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PhD Project Description

Project Title

Developing time-series InSAR tools for understanding changes to the ground surface, subsurface, biosphere and environment

Supervisors

Lead Supervisor: Philippa Mason

Co-supervisor(s):James Lawrence, Richard Ghail (external)

Research Group

Climate and Environment

Project Summary

Interferometric Synthetic Aperture Radar (InSAR) is a technique with proven value for monitoring of changes to infrastructure, ground and environment. Time-series InSAR technology has progressed very rapidly and now allows global monitoring and measurement at mm-scale accuracies. Such developments are of great value in geohazards, infrastructure and agronomy. Earth Observation and InSAR are now standard tools for monitoring a wide range of natural and anthropogenic processes.

One such technique is Persistent Scatterer InSAR (PSI), which tracks small motions of scattering ground objects through a stack of SAR images. Regular global coverage and improving spatial resolution has led to thousands of publications but there are few open source tools offering PSI, and none with GUI or Windows PC support; which prohibits ease of use by researchers and industry. The lack prompted the development of our own Imperial College Synthetic Aperture Radar (ICSAR) toolset, which includes standard data processing, and several novel features for extraction of quantitative information about land cover, crops and physical environment.

Research Context and Objectives

Seasonally variable scattering patterns caused by natural and cultivated vegetation, soils, and regolith produce spatiotemporally complex phase changes in InSAR data. These patterns store valuable information relating to plant phenology, soil moisture, freeze-thaw and other behaviour. The lengthening global Sentinel-1 SAR archives (and new SAR satellites coming online soon), enable monitoring and retrospective analysis of such patterns to reveal some longer-term trends linked to groundwater, weather and climate. Hence, time-series InSAR analysis has potential to improve understanding of plant development and response to stress over time, to develop biomass analysis, and to better understand the physical landscape responses to environmental change.

This project will develop ICSAR's library of scripts and tools, and will incorporate Deep Learning techniques to exploit the InSAR phase variations – aiming to extract quantitative information about ground behaviour, land-cover and biomass changes, and/or soil moisture variations; analysing these to identify change, in relation to weather patterns and longer-term climate patterns. The broad research objectives are:

1. Evaluate ICSAR's capabilities
2. Assess DL approaches

3. Integrate & develop DL capabilities, & testing

This project outline has very broad scope and allows room for the candidate to pursue any one of several potential directions but all demand strong coding skills (e.g. Matlab, Python), a mathematics, physics or geophysics background, some familiarity with Earth Observation, SAR and/or InSAR, and with an interest in AI techniques, and in geo/environmental science.

The multi-disciplinary project brings together understanding of SAR data processing, InSAR time-series extraction methods and of ground, environment and biosphere, with new Deep Learning methods. Our team brings together supervisors with technical knowledge of data and processing techniques. In our research and development thus far, we have developed links with an agricultural college and have benefited from their ground-truth data and knowledge to assist in understanding the complex phase variations and what they mean on the ground. We will continue to develop this relationship and seek others. We also have working relationships with other InSAR providers and a wide variety of stakeholders on whom we can call, as and when, depending on the direction of the project.

Collaborators and partners on the project:

This project will be undertaken as part of the wider activities of the Engineering Scale Geology Research Group which is run jointly between the Depts of ESE and Civil & Environmental Engineering. There are between 4-6 other PhD students in this group working on a variety of cross-disciplinary projects related to this topic, which involve the use of spaceborne SAR data, drone SAR development, and laboratory experiments.

Further reading:

Essential InSAR background literature

Li, H.-Y. et al., 2025. Fast Dynamic Time Warping and Hierarchical Clustering with Multispectral and Synthetic Aperture Radar Temporal Analysis for Unsupervised Winter Food Crop Mapping. Agriculture, 15, 82. https://doi.org/10.3390/agriculture15010082

Mason, P. J., et al., 2022. Monitoring ground movement at Volcán de Colima, Mexico, using Sentinel-1 data and SqueeSAR®, Quarterly Journal of Engineering Geology & Hydrology, 55(1), https://doi.org/10.1144/qjegh2022-047

Wang, Z., et al.., 2022. Characterizing Micro-Displacements on Active Faults in the Gobi Desert with Time-Series InSAR. Appl. Sci., 12, 4222. https://doi.org/10.3390/app12094222

Scoular, J., et al.., 2022. Are measured InSAR displacements a function of the chosen processing method? Quarterly Journal of Engineering Geology & Hydrology, 55(4), https://doi.org/10.1144/qjegh2022-049

Mider, G., et al., 2020. Monitoring Littoral Platform Downwearing using Differential SAR Interferometry, Remote Sensing, 12(19), p3243, doi.org/10.3390/rs12193243

Scoular, J., et al., 2020. Retrospective InSAR analysis of East London during the construction of the Lee Tunnel. Remote Sensing, 12(5):1-19. doi.org/10.3390/rs12050849

Scoular, J. M., et al., 2019. Limitations of Persistent Scatterer Interferometry to measure small seasonal ground movements in an urban environment, Quarterly Journal of Engineering Geology & Hydrology, 53(1), 39-48, doi.org/10.1144/qjegh2018-160

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Who are we looking for?

We are looking for motivated hard hard-working students with an excellent background in earth science, geophysics, mathematics, or engineering, with some coding skills and an open attitude and willingness to learn computational and/or laboratory methods as needed. Skills developed will include advanced experimental and numerical methods, with extensive training provided.

Successful applicants have a proven aptitude for practical, computational and experimental work, curiosity and a genuine passion for research.

The candidate will have the opportunity to develop their career and profile by presenting at international conferences and publishing in high-impact journals. The projects involve interaction with other research groups within and beyond ESE.