Identifying Predictors of Rapid Intensification Droughts

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What are Rapid Intensification Droughts?

Rapid intensification droughts or 'flash droughts' occur when regular drought conditions rapidly intensify. Drier-than-normal conditions transform into severe or extreme drought **over timescales of weeks to months** because of factors such as deficits in precipitation, high temperatures, low humidity, strong winds and clear skies.

These conditions make the air 'thirsty', leading to '**increased evaporative demand**'. More water evaporates from the surface and transpires from plants, leading to **rapid depletion of soil moisture**. This causes rapid wilting of vegetation and often has a major impact on agriculture.

These events impact agriculture, livestock, economy, water utilities, aquatic life, hydro-electric supplies, etc.

While sufficient literature exist on identification and monitoring of flash droughts, the physical processes governing these events are still not well understood.

Study Region

Four catchments from across Australia, viz., the Murrumbidgee river catchment (33-37°S, 143-150°E), Swan Coast Avon river catchment (29-34°S, 115-122°E), Richmond river catchment (28-30°S, 152-154°E), Daly river catchment (13-16°S, 129-131°E).

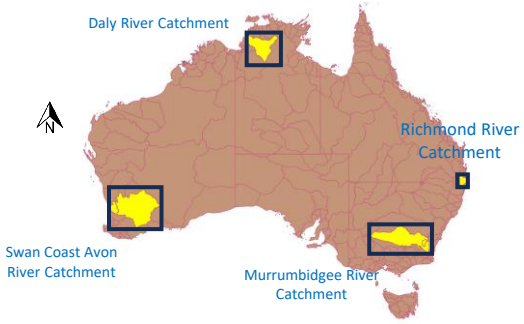

Figure 1: Location of the four catchments used for the study.

Period of study:

1990-2018 warm season (September to April)

Identification periods of rapid depletion in soil moisture

- Rapid intensification of drought conditions were identified using changes in percentiles of Root Zone Soil Moisture (RZSM).
- Daily percentiles of RZSM were averaged over pentads (5 days). Set of pentads for which this series goes from above 40th percentile to below 20th percentile in less than 4 pentads time were identified as periods of rapid intensification of drought conditions.

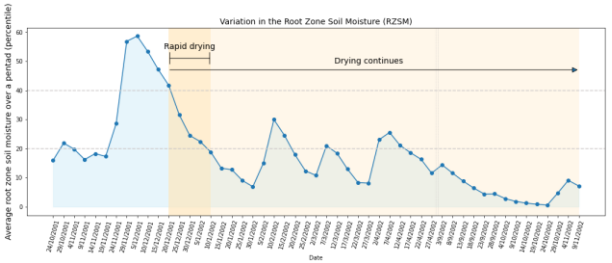

Figure 2: Variation of Root Zone Soil Moisture (RZSM) for a representative grid in the Richmond river catchment.

Random Forest model for identifying predictors of rapid drying

- A random forest model was built regressing the RZSM over rapid drying periods with data of 7 atmospheric variables for the same period as predictors.
- The 7 Predictors considered: Precipitation, Minimum Temperature, Maximum Temperature, Vapour Pressure Deficit, Actual Evapotranspiration, Potential Evapotranspiration, Average Temperature.
- Variable importance metric was estimated for each predictor to identify important processes controlling rapid drying

Data:

- 0.05 degree spatial resolution.
- RZSM, Precipitation, AET, PET: sourced from AURA-L.
- Daily RZSM, AET, PET: Data from AWRA-L.
- Daily precipitation, minimum and maximum air temperature: Data from site-based observation data recorded in the Australian Database for Meteorology and processed and interpolated.
- Daily VPD and average temperature: Data generated using the ANUClimate 2.0 model model.

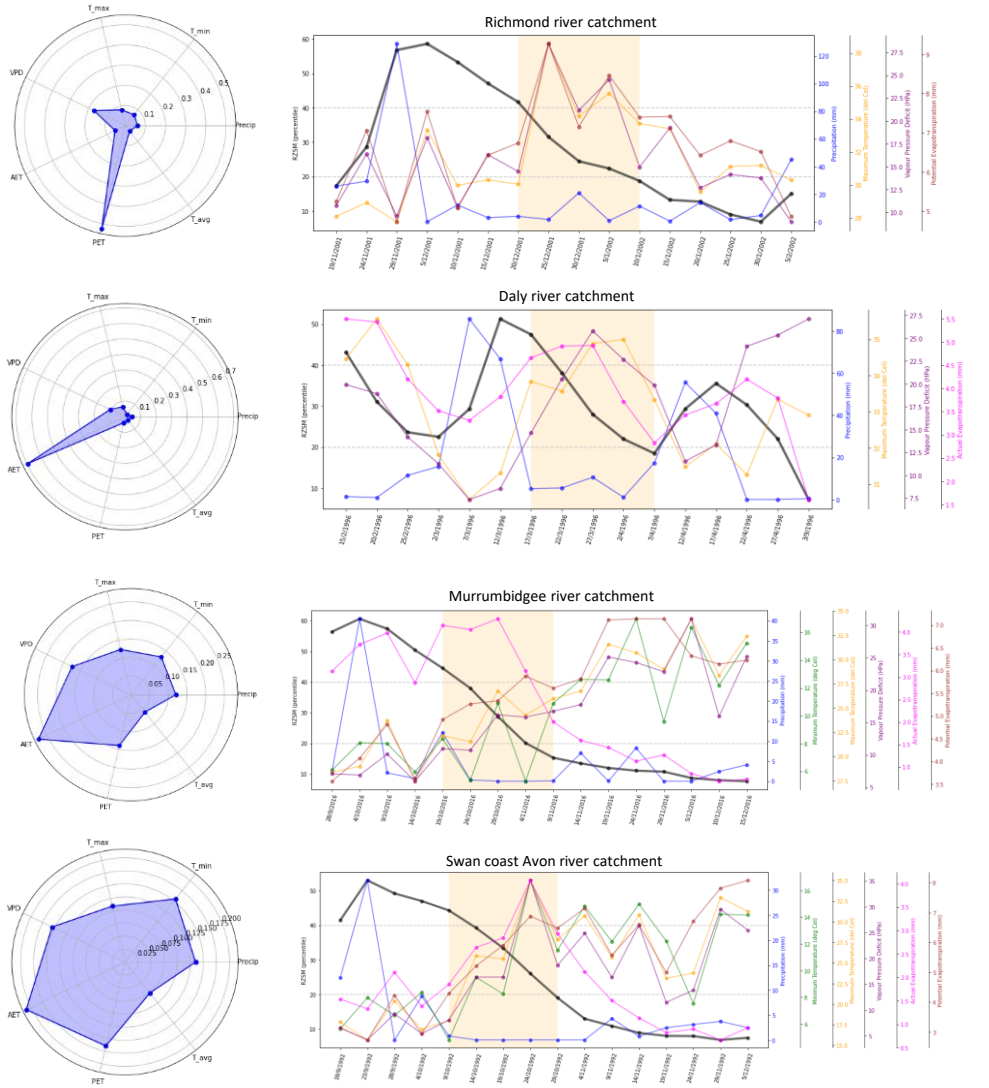

Figure 3: [Left] Predictor importance signifying relative importance of each predictor on a scale ranging from 0 to 1 and [Right] variation of RZSM with the important predictors for the rapid drying for the 4 catchments.

Conclusions

- Processes driving Flash Droughts vary across space.
- Vapour Pressure Deficit is an important driver of flash drought.
- Changes in evapotranspiration and the evaporative demand in conjunction with deficits in precipitation govern the rapid drying. These conditions rapidly cause the region to transition from being ***energy-limited*** to being ***water-limited***.