Supporting Information for "A Lagrangian perspective on tropical anvil cloud lifecycle in present and future climate"

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Introduction

Text S1. The broad evolution of the anvil cloud decay along tracked trajectories does not depend significantly on whether the ice crystal sedimentation velocity is included in the calculation or not (Fig. S1a,b). The exception is a smaller amount of trajectories fulfilling the thick anvil criterion in the SEDI setup. The decay of anvil cloud fraction is also not significantly biased by our decision to consider only trajectories not encountering any significant ice detrainment tendency after the initial 4 hours of the evolution. However, when considering all trajectories, we observe an increased cloud lifetime and the existence of a small amount of thick anvil clouds throughout the whole 40 hours of evolution (Fig. S1b), whereas such clouds disappear completely after hour 10-15 of the simulation in the standard case (Fig. S1a). The larger fraction of thick clouds is explains an increase in both SWCRE and LWCRE when including all detrained trajectories (Tab. S1). A larger proportion of thick anvil clouds that increase their IWC and COD in a warmer climate is also responsible for a more negative cloud feedback (-0.3 W m^{-2} K^{-1} compared with 0.5 W m^{-2} K^{-1}) along all detrained trajectories, including those that are re-entrained in new convective events (Tab. S1).

The standard set of trajectories uses a minimum IWC limit of 0.1 mg kg^{-1} for the determination of a cloud. The lifetime decreases by about 1 hour when using an order of magnitude larger ice mixing ratio limit in the definition of a cloud lifetime, similar to that used by Mace, Deng, Soden, and Zipser (2006), while a lower ice limit would not change the cloud decay (Fig. S1c). The lifetime was also found to be sensitive to the minimum cloud fraction allowed for calling an air parcel cloudy. The lifetime increases by about 1 hour when using a limit of 1% cloud fraction instead of the default value of 10%. On the other hand, the lifetime decreases by more than 1 hour when increasing the limit from 10% to 30% (Fig. S1d).

References

Mace, G. G., Deng, M., Soden, B., & Zipser, E. (2006). Association of Tropical Cirrus in the 10–15-km Layer with Deep Convective Sources: An Observational Study Combining Millimeter Radar Data and Satellite-Derived Trajectories. *J. Atmos. Sci.*, *63*(2), 480–503. doi: 10.1175/JAS3627.1

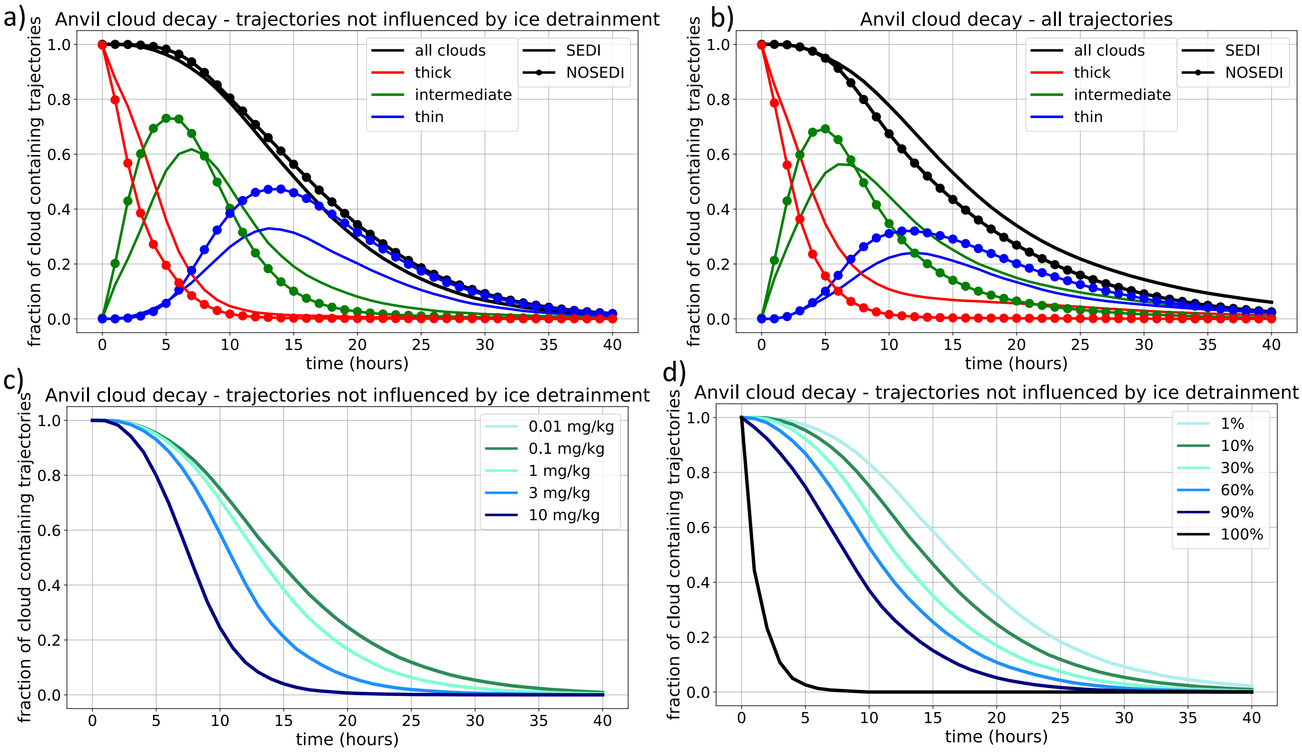

Figure S1. Anvil cloud decay for the case of trajectories with sedimentation velocity (SEDI) or without (NOSEDI) and when considered (a) only trajectories not affected by ice detrainment after hour 4 of evolution as used in the main part of the manuscript and (b) all trajectories. (c) shows sensitivity tests of anvil cloud decay when using different in-cloud IWC limits for cloud definition and a constant minimum cloud fraction limit of 10%. (d) shows sensitivity tests with different minimum cloud fraction limits considered in the definition of anvil cloud and a constant minimum in-cloud IWC limit of 0.1 mg kg^{-1}.

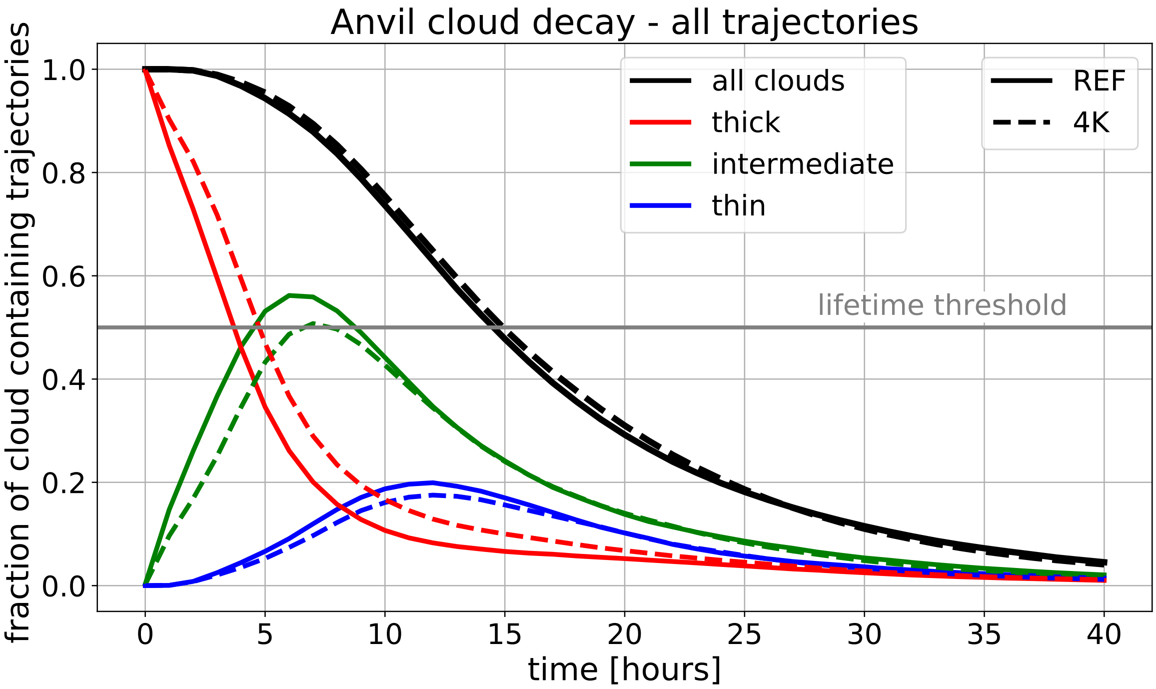

Figure S2. As Fig. 6 but with all trajectories considered (i.e. not excluding those affected by subsequent detrainment of ice after hour 4 of the evolution).

Table S1. Mean changes in cloud radiative effects (CRE) during the 20 h long trajectories for all computed trajectories.

	REF	**4K-REF**
LW CRE [W m^{-2}]	105.7	10.8
SW CRE [W m^{-2}]	-114.9	-16.3
NET CRE [W m^{-2}]	-9.2	-5.6
NET feedback [W m^{-2} K^{-1}]	/	-0.3