Australian Water Resources Assessment (AWRA)

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Outline

- Objective of AWRA Modelling System
- AWRA-Landscape model and its implementation
  - Continental and regional gridded calibration
- AWRA-River system model and its implementation
  - Overall calibration and validation
  - AWRA-R irrigation modelling
  - AWRA-R floodplain inundation modelling
- Conclusions

AWRA Modelling System

Objective:

- To provide seamless water balance information and data for the nation for the past and present, using observations where available, and modelling otherwise.

Outcomes:

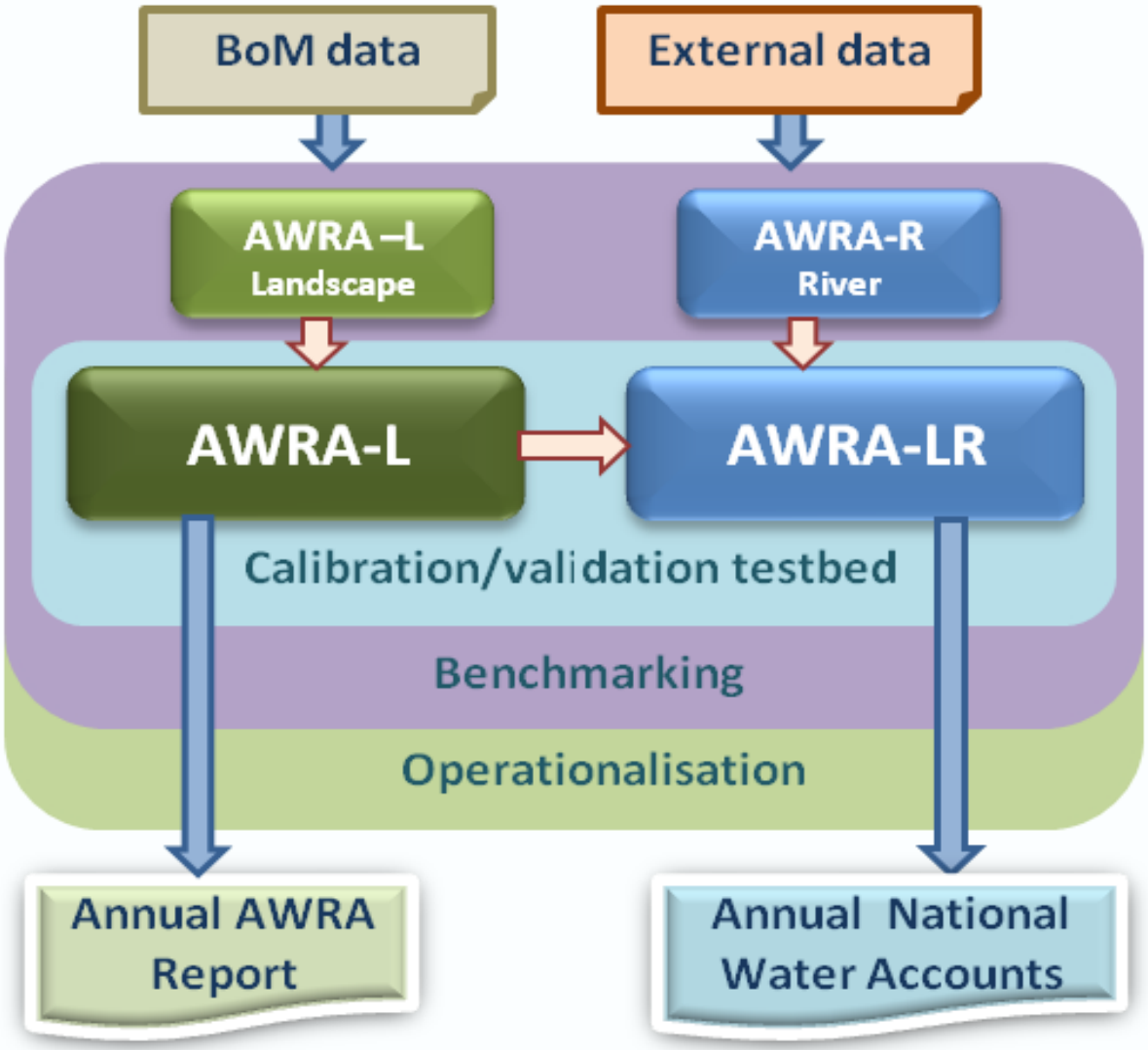
- Consistent, accurate and robust continental scale modelling to underpin the Australian Water Resource Assessment Report and the National Water Accounts.
- Water management and water market informed by accurate and timely annual water accounts.
- A national picture on water availability over time (spatial and temporal trends across the continent) which will help guide the significant water reforms that are happening across Australia and to support national resources policy.

AWRA Modelling System - Components

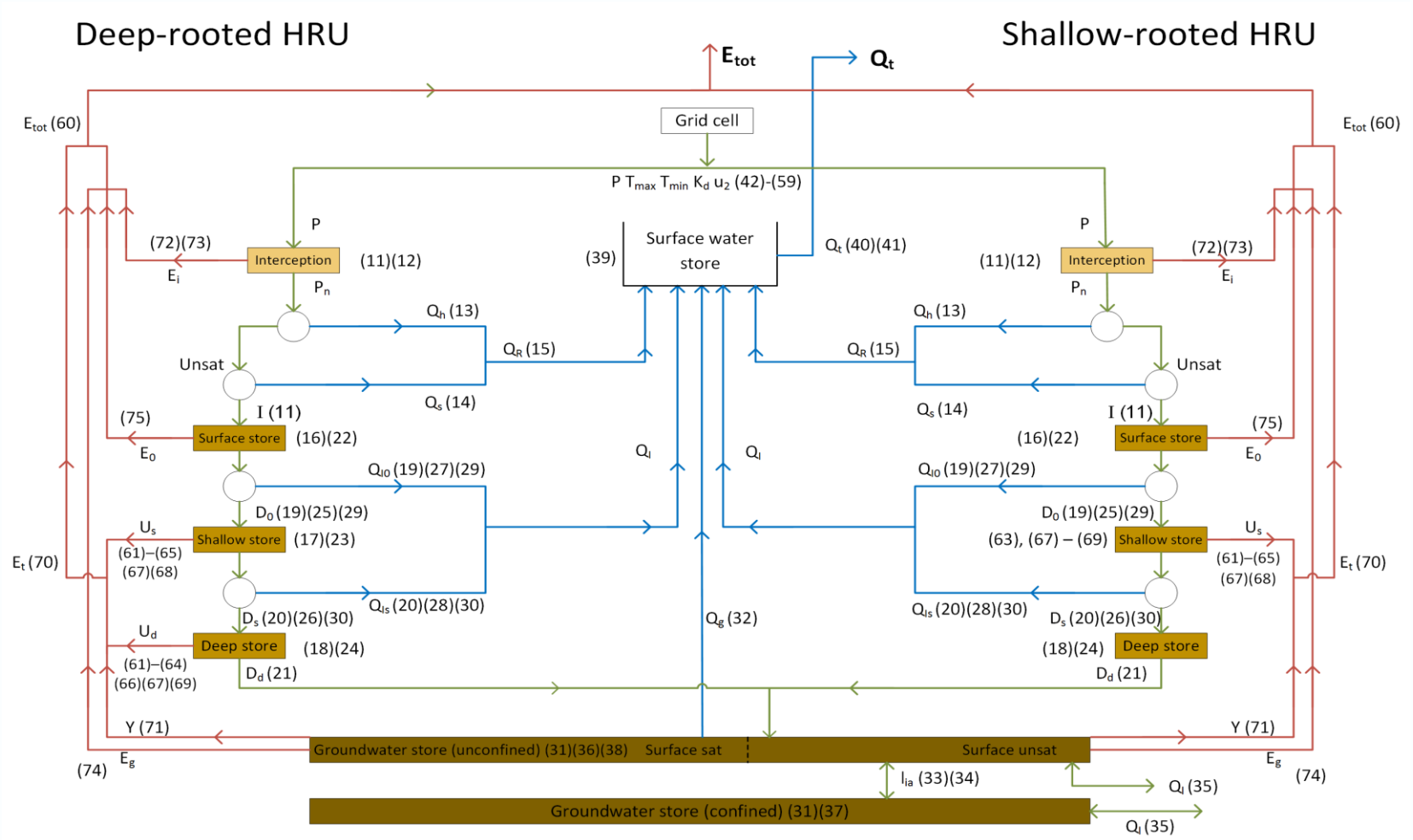
Two major components:

AWRA-L (Landscape model)

AWRA-R (River system model)



AWRA-L current version

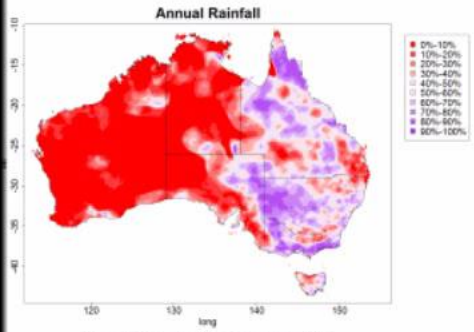


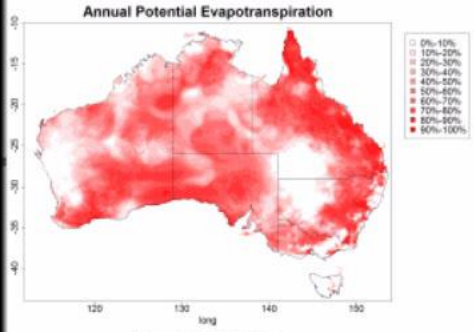
Conceptual diagram of AWRA-LG showing stores and fluxes. The red arrows represent fluxes of water to the atmosphere, the blue arrows represent fluxes of water into the surface water and the green arrows are internal fluxes of water within the model.

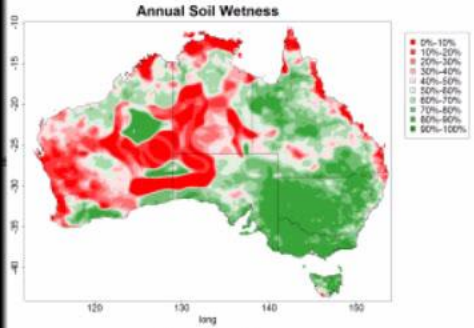
Viney et al., 2014

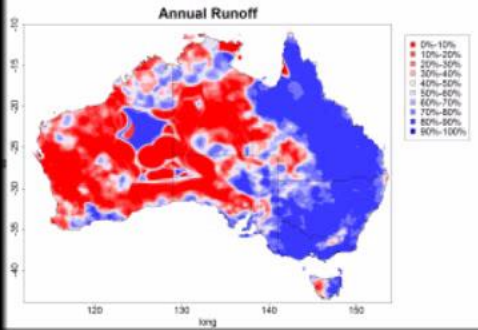
1911

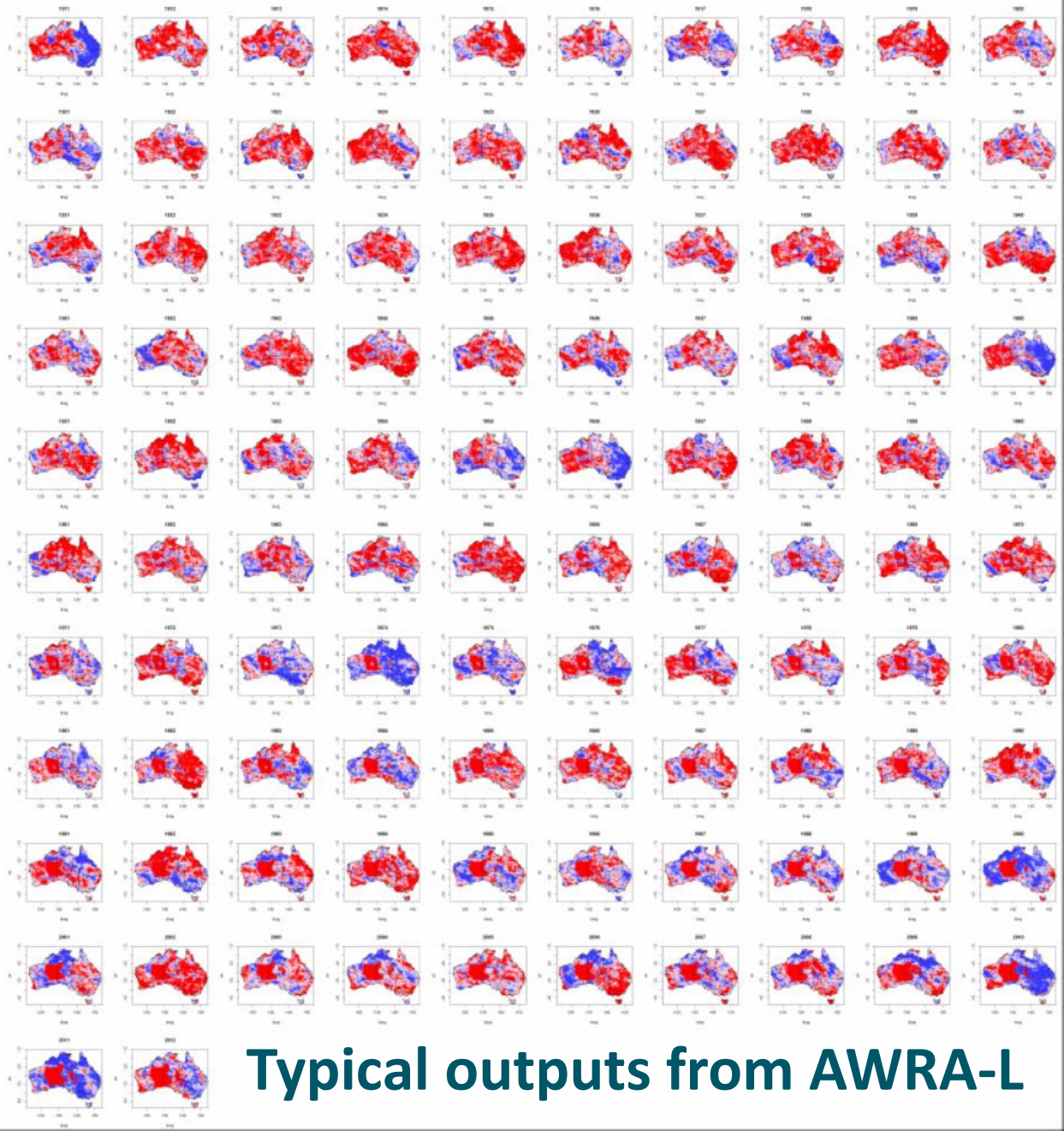
Runoff Deciles (1911-2012)





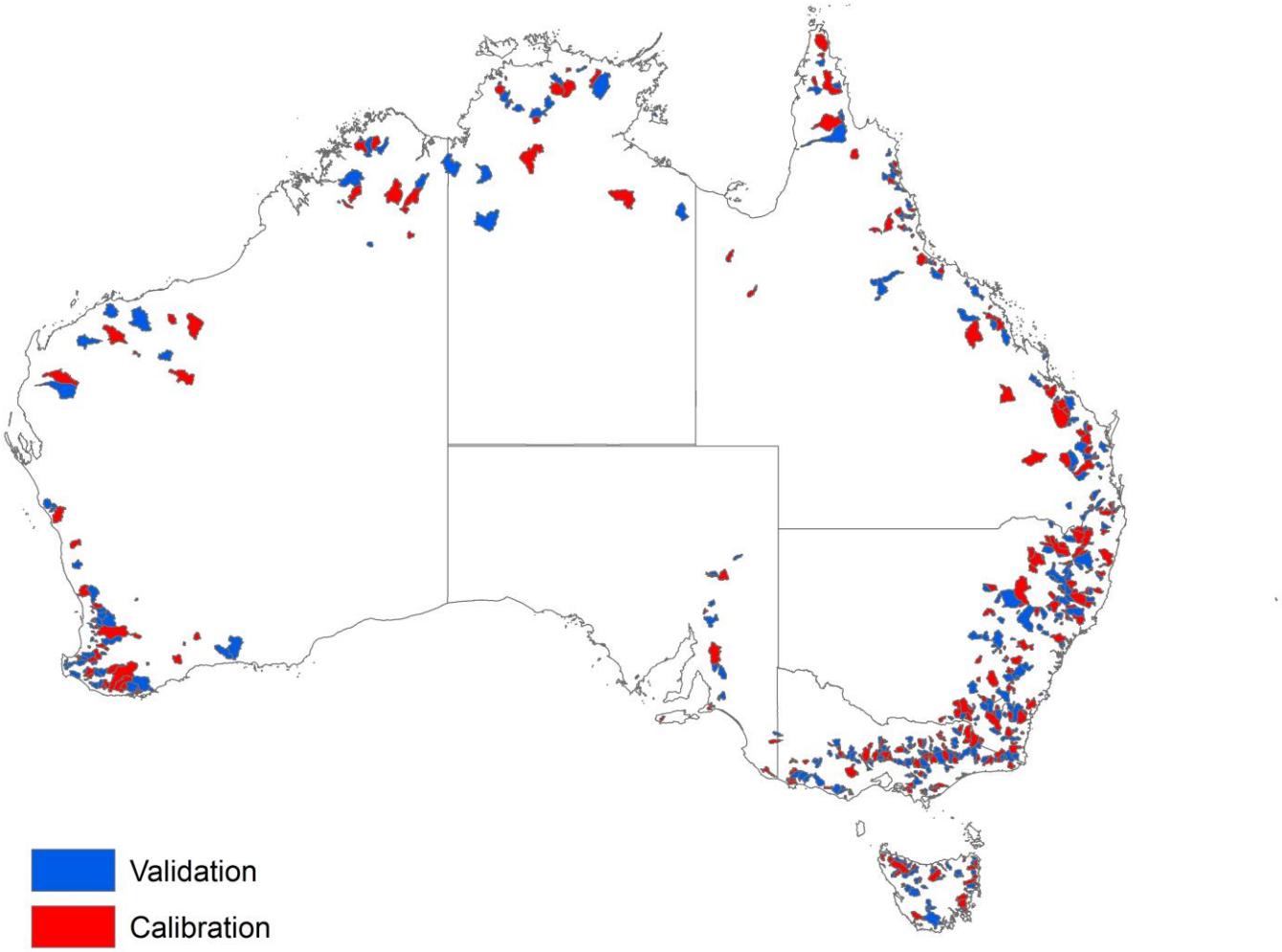




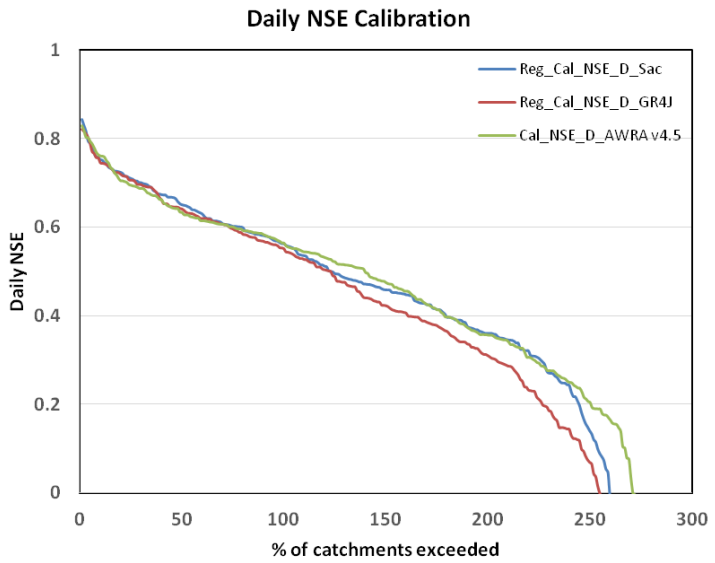


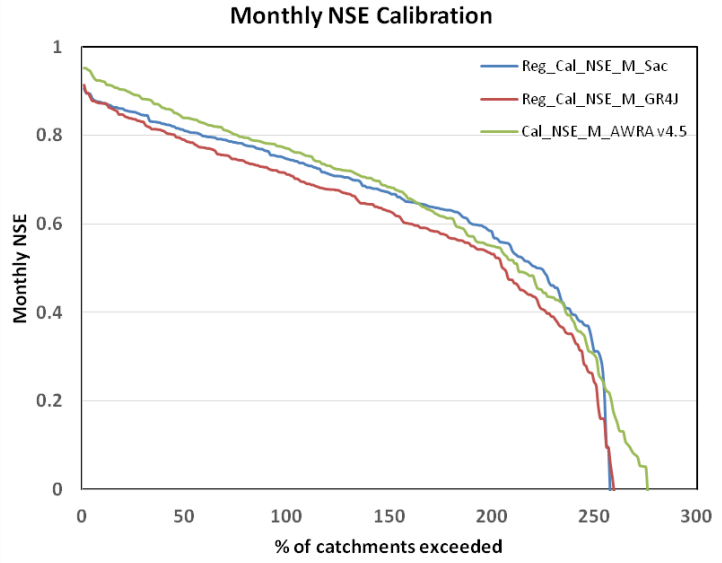
Typical outputs from AWRA-L

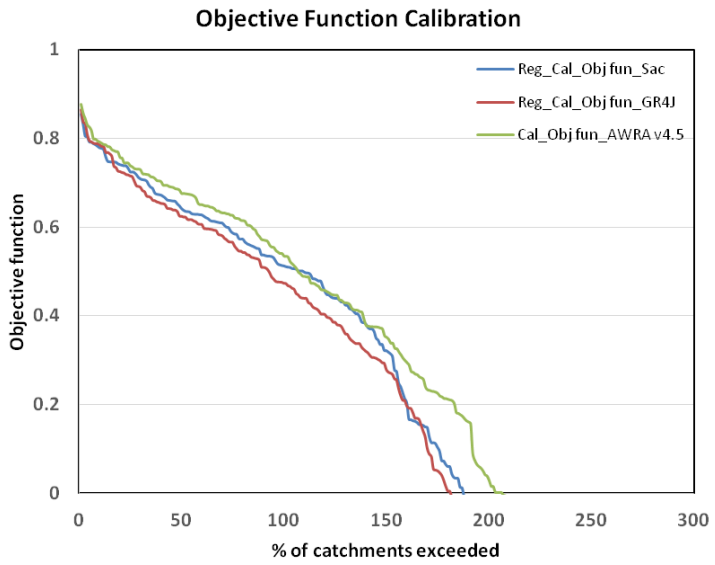
AWRA Calibration and Validation Catchments

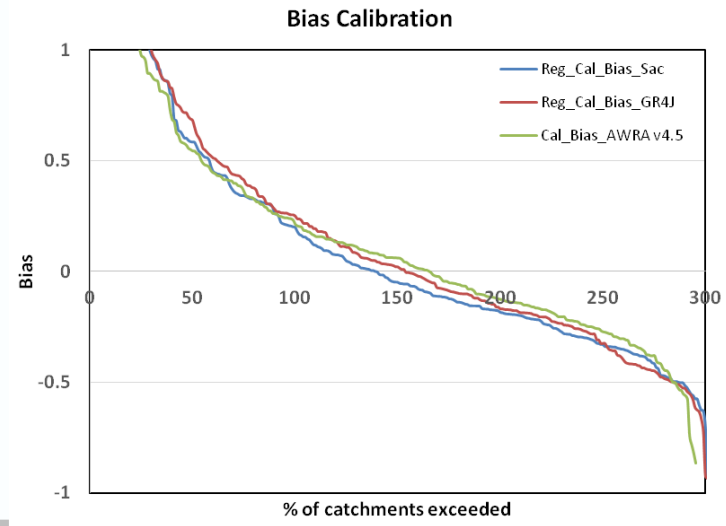


Comparison of AWRA-L results against Sacramento and GR4J - Calibration

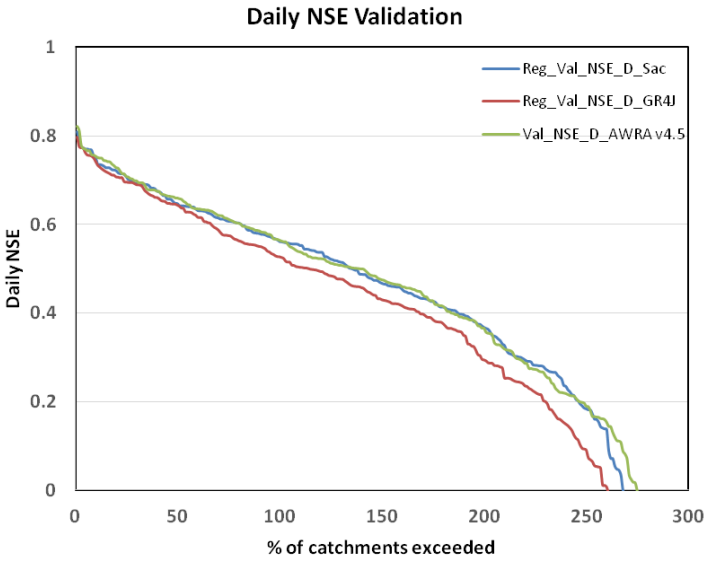


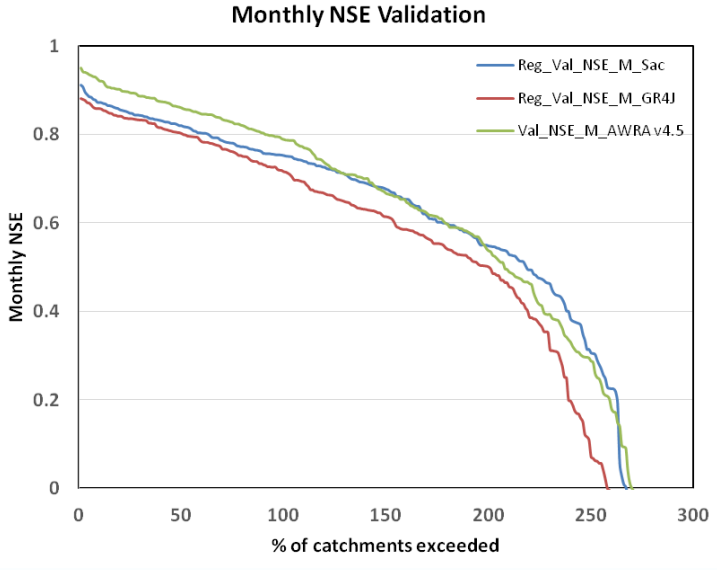


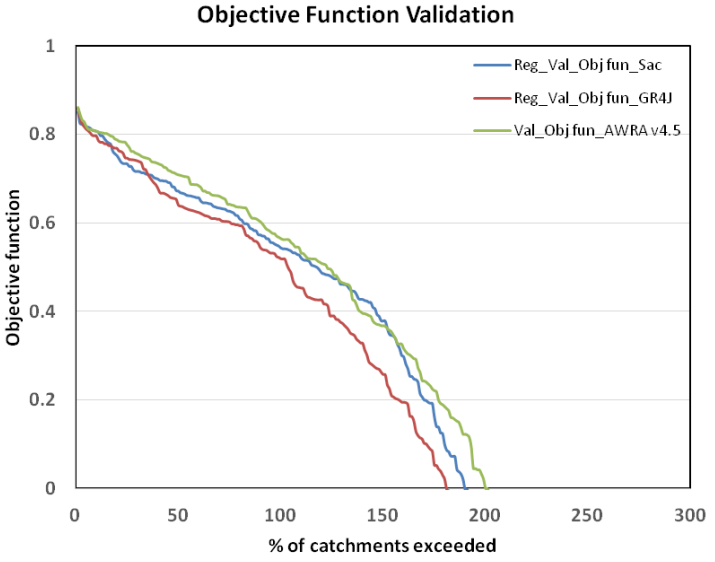


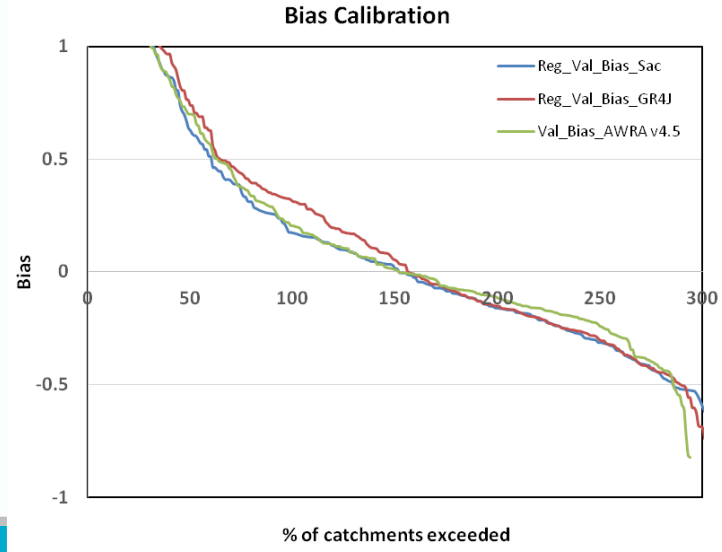


Comparison of AWRA-L results against Sacramento and GR4J - Validation



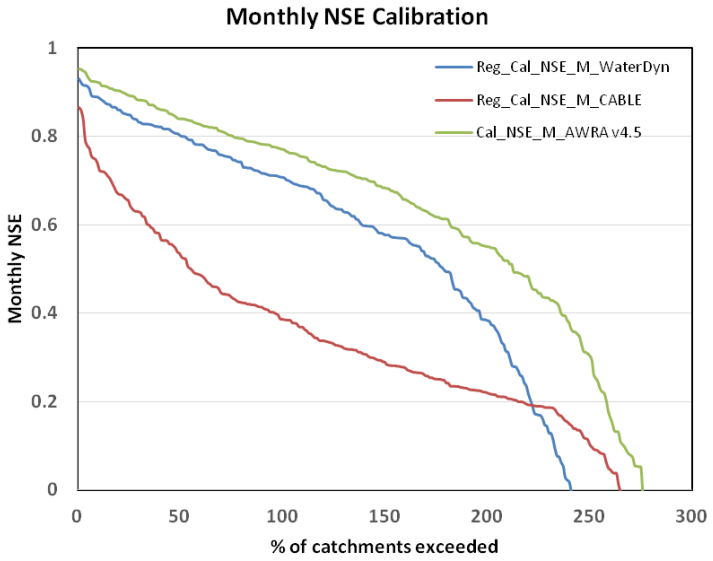


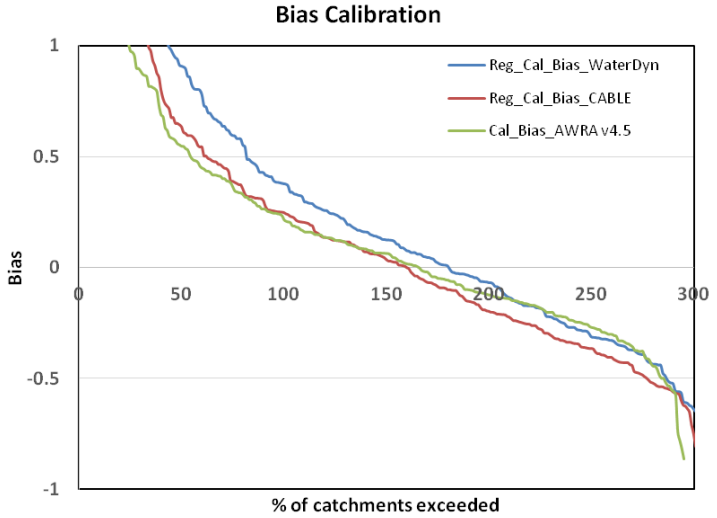




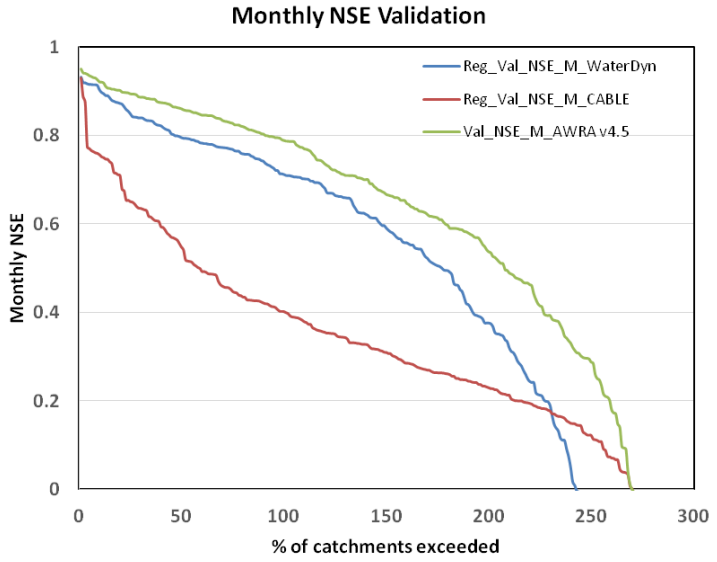
Comparison of AWRA-L results against WaterDyn and CABLE

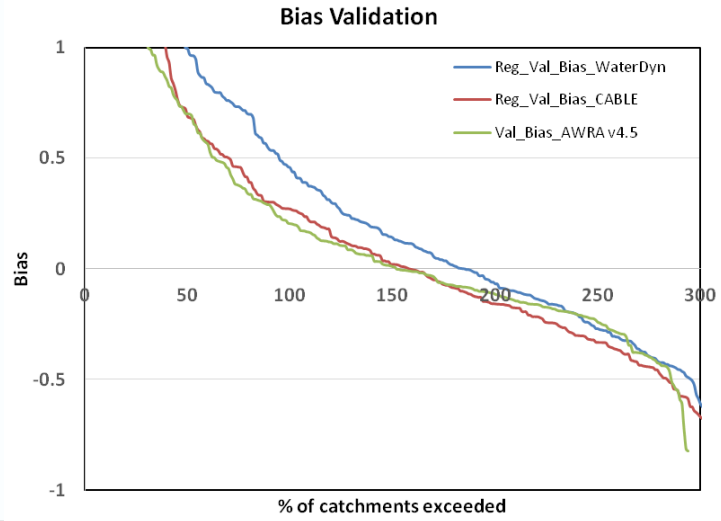
Calibration



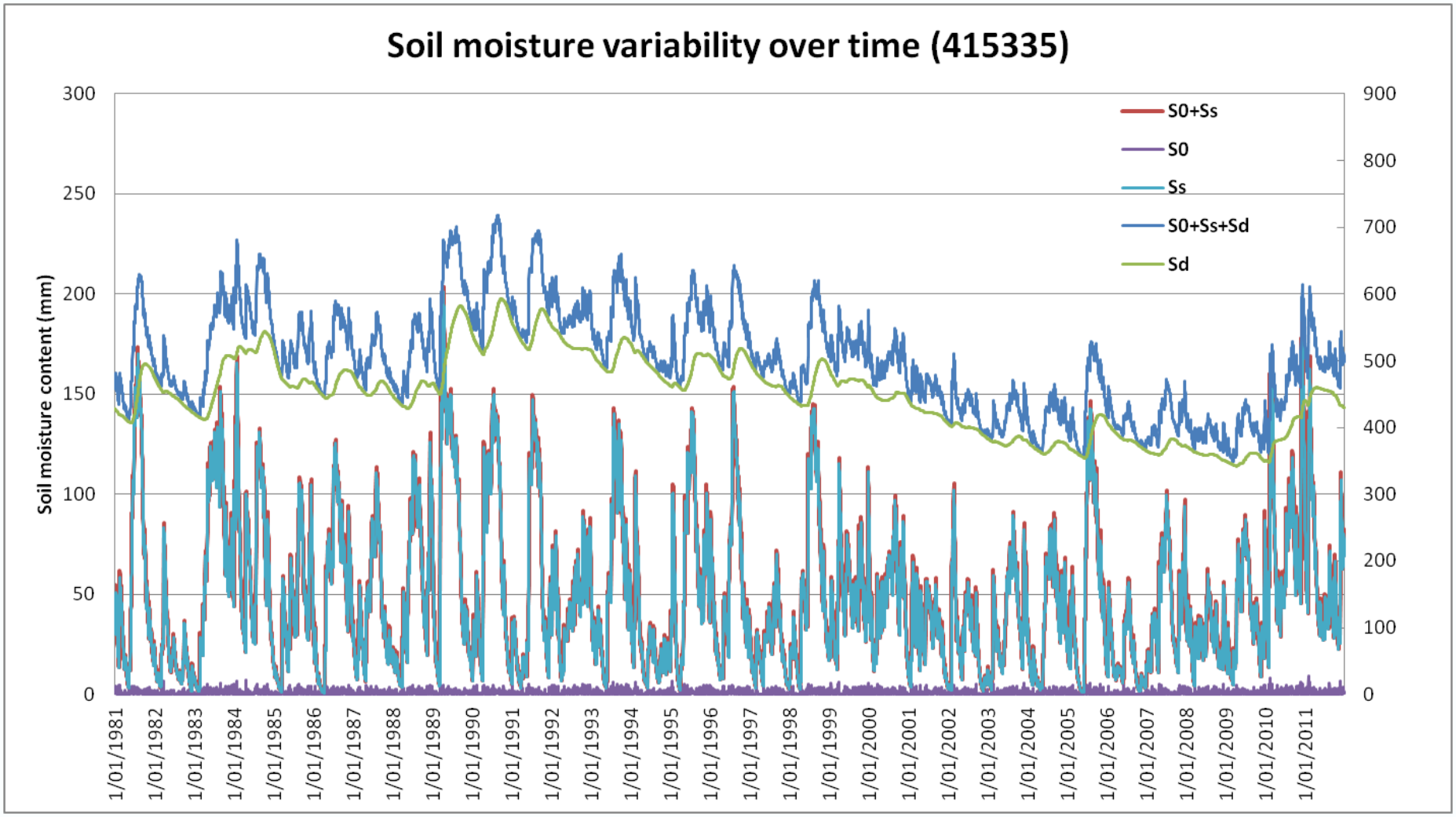


Validation

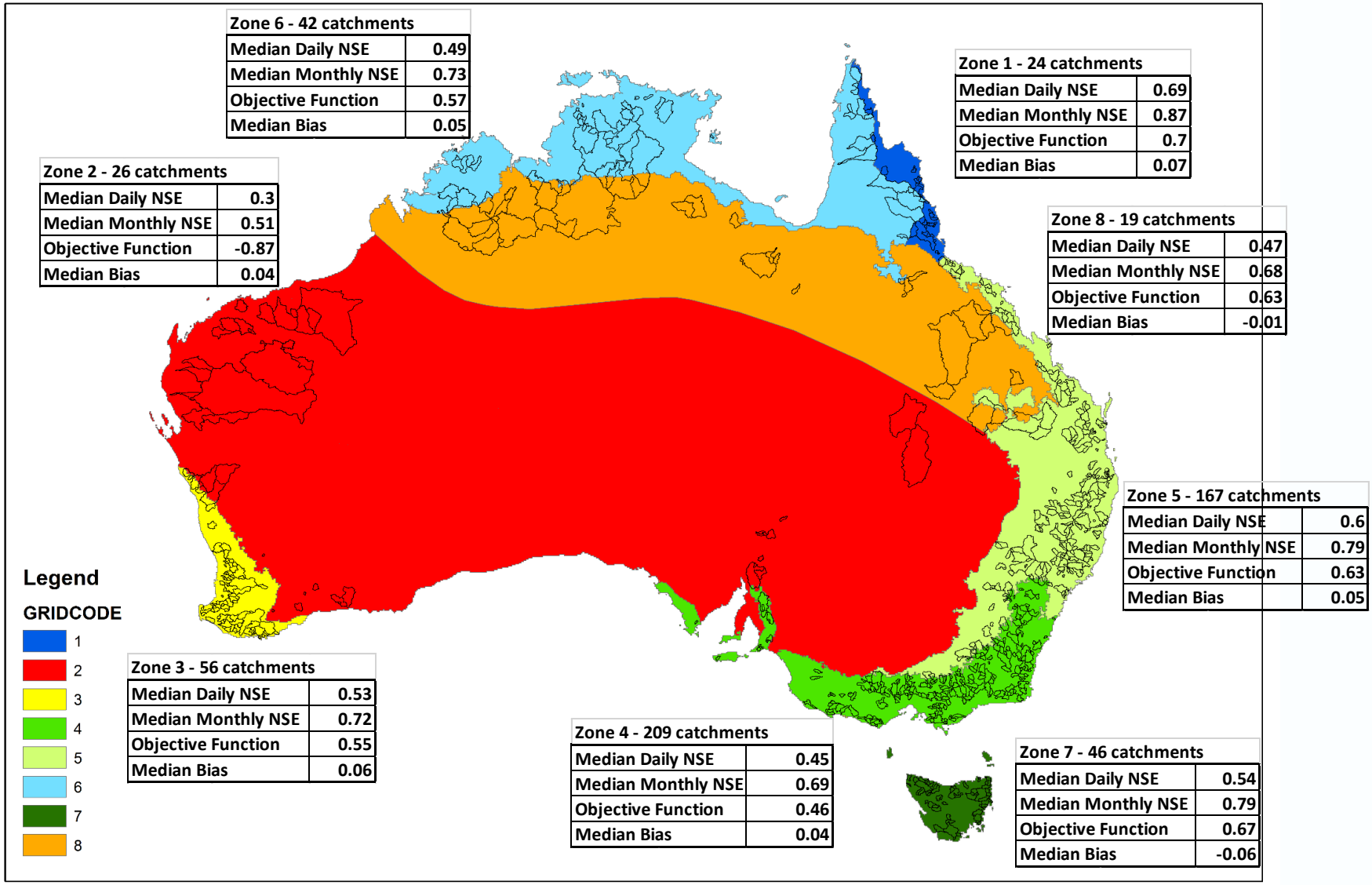




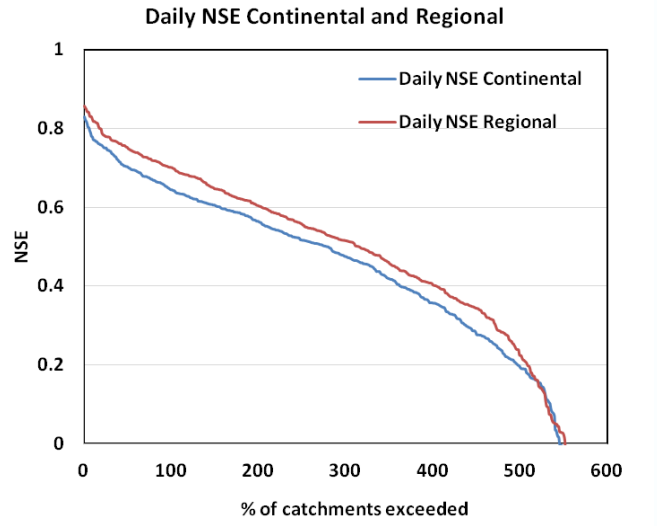
Temporal variability of soil moisture content for a selected catchment

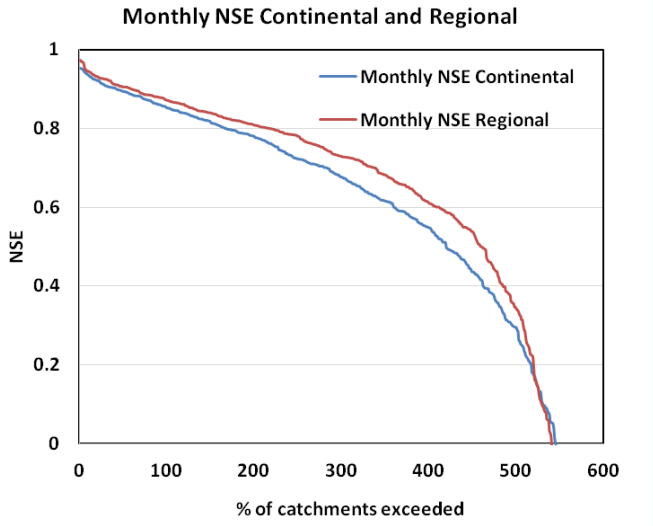


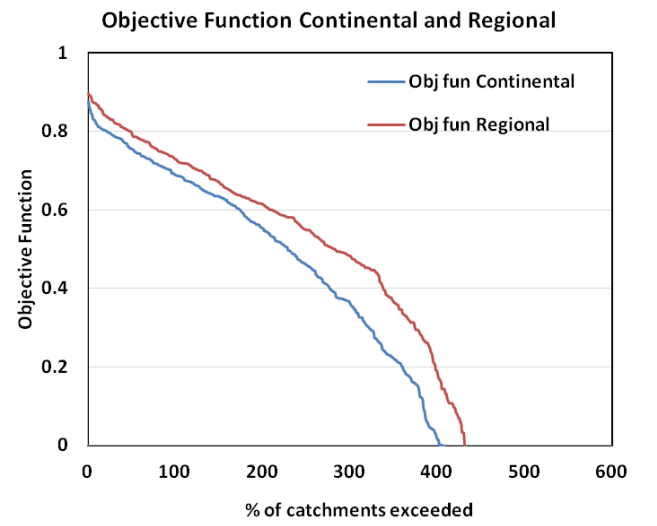
Regional Calibration Statistics

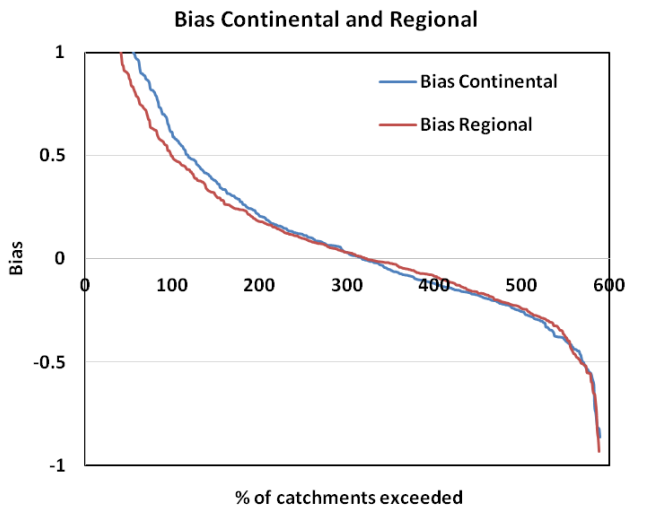


Comparison of regional and continental calibration of AWRA-L









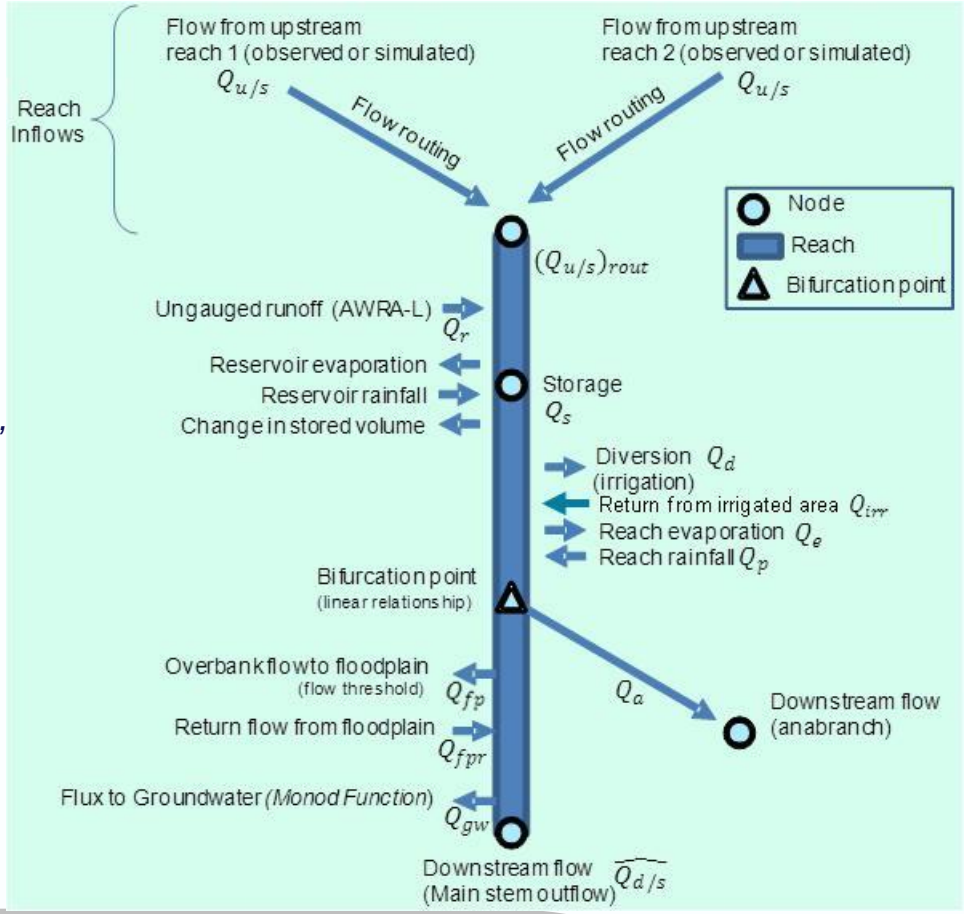
AWRA-R current version - components

The general form of the water balance equation used in the model calibration:

$$\widehat{Q_{d/s}} = (Q_{u/s})_{rout} + Q_r + Q_s - Q_d + Q_{irr} - Q_u + Q_p - Q_e - Q_a - Q_{fp} + Q_{fpr} - Q_{gw}$$

Where,

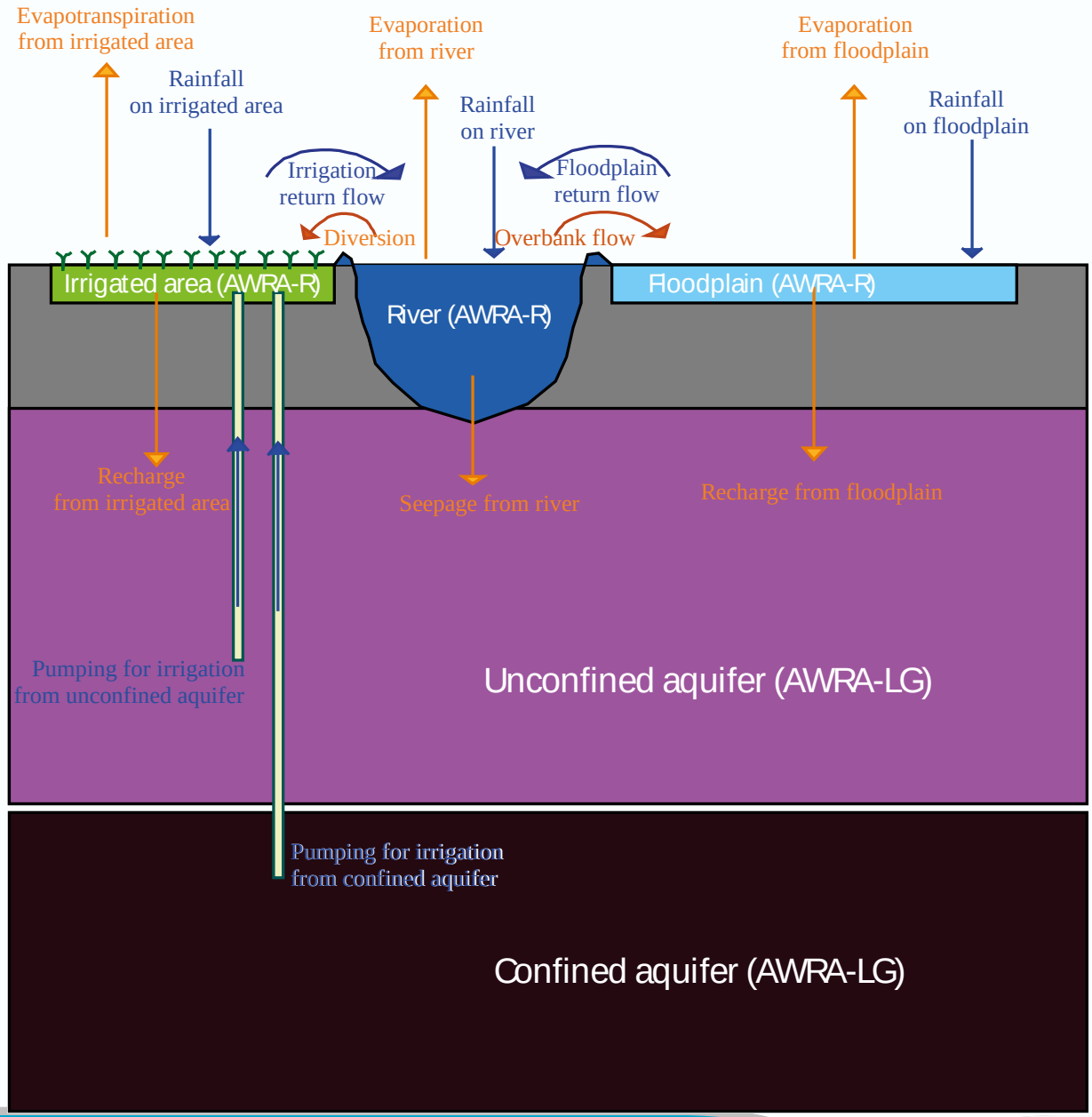
- $\widehat{Q_{d/s}}$ ⟶ *: estimated flow at the downstream gauge,*
- $(Q_{u/s})_{rout}$ ⟶ *: concurrent flow at the upstream gauges (including gauged tributaries) following routing (Muskingum routing),*
- Q_r ⟶ *: runoff locally generated,*
- Q_s ⟶ *: contribution from any storages including rainfall on storage area, evaporation from storage area and change in storage volume,*
- Q_d ⟶ *: loss due to irrigation diversion,*
- Q_{irr} ⟶ *: total return from irrigated area.*
- Q_p ⟶ *: flux to river due to rainfall,*
- Q_e ⟶ *: flux from river due to evaporation,*
- Q_a ⟶ *: flow diverted to anabranches*
- Q_{fp} ⟶ *: overbank flow to floodplain,*
- Q_{fpr} ⟶ *: return flow from floodplain,*
- Q_{gw} ⟶ *: flux from river to groundwater,*



Lerat J, Dutta D, Kim S, Hughes J, Vaze J and Dawes W (2013) Refinement and extension of the AWRA-R model, CSIRO: Water for a Healthy Country National Research Flagship, 58 pages (https://publications.csiro.au/rpr/download?pid=csiro:EP136859&dsid=DS6).

Interaction between AWRA-L and AWRA-R

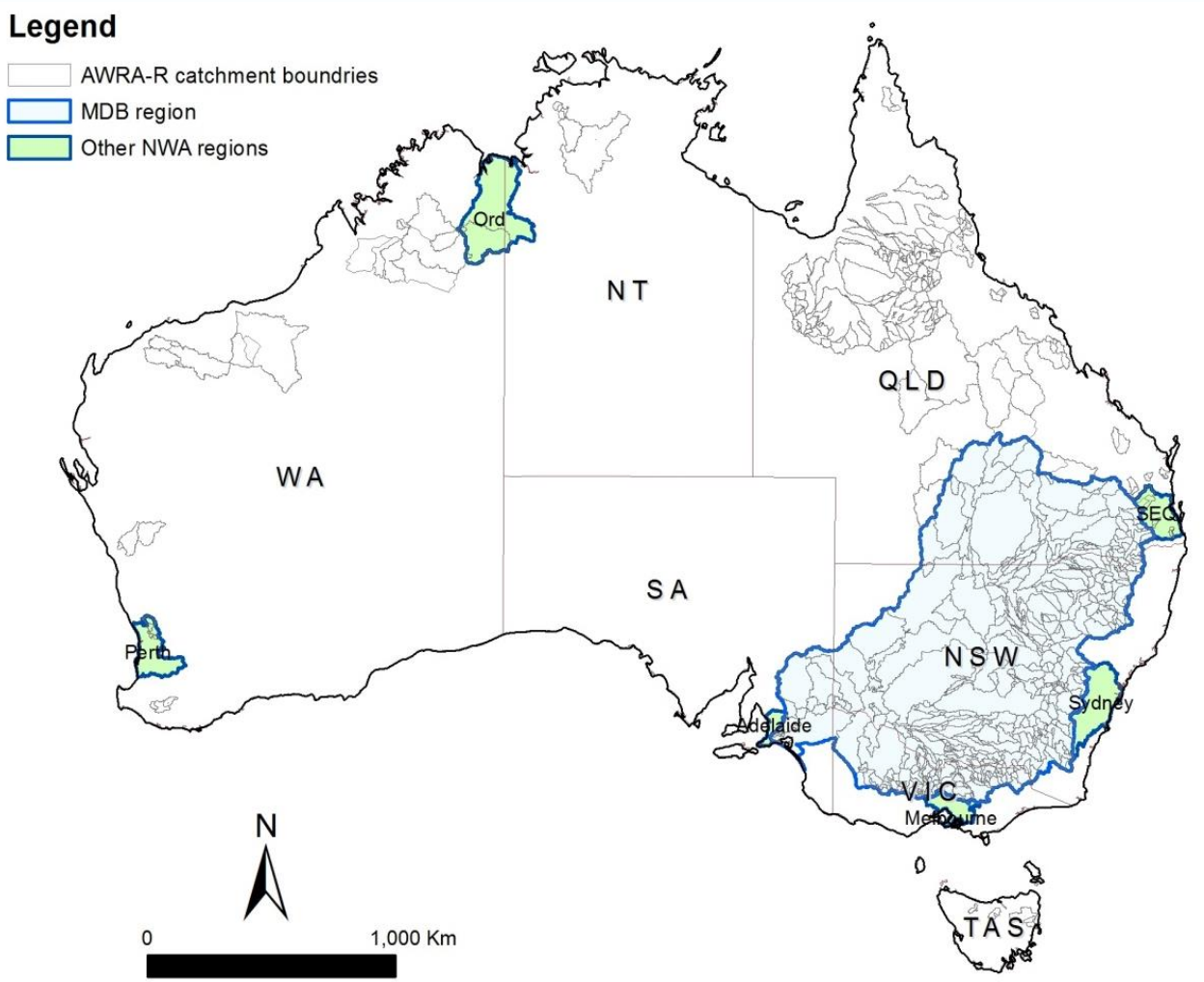
Total runoff from all the AWRA-L grid cells in the river reach are added as inflow into the river store.



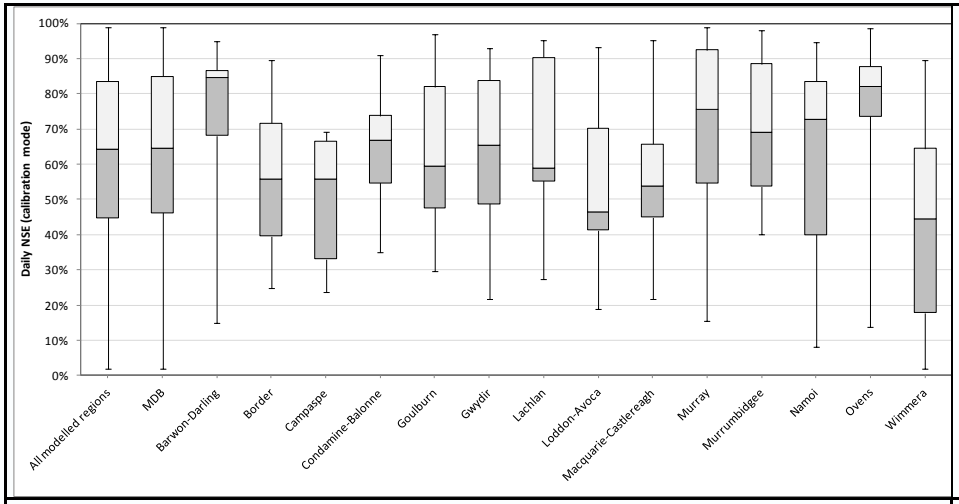
AWRA-R Implementation

The model has been so far implemented in 9 regions (covering 41 large catchments with a total area of over 1.6 million km^2):

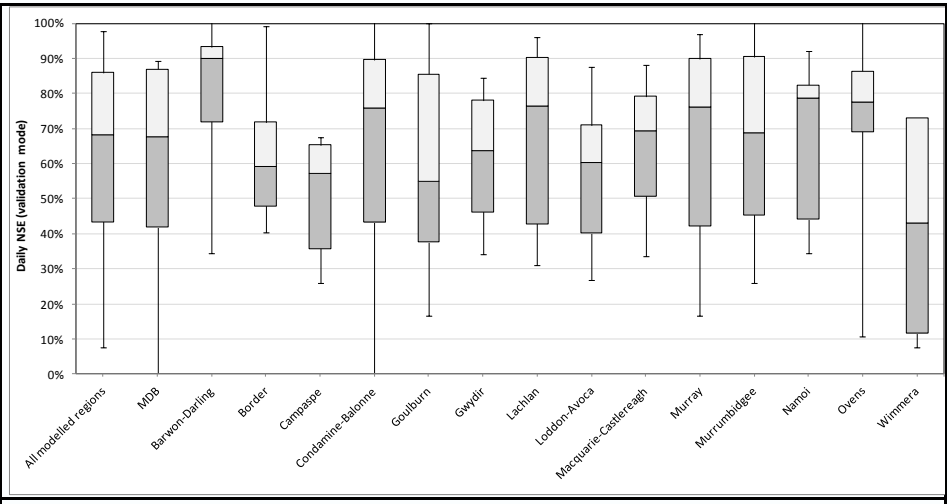
- Three NWA regions
  - MDB
  - SEQ
  - Melbourne
- 6 other regions



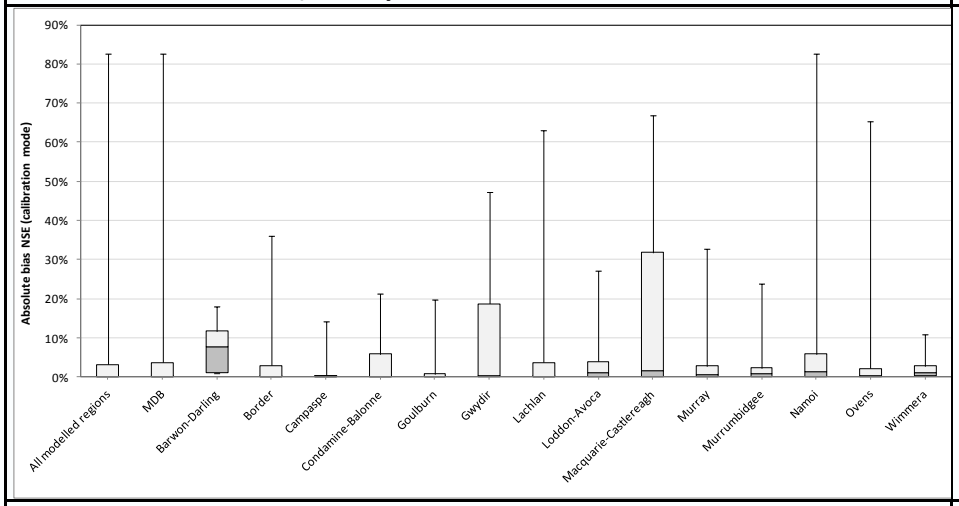
AWRA-R calibration and validation statistics



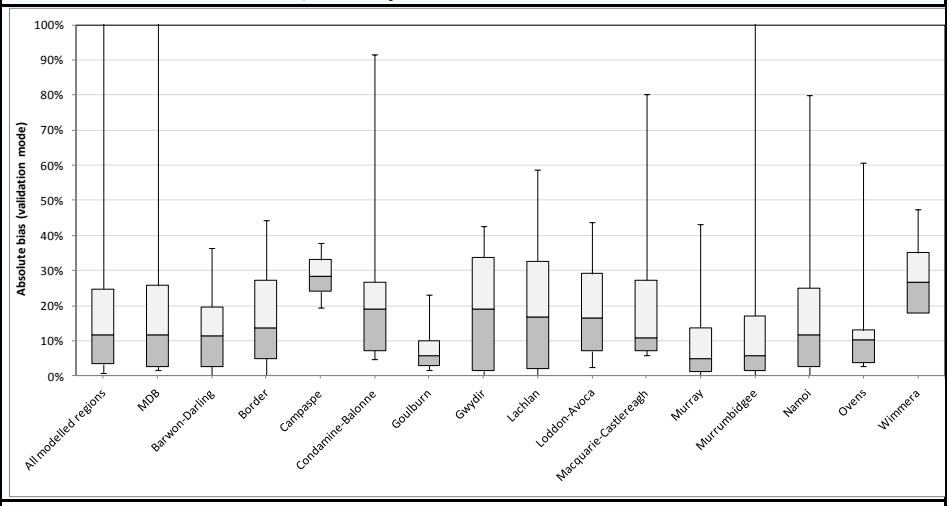
a) daily NSE: calibration



b) daily NSE: validation

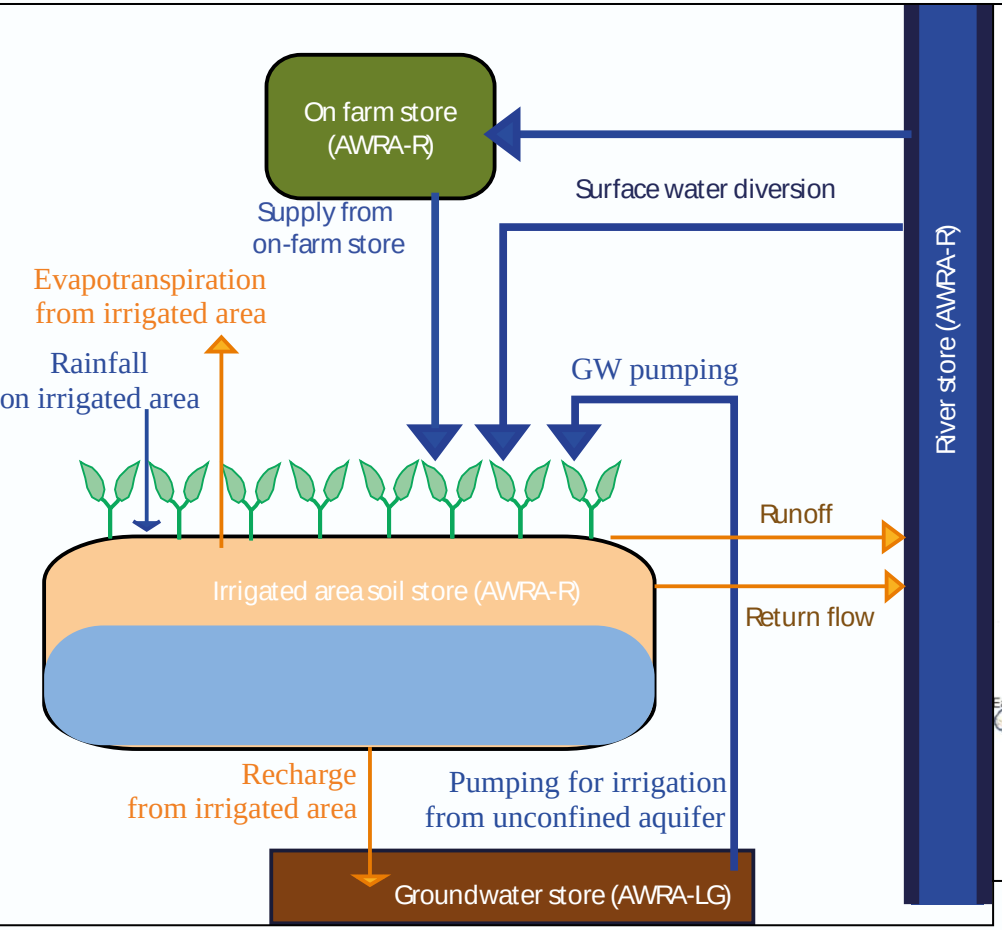


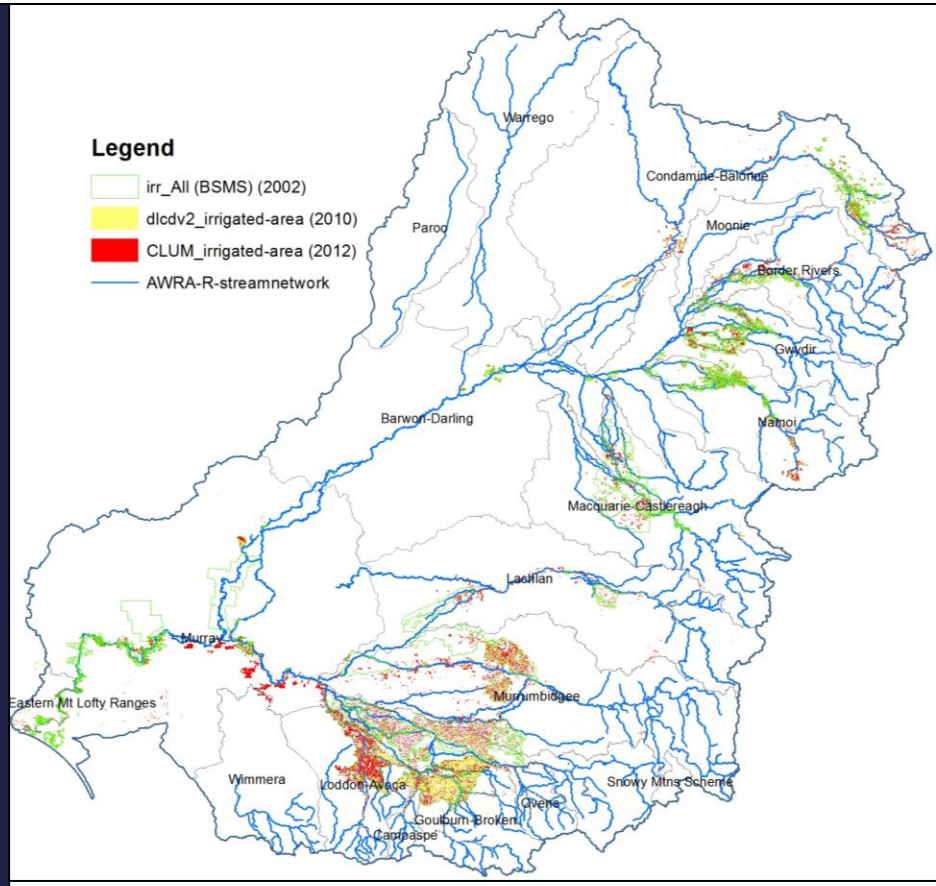
c) bias: calibration



d) bias: validation

AWRA-R irrigation model



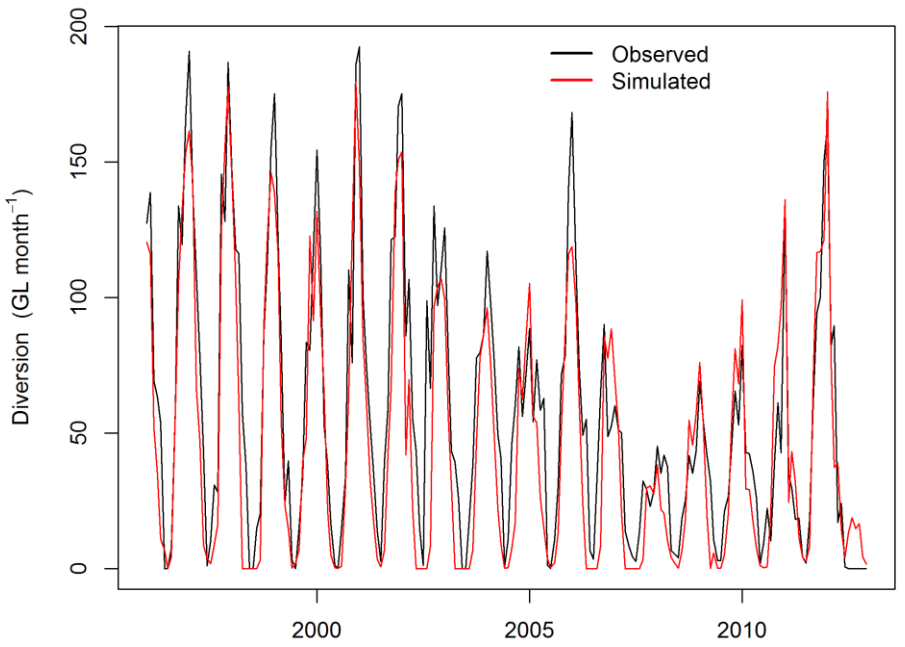


Hughes J, Mainuddin M, Lerat J, Dutta D (2013). An irrigation model for use in river systems modelling, *Proceedings of MODSIM2013*, 2464-2470.

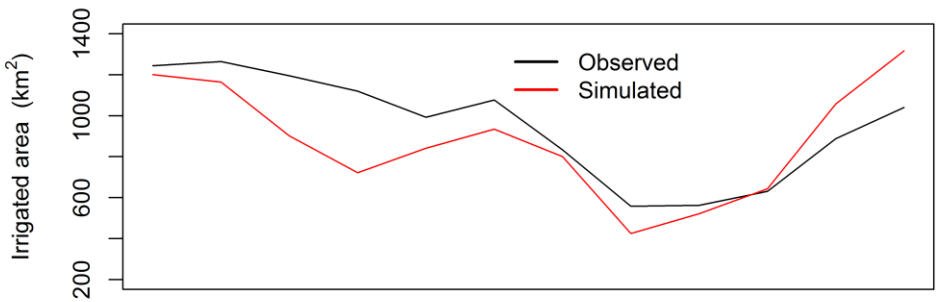
Performance of AWRA-R irrigation model

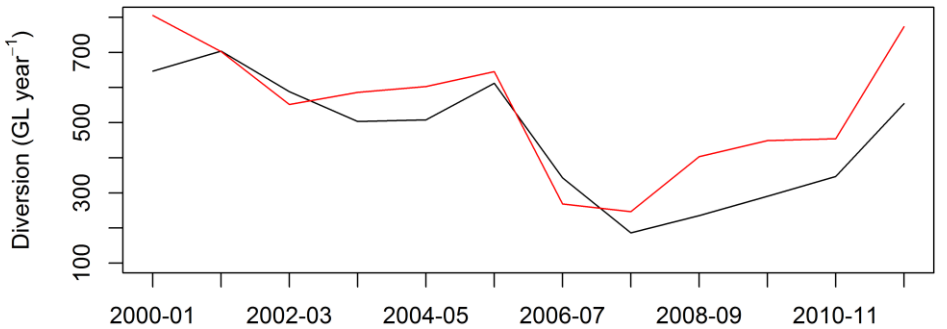
Calibration stats in Murrumbidgee: Period: 1975- 2006

D/S gauge of modelled reach	Monthly NSE	%Bias
410001	0.86	0%
410002	0.72	0%
410003	0.67	-7%
410021	0.59	-1%
410023	0.7	-8%
410021	0.81	-1%
410078	0.64	-7%
410169	0.69	-14%

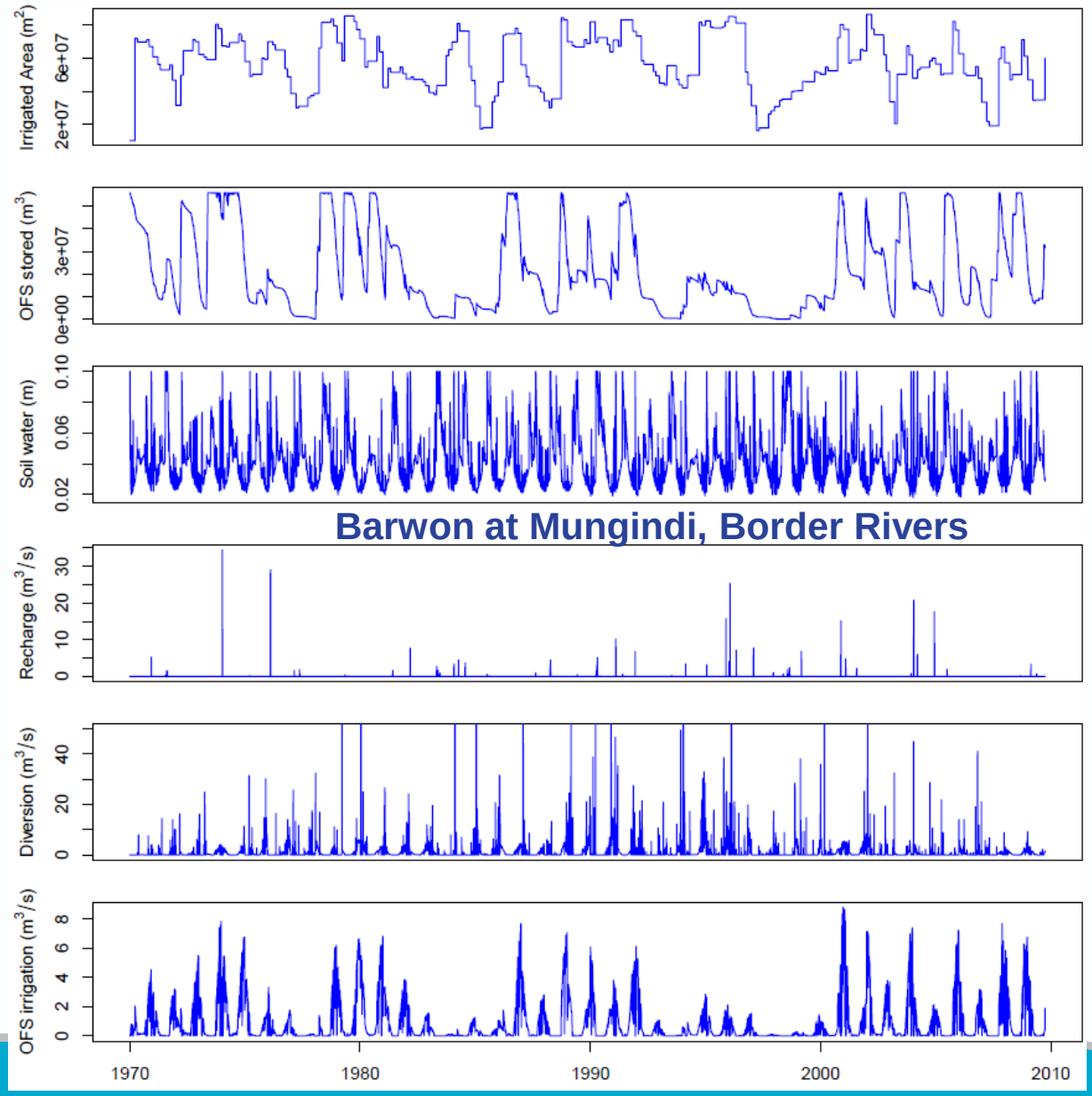


Observed and simulated annual irrigated area and annual diversion for the Murrumbidgee at Berembed Weir (410023) from Makireddi (2014)



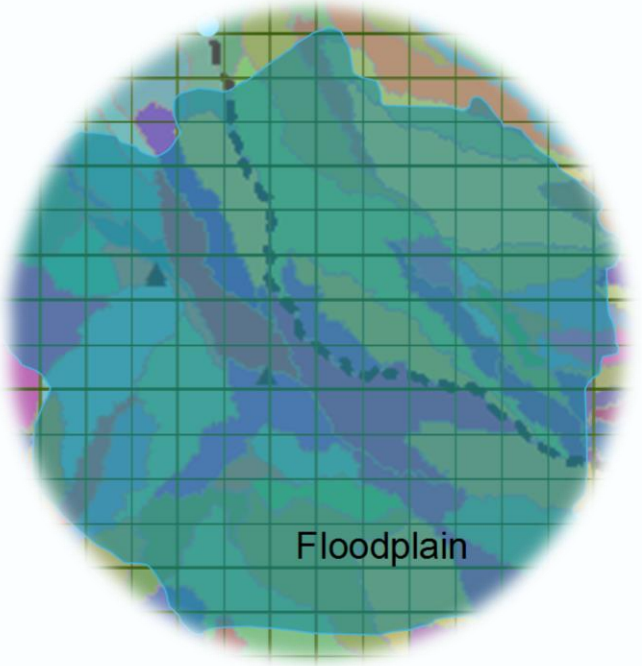


Modelled Irrigation related stores and fluxes

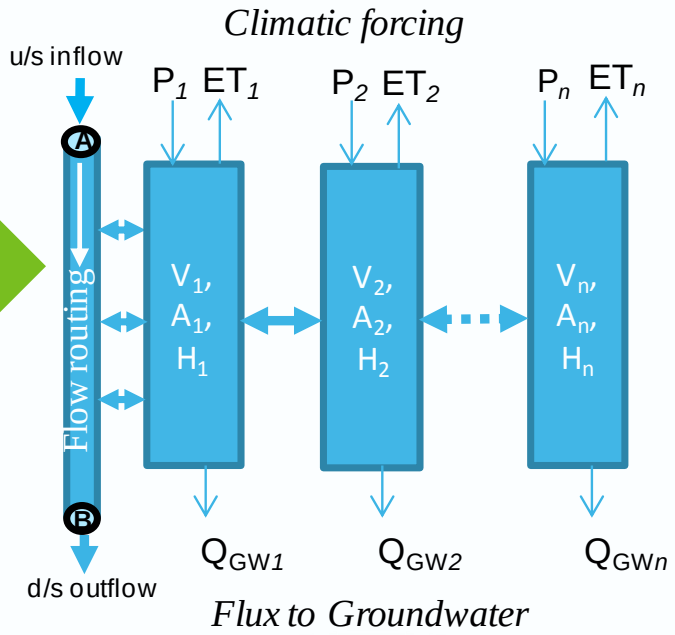


AWRA-R floodplain inundation model

Digital Elevation Model



Floodplain Concept



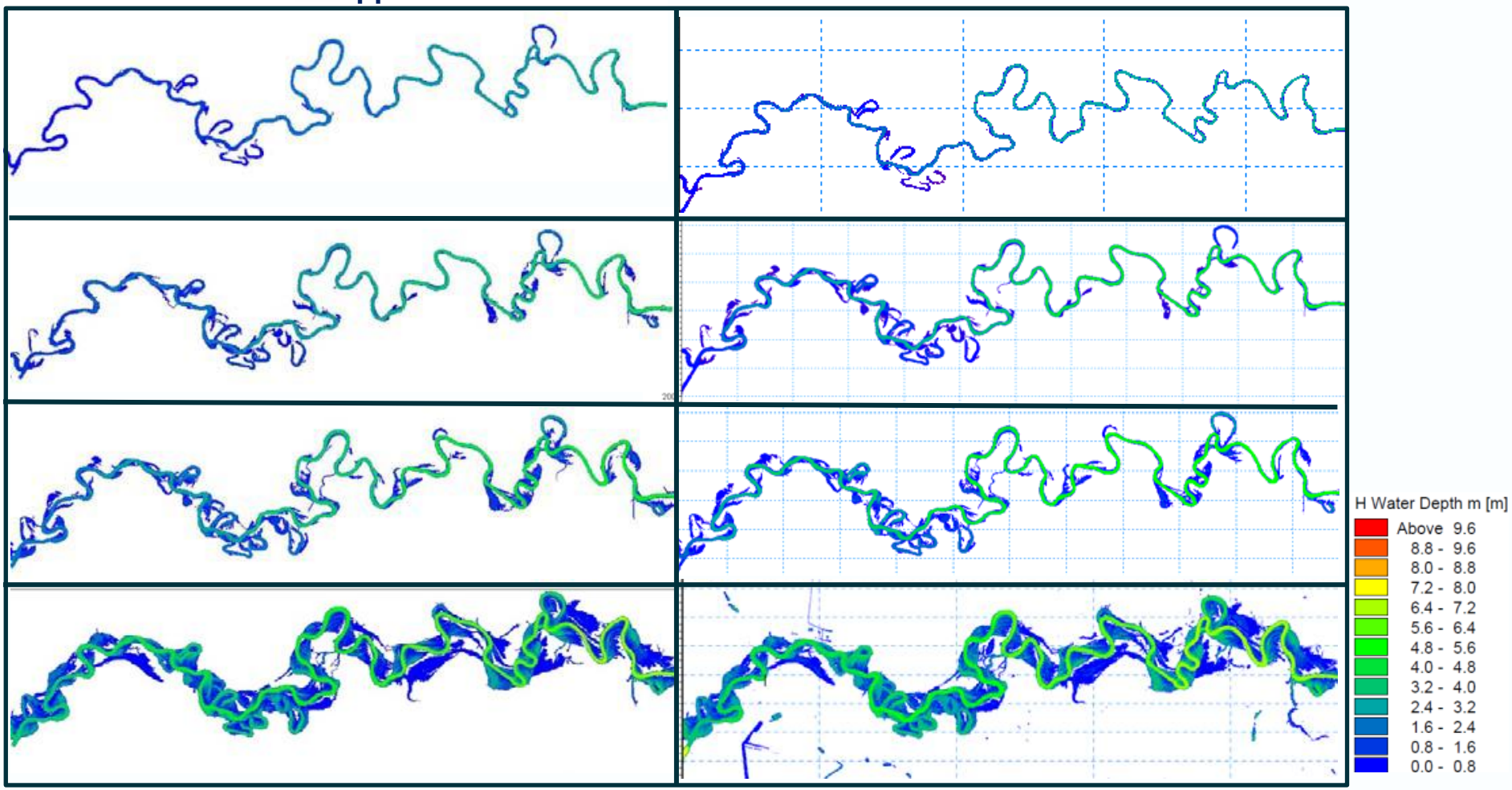
Dutta D, Teng J, Vaze J, Lerat J, Hughes J, Marvanek S (2013). Storage-based Approaches to Build Floodplain Inundation Modelling Capability in River System Models for Water Resources Planning and Accounting, *Journal of Hydrology,* 504:12-28.

Teng J, Vaze J, Dutta D(2013). Simplified methodology for floodplain inundation modelling using LiDAR DEM, In: *Climate and land surface changes in hydrology, IAHS Red Book* (ed by Boegh et al.), IAHS Publication, 198–204.

Results (comparison to MIKE21)

a) Simulated inundation by LiDAR based approach

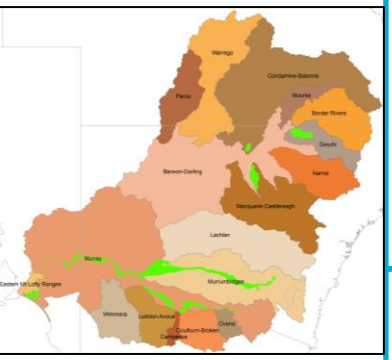
b) Simulated inundation by 2D HD model



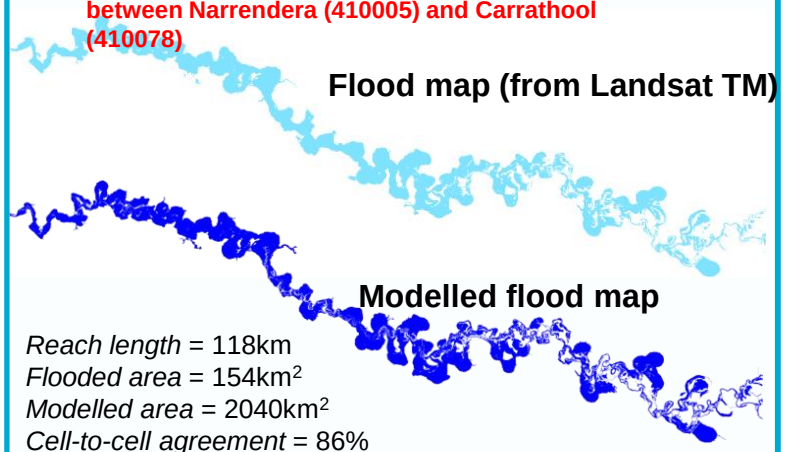
Run time : ~10 minutes for 2 years

Run time : ~10 days for 20-day event

Flood inundation modelling: Analysing model performance



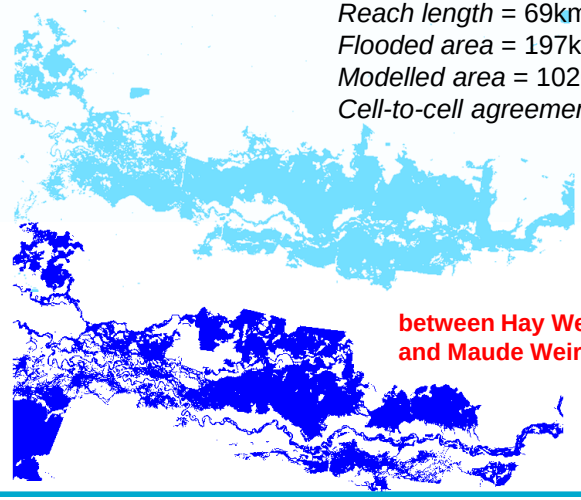
between Narrendera (410005) and Carrathool (410078)



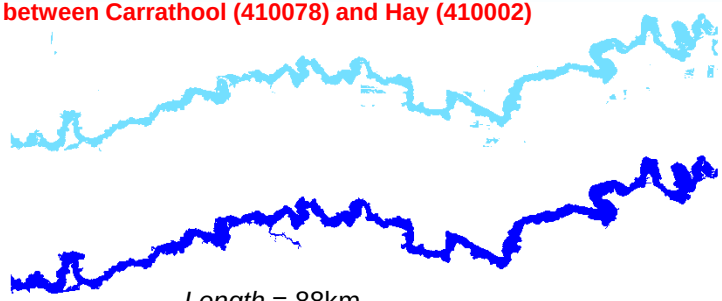
Reach length = 118km
Flooded area = 154km^2
Modelled area = 2040km^2
Cell-to-cell agreement = 86%

Reach length = 69km
Flooded area = 197km^2
Modelled area = 1020km^2
Cell-to-cell agreement = 60%

between Hay Weir (410136) and Maude Weir (410040)

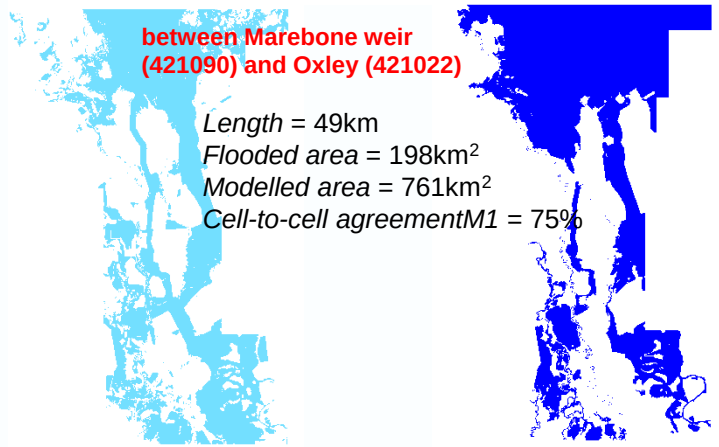


between Carrathool (410078) and Hay (410002)



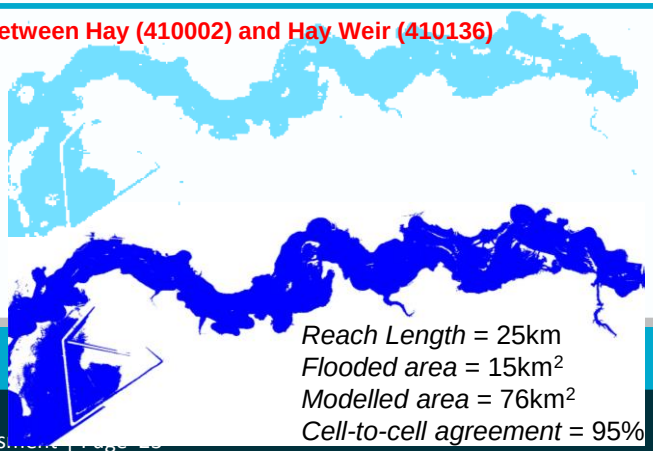
Length = 88km
Flooded area = 54km^2
Modelled area = 576km^2
Cell-to-cell agreement = 99%

between Marebone weir (421090) and Oxley (421022)



Length = 49km
Flooded area = 198km^2
Modelled area = 761km^2
Cell-to-cell agreementM1 = 75%

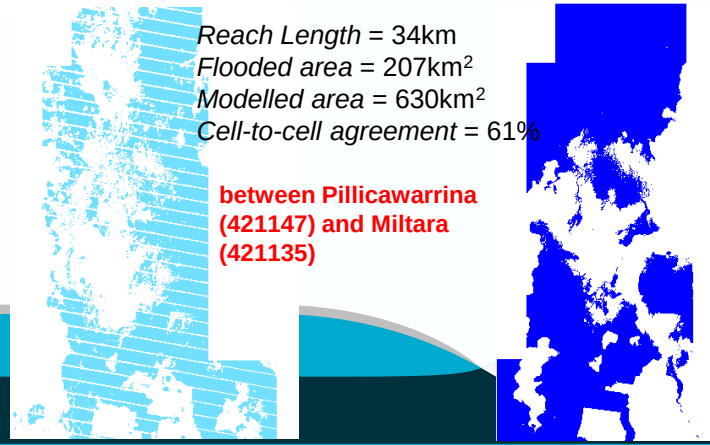
between Hay (410002) and Hay Weir (410136)



Reach Length = 25km
Flooded area = 15km^2
Modelled area = 76km^2
Cell-to-cell agreement = 95%

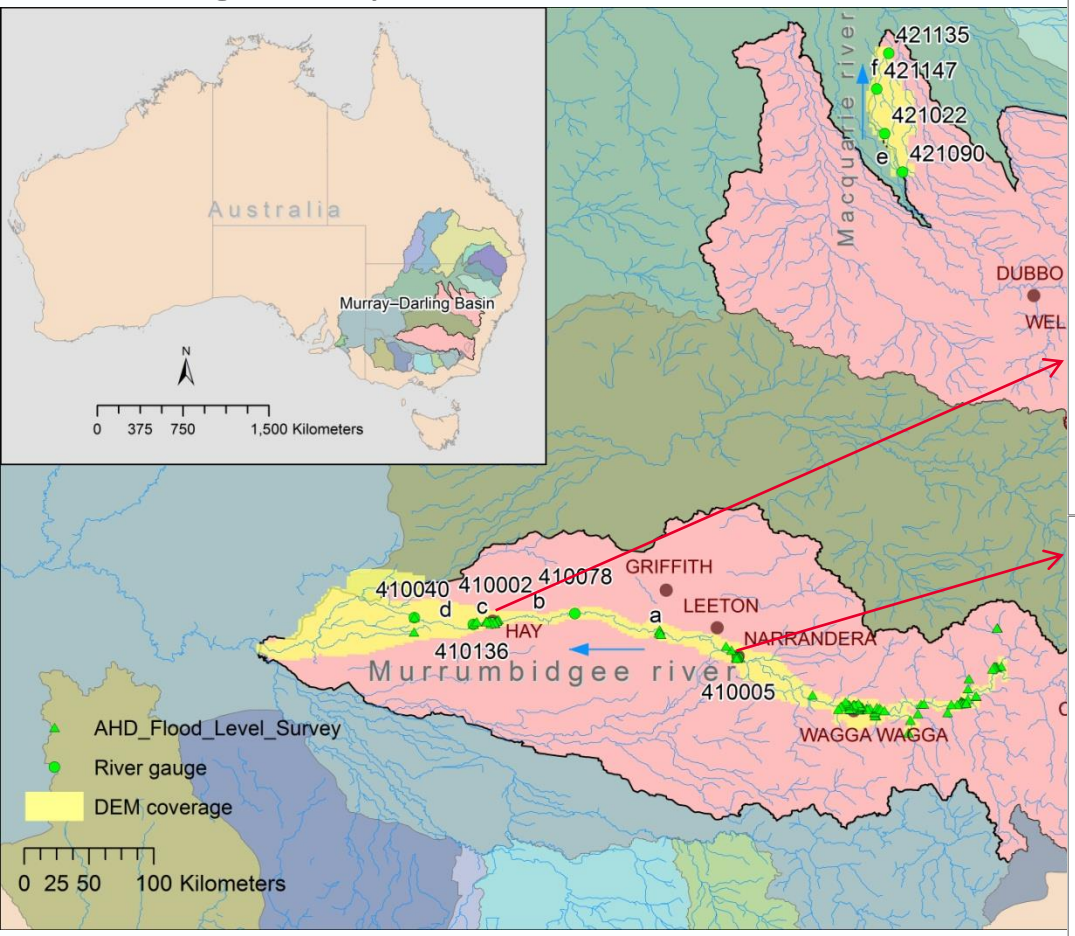
Reach Length = 34km
Flooded area = 207km^2
Modelled area = 630km^2
Cell-to-cell agreement = 61%

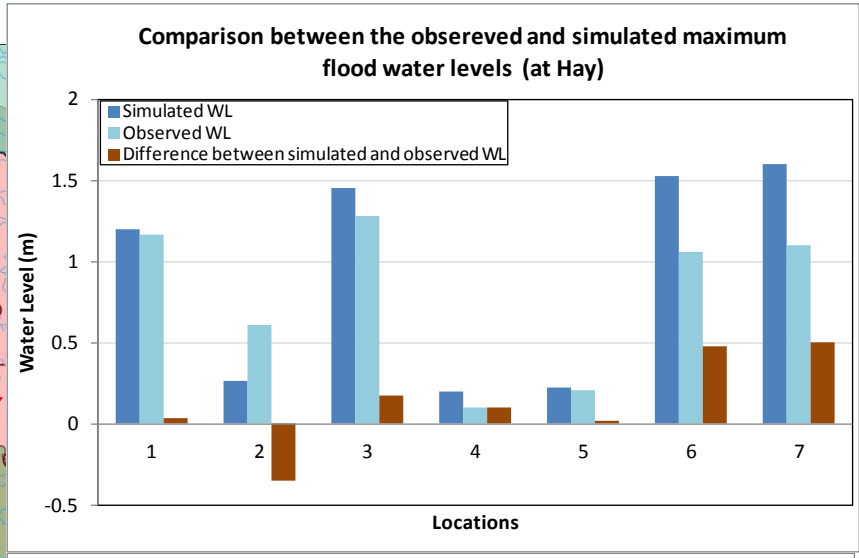
between Pillicawarrina (421147) and Miltara (421135)

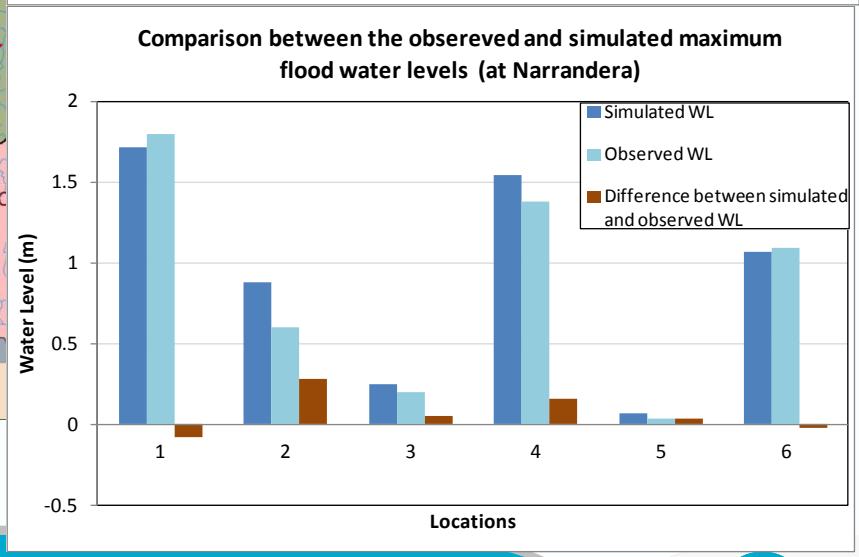


Spot height comparison

- Using surveyed flood marks (2012 floods)

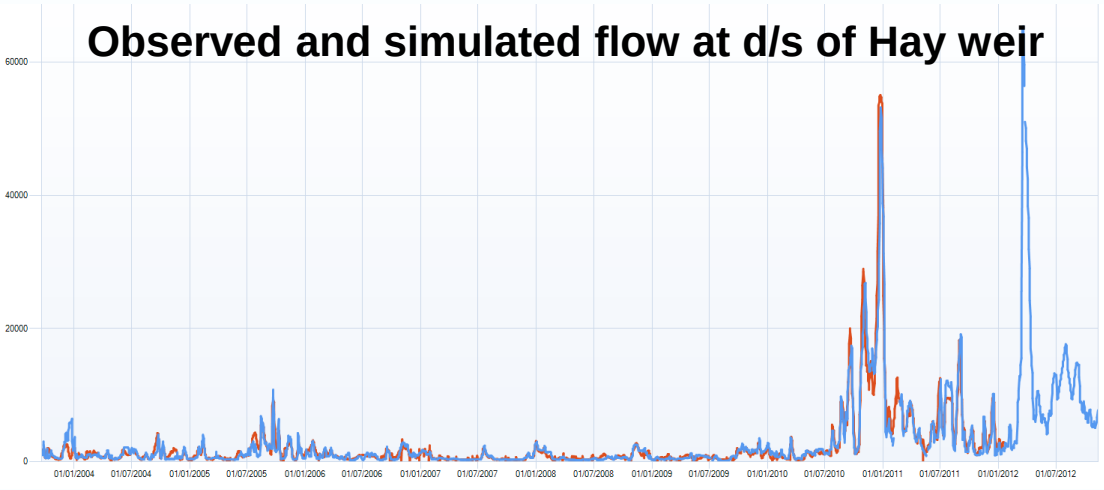


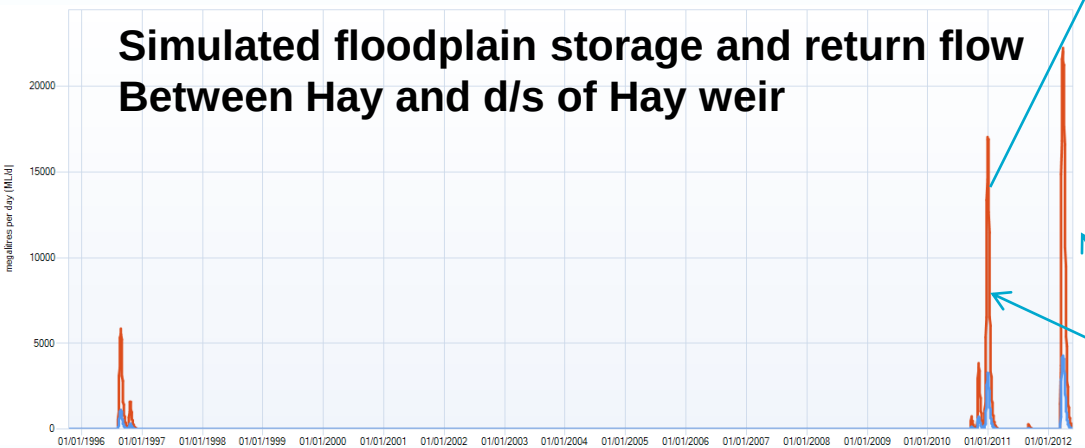


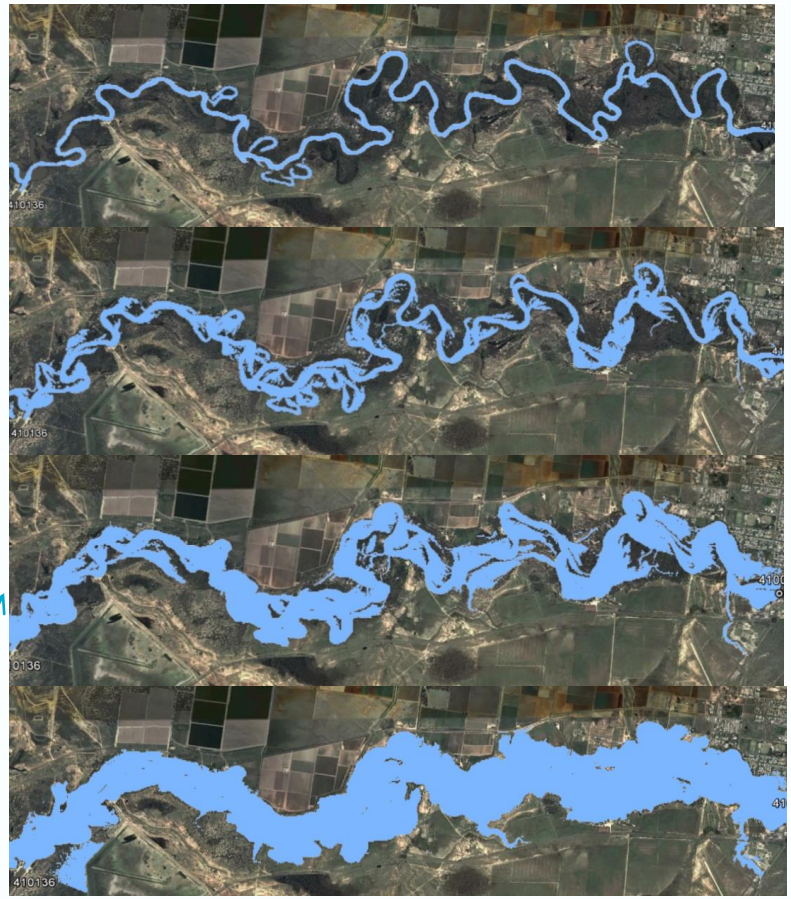


Surveyed flood heights for March 2012 floods were obtained from SES, NSW.

Inundation simulation



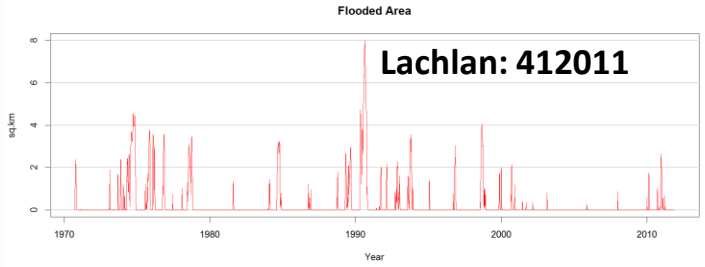


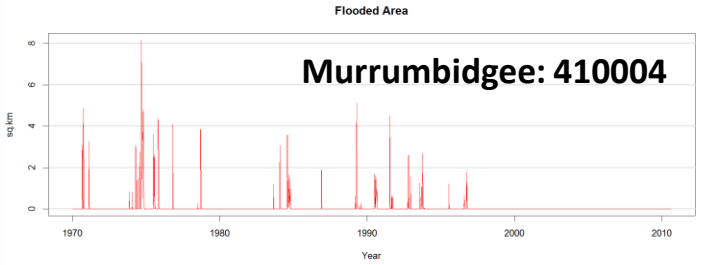


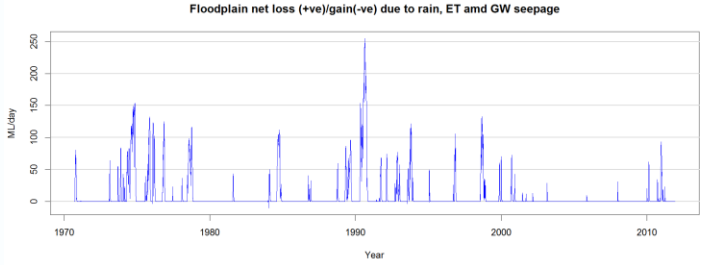
Recent floods in Murrumbidgee:

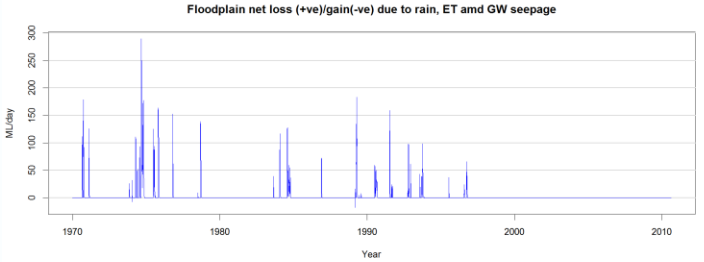
- December 2010
- March 2012

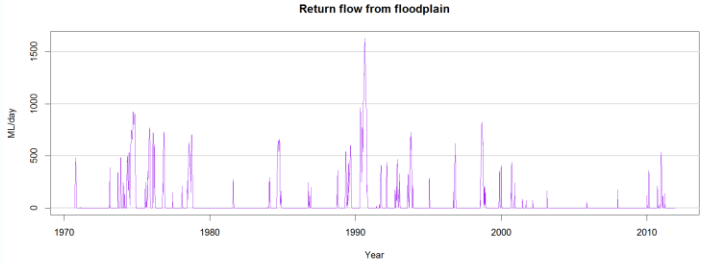
Floodplain Fluxes

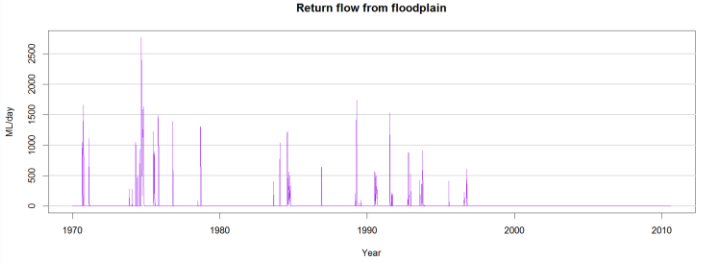


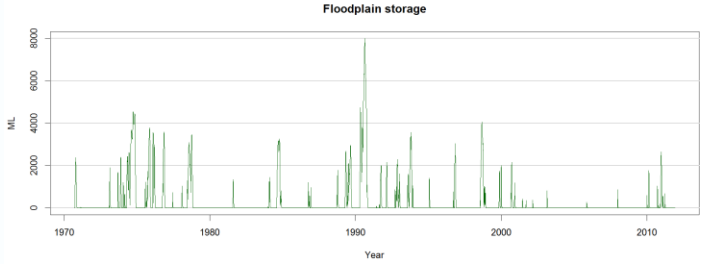


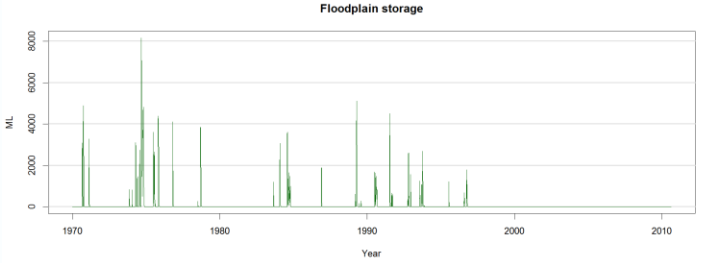


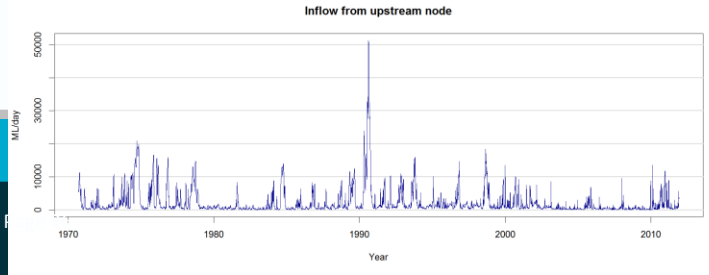


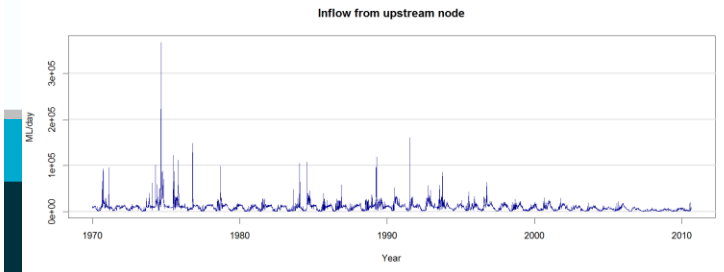












Summary

- The current version of **AWRA Landscape model** incorporates detailed conceptual representation of all important hydrological processes underpinning catchment to continental scale water balance.
- The performance of AWRA-L continental gridded calibration and validation is overall better than Sacramento and GR4J.
- The water balance components and internal fluxes and stores from AWRA-L are conceptually and hydrological sensible and defendable.
- The performance of AWRA-L is improved when we move from continental to regional calibration.
- The **AWRA River system model** has been developed for National Water Accounts in regulated and unregulated river systems incorporating all relevant hydrological processes and anthropogenic water use.
- The AWRA-R model has been implemented in 9 regions across the continent and the model performance is highly satisfactory.
- AWRA irrigation and floodplain models have been developed and successfully implemented across the Murray-Darling Basin.

Thank you

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