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

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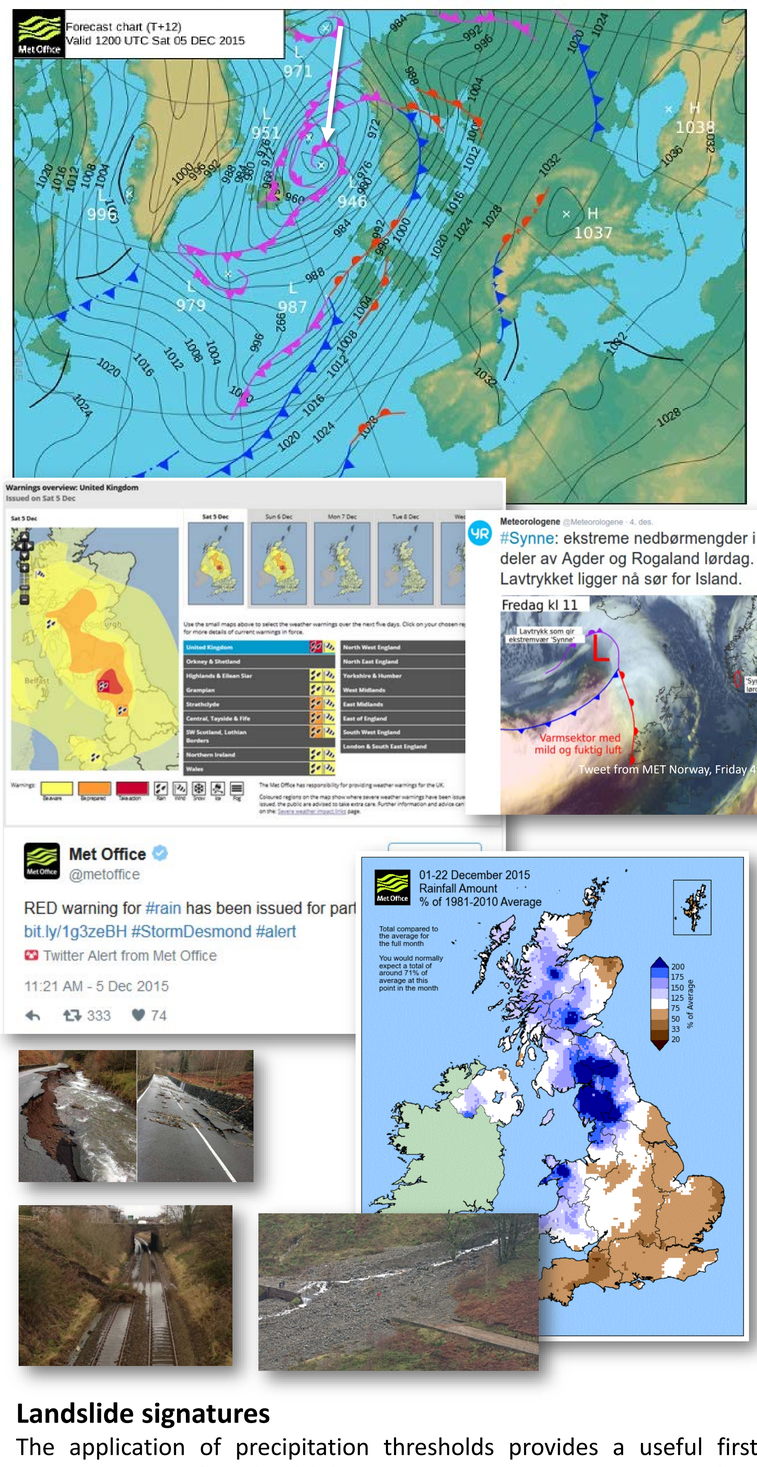
Introduction

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.

Desmond/Synne

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).

Desmond/Synne



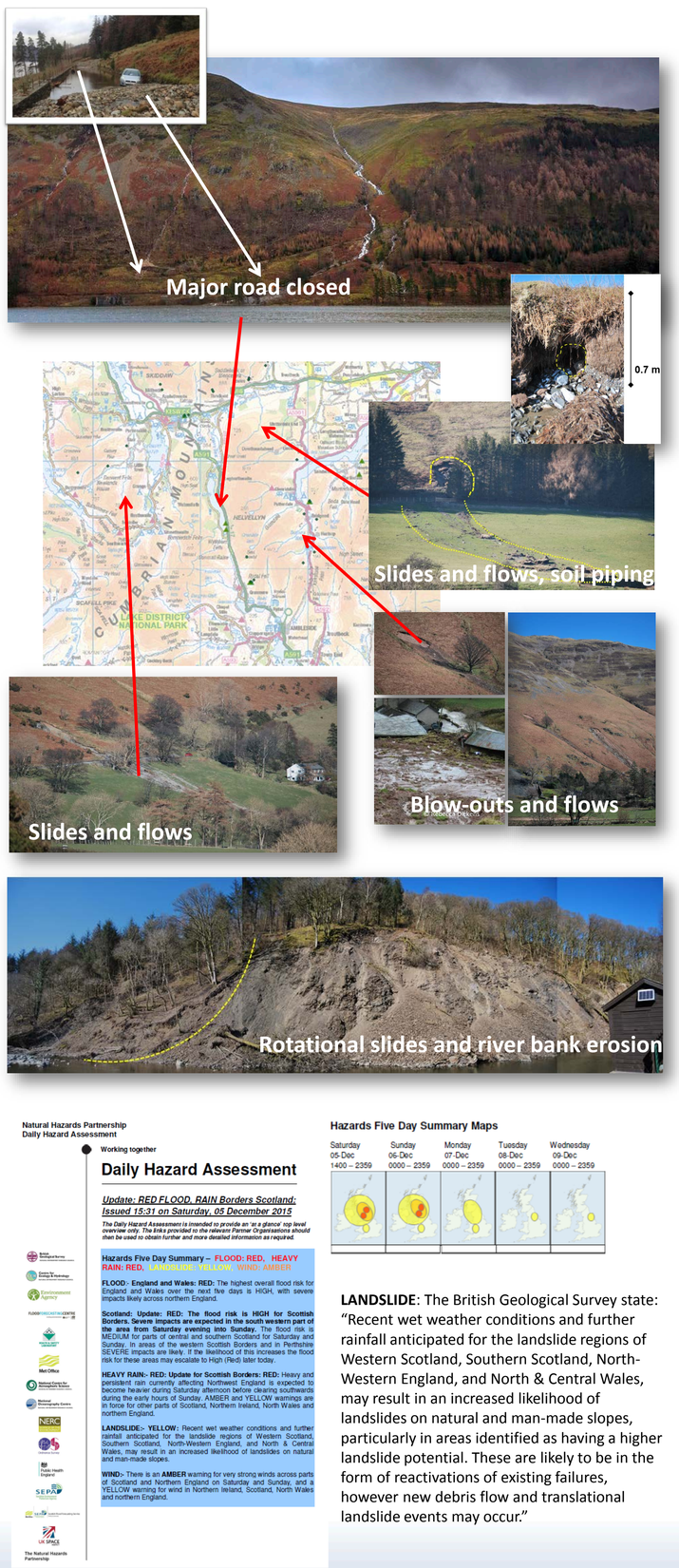
Landslide signatures

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 were recorded in GB and circa 30 events in Norway. 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).

GB events

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. See examples from Cumbria shown to the left. Different types of landslides were observed, ranging from slides to flows. There appears to be a dominance of shallow, mainly translational events, commonly driven by rapid build-up of pore-pressures in soil pipes. Rapid drainage through overland flow and throughflow through coarse regolith resulted in large discharge peaks and critically enhanced erosive capacity of stream channels. This dislodged large amounts of sediment although it is argued that these flows did not quite generate debris flows.



LANDSLIDE: The British Geological Survey state: "Recent wet weather conditions and further rainfall anticipated for the landslide regions of Western Scotland, Southern Scotland, North-Western England, and North & Central Wales, may result in an increased likelihood of landslides on natural and man-made slopes, particularly in areas identified as having a higher landslide potential. These are likely to be in the form of reactivations of existing failures, however new debris flow and translational landslide events may occur."

Twitter was the greatest source of information in GB and high profile landslides were subsequently reported via News agencies. In both countries numerous landslides reported affecting major transport routes. However, under-reporting of landslides is expected in these rural landscapes and field inspection was carried out to gain better understanding of landscape response and landslide event signatures.

Norway events

In Norway, roughly equal numbers of debris flows, shallow slides, rock falls, slush flows and snow avalanches are recorded in close proximity to infrastructure.

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 the characteristics of the medium covering the bedrock (soil type, snow cover), the antecedent soil moisture condition, and precipitation signature.

Conclusions

Natural slopes: The dominant mechanisms in **Norway** involved debris flows and slush flows in the Sørfjorden area (Hordaland) and translational slides in areas with thick till. The dominant mechanism in **Cumbria** involved shedding of surplus water through thin regolith following natural pathways/pipes and where flow becomes impeded, rapid build-up of pore pressures causes a 'blow-out' failure of root mat and thin regolith. Large rotational events are relatively few and are mainly associated with river incision and channel bank erosion in till. Coarse regolith appears able to shed surplus water (Cumbria - soil pipes with pre-existing outlets) and overland flow dominates in these high-intensity precipitation events – resulting more in flooding rather than landsliding.

Events affecting infrastructure slopes: small translational/flow events in Cumbria stopped trains (small events, large impact) and mainly shallow soil slides occurred along road cuts (e.g. Vest Agder). Major effects from debris accumulations from streambed erosion/debris flows and from undercutting of roads causing long diversions.

Value of this Case Study is in gaining a better understanding of precipitation trigger magnitude and associated modes of landscape response. This has resulted in further developments of the GB Daily Landslide Hazard assessment, a better appreciation of the UK→Norway impact transition as weather systems move northeast and improved international collaboration that leads to synergies in forecasting capabilities and communication.

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