Continuous streamflow simulation for index flood estimation in an Alpine basin of Northern Italy

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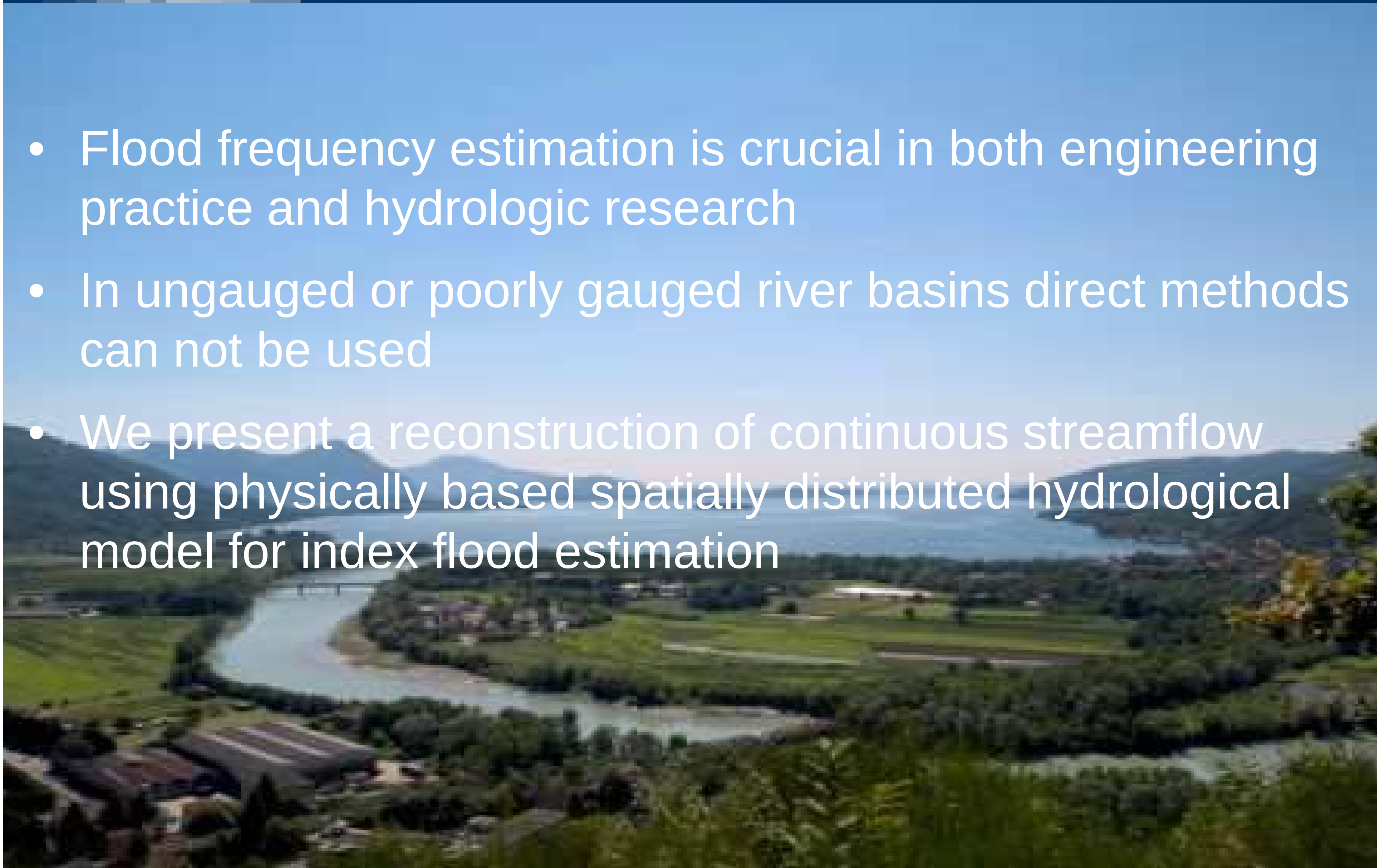
Aim of the work

- Flood frequency estimation is crucial in both engineering practice and hydrologic research
- In ungauged or poorly gauged river basins direct methods can not be used
- We present a reconstruction of continuous streamflow using physically based spatially distributed hydrological model for index flood estimation



The index flood method

For homogeneous region

$$\underline{q_T} = \underline{x_T} \cdot \underline{q_{index}}$$

T-year quantile of flood flows

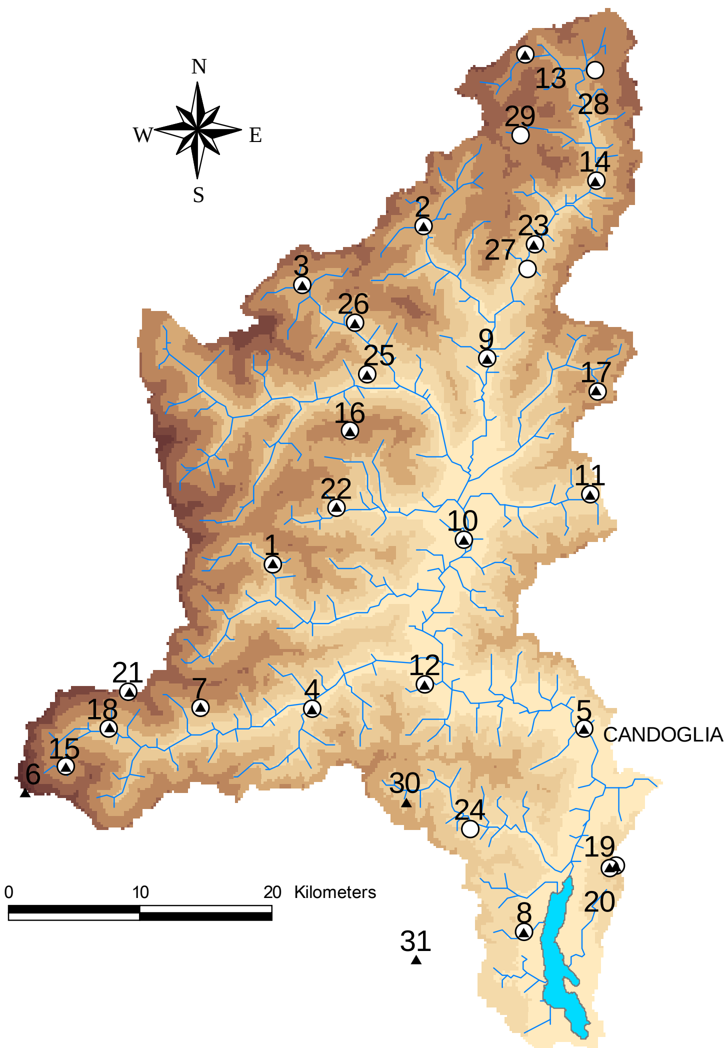
T-year quantile of normalized flood flows in the region, growth factor

index flood

generally assumed equal to the mean maximum annual flood

Bocchiola, D., De Michele, C., and Rosso, R., (2003). "Review of recent advances in index flood estimation." Hydrol. Earth Syst. Sc., 7(3), 283-296.

The case study: Toce river



▲ Thermometers
○ Rain gauges
DEM (m a.s.l.)
194 - 679
680 - 1165
1166 - 1651
1652 - 2137
2138 - 2623
2624 - 3109
3110 - 3595
3596 - 4081
4082 - 4567

Area: 1800 km^2

Alpine basin: nearly 32% of the total area above 2000 m a.s.l..

28 rain gauges

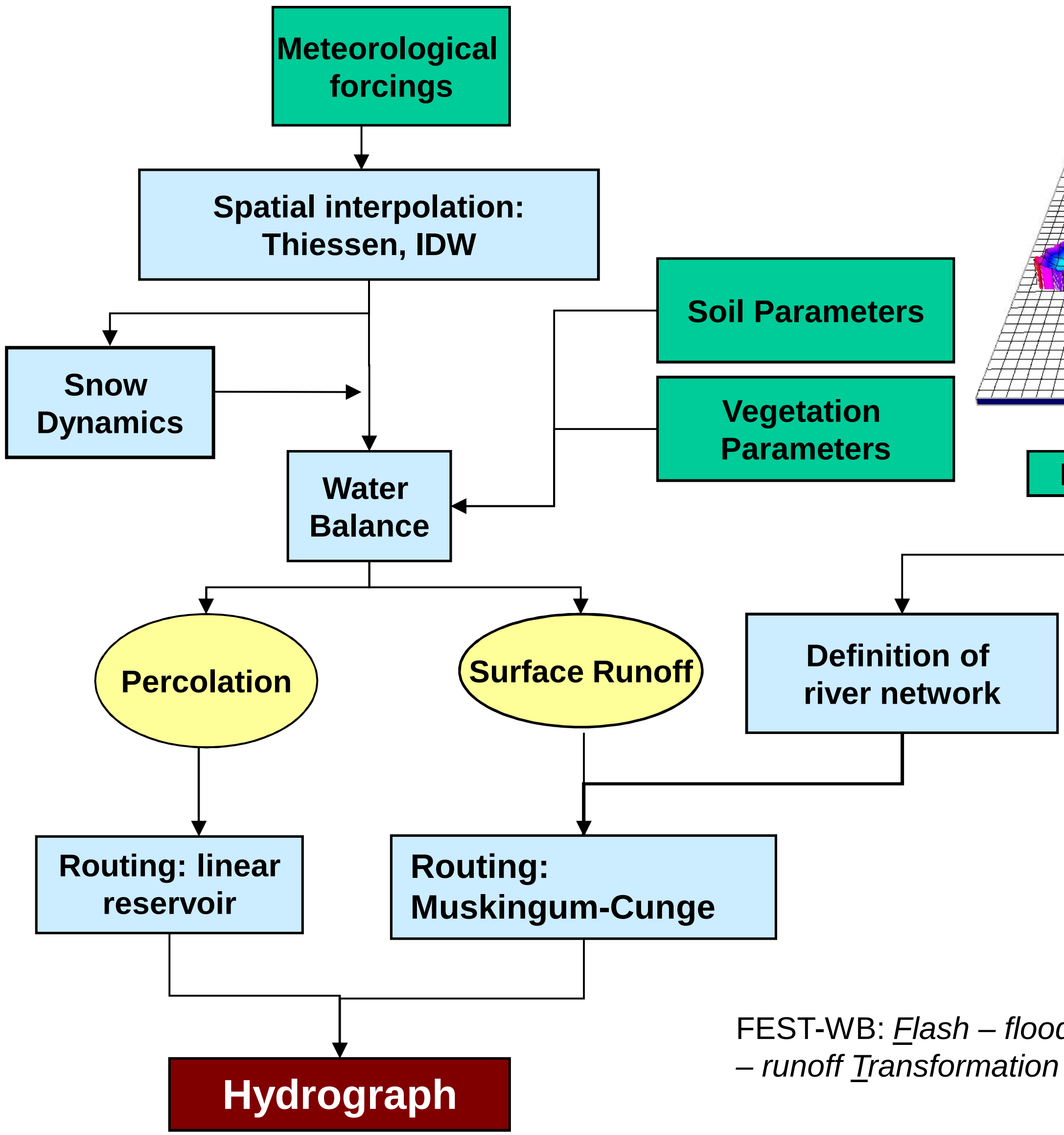
27 thermometers

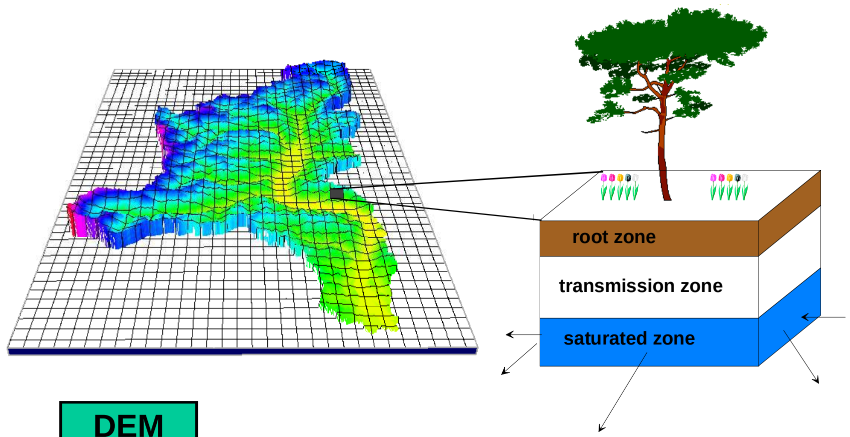
Number of available station is variable from 1982

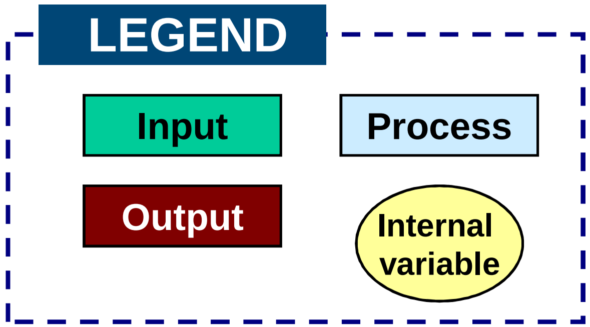
At Candoglia (1500 km^2) 53 years of max annual flood (1933-1998) and hourly discharge measurements from 2000-2010

Qindex = 1076 m^3/s

Hydrological model FEST-WB



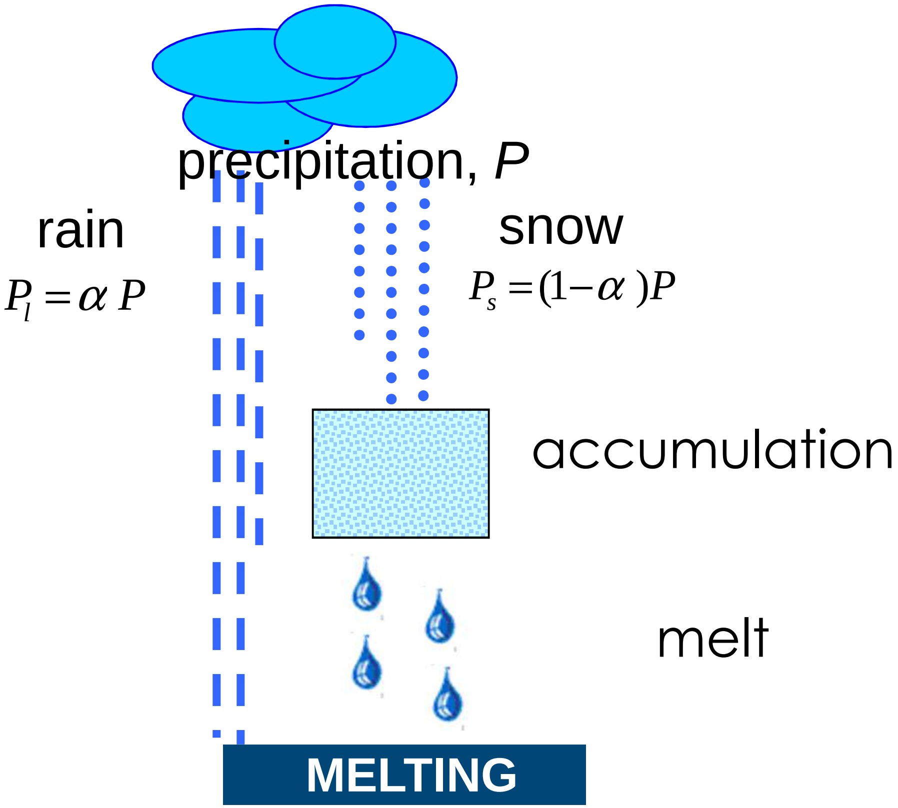




FEST-WB: *F*lash – flood *E*vent – based *S*patially – distributed rainfall – runoff *T*ransformation – including *W*ater *B*alance

Hydrological model FEST-WB

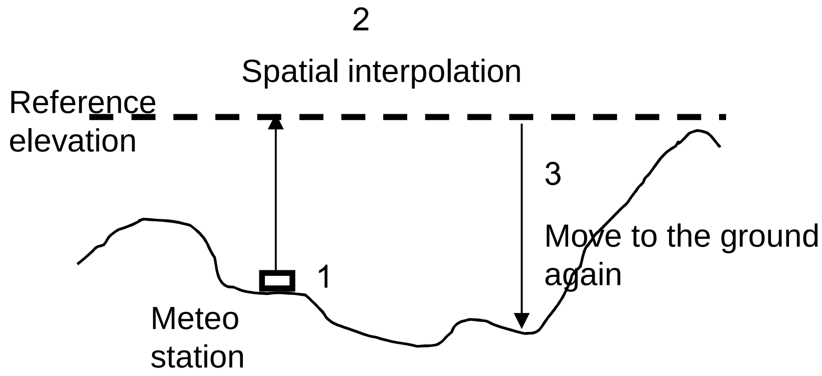
Snow dynamics



$$SnowMelt = C_m (T_a - T_b)$$

T_a = air temperature
T_b = threshold temperature
C_m = melt coefficient [m/(s °C)]

Air temperature spatial interpolation



(1) Move measurements on a reference plane keeping into account a fixed thermal gradient (-0.0065 °C m^{-1})

(2) Spatial interpolation on the reference plane

(3) Data are taken to the ground keeping into account a fixed thermal gradient (-0.0065 °Cm-1).

Hydrological model FEST-WB

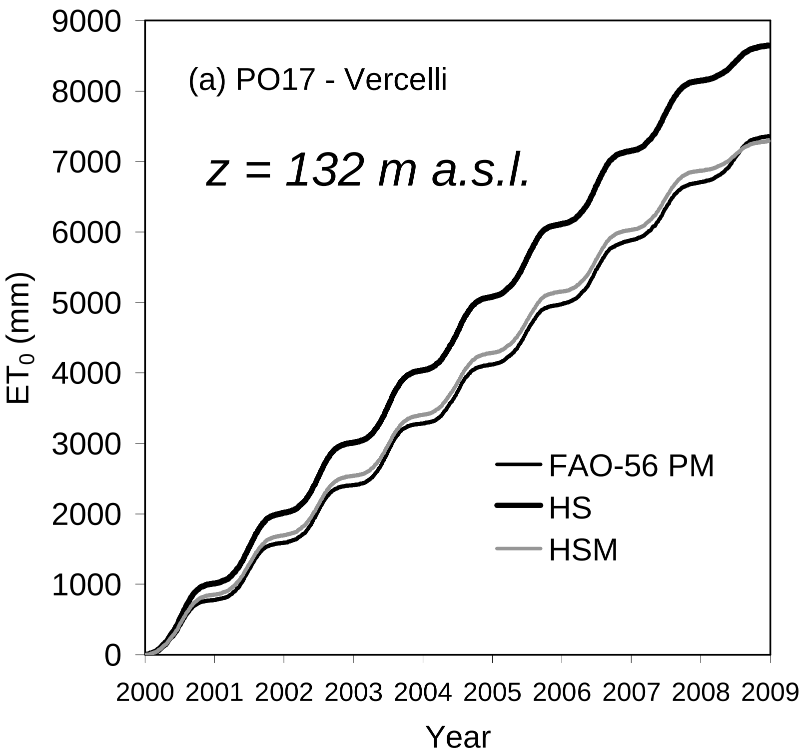
Modified Hargreaves equation
keeping into account elevation

Evapotranspiration

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

	HS	HS elev
upper Po		
MBE	0.154	**-0.030**
RMSE	0.885	**0.784**
Rhone		
MBE	-0.145	**0.031**
RMSE	0.670	**0.655**
upper Po + Rhone		
MBE	0.079	**-0.014**
RMSE	**0.836**	**0.754**

Ravazzani, G., Corbari, C., Morella, S., Gianoli, P., Mancini, M. (2011), Modified Hargreaves-Samani equation for the assessment of reference evapotranspiration in Alpine river basins. J. Irrig. Drain. E-ASCE, accepted, 10.1061/(ASCE)IR.1943-4774.0000453available online



Reduces overestimation at low elevation

Hydrological model FEST-WB

Modified Hargreaves equation keeping into account elevation

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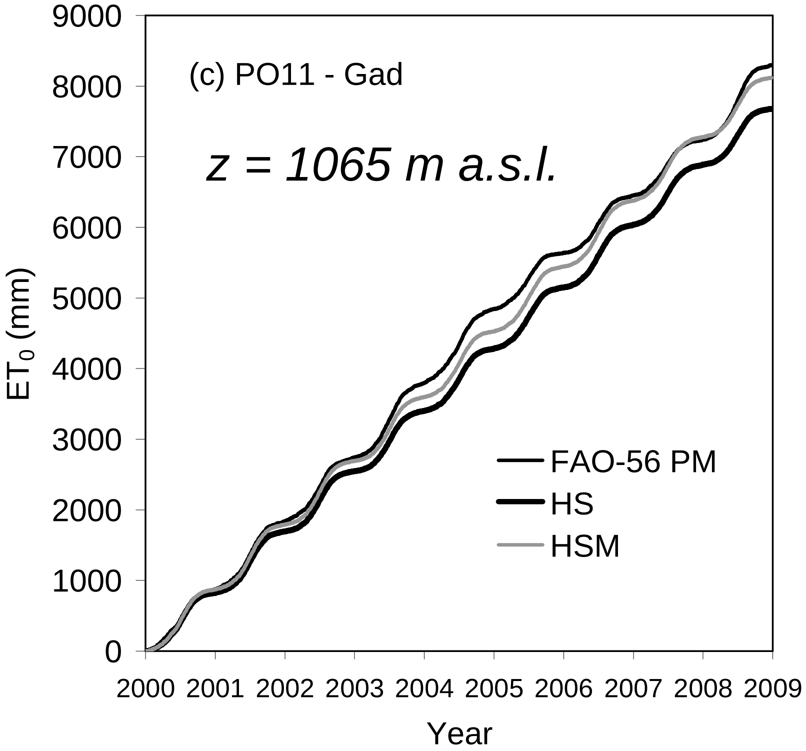

Reduces underestimation at high elevation

Model validation

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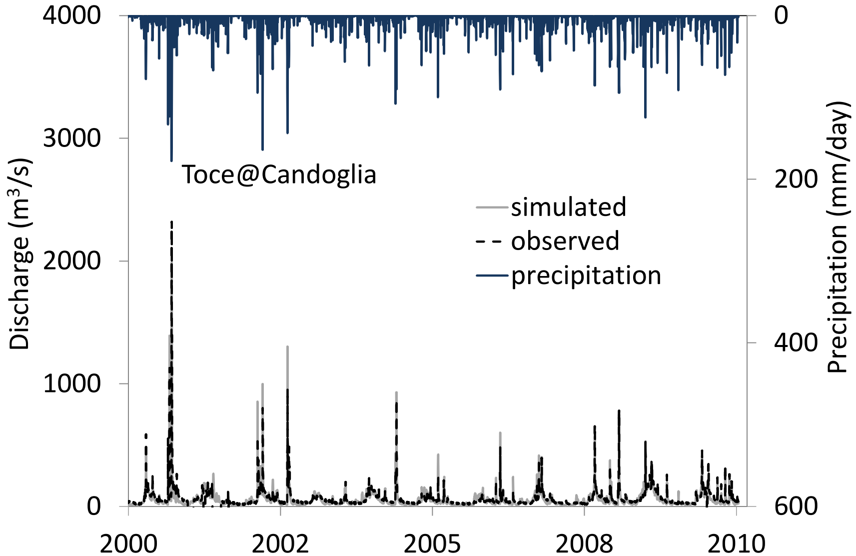
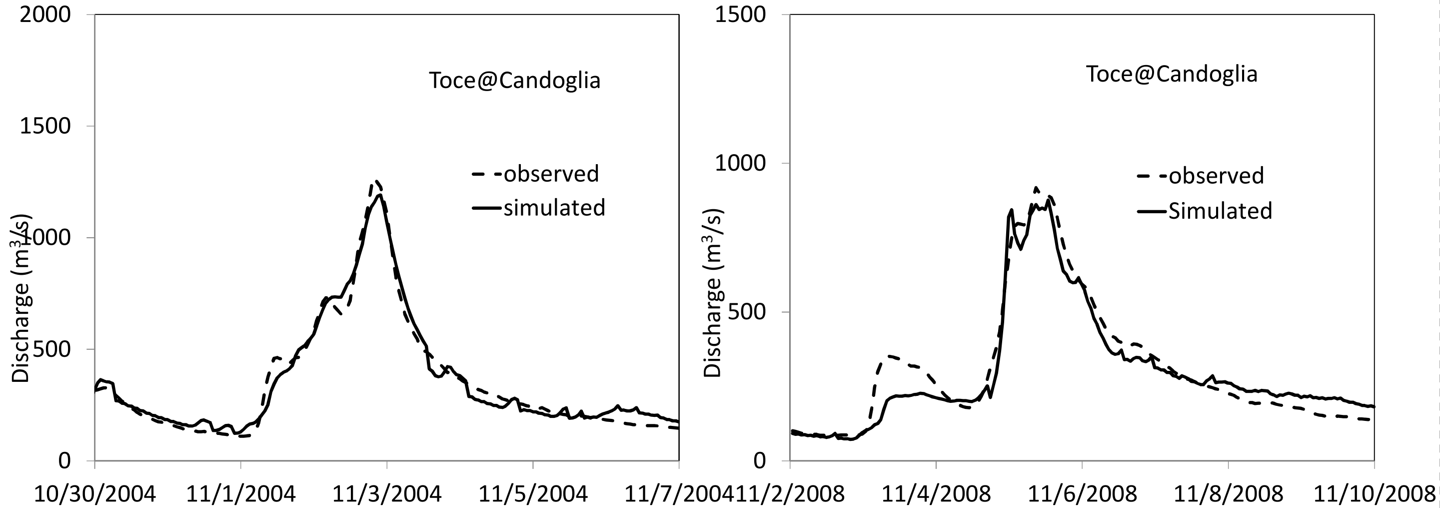
ENVIRON



DAILY

Period	RMSE	Nash-Sutcliffe
2000-2010	29.53	0.88

HOURLY



max annual flood

Simulated years: 29

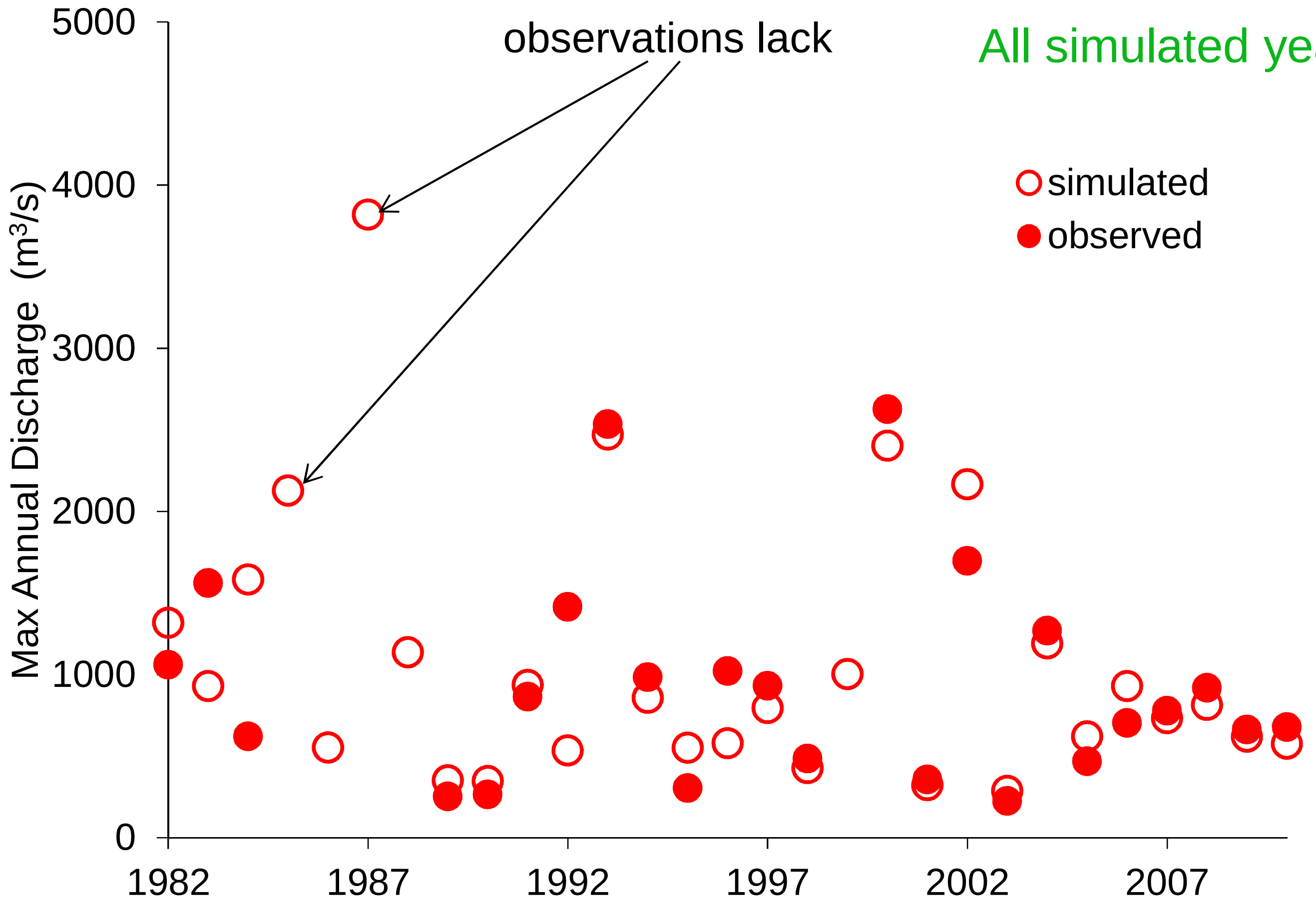
Available observations: 24

INDEX FLOOD ESTIMATION

All observations: 945 m^3/s

24 Selected simulated years: 935 m^3/s

All simulated years: 1070 m^3/s



Conclusions

- The FEST-WB distributed hydrological model proved to be accurate in simulating flood events on river Toce even without calibration

- Index flood estimation based on continuous streamflow simulation is useful in ungauged or poorly gauged basin

- Index flood estimation based on continuous streamflow simulation is useful for reconstruction of missing data so to reduce probability of underestimating index flood

Acknowledgments

This work was carried out under the umbrella of the Characterization of Lake Maggiore and Toce River project, funded by Syndial SpA, which also supported the characterization activities. Thanks to ARPA Piemonte for providing temperature and precipitation data from their stations

THANK YOU FOR YOUR ATTENTION !

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