

H-SAF Associated/Visiting Scientist Activity ref. H_AVS15_02

Assessment of alternative data assimilation techniques for HSAF products under different climatic conditions"

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1220957-000



Title H-SAF Associated/Visiting Scientist Activity ref. H_AVS15_02

Client	Project	Reference	Pages
EUMETSAT	1220957-000	1220957-000-ZWS-0004	8

Trefwoorden data assimilation, satellite, gauge

Summary

Report workshop HSAF-data assimilation at IMGW.

Versie	Datum	Auteur	Paraaf	Review	Paraaf	Goedkeuring	Paraaf
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1 Introduction

Data assimilation in hydrological models is a relatively recent advance, but one which has been enthusiastically taken up, with various approaches being used: refer to recent reviews by Reichle (2008) and Liu et al. (2012), and references therein. The feasibility of undertaking spatially distributed data assimilation in hydrological models has been demonstrated by a number of recent studies.

Therefore, one of the objectives of this study is the implementation of a distributed hydrologic model for the Raba and Karasu catchments and connect this to a HSAF framework developed in an earlier part of the project. The next step is to apply OpenDA (http://www.openda.org). Pre- and post-processing of remote sensing data relies on the open platform Delft-FEWS (oss.deltares.nl/web/delft-fews) (Werner et al., 2013). The main objective of this activity is the technical integration and exemplary application of the modular framework.

The main objectives of this VS activity are:

- Training of IMGW in the testbed setup of the HSAF project (RTC-Tools, Delft-FEWS, WFLOW, OpenDA).
- Setup of a distributed hydrologic model using the OpenStreams/WFLOW open source package and RTC-Tools models for the Raba catchment.
- Couple the distributed model and OpenDA into the HSAF testbed (see also H-SAF Associated/Visiting Scientist Activity ref. H-SAF_VSA_13_03 Generic Data Assimilation Test Bed for H-SAF Snow Products and a Conceptual Hydrological Model) including some tests.

2 Workshop November

The workshop was held November 2-6 at IMGW in Krakow with the following participants Michal Kasina (IMGW) Michal Ziemski (IMGW) Marcin Dominikowski (IMGW) Bulut Akkol (Anadolu University) Rodolfo Alvarado-Montero (University of Duisburg-Essen) Dirk Schwanenberg (University of Duisburg-Essen) Albrecht Weerts (Deltares)



Figure 1 Workshop impression (second day)

During the workshop, IMGW was trained in using Delft-FEWS for running the RTC-Tools and WFLOW models in hindcast and forecast mode. A setup was made for the Raba catchment with all relevant meteorological locations (see Figure 2 and 3).

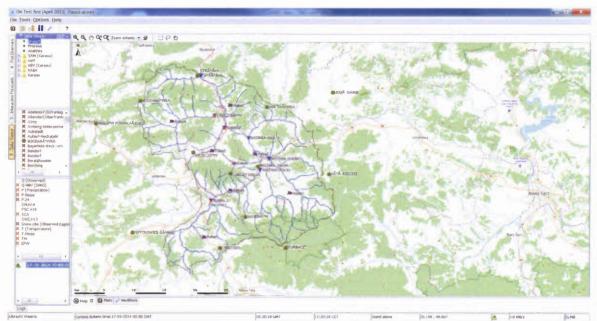


Figure 2 Overview Raba catchment and measurement locations

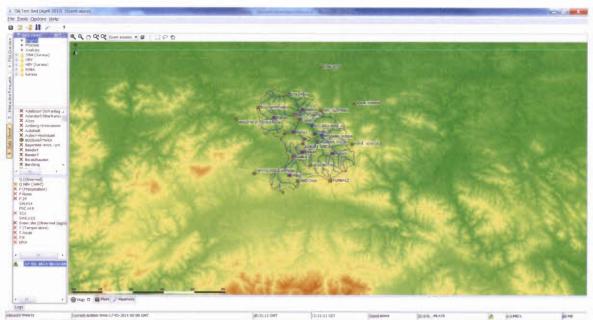


Figure 3 See Figure 2 using SRTM as layer instead of Landscape/OSM

RTC-Tools models were setup and calibrated. A WFLOW model was setup using the standard setup procedure (WFLOW manual, 2015). A spatial interpolation scheme was setup as pre-processing in Delft-FEWS (Figure 4). For temperature we make use of the digital elevation model (DEM) resulting in more realistic (most of the time) interpolation fields

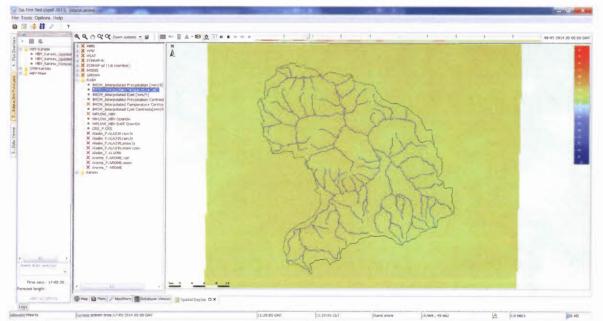


Figure 4 Spatial interpolated temperature field using DEM

For rainfall a simple inverse distance scheme was implemented which may need improvement when the final results are produced (Figure 5).

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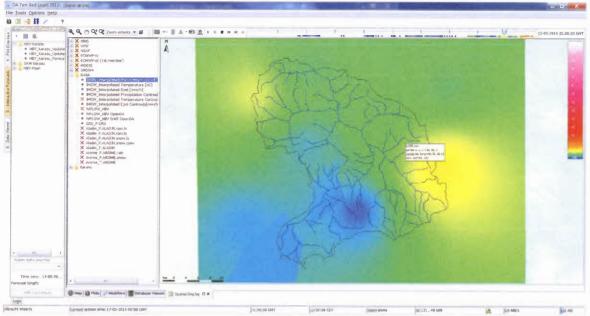


Figure 5 Spatial interpolated rainfall field using inverse distance interpolation

Figure 6 shows the resulting distributed flow routing of the WFLOW_hbv model for the Raba catchment.

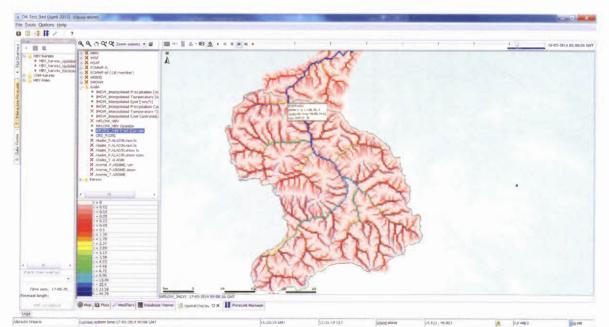


Figure 6 Example output of the WFLOW model setup for the Raba catchment

The WFLOW_hbv model was coupled to Delft-FEWS in three different ways:

- Via the Delft-FEWS general adapter
- Via OpenDA as a single run
- Via OpenDA as an ensemble run (e.g. Ensemble Kalman filter)

It was shown how to derive, couple and run the model in the platform and how to connect WFLOW and OpenDA (a generic manual with examples will become available early 2016).

During the last days of the visit a bug in the new linkage of OpenDA and WFLOW was discovered. This problem is being solved at this moment. This bug prevented the participants of the workshop to conduct DA experiment with the OpenDA-WFLOW model setup; instead IMGW was trained in conducting DA and calibration setup of RTC-Tools models.

3 Conclusions and follow up

- The configuration of the test bed was consolidated to make it more generic and to easier integrate additional test cases,
- Additional HSAF data and additional data sources were integrated
- A distributed HBV WFLOW model of Raba catchment was setup and linked to the HSAF framework for data assimilation experiments;
- IMGW numerical weather predictions (NWP) was linked to the framework as well (import of the Aladin and Arome models).
- This setup allows lead-time a performance assessment of the assimilated model in combination with NWP
- A RTC-Tools model for Raba catchment was setup (in collaboration with University of Duisburg-Essen) and is ready for testing using different HSAF project;
- A distributed WFLOW_hbv model for Karasu catchment was setup and linked to the HSAF test bed using OpenDA/WFLOW; A full report on applying the DA method (OpenDA/EnKF) to the Turkish catchment is available.
- All contributions are in SVN repository for usage by HSAF group (BfG, IMGW, Anadolu University)
- Manual of OpenDA-WFLOW to follow in Q1 2016;
- Update of OpenDA-WFLOW code to follow January 2016 (with setup for assimilation of discharge) via SVN repository and this will be discussed at the next workshop February 2016 in Koblenz;

4 References

Liu, Y., Weerts, A.H., Clark, M., Hendricks Franssen, H.J., Kumar, S., Moradkhani, H., Seo, D.J., Schwanenberg, D., Smith, P., van Dijk, A.I J M., van Velzen, N., He, M., Lee, H., Noh, S.J., Rakovec, O., Restrepo, P. (2012) Advancing data assimilation in operational hydrologic forecasting: progresses, challenges, and emerging opportunities, Hydrol. Earth Syst. Sci., 16, 3863–3887,doi:10.5194/hess-16-3863-2012.

Reichle, R.H. (2008). Data assimilation methods in the Earth sciences, Adv. Water Res., 31, 1411–1418, doi:10.1016/j.advwatres.2008.01.001.

Werner, M., Schellekens, J., Gijsbers, P., van Dijk, M., and van den Akker, O., Heynert, K (2013) The Delft-FEWS flow forecasting system, Environ. Model. Softw., 40, 65-77.

Wflow manual (2015). <u>https://github.com/openstreams/wflow/tree/master/manual</u> (last access December 2015).

5 APENDIX I: RTC-Tools models

During the visiting scientist activity, two conceptual HBV rainfall-runoff models were configured for Raba catchment. The first one consists of a lumped model which aggregates all information into one hydrological unit, whereas the second considers a semi-distributed version with subdivisions according to the location of the existing flow gauge stations. Figure 7 shows these two models.

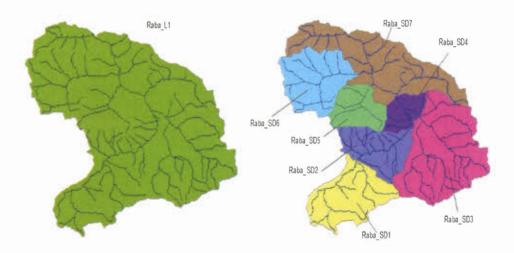


Figure 7 Spatial discretization for lumped and semi-distributed models

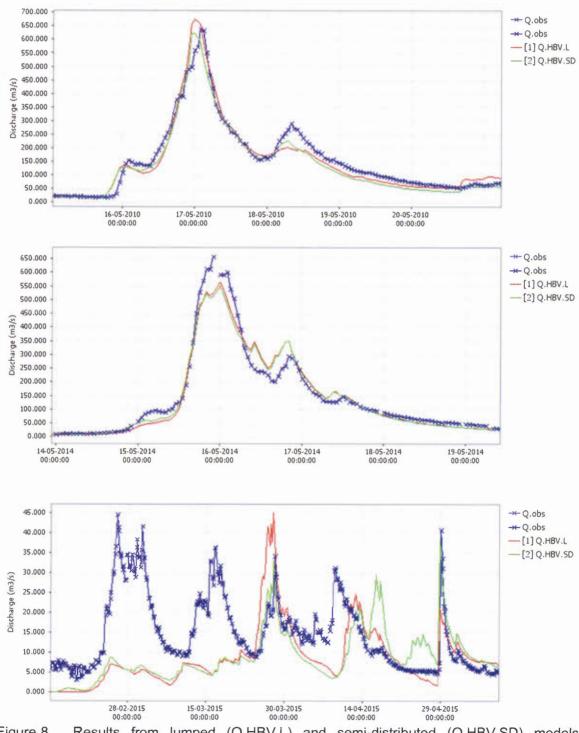
The lumped model considers 2 land uses and 10 elevation zones, following the existing model from IMGW. The semi-distributed model is based on the following distribution of land use and elevation zones for each Sub-basin.

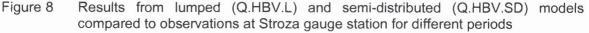
Sub-basin	Kasinka	Krczono w	Lubie n	Mszana_ Dolna_R	Mszana_ M	Rabka 2	Stroza	Total
Sum of Area								
Field	17.24	45.82	26.7	39.73	87.97	54.59	76.3	348.35
Forest	12.39	43.79	21.06	25.53	78.44	37.19	76.93	295.33
Number of Elevations								
Field	5	6	5	6	6	5	6	39
Forest	7	6	7	7	9	5	8	49
Sum of Area	29.63	89.61	47.76	65.26	166.41	91.78	153.23	643.68
Total Elevation Zones	12	12	12	13	15	10	14	88

Table 1 Area and elevation zones for each sub-basins

The semi-distributed model includes the flow routing between sub-basins according to the Muskingum method using a constant value of 0.25 for Epsilon in all cases and a constant K dependent on the distance of each connection reach.

Both models use hourly data and were automatically calibrated to fit the observed discharge. Figure 8 shows the results of the calibration for three representative periods. As seen, the models can properly reproduce the highest range of observed discharges. Low discharge values, however, seem to be underestimated with the current calibration set and performance decreases for these events.





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The NSE performance of the lumped model for the period between January 2010 and November 2015 is 0.787 whereas the semi-distributed model shows a NSE of 0.805 for the same period.

The semi-distributed model allows the computation of intermediate discharges along the basin, at the location of flow gauges. This model currently uses the calibrated parameters from the lumped model. It is expected that the model could be further improved with a calibration based on observed discharges from intermediate stations.

In addition, data assimilation workflows were configured into DELFT-FEWS for both lumped and semi-distributed models. This currently allows the assimilation of discharge observations. Additional observations from H-SAF products can be activated within the assimilation procedure. Further improvements are expected to be included to the system to facilitate these modifications to the end user.

Additional configurations for lumped and semi-distributed models:

- Forecasts workflows based on updates with and without data assimilation
- Performance indicators BIAS, RMSE, R2 and NSE to assess each model