SuperflexPy: a new open source framework for building conceptual hydrological models

Marco Dal Molin[1], Dmitri Kavetski[2], and Fabrizio Fenicia[1]

[1]Eawag, Swiss Federal Institute of Aquatic Science and Technology
[2]School of Civil, Environmental and Mining Engineering, University of Adelaide

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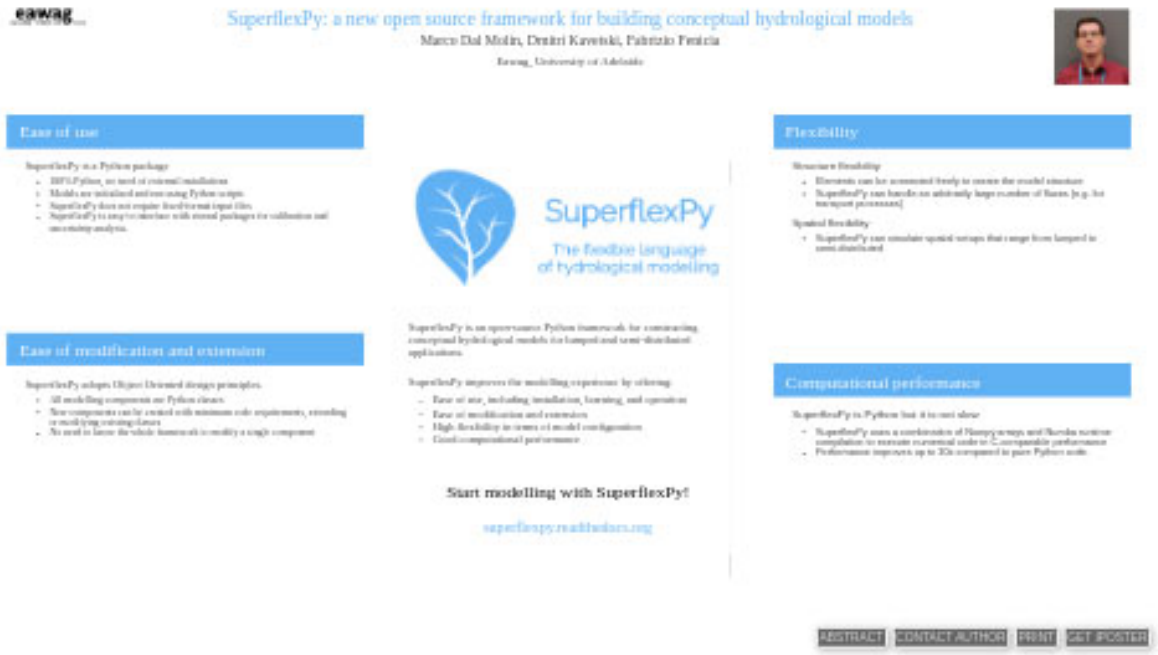
Abstract

Conceptual models are among the most frequently used type of models in watershed modelling studies, due to their low computational requirements and ease of interpretation. Model selection requires the comparison of model alternatives, which is complicated when the models present in the literature differ in many uncontrolled aspects, such as conceptualization, implementation, and source code availability. To overcome this limitation, several model-building frameworks have been introduced in the last decade, which facilitate model comparisons by enabling different model alternatives within the same software and numerical architecture. Building on the decennial experience with the development and usage of Superflex, a flexible modeling framework for conceptual model building, so far implemented in FORTRAN language and not available as open source, we propose SuperflexPy, an open source Python framework for building conceptual hydrological models. Compared to other existing models or flexible frameworks, SuperflexPy is designed to be extremely easy to modify or extend, allowing scientists to build models that reflect their processes understanding; thanks to its object-oriented architecture and its complete integration with the Python programming environment, SuperflexPy can be seen as a high-level programming language for constructing hydrological models that are extremely flexible both in terms of elements configuration (i.e. how the elements are connected into a structure) and spatial organization. By design, SuperflexPy is not limited to water quantity but can be extended to simulate transport processes (water quality). In this presentation, we will illustrate the principles behind the design of the framework and showcase some applications.

SuperflexPy: a new open source framework for building conceptual hydrological models



Marco Dal Molin, Dmitri Kavetski, Fabrizio Fenicia

Eawag, University of Adelaide

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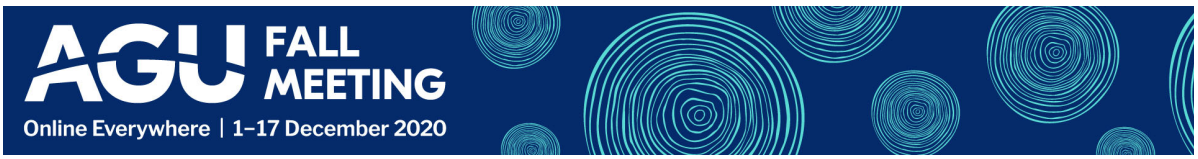

EASE OF USE

SuperflexPy is a Python package

- 100% Python, no need of external installations
- Models are initialized and run using Python scripts
- SuperflexPy does not require fixed-format input files
- SuperflexPy is easy to interface with eternal packages for calibration and uncertainty analysis.

EASE OF MODIFICATION AND EXTENSION

SuperflexPy adopts Object Oriented design principles.

- All modelling components are Python classes
- New components can be created with minimum code requirements, extending or modifying existing classes
- No need to know the whole framework to modify a single component

SuperflexPy

The flexible language of hydrological modelling

SuperflexPy is an open-source Python framework for constructing conceptual hydrological models for lumped and semi-distributed applications.

SuperflexPy improves the modelling experience by offering:

- Ease of use, including installation, learning, and operation
- Ease of modification and extension
- High flexibility in terms of model configuration
- Good computational performance

Start modelling with SuperflexPy!

superflexpy.readthedocs.org (http://superflexpy.readthedocs.org)

FLEXIBILITY

Structure flexibility

- Elements can be connected freely to create the model structure
- SuperflexPy can handle an arbitrarily large number of fluxes (e.g. for transport processes)

Spatial flexibility

- SuperflexPy can simulate spatial setups that range from lumped to semi-distributed

COMPUTATIONAL PERFORMANCE

SuperflexPy is Python but it is not slow

- SuperflexPy uses a combination of Numpy arrays and Numba runtime compilation to execute numerical code in C-comparable performance
- Performance improves up to 30x compared to pure Python code.

ABSTRACT

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Building on the decennial experience with the development and usage of Superflex, a flexible modeling framework for conceptual model building, so far implemented in FORTRAN language and not available as open source, we propose SuperflexPy, an open source Python framework for building conceptual hydrological models. Compared to other existing models or flexible frameworks, SuperflexPy is designed to be extremely easy to modify or extend, allowing scientists to build models that reflect their processes understanding; thanks to its object-oriented architecture and its complete integration with the Python programming environment, SuperflexPy can be seen as a high-level programming language for constructing hydrological models that are extremely flexible both in terms of elements configuration (i.e. how the elements are connected into a structure) and spatial organization. By design, SuperflexPy is not limited to water quantity but can be extended to simulate transport processes (water quality).

In this presentation, we will illustrate the principles behind the design of the framework and showcase some applications.