AEROSOL STUDIES IN MID-LATITUDE COASTAL ENVIRONMENTS IN AUSTRALIA

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INTRODUCTION

LIDAR is capable of remotely measuring range - resolved aerosol and molecular backscattering with good spatial and temporal resolution over significant ranges. Under certain atmospheric conditions, extinction coefficients can be derived from the backscattered signal through a β/σ relationship. Under conditions of horizontal homogeneity and moderate levels of atmospheric extinction, it should be possible to establish useful β/σ relationships for each of the particular air masses studied. Hence, the potential capability exists for LIDAR to measure and characterise aerosol extinction height profiles which are representative of temperate and tropical maritime environments around Australia that include both seasonal and diurnal variations. The long term aim is to establish a database and to use the data in the LOWTRAN atmospheric computer model[1] to make it more representative of the Australian environment.

This paper will present the results of the evaluation of several inversion procedures that were used to select one which provides the most accurate atmospheric extinction profiles for small aerosol extinction coefficients (that often predominate in the maritime airmass). Height profiles of atmospheric extinction calculated by a two component atmosphere solution to the LIDAR equation will be compared with corresponding in situ extinction profiles based on the size distribution profiles obtained in Western Australia. Values of the aerosol backscatter to extinction ratio obtained from multi-angle LIDAR measurements will be used in this solution.

INSTRUMENTATION

A LIDAR from WAIT was employed for determining the aerosol backscattered signal. The instrument, which is of a standard configuration, employs a Quanta Ray DCR 2A Nd:YAG frequency-doubled laser as the source. A 25 cm diameter telescope, a 1 nm bandwidth interference filter centred on 0.53 µm and an EMI model 9816B comprise the receiver. Linearly or logarithmically amplified signals are sampled at up to 20 MHz using an 8-bit digitiser based on the TRW 1007J ADC. Data are stored on floppy discs by a PDP11/23 processor. Other data including laser output pulse energy, azimuth and elevation angles, signal sampling interval etc., also are stored. The laser has a plane polarized output beam enabling total backscatter or the parallel and depolarised components to be measured.

Ground based meteorological measurements consisted of air temperature, relative humidity, wind speed and direction. An integrating nephelometer operating at an effective wavelength of 0.5 µm and a condensation nuclear particle counter provided data on aerosol scattering and total particle concentrations, respectively: such data helped classify the air mass.

Slow ascent radiosonde data provided air temperature and relative humidity profiles to about 7 km with a resolution of 150-200 m. Balloons were released at the lidar site with a minimum of one for each measurement period and an extra flight if conditions changed sufficiently to warrant it.

The instrumentation in the CSIRO F27 aircraft consisted of three instruments which could size aerosol particles over the size range 0.2-100 µm diameter plus total particle counter, air temperature and dew point meter units.

FIELD STUDIES

Four field studies have been undertaken at a coastal site (Garden Island, lat.32S, long.116E), 40 km SSW of Perth, Western Australia. The study periods were selected to allow the seasonal variability of aerosols to be investigated.

Typically winter is dominated by low pressure systems of polar origin which bring easterly moving cold fronts and winter rains to the coastal region. The airmass in these circumstances is expected to be representative of very clean maritime air.

Summer is dominated by slow moving sub-tropical high pressure systems which, when located over the continent, can bring strong easterly flows of 3-6 days persistence. In a typical weather pattern the coastal region experiences warm easterly flows during night and mornings and a strong sea breeze from mid-morning to the evening.

In order to study aerosol variability, not just seasonally, but also over the diurnal cycle, measurements were taken during morning, afternoon and evening periods. Slant path measurements were normally recorded at 5° increments in elevation angle, although occasionally 1° increments were used to study events of interest. The October 1984 study was supported on 3 days by an instrumented Fokker F27 aircraft operated by the CSIRO Division of Atmospheric Research. Aerosol and meteorological parameters were obtained in a series of spiral descents from 6000 m to the surface through the same airmass sampled by the LIDAR.

The investigation of aerosol scattering close to the sea surface was supported by separate measurements with the LIDAR beam horizontal and as close to the surface (~4 m) as the site permitted. Typically, sequences of 20 shots at 2 Hz were recorded with this configuration.

Over 1986-1987 three further field studies are planned in tropical maritime air at Cowley Beach (lat.17.4S, long.146E) 30 km south of Innisfail on the North Queensland Coast.

DATA ANALYSIS PROCEDURES

The maritime atmospheres at Garden Island studied by the LIDAR are usually very clear with high visibilities and low aerosol scattering coefficients. For this reason we were concerned that analysis procedures that assumed a single-component atmosphere with backscatter and extinction related by an expression of the form $\beta = C\sigma^{K}$ would be inappropriate. Extinction profile solutions, even if performed in the backward direction as recommended by Klett[2], and Ferguson and Stephens[3] were expected to converge very slowly if an incorrect boundary value was assumed. As the extinction by air molecules was considered to be significant this should be included in the analysis (cf. Fernald[4] and Klett[5]).

Accordingly different analysis schemes were compared. A scheme that assumed an atmosphere containing both aerosols (A) and air molecules (M) with backscatter (β) and extinctions (σ) related by the expression $\beta_T = \frac{1}{4\pi}(P_A\sigma_A + P_M\sigma_M)$ was compared with the single-component atmosphere solution. The sensitivity of the solutions to the assumed value of the aerosol phase function for backscatter (P_A) was also tested.

RESULTS

In that the project is not scheduled for completion until December 1987 we will present a review of data analysed to date.

Initially, we present a review of the relative performance of the LIDAR data analysis procedures which have been tested on synthetic atmospheric and aerosol profiles. This will be followed by examples of analysed field data for selected cases.

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