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Future changes in wind and rain and the implications for wind driven rain

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Summary

Wind driven rain is a result of wind and rain occurring together, causing water to penetrate vertical walls. In winter in the UK this is likely to be associated with storms. There are small increases projected over the UK and Scotland for some measures of storminess, confidence in this projection remains low. There is currently limited evidence regarding future changes in the wind speeds associated with storms. Mean winter precipitation and the intensity of precipitation in storms are both projected to increase, which may be associated with increased risk of wind driven rain. However, year-on-year variability in storminess will remain high and over the next few decades this is likely to dominate over the effects of climate change. This has implications for existing building stock, and also for design in new construction.

Part 1: Wind, rain, and winter storms; future projections for Scotland

Precipitation

The climate projections produced by the UKCP09 project give the probabilities of certain levels of change in variables including precipitation for different future periods. Both mean winter precipitation and precipitation of the wettest winter day are projected to increase in the future (Table 1). For mean precipitation, a decrease in any region is very unlikely, and projected increases are largest in the west. Therefore the well-known West-East differential in mean precipitation will remain, if not strengthen, in the future. Projected changes in the wettest winter day are similar to that in the mean for East Scotland, and slightly smaller than that in the mean for North and West Scotland, although the reason is unclear.

The use of a high GHG emissions scenario substantially increases the upper estimate of mean change for the 2080s; otherwise, the effect of the emissions scenario on mean precipitation change is small (a few percent only).

These regional values hide much of the detail in projections; maps of changes show largest increases on the coast and smallest increases inland and at altitude. However, caution should be exercised when interpreting precipitation responses on such fine scales as they are highly dependent on model representation of fine scale processes. Both local and regional changes are also dependent on large-scale biases, for example in the storm track position.

		East Scotland	North Scotland	West Scotland
Mean winter Precipitation	2050s	**+10% (1%, 20%)**	**+13%** (3%, 24%)	**+15% (5%, 29%)**
	2080s	**+12% (1%, 25%)**	**+18% (4%, 35%)**	**+21% (6%, 42%)**
Wettest Winter Day Precipitation	2050s	**+10% (0%, 21%)**	**+6%** (-4%, 17%)	**+9%** (-2%, 21%)
	2080s	**+14% (2%, 28%)**	**+9% (-2%, 22%)**	**12% (-1%, 29%)**

Table 1. Changes in winter precipitation relative to the period 1961--1990 for the Scottish regions. Values from UKCP09 probabilistic projections under a medium emissions scenario. '2050s' refers to 2040—2069 and '2080s' to 2070—2099. The central estimate of change is shown in bold, and the change is very unlikely to lie outside the range shown in brackets (which indicates the 10th and 90th percentiles).

Variability

Even in the absence of an external forcing such as the increase in greenhouse gases in the atmosphere, precipitation, storms and wind exhibit year-to-year and decade-to-decade variability, known as 'natural' or 'internal' variability. In the next few decades, changes in storm frequency, precipitation and wind will be dominated by this variability (a concept demonstrated in Deser *et al* 2014), which is largely unpredictable. However, by the end of the 21st century, the effect of greenhouse gases relative to this internal variability will become increasingly significant, leading to the changes in Table 1.

In particular, changes in Table 1 are for a thirty year average and taken relative to a particular baseline (1961—1990). Use of a different baseline period would result in slightly different numbers. Consideration of individual years or even decades within the thirty year period would give a wider range of possible changes (e.g. Sexton and Harris, *2015*). [1]

Wind speeds

The spread in projections of changes in surface wind speed from UKCP09 (Sexton and Murphy, 2010) give a central estimate of no change in Scotland, with either positive or negative changes possible. There is no coherent spatial signal within Scotland. Wind speed changes well above the surface in the driving models are dependent on the ocean conditions (Sexton and Murphy, 2010) so certainty regarding changes is low.

[1] This must also be borne in mind when comparing these thirty-year-average changes to recent trends in Scottish precipitation, which include this year-to-year and decade-to-decade variability.

Storms

Strong wind speeds and heavy precipitation in the winter in Scotland are typically associated with extratropical cyclones, commonly referred to as storms. Data from the most up-to-date set of climate models, as used in the last IPCC report, suggest that an appropriate description for changes in the North Atlantic storm track is an extension into Europe, rather than the poleward shift more common in other regions and seasons (Christensen *et al*/IPCC 2013, Chang *et al*. 2012, Zappa *et al.* 2013). For the UK, there is a projected small increase in the number of storms and individual storms are associated with increased precipitation (Zappa *et al.* 2013). While change in winds associated with individual storms is near-zero (Zappa *et al.* 2013), the increased number of storms may of course increase the number of days with high winds. A projected increase in the number of storms associated both with extreme precipitation (an increase of over 25%), and extreme wind speeds (a small increase, of 3%), has been identified for the UK (Zappa *et al.* 2013).

Confidence in these projections of cyclones and their impact on surface weather is still low due to model deficiencies and a lack of understanding due to conflicting processes in the North Atlantic (Christensen *et al*/IPCC, 2013). Future improvements in model resolution may provide new information on projected storm track changes. For example, Haarsma *et al.* (2013) found projected increases in a particular type of storms over Europe in a high resolution model, which would not be well simulated at lower resolution. However, results such as this must be more robustly tested, for example in several climate models, before they can be treated with confidence.

Finally, there is a tendency for storms to ‘cluster’, so that the occurrence of storms is unevenly distributed in time. For wind-driven rain, this clustering of wind driven rain may cause an added risk to buildings. Evidence has been found of a future decrease in storm clustering over the UK (Pinto et al, 2013) but in a single climate model only, so this result should be viewed with caution at present.

Part 2: Implications for wind-driven rain

Wind driven rain is rain incident on a vertical wall which can cause penetration of damp and therefore building damage. The important factors are rain intensity, frequency and persistence and wind strength and direction (Building Research Establishment, 2011). In particular ‘rain per spell’, where a spell ends when dry conditions persist for a long enough time, is used to define exposure to wind driven rain. Therefore, not only the total rainfall but also its distribution is important for determining wind driven rain. Wind driven rain exposure varies across Scotland consistent with the west-east differential in rainfall, with greatest exposure on the west coast.

Therefore, although there is no consistent signal in wind speeds for Scotland, there is some evidence that wind driven rain risk will increase due to mean and extreme precipitation increases. Year-on-year variability in the variables considered here will remain high and over the next few decades this is likely to dominate over the effects of climate change.

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