General comments

This paper investigates the validity of the maximum entropy production (MEP) conjecture for simplified and complex box models of the climate by comparing the model results with a GCM steady state. Given fixed longwave opacity, the MEP state shows a reasonable agreement with horizontal structure of the climatic steady state, whereas it shows unrealistic features on the vertical atmospheric structures and surface temperature discrepancy. When the longwave opacity is set to be a free parameter that is independent of the temperature and humidity of the present atmosphere, the MEP state becomes quite unrealistic. The conclusion of this paper is then obscure since we cannot judge whether the proposed conjecture is invalidated or whether some important physical processes/constraints are simply missing. As the authors stated in page 408: "it is questionable whether such a solution is general enough for debating MEP validity, since the longwave transmissivity τ is prescribed and the temperature varied, whereas τ should be varied as well consistently with T_a", and in page 413: "it is unrealistic to think of the longwave transmissivity as a variable independent from temperature, as in reality it strongly depends on water vapour concentration and thus temperature"; this seems to be the weakest point of this paper.

As far as this referee know, the temperature–opacity feedback was investigated by Pujol (2003), who assumed a fixed profile of relative humidity for the atmosphere and sought a MEP state in a radiative-convective model where the longwave opacity is a function of the temperature. His result shows the existence of a unique MEP state that is in close agreement with observations. The authors may be able to implement the same line of research in this respect. Or, at least, appropriate explanations about the temperature–opacity feedback and its consequences should be included in the discussion of this paper.

Specific comments

1. Page 400: "The interior of the ocean is neglected since the material entropy production due to the small-scale eddy turbulence (~1 mW m^{-2} K^{-1}) is negligible when compared to the material entropy production of the whole climate system".

According to Paltridge (1978), the oceanic meridional entropy production is of the same order of magnitude as the atmospheric meridional entropy production (see

Fig. 2 of Paltridge, 1978). Thus, even though small-scale eddy turbulence entropy production may be negligible, the overall contribution to entropy production due to the oceanic meridional heat transport cannot be omitted. Most probably, this omission results in an enhancement of the atmospheric meridional heat transport, which tends to reduce the surface temperature gradient to a realistic one. The situation should be explained in the text.

2. Equation (15): material entropy production in terms of the radiative heating rates.

This equation may deserve a further explanation. The actual meaning of this equation is the net entropy export rate by radiative processes (heating and cooling). If radiative heating (cooling) takes place, this rate is negative (positive). For a radiatively driven system, heating leads to an increase in the heating place temperature whereas cooling leads to a decrease in the cooling place temperature. The supplied energy will be transported by material processes (e.g. turbulence) in the system. In a steady state, the radiative heating and cooling rates should be balanced by the material energy transport rate (say, q), and the radiative entropy export is balanced by the material entropy production: $-\int Q/T\ dV = -q/T_h + q/T_c = q(T_h - T_c)/(T_h T_c)$. Thus, the material entropy production rate can be expressed by the radiative entropy export rate provided that the system is in a steady state. It would be good to add some explanations about the meaning and the limitation of this equation so that the reader can clarify the relation of Eq. (5) with other explicit expressions Eqs. (9) and (21).

3. Page 407: "The value of the material entropy production for MEP is $\dot{S}_{mat}$ ~70 mW $m^{-2}K^{-1}$ … MEP2 is instead associated to an entropy production ≈ 57 mW m^{-2} K^{-1}".

The reason of the large discrepancy in $\dot{S}_{mat}$ as well as those in temperature, heat flux and entropy production (Figs. 9b and 10c, d) is not clear. The difference seems to result from a slight difference in the prescribed emissivity profiles ε(z). If so, I would suggest checking the difference in ε(z) between MEP and MEP2. Also, since the distributions of ε(z) and τ(z) are prescribed from a GCM steady state (i.e. the temperature and humidity of a FAMOUS steady state), the validity of this assumption is limited to cases where the predicted temperature distributions are not very apart from the GCM mean state. The situation should be explained in the text in addition to the temperature–opacity feedback problem pointed out in the general comments.

Ref.)

T. Pujol, J. Meteor. Soc. Jpn. 81, 305, 2003.

G. W. Paltridge, Quart. J. Roy. Meteor. Soc. 104, 927, 1978.