SOIL DRYNESS IN FIRE DANGER RATING: TIME FOR A CHANGE IN APPROACH?

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SOIL DRYNESS IS A KEY COMPONENT IN OPERATIONAL FIRE DANGER RATING SYSTEMS. EMERGING NEW APPROACHES TO ESTIMATE SOIL DRYNESS THROUGH THE USE OF SATELLITE REMOTE SENSING DATA, LAND SURFACE MODELLING AND DATA ASSIMILATION TECHNIQUES ARE AVAILABLE, MEASURING DRYNESS MORE SYSTEMATICALLY THAN CURRENTLY USED EMPIRICAL METHODS. THE PRESENT STUDY EVALUATE AVAILABLE DATASETS BASED ON THESE OLD AND NEW METHODOLOGIES OF SOIL DRYNESS ESTIMATION AGAINST IN-SITU OBSERVATIONS.

Introduction

The fuel availability estimates in McArthur Forest Fire Danger Index used in Australia for issuing fire warnings is based on soil moisture deficit, calculated as either the Keetch–Byram Drought Index (KBDI) or Mount's Soil Dryness Index (MSDI). These indices were designed in 1960's and are essentially simplified, empirical water balance models. The two models over-simplify processes like evapotranspiration and runoff which are critical in calculating accurate soil moisture states. Recent progresses in the remote sensing of soil moisture, data assimilation techniques and physically based land surface models has led to the development of new soil moisture products. Two examples of such datasets are the soil moisture analyses produced from the Bureau of Meteorology's operational Numerical Weather Prediction (NWP) system and remotely sensed soil wetness measurements from the Advanced Scatterometer (ASCAT) instrument. This study undertakes an evaluation of the latter two datasets along with KBDI, MSDI. In-situ observations of soil moisture from the OzNet hydrological monitoring network, Australian national cosmic ray soil moisture monitoring facility (CosmOz) and OzFlux ecosystem network are used to validate the modelled and remotely sensed soil moisture datasets.

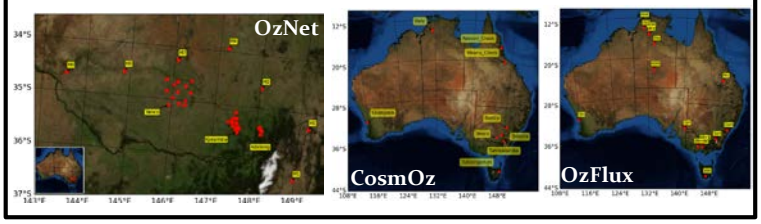
Datasets

KBDI and MSDI at ~5km, 1974-present.
ACCESS_80km – NWP model at ~80 km, Sept. '09 – May '11.
ACCESS_40km – NWP model at ~40 km, Jun '11 – Mar '16.
ASCAT – Onboard MetOp-A, 25 km, Jan '12 – present.

Verification period

OzNet – 01 September 2009 to 31 May 2011 (21 months)
CosmOz – 01 May 2012 to 31 December 2014 (32 months)
OzFlux – 01 January 2012 to 14 December 2015 (47.5 months)

In-situ observations



Surface soil moisture verification

Data Set	Correlation [-]			Bias [-]			RMSD [-]		
	OzNet	*CosmOz*	*OzFlux*	*OzNet*	*CosmOz*	*OzFlux*	*OzNet*	*CosmOz*	*OzFlux*
ACCESS_80km	0.72	–	–	0.02	–	–	0.19	–	–
ACCESS_40km	–	0.81	0.75	–	-0.03	-0.07	–	0.15	0.21
KBDI	0.64	0.63	0.7	-0.26	-0.22	-0.22	0.36	0.33	0.3
MSDI	0.71	0.76	0.73	-0.02	-0.07	-0.08	0.23	0.2	0.22
ASCAT	–	0.81	0.74	–	-0.03	-0.05	–	0.18	0.22

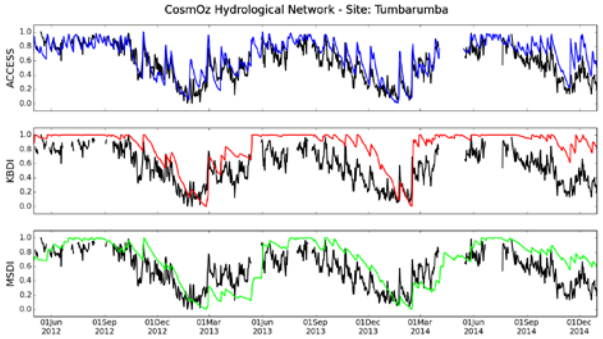
Number of sites: OzNet = 30; CosmOz = 9; OzFlux = 18

Deeper layer verification

Correlation [-]		Bias [-]		RMSD [-]	
OzFlux	*OzNet*	*OzFlux*	*OzNet*	*OzFlux*	*OzNet*
–	0.64	–	0.00	–	0.22
0.72	–	0.04	–	0.22	–
0.82	0.71	-0.15	-0.26	0.26	0.34
0.82	0.73	-0.04	-0.01	0.20	0.21
–	–	–	–	–	–

Number of sites: OzNet = 28; OzFlux = 10

Sample time-series plot of shallow soil layer



Conclusions

- The verification results show that both KBDI and MSDI are poor indicators of duff layer soil moisture. NWP model have a better skill than the traditional indices at duff layers.
- KBDI and MSDI represent the deep layer soil moisture variations better. However, large biases are still observed in KBDI.
- The skill obtained for ACCESS products are encouraging since they are at a much coarser resolution (~80 km & ~40 km) than KBDI and MSDI (~5km) estimates. Further, KBDI and MSDI use observation based rainfall analyses, while NWP doesn't use any observations of precipitation.
- NWP is a flexible system and hence there are scope for further improvement. Future work will aim to improve the resolution of NWP based soil moisture. In addition, model tuning and implementation of an advanced data assimilation system is also proposed.

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