Regime Algebra and Climate Theory

by

Dr. Christopher Essex,
Professor,
and Associate Chair,
Department of Applied Mathematics
the University of Western Ontario
London, Canada N6A 5B7

While there has been plenty of important theoretical work on climate, it is noteworthy that there is still no physical theory for climate. There is, of course, a plethora of heuristic didactic models, often referred to in the jargon as “simple models,” from which much has been learned. But for very practical reasons, empirical computer models have been the default substitute for a theory for at least three decades. During that time, direct theoretical work has faded, and even been forgotten, as generations of theoreticians have gradually stepped aside in favor of the big empirical models. There are now even “simple models” of the big models. Nonetheless, it is worth revisiting the problem of very long term forecasting from a fundamental standpoint. What can we learn from discoveries in other fields of physics to guide us? One thing they tell us is that passing between physical regimes theoretically, as one does sometimes with averaging, is a deep and subtle matter. But in contrast averaging is nearly a clich\'e in the study of climate. The popular definition of climate as ``averaged weather,” while charming, is not adequate. We need to know what to average over. In what way should we average? Is there a function relating resulting averages to each other, or do the averages satisfy differential equations instead? Are these averaged quantities analogues to the physical variables we are used to, or are they something completely new, outside of our intuition? While it is easy to produce an average, finding non-heuristic, non-empirical physical equations that can stand on their own in terms of averaged quantities only is not. Does such a relationship even exist in Nature? These questions and more will be raised in this talk.