Support for a Tropical Lidar in Latin America

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The vertical profile of stratospheric aerosols is a crucial parameter to monitor the effects of volcanic eruptions on climate. These effects include climate change and ozone depletion. Satellites provide the best instruments for producing global coverage, but existing and planned satellite missions all have limitations. Ground-based lidar observations are needed for calibration and validation of satellite observations, as well as for filling the gaps when satellite observations are not available.

SAGE (Stratosphere Aerosol and Gas Experiment) II has been a very successful satellite mission, providing global high quality measurements of ozone, nitrogen dioxide, water vapor, and multi-wavelength aerosol extinction from the mid-troposphere to as high as the lower mesosphere. The mission was initially conceived for two years duration, but it has lasted more than 16 years and still is providing information, although in the past several months with only half the designed frequency. Unfortunately, it is expected to end soon, resulting in a lack of global aerosol measurements. Furthermore, the orbit only allows observations at any one latitude once per 40 days and dense aerosol clouds, like those in the tropics after the 1991 Mt. Pinatubo eruption, preclude any observations.

The next satellite mission carrying such an instrument (SAGE III) is scheduled later this year on Meteor-3M, but only with high latitude coverage. SAGE III, with mid-latitude and tropical coverage, is not expected before 2004 in the International Space Station. ICESat, scheduled to be launched in 2002, will have a vertically pointing lidar that will provide some aerosol data, but only in very small footprints, which will produce sampling problems for stratospheric aerosols. HIRDLS on EOS Aura is scheduled for launch in December 2002, and will be able to measure stratospheric aerosols. PICASSO-CENA, with global lidar coverage from space, will not fly before 2004.

Need for Tropical Lidar Observations

Lidar observations were necessary after the Pinatubo eruption to fill in the large gaps in satellite coverage. However, in the densest part of the cloud over the Equator, there were no measurements. Only the lidars in Hawaii and Cuba (at about 20°N) and the one in Brazil (at 23°S) were able to see the edges of the cloud. The discrepancy at the Equator in total optical depth derived from reflectivity measurements from the Advanced Very High Resolution Radiometer (AVHRR) on polar orbiting satellites [*Stowe et al.*, 1997] and the integral of the SAGE II vertical profile [*Russell et al.*, 1996] has never been satisfactorily resolved, as there were no lidar observations made in the tropics to give the vertical profile of stratospheric aerosols.

Current Latin American Lidars

For validation of satellite observations and gap-filling, it is important to develop a global lidar network to be able to observe future large eruptions. The Northern Hemisphere is fairly well represented, the Workshop on Lidar Measurements in Latin America was organized to focus on the tropics and Southern Hemisphere, taking advantage of current lidar observatories in Latin America. The Inter-American Institute for Global Change Research (IAI) has funded a joint project called “Characterization of Stratospheric and Tropospheric Aerosols over Central and South America,” between the Universidad de Buenos Aires, the Camagüey (Cuba) Lidar Station, and Rutgers University for the purpose of improving the observations of aerosols in this region. To further these aims we organized a workshop, which was held in Camagüey, Cuba on March

6-8, 2001. In addition to the IAI, the workshop was sponsored by the World Climate Research Programme and the Stratospheric Processes and their Relationship to Climate (SPARC) program. The specific goals of the workshop were to promote communication and cooperation between the members of the scientific community engaged in lidar research in Latin America, and to plan future lidar research projects in the region. This was the first IAI workshop held in Cuba since the beginning of IAI.

Twenty-seven scientists attended the workshop, including representatives from lidar sites in Puerto Rico, Brazil, Cuba, and Argentina, from the European Space Agency, from Rutgers University, and from two potential sites in Ecuador and Bolivia. After one day of presentations, the attendees met the next day in a plenary session to discuss future plans. The highlight of the conference was an evening visit to the Camagüey Lidar Station, for a demonstration. The pencil of green light disappearing into the heavens was a new experience for several of the scientists. The attendees from outside of Cuba were impressed with the ability of the Cuban scientists and engineers to operate such a sophisticated piece of equipment in the conditions there. In fact, during the operation, one of them saw that with a few minor modifications, the strength of the signal could be improved. One of the goals of the workshop was satisfied before it was even over! On the final day, agreements were made for future joint collaboration.

After a warm welcome from Barbara Garea, Cuban IAI Representative and chair of the Cuban Climate Change Research Program, the first set of presentations described the current lidar stations in Latin America. These include the Instituto Nacional de Pesquisas Espaciais (INPE) in São José dos Campos, Brazil (23°S, 46°S). It has a record from 1972 to the present, by far the longest such record in Latin America, and observations are currently made three times a week. The Camagüey Lidar Station (21.4°N, 77.9°W) in Cuba started in 1988. In cooperation with the former Soviet Union, a Russian-built lidar was installed and began irregular measurements. Only in 1991, after replacing much of the original system and the computer, did they begin regularly measuring stratospheric aerosols. Their record of the decay of the Mt. Pinatubo aerosols in 1992-1993 has been used to prepare forcing data sets for climate model simulations [*Stenchikov et al.*, 1998], and as ground truth for satellite observations, particularly those from SAGE II. The Arecibo Observatory (18.4°N, 66.8°W) in Puerto Rico, has a suite of instruments measures the atmosphere from the surface out to 1000 km. Their lidar system was installed in the late 1980's. Their facility is used by many visiting scientists, and they have facilities to fabricate new equipment. The fourth operating lidar in Latin America is the Centro de Investigaciones en Láser y Aplicaciones of the Instituto de Investigaciones Científicas y Técnicas de las Fuerzas Armadas, Buenos Aires, Argentina (34.6°S, 58.4°W). The main work is observing the atmospheric boundary layer, but they also conduct cirrus cloud and stratospheric aerosol observations.

In addition to ground-based lidar systems, Errico Armandillo from the European Space Agency described his agency's new satellite missions, which will have downward looking lidar instruments, including EarthCARE and the Atmospheric Dynamics Explorer. While the EarthCare mission is designed primarily for tropospheric aerosols, planetary boundary layer, and clouds, the Atmospheric Dynamics Explorer is designed primarily to measure atmospheric winds for initialization of weather prediction models. They both also will measure stratospheric aerosols. These future space-based systems will need surface observations for validation.

Other sessions were devoted to applications of lidar observations, including attempts to measure temperature and density with the Camagüey Lidar, ozone measurements with the

Buenos Aires lidar, and the uses of lidar data in general circulation model simulations of the impacts on climate of the 1991 Mt. Pinatubo volcanic eruption.

Potential Sites

Presentations were also made by representatives from two locations for potential new lidar installations–Minard Hall from Quito, Ecuador (0.2°S, 78.5°W), and Francesco Zaratti from La Paz, Bolivia (16.5°S, 68.2°W). Both prospective locations are high altitude in dry portions of the Andes. Dr. Hall discussed the climate of Quito and its geographical setting. There are 30 active volcanoes in Ecuador, with one right next to Quito.

Dr. Zaratti discussed the recent work of the Laboratorio de Física de la Atmósfera in monitoring ultraviolet-B radiation, and in measuring ozone and carbon dioxide. He discussed an interesting negative ozone anomaly above the Altiplano of 15 DU–less than expected due just to the altitude of the measuring station–and explained it by orographic stratospheric clouds over the Andes that provided surfaces for heterogeneous chemistry. A new lidar would be useful in addressing this issue.

Both locations, Quito and La Paz, have the infrastructure for a new lidar. In discussions the next day, the group felt that it would be a good idea to install a new lidar in one or both of these locations. The decision will be based on the future evolution of international and local funding, as well as the local capabilities at both sites. A new lidar in Quito would be ideal, as it is at the center of a 40°-wide latitude band with no current lidar observations of the stratosphere, except for the Bandung, Indonesia (6.9°S, 107.6°E) site, which is plagued by bad weather.

Future Plans

The workshop ended on the third day with several groups promising steps toward a installing a new Latin American tropical lidar. Minard Hall will conduct a survey of locations for the instrument, and investigate existing equipment. Craig Tepley offered the Arecibo facilities for the construction and testing of the lidar. Barclay Clemesha and Dale Simonich will conduct calculations to aid in the optimal combination of lidar power and telescope size in the design and prepare a preliminary cost estimate for the lidar. Alan Robock will write a proposal and investigate several funding sources in the United States. (Several scientists who were unable to attend the workshop have since been active in the design of the new lidar.)

A longer-term plan was also discussed to establish a network of lidars in Latin America using identical instruments, identical data processing, and identical measurement protocols, including taking measurements on the same days, and during satellite overpasses. This America's LIdar NEtwork (ALINE) was strongly endorsed by the participants, and they agreed to work together toward its establishment

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Correction to "Support for a Tropical Lidar in Latin America"

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Robock and Antuña [2001] stated that the ICESat lidar, the Geoscience Laser Altimeter System (GLAS), scheduled to fly in 2002, will produce sampling problems for stratospheric aerosols in contrast to the PICASSO-CENA (now known as Earth System Science Pathfinder 3, ESSP3) lidar, which will not fly before 2004. Actually, as kindly pointed out by J. D. Spinhirne (personal comm., 2001), both GLAS and ESSP3 will provide similar global coverage and both will be useful for measuring stratospheric aerosols.

Reference:

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