DYNAMICAL SYSTEMS THEORY SHEDS NEW LIGHT ON COMPOUND CLIMATE EXTREMES IN EUROPE AND EASTERN NORTH AMERICA

Pons, F.M.E., De Luca, P., Messori, G., and Faranda, D.

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Synthesis of the method

Given two atmospheric variables their joint Poincaré recurrences in the phase-space are quantified (Faranda et al. 2020).

Three joint dynamical systems metrics are computed:

i) the co-recurrence ratio ($\alpha$);

ii) the local co-persistence ($\theta^{-1}_{x,y}$);

iii) the local co-dimension ($d_{x,y}$).

The $\alpha$ extremes (or compound dynamical extremes) reflect compound events observed within climate data.

$$\alpha(\zeta) = \frac{\nu \left[ g\{x(t)\} > s_x(q) | g\{y(t)\} > s_y(q) \right]}{\nu [g\{x(t)\} > s_x(q)]}$$
Europe: daily total precip (mm) and wind gust mean (ms$^{-1}$) from 1979 to 2018 (ERA-Interim);

$\alpha$ peaks during late autumn SON and winter DJF $\rightarrow$ storm season in N-NW Europe;

d_{x,y}$ and $\theta^{-1}_{x,y}$ anomalies during $\alpha$ extremes ($>99^{th}$ quantile) are negative and positive $\rightarrow$ predictable configurations;

$\alpha$ extremes = compound dynamical extremes.
NAOI daily values during $\alpha$ extremes are largely positive (orange dashed line, $p<0.05$) -> a positive NAO brings storms (i.e. ETCs) over N-NW Europe;

$\alpha$ extremes peak during late autumn SON and winter DJF.
Precip and wind anomalies during $\alpha$ extremes are positive ($p<0.05$) over N-NW Europe -> ETCs;

concurrent (i.e same-day) precip and wind extremes ($>99^{th}$ quantile) peak during late autumn SON and winter DJF
-> as for $\alpha$ extremes;

$\alpha$ anomalies during concurrent precip-wind extremes are significant ($p<0.05$) over W Europe (panel f) -> $\alpha$ extremes reflect ETCs patterns.
Eastern North America (ENA) and Europe: daily temperature (K) and total precipitation (mm) from 1979 to 2018 (ERA-Interim);

temp and precip anomalies during $\alpha$ extremes are negative and positive ($p<0.05$) over N-NE ENA and W Europe;

concurrent temp and precip extremes (>99th quantile) peak during winter DJF;

$\alpha$ anomalies during concurrent temp-precip extremes are significant ($p<0.05$) over N-NE ENA and W Europe (panel f).
Thank you

Any questions?

References
