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From air to water: modeling & monitoring approaches to identify and estimate atmospheric depositions in rivers

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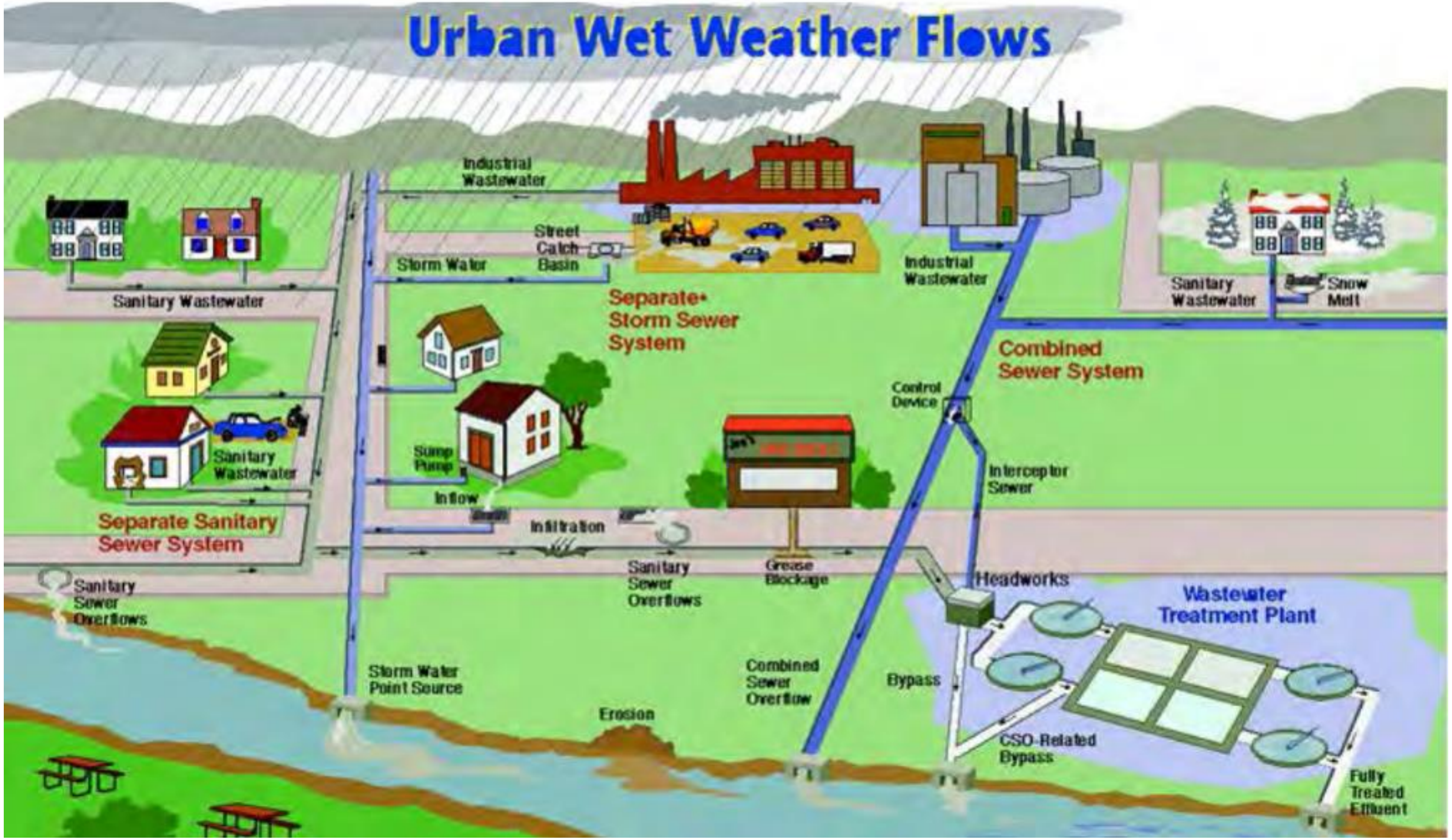
Causes of water pollution in the Greater Moscow region



Interrelations and chemical (microparticles) transfer between urban atmosphere, soils and surface water

- **Task 6.1** Supradisciplinary (i.e. simultaneous multi-, inter- and transdisciplinary) and multidisciplinary (physics, chemistry, biology, meteorology, etc.) scientific framework
- **Task 6.2** Conceptual and integrated analysis of urban atmospheric and environmental pollution formation, effects and feedback

Hypothesis: *atmospheric deposition is one of the most important pathways of urban water pollution*

- **Task 1**: To estimate non-point pollution loading in the Setun Basin due to atmospheric deposition
- **Task 2**: To evaluate the total contribution of atmospheric deposition in the chemical fluxes of the Moscow River

Modeling approach: **Enviro-HIRLAM + SWMM**

Task 1: *To estimate non-point pollution loading in the Setun basin due to atmospheric deposition*

Enviro-HIRLAM

Meteorological output: rainfall, relative humidity, wind speed, temperature

Atmospheric composition output: concentrations, wet/dry deposition, sedimentation

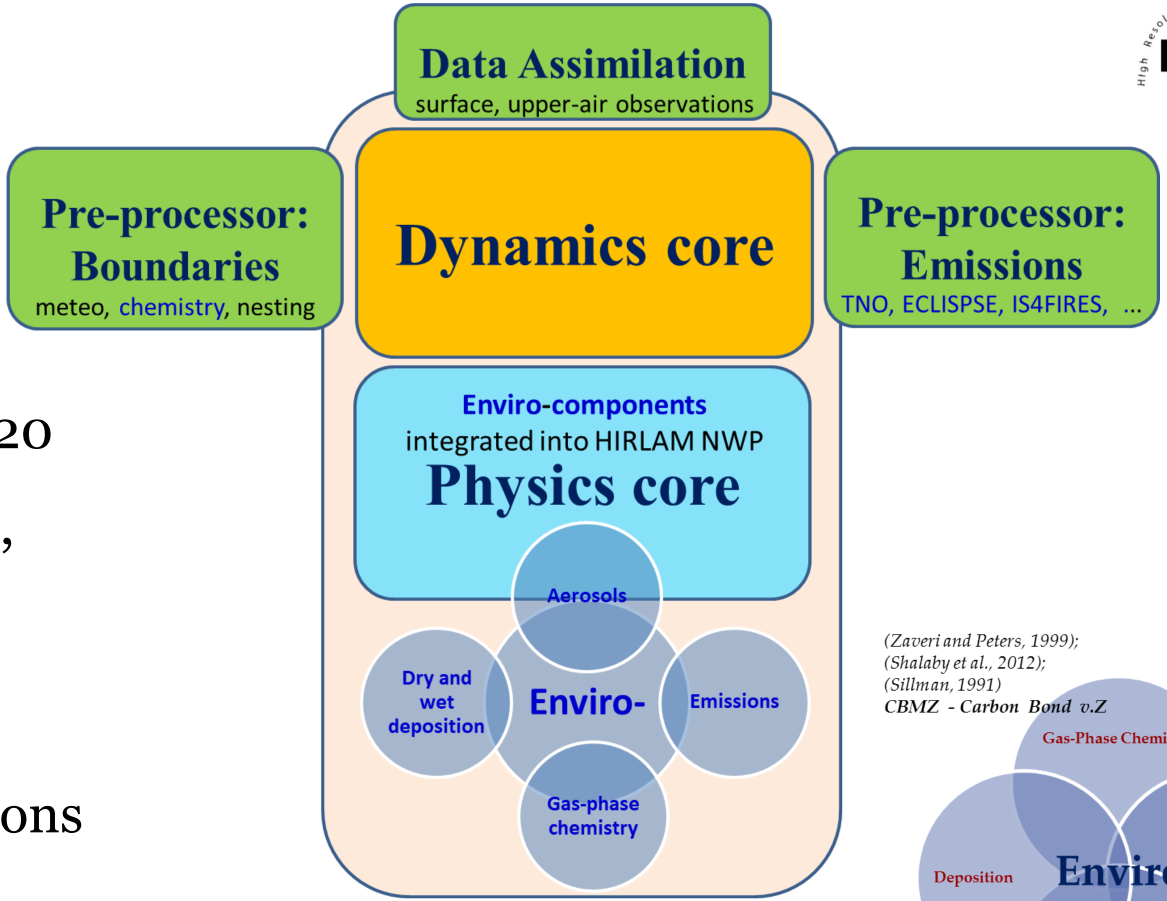
SWMM

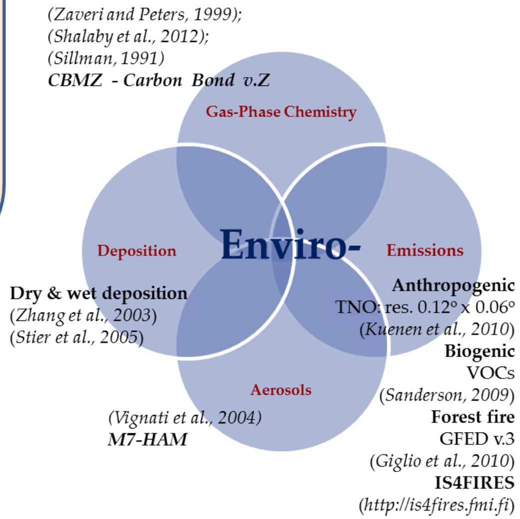
Meteorological input: rainfall, relative humidity, wind speed, temperature

Atmospheric deposition input

Modeling approach: seamless/ online integrated **Enviro-HIRLAM**

- **domain size:** 300+ x 300+ km; Moscow region is in the center)
- **horizontal resolution:** 1-2+ km;
- **periods:** for 2018-2019 (Mar-Apr), for 2020 (Mar-Apr-May) & extra for 2022 (Mar, Apr, May, Jun, Jul)
- **model output:** both 3D meteorology & atmospheric composition (incl. concentrations & wet/dry deposition & sedimentation)





Modeling approach: **SWMM overview**

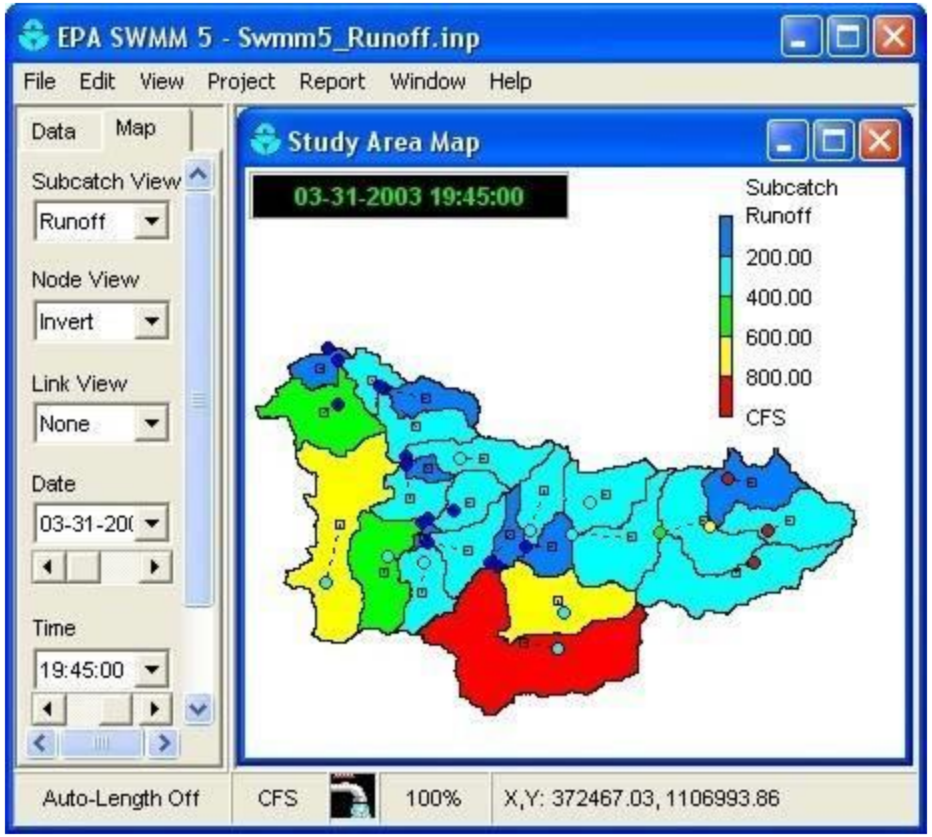
Storm Water Management Model

Distributed dynamic rainfall-runoff simulation model used for single event or long-term (continuous) simulation of runoff quantity and quality from primarily urban areas

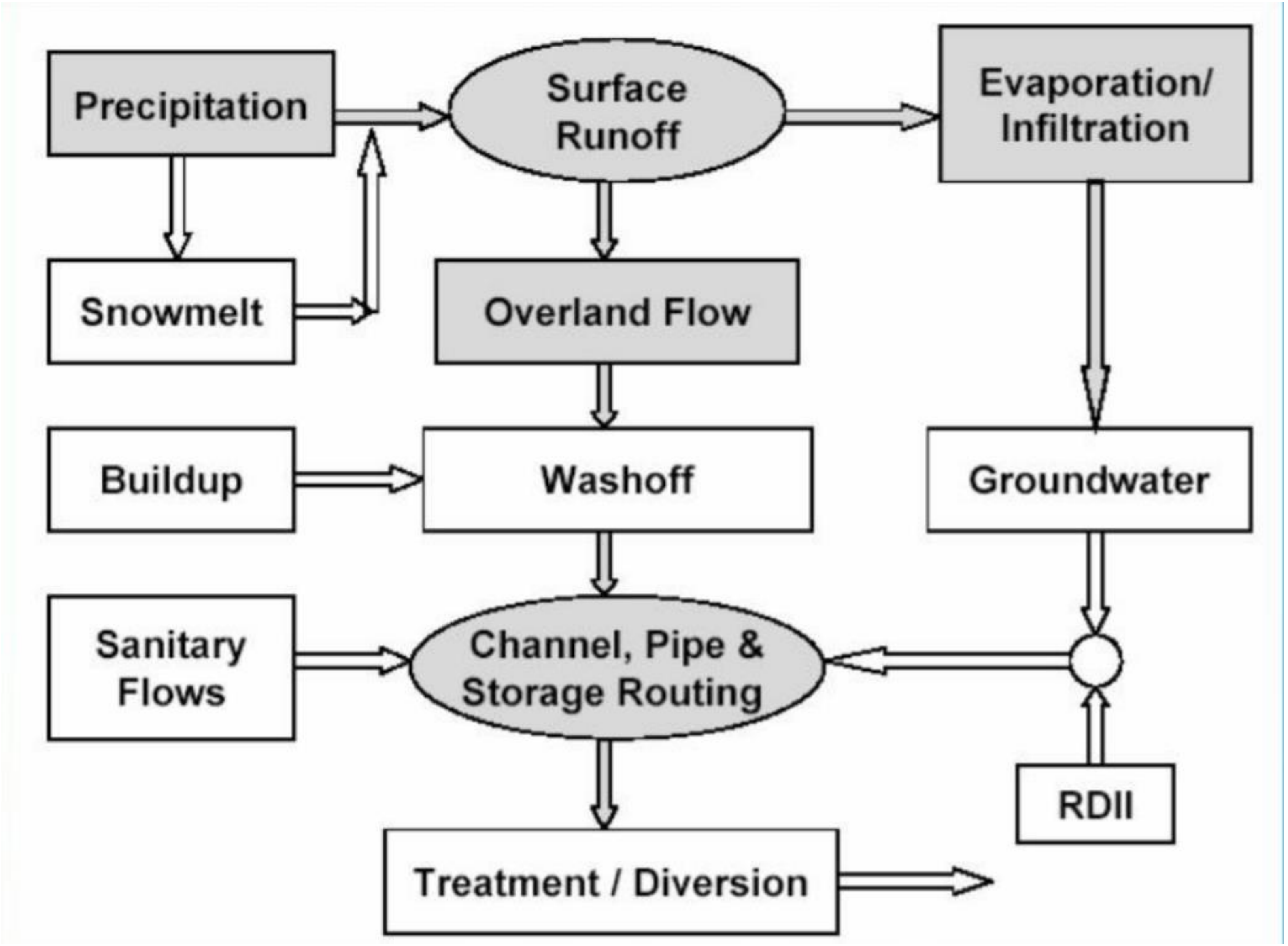
Developed in 1971 by US EPA

Includes 3 modules:

- Hydrology
- Hydraulics
- Water quality



SWMM description: process models

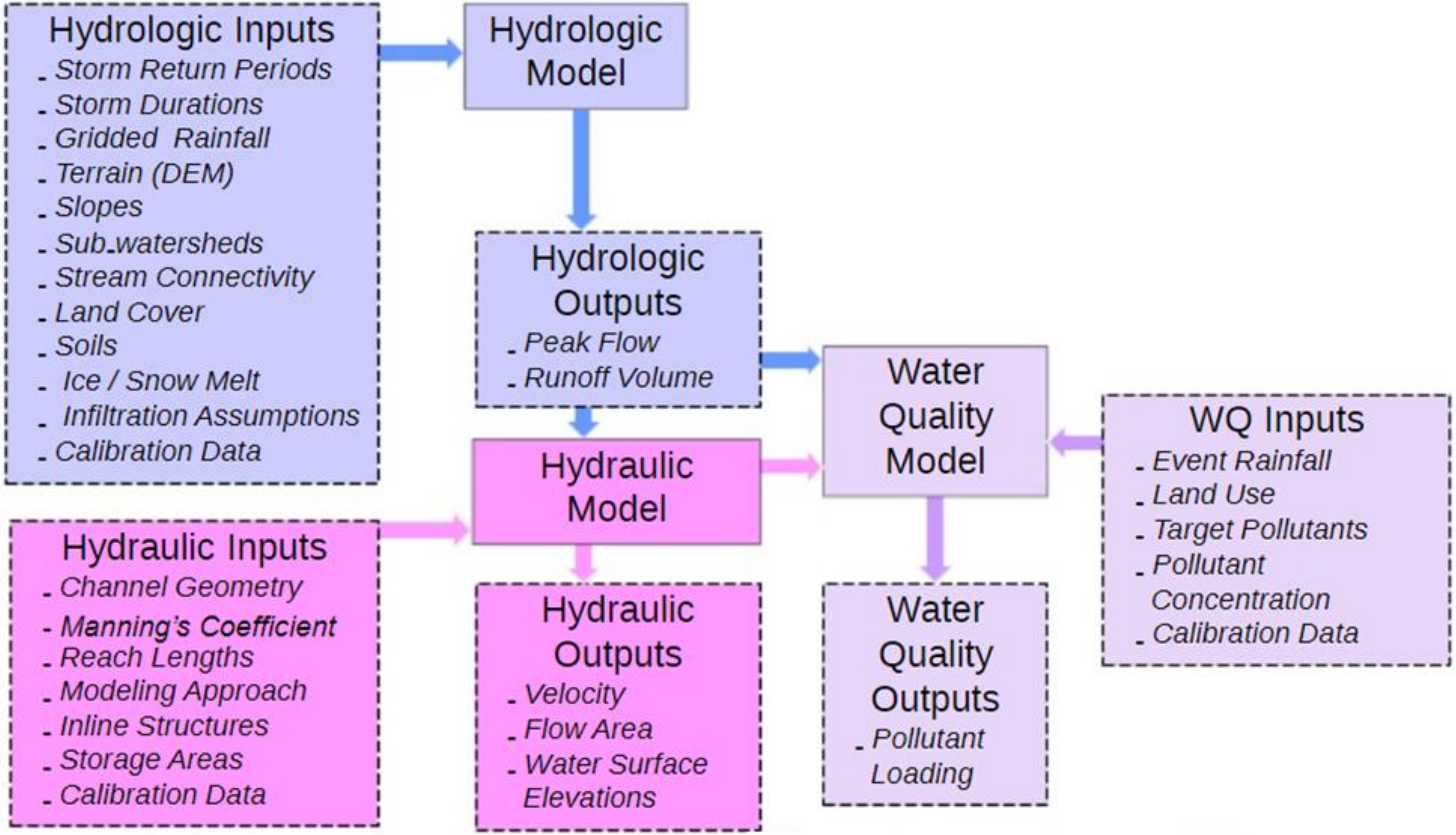


SWMM limitations

- Not applicable to large-scale, non-urban watersheds
- Not applicable to forested areas or irrigated cropland
- Cannot be used with highly aggregated (daily) rainfall data

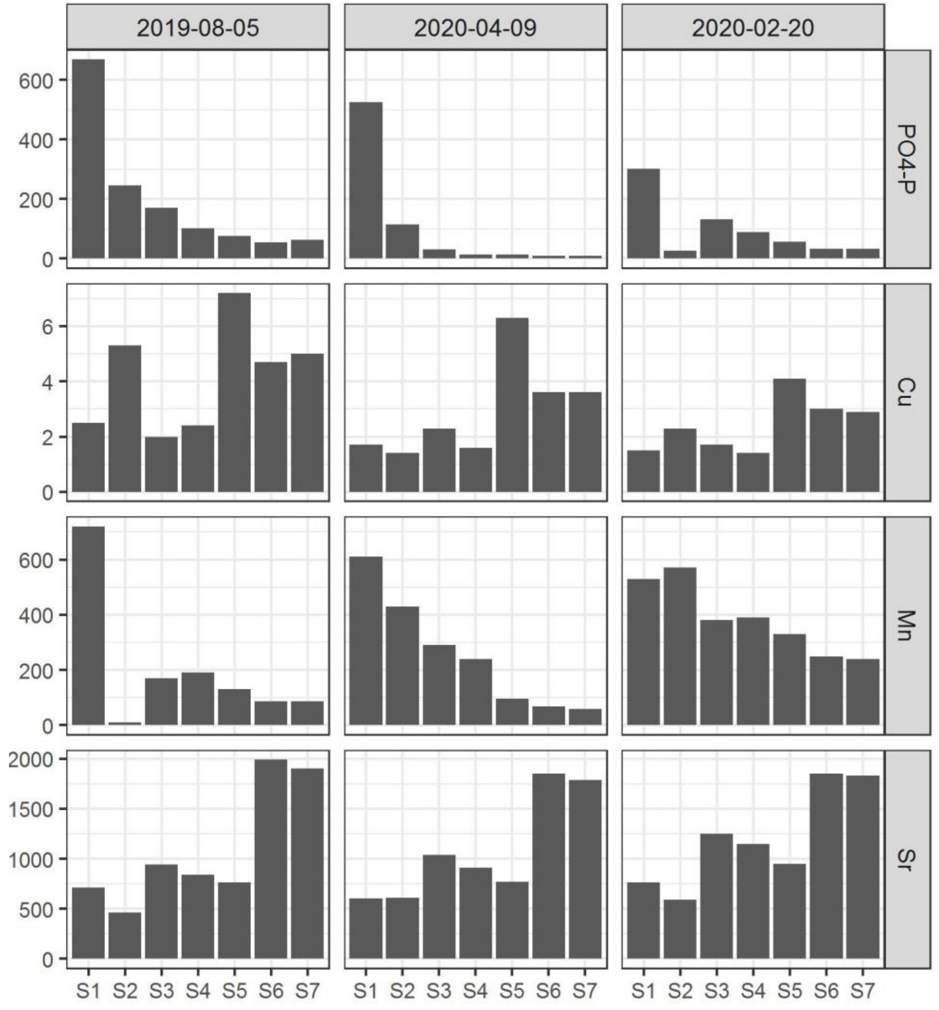
- Applicable **for The Setun Basin only**, not for the entire Moscow River

SWMM: inputs and outputs

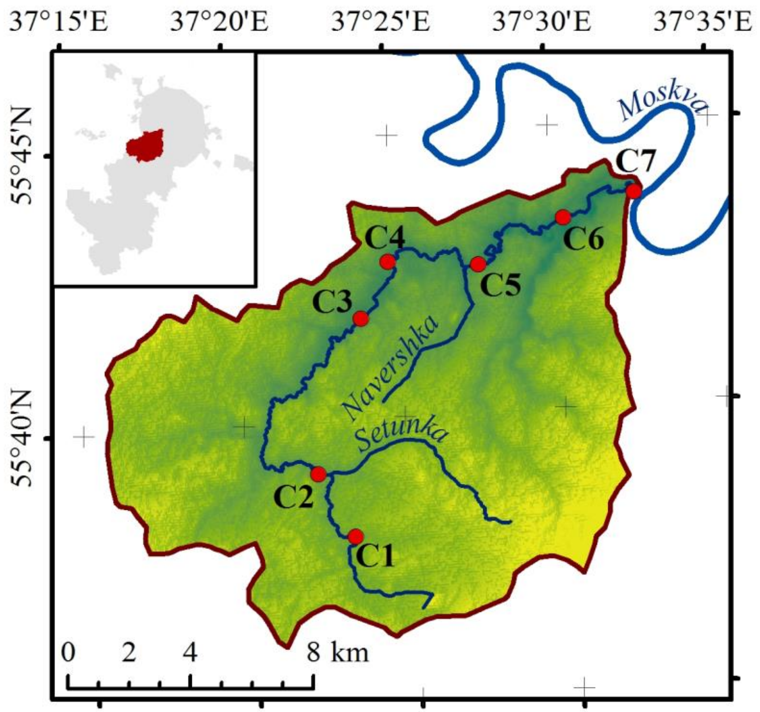


Modeling approach: SWMM **calibration for the Setun Basin**

- Monthly and seasonal sampling data since 2019
- High-frequency hydrological monitoring data since 2019



- Daily & subdaily sampling for coming rain events in 2021-2022

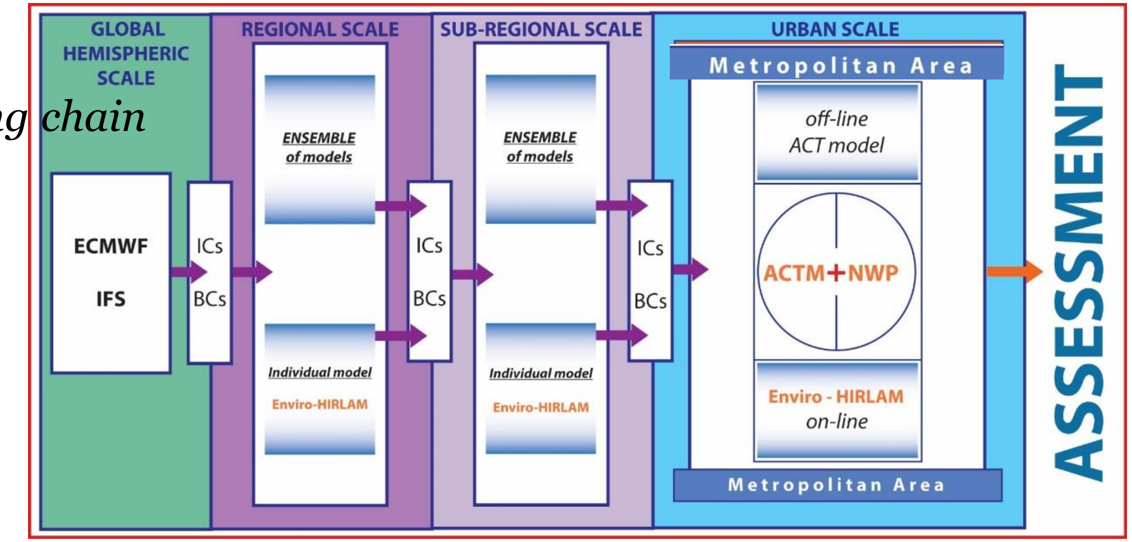


Modeling approach: Study of aerosol effects on atmospheric deposition rate

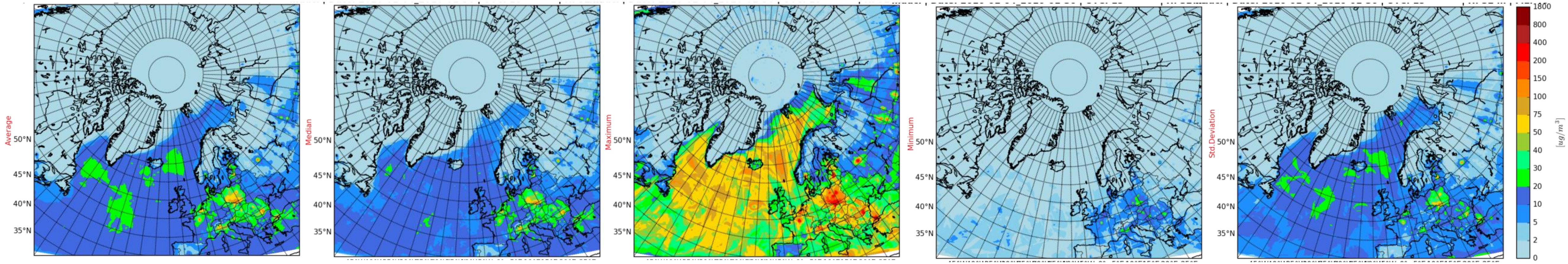
Planned 4 types of Enviro-HIRLAM model (**urban scale**) runs for selected episode(s):

- no aerosol effects included (REFERENCE)
- only direct aerosol effect (DAE)
- only indirect aerosol effect (IDAE)
- direct + indirect aerosol effects (DAE+IDAE)

Downscaling chain approach



*Example of analysis for **regional scale** runs (DAE+IDAE, 15 km resol) over period 1-31 Jan 2010*

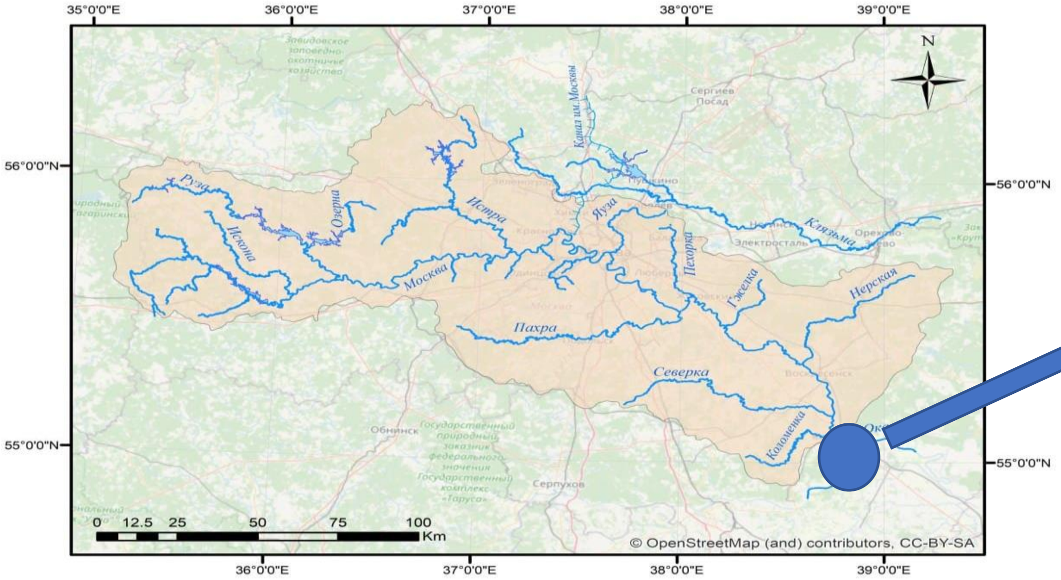


Monitoring approach: evaluation of the rate of atmospheric deposition in the chemical fluxes of the Moscow River

- High-frequency monitoring based on logging (TSS, pH, level-water discharge, TDS + ammonia, PAH, petroleum products)

COMBINED WITH

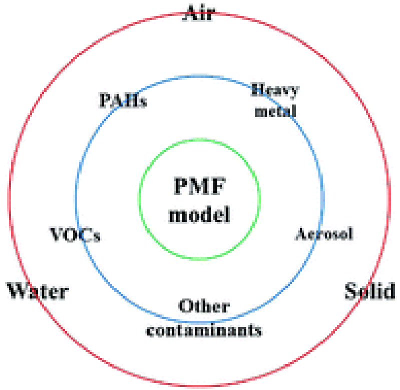
- Manual monthly sampling at the Moscow River outlet (to estimate concentrations of toxic elements in suspended sediments)

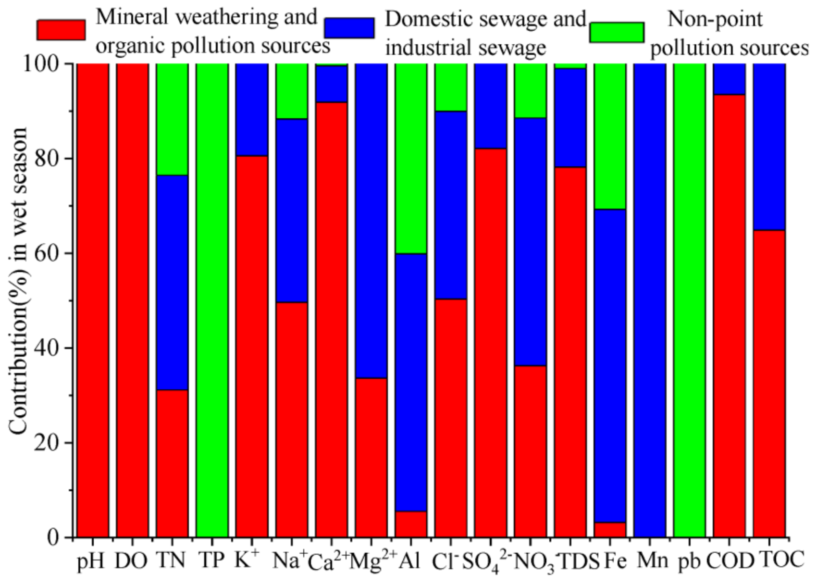


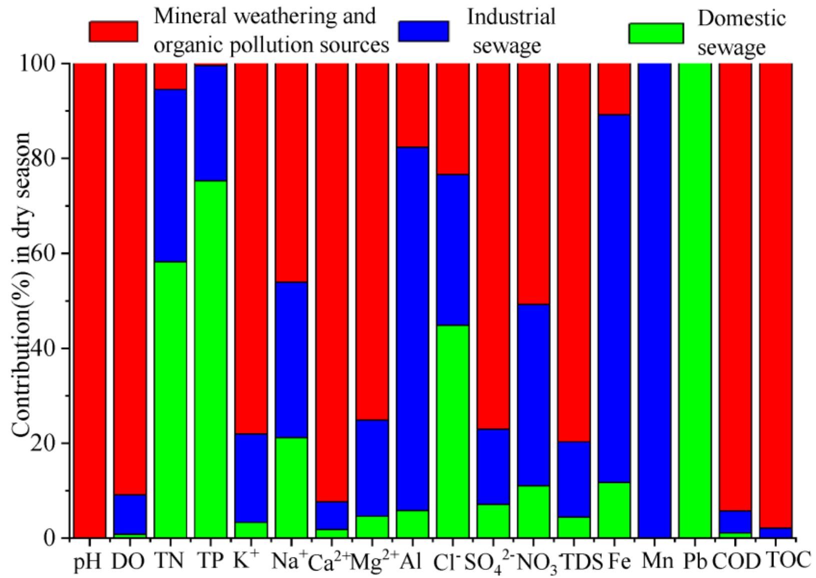
Deliverable 6. pollutants delivery at the outlet of the Moscow River and connection with atmospheric accumulation

Monitoring approach: source identification and apportionment

- **Positive matrix factorization model**
- mathematical receptor model
- provides scientific support for the development and review of air and water quality standards, exposure research and environmental forensics.
- can analyze a wide range of environmental sample data: sediments, wet deposition, surface water, ambient air, and indoor air.

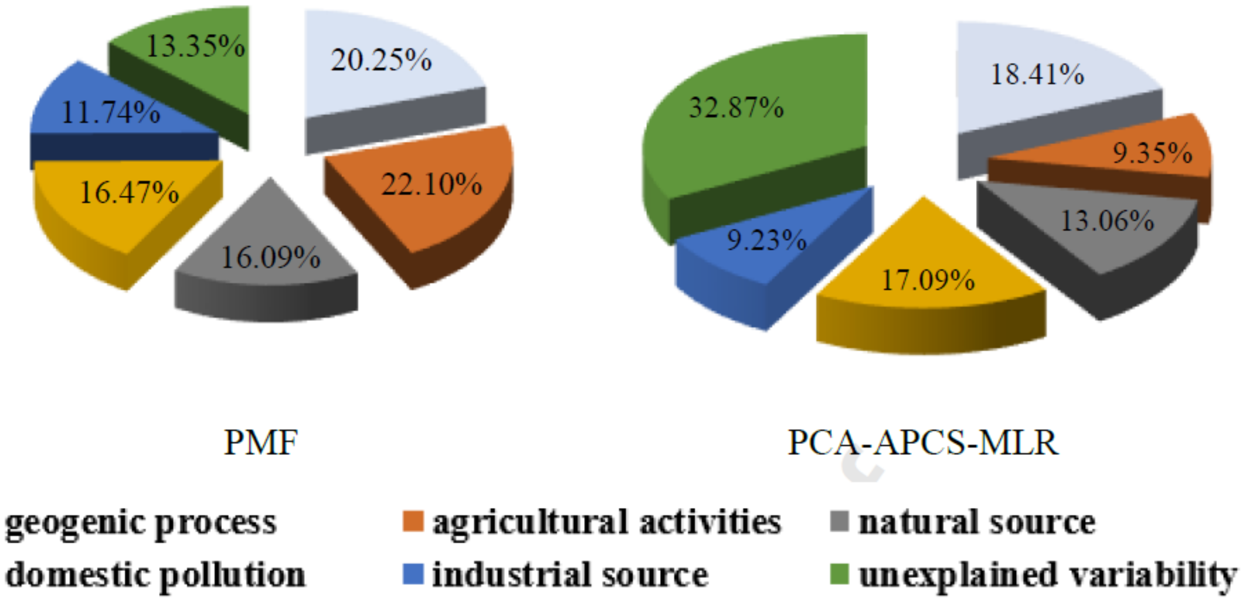


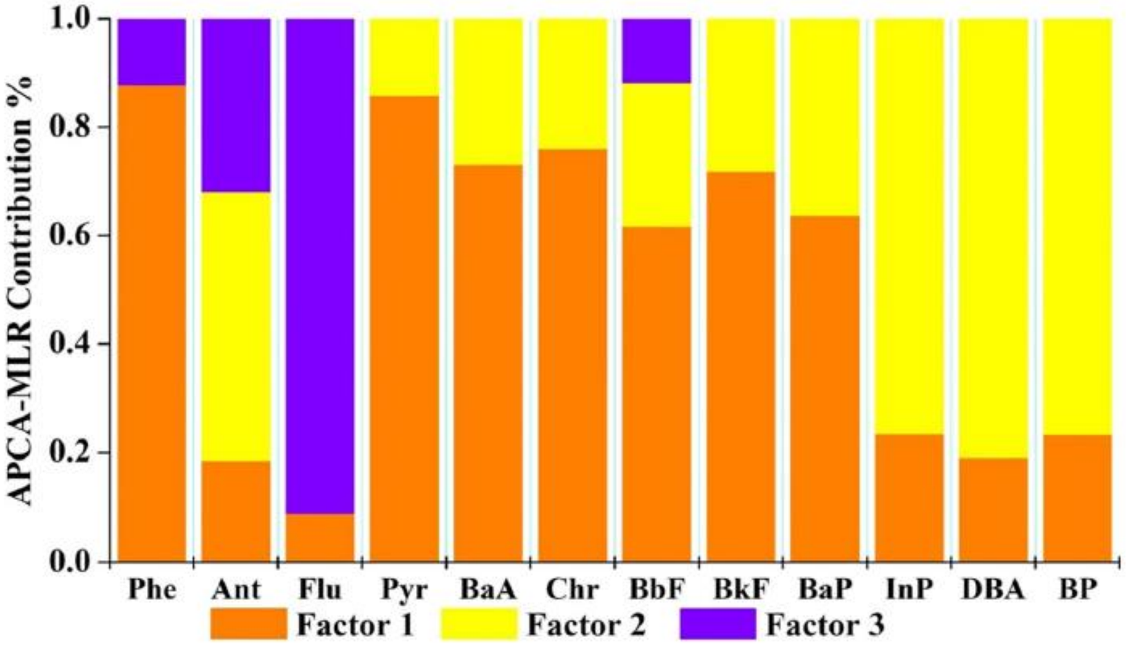


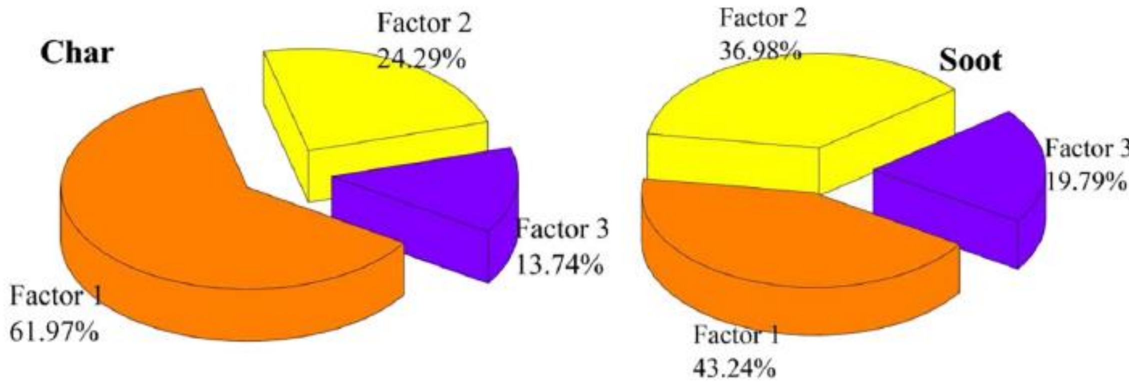


Monitoring approach: source identification and apportionment

- **APCS-MLR model**
- multiple linear regression receptor model







Monitoring approach: Comparison of atmospheric deposition and point-source load from the Moscow River

Loading with point sources will be estimated based on Russian Federal Statistics data about input of toxic elements with wastewater discharge

Deposition rate will be estimated for the entire Moscow river based on Enviro-HIRLAM