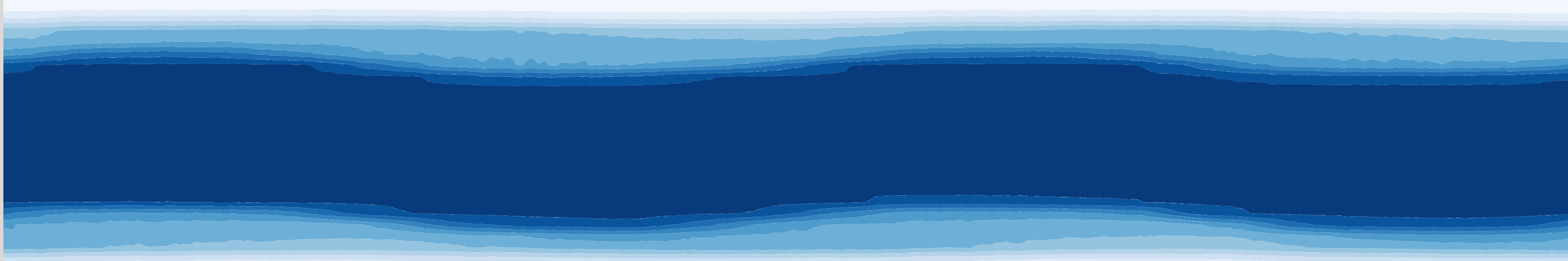
Subtropical Clouds Stabilize Near-Snowball Earth States

Christoph Braun, Aiko Voigt, Johannes Hörner, Joaquim G. Pinto

christoph.braun@kit.edu

Karlsruhe Institute of Technology - IMK-TRO



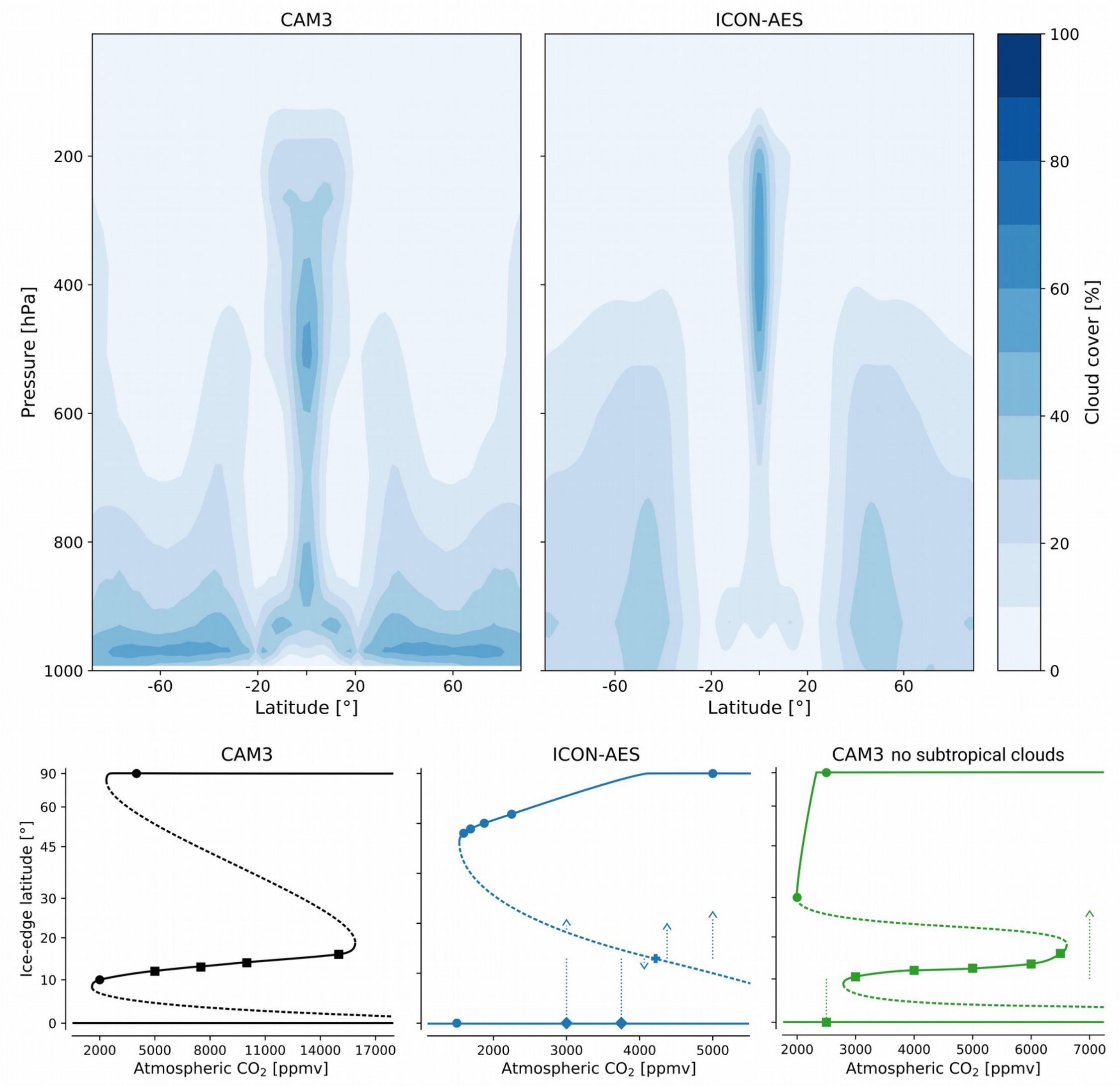
Gefördert durch
DFG Deutsche Forschungsgemeinschaft

Motivation and research question

- Waterbelt climate states may extend the outer limit of the habitable zone on terrestrial planets[1] and explain the survival of advanced marine species during the Neoproterozoic glaciations on Earth[2].
- The stability of waterbelt states is impacted by the interaction of cloud-radiative effects and albedo feedbacks[3,4,5,6,7,8,9].
- State-of-the-art tools for studying climate feedbacks in extraterrestrial atmospheres are 3D general circulation models[10].
- Cloud-radiative effects contribute significantly to the uncertainty of the climate response of general circulation models[11].

→ How do simulated cloud-radiative effects impact the stable range of waterbelt climate states?

Subtropical cloud-radiative effects increase the stable range of waterbelt climate states in general circulation models



C. Braun, A. Voigt, J. Hörner, J.G. Pinto

References

(1) Wolf, E. T., Shields, A. L., Kopparapu, R. K., Haqq-Misra, J., and Toon, O. B. (2017). Constraints on climate and habitability for earth-like exoplanets determined from a general circulation model. The Astrophysical Journal, 837(2):107.

(2) Abbot, D. S., Voigt, A., and Koll, D. (2011). The jormungand global climate state and implications for neoproterozoic glaciations. Journal of Geophysical Research: Atmospheres, 116(D18).

(3) Hyde, W. T. et al. (2000). Neoproterozoic 'snowball earth' simulations with a coupled climate/ice-sheet model. Nature, 405(6785):425–429.

(4) Poulsen, C. J. and Jacob, R. L. (2004). Factors that inhibit snowball earth simulation. Paleoceanography, 19(4).

(5) Poulsen, C. J., Pierrehumbert, R. T., and Jacob, R. L. (2001). Impact of ocean dynamics on the simulation of the neoproterozoic "snowball earth". Geophysical Research Letters, 28(8):1575–1578.

(6) Joshi, M. M. and Haberle, R. M. (2012). Suppression of the water ice and snow albedo feedback on planets orbiting red dwarf stars and the subsequent widening of the habitable zone. Astrobiology, 12(1):3–8. PMID: 22181553.

(7) Kitzmann, D., Patzer, A., and Rauer, H. (2013). Clouds in the atmospheres of extrasolar planets-iv. on the scattering greenhouse effect of co2 ice particles: numerical radiative transfer studies. Astronomy & Astrophysics, 557:A6.

(8) Shields, A. L., Meadows, V. S., Bitz, C. M., Pierrehumbert, R. T., Joshi, M. M., and Robinson, T. D. (2013). The effect of host star spectral energy distribution and ice-albedo feedback on the climate of extrasolar planets. Astrobiology, 13(8):715–739. PMID: 23855332.

(9) von Paris, P., et al. (2013). The dependence of the ice-albedo feedback on atmospheric properties. Astrobiology, 13(10):899–909. PMID: 24111995.

(10) Shields, A. L. The Climates of Other Worlds: A Review of the Emerging Field of Exoplanet Climatology The Astrophysical Journal Supplement Series, IOP Publishing, 2019, 243, 30.

(11) Boucher, O. et al. (2013). Clouds and aerosols. In Climate change 2013: the physical science basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, pages 571–657. Cambridge University Press.