Improving reconstructions of historical extreme weather events in 20CRv3 by rescuing undigitized observations with citizen scientists

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1. Introduction

1.8 million observations of sub-daily pressure, temperature and rainfall were recovered from 72 stations across Great Britain, Ireland and western Europe (Figure 1) from the 1900-1910 Met Office Daily Weather Reports (DWRs) using the Weather Rescue citizen science project.

The dataset is available from the Centre for Environmental Data Analysis (CEDA) and described in Craig & Hawkins (2019).

Much of this data is not yet included in datasets such as the International Surface Pressure Databank (ISPD) or the Met Office's HadUK-Grid (Hollis *et al.*, 2019).

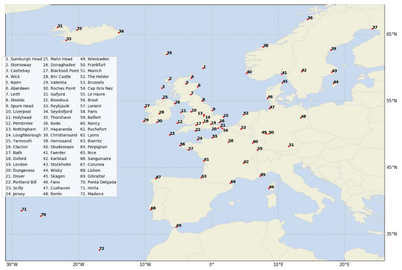


Figure 1: Stations in the 1900-1910 DWRs.

2. Comparing to ISPD

- ISPDv4.7 (Compo *et al*, 2019) has sparse and irregular coverage of pressure observations (Figure 2)
- Data from some of the DWR stations are already in ISPDv4.7 (Figures 1 & 2).
- At Aberdeen, the evening DWR observations agree well with ISPDv4.7 but with a one day offset in October 1903 (Figure 3a).
- More severe problems with the existing Aberdeen data are found in 1900 and 1909 which can now be corrected
- At Stornoway there are two days in 1903 where ISPDv4.7 exceeds the DWR value by about 33 hPa (~1 inHg; Figure 3b). This is likely due to mistakes when the data were transcribed before submission to ISPD.
- There is also a consistent offset of ~1.1 hPa since the DWR pressure observations were not corrected for gravity in 1903 (Craig & Hawkins, 2019).
- There is good overall agreement which demonstrates the value of using volunteers to digitize hand-written weather data

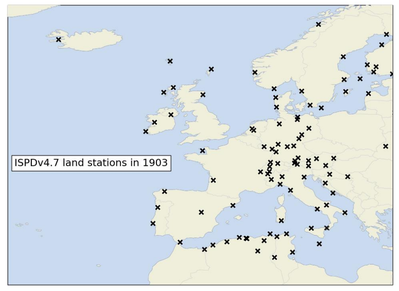


Figure 2: Land stations in ISPDv4.7 in 1903.

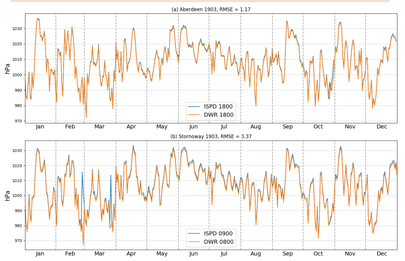
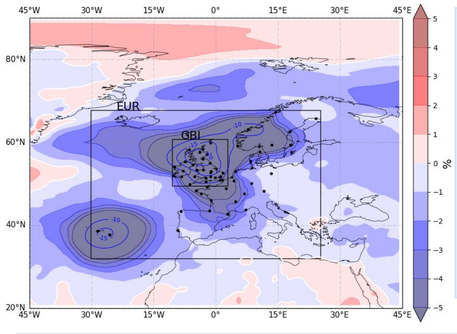


Figure 3: Comparison between mslp from ISPDv4.7 (orange) and the DWRs (blue) for (a) Aberdeen 1800 UTC and (b) Stornoway 0800 & 0900 UTC throughout 1903.



3. Improving the 20th Century Reanalysis

The NOAA-CIRES-DOE 20th Century Reanalysis version 3 (20CRv3; Slivinski *et al.*, 2019) assimilates only pressure observations from ISPDv4.7. An experiment covering 1902 and 1903 was run with added pre-quality controlled pressure data from the DWR stations not already in ISPDv4.7 (referred to as 'scout').

Averaged over 1903, the new data causes reductions in ensemble spread of up to 20% over regions sparsely covered by ISPDv4.7. Area-averaged reductions in ensemble spread were 13.7% over GBI and 2.57% over EUR (Figure 4).

Figure 4: difference in the ensemble spread averaged over 1903 between scout and 20CRv3 with locations of 1903 DWR stations. Boxes (GBI = Great Britain & Ireland; EUR = Europe) show regions over which the change in ensemble spread is averaged.

4. February 1903 storm

- A particularly violent storm passed over Scotland on 27th February 1903 (Shaw, 1903) with observed pressures as low as 959 hPa published in the DWR (Figure 5a).
- 20CRv3 ensemble mean is about 10 hPa too high around the centre of the cyclone with a large spread across Scotland (Figure 5a,b).
- Additional pressure data from DWRs deepens the low over Scotland by 4 hPa and reduces the ensemble spread by about 1 hPa. (Figure 5c,d).
- Across the region covered by the DWRs the ensemble mean has been reduced across Europe and the ensemble spread has fallen across northern Europe with a small increase over regions where no new data was added (Figure 5e,f).
- The erroneous value at Stornoway on 27th February (Figure 3b) was rejected in the scout run due to the reduced ensemble spread, whereas it was retained in 20CRv3.

5. October 1903 rainfall

- Wettest month in England & Wales precipitation record (Wigley et al., 1984)
- 20CRv3 ensemble mean underestimates total rainfall compared to Had-UK Grid (Figure 6)
- In scout run, ensemble mean has more rain in regions observed to be wettest, and less rain in the areas observed to be drier (Figure 6)
- One storm late in month provided about 25% of the month's rain at some stations.
- Scout run has deeper low with more precipitation localized over Wales (Figure 7) where heavy rain was observed at the DWR stations on 27th October

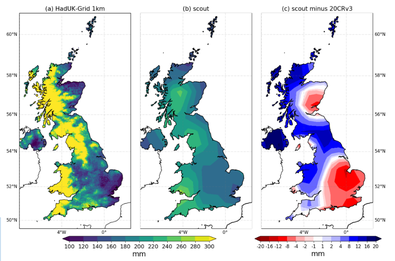


Figure 6: Total precipitation across the United Kingdom for October 1903 in (a) HadUK-Grid and (b) scout ensemble mean. The change in the total ensemble mean precipitation using new pressure observations from 20CRv3 to scout is shown in (c).

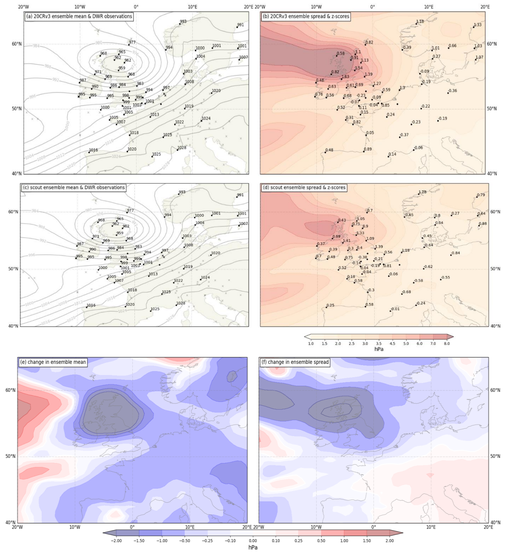


Figure 5: Ensemble means and spreads for a cyclone crossing Scotland at 0800 UTC on 27th February 1903 in 20CRv3 and the scout run with the changes in ensemble mean and spread.

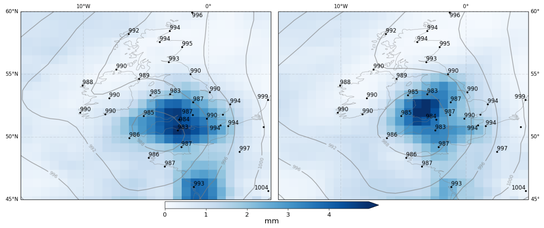


Figure 7: 20CRv3 (left) and scout (right) ensemble mean mslp (contours) and precipitation (colours) accumulated over the previous 3 hours at 1800 UTC on 27th October 1903.

6. Conclusions

- Newly rescued data from UK DWRs has increased the coverage of pressure observations available to 20CR for 1900-1910
- Extra pressure observations reduce ensemble spread by up to 20%
- Case studies of cyclones shows deeper lows in the ensemble mean and closer agreement to observations
- Precipitation is also improved in scout run for the wettest ever month in England and Wales
- Volunteers can accurately digitize historical weather data

References

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