Statistical Physics Seminar

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ELTE TTK Northern Building 2.54

Tamás Bódai
University of Reading

Linear response theory applied to geoengineering

We investigate in an intermediate-complexity climate model (I) the applicability of linear response theory to a geoengineering problem and (II) the success of the considered geoengineering method. The geoengineering method is framed here as a special optimal control problem, which leads mathematically to the following inverse problem. A given rise in carbon dioxide concentration would result in a global climate change with respect to an appropriate ensemble average of the surface air temperature. We are looking for a suitable modulation of solar forcing which can cancel out the said global change, or modulate it in some other desired fashion. It is rather straightforward to predict this solar forcing, considering an infinite time period, and we will spell out an iterative procedure suitable for numerical implementation that applies to finite time periods too.

Regarding (I), we find that under geoengineering, i.e. the combined greenhouse and solar forcing, the actual global mean surface temperature response asymptotically is not zero, indicating that the linear susceptibility is not determined correctly. This is due to a significant quadratic nonlinearity of the response under system identification achieved by a forced experiment. This non- linear contribution can in fact be easily removed, which results in much better estimates of the linear susceptibility, and, in turn, in a five-fold reduction in a residual global mean surface temperature response under geo- engineering. Regarding (II), however, we diagnose this geoengineering method to result in a considerable spatial variation of the surface temperature anomaly, reaching more than 2 K at polar/high latitude regions upon doubling the carbon dioxide concentration, even in the ideal case when the geoengineering method was successful in cancel- ing out the response in the global mean. In the same time, a new climate is realised also in terms of e.g. an up to 4 K cooler tropopause or drier/disrupted Tropics, relative to unforced conditions.

1117. Budapest, Pázmány Péter sétány 1/A (Északi tömb)
Room 2.54
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