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The adiabaticity of warm cumulus clouds simulated in high-resolution

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The strong coupling between dynamic, thermodynamic, and microphysical processes and the numerous environmental parameters on which they depend makes clouds a highly complex system. Adiabatic regions (i.e., undiluted core) in the cloud allow to approximate in a simple way thermodynamic and microphysical profiles and provide local boundary conditions (i.e. core is a source of adiabatic values in each level). Mixing of the cloud with its environment affects both the cloud and the environmental properties. While environmental humidity, temperature and aerosol loading affect the clouds' buoyancy and droplets size distribution (DSD), clouds simultaneously affect their surrounding via detrainment of droplets, humid air, and processed aerosols. Mixing occurs within a large spectrum of scales and leads to deviation of parts of the cloud from adiabaticity. The level of adiabaticity can be represented continuously by the adiabatic fraction (AF; defined as the ratio of the liquid water content to the theoretical adiabatic value). In this work we used the System of Atmosphere Modeling (SAM) with the Hebrew University Spectral Bin Microphysics to simulate a few isolated non-precipitating trade cumulus clouds (in different sizes and aerosol loading) in high resolution (10m). Passive tracer was added to all the simulations. We found cloudy volumes that contain both high tracer concentration and high AF (up to the clouds' top), compared these two measures of mixing, and discuss their differences. The accuracy of AF calculations, based on different known methods is tested. For example, we show that the saturation adjustment assumption that is often used in AF calculations can lead to an underestimation of AF in pristine environments. This will mask microphysical effects and cause biases when comparing the adiabaticity of clouds under different aerosols loading. We show that the space spanned by the AF versus height in the cloud is a good measure for describing changes in cloud's key variables in space and time (like temperature, updraft, and DSD properties). This space of AF vs height demonstrates how certain processes (e.g. in-cloud nucleation, mixing, evaporation, etc.) dominate different regions in the cloud (core, edge), and cause different dependence of the DSD on AF under different aerosols loading.