ANNUAL PROGRESS REPORT ON PARTICIPATION IN GACP BY DEAN HEGG

1. Form A: GACP Accomplishment Report

Name: Dean A. Hegg

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TITLE: "Investigation of the Relationships Between Aerosol Physical and Chemical Properties Derived From In-situ Measurements and Their Impact on Aerosol Remote Retrieval"

ORIGINAL ABSTRACT OF PROPOSAL:

Funding is requested for the PI to participate in the Aerosol Forcing Science Team (AFST) and for modest salary support to pursue analyses of data sets which are largely in hand. This funding will supplement support, which is currently in place from both ONR and NASA itself (in the form of a NASA Global Change Fellowship for one of the PI's graduate students). In addition to the obvious tasks associated with participation in the AFST, two objectives are proposed for the supplemental support. The first is the quantification of the role of water of hydration on the radiative properties of atmospheric aerosols. Current remote sensing algorithms cannot differentiate the impact of water from that of changes in dry aerosol mass, composition or size. Clearly this is undesirable. The second objective is to find a widely applicable quantitative relationship between aerosol mass and number concentration over the critical size range in which particles can act as cloud condensation nuclei (CCN). This will greatly facilitate remote retrieval of CCN concentrations—a key parameter for assessment of indirect radiative forcing of climate by aerosols.

GOALS AND OBJECTIVES:

The general issue which we hope to explore in the course of this study involves the impact of water of hydration on aerosol optical properties and thus on the top of the atmosphere radiance attributable to these aerosols. Currently, satellite aerosol retrievals inseparably convolute dry aerosol mass and water of hydration together. For example, there is no explicit RH dependence in such retrievals. This has adverse ramifications for elucidation of both direct and indirect aerosol forcing. Hence, the explicit goal of our study is the formulation of parameterizations to relate water of hydration and "intrinsic" aerosol properties to aerosol optical properties as orthogonal factors, most likely as a function of aerosol type. This can be broken down into several more specific goals. First, we wish to assess the impact of aerosol hygroscopicity on satellite detected irradiances from the standpoint of remotely detecting this quantity. Second we wish to explore the feasibility of retrieving the dry aerosol volume in marine air. Preliminary studies suggest that this quantity may directly relate to the CCN number concentration at typical supersaturations in marine clouds and retrieval could permit remote retrieval of CCN concentration.

APPROACH:

The methodology, which we employ to address the above issues, is a combination of analysis of in-situ aerosol measurements and numerical modeling to link the observed aerosol properties with satellite measurements (or other types of remote retrieval). For example, direct, in-situ measurements of aerosol hygroscopicity obtained during the ACE-2 experiment have been used to generate model prediction of the impact of this hygroscopicity on top-of-the-atmosphere radiances (see below).

TASKS COMPLETED:

During the second calendar year of this grant, a number of tasks have been completed. Based on an analysis of data from the ACE-2 field experiment (now published in a series of articles but predominantly in Gasso et al., *Tellus, 52B,* 546-567, 2000), it appeared feasible to retrieve information on aerosol hygroscopicity via satellite radiometers such as MODIS. We have pursued this with a series of diagnostic modeling studies constrained by field data. In the course of this, we have developed an expanded version of the MODIS look-up table (LUT) which includes RH as an additional input parameter (based on the ability of MODIS to retrieve this parameter and the still more refined retrieval projected to be available from AQUA), and aerosol hygroscopicity as an additional retrievable variable. Exercising the expanded LUT on in-situ data for which the TOA radiation field was calculated (forward radiative transfer calculations), we found that a retrieval of γ (in addition to the standard MODIS retrieved variables such as effective radius and optical depth) was only generally feasible when the aerosol distribution sought was actually one of those already included in the look-up table. For more general distributions, successful retrievals could only be achieved at certain viewing geometries and for selected parameters only (for example, the rate of accumulation to total model aerosol volume could not be achieved under any circumstances). A principle component analysis of the variance in the synthetic radiation fields, similar to that done by Tanre et al. (*J. Geophys. Res., 101*, 19,043-19,060, 1996), revealed that at most three variables were retrievable with the expanded LUT, one of which was indeed aerosol hygroscopicity. However, because these variables were different from those identified by Tanre et al., it has become clear that precisely which variables can be retrieved depends on the structure of the LUT.

Other tasks completed include the development of a refined version of the aerosol volume retrieval of Fraser et al. (*Atmos. Environ., 18*, 2577-2584, 1984) and, based on this, the development of a retrieval for CCN concentration over the ocean.

FUTURE PLANS:

It is our intention in the next year to write-up the above results for publication and to further pursue the retrieval of aerosol properties taking into account aerosol hygroscopicity. We have commenced, and will continue, to perform retrievals of CCN concentrations and to compare those retrievals, where possible, with co-located in-situ measurements.

RESULTS:

Essentially covered in tasks completed. A manuscript dealing with the above results is currently in preparation.

2. Form C

See future plans in Form A.