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

Lead Researchers: Dr Imtiaz Dharssi and Dr Vinod Kumar

Land Surface Data Assimilation Scientist, CAWCR, Bureau of Meteorology

Melbourne, Australia

BNHCRC Research Advisory Forum, Brisbane,
November 2015

An Australian Government Initiative

Australian Government
Bureau of Meteorology

CSIRO

Project Team Members

ACT parks, Tasmania Fire Service, South Australian Country Fire Service, Fire and Emergency Services Authority of Western Australia, Parks and Wildlife Service Tasmania, Monash University, BoM, CAWCR, CSIRO

- Imtiaz Dharssi
- Vinod Kumar
- Adam Smith
- Peter Steinle
- Jeff Walker
- Ian Grant
- Jeff Kepert
- Claire Yeo
- John Bally
- Paul Fox-Hughes
- Adam Leavesley
- Mark Chladil
- Rob Sandford
- Ralph Smith
- David Taylor

The team has a track record of delivering operational results.

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 2012 total economic cost of natural disasters in Australia exceeded $6 billion

- A recent UK Met Office report concludes that investment in weather services provides an at least seven fold return
  - The Public Weather Service's contribution to the UK economy, 2007

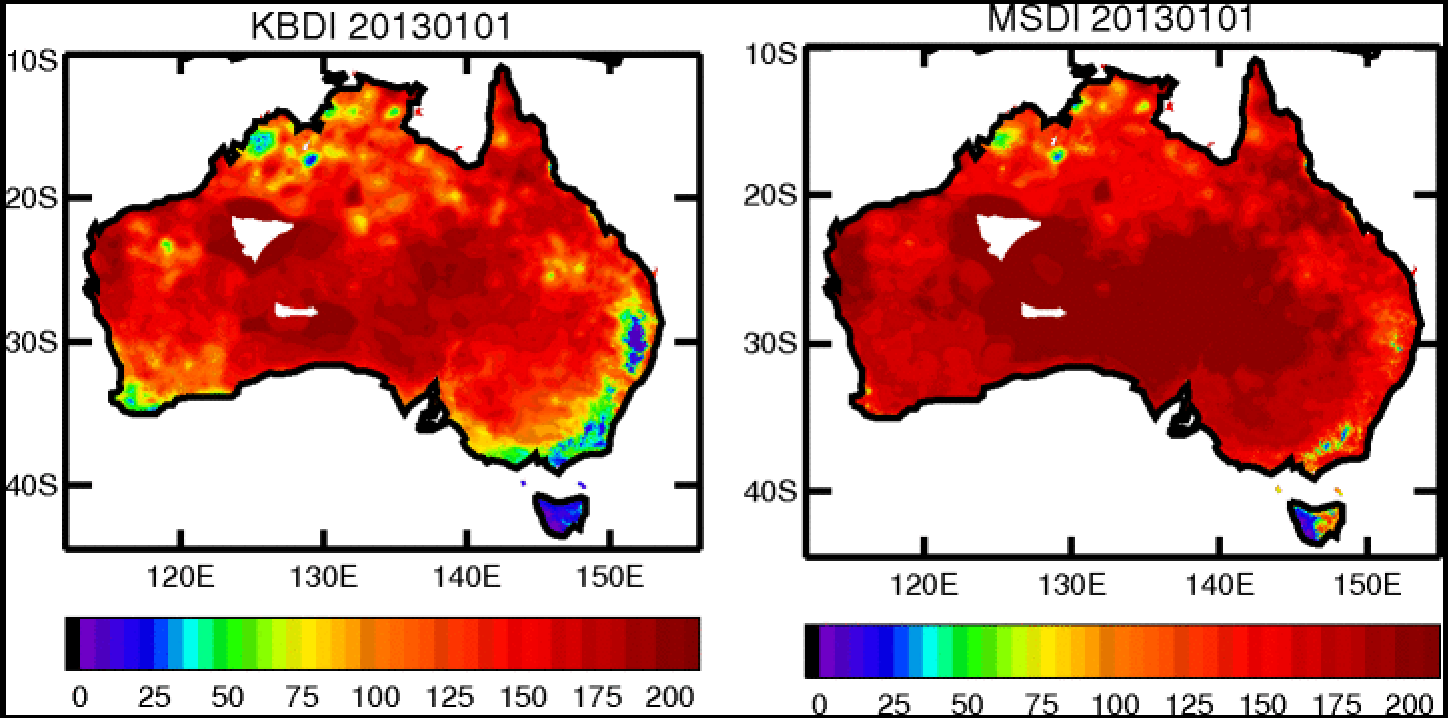
Landscape Dryness is Currently Calculated Using Simple Methods Developed in the 1960s

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

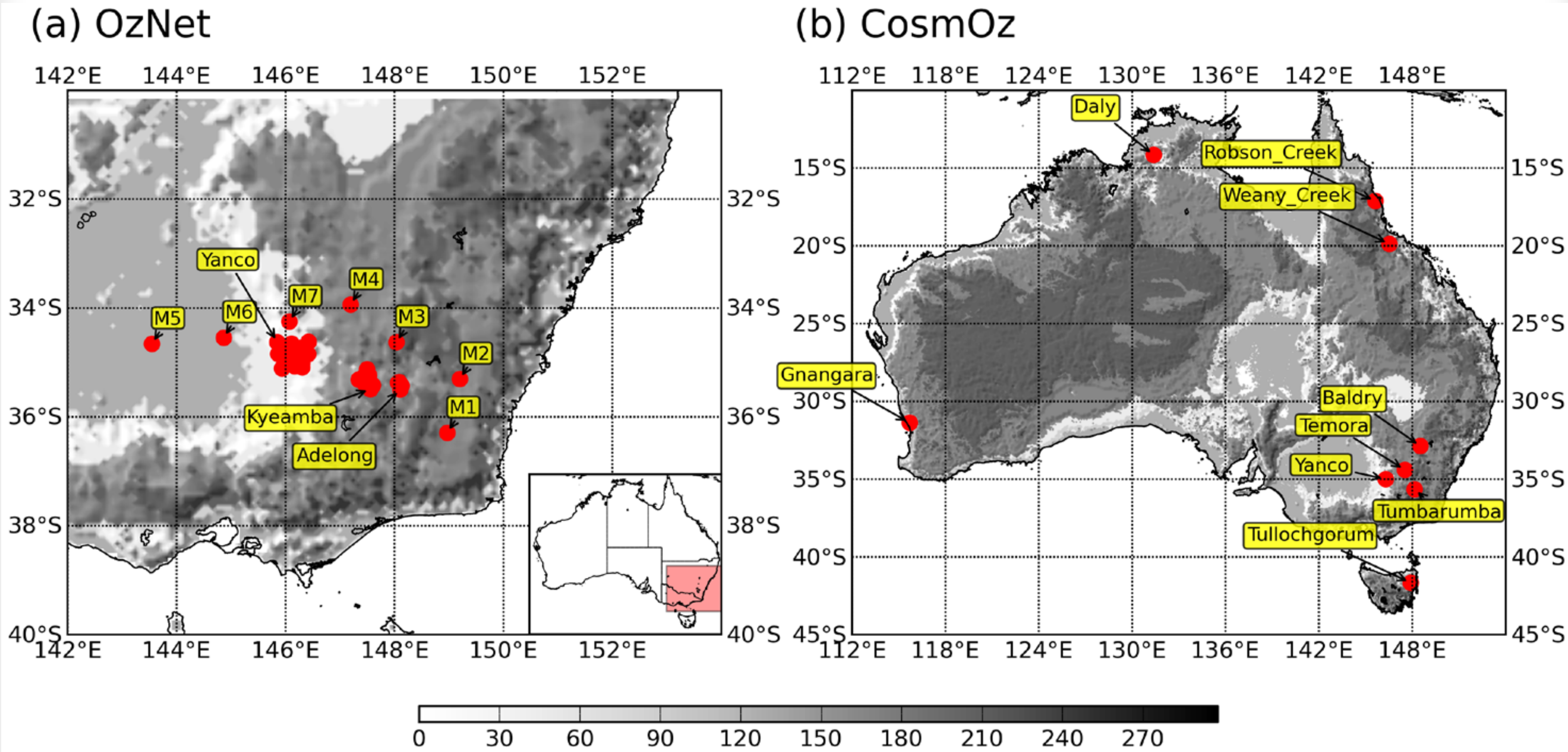
- Current simple landscape dryness methods make simplistic assumptions about
  - Canopy Interception
  - Evaporation and Transpiration
  - Rainfall Runoff

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

KBDI and MSDI



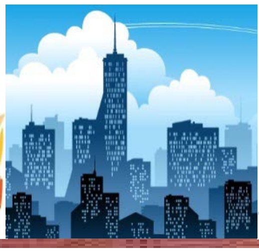
Soil Moisture Observation Sites

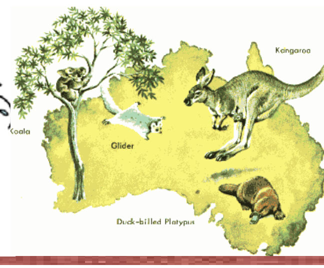


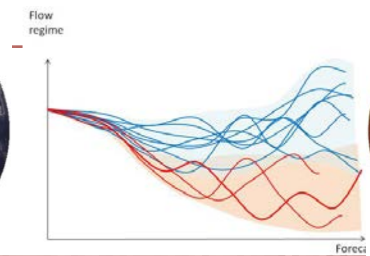
ACCESS

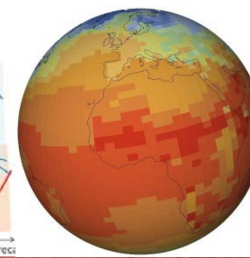
Seamless Modelling of Weather and Climate

Hours	Days	Weeks	Months	Decades	Centuries





1km	4km	10km	20km	50km	100km

Different configurations of the ACCESS model are used across time and space scales; from very high resolution fire modelling to lower resolution climate prediction.

The atmosphere and land Surface are fully coupled in all configurations of ACCESS.

Verification Scores

CosmOz Soil Wetness observations vs. Model or ASCAT

Data Set (2012 to 2014)	Correlation [-]	Bias [-]	RMSD [-]
ACCESS NWP 40km	0.81	-0.03	0.15
Keetch Byram Drought Index	0.63	-0.22	0.32
Mount's Soil Dryness Index	0.76	-0.07	0.20
Antecedent Precipitation Index	0.73	0.14	0.23
Remotely Sensed ASCAT Soil Wetness	0.81	-0.03	0.18

OzNet Soil Wetness observations vs. Model

Data Set (2009 to 2011)	Correlation [-]	Bias [-]	RMSD [-]
ACCESS NWP 80km	0.72	0.02	0.19
Keetch Byram Drought Index	0.64	-0.26	0.36
Mount's Soil Dryness Index	0.71	-0.02	0.22
Antecedent Precipitation Index	0.66	0.14	0.26

Verification Scores

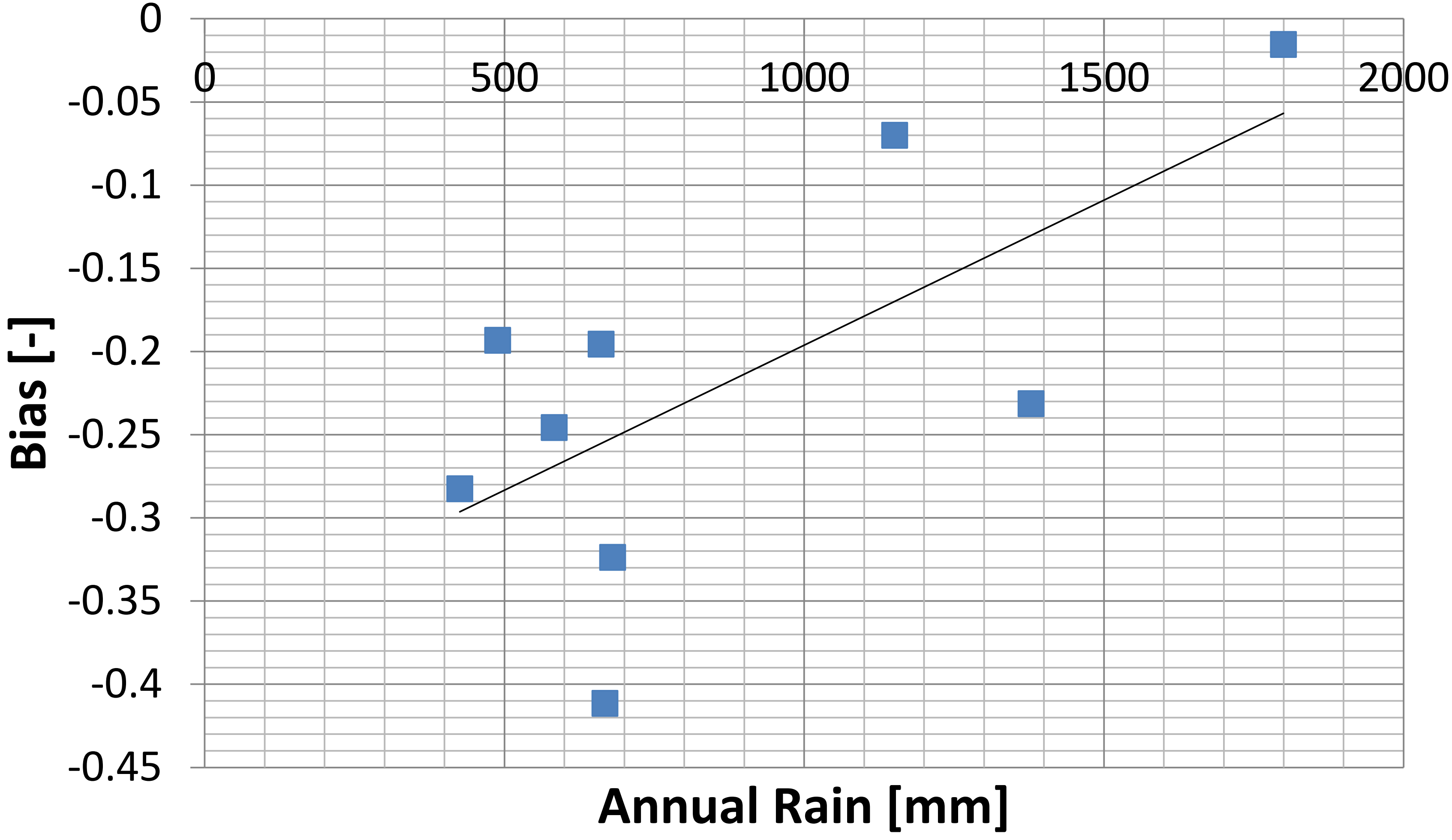
Compared to Finkele et al

CosmOz Soil Wetness observations vs. Model or ASCAT

Data Set (2012 to 2014)	Correlation [-]	Bias [-]	RMSD [-]
ACCESS NWP 40km	0.81	-0.03	0.15
Keetch Byram Drought Index (5 km)	0.63	-0.22	0.32
KBDI (25 km, Finkele et al)	0.61	-0.21	0.32
Mount's Soil Dryness Index (5 km)*	0.76	-0.11	0.21
MSDI (25 km, Finkele et al)*	0.59	0.0	0.26

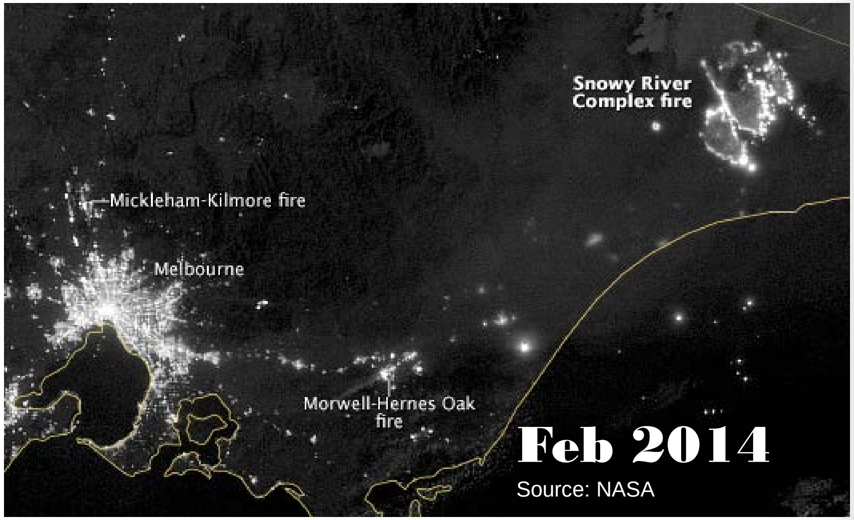
*Verifying Against Observation Sites South of Latitude 30S Only.

KBDI BIAS VS ANNUAL RAIN



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

- Develop a high resolution (initially 4km) land DA scheme for natural hazard monitoring and prediction
- Develop Downscaling techniques to estimate landscape dryness at 1km horizontal resolution



- Use daily rainfall analyses from AWAP disaggregated to hourly fields
- Hourly analyses of T2m, q2m, 10m wind speed and surface pressure (MSAS)
- Hourly surface SW radiation generated from satellite data

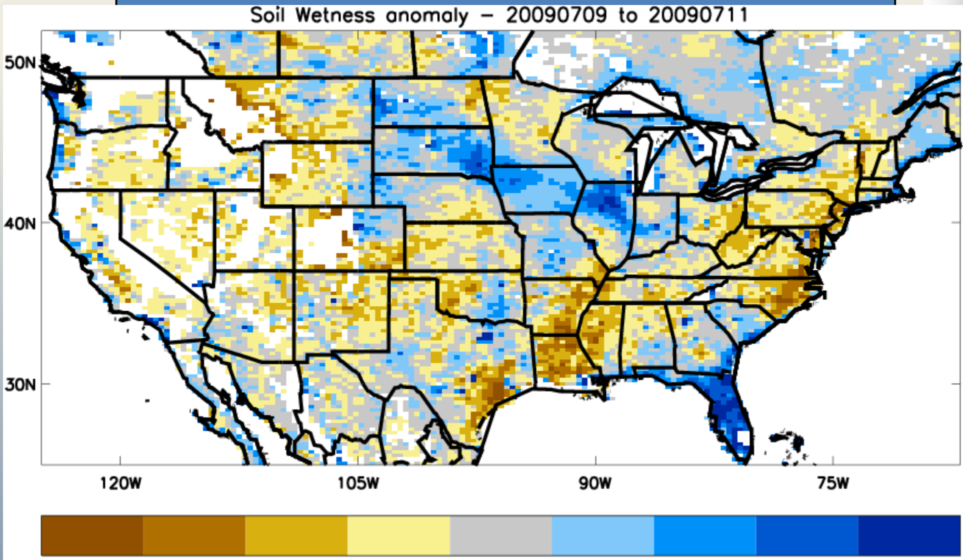
DATA ASSIMILATION EXAMPLE

Assimilation of ASCAT surface soil wetness into a global numerical weather prediction model

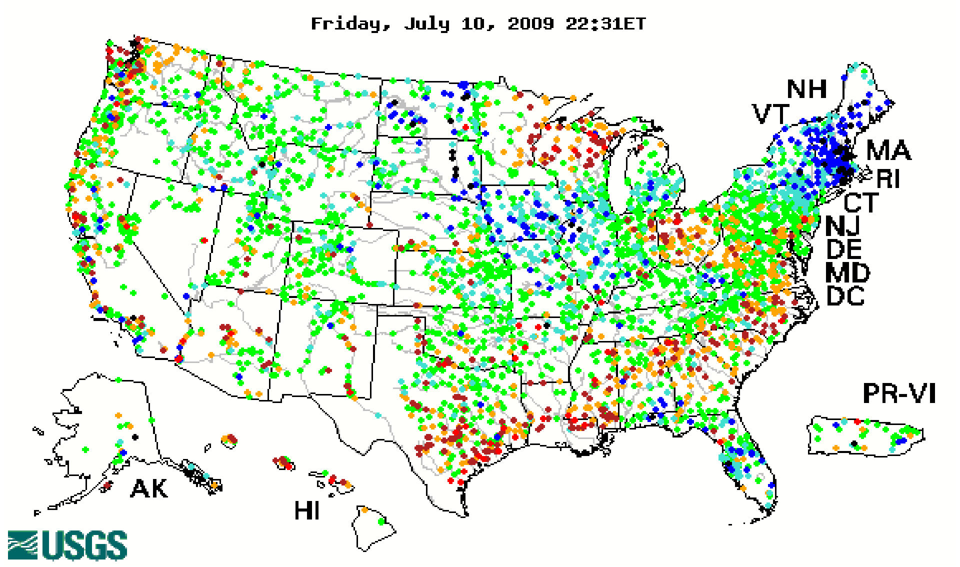
Dharssi, I., Bovis, K. J., Macpherson, B., and Jones, C. P.: Operational assimilation of ASCAT surface soil wetness at the Met Office, Hydrol. Earth Syst. Sci., 15, 2729-2746, doi:10.5194/hess-15-2729-2011, 2011.

WATER ANOMALIES: 9 TO 11 JULY 2009

ASCAT surface soil wetness anomaly



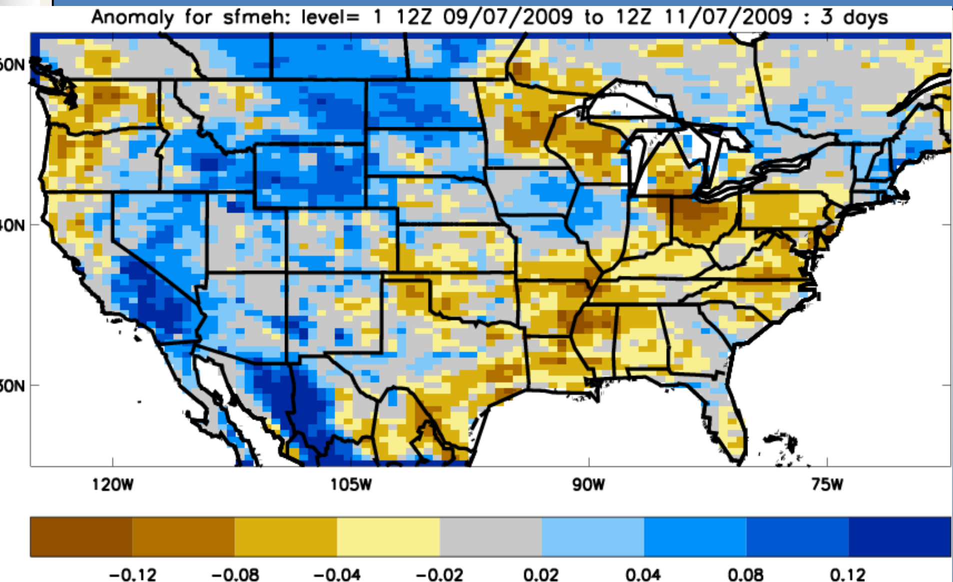
Good qualitative agreement between the two data.



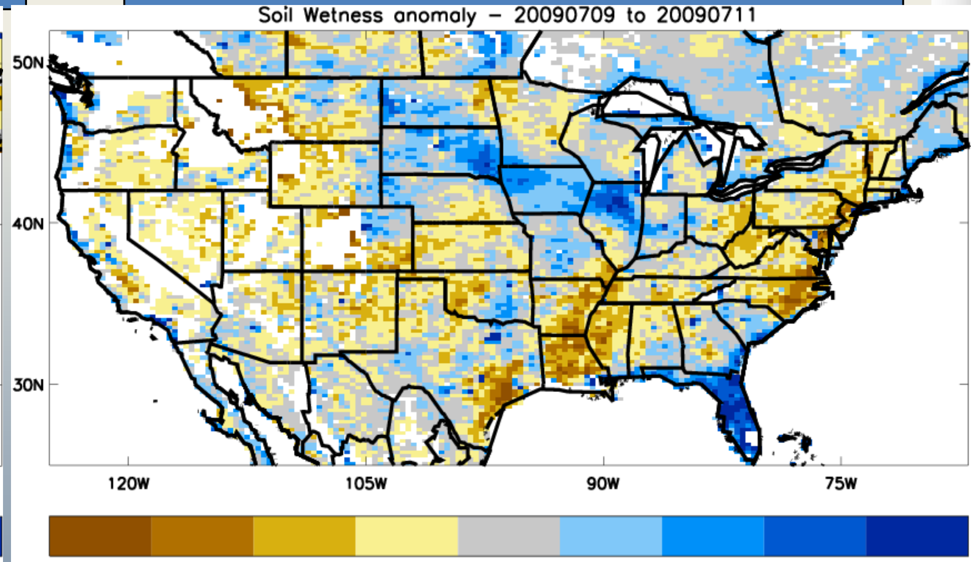
River Flow anomaly

MODEL: 9 TO 11 JULY 2009

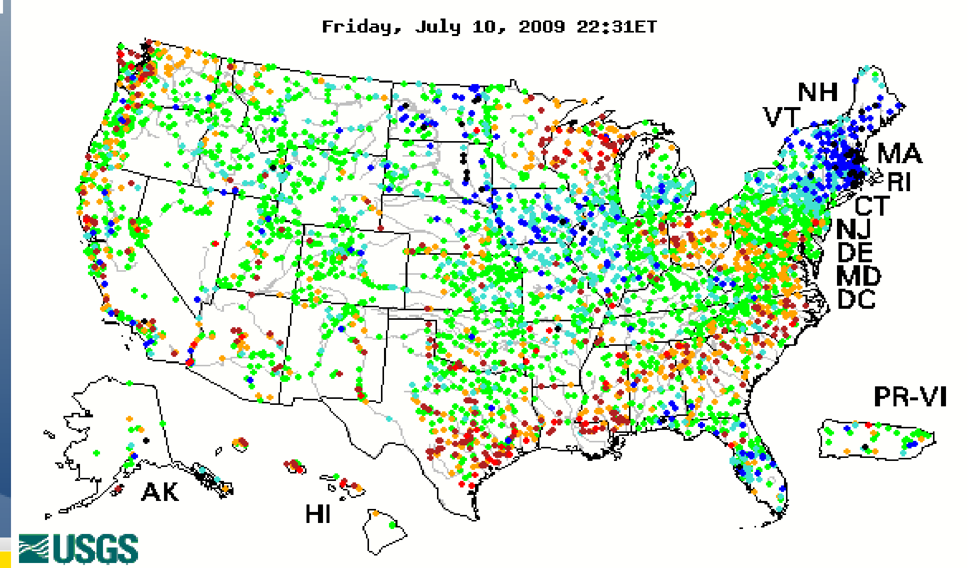
Control run: top 10cm soil moisture anomaly



ASCAT surface soil wetness anomaly



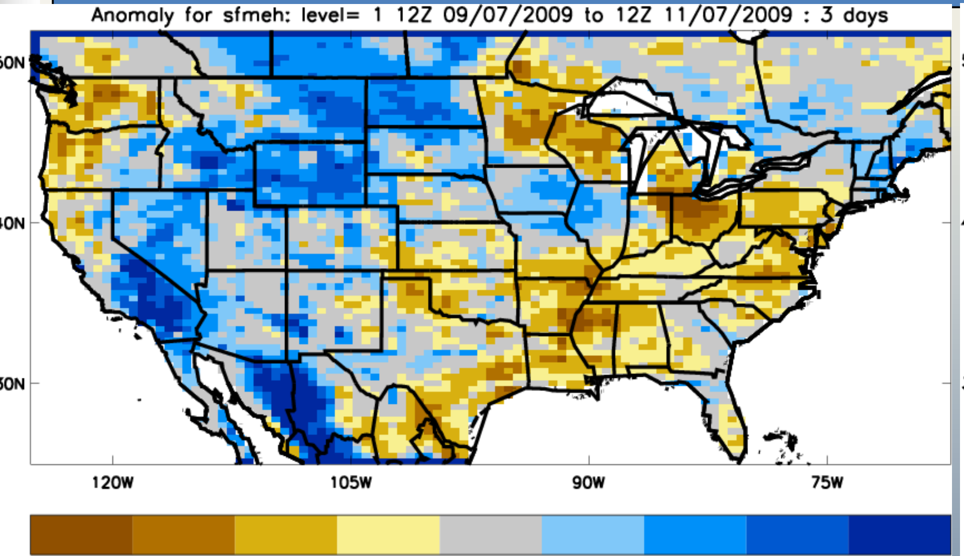
Model soil too wet in the west and possibly too dry in the east (e.g. Florida).



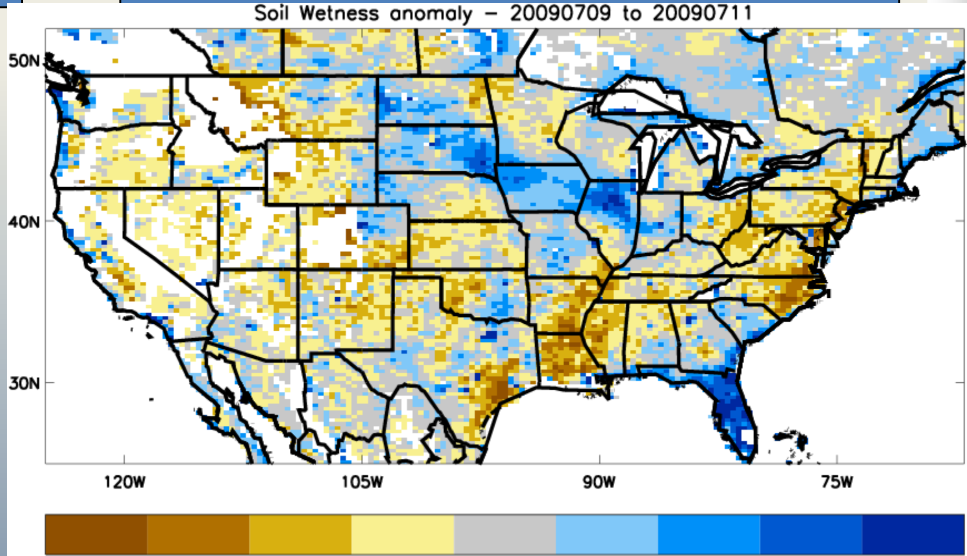
River Flow anomaly

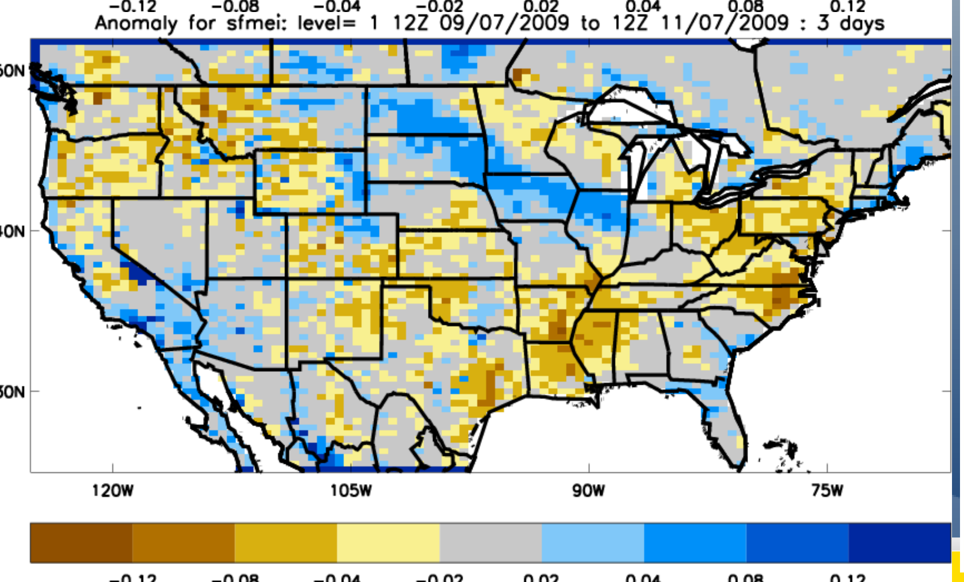
DATA ANALYSIS: 9 TO 11 JULY 2009

Control run: top 10cm soil moisture anomaly

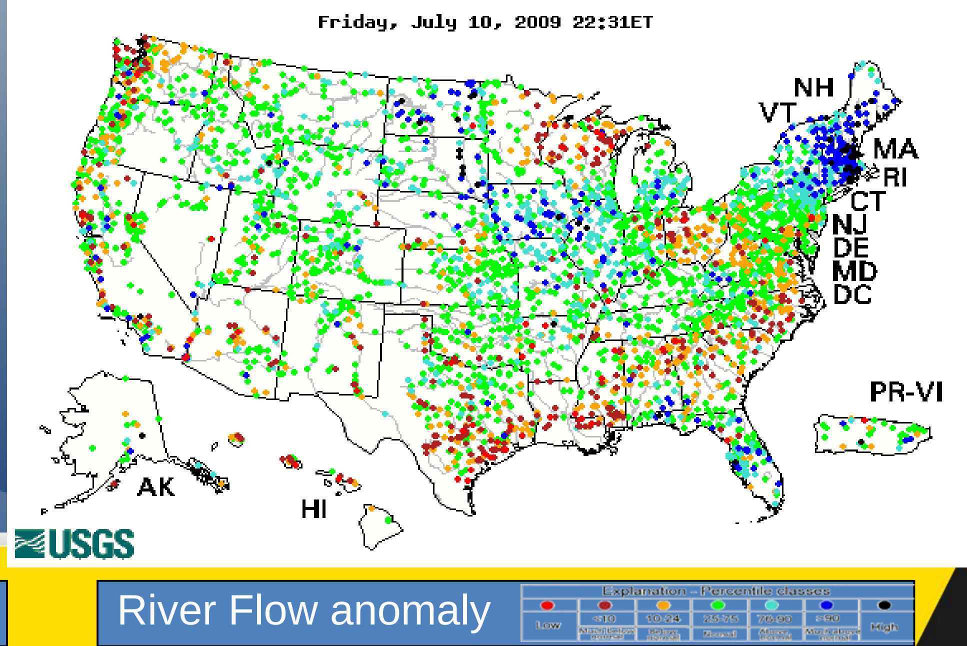


ASCAT surface soil wetness anomaly





Test run: top 10cm soil moisture anomaly

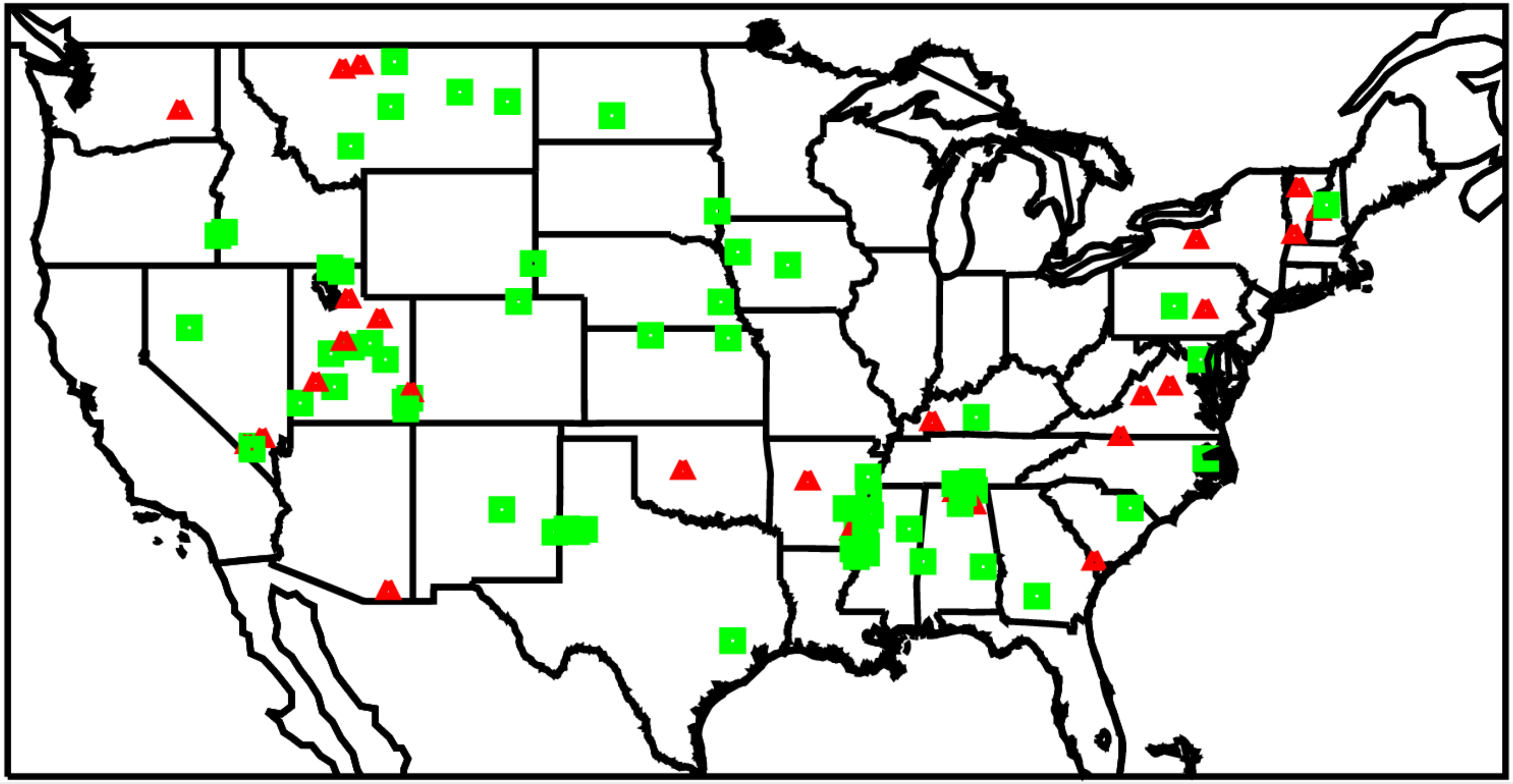


River Flow anomaly

ASSIMILATION OF ASCAT SOIL WETNESS IMPROVES VERIFICATION AGAINST GROUND BASED SOIL MOISTURE MEASUREMENTS

□ Reduction in random errors (Better)

△ Increase in random errors (Worse)



Data Assimilation Can Extract the Maximum Amount of Useful Information from Observations

- Satellite systems provide national coverage, but:
  - Satellite data is prone to biases and corruption and can therefore contain large errors
  - Satellite data contain large spatial and temporal gaps
- It is essential to quality control and bias correct the satellite data
- Data assimilation can filter the random errors in the measurements and fill in both the spatial and temporal gaps

Expected Benefits

✓ **Far improved versions of the operational systems** emergency planners are already familiar with.

✓ The outputs will **improve Australia's ability to manage multiple hazard types** and create a more resilient community, **by developing a state of the art, world's best practice in soil moisture analysis** that underpins flood, fire and heatwave forecasting.

✓ Longer term work will **use multiple-models and optimal data analysis to forecast soil dryness indices for operational fire, flood and heat wave applications.** The vegetation and soil parameterisations in models will be developed to match Australian conditions.

End User Comments

Gary Featherston, Australasian Fire and Emergency Services Authority Council

Knowing the underlying soil moisture is critical in determining fire behaviour and fire danger. This project has the right mix of underpinning science and operational application. The improved soil moisture estimation processes based on models and data assimilation will provide fire agencies nationally with the tool to monitor and predict the moisture content of bushfire fuels. This is pivotal to the application of the revised National Fire Danger Rating system.

Paul Fox-Hughes, Severe Weather Section, Hobart, Bureau of Meteorology

This project stands to contribute some very substantial benefits for emergency and land managers, both directly, through better assessments of soil moisture across the landscape, and Indirectly, by improving the quality of weather and other environmental forecasts. The progress to date has been very encouraging and highlights the advantages of this work, with improved soil moisture estimates already demonstrated.

Rob Sandford, Director State Operations, SA Country Fire Service

With a greater focus on improving community resilience through preparation and planning for bushfire events, this project will improve the accuracy of the likely impact and severity of fires on the community. The further benefits for other hazards including flood and heatwave will again allow the development of greater community resilience and minimise the impacts of these events.

Australian Government
Bureau of Meteorology

Imtiaz Dharssi

Email: i.dharssi@bom.gov.au
Web: http://www.cawcr.gov.au/staff/idharss/

QUESTIONS?