Climate change impacts on water resources in the Upper Po basin

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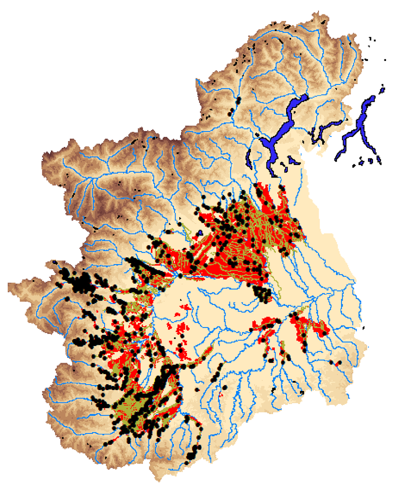
Water and risk management facing climate change: towards the local adaptation
Brescia, Italy – October 10, 2013
Centro Paolo VI

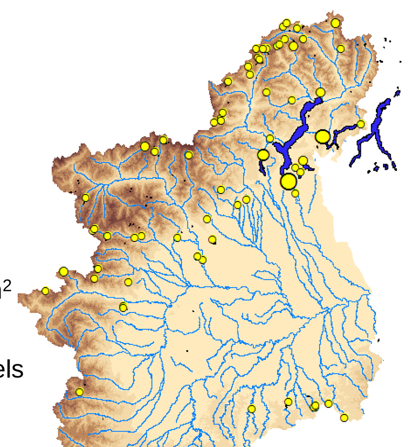
CASE STUDY

The upper Po river basin

Basin Area = 38000 km²



Irrigated area = 4'500 km²
1056 river intakes
7'700 km artificial channels



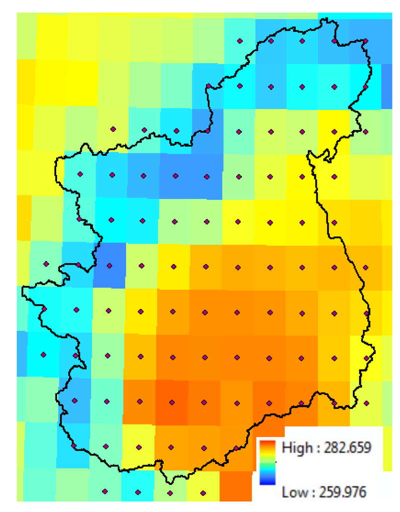
57 reservoirs and 13 lakes
$1 \cdot 10^9$ m³ capacity artificial reservoirs

Development of modules for simulating reservoirs and irrigation

CLIMATE SCENARIOS
REMO and RegCM3
Precipitation and Temperature
Bias corrected
Spatial resolution = 25 km
Time resolution = 3 hours

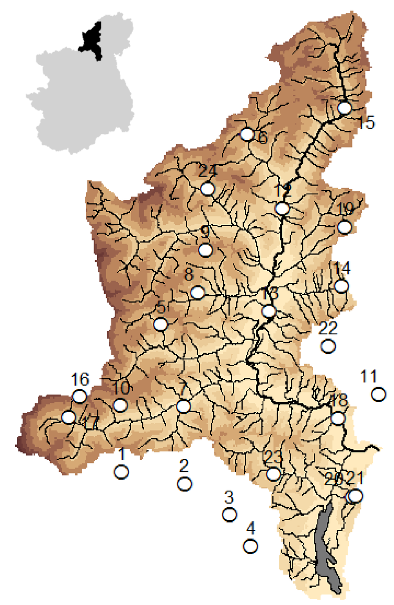
HYDROLOGICAL MODEL
FEST-WB
Spatial resolution = 1 km

REMO T (K) - 1ST January 2001



SMALL CASE STUDY

The Toce river basin



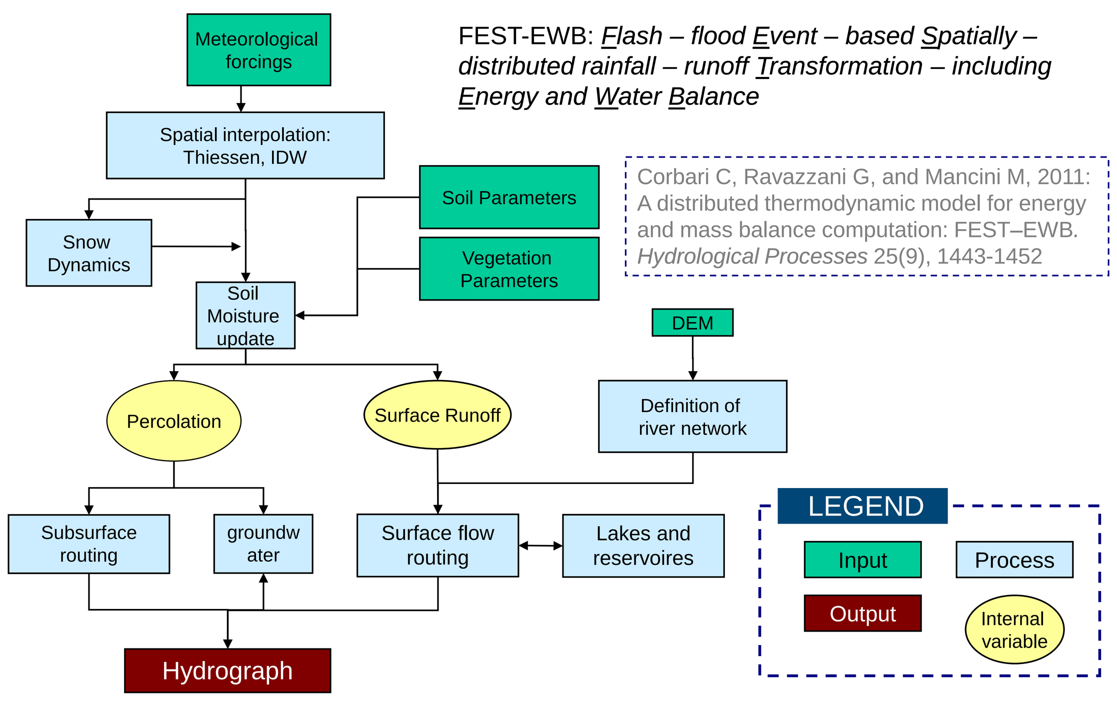
CLIMATE SCENARIOS
REMO and RegCM3
Precipitation, Temperature, Wind Speed, Solar Radiation, Relative Humidity
Bias corrected
Spatial resolution = at site
Time resolution = 3 hours

HYDROLOGICAL MODEL
FEST-WB and FEST-EWB
Spatial resolution = 200 m

HYDROLOGICAL MODEL

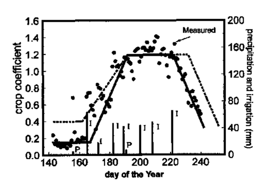
FEST-EWB: *Flash – flood Event – based Spatially – distributed rainfall – runoff Transformation – including Energy and Water Balance*

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



MODIFIED HARGREAVES FOR ALPS

Need to use a simplified model that requires only temperature

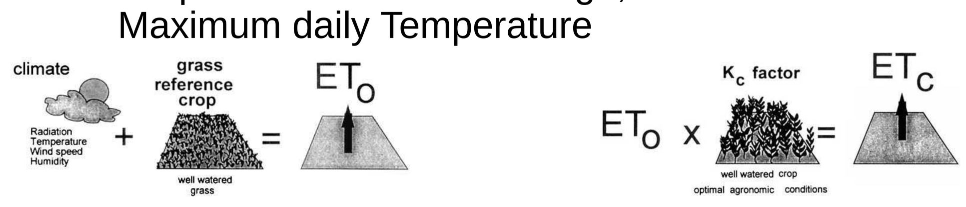


$$ET_P = K_C \cdot ET_0$$

Crop Coefficient — Reference evapotranspiration

$$ET_0 = 0.0023 \cdot R_a \cdot (T_{max} - T_{min})^{0.5} \cdot (T_{mean} + 17.8)$$ Hargreaves (1982)

Required variables: Average, Minimum and Maximum daily Temperature

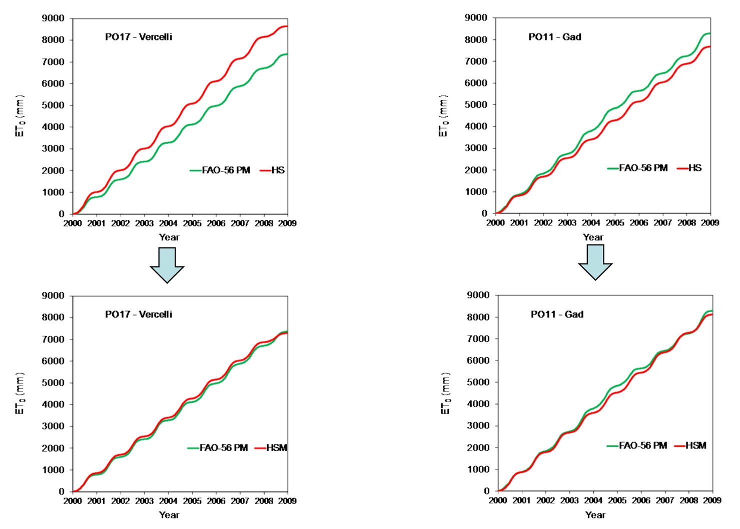


Hargreaves for ET_0 over Alps

$$ET_{0,HSM} = (c_0 + c_1 z) ET_{0,HS}$$

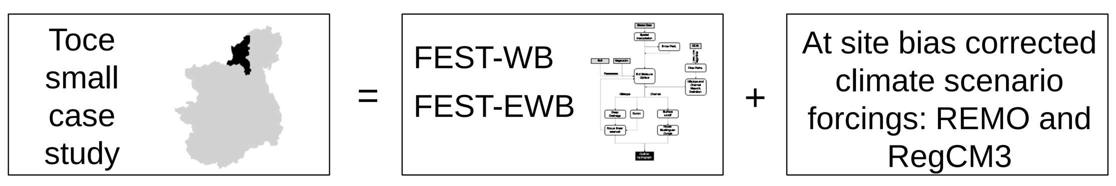
$$ET_{0,HSM} = (0.817 + 0.00022 \cdot z) \cdot HC \cdot R_a \cdot (T_{max} - T_{min})^{HE} \left(\frac{T_{max} + T_{min}}{2} + HT\right)$$

132 m asl — 1065 m asl

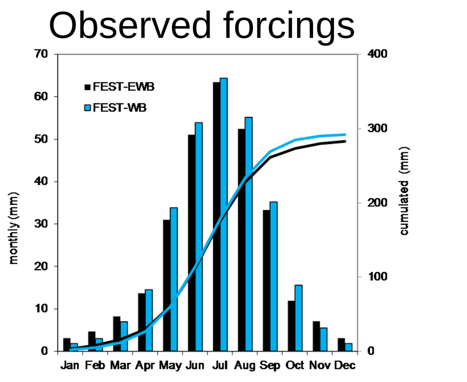


Ravazzani G, Corbari C, Morella S, Gianoli P, and Mancini M, 2012: Modified Hargreaves-Samani Equation for the Assessment of Reference Evapotranspiration in Alpine River Basins. *Journal of Irrigation and Drainage Engineering* 138(7), 592–599

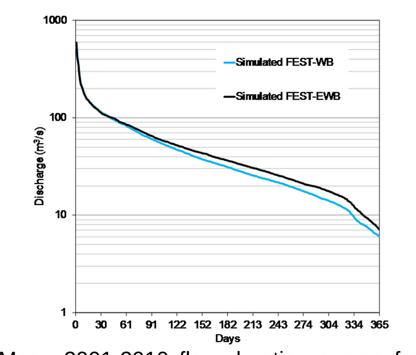
SMALL SCALE STUDY RESULTS



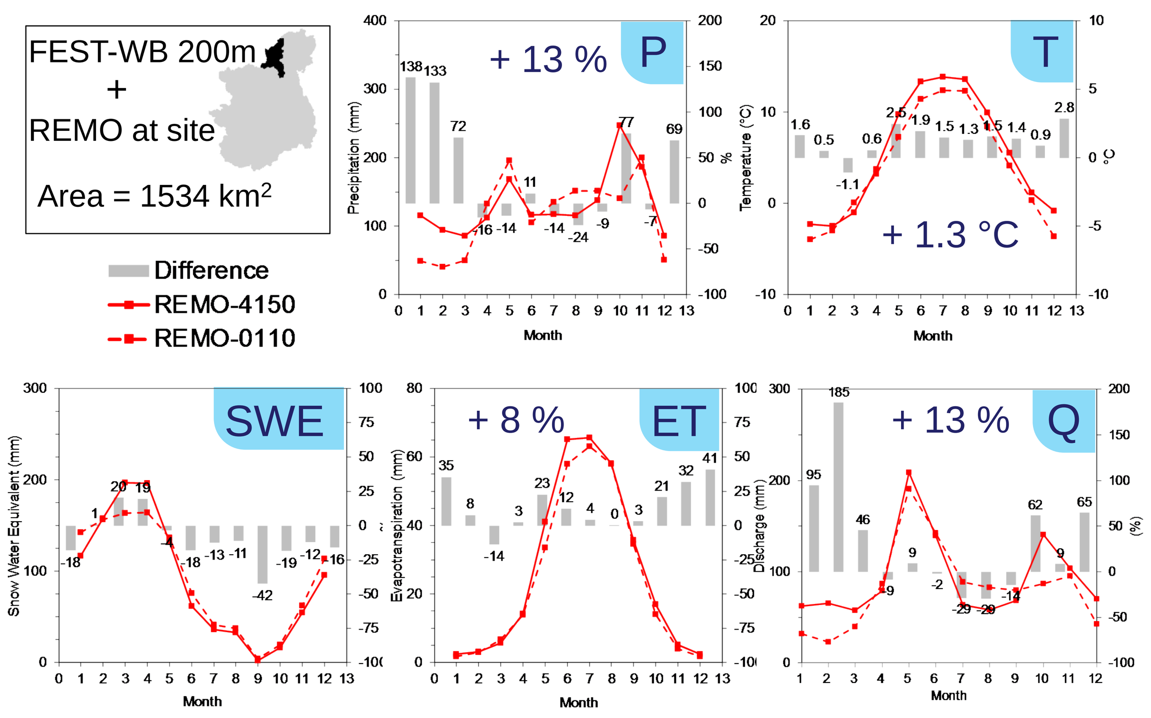
Observed forcings

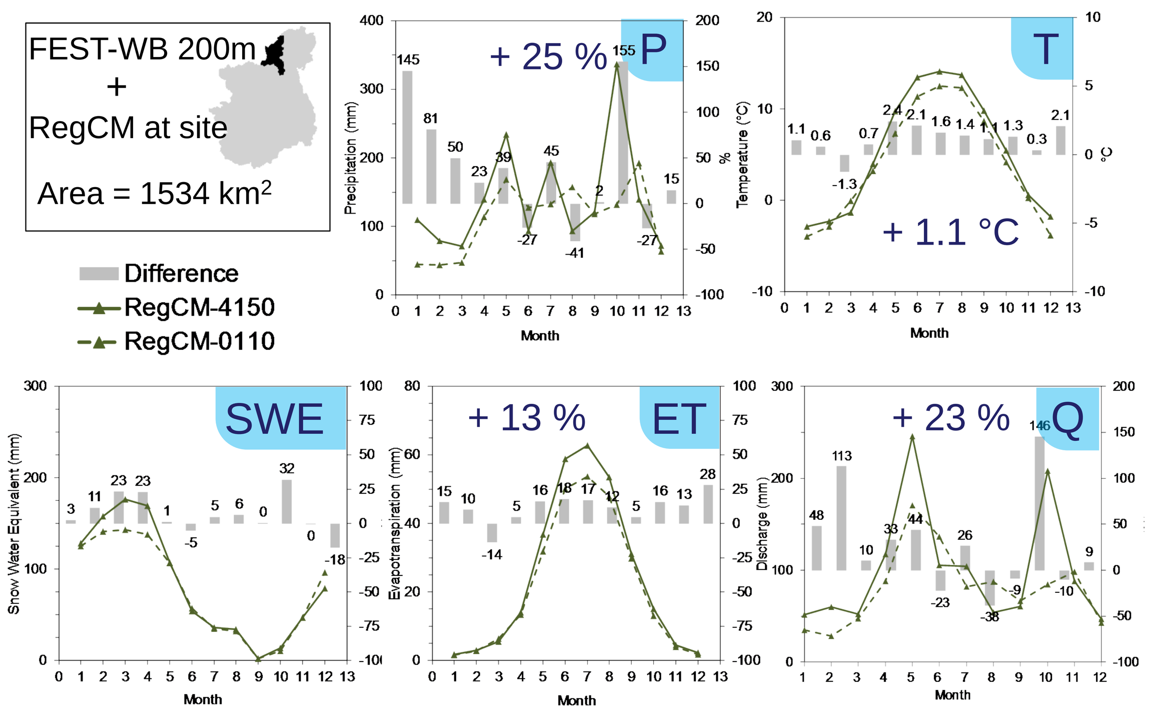


Mean monthly and cumulated actual evapotranspiration as computed by FEST-WB and FEST-EWB model driven by meteorological observations

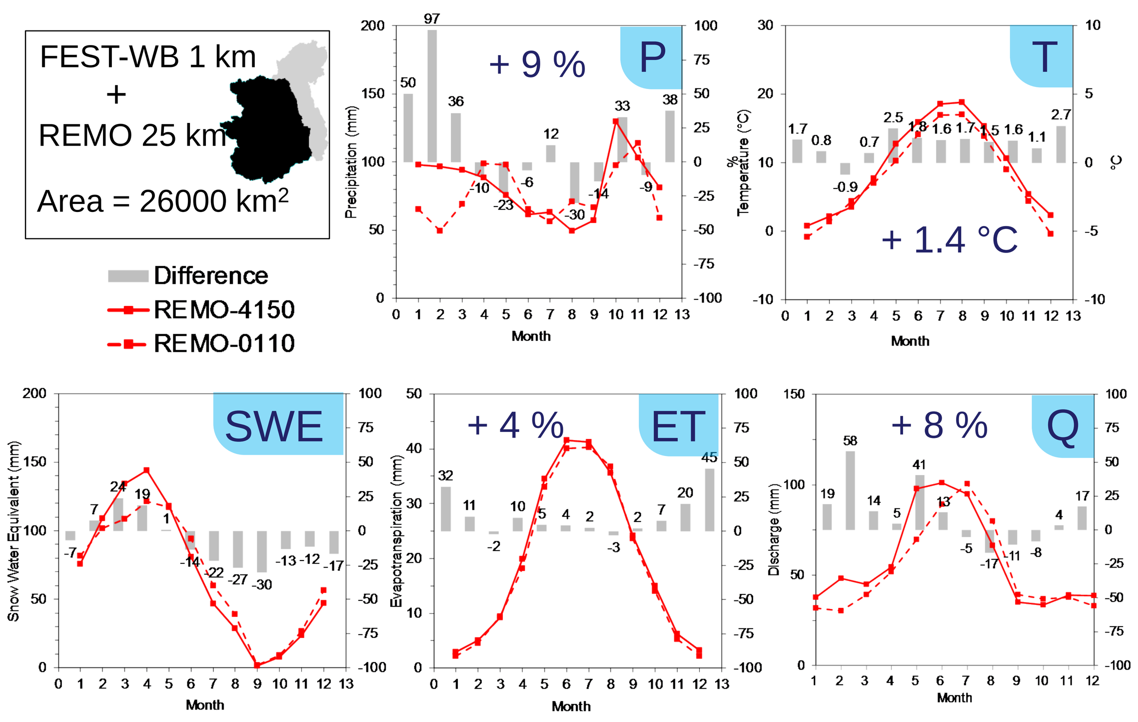


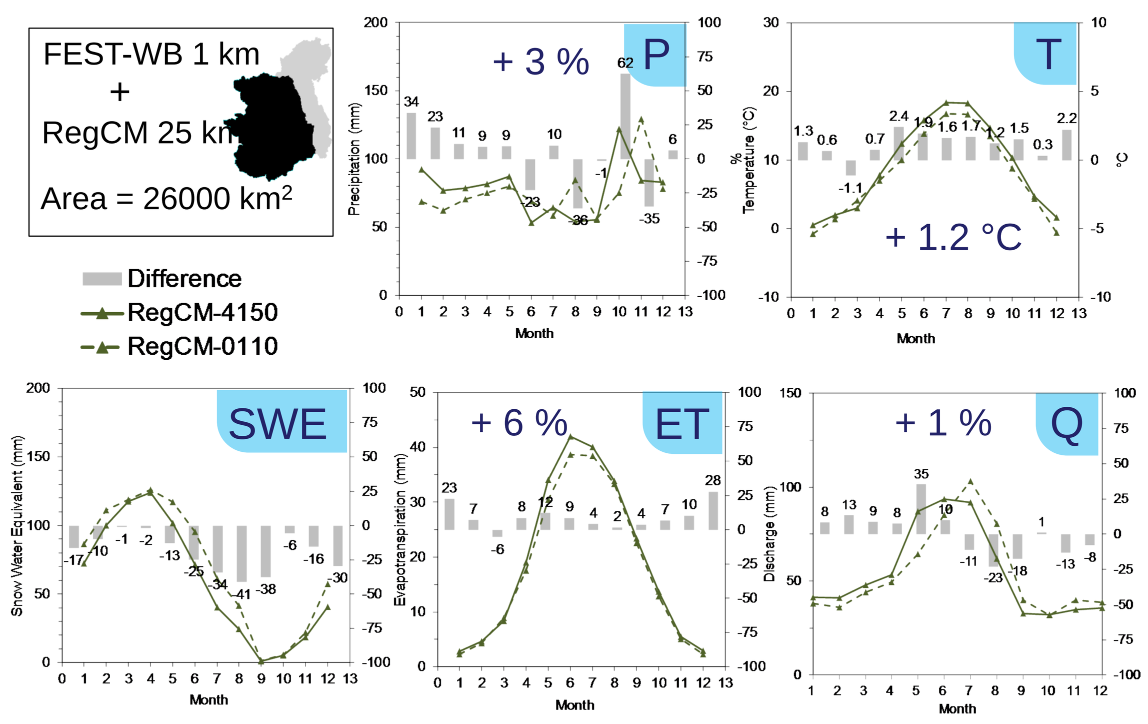
Mean 2001-2010 flow duration curves from observed discharges and simulated by FEST-WB and FEST-EWB models driven by meteorological observations





IMPACTS ON UPPER PO



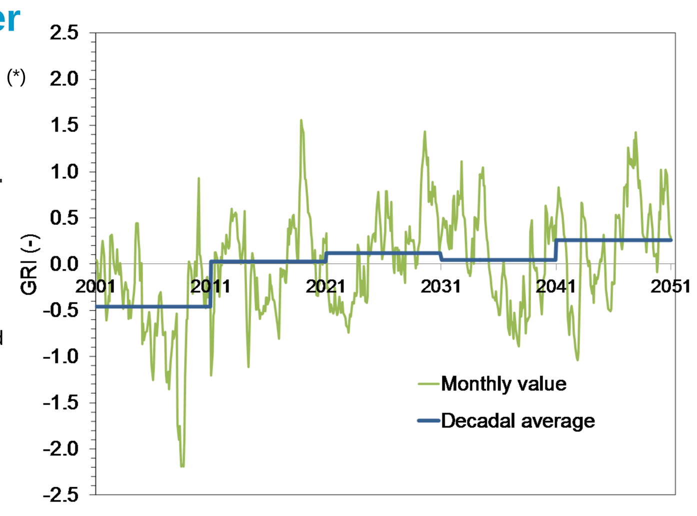


Impact on Groundwater

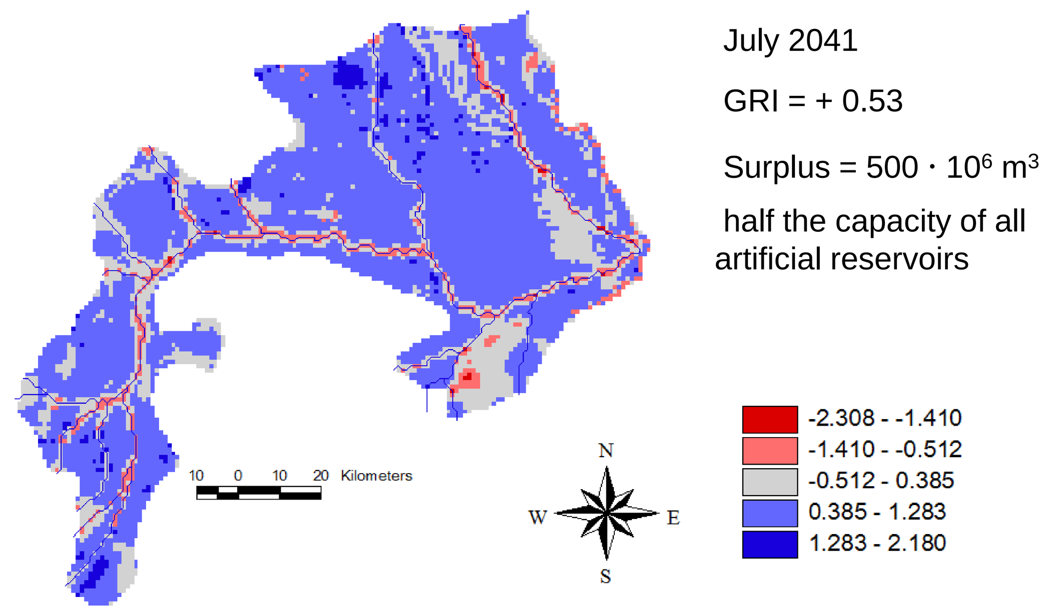
Groundwater Resource Index (*)

$$\mathrm{GRI}_{y,m} = \frac{D_{y,m} - \mu_{D,m}}{\sigma_{D,m}}$$

where $\mathrm{GRI}_{y,m}$ and $D_{y,m}$ are respectively the values of the index and of the groundwater detention for the year y and the month m, while $\mu_{D,m}$ and $\sigma_{D,m}$ are respectively the mean and the standard deviation of groundwater detention values D simulated for the month m in a defined number of years.



(*) Mendicino, G., Senatore, A., Versace, P. , 2008: A Groundwater Resource Index (GRI) for drought monitoring and forecasting in a mediterranean climate. Journal of Hydrology, 357(3–4), 282–302



July 2041
GRI = + 0.53
Surplus = 500 · 10⁶ m³
half the capacity of all artificial reservoirs

CONCLUSIONS

Climate projections on Upper Po basin show an increase of annual precipitation and temperature but a decrease of precipitation during summer period

Intensity of climate change depends on climatic models and downscaling technique

Shift in temperature and precipitation patterns and amount reflect an increase of snow accumulation during winter but a rapid melt during spring. An increase of mean annual discharge but a decrease during summer are expected.

Groundwater detention is expected to increase with positive value of Groundwater Resource Index during summer that can compensate the decrease of discharge.

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