TRANS - BOUNDARY FORECASTING SYSTEM ON MUR RIVER

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Abstract: A trans-boundary real time flood forecasting system on the Mur river has been implemented within the EU INTERREG IIIB CADSES program - Project „Flussraumagenda Alpenraum". The Mur watershed extend over Austria (10000 km²), Slovenia (1400 km²), Hungary (1900 km²) and Croatia (500 km²). Although only Austria and Slovenia have participated to this project, an extended solution including all 4 countries has been discussed and approved within the Mur commission, i.e., the system has been developed so that Hungary and Croatia can easily join the structure in the future.

The challenge of the project was to have one common flood forecasting system working for all 2 (4) countries, where exchange of real time information, modeling and dissemination can be performed rapidly and accurate working in a robust system, required in a real time forecasting system. Initially a flood forecasting decision support system has being prepared for Mur and its most important tributaries. The modeling system includes extended snow modeling in the Alps and flood plain modeling in south Austria with many hydroelectric structures on the rivers.

The structure that has been established build out of one International Flood Forecasting Centre and two national centres illustrates how a trans-boundary flood forecasting system can operate. The main element is the International Flood Forecasting Centre installed in Graz (Austria) where all the necessary online data and meteorological forecasts are automatically collected and formatted for the simulations. Furthermore, each hour starts a simulation with a forecasted time of two days whereas the main results are published on the internet and the complete model setup and result are transferred to the two national centres. Therefore, on both national centres it is possible to analyse detailed results and to develop local scenarios using for example modified meteorological forecasts or other initial conditions.

This technical solution allows a perfect synchronisation for online data, pre and posts processing files, information and results from the simulations between all three Flood Forecasting Centres. It contributes therefore to a noticeable improvement for information organisation between Austria and Slovenia and should be considered as a new method for Flood and Risk management. This new communication strategy coupled with the automatic and continuous modeling as well as the result publication on internet delivers a concrete example for Flood prevention and resources management that can be transferred to other trans-boundary watersheds.

Keywords: automatic forecasting system, international forecasting centre, flood watch, NAM, MIKE 11, Mur

1 INTRODUCTION

A trans-boundary real time flood forecasting system on the Mur river is implemented within the EU INTERREG IIIB CADSES program - Project „Flussraumagenda Alpenraum“. The Mur watershed extends over Austria (around 10000 km²), Slovenia (around 1400 km²), Hungary (around 1900 km²) and Croatia (around 500 km²). Although only Austria and Slovenia currently participate in this project, an extended solution including all 4 countries has been discussed and approved within the Mur commission.

The challenge of the project is to have one common flood forecasting system working for countries (Austria and Slovenia), where exchange of real time information, modeling and dissemination can be performed rapidly and accurate working in a robust system, required in a real time forecasting system. Initially a flood forecasting decision support system is being prepared for Mur and its most important tributaries.

All in all three Flood Forecasting Centres have been implemented in the frame of this project: one International Centre in Graz Austria, one National Centre for the Austrian part of the Mur watershed also set in Graz and a second National Centre for the Slovenian part of the Mur watershed set in Ljubljana. All three Centres have the same information and data status so that simulations can be executed for the entire Mur watershed.

The final real time system operates from Graz, which automatically receives data from the telemetric network in both countries and from meteorological models. This system is defined as the International Mur Flood Forecasting Centre. In a first stage data from the ALADIN model are used. Simulations are started automatically each hour with a forecasted period of 48 hours whereas the modeling results using meteorological forecasts are made available on the internet within 20 minutes.

To include more flexibility in the flood forecasting and flood survey, each country also manages its own Flood Forecasting Centre. The meteorological forecasts as well as the flood forecasting system (online data, model setup and results) from the International Mur Flood Forecasting Centre are made automatically available. In each National Flood Forecasting Centre it is then possible to develop local scenarios adapted to the actual flood event characteristics.

The present paper focuses on the structure of the trans-boundary flood forecasting system for the Mur watershed,. The methodology used in this project “Hochwasserprognosemodell Mur” (JOANNEUM Research and DHI Water and Environment, 2006) and the setup of the system, especially the homepage for the result publication on internet are presented in chapter 2 and chapter 3 respectively whereas the conclusion is given in chapter 4.

2 METHODOLOGY

2.1 Software/Model

2.1.1 <u>The Hydrologic model NAM</u>

MIKE 11 (DHI – Water & Environment, 2005) includes several rainfall-runoff models. The most appropriate model for the present study is the NAM model. The NAM model is a so-called lumped-conceptual type of model (see Figure 1) for continuous simulation. The term "conceptual" model implies that the hydrological cycle in the nature is conceptualised using a number of interconnected storages in the model. "Lumped" means that the physical properties of the area modelled (a catchment or a sub-catchment) are amalgamated into a few characteristic or nominal quantities and parameters. The term "continuous modeling" is used because the model in principle accounts continuously for the water content in the surface (soil moisture) and ground water storages.

The NAM model simulates the rainfall-runoff processes occurring on the catchment scale. In this model the conservation of water mass is formulated for four linked storages: snow storage, surface storage, lower zone storage and groundwater storage. The surface storage receives water from rainfall and losses water through evapotranspiration, horizontal leakage (overland flow and interflow to the river network) and infiltration to the lower zone storage. The lower zone storage receives water through infiltration from the surface storage and capillary flux from the groundwater storage and losses water through transpiration and groundwater recharge. The groundwater storage receives water through the groundwater recharge and losses water through the base flow to the river network. The exchanges are calculated both by physical and by semi-empirical formulations. The NAM model is a well-proven engineering tool that has been applied to a large number of catchments around the world, representing many different hydrological regimes and climatic conditions.

The NAM hydrological model simulates the rainfall-runoff processes occurring at the catchment scale. NAM forms part of the rainfall-runoff (RR) module of the MIKE 11 river modeling system. The rainfall-runoff module can either be applied independently or used to represent one or more contributing catchments that generate lateral inflows to the river network. In this manner it is possible to treat a single catchment or a large river basin containing numerous catchments and a complex network of rivers and channels within the same modeling framework.

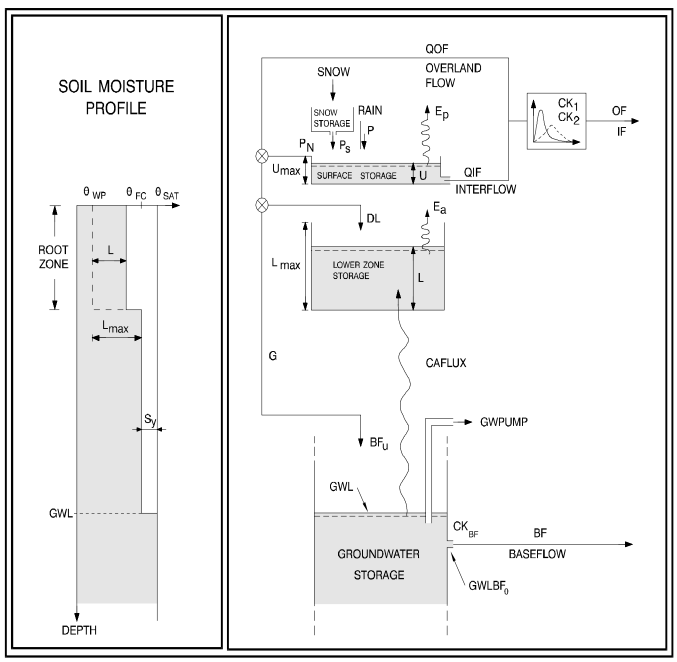


Figure 1: The NAM model structure.

The meteorological input data to the NAM model are precipitation, potential evapotranspiration and temperature (for snow modeling). On this basis, it produces, as its main results, catchment runoff and groundwater flow values as well as information about other elements of the land phase of the hydrological cycle, such as soil moisture content and groundwater recharge. The resulting catchment runoff is split conceptually into overland flow, interflow and baseflow components.

The snowmelt component of the runoff is incorporated as an integrated module within NAM. Two different models can be applied; a simple lumped calculation or a more general approach that divides the catchment into a number of altitude zones with

individual snowmelt parameters, temperature and precipitation input for each zone. It is this second approach that is used in the present project.
An automatic calibration module is available in NAM which allows calibration of the 9 most important model parameters. The autocalibration tool is based on a simultaneous optimisation of up to four different objectives, including water balance, overall hydrograph shape, peak flows and low flows. For a model calibration that includes all 9 parameters, a maximum number of model evaluations in the range 1000-2000 normally ensures an efficient calibration.

2.1.2 The Hydrodynamic Model MIKE 11

The main purpose of the hydrodynamic modeling in the present study is to provide the basis for the Flood Forecasting modeling and especially the high discharge values at different gauging stations. Whereas in the hydrologic modeling no river flow is considered, effects of water routing in the river channel are analyzed and simulated in the hydrodynamic modeling part.

MIKE 11 HD (hydrodynamics) has been used for the hydrodynamic modeling. It is a one-dimensional model typical used in studies related to flood forecasting and simulation of flood control measures, operation and design of irrigation and surface channel systems and in studies of tides and storm surges in rivers and estuaries. Results from the hydrodynamic simulations form the basis for succeeding the Flood Forecasting simulations.

The model is based on the vertically integrated equations of conservation of continuity and momentum, i.e. the Saint Venant equations (DHI – Water and Environment, 2005). The continuity equation is given by:

$$\frac{\partial A}{\partial t} + \frac{\partial Q}{\partial x} = q_0 \qquad (1)$$

and the equation for conservation of momentum:

$$\frac{\partial Q}{\partial t} + \frac{\partial\left(\beta \frac{Q}{A} Q\right)}{\partial x} + gA\frac{\partial h}{\partial x} + \frac{g|Q|Q}{M^2 AR^{4/3}} = 0 \qquad (2)$$

Where A (m2) is wetted cross-sectional area, Q (m3s-1) is river discharge, q0 (m3s-1m-1) is lateral inflow as e.g. may be calculated by the rainfall-runoff module, t (s) is time, x (m) is distance, β is non-uniform velocity distribution coefficient, g (=9.81 ms-2) is gravitational acceleration, M is the Manning number (the Manning number is also seen in the literature as n=M-1) and R (m) is hydraulic radius.

These equations are solved using an implicit finite difference scheme by applying a Double Sweep algorithm. The solution applies to single branched as well as looped and branched river systems. The computational grid comprises alternating Q (discharge) and H (water level) points. Cross-sectional data are given at H-points whereas Q-points are automatically placed midway between neighbouring H-points and at hydraulic structures.

2.1.3 The Decision support system MIKE FLOOD WATCH

The MIKE FLOOD WATCH system is a modern and robust forecast modeling shell that integrates data management, forecast models and dissemination methodologies in a single system (Figure 2). The system, which is fully integrated into

ESRI ArcMap GIS 9, takes advantage of the newest GIS technology available on the market; including modern scripting facilities and fast and robust methods for visualisation and processing of geographical data.

Real-time data such as meteorological forecasts, radar imagery and point based telemetry data can be imported into the system and used e.g. as input to hydrologic and hydraulic forecasting models. Real-time data imported from external sources are quality assured according to user-defined quality criteria and stored in the system database. The system provides automated tools for the derivation of accurate and robust forecast model input time series to help improve the forecast accuracy and reliability.

In order to ensure a high level of openness and flexibility, the system makes consistent use of industry standards for model interfacing. The system can interface a wide range of model types; including meteorological models, hydrologic models, hydraulic and hydrodynamic models, advection-dispersion models, water quality models, forecasting models, error forecast models and others.

System tasks such as import of real-time data from remote data acquisition stations, initiation of forecast modeling tasks and dissemination of selected results to emergency staff, authorities and the public, are handled consistently using a task scheduler, which is capable of executing predefined tasks upon request by a user, as scheduled or in the case of an alarm.

Access restrictions can be defined for each user or group of users, hence making it possible to ensure that only suitably qualified and experienced staff can gain access to the parts of the system that require particular know-how. In turn, this adds to the philosophy of offering an extremely robust system that can operate in a range of user environments.

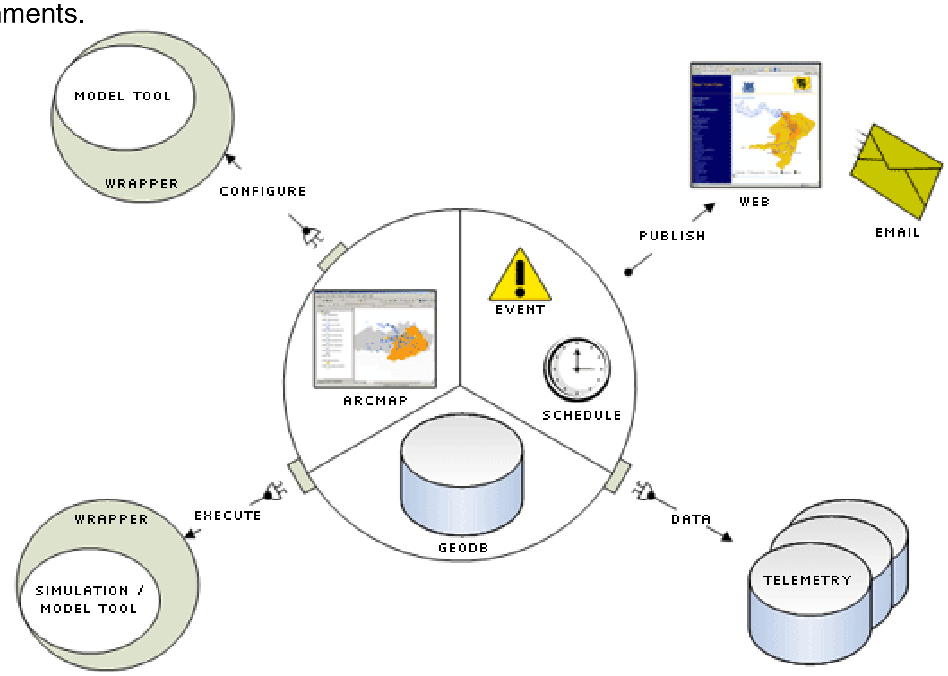


Figure 2: Mike flood watch structure.

2.2 Development of a common international solution

The goal of this project was to setup a flood forecasting system for the Austrian and Slovenian part of the Mur watershed whereas this river flows through 4 countries: Austria, Slovenia, Croatia and Hungary (see Figure 3). The Mur watershed in Austria (around 10000 km^2) is much larger than in Slovenia (around 1400 km^2) in Hungary (around 1900 km²), and in Croatia (around 500 km²) whereas the three last countries are located downstream compared to the Austrian part. Due to these geographical characteristics the probability for a flood genesis is much more significant in Austria as in the other countries but the related flooding risks are distributed over the entire watershed. Furthermore, it is clear that the forecast quality in Austria is not depending on foreign information but in contrast, the forecast quality in Slovenia for example depends from the Austrian information. These facts illustrate that the definition of a common solution and its technical application constitute the particular challenge of this project.

The good relations in the frame of the Mur Commission allowed to work out a common solution with representatives of all four countries from the very beginning. A general solution that can also be used for other trans-boundary watersheds emerged out of several meetings. Two national Forecasting Centres, one in Graz (Austria) and one in Ljubljana (Slovenia) are working parallel to the International Forecasting Centre established in Graz.

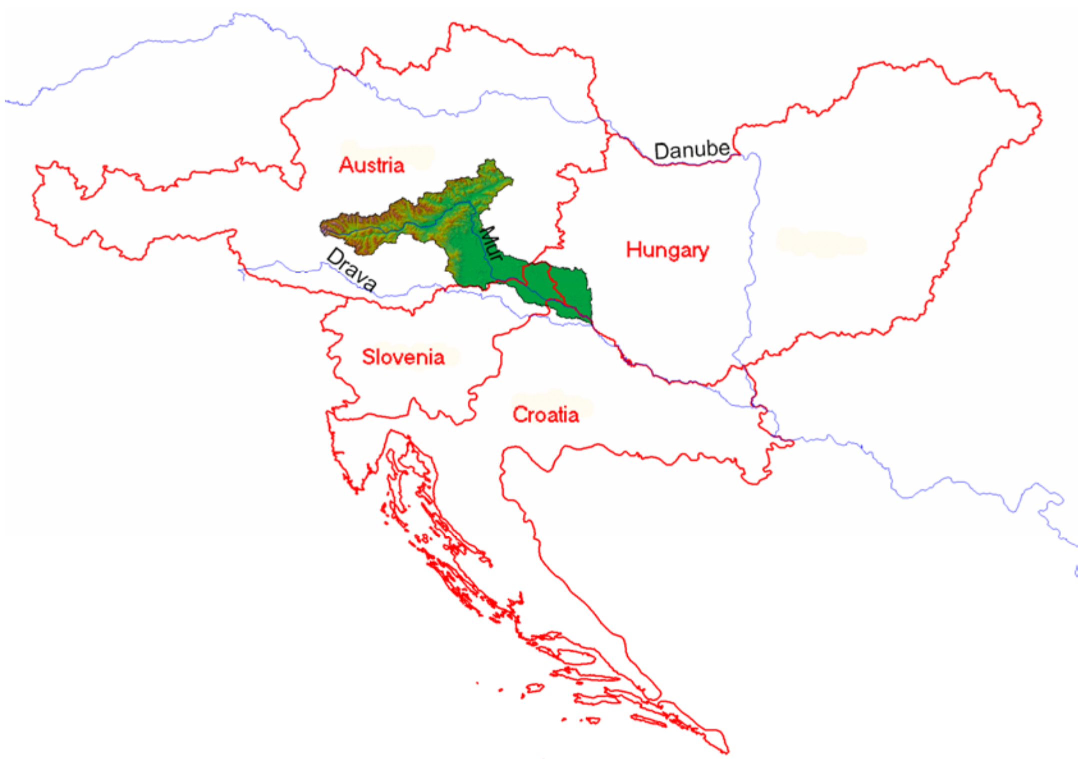


Figure 3: The trans-boundary watershed of the Mur river.

At the International Forecasting Centre the simulations are run continuously and automatically each hour, i.e., without human intervention. To run the model real-time, online precipitation, air temperature and water level data on the one side 48h meteorological forecasts (model Aladin) for precipitation and air temperature on the other side are used. Each country runs its own model for the common Austrian and Slovenian watershed with the possibility to develop scenarios using for example data from other meteorological models. The schematic representation of this global solution is presented on Figure 4 whereas the communication structure between all three forecasting centres is shown.

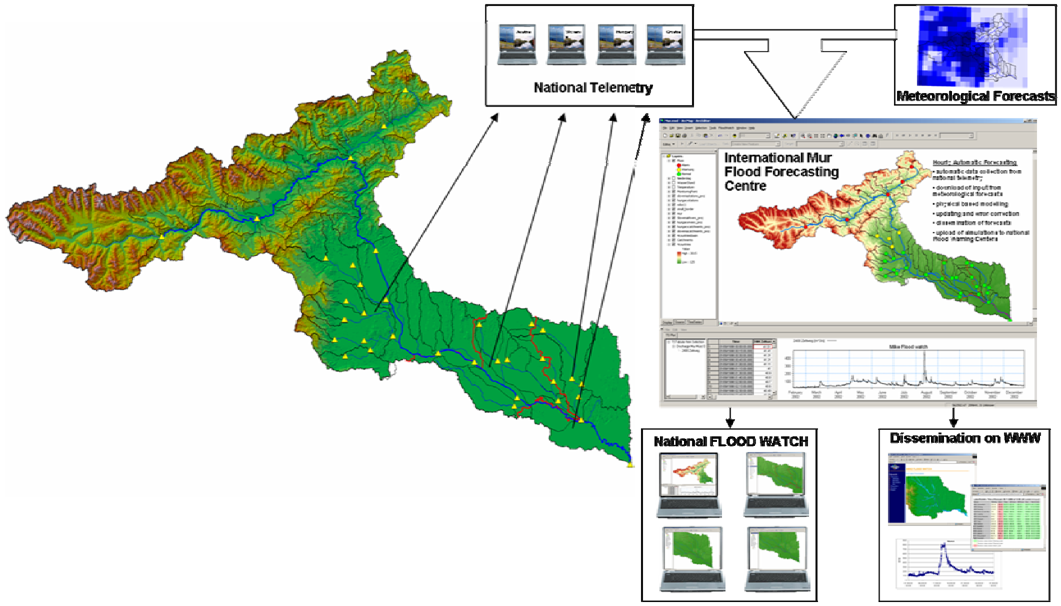


Figure 4: Schematic presentation of the common international flood forecast solution.

3 SETUP OF THE SYSTEM

3.1 Calibration of the Nam and the MIKE11 models

The area under investigation has been divided in 40 sub-catchments in Austria and 12 sub-catchments in Slovenia (Hidrološki Letopis Slovenije, 2000 and Površinski Vodotoki in Vodna Bilanca Slovenije, 1998) whereas the NAM model has been calibrated for the period 1.9.1998 to 31.12.2002 in 18 units and the parameters are transferred to the ungauged hydrological units. During this calibration phase all the available hydro-meteorological stations have been used, which includes approximately 30 hydrometric stations and 80 rainfall and air temperature stations. During the summer 2005 an important flood event occurred so that it was possible to enhance the calibration using only data from online stations (18 hydrometric stations and 45 rainfall and air temperature stations), i.e., the calibration is supported only with hydro-meteorological stations that are available in operational modus. In Slovenia only one online hydrometric station and two rainfall and air temperature stations exist in area of interest, but new stations should be installed and implemented in the flood forecasting system in the next years.

The “real” river network has been considerably simplified so that only the Mur River and its main affluent (Mürz, Kainach, Lafnitz, Sulm, Scavnica and Ledava) are included in the hydrodynamic setup. The entire schematised river network has a length of approximately 900 km including around 1000 cross sections. It must be emphasised that for the Slovenian part of the watershed only 12 cross sections are available. Moreover on the Austrian part of the watershed 9 hydro power structures have been implemented in the hydrodynamic setup.

The complete hydrologic and hydrodynamic setup can be seen on Figure 5 whereas an example of the Nam and the Mike11 calibration is given in Figure 6 and Figure 7 respectively.

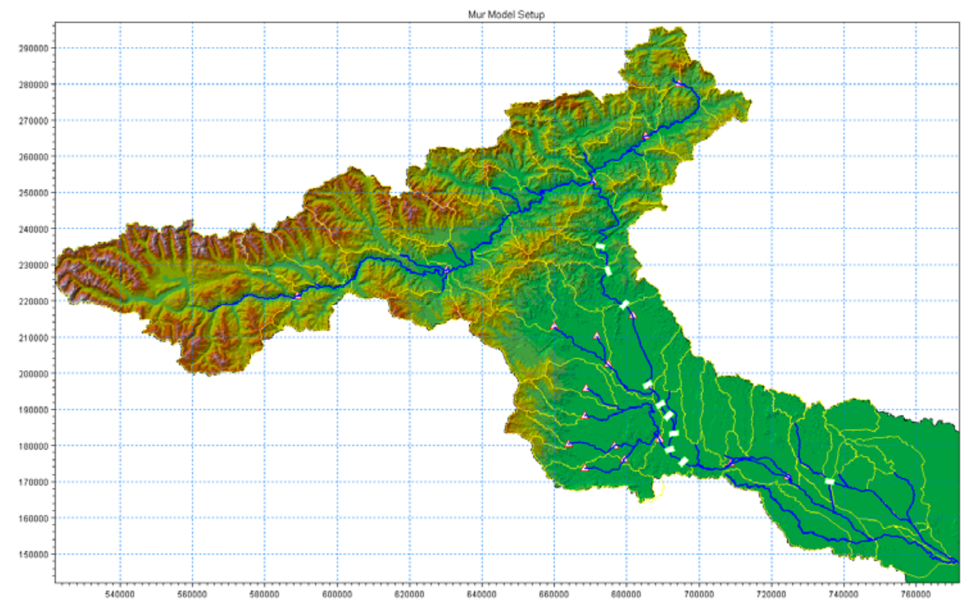


Figure 5: Complete model setup including online river station network (red/white triangles), sub-catchments (yellow lines), river network (blue lines) and hydropower/control structures (blue/white rectangle).

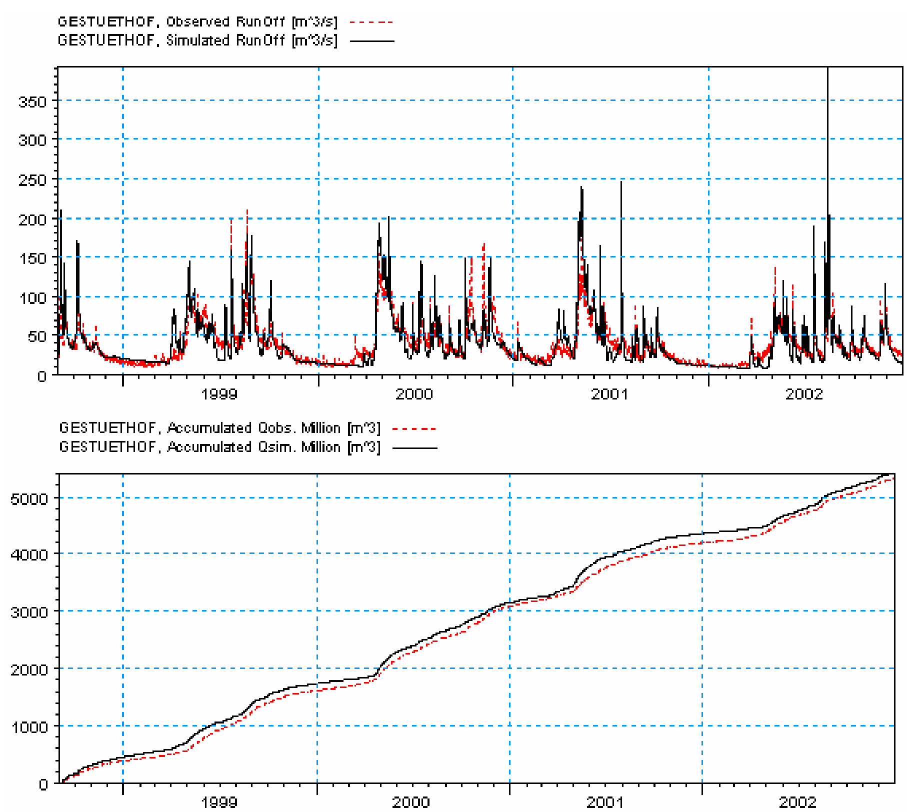


Figure 6: Example of NAM calibration results from one of the 18 catchments (Gestuethof), where calibration has been possible. Upper part of the figure: Comparison of observed and simulated runoff. Lower part of the figure: Comparison of accumulated runoffs.

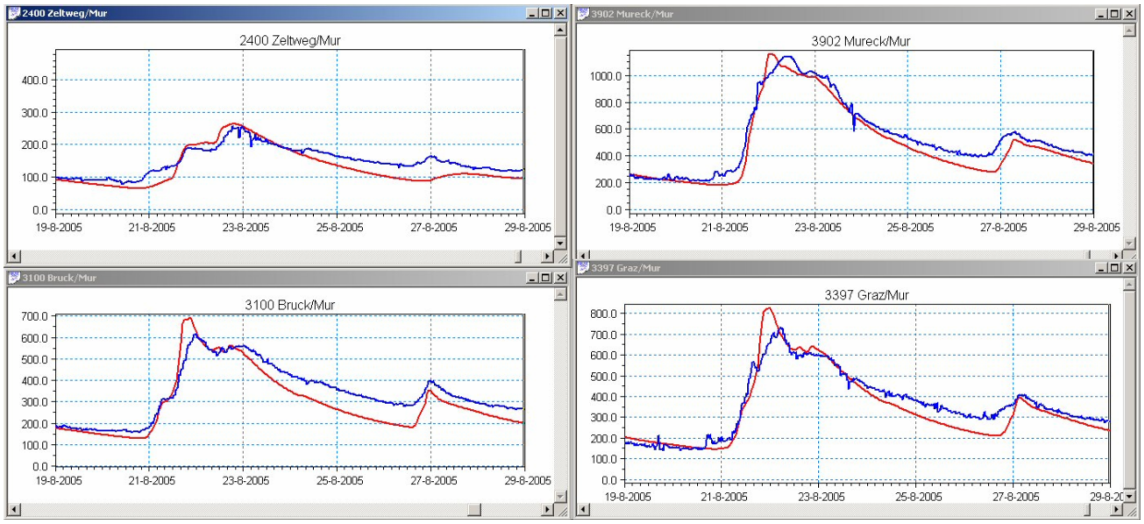


Figure 7: Example of MIKE11 calibration for the flood event in August 2005 at 4 gauging stations on Mur river: (blue line observed discharge, red line simulated discharge).

3.2 Setup of the Automatic Flood Forecasting Centre

The main goal of this project is to implement a common Flood Forecasting system for Austria and Slovenia. Thus, the common system must combine the hydrologic and hydrodynamic set-ups from both countries. The complete set-up must be available at The Environmental Agency of the Republic of Slovenia so that it will be possible for the flood specialists to simulate flood waves coming from Austria, i.e., the specialists will have the possibility to modify the forecasted precipitation as well as all model implementation at the local forecast centre in Slovenia and also in Austria.

The challenge of this project is to automate the Flood Forecasting in the International Centre in Graz and to enable the national Institutes to carry out their own forecasts. Therefore, the function of the national Flood Forecasting System implemented at ARSO is twofold:

Export the data to the international centre in Graz so that the simulations can be made for the international Mura River watershed (actually Austria and Slovenia).

Import the simulation results and the setup from the International Centre from Graz to be able to make national forecasts.

The Flood Forecasting System is set up under the MIKE FLOOD WATCH software, version 2006 (DHI Water&Environment). This software is implemented in ARC GIS (ESRI) and can be considered as an extension of the ARC GIS software. This extension is simply called Floodwatch. It should be noted that the ARC GIS software has not to be implemented on the PC but is delivered in a light version with the MIKE FLOOD WATCH software.

3.3 Setup of the homepage for result publication

The forecasts simulations made at the International Centre in Graz are presented on this homepage in German, Slovenian and English. At the moment the homepage is password protected. It contains:

An overview to describe when the last forecast is run.

A map with the river gauging stations. On this map it is possible to see the forecasted discharge and water level graphs by clicking on the stations. This map is a so called “River Status Map” where the colour of the stations as well as the colour of the river, change according to the actual and forecasted values: when a value exceeds a pre-defined warning level the colour is adapted to the warning level that is passed. Furthermore, it is possible to display different river and station status for several forecasted time steps (e.g. time of forecast + 1 hour, + 2 hours, + 6 hours, +12 hours etc.)

A table with the water level at time of forecast and at several forecasted time steps (e.g. time of forecast + 1 hour, + 2 hours, + 6 hours, +12 hours etc.) as well as the maximum water level during the simulation and its timing.

A table with the discharge at time of forecast and at several forecasted time steps (e.g. time of forecast + 1 hour, + 2 hours, + 6 hours, + 12 hours etc.) as well as the maximum discharge during the simulation and its timing.

A map of the actual flood extend only available for the Austrian part of the Mura watershed.

The Austrian and Slovenian Aladin meteorological forecasts. Like for the river status view; the meteorological forecasts can be displayed for different time steps. A forecast for each hour until 24 hours is available and can be displayed step by step or as a movie.

This homepage presents all the most important results in a very efficient way. Information are displayed in different formats and the specialists can access very rapidly to an overview for the entire watershed in a map or tabular form as well as to particular information for a specific station.

In the following is given an overview of the homepage functionalities and information content for the flood forecasting on the Mura River. Clearly, a better understanding of the functionalities is reached by surfing directly on the homepage. Only the main pages are presented in this chapter. The homepage is password protected so that unauthorised persons cannot access to the data.

On this homepage are presented all the main results from the automatic simulations made on the International Centre in Graz. The simulations are run automatically every hour and the results presented are automatically updated every hour. As the simulations are made in an automatic modus, no human intervention is needed. Thus errors can happen and it is absolutely necessary to check the results plausibility on the national PC using the simulation sets that can be retrieved automatically or manually.

The figures presented in this chapter are in Slovenian language. For the moment 3 language versions are available: Slovenian, German and English. Further languages can be added if for example Hungary and Croatia join the project in the future.

3.3.1 The river status page

The river status page is updated and uploaded to the web server automatically each hour with the latest flood information. It can be considered as the central page because it gives an overview for water flow in time and space. The river branches (lines) and the gauging stations (circles) are located on a topographic map as illustrated on Figure 8. The colour of these symbols is changing according to the flow situation compared to the warning levels. For example if discharge is exceeding the red warning level on some stations, then these stations will be coloured in red and the river branches in between also.

It can be seen on the right side of Figure that it is possible to display river status maps for different time steps. These time steps are: time of forecast, time of forecast + 1 hour, 2 hours, 3 hours, 6 hours, 12 hours, 18 hours, 24 hours, 36 hours and 48 hours. Thus it is possible for the personnel of the flood centre to see very rapidly the forecasted evolution of flow conditions in the basin.

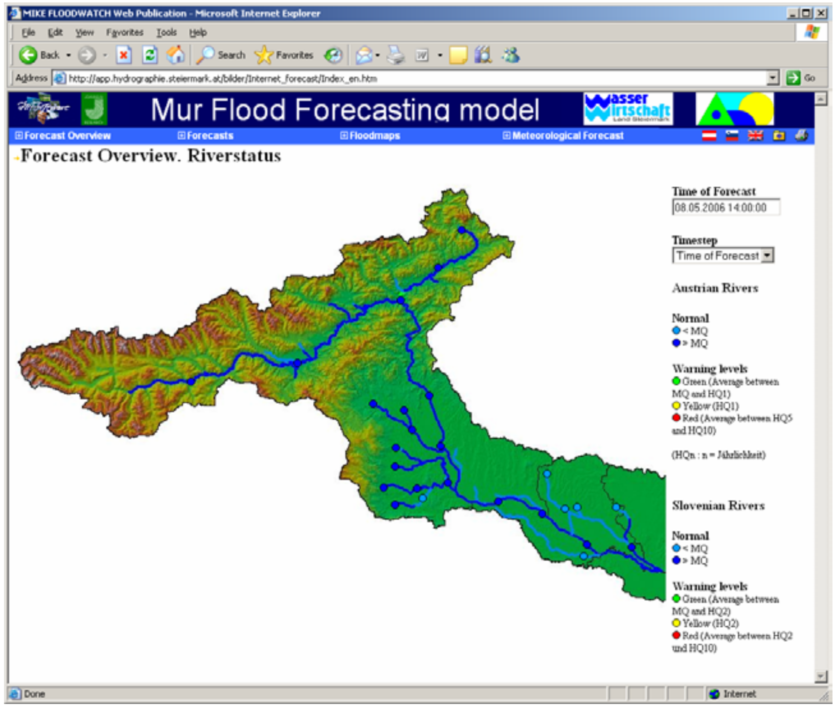


Figure 8: The river status map on the Slovenian homepage.

More detailed information for each gauging station can be seen by clicking on a given station (circle). A page is uploaded where time series for discharge and water level are displayed for the entire simulation period. A graph example for the station Gornja Radgona (ID 1060) is presented on

Figure 9. All in all 4 days are presented on the graphs because the simulation starts always 2 days before the time of forecast (warm-up period, dark blue on the graph) and the forecasted time is two days (light blue on the graph).

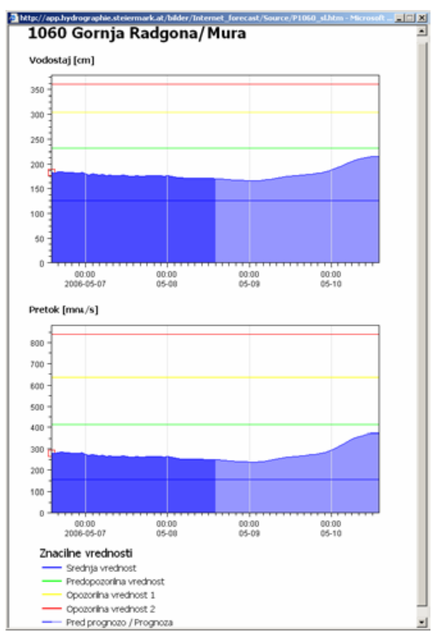


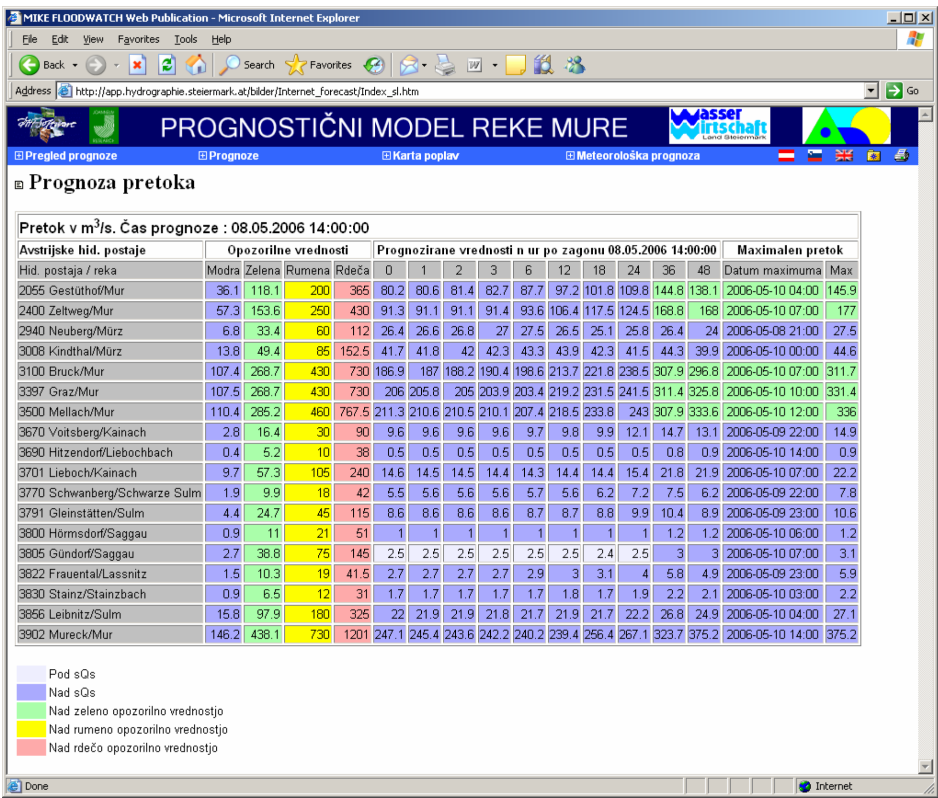
Figure 9: Example of time series graphs on the Slovenian homepage. The discharge and water level values as well as the warning level values are fictive.

3.3.2 The table overview

A further possibility to get a rapid and complete overview is given in the table overview. The information content from the tables presented on Figure 10 is based on the same principle as for the river status map. The same colour code is used when discharge or water level values are rising over a warning level.

The tables are presented separately for the Austrian and the Slovenian stations. The warning levels for each station are remembered in the first four rows beside the raw containing the name and the ID of the gauging stations. The next ten rows include the discharge or water level values at time of forecast and at time of forecast + 1 hour, 2 hours, 3 hours, 6 hours, 12 hours, 18 hours, 24 hours, 36 hours and 48 hours. Here also, when a value exceeds a warning level the entire cell is coloured according to the warning level that is exceeded.

Furthermore, the last two rows are dedicated to the timing and the value of the forecasted peak flow. This is also very important information for the flood management and defence.



Pretok v m³/s. Čas prognoze : 08.05.2006 14:00:00

Avstrijske hid. postaje	Opozorilne vrednosti				Prognozirane vrednosti n ur po zagonu 08.05.2006 14:00:00										Maximalen pretok	
Hid. postaja / reka	Modra	Zelena	Rumena	Rdeča	0	1	2	3	6	12	18	24	36	48	Datum maximuma	Max
2055 Gestüthof/Mur	36.1	118.1	200	365	80.2	80.6	81.4	82.7	87.7	97.2	101.8	109.8	144.8	138.1	2006-05-10 04:00	145.9
2400 Zeltweg/Mur	57.3	153.6	250	430	91.3	91.1	91.1	91.4	93.6	106.4	117.5	124.5	168.8	168	2006-05-10 07:00	177
2940 Neuberg/Mürz	6.8	33.4	60	112	26.4	26.6	26.8	27	27.5	26.5	25.1	25.8	26.4	24	2006-05-08 21:00	27.5
3008 Kindthal/Mürz	13.8	49.4	85	152.5	41.7	41.8	42	42.3	43.3	43.9	42.3	41.5	44.3	39.9	2006-05-10 00:00	44.6
3100 Bruck/Mur	107.4	268.7	430	730	186.9	187	188.2	190.4	198.6	213.7	221.8	238.5	307.9	296.8	2006-05-10 07:00	311.7
3397 Graz/Mur	107.5	268.7	430	730	206	205.8	205	203.9	203.4	219.2	231.5	241.5	311.4	325.8	2006-05-10 10:00	331.4
3500 Mellach/Mur	110.4	285.2	460	767.5	211.3	210.6	210.5	210.1	207.4	218.5	233.8	243	307.9	333.6	2006-05-10 12:00	336
3670 Voitsberg/Kainach	2.8	16.4	30	90	9.6	9.6	9.6	9.6	9.7	9.8	9.9	12.1	14.7	13.1	2006-05-09 22:00	14.9
3690 Hitzendorf/Liebochbach	0.4	5.2	10	38	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.8	0.9	2006-05-10 14:00	0.9
3701 Lieboch/Kainach	9.7	57.3	105	240	14.6	14.5	14.5	14.4	14.3	14.4	14.4	15.4	21.8	21.9	2006-05-10 07:00	22.2
3770 Schwanberg/Schwarze Sulm	1.9	9.9	18	42	5.5	5.6	5.6	5.6	5.7	5.6	6.2	7.2	7.5	6.2	2006-05-09 22:00	7.8
3791 Gleinstätten/Sulm	4.4	24.7	45	115	8.6	8.6	8.6	8.6	8.7	8.7	8.8	9.9	10.4	8.9	2006-05-09 23:00	10.6
3800 Hörmsdorf/Saggau	0.9	11	21	51	1	1	1	1	1	1	1	1	1.2	1.2	2006-05-10 06:00	1.2
3805 Gündorf/Saggau	2.7	38.8	75	145	2.5	2.5	2.5	2.5	2.5	2.5	2.4	2.5	3	3	2006-05-10 07:00	3.1
3822 Frauental/Lassnitz	1.5	10.3	19	41.5	2.7	2.7	2.7	2.7	2.9	3	3.1	4	5.8	4.9	2006-05-09 23:00	5.9
3830 Stainz/Stainzbach	0.9	6.5	12	31	1.7	1.7	1.7	1.7	1.7	1.8	1.7	1.9	2.2	2.1	2006-05-10 03:00	2.2
3856 Leibnitz/Sulm	15.8	97.9	180	325	22	21.9	21.9	21.8	21.7	21.9	21.7	22.2	26.8	24.9	2006-05-10 04:00	27.1
3902 Mureck/Mur	146.2	438.1	730	1201	247.1	245.4	243.6	242.2	240.2	239.4	256.4	267.1	323.7	375.2	2006-05-10 14:00	375.2

Pod sQs
Nad sQs
Nad zeleno opozorilno vrednostjo
Nad rumeno opozorilno vrednostjo
Nad rdečo opozorilno vrednostjo

Figure 10: The discharge table on the Slovenian homepage. Note that the warning level values are fictive.

4 CONCLUSION

The Mur Flood Forecasting System generation is a project with European dimensions. Rivers don't care about human borders, wishes and needs. The Mur watershed extends over four countries: Austria (around 10000 km²), Slovenia (around 1400 km²), Hungary (around 1900 km²) and Croatia (around 500 km²) whereas the three last mentioned countries are located downstream compared to Austria. Due to these geographical characteristics the probability for a flood genesis is much more significant in Austria than in the other countries but the related flooding risks are distributed over the entire watershed.

This project gives a concrete example of international cooperation in the field of Flood management but unfortunately limited to Austria and Slovenia. The good and long cooperation between the four countries concretised in the “Mur Commission” on the one side and the financial support from the European Commission on the other side were the basis for creation of this project. The responsible from the Mur watershed have made a decisive step in the direction of an integrated and sustainable watershed management. The structure developed in this project allows enlarging (1) the study field to topics like water quality, sediment transport and erosion or even low flow and (2) the studied area to Hungary and Croatia or even to the Drau River in which the Mur is flowing.

The structure that has been established build out of one International Flood Forecasting Centre and two national centres illustrates how a trans-boundary flood forecasting system can operate. The main element is the International Flood Forecasting Centre installed in Graz (Austria) where all the necessary online data and meteorological forecasts are automatically collected and formatted for the simulations. Furthermore, each hour starts a simulation with a forecasted time of two days whereas the main results are published on the internet and the complete model setup and result are transferred to the two national centres. Therefore, on both national centres it is possible to analyse detailed results and to develop local scenarios using for example modified meteorological forecasts or other initial conditions.

This technical solution allows a perfect synchronisation for online data, pre and posts processing files, information and results from the simulations between all three Flood Forecasting Centres. It contributes therefore to a noticeable improvement for information organisation between Austria and Slovenia and should be considered as a new method for Flood and Risk management. This new communication strategy coupled with the automatic and continuous modeling as well as the result publication on internet delivers a concrete example for Flood prevention and resources management that can be transferred to other trans-boundary watersheds.

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