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Effect of Increasing Temperature on Carbonaceous Aerosol Direct Radiative Effect over Southeastern US

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Aerosols are an important regulator of the Earth's climate. They scatter and absorb incoming solar radiation and thus cool the climate by reducing the amount of energy reaching the atmospheric layers and the surface below (direct effect). A certain subset of the particles can also act as initial formation sites for cloud droplets and thereby modify the microphysics, dynamics, radiative properties and lifetime of clouds (indirect effects). The magnitude of aerosol radiative effects remains the single largest uncertainty in current estimates of anthropogenic radiative forcing. One of the key quantities needed for accurate estimates of anthropogenic radiative forcing is an accurate estimate of the
radiative effects from natural unperturbed aerosol. The dominant source of natural aerosols over Earth's vast forested regions are biogenic volatile organic compounds (BVOC) which, following
oxidation in the atmosphere, can condense onto aerosol particles to form secondary organic aerosol (SOA) and significantly modify the particles' properties. In accordance with the expected positive temperature dependence of BVOC emissions, several previous studies have shown that some aerosol properties, such as mass concentration and ability to act as cloud condensation nuclei (CCN), also correlate positively with temperature at many forested sites. There is conflicting evidence as to whether the aerosol direct effects have a temperature dependence due to increased BVOC emissions.

The main objective of this study is to investigate the causes of the observed effect of increasing temperatures on the aerosol direct radiative effect, and to provide a quantitative estimate of this effect and of the resulting negative feedback in a warming climate. More specifically, we will investigate the causes of the positive correlation between aerosol optical depth (AOD) and land surface temperature (LST) over southeastern US where biogenic emissions are a significant source of atmospheric particles. In addition to BVOCs, SOA formed in clouds and biomass burning emissions could also explain the temperature dependence of aerosol direct radiative effect.

The study is done using a combination of satellite data and climate modeling. Key remote sensing data used are the AATSR based AOD and LST products available from the Aerosol-CCI and GlobTemperature projects, together with ancillary data, such as column concentrations of CO and water vapour from AIRS, NO_2 from OMI, and aerosol profiles from CALIOP, and ESA's Soil Moisture-CCI products. The aerosol-chemistry climate model used is ECHAM-HAMMOZ, which describes all known relevant atmospheric aerosol processes. It includes all the main atmospheric aerosol compounds as well as the interactive biogenic emission model MEGAN, which enables the simulation of the effects of temperature changes on atmospheric aerosol load. With these tools, we can estimate the significance of the negative feedback due to a warming-induced aerosol direct effect and specify the aerosol species contributing to it.