AN AIRBORNE INSTRUMENT SYSTEM FOR ATMOSPHERIC BOUNDARY-LAYER RESEARCH

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Abstract. A description is given of an airborne instrument system that was designed for meso-meteorological research. The system was constructed so that it could be transported in a light twin-engined aircraft (Piper Aztec D), primarily to measure the fluxes of heat, momentum, and water vapor near the surface, together with several climatic variables. Parameters related to aircraft performance, behaviour and position were also measured. Most of the instruments were positioned on a rigid, fuselage-mounted nose-boom.

Various components of the instrument system are briefly described and evaluation data are presented which establish the design performance of the instrument system. Some present and future applications of airborne techniques in climatological and boundary-layer research are outlined.

1. Introduction

Much of our understanding of the dynamics of mesoclimate is based on data obtained from surface observing stations. Recently, however, the new surge of interest and concern in many areas of the environmental sciences has created a marked interest in using aircraft for mesoscale research. This makes available a sensor platform uniquely capable of obtaining atmospheric and environmental data while being immersed in and moving through the atmosphere. The versatility of aircraft as sensor platforms is enormous, with an entire spectrum of aircraft sizes, power capabilities, weight-carrying capacities, speeds, etc., available.

First experiments of the author with small, light aircraft began in 1964 and were related to determining the effects of irrigation, lakes and forest oases, etc. on the characteristics of the boundary layer. Later, observations were related to various agricultural practices and to watershed evaporation and then to determining the actual rate of heat and water loss from selected areas of study. The first aircraft were small and maneuverable (Cherokee 140, 180) and research instruments and sensors were crude, damped and heavy (Holmes, 1969a, b, c, 1970). In 1967–68, serious work began on the design of an airborne instrument system for use mainly in hydrology, agriculture and forestry.

Since a high priority was placed on the flux measurements of momentum, heat and water vapor, a light twin-engined aircraft was obtained so that turbulence instruments could be nose-boom mounted to the fuselage in a relatively rigid and flex-free environment. After an examination of the flight characteristics, space, weight-carrying capacity, endurance, etc., of many light twin aircraft, a Piper Aztec was chosen. This machine also has a relatively simple air frame, which greatly simplified necessary structural modifications.

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The instrumentation on the aircraft is described below. Full engineering details are available elsewhere (Holmes, 1972).

2. Description of the Aircraft

The essential features of the Aztec D aircraft are shown in Figure 1. There were several problems that had to be overcome before the aircraft could be instrumented. The normal 12-V DC electrical system that powered all aircraft systems left little surplus available for invertors and electronic research instruments. Further, the air frame required suitable skin-stress doublers, bulkheads, etc., to support exterior and interior-mounted sensors. As well, the dressing of low-level signal and or high-voltage wires (AC and DC) throughout the aircraft frame required great care and shielding to meet Federal Air Regulations requirements and to reduce signal noise and interference (see Figure 2).

Because of the requirement for electrical power for a variety of present and future instruments, it was considered essential to add a second electrical system to the aircraft. This was done by mounting a 24-V DC alternator to each engine in such a way that a common belt would drive two alternators (12 and 24 V).

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**Fig. 1. Essential features of size and shape of piper Aztec D (Pa-23-250).**