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How does the background atmosphere affect the onset of the runaway greenhouse? Insights from 1D radiative-convective modeling.

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There is a strong interest to study the runaway greenhouse effect [1-4] to better determine the runaway greenhouse insolation threshold and therefore the inner edge of the habitable zone (HZ). Some studies [5-7] have shown that the onset of the runaway greenhouse may be delayed due to an increase of the Outgoing Longwave Radiation (OLR) by adding radiatively inactive gas (e.g. N_2 or O_2, as in the Earth's atmosphere). For such atmosphere the OLR may "overshoot" the Simpson-Nakajima limit [4], i.e. the moist greenhouse limit of a pure vapor atmopshere. This has direct consequences on the position of the inner edge of the HZ [8-11] and thus on how close the Earth is from a catastrophic runaway greenhouse feedback. The OLR overshoot has previously been interpreted as a modification of the atmospheric profile due to the background gas [7,12]. However there is still no consensus so far in the literature on whether an OLR overshoot is really expected or not.

The first aim of our work is to determine, through sensitivity tests, the main important physical processes and parametrizations involved in the OLR computation with a suite of 1D radiative-convective models. By doing multiple sensitivity experiments we are able to explain the origin of the differences in the results of the literature for a H_2O+N_2 atmosphere. We showed that physical processes usually assumed as second order effects are actually key to explain the shape of the OLR (e.g., line shape parameters). This work can also be useful to guide future 3D GCM simulations. We propose also preliminary results from the LMD-Generic model to study how these effects may be understand in a 3D simulation.

Secondly we propose a reference OLR curve, done with a 1D model built according to the sensitivity tests, for a H_2O+N_2 atmosphere, to solve the question of the potential overshoot.

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