A national flood awareness forecasting system for ungauged catchments in New Zealand

*Shaping a more resilient tomorrow*

SPC & NIWA learning exchange

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https://sv-se.facebook.com/NIWAWWeather/videos/canterbury-flooding/229162631972248/

Climate, Freshwater & Ocean Science
NZ river flow forecast project – key contributors

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https://niwa.co.nz/climate/research-projects/river-flow-forecasting
Outline

1. Ensemble flood forecasting – towards national and global scale
2. Hydrometeorological and flood context in NZ
4. Forecast communication
5. Evaluation of NZ river flow forecasting system
6. Challenges and perspectives
Ensemble flood forecasting – towards national and global scale

European Flood Awareness System (EFAS)

Global Flood Awareness System (GLOFAS)

GLObal Flood Forecasting Information System (GLOFFIS)
Insurance Costs¹:
Between 1996-2014: $442 Million (NZD)
2017-2019: >$350 Million (NZD), 6 ex-cyclones

Responsibilities for floods:
Local authorities - primary agents responsible for civil defence emergency management (CDEM)

¹Reference: Insurance Council of New Zealand (ICNZ)
National scale river flow forecasting system for New Zealand

Meteorological forcing
- Global UM ~12km
- NZLAM 4.4km
- NZCSM 1.5km

Hydrological forecasts
- New Zealand Water Model (NZWaM)
- Hydrological initial conditions
  - Climate data (VCSN+) followed by concatenated NZCSM forecast up to cycle time T (bridging observational gap) forced through NZWaM

Post-Processing
- Reference flow climatology
  - 40 years simulations from climate observations
- Exceedance thresholds
  - Percentile thresholds computed from reference flow climatology

River flow categories
- Geofabric dataset
  - Topography, river network, soil type, land use, lakes

Forecast Communication

Climate, Freshwater & Ocean Science
### Why developing a national scale system for New Zealand?

**Shaping a nationwide approach for New Zealand’s river flow forecasts**

- A co-design approach: we seek to complement and support existing local models and work together to shape research that is designed for decision-makers’ needs and priorities.

<table>
<thead>
<tr>
<th>Stakeholders</th>
<th>Format</th>
<th>Purpose and outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 organisations</td>
<td>presentations</td>
<td>Project awareness, formation user group, complementing strategy</td>
</tr>
<tr>
<td>(central, regional gvt)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9 organisations</td>
<td>workshops</td>
<td>Introduce methodology, improved user needs and priorities, data agreements</td>
</tr>
<tr>
<td>(regional gvt)</td>
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</tr>
<tr>
<td>Conference</td>
<td>questionnaire</td>
<td>Stakeholder mapping and decision-making</td>
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<tr>
<td>attendees</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8 participants</td>
<td>interviews</td>
<td>Insight to aligned research and capabilities, feedback on tool</td>
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**Timeline:**
- 2017-2018
- 2019, 2020
- Dec 2018
- 2019
Getting enough (long historical records) and real-time data is challenging.

**Rain data at NIWA**

**Flow data: no national database**

**Modelled rivers**

- Rain data at NIWA
- Flow data: no national database
- Modelled rivers

~300 sites

~50,000 basins
The national scale approach produces forecast relative to a long-term modelled flow climatology at gauged and ungauged catchments

Flow climatology

- 40 year model simulations using observed climate data (VCSN)
- Model flow statistics Flow Duration Curve (FDC) at ~50,000 basins

Categorical flow forecasts

- < 1% FDC
- 2% - 10% FDC
- 10% - 33% FDC
- 33% - 66% FDC
- 66% - 90% FDC
- 90% - 100% FDC

[Diagram showing Flow Duration Curve (FDC) with various categorical flow forecasts]
Example absolute and categorical river flow forecasts for a flood event 26th March 2019
The scientific workflow for operational forecasting is very complex

**Cylc (“Silk”)**

Weather forecast suite

National River flow forecast suite

High Performance Computing

doi: 10.1109/MCSE.2019.2906593
Streamflow forecast initialisation are constrained by operational data availability
Forecast visualisation and warning dissemination at national scale

Daily videos publicly available

Website under construction: Webapp ESRI

Dissemination via DOC national park forecast and social media
Flow climatology evaluation: categorical flow (1975-2020)

What was the accuracy of model in predicting the correct category, relative to that of random chance?

Categorical performance: Gerrity Score (GS) for 6 categories
Flow climatology evaluation: categorical flow (1975-2020)

What was the accuracy of model in predicting the correct category, relative to that of random chance?

Absolute performance

Relative performance

All time vs Seasonal

FDC sampling
Flow climatology evaluation: flood category (1975-2020)

How well did the “yes” flood event predicted correspond to the observed “yes” flood event?

Flood performance: Critical Success Index (CSI) 99% threshold (>2yr)
Flow climatology evaluation: flood category (1975-2020)

How well did the “yes” flood event predicted correspond to the observed “yes” flood event?

Contingency table

<table>
<thead>
<tr>
<th></th>
<th>Observed (True class)</th>
<th>Simulated (Predicted class)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Hits</td>
<td>False Alarm</td>
</tr>
<tr>
<td></td>
<td>Misses</td>
<td>Correct negative</td>
</tr>
</tbody>
</table>

Model underpredicts baseflow

Model overpredicts # high flood peaks

Dry             Wet

Model underpredicts baseflow

Model overpredicts # high flood peaks

Wet

Too many False Alarms

Worse flood performance

Flood performance: Critical Success Index (CSI) 99% threshold (>2yr)
Forecast performance: 2.5yr reforecast (2018-2020)  
(ongoing work, recent flow data update)

**Flow forecasts (preliminary)**

Ensembles improves performance, error on average by 0.5 of a category

Slight wet bias between flow climatology and NZCSM forecasts

Preliminary evaluation of a national-scale river flow forecasts for New Zealand, NIWA SSIF report, 2020250CH
Canterbury flooding 29-31 May 2021

Full evaluation underway but forecast spatial pattern matched what occurred according to media reports and NIWA staff on the ground
Challenges and Perspectives

• Real-time access to climate and flow data at national scale is problematic (24h embargo and no national flow database)
• Engagement with stakeholder shaped a co-design process and tool design
• Relative river forecasts provide more detailed information than rainfall forecast alone about which rivers will be affected by high flow and when
• Further model developments required for flood process representation
• Absolute flow forecasts: calibration or machine learning with bias correction
• Links to International community (e.g. HEPEX) critical
• Scientific feasibility proof of concept established for New Zealand
Conclusion

Shaping a nationwide approach for New Zealand’s river flood forecasts

➢ Proof of concept of a national scale river flow forecasting

➢ Models, data, HPC, machine learning and social science play a central role
Thank you

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