Model couplings to include
- river water temperature,
- overland and instream water-quality and
- river ice processes
in the MESH modelling system

Karl-Erich Lindenschmidt
Sujata Budhathoki, Apurba Das, Hinata Kadowaki,
Zhaoqin Li, Luis Morales, Prabin Rokaya

MESH-RBM:
In-stream water temperature model

RBM model source

WATER RESOURCES RESEARCH, VOL. 45, W12405, doi:10.1029/2008WR007629, 2009

A semi-Lagrangian water temperature model for advection-dominated river systems

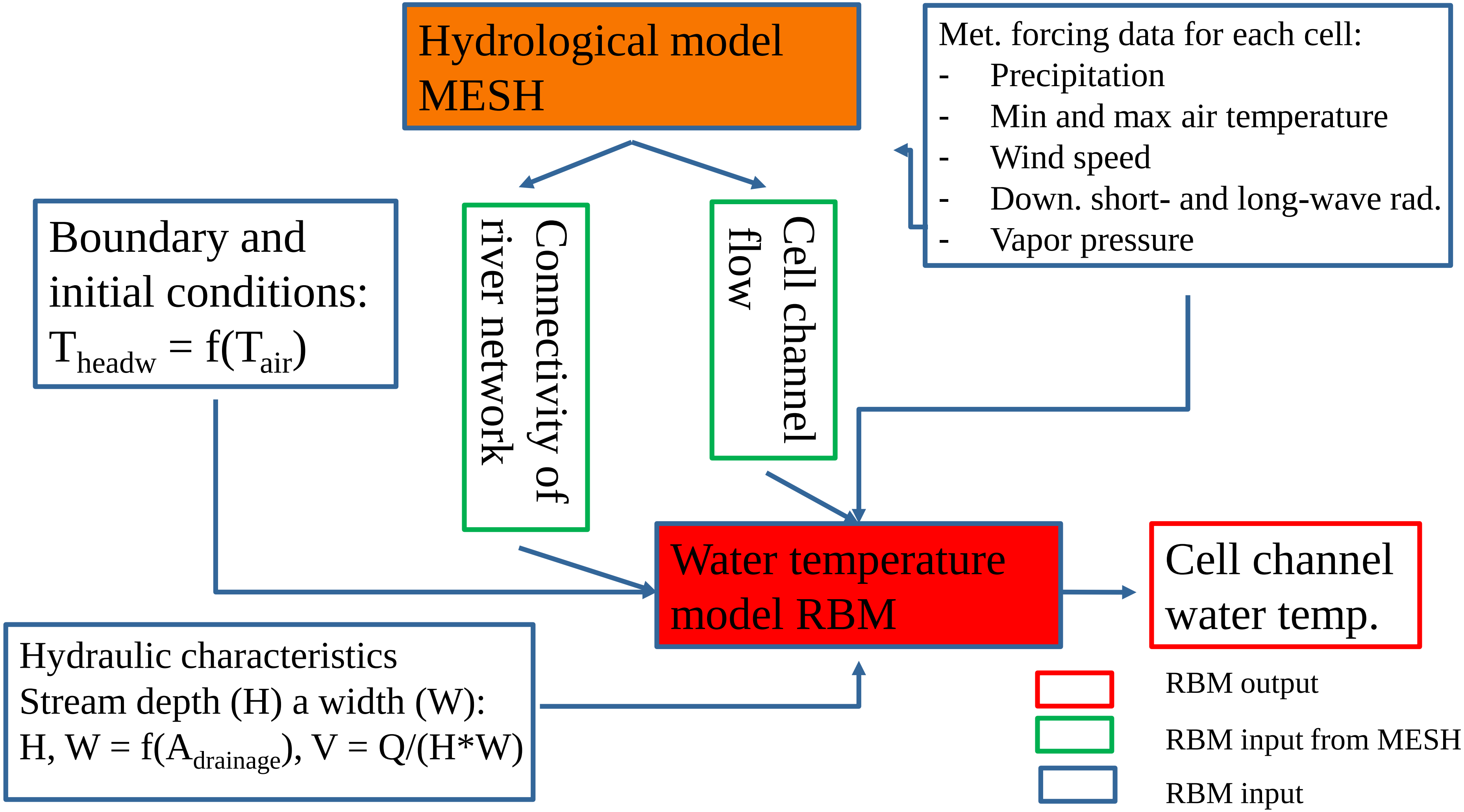
John R. Yearsley[1]

Received 1 December 2008; revised 28 July 2009; accepted 8 September 2009; published 8 December 2009.

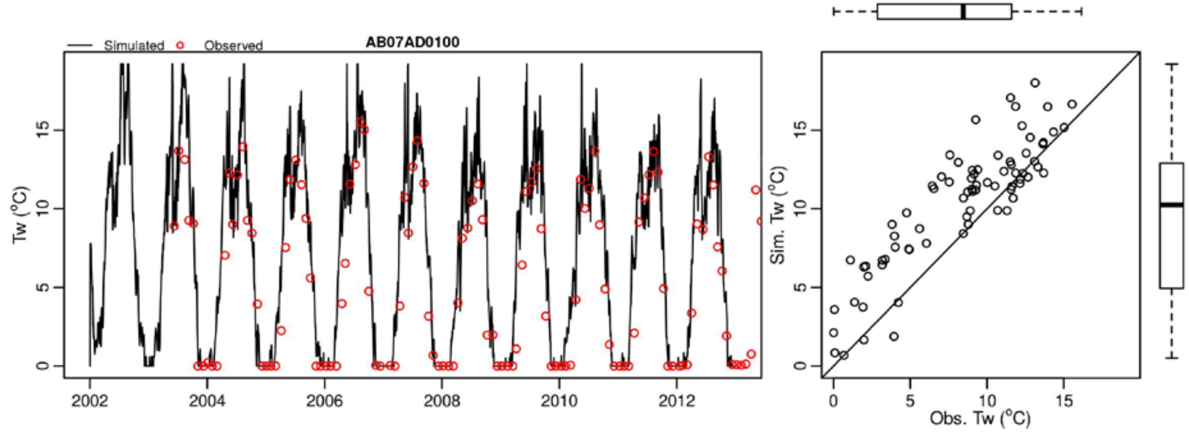
[1] This paper describes a one-dimensional stream temperature model that is computationally efficient and highly scalable in both time and space. The model is developed within the framework of state space structure. The time-dependent equations for the conservation of thermal energy in a flowing stream or river are solved using a mixed Eulerian-Lagrangian, or semi-Lagrangian, numerical scheme. Solutions are obtained by tracking individual water parcels along their flow characteristics and storing the simulated results at discrete points on a fixed grid. Computational efficiency and accuracy of the numerical scheme are demonstrated by comparison of model estimates with observations of stream temperatures from rivers in the Pacific Northwest as well as with results from a closed-form solution of the energy equation. A preliminary analysis of the impact of climate changes on stream temperature in the Columbia River system illustrates the strengths of the semi-Lagrangian method for addressing water quality issues of regional, national, and, ultimately, global scale. Further development of the semi-Lagrangian method has the potential to improve the ability of water quality planners to perform uncertainty analysis, risk analysis, and forecasting for large, complex river systems.

Citation: Yearsley, J. R. (2009), A semi-Lagrangian water temperature model for advection-dominated river systems, *Water Resour. Res.*, *45*, W12405, doi:10.1029/2008WR007629.

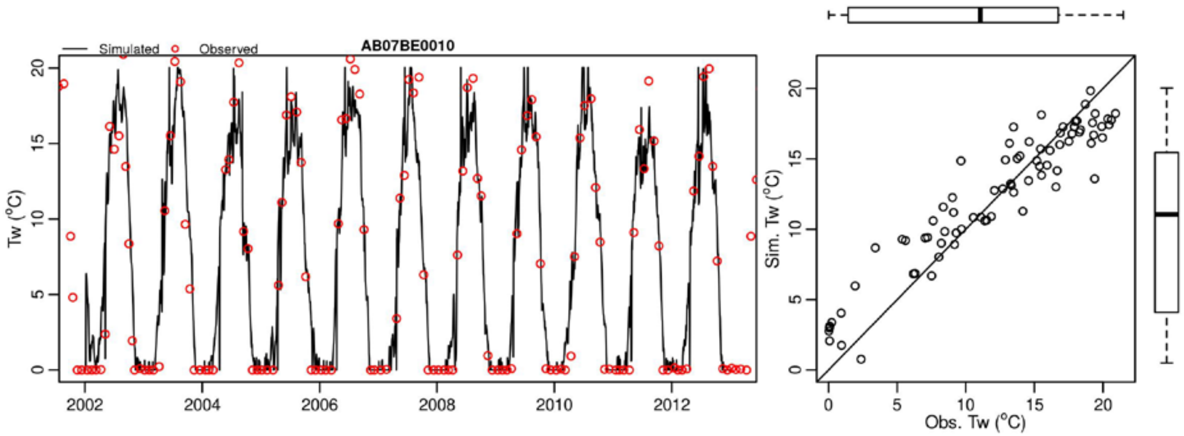
A grid-based semi-Lagrangian water temperature model for MESH: Structure



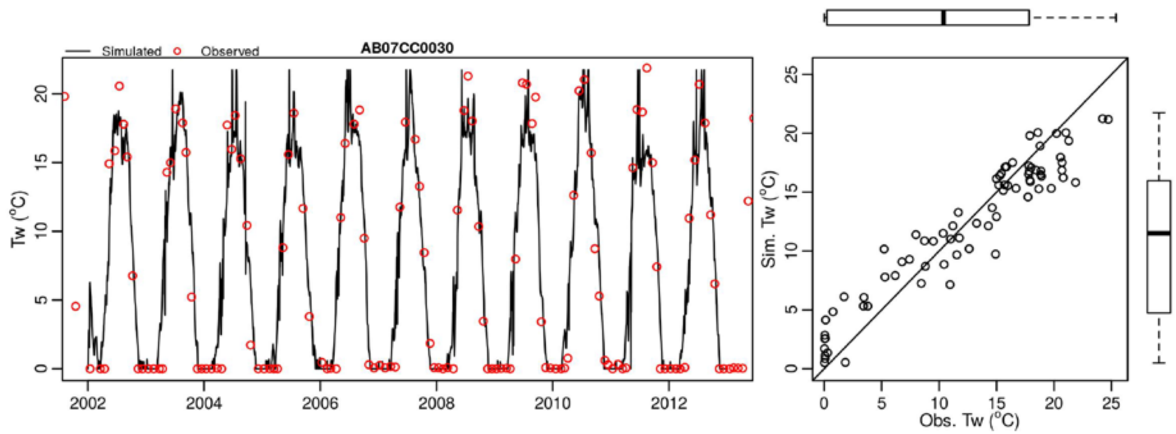
Water temperatures at three different stations



Hinton:
RMSE = 1.78 °C
PBIAS = 5.20%
NSE = 0.82

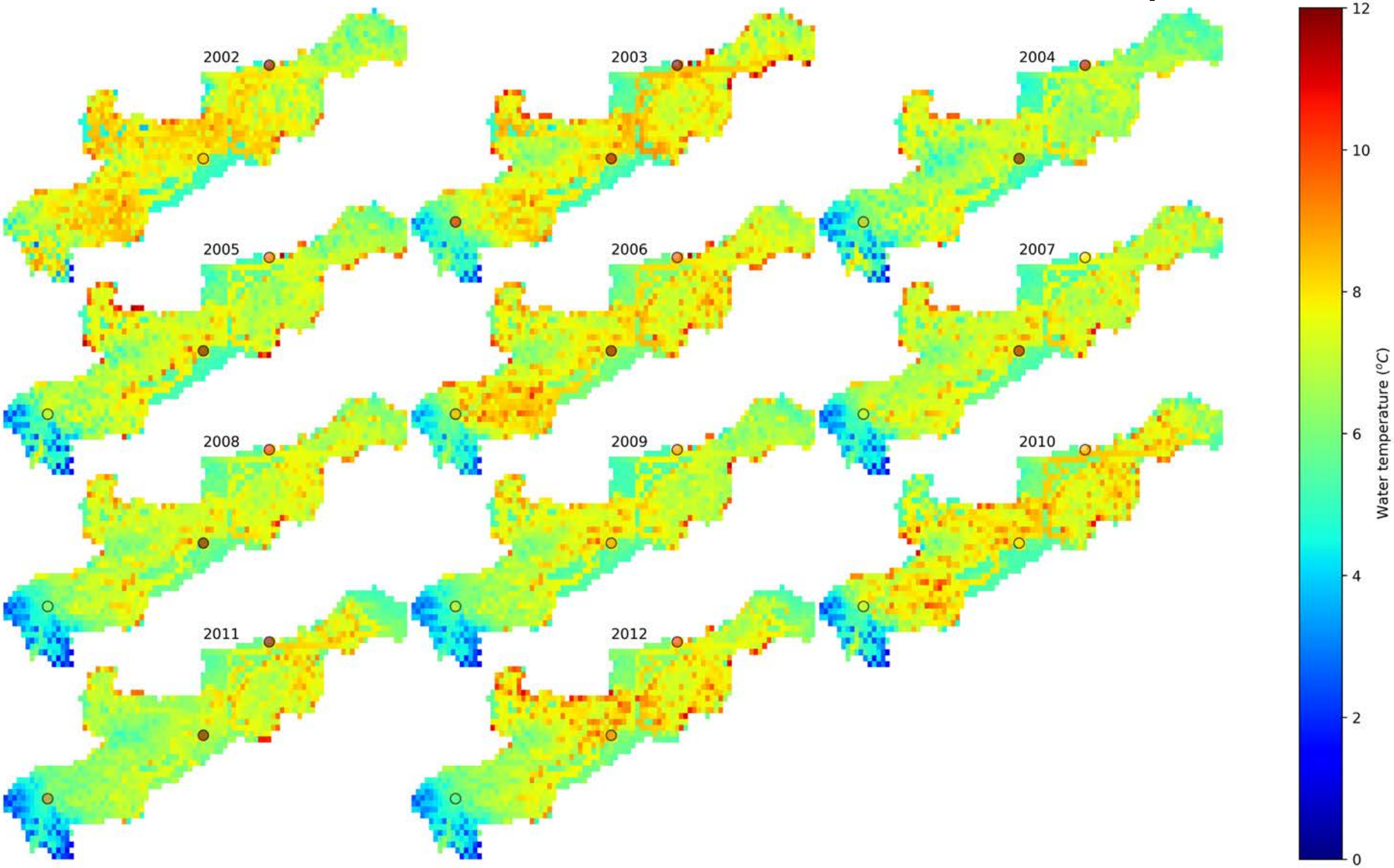


Athabasca:
RMSE = 2.25 **°C**
PBIAS = 2.20%
NSE = 0.87

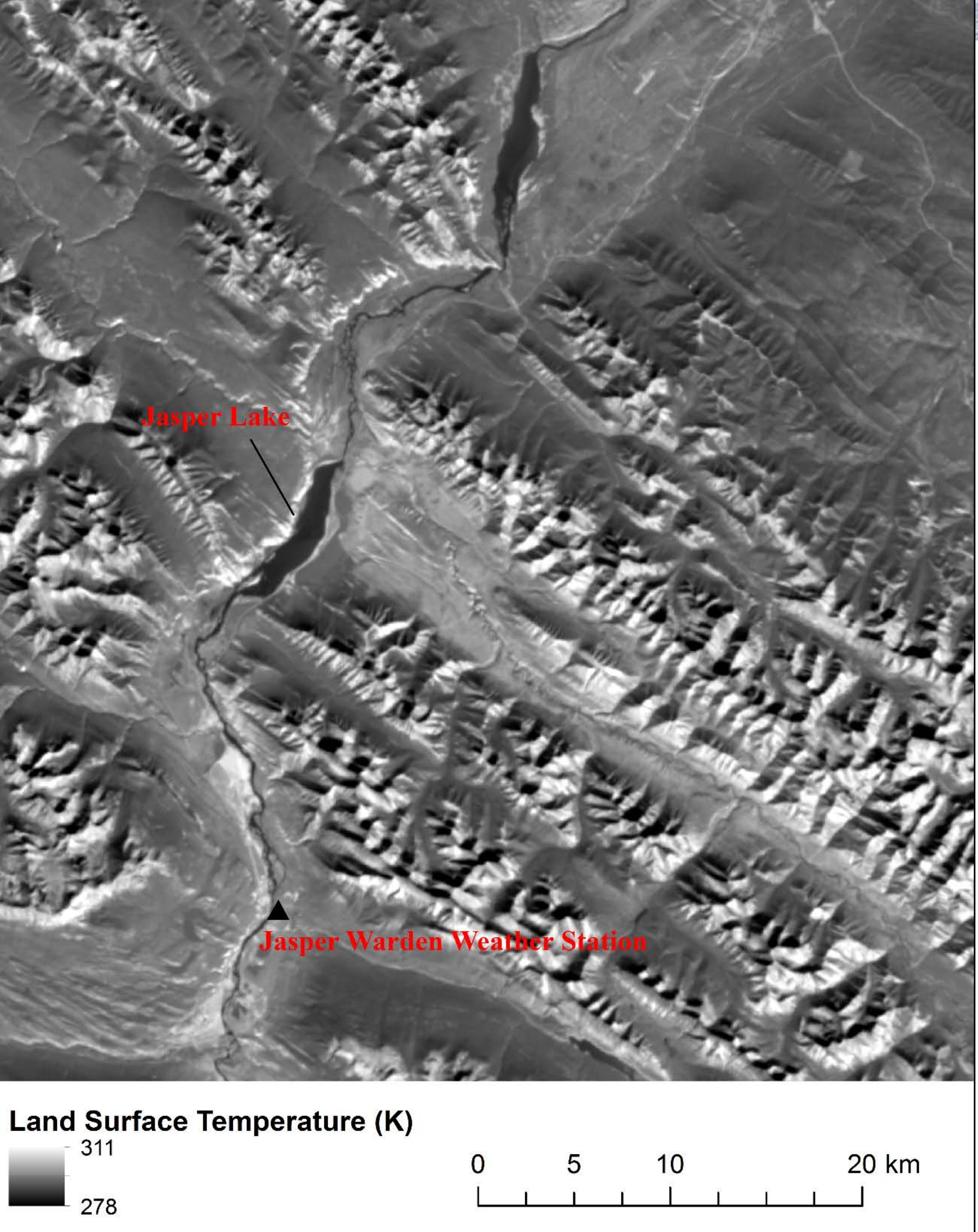


Fort McMurray:
RMSE = 2.37 **°C**
PBIAS = -1.80%
NSE = 0.89

Maps of multi-annual averages of simulated water temperature



Landsat heat map



MESH-SED:

Sediment & nutrient transport

modelling

SHESED model source

ELSEVIER

Journal of Hydrology 175 (1996) 213–238

Journal of Hydrology

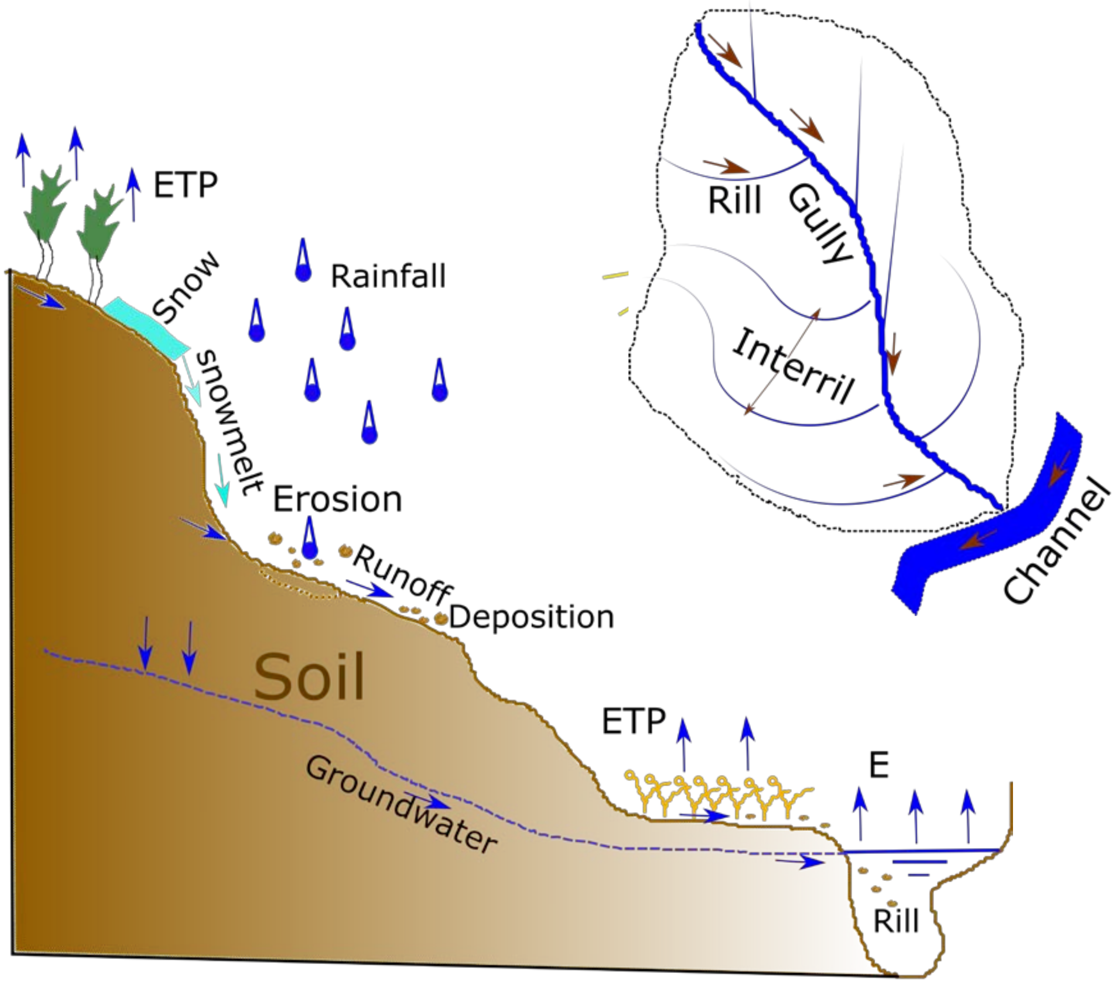
SHESED: a physically based, distributed erosion and sediment yield component for the SHE hydrological modelling system

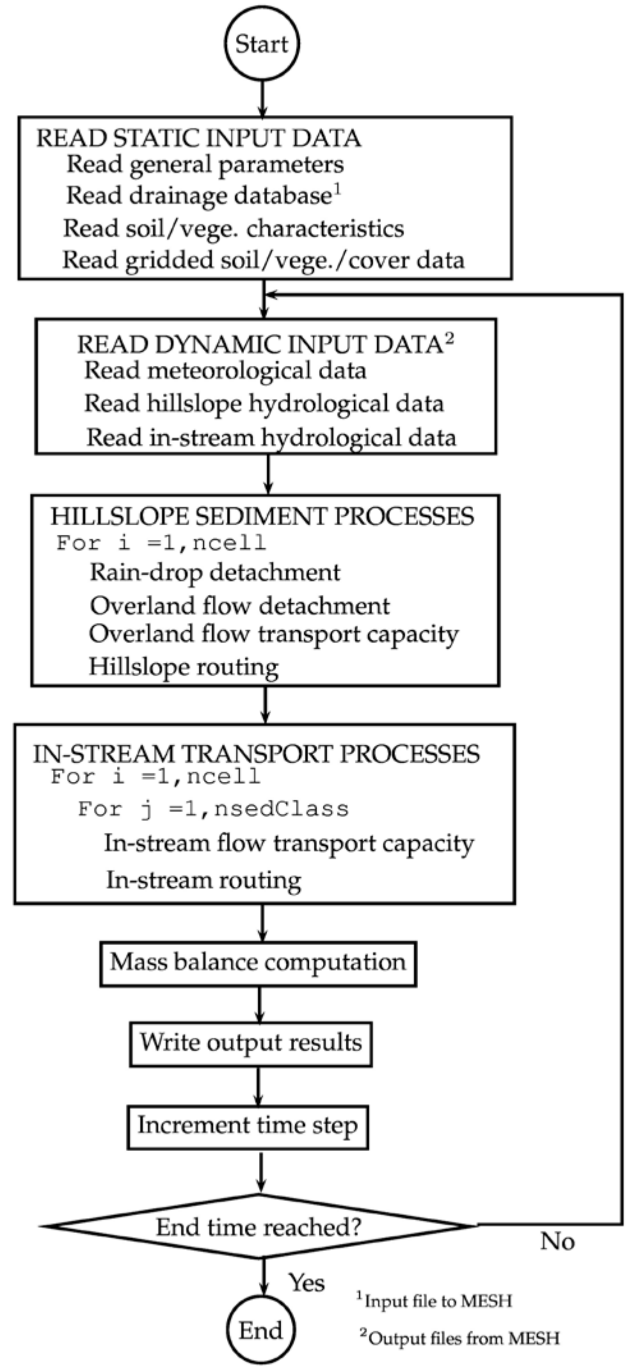
J.M. Wicks[a,1], J.C Bathurst[b,*]

[a] *Department of Civil Engineering, University of Newcastle upon Tyne, Newcastle upon Tyne NE1 7RU, UK*

[b] *Water Resource Systems Research Unit, Department of Civil Engineering, University of Newcastle upon Tyne, Newcastle upon Tyne NE1 7RU, UK*

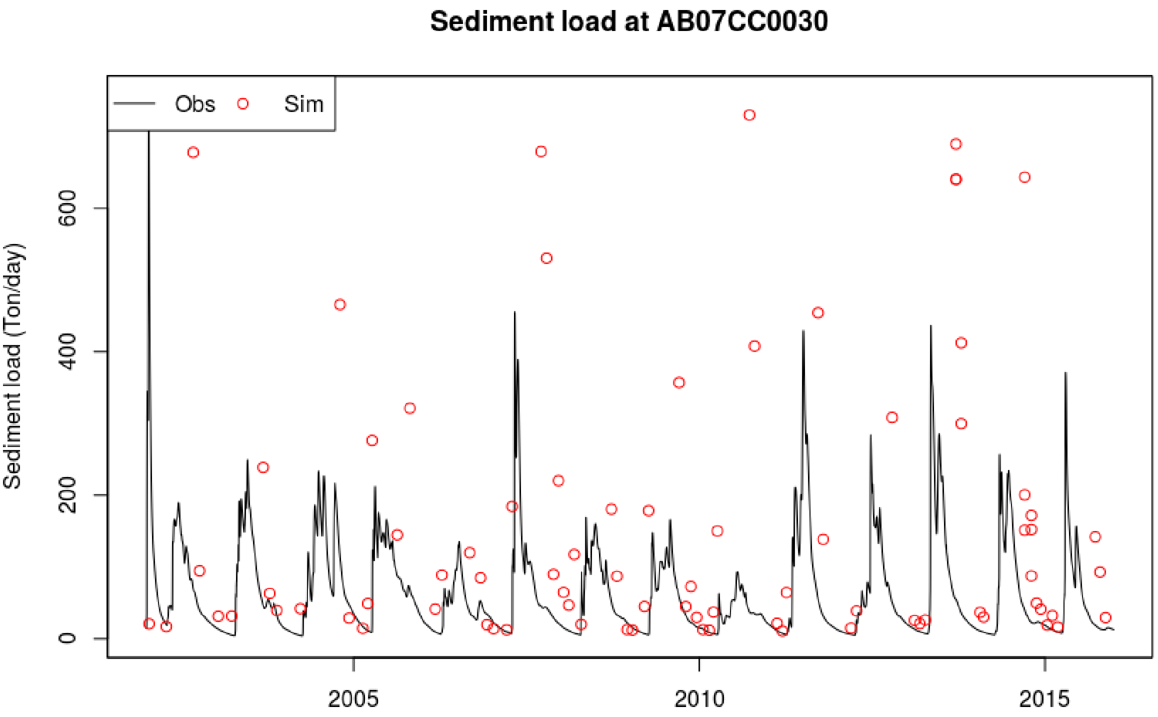
MESH-SED conceptualization and software flow diagram

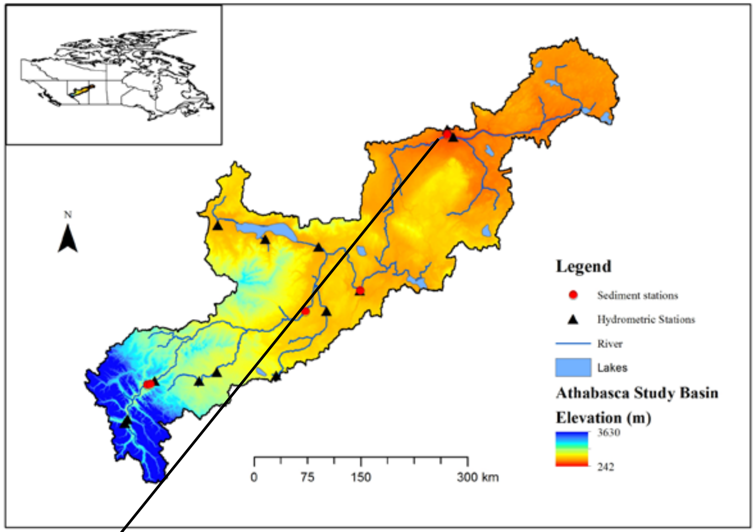




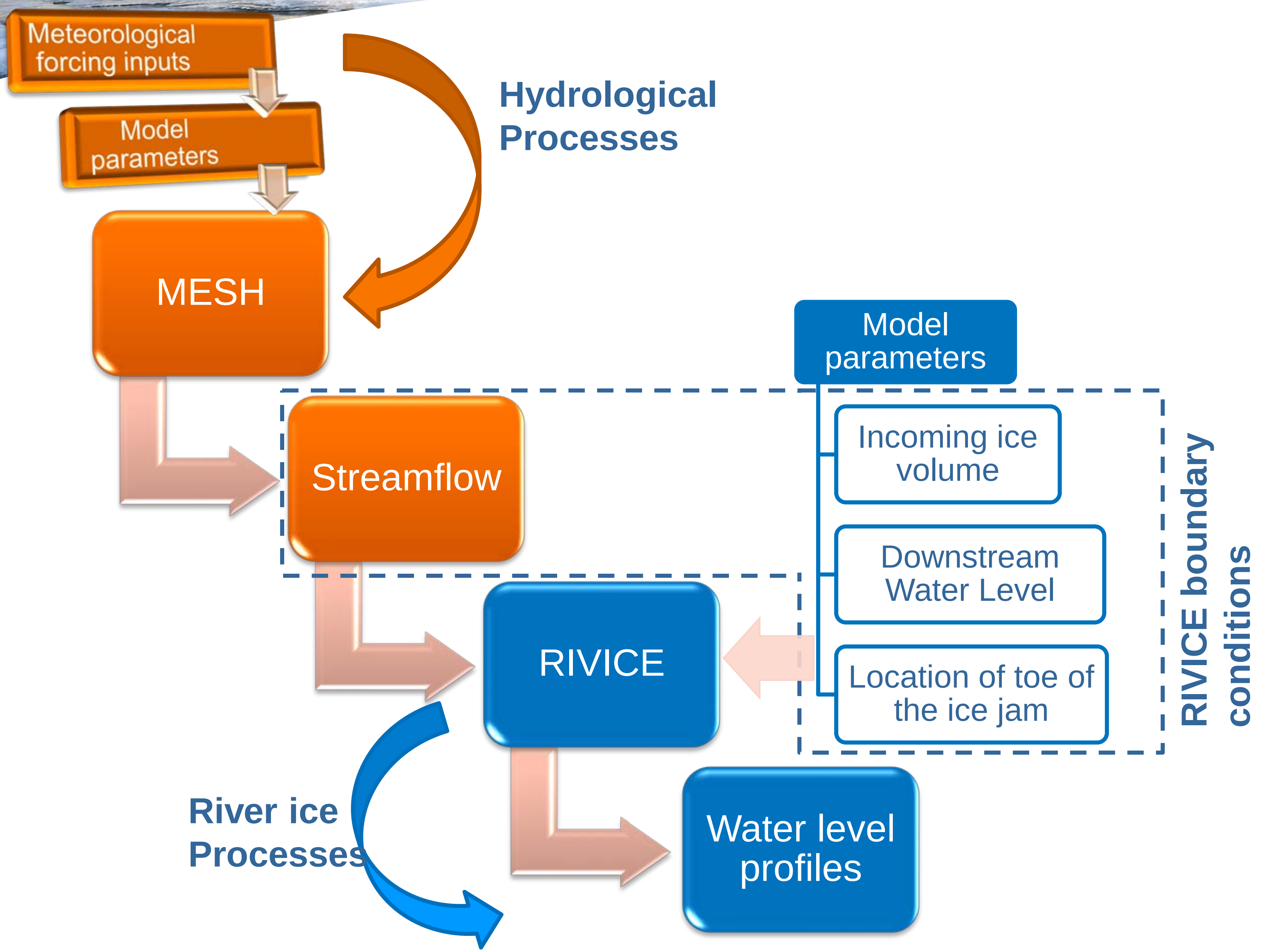
Preliminary results: observed vs. simulated sediment loads at Fort McMurray

Requires seasonally varying vegetation cover to refine simulations

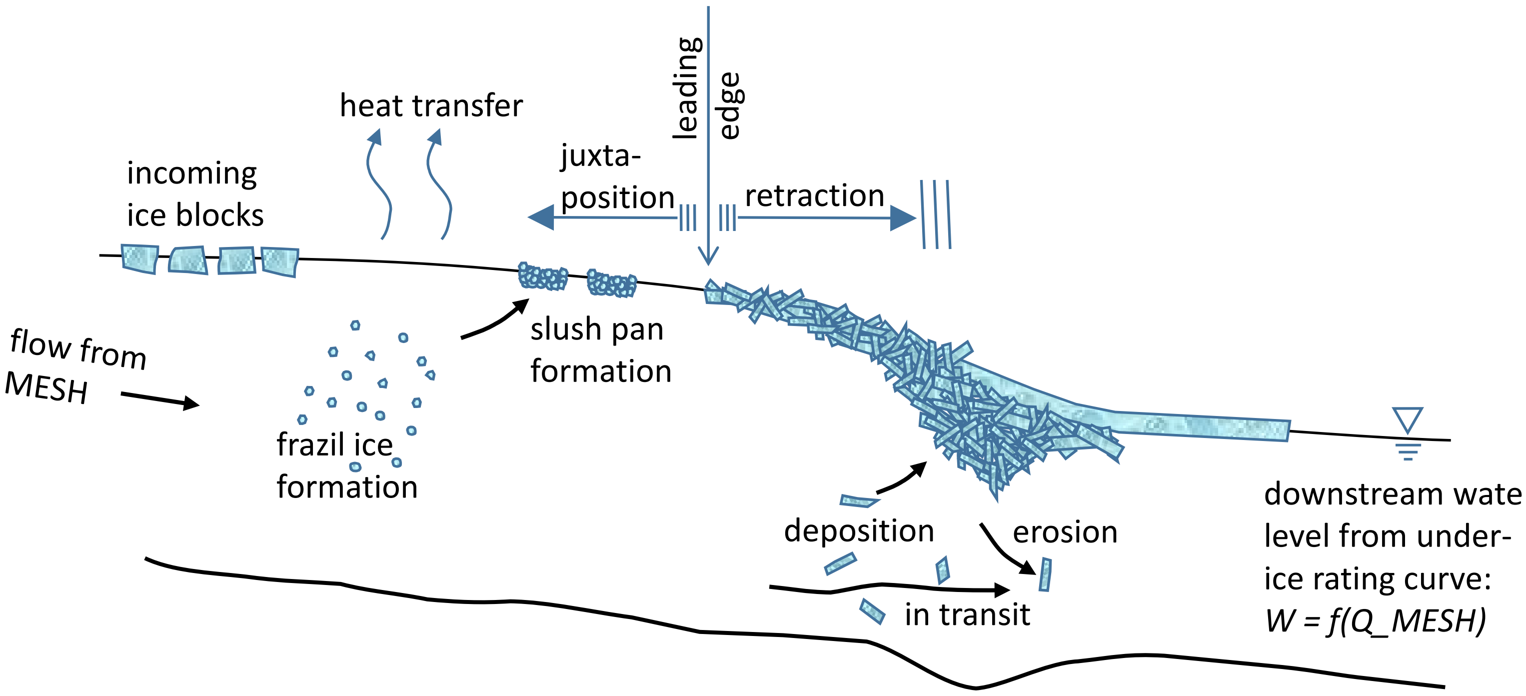




MESH-RIVICE:
Ice-jam flood modelling

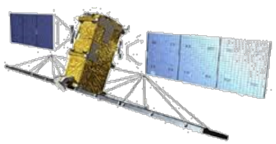

Meteorological forcing inputs
Model parameters
MESH
Hydrological Processes
Streamflow
Model parameters
Incoming ice volume
Downstream Water Level
Location of toe of the ice jam
RIVICE boundary conditions
RIVICE
River ice Processes
Water level profiles

River ice processes

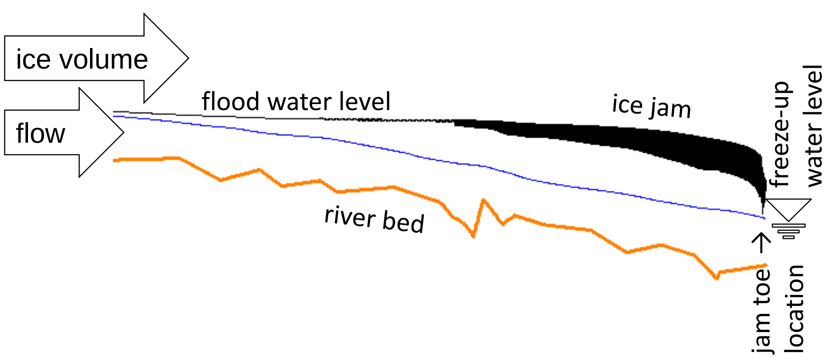


RIFHA – Real near-time flood hazard assessment
Funding and Radarsat-2 data from CSA's EOADP

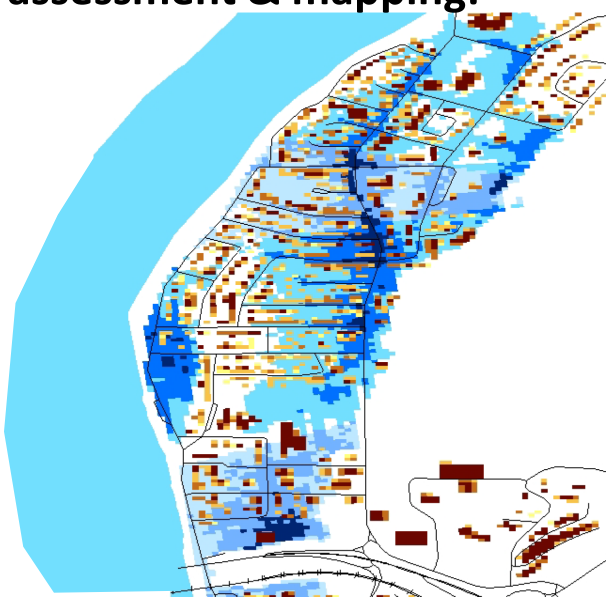
(1) Remote sensing: provides info on
- ice types
- ice thicknesses
- upstream ice extent



(2) Stochastic, real-time, river ice flood modelling:



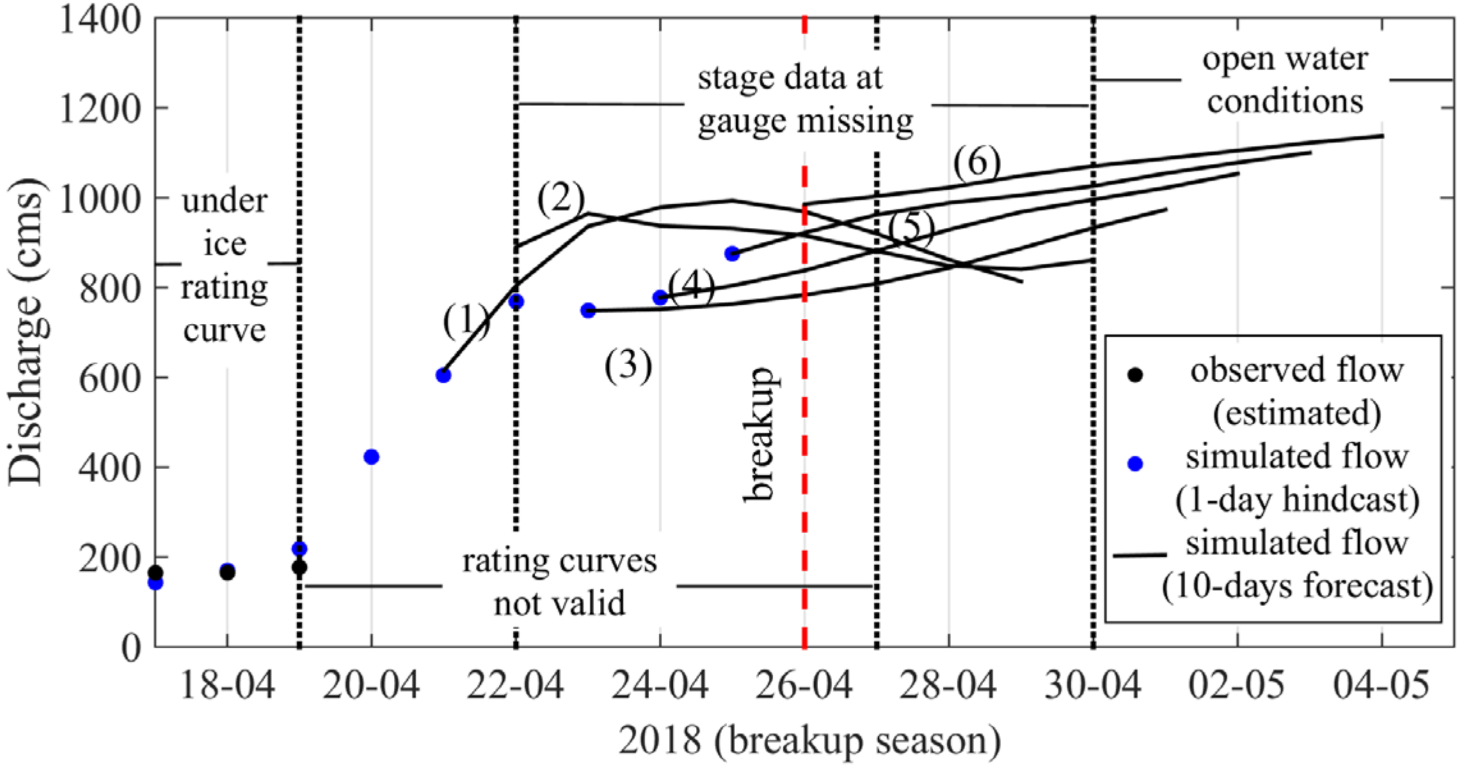
(3) Dynamic flood hazard assessment & mapping:



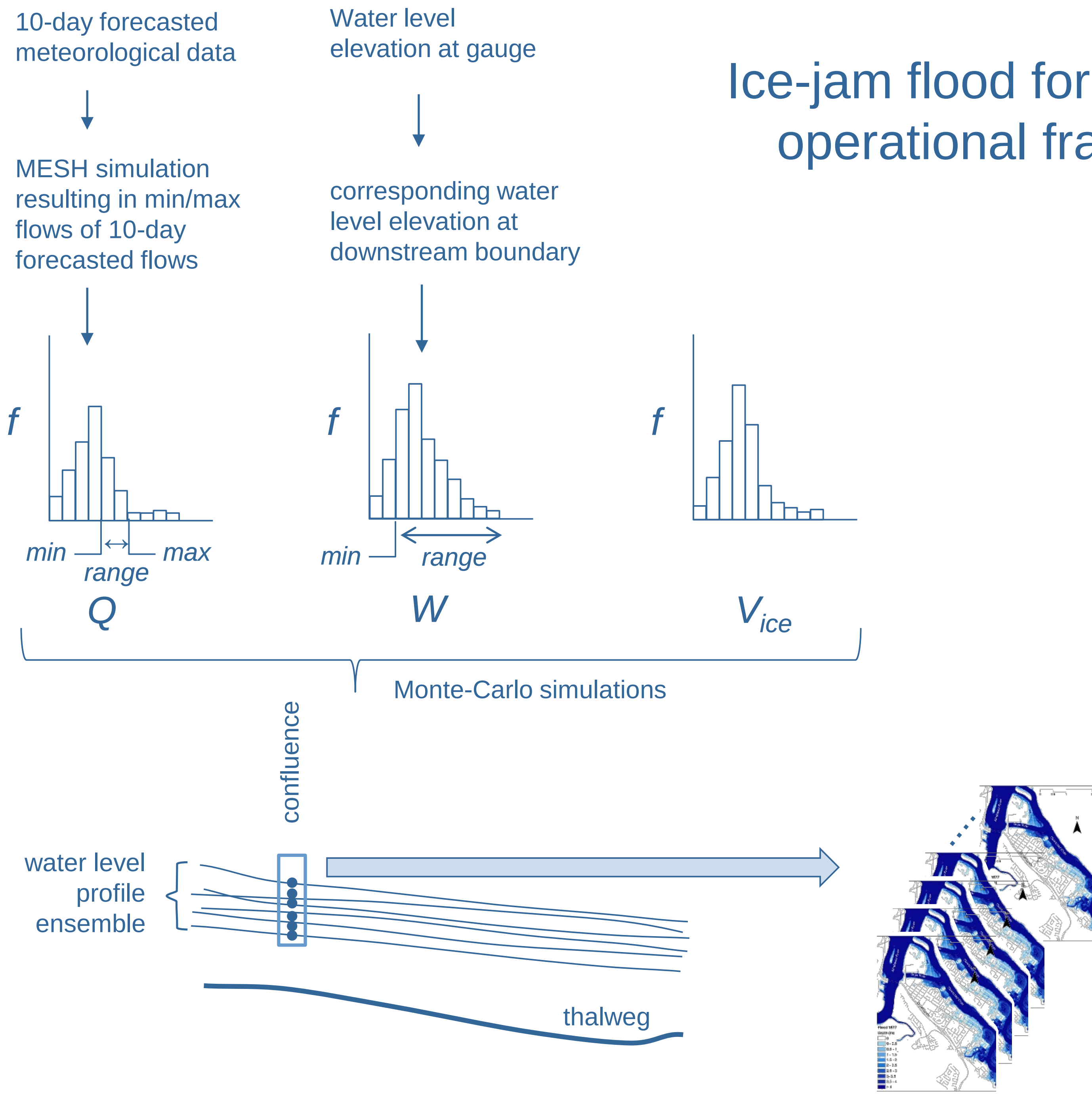
(4) Flood advisories & warnings: provides info for
- decision support
- preparedness measures
- disaster management

Flow forecasts from MESH

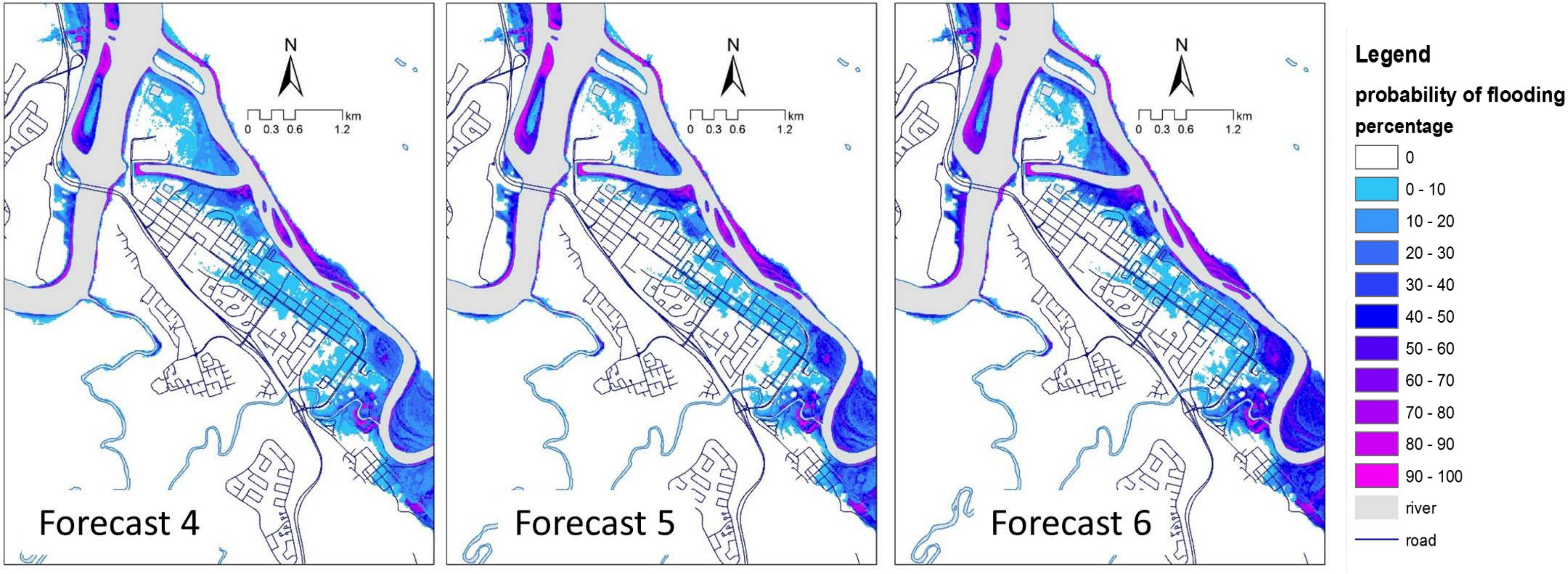
MESH inputs from the
Canadian Global Deterministic Prediction System (GDPS)



Ice-jam flood forecasting operational framework



Flood_hazard maps for Forecasts 4 to 6



Lindenschmidt, K.-E. et al. (in prep.) A novel stochastic modelling approach to operationally forecast ice-jam flooding.

Thank you