POLITECNICO
MILANO 1863

CLIMATE LAB

“Assessment of hydrological flows in Lombardy Alpine rivers, and their connection with the underground aquifer, under potential climate change scenarios in the XXI century”

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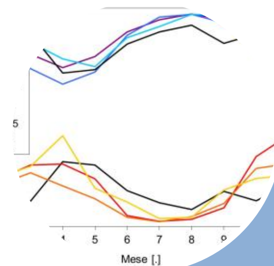
Production of **weather based hydrological scenarios** in the catchment as boundary conditions for **acquifer modeling during 21° century**



Hydrological scenarios

Climate scenarios:

4 GCMs models

(4 RCPs scenarios)

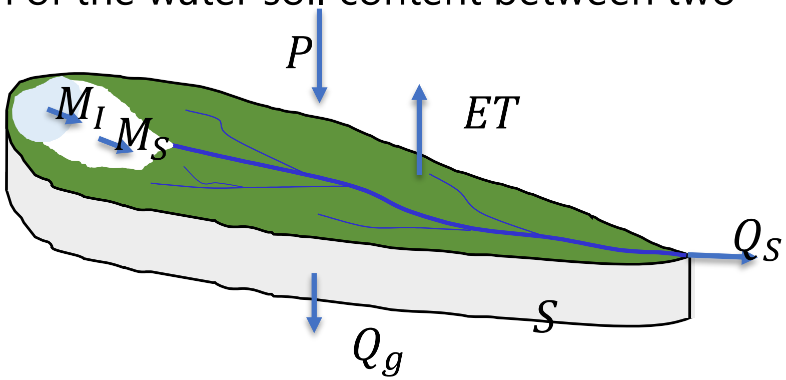
Hydrological model

Data based set up of the hydrological model *Poli-Hydro:*

- It is a weather driven, physically based, semi distributed hydrological model
  - Spatial resolution: 1 km
  - Temporal resolution: daily

- It is based on the Mass conservation equation of the water soil content between two subsequent temporal steps:

$$S^{t+\Delta t} = S^t + R + M_s + M_i - ET - Q_g$$



Condition for the run-off flow:

$$\begin{cases} Q_s = S^{t+\Delta t} - S_{max} & se \quad S^{t+\Delta t} > S_{max} \\ Q_s = 0 & se \quad S^{t+\Delta t} < S_{max} \end{cases}$$

S: soil water content
R: precipitation
Ms: snow melting
Mi: ice ablation
ET: evapotranspiration
Qg: underground flow
Qg: runoff flow

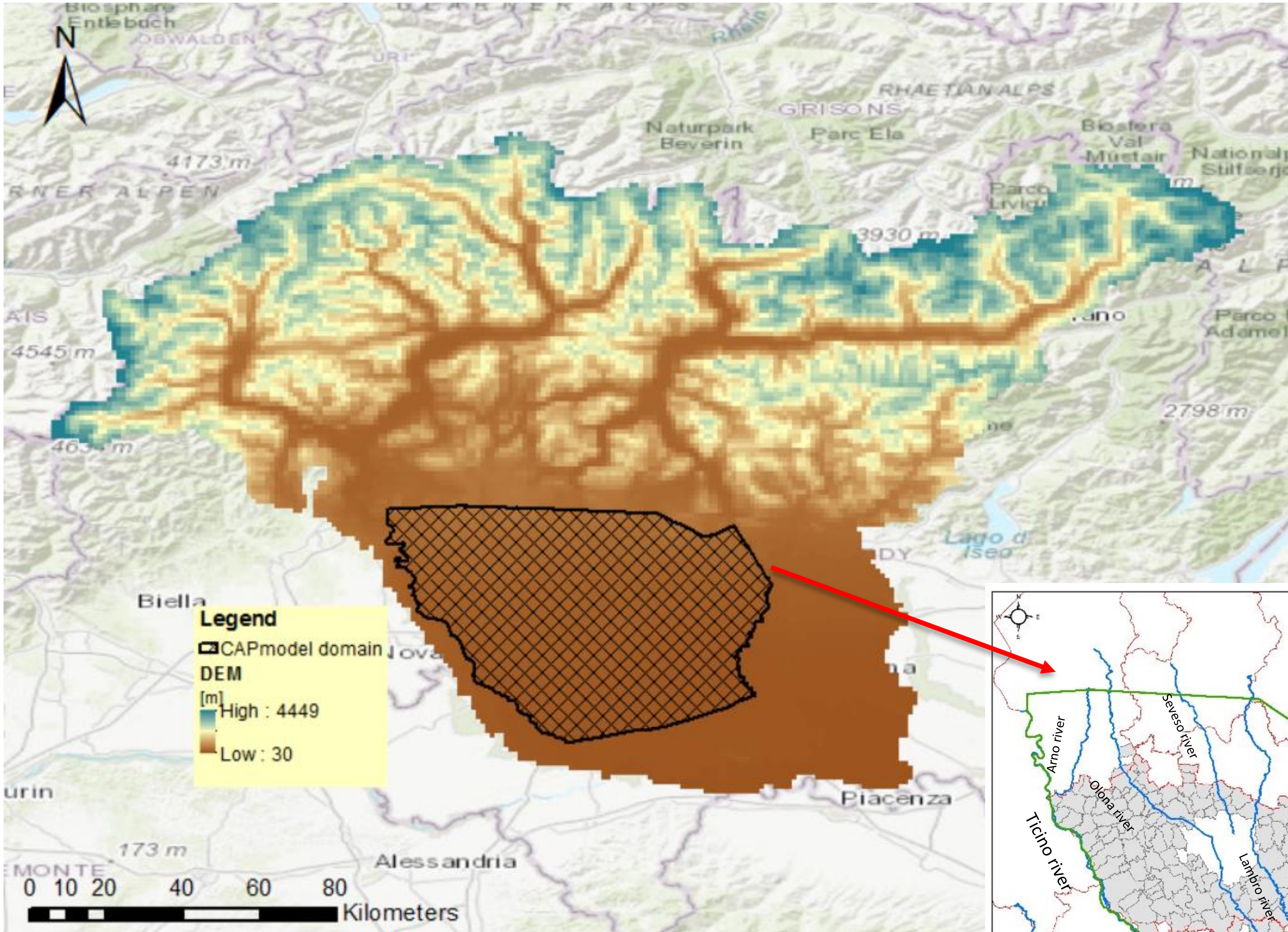
- Evapotranspiration: Hargreaves formula

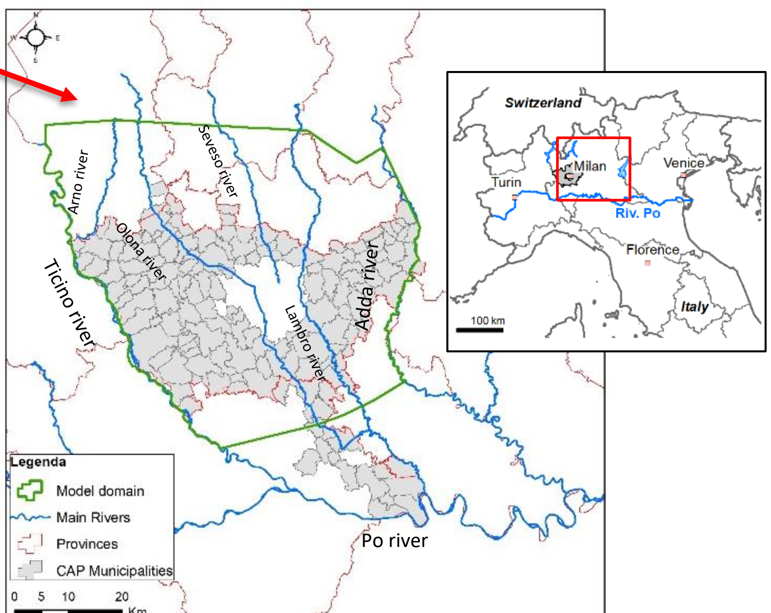
- Underground flow: $Q_g = k\left(\frac{S}{S_{max}}\right)^{k_g}$

- Snow melting: Pellicciotti model $\begin{cases} M = DDS * (T - T_{critical}) & if \quad T > 0 \\ M = 0 & if \quad T \leq 0 \end{cases}$

- Flow routing: Nash model $Q = \int_0^t P(\tau) * u(t-\tau)d\tau \quad with \quad u(t) = \frac{1}{k*\Gamma(n)}\left(\frac{t}{k}\right)^{n-1} e^{-\frac{t}{k}}$

Study area – Hydrological modelling





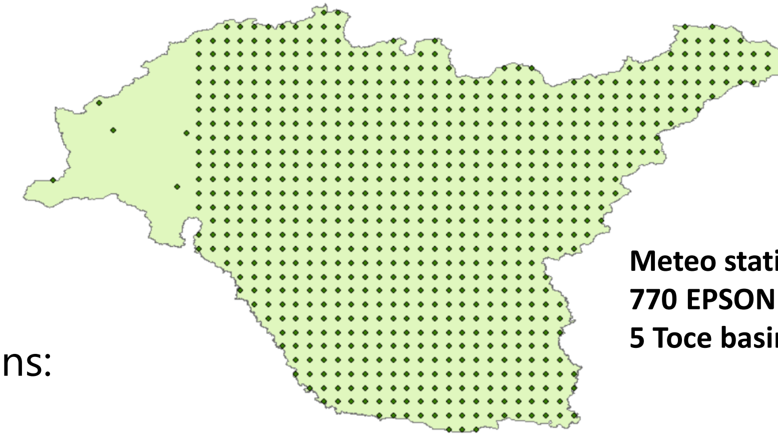
INPUT

- ➢ DEM of the basin

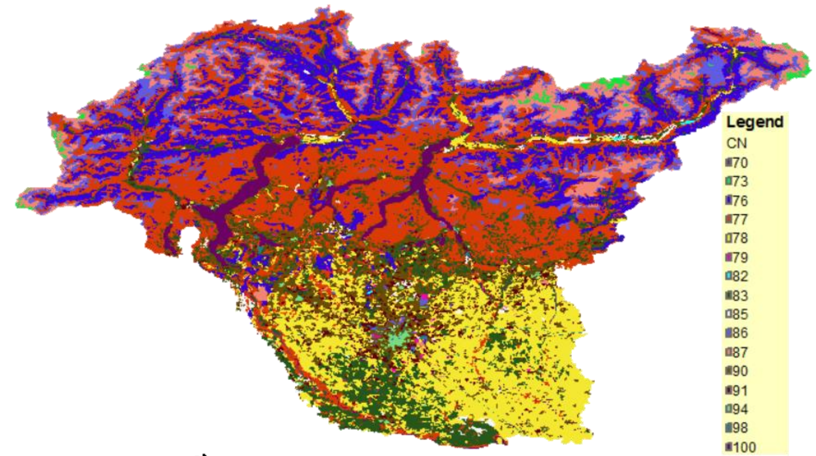
- ➢ Meteorological data in the available stations:
  - Daily mean total precipitation(2001-2018)
  - Daily mean temperature(2001-2018)

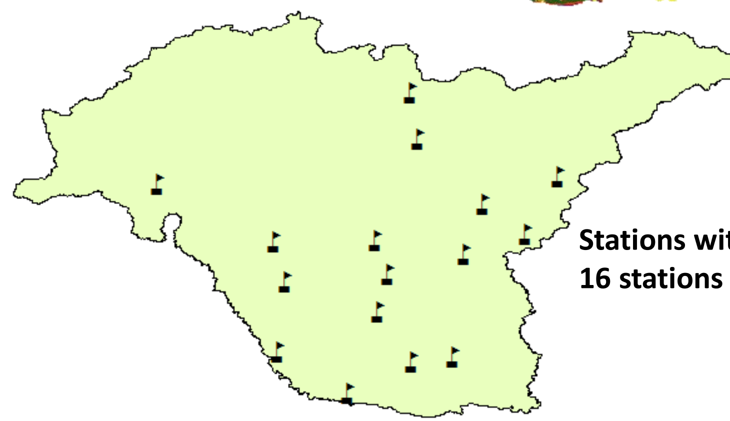
- ➢ Maps:
  - Land use→ CurveNumber maps
  - Vegetation covered areas
  - Ice covered areas

- ➢ Sub-basins areas for model calibration through the comparison of measured historical flow and modelled flow



Meteo stations:
770 EPSON stations
5 Toce basin's stations



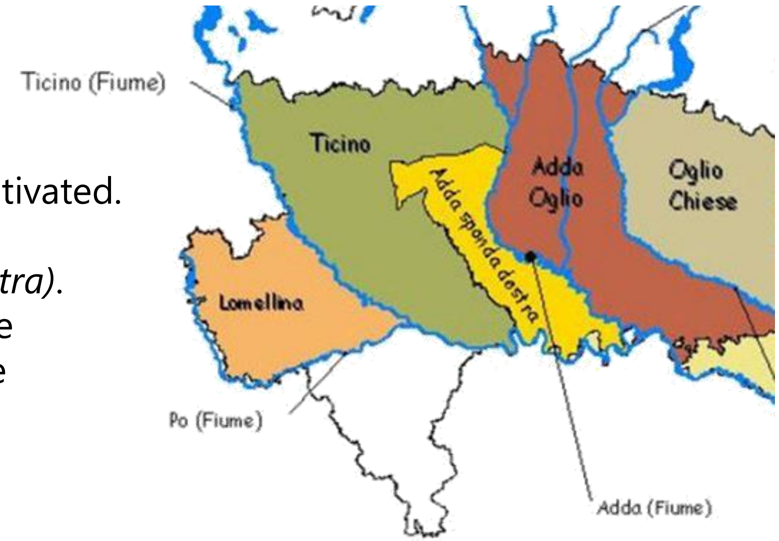


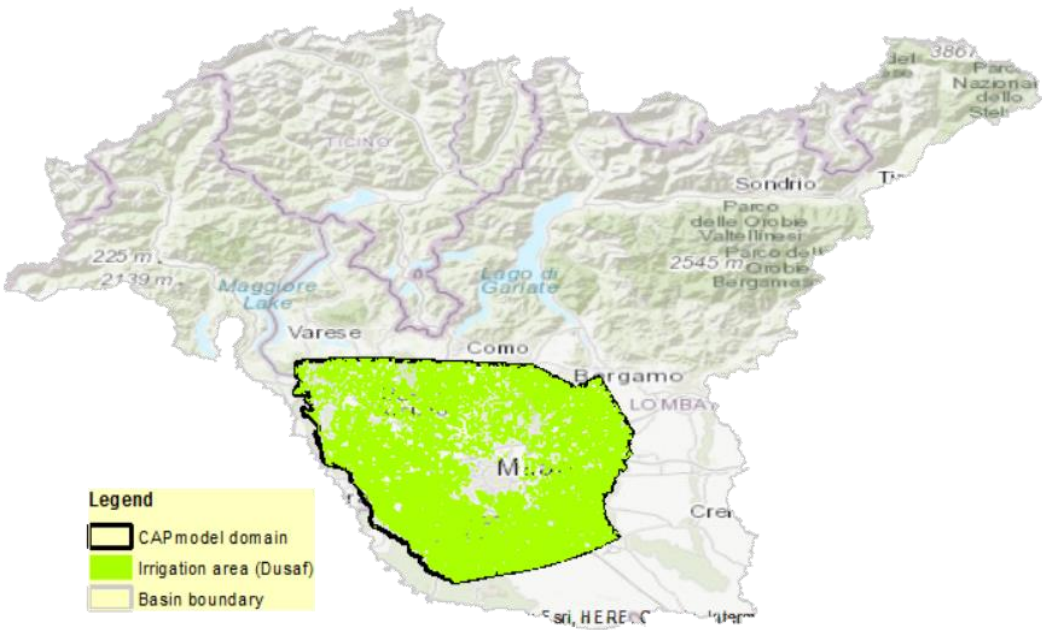
Stations with flow-rate scale:
16 stations

INPUT

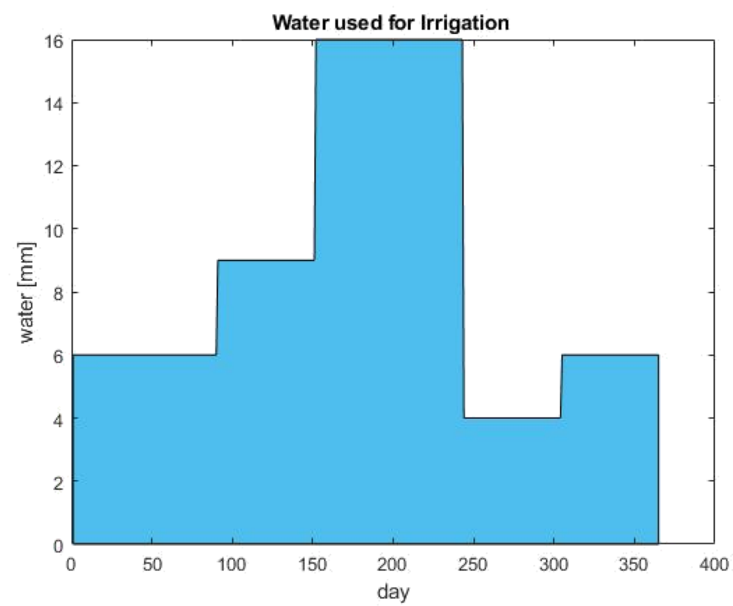
➢ Irrigation demand

The plain area around Milan (CAP model domain) is highly cultivated. The water for irrigation is taken from the main rivers Ticino *(Consorzio est Villoresi)* and Adda *(Consorzio Adda sponda destra)*. Therefore, the hydrological model has to take into account the irrigation water which contributes with the precipitation at the hydrological budget of the domain.





Irrigation areas of Lombardy region - http://www.geoportale.regione.lombardia.it/download-ricerca



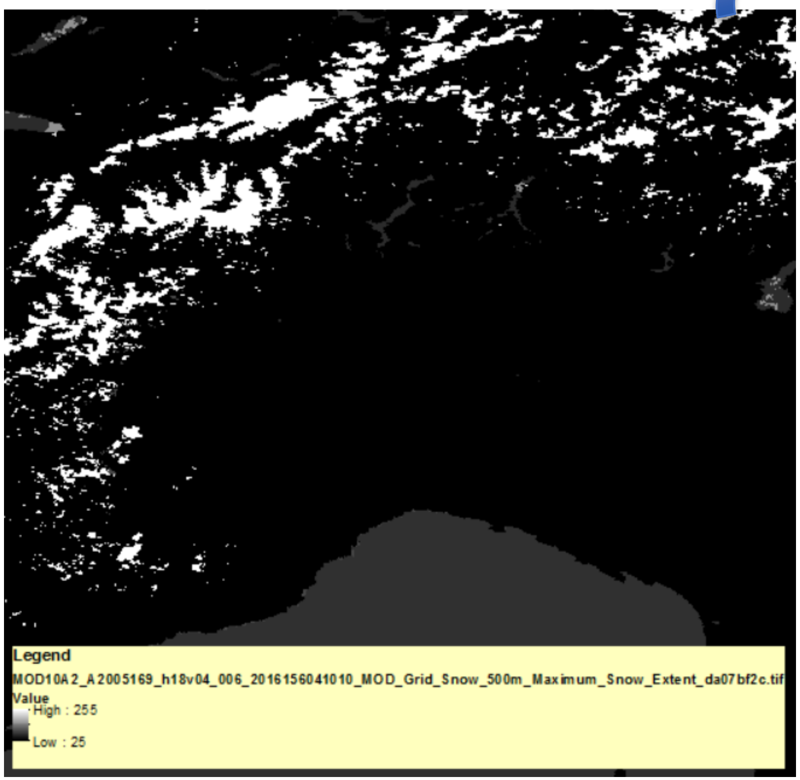
Mean values of irrigation demand per year

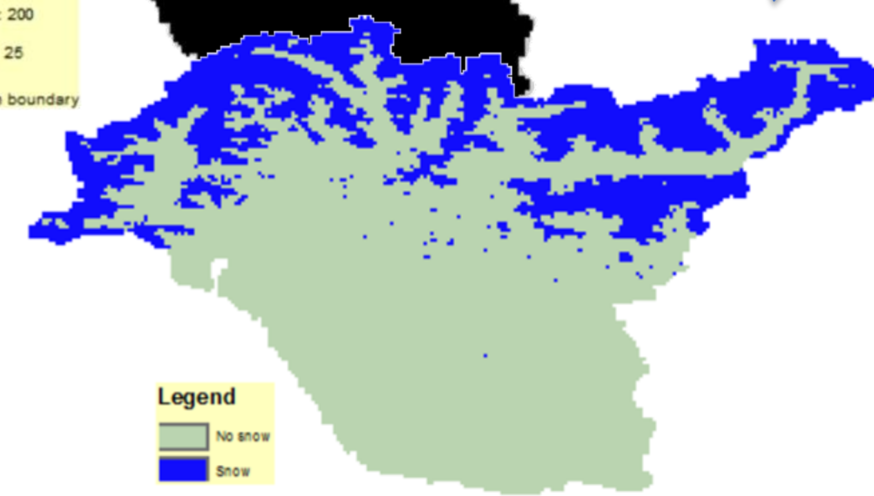
CALIBRATION

DDS (Degree-day-snow)

The snow melting model is tackled using the degree day approach and melt factor [mm °C^{-1} day^{-1}].
The DDS is calibrated by comparing the Poli-Hydro simulated snow covered Area (SCA) in different periods during melting season (march-july) with the NASA satellite images MODIS SCA.

Modis image processing

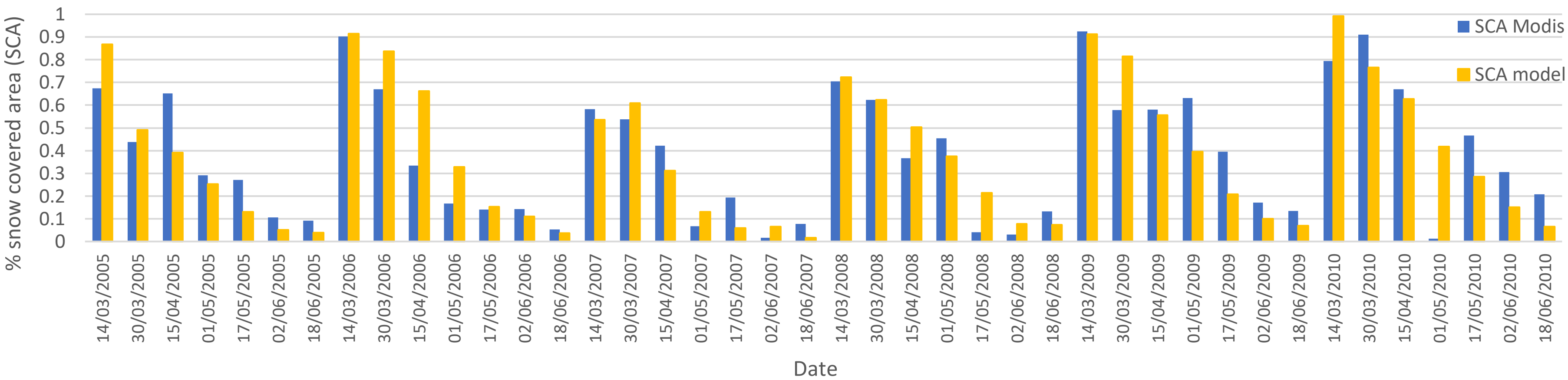




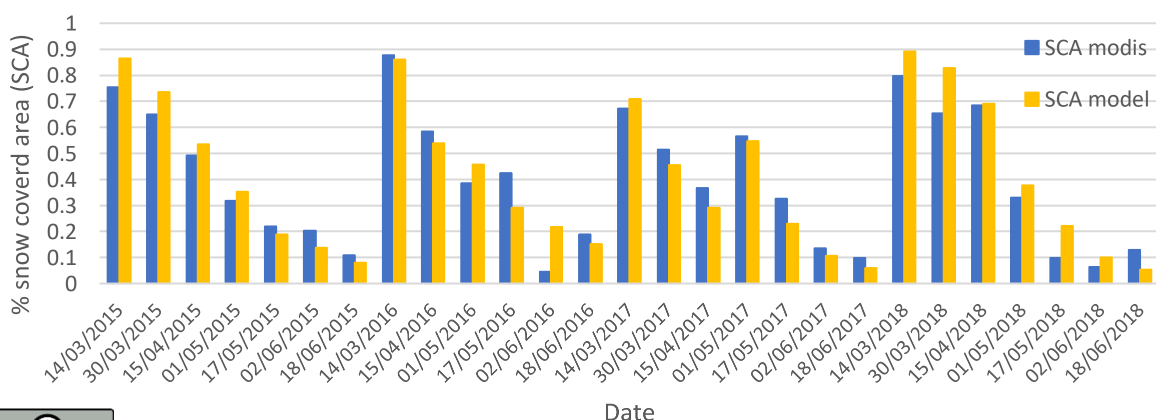
CALIBRATION

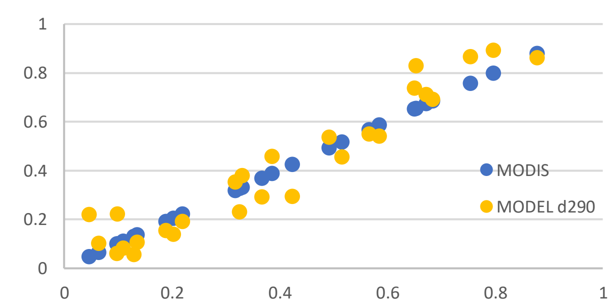
DDS = 2.9 mm °C^{-1} day^{-1}

Calibration period: 03/2005 – 06/2010



Validation period: 03/2015 – 06/2018





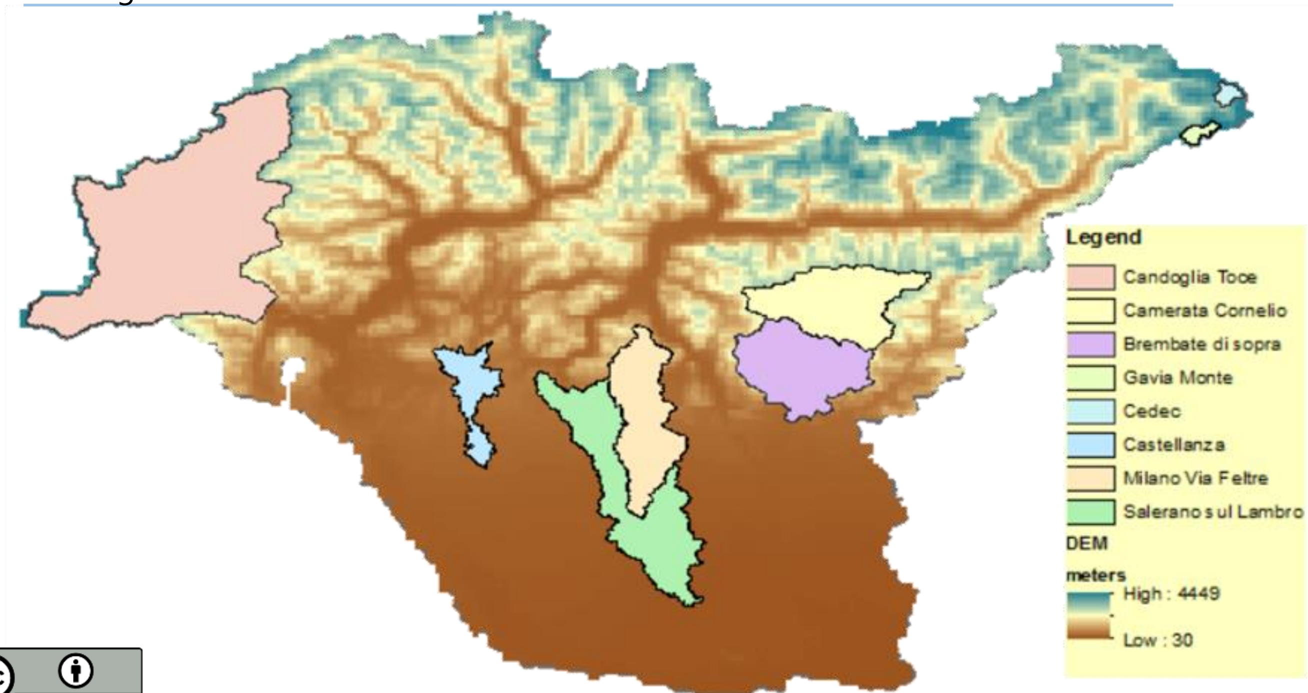
CALIBRATION

Model accuracy for natural basins

	Qobs [m³/s]	Qmod [m³/s]	Err%	NSEmonthly
Brembate di Sopra	26.480	20.957	20.86%	0.301
Camerata Cornelio	10.331	10.526	1.89%	0.615
Cedec	1.067	0.423	60.33%	0.789
Gaviamonte	1.218	0.471	61.62%	0.723
Milano via Feltre	9.312	9.842	5.69%	0.591
Lesmo peregallo	5.644	6.362	12.71%	0.648
Castellanza	4.166	3.978	4.52%	0.085
Candoglia Toce	64.927	76.236	17.42%	0.225

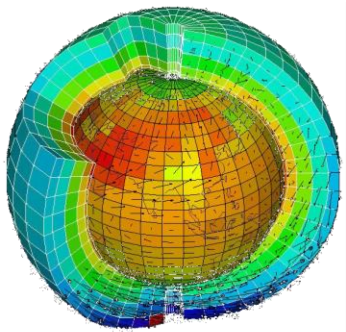
Calibration parameters:

- Superficial and sub-superficial lag times
- Hydraulic conductivity k
- Exponent of the underground discharge Q_g



Climate data forecast until 2100

6 Global circulation models (GCM)

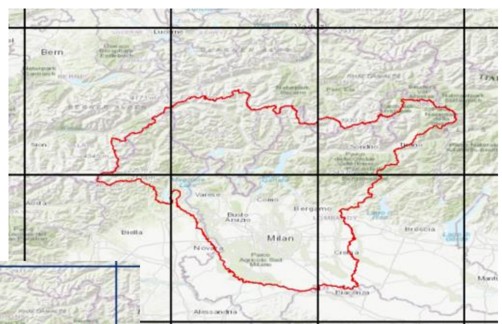


AR5
- Ec-Earth
- CCSM4
- Echam6

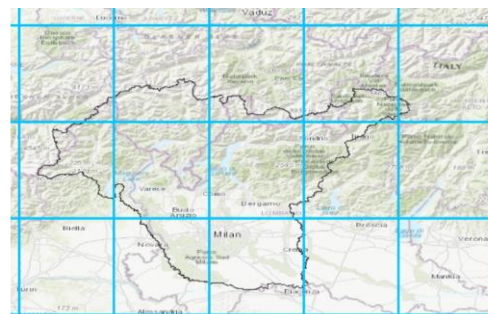
RPC (Representatives pathways for CO2 emissions)
- 2.6
- 4.5
- 8.5

AR6
- Ec-Earth3
- CESM2
- Echam6.3

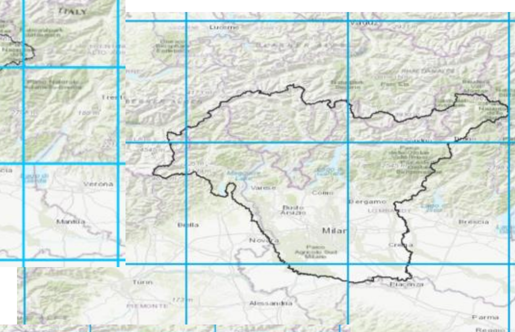
RPC (Representatives pathways for CO2 emissions)
- 2.6
- 4.5
- 7.0
- 8.5



Ec-Earth

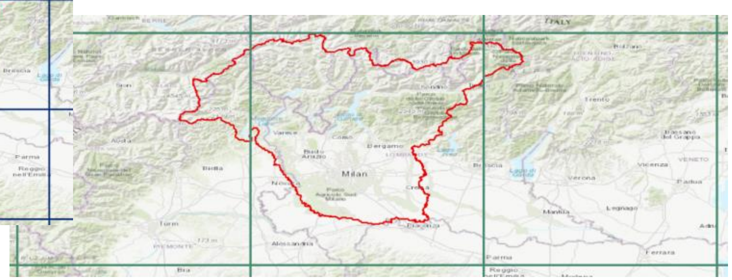


Ec-Earth3



CESM2

CCSM4

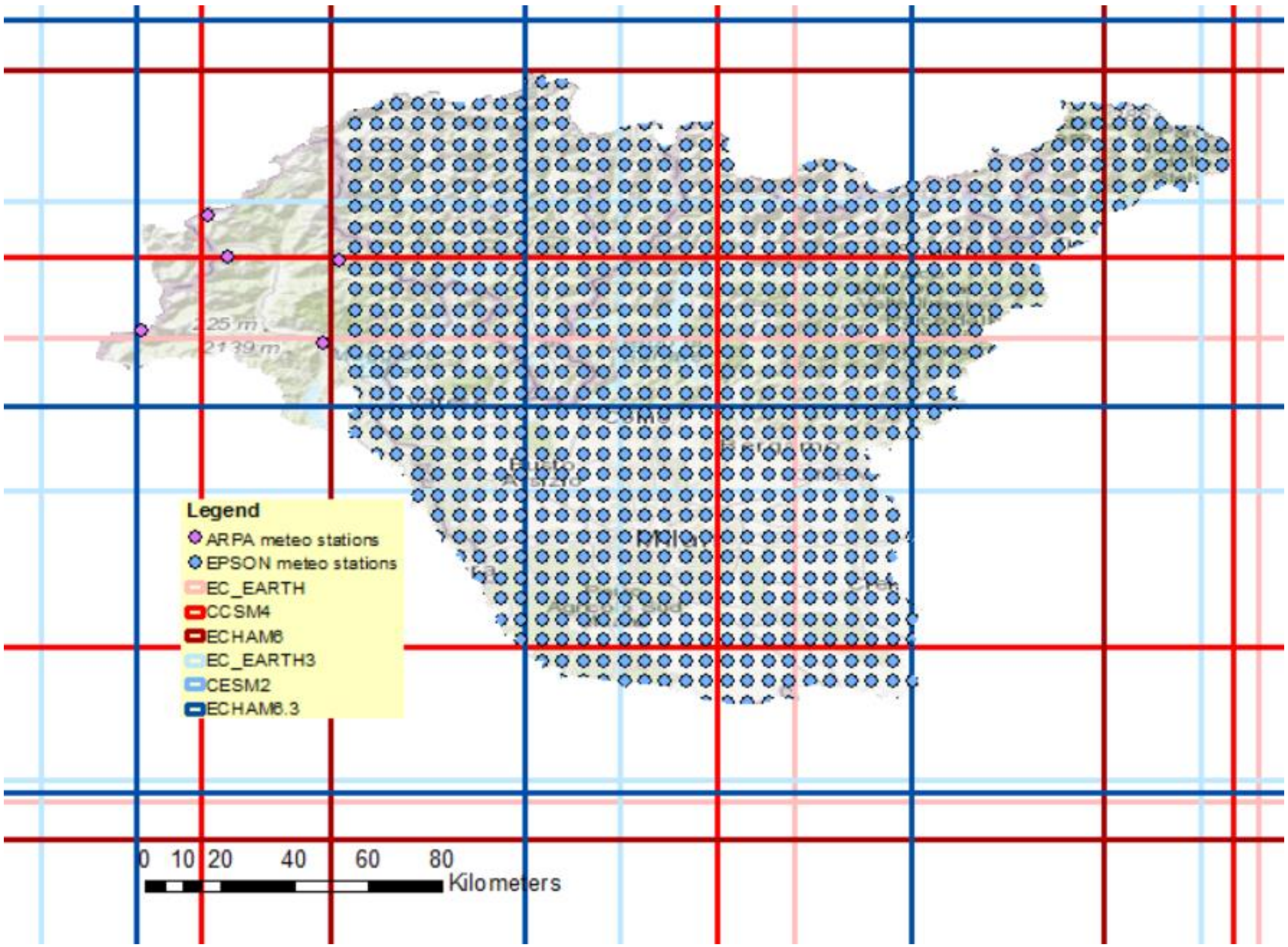


Echam 6

Echam6.3

Downscaling

Spatial statics disaggregation of the climate projections from the global scale to the local scale



Future concerns – Work in progress

How the climate in the future will affect the water budget in the catchment?

What will be the regulation politics for the big Lakes inside the catchment?

How the irrigation efficiency will change in the future?

Final goal

Understand how these factors will affect the dynamic of the aquifer for a smart management of the hydric resource