Evaluation and calibration of a land surface model based soil moisture analysis for fire prediction
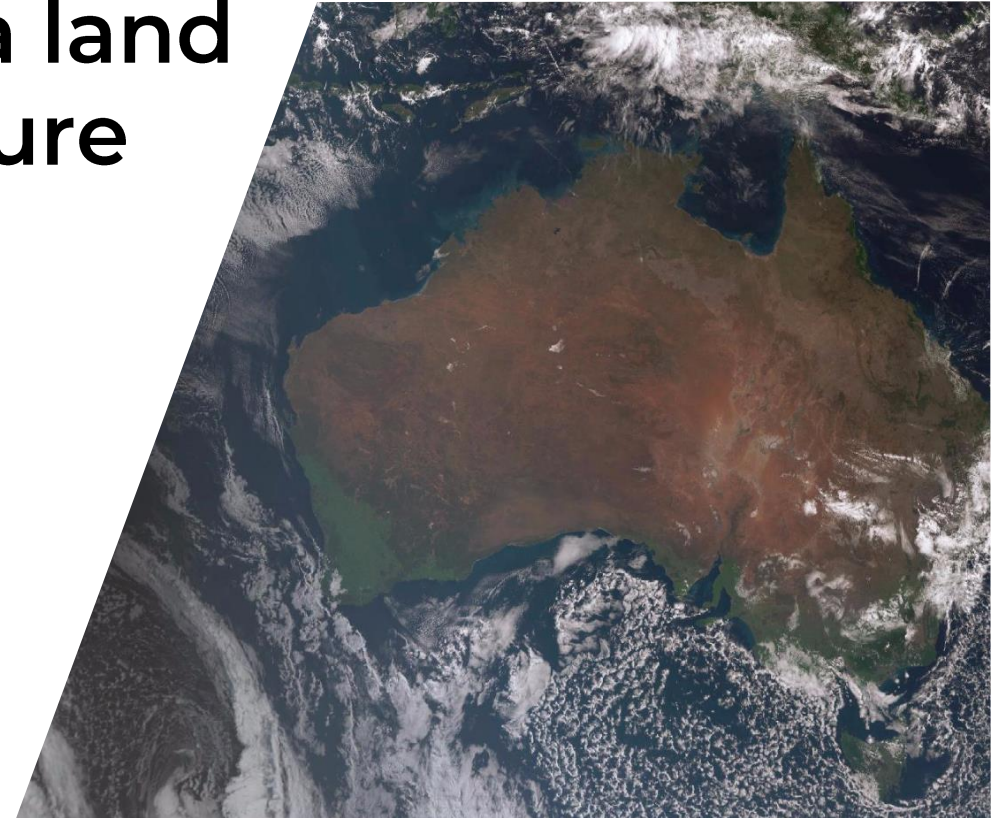
AFAC Research forum / **2018**

Dr Vinod Kumar / Bureau of Meteorology

Dr Imtiaz Dharssi / Bureau of Meteorology

Dr Paul Fox-Hughes / Bureau of Meteorology

@bnhcrc   @bnhcrc

bushfire&natural
HAZARDSCRC

Australian Government
**Department of Industry,
Innovation and Science**

Business
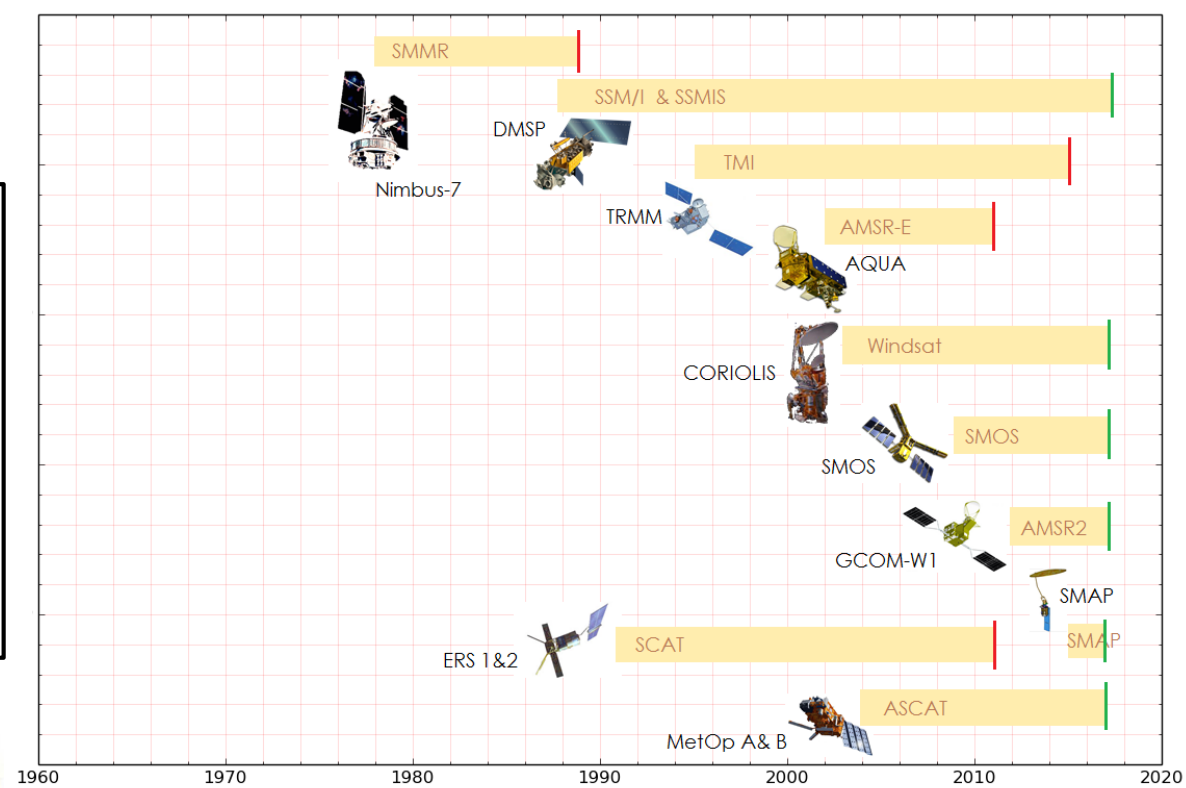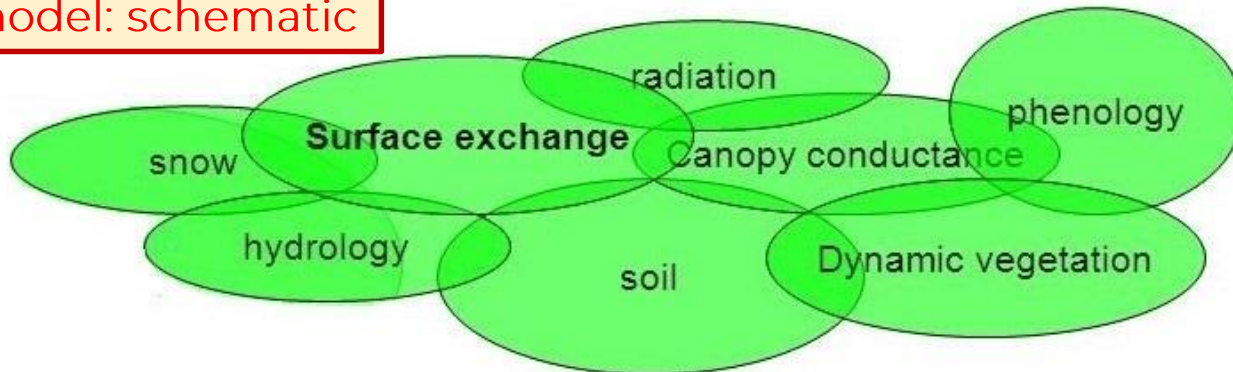Cooperative Research
Centres Programme

Background

- Soil moisture is used as a tool to assess flammability.

- Often estimated as soil moisture deficits using drought indices (e.g. KBDI, SDI).

- KBDI/SDI are simple, empirical methods.

Precipitation LW, SW, Wind, T, q, P

Ancillary Data
Soil texture, vegetation type, topography, etc.

Data Assimilation

Land surface model: schematic

Surface exchange
snow
radiation
Canopy conductance
phenology
hydrology
soil
Dynamic vegetation

Soil moisture remote sensing from space

- Great scientific advances in soil moisture science in last two decades.

- Advances in microwave remote-sensing.

- Emergence of land surface models with solid physics basis.

JASMIN

JULES based Australian Soil Moisture INformation

- **JULES: Joint UK Land Environment Simulator**

  - Physics based land surface model.
  - Used in BoM's weather and seasonal forecasting models.
  - In active development
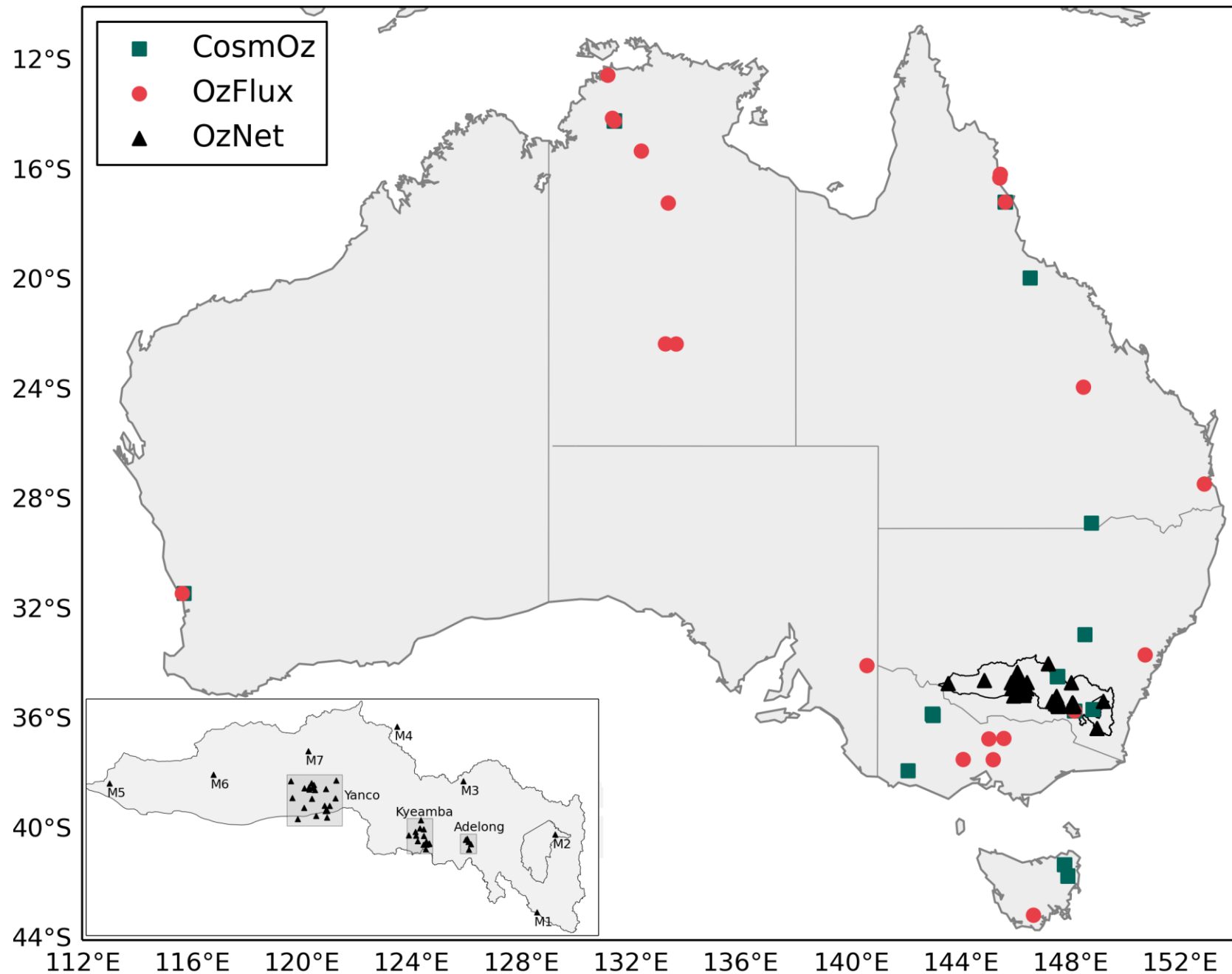
- **JASMIN**

  - High resolution (5 km).
  - Hourly time step.
  - 4 soil layers.
  - 0–10; 10–35; 35–100; 100–300 (in cm)
  - Data from 2010 onwards.
  - Can assimilate satellite data.

Ground observation networks

Courtesy: OzFlux, CosmOz & OzNet

Calperum, SA

JASMIN follows observations better!

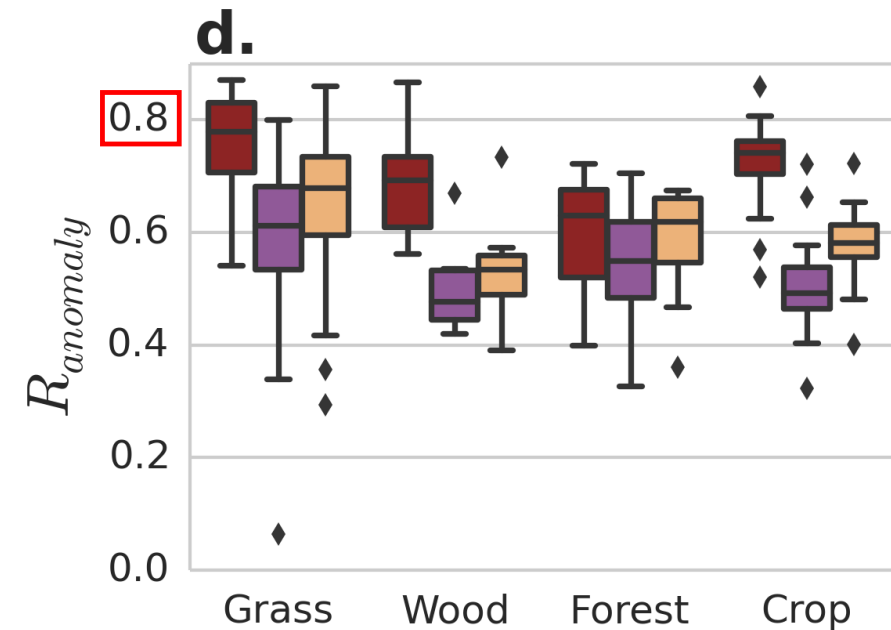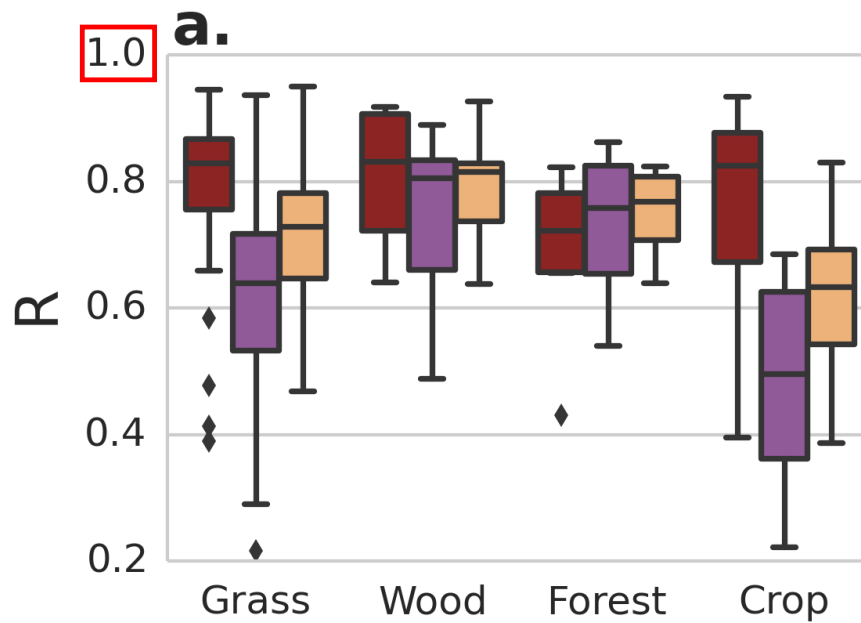| Model	R	Bias	ubRMSD	$R_{anomaly}$
JASMIN	0.76	0.00	0.12	0.76
KBDI	0.27	-0.22	0.24	0.56
SDI	0.58	-0.12	0.15	0.63

Courtesy: TERN

Normalized soil moisture
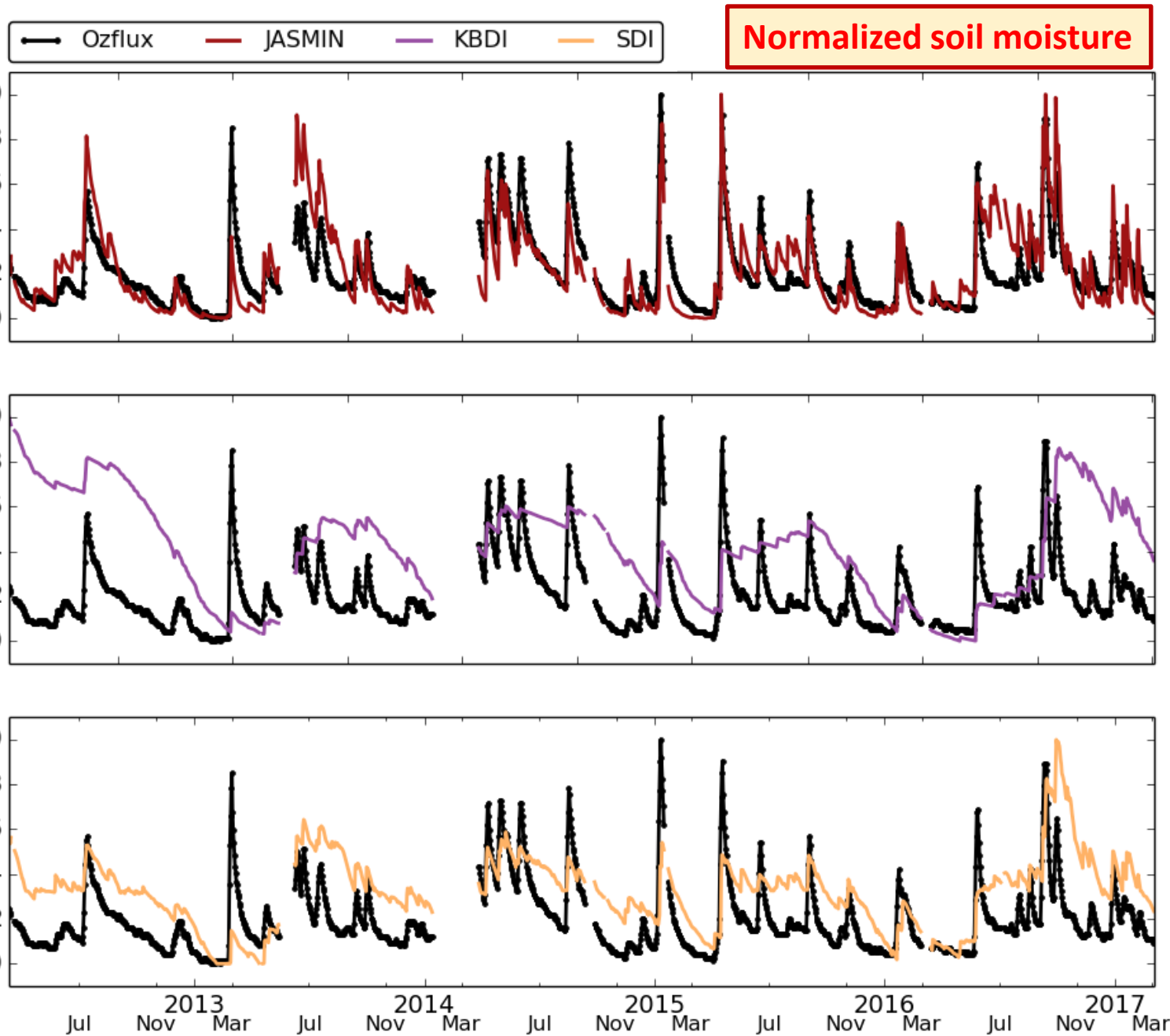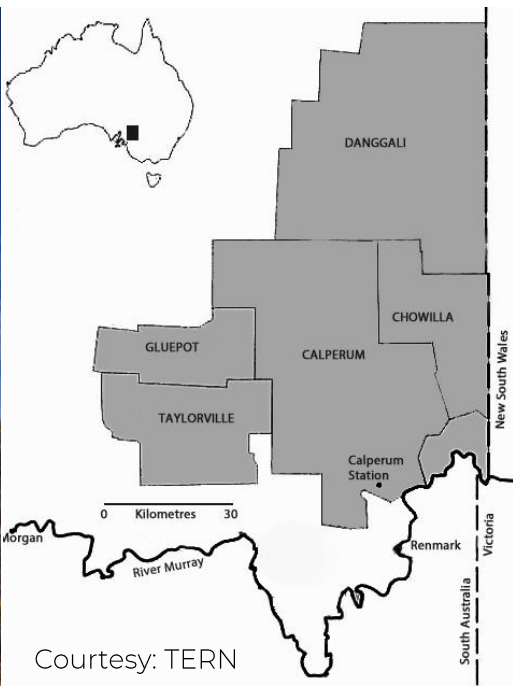
Skill break-up

JASMIN consistently good!

Number of sites under:
- Cropland =12,
- Forest = 12,
- Woodland = 9,
- Grassland = 27

	JASMIN
	KBDI
	SDI

Bias:
-ve = wet bias
+ve = dry bias

a. R — boxplots for Grass, Wood, Forest, Crop (JASMIN, KBDI, SDI); y-axis from 0.2 to 1.0

b. $ubRMSD$ [-] — boxplots for Grass, Wood, Forest, Crop; y-axis from 0.05 to 0.35

c. Bias [-] — boxplots for Grass, Wood, Forest, Crop; y-axis from -0.8 to 0.4

d. $R_{anomaly}$ — boxplots for Grass, Wood, Forest, Crop; y-axis from 0.0 to 0.8
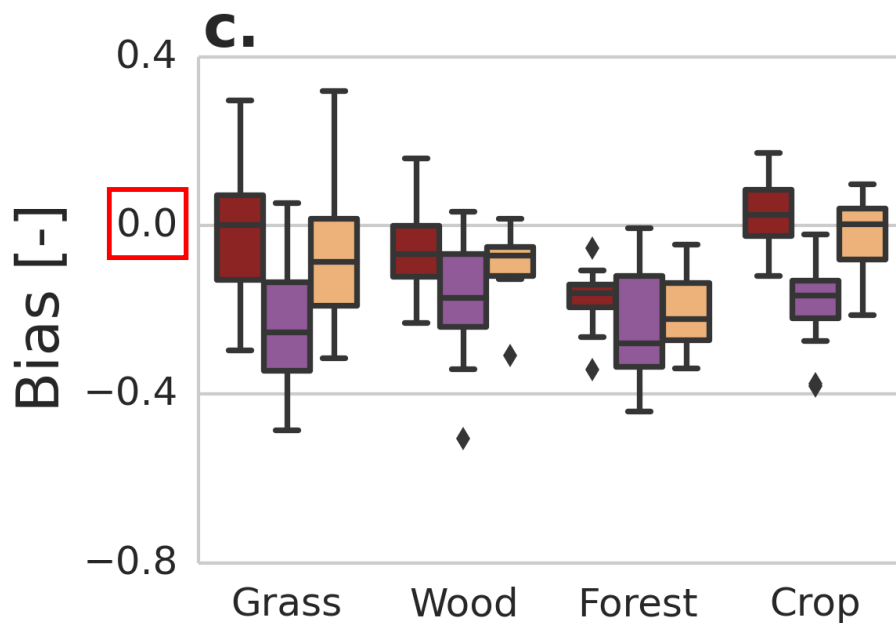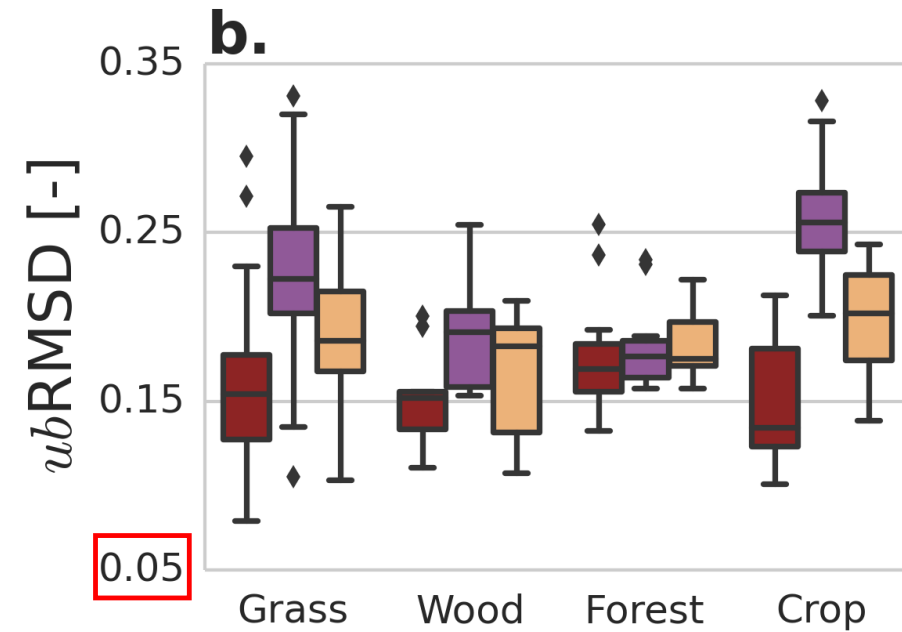
Calibration of JASMIN

For easier utilization of JASMIN

- Utilization of JASMIN in existing operational frameworks.
- Moisture content (Kg m^{-2}) → moisture deficit (0 – 200 mm).
- The calibration methods applied here are:
  - minimum-maximum (MM) matching,
  - mean-sd matching (μ–σ), and
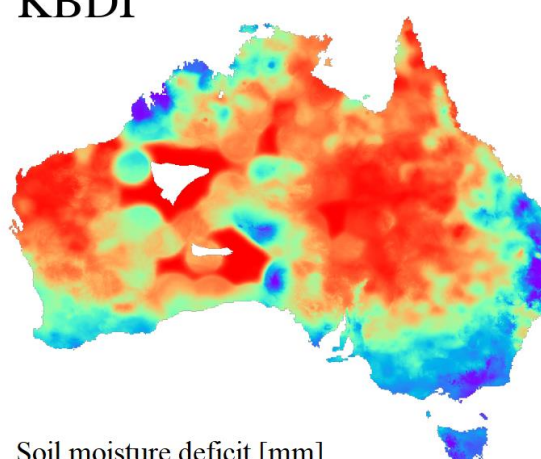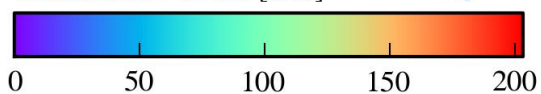 - cumulative distribution function (CDF) matching
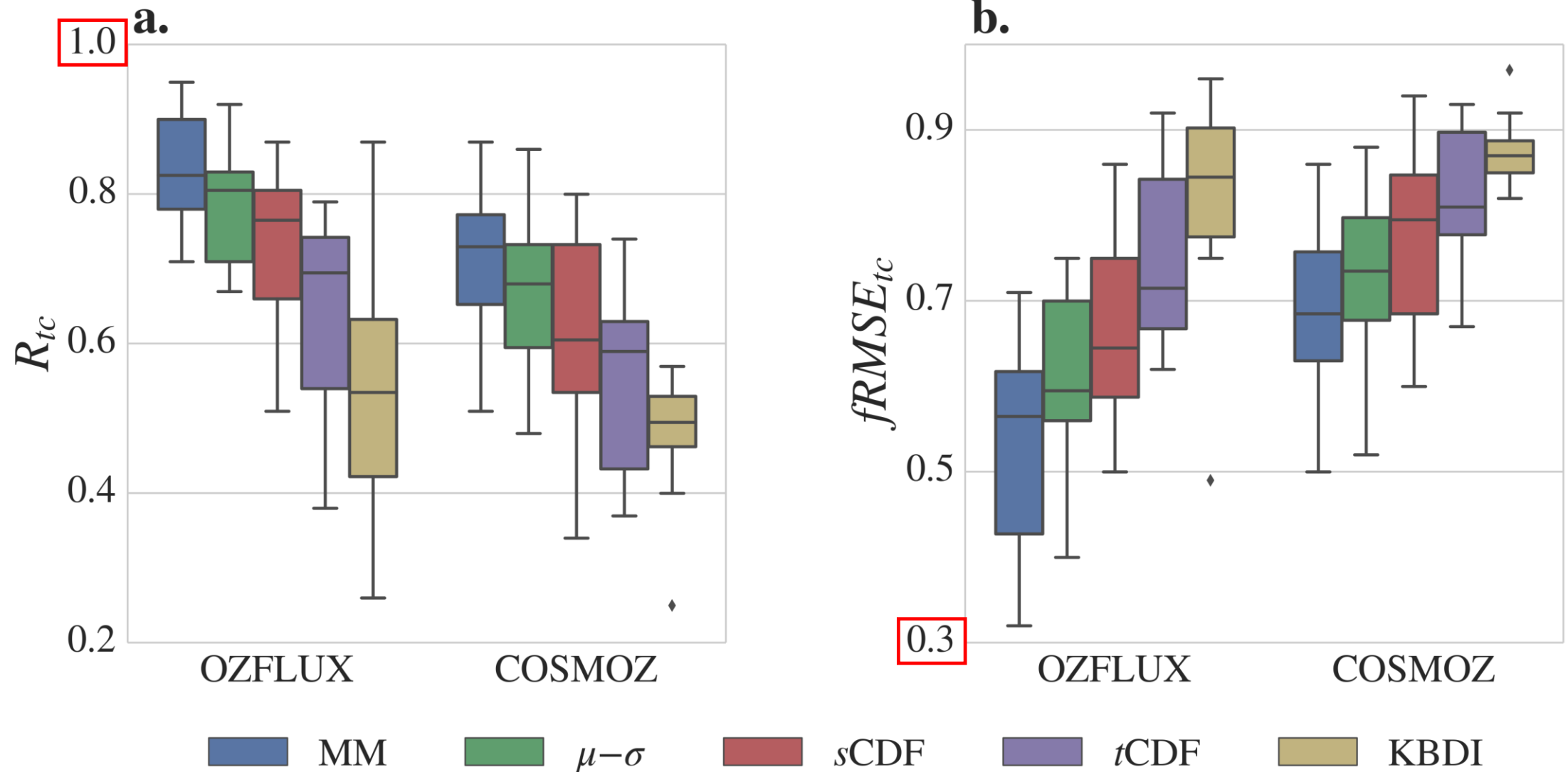
JASMIN   KBDI   CALIBRATED
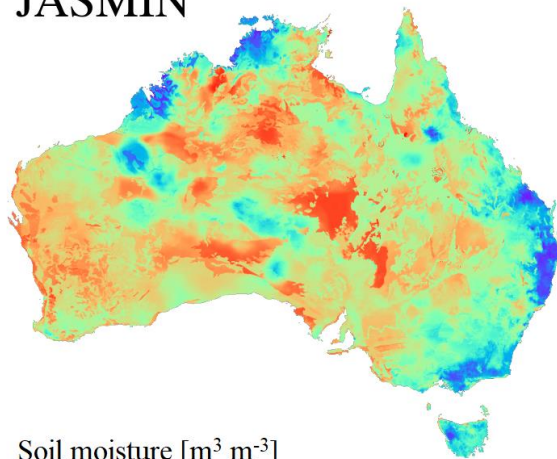
Soil moisture [m³ m⁻³]

0.1   0.2   0.3   0.4

Soil moisture deficit [mm]

0   50   100   150   200
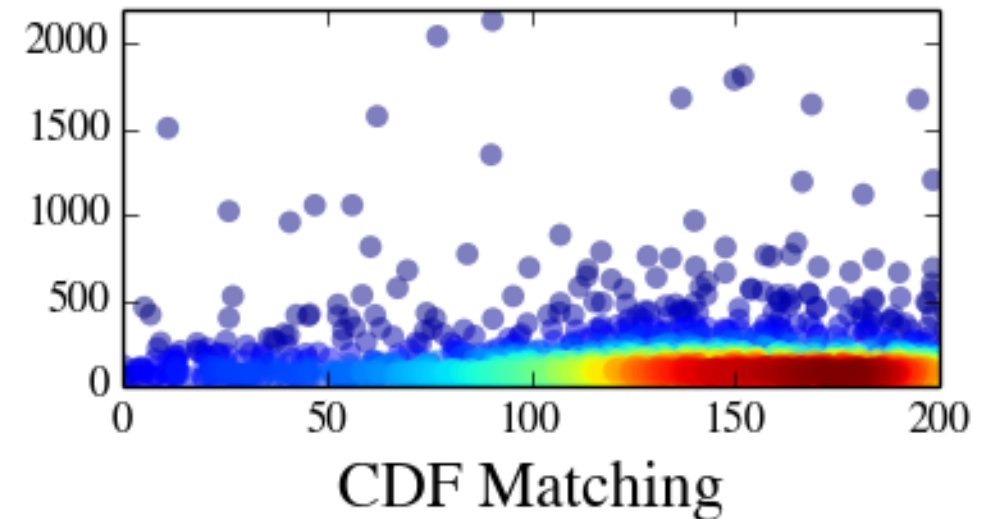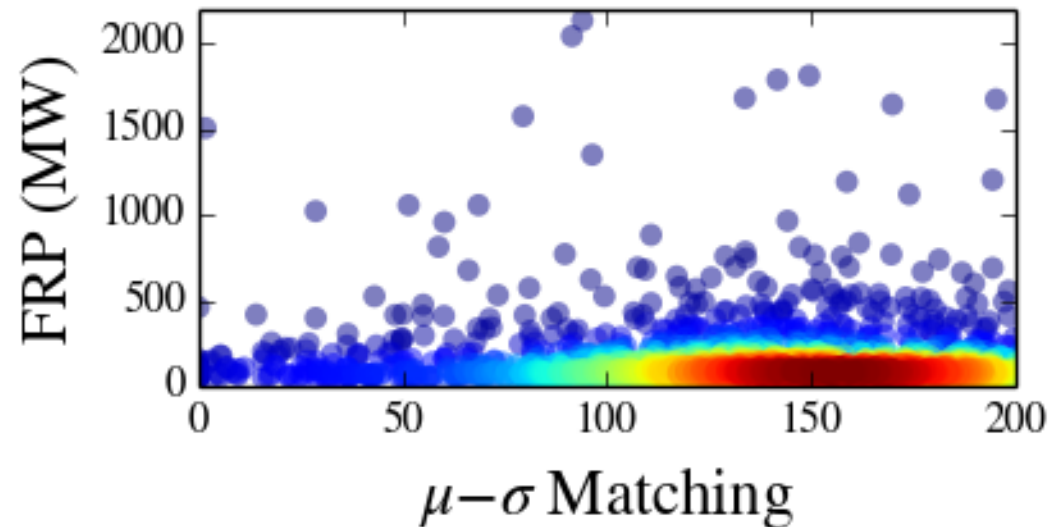
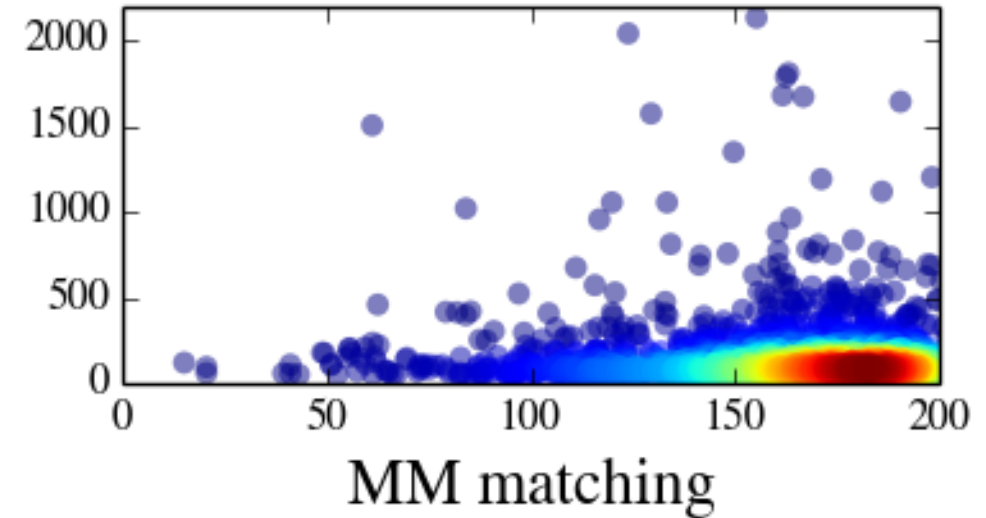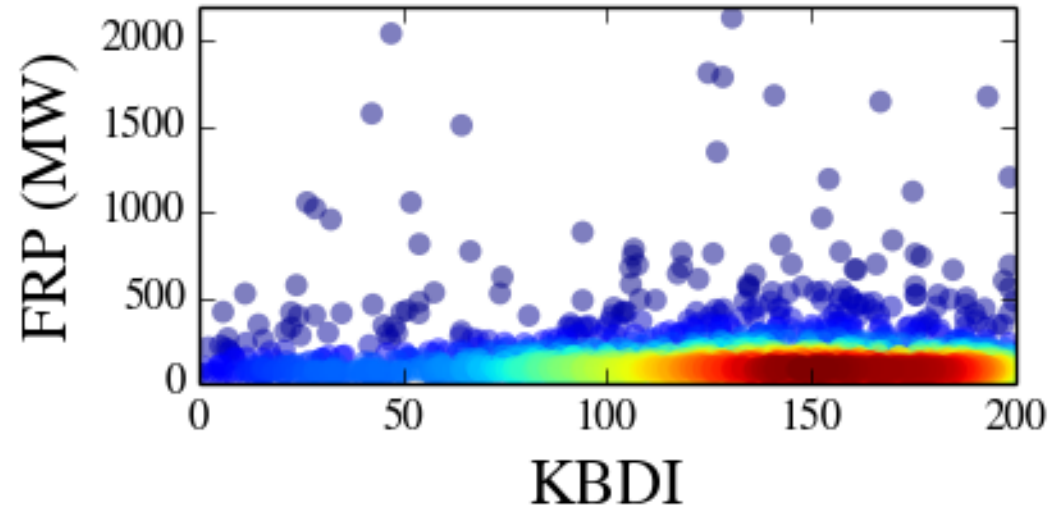Soil moisture deficit [mm]

0   50   100   150   200
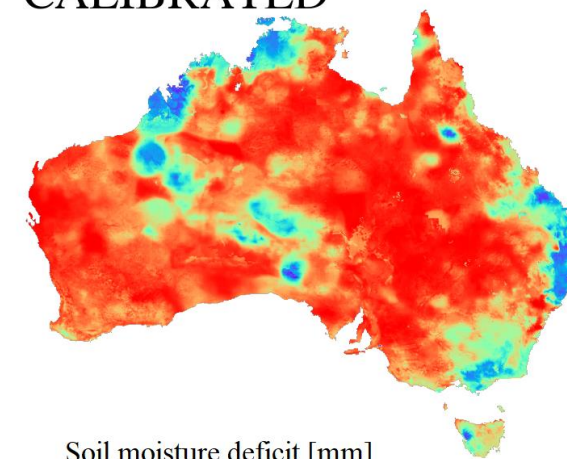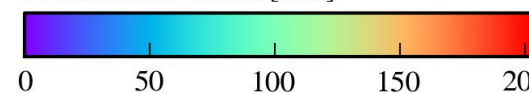
Verification of calibrated products
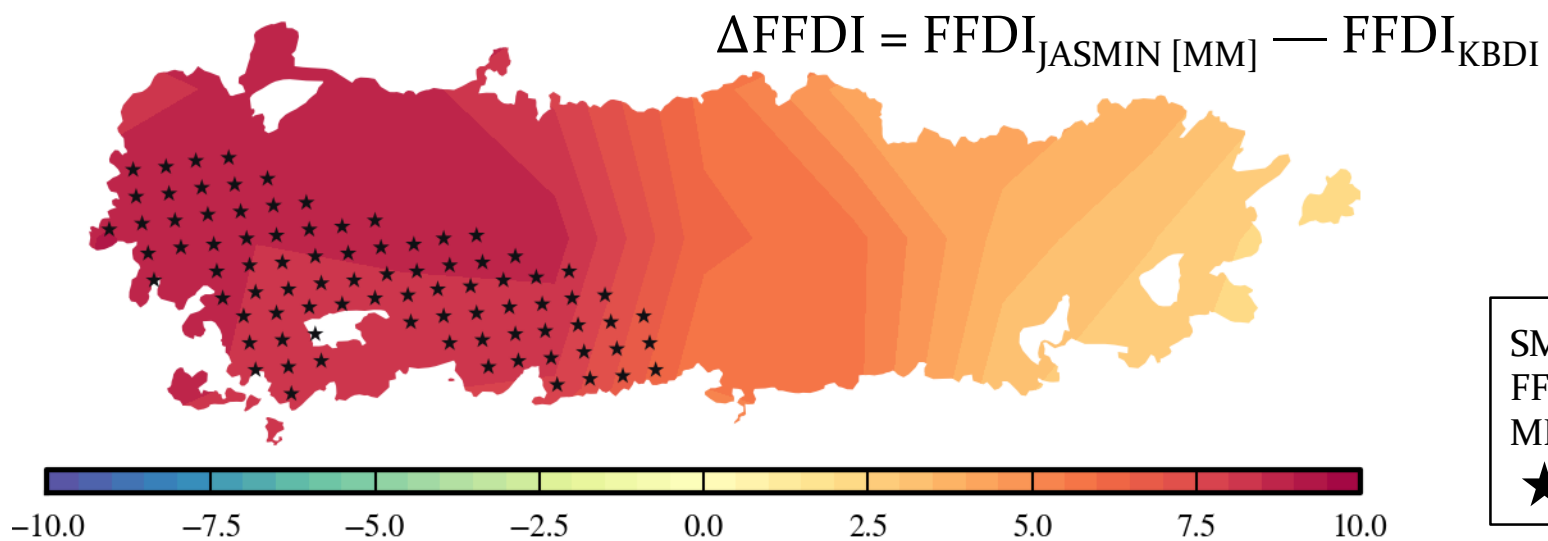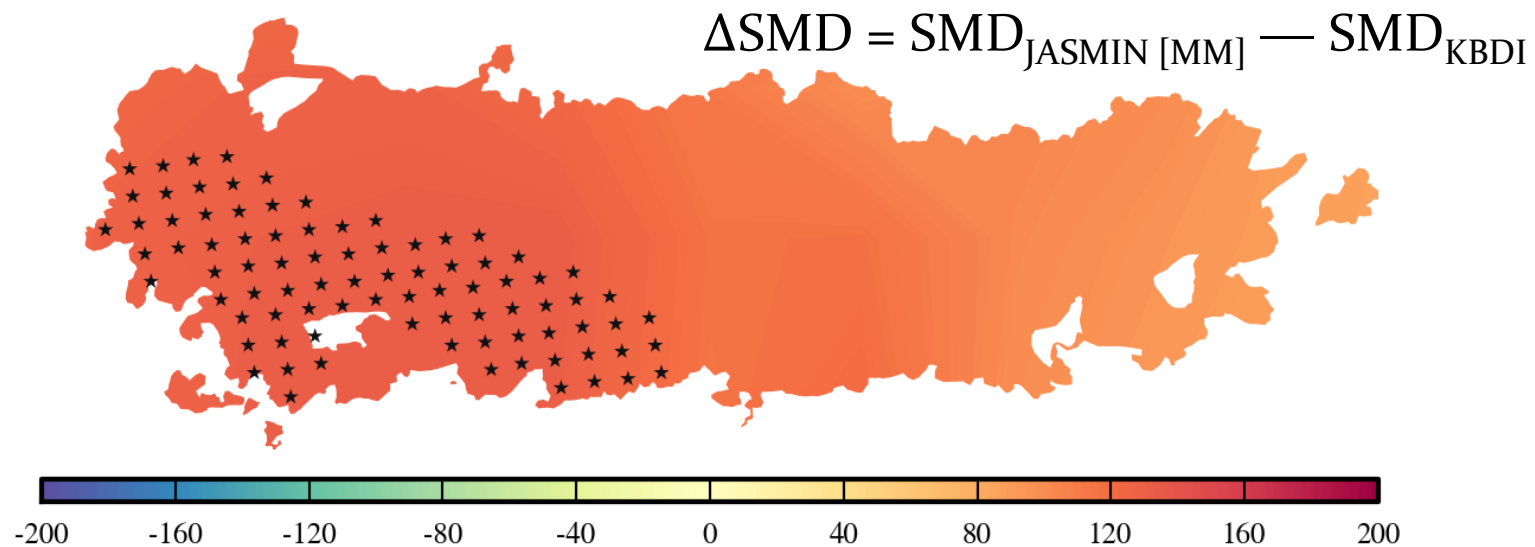
Min-Max (MM) approach give better skills.

Calibrated JASMIN vs MODIS FRP

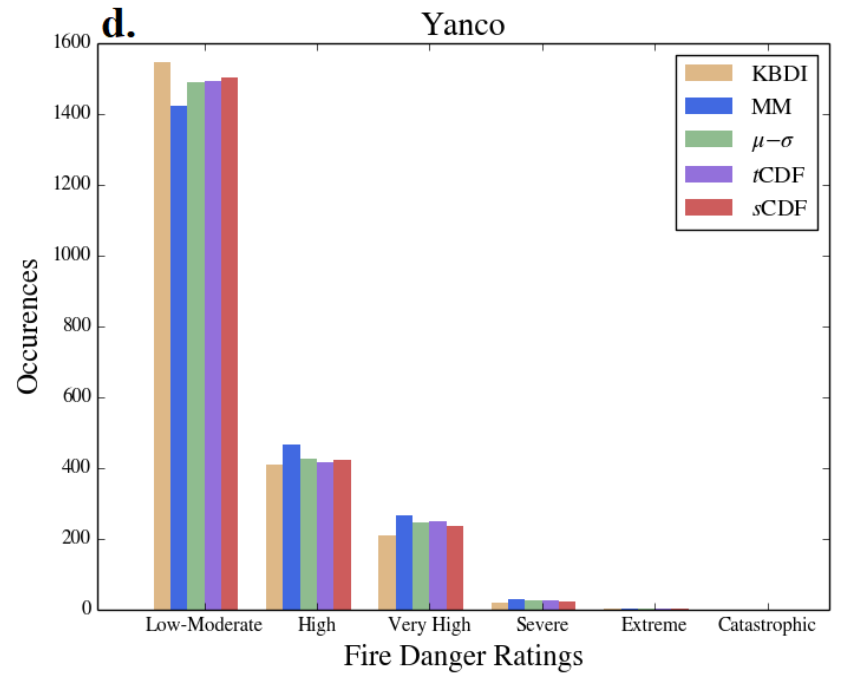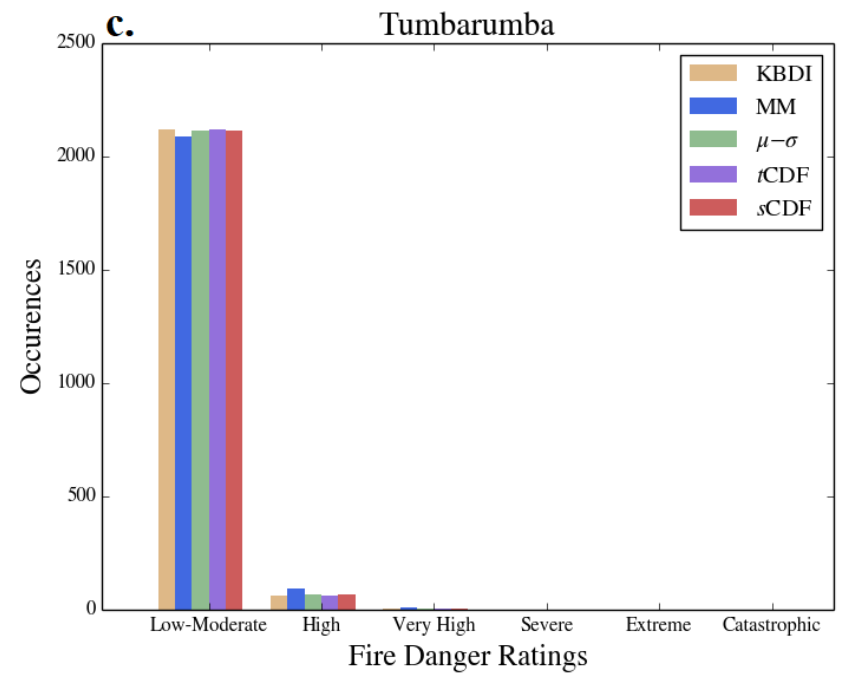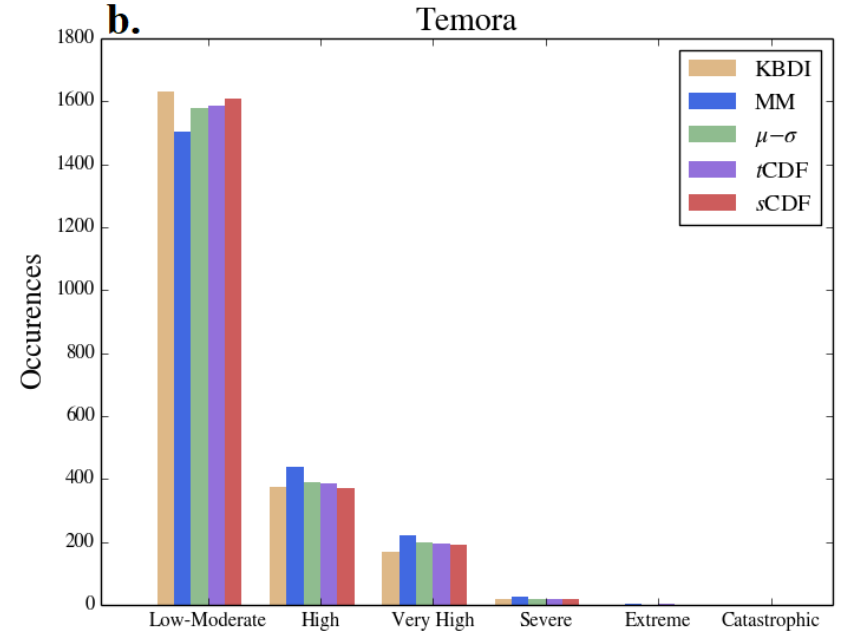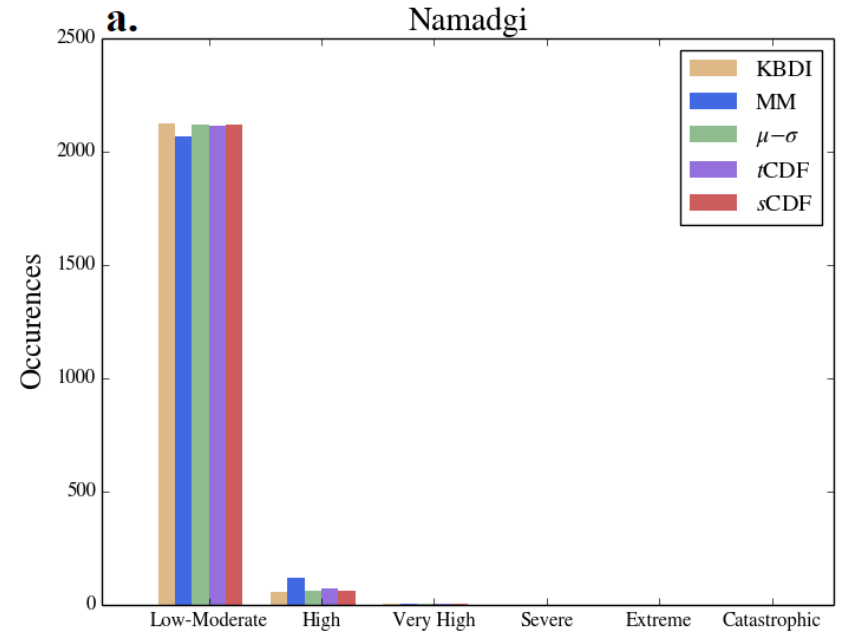Min-Max (MM) approach display the drier soils.

Case study

State Mine Fire, October 17th 2013

$$\Delta\text{SMD} = \text{SMD}_{\text{JASMIN [MM]}} - \text{SMD}_{\text{KBDI}}$$

$$\Delta\text{FFDI} = \text{FFDI}_{\text{JASMIN [MM]}} - \text{FFDI}_{\text{KBDI}}$$
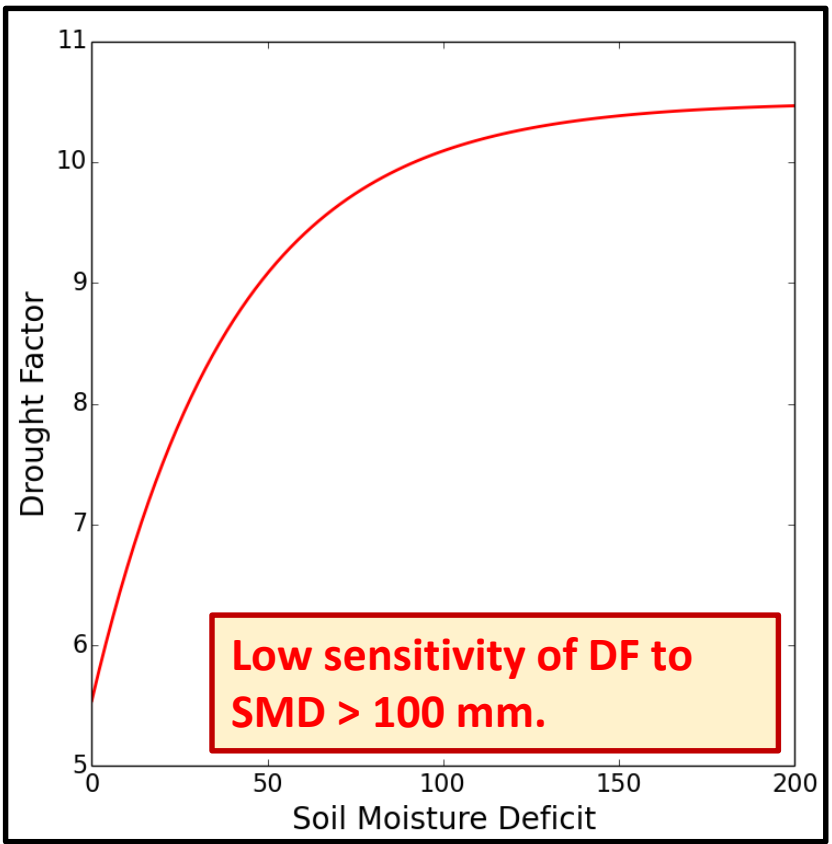

SMD = Soil Moisture Deficit
FFDI = Forest Fire Danger Index
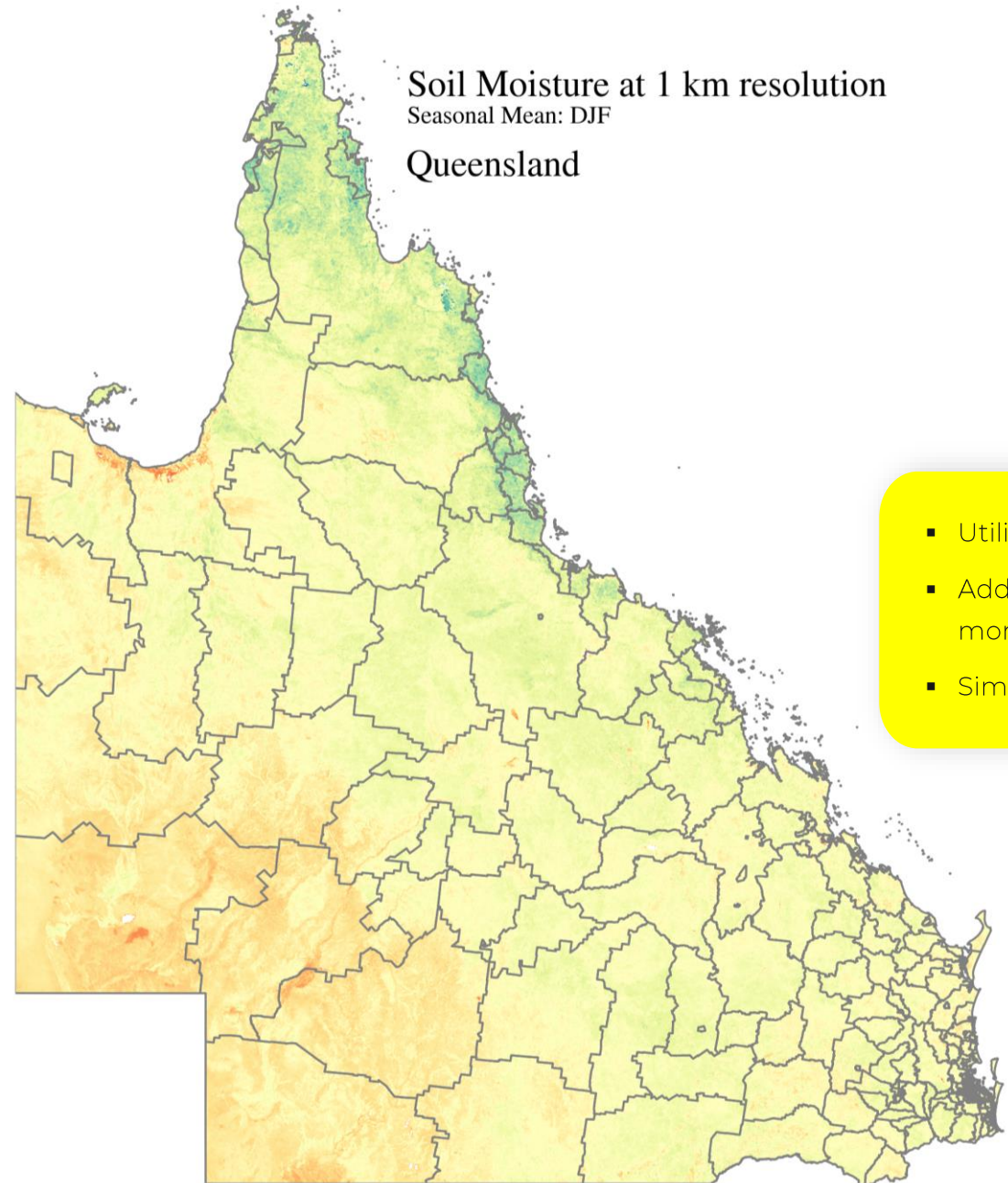MM = Minimum-Maximum Matching
★ = MODIS hot spots

FFDI sensitivity

Frequency Histograms

Low sensitivity of DF to SMD > 100 mm.

Soil Moisture at 1 km resolution
Seasonal Mean: DJF

Queensland

JASMIN

- High-resolution
- Better skill than traditional indices
- Can address gaps in existing methods (e.g., multiple soil layers).

Calibration of JASMIN
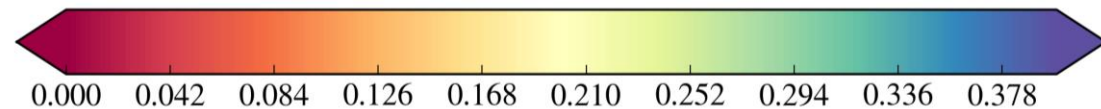
- Utilization strategy.
- Addresses immediate requirement for more accurate soil dryness product.
- Simple, faster and cost-effective.

Future plans

- JASMIN in the prototype National Fire Danger Rating System.
- JASMIN within NASA's Land Information System (LIS) framework.
- Downscale JASMIN product to 1 km.

0.000 0.042 0.084 0.126 0.168 0.210 0.252 0.294 0.336 0.378

Thank you

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