SUPERVISOR: CLAUDIA PASQUERO	
TITLE	**EFFECTS OF LAND COVER ON EXTREME PRECIPITATIONS**

The project builds upon previous studies on the relationship between land surface properties and precipitation. For instance, the observational and modeling investigations performed in the framework of the international AMMA project showed that precipitations in semi-arid regions are affected by soil moisture gradients, favoring precipitations on drier land next to moister surfaces. The importance of surface gradients has also been studied over the oceans, demonstrating that precipitations are favoured over strong sea surface temperature fronts. Current studies are also indicating that extreme precipitations in urban areas have been increasing over the last few decades more than in rural areas. These studies indicate that the reasons at the base of the generally observed increase in occurrence and/or intensity of heavy rainfall events might be both related to global climate change and to local land use change. Discovering under what circumstances one of the two processes dominates is of paramount importance for policymakers and administrators, in order to tackle the problem in the correct way and reduce risks associated to strong meteorological events.

In this project, high resolution precipitation and land surface properties datasets will be analysed to investigate the presence of links between land cover and its gradient with extreme precipitations. Based on the results of this data analysis part, physical hypothesis on the possible mechanisms at play will be formulated, most likely involving surface fluxes, boundary layer dynamics, and stability of the air column. In the second part of the PhD, high resolution numerical modelling tools will be used to test the hypothesis and study the sensitivity to large scale climatic conditions (such as, for instance, sub-tropical vs mid- and high-latitude settings). The project will be performed in collaboration with the Ecole Normale Superieure in Paris, where the PhD student is expected to spend 12 months. It is foreseen that a joint PhD agreement (co-tutelle) will be signed by the two Universities, with the possibility of awarding two PhD degrees.

More info on the research group can be found at https://sites.google.com/unimib.it/pasquero.

SUPERVISOR: DANIELA BASSO	
TITLE	**CALCAREOUS RED ALGAE AS MEDITERRANEAN HABITAT ENGINEERS**

Calcareous red algae Corallinophycidae and Peyssonneliales are the most important groups of Mediterranean habitat engineers. They play a fundamental role in building the physical structure of two among the most important Mediterranean habitats: the Coralligenous algal reefs and the rhodolith beds. These calcareous bioconstructions are hotspots of biodiversity, provide many economically significant ecosystem services and are target of protection at a global scale. Nevertheless, they are still insufficiently known, and the modern molecular investigations showed an unexpected biodiversity that do not match morphological descriptions, while ultrastructural studies of the cell walls reveal promising implications. The present-day Mediterranean bioconstructions are Holocene in age and they record the climatic and oceanographic fluctuations of this epoch. They play an important role in modeling the future consequences of the ongoing rise in temperature and marine acidification.

The doctoral project is aimed at investigating the present-day and Holocene biodiversity of the coralligenous algal reefs, also in the context of conservation paleobiology. Material collected at several localities of the Mediterranean will be investigated with a multi-scale approach. A conceptual framework for understanding tempo and mode of algal bioconstruction and species distribution and ecological significance is one of the main targets.

Specimens collected alive will be studied in the frame of integrated taxonomy, involving both molecular and morphological characterization. The latter will be obtained by a suite of techniques, including the preparation of decalcified sections, Optical and Scanning electron microscopy (SEM). The Holocene material will be observed on thin sections and SEM. These observations will be interpreted on the base of the geological, ecological, and human-derived factors controlling the marine environment.

Periods abroad may include a 6 month stay in France (MNHN, Paris) for improving the techniques of molecular investigations, depending on the skills of the candidate. Other international collaborations are planned with KAUST (Saudi Arabia) and Griffith University (Australia).

SUPERVISOR: ISABELLA GANDOLFI	
TITLE	**ROLES OF CORAL-ASSOCIATED MICROBIOMES IN CORAL HEALTH, CONSERVATION AND RESTORATION**

In the last 15 years, it has clearly emerged that corals, in addition to the the well-known eukaryotic Symbiodiniaceae family, are associated with complex microbiomes, formed by hundreds or thousands different taxa of highly diverse bacteria. There is strong evidence that some of these microorganisms play critical functional roles in the coral holobiont, through functions including e.g. photosynthesis, protection against pathogens, nitrogen and sulfur cycling. Moreover, the study of coral-associated microbiomes has emerged as an extremely important research field for their key role in the health of corals and their potential response to environmental pressures, especially in a scenario of rapid environmental changes. It can be therefore hypothesized that a deeper understanding of assembly processes and functional roles of coral microbiomes will play a role also in coral conservation and restoration. However, at present knowledge about coral microbiomes is still scarce.

This project aims at expanding knowledge about taxonomic and functional diversity of microbiomes associated to corals that are found in different geographic, climatic and health conditions. Research will be especially focused on aspects related to coral conservation and restoration, e.g. how coral microbiomes are modified by bleaching and illnesses; how microbiomes develop over coral life in restoration interventions; how coral health can be preserved and/or recovered by probiotic use. Moreover, relations of microbiomes with interstitial associates (macrobiomes) may be explored as a further source of interactions that can alter coral fitness and their ability to survive in a changing environment.

Coral microbiomes will be deeply characterized through molecular methods, mainly the high-throughput sequencing platform Illumina MiSeq. Particular attention will be paid to the development of standardized protocols for sample handling and preparation, which are still lacking. Potential functions of coral microbiomes will be evaluated also with quantitative and semi-quantitative methods (e.g. qPCR).

Possible collaborations are envisaged with foreign universities, e.g. King Abdullah University of Science and Technology (KAUST), where the Ph.D. student may spend a period abroad.

SUPERVISOR: LEONI BARBARA	
TITLE	**THE INFLUENCE OF PLASTIC POLLUTION ON BIODIVERSITY OF FRESHWATER BODIES**

Plastic pollution of freshwater ecosystems is increasingly recognized as widespread and growing issue however less information is known about their influence on ecological processes. Plastics can have potentially negative effects on aquatic organisms and food-webs, but they can also serve as a surface for biofilm growth, known as the "plastisphere".

The project's objective is to examine how plastics affect the aquatic food web and ecosystem functioning by conducting experiments on their interaction with microorganisms, especially microalgae. The overreaching goal is to understand whether plastics and microplastics represent a new niche in aquatic systems for microalgal and microbial community and determine whether their presence can trigger effects throughout the food web with potentially detrimental effects for freshwater cosystems. The project addresses the impact of plastic pollution on river metabolism (i.e., primary productivity), providing a more comprehensive framework for understanding the overall effect of plastic pollution. At the same time, it allows obtaining information that is highly relevant for management actions, which should be informed about the implication of the presence of plastic pollution and which can consequently take actions devoted to safeguarding river ecosystems and their functionality. The project will be developed in different water bodies around the world.

To achieve the aforementioned objectives, field experiments will be performed to evaluate the colonization by microalgae of plastics with different polymeric composition and the subsequent effects on primary productivity. Plastic substrates will be deployed or collected in different types of waterbodies. On samples, CHL-a, biodiversity characterization (based on genetic and morphological features) and primary production rates will be evaluated.

The project will be developed in collaboration with Prof. Sudeep Chandra (University of Nevada-Reno, United States) and several researchers in UE (Polland, Spain, Austria, Germany). The phD student will spend a period of at least 6 months abroad.

SUPERVISOR: MARINA LASAGNI	
TITLE	**CARBONACEOUS AEROSOL IN MOUNTAIN REGIONS AND CLIMATE IMPLICATIONS**

Introduction: Atmospheric aerosol affects climate through several pathways. Aerosols can scatter/absorb incoming radiation and cool/warm the atmosphere. After deposition, absorbing aerosol species alter snow and ice albedo, modifying the surface energy budget. Acting as cloud condensation and ice nuclei (CCN and IN), aerosol particles change cloud formation and cloud optical properties, contributing to short-wave and long-wave radiation scattering and absorption. Investigating the properties of atmospheric aerosol in mountain regions (high altitude sites) is challenging, but essential to understand aerosol atmospheric ageing, aerosol transport mechanisms, and aerosol climate regional impacts on these fragile environments.

Project objectives: Chemical and physical characterization of carbonaceous aerosol (organic aerosol and black carbon) in a high altitude site of the Italian Alps.

Project activities: Sampling of atmospheric aerosol in a high altitude observatory. Analysis of on-line measurements of aerosol size distribution and optical properties. Off-line chemical characterization of organic aerosol and black carbon with different analytical techniques for bulk and single particle analysis.

Possible international collaborations and periods abroad: International collaborators will include Paul Sherrer Institute – Switzerland (leader of atmospheric measurements at the Jungfraujoch observatory) and Instituto Geofísico del Perú – IGP (leader of atmospheric measurements at the Huaytapallana Observatory in the Andes). A period of collaborative research at PSI could be offered.

SUPERVISOR: EMILIO PADOA-SCHIOPPA	
TITLE	**BIODIVERSITY AND ECOSYSTEM SERVICES IN URBAN FORESTS AND GREEN AREAS**

Urban forests are fundamental elements for the provision of ecosystem services (ES). However, the management of the elements that make up urban forests can strongly influence their functioning, and therefore the conservation of the associated biodiversity and the ES provided. The aim of this project is to investigate the biodiversity associated with green areas in an urban environment, to understand which are the factors that determine it, and to study the associated ecosystem services, in order to provide useful management indications. The Ph.D. candidate is required to explore innovative approaches to evaluated several ES (as example, carbon stock, pollination, pollutants removal, cultural services ...) and to contribute to disentangle the linkages between urban biodiversity and ecosystem services provision. As innovative approaches we will consider a combination of study techniques, such as e-DNA, use of drones, Habitat-tree approaches (just as examples), focus groups and single interviews, that can improve the knowledge on ES and biodiversity in urban areas. that Both theoretical a practical (management) aspects will be considered into the research. The urban green areas and forests of Milan will be one the case studies, other examples outside Italy will be part of the research, accordingly with cooperation that will be established with other research groups.

SUPERVISOR: CHIARA URANI	
TITLE	**ENVIRONMENTAL METAL CONTAMINATION, NEUROTOXICITY AND NEURODEGENERATION: WHICH IS THE INTERPLAY?**

Background - The contamination of different environmental matrices (soils, water, and air) poses serious concerns for human health. Among contaminants, the metals need particular attention for their spread, persistence, and bioaccumulation in organisms. Epidemiological and environmental data suggest a role played by metal exposure through inhalation (particulate matter) and ingestion (contaminated food and water) to an increased risk of developing neurological disorders, such as the amyotrophic lateral sclerosis (ALS). Only around 10% of ALS cases are related to genetic mutations; the remaining 90% are related to environmental factors, or to an interplay between the environment and genetic causes. Studies in the past two decades have highlighted possible roles of metals, ionic homeostasis dysregulation, and oxidative stress in neurodegeneration (de Jesus and Zezzi Arruda, 2020; Tesauro et al., 2020).

That said, two questions arise leading to knowledge gaps to be filled: 1) which is the role played by environmental factors, and particularly, by the metals in ALS pathogenesis, and 2) which are the mechanisms and pathways dysregulated that lead to neurotoxicity and neurodegeneration.

Project aims - This project aims at: i) the identification and characterization of metal contamination in areas with high anthropic impact and incidence of ALS; ii) the study of essential and non-essential metals' role and mechanisms in processes of neurotoxicity and neurodegeneration, with particular attention to ALS; iii) the identification of possible correlation between sources of exposure and neurotoxicity.

Project activities - The research work will comprise the following integrated and complementary approaches:

1) Collection, elaboration, and analyses of data related to metal contamination in different environmental matrices.

2) Biological investigations using cell models for mechanistic and possible recovery studies of neurotoxic metals' effects.

3) Analytical analyses (e.g., ICP-MS) for metal accumulation in biological systems to be related to dysregulated processes, and to be possibly correlated to environmental and/or occupational exposure and to personal habits.

The project has components of environmental data analyses, to be supported and integrated with biological and analytical experimental work.

This project will be developed within the existing interdisciplinary collaboration with the ALS Centre, Department of Neurology-Maggiore della Carità University Hospital (UPO University, Novara), the University of Milan, and the Interuniversity Research Centre MISTRAL. In addition, the ETT company will contribute to this project providing its knowledge and skills in the field of in vitro neurotoxicology and will make available the technical equipment and platforms for reaching the project's goals. The candidate is expected to spend a period abroad at the Thomas Jefferson University, Philadelphia USA.

SUPERVISOR: ELISA MALINVERNO	
TITLE	**GLACIAL-INTERGLACIAL OCEAN PRODUCTIVITY CHANGES IN THE SOUTHERN OCEAN**

The Southern Ocean plays an important role in the climate system, and in particular on the ocean-atmosphere CO_2 exchange. The Antarctic Circumpolar Current (ACC), the world's strongest zonal current system, driven by strong westerly winds, connects all three major ocean basins of the global ocean and therefore integrates and responds to global climate variability. Three major ACC oceanographic fronts occur from north to south in the Southern Ocean and are characterized by major changes in water mass properties and associated plankton assemblages. Sampling of long sediment cores in the Pacific sub-antarctic zone, performed during IODP-383 Expedition, allows tracking the shift in the oceanographic fronts that occurred along with glacial-interglacial climatic changes, through the analysis of multiple proxies based on both calcareous and siliceous biogenic fractions as well as lithogenic components.

We want to investigate the Plio-Pleistocene dynamics of the ACC in the South Pacific, focusing in particular on the changes in phytoplankton productivity. The target is on coccolithophores, microscopic planktonic algae that produce micron-sized calcite plates called coccoliths. After cell death, coccoliths sink to the seafloor and become part of the sediment sequence: they reflect the living assemblage composition at each time and are therefore a proxy for their past productivity, related to oceanographic conditions.

The main work consists in the production of a dataset of coccolith assemblage variation along the investigated cores and will include laboratory preparation techniques for quantitative analysis and microscope counts. This main analysis will be complemented with the study of geochemical proxies associated to coccolithophore paleo-productivity, such as Sr/Ca measurements. The data will be integrated with other proxies analysed within the IODP-383 science group.

Within the framework of IODP-383 project, several collaborations have been established and a period abroad can be planned for the analysis of various proxies. In particular, one well-established collaboration is with Dr. Saavedra-Pellittero at the University of Portsmouth, UK, for SEM-based coccolith analysis and Sr/Ca analyses.

SUPERVISOR: SANDRA CITTERIO	
TITLE	**SOIL PHYTOREMEDIATION: EXPLORING THE MOLECULAR MECHANISMS ON THE BASIS OF PLANT-MICROBE INTERACTIONS**

Nowadays, one of the most concerning issues that the world is facing is environmental contamination that is endangering human health and the ecosystem. The identification and proper implementation of suitable technologies for the remediation of contaminated sites is, thus, a prerequisite for sustainable development. Among nature-based solutions, there are phytoremediation technologies, 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 new technology, its application is still limited, in particular, due to the low bioavailability of pollutants and/or the limited tolerance of plants to contaminants. This project aims at exploring and exploiting the potential of plant-microbe interactions for the remediation of soils polluted by metals and hydrocarbons. These beneficial plant symbiotic relationships with microorganisms and fungi lead to a number of benefits such as the promotion of plant growth and the mobilization of nutrients that are not readily available to plants. Recently, it has been shown that this positive interaction is often mediated by the release of volatile organic compounds (VOC). However, a few studies are available on the role of VOCs as signaling molecules during plant–microbe interactions in contaminated soils. In the project the role of VOC in enhancing plant tolerance to major inorganic and organic pollutants and in improving plant efficacy to remove pollutants from soils will be specifically examined. Experiments will be undertaken under laboratory and field conditions. Biomolecular techniques, including microscopy and flow cytometry, along with chemical methodologies, will be applied. The project will involve foreign institutions active in the study of plant symbiosis.

SUPERVISOR: PATRIZIA BONFANTI	
TITLE	**CHEMICAL NATURE, MORPHOLOGY, AND PERSISTENCE AS DETERMINING FACTORS IN THE TOXICITY OF BIO-BASED NANOPARTICULATE SYSTEMS USING ZEBRAFISH**

The PhD project targets the yet only partly understood connection between the chemical nature, the morphology, and the persistence of nanoparticles and their toxicity to organisms.

While nanoparticles and their production represent an emerging trend thanks to the unique features that are offered by the nanoscale as such for various applications, concerns grow regarding especially the long-term toxicity of nanoparticles. Looking in more detail into the various nanoparticle types described in the scientific and patent literature, clear differences can be seen in terms of the nanoparticle chemistry, morphology, and stability as function of the materials and processes used for their production. Differences are expected to directly translate into significant differences in the toxicological profiles of the nanoparticles for organisms.

Within the PhD project, various types of nanoparticles will be generated, ranging from benchmark systems to particles realised on the basis of renewable resources, such as to build up a representative library of particle systems with gradually changing morphology, ranging from persistent systems to particles that disintegrate in a few hours. The toxicological effects of the various systems will be tested using the Zebrafish model, i.e., early life stage up to 120 hpf, within the Zebrafish facility newly established at the DISAT, applying a range of standard biological analyses including i) imaging suitable to delineate the particle bio-interaction; ii) effects on the neurodevelopment and behaviour of the embryos; iii) potentially altered gene expression and iii) effects on morpho-functional aspects. The aim of the transdisciplinary PhD project, placed at the interface of material science, applied chemistry, and applied biology, is to device a practical standard protocol for mapping environmental nanoparticle toxicology and to delineate a series of key factors that allow to a priori estimate toxicological aspects of newly generated nanoparticulate systems. The insights are used to establish practical guidelines for the choice of the materials for generating environmentally benign and health promoting nanoparticulate systems

SUPERVISOR: SERGIO COGLIATI	
TITLE	**DEVELOPING ADVANCED STRATEGIES FOR CALIBRATION/VALIDATION ACTIVITIES IN THE FRAMEWORK OF ESA'S FLEX SATELLITE MISSION AND IMAGING SPECTROSCOPY SATELLITES**

Remote sensing provides a unique opportunity to map in space and time several biochemical and structural parameters of the terrestrial vegetation (e.g., leaf area index, chlorophyll content etc.) and to infer physiological processes such as the solar-induced fluorescence (SIF). The knowledge of these variables is crucial to quantify the vegetation status and allows performing different applications encompassing precision farming and photosynthesis studies, as example.

The advent of high-performance and compact instruments operated aboard of drone platforms offer unprecedent observations with high spatial and temporal resolutions of the investigated target. These observations prompt novel studies and could greatly support the calibration/validation (cal/val) and interpretation of satellite measurements. Furthermore, the integration of data collected by optical imaging spectrometer with LiDAR instruments, recently available from the Geo-Environmental Measuring and Monitoring from multiple plAtforms (GEMMA) Laboratory, represent a valuable approach to improve the Earth surface characterization. Imaging spectroscopy primarily provides quantitative insights about vegetation biochemistry, while LiDAR measurements offer information on vegetation canopy structure. However, drone measurements require dedicated processing workflow to account for the specific measurement set-up, but also novel methods to fully exploit and interpret the data. In this regard, Radiative Transfer (RT) models represent a valid support for linking remotely sensed data to the surface parameters, especially 3D models (i.e., Discrete Anisotropic Radiative Transfer, DART) that well describe complex geometric scenes and could strongly support the interpretation of high-resolution data on heterogenous scenes.

In this context, the research project aims to develop a novel method to detect vegetation parameters and SIF from the synergistic exploitation of imaging spectroscopy, LiDAR and thermal data collected in different experiments from drone platforms and by using the state of the art of physical RT models. The main goal is to set up an operational procedure to map spatial and temporal variability of vegetation parameters in selected sites and to make a comparison with satellite retrievals for cal/val activities. This study will be conducted in

experimental sites and in the framework of new space missions promoted by the European Space Agency (ESA) and by the Italian Space Agency (ASI).

The activity will include the participation to field surveys at national/international level, the processing of remote sensing and drone data, and development of dedicated retrieval algorithms. Collaborations with abroad universities and research institutes are foreseen during the project.