River Routing models to support NWP verification

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Acknowledgements: G Balsamo, Jutta Thielen, Ad de Roo, HL Cloke, K Bogne ...
TOC

- Introduction
- Support NWP: Diagnostics
- Support NWP: Evaluation
- Support NWP: severe weather
- Summary
Hydro-meteorological verification

Schematic representation of a global daily hydrometeorological verification

Air 2m temperature data

River discharge data

Balsamo et al. (submitted)
Properties of a discharge based evaluation

- Discharge is a:
  - Spatial Integrator
  - Temporal Integrator
  - Process Integrator

- ‘Holistic’ Evaluation
- End-user targeted
Properties of a discharge based evaluation

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Cloke et al, 2004
Properties of a discharge based evaluation

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Properties of a discharge based evaluation

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  ➢ Temporal Integrator
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• ‘Holistic’ Evaluation

• End-user targeted (Value)
Example I: Land-surface scheme HTESSEL & TRIP2

Pappenberger et al. in press
Example II: LISFLOOD (part of the European Flood Alert System)

Joint Research Centre of the European Commission

Thielen et al. 2007

EU Flood GIS
Realtime H-Q data
Historical Data

Static Data
Europ. Data Layers

Meteo -Data
Expert Knowledge of Member States

5x5 km

EFAS Reports
Support NWP: Diagnostics

Model and Predictive Uncertainty for the Danube (Neu Ulm). Application of the Wavelet-VARX error correction + Hydrological Uncertainty Processor (Krzysztofowicz, 1999). The routing component gives and indication where model improvements can be most effective.
Support NWP: Diagnostics

We can further conduct a more in depth analysis for example by using the SOBOL Sensitivity analysis, which will tell us in the case of HTESSEL, that the most sensitivity to the river routing comes from the Groundwater delay parameter (GTM) indicating, that further research is needed on the split between surface-groundwater flow (e.g. adding a third outflow) and/or the free outflow (e.g. adding a groundwater boundary).

Pappenberger et al. (in press)
Support NWP: Diagnostics

Danube, Station: 1

Danube, Station: 5

Danube, Station: 9

Danube, Station: 13

Model

Observations

Pappenberger et al. (in press)

HTESSEL
Relative differences (in %) for the river discharges obtained by TESSEL compared to HTESSEL (top panel) and by SNOWHTESSEL compared to HTESSEL (bottom panel) for the month of January (mean of 1986-1995)

Balsamo et al., submitted
Relative differences (in %) for the river discharges obtained by TESSEL compared to HTESSEL (top panel) and by SNOWHTESSEL compared to HTESSEL (bottom panel) for the month of June (mean of 1986-1995)

Balsamo et al., submitted & see poster Dutra
Support NWP: Evaluation

Indication of best correlated modelled and observed river discharges. Models include SNOWHTESSEL (blue), HTESSEL (green), and TESSEL (red). Balsamo et al., submitted
Gain in lead time over a decade for three thresholds (ETS score). The dotted straight line indicates the average gain for precipitation as published by Ghelli and Primo (2009) from Pappenberger and Thielen (submitted).
Support NWP: Evaluation

Average Brier Skill Score (Q50) across Europe for the entire evaluation time (from Pappenberger and Thieken (submitted))

Lisflood
Support NWP: Evaluation by Model Comparison

7 different forecasts for the October 2007
Support NWP: Evaluation by Model Comparison

Warning maps:
Allow for the comparison of integrated forecast fields from different models.

Lisflood
Support NWP: Severe Weather

One of the ECMWF goals is to produce better forecasts for severe weather. The Extreme Forecast Index focuses on meteorological forecasts.

River routing can assist the development and support of such a goal:

Example 1: Flood Forecasting in the Po (precipitation induced)

Example 2: Flood Forecasting in Danube 2006 (Precipitation and Temperature induced)
Support NWP: Extreme Weather: Po floods (April 2009)

(photo A Contaldo, Photonews, available from http://torino.repubblica.it/)

(Buizza et al., ECMWF newsletter, summer 2009)
Support NWP: Extreme Weather: Po floods (April 2009)

The left panels show the t+48-to-96h forecast probability of occurrence of rainfall in excess of 15mm (top) and 30mm (bottom), issued on the 25th of April. The right panels show the corresponding t+96-to-144h forecast probability issued on the 23rd of April.
Support NWP: Extreme Weather: Po floods (April 2009)

Lisflood

Buizza et al., 2009

Number of ensemble members based on the ECMWF EPS forecast from the 24th of April 00 UTC simulating discharges which exceed the EFAS high alert level for the Po river basin.
Support NWP: Extreme Weather: Danube 2006 floods

High Danube levels caused significant flooding in parts of Serbia, Bulgaria and Romania, with damage to property and infrastructure in localities near the shores of the river. The 2006 European floods were one of the most devastating natural disaster from the History of Romania. The flooding was caused by snowmelt and in particular rain on snow.
Support NWP: Extreme Weather: Danube 2006 floods
## Support NWP: Extreme Weather: Danube 2006 floods

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Legend:
- **Red**: 46 - 51
- **Orange**: 41 - 45
- **Dark Orange**: 36 - 40
- **Light Orange**: 31 - 35
- **Yellow**: 26 - 30
- **Light Yellow**: 21 - 25
- **Light Green**: 16 - 20
- **Light Blue**: 11 - 15
- **Green**: 11 - 15
- **Blue**: 6 - 10
- **Teal**: 1 - 5

*Lisflood*
Total Mean Precipitation

Snowline

Soil Moisture

Max Precipitation
Conclusions

River Routing:

1. Can help you to identify where to improve your model in particular the Land Surface Scheme and benchmark

2. Evaluate performance integrated over multiple forecast fields (e.g. temperature, precipitation, evaporation) taking account of co-variances and spatio-temporal correlations in an enduser value oriented framework

3. Support the goal of improving extreme weather predictions

Comments? Now or Florian.Pappenberger@ecmwf.int

Announcement: EGU2010 Session HS4.8 on Large scale hydrology (Support Application deadline 04.12.2009!!!!!!)
Submitted/Under review
McMillan, M., Krueger, T., Freer, J., Clark, M., Pappenberger, F., in press, Impacts of uncertain river flow data on rainfall-runoff model calibration and discharge predictions, Hydrological Processes

Accepted/in press
Schumann, G., Bates, P., Horritt, M.S., Matgen, P., Pappenberger, F. in press Progress in integration of remote sensing derived flood extent and stage data and hydraulic models, Reviews of Geophysics
Pappenberger, F., Cloke, H.L., Balsamo, G. Okl, P., Ngo-Duc, T., Global routing of surface and subsurface runoff produced by the hydrological component of the ECMWF NWP system, International Journal of Climatology
References

Published in 2009


Thielen, J., Bogner, K., Pappenberger F., Kalas, M., del Medico, M., de Roo, A., 2009, Monthly-, medium- and short range flood warning: testing the limits of predictability, *Meteorological Applications*, 16 (1), 77-90


For earlier publications please go to http://www.ecmwf.int/staff/florian_pappenberger/pub_index.html