Covariance of Storm Hazards in the Atlantic Basin

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Are Regional Climate Perils Related?

Risk of Global Weather Connections,
Lloyd’s and Met Office 2016
Hypothesis

The Atlantic Hurricane Season and European winter windstorm season are *not* independent from one another.

A pathway exists between the two through a climate teleconnection.
Hypothesised pathways

1. El Niño event in Eastern Tropical Pacific
2. Rising motion and associated upper level wind flow from Equatorial Pacific to Atlantic
3. Reduction in Atlantic Hurricanes due to upper level wind shear increase
4. Tropical to Extratropical connection through Rossby wave
5. Increase in European windstorms through positive North Atlantic Oscillation

Gray 1984
Scaife et al. 2017
Hypothesised pathways

1. Tripole pattern of sea surface temperature in Atlantic

2. Decrease in Hurricane activity due to cold Sea Surface temperature

3. Increase in European windstorms through positive North Atlantic Oscillation

Fan and Schneider 2012
Hallam et al. 2019
Wild et al. 2015, Dunstone et al. 2016
Data Limitations

Reliable count data for both Tropical and Extratropical Cyclones only in the satellite era (1979-present)

Extend by building event climatology from Ensemble Prediction System

Pearson Correlation coefficient: $-0.2$

Not significant at the 95th percent confidence level

Tropical Cyclone count: IBTrACS best Track data
Extratropical Cyclone count: Cyclone Tracking in ERA-interim
Methodology

Repurpose a forecast ensemble to treat each ensemble member as a different climate realization

National Hurricane Center, Hurricane Katrina Uncertainty August 25th
Ensemble Prediction System

European Centre for Medium Range Weather Forecasting (ECMWF) System 5 EPS (SEAS5)

51 ensemble members over 36 years (1981-2016), total of 1836 model years

Initialised 1st of each month, run for 7 months. Selected 1st of August initialisation to cover peak Atlantic Hurricane Season (Aug-Oct) and peak European Windstorm season (Dec-Feb)

Horizontal grid spacing TCo319 (~35km, cubic grid)
Event Tracking Methodology

Find Clusters of 98th percentile windspeed exceedance (Leckebusch et al. 2008)

Track storms over time using nearest neighbour approach (WiTRACK; Kruschke 2015)

Focus on area of damaging winds, rather than central core pressure
Event Tracking Methodology

EUMETSAT storm track, from Meteo Sat-9 Air Mass Product. Windstorm Klaus 2009

Blue = Murray and Simmonds (1991) min. pressure tracking methodology
Extended Event Set

Atlantic TC Events

Observations from ERA interim

SEAS5 climatology

Atlantic ETC events
Tropical Cyclone Season in SEAS5

Best Tracks (IBTrACS)

SEAS5 Tracks

ERAinterim Tracks
European Windstorm Season

ERAIterim Tracks

SEAS5 Tracks

Difference

Track Density (events/year)

Track Density (events/year)
Seasonal Intensity Measures

Number of Storms

Total Seasonal Storm Severity Index (SSI)

Land Impacting SSI
Probability of Independence

Theoretical Calculation of *Independent* Hurricane and European windstorm season

- **Hurricane season**
- **Windstorm season**

- $\frac{1}{10} \times \frac{1}{10} = 1 \text{ in } 100$
- $\frac{1}{10} \times \frac{9}{10} = 9 \text{ in } 100$
- $\frac{9}{10} \times \frac{1}{10} = 9 \text{ in } 100$
- $\frac{90}{10} \times \frac{90}{10} = 81 \text{ in } 100$
Observed European Windstorm Seasons - 90\textsuperscript{th} percentile
Hurricane season

Predicted Number of Seasons, if independent
Observed European Windstorm Seasons - 90\textsuperscript{th} percentile Hurricane season

Predicted Number of Seasons, if independent
Observed European Windstorm Seasons - 90th percentile
Hurricane season

Total SSI  Land Impacting SSI  Number of Storms
Observed European Windstorm Seasons

Track Density of windstorm season following top 10% hurricane season – windstorm season following bottom 10% hurricane season

Total SSI  Land Impacting SSI  Number of Storms
Conclusions and Future Work

- A highly active (more than 90\textsuperscript{th} or 95\textsuperscript{th} percentile) Atlantic Hurricane season is followed by a highly active European Windstorm season \textbf{less often} than if they were independent.

- A highly active Atlantic Hurricane season is followed by a highly inactive (less than 5\textsuperscript{th} or 10\textsuperscript{th} percentile) European Windstorm season \textbf{more often} than if they were independent.

- Intense Atlantic Hurricane season precedes slight storm track shift towards Central and Southern Europe

- Currently testing hypothesised pathways which explain this connection
TC WiTRACK interannual variability

Interannual variability of same magnitude as observations, with significant covariation

August Initialized SEAS5 ensemble mean performs as well as ERAinterim
Individual Case Studies

Range of most damaging Hurricanes, 1989-2009