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

<table>
<thead>
<tr>
<th>Country</th>
<th>Share of the basin (%)</th>
<th>Share of the territory (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bosnia &amp; Herzegovina</td>
<td>39.2</td>
<td>75.8</td>
</tr>
<tr>
<td>Croatia</td>
<td>26.0</td>
<td>45.2</td>
</tr>
<tr>
<td>Serbia</td>
<td>15.5</td>
<td>17.4</td>
</tr>
<tr>
<td>Slovenia</td>
<td>12.0</td>
<td>52.8</td>
</tr>
<tr>
<td>Montenegro</td>
<td>7.1</td>
<td>49.6</td>
</tr>
<tr>
<td>Albania</td>
<td>0.2</td>
<td>0.6</td>
</tr>
</tbody>
</table>
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**

<table>
<thead>
<tr>
<th>Year of flood</th>
<th>Affected area/ river</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oct/Nov 1896</td>
<td>Drina River</td>
</tr>
<tr>
<td>Apr 1932</td>
<td>Sava River</td>
</tr>
<tr>
<td>Oct 1933</td>
<td>Sava River</td>
</tr>
<tr>
<td>Nov 1944</td>
<td>Sava River</td>
</tr>
<tr>
<td>Oct 1964</td>
<td>Sava River</td>
</tr>
<tr>
<td>Dec 1966</td>
<td>Sava and Kupa rivers</td>
</tr>
<tr>
<td>Dec 1968</td>
<td>Bosna River</td>
</tr>
<tr>
<td>Jan 1970</td>
<td>Sava and Bosut rivers</td>
</tr>
<tr>
<td>Oct 1974</td>
<td>Sava, Krapina, Kupa and Una</td>
</tr>
<tr>
<td>Jul 1989</td>
<td>Krapina River</td>
</tr>
<tr>
<td>1990</td>
<td>Upper Sava River Basin</td>
</tr>
<tr>
<td>Oct/Nov 1998</td>
<td>Upper Sava River Basin</td>
</tr>
<tr>
<td>Nov 1998</td>
<td>Kupa River</td>
</tr>
<tr>
<td>Jul 1999</td>
<td>Tamnava, Ub and Gračica rivers</td>
</tr>
<tr>
<td>Jun 2001</td>
<td>Kolubara, Jadar and Ljubovija r.</td>
</tr>
<tr>
<td>Mar 2006</td>
<td>Tamnava, Ub and Gračica rivers</td>
</tr>
<tr>
<td>Apr 2006</td>
<td>Sava River</td>
</tr>
<tr>
<td>Sep 2007</td>
<td>Upper Sava River Basin</td>
</tr>
<tr>
<td>Mar 2009</td>
<td>Tamnava, Ub and Gračica rivers</td>
</tr>
<tr>
<td>Dec 2009</td>
<td>Upper Sava River Basin</td>
</tr>
<tr>
<td>May/Jun 2010</td>
<td>Middle Sava River Basin</td>
</tr>
<tr>
<td>Sep 2010</td>
<td>Middle Sava River Basin</td>
</tr>
<tr>
<td>Dec 2010</td>
<td>Drina, Kupa and Una rivers</td>
</tr>
<tr>
<td>Feb 2014</td>
<td>Kupa River</td>
</tr>
<tr>
<td><strong>May 2014</strong></td>
<td><strong>Middle/ lower Sava River Basin</strong></td>
</tr>
</tbody>
</table>
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 WBF, 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
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**

- **Hydraulic model**
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

• 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

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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)
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

Database
- Historical HM data
- Real time HM data
- Sediment transport data

Standards
- INSPIRE
- WMO resolutions
- WaterML 2.0

www.savahis.org

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Sava HIS – available data

- **Hydrological data**

- **Meteorological data**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Temporal Resolution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water Level</td>
<td>Current value; Daily mean; Statistics</td>
</tr>
<tr>
<td>River Discharge</td>
<td>Current value; Daily mean; Statistics</td>
</tr>
<tr>
<td>Water Temperature</td>
<td>Current value; Daily mean; Statistics</td>
</tr>
<tr>
<td>Susp. Sediment Discharge</td>
<td>Current value; Daily mean; Statistics</td>
</tr>
<tr>
<td>Ice Condition</td>
<td>Daily description</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Temporal Resolution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Precipitation</td>
<td>Hourly total; Daily total; Statistics</td>
</tr>
<tr>
<td>Air Temperature</td>
<td>Current value; Daily mean; Statistics</td>
</tr>
<tr>
<td>Snow Depth</td>
<td>Hourly total; Statistics</td>
</tr>
<tr>
<td>Relative Humidity</td>
<td>Statistics</td>
</tr>
<tr>
<td>Wind Speed</td>
<td>Statistics</td>
</tr>
<tr>
<td>Evaporation</td>
<td>Statistics</td>
</tr>
<tr>
<td>Solar Radiation</td>
<td>Statistics</td>
</tr>
<tr>
<td>Sunshine</td>
<td>Statistics</td>
</tr>
<tr>
<td>Atmospheric Pressure</td>
<td>Statistics</td>
</tr>
</tbody>
</table>
## Sava HIS Monitoring locations

<table>
<thead>
<tr>
<th>Country</th>
<th>Data Provider</th>
<th>Hydro</th>
<th>Meteo</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Data Policy</td>
<td>Sava HIS</td>
</tr>
<tr>
<td><strong>Bosnia and Herzegovina</strong></td>
<td>FHMZFBIH</td>
<td>2</td>
<td>3 (3)</td>
</tr>
<tr>
<td></td>
<td>AVPSAVA</td>
<td>21 (8)</td>
<td>39 (16)</td>
</tr>
<tr>
<td></td>
<td>RHMZRS</td>
<td>11 (1)</td>
<td>31 (18)</td>
</tr>
<tr>
<td><strong>Croatia</strong></td>
<td>DHMZ</td>
<td>22 (13)</td>
<td>130 (125)</td>
</tr>
<tr>
<td><strong>Montenegro</strong></td>
<td>ZHMS</td>
<td>2</td>
<td>11 (11)</td>
</tr>
<tr>
<td><strong>Serbia</strong></td>
<td>RHMZ</td>
<td>18 (13)</td>
<td>25 (19)</td>
</tr>
<tr>
<td><strong>Slovenia</strong></td>
<td>ARSO</td>
<td>17 (13)</td>
<td>31 (26)</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td>5</td>
<td>7</td>
</tr>
</tbody>
</table>
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 Deltaires, NL
  - Implementation period: 2016-2018
Sava FFWS - schematic overview

Delft-FEWS

NWP models
- ALADIN SI short term (up to 3 days)
- ALADIN HR short term (up to 3 days)
- ECMWF single medium term (3-9 days)
- ECMWF EPS/ensembles
- WRF-NMM Bosnia and Herzegovina
- WRF-NMM Montenegro
- WRF-NMM Serbia
- NMMB Serbia

Radar & satellite imagery
- OPERA/ERICHA
- H-SAF

SAVA HIS
data harmonization by standards

Precipitation
Snow Depths
Air temperatures
Water levels
Discharges

Telemetry Systems

National Gauges

Forecast of the expected flow conditions
(floods & low flows)

archive
web service
warnings
dissemination

Operations Scenarios
...
**Sava FFWS**

**System already operational**

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

<table>
<thead>
<tr>
<th>Integration &amp; Cooperation</th>
</tr>
</thead>
</table>

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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

Intensive schedule of Training Workshops and User Trainings

Fully operational system expected in 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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