



## **Long term changes in flood risk in the Eden Catchment, Cumbria: Links to changes in Weather Types and Land Use**

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Both flood magnitude and frequency are thought to be increasing in recent decades, although this might be a result of inadequate record lengths. Climate change and land use change are possible drivers of this hydrological response. It is therefore important to assess changes in these factors over a longer timescale to see if there is a trend in hydrological change and whether it can be attributed to any of the drivers.

Here we present a long flood record, extending back to 1880, for the Eden catchment, Cumbria, UK, which has been compiled from multiple sources of historical data, including the Chronology of British Hydrological Events and discharge records for the city of Carlisle. Since 1880 there have been 90 recorded floods over of threshold of 500m<sup>3</sup>/s. However, through looking at this longer period of floods, it is clear that there is not a unidirectional trend of flood risk in Carlisle increasing over time. Instead, there are particularly flood rich periods, separated by times which were relatively flood poor. There have been three main flood rich periods since 1880; 1880-1900, 1924-1933 and 1997-2006. Of these, the most flood intense period has been the last decade (1997-2006), with two high flows occurring every year on average. This period also had the highest magnitude flood in it, the January 2005 Carlisle flood, which was 1516m<sup>3</sup>/s.

As mentioned, either climate change or land management change are the main two possible reasons for these flood trends over time. Climate-Hydrology interactions have been investigated through looking at the weather types, in terms of their pressure and direction, affecting the UK. Lamb weather types have been used for this purpose, and out of the 25 lamb weather types, only 13 have caused floods in the last 30 years, of which 5 account for >90% of the floods.

The importance of these five weather types over a longer timescale on flood risk in Carlisle was assessed, through calculating the proportion of each hydrological year classified as one of these flood generating weather types. Two periods clearly have more than the average proportion of the year classified as one of the flood causing weather types; 1900-1940 and 1980-Present. These two periods correlate with times of increased frequency of large floods in Carlisle.

Other possible causes of the flood rich periods relate to changes in which precipitation interacts with the landscape. The Eden catchment is predominantly agriculture, and farming practices have changed significantly over the last 100 years or so. Through comparing historical and modern land uses, it is clear that one of the main changes in the Eden catchment is the increase in field size. Other major changes are the expansion of settlements, like Penrith and Carlisle, deforestation and channel modification, such as straightening. Another important aspect of one particular sub-catchment, the Eamont is the regulation through Haweswater reservoir and how the water resource system has changed over time. However, it is practically impossible to attribute the past changes in flood risk to any land management change.