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Title: GLObal Backscatter Experiment (GLOBE) Pacific Survey Mission

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The National Aeronautics and Space Administration (NASA) conducted the GLObal Backscatter Experiment (GLOBE) Survey Missions on a NASA DC-8 aircraft over the near-coastal and remote Pacific Ocean during November 6 - 30, 1989 (GLOBE I) and May 13 - June 5, 1990 (GLOBE II). These missions were designed to study the optical, physical, and chemical properties of atmospheric aerosols. Particular emphasis was given to the magnitude and spatial variability of aerosol backscatter coefficients (β, $m^{-1} sr^{-1}$) at mid-infrared (9-11 μm) wavelengths, and to the remote middle and upper troposphere, where these aerosol properties are poorly understood.

Survey instruments (Table 1) were selected to provide either direct β measurements at the key wavelengths, empirical links with long-term or global-scale aerosol climatologies, or aerosol microphysics data required to model any of the above quantities. The core instruments included three lidar systems, a pulsed coherent CO_2 lidar, a pulsed incoherent Nd:YAG lidar, and two focused continuous-wave (CW) CO_2 Doppler lidars. The pulsed lidars provided β profiles above and below the aircraft, while the CW lidars provided complementary flight-level β measurements. The lidar instruments were supported by flight-level instruments for aerosol microphysical and optical properties. Some of the supporting instruments were mounted on aerodynamic pylons below the wingtips, to characterize aerosol concentrations and size distributions as nearly *in situ* as possible, with minimal interference from the aircraft boundary layer. Other sensors were mounted in the DC-8 cabin, where they sampled isokinetically from nozzles mounted on the aircraft fuselage, to provide detailed information on aerosol chemical, morphological, and visible-wavelength optical properties. Supporting meteorological data on the Survey aircraft were obtained from a microwave moisture sounder, video camera cloud monitors, and standard meteorological sensors. In addition, satellite imagery, rawinsonde soundings, weather analyses, and calculated airmass trajectories were obtained to augment Survey aerosol data analyses.

The Survey deployment included both long-distance 6-8 hour transit flights and detailed 4-6 hour local flights (Fig. 1). Transit flight altitudes were usually near 8 km, except when higher altitudes were required to avoid extensive cloud fields. Overall, the transit flights provided relatively rapid and nearly pole-to-pole coverage, along with important seasonal, hemispheric, and airmass contrasts. Local flights usually involved multiple passes over the same test area at varying altitudes. These flights were conducted before and after deployment for engineering check-out and measurement validation, and during deployment for additional validation and for empirical links with key aerosol climatologies. Overall, approximately two-thirds of mission flight hours were used for transit, and the remainder for validation experiments and aerosol climatology intercomparisons.

Several general features have been observed from preliminary Survey data analyses. Validation and intercomparison results have shown good agreement, usually better than a factor of two. Atmospheric aerosols frequently exhibited a three-layer vertical structure, with: (1) high and fairly uniform backscatter in the shallow cloud-capped marine boundary layer; (2) moderate and highly variable backscatter in a deeper overlying "cloud-pumped" layer; and (3) low, regionally uniform, but seasonally and latitudinally variable backscatter in the middle and upper troposphere. Frequent clouds and cloud residues were observed, often with lidar returns from deep within visually opaque cirrus shields. CO_2 β values were correlated with aerosol composition, even when subtle chemical changes were not accompanied by changes in aerosol concentration or size distribution. CO_2 β values were also correlated with water vapor concentration. Detailed statistical and case study analyses are underway to quantify these observations.

Three major uncertainties remain in the characterization of the global aerosol system for the middle and upper troposphere over the Pacific Ocean. The first concerns identification and quantification of the physical mechanisms that produced the observed low backscatter conditions. The second concerns the representativeness of the low backscatter regimes, including backscatter magnitude and seasonal / latitudinal variability. The third concerns the validity of a quasi-steady-state "background" aerosol model concept. Exploration of these issues will require detailed analyses of the comprehensive Survey data base, including the extensive validation data from both missions -- initially to quantify sensor sensitivities, sampling biases, and correction factors, and ultimately to develop robust estimates of "background" backscatter properties. The results of these analyses will provide important new insights into the dynamics of the global aerosol system.

The Survey Missions represent two isolated snapshots of a small portion of the global aerosol system. Consequently, Survey results can best be understood by synthesizing them with the more comprehensive GLOBE data base, which is being compiled at NASA Marshall Space Flight Center, Huntsville, AL. This data base will include key aerosol climatologies, as well as results from the Survey Missions and smaller GLOBE-related field programs. The overall GLOBE data base is being incorporated into a global-scale aerosol backscatter model at MSFC. The model results, in turn, are being used for design and simulated performance studies on MSFC's Laser Atmospheric Wind Sounder (LAWS), one of several NASA Facility Instruments planned for the Earth Observing System (EOS) in the late 1990's. GLOBE results will also be useful in the design of other lidar-based systems that use atmospheric aerosols as passive scattering targets for measurements of primary atmospheric variables.

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TABLE 1 – GLOBE SURVEY MISSION INSTRUMENTATION

INSTRUMENT	MEASUREMENT	REMARKS	INVESTIGATOR	AFFILIATION
Pulsed CO_2 Lidar	9.25 micrometer backscatter	coherent detection	R.T. Menzies	Jet Propulsion Laboratory (NASA)
Pulsed Nd:YAG Lidar	0.53, 1.06, 1.54 micrometer backscatter	incoherent detection 1.54 is Raman–shifted	J. Spinhirne	Goddard Space Flight Center (NASA)
CW CO_2 Doppler Lidars	9.11 and 10.6 micrometer backscatter	coherent detection 9.11 is CO_2 isotope	W.D. Jones	Marshall Space Flight Center (NASA)
Optical Particle Counters Wire Impactors	size distribution, concentration chemistry, morphology	pylon–mounted in–situ sampling	R. Pueschel	Ames Research Center (NASA)
Optical Particle Counters Condensation Nuclei Counters Filters / Impactors	size distribution, concentration size–distributed chemistry airmass source monitoring	cabin–mounted aspirated sampling thermal pretreatment	A.D. Clarke	University of Hawaii
Optical Particle Counter Filters / Impactors Integrating Nephelometer	size distribution, concentration elemental / molecular chemistry 0.69 micrometer scattering	cabin–mounted aspirated sampling batch chemistry	E.M. Patterson	Georgia Institute of Technology
Integrating Nephelometer	0.45, 0.55, 0.70 micrometer scattering	cabin–mounted aspirated sampling GLOBE I only	B. Bodhaine	Geophysical Monitoring for Climatic Change (NOAA)
Advanced Microwave Moisture Sounder	water vapor column content	GLOBE I only	J. Wang	Goddard Space Flight Center (NASA)
Data Acquistion and Distribution System (DADS)	meteorological and navigational data	data broadcast to DC–8 experimenters	D. Jaynes	Ames Research Center (NASA)
DC–8 Aircraft	instrument platform	high–altitude, long–distance, large payload	D. Jaynes	Ames Research Center (NASA)

FIGURE 1 – GLOBE SURVEY MISSION FLIGHT TRACKS