Improving a continental hydrological model by enhancing its hydrological representation and implementing at 1km spatial resolution

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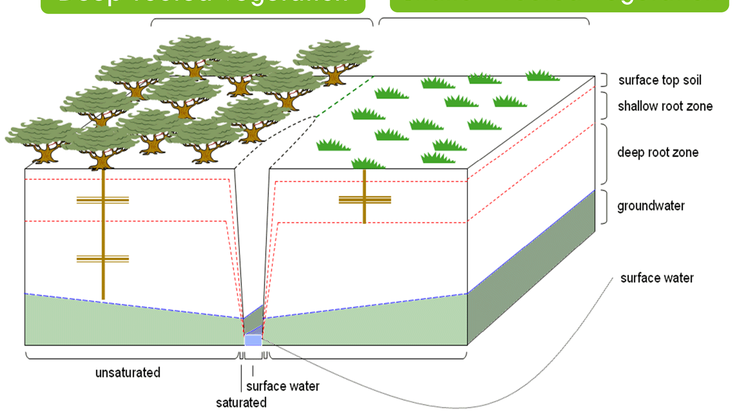
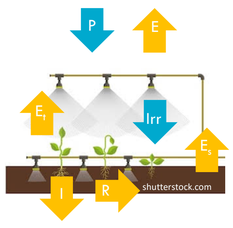
The Australian Water Resources Assessment Landscape (AWRA-L) model is a continental hydrological model developed by the Commonwealth Scientific and Industrial Research Organization (CSIRO) and Bureau of Meteorology (BoM) of Australia which is essential in providing consistent and reliable water resources assessments and accounts across continental Australia. The operational version of the AWRA-L model provides estimates of landscape runoff, evapotranspiration, soil moisture, and groundwater recharge/storage at a spatial resolution of 5km grids. Each 5km grid is assumed to have two hydrological response units (HRUs) – shallow-rooted vegetation and deep-rooted vegetation. To improve the landscape dynamics within the model, CSIRO and BoM increased the number of HRUs from two to five by representing the hydrological processes of the following: irrigated agricultural areas, perennial large water bodies, and impervious areas. The spatial resolution of the model was also increased to 1km grids to improve its applicability for management purposes in local areas.

Inclusion of 3 additional hydrological response units (HRUs)

Deep-rooted vegetation | Shallow-rooted vegetation

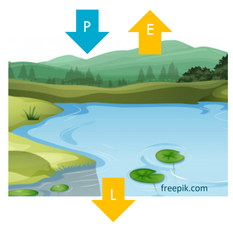


Irrigated agriculture



- Similar to shallow-rooted vegetation
- Irrigated water is added (from fixed allocation) when soil water is low during cropping season

Large water bodies



- Open water evaporation
- Saturated soil, minimal infiltration (leakage)

Impervious areas

- Rainfall becomes runoff or evaporation
- No infiltration and transpiration

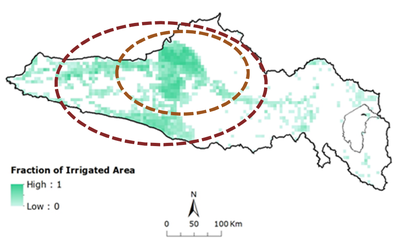
Comparison of results using Murrumbidgee as test basin

A total of eight model setups varying the spatial layer inputs, climatological inputs, HRUs considered, and spatial resolutions were run to examine the suitability of the model developments. The numerical experiments were run using the Murrumbidgee River, one of the widely observed catchments in Australia, as test basin. The figures below show the comparison focusing on the impacts of HRUs and spatial resolutions.

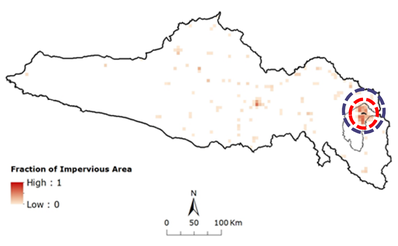
2 HRUs vs 5 HRUs

Maps for the additional HRUs (~5km)

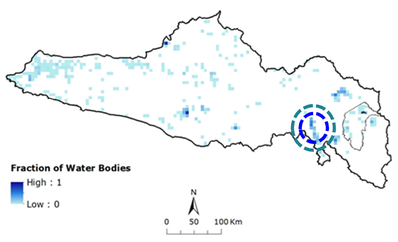
Irrigated Area



Impervious Area

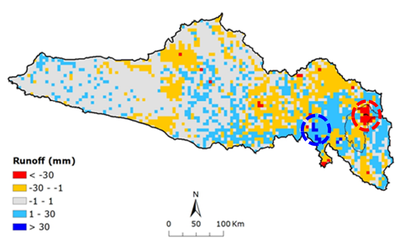


Large Water Bodies

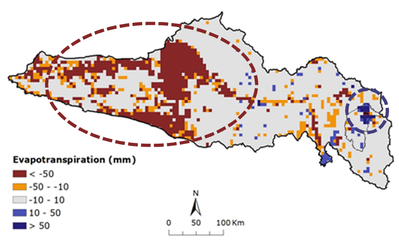


Differences (2HRUs – 5HRUs)

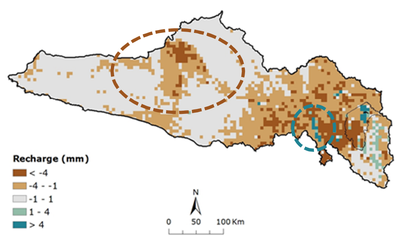
Mean Annual Runoff (1970-2012)



Mean Annual Evapotranspiration (1970-2012)



Mean Annual Recharge (1970-2012)



Observed trends

Irrigated areas
Impervious areas

Large water bodies

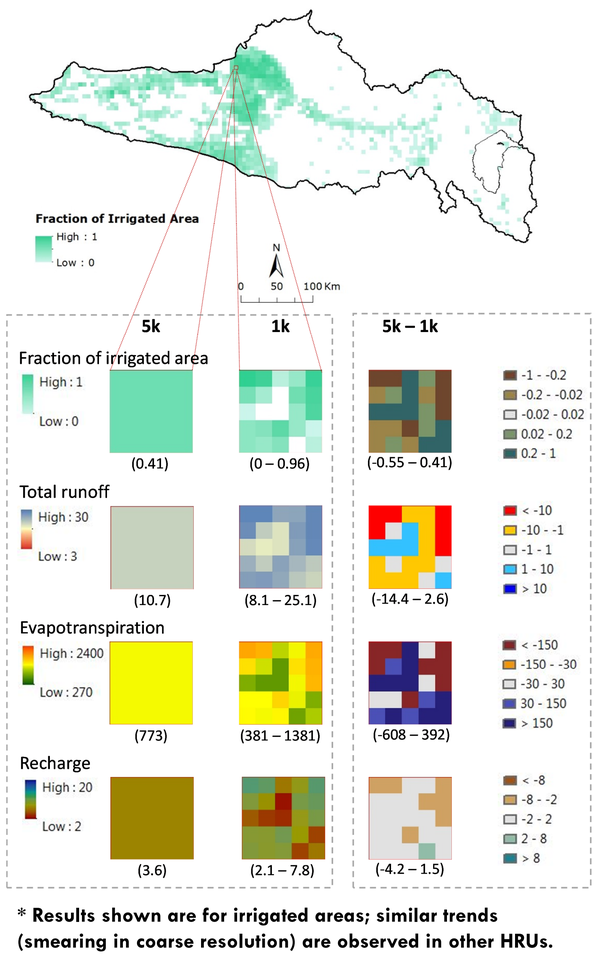
Irrigated areas
Large water bodies

Impervious areas

Irrigated areas

Impervious areas
Large water bodies

5 km vs 1 km



*** Results shown are for irrigated areas; similar trends (smearing in coarse resolution) are observed in other HRUs.**

Statistical comparisons for the means and median NSEs, bias, and correlation with runoff do not show significant changes with the increase in the number of HRUs or increase in the spatial resolution of the model. This is expected because most of the gauging stations in the test basin are located in natural subcatchments (no irrigation, man-made reservoirs, or urban areas). The comparisons above, however, show that the model developments enabled the more explicit representation of hydrological processes in the three areas which are important for water resources management. The implementation of the model at a finer 1km spatial resolution provides more realistic estimates of the water balance which are more suitable for use in catchment and local applications.

FOR FURTHER INFORMATION
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REFERENCES

Vaze, J.; Mateo, C.; Wang, B. AWRA-L implementation with 2 and 5 HRUs at 5km and 5 HRUs at 1km spatial resolution – inter-comparison and comparison with observations. Australia: CSIRO; 2017. http://hdl.handle.net/102.100.100/88525?index=1

ACKNOWLEDGEMENTS

This work is carried out in CSIRO Land and Water as part of the AWRA project and is funded by the WIRADA research alliance between the Bureau of Meteorology and the CSIRO.

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The improvements to the model may only be implemented in other catchments in Australia as well as for the entire continent if all spatial data inputs to the model are available. To ensure the reliability and consistency of the spatial data layers, the most recent and best available data were used to derive and regenerate all the AWRA-L spatial input layers for the Australian continent. The 48 input spatial layers to the improved 5 HRU AWRA-L model have been updated and made available at 5km and 1km spatial resolutions. The climatological inputs from 1970-2012 have also been prepared to match with the spatial grids of the AWRA-L model.

Climatological data

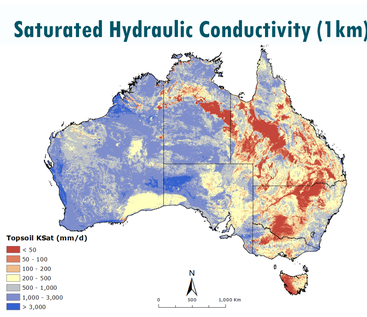
AWRA-L spatial layer	Units	Description	Source data used to derive the layers
K_D	MJ M^{-2} D^{-1}	Incoming shortwave radiation	AWAP at 0.05° and resampled uniformly to 0.01°
P	Mm	Precipitation (daily)	ANUClimate from TERN (Michael Hutchinson)
T_{max}	°C	Maximum temperature (daily)	ANUClimate from TERN (Michael Hutchinson)
T_{min}	°C	Minimum temperature (daily)	ANUClimate from TERN (Michael Hutchinson)

Significance

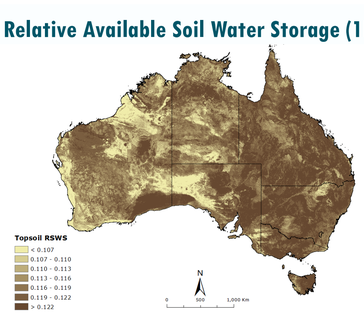
The updated input spatial layers are essential for implementing the improved AWRA-L model at any catchment within continental Australia. Local catchments with a high fraction of irrigated agricultural areas, impervious areas, or large water bodies will benefit the most from these updates. While the spatial layers were prepared for use in the AWRA-L model, they may also be useful for the development of other large-scale hydrological models, especially those that are seeking to implement models at finer spatial resolutions.

Updated spatial layers

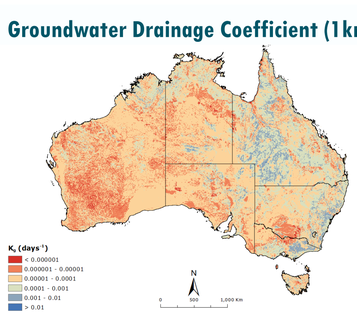
Saturated Hydraulic Conductivity (1km)



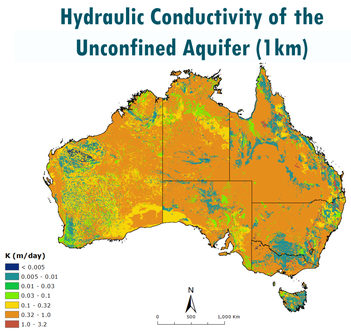
Relative Available Soil Water Storage (1km)



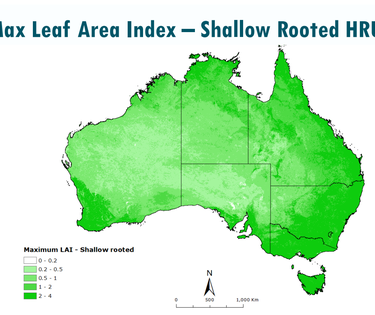
Groundwater Drainage Coefficient (1km)



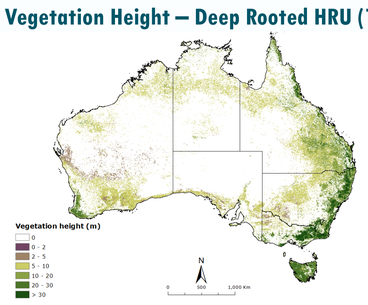
Hydraulic Conductivity of the Unconfined Aquifer (1km)



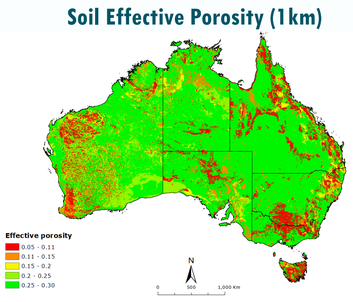
Max Leaf Area Index – Shallow Rooted HRU (1km)



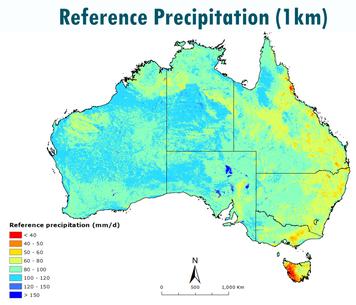
Vegetation Height – Deep Rooted HRU (1km)



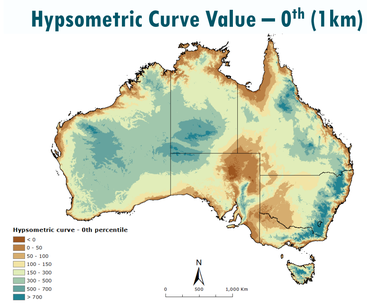
Soil Effective Porosity (1km)



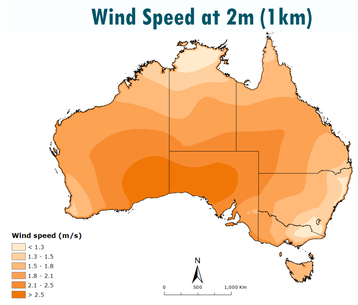
Reference Precipitation (1km)



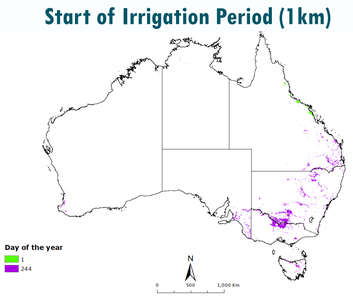
Hypsometric Curve Value – 0th (1km)



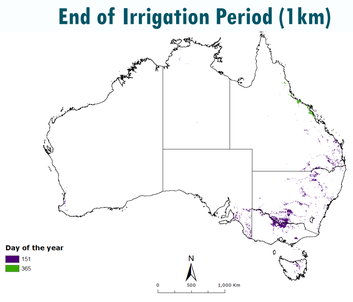
Wind Speed at 2m (1km)



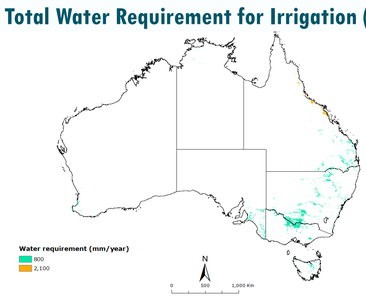
Start of Irrigation Period (1km)



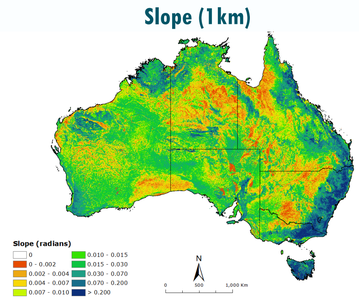
End of Irrigation Period (1km)



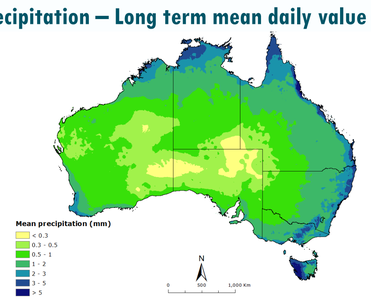
Total Water Requirement for Irrigation (1km)



Slope (1km)

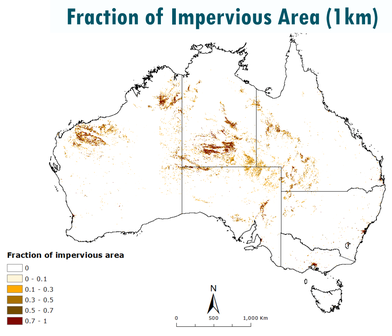


Precipitation – Long term mean daily value (1km)



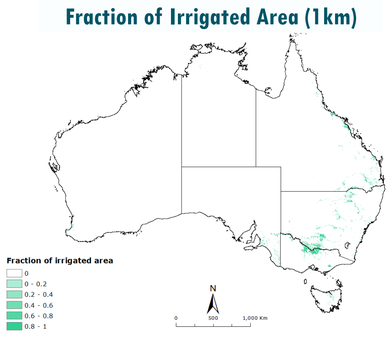
New 5HRUs spatial layers

Fraction of Impervious Area (1km)



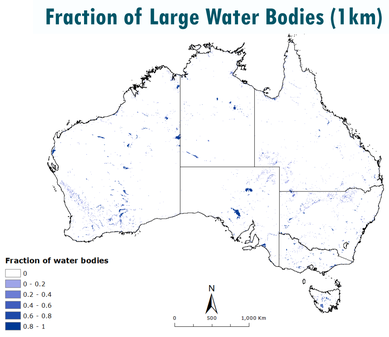
Combined impervious area mapping from Geoscience Australia (GA) and rock outcrop and urban mapping from Juan Guerschman

Fraction of Irrigated Area (1km)



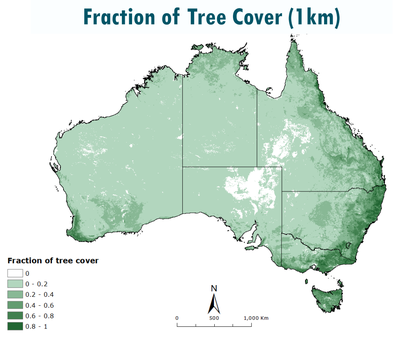
Combined irrigated area mapping from GA and the CLUM data for MDB from Justin Hughes

Fraction of Large Water Bodies (1km)



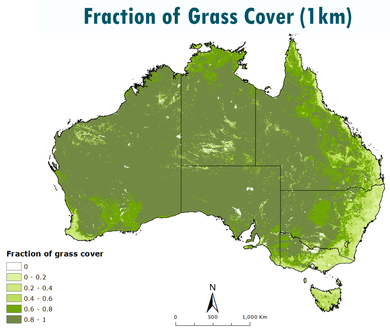
Combined Water Observation from Space (WOfS) data from GA (better in eastern Australia) and water bodies mapping undertaken by CSIRO (better in western Australia)

Fraction of Tree Cover (1km)



From Advanced Very High Resolution radiometer (AVHRR) satellite derived fractions of recurrent photosynthetically active absorbed radiation (fPAR) (Donohue et al., 2008)

Fraction of Grass Cover (1km)



From Advanced Very High Resolution radiometer (AVHRR) satellite derived fractions of recurrent photosynthetically active absorbed radiation (fPAR) (Donohue et al., 2008)

FOR FURTHER INFORMATION
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REFERENCES

Vaze, J.; Mateo, C.; Wang, B.; Teng, J.; Marvanek, S. AWRA-L input spatial layers at ~1 km and ~5 km resolutions for the Australian continent - Source daat and comparison between 1 km and 5 km resolutions. Australia: CSIRO; 2018. https://doi.org/10.4225/08/5b182f36b6fec

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HS2.5.1 – Large scale hydrology