SNAPSHOT

Flooding costs

The number, extent and global impact of the flood events this year is extraordinary, and accounts for about 47% of global economic losses from nature disasters (Munich Re; http://go.nature.com/ku2qff). The year started with flooding in eastern Australia. Canada experienced flooding in mid-June — massive rainfall and late snowmelt contributed to flash floods in Alberta, with similar events occurring across the country in Toronto and Calgary. China had massive evacuations (up to six million people were affected) in early July in response to extreme rainfall and flooding.

Flooding events in Germany and central Europe in May and June were the most expensive in terms of economic loss, costing around US$16 billion; whereas the disaster in Uttarakhand, North India, in June resulted in the highest loss of life — the death toll is estimated to be in the region of 6,000. There are different contributing causes for each of these events, making it difficult to link individual extreme precipitation events to climate change; but episodes are becoming more frequent.

The floods in Germany and central Europe were comparable in magnitude to the 2002 European flood — a 1-in-100-year event — however, water levels were higher in some regions along the Danube and Elbe Rivers. They were caused by a large loop in the northern jet stream (for an explanation of jet stream meanders and climate change see *Nature Clim. Change* **3,** 689; 2013), which resulted in a stationary high-pressure system over northern Europe. The position of the stationary system forced low-pressure systems to move over central Europe, where they met warm, moist air drawn north from the Mediterranean — leading to heavy rainfall of up to 400 l m^{-2} over a few days. This rainfall followed a wet spring, which had saturated the earth, meaning that the water ran straight into the rivers. However, extensive protection measures implemented after the 2002 floods reduced the impact and financial cost on many cities — such as Dresden, where the old city centre was largely spared — and meant that the rivers did not break through as many dykes. The result of this was that the flood surge reached further downstream.

Development (including deforestation) and poor local planning is thought to have contributed to the death toll and destruction caused by the floods in Northern India. The monsoon arrived early in the state of Uttarakhand, with a multi-day cloudburst — an intense but short period of precipitation — occurring on 14–17 June. This was approximately 847% more rainfall than normal for the time of year (Wunderblog; http://go.nature.com/3iELaZ) with the state's capital city experiencing its highest recorded 24-hour rainfall. The region, which is in the Himalayan foothills, did not have sufficient preparations in place, despite three days of warnings. In addition to this, deforestation and development had destabilized the mountain slopes, thereby increasing the risk of landslides. The extreme rainfall, in combination with residual snow and rain-driven melt from the Chorabari Glacier, triggered a landslide that hit the Hindu shrine in Kedarnath (part of the Chota Char Dham pilgrimage circuit, which experiences high numbers of visitors pre-monsoon). The flood waters were funnelled into the Mandakini River, washing out roads and bridges and hampering the recovery effort. The estimated death toll ranks this as the fourth deadliest weather-related disaster since 2000.

These flood events highlight the variable nature of the climate system. The impact on population centres in Europe from flooding was lower than expected, and illustrates the benefits of preparation for extreme rainfall events. Lessons learnt from this year will be implemented through responsible development and flood control measures, and will help to reduce losses — both human and financial — from future flood events.

BRONWYN WAKE