Ph.D. in Information Technology
Thesis Defenses

March 3rd, 2022
at 16:00
online by Zoom

Angelo CARLINO – XXXIV Cycle

Decision-making under uncertainty for complex socio-environmental systems

Supervisor: Prof. **Andrea Castelletti**

Abstract:

Environmental system models used to examine and provide answers to the grand policy challenges affecting our society and its relationship with the environment are often relying on simplifying assumptions to deal with the deep uncertainty involved in their dynamics and evolution. Indeed, the most common approaches assume a reference, or a set of multiple reference scenarios, to study potential policy solutions to the issue examined under the assumption of perfect foresight, an approach called scenario analysis or scenario planning.

This flaw also affects two types of models crucial for the next decades of policymaking: integrated assessment of climate change and long-term energy system planning models. In this work, focusing on those two categories of models, we remove this assumption, and we focus on how to effectively deal with uncertainties of different nature, i.e., stochastic, parametric, and structural, by adopting and refining existing methodologies for decision-making under uncertainty.

In particular, we examine how adaptive decision-making via multi-objective optimal control can help reduce conflicts between multiple climate policy targets in DICE, a well-known cost-benefit integrated assessment model of climate change, and in RICE50++, an extension of RICE, the regionalized version of DICE, considering 57 individual economic agents taking climate relevant decisions.

For what concerns energy system planning models, we focus on the impact of different socio-economic and hydroclimatic uncertainties on power capacity expansion strategies. After providing evidence of the need for an adaptive approach also in this domain, we employ robust optimization to develop a methodology that allows including uncertainty and adaptation to the realization of uncertainty in an open-source energy system model.

Results show that accounting for uncertainty with coherent methodologies results not only in improved realism of the decision-making process but also in a clearer understanding of how to deal with and leverage uncertainties to produce satisfying performance across multiple dimensions over a broad range of future scenarios.

Marco TANGI – XXXIV Cycle

Dynamic Sediment Connectivity Modelling for Strategic River Basin Planning

Supervisor: Prof. **Andrea Castelletti**

Abstract:

Rivers sediment (dis)connectivity is a distributed property of river networks, emerging from numerous sediment transport processes across the entire network and their interactions in time and space. Anthropic activities have profoundly altered river sediment transport, and the resulting impacts range from delta shrinking and banks instability to ecosystem degradation in the river and on the connected floodplains. Typically, the evaluation of sediment (dis)connectivity degradation is performed at the local scale, ignoring the basin-wide implications on the network morphology and the cumulative effects of multiple alterations. The research in this thesis focuses on developing network-scale sediment (dis)connectivity models for sediment processes characterization, anthropic alteration impact assessment and strategic reservoir planning and management.

The main achievement is the development of D-CASCADE, a dynamic, network-scale sediment (dis)connectivity model. The framework traces sediment delivery and transport patterns across time and space, allowing for more thorough representation of sediment (dis)connectivity and detailed representation of channel morphodynamic response to sediment delivery alterations.

D-CASCADE represents an important tool for strategic and sustainable planning and management of multiple human infrastructures on river systems. In this research, we focused on water and sediment management in reservoirs, and demonstrated the potential of D-CASCADE to quantify the spatio-temporal effects of dam operations, both locally, e.g, reservoir storage losses due to sedimentation, and on the broader river sediment (dis)connectivity.

The model network-scale scope allows for the representation of multiple reservoirs on the same system, and the evaluation of the changes in the cumulative effects on sediment transport given by different design and timing of reservoirs management strategies.

The new model presented is designed to be integrated in optimization-based framework for strategic reservoir management, to evaluate optimal trade-off between more traditional objectives like hydro-power production and irrigation demand, and the conservation of natural sediment (dis)connectivity.

PhD Committee

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