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ATMOSPHERIC AND ENVIRONMENTAL RESEARCH, INC.

December 16, 1997

Dr. Yogesh Sud
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NASA Goddard Space Flight Center
Greenbelt, MD 20771

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Re: Final report, contract NAS 5-32861 (AER Project P602)

Dear Dr. Sud:

This report, prepared by Atmospheric and Environmental Research, Inc., will function as the final report on the project.

We finished our assessments of the NASA Goddard Earth Observing System-1 Data Assimilation System (GEOS-1 DAS), regarding heating rates, energetics and angular momentum quantities. These diagnostics can be viewed as measures of climate variability. We have done extensive work, including comparisons with the NOAA/NCEP reanalysis system of momentum and energetics diagnostics. On these subjects, an extended abstract in the Proceedings of the American Meteorological Society Seventh Conference on Climate Variations has appeared (Enclosed), and we have also presented a report to the First International Conference on Reanalyses in October 1997. Our proceedings for that conference is also enclosed. A manuscript, entitled "Global momentum signals from reanalysis systems," by D.A. Salstein and R.D. Rosen, is under preparation for publication on this subject as well.

Two manuscripts on aspects of assessments of model behavior from the Atmospheric Model Intercomparison Project (AMIP), in which two Goddard general circulation models participate, have been accepted by journals. They are focused on atmospheric angular momentum (Hide, R., J.O. Dickey, S.L. Marcus, R.D. Rosen, and D.A. Salstein, 1997: Atmospheric angular momentum fluctuations in global circulation models during the period 1979-1988. J. Geophys. Res., 102, 16423-16438), and water vapor and its transports (Gaffen, D.J., R.D. Rosen, D.A. Salstein, and J.S. Boyle, 1997: Evaluation of tropospheric water vapor simulations from the Atmospheric Model Intercomparison Project, J. Climate, 10, 1648-1661). Copies of reprints are included.

Dr. Salstein submitted two "Diagnostic Subproject proposals" to the Program for Climate Model Diagnosis and Intercomparison of the Lawrence Livermore National Laboratory to continue the work on atmospheric diagnostics in the areas of angular momentum and water vapor. Dr. Salstein will take the lead in the proposal on angular momentum and he is a participant in the proposal on water vapor and its transports. Both proposals were accepted. This acceptance will lead to involvement in the "AMIP-2" project, in which more advanced models will be used for these intercomparisons. Here, the models in the intercomparison projects will be run for 18-year periods, an extension of the previous project that will encompass more ENSO events.

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We have noted that GEOS-1 and NOAA/NCEP global atmospheric angular momentum values are coherent on time scales down to about three days. Furthermore, they agree with the series of Earth angular momentum, as measured by tiny fluctuations in the rotation rate of the Earth, reckoned as variations in the length of day. The torques that effect such changes in atmospheric and Earth momentum consist principally of the friction torque, acting tangentially, against the surface of the land and the mountain torque, based on normal pressure gradients against the mountainous topography. Our work has shown the influence of particular mountain systems, including the Rockies, Himalayas, and Andes, upon mountain torques on time scales shorter than about two weeks. Aspects of this work were presented at the Fall American Geophysical Union in December 1996. Other portions of the work, as well as a paper on the AMIP project, were presented at the European Geophysical Society meeting in April 1997. A manuscript, entitled "Regional sources of mountain torque variability and high-frequency fluctuations in atmospheric angular momentum," by Iskenderian and Salstein, has been accepted and is in press at *Monthly Weather Review* (copy enclosed). We hosted Olivier de Viron, a visiting student from the Royal Observatory of Brussels, who calculated the torques from the GEOS-1 DAS analyses that link the surface pressure patterns of the atmosphere with various motions of the Earth. In so doing we have also investigated the "gravitational torque" associated with the pull of the Earth on the changing mass of the atmosphere. A manuscript (De Viron, O., Ch. Bizouard, D. Salstein, and V. Dehant, 1997: Atmospheric torque on the Earth and comparison with the atmospheric angular momentum variations) is under preparation on the results of this work; a copy of the abstract is enclosed.

We have been involved in a collaboration with Dr. Sud, of Goddard Space Flight Center, whose purpose is to examine the impact of mountainous areas on diagnoses of the atmosphere. To that end we have examined one year of data from three experiments, in which (1) the full Himalayan mountains are included (2) the Himalayan mountains have been reduced to 50% of their height, and (3) the Himalayan mountains have been reduced to 10% of their height. Some initial findings of the study are as follows: The largest impact of the Himalayas occurs in the Northern Hemisphere during winter season, and, most specifically, during February and March. This result indicates that the variations of wind and temperature during this cold season lead to a reduction in the eddy kinetic energy and eddy-available potential energy, indicating the necessity of this mountainous area for producing the phenomena under question. We have studied the zonal mean and eddy kinetic and available potential energy values for the SIB147 run (full mountains), SIB149 run (50% mountains) and SIB148 (10% mountains). Interestingly the zonal mean energy terms appear to be affected by the mountains in the Northern Hemisphere, especially in the winter.

Earlier in the project, Dr. Salstein convened and chaired a session at the Spring 1996 American Geophysics Union Meeting in Baltimore, on the topic of Earth System Dynamics. Participants in that session included invited speakers from NASA Goddard

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Space Flight Center, who highlighted the developments of the Goddard Laboratory for Atmospheres, in relation to the atmospheric component of the planetary angular momentum balance.

We worked out assessments of the NASA Goddard Earth Observing System-1 Data Assimilation System (GEOS-1 DAS), regarding energetics and angular momentum quantities. The energetics diagnostics, in particular, are useful in determining a measure of the types of climate signals during the multi-year period already analyzed as part of the GEOS DAS-1 reanalysis effort. For example, we see a distinct difference in the zonal mean and in the eddy kinetic energy terms between a year featuring a warm Pacific water El Niño event (1987) and one that had a cold La Niña event (1988). We presented some of our results concerning this topic at the Annual NOAA Climate Diagnostics Workshop in November 1995, in a presentation entitled, "Angular momentum and energetics in reanalysis products." There we focused on comparisons of the NASA EOS DAS-1 system with the NOAA NCEP/NCAR Reanalysis Project. Some of the differences in the energetics terms led us to conclude that the mean zonal winds and eddy terms had considerable differences. A copy of the relevant Proceedings contribution from that workshop is enclosed.

In a related vein, we have compared the heating rates from the GEOS DAS-1 with values of outgoing longwave radiation for an eight-year period. We found, in particular, that there is considerable correlation in the west central Pacific between (negative) heating and vertically averaged latent heating. Also, comparisons of latent heating in a Goddard Global Circulation Model with and without the inclusion of downdrafts were performed. The effect of such a parameterization is particularly influential in the tropics. An Extended Abstract for the AMS Tenth Conference on Numerical Weather Prediction, addresses this subject and is included here too.

A book chapter by D.A. Salstein, Mean Properties of the Atmosphere, in *Composition, Chemistry, and Climate of the Atmosphere* has been published with some support from this NASA Program. Enclosed is a single copy of this chapter in its final form.

Sincerely yours,



David A. Salstein
Principal Investigator

Enclosures

cc: Contracting Officer, Code 289, 1 copy
Center for AeroSpace Information, 2 copies, Publications and graphics services section,
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Report Documentation Page

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16. Abstract <p>Assessments of the NASA Goddard Earth Observing System-1 Data Assimilation System(GEOS-1 DAS), regarding heating rates, energetics, and angular momentum quantities were made. These diagnostics can be viewed as measures of climate variability. Comparisons with the NOAA/NCEP reanalysis system of momentum and energetics diagnostics are included. Water vapor and angular momentum are diagnosed in many models, including those of NASA, as part of the Atmospheric Model Intercomparison Project.</p> <p>The GEOS-1 and NOAA/NCEP global atmospheric angular momentum values are coherent on time scales down to about three days. Furthermore, they agree with the series of Earth angular momentum, as measured by tiny fluctuations in the rotation rate of the Earth, as variations in the length of day. The torques that effect such changes in atmospheric and Earth momentum are dominated by the influence of particular mountain systems, including the Rockies, Himalayas, and Andes, upon mountain torques on time scales shorter than about two weeks. Other project areas included collaboration with Goddard Space Flight Center to examine the impact of mountainous areas and the treatments of parameterizations on diagnoses of the atmosphere. Relevant preprints are included herein.</p>					
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