Integrated Modelling for Prediction and Management of Change in Canada's Major River Basins (IMPC)

Overview of the objectives and research themes

Saman Razavi and Al Pietroniro, September 14, 2017

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Overarching Challenges

(I) Failure to link important features of climate, hydrology, water quality, ecosystem, and water management systems. Important positive and negative feedback loops, tipping points, and dynamical behaviour of these human-natural systems are not included in current modelling schemes.

(II) Fragmentation in operations, management, and governance of Canadian water resources systems leads to piecemeal science, policy, and modelling. Our research transcends artificial boundaries (international, provincial, and local) and provides information at scales appropriate for decision-making.

(III) Current practice assumes stationarity, the idea that the past empirical record is a basis for understanding the present and future conditions. We now know that stationarity is dead and that our environmental systems are in the throes of unprecedented climate and environment change.

Overarching Objective

*"This program aims to develop a pan-Canadian **integrated modelling platform** to diagnose, simulate, and predict interactions amongst **natural and human-driven water-resource components** of the changing Earth and environmental systems, and to deliver **optimal decision making tools and solutions** for uncertain future water resources, considering the range of **stakeholder needs** in Canada's major river basins."*

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Structure

This program has assembled a strong transdisciplinary research team

- 5 universities, 12 government agencies and more than 10 other users
- Strong international advisory team
- Our team integrates atmospheric science, hydrology and ecology with social science, computer science, economics and water resource engineering
- Funding $1.65 M for the first 3 years (ending August 2020) with possibility for extension for another three years
- Benefits from ~$2 M GWF Core Modelling Support in connection with IMPC, in the first three years (Lead: Al Pietroniro)

Geographical Scope

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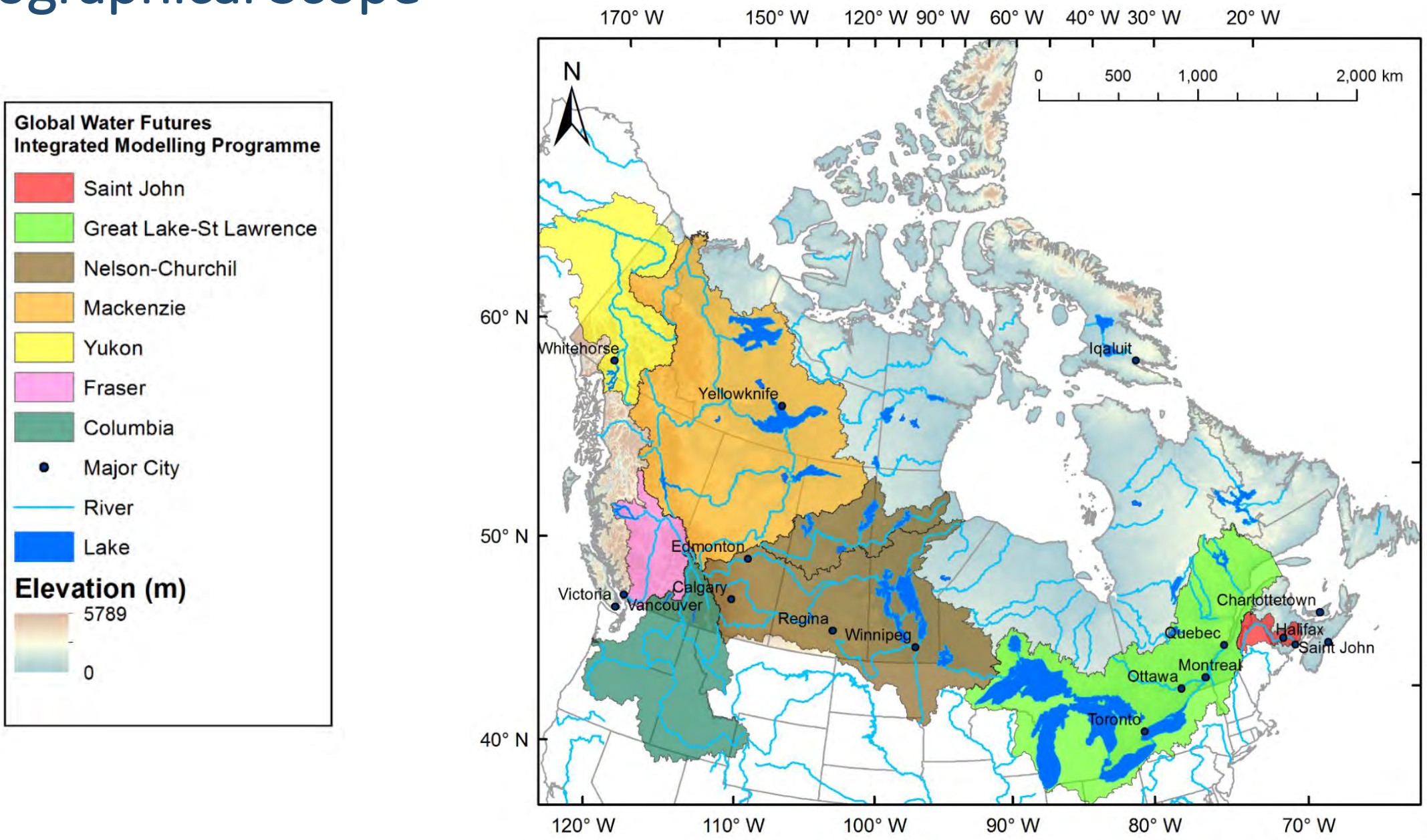

Sask-Nelson-Churchill River Basin: A Test Bed

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Hydrologic Prediction Issues:

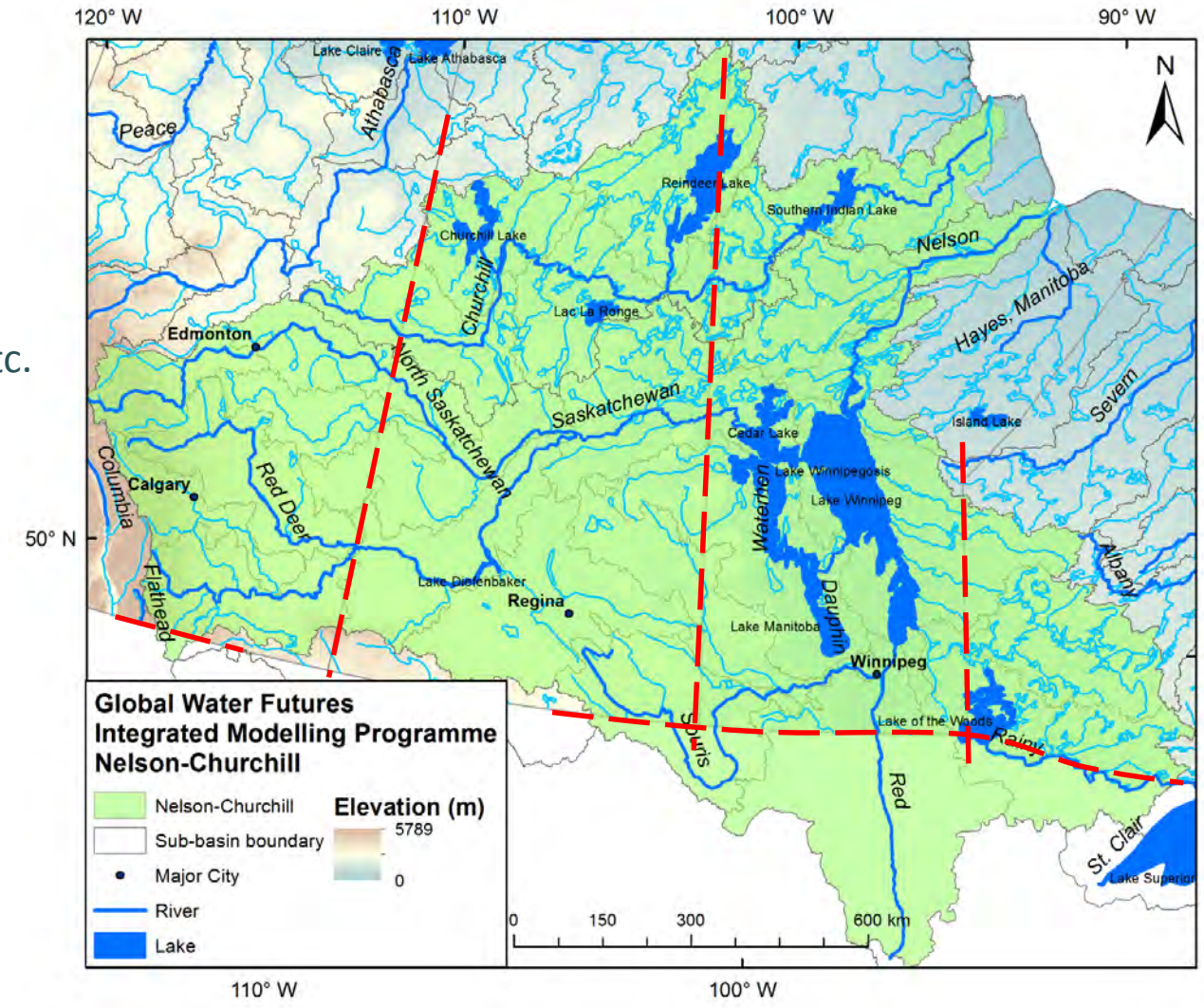
- Complex hydrology (Rockies, prairies, boreal forest),
- Floods and drought,
- River ice,
- Lakes and wetlands,
- Heavily regulated catchments,
- Land cover change and atmospheric feedback loops, etc.

Water Quality Issues:

- Eutrophication and nutrient transport,
- Algal blooms,
- Manure and fertilizer application,
- Contamination due to oil and gas extraction, etc.

Water Management Issues:

- Transboundary water issues,
- "Localized" approach to water management,
- Indigenous water needs,
- Over-allocation and competing demands,
- Environmental flows, etc.



And there are plans for new agricultural and industrial developments.

Research Themes

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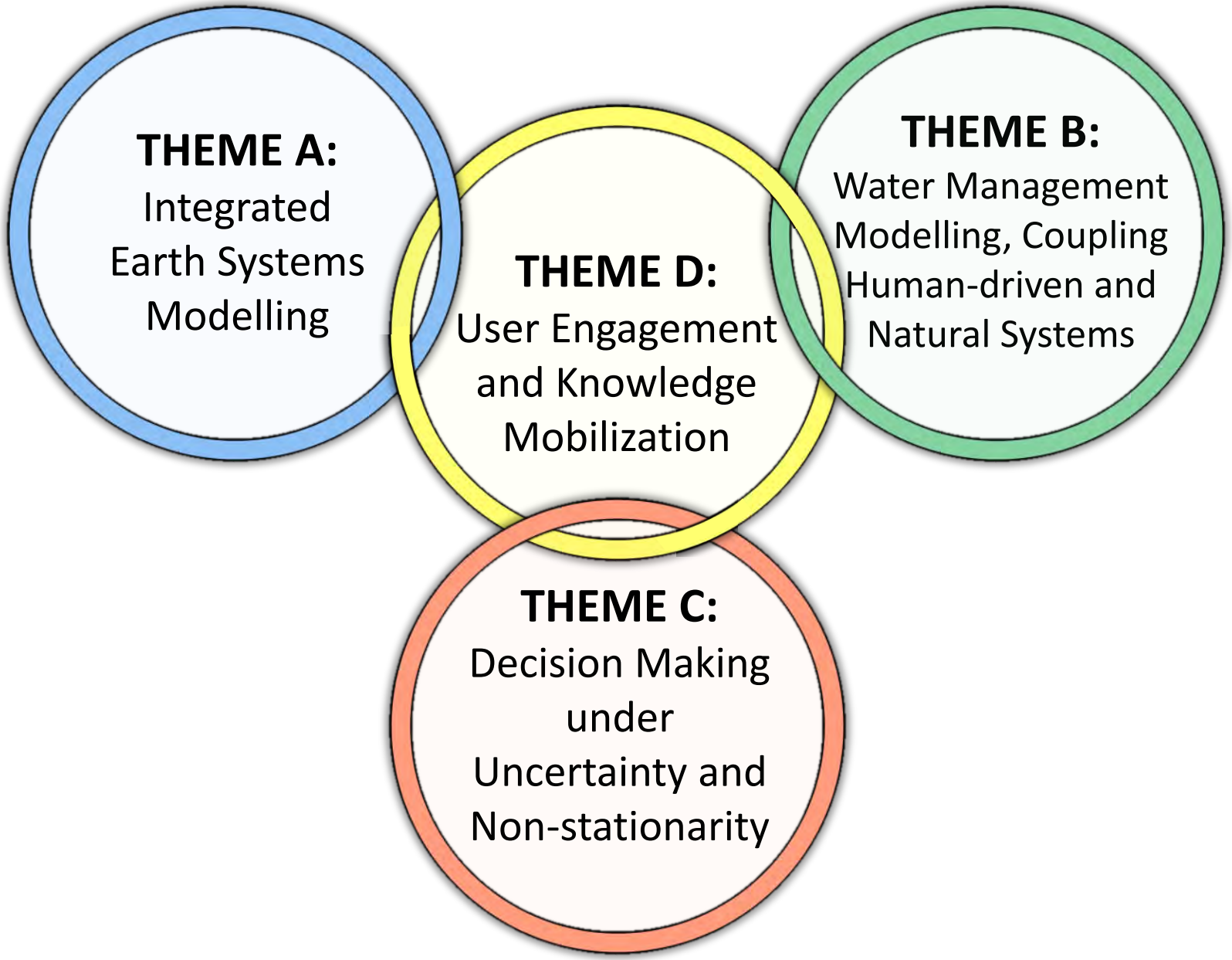

Network Structure and Research Components

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Science Committee

THEME A: Integrated Earth Systems Modelling

A1: Atmospheric Modelling

Coupled atmospheric-hydrologic modelling to represent feedbacks under scenarios of change

A2: Hydrologic Modelling

Improving process representations to better simulate snow, glacier, groundwater, and permafrost

A3: Water Quality Modelling

Integrating land-surface and in-stream water quality processes into hydrologic modelling

A4: River Ice Modelling

Integrating river ice processes into hydrological modelling for operation and flood forecasting

A5: Model Intercomparison

Model intercomparison and multi-model analysis for improved prediction

A6: Floodplain Mapping

Improving floodplain mapping in flood sensitive watersheds

A7: Characterization and Communication of uncertainty

THEME B: Water Management Modelling and Coupling Human-driven and Natural Systems

B1: Basin-Wide Water Resources Modelling

Developing a basin-wide water resources model to simulate different operational policies of existing and future water infrastructure

B2: Environmental Demands

Developing hydro-ecologic metrics for environmental demands in water management

B3: Hydro-economic Modelling

Developing an integrated hydro-economic model to assess the direct and indirect impacts of policy decisions based on socio-economic water valuation studies

THEME C: Decision Making under Uncertainty and Non-stationarity

C1: Future scenario generation

Projection of river-basin scale changes in climate, land surface, and water resources

C2: Optimization and Multi-Criteria Decision Analysis

Optimization and multi-criteria decision analysis to optimize policy and decision scenarios and evaluate trade-offs between different competing objectives

THEME D: User Engagement, Knowledge Mobilization, and Decision Support Systems

D1: Outreach and user engagement

Outreach and user engagement to inform model development and output design, inclusion of user community representative on modeling team, and iterative, two-way sharing of information between scientists and users

D2: Decision support systems

Developing decision support systems with advanced visualization tools and expert systems built on research in Themes A-C and linked to the programme data inventories

THEME A: Integrated Earth Systems Modelling

(A1) High resolution atmospheric modelling to represent scenarios of change and land-atmosphere feedbacks

(A2) Improving hydrologic process representations for cold regions to better simulate snow and glacier and accommodate hyper-resolution modelling

(A3) Integrating land-surface and in-stream water quality processes into hydrologic modelling

(A4) Integrating river ice processes into hydrological modelling for improved operation and flood forecasting

(A5) Hydrologic model inter-comparison and multi-model analysis for improved prediction

(A6) Improving floodplain mapping in flood sensitive areas

(A7) Characterization and communication of uncertainty

THEME B: Water Management Modelling, Coupling Human-driven and Natural Systems

(B1) Developing a water resources model to simulate different operational policies of existing and future water infrastructure

(B2) Developing a performance model for aquatic ecosystems based on hydro-ecologic metrics and environmental demands

(B3) Developing an integrated hydro-economic model to assess the direct and indirect impacts of policy decisions based on socio-economic water valuation studies

THEME C: Decision Making under Uncertainty and Non-stationarity

(C1) Future scenario generation for river-basin scale changes in climate, land surface, and water resources

(C2) Optimization and multi-criteria decision analysis to optimize policy and decision scenarios and evaluate trade-offs between different competing objectives

THEME D: User Engagement, Knowledge Mobilization, and Decision Support Systems

(D1) Outreach and user engagement to inform model development and output design, inclusion of user community representative on modelling team, and iterative, two-way sharing of information between scientists and users

(D2) Developing decision support systems with advanced visualization tools and expert systems built on research in Themes A-C and linked to the programme data inventories

Exciting Two Days Ahead!

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