Enhancing Heatwave Forecasting & Public Uptake in British Columbia

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OUTPUTS

- Needs analysis and innovation report validated by ECCC
- Report on GenCast performance for forecasting PNW 2021 heatwave
- A simple guide to machine learning models for weather forecasting

Project Overview

Extreme heat events in British Columbia are intensifying, but the public response to heat warnings remains low. This collaborative research project explores how we can:

- **Enhance technical forecasting systems**
- **Strengthen public understanding and action**
- **Design inclusive, user-centered warning tools**

We explored how AI and user-centered design principles can transform BC's heat wave preparedness.

Formative Needs Assessment

The project began with an in-depth Needs Assessment, guided by a human-centered design approach. We engaged internal ECCC stakeholders and decision-makers to understand:

- Gaps in BC's current heatwave forecasting system
- Public challenges and behavioral barriers
- Visioning exercises for an ideal system

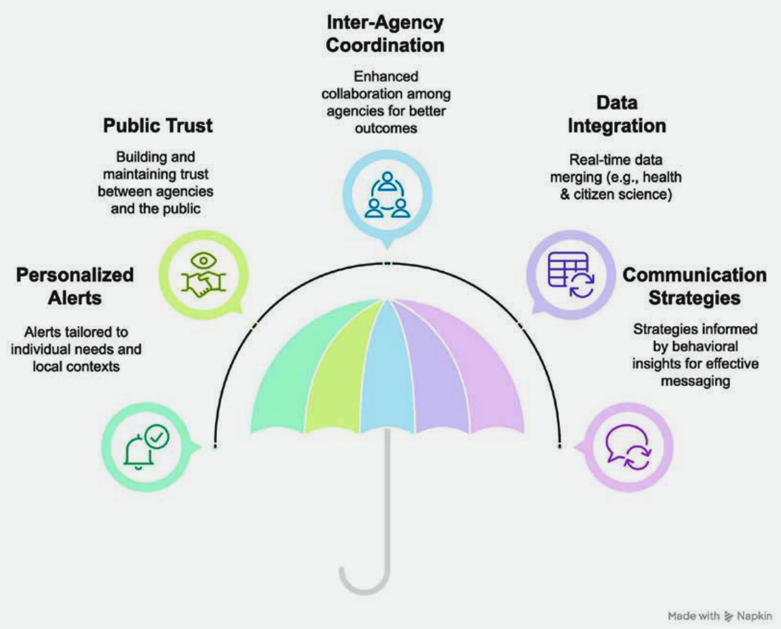
Any system built to address heat risks must be both technically robust and behaviorally smart—designed not just to inform, but to activate and empower users.

Key Priorities & Opportunities

- Develop user-friendly forecast outputs and decision support tools
- Use AI/ML to automate forecasts and generate plain-language alerts
- Integrate behavioral insights and gamification to drive public engagement
- Design for accessibility, personalized communication, and multi-agency coordination

Challenges & Gaps

- Limited real-time data (e.g., health impacts, local conditions) to tailor warnings and response
- Gaps in feedback mechanisms to understand public needs and preferences
- Inconsistencies in how warning messages and preparedness information gets communicated to agencies and the public
- Resource constraints hinder adaptation and outreach efforts and limit response capacity



"Our project has illustrated that enhancing heatwave forecasting and public uptake isn't just about technology—it's also about people. By prioritizing accessibility, usability testing, and inclusive design from the start, solutions can bridge the gap between forecasting and public action."

Our work envisions a system that:

- Learns from user feedback
- Guides through targeted, actionable steps
- Integrates with devices people already use (e.g., wearables, health apps)
- Empowers communities through both high-tech and low-tech access

SUB-PROJECT 1: *Perceptions of AI in Forecasting*

Explored public and institutional trust in AI-generated forecasts.

- Found AI can enhance accuracy but raises trust and transparency concerns
- Identified "algorithm aversion" as a challenge: people prefer human forecasts when errors occur—even if AI is more accurate
- Emphasized need for explainable AI, iterative design, and user feedback loops
- Recommended early usability testing and public education on AI's role in forecasting

Trust is not automatic. Design AI systems that are clear, participatory, and human-informed.

SUB-PROJECT 2: *Bridging Forecasts and Public Action*

Focused on turning awareness into action, especially for at risk populations. Identified innovations from global best practices:

- Color-coded warning systems to improve clarity (e.g., Ireland, Germany)
- Citizen science integration and and real-time data loops (e.g., Weatherhood, UK Met Office)
- Finance-integrated alerts—e.g., pairing early warnings with parametric insurance and heat safety funds
- Gamification and public education tools to drive long-term engagement (e.g., Minecraft for resilience learning)

Forecasts are only effective if people act on them—public action needs clarity, financial resilience, and behavioral nudges.

Heat Wave Resilience through Gaming

Climate Resilience Center integrating climate resilience into gameplay, aiming to reach 300 million players by 2030.

SUB-PROJECT 3: *Forecasting Innovation & Technical Modelling*

Focused on evaluating emerging heatwave forecasting techniques, including:

- State-of-the-art AI/machine learning models (GEN CAST)
- Retrospective testing on events like the 2021 BC heat dome
- Technical feasibility for extended lead times and impact-based forecasting

Innovation Spotlight

Challenge

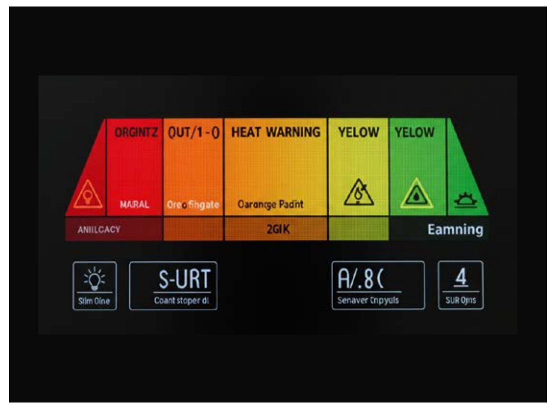
- Public doesn't trust AI forecasts
- At risk groups often lack resources to respond
- Generic warnings don't engage
- Siloed communication across agencies
- Lack of feedback on what works

Innovation

- Co-design with end users, usability testing, explainable AI
- Finance-linked warning systems (e.g. micro-insurance, safety funds)
- Personalization + color-coding + gamified alerts
- Integrated systems and "single voice" strategies for messaging
- Iterative feedback loops via social media and citizen science

Color-Coded Warning Systems

Tiered alert systems improve public understanding and appropriate response to varying heat severity levels



Citizen Science Networks

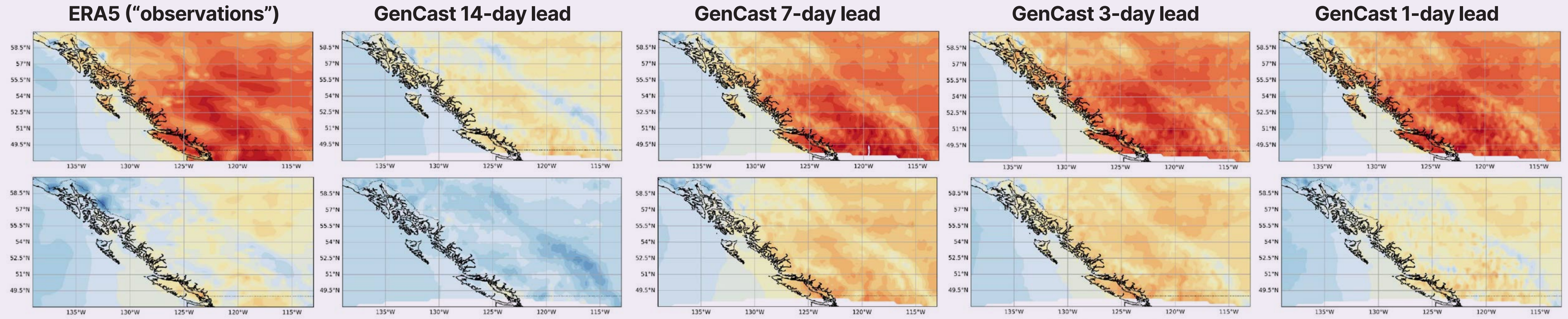
Crowdsourced data enhances granularity of forecasting models while increasing public engagement

Integrated Finance

Combining alerts with financial mechanisms ensures at risk populations can take protective action

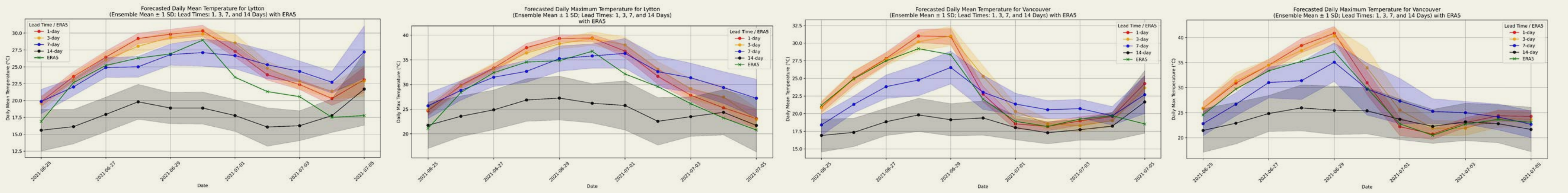
Evaluating Google GenCast's Prediction of 2m Temperatures during the 2021 Heatwave

In late June 2021, a record-breaking heatwave struck the Pacific Northwest. We show forecasts for June 29, 2021, the peak of the heatwave, comparing observations (ERA5 Reanalysis) to Google GenCast Forecasts at Decreasing Lead Times



Evaluating Google GenCast's Prediction of 2m Temperature evolution during the 2021 Heatwave

Among the affected locations, Lytton, (BC) experienced the most extreme temperatures, breaking Canada's all-time heat record at 49.6 °C. We show the evolution of daily mean and daily max temperature at Lytton (left 2 plots), and Vancouver (right 2 plots) in "observations" (ERA5 reanalysis) and GenCast at different leadtimes. In each plot, the lead time is relative to the day being forecast, so the forecast initialization date changes within each timeseries.



14-day lead:
GenCast underestimates both daily max and mean temperatures.

Shorter leads (7, 3, 1 days):
As the event drew closer, the forecast flipped to overestimating the daily maximum temperature – predicting peak values higher than those observed in ERA5. Despite this overshoot of the extreme highs, the daily mean temperature predictions became much more accurate at these shorter lead times, closely aligning with the ERA5 reanalysis values.