The invigoration of deep convective clouds over the Atlantic: aerosol effect, meteorology or retrieval artifact?

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Associations between cloud properties and aerosol loading are frequently observed in products derived from satellite measurements. These observed trends between clouds and aerosol optical depth suggest aerosol modification of cloud dynamics, yet there are uncertainties involved in satellite retrievals that have the potential to lead to incorrect conclusions. Two of the most challenging problems are addressed here: the potential for retrieved aerosol optical depth to be cloud-contaminated, and as a result, artificially correlated with cloud parameters; and the potential for correlations between aerosol and cloud parameters to be erroneously considered to be causal. Here these issues are tackled directly by studying the effects of the aerosol on convective clouds in the tropical Atlantic Ocean using satellite remote sensing, a chemical transport model, and a reanalysis of meteorological fields. Results show that there is a robust positive correlation between cloud fraction or cloud top height and the aerosol optical depth, regardless of whether a stringent filtering of aerosol measurements in the vicinity of clouds is applied, or not. These same positive correlations emerge when replacing the observed aerosol field with that derived from a chemical transport model. Model-reanalysis data is used to address the causality question by providing meteorological context for the satellite observations. A correlation exercise between the full suite of meteorological fields derived from model reanalysis and satellite-derived cloud fields shows that observed cloud top height and cloud fraction correlate best with model pressure updraft velocity and relative humidity. Observed aerosol optical depth does correlate with meteorological parameters but usually different parameters from those that correlate with observed cloud fields. The result is a near-orthogonal influence of aerosol and meteorological fields on cloud top height and cloud fraction. The results strengthen the case that the aerosol does play a role in invigorating convective clouds.

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