



Your friends in every weather

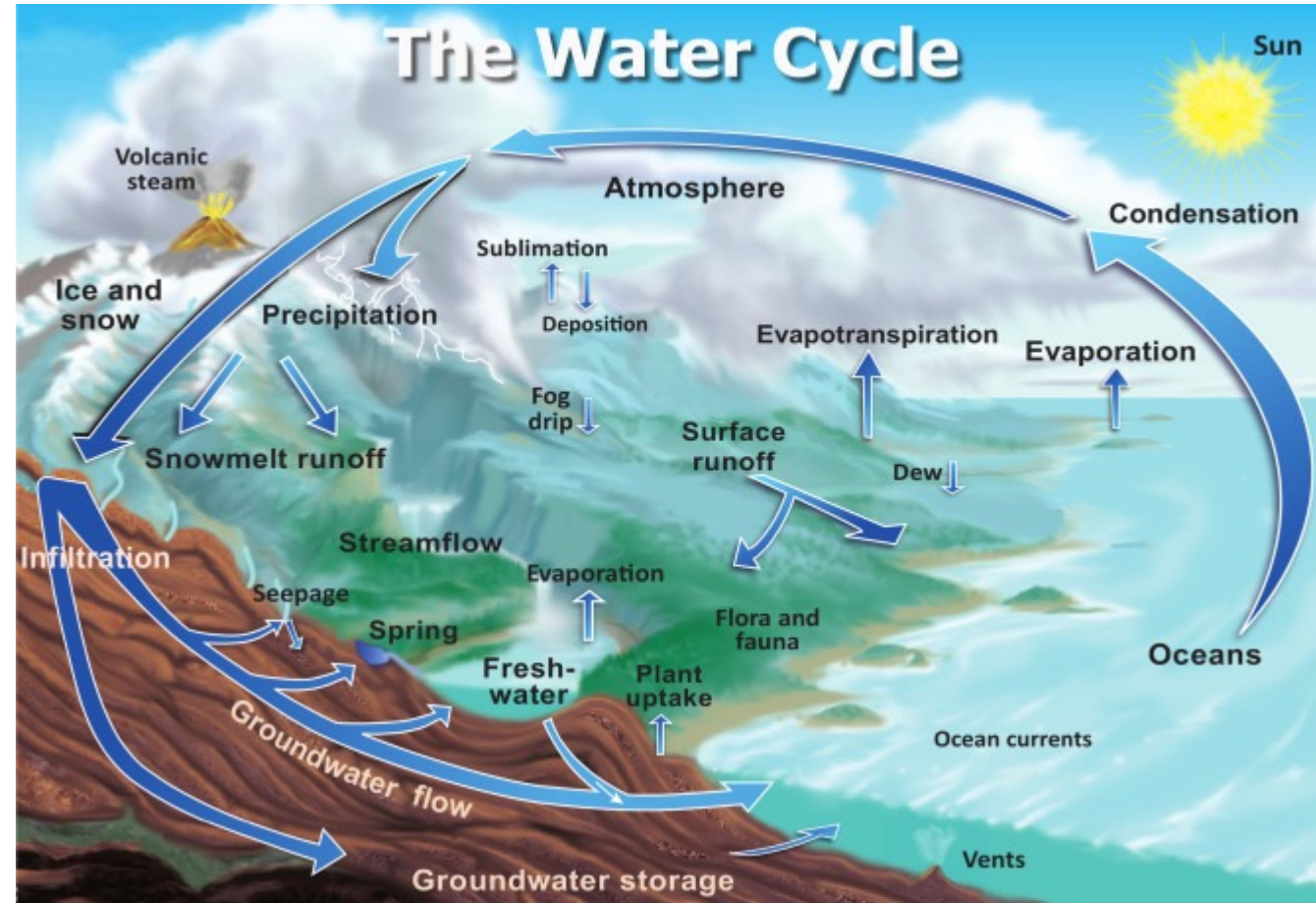
HYDROLOGICAL FORECASTING MODELS AND SYSTEMS

Michal Hazlinger

IWAC Training Meeting, Bratislava, 10 – 11 Nov. 2021

HYDROLOGICAL MODELLING

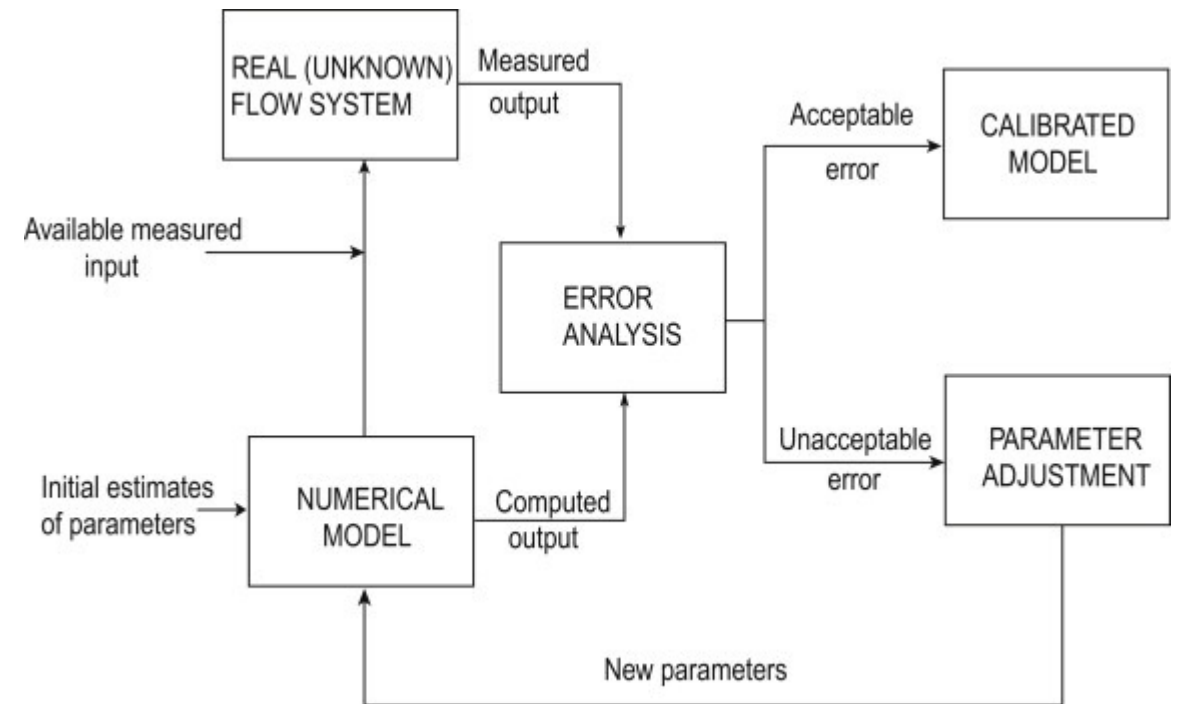
- Hydrologic modeling is used to answer questions where water excess, scarcity, or dissolved or solid content is of primary importance (Burges, 1986)
- many plausible solutions, depending on purpose and needed complexity - wide variety of different hydrologic models
- uncertainties in process and the overwhelming influence of heterogeneities
- poorly understood and ill-described natural phenomena



Water cycle is the complex of processes in the real watersheds

HYDROLOGICAL MODEL

- Tool for simulation of natural processes via mathematical functions
- Preparing of model for operation is long distance run:
 - Data collection
 - Calibration of model
 - Validation (verification) of model
 - Set –up of model for daily use
 - Regular real time QC
 - Visualization of model outputs
- Calibrated model is not forever, but has to be updated

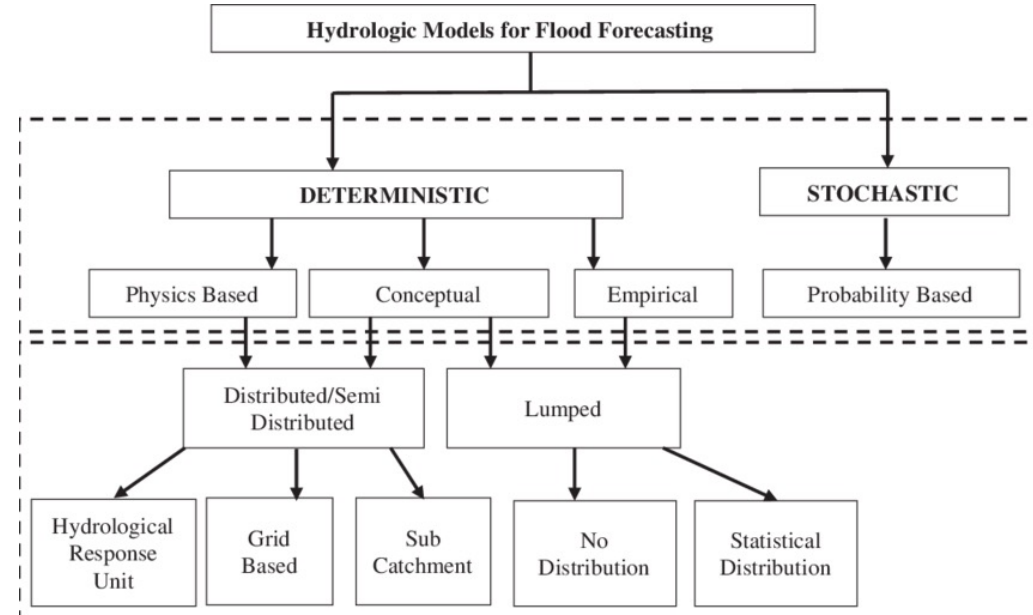


Calibration of hydrological model is sophisticated and complex process. Positive results is not ensured.

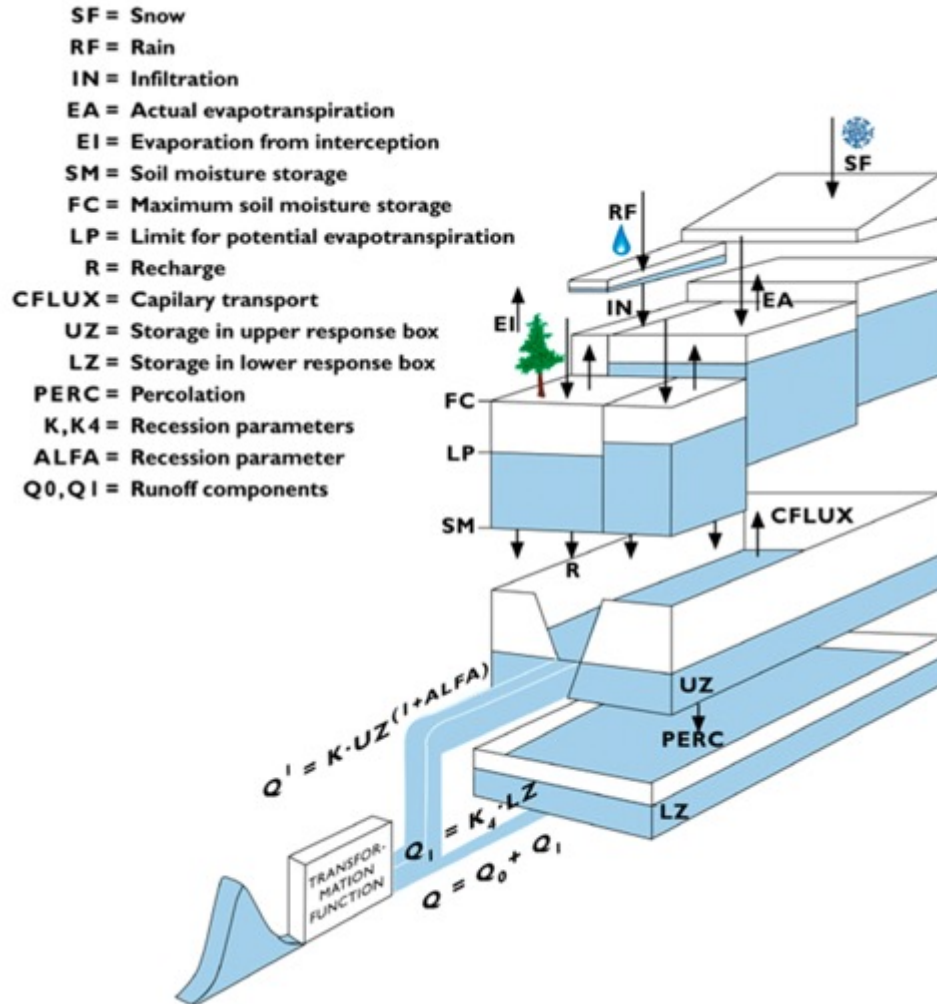
TYPES OF HYDROLOGICAL MODEL

- Principle of model:
 - black box,
 - grey box,
 - white box
- Spatial heterogeneity:
 - lumped parameters
 - spatially distributed
- Complexity:
 - complex models
 - models of parts of hydrological cycle
- Purpose:
 - operational
 - event based
 - research

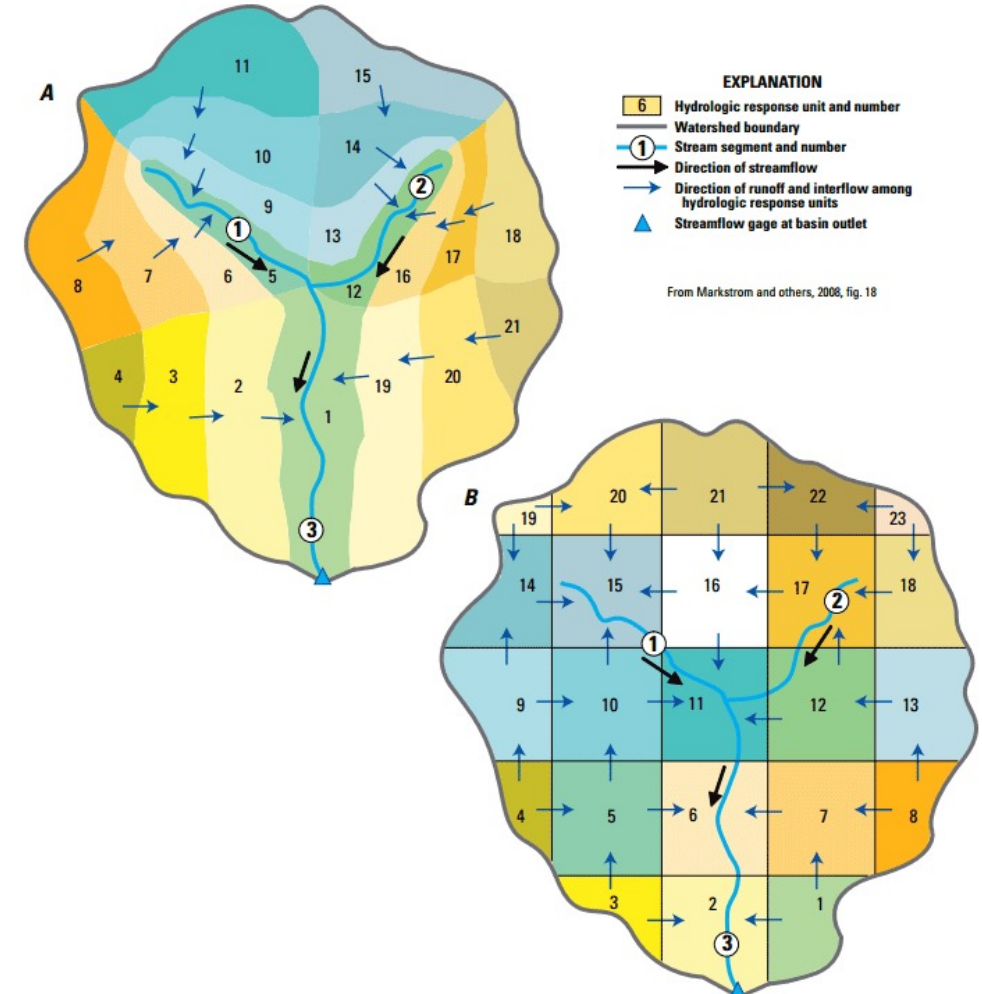
- Purpose of the model:
 - Rainfall –runoff m.
 - HD, flow m.
 - UGW m.
 - Pollution spread / sedimentation models m.
 - M. of parts of hydrological cycle



SPATIAL HETEROGENEITY



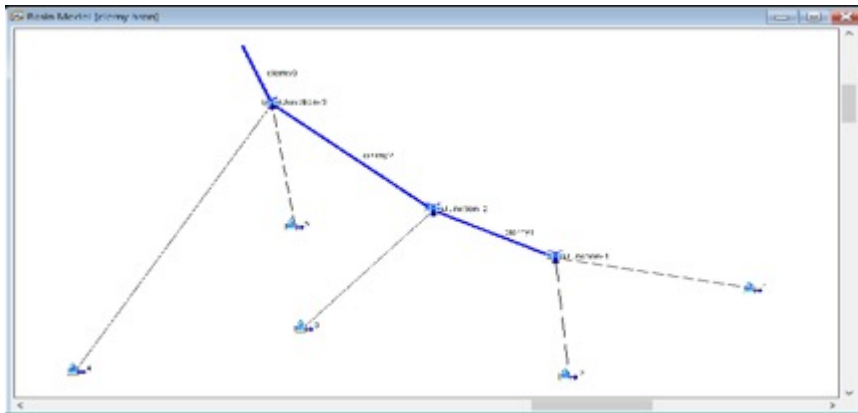
Lumped parameters



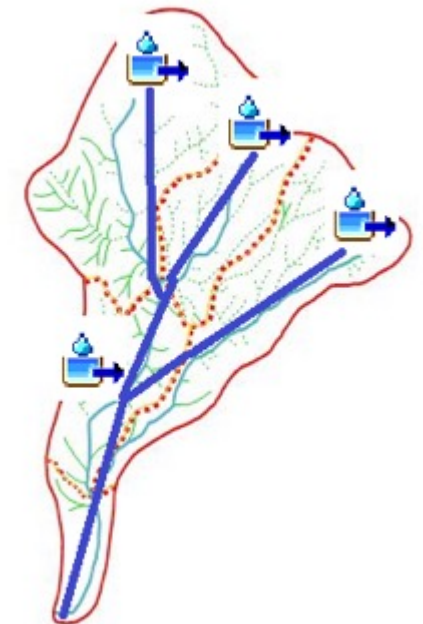
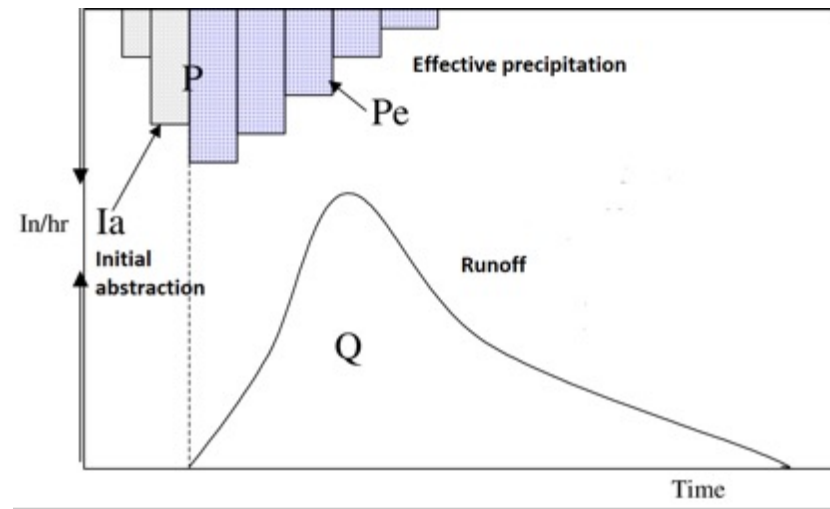
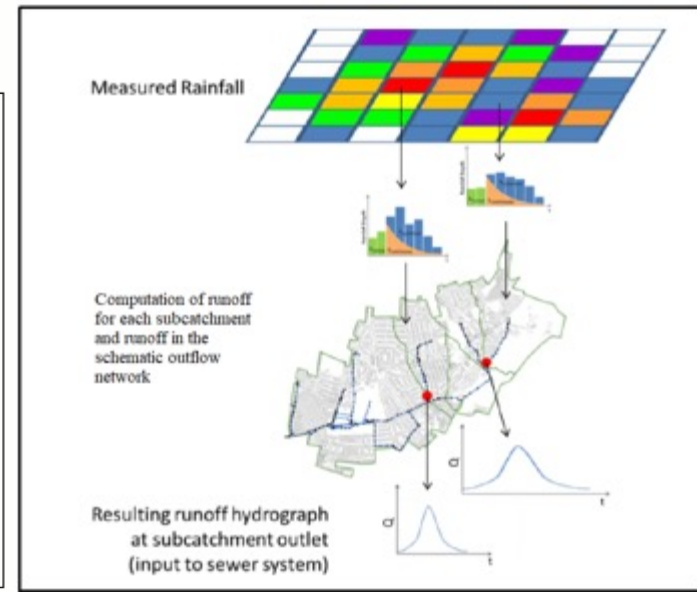
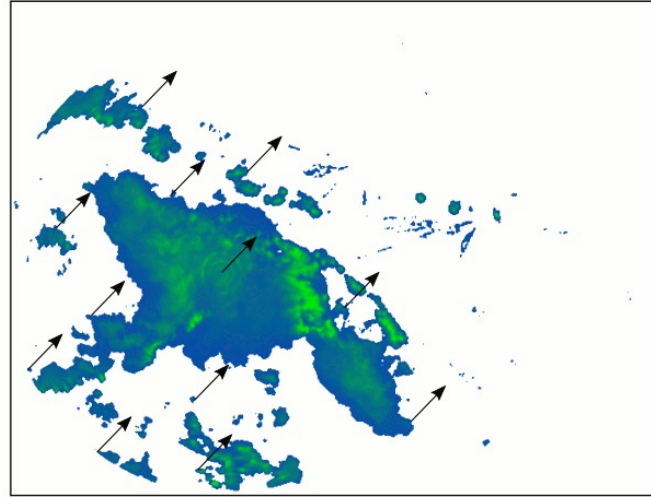
Spatially distributed parameters

RAINFALL – RUNOFF MODEL

- Transformation of precipitation to runoff
- Input data: precipitation, temperature, soil, land cover, DEM
- Precipitation measured / predicted - NWP
- Transformation function is the set of parameters of watersheds properties
- Distribution of runoff in space and time

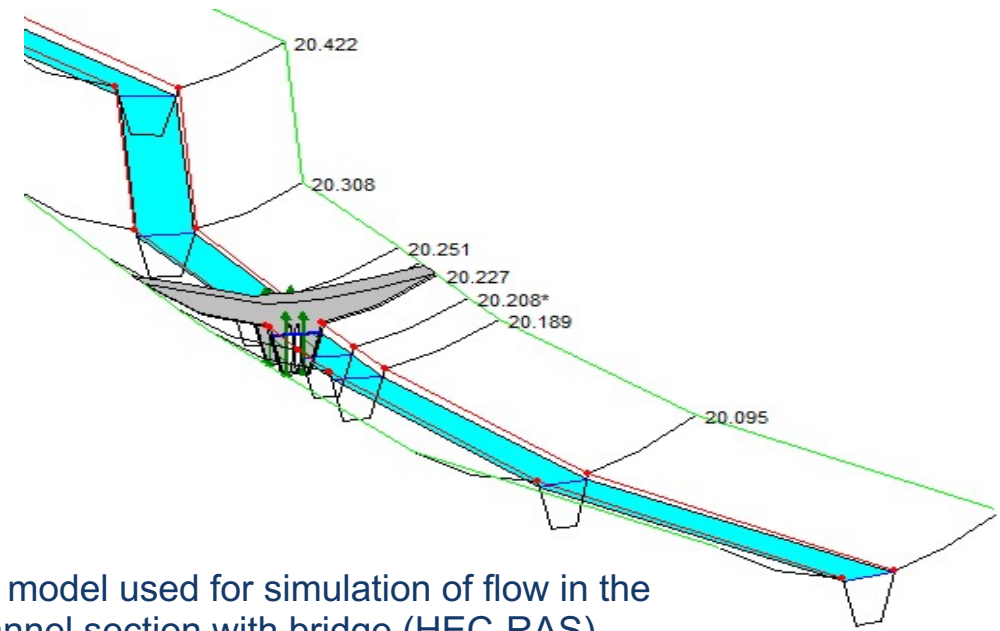


The 1st image with time: t

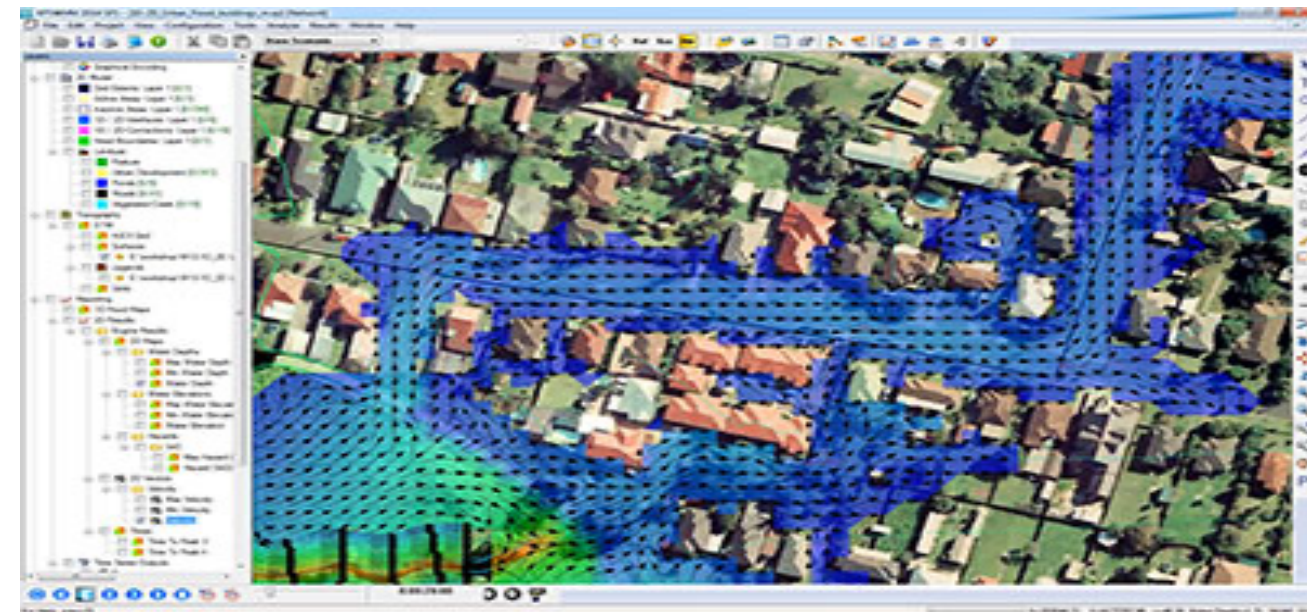


HYDRODYNAMIC AND FLOW MODELLING

- Transformation (Attenuation) of outflow wave in the river channel (in inundation)
- Input is the value of inflow on the beginning of the modeled section
- Output is the value of outflow in the outflow section / map of inundated area
- 1D model – high of water in the channel in time
- 2D model computing of spatial relations (used for flood risk mapping)
- 3D spatial aspect (used for simulation of flooding in the real time / event simulation)



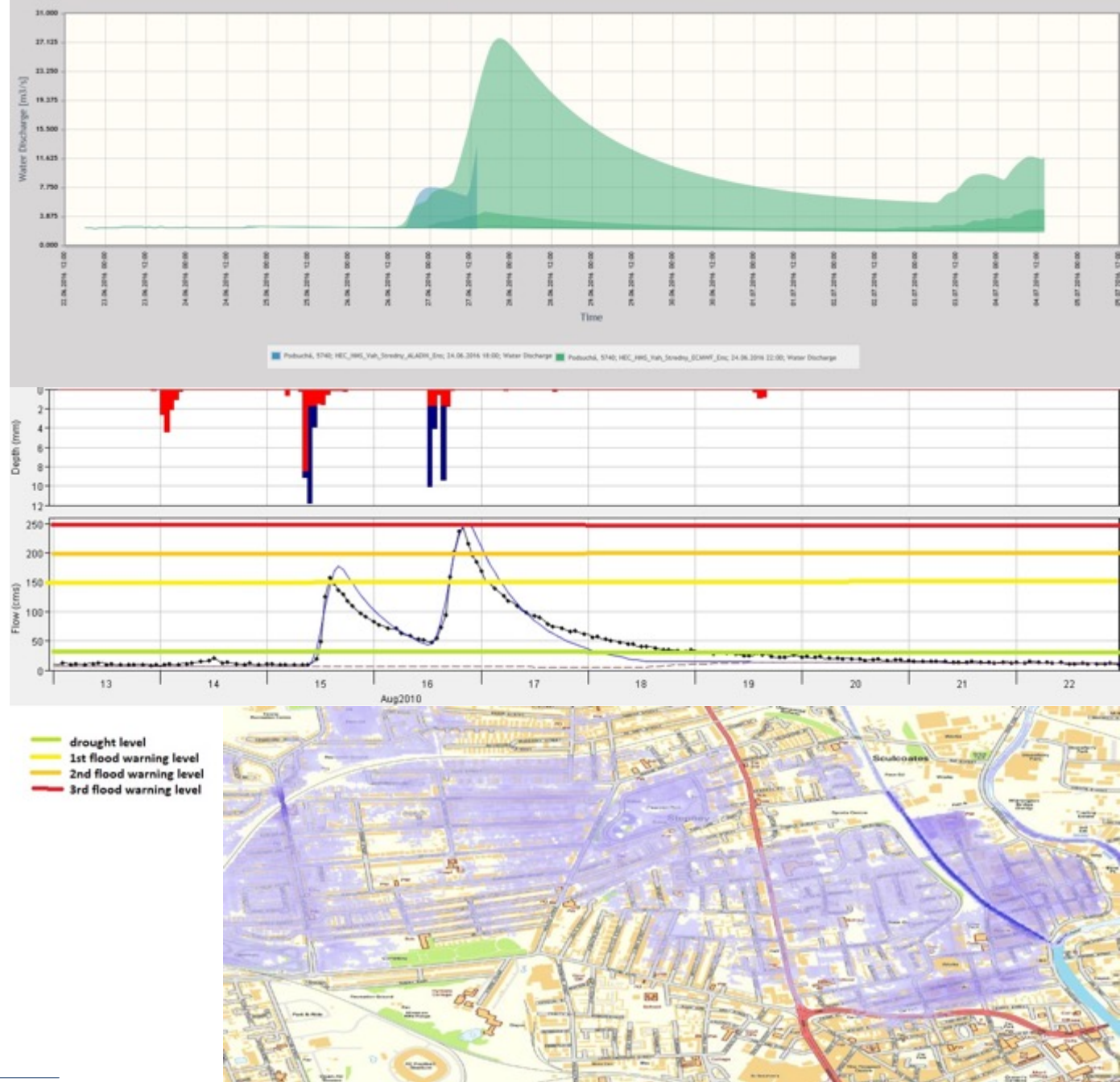
HD model used for simulation of flow in the channel section with bridge (HEC-RAS).



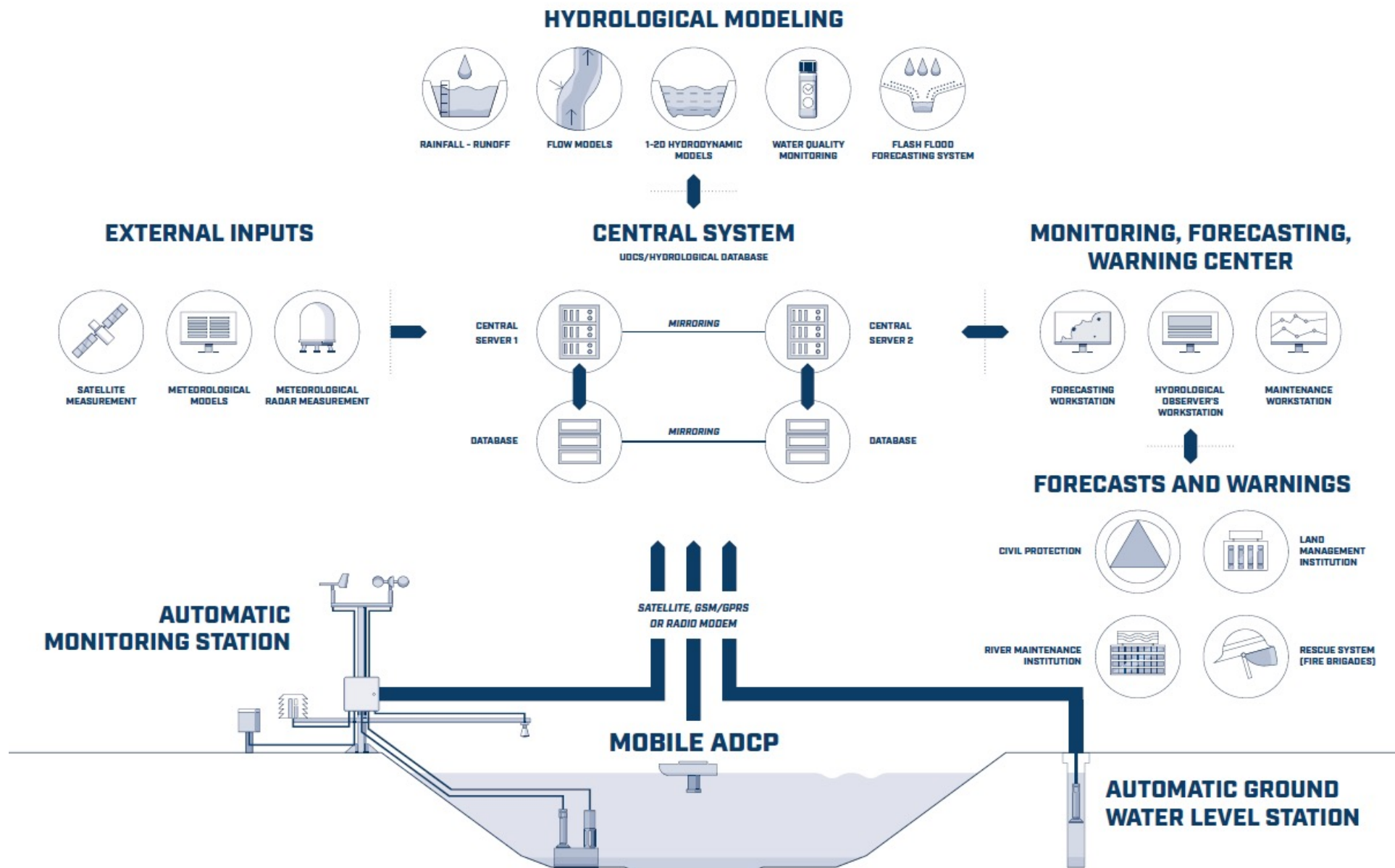
Simulation of flow in the city streets (HEC-RAS+GIS)

USING OF HYDROLOGICAL MODELS

- Forecasting and warning services – daily operation
- Daily operation of dams/ other hydrological structures (monitoring, prediction, warning)
- Planning purposes
- Flood Hazard and Flood Risk mapping
- Hind – casting and re- simulations – event based
- Research and development purposes



COMPLEX HYDROLOGICAL MONITORING & FORECASTING SYSTEM



INPUT DATA FOR HYDROMODELS

Data for model calibration and for operative usage

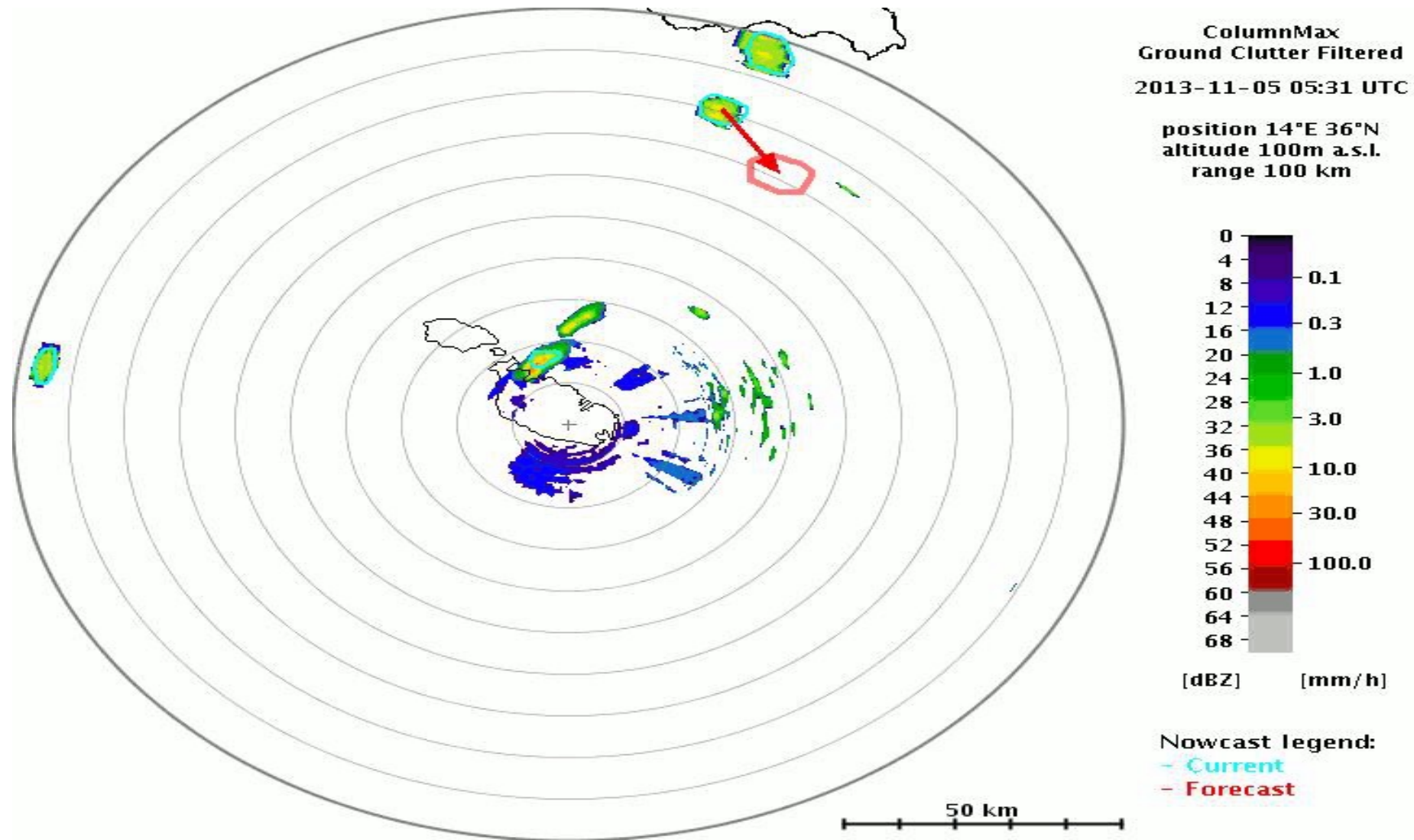
Calibration data:

- Meteo input data (temperature, precipitation)
- Hydrological data
- Land parameters - elevation bands
 - Infiltration and retention potential (soil, UGW, Land cover)
- Channel parameters – length, width, roughness
- Reservoir and storage object parameters
- Other (sinks, water sources)

Operation data

- Precipitation incl. snow – station based, meteorological radar
- Temperature – station based – extra and interpolation methods
- Satellite data
- NWP + short prediction methods (nowcasting)
- Hydrological data – water level in crucial points, discharge data
- Other (dam operation data, irregular water releases)

RADAR BASED NOWCASTING



NUMERIC WEATHER PREDICTION MODEL

Purpose:

Modeling of basic meteo parameters

Input to other subsystems

System Configuration:

Access to global model data (via internet, etc.)

NWP limited area model (existing or MicroStep-MIS supplied)

AWDSS Output:

Meteograms

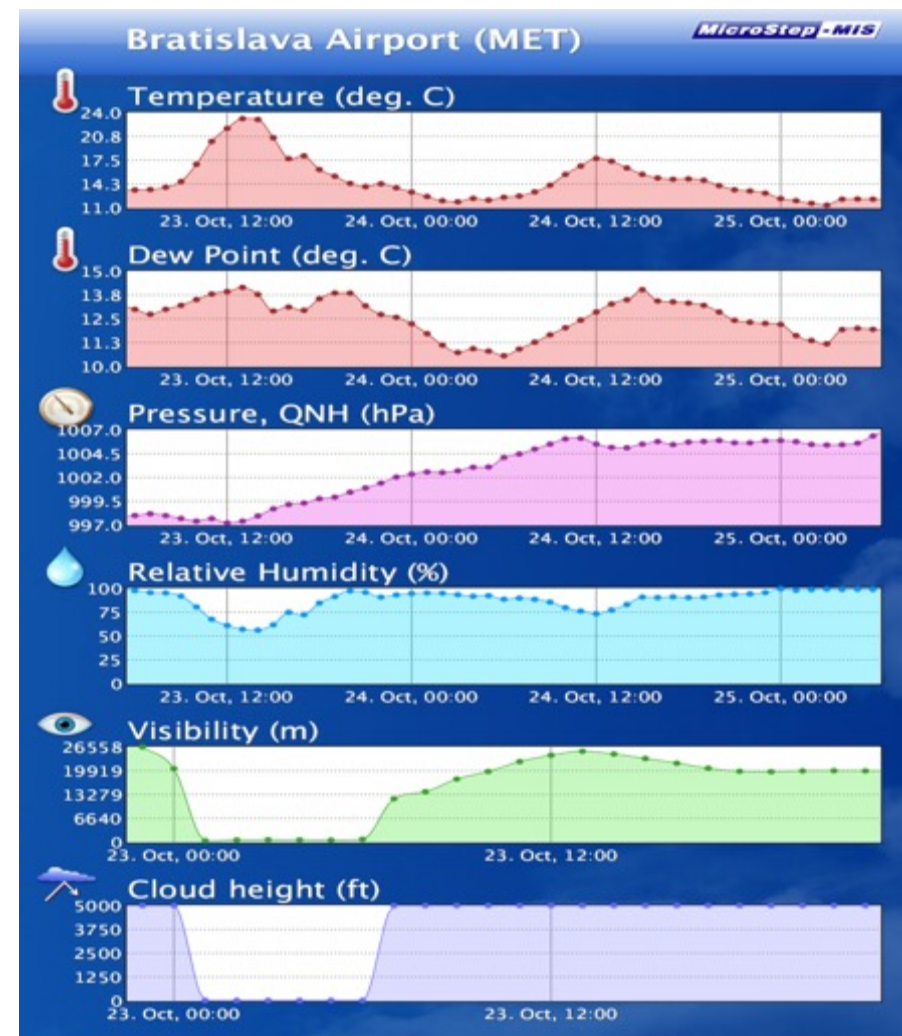
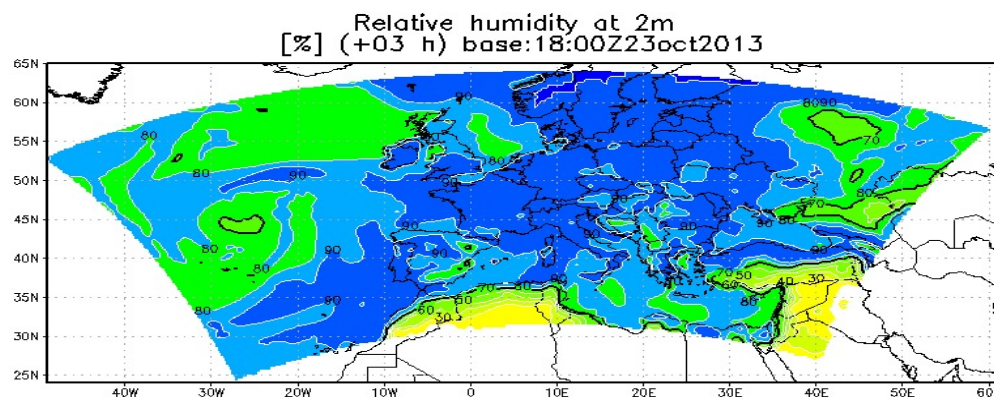
Weather forecasts

Vertical profiles

Weather charts

Turbulence index

Icing index



CENTRAL SYSTEM

Integration of all hydrological and meteorological data

IMS Central Computer Rack

- Single or dual hot-failover system
- Powerful servers (HP, IBM, Fujitsu Siemens)
- Main communication hub (modems, radiomodems, LAN switch)
- Data input, processing, verification
- Configurable interfaces to 3rd party systems
- Measurement, report, event database
- Models and warning
- Maintenance utilities
- Server for thin or thick clients
- Linux or Windows XP/2003/Windows7,8,10

Rack installation is recommended, but small systems can run on the standard PC.

IMS Workstations

- Real time access to hydrological data
- Thin or thick clients
- Linux (SuSE, RedHat, CentOS) or Windows XP/2003/Windows 7/8/10



IMS4 – APPLICATION SOFTWARE

4th generation of Integrated Meteorological System

Being developed since 1993.

Designed for 24 x 7 unattended operation.

More than 200 installations in various countries of Europe, Middle East, Asia, Africa.

Compliant with applicable regulations and recommendations (WMO, EU, OGC, ISO, OASIS), open for adjustment for compatibility with national practices.

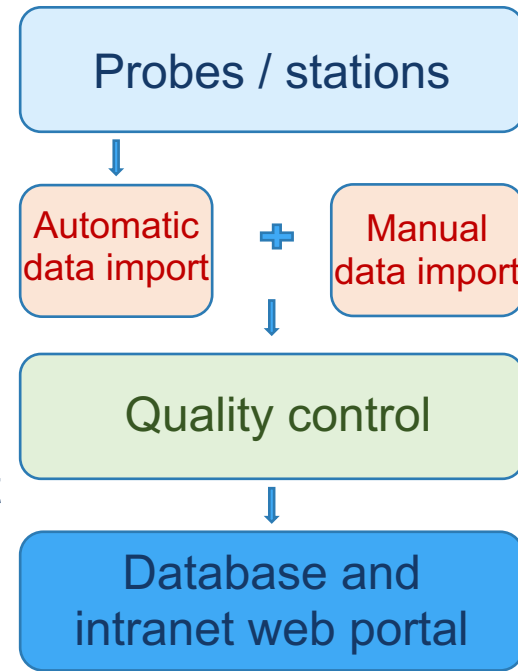
Complex multipurpose software:

- Hydrological systems
- Marine meteorology
- Synoptic and Climatological monitoring
- Aviation Systems
- Gamma radiation monitoring



DATABASE

- Heart of the system
- Data from various sources in various formats – from weather and hydrostations, buoys, modelling systems
- Data tables in various formats (.csv, .txt, Microsoft Excel)
- Data charts in various formats (Microsoft Excel, .jpg, .png)
- Excel, PDF reports
- DQC (Data Quality control)
- Ability of manual control and change of data in DB. Automatic labeling of manually changed values
- Selection and grouping tools
- Reports, statistics
- Import of data from external sources – other DBs



Data flow scheme

The screenshot shows the 'HYPOS Data Entry' web interface. On the left, there are several sections: 'Regions' with a dropdown for 'Stations by property' (set to 'Vletky_stanice'), 'Stations' with a dropdown for 'Swity Kriz, 5480 ang', 'Entry forms' with a dropdown for 'ModelPTQ', 'Details' with fields for 'Source' (Set 1), 'Options' (RAM), and 'QC', and 'Date and Time' with a 'Timezone' dropdown (UTC) and a 'Date' field (23.01.2018). On the right, there is a table with columns: 'Time', 'Prec.Sum.Last1h (mm)', 'Temp.Dry (°C)', and 'Water Discharge (m3/s-1)'. The table contains data for various times from 00:00 to 23:00. At the bottom, there are buttons for 'Get data', 'Run QC', 'Save', 'Force', 'Settings', 'Show preview', 'Graph edit', 'Calculate statistics', 'Interpolate data', and 'Select all columns'.

Manual data entry

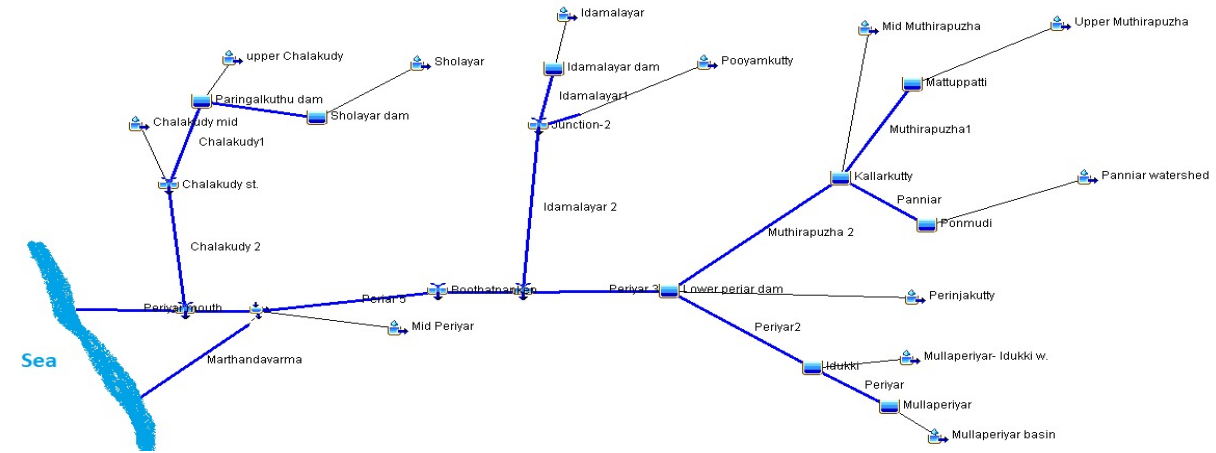
The screenshot shows the 'HYPOS Data Selection and Aggregation' web interface. It has a top navigation bar with 'SETTINGS', 'DATA', 'SQL', 'CHART', 'CSV XLS TXT', and 'History Exports'. The main area is divided into several panels: 'Select by' with a dropdown for 'Regions' (set to 'Vletky_stanice') and a list of stations; 'Sources' with a dropdown for '8 selected of 8'; 'Time and Date' with a 'Timezone' dropdown (UTC), a 'Period' dropdown (Quarter), and 'From' and 'To' date fields; 'Variables' with a dropdown for '76 selected of 76'; 'Aggregations' with a 'Grouping' dropdown (Day) and a 'Functions' dropdown (1 selected of 6); and a 'Filter' panel with fields for 'Minute', 'Hour', 'Day', 'Month', and 'Year'. At the bottom, there are buttons for 'Get data', 'Get SQL', 'Get chart', 'Export to CSV', 'Export to XLS', and 'Export to TXT'.

Data selection and aggregation

HYDROLOGICAL MODELING SYSTEM

- **Complexity** - combination of RR, HD, flow models and reservoir management models
- **Automatization** – all inputs and outputs are automatically processed by the system, no need of human input to comp. process
- **Actuality** – all data are available in the real time
- **Correctness** – automatic QC on input and output
- **Visualization** – overview of inputs and outputs is available in the form of tabs, graphs and maps

Model inventory:
operator has overview
of actual status of
models



System of hydrological models – RR+flow model in the watershed network scheme (HEC-HMS)

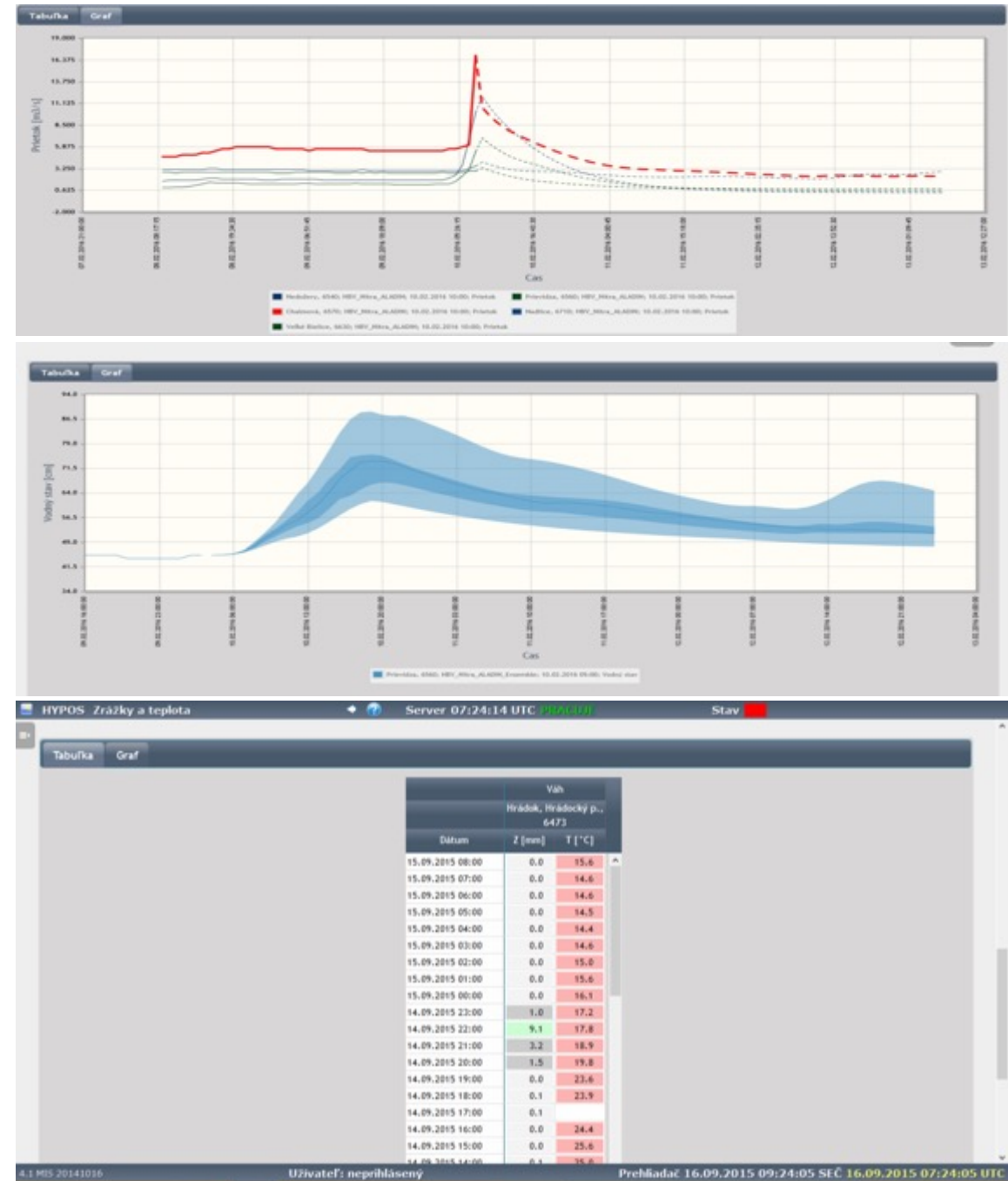
Model Status

Model Status Server 09:55:59 UTC

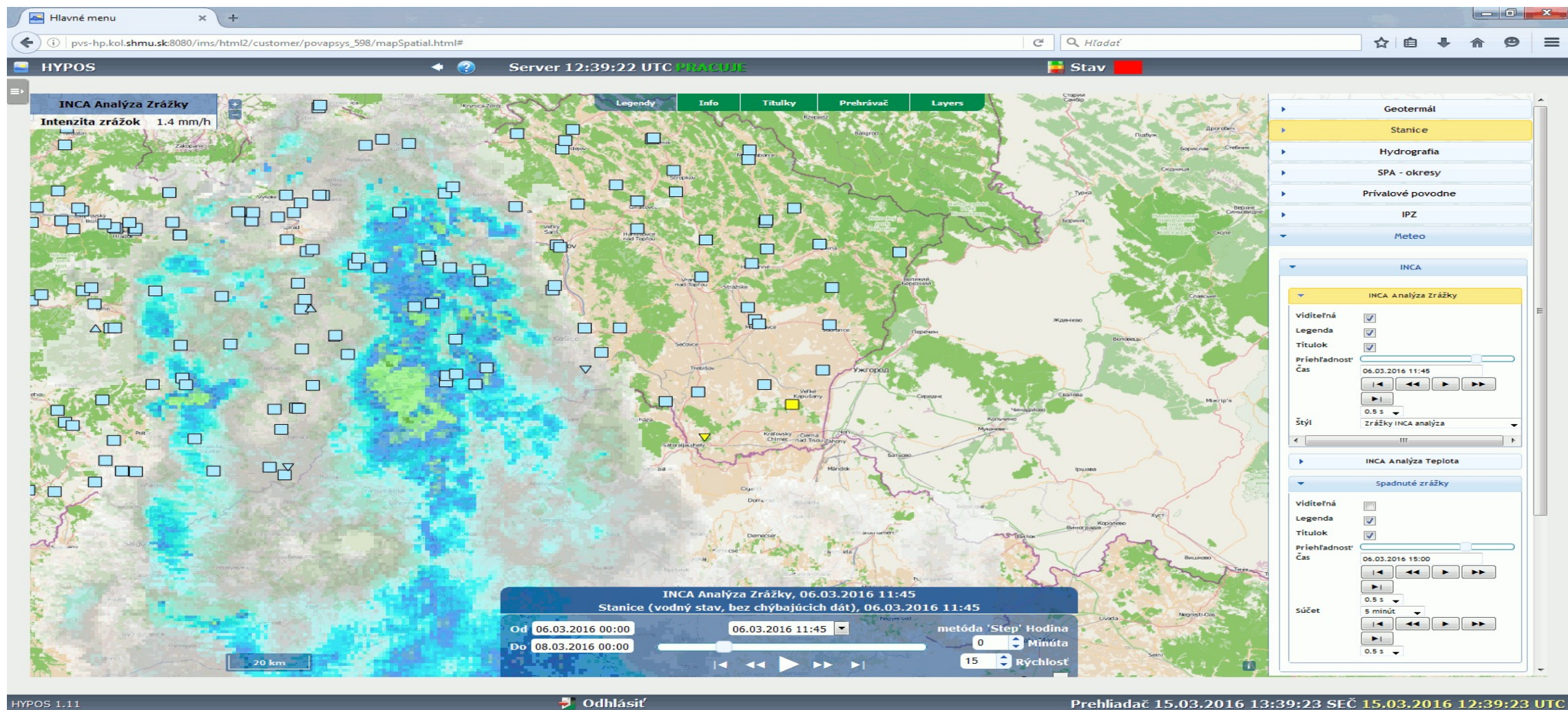
HYPOS: Model Status	Status		
Enkrasitosa_Potova	Čakane na nasledovni spusteni 23.01. 10:00 UTC		23.01.2018 11:00
HEV_jnos_01a	Čakane na vstopni predpovedi: ALADIN 2018-01-23 06:00:00.000 UTC, Updating - AR korekci: vprniti, Updating - korekci: vprniti		23.01.2018 10:00
HEV_jnos_01a_ens	Čakane na nasledovni spusteni 23.01. 10:00 UTC, Updating - AR korekci: vprniti, Updating - korekci: vprniti		23.01.2018 10:00
HEV_jnos_01m	Čakane na nasledovni spusteni 23.01. 19:00 UTC, Updating - AR korekci: vprniti, Updating - korekci: vprniti		23.01.2018 05:00
HEV_jnos_01m_ens	Čakane na nasledovni spusteni 23.01. 20:00 UTC, Updating - AR korekci: vprniti, Updating - korekci: vprniti		23.01.2018 20:00
HEV_jnos_01m_01a	Čakane na nasledovni spusteni 23.01. 20:00 UTC, Updating - AR korekci: vprniti, Updating - korekci: vprniti		23.01.2018 21:00
HEC_jnos_hor_20_01a	Čakane na vstopni predpovedi: ALADIN 2018-01-23 00:00:00.000 UTC		23.01.2018 04:00
HEC_jnos_hor_20_01a_ens	Čakane na nasledovni spusteni 23.01. 16:00 UTC		22.01.2018 10:00
HEC_jnos_hor_20_01m	Čakane na nasledovni spusteni 23.01. 19:00 UTC		23.01.2018 17:00
HEC_jnos_hor_20_01m_ens	Čakane na nasledovni spusteni 23.01. 20:00 UTC		23.01.2018 05:00
HEC_jnos_hor_20_01a_01a	Čakane na nasledovni spusteni 23.01. 20:00 UTC		23.01.2018 20:00
HEC_jnos_hor_20_01a_01a_ens	Čakane na vstopni predpovedi: ALADIN 2018-01-23 00:00:00.000 UTC		23.01.2018 21:00
HEC_jnos_hor_20_01m_01a	Čakane na nasledovni spusteni 23.01. 16:00 UTC		23.01.2018 04:00
HEC_jnos_hor_20_01m_01a_ens	Čakane na nasledovni spusteni 23.01. 19:00 UTC		22.01.2018 10:00
HEC_jnos_hor_20_01m_01m	Čakane na nasledovni spusteni 23.01. 20:00 UTC		23.01.2018 17:00
HEC_jnos_hor_20_01m_01m_ens	Čakane na nasledovni spusteni 23.01. 20:00 UTC		23.01.2018 20:00
HEC_jnos_d01_01a	Čakane na vstopni predpovedi: Q-HEC_jnos_hor_01a 23.01. 03:00 UTC Banak Bystica, T160		23.01.2018 21:00
HEC_jnos_d01_01a_ens	Čakane na nasledovni spusteni 23.01. 16:00 UTC		23.01.2018 04:00
HEC_jnos_d01_01m	Čakane na nasledovni spusteni 23.01. 19:00 UTC		22.01.2018 10:00
HEC_jnos_d01_01m_ens	Čakane na nasledovni spusteni 23.01. 20:00 UTC		23.01.2018 17:00
HEV_ipol_01a	Čakane na vstopni predpovedi: ALADIN 2018-01-23 06:00:00.000 UTC, Updating - AR korekci: vprniti, Updating - korekci: vprniti		23.01.2018 20:00
HEV_ipol_01a_ens	Čakane na nasledovni spusteni 23.01. 16:00 UTC, Updating - AR korekci: vprniti, Updating - korekci: vprniti		23.01.2018 10:00
HEV_ipol_01m	Čakane na nasledovni spusteni 23.01. 19:00 UTC, Updating - AR korekci: vprniti, Updating - korekci: vprniti		23.01.2018 17:00
HEV_ipol_01m_ens	Čakane na nasledovni spusteni 23.01. 20:00 UTC, Updating - AR korekci: vprniti, Updating - korekci: vprniti		23.01.2018 05:00
HEC_ipol_01a_ens	Čakane na vstopni predpovedi: ALADIN 2018-01-23 00:00:00.000 UTC		23.01.2018 21:00
HEC_ipol_01m	Čakane na nasledovni spusteni 23.01. 16:00 UTC		23.01.2018 04:00
HEC_ipol_01m_ens	Čakane na nasledovni spusteni 23.01. 19:00 UTC		23.01.2018 17:00
HEC_ipol_01m_ens	Čakane na nasledovni spusteni 23.01. 20:00 UTC		23.01.2018 05:00
HEC_ipol_01m_ens	Čakane na nasledovni spusteni 23.01. 19:00 UTC		23.01.2018 20:00
HEC_ipol_01m_ens	Polos o spusteni modelu 09:40:29 UTC		23.01.2018 09:00
HEV_01a_01a	Čakane na vstopni predpovedi: ALADIN 2018-01-23 06:00:00.000 UTC, Updating - AR korekci: vprniti, Updating - korekci: vprniti		23.01.2018 10:00
HEV_01a_01a_ens	Čakane na nasledovni spusteni 23.01. 16:00 UTC, Updating - AR korekci: vprniti, Updating - korekci: vprniti		22.01.2018 10:00
HEV_01a_01m	Čakane na nasledovni spusteni 23.01. 19:00 UTC, Updating - AR korekci: vprniti, Updating - korekci: vprniti		23.01.2018 05:00
HEV_01a_01m_ens	Čakane na nasledovni spusteni 23.01. 20:00 UTC, Updating - AR korekci: vprniti, Updating - korekci: vprniti		23.01.2018 20:00
HEC_01a_01a_01a	Čakane na merilni d01a: P INCA Rožava, 7890 avg 23.01. 08:00 UTC, Updating - AR korekci: vprniti, Updating - korekci: vprniti		23.01.2018 04:00
HEC_01a_01a_01a_ens	Čakane na nasledovni spusteni 23.01. 16:00 UTC		22.01.2018 10:00
HEC_01a_01a_01m	Čakane na nasledovni spusteni 23.01. 19:00 UTC		23.01.2018 17:00
HEC_01a_01a_01m_ens	Čakane na nasledovni spusteni 23.01. 20:00 UTC		23.01.2018 05:00
HEC_01a_01a_01m_ens	Čakane na merilni d01a: P INCA Rožava, 7890 avg 23.01. 08:00 UTC		23.01.2018 20:00
HEC_01a_01a_01m_ens	Čakane na nasledovni spusteni 23.01. 19:00 UTC		23.01.2018 09:00
HEC_01a_01a_01a_01a	Čakane na vstopni predpovedi: Q-HEC_01a_01a_01a 23.01. 03:00 UTC Rožava, 7890		23.01.2018 21:00
HEC_01a_01a_01a_01a_ens	Čakane na nasledovni spusteni 23.01. 16:00 UTC		22.01.2018 10:00

DATA VISUALIZATION

- In the form of tabs, graphs and maps
- **Map server**
 - OGC Web Services
 - Station data layer
 - Forecast layer
 - Meteo data layer – gridded data (models, radars, satellite images)
 - Topographic data
 - Soil properties data
 - Geographic data
 - “Movie” mode

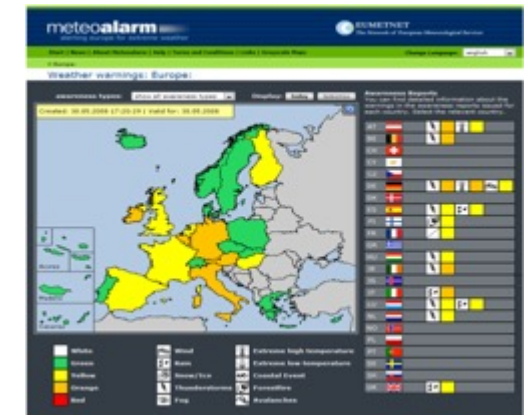


HYPOS MAP SERVER - ANIMATIONS



USING OF THE OUTPUTS OF MODEL SYSTEM

- Hydrological forecasts for public – Hydromet institutes, responsible organisations
- Hydro forecasts for partner institutions
- Comercial forecasts (insurence comp.)
- Hydrological warnings (for public, partner, commercial)
- DSS (Decission Support system) – management of reservoir operation
- Sharing of info via:
 - internal links (ftp),
 - public links (internet),
 - standard media (TV, radio, newspaper)
 - Mobile apps



Stanica	Tok	Čas merania	Vodný stav	19.2.2016 12:00 (N716)	19.2.2016 18:00 (+120)	20.2.2016 00:00 (+120)	20.2.2016 06:00 (+120)	20.2.2016 12:00 (+240)	21.2.2016 12:00 (+140)
<input type="checkbox"/> Holča	Ipeľ	19.2.2016 06:45	174	203	236	255	256	245	
<input type="checkbox"/> Kalonda	Ipeľ	19.2.2016 06:45	257	249	285	291	281	296	
<input type="checkbox"/> Dolná Strehová	Travník	19.2.2016 06:45	141	182	209	215	203	181	
<input type="checkbox"/> Želovce	Kriš	19.2.2016 06:45	93	155	175	166	135	106	
<input checked="" type="checkbox"/> Slovenská Ľupča	Ipeľ	19.2.2016 06:45	467	496	504	506	513	512	
<input type="checkbox"/> Páštovce	Krupica	19.2.2016 06:45	212	213	228	232	224	214	
<input type="checkbox"/> Horné Semerovce	Štavnica	19.2.2016 06:45	204	231	257	255	227	193	
<input type="checkbox"/> Salka	Ipeľ	19.2.2016 06:45	370	386	396	411	422	426	
<input type="checkbox"/> Rožňava	Staná	19.2.2016 07:00	119	114	117	115	109	102	
<input type="checkbox"/> Prieľec	Širok	19.2.2016 06:45	1	106	109	109	105	101	
<input type="checkbox"/> Breška	Staná	19.2.2016 06:45	144	155	163	164	160	150	
<input type="checkbox"/> Breška	Muráň	19.2.2016 06:45	151	184	225	264	277	269	
<input type="checkbox"/> Beňnyce	Turec	19.2.2016 06:45	173	191	215	232	236	228	
<input type="checkbox"/> Lenarovoce	Staná	19.2.2016 06:45	237	302	320	342	345	327	
<input type="checkbox"/> Hnúšťa - Líker	Rimava	19.2.2016 06:45	136	146	156	161	156	151	
<input type="checkbox"/> Rimavská Sobota - Sobótka	Rimava	19.2.2016 06:45	174	161	178	192	196	194	
<input type="checkbox"/> Vákyňa	Rimava	19.2.2016 06:45	194	204	229	253	269	271	





MicroStep-MIS Head Office

Čavojského 1, 841 04 Bratislava, Slovak Republic
Tel: +421 2 602 00 100, Fax: +421 2 602 00 180
info@microstep-mis.com

