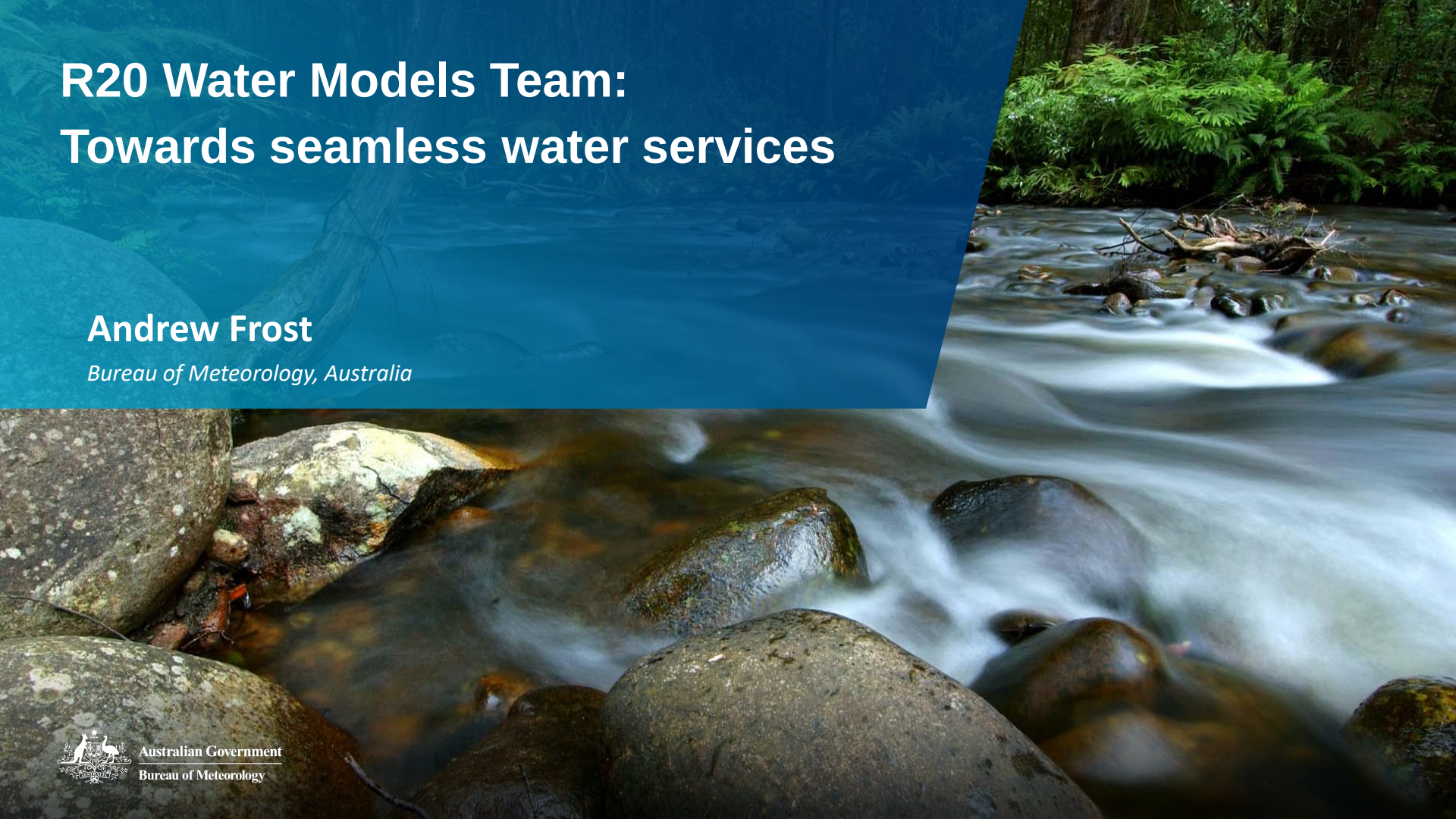
R20 Water Models Team: Towards seamless water services

Andrew Frost

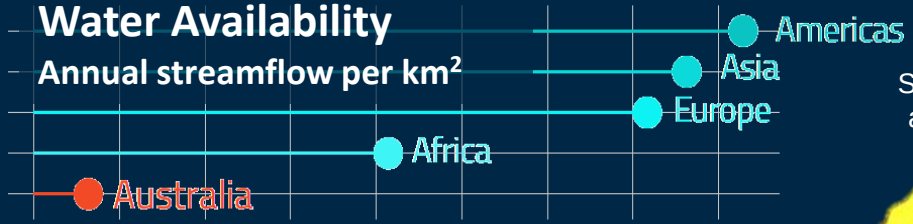
Bureau of Meteorology, Australia



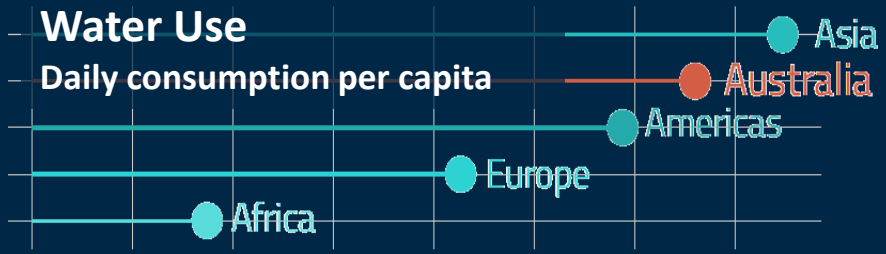
Australian Government
Bureau of Meteorology

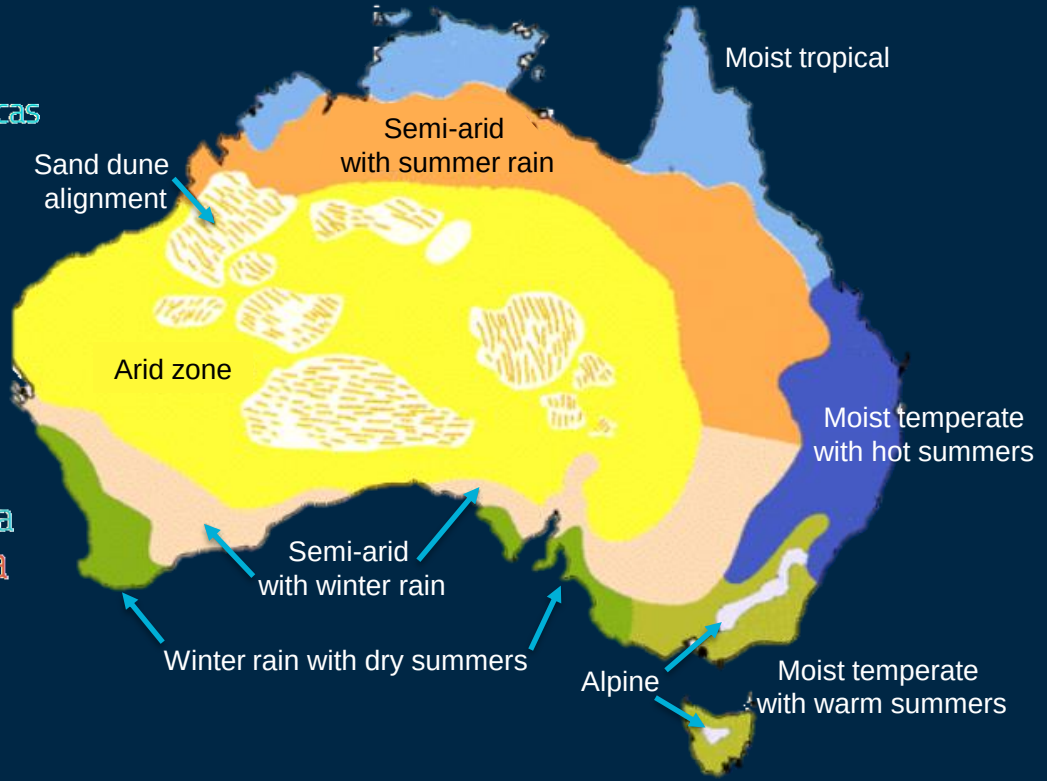
Australia's Hydroclimate

Driest inhabited continent



High water use per capita



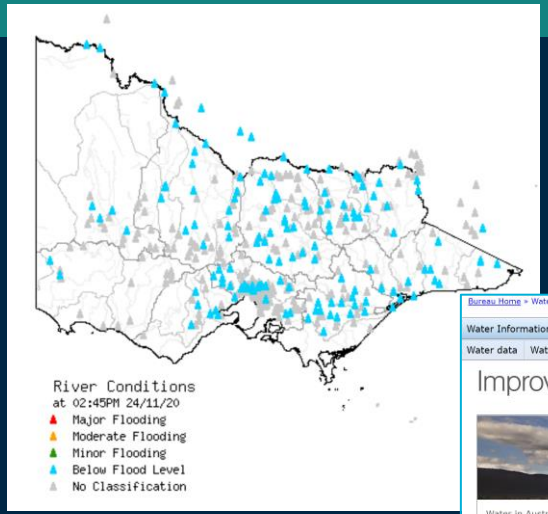


Rod Marsh for the Ian Potter Foundation and The Myer Foundation 2019

Sources: FAQ Aquastat and Chiew et al. (2006, 2007)

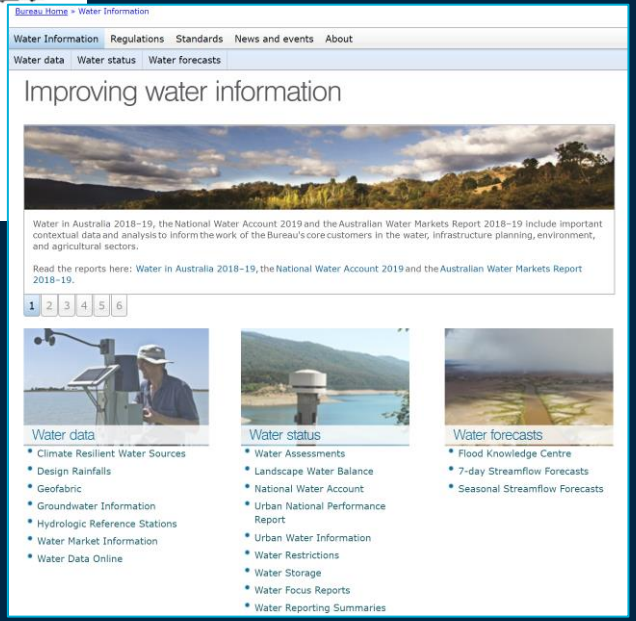
A brief history of water in the BoM

1. Flood forecasting, IFDs
2. Water Division ~ 2007
   - Water Act
   - Collating data
   - monitoring, reporting, forecasting
3. 2020 Restructure: Impact and Value
   - Customer focus (BSG)
   - Services (CSG)
   - **Water R&D in SIG!**



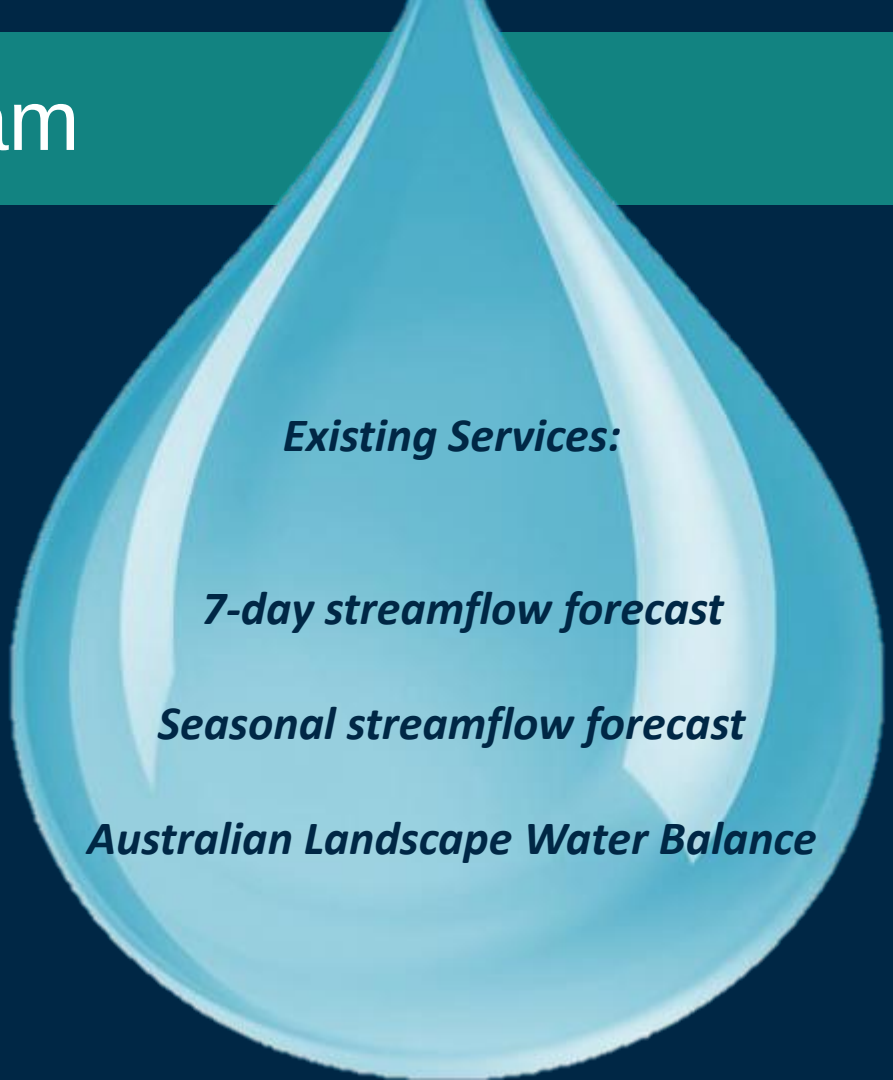
Flood forecasting service
www.bom.gov.au/water/floods

Water Information
www.bom.gov.au/water

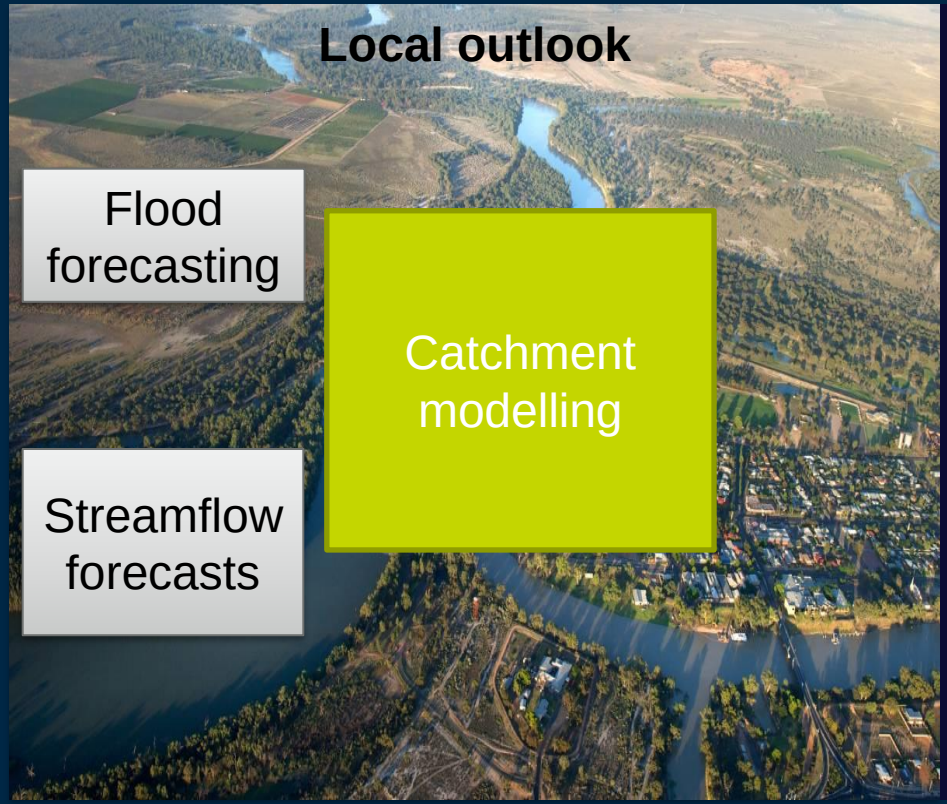


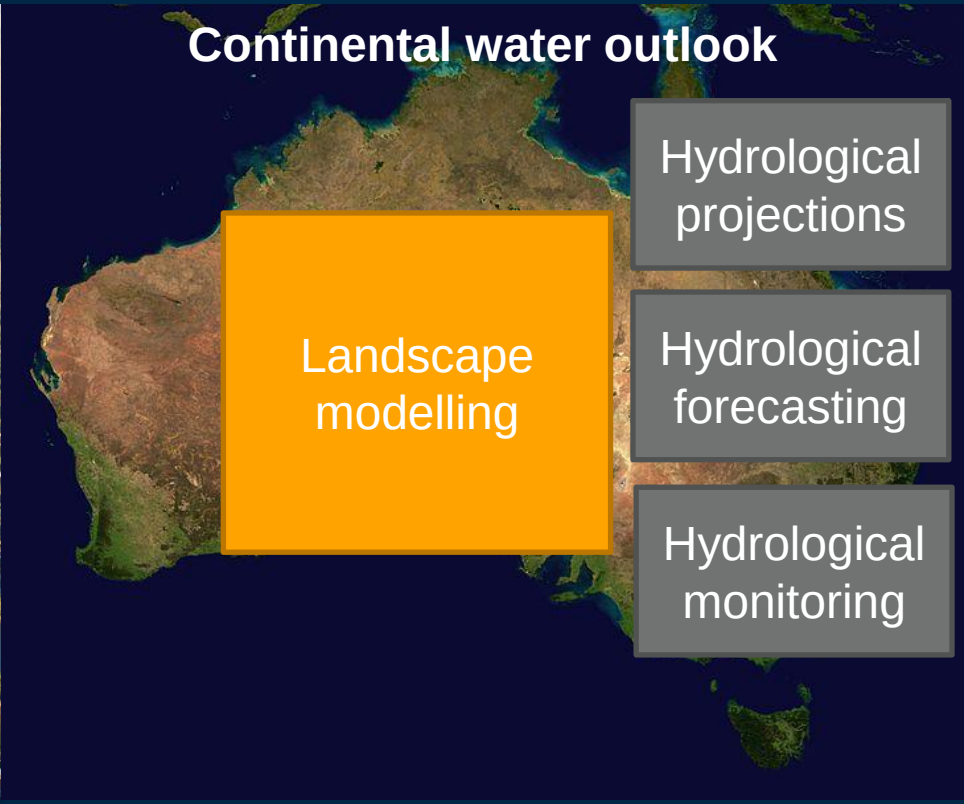
R20 Water Modelling Team

1. Develop and improve hydrological models and systems
   - Maintain existing services
   - **New services towards seamless water information**
2. Future: + floods & integration with weather models



Moving towards a consolidated Australian Water Outlook service

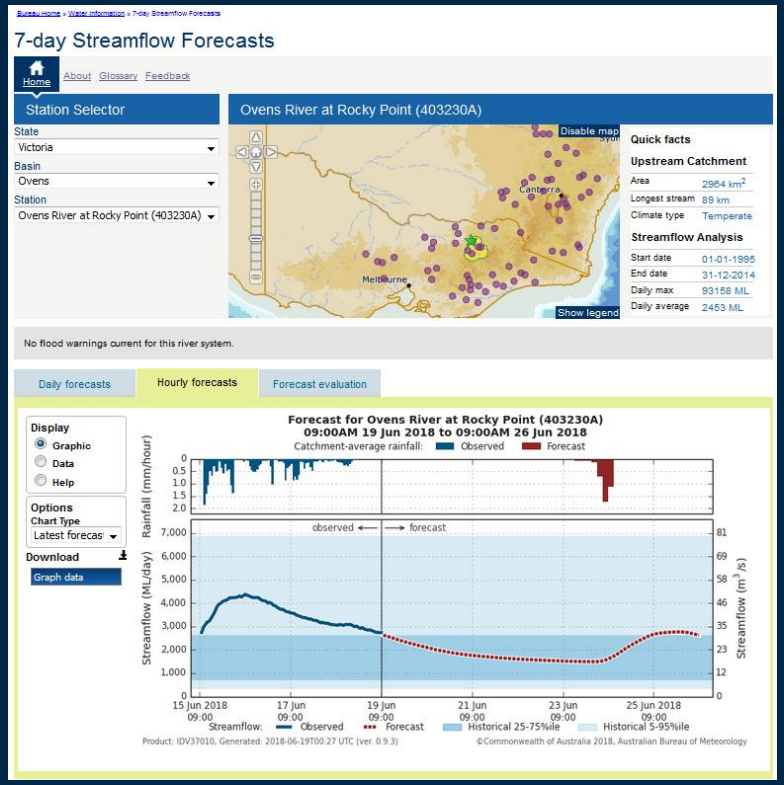


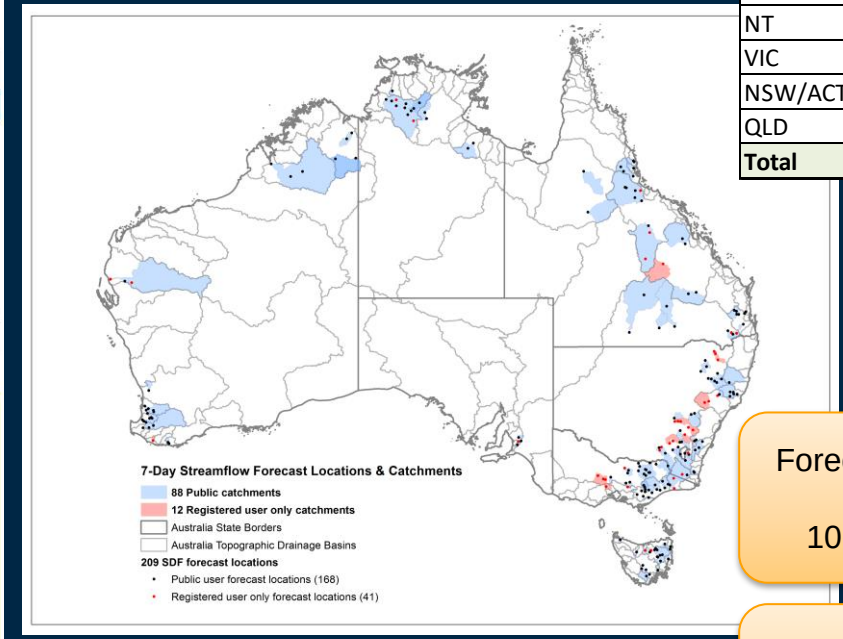


Local outlook: 7-day streamflow forecasts

Registered users: reg.bom.gov.au/water/reg/stf/index.shtml

Public: www.bom.gov.au/water/7daystreamflow/index.shtml





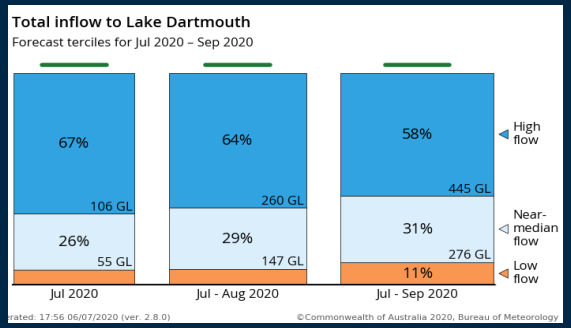
Region	Registered User Sites	Public Sites
TAS	24	22
WA	28	25
SA	5	3
NT	16	14
VIC	43	34
NSW/ACT	56	38
QLD	38	32
Total	**210**	**168**

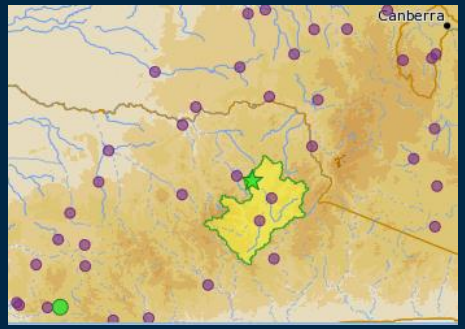
Forecasts are updated daily around 10:00-11:00 AEST

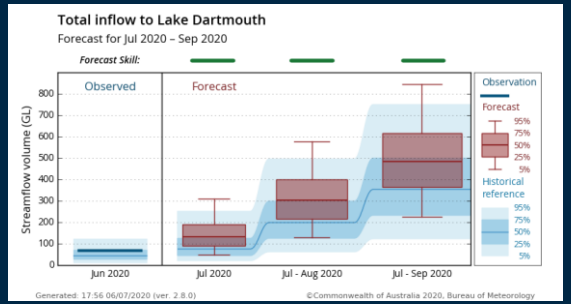
Data provision via the website and FTP to key stakeholders

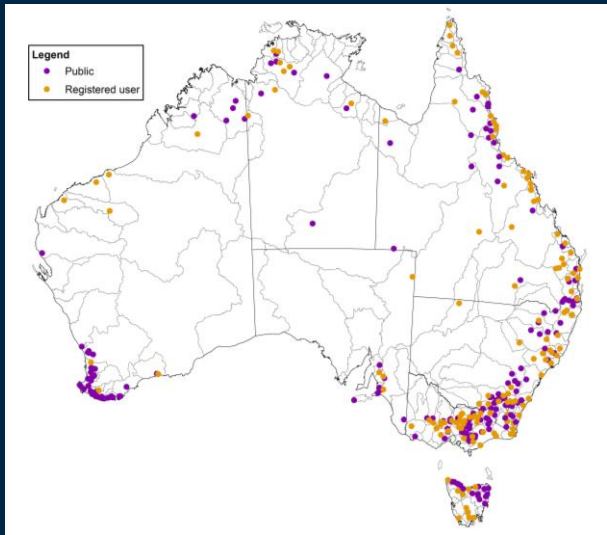
Local outlook: Seasonal streamflow forecasts

- Delivered monthly to 215 locations to public, 344 registered user
- Forecast key goals:
  - Reduce uncertainty in expected streamflow volume
  - Maintain reliability – Observation lies within ensemble





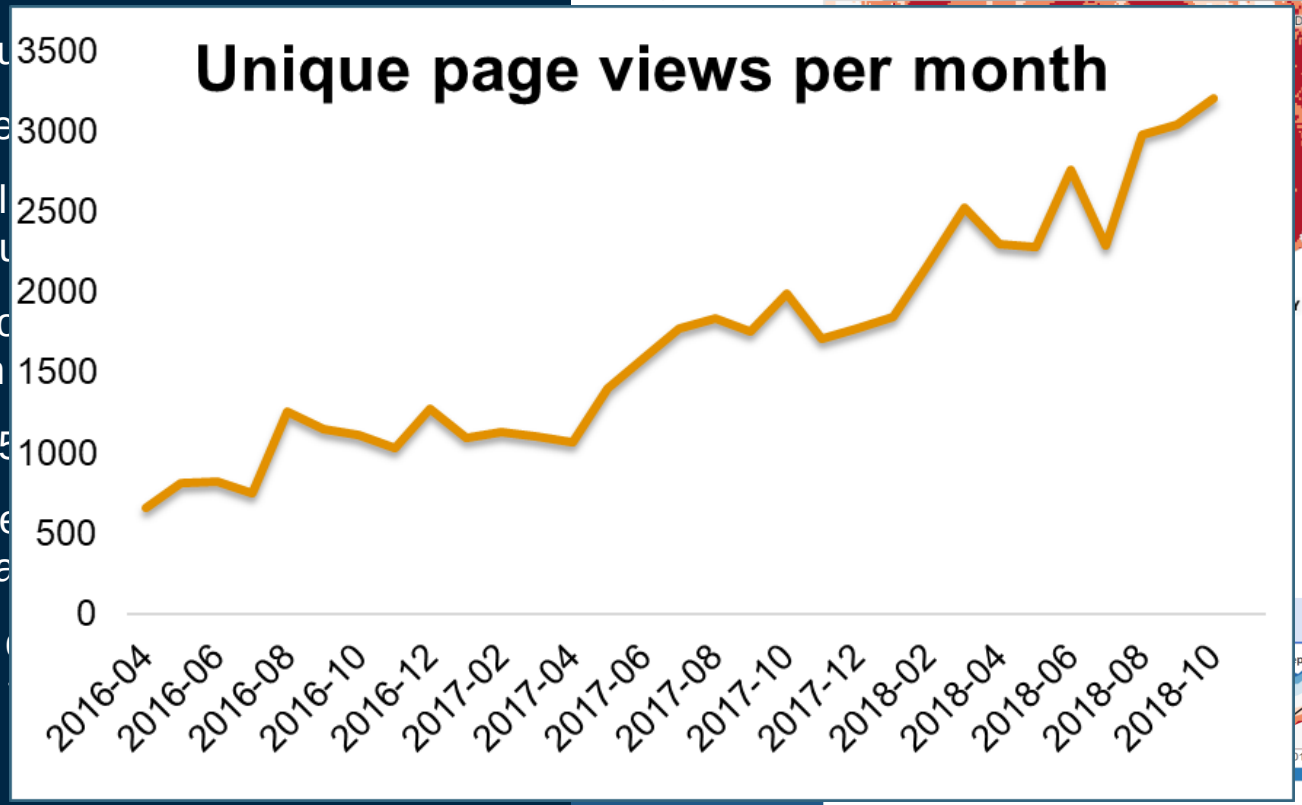




Existing Australian Landscape Water Balance web application

www.bom.gov.au/water/landscape

- A uniqu
- Update
- See all
  or annu
- Downlo
  of 5km
- Past 15
- Registe
  years a
- Model
  'About



Overview and outputs: AWRA-L

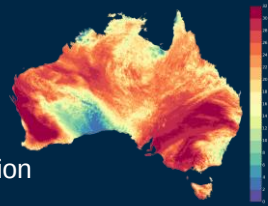
The Australian Water Resources Assessment Landscape model

National, daily time-step, 5 km resolution

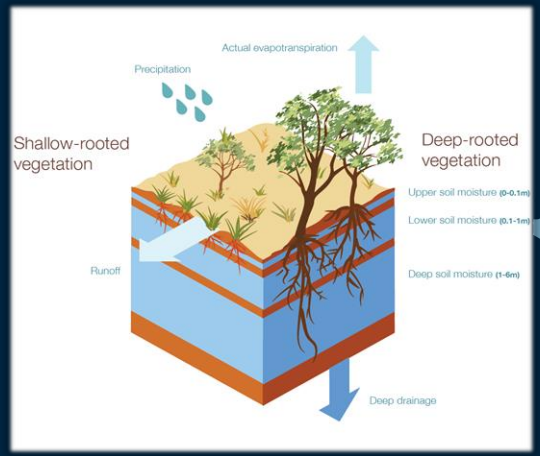
Inputs

Rainfall

Solar radiation



Model analysis



Outputs

Actual evapotranspiration

Runoff

Deep drainage

Soil moisture

AWRA-L v5 operational in the Bureau since 2016, AWRA v6 late 2018

AWRA v7 early 2021

Australian Government

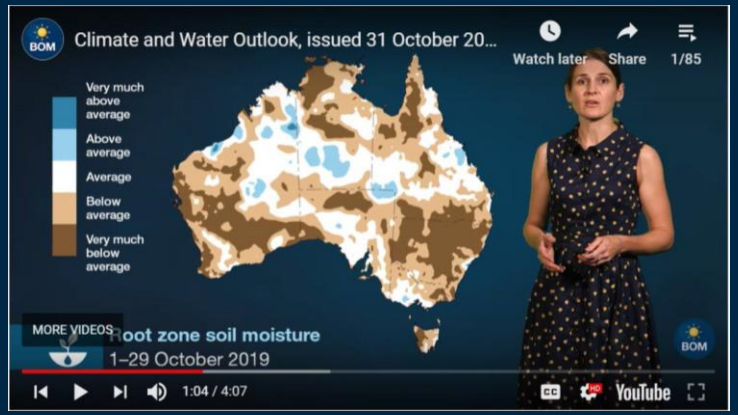
Bureau of Meteorology

CSIRO

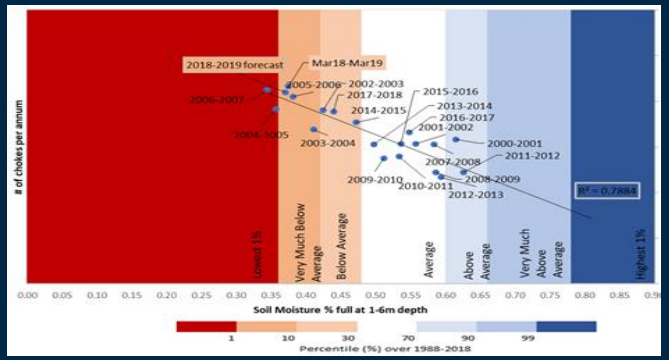
AWRA-L: Past to present

Monitoring/reporting:

National Climate and Water Briefings, Special Climate Statements, NWA, Water In Australia, Regional Water information, Landline, Fire risk

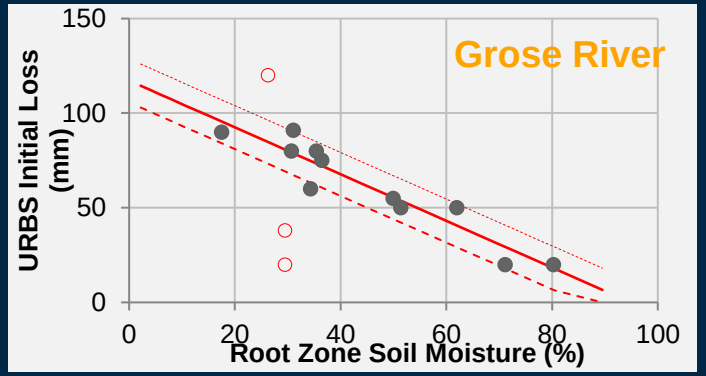


Water Utilities: eg. Pipe chokes vs. soil moisture

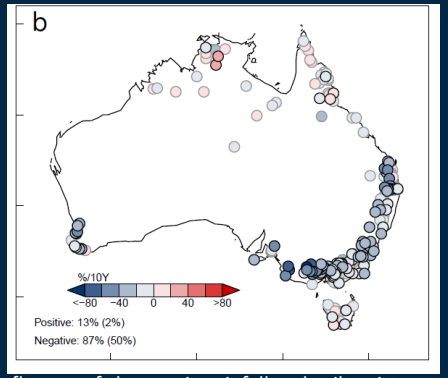


Emergency Services:

Flooding initial loss, fire dryness: eg. BoM initial loss estimation from model calibration correlated with AWRA-L Root Zone Soil Moisture



Design: Australian Rainfall & Runoff design initial loss and trends in soil moisture/floods



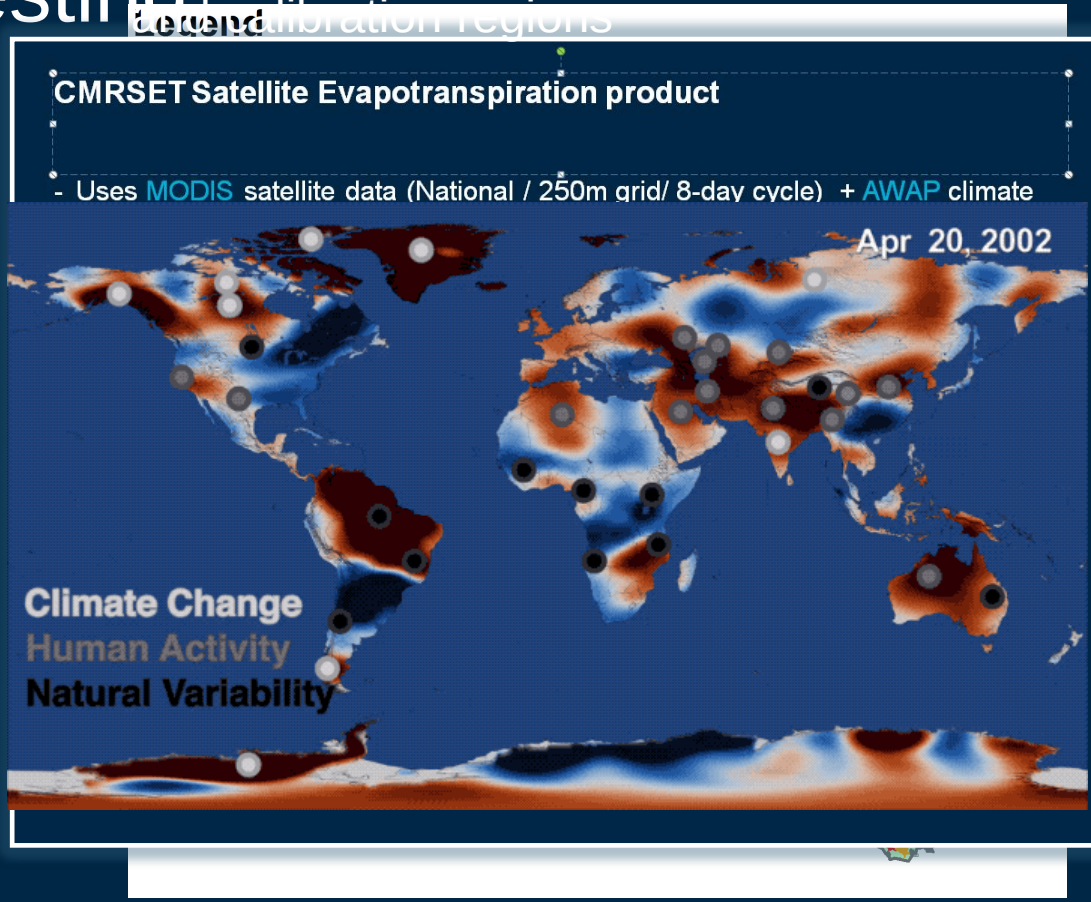
Wasko and Nathan (2019) Influence of changes in rainfall and soil moisture on trends in flooding

Development and testing

- CSIRO/BoM development 2009-2016

- Calibrated to catchment streamflow, satellite CMRSET **ET and AMSRE soil moisture**
- **Evaluate water balance**:
  - **Ground based:** Streamflow, Soil moisture, Recharge, ET
  - ***SPACE!*** **GRACE** Water storage, soil moisture, ET, ***MODIS*** vegetation

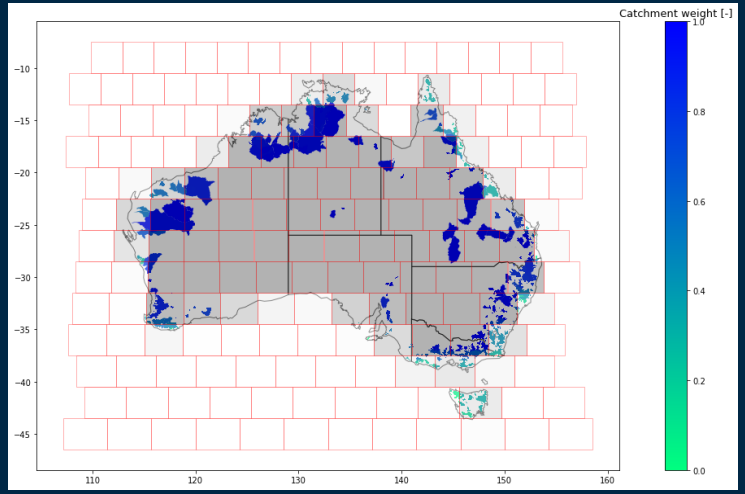
Calibration/Validation catchments



v7 Development

- Better drought and recharge performance
- Better flood and fire performance
- Approach:
  - **Calibration**: +GRACE and vegetation
  - **Input data**: updated streamflow, grids, ASCAT, CMRSET, climate
  - **Model improvements**: baseflow, top layer soil moisture, maximum transpiration

GRACE has large pixels – treat catchments/coast with care

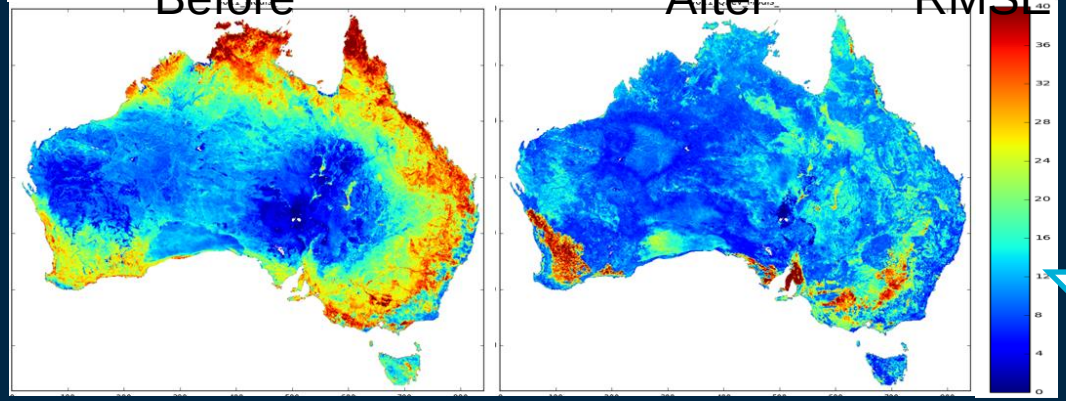


MODIS fraction of vegetation in calibration

Before

After

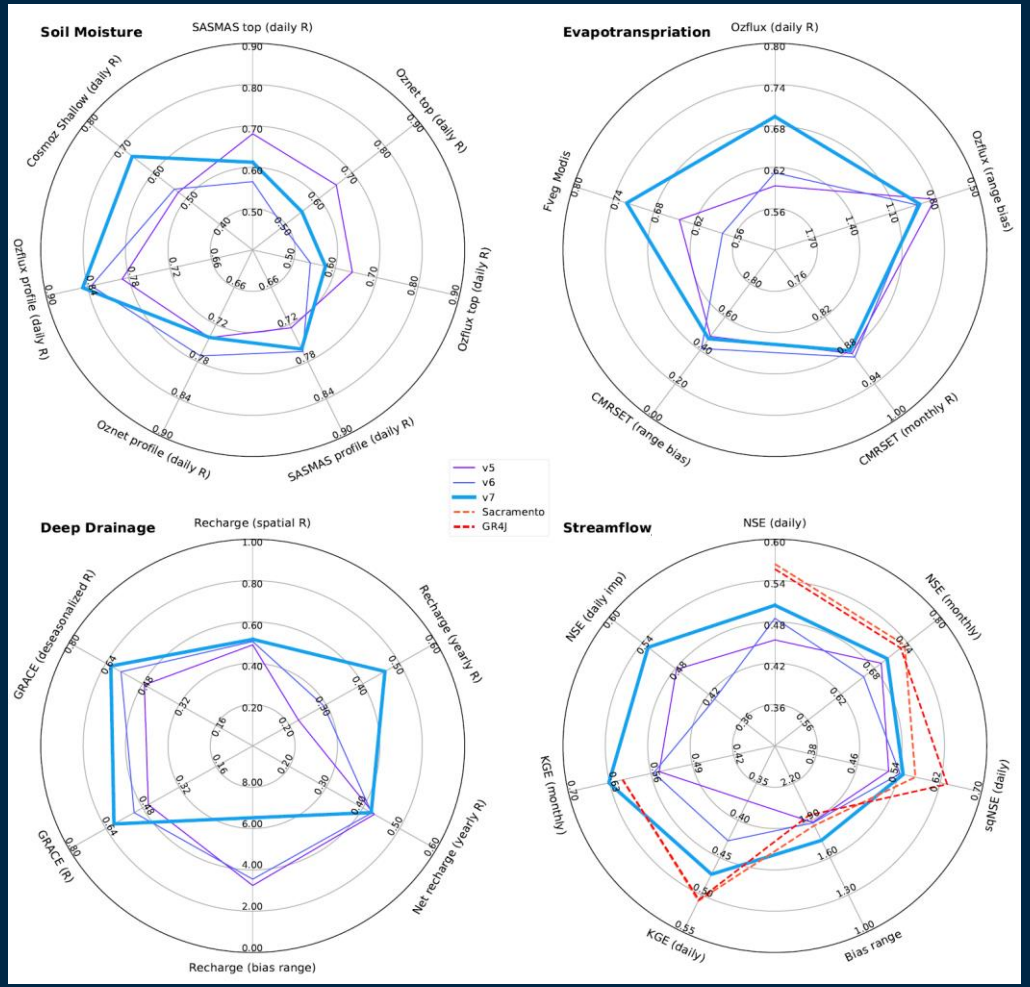
RMSE



Changes in v7

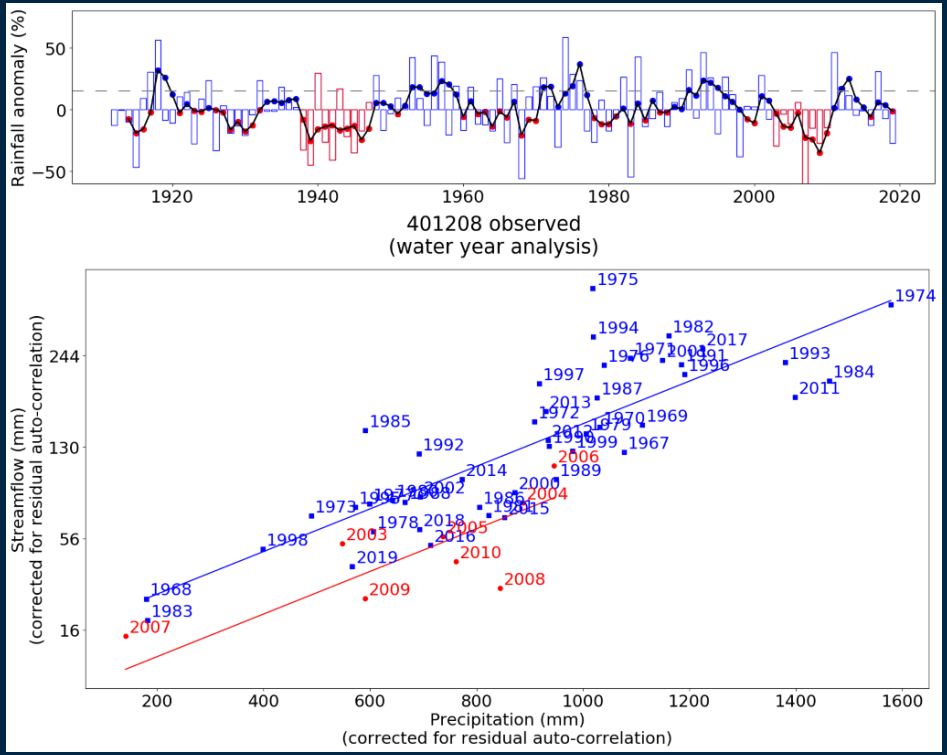
Calibration	SM ASCAT
Input data	Top layer ksat
Input data	Climate input alignment
Input data	Vapour pressure input
Input data	Weight average temperature
Calibration	Updated ET
Calibration	Use spatial calibration
Calibration	Use vegetation fraction
Calibration	Use GRACE TWS
Input data	Initialization groundwater
Structure	New impervious HRUs
Structure	Max. tree water uptake
Input data	New spatial grids
Structure	Baseflow
Calibration	Calibration weight
Calibration	Streamflow update

AWRA-L v7 Validation performance summary

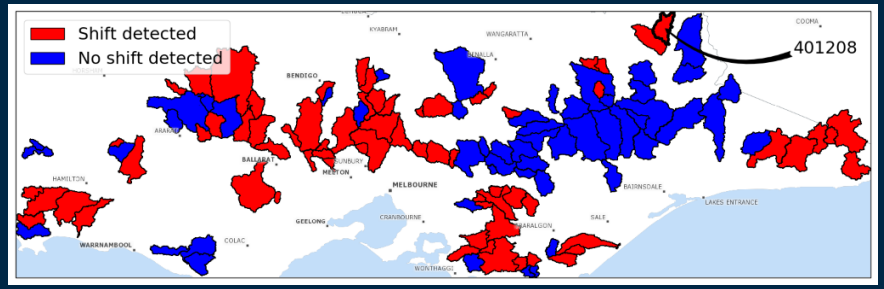


Droughts: Shift in rainfall-runoff response in Victoria

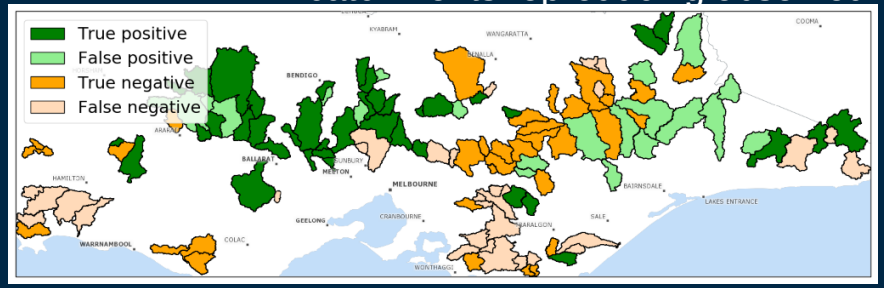
Annual rainfall and streamflow for catchment 401208



Observed catchments showing shift in red



AWRA-Lv7 catchments reproducing observed



Water Resources Research

Research Article | Open Access

Many Commonly Used Rainfall-Runoff Models Lack Long, Slow Dynamics: Implications for Runoff Projections

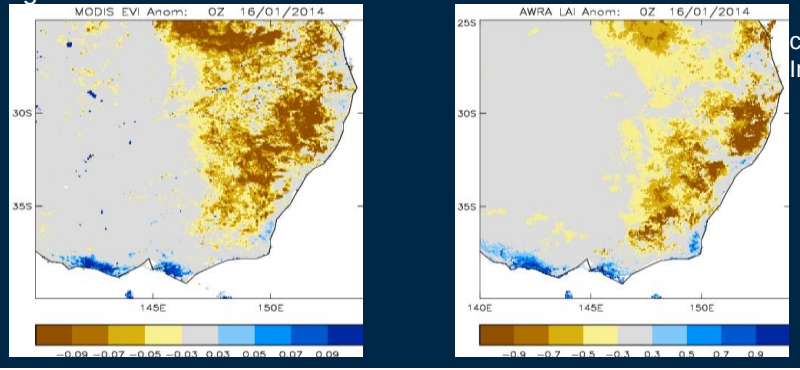
Keirnan Fowler, Wouter Knoben, Murray Peel, Tim Peterson, Dongryeol Ryu, Margarita Saft, Ki-Weon Seo, Andrew Western

First published: 28 January 2020 | https://doi.org/10.1029/2019WR025286

Fire use case: live fuel moisture content (LFMC) prediction

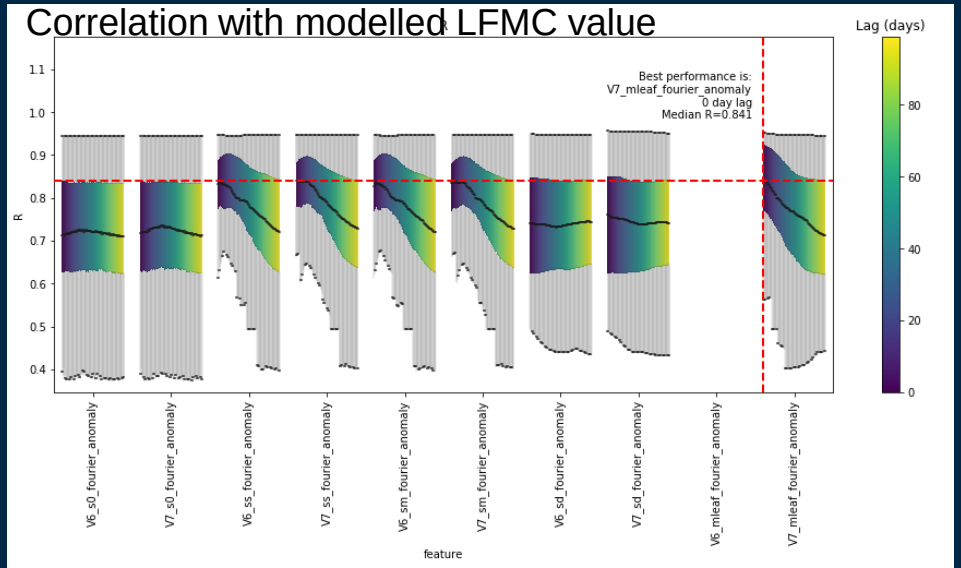
- Trial AWRA-L SM as predictor of LFMC following Vinodkumar et al
  - Tested at ~80 OzNet, COSMOZ, Ozflux monitoring sites
- Trials:
  - all AWRA-L soil layers
  - **leaf mass (mleaf)**
  - lags from 0-100 days
  - Version 6 and version 7
- Vegetation 0-day lag has highest correlation with LFMC

Vegetation? 2014 MODIS vs AWRA LAI anomalies

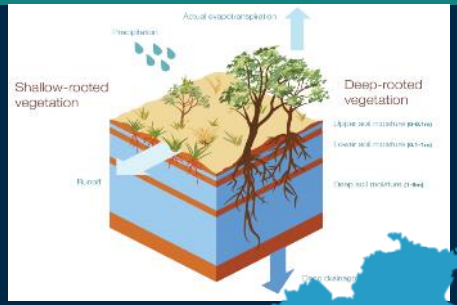


courtesy: Imtiaz Dharssi

Correlation with modelled LFMC value



Enhanced *Australian Water Outlook* service



1-10 day **forecast**

Seasonal **forecast**

Future **projections**

Gridded output for all of Australia
- Uses the existing AWRA-L model
- Daily output at 5x5 km

Included variables:
- Soil moisture
- Evapotranspiration
- Runoff

Information to assist with decision making:
- For gauged and ungauged catchments
- Long term strategic planning
- Assessing climate risk

Forecasting service

1-10 day **forecast**

Seasonal **forecast**

ASCAT/SMAP

Data Assimilation

- State updating
- Triple collocation for model & obs error estimates

S. Tian et al. (in review); Satellite soil moisture data assimilation for improved operational continental water balance prediction

NWP

Climate outlook

AWRA-L

9 days forecasts

6 months outlook

Derived products - User generated

Parameters include:

- Soil moisture (output from AWRA-L)
- Runoff (gridded) (output from AWRA-L)
- PET (output from AWRA-L)

Short-term forecast:

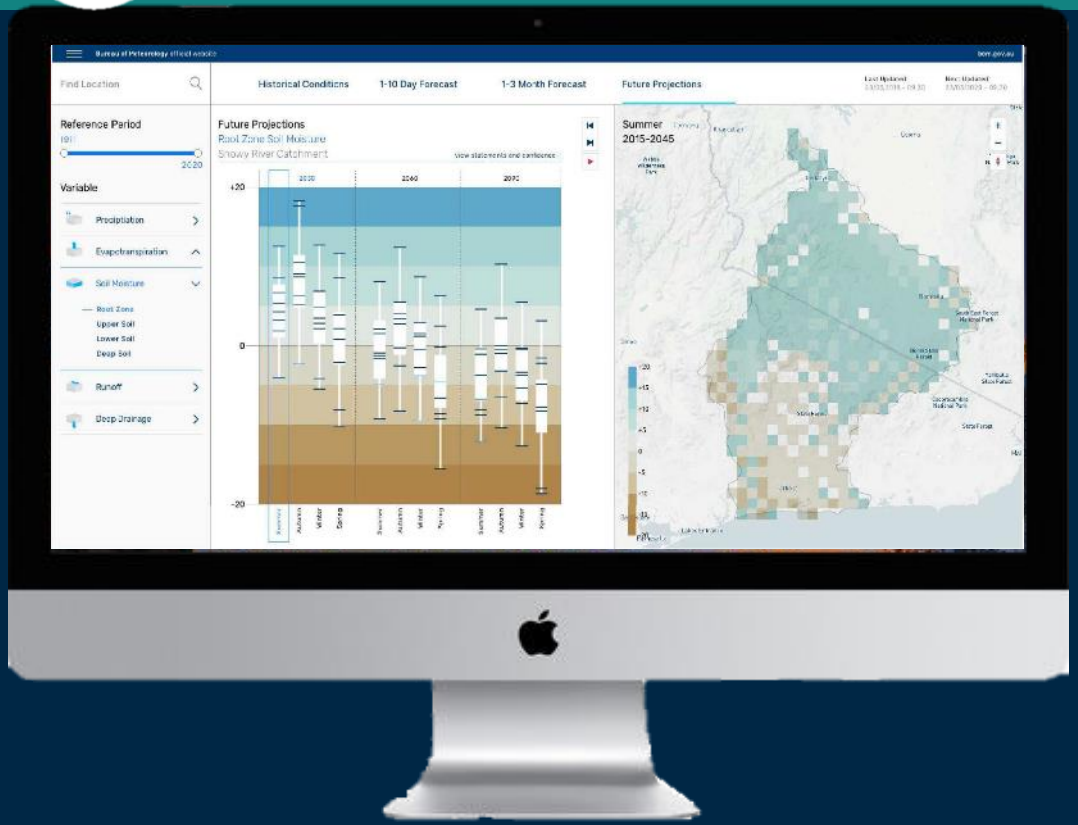
- Daily, 5x5 km for 10 days, released daily
- 99-member ensemble

Seasonal forecast:

- Out to 6 months, released monthly
- 99-member ensemble

Hydrological projections

Future **projections**



Parameters include:

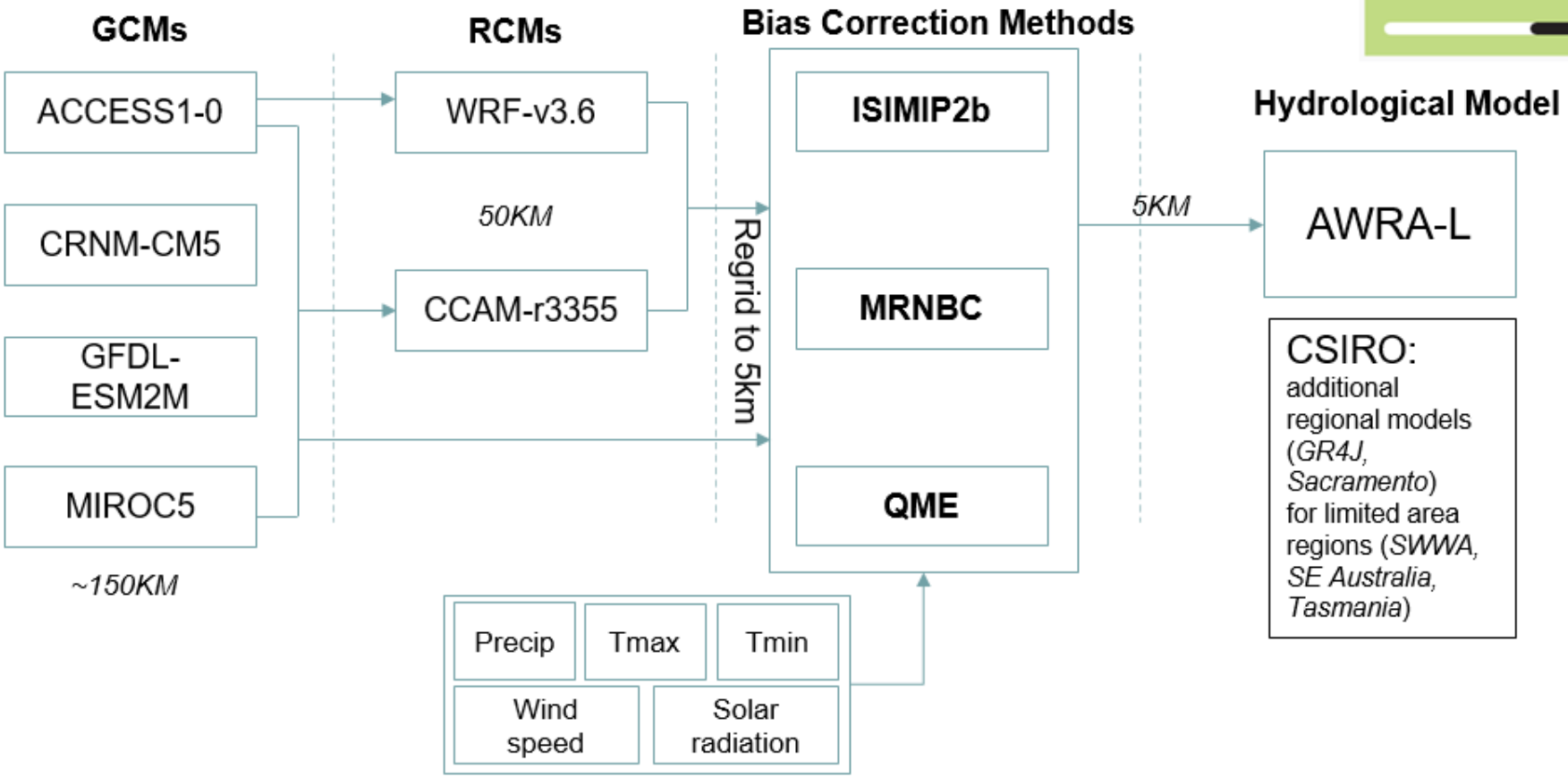
- Rainfall
- Tmax
- Tmin
- Solar Radiation
- Surface wind
- Soil moisture (output from AWRA-L)
- Runoff (gridded) (output from AWRA-L)
- PET (output from AWRA-L)

Ensemble members:

- Daily, 5x5 km for period 1960 – 2100
- Multiple scenarios: RCP45, RCP85
- Multiple BC methods
- Multiple Hydrological Models in some regions

Modelling Framework

Future **projections**

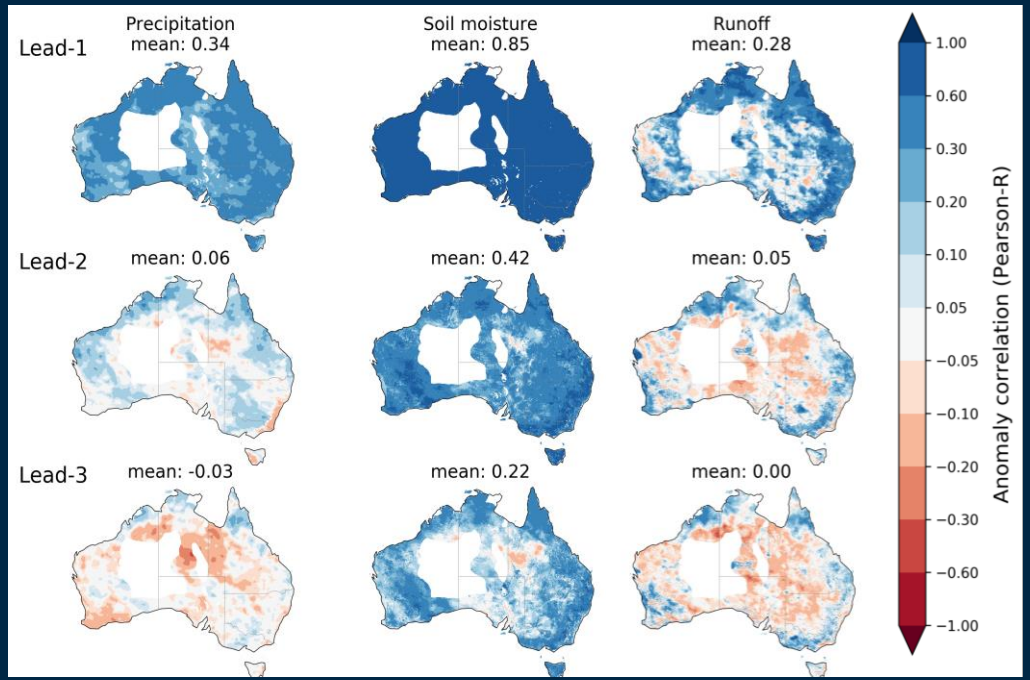


Evaluation

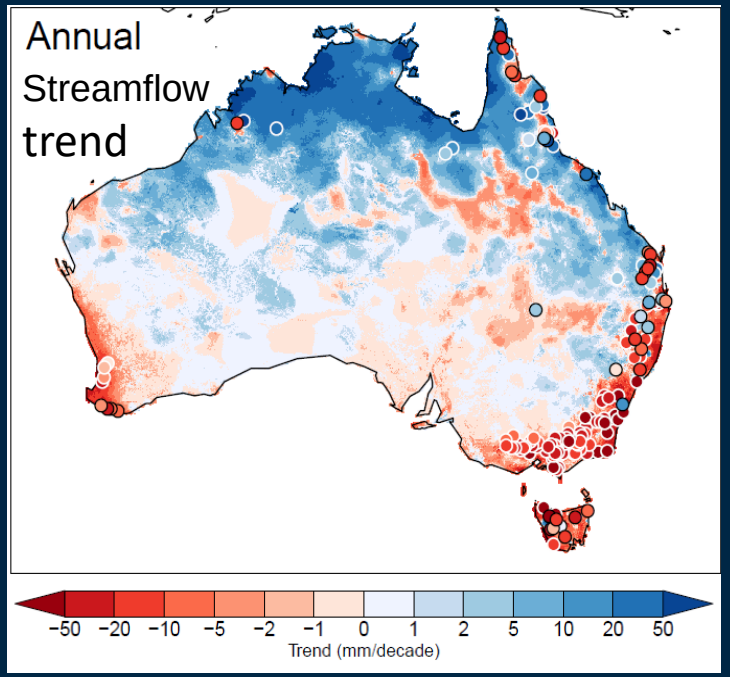
Seasonal **forecast**

Future **projections**

Vogel et al (in prep) Seasonal ensemble forecasts for soil moisture, evapotranspiration and runoff across Australia

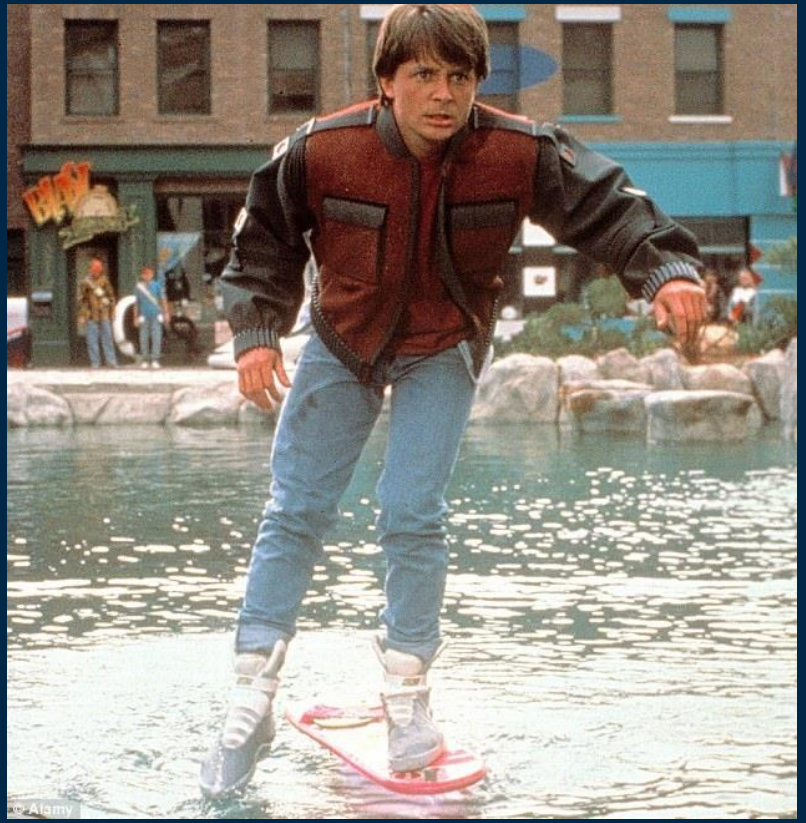


Wasko et al (subm) Understanding trends in hydrologic extremes across Australia



Future

1. Next generation flood systems
2. Integration with weather and climate models
3. More data assimilation, post-processing, machine learning, blending methods
4. Targeted water services for our customers:
   - Seamless water services
   - National Hazard Risk Service
   - Customer projects



Thanks for your interest

Questions?

Thank you to the Water Models Team

andrew.frost@bom.gov.au