Integration of Climate Model Projections and Pesticide Application Scenarios for Probabilistic Risk Assessment with a Bayesian Network Approach

Jannicke Moe[1], Sophie Mentzel[1], Rasmus Benestad[2], John F. Carriger[3], John D. Hader[4], Taro Kunimitsu[5], Rory Nathan[6], Rik Oldenkamp[7], Andy Pitman[8], Wayne G. Landis[9]

(1) Norwegian Institute for Water Research (NIVA), (2) Norwegian Meteorological Institute, (3) U.S. Environmental Protection Agency, Cincinnati, OH, (4) Stockholm University, Sweden, (5) Center for International Climate Research, Norway, (6) University of Melbourne, Australia, (7) Radboud University Nijmegen, Netherlands, (8) University of New South Wales, Australia, (9) Western Washington University, USA

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Session 5.06: Continuing Discussions on Incorporating Climate Change Model Predictions into Ecological Risk Assessments
Presentation 5.06.T-04

A case study from the SETAC Pellston Workshop Oslo, 20-23 June 2022:

SETAC Pellston WORKSHOP

Integrating Global Climate Change into Ecological Risk Assessment

Background for the workshop

- Ecosystem **damage by pollutants**, together with habitat fragmentation and unsustainable use of natural resources, will **increase ecosystem vulnerability to climate change globally**, even within protected areas
  – Intergovernmental Panel on Climate Change (2022), 6th Assessment Report
- Still, potential influence of climate change is often ignored in assessments of chemical pollution and risk
  – E.g. European Environment Agency (2018). Chemicals in European waters.
- Better integration of climate science and risk assessment approaches needs
  – Suitable methodology
  – Handling of uncertainty
  – More collaboration across disciplines – climate modelling and ecotoxicology

Uncertainty assessment in climate modelling vs. environmental risk assessment

CLIMATE IN NORWAY 2100

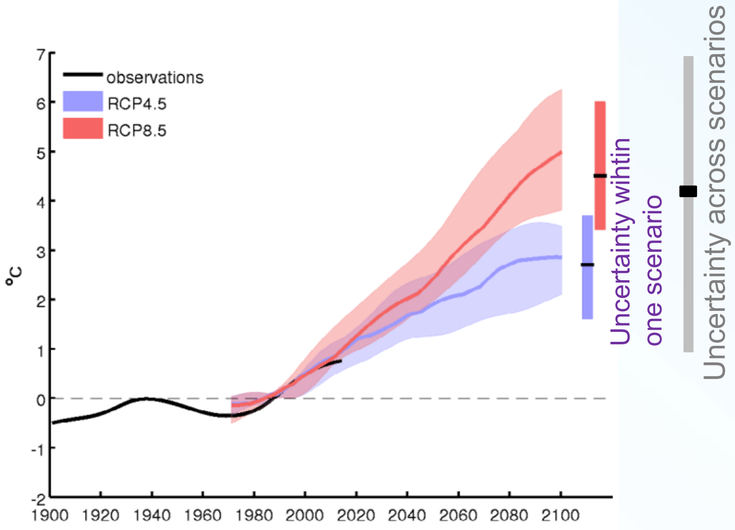
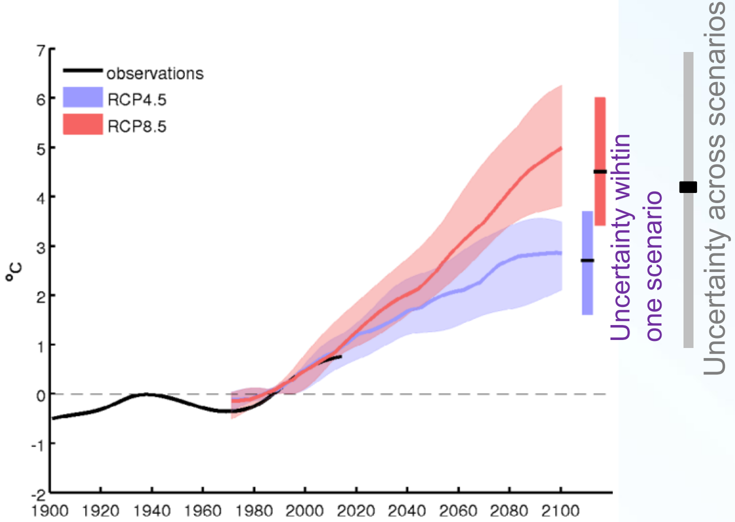


Figure 3.4 Annual temperature for Norway as deviation (in °C) from the mean for the reference period 1971-2000. Black curve shows observations (1900-2014), red and blue curve show median value for the ensemble of ten RCM simulations for emission scenarios RCP4.5 and RCP8.5. All curves are smoothed by low-pass filtering. Shading indicates spread between low and high climate simulation (10th and 90th-percentile). The box plots on the right show values for 2071-2100 for both scenarios.

[The Norwegian Centre for Climate Services (2017)]

Uncertainty assessment in climate modelling vs. environmental risk assessment cont.

CLIMATE IN NORWAY 2100



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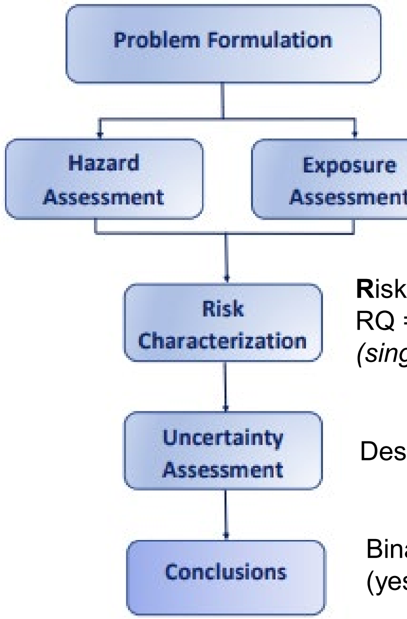
[The Norwegian Centre for Climate Services (2017)]

HC5, AF, PNEC
(single values)



PEC
(single value)

Risk **Q**uotient
RQ = PEC/PNEC
(single value)

Descriptive?

Binary?
(yes/no)

https://www.setac.org/page/SETACTechPapers
Environmental Risk Assessment of Chemicals (2018)

What is required for better integration of GCC & ERA?

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Editorial | Free Access

Robust risk assessments require probabilistic approaches

S. Jannicke Moe, Rasmus E. Benestad, Wayne G. Landis

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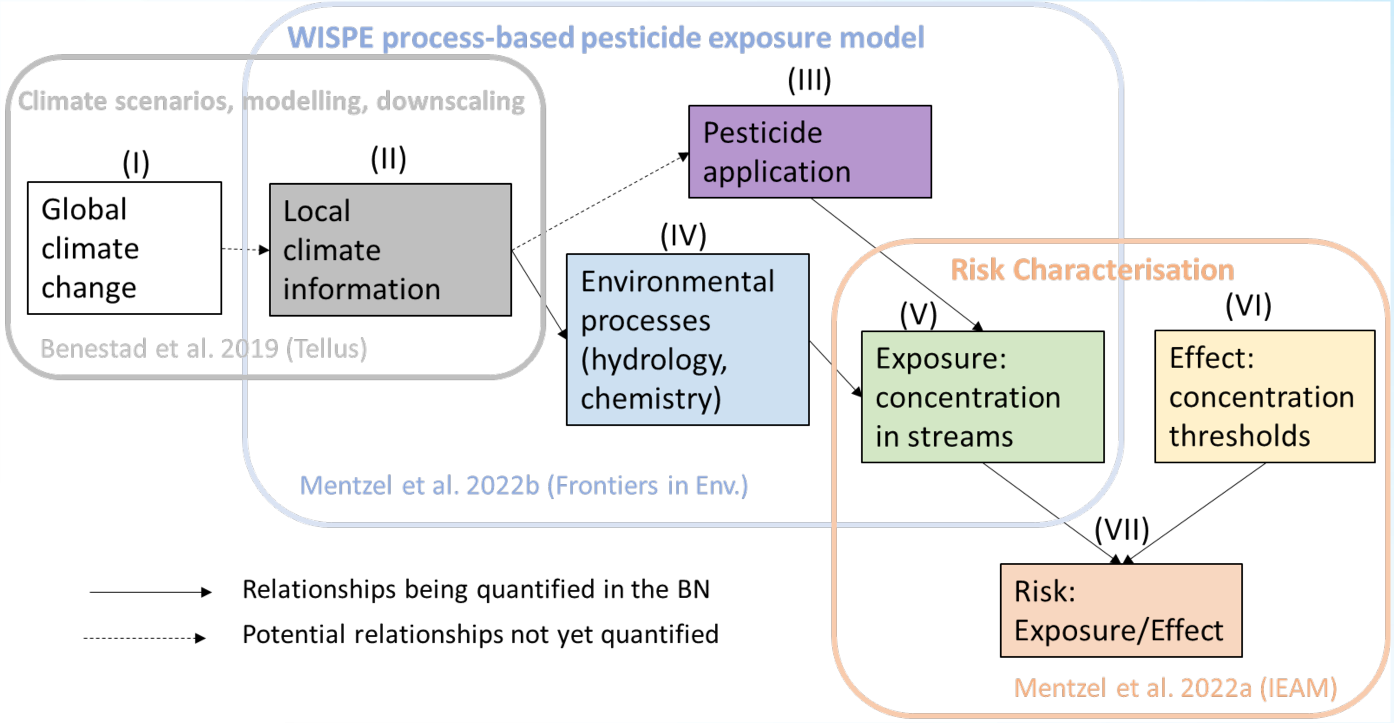
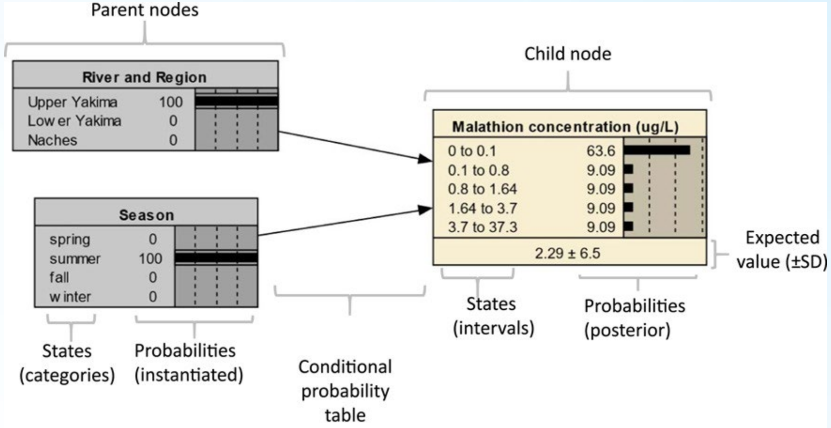
Ideally, we should

- Use **ensembles** of Global Circulation Models, not single models
  - Projections from 30-100 models
- Generate robust "**climate information**" from these projections
  - Probability distributions characterised by statistical properties
- **Downscale** the climate information to the assessment region
  - Empirical-statistical and/or dynamical downscaling methods
- **Integrate** with exposure and/or effect assessment, using probablistic methods
  - Bayesian networks (BN) as a tool for probabilistic modelling and communication

Approach: connecting climate information to pesticide exposure assessment with a Bayesian network model



Main components of a Bayesian network model

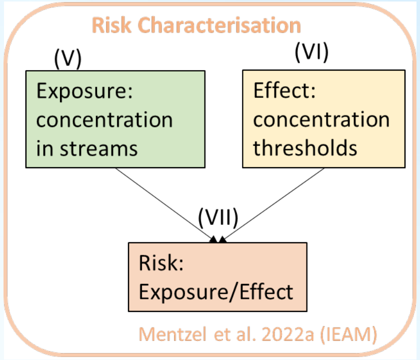


Parent node states | Probabilities (%) of child node states conditional on parent node states

River and Region	Season	0 to 0.1	0.1 to 0.8	0.8 to 1.64	1.64 to 3.7	3.7 to 37.3
Upper Yakima	spring	20	20	20	20	20
Upper Yakima	summer	63.636	9.091	9.091	9.091	9.091
Upper Yakima	fall	50	12.5	12.5	12.5	12.5
Upper Yakima	winter	20	20	20	20	20
Lower Yakima	spring	98.039	1.225	0.245	0.245	0.245
Lower Yakima	summer	98.126	1.171	0.234	0.234	0.234
Lower Yakima	fall	96.8	0.8	0.8	0.8	0.8
Lower Yakima	winter	76.471	5.882	5.882	5.882	5.882
Naches	spring	20	20	20	20	20
Naches	summer	42.857	14.286	14.286	14.286	14.286
Naches	fall	33.333	16.667	16.667	16.667	16.667
Naches	winter	20	20	20	20	20

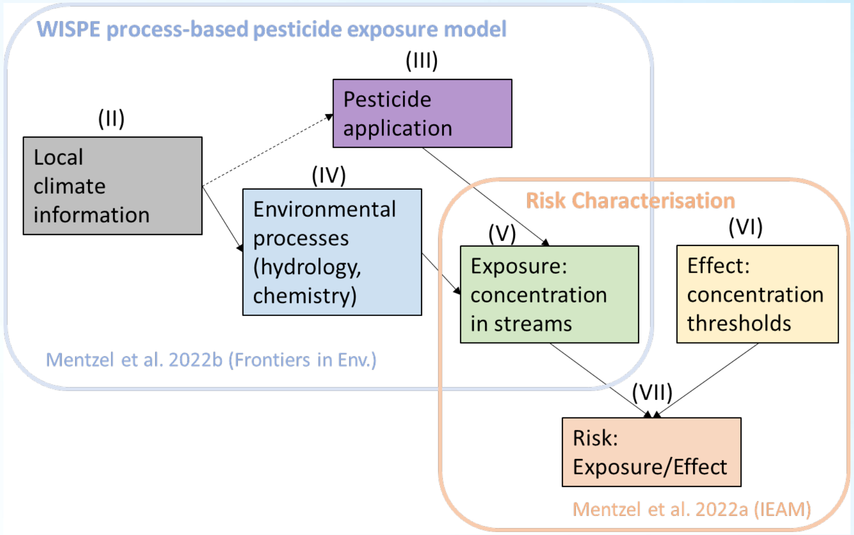
Case study: agricultural streams in South-East Norway

- Case study of ECORISK2050 - Environmental risks of chemicals in the future
  - European Union Innovative Training Network
  - https://ecorisk2050.eu/
- Representing Northern Europe
  - Temperate / Subarctic climate zone
- Pesticide application and run-off to streams
- Purpose: Novel tools for risk assessment
  - Quantification of uncertainty in each step
  - Effects: probability distribution of PNEC or EC50
  - Risk: probability of risk quotient (RQ) >1, or other threshold



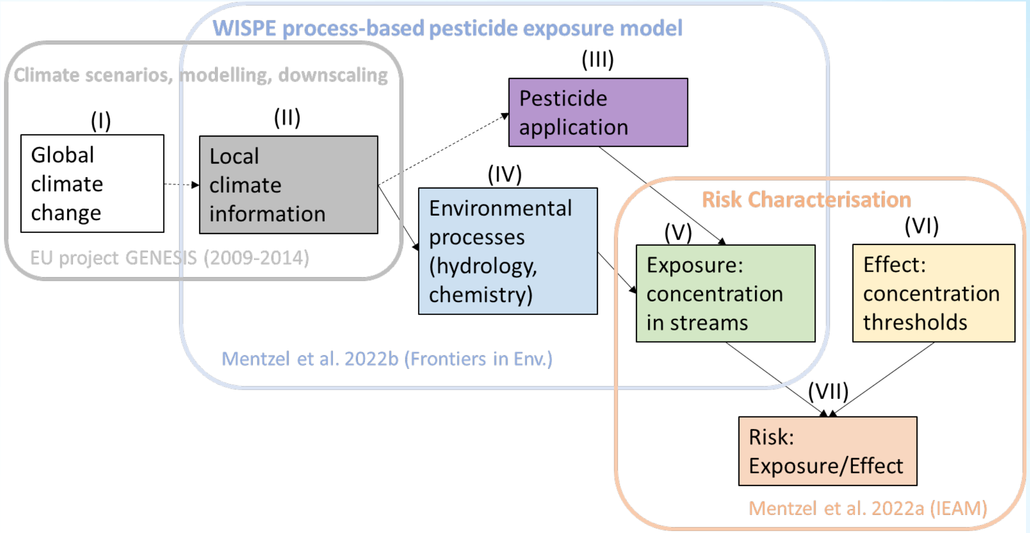
Case study: pesticide exposure components

- Pesticide exposure model
  - World Integrated System for Pesticide Exposure (WISPE)
  - Effects of temperature and precipitation on pesticide transportation, degradation etc.
- Pesticides:
  - 2 herbicides (spring)
  - 2 fungicides (fall)
- Pesticide application scenarios
  - Reference = 100%
  - Worst case: 150% (increased pest)
  - Best case: 50% (EU green deal)



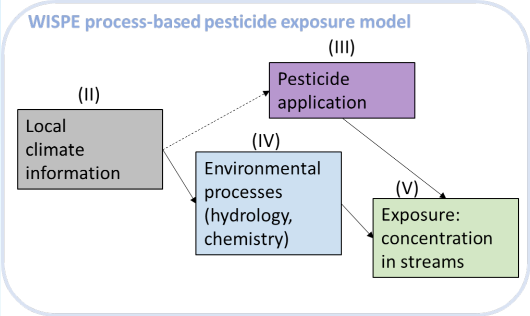
Case study: previous use of climate models

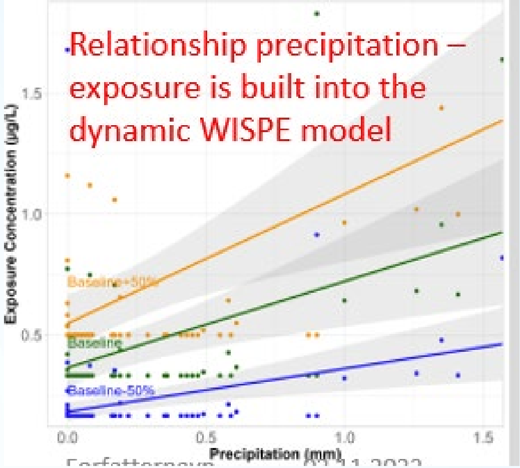
- Use of existing climate projections
  - Source: EU project GENESIS (2009–2014) (https://cordis.europa.eu/project/id/226536)
  - 1 GHG emission scenario: A1B (IPCC 2000)
  - 2 Global circulation models: ECHAM5-r3 + HADCM3-Q0
  - 1 Regional downscaling: SMHI-RCA3
  - Daily projections for years 2000-2100
- All used as input for WISPE
  - Daily temperature, precipitation, etc.
- Shortcomings
  - Old climate projections
  - Only one climate scenario
  - Only two climate models



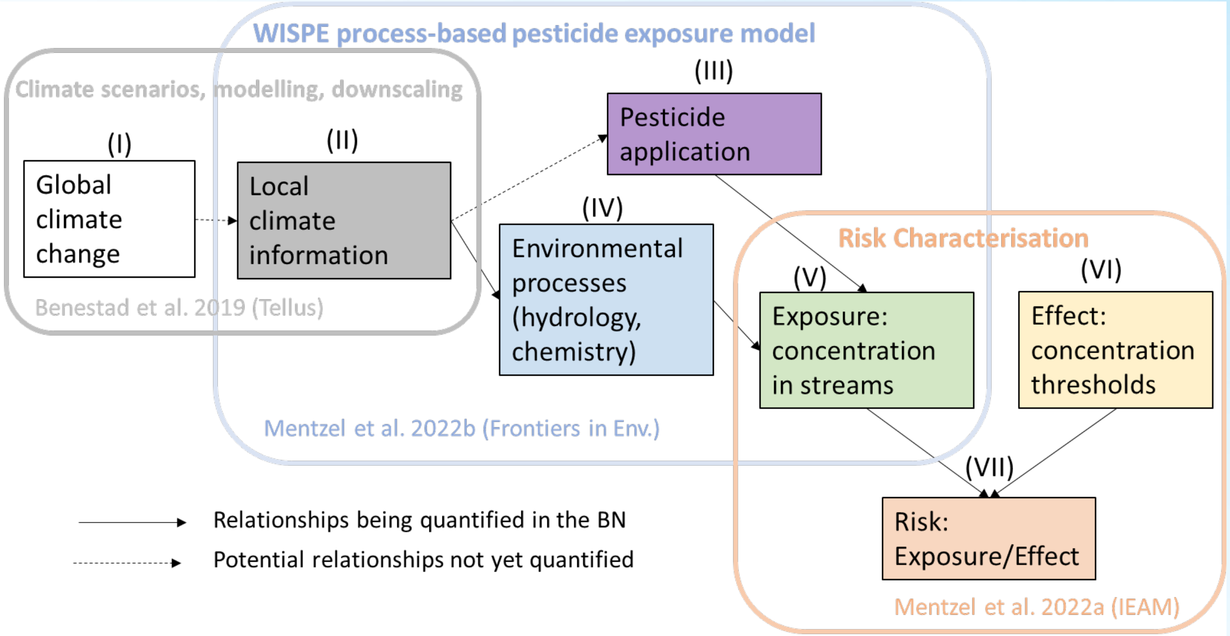
SETAC Pellston Workshop on GCC & ERA: new approaches to integrating climate projections

- Opportunity: new climate projections available from large ensemble of climate models
  - Norwegian Centre for Climate Services
- Challenge: running process-based pesticide model (WISPE) for 100-1000 climate files
  - 4 scenarios x 100 GCMs x 2 downscaling methods x ...
- Alternative to re-running of WISPE:
  - Re-use the existing WISPE model input & output
  - Explore the main relationships between climate, pesticide application and exposure
  - Quantify the functional relationships by equations or conditional probability tables for the BN model



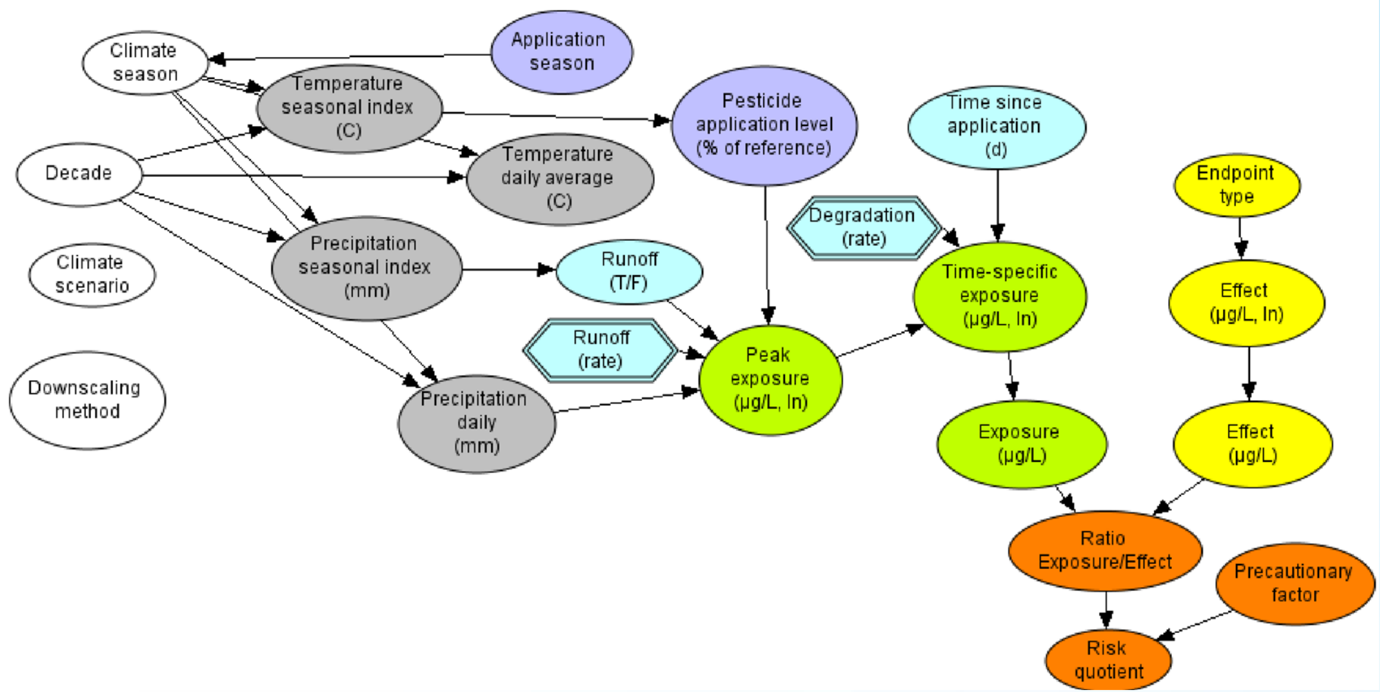


Bayesian network model: main modules



Online user interface to BN model under development:
https://demo.hugin.com/example/PesticidesInStreams

BN model under development: tentative structure

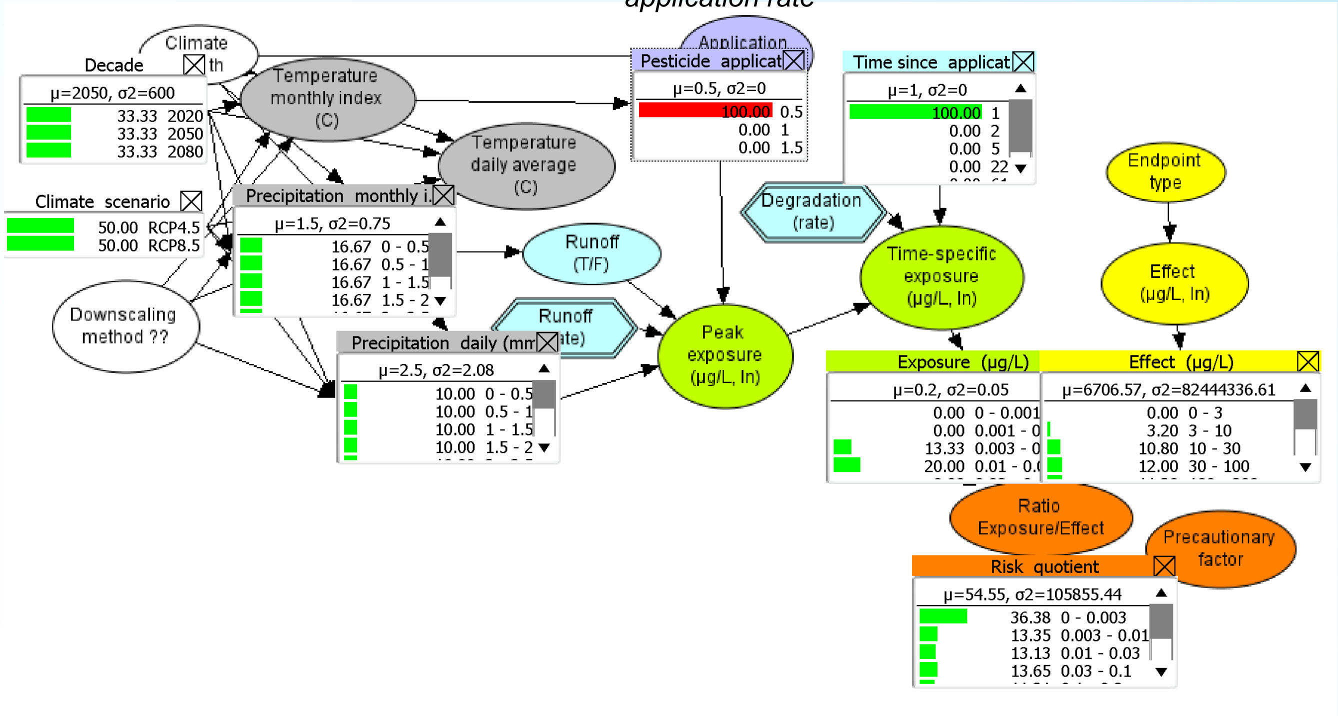


Online user interface to BN model under development:
https://demo.hugin.com/example/PesticidesInStreams

BN model under development: example of use

(2) Selected pesticide application rate

(1) Selected climate scenario and prediction period



(3) Predicted Risk Quotient (probability distribution)

Ongoing & future work

1) Further analysis of functional relationships from simulations
   – E.g. effects of precipitation on probability & amount of run-off
2) Propose impacts of GCC on pesticide application
   – E.g. regional changes in growing season or pest pressures
3) Derive relevant climate information as probability distributions, in collaboration with climate modellers
   – E.g. probability of days with heavy precipitation (Benestad et al. 2019)
   – Sensitivity analysis: identify key variables, define boundaries etc.
4) Connect climate information to future climate scenarios
5) Develop a public online user interface to the BN model
   – Purpose: demonstration and exploration

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