ICYESS2013-119-1
Interdisciplinary Conference of Young Earth System Scientists
Hamburg, Germany, 22 – 25 September 2013

Need for simple models in climate prediction

J. O. Haerter

Center for Models of Life, Niels Bohr Institute, Blegdamsvej 17 ,2100 København Ø, Denmark (jan.haerter@gmail.com)

Climate prediction is a field of research of tremendous societal importance. Yet, the task of reliably predicting potential future climate change is hampered by the extreme complexity of the climate system, with interactions on vastly varying temporal and spatial scales and physical mechanisms of often compensating net effect. Currently, the climate modeling community is focusing its efforts on obtaining more and more detailed simulations taking into account a growing number of processes. In keeping with the increasing amount of detail in computation, the analysis of model data output – its processing and compression to meaningful statistical quantities – becomes a cumbersome task in itself.

While more detailed simulations can in principle allow some model parameters to be removed from the simulation, tracing features of the data produced by today's global climate models to the action of underlying physical processes is nearly as cumbersome as the analysis of observational records themselves. This means, the original aim of using a model as a simplified view on the basic processes driving climate change is becoming more and more challenging in the light of growing computational and model complexity.

Meanwhile, the large number of uncertain modeling parameters (e.g. those in cloud microphysics) has led to statistical efforts to quantify model output uncertainty as far as it relates to such uncertain parameters. However, such "perturbed physics" approaches have generally led to limited insight, as uncertainty ranges of parameters, let alone their prior distributions, are largely unknown. Quantification of structural uncertainty, the "evil twin" of parametric uncertainty, is inherently unquantifiable and thereby renders quantitative uncertainty bounds of future climate projections improbable at this point.

In an attempt to take advantage of the original benefit of models as simplified descriptions of the physical system, we propose to exert more effort in the construction of effective models capable of producing qualitative relations between observables in isolated processes. The number of parameters in these models should be small so that the models can be understood in detail by computer simulations and (in limiting cases at least) remain analytically tractable. We try to motivate the construction of such models for the case of precipitation extremes, often triggered by processes of relatively local extent. While convective precipitation appears to be a result of both thermodynamic and dynamical processes - in principle requiring detailed microscopic modeling - current research initiatives highlight the system perspective of cloud fields with convective plumes as relatively organized, yet laterally interacting entities. Such descriptions build hope for obtaining qualitative effective interactions, possibly reducing the complexity implied by the microscopic physics.