Identifying mechanisms influencing non-stationarity in rainfall-runoff relationships in southeast Australia

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1. Motivation and objective

- Southeast Australia has experienced several multi-year droughts in the past century which led to changes in rainfall-runoff (R-R) relationships (Kiem et al. 2010; Saft et al. 2015)
- Hydrological models are unable to realistically simulate runoff during multi-year droughts (Saft et al. 2016)
- Past investigations into mechanisms causing non-stationarity in R-R relationships are limited to the annual scale (Ajami et al. 2017; Saft et al. 2015)

Aim: Identify the mechanisms which contribute to annual and seasonal scale non-stationarity in R-R relationships, especially during multi-year droughts

2. Study area and data

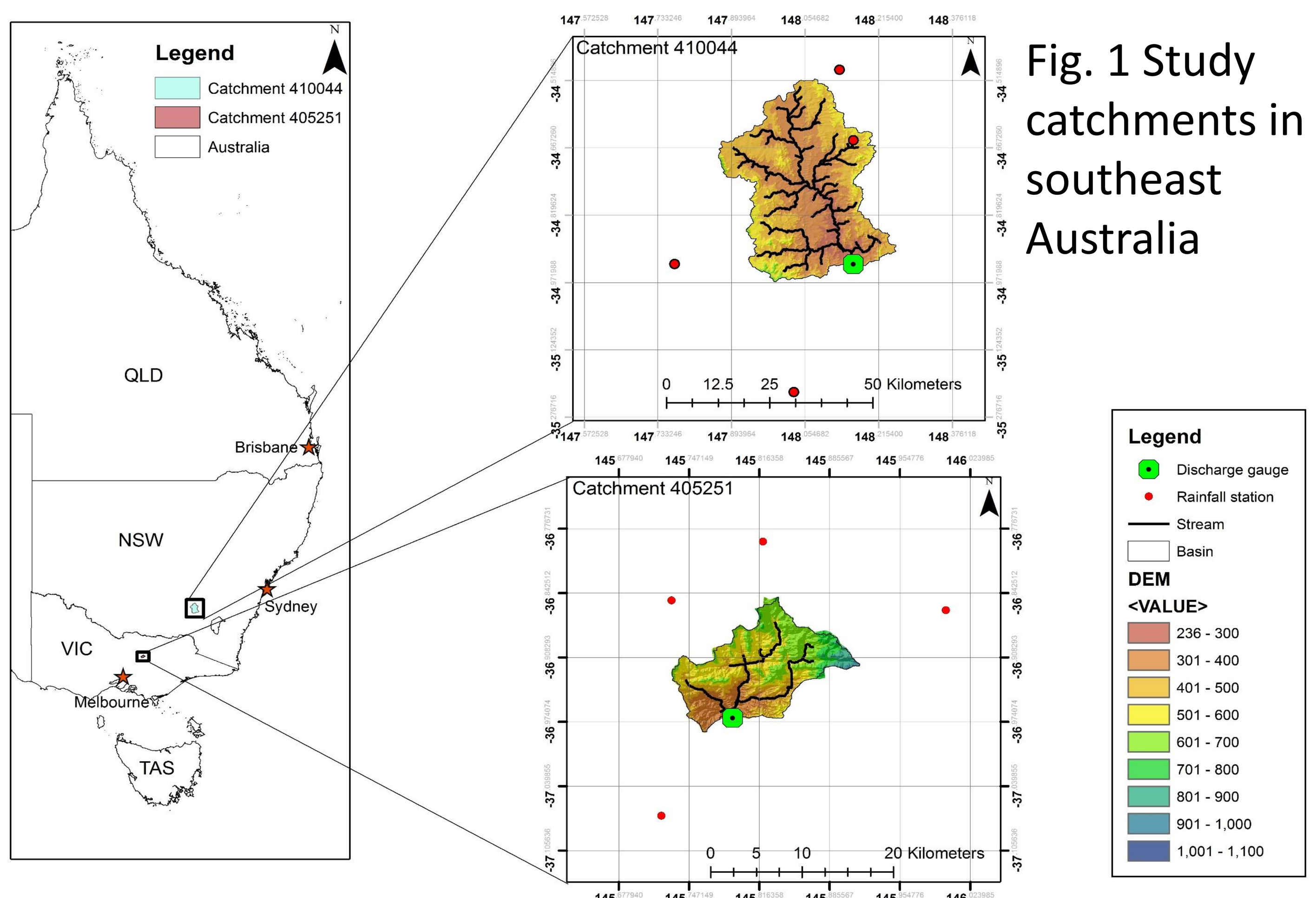


Fig. 1 Study catchments in southeast Australia

- Daily rainfall, streamflow, maximum and minimum temperatures and monthly groundwater (GW) table data were collected from Australian Bureau of Meteorology [1974 – 2013 for catchment 405251 and 1939 – 2015 for catchment 410044]
- Bi-monthly Leaf Area Index (LAI) data was collected from Integrated Climate Data Center, University of Hamburg, Germany for the period 1981 - 2015

3. Methods

1. Calculation of reference evapotranspiration (ET_0) [**Hargreaves-Samani equation**], Horton Index (HI) [**ratio of actual evapotranspiration to catchment wetting**] and baseflow [**one parameter recursive filter** (Lyne and Hollick, 1979)]

3. Methods continued…

2. Drought identification (**3 year moving average of annual rainfall**) (Saft et al. 2015); drought of duration ≥ 7 years considered.

3. Direction of change in R-R relationships during drought: Relative change of the runoff generated for a representative rainfall (average the mean annual/seasonal rainfall and minimum annual/seasonal rainfall) during drought compared to non-dry periods

4. Mechanisms contributing to non-stationarity: Kolmogorov-Smirnov (KS) test for (a) endogenous catchment mechanisms: GW table, baseflow, LAI and HI and (b) exogenous mechanisms: rainfall, ET_0, maximum and minimum temperatures for drought and non-dry periods

4. Results

1. Drought identification:

Catchment	Drought	Periods
405251	Millennium drought (MD)	1998 – 2011
410044	World War II drought (WWII)	1941 – 1953
	MD	2002 – 2009

2. Direction of change in R-R relationships:

Catchment	Comparison periods	Annual	Summer (DJF)	Autumn (MAM)	Winter (JJA)	Spring (SON)
405251	ND and MD	-48.9%	-19.6%	-59.2%	-57.8%	-43.1%
410044	ND and WWII	6.5%	53.1%	50.4%	8.9%	28.7%
	ND and MD	-86.8%	-75.7%	-92.8%	-91.0%	-83.3%

Coloured values indicate the periods when significant changes in R-R relationship are observed

4. Results continued…

3. Mechanisms contributing to non-stationarity in R-R relationships:

Fig. 2 Endogenous catchment mechanisms contributing to non-stationarity

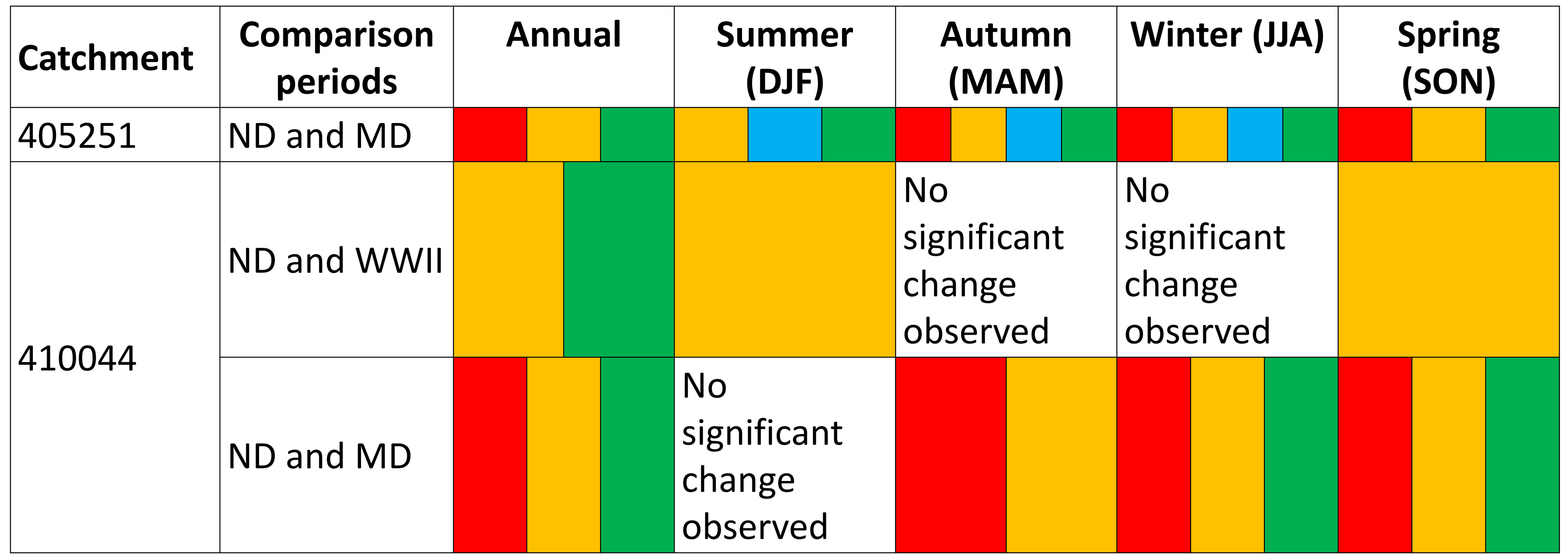
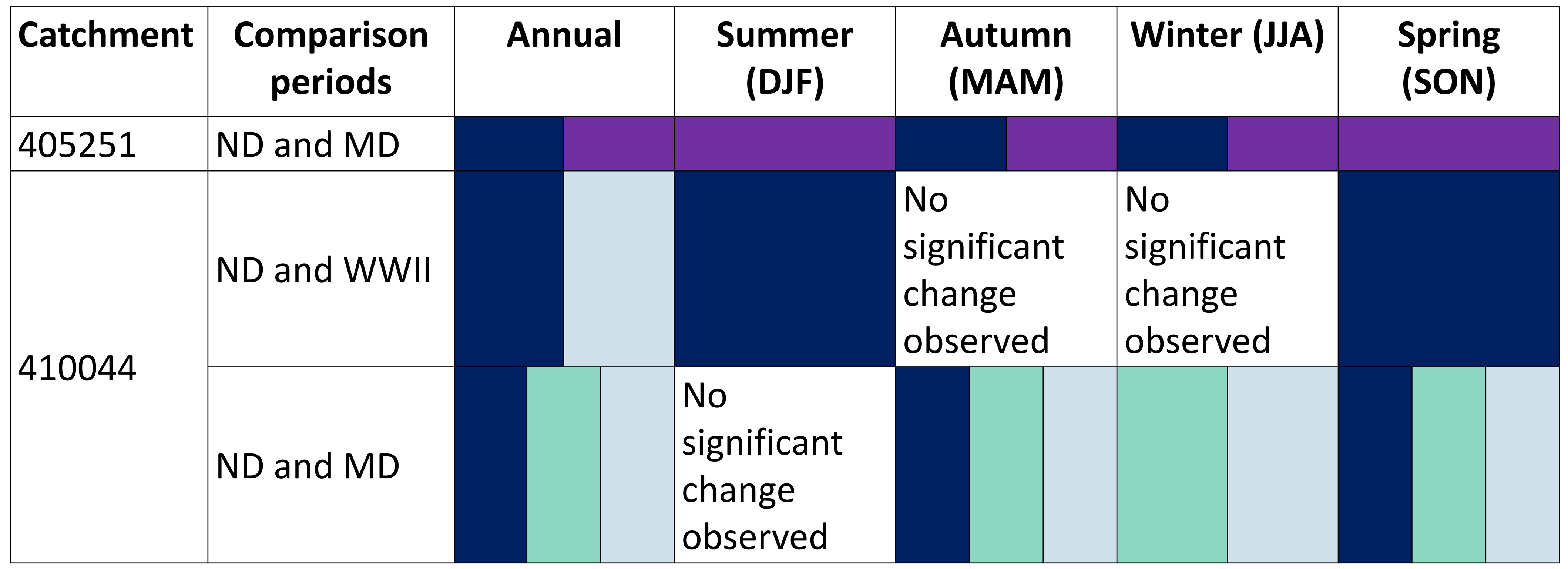
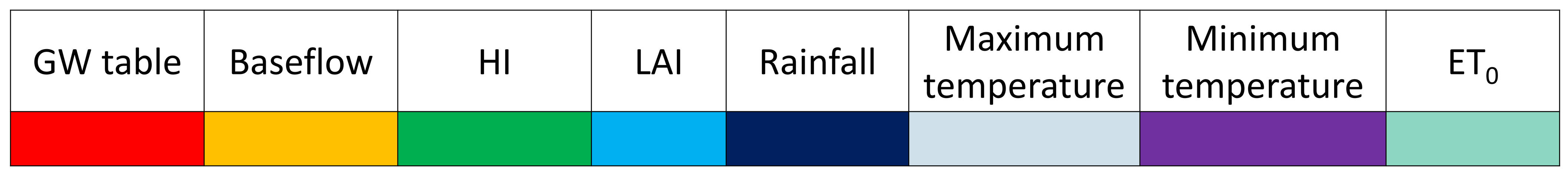


Fig. 3 Exogenous catchment mechanisms contributing to non-stationarity



Legend



5. Conclusions and recommendations

- Positive and negative changes in R-R relationships are observed for WWII and Millennium droughts respectively when compared to non-dry periods
- Endogenous mechanisms (especially GW table and baseflow) have the strongest influence on non-stationarity in R-R relationships
- Exogenous mechanisms (rainfall, min/max temp, and ET_0) also contribute to non-stationarity in R-R relationships, but not as much as endogenous mechanisms
- Hydrological processes in a catchment change due to multi-year droughts and these changes introduce high uncertainties in model predictions
- Drought/climate related changes in catchment properties (surface water-GW interaction, land use changes) must be considered while conducting hydrological studies

References

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