Final Report on Radiative Effects of Aerosols
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The paper "Vertical Profiles, Aerosol Microphysics and Optical Closure during ASTEX: Measured and Modeled Column Optical Properties", Clarke et al, describes the work done during the period of this grant. It can be summarized as follows:

During the Atlantic Stratocumulus Transition Experiment (ASTEX) in June 1992, two descents in cloud-free regions allowed comparison of the change in aerosol optical depth as determined by an onboard total-direct-diffuse radiometer (TDDR) to the change calculated from measured size-resolved aerosol microphysics and chemistry. Both profiles included pollution haze layer from Europe but the second also included the effect of a Saharan dust layer above the haze. The separate contributions of supermicrometer (coarse) and submicrometer (fine) aerosol were determined and thermal analysis of the pollution haze indicated that the fine aerosol was composed primarily of a sulfate/water mixture with a refractory soot-like core. The soot core increased the calculated extinction by about 10% in the most polluted drier layer relative to a pure sulfate aerosol but had significantly less effect at higher humidities. A 3 km descent through a boundary layer airmass dominated by pollutant aerosol with relative humidities (RH) 10-77% yielded a close agreement between the measured and calculated aerosol optical depths (550nm) of 0.160 (+/- 0.07) and 0.157 (+/- 0.034) respectively. During descent the aerosol mass scattering coefficient per unit sulfate mass (inferred) varied from about 5 to $16m^2g^{-1}$ and primarily dependent upon ambient RH. However, the total scattering coefficient per total fine mass was far less variable at about 4+/- $0.7m^2g^{-1}$. A subsequent descent through a Saharan dust layer located above the pollution aerosol layer revealed that both layers contributed similarly to aerosol optical depth. The scattering per unit mass of the coarse aged dust was estimated at 1.1 +/- $0.2m^2g^{-1}$. The large difference (50%) in measured and calculated optical depth for the dust layer exceeded estimated measurement uncertainty (12%). This is attributed to inadequate data on the spatial variability of the aerosol field within the descent region, a critical factor in any validation of this type. Both cases demonstrate that surface measurements may be a poor indicator of the characteristics and concentration of the aerosol column.

The optical properties of Arctic Haze were studied using a total-direct-diffuse radiometer as part of the Arctic Gas and Aerosol Sampling Project, part III (AGASP III). The radiometer was installed on the NOAA WP-3D research aircraft and measured solar downwelling irradiance in seven narrow-band channels in the visible and near-infra-red. Haze optical depths had maximum values near 0.1 in the mid-visible for AGASP flights 310 and 311. An inferred particle size spectrum from flight 311 extinction measurements showed two dominant modes near 0.1 and 0.8 μm. A method of retrieving the angular dependence of scattered radiation is presented and suggests the presence of thin cirrus.

The radiative effects of the smoke from the Kuwait oil fires were assessed by measuring downwelling and upwelling solar air flux, as well as spectral solar extinction beneath, above and within the smoke plume. Radiative flux divergence measurements were made to determine smoke-induced heating and cooling rates. Seven radiation flight missions were undertaken between May 16 and June 2, 1991, to characterize the plume between the source region in Kuwait and approximately 200 km south, near Manama, Bahrain. We present results from one flight representative of conditions of the composite plume. On May 18, 1991, in a homogeneous, well-mixed region of smoke approximately 100 km downstream of the fires, visible optical depths as high as 2 were measured, at which time transmission to the surface was 8%, while 78% of the solar radiation was absorbed by the smoke. The calculated instantaneous heating rate inside the plume reached 24K/d. While these effects are probably typical of those regions in the Persian Gulf area directly covered by the smoke, there is no evidence to suggest significant climatic effects in other regions.