Severe Windstorms in Europe

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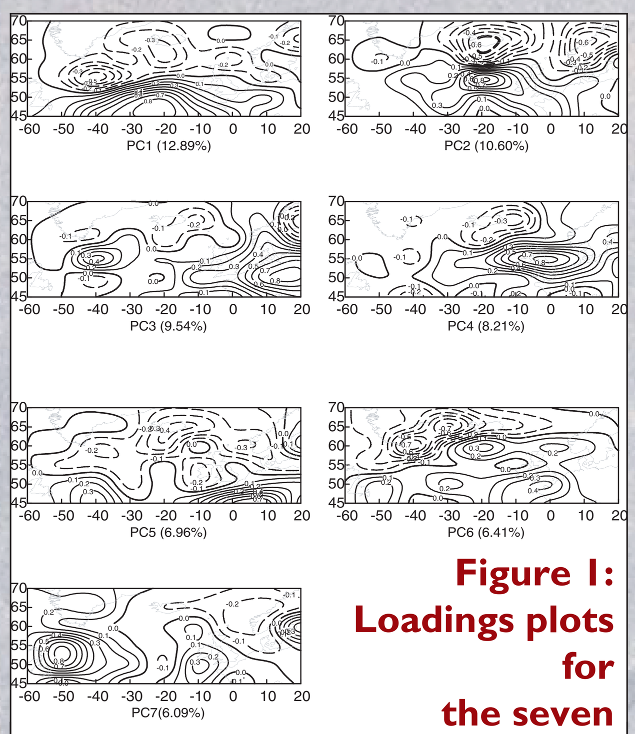

Figure 1: Loadings plots for the seven frequency PCs

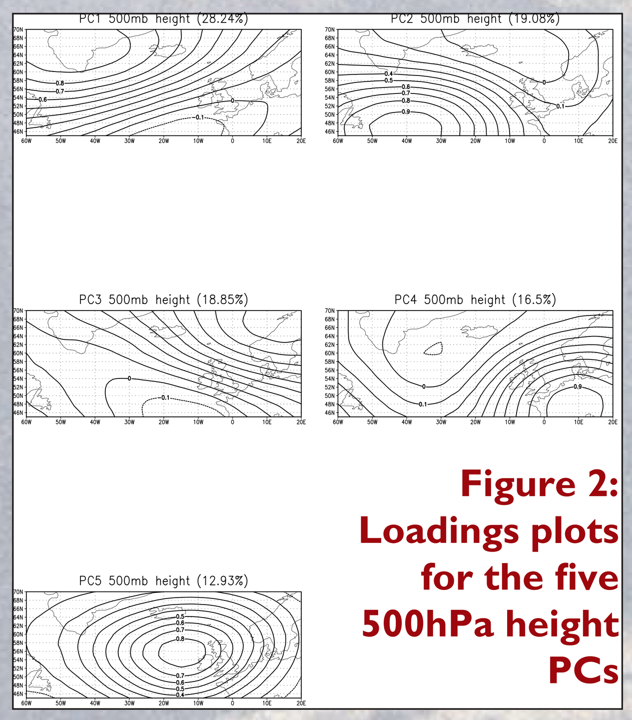

Figure 2: Loadings plots for the five 500hPa height PCs

1. Introduction

Europe is vulnerable to the impact of storms developing across the North Atlantic.
Investigating changes in the behaviour of these storms can help us mitigate against the severest events to minimize human and economic losses.
This study focuses on the variations in storm activity across the North Atlantic and the impact of storms on Northwest Europe by developing a storm climatology of the region and a storm damage model.

2. Storm Climatology

Low pressure events have been identified and tracked during winter periods (October-March) 1958-1996.
Principal Components Analysis (PCA) has been carried out on the occurrence of storms across the North Atlantic.
For this study, PCA has been used to isolate the dominant modes of variability in storm occurrence.
This analysis technique organises the total variance in a data set into uncorrelated components each representing a smaller amount of the variance of the original data than the previous one.
Seven principal components (PCs) have been investigated. The loadings plots for these PCs are shown in Figure 1.

Interpretation of 500hPa PCs

PC1	SW-NE orientated flow – the dominant storm track in the North Atlantic
PC2	Events are directed across the UK
PC3	NW-SE orientation of activity
PC4	Activity is concentrated to the north of the UK, following the Greenland coast on a path from the East coast of the USA
PC5	Activity is located to the north of the study region with a lack of activity in the centre

Interpretation of Frequency PCs

PC1	Represents the north-south variation in storm activity
PC2	Correlated with the Arctic Oscillation
PC3	Azores High Pressure region deflecting storms over the UK and northwards
PC4	Correlated with the Southern Oscillation (2 year lag)
PC5	Correlated with the North Atlantic Oscillation and the position of the Gulf Stream
PC6	Variability due to the Arctic Oscillation
PC7	Influence of the Siberian Anticyclone

The majority of variance is orientated in a north-south direction.
Correlations were calculated between the seven PCs and the North Atlantic Oscillation Index, the Arctic Oscillation Index, the position of the Gulf Stream and the Southern Oscillation Index (Table 1).
For predictive purposes lag time correlations were carried out between the indices and the number of storms in each Beaufort Scale intensity category, the statistically significant correlations are shown in Table 2.

Mechanism	Correlation with Mechanism
NAO	PC1=-0.370*; PC5=-0.484**; PC6=-0.379*
NAO (0.5)	PC1=-0.534*; PC5=-0.617**
AO	PC1=-0.375*; PC2=-0.362*; PC6=-0.475**
SO (2yr lag)	PC4=-0.376*
Gulf Stream (1yr lag)	PC5=0.379*

* significant at 0.05 level ** significant at 0.01 level

Table 1: Correlation between indices and frequency PCs

Mechanism	Category	Correlation (0.05 level)
NAO	7+ (no lag)	0.361
	8+ (no lag)	0.375
AO	7+ (no lag)	0.382
	7+ (1yr lag)	0.370
	9+ (no lag)	0.324
	10+ (no lag)	0.318
	12 (1yr lag)	0.332
Gulf Stream	8+ (2yr lag)	-0.408

Table 2: Lag time correlations between indices and the number of storms in each Beaufort Scale category

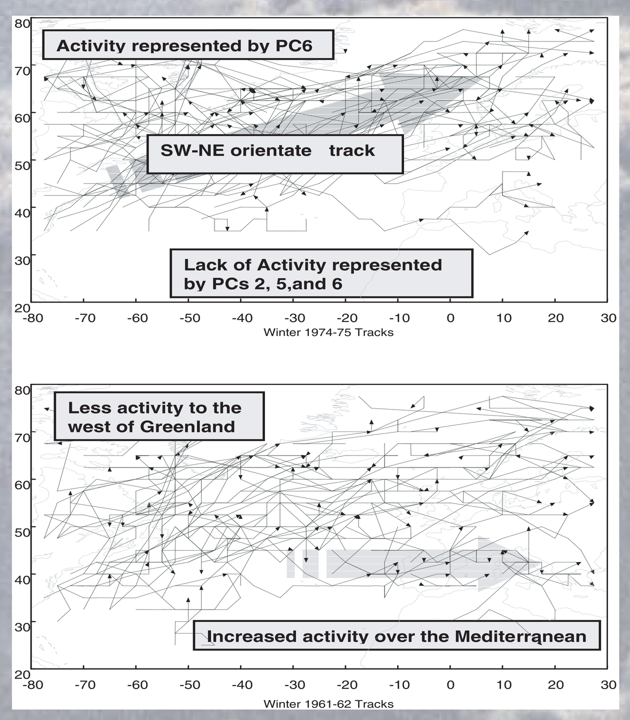

Figure 3: Winter storm tracks 1974-75 (above) and 1961-62 (below)

Year	PC1	PC2	PC3	PC4	PC5	PC6	PC7
1961-62	0.88	-1.43	-0.21	0.58	2.95	-0.23	1.30
1974-75	0.15	-0.56	2.54	0.06	-0.7	-1.23	0.30

Table 3: PC Scores for 1961-62 and 1974-75

PCA was also carried out on 500hPa geopotential height data (Figure 2). The 500hPa height reflects the 'dampened' or 'smoothed' variations in pressure at the surface.

Storm activity for the winter periods 1961-62 and 1974-75 are shown in Figure 3.
The PC scores, which represent the temporal importance each PC, are shown in Table 3.
During 1974-75 PCs 3, 6, 2 and 5 are significant in representing the activity across the region.
PC3 indicates activity across the entire region with a decline around Greenland and Iceland.
PC6 represents activity to the north of the region and sparse activity above 70N.
PCs 5 and 2 support this northern activity. In association with PC6 they reduce the influence of PC3 resulting in a lack of activity to the south.
In comparison, 1961-62 has more dispersed activity and fewer storms found over and to the west of Greenland.
Tracks penetrate further south represented by a strong, positive PC5, indicating a strong, negative NAO.

3. Catastrophe Modelling

Aim: to develop a model that will calculate the total damage produced by individual storm events with data from the October 1987; January 1990 and February 1990 storms.

Data: wind speeds around the UK and residential buildings insurance data.

Model variables: damage indicators - the percentage of policies claiming (Figure 4) and the percentage of the total claimed to that insured (Figure 5); distance from track; distance from landfall; elevation and maximum gust speed for each of the three storms.

Results for the October 1987 storm are shown (Figures 4-8). For each postcode region maximum gust speeds (Figure 6) and the distance from the track has been caluclated.

The greatest damage is restricted to the SE of England.
The percentage of policies claiming increases with wind speed and a maximum is reached around 250km from the track (Figure 7).

The percentage of the total claimed to that insured produces a clustering of claims within 200km of the track with a maximum at around 400km. The greatest proportion of claims occurs at maximum gust speeds of between 20-25 m/s (Figure 8).

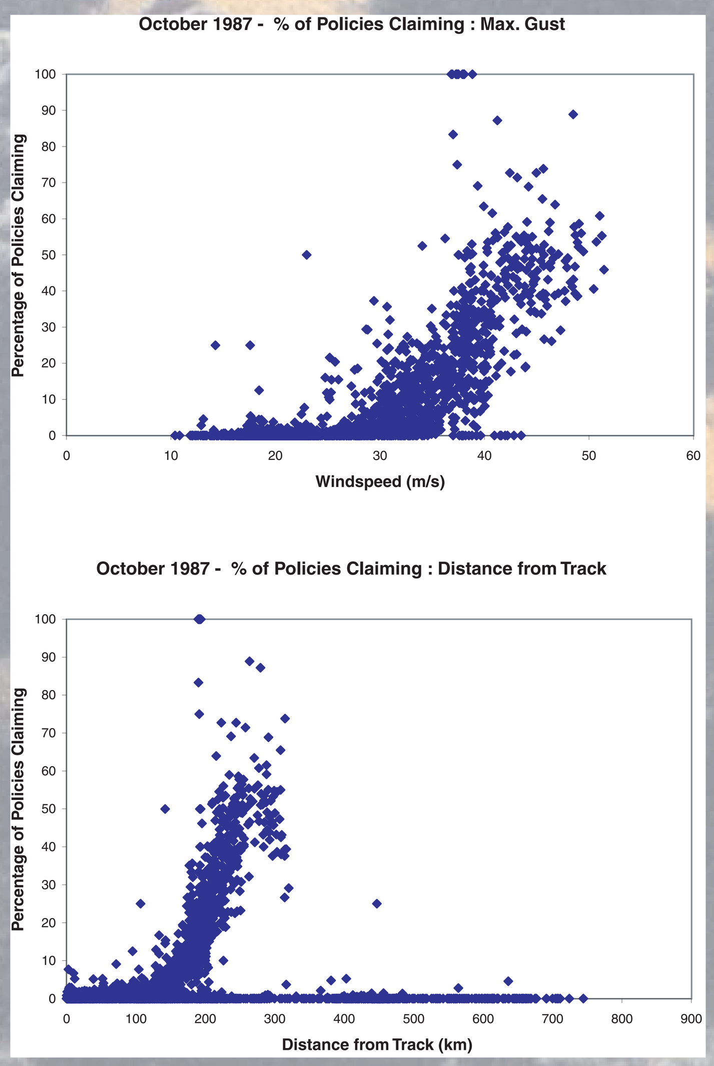

Figure 7: Relationship between the percentage of policies claiming and max. gust speed (above) and distance from track (below)

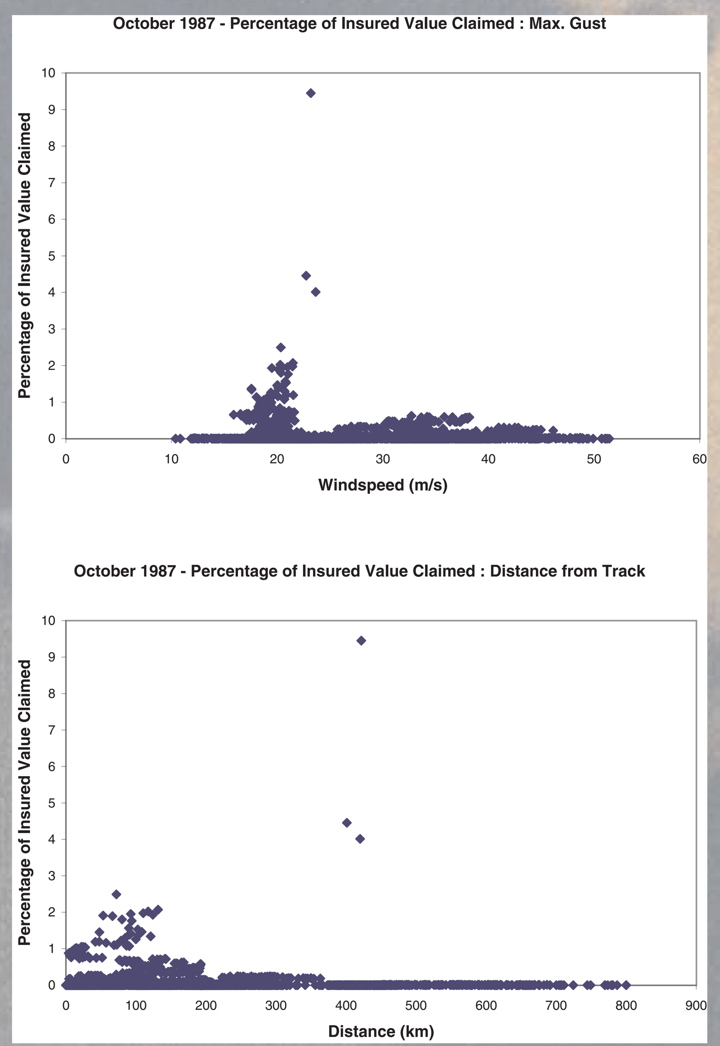

Figure 8: Relationship between the percentage of insured value claimed and max. gust speed (above) and distance from track (below)

Relevant Reading

Hayden, B. P. (1981) 'Secular Variation in Atlantic Coast Extra-Tropical Cyclones', Monthly Weather Review, 109: 159-167

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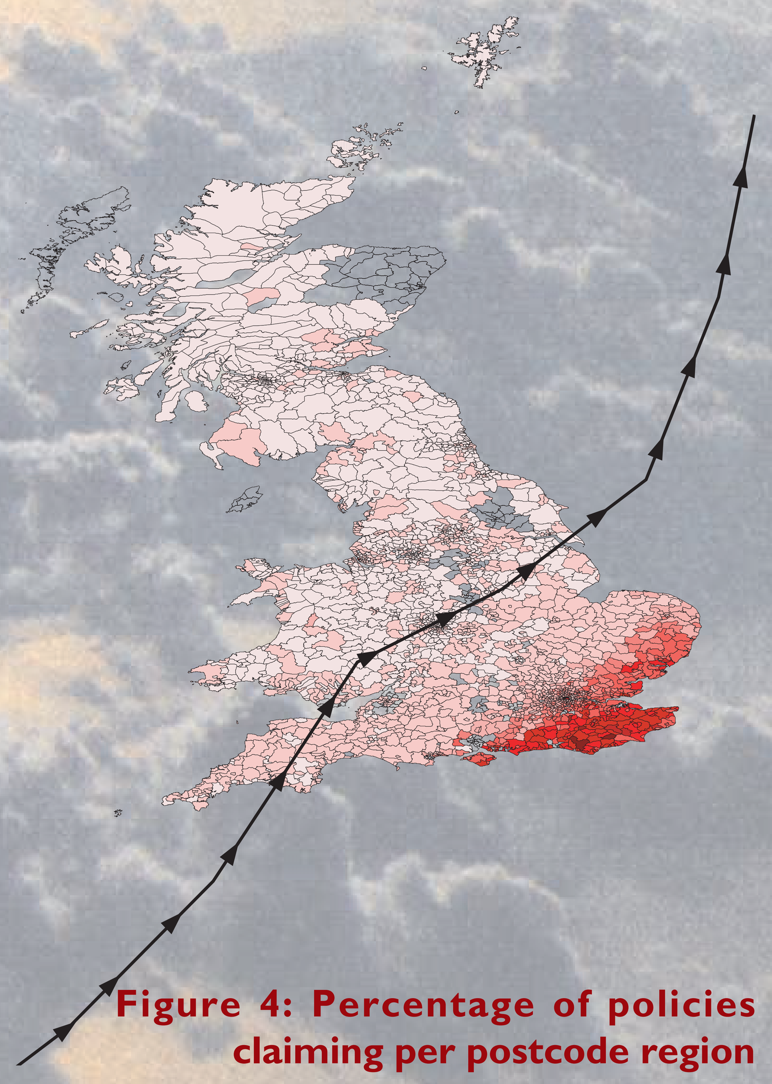

Figure 4: Percentage of policies claiming per postcode region

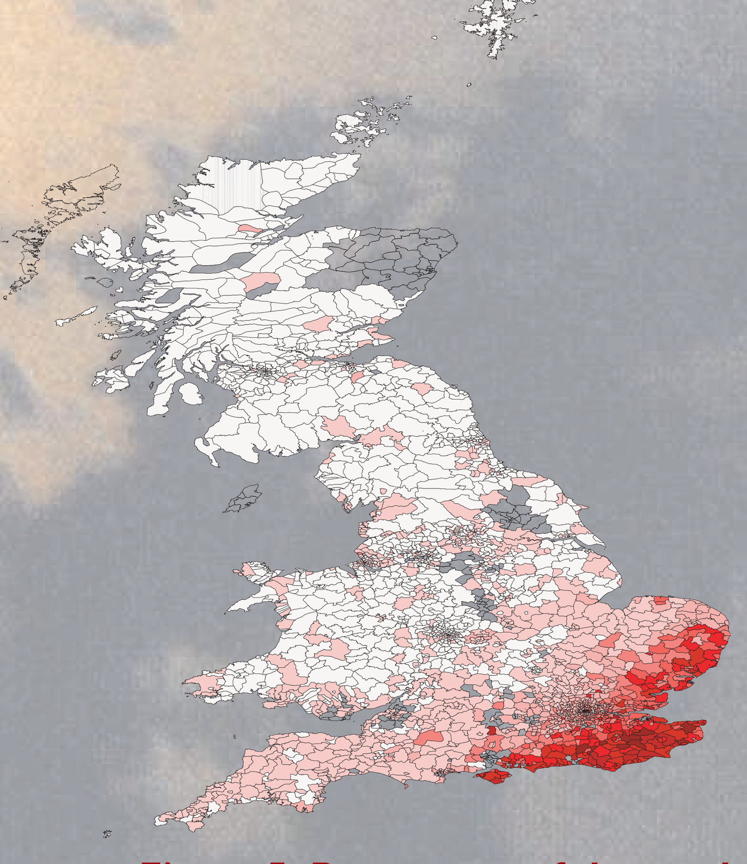

Figure 5: Percentage of the total claimed to that insured

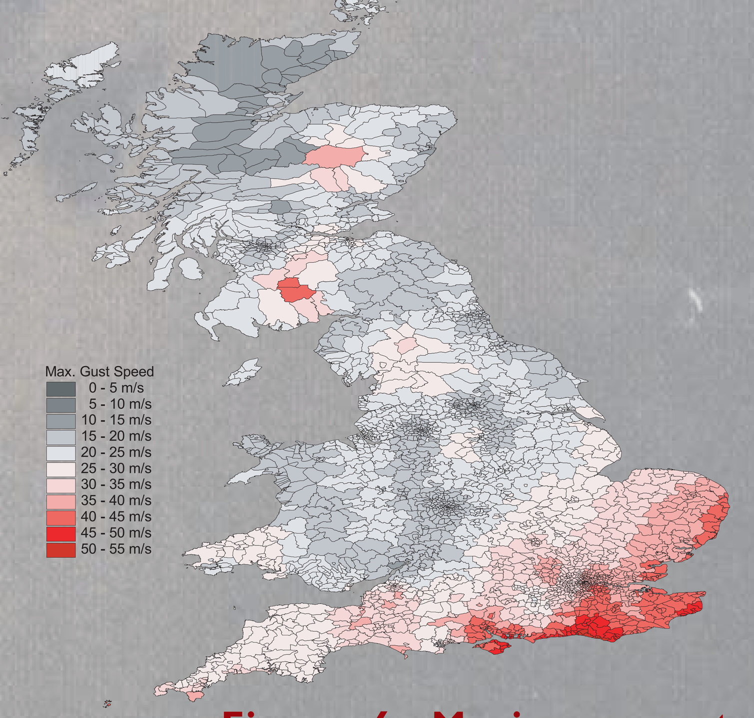

Figure 6: Maximum gust speeds (m/s)

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