A Proposed Study on the Interaction Between Aerosols and Arctic Stratocumulus

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The Arctic region is one of particular interest in climate studies because of the potential implications of both small and large-scale climate change in that region. Many of these prospective changes can be linked directly to the radiative properties and influence of clouds. One prominent example of a link between global climate and cloud properties is the dependence of sea-ice thickness to the cloud radiative characteristics. Curry and Ebert (1990) demonstrated in simulations that perturbations to the surface radiative flux resulting from alteration of droplet equivalent radius and ice crystal frequency had significant implications on the arctic equilibrium ice thickness. Past climate studies have indicated that changes in sea-ice cover have the potential to affect general circulation patterns, leading to climate changes at a global scale (Broecker et al., 2001), and a reduction in Arctic sea-ice has already been observed (Serreze et al., 2003; Johannessen et al., 1999; Rothrock et al., 1999). Other potential arctic cloud influences on regional and global climate include modification of snowfall amounts and surface albedo. Because of these potential stimuli, accurate and thorough understanding of Arctic cloud properties and coverage, along with proper reproduction of these characteristics in Global Climate Models (GCMs) is vital to furthering our ability to understand climate modification at the regional and global levels.

Of the influential types of Arctic clouds, some of the most intriguing and challenging to be understood are mixed-phase Arctic stratocumulus clouds. Some of these lower tropospheric cloud decks have been known to persist for days and weeks. The mechanisms behind their longevity are yet to be well understood. A recent study by Harrington and Olsson (2001) pointed to the presence but relatively small abundance of ice-forming nuclei (IN) as a major influence on the maintenance of these cloud structures. Although this is likely a part of the solution, the theory presented appears to result in a highly unstable situation in which the cloud structure is highly sensitive to the IN population. Since these clouds are known to persist for long periods of time, it would seem that additional mechanisms must be involved. In addition to the fundamental lack of data and understanding of the microphysics involved, there is also a lack of understanding of the sources, types, and transport mechanisms of the IN in question.

As part of the Study of Environmental Arctic Change (SEARCH, 2001) the University of Wisconsin Arctic High Spectral Resolution Lidar (AHSRL, Eloranta, 2005) will be deployed to Eureka, Canada in the summer of 2005 along with a suite of measuring devices to capture important cloud microphysical properties and relative cloud condensation nuclei (CCN) and IN concentrations. The Eureka site will be one of several in the Arctic designed for long-term observation of Arctic climate and atmospheric phenomena. Measurements taken during temporary deployment of the AHSRL to Barrow, AK last fall for the Mixed-Phase Arctic Cloud Experiment (M-PACE) are already actively being studied. Figure 1 shows an example of Arctic Stratocumulus as observed by the AHSRL from M-PACE.

This study proposes the incorporation of aerosol handling into the University of Wisconsin Non-Hydrostatic Modeling System (UW-NMS, Tripoli, 1992) so that if can be used as an investigative tool to study the potential mechanisms and transport processes supporting the longevity of these stratocumulus, along with their general microphysical characteristics and the uncertainties outlined in figure 2. The data collected at the SEARCH and M-PACE sites will provide an excellent means of model validation, while simultaneously serving as a source of independent insight into the structure and maintenance of these long lasting cloud formations.

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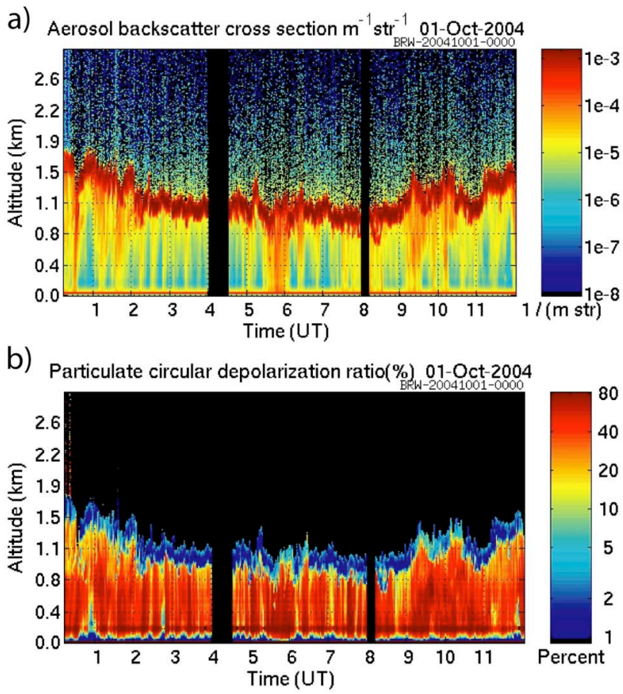

Figure 1. Arctic Stratocumulus as measured by the AHSRL during M-PACE. Aerosol backscatter cross-section (a) shows the vertical extent of the cloud deck and precipitation. Depolarization ratio (b) provides information on cloud phase, with high depolarization ratios indicating non-spherical (ice) precipitation particles and a band of low depolarization values at 0.9-1.6 km indicating spherical (liquid) cloud particles.

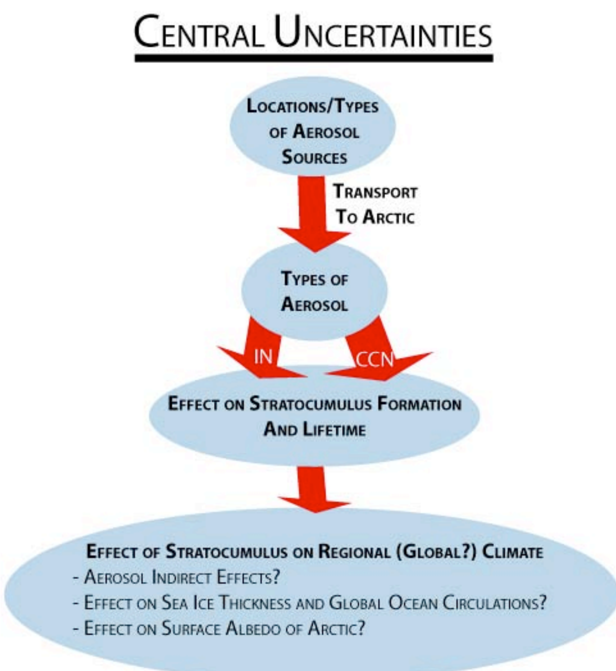

Figure 2. A flow chart addressing the central uncertainties for the Arctic stratocumulus question, starting with actions and ending in forcing and affect on climate.

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