University of Milano-Bicocca
PhD Course in Chemical, Geological and Environmental Sciences
Call for Interest 41st cycle – session I - Curriculum Environmental Sciences

1		**Supervisor**	**Roberto Colombo**
Title	**Modelling snow processes and ice melting by combining field experiments and thermal infrared remote sensing**		

The cryosphere is particularly sensitive to climate variability. Extreme events such as heat wave have the potential of triggering intense surface melting of snow and ice both in polar and alpine areas of the planet. Thus, monitoring the melting dynamics from space is an active field of research nowadays. Recent remote sensing research suggests that Land Surface Temperature (LST) can provide useful information to retrieve snow surface properties such as snow density and to track snowmelt dynamics (Colombo et al., 2023). Although LST can be observed from space, its potential to improve snow and ice observations in alpine regions remains underexplored.

In this context, the main aim of the proposed research is to understand if LST and snow thermal inertia can be used for monitoring spatial and temporal evolution of melting of snow and ice in alpine regions.

In this research, we will use a combination of snowpack physical models (e.g. CROCUS), thermal infrared satellite images, airborne imaging spectroscopy and field/lab experiments. An intensive field campaign in the Alps simultaneously to airborne overpasses is expected to collect snow parameters and spectral data.

This research will be conducted in collaboration with the University Grenoble Alpes in France, where we expect the candidate would spend his/her period abroad.

Supervisor webpage: https://ltda-disat.it/

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2		**Supervisor**	**Claudia Pasquero**
Title	**Mediterranean cyclones: transition to tropical-like cyclones.**		

Classical extratropical cyclones in the Mediterranean region sometimes evolve into tropical-like disturbances, characterized by strong convective activity and more intense rainfall, resulting in a significant increase in the hazard they pose to coastal communities. For those reasons, it is of paramount importance to understand what favors the tropical transition, how it occurs, and whether its occurrence is affected by climate change. Although the increasing sea surface temperature, which boosts evaporation and convective activity, is known to promote intensification of those perturbations, the temperature increase in the upper troposphere stabilizes the atmosphere and disrupts the convective organization. In this research project, the interplay between the different processes that lead to the development of tropical-like cyclones in the Mediterranean region will be investigated using observational data, reanalysis data, and numerical simulations. Expected work allocation: ~15% bibliographic work, ~25% modeling work, 40% data analysis, 20% papers writing. The project will be held in collaboration with external partners (e.g., Caroline Muller from IST Austria, Fabio D'Andrea from ENS Paris, Annalisa Bracco from Georgia Tech).

Supervisor webpage: https://sites.google.com/unimib.it/pasquero

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3		**Supervisor**	**Marco Rotiroti**
Title	**Groundwater recharge assessment in a changing climate**		

Groundwater is a vital source of freshwater, providing a quarter of the world's water needs. Sustainable management of groundwater resources requires a thorough understanding of groundwater recharge processes, which is also necessary to address mitigation and adaptation strategies to climate change.

The aim of this research is to quantitatively assess the recharge to the alluvial aquifers of the Po Plain in the Lombardy region. In addition to the already known process of surface-water-irrigation, which is the main source of recharge to this aquifer, attention will be paid to the mountain-front recharge processes and the infiltration from losing rivers, whose quantitative contribution to recharge is less known. Improved knowledge of aquifer recharge will also support the risk assessment of catchment areas for water abstraction points intended for human consumption, according to the EU Directive 2020/2184.

Quantitative recharge assessment will be based on at least three approaches: (1) end-member mixing modelling based on conservative tracers of groundwater recharge (2) water balance calculations based on discharge measurements and (3) analysis of long time series of groundwater levels measured by regional authorities and/or water supply companies, using advanced statistical and modelling techniques. Field work for water sampling and discharge measurements will account for about one third of the total activities.

A six-month internship at the Complutense University of Madrid (Spain) could support the development of advanced statistical and modelling techniques.

Supervisor webpage: https://en.unimib.it/marco-rotiroti

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4		**Supervisor**	**Sandra Citterio**
Title	**Synergy between plants and micro-organisms in soil phytoremediation: molecular insights into the role of volatile organic compounds**		

One of the most pressing global challenges today is environmental contamination, which poses a serious threat to both human health and ecosystems. The identification and effective implementation of appropriate and sustainable remediation technologies for contaminated sites are therefore essential.

Among nature-based solutions, phytoremediation technologies stand out. These are defined as "the use of green plants and the associated microorganisms, along with proper soil amendments and agronomic techniques to either contain, remove or render toxic environmental contaminants harmless".

Although phytoremediation is not a novel approach, its application remains limited, primarily due to the low bioavailability of pollutants and/or the restricted tolerance of plants to contaminants. This project aims to explore and exploit the potential of beneficial plant-microbe interactions for the remediation of soils contaminated with metals and hydrocarbons. Specifically, the role of volatile organic compounds (VOCs) as signal molecules that modulate plant-microbe interactions in contaminated soils will be investigated to increase plant tolerance to key inorganic and organic pollutants and improve their efficiency in pollutant removal.

The research will be conducted under both laboratory (80%) and field conditions (20%). A combination of biomolecular techniques, including proteomics, microscopy, and flow cytometry, along with chemical methodologies, will be employed.

This research is part of the Horizon project Connect2Green, which will provide financial support. Furthermore, the project will involve collaboration with international institutions within the COST Action: "Root-Benefit network", which focuses on plant symbiosis studies (https://www.root-benefit.eu/). As part of the project, the student will spend one year at one of these partner institutions, such as Ghent University (Belgium).

Supervisor webpage: https://www.unimib.it/sandra-citterio

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5		**Supervisor**	**Maurizio Gualtieri**
Title	**Exploitation of portable sensors for the characterization of citizens personal exposure to air pollutants**		

Air pollution, and especially fine particulate matter ($PM_{2.5}$), is the first environmental leading cause of death, accounting up to 239000 cases in the sole EU (EEA, 2024) considering the WHO guideline on $PM_{2.5}$ of 5 ug/m^3.

Despite the strong association between environmental concentration of air pollutants and epidemiological effects, a significant gap remains in understanding the real exposure at which citizens are subjected, in relation to their personal activities (work, social, leisure etc…).

The use of portable sensors, after a dedicated phase of calibration with reference instruments, also to assess the accuracy of the portable sensors, can help in closing the gap between the overall airborne concentration of pollutants and the identification of personal exposure levels.

To achieve this main objective a population, working or living around the University of Milano-Bicocca (UniMiB), will be selected and, after the collection in an anonymous way basic information such as age, gender, smoking habits, commuting habits, the sensors will be deployed. Each person will be associated with a sensor and the data will be collected over a period of at least one month during each season. The data collected will be then analyzed in comparison to the personal habits collected and to available reference value, such as those from the Environmental Regional Agency, or from data collected with dedicated monitoring campaigns at UNIMIB. For the dedicated monitoring campaign both sampling equipment and high-resolution monitors will be used to obtain reference values and daily variations. The candidate will be asked to spend at least six months abroad.

Supervisor webpage: https://www.unimib.it/maurizio-gualtieri

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6		**Supervisor**	**Sergio Cogliati**
Title	**Advanced Techniques for Solar-Induced Fluorescence Retrieval in Earth Observation**		

Solar-Induced Fluorescence (SIF) is an emerging and powerful indicator in Earth Observation, providing critical insights about vegetation functioning. In recent years, numerous international efforts and new space missions have been dedicated to observing SIF at different spatial scales.

The PhD project aims to evolve current techniques for observing SIF using high spectral resolution remote sensing data acquired from airborne (IBIS) or ground-based (FLOX) VNIR spectrometers during dedicated campaigns. These efforts support the calibration-validation activities and the evolution of scientific products of the upcoming European Space Agency FLEX satellite mission (launch 2026-2027).

Specifically, the research focuses on advancing existing techniques through the use of radiative transfer models of the atmosphere (MODTRAN) and vegetation canopy (SCOPE), employing probabilistic inverse problem theory and/or artificial intelligence methods. The PhD activities include active participation in the design and execution of ground, airborne, and satellite campaigns within national and international projects (20% of the time) on different types of ecosystems (e.g., agriculture, forest).

Additionally, the PhD project includes a six-month period abroad at partner research institutions to complement knowledge and expertise in the field of study. This project applies to open-topic positions and is contextualized within the "FLEX Data Innovation Science Cluster" and "FLEX-ITA - FLEX Inland Water and Terrestrial Airborne Measurements and Scientific Exploitation" projects.

Supervisor webpage: https://www.unimib.it/sergio-cogliati

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7		**Supervisor**	**Roberto Colombo**
Title	**Development of cal/val tools and algorithms for fluorescence retrieval in the context of the FLEX space mission**		

The research activities are part of the FLuorescence EXplorer (FLEX) mission promoted by the European Space Agency (ESA) to generate global maps of vegetation fluorescence that can reflect photosynthetic activity and plant health and stress. In turn, this is not only important for a better understanding of the global carbon cycle, but also for agricultural management and food security. The innovative instrument aboard FLEX will not directly measure photosynthesis but will provide all the essential variables needed to enable its estimation from space to address several scientific and societal challenges. The mission was selected as the eighth Earth Explorer in ESA's Living Planet Programme in 2015. FLEX will fly in tandem with the Copernicus Sentinel-3 mission, working in combination with the OLCI and SLSTR instruments. FLEX is expected to be launched in 2026, with a three-and-a-half-year design lifetime.

The planned activities have a twofold objective. The first objective involves the definition of the validation procedures for the mission's data products, while the second research topic focuses on the development and improvement of algorithms for estimating fluorescence, both from satellite data and from airborne hyperspectral sensors.

The validation component is related to the development of an indirect validation method based on radiative transfer model simulations. In this context, the fluorescence will be simulated at selected sites using radiative transfer models parametrized with high resolution plant trait maps (derived for example from other satellite missions and ground-measured vegetation parameters). This would open to the use of well-characterised sites in terms of vegetation properties where fluorescence measurements are instead not available.

The improved retrieval algorithm will include the modelling of canopy anisotropy and the inclusion of the adjacency effect, and it will be also optimised for airborne instruments. Both aspects aim at providing improved fluorescence retrieval that could be better exploited for the further scientific interpretation of the physiological status of the canopy. For example, toward an improved retrieval of the fluorescence quantum yield and all downstream exploitation of fluorescence products.

Supervisor webpage: https://ltda-disat.it/

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