



A COMPLETE WATER RESOURCES MANAGEMENT SOLUTION



**A disruptive way information
is provided**



IDEA

Enable Water Resources Management

Disruptive Intelligent web-based workflow for river and dams monitoring
Integrated System for Monitoring and Exploitation of dams and rivers
E-Infrastructure for water resources management
A novel way to provide information Based on Earth Observation and AI

Automates routine tasks and re-risks complex tasks in water resources management

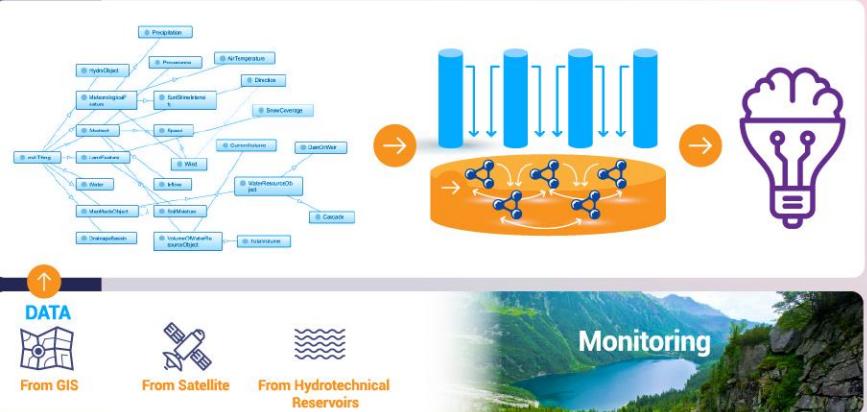
- 
- + Improves operational efficiency
 - + Enables in-depth analysis and planning
 - + Provides advanced warning for potential hazardous situations
 - + Facilitates decision making for daily exploitation of dams and rivers
 - + Supports policy making for sustainable water resources management and climate change adaptation

OUR SOLUTION ADDRESSES ALL THESE NEEDS IN A VERY EFFECTIVE MANNER



In addition it provides an answer to the ongoing challenge of the Earth Observation community to turn earth observation data consistently and systematically into valuable information layers

SEMANTIC INFRASTRUCTURE FOR WATER MANAGEMENT

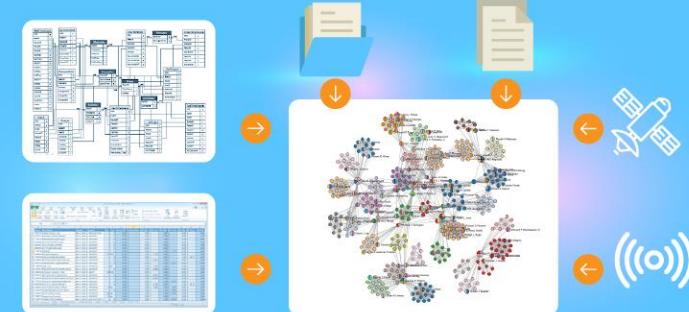


INFORMATION INFRASTRUCTURE

- Easy interlinking
- Efficient storage
- Interoperability
- Easy extendibility



NETWORK OF CONNECTED OBJECTS



NEURAL NETWORKS



A NOVEL WAY TO PROVIDE INFORMATION



The forecasts are integrated into the linked data infrastructure and are made available for further use such as



querying



alerting



reviewing



analysing



superior interactivity



easy extenddbility



optimal utilization of earth observation data and in-situ measurements



multifaceted visualization



effective maintenance

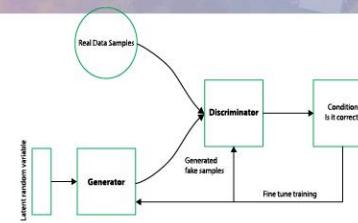


geo-spatial information and domain knowledge

FORECASTING METHOD – EO4GEO



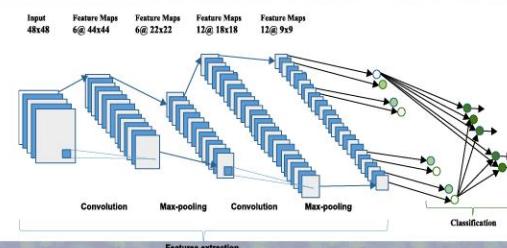
Satellite data



GAN



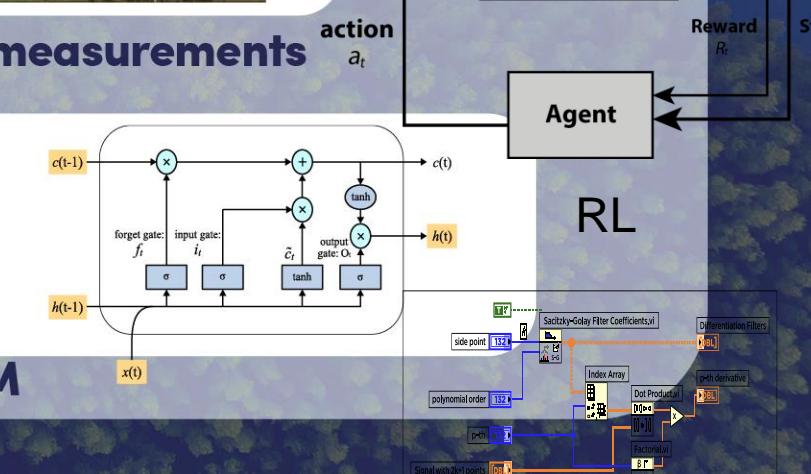
Geospatial position



CNN



In-situ measurements



LSTM

SG

METEOROLOGICAL AND ENVIRONMENTAL FACTORS



Turbidity



Surface reflection



Precipitation



Snow cover



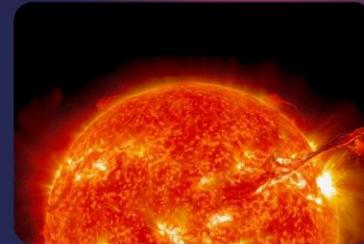
Soil moisture



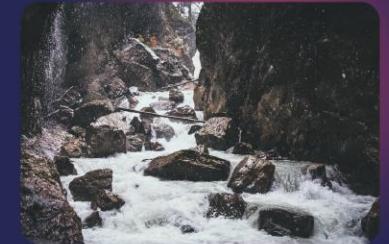
Wind



Vegetation index



Solar radiance



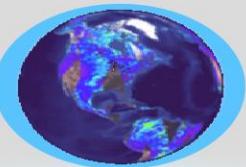
Velocity

EARTH OBSERVATION DATA

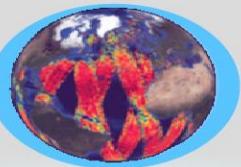


ADAM (former eodataservice) is an interdisciplinary / cross domain platform

climate health



ocean



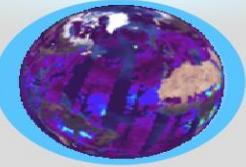
land cover



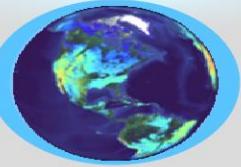
agriculture



pollution



weather



makes global environmental geospatial data
Findable, Accessible, Interoperable and
Reusable (FAIR)

provides an effective subsetting functionality that
accesses the data only when requested and serves to
the client only the data amount that is really needed

- exposes OGC-standardised discovery (openSearch)
and access (WCS 2.0) interfaces

Discovery



Exploration



Visualization



Processing



Value of ESA NoR

- The satellite data from ADAM were provided via NoR Sponsorship
- The satellite data have been a crucial element for building forecast models in our EO4AI approach and for designing the novel data interactivity solution
- ESA NoR Service allowed to obtain these crucial satellite data from ADAM and benefit from extra budget allocation and enabled the project to be executed and realized with success

IN-SITU MEASUREMENTS

Discharge



Water level



Turbidity



GENERATE FORECASTS FOR

Rivers

Discharge

Water level

Turbidity

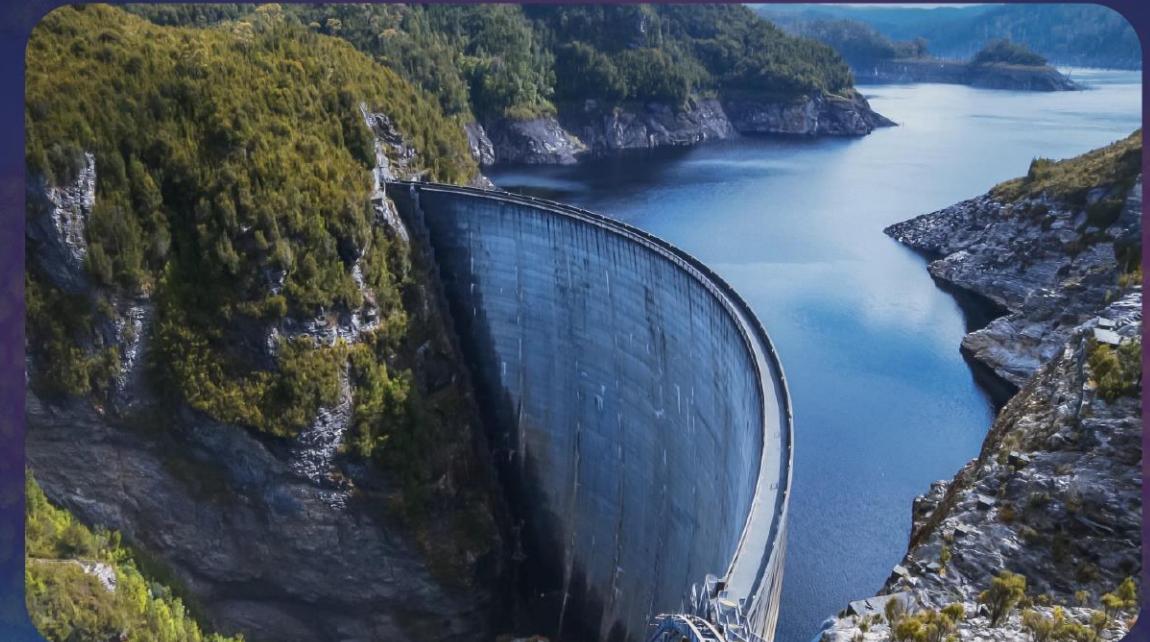
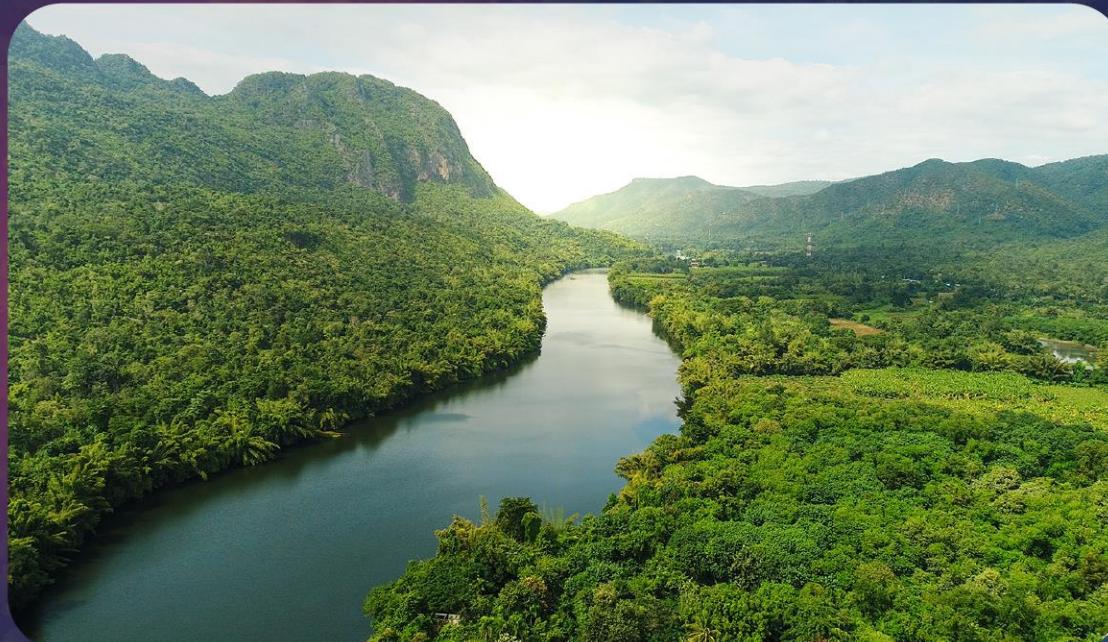
Dams

Available volume

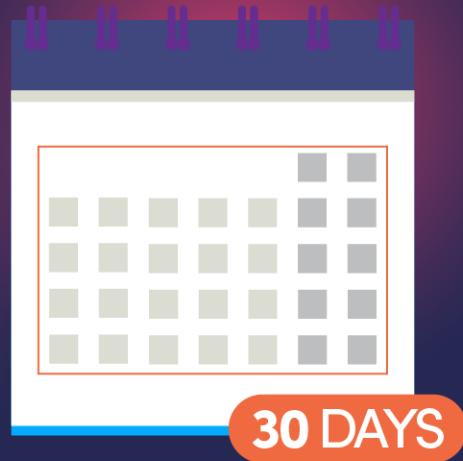
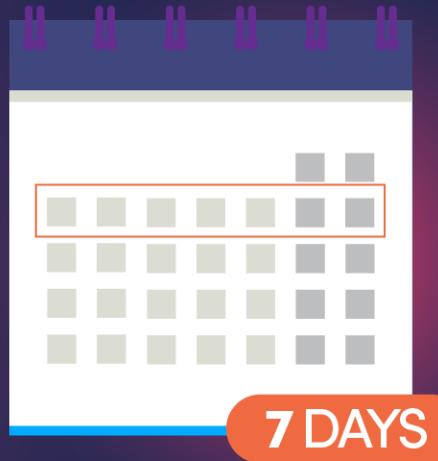
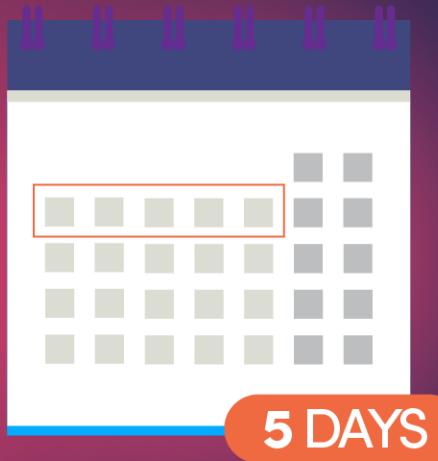
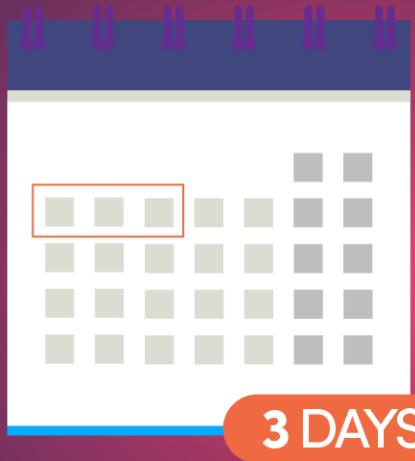
Water level

Inflow

Water equivalent of Snow Stock



FORECAST MODELS



TRAINING WITH HISTORIC DATA



5 years back for rivers

10 years back for dams

- meteorological factors from satellites
- liquid precipitation, solid precipitation and snow cover
- in-situ measurements

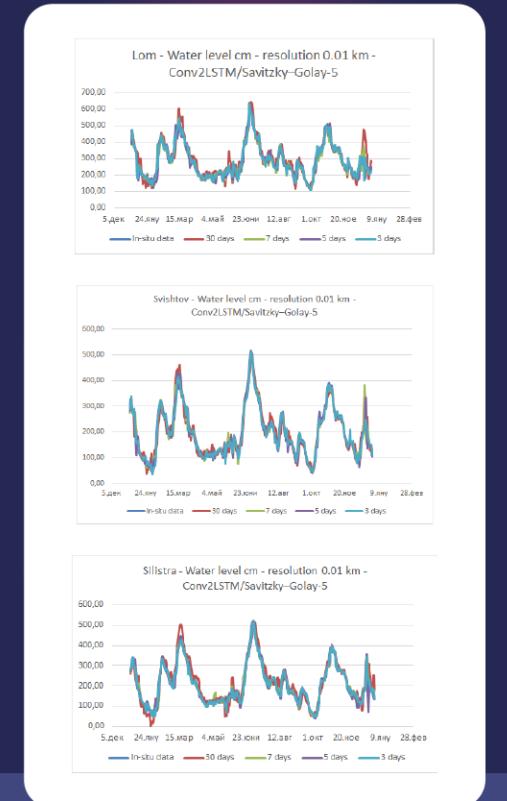
Experiments with results for one year ahead with each model



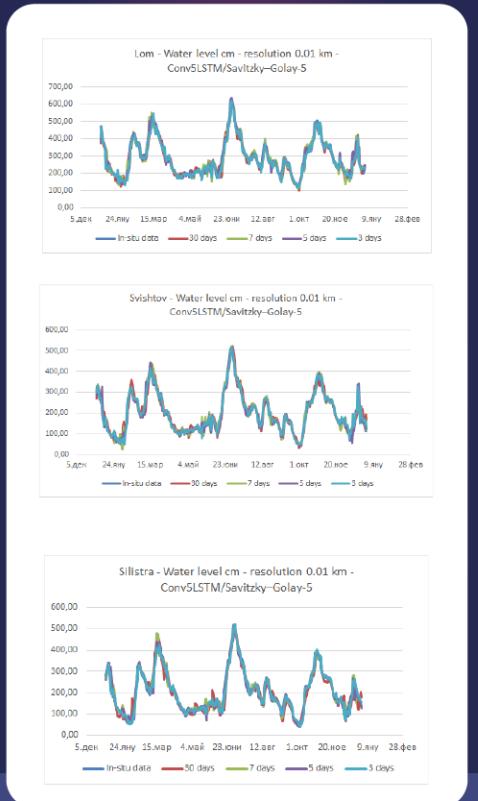
Performance estimated comparing forecast data with in-situ measurements



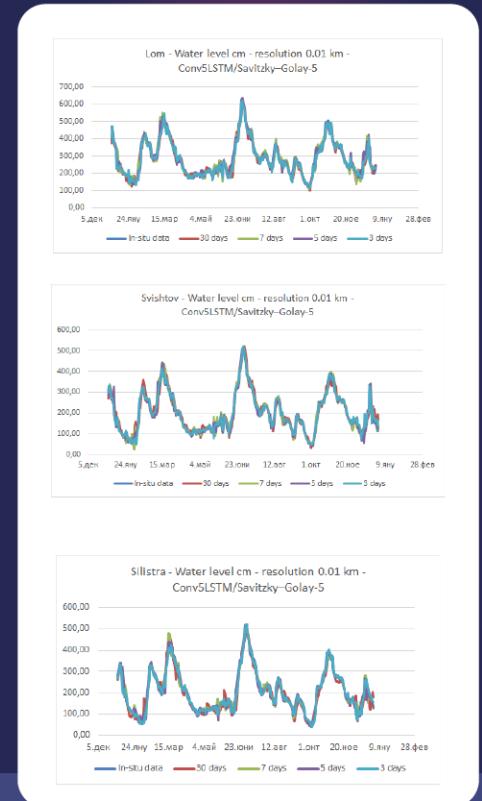
EXPERIMENTS RESULTS FOR WATER LEVEL ON THE DANUBE



Lom (cm)				
	3 days	5 days	7 days	30 days
Conv2LSTM/SG5	4,06	6,74	6,5	-4,86
Conv2LSTM/SG11	16,78	19,13	17,82	27,72
Conv5LSTM/SG5	6,57	2,23	1,11	6,41
Conv5LSTM/SG11	5,87	3,83	6,1	2,84
Conv5LSTM/RL	16,19	19,81	19,62	20,41

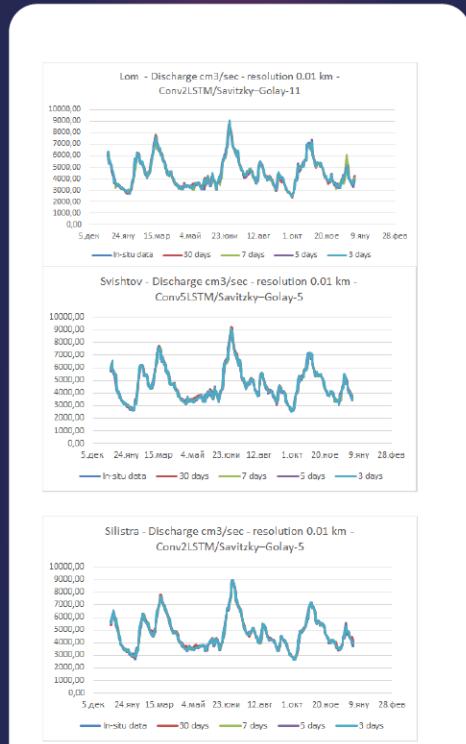


Svishtov (cm)				
	3 days	5 days	7 days	30 days
Conv2LSTM/SG5	2,83	3,24	2,86	-0,61
Conv2LSTM/SG11	3,07	2,06	3,53	4,67
Conv5LSTM/SG5	0,74	3,26	1,36	-1,61
Conv5LSTM/SG11	2,78	5,39	2,71	-0,7
Conv5LSTM/RL	12,78	13,86	15,78	16,71

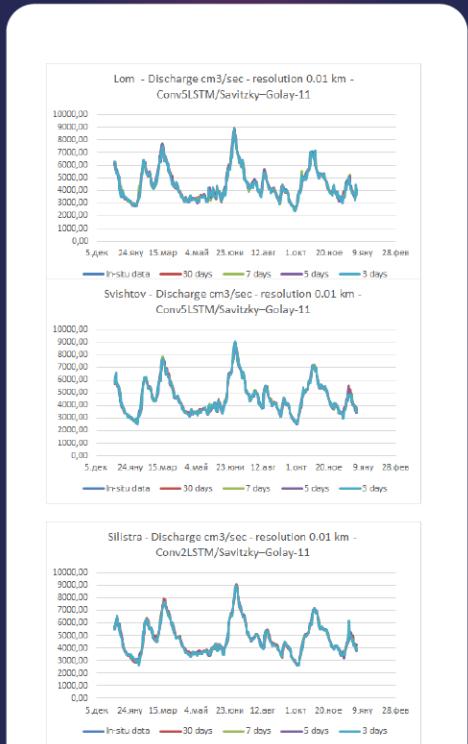


Silistra (cm)				
	3 days	5 days	7 days	30 days
Conv2LSTM/SG5	2,69	1,93	0,06	-5,8
Conv2LSTM/SG11	1,48	3,2	3,31	-3,09
Conv5LSTM/SG5	3,93	4,09	2,58	6,23
Conv5LSTM/SG11	2,95	2,31	2,22	-3,88
Conv5LSTM/RL	9,83	12,12	11,58	18,68

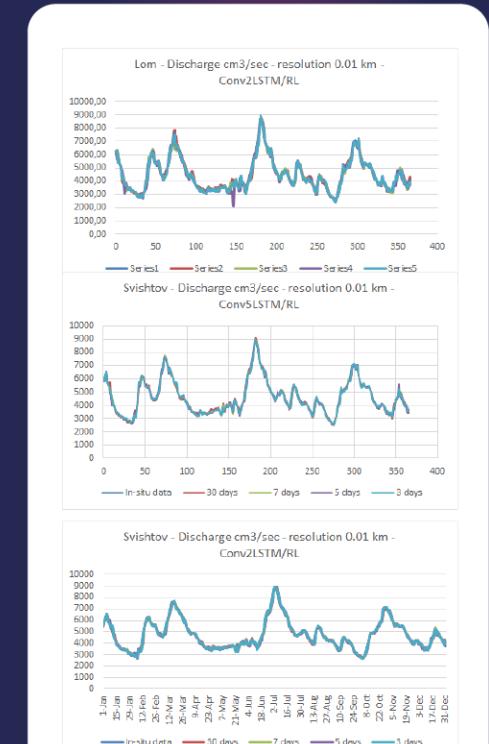
EXPERIMENTS RESULTS DISCHARGE FOR THE DANUBE



Lom Discharge				
	30 days	7 days	5 days	3 days
Conv5LSTM/RL	0,97	0,97	0,97	0,97
Conv2LSTM/RL	0,97	0,97	0,96	0,98
Conv5LSTM/SG5	0,97	0,96	0,96	0,96
Conv2LSTM/SG5	0,97	0,96	0,97	0,98
Conv5LSTM/SG11	0,97	0,97	0,97	0,97
Conv2LSTM/SG11	0,97	0,96	0,97	0,98



Svishtov Discharge				
	30 days	7 days	5 days	3 days
Conv5LSTM/RL	0,98	0,99	0,99	0,99
Conv2LSTM/RL	0,98	0,98	0,98	0,99
Conv5LSTM/SG5	0,99	0,99	0,99	0,99
Conv2LSTM/SG5	0,98	0,99	0,99	0,99
Conv5LSTM/SG11	0,99	0,99	0,99	0,99
Conv2LSTM/SG11	0,98	0,99	0,98	0,99

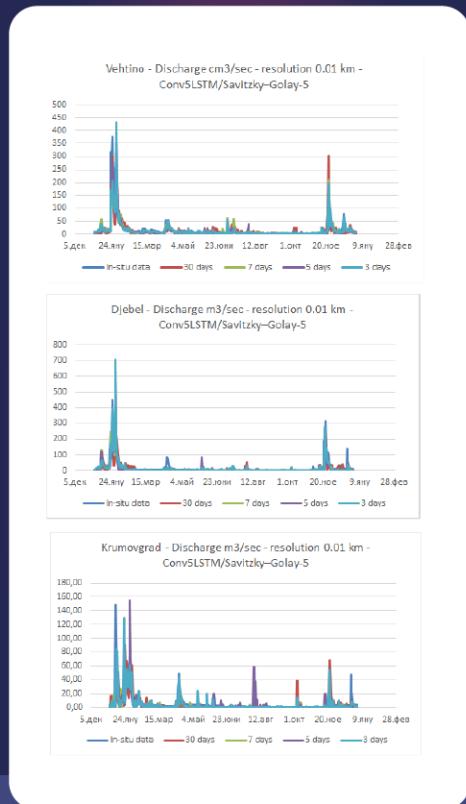


Silistra Discharge				
	30 days	7 days	5 days	3 days
Conv5LSTM/RL	0,99	0,99	0,99	0,99
Conv2LSTM/RL	0,99	0,99	0,99	0,99
Conv5LSTM/SG5	0,99	0,99	0,99	0,99
Conv2LSTM/SG5	0,99	0,99	0,99	0,99
Conv5LSTM/SG11	0,98	0,99	0,99	0,99
Conv2LSTM/SG11	0,98	0,99	0,99	0,99

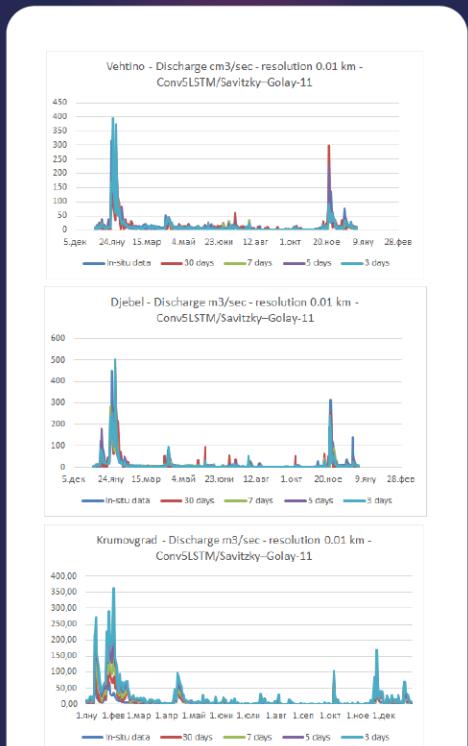
Nash-Sutcliffe Efficiency equals 1 (NSE=1):

1 - SUMPRODUCT((Real measurement - Forecast)²) / SUMPRODUCT((Real measurement - Avg of Real measurement)²)

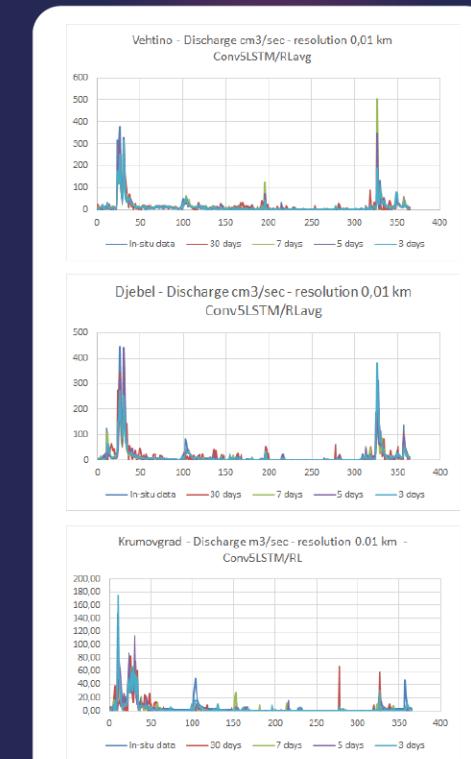
EXPERIMENTS RESULTS FOR DISCHARGE FOR ARDA



Vehtino Discharge				
	30 days	7 days	5 days	3 days
Conv5LSTM/RL	0,64	0,74	0,73	0,63
Conv5LSTM/SG5	0,67	0,63	0,69	0,66
Conv5LSTM/SG11	0,54	0,69	0,7	0,75
Conv5LSTM/SG11avg	0,34	0,44	0,55	0,61
Conv5LSTM/Rlavg	0,63	0,36	0,64	0,71



Djebel Discharge				
	30 days	7 days	5 days	3 days
Conv5LSTM/RL	0,57	0,71	0,48	0,56
Conv5LSTM/SG5	0,62	0,6	0,52	0,51
Conv5LSTM/SG11	0,59	0,61	0,67	0,7
Conv5LSTM/SG11avg	0,55	0,49	0,48	0,55
Conv5LSTM/Rlavg	0,74	0,69	0,71	0,71



Krumovgrad Discharge				
	30 days	7 days	5 days	3 days
Conv5LSTM/RL	0,04	0,45	0,16	0,45
Conv5LSTM/SG5	0,18	0,23	-0,03	0,28
Conv5LSTM/SG11	0,22	0,19	0,17	0,15
Conv5LSTM/SG11avg	-0,09	0,25	0,28	0,32
Conv5LSTM/Rlavg	-0,03	0,33	0,07	-0,07

Nash-Sutcliffe Efficiency equals 1 (NSE=1):

1 - SUMPRODUCT((Real measurement - Forecast)²) / SUMPRODUCT((Real measurement - Avg of Real measurement)²)

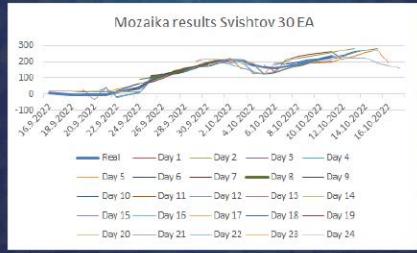
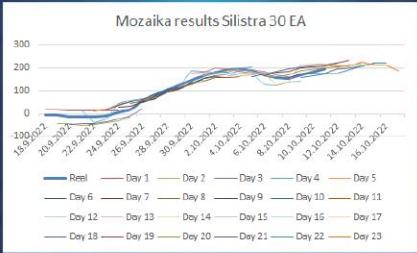
COMPARISON OF THE PRECISION OF THE DIFFERENT MODELS



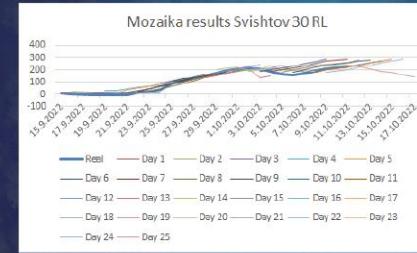
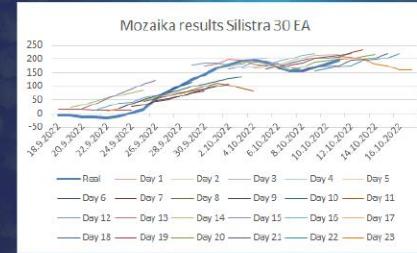
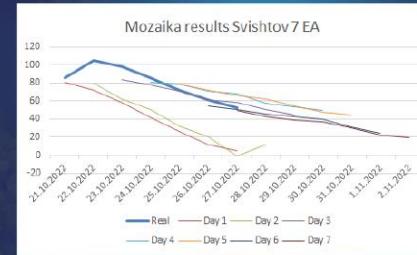
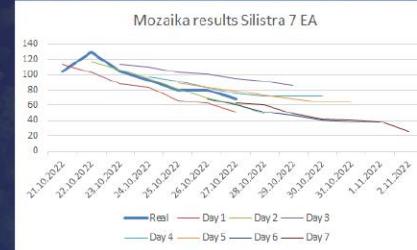
COMPARISON OF THE RESULTS FROM OUR MODELS WITH THE OFFICIAL RESULTS FOR WATER LEVEL ON THE DANUBE



Official forecast



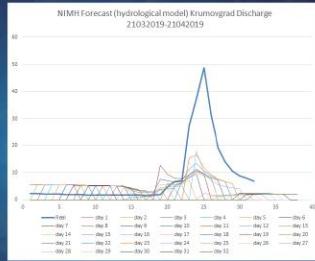
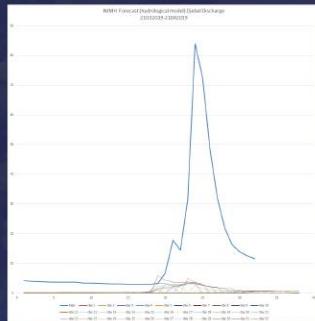
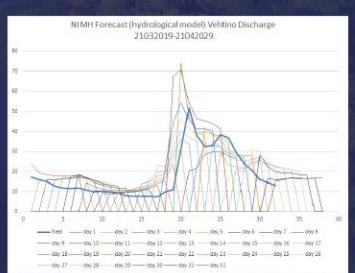
Training with 9 years of daily data



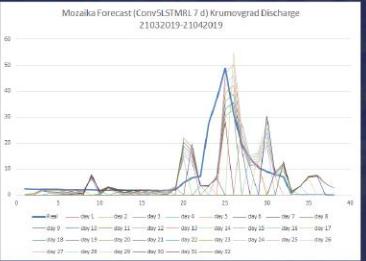
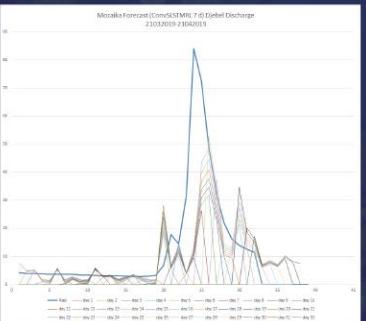
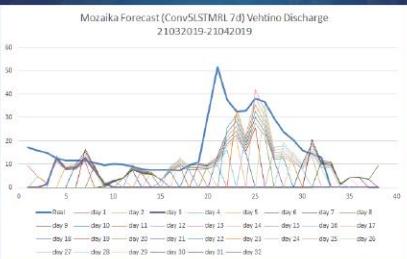
Training with 5 years of daily data

COMPARISON OF THE RESULTS FROM OUR MODELS WITH THE OFFICIAL RESULTS FOR DISCHARGE ON ARDA

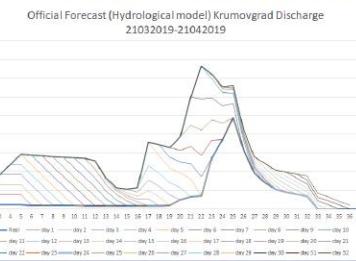
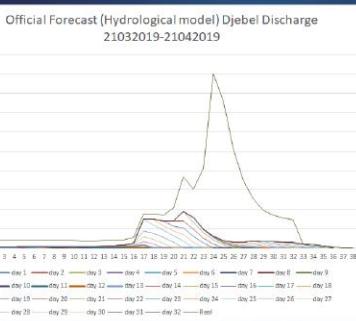
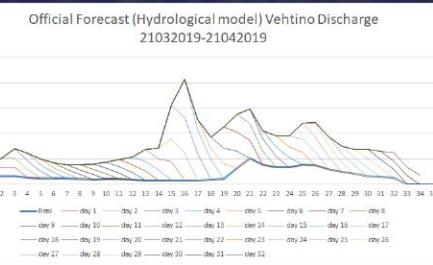
Traditional hydrological model



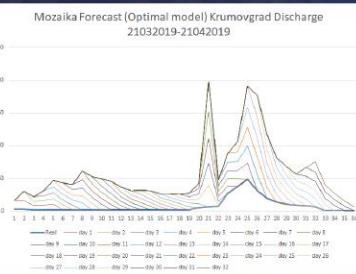
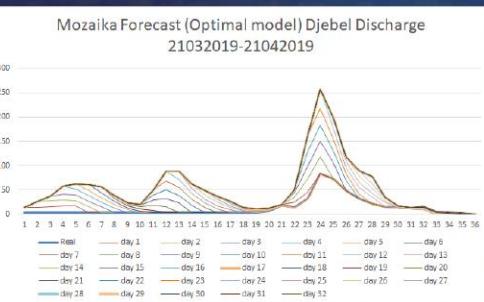
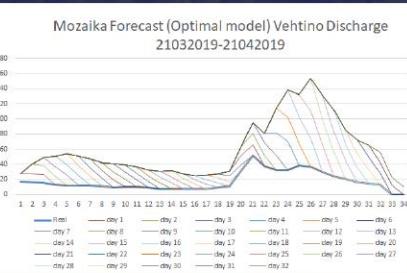
7 days model, training with 5 years daily data



Traditional hydrological model



Best model, training with 5 years daily data



Experiments results for Turbidity on the Danube



Lom (ntu)

	3 days	5 days	7 days	30 days
Conv2LSTM/SG5	-0,0072	-0,0091	-0,0093	-0,0135
Conv2LSTM/SG11	-0,0079	-0,0086	-0,0065	-0,0111
Conv5LSTM/SG5	-0,0081	-0,0099	-0,0126	-0,0091
Conv5LSTM/SG11	-0,0086	-0,0117	-0,0092	-0,0172
Conv5LSTM/RL	0,0072	0,007	0,0071	0,011

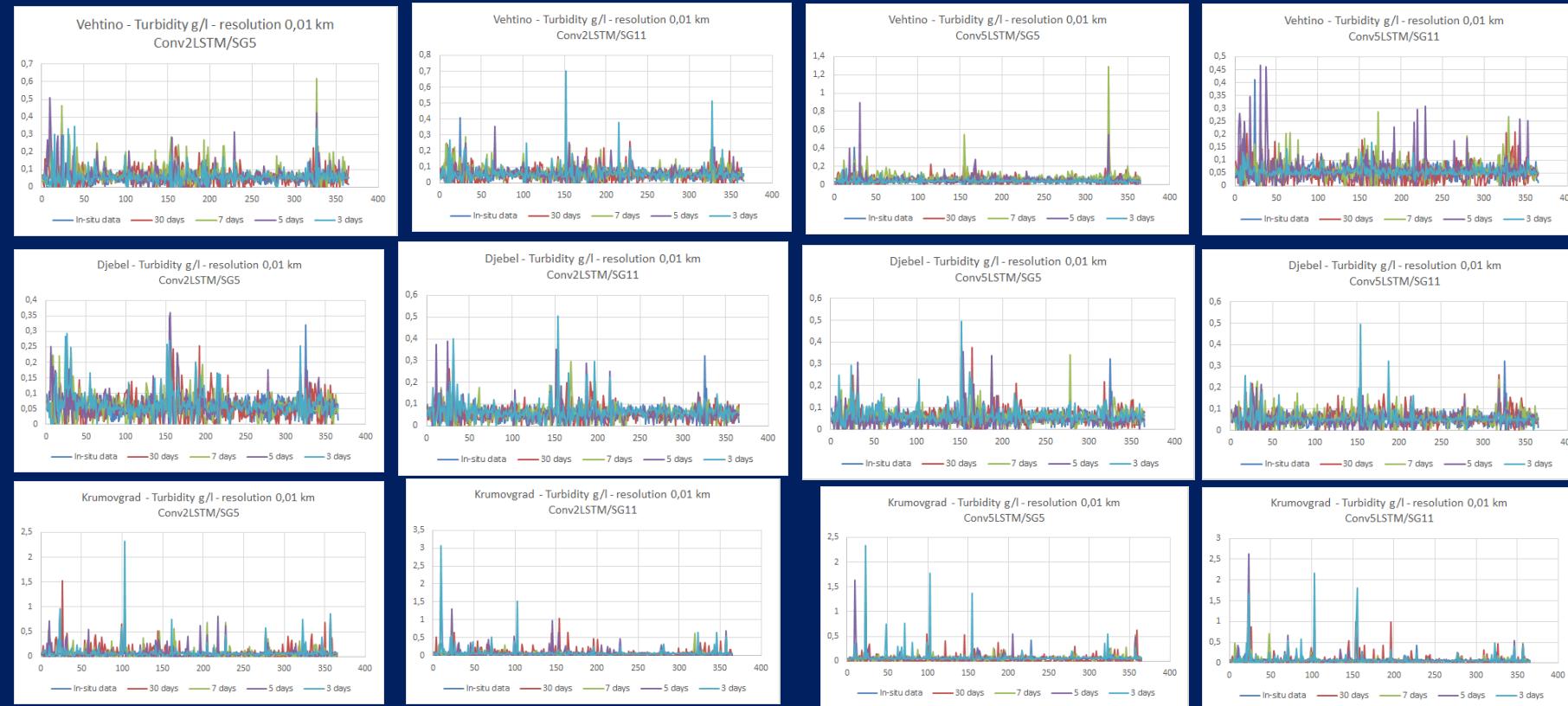
Svishtov (ntu)

	3 days	5 days	7 days	30 days
Conv2LSTM/SG5	-0,0099	-0,0055	-0,0064	-0,0076
Conv2LSTM/SG11	-0,0094	-0,0048	-0,0049	-0,0038
Conv5LSTM/SG5	-0,0094	-0,0048	-0,0049	-0,0038
Conv5LSTM/SG11	-0,0079	-0,0051	-0,0055	-0,0025
Conv5LSTM/RL	0,0144	0,0075	0,0073	0,0083

Siliistra (ntu)

	3 days	5 days	7 days	30 days
Conv2LSTM/SG5	-0,0023	-0,0014	-0,0011	0,0039
Conv2LSTM/SG11	-0,0003	0,0004	0,0026	0,005
Conv5LSTM/SG5	-0,0021	-0,0013	-0,0007	-0,0006
Conv5LSTM/SG11	0,0002	0,0029	0,0011	0,0017
Conv5LSTM/RL	0,0277	0,0271	0,0263	0,0296

Experiments results for Turbidity on Arda



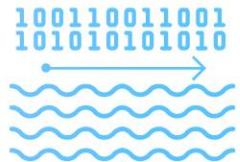
Vehtino (g/l)				
	3 days	5 days	7 days	30 days
Conv2LSTM/SG5	-0,0024	-0,0089	-0,0239	-0,0035
Conv2LSTM/SG11	-0,0043	-0,0066	-0,0099	-0,0021
Conv5LSTM/SG5	0,0124	-0,0003	-0,0246	0,0012
Conv5LSTM/SG11	-0,0003	-0,0102	-0,0076	0,0093

Djebel (g/l)				
	3 days	5 days	7 days	30 days
Conv2LSTM/SG5	-0,0071	-0,0091	-0,0023	0,002
Conv2LSTM/SG11	-0,0112	-0,0014	-0,0009	0,0003
Conv5LSTM/SG5	-0,0098	0,0096	-0,0022	-0,0037
Conv5LSTM/SG11	-0,0006	0,0057	-0,0014	-0,0074

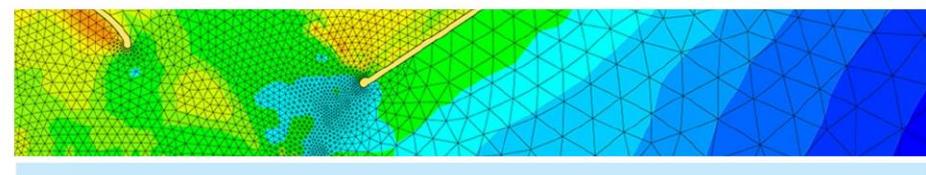
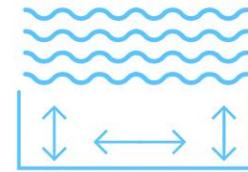
Krumovgrad (g/l)				
	3 days	5 days	7 days	30 days
Conv2LSTM/SG5	-0,0184	-0,0133	0,0039	-0,0068
Conv2LSTM/SG11	-0,0217	-0,021	-0,0114	0,0037
Conv5LSTM/SG5	-0,0206	-0,0034	-0,0057	0,0209
Conv5LSTM/SG11	-0,0197	-0,0143	-0,0182	0,0163

FORECAST OF RIVER DYNAMICS

Forecasted data for
river discharge



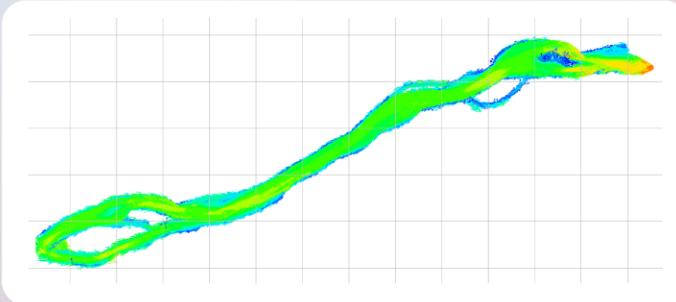
Bathymetry, riverbed



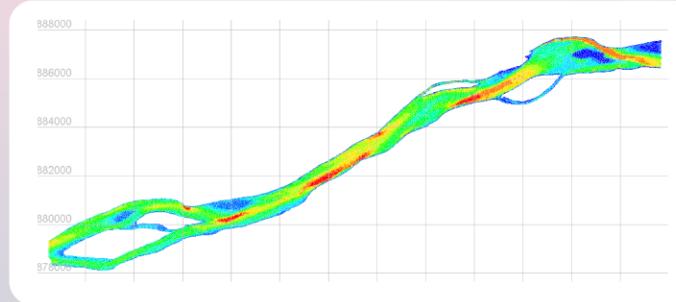
 **TELEMAC**

TELEMAC SIMULATION RESULTS

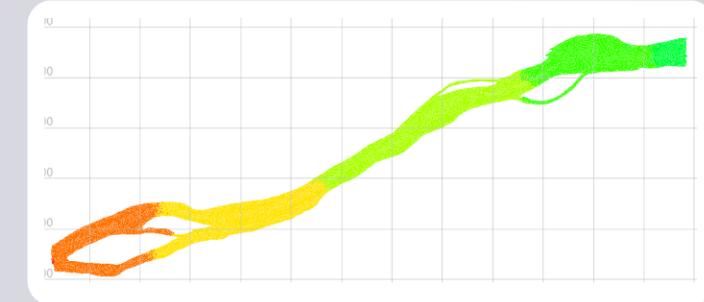
VelocityUV (Velocity U and Velocity V)



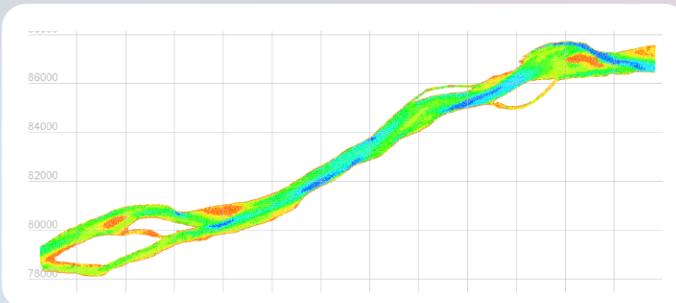
WaterDepth



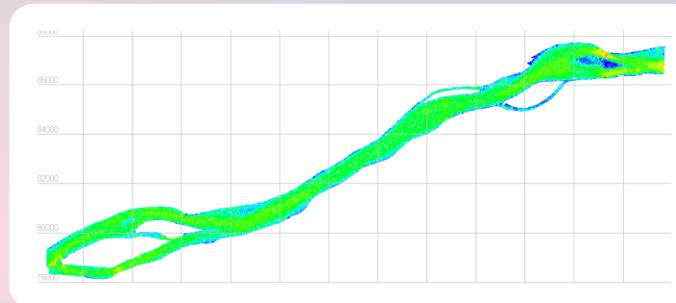
Free surface



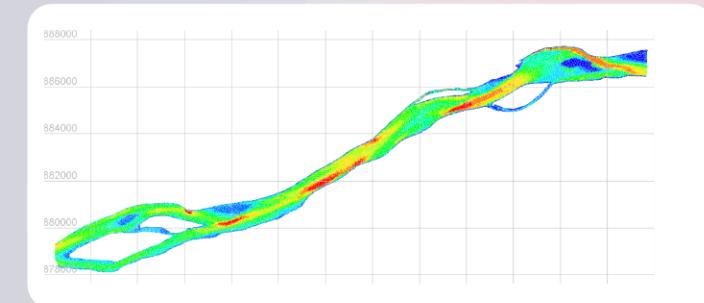
Bottom



Friction Vel.



WaterDepth



DEPTH CRITICAL AREA AROUND SVISHTOV DANUBE RIVER

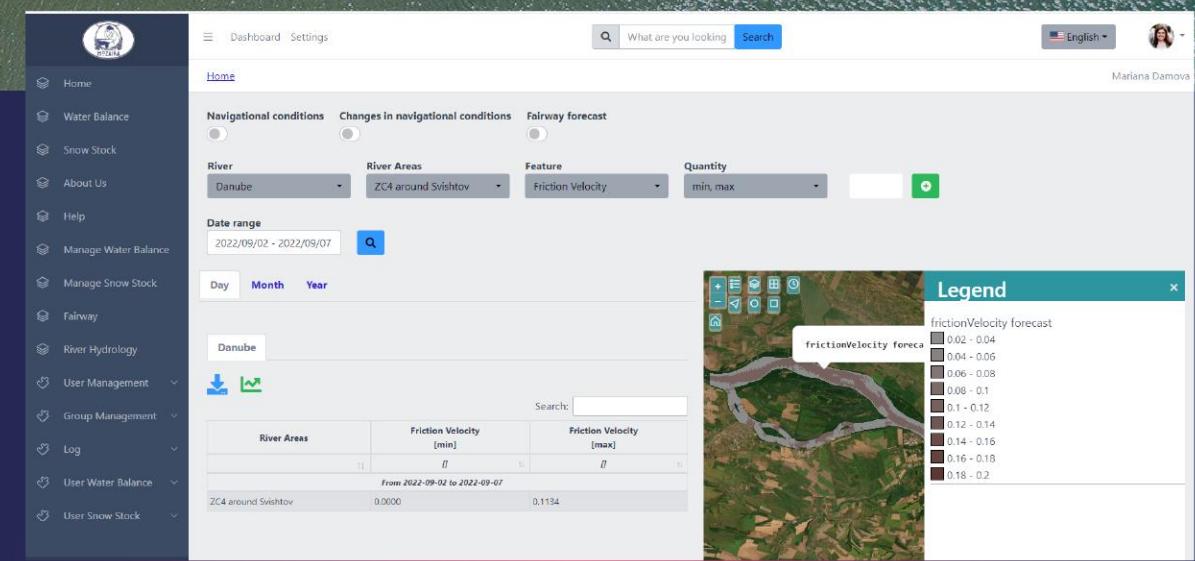
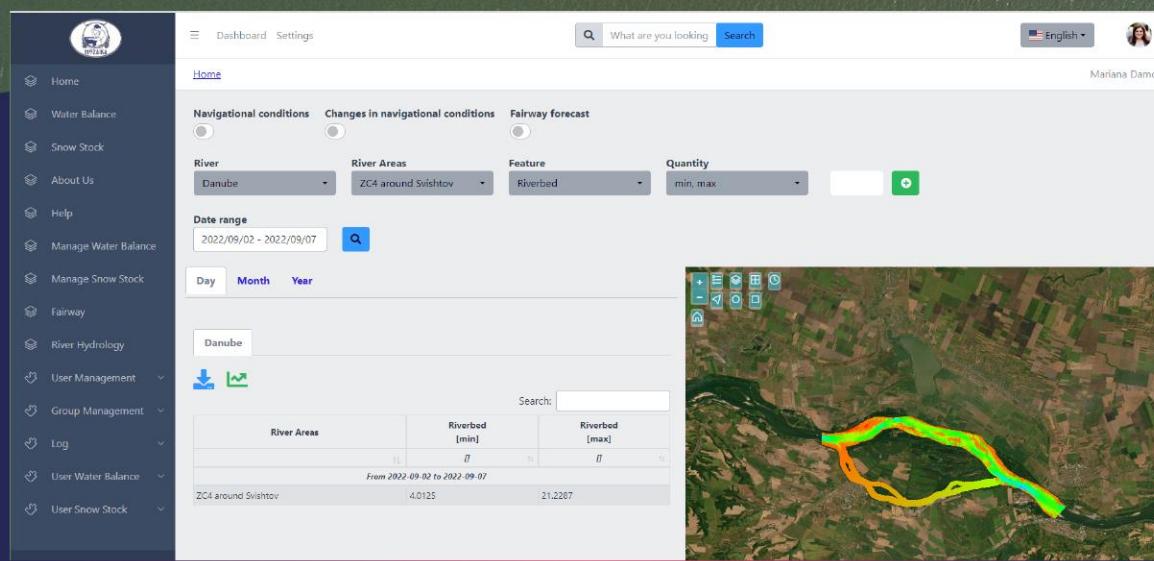
Real data for January 2020



Forecast for January 2020



INTEGRATION OF THE FORECASTED HYDRODYNAMIC MODEL INTO A WEB-BASED WORKFLOW BASED ON LINKED DATA E-INFRASTRUCTURE





Further we can use forecast on river runoff and turbidity to predict the changes in the fairway of navigable rivers.



FAIRWAY MODIFICATION VISUALIZATION

The screenshot shows the application's dashboard with a sidebar containing navigation links such as Home, Water Balance, Snow Stock, About Us, Help, Manage Water Balance, Manage Snow Stock, Fairway, River Hydrology, User Management, Group Management, Log, User Water Balance, and User Snow Stock. The main content area displays a map of the Danube river, specifically the ZC4 around Svishtov area. A search bar at the top right is set to "English". The interface includes tabs for "Fairway forecast" and "Changes in navigational conditions". A date range selector shows "2022/12/05 - 2022/12/10". Below the map is a table with columns for "River Areas", "Fairway [min]", and "Fairway [max]". The table shows data for ZC4 around Svishtov: Fairway [min] 16.2833, Fairway [max] 21.7132.

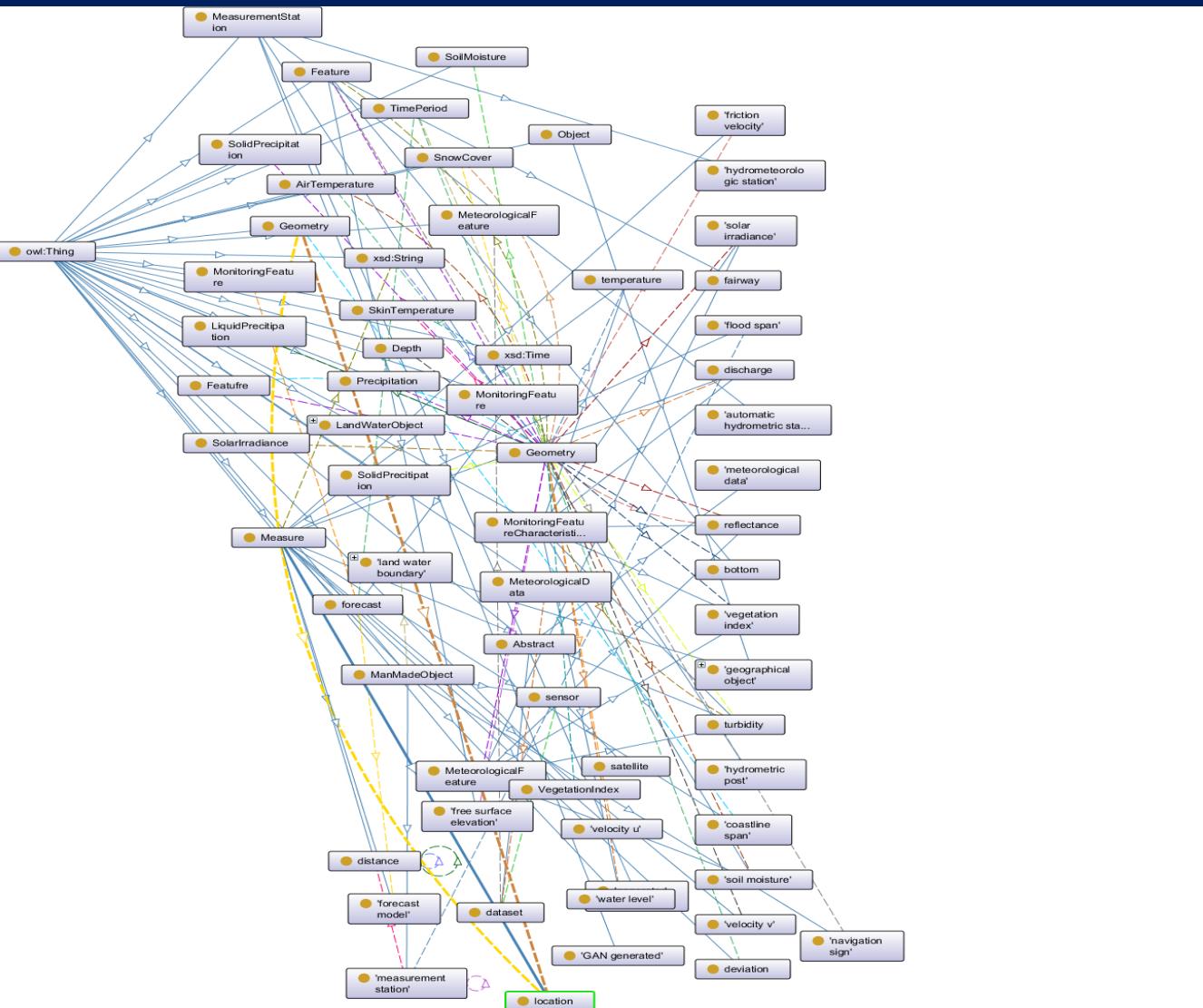
This screenshot is identical to the one above, showing the same application interface and data visualization for the ZC4 around Svishtov area on the Danube river.

This screenshot is identical to the ones above, showing the same application interface and data visualization for the ZC4 around Svishtov area on the Danube river.



ISMoSeDe Ontology

- 50 Classes -> 40 Classes -> 38 Classes
- 37 Properties -> 56 Properties -> 54 Properties



ISME-HYDRO Ontology

- 71 Classes
- 53 Properties

Semantic Data Lake Repository

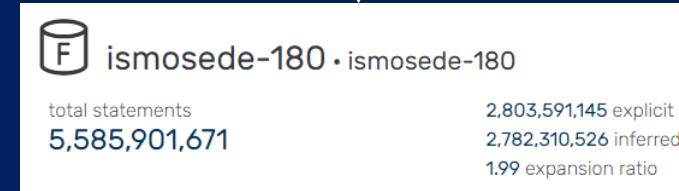
V1

Repository ismosede-66	
Type:	Free
Access:	Read/write
Total statements:	19,904,332
Explicit:	12,449,668
Inferred:	7,454,664
Expansion ratio (total/explicit):	1.60

V2

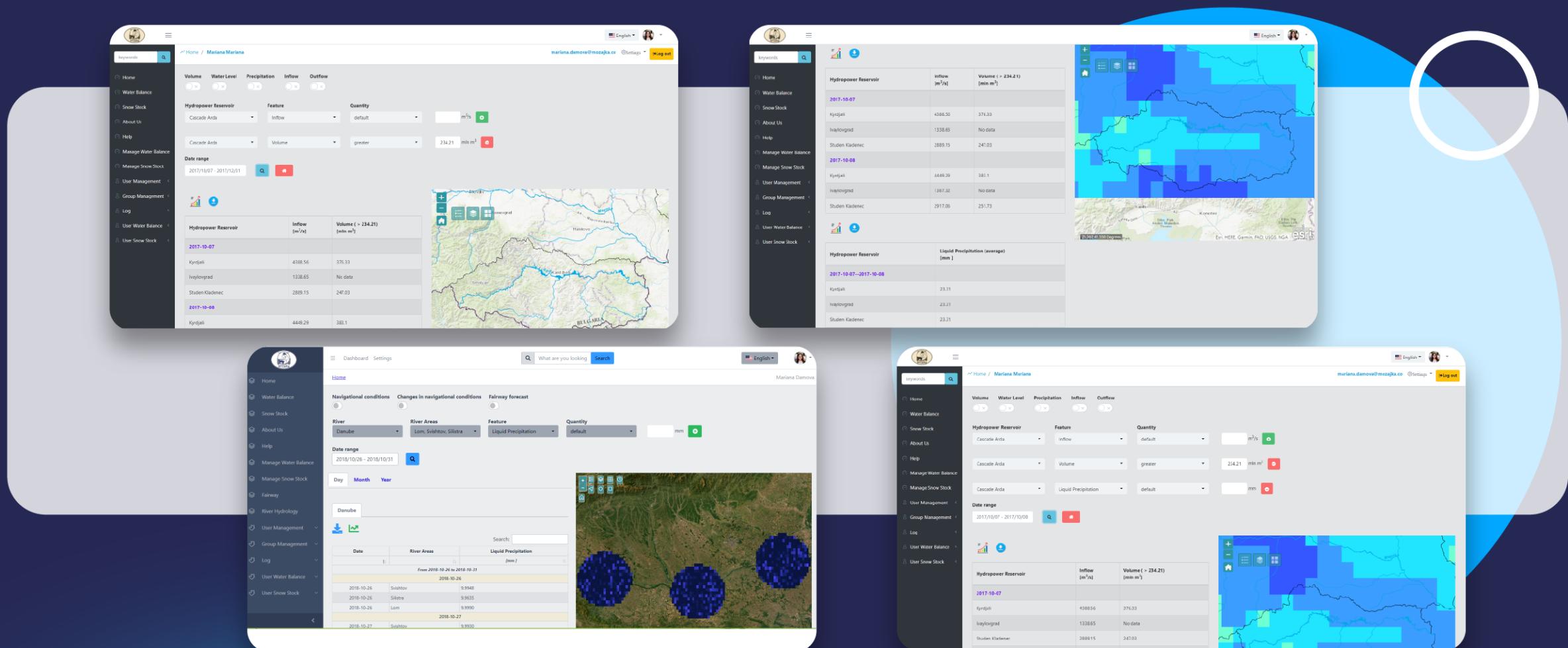


V3



- in-situ measurements
- Geospatial information
- Satellite data
- Fairway
- River dynamics
- Domain knowledge

THE APPLICATION – ISME-HYDRO



The image displays three screenshots illustrating hydrological monitoring and mapping:

- Top Screenshot:** A desktop application window showing a satellite map of a river network. A floating "Basemap Gallery" window is open, displaying various basemap options including "Imagery with Labels".
- Middle Screenshot:** A mobile device screen showing a topographic map of a river system, with labels for countries like Bulgaria and Greece.
- Bottom Screenshot:** A desktop application window titled "Dashboard - Settings" showing a list of monitoring stations and their skin temperatures. The stations listed are Krumovgrad, Djebel, Vethino, and Krumovgrad again. The dates range from 2016-09-26 to 2016-09-28. The skin temperature values are 279.8994, 279.8994, 279.8994, 279.7595, 279.8990, 279.8990, and 279.7595 respectively.



ACKNOWLEDGEMENT

- This work has been carried out within ESA Contract No
4000133836/21/NL/SC
- ESA NoR Sponsorship No 56090

A photograph of Earth from space, showing clouds and continents against a dark blue void. A large satellite, likely the International Space Station, is visible in the lower half of the frame, with its solar panels reflecting light.

THANK YOU



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