COHERENT LIDAR TECHNOLOGY FOR GLOBAL WIND PROFILING

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INTRODUCTION

Coherent lidar systems are proven sensors for atmospheric wind measurement. Ground-based and airborne CW and pulsed CO2 systems have been developed and applied to several wind measuring applications. Analytical and hardware feasibility studies[+] indicate the feasibility of measuring the global wind field from a space platform. Global wind profiles are a needed input to global circulation models for improved weather forecast accuracy. A recent workshop sponsored by NASA on "Global Wind Measurements," in August, 1985 recommended the development of a space-based global wind profiling system.

GLOBAL AEROSOL BACKSCATTER

The most critical unknown in the design of a Global Wind Profiling System is the aerosol backscatter cross section for the selected laser wavelengths. For the CO2 laser a wavelength of 9.11 microns was recommended. A Global Backscatter Experiment (GLOBE) is planned by NASA to develop a global model of aerosol backscatter. Several existing lidar systems have been and can be utilized to obtain this data base.

NOAA has obtained a 3-year set of aerosol backscatter profiles at 10.6 microns in the Boulder, Colorado area, using a 100 mJ/pulse coherent CO2 TEA lidar.* The 95% backscatter value was found to be 5E-11 1/m 1/sr for an 8-km altitude.

JPL has measured aerosol backscatter profiles at 9.25 and 10.6 micron wavelengths in the Los Angeles area for approximately 2 years.[∇] These data indicate a significant increase in backscatter at 9.25 microns in the upper troposphere. The 95% backscatter values at 5-km altitude were found to be 4E-11 and 4E-12 1/m 1/sr at 9.25 and 10.6 microns, respectively.

The Royal Signals and Radar Establishment lidar group has obtained aerosol backscatter profile data at 10.6 microns using an airborne CO2 CW lidar. Considerable data have been taken over the British Isles and the North Atlantic for the past 3 years.

Ground-based and airborne CW and pulsed CO2 lidar systems have been used by NASA-MSFC to obtain aerosol backscatter data.

[+] R.M. HUFFAKER, NOAA TECH. MEMO. ERL WPL-37 SEPT 1978
* M.J. POST, APPLIED OPTICS, VOL. 23, NO. 15, AUG 1984
[∇] R.T. MENZIES, M.J. KAVAYA, F.H. FLAMANT, D.A. HANER, APPLIED OPTICS, VOL. 23, NO. 15, AUG 1984

A joint experiment between NASA and CSIRO, to measure aerosol backscatter in the Southern Hemisphere, is under way in Melbourne, Australia using a NASA-MSFC CW coherent CO2 lidar operating on a CSIRO aircraft. Ground-based aerosol backscatter profiles will also be obtained using a ruby and a pulsed CO2 lidar. The CSIRO aircraft will be equipped with aerosol sampling instruments such as optical particle counters and cascade impacters.

Aerosol backscatter data are needed in the Southern Hemisphere where aerosol concentrations are expected to be minimal. The current aerosol backscatter data set is primarily in the mid-latitude northern hemisphere. The NASA GLOBE program should answer this critical design parameter for a global wind profiling system.

COHERENT LIDAR HARDWARE TECHNOLOGY

The NOAA 2 J/pulse CO2 injection-locked TEA lidar is the most engineered coherent TEA lidar presently in operation. This lidar is being used for meteorological research and includes a hardware processor and real-time color displays.

The JPL 2 J/pulse injection-locked CO2 TEA lidar has been used primarily for aerosol backscatter measurement but is now capable of wind observation.

The Air Force Geophysics Laboratory is developing an e-beam excited 2 J/pulse CO2 TEA lidar for wind and aerosol backscatter measurement.

The recommended laser power for a global wind profiling system is 10 J/pulse. Current CO2 lidar systems are demonstrating 2 J/pulse capability. Scaling to 10 J/pulse should not be a major consideration. The required life-time in space is now the critical hardware issue.

It now seems possible to develop a Nd:YAG coherent lidar. Components have been stabilized at Stanford University. A solid-state laser source, the most critical element in a solid- state coherent lidar, is now possible for coherent Doppler measurements. The system problems that need to be solved are significant but should be solvable. Coherent Technologies, Inc. has plans to develop a 0.5 J/pulse coherent Nd:YAG lidar for wind and aerosol backscatter measurement. Eyesafe wavelength solid-state coherent lidar systems also appear to be feasible.

Coherent lidar technology continues to advance rapidly. Current systems are certainly scalable to satellite conditions. Technology assessments continue to indicate the feasibility of measuring the global wind field from a space platform.