Development of the Nemunas River watershed model for hydrology, sediment and nutrient calculations

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Case study

Watershed area:
100 458 km²

Shared by:

Lithuania: 46 %

Belarus: 48 %

Poland: 2.57 %

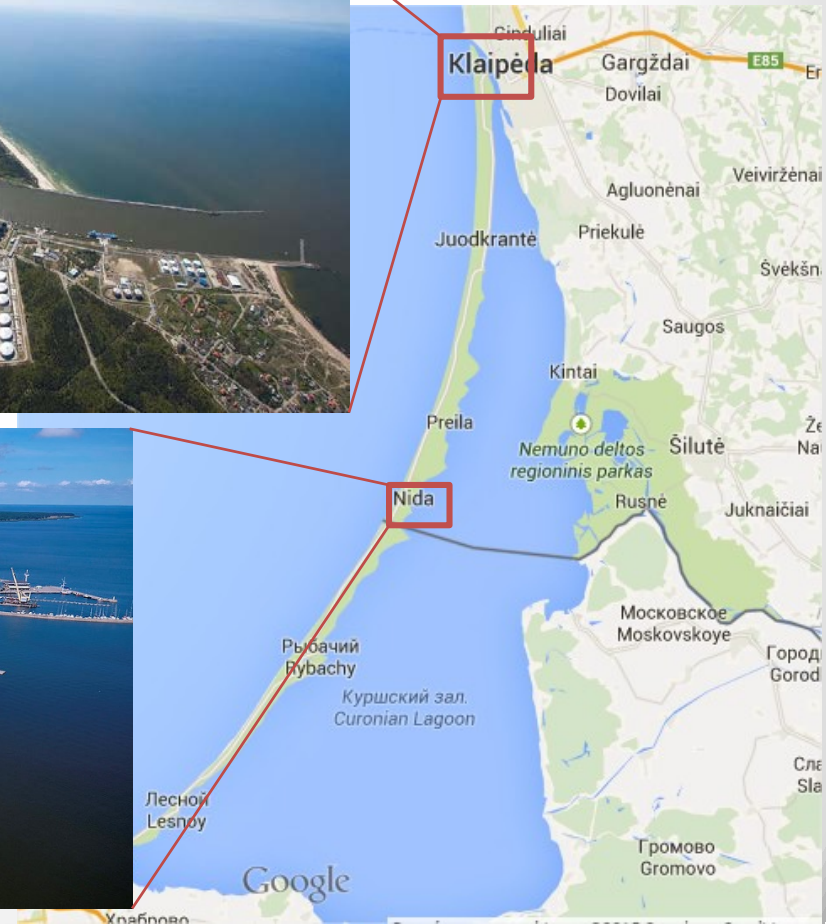
Russian Federation
Kaliningrad Oblast: 3.34 %

Latvia: 0.09 %

Case study

Drains into *Curonian Lagoon;*

Provides up to 98% of inflow (in terms of flow rates and nutrient inputs)



Context

- HELCOM Baltic Sea Action Plan (BSAP) – achieve GES by 2021!
- Dealing with:
  - Eutrophication;
  - Biodiversity;
  - Hazardous substances;
  - Marine activities;
- Nutrient Reduction Scheme
  - Some countries achieved reduction levels;
  - Lithuania on the way… (long, long way)

Country Allocated Reduction Targets (CARTs) **for pollution from both land and air, in tonnes, agreed in 2013**

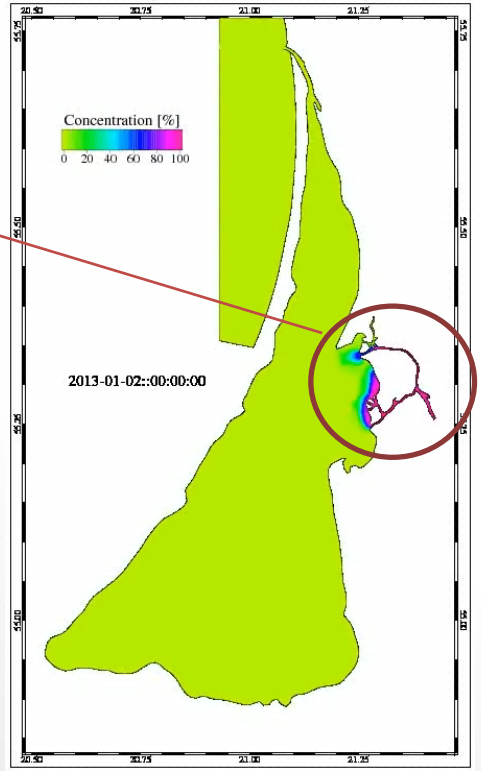
	Nitrogen	**Phosphorus**
Denmark	2,890	38
Estonia	1,800	320
Finland	2,430 +600*	330 +26*
Germany	7,170 +500*	110 +60*
Latvia	1,670	220
Lithuania	*8,970*	*1,470*
Poland[1]	43,610	7,480
Russia	10,380*	3,790*
Sweden	9,240	530

Exploring the sources within the lagoon

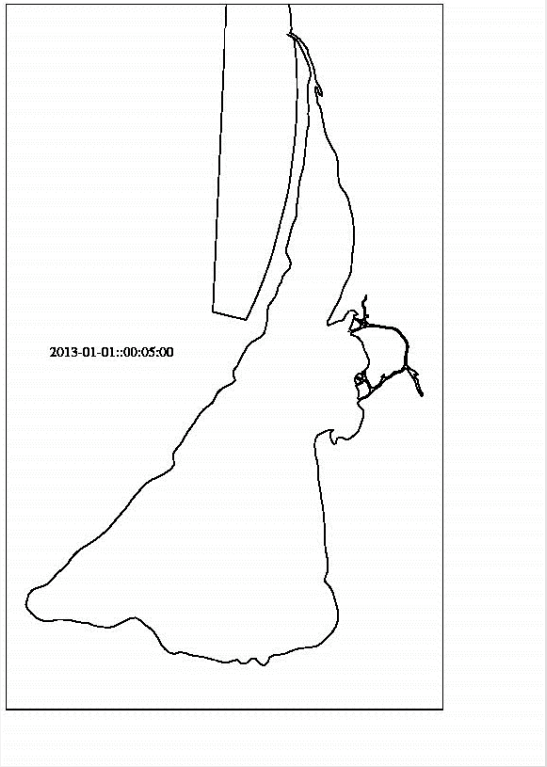
3D hydrodynamic model (SHYFEM) of the Curonian Lagoon with an ecological module;

Concentration modeling;

What is happening in the watershed?



Particle transport modeling;



Exploring the sources in the watershed

Most of the unknown (to us) in the watershed comes from Belarus

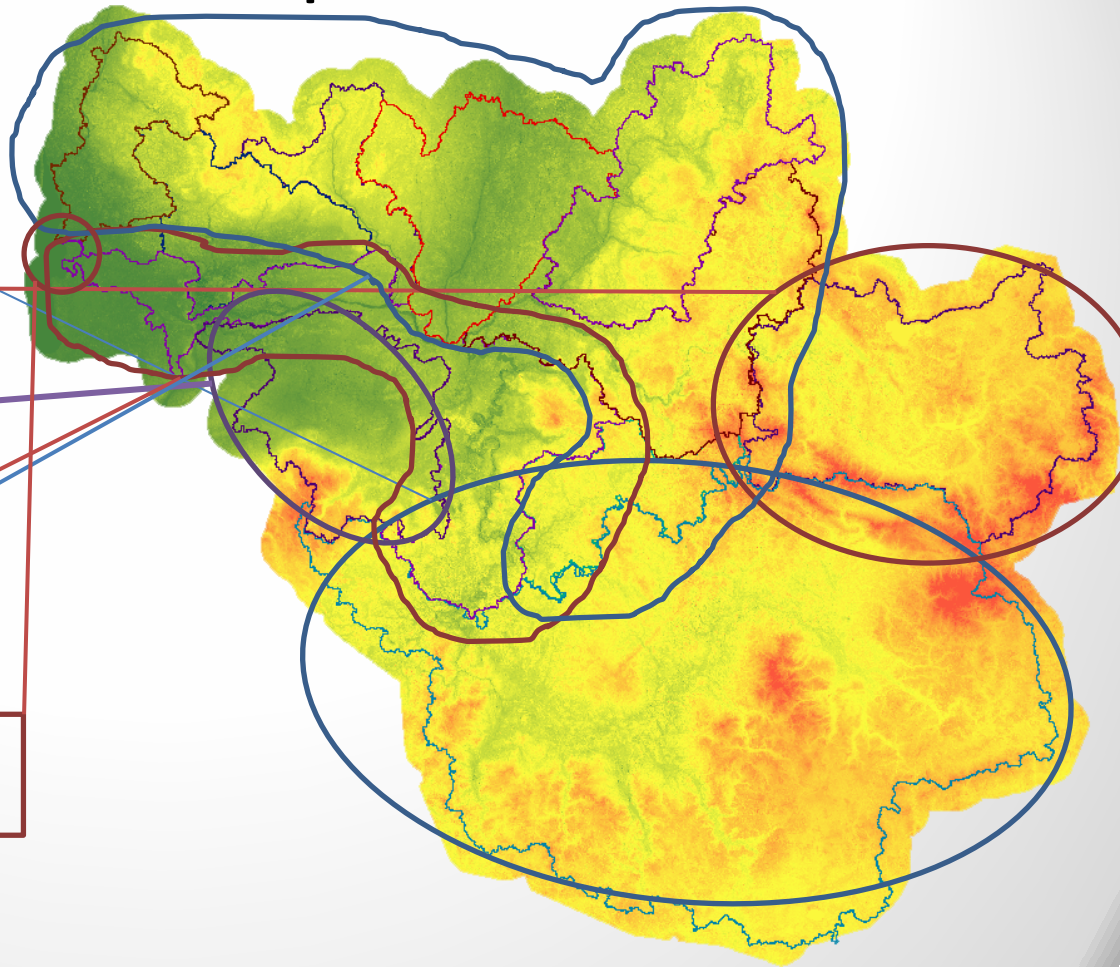
Model development

"Cut" the model into manageable pieces:

- BY Nemunas part;
- BY Nemunas tributary part (Vilija);
- RU/PL/LT transboundary river (Šesupė);
- Main Nemunas channel;
- 7 LT Tributary rivers

Total 11 "pieces"

Did not include the delta region!



DEM

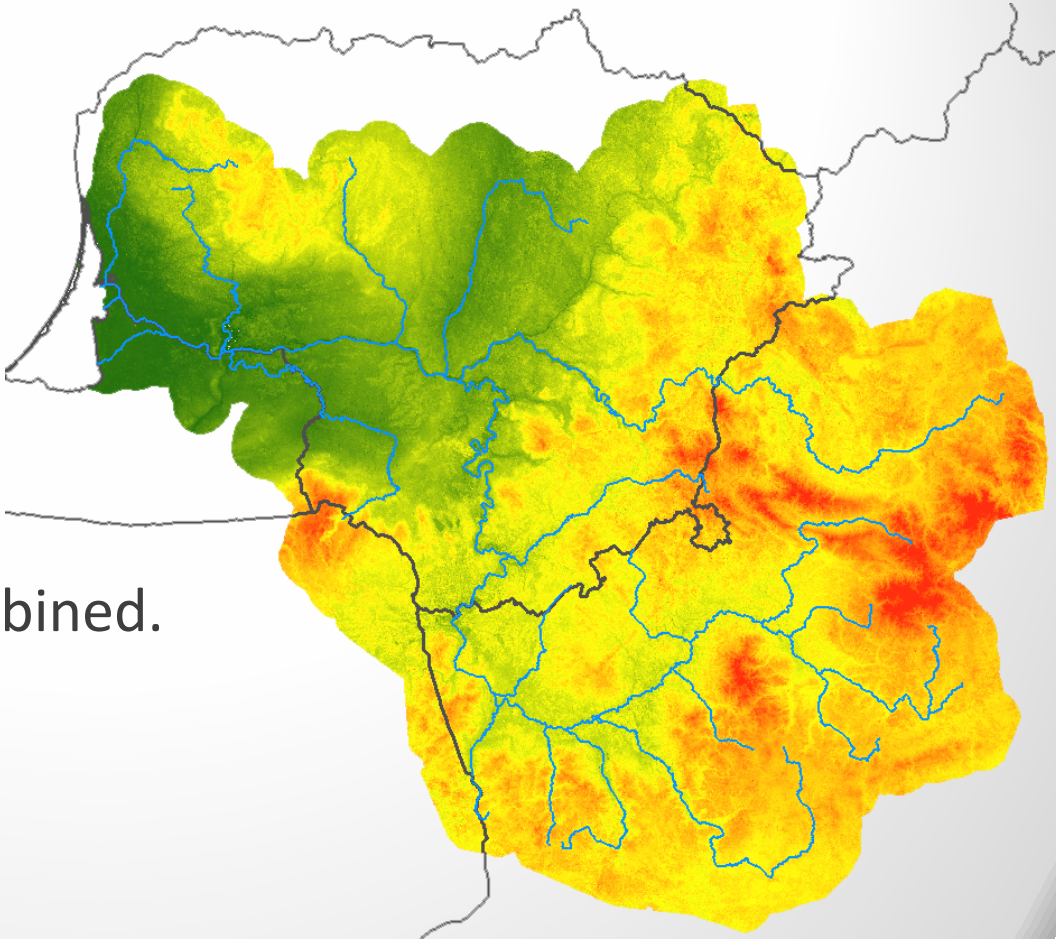
4 DEMs:

Lithuania: 5 m;
Poland: 30 m;

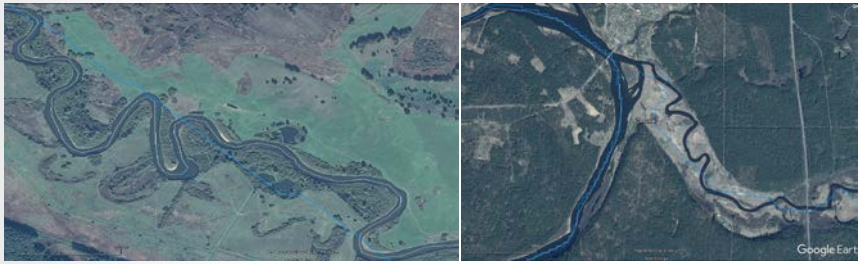
Russia: 35 m;

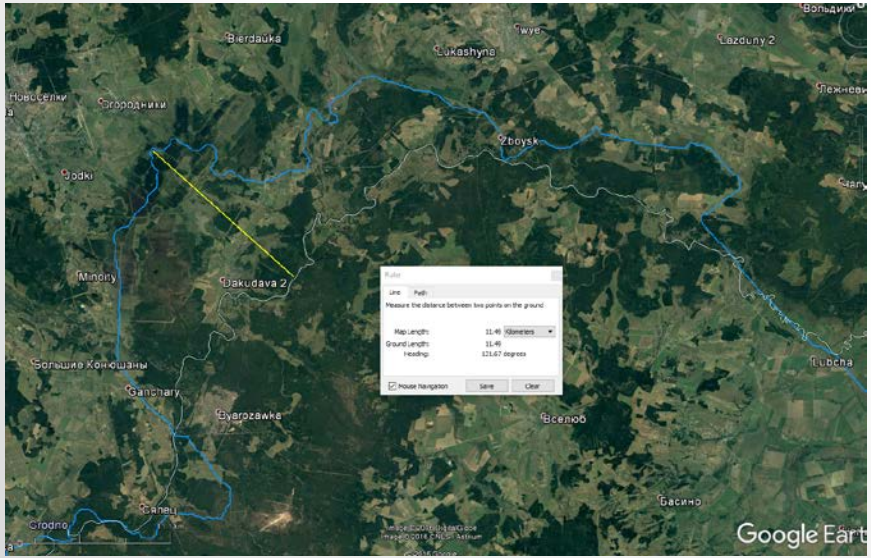
Belarus: 35 m.

Resampled, snapped and combined.



Data quality





Inaccurate stream network in Belarus and Lithuania

Soil and Land-use

Different **soil** data sources

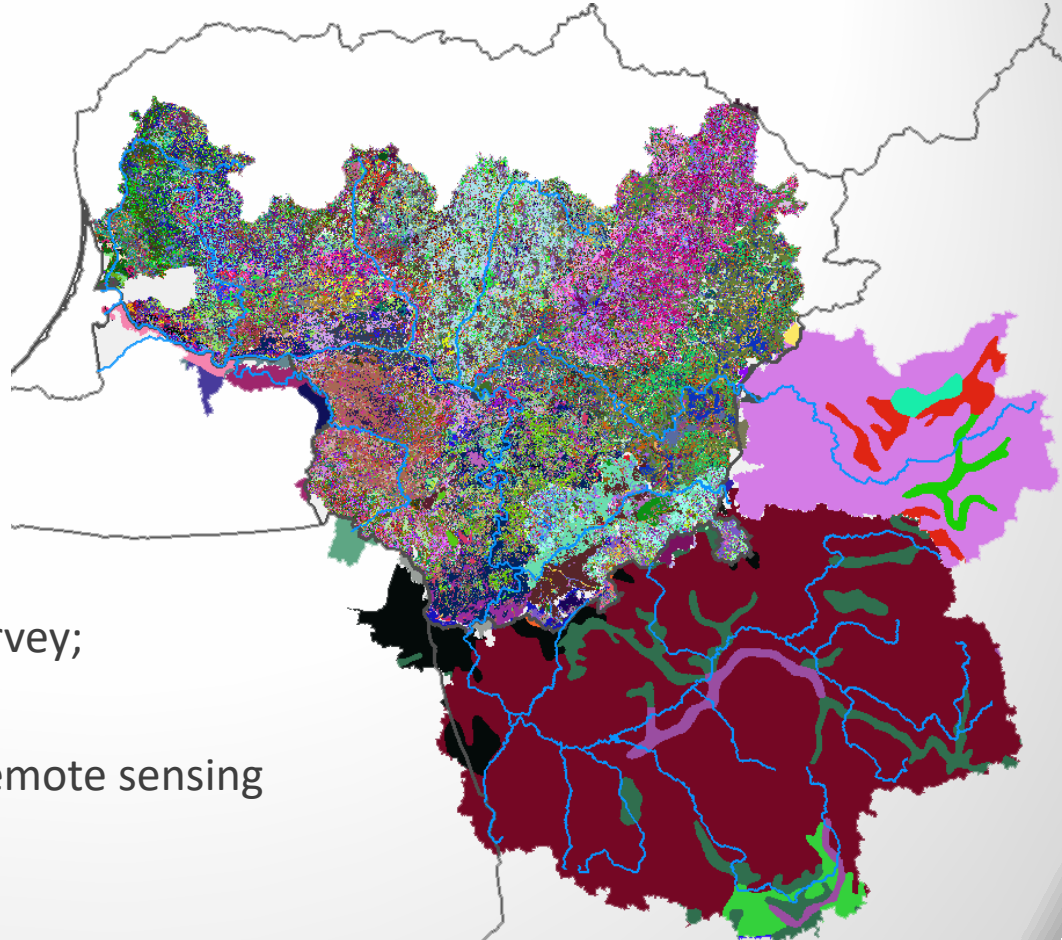
Total 121 SWAT **soil** types:

- Lithuania: National soil survey;
- Other: FAO;

Different **land-use** data sources

Total 76 SWAT **land-use** types:

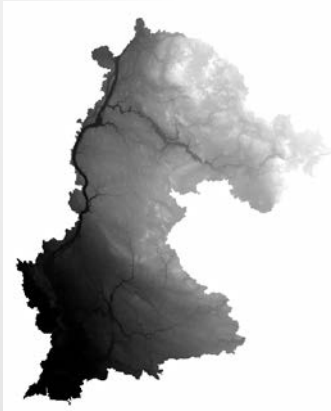
- Lithuania: National land-use survey;
- Poland, Latvia: Corine;
- Belarus, Russia: Waterbase + Remote sensing



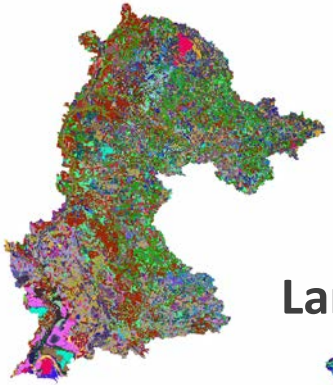
HRU Definition

The combination of:

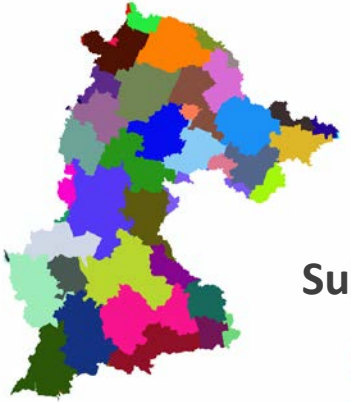
DEM



Soil

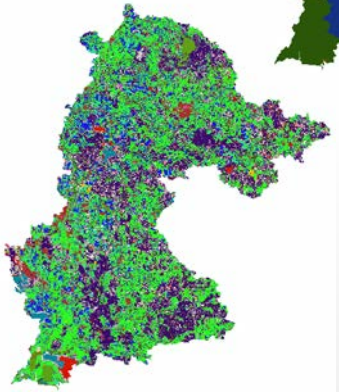


Administrative units

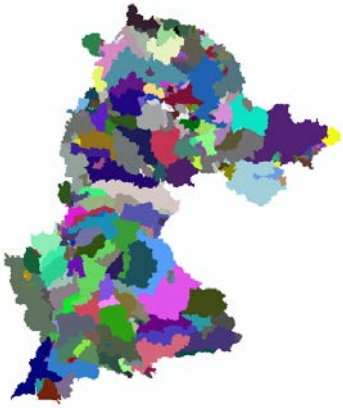


Slope

Land-use



Sub-basin grid



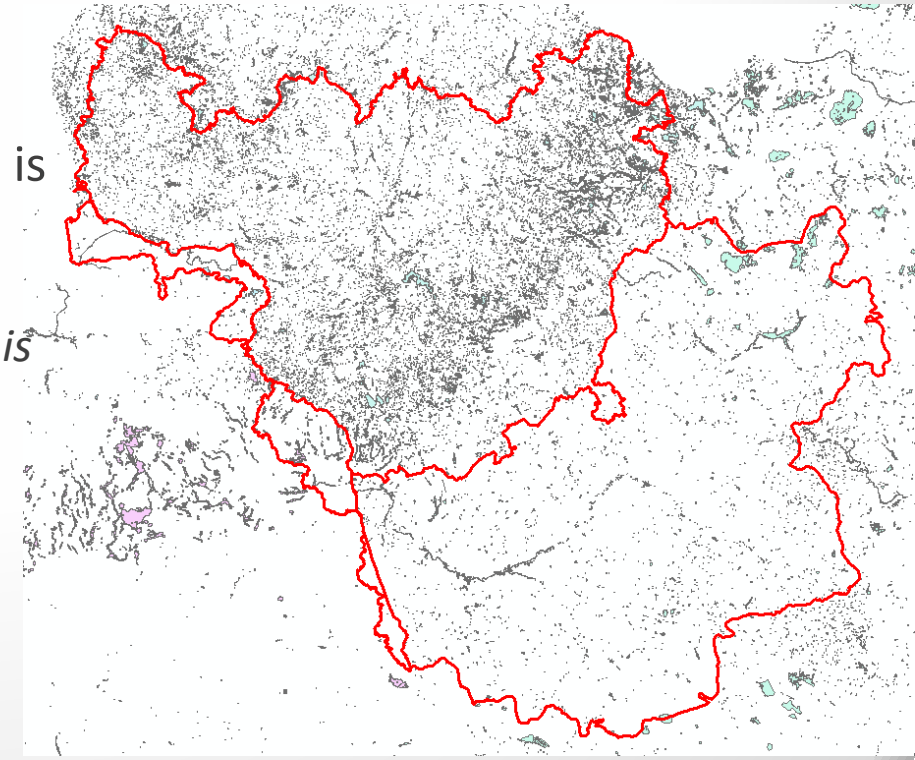
Lakes/Reservoirs

Dilemma: How big is a lake to be a lake?

Common Implementation Strategy for the Water Framework Directive (2000/60/EC): smallest size range for a System A lake type is 0.5 – 1 km^2 surface area*

**However, it is recognized that in some regions where there are many small water bodies, this general approach will need to be adapted.*

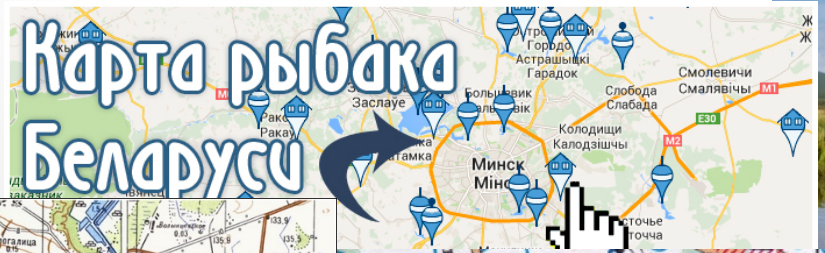
In Lithuania alone: > 250 000



Lakes/Reservoirs in Belarus

Dilemma: Where to get data on Belarus lakes and reservoirs?

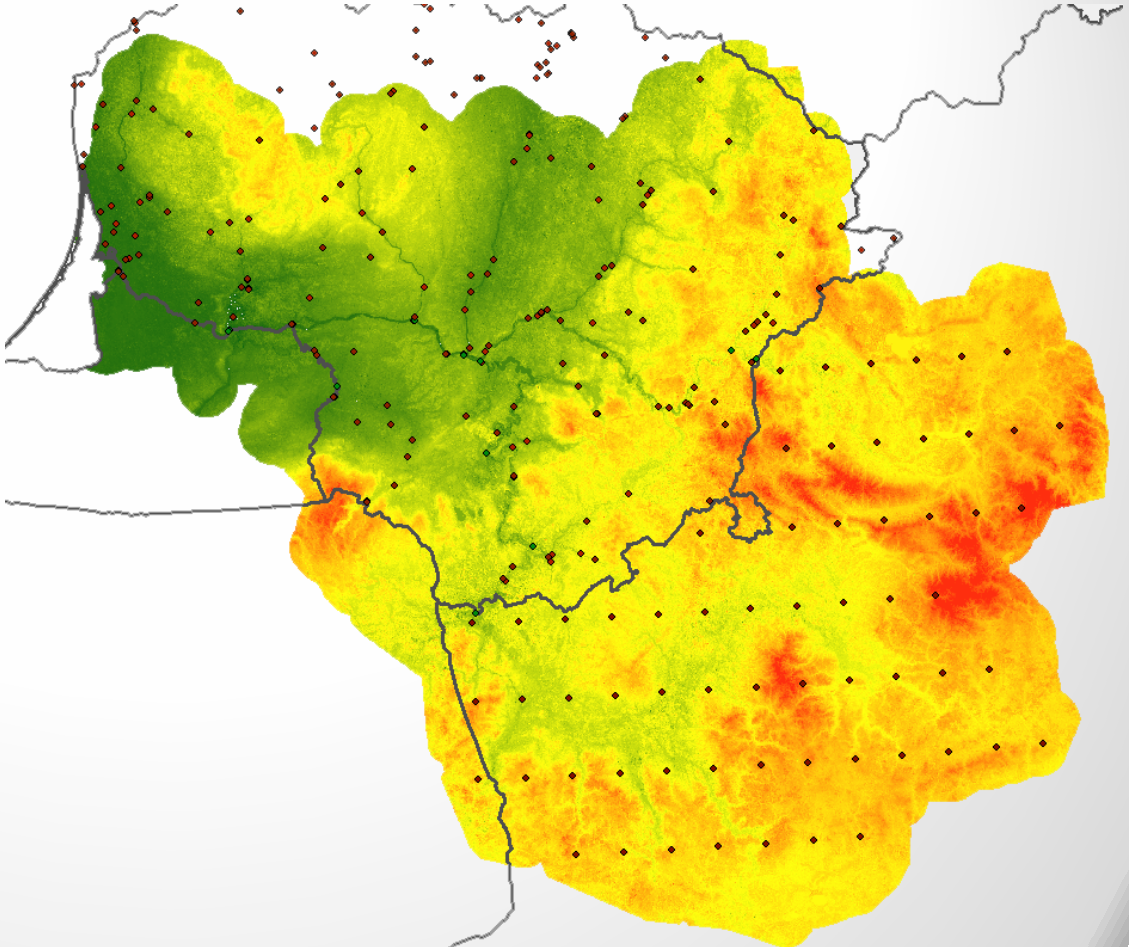
- Knowledge of Russian Language; ← Born in USSR
- Official governmental Issues of Belarus Republic;
- Old (Soviet Union time) datasheets;
- Fishing sites/forums!



Monitoring grid

Different sources:

- Measured data;
- Modeled/WGN.



Hydrology results (calibrated)

Modeling period: 1995-2012

5 year warm-up period [1995-1999]

8 years calibration [2000-2007]

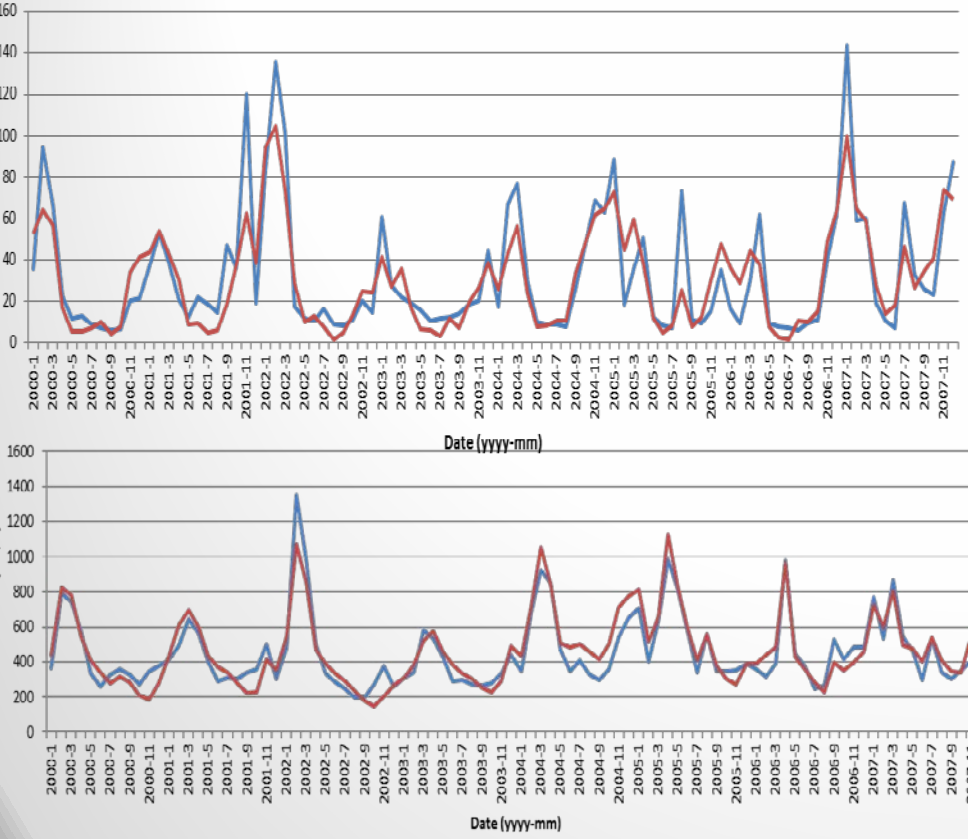
5 validation [2008-2012]

Did not try on newest data [2013-2015]

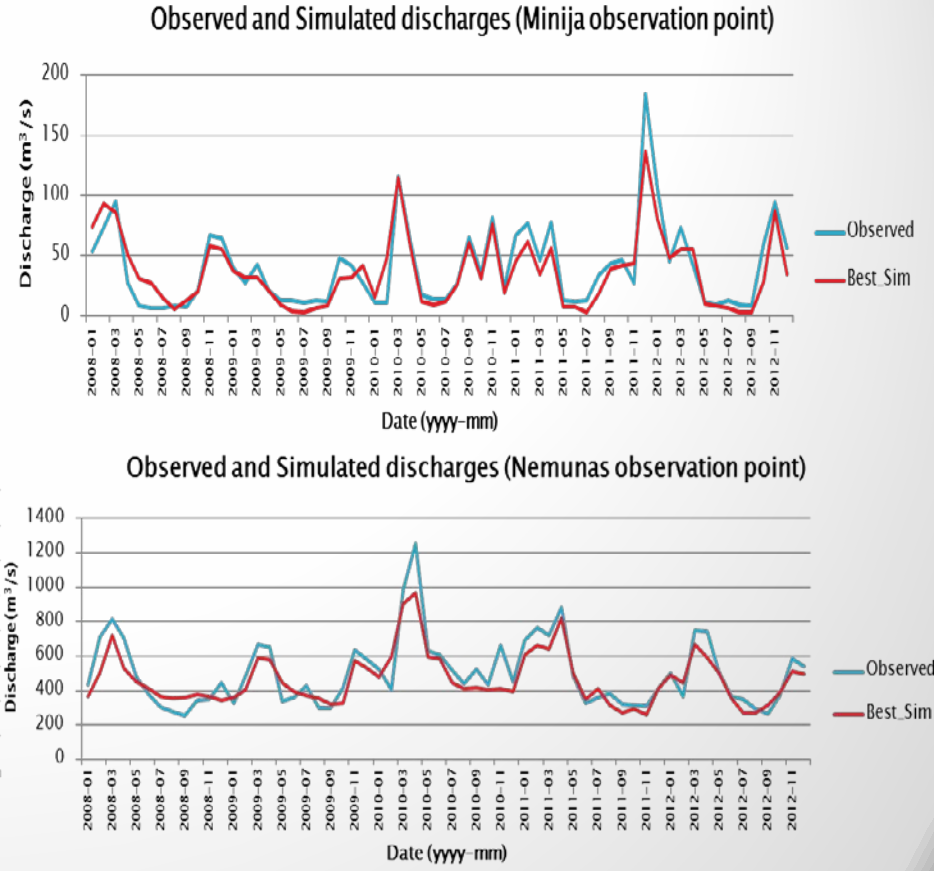
Global performance Calibration: NS = 0,74; R^2 = 0,7;

Global performance Validation: NS = 0,6; R^2 = 0,63;

Calibration example

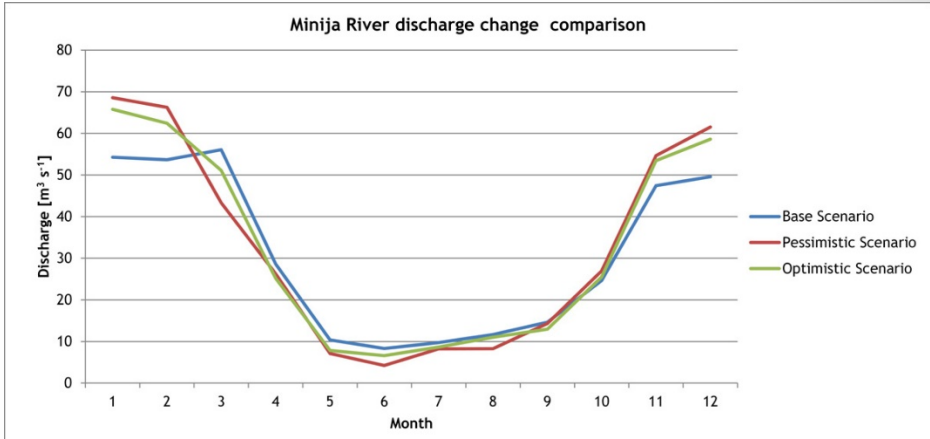


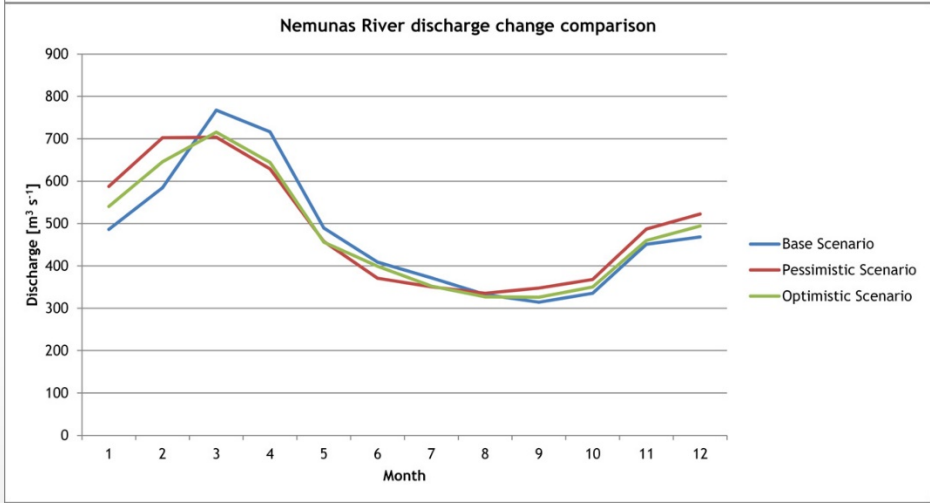
Validation example



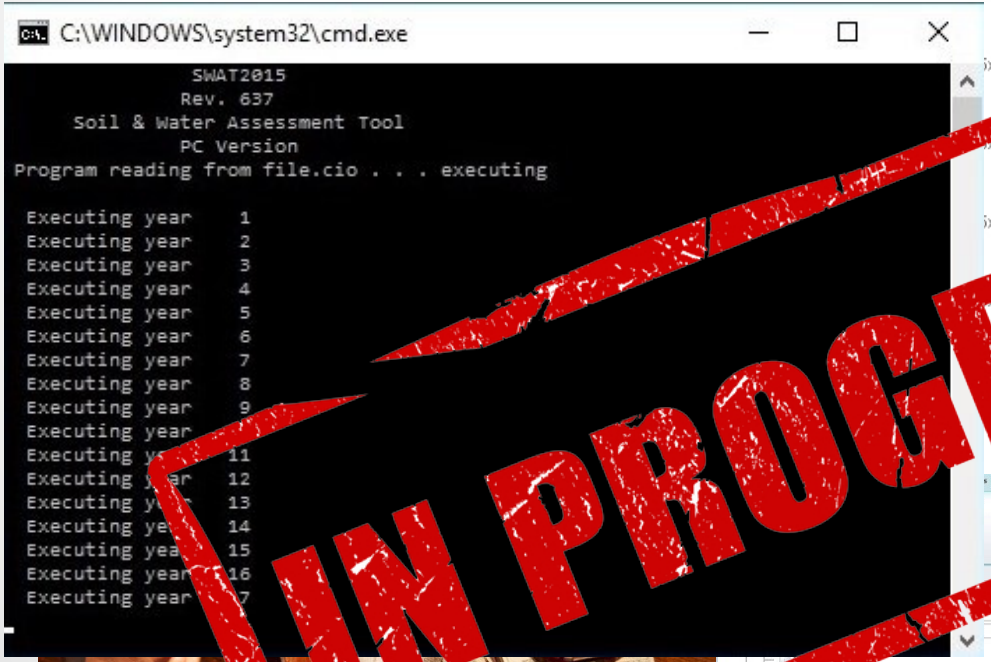
Climate change impact

- Change in annual runoff (increase);
- Intersessional redistribution of runoff (moving from spring to winter);
- Summer droughts (big vulnerability of small rivers);
- Potential impact on the Curonian Lagoon: salinity change, sediment, biogeochemistry.

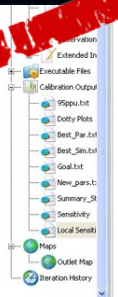


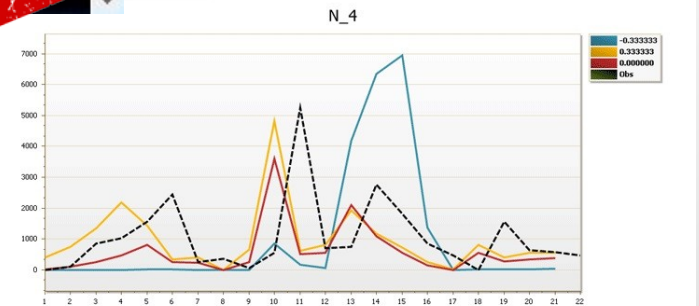


Sediment and Nutrient



IN PROGRESS





Conclusions

- Find data → to make sure that the data is of sufficient quality; Many hours of “manual” labor;
- Preliminary results for sediment and nutrient calibration are promising;
- GIS (generally GUI) limits the potential of the model setup;
- Risk: too long to calibrate; *(I may not finish in time for the end of the PhD)*

Thank you