A31N-0231:

Regional SH Westerly Wave Variability and Cape Town's "Day Zero" Drought

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Background & Introduction

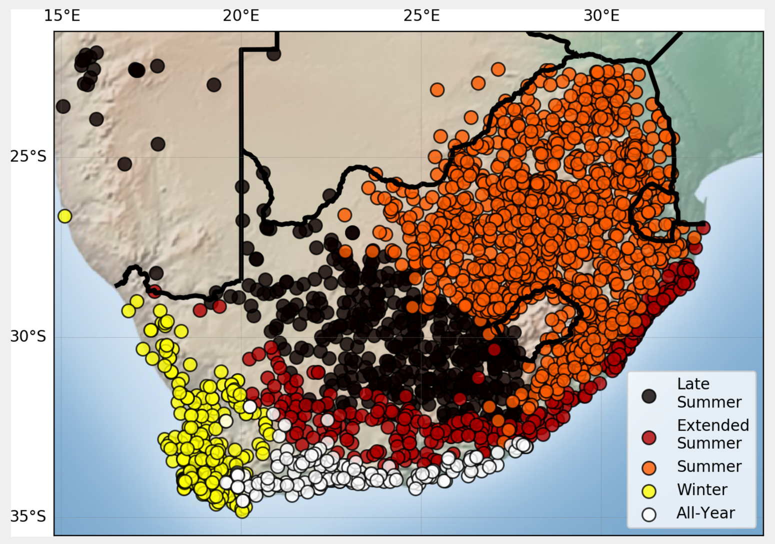

Figure 1:Ward's clustering by seasonality.

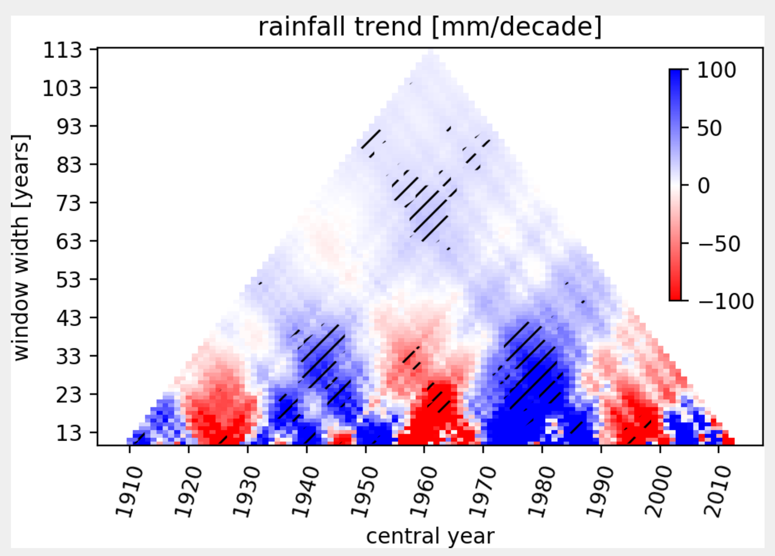

Figure 2:Theil-Sen trends near major dams.

- Southern Africa rainfall seasonality
  - Mostly summer rain
  - Far-SW winter rainfall zone (WRZ) depends on winter frontal rain
- "Day Zero" Drought:
  - Most intense 3-yr drought observed: Spring 2014–Spring 2017 (Wolski, 2018)
  - 2017 driest year on record across WRZ
  - Severe water crisis ⇒ warning of taps running dry (Baudoin et al., 2017)
  - Politically contentious in divided & unequal city, country (Ziervogel, 2018)
  - Related to poleward shift in subtropical highs, moisture transport & ARs in SH & South Atlantic (Sousa et al., 2018)
- Climate change?
  - 3x increase in risk (Otto et al., 2018)
  - Variability overwhelms trend long-term
  - Mechanisms?
- Seasonal prediction: low-skill
  - Weak correlation with major global & hemispheric modes of variability

Data & Methods

- Self-Organising Map (SOM) Analysis of ERA-Interim (Dee et al., 2011) 500-hPa geopotential
  - SOM: artificial neural network (ANN) commonly used for non-linear circulation clustering (Hewitson and Crane, 2002)
  - SE-Atlantic domain: identify 1 trough/ridge affecting WRZ at a time $-55 \leq \phi \leq -25°$; $0 \leq \theta \leq 27°$
  - 6 hourly, AMJJAS 1979-2017
- Cut-Off Lows (COLs)
  - Closed, cold-cored lows at 500hPa
  - COL days considered separately
- SOM node & stations clustering
  - Ward's linkage; Euclidian distance
  - SOM nodes: divergence & geostrophic vorticity near WRZ
  - Stations: contribution of SOM node clusters to AMJJAS rainfall
- Observed station rainfall:
  - > **98%** coverage 1979-2017
  - Cleaned, date corrected, gap-filled

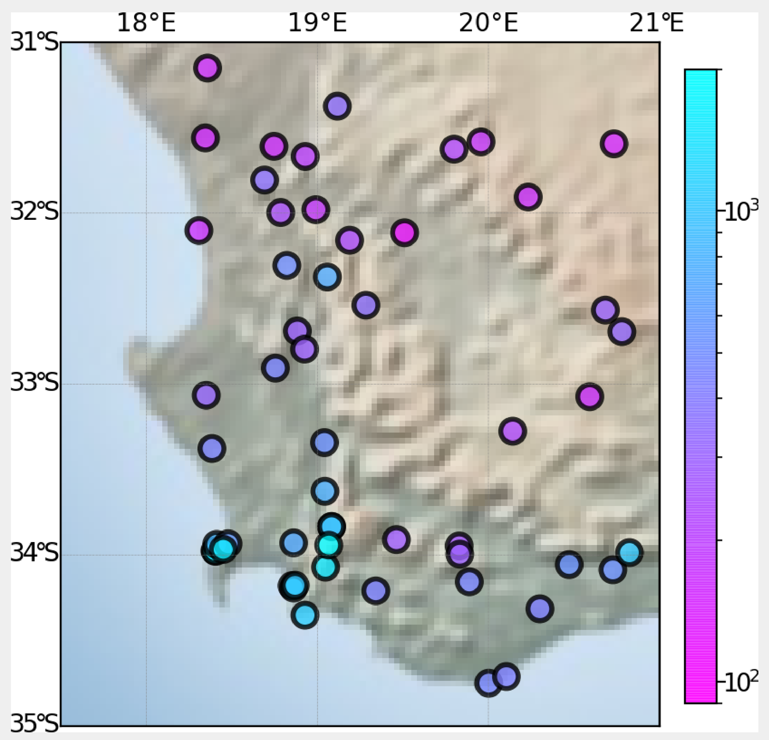

Figure 3:Mean annual station rainfall (mm)

Results: SOM & Station Rainfall

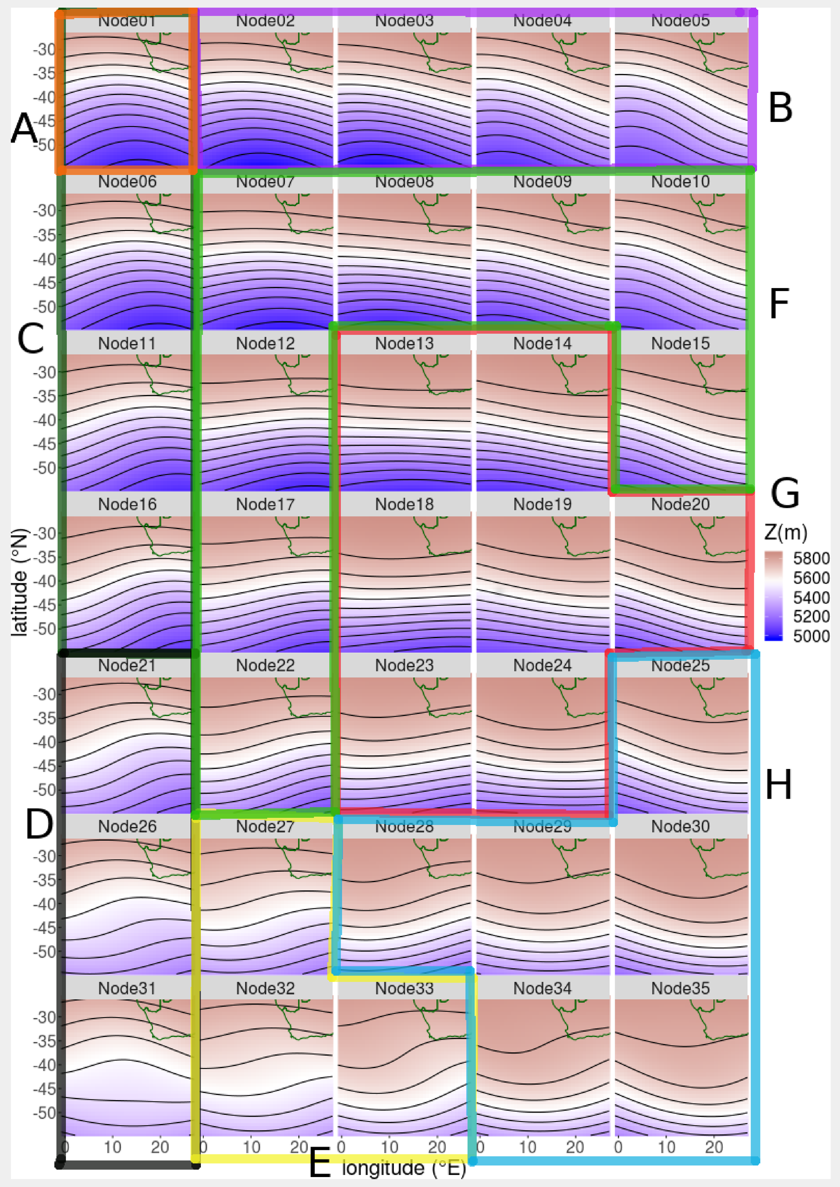

Figure 4:**5** × **7** Z500 SOM, with clusters

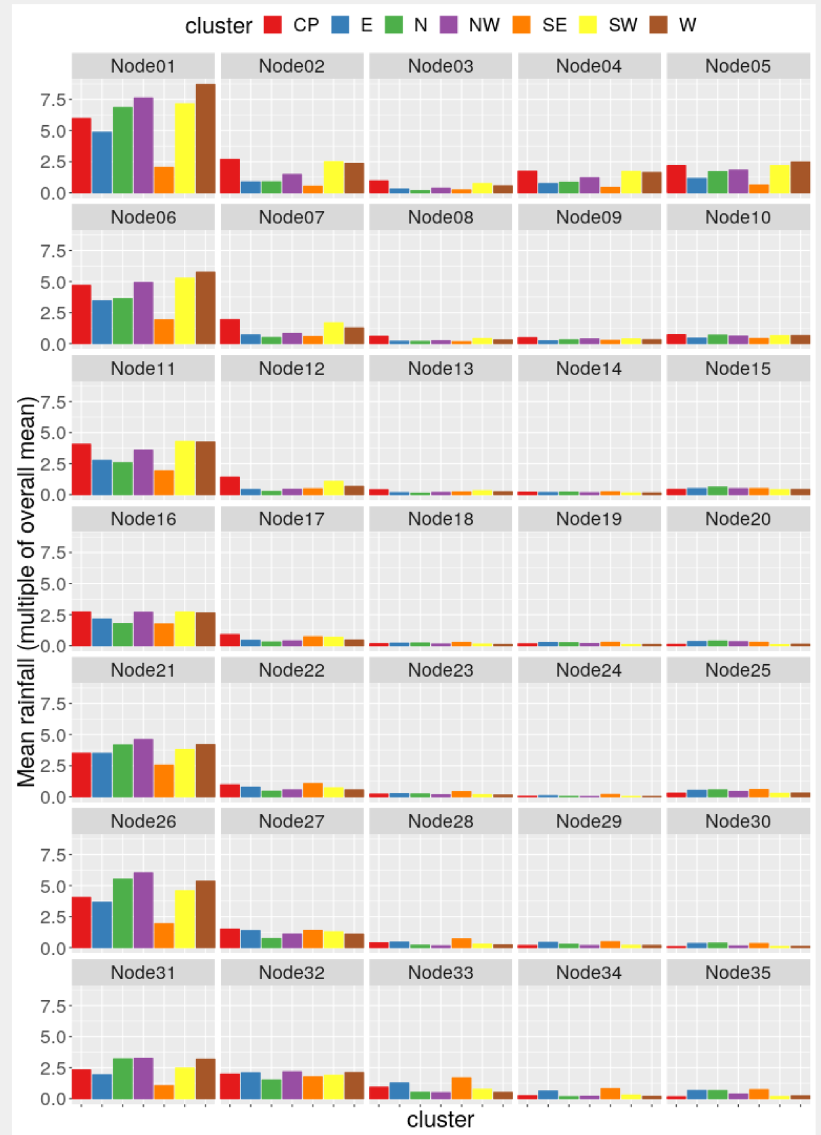

Figure 5:Normalised SOM node mean rainfall

Node Cluster	Freq (%)	Rainfall (% range)
A: Strong trough	3.3	6.2(SE)–18.0(W)
B: NW trough	13.5	6.5(SE)–17.8(CP)
C: S steep trough	8.0	15.6(N)–22.5(SW)
D: Curved trough	8.2	14.2(SE)–24.5(NW)
E: Weak trough	6.8	4.3(N)–12.2(SE)
F: Zonal flow	20.2	5.9(NW)–10.8(CP)
G: Ridge	16.9	1.6(W)–4.7(SE)
H: Strong ridge	20.2	2.3(W)–10.7(SE)
COLs	3	7.3(SW)–18.1(SE)

Table 1:SOM node cluster frequency & contribution to AMJJAS rainfall

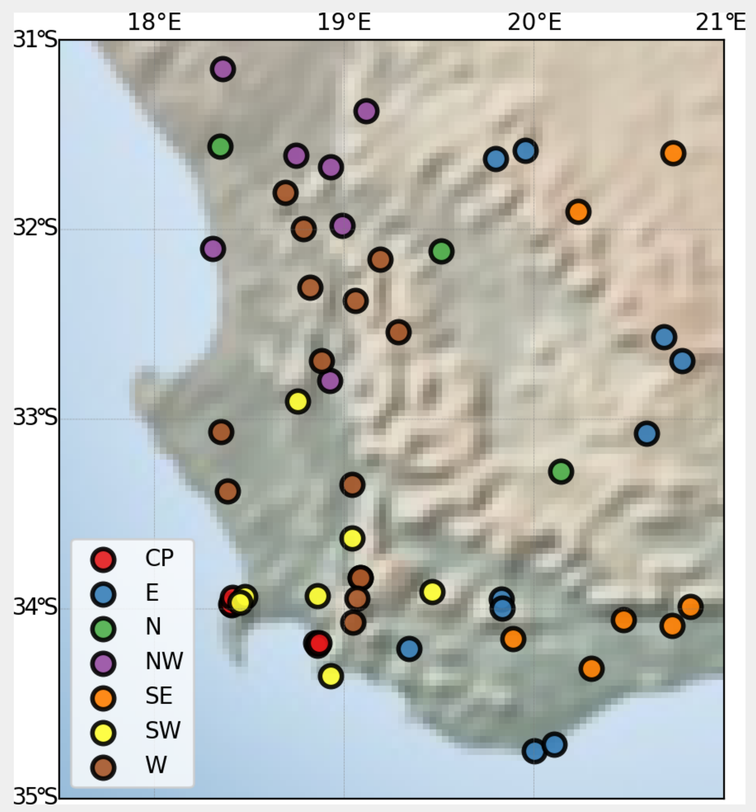

Figure 6:Station clusters obtained

- Troughs (40% frequency) responsible for ≈ **80%** of all AMJJAS rainfall in core WRZ; strongest half bring ≈ **60%** of rain in mnts and NW.
- Contribution from troughs is highest in the W cluster; from COLs is highest in the E& SE; N & NW are most dependent on troughs with large curvature

Results: Circulation & Rainfall Prediction

- Annual SOM node cluster frequency anomalies with mean rainfall patterns for each are used to predict station cluster annual AMJJAS rainfall.
- Each year predicted using all others in turn.
- 2 strongest ridge nodes (34, 35) exhibit blocking behaviour & unprecedented frequency during drought; hence, they are separated in frequency time series

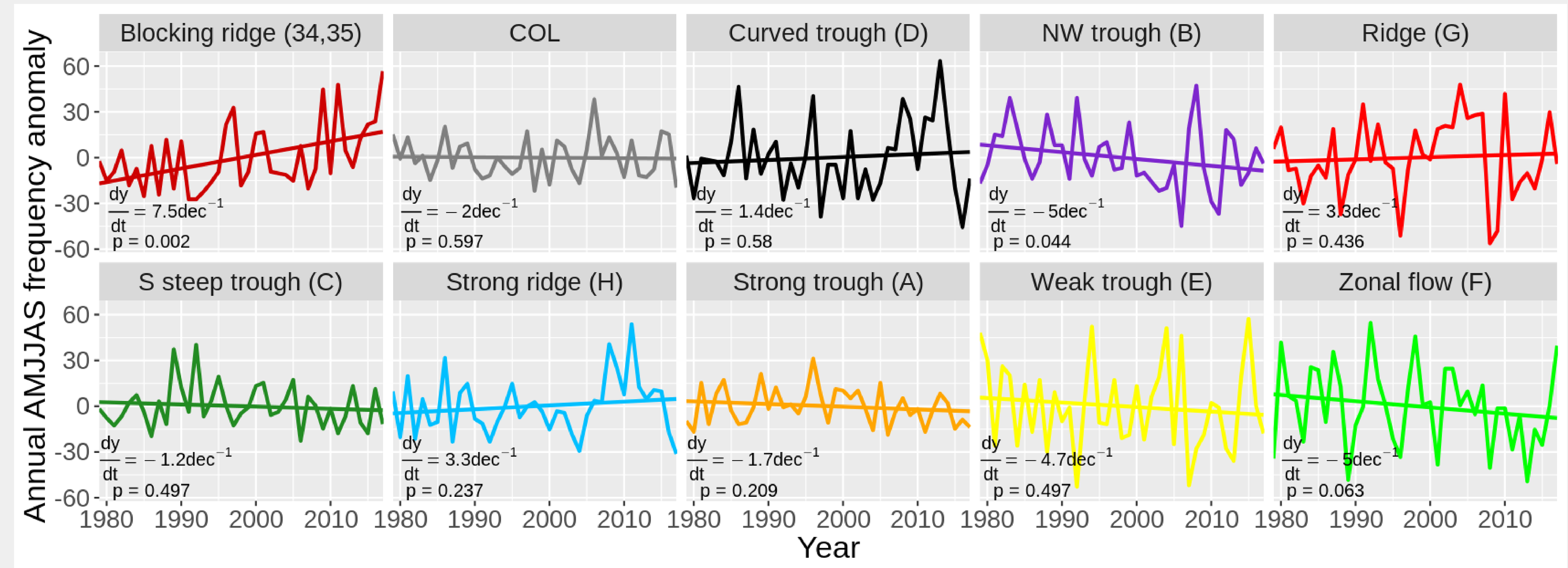

Figure 7:AMJJAS circulation type anomaly 1979-2017 with decadal trend and significance

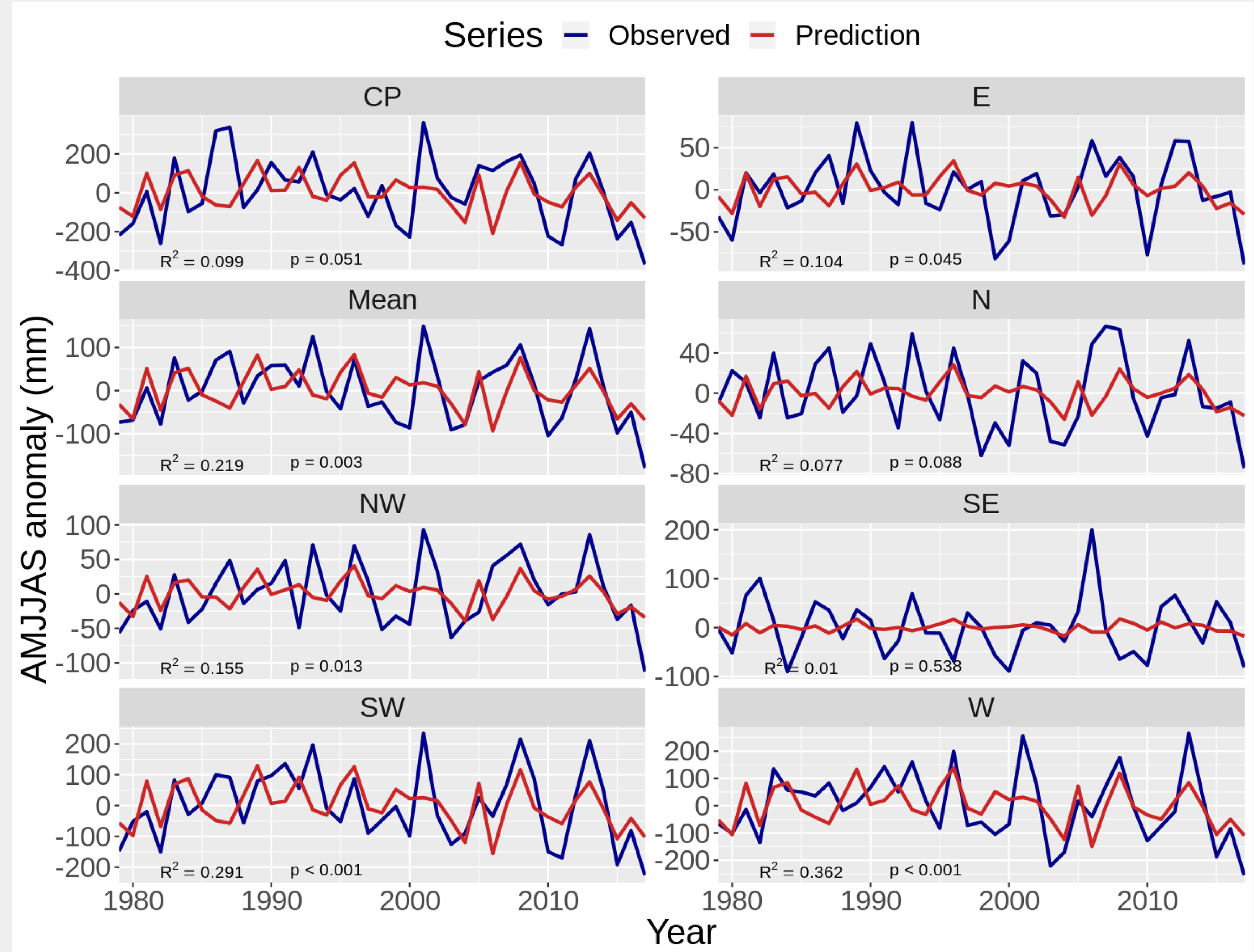

Figure 8:Observed and predicted station cluster mean anomaly 1979-2017

- Prediction best in the W & SW mnts; model explains essentially none of the variability in E & SE

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- CSAG and UCT PGFO for sponsoring attendance at this conference

Conclusion: Circulation Contribution to Drought

- Most rainfall in extended winter associated strong troughs in mid-tropospheric westerlies
- Circulation type frequency variation explains **2−36%** of rainfall variability across WRZ
- Explanatory power greater in recent years (≲ **50%**)
- ≈ **55%** of Day Zero Drought shortfall explained by trough/ridge variability & trend.
- Unprecedented autumn (AM) frequency of most intense ridge node during severe drought year 2017, consistent with increasing trend ($p < 0.01$) over 39 yrs

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