Invited talk (Mathematics in atmospheric science and Climate change)

Applications of dynamical systems theory in the study of extreme climate events.

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Abstract

Atmospheric motions are chaotic, which implies an unavoidable loss of predictability with increasing lead time. Extreme events such as heatwaves, intense cyclones, droughts and floods are becoming more frequent, intense and more lasting in a warming climate. Even though studies on the detection and characterization of extreme events in Europe are numerous, little is known about the predictability of these events. It has been recently demonstrated that applying the dynamical systems theory to the atmospheric conditions we can study the intrinsic predictability of an extreme event [1], and so, we can know the capacity we have to anticipate it, thus being able to take action for the minimization of its impacts by using early warning systems.

Climate information on the most predictable or unpredictable atmospheric configurations can be understood by applying the dynamical systems theory and using two properties of the underlying attractor: persistence and local dimension [1]. The argument is that low-dimension, high persistence atmospheric patterns should afford a higher predictability than high-dimension, low persistence cases.

To illustrate this, the predictability of several extreme events affecting the Iberian Peninsula [2], such as the intense low-pressure systems Filomena and Gloria, recent heatwaves, and record-breaking summers, among other events, will be examined during this talk. Additionally, the different applications and potential of this technique in seasonal forecasting [3] will be discussed, with the aim of enhancing our understanding and early warning systems for these great impact extreme events.

References

[1] Faranda, D., Alvarez-Castro, M. C., Messori, G., Rodrigues, D., Yiou, P.(2019): *The hammam effect or how a warm ocean enhances large scale atmospheric predictability.* **Nature communications 10(1), 1316**. https://doi.org/10.1038/s41467-019-09305-8

[2] Faranda, D., Messori, G., Alberti, T., Alvarez-Castro, C., et al (2024): *A statistical physics and dynamical systems perspective on geophysical extreme events.* Physical Review E (pre-print) https://arxiv.org/abs/2309.15393

[3] Pérez-Zanón, N., Caron, L.-P., Terzago, S., Van Schaeybroeck, B., Lledó, L., Manubens, N., Roulin, E., Alvarez-Castro, M. C., et al (2022): *Climate Services Toolbox (CSTools) v4.0: from climate forecasts to climate forecast information.* **Geosci. Model Dev., 15, 6115–6142**. https://doi.org/10.5194/gmd-15-6115-2022