



# PhD in MODELLI E METODI MATEMATICI PER L'INGEGNERIA / MATHEMATICAL MODELS AND METHODS IN ENGINEERING - 41st cycle

**THEMATIC Research Field: SIMULATION, MONITORING, AND FORECASTING OF NATURAL  
HAZARDS INTEGRATING NUMERICAL AND STATISTICAL MODELLING OF SATELLITE  
DATA**

**Monthly net income of PhDscholarship (max 36 months)**

**1400.0**

In case of a change of the welfare rates during the three-year period, the amount could be modified.

## Context of the research activity

**Motivation and objectives of the research  
in this field**

The present PhD work is to be carried out in the framework of the collaboration project “Tecnologie innovative per lo Spazio” (Innovative Technologies for Space) between Agenzia Spaziale Italiana and PoliMi: <https://www.polimi.it/ricerca/partnership-con-le-imprese-jrp/agenzia-spaziale-italiana>. It focuses on the study, development, and implementation of high-performance methods to assist satellite monitoring of Italian territory and help prevent natural disasters such as landslides and volcanic eruptions, based on the integration of mathematical, statistical and numerical modelling. The main objective is integrating interpretable statistical detachment and susceptibility mapping with efficient Material Point Method (MPM) landslide runout simulation, exploiting satellite Earth Observation (EO) data, and providing probabilistic Uncertainty Quantification (UQ) about the impacts. The techniques and approaches will be then applied to the study of other natural hazards such as lava flows, rockfalls, and flooding.

**Methods and techniques that will be  
developed and used to carry out the  
research**

Starting points are the works of Patane et al. (2025), Fois et al. (2024), and Diquigiovanni et al. (2024). The first one presents a statistical model for the probability of landslide detachment driven by satellite measurements based on heterogeneous Poisson processes and generalized



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|                               | <p>heterogeneous Poisson processes and generalized additive models; the second one illustrates an efficient physics-based numerical model based on material point methods for landslide runout; the third one deals with a probabilistically guaranteed method based on conformal prediction for building prediction bands for space and time varying functions.</p> <p>Sentinel-1/2 and Copernicus Digital Elevation Model provide globally consistent elevation, deformation (InSAR), and vegetation/land distribution. By integrating the statistical and numerical methods with the satellite data above, we expect to create an end-to-end coupled pipeline with Uncertainty Quantification (UQ) that provides probabilistic risk maps with uncertainty attribution. The techniques and approaches will be then applied to other natural hazards such as lava flows, rockfalls, and flooding.</p> <p>References:</p> <p>Patane G. et al. (2025): "An interpretable and transferable model for shallow landslides detachment combining spatial Poisson point processes and generalized additive models." <i>Stochastic Environmental Research and Risk Assessment</i> 39.4: 1723-1740.</p> <p>Fois M. et al. (2024): "A semi-conservative depth-averaged material point method for fast flow-like landslides and mudflows." <i>Communications in Nonlinear Science and Numerical Simulation</i> 138 (2024): 108202.</p> <p>Diquigiovanni J. et al. (2024): The Importance of Being a Band: Finite-Sample Exact Distribution-Free Prediction Sets for Functional Data, <i>Statistica Sinica</i>, 35(2), DOI: 10.5705/ss.202022.0087.</p> |
| <b>Educational objectives</b> | <p>The researcher, upon completion of the PhD, will possess a unique and highly sought-after set of transversal skills in advanced mathematical, numerical and statistical modeling, as well as the ability to collaborate with researchers from other disciplines.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| <b>Job opportunities</b>      | <p>Positions in leading national and international research centers—both in academia and in industry. Consultancy firms or regulatory bodies.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |



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|------------------------------------------|------------------------------------------------------------------------------------------|
| <b>Composition of the research group</b> | 3 Full Professors<br>4 Associated Professors<br>0 Assistant Professors<br>2 PhD Students |
| <b>Name of the research directors</b>    | Prof. L. Formaggia e Prof. S. Vantini                                                    |

| <b>Contacts</b>                                      |
|------------------------------------------------------|
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| <b>Additional support - Financial aid per PhD student per year (gross amount)</b> |    |
|-----------------------------------------------------------------------------------|----|
| <b>Housing - Foreign Students</b>                                                 | -- |
| <b>Housing - Out-of-town residents</b>                                            | -- |

| <b>Scholarship Increase for a period abroad</b> |         |
|-------------------------------------------------|---------|
| <b>Amount monthly</b>                           | 700.0 € |
| <b>By number of months</b>                      | 6       |

| <b>Additional information: educational activity, teaching assistantship, computer availability, desk availability, any other information</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
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| <p>Educational activities (purchase of study books and material, funding for participation to courses, summer schools, workshops and conferences): financial aid per PhD student per year</p> <p>1st year: max 1.902,40 euros<br/>2nd year: max 1.902,40 euros<br/>3rd year: max 1.902,40 euros</p> <p>The PhD students are encouraged to take part in activities related to teaching, within the limits allowed by the regulations. 1 individual PC per student + several shared PC.<br/>Access will be granted to the Department cluster which features 40 CPU nodes and one GPU node. Each CPU node is powered by two 24-core CPUs with 512 GB RAM.<br/>The GPU node includes two 16-core CPUs with 512 GB RAM, and three GPUs, each possessing 64 GB of memory.</p> |