A novel metric to assess the “extremeness” of cyclones

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Motivation

- Cyclones can cause high impact weather (HIW) over large regions
  - Heavy precipitation (e.g. Brig flood 1993)
  - Strong winds (e.g. winterstorm Lothar 1999)
- Do extreme cyclones have specific characteristics?
Approach & Data

- ERA-Interim reanalysis (1979-2013)
  - 1° horizontal lat-lon grid spacing,
  - 6h temporal resolution

- "HIW" flag at each time step and grid point
- match with individual cyclone

area affected by HIW linked to individual cyclone at each time step
Cyclone identification and tracking

- detection of pmsl minima
- detection of enclosing contour
- contour splitting if necessary

(based on Wernli & Schwierz (2006) adapted by M. Sprenger & C.M. Grams)
Cyclone objects & HIW

- characteristics emerging directly from the diagnostics:
  - size
  - lifetime
  - track
HIW definition

• grid-point based extremes: > 99% percentile (1989-2009)
  – 2m min/max temperature, precipitation, 10m wind gusts
  – six-hourly data


Cyclone objects & HIW

• characteristics in terms of HIW area affected by extreme ...
  - temp.
  - wind
  - precip.
Directions of investigation

• Definition of extremeness:

\[
\text{extremeness} = \sum \text{of local extreme events along track of cyclone}
\]
TOP50 most extreme cyclones

(extreme area accumulated over lifetime, TOP50 of 94522 cyclones)

extremeness = \sum \text{of local extreme events along track of cyclone}

→ most extreme cyclones have tropical origin and undergo ET
Directions of investigation

- Definition of extremeness:
  - \( \Sigma \) of local extreme events along track of cyclone
    - of specific type of extreme?
    - at specific times during cyclone lifecycle?

- Regional aspects
  - cyclones affecting a specific region?

- Cyclone characteristics
  - cyclone type?
    - tropical vs. extratropical cyclones matching with IBTrACS
  - differences extreme vs. non-extreme cyclones?
Global perspective

(94522 cyclones 1979-2013)

• Extremeness and latitude of cyclogenesis

![Graph showing the relationship between latitude of cyclogenesis and area affected by extremes.]

extremeness = \sum \text{of local extreme events along track of cyclone}
Global perspective

(94522 cyclones 1979-2013)

- Extremeness and cyclone type

<table>
<thead>
<tr>
<th># all</th>
<th>75956</th>
<th>11347</th>
<th>3980</th>
<th>3239</th>
</tr>
</thead>
</table>

![Graph showing distribution of extreme area category](image)

![Graph showing percentage of same type](image)
Regional perspective: Europe

(TOP50 of 9085 cyclones 1979-2013)

- TOP50 most extreme cyclones affecting Europe

(ex tremes counted during entire cyclone lifetime)
Regional perspective: Europe

(TOP50 of 9085 cyclones 1979-2013)

• TOP50 most extreme cyclones affecting Europe

(extremes counted when cyclone centre in “Europe box“)
Regional perspective: Europe
(9085 cyclones 1979-2013)

• Which type of extremes contribute to total extreme area?

<table>
<thead>
<tr>
<th>Fraction of extreme category in extended extreme area [%]</th>
<th>#8271</th>
<th>#627</th>
<th>#144</th>
<th>#43</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;250</td>
<td></td>
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<td>250-500</td>
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<tr>
<td>500-750</td>
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<td></td>
<td></td>
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<tr>
<td>&gt;750</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

(extended) extreme area category \([10^4 \text{ km}^2]\)
Regional perspective: Europe

(9085 cyclones 1979-2013)

• TOP50 most extreme cyclones affecting Europe
Extremeness based on accumulated area affected by ….
Regional perspective: Europe
(TOP50 of 9085 cyclones 1979-2013)

• TOP50 most extreme cyclones affecting Europe
Extremeness based on …. 

Accumulated area affected by any type of extreme

Minimum pmsl

(when cyclone centre in “Europe box“)
Cyclone characteristics (Europe)

minimum centre pressure

(9085 cyclones 1979-2013)

boxplot: min, 5, 25, 50, 75, 95%, max; avg ± std, avg

TOP&FLOP 5% (454) most extreme in ...

min

max

95%

avg + std

75%

avg

50%

25%

avg - std

5%

min
Cyclone characteristics (Europe)

minimum centre pressure

(9085 cyclones 1979-2013)
Cyclone characteristics (Europe)

(9085 cyclones 1979-2013)

TOP&FLOP 5% (454) most extreme in...

* max
95% avg+std
75%
avg
50%
25%
avg-std
5%
min

Time: lifetime [h]

boxplot: min, 5, 25, 50, 75, 95%, max; avg+-std, avg

* lifetime (9085 cyclones 1979-2013)
Cyclone characteristics (Europe)

Zonal propagation speed [km/h] (9085 cyclones 1979-2013)

TOP&FLOP 5% (454) most extreme in ...

* max

95% avg+std

75% avg

50% avg-std

25% 5%

25% 5%
Summary

• novel diagnostic to study cyclone objects

• extremeness = Σ of local extreme events along cyclone track

• TCs undergoing ET are globally most extreme cyclones

Europe:

• the larger the extreme area the more likely affected by wind

• cyclones extreme in …
  – precip.: form over continent, high pmin, less zonal
  – wind track over N.Atl. or Med. Sea
Cyclone objects & HIW

Example: winterstorm “Joachim” 16 December 2011