GACP PROGRESS REPORT

A. Personal Information

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B. Original Project Overview

Name/Institution: David Bowdle/University of Alabama in Huntsville

Original Title: Characterization of Elevated Aerosol Layers as a Liaison to NASA's Aerosol Climatology Program from NASA's MACAWS, ACLAIM, SPARCLE, and ATMOS/CCSOM Programs

Original Abstract: This letter proposal requests a three-year term of service on the Aerosol Science Team (AST) for NASA's Global Aerosol Climatology Program (GACP), as a scientific liaison from related NASA programs for the Multi-center Airborne Coherent Atmospheric Wind Sensor (MACAWS), the Airborne Coherent Lidar for Advanced Inflight Measurements (ACLAIM), the SPAce Readiness Coherent Lidar Experiment (SPARCLE), and the Atmospheric Trace Molecule Spectroscopy (ATMOS) sensor / Chemistry and Circulation Occultation Spectroscopy Mission (CCOSM). The proposal requests funding for participation in the AST and for data management in the characterization of elevated aerosol layers. The rest of the proposed research will be funded by the proposer's participation in MACAWS, ACLAIM, SPARCLE, and ATMOS/CCOSM.

Original Goal: The long-term goal of this research is to develop semi-empirical models for aerosol backscatter statistics at selected laser wavelengths in the middle and upper troposphere. These models will provide inputs to Doppler lidar design studies for remote measurements of turbulence from aircraft and remote measurements of global wind fields from low earth orbit. The aerosol measurement and modeling studies for these prospective Doppler lidar systems will also provide useful inputs to the NASA GACP.

Original Objective: The objective of the proposed research is to develop a climatology for elevated aerosol layers that originate in the planetary boundary layer (PBL). Relevant properties for these layers include aerosol physicochemical properties; their variability and correlation with meteorological features on meso- to synoptic spatial/temporal scales; plus their variability and frequency of occurrence on regional to global and seasonal to inter-annual spatial/temporal scales.

Original Approach: Baseline aerosol properties, and perturbations around those baseline values, will be derived from selected aerosol databases. Positive perturbations larger than empirically derived thresholds will usually be assumed to originate from elevated aerosol layers. Perturbations due to PBL aerosols will be identified using aerosol composition, wavelength dependence of aerosol optical properties, and collocated water vapor concentrations. PBL-sourced perturbations will be correlated with meteorological features that are diagnosed from global gridded meteorological data sets. Particular emphasis will be given to meteorological features that are associated with vertical transport, long-distance transport, and other strong dynamic activity. The PBL-sourced aerosol distributions and their meteorological contexts will be combined into a global climatology.

C. Programmatic Restructuring

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1. The proposed research continues to be affected by various programmatic factors.
2. The first year funding for this proposal arrived in late April 1999. The second year funding arrived in March 2000. Therefore, the progress summary covers the first 15 months instead of the second year, while the plans cover the remaining 21 months, instead of the third year.
3. The original research plan was based on synergism with other NASA-sponsored aerosol research. Significant changes have occurred in the liaison programs. These changes affect the potential synergism between this proposal and the liaison activities, as summarized below.
   a) MACAWS has not flown since CAMEX 3 (summer 1998). The MACAWS aerosol backscatter calibration from CAMEX 3 has not been finalized. Planned inputs to this proposal from new MACAWS measurements have not been realized. MACAWS will not fly again until CAMEX 4 next year, shortly before this proposal activity terminates.
   b) ACLAIM has not flown since Spring 1998. New flights are planned later this year, but with limited NASA involvement. Preliminary results from the new flights should be available in time to impact the rest of this proposal.
   c) The SPARCLE mission was canceled. Runout SPARCLE activities have not involved the expected atmospheric aerosol backscatter measurements with a highly sensitive ground-based Doppler lidar.
   d) The CCOSM mission proposal was not selected. ATMOS data analysis activities were modified to optimize the information content of the retrospective data from ATMOS.
4. In consideration of the above factors, current activity under this proposal has been modified to optimize synergism with the ATMOS activity. ATMOS analysis has been extended to include the potential for limb retrievals deep in the troposphere. GACP funding for the first fifteen months has been applied to the expanded ATMOS analysis. Research activities for the rest of the proposal period will revert as much as possible to the original plan.

D. New Project Overview

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New Title: Characterization of Elevated Aerosol Layers

New Goal: The long-term goal of the proposed research is to develop semi-empirical statistical models of aerosol scattering, absorption, and extinction spectra at mid-infrared and near-infrared wavelengths in the middle and upper troposphere.

Same Objective: The objective of this research is to develop a climatology for elevated aerosol layers that originate in the planetary boundary layer (PBL). Relevant factors include aerosol physicochemical properties; their variability and correlation with meteorological features on meso- to synoptic spatial/temporal scales; plus their variability and frequency of occurrence on regional to global and seasonal to inter-annual spatial/temporal scales.

Same Approach: Baseline aerosol properties, and perturbations around those baseline values, will be derived from selected aerosol databases. Positive perturbations larger than empirically derived thresholds will usually be assumed to originate from elevated aerosol layers. Perturbations due to PBL aerosols will be identified using aerosol composition, wavelength dependence of aerosol optical properties, and collocated water vapor concentrations. PBL-sourced perturbations will be correlated with meteorological features that are diagnosed from global gridded meteorological data sets. Particular emphasis will be given to meteorological features that are associated with vertical transport, long-distance transport, and other strong dynamic activity. The PBL-sourced aerosol distributions and their meteorological contexts will be combined into a global climatology.

E. 2nd Year Progress Report

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Note: the following progress report covers the first 15 months, rather than the second year.

- Developed new analytical methods to estimate and correct residual non-linearity in ATMOS interferograms and the resulting atmospheric extinction spectra. The maximum non-linear error in a given filter band is now smaller than the previous minimum error in that band. The minimum non-linear error is now negligible.
- Developed new analytical methods to reduce all other sources of radiometric calibration errors in ATMOS particulate retrievals. The maximum total error in a given filter band is now smaller than the previous minimum error in that band. The minimum total error is now almost negligible.
- Estimated ATMOS calibration errors as a function of penetration depth into the troposphere. The new calibration methods improve the accuracy and extend the penetration depth.
- Developed new analytical methods for isolating concentration, composition, and size effects in ATMOS retrievals.
- Explored Fourier filtering methods for particulate optical properties at infrared wavelengths.
- Developed recommendations for improvements in instrument design, data acquisition, and signal processing on new space-based missions that use multi-spectral limb sounding from Fourier Transform Infrared (FTIR) spectrometers similar to ATMOS.
- The results of these studies should also be applicable to other research efforts that use FTIR measurements of spectral scattering, absorption, or extinction in atmospheric aerosols.

F. 3rd Year Statement of Work

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Note: the following statement of work covers the last 21 months, rather than the third year.

FUTURE PLANS:

- continue analysis of existing ACLAIM data, and participate in new ACLAIM field programs
- use new calibration method in improved particulate retrieval algorithms for ATMOS
- develop ATMOS retrieval algorithm for particulate concentration, composition, and size
- acquire measured and modeled aerosol data sets from selected data providers
- convert compiled data sets into standard file formats and standard aerosol properties
- analyze statistical properties of aerosol data sets using proposed methodology
- evaluate relative roles of “nucleation and aging” versus “vertical transport and dilution”

G. GACP Bibliography

Name/Institution: David Bowdle/University of Alabama in Huntsville

Papers, reports, and presentations published, in progress, or planned during GACP by the Principal Investigator, Co-Investigators, and other researchers supported by your agency for aerosol research. The following listing includes publications prepared under both GACP funding and GACP-related funding, due to the close relationship between these activities.

1. List of publications (including books, book chapters, and refereed papers)
- Published

none

- In Progress

Bowdle, D.A., and M.A. Jarzembski: Aerosol backscatter measurement uncertainty with focused CO_2 Doppler lidars. In preparation for submission to *Appl. Opt.*

Bowdle, D.A., M.J. Newchurch, M.R. Gunson, A. Eldering, and C.P. Rinsland: Atmospheric aerosol and cloud retrievals from ATMOS infrared transmittance spectra: Broadband calibration spectra. In preparation for submission to *Appl. Opt.*

Bowdle, D.A., M.J. Newchurch, M.R. Gunson, and A.Y. Chang: Atmospheric aerosol and cloud retrievals from ATMOS infrared transmittance spectra: Improved non-linearity correction. In preparation for submission to *Appl. Opt.*

Bowdle, D.A., and M.J. Newchurch: Atmospheric aerosol and cloud retrievals from ATMOS infrared transmittance spectra: Parameterization of particulate optical properties. In preparation for submission to *J. Geophys. Res.*

Bowdle, D.A., and J. Rothermel: Turbulent-scale aerosol backscatter variability in the middle and upper troposphere: Atmospheric and instrumental effects on backscatter measurements by focused CO_2 Doppler lidars. In preparation for submission to *J. Atmos. Oceanic Technol.*

Srivastava, V., J. Rothermel, A. D. Clarke, D. R. Cutten, M. A. Jarzembski, D. A. Bowdle, R. T. Menzies, J. D. Spinhirne, and E. W. McCaul: Backscatter modeling at 2.1 μm wavelength for space-based and airborne lidars using aerosol microphysics and lidar datasets. In preparation for submission to *Appl. Opt.*

2. Printed technical reports and non-refereed papers
- In Progress

Soreide, D., D.A. Bowdle, S.M. Hannon, R.K. Bogue, and L.J. Ehrenberger: ACLAIM Flight Test Results. In preparation as NASA Technical Report. National Aeronautics and Space Administration, Washington, DC.

3. Oral presentations or posters at professional society meetings and conferences
- Published/Presented

none