ICARO

Ministry for the Environment
Land and Sea

UNITED NATIONS
ECONOMIC COMMISSION FOR EUROPE

Definition of oil spill scenario

Joint management of transboundary emergencies from spills of hazardous substance into the Danube River

Dobreta Turnu Severin, 16-18 June 2009

SITE OF PRAHOVO, SERBIA

- **Gas Oil tank farm**
- **Loading jetty to unload naval tanker into the storage tanks**
- **Operator on site controls each operation**
- **The circuit is provided with automatic and semi-automatic preventive measures**

REFERENCE SCENARIO

Source terms

- Maximum release diameter (worst case scenario)
- Maximum flow rate that can be released on the river

Mitigating measures

- Measures and organization to manage the emergency
- Definition of the time to isolate the leakage

Definition of the released amount

REFERENCE SCENARIO

Source terms

- Sudden rupture of loading arm (diameter of 200 mm)
- Release of 118 kg/s of diesel oil on the Danube river

Mitigating measures

- Continuous presence of operators in the jetty
- Possibility to stop the pumps and isolate the line

Release time = 3 minutes

Total released amount = 21250 kg of gas oil

ENVIRONMENTAL FATE

Gas Oil:

- is not soluble with water;
- has lower density than water;
- will partly evaporate in contact with air;
- will partly reach the river banks.

The released substance will determine a film of oil floating above water, which will be dispersed along to river flow stream.

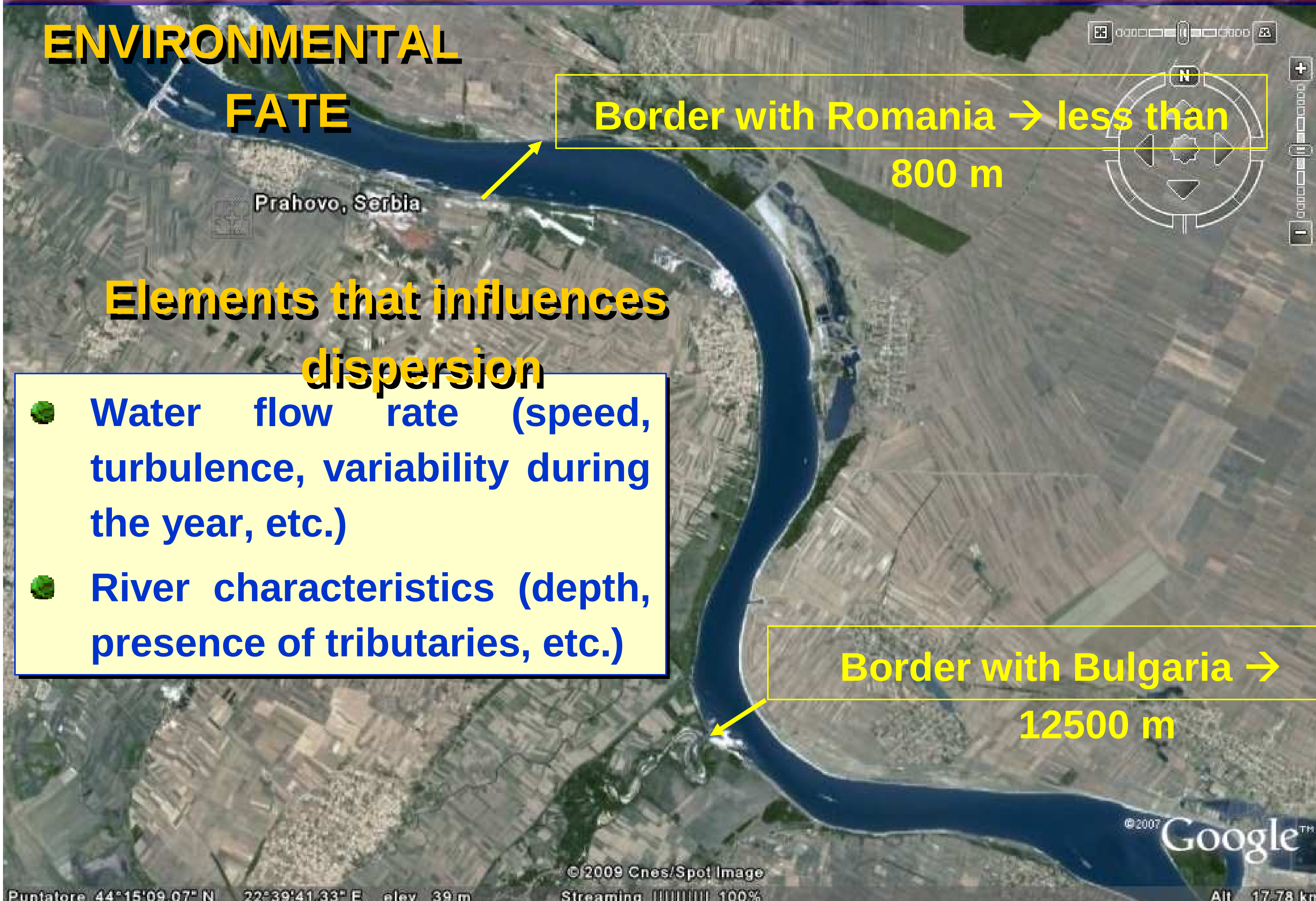
ENVIRONMENTAL FATE

Border with Romania → less than 800 m

Elements that influences dispersion

- Water flow rate (speed, turbulence, variability during the year, etc.)
- River characteristics (depth, presence of tributaries, etc.)

Border with Bulgaria → 12500 m



ENVIRONMENTAL FATE

Main transport and weathering processes

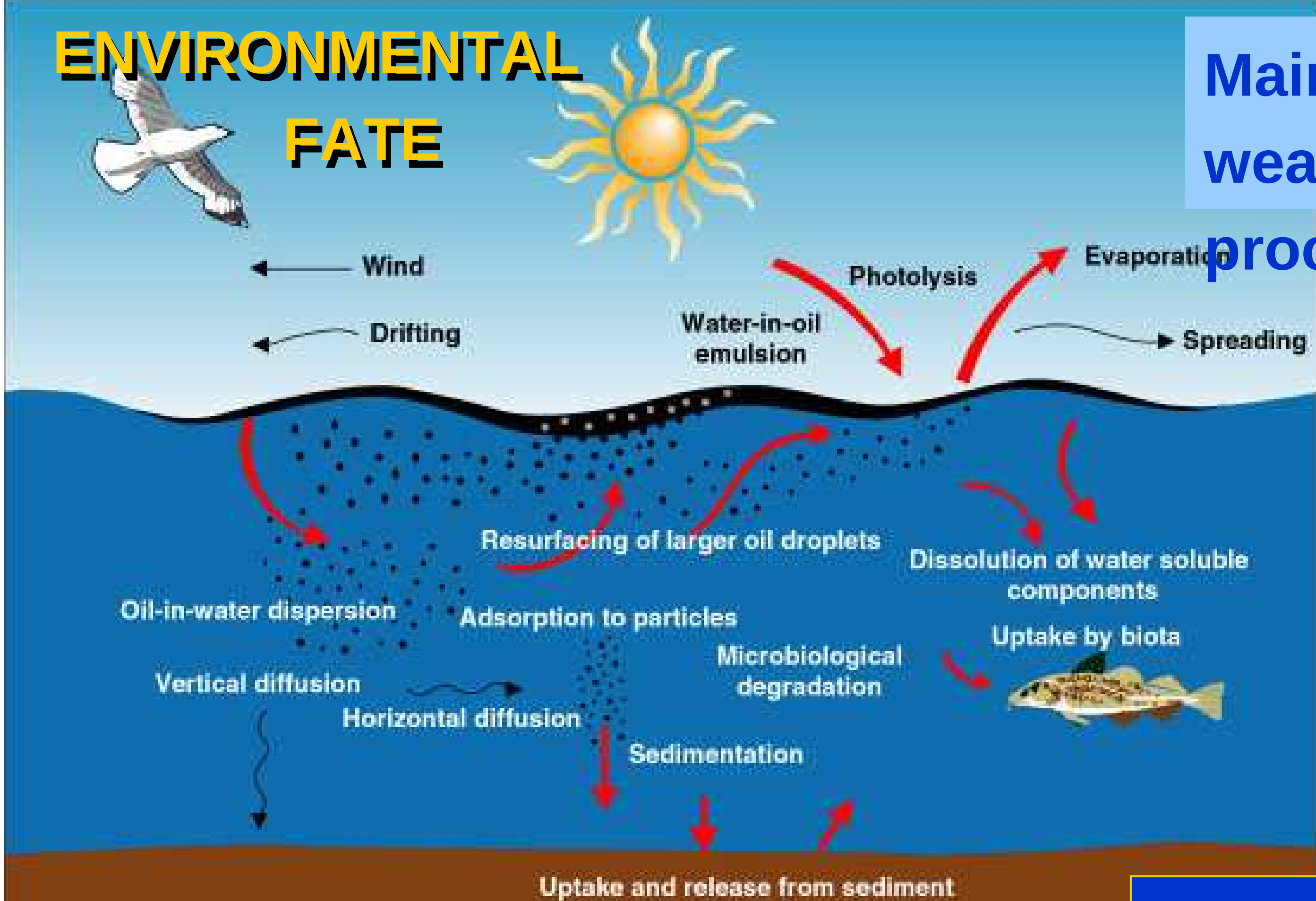
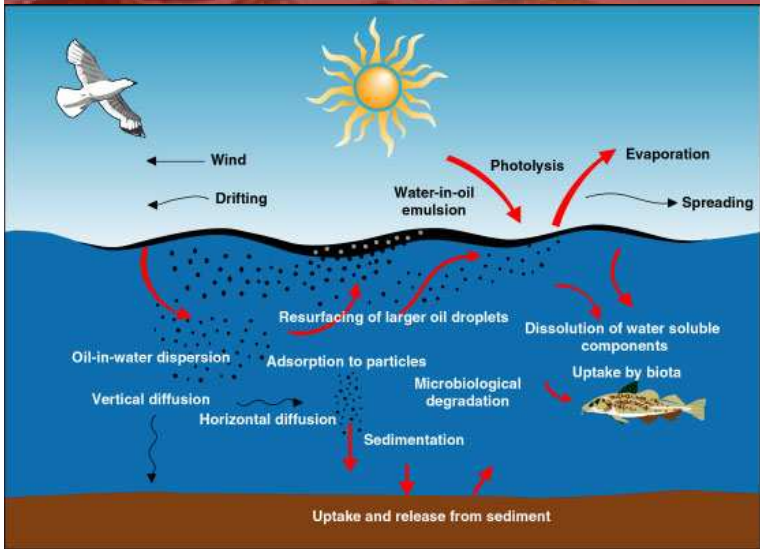


Figure from SINTEF Web page with minor additions

- Emulsification
- Biodegradation
- Shoreline stranding
- Dissolution
- Photolysis

1. Spreading
2. Evaporation
3. Transport by current

- Natural dispersion and oil resurfacing (buoyancy effect)
- Sedimentation

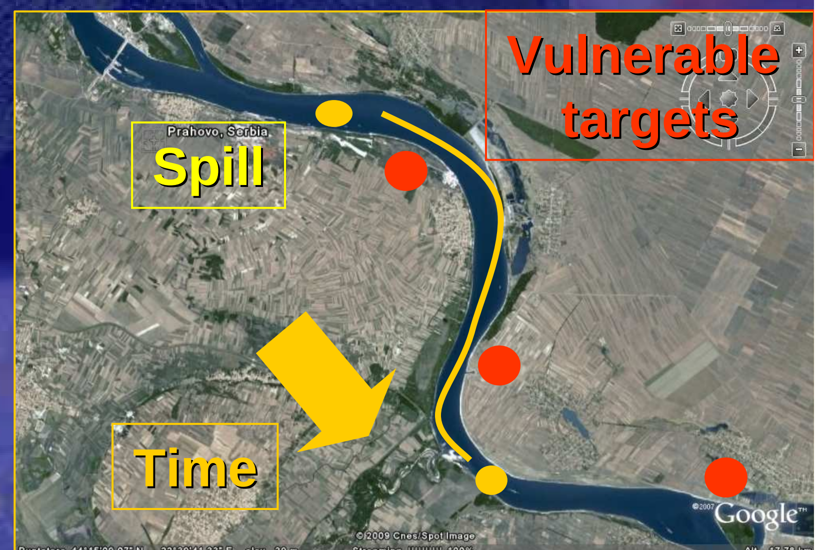


The physical phenomenon is rather complex and involves

The exact resolution of balance equations requires advanced tools and a significant amount of data that might be difficult to handle during an emergency

Proposed approach for modelling

- internationally referenced;
- simplified and easy to use;
- rapid estimate of endangered areas.



ENVIRONMENTAL FATE

Fay model

Models for analysis of oil lispersion

1. Spreading

Spreading is the movement of the entire oil slick horizontally on the surface of water due to effects of gravity, inertia, friction, viscosity and surface tension

Gravity-inertial phase

Gravity and inertia forces dominate the spreading process with gravity being the accelerating force and inertia the retarding force.
This phase usually lasts a few minutes after the release.

Gravity-viscous phase

Gravity and viscous forces dominate the spreading with viscous force being the retarding one. This phase usually lasts the first hours after the spills (i.e. 10-20 hours). More the amount released, more the tension viscous phase lasts.

Tension-viscous phase

Interfacial tension and viscous forces dominate the spreading. This phase takes place when the slick can be broken in parts, dispersed, etc.

ENVIRONMENTAL FATE

Fay model

Models for analysis of oil
lispersion

1. Spreading

FAY Model

- **Based on real tests developed in the early 70's with different oil slick on water;**
- **The model is the base for further more detailed approaches for analysis of oil spill on water;**
- **More details in: Fay, J.A. – "Physical processes of the spread of oil on a water surface" – proceedings of the Joint Conference on the prevention and control of oil spill – API, Washington DC, 1971**

ENVIRONMENTAL FATE

Fay model

Models for analysis of oil dispersion

1. Spreading

Main assumptions for Danube study

- **Simplification of the overall dynamics by selection of the sole gravity-viscous phase (which provides better results on long term spreading);**
- **The model is direct to predict the surface extension of the oil slick above water;**
- **The model is capable to change the prediction in case of sudden changes in dynamics (e.g. oil removal from external action), according to hypothesis defined by the user.**

ENVIRONMENTAL FATE

Fay model

Models for analysis of oil lispersion

1. Spreading

From material balance and support by real tests, the following equation is proposed:

Fay's equations for gravity - viscose slick spreading:

$$R = K \cdot \left(\Delta\rho \cdot g \cdot V^2 \cdot t \cdot \sqrt{\frac{t}{\upsilon}} \right)^{\frac{1}{6}}$$

Being:

K = dispersion constant, 0.98 for fresh water

R = radius of oil surface (m)

Δρ = density difference, water-oil (kg/m³)

g = gravity acceleration (9.81 m/s²)

V = Volume of spill (m³)

t = time (s)

υ = kinematic viscosity (stokes, m²s)

ENVIRONMENTAL FATE

ADIOS model

Models for analysis of oil ...spersion

2. Evaporation

Evaporation is a transfer of light and medium-weight components of the oil from the liquid phase to the vapor phase in atmosphere

During first 24-48 hours following the spillage, evaporation is a the single most important weathering process from the standpoint of volume reduction of the spill.

Depending on oil composition, a 20 to 40 percent loss by volume of product is considered normal for crude oils following a release.

This percentage can increase up to 75 to 100 percent loss in volume for many light-weight refined products (e.g. gasoline and kerosene).

ENVIRONMENTAL FATE

ADIOS model

Models for analysis of oil ...spersion

2. Evaporation

ADIOS model:

- ADIOS (Automated Data Inquiry for Oil Spills), developed by US NOAA for assistance in managing emergency situation due to oil spill;
- The model is direct to predict the environmental fate of oil slick on a water surface, considering evaporation, emulsification and dissolution;
- The model is capable to analyze different types of oils and oil derivatives.

ENVIRONMENTAL FATE

ADIOS model

Models for analysis of oil
spersion

2. Evaporation

Main assumptions for Danube study

- **Select a specific sunstance for the representation of the dynamics (automotive diesel, density = 850 kg/m^3)**
- **Neglect (at first approximation) the effects of emulsification and dissolution;**
- **The model is capable to change the prediction in case of sudden changes in dynamics (e.g. oil removal from external action, shore stranding), according to hypothesis defined by the user.**

ENVIRONMENTAL FATE

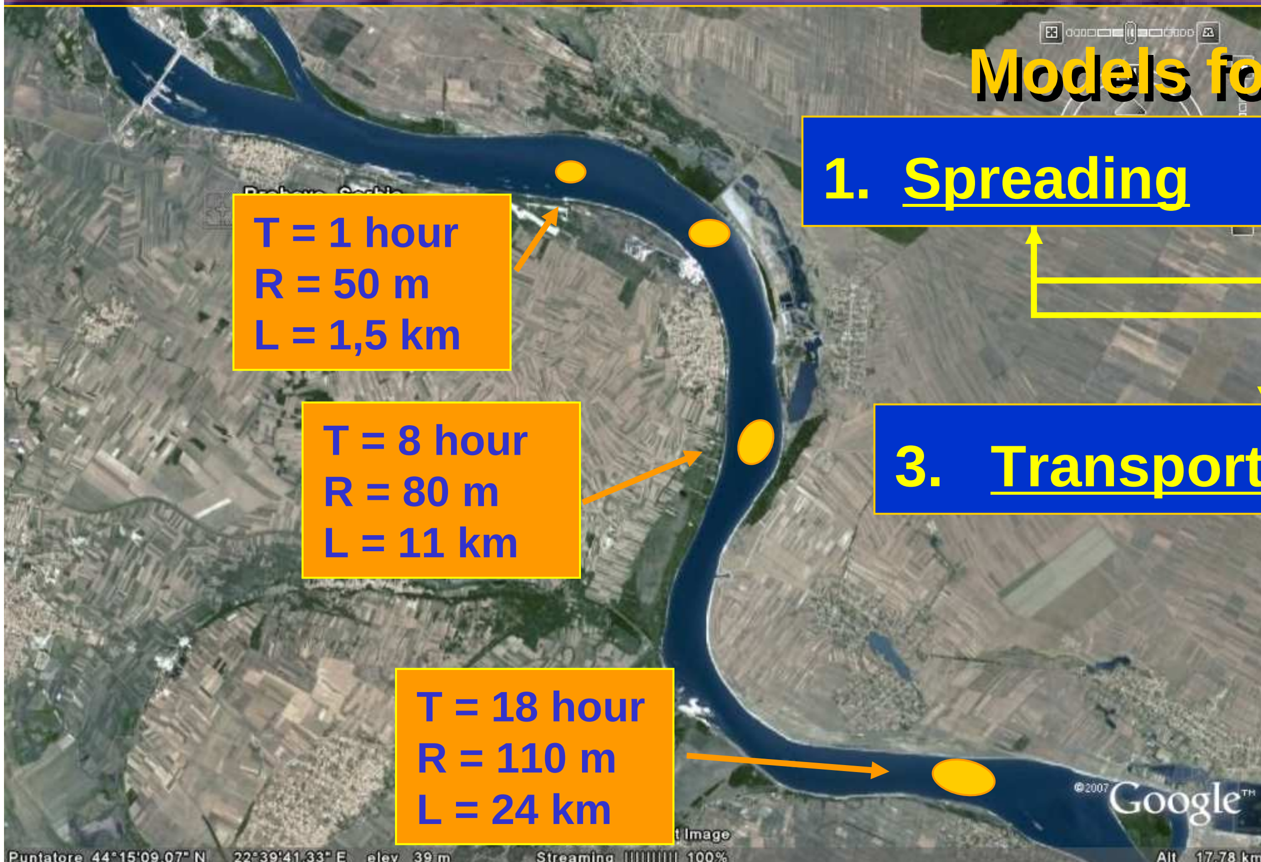
Models for analysis of oil

3. Transport by current

Floating oil slick is transported by the water current according to flow rate and surface speed of the water.

- **Values of mean flow rate and water speed derived from recorded data in three Countries;**
- **The oil slick moves downstream following the current, reducing its volume due to evaporation and other phenomena (shore stranding, dissolution);**
- **In consideration of the distances between Countries, it is possible to estimate the time sufficient to determine transboundary effects.**

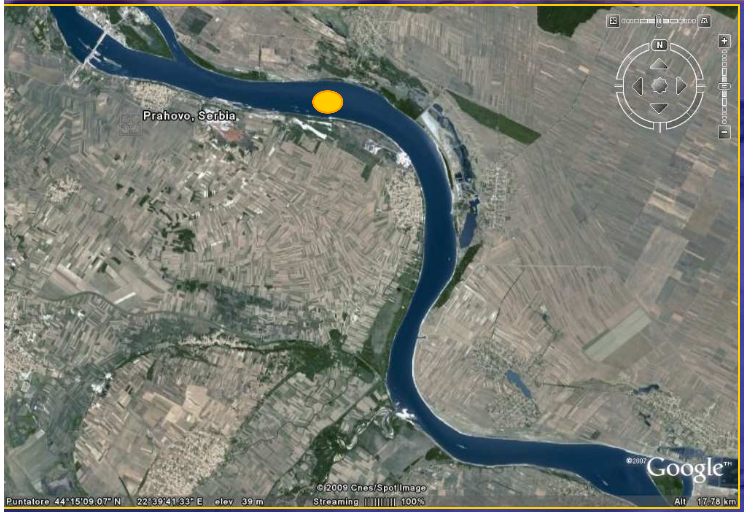
Models for analysis of oil dispersion



1. Spreading
2. Evaporation
3. Transport by current

ENVIRONMENTAL FATE

- Combination of selected models allows identification of the oil slick along the river at different times;
- Model is applied at different boundary conditions (river flow rate, water speed, water temperature, etc.)

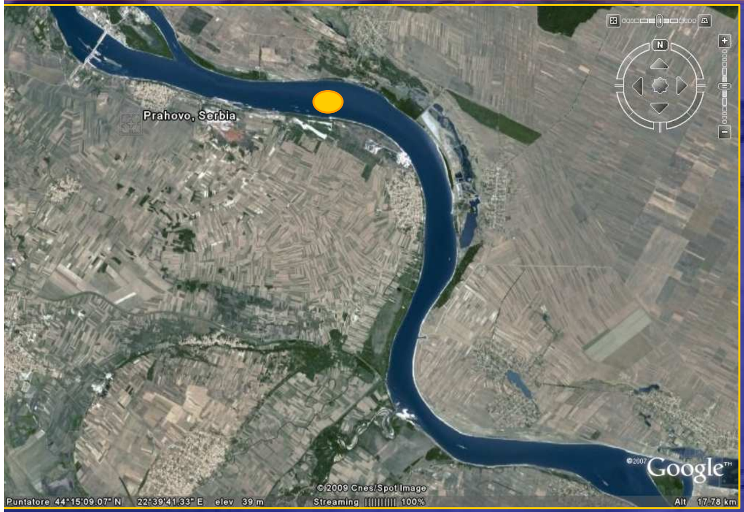


Application of the model

A. Mean river flow rate

Boundary conditions:

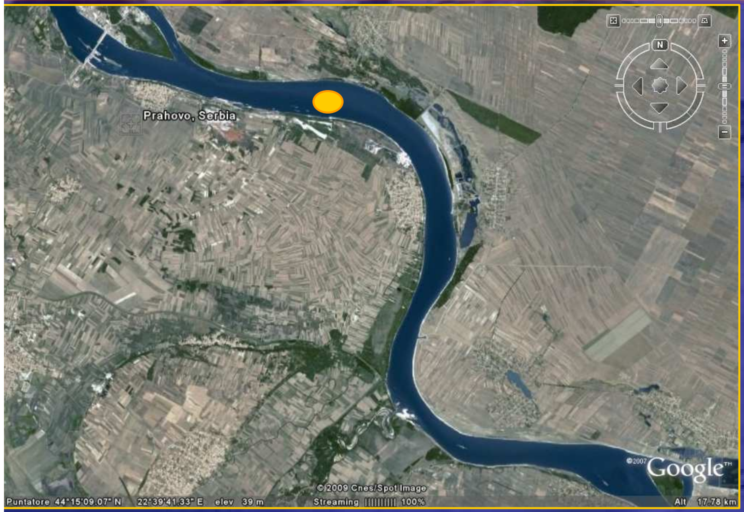
- Diesel oil release = 21,25 tons (instantaneous release) on june 17th, 9.00 a.m.
- Water flow rate = 5000 m^3/hr
- Water speed = 2,84 m/s
- Water temperature = 15°C
- Wind speed = 2 m/s



Application of the model

A. Mean river flow rate

Results:

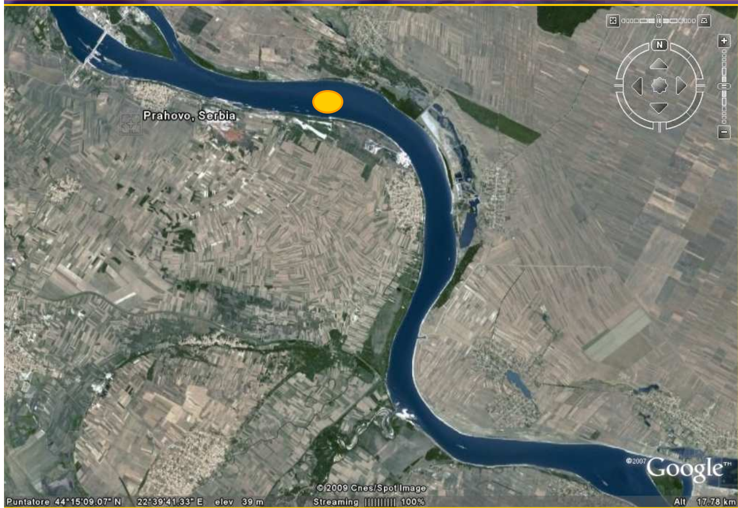


Application of the model

B. High river flow rate

Boundary conditions:

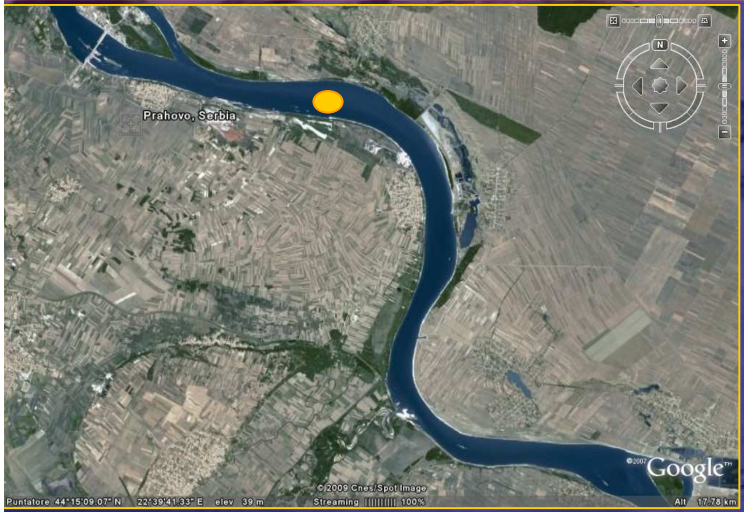
- **Diesel oil release = 21,25 tons (instantaneous release) on june 17th, 9.00 a.m.**
- **Water flow rate = 15000 m^3/hr**
- **Water speed = 4,82 m/s**
- **Water temperature = 12°C**
- **Wind speed = 3 m/s**



Application of the model

B. High river flow rate

Results:

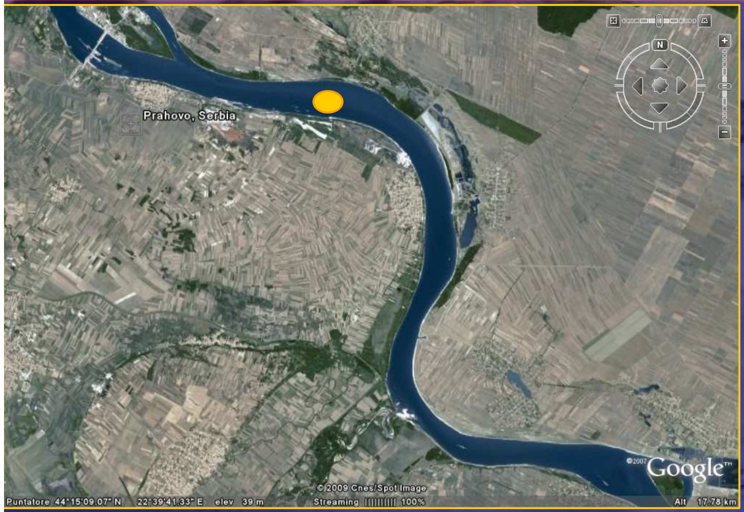


Application of the model

C. Low river flow rate, oil removal 25%

Boundary conditions:

- Diesel oil release = 21,25 tons (instantaneous release) on june 17th, 9.00 a.m.
- Diesel oil removal = 5,3 tons on june 17th, 6.00 p.m
- Water flow rate = 5000 m^3/hr
- Water speed = 2,84 m/s
- Water temperature = 15°C
- Wind speed = 2 m/s



Application of the model

C. **Low river flow rate, oil removal 25%**

Results:

THANK YOU !!!