A DISTRIBUTED RAINFALL-RUNOFF MODEL FOR THE INVESTIGATION OF CLIMATE CHANGE EFFECTS ON RIVER FLOODS IN THE EUROPEAN ALPS

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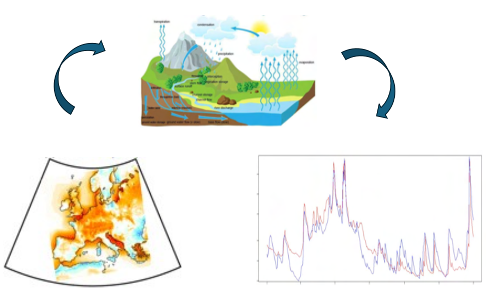
MAPPING EXTREMES CHANGES ON THE EUROPEAN ALPS

As our climate system climbs through its current warming path, temperature and precipitation are greatly affected also in their extreme. There is a general concern that climate change may affect also the magnitude and frequency of river floods and, therefore, that existing and planned hydraulic structures and flood defenses may become inadequate to provide the required protection level in the future.

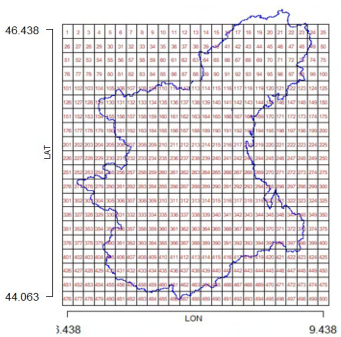
Inside this evolving context, the ***CLIM2FLEX*** project aims to assess, under potential climate scenarios, the variations at a regional scale in the intensity and frequency of river floods, how they are related to changes in climate extremes, and how climate extremes are related to large scale predictors. The study area comprehends the entire GAR (Great Alpine Region), ranging from France, passing through Italy, Austria and Switzerland, to Slovenia.



To do so, an integrated modelling chain has to be developed, starting from climatic projections, passing through hydrologic modelling, to arrive at the identification of which climate extremes indices are better correlated to river floods indices, and how they will modify due to climate change and the associated uncertainties.

CASE STUDY

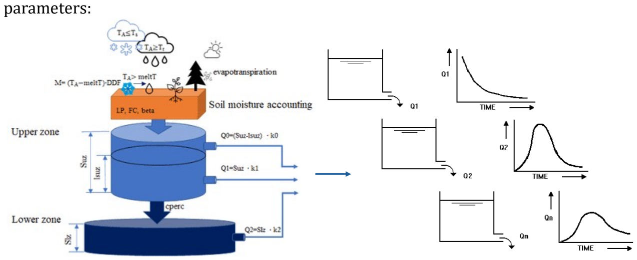
In the following sections we will focus on the hydrological module of the modelling chain, to show, through a smaller case study, how the selected rainfall-runoff model can be considered suitable for the desired application.



- The Piedmont region (north-west Italy) is characterized by the Alps in the north-west sides, and by plains in the east;
- 127 gauged station, with heterogeneous quality and time coverage of mean daily discharge observations;
- Gridded climate input data provided by the regional agency (Figure on the left), resulting from the interpolation of meteo-stations for precipitation and temperatures.

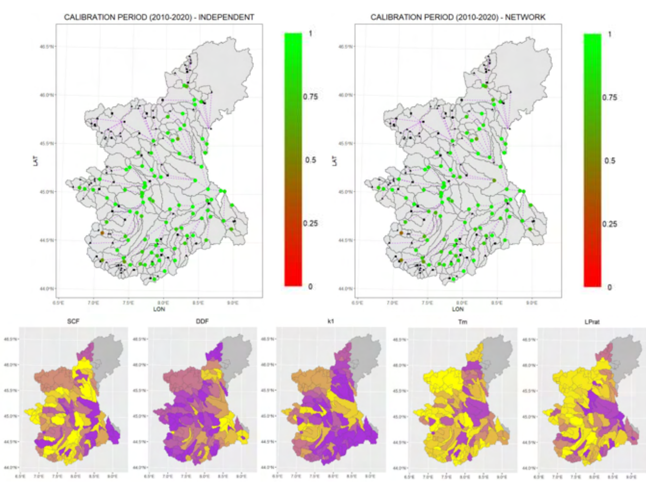
RAINFALL-RUNOFF MODEL

The rainfall-runoff model used for the hydrological module is composed of a generative and a routing routines. The first is performed with the ***TUWmodel [1]***, while the second is implemented through a unique ***Nash-Cascade*** (two parameters, *N* and *k_nash*) for the combined contributions of the hillslopes and river runoff. In total the model has 15 parameters:



MODEL CALIBRATION

Two different *modes* have been tested in calibration: an «***independent mode***», in which each gauged basin is calibrated independently from the others: to each sub-basin composing the catchment, are assigned the same parameters that maximise the ***KGE***. A second «***network mode***», in which each catchment calibration depends from all the already calibrated sub-basins connected upstream. Here are assigned identical parameters only to the still uncalibrated sub-basins composing the catchment. In both cases, the *N* parameter from the Nash-Cascade is set equal to 1 for every sub-basin (assumed to be homogeneous, small and with negligible differences in channel length), reducing the parameteres to be tuned to 14:



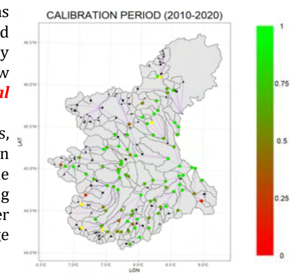
[Maps for some parameters in network mode, from purple (min) to yellow (max) of the parameter range]

REGIONALIZATION

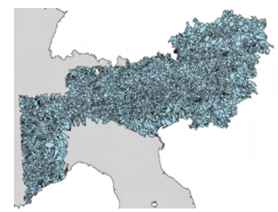
The locally lumped calibrated catchments are used to derive a regional model using a Machine Learning algorithm called ***HydroPASS [2]***. Starting from multiple feasible sets of model parameters for each basin and some catchement descriptors (***CD***) calculated for every *UH* (in this case the sub-basins) and the catchments themselves, using decision trees, an optimal regional functional relationship is found.

The resulting Kling-Gupta efficiency, as expected, is generally lower at the single gauged stations (with some catchments very badly reproduced, in the map the red and yellow dots), but overall the ***median regional efficiency*** was equal to ***0.71***.

A single map is reported because the results, starting from the two different calibration approaches, were nearly identical, showing the strong consistency of the algorithm used. Using the newly obtained distributed model (after validation), it is possible to simulate discharge also at ungauged sub-basins (black dots).



MOVING TO THE GAR….INPUT DATA AND CATCHMENTS DATASET



Moving from the Italian example to the entire *GAR*, there are two practical issues that must be faced:

1. A single input climate dataset should be used, and its resolution should be high enough to be used for small catchments (at the moment *CERRA/UERRA* datasets investigated as possible choices).
2. The shapefiles of the sub-basins should also be coherent: currently the *ECRINS* european dataset (for its easy accessibility and coverage) is selected.

CHALLENGES, OPEN QUESTIONS AND FUTURE STEPS

DATASETS

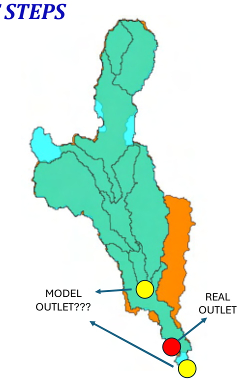
- Need to meaningfully assign gauged stations to sub-basins in the selected shapefiles dataset (e.g. contour-based methods);
- Validation of climate input products for the application;

MODEL

- Collection of international discharge observation data for calibration;
- Model construction and validation over the entire GAR, and simulations for future scenarios;

INDEX

- Definition of flood streamflow indices, and correlation with climate extremes indices and large scale climate patterns.



MAIN REFERENCES:

[1] Merz, R., Blöschl , G. (2004), Regionalisation of catchment model parameters.

[2] Merz, R., Tarasova, L., & Basso, S. (2020), *Parameter's controls of distributed catchment models—How much information is in conventional catchment descriptors?*

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SESSION HS2.1.4 - MOUNTAIN HYDROLOGY UNDER GLOBAL CHANGE: MONITORING, MODELLING AND ADAPTATION

TO THE PROJECT WEBPAGE!!!