides induced by large earthquakes***
32244_3	*Dr. Yaxin Bi,* *Prof. Guoze Zhao*	***Earthquake Precursors from Space and Ground – Detecting Seismic Anomalies from Satellite and Ground Data with Multiple Parameters***

EXECUTIVE SUMMARY

Earthquakes represent a major natural hazard faced by human societies, and their destructive impact is often greatly enhanced by the triggering of landslides during or after the shaking they cause. It is believed that several million deaths, and severe economic damage, will be caused directly by earthquakes during this century due to the continuous growth of megacities, especially across the India-Asia collision. Landslides can be caused by other factors including rainfall and water level changes (rather than earthquakes), which can be another cause of loss of life and damages to buildings, infrastructure and cultural heritage. Scientific advances are needed for policy makers to make informed decisions about preparing for such events and mitigating their consequences. Building on our research in the Dragon-1/2/3 programmes and others, we aim to employ earth observations to rapidly respond to large earthquakes and induced landslides, make detailed active fault maps, determine present-day deformation and assess seismic and landslide risks in the study regions. This project consists of three sub-projects:

1. sub-proposal 1: Active faults and seismic risk assessmentáin China;
2. sub-proposal 2: Landslide hazards in the Three Gorges region, China and landslides induced by large earthquakes;
3. sub-proposal 3: earthquake precursors from space.

The overall objective of sub-project 1 is to further develop InSAR processing chain to better map crustal deformation and then assess seismic risks, sub-project 2 is to combine advanced SAR/InSAR/optical techniques to better monitor and assess landslide hazards with an attempt to rapidly respond to earthquake induced landslides, and sub-project 3 is to identify earthquake precursors from space. For specific objectives, please refer to the sub-project proposals.We expect that this project will lead to:(1). Improved capability to handle earth observations(2). Better knowledge of earthquake/landslide mechanisms and their future hazards in the study regions(3). More than 30 young researchers in China and Europe trained by the end of this Dragon-4 project(4). Regular academic exchanges between China and Europe(5). Joint workshops with young researchers involved(6). Joint publications in high impact journalsThis project is a collaboration among fourteen Chinese and EU institutions. We will take advantage of the opportunity offered by the Dragon framework for Chinese-European exchange. We plan joint workshops in China for young postdoctoral scientists and students. Young scientists will also take part in exchanges, e.g. visits by Chinese scientists to work at EU universities, field visits to China by EU scientists.This project will be supported by (1) National Natural Science Foundation of China (NSFC) [41374050], 2014.01-2017.12 (PI: Jingfa Zhang); (2) National Natural Science Foundation of China (NSFC) [41571337], 2016.01-2019.12 (PI: Qiming Zeng); (3) Research grant from Institute of Crustal Dynamics, China Earthquake Administration [ZDJ2013-22, ZDJ2015-15], 2014-2019 (PI: Jingfa Zhang); (4) Community-based earthquake disaster risk reduction in China: integrating local and scientific knowledge for planning and preparedness, the NERC-ESRC-NSFC Newton Fund – Increasing Resilience to Natural Hazards in Earthquake Prone Regions of China (IRNHiC), 2016.01-2018.12. (Newcastle PI: Zhenhong Li); (5) Centre for the Observation and Modelling of Earthquakes, Volcanoes and Tectonics (COMET), Natural Environment Research Council (NERC), 2014-2019 (Lead PI: Tim Wright; PIs: Zhenhong Li, Barry Parsons); (6) Looking inside the Continents from Space: Insights into Earthquake Hazard and Crustal Deformation, Natural Environment Research Council (NERC) Large Grant, (Lead PIs: Barry Parsons and Tim Wright, PI: Z. Li, 2013-2018); (7) University and CSC scholarships to support PhD students in EU universities.

ABSTRACT 32244_1: "Active Faults and Seismic Risk Assessment in China"

European Principal Investigator	***Chinese Principal Investigator***
Prof. Zhenhong Li	Prof. Jingfa Zhang
(Newcastle University,UK)	(China Earthquake Adminstration,CHINA)

Earthquakes represent an increasing risk of human loss and severe economic damage as vulnerable populations grow in areas of seismic hazard. Scientific advances are needed for policy makers to make informed decisions about preparing for such events and mitigating their consequences. Building on our research in the Dragon-1/2/3 programmes and others, we aim to employ earth observations to make detailed active fault maps, determine present-day deformation and assess seismic risks in the study regions.

The main objectives of the project are as follows:

O1. Further develop the COMET InSAR processing chain by incorporating High RESolution European Centre for Medium-Range Weather Forecasts (HRES ECMWF) based atmospheric correction model to reduce atmospheric water vapour effects on radar measurements.

O2. Determine present-day deformation and strain map for selected regions using InSAR, GNSS and levelling. The COMET InSAR processing chain will be employed to generate inter-seismic strain accumulation, and hence the slip rates for selected regions with Sentinel-1 and other archived SAR images.

O3. Enable our existing geodetic inversion packages to be automated for the determination of earthquake source parameters; Undertake InSAR studies of the source mechanisms and, combined with seismology, rupture histories of any large earthquakes in the study regions that may occur during the lifetime of the project.

O4. Investigate post-seismic deformation for the 2008 Yutian earthquakes. Initiate InSAR studies of postseismic motion for any large earthquakes in China that may occur during the lifetime of the project.

O5. Assess time-dependent hazard following major earthquakes. For large earthquakes, a semi-automated system will be developed to calculate stress changes on neighbouring faults, enabling us to rapidly reassess the evolving aftershock hazard.

We expect that this project will lead to:

(1). Improved COMET InSAR processing chain together with robust time series approaches

(2). Improved PSOKINV allowing us to carry out geodetic inversion automatically

(3). Better knowledge of the distribution of active faults and deformation in the four study regions

(4). More than 20 young researchers in China and Europe trained in the EO and Geophysics fields by the end of this Dragon-4 project

(5). Regular academic exchanges between China and Europe

(6). Joint workshops with young researchers involved

(7). Joint publications in high impact journals

This project is a collaboration among seven Chinese institutions and the Center for the Observation and Modelling of Earthquakes, Volcanoes and Tectonics (COMET) involving eight UK universities (the Universities of Oxford, Cambridge, Leeds, Bristol, Reading, Liverpool and Newcastle and University College London). We will take advantage of the opportunity offered by the Dragon framework for Chinese-European exchange. We plan joint workshops in China for young postdoctoral scientists and students. Young scientists will also take part in exchanges, e.g. visits by Chinese scientists to work on InSAR at the COMET member universities, field visits to China by COMET scientists.

This project will be supported by

(1) National Natural Science Foundation of China (NSFC) [41374050], 2014.01-2017.12 (PI: Jingfa Zhang)

(2) Research grant from Institute of Crustal Dynamics, China Earthquake Administration [ZDJ2013-22, ZDJ2015-15], 2014-2019 (PI: Jingfa Zhang)

(3) Community-based earthquake disaster risk reduction in China: integrating local and scientific knowledge for planning and preparedness, the NERC-ESRC-NSFC Newton Fund - Increasing Resilience to Natural Hazards in Earthquake Prone Regions of China (IRNHiC), 2016.01-2018.12. (Newcastle PI: Zhenhong Li)

(4) Centre for the Observation and Modelling of Earthquakes, Volcanoes and Tectonics (COMET), Natural Environment Research Council (NERC), 2014-2019 (Lead PI: Tim Wright; PIs: Zhenhong Li, Barry Parsons)

(5) Looking inside the Continents from Space: Insights into Earthquake Hazard and Crustal Deformation, Natural Environment Research Council (NERC) Large Grant, (Lead PIs: Barry Parsons and Tim Wright, PI: Z. Li, 2013-2018)

ABSTRACT 32244_2: "Understanding Landslide hazards in the Three Gorges, China and landslides induced by large earthquakes"

European Principal Investigator	***Chinese Principal Investigator***
Prof. Jan-Peter Muller (University College London,UK)	Prof. Qiming Zeng (Peking University,CHINA)

Landslides are a major global hazard, controlled by geology, weather and land-use, and also a major secondary hazard in most continental earthquakes. Recent catastrophic landslides in China and elsewhere have demonstrated the importance of understanding this hazard and of developing early-warning systems. Developing and validating technology for direct monitoring of landslide hazards meets the Sentinel mission objective of geological hazard mapping. InSAR techniques allow hazard assessments to be made and enable improved planning, design and warning systems. In our Dragon-1/2/3 project, we have successfully employed InSAR to map several active landslides in the Three Gorges region of China, e.g. the Badong, Xintan and Shuping landslides.

In this project, we aim to further develop advanced SAR techniques to investigate landslide hazards for the whole Three Gorges region, and combine satellite optical and radar data to rapidly respond to earthquake induced landslides.

The main objectives of the project are as follows:

O1. Integrate various SAR/InSAR/Optical techniques to detect and monitor extremely-slow through very-slow to slow-moving landslides

O2. Combine various SAR datasets to recover 2D/3D displacements of landslides

O3. Model earth surface observations to determine the geophysical mechanisms responsible for landslides and provide a quantitative risk assessment in the Three Gorges region

O4. Combine satellite optical and radar images to rapidly respond to landslides induced by large earthquakes.

We expect that this project will lead to:

(1). A processing chain to integrate Conventional InSAR, MAI, Small Baseline InSAR and SPOT

(2). Optimised ways to combine satellite radar and optical images for rapid response to earthquake induced landslides

(4). More than 15 young researchers in China and Europe trained in the landslide field by the end of this Dragon-4 project

(5). Regular academic exchanges between China and Europe

(6). Joint workshops with young researchers involved

(7). Joint publications in high impact journals

This project is a collaboration among six institutions in China and the UK. We will take advantage of the opportunity offered by the Dragon framework for Chinese-European exchange. We plan joint workshops in China for young postdoctoral scientists and students. Young scientists will also take part in exchanges, e.g. visits by Chinese scientists to work on InSAR at the UK universities, field visits to China by UK scientists.

This project will be supported by

(1) National Natural Science Foundation of China (NSFC) [41571337], 2016.01-2019.12 (PI: Qiming Zeng)

(2) National Natural Science Foundation of China (NSFC) [41374050], 2014.01-2017.12 (PI: Jingfa Zhang)

(3) Community-based earthquake disaster risk reduction in China: integrating local and scientific knowledge for planning and preparedness, the NERC-ESRC-NSFC Newton Fund - Increasing Resilience to Natural Hazards in Earthquake Prone Regions of China (IRNHiC), 2016.01-2018.12. (Newcastle PI: Zhenhong Li)

(4) China Scholarship Council and UCL MAPS Dean prize (as well as GRS/ORS) to support one new PhD student starting each year (PI: Jan-Peter Muller)

ABSTRACT 32244_3: "Earthquake Precursors from Space and Ground – Detecting Seismic Anomalies from Satellite and Ground Data with Multiple Parameters"

European Principal Investigator	*Chinese Principal Investigator*
Dr. Yaxin Bi	Prof. Guoze Zhao
(Ulster University,UK)	(Institute of Geology, CEA,CHINA)

Earthquake is a natural devastating disaster, which causes enormous human and economic losses and disruption, examples are the 1976 Tangshan earthquake (magnitude 7.8), the 2008 M7.9 Wenchuan earthquake, the 2010 Haiti earthquake, and the 2011 Japan earthquake and subsequent tsunami, and it continues to grow worldwide. Many case studies show there was a mixture of seismic anomalies before earthquakes in respect of electromagnetic fields, crustal deformation, ionospheric perturbations, etc. Clearly appropriate understanding and identifying of these anomalies in conjunction with a reliable three dimensional early warming system in place will reduce earthquake damage and save loss of human life.

The evolutionary process of earthquakes is rich of complex features, often depending on the tectonic background and crustal structure. When respective tectonics and structure change along with earthquakes, fluid in the crust could redistribute, so that may cause the anomalous change of ground resistivity and abnormal emission of electromagnetic fields, these anomalies can be observed from ground and space. Satellite observation provides the enormous capability of observing regional and global areas of our planet, and captures a variety of activities occurring on the earth and in its interior. Since 2000s, China Earthquake Administration (CEA) started to collaborate with European Space Agency on developing an electromagnetic satellite, namely China Seismo Electromagnetic Satellite (CSES). Its main objectives are to conduct experimental studies on if there are anomalous electromagnetic disturbances relative to earthquake activities through monitoring the behaviors of electromagnetic fields, Ionosphere plasma, and energetic particles. The CSCS satellite is being developed and will be launched at the end of 2016 as planed.

More recently CEA has also developed a Control Source Extremely Low Frequency (CSELF) observatory network that will be composed of 42 stations, covering the main seismic zones across the mainland of China. The CSELF is a particularly designed dual-function network, monitoring changes of electromagnetic fields and ground resistivity from natural and artificial sources. It is able to record a wider range of frequencies of signals that can be simultaneously observed by the SWARM and CSES satellites, thus the variations and precursors of electromagnetic parameters can be compared and validated. In the 13th Five-Year Plan period, CEA aims to integrate the ground and space observations to establish a new three dimensional and comprehensive observation system. This framework will significantly advance seismic monitoring technology and promote understanding of earthquake preparation process and capturing seismic precursors in the world.

In the Dragon 3 project, three anomaly detection algorithms have been developed and applied to analyse NOAA, SWARM and CSELF data for analysing and comparing anomalies in relation to the Wenchuan, Lushan, Pure, Jinggu, Taoyaun earthquakes occurred in China, the preliminary results have been achieved and published (Zhao, et al. 2015, Kong, et al. 2015, Han, et al. 2014, Christodoulou, et al. 2015). The proposed Dragon 4 project is aimed to carry out a comprehensive study on seismic precursors and assessment of their correlations with the cycles of earthquakes. The project will develop more sophisticated algorithms and employ these inherited and new algorithms to analyse SWARM, CSES, ENVISAT, Sentinel-3A, NOAA and other satellite data in addition the CSELF data across the selected areas, detecting precursors in ionosphere and lithosphere before and during the large earthquakes. The specific objectives are to

• Review the various forms of seismic anomalies in respect of electromagnetic fields, electron and Ion density, ORL anomalies, etc. and develop novel representation methods for observation data and anomalies
• Scale up data analysis for detecting anomalies by using these algorithms above, and incorporate the new representation and analysing results into the development of sophisticated detection algorithms
• Carry out a large scope of analysis and comparative studies on electromagnetic anomalies detected from the Swarm, CSES and CSELF data and comparative analysis with thermal anomalies from OLR and SLHF in temporal-spatial axes
• Perform correlation analysis between anomalies and large earthquakes in depth, and identify occurrence times of anomalies before and during earthquakes, anomaly cycles with different parameters, frequencies, spectrums in temporal-spatial axes

The Dragon 3 projects have been supported by a matched PhD studentship from Ulster University and the project funded by National Natural Science Foundation of China. The Dragon 4 project will be continually supported by these funding sources in addition to the CSES sources.