NONAUTONOMOUS MODELLING IN ENERGY BALANCE MODELS OF CLIMATE. LIMITATIONS OF AVERAGING AND CLIMATE SENSITIVITY

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Starting from a classical Budyko-Sellers-Ghil energy balance model for the average surface temperature of the Earth, a nonautonomous version is designed by allowing the solar irradiance and the cloud cover coefficients to vary with time in a fast timescale, and to exhibit chaos in a precise sense. The dynamics of this model is described in terms of three existing nonautonomous equilibria, the upper one being attracting and representing the present temperature profile. The theory of averaging is used to compare the nonautonomous model and its time-averaged version. We analyse the influence of the qualitative properties of the time-dependent coefficients and develop physically significant error estimates close to the upper attracting solution. Furthermore, previous concepts of two-point response and sensitivity functions are adapted to the nonautonomous context and used to value the increase in temperature when a forcing caused by CO_2 and other emissions intervenes.