12.12 OBJECTIVE CYCLONE CLIMATOLOGIES OF THE NORTH ATLANTIC USING NCEP/NCAR AND ECMWF REANALYSES: IMPLICATIONS FOR THE UK INSURANCE INDUSTRY

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1. INTRODUCTION

An investigation into the behaviour of North Atlantic cyclones has been conducted and a GIS-based windstorm hazard model developed that can predict patterns of damage across the UK. The underlying motivation arises from the perceived increase in the frequency of severe windstorms in parts of Europe over the past few decades. Examples include the 'hurricane' of October 1987, which devastated southern England and resulted in an insurance pay-out of ~£1.2bn, and the gales of January to March 1990 which produced average wind speeds exceeding 32.7m/s. The storm of 25th January 1990, in particular, produced wind speeds greater than 45m/s, and killed 47 people in the UK alone. Subsequent winters have been characterised by storms of this nature with high wind speeds and heavy precipitation. Examples include the severe winter storm of Christmas 1997 in the UK and the series of storms including Lothar and Martin that affected northern France in December 1999.

2. CYCLONE CLIMATOLOGIES

Two objective cyclone climatologies of the North Atlantic, spanning a period of 39 winters (October - March 1958-1996), have been constructed from mean sea level pressure data from the European Centre for Medium-Range Weather Forecasts (ECMWF) and the National Centres for Environmental Prediction/National Centre for Atmospheric Research (NCEP/NCAR) reanalysis models. The major temporal and spatial characteristics of North Atlantic cyclones have been examined and a comparison between the climatologies developed from both data sets carried out.

Cyclone intensity has been determined from the maximum gradient wind speed achieved by each cyclone event. This has been calculated using the cyclone radius and maximum pressure gradient attained at any point during the cyclone's lifespan. This has enabled the assignment of an appropriate Beaufort Scale (BS) category to each cyclone.

While discrepancies are evident between the cyclone climatologies of the two reanalysis models, the well-known cyclogenesis regions along the east coast of the United States and to the south-east of Greenland are replicated by both models, as is the characteristic south-west/north-east orientation of the dominant cyclone track across the Atlantic basin. However, only weak correlations are found between the time series of cyclone frequency produced from the two models, particularly for the lower intensity Beaufort Scale category 3-7 cyclones (Table 1). This, together with the large differences in the spatial distribution of cyclones over Greenland for Beaufort Scale 3-6 cyclones, indicates that the NCEP/NCAR model replicates fewer of the weaker systems than the ECMWF model. In general, the results from this study suggest that the NCEP/NCAR model has problems replicating the weaker cyclones and that the ECMWF data generate a more comprehensive climatology of North Atlantic cyclones.

BS Category	Correlation
3+	0.21
4+	0.17
5+	0.21
6+	0.13
7+	0.22
8+	**0.69**
9+	0.42
10+	**0.77**
11+	**0.68**
12	0.32

Table 1. Correlation coefficients between ECMWF and NCEP/NCAR cyclone counts at different BS scale intensities. R-values in bold are statisitically significant at the <0.01 level.

The cyclone climatologies show no significant time-dependent trend in the frequency of North Atlantic cyclones affecting NW Europe. The only increase in activity is in cyclones of Beaufort Scale 8 and above, which reveal an increase in frequency throughout the late 1970s and 1980s, peaking in the early 1990s, followed by a downturn in activity thereafter. This result is confirmed by the analyses of Alexandersson et al. (2000) who

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extended the time series used by WASA (1998) to 1998.

A detailed investigation of cyclone distribution across the North Atlantic has been carried out on the NCEP/NCAR climatology using Principal Component Analysis (PCA). Analyses of gridbox cyclone counts and 500hPa geopotential heights demonstrate a general northward shift in the dominant SW/NE orientated cyclone track across the region over the 39 year study period. PCA has also been used to investigate the relationships between cyclone occurrence and major atmosphere-ocean mechanisms such as the North Atlantic Oscillation (NAO), Arctic Oscillation (AO), the position of the Gulf Stream and the Southern Oscillation.

The analyses described above confirm the dominance of the influence of the NAO and AO on the distribution and frequency of North Atlantic cyclones. The indices used to represent the AO and NAO reveal that during a positive phase of both oscillations (i.e. in the NAO, lower than average pressure over Iceland and higher than average pressure over the Azores, and in the AO, lower than average pressure over the North Pole and higher pressure around 55°N), cyclones track further north between Iceland and the UK bringing warmth and moisture to Northwest Europe and leaving the south and the Mediterranean cool and dry. During a negative phase (the pressure over Iceland is higher than average and over the Azores is lower than average in the NAO, and in the AO lower than average pressure around 55°N and higher than average pressure over the North Pole), cyclones are able to track further south, entering the Mediterranean. These analyses have also confirmed the uncertainty of the relationship between the position of the Gulf Stream and cyclone activity found by Taylor (1996) and has also confirmed the 2 year lag relationship between the Gulf Stream and the NAO (Taylor and Stephens, 1998). No evidence could be found to suggest an influence of the Southern Oscillation on North Atlantic cyclone activity.

3. INSURANCE DAMAGE MODEL

Building on the cyclone climatology, a GIS-based windstorm damage model has been developed. This model is based on the physical characteristics of mid-latitude cyclones and their relationship to damage indices based on domestic buildings insurance claims data for the UK at the postcode district level. These indices include the claim density (number of policies making a claim in each postcode district) and relative damage (the total value of the claim in each postcode district relative to the total insured value of the district). The model was developed using damage information from the October 1987, January 1990 (Daria) and February 1990 (Vivian) storms. The predictor variables include wind speed, mean elevation of the postcode district, and distance of the postcode district from the storm track and also from the point of landfall.

As a result of the small number of storms for which damage data are available, and the uncertainties regarding the reliability of the February 1990 claims data, it has not been possible to construct a generic damage model. The uncertainties are based on the fact that between Daria and Vivian there was high windstorm activity over the UK, particularly between the 7th and 8th February 1990. This activity has without a doubt contributed to the level of insurance claims made during February 1990, which have largely been attributed to windstorm Vivian. Hence, damage due to Vivian only is overestimated. Two models have been developed for the October 1987 and January 1990 storms. Attempts to validate have been made using the remaining storm e.g. the October model has been validated using the January 1990 data and vice versa. These models are termed 'one-storm models'. Despite the fact that a generic model could not be developed due to problems with data, the 'one storm' models for the October 1987 and January 1990 storms can realistically be applied to future storms with characteristics similar to either of these two events.

4. REFERENCES

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