

Supporting Information for

Coupled atmospheric chemistry, radiation and dynamics of an exoplanet generate self-sustained oscillations

Yangcheng Luo^{1,2,3}, Yongyun Hu^{2,*}, Jun Yang², Michael Zhang¹, Yuk L. Yung^{1,†}

¹Division of Geological and Planetary Sciences, California Institute of Technology, Pasadena, CA 91125, USA.

²Department of Atmospheric and Oceanic Sciences, School of Physics, Peking University, Beijing 100871, China.

³Laboratoire de Météorologie Dynamique/Institut Pierre-Simon Laplace, Sorbonne Université, École Normale Supérieure, Université Paris Sciences et Lettres, Ecole polytechnique, Institut Polytechnique de Paris, Centre National de la Recherche Scientifique, Paris 75005, France

*Corresponding author: Yongyun Hu. Email: yyhu@pku.edu.cn

†Corresponding author: Yuk L. Yung. Email: yly@caltech.edu

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Figures S1 to S5

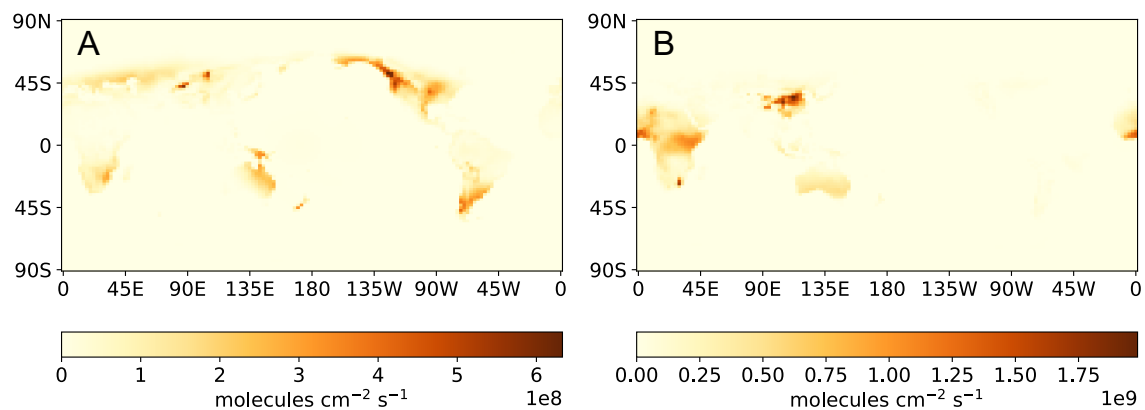


Fig. S1. Lightning emission of NO depends on the location of the substellar point. Column-integrated NO production rates from lightning with the substellar point fixed at (A) 0°N, 180°E and (B) 0°N, 0°E. The total NO emission rate from lightning over the globe is 0.06 Tg N per year for (A) and 0.16 Tg N per year for (B).

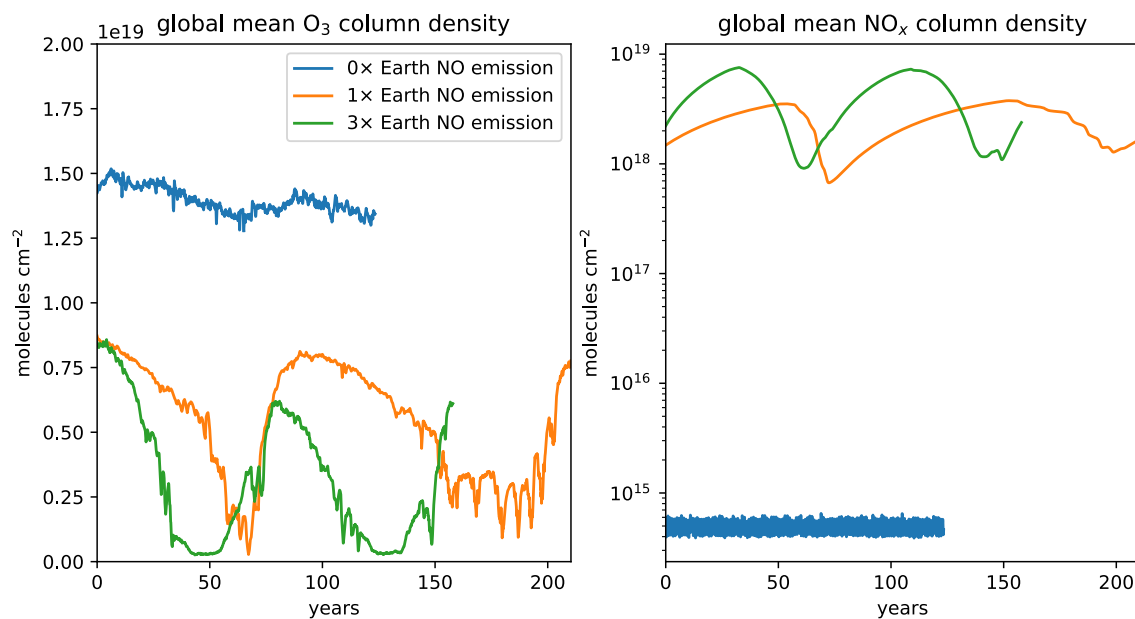


Fig. S2. Time series of the global mean column abundances of (left) O₃ and (right) NO_x with different surface NO emission fluxes. Large-magnitude, periodic oscillations in O₃ and NO_x abundances occur with an Earth-like (or higher) surface NO emission flux. Stronger surface NO emission drives faster oscillations. There is no significant oscillation without surface NO emission.

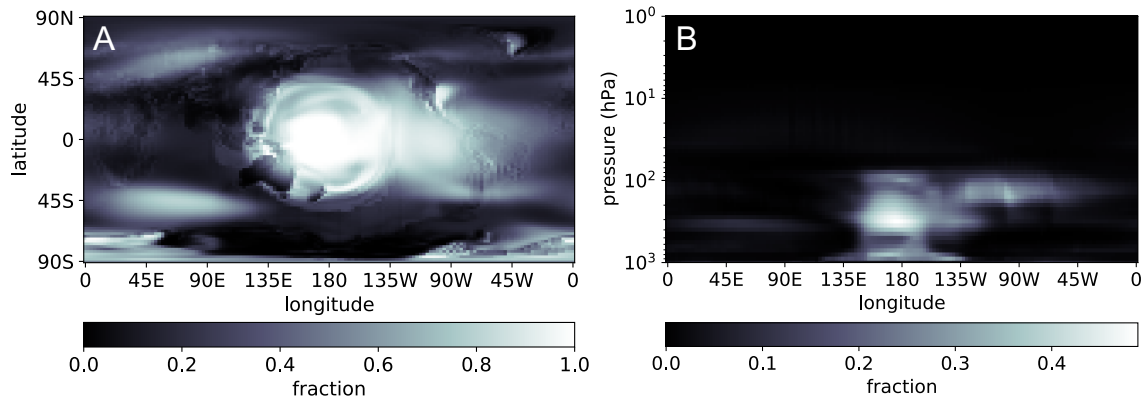


Fig. S3. Average cloud distribution. (A) Cloud fraction. The contributions from all vertical layers are considered. (B) Meridional mean cloud fraction as a function of longitude and atmospheric pressure. The substellar point is located at 0°N, 180°E. Convective clouds form in the substellar region and are transported eastward by westerly wind in the upper troposphere. The terminator at 90°E is almost free of cloud. Some cloud exists at the terminator at 90°W. Cloud top is located at about 100 hPa.

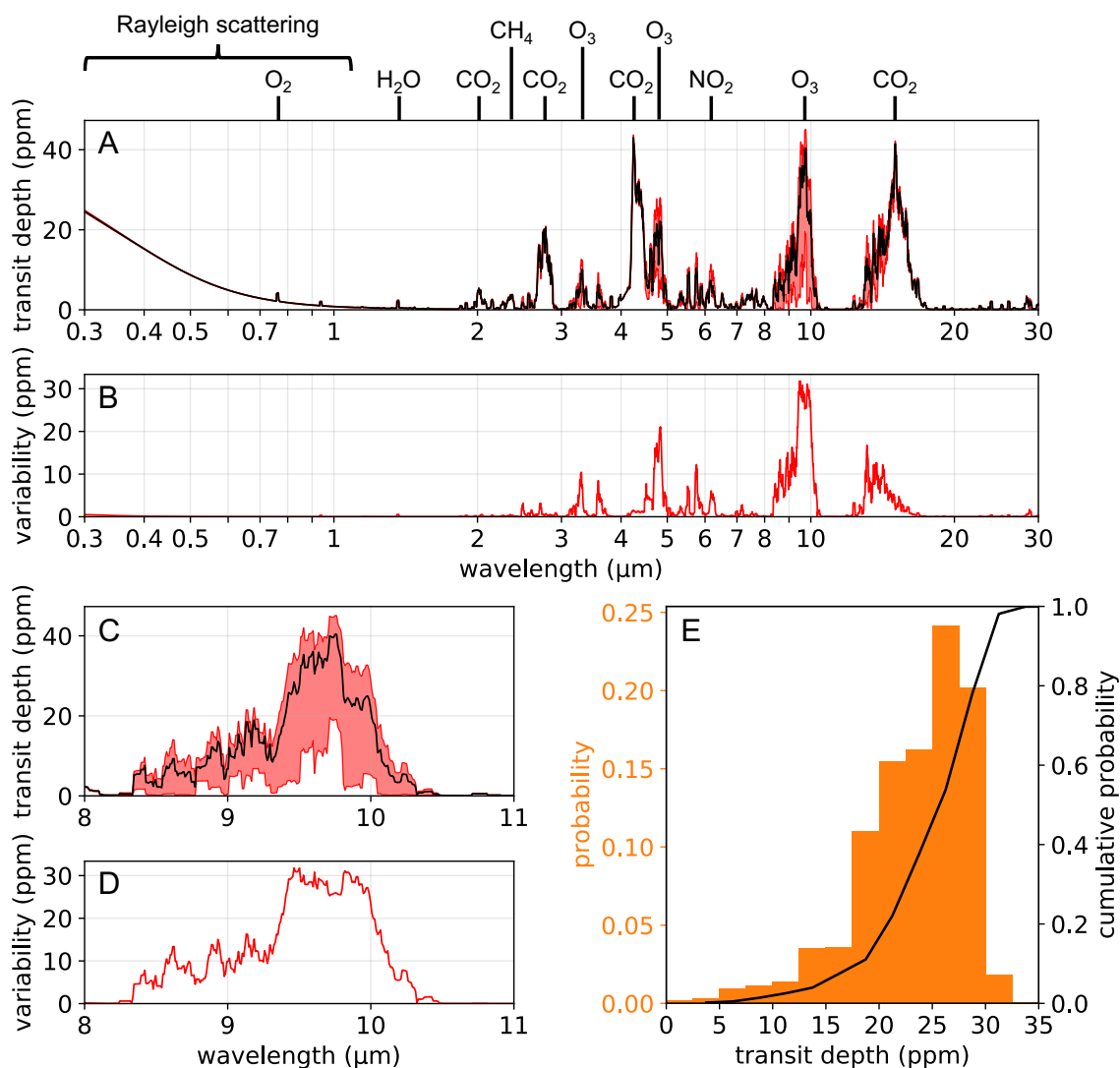


Fig. S4. Observational prospects in a cloudy scenario. Same as Fig. 5, except for an assumed, optically thick cloud deck located at 100 hPa over the entire globe which mutes all spectral features of absorbing species underneath. Compared to the clear-sky scenario, the time mean transit depth at 9.6 μm is reduced from 60 ppm to 40 ppm, which doubles the required exposure time. The variability of transit depth is reduced from 50 ppm to 30 ppm, almost tripling the required exposure time. But these reductions should be considered as the upper bound as cloud is patchy at the terminators (Fig. S3).

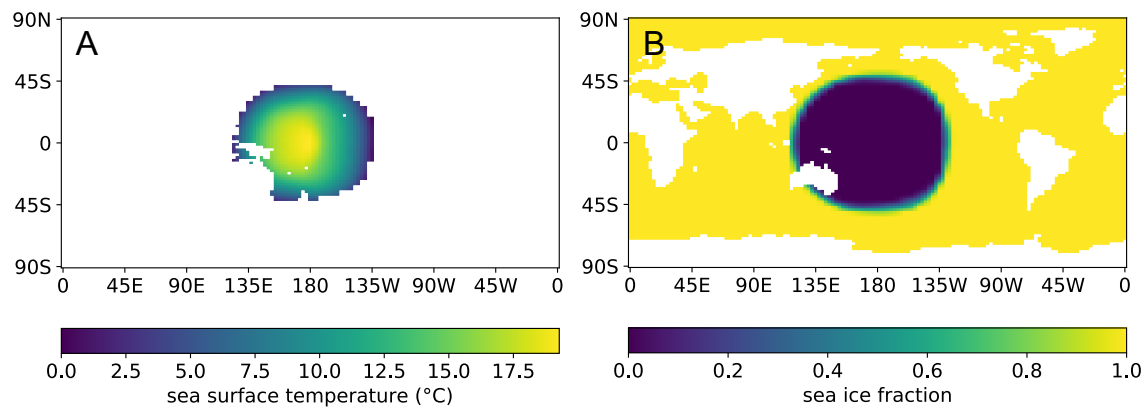


Fig. S5. Sea surface temperature and sea ice distribution. (A) Fixed sea surface temperature. Only grid boxes with 100% ocean fraction are shown. (B) Fixed sea ice fraction. Continent-only grid boxes are shown in white. Land-sea distribution of the modern Earth is used in the simulation.