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## Butterflies, Elephants and Gravity to Model Human-Earth Interactions

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The call for this session mentions that “Earth system resilience critically depends on the nonlinear interplay of positive and negative feedbacks of biophysical and increasingly also socio-economic processes. These include dynamics in [many physical events], as well as the dynamics and perturbations associated with human activities.” In this contribution, I would like to mobilize a few notions to discuss this issue.

A typical approach is to scale up human dimensions to Earth system model scales. Humans become aggregated into social structures, even societies, that change every year or so. I propose to scale down the Earth system to humans, both in terms of space and time. I think this offers exiting possibilities to study climate and earth systems in a different way, but also allows for answering the question how we could act today, tomorrow and next week in order to understand which long-term scenarios over decades are more likely to occur.

This would move us away from the view of the Earth as a single system or pattern to a perspective of Earth as an interconnected world of different non-human and human agencies. I would position this idea against the rather popular metaphor of the butterfly effect, “the sensitive dependence on initial conditions in which a small change in one state of a deterministic nonlinear system can result in large differences in a later state”. This may be too simple, as one butterfly will meet many other butterflies along the way. As such, the butterfly effect may be a specific example that claims a certain agency for smaller actors within the Earth System, but that builds its analysis on pattern replication through non-linear relations.

Our (perceived) knowledge of patterns colors our analysis of those patterns. We are all familiar with the metaphor of the men observing different parts of the elephant. The metaphor assumes that we know that what the men are examining is an elephant. However, once we do not know either what they are looking at, we need to start with them seeing different things. In the perspective that we know the elephant, the men are just short-sighted. In the more realistic setting that we cannot be certain about what the men observe, we are the ones that need to come up with a convincing way to analyze what is happening, has happened or may happen.

Much work in Earth system modelling model patterns in society, but do not explain how these patterns are the result of continuously performing agencies. The models are built to mimic the

patterns that we observed. I propose to replace the patterns we use to explain the same patterns – whether they are power relations or gravity – with representations of the interacting agencies that together produce the Earth system that we think we observe. Gravity may be a nice explanation of the observed pattern that we do not glide away from the surface, but it remains just that. In our modelling efforts, we may apply the notion that gravity acts.