Stepwise development of catchment hydrology for effect modelling in regulatory landscape-scale aquatic risk assessment

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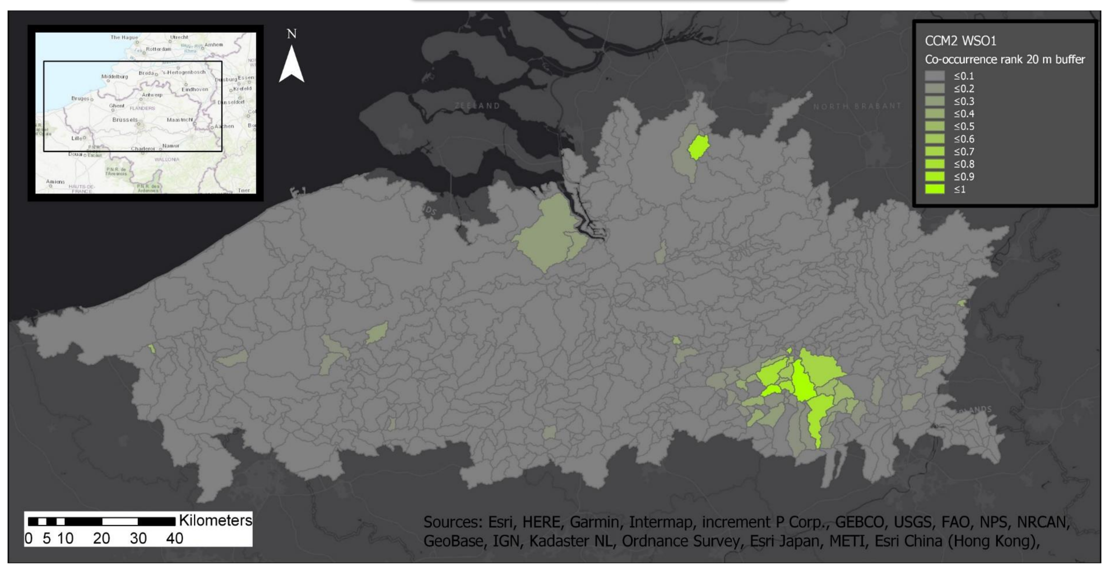
1. Objectives

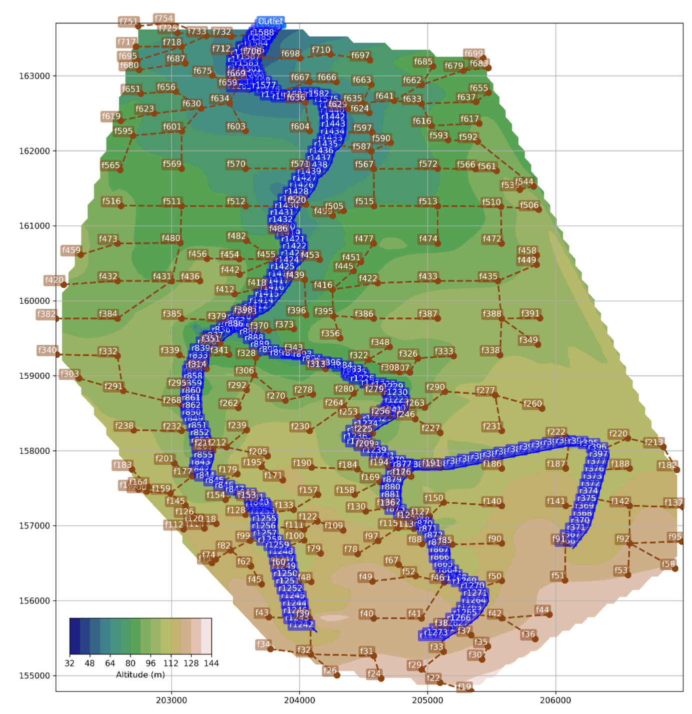
The EFSA Guidance Document on Aquatic Risk Assessment (EFSA, 2013) indicates a key role for effect modelling in future aquatic risk characterization in a tiered risk assessment framework. Such approaches require correspondingly adapted exposure tools and scenarios ranging from simple edge-of-field to spatio-temporally explicit landscape-scale catchment models. These approaches should be sufficiently flexible and transparent in order to design lower- and higher-tiers of consistent protection levels. On the catchment scale, a hydrological model needs to be set up with explicit locations of fields und streams. Furthermore, the simulation time steps should be in an appropriate resolution (e.g. 1 h) in order to cover exposure profile resolutions needed for a proper effect assessment. In the present study, a flexible modelling setup using the Catchment Modeling Framework CMF (Kraft et al. 2011) is introduced. This generic framework allows developing model setups adapted to the data availability for the catchment of interest. The aim is to produce spatially and temporally explicit calculations of Predicted Environmental Concentrations allowing to analyse effects at the landscape scale for regulatory aquatic risk assessment.

2. Modelling approach

Site Selection



Catchment setup



The fully distributed hydrologic catchment setup, thus the spatial discretisation of streams and fields, needs to be set up only once. The setup is now ready to be run by pre-calculated hydrologic time series derived by Level 0 – Level 2 approaches. As the CMF model setup works time-continuously, hydrologic flux information within the catchment is available for any temporal resolution. Drift exposure can be calculated by an integrated drift module applying the Rautman formula. E-fate is simulated using the Steps1234 approach (Klein 2007).

As the gauging data is the most important data requirement, this modelling approch is limited to the availability of gauging data capturing the hydrological flashiness properties of the catchment. For small catchment hourly discharge data are required, for larger catchments (> ca. 150 km²) daily discharge data are the minimum requirement.

cmf 1.4.1 catchment modelling framework

Steps1234

Level 0 - hydrology

AreaYield

The gauging data at the catchment outlet is used as input for the discharge distribution over the catchment by calculating an area-specific discharge for each field (AreaYield). Even though the water balance and discharge pattern at the outlet of the catchment are well reflected, the limitation is that identical discharge patterns occur in the catchment for all stream segments. However, this approach offers a straightforward way to simulate in-stream substance transport. Using the implemented Steps1234 E-fate module, it can be directly used for analysing spray drift.

Exposure pathway: **Drift**

Data requirements:

- Gauging data
- Stream network
- Digital elevation model
- Land use

Level 1 - hydrology

Landscape based

The discharge is calculated using the water balance of each field and its specific pedoclimatic attributes. The Level 1 hydrology implements the spatial heterogeneity of discharge generation and enables further analysis of the catchment regarding criteria relevant for risk assessment, such as the identification of low water levels and reaches falling dry. In contrast to Level 0, the hydrology needs to be calibrated (e.g. through gauging data, residence time). The calibration is done using the SPOTPY Python package developed by Houska et. al (2015).

SPOTPY

Exposure pathway: **Drift / Runoff / Drainage**

Data requirements:

Data requirements Level 0 +

- Soil
- Climate
- Drained fields (for Drainage)

Level 2 - hydrology

Landscape based

The robustness of hydrologic predictions can be further improved by adding additional monitoring data at specific locations. The results of Level 0 and/ or Level 1 calculations are used to identify suitable locations for nested discharge gauging and substance sampling, as well as for specific measurements like thermal monitoring to identify significant groundwater emissions to the stream or sampling of stable isotopes of water to derive mean water transit times. The Level 2 approach further facilitates to fully account for various rainfall-runoff generation processes such as saturation excess and infiltration access overland flow, throughflow and preferential flow paths.

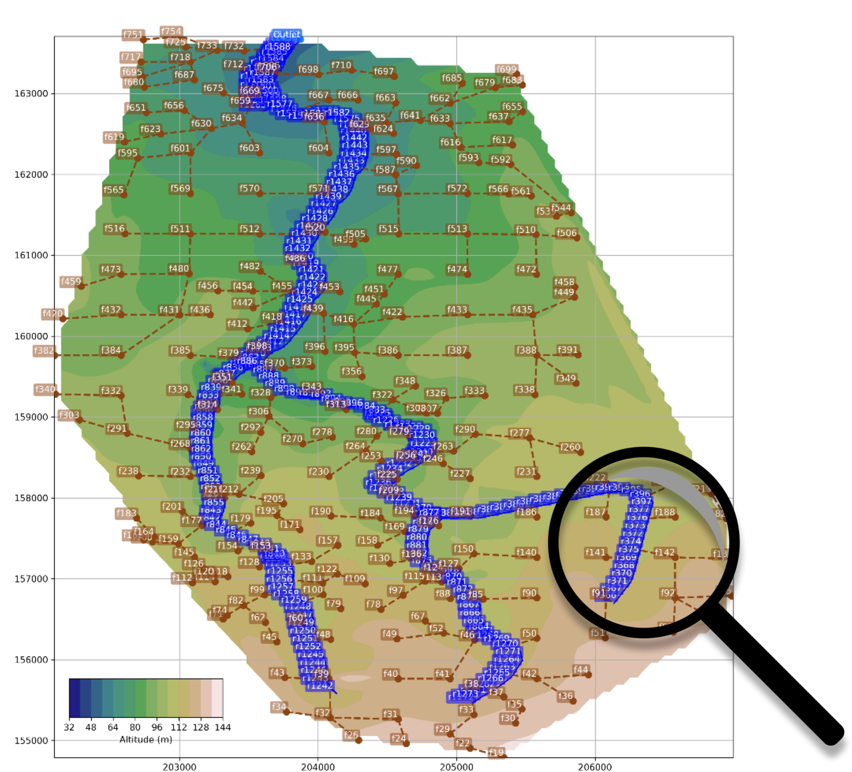
Exposure pathway: **Drift / Runoff / Drainage**

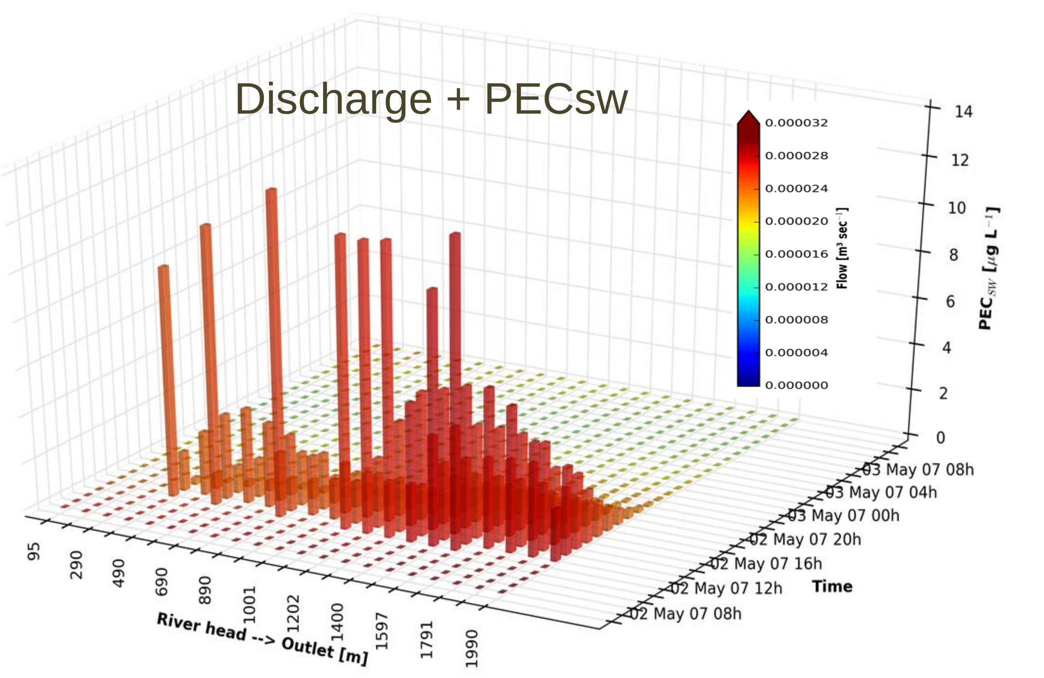
Data requirements:

Data requirements Level 1 + Adapted, Individual site-specific samplings

Increasing realism / increasing predictive performance / increasing data requirements

3. Conclusion & Outlook





Example concentration time series for a river stretch calculated with Level 0 hydrology for drift* assessment.

* Provided by our project partners

- Adequate hydrological monitoring data are not always available at catchment scale. Hence, we introduce a stepwise modelling approach with different levels of mechanistic process complexity to simulate catchment hydrology with different levels of realism, predictive performance and data requirements.
- For this aim, we use a fully distributed catchment model at landscape scale based on CMF.
- Already the lowest level (Level 0) provides first insights in PEC distributions with a high spatial and temporal resolution.
- The here presented model with all mentioned components will be published soon with an open-source license by Multsch et al. (*in preparation*), according to the concept by Multsch et al. (2019).
- An analysis of possible input data for pan-European catchment modelling see compagnion poster Krebs et al. (3.10P.14).
- The application of this Level-0 approach for effect modelling is shown in the platform presentation by Beltman et. al. (4.07.9).

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