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ADVANCES IN THE HOMOGENIZATION OF DAILY PEAK WIND GUSTS: AN APPLICATION TO THE AUSTRALIAN SERIES

CL5.03 - *Climate Data Homogenisation and Analysis of Climate Variability, Trends and Extremes*
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ABSTRACT. Daily Peak Wind Gusts (DPWG) time-series are valuable data for evaluation of wind related hazard risk to the population and different economic sectors. Yet wind time-series are prone to be affected by inhomogeneities temporally and spatially (e.g. through change of instruments at a site compared to surrounding sites) that may mislead the studies of their variability and trends. The aim of this work is to present the advances in the homogenization of DPWG by analyzing 548 sites time-series across Australia covering the 1941-2016 time period. Due to the low correlation coefficients between these series, especially in the first decades when the station density is much lower, the average wind speed data from the NCEP/NCAR reanalysis were tried as reference series. However, their lower correlations with the DPWG data suggests avoiding this approach. We proposed a robust monthly homogenization using the R package Climatol, which detected 353 break-points at the monthly scale. Some of them were supported by the history of the stations, but detailed analysis of the metadata of 35 selected stations did not find a good correspondence since many changes do not necessarily produce inhomogeneities. When NCEP/NCAR reanalysis are used as references, more break-points are detected around 2003, but it is not clear whether they are due to a general change of the DPWG algorithm in the observation network or rather an artifact due to inhomogeneities in the reanalysis series. The monthly dates of the detected break-points were used in a new application of the Climatol package to adjust the series at daily basis, yielding a homogenized and filled DPWG database for assessing the variability of extreme wind events. Resultant trends of the homogenized DPWG series showed the benefits of the homogenization in the form a much lower dispersion of their values.

1. STATE OF THE ART - OBJECTIVE

➢(i) Most of previous homogenization studies have focused on air temperature and precipitation, **with very few efforts on winds**;

➢(ii) Only **very few approaches has attempted to homogenize wind speed series**, mainly at monthly basis.

➢(iii) The aim of this study is to present **a new statistical approach to homogenize daily peak wind gusts (DPWG) at daily basis** using large data series.

2. DATA AND METHODS

Observed and reanalysis DPWG datasets

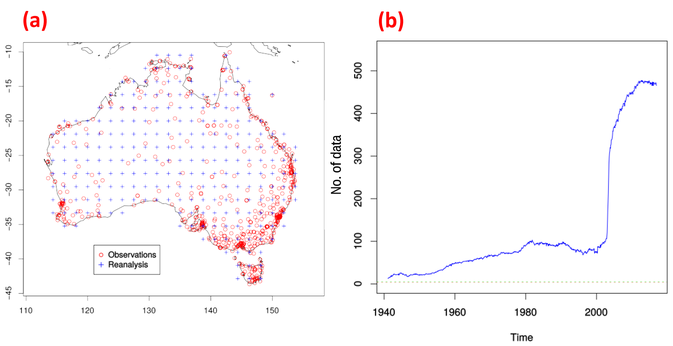

Figure 1. Data characteristics: (a) shows the locations of the 546 stations and center-points of the 245 NCEP/NCAR reanalysis grid-cells (791 series in total) used here; and (b) tracks the BoM observed data availability over 1/Jan/1941 to 31/Dec/2016 for the 546 stations.

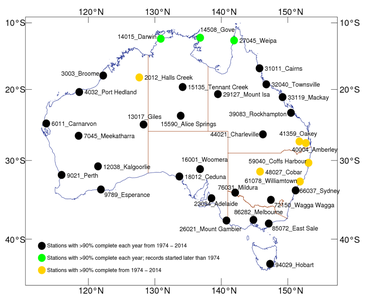

Figure 2. (left) Location of the 35 Bureau of Meteorology operated stations used in the analysis. Darwin (14015) commenced in 1976 (after re-building following Cyclone Tracey), Gove (14508) commenced records in 1986 and Weipa (27045) in 1994.

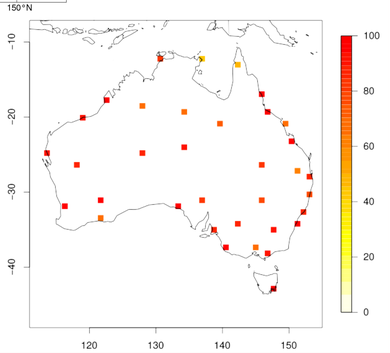

Figure 3. (right) The same as Fig. 1, but maximizing their temporal coverage for 1/Jan/1948 to 31/Dec/2016 (69-years) series. Colors indicate the percentage of observations.

3. THE CLIMATOL PACKAGE v3

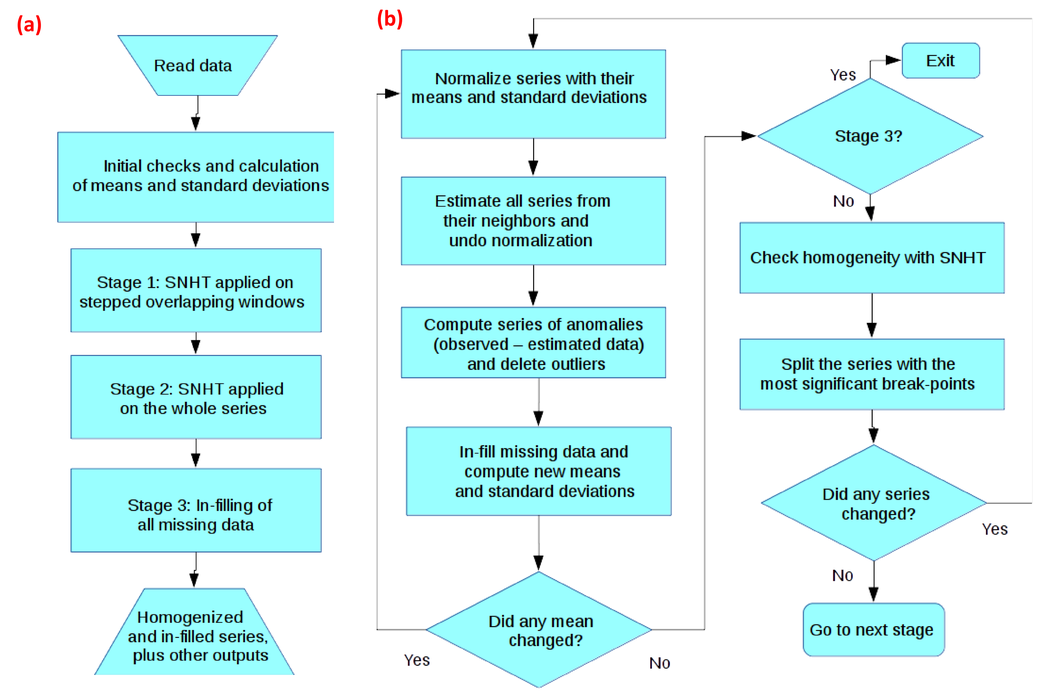

Figure 4. (a) Flowchart of the homogenization procedure in the Climatol package v3; (b) Operations performed within each stage in (a).

The main **advantages of Climatol V3** compared to other methods are its ability:

➢**(i)** To **automatically homogenize a large number of series**, including short-term ones;

➢**(ii)** To use the **closest reference series even though they do not have a common observation period** with the candidate series **or present missing data**.

➢**(iii)** To supply **homogenized series**, **correcting anomalous data** (quality control by spatial coherence) and **filling in all the missing data**.

4. RESULTS

4.1. Outputs of the Climatol package v3

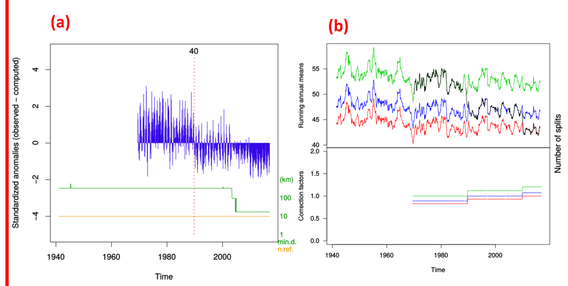

Figure 5. Break-point detection and correction in the Esperance station (a): Standardized spatial anomalies (blue bars), with the dashed red line marking the most significant SNTH value. The green line informs about the distance to the nearest available data along the series, and the orange line shows the number of references used. (b): Series reconstruction (top) and correction factors (bottom) applied to the three homogeneous sub-periods. Original data in black and reconstructed series in different colors.

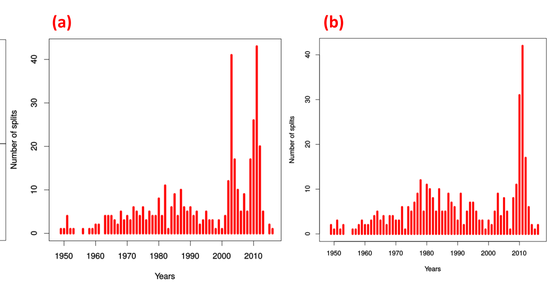

Figure 6. Number of splits per year applied to the series homogenized (a) without and (b) with the support of NCEP/NCAR reanalysis series.

Dataset	Break-points	Parameter	Min.	1st Qu.	Median	Mean	3rd Qu.	Max.
1941-2016 Without NCEP/NCAR	353	SNHT	0.90	4.70	8.00	9.69	13.25	42.20
		RMSE	0.21	0.46	0.66	0.74	0.93	3.23
1948-2016 Without NCEP/NCAR	384	SNHT	0.90	4.50	7.70	9.47	12.70	48.30
		RMSE	0.21	0.46	0.66	0.74	0.91	3.23
1948-2016 With NCEP/NCAR	401	SNHT	1.00	4.30	6.90	8.59	11.00	49.10
		RMSE	0.19	0.53	0.75	0.83	1.06	3.22

Table 1. Number of detected break-points and statistical summaries of final SNHT and RMSE (m s^{-1}) after the monthly homogenization of the 546 observed series for 1948-2016 without and with NCEP/NCAR reanalysis reference series.

4.2. Assessment of the added value of reanalysis series

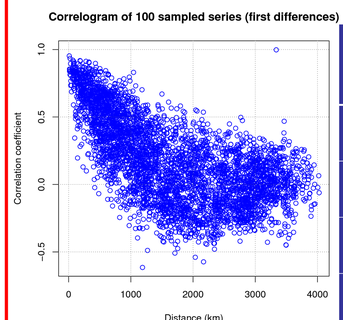

Figure 7. Correlations vs. distance scatter-plot of a 100 sample of the DPWG series, showing a degradation as distance increases. (Correlations were calculated between the first differences of the DPWG series, to minimize the influence of inhomogeneities.)

Period	Years	No. of stations	NCEP/NCAR	4 references		10 references	
				Mean correl.	Mean dist.	Mean correl.	Mean dist.
1948-2016	69	139	No	0.635	227	0.577	355
			Yes	0.575	108	0.546	180
1948-2002	55	86	No	0.580	291	0.517	463
			Yes	0.554	116	0.512	204
1948-1982	35	58	No	0.592	356	0.519	542
			Yes	0.547	122	0.513	215
1948-1965	15	7	No	0.501	626	0.532	1244
			Yes	0.558	131	0.512	220

Table 2. Mean correlations and distances (in km) from the closest 4 and 10 references for stations with a minimum of 10 years of common observations in different periods, with and without reference series from the NCEP/NCAR reanalysis.

4.3. Comparison with station metadata

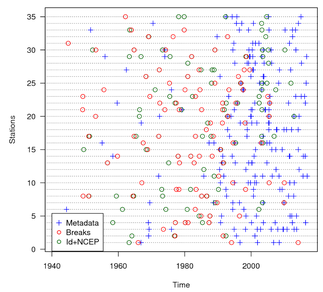

Figure 8. Dates of the break points detected in the homogenizations of the 35 selected stations with and without the NCEP/NCAR references (circles), plotted on reported metadata dates related with to wind instrumentation changes (crosses).

4.4. Trends

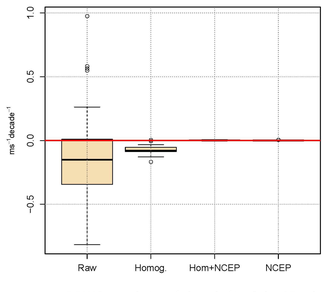

Figure 9. DPWG trends (m s^{-1} $decade^{-1}$) of the 35 selected series computed from the original (Raw) series, the homogenized series without (Homog.) and with (Hom+NCEP/NCAR) reanalysis references, plus trends of the 35 NCEP/NCAR reference series drawn from the closest grid-points to the selected series.

5. CONCLUSION

The main conclusion of this study can be summarized as follows:

➢**(i) The strong decrease of correlations** between the observed DPWG series as distance increase **cannot be minimized with the use of the NCEP/NCAR reanalysis series as references**. This is because reanalyzes series represent mean wind speed (both spatially and temporally) instead of gust winds observed at a station.

➢**(ii)** In spite of the low correlations, **the homogenization procedure implemented here using Climatol V3 detected 353 significant break-points** in the 548 Australian series with DPWG data for 1941-2016.

➢**(iii) Only a small proportion of the detected break-points are supported by metadata** because not all metadata necessarily produce a shift in the mean, and not all relevant metadata are reported (especially in the firsts decades).

➢**(iv) This study has produced a quality-controlled and homogenized DPWG dataset** that will serve for assessing long-term variability and trends of this extreme weather-related hazard across Australia for 1941-2016.

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