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Interactive comment on “Residence Time of Energy in the Atmosphere” *by* Carlos Osácar et al.

Anonymous Referee #2

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This review concerns tha manuscript entitled ’Residence time of energy in the atmosphere’ by O. Carlos, M. Manuel, and R-P. Amalio

The authors use steady state heuristics to find a time scale for the energy in the earth’s atmosphere and in the sun that corresponds to the ’residence time’ that may be defined for gas components or chemical species in atmospheric chemistry. For the case of the earth, the claim is that the residence time found based on current energetics is equivalent to the K-H time, which is claimed to be the ’residence time’ for solar energetics.

[Please forgive my hybrid LaTeX-text formulas below.]

The heuristics used are commonly employed to establish integrated rates–and therefore sort of average timescales–for quantities, q, that satisfy strict conservation laws:

(1) \partial_t q + div (q vector{v}) = 0.

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While it is interesting to tie together the energetics of the earth's atmosphere with that of the sun (or other stars), making the claim that the residence time of the earth atmospheric energy and the solar K-H processes are equivalent isn't particularly original, since 'residence times' in each case derive from equation (1), which you can see by integrating over the relevant (spherical) vollumes.

dQ/dt = \integral q \vector{v} dV = \integral_surface q\vector{v} . dS, = f_q A = F_Q

f_q is the 'flux of q' through any portion of the surface, and F_Q is the net inflow/outflow rate through the surface, A. It does not matter what q is, a sort of 'average' 'q-rate' can be defined by Q/T ∼ dQ/dt = F_Q. This may be used to define a timescale T ∼ Q/F_Q, so _of course_ the time scale for earth's atmosphere energy residence time is equivalent to the K-H timescale: they both come from the exact same conservation law, and this is the same law that describes conservation of mass in the atmospheric chemistry context. The time scale can always be interpreted as the time required to 'deplete' a value of Q, if its rate-of-depletion is F_Q.

So, I'm just not sure what this article is purporting to do, to be honest, other than to perhaps give an explicit interpretation of geophysical and astrophysical processes in terms (i.e., 'residence time') of concepts familiar in atmospheric chemistry. Am I missing something? Even though it's interesting to see actual numbers for the energetics (especially for the earth), the concepts presented here are not new, and are, in any case, very imprecise. The connection of the earth energy residence time to the the K-H time, which is evidently one of the main conclusions, isn't at all surprising given the starting point. Based on these observations, I must decline the manuscript, but will reconsider if the authors can provide some new ideas or at least some new implications, or even a new way of looking at things.

Below are a few other comments about the manuscript that may be worth considering:

(1) Intro: Text beginning with 'Both cases correspond to steady state problems..': This is true strictly at the current epochs of both solar and earth systems because the flux

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rates change over geological and stellar lifetimes.

(2) Text beginning 'but 4e escapes to the space using the called atmospheric window).' should read 'but 4e escapes to space using the so-called {\it atmospheric window}).'

(3) Text that reads 'component emitted toward the space, 66e, and that emitted to the surface, commonly denoted by greenhouse effect, 88e.' should read 'component emitted spaceward, 66e, and that emitted towards the surface, commonly denoted by the {\it greenhouse effect}, 88e.'

(4) Regarding Eq. (10): I agree with this formula for the sun; however the same conservation principle applies to larger stars, like O and B-type stars, which have stellar winds that are 4-5 orders of magnitude greater than our sun, and have 'luminosities' comparable to or greater than their star's radiative luminosity. For these cases, the total luminosity must be replaced with L_p + L_w, where L_w = \dot{M} v_\infinityˆ2, and \dot{M} is the stellar wind mass loss rate, and v_\infinity is the terminal velocity of its wind, and L_p refers to the 'photonic' luminosity. So, L_w becomes the 'wind luminosity'. But in this case, '||E||" must, as you say, include the total 'free energy', which should be understood to _include_ the kinetic energy of the wind at the photosphere, and the connection to the question 'how long a photon might take to escape to the surface' becomes a bit more nuanced. But the connection to the K-H timescale I think still remains, as you've indicated.

(5) Near line 60 with text beginning with 'Therefore, after a global thermal perturbation...': This is a very coarse rule of thumb that follows only from the simple conservation principle you've used. In reality, the earth's atmosphere is a turbulent fluid, and the time to establish equilibrium after a large scale perturbation will be governed by how quickly the cascade of energy takes place from the scales where the perturbation occurs to the scales where dissipation occurs (given that all other energy inputs you've identified remain the same). This can lead to a equilibration time that is significantly shorter that 56 days because of so-called turbulent mixing, which is not an equilibrium

process

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