Assessing climate impacts on hydropower production of Toce alpine basin

Giovanni Ravazzani[1], Francesco Dalla Valle[2], Thomas Mendlik[3], Giorgio Galeati[2], Andreas Gobiet[3], Marco Mancini[1]

[1] Politecnico di Milano (giovanni.ravazzani@polimi.it), Italy
[2] ENEL S.p.A.- Energy Management Division, Italy
[3] Wegener Center for Climate and Global Change , Austria

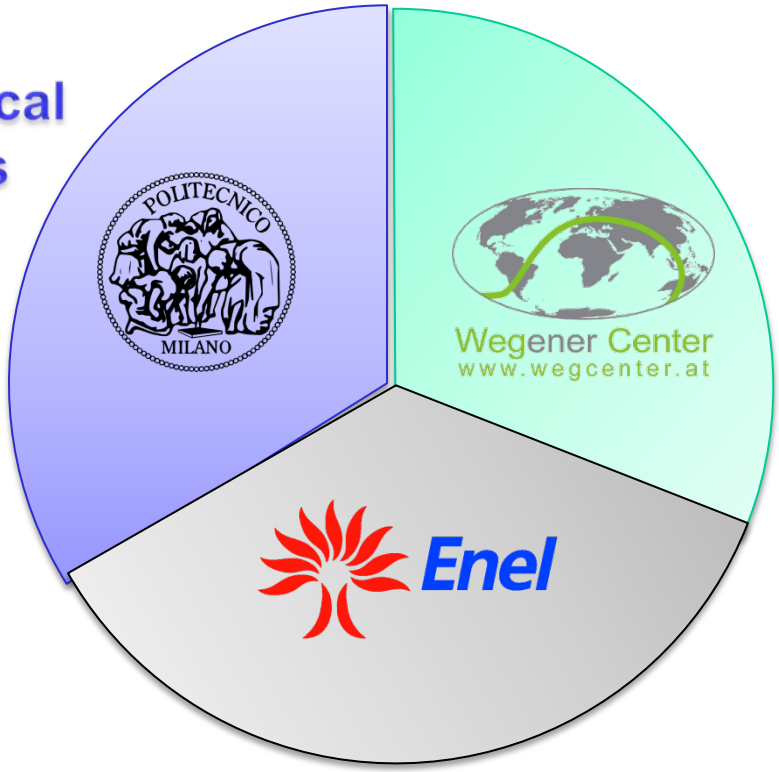
Objectives

Investigate climate change impacts on hydrological regime and hydropower production of an Alpine river basin

The ACQWA Project (Assessing Climate impacts on the Quantity and quality of WAter) is a large-scale integrating project, coordinated by University of Geneve and with 35 partners.

The goal of the project is to use advanced modelling techniques to quantify the influence of climatic change on the major determinants of river discharge at various time and space scales, and analyse their impact on society and economy, also accounting for feedback mechanisms

Collaboration



PIEMONTE
Arpa
Agenzia Regionale per la Protezione Ambientale

Toce case study

RESERVOIRS

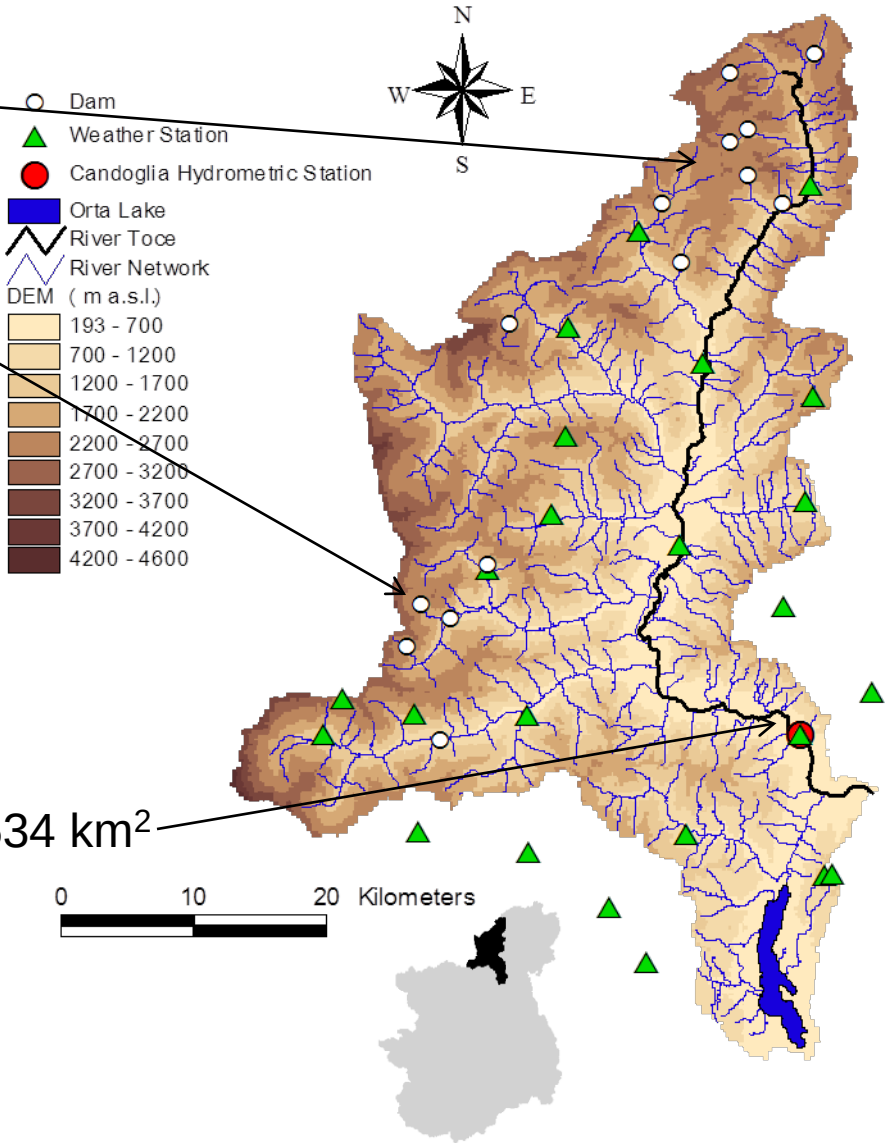
14 major dams

Total effective storage capacity 151 10^6 m^3

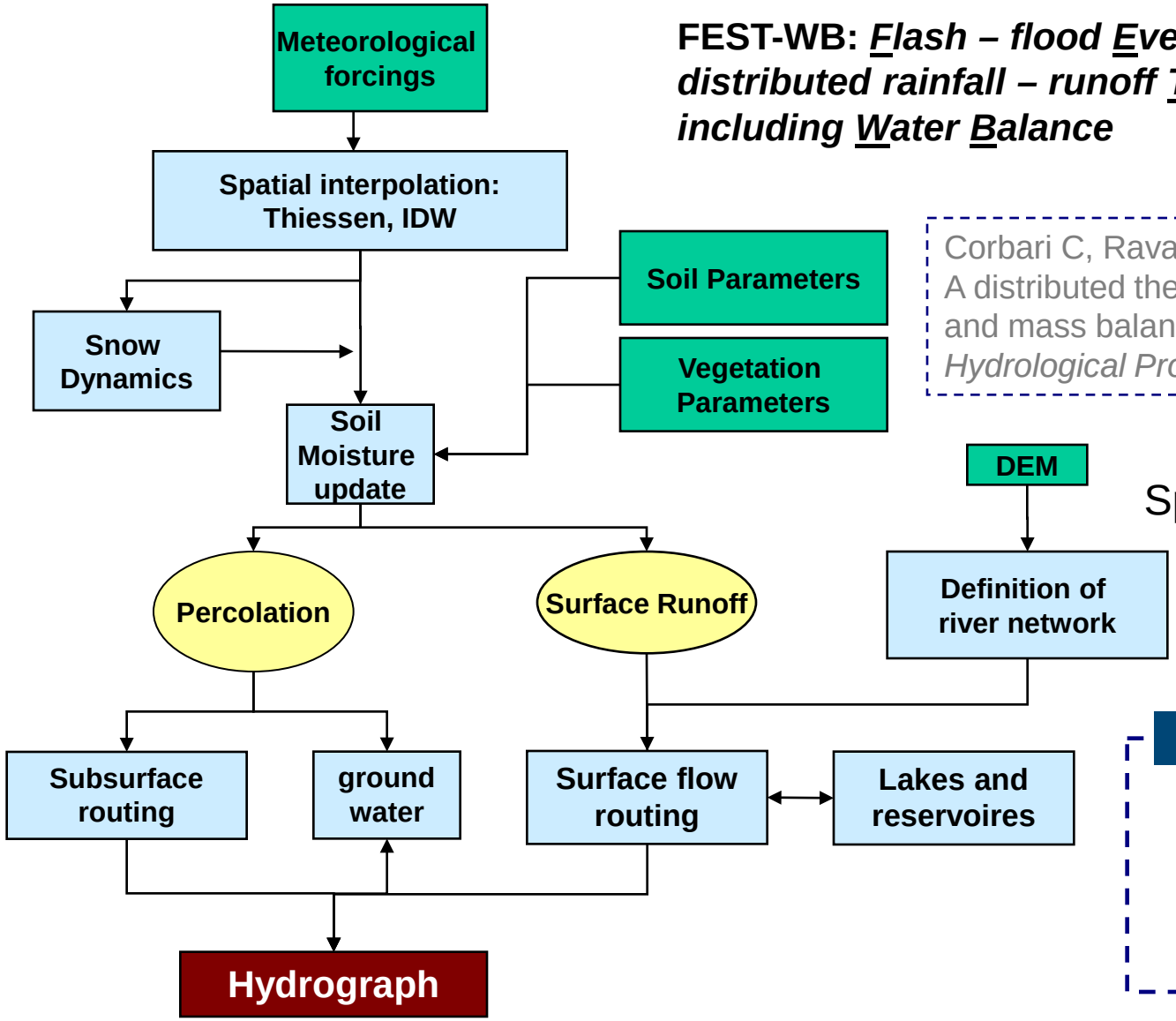
AVAILABLE TIME SERIES (2000-2010)

Hourly precipitation and temperature

Hourly river discharge at Candoglia, area 1534 km^2



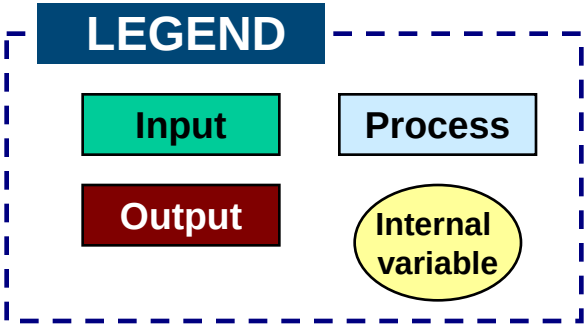
FEST-WB hydrological model



FEST-WB: *Flash – flood Event – based Spatially – distributed rainfall – runoff Transformation – including Water Balance*

Corbari C, Ravazzani G, and Mancini M, 2011: A distributed thermodynamic model for energy and mass balance computation: FEST–EWB. *Hydrological Processes* 25(9), 1443-1452

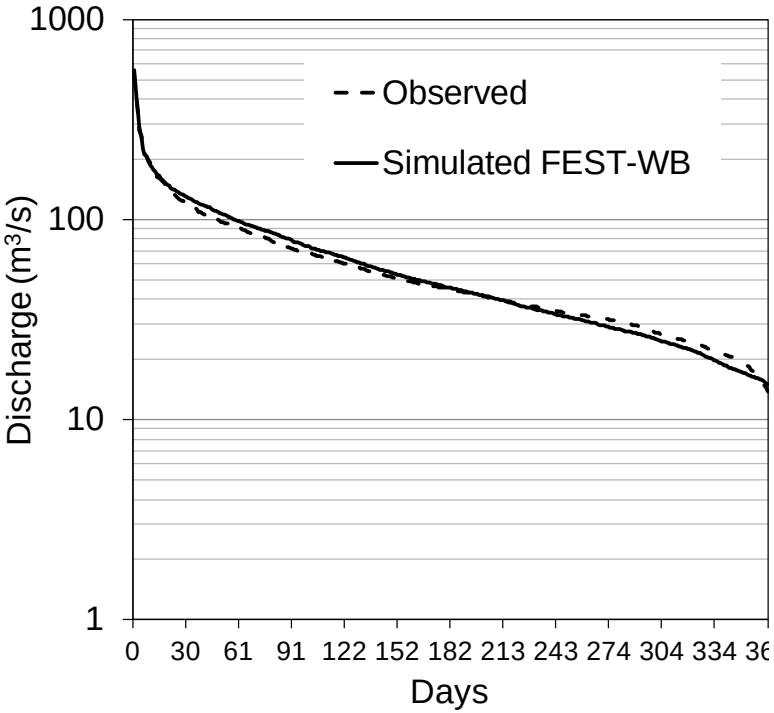
Spatial resolution = 200 m

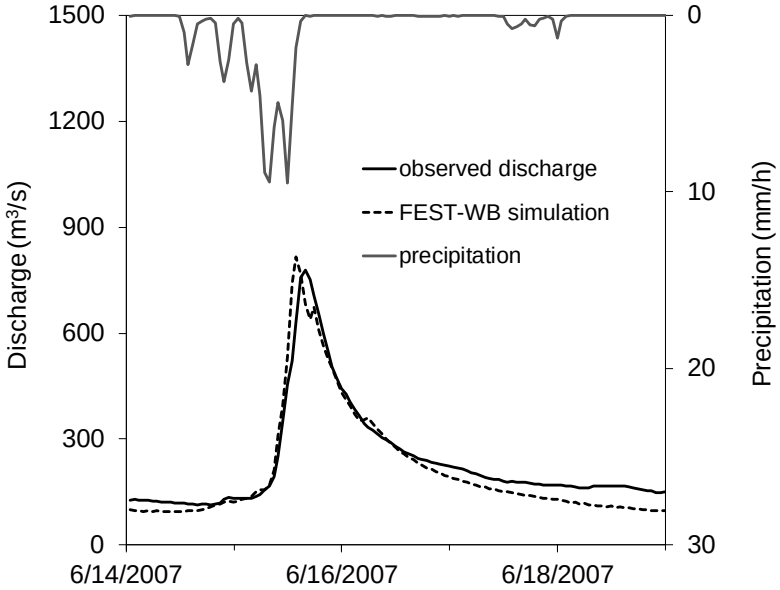


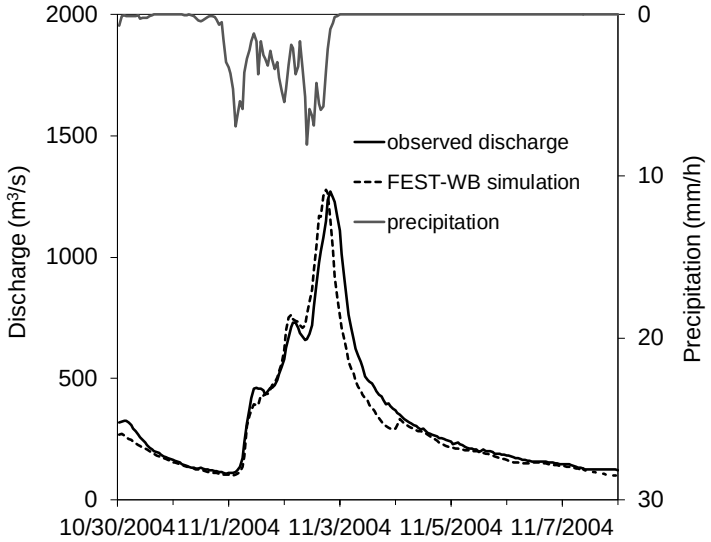
Hydrological model calibration

Toce@Candoglia

Flow duration curve







Flood events

At-site climate forcings

CLIMATE SCENARIOS

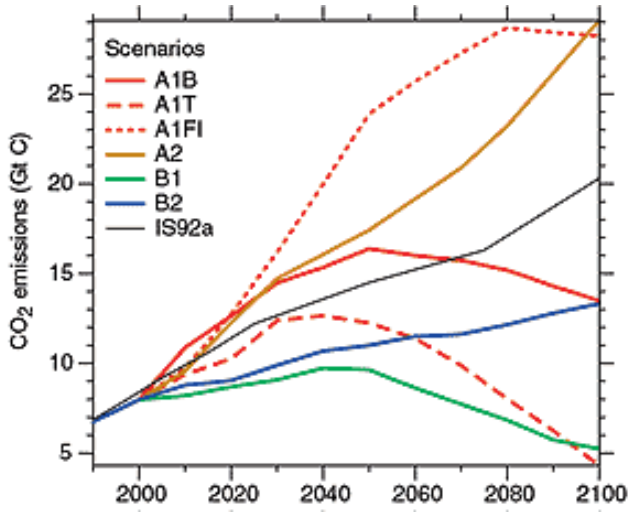
REMO and RegCM3

Precipitation, Temperature

Bias corrected

Spatial resolution = at site

Time resolution = 3 hours



source: IPCC

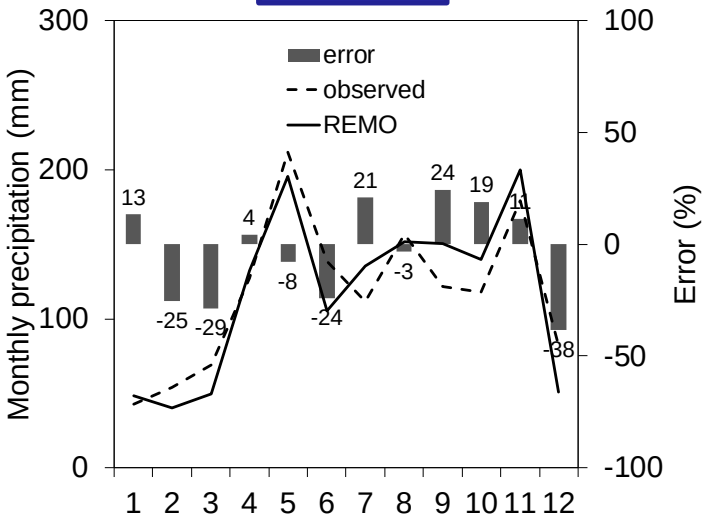
The **A1 storyline** and scenario family describes a future world of **very rapid economic growth**, global **population that peaks in mid-century and declines thereafter**, and the rapid **introduction of new and more efficient technologies**. Major underlying themes are convergence among regions, capacity building and increased cultural and social interactions, with a substantial **reduction** in regional **differences in per capita income**.

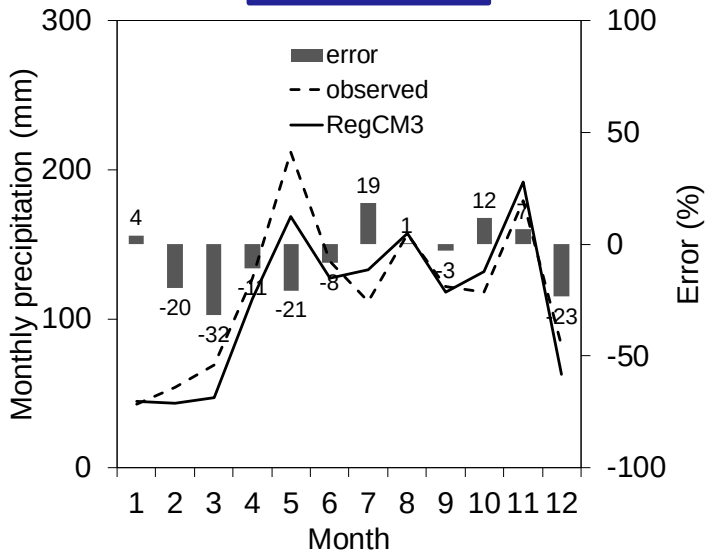
Climate in the control period

Wegener Center

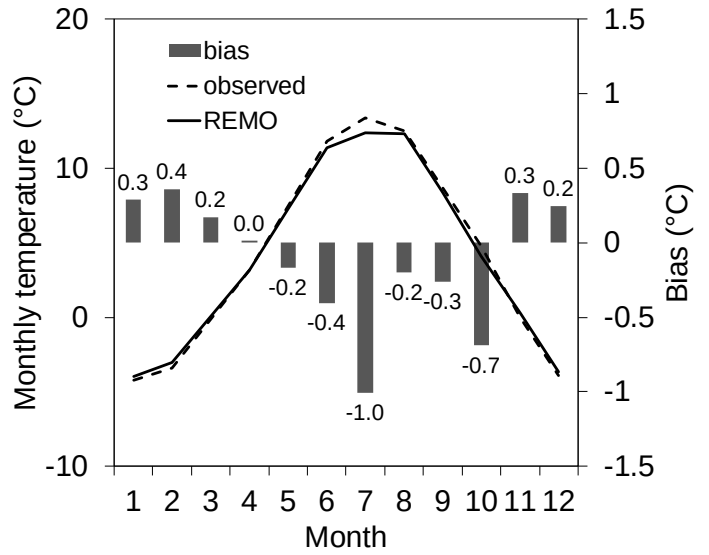
REMO | **RegCM3**

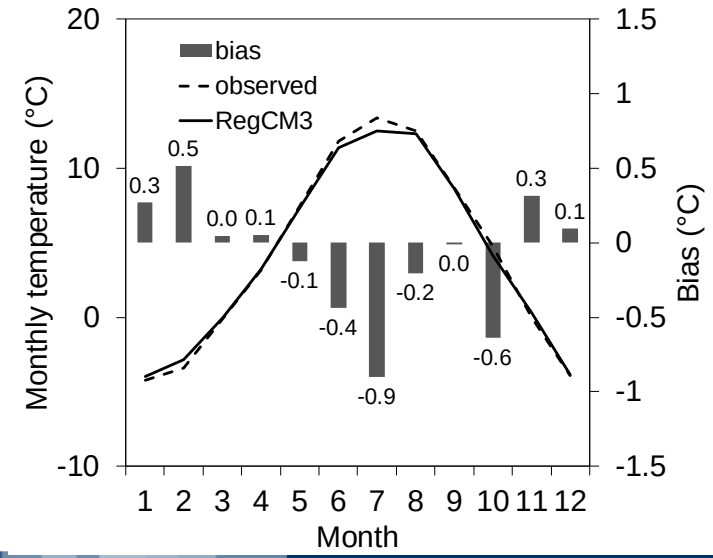
Precipitation





Temperature





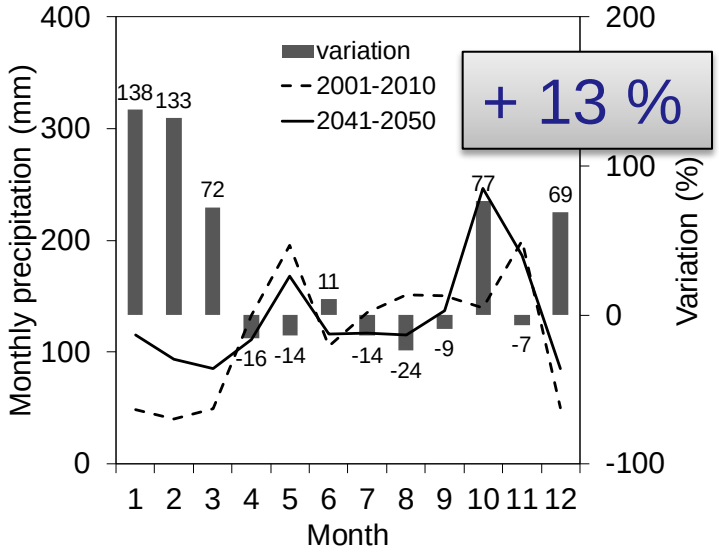
Projected climate change

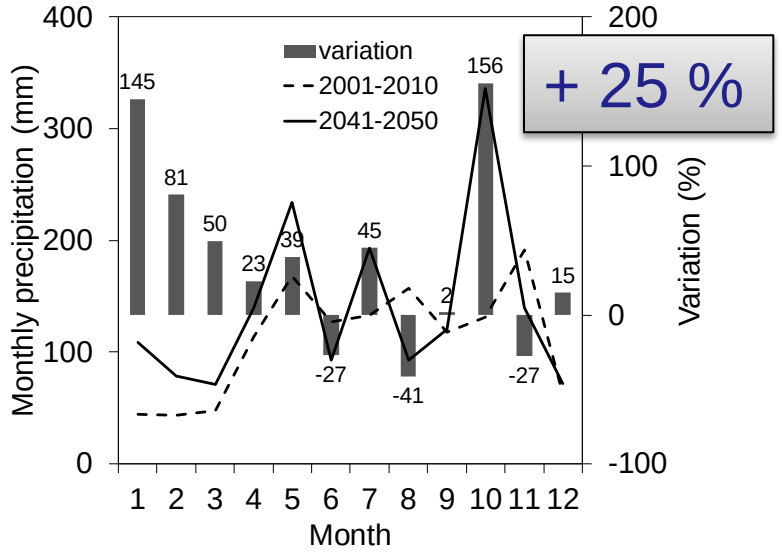
Wegener Center

REMO

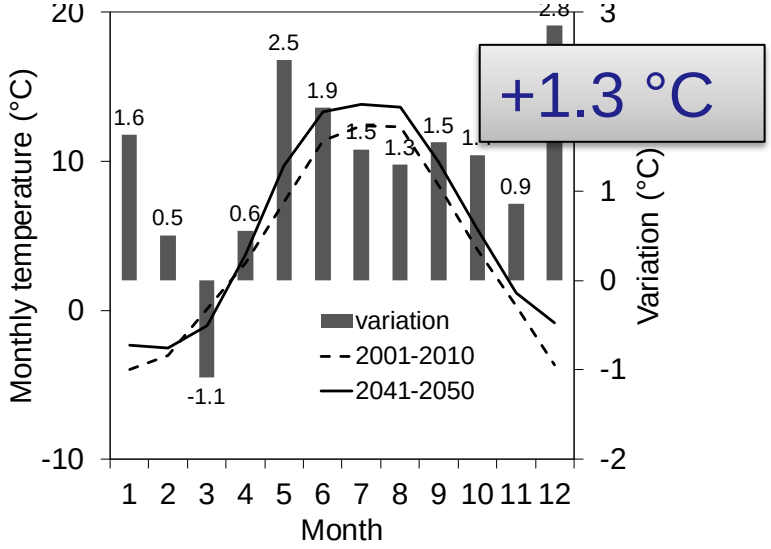
RegCM3

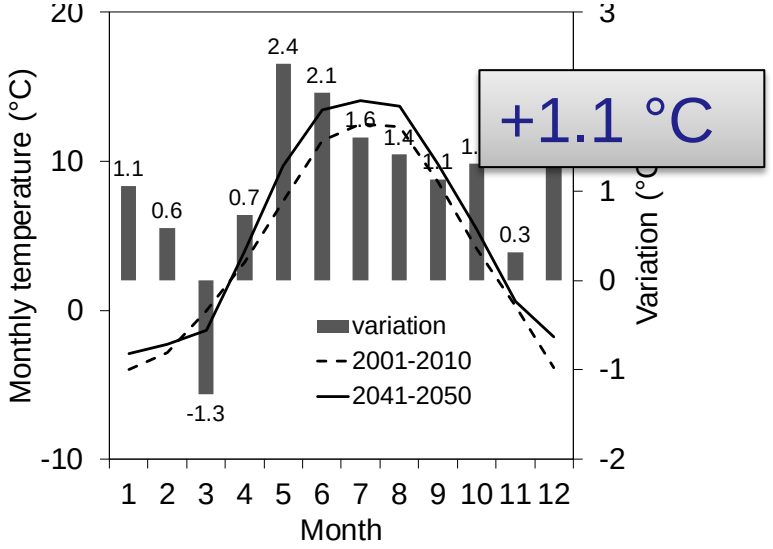
Precipitation





Temperature



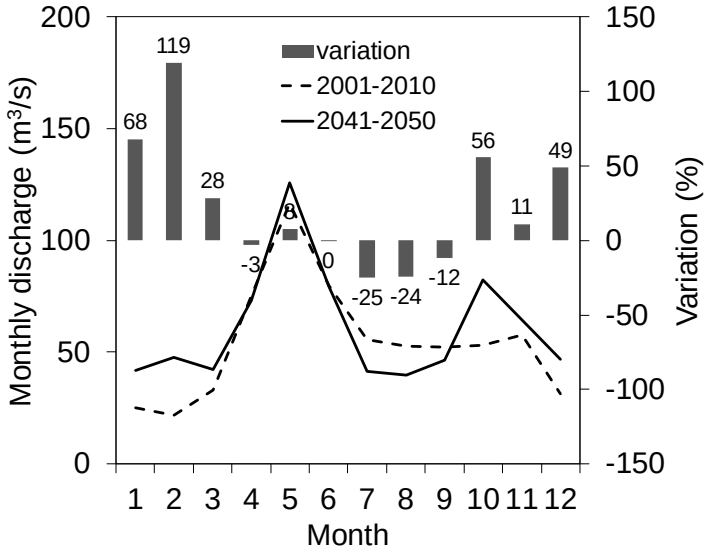


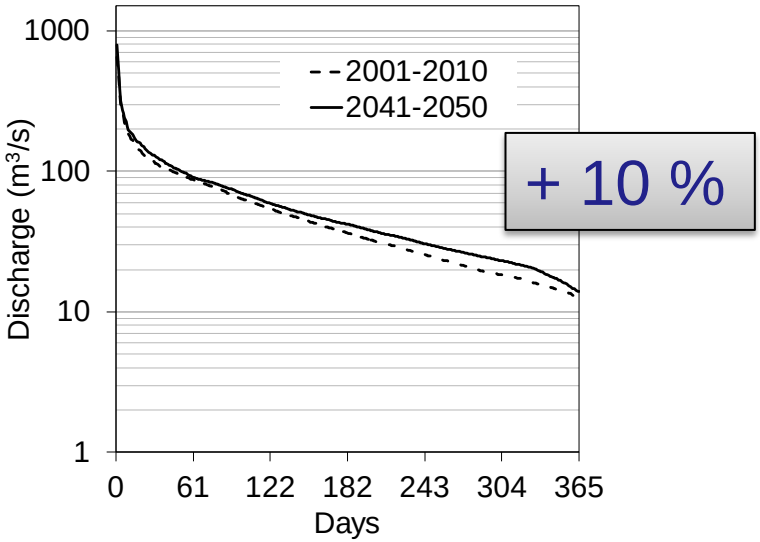
Climate change impacts on hydrology

Discharge

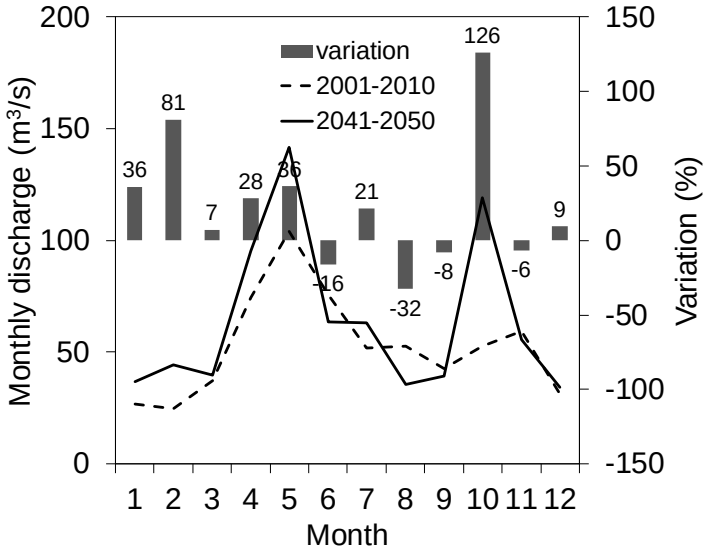
FDC

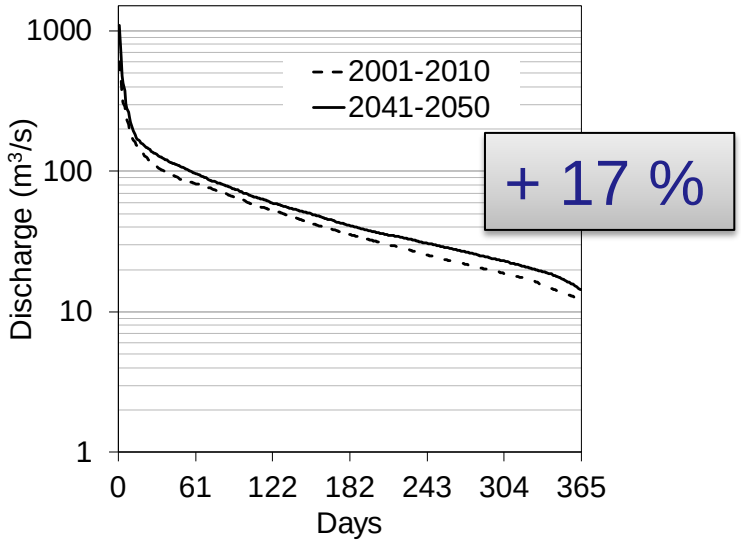
REMO





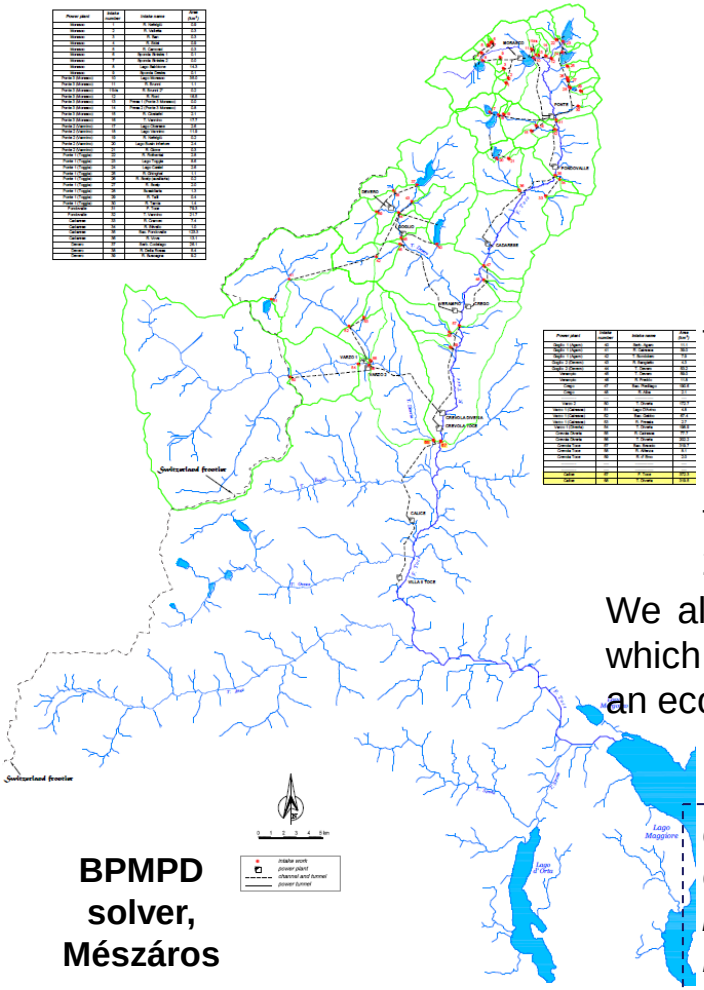
RegCM3





The model of the hydropower system

18 plants (total installed capacity ≈ 470 MW) and 10 reservoirs, Basin Area 700 km^2



BPMPD solver, Mészáros

The hydropower system has been represented by a network of **27 nodes** and **64 arcs**. Nodes represent intakes and reservoirs; arcs represent rivers, channels, hydropower plants and water volume stored into the reservoirs. Each node is characterized by **an inflow time series** that describe natural discharges produced by the upstream sub-catchment, generated by hydrological model. The model is run with **a two-hour time step** to gain an adequate representation of the hydraulic network.

Energy prices were based on the "Prezzo Unico Nazionale" (PUN) of the Italian electric energy market registered from 2006-1-1 to 2010-12-31 by GME (Energy Markets Operator). Data were averaged by hour of the day, by day of the week, and by week of the year. The hourly energy prices so calculated were finally averaged on a 2-hour time step basis and used for all the simulated time horizon (2001 - 2050).

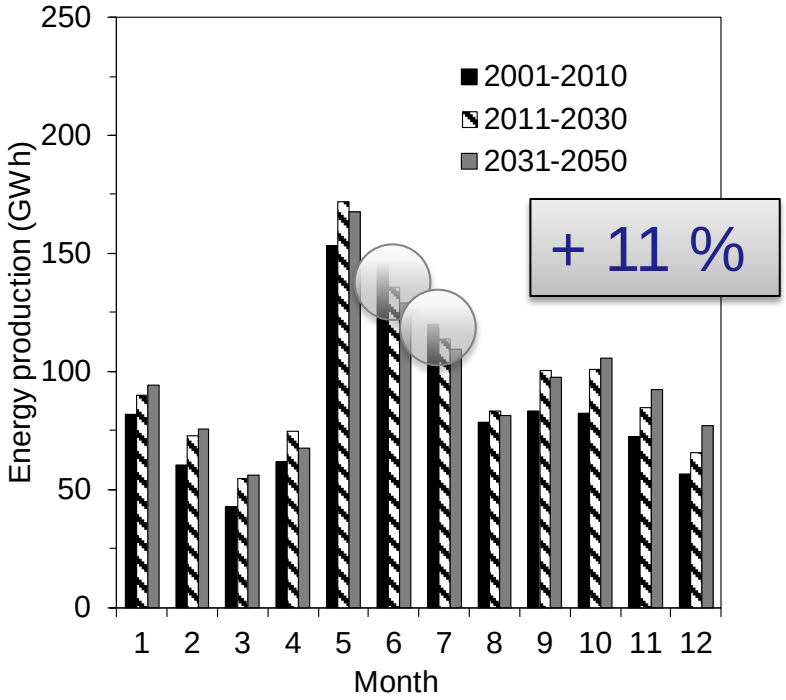
We also look at the impact of climate change on **demand of electricity**, which in turn influences hydropower management. In this purpose, we use an econometric model with autoregressive error term (Filippini, 2011)

Gaudard, L., Romerio, F., Dalla Valle, F., Gorret, R., Maran, S., Ravazzani, G., Stoffel, M., Volonterio, M. (2014), Climate change impacts on hydropower in the Swiss and Italian Alps, Science of the Total Environment, 493, 1211-1221. Doi: 10.1016/j.scitotenv.2013.10.012

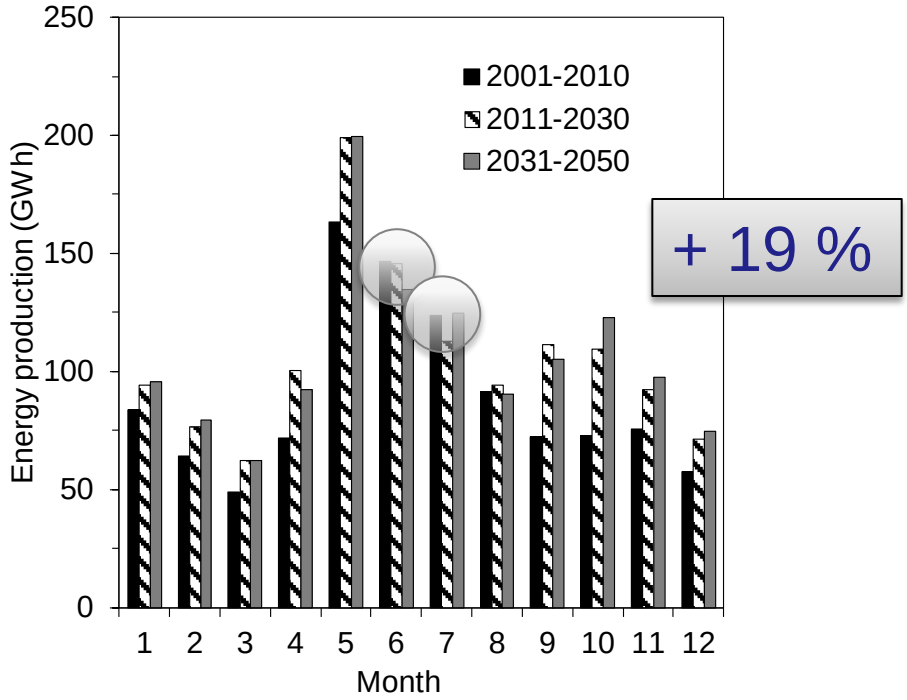
Changes in hydropower production

Average monthly total hydropower production

REMO



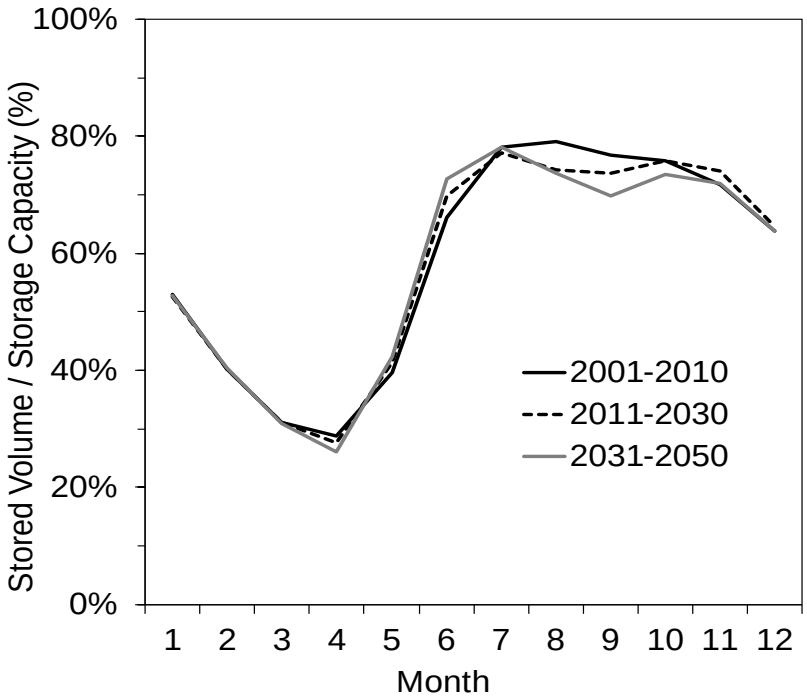
RegCM3



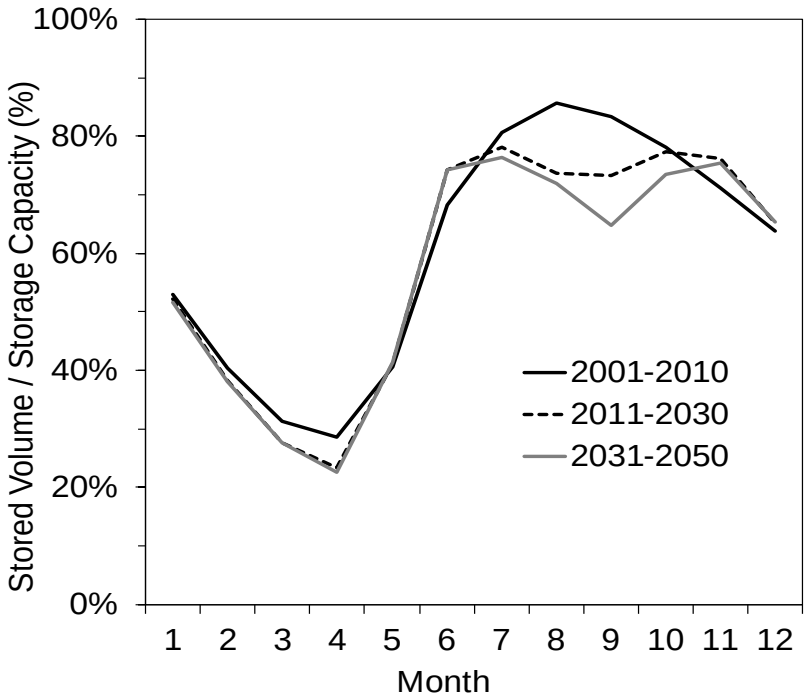
Changes in stored volume

Average monthly stored water volume

REMO



RegCM3



Conclusions

Projected climate change showed an increase of precipitation but with a seasonal change with a decrease during summer.

Analysis of the impacts on hydrological regime showed an increase of discharge for all the durations of the flow duration curve but a decrease during summer.

Relevant increase of hydropower production. The production increase is distributed in autumn, winter and spring, while in June and July simulation results show a reduction of hydropower production.

Important change in the reservoirs management policy: trend to anticipate the date when the maximum volume of stored water has to be reached, which moves from August (2001-2010) to July (2031-2050). An increase of reservoir drawdown during August and September to prepare empty storage capacity for autumn inflows.

THANK YOU FOR YOUR ATTENTION