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**AN OUTLINE OF WISKI 7 & HBV SYSTEMS
IMPLEMENTED AT
THE HYDROLOGY DEPARTMENT OF RHMSS**
by

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BACKGROUND

- Partnership between NVE & RHMSS in executing several projects in Serbia in the field of hydrology has started in 2006 with financial support of the Norwegian Government and is still ongoing
- NVE– Norwegian Water Resources and Energy Directorate
 - Under the Ministry of Petroleum and Energy, based in Oslo
 - Responsible for the management of Norway's water and energy resources
 - Has sole responsibility for hydrology in Norway, including real-time hydrological forecasting & flood warning
- RHMSS – Republic Hydrometeorological Service of Serbia
 - Independant Government Agency
 - Solely responsible for monitoring & forecasting of meteorological and hydrological phenomena in Serbia



BACKGROUND (continued)

- Current NVE-RHMSS Project
 - A 2-year project (2009 & 2010) entitled - Hydrological flood forecasting system for small and medium sized catchments in Serbia
 - It is currently being implemented and scheduled to be completed soon - in December 2010
 - Financial support provided by the Government of Norway
- Objective:
 - Assist Hydrology Department of RHMSS in improving its data management and hydrological flood warning and forecasting services



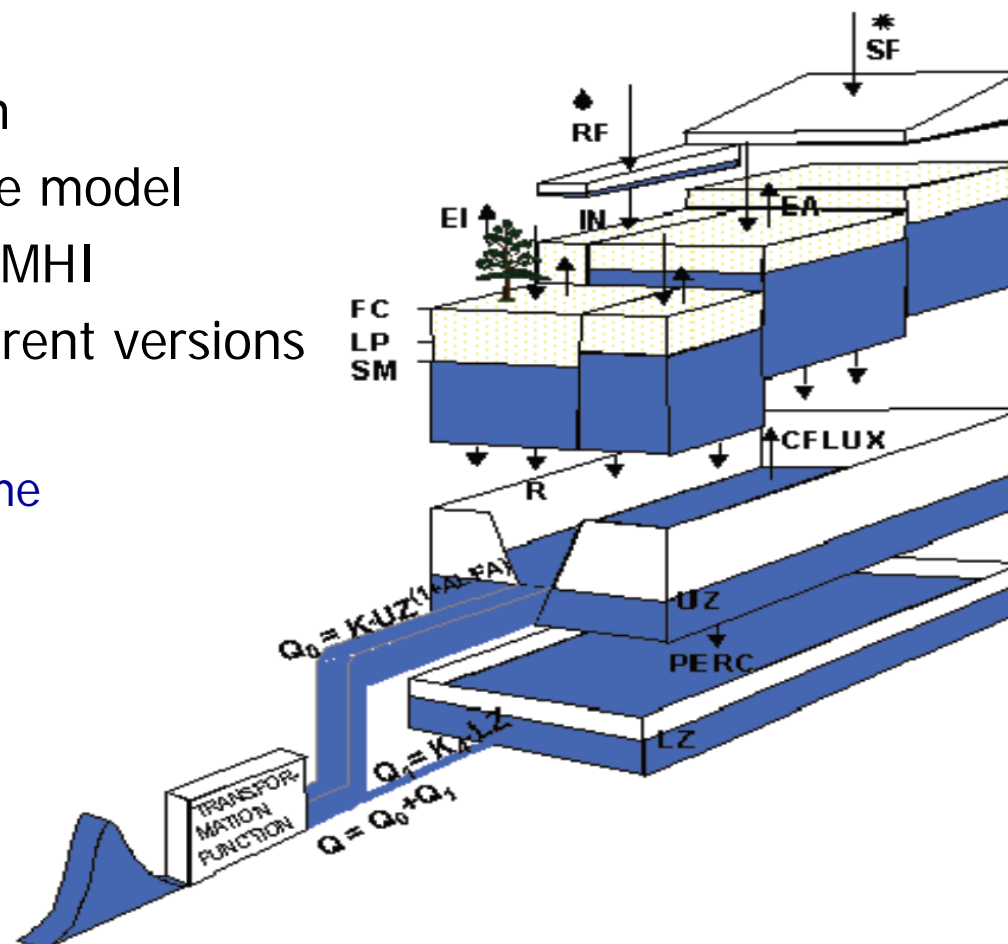
BACKGROUND (continued)

- Project outputs:
 - Introduced and used operationally a new modern hydrological information management system(HIMS) for management of both real-time and non real-time hydrological, meteorological and other data
 - Installed and used regularly a viable rainfall-runoff model for real-time flood warning and forecasting at 10 selected small & medium river basins in Central Serbia
 - The two systems integrated to provide smooth data management and flood forecasting procedures in real-time
 - Technical staff of HD/RHMSS trained as appropriate



HBV/IHMS MODEL

- Purchased from SMHI, Sweden
- Rainfall/snowmelt – runoff type model
- Developed in early 1970s at SMHI
- Worldwide applications in different versions
- Used for various purposes:
 - simulations of river flow regime
 - flood forecasting
 - energy inflow forecasts
 - flash flood forecast
 - simulation of climate change
 - water quality simulation



HBV/IHMS IMPLEMENTED AT HD/RHMSS



- Semi-distributed conceptual catchment model
- Spatial structure of catchment area is not explicitly modeled
- Instead, sub-basin represents primary modelling unit while basin is characterised by
 - Area-elevation distribution
 - Classification of vegetation cover and land use distributed by height zone
- HBV consists of three main modules:
 - Snow accumulation and snowmelt
 - Soil moisture accounting
 - Catchment response module
- Rainfall/snowmelt-runoff processes in the catchment are controlled by parameters selected during the model calibration



HBV/IHMS AT HD/RHMSS

- Minimum catchment data required for model calibration and verification:
 - 20 years of historical daily (or higher resolution- down to 1 hour) discharge, temperature and precipitation time series of good quality
 - 10 years for model calibration
 - 10 years for model performance verification
 - Estimated average monthly evapotranspiration
 - Hypsometric curve (area-elevation distribution)
 - Vegetation cover and land use distributed by height zone
 - No significant man-made influence on natural streamflow regime
- Real time input data required for flood warning/forecasting
 - Observed stage, discharge
 - Observed precipitation and temperature data (or interpolated values)
 - Gridded quantitative precipitation and temperature forecasts (QPF & QTF)



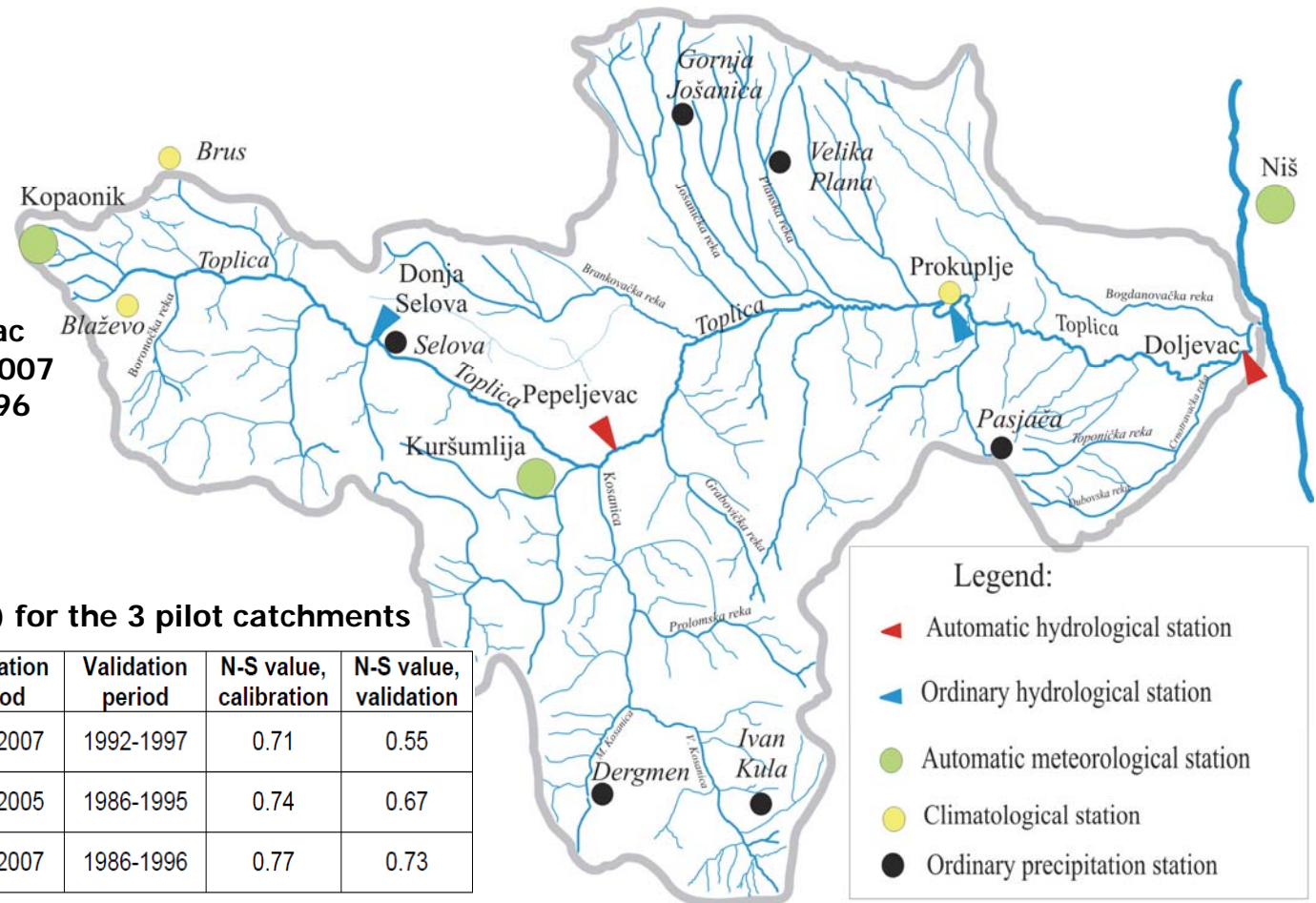
HBV/IHMS – INITIAL USE

- Three pilot catchments
 - Rivers Jasenica, Kubrsnica & Toplica
- Model calibrated by manually and/or automatically adjusting model parameters
- Main criteria used for final selection of parameter values:
 - Optimal fit of observed versus simulated discharge
- Model performance evaluated through:
 - Visual inspection of the observed and simulated hydrographs
 - Double mass plot, and
 - Three quantitative measures of forecast accuracy
 - Mass bias
 - Nash-Sutcliffe (N-S) error function
 - Log transformation of the N-S function

HBV/IHMS: Case Study Toplica River

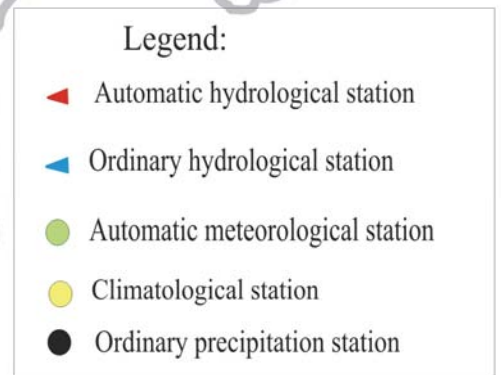


- Hydrological profile: Doljevac
- Calibration period: 1997 – 2007
- Validation period 1986 – 1996
- Area: 2054 km²



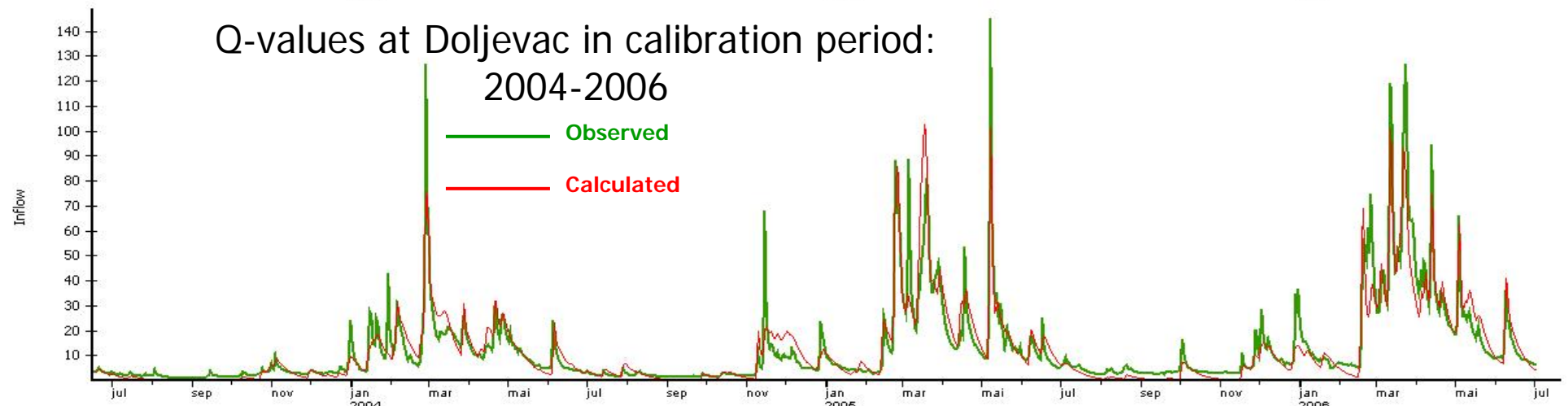
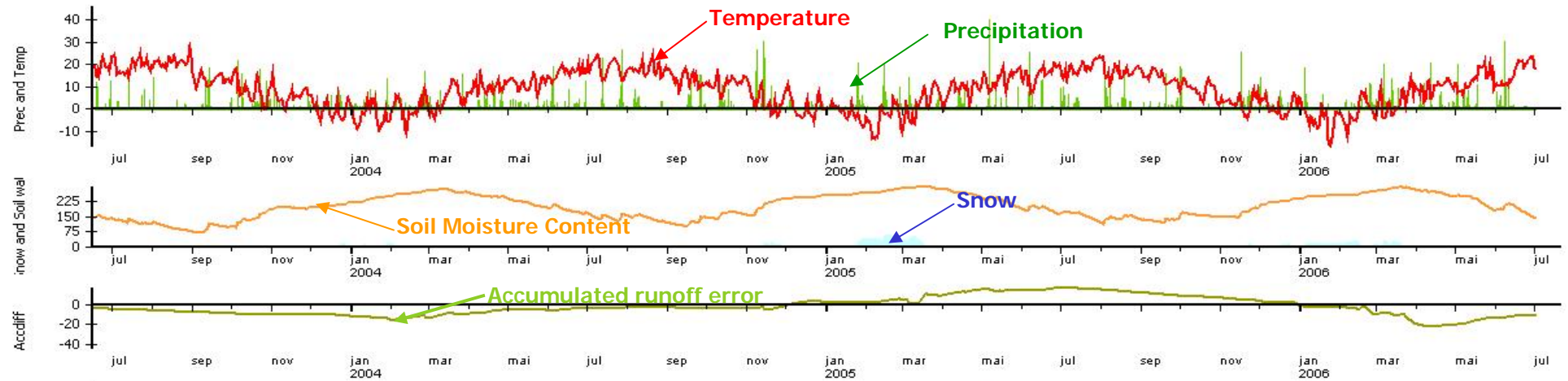
Model performance (N-S value) for the 3 pilot catchments

Station name and river	Catchment area (km ²)	Calibration period	Validation period	N-S value, calibration	N-S value, validation
Smederevska Palanka, Jasenica river	496 km ²	1998-2007	1992-1997	0.71	0.55
Smederevska Palanka, Kubrsnica river	743 km ²	1996-2005	1986-1995	0.74	0.67
Doljevac, Toplica river	2052 km ²	1997-2007	1986-1996	0.77	0.73



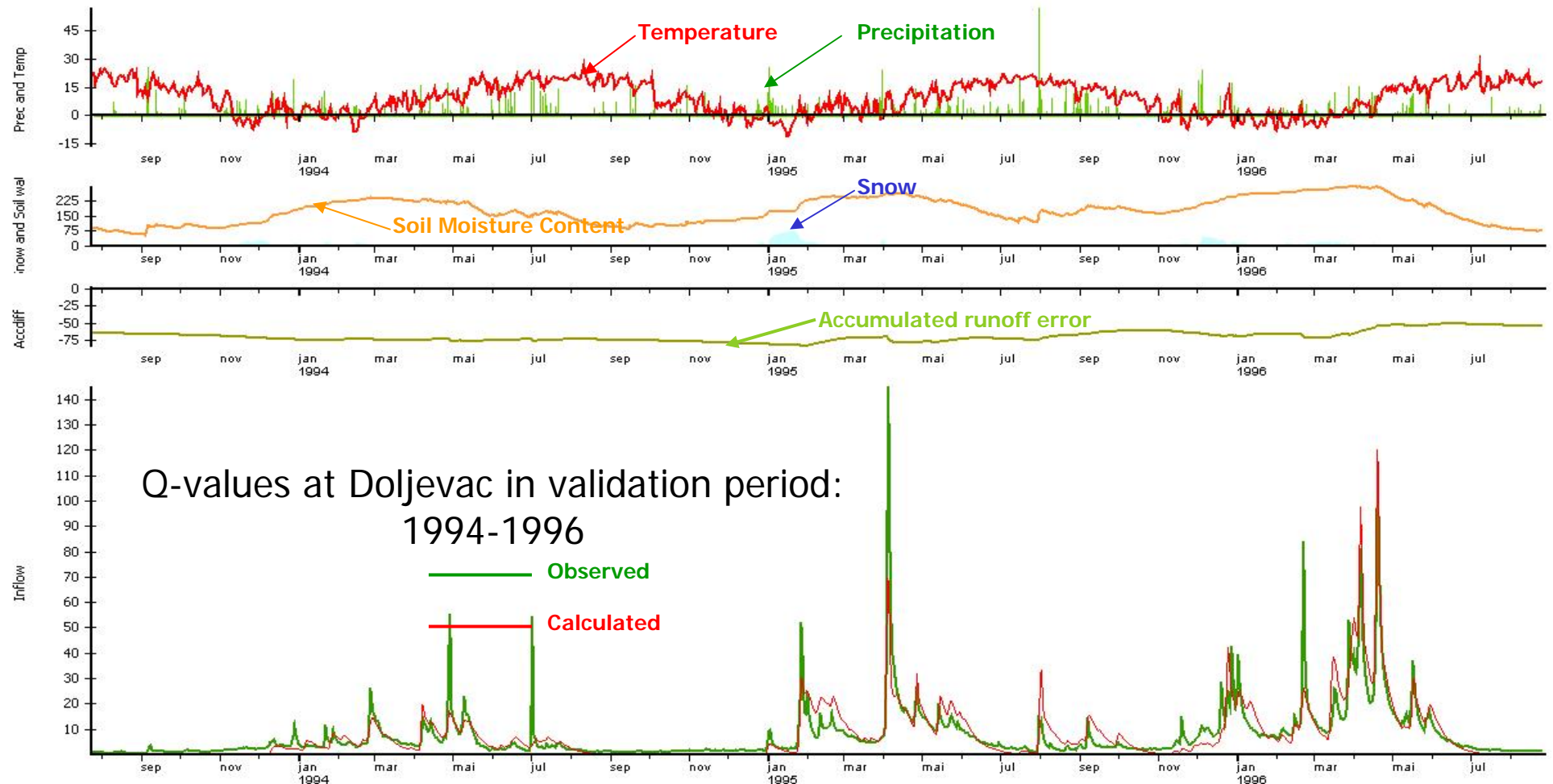


HBV/IHMS: Case Study Toplica River





HBV/IHMS: Case Study Toplica River

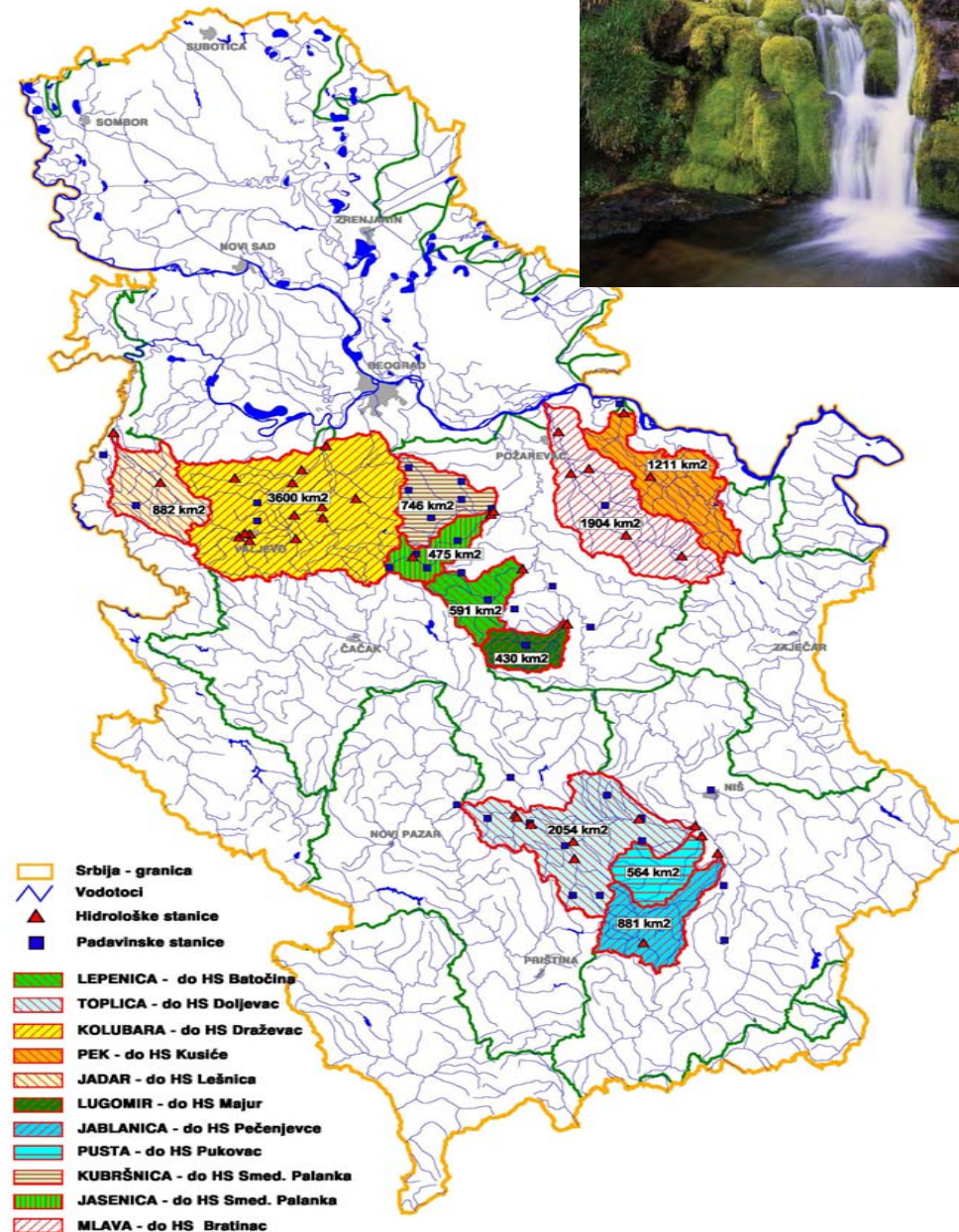


Q-values at Doljevac in validation period:
 1994-1996

HBV/IHMS – CURRENT STATUS

- Necessary data compiled for 10 catchments in Serbia
- HBV model calibrated and verified at all 10 catchments
- Integration of HBV and WISKI 7 systems - for export and import of real time data and HBV output results – is in final stage
- HD/RHMSS has recently started issuing operational real-time flood forecasts at the 3 (**Toplica, Jasenica & Kubrsnica**) out of 10 catchments using HBV model & W7 data management system

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WISKI 7

DATA MANAGEMENT SYSTEM

- New system for water resources and hydrological information management - purchased from KISTERS AG, Germany
- KISTERS AG is a reputed company working over 20 years in developing and providing data management software solutions
- Core business: implementation of data management systems for environmental, water resources, hydrological, meteorological, air quality, health and energy applications
- KISTERS is said to strive to meet rigorous data management requirements promulgated by:
 - the EU Water Framework Directive and
 - the US Geological Survey



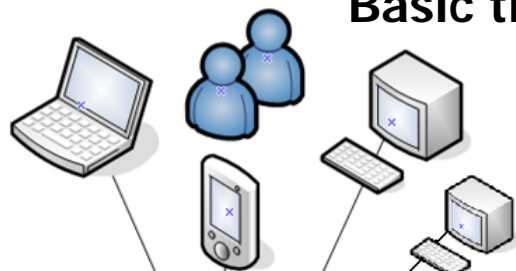
WISKI 7: Basic Characteristics

- High performance time series management
 - structural relational database
 - data acquisition, data validation
 - calculations, statistics
 - data exchange
 - storage management
 - data presentation
 - spatial projection
 - web publishing
- Integrated modules
 - **BIBER** – for hydrometric flow measurements, data storage and calculation of hydraulic parameters
 - **SKED** – Rating curve editor
- WSP: **W**ISKI **S**ervice **P**rovider for automation of operational processes



WISKI 7 ARCHITECTURE

Basic three tier client-server architecture



Desktop application offering
 WISKI7, WISKI Reporting
 BIBER and SKED;
 Handheld applications
 HBV / IHMS

Front Ends

SODA Telemetry



KiTSM Server



Time Series Management managing:
 Imports, Calculation, Autovalidations, Exports
 As well as integration to other systems (API,
 Files)

Business Logic

WISKI Database

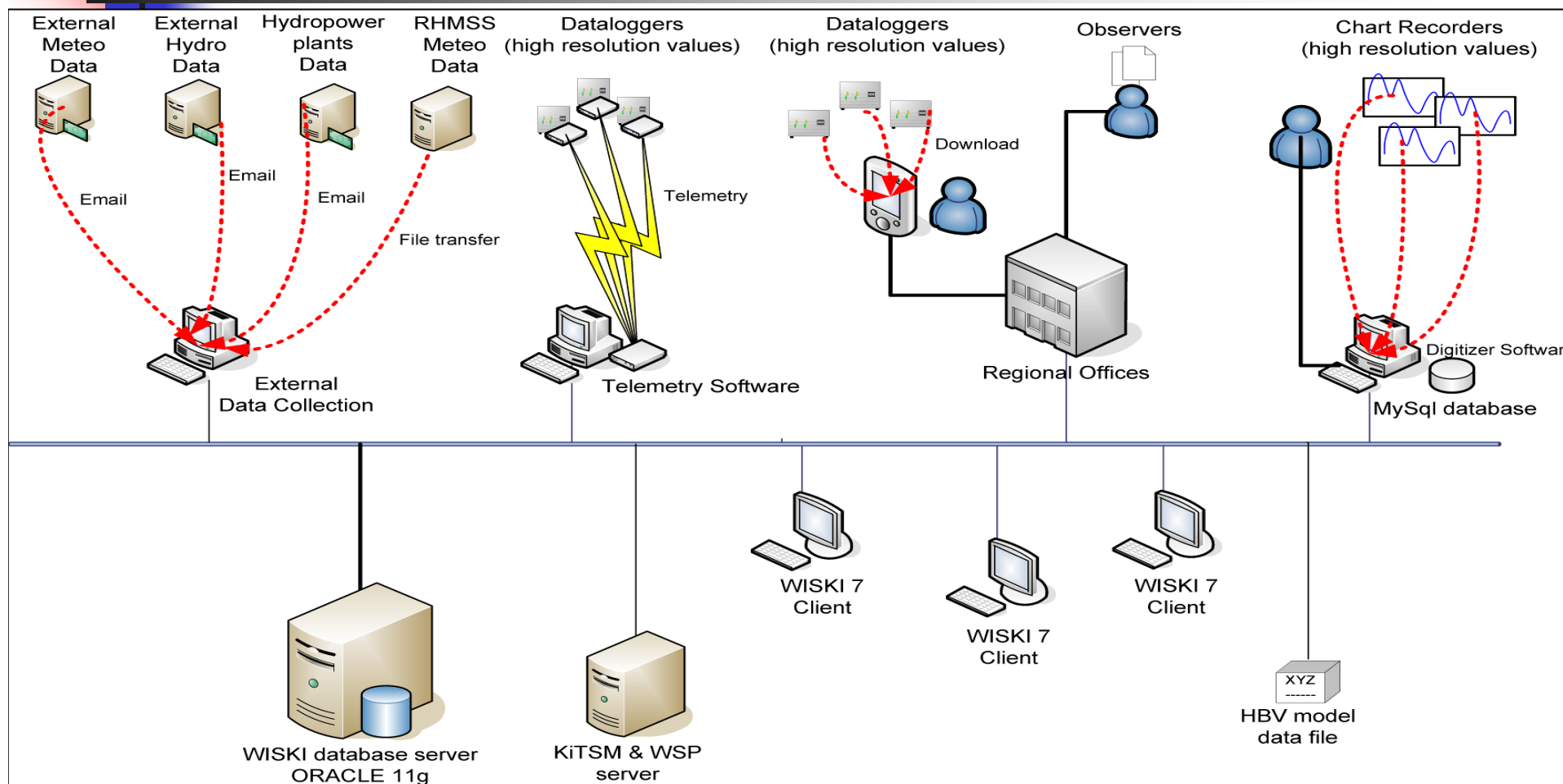


Storage (Relational Database Systems such
 as ORACLE, MSSQL; optional File System for
 Time Series Data)
 Backup and Housekeeping, integration to
 other systems on Database level (Views,
 Links, Replications)

Backend



WISKI 7 IMPLEMENTED AT HD/RHMSS





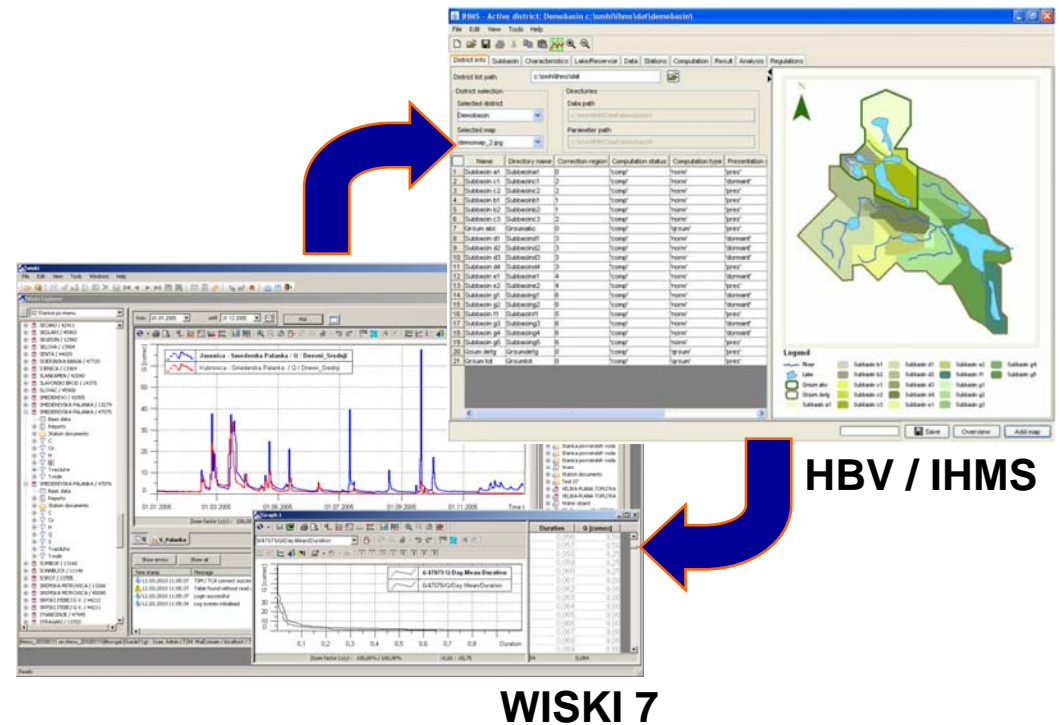
WISKI 7: Current Status

- The aim is to integrate within WISKI the following main data collection, processing and management components of the RHMSS' Hydrology Department:
 - Replace the existing Oracle-based database with W7 (**in the process**)
 - Migrate all the historical data into W7 (**in the process**)
 - Link the digitizer currently used for digitization of chart recorders to W7 (**in place**)
 - Use W7 utilities for preparing various types of reports, graph presentations, etc. (**started, albeit on a limited scale**)
 - Use W7 for import and management of all the real-time data (**in place**)
 - Develop within W7 the necessary routines for exporting data to the HBV server and importing all the HBV output results (**in final stage**)
 - Use W7 for preparing flood forecasting bulletins and their dissemination (**not yet, planned for the next year, new project**)
 - Use available W7 utilities for various types of classical deterministic and statistical analysis in hydrology (**started, planned in the next year, new project**)
 - Manual entry of non-real time data into W7 using W7 Web Input Mask (**future task, new project, W7 Web Input Mask to be purchased**)

HBV & W7: Tasks ahead...



- The two systems are now operational but not yet in full use at the HD/RHMSS
- Some of the major tasks ahead:
 - Continue advanced training of HD professionals on the use & operation of HBV and WISKI 7
 - Complete integration of W7 and HBV
 - Complete migration of all archived historical data from old Oracle database to W7
 - Use W7 & HBV for preparing flood forecasting bulletins and their dissemination



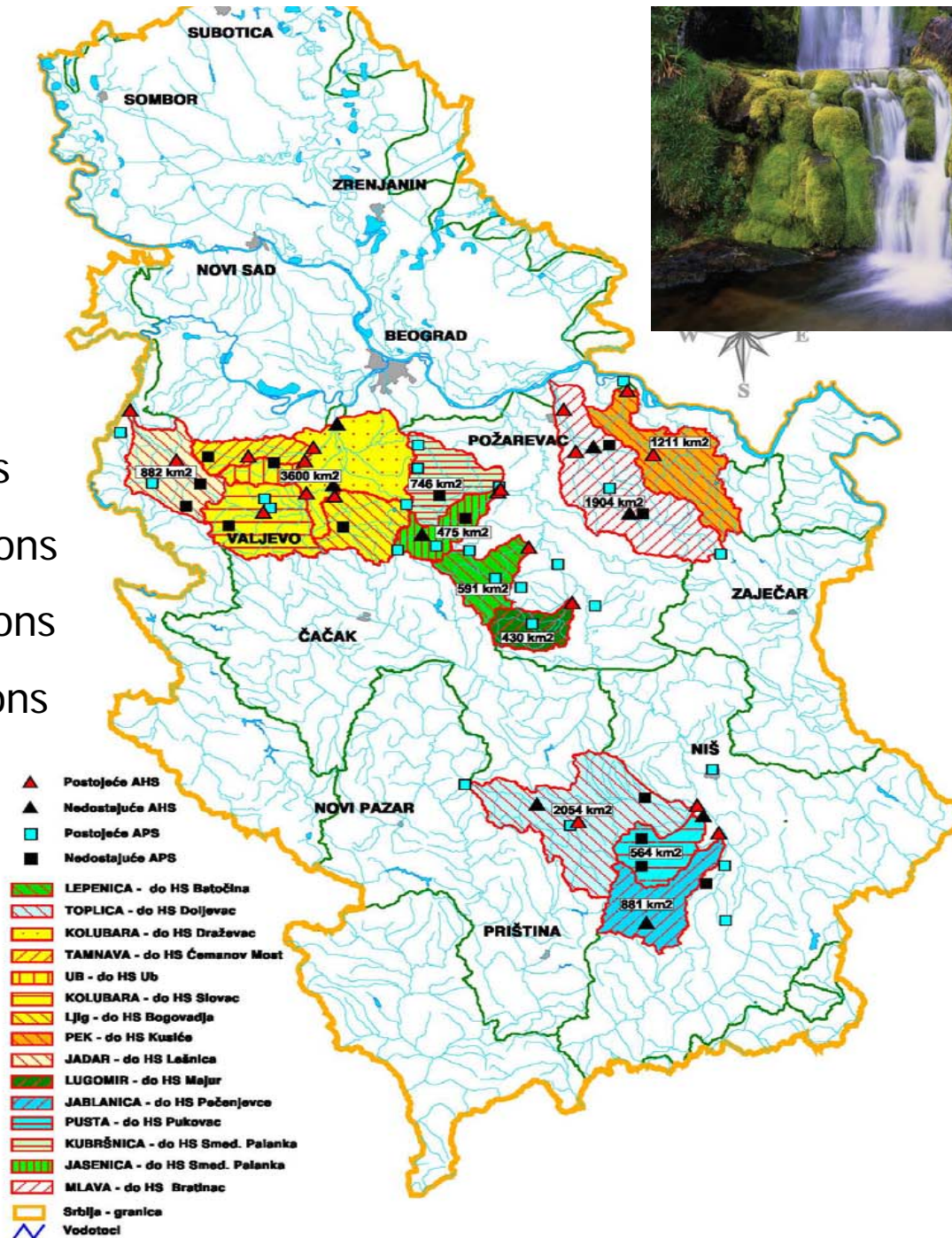
HBV & W7: Tasks ahead...



- Purchase WISKI Web Input/Web Public/Web Pro modules for external/internal publication & dissemination of specified WISKI data & products via Internet/Intranet, including web-based user-oriented flood warning & forecasting bulletins
- Expand real-time monitoring network in the 10 catchments as necessary for operational real-time flood forecasting in these catchments (**see next slide**)
- Set up an operational real time flood forecasting system for the 10 calibrated catchment areas using HBV model
- Calibrate HYPROM (**HY**drology **PRO**gnostic Model) developed and used by Slobodan Nickovic & the SEEVCCC for the same 10 catchments
- Compare HYPROM & HBV/IHMS and introduce HYPROM in operational flood forecasting practice where it proves advantageous
- Continue expanding flood warning & forecasting services to all small/medium catchments with flood prone areas of significant socio-economic and environmental value

Network Expansion...

- ▲ Existing real time hydro stations
- ▲ Missing real time hydro stations
- Existing real time precip stations
- Missing real time precip stations





Follow-up Project

- **Title:** Further Improvement of Flood Forecasting Services in Serbia
- **Objective:** Further expansion, improvement and modernization of flood warning & forecasting system to all small & medium catchments in Serbia with flood prone areas of significant socio-economic and environmental value
- **Three outputs:**
 - The real time data processing and forecasting systems (WISKI 7 and HBV) fully integrated at the HD/RHMSS and operational flood forecasting services expanded to all the major flood prone catchments of significant socio-economic value for Serbia
 - User-oriented bulletin developed using web publishing technology, tested and operationally used for on-line dissemination of new hydrological flood warning and forecasting products for the whole country in accordance with users needs and requirements
 - A hydrological study of possible climate change impact on water resources and flood regime in selected pilot catchments in Serbia carried out by using the HBV and/or HYPROM models and plausible climate change projections such as the SEEVCCC of the RHMSS. Recommendations given to decision makers in the water sector on the necessary further steps in this domain.

Climate Change Impact on WR in Serbia



- Mean Annual Precipitation will decrease by some percentage – $dP[\%]$
- Mean Annual Air Temperature will increase by some degree – $dT[^\circ\text{C}]$
- dP values used : $\text{max}dP = -16\%$; $\text{mean } dP = -7\%$ and $\text{min } dP = -2.5\%$
- dT values used: $\text{max}dT = +3.3^\circ\text{C}$; $\text{mean } dT = +2.2^\circ\text{C}$ and $\text{min } dT = +1.4^\circ\text{C}$

By using simple statistical and water balance methods the following estimates of mean annual runoff decrease (%) have been obtained for Serbia:

**Estimated decrease (%)
of mean annual runoff
till the year 2050**

$dP(\%)$	$dT(^\circ\text{C})$		
	1.4	2.2	3.3
-16	-57	-60	-63
-7	-35	-40	-45
-2.5	-21	-26	-32

**Thank you for your
patience!**

