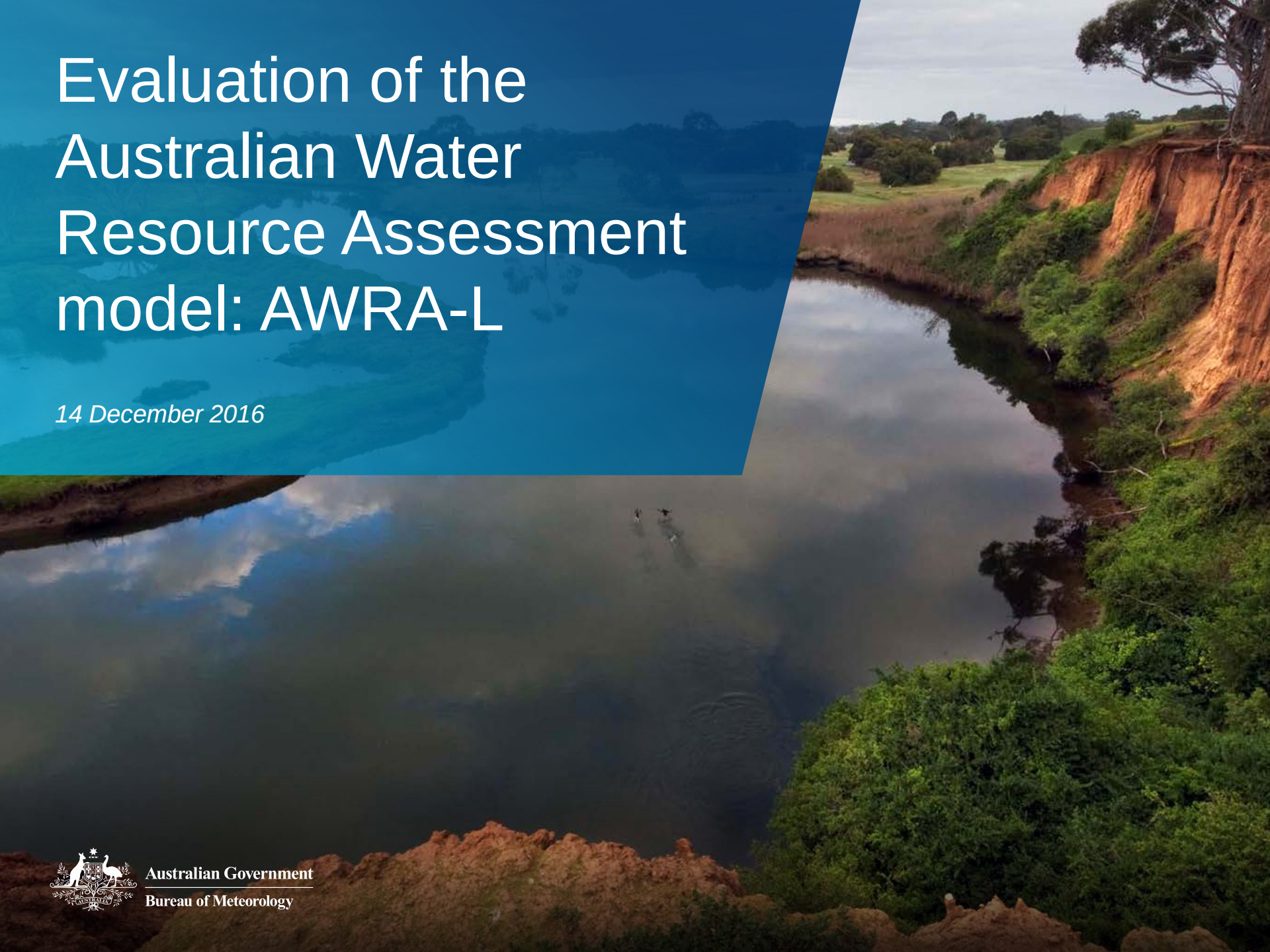
# Evaluation of the Australian Water Resource Assessment model: AWRA-L

*14 December 2016*



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# Benchmark for AWRA community modelling system

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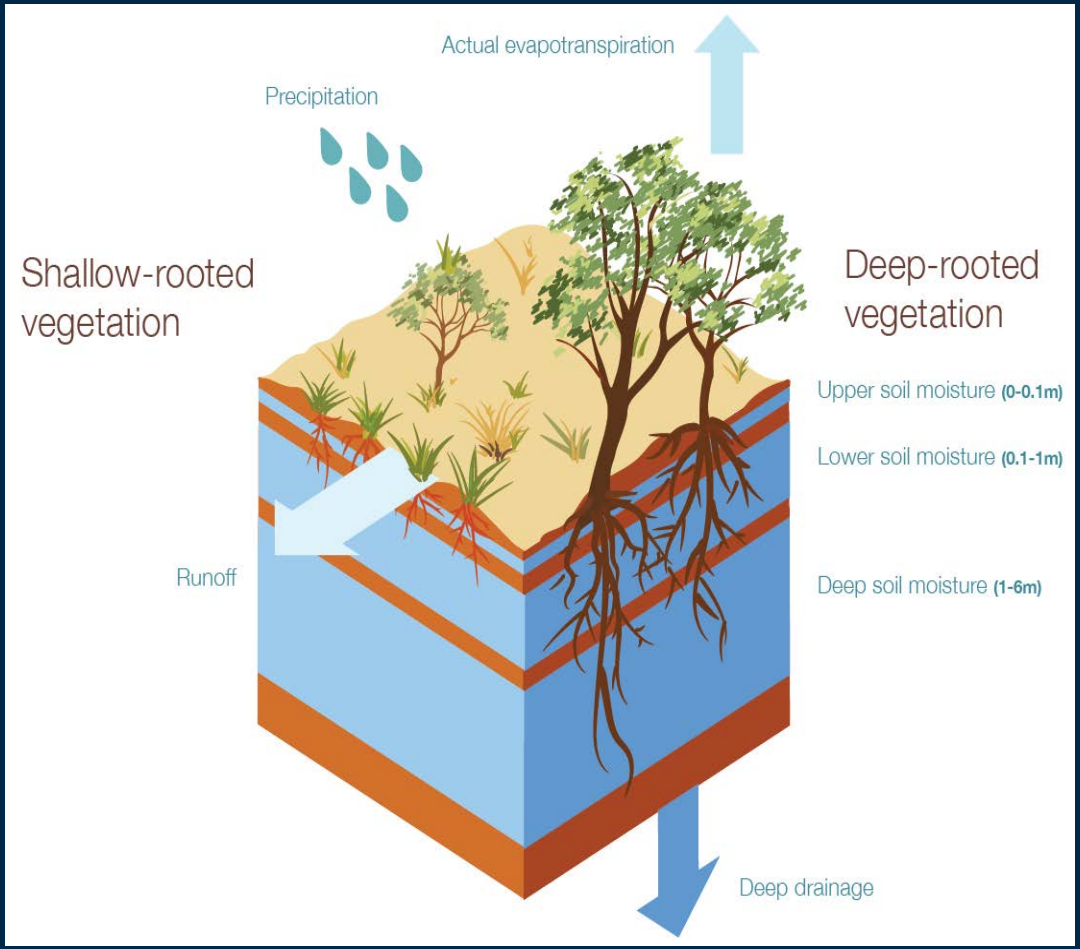
# Overview

- What is AWRA-L?
  - Background
  - Model structure
- Calibrating and Benchmarking
  - Data
  - Results
- AWRA community modelling system
  - Benchmarking module
  - Data
  - Benchmarks



# What is AWRA-L?

**National landscape water balance model**

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# Operational continental landscape water balance model

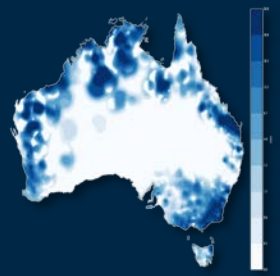
*AWRA-L: national, daily time-step, 5 km resolution*

Inputs

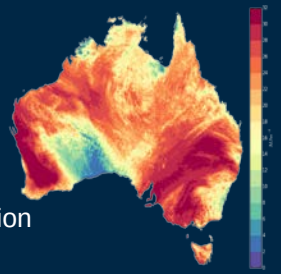
Model analysis

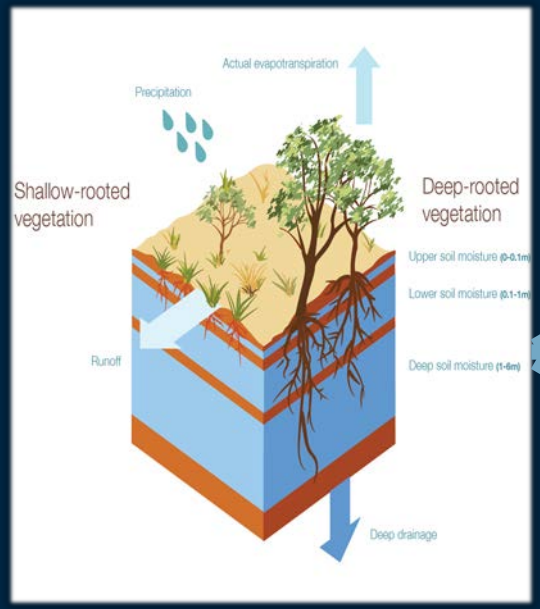
Outputs

Rainfall

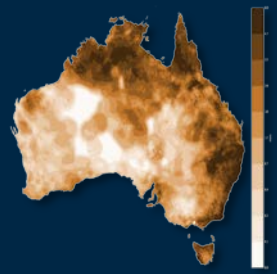


Solar radiation






Actual evapotranspiration



Runoff

Deep drainage

Soil moisture

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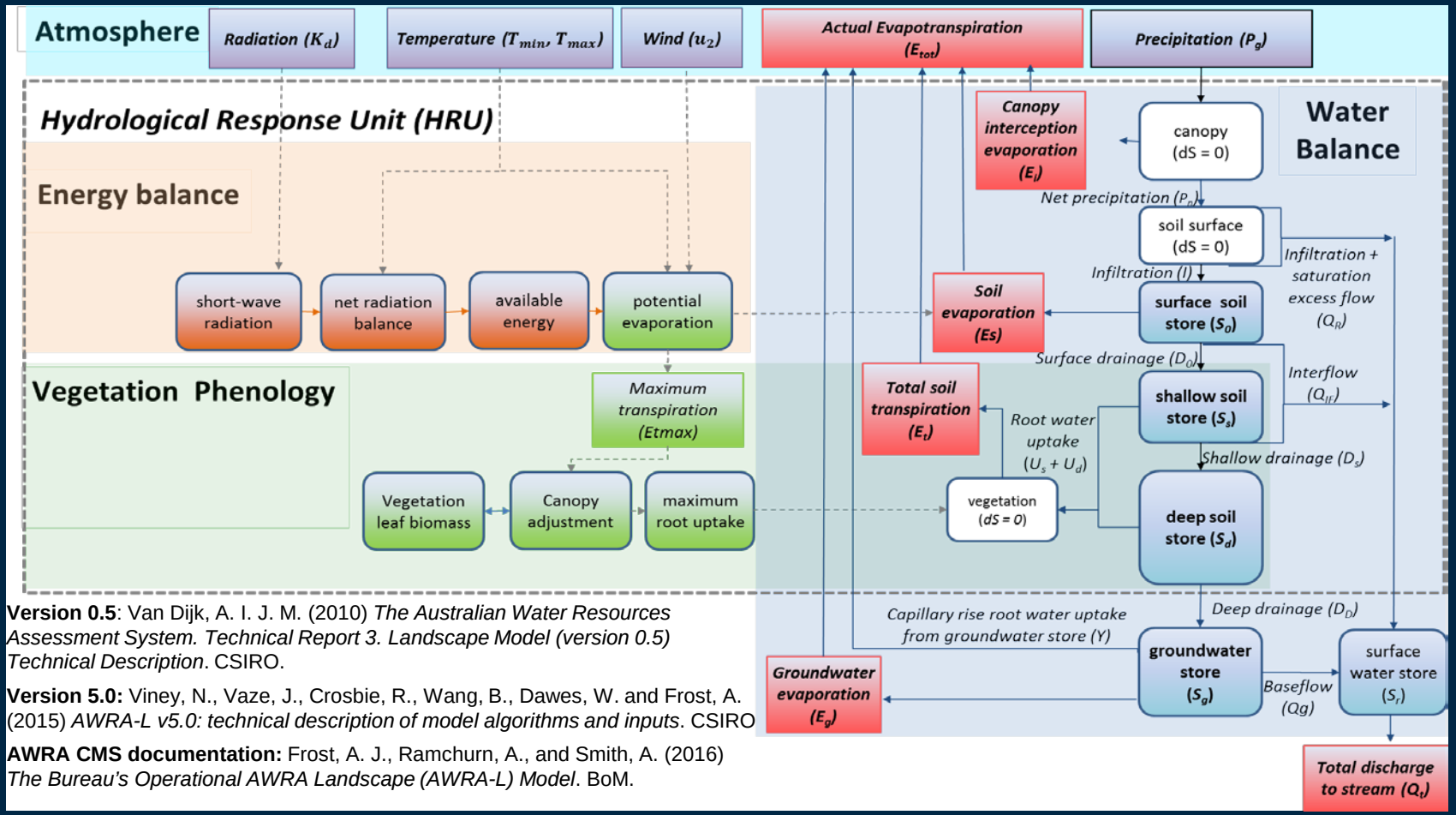
# AWRA-L
# Australian Water Resource Assessment Landscape model

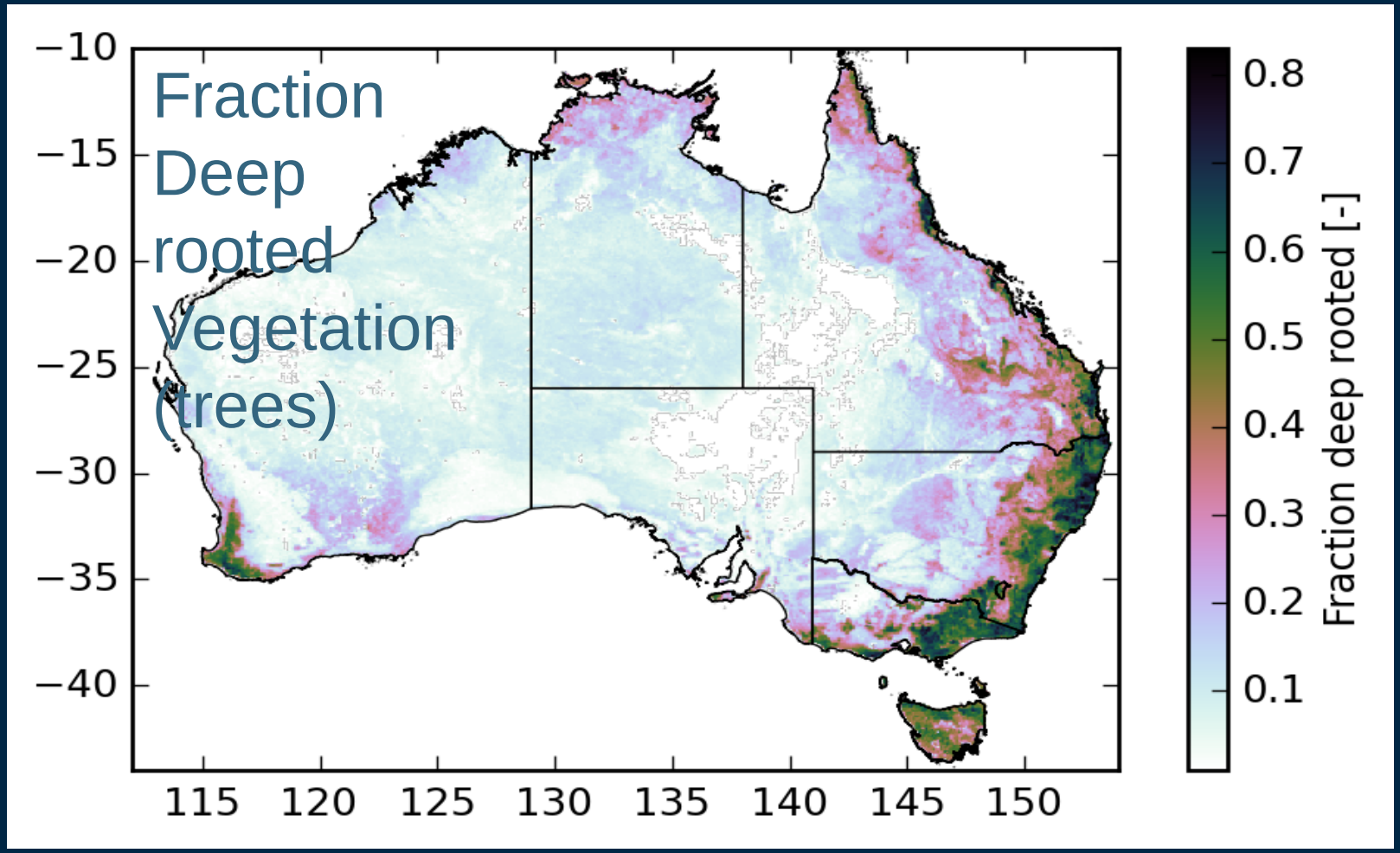



**Version 0.5**: Van Dijk, A. I. J. M. (2010) *The Australian Water Resources Assessment System. Technical Report 3. Landscape Model (version 0.5) Technical Description*. CSIRO.

**Version 5.0:** Viney, N., Vaze, J., Crosbie, R., Wang, B., Dawes, W. and Frost, A. (2015) *AWRA-L v5.0: technical description of model algorithms and inputs*. CSIRO

**AWRA CMS documentation:** Frost, A. J., Ramchurn, A., and Smith, A. (2016) *The Bureau's Operational AWRA Landscape (AWRA-L) Model*. BoM.

# 2 Hydrological Response Units: grass and trees (Shallow rooted 0-1m and Deep rooted veg 0-6m)



# Calibrating and Benchmarking AWRA-L

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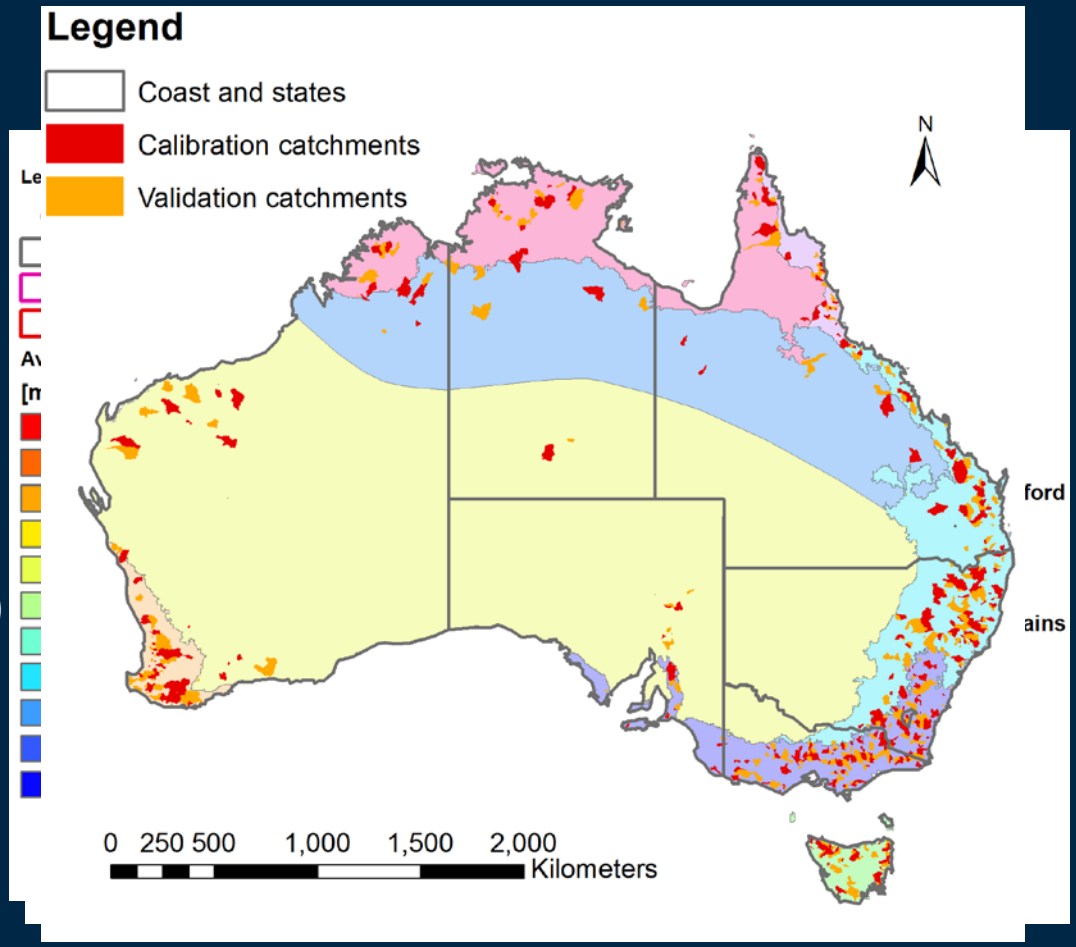
# Calibration and Benchmarking

**Unimpaired catchment testing**

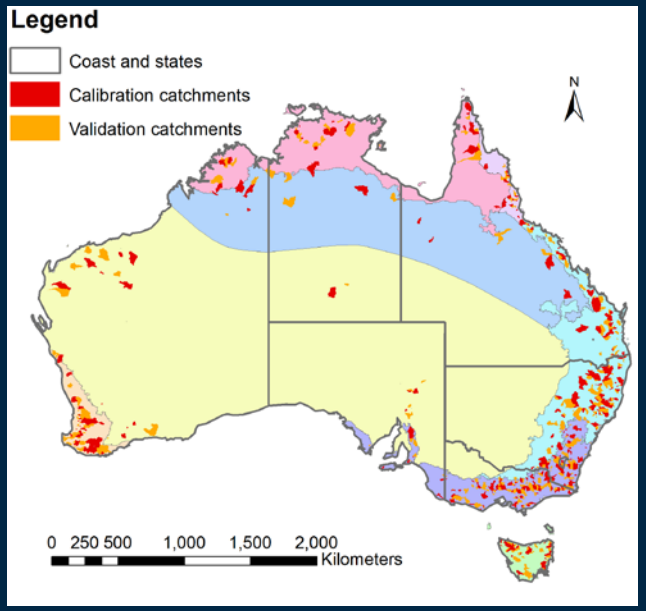
- **Streamflow** – 295 calibration and 291 validation
- **Actual Evapotranspiration** [Satellite - CMRS, SLS]
- **Soil moisture** [Satellite - AMSR-E, ASCAT]

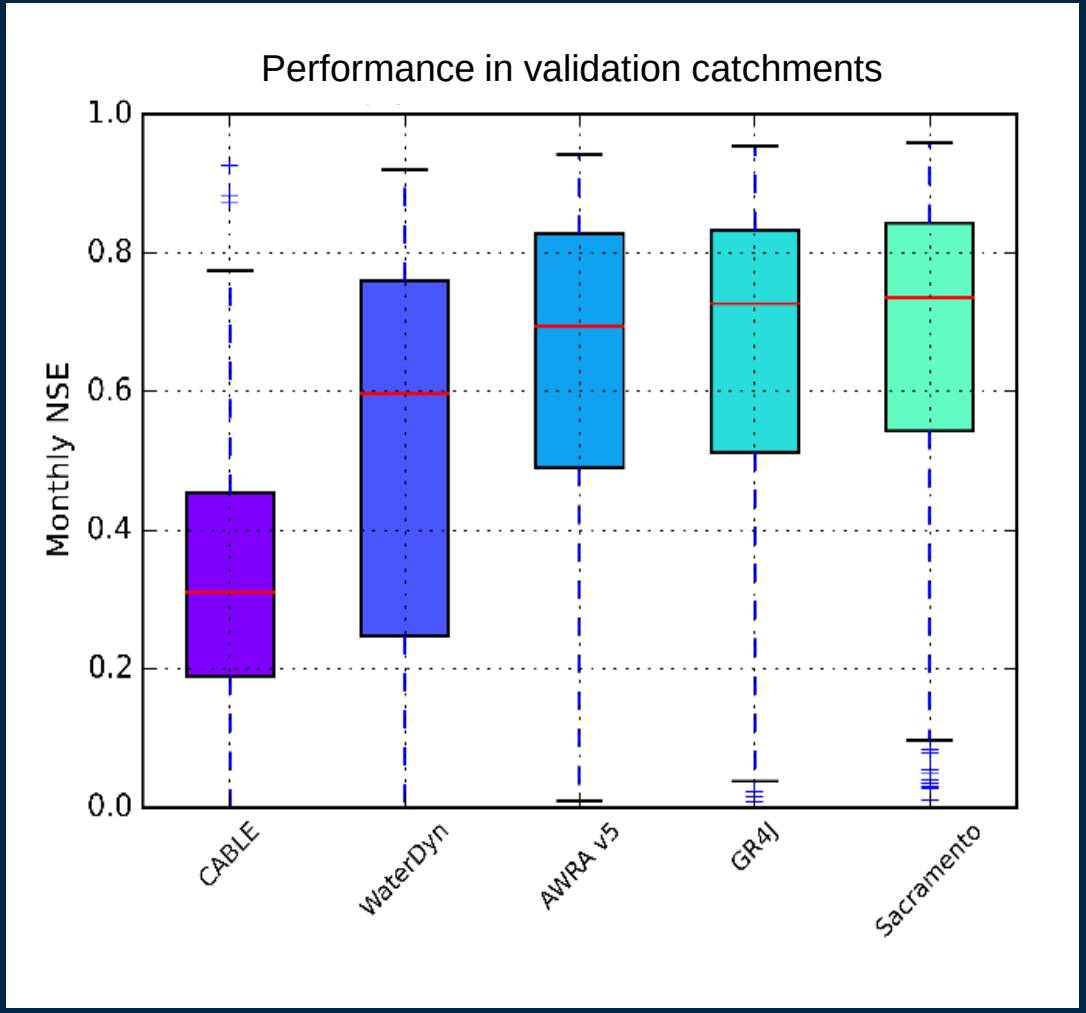
**Point testing**

- **Actual Evapotranspiration** – OzFlux towers (DINGO processing)
- **Soil moisture**
  - OzNet Murrumbidgee
  - SASMAS Upper Hunter
- **Recharge** data



# Streamflow: National unimpaired streamflow dataset




AWRA performs well in validation for streamflow compared to peer national *and* locally calibrated rainfall runoff models

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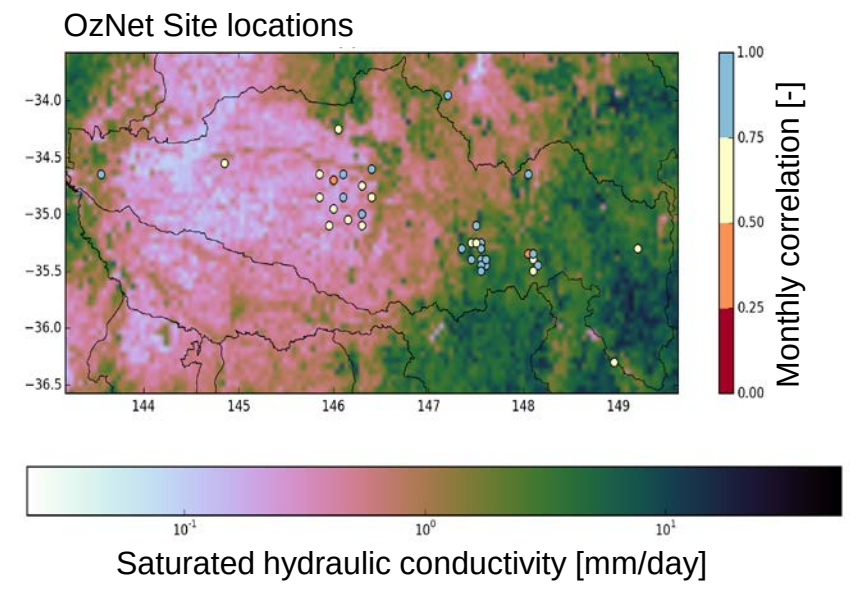
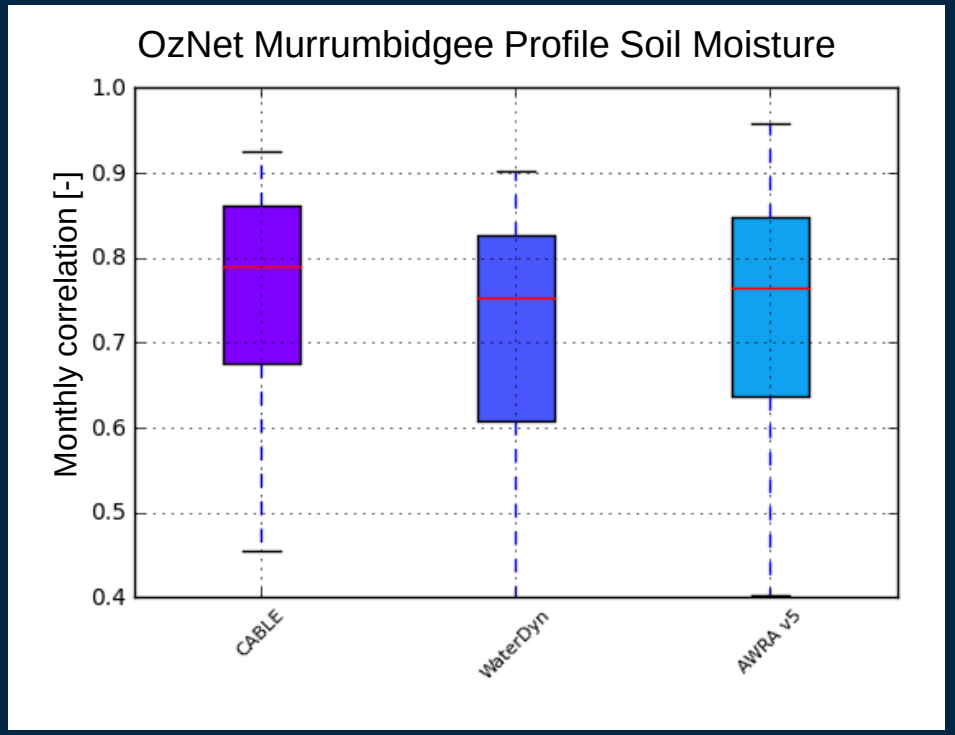
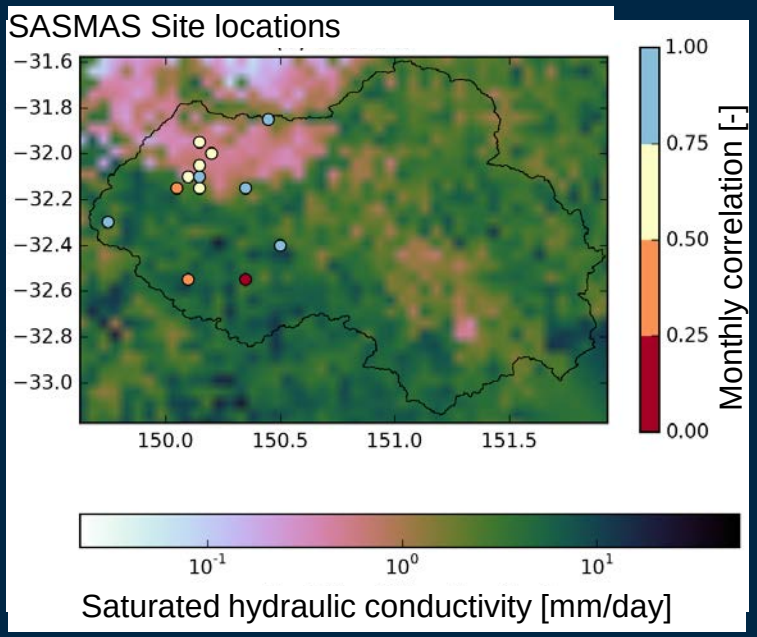
# Soil Moisture: OzNet Murrumbidgee

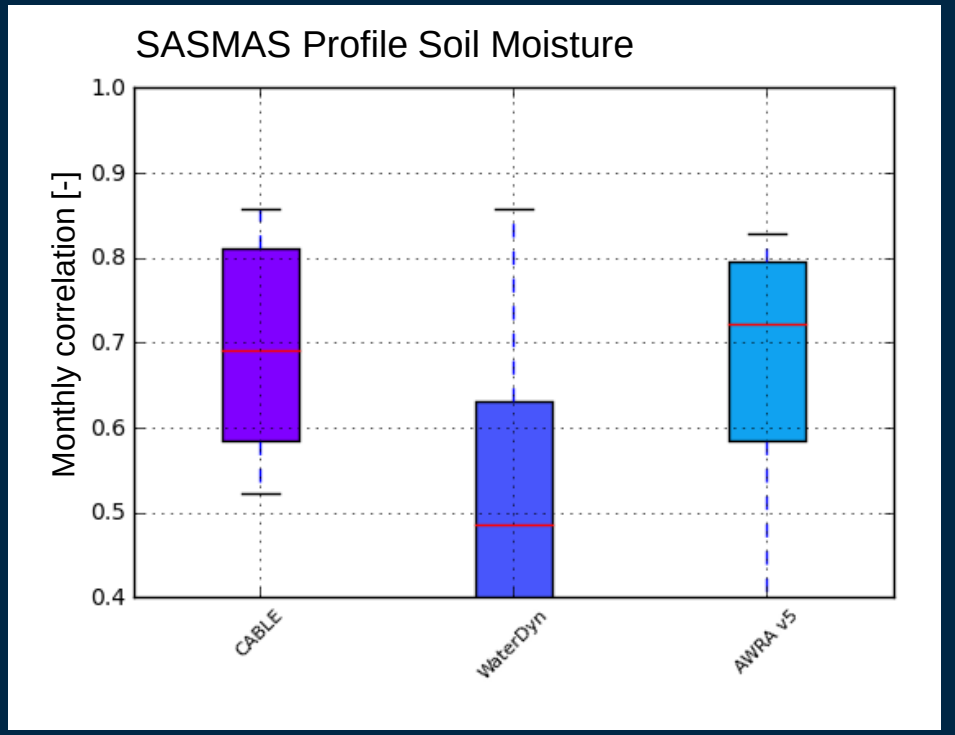



- AWRA-L performs well for profile 0-90cm soil moisture
- 0-5 cm poorer

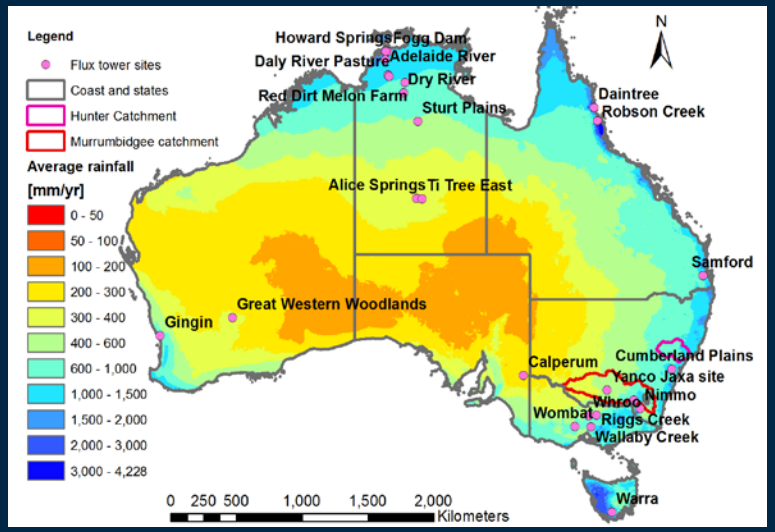
# Soil Moisture: SASMAS Upper Hunter



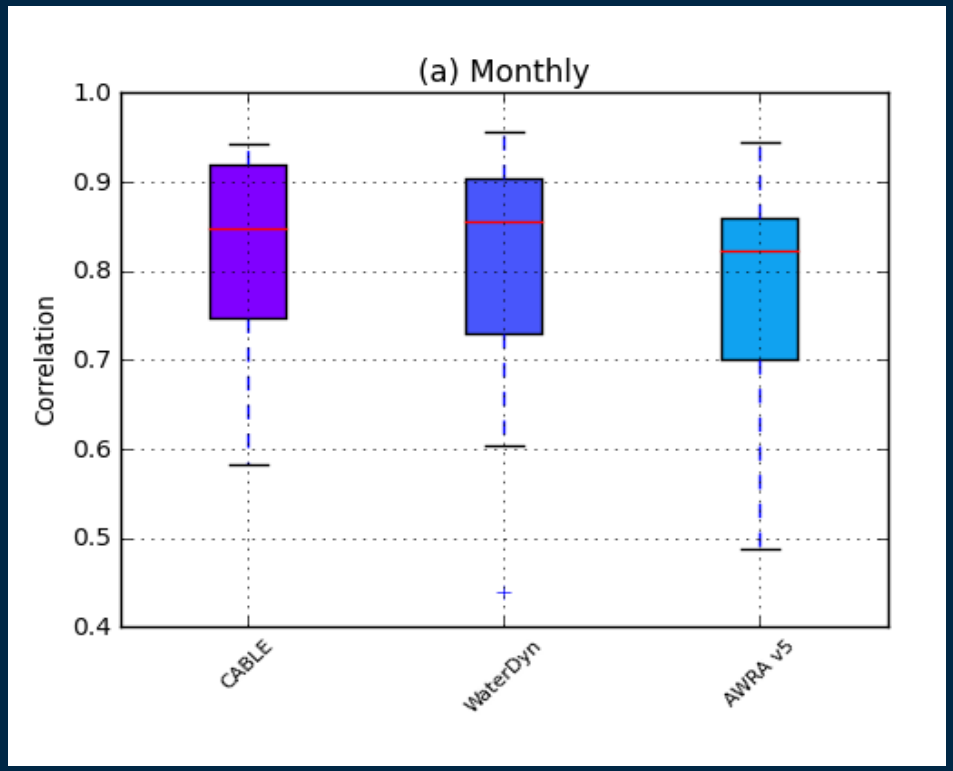




- AWRA-L performs well for profile 0-90cm soil moisture
- 0-5 cm poorer

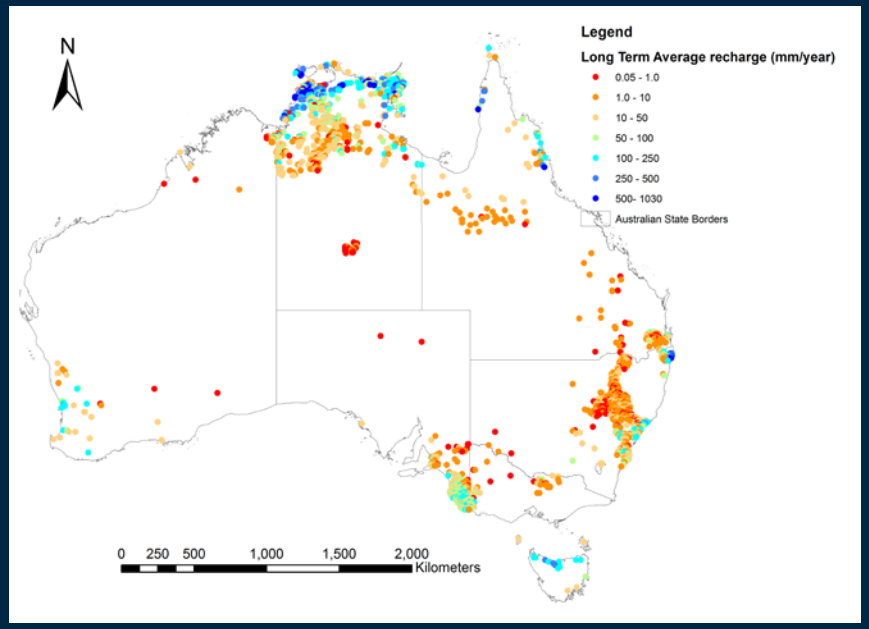
# Evapotranspiration: OzFlux with DINGO processing



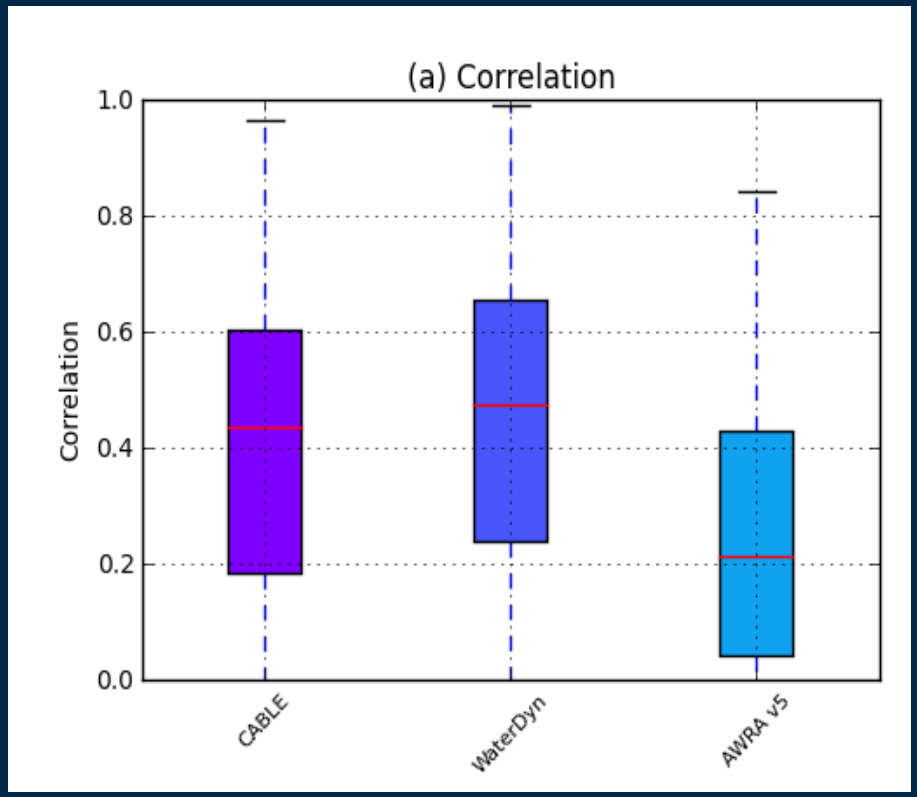

- CABLE/WaterDyn perform better than AWRA v5 for ET



# Recharge: long term average dataset




- CABLE/WaterDyn perform better than AWRA v5 for recharge
- Annual time-series data available in South Australia



# AWRA Community modelling system

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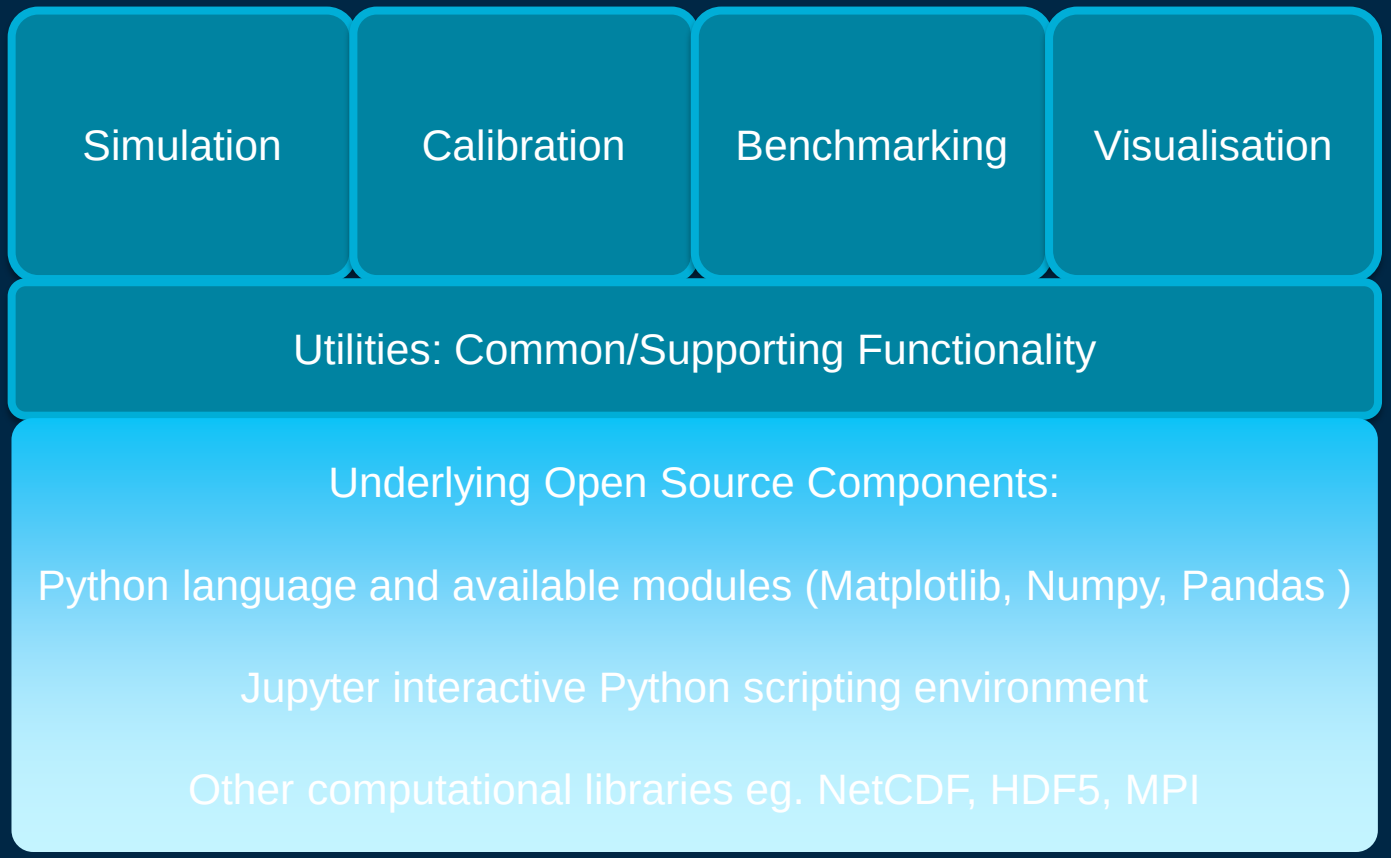
# AWRA Landscape Modelling System (Python)

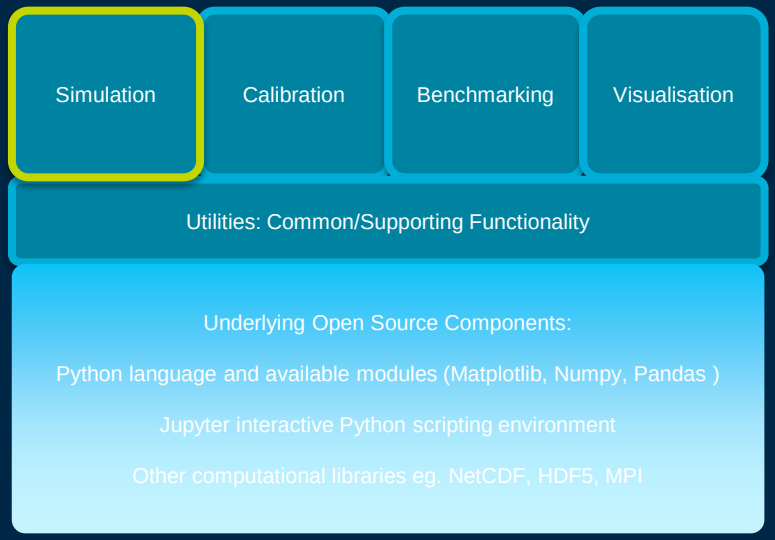


# Simulation

- Running the model

- Two modes of simulation:
  - On-demand simulator: RAM intensive
  - Server simulator: for writing outputs/large runs

- User specifies the following:
  - Spatial extent
  - Time period
  - Input nodegraph:
    - Parameter set
    - Initial soil moisture, groundwater and leaf mass
    - Daily gridded climate inputs
    - Static spatial inputs
  - Output nodegraph if Server Sim




```
initial_states_from_dict(imap,period,extent)
sim = Server(awral)
sim.run(imap,omap,period,extent)
```

```
/home/awrams_user/.venv/virtualenv/lib/python3.5/site-packag
s.py:565: VisibleDeprecationWarning: using a non-integer nur
 the future
  mask = extent.mask[y_start[y]:y_stop[y]+1,x_start[x]:x_sto
2016-12-12 14:53:43,796 INFO Getting I/O dataspecs...
2016-12-12 14:53:44,279 INFO Initialising output files...
2016-12-12 14:53:44,429 INFO Building buffers...
2016-12-12 14:53:44,486 INFO Running simulation...
```

```
worker pid: 2140
worker pid: 2145
reader pid: 2147
```

```
2016-12-12 14:53:44,548 INFO reader pid: 2147
```

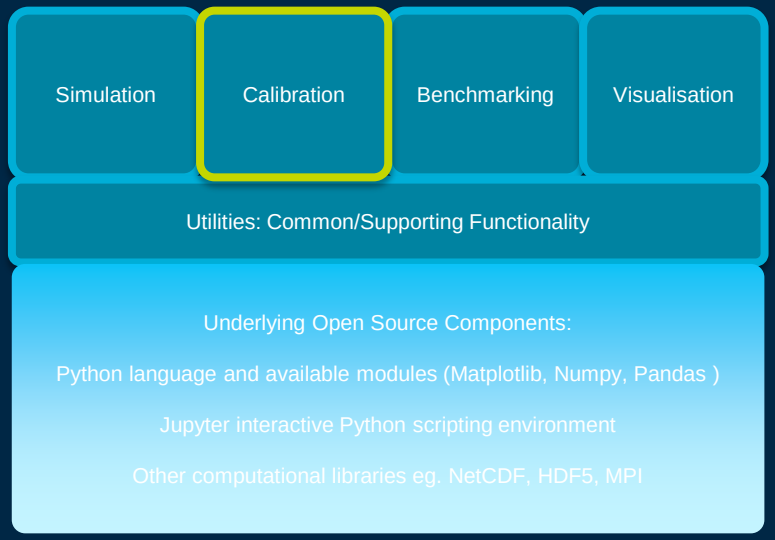
```
worker pid: 2141
```

```
2016-12-12 14:53:44,544 INFO writer pid: 2148
```

```
worker pid: 2143
```

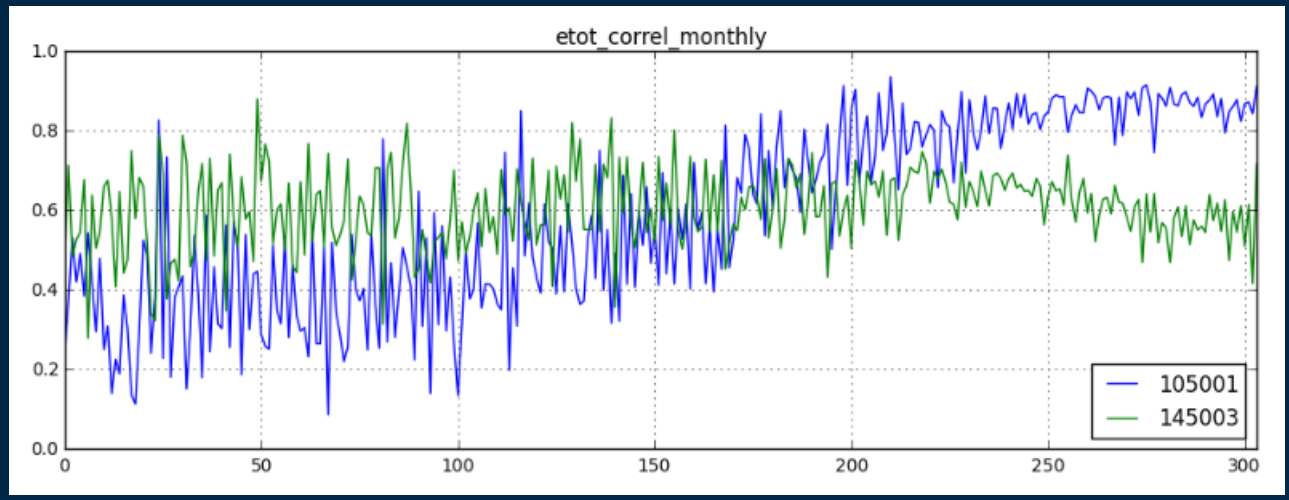
```
2016-12-12 14:53:45,654 INFO completed 25.00%
2016-12-12 14:53:45,750 INFO completed 50.00%
2016-12-12 14:53:45,843 INFO completed 75.00%
2016-12-12 14:53:45,955 INFO completed 100.00%
2016-12-12 14:53:45,957 INFO Completed period December 2010
2016-12-12 14:53:46,089 INFO completed 25.00%
2016-12-12 14:53:46,159 INFO completed 50.00%
2016-12-12 14:53:46,236 INFO completed 75.00%
2016-12-12 14:53:46,304 INFO completed 100.00%
2016-12-12 14:53:46,310 INFO Completed period January 2011
2016-12-12 14:53:48,879 INFO elapsed time: 5.09
```

# Calibration



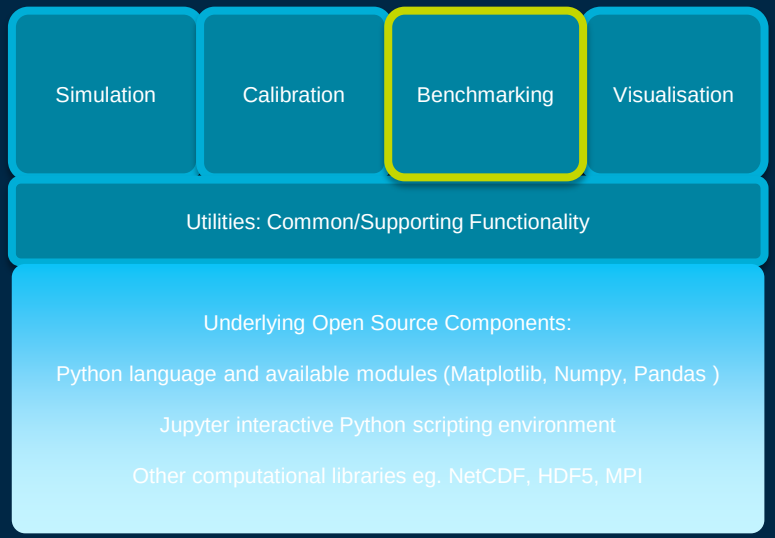

- Make simulations match observed data given and objective function
- Shuffled Complex Evolution (Duan et al, 1992)
- Parrallelises catchment simulations

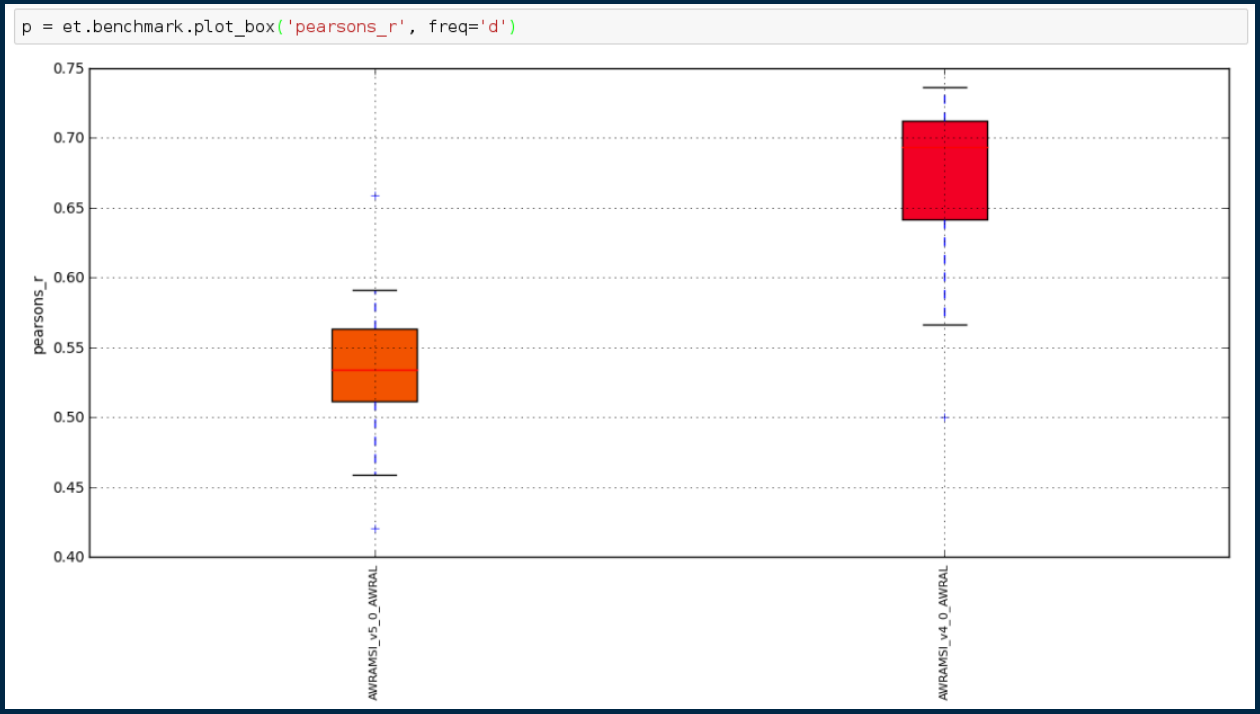
- Requires:
  - Setting input nodegraph as per simulation
  - Setting which parameters to optimise
  - Setting data to optimise against
  - Setting objective function
  - Setting SCE options



# Benchmarking (Part 1)

- Compare simulations to observational data
- Catchment comparisons:
  - Streamflow, satellite ET (CMRSET), soil moisture (AMSR)
- Point comparisons:
  - OzNet Murrumbidgee 0-90cm
  - SASMAS Hunter 0-90cm
  - ET Flux Towers - DINGO



# Benchmarking (Part 2)

- Benchmarking report details AWRA-L v5 performance and **benchmarks**
- Data released includes streamflow, ET and soil moisture datasets
- AWRA-L v5 simulations also released for comparison
- Data and documentation released to **Registered Users**

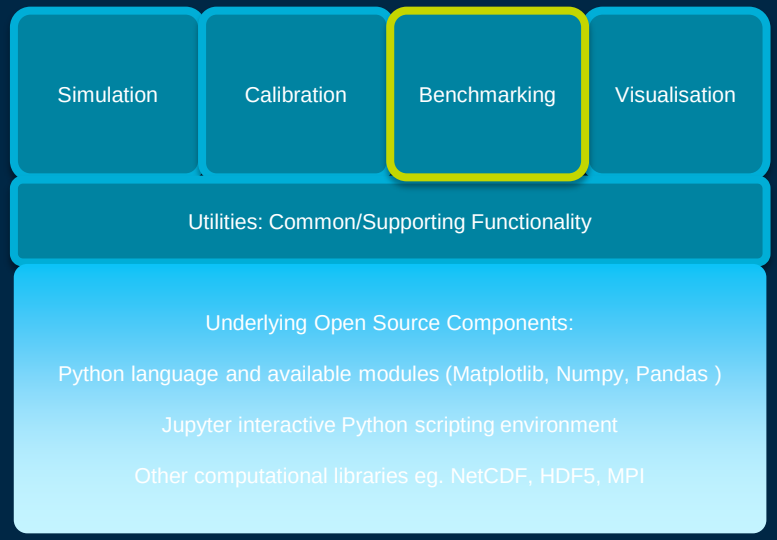




**Table 10. AWRA-L v5 Performance according to benchmark statistics**

| Streamflow | Percentile | Calibration catchments (295 Nationally) | Validation catchments (291 Nationally) | Aspirational target |
|---|---|---|---|---|
| Daily Nash-Sutcliffe Efficiency (NSE) | 5% | -1.16 | -0.30 | Less than 5% catchments with NSE<0 |
| | 50% | 0.46 | 0.45 | Greater than 50% catchments with NSE>0.5 |
| Relative Bias | 25% | -21% | -18% | 25%-75% catchments (50%) with -30%<bias<30% |
| | 75% | 32% | 28% | |
| | 5% | -49% | -46% | 5%-95% catchments (90%) with -50%<Bias<100% |
| | 95% | 136% | 128% | |
| **Soil moisture** | **Percentile** | **OzNet Murrumbidgee** | **SASMAS Hunter** | **Aspirational target** |
| 0-90cm Daily | 50% | 0.74 | 0.73 | 50% with daily correlation >0.75 |

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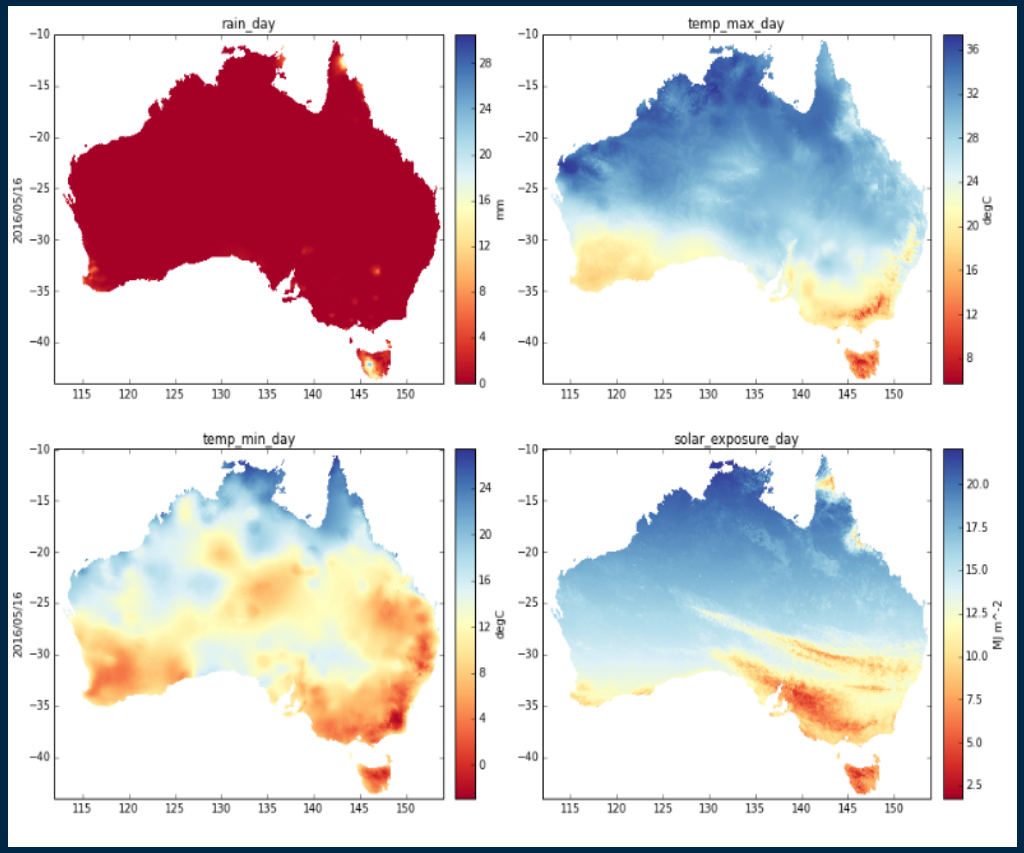
# Visualisation




Simulation | Calibration | Benchmarking | Visualisation

Utilities: Common/Supporting Functionality

Underlying Open Source Components:

Python language and available modules (Matplotlib, Numpy, Pandas )

Jupyter interactive Python scripting environment

Other computational libraries eg. NetCDF, HDF5, MPI

# Summary

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# Summary

- AWRA-L v5 tested against:
  - streamflow
  - soil moisture
  - ET
  - recharge datasets
- AWRA-L performs:
  - well for streamflow and profile [0-90cm] soil moisture
  - Less so for ET and recharge
  - Better overall for water resource assessment and agricultural purposes
- AWRA Community modelling system
  - Released by Bureau
  - Benchmarking data and documentation released to demonstrate improvements

# Thank you

**Questions?**

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