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Climate stability and sensitivity in some simple conceptual models

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A theoretical investigation of climate stability and sensitivity is carried out using three simple linearized models based on the top-of-the-atmosphere energy budget (Bates, 2010). The simplest is the zero-dimensional model (ZDM) commonly used as a conceptual basis for climate sensitivity and feedback studies. The others are two-zone models with tropics and extratropics of equal area; in the first of these (Model A), the dynamical heat transport (DHT) between the zones is implicit, in the second (Model B) it is explicitly parameterized.
It is found that the stability and sensitivity properties of the ZDM and Model A are very similar, both depending only on the global-mean radiative response coefficient and the global-mean forcing. The corresponding properties of Model B are more complex, depending asymmetrically on the separate tropical and extratropical values of these quantities, as well as on the DHT coefficient. Adopting Model B as a benchmark, conditions are found under which the validity of the ZDM and Model A as climate sensitivity models holds. It is shown that parameter ranges of physical interest exist for
The 2 $\times$ CO2 sensitivities of the simple models are studied and compared. Possible implications of the results for sensitivities derived from GCMs and palaeoclimate data are suggested. Sensitivities for more general scenarios that include negative forcing in the tropics (due to aerosols, inadvertent or geoengineered) are also studied. Some unexpected outcomes are found in this case. These include the possibility of a negative global-mean temperature response to a positive global-mean forcing, and vice versa.

Reference
Bates, J.R., 2010. Climate Stability and Sensitivity in Some Simple Conceptual Models.
Climate Dynamics (in press).