An application of HOMER and ACMANT for homogenising monthly precipitation records in Ireland

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An application of HOMER and ACMANT for homogenising monthly precipitation records in Ireland

John Coll[1], Mary Curley[2], Peter Domonkos[3] Enric Aguilar[3] Séamus Walsh[2], John Sweeney[1]

[1] Irish Climate Analysis and Research Units, Department of Geography, Maynooth University, Maynooth, Ireland. [2] Met Éireann, Glasnevin Hill, Dublin, Ireland. [3] Centre for Climate Change, C3, University Rovira i Virgili, Spain.

Introduction

Motivation: Climate change studies based only on raw long-term data are potentially flawed due to the many breaks introduced from non-climatic sources, consequently quality controlled and homogenised climate data is desirable for basing climate related decision making on. Seasonal cycles of precipitation in Ireland and the UK are projected to become more marked as the climate changes, and regional extremes in summer dry spells and winter precipitation have been recorded in recent years. Therefore to analyse and monitor the evolution of precipitation patterns across Ireland, quality controlled and homogenous climate series are needed.

Aims and objectives: To compare the results of two modern homogenisation methods (HOMER and ACMANT) for a regionalised split of 198 series from the Irish monthly precipitation series network for the 1950 – 2010 period.

Study area: The study area is the whole island of Ireland, that covers ~84 421 km^2 on the Atlantic margin of northwest Europe, between ~51° and 56° N. Elevations reach up to 1038 m above sea level (a.s.l.) although much of the island is lowland, partly surrounded by mountains, with a characteristic temperate oceanic climate. On average, annual precipitation ranges from 750 to 1000 mm in the drier eastern half of the country and >3000 mm yr^{-1} in parts of the western mountains (Rohan 1986).

Data

Monthly series: Rainfall has been measured in Ireland since the early nineteenth century with a peak of over 800 rainfall stations in the late 1950s, and currently rainfall is recorded at synoptic and climatological weather stations; in addition, there is a wide network of voluntary rainfall observers (Walsh, 2012). For the country-wide 198 station series used here, station elevations ranged from 5 – 701 m above sea level (a.s.l.) with a mean elevation of ~115 m, and intact contiguous records ranged from ~31 to ~72 years for the 1941-2010 period.

However, the network analysis here focuses on the 1950-2010 period to accommodate the version of ACMANT (v2.1) applied to the station series. In addition, the station series were split into four regional networks for the results reported here with the number of station series in the networks ranging from 38 – 61 (Figure 1).

Homogenisation methods: HOMER (Mestre et al. 2013) and ACMANT (Domonkos, 2011, 2014) are two modern, multiple break homogenisation methods developed to detect and correct multiple change points using reference series, and were developed during the Action COST-ES0601 (HOME, Venema et al. 2012). HOMER includes the best segments and best features of some other state-of-the-art methods: PRODIGE (Caussinus and Mestre, 2004), ACMANT and Joint Detection (Picard et al. 2011). A summary of common and different properties of the methods is provided (Table 1 and Table 2).

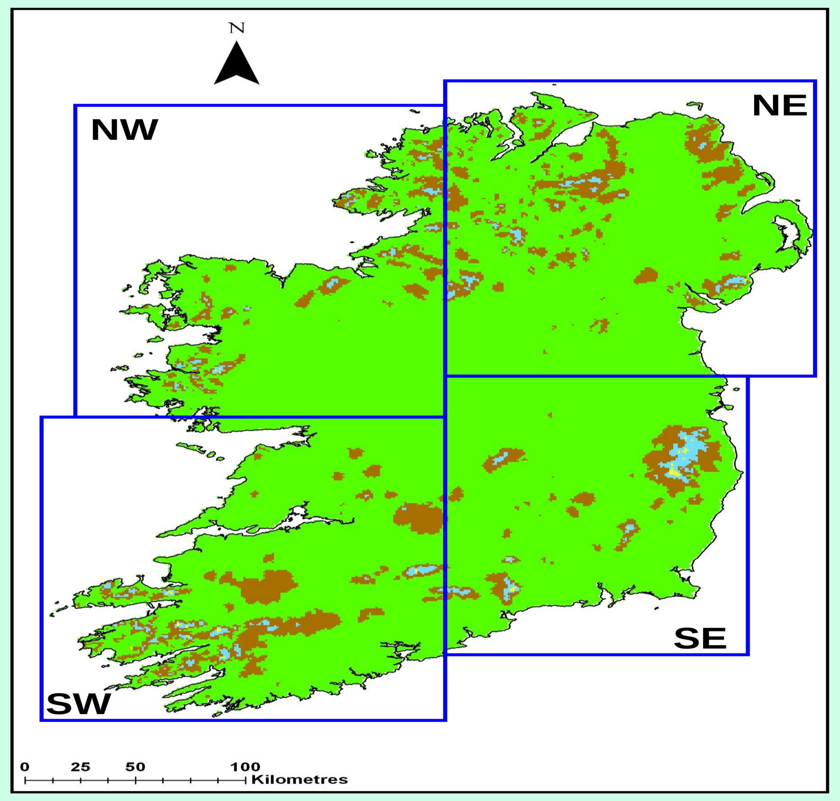

Figure 1: Annotated map of Ireland showing the proximal station network regions. NW = North West; NE = North East; SW = South West; SE = South East. Upland areas are represented by graded shading.

Table 1: Similarities between HOMER and ACMANT

Time Resolution	Monthly
Reference series selection	Correlation-based
Detection method	Step function fitting
Detection statistic	Penalised likelihood
Correction method	ANOVA

Table 2: Differences between HOMER and ACMANT

Implementation	HOMER	ACMANT
Time series comparison	pairwise	weighted reference
Harmonisation of detection	network wide	in individual series
Working mode	interactive	automatic

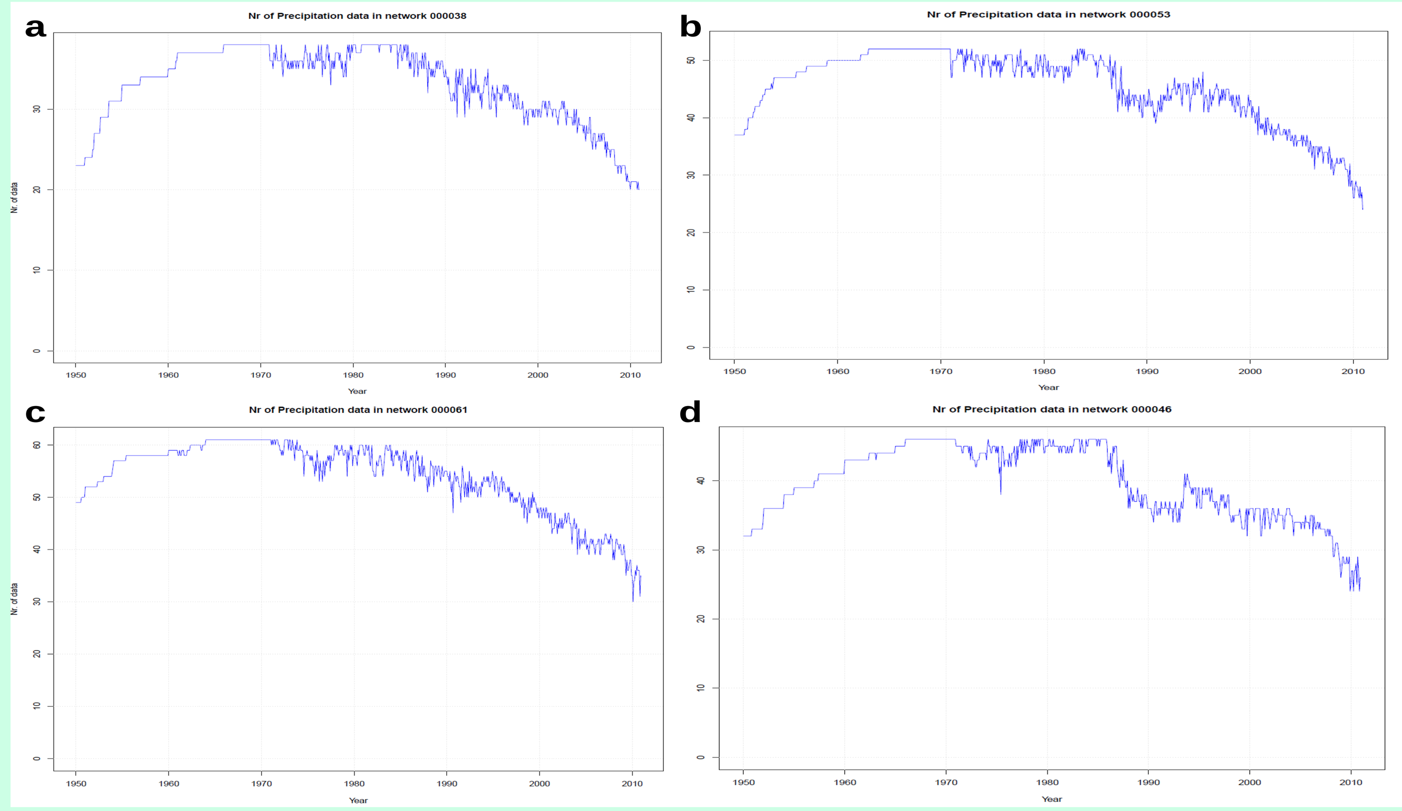

Figure 2a) :HOMER diagnostic plots summarising the amount of monthly precipitation by year for the NW regional station network. **b)** The same for the NE. **c)** The same for the SW. **d)** The same for the SE. The x axis denotes the years analysed; the y axis denotes the data available by year (the different y axes scales reflect the number of stations in the networks).

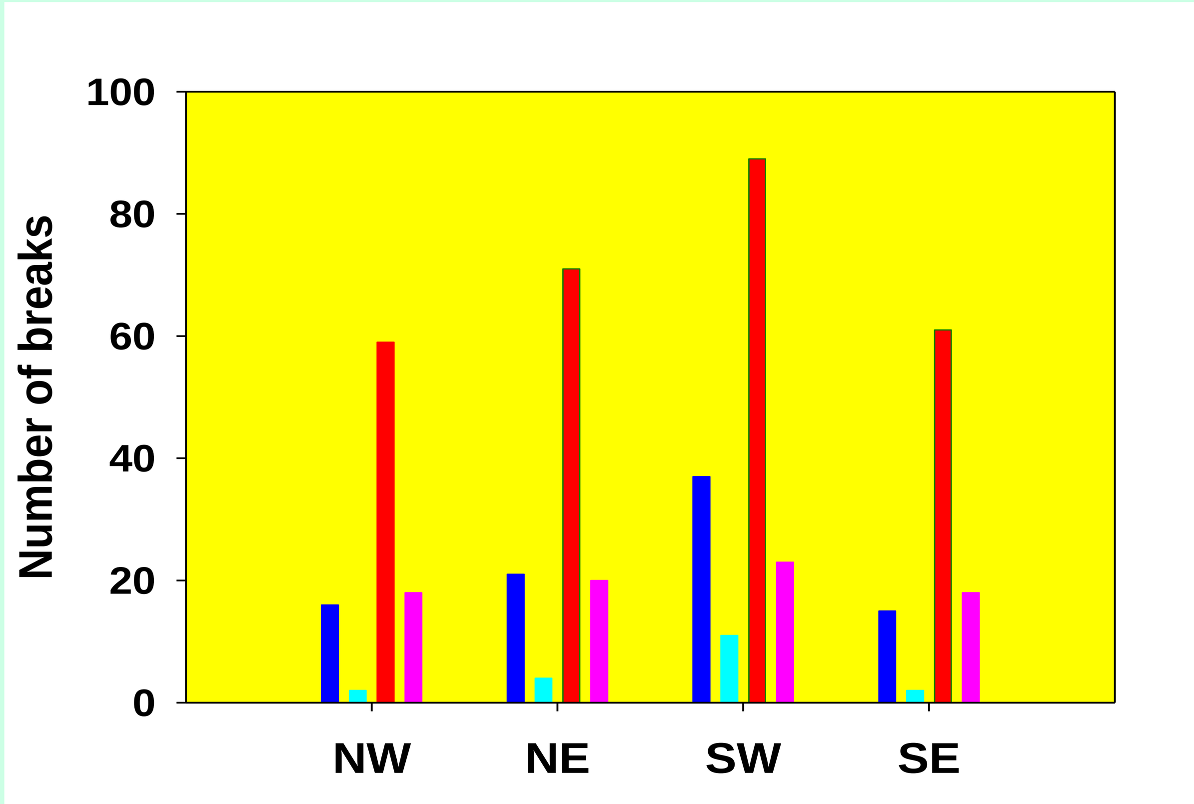

Figure 3: Histogram break detection count summary by HOMER and ACMANT for the four regional networks (station n = 198). Blue and cyan bars HOMER single and multiple detections: red and pink bars ACMANT single and multiple detections.

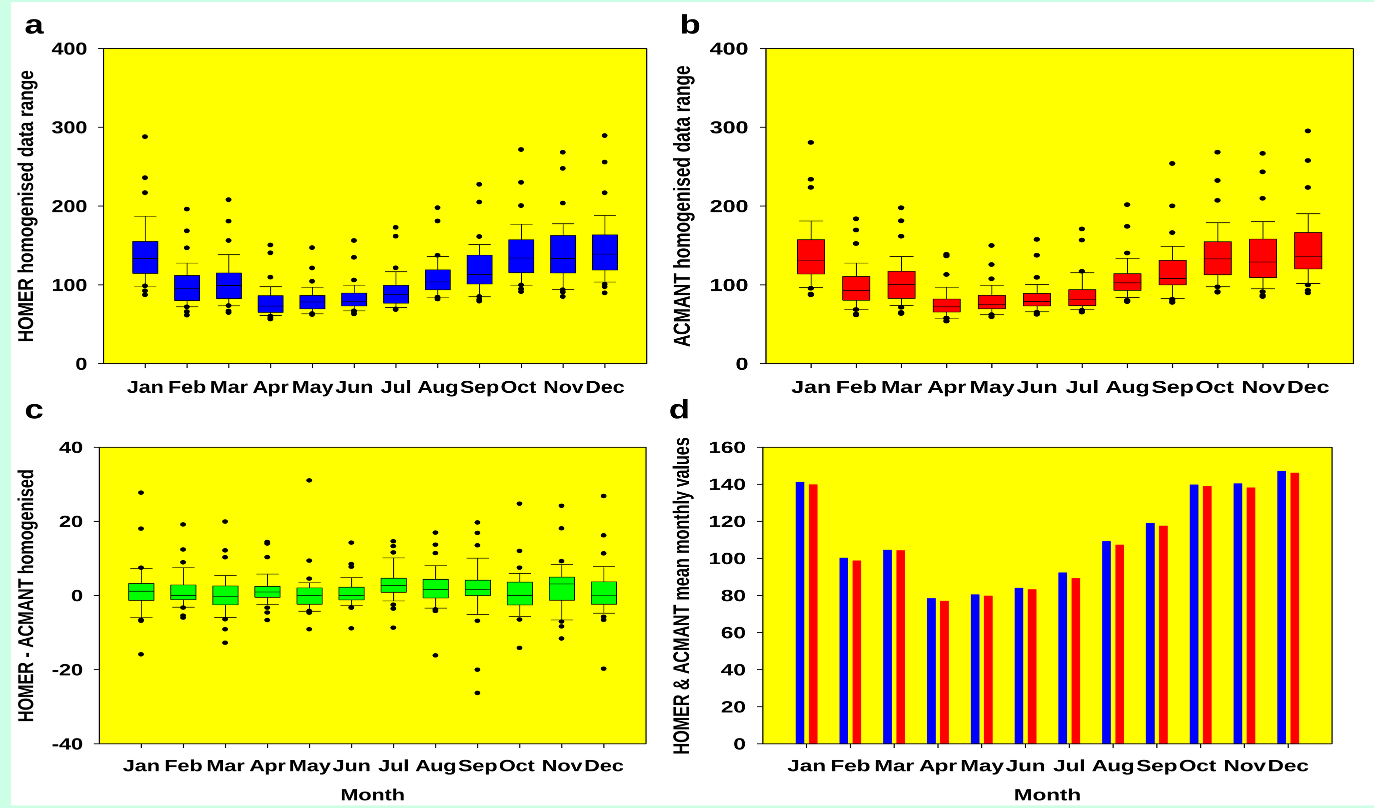

Figure 4a): Boxplot summary of the range of HOMER homogenised monthly values for the 38 series in the NW network. **b)** The same for ACMANT. **c)** Boxplot summary of the range of difference for HOMER and ACMANT homogenised monthly values for the NW network. **d)** Histogram comparison of HOMER (blue bars) and ACMANT (red bars) homogenised mean monthly values for the NW network. All units are mm^{-1}.

Results

For all four of the regional networks, both HOMER and ACMANT are having to account for more missing values in the station series for the earlier and later decades of the period analysed (Figure 2). HOMER consistenly detects less breaks than ACMANT in series across all the networks (Figure 3). Series with no break comparisons for HOMER and ACMANT respectively are: NW 57.9% and 32.6% (station n = 38); NE 60.4% and 34.0% (station n = 53); SW 39.3% and 24.6% (station n = 61); and SE 67.4% and 32.6% (station n = 46). However, and despite the marked difference in break detection frequency; across the range of all the homogenised monthly data points for the NW network example, the differences between HOMER and ACMANT are small (Figures 4a – 4c). Similarly, the monthly mean of the homogenised values for the 38 series are similar for HOMER and ACMANT (Figure 4d).

Discussion

These results indicate a relatively high proportion of detected breaks in the series, a situation not generally reflected in observed later 20th century precipitation records across Europe (Domonkos, 2014). However, this elevated ratio of series with detected breaks parallels the break detection rate in a recent analysis of series in the Netherlands (Buishand et al 2013). The climate of Ireland is even more markedly maritime than that of the Netherlands and the spatial correlations between the Irish series are high. For example the mean correlation coefficient within the 4 ACMANT networks was ~0.8 compared to mean correlation coefficients of >0.8 and 0.9 for many of the HOMER station networks. Therefore it is likely that both HOMER and ACMANT are detecting relatively small breaks in the series. A number of properties of our Irish data lend themselves to the testing of relative homogenisation methods on real data as the country has a dense network of highly correlated candidate neighbour series. For a small and predominantly maritime-influenced country such high correlations are largely to be expected for data at a monthly resolution where much of the daily synoptic and local terrain-induced variations will be smoothed out. In addition, the available metadata for many of the Met Éireann station series is of high quality and allows for a thorough investigation of breaks detected by modern multiple homogenisation methods such as HOMER and ACMANT.

Conclusions and future prospects

- HOMER consistently detected substantially less breaks than ACMANT across the four regional networks..
- For the 89 breaks identified by HOMER across all the networks, 64 (~72%) were confirmed by the metadata. However, metadata were not available for all the station series in the current networks.
- The spatial characteristics of the Irish precipitation records (dense networks) allied to the climatic characteristics of a maritime region (relatively low amplitudes of variation) result in highly correlated series.
- These properties of the data and the networks are useful for the test application of relative homogenisation methods to observed series, and the analysis using both HOMER and ACMANT is currently being extended to a wider network of ~700 series.
- We therefore consider that by using Ireland as a case study, the prospects for evaluating variations in network density on the break detection frequency of methods such as HOMER and ACMANT for real world precipitation time series are excellent.

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