Geophysical Research Abstracts
Vol. 18, EGU2016-12583, 2016
EGU General Assembly 2016

Glacier-derived climate for the Younger Dryas in Europe

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We have reconstructed and calculated the glacier equilibrium line altitudes (ELA) for 120 Younger Dryas palaeoglaciers from Morocco in the south to Svalbard in the north and from Ireland in the west to Turkey in the east. The chronology of these landform were checked and, when derived from cosmogenic dates, these were recalculated based on newer production rates. Frontal moraines/limits for the palaeoglaciers were used to reconstruct palaeoglacier extent by using a GIS tool which implements a discretised solution for the assumption of perfect-plasticity ice rheology for a single flowline and extents this out to a 3D ice surface. From the resulting equilibrium profile, palaeoglaciers palaeo-ELAs were calculated using another GIS tool. Where several glaciers were reconstructed in a region, a single ELA value was generated following the methodology of Osmaston (2005).

In order to utilise these ELAs for quantitative palaeo-precipitation reconstructions an independent regional temperature analysis was undertaken. A database of 121 sites was compiled where the temperature was determined from palaeoproxies other than glaciers (e.g. pollen, diatoms, choleoptera, chironimids…) in both terrestrial and offshore environments. These proxy data provides estimates of average annual, summer and winter temperatures. These data were merged and interpolated to generate maps of average temperature for the warmest and coldest months and annual average temperature. From these maps the temperature at the ELA was obtained using a lapse rate of 0.65°C/100m.

Using the ELA temperature range and summer maximum in a degree-day model allows determination of the potential melt which can be taken as equivalent to precipitation given the assumption a glacier is in equilibrium with climate.

Results show that during the coldest part of the Younger Dryas precipitation was high in the British Isles, the NW of the Iberian Peninsula and the Vosges. There is a general trend for declining precipitation to the east with some regional exceptions. Local rain shadow effects can be seen in NW Scotland, NW Iberian Peninsula, the Balkans and the Alps. Precipitation is lowest for glaciers in N Norway, which appear to have had their Younger Dryas maxima later in the stadial. This is interpreted to be the result of limited precipitation north of the polar front due to the presence of a near permanent sea ice cover.