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Statistical Mechanics of Climate

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Understanding the relationship between climate variability across multiple scales and the climate response to forcings is an endeavor of primary relevance both at strictly scientific level and in terms of impacts on human and environmental welfare.

In my presentation I will deal with the analysis of climate response to perturbations using methods of dynamical systems theory and nonequilibrium statistical mechanics. The main research program I am currently working on, aims at providing stronger mathematical and physical foundations to climate science.

In the first part of my talk, I will focus on the regimes where we expect a smooth response to perturbations, and I will describe how Ruelle response theory can be effectively used to perform climate projections.

In the second part of the talk, I will instead look in the proximity of critical transitions, where the response is expected to diverge, and in the region of climate multistability. If time allows, I will explain how Ruelle response theory can be used for constructing rigorous parameterizations of unresolved processes.

Relevant references

V. Lucarini, R. Blender, C. Herbert, S. Pascale, F. Ragone, and J. Wouters, Mathematical and Physical Ideas for Climate Science, Rev. Geophys. DOI: 10.1002/2013RG000446 (2014)

V. Lucarini, F. Ragone, F. Lunkeit, Predicting Climate Change Using Response Theory: Global Averages and Spatial Patterns, J. Stat. Phys., doi: 10.1007/s10955-016-1506-z (2016)

A. Gritsun, V. Lucarini, Fluctuations, Response, and Resonances in a Simple Atmospheric Model, arXiv: 1604.04386

V. Lucarini, T. Bodai, Melancholia States in the Climate System: Exploring Global Instabilities and Critical Transitions, arXiv:1605.03855