EGU GENERAL ASSEMBLY 2020 – EGU2020-6877

Forecast-informed operation of transboundary water-energy systems: a case study in the lower Mekong Basin

HS5.1.1 Water resources policy and management – forecast and control methods

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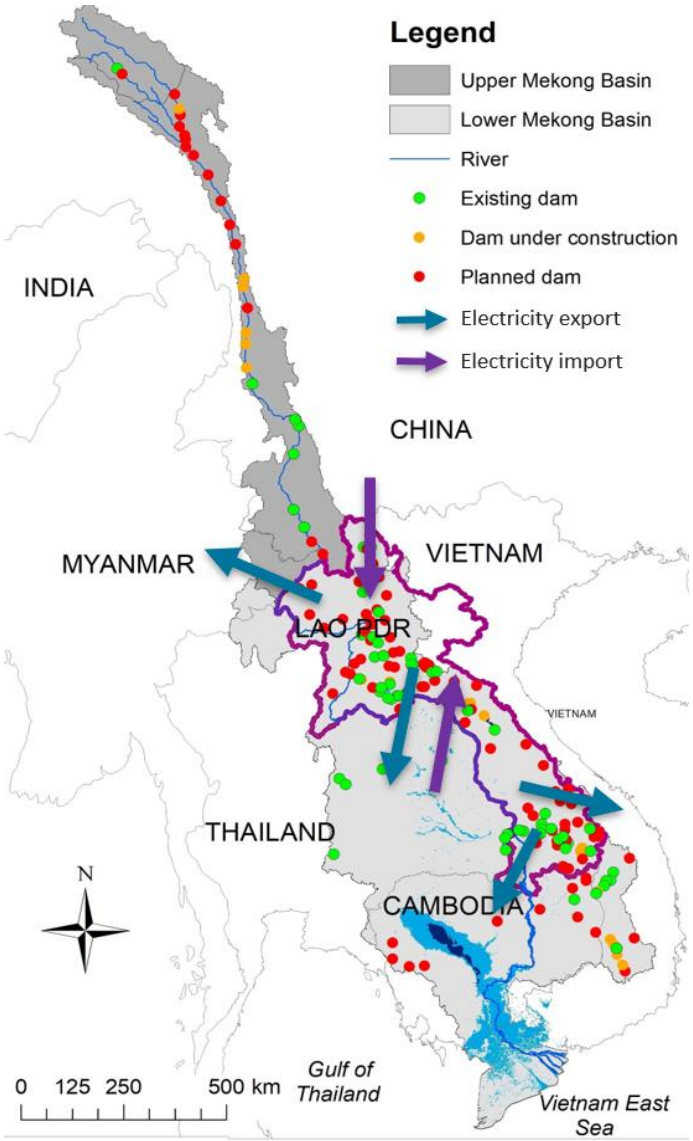
Study area: Mekong River basin



The Mekong River basin

- The whole basin is shared by six countries
- 60 millions people living in the lower basin
- The Mekong's fisheries have a retail value of ~US$4 billion

More than 100 dams have been built in the past decades. They are altering hydrological regimes, sedimentation processes, and ecological systems.

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Review papers

Hydropower dams of the Mekong River basin: A review of their hydrological impacts

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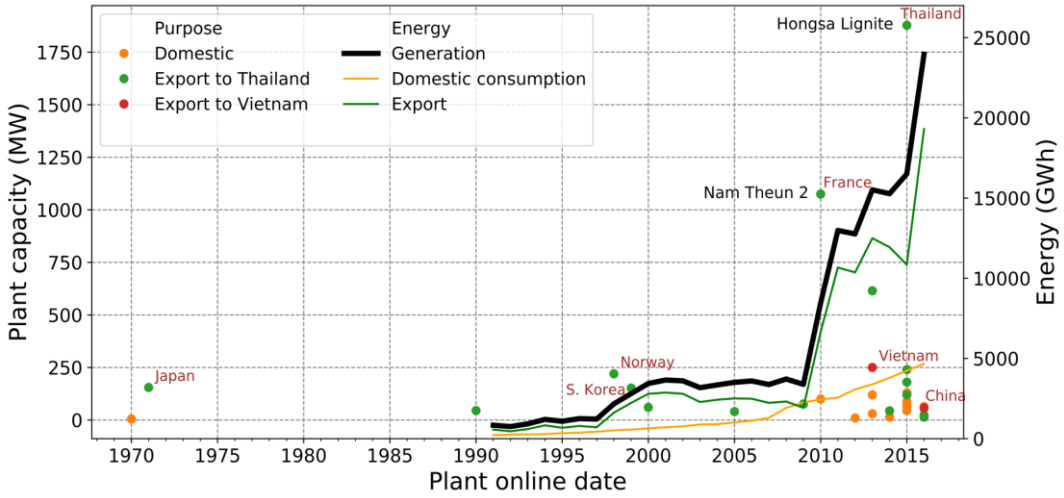
ABSTRACT

Hydropower production is altering the Mekong River basin's riverine ecosystems, which contain the world's largest inland fishery and provide food security and livelihoods to millions of people. The basin's hydropower reservoir storage, which may rise from ~2% of its mean annual flow in 2008 to ~20% in 2025, is attenuating seasonal flow variability downstream of many dams with integral powerhouses and large storage reservoirs. In addition, tributary diversions for off-stream energy production are reducing downstream flows and augmenting them in recipient tributaries. To help manage tradeoffs between dam benefits (hydropower, irrigation, flood control, domestic water supply, and navigation) and their consequences for livelihoods and ecosystems, we review observed and projected impacts on river flows along both the Mekong mainstream and its tributaries. We include the effects of diversions and inter-basin transfers, which prior reviews of flow alteration in the Mekong basin have largely neglected. We also discuss the extent to which concurrent changes in climate, water demand, and land use, may offset or exacerbate hydropower-induced flow alteration. Our major recommendations for

Study area: Mekong River basin

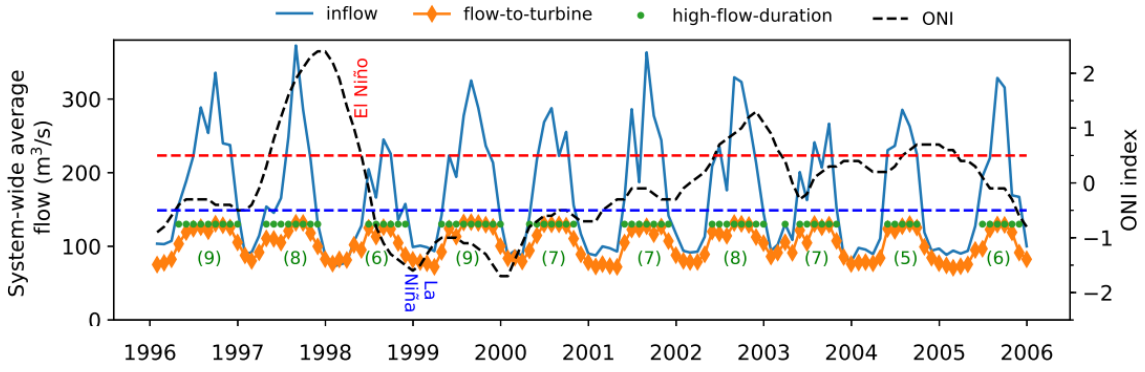
Hydropower

- Laos - “The Battery of Asia”
- Hydroelectric power is a significant resource



Hydrological variability and energy security:

- Strong seasonal and inter-annual hydro-climatic variability
- The energy system is subject to an alternating risk of shortfall and oversupply

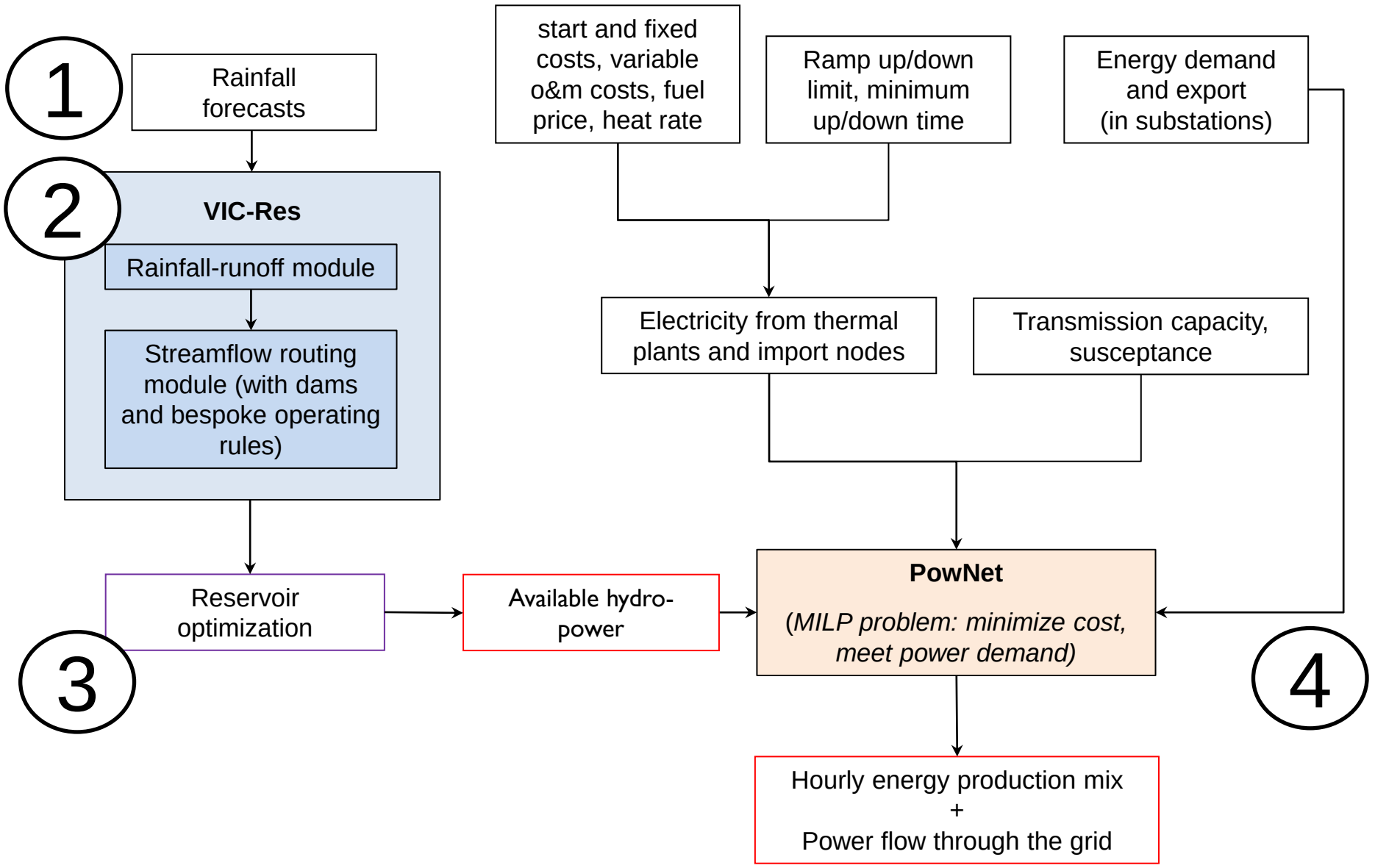


Research questions

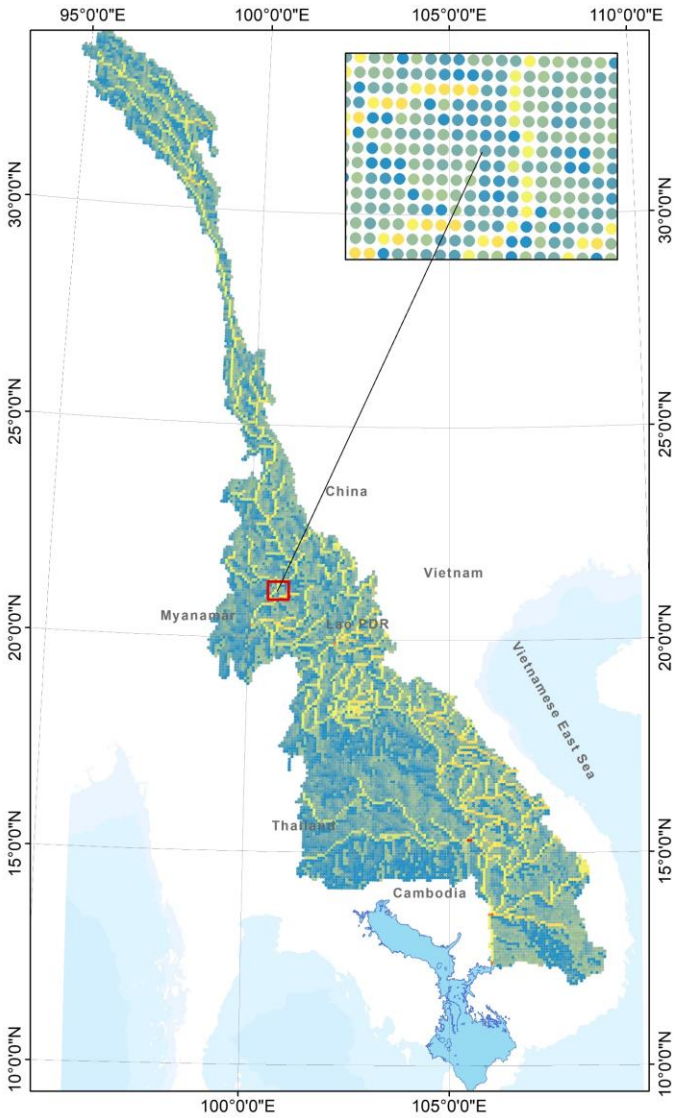
1) Can the performance of the hydropower system be improved by informing and coordinating reservoir operations with seasonal forecasts?

2) Can such intervention reduce CO_2 emissions and operating costs of the power sector?

Modelling framework



Models: VIC-Res



1. In this study, our model

- Covers the whole Mekong basin (until Kratie)
- Consist of ~15,000 cells
- Models 107 dams

2. Forecast-informed reservoir operations focussed on reservoirs in Laos with

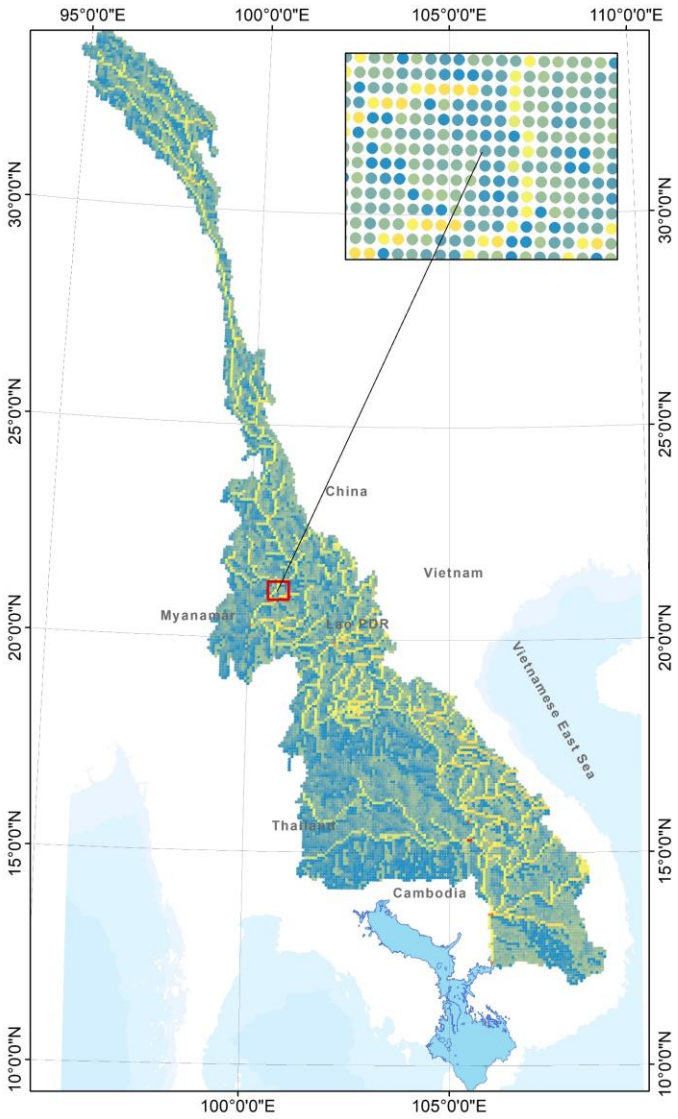
- Filling and emptying periods < 6 months
- Live storage > 100 million m^3
- → 14 dams

3. For more information on VIC-Res, please refer to

Dang, T.D., Chowdhury, A.F.M.K., & Galelli, S. (2020). On the representation of water reservoir storage and operations in large-scale hydrological models: implications on model parameterization and climate change impact assessments. Hydrology and Earth System Sciences, 24: 397-416.

Dang, T. D., Vu, D. T., Chowdhury, A. K., & Galelli, S. (2020). A software package for the representation and optimization of water reservoir operations in the VIC hydrologic model. Environmental Modelling & Software, 126, 104673.

Models: VIC-Res

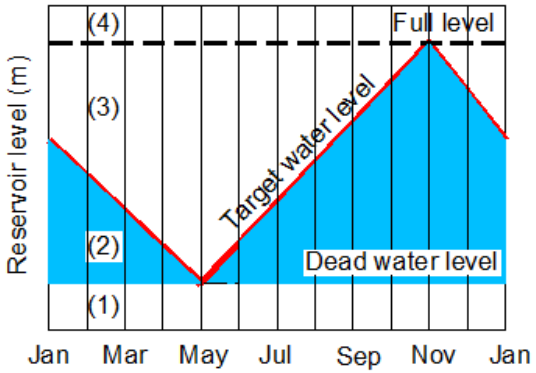


1. Streamflow forecasts

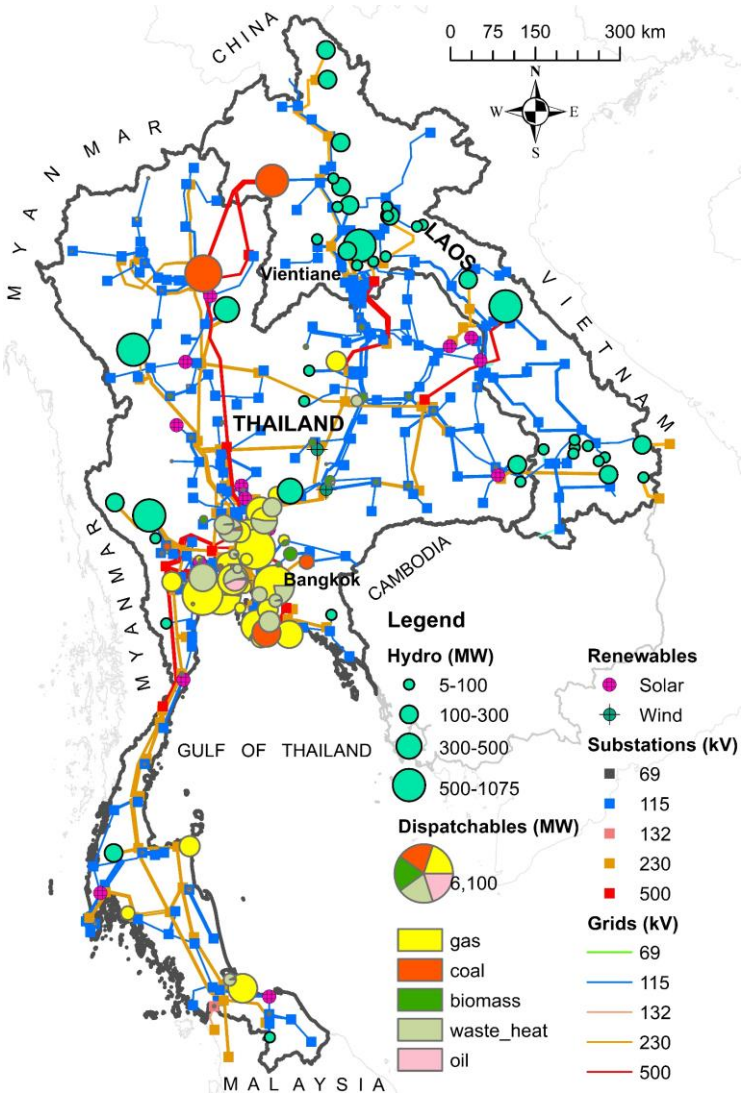
- Climatology
- Perfect forecasts
- → represent upper and lower bound of what could be achieved with real forecasts

2. Optimization algorithm: MOEA ε-NSGA II

- Variables: reservoir target level (for 14 reservoirs)
- Objectives: annual energy production vs firm hydropower



Models: PowNet



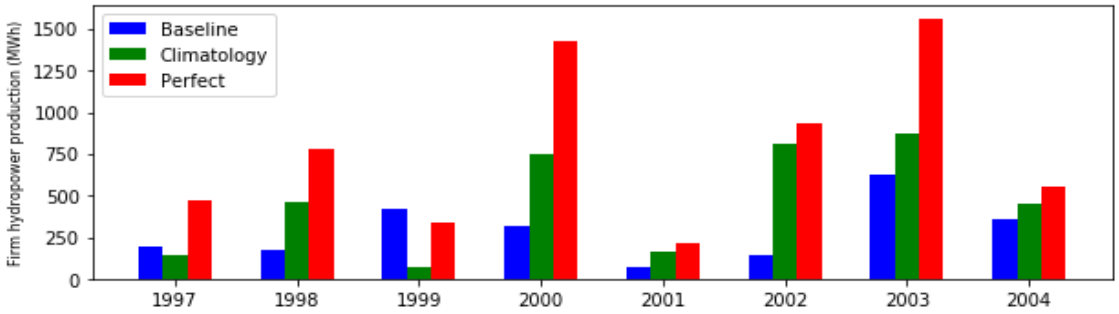
1. Model setup

- Two countries: Thailand and Laos
- Simulates the export of hydropower from Laos to Thailand

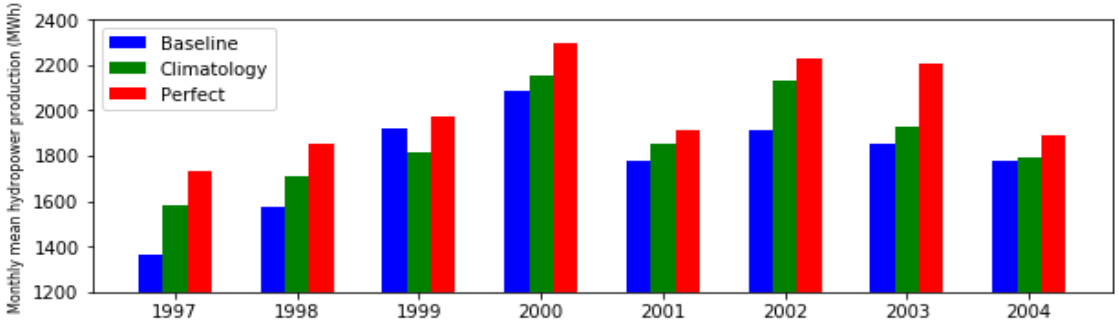
2. For more information on PowNet, please refer to

Chowdhury, A. F. M. K., Kern, J., Dang, T. D., & Galelli, S. (2020). PowNet: a power systems analysis model for large-scale water-energy nexus studies. Journal of Open Research Software, 8 (1).

Results



Firm hydropower (MWh)



Total hydropower (MWh)

Results

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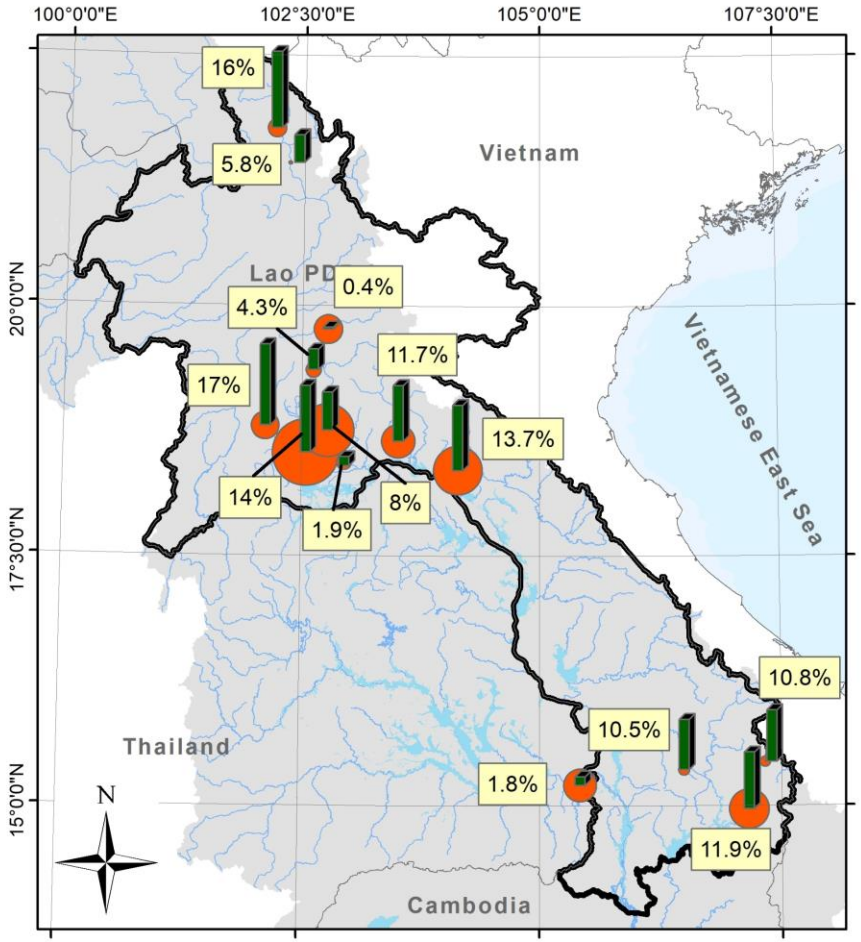
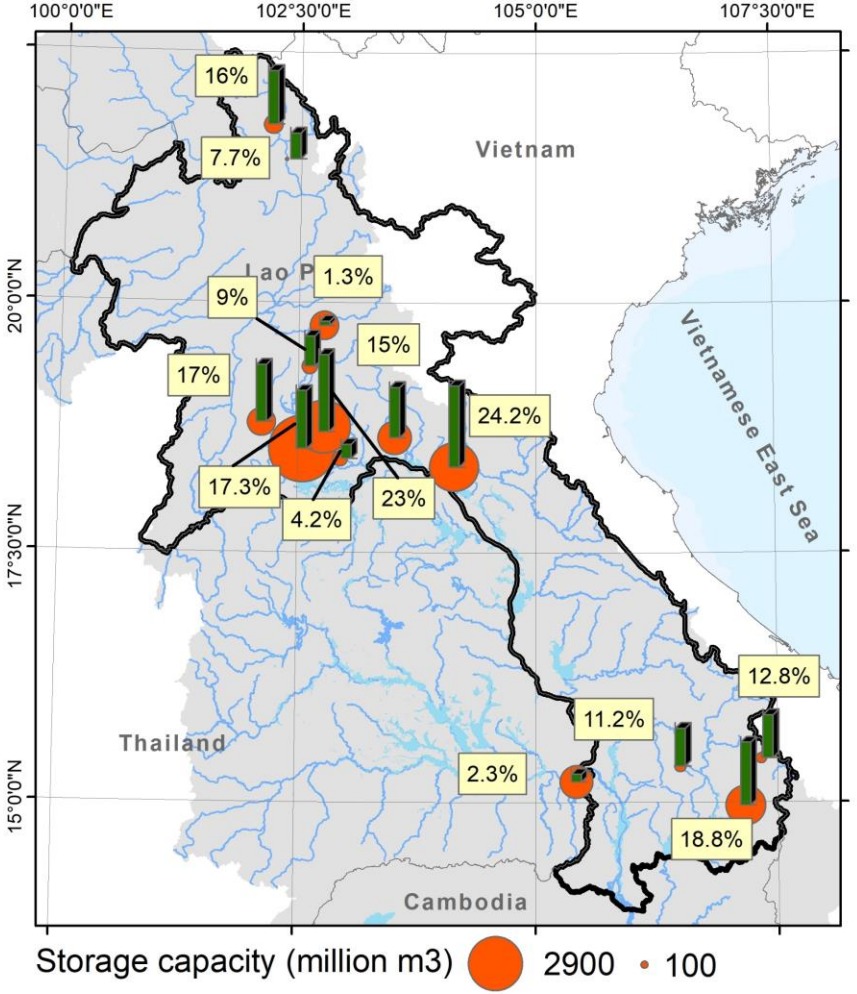
Changes in annual hydropower production with forecasts

Climatology



Perfect



Results

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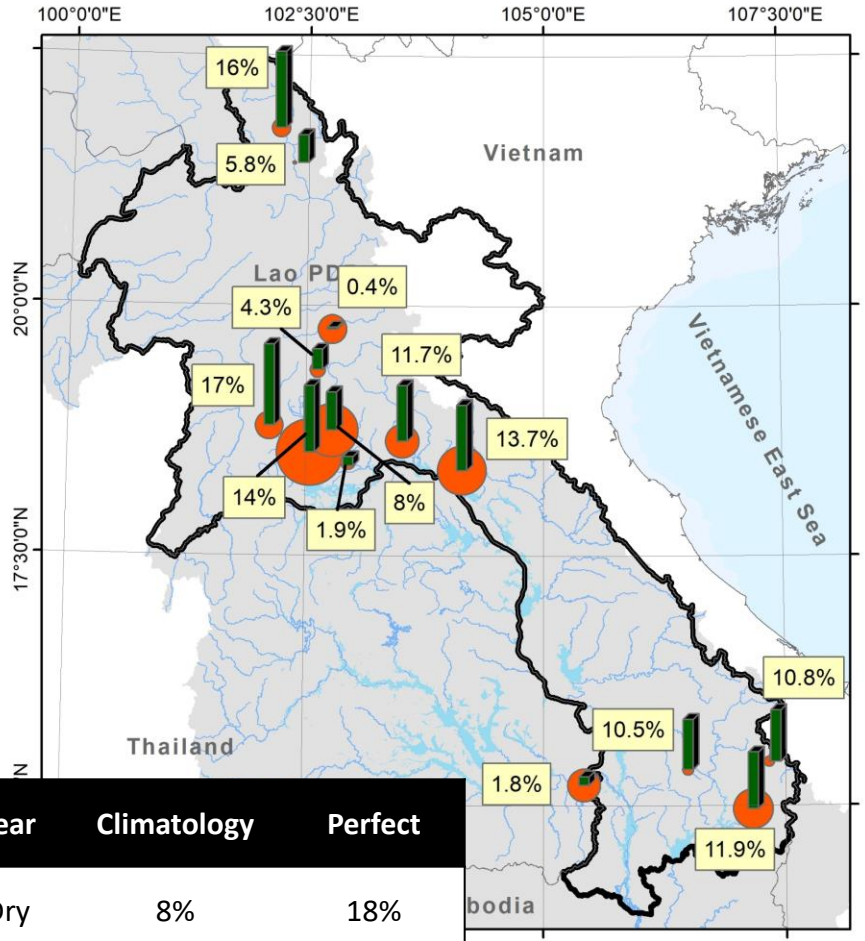
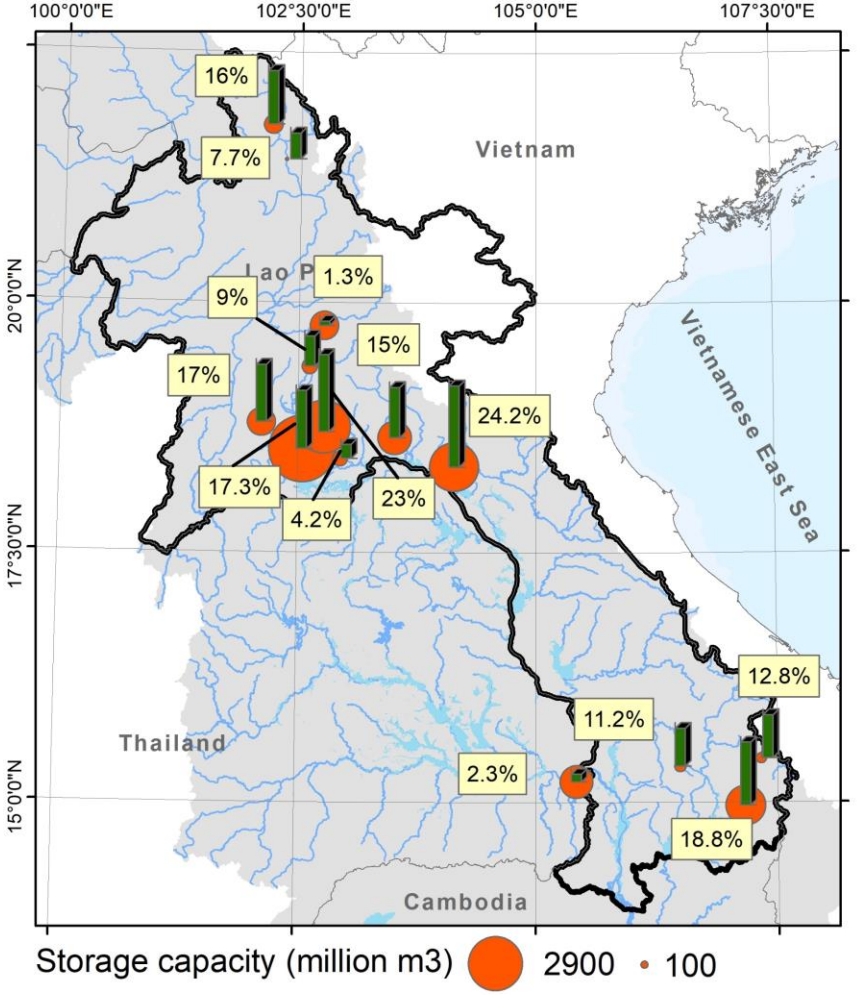
Changes in annual hydropower production with forecasts

Climatology



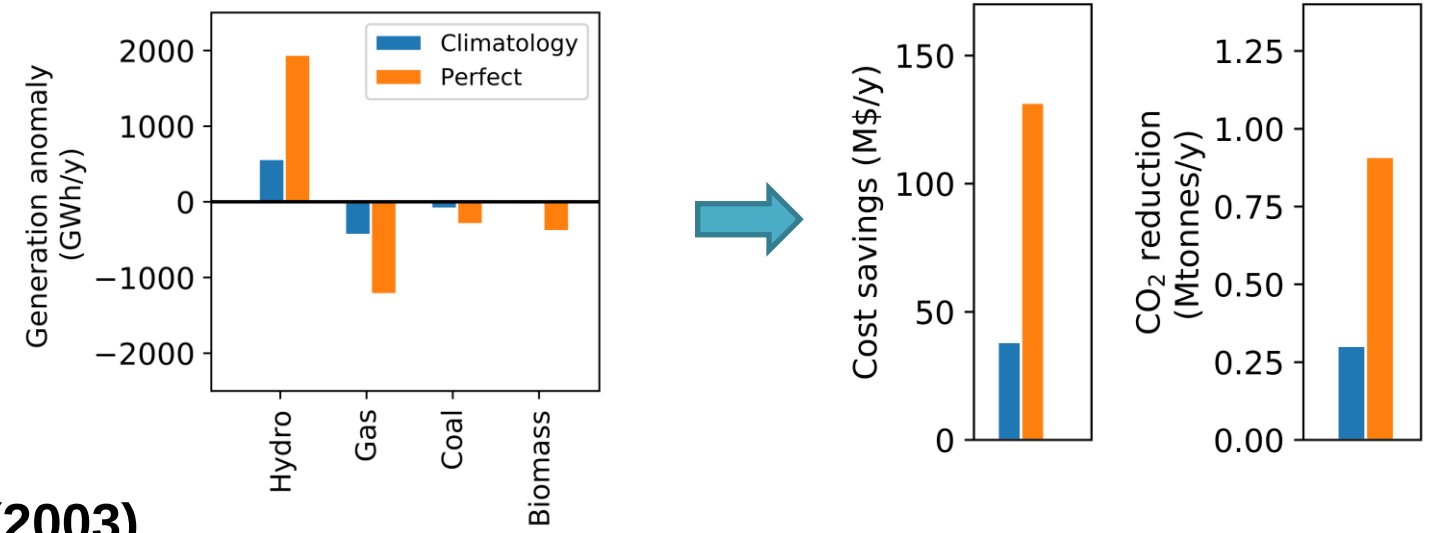
Perfect



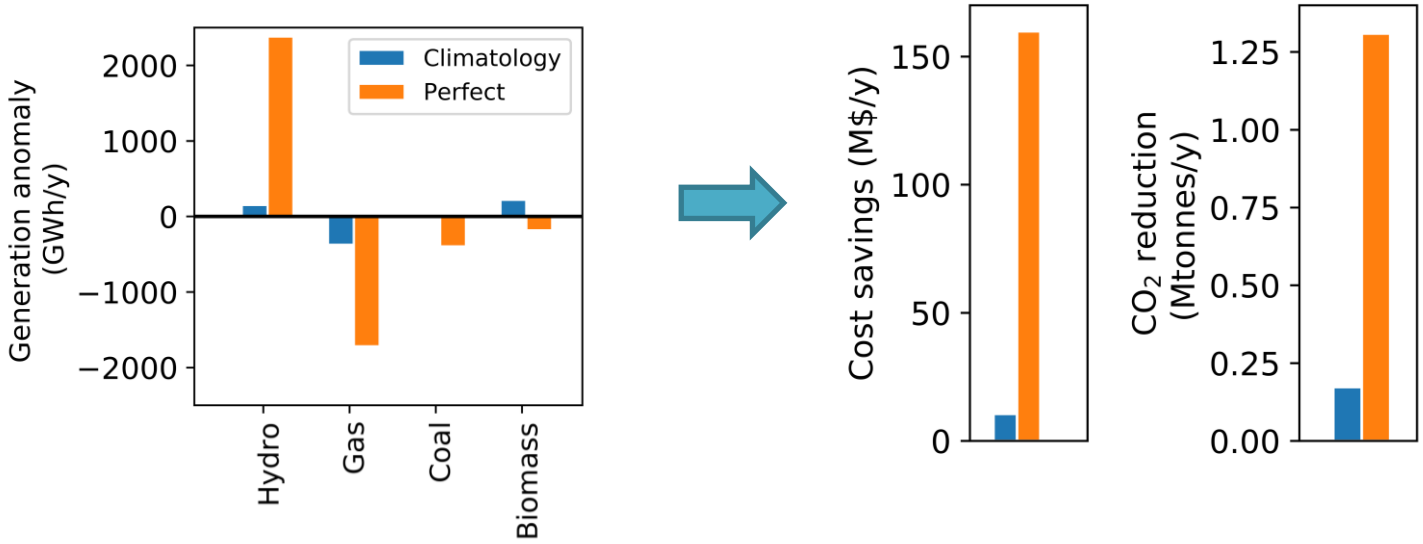
Year	Climatology	Perfect
Dry	8%	18%
Wet	4%	19%

Results

Dry year (1998)



Wet year (2003)



Conclusions

- Forecast-informed reservoir operations could positively impact both firm and total hydropower production
- Increased hydropower production reduces the dispatch from gas and coal plants
- → CO_2 emissions and operating costs could decrease up to 1.25 Mt and 150 M$ per year

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