Review by David Crookall, crookall.consulting@gmail.com, 14 June 2018,

Of Peter O. Passenier's article:

STAGE 2.0: Sensitivity Transfer Analysis of Greenhouse Emissions,

Submitted to *Geoscience Communication* – Copernicus

I will write this in a more personal manner than some reviews are done; it helps simplify language. I will also write this as I read the ms.

Your ms, Peter, addresses some important issues and presents a learning tool to communicate aspects of climate change. My impression is that your ms is still in a somewhat embryonic form, and needs some considerable modification and development to be published in *Geoscience Communication*. Indeed, it is a pity that you submitted this early draft 'so soon'. Here are some indicators of what I would consider to be necessary or highly desirable changes.

Language/grammar. Shorter and simpler sentences would improve readability and clarity. I urge you to work with a good copy editor once you have your final draft to submit. Please remember that, in much academic publication, language and clarity are greater determinants of being cited than are novelty and strength of content.

Objectives. It seems to me that you have two sets of objectives:

1. Objectives of your article, in relation to the potential reader.
2. Objectives of your simulation, for users (students, et al).

Keep these two sets separate. A potential reader needs to know very early on (in the abstract and the intro) if the article is of potential interest. If the article objectives are not clear, you will lose the reader. Here are two suggested sentences: *The main objective of this article is to present a pedagogical tool that takes the form of an interactive simulation for use in university courses on climate change. The purpose of the simulation is twofold: (1) to help students understand the sensitivity of the climate system, especially in regard to GHG emissions, and (2) to provide students with insight into the long-term consequences of global warming.*

Article objectives. I found it difficult to figure out what objectives you have for the article. Early on you talk about your simulation and its purpose of helping students understand CC. However, later, in Section 3, you go on to talk about the workings and adequacy of various climate models, without (I think) clearly showing how the intricate nature of these climate models and what seems to be your suggested model

fit into your simulation for students. In my view Section 3 belongs in a journal on climate modelling.

I may be missing something, but I also found it hard to understand how your Sections 4 and 5 relate to your simulation? Section 4 is titled "simulation set-up", which made me expect to see aspects of the practical working of your simulation in the classroom, such as, starting the simulation, interface configuration, student interaction with the simulation, etc. However, I then encountered more discussion about the climate system, and not about your simulation, how it is used, and what results you have obtained in using it. Section 6 seems to do something similar.

Your **Methods** section provides interesting mathematical analysis and model comparison. However, is this the objective of your simulation, and is this what you wish your students to learn? If so, then it does not seem to match (fully?) your objectives as laid out at the start.

All that gives the impression that your accomplished (as opposed to your stated) **objective** is to discuss aspects of climate modelling. Of course, that is of crucial importance, and is discussed in several climate journals, two of which are published by the AGU and the EGU. Again, *Geoscience Communication*, as eclectic and interdisciplinary as it is, does not, in my view stretch that far, unless it is to discuss how such models can communicate aspects of geoscience. May I suggest that you bring out this aspect of your article: How does your tool (better) communicate, and how do we know that it does?

My suggestion is to focus on your simulation as a **learning tool**. For example, you could discuss (and measure and analyse) the various ways in which students benefit from your simulation – how your simulation is revived by, and communicates climate change to, a given audience. You can of course, focus on a (small) selection of (already existing) models, and allow students to manipulate the various variables and feedbacks in the climate system: GHG behaviour, feedback loops (eg, increase in atmospheric H2O, thawing of CH4 substrates), albedo effects, etc. This audience is likely to be a more sophisticated audience.

At one point you say "The main learning objective is to 'get a feel' for both 'short-term' (current century) and possible 'long-term' (beyond) consequences of greenhouse-gas **mitigation** measures." However, I could not find how students in your simulation would manipulate variables representing mitigation measures and thus see their effects.

You say that "The conceptual design of the tool is based on the paradigm '**learning as experimenting**', encouraging students to explore climate sensitivity in its various

aspects in an active manner.". In my view, this is what your article should focus on, not the detailed analysis of the validity of various climate models. You state that your tool aims to counter common misconceptions [regarding the climate system]. This sounds like it is intended for a lay or general-public audience, not students specializing in climate models. If so, then the mathematics will not serve any purpose. In a simulation, you need to strike a careful balance between detail (a high fidelity simulation) and relatively simple pedagogically-useful simulation. The beauty of pedagogical simulation is its ability to represent reality at the most useful level of representivity for a given audience (sufficiently simple to provide powerful insight and so as not to swamp the main message, and sufficiently complex to provide realistic insight); the more sophisticated (educated) the audience, the more complex the simulation. At a certain point of increasing sophistication, the simulation will cease to have a pedagogical purpose and will manifest a research purpose, poorly adapted to helping lay people understand. Some useful discussion on this has been published, and could be cited.

You mention "the paradigm '**learning as experimenting**', encouraging students to explore climate sensitivity in its various aspects in an active manner". You really do need to provide references to this method. I would probably not call it a paradigm, but rather a method or an approach. A widely used approach goes under the name of the '**experiential learning cycle**', pioneered by Dave Kolb. Simulation designed and conducted within the framework of this cycle tends to provide a powerful method for communication, and is thus relevant to *Geoscience Communication*. However, a word of warning: No game, simulation or role-play or similar activity can hope to produce its full learning potential without the crucial step of **debriefing**. For the purpose of debriefing, it would be useful for facilitators and participants to have the underlying model, probably in non-mathematical terms, for example, as a system dynamics model. One question in the debriefing might cover 'what if' this or that variable in the model were modified?

I am not sure if you have done this, but a study on the **communicative effectiveness** for the various audiences of your simulation would contribute greatly the literature. Simulation can be a particularly powerful tool for communicating insights into geoscience phenomena, but it and its use (including the debriefing) need to be evaluated in a rigorous manner.

So, Peter, I hope these notes will help you to reshape your ms, to provide more structure, to decide on and achieve clear objectives, and to keep in mind the purpose of *Geoscience Communication*. The Edito by Illingworth et al is especially useful.