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Combined observational and modeling efforts of aerosol-cloud-precipitation interactions over Southeast Asia

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Low-level stratocumulus clouds cover more of the Earth's surface than any other cloud type rendering them critical for Earth's energy balance, primarily via reflection of solar radiation, as well as their role in the global hydrological cycle. Stratocumuli are particularly sensitive to changes in aerosol loading on both microphysical and macrophysical scales, yet the complex feedbacks involved in aerosol-cloud-precipitation interactions remain poorly understood. Moreover, research on these clouds has largely been confined to marine environments, with far fewer studies over land where major sources of anthropogenic aerosols exist.

The aerosol burden over Southeast Asia (SEA) in boreal spring, attributed to biomass burning, exhibits highly consistent spatiotemporal distribution patterns, with major variability due to changes in aerosol loading mediated by processes ranging from large-scale climate factors to diurnal meteorological events. Downwind from the smoke source regions, the aerosol-cloud system is tightly coupled and provides a unique, natural laboratory for further exploring the micro- and macro-scale relationships of the complex interactions. Compared to other locations worldwide, studies of springtime biomass-burning aerosols and the predominately stratocumulus cloud systems over SEA and their ensuing interactions are underrepresented in scientific literature. Recent 7-SEAS (7 South East Asian Studies) campaigns (i.e. springtime 2010–2013) capture the spatiotemporal evolution of surface radiant energy and characterize the properties of regional aerosols extensively, as well as exploit critical measurements of the properties of clouds, drizzle, and light precipitation by multi-frequency radars.

Measurements of aerosol and cloud properties, whether ground-based or from satellites, generally lack information on microphysical processes; thus cloud-resolving models are often employed to simulate the underlying physical processes in aerosol-cloud-precipitation interactions. The Goddard Cumulus Ensemble (GCE) cloud model has recently been enhanced with a triple-moment (3M) bulk microphysics scheme that fully predicts hydrometeor size distributions, and inclusion of aerosol microphysical sinks and sources is imminent. Given that the aerosol burden not only affects cloud droplet size and number concentration, but also the spectral width of the cloud droplet size distribution, the 3M scheme is well suited to simulate aerosol-cloud-precipitation interactions within a three-dimensional regional cloud model. Moreover, the additional variability predicted on the hydrometeor distributions will be beneficial input for forward models to link the simulated microphysical processes with observations as well as to assess both ground-based and satellite retrieval methods.

In this presentation, we will provide an overview of the 7-SEAS/BASELInE (Biomass-burning Aerosols and Stratocumulus Environment: Lifecycles and Interactions Experiment) operations in northern Vietnam during the spring of 2013 and present preliminary findings for a case of stratocumulus encroachment and transition to a lightly precipitating system over land. Preliminary results from cloud-resolving model simulations of this particular case using double-moment and the new 3M bulk microphysics schemes under various aerosol loadings will be used to both showcase the 3M scheme as well as provide insight into the impact of aerosols on cloud and precipitation processes in stratocumulus over land. Applications and future work involving the ongoing 7-SEAS campaigns aimed at improving our understanding of aerosol-cloud-precipitation interactions of will also be discussed.