FORECASTING DISCHARGE AND WATER LEVELS OF RIVERS AND DAMS USING EARTH OBSERVATION AND AI

FORECASTING METHOD – EO4GEO


Satellite data


Geospatial position


In-situ measurements

METEOROLOGICAL AND ENVIRONMENTAL FACTORS


Precipitation


Snow cover


Soil moisture


Vegetation index

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

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THE PROBLEM

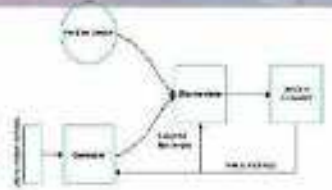
- The exploitation of rivers and hydropower reservoirs involves daily monitoring of the water resources, the meteorological conditions, the status of the river banks, the flood areas, etc.
- As maximum river discharge often results in flooding, it is of importance to provide with timely and reliable forecasts of discharge and water levels.
- Predicting river discharge and water levels has been a subject of hydrological modelling and a topic of serious research.
- However, only in recent years scholars and practitioners have turned to consider earth observation data for their studies, mainly to compare evidence of flood mapping.

FORECASTING METHOD – EO4AI

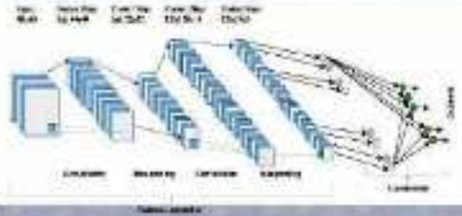
Satellite data

Geospatial position

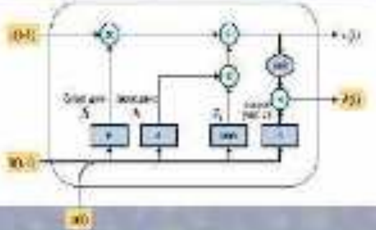
In-situ measurements



GAN



CNN



LSTM

METEOROLOGICAL AND ENVIRONMENTAL FACTORS

Turbidity

Surface reflection

Precipitation

Snow cover

Soil moisture

Wind

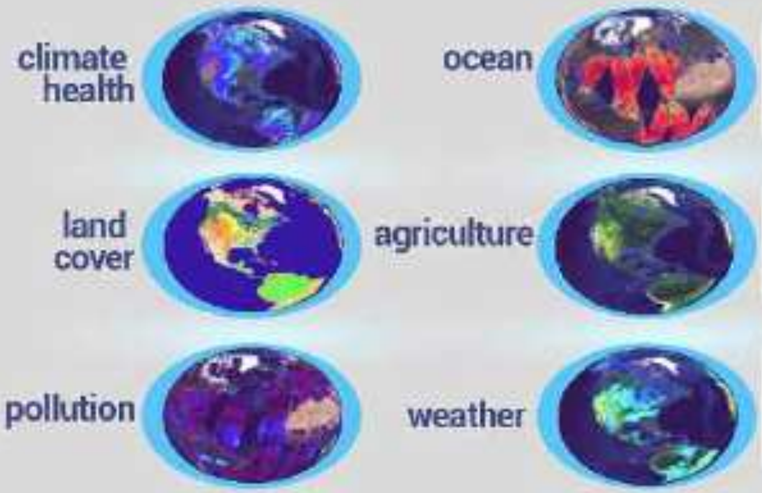
Vegetation index

Solar radiance

Velocity

EARTH OBSERVATION DATA

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



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

MISSING DATA GENERATION – GAN

GAN Architecture

Results missing data generation
Arda river

Meteorological feature	Satellite dataset name	Min/Max of generated values with the average formula	Min/Max of generated with GAN missing values
Soil moisture	ESACCI SOILMOISTURE C3S SSMV COMBINED 4326 025	-0.12	-0.44
Liquid precipitations	IMERG_DAY_LIQUID_SCALED_4326_01	0.00	1.62
Snow cover	MODIS_SNOW_4326_005	0.00	-0.10
NDVI	MOD13_NDVI_4326_005	0.00	0.06
Solid precipitations	IMERG_DAY_ICE_SCALED_4326_01	0.00	3.88

Danube river

Meteorological feature	Satellite dataset name	Min/Max of generated values with the average formula	Min/Max of generated with GAN missing values
Soil moisture	ESACCI SOILMOISTURE C3S SSMV COMBINED 4326 025	0.01	0.11
Liquid precipitations	IMERG_DAY_LIQUID_SCALED_4326_01	2.17	2.24
Snow cover	MODIS_SNOW_4326_005	0.28	0.56
NDVI	MOD13_NDVI_4326_005	0.30	0.11
Solid precipitations	IMERG_DAY_ICE_SCALED_4326_01	0.20	0.39

Satellite data from ADAM

Harmonized spatial resolution 1,1 km
Harmonized temporal resolution 1 day
Training data
2014 - 2019
Testing data
2020

IN-SITU MEASUREMENTS

- Discharge
- Water level
- Turbidity

GENERATE FORECASTS FOR

Rivers
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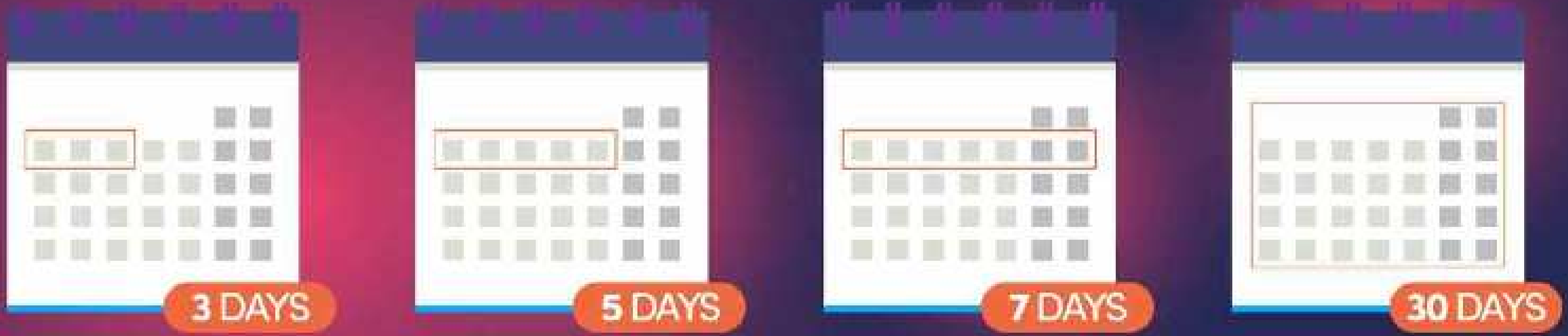
Water level
Turbidity

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

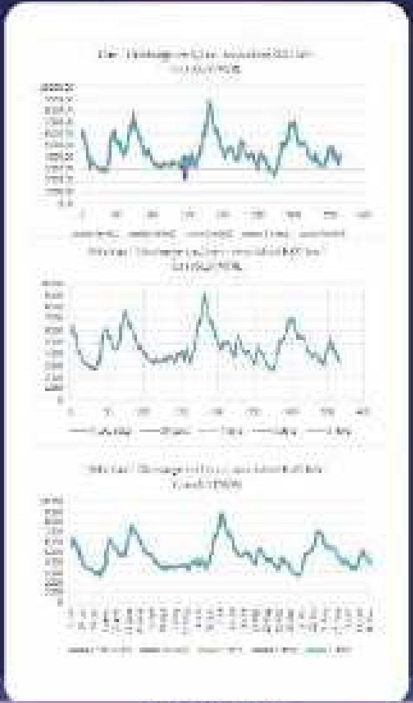
Svishtov (cm)				
	3 days	5 days	7 days	30 days
Conv2LSTM/SG5	2,83	3,24	2,86	-0,61
Conv2LSTM/SG11	3,07	2,06	3,53	4,67
Conv5LSTM/SG5	0,74	3,29	1,36	-1,61
Conv5LSTM/SG11	2,78	5,39	2,71	-0,7
Conv5LSTM/RL	12,78	13,86	15,78	16,71

Silistra (cm)				
	3 days	5 days	7 days	30 days
Conv2LSTM/SG5	2,69	1,93	0,06	-5,8
Conv2LSTM/SG11	1,48	8,2	8,81	-3,09
Conv5LSTM/SG5	3,93	0,09	2,58	6,25
Conv5LSTM/SG11	2,95	2,31	2,22	-3,88
Conv5LSTM/RL	3,83	12,12	11,58	19,68

EXPERIMENTS RESULTS DISCHARGE FOR THE DANUBE

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

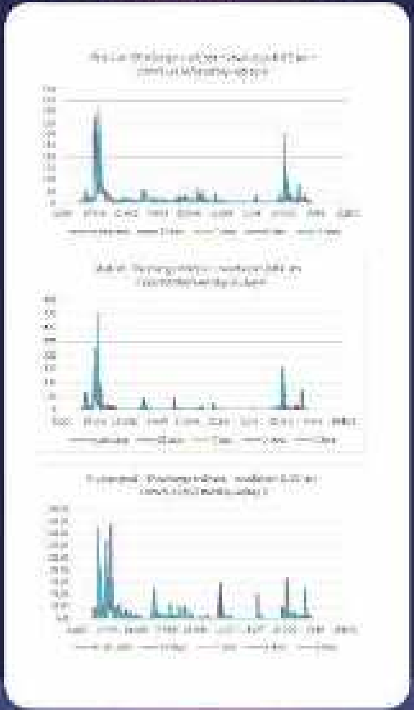
Svishtov Discharge	30 days	7 days	5 days	3 days
ConvSLSTM/RL	0,98	0,99	0,99	0,99
Conv2LSTM/RL	0,98	0,99	0,98	0,99
ConvSLSTM/SG5	0,99	0,99	0,99	0,99
Conv2LSTM/SG5	0,98	0,99	0,99	0,99
ConvSLSTM/SG11	0,99	0,99	0,99	0,99
Conv2LSTM/SG11	0,98	0,99	0,98	0,99



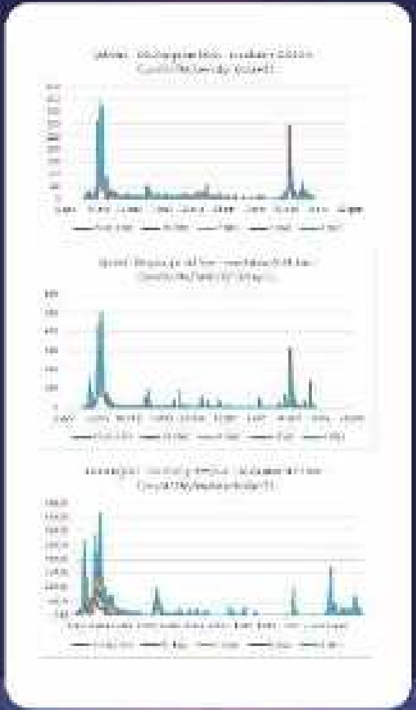
Silistra Discharge	30 days	7 days	5 days	3 days
ConvSLSTM/RL	0,99	0,99	0,99	0,99
Conv2LSTM/RL	0,99	0,99	0,99	0,99
ConvSLSTM/SG5	0,99	0,99	0,99	0,99
Conv2LSTM/SG5	0,99	0,99	0,99	0,99
ConvSLSTM/SG11	0,98	0,99	0,99	0,99
Conv2LSTM/SG11	0,98	0,99	0,99	0,99

Nash–Sutcliffe Efficiency equals 1 (NSE=1): 1 - SUMPRODUCT((Real measurement - Forecast)^2) / SUMPRODUCT((Real measurement - Avg of Real measurement)^2)

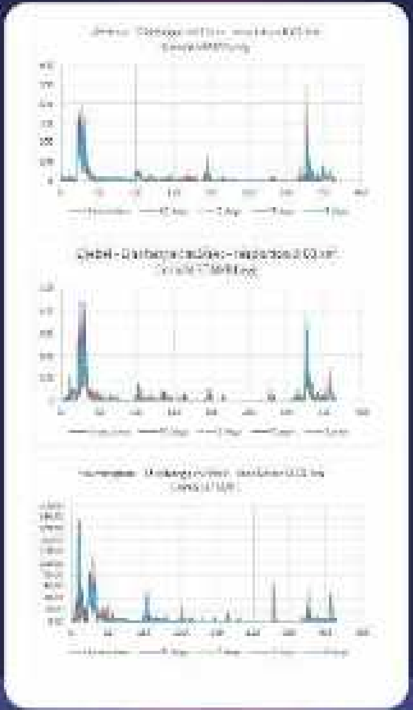
EXPERIMENTS RESULTS FOR DISCHARGE FOR ARDA



Vehtitsa Discharge	30 days	7 days	5 days	3 days
ConvSLSTM/RL	0,64	0,74	0,73	0,53
ConvSLSTM/SG5	0,67	0,65	0,49	0,66
ConvSLSTM/SG11	0,54	0,69	0,7	0,75
ConvSLSTM/SG11avg	0,34	0,44	0,55	0,61
ConvSLSTM/RLavg	0,63	0,36	0,64	0,71



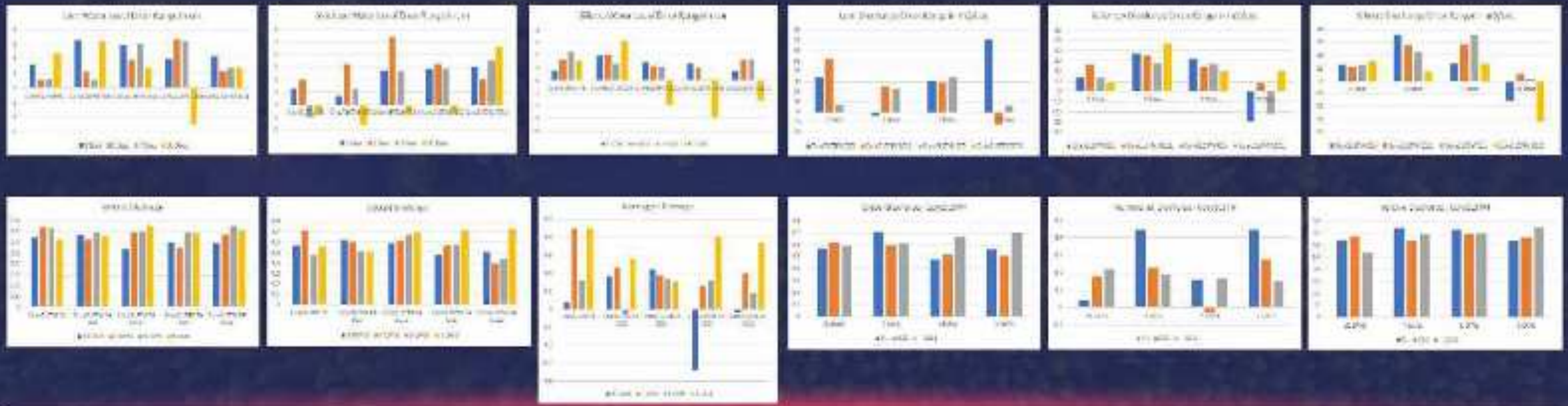
Djebel Discharge	30 days	7 days	5 days	3 days
ConvSLSTM/RL	0,57	0,71	0,48	0,56
ConvSLSTM/SG5	0,62	0,6	0,52	0,51
ConvSLSTM/SG11	0,59	0,61	0,67	0,7
ConvSLSTM/SG11avg	0,55	0,49	0,48	0,55
ConvSLSTM/RLavg	0,74	0,69	0,71	0,71



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

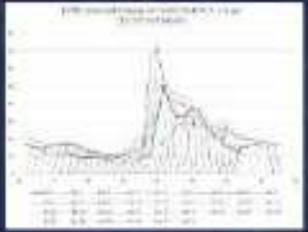
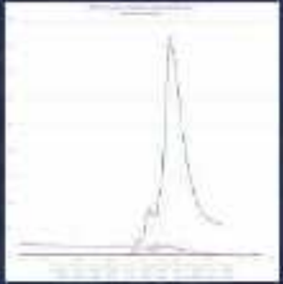
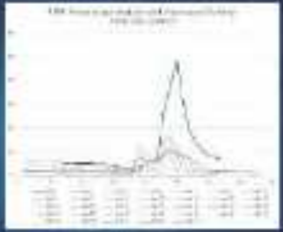
Official forecast

Training with 9 years of daily data

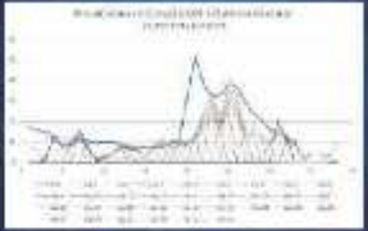
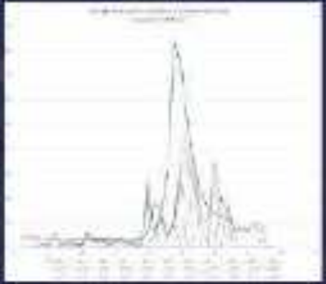
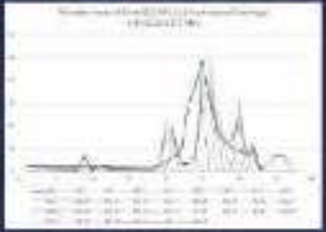
Training with 5 years of daily data

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

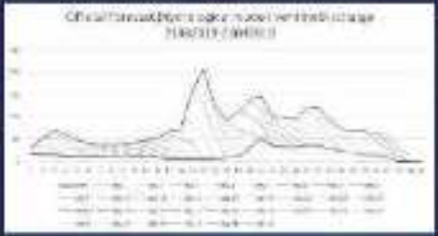
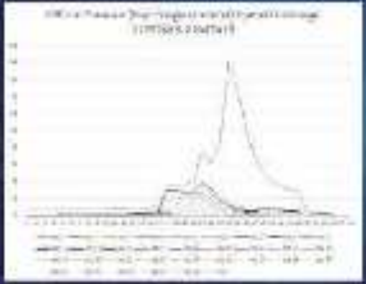
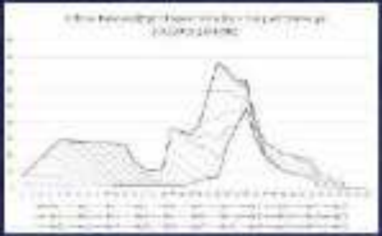
Traditional hydrological model

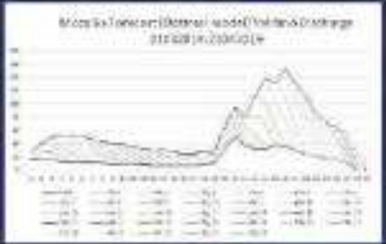
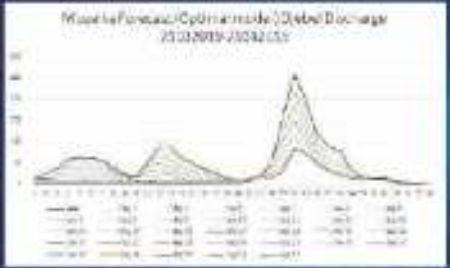
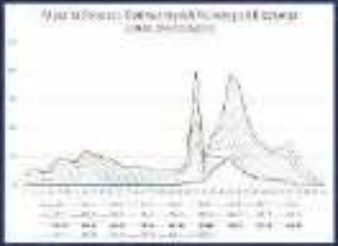
7 days model, training with 5 years daily data

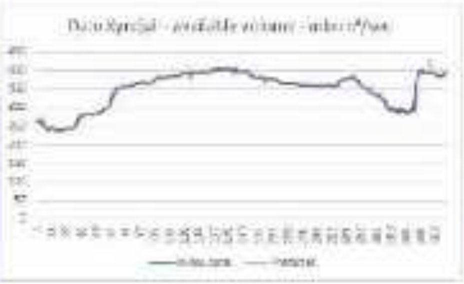
Traditional hydrological model

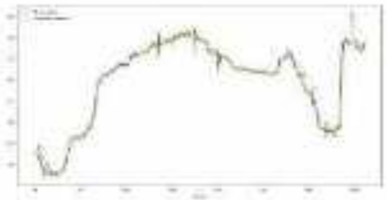




Best model, training with 5 years daily data

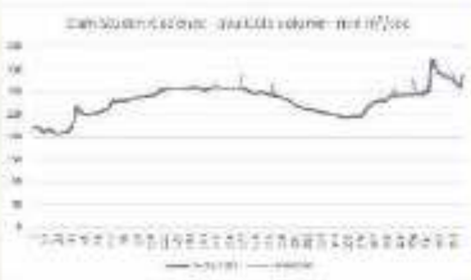
EXPERIMENTS RESULTS FOR AVAILABLE VOLUME OF THE DAMS OF CASCADE ARDA

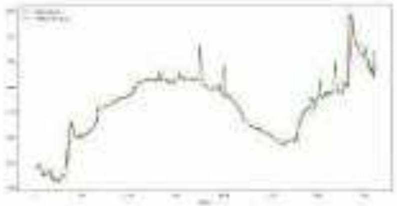




Kardjali	
Months	Error ratio in mln m3
January	3,17
February	3,74
March	4,39
April	3,03
May	2,38
June	2,37
July	3,32
August	1,38
September	1,43
October	4,42
November	5,27
December	

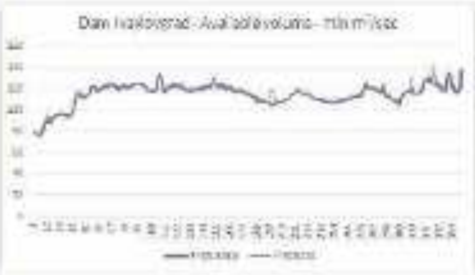
Total volume mln m^3	Useful volume mln m^3
497,2	300,0

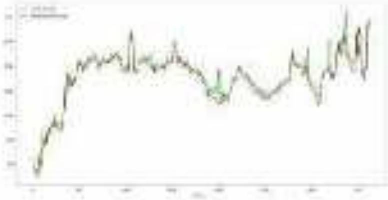




Studen Kladenets	
Months	
January	1,80
February	3,37
March	2,13
April	1,72
May	2,96
June	2,31
July	3,19
August	1,21
September	0,38
October	[illegible]
November	0,39
December	

Total volume mln m^3	Useful volume mln m^3
387,8	297,1

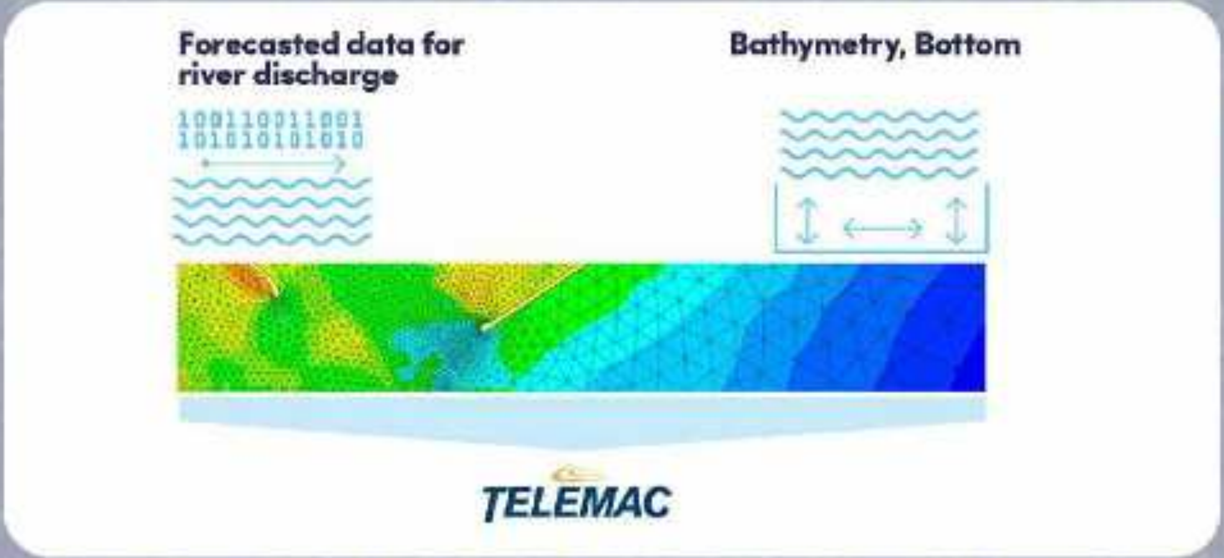




Ivaylovgrad	
Months	
January	1,06
February	[illegible]
March	6,96
April	1,61
May	[illegible]
June	[illegible]
July	3,27
August	1,18
September	[illegible]
October	1,96
November	1,38
December	

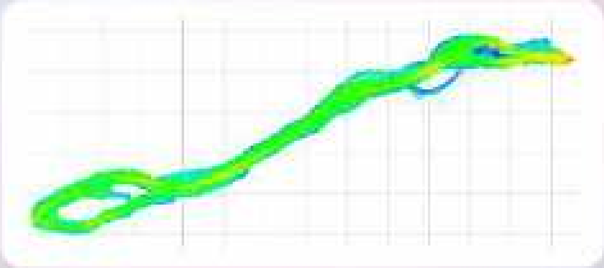
Total volume mln m^3	Useful volume mln m^3
156,7	97,2

FORECAST OF RIVER DYNAMICS

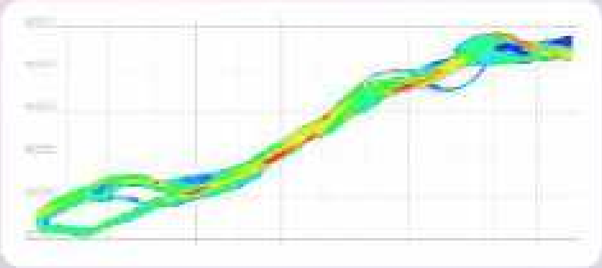


TELEMAC SIMULATION RESULTS

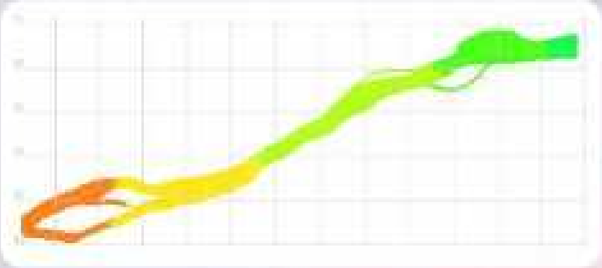
VelocityUV (Velocity U and Velocity V)



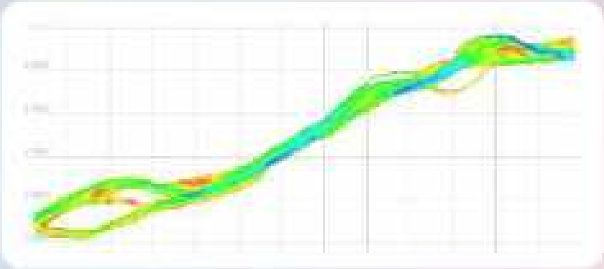
WaterDepth



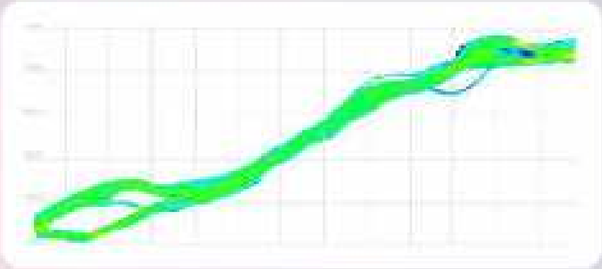
Free surface



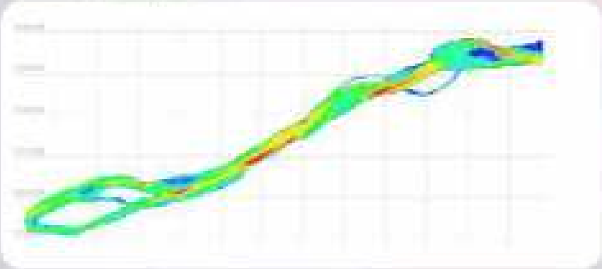
Bottom



Friction Vel.



WaterDepth



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DEPTH CRITICAL AREA AROUND SVISHTOV DANUBE RIVER

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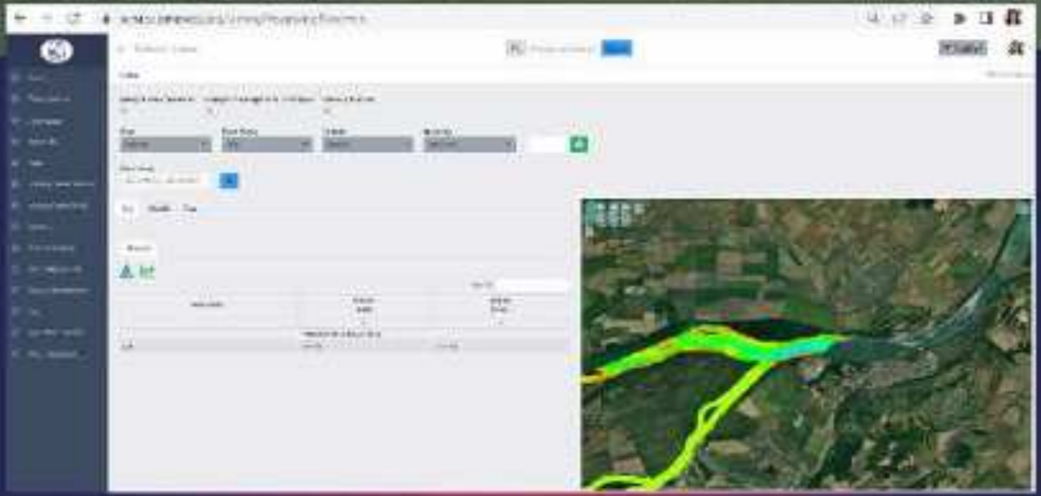
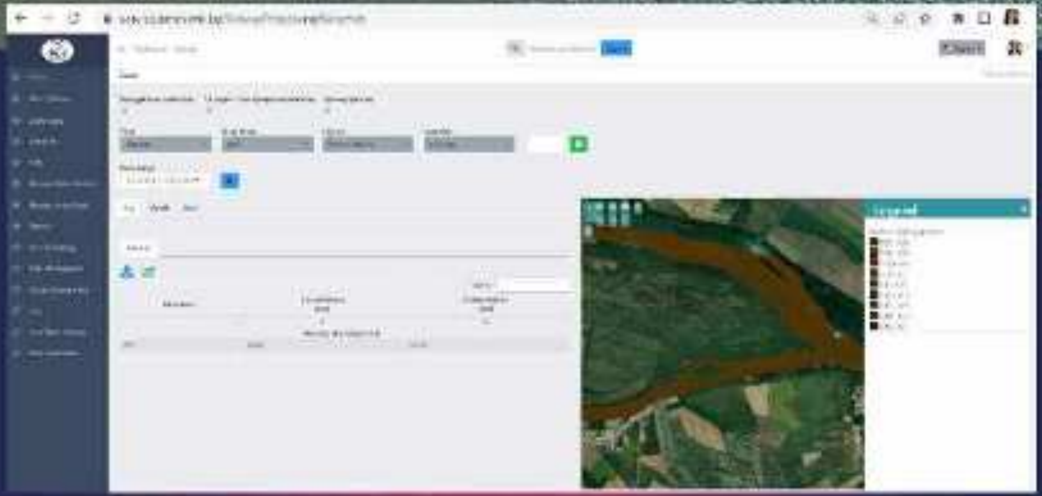
INTEGRATED FORECASTED HYDRODYNAMIC MODEL





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FAIRWAY MODIFICATION VISUALIZATION

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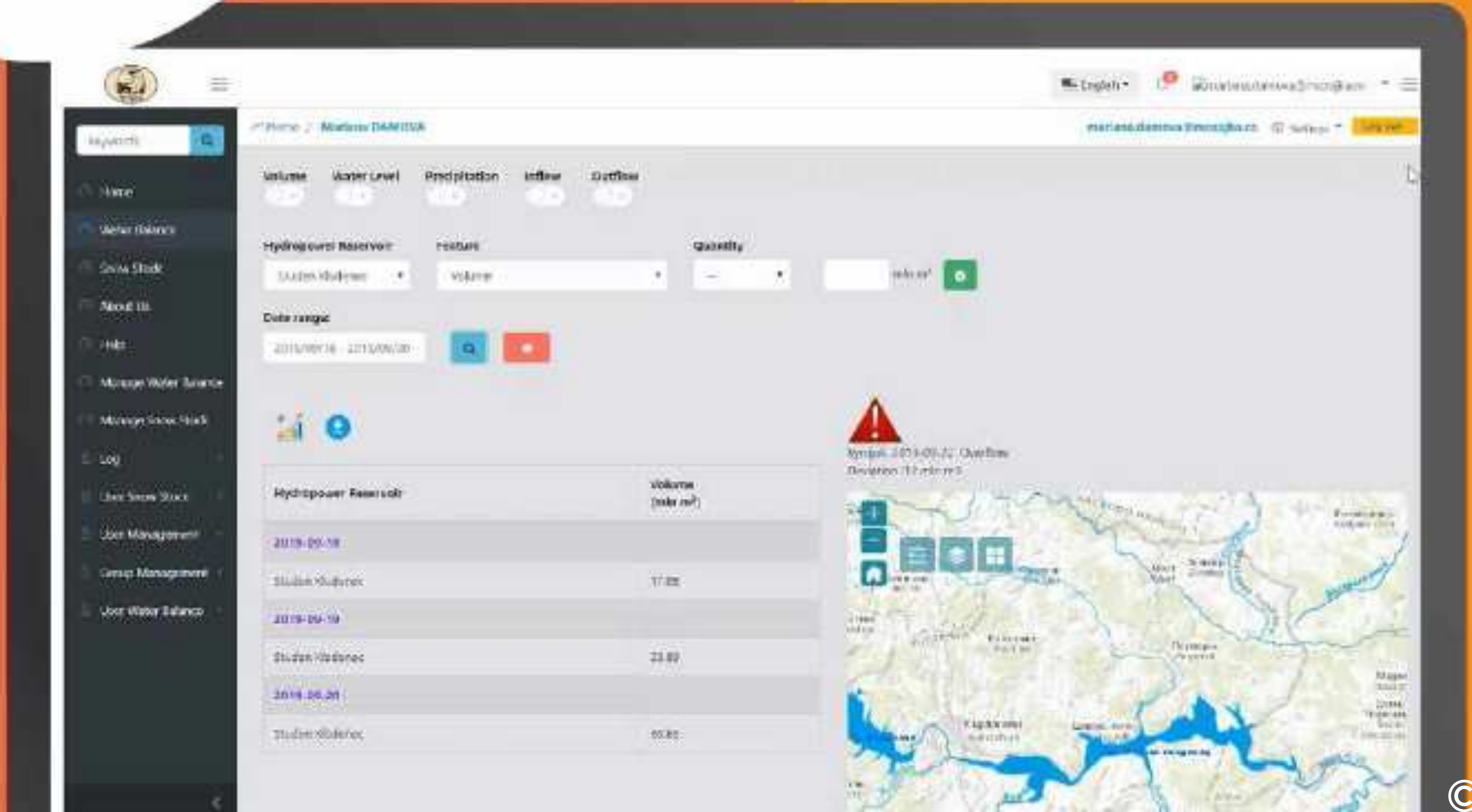
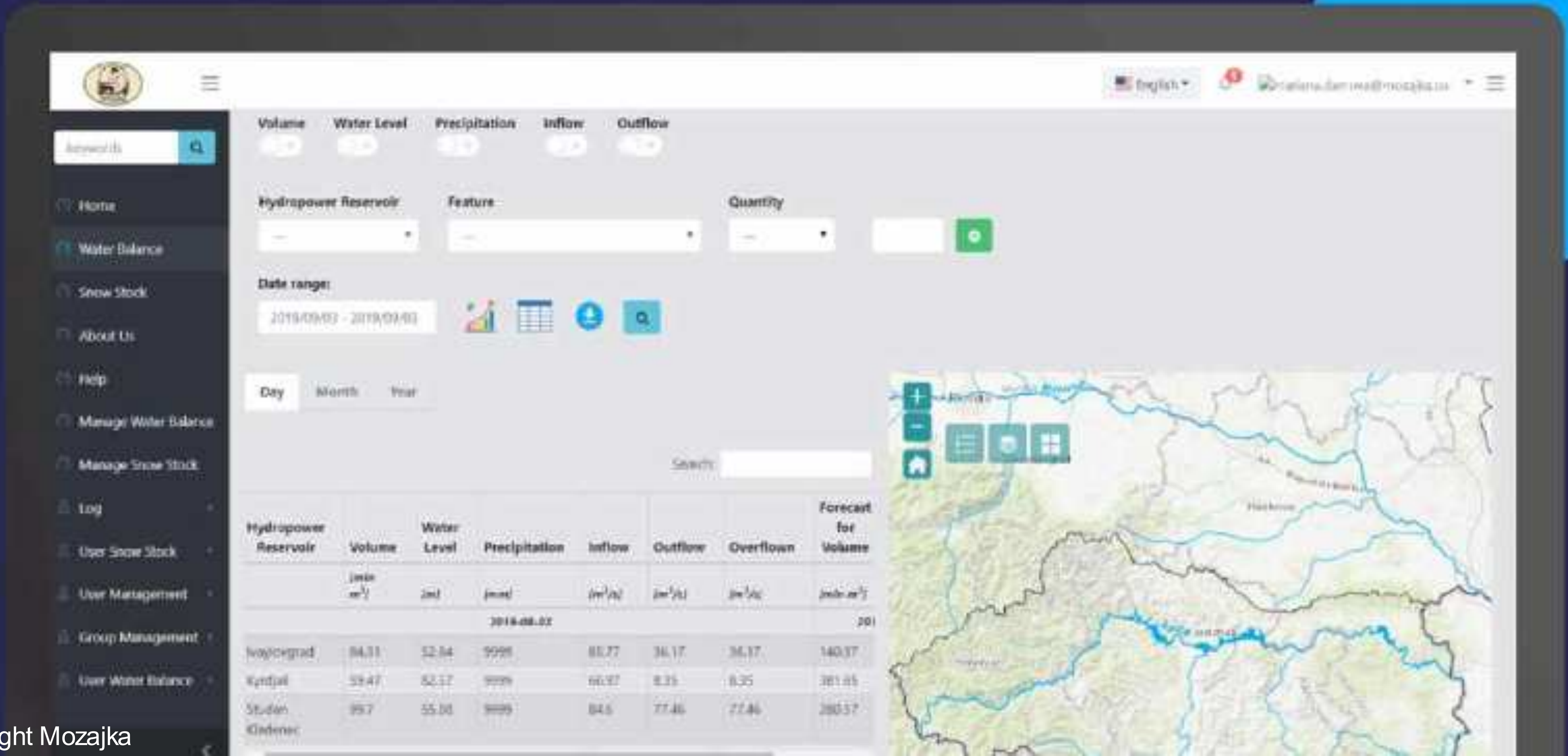
ALERTING


English
Volume
Water Level
Precipitation
Inflow
Outflow
Hydropower Reservoir
Feature
Quantity
Date range
Home
Log
User Management
Group Management
Hydropower Reservoir
Volume

THE APPLICATION – ISME-HYDRO



THE APPLICATION – ISME-HYDRO

ISME-HYDRO – AN INTEGRATED INFORMATION SYSTEM FOR THE BENEFIT OF WATER RESOURCES MANAGERS

- a disruptive web-based workflow
- that makes use of a combination of AI methods
- and delivers a viable and hands-on solution

WE ARE READY TO ASSESS & DEPLOY ALL AROUND THE WORLD.
WATER RESOURCES MANAGEMENT AND MORE

ACKNOWLEDGEMENT

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ESA NoR Sponsorship No 56090

THANK YOU

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For further information ISMoSeDe project – http://ismosede.bg