

GACP Second Year Progress Report for NAG5-8118

A. Accomplishment Report

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TITLE: **A Preliminary Aerosol Climatology for the Pacific Boundary Layer and Free Troposphere**

2nd Year Progress Report

Reanalysis of our extensive aerosol data collected during the past two decades around the Pacific Basin is being used to develop a climatology of aerosol microphysics for this region. Our aircraft and ship measurements include aerosol size distributions, optical properties (light scattering and light absorption) and chemistry. The aerosol measurement systems were able to characterize aerosol concentrations and properties over all size ranges of primary interest to processes in atmospheric chemistry and aerosol physics (i.e. 0.003 to 20 μm). These included processes ranging from aerosol nucleation and evolution of the size distribution to mass burdens and aerosol radiative effects.

Some observations from these data sets have formed the core of two presentations being made at the AGU 1999 Fall Meeting last December by V. Kapustin and A. Clarke (see Bibliography below). Some of this work was also reported at the GACP meeting (N.Y.) in October, 1999. Also we have much of this material available under a GACP Project segment in our Web Page (<http://pali.soest.hawaii.edu/>).

Variations in the smaller sizes reveal processes related to the formation and evolution of aerosol while the larger sizes reveal features that dominate aerosol radiative effects and optical depth. Analysis of data sets taken in the Pacific free troposphere (FT) has revealed regimes with distinct characteristics. These include the tropics with low aerosol mass but high number and a volatile (at 300C) aerosol. These aerosols are often naturally formed from sulfuric acid (nucleation) at very high numbers near cloud edges associated with ITCZ convection but appear to grow in size during subsidence. Details of the aerosol climatology and processes involve a complex interplay between source regions, cloud dynamics, chemistry, microphysics and regional meteorology are discussed in Kapustin et al. "Aerosol Production, Evolution and Mixing over the Pacific: Towards an Aerosol Climatology", AGU 1999 (see Bibliography).

These background aerosols are often internally mixed with combustion derived aerosol and also often associated with meteorology that transports aerosol from dust events. The subtropics tend to show marked transitions and mixing between these clean and continental aerosol types. Aerosol layers frequently appear to leave Asia at up to 7km altitude but by the time they reach the central Pacific near Hawaii they are often near or below 3.5km, presumably due to subsidence during transport. Some climatological

and microphysical characteristics of these aerosol types and aerosol river/layer structures have been organized into two presentation (AGU 2000) and two JGR papers by A. Clarke and K. Moore (see Bibliography).

In K. Moore et al. "Long Range Transport of Continental Plumes over the Pacific Basin: Aerosol Physiochemistry and Optical Properties during PEM-Tropics A and B" we extended the aerosol layers characterization to different data sets. Recent experiments, satellite observations, and modeling efforts have revealed the presence of "rivers" of continental outflow propagating into the remote marine atmosphere. Airborne measurements of both the coarse and fine mode aerosol during The PEM-Tropics A and B field campaigns provided assessment of the spatial variability in aerosol mass, the degree of internal vs. external mixing, and optical properties in the plumes encountered over the Pacific Ocean. Large perturbations from the "pristine" marine atmosphere were observed. Most continental plumes were encountered in the Southern Hemisphere during PEM-Tropics A while the opposite was observed during PEM-Tropics B. A variety of anthropogenic and natural sources for these continental plumes are suggested by the data, including biomass burning, urban/industrial emissions, and in the case of Asian outflow, dust storms. Aerosol size distributions (particularly for the refractory component) varied considerably from one plume to another and most combustion-derived aerosol appeared to be an internal mix of a refractory soot-like component in a volatile matrix. The radiatively important single scatter albedo (ω) obtained from measured "dry" scattering and absorption coefficients ranged from approximately 0.88 (pollution with no coarse particles) to 0.94 (pollution and dust) in the Free Troposphere (FT) to 0.96 (pollution and sea salt) within the Marine Boundary Layer (MBL). Vertical profiles often revealed more concentrated plumes aloft and much lower values of ω than in the underlying marine boundary layer. Evidence for particle nucleation around the edges of several aged pollution plumes occurred where "clean" air with high relative humidity and low pre-existing surface area mixed with polluted air with high concentrations of pre-cursor gases.

In A. Clarke et al. "Dust and Pollution Transport on Global Scales: Aerosol Measurements and Model Predictions" measured vertical profiles of aerosol and gas phase species were compared with Chemical Transport Model (CTM) predictions. These measurements characterized aerosol microphysics, inferred chemistry, optical properties and gases in several extensive dust and pollution plumes, also detected by satellites, which had 10,000km trajectories back to sources in Asia. CTM model that includes aerosol with meteorological wind fields, gas and particle source emissions, a chemistry component and assimilated satellite data was used to predict aerosol and gas concentrations and the aerosol optical effects along our flight path. Flight measurements confirmed the "river-like" plume structures predicted by the CTM and showed close agreement with the predicted contributions dust and sulfate to aerosol concentrations and optical properties for this global-scale transport path. Consistency between satellite, model and in situ assessment of aerosol optical depth was found, with few exceptions, within about 25%. Both model results and observations confirmed that this aerosol was being entrained into the marine boundary layer between Hawaii and California where it is likely to play a role in increasing cloud condensation nuclei and thereby modifying properties of low level stratus clouds. These observations document the significance and complexity of long range transport highlight the potential of emerging CTM models to address related issues on global scales.

3rd Year Statement of Work

During the upcoming year we will complete the analysis of our earlier reformatted combined data sets and prepare publications describing microphysical, optical and climatological characteristics of the aerosol that can be linked to known meteorological regimes.

We will also include the addition of the combined recent data sets from INDOEX (1999), PEMT(1999), SEAS(2000) experiments in order to establish microphysical, optical and climatological characteristics of the MBL aerosol that can be linked to known meteorological regimes and long range transport. We will also focus on the many vertical profiles available from these data in order to develop improved models of aerosol size, properties, evolution and vertical structure over diverse regions. In the event that any of these data sets are deemed appropriate for direct modeling and/or satellite comparison studies we are prepared to work with others on the GACP team to carry out such case studies. Key data, observations and products from all of these activities will be made available to the GACP team via our web site for the Hawaii Group for Environmental Aerosol Research [HiGEAR] to be found at <http://pali.soest.hawaii.edu/>

B. GACP BIBLIOGRAPHY

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Papers for JGR

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