Analysis of New Zealand daily weather patterns (DWTs) and large-scale climatic patterns as extreme rainfall and flooding drivers

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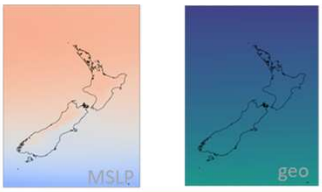
Introduction

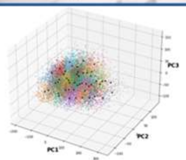
The overall aim of this research project is the generation of flood inundation maps for a specific study site, namely the Wairewa catchment (Little River, Canterbury) for the benefit of community stakeholders. To this end, accurate analysis and characterization of extreme rainfall is required since this is the main inundation driver. This work aims to study extreme rainfall events that can potentially lead to flooding using synoptic climatological techniques. It builds on previous work in the field (Jiang 2011; Kidson 1997,2000) and proposes a new weather type classification; consisting of 49 Daily Weather Types (DWTs), with a focus in characterizing heavy rainfall events. This synoptic classification is based on ERA5 reanalysis daily fields of mean sea level pressure (MLSP) and 500 hPa geopotential height. The relationship between the DWTs, heavy rainfall and historical flooding events is investigated in the study site; as well as the influence of three large-scale climatic patterns: El Niño Southern Oscillation (ENSO), the Southern Annular Mode (SAM) and the Indian Ocean Dipole (IOD).

Methodology

Predictor

- ERA5 reanalysis
- MSLP and 500 hPa geopotential height
- Daily fields
- Spatial resolution: 0.25˚
- Time span: 1979 - 2020



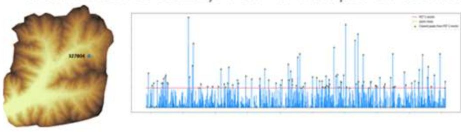


PCA → MDA → KMA

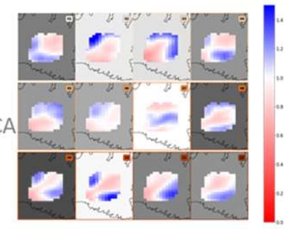
49 DWTs

Predictand

- Rain gauge time series (one location, hourly, from 2012 to 2022): POT → sample of storms



- Validated WRF rainfall database (0.1˚ spatial resolution, hourly temporal scale, from 2002 to 2022): sample of storms → filter PCA → KMA → storms spatial pattern classification



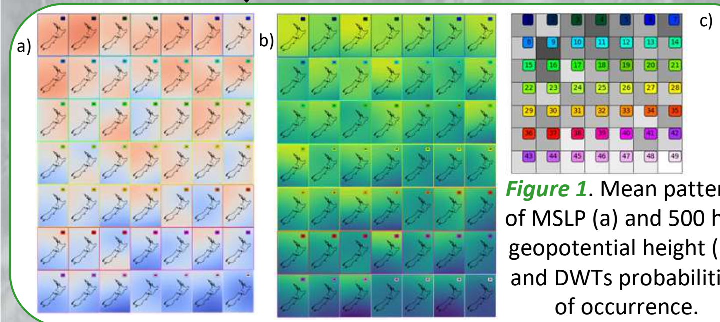
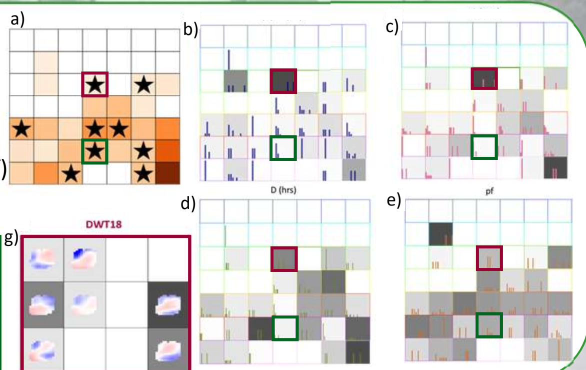


Figure 1. Mean patterns of MSLP (a) and 500 hPa geopotential height (b), and DWTs probabilities of occurrence.

Figure 3. DWTs chronology (2010-2020) with black dots indicating extreme rainfall events and black stars flooding events.

Figure 4. DWTs seasonal probabilities.

Results



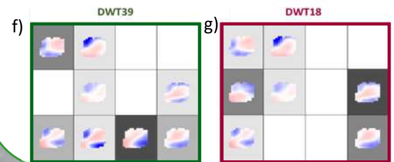


Figure 2. DWTs extreme rainfall event probabilities, including flooding events as stars (a); probability histograms for storms temporal shape characteristics (Ip (b), A (c), D (d), pf (e)) with mean values as background colour; and storms spatial pattern probabilities for DWT39 (f) and DWT 18 (g)

Figure 5. Seasonal frequency of occurrence of extreme rainfall events for the climatic indexes.

Positive phase

	El Niño 3.4	SAM index	DMI
Autumn (MAM)	15.80	15.09	16.00
Winter (JJA)	17.93	15.93	17.35
Spring (SON)	16.76	14.58	14.94
Summer (DJF)	16.02	14.94	16.11

Negative phase

	El Niño 3.4	SAM index	DMI
Autumn (MAM)	12.90	17.30	14.13
Winter (JJA)	10.10	14.98	13.02
Spring (SON)	14.38	17.24	18.18
Summer (DJF)	13.45	19.12	14.77

Conclusions

- Useful relationships have been found between the DWTs, extreme rainfall and flooding.
- Big variability in storms temporal shape characteristics between DWTs.
- Big variability in storms spatial distribution within and between the DWTs.
- DWTs strong seasonality.
- Relevant signal of large-scale climatic patterns (ENSO, SAM, IOD).

References

Jiang, N 2011, 'A new objective procedure for classifying New Zealand synoptic weather types during 1958–2008', International Journal of Climatology, vol. 31, no. 6, pp. 863-879.
Kidson, JW 1997, 'The Utility of Surface and Upper Air Data in Synoptic Climatological Specifications of Surface Climatic Variables', International Journal of Climatology, vol. 17, pp. 399-413.
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