GACP First 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**

ABSTRACT: We propose to combine and interpret extensive aerosol size distribution data collected during the past decade around the Pacific Basin in order to develop a preliminary climatology of aerosol microphysics and properties for the Pacific. This includes aircraft, ship and ground based data collected as part of our numerous field experiments supported by NASA, NOAA and NSF. Although these experiments frequently had diverse goals, most included extensive data on aerosol size distributions, optical properties (light scattering and light absorption) and chemistry. We propose to specifically assemble the aerosol data in order to provide spatial and temporal characterization of aerosol fields over the North and South Pacific. Aircraft vertical profiles (about 100) of aerosol size distributions and light-scattering will be used to characterize vertical structure. When appropriate case study intercomparison with other GACP model or satellite data will be possible. Some airborne experiments also allow us to extend in-situ aerosol measurements in order to compare and interpret aerosol fields in the troposphere characterized by airborne lidar.

We propose to put our in-situ data in context and to identify links to regional meteorological regimes and processes. Specific size resolved aerosol types will include dust, pollution, sea-salt, sulfates and clean cloud-processed air. Characteristics will be identified that are associated with meteorological regimes in the Pacific such as the westerlies, subtropical trade-wind and equatorial regions as well as processes associated with particle formation, growth and evolution. Interhemispheric differences will be identified as well as transitional boundaries established by the Intertropical Convergence Zones (ITCZ) and the South Pacific Convergence Zones (SPCZ). Aircraft data (GLOBE1, GLOBE2, CPACE, ACE1, PEM-Tropics) will be emphasized along with shipboard data from our cruises during SAGA1, SAGA2, SAGA3, RITS88, RITS93, RITS94, ACE-1. The data will be placed in a meteorological context and made available to NASA for distribution as an accessible database.

GOALS: Our goal will be to provide tools and insight into improved characterization of aerosol properties, transport, vertical structure, optical effects and associated climatology over the Pacific. We will provide these products in a form that can assist in modeling these properties as well provide guidance to interpretation of satellite radiance data for specified regions.

OBJECTIVES: We plan to assemble our extensive data sets collected primarily from aircraft over the Pacific during the past decade in order to constrain plausible effective aerosol size distributions for the various meteorological zones and altitudes over the Pacific. These will include descriptions of the most common cases expected and characterisitics of identifiable events (eg. pollution plumes) that can perturb effective mean aerosol size and optical properties. In situ vertical profiles and lidar data, when available, will be assimilated in order to link aerosol structure and meteorological fields.

APPROACH: We are returning to various extensive data sets (see above) collected on different computer and storage media and putting them on new media and in standardized formats so that they can be integrated and analyzed with contemporary more effective analysis programs. These data sets were previously analyzed primarily for event driven issues for the missions that funded them. Here we will be looking at aerosol properties for larger scale features and their relationship to regional and climatological signatures. We will also be assembling vertical profile data for these data sets in order to build up statistical characterization of vertical variability in aerosol microphysical and optical properties in various regions, primarily in the Pacific. Many of these profiles include layers of aerosol aloft that we hope to characterize with regard to properties (eg. thickness, size distribution, scattering coefficient, single scatter albedo, state of mixing and composition) and to source regions (back trajectories, meteorological fields and processes) when possible. We plan to assemble common physical, optical and spatial properties of such layers and the unperturbed troposphere for various Pacific regions. We will provide data products and/or links to data products (eg. our web site and/or other archives) for these data sets. We anticipate that this data will be usable for modeling aerosol properties, transport behavior and processes that influence the radiative effects of various common aerosol types.

TASKS COMPLETED: As we indicated prior to our start date (Feb. 1999), the early part of this year until May was taken up with a full commitment to the major field program INDOEX and NASA PEMT-B. These were productive new aerosol and radiation experiments that will contribute important data to our GACP objectives. Consequently, we have had limited time to prepare and analyze our earlier data sets. Even so, we have made significant headway in moving some of these older data sets onto contemporary media in preparation for analysis. At the same time we have revisited some of our more recent experiments (PEMT-A, ACE-1) and have started generating products from these experiments. Some preliminary observations from these experiments have formed the core of two presentations being made at the IUGG in Birmingham (UK) this July by Dr. Kapustin (see Results below) and a presentation to be made by Prof. A. Clarke at the IGAC conference in Bologna (Italy) this September. Some of this work will also be reported at the GACP meeting (N.Y.) in October, 1999. Also, by that time we expect to have much of this new material available under a GACP Project segment in our upcoming Web Page (under construction in August 1999). In addition, we are also in the process of revising a paper (K. Moore et al. – JGR) based upon our PEMT-A data that describes physical, chemical and optical properties of layers in the free troposphere over the South Pacific (see below).

In a separate effort we have begun the analysis and interpretation of several years of our differential aerosol optical depth made here in Hawaii under the NASA/GISS GLOBE program. Data was collected between the surface and Mauna Loa Observatory (alt. 3,400m) with seven wavelength MFRSR shadowband instrumentation. This is already defining the magnitude of seasonal perturbations to the lower troposphere and placing bounds on the altitude range where most optically effective aerosol are confined in the central Pacific.

FUTURE PLANS (for this year): Our plans for the balance of this first year funding (Aug- Jan – 5mo.) are to continue reprocessing our earlier data and to initiate analysis of selected data already processed. These will expand on the aerosol cycling and climatology themes presented at the IUGG and IGAC conferences mentioned above. We will also complete revision and resubmission of our aerosol layer paper to JGR. These new results will also be prepared for presentation at GACP and expanded into two related presentations at AGU in December 1999. We also expect to complete initial analysis of the differential optical depth data for the central Pacific and to provide data to interested parties (another GACP member, Dr. T. Nakajima, has already asked for it)

RESULTS: Preliminary analysis of our data taken in the Pacific free troposphere has revealed regimes with distinct characteristics including the tropics with low aerosol mass but high number and a volatile (at 300C) aerosol. These aerosol are often naturally formed near cloud edges from sulfuric acid (nucleation) associated with the ITCZ convection. Fewer but larger aerosol are characteristic of the mid-latitude free troposphere. These are often internally mixed and with a non-volatile core indicative of soot with volatile surface components (sulfate etc.). These combustion derived aerosol are 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 presentations by V. Kapustin [IUGG – Birmingham England- July 1999] one by A. Clarke [IGAC – Bologna, Italy – September 1999] and a JGR paper by K. Moore (see Bibliography).

FORM B. GACP SIGNIFICANT HIGHLIGHTS

For the limited time and data analyzed to date we are reluctant to single out highlights this early in the process. Key data, observations and products from all of our activities will be made available to the GACP team on a regular basis via our web site for the Hawaii Group for Environmental Aerosol Research [HiGEAR]. We plan to have significant results/highlights posted well before the GACP October 1999 meeting. This site is presently under construction but by late August 1999 it should include GACP products and will be found at http://pali.soest.hawaii.edu/

FORM C: FUTURE FUNDING (next year)

During the upcoming year we expect to have our earlier data sets reformatted and subject to analysis. We will also extend the kind of layer characterization in the paper (under current revision for JGR, K. Moore et al.) to these other data sets. We will complete the multiyear differential optical depth analysis mentioned above and expect to turn it into a publication on the climatology of the optical depth in the central Pacific lower troposphere. Dr. T Nakajima is also interested in working with this data set.

Much of the time will be spent examining and interpreting the reformatted combined data sets in order to establish microphysical, optical and climatological characteristics of the aerosol that can be linked to known meteorological regimes. 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 on a regular basis via our web site for the Hawaii Group for Environmental Aerosol Research [HiGEAR] to be found at http://pali.soest.hawaii.edu/

FORM D: GACP BIBLIOGRAPHY

Names: Antony Clarke, Vladimir Kapustin, Kenneth Moore

Institution: School of Ocean and Earth Science and Technology
University of Hawaii

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REGIONAL AEROSOL AND LONG RANGE TRANSPORT OVER THE PACIFIC OCEAN
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<u>Paper for JGR</u>

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