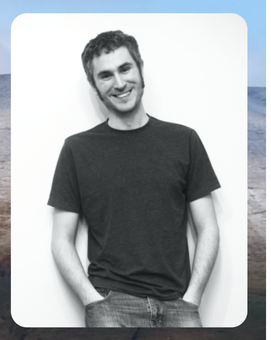
Snowmelt frequency in a mountainous temperate maritime environment



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Importance

Snowmelt is both a hazard and important water resource. In a temperate climate snowmelt is sometimes ignored as the impacts, while severe, are not frequent. Here we assess the recurrence magnitude of snowmelt for use in hazard and resources planning.

Method

A degree day snow model (Fig. 1) was used to estimate winter (Oct-May) daily snow accumulation and melt between 1960 and 2011 in Scotland.

The model was calibrated and verified using station observations from four MOst and remotely observed snow cover observations at five SSGB stations spread across mainland Scotland (Fig. 2).

The calibrated model was run for the whole of Scotland between 1960 and 2011 with extreme value statistics calculated for daily snowmelt in each grid cell. Current industry practice applies a uniform melt rate of 42 mm/day.

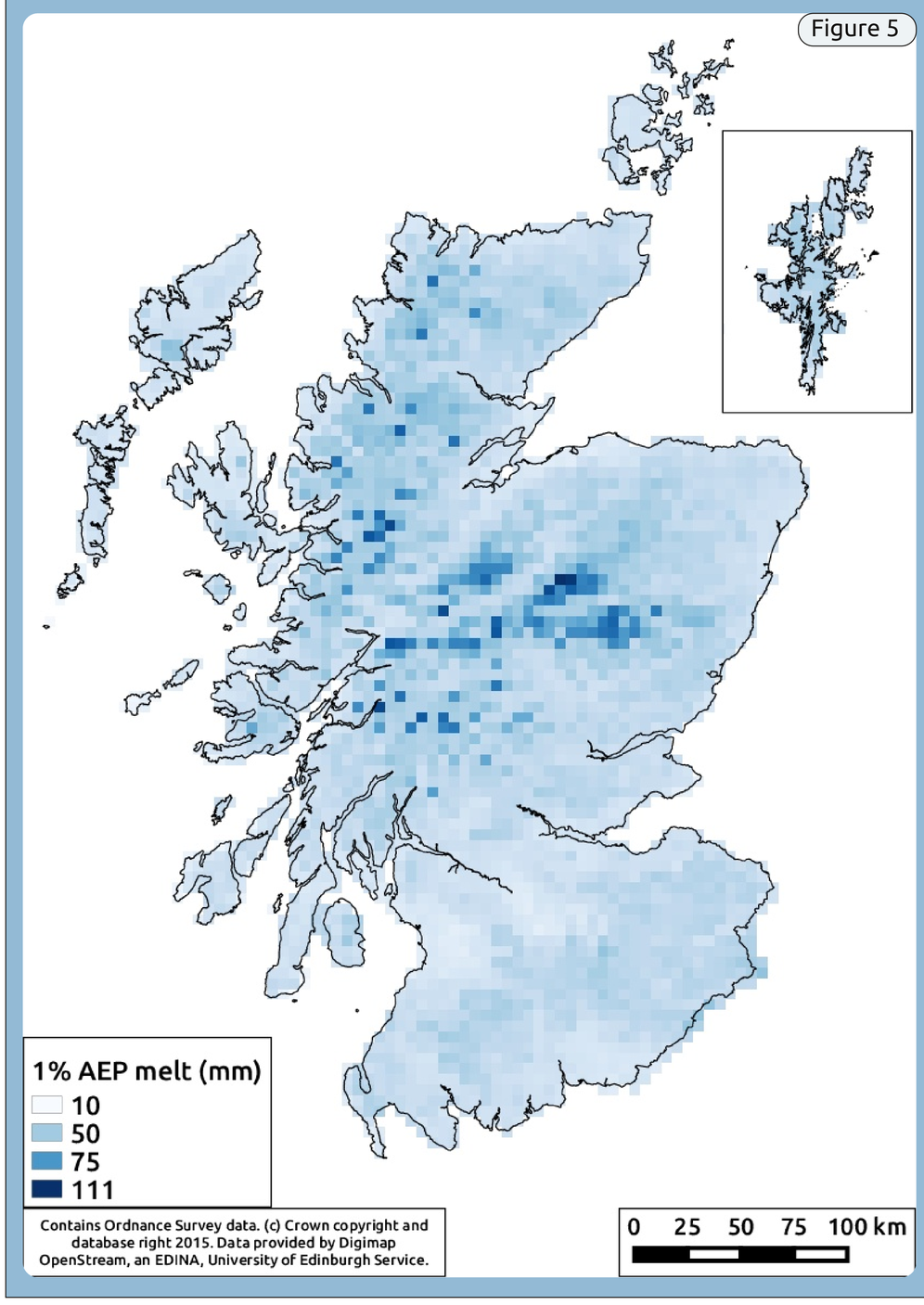
Calibration and verification

Model runs at four single MOst (Fig. 2) with complete years of data between 1979 and 1997 were used to establish model parameter space (Fig. 3). The MOst data are observed on location and are less subjective than the SSGB, hence the use for establishing parameter space.

The model was run between 1960 and 1990 on a 5 km grid which matched MOgrid. 76 cells overlapped observations by five SSGB stations (Fig. 2). SSGB data were used for their long record and observations over a range of elevations (matching cells 150 m to 900 m). Note, SSGB were collected subjectively. 189 parameter combinations for DDF and Temp.b between the upper and lower quartiles (Fig. 3) were run. The best parameter combinations for each cell were taken and the cells grouped by 150 m elevation band. No clear trend was found for parameters at varying elevation so median values for DDF (**7.2**) and Temp.b (**0.7**) were selected.

The calibration was verified against SSGB data between 1990 and 2007 for the five SSGB stations previously described. Model performance (where 1 is best) for the calibration and subsequent verification are shown by year (Fig. 4).

Figure 5



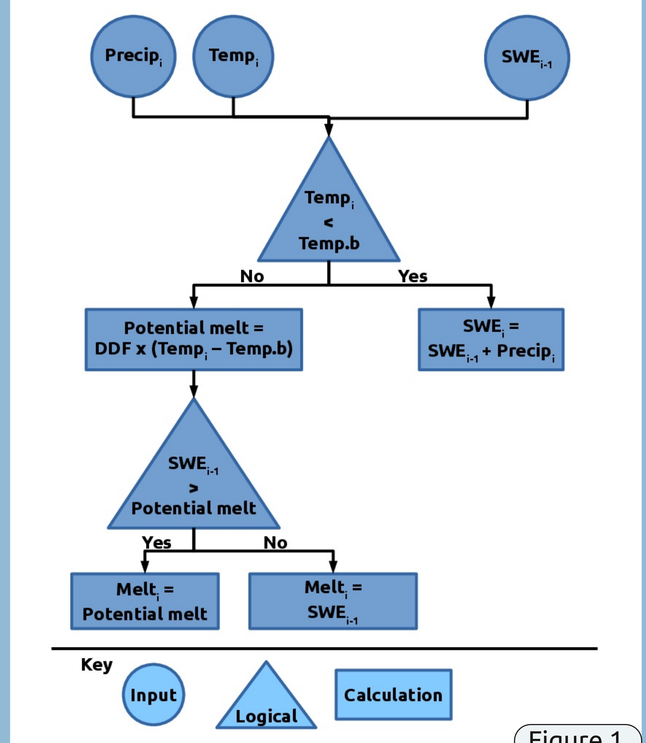
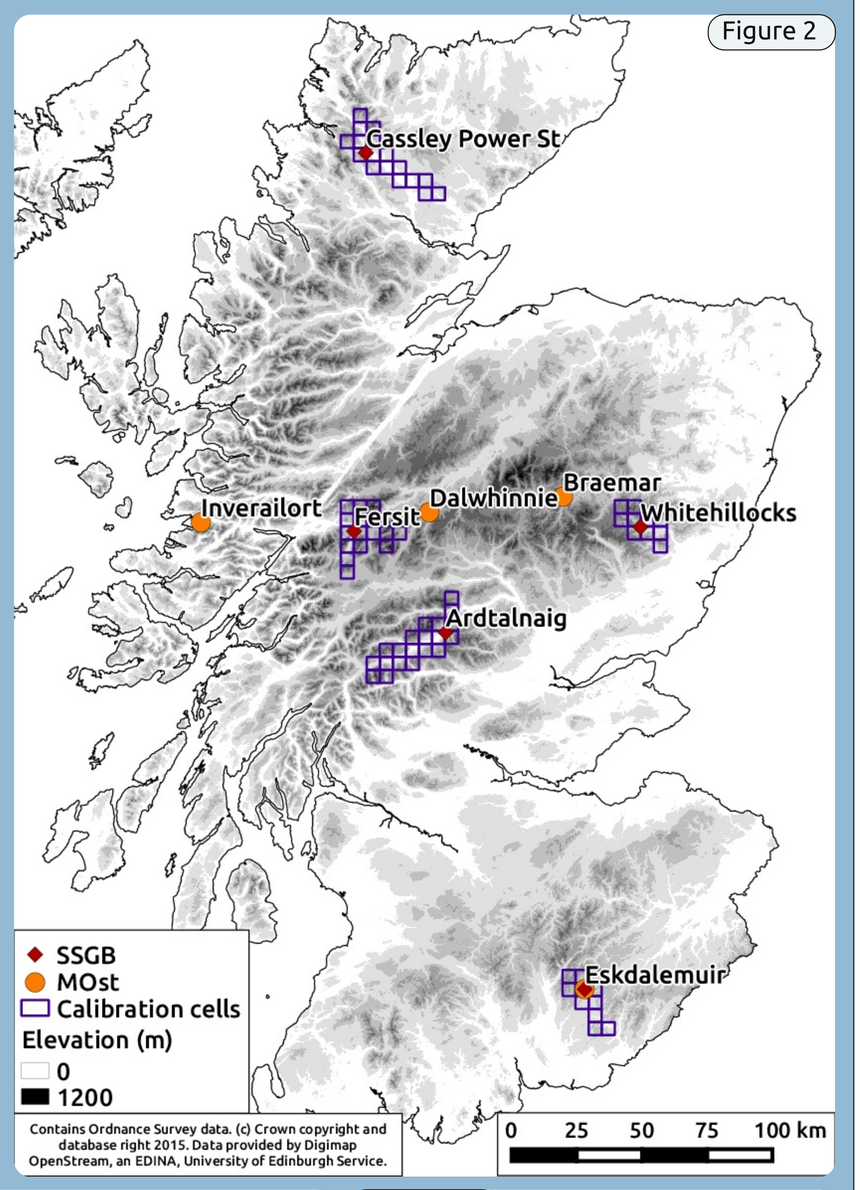


Figure 1

Data sources

1) Snow Survey of Great Britain (SSGB)
2) Met Office station observations; precipitation, temperature and snow lying (MOst)
3) Met Office 5 km interpolated temperature grid (MOgrid)
4) CEH GEAR 1 km interpolated precipitation grid (GEAR)

Figure 2



Conclusion

A degree day snowmelt model calibrated across a wide elevation range has yeilded snowmelt exceedance statistics. This is of great use in temperate climates where ephemeral snow makes annual snow pack estimation invalid.

This work will be of interest to water planners and natural hazard managers. It is straight forward to extend the method to annual days snow cover for use in ecological studies, etc..

Figure 3

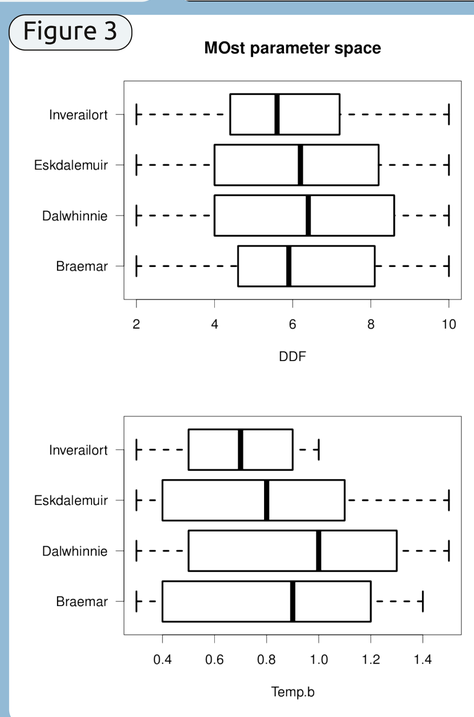


Figure 4

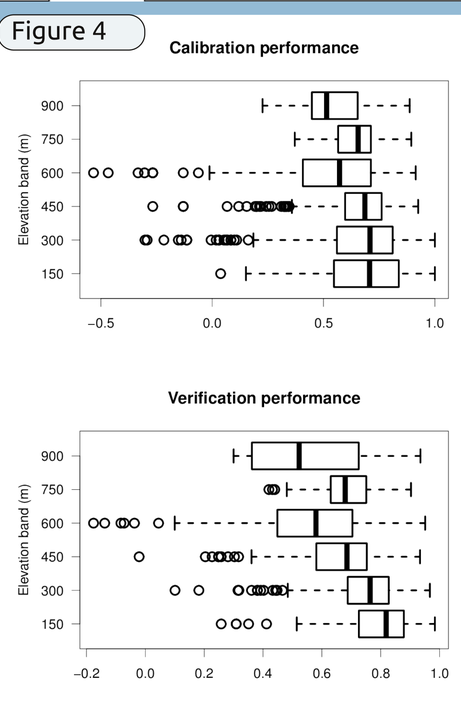
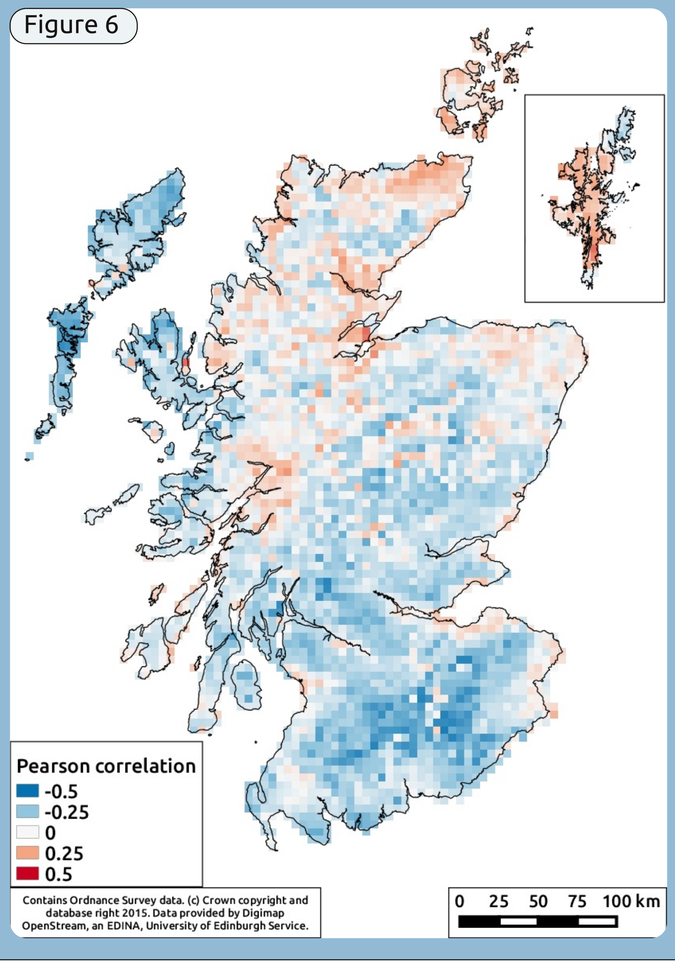


Figure 6



Statistical results

A Generalised Extreme Value model was fitted using l-moments to the 51 annual maximum (AMAX) daily melt rates for each grid cell. The fitted model was then extrapolated to a 1% Annual Exceedance Probability (AEP) and the results plotted (Fig. 5).

Pearson correlation coefficients were calculated for the AMAX series against time. These are plotted (Fig. 6) and show a weak negative trend in the Southern Uplands and Western Isles.

References

Gilleland E and Katz RW, *New software to analyze how extremes change over time*, EOS, **2011**, 92(2), pp. 13-14

Hough, M. N. & Hollis, D. *Rare snowmelt estimation in the United Kingdom*, Meteorological Applications, John Wiley & Sons, Ltd., **1997**, 5, 127-138

Met Office (2012): *Met Office Integrated Data Archive System (MIDAS) Land and Marine Surface Stations Data (1853-current)*. NCAS British Atmospheric Data Centre, **2015**

Ordnance Survey. Land-Form Panorama digital terrain model. http://www.ordnancesurvey.co.uk/oswebsite/products/land-form-panorama/index.html

Perry, M. and Hollis, D. *The generation of monthly gridded datasets for a range of climatic variables over the UK*, International Journal of Climatology, **2005**, 25(8): 1041-1054

Spencer, M., Essery, R., Chambers, L. and Hogg, S. *The historical snow survey of Great Britain: digitised data for Scotland*, Scottish Geographical Journal, **2014**, 130: 252-265

Tanguy, M.,Dixon, H.,Prosdocimi, I.,Morris, D. G.,Keller, V. D. J., **2014**. *Gridded estimates of daily and monthly areal rainfall for the United Kingdom (1890-2012) [CEH-GEAR]*. NERC Environmental Information Data Centre