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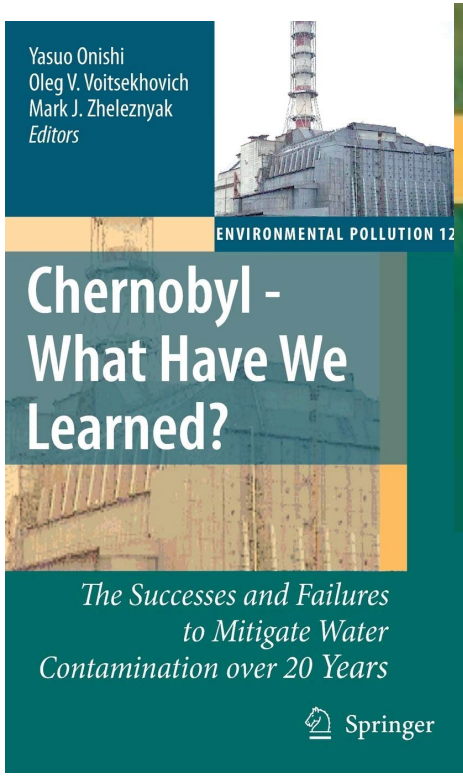
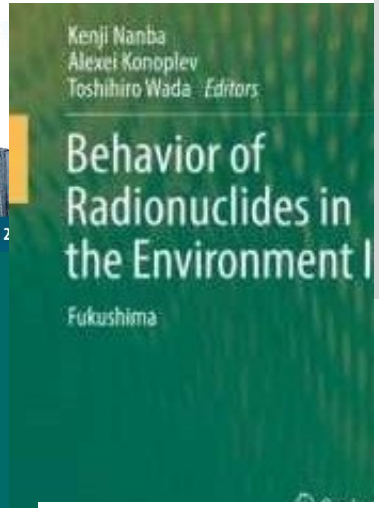
Chairman, Scientific- Expert Council State Environmental Inspectorate of Ukraine www.dei.gov.ua

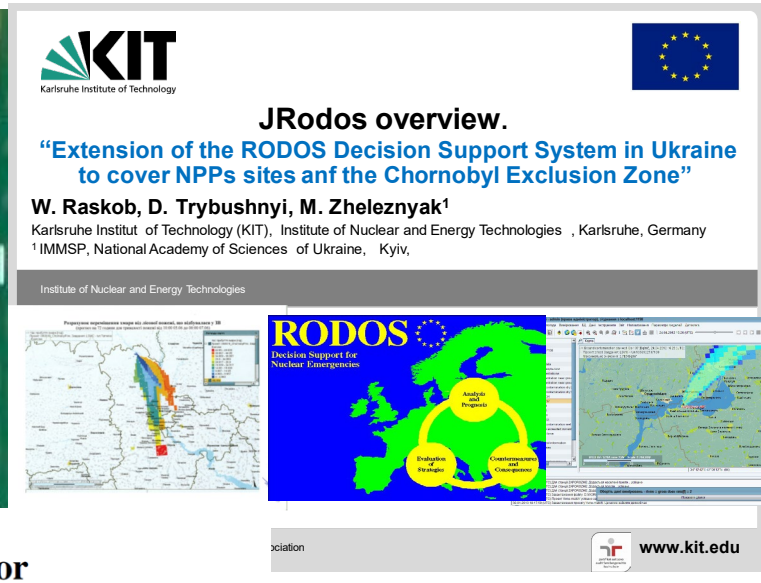
Member, Scientific- Technical Council, State Agency of Ukraine on Exclusion Zone Management https://dazv.gov.ua

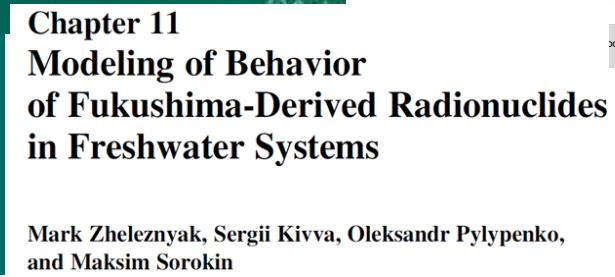
Modeling Environmental and Health Risks from Infrastructure Damage: Nuclear and Hydropower

My background till 24.02.2022:









Research before 1986:

"Zheleznyak-Pelinovsky's y equations (1985) have been used extensively in numerical calculations (tsunami) for many years.(Manolin et al 2009)
https://meetingorganizer.copernicus.org/EGU2009/EGU2009-8783.pdf

NATIONAL ACADEMIES Sciences Engineering Medicine

Workshop: Addressing Environmental Damage in Ukraine
Session 5: Environmental Impacts: Risks from Damage to Nuclear Infrastructure

May 3, 2024

Since 24.02.2022 –International team of experts worked for the assessment of environmental damages and losses on the basis of previous joint developments

Most active team members:

M.Sorokin, R,Bezhenar, A. Demydenko, S.Kivva, V, Maderich, I,Brovchenko. A.Morozov. *IPMMS NASU* , O.Pylypenko *AFU - IPMMS*

G.Laptev, V.Protsak, V.Kanivets, O.Ischuk, A.Oreschenko, O.Voitsekhovich, V.Osadchiy
Ukrainian Hydrometeorological Institute NASU and SSES

S,Kirieiev and team *SSE ECOCENTRE of SAUEZM, Chornobyl*

M, Talerko and T.Lev *Institute of Safety Problems of NPPs, NASU*

O, Nasvit *Ukrainian Center of Environmental and Water Projects ATSU*

L, Tabachny, I, Kokot *Ukrainian Hydrometeorological Center SSES*

M.Gusyev , K,Nanba *IER, Fukushima, Japan*

D Trybushny, W.Raskob *Karlsruhe Institute Technologies, Germany*

B. Faybishenko *LLBNL, Berkley, CA*

Assessment results users

- State Nuclear Regulatory Inspectorate of Ukraine
- State Emergency Service of Ukraine
- State Environmental Inspectorate of Ukraine
- State Agency of Ukraine on Exclusion Zone Management
- Kyiv City State Administration, Emergency response Department
- ...*****....

Backgrounding & Supporting Institutions and Programs :

- NAS Ukraine (A.Zagorodniy)
- National Research Foundation of Ukraine, Project no. 2020.01/0421 (R.Bezhenar)
- Parliamentary Committee on Environmental Policy and Nature Management (O.Kryvoruchkina, A.Moroz)
- World Data Center for Geoinformatics and Sustainable Development, Ukraine (M.Zgurovskyi)
- Project of SATREPS program funded by JICA and JST, Japan “ Fukushima- Chornobyl (K.Nanba)

M. Zheleznyak[1]*, G. Donchyts[2], V. Maderich[3], I. Dronova[4], P.Tkalich[5], D.Trybushnyi[6], B.Faybishenko[7], A.Dvorzhak[8]

[1]Institute of Environmental Radioactivity, Fukushima University, Japan.
[2]Deltares, Delft, Netherlands.
[3]Institute of Mathematical Machine and System Problems, National Academy of Science, Kyiv, Ukraine.
[4]University of California Berkeley, CA , USA.
[5]Tropical Marine Science Institute, National University of Singapore,
[6]Institute for Thermal Energy Technology and Safety, Karlsruhe Institute of Technology, Karlsruhe, Germany.
[7]Energy Geosciences Division, Earth and Environmental Sciences Area, Lawrence Berkeley National Laboratory, Berkeley, CA , USA.
[8]Centre for Energy, Environment and Technology Research, Madrid, Spain

Science

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LETTER

Ecological footprint of Russia's Ukraine invasion

MARK ZHELEZNYAK , GENNADII DONCHYTS, VLADIMIR MADERICH, IRYNA DRONOVA, PAVEL TKALICH, DMYTRO TRYBUSHNYI, BORIS FAYBISHENKO, AND ALLA DVORZHAK

Affiliations

15 September 2022 vol 377

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….**The international science community can complement the top-down, government-driven, centralized approach by Ukrainian institutions by conducting robust, decentralized, distributed research.** Researchers, managers, and funding institutions can help by developing collaborative projects that focus on the **ecological impacts of the war, including assessment of the costs of remediation efforts**.

.. We hope that the body of the knowledge accumulated through such studies would provide a reference point for subsequent remediation plans in Ukraine as well as evidence **to support post-war reparation claims to Russia.** It could also provide a blueprint for wartime damage and recovery assessments in other parts of the world affected by military conflicts.

List of the R &D tasks addressing Environmental Damage in Ukraine during the war:

1. Emergency preparedness to reduce environmental and health risks from infrastructure damage (zoning of high-risk areas, evacuation plans and recommendations for other measures to protect the population).
Tools: scenarios produced by validated models of environmental contamination and hazards (e.g. flooding), exposure dose predictions for nuclear predictive modelling.

2. Emergency response - implementation of emergency plans to be updated on-line monitoring data and refined modelling
Tools: strengthening of on-line monitoring networks and model-based decision support systems (ensemble modelling)

3. Fixing the evidence of environmental damage to support post-war reparation claims to Russia.
Tools: Strengthening of measuring devices & laboratory equipment & remote sensing data for relevant agencies (SEI, SNRIU, SAUEZM).

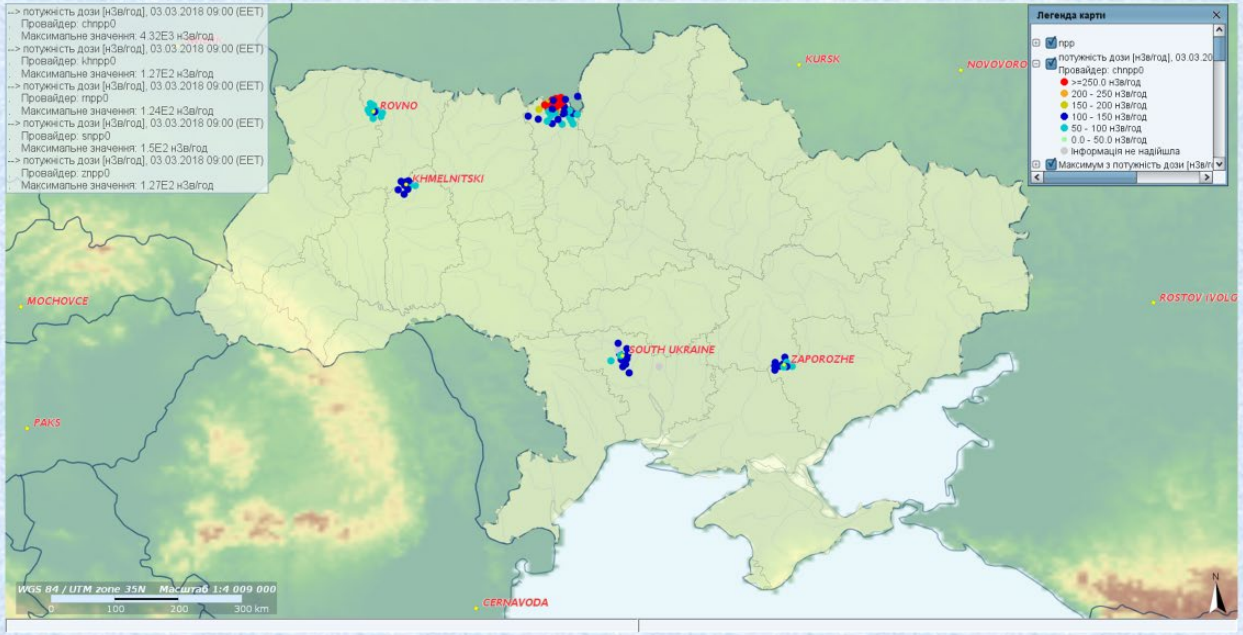
4. Implementation of internationally recognized methods for quantifying environmental damage and losses.
Tools: Modification and testing for these war conditions of best practice approaches from the USA and other countries.

5 Feasibility studies for the analysis of optimal remediation efforts, including assessing the costs of engineering projects, their economic, environmental and health impacts.

Our view today - until the end of the war, the highest priority should be given to tasks 1-3 from this list. We now present the results of our work on tasks 1 and 2, for emergency preparedness and response to damage to nuclear and hydropower facilities.

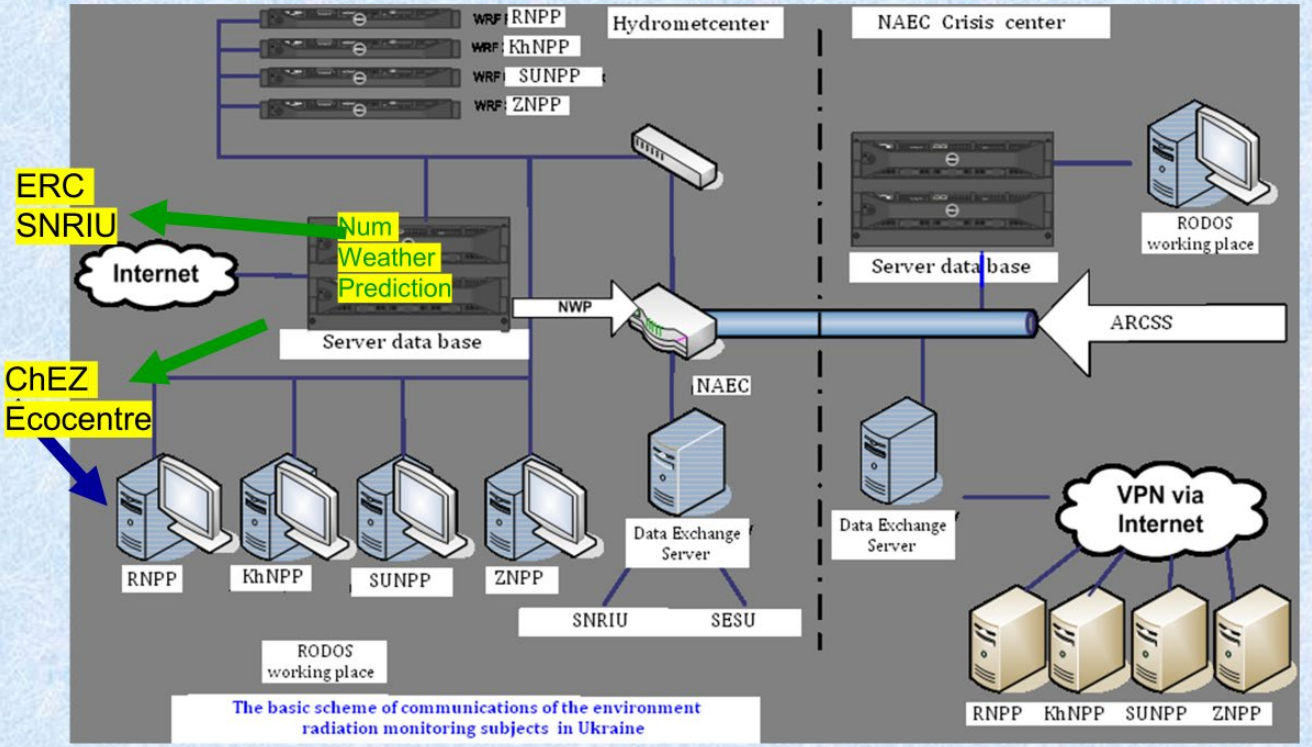
Automated system for control of the radiation situation

There are 5 separated automated systems in Ukraine : Rivne NPP, Khmelnytskyi NPP, South Ukraine NPP, ZNPP, Exclusion zone of Chornobyl NPP.
In the picture, the results of the dose rate measurement on March 3, 2018. The highest value was detected at the Exclusion zone of Chernobyl NPP and was 7000 μSv/h



Slide UHMC, 07.2018

The overall structure of the RODOS - Ukraine network



Slide UHMC, 07.2018

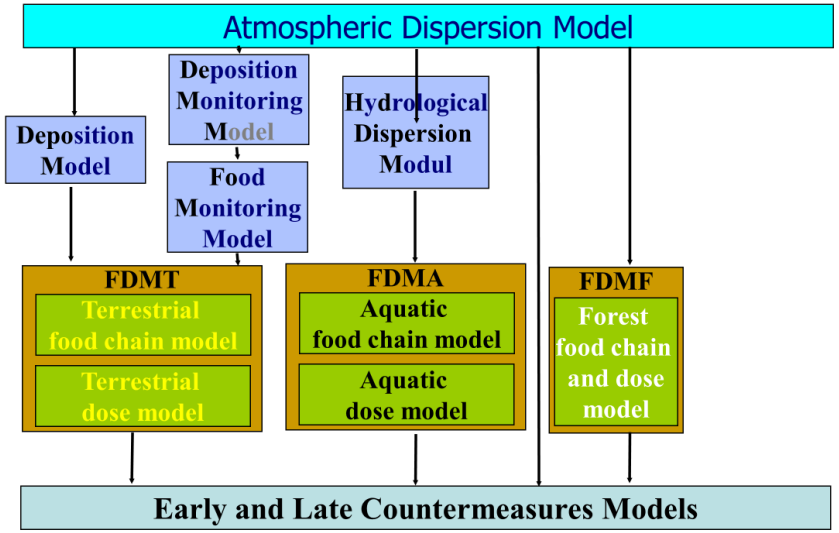
Emergency response system for offsite nuclear emergency in Ukraine before the war: JRODOS centers and automatic monitoring networks

EC Rodos – real time online decision support system for nuclear emergency management developed under auspices of EC EURATOM Programme since 19
IMMSP NASU – the key developer of Hydrological Dispersion module of RODC
JAVA software interfaces Software:

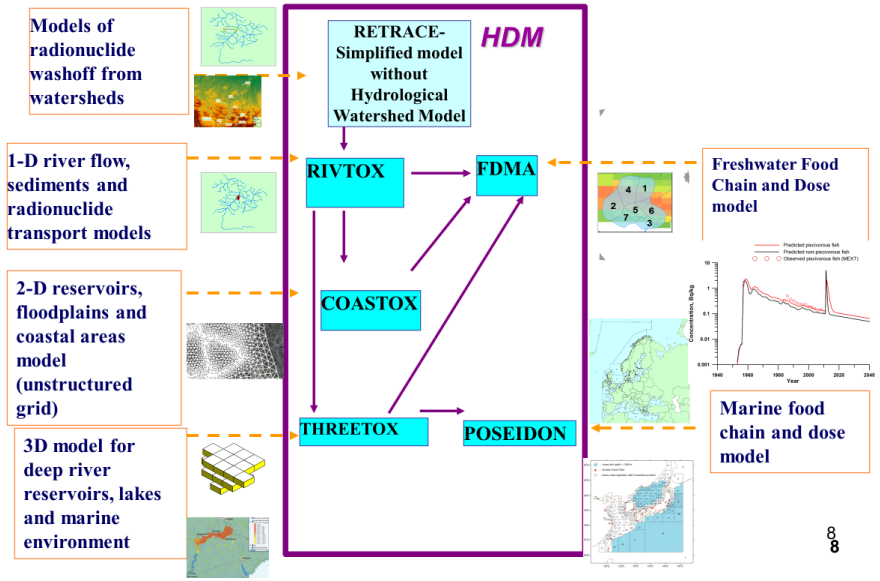
HP-UX and Linux (RODOS) since 1992,

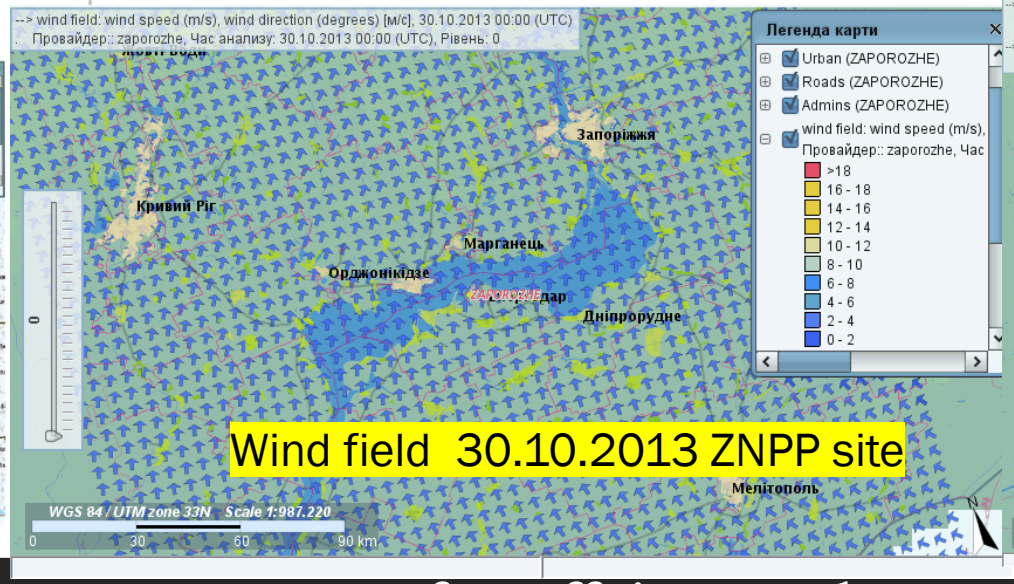
Multiplatform Java system: MS Windows, Linux and Mac OS (JRODOS , 2007)

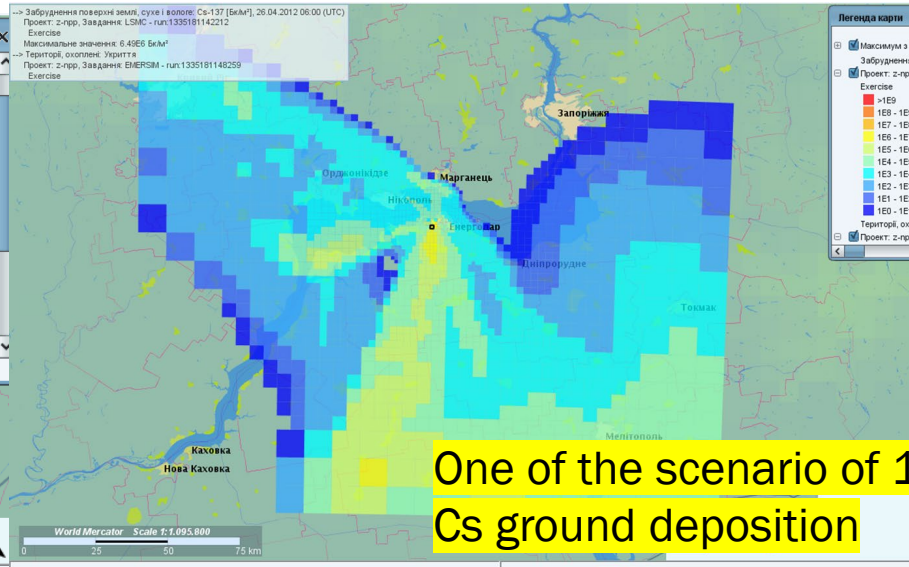
Radio-ecological and dose models in RODOS



Hydrological Dispersion Models (HDM) of EC Decision Support System for Nuclear Emergency- RODOS

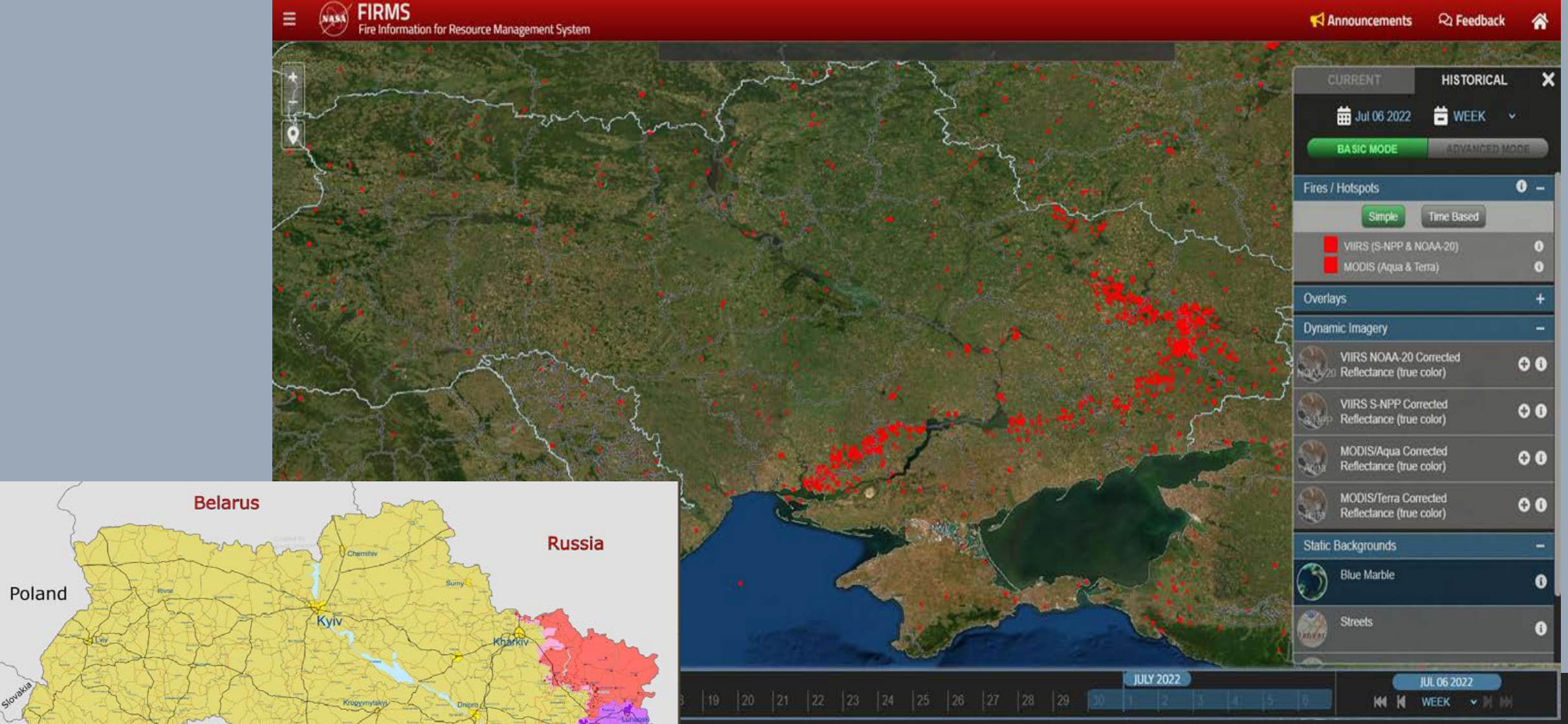




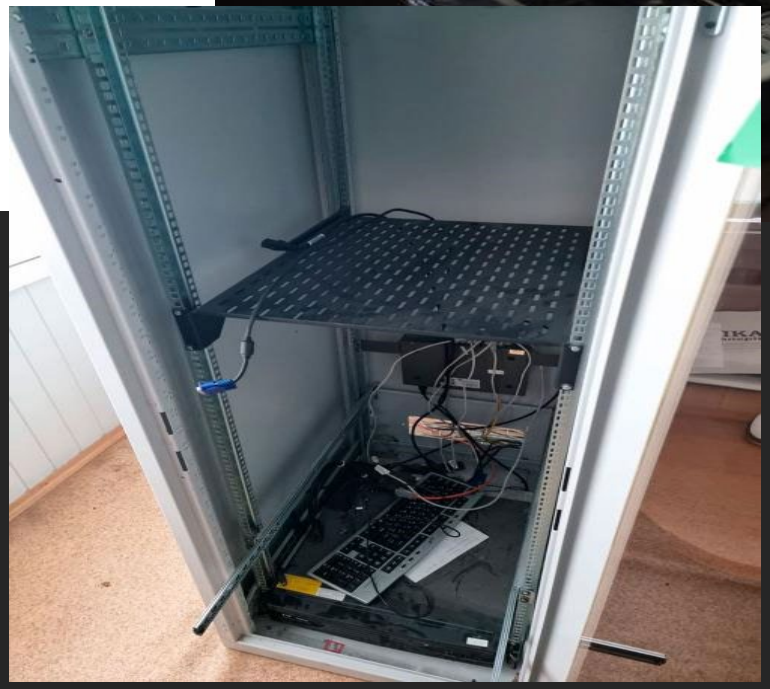


Emergency response system for offsite nuclear emergency in Ukraine before the war: JRODOS models and implementation

Forest fire
at ChNPP
5.06.2018

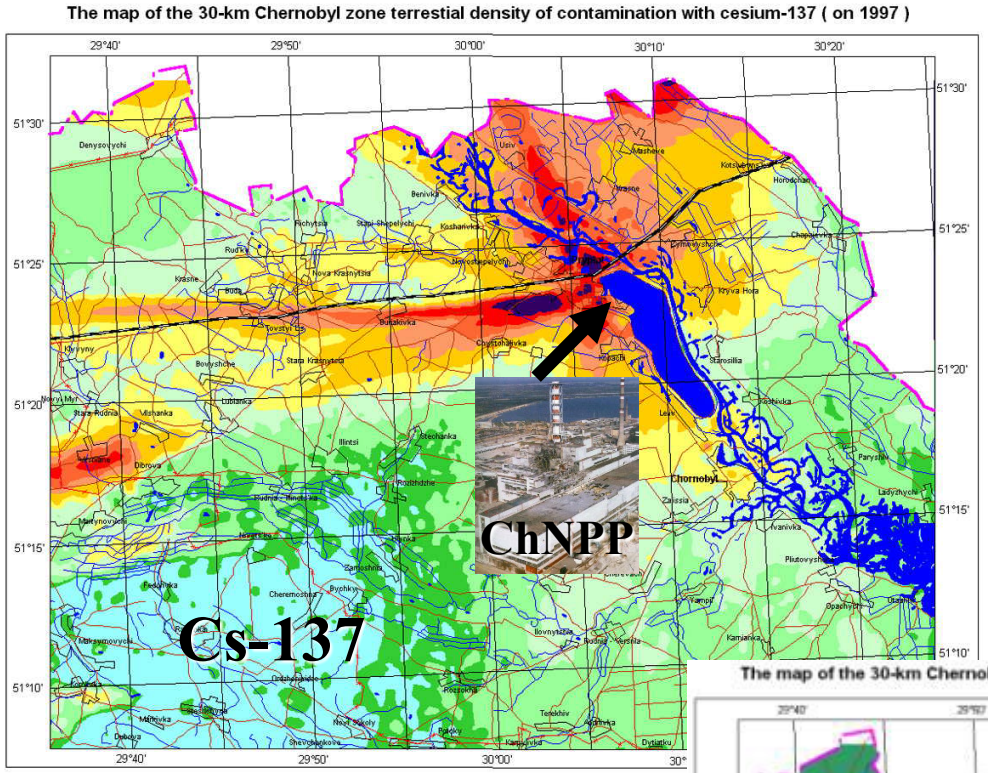


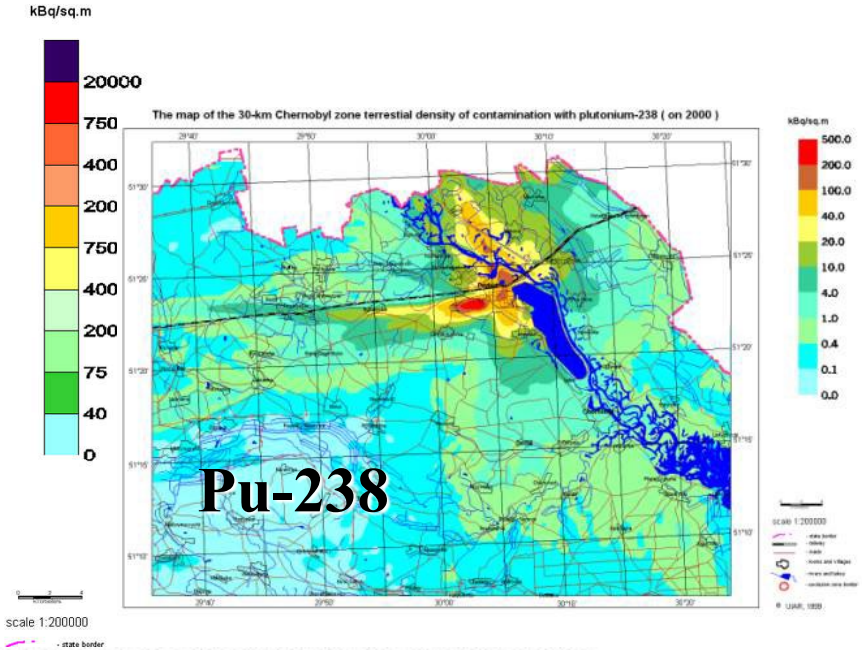
Frontline and wildfire June 6, 2022



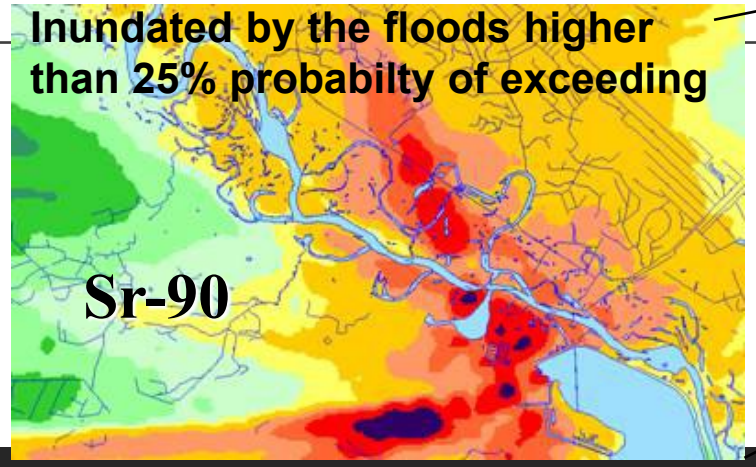
RODOS server and workstations of the RODOS users

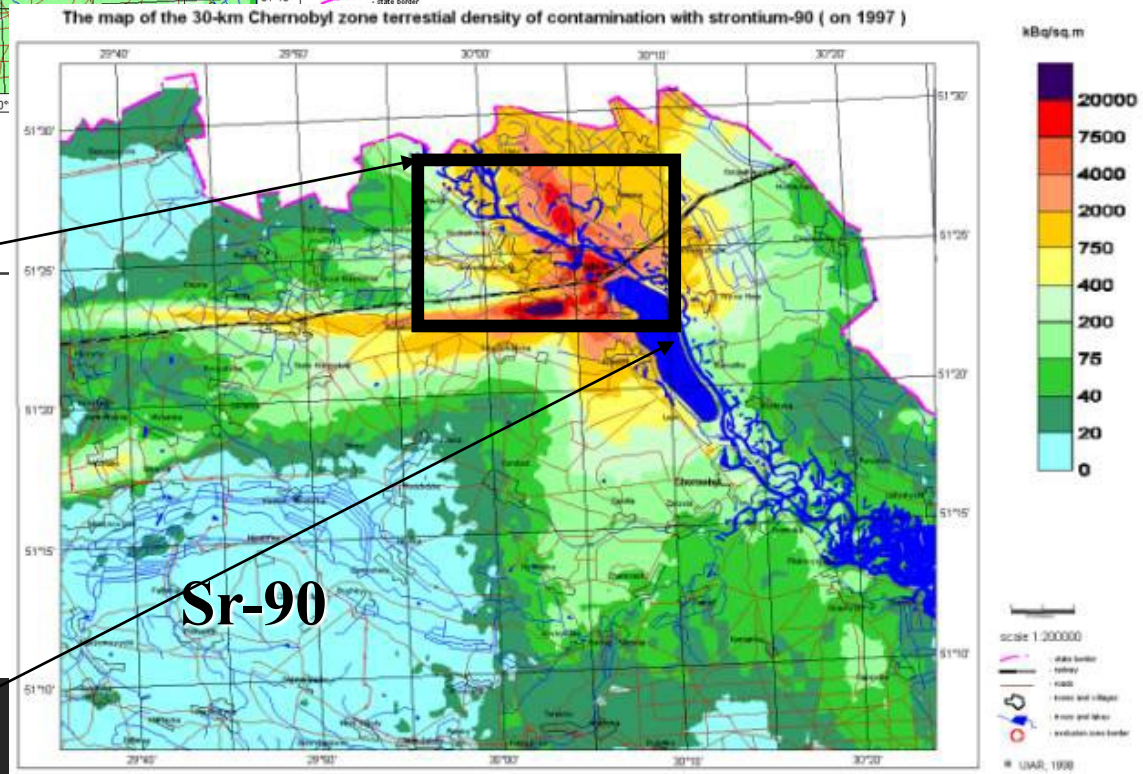
Premises Information center SSE Ecocentre, Chornobyl after de-occupation 04.2022





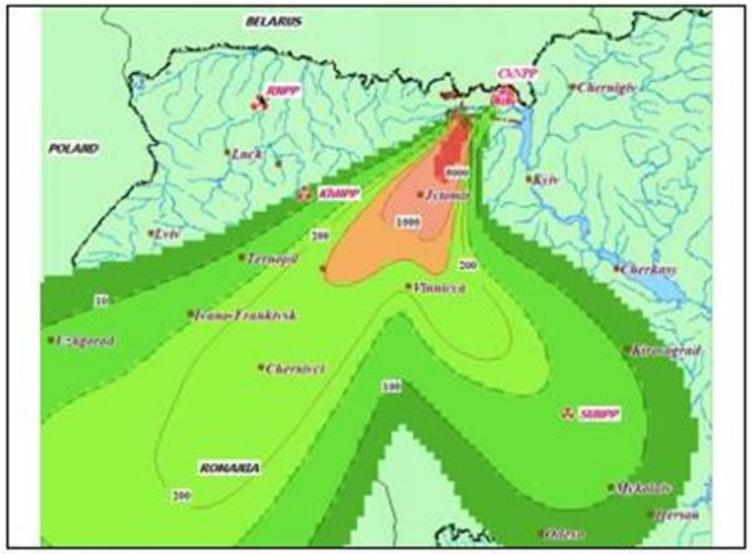
Pripyat River Floodplain at ChNPP



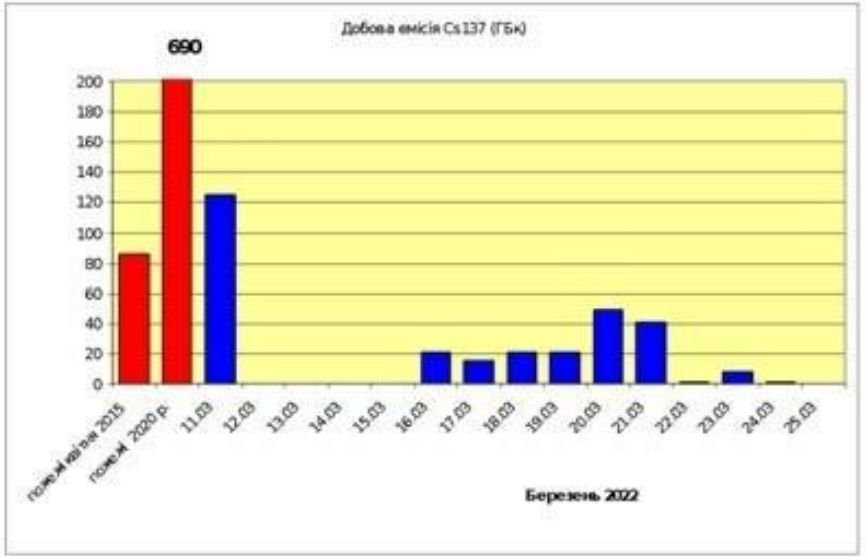


“Red Forest “

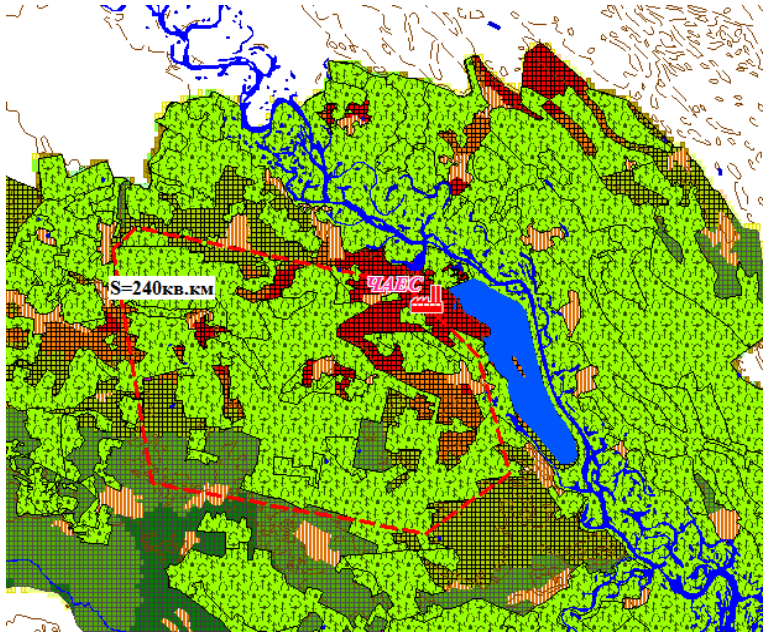
Active burning points in the Kyiv region for the period from 11 to 18 March 2022 according to https://firms.modaps.eosdis.nasa.gov/



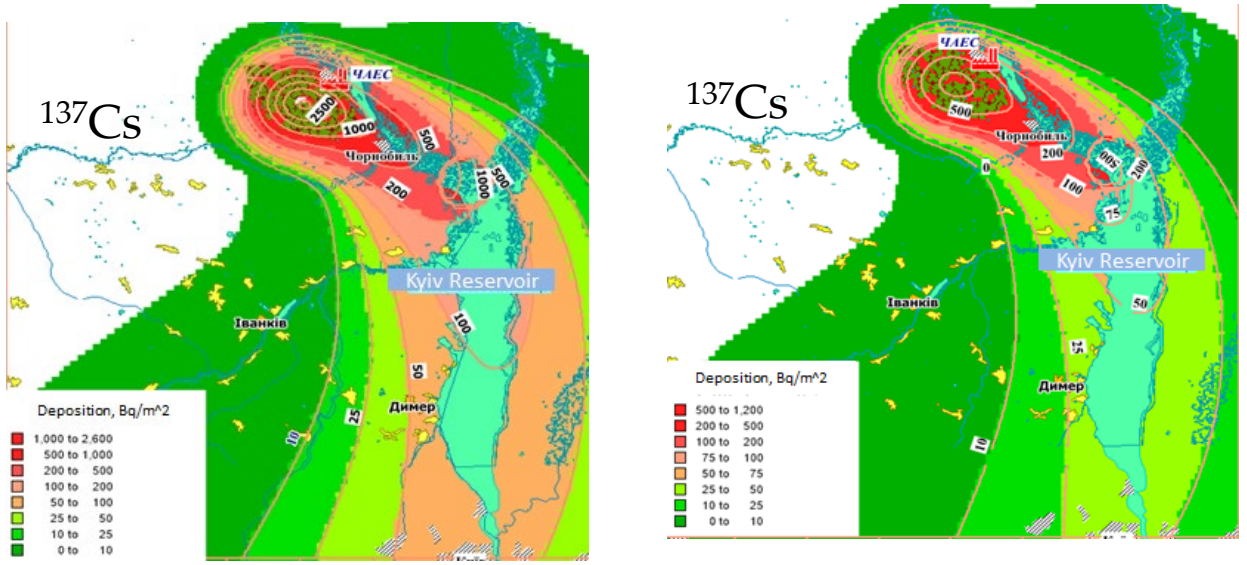
Average daily activity concentration of 137Cs in the surface air layer (μBq/m3) due to emission of combustion products on 11 March 2022.



Values of daily emission of ^{137}Cs activity into the atmosphere as a result of wildfires in the Chornobyl zone during the period from 11 to 25 March 2022, as well as values of total ^{137}Cs emission during wild fires in 2015 and 2020. (Talerko et al. IPS NPP, 2022)



The area of a hypothetical wildfire (boundaries marked with a dashed red line) that could cause a "maximum hazard scenario".



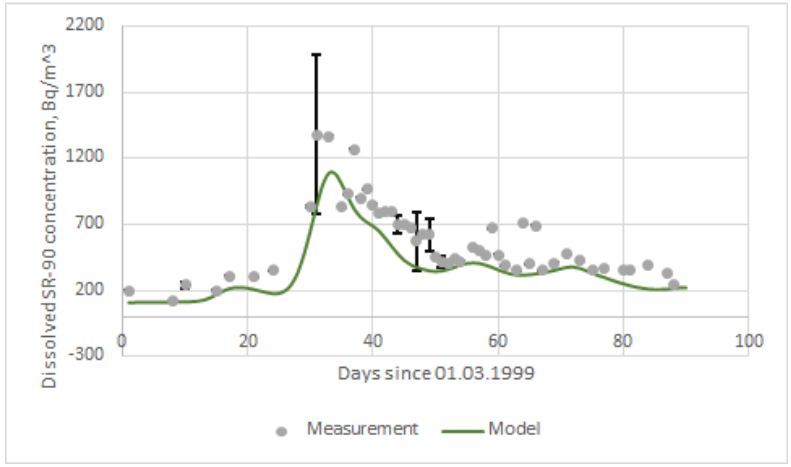
Atmospheric deposition the radionuclide (Bq m^{-2}) for "maximum danger scenario" of the forest fire in the CEZ under o chosen meteohazards scenario

Scenario	^{90}Sr deposition on water surface, GBq	^{90}Sr watershed wash-off, GBq	^{137}Cs deposition on water surface, GBq	^{137}Cs watershed wash-off, GBq
April 26-29, 2015	0.001	0.016	0.005	0.0095
April 4-20, 2020	0.300	0.048	0.970	0.016
Hypothetical, Meteoscenario 1	40.1	-	91. 5	-
Hypothetical, Meteoscenario 2	75.7	0.5	158	13

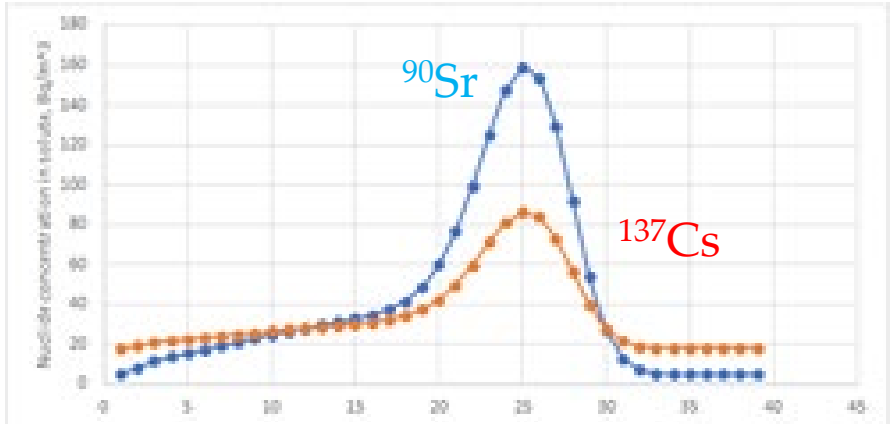
Total amount of radionuclidedeposited on Kyiv reservoir surface and washed-off from the watershed for the calculated scenarios. Meteoscenario 1 has no wash-off due to absence of precipitation.

Assessment of maximum wildfire impact of the water transport of radionuclides cross ChEZ border to Kyiv city region via Pripyat river and Kyiv reservoir (Pylypenko, Talerko, Kirieiev, Protsak et al. 2024)

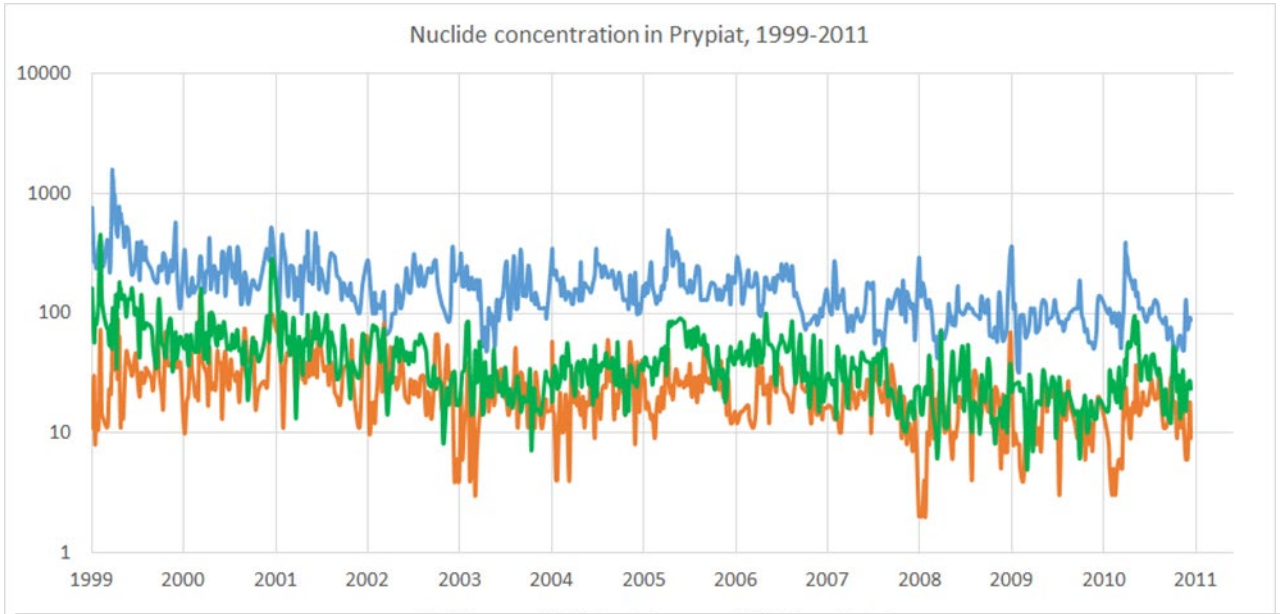
Kyiv HES

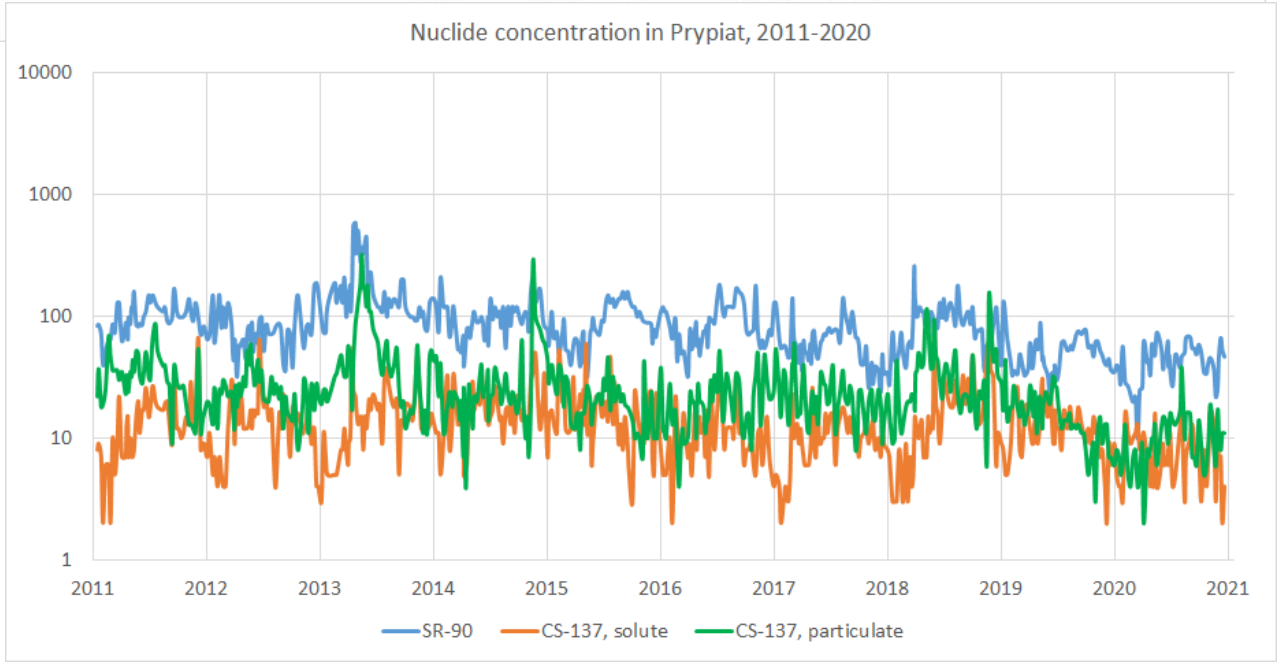


^{90}Sr dissolved concentrations at Kyiv HES (Bq/m^3) during the last significant increasing of concentrations - spring flood 1999 measured (grey), and RIVTOX model output (green).



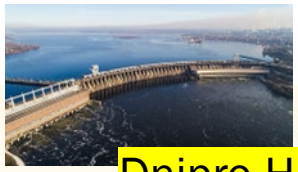
^{90}Sr and ^{137}Cs dissolved concentrations at Kyiv HES (Bq/m^3) predicted for the maximum harmful combination of wildfire source term and meteorological conditions



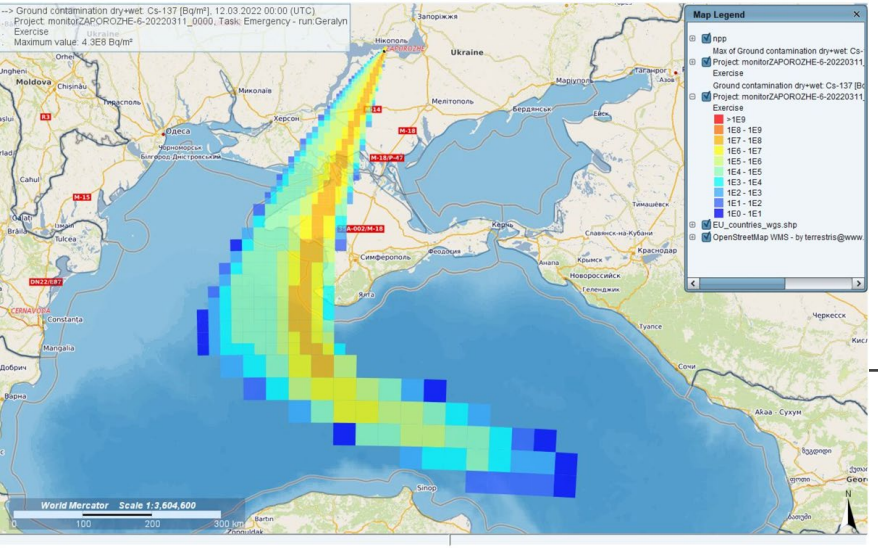


Assessment of maximum wildfire impact of the water transport of radionuclides cross ChEZ border to Kyiv city region via Pripyat river and Kyiv reservoir (Pylypenko, Talerko, Kirieiev, Protsak et al. 2024)

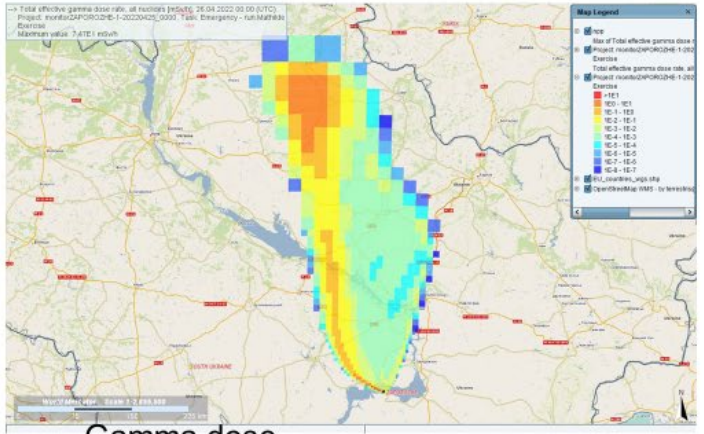
Assessing of radiation risks at ZNPP



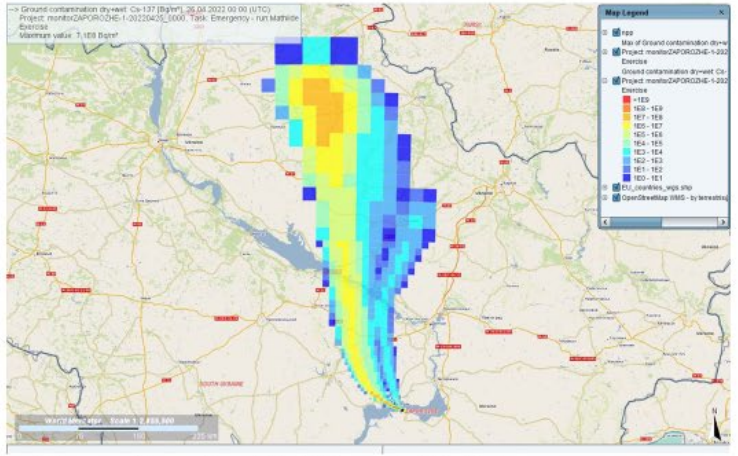
https://deepstatemap.live/en#6/48.612/32.344



KIT RODOS modeling 12.03.2022 00:00 (UTC)
ZNPP accident density Cs-137 Surface deposition density Cs-137

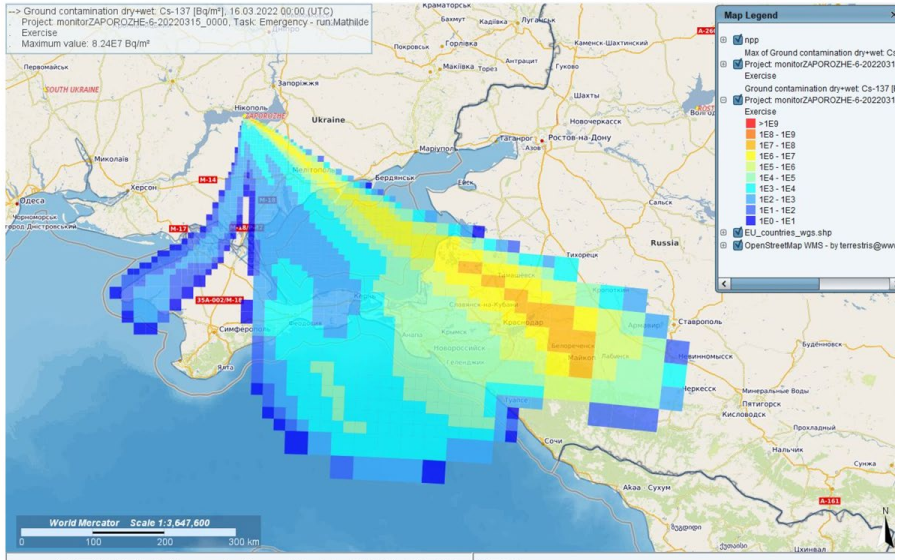


Gamma dose



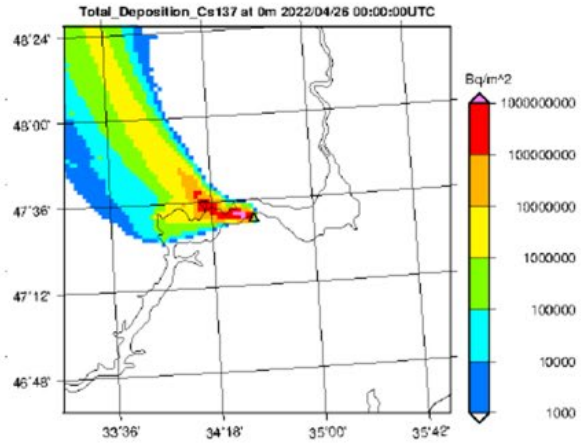
Deposition Cs-137 Density Bq/m2

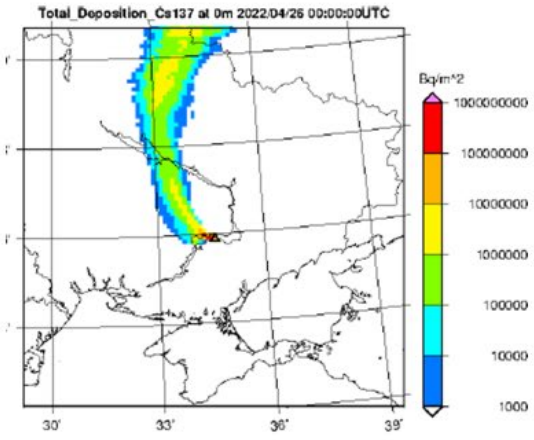
RODOS KIT modeling ZNPP Results of 26.04. 2022 00:00 RODOS KIT



KIT RODOS modeling 16.03.2022 00:00 (UTC)
ZNPP accident. Surface deposition d ensity Cs-137

wSpeedi JAEA modeling ZNPP Results of 26.04. 00:00

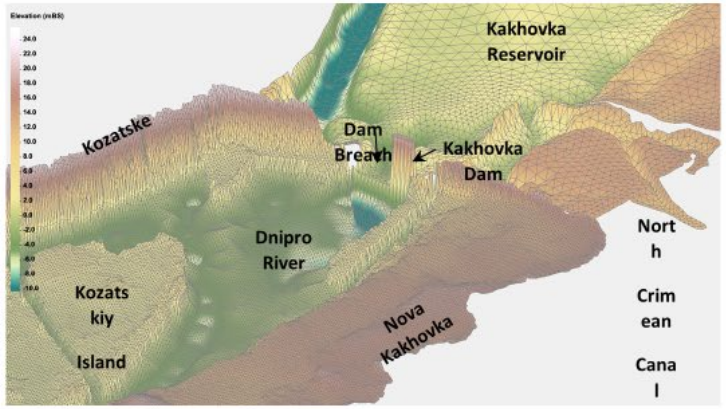


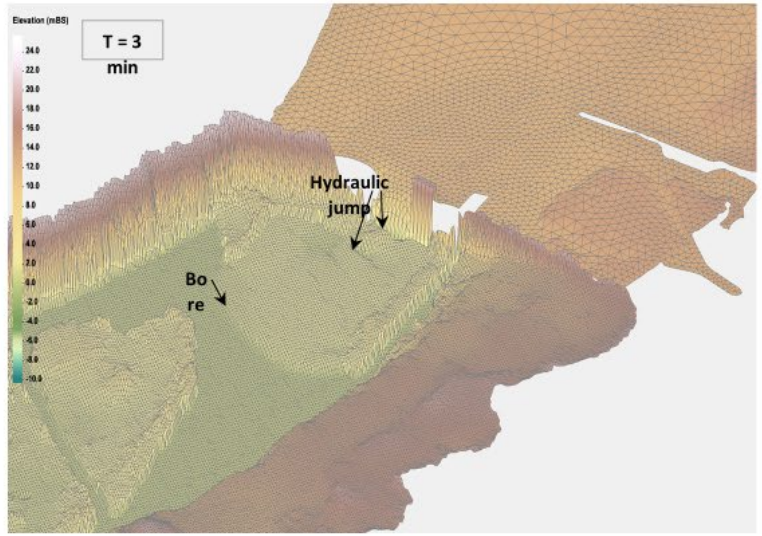


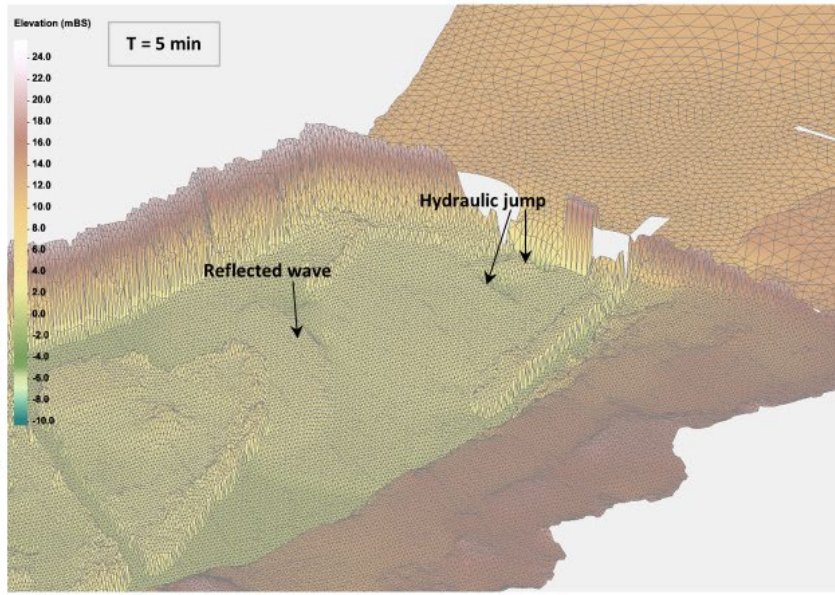
Incorporating U.S. modeling capabilities into this day-to-day ensemble modeling could increase the predictive power of these efforts.

Ensemble modeling consequences of ZNPP accident by RODOS in KIT, Germany and Ukraine and by Japanese DSS

Modeling - breach (400 m long by 15 m high behind the dam) , included in the calculations in February 2022 and the first minutes of wave propagation)

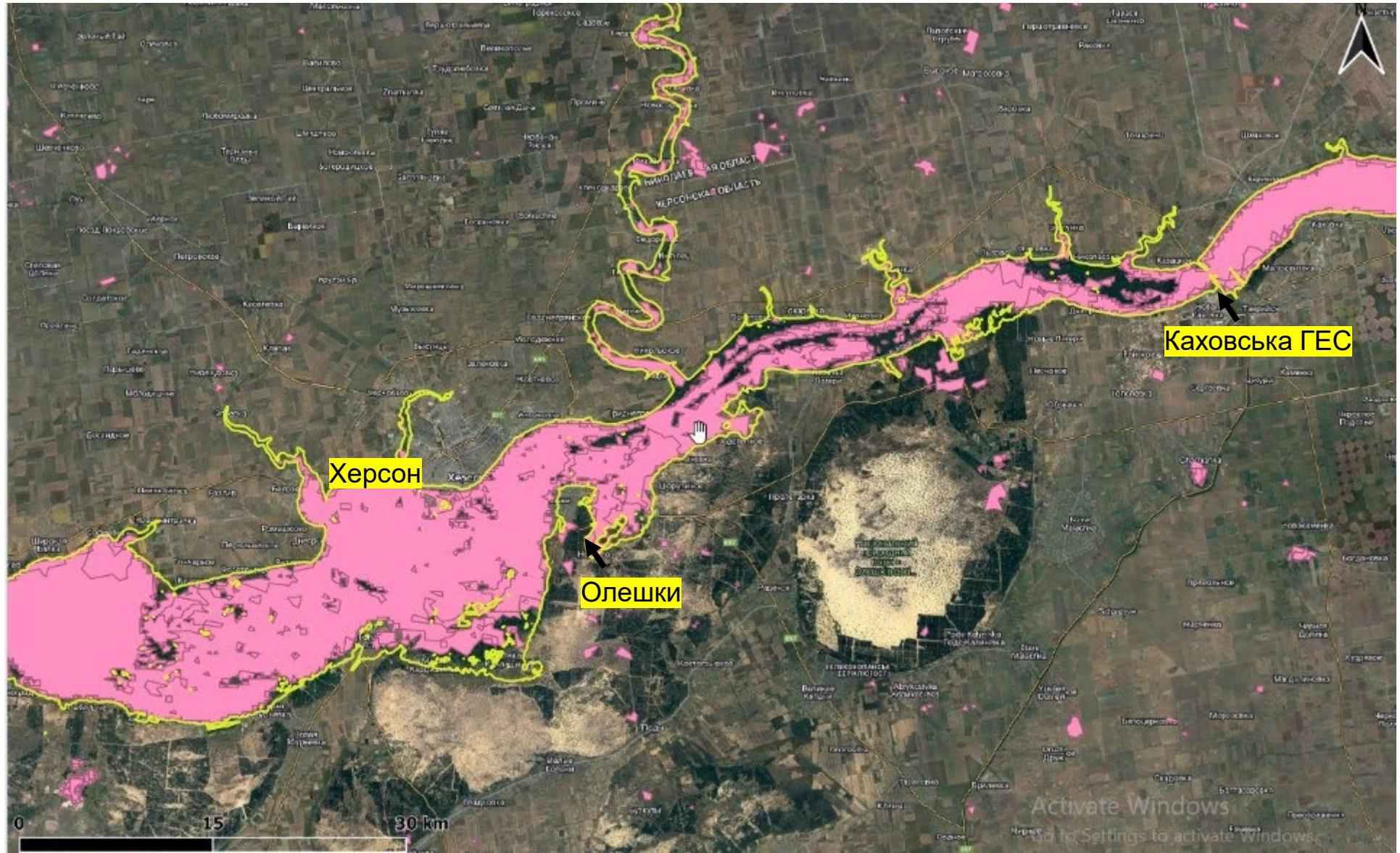


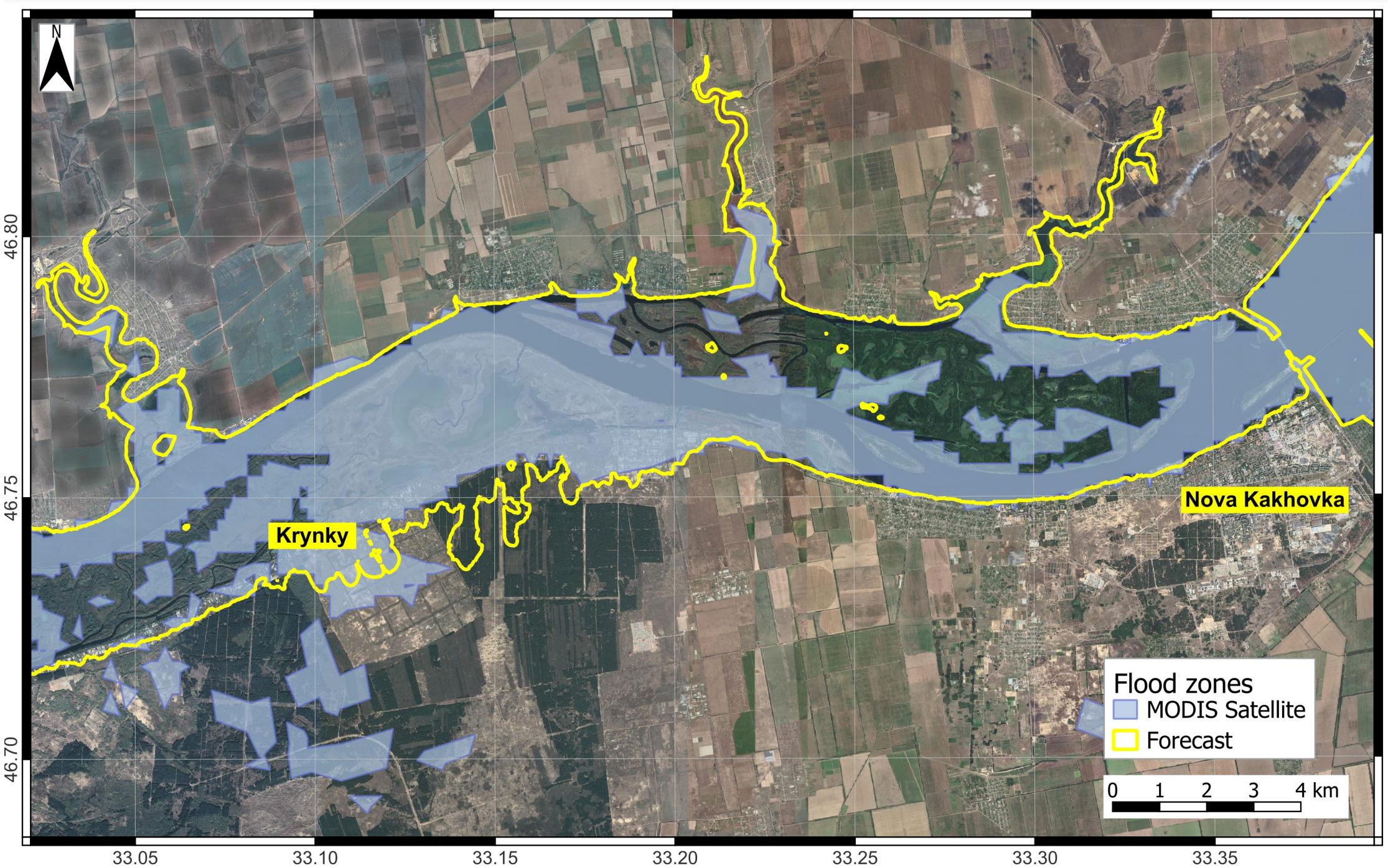


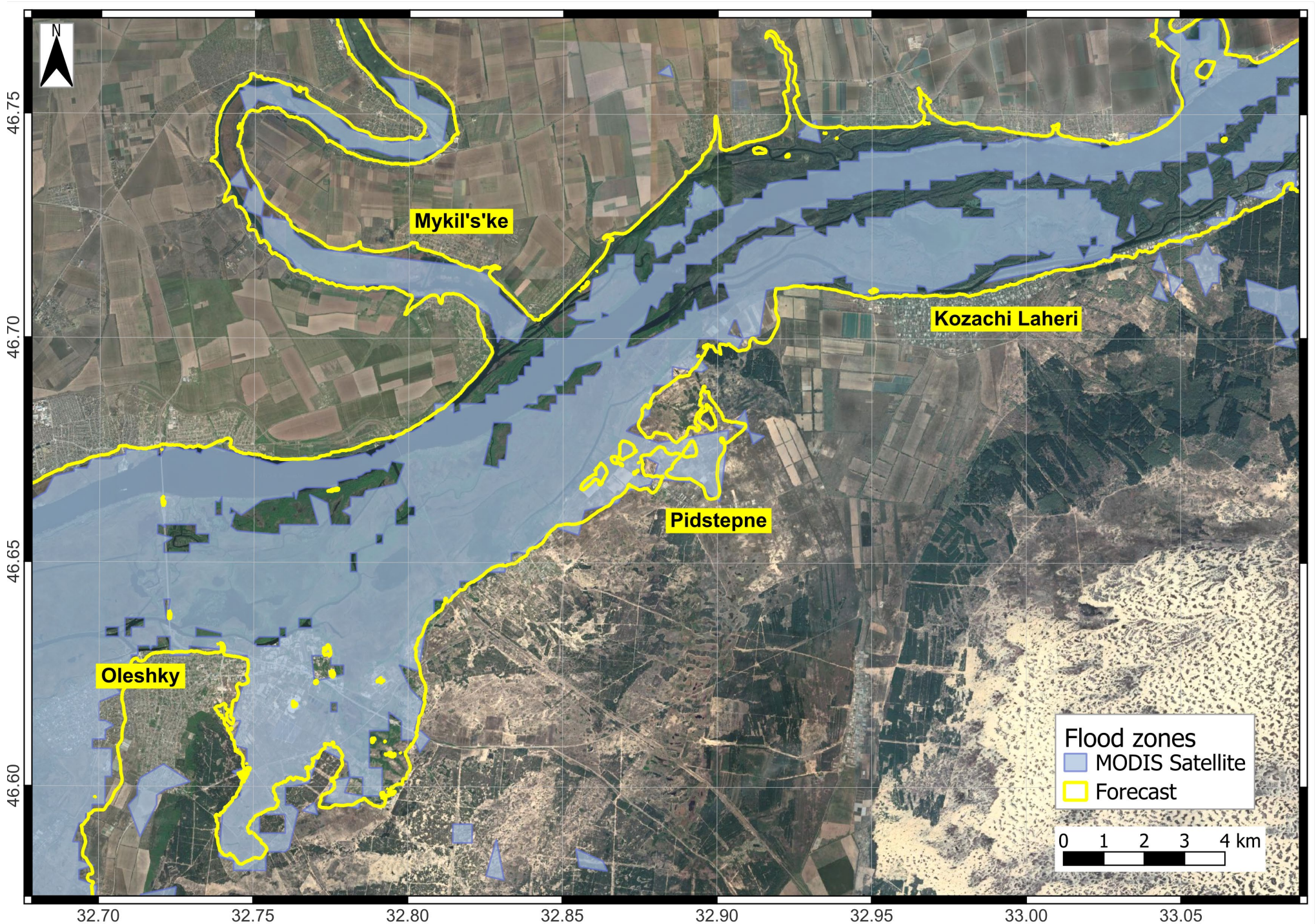


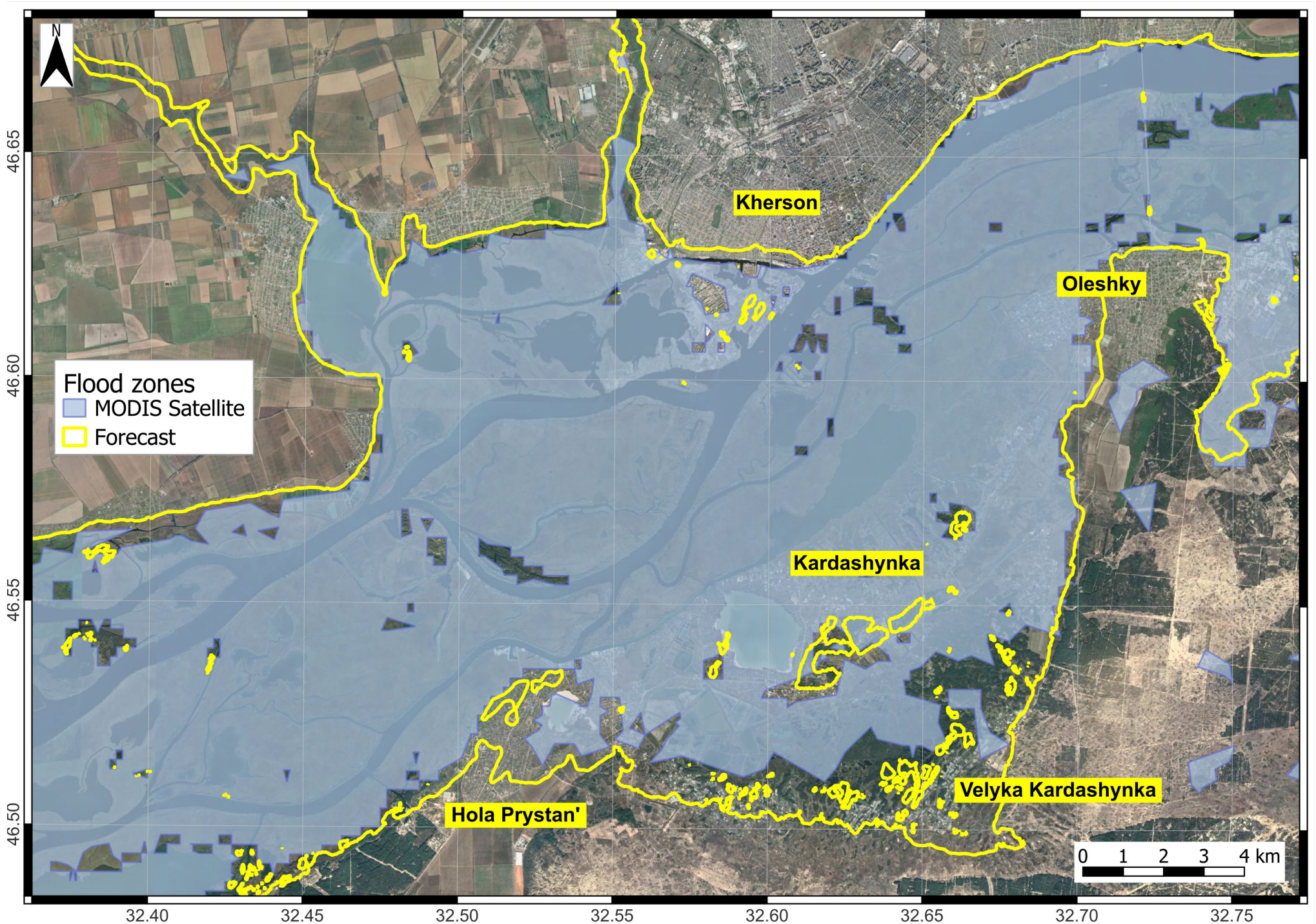
Modeling of Kakhovka HPP dam break performed by COASTOX in October – February 2022, which results have been presented as GIS maps flooding maps to State Emergency Service of Ukraine, and satellite images of Kakhovka HES dam

Comparison of flooding areas after the dam break at Kherson city predicted by our model (yellow line) measured from satellite picture (pink marked area)




N
46.80
46.75
46.70
33.05
33.10
33.15
33.20
33.25
33.30
33.35
Krynky
Nova Kakhovka
Flood zones
MODIS Satellite
Forecast
0 1 2 3 4 km


N
Mykil's'ke
Kozachi Laheri
Pidstepne
Oleshky
Flood zones
MODIS Satellite
Forecast
0 1 2 3 4 km
46.75
46.70
46.65
46.60
32.70
32.75
32.80
32.85
32.90
32.95
33.00
33.05

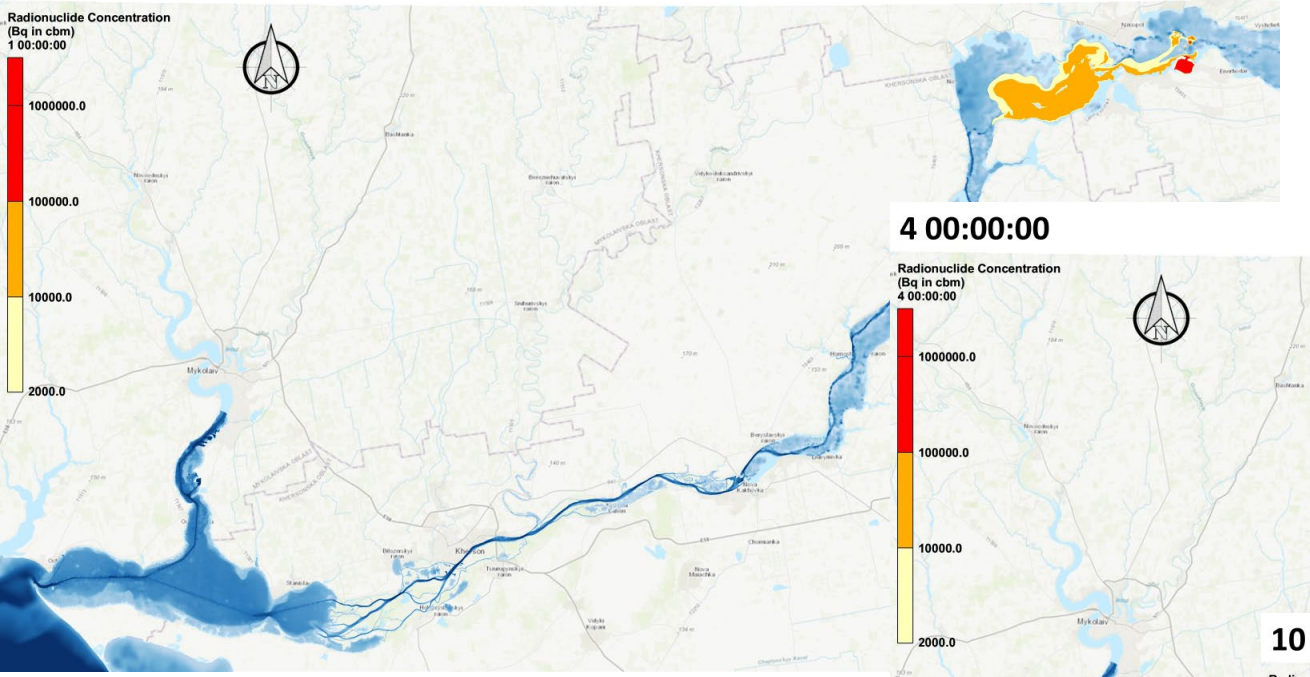

N
Flood zones
MODIS Satellite
Forecast
Kherson
Oleshky
Kardashynka
Velyka Kardashynka
Hola Prystan'
0 1 2 3 4 km
46.65
46.60
46.55
46.50
32.40
32.45
32.50
32.55
32.60
32.65
32.70
32.75

Sentinel 5 July 2023 Nikopol – ZNPP

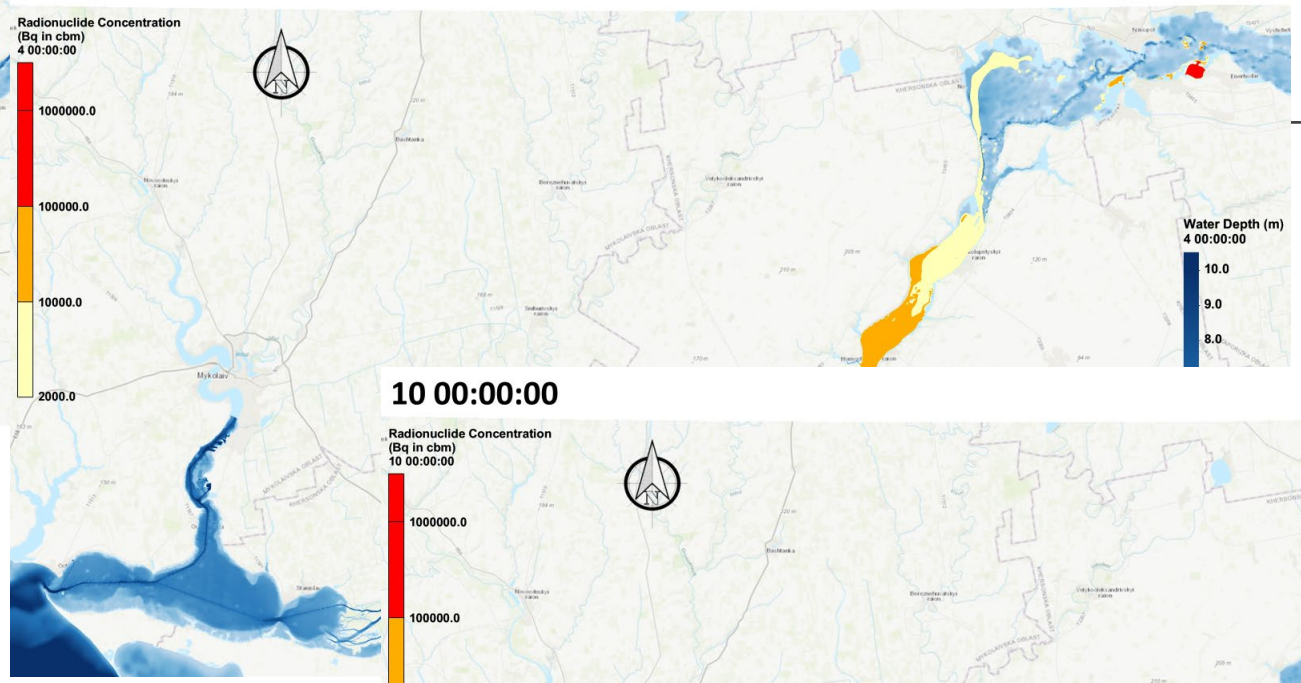
The load of 18 cubic kilometers of water of the Kakhovka reservoir provided a load (head) on the groundwater levels in the region. The result of this load was the problem of waterlogging of large areas by groundwater in the region between the reservoir and the sea coast. The decrease of the groundwater level after the emptying of the Kakhovka reservoir, including the possible decline of the groundwater level in the wells drilled on the territory of the ZNPP for the use of this water in the cooling of the ZNPP, is a comprehensive problem that has not yet been studied.

This problem needs joint efforts of researchers from different countries to get the reliable assessments.

1 00:00:00



4 00:00:00



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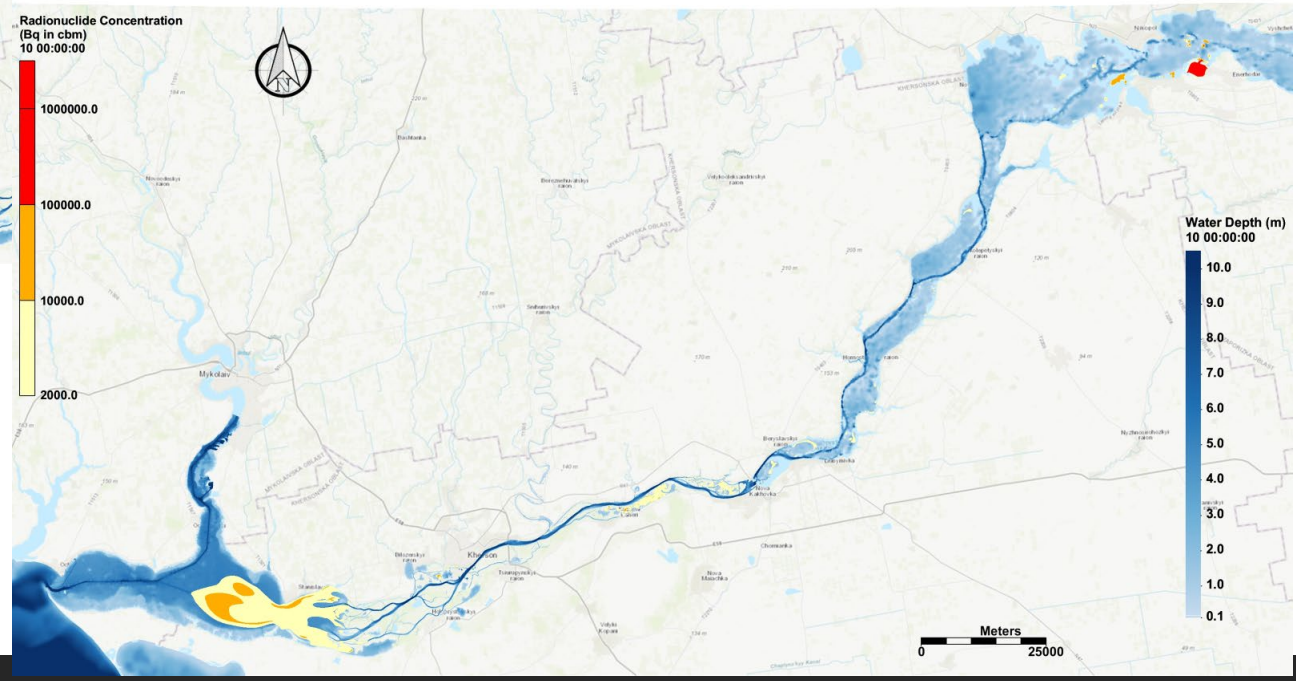
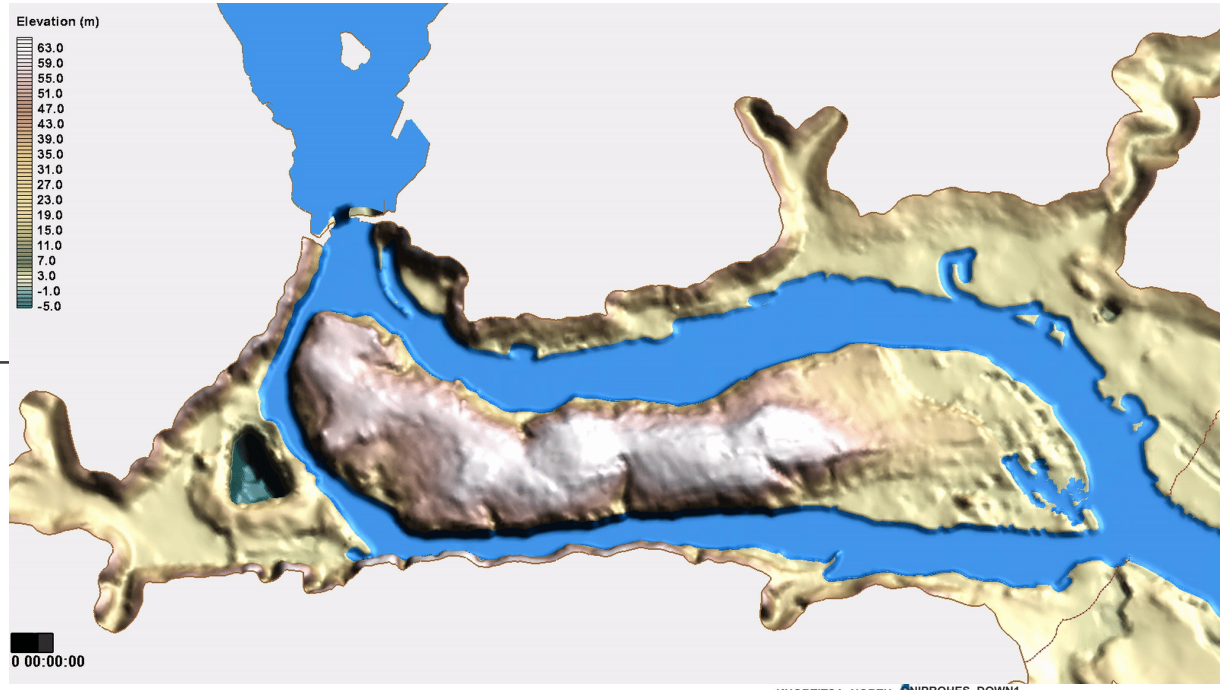
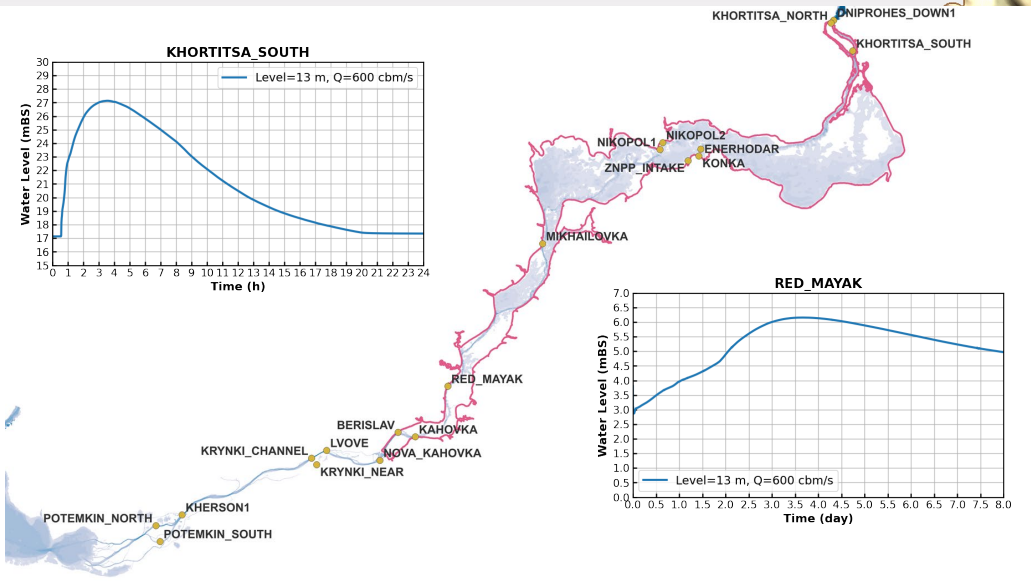


Modeling of radionuclides release to Dnipro river due to dam break of ZNPP





Modeling of Dnipro HES dam break Scenario 1941

To increase efficiency of “environmental” R&D in Ukraine

Need for coordination in Ukraine for joint efforts of researchers and various state agencies to increase the level of emergency preparedness and response to interdisciplinary comprehensive environmental hazards and public health protection problems

.Next steps - feasibility studies for remediation problems.

It seems that there is a need to establish in Ukraine at the inter – ministries state level a Working group on

"Comprehensive assessment of environmental and health risks from infrastructure damage for strengthening emergency preparedness and response to attacks on critical infrastructure and subsequent remediation".

Working group at the РНБО i.e. State National Security Council?

We need interdepartmental interaction to increase efficiency of R&D support to our country .

International coordination of “ environmental” R&D activities and technical support to Ukraine

1) **USA-Ukraine Bilateral NASEM Workshop as first step**

2) **It is need for “ Environmental Ramstein” group to coordinate “environmental support” ???? ”**

“The **Ukraine Defense Contact Group** (**UDCG**, also known as the **Ramstein group**[]) is an alliance of 56 countries (all 32 member states of NATO and 24 other countries) and the European Union supporting the defence of Ukraine by sending military equipment in response to the 2022 Russian invasion.[] The group coordinates the ongoing donation of military aid at monthly meetings.” (Wikipedia)

Support - joint R&D activities and strengthening of the measurement and data processing capabilities of the most acute and comprehensive problems of environmental damage in Ukraine, increasing the monitoring, modelling and implementation capabilities of Ukrainian teams.