International Symposium on Distributed Hydrological Modelling
University of Bologna
To mark the 70th birthday of Prof. Ezio Todini
BOLOGNA 5-7 June 2013

POLITECNICO DI MILANO

From droughts to floods: applications of real-time hydro-meteorological models

A. Ceppi*, G. Ravazzani, M. Mancini

Department of Civil and Environmental Engineering (D.I.C.A.), Politecnico di Milano, Piazza L. da Vinci 32, Milano, Italy

*Corresponding author: alessandro.ceppi@polimi.it

Abstract

Hydro-meteorological forecasts are nowadays crucial for activating the necessary mitigation measurements and alert systems in advance and can be used to define early water-system control actions to prevent or reduce problems with floods or droughts.

In this study the implementation of a real-time forecasting system, developed at Politecnico di Milano, coupling hydro-meteorological models over different areas in the North-West of Italy, is shown.

The POLIMI hydro-meteorological chain includes probabilistic weather forecasts based on ensemble prediction systems, and hydrological simulations based on the rainfall-runoff distributed hydrological model (FEST-WB).

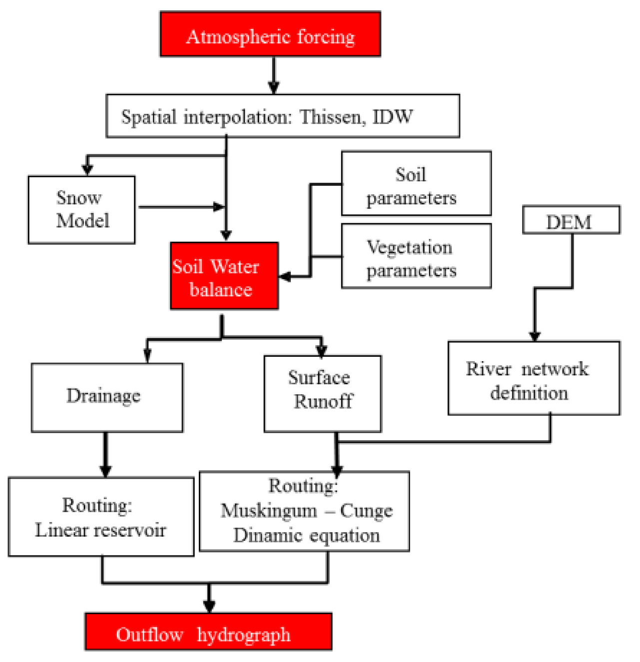
Main uncertainties and benefits in runoff and soil moisture simulations, respectively for flood and drought forecasts at different temporal and spatial scales, are shown with some case studies in the Piedmont and Lombardy region.

The POLIMI hydro-meteorological chain: the forecasting cascade system

Operational real time flood forecast systems are realized by use of one-way coupling, i.e. the meteorological output variables are driven into hydrological models to obtain the Quantitative Discharge Forecasts.

Further, combining hydro-meteorological models and with the knowledge of irrigation turn it was possible to know in advance soil moisture content and expected cumulated precipitation for irrigation management and drought control from 1 up to 30 days as forecast horizon.

PoliMi - Distributed Hydrological Model: FEST-WB



Input data:

- Meteorological data (observed and forecasted)
- Irrigation turns and volumes (for soil moisture forecasts)
- Soil parameters
- Vegetation parameters

Full scheme of the rainfall-runoff distributed hydrological model FEST-WB, physically based (Corbari et al., 2011)

Meteorological models: WRF and COSMO-LEPS

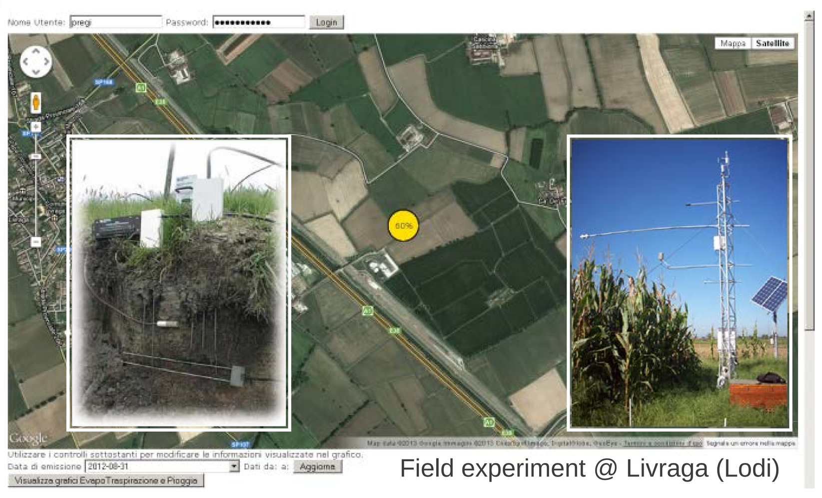
- WRF Model (Skamarock et al., 2007)

- **Spatial Resolution:** 18.0 km
- **Temporal Resolution:** 12 h
- **Vertical levels:** 36 (non-hydrostatic)
- **Ensemble members:** 20
- **Forecast range:** + 30 days
- **Run starting at:** 00:00 UTC
- **Owner:** MOPI – Epson Meteo Centre

COSMO-LEPS Model (Marsigli et al., 2005)

- **Spatial Resolution:** 10.0 km
- **Temporal Resolution:** 3 h
- **Vertical levels:** 40 (non-hydrostatic)
- **Ensemble members:** 16 nested on ECMWF EPS
- **Forecast range:** +132 h
- **Run starting at:** 12:00 UTC
- **Owner:** ARPA Emilia-Romagna

Real time soil moisture forecasts: the Pre.G.I Project

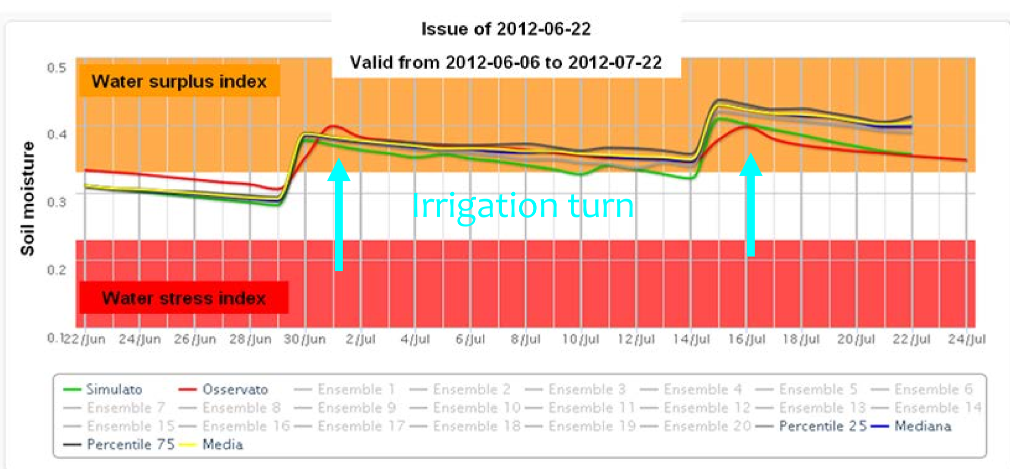


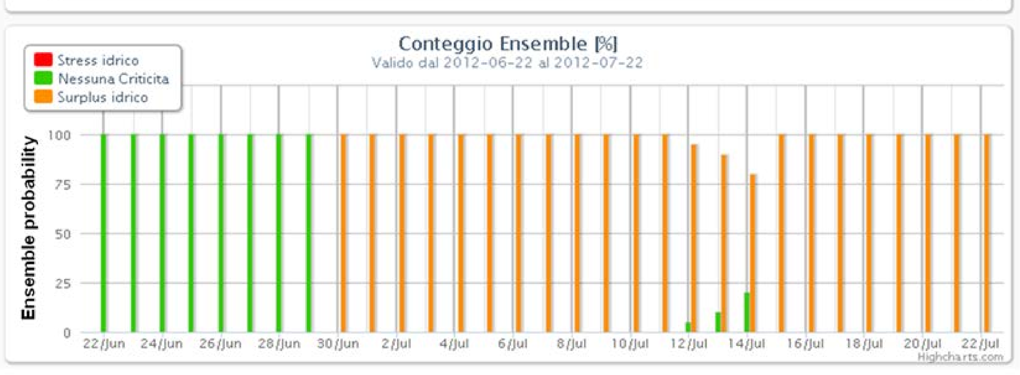
Field experiment @ Livraga (Lodi)

Simulation data have been uploaded on a google maps platform and saved in a database specifically created for the project. The main page on the website platform is shown with the google view over the Cascina Nuova farm. A colored dot located in Livraga field shows the exceeding probability of the stress threshold (red dot), surplus (yellow dot) or the probability of no alert (green dot).

Probability of exceeding the two thresholds:

water stress and water surplus



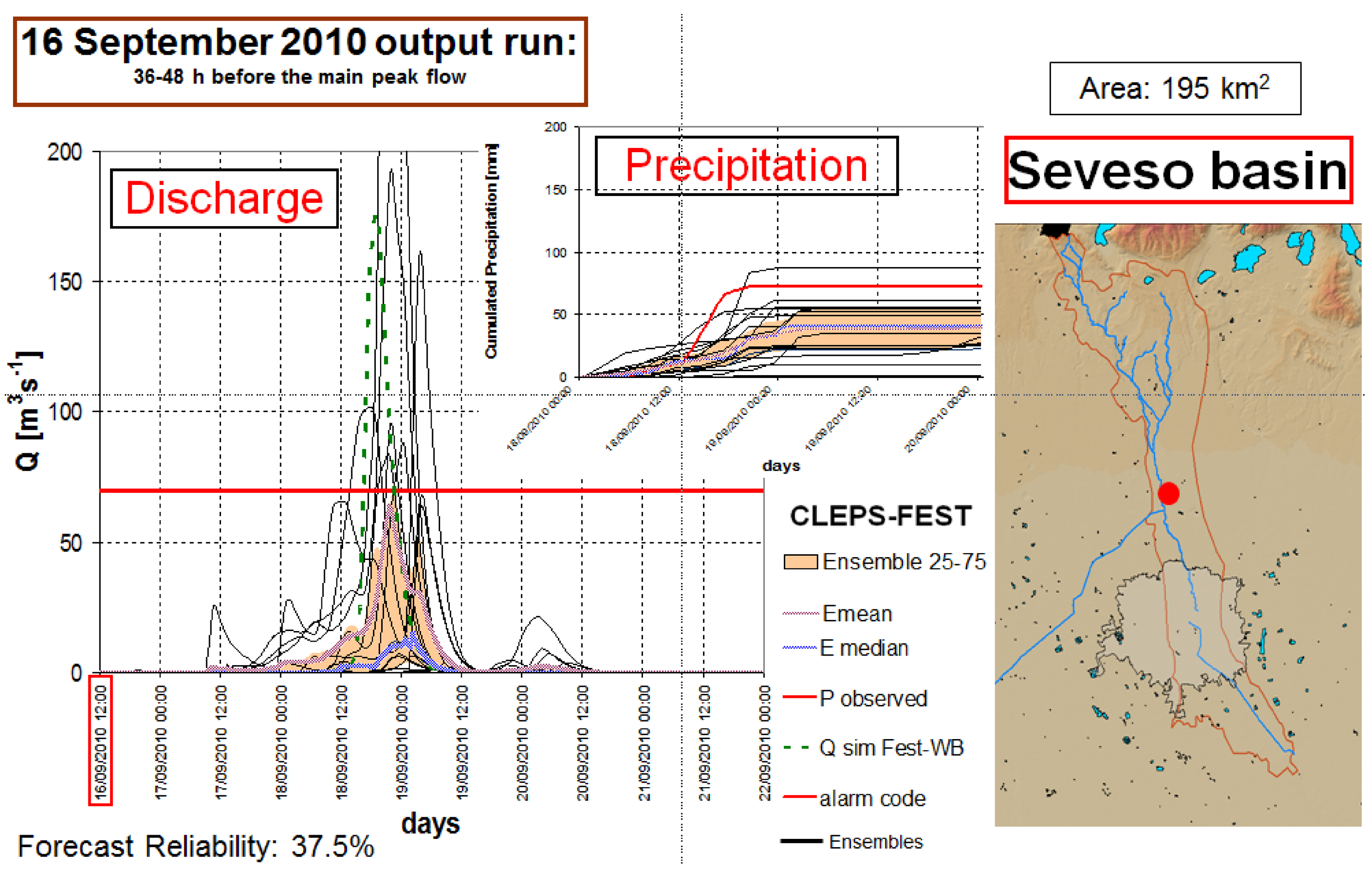


Pre.G.I. Project: Previsione meteo idrologica per la Gestione Irrigua (Hydro-Meteorological forecast for irrigation management)

The project develops a support decision system based on meteorological and hydrological models in order to give long predictions of soil water content. This, combined to the knowledge of the irrigation turn which occurs about every 14 days in each field parcel of the MBL (Muzza Bassa Lodigiana) Consortium subbasins, gives a probability forecast of the soil moisture conditions.

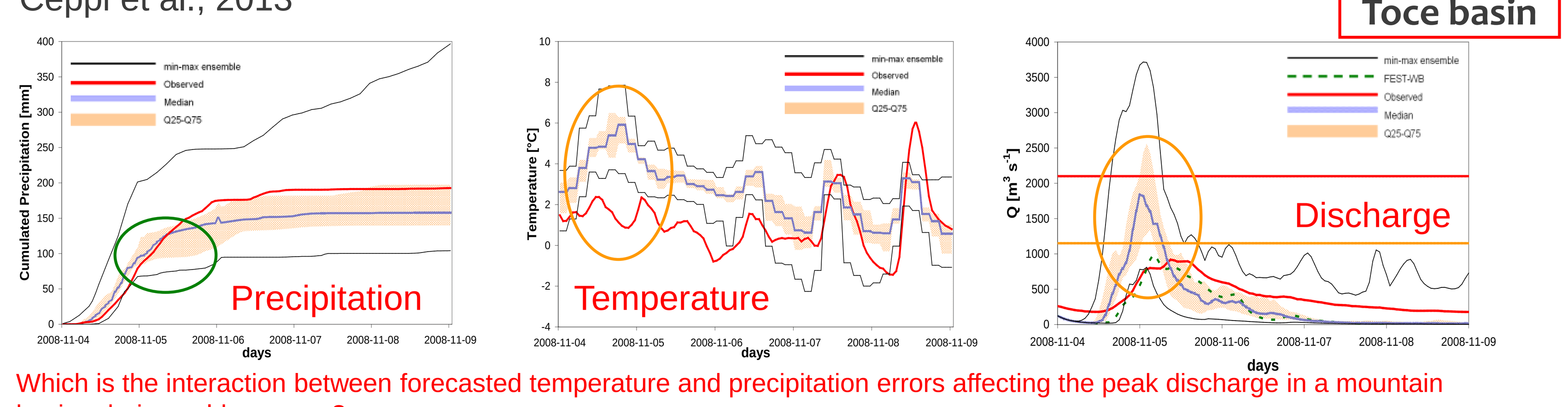
Soil moisture reanalysis forecast initialized on 22-06-2012 valid until 22-07-2012. Red line shows the soil moisture measured with TDR probes, green line shows the simulated soil moisture using the FEST-WB model initialized with observed data and grey, blue, black and yellow lines show forecasted soil moisture values by the FEST-WB model initialized with the WRF meteorological model respectively for the 25th, 50th, 75th percentile and the mean.

Flood in Milan urban area: the River Seveso



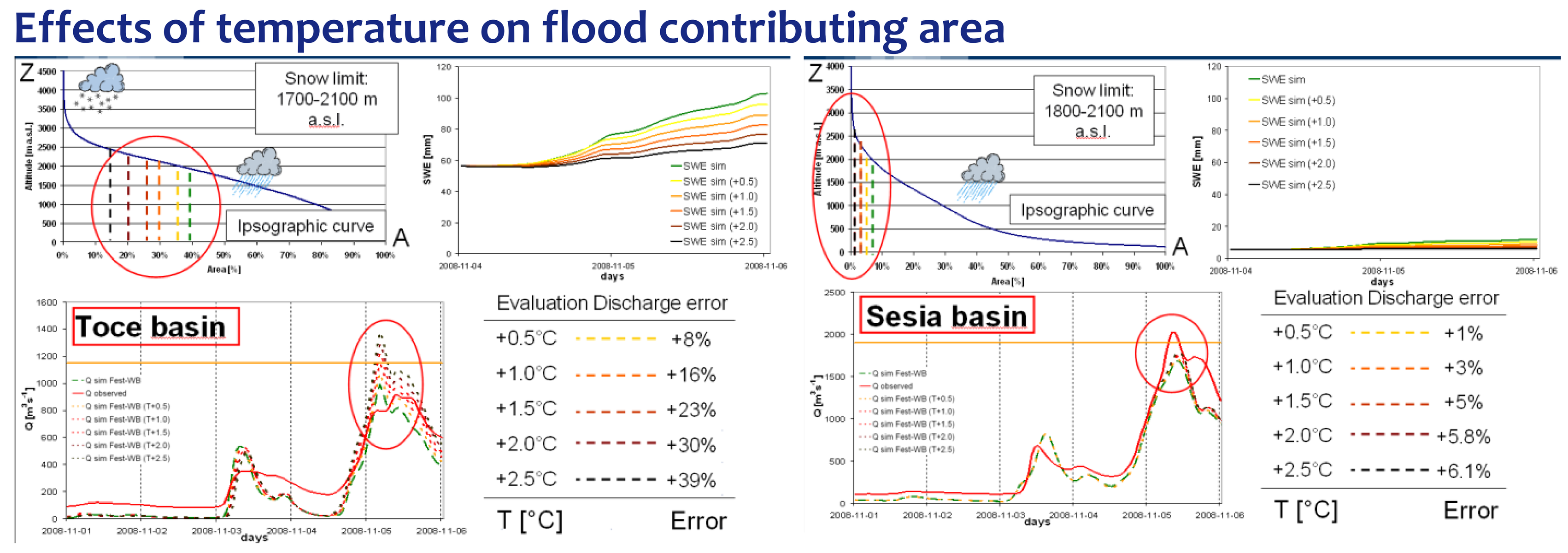
80 million € of damages: was it predictable?

The role of atmospheric forcing: temperature



Which is the interaction between forecasted temperature and precipitation errors affecting the peak discharge in a mountain basins during cold seasons?

Effects of temperature on flood contributing area



We correlate the increase in temperature to the ipsographic curve of each individual basin, which defines the contributing area in snow melt dynamics, to better investigate what happens over the Toce and Sesia basins respectively. The dashed coloured lines correlate the percentage of contributing area in runoff with different snow lines, related to our "synthetic" increase in temperature fields (from 0.5° C up to 2.5° C). Rising the 0° C line over the Toce catchment, the snowfall line also increases, and the drainage area becomes greater. If we consider this in terms of discharge simulations, a temperature increase, with a consequence higher snow line, results in more liquid water reaching the basin gauging station quicker. On the contrary, with a totally different ipsographic curve over the Sesia basin even a rising of the temperatures and therefore the snow line, no relevant differences are shown in peak discharges.

Conclusions

1) The hydro-meteorological chain is a very useful tool to predict in real time possible river floods in advance (generally with 24-48 hours before the main peak discharge).

2) Precipitation is not the only atmospheric forcing to be considered in hydro-meteorological forecasts. The quantitative discharge forecast (QDF) is influenced by temperature errors and it is related to the basin ipsographic curve, therefore to the percentage of area that contributes with more liquid water (rain) over watershed.

3) The joint knowledge of observed and forecasted soil moisture content allows to suggest real needs of water crop in order to manage better distributed volumes in different season times, avoiding the waste of irrigation water and fertilizers. Benefits of PRE.G.I. project are both direct and indirect: the first regard the monitoring and forecasting the soil water content according to the current state of soil moisture value and water crop requirements in order to reduce plant stress and maximize the production, while the latter regard the optimization of water irrigations pursuing the best quantitative distribution, in particular periods of water scarcity, in order to minimize production losses caused by water stress due to lack or insufficient watering. This opportunity is extremely useful in contexts of plural use of water resource.

References

- Ceppi, A., Ravazzani, G., Salandin, A., Rabuffetti, D., Montani, A., Borgonovo, E., and Mancini, M.: Effects of temperature on flood forecasting: analysis of an operative case study in Alpine basins, Nat. Hazards Earth Syst. Sci., 13, 1051-1062, 2013.
- Corbari, C., Ravazzani, G., Mancini, M., A distributed thermodynamic model for energy and mass balance computation: FEST-EWB. Hydrol. Process., 25(9), 1443-1452, 2011.
- Marsigli, C., Boccanera, F., Montani, A., and Paccagnella, T.: The COSMO-LEPS mesoscale ensemble system: validation of the methodology and verification, Nonlin. Processes Geophys., 12, 527-536, 2005.
- Skamarock, W. C., and J. B. Klemp. A time-split non hydrostatic atmospheric model for research and NWP applications. J. Comp. Phys., Special issue on environmental modeling, 3465-3485, 2007.

arpa agenzia regionale prevenzione e ambiente dell'emilia-romagna

CAE monitoring your world.

SIHS