Aerosol-cloud interactions in marine stratocumulus: cloud radiative effects or forcing?

DANIEL ROSENFELD[1] AND TOM GOREN[1]

[1]The Hebrew University of Jerusalem

Marine stratocumulus cloud fractional cover changes dramatically in association with changes in aerosols. Abrupt changes from a full cloud cover to broken clouds (pockets of open cells) occurs when the aerosol amount is sufficiently small for allowing heavy drizzle, which further cleans the aerosols in a positive feedback loop. The change from closed to open cells is associated with a respective change of cloud radiative effect that often exceeds 100 wm^{-2}. Most of the change in cloud radiative effect comes from the cloud cover and liquid water path effects, and only 25% from the Twomey effect. These large changes are not usually considered as radiative forcing, because natural mechanisms were proposed for alterations between those two regimes in the open ocean.

Ship tracks were recently shown to be able to close the open cells, thus rendering this large cloud radiative effect as forcing, where this could be clearly associated with ship emissions. However, overall ship tracks were shown to have an insignificant radiative forcing at the global account. But, can the continents be regarded as huge ships within the ocean, which emit anthropogenic aerosols that modify the marine stratocumulus to the extent of having a substantial impact on the global energy balance?

Recent studies from VOCALS experiment off the coast of Chile have shown that anthropogenic pollution modifies cloud properties for thousands of km into the ocean. We have examined similar situations over the North Atlantic and tracked cloudy regions for several days until they opened into open cells. In this lagrangian approach we were able to separate the roles of aerosols and meteorology (cloud depth) and show the decisive role that continental aerosols have on keeping the marine stratocumulus in the fully cloudy regime for several days. This implies that in such circumstances the large negative cloud radiative effect can be regarded as forcing. This means that much of the cooling due to cloud-aerosol interactions might be occurring in this way. Our inability to quantify this effect until now possibly plays a major role in keeping the high uncertainty of cloud aerosol interactions on anthropogenic climate forcing.