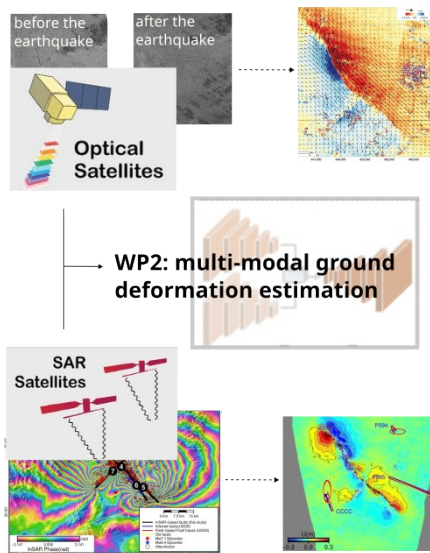


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## **Multi-modal estimation of earth displacement fields using remote sensing and AI: application to earthquakes**

**Motivation:** Accurately estimating the extent and spatial distribution of earthquake-induced deformation is crucial for both disaster planning and advancing scientific understanding. Current remote sensing techniques rely either on satellite *radar*, e.g. *interferometry*, measuring the phase delay between two radar acquisitions, or satellite *optical imagery*, comparing two optical acquisitions separated by weeks or months. While they are complementary, their processing remains up to now independent. Fusing the different modalities in a single framework, instead of estimating the deformation separately, would be beneficiary. Remote sensing allows a dense estimation by producing deformation fields, yet the task is challenging: 1) small displacements (< few meters) compared to the data resolutions, 2) the two acquisitions, before and after the event, are separated by weeks or months, leading to anthropic, vegetation and illuminance changes. ISTERre members have successfully explored how to build a synthetic realistic database for training a deep learning U-net for optical satellite sub-pixel flow estimation [1]. They have also recently investigated an adaptation for amplitude radar (SAR) acquisitions with INRIA [2]. However, earth scientists need to combine different complementary sources, for now *a posteriori*, in order to well estimate the deformation on both near and far-field: optical, amplitude SAR as well as Interferometric SAR. Interferometric SAR can potentially measure millimeter-scale

deformations, yet necessitates to unwrap the phase difference which is most of the time unsolvable close to abrupt ruptures such as faults, and is corrupted by tropospheric delays. On the other hand, optical methods rely on correlation techniques between the two optical acquisitions but the estimated displacement field suffers from the resolution acquisition and the noise between the two acquisitions (vegetation, illumination, anthropogenic).



**Goal:** In this PhD, we want to develop a new multi-modal AI remote sensing deformation estimation, which involves combining recent multi-modality models and optical flow deep learning architectures. The PhD candidate will first incorporate Digital Elevation Models in order to tackle illuminations changes. Then an optical + amplitude SAR model will be built, where the challenge is the acquisition geometry difference. The fusion with InSAR will be the final goal. Though more precise, InSAR suffers from phase ambiguities: the crucial phase unwrapping will thus benefit from a joint estimation. Different machine learning techniques could be developed, derived from U-net convolutional architectures, ML optical flow models (RAFT, SEA-RAFT), remote sensing foundation models, diffusion models.

**Environment:** This PhD is part of the [MOHAIR chaire MIAI Cluster](#), and will thus benefit from the interactions within the Chaire and withing MIAI Cluster. The PhD student will be part of the Institut des Sciences de la Terre (ISTERre), in Université Grenoble Alpes, one of the best and large Earth Science laboratory in Europe. He/She will be supervised by Sophie Giffard-Roisin, an ISTERre permanent researcher specialized in machine learning for natural hazards. Within ISTERre, the student will be part of the Cycle Sismique et Déformations transitoires team, and will also be in interaction with optical and radar geodesy experts (James Hollingsworth, Erwan Pathier, Marie-Pierre Doin). Moreover, the student will be jointly co-supervised by Emanuele Dalsasso, at Institut National de Recherche en Informatique et Automatique (Inria) Grenoble, within the Thoth team. E. Dalsasso is a permanent researcher expert in remote sensing and AI. The PhD student will benefit from the expertise of the Thoth team in remote sensing (Emanuele Dalsasso, Jocelyn Chanussot) and more generally AI and image processing.

**Profile:** We are looking for a candidate with a Master degree in either image processing/machine learning with a strong interest in remote sensing and geoscience applications, or a remote sensing/geoscience degree with a motivation and experience in coding and AI. Because fo the interdisciplinarity of this research project, we are seeking for a mature and autonomous candidate able to understand the geoscience motivations as well as being interested in the technical developments. For more details, contact Sophie Giffard-Roisin ([sophie.giffard@univ-grenoble-alpes.fr](mailto:sophie.giffard@univ-grenoble-alpes.fr)). Applications should be sent by email asap and come with CV, a short motivation in the main body of the email, and academic transcripts and reference contacts if available.

[1] Montagnon, T., Hollingsworth, J., Pathier, E., Marchandon, M., Dalla Mura, M., Giffard-Roisin, S., & Dalla, M. (2024). GeoFlowNet: Fast and Accurate Sub-pixel Displacement Estimation From Optical Satellite Images based on Deep Learning.

[2] Junjie Wang, James Hollingsworth, Erwan Pathier, Tristan Montagnon, Wei Li, Mengmeng Zhang, Ran Tao, Jocelyn Chanussot, Sophie Giffard-Roisin (2025). GeoFlowNet-SAR: Earthquake Displacement Estimation from Synthetic Aperture Radar Images