Project: **909**

Project title: **Learning on cloud brightening under risk and uncertainty: Whether, when and how to do a field experiment (LEAC)**

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The project aims at an assessment of the radiative forcing, side impacts and options to learn about especially the geoenineering scheme by spraying marine boundary-layer clouds with sea salt.

The particular focus of the LEAC project within the DFG Priority Programme on climate engineering was to assess the feasibility and detectability of a field experiment for marine stratocumulus brightening (Quaas et al., 2016). This was on the one hand conducted by the analysis of satellite data (Aswathy et al., 2016), but on the other hand assessed using simulations with the ECHAM5-HAM2 global aerosol-climate model (Zhang et al., 2012).

The hypothesis, based on the difficulty to detect cloud changes due to inadvertent anthropogenic aerosol emissions (Quaas, 2015), was that a field experiment might need to be very large in spatial extent, very long in duration, and/or very intense in terms of cloud seeding, in order to obtain a signal-to-noise ratio large enough to allow for the detection of the signal with statistical significance.

As an example, the extreme perturbation case is shown in Fig. 1 in which the cloud droplet number concentration in the planetary boundary layer is doubled in the target regions. In this extreme case, a the seeding area is clearly visible as a distinguishable rectangle in cloud liquid water path and also planetary albedo and top-of-atmosphere solar radiation, albeit not in total cloud cover (Aswathy, 2016).

The results for various seeding intensities and various seeding domain sizes are shown in Fig. 2. It is clear from this result that the best target region is the South Atlantic stratocumulus deck, where even for a modest increase of the droplet concentration by 20% a field experiment time period of three months is sufficient to obtain a statistically significant result (Aswathy, 2016).

References

***Aswathy, V. N.**, Learning about cloud brightening under uncertainty: How to do field experiments, PhD thesis, Faculty for Physics and Earth Sciences, University of Leipzig, in preparation (2016).*

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*Quaas, M. F., **J. Quaas**, W. Rickels, and O. Boucher, Are there good reasons against research into solar radiation management?, J. Environ. Econ. Manage., in revision (2016).*

***Quaas, J.**, Approaches to observe effects of anthropogenic aerosols on clouds and radiation, Current Climate Change Reports, 1, 297-304, doi:10.1007/s40641-015-0028-0, 2015.*

*Zhang, K., D. O'Donnell, J. Kazil, P. Stier, S. Kinne, U. Lohmann, S. Ferrachat, B. Croft, **J. Quaas**, H. Wan, S. Rast, and J. Feichter, The global aerosol-climate model ECHAM5-HAM, version 2: sensitivity to improvements in process representations, Atmos. Chem. Phys., 12, 8911-8949, doi:10.5194/acp-12-8911-2012, 2012.*

Figures

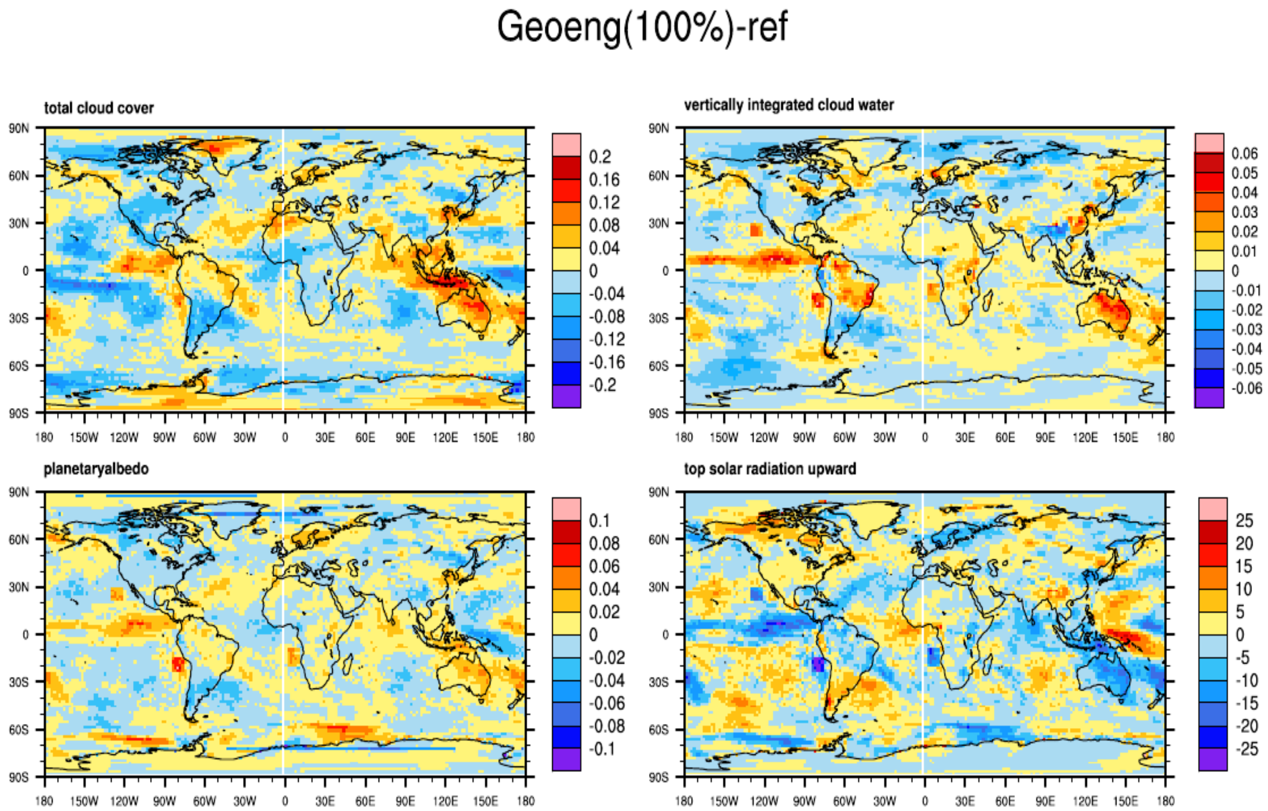

Fig. 1. Difference between a simulation with seeding marine stratocumulus clouds in three different areas (doubling of cloud droplet number concentration in the boundary layer minus control simulation) for (top left) total cloud cover, (top right) cloud liquid water path [kg m^{-2}], (bottom left) planetary albedo, and (bottom right) absorbed solar radiation [W m^{-2}].

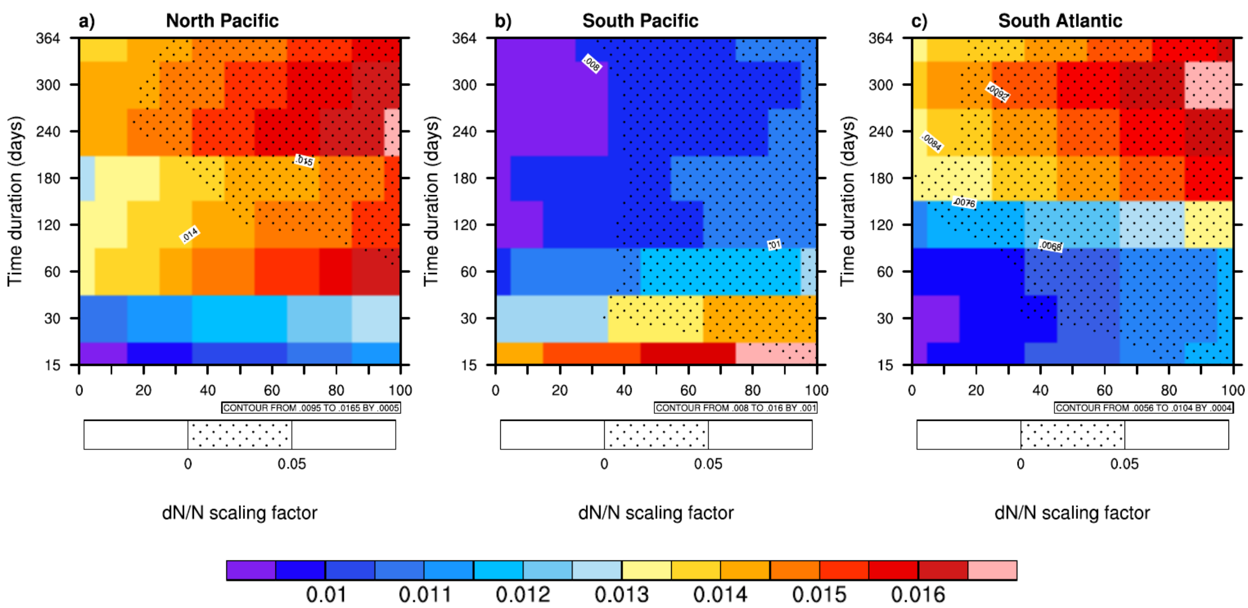

Fig. 2. Cloud albedo variance as a function of time duration of a field experiment (y-axis) and seeding intensity (x-axis) for the three optional target regions (stratocumulus decks). Statistically significant regions are stippled.