



Simulating the Water Resources of an Alpine Catchment

A Coupled Water Resource, Glacier and Snowmelt Model Framework

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EGU: HS2.1.5 – Mountain hydrology under global change: monitoring, modelling and adaptation



UNIVERSITY OF BIRMINGHAM



UK Research and Innovation

Background

Why do this?



Complex System

Glacial runoff, Snow,
Groundwater, Rain

- **Climate Change reduces snow and ice input**

Mountain meltwaters provide up to 60% world's annual freshwater

- **Need for a high resolution, efficient model**

Strike the balance between efficient lumped models and detailed gridded models

Gauging the Past, Present and Future

The Big Thaw Project

- Goal to study past and present water resources in mountains

Our side: the water modelling.

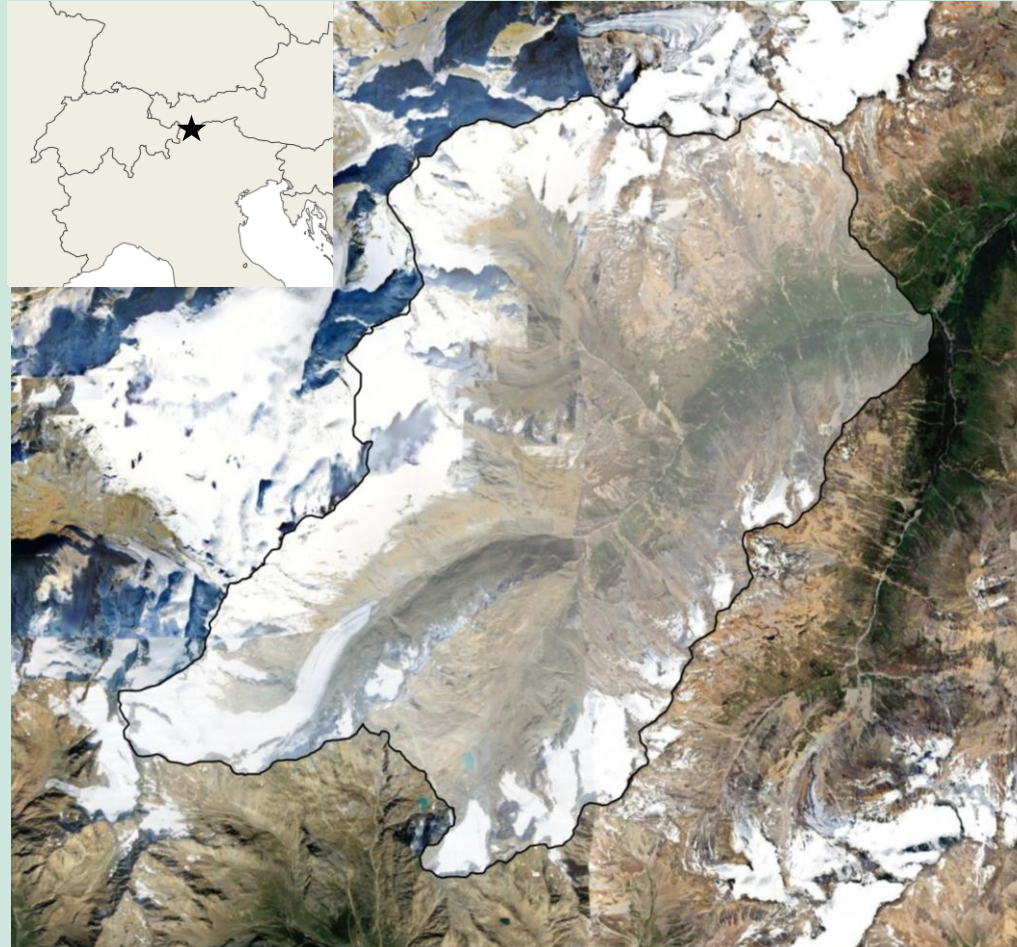
The Model

- Global Water Availability Assessment Model (GWAVA)
- Probability-Distributed Model (PDM) Runoff Generation

Characteristics

- 98.1 km²
- 1891-3772m
- Mean Temperature at Gauge point: 2.5°C

Rofental Catchment, Austria



Why Rofental

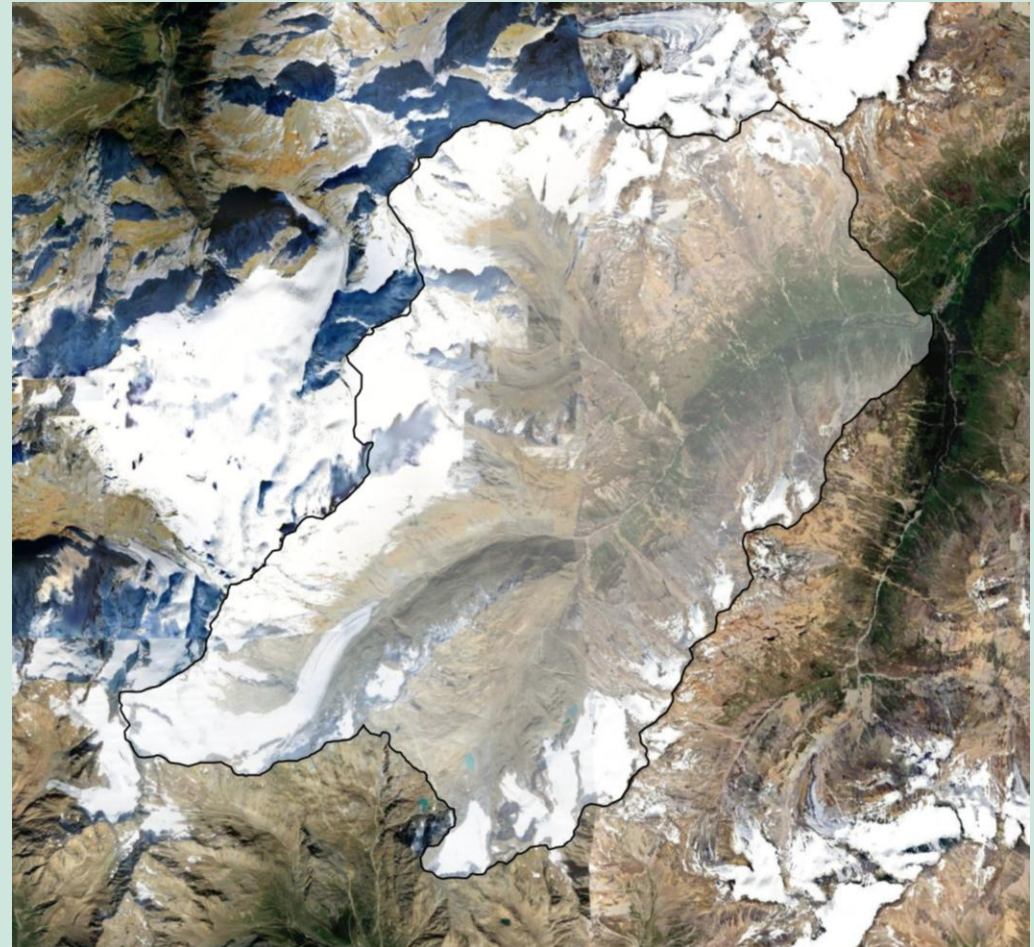
- Long-running gauged dataset (>150 years)
- At the intersection between many geosciences

Gauging the Past, Present and Future

The GWAVA Model

- Gridded, Semi-Distributed Model
 - 1.5km x 1.5km grid
 - Hourly temporal resolution
- PDM Routine generates runoff from rainfall
 - Tracking surface and subsurface flow

Rofental Catchment, Austria

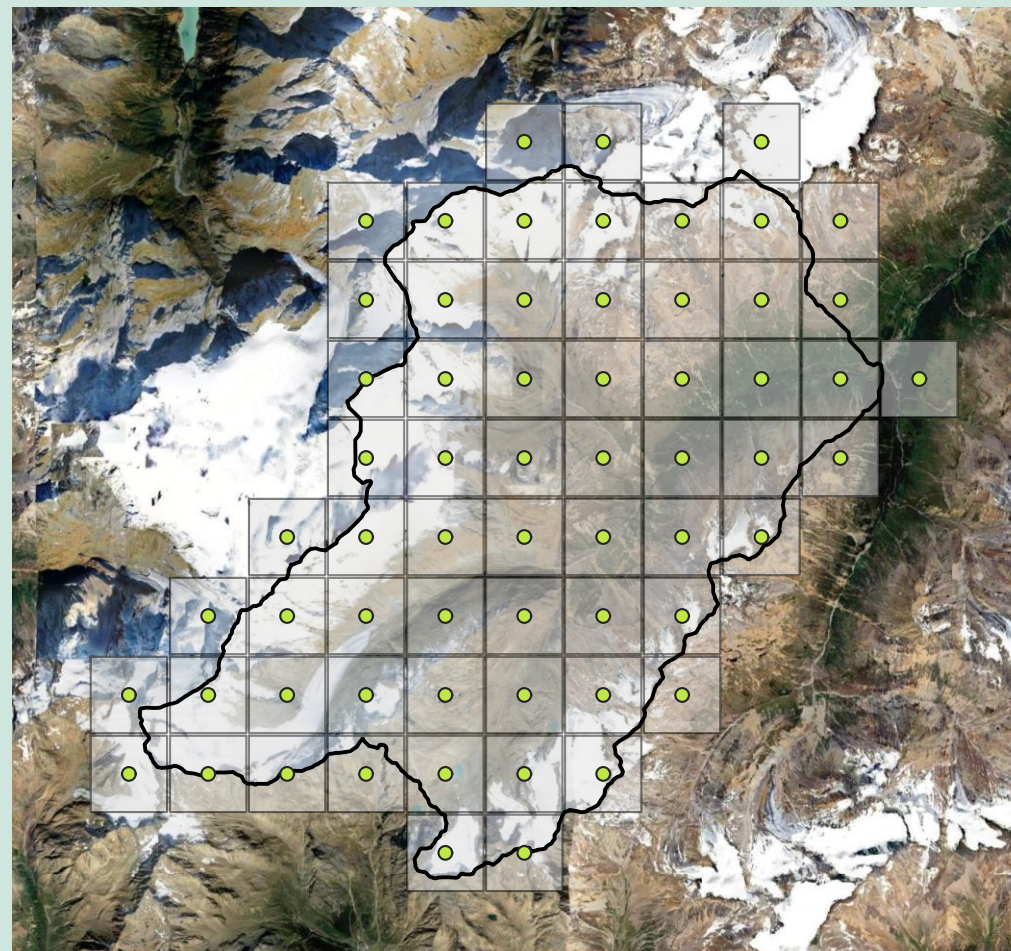


Gauging the Past, Present and Future

The GWAVA Model

- 63 model cells
- Land Use, Soil Characteristics and Mountain Profiles included

Rofental Catchment, Austria

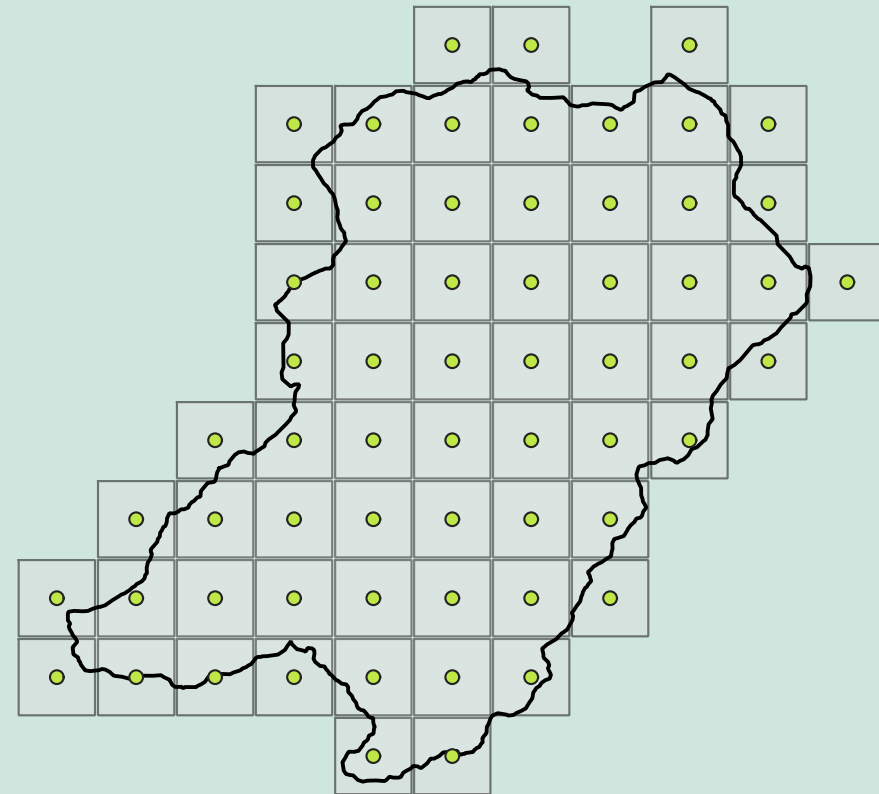


Gauging the Past, Present and Future

The GWAVA Model

- Edge Cases for Cells included (glacial extent will be included)
- External Inputs are possible

Rofental Catchment, Austria

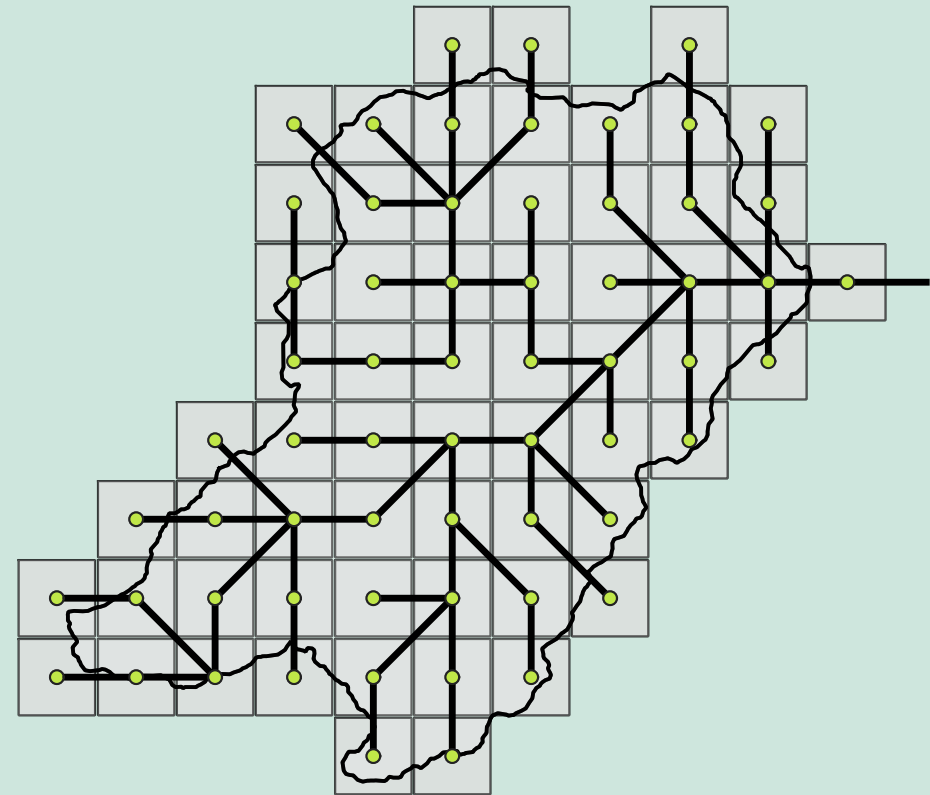


Gauging the Past, Present and Future

The GWAVA Model

- River Pathways added
- Model source tracking functionality

Rofental Catchment, Austria



New GWAVA Workflow



**MetUM Precipitation-optimised
models and forecasts**

New GWAVA Workflow



Met Office



**MetUM Precipitation-optimised
models and forecasts**

**Unified Model
1997 – 2024
1.5km x 1.5km
Hourly
Precipitation
Temperature
PET (Hargreaves)**

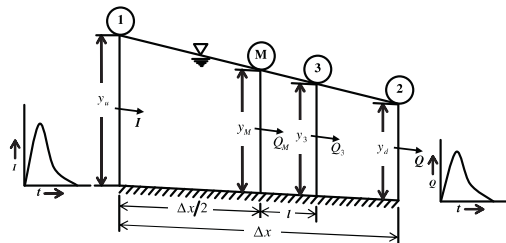
Climate Driving Data



GWAVA

GWAVA

Variable
Parameter
McCarthy
Muskingum



Perumal &
Price (2013)

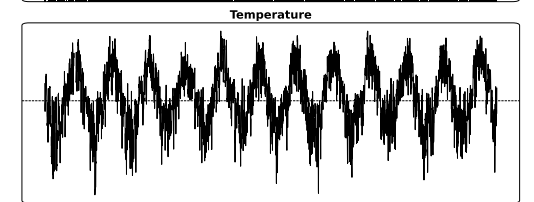
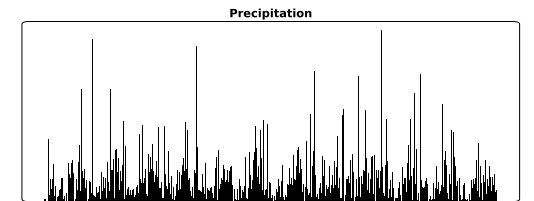
Climate Driving Data

Rainfall-Runoff PDM

Routing

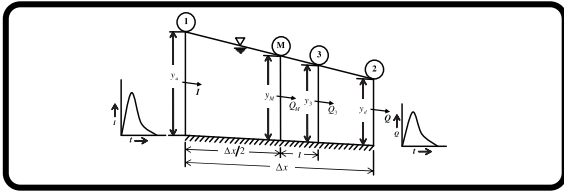
Calibration

1964-
2025

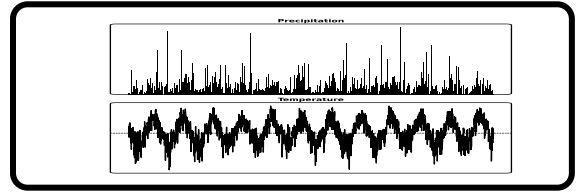



Continuous
Gauge Data

Subdaily Timestep

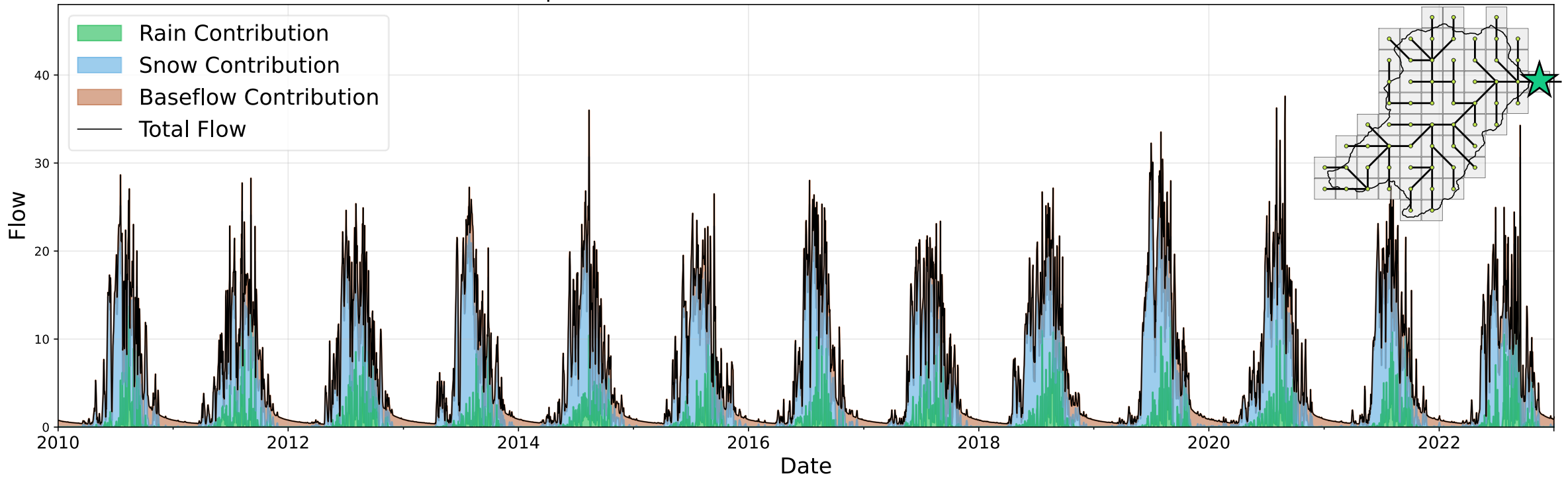


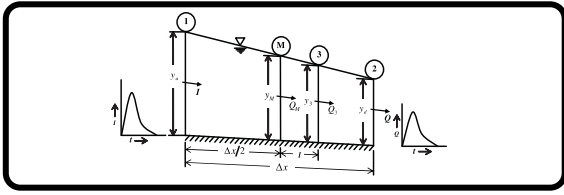
GWAVA



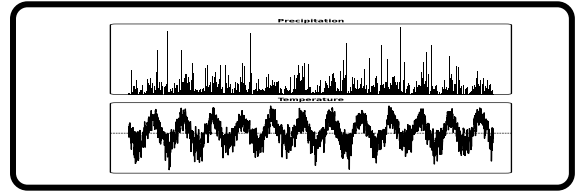
GWAVA Tracked Run for Downstream Cell, 2010-2022 


GWAVA Model Output - Contribution Tracked at Most Downstream Cell - 2010 - 2022



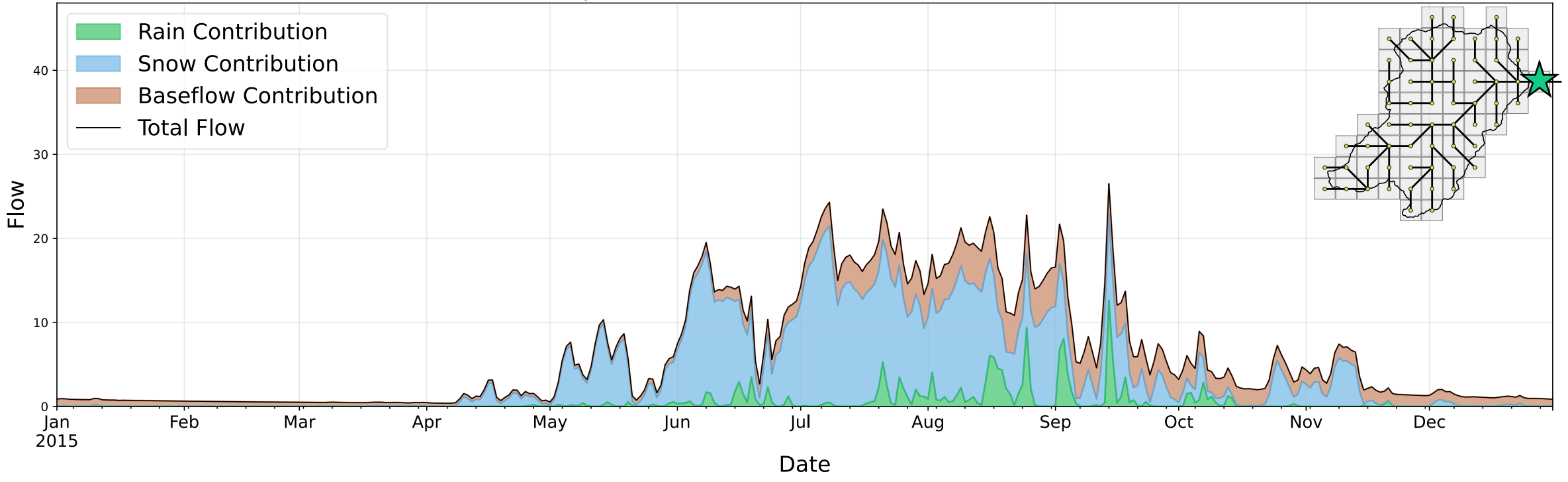


GWAVA

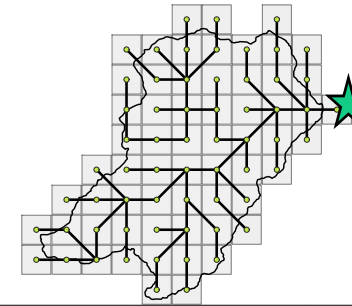


GWAVA Tracked Run for Downstream Cell, 2010-2022 

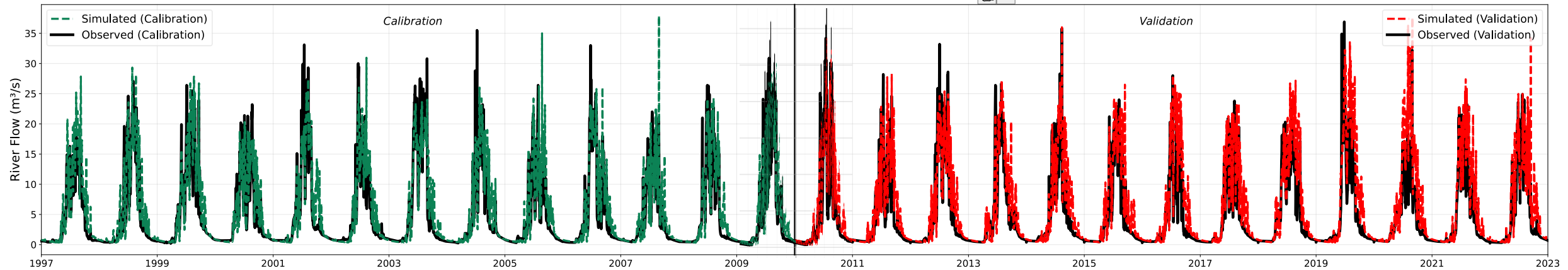
GWAVA Model Output - Contribution Tracked at Most Downstream Cell - 2015



Model Performance



GWAVA Run for Gauging Cell, 1997-2022



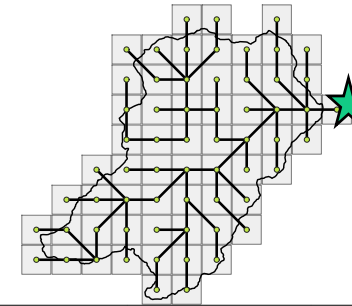
**0.88 Log Nash Estimate –
Low Flows well Represented**

0.83 Log Nash Estimate

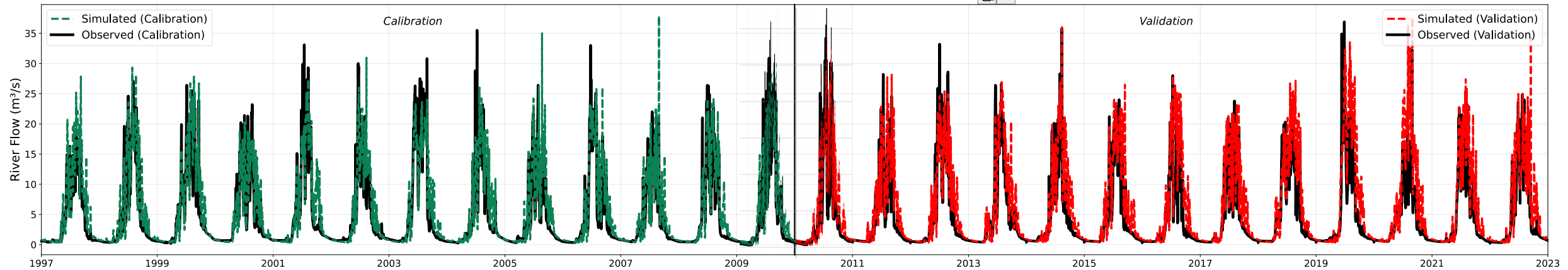
**0.83 Nash Sutcliffe Estimate
Good Overall Behaviour**

0.69 Nash Sutcliffe Estimate

Model Performance



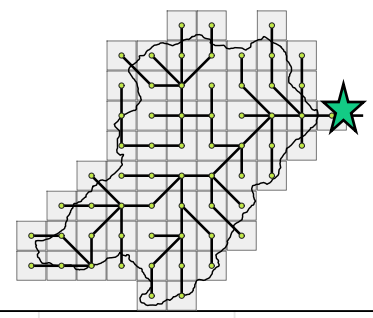
GWAVA Run for Gauging Cell, 1997-2022



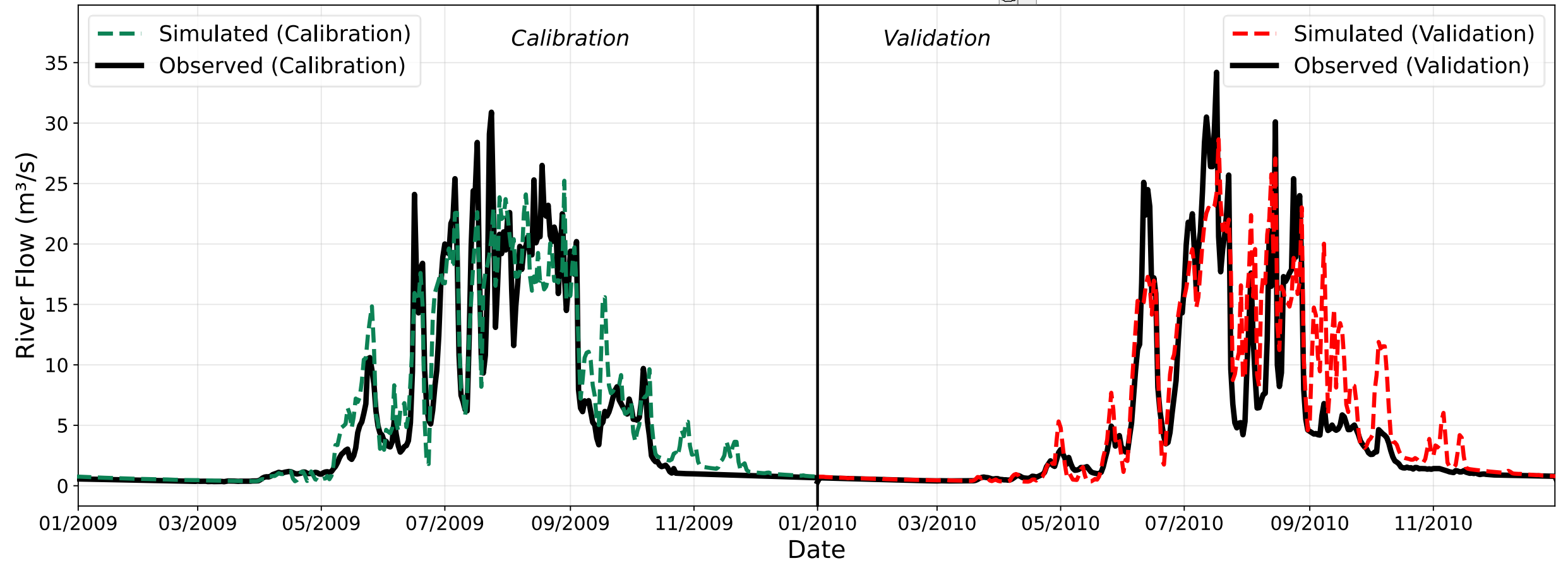
Baseflow-dominated winter is well represented

Renewed routing and temporal resolution improve model response to heavy rain input.

Model Performance - Validation



GWAVA Validation Run for Gauging Cell, 2010-2022



Gauging the Past, Present and Future

The GWAVA Model – Takeaways for Rofental

- Source Partitioning adds nuance to inform model performance: baseflow dominance in winter is well represented
- High Flow behaviour can be improved
- Hourly tracking and updated routing routine improve process realism
- GWAVA is efficient (5 minutes for 26 years of hourly data!)

What we're working on

Progress and Next Steps



Coming soon...



Sensitivity Analysis for Driving Data

Coupled Driving Dataset

Source Partitioning Validation

$\delta^{18}\text{O}$, $\delta^2\text{H}$ isotopes

Glacier Runoff Tracking

Surface PDM Component

Transferrable to other catchments

GWAVA Methodology

Thank you.

Please speak to me if interested!

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Any Questions?

Link to EGU
Abstract:



Big Thaw
Project
Page:



GWAVA
Model Page:

