THE RUNAWAY GREENHOUSE: NEW MODEL RESULTS AND IMPLICATIONS FOR PLANETS AND ANTHROPOGENIC GLOBAL CHANGE Colin Goldblatt[1,] David Crisp[2], Tyler Robinson[3], Andrew Watson[4] and Kevin Zahnle[5]. [1]School of Earth and Ocean Sciences, University of Victoria (czg@uvic.ca) , [2]NASA Jet Propulsion Laboratory, [3]Astronomy Department, University of Washington, [4]School of Environmental Sciences, University of East Anglia, [5]NASA Ames Research Center.

Introduction: The ultimate and final end for Earth as a habitable planet will be the transition to a "runaway greenhouse", an apocalypse triggered by failure of the planet to maintain energy balance. This likely happened to Venus in the past, and sets a hard bound on the inner edge of the circumstellar habitable zone. For the survival of humanity, a critical question is whether anthropogenic greenhouse gas emissions could trigger a runaway greenhouse.

Theory: For a moist atmosphere, there are limits on the amount of outgoing thermal radiation that can be emitted [1,2,3,4]. If net radiation absorbed by the planet is more than the relevant radiation limit, energy balance cannot be maintained and runaway heating will ensue. For practical purposes, the relevant limit is the maximum emission from the upper troposphere which we term the Simpson-Nakijima limit, for Simpson [1] who first observed it in a model and Nakajima [4] who described the physics (the more commonly referred to Komabayashi-Ingersoll limit [2,3] is actually stratospheric limit, and very hard to achieve in practice). We recently reviewed this theory and more [5].

New calculations: There is a long history of numerical calculations of radiation limit [6,7,8,9], the most recent of which, by Kasting [8] and Abe & Matsui [9] are a quarter of a century old. We talk advantage of faster computers, new line databases for water absorption and new data for scattering by water to recalculate the radiation limit. Ours are the first calculations to be done at high spectral resolution. Our new calculations put the limit on outgoing thermal radiation at 283Wm^{-2}, less than the classical value of 310Wm^{-2} [8]. We also find that there is increased absorption of incoming solar radiation, and decreased Rayleigh scattering relative to these classic calculations, also making the runaway greenhouse more likely.

Anthropogenic global change: Hansen has suggested that anthropogenic carbon dioxide emissions could cause a runaway greenhouse [10]. Classical theory suggests that this is not the case: even our new, lower radiation limit of 283Wm^{-2} is much more than the net amount of energy absorbed by Earth, 240Wm^{-2}. Making the CO_2 mixing ratio 1% decreases the radiation limit by only 2Wm^{-2}, because CO_2 absorption in the 10μm water vapour window is weak (it is the amount of absorption here that most directly influences the radiation limit). However, the radiation limit is less than the total energy incident on Earth, 342Wm-^{2}, so a reduction in planetary albedo could in fact trigger a runaway greenhouse. Our new calculations indicate that a hot moist atmosphere will absorb much more incoming solar radiation than previously thought, reducing albedo. Is this a mechanism by which humans could trigger a runaway greenhouse? I will present new results on this at the meeting.

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