Highlighting model code selection and application process in policy-relevant water quality modelling

-Lake Vansjø case story as an example

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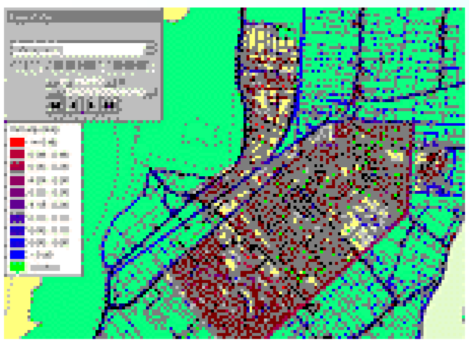
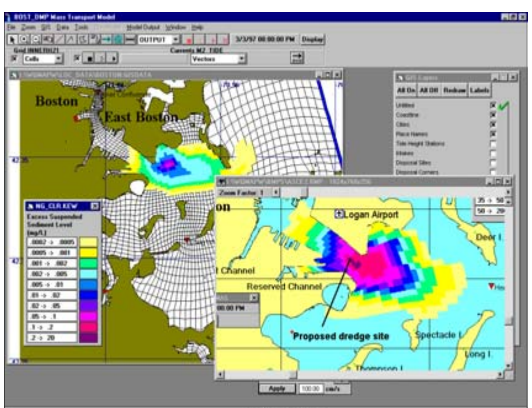
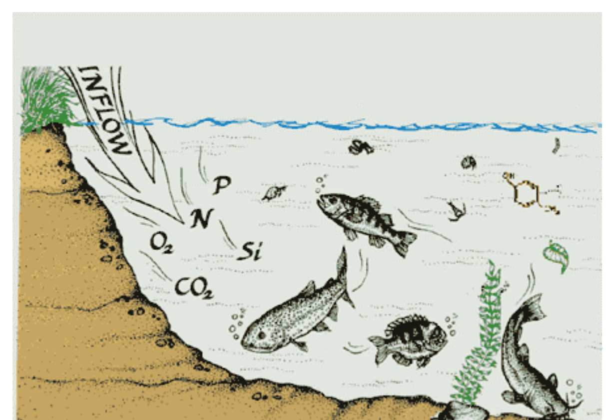


”Could I use this model...

...or that...



...or maybe this one?”



This study illustrates and discusses some rather simple and pragmatic means to enhance the quality of model-based knowledge input for decision-making.

1) Firstly, we follow a stepwise description of the modelling process which is based on the templates given in the “Handbook of Good Modelling Practise” (van Waveren et al., 1999).

2) Secondly, a major target of our study was to test-use the “benchmark criteria” model code evaluation method, developed by Saloranta et al. (2003).

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Furthermore, the focus in this study is two-fold, as it both describes

1) model results themselves, and

2) **the different elements of the modelling process**, starting from problem definition, proceeding via model code selection, sensitivity analysis, and calibration, and ending with simulation of management scenarios.

The modelling process

Van Waveren et al., 1999
Good modelling practise: A handbook
(available in web)

- Step 1: Start a model journal
- Step 2: Set up the modelling project
- **Step 3: Select and set up the model**
- **Step 4: Analyse the model (sensitivity analysis & calibration)**
- **Step 5: Using the model (model simulations & uncertainty analysis)**
- Step 6: Interpret the results
- Step 7: Report and file

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Step 3: Select and set up the model

- In BMW project we develop criteria for selecting appropriate models and integrated model systems to be used in the implementation of the WFD.
- Benchmark criteria (Saloranta et al., 2003) provides a structured way to evaluate the suitability of model codes to be used in decision-making.
- Evaluation is done with help of 14 questions and a 3-level scoring system.
- The questions allow the evaluation of different model characteristics from the perspective of non-experts and model users.

BMW

Benchmark Models for Water Framework Directive

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Step 3: Select and set up the model

NIVA uses ~50 different model codes ranging from:

- **simple to complicated**
- **applied only to developed & applied**
- **data-based to physically-based**

- easy to time demanding
- freeware to commercial
- field, via river basin, to the sea
- physics to ecology
- widely used to personal
- well-docum. to poor-documented

=hundreds of different possible combinations

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Benchmark criteria - questions for model evaluation (1)

Q1.1. How well does the model's output relate to the management task?

Q1.2. How well does the model's span and resolution in time and space compare with the requirements of the management task?

Q1.3. How well has the model been tested?

Q1.4. How complicated is the model in relation to the management task?

Q1.5. How is the balance between the model's input data requirements and data availability?

Q1.6. How is the identifiability of the model parameters?

Q1.7. How easily are the model results understood and interpreted?

Q1.8. How is the peer acceptance for the model and the model's consistency with scientific theory?

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Benchmark criteria - questions for model evaluation (2)

Q2.1. How well is the model suited for sensitivity and uncertainty analyses and how well have these analyses been performed and documented?

Q3.1. How is the model's version control?

Q3.2. How are the model's user manual and tutorial?

Q3.3 How is the model's technical documentation?

Q3.4. How is the model's interactiveness, user-friendliness, and its suitability for end-user participation?

Q3.5. How is the model's flexibility for adaptation and improvements?

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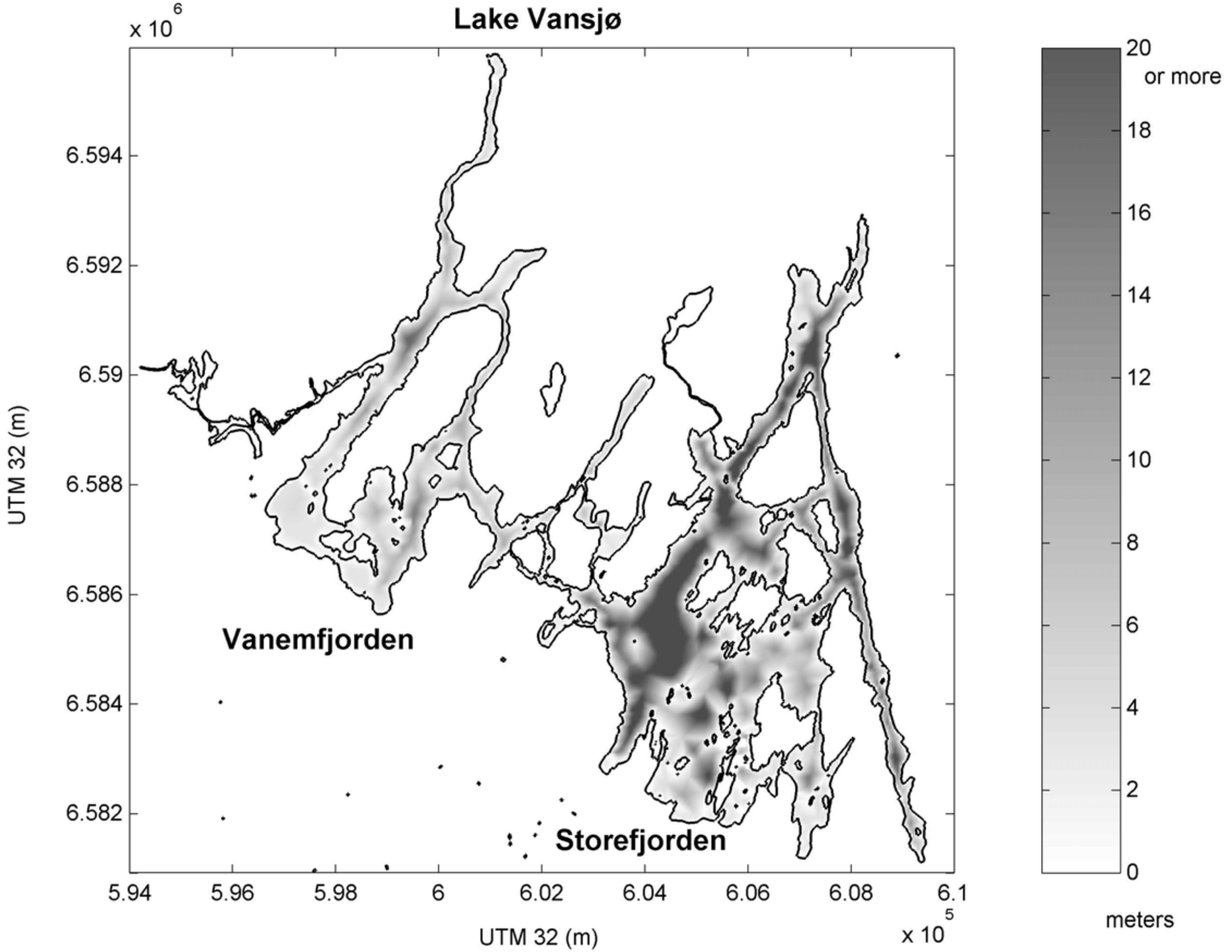
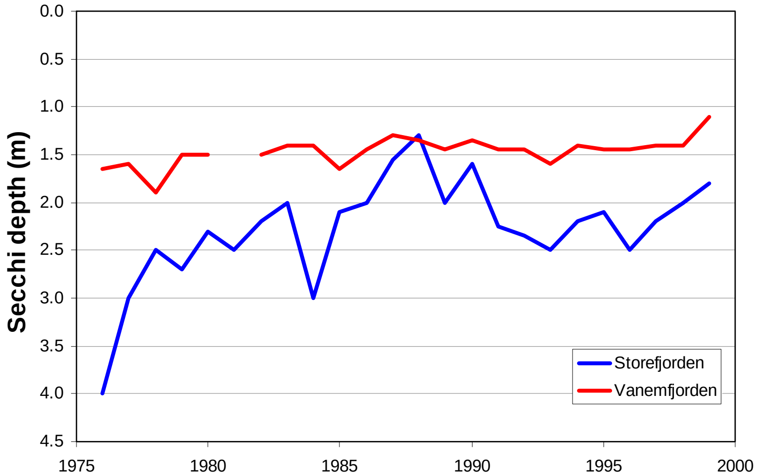
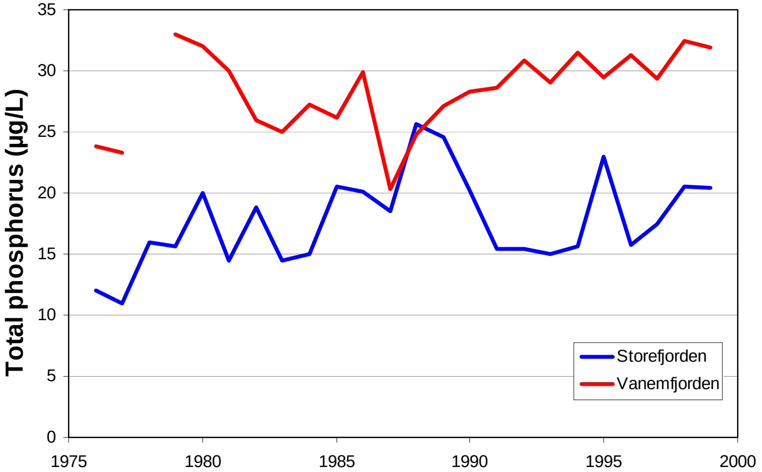
Step 3: Select and set up the model



Vansjø - 25 years of eutrophication





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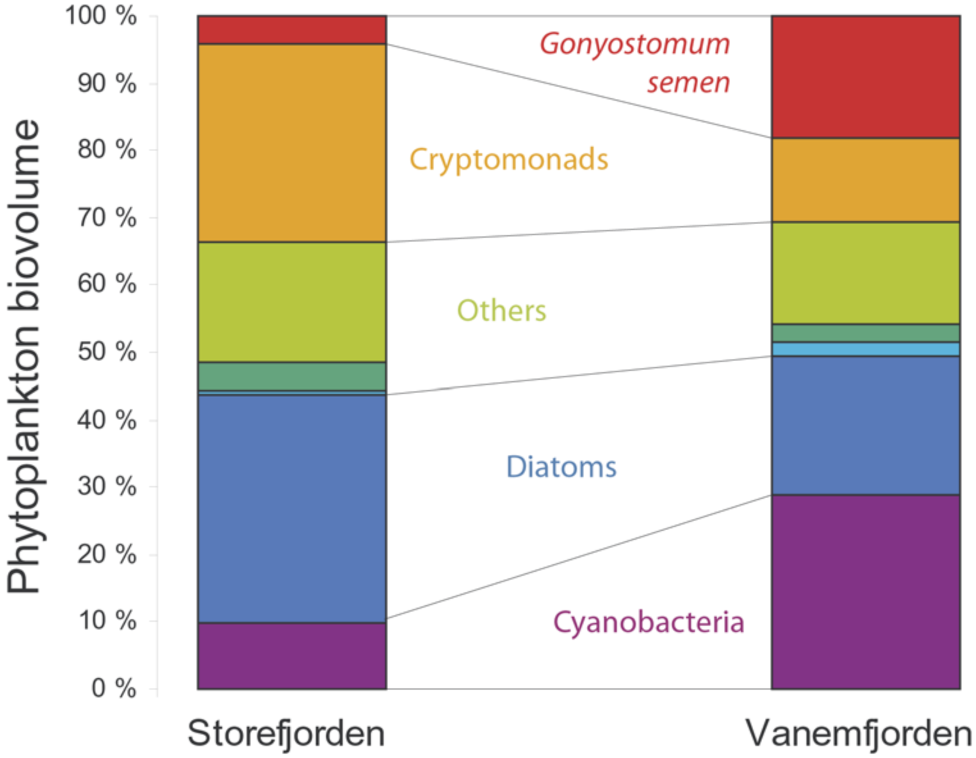
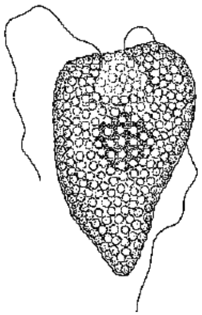
Harmful algal blooms





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Step 3: Select and set up the model

Four lake model candidates were initially considered:

- The 1-dimensional hydrodynamic model code DYRESM linked with the water quality model code CAEDYM;
- The 1-dimensional water quality model code MINLAKE ;
- The 1-dimensional water quality model code MyLake ;
- The 2-dimensional water quality model code CE-QUAL-W2.

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Step 3: Select and set up the model

Evaluated model code: MyLake

Evaluation is connected to the following management/modelling task: Study of the long-term (i.e. decades) impacts of reduction of phosphorus load (both particle-bound and dissolved) on the water quality in the Vansjø-Storefjorden. Water quality is mainly expressed in terms of total phosphorus concentration.

Question	Score	Justification
Q1.1. How well does the model's output relate to the management task?	Good	The different phosphorus fractions in MyLake output are easily summed up to *totP*, which is the main desired water quality indicator in this study.
Q1.2. How well does the model's span and resolution in time and space compare with the requirements of the management task?	Adequate	The short run-time and inclusion of lake ice and snow processes in MyLake allows simulation over decades. The vertical resolution in the model can be adjusted, but the model time step is fixed to 24h. However, this time resolution is adequate for the management issue.
Q1.3. How well has the model been tested?	**Inadequate**	MyLake is a newcomer and not well tested. Only the thermodynamic part of the model code has been applied in two other lakes before. No peer-reviewed scientific publications exist on the model application so far (cf. Q1.8).

Step 3: Select and set up the model

Q3.3 How is the model's technical documentation?	Adequate	Comprehensive description of the processes and algorithms in the model code is available.
Q3.4. How is the model's interactiveness, user-friendliness, and its suitability for end-user participation?	Good	MyLake is rather transparent model code, which is easy to set up. MyLake is executed in Matlab software (command line based software), and the model outputs are easily visualised. Active user support is available from the model code developers, and the model should be well suited for use in e.g. negotiations between the stakeholders.
Q3.5. How is the model's flexibility for adaptation and improvements?	Good	MyLake model code is rather well-structured, commented and flexible for adaptations and improvements. The code is available from the developers on request.

Conclusion: MyLake model code did not fullfill the benchmark criteria for the specified Vansjø-Storefjorden management/modelling task due to one "inadequate" score by question 1.3, related to inadequate model testing and lack of documented previous applications.

Date & Evaluator: 11.02. 2004, Tuomo Saloranta, NIVA

Step 3: Select and set up the model

MyLake

- MyLake is a 1-dimensional, dynamic, process-based model code for simulation of daily:

  1) vertical distribution of lake water temperature (stratification)

  2) evolution of seasonal lake ice and snow cover

  3) phosphorus-phytoplankton dynamics.

- Technical documentation and user's guide is available

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Step 3: Select and set up the model

MyLake

Strengths of MyLake model code include:

- MyLake has a relatively simple and transparent model structure, it is easy to set up, and is suitable both for making predictions and scenarios, and to be used as an investigative tool.
- Short runtime allows application of comprehensive sensitivity and uncertainty analysis as well as simulation of a large number of lakes or over long periods (decades).
- MyLake aims to include only the most significant physical, chemical and biological processes in a well-balanced and robust way.

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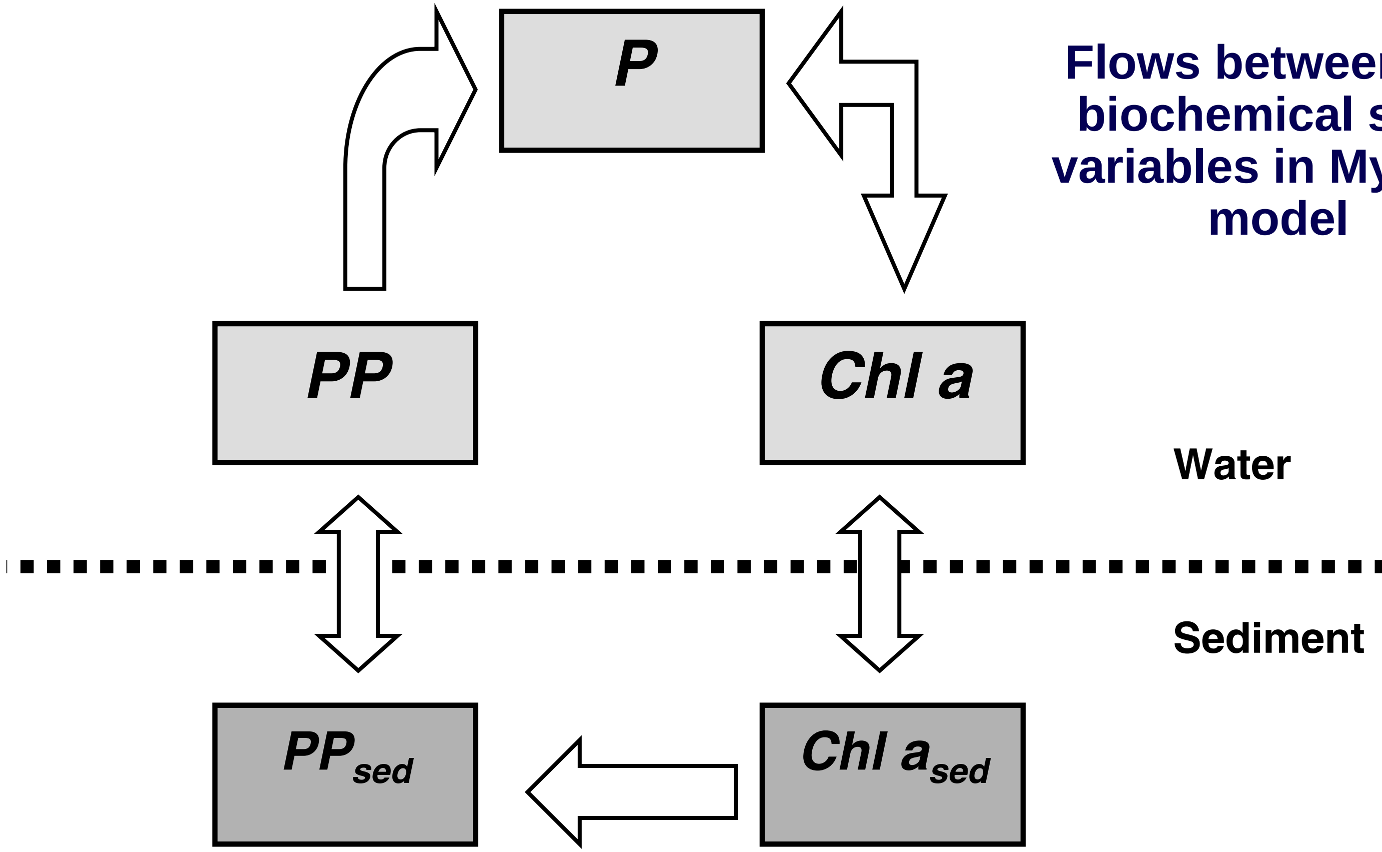
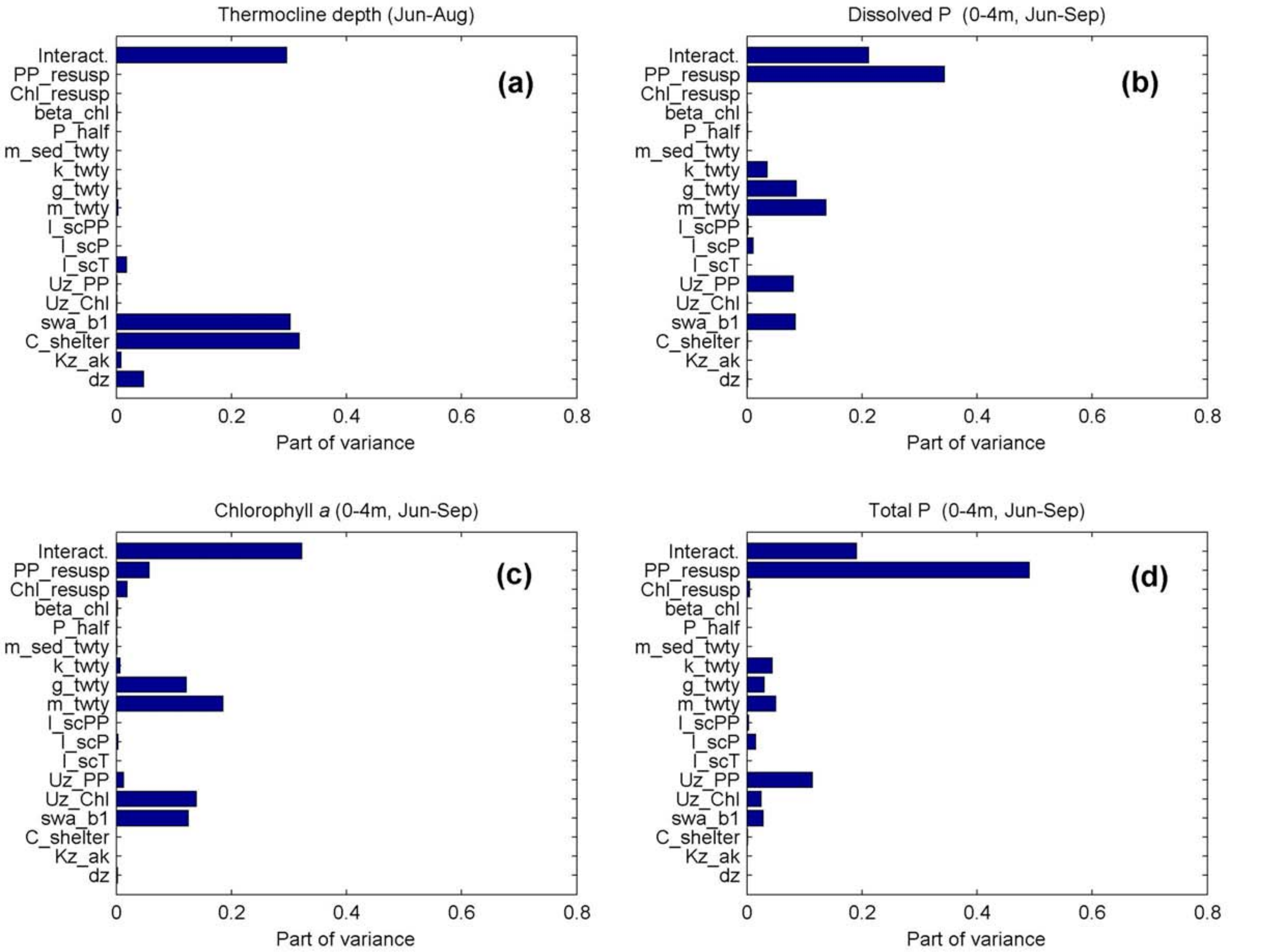
Step 3: Select and set up the model



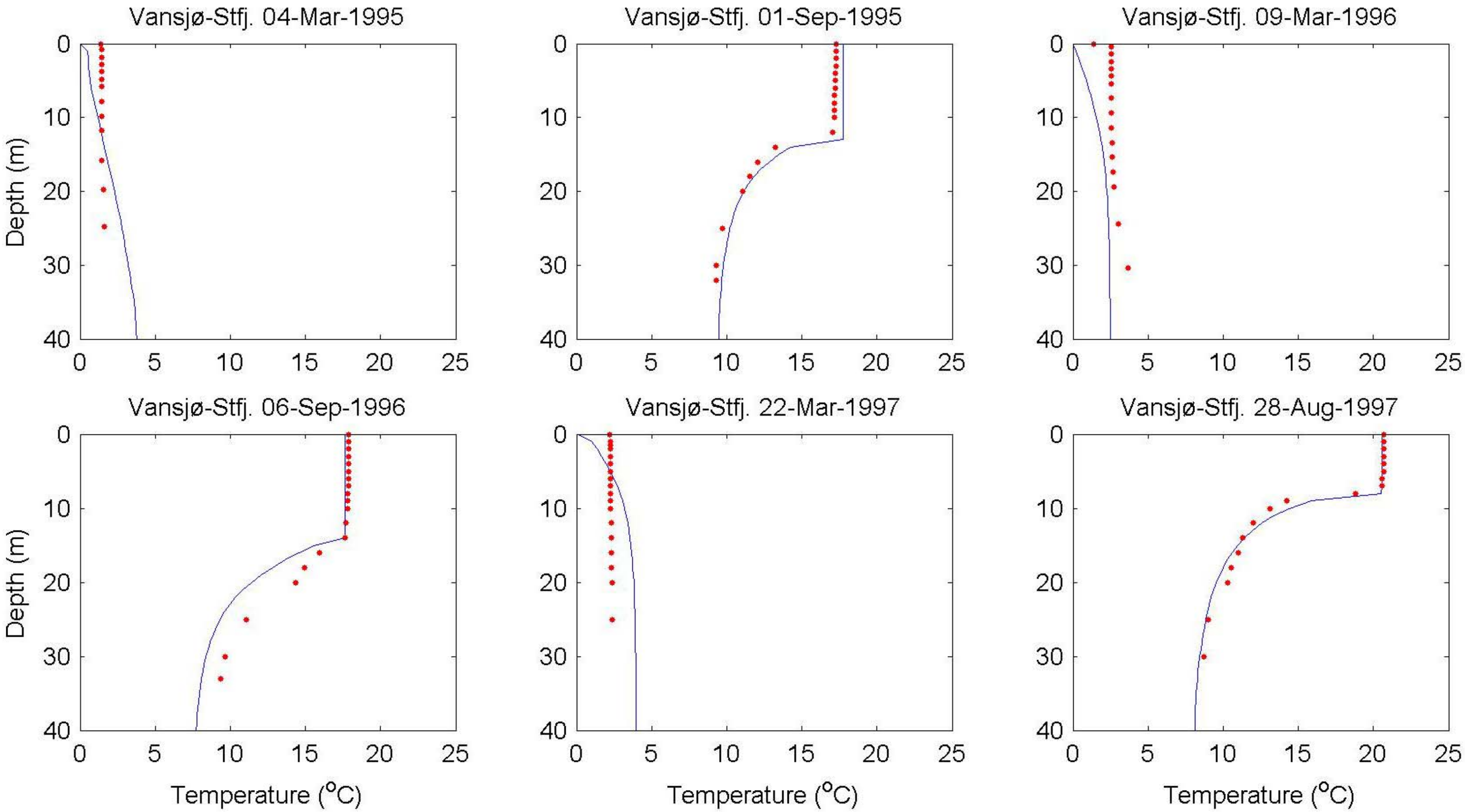
Flows between the biochemical state variables in MyLake model

Step 4: Analyse the model



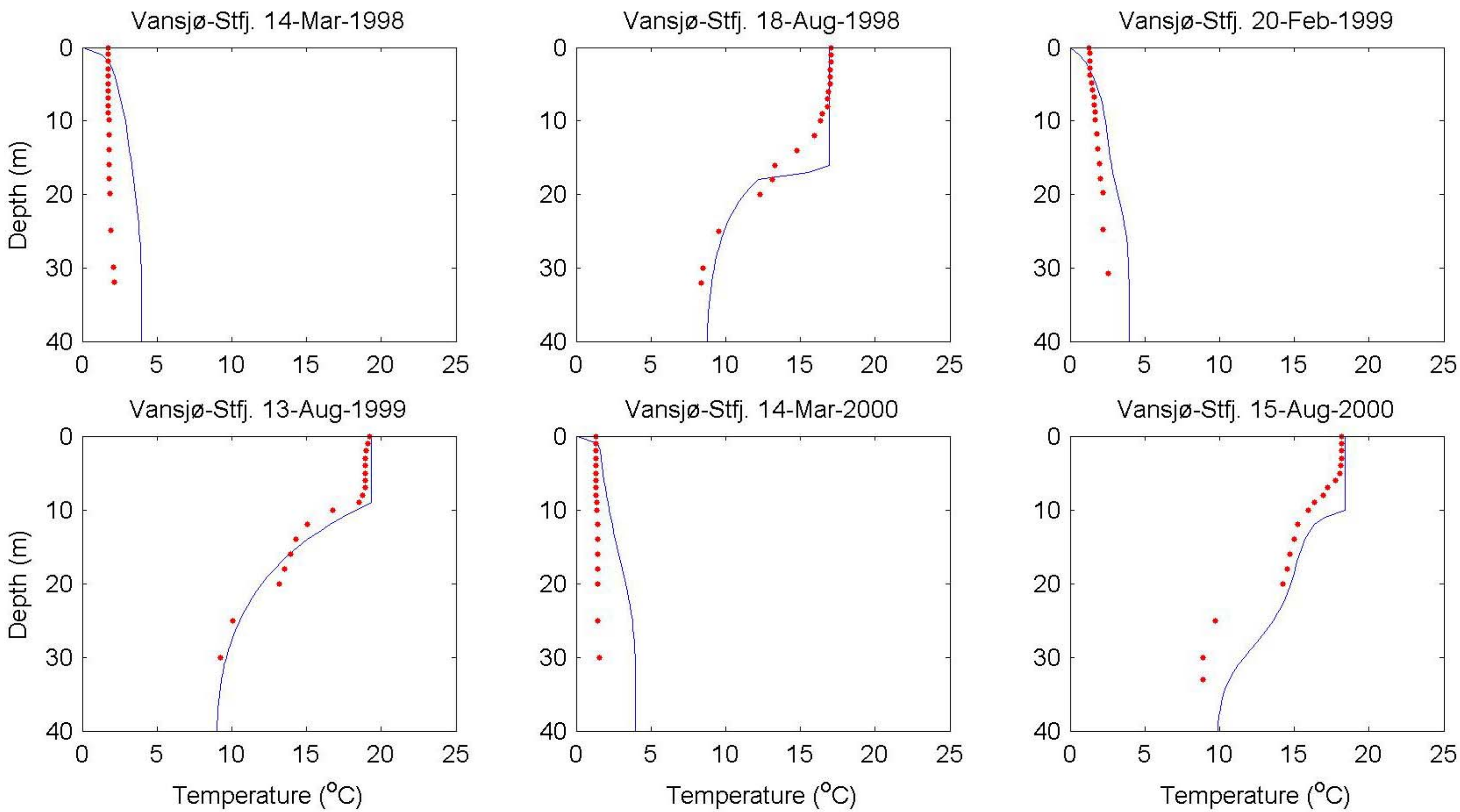
Step 4: Analyse the model

Calibration period 1994-1997

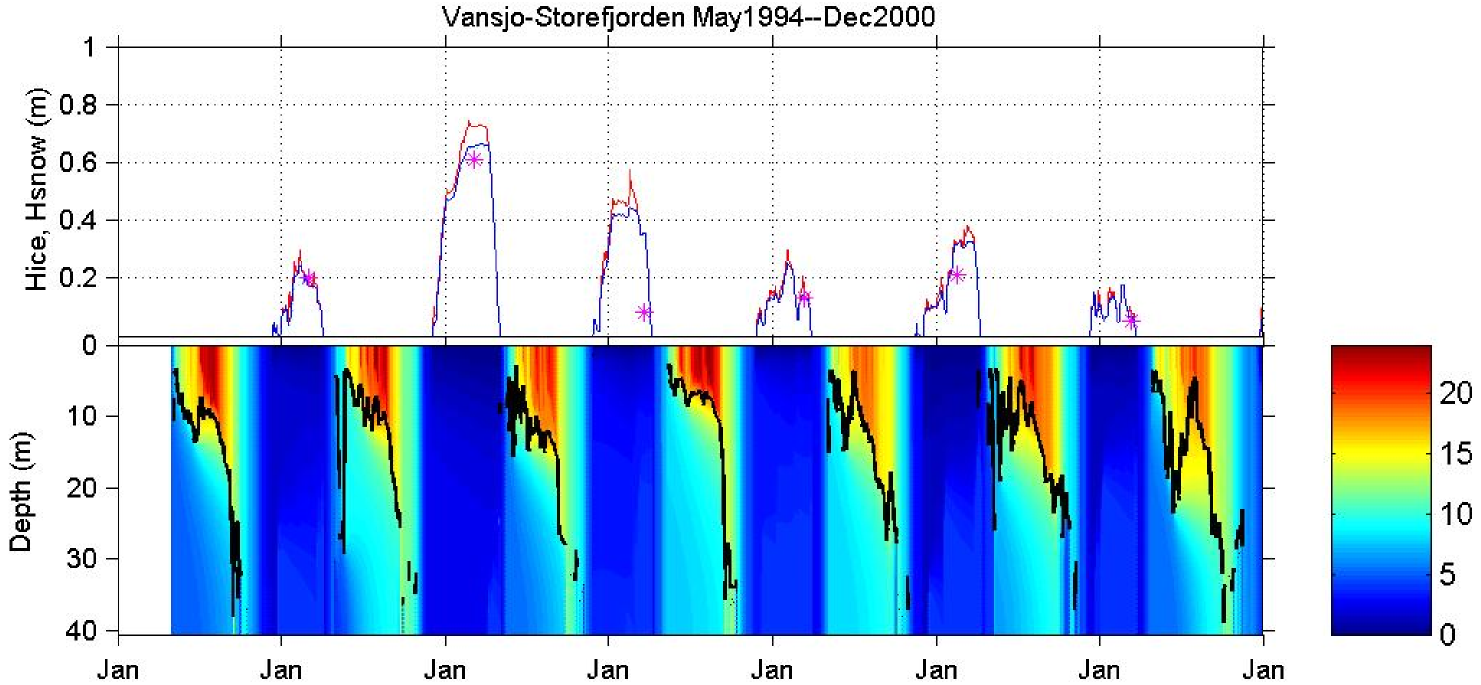


Step 4: Analyse the model

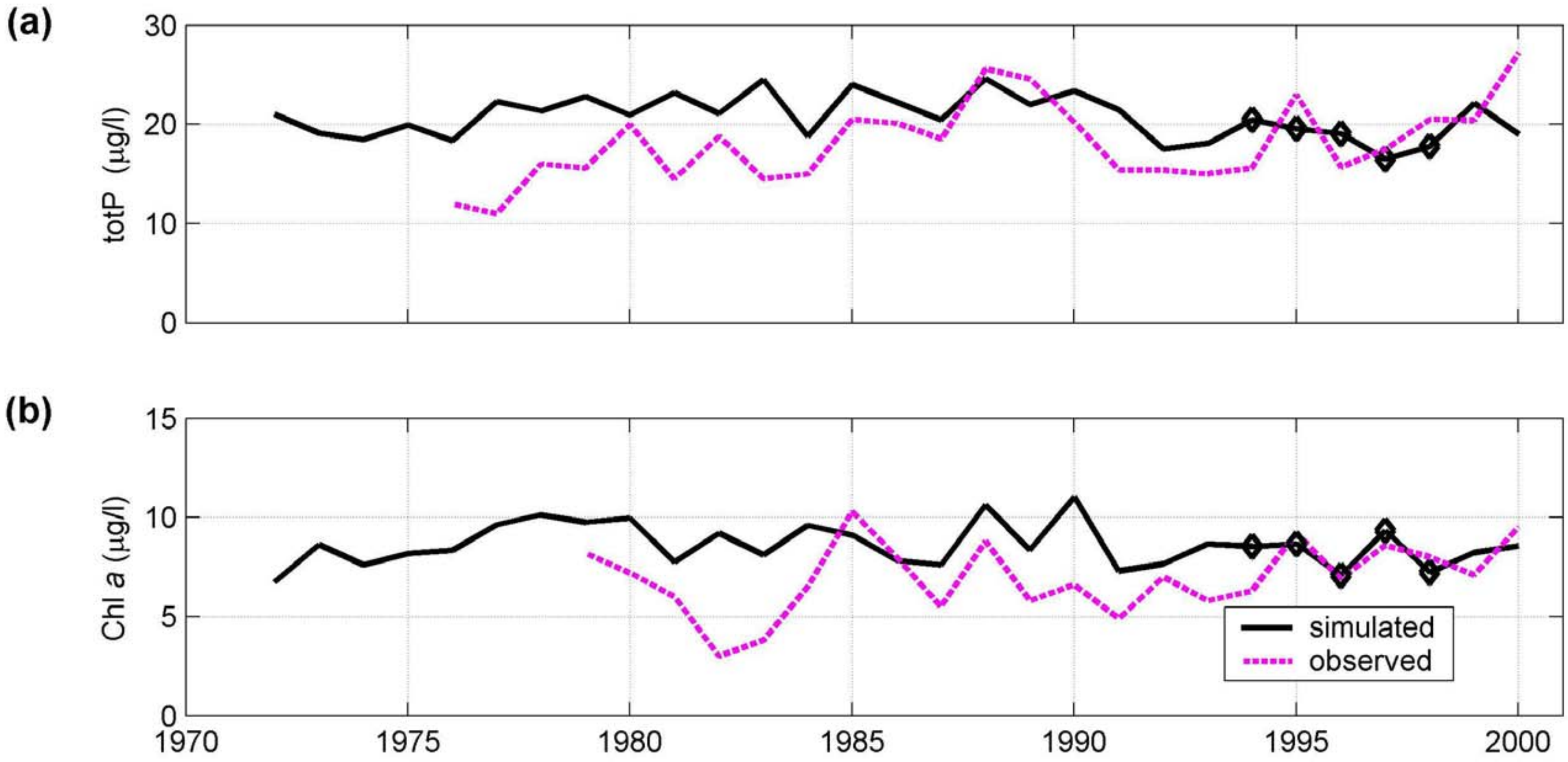
Evaluation period 1998-2000



Step 4: Analyse the model



Step 4: Analyse the model



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Step 5: Using the model

- The main question to be answered by the modelling study is the following: if phosphorus loading into the Storefjorden subbasin of Vansjø is reduced by 50%, will the water quality reach the two preset environmental goals of TotP <11 and <15 µg/L?

- Four modelling scenarios were defined
  - No reduction in loads of *P* and *PP*
  - 50% reduction in load of *PP*
  - 50% reduction in load of *P*
  - 50% reduction in load of *PP* and *P*

- MyLake application was run for period 1971-2000 for these scenarios.

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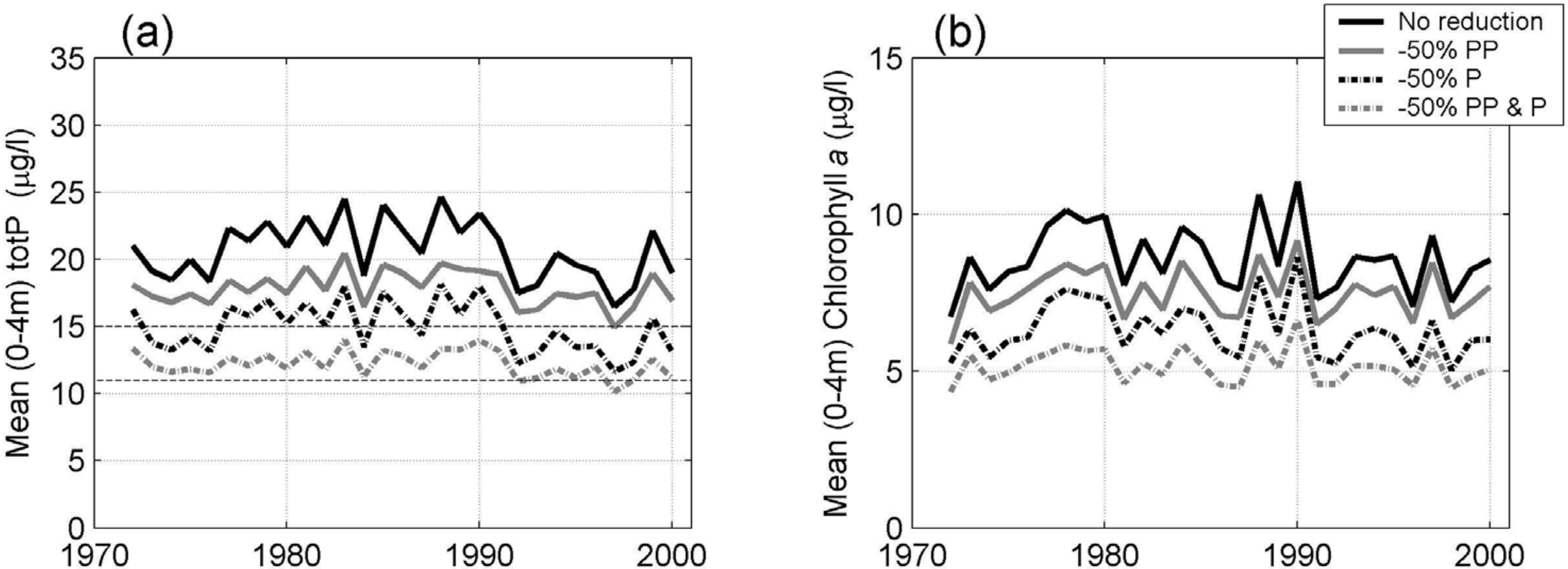
Step 5: Using the model



Some relevant questions

- Clearer instructions for benchmark criteria?
- Technical model performance?
- Biased selection of a “familiar” model?
- Could decisions be based now on these model results?
- Justification for use of MyLake instead of a simpler method?

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Models and water management

”Models are not used in environmental management as often as they could be”

(Dale, 2003)

The main barriers (?):

- poor communication;
- poor understanding of the modelling process;
- poor availability/knowledge of suitable models;
- poor resources.

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Models and water management

Conclusion:

We believe that by

1) following (and documenting) the step-by-step modelling process (Van Waveren et al., 1999),

2) using available (internet-based) inventories to get an overview of available model codes, and by

3) performing and documenting the model code selection with help of the benchmark criteria approach (Saloranta et al., 2003),

at least some of the *barriers to model use in environmental management* can be removed.

References:

Van Waveren, R. H. et al., 1999, *'Handbook of good modelling practise'*, STOWA report 99-05, Dutch dept. of public works. http://www.info.wau.nl/research%20projects/gmp.htm

Saloranta, T. M. et al., 2003, 'Benchmark criteria: A tool for selecting appropriate models in the field of water management', *Environmental Management 32*, 322-333.

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