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HAZARDSCRC

MITIGATING THE EFFECTS OF SEVERE FIRES, FLOODS AND HEATWAVES THROUGH IMPROVEMENTS TO LAND DRYNESS MEASURES AND FORECASTS

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An Australian Government Initiative



Introduction

- The McArthur Forest Fire Danger Index (FFDI) uses "Drought Factor" (DF) to represent fuel availability.
- DF is based on soil moisture deficit.
- SMD in DF is commonly calculated as either:
 - Keetch–Byram Drought Index (KBDI)
 - Mount's Soil Dryness Index (SDI).
- KBDI/SDI make empirical assumptions to moisture depletion in the upper soil layers.

KBDI/SDI in more detail

KBDI

Assumes:

- Rate of moisture loss due to ET is a function of vegetation cover density.
- VCD is an exponential function of mean annual rainfall.
- ET is an exponential function of T_{max} .
- Maximum water available for transpiration is 203.2 mm.

SDI

- Based on KBDI.
- But interception and runoff are treated separately.
- The interception and runoff is based on seven vegetation categories.
- ET is a linear function of T_{max} .

Objective I

Production of historical KBDI/SDI data sets

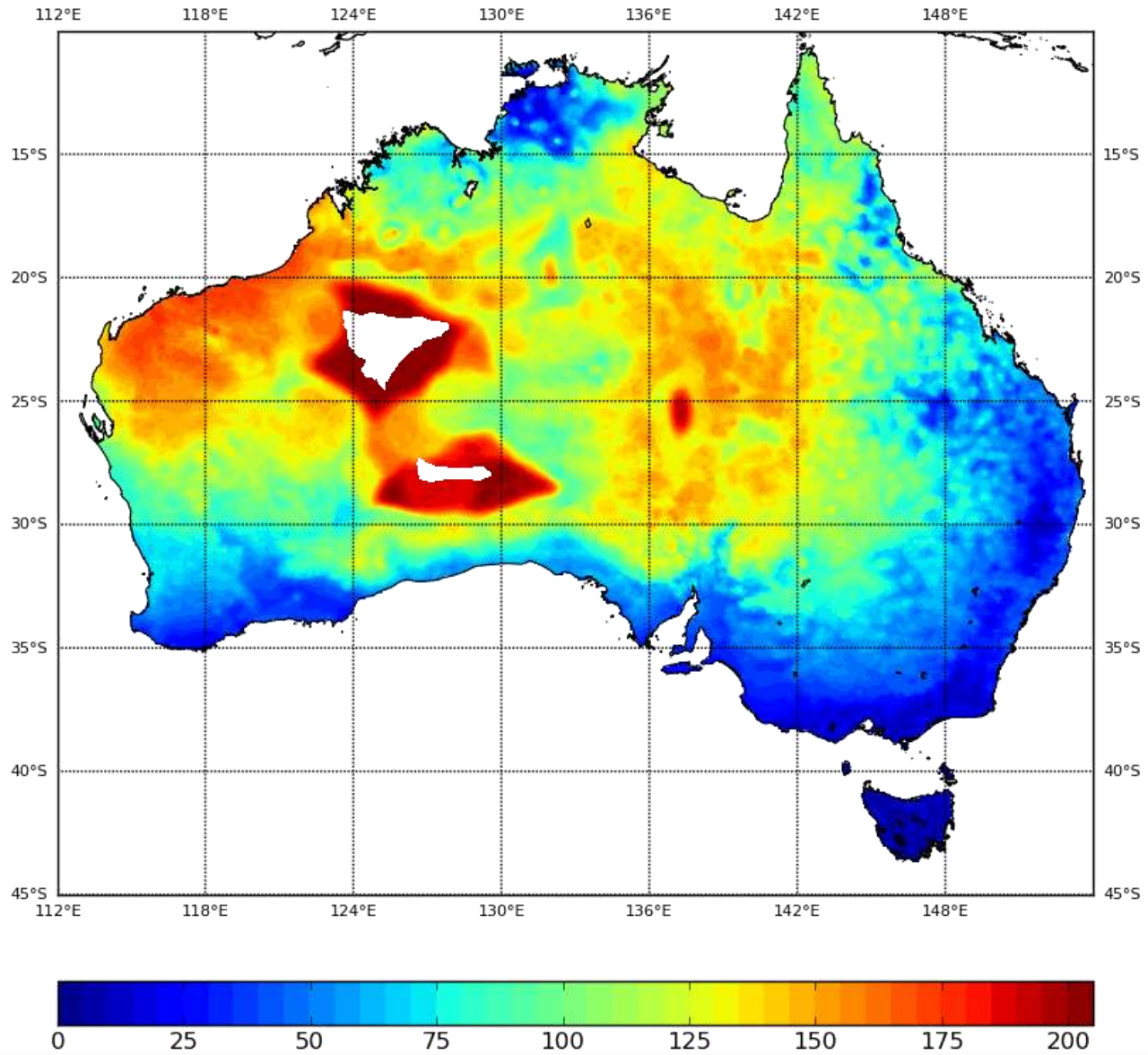
- Produced 40 year (1974 – 2014) KBDI and SDI data set.
- For whole of Australia.
- Daily.
- At ~5 km spatial resolution.
- Data

Input rainfall and T_{Max} fields from AWAP.

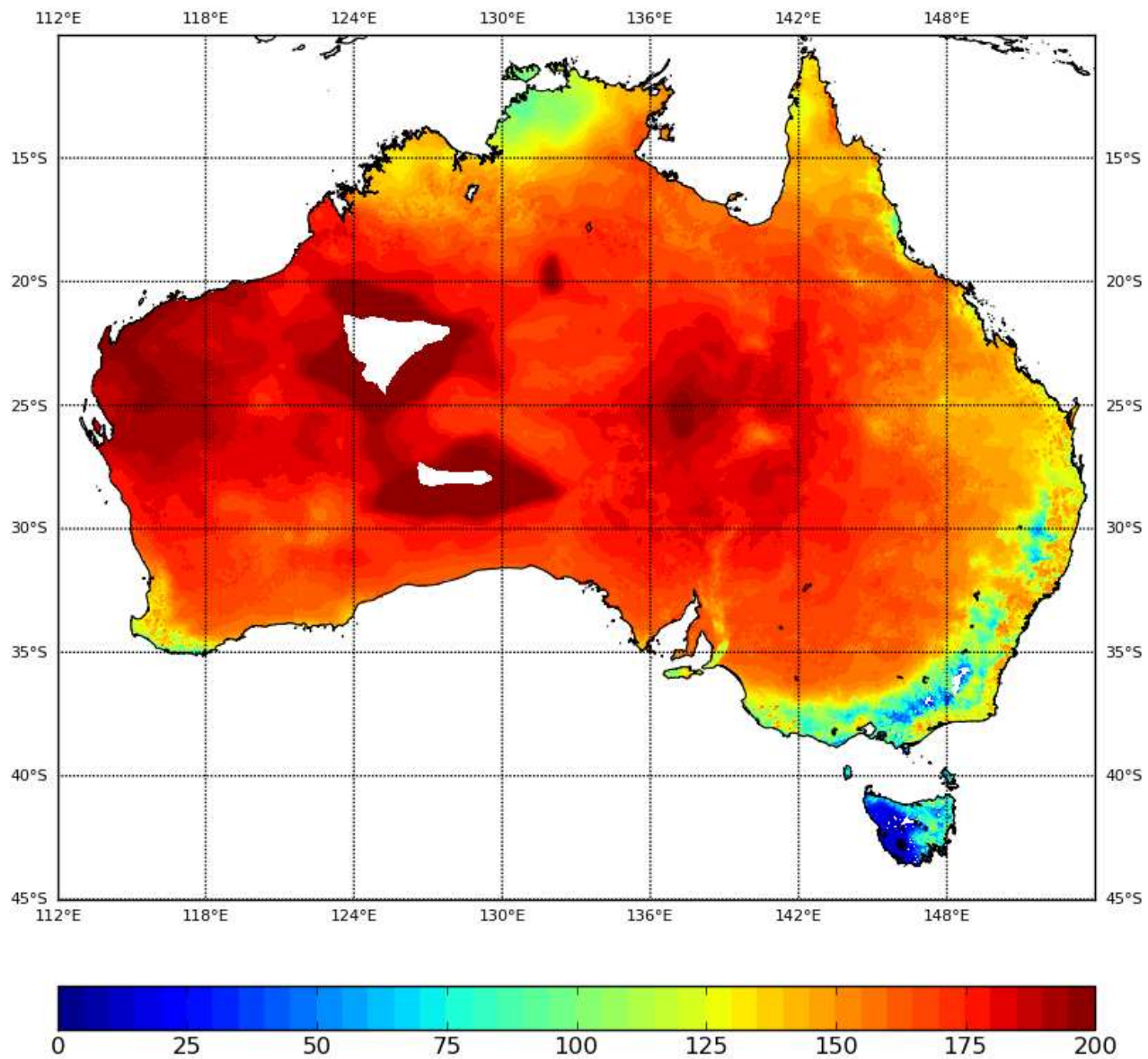
Vegetation class from MODIS LAI (Courtesy AUSCOVER).

SDI: ET coefficients & Veg Class parameter values from operations.

Mean KBDI -- Dec



Mean SDI -- Dec



Objective II

Inter-comparison of KBDI/SDI with other sources

The selected sources are:

- *in situ* observations, and
- NWP soil moisture fields

In situ observations

- From OzNet hydrological network in Murrumbidgee
- *Managed by Monash Uni. & Uni. Melbourne*
- *Data from 2002 – 2011*

NWP data

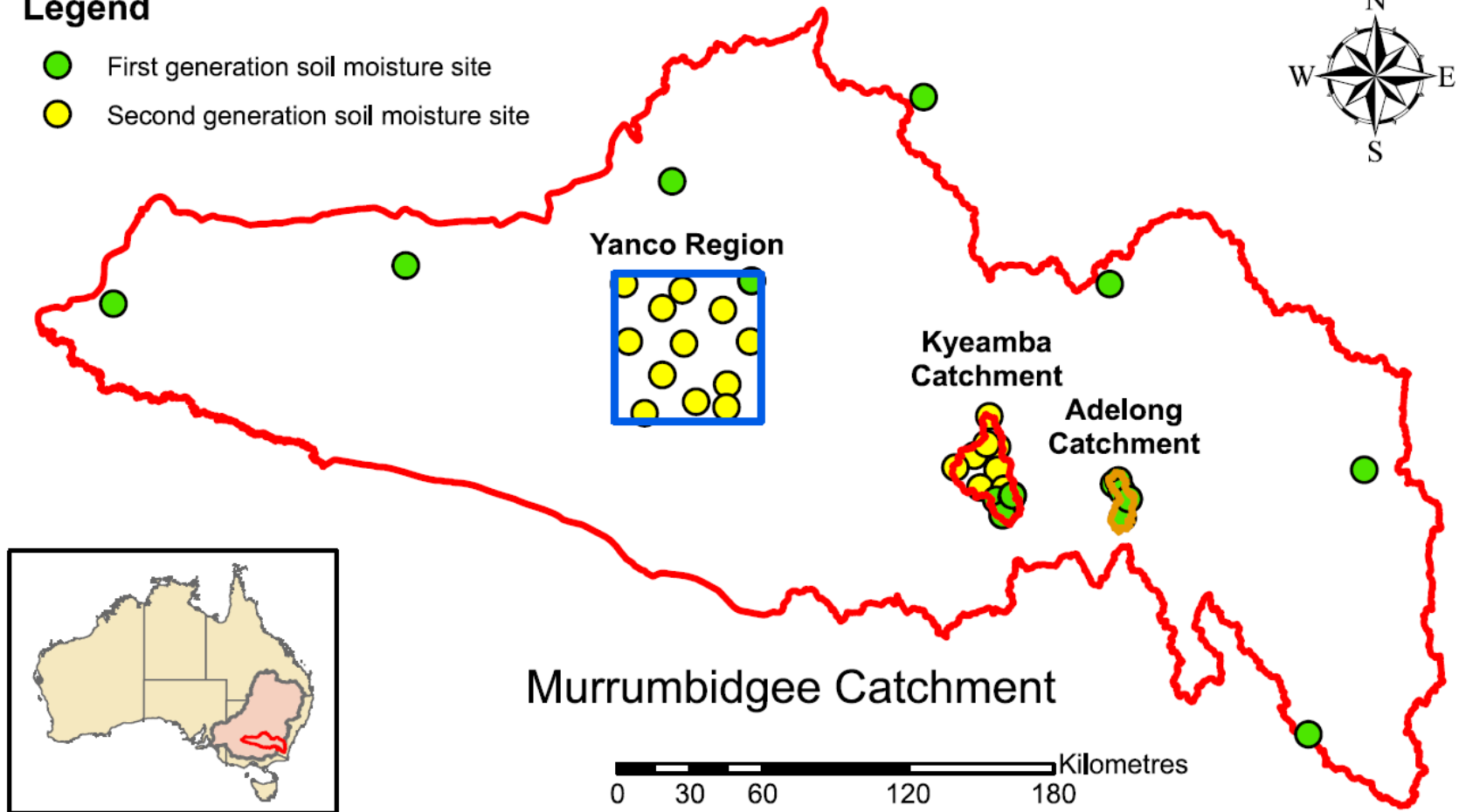
- *ACCESS operational global weather forecasting model (Suite Vn. – APS0)*
- *Spatial Resolution - ~80 km*
- *Uses "MOSES" land surface model*
- *Includes soil moisture nudging*

The Murrumbidgee Soil Moisture Monitoring Network.

Image courtesy: Smith et al. (2012).

Legend

- First generation soil moisture site
- Second generation soil moisture site

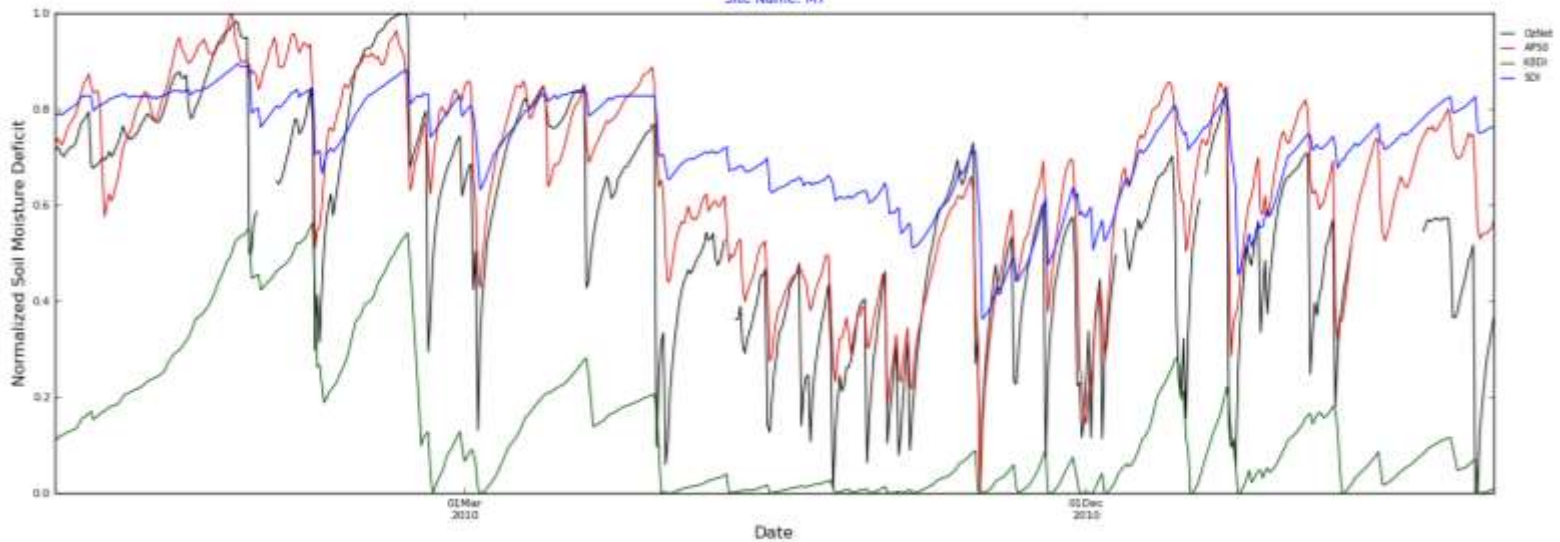


Smith, A. B., Walker, J. P., Western, A. W., Young, R. I., Ellett, K. M., Pipunic, R. C., et al. (2012). The Murrumbidgee Soil Moisture Monitoring Network data set. *Water Resources Research*, 48(07).

Time Series of Normalized Soil Moisture Deficit

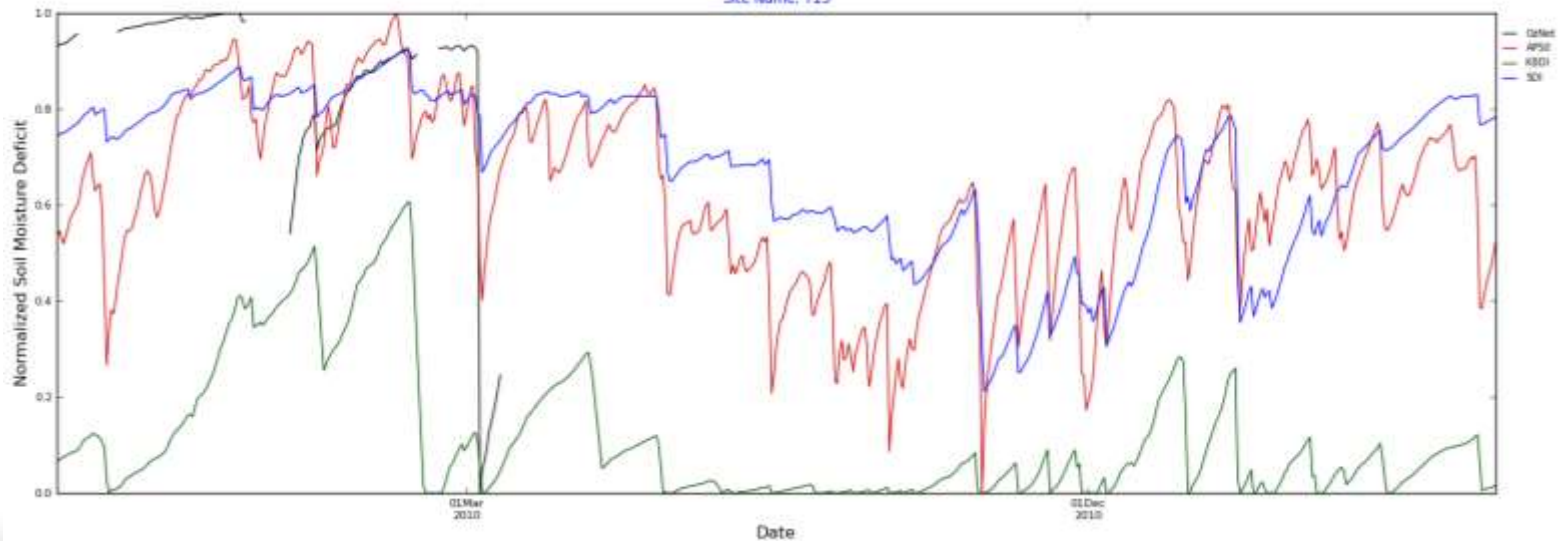
Soil Moisture Deficit Comparisons

Site Name: M7



Soil Moisture Deficit Comparisons

Site Name: Y13



Validation Against OzNet Hydrological Observations

Correlation

Site	APS-0	KBDI	MSDI
M1	0.69	0.59	0.51
M2	0.7	0.66	0.6
M3	0.69	0.64	0.6
M4	0.83	0.65	0.75
M5	0.77	0.56	0.74
M6	0.81	0.7	0.62
M7	0.87	0.57	0.72
Y1	0.8	0.62	0.8
Y2	0.57	0.45	0.75
Y3	0.75	0.59	0.81
Y4	0.67	0.33	0.49
Y5	0.74	0.41	0.59
Y6	0.4	0.3	0.49
Y7	0.69	0.51	0.7
Y8	0.79	0.63	0.75
Y9	0.76	0.23	0.31
Y10	0.65	0.67	0.75
Y11	0.63	0.71	0.79
Y12	0.74	0.61	0.71
Y13	0.28	0.53	0.67
K1	0.7	0.55	0.66
K2	0.83	0.65	0.79
K3	0.83	0.63	0.78
K4	0.77	0.7	0.77
K5	0.87	0.65	0.83
Mean	0.71	0.57	0.68

Bias [-]

Site	APS-0	KBDI	MSDI
M1	-0.07	0.43	-0.08
M2	-0.04	0.42	-0.09
M3	-0.02	0.44	0.02
M4	0.05	0.47	0.01
M5	-0.06	0.46	-0.11
M6	-0.1	0.31	-0.12
M7	-0.04	0.37	-0.11
Y1	-0.12	0.24	-0.21
Y2	-0.12	0.33	-0.21
Y3	0.05	0.46	-0.05
Y4	0.02	0.31	-0.16
Y5	0.08	0.43	-0.1
Y6	0.15	0.42	-0.09
Y7	0	0.37	-0.06
Y8	-0.05	0.43	-0.08
Y9	-0.5	-0.2	-0.67
Y10	-0.08	0.4	-0.09
Y11	-0.04	0.42	-0.04
Y12	-0.12	0.29	-0.16
Y13	0.11	0.41	-0.06
K1	0.05	0.49	0.19
K2	0.02	0.45	0.07
K3	0.01	0.44	0.08
K4	-0.12	0.36	-0.01
K5	-0.05	0.47	0.1
Mean	-0.04	0.38	-0.08
SD	0.12	0.13	0.15

RMSD [-]

Site	APS-0	KBDI	MSDI
M1	0.18	0.47	0.23
M2	0.21	0.46	0.22
M3	0.19	0.49	0.21
M4	0.13	0.51	0.14
M5	0.18	0.51	0.21
M6	0.19	0.37	0.2
M7	0.1	0.43	0.18
Y1	0.18	0.32	0.26
Y2	0.22	0.41	0.27
Y3	0.15	0.51	0.14
Y4	0.15	0.44	0.29
Y5	0.17	0.49	0.18
Y6	0.26	0.51	0.22
Y7	0.16	0.43	0.15
Y8	0.15	0.48	0.17
Y9	0.52	0.33	0.68
Y10	0.22	0.45	0.2
Y11	0.21	0.46	0.16
Y12	0.19	0.36	0.22
Y13	0.2	0.47	0.18
K1	0.16	0.53	0.28
K2	0.13	0.5	0.16
K3	0.15	0.49	0.19
K4	0.18	0.41	0.17
K5	0.15	0.51	0.17
Mean	0.19	0.45	0.22

Summary

- ❑ KBDI is wetter than SDI.
- ❑ NWP soil moisture show good agreement with observations.
- ❑ Despite the coarse resolution, NWP soil moisture deficit is better than SDI/KBDI.

THANK YOU

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ADDITIONAL SLIDES

KBDI formulation

$$KBDI_t = KBDI_{t-1} - P_{Net} + ET$$

$$ET = \frac{(203.2 - KBDI_{t-1})(0.968e^{0.0875T_{Max}+1.5552} - 8.3)}{1 + 10.88e^{-0.00173R_{annual}}}$$

SDI formulation

$$SDI_t = SDI_{t-1} - P_{Net} + ET$$

$$P_{Net} = Rain - Interception - Runoff$$

$$Interception = \begin{cases} R * Rain, & R * Rain + CW_{t-1} \leq C \\ C - CW_{t-1}, & R * Rain + CW_{t-1} > C \end{cases}$$

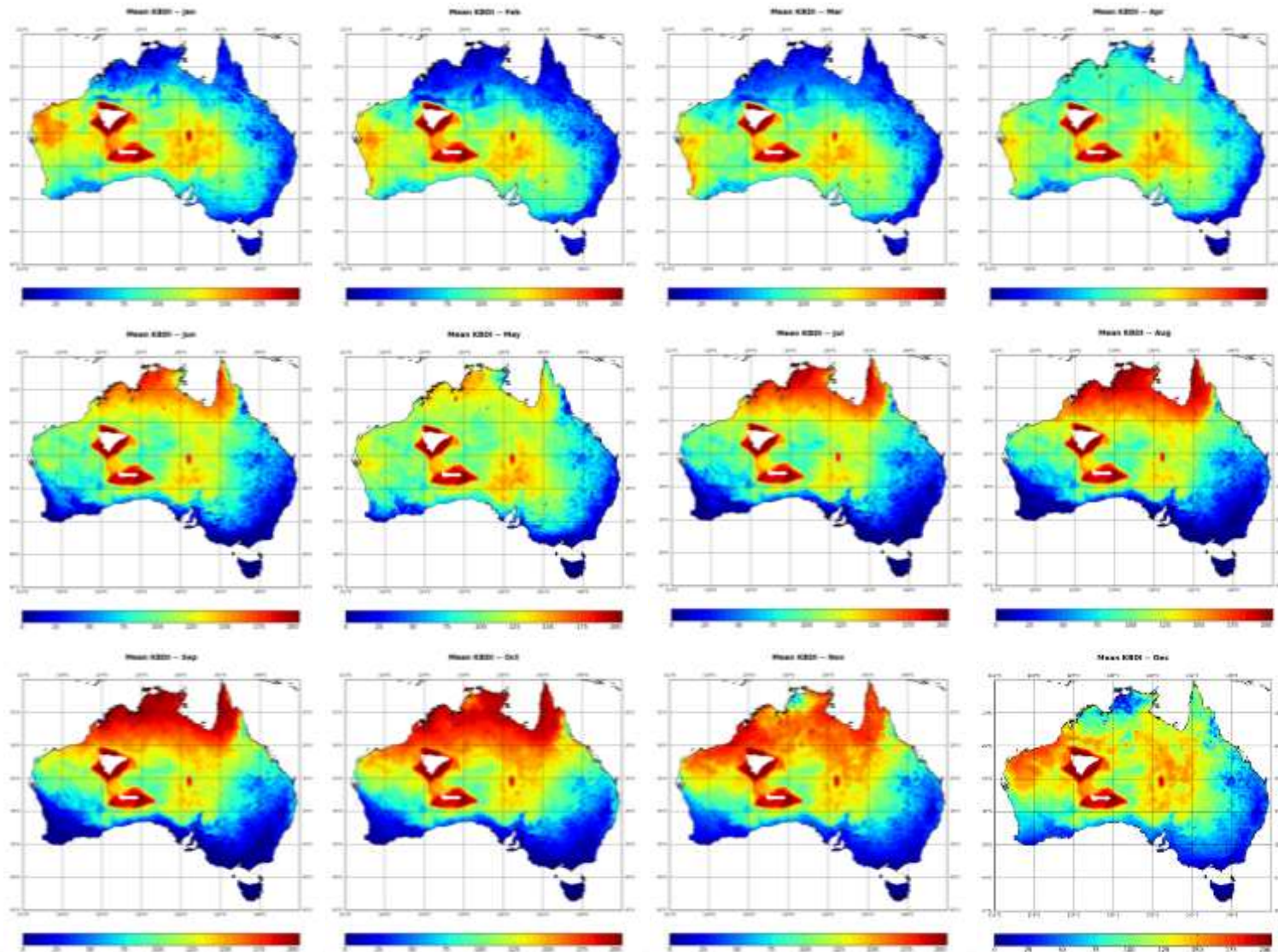
$$CW_t = \begin{cases} CW_{t-1} + Interception - W, & \text{if } Rain > 0 \\ 0, & \text{if } Rain = 0 \end{cases}$$

$$Runoff = FR \times Rain$$

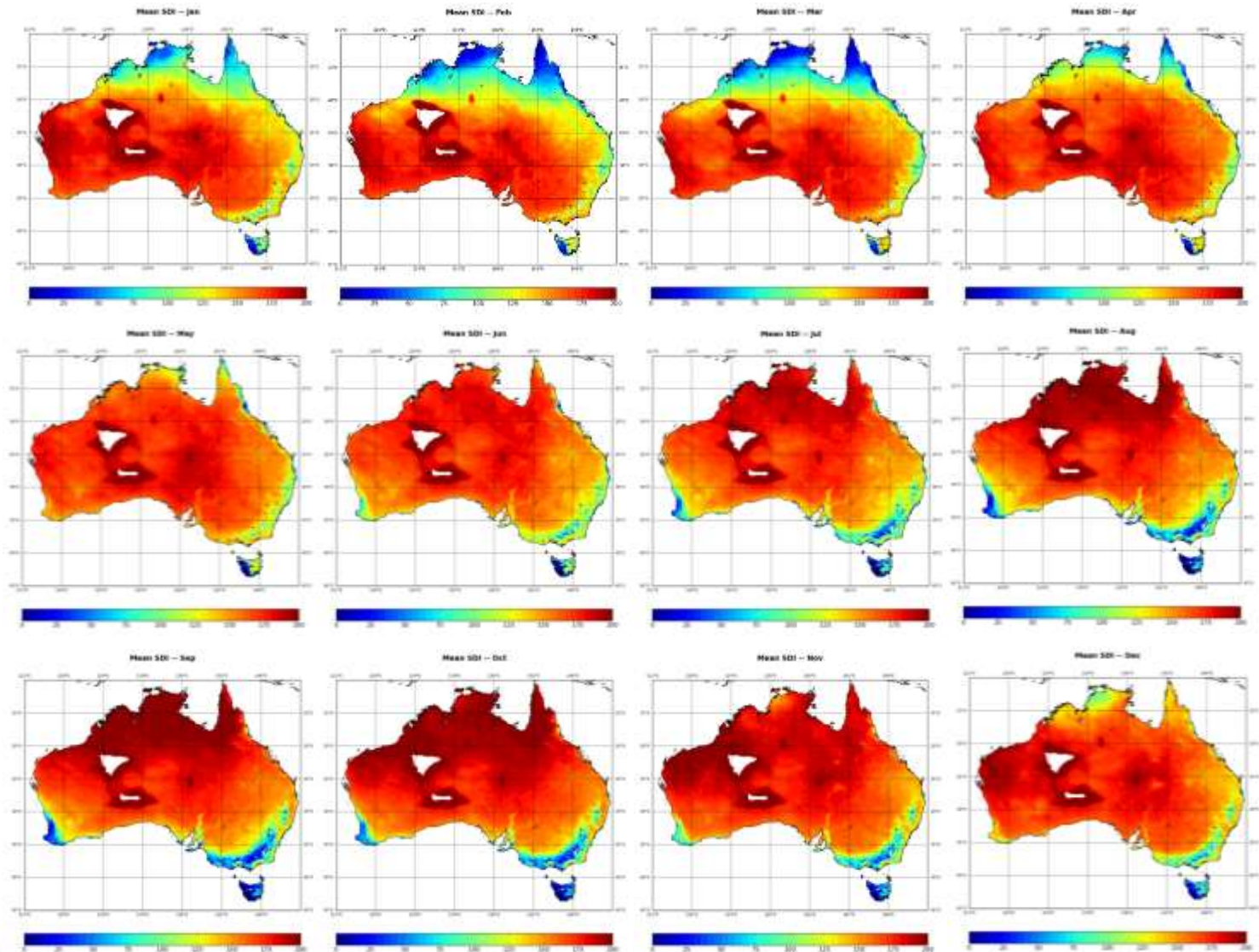
$$ET = a_i T_{Max} + b_i$$

Vegetation Class	O	A	B	C	D	E	F
Canopy rainfall interception fraction (R)	0	0.1	0.2	0.3	0.4	0.5	0.6
Canopy storage capacity (C)	0	0.5	1.0	2.0	2.5	3.5	4.0
Canopy loss per wet day (W)	0	0.5	0.5	0.5	0.5	0.5	1.0
Flash runoff fraction (FR)	1/10	1/20	1/30	1/40	1/50	1/60	1/70

Monthly average of KBDI based on data from 1974 - 2013 at ~5 km grid resolution

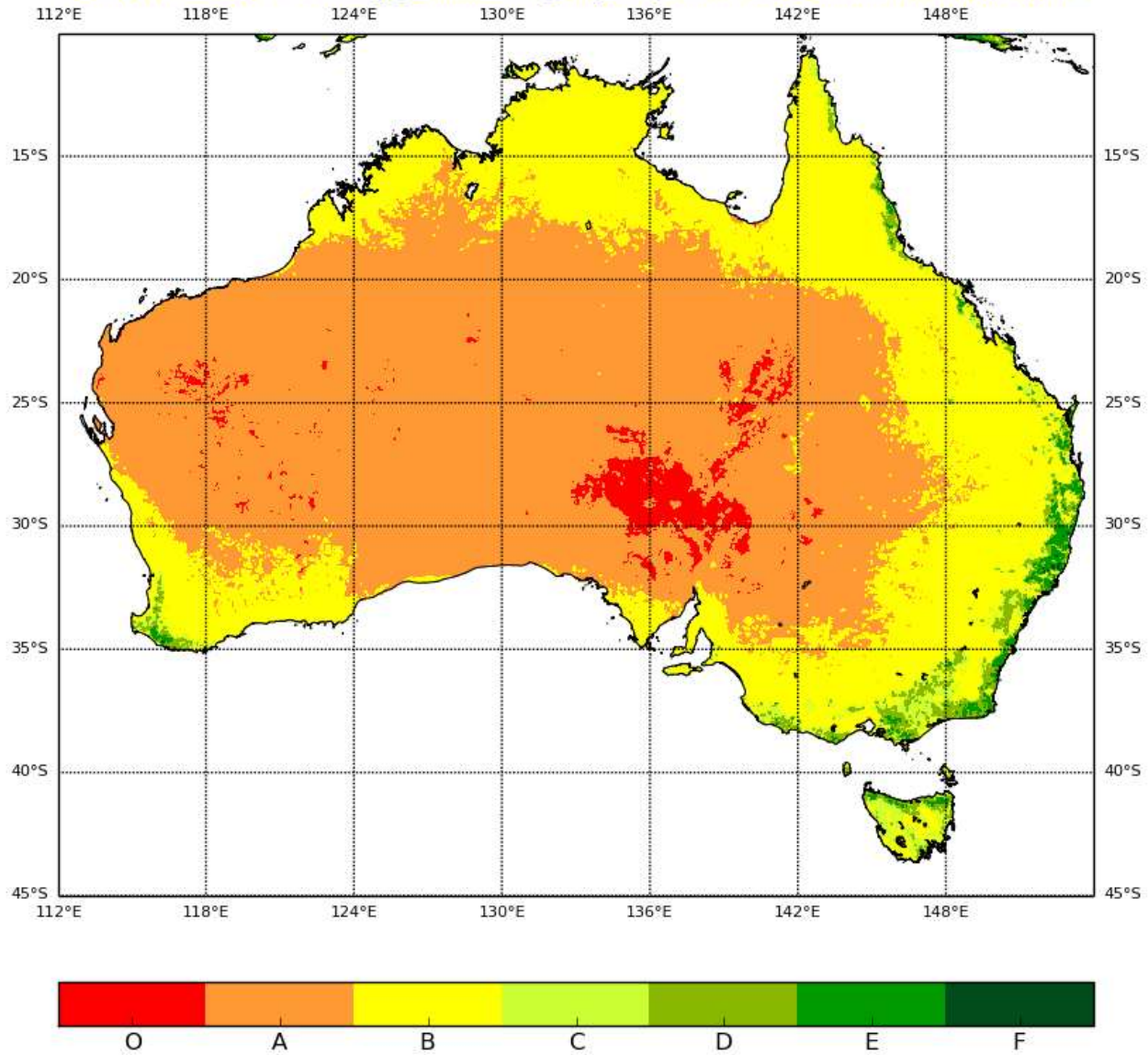


Monthly average of SDI based on data from 1974 - 2013 at ~5 km grid resolution



SDI Vegetation Class

(Based on mean LAI climatology generated using 10 years years of MODIS LAI data from 2003 - 2012).



Mean LAI

(Based on MODIS 8-day composite LAI data from 2002 to 2012)

