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# Landslide response signatures from storm Desmond (UK)/Synne (Norway), December 2015.

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Great Britain (GB) and coastal Norway share a common humid maritime climate and annually receive precipitation in the form of cyclonic low-pressure systems or as extra-tropical storms that travel across the Atlantic. Extreme meteorological events capable of triggering floods and landslides are becoming more frequent, with both GB and Norway being affected by a sequence of record-breaking precipitation events in the past decade. On the 5th and 6th of December 2015, storms Desmond/Synne struck northern GB and southwestern Norway with record-breaking rainfall; >340 mm in 24-hour in Cumbria (or 200% of long term average) and daily accumulations in Norway in excess of 140 mm and 236 mm/48hr. Landscape responses to hydro-meteorological stress are non-uniform and the result of a complex interaction of processes. Therefore, event-specific analysis provides an important tool to further our understanding, particularly to enhance the quality of daily landslide hazard assessments (DLHA) issued by the Norwegian Water Resources and Energy Directorate (NVE) and the British Geological Survey (BGS).

The application of precipitation thresholds provides a useful first approximation for landslide triggering. However, antecedent conditioning of slopes and the spatial variability of precipitation signatures are important factors in determining the location of landslides. Given the magnitude of storms Desmond/Synne a much larger population of landslides was expected to occur. Within one month of the events occurring some 25 events are recorded in GB and circa 30 events in Norway. In GB most of these events are relatively small scale, dominated by translational slides and flows and about 80% of cases reported to occur along transport infrastructure. In Norway, roughly equal numbers of debris flows, shallow slides, rock falls, slush flows and snow avalanches are recorded in close proximity to infrastructure. As the media largely focused on simultaneous severe consequences of extensive flooding, landslide events appeared to be relatively under-reported. In the following days, information gradually emerged through anecdotal photographic evidence and social media of how landslide impacts. By their nature, rural areas with limited transport links will remain under-reported. Forensic analysis of landslide events highlights the importance of other contributing factors responsible for event localisation, particularly where larger events are concerned.

There are many physiographic similarities of the landscapes of western Norway and those of Cumbria and Scotland. Many places can be characterised by relatively thin superficial deposits covering bedrock resulting in similar hydro-geological response mechanisms, e.g. the formation of debris flows at Rest and be Thankful (A83, Scotland) and at Sørfjorden (Hordaland, Norway). In Norway an impact transition was observed as the weather system moved further northeast first affecting areas with rain on soil causing landslides, then rain on snow causing slush flows. Impacts clearly are a function of 1) the characteristics of the medium covering the bedrock (soil type, snow cover), 2) the antecedent soil moisture condition, and 3) precipitation signature. Comparative analyses lead to improved understanding of triggering thresholds and synergies delivered by transfer of skill sets on landslide data management, analysis and communication for DLHA.