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Putting the Weather Back Into Climate

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The literature contains a variety of definitions of climate, and the emphasis in these definitions has changed over time. Defining climate as a mean value is, of course, both limiting and misleading; definitions of climate based on averages have been deprecated as far back as 1931 [1]. In the context of current efforts to produce climate predictions for use in climate adaptation, it is timely to consider how well various definitions of climate serve the research for applications community.

From a nonlinear dynamical systems perspective it is common to associate climate with a system's natural measure (or "attractor" if such an object exists). Such a definition is not easily applied to physical systems where we have limited observations over a restricted period of time; the duration of 30 years is often mentioned today and the origin of this period is discussed. Given a dynamic system in which parameters are evolving in time, the view of climate as a natural measure becomes problematic as, by definition, there may be no attractor per se. Attractors defined for particular parameter values cannot be expected to have any association with the probability of states under transient changes in the values of that parameter. Alternatively, distributions may be determined which reflect the transient situation, based on (rather broad) additional assumptions regarding the state of the system at some point in the past (say, an ice age planet vs an interglacial planet). Such distributions reflect many of the properties one would hope to be represented in a generalised definition of the system's climate.

Here we trace how definitions of climate have changed over time and highlight a number of properties of definitions of climate which would facilitate common use across researchers, from observers to theoreticians, from climate modellers to mathematicians. We show while periodic changes in parameter values (such as those found in an annual cycle or a diurnal cycle) are easily incorporated within the traditional nonlinear dynamical systems view, non-periodic or secular changes (such as those due to increasing atmospheric greenhouse gas concentrations) yield an open challenge. We argue the need both for clarifying and for clearly meeting the open challenges of defining climate in relation to the state of an evolving system, and suggest a path forward.

[1] Miller, A.A., 1931: Climatology. First Ed. Methuen.