bushfire&natural HAZARDSCRC

A high resolution land dryness analysis system for Australia.

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Melbourne, Australia

An Australian Government Initiative

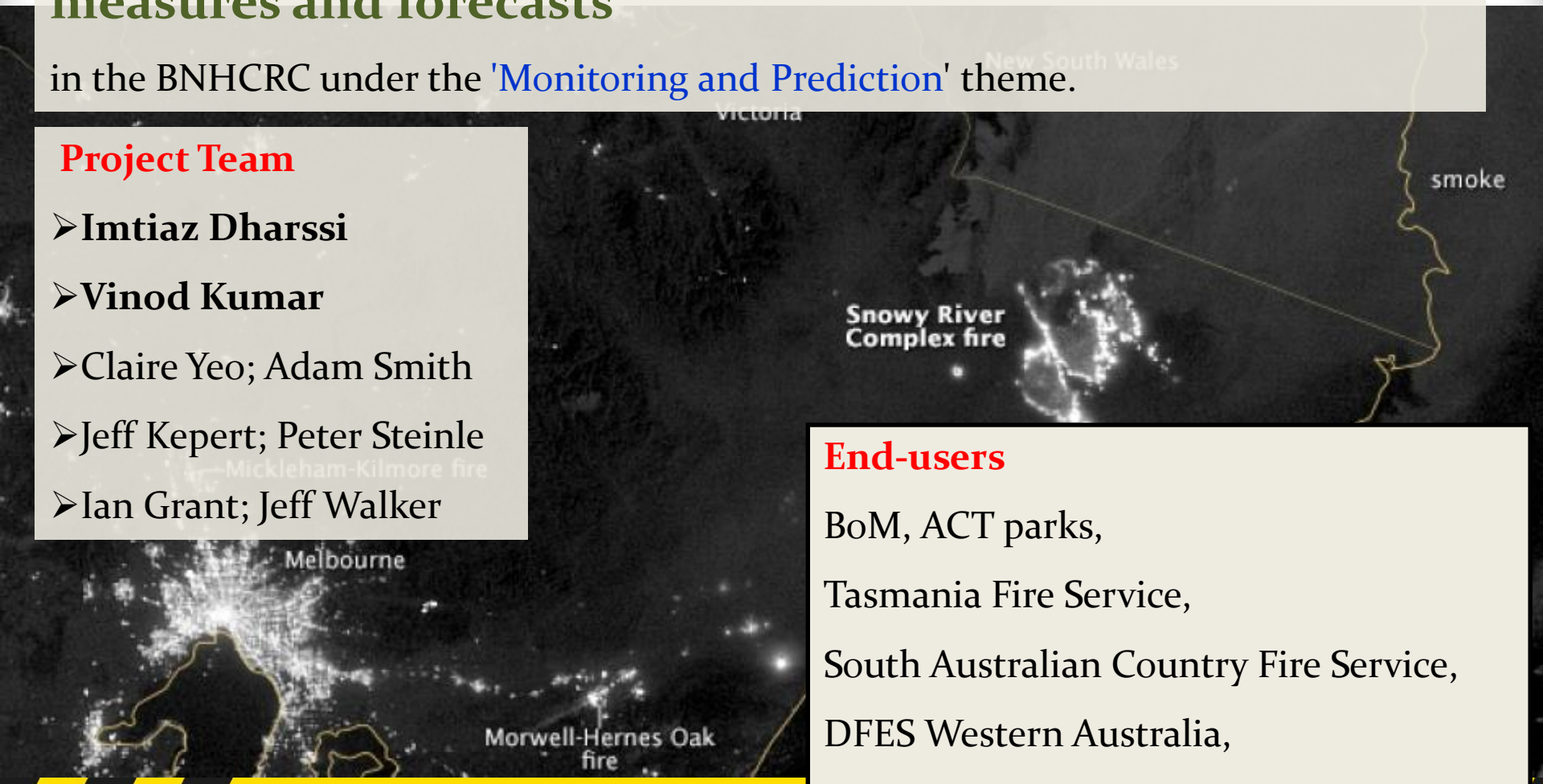
CRC AUSTRALIA

Australian Government
Bureau of Meteorology

Project Background

"Mitigating the effects of severe fires, floods and heatwaves through the improvements of land dryness measures and forecasts"

in the BNHCRC under the 'Monitoring and Prediction' theme.



Project Team

- **Imtiaz Dharssi**
- **Vinod Kumar**
- Claire Yeo; Adam Smith
- Jeff Kepert; Peter Steinle
- Ian Grant; Jeff Walker

End-users

BoM, ACT parks,

Tasmania Fire Service,

South Australian Country Fire Service,

DFES Western Australia,

Queensland Fire Service

Economic Motivation

- The Australian people, environment and businesses are all vulnerable to extreme weather events such as Bushfires, Droughts, Heatwaves, Floods and Storms

- Extreme weather events cost the Australian economy many billions of Dollars every year
  - Deloitte Access Economics estimate the 2015 total economic cost of natural disasters in Australia exceeded $9 billion

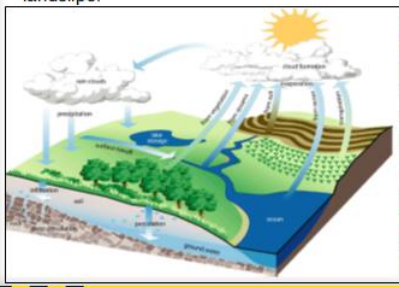
- A recent UK Met Office report concludes that investment in weather services provides an at least ten fold return
  - Gray, M. 2015: Public Weather Service Value for Money Review.

Science Motivation

- Fire ignition, intensity and spread rate are strongly influenced by soil moisture content.
- The occurrence of large destructive fires corresponds to very dry soils.
- Soil moisture strongly influences temperatures and heatwave development.
- Many studies suggest strong feedback between rainfall and soil moisture so that soil moisture can significantly influence rainfall.

Landscape dryness is important

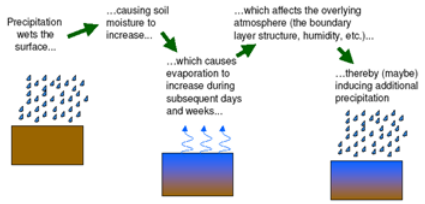
Knowledge of landscape dryness is critical for the management and warning of fires, floods, heatwaves and landslips.



Strong positive feedbacks between soil moisture and rainfall give the Earth system a long memory allowing extreme conditions to persist for long periods.

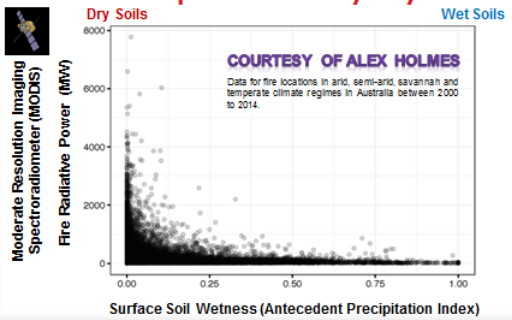
Land-atmosphere feedback

A simple view of land-atmosphere feedback

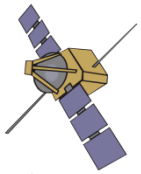


From Reichle and Koster:
Land data assimilation and sub-seasonal climate prediction

The occurrence of large destructive fires corresponds to very dry soils



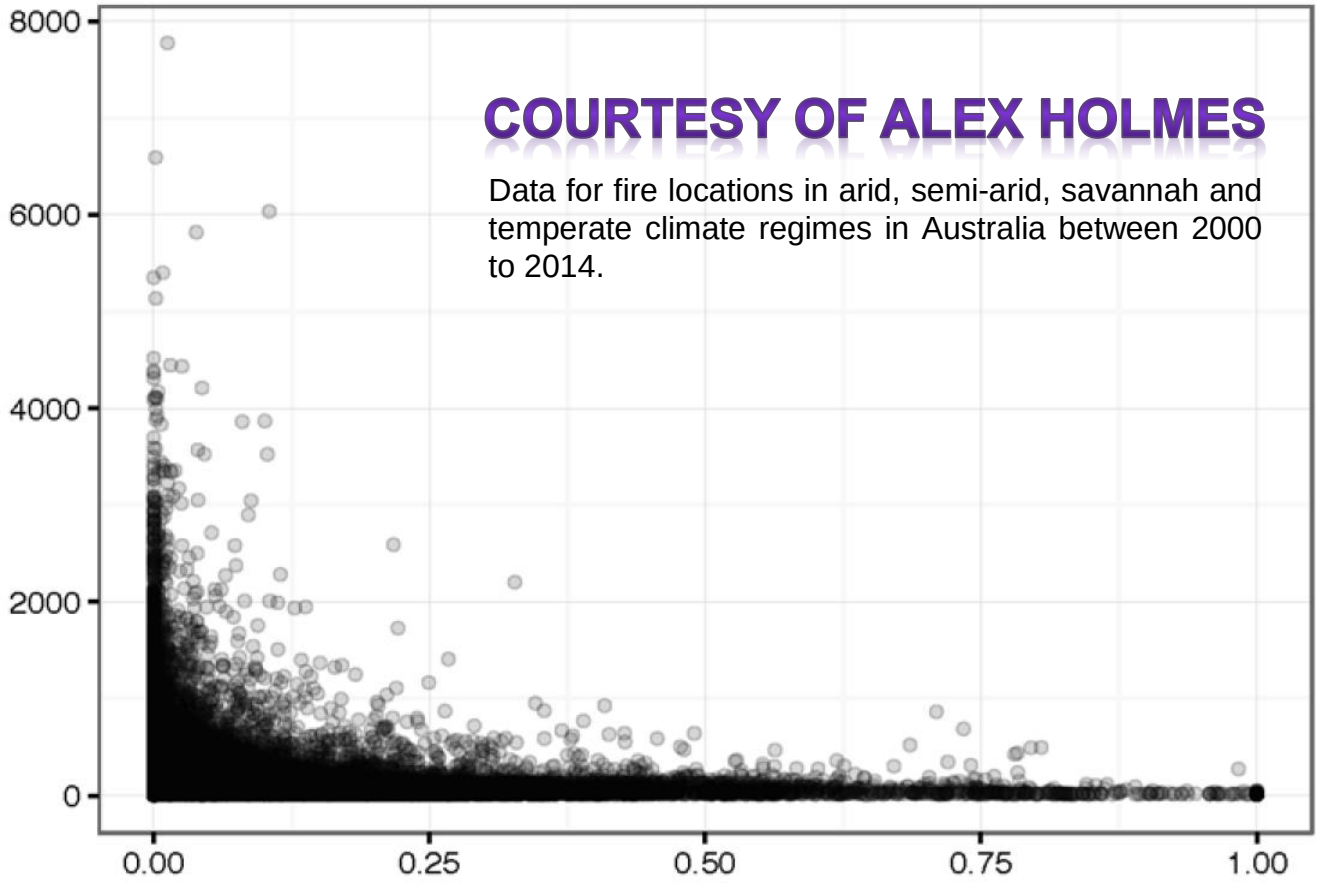
The occurrence of large destructive fires corresponds to very dry soils



Moderate Resolution Imaging Spectroradiometer (MODIS)

Dry Soils

Wet Soils



Fire Radiative Power (MW)

Surface Soil Wetness (Antecedent Precipitation Index)

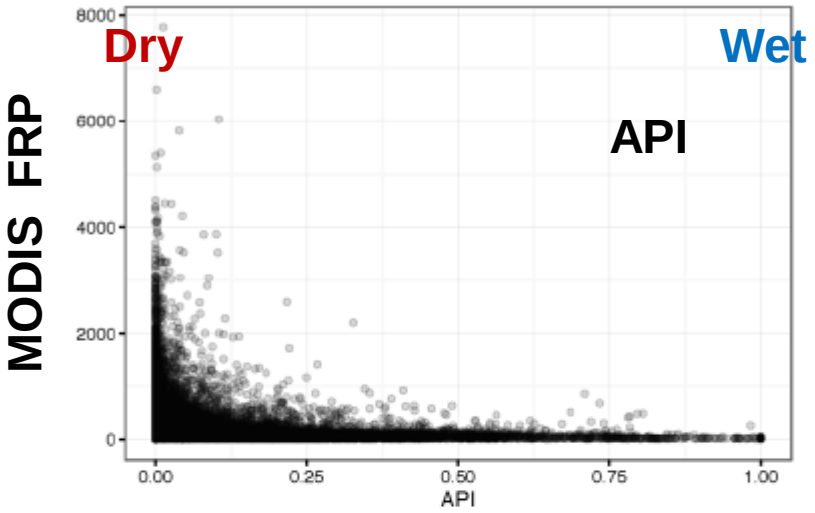
Landscape Dryness is Currently Calculated Using Simple Methods Developed in the 1960s

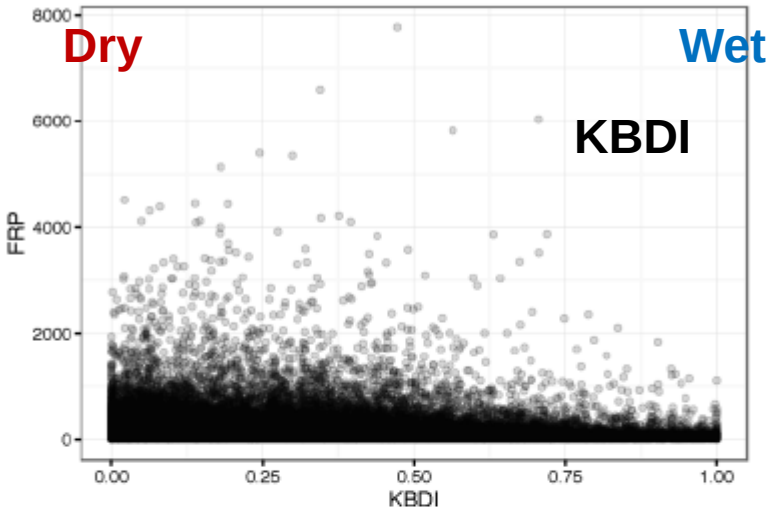
- In Australia the operational McArthur Forest Fire Danger Index uses as landscape dryness input either:
  - The Mount Soil Dryness Index (Mount 1972)
  - The Keetch-Byram Drought Index (Keetch & Byram 1968)

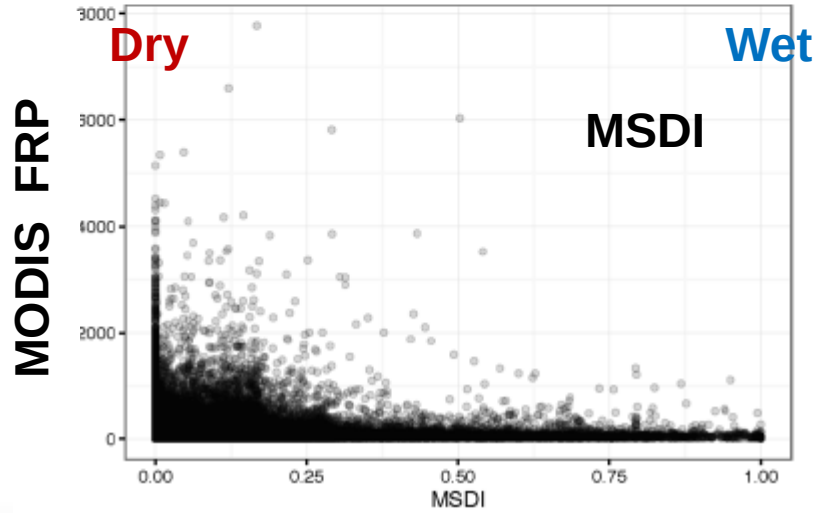
- Current simple landscape dryness methods make simplistic assumptions about
  - Canopy Interception
  - Evaporation and Transpiration
  - Rainfall Runoff

- Current simple landscape dryness methods ignore factors such as
  - Soil Texture
  - Vegetation type and Root depth
  - Solar Insolation
  - Topography and Aspect

Comparison of Soil Wetness Indices





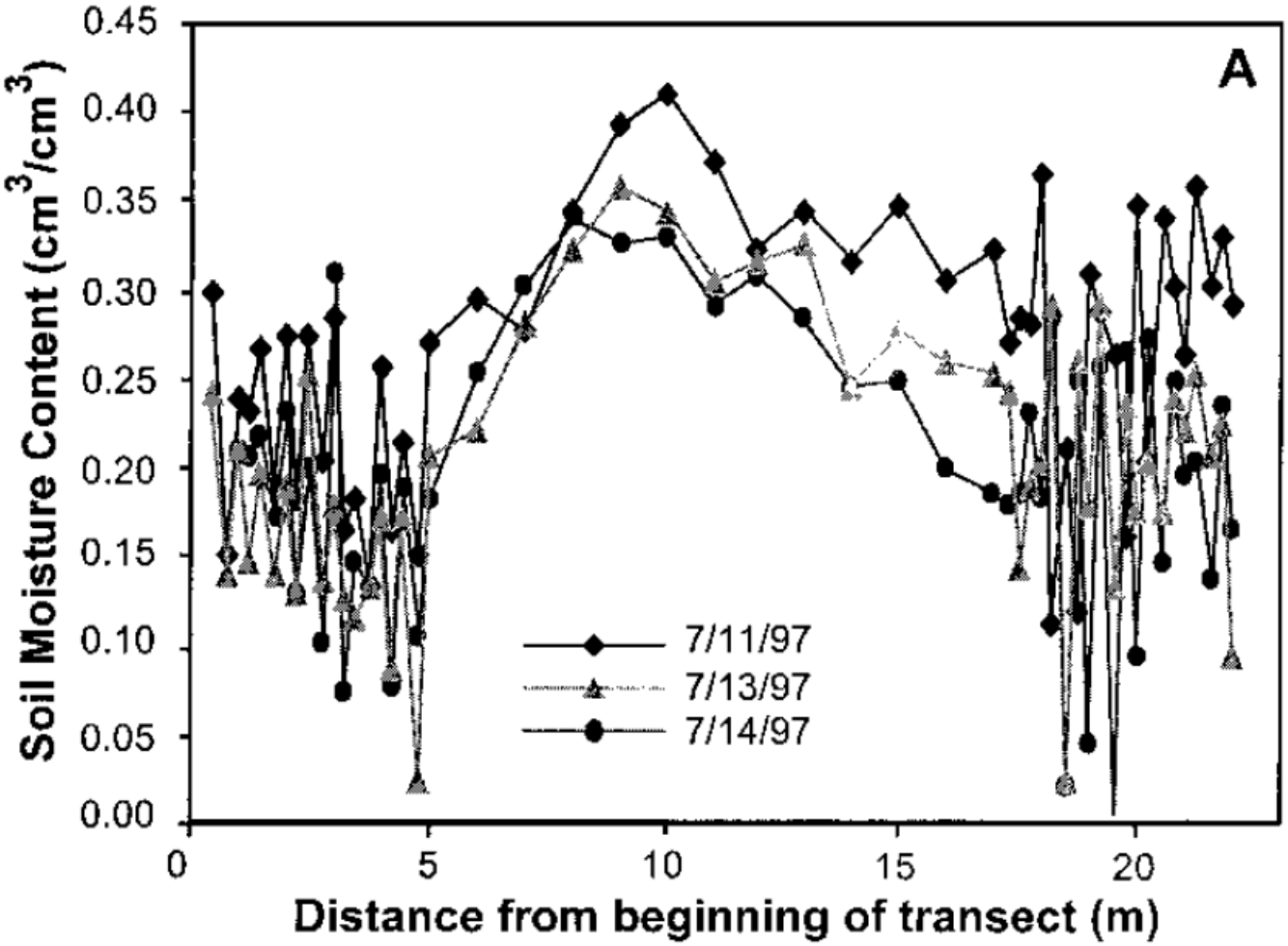


COURTESY OF ALEX HOLMES

Data for fire locations in arid, semi-arid, savannah and temperate climate regimes in Australia between 2000 to 2014.

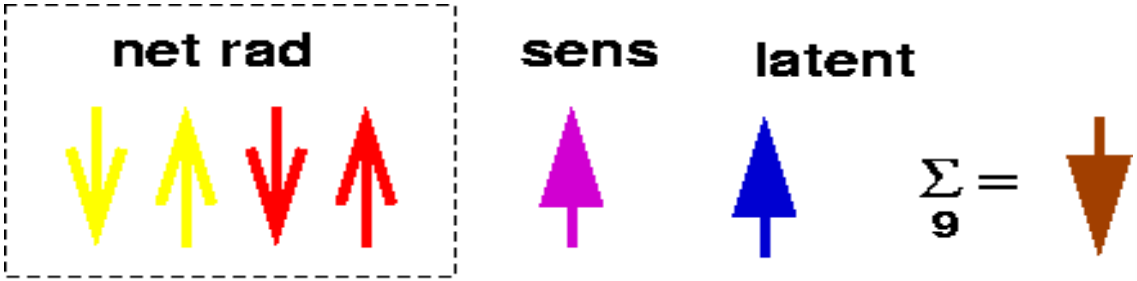
SOIL MOISTURE HAS A VERY HIGH SPATIAL VARIABILITY

Famiglietti, J. S., et al. "Ground-based investigation of soil moisture variability within remote sensing footprints during the Southern Great Plains 1997 (SGP97) Hydrology Experiment." *Water Resources Research* 35.6 (1999): 1839-1851.

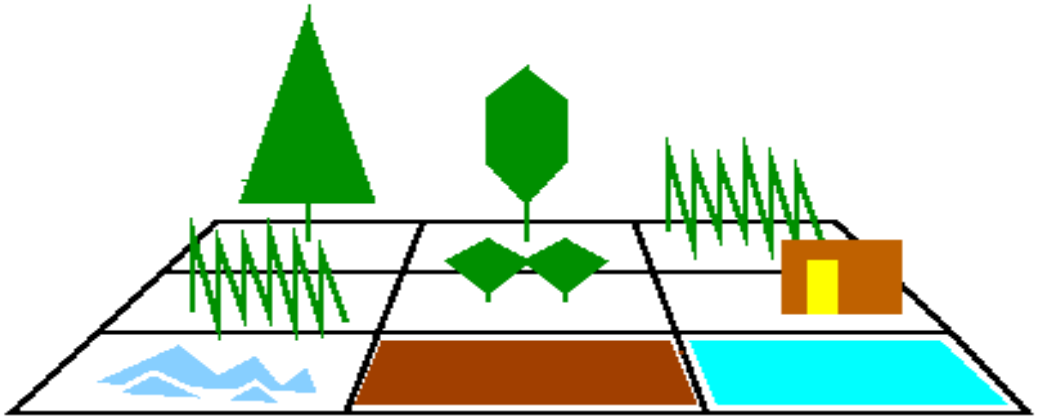


A PHYSICALLY BASED LAND SURFACE MODEL

JULES

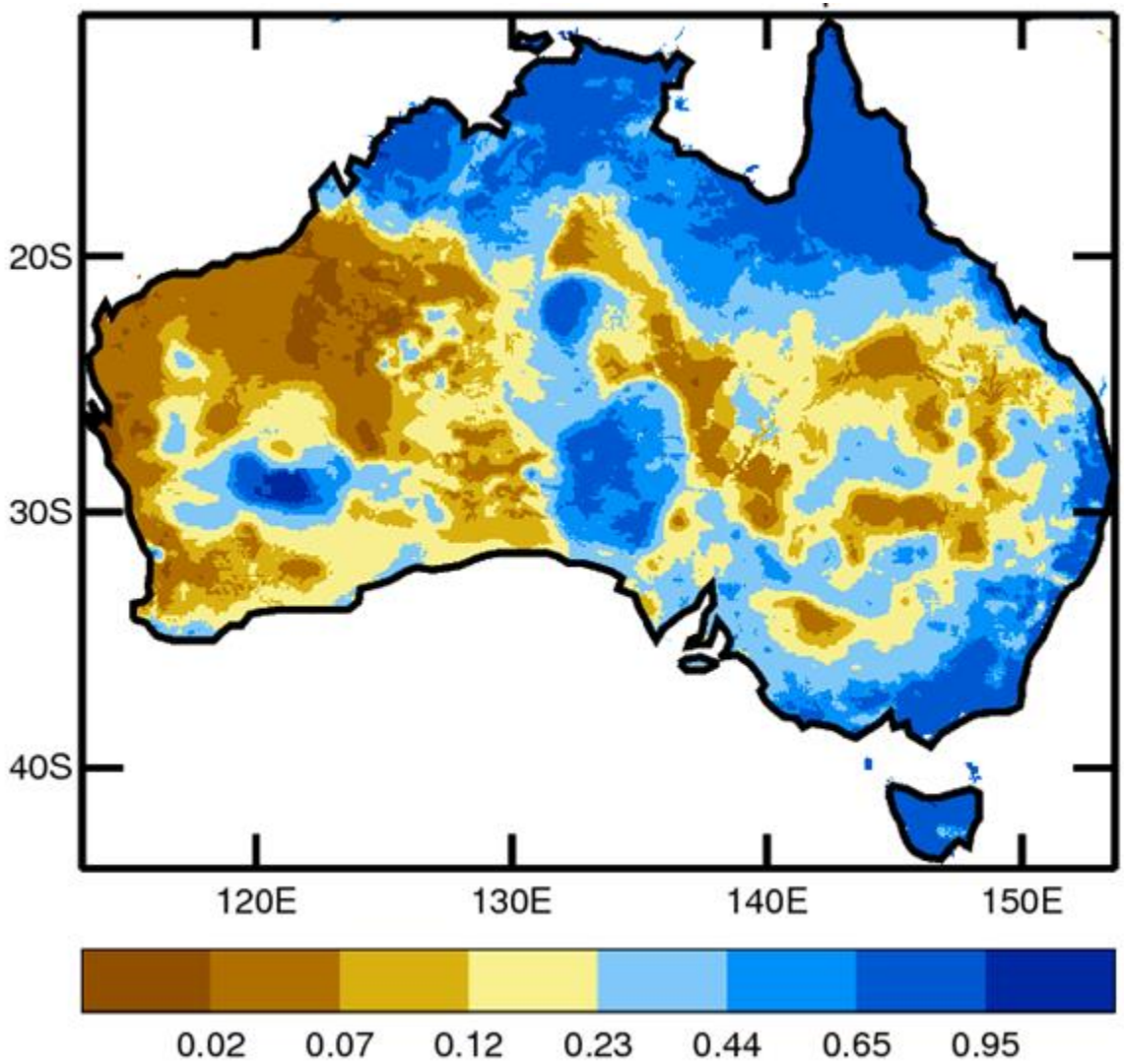


1. **Used by the Bureau of Meteorology** in our Numerical Weather Prediction models.
2. **Four soil layers**, top layer is 10cm thick and total soil column is 3m thick.
3. Five Plant Functional types and 4 non vegetation types.



4. A photosynthesis model that includes the effects of incident solar radiation, vegetation type, leaf area index, surface air temperature and humidity deficit.

EXAMPLE SOIL WETNESS ANALYSIS



Example analysis, at a spatial resolution of 5 km, from the JULES system of the top 10 cm soil wetness for 19th March 2016 .

COSMOZ

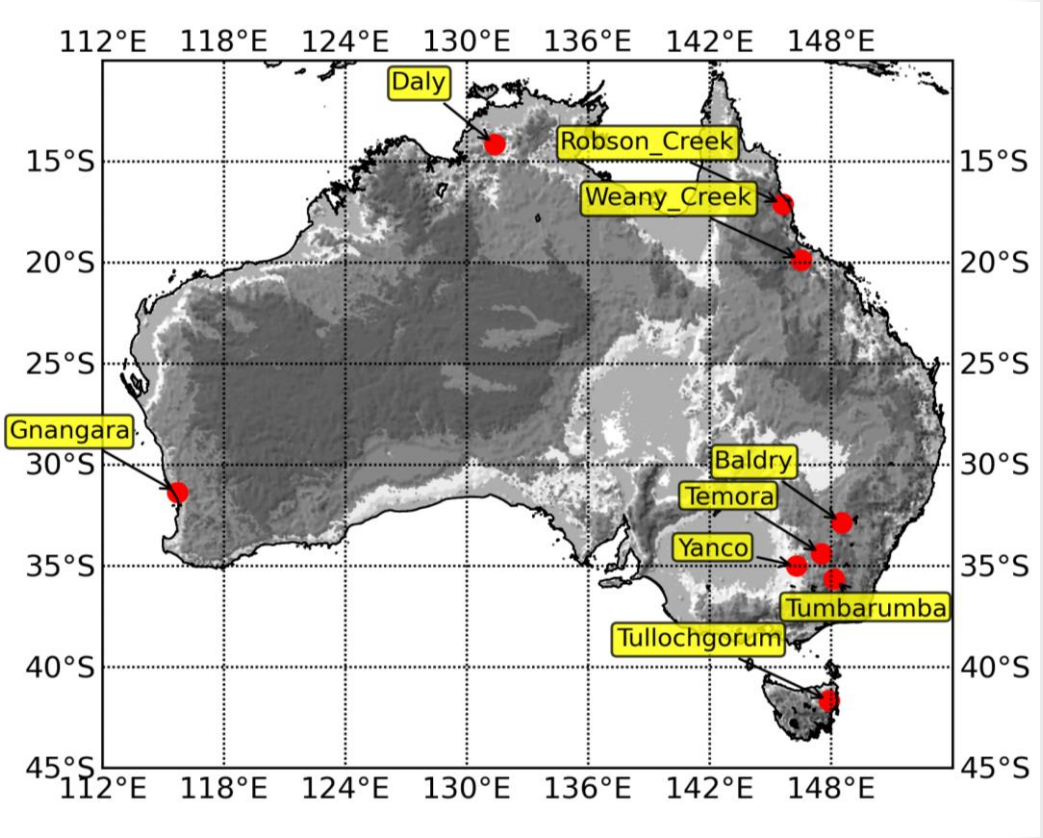
1. Network of cosmic ray soil moisture probes installed at about 13 locations around Australia (Hawdon et al. 2014).

2. The effective sensing depth depends strongly on soil moisture itself, decreasing from about 70 cm (dry soils) to 10 cm (wet soils).

3. We only use the 9 calibrated and quality controlled CosmOz sites.

4. Range of land-cover types.

5. CosmOz is managed by CSIRO.

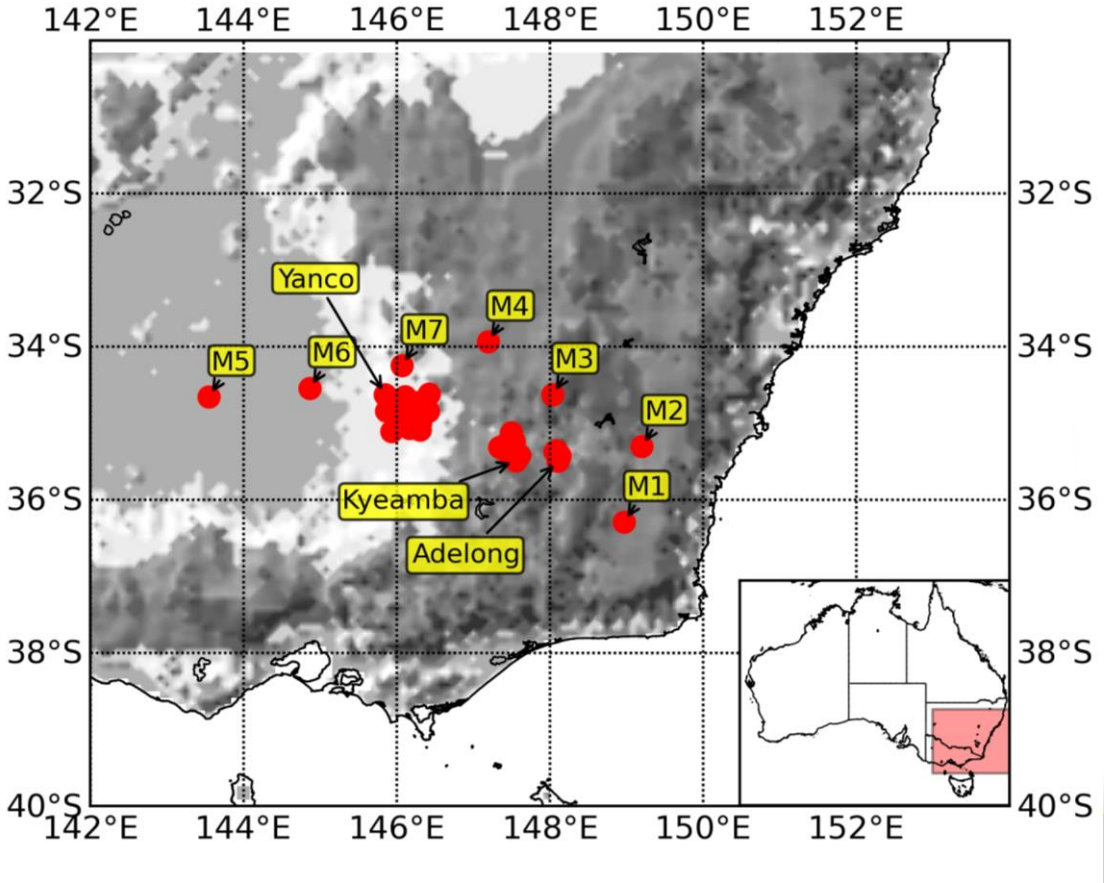


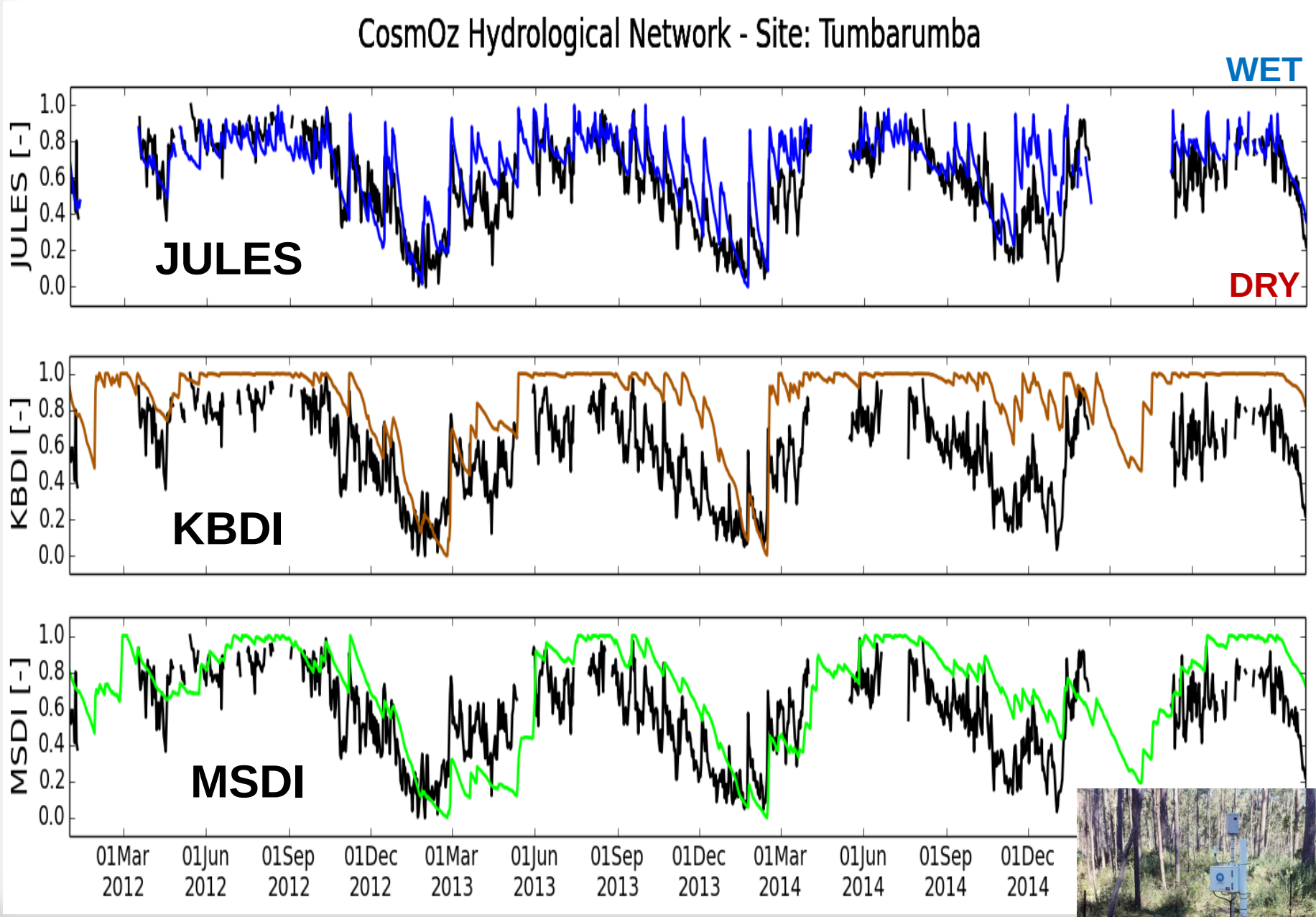




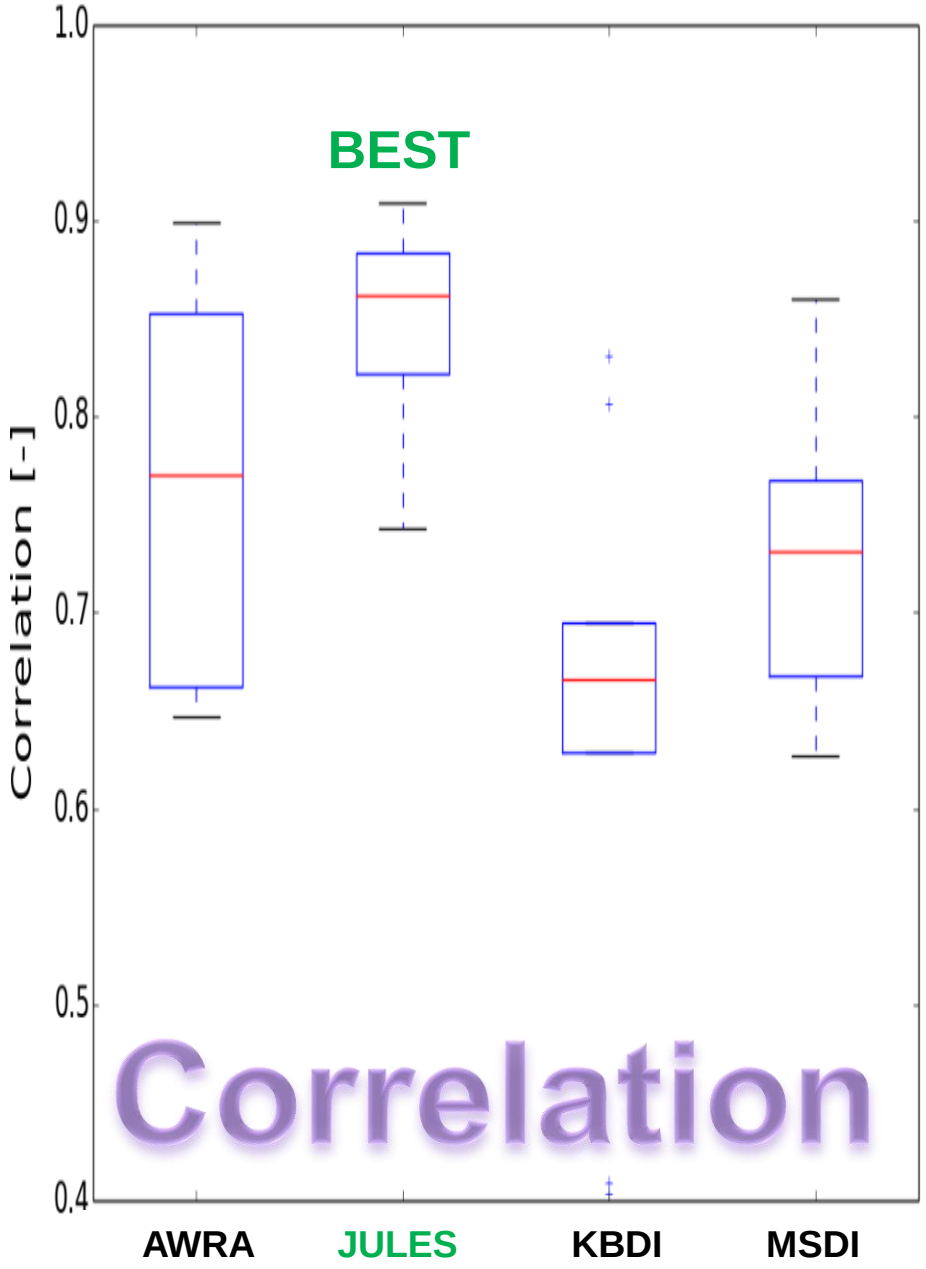
OZNET

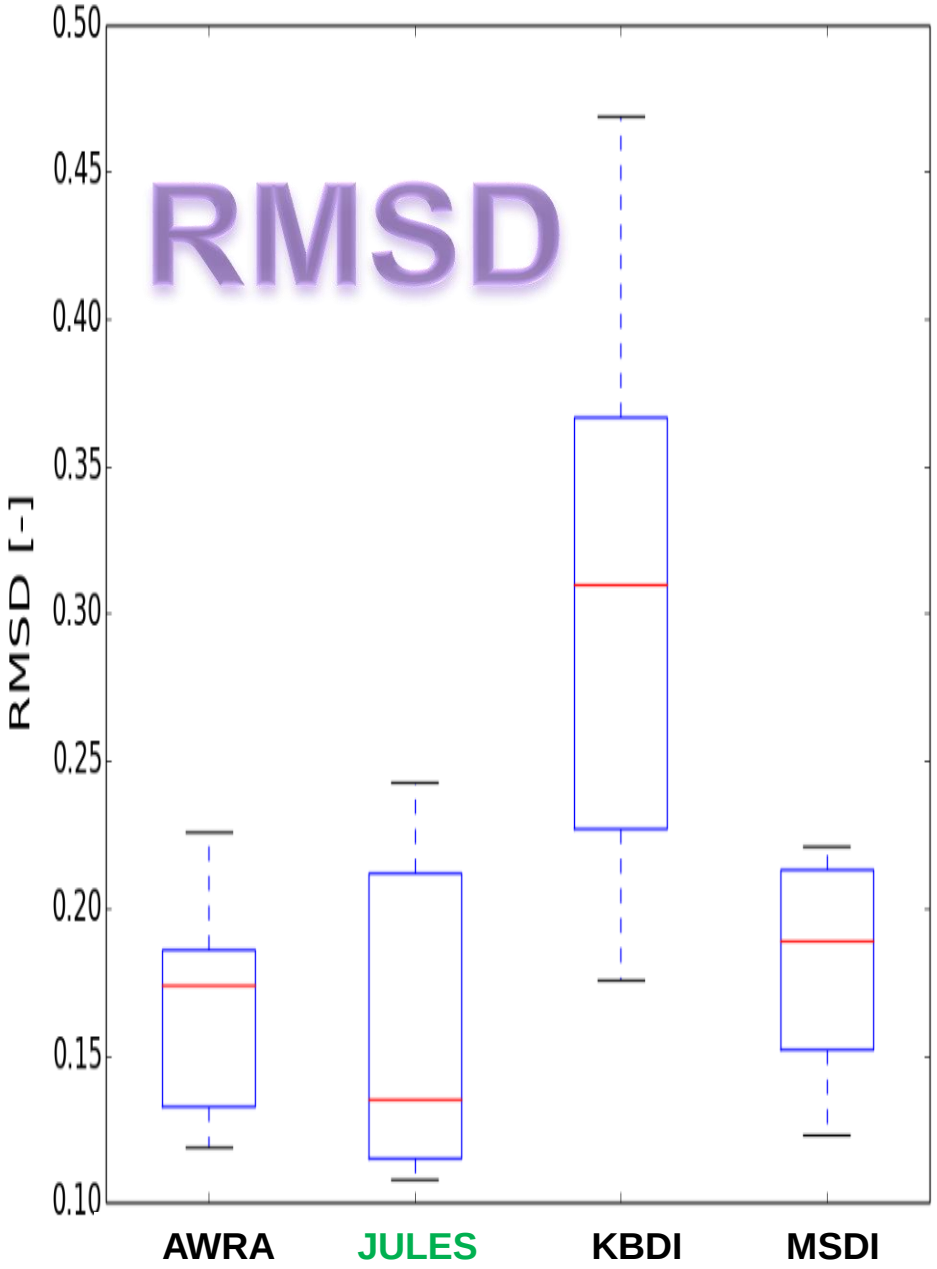
1. 38 observing stations situated in the Murrumbidgee river catchment.
2. Most stations are located in croplands or grasslands.
3. Observations are visually inspected to identify quality issues, the quality control includes comparisons with rainfall observations.
4. Managed together by Monash University and University of Melbourne

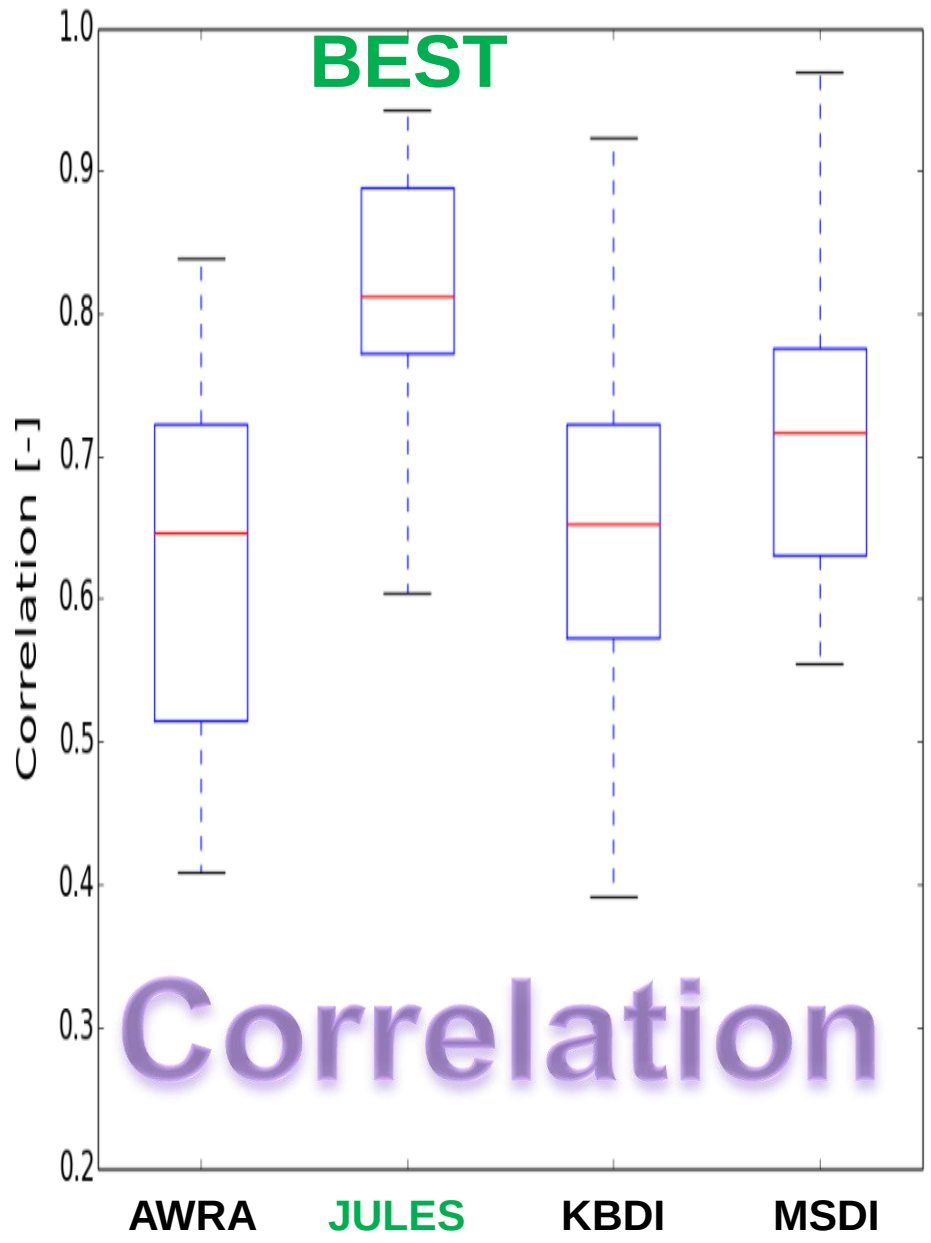




COSMOZ TUMBARUMBA (NSW)


BEST
Correlation [-]
1.0
0.9
0.8
0.7
0.6
0.5
0.4
Correlation
AWRA
JULES
KBDI
MSDI


RMSD
RMSD [-]
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
AWRA
JULES
KBDI
MSDI
BEST


BEST
Correlation [-]
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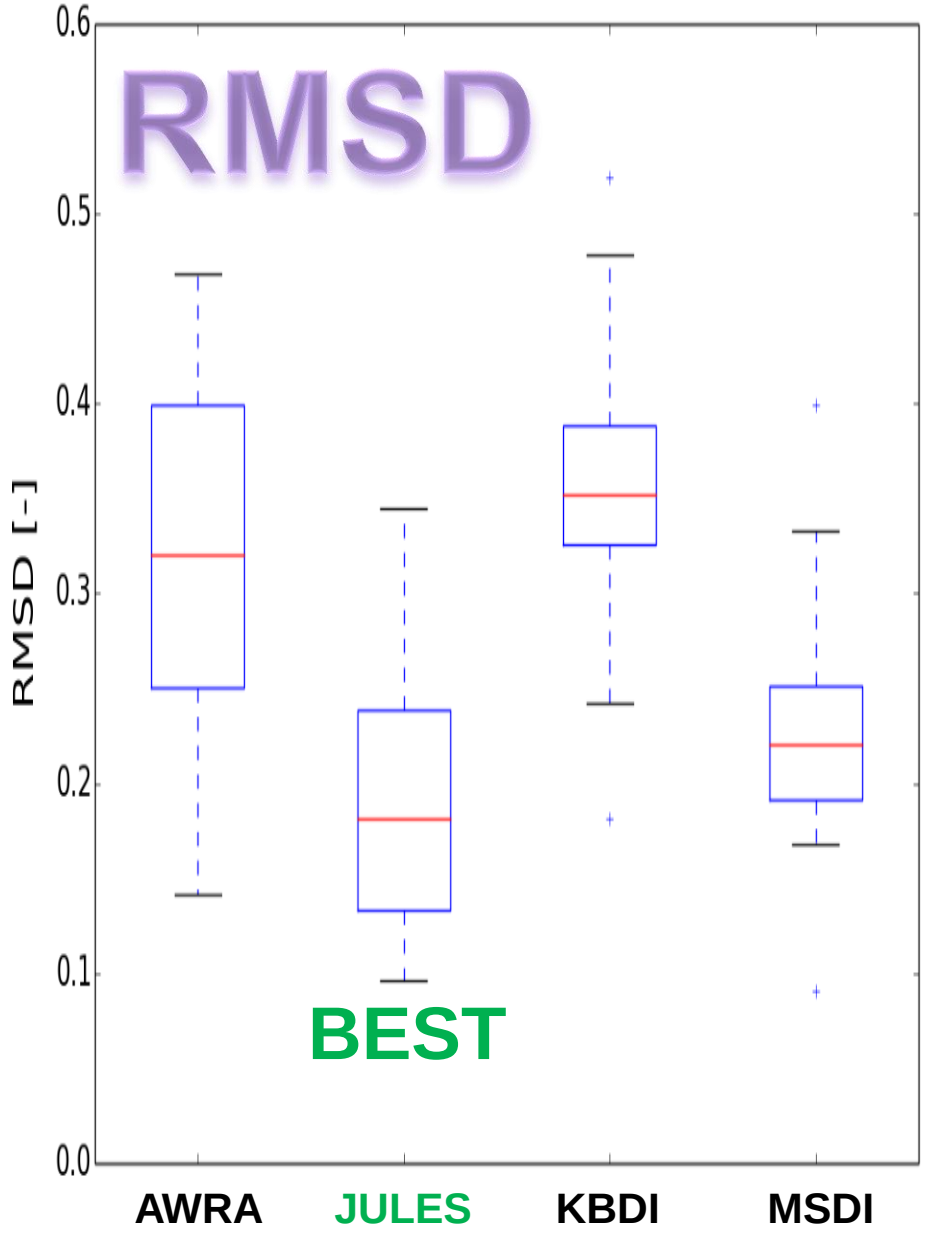
Correlation
AWRA
JULES
KBDI
MSDI


RMSD
RMSD [-]
0.6
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0.3
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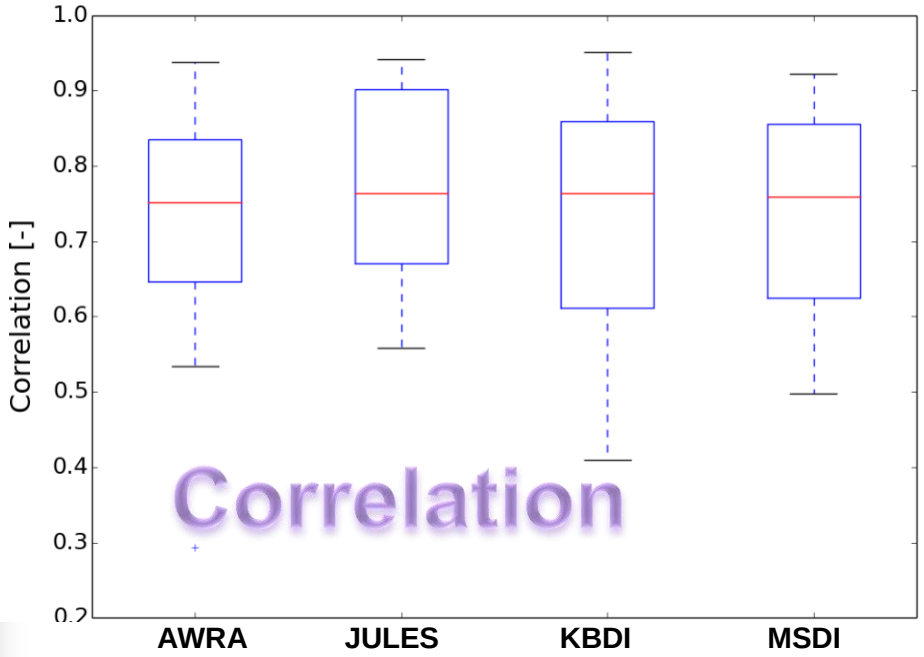
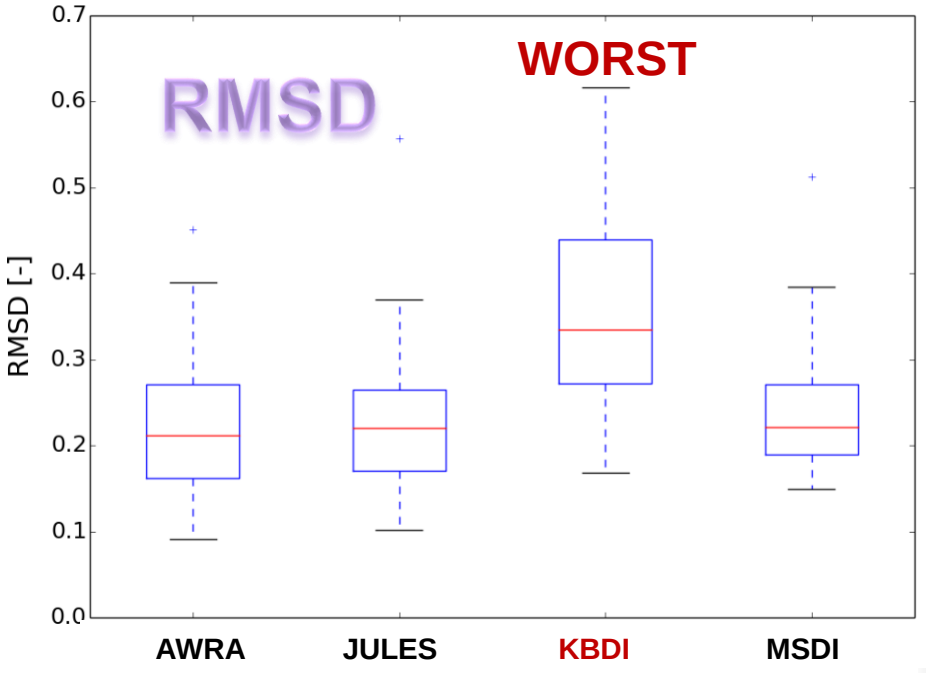
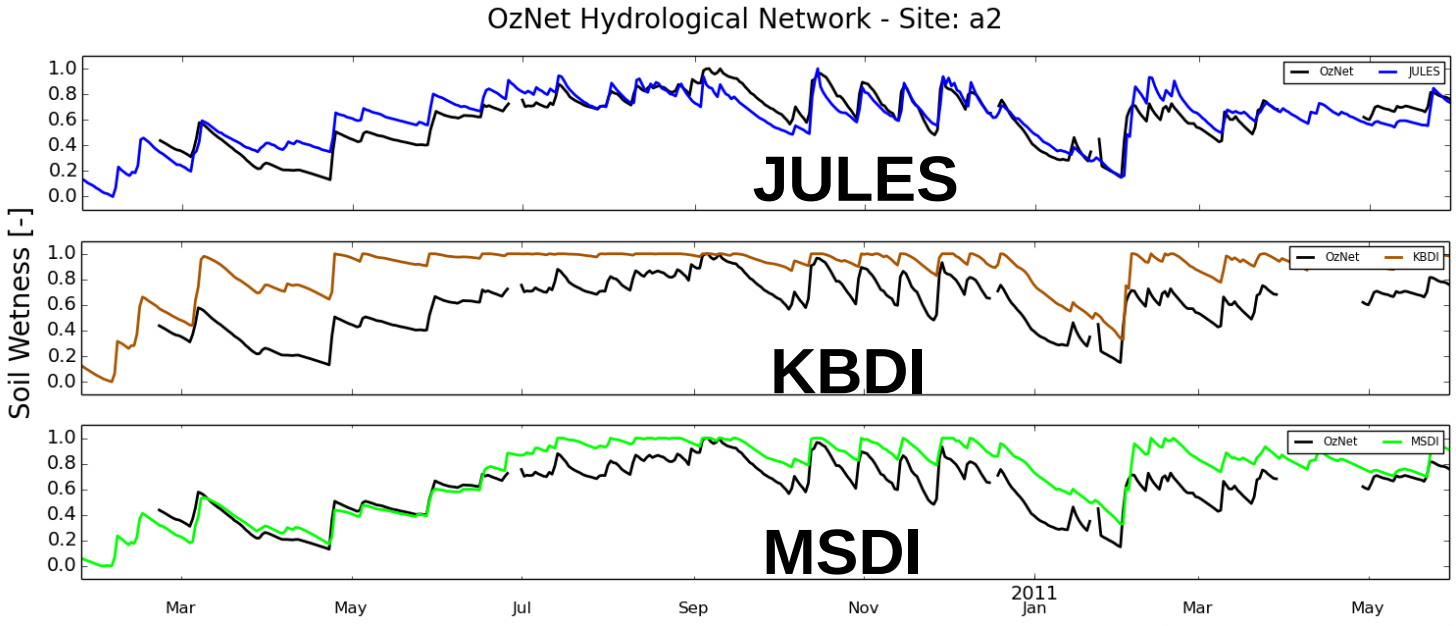
0.1
0.0
BEST
AWRA
JULES
KBDI
MSDI

OZNET: 10 CM



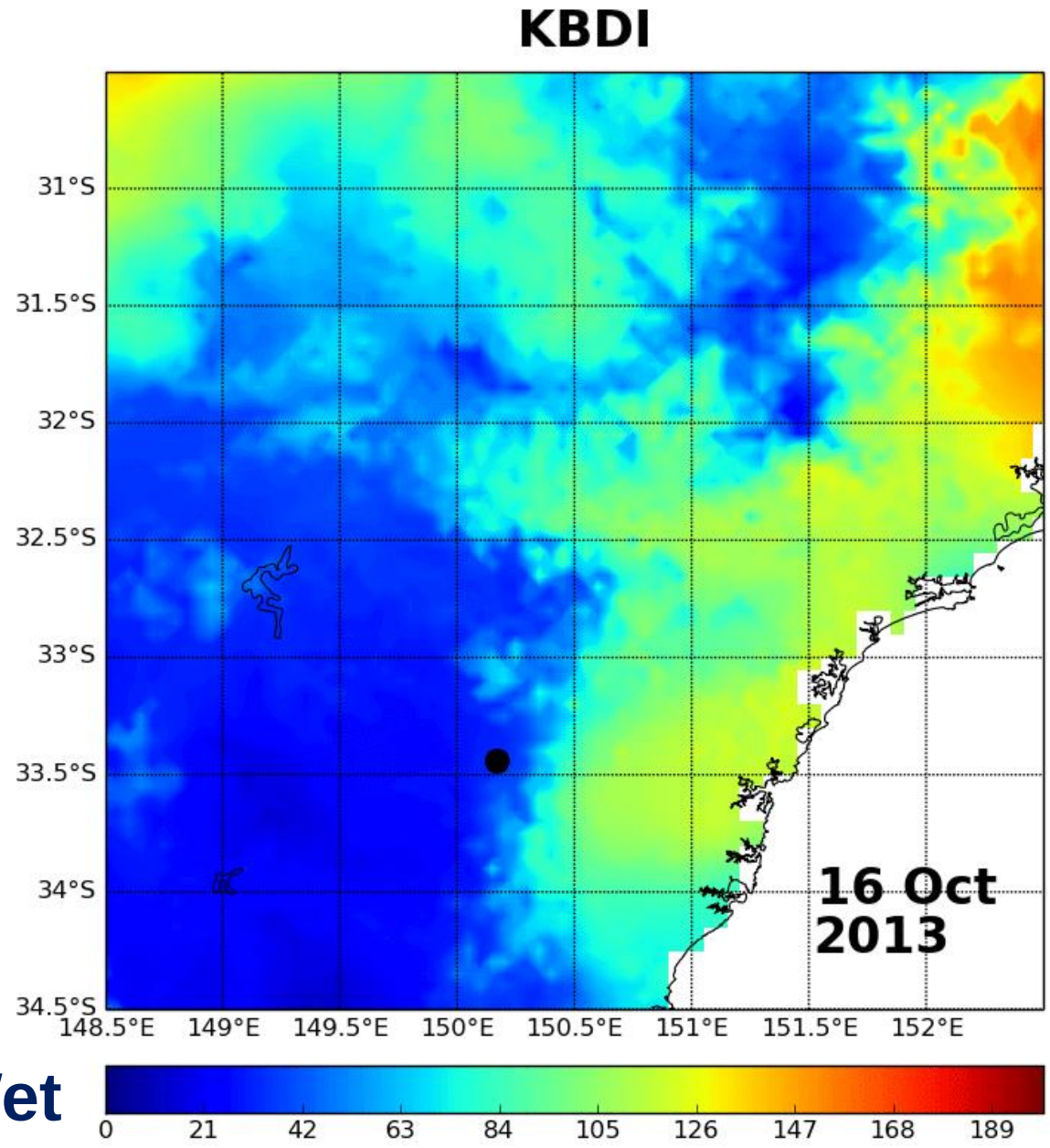




OZNET: 90 CM (NSW)

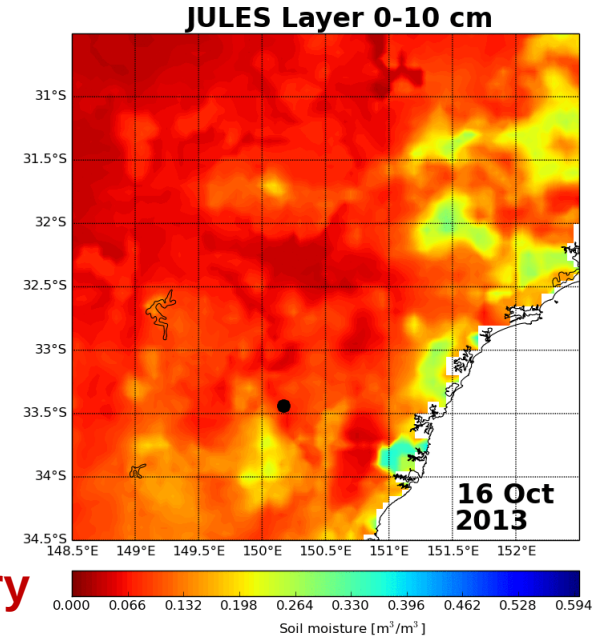
bnhcrc.com.au

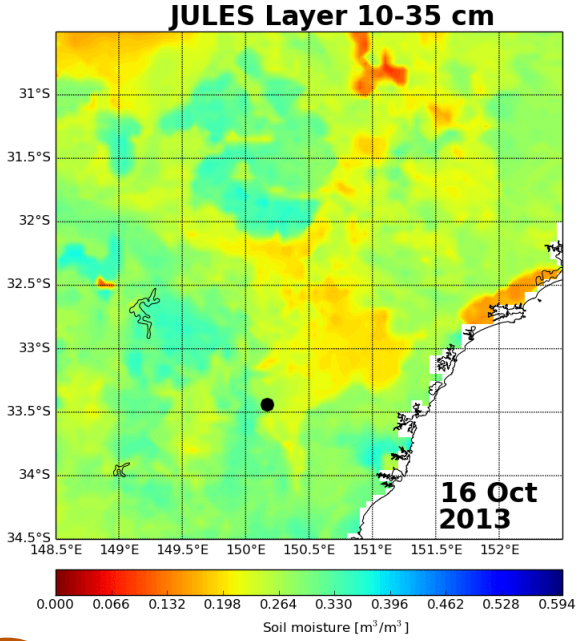
State Mine fire – in the Blue Mountains



KBDI

State Mine fire – in the Blue Mountains

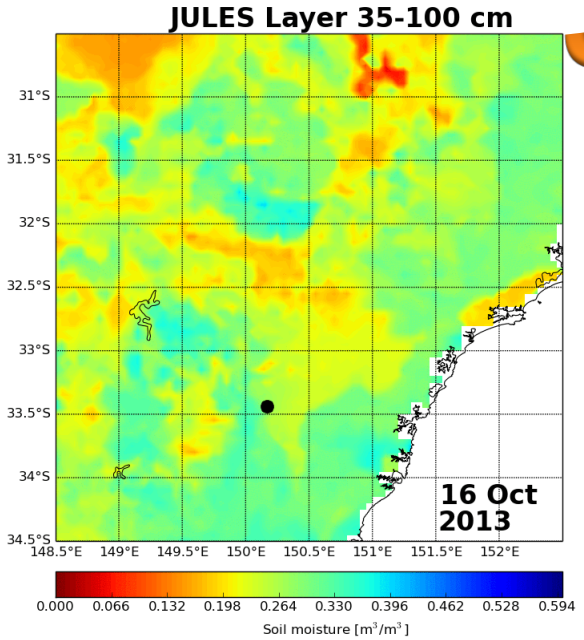


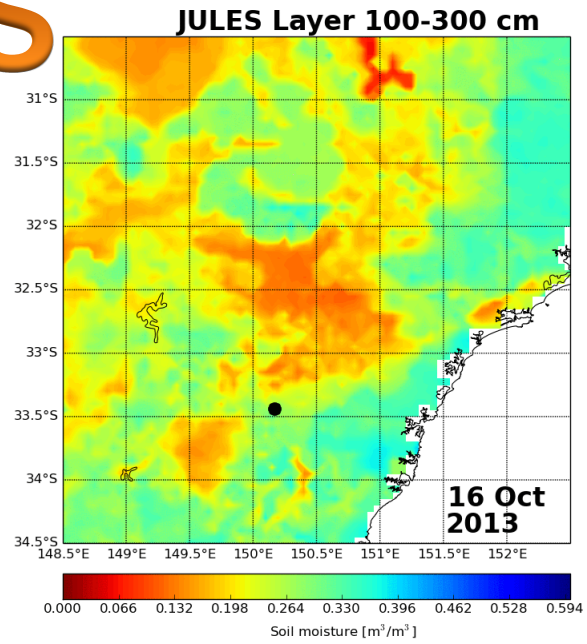


Dry

Wet

JULES





CONCLUSIONS & FUTURE WORK

- High res JULES soil moisture analysis being developed
  - Jules based Australian Soil Moisture InformatioN system

JASMIN

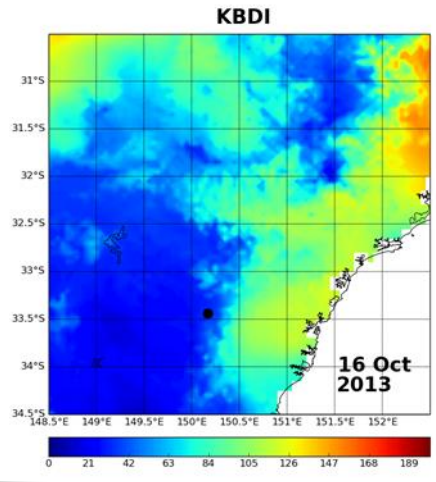
- Verification shows that the JASMIN has greater skill
- Will assimilate satellite surface soil wetness and land temp.
- Can downscale soil moisture to higher resolution (~ 1km).

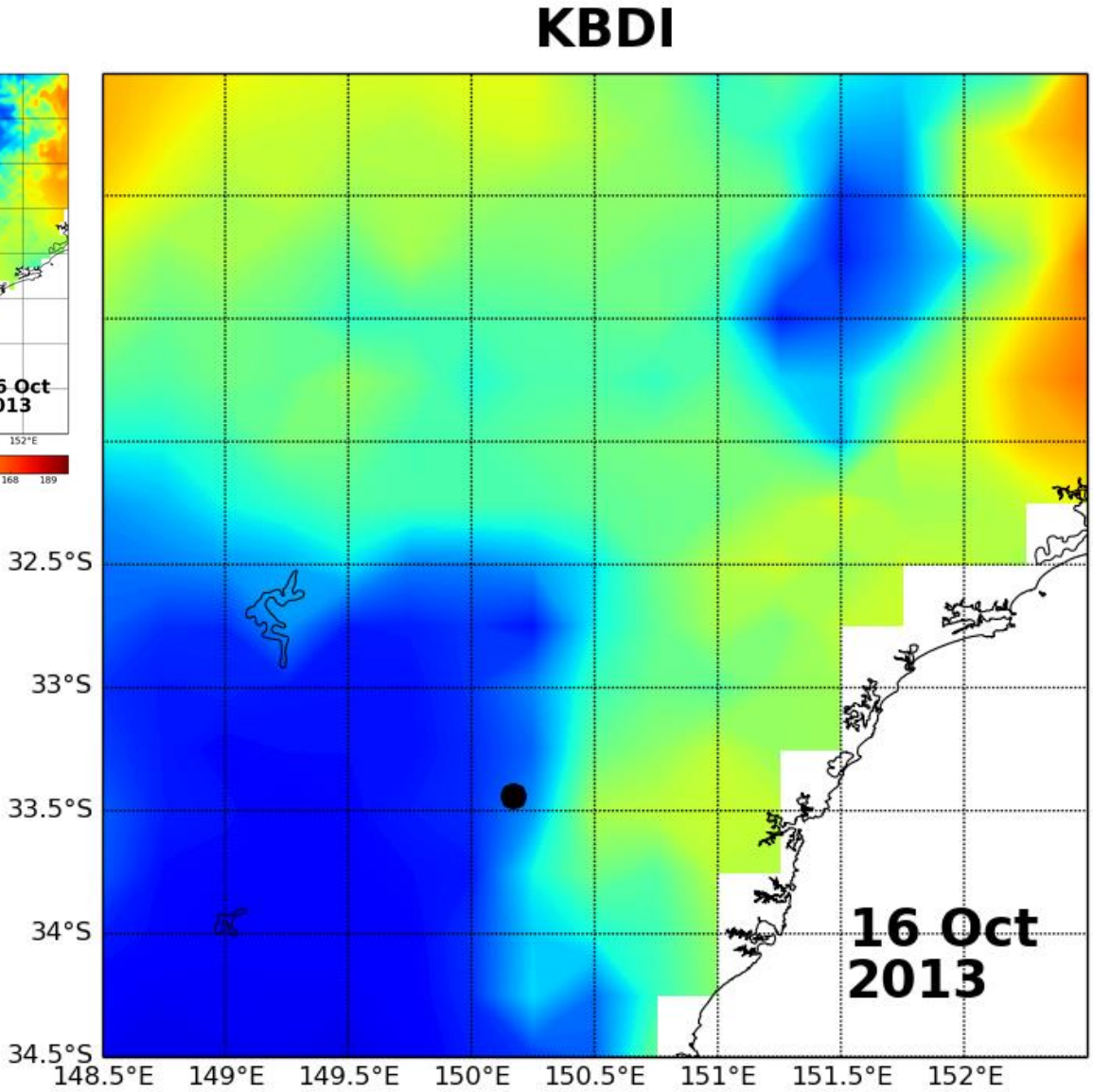
IMMEDIATE PLANS & TRIALS

- Probability match JASMIN to KBDI / MSDI.
- Comparison & evaluation period against the current operational system this summer.
- Evaluation based on case studies of past fire occurrence.
- The evaluations also include Drought Factor (DF) calculation.
- Raw soil moisture layers (4) will also be available to potential pilot of NFDRS.

Thank You

State Mine fire – in the Blue Mountains



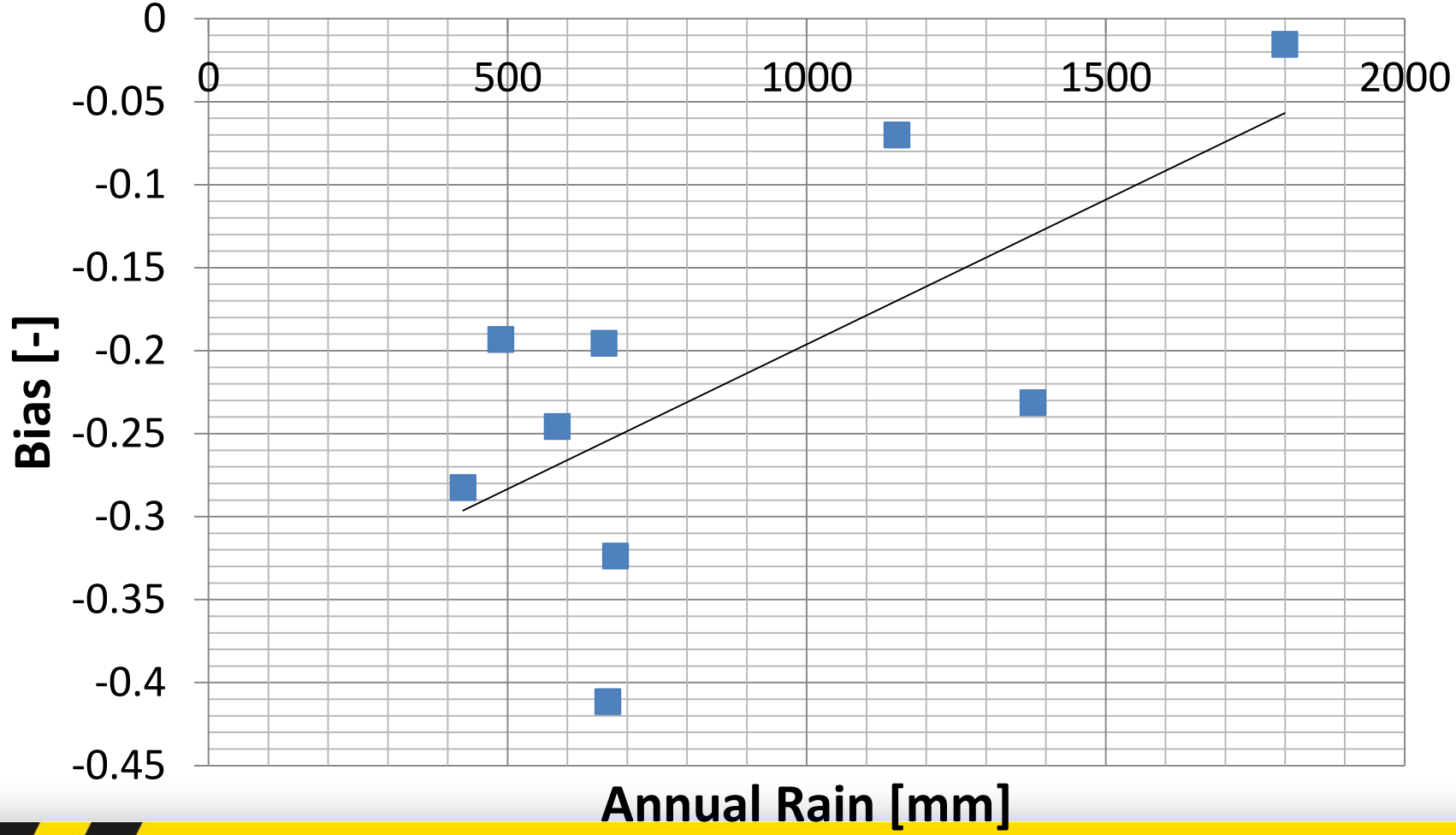


KBDI

Wet

Dry

KBDI BIAS VS ANNUAL RAIN



KBDI BIAS VS LAND COVER

	CosmOz	OzNet Sfc	OzFlux Sfc	OzNet RZ	OzFlux RZ
Forest or Savanna	-0.18 (5)	-	-0.24 (15)	-	-0.19 (10)
Other	-0.27 (4)	-0.27 (30)	-0.17 (6)	-0.25 (28)	0.0 (2)

AUSTRALIAN WATER RESOURCE ASSESSMENT LANDSCAPE MODEL

1. Developed jointly by the Bureau of Meteorology and CSIRO through the WIRADA initiative.
2. Three soil layers (top: 0-10 cm, shallow: 10 cm-1 m, deep: 1 m-6 m).
3. Two hydrological response units (shallow rooted versus deep rooted vegetation).
4. AWRA has a spatial resolution of 5 km and is driven by AWAP analyses of daily rainfall and temperature, as well as satellite derived analyses of daily incoming shortwave radiation.
5. AWRA has been calibrated to streamflow, catchment average soil moisture and Evapo-transpiration for around 300 unimpaired catchments across Australia.
6. AWRA has been found to perform better than other continental-scale models and is better able to capture the observed soil moisture patterns than previous models (Bureau of Meteorology 2016).
7. AWRA-L model outputs are released daily to the public through the Australian Landscape Water Balance website (http://www.bom.gov.au/water/landscape/).

STATE MINE FIRE SUMMARY

September 2013 was the warmest September on record for New South Wales, 0.9 ºC above the previous September record, set in 1965. October was the 10th warmest on record, and 8th driest on average across the state. In particular, parts of the Blue Mountains experienced record dry conditions. Against this climate backdrop, more than 100 fires had ignited across NSW by 18 October, many in the Blue Mountains area. Two people died during the fires, and more than 200 homes were destroyed.

The State Mine fire was one of these fires, and was ignited as a result of Australian Defence Force explosives training on 16 October. The fire burnt through approximately 55,000 Ha, threatening many home and destroying much of the historic Zig-Zag railway. On 17 October, its most active day, the fire front moved some 25 km, during conditions of Severe fire danger. In total, the State Mine fire burnt for over a month, and was eventually declared out on 19 November.