



Earth Sciences
New Zealand

On July 1, 2025 NIWA and GNS Science merged to become a new Public Research Organisation:
Earth Sciences New Zealand

MetService and NZ Measurement Standards Laboratory are planned to join ESNZ in 2026 (pending enabling legislation)





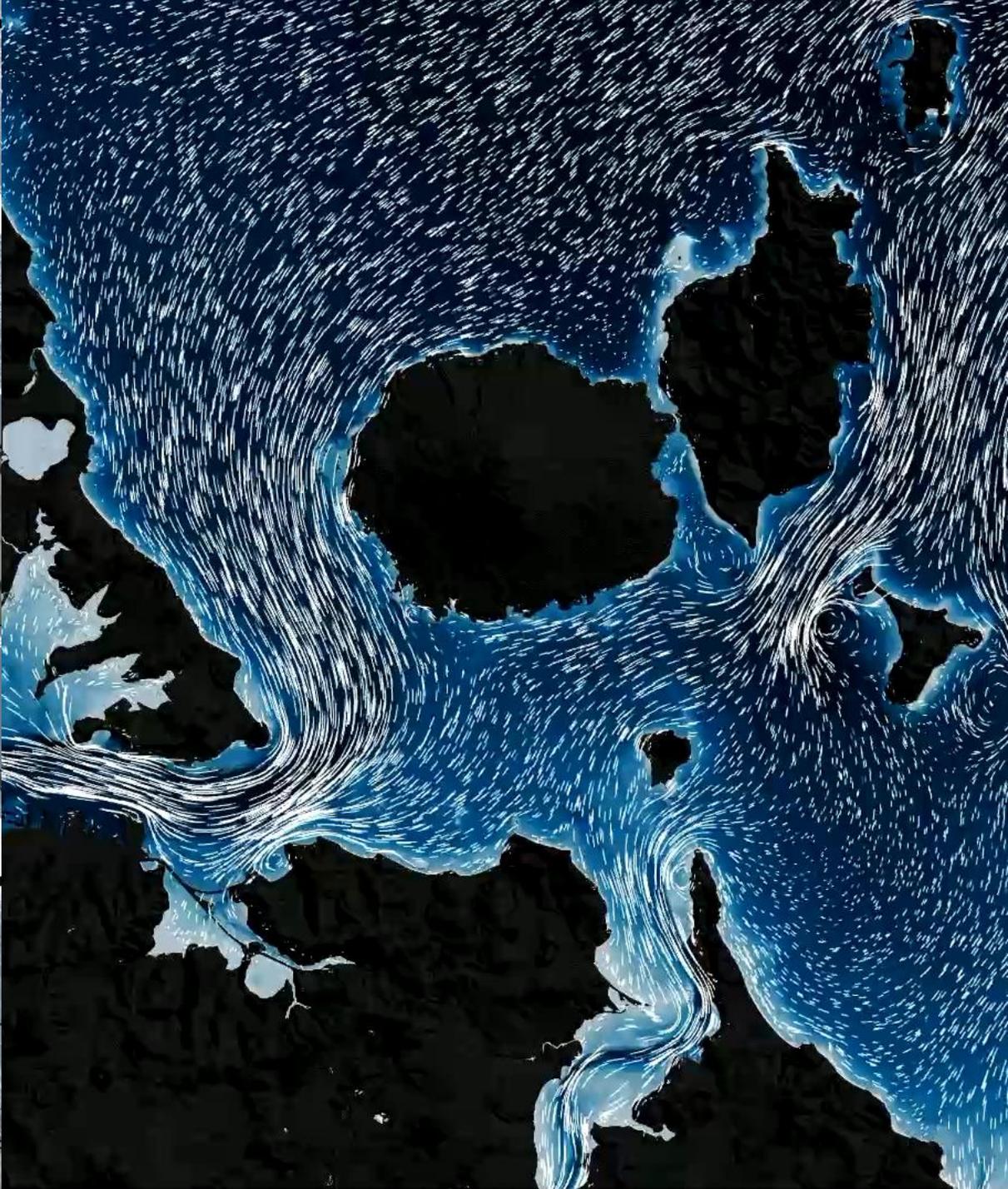
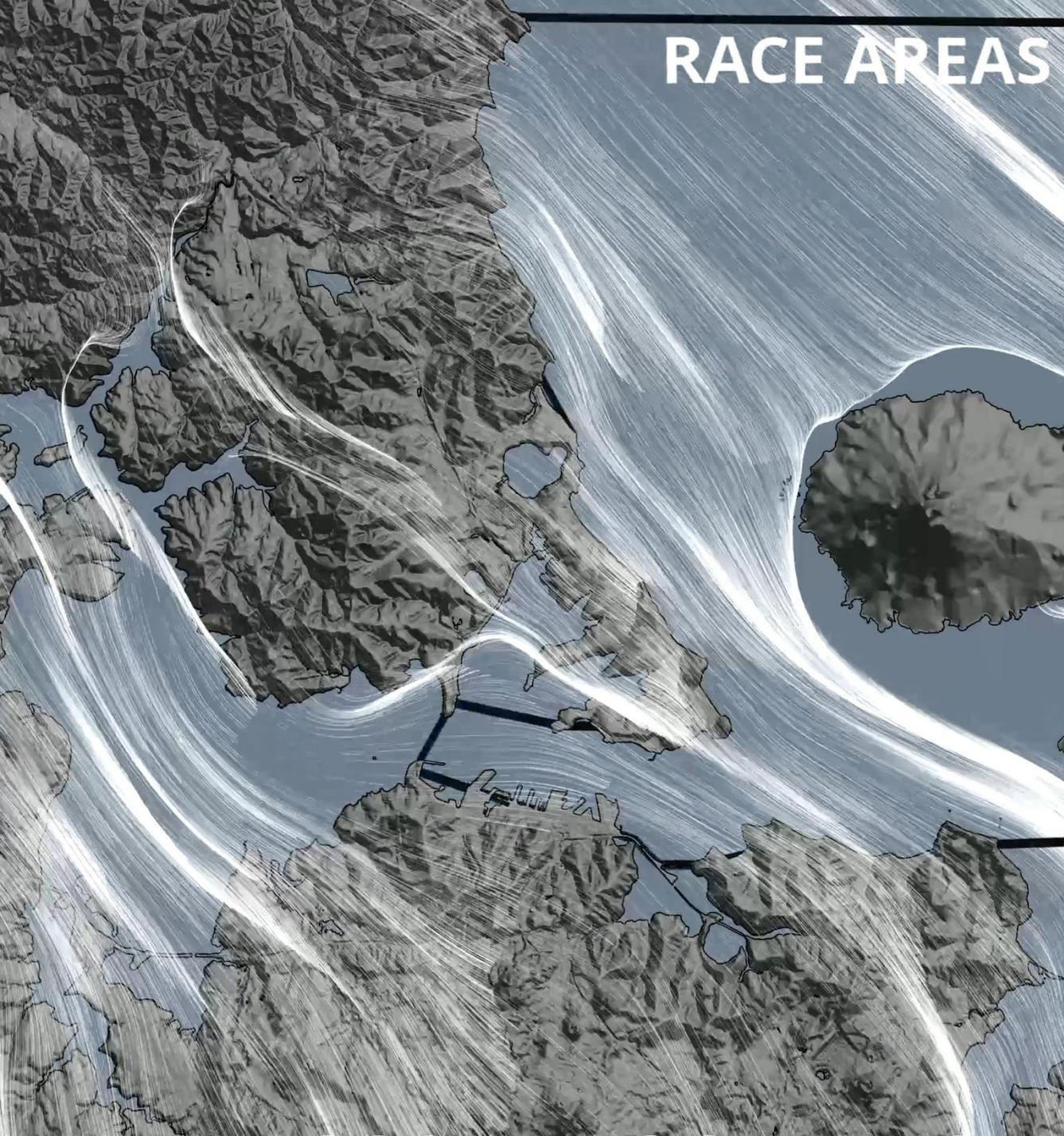
What does
advanced
technology
sovereign
capability
look like?

An aerial photograph of a racing catamaran on a large body of water. The catamaran is dark-colored with red and white accents, featuring logos for 'Emirates' and 'Fly Better'. It is moving towards the right, leaving a white wake. In the background, a city skyline is visible across the water, including a prominent tower. The sky is blue with scattered white clouds. A large white triangle graphic is overlaid on the image, pointing downwards towards the catamaran.

RA

TE AIHE

RACE AREAS





FORECAST WIND GUST

SUN
6 pm

How do we use advanced technologies to improve NZ preparedness for future hazards?

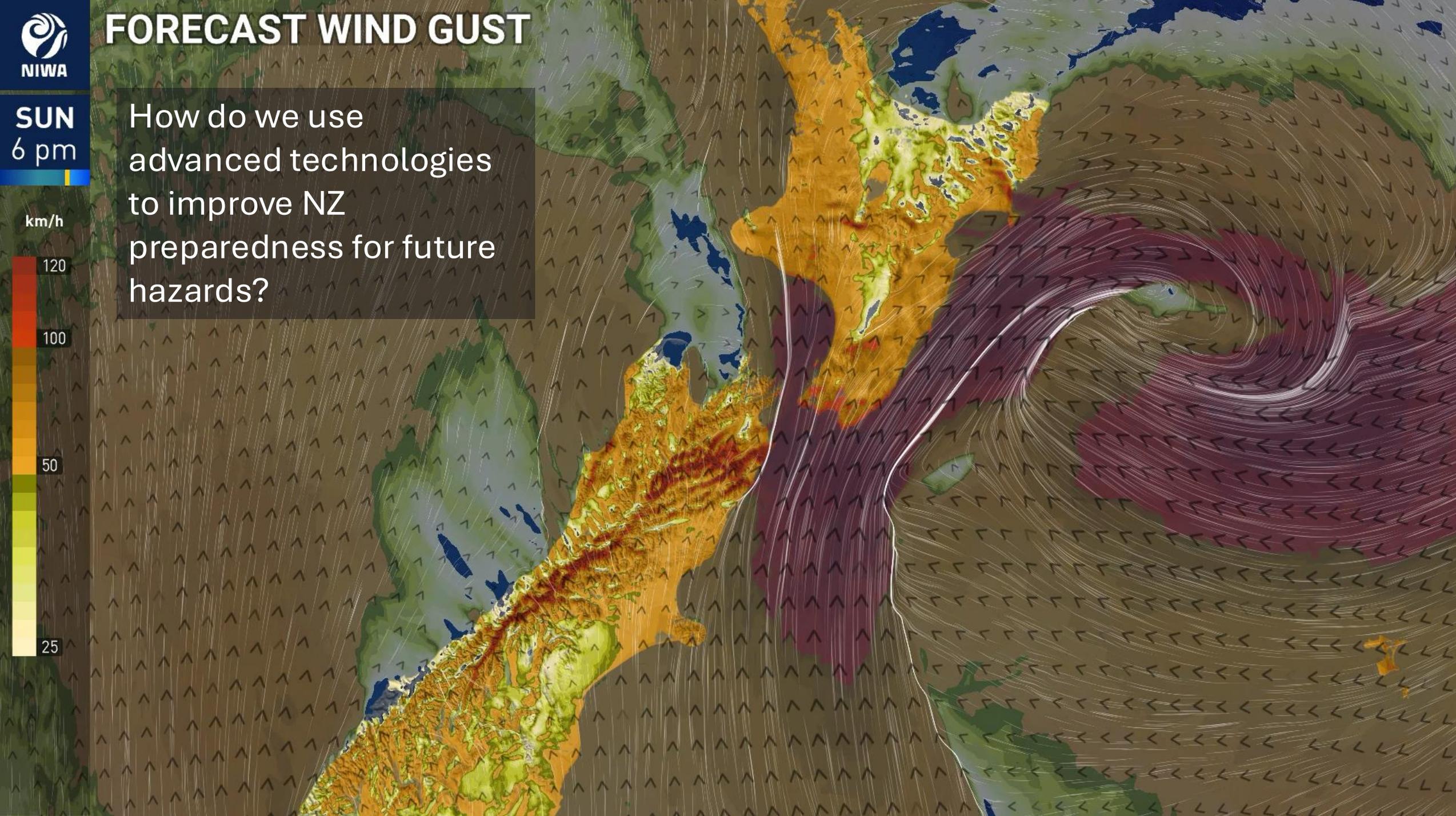
km/h

120

100

50

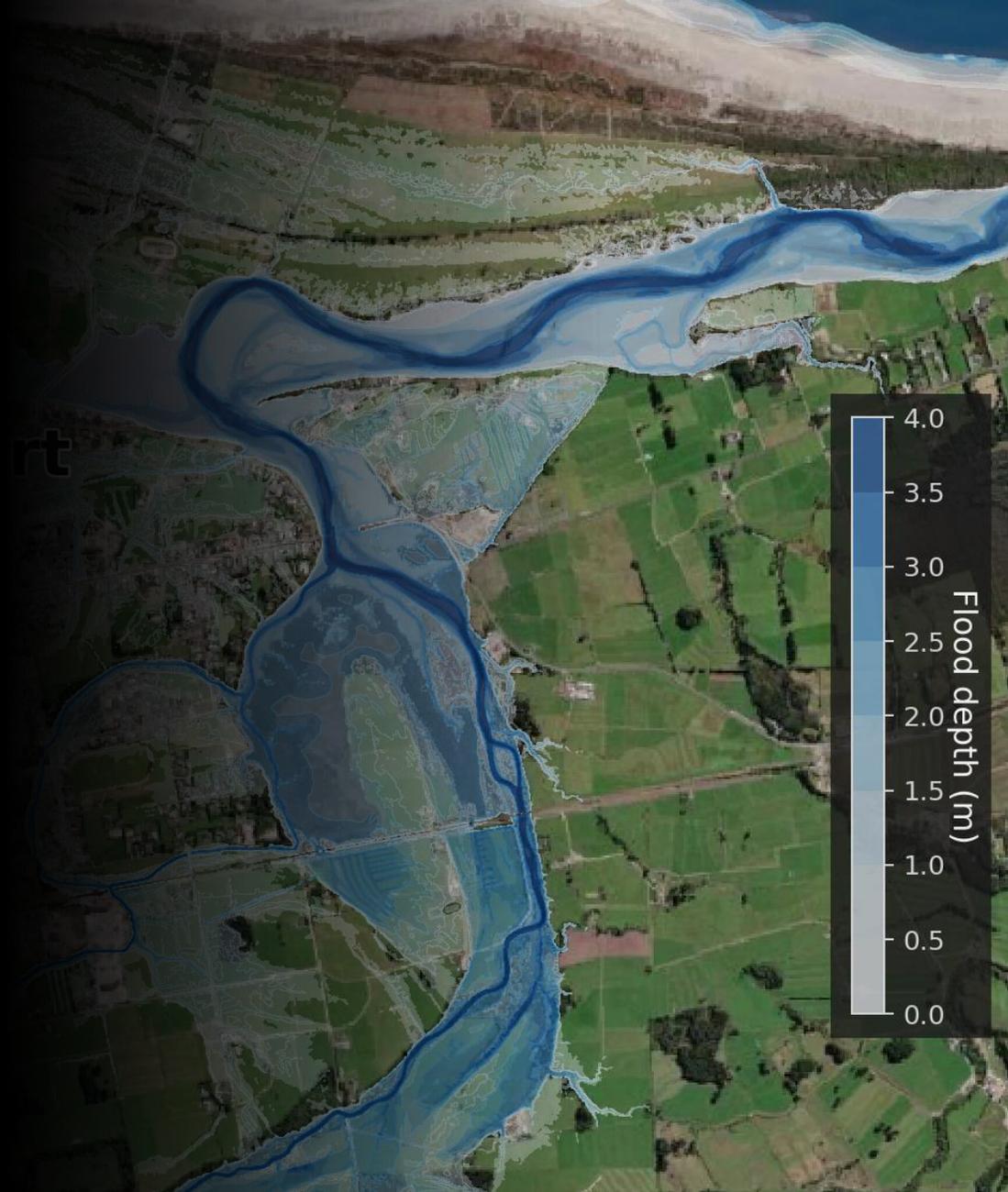
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Addressing Computational Challenges in Earth Sciences with Advanced Technologies

Jess Robertson and Deidre Cleland

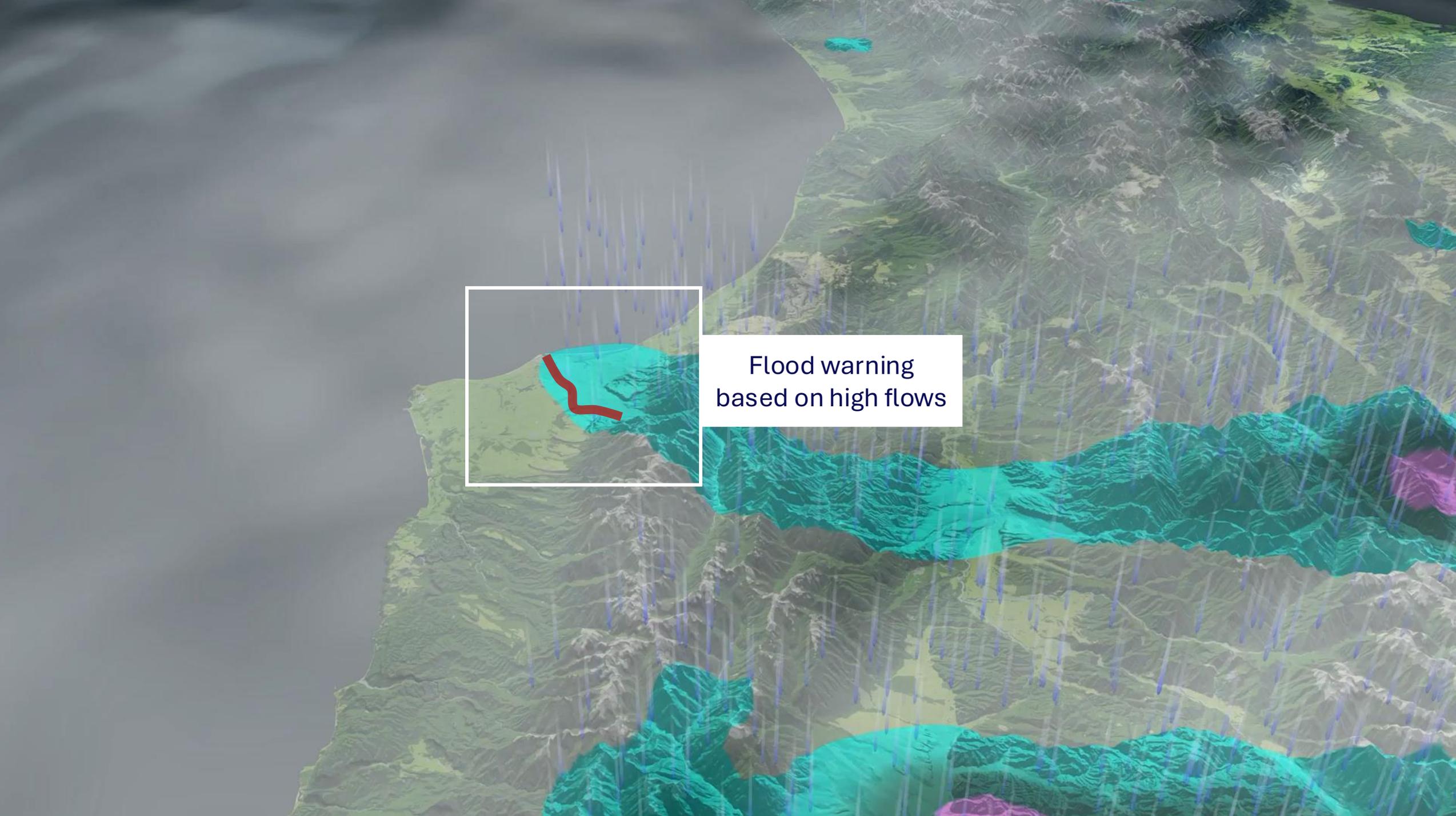
Earth Sciences NZ



Forecasting flood maps in real-time with ML



Deidre Cleland

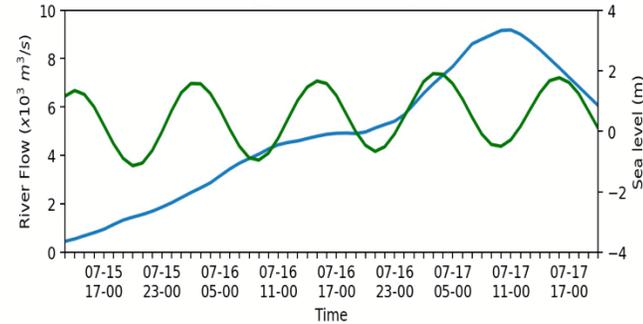
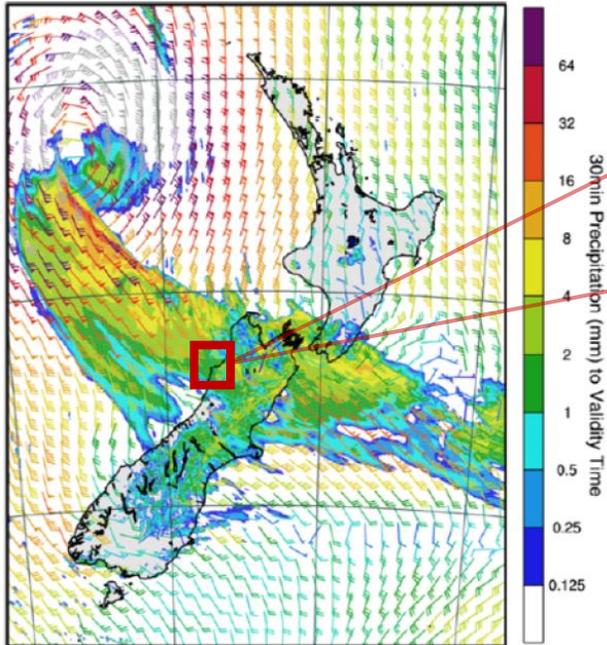


Flood warning
based on high flows



RiskScape forecasted human safety threat, derived from flood map.

Flood maps with physical models



— Sea level at the Westport coast
— River flow down the Buller



10-24 hours

with hydrodynamical modelling



Deidre Cleland

ML forecasted flood maps

Westport

July 15th 17:00



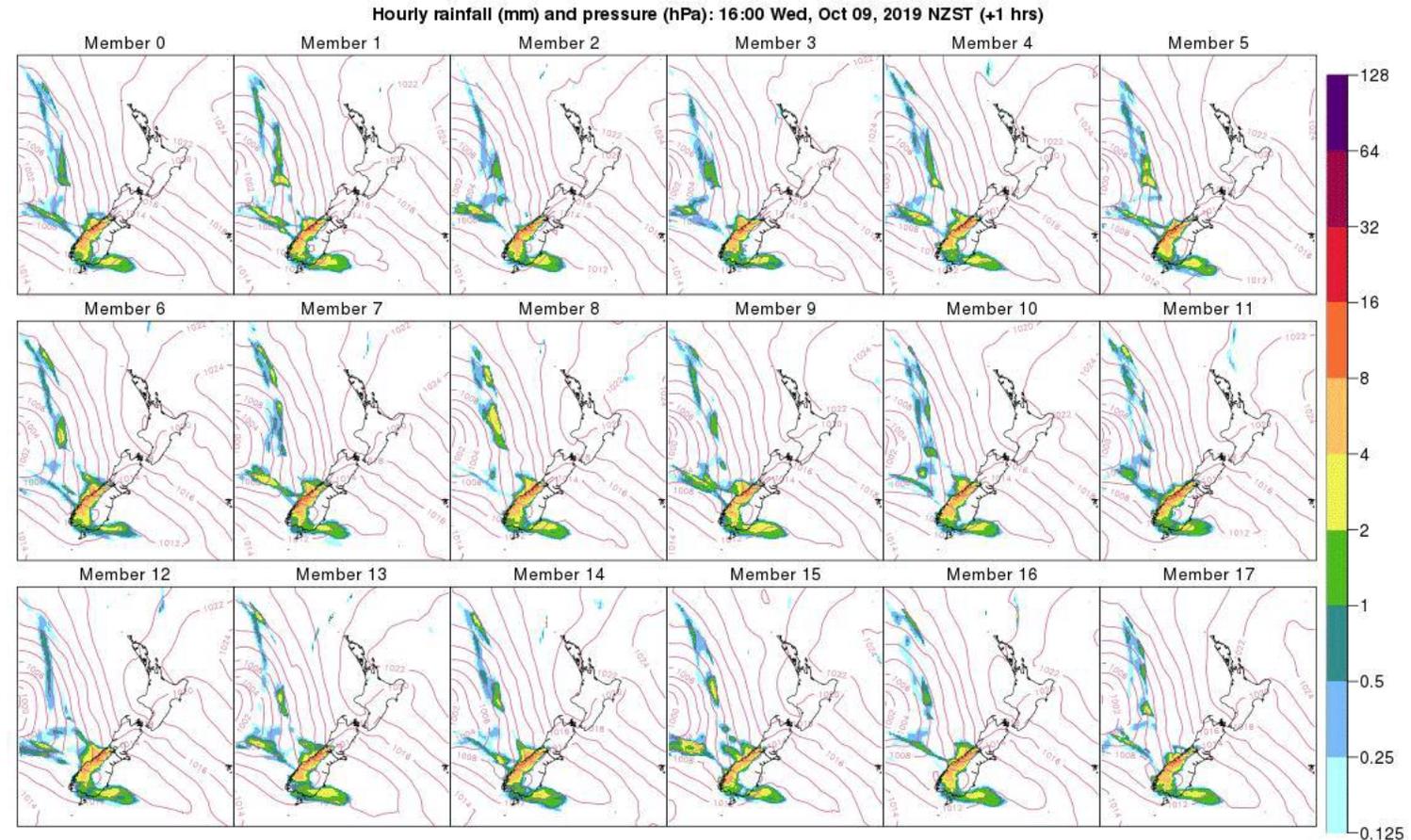
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Ensemble forecasts propagate through to maps

Ensemble forecasts are used to capture forecast uncertainties.

The ensembles feed through to our hydrological model to predict a range of possible river flows.

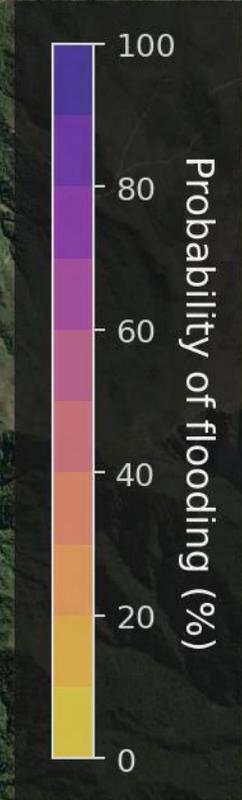
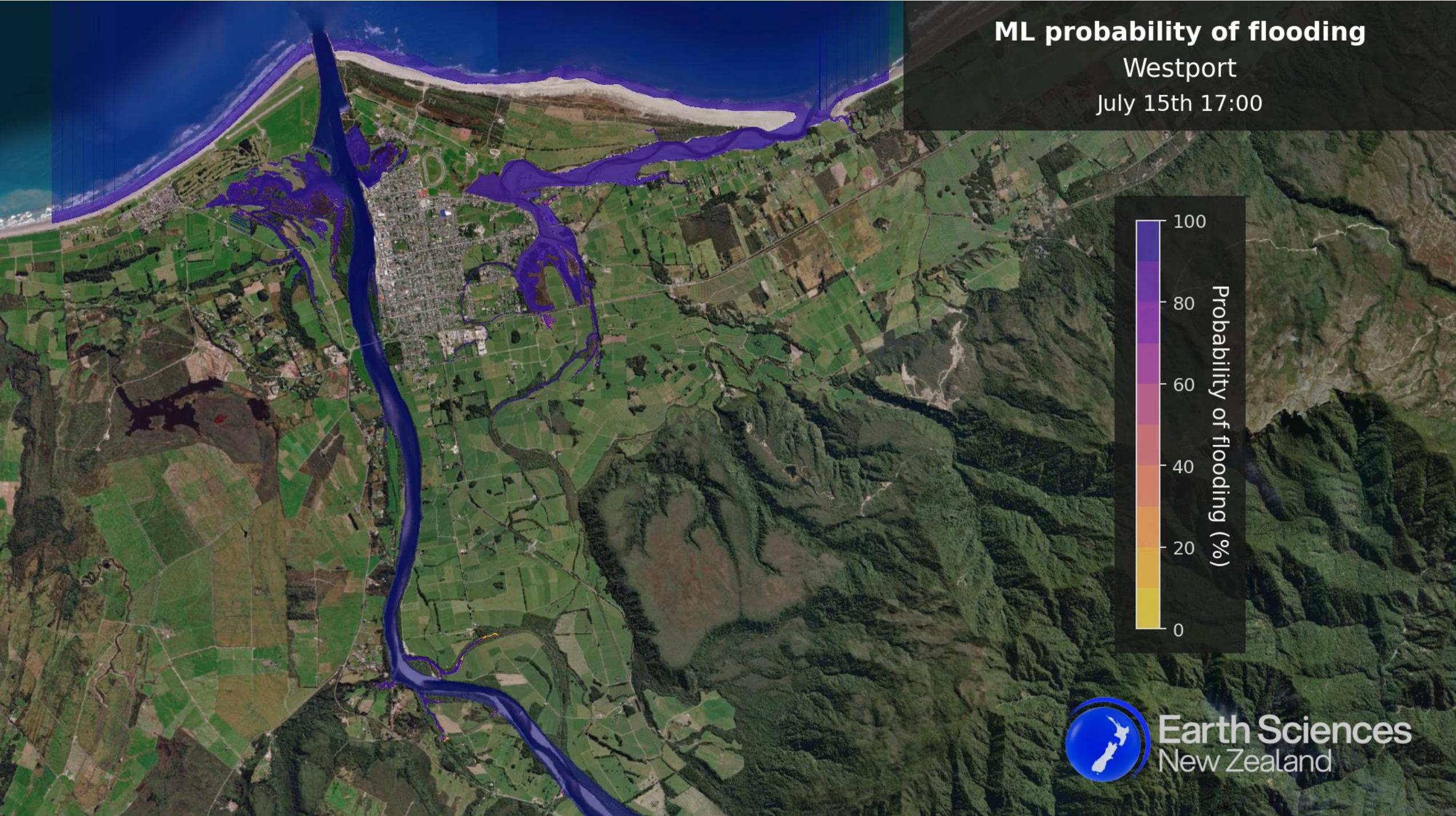
With an efficient ML flood map model, the ensemble river flows can be used to forecast a probability of flooding.



ML probability of flooding

Westport

July 15th 17:00

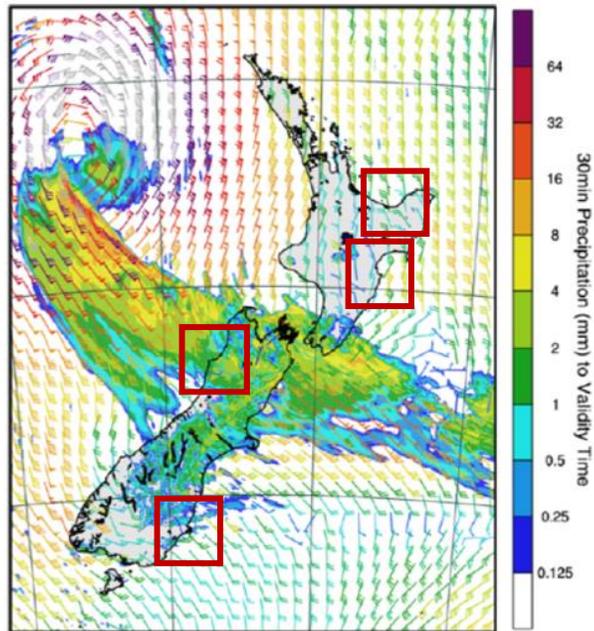


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NZ-wide real-time flood map forecasting

Can we develop one model to forecast flood maps anywhere in NZ, for any storm?

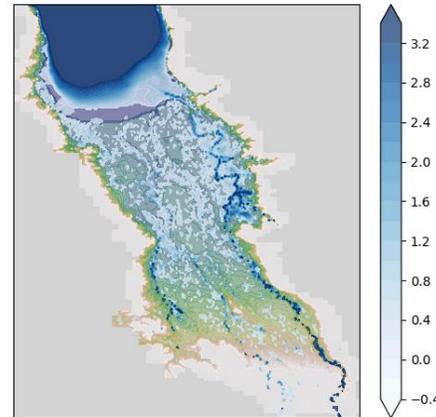
Forecasted weather event



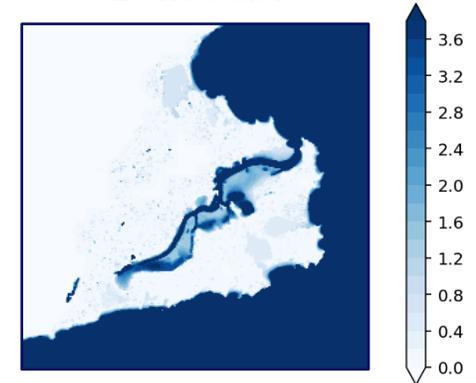
Real-time
ML model



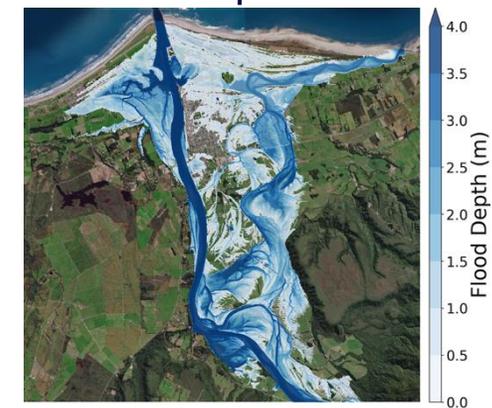
Heretaunga Plains



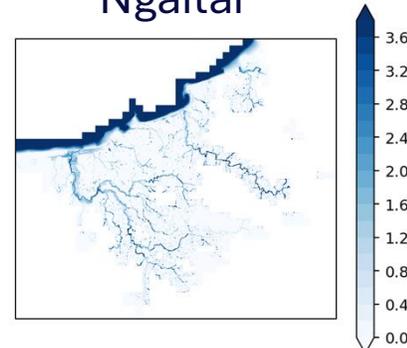
Dunedin



Westport



Ngaitai



Deidre Cleland

NZ-wide real-time flood map forecasting

National dataset of flood maps now available for training NZ-wide model.

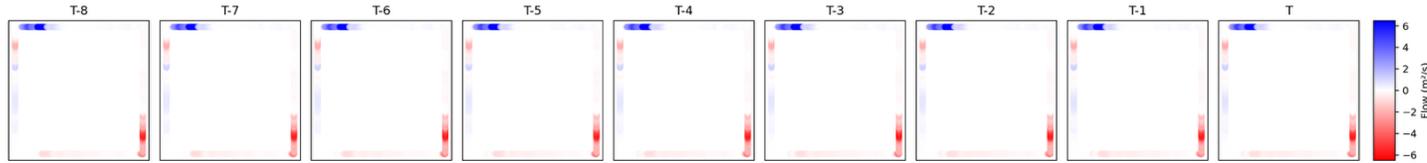


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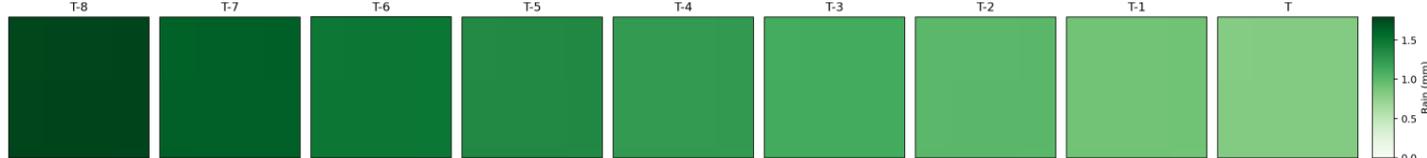
Tiled NZ-wide ML model



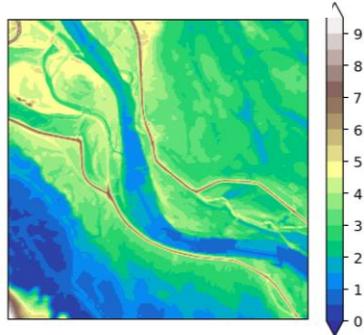
Flow from rivers and coast (T-8 -> T)



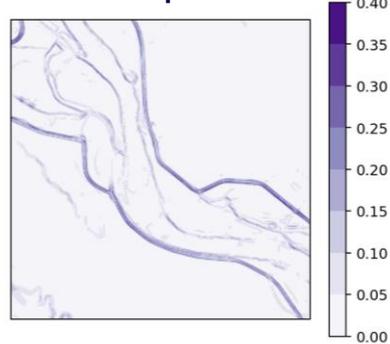
Rain incoming (T-8 -> T)



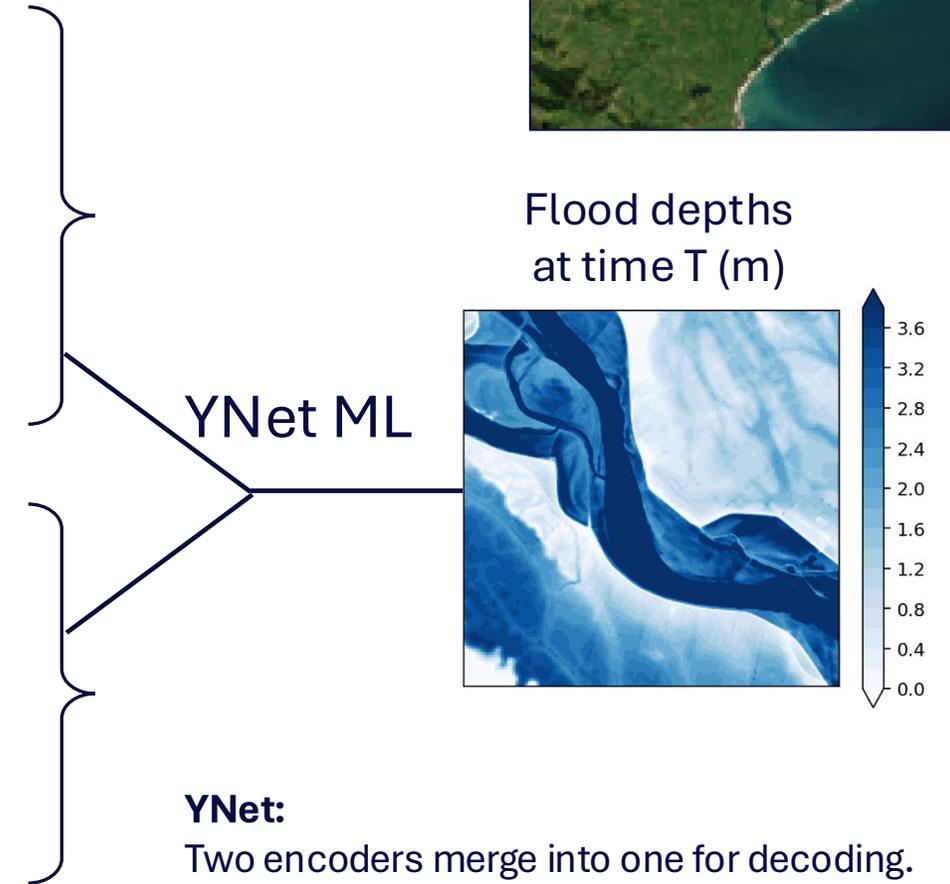
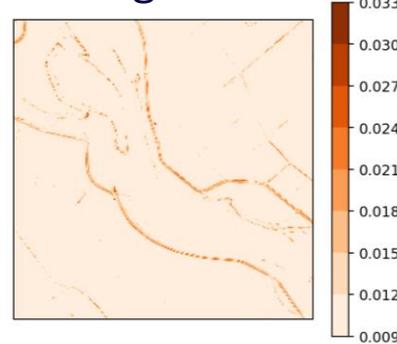
Elevation



Slope

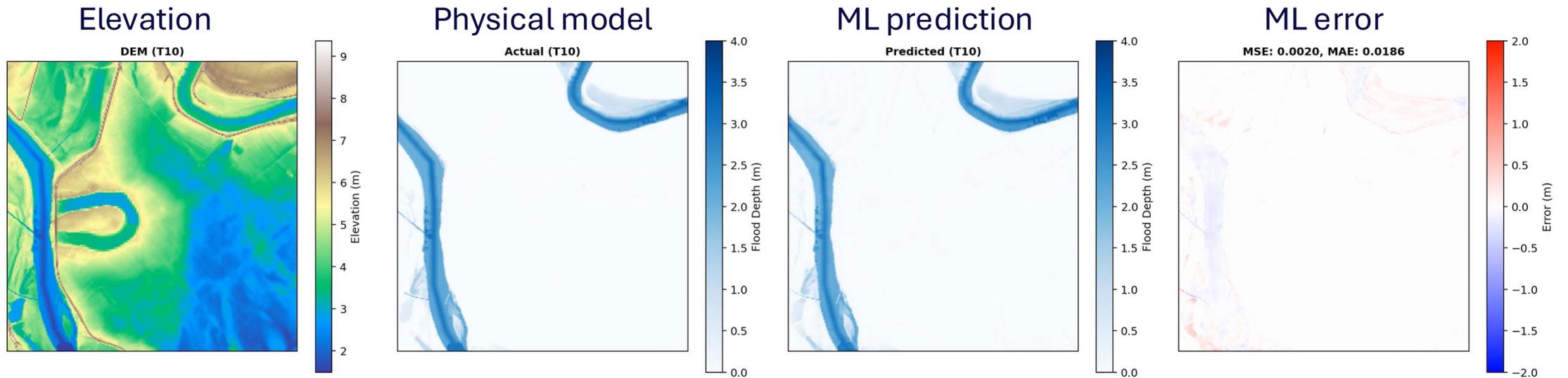


Roughness



Tiled NZ-wide ML model

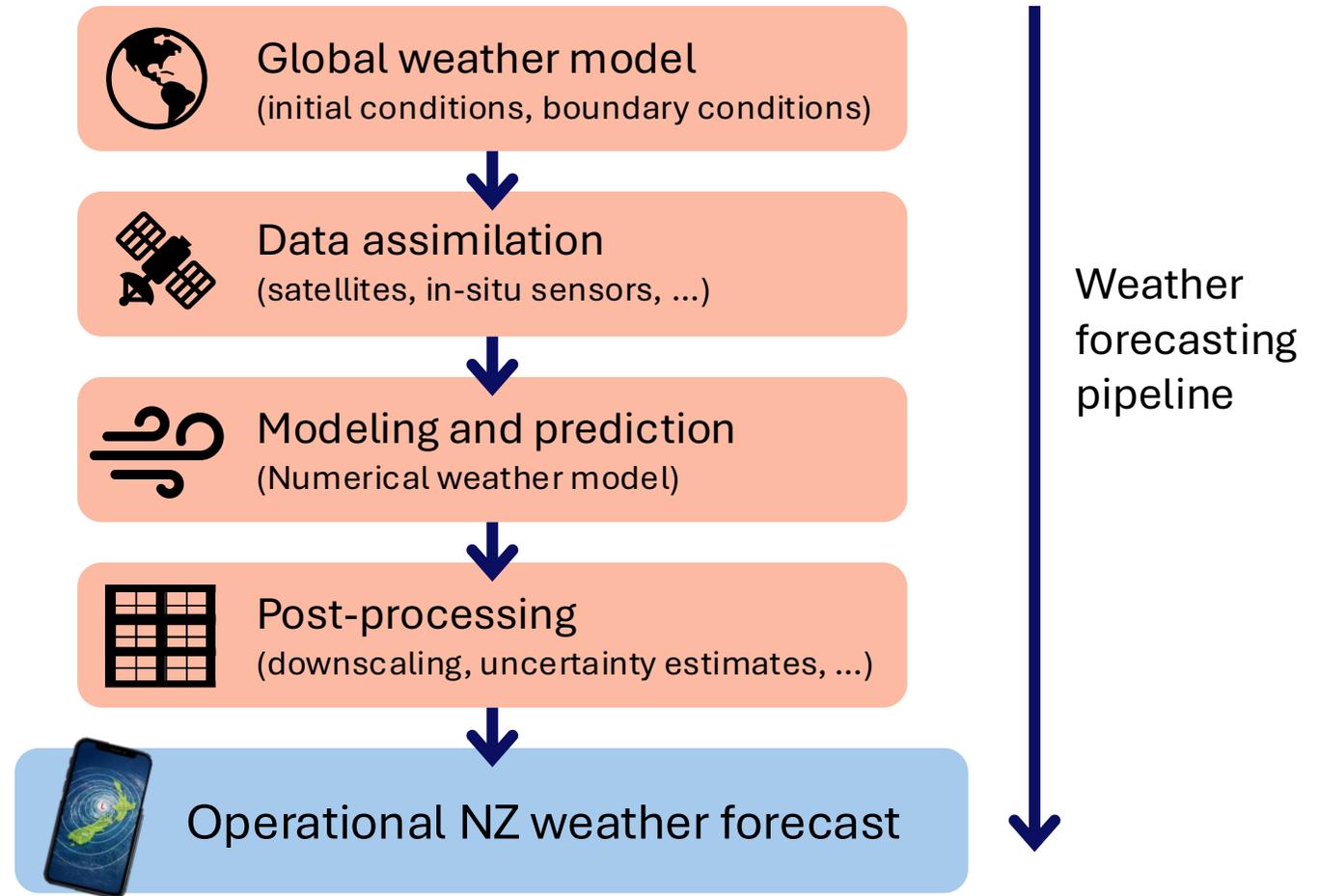
Prediction outside training data showing potential...



Deidre Cleland

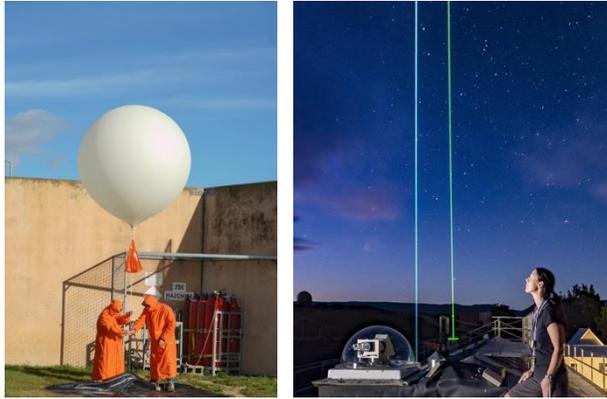
Quantum computing for Earth Science

Exploring the potential for quantum computing to address Earth Sciences computational challenges.

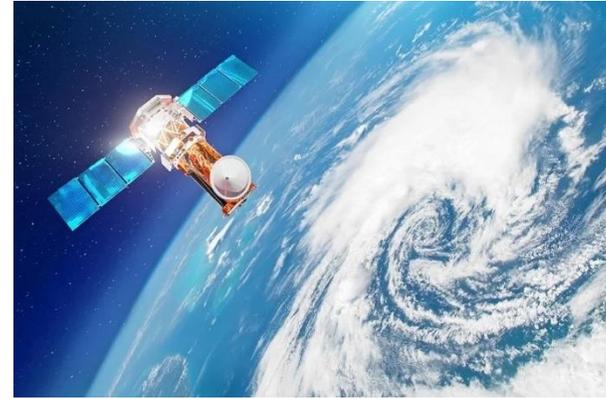


Quantum computing exploration at ESNZ

Case study #1:
Quantum chemistry for
atmospheric applications



Case study #2:
Optimisation for
data assimilation



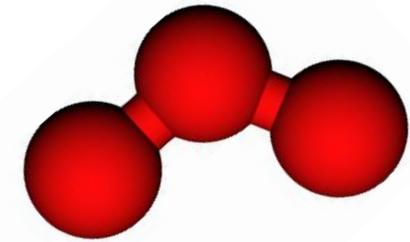
Build capability, tools, and experience in applied quantum computing algorithms.

What can be done using existing packages and technology?

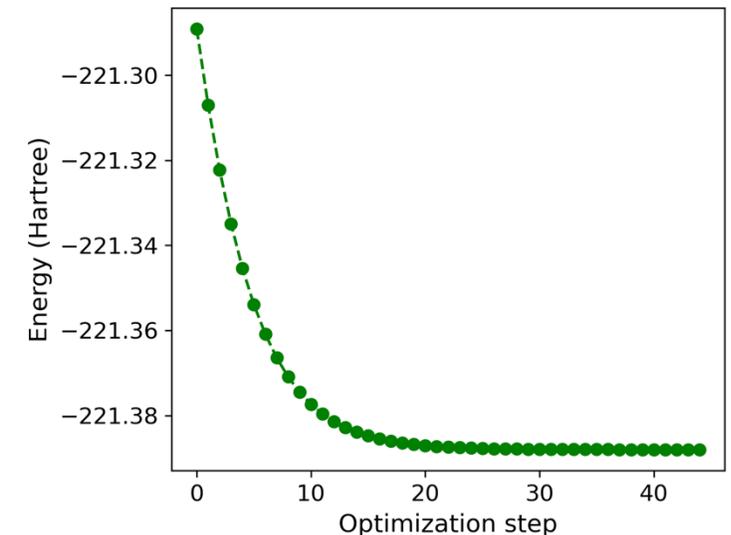
Is there future potential for Earth Science worth pursuing?

Quantum computing for quantum chemistry

- Used quantum computing simulators to estimate the ground-state energy of ozone.
- Characterised the features of quantum chemistry problems that make them strong candidates for quantum computing – to transferring insight to other applications.
- Assessed the cost, accuracy, scaling.
- Looking at future algorithms with potential as quantum technology continues to advance.
- Implement on quantum computer.

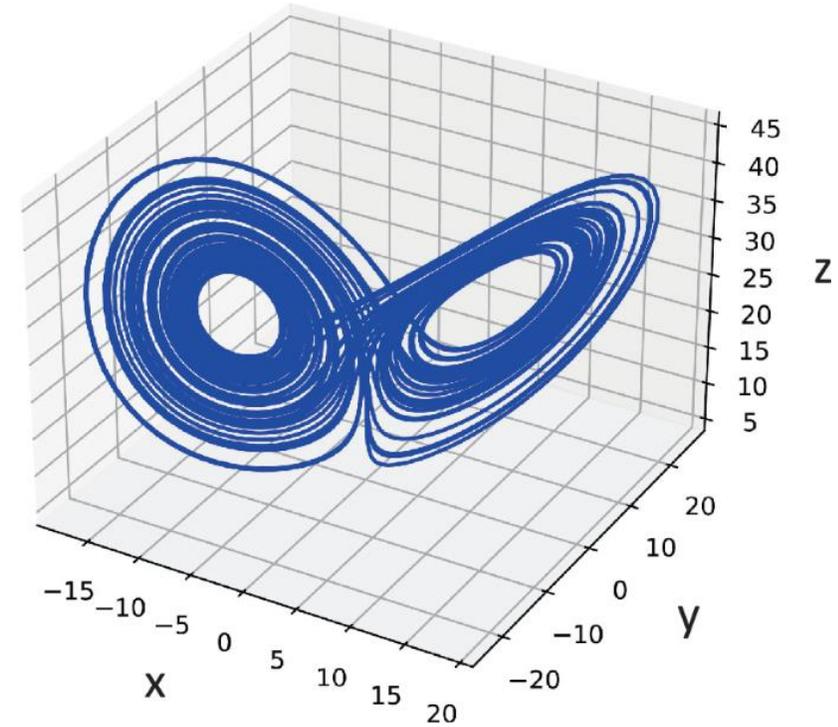


Ozone (O_3)



Quantum computing for data assimilation

- Used Lorenz-63 (a simplified model of atmospheric chaos) to test 4DVar data assimilation methods.
- Formulated the data-assimilation problem to be solved with quantum computing.
- Identified key limitations that prevent beneficial scaling of this approach to realistic systems.
- Exploring alternative pathways for more practical or scalable solutions for future implementation.



Lorenz-63: A simplified model of atmospheric chaos.

Thank you.

Pātai?