Shifts in Streamflow Regimes in Victorian Catchments under multi-year drought

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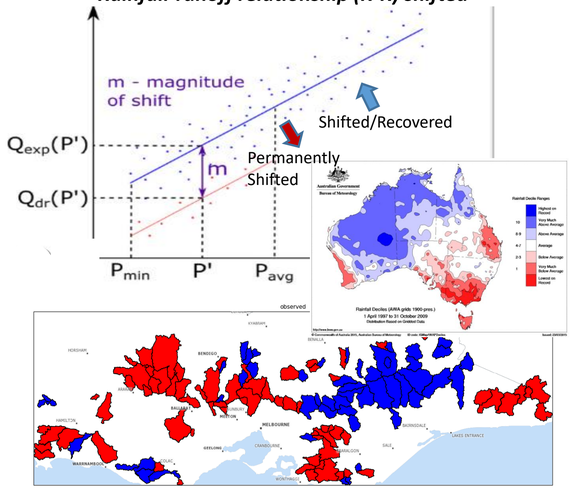
Background & Motivation

Recent multi-year Millennium Drought 1997-2009 affected South-East Australia. 13 years below average cool season rainfall led to strong decline in river flows.

The Millennium drought caused a notable shift in the relationship between rainfall and runoff. This shift resulted in reduced annual runoff for a given amount of annual rainfall when compared to the historical pattern. However, Impacts on streamflow behaviour itself is unclear under/after multi-year drought.

Rainfall-runoff relationship (R-R) shifted



Future climate projections across Victoria, Australia indicate considerable increases in dry days and length of dry spells. Therefore, it is important to understand where do runoff rates across Victoria have reduced due to prolonged drought and what are the reasons for the decline?

Objectives

Investigating the streamflow behaviour under/after drought condition:

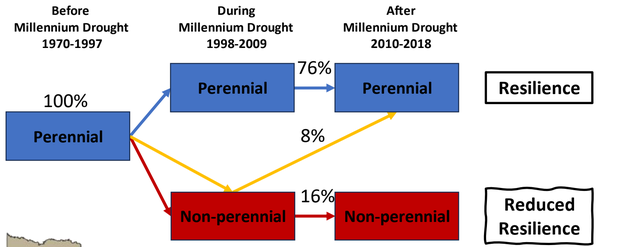
- *Where do runoff rates across Victoria have reduced and what are the reasons for the decline?*
- *Are some rivers types more resilient/vulnerable to drought than others? If so, why?*

Material and Methods

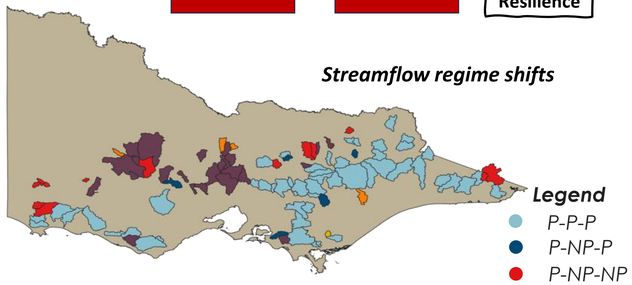
Number of no-flow days per year is affected by different flow characteristics and climate indicators (Sauquet et al, 2021).

We investigated streamflow regime changes using indicators that represent the magnitude, duration, frequency, variability, timing of streamflow under pre-, during and post-drought conditions (e.g., peak over threshold, min and mean flow, low flow deficit, extremes: number of days in top 5th.95th percentile, peak frequency, duration of dry spell etc.).

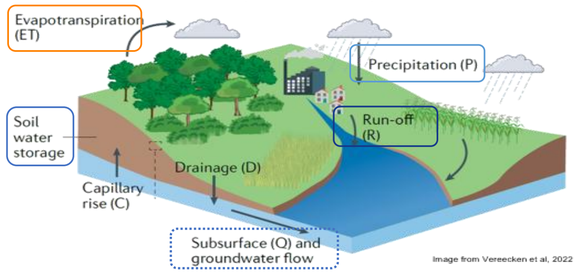
Hydrological Reference Sites (HRS) with perennial flow regime in Victoria



Streamflow regime shifts

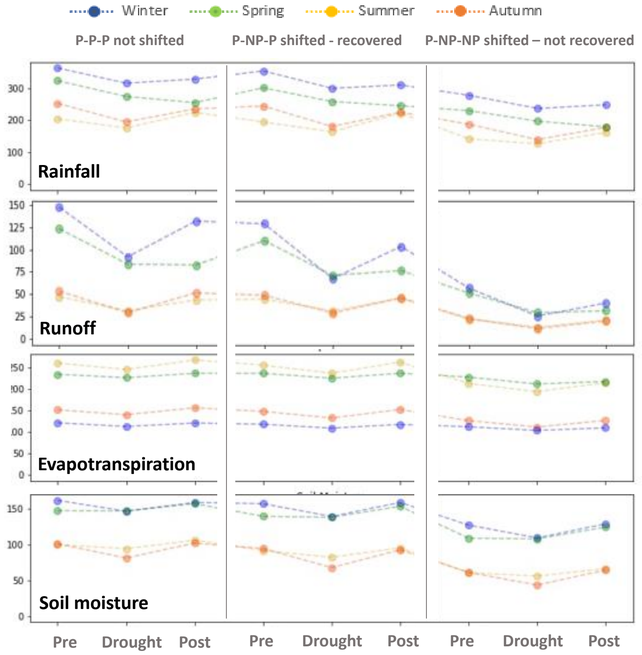


Linking streamflow regime shifts to landscape water component



Results

We explored the linkage between the streamflow regime shifts and water balance components modelled by AWRA-L landscape model.



Precipitation post drought

- *Winter & spring: below pre-drought*
- *Autumn: recovered to pre-drought*
- *Summer: higher than drought/pre-drought*

Runoff post drought

- *Spring: below drought/pre-drought*
- *Summer/autumn: recovered to pre-drought*
- *Winter: below drought*

- *Further explored streamflow percentages/characteristics*

Evapotranspiration

- *About similar levels.*
- *Except for*
  - *ET in summer lower in non-recovered catchments*
  - *Higher post-drought.*

Soil moisture

- *Recovered to pre-drought conditions*
  - *Higher in summer & spring*
  - *But does not leading to more runoff.*

Conclusions

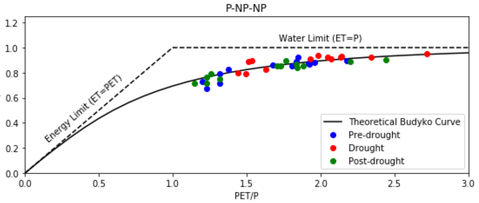
Shifted catchment broadly align with catchment in R-R change.

Controls of streamflow regime shifts during/post multi-year drought:

- Rainfall decline ~1/3 – 1/2 in all catchments, strongly reducing streamflow
  - Streamflow changes include both low and high flows
  - 17% of perennial catchments shifted to non-perennial flows
  - Shifted catchment broadly align with catchment in R-R change
- Near pre-drought rainfall recovery did not lead to full streamflow recovery
  - 12% of shifted catchments stayed non-perennial.

Vulnerability for streamflow regime shifts and non-recovery:

- Low mean annual rainfall and more no rainfall days
- Low runoff and longer durations of no flow events, more variable flows
- Evapotranspiration was not the key driver of streamflow regime shifts.



- Increased summer and autumn rainfall increased soil moisture store but did not lead to runoff.

Next Steps

- Catchment recovery processes and streamflow response after multi-year drought through sequencing water deficit propagation: water fluxes into ET, soil moisture and runoff water fluxes through lag times, frequencies & intensities of events.
- Surface and ground water interactions.
- Linkages to *Tolhurst et al 2023*: decrease in light and moderate precipitation, and an increase in heavy precipitation across Victoria since 1997.