

Creating large-scale compound flood models in an automated and reproducible way

Roel de Goede, Deltares, roel.degoede@deltares.nl
Dirk Eilander, Deltares & VU Amsterdam, dirk.eilander@deltares.nl
Tim Leijnse, Deltares, & VU Amsterdam tim.leijnse@deltares.nl
Maarten van Ormondt, Deltares USA, maarten.vanormondt@deltares-usa.us
Tim de Wilde, Deltares, tim.dewilde@deltares.nl

INTRODUCTION

The United Nations "Early Warnings for All" initiative aims to protect everyone from water hazards, among other hazards, through life-saving early warning systems by the end of 2027.

To make this possible, flood warning systems on large spatial scales need to be developed that can run within an operational forecast window. For coastal systems, these systems need to be able to compute compound flooding (Wahl et al., 2015) due to the combination of different forcing mechanisms, such as high sea levels (due to extreme tides and/or storm surges), wave-induced runoff and flooding, large river discharges and direct rainfall.

To enable this, the reduced-physics solver SFINCS (Leijnse et al. 2021) was developed, combining all relevant processes to model compound flooding events, with strongly reduced computation times.

However, large area models require large input data sets. While global and regional data are becoming more widely available and are continuously updated, setting up models becomes too cumbersome to do manually. Semi-automated and reproducible workflows may help the modeler to select physically realistic model extents and use appropriate data with acceptable quality with an appropriate resolution in order to ensure a good model performance.

REPRODUCIBLE MODEL SET-UP WITH HYDROMT

To facilitate this HydroMT (Eilander et al, 2023a) was developed. HydroMT (Hydro Model Tools) is an open-source Python package that aims to make the process of building a model instance and analyzing model results automated and reproducible for any hydro software (Eilander et al, 2023a). Within HydroMT, models can have their own plugin with some dedicated features. For SFINCS the plugin is called HydroMT-SFINCS, which contains some smart features for model delineation.

COUPLED MODEL TRAIN BASED ON SAME DATA

With the ability to build several different hydrodynamic models and processing tools within one Python package, comes the opportunity for easy coupling of different models. For instance, a modelling train where the coastal compound flood model (SFINCS) receives upstream river boundary conditions from a hydrological model (Wflow) and downstream water level boundary conditions from another hydrodynamic model (Delft3D-FM). Because they are all based on the same workflow and data, the set-up is easy and the link between the models solid. Additionally, calculated flood maps can be translated into information about people affected and

projected damages (using Delft-FIAT), which is more relevant for policy makers.

APPLICATION - IMPORTANCE LOCAL DATA

In the presentation we will discuss several applications where HydroMT and SFINCS have been applied to setup flood models covering 1000s kilometers of coastline. Each case showcases one or multiple aspects that should be considered while modelling compound flooding on large scales.

For Eastern Australia, a model encompassing more than 7000 km of coastline was set up (Leijnse et al., 2022, Figure 1). In the present presentation we will discuss the model performance for a broad range of input data. A comparison of observed water levels (Figure 2; black-dashed line) versus model results shows that the water level prediction dramatically improves when using higher resolution data but that the timing of the high water is relatively unaffected.

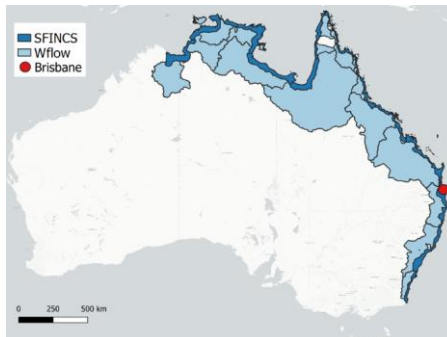


Figure 1 Overview of the hydrodynamic (SFINCS) and hydrological (Wflow) models covering Eastern Australia, with Brisbane indicated with a red dot.

The Australia case also demonstrates the strength of an approach using the combination of a hydrological Wflow model to compute upstream discharges and the hydrodynamic SFINCS model to model compound flooding downstream. When doing this, accurate results can be obtained (Figure 3).

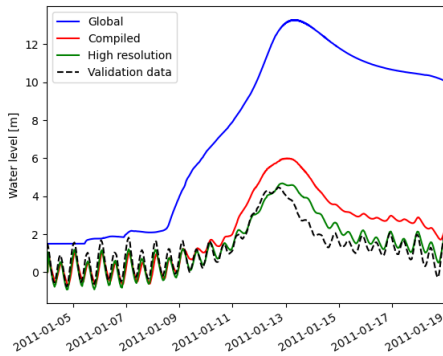


Figure 2 - Model-observation comparison for water levels in the Brisbane river during the 2011 flood event. MERIT Hydro (~90m resolution) was used as the global dataset, whereas local measurements (1-5 m resolution LIDAR and multibeam surveys) were used in the high-resolution model setup. The compiled dataset (~30m resolution) is a global dataset corrected on a regional scale (using information from the local measurements).

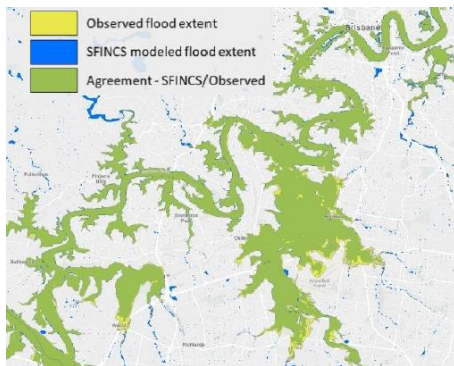


Figure 3 - Model-observation comparison for flood extents in downtown Brisbane during the 2011 flood event.

APPLICATION - MODELS FOR DEVELOPING COUNTRIES

In the presentation we will also discuss the experiences with setting up models in areas such as Beira, Mozambique (Figure 4) where we mostly rely on global data (Eilander et al, 2023b), and the United States where high-resolution local data is available.

The presented tools are made available to the engineering community in open-source form. This enables engineers and scientists to make better flood estimates in less time using the best available data, modelling approach and without cumbersome manual work.

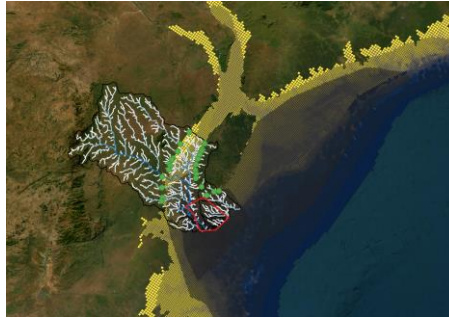


Figure 4 - SFINCS flood model (red boundary) for Beira, Mozambique, the hydrological model in white stream lines and a surge model in yellow. Green dots are inflow points from the hydrological model into SFINCS.

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Met opmerkingen [TL1]: Wanneer je tekst af is, dubbel check dan even of benaming etc niet te veel lijkt op mijn 2022 ICCE abstract (valt denk ik wel mee) - <https://icce-ojs.tamu.tdl.org/icce/article/view/13007>