Towards a landscape scale risk assessment: development of a coherent and flexible framework for the integration of aquatic exposure and effect modelling

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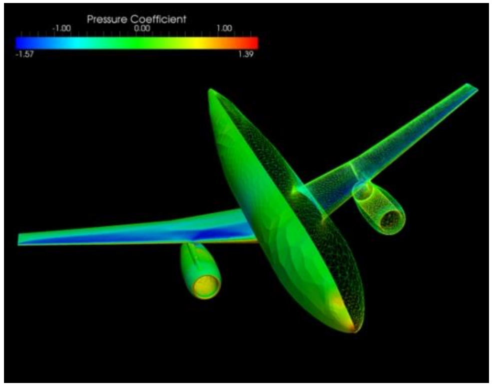
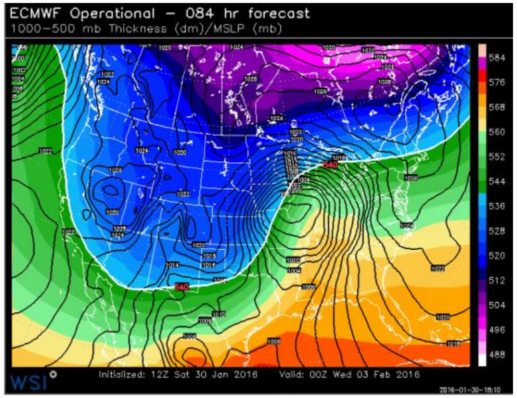
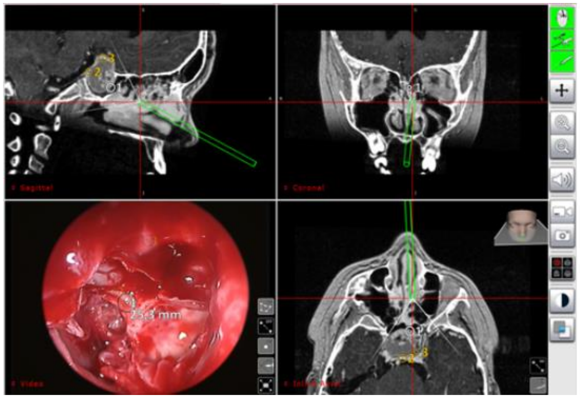
Computer models are useful

- Computers can do amazing things







- They have an almost infinite computing capacity
- They can also be used to optimise agricultural production and to improve risk assessment and management of pesticides!

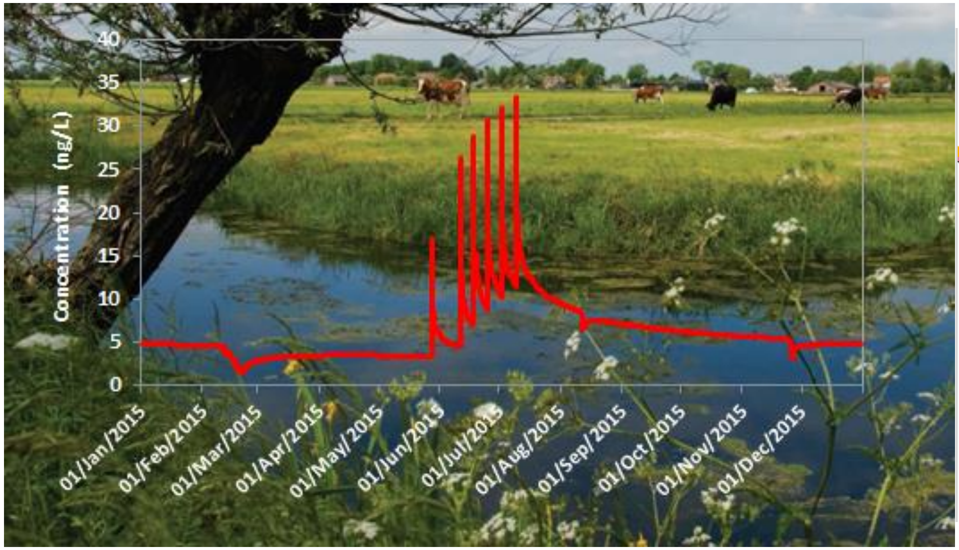
Challenges with current ERA of pesticides at larger spatial-temporal scales

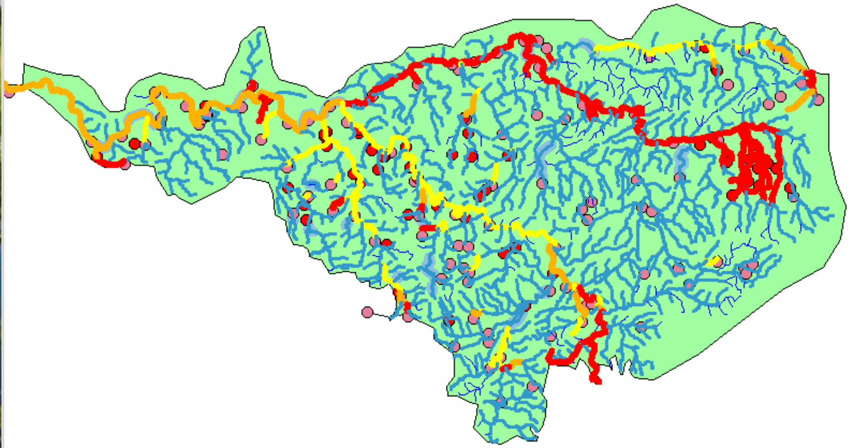
- Current risk assessment is generic, unknown overall level of protection
- Risk assessment not focussing on site-specific areas, ignoring local environmental conditions
- Poor mechanistic link between exposure and effects, no indirect or sublethal effects are accounted for
- FOCUS exposure scenarios lack an ecological component and are not fit for being linked to ecological models
- Risk assessment on the effect side ignores ecological processes

Aquatic environment: temporal and spatial scales

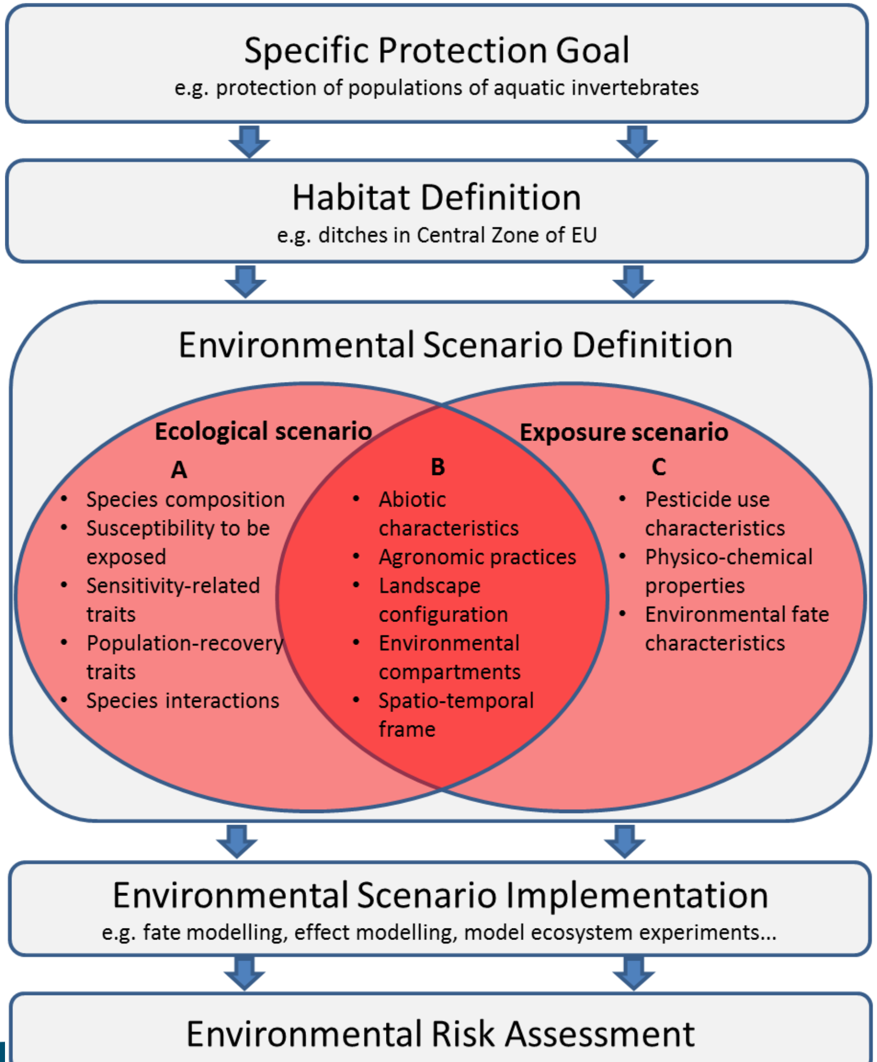
Specific for aquatic systems (in comparison to terrestrial systems):

- Exposure patterns in water due to dilution and transport highly dynamic over time
- Hydrology and transport of chemicals require to account for spatio-temporal process modelling on the exposure side





Definition of environmental scenarios as prerequisite of model application



- Selection of focal species through a vulnerability assessment
- Defines a consistent context for exposure and effect modelling

Rico et al., 2016;
Rico and Van den Brink, 2015

Toxicokinetic-toxicodynamic modelling

Progress in linking environmentally relevant exposure patterns to effects on the survival

Ashauer, R. *et al.* Modelling survival: exposure pattern, species sensitivity and uncertainty. *Scientific Reports* **6**, 29178, (2016).

www.nature.com/scientificreports

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Modelling survival: exposure pattern, species sensitivity and uncertainty

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Integrated exposure and effect modelling at landscape scales

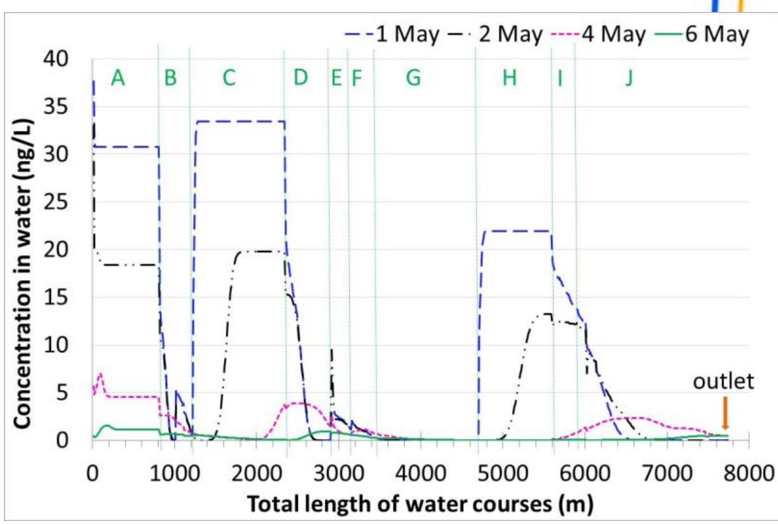
Ditch network of 65 km length, 10 km^2

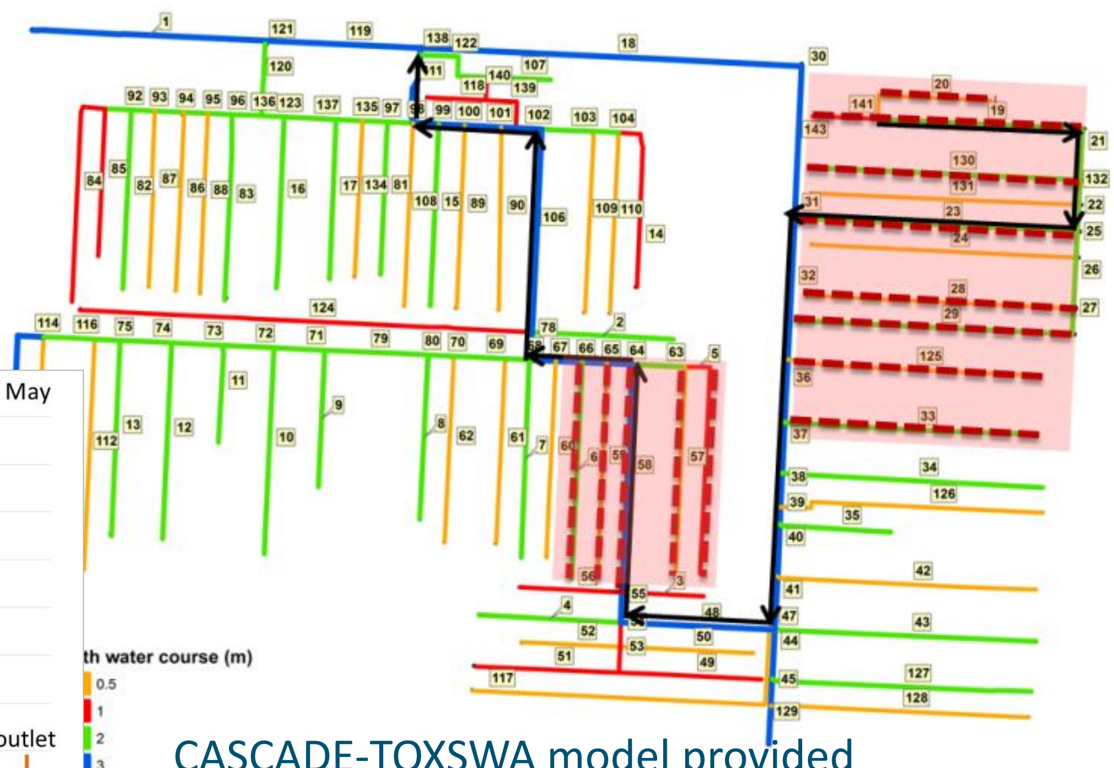
Pyrethroid application

in potato crops

multiple applications

at maximum allowed rate





CASCADE-TOXSWA model provided exposure simulations in high temporal and spatial resolution

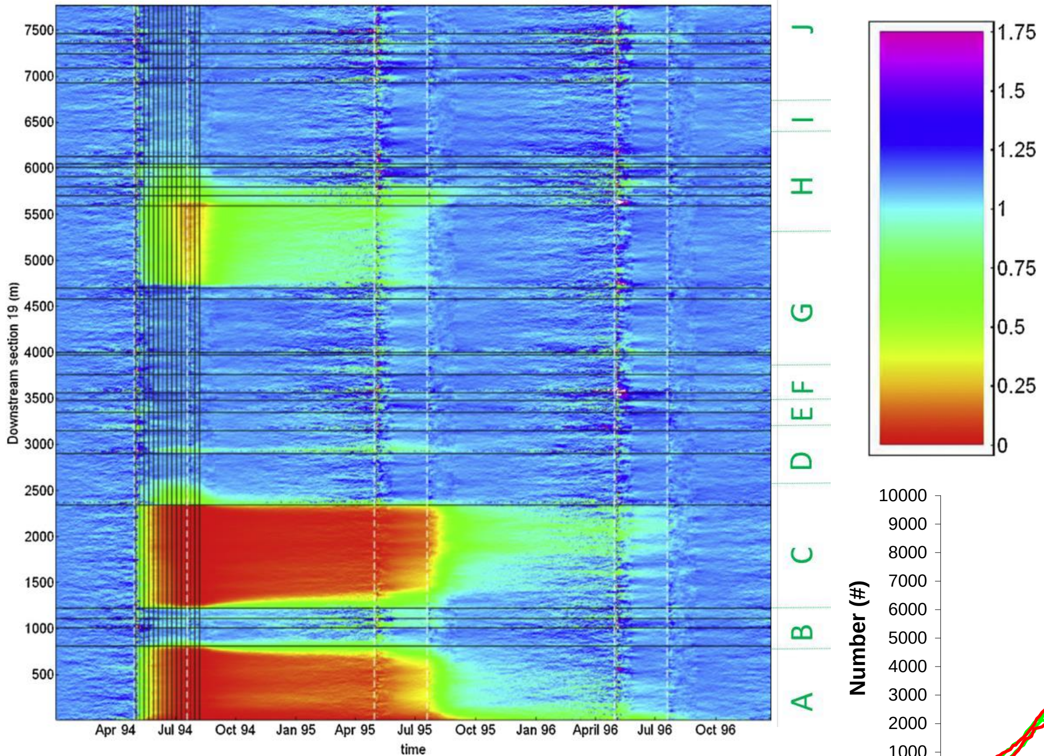
Focks et al., 2014

Population dynamics at landscape scale

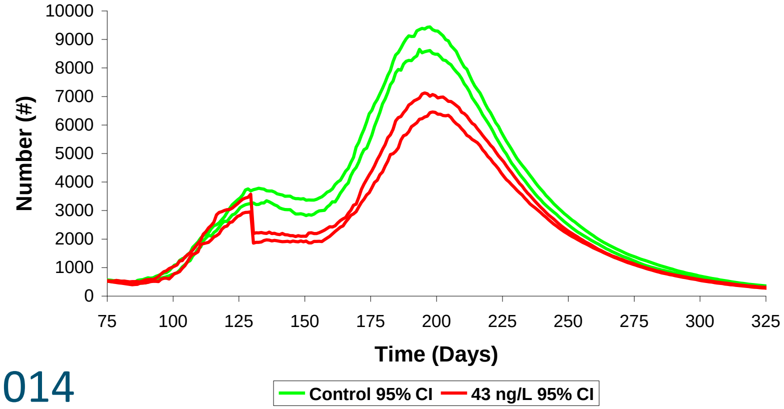
Predicted numbers relative to untreated runs using an individual based model of *Asellus aquaticus*

Population level effects at landscape scales can be simulated –specific protection goals may need to be defined at local and landscape scale

Segment



Time



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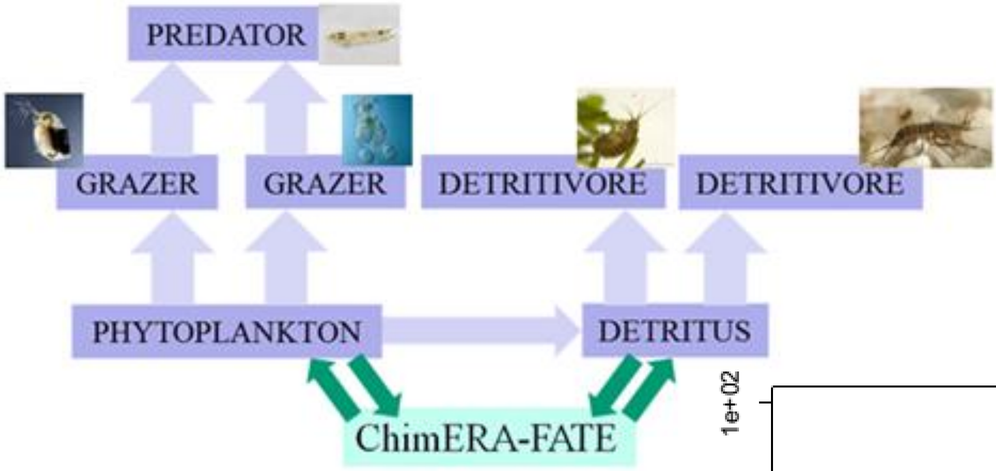
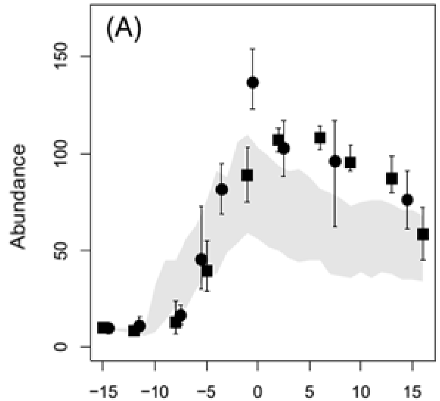
Focks et al., 2014

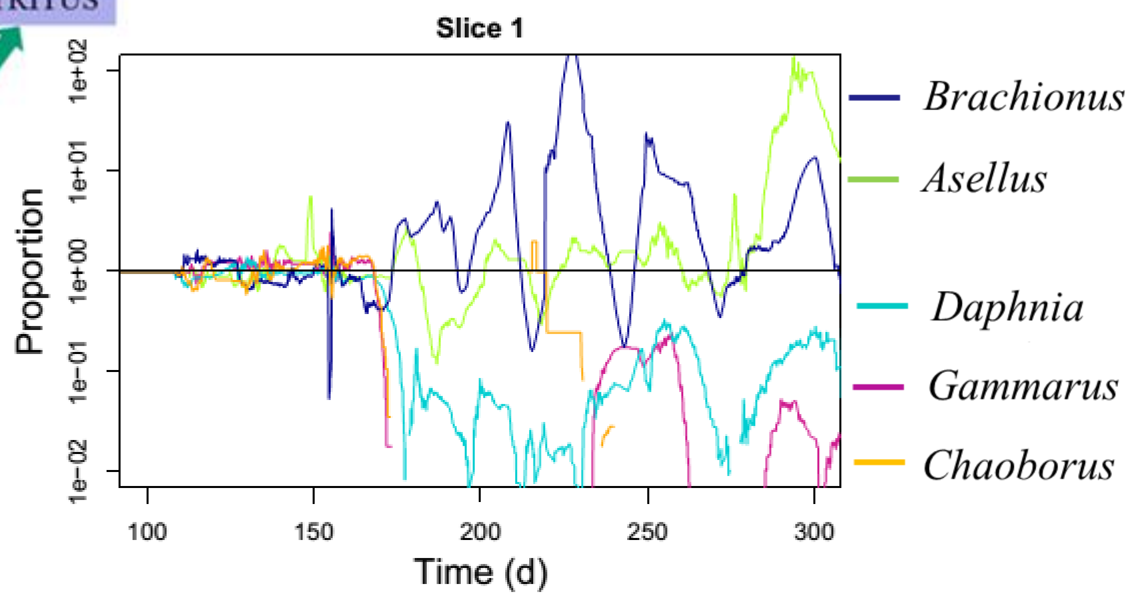
ChimERA food-web: composed of population models

- Coupled DEB-IBMs
- Food-web interactions: resource competition and predation



- Daphnia magna population dynamics, model predictions





Chlorpyrifos effects: Direct on *Daphnia* and *Gammarus*, indirect on *Asellus* and *Chaoborus*

De Laender et al., 2014; Viaene et al., 2015

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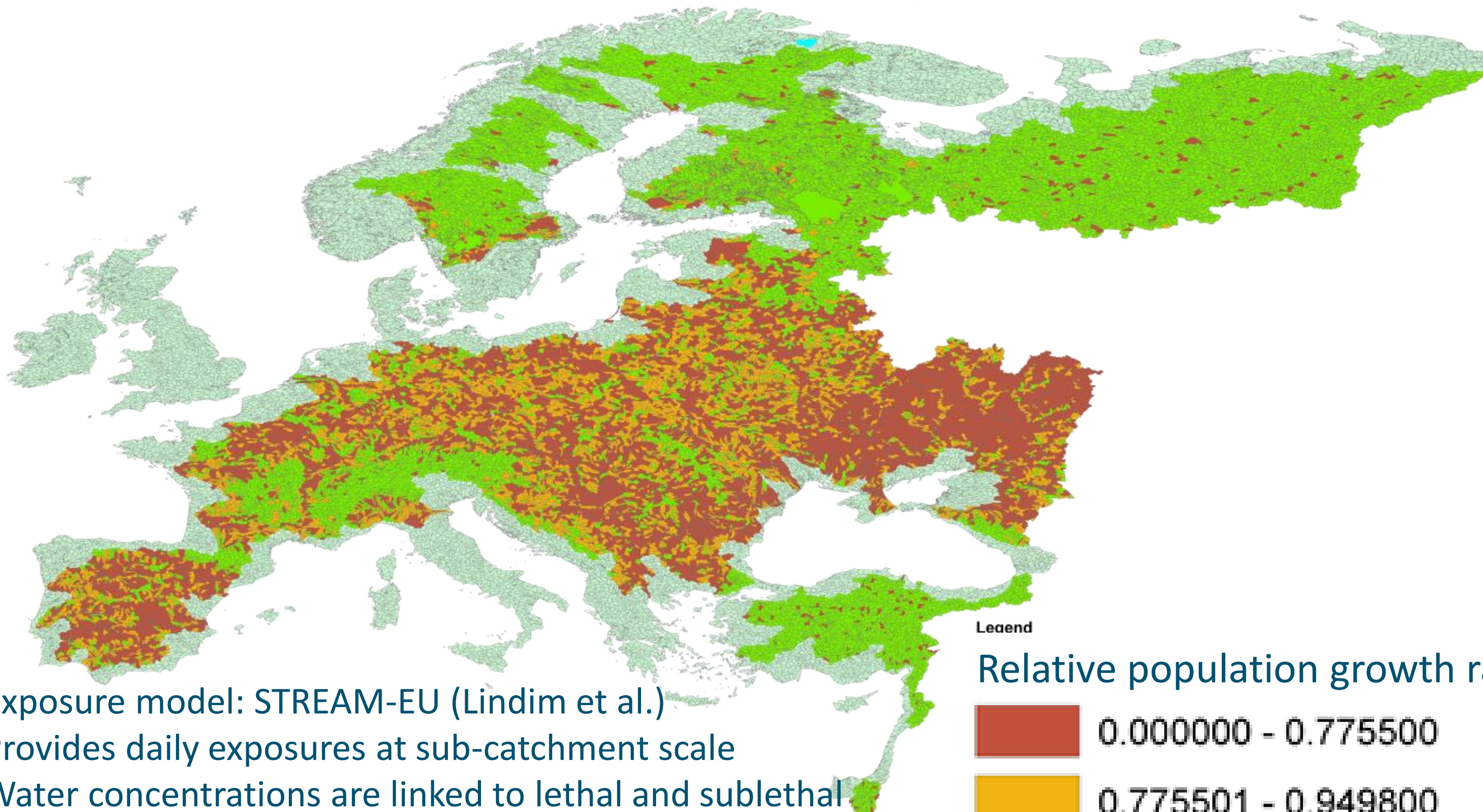
Generic aquatic ecological models at continental scale

Impact of chlorpyrifos on the population growth rates of *Asellus* in ~25.000 subcatchments of major European rivers



- Exposure model: STREAM-EU (Lindim et al.)
- Provides daily exposures at sub-catchment scale
- Water concentrations are linked to lethal and sublethal effects in IBM model

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Baveco et al, in progress

Computer models have their value - BUT

- Computers are only as good as they are programmed
- Computers do what the user told them to do (which can also be wrong)
- Computer model results have to undergo reality checks

Models need reality checks

- Proper understanding of ecological effects at laboratory/cosm scale necessary a priori for modelling
- Real-world / field monitoring data are necessary for validation

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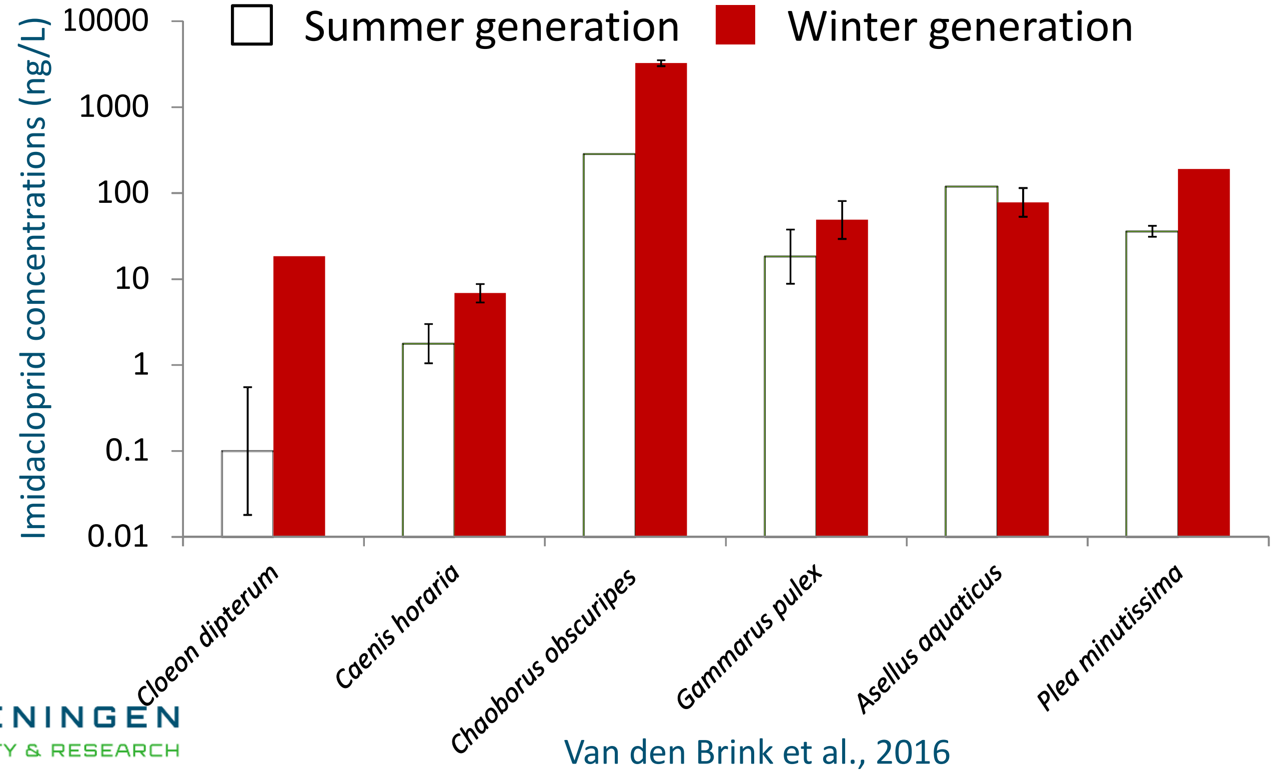
Proper assessment of ecological effects

- Current studies too short for persistent compounds and to detect "ecological surprises"
- We need tests with non-standard test species
- We need to understand context dependency of effects



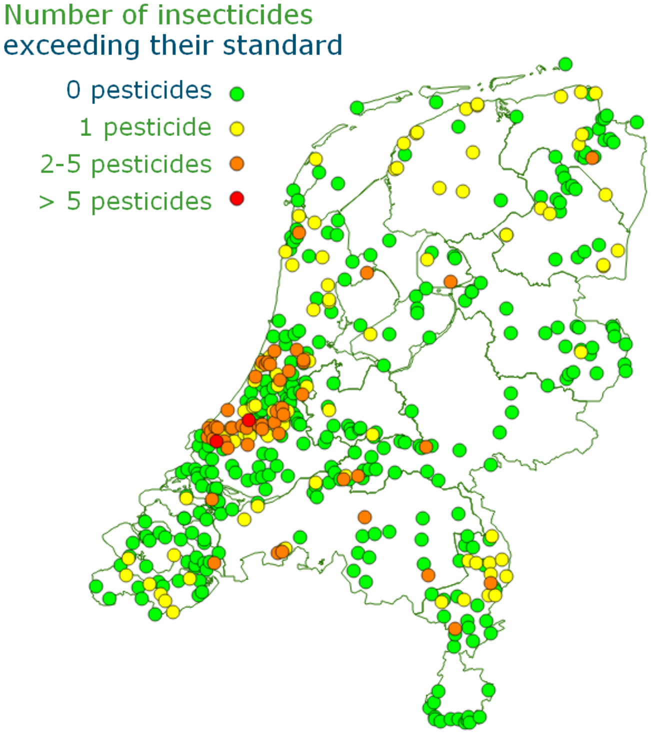
Van den Brink et al., 2016

Field monitoring data : Base models on solid ground

- Field monitoring of concentrations and biota provide data to check quality of modelling, many (sub-)national and international monitoring networks

BUT

- Monitoring is only done through academia and water managers in the context of the WFD, smaller waterways are less frequently sampled
- Monitoring studies sometimes are flawed methodologically (e.g. samples of chemistry and biology not taken at same place and time)
- Monitoring studies often suffer from collinearity between multiple stressors



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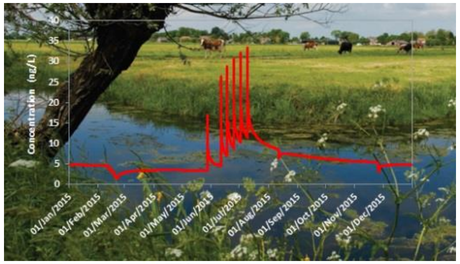
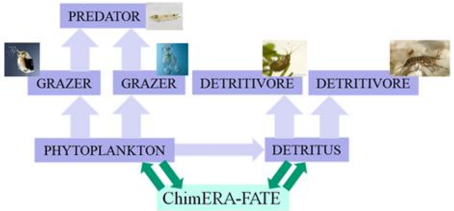
Possible solution: Post registration monitoring programs to support and complement monitoring

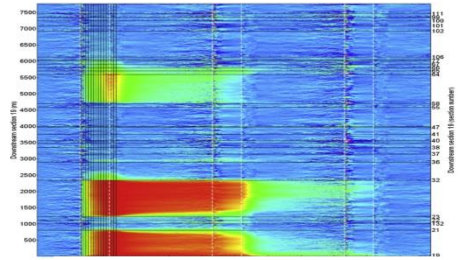
- Many product or environmental stewardship programs are maintained by companies
- Develop an integrated chemical and biological post-registration monitoring framework which enables to differentiate pesticide effects from other stressors
- Make the monitoring data publicly available
- Assess the risks of current exceedances of standards using ecological experiments (cosms) and models to predict recovery and indirect effects

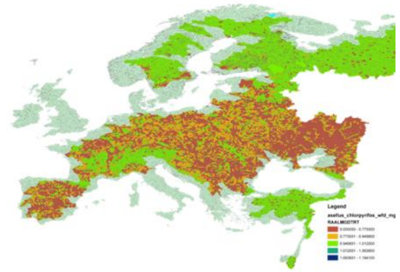
Future aquatic pesticide ERA

- Develop environmental scenarios, framework is ready (Rico et al., in press)
- Adapt or develop exposure models to make them fit for simulating chemodynamics in real (GIS) landscapes
- Overcome reluctance of acceptance of ecological models, adapt ecological models and link them to the appropriate exposure models
- Develop an integrated chemical and biological post-registration monitoring approach for validation of modelling results at landscape scales









Future aquatic pesticide ERA II

- Make better use of (and provide) raw data for modelling: Laboratory (survival over time) and mesocosm (control dynamics)
- Link GIS data to modelling for vulnerability assessment and scenario definition
- Evaluate (spatial) risk mitigation measures within integrated models and scenarios at landscape scales
- Include integrated pest management practices into model simulations
- Develop an integrative framework where all dat and models work together

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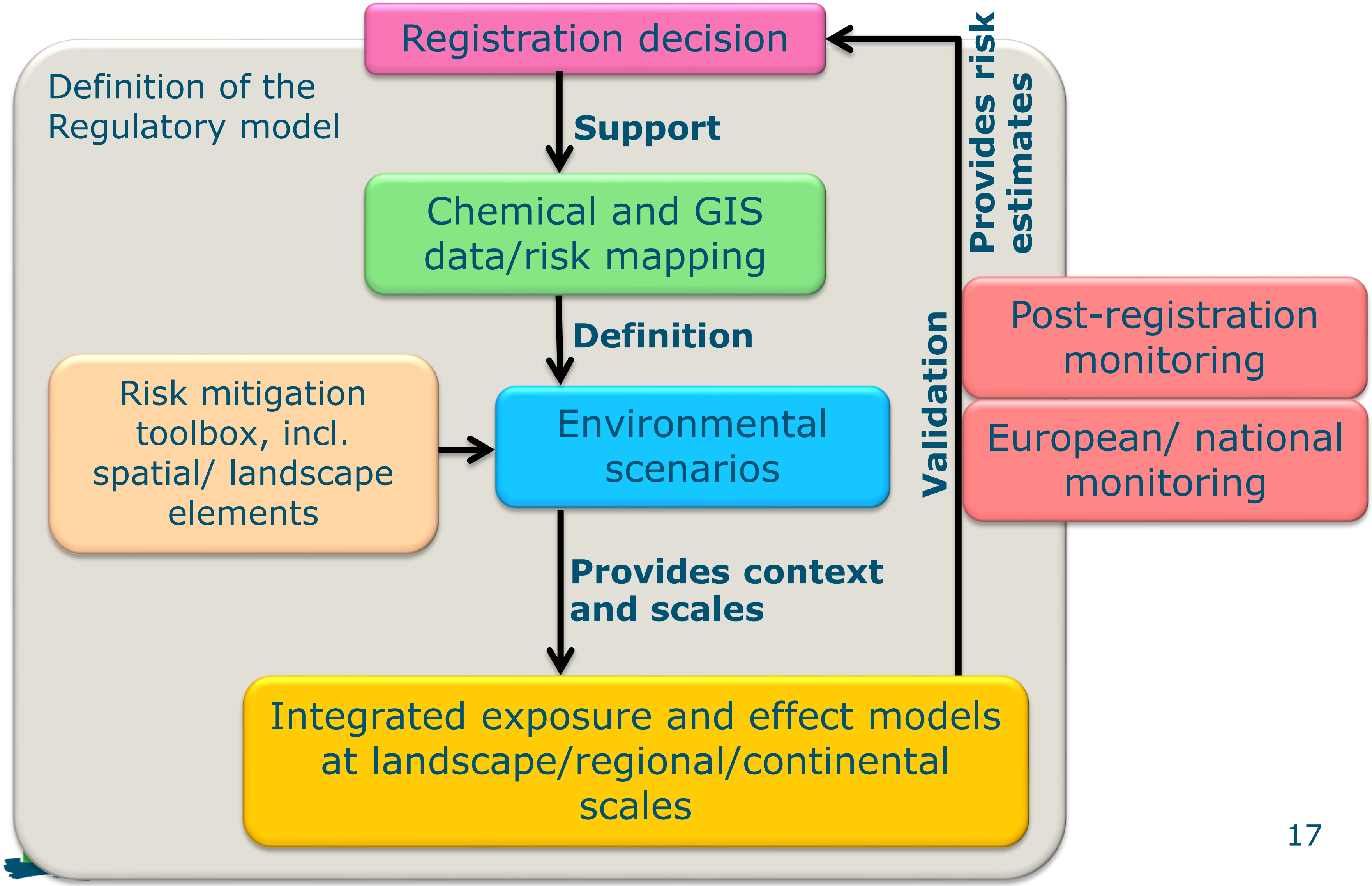
Integrated framework



Conclusions: The main target from a scientific perspective

- Understanding the fate and effects of agrochemicals in the environment, in all its complexity where necessary. Aquatic systems are special.
- GIS-type spatial information provides a basis for linking exposure and effect models within consistent environmental scenarios.
- Many building blocks are there, but the overall framework needs to be developed, in a conceptual, regulatory and in parts also technical sense.
- Such approaches offer the opportunity to understand pesticide effects in a local context and to manage risks more efficiently.

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Thank you for your attention!