EXPLORING THE DIFFERENCES AMONG 3D GLOBAL CLIMATE MODEL SIMULATIONS OF THE HABITABLE ZONE INNER EDGE. Jun Yang[1], Jérémy Leconte[2], Eric T. Wolf[3], Timothy Merlis[4], Colin Goldblatt[5], Brain O. Toon[3], Francois Forget[6], and Dorian S. Abbot[1]. [1]Department of Geophysical Sciences, University of Chicago, Chicago, IL, USA, Email: junyang28@uchicago.edu, [2]Canadian Institute for Theoretical Astrophysics and Center for Planetary Science of University of Toronto, Toronto, Canada, [3]Laboratory for Atmospheric and Space Physics, University of Colorado in Boulder, Colorado, USA, [4]Department of Atmospheric and Oceanic Sciences at McGill University, Montréal, Canada, [5]School of Earth and Ocean Sciences, University of Victoria, Victoria, BC, Canada, and [6]Laboratoire de Météorologie Dynamique, Institut Pierre Simon Laplace, CNRS, Paris, France.

Accurate estimates of the width of the habitable zone are critical for finding potentially habitable exoplanets and estimating the frequency of Earth-like planets in the galaxy. A hard limit on the inner edge of the habitable zone is the runaway greenhouse effect [1]. Recently, a number of calculations have been done with three-dimensional atmospheric general circulation models (GCMs) to estimate the inner edge of the habitable zone. Leconte et al. (2013 [2]) found that the insolation threshold for the runaway greenhouse on Earth is $\approx$1500 W m^{-2} (i.e., 110 % of modern Earth's insolation) in the GCM generic-LMD, but Wolf and Toon (2014 [3]) and Yang et al. (2014 [4]) found that the insolation threshold is $\approx$1600 W m^{-2} in the GCM CAM3. Yang et al. (2013 [5], 2014 [4]) also found that cloud reflection on slowly rotating or tidally locked planets could lead to a much higher insolation threshold.

We study the sources of model differences through a series of comparisons of radiative transfer, clouds, and dynamical core for Earth-like and tidally locked simulations in five GCMs (CAM3, CAM4, generic-LMD, AM2, and CAM4 with an updated radiative transfer scheme). These comparisons will identify the specific components of the models that are the sources of disagreement, which will focus model improvement. So far, we have found that: (1) Cloud parameterizations lead to the largest differences among the models; (2) Differences in shortwave and longwave radiative transfer of water vapor is moderate (less than 20 W m^{-2}, as long as surface temperature is less than 360 K (Fig. 1)); and (3) Differences in the atmospheric dynamical cores have a very small effect on the surface temperature.

References: [1] Kasting J. F., Whitmire D. P. and Reynold R. T. (1993), *Icarus, 101,* 108-128. [2] Leconte J., Forget F., Charnay B., Wordsworth R. and Pottier A. 2013, *Nature, 504,* 268-271. [3] Wolf E. T. and Toon B. O. 2014, *Geophys. Res. Lett., 41*, 167-172. [4] Yang J., Boué G., Fabrycky D. C. and Abbot D. S. 2014, *ApJ Letters, 787*, L2. [5] Yang, J., Cowan N. B. and Abbot D. S. (2013), *ApJ Letters, 771*, L45.

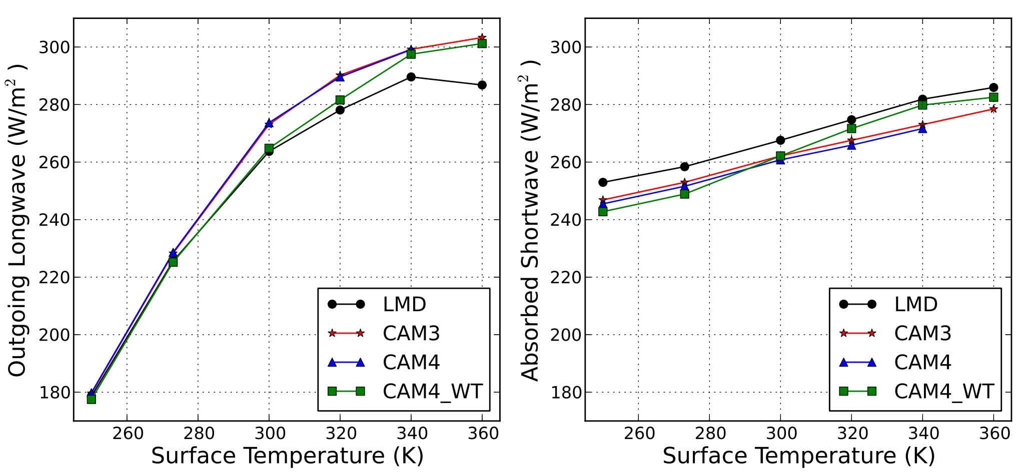

Figure 1: Differences in water vapor radiative transfer between four climate models for a 1 bar N_2 background atmosphere with 376 ppmv of CO_2. Left panel: Outgoing longwave radiation at the top of the atmosphere as a function of surface air temperature. Right panel: same as the left panel but for absorbed shortwave radiation. In these calculations, the relative humidity is 100%, the solar insolation is 1360 W m^{-2}, and the surface albedo is 0.25. CAM4_WT is the same as CAM4 but with an updated radiative transfer scheme by Wolf E. T. and Toon B. O.