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Turbulence and high frequency trace gas measurements aboard the research aircraft Dornier 128-6 D-IBUF

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Due to its performance the research aircraft Dornier 128-6, D-IBUF is particularly suited for investigations within the lower troposphere over regions with complex terrain. Its unique instrumentation including weather radar, GPS, INS, and Web access has been substantially renewed and expanded and makes this aircraft an ideal measurement platform for convection studies and turbulence measurements, including the direct measurement of turbulent fluxes of momentum, heat, moisture and trace gases. New sensors, cameras and a data acquisition unit were installed, a module for high frequency measurements of the gases (ozone, nitrogen oxides, carbon monoxide and carbon dioxide) was developed and finally an airdrop system for meteorological sondes was integrated. Additionally a permanent internet connection via satellite is installed to enable real time access to radar and lidar data and communication with the experiment coordinator via messenger software.

The new noseboom integrates a Rosemount 5 hole probe connected to Setra pressure transducers mounted directly behind the probe, two platinum wire temperature sensors in Rosemount housings as well as an Vaisala Humicap, a Meteolabor dew point mirror and an Lyman-α sensor for humidity measurements. Two smaller booms at both wing tips and a third one at the top of the vertical stabilizer, all equipped with 5 hole probes, are providing the basis for 3D turbulence data. The data acquisition system is based on a VME-bus PC running with real-time DOS. Several inputs are available for additional sensors which can be connected via analogue, RS-232, TTL and ARINC429. The maximum sampling frequency of the acquisition system is 1 kHz, output data rate is 100 Hz. During the flight graphics and printouts of actual data are available on demand

The chemical measurement module (CMOD) is designed for fast and precise trace gas measurement to calculate turbulent fluxes by eddy correlation. It consists of a 3 way gas inlet on top of the fuselage and 4 modules mounted within the cabin directly under the inlet system. The modules contain gas analysers, a gas-distribution system, data acquisition and instrument control. A combination of a chemiluminescence ozone sensor with a UV-absorption ozone analyser delivers high quality ozone data with measurement frequencies up to 20 Hz. A modified 4 channel Luminol-chemiluminescence analyser NOxTOy detects NO_2, NO_x, PAN and NO_y with a frequency resolution between 1 and 7 Hz. For the measurement of CO_2 a Licor LI-6252 analyser, provided with pressure stabilized air is used. It delivers undisturbed data up to 2 Hz; CO measurements are made by a very reliable Aero Laser AL5001. Redundant data acquisition is done by the on board acquisition system of the airplane and the module data acquisition which allows running the CMOD stand-alone. A reverse flow system prevents contamination of the system by engine exhausts while operating the aircraft on the ground; calibration is done by an automated calibration system before and after each flight.

Several flight tests have been performed to determine the performance of the CMOD. Signal delays and response times were determined by flights through a power plant plume next to the chimney. Flight attitude effects were examined by vertical soundings, constant level flights with different true air speed and combinations of turns. Calibration strategies were developed as well as post flight data processing routines for removal of flight attitude influences. Synchronization of gas measurements with wind data measured at the nose boom, frequency correction, and filtering was done.

The very good data quality of the new measurement system was proven during the QA/QC program of the ESCOMPTE campaign. The development of the measuring system was done in cooperation with enviscope Inc., MetAir Inc., Ansyco Inc. and the University of Braunschweig as the owner and operator of the aircraft.