### SWAT conference 2018 - Brussels

# A web platform to activate an operational forecast mode for existing SWAT setups







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Dennis Trolle, Anders Nielsen, Anders Lehmann

## Outline

- Rationale why could this be a good idea?
- What is the main idea and concept?
  - Illustration of an early prototype example
- How could you use the forecast system for your own SWAT applications, and what is the timeline?

## **Rationale – the challenges**

Why could it be a good idea with easy access to a forecast system?
Water issue 1: flooding



Flooded urban area in Elling, Denmark (Elling river flooding in October 2014)



Flooded urban area in Lystrup, City of Aarhus (Lystrup river flooding in August 2012)

## **Rationale – the challenges**

Why could it be a good idea with easy access to a forecast system?
Water issue 2: drought



Due to severe summer drought of 2018, about 5% of the Danish agricultural enterprises is at risk of bankruptcy (SEGES knowledge center)



Mitigation of drought by irrigation (water from rivers or shallow groundwater)

## Rationale – the challenges

Why could it be a good idea with easy access to a forecast system?
Water issue 3: reservoir water storage and quality

Lake Benmore, New Zealand's largest man-made lake used for recreation and hydropower.

**Ensuring a safe and stable water storage**, e.g. for <u>drinking water</u> supply, storage for <u>crop irrigation</u>, <u>flood</u> <u>storage/protection</u> in association with river corridors, <u>hydropower</u> creation, <u>nature conservation</u> and <u>recreation</u>.

> Example of **fish kill** due to hypoxia followed by water column turnover in Lake Erie (September, 2012), picture by Ontario Ministry of the Environment

Example of **bluegreen algae** (potentially toxin producing) bloom in Lake Stilling, Denmark (2016)

### Rationale – the "solution"



- A readily available forecast system could help address urgent societal challenges.
  - Early warnings
  - Short term and seasonal planning (e.g. flood protection, reservoir operations, agricultural irrigation)

### **Rationale – current state-of-the-art**

- For the past three years, several research projects have taken steps in improving short-term and seasonal forecasts of lake and reservoir dynamics (several EU JPI programs have supported these), however:
  - The watershed is largely ignored in these projects.
  - The need for watershed input is acknowledged but not delivered.

### **Rationale – current state-of-the-art**

- The process of coupling complex watershed models with complex lake and reservoir models is tedious and potentially error prone (but now WET can help you).
- Some studies exist (e.g. from US) where SWAT is used to run forecasts, but the forecast system is not easily transferred to other SWAT sites across the globe.
- Other (non-SWAT) large scale forecasting systems for specific areas also exist, but systems are generally not easily transferred to other sites

## The main idea and concept

"Develop software components that enable a "scalable" plug-andplay forecast solution, that can integrate any existing SWAT application in the world."

"This could save huge amounts of time for people who already have a SWAT set up, but who may lack the sufficient technical knowledge to develop the software infrastructure needed to run forecast."

### The core of the forecast system



## What is WET?

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### SWAT Soil & Water Assessment Tool

SOFTWARE DOCUMENTATION WORKSHOPS CONFERENCES PUBLICATIONS DEVELOPERS 🔍 🍱 🦊

SEP 17-21, 2018

SEP 24-28, 2018

### **SOFTWARE TOOLS**

SWAT-CUP SWAT calibration/uncertainty or sensitivity

WGEN Parameters Estimation Tool Tool Using Microsoft Access. Version 0.18.03

**QSWAT 1.5** QGIS interface for SWAT

 WET - Water Ecosystems Tool
 OCT 16, 2017

 Advanced lake and reservoir modeling coupled to SWAT

 SWAT-MODFLOW v2
 FEB 21, 2016

 ArcSWAT 2012.10.19
 JAN 24, 2017

 For ArcGIS 10.4, 10.3, and 10.2
 JAN 24, 2017

 SWATeditor 2012.10.19
 JAN 24, 2017

 Companion to ArcSWAT
 DEC 23, 2016

Executables and source code

SWAT Check 1.2.0.9 JAN 11, 2017 Identify potential model input problems

### SWAT+

JUN 2018

JAN 3, 2018

Introducing SWAT+, a completely revised version of the SWAT model. SWAT+ provides a more flexible spatial representation of interactions and processes within a watershed. <u>Download the interface</u>.

### **UPCOMING EVENTS**

LS, BELGIUM

2018 International SWAT Conference & Workshops

NTON, ALBERTA, CANADA

Beginner and Advanced SWAT Workshops

Additional learning resources:

Instructional videos User groups Documentation

### 2018 AGU Fall Meeting - Applications of SWAT and other watershed simulation models

The 2018 AGU Fall Meeting in Washington, D.C. will take place 10-14 December. We would like to bring the following sessions to your attention.

Advances in Watershed Modeling: Hydrologic/Nutrient
 Processes, Conservation Management and Model Integration
 Haw Yen, Aleksey Sheshukov, Abeyou W. Worqlul, and Jeffrey G.
 Arnold

### 2018 BRUSSELS



The 2018 International SWAT Conference and Workshops will be held at Vrije Universiteit Brussel (VUB), Belgium, September 17-21. <u>View the agenda and get</u> more information.

### CALL FOR ABSTRACTS

An integrated modeling workshop, sponsored by Cornell University and Iowa State University, will be held at the David R Atkinson Center, Cornell University, Ithaca, NY during April 3-5, 2019. The workshop organizers are Dave Keiser (Iowa State University), Cathy Kling (Cornell University) and Dan Phaneuf (University of Wisconsin, Madison). Abstracts are being solicited that describe integration of the Soil and Water Assessment Tool (SWAT), Agricultural Policy/Environmental eXtender (APEX) and/or other ecohydrological or environmental models, with economic models or other types of models. Accepted abstracts will also be considered for a special issue of Land Economics. <u>Additional details regarding the topics of</u> interest and abstract submission process. - 🗆 🗙

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## What is WET?

🥘 2018 - Brussels, Belgium 🗙 🔪

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SWAT Soil & Water Assessment Tool

SOFTWARE DOCUMENTATION WORKSHOPS CONFERENCES PUBLICATIONS DEVELOPERS 🔍 🎽 😃

### CONFERENCES > 2018 - BRUSSELS, BELGIUM



### Workshops

Four workshops will be offered in parallel. Participants must bring their own laptops with software loaded.

### Introductory SWAT (QSWAT)

This is a beginner course designed to introduce new users to the SWAT model, review necessary and optional inputs, and familiarize the user with the QGIS interfaces. It is assumed that attendees have a working knowledge of QGIS. The two-day course will not review basic concepts on QGIS usage prior to covering the SWAT/QGIS interface. Introductory workshop topics.

### SWAT-MODFLOW

This workshop will cover the basics of using MODFLOW to simulate groundwater flow in SWAT simulations. The SWAT-MODFLOW coupled model will be introduced and its use will be demonstrated using example datasets. Linking RT3D with SWAT-MODFLOW for simulating nutrient fate and transport in groundwater also will be presented.

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### WET (Water Ecosystem Tool)

WET is an open source QGIS plugin aiming to provide an easy-to-use tool for user adaptation and application of state-of-the-art aquatic ecosystem models, and model-based experimentation for research and management. Learn more about the workshop,

### Advanced SWAT (SWAT-CUP)

# WET is an interface for setting up and applying a coupled hydrodynamic-ecosystem model

The configuration of the conceptual ecosystem model is flexible, but by default it describes interactions between multiple trophic levels, including piscivorous, zooplanktivorous and benthivorous fish, zooplankton, zoobenthos, phytoplankton and rooted macrophytes. The ecosystem model also accounts for oxygen dynamics and a fully closed nutrient cycle for nitrogen and phosphorus.



PCLake, originally by Jan Janse 1995, Further developed by AU (Hu et al. 2016)

# WET is an interface for setting up and applying a coupled hydrodynamic-ecosystem model







experimentation with aquatic ecosystems

Anders Nielsen <sup>a, \*</sup>, Karsten Bolding <sup>a, b, c</sup>, Fenjuan Hu <sup>a</sup>, Dennis Trolle <sup>a, b</sup>

<sup>a</sup> Aarhus University, Department of Bioscience, Vejlsøvej 25, 8600 Silkeborg, Denmark <sup>b</sup> Sino-Danish Centre for Education and Research, University of Chinese Academy of Sciences, Beijing, China <sup>c</sup> Bolding & Bruggenan ApS, Standgedor 25, 5466 Apperup, Denmark

### ARTICLE INFO ABSTRACT

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Keywords: Aquatic ecosystem modelling QGIS plugin FABM-PCLake GOTM We present the new Water Ecosystems Tool (WET), a workflow implemented (as a plugin) in QGLS, for application and evaluation of aquatic ecosystem models. WET provides a Graphical User Interface (GIU) for the coupled one-dimensional hydrodynamic-ecosystem model GOTM-FABM-FALLek. WET is unique as it enables a standardized and easy-to-use workflow for an otherwise complex model application and is readily applicatiole to any individual lake and reservoir in the world. WET Integrates a platform for model experimentation through scenario simulations – currently encompassing changes in climate and nutrient loads. WET also includes a link to the SWAT (Soil & Water Assessment Tool) watershed model, which can be used to simulate how land use changes affect aquatic ecosystems. The tool is open source and may therefore be readily expanded and adapted for additional model experimentations. 0 2017 The Authors. Published by JEsveir LIA. This is an open access article under the CC BW license.

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### Software availability

Name of software: WET (Water Ecosystems Tool) Developers: Anders Nielsen, Karsten Bolding and Dennis Trolle Contact Address: Department of Bioscience, Aarhus University, Vejlsøvej 25, 8600 Silkeborg, Denmark

Email: wet.info@wet.au.dk Availability: wet.au.dk

### 1. Introduction

For decades, both simplisitic, empirically derived water quality models (Vollenweider and Kerekes, 1982) and, more recently, complex mechanistic ecosystem models minicking processes and food web structures (Mooij et al., 2010; Trolle et al., 2012), have been available for scientists and water quality managers in the effort to obtain a greater understanding of system behavior (Trolle et al., 2008; Nielsen et al., 2014; Rolighed et al., 2016). While the computational power of a standard desktop computer currently allows complex model simulations to be performed with ease, application of state-of-the-art mechanistic models as supportive

 Corresponding author. E-mail address: an@bios.au.dk (A. Nielsen).

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tools, e.g. in water quality management, is still very limited. A key reason for this is, in our view, the high level of technical expertise required of the users to complete the preparation, configuration, and execution of a complex ecosystem model. Bottleneck steps typically involve numerous configuration file edits and script syntaxes (with high exposure to errors) as well as solid insight into file structures and formatting. In parallel to this, the credibility of the models are (rationally) questioned when their use is considered to support a decision-making process for a given ecosystem, often due to lack of existing validation cases. Consequently, application of ecosystem models is primarily a niche for dedicated expert users and scientific communities.

In other scientific modelling disciplines Graphical User Interfaces (GUI) have assisted in bridging the expertise gap experienced by potential new model users and thereby eased their model application to specific sites of interest. The SWAT model (Soil & Water Assessment Tool), an eco-hydrological watershed model (Arnold et al., 1998; Neitsch et al., 2005), acts in our view as a sound example of how GUI support of a model have facilitated outreach and application worldwide. To enable a much wider use and accelerate the development of ecosystem models as well, we constructed a standardized workflow enveloping a state-of-the-art model in a GUI called WET (Water Ecosystems Tool). WET makes

### WET can import and process SWAT reach output - can potentially be integrated into SWAT(+) code



### **Example of output from a WET simulation**



### Let's get back to the forecast system



### Initial illustration

• Prototype based on the Dashahe (Kaiping) reservoir area (illustrated through website)





### How could you use it and what is the timeline?

- Initial proof-of-concept prototype development is soon complete
- To ensure a stabile, scalable (and safe) operation of forecast system, we are currently contemplating on developing the software for a cloud solution, where we buy hosting and runtime service from a secure, stable supplier (such as Amazon, Google and Microsoft)
- Maintaining the forecast system, and using a cloud solution, would come at a cost, which has to be paid somehow by the users of the system
- If there is significant interest in the system, we continue the software development, and could likely have something that is operational in 2019

# Inputs from you...

If you have any comments, ideas or requests of the forecast system, please et us know here at the conference, or contact us by email.

### Thank you

