

Earth Syst. Dynam. Discuss., author comment AC3
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Reply on RC2

Oliver López-Corona et al.

Author comment on "ESD Ideas: Planetary Antifragility: A new dimension in the definition of the Safe Operating Space for Humanity" by Oliver López-Corona et al., Earth Syst. Dynam. Discuss., <https://doi.org/10.5194/esd-2021-26-AC3>, 2021

Dear Professor Michaelian, Thank you for pointing out the seminal work in the topic. We were trying to not make evident that RR has refused to try to understand and failed to do what we kindly suggested in the first response to his comment. That most relevant work was already cited in the manuscript including several of the papers you shared and that he should read them first. We will include more references to help other readers to find proper foundations and materials for deep in.

We refused to establish a higher level discussion with RR because we do consider that even when this might be a non standard topic that comprehensively may rise to questioning, this should be done in good faith and under scientific argumentation not only disqualifying. We apologise if this may have been seen as neglation on our part.

As you insightfully point, it is not entropy but entropy production that we need to measure as done in the very statement of the second law and in all the Prigogine's out of equilibrium formulation of thermodynamics, in which the central concept is entropy production defined as the product of generalized forces en fluxes.

Almost all concerns RR has about the link Thermodynamics and albedo as a proxy are covered in great detail on your ouen paper about Photon dissipation we recommended RR to read (http://dx.doi.org/10.1007/978-94-017-9499-2_2) and that is, as you mention in your paper, built upon the most rigorous work by Ulanowicz and Hannon (1987), Prigogine (1967), Prigogine and co-workers (1972) and could be even tracked down to Boltzman ideas about how life was surviving off entropy production.

Of course Albedo is not entropy production but a proxy among other candidates such as Red-edge, and therefore it has some advantages and limitations as we will discuss with much more detail on the response we are preparing for your first comment.

As you highlight correctly we are not trying to assess entropy production of all and every single living system and biogeochemical processes involved, but rather to take a systemic signal that encapsulates the way the Earth system (not its components) respond to perturbations. Maybe it is important to mention that it is an approach that has shown to be very useful in human health for example using hearth R-R interval fluctuations time series as a systemic indicator of health (which we also recomended RR to read on our

PLoS one paper).

In than sense, the readers could be interested in:

Heymans, O., et al. "Is fractal geometry useful in medicine and biomedical sciences?." *Medical hypotheses* 54.3 (2000): 360-366.

Kiyono K, Struzik ZR, Aoyagi N, Togo F, Yamamoto Y. Phase transition in a healthy human heart rate. *Physical review letters*. 2005;95(5):58101.

Rivera AL, Estañol B, Senties-Madrid H, Fossion R, Toledo-Roy JC, Mendoza-Temis J, et al. Heart rate and systolic blood pressure variability in the time domain in patients with recent and long-standing diabetes mellitus. *PloS one*. 2016;11(2):e0148378.
pmid:26849653

Goldberger AL, Peng CK, Lipsitz LA. What is physiologic complexity and how does it change with aging and disease?; 2002.