POLITECNICO DI MILANO

# PhD in INGEGNERIA AMBIENTALE E DELLE INFRASTRUTTURE / ENVIRONMENTAL AND INFRASTRUCTURE ENGINEERING - 41st cycle

**Research Area n. 3 - Environmental and Hydraulic Engineering and Geomatics**

**BORSE TEF Research Field: GEOSPATIAL FOUNDATION MODELS IN EARTH OBSERVATION**

| Monthly net income of PhDscholarship (max 36 months) |
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| **1800.0**<br>In case of a change of the welfare rates during the three-year period, the amount could be modified. |

| Context of the research activity | |
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| **Motivation and objectives of the research in this field** | Geospatial foundation models are revolutionizing Earth Observation (EO) by integrating diverse data sources like optical, hyperspectral and mapping data. This research explores their development, fine-tuning, and application to enhance scene classification, object detection, and temporal forecasting. Traditional remote sensing models struggle with generalization, whereas large-scale pretraining and instruction tuning offer greater flexibility and scalability. The growing need for efficient EO analytics in areas such as climate monitoring and disaster response drives this study. AI-powered models can automate complex tasks, reducing reliance on labeled datasets. By transitioning to multimodal AI, these models improve adaptability across spatial, spectral, and temporal dimensions. |
| **Methods and techniques that will be developed and used to carry out the research** | The research assesses existing models, optimizing them for EO-specific challenges. The goal is to refine multimodal alignment, instruction tuning, and deployment strategies. It aims to advance AI-driven EO applications, enhancing geospatial analysis and decision-making. It integrates multimodal machine learning approaches to improve the analysis of EO, utilizing pre-trained vision |

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| | models, large language models, and multimodal fusion techniques. The process begins with preparing and normalizing EO and geospatial datasets, which include multi/hyperspectral imagery, and authoritative and user-contributed geospatial data. These datasets undergo standardization and normalization to ensure compatibility across different sensors. For representation learning, the research employs three primary approaches: supervised learning techniques and contrastive learning methods, used to align vision and language representations, as well as self-supervised learning models to extract meaningful features from unlabeled data. The pre-trained models are then fine-tuned for EO applications. Vision-language models are adapted through instruction tuning, integrating geospatial knowledge to improve classification, segmentation, and object detection. The models are evaluated using benchmark EO datasets, with performance assessed through accuracy, generalization, and computational efficiency.<br>**Gantt:** Analysis of the State of art (Months 1-4); Data Collection and Preparation (M 4-10); Development of Representation Learning Models (M 10-18); Multimodal Fusion (M18-24); Validation and Performance Evaluation (M24 -30); Final model revision and thesis compilation (M 30-36). |
| **Educational objectives** | The research is part of the growing European ecosystem of EO and AI, promoting technology transfer to companies and start-ups active in the field of geospatial services. It opens new business opportunities in the rapidly growing sector of advanced EO data analysis, a strategic market for applications in environmental monitoring, natural resource management, and disaster response. The development of geospatial foundational models, capable of integrating heterogeneous data, enables scalable and adaptable solutions suitable for transformation into innovative products and services. The developed technologies – particularly instructional tuning, multimodal fusion, and self-supervised learning techniques – can be transferred to academic start-ups or spin-offs focused on intelligent geospatial analysis services. Furthermore, the proposed approach reduces |

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| | dependence on labeled datasets, lowering the barriers to accessing advanced AI tools for SMEs, public bodies, and NGOs. The modular and composable nature of the models facilitates integration with commercial or open-source platforms, enabling rapid and customizable Proof of Concept (PoC).The PhD research includes 6 months abroad in centers relevant to the initiative. |
| **Job opportunities** | Academic and Research Positions<br>AI and Earth Observation Companies and Startups<br>Space Agencies<br>Environmental and Urban Planning Departments |
| **Composition of the research group** | 1 Full Professors<br>1 Associated Professors<br>2 Assistant Professors<br>1 PhD Students |
| **Name of the research directors** | M.A. Brovelli, L. Biagi, V. Yordanov |

| **Contacts** |
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| maria.brovelli@polimi.it<br><br>ludovico.biagi@polimi.it<br><br>vasil.yordanov@polimi.it |

| **Additional support - Financial aid per PhD student per year (gross amount)** | |
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| **Housing - Foreign Students** | -- |
| **Housing - Out-of-town residents** | -- |

| **Scholarship Increase for a period abroad** | |
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| **Amount monthly** | 900.0 € |
| **By number of months** | 6 |

| **Additional information: educational activity, teaching assistantship, computer availability, desk availability, any other information** |
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| *Educational activities* (purchase of study books and material, funding for participation to courses, summer schools, workshops and conferences): financial aid per Ph.D. student per year. The Ph.D. course supports the educational activities of its Ph.D. students with an additional funding equal to 10% of the scholarship, starting from the first year. |

*Teaching assistantship*: availability of funding in recognition of support to teaching activities by the Ph.D. student. There are various forms of financial aid for activities of support to the teaching practice. The Ph.D. is encouraged to take part in these activities, within the limits allowed by the regulations.

*Computer availability*: each Ph.D. candidate has their own computer for individual use.

*Desk availability*: each Ph.D. candidate has their own desk, cabinet and locker.