Geophysical Research Abstracts
Vol. 21, EGU2019-16514, 2019
EGU General Assembly 2019

Toy models to analyze emergent constraint approaches

Xavier-Andoni Tibau (1), Christian Reimers (1,2), Veronika Eyring (3,4), Joachim Denzler (2,5), Markus Reichstein (6), and Jakob Runge (1)

(1) Institute of Data Science , German Aerospace Agency (DLR), Jena, Germany. (Xavier.Tibau@dlr.de), (2) Computer Vision Group, Friedrich-Schiller-Universität Jena, Germany., (3) Institute for Atmospheric Physics, German Aerospace Center (DLR), Oberpfaffenhofen, Germany., (4) Institute of Environmental Physics, University of Bremen, Bremen, Germany., (5) Michael Stifel Center Jena for data-driven and simulation science, Jena., (6) Max-Planck-Institute for Biogeochemistry, Jena, Germany.

Climate projections are limited by the arising uncertainties associated with not well-known physical processes in climate change. In every new generation, climate models improve several aspects of projections, while others remain in the same uncertainty range, especially those regarding equilibrium climate sensitivity (ECS) and climate feedbacks. Emergent constraints, defined as a 'physically explainable empirical relationships between characteristics of the current climate and long-term climate prediction that emerge in collections of climate model simulations' [1], is a promising novel approach that can shed light on climate change uncertainties and improve climate models. Since the first emergent constraint was proposed to constrain the Surface Albedo Feedback in 2006 by Hall & Qu [2], several of them have been proposed for constraining feedbacks and uncertainties of climate models, e.g., ECS, low-level cloud optical depth or tropical primary production. Emergent constraints have already been a prolific approach to improve our climate models.

The typical approach to identify emergent constraints comes from expert knowledge when this is used to explore climate data and select those emergent constraints that are physically explainable. Caldwell et al. [3] presented a work where a new approach was suggested. In that paper, they attempt to identify quantities in the current climate which are skillful predictors of ECS yet can be constrained by observations. One of the main conclusions of this work was that the development of data mining methods for identifying emergent constraints should be aware of spurious emergent relations that could arise by chance. This becomes especially relevant in the next phase of the CMIP Project (6th).

In the present work, we discuss simple spatiotemporal climate ("toy") models to analyze and evaluate methodologies to identify predictors for emergent constraints. Such models are simple enough to be analyzed not only empirically but also analytically, and at the same time incorporate relevant aspects of the complexity of a nonlinear dynamical spatiotemporal system. Consequently, they can be used to study assumptions and pitfalls of data mining methods for emergent constraints and guide the development of future approaches.

[1]: Klein, S. A., & Hall, A. (2015). Emergent constraints for cloud feedbacks. Current Climate Change Reports, 1(4), 276-287.
[2]: Hall, A., & Qu, X. (2006). Using the current seasonal cycle to constrain snow albedo feedback in future climate change. Geophysical Research Letters, 33(3).
[3]: Caldwell, P. M., Bretherton, C. S., Zelinka, M. D., Klein, S. A., Santer, B. D., & Sanderson, B. M. (2014). Statistical significance of climate sensitivity predictors obtained by data mining. Geophysical Research Letters, 41(5), 1803-1808.