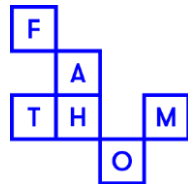


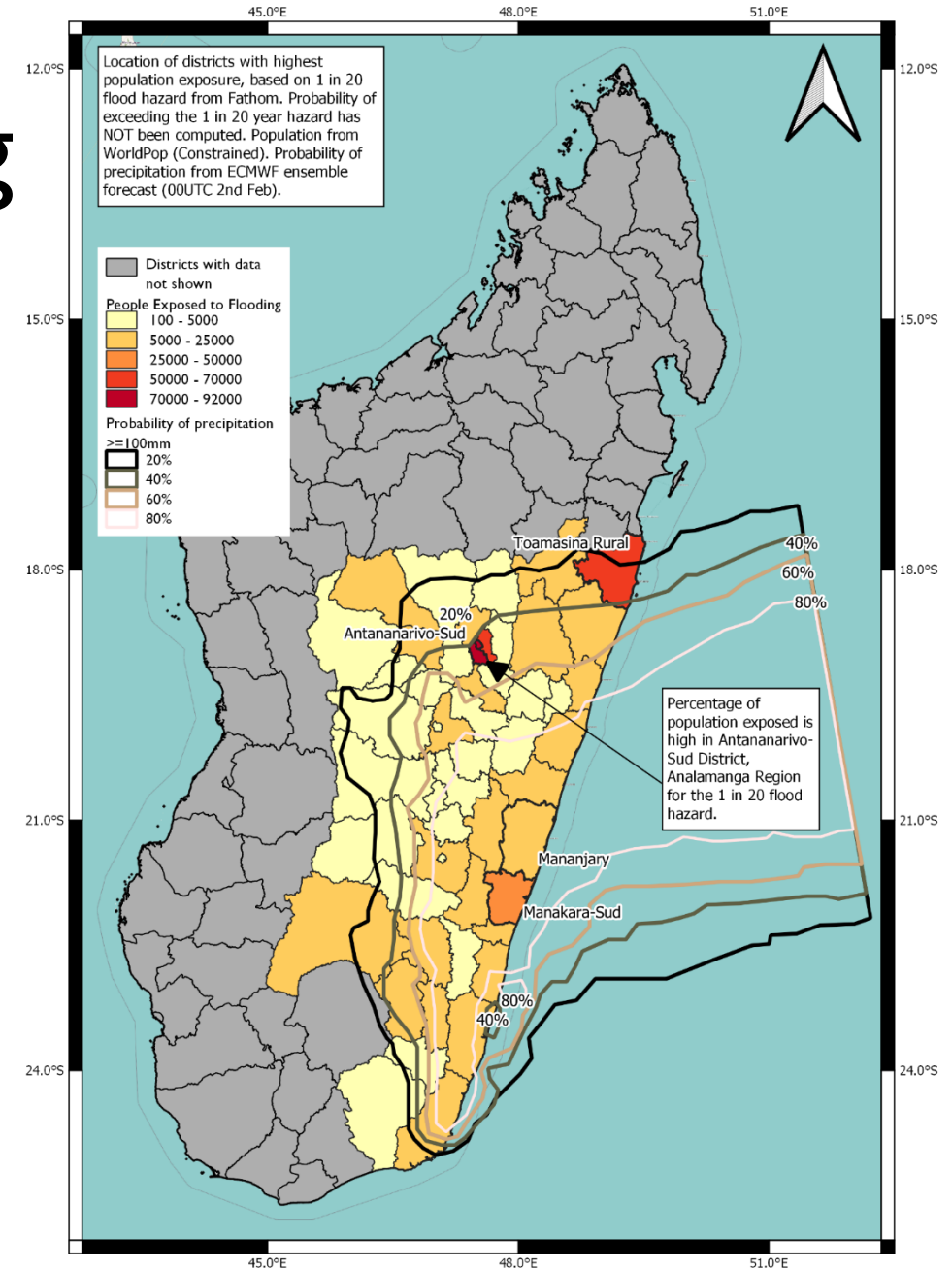
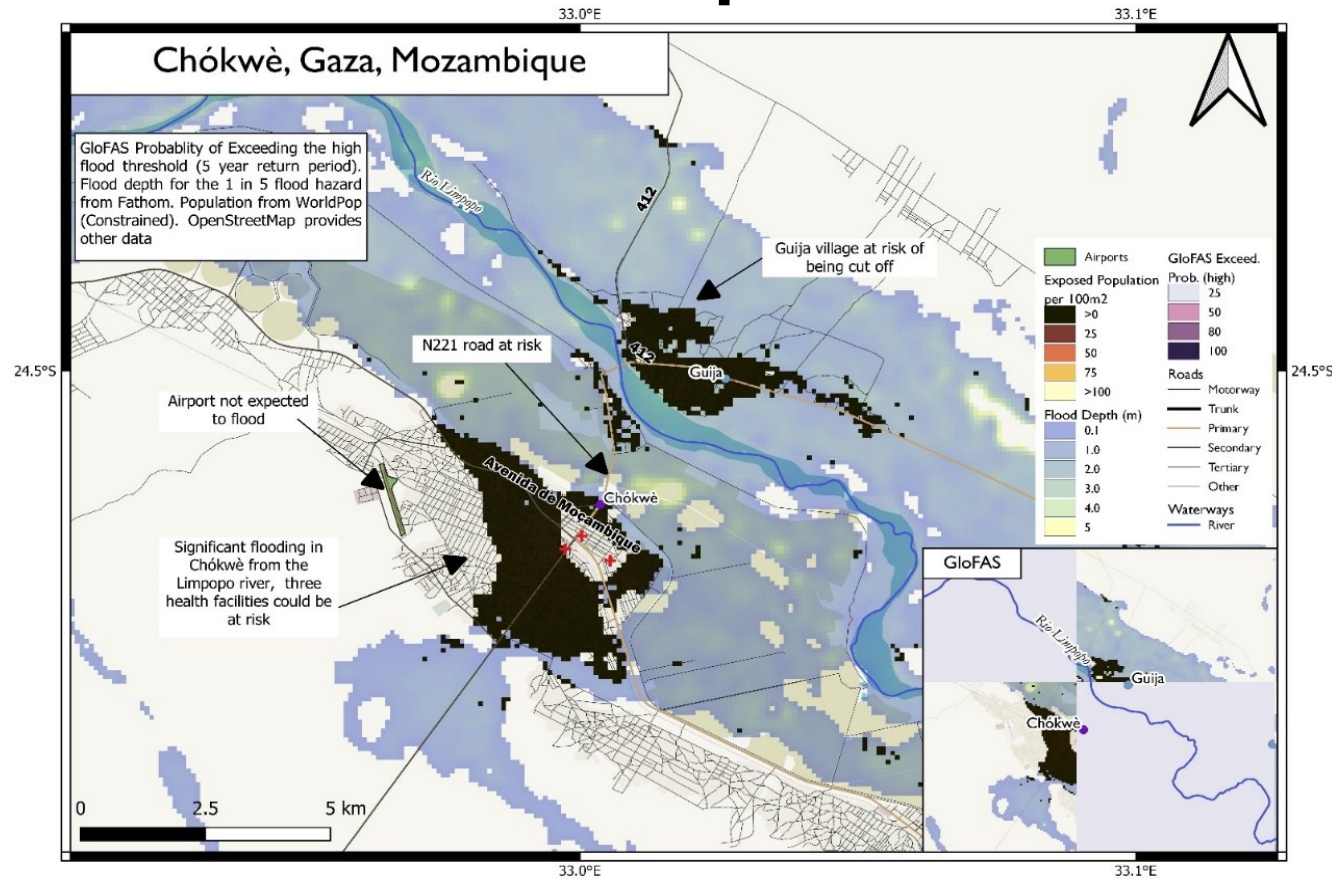
Simulating flooding from tropical cyclones in Southern Africa with SWOT

Jeffrey Neal, Xiaoli Su, Laurence Hawker, Steve Chuter, Paul Bates

Collaborators on EVOFLOOD and REPRESA projects



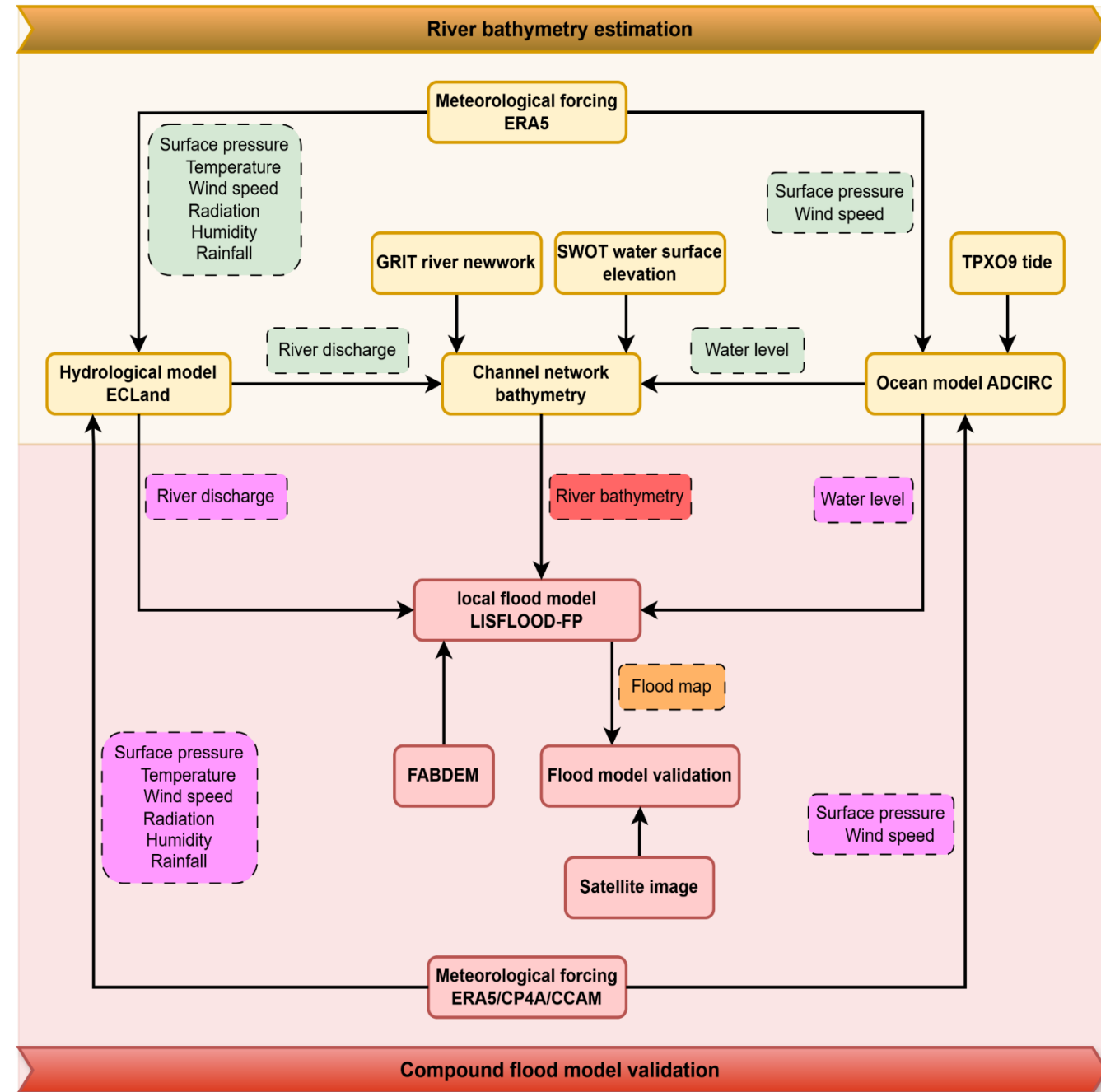
REPRESA: Impact forecasting



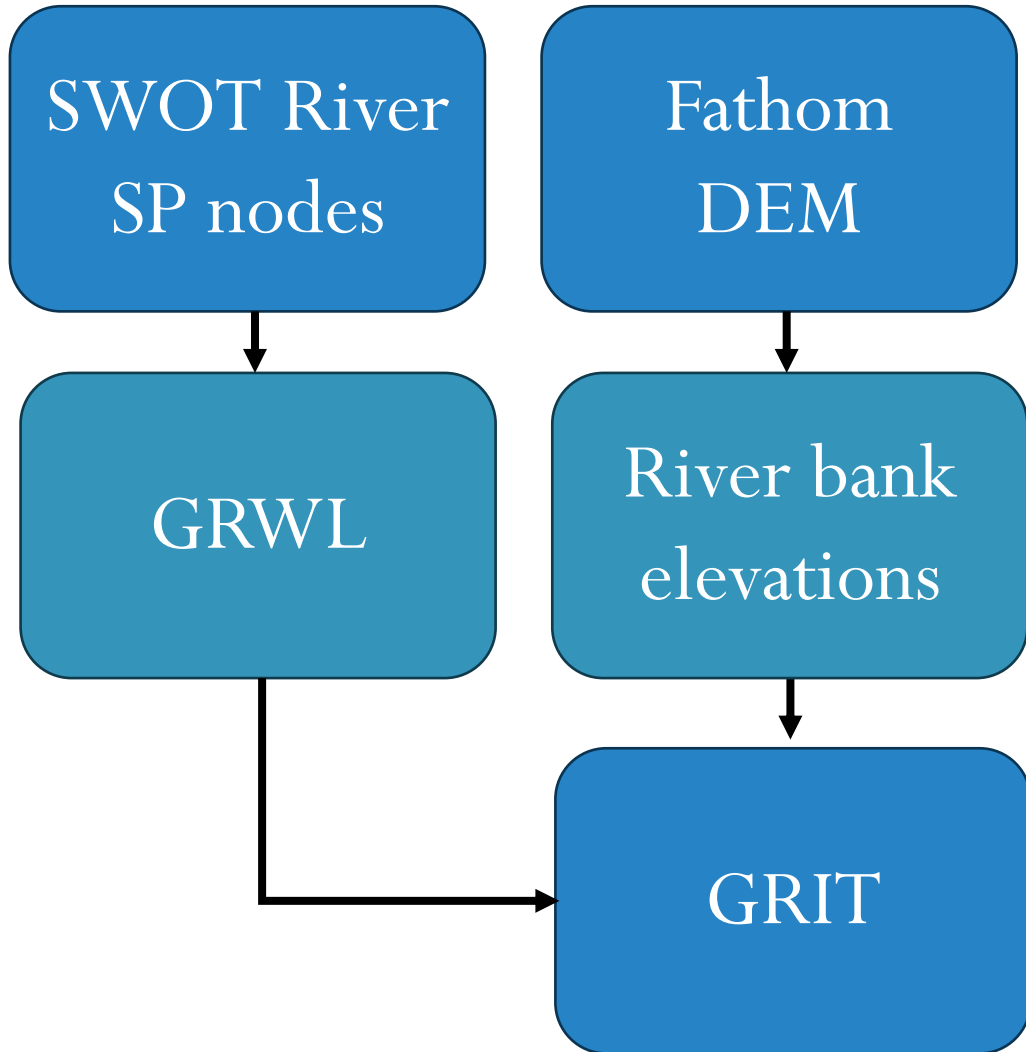
Emerton, R., Cloke, H., Ficchi, A., Hawker, L., de Wit, S., Speight, L., Prudhomme, C., Rundell, P., West, R., Neal, J., Cuna, J., Harrigan, S., Titley, H., Magnusson, L., Pappenberger, F., Klingaman, N., Stephens, E. (2020) Emergency flood bulletins for Cyclones Idai and Kenneth : A critical evaluation of the use of global flood forecasts for international humanitarian preparedness and response. *International Journal of Disaster Risk Reduction*. Vol. 50. <https://doi.org/10.1016/j.ijdrr.2020.101811>

REPRESA

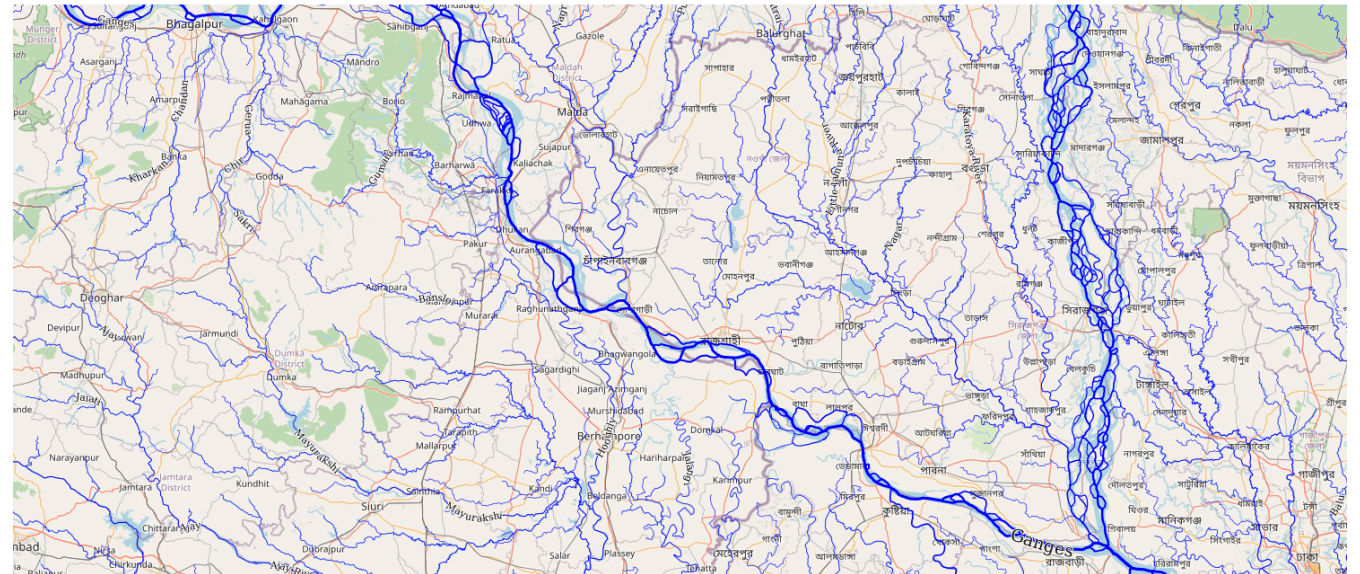
- How can we simulate flood hazards from tropical cyclones in Southern Africa and the impact of climate change?
- Problems
 - Data scarcity
 - Most rivers are ungauged
 - River bathymetry is unknown
 - Little information for calibration
 - Computationally expensive
 - Floods are very sensitive to small-scale changes in topography
 - Tropical cyclones are not explicitly represented by climate models
 - Compounding effects are not included

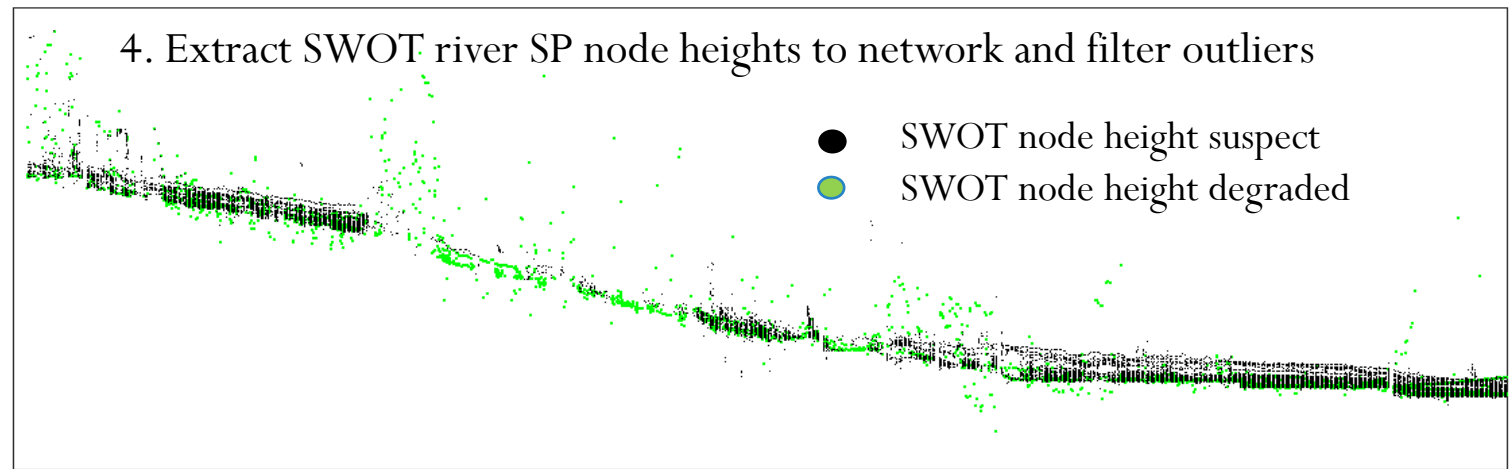
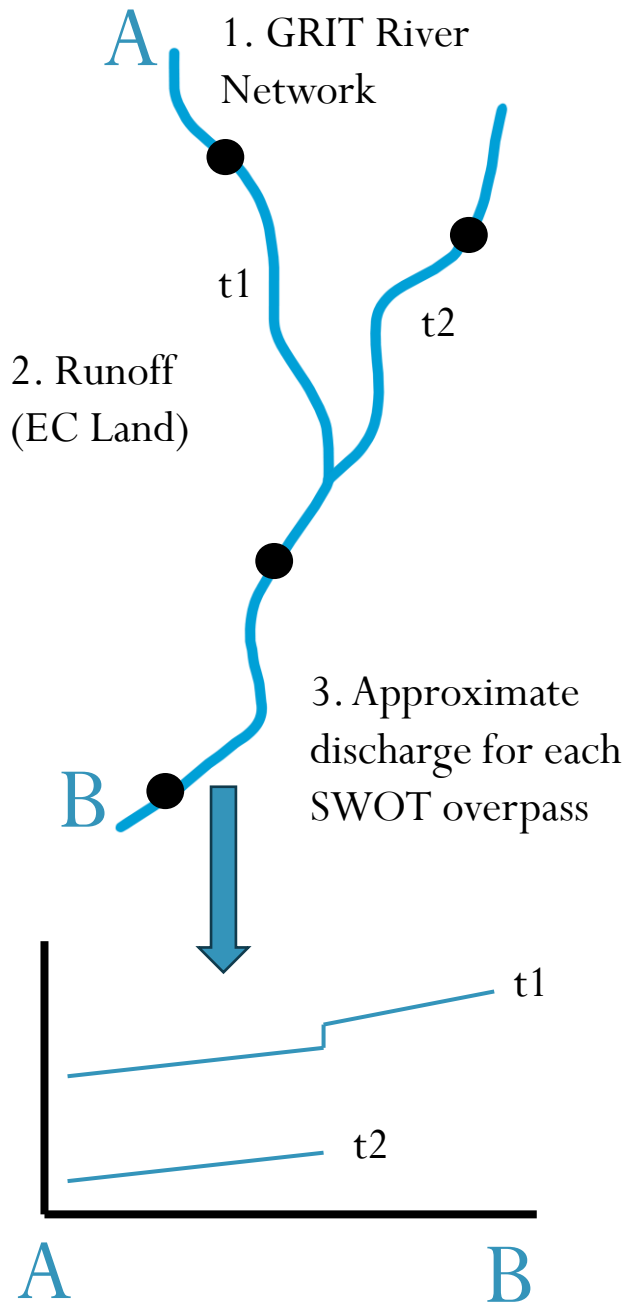


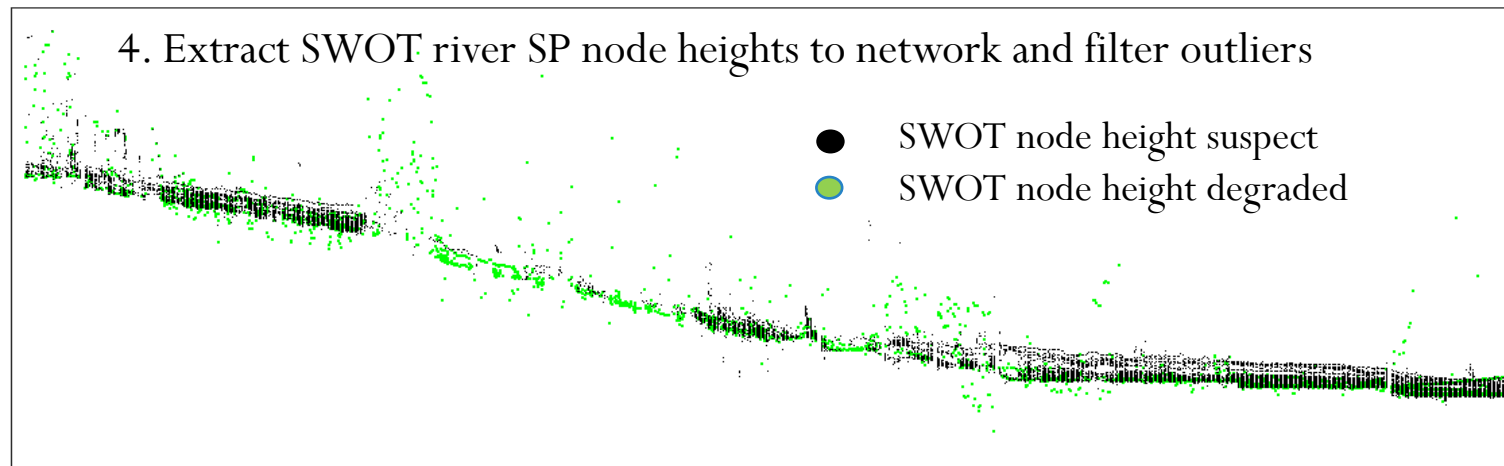
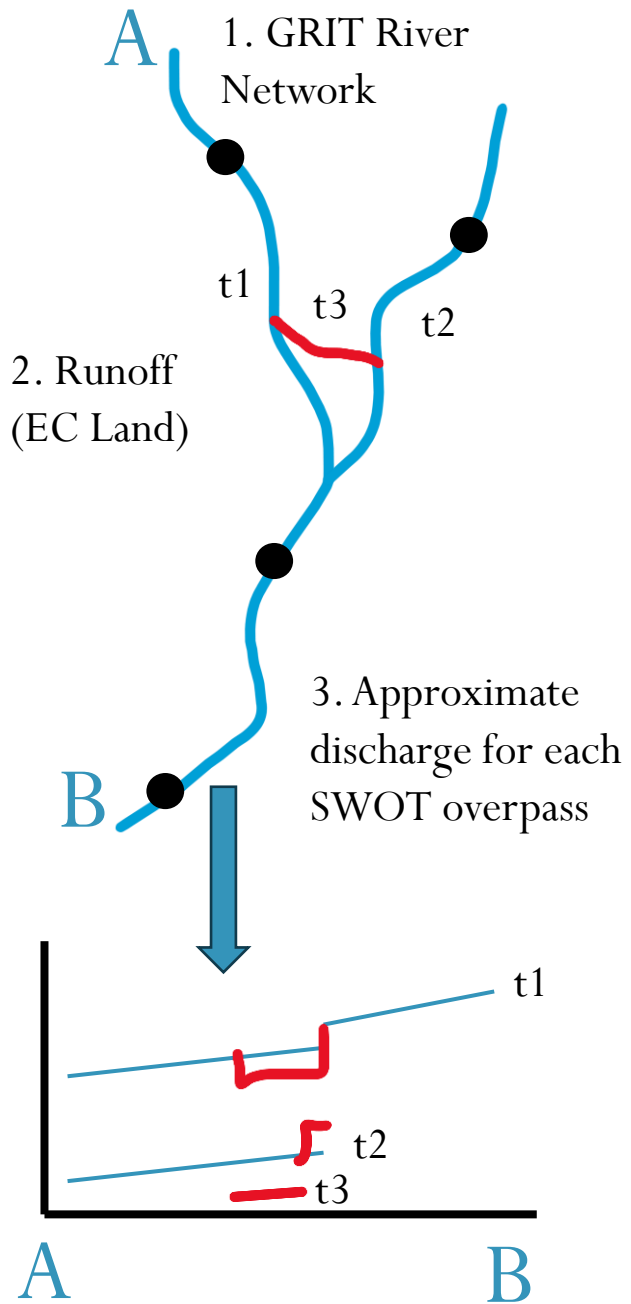
SWOT, GRIT and water surface elevations

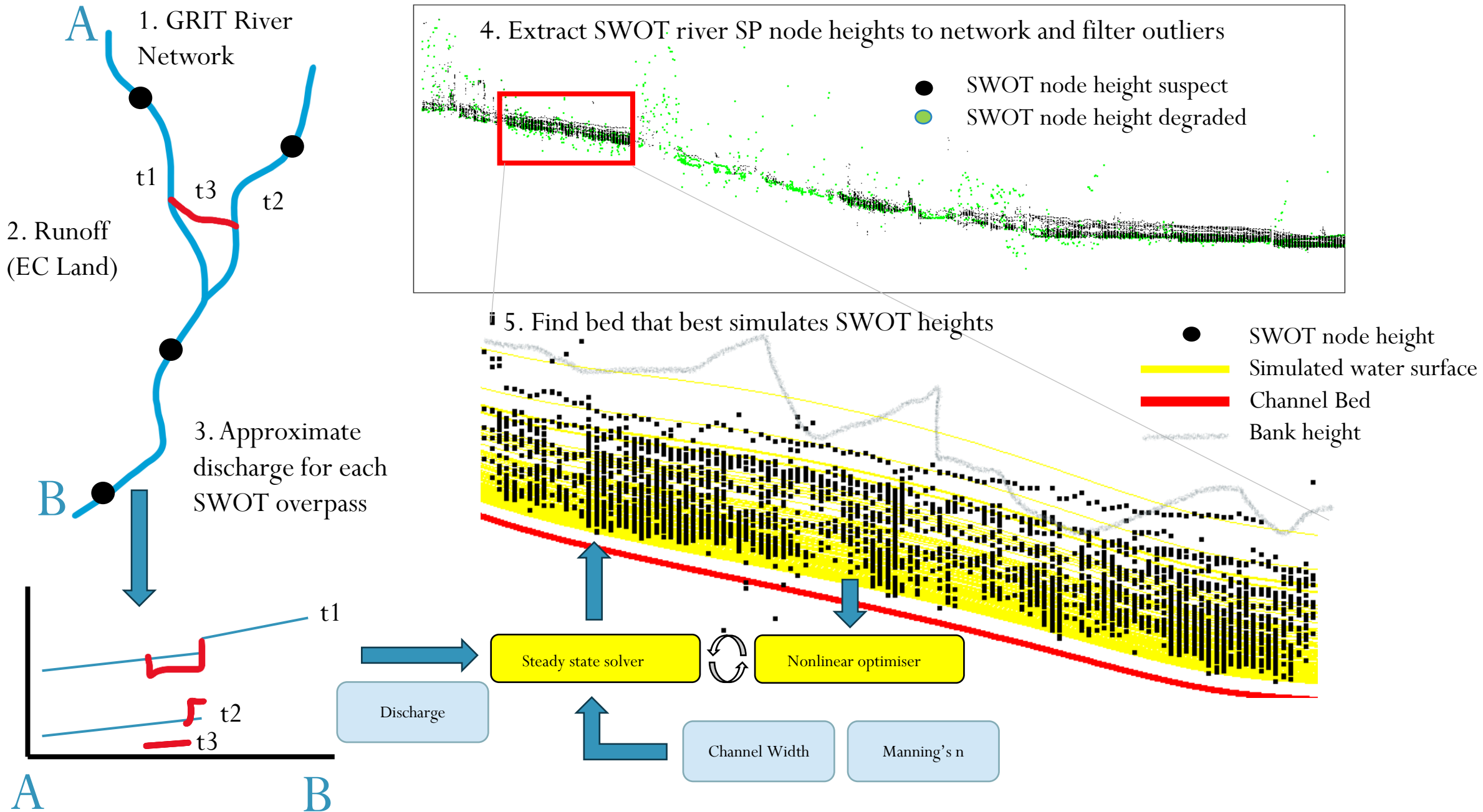


GRITv0.5 segments with river names







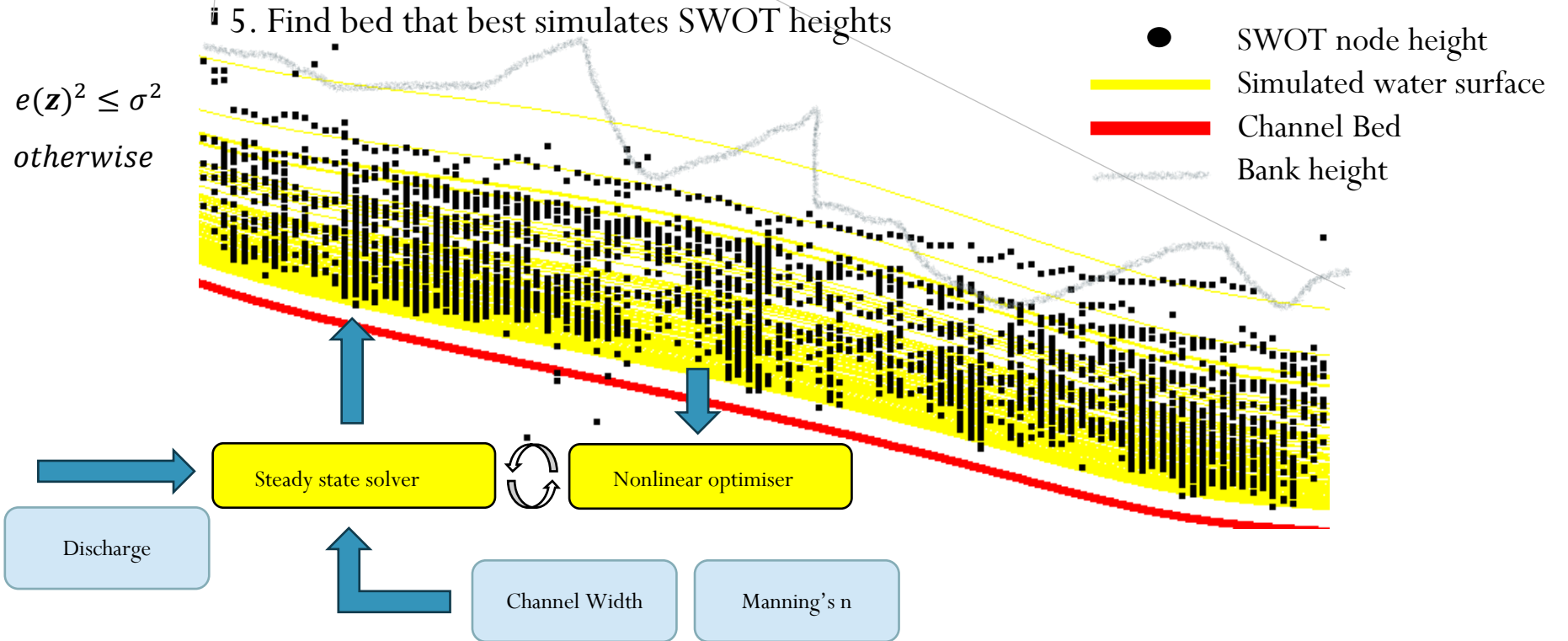
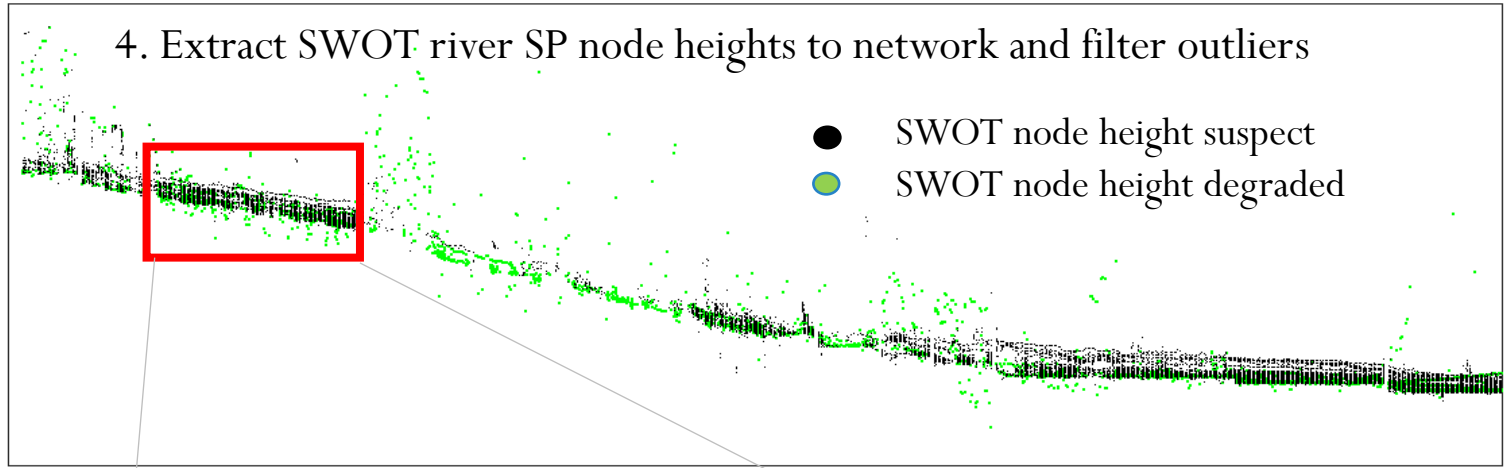
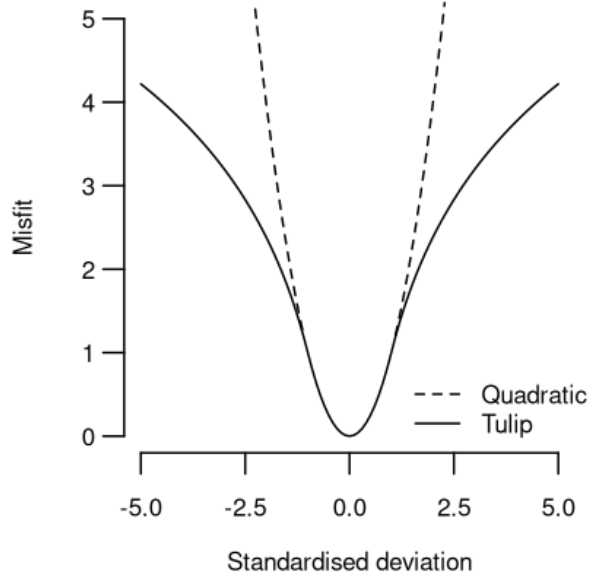


Water height simulation

$$\frac{dh}{dx} = S_0 - S_f$$

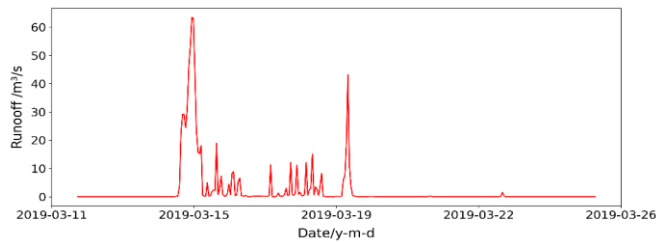
“Tulip” misfit function that downweights outliers

$$D(\mathbf{z}) = \begin{cases} \frac{e(\mathbf{z})^2}{\sigma^2} \\ \log(e(\mathbf{z})^2) - \log(\sigma^2) + 1 \end{cases}$$



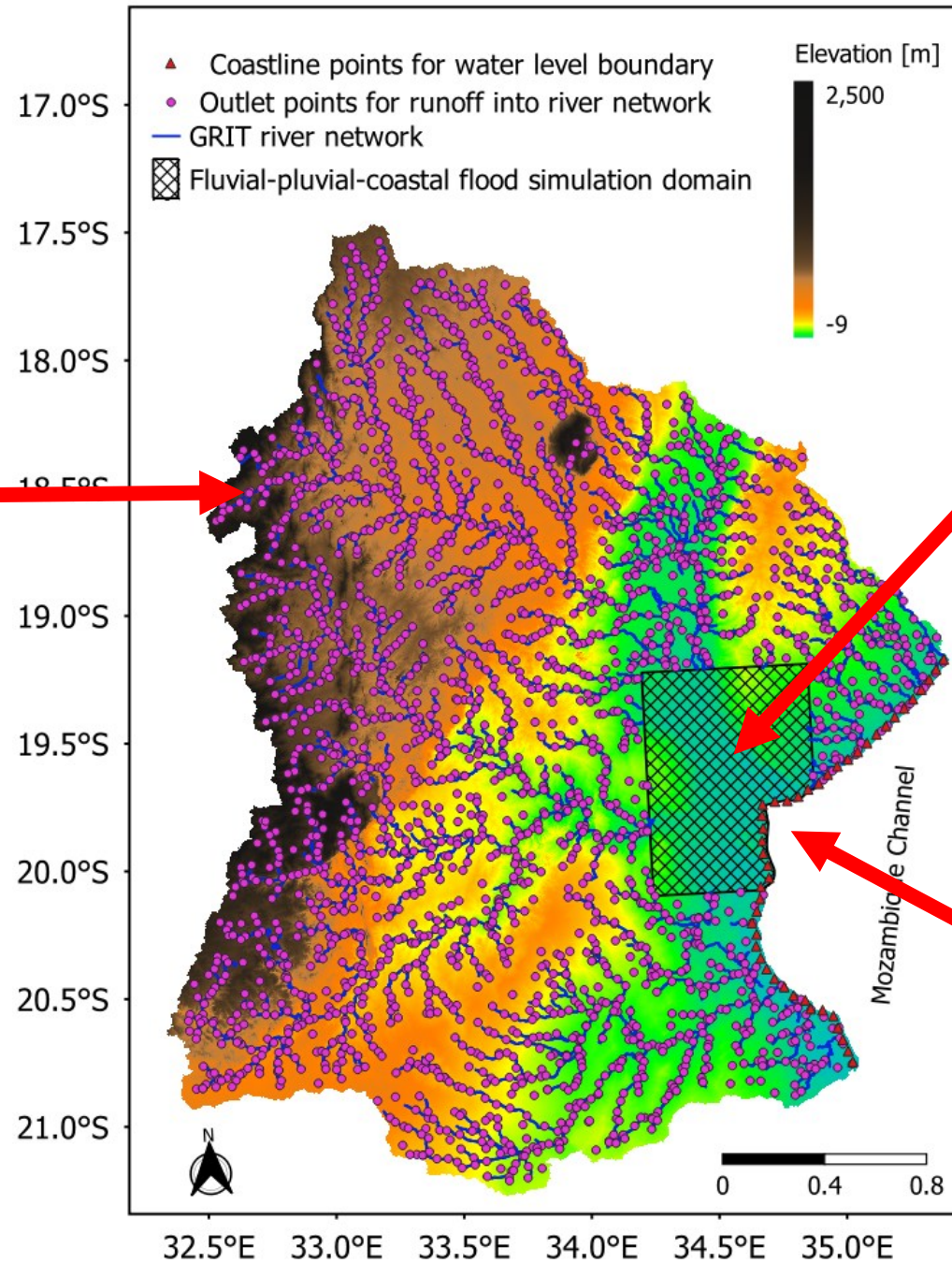
Flood Model

Runoff – Hydrological model EC Land (Rainfall)

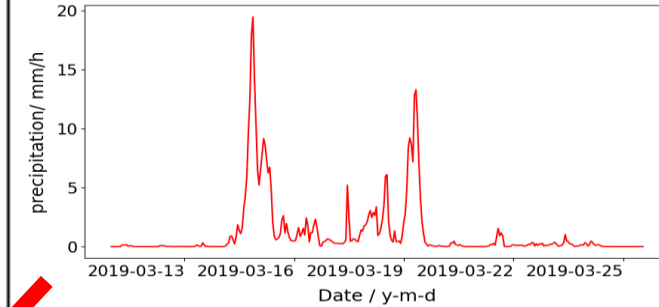


Other model components

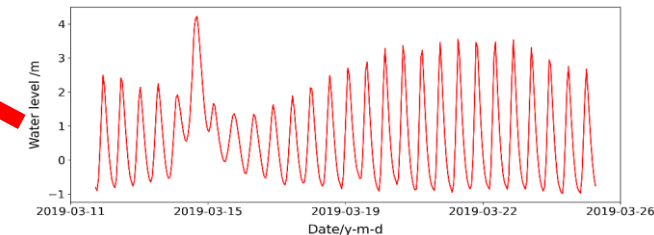
- **DEM: Fathom DEM** - Uhe et al., 2025 [FathomDEM: an improved global terrain map using a hybrid vision transformer model – IOPscience](#)
- **River Network: GRIT** - Wortman et al., 2024 [Global River Topology \(GRIT\) \(zenodo.org\)](#)
- **Width: GRWL** - Allen and Pavelsky, 2018 [Global River Widths from Landsat \(GRWL\) Database \(zenodo.org\)](#)
- **Hydrodynamic model: LISFLOOD-FP** Neal et al., 2012 [A subgrid channel model for simulating river hydraulics and floodplain inundation over large and data sparse areas - Neal - 2012 - Water Resources Research - Wiley Online Library](#)



Rainfall – Reanalysis (ERA5) CPM (CP4A, CCAM)



Coastal tide and surge – ADCIRC (Wind, Pressure)



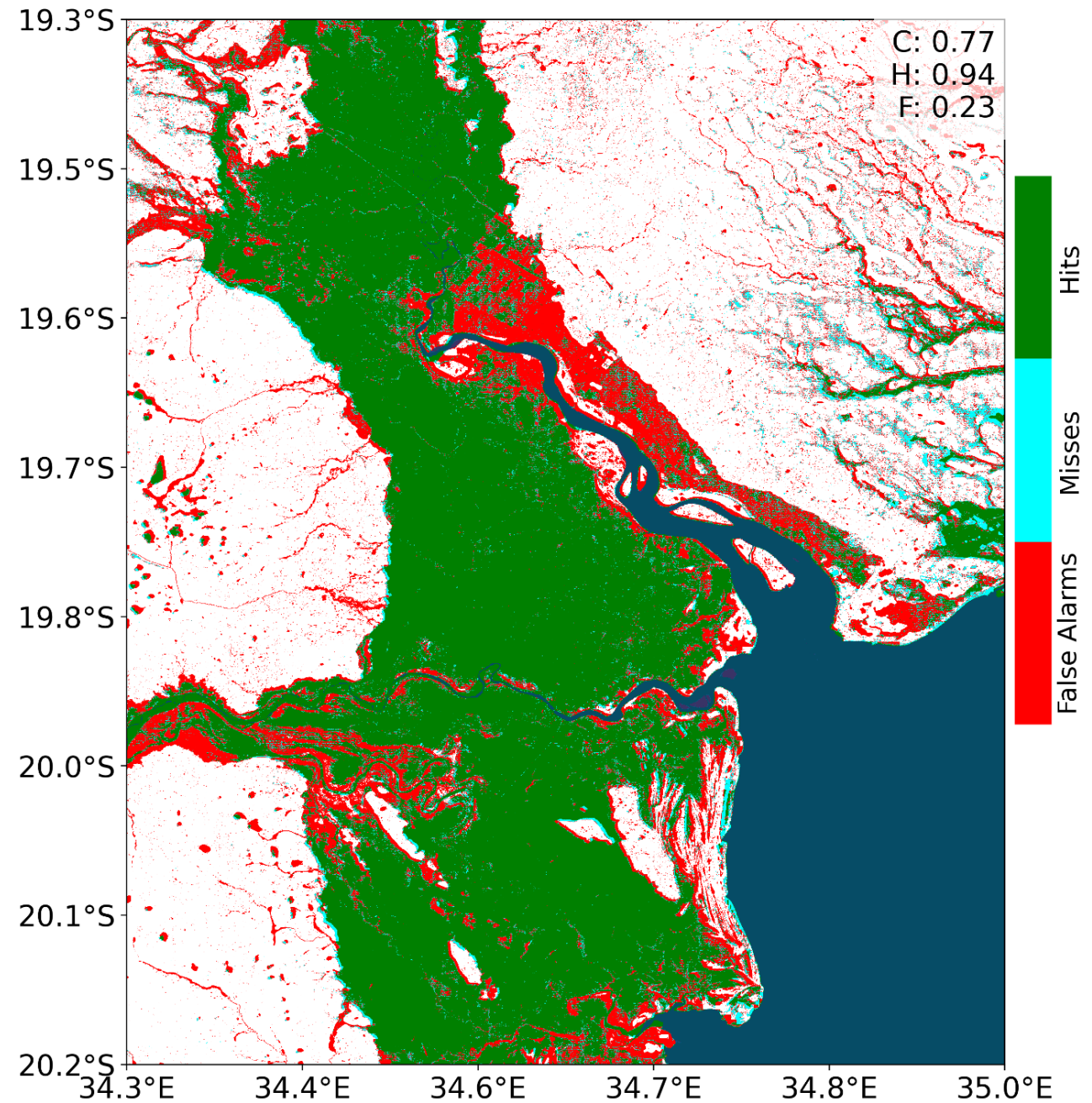
Results – Validation

- Comparison to Sentinel 1 flood extents
 - Critical success index (**0.77**)
 - Hit rate (**0.94**) and false-alarm ratio (**0.23**)

$$C = \frac{\textit{Hits}}{\textit{Hits} + \textit{Misses} + \textit{False Alarms}}$$

$$H = \frac{\textit{Hits}}{\textit{Hits} + \textit{Misses}}$$

$$F = \frac{\textit{False Alarms}}{\textit{Hits} + \textit{Misses}}$$




























Complete

- Cyclone Idai Simulations
 - Fully compounding pluvial, fluvial and coastal.
 - CCAM driven surge
 - CCAM precipitation

/scratch/hydro4/projects/REPRESA/LISFLOOD_TCidai_floodmodel/Simulations_Isambard/

Name

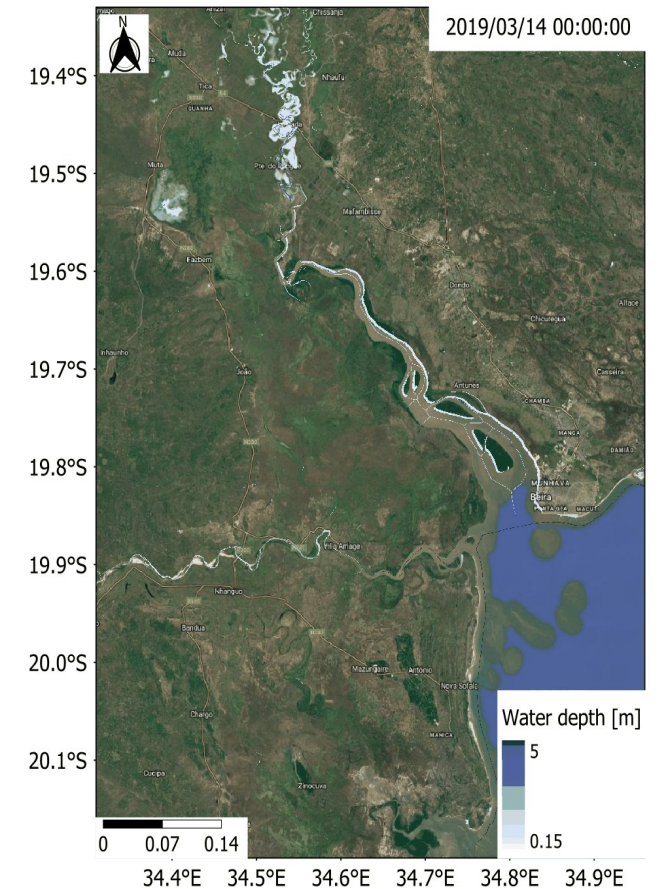
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 results_0311_0318_ERA5_flow_CCAM_wl_ERA5_pr
 results_0311_0318_ERA5_flow_CCAM_wl_CCAM_pr

In progress

- Malawi, Mozambique, Madagascar models (all build simultaneously)
 - Complete
 - DEM (Fathom DEM) and river network (GRIT)
 - Integration of model builder with EC Land outputs
 - GRIT based hydrological routing for prior Q
 - Linking of SWOT node heights and ERA5 EC Land historical discharge
 - ADCIRD boundary conditions
 - Codes written but to run
 - River bathymetry inversion from SWOT nodes heights
 - LISFLOOD-FP model build
 - Codes to write
 - Extract GRIT Q at SWOT node overpass times
 - Code to write initial conditions for model warm start (uses bathymetry inversion solver)

Summary

- We combine GRIT and SWOT to build a multithreaded 1D river hydrodynamic model calibrated to SWOT heights
- This was linked with a 2D inundation model for compound flood simulation
- We simulate flooding from Tropical Cyclones given kilometre-scale convection permitting climate model forcing data
- Early results show promise against flood extent imagery for tropical cyclone Idai.



Compound flood hazard
dynamic process