Modelling Group
WATER NEW ZEALAND

Modelling Symposium

Complex Workflow for National Flood Assessment

Presented by
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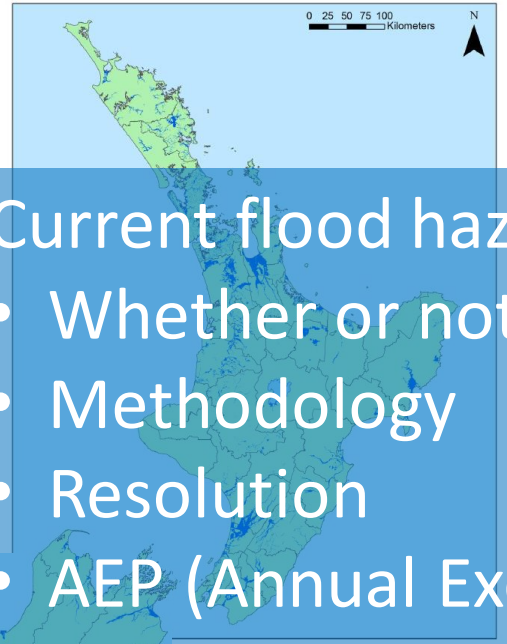
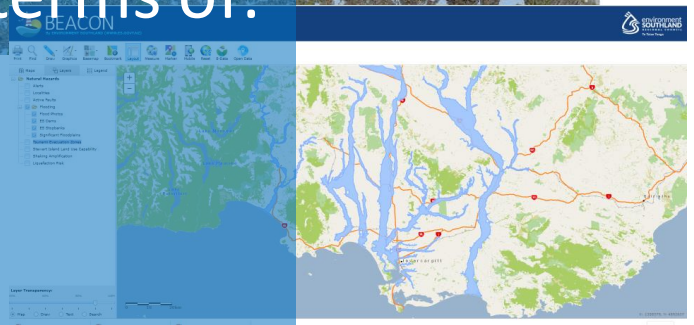
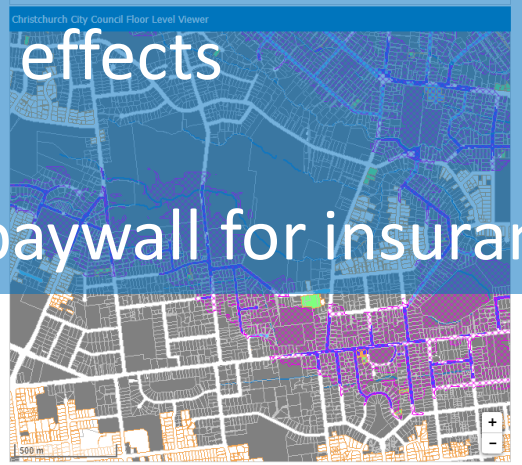
T Carey-Smith, R Srinivasan, R Pearson, M Wilkins

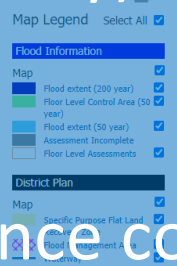
water NEW ZEALAND
The New Zealand Water & Wastes Association Waiora Aotearoa

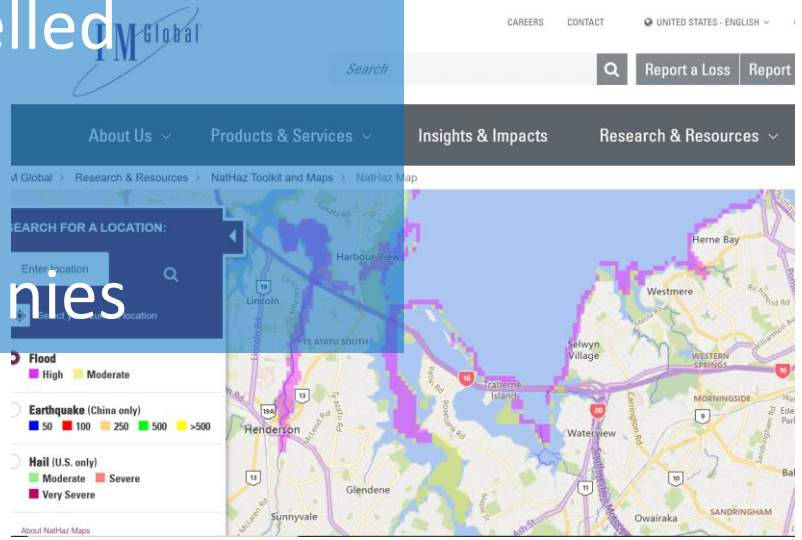
Large diversity…











- Current flood hazard data has no consistency in terms of:
  - Whether or not flood modelling is done
  - Methodology
  - Resolution
  - AEP (Annual Exceedance Probability) modelled
  - Climate change effects

Or it is behind a paywall for insurance companies

MBIE Endeavour 5-year Research Programme:

Mā te haumaru ō ngā puna wai ō Rākaihautū ka ora mō ake tonu:
Increasing flood resilience across Aotearoa

Overall aim: A more Flood-Resilient Aotearoa New Zealand

- Produce an updateable nationally-consistent flood inundation hazard and risk assessment for current conditions and future scenarios under climate change.
- Create a forum between science, iwi, policy-makers and stake-holders to ensure desired outcomes

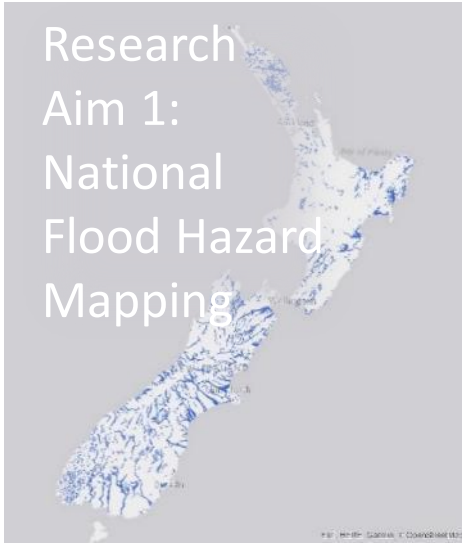
Why?

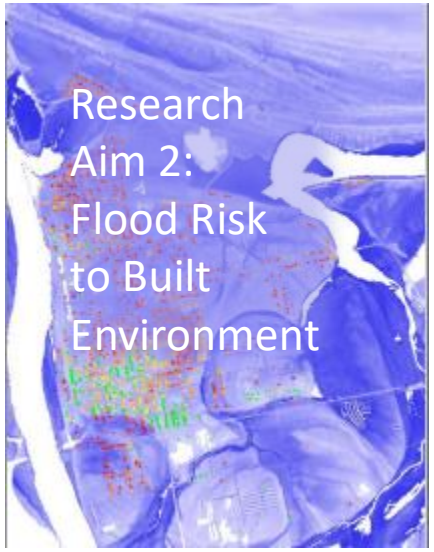
National screening tool:

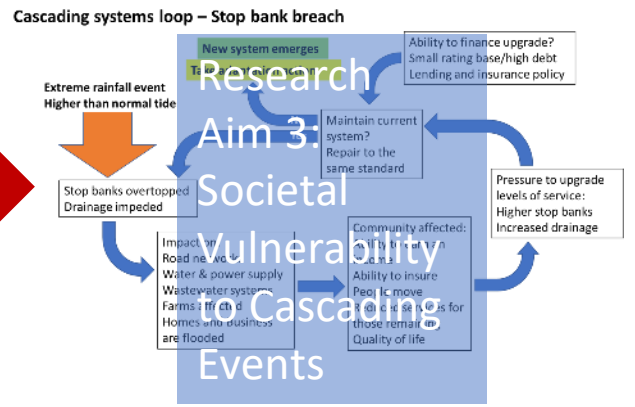
- Identify where the flood hazard/risk are high – especially in rural areas where there may not currently be information.
- Identify where the flood hazard/risk may increase under climate change.
- Work with local and central government, iwi, stake-holders to determine how to use this information to increase resilience

NIWA Taihoro Nukurangi · The University of Waikato Te Whare Wānanga o Waikato · UC University of Canterbury Te Whare Wānanga o Waitaha Christchurch New Zealand · The University of Auckland New Zealand · Manaaki Whenua Landcare Research · wsp

Mātauranga Māori Theme







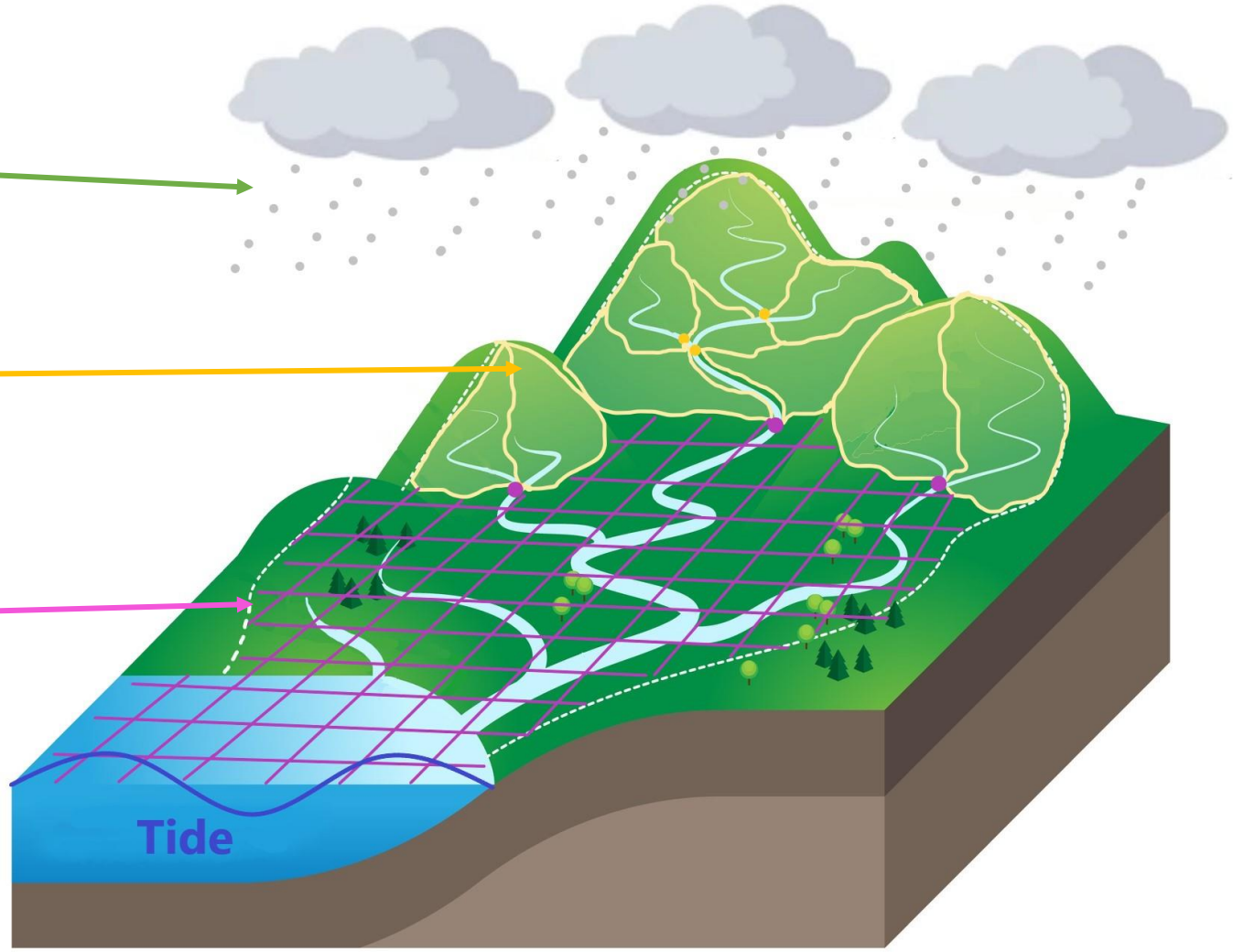
Uncertainty Theme

A Cascade of Tools:

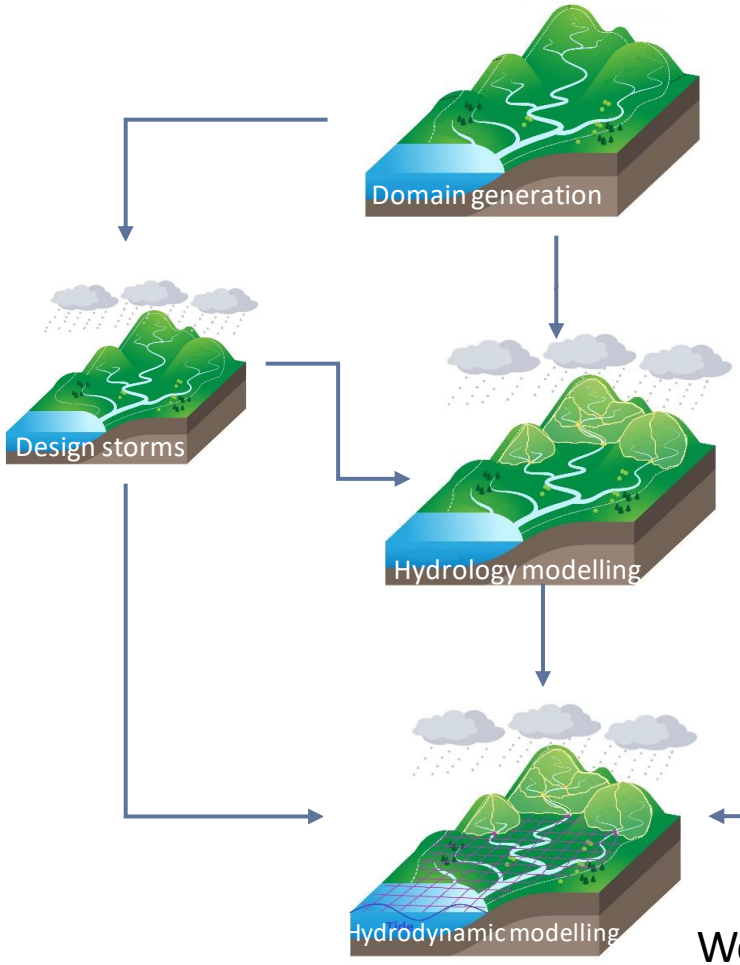
Observation / Design Storms

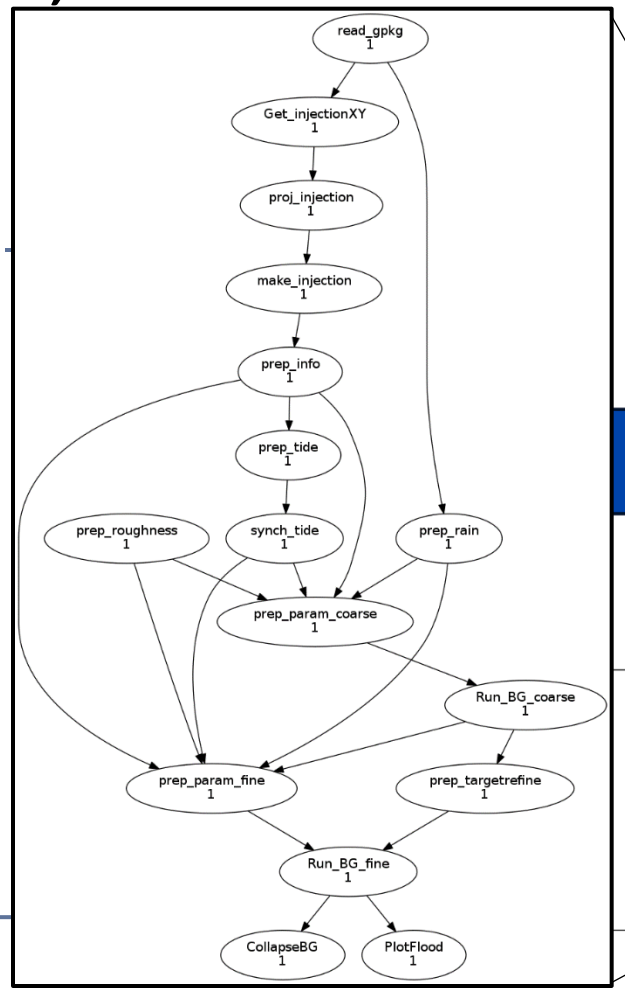
Hydrological Model

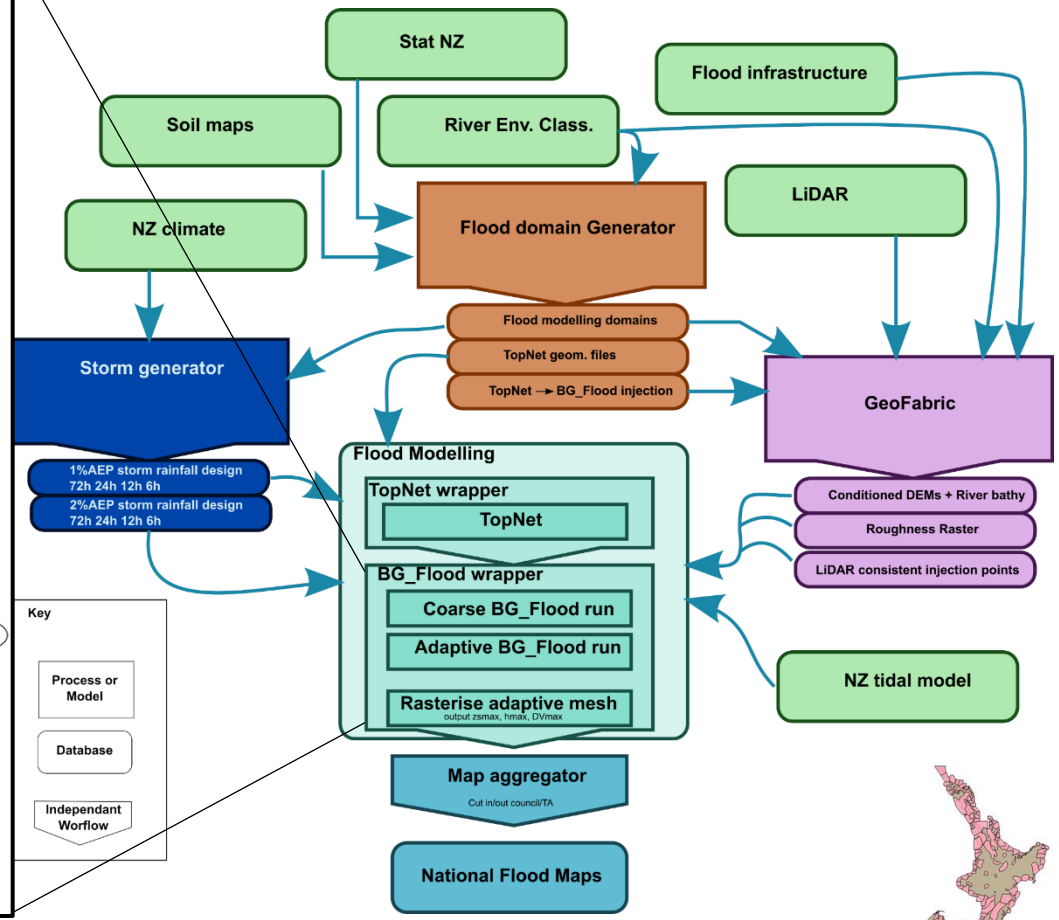
Hydrodynamic Model



A Cascade of Tools, written as an automated workflow:

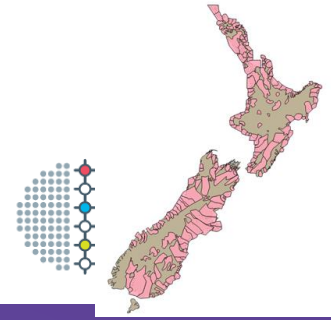






Workflow engine:
https://cylc.github.io

High Performance Computing:

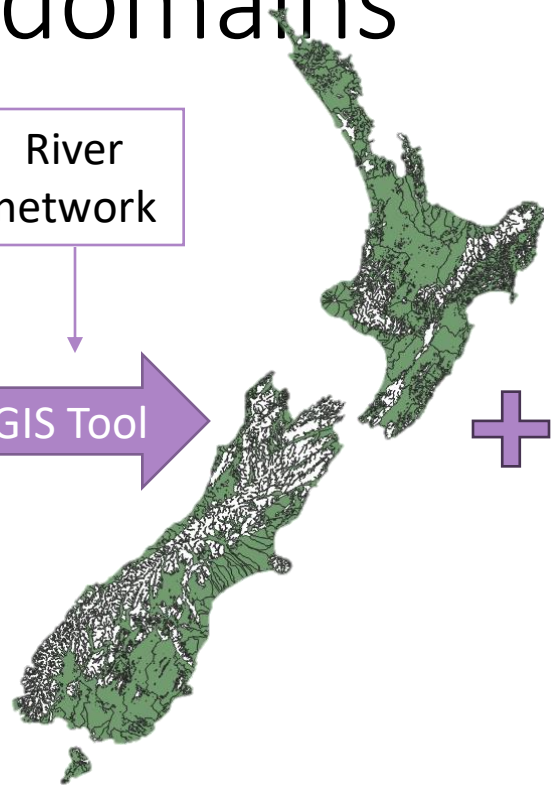


Creation of the domains

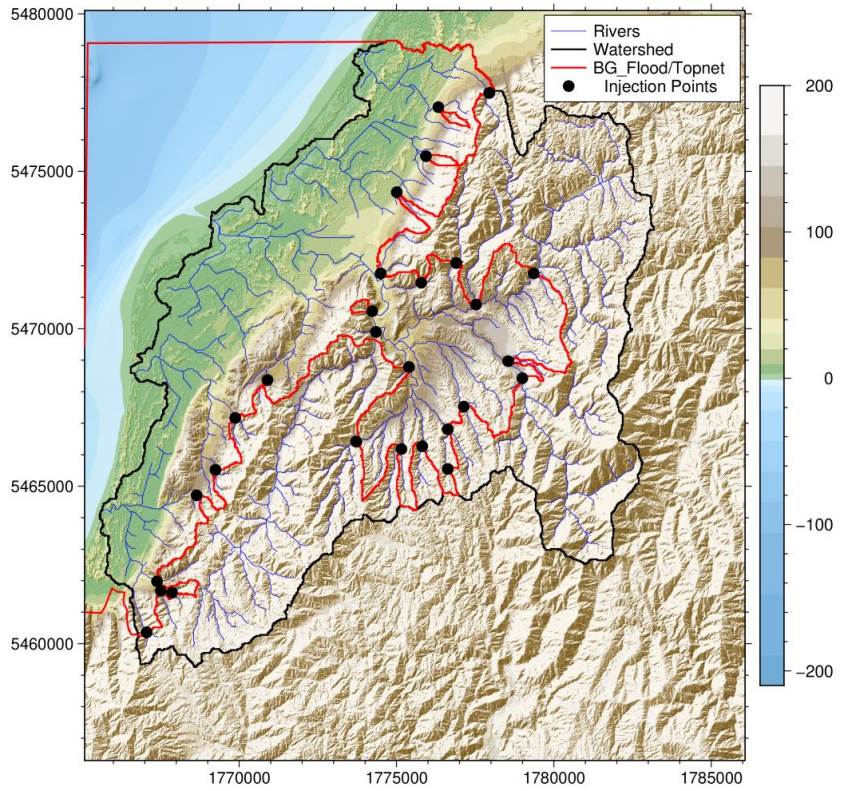
River network

Manual selection of flood plains

GIS Tool



Creation of simulation domains based on catchments.

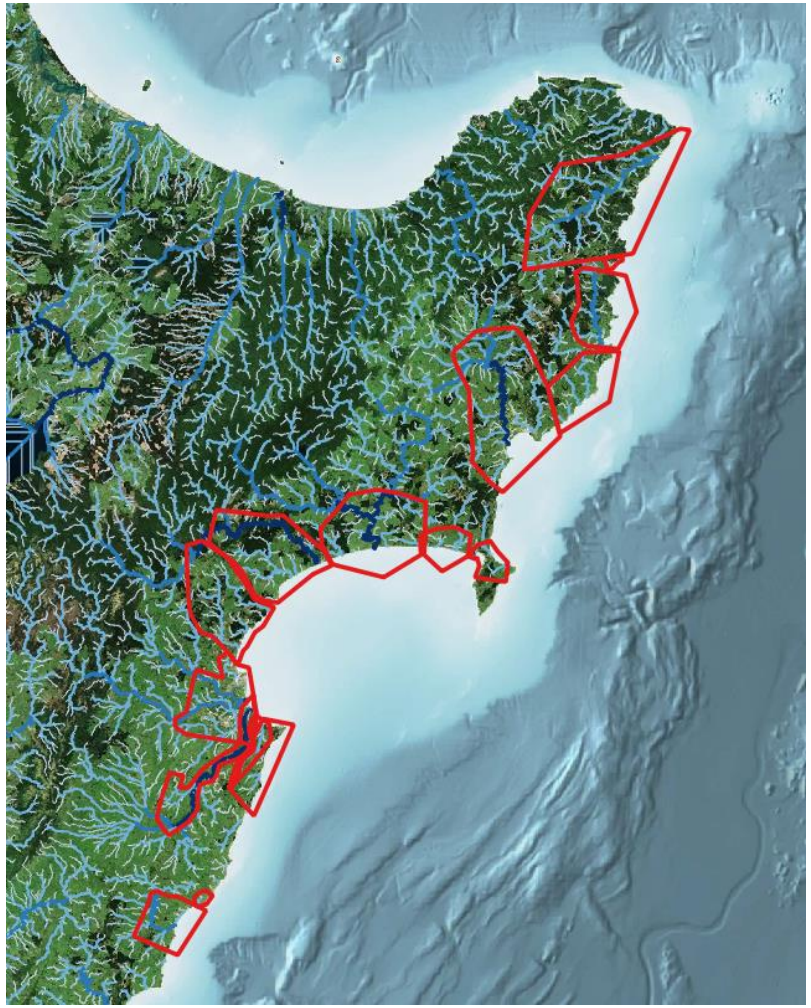


Separation in an Upper Catchment and Lower Catchment areas
(based on geographic characteristic and data availability)
+
Calculation of domain information (area, time of concentration,…)

Upper Catchment:
Hydrological model
(-)

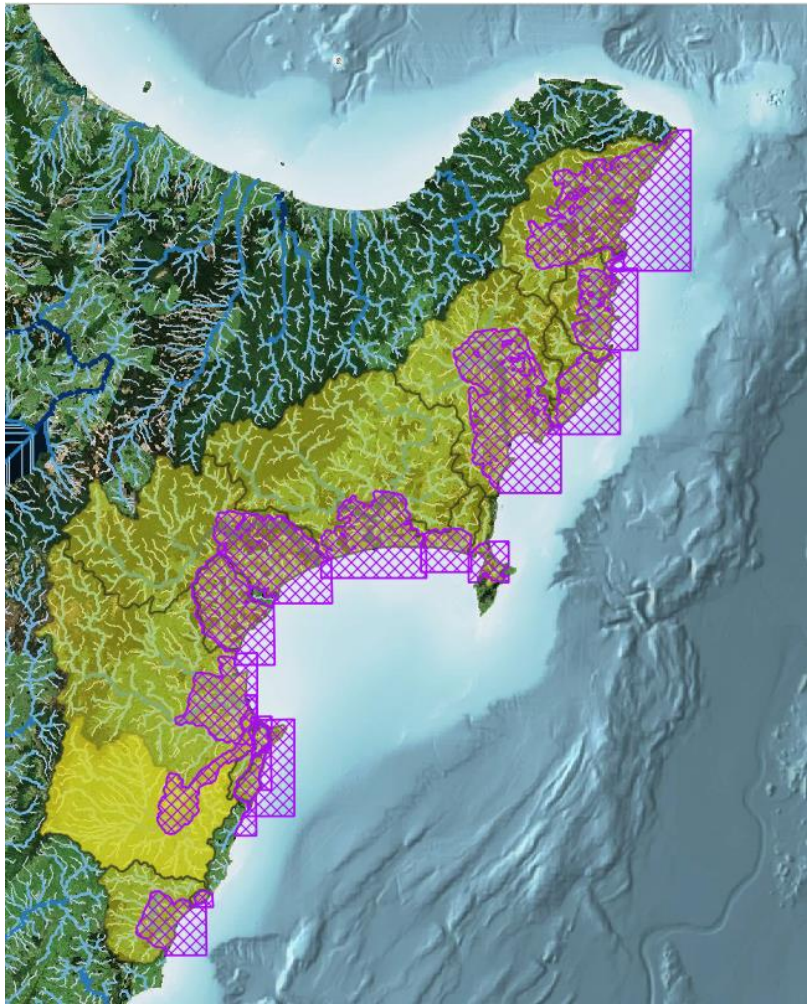
Lower Catchment:
Hydrodynamic model
(-)

Creation of the domains



Crude Floodplains through Hawkes Bay and Tairawhiti regions

GIS Tool

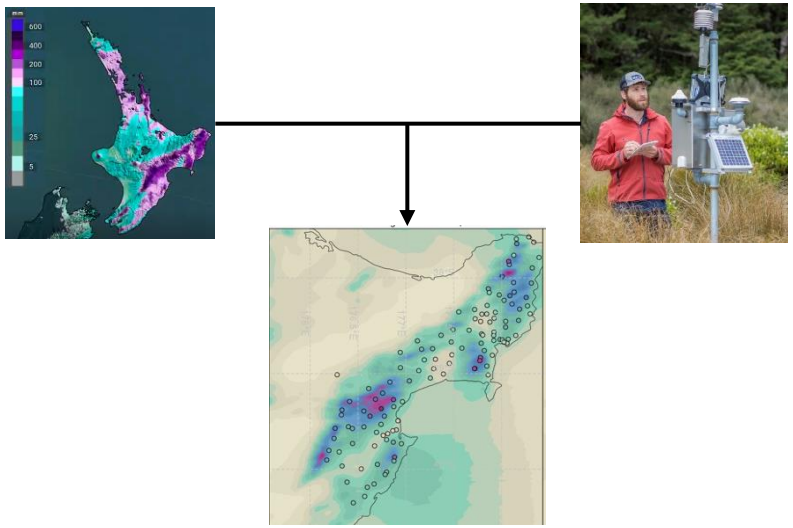


Computational domains through Hawkes Bay and Tairawhiti regions

Rain input

Validations runs:

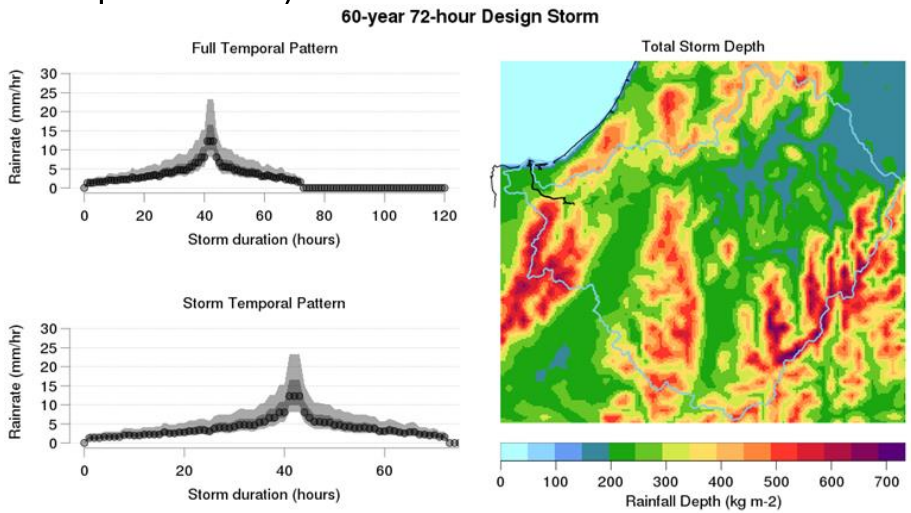
- Use of observations interpolated to create space and time varying maps (VCSN)
- Time series of 500m resolution maps



Rain intensity snapshot during the storm

Design floods runs:

- Creation of ideal storms for the whole country
- Based on HIRDS (High Intensity Rainfall Design System V4) https://hirds.niwa.co.nz/
- Duration based on catchment accumulation time
- Under actual and future climate (based on observation of change in rainfall due to temperature)



TopNET: hydrological model

- The NIWA hydrological model, calculating water balance at a reach/catchment unit.
- Used uncalibrated with the soil permeability model (mapped infiltration rate).
- Creation of antecedent conditions for design runs

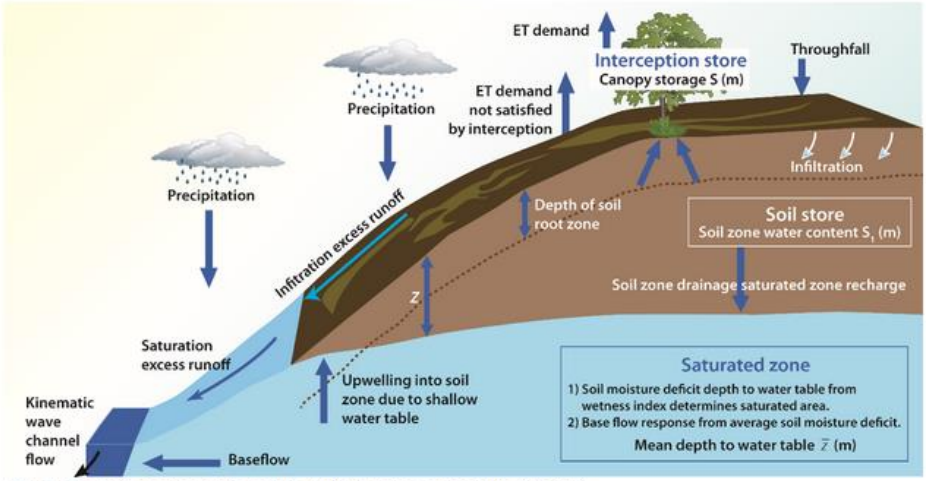
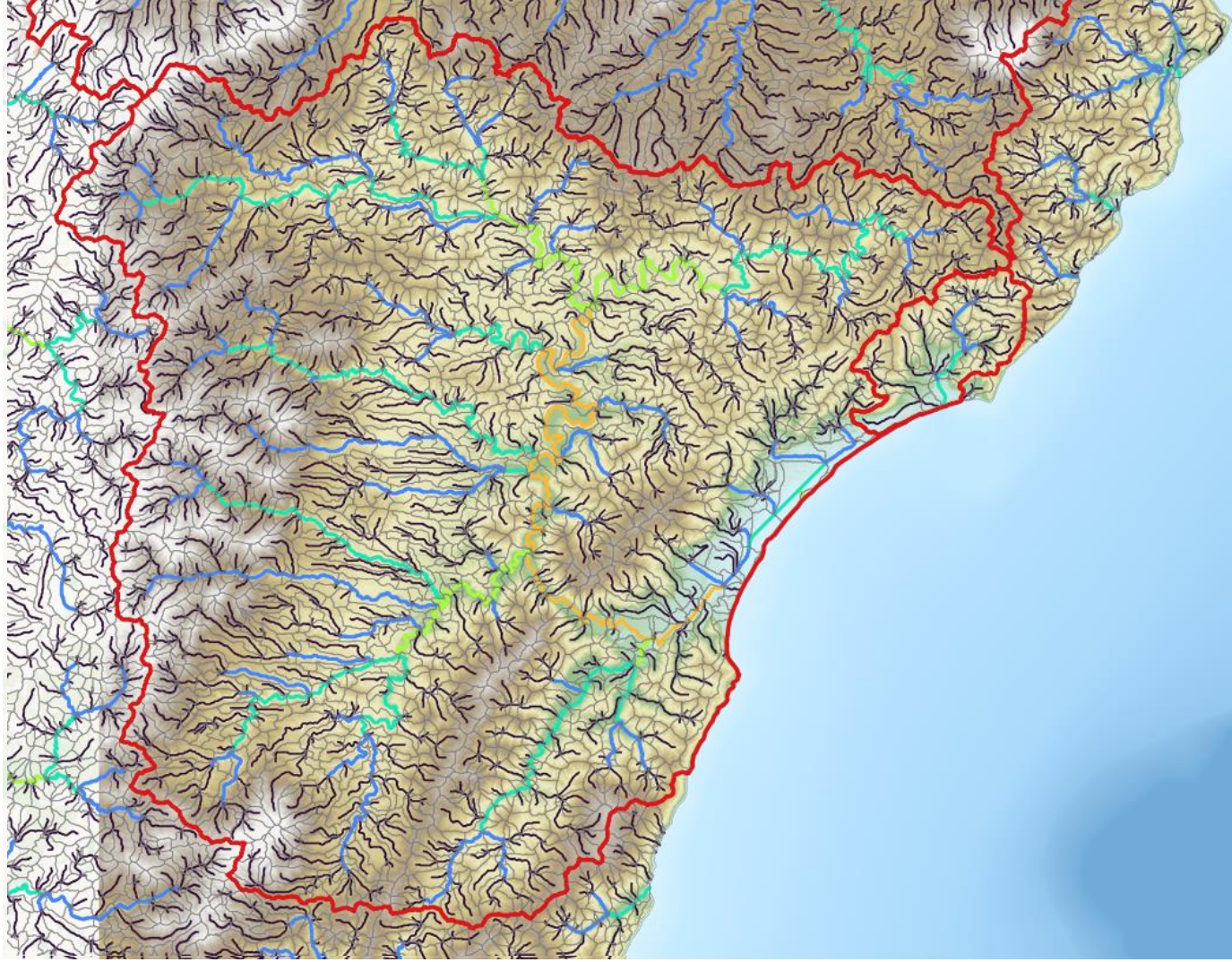
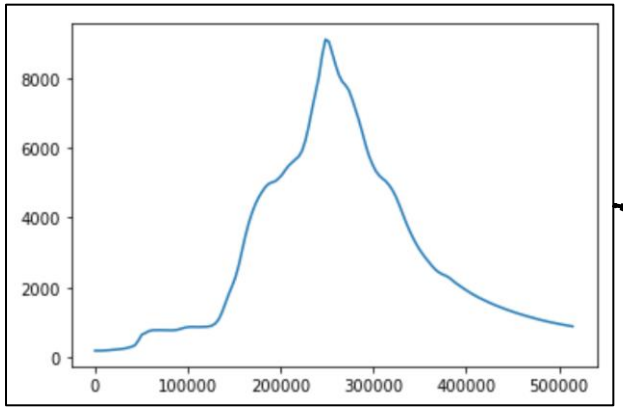


Fig. 1: Schematic representation of the water balance component of TopNet (adapted with permission from Bandaragoda et al., 2004)

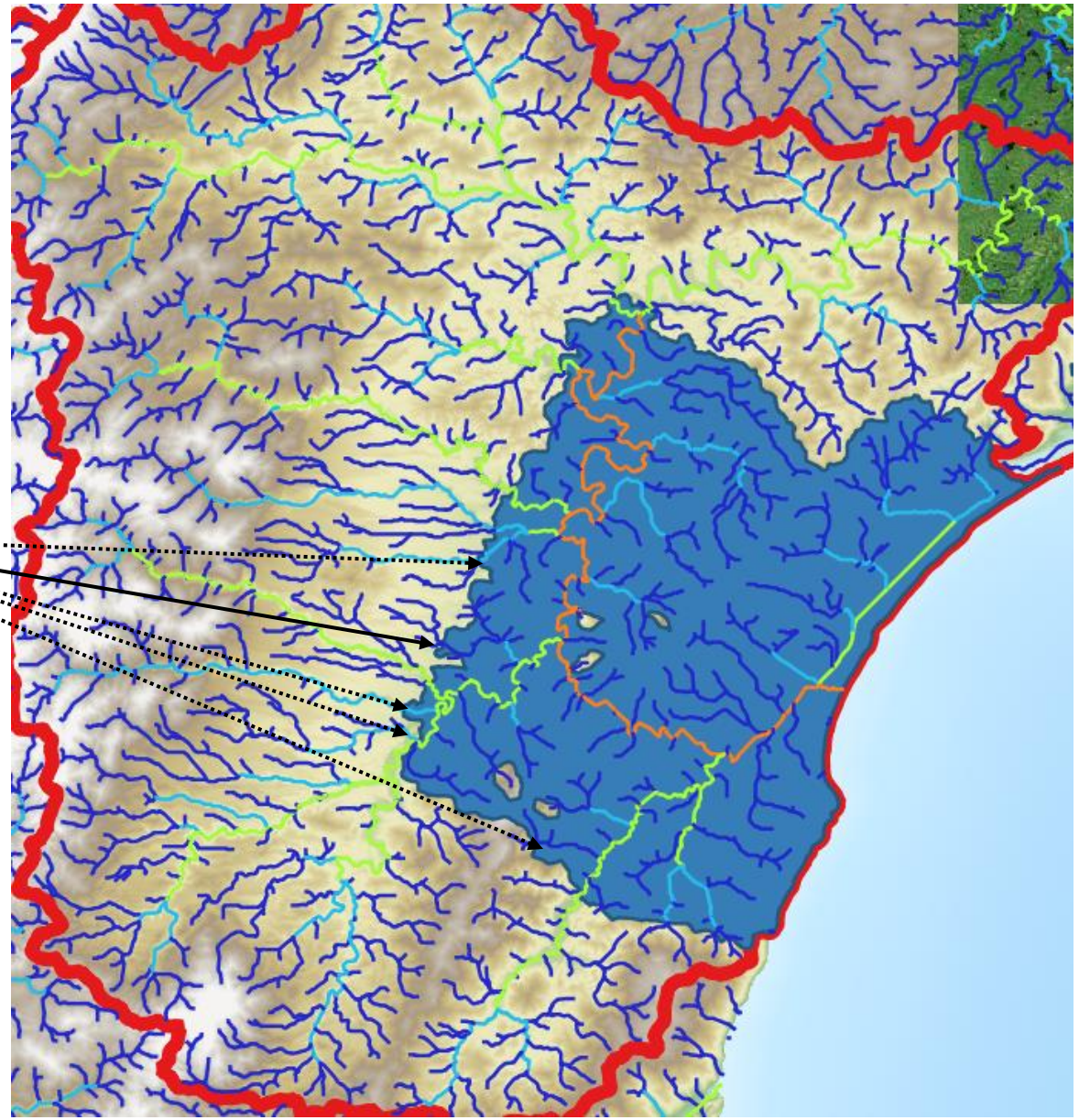


River network and unit catchments used for TopNET routing

TopNET: hydrological model



Hydrograph from TopNet



River network and unit catchments used for TopNET routing

Large number of injections:

- Porangahau: ~50 injections
- Gisborne: ~450 injections

Geofabrics :
Automatic generation of the maps

Creation of a hydrologically conditioned DEM (Digital Elevation Model)

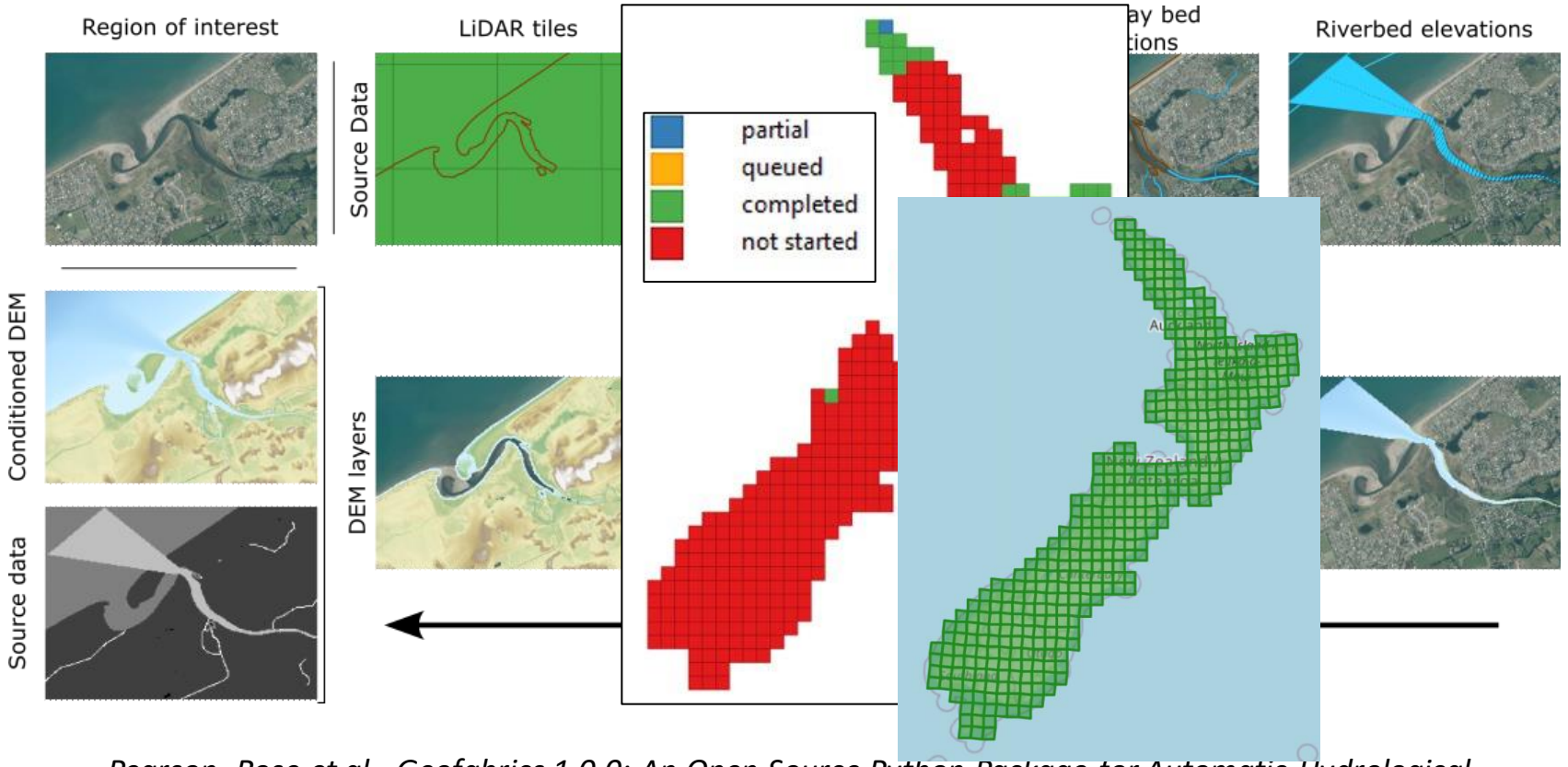
- Extraction of LiDAR data
- Add sea iso-contours
- Open waterways
- Estimate the River Bathymetry
- Add estuary fan (for big rivers)
- Using OSM (Open Street Map) to include drains, culvert, streams

Creation of the roughness map

- Based on LiDAR data distribution

Open-source, automatic

GitHub: *https://github.com/rosepearson/GeoFabrics*



Pearson, Rose et al., Geofabrics 1.0.0: An Open-Source Python Package for Automatic Hydrological Conditioning of Digital Elevation Models for Flood Modelling. Available at SSRN: http://dx.doi.org/10.2139/ssrn.4463610

Hydrodynamics model: BG_Flood

Fast, open-source, multi-hazard, inundation model

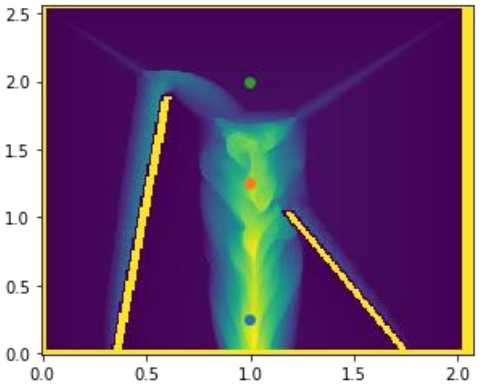
- Compounding (e.g. Tsunami + storm surge + river flooding + rain)
- Free and open-source
- Short setup time + short run time

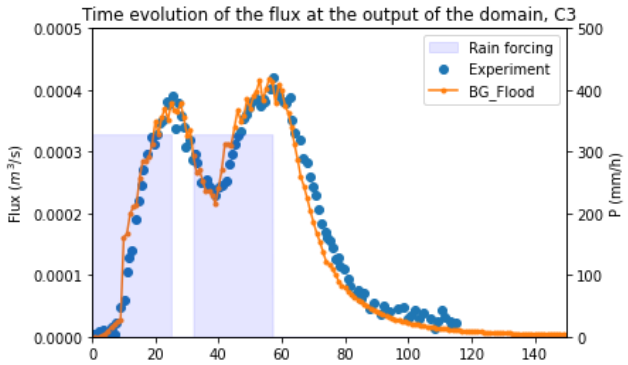
→ Shock-capturing Shallow Water Equation

→ Built on Basilisk model basilisk.fr

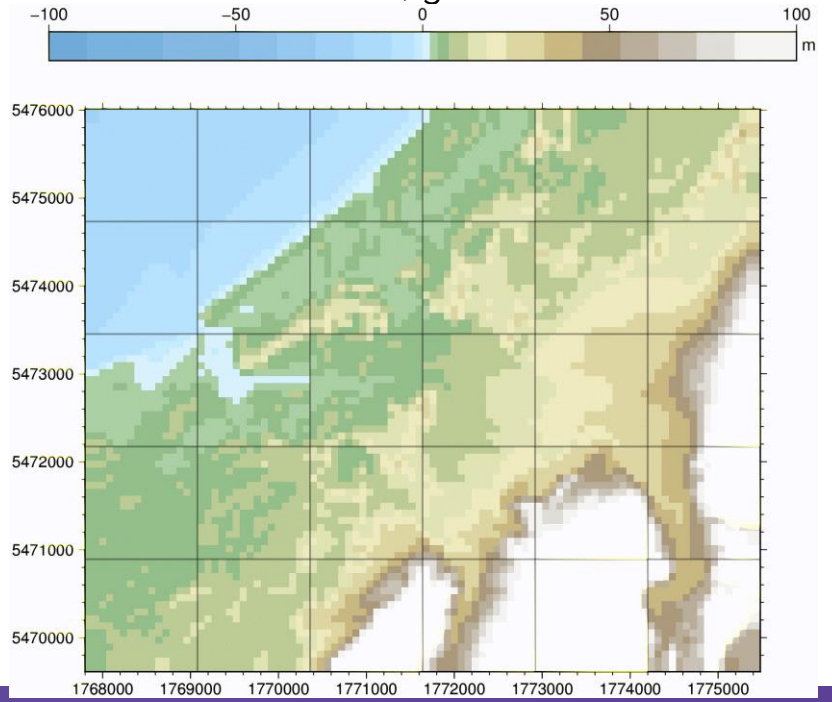
→ GPU + No interface + BUQ grid

CEA2008 benchmark test: Uniform rain on grid





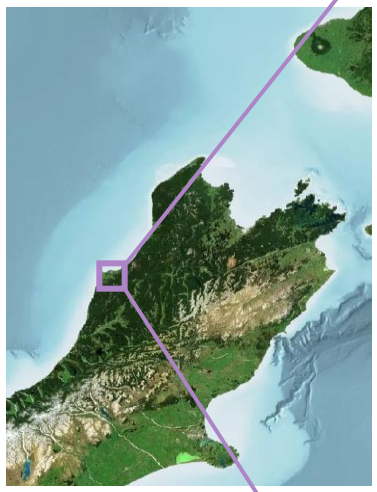
Square adaptable grid:

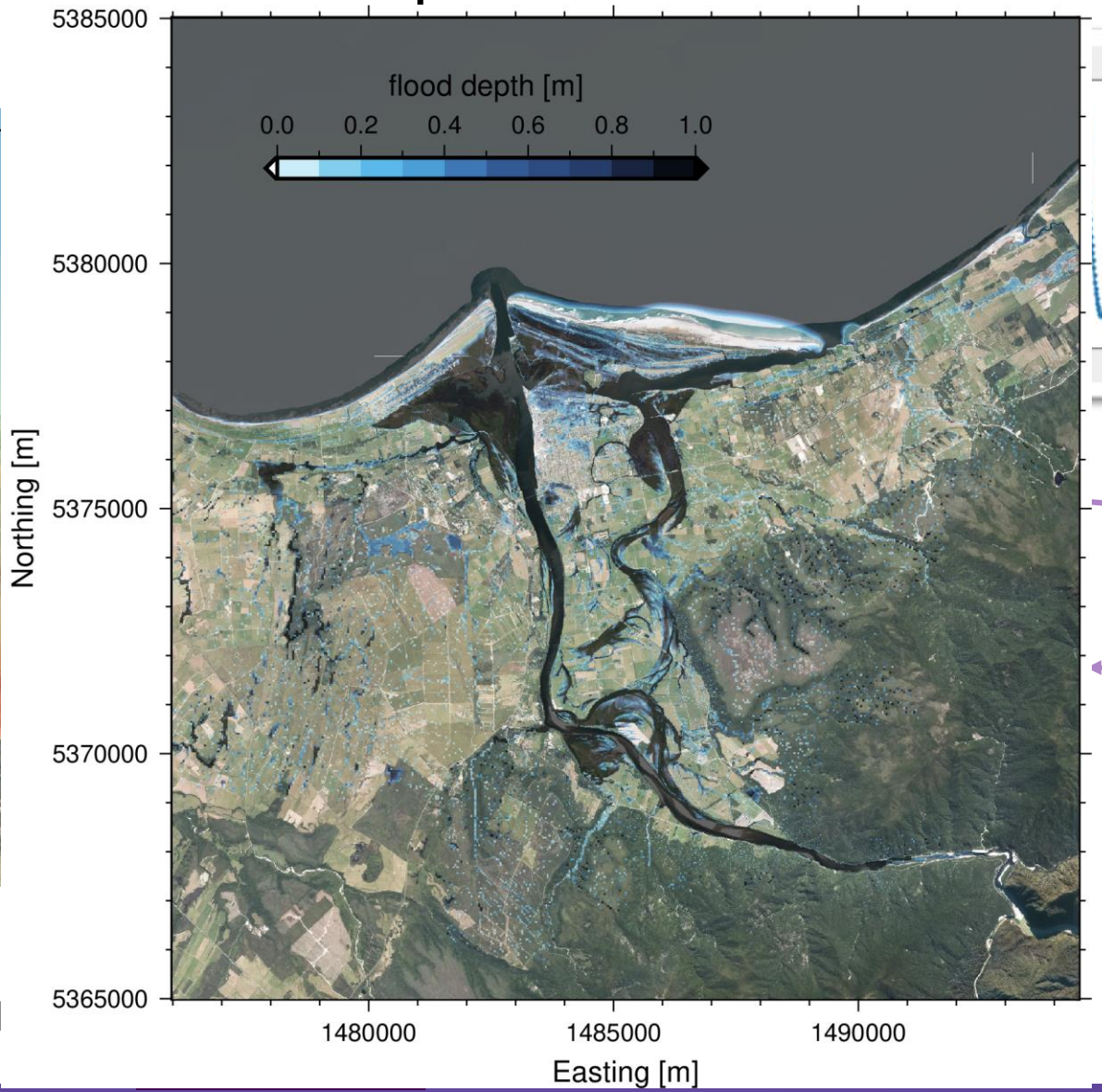


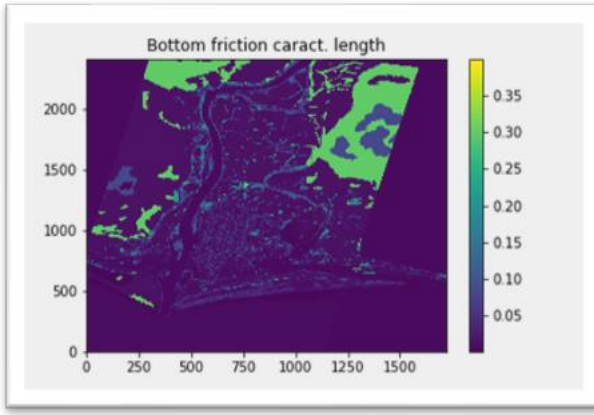
https://github.com/CyprienBosserelle/BG_Flood

Bosserelle, C.; Lane, E.; Harang, A. BG-Flood: A GPU adaptive, open-source, general inundation hazard model. In Proceedings of the Australasian Coasts & Ports 2021 Conference, Christchurch, New Zealand, 11–13 April 2022.

Westport test-case set-up

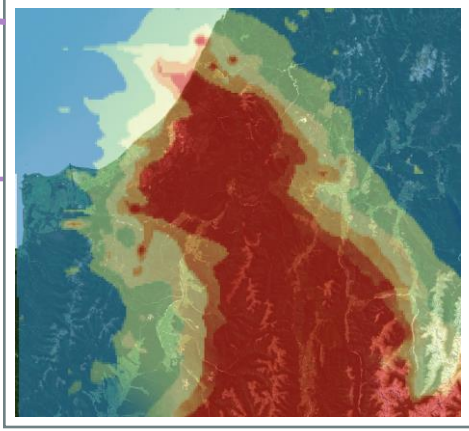






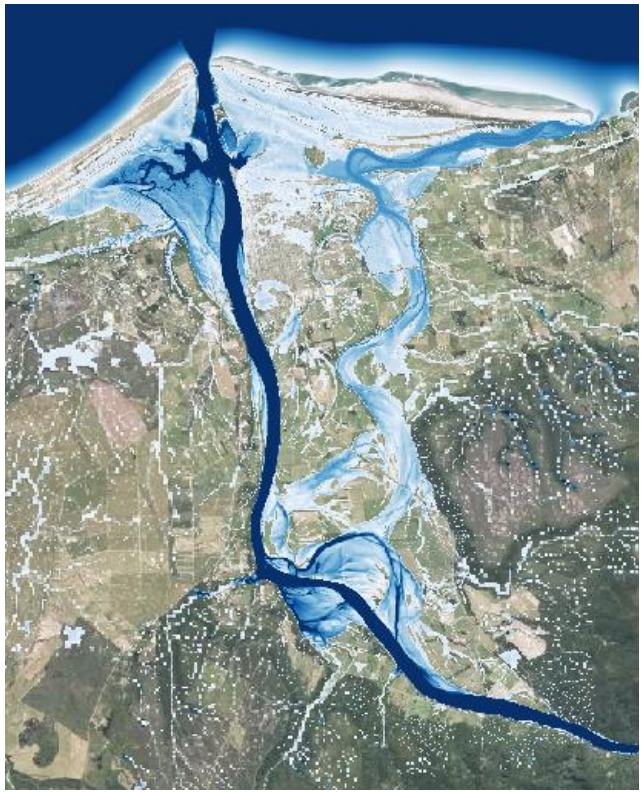
TopNET

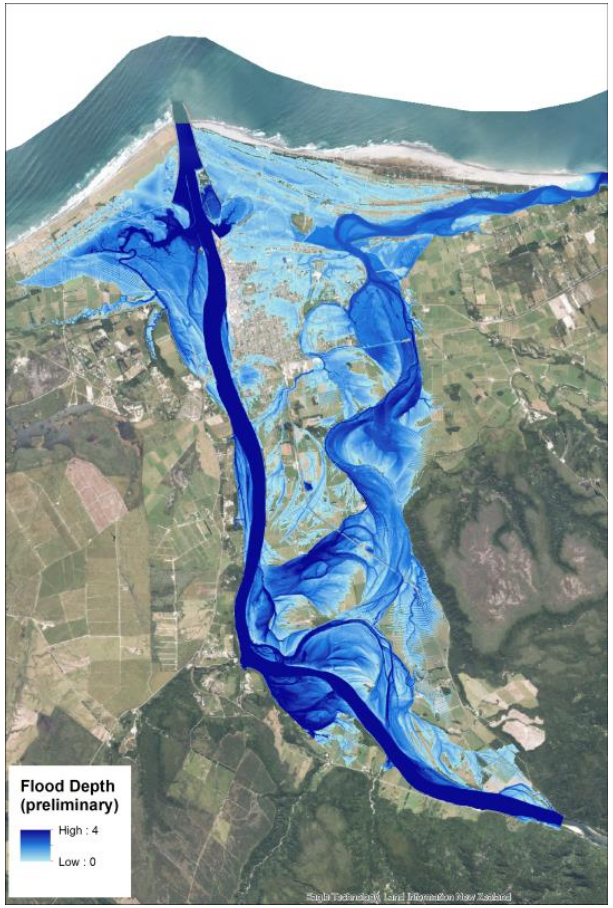
VCSN Rain Map

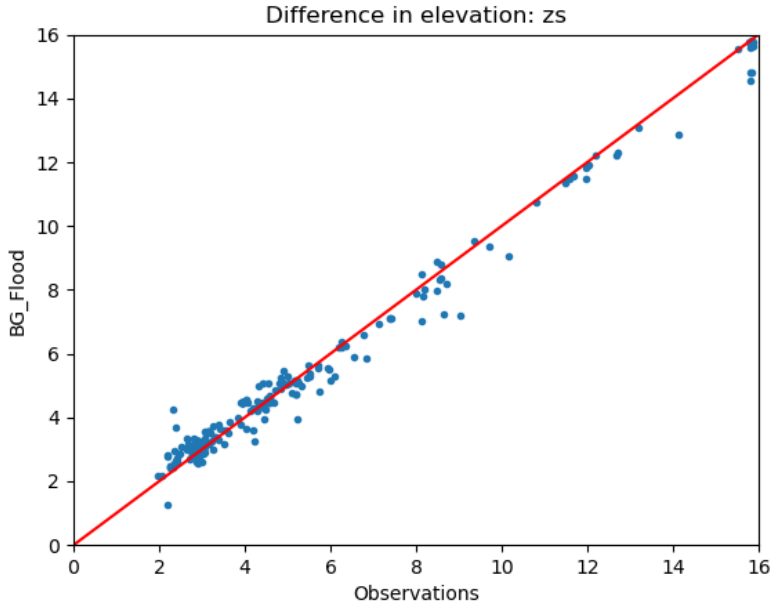


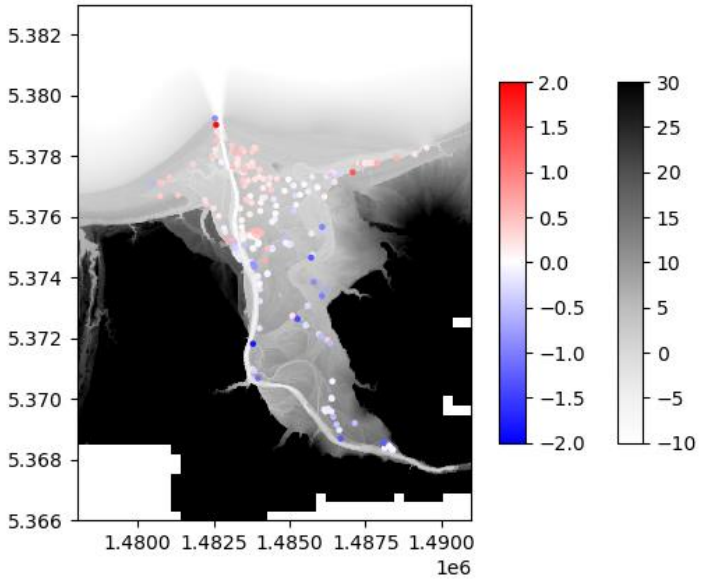
Use of an adaptative mesh,
from 10m (■) to 40m (■) reso

Comparison with the observations

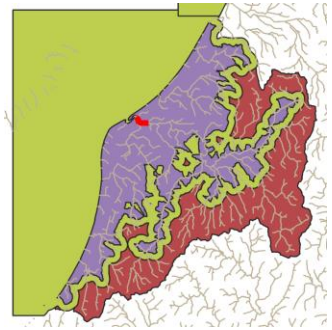




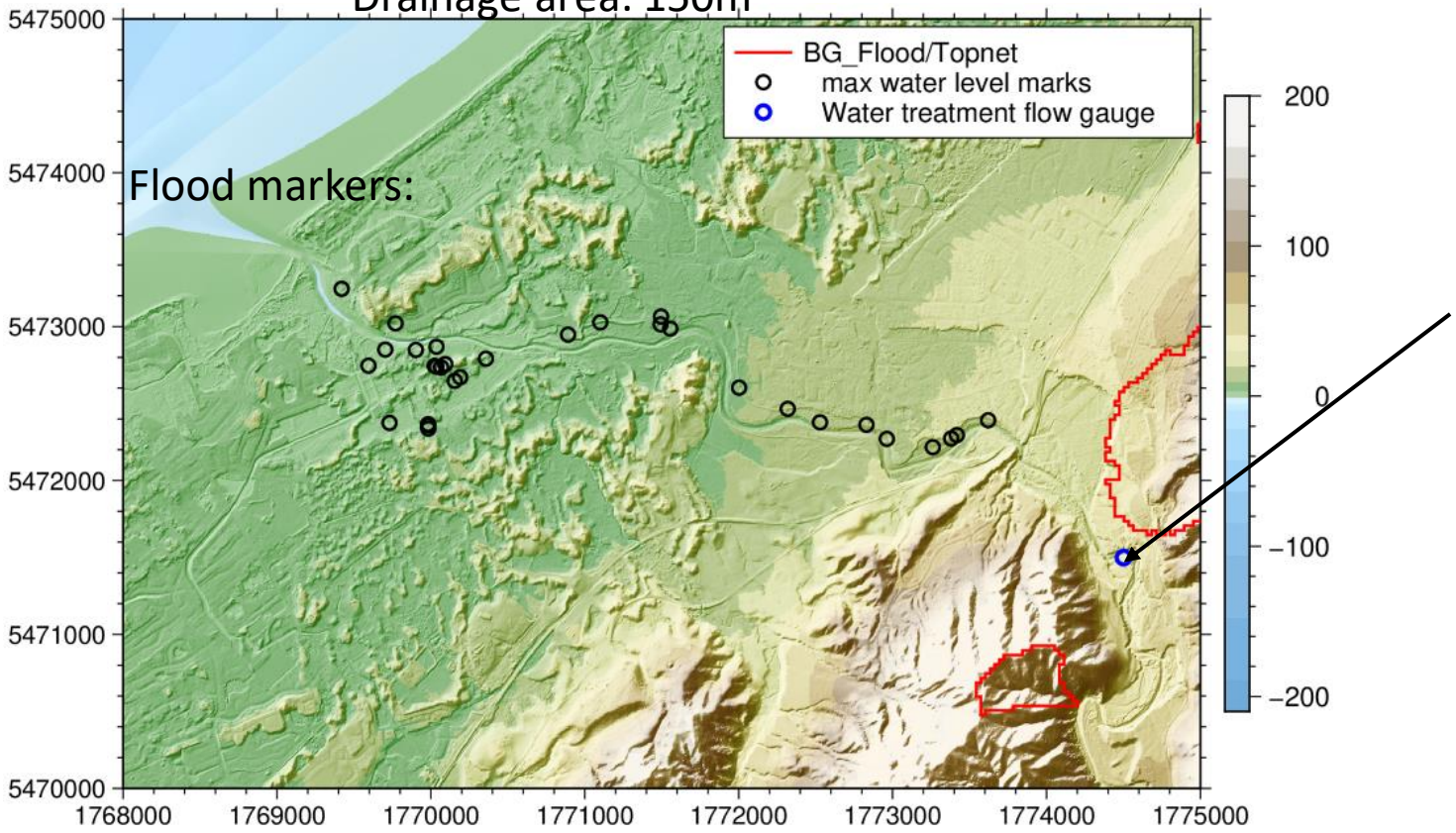


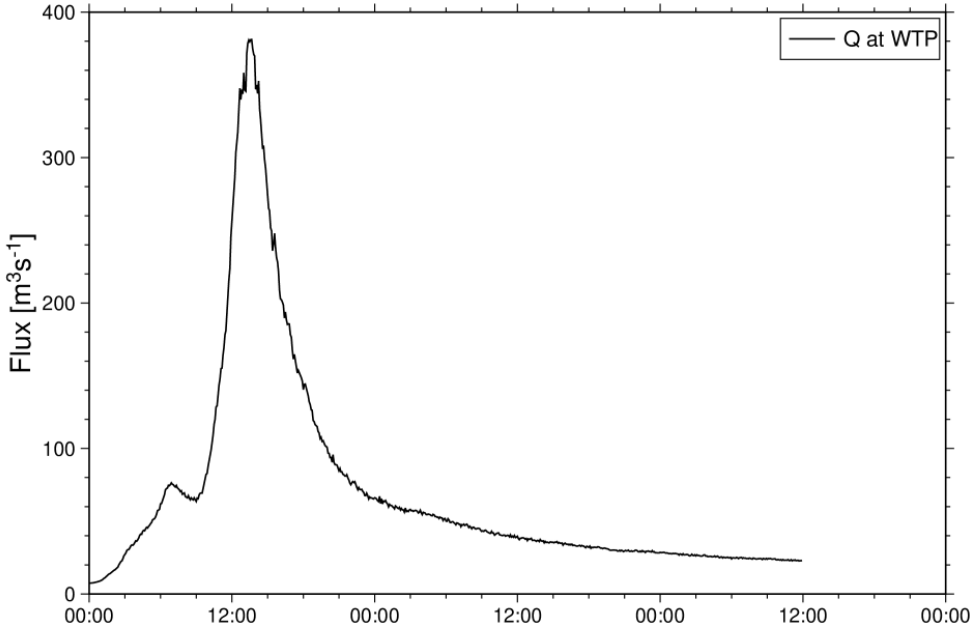


Pluvial and fluvial flooding: 2005 flood event in Waikanae

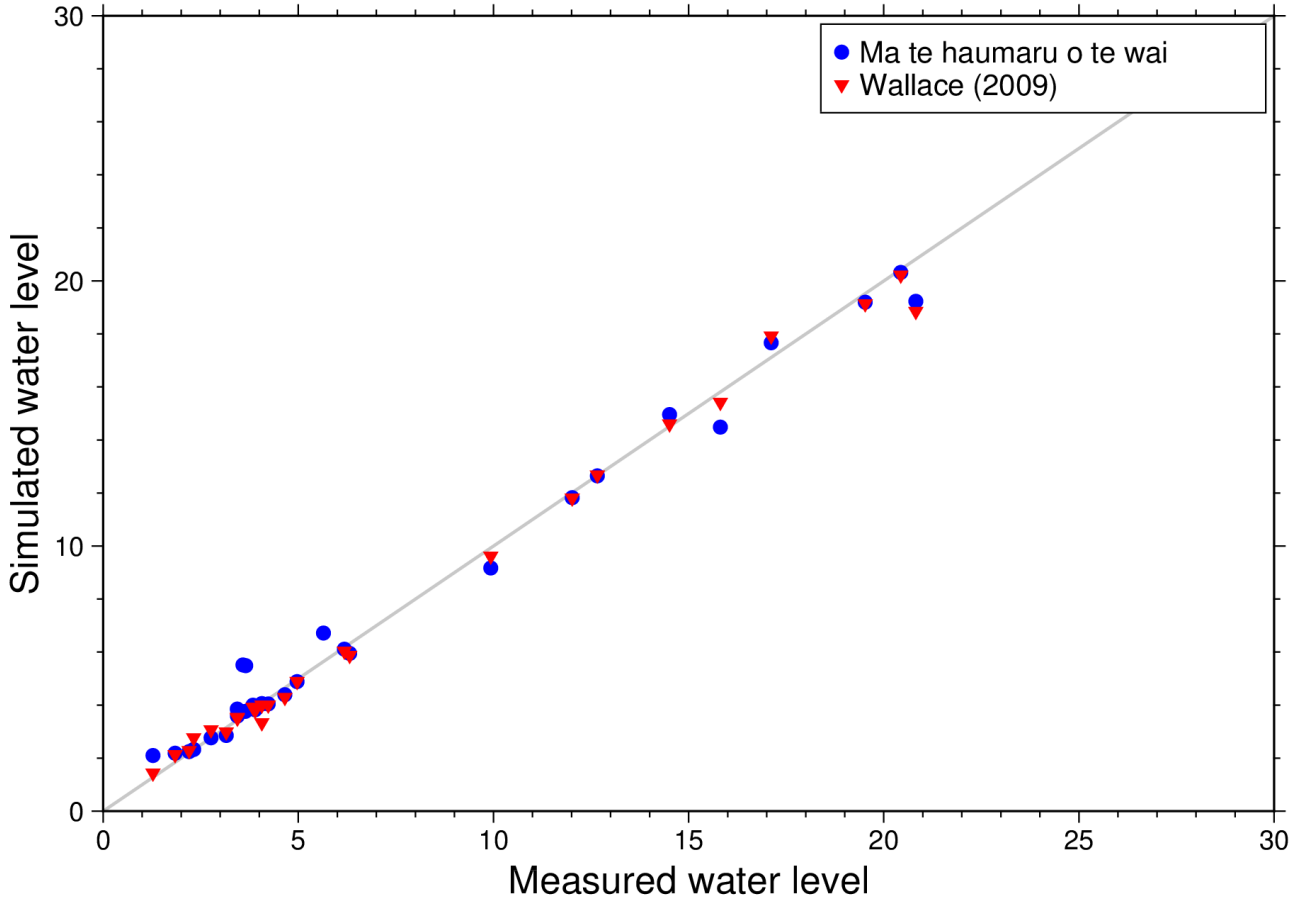


- Peak flow at treatment plant of 380 m^3/s
- ~ 80 years return period
- Max water level mark
- Drainage area: $150m^2$

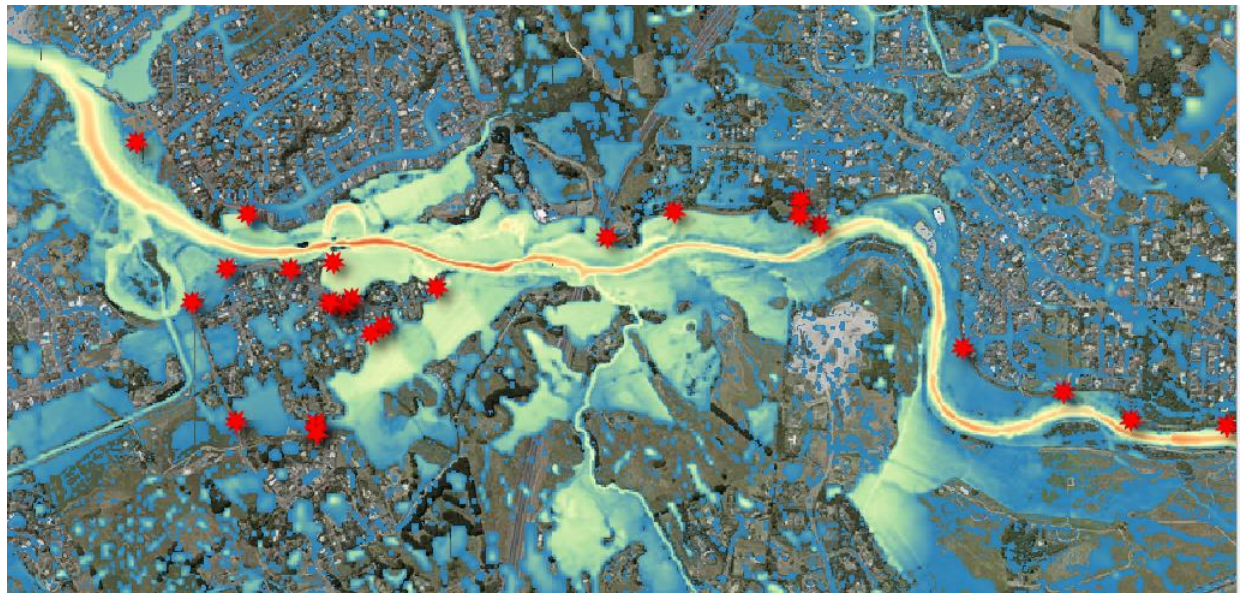




Comparison to observation and other models

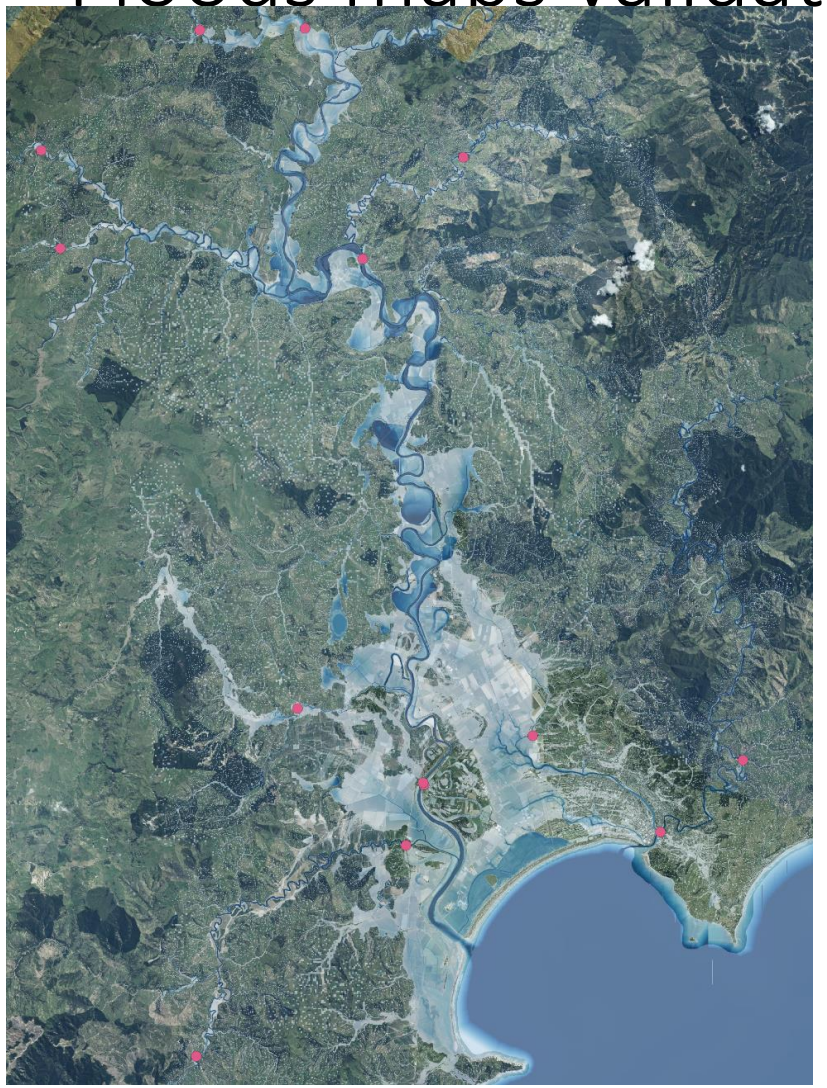


Calibrated (Wallace) vs uncalibrated peak flood levels



Inundation map with max. water level marks

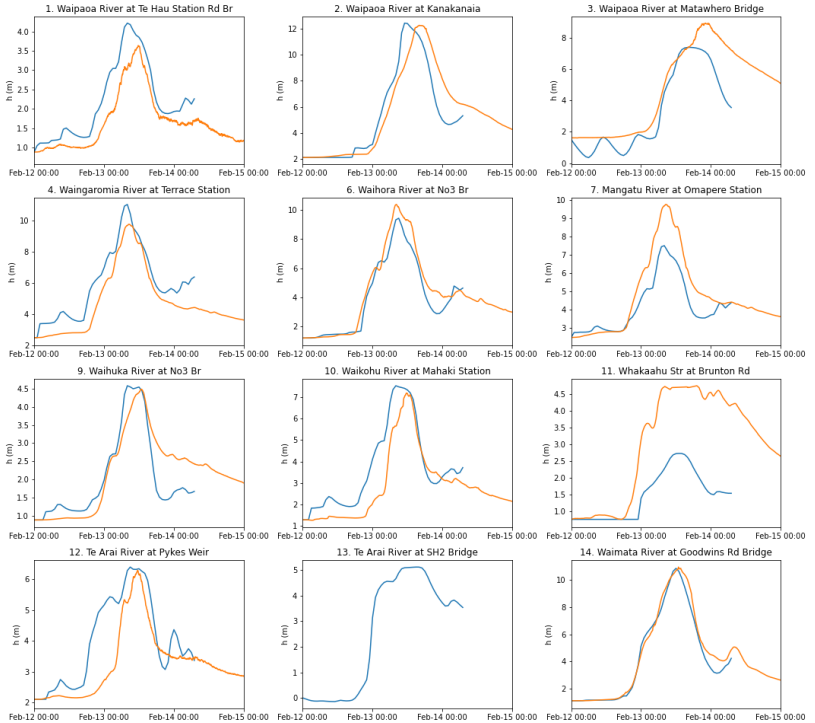
Floods maps validation in Gisborne



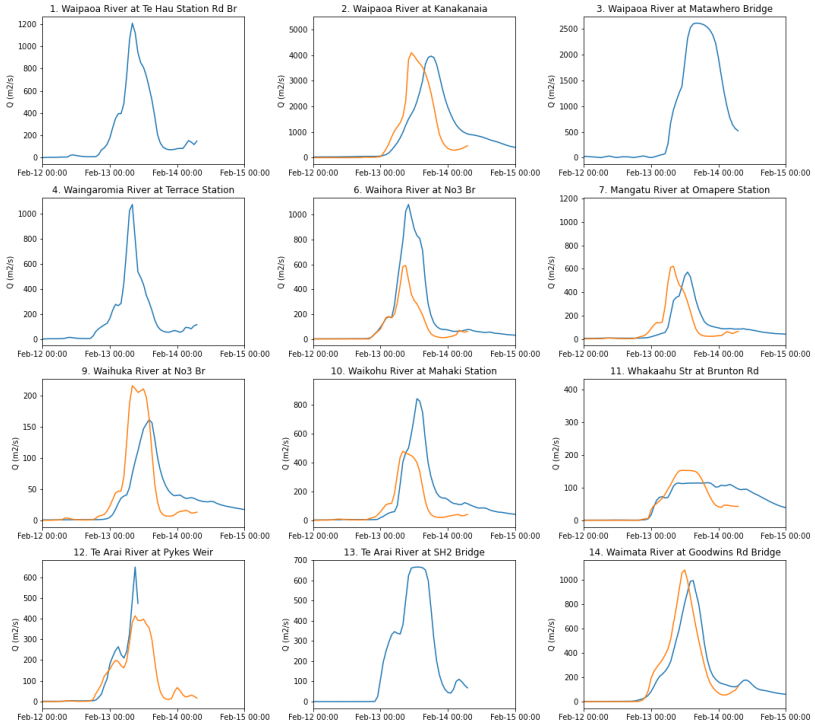
Modelled water elevation in the Gisborne area following TCGabrielle, with gauges and other locations of interest

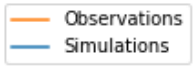
Comparison with observations:

H (m)



Q (m3/s)





Bringing it all together...

(A sneak preview of our private dashboard)

Mā te haumaru ō te wai flood simulations

Return period to view?

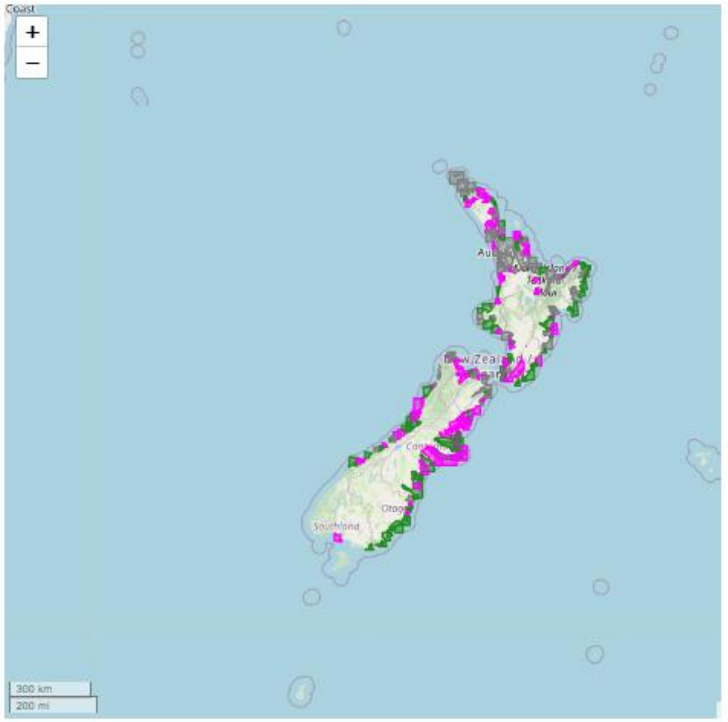
100

Maps - Overall Flood Domain Status

Empty geometries excluded

Status to view?

bgflood status

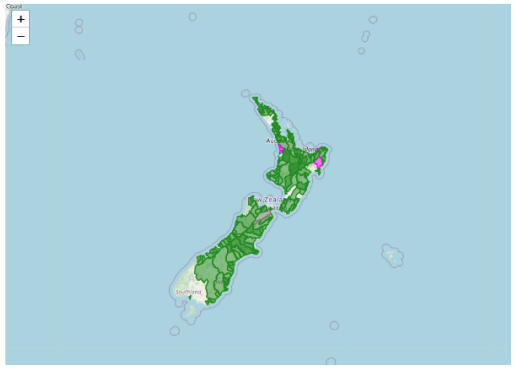


Design Storm status over Basin Domains

Return period to view?

100

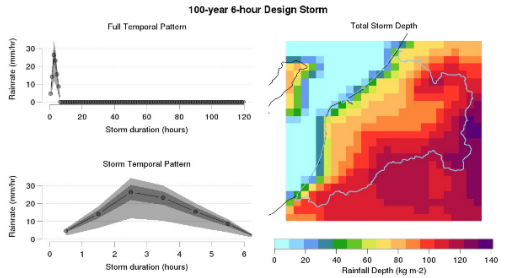
Maps



Design Storm properties: Waikanae

Other plot to view?

100y_6h_0c_latlon.png

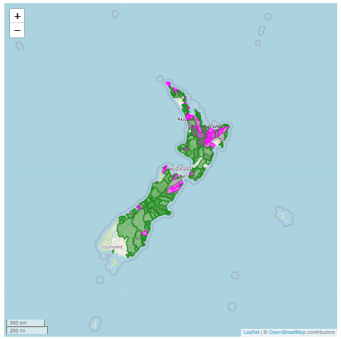


TopNet Simulation status over Basin Domains

Return period to view?

100

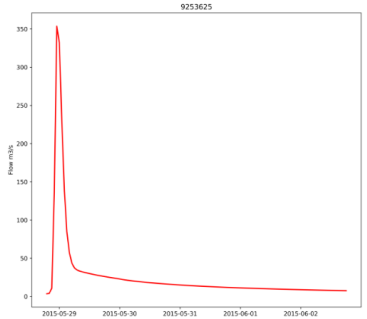
Maps



Hydrographs: Waikanae

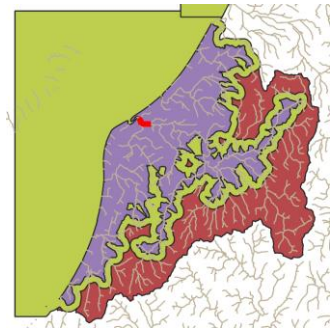
Other plot to view?

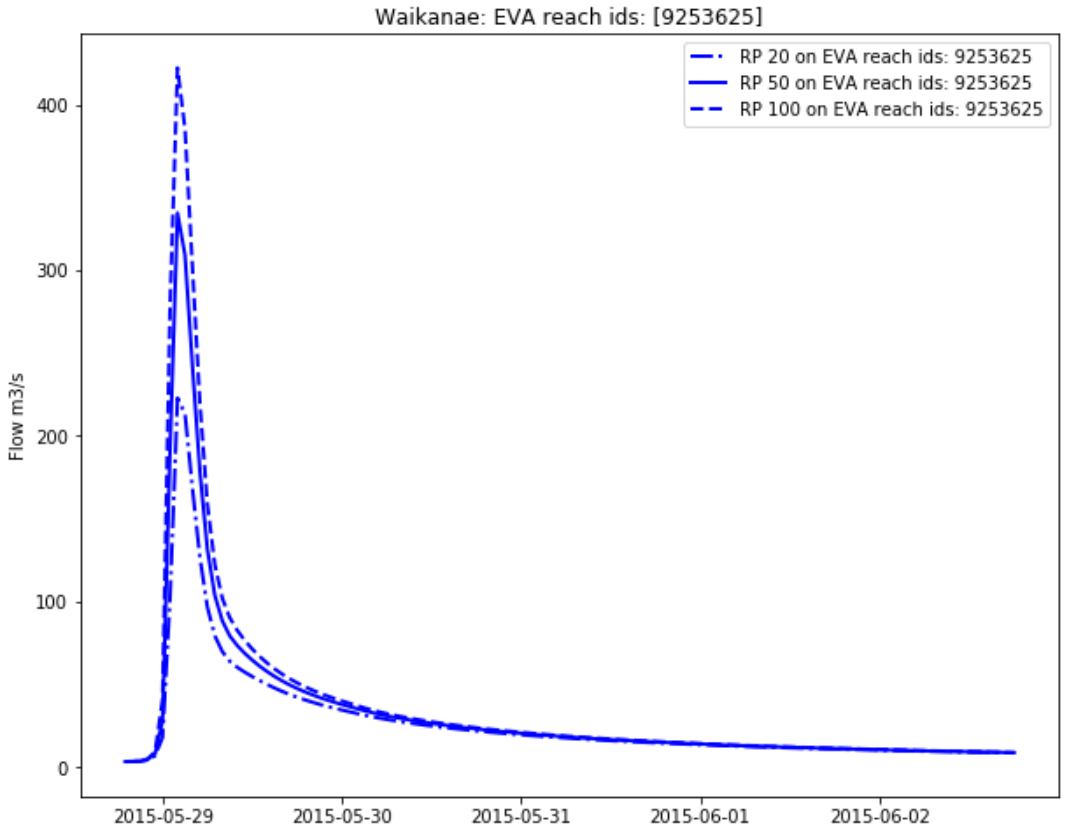
flow_9253625.png

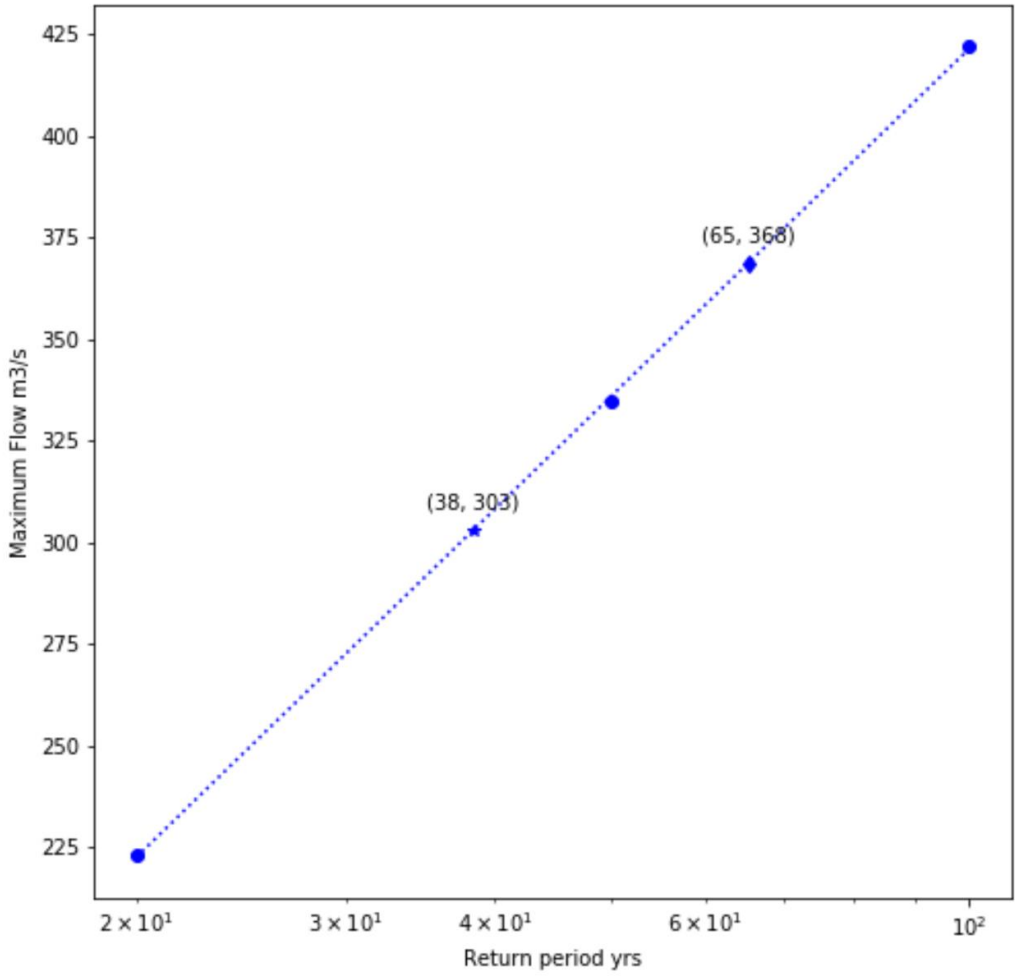


What is a 1% AEP Flood?

Waikanae, 12h storm



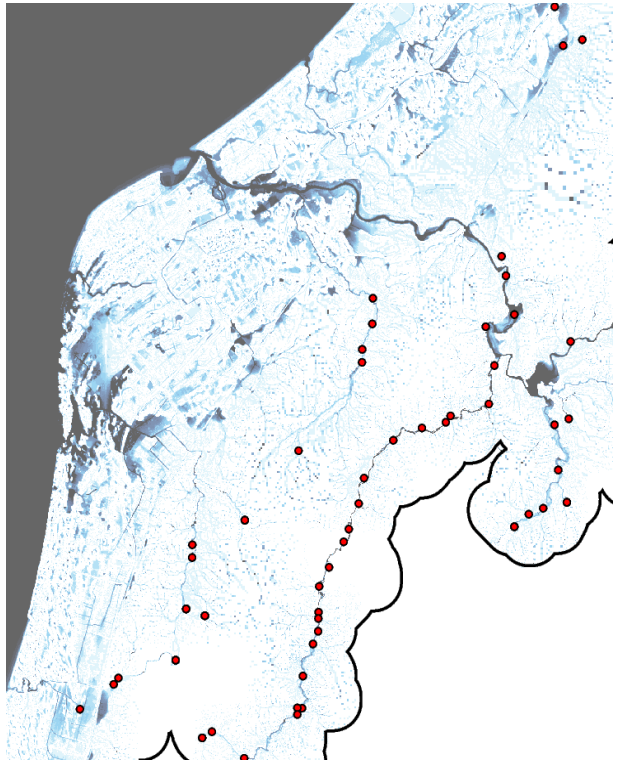




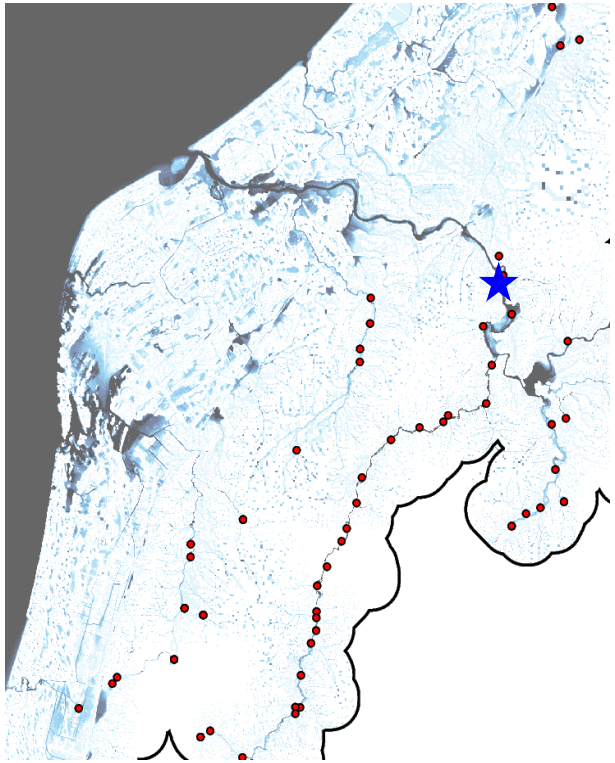
- Design Rainfall
- 1%AEP @ Gauge
- 1%AEP @Township

(Henderson and Collins 2018)

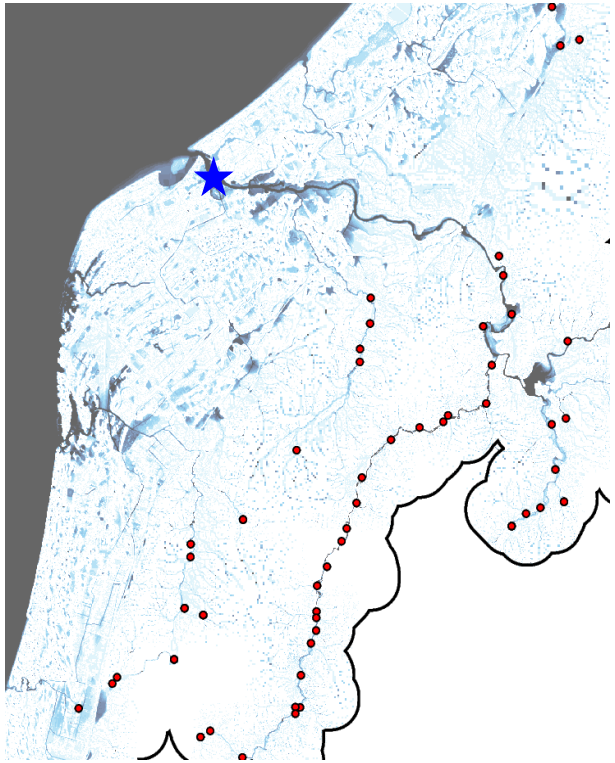
What that looks like on the ground



1% AEP Design Rainfall

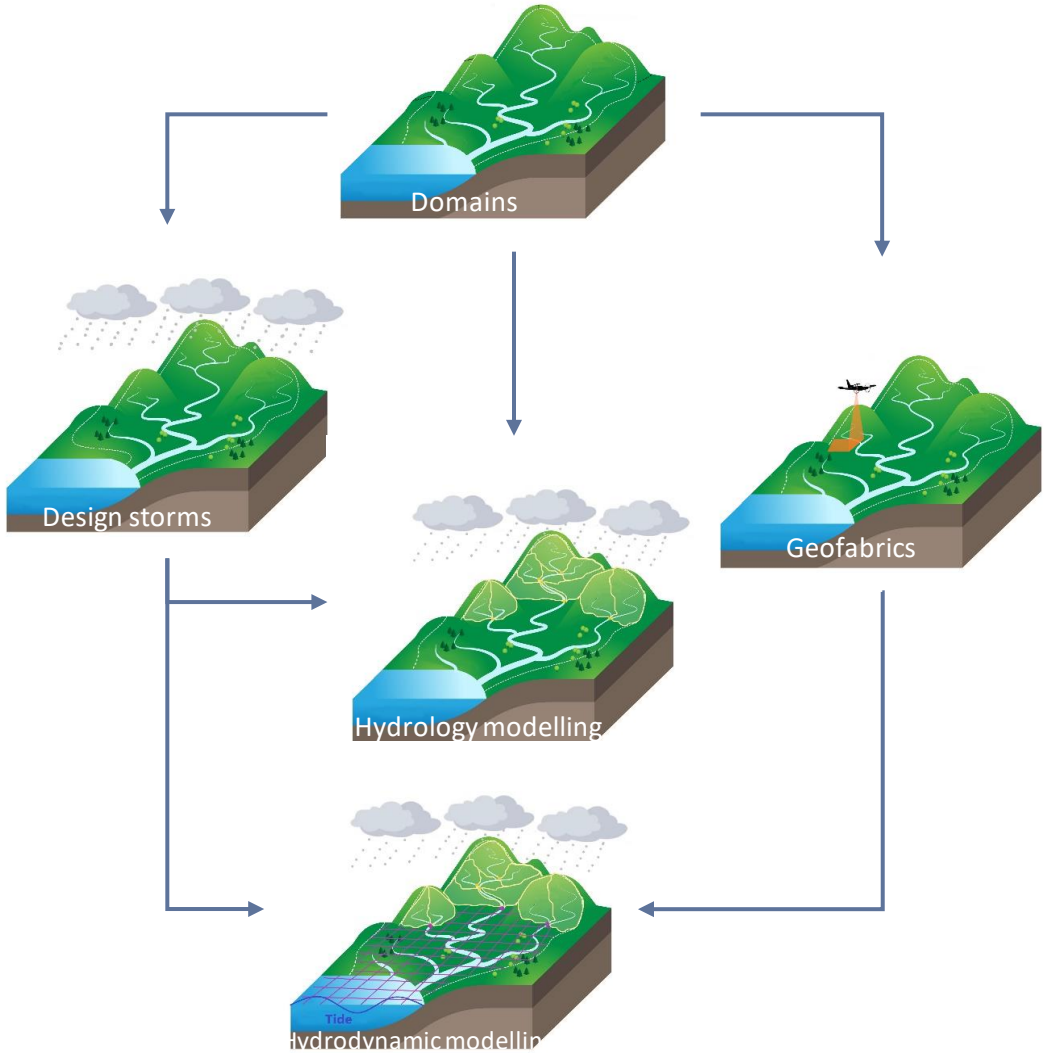


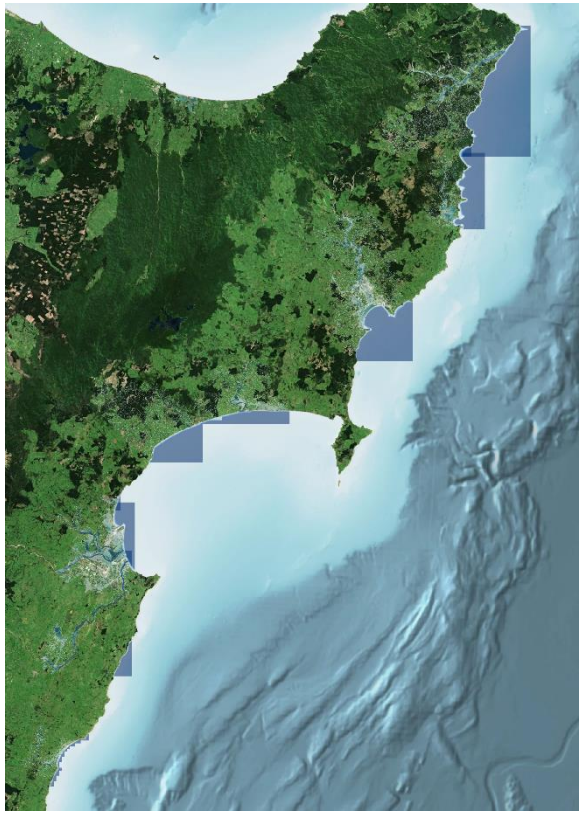
1% AEP Peak Flow at Gauge

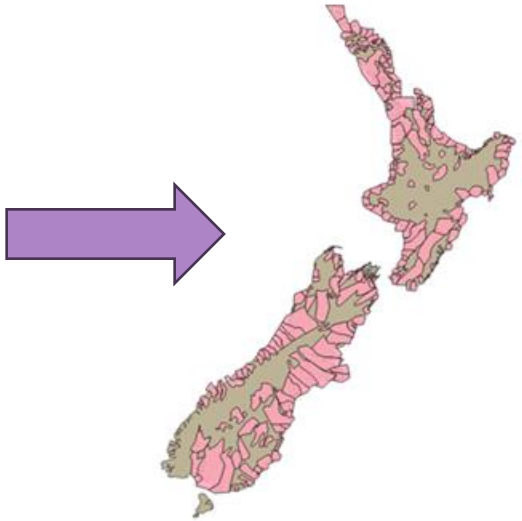


1% AEP Peak Flow at Township

Next steps: Design runs for the whole country







- *Initial runs on all the country planned for June 2024*
- *Second iteratively improved version for June 2025*

Modelling Group
WATER NEW ZEALAND

Modelling Symposium

Thank you!
Questions? Patai?

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The New Zealand Water & Wastes Association Waiora Aotearoa