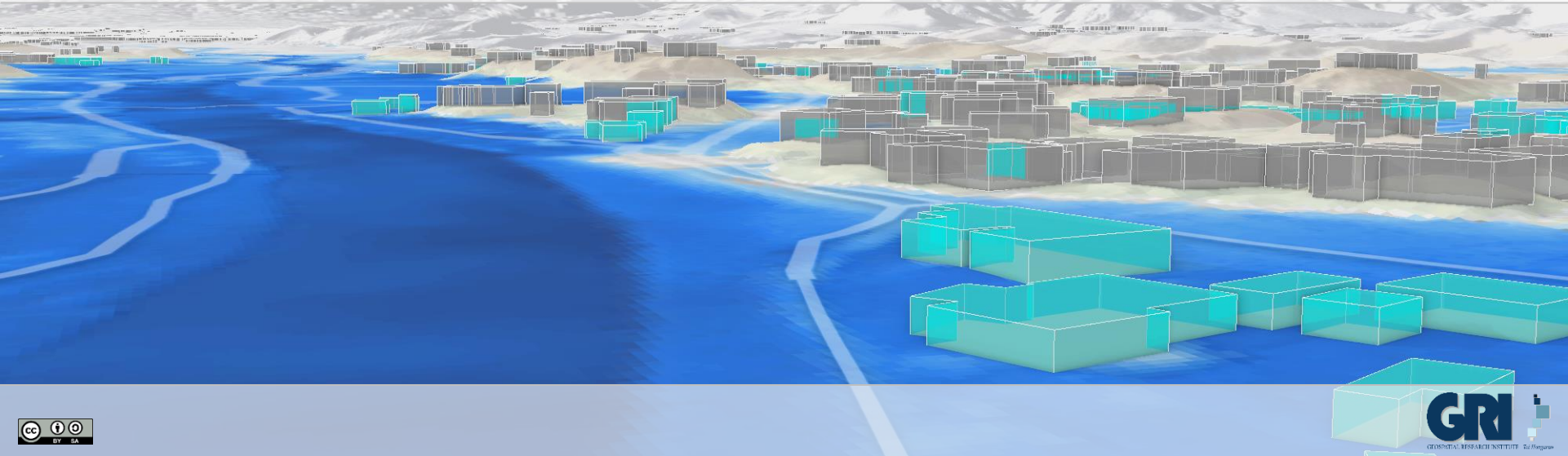
Second United Nations World Geospatial Information Congress, Hyderabad, 10-14 October 2022
Determining the Future Geospatial Information Ecosystem
TP6E Decision Support Systems, 13 October, 14:30-16:00

Empowering decision making for sustainable development through environmental digital twins

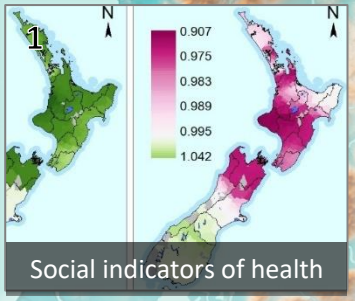
Prof. Matthew Wilson
Geospatial Research Institute Toi Hangarau, University of Canterbury, Aotearoa New Zealand



GEOSPATIAL RESEARCH INSTITUTE *Toi Hangarau*

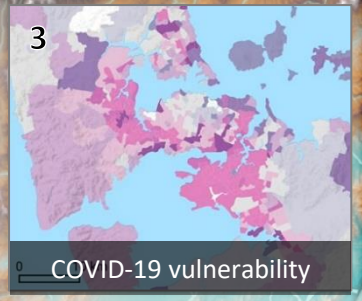
The Geospatial Research Institute Toi Hangarau is a world class centre of interdisciplinary geospatial expertise in New Zealand.

We conduct interdisciplinary partnership-based geospatial research across the social and physical sciences.



Social indicators of health

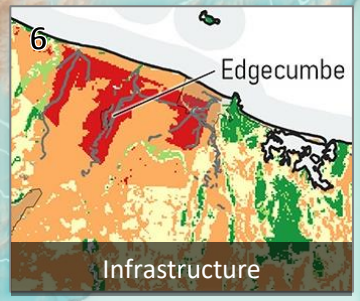
Healthy neighbourhoods



COVID-19 vulnerability

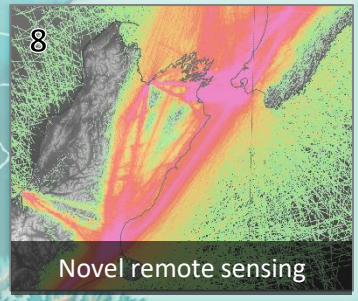
Urban planning

Bicultural governance



Infrastructure

Natural hazards



Novel remote sensing

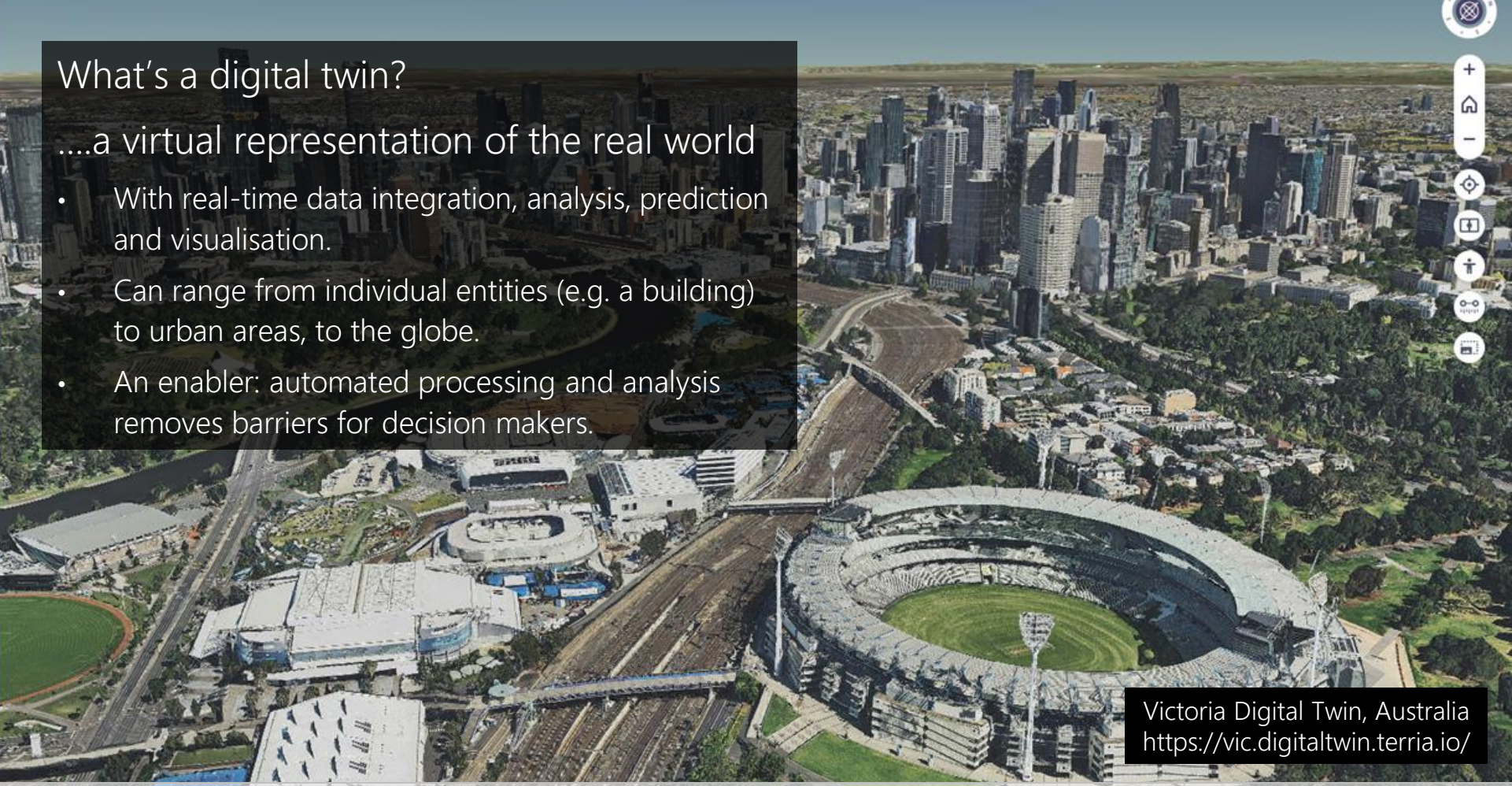
1. Marek et al. 2020, https://doi.org/10.1016/j.socscimed.2020.113292
2. Hobbs et al. 2022, https://doi.org/10.1016/j.socscimed.2021.114901
3. Wiki et al. 2021, https://doi.org/10.1080/03036758.2021.1900994
4. Schindler et al. 2020, https://doi.org/10.1061/(ASCE)UP.1943-5444.0000575
5. Dionisio et al. 2021, https://doi.org/10.1111/nzg.12299
6. Crawford-Flett et al. 2021, https://doi.org/10.1111/nzs.12372
7. National flood risk programme: https://niwa.co.nz/natural-hazards/research-projects/ma-te-haumaru-o-te-wai-increasing-flood-resilience-across-aotearoa-0
8. Rongowai: https://spoc.blogs.auckland.ac.nz/

Background image: Te Wei Pounamu, Aotearoa; South Island, New Zealand: David Garcia @mapmaperdavid

What's a digital twin?

....a virtual representation of the real world

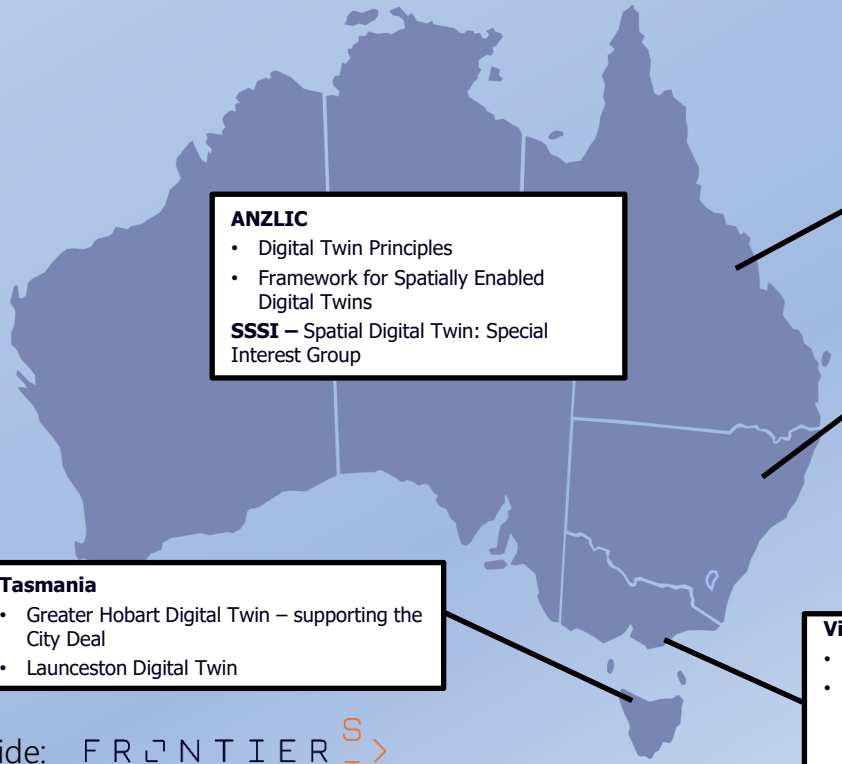
- With real-time data integration, analysis, prediction and visualisation.
- Can range from individual entities (e.g. a building) to urban areas, to the globe.
- An enabler: automated processing and analysis removes barriers for decision makers.



Victoria Digital Twin, Australia
https://vic.digitaltwin.terria.io/

Digital twin examples

- **Centre for Digital Built Britain:** National Digital Twin programme
- **Singapore:** Virtual Singapore
- **India:** Amarvati, Andra Pradesh
- **Europe:** Vienna, Zurich, Rotterdam, Flanders, Athens, Pilsen, Helsinki ....
- **USA**: Boston, New York, San Francisco



ANZLIC
- Digital Twin Principles
- Framework for Spatially Enabled Digital Twins

SSSI – Spatial Digital Twin: Special Interest Group

Queensland –
- Queensland Digital Twin – Statewide, and supporting the SEQ City Deal
- Brisbane Digital Twin
- Cross River Rail

New South Wales – Spatial Digital Twin: Live.NSW
- Morriset (Lake Macquarie Council) Digital Twin
- Sydney Water – Digital Twin Program
- Liveable Cities Digital Twin Research Project – UNSW, Liverpool City Council, DCS, AURIN...

New Zealand –
- Digital Twin identified as priority in National Infrastructure Strategy
- Flooding Digital Twin Research Project
- Wellington Digital Twin

Tasmania
- Greater Hobart Digital Twin – supporting the City Deal
- Launceston Digital Twin

Victoria –
- **City of Melbourne Digital Twin**
- **Digital Twin Victoria**, including
  - Statewide Digital Twin
  - Fishermans Bend Digital Twin Pilot
  - e-Comply planning demonstrator

Slide: FRONTIER SI

- Environmental digital twins:
  - Can be an enabler for decision makers towards the SDGs through automated processing of data and predictive capabilities.
  - Form key components of development of a geospatial knowledge infrastructure.
- This talk:
  1. Explore possibilities through a prototype under development for **flood risk** assessment and management
  2. Call for embedding computational models within **a framework of interconnected digital twins**

Destination Earth (DesdinE):
https://www.esa.int/Applications/Observing_the_Earth/Destination_Earth

The challenge: Flood risk management and mitigation requires substantial amounts of spatial data related to infrastructure and the environment, making it expensive to develop suitable risk assessments or scenarios, particularly when the information needed is time-critical.

Edgecumbe 2017, https://teara.govt.nz/en/photograph/46848/edgecumbe-flood-2017

Towards a National Digital Twin for Flood Resilience in New Zealand

- ✓ A prototype digital twin to improve flood risk assessment and emergency management.
- ✓ Automated analysis:
  - Generation of flood models for user defined areas.
  - Running of multiple standardised or user-defined flood scenarios.
  - Assessment of flood impacts across the scenarios.
- ✓ Interface for visualisation of flood impacts and scenario control.
- ✓ Inclusion of real-time information during an event, predictive analytics.
- ✓ Open source and open data.

Funding:

FRONTIER SI

BUILDING INNOVATION PARTNERSHIP

Project team:

NIWA Taihoro Nukurangi

Land Information New Zealand Toitū te whenua

UC UNIVERSITY OF CANTERBURY Te Whare Wānanga o Waitaha CHRISTCHURCH NEW ZEALAND

Matt Wilson, Greg Preston, Casey Li, Luke Parkinson (University of Canterbury)

Emily Lane, Rose Pearson and Cyprien Bosserelle (National Institute of Water and Atmospheric Research),

Rob Deakin (Land Information New Zealand)

Follow the code development (or contribute!)

https://github.com/GeospatialResearch/Digital-Twins

Updates via Twitter: @geospatialnz

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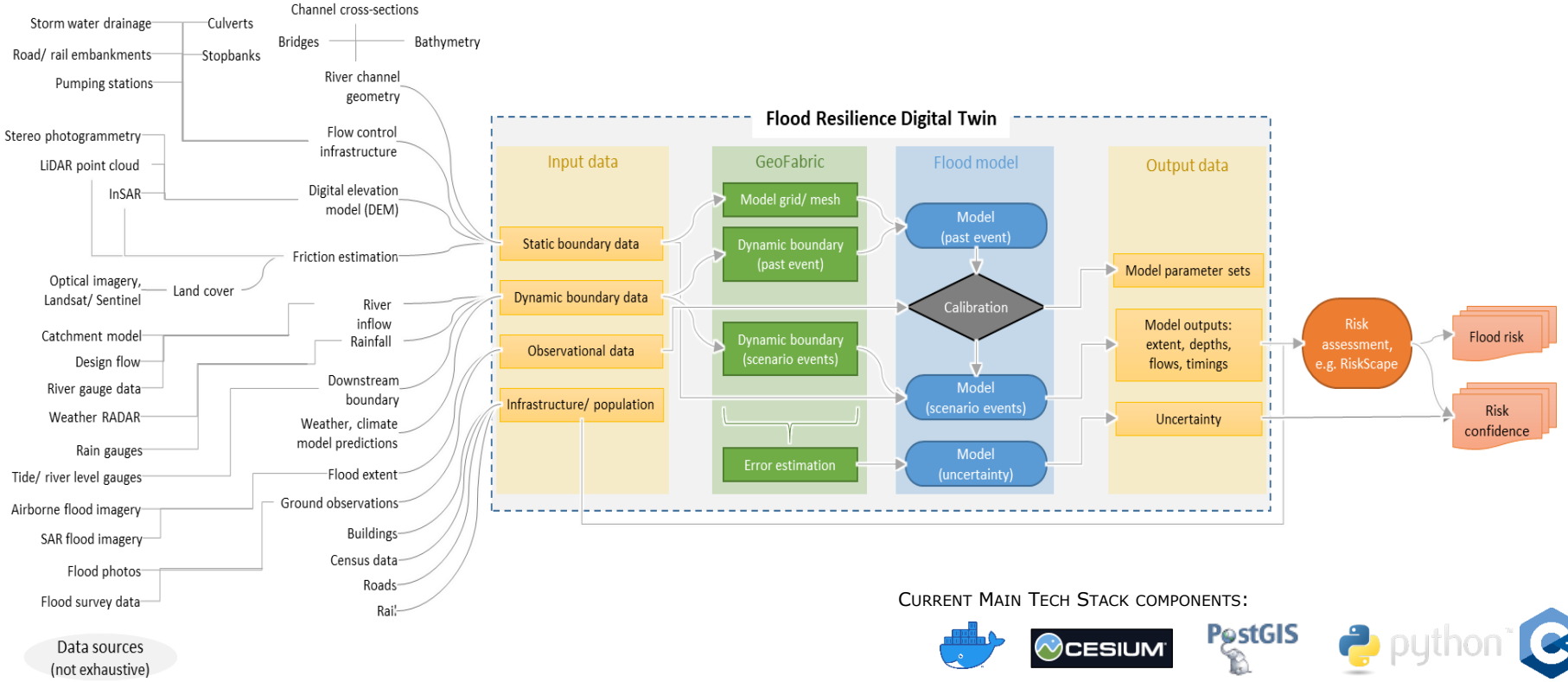
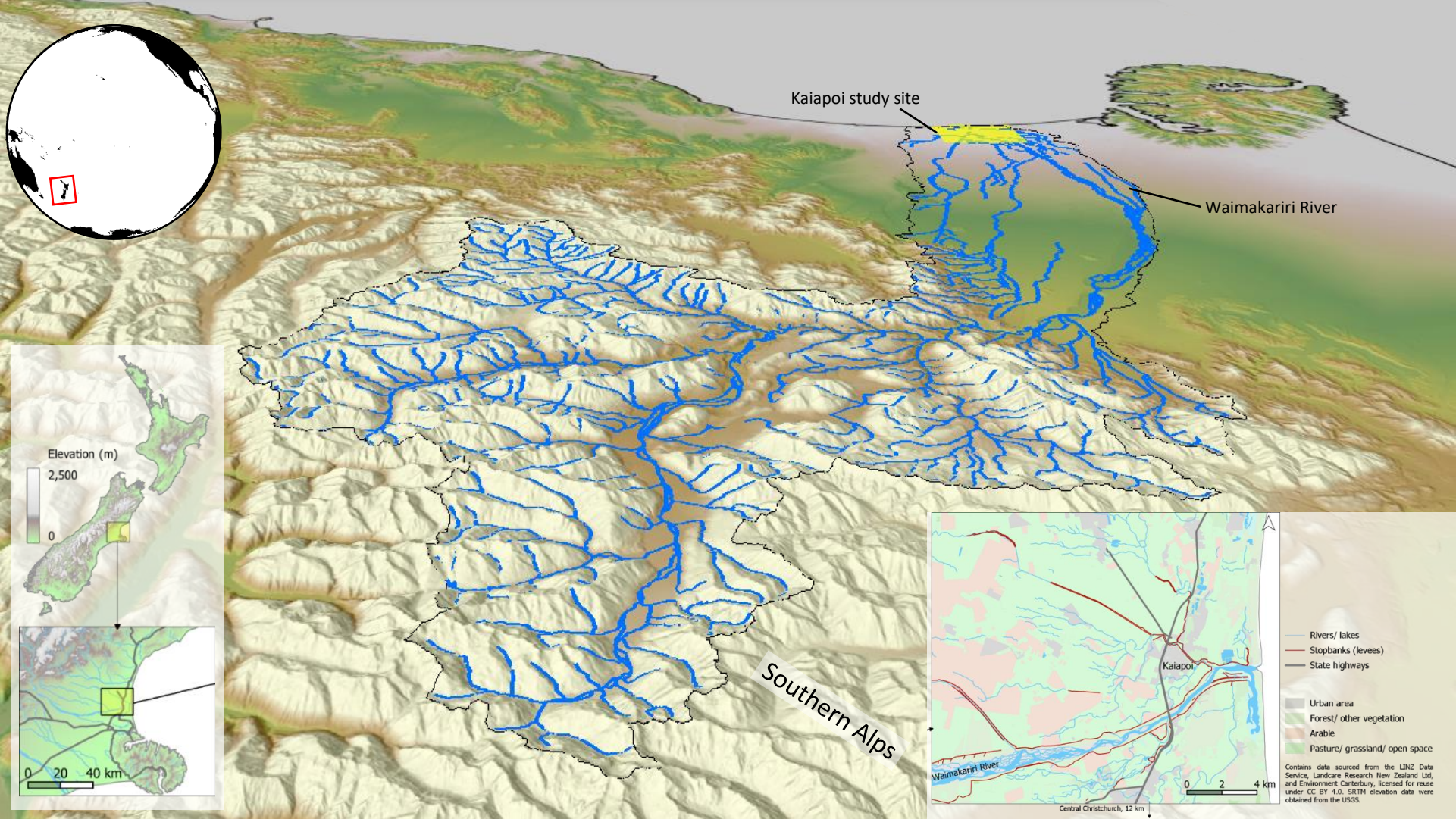
GRI GEOSPATIAL RESEARCH INSTITUTE Te Hangarau

Towards a National Digital Twin for Flood Resilience in New Zealand



CURRENT MAIN TECH STACK COMPONENTS:

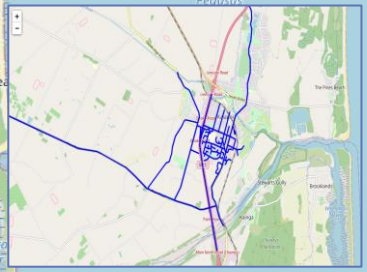

Kaiapoi study site
Waimakariri River
Southern Alps
Elevation (m)
2,500
0
0 20 40 km
Kaiapoi
Waimakariri River
0 2 4 km
Central Christchurch, 12 km
Rivers/ lakes
Stopbanks (levees)
State highways
Urban area
Forest/ other vegetation
Arable
Pasture/ grassland/ open space
Contains data sourced from the LINZ Data Service, Landcare Research New Zealand Ltd, and Environment Canterbury, licensed for reuse under CC BY 4.0. SRTM elevation data were obtained from the USGS.


Waimakariri River
Kaiapoi
"red zone" area
Ferry Rd
Image Landsat / Copernicus
Image © 2022 Maxar Technologies
Image © 2022 Planet Labs
Google Earth
Imagery Date: 11/12/2020 43°23'18.09" S 172°38'31.69" E

Automated data ingest

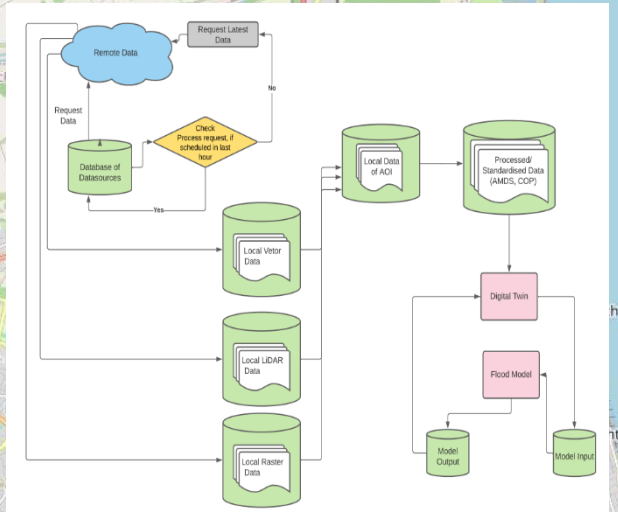
User's area of interest

Roads



Rail

Buildings



DT DATABASE

Vector Data

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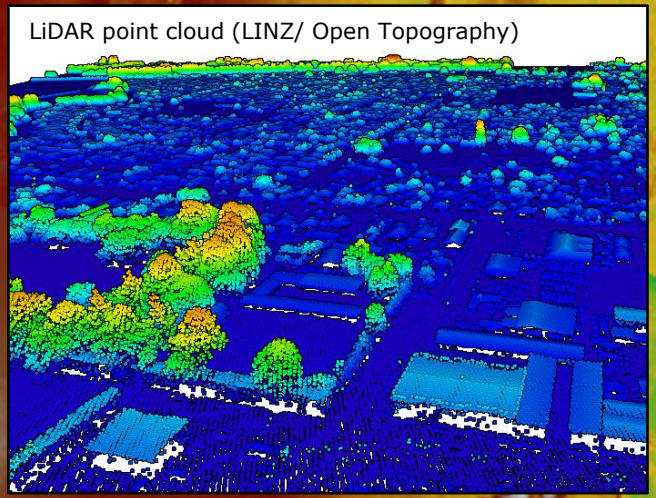
Generation of model input data

Automated production of "hydraulically conditioned" model grid from LiDAR point cloud and supporting data.

Kaiapoi

Waimakariri River

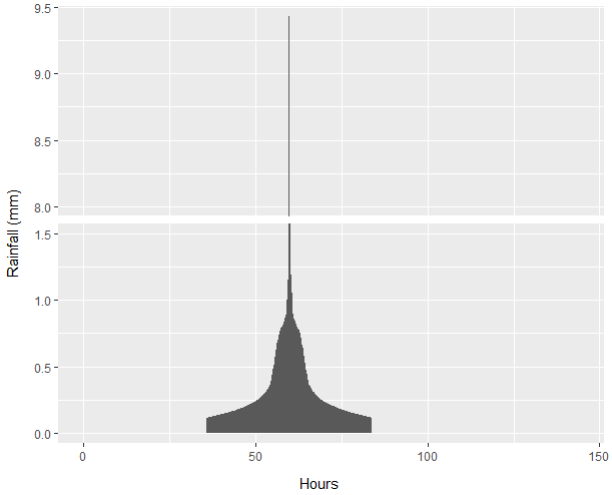


Model grid, processed using: https://github.com/rosepearson/GeoFabrics

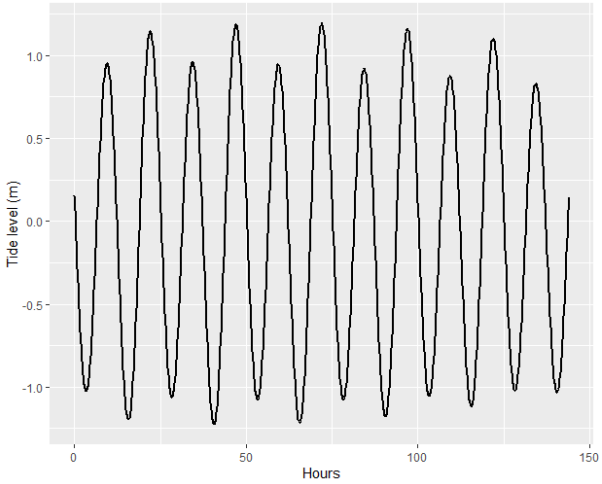
Generation of model input data

Automated standardised scenarios, or from observed data.

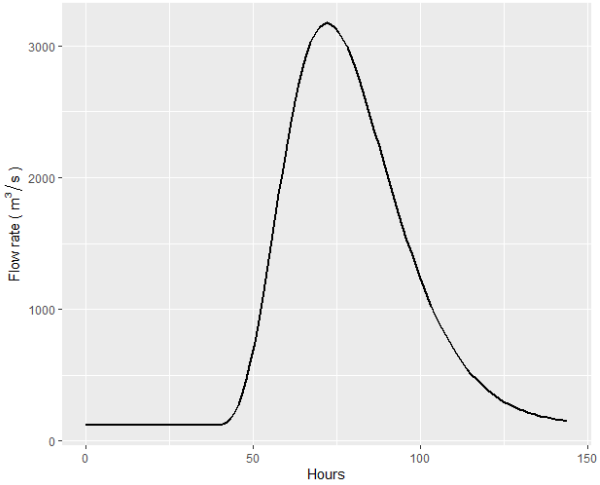
Rainfall design storm



High perigean-spring "king" tide level

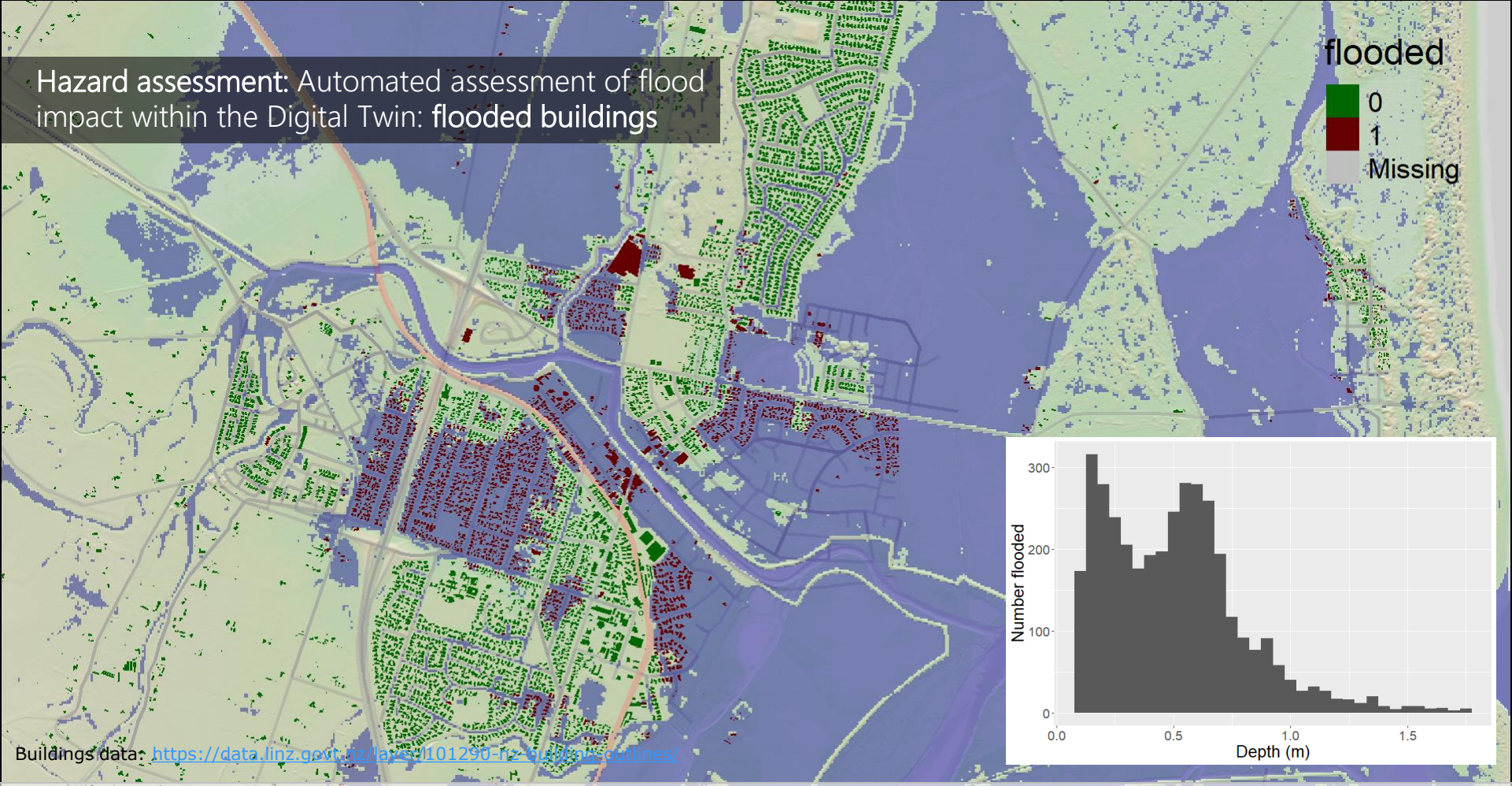


River flow design hydrograph



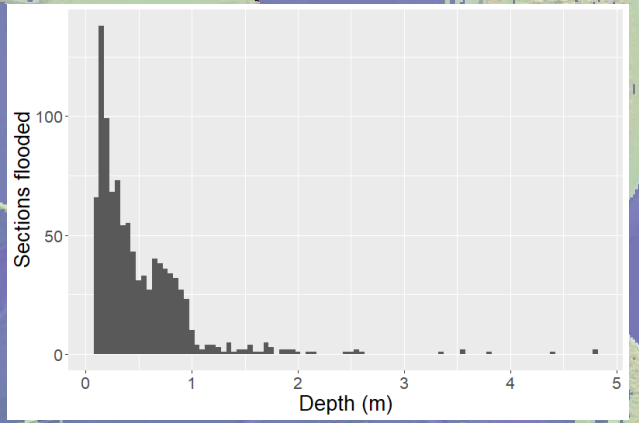
Annual exceedance probability = 0.02 (50 year average recurrence interval)

Hazard assessment: Automated assessment of flood impact within the Digital Twin: **flooded buildings**



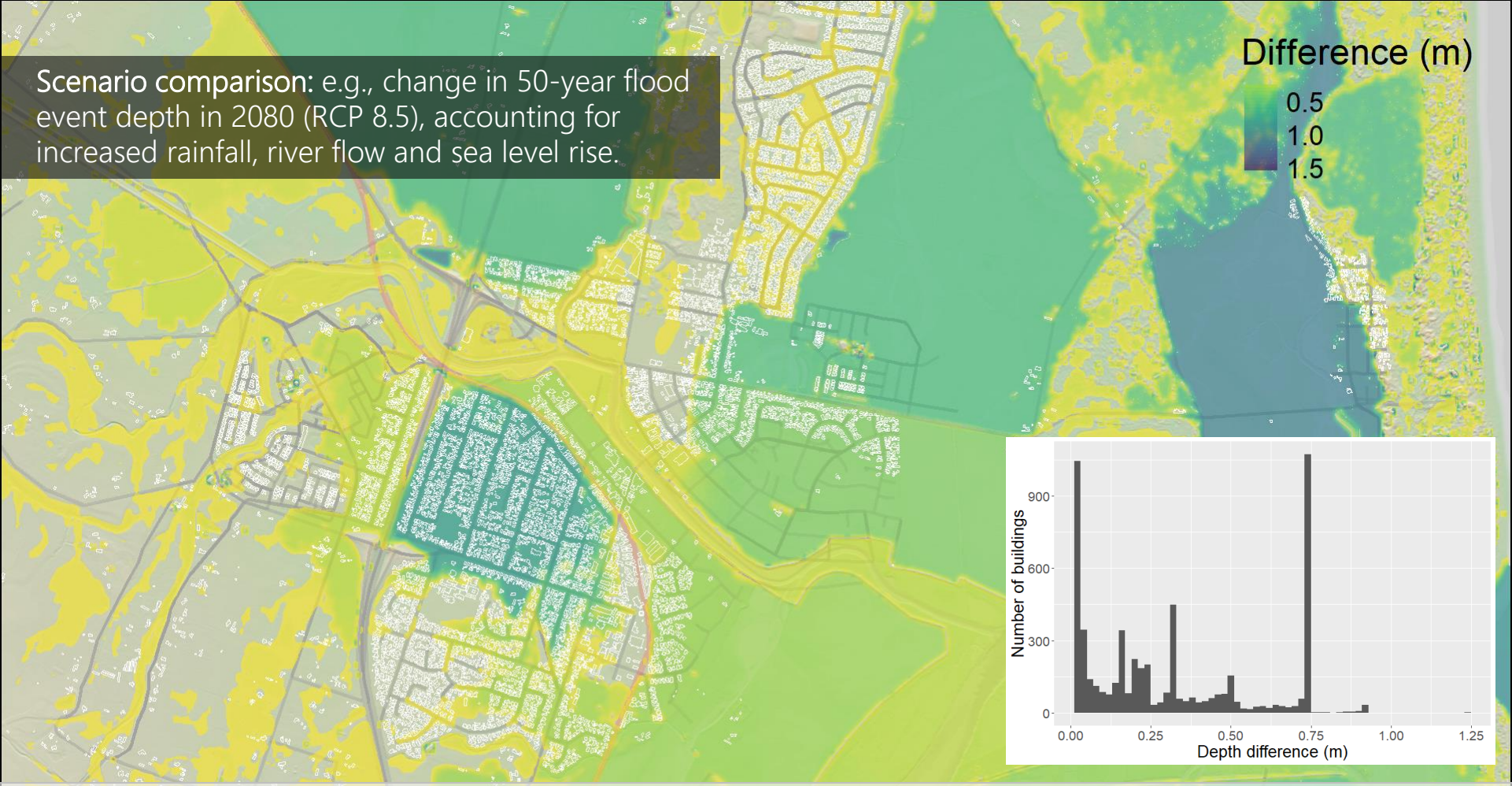
Buildings data: https://data.linz.govt.nz/layer/101290-nz-building-outlines/

Hazard assessment: Automated assessment of flood impact within the Digital Twin: **flooded roads**



Roads data: https://data.linz.govt.nz/layer/53378-nz-roads-road-section-geometry/

Scenario comparison: e.g., change in 50-year flood event depth in 2080 (RCP 8.5), accounting for increased rainfall, river flow and sea level rise.



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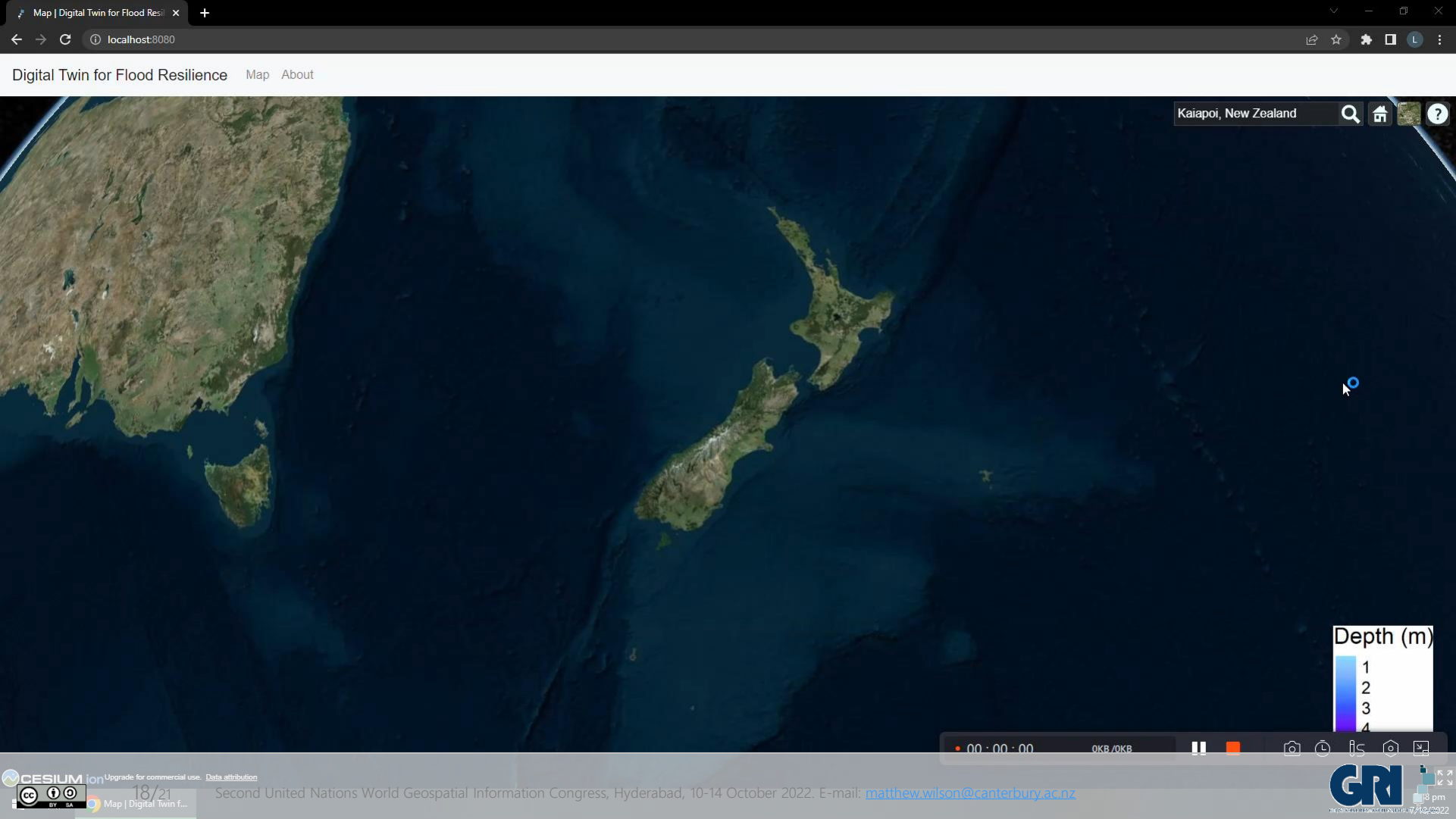
Map | Digital Twin for Flood Resil
localhost:8080
Digital Twin for Flood Resilience
Map
About
Kaiapoi, New Zealand
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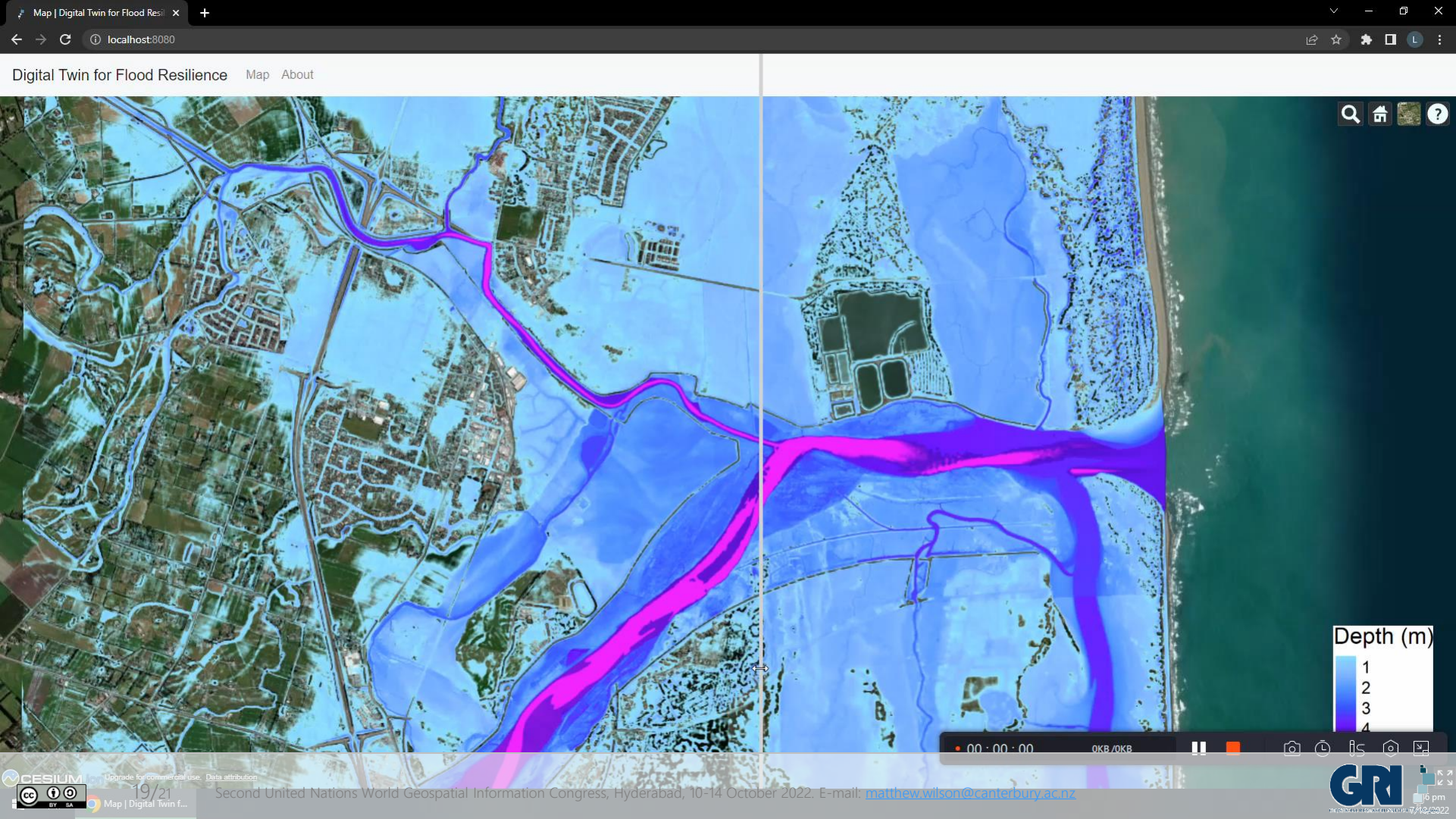
Data attribution
Map | Digital Twin f...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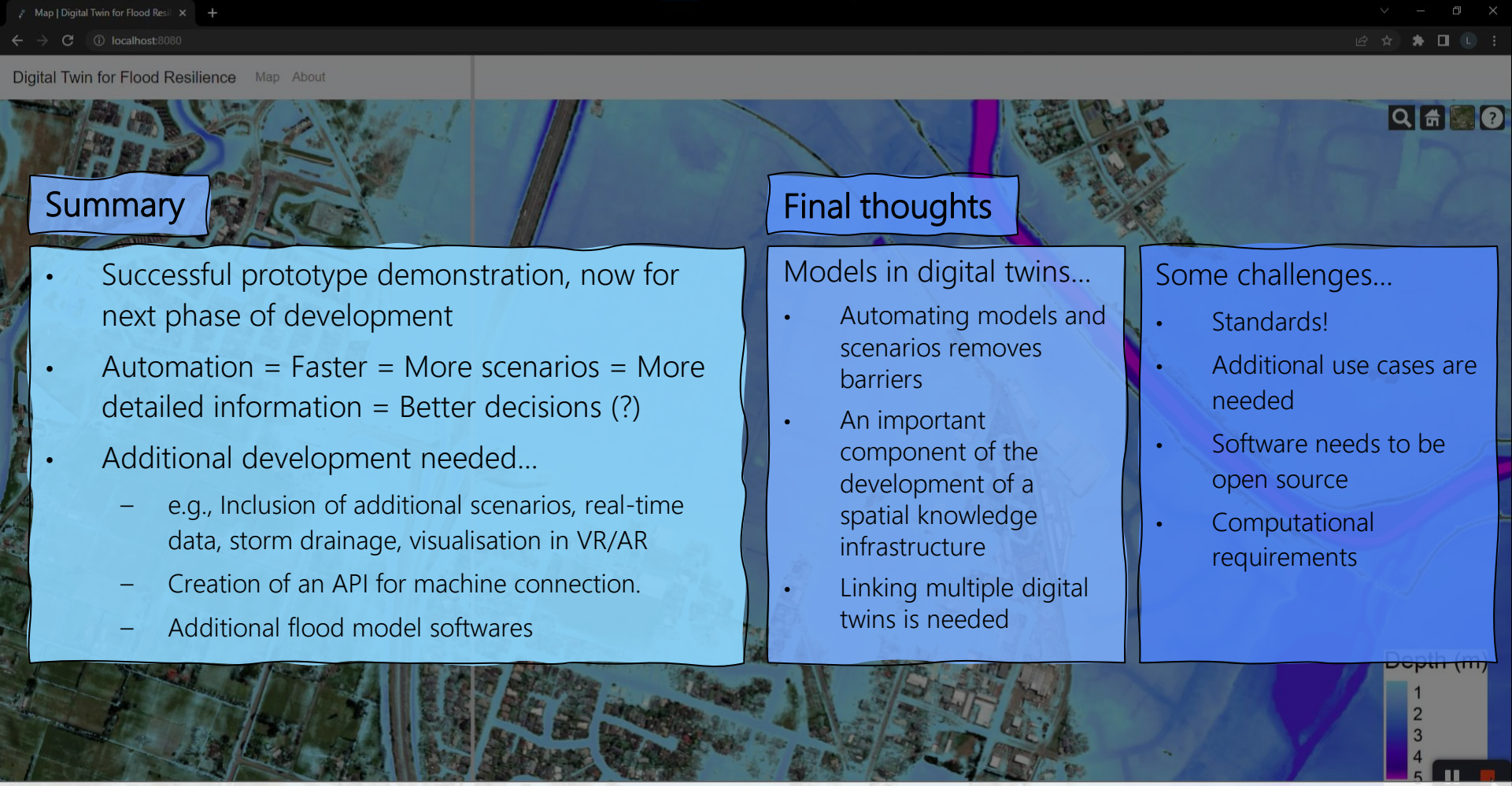

Summary

- Successful prototype demonstration, now for next phase of development
- Automation = Faster = More scenarios = More detailed information = Better decisions (?)
- Additional development needed…
  - e.g., Inclusion of additional scenarios, real-time data, storm drainage, visualisation in VR/AR
  - Creation of an API for machine connection.
  - Additional flood model softwares

Final thoughts

Models in digital twins…

- Automating models and scenarios removes barriers
- An important component of the development of a spatial knowledge infrastructure
- Linking multiple digital twins is needed

Some challenges…

- Standards!
- Additional use cases are needed
- Software needs to be open source
- Computational requirements

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Thank you, tēnā koutou katoa, धन्यवाद

Connect: matthew.wilson@canterbury.ac.nz