Assessing the soil moisture-precipitation feedback in Australia: CYGNSS observations

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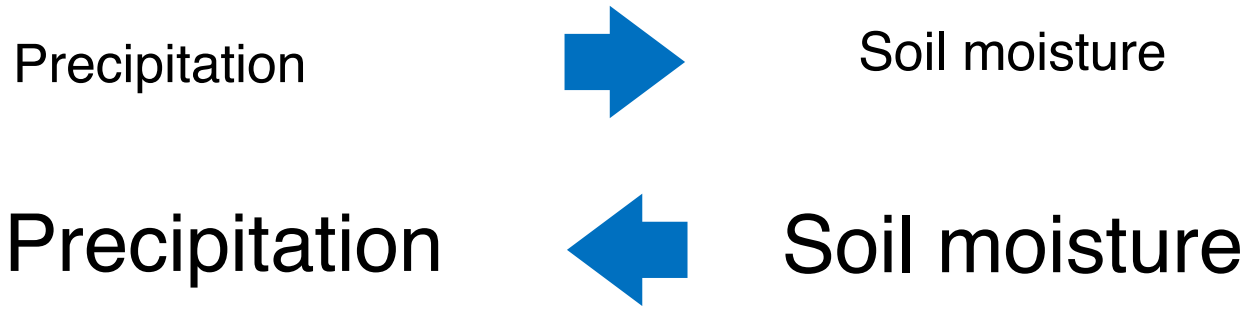
- Soil moisture: water content in surface soils, 0-5 cm depth
- Previous studies: impacts of soil moisture on drought, heatwaves, floods, ground water resources, …



Daily timescale: soil moisture vs. next-day precipitation
Feedback (positive/negative)
Persistence of dry/wet soil vs. extremes

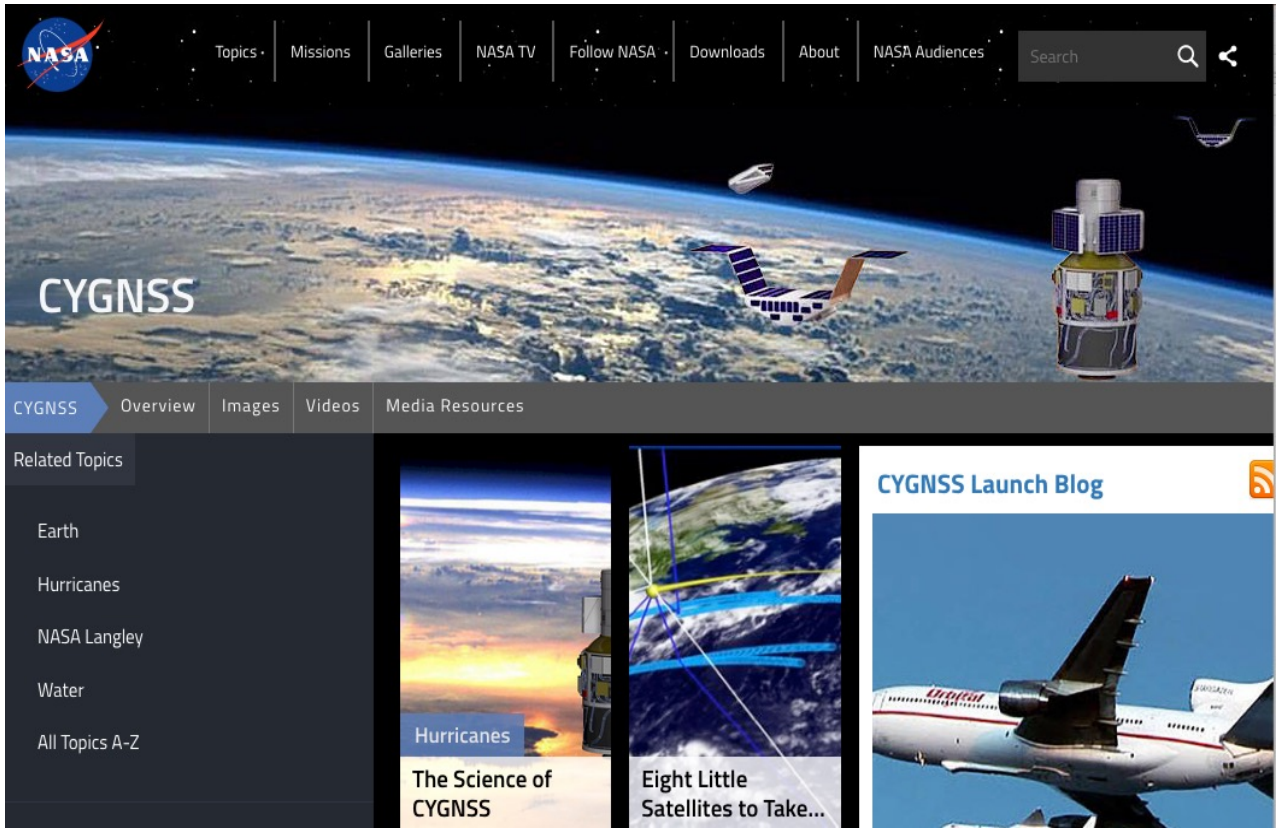
CYGNSS – Cyclone Global Navigation Satellite System

Launch date: 15 Dec 2016

Coverage: 38°S-38°N

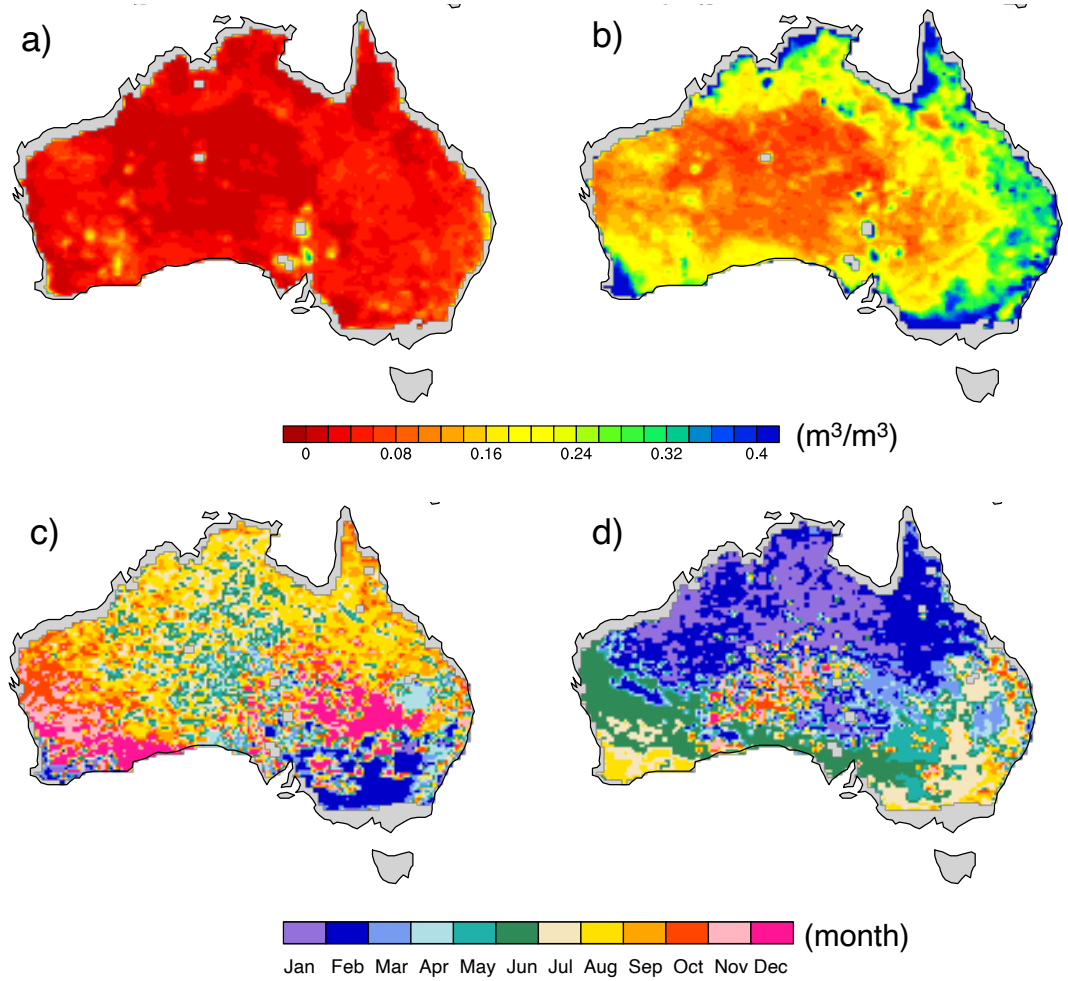
Advantages: Not affected by rainfall, high temporal and spatial resolution

Measurement: Ocean surface winds, Soil moisture, …



https://www.nasa.gov/cygnss

Spatiotemporal distribution of extreme soil moisture



Driest soil moisture:

Western desert region
Peak from July/August (north) to December/January (south)

Wettest soil moisture:

North and southeastern coast
Peak occurs in January/February (north) to later (south)

- Daily data from 1/2018 to 12/2022, 0.5x0.5 latitude-longitude grid

Relationship between soil moisture and next-day precipitation

❖ Multiple linear regression models

Today precipitation

Yesterday precipitation

Model 1
(restricted model)

$$P_{day-0} = a_1 \times P_{day-1} + b_1$$

Model 2
(full model)

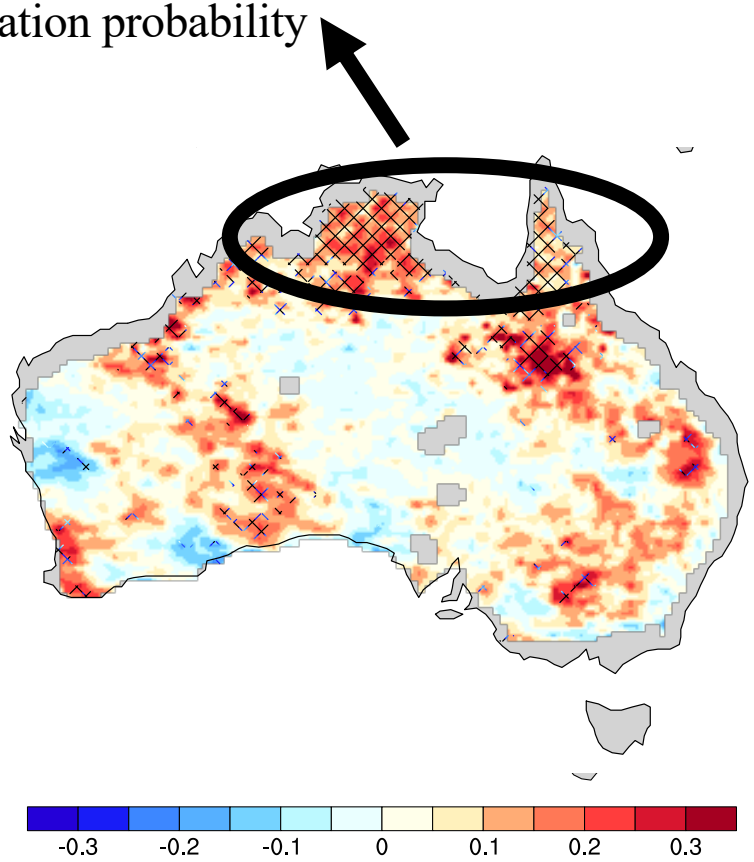
$$P_{day-0} = a_2 \times P_{day-1} + b_2 \times S_{day-1} + c$$

Yesterday soil moisture

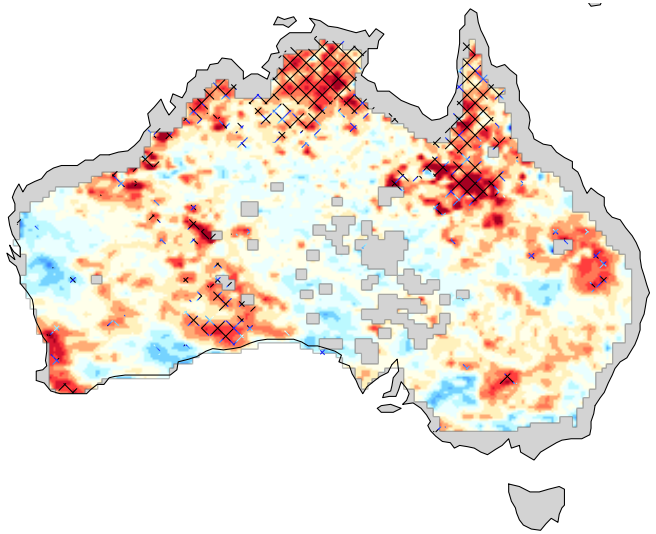
❖ Lagged precipitation to represent the persistence of precipitation affecting precipitation occurrence

Relationship between soil moisture and next-day precipitation

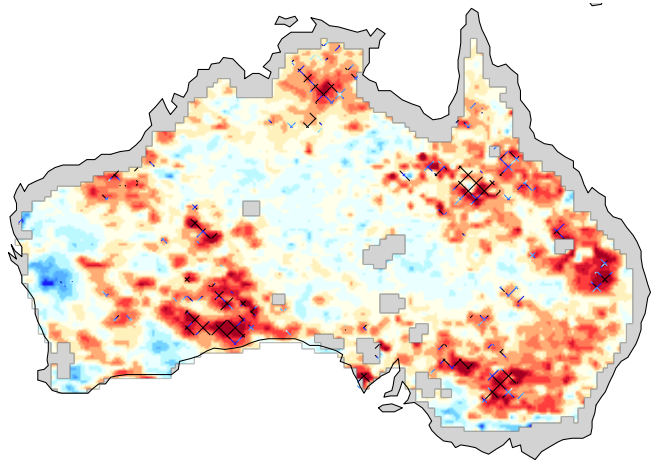
The inclusion of soil moisture increased the predicted precipitation probability



Non-monsoon (May-Oct)



Monsoon (Nov-Apr)

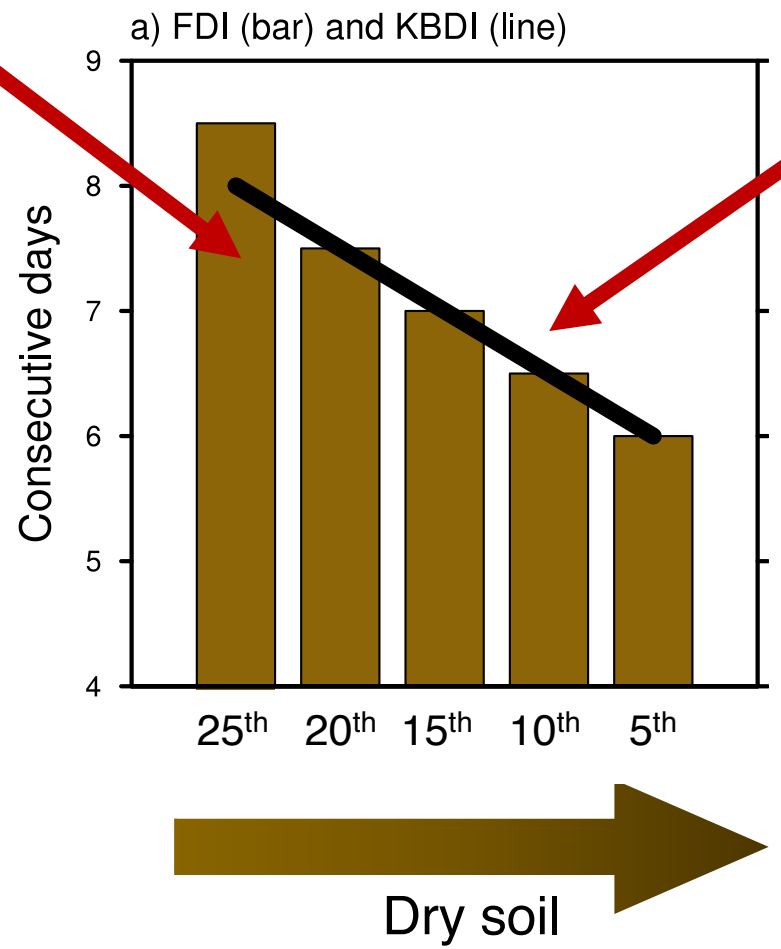


❖ Cross-hatching indicates the significant non-zero regression coefficient of the previous day's soil moisture ($p<0.1$)

How long the dry soil conditions must persist before a drought/fire starts?

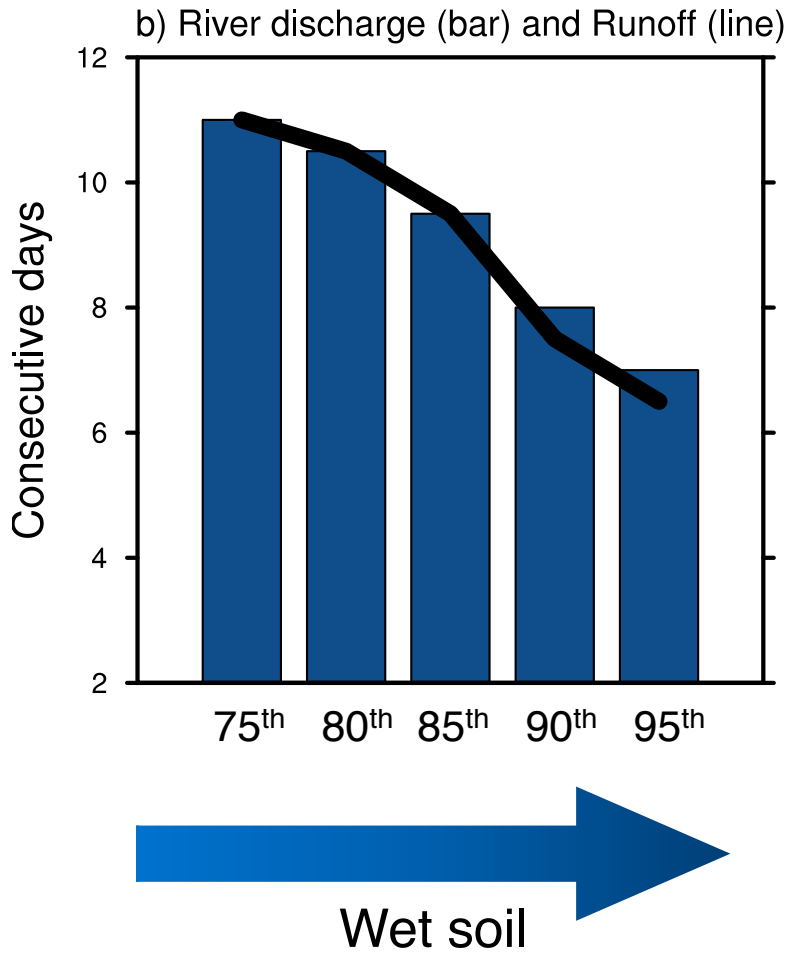
The McArthur Mark 5 Forest Fire Danger Index (FDI)
(air temperature, relative humidity, wind speed, and drought effects)

The Keetch-Byram Drought Index (KBDI)
(precipitation and maximum temperature)



❖ Domain: northern Australia (north of 18°S)

How long the wet soil conditions must persist before a flood starts?



CAVEATS

- Depending on satellite precipitation data quality and incur the attendant errors and biases
- Did not include other meteorological information (e.g., humidity, wind, …)
- Diurnal cycle
- Other climate modes (ENSO, IOD, MJO, …)

❖ Global Flood Awareness System

Conclusions

- CYGNSS soil moisture is used to study the soil moisture-precipitation feedback in Australia
- Positive feedback between soil moisture and next-day precipitation occurs over northern Australia during the non-monsoon period
- More persistent regional dry or wet soil moisture conditions further increase wildfire or flood probabilities

Thank you!