Flood forecasting using analogue-based rainfall prediction ensembles

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Purpose

The hourly quantitative precipitation forecasts (QPFs) provided by an analogue-based approach and the Limited Area Model LAMBO are used as different input to the distributed rainfall-runoff model TOPKAPI and the corresponding discharge forecasts are combined, in a Bayesian framework, to reduce the overall uncertainty of the flood forecast over the Reno river basin in northern Italy.

How the analogue-based approach proceeds

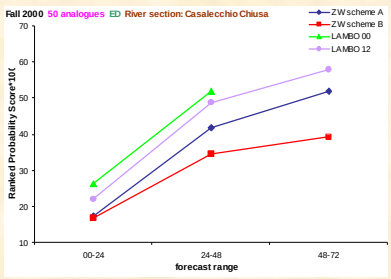
Analogue search ⇒ **Precipitation forecast** ⇒ **Discharge forecast** ⇒ **Combining discharge forecasts**

- METEOROLOGICAL ARCHIVE — *1990-2000 ECMWF analyses of Z at 500 hPa and W at 700 hPa*
  - *ANALOGY CRITERIA* — *Euclidean Distance*
  - ANALOGUE SUBSET — *the best 50 analogues*
- HYDROLOGICAL ARCHIVE — *1990-2000 hourly rain-gauge recordings*
  - *50 TIME SERIES OF 72 HOURS* — *starting from 12 UTC of each analogue day*
  - ANALOGUE-BASED PRECIPITATION FORECASTS — *taken as different input to the rainfall-runoff model*
- TOPKAPI — *physically based rainfall-runoff model*
  - *RUN IN A CONTINUOS WAY* — *at hourly time step*
  - A PRIORI DISCHARGE FORECAST ENSEMBLE — *50 members*
- A PRIORI DISCHARGE FORECAST ENSEMBLE — *50 members*
- LAM BASED DISCHARGE FORECAST — *taken as an error affected measurement of future flows*
  - *KALMAN FILTERING APPROACH* — *for each member of the a priori ensemble*
  - A POSTERIORI DISCHARGE FORECAST ENSEMBLE — *removing the bias of forecast error and reducing its uncertainty*

The discharge forecast

Scheme A: each analogue day D characterised by ECMWF analyses at 12 UTC of day D and day D-1

Scheme B: each analogue day D characterised by ECMWF analyses and model forecast at +24, +48 and +72 hours



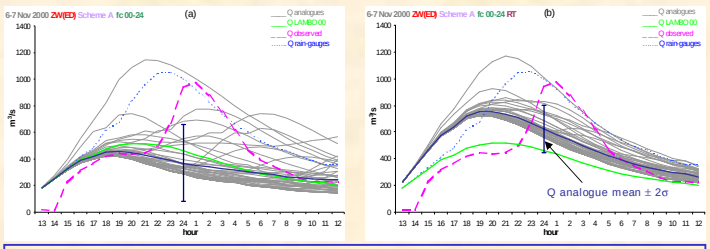
Statistical analysis for fall 2000

- Ù good first 24 hour discharge forecasts
- Ù decay of performance with lead-times increasing, which can be partially reduced updating the search for analogues every 24 hours (scheme B)
- Ù the deterministic predictions based on LAMBO show worse scores than the analogue-based ones

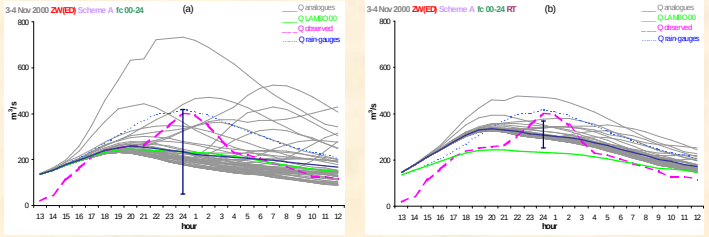
⇐ ***Figure 1***
Discharge performance decay with increasing forecast lead-times for predictions based on QPFs provided by LAMBO (runs at 00 and 12 UTC) and 50 analogues of Z at 500 hPa and W at 700 hPa selected by euclidean distance criterion according to schemes A and B.

The Bayesian combination effect

BEFORE AFTER



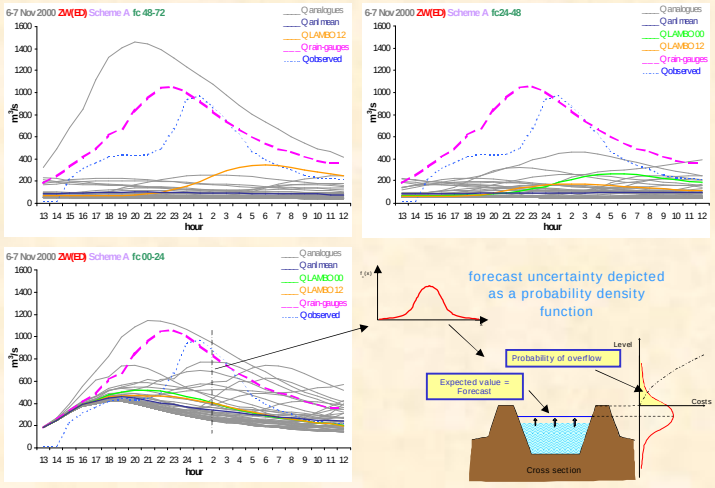
⇑ ***Figure 3***
Discharge prediction achieved using the first 24 hour precipitation forecasts for the event occurred on 6-7 November 2000: "a priori "ensemble (a) and "a posteriori "ensemble (b).



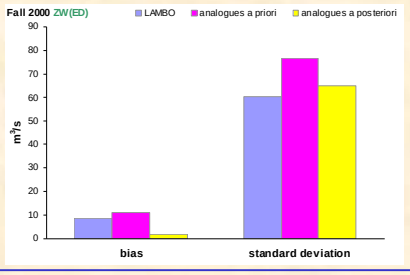
⇑ ***Figure 4***
Discharge prediction achieved using the first 24 hour precipitation forecasts for the event occurred on 3-4 November 2000: "a priori "ensemble (a) and "a posteriori "ensemble (b).

Highlighting a flood event

Date : 06/11/2000 13 UTC - 07/11/2000 12 UTC *River section*: Casalecchio Chiusa *Scheme adopted* : A
Meteorological variables considered : Z at 500 hPa and W at 700 hPa *Analogues selected by* : ED



⇑ ***Figure 2***
Discharge forecasts issued one day (fc 00-24), two days (fc 24-48) and three days (fc 48-72) before the event



⇑ ***Figure 5***
Mean values over the first 60 hours of bias and standard deviation of forecast error relative to discharge predictions based on LAMBO, "a priori "and "a posteriori "analogue ensembles (fall 2000).

Conclusions

- The discharge predictions supplied by the analogue method are quite good for the first 24 forecast hours, while the performances decay with lead-times increasing. This drawback can be partially overcome updating the search for analogues every 24 hours by means of the meteorological variable forecast provided by a numerical model.
- The analogue-based discharge forecast ensemble allows to convey a quantification of uncertainty about the flood prediction.
- The probabilistic information on future flows obtained by the analogue method has to be considered complementary, and not alternative, with the deterministic one based on LAMBO in view of a joint employment to improve the real-time flood forecasting.
- The Bayesian combination allows the forecast to draw on the observation removing the bias and reducing the prediction uncertainty.
- A shortcoming is that the available historical meteo-hydrological archive is not large enough to reproduce a reliable scenario in case of extreme events.

References

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