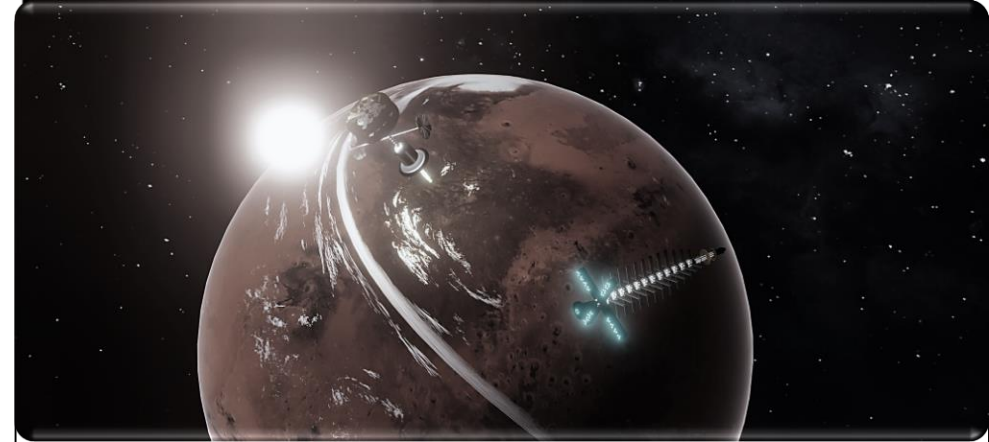**Satellite-based Services for Disaster Risk Management in Slovakia**

Space data
in nuclear and radiological
emergency preparedness
and response

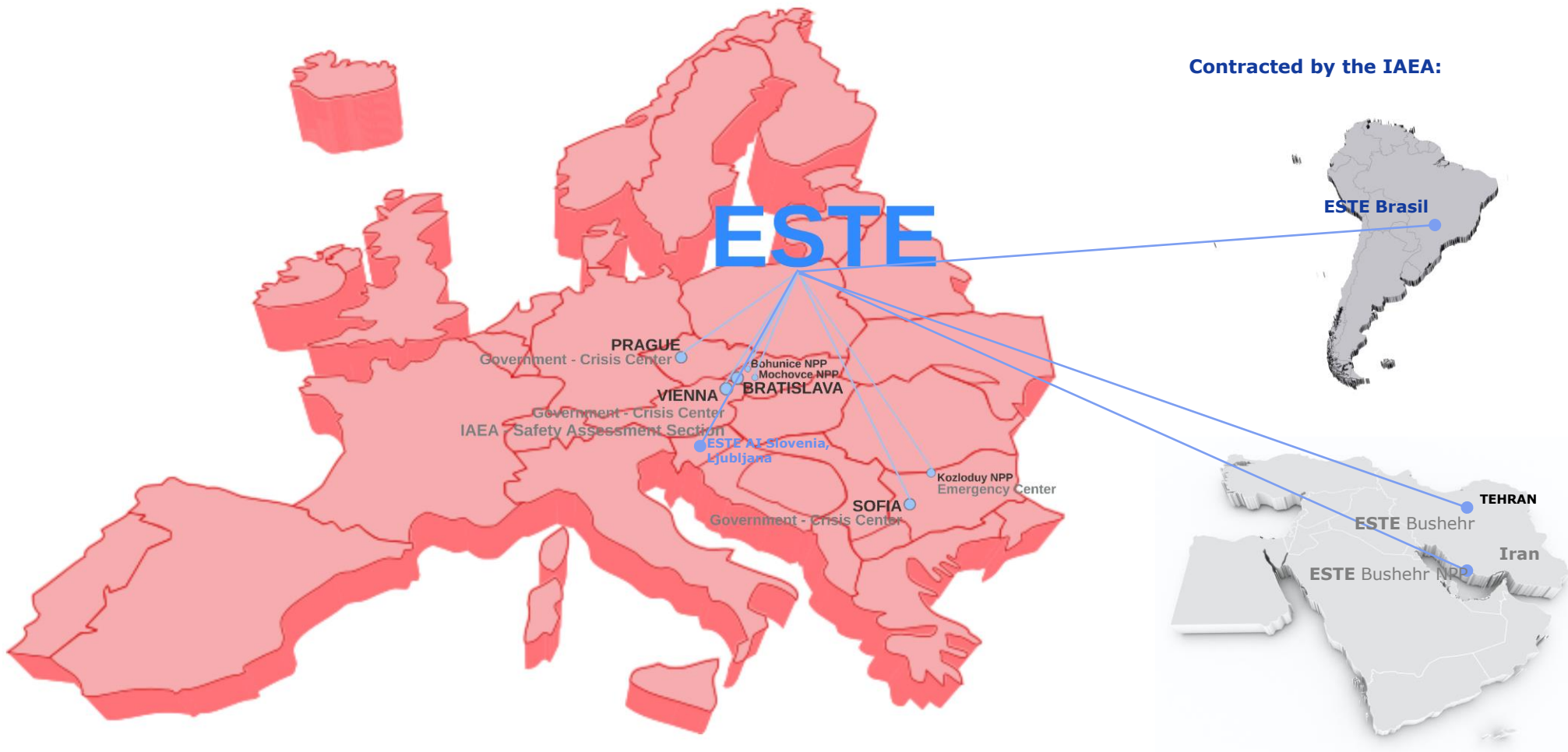N o v e m b e r 30 , 2 0 2 3
Faculty of Informatics and Information Technologies
Slovak Technical University Bratislava

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NUCLEAR SCIENCE AND SOFTWARE

ESTE systems and satellite based services

- Nuclear decision support systems ESTE use and are connected to data from satellites (Sentinel, Landsat); also Corine Landcover data (CLC, Copernicus Land Monitoring Service). Those services are used by ESTE in the process of radiological consequences assessment of nuclear accidents.

- Systems ESTE deployed on government level are applicable also for response to CBRN events in urban environment and for response to nuclear weapon bursts far away from the territory of Slovakia.

- Within the running project funded by ESA, nuclear decision support system ESTE4Space is created and developed by ABmerit. Our subcontractor and co-operator in this project is ArianeGroup. ESTE4Space will use EU-SST services.

ESTE implementations **over the world**

Contracted by the IAEA:

ESTE Brasil

PRAGUE
Government - Crisis Center

Bohunice NPP
Mochovce NPP
BRATISLAVA

VIENNA
Government - Crisis Center
IAEA - Safety Assessment Section

ESTE AI Slovenia,
Ljubljana

Kozloduy NPP
Emergency Center

SOFIA
Government - Crisis Center

TEHRAN

ESTE Bushehr

Iran

ESTE Bushehr NPP

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ESTE Implementations

Czech Republic:
- Czech Nuclear Regulatory Body SUJB Prague – ESTE Dukovany, ESTE Temelin, ESTE EU
- Czech Nuclear Regulatory Body SUJB Prague – ESTE Annual Impacts Temelin, ESTE Annual Impacts Dukovany
- Czech Technical University FJFI ČVUT Prague – school version of ESTE EU

Slovakia:
- SE a.s. (Slovakia) – ESTE Mochovce, ESTE Bohunice, Simulator ESTE SIM Mochovce, ESTE Annual Impacts Bohunice,
- JAVYS a.s. (Nuclear and Decommissioning Company, Bohunice site, Slovakia) – ESTE Annual Impacts Bohunice
- Public Health Authority of the Slovak Republic - ESTE UVZ, ESTE Annual Impacts UVZ
- Slovak Technical University FEI STU Bratislava– school version of ESTE EU

Bulgaria:
- Kozloduy NPP – ESTE Kozloduy (the Crisis Emergency Centre of Kozloduy NPP, Bulgaria)
- Bulgarian Nuclear Regulatory Body NRA, Sofia – ESTE EU, ESTE Kozloduy

Austria:
- Austrian BMK (the Crisis Centre of the Austrian Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology, Division V/8 – Radiation Protection, BMK, Vienna) – ESTE EU with module for Dukovany and Temelin

Projects funded by IAEA:
Slovenia:
- Institute Jozef Stefan, Ljubljana, Slovenia (delivered in the frame of the IAEA project)

Brasil:
- Aramar Nuclear Facility - Centro Tecnológico da Marinha em São Paulo: Centro Industrial Nuclear de Aramar (delivered in the frame of the IAEA project)

Iran:
- Bushehr NPP – ESTE Bushehr, ESTE Annual Impacts Bushehr (delivered in the frame of the IAEA project)

- IAEA, Safety Assessment Section – ESTE EU, ESTE Fukushima
- Incident and Emergency Centre (IEC) of International Atomic Energy Agency, IAEA – ESTE Europe

Connection of decision support system ESTE with European Space Agency ESA Sen2Agri system (Sentinel satellites)

Radiation dose assessment

In emergency, agricultural geodata are applied

- for evaluation of **mass activity of radionuclides** in agricultural crops after accident

- for **ingestion doses** assessment and

Long-term analysis (e.g. performed by public health authorities) after nuclear/radiological accident or incident could be supported with ESTE code calculations using crop type maps.

Agricultural data (fields)

In ESTE analyses

-spatial distribution of pastures (impact to the animals of pastures),

-data about food consumptions (mostly milk, vegetables, fruits, cereals)

- placement of various types of agricultural plants (mainly wheat, barley, maize, rapeseed, sunflower, hop, and potatoes)

are applied.

Satellite imageries

ESA Sentinel 2A, 2B

NASA Landsat 8

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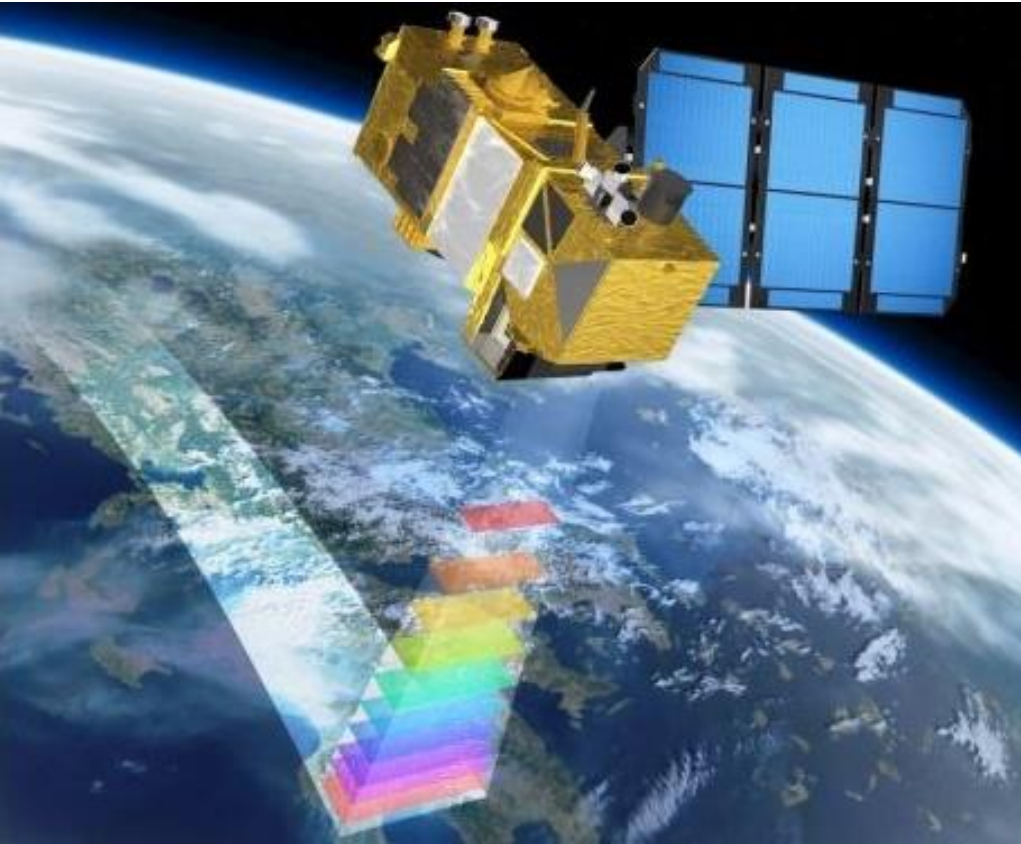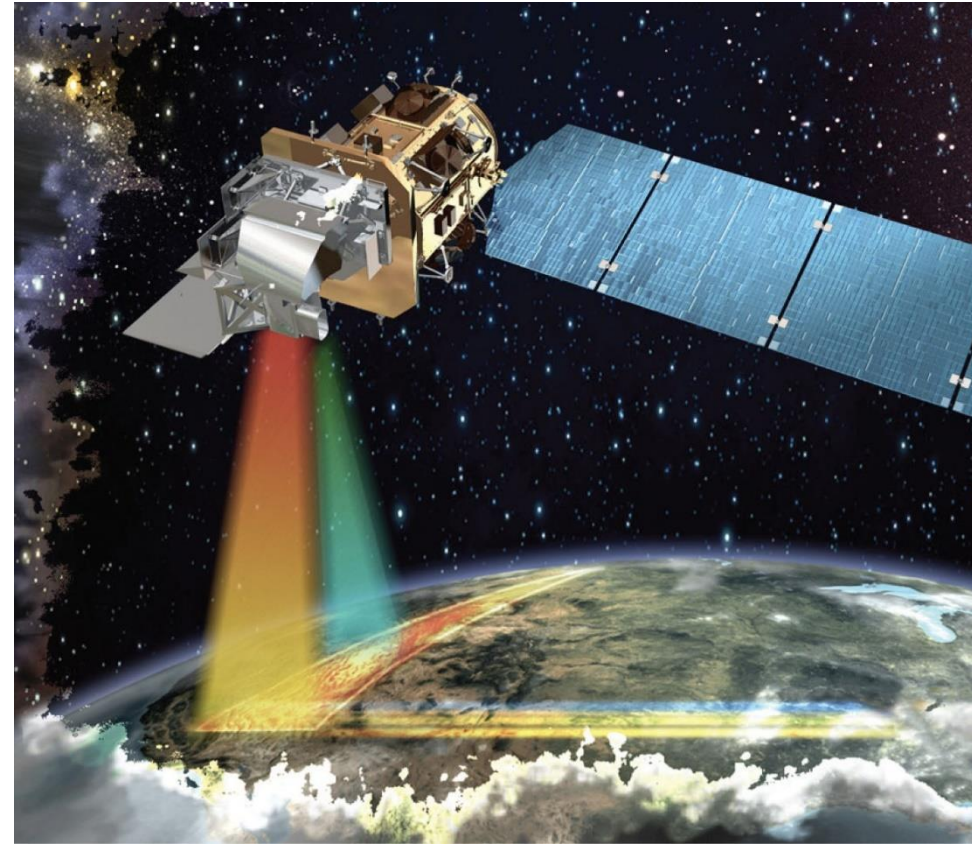
Module: connecting ESA and ESTE

- Module ESTE-ESA is periodically updating the outputs from ESA Sen2Agri system into the ESTE database (snow cover if relevant, LAI and types of crops)

- In the ESTE database, the most actual data, latest data that were processed by the Sen2Agri system

- In case of nuclear or radiological emergency, the latest processed data can be at the input to the calculations of mass activity concentrations of radionuclides in agricultural crops
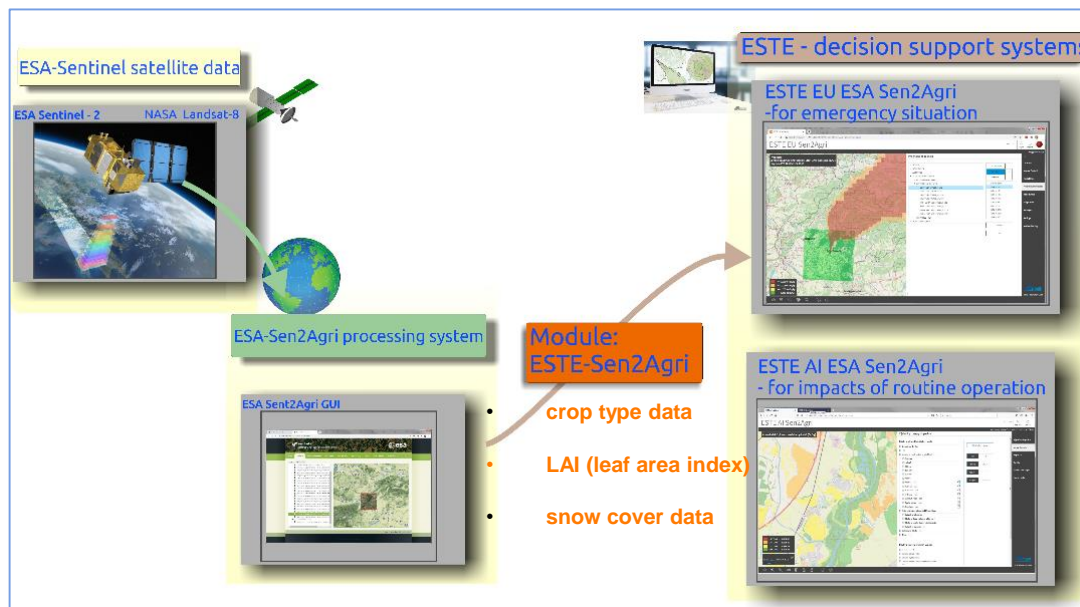
ESA-Sentinel satellite data

ESA Sentinel - 2   NASA Landsat-8
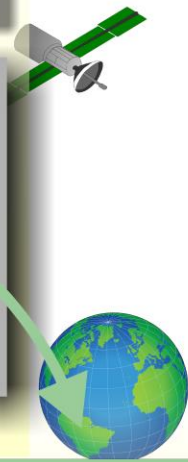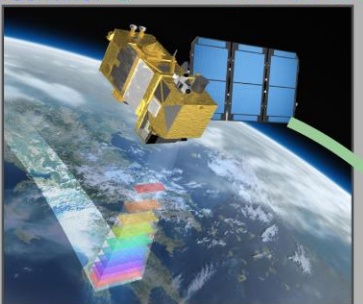
ESA-Sen2Agri processing system

ESA Sent2Agri GUI
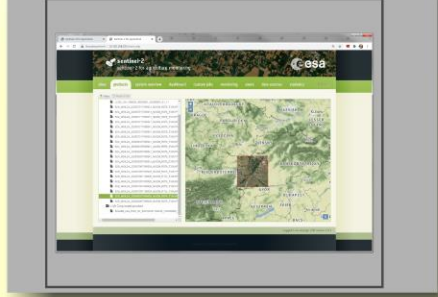
Module:
ESTE-Sen2Agri

crop types at the territory of interest;

leaf are indexes;

snow cover at the territory of interest.

ESTE - decision support systems

ESTE EU ESA Sen2Agri
-for emergency situation
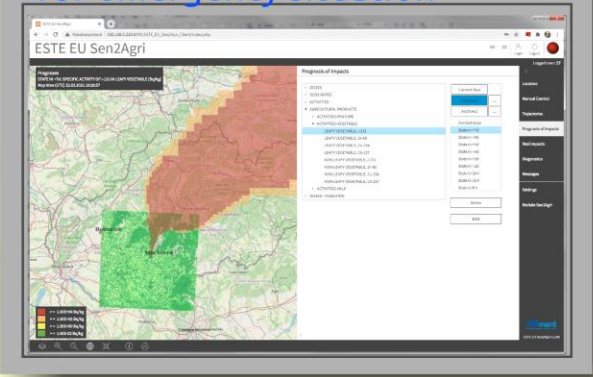
ESTE EU Sen2Agri

ESTE AI ESA Sen2Agri
- for impacts of routine operation

ESTE AI Sen2Agri

ABmerit
NUCLEAR SCIENCE AND SOFTWARE
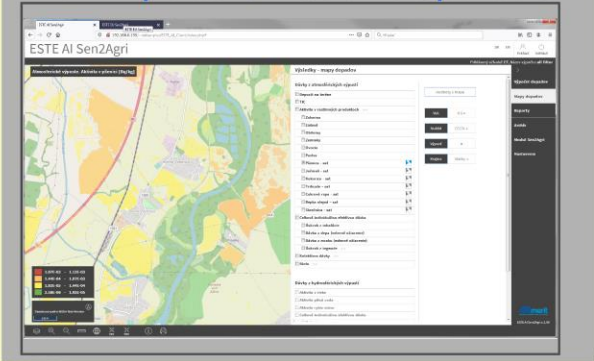
Example: processed LAI data in ESTE (05/2020, Central Europe)

Example: processed snow data in ESTE (01/2020, Central Europe)
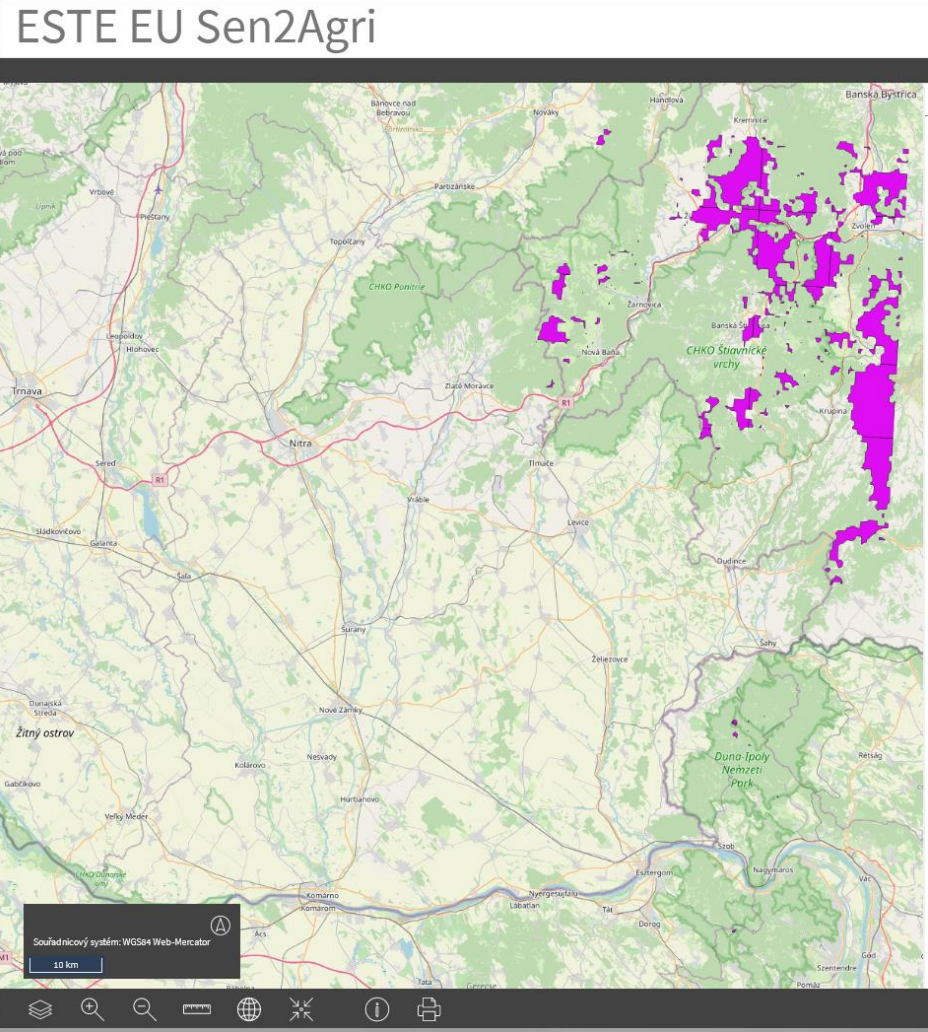
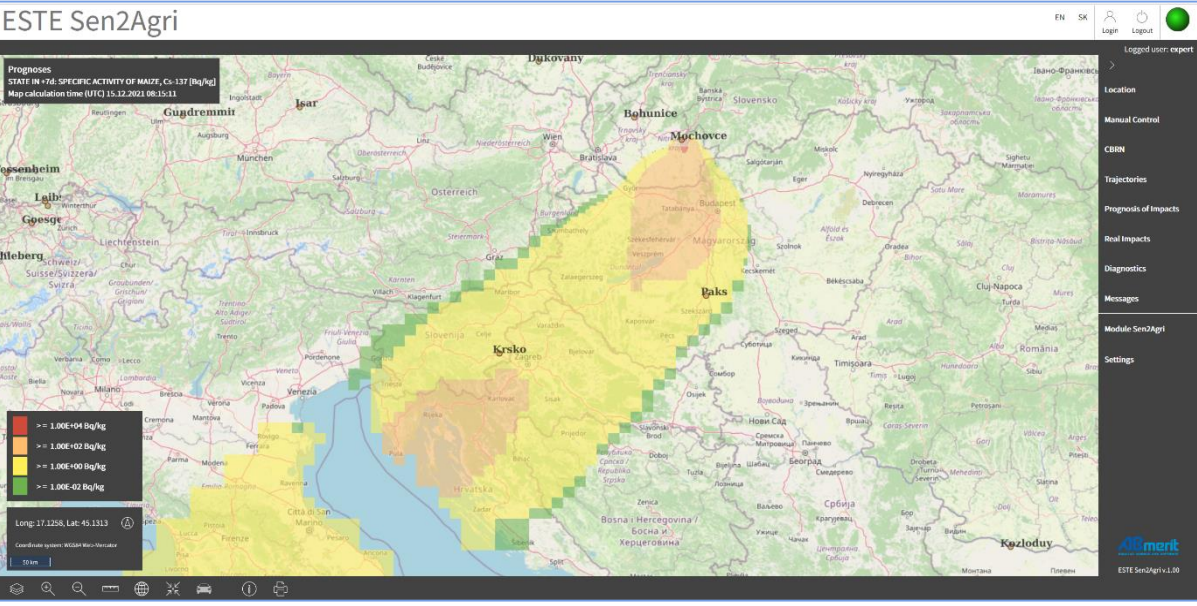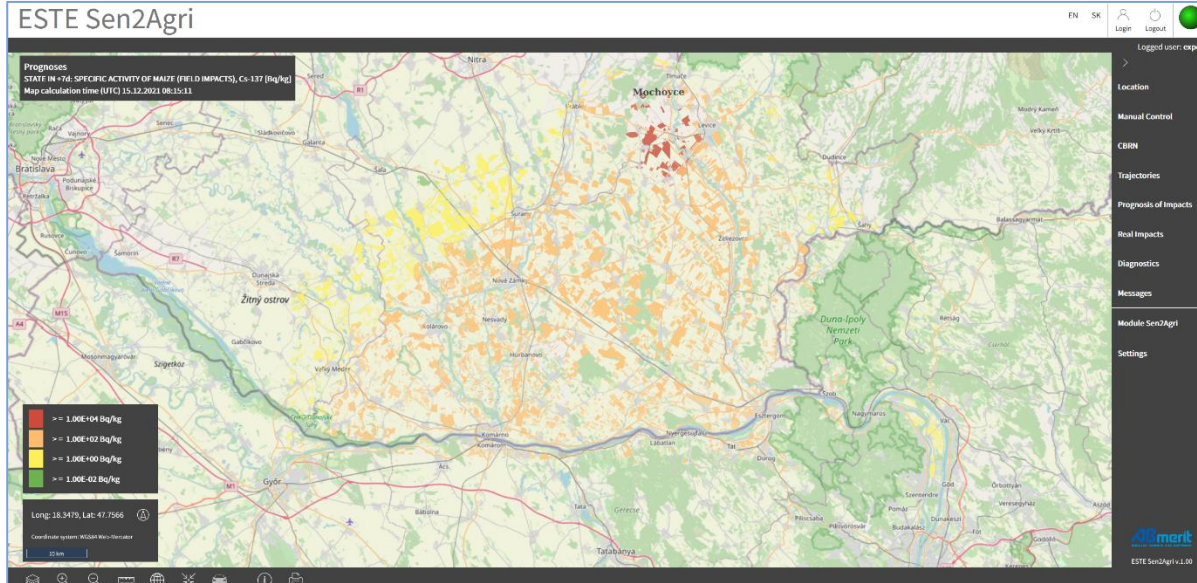# Example: processed crop type data in ESTE (07/2020, Central Europe)
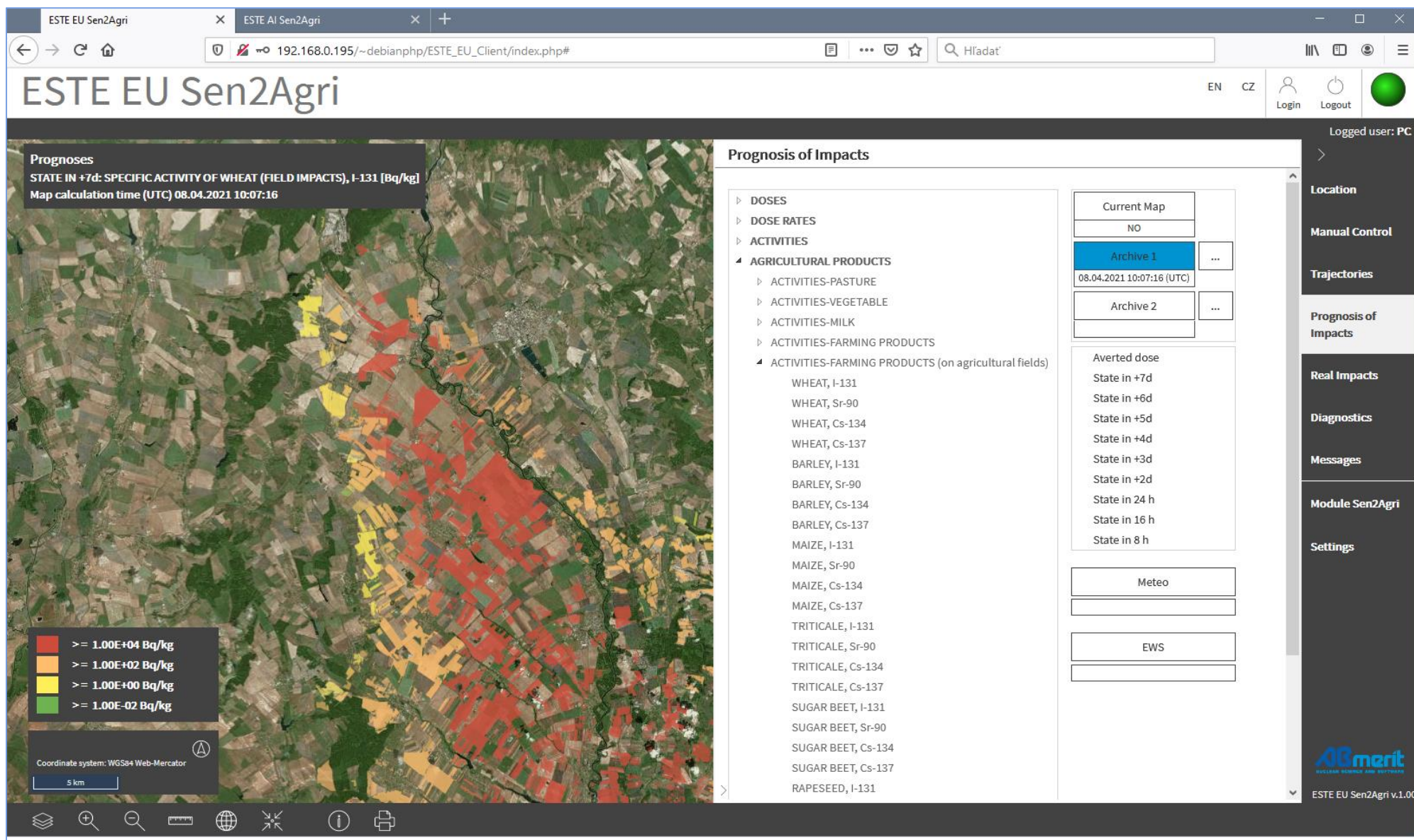
ESTE for emergencies

Potential concentration of Cs-137, Bq/kg, in maize (without knowledge about real distribution of maize fields)

Concentration of Cs-137, Bq/kg, in maize, in real maize fields as processed by Sent2Agri connected to ESTE.

Calculated activity, I-131 in wheat [Bq/kg]

Results of ESTE are useful also for management of radiation monitoring teams.

ESTE4Space

- includes connection to EU-SST service (Re-Entry services)
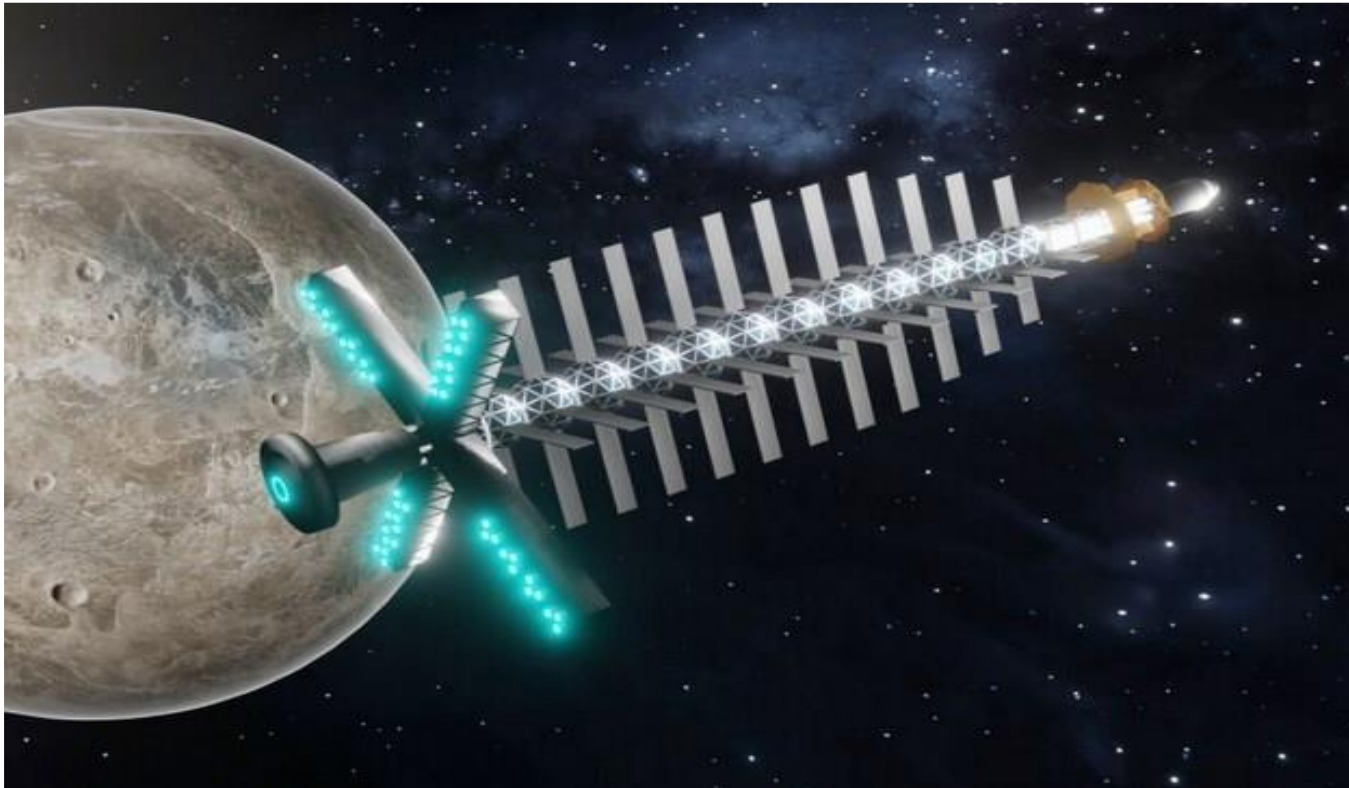
- cooperation with ArianeGroup

ESTE4Space project

- To initiate development of a radiological decision support system for space missions with radioisotope power sources, ESTE4Space

European NEP (nuclear electric propulsion) spacecraft. Image by ESA (source: https://www.esa.int/)

ESTE4Space

- Outputs and services provided by ESTE4Space tool will be tailored to the needs of the potential future End-User (e.g.ArianeGroup), for radiological impact assessment of events related to failure during launch or inadvertent re-entry of spacecraft with nuclear power sources
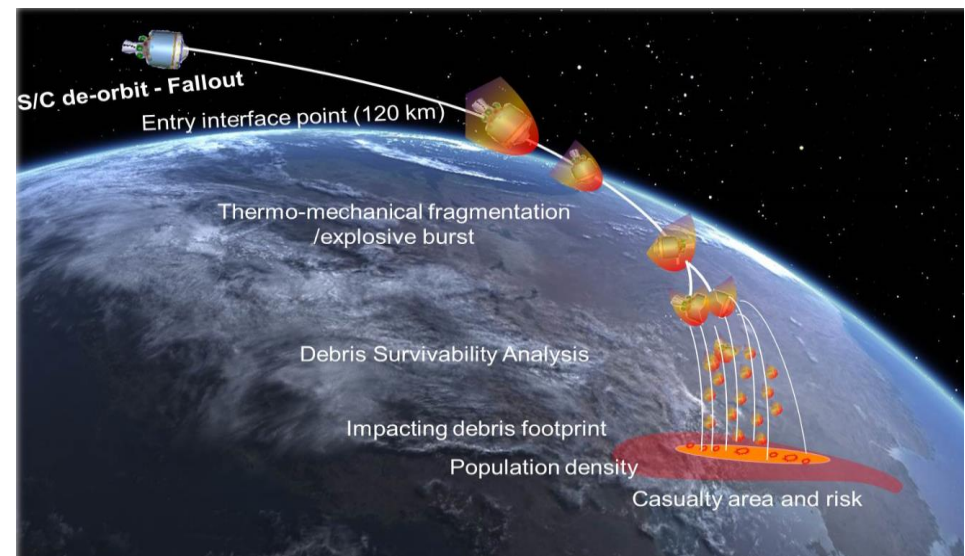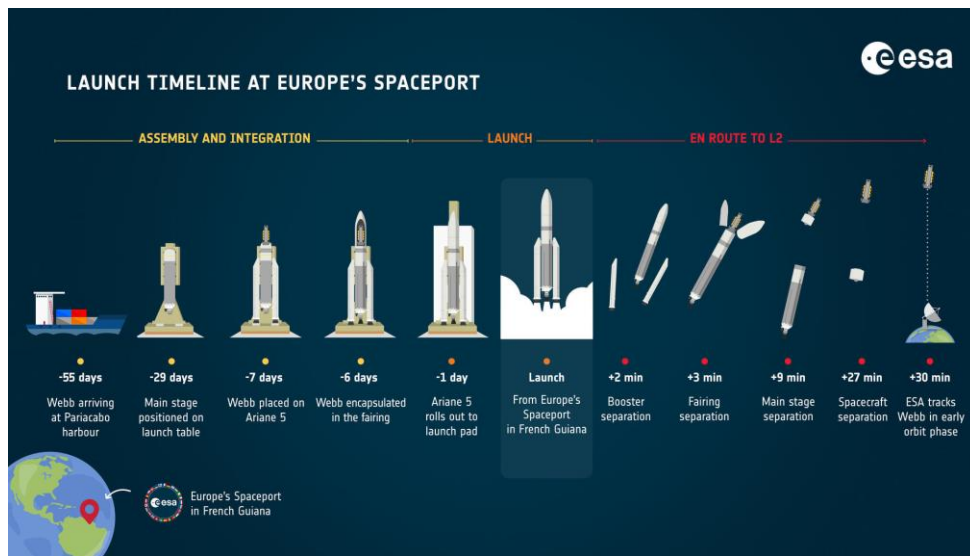
Webb launch timeline at Europe's Spaceport

Image by ESA (source: https://www.esa.int/)

Example of accidental scenario

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NUCLEAR SCIENCE AND SOFTWARE
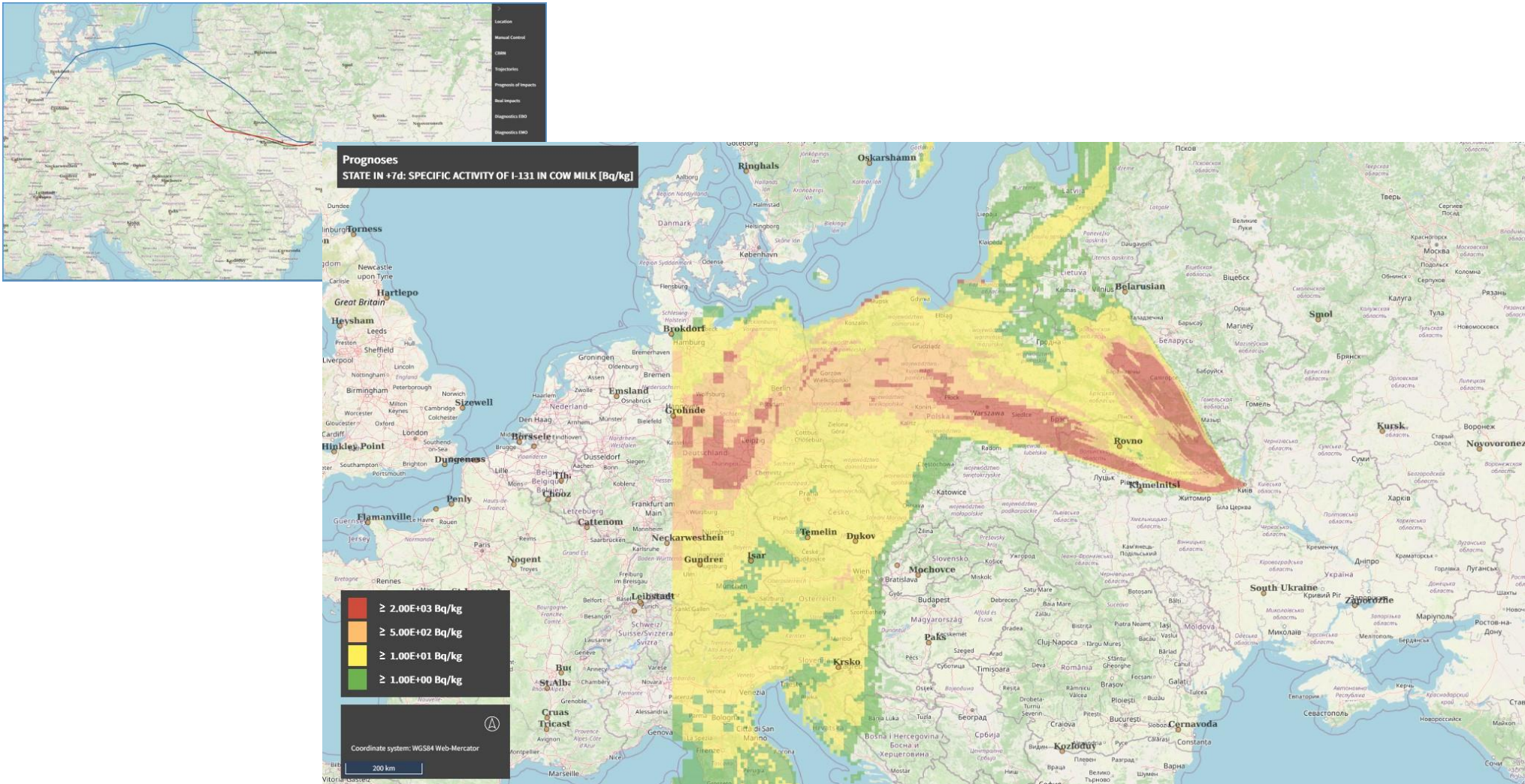
ESTE
-
extension to nuclear weapons threat

ESTE extension to nuclear weapons threat

- The use of nuclear weapons in current or potential future war conflicts will lead to the release of radioactive particles, aerosols, and gasses in the Earth's atmosphere with an **impact** also on the territories (and population) which are far enough from the epicenter of the detonation, where the consequences are not immediately life-threatening, but **can be considerable**.

- In case of an airburst of a nuclear weapon, such as an "escalatory warning shot," the initial source term containing fission products (and also products of neutron activation of weapon construction materials) can reach the height above ground of 40-50 km. **Therefore, modeling of upper atmospheric layers is also required**.
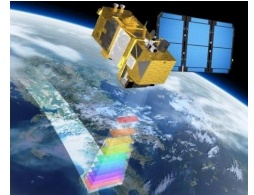
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NUCLEAR SCIENCE AND SOFTWARE

ESTE extension to nuclear weapons threat

- Example of simulation using ESTE code: Mass activity of I-131 in cow milk after hypothetical nuclear weapon detonation

Summary: ESTE systems and satellite based services

- Nuclear decision support systems ESTE use and are connected to data from satellites (Sentinel, Landsat);

- also Corine Landcover data (CLC, Copernicus Land Monitoring Service). Those services are used by ESTE in the process of radiological consequences assessment of nuclear accidents. One of our meteo data (numerical weather prediction) source is ECMWF.

- Systems ESTE deployed applicable also for response to CBRN events in urban environment and for response to nuclear weapon bursts far away from the territory of Slovakia.

- ESTE4Space

Thank you
abmerit@abmerit.sk