OzEWEX

2017 AUSTRALIAN CLIMATE AND WATER SUMMER INSTITUTE

Towards improving the accuracy of AWRA-L model by adding routing processes in model calibration

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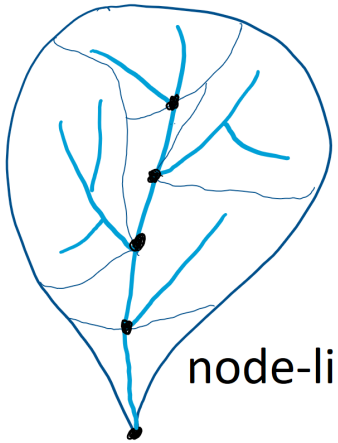
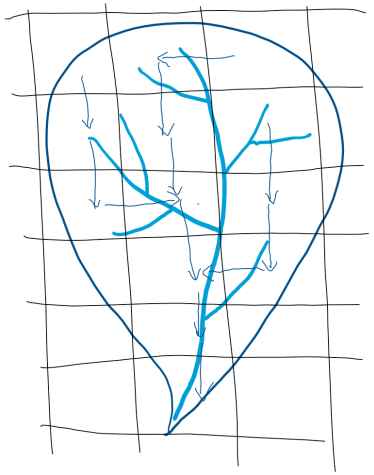
Contents

- Introduction and study catchment
- Grid-link routing
- Node & Grid-link routing with RAPID model

Introduction

- AWRA-L is a grid based distributed water balance model
- No inter-connection among grids
- To add routing processes to AWRA-L may help to produce more precise discharge output
- Provide better information for water decision-making processes

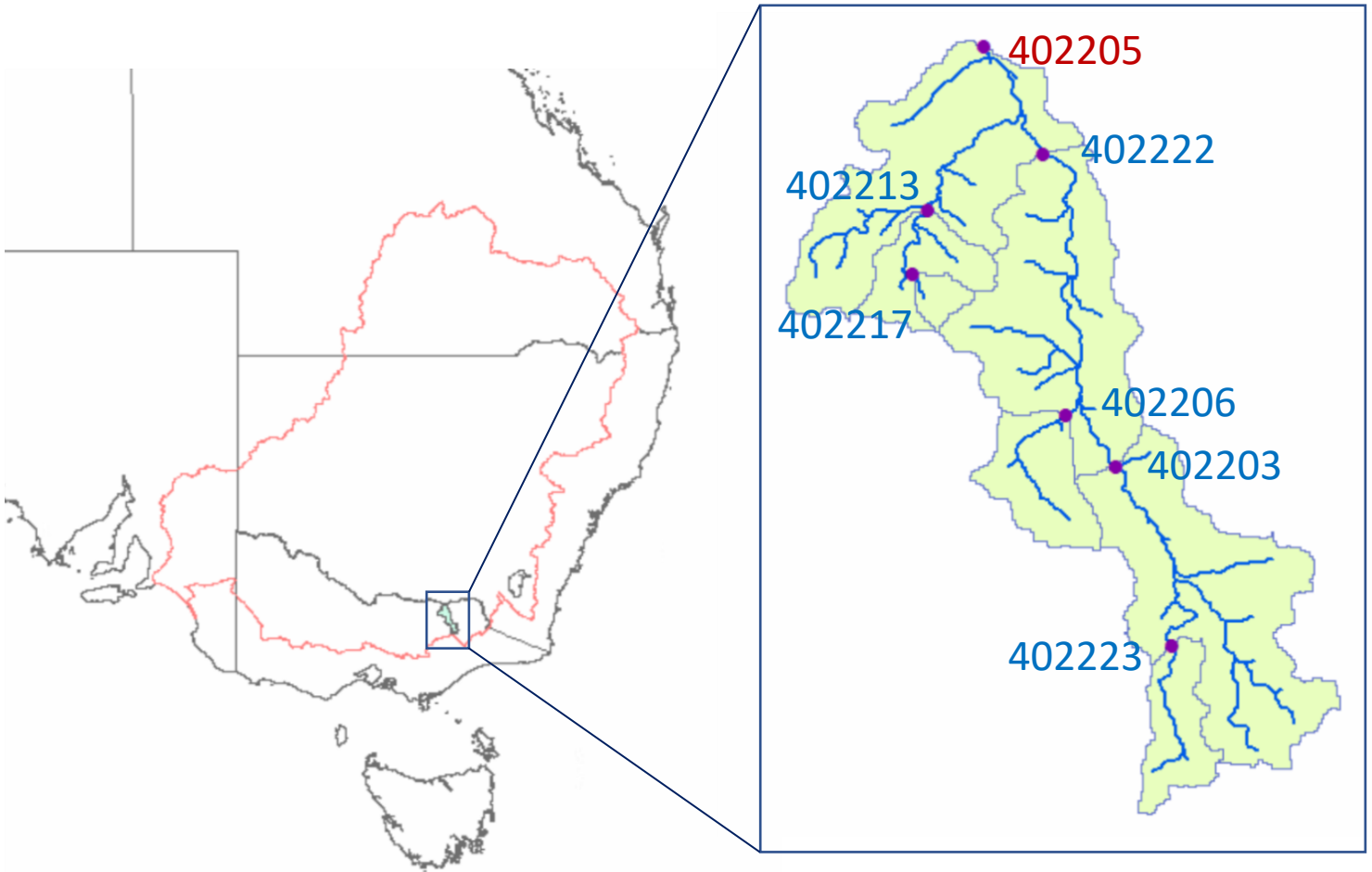




Evaluation

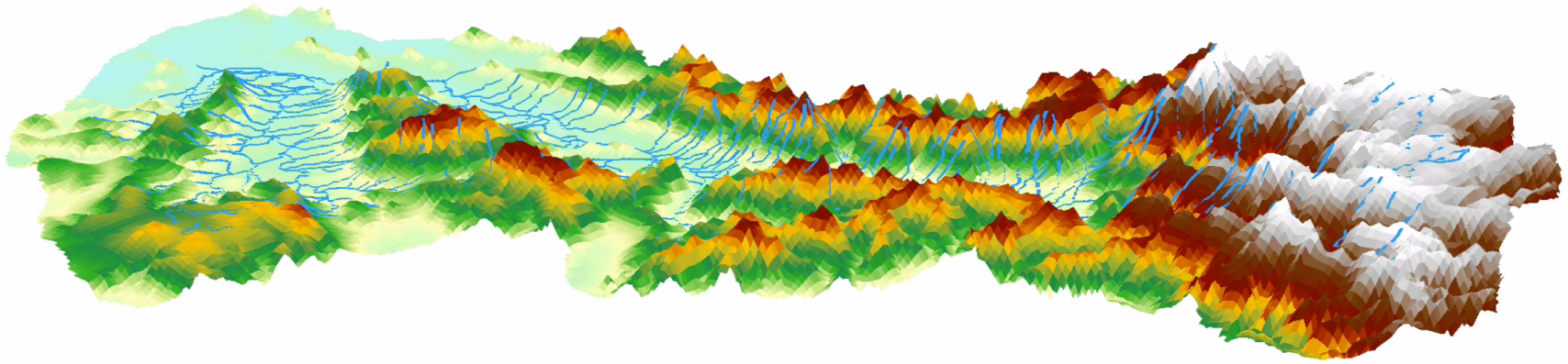
Item	**Purpose**
AWRA-L vs AWRA-L with routing	To test if routing improves model performance

Study catchment – Kiewa River

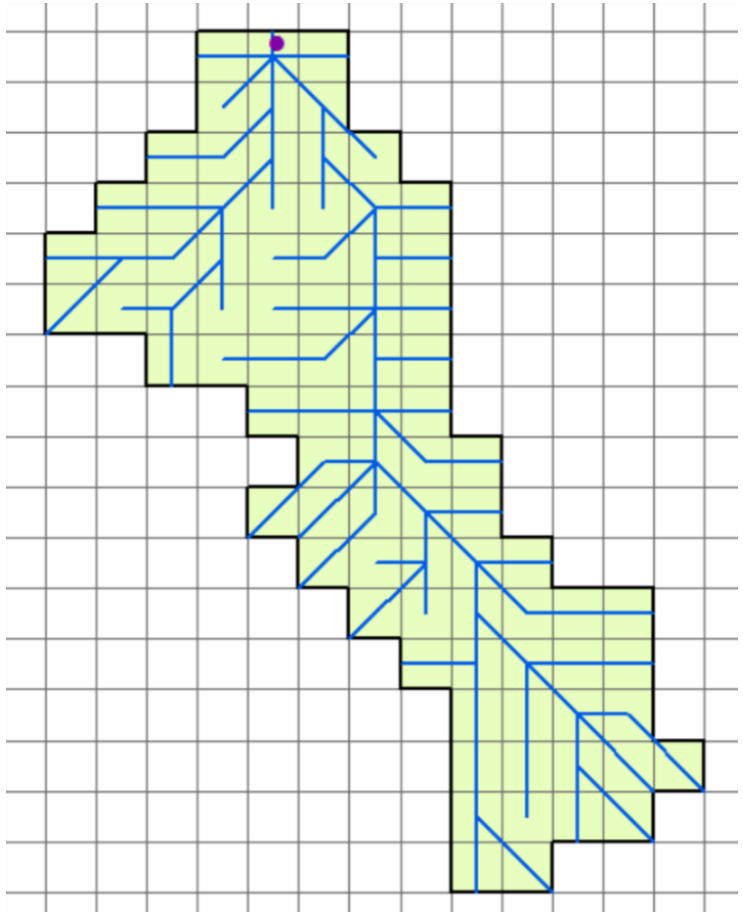


- Long & narrow
- Some sub-catchments inside it
- In southeast Murray-Darling Basin

Study catchment – Kiewa River 3D



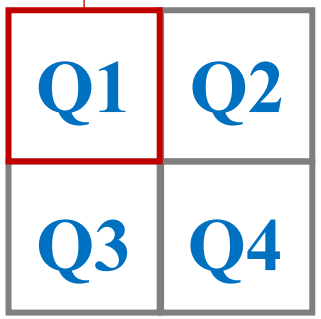
Grid-link

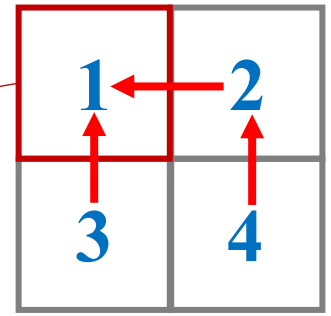


Grid-link: Steps to calculate daily Q

$$Q_{mean} = \frac{Q1+\ldots+Q4}{No.\,of\ cells}$$

$$Q_{mean} = \frac{Qout1}{No.\,of\ cells}$$





AWRA-L	AWRA-L with routing
Calculate Q for each cell	
-	Routing (every time step): • Divide daily Q by number of time steps • Calculate *loss* by surface water volume *S* • Transfer *loss* to next cell • Update surface water volume *S* • Accumulate *Qout* for the outlet cell
At the end of the day, calculate mean Q	
Q_est = mean Q	

$$Q1_{step\_i} = \frac{Q1}{No.\,of\ steps}$$

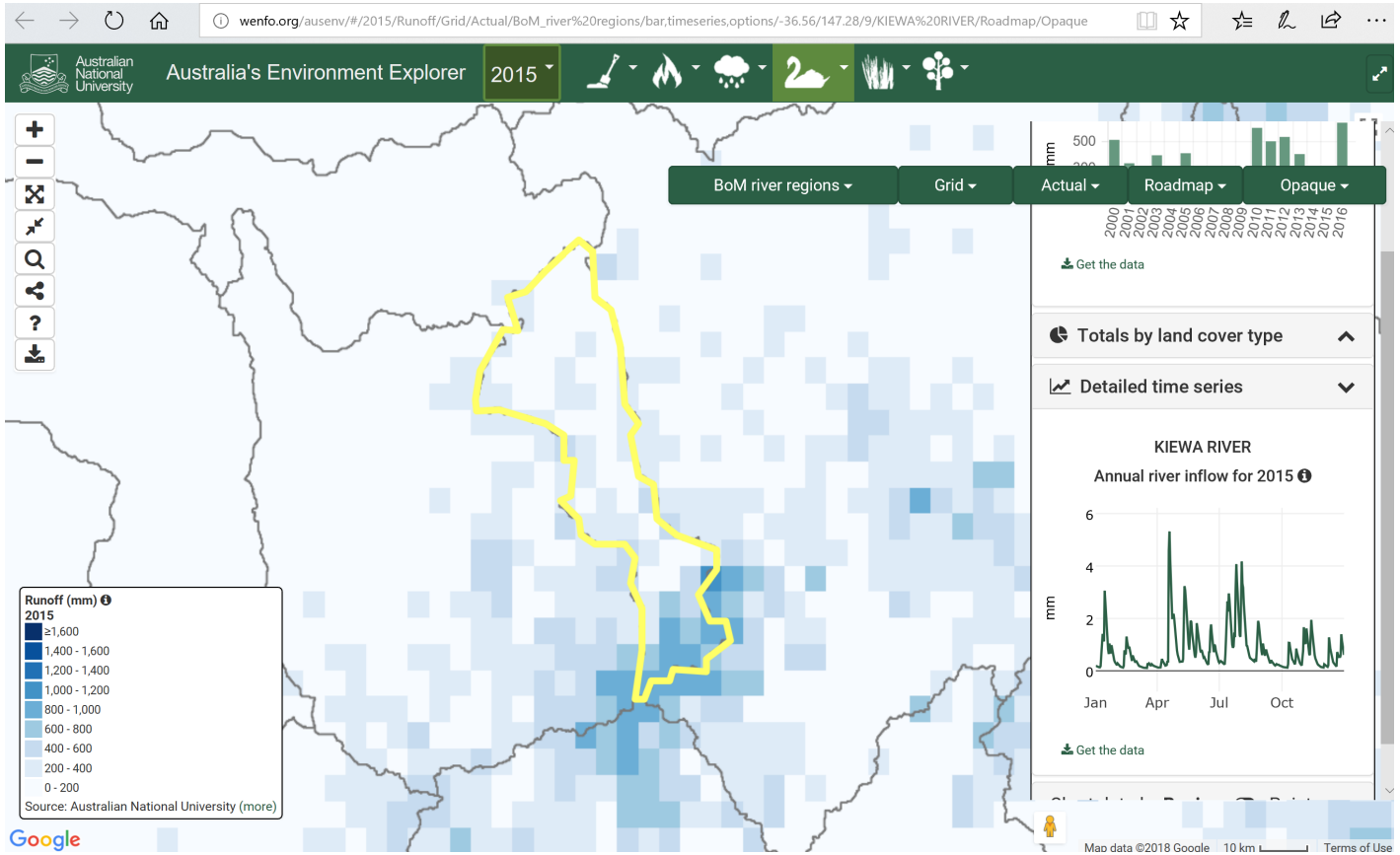
$$loss1_{step\_i} = S1_0 \times k$$

$$inwater1_{step\_i} = (loss2_{step\_i} + loss3_{step\_i}) \times scale$$

$$S1_{new} = S1_0 + Q1_{step\_i} + inwater1_{step\_i} - loss1_{step\_i}$$

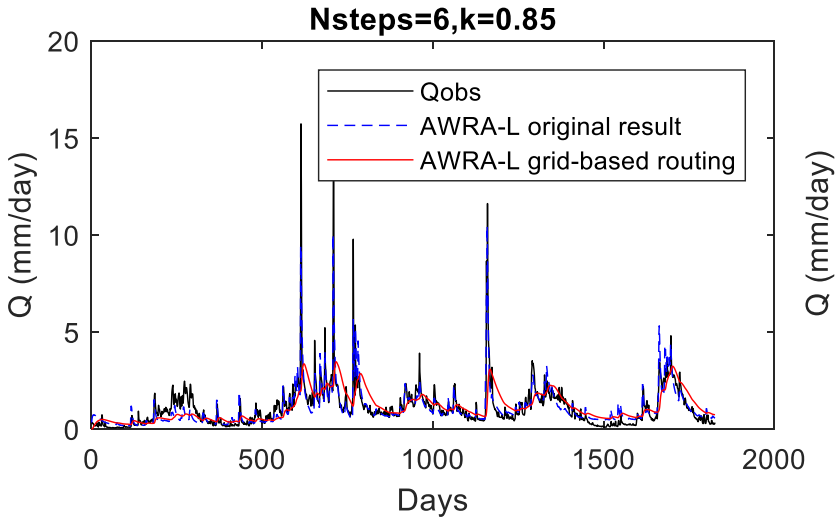
$$Qout1_{step\_i} = Qout1_{step\_i-1} + loss1_{step\_i}$$

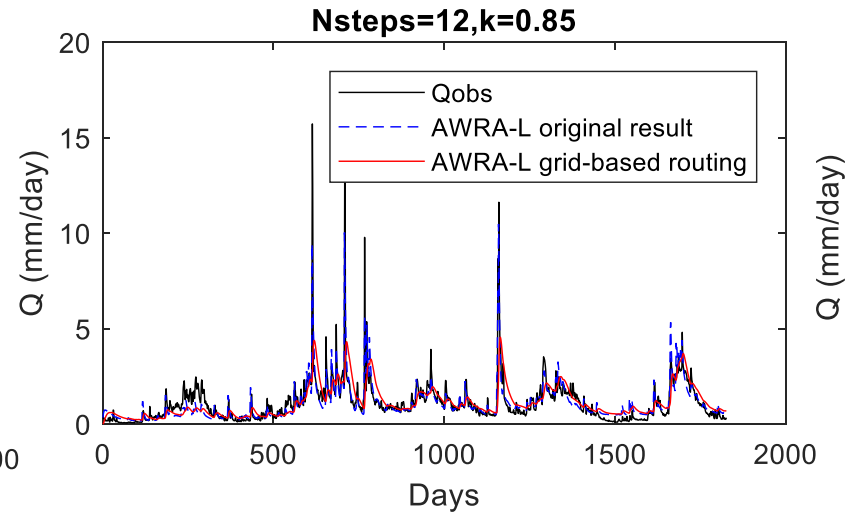
Grid-link: routing without calibration – Albert's web

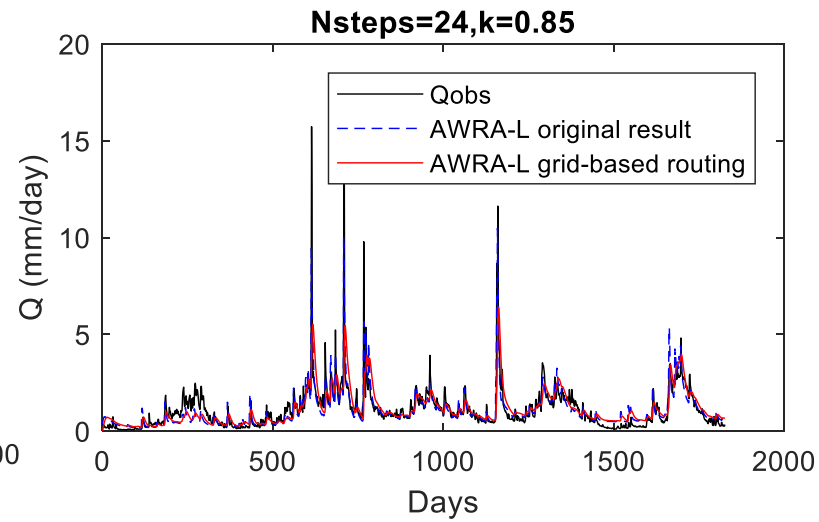


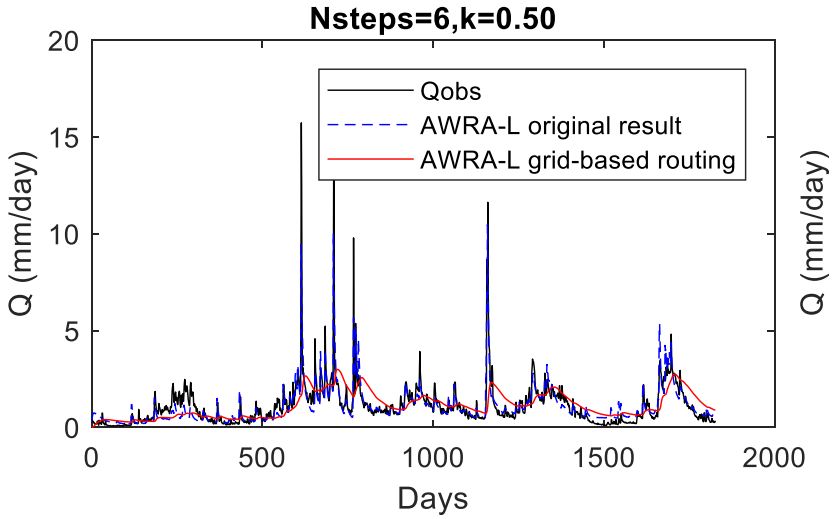
- Get daily Q from AWRA-L model (grid)
- Use default parameters to conduct routing
- Generate new daily Q
- It is a post-processing (No calibration)

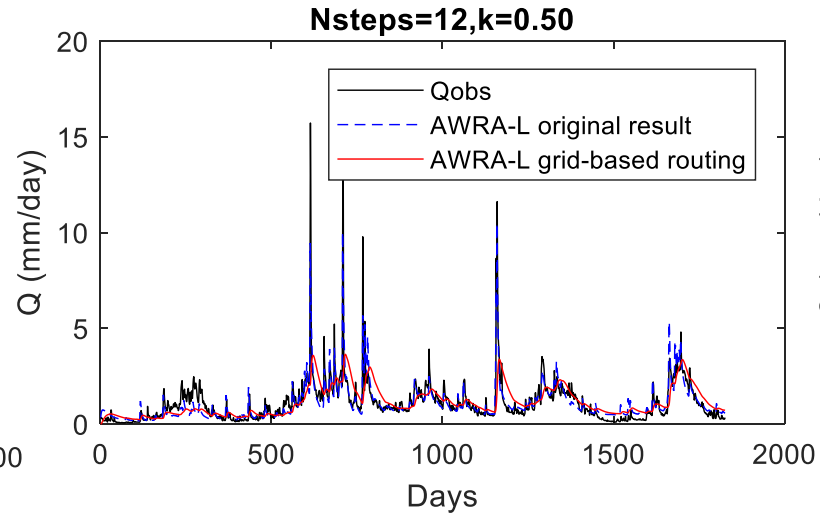
Grid-link: routing without calibration

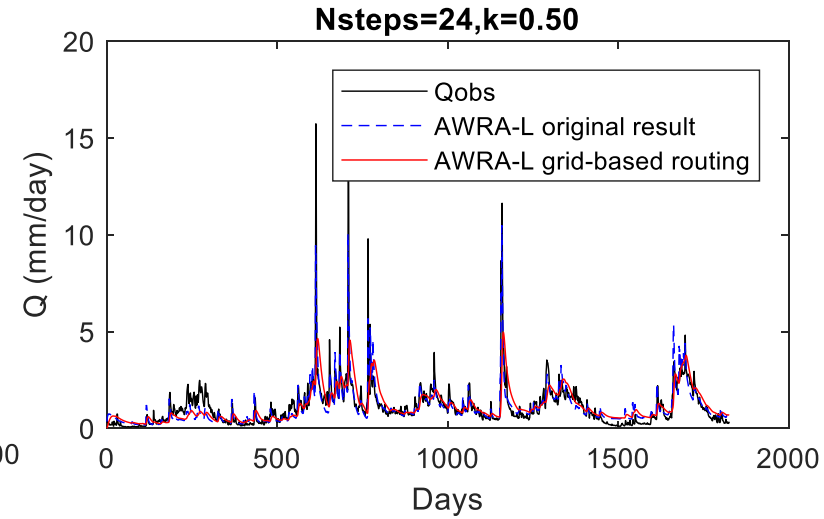




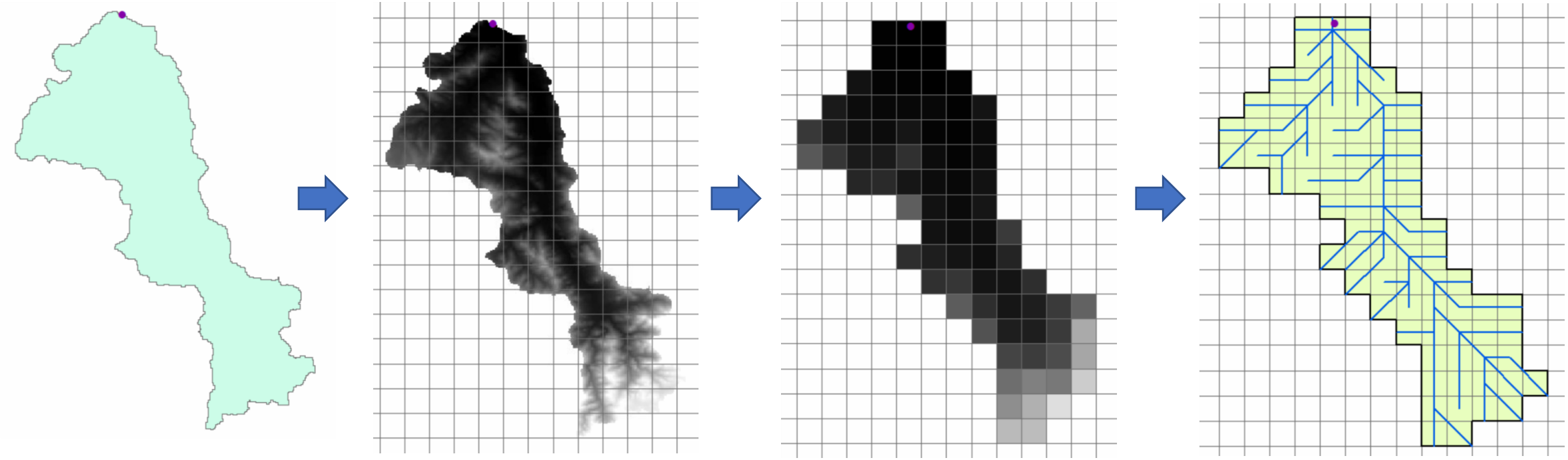






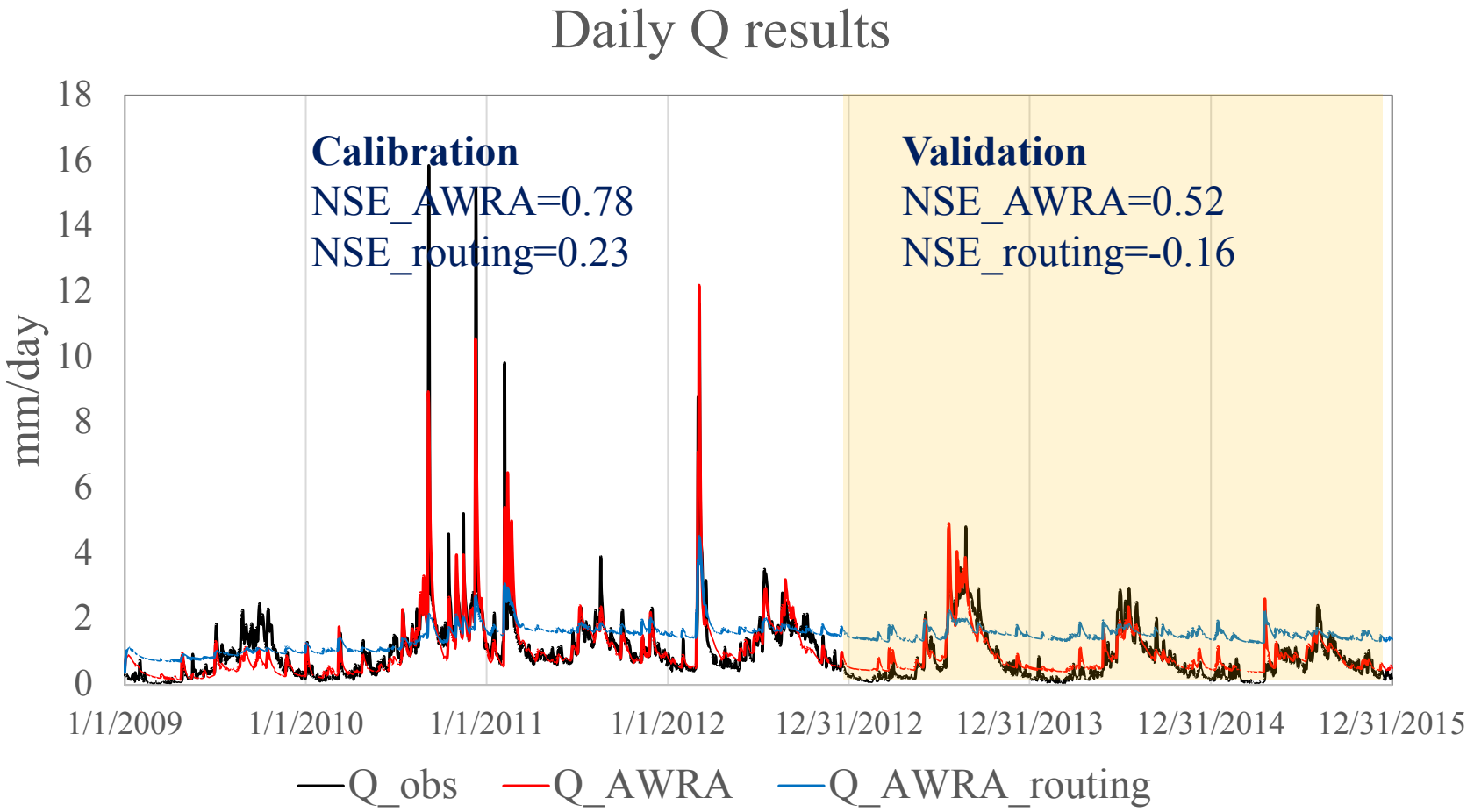


Grid-link: to get connections among grids

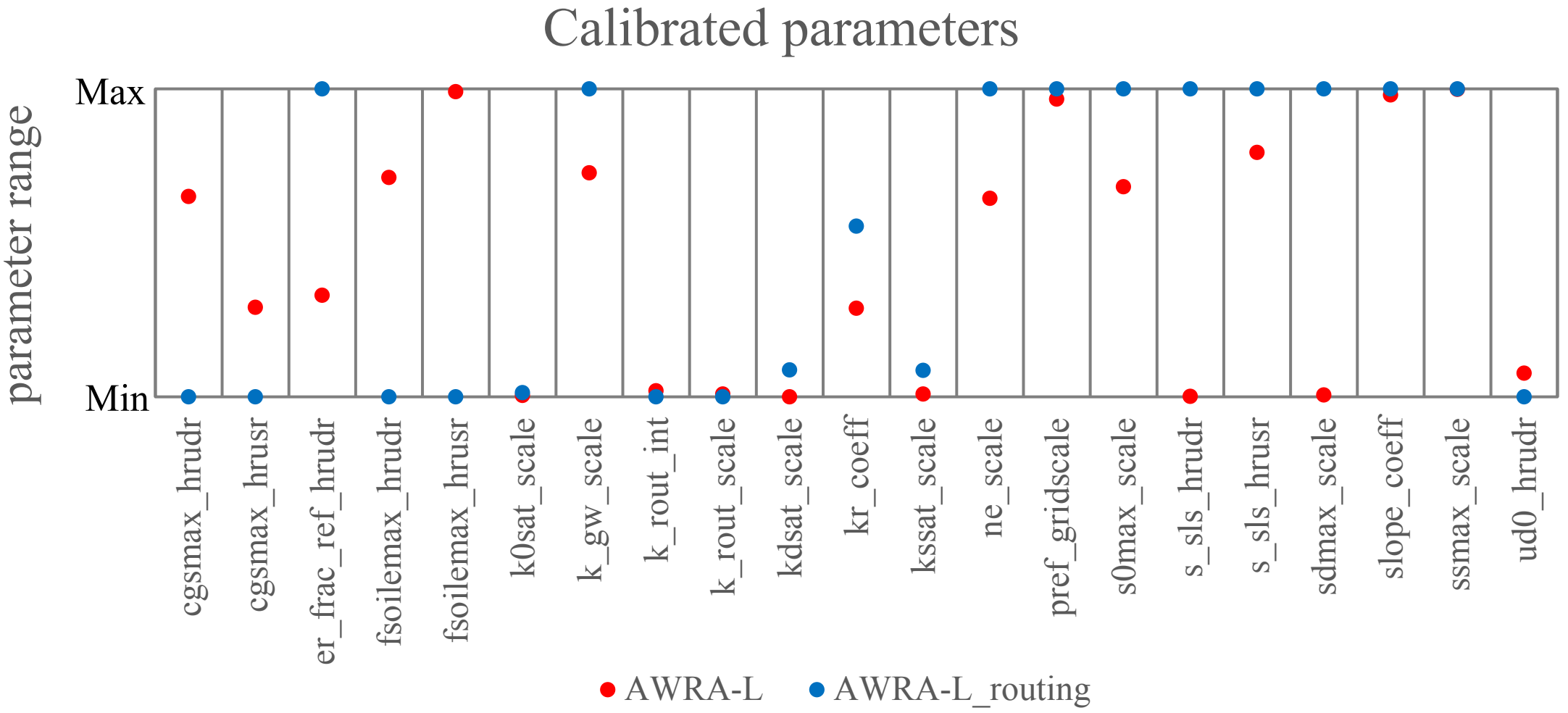


Grid-link: routing with calibration

- Python, awra_training
- *Nsteps*=6 & *k*=0.85
- *Q_est* vs *Q_daily_obs*
- Warm-up: 2006-2008
- Calibration: 2009-2012
- Validation: 2013-2015
- 9 times calibration time



Grid-link: AWRA-L parameters



Grid-link: discussion – reasons for inaccurate results

- *Q_obs* is daily
- May not have the best ***k*** and ***Nsteps*** (need to be included in the calibration)
- Should also update soil moisture stage after each time step (if possible), now – update daily

Node & Grid-link with RAPID model

Geofabric
(605 subcatchments)

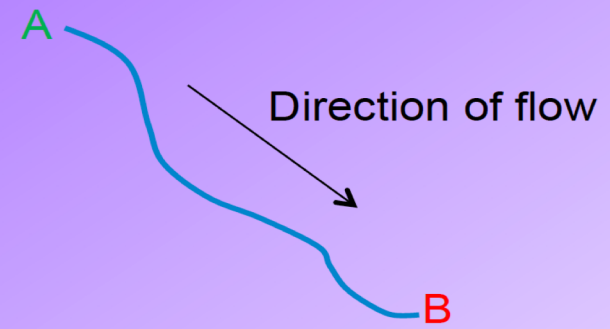
1km
(1700 grids)

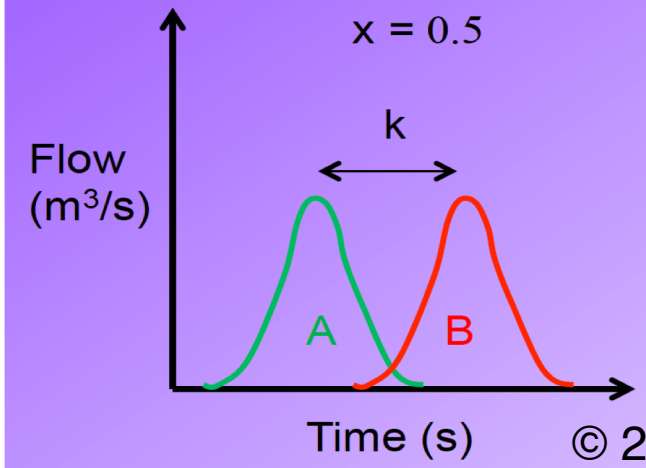
RAPID model

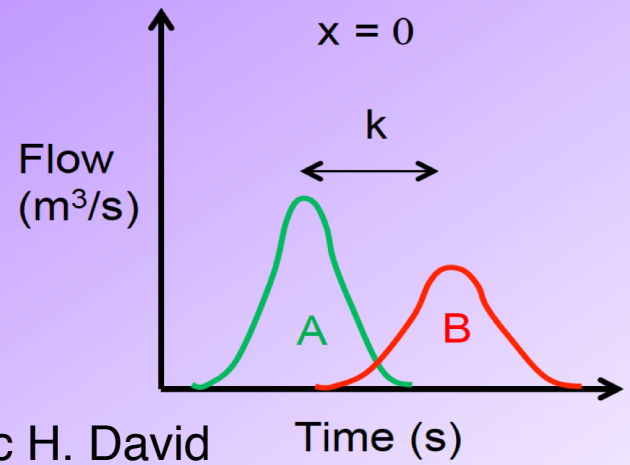
RAPID is based on the Muskingum method

k is a time ($k \geq 0$) related to the celerity of the flow wave

x is a non-dimensional parameter ($0 \leq x \leq 0.5$) related to diffusion of the flow wave







RAPID: k and x calculation

- *k* is calculated based on a wave celerity c (m/s) and the river reach length:

  $k = LENGTH_{(km)} * 1000/c.$

  c = 0.8 m/s (default)

- *x* is set as 0.1 as default

- RAPID model can calibrate *k* and *x* against Q_obs using the first guess (default) of k and x

Inputs and settings for RAPID model

- Data resources
  - Daily Q from AWRA-L (BoM web) (a single set of parameters for all catchment in Australia)
  - Re-calibrated daily Q for Kiewa River
- Spatial scale (network connectivity)
  - Geofabric river network
  - 1km grid
- Time steps for input Q
  - Daily
  - 3 hours (Q_3h = Q_daily / 8)

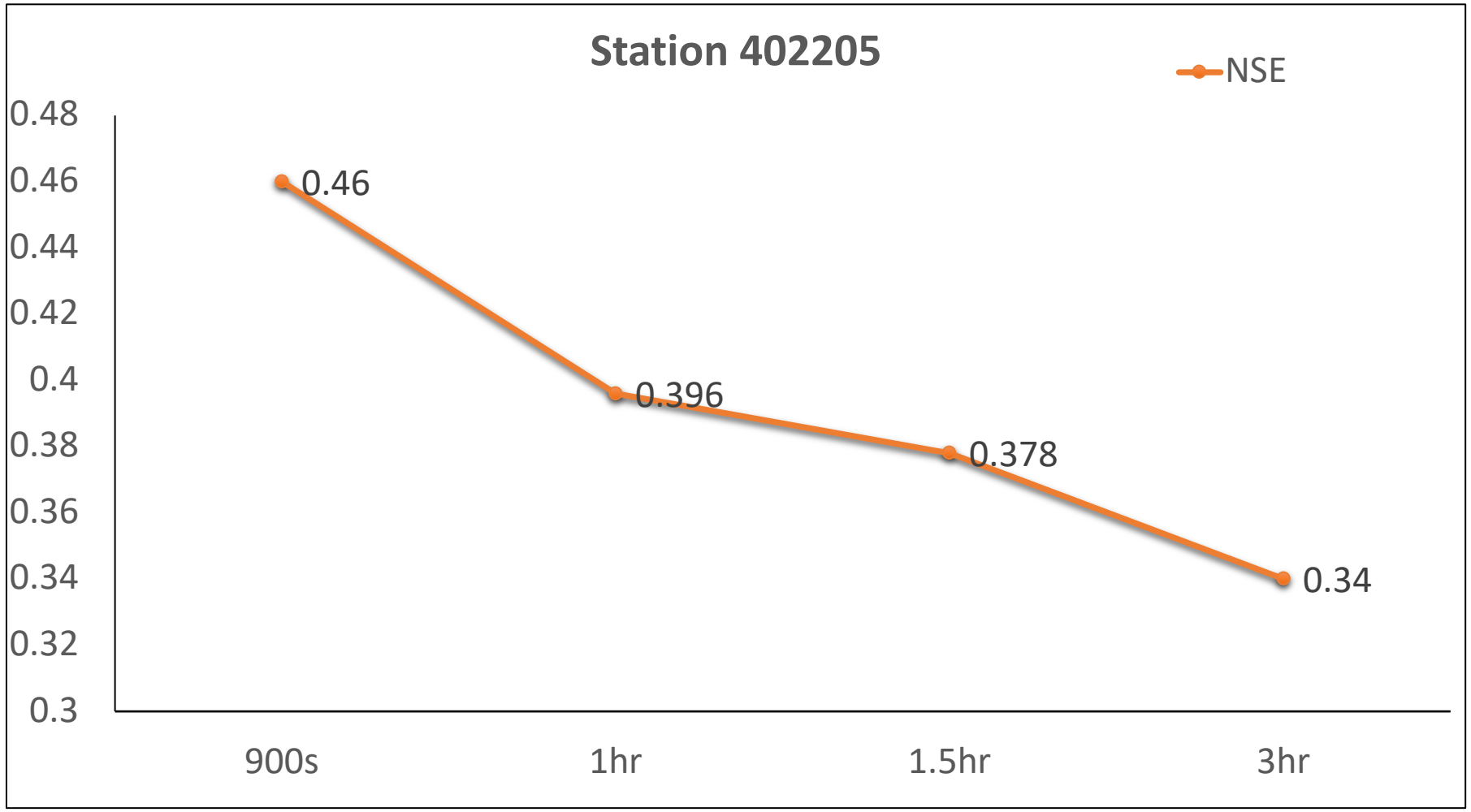
RAPID: Internal time step for routing

- The time step for RAPID routing should be less than the time step for input Q

- It determined by wave celerity and river network length

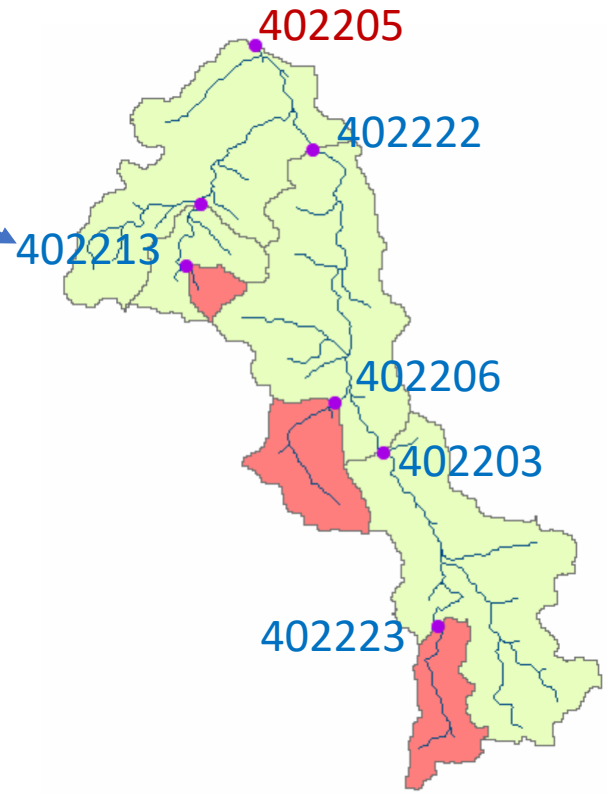
So we design 900s (15min), 1hr, 1.5hr and 3 hr to test the best time step for routing

Time step test result



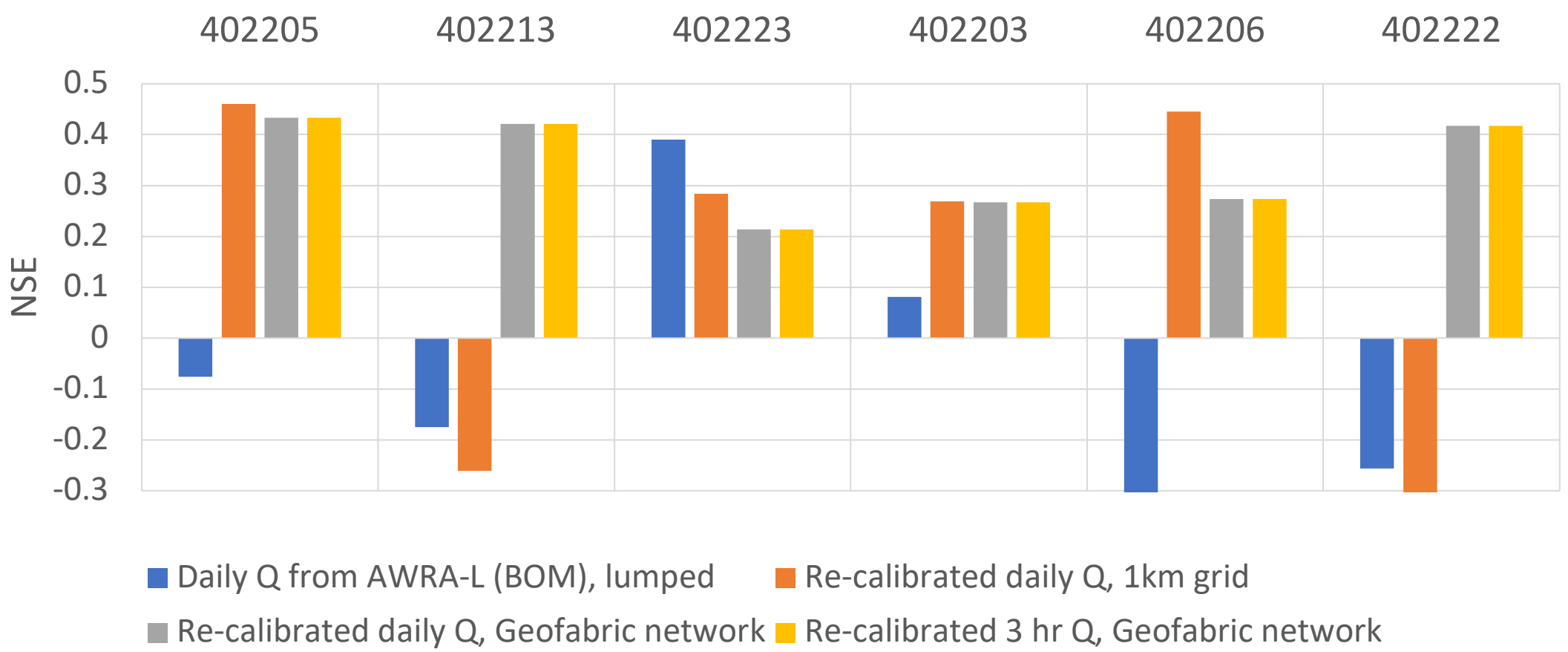
NSE values for different calibration methods in AWRA-L

- Regional calibration using all catchments in Australia
- vs regional calibration using 3 catchments in Kiewa River
- vs calibration using single catchment

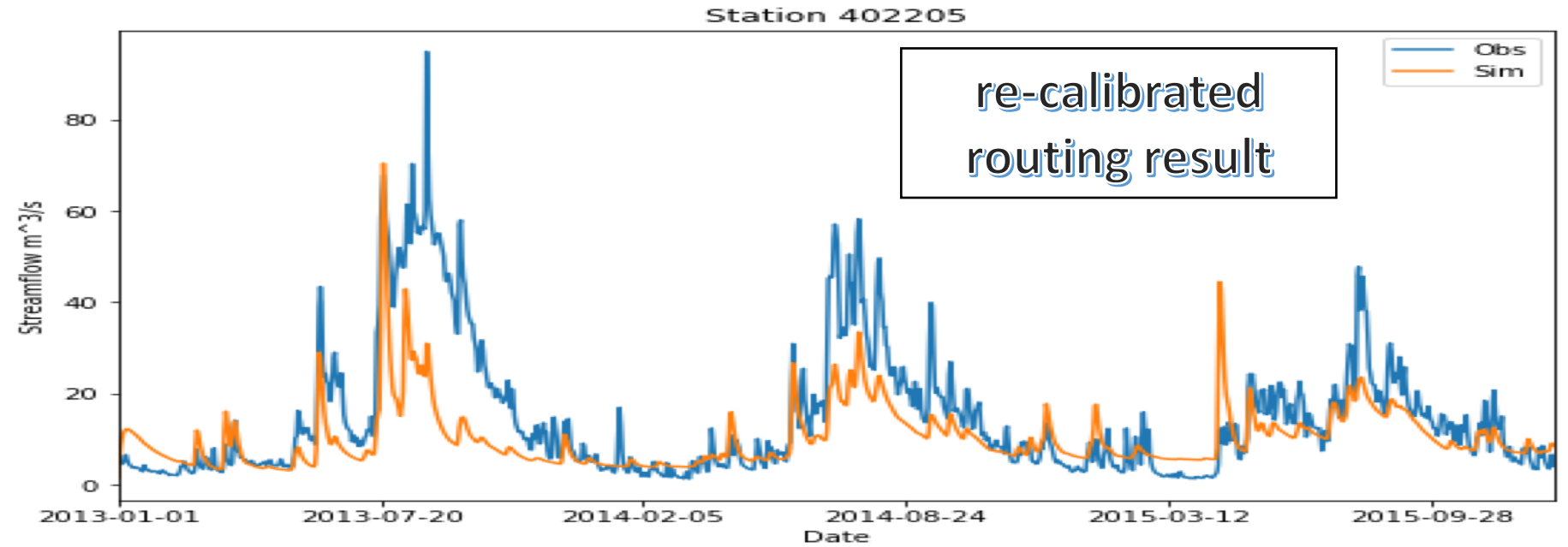


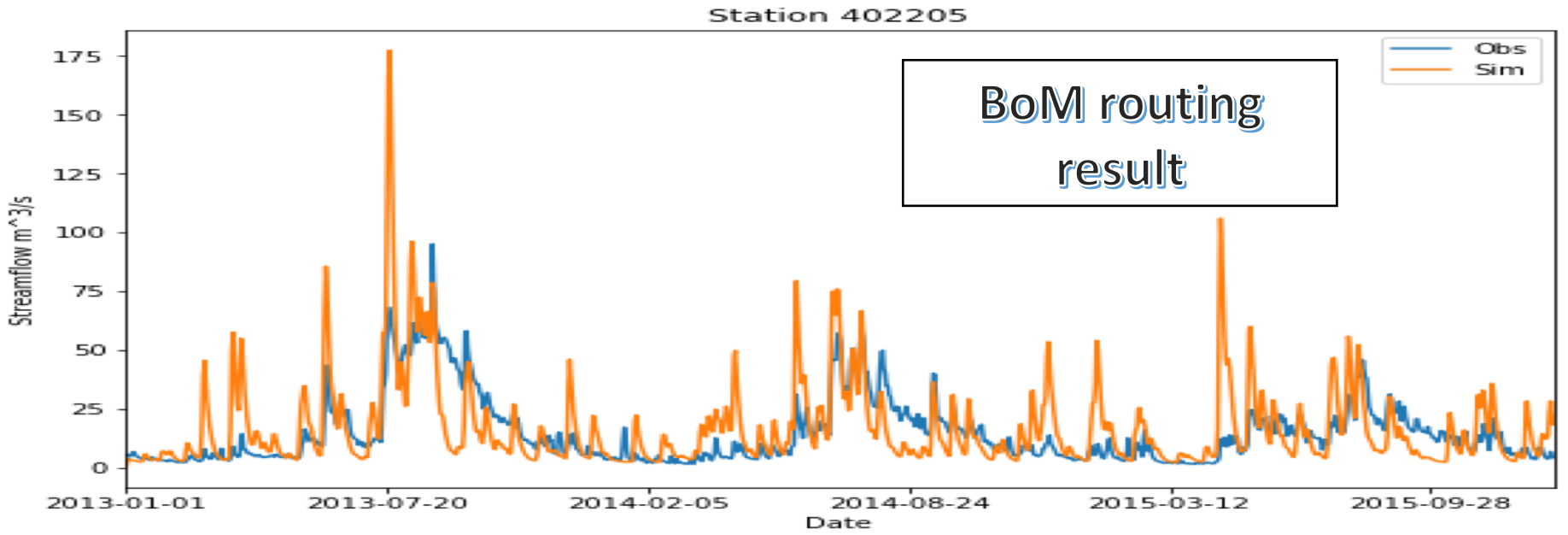
Site	parameter from AWRA-L BoM	regional calibration using 3 catchments	single site re-calibration
402205	-0.65	0.43	0.79
402206	-3.5	0.61	
402213	-0.18	0.43	
402223	0.38	0.44	

RAPID: NSE values for different RAPID inputs and settings

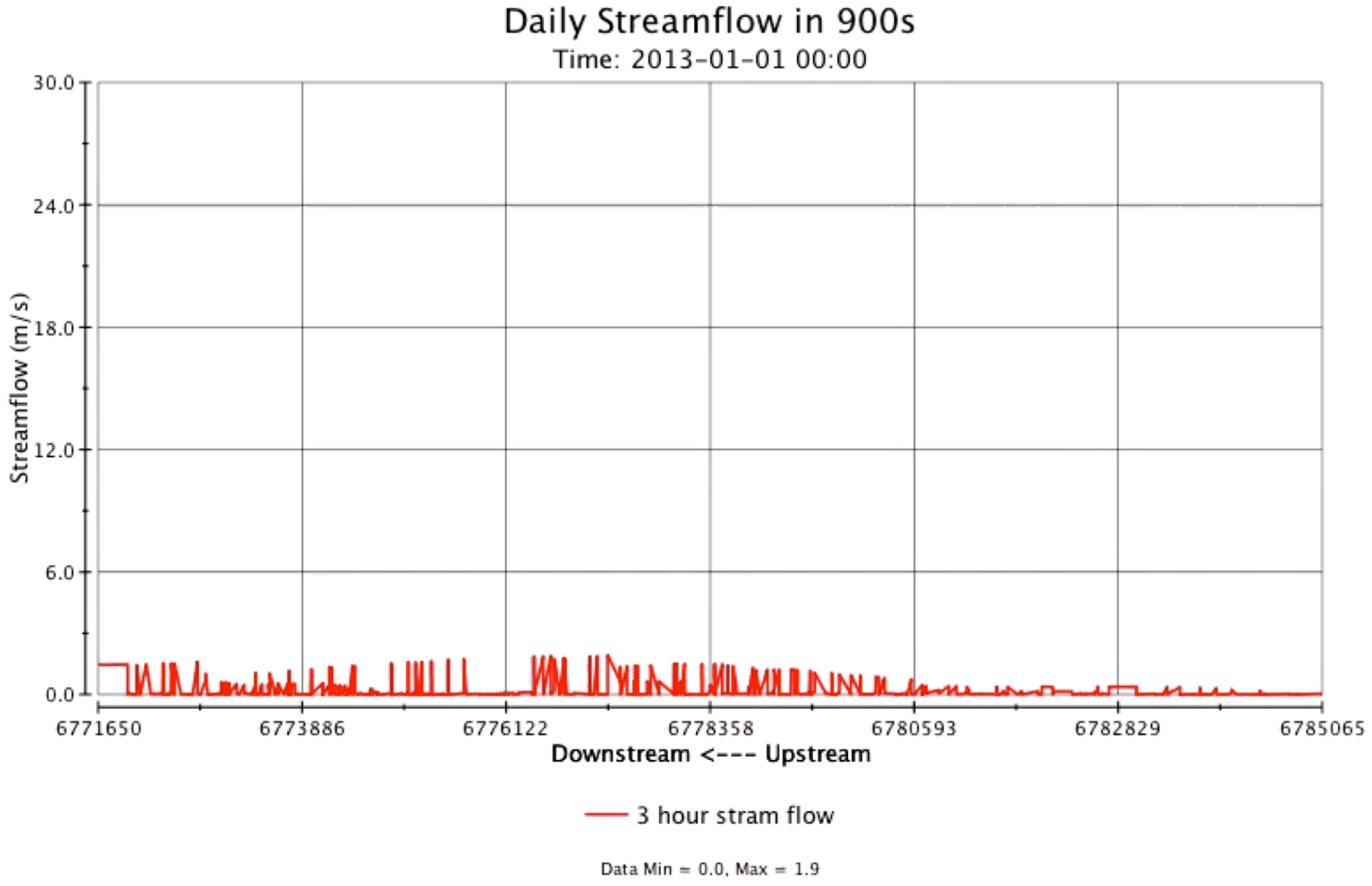


Towards improving the accuracy of AWRA-L model by adding routing processes in model calibration



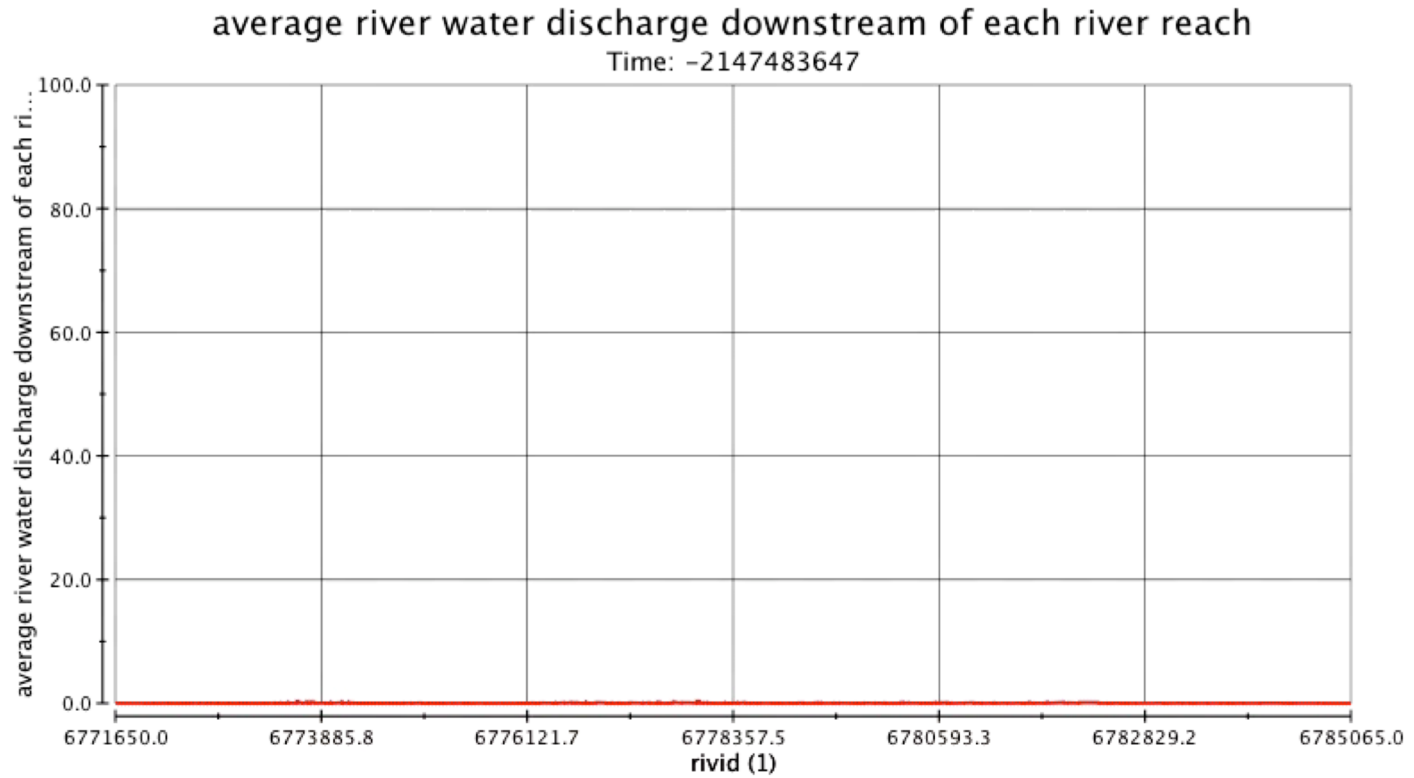


RAPID: water discharge with daily input



RAPID: water discharge with 3h input

Flow m^3/s



Downstrem ← Upstream

RAPID: discussion

- The best time step is 900s, which is better than other longer time steps;
- Geofabric sub-catchment input is slightly better than 1km grid in overall;
- There is no difference between 3hr and daily flow input for routing performance, but small time scale flow input can get more reasonable sub-daily routing result;
- Re-calibrated runoff output from AWRA-L model showed much better result than original output in BOM's website in Kiewa catchment.

RAPID: Our improvement

- Previous shortage (2016 SI)
  - *Deal with sub-hourly data observations (to estimate RAPID parameter): >200,000 entries for each station.*
  - *To process 1-year daily runoff of Tamar River (2,459 sub-catchments): **7-hours** with **16** cores of Raijin (we need data for four – seven years).*
- Our solution
  - By setting different routing time step and using RAPID model's optimisation function to get the best result
  - Rewrite runoff process code to reduce the input data process time. (our code can finish processing 3 years' daily input of 2000 sub-catchments within 5 mins with 1 core)

RAPID: future work

- Integrate AWRA-L + RAPID model in calibration
- Test higher resolution AWRA-L model result (<=1km)
- Using the calibrated AWRA-L+RAPID model to simulate the impacts of land cover change on peak flow;
- Routing parameter calibration for AWRA-L model

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Prof Richard Harper

Previous SI team, Rowena and Zac

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