

National and Regional Activities, Needs and Expectations

The perspective from the International Sava River Basin Commission

**International collaboration in the forecasting of river flows
within the Sava River Basin - Sava FFWS**

EDO User Meeting

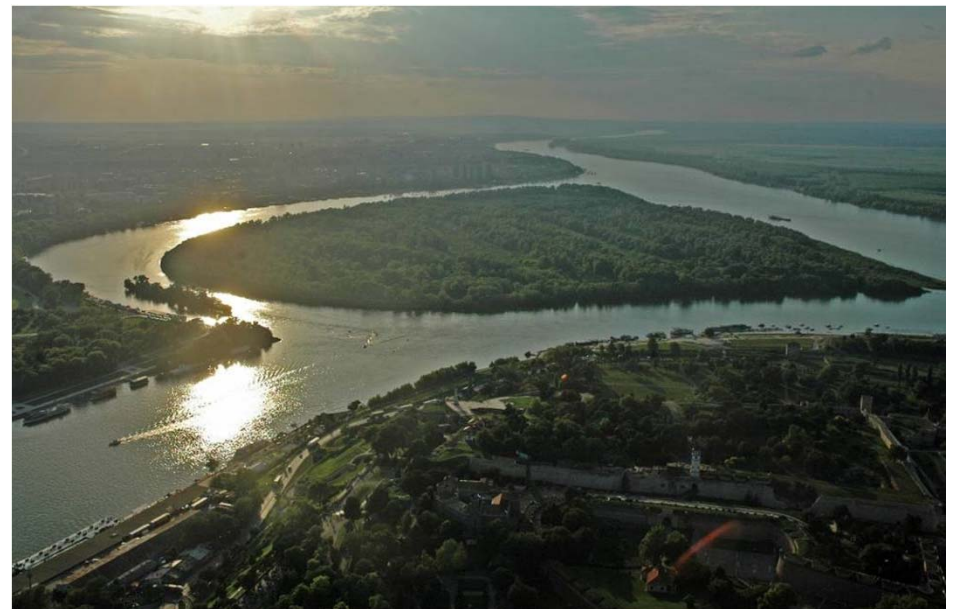
9-10 November, 2017 JRC Ispra

Mirza Sarač, International Sava River Basin Commission

Sava river basin

- **Sava – the largest Danube tributary by discharge**
(contribution: 25%)

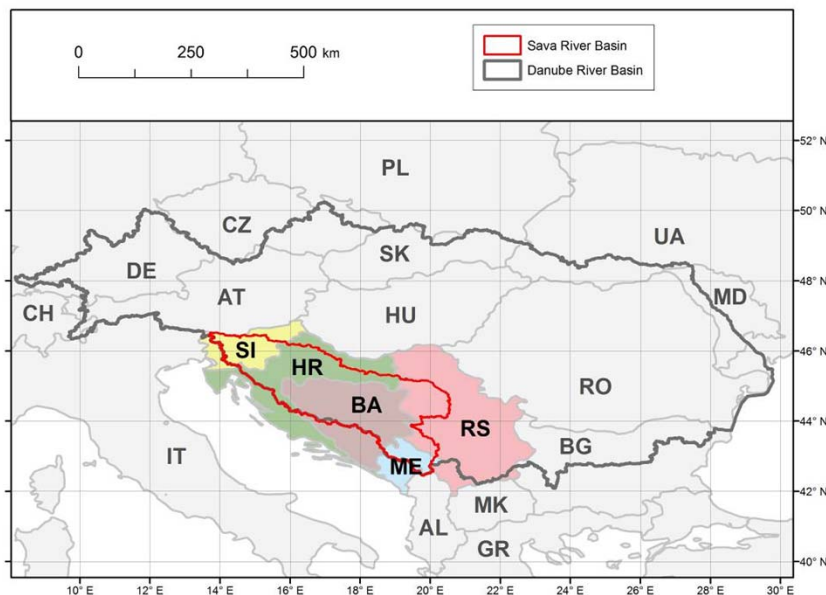
Sava spring - Slovenia



Sava mouth - Serbia

Sava river basin

- **Area:** 97 713 km² (the second largest Danube sub-basin; share: 12%)
- **Average flow at the mouth:** 1722 m³/s (the largest Danube tributary)
- **River length:** 940 km (594 km of which is the waterway)
- **Population:** approx. 9 million



| Country | Share of the basin (%) | Share of the territory (%) |
|----------------------|------------------------|----------------------------|
| Bosnia & Herzegovina | 39.2 | 75.8 |
| Croatia | 26.0 | 45.2 |
| Serbia | 15.5 | 17.4 |
| Slovenia | 12.0 | 52.8 |
| Montenegro | 7.1 | 49.6 |
| Albania | 0.2 | 0.6 |

International Sava River Basin Commission



- **Established in 2005** (Secretariat: in 2006, seated in Croatia)
- **Established for** implementation of the Framework Agreement on the Sava River Basin (FASRB, signed in 2002)
- **Four countries fully involved as the Parties to FASRB**
 - **Bosnia and Herzegovina**
 - **Croatia**
 - **Serbia**
 - **Slovenia**
 - **Montenegro**
 - **It was involved** at the beginning (as a part of Serbia & Montenegro)
 - **Cooperation on technical level**, in some fields of work
 - **Formalization of cooperation** (until the full membership) under consideration

ISRBC links to national institutions



- Institutions **officially nominated by the governments** (mostly ministries)
- **NHMSs**
 - **Expert Group for HM issues** – all members come from the NHMSs
 - **Annual meetings** with directors of the NHMSs representatives
- **Water agencies** and other institutions
 - **Expert Groups** (River Basin Management, Floods Prevention, Accident Control, GIS, Navigation,...)
 - Core Working Groups

ISRBC Scope of cooperation

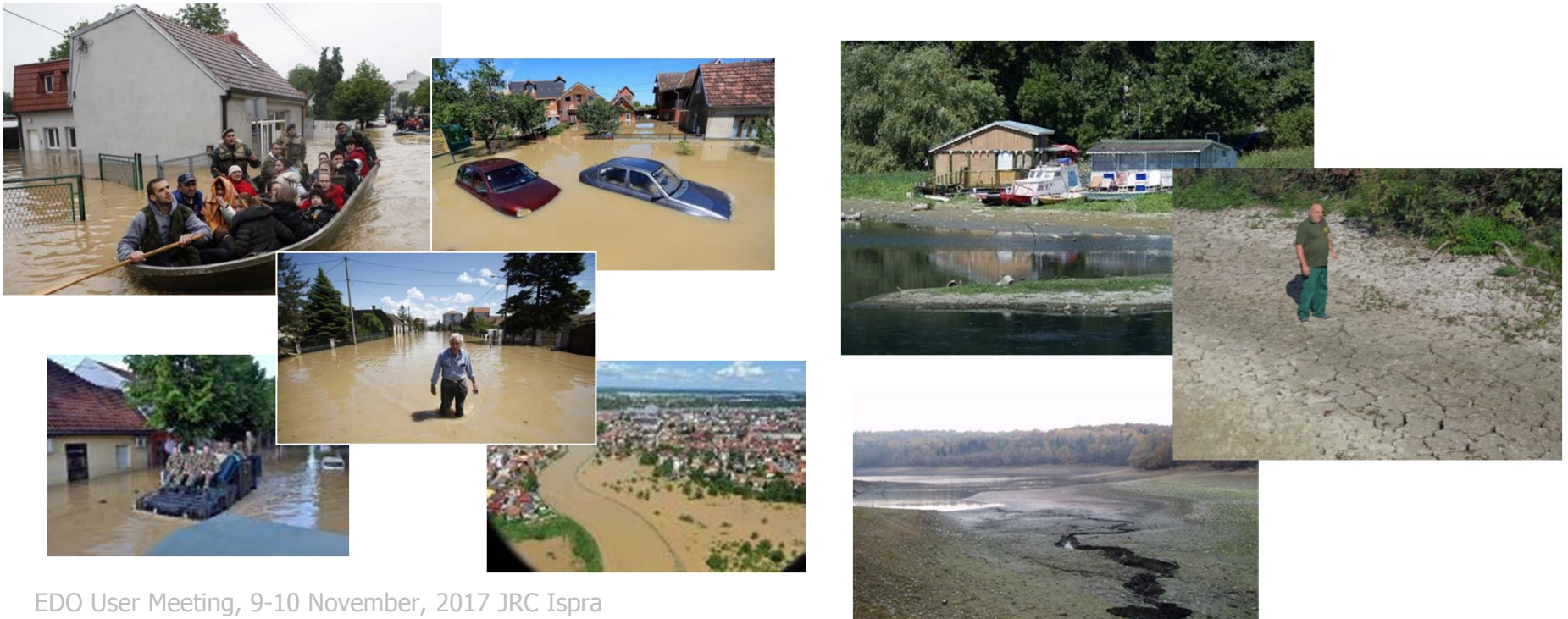
- **Management plans**
(river basin, flood risk, sediment, climate change adaptation)
- **Integrated systems**
(information, forecasting, warning)
- **Economic activities**
(navigation, river tourism)
- Harmonization of **regulation**
(national → EU)
- **Protocols to the FASRB**



Emergency Management

- **Main objective by FASRB:**

Prevent or limit hazards, such as **floods**, ice, **droughts** and accidents involving substances hazardous to water, and to reduce or eliminate related adverse consequences



Flood Risk Management

Significant floods



| Year of flood | Affected area/river |
|-----------------|--------------------------------------|
| Oct/Nov 1896 | Drina River |
| Apr 1932 | Sava River |
| Oct 1933 | Sava River |
| Nov 1944 | Sava River |
| Oct 1964 | Sava River |
| Dec 1966 | Sava and Kupa rivers |
| Dec 1968 | Bosna River |
| Jan 1970 | Sava and Bosut rivers |
| Oct 1974 | Sava, Krapina, Kupa and Una |
| Jul 1989 | Krapina River |
| 1990 | Upper Sava River Basin |
| Oct/Nov 1998 | Upper Sava River Basin |
| Nov 1998 | Kupa River |
| Jul 1999 | Tamnava, Ub and Gračica rivers |
| Jun 2001 | Kolubara, Jadar and Ljuboviđa r. |
| Mar 2006 | Tamnava, Ub and Gračica rivers |
| Apr 2006 | Sava River |
| Sep 2007 | Upper Sava River Basin |
| Mar 2009 | Tamnava, Ub and Gračica rivers |
| Dec 2009 | Upper Sava River Basin |
| May/Jun 2010 | Middle Sava River Basin |
| Sep 2010 | Middle Sava River Basin |
| Dec 2010 | Drina, Kupa and Una rivers |
| Feb 2014 | Kupa River |
| May 2014 | Middle/lower Sava River Basin |

Drought Risk Management

- The Sava region recently suffered severe droughts
- 2012 was one of the driest in 40 years
- In 2015, the year after the major floods, the area suffered from droughts

Two extremes in one area



Forecasting and warning

Protocol on flood protection to the FASRB

The Parties shall establish a Flood Forecasting, Warning and Alarm System in the Sava River Basin and to jointly undertake all necessary actions for establishment of the System, including the development of the project documentation

The Sava Commission shall coordinate the activities on establishment of the System

Objectives of the forecasting system for the Sava River Basin

The forecasting system is designed to forecast both floods and **low flows – the latter for the purpose of drought management at basin scale**

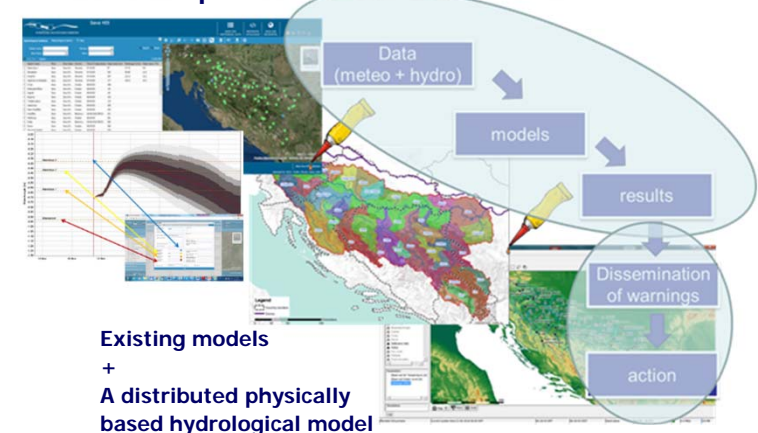
The principal objective of the FFWS is to support the stakeholders in taking balanced decisions in emergency situations during flood and drought events

Forecasting and warning

• Initial steps

- Initiated by national NHMSs of the Sava countries, 2003
- ISRBC supported the initiative since its establishment, 2006
- World Bank supported preparation of assessment of the status and needs in national institutions, 2007 (estimate 16 mil USD)
- Development of the **first ever basin-wide hydrologic model**, 2010
- Development of the **first ever Sava mainstem hydraulic model**, 2012
- Hydrologic **model improvements**, 2014
- **Project proposal for FFWS establishment approved by WBIF**, 2014
- **Sava River Basin Management Plan**, 2014
- Development of the **system for real-time HM data collection**, as a part of Sava HIS, 2015
- Water & Climate Adaptation Plan - **WATCAP** for the Sava River Basin, 2016
- Hydrologic and hydraulic **models improvements**, 2016-2017

SavaHIS components

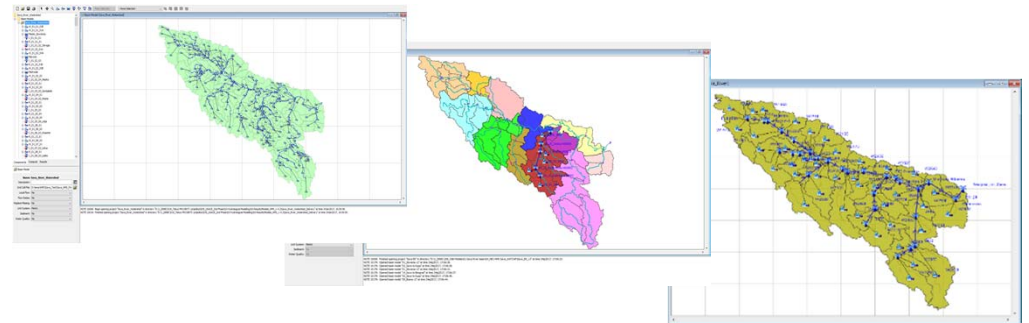


Supporting actions in flow modeling

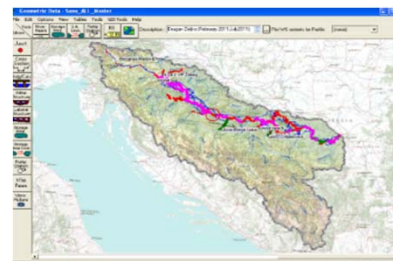
US Government support to the Sava countries

1. To support the **development of hydrologic and hydraulic models** of the Sava River Basin, tools that will strengthen multilateral cooperation in the basin, primarily in the area of flood protection
2. To support activities leading to the **preparation of a flood risk management plan** as well as the **development of the system for forecasting**
3. To establish the models that could be used for other purposes in future (modeling sediment transport, water quality, climate change analysis, etc.)

- **Hydrologic model**
of the Sava River Basin (2010, 2014, 2016)



- **Hydraulic model**
of the Sava River (2012, 2016-2017)



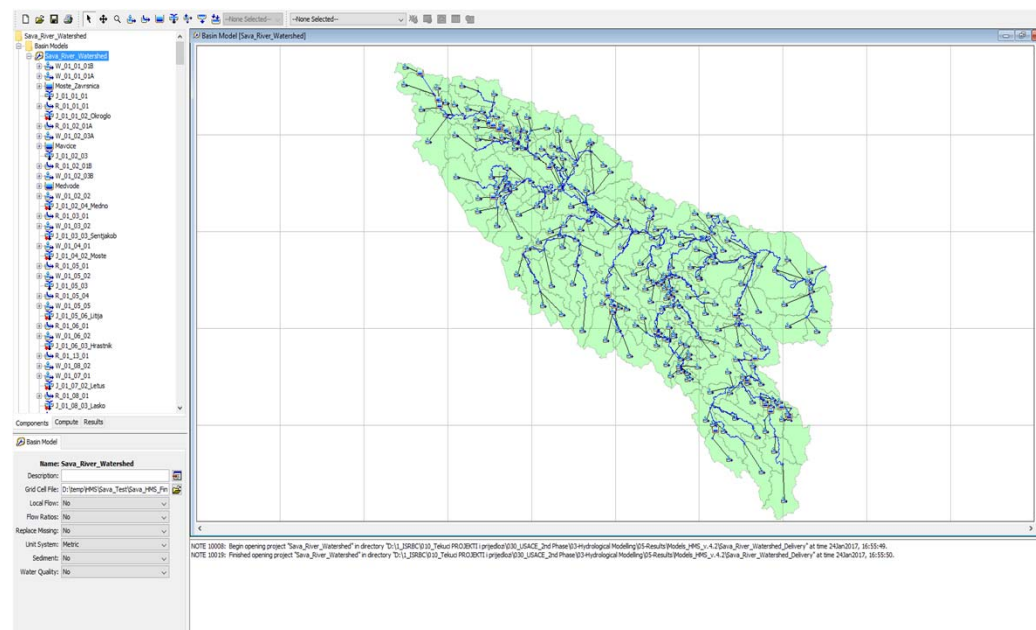
Sava HMS hydrological model



Technical support was provided by the
US Army Corps of Engineers

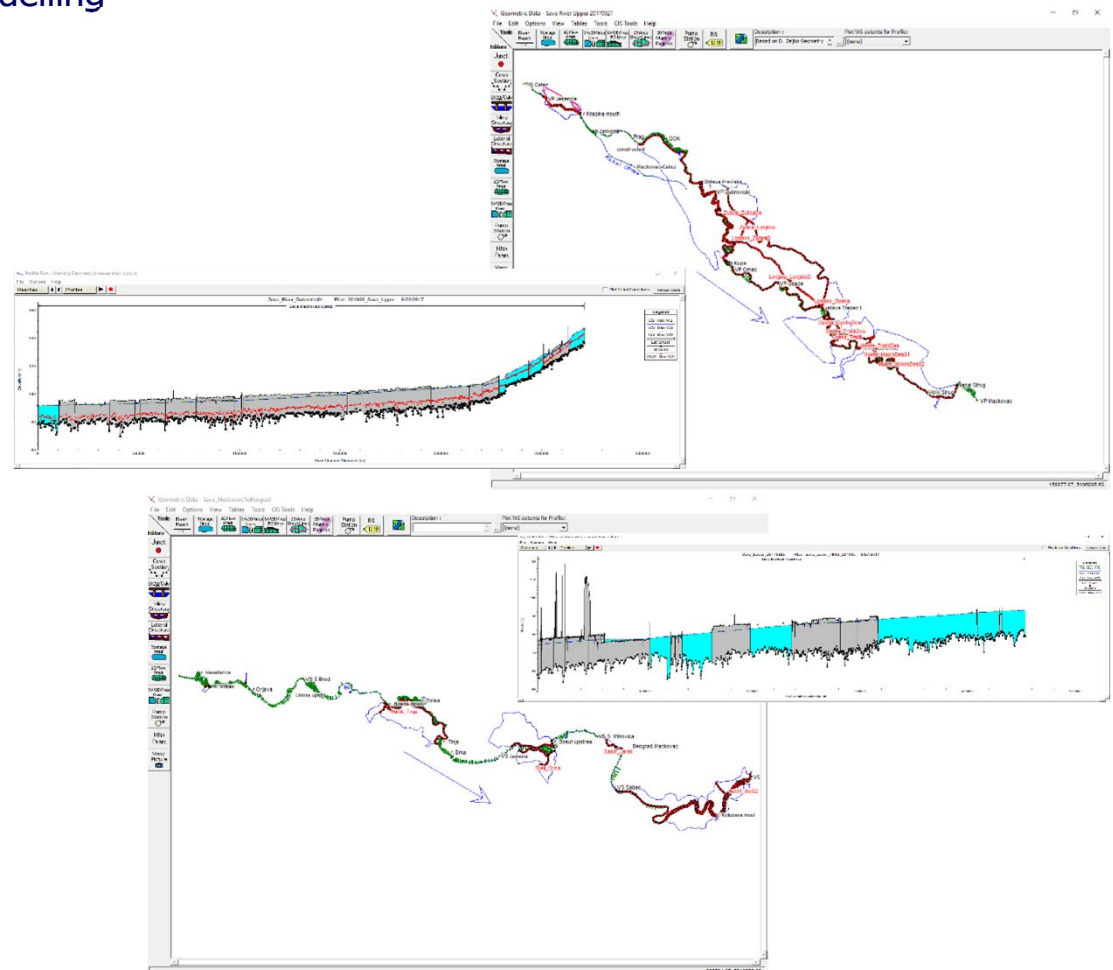
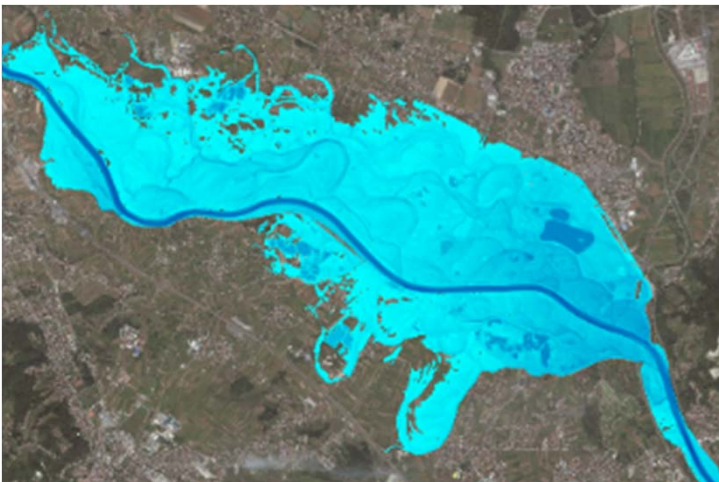
Final Sava HEC-HMS model contains a separate basin models for each tributary basin and mainstem reach (**22 models in total**):

- 1 for the complete Sava River basin (**SavaFFWS**)
- 4 for the Sava River mainstem
- 17 for the main tributaries



Sava RAS hydraulic model

- Improve upon the latest mainstem Sava River **hydraulic model**
 - Setting up of a new geometry of the model started
 - The results from the calibrated hydrological HEC-HMS model (already completed as a first activity), are used in hydraulic modelling
- Areas (around 3.315 km²)
- LiDAR based geometry
- 2-D simulation possibilities



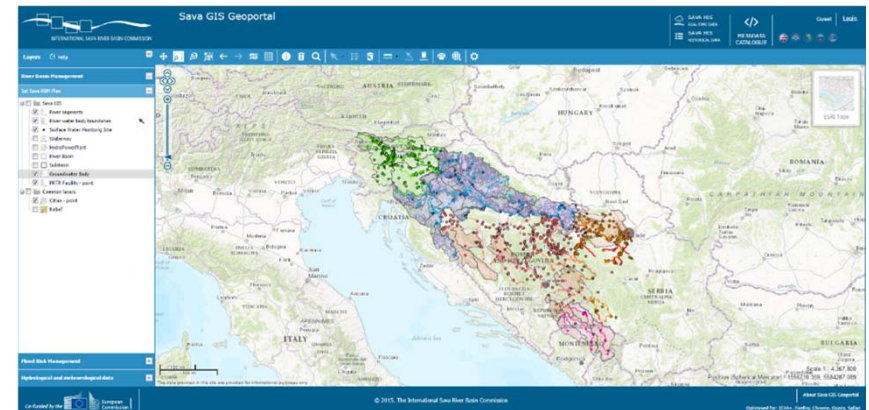
Information Management - Sava GIS

A common platform for sharing and dissemination of information and knowledge about WRM in the basin

2007-2015

- Sava GIS Strategy, 2008
- Implementing documents, 2010
- Establishment start, 2012
- Establishment of **Sava GIS Core Functionalities**, 2015

www.savagis.org



- **Wide range of data** to be exchanged
 - River basin management
 - Flood management
 - Navigation safety management
 - Sediment management
 - Accident prevention and control

HM data exchange

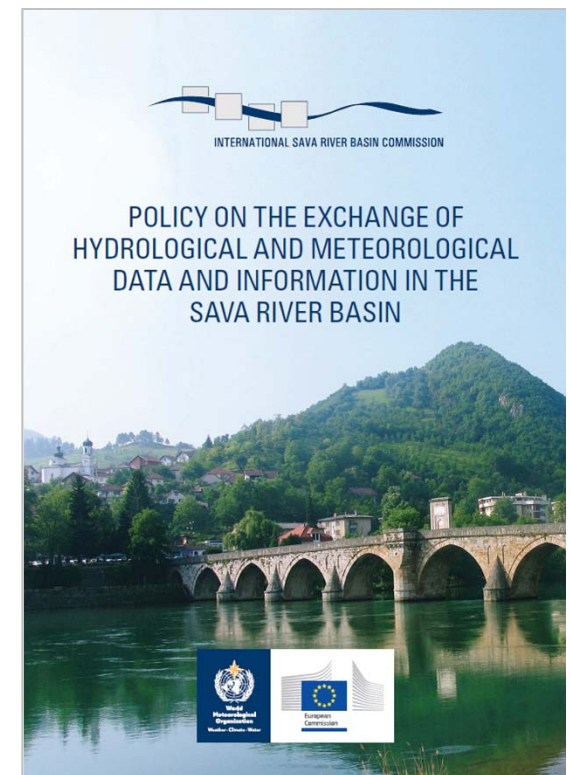
Hydrological Yearbooks (data from 2000)

Joint measurements at border sections

HM Data Exchange Policy

- **In accordance with**
 - International legal framework
 - FASRB
 - Protocol on Flood Protection to FASRB
 - WMO Resolutions
 - Resolution 25 (Cg-XIII) – Exchange of Hydrological Data and Products
 - Resolution 40 (Cg-XII) – Policy and Practice for the Exchange of Meteorological and Related Data and Products
 - Danube River Protection Convention
 - ISRBC's Data Exchange Policy
 - National legal framework
- **Principles** (procedures, timetable, quality standards, use and redistribution, routes, ownership, charging, harmonization, monitoring locations, data to be exchanged)
- **Organizations**
 - Hydro-meteorological services
 - Water / environment agencies
 - Hydropower companies (to be included)

First Data Policy document initiated by int'l basin organizations and supported by the WMO
Signed by NHMSs (6/6) and water agencies (2/4)



Sava HIS

HM data management within Sava GIS



CUAHSI

Consortium of Universities for the Advancement of Hydrologic Science, Inc.

1. Standards

- WaterML language for describing water data

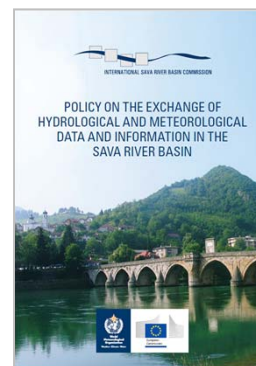
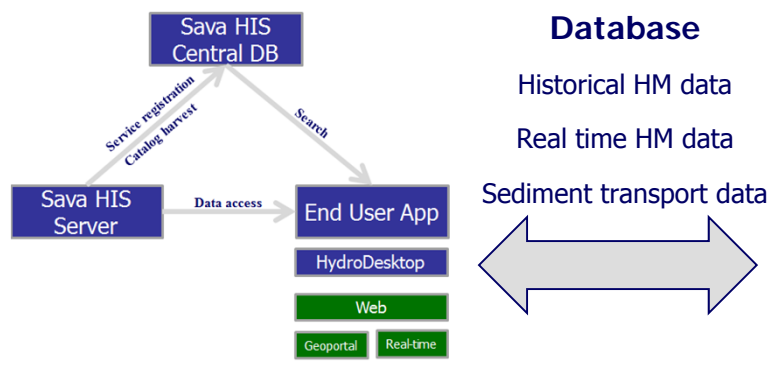
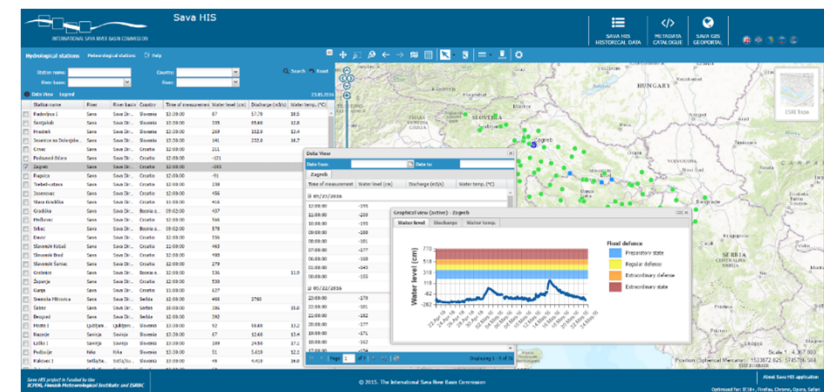
2. Services

- Catalog of water data sources – web services

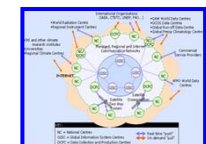
3. End user applications

- Web apps and software for data access

www.savahis.org

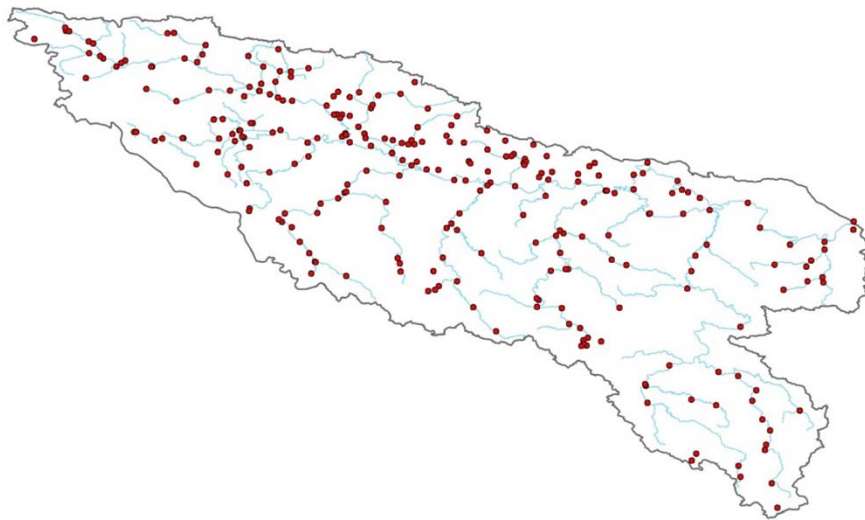


WIS – WMO
Information
System



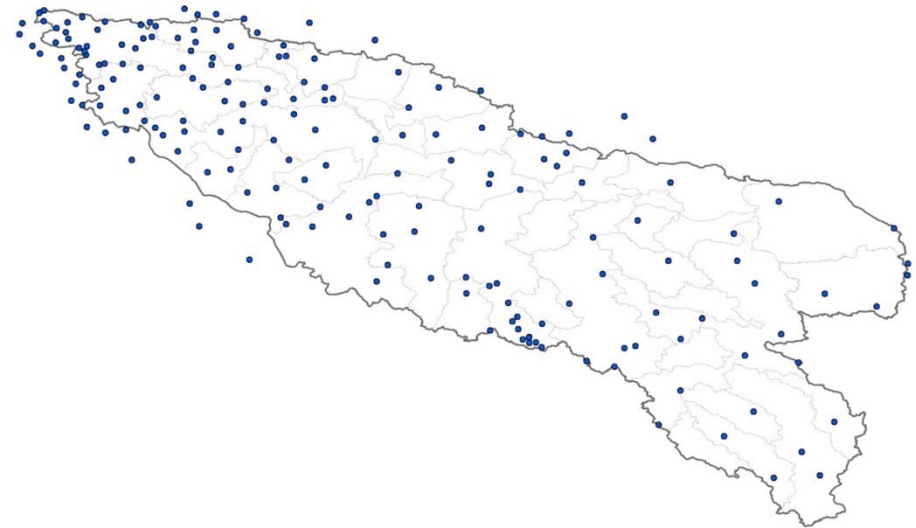
Sava HIS – available data

- Hydrological data**



| Parameter | Temporal Resolution |
|--------------------------|---------------------------------------|
| Water Level | Current value; Daily mean; Statistics |
| River Discharge | Current value; Daily mean; Statistics |
| Water Temperature | Current value; Daily mean; Statistics |
| Susp. Sediment Discharge | Current value; Daily mean; Statistics |
| Ice Condition | Daily description |

- Meteorological data**



| Parameter | Temporal Resolution |
|----------------------|---------------------------------------|
| Precipitation | Hourly total; Daily total; Statistics |
| Air Temperature | Current value; Daily mean; Statistics |
| Snow Depth | Hourly total; Statistics |
| Relative Humidity | Statistics |
| Wind Speed | Statistics |
| Evaporation | Statistics |
| Solar Radiation | Statistics |
| Sunshine | Statistics |
| Atmospheric Pressure | Statistics |

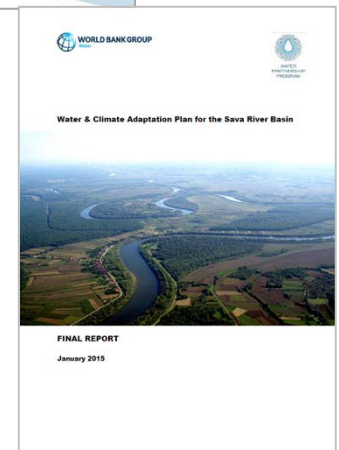
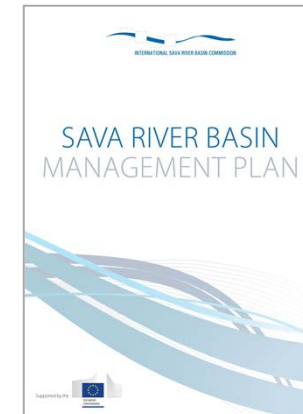
Sava HIS

Monitoring locations

| Country | Data Provider | Hydro | | Meteo | |
|------------------------|---------------|-------------|-----------|-------------|-----------|
| | | Data Policy | Sava HIS | Data Policy | Sava HIS |
| Bosnia and Herzegovina | FHMZFBIH | 2 | 3 (3) | 12 | 20 (20) |
| | AVPSAVA | 21 (8) | 39 (16) | - | 10 (10) |
| | RHMZRS | 11 (1) | 31 (18) | 16 | 16 (16) |
| Croatia | DHMZ | 22 (13) | 130 (125) | 11 | 49 (42) |
| Montenegro | ZHMS | 2 | 11 (11) | 3 | 5 (5) |
| Serbia | RHMZ | 18 (13) | 25 (19) | 6 | 12 (10) |
| Slovenia | ARSO | 17 (13) | 31 (26) | 5 | 76 (76) |
| 5 | 7 | 93 (48) | 270 (218) | 53 | 188 (179) |

Other relevant activities

- **Sava River Basin Management Plan, 2014**
- **Water and Climate Adaptation Plan, 2016**
 - Guidance Notes (e.g. agriculture)
 - Measures, recommendations
 - Recommended adaptation measures for agriculture
 - Drought management is the top priority for agriculture
 - The **establishment of early warning systems for droughts** and other extreme climate episodes is considered of greatest importance, followed by the need to promote water retention in drought-prone agricultural areas
- **SWMI document, 2017**
- **2nd Sava River Basin Analysis, 2017**



Sava FFWS establishment

Project Official Title:

Improvement of Joint Flood Management Actions in the Sava River Basin

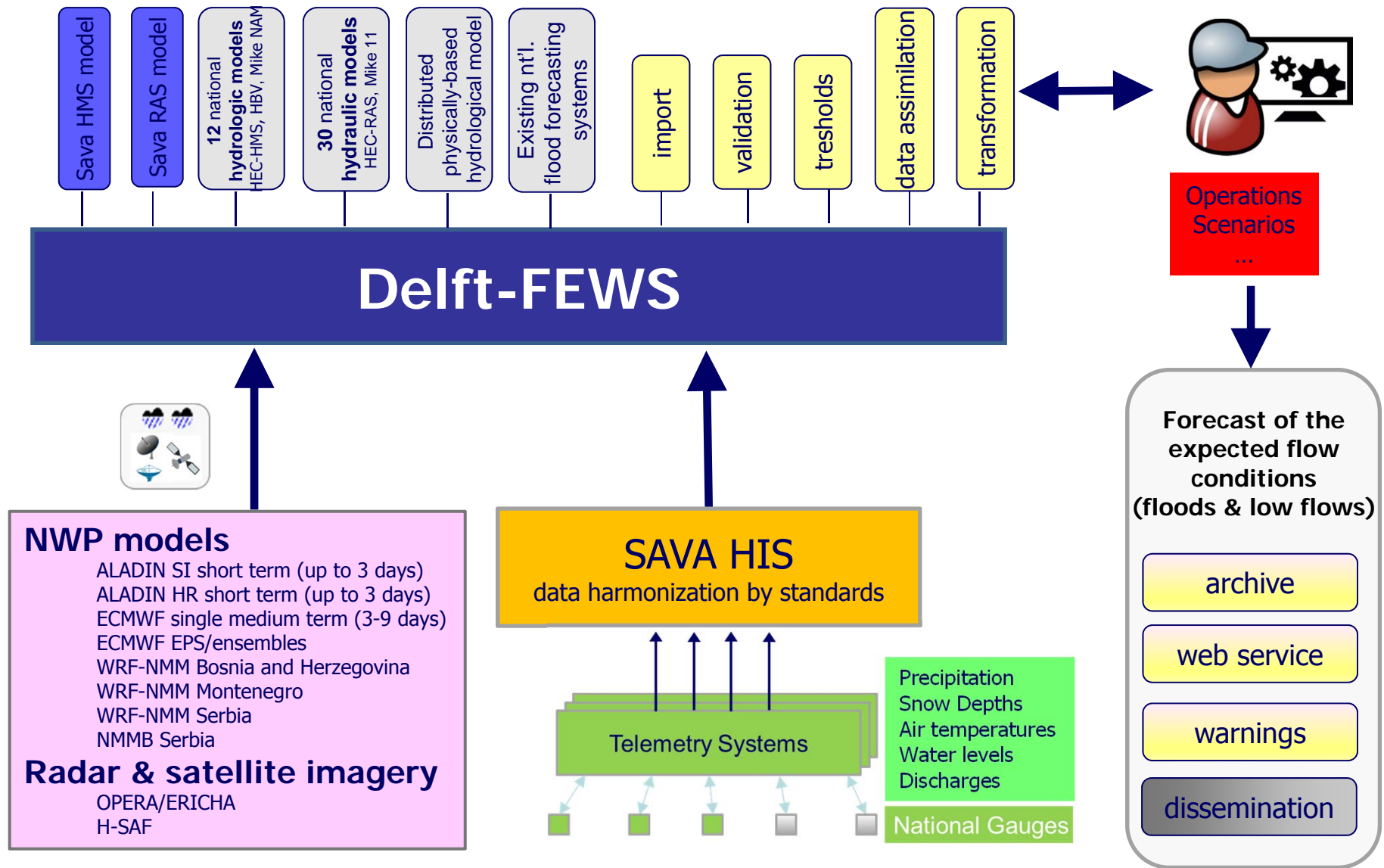
- **Approved in June 2014** by WBIF and WB
- **Geographical coverage:** 5 countries (BA, HR, ME, RS, SI)
- **Beneficiaries:** 19 institutions from 5 Sava countries
- **Two Components**

C1 - Flood Risk Management Plan for the Sava River Basin

c2 - Flood Forecasting and Warning System for the Sava River Basin

- Project formally launched on June 21, 2016 (27 months)
- A Consortium of technical experts is contracted, led by **Deltares, NL**
- Implementation period: 2016-2018

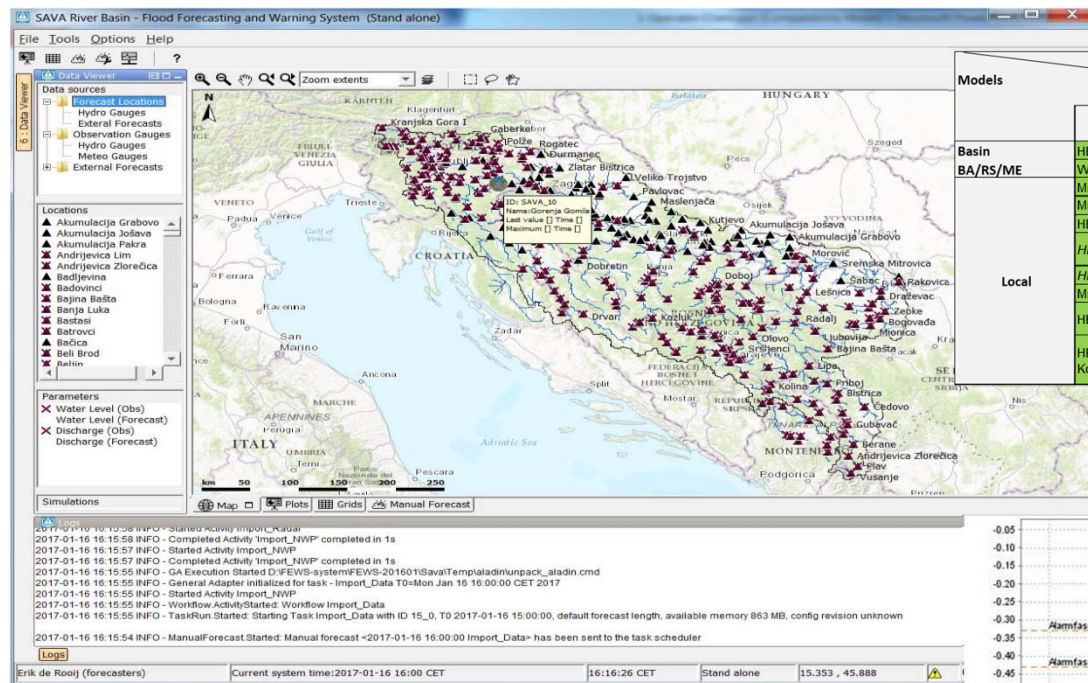
Sava FFWS - schematic overview



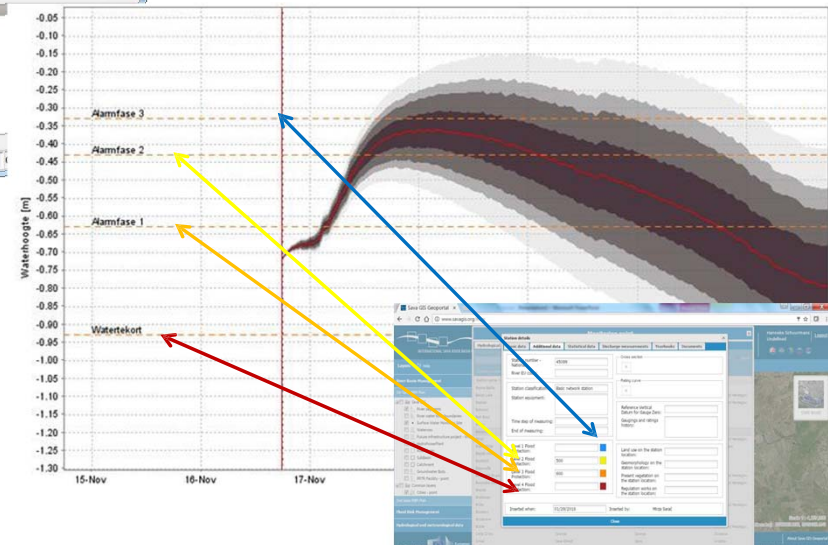
Sava FFWS

System already operational

testing of the pre-release 0.2 and steps to 0.3 delivery



| Models | | NWP | | Default Run | | | Manual User Run | | | | |
|-------------------|----------------------------------------------------|--------------------------------|-----------|--------------------|----------------------|--------------|-----------------|---------|----------------|----------------|---------|
| | | Hydrological | Hydraulic | Aladin SI ECMWF | Aladin HR + ECMWF | ECMWF EPS | NMMB | WRF BIH | WRF MNE 1km | WRF MNE 3km | WRF SRB |
| Basin BA/RS/ME | HEC-HMS Sava | HEC-RAS Sava | X | | X | X | | | | X | X |
| | WFlow (BA/RS/ME) | | X | | X | X | | | | X | X |
| Local | Mike-NAM (HR) | Mike 11 Croatia | | X | | | | | | | |
| | Mike-NAM Una (BA) | Mike 11 Una | | X | | | | | | | |
| | HBV-light Bosna (BA) | | X | | X | X | X | | | X | X |
| | HEC-HMS Sava | HEC-RAS Bosna (ISRBC) | X | | X | X | | | | X | X |
| | HEC-HMS Sava | HEC-RAS (BA) [9] | X | | X | X | | | | X | X |
| | Mike-NAM Vrbas | Mike 11 Vrbas | X | | X | X | X | | | X | X |
| | HEC-HMS Kolubara (SRB) | HEC-RAS Kolubara (SRB) [17] | X | | X | X | | | | X | X |
| | HBV (SRB) [5] Jadar, Kolubara, Tarnava,Ub, Ljig | | X | | X | X | | | | X | X |



Integration & Cooperation



EDO User Meeting, 9-10 November, 2017 JRC Ispra

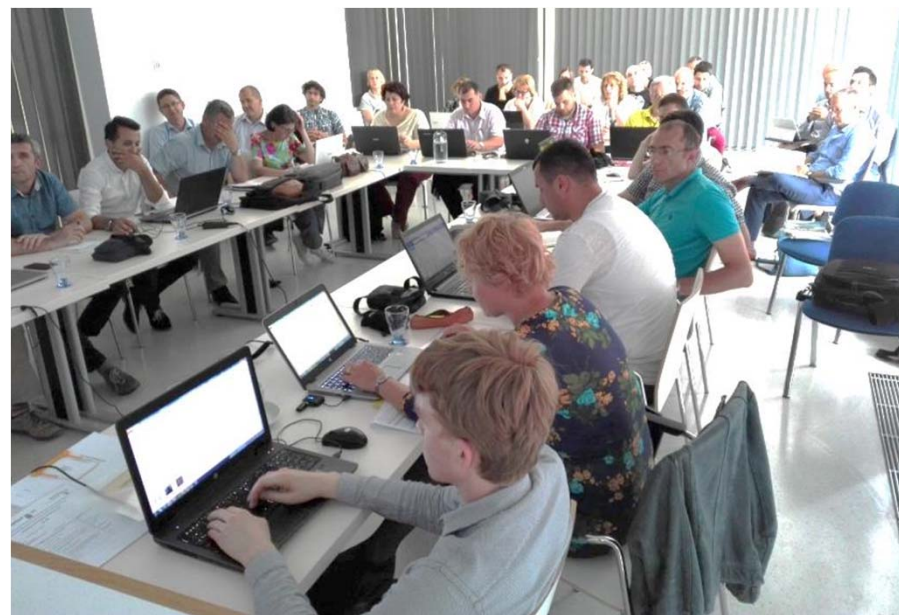
Sava FFWS – knowledge transfer

1st Training Workshop and User Training (February 2+14th)

- 26 participants from 5 beneficiary countries

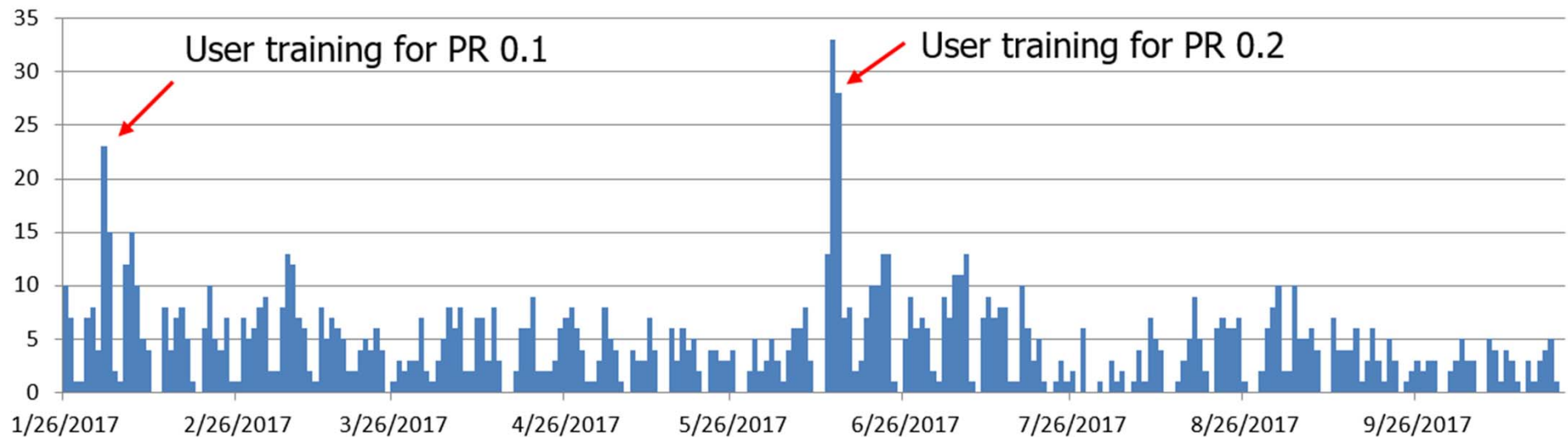
2nd Training Workshop and User Training (June 13+14th)

- 35 participants from 5 beneficiary countries + guests from WMO, UNESCO and the Joint Research Centre (EU)



Sava FFWS - use of the System

unique daily logins to Sava FFWS



**Intensive schedule of Training Workshops
and User Trainings**

Fully operational system expected in fall 2018

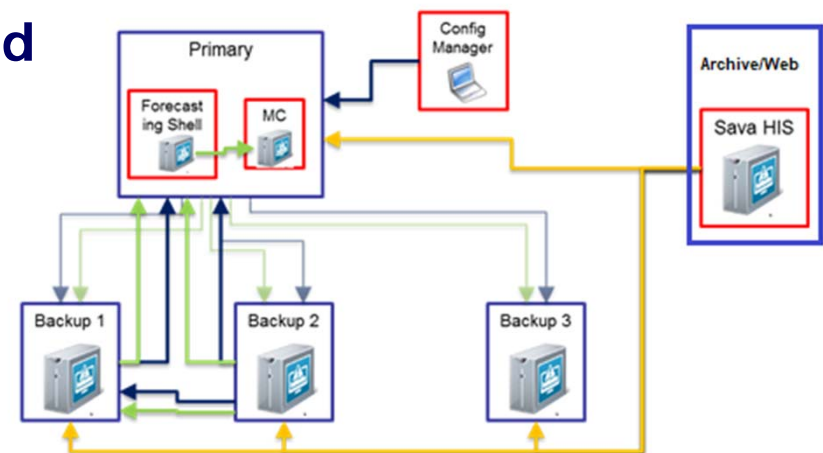
Preparation for the Sava FFWS operational period - after fall 2018

Protocol on flood protection to the FASRB

After the System is established, the **Parties shall ensure its regular maintenance and performance control**, as well as regular training of the engaged personnel, with application of joint standards

- **A Joint System Hosting approved**

- 1 Primary server
- 3 Backup servers
 - 1 Archive/Web server



- **Consultation process on the post-project organization ongoing**

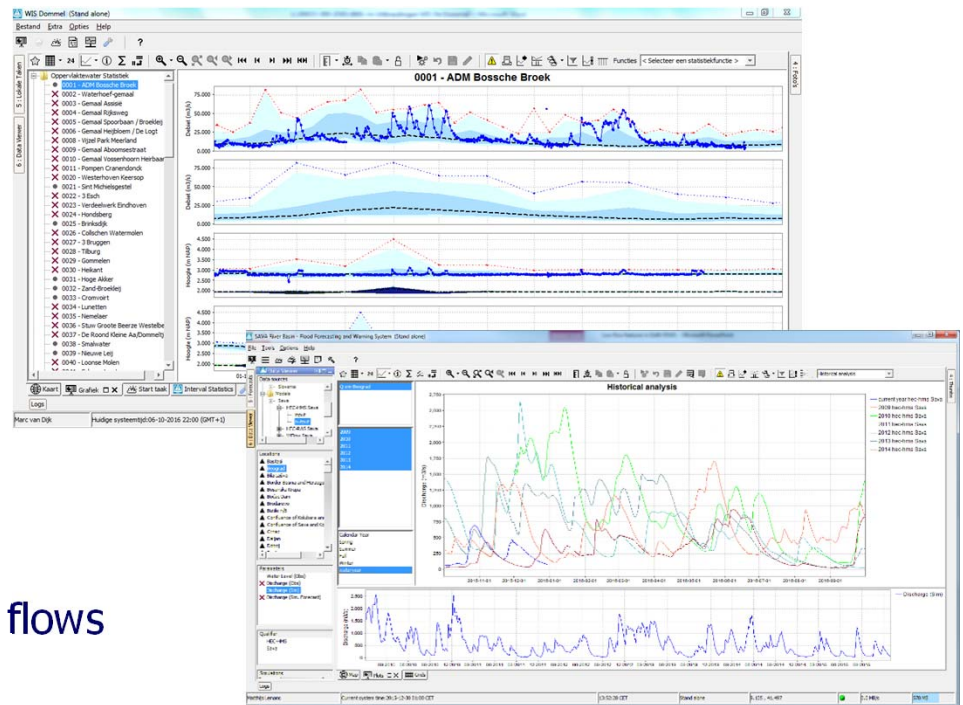
Low flow/drought features in Sava FFWS

WHY ?

- Forecasting of low flows is needed for:
 - Water resources
 - Agriculture
 - Industry
 - Hydropower
 - etc
 - Navigation

HOW ?

- Using simulation models
 - Tuned with special attention to low flows
- Low flow warnings
 - Threshold + duration (based on e.g. moving average)
 - Comparison to historical dry years
 - Comparison to statistics (like $Q_{1\%}$, etc)



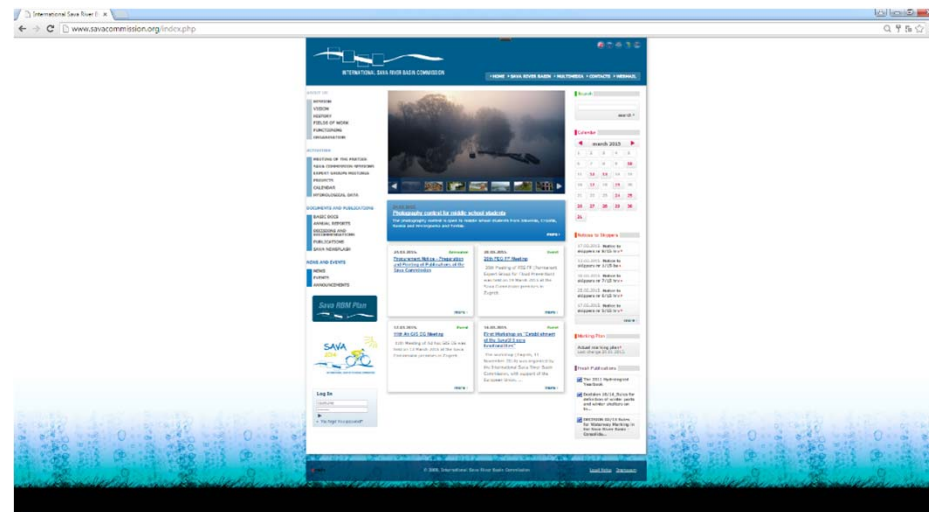
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