Multiple ensemble forecasts in the operational forecasting system for the Rhine basin in Switzerland

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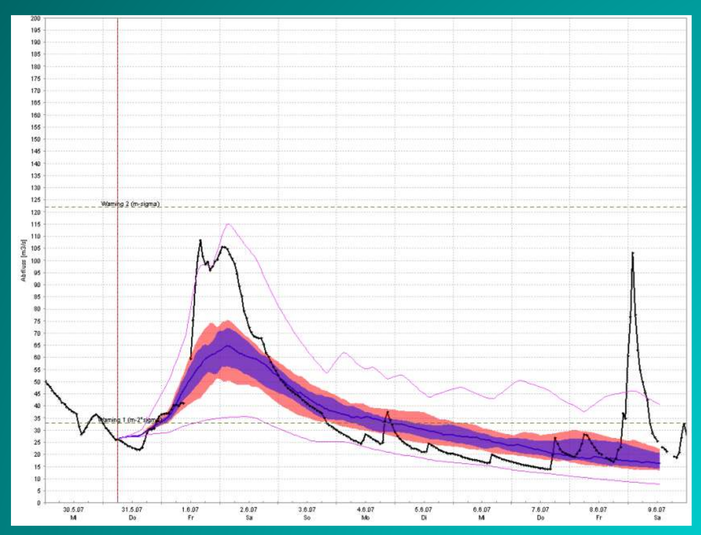
With the advent of meteorological ensemble forecasting, ensemble approaches in operational flood forecasting are now also becoming more and more prolific. Where uncertainty in the hydrological forecast has previously either been ignored or has been incorporated through empirical approaches, the more statistically sound approach to representation of uncertainty through ensemble based forecasts are being adopted.
The operational forecasting system for Rhine basin in Switzerland, which is used operationally by the Swiss Federal Office for the Environment FOEN currently uses such an empirical approach to representing uncertainty. Within the context of the WMO sponsored MAP-D PHASE project, ensemble forecasts are now being integrated into the operational forecasts to provide for the representation of uncertainty. This considers multiple ensembles, including the high resolution COSMO-LEPS ensemble and the multi-model SRNWP-PEPS ensemble. The ECMWF-EPS ensemble was not considered for operational use, but has been included for comparison to the high resolution ensembles.
Some initial results from the integration of these ensembles into the operational forecasting system are presented. Despite the use and evaluation of these ensembles being as yet in the early stages, these initial results show that several scientifically challenging questions on the use of ensemble forecasting in hydrology are yet to be resolved. These include the spatial and temporal scale issues of the different ensembles, as well as issues in dealing with multiple and multi-model ensembles in decision making.

ECMWF-EPS Ensemble

1 control run and 50 ensemble members using the ECMWF global forecast model with resolution of around 80km. Initial conditions for ensemble members created by adding small "perturbations".



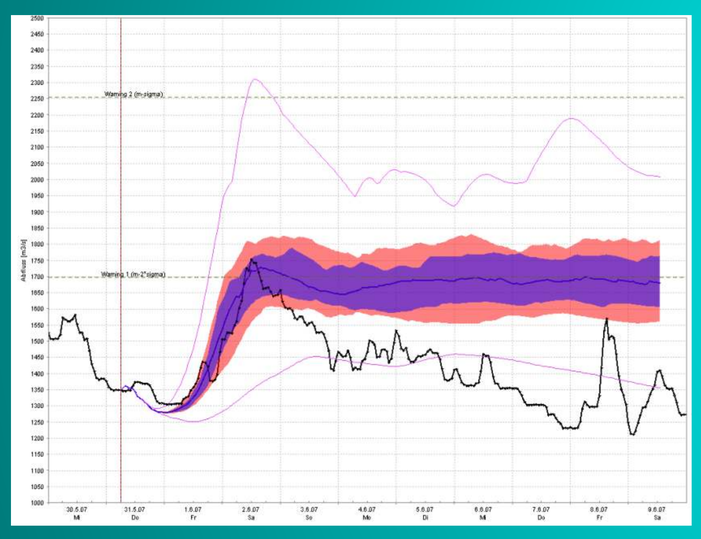
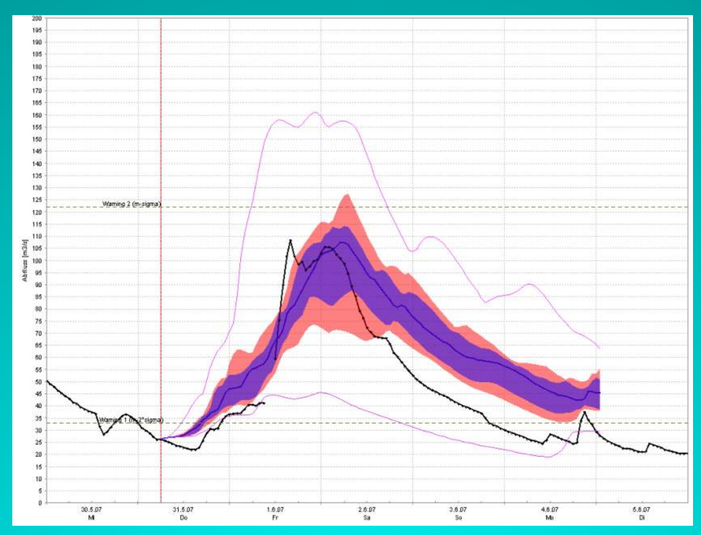


figure 1
results of the ensemble run at 06:00 31/5/2007 with ECMWF-EPS at Emme-Emmenmatt (441 km²) and Rhein-Rheinfelden (34361 km²)

COSMO-LEPS Ensemble

16 member high resolution ensembe model , horizontal resolution of approx. 10km. Initial/Boundary conditions for each member derived from ECMWF-EPS ensemble, with 16 members selected through cluster analysis.



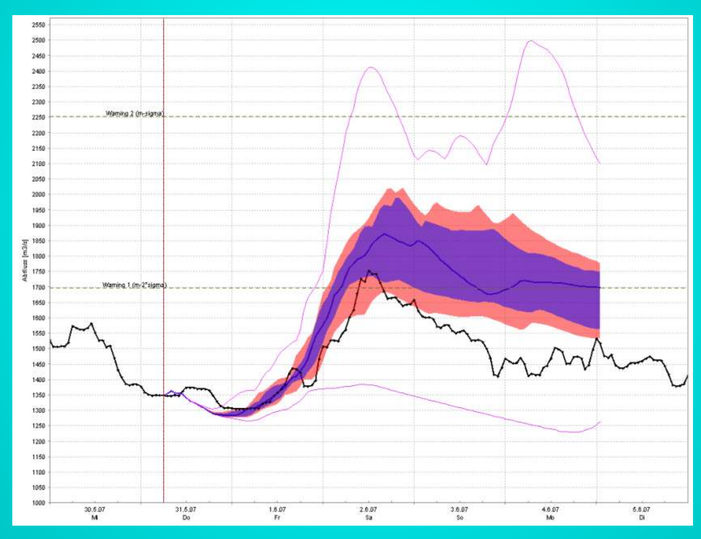
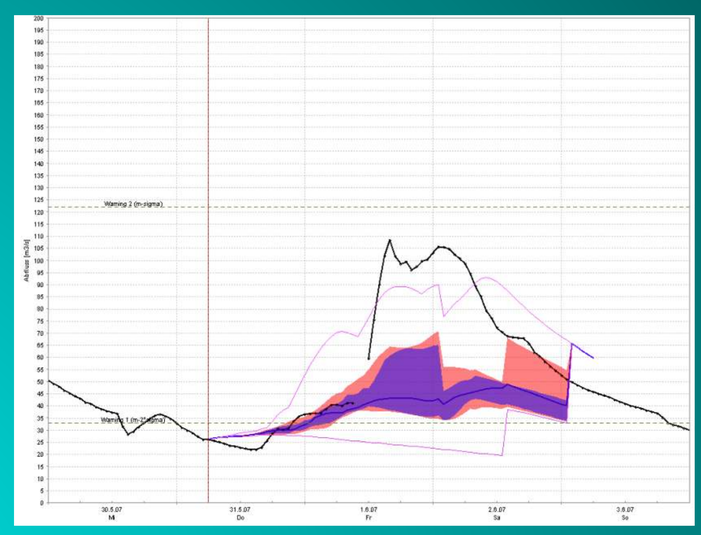


figure 2
results of the ensemble run at 06:00 31/5/2007 with COSMO-LEPS at Emme-Emmenmatt (441 km²) and Rhein-Rheinfelden (34361 km²)

SRNWP-PEPSEnsemble

21 member Multi-model ensemble including the most important operational limited-area models in Europe: the ALADIN, the HIRLAM, the Local-Model of the COSMO Consortium and the LAM Version of the UKMOUnified Model



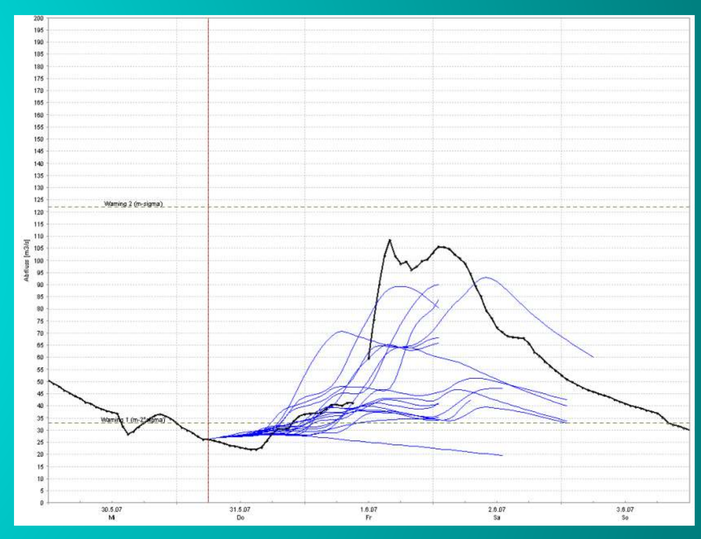
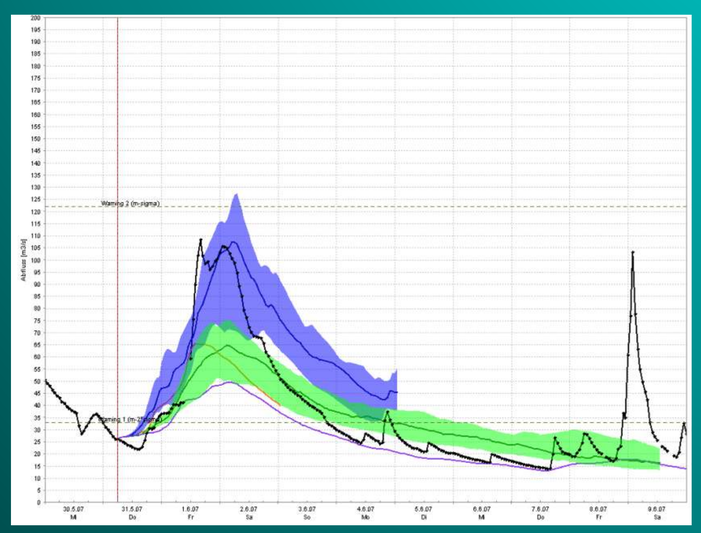
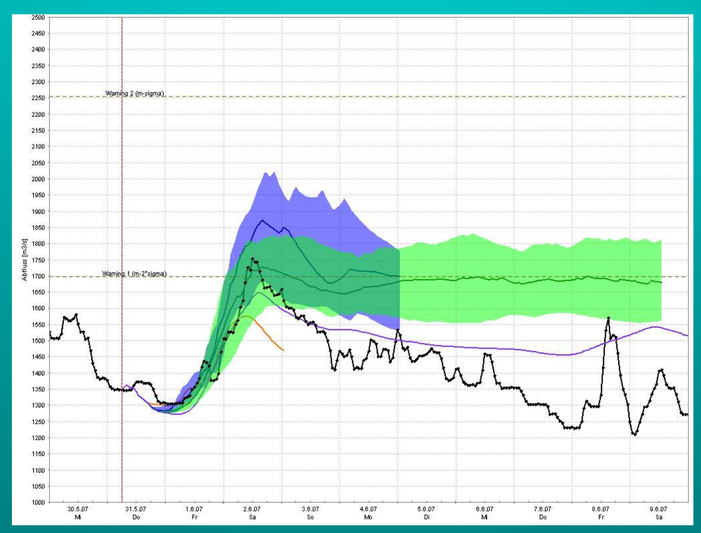


figure 3
results of the ensemble run at 06:00 31/5/2007 with SRNWP-PEPS at Emme-Emmenmatt (area 441 km²). The second plot shows the inidviudal ensemble members, each with different lead times.





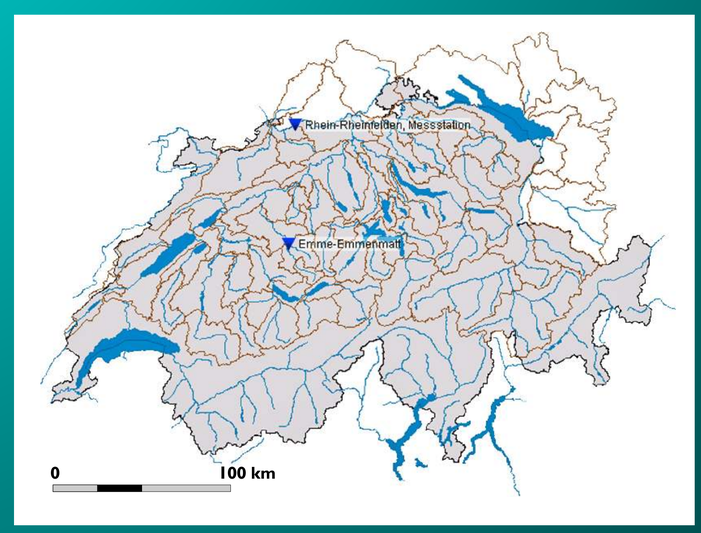


figure 4
comparison of ECMWF-EPS (green) and COSMO-LEPS (blue) ensemble at Emme-Emmenmatt (left) and Rhein-Rheinfelden (right). The ensemble median values are shown, as well as the results of the COSMO 7km deterministic model (orange), the ECMWF deterministic model (magenta). Observed values are in black.
Rhein-Rheinfelden: Ranked Prob. Score at 48hrs lead time : RPS_{ECMWF}: 0.979 RPS_{CLEPS}: 0.965
Emme-Emmenmatt: Ranked Prob. Score at 48hrs lead time : RPS_{ECMWF}: 0.987 RPS_{CLEPS}: 0.935

discussion and issues

high resolution ensemble visually shows marginal increase of skill for smaller catchments, and negligible increase for larger catchments. This is clear in examples used here, but not consistent across all small sub-catchments. Needs evaluation on long series of forecasts

multi-model ensembles such as SRNWP-PEPS cannot be summarised using standard statistics, partly due to the differences in lead time. Approaches such as Bayesian Model Averaging may help. These are more difficult to apply in 'standard'ensembles as ensemble members are stochastic realisations

limited number of ensemble members in COSMO-LEPS ensemble may introduce bias in determining e.g. Rannked Probability Score and Skill Scores – the effect of varying ensemble size needs to be taken into account when comparing different ensembles.

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