



PhD in INGEGNERIA DELL'INFORMAZIONE / INFORMATION TECHNOLOGY - 38th cycle

Research Area n. 3 - Systems and Control

**PNRR_351_PUBBL_AMMIN Research Field: MULTI-SCALE FORECAST-BASED DIGITAL
PLATFORM TO SUPPORT EFFICIENT AND RESILIENT WATER MANAGEMENT
STRATEGIES UNDER GLOBAL CHANGE**

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 main research objective of the PhD will be to investigate how to best support Public Administration (PA) bodies in ensuring a more efficient and resilient management of water resources systems under changing and more challenging climate conditions. This is urgently needed in order to increase these systems' resilience with respect to the increasing frequency and intensity of extreme hydrometeorological events, as recently seen during the current drought season and the extreme dry events of the last decade. Not only drought events but also floods are challenging the water system performance with increased water stress conditions and large economic impacts for several stakeholders, including agricultural districts and hydropower companies.

The specific operational objective is to develop a digital platform for the real-time strategic management of water resources using leading-edge multi-time scale forecasts (from few hours to several months ahead). The main case study focus will be on the operation of multipurpose Lake Como, operated by Consorzio dell'Adda balancing flood and drought impact. In particular, this will be done by coupling the most advanced forecast products after downscaling and bias-adjustments, with advanced robust



	<p>multi-objective control methods, both off-line and online. The platform will include a tool based on Machine Learning techniques that will be developed for the selection of the optimal forecast lead times and observational variables that will be tested for the real-time lake operation.</p> <p>This innovative PhD will cover the CUN Disciplinary Area 09 - Industrial and Information Engineering and will be multi-disciplinary in nature involving control theory, environmental decision analytics, hydrology, meteorology, and climate science. The PhD fully meets the priorities of Italy's National Recovery and Resilience Plan (PNRR), as it is aimed at fostering the digital transition of PA bodies, contributing to the redesign and simplification of organizational models, as well as to the processes of selection and adoption of the most suitable digital technologies and solutions, to ensure greater effectiveness, efficiency, and economic value of PA actions.</p>
<p>Methods and techniques that will be developed and used to carry out the research</p>	<p>State-of-the art Control Algorithms (e.g. Direct Policy Search, Model Predictive Control) will be integrated with novel Machine Learning methods (e.g. input variable selection, deep learning) for the selection of the most valuable information to support operational decisions. The candidate data (precipitation, temperature, snow water equivalent, streamflow) will include local observations and operational forecasts, as well as global datasets that are publicly available, including sub-seasonal and seasonal hydro-meteorological forecasts, sea surface temperature and indices of global oscillations (e.g. ENSO, NAO).</p> <p>The multi-time scale hydrological forecasts will include the operational extended-range and seasonal ensemble forecasts of the European Flood Awareness System (EFAS, https://www.efas.eu/en) run at the European Centre for Medium-Range Weather Forecasts (ECMWF) as part of the Copernicus Emergency Management Service of the European Commission (EC). As the hydrological model used in EFAS is not currently calibrated in the Adda River Basin upstream of Lake</p>



	<p>Como, the collaboration with ECMWF, the Joint Research Centre (JRC) of the EC, and Consorzio dell'Adda in the project will help move towards a possible local re-calibration. Bias-adjustment techniques will be used to correct the forecasts. The improvements in the prediction of the inflows to Lake Como will be evaluated with user-oriented skill scores and event-based metrics, like the probability of detection of drought and flood events at different lead times.</p>
<p>Educational objectives</p>	<p>The doctoral program offers advanced training organized in three pillars:</p> <ol style="list-style-type: none"> 1. Basic Research, which includes methodological courses related to key aspects of theoretical and applied research in science, policy, and technology of sustainable change. 2. Specific Research, designed to strengthen candidates' knowledge on specific topics aligned with their research interests and increase their presence in the international scientific community through participation in conferences and presentation of their scientific work in academic contexts. 3. Development of the Doctoral Thesis, which allows candidates to develop leading-edge research competencies and produce original scientific work on a topic that contributes to scientific debate and has societal impacts. <p>For this PhD, the Basic and Specific Research training will cover multi-disciplinary subjects in applied hydro-meteorological forecasting, optimal control theory, environmental decision analytics, machine learning and big-data analytics. The whole program will be oriented towards the integrated development of knowledge and skills to foster the digital transition of PA bodies and to design digital enabling solutions for the management of water resources systems under climate change. A period of study in worldwide most recognized research institutions is supported by the doctoral school and the supervisor; for this PhD, this will involve a 6-month visiting period at the European Centre for Medium-Range</p>



	Weather Forecasts (ECMWF) and a short research visit at the Joint Research Centre (JRC) of the European Commission.
Job opportunities	The PhD graduates will be equipped with distinctive skills and advanced trans-disciplinary knowledge that will open up career opportunities as analysts or planners at regulatory authorities, policy institutions, PA and other public bodies, or researchers in universities, international research centers, public and international institutions, and R&D departments.
Composition of the research group	1 Full Professors 1 Associated Professors 19 Assistant Professors 6 PhD Students
Name of the research directors	A. Castelletti, M. Giuliani, L. Bertoli

Contacts	
Prof. Andrea Castelletti, Prof. Matteo Giuliani, Ing. Luigi Bertoli andrea.castelletti@polimi.it 0223993584 https://www.ei.deib.polimi.it/	

Additional support - Financial aid per PhD student per year (gross amount)	
Housing - Foreign Students	--
Housing - Out-of-town residents (more than 80Km out of Milano)	--

Scholarship Increase for a period abroad	
Amount monthly	700.0 €
By number of months	6

National Operational Program for Research and Innovation	
Company where the candidate will attend the stage (name and brief description)	Consorzio dell'Adda
By number of months at the company	6
Institution or company where the candidate will spend the period abroad (name and brief description)	European Centre for Medium-Range Weather Forecasts (ECMWF)
By number of months abroad	6

Additional information: educational activity, teaching assistantship, computer availability, desk availability, any other information

**PUBLIC ADMINISTRATION WHERE THE CANDIDATE WILL ATTEND THE STAGE**

Consorzio dell'Adda (<https://www.addaconsorzio.it/>) is a public (non-economic) body established in 1938 for the "construction and management of the Lake Como regulation dam" and is supervised by the Ministry of the Ecological Transition of Italy. The candidate will carry out 6 months of activity: 1 initial month for the collection of requirements and specifications related to the development of the digital platform; 5 months for the development and testing of the platform. The research group has been actively collaborating for several years with Consorzio dell'Adda in the context of national and international projects, including TwoLE (Fondazione Cariplo), So-WATCH (Fondazione Cariplo), ADDApt (Regione Lombardy), GONexus (H2020).

INSTITUTION OR COMPANY WHERE THE CANDIDATE WILL SPEND THE PERIOD ABROAD

The European Centre for Medium-Range Weather Forecasts (ECMWF, <https://www.ecmwf.int/>) is an intergovernmental organization supported by 20 European Member States and 14 Co-operating States, which carries out a dual activity of research center and 24/7 operational service producing global numerical weather predictions, hydrological forecasts, and other environmental and climate data. ECMWF provides data to the national hydro-meteorological services of the Member and Co-operating States, to the scientific community and to the broader community of users of public and private climate services. The research activities will be carried out in collaboration with the Copernicus Emergency Management Service (CEMS) group and the Forecasting Department (Prof Florian Pappenberger). The candidate will carry out 6 months of activity at ECMWF: 1 month for the acquisition of multiscale forecasts for the study area; 5 months for downscaling, post-processing and bias correction of the forecasts to make them usable by the management platform for the case study of Lake Como. The research group has been actively collaborating for several years with ECMWF in the context of international projects, including IMPREX, and CLINT (H2020).

EDUCATIONAL ACTIVITIES (purchase of study books and material, including computers, funding for participation in courses, summer schools, workshops and conferences): financial aid per PhD student 5.707,13 Euro per student

TEACHING ASSISTANTSHIP: (availability of funding in recognition of supporting teaching activities by the PhD student) There are various forms of financial aid for activities of support to the teaching practice. The PhD student is encouraged to take part in these activities, within the limits allowed by the regulations.

COMPUTER AVAILABILITY: individual use

DESK AVAILABILITY: individual use