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Dual channel airborne hygrometer for climate research

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Airborne hygrometry has an increasing role in climate research and nowadays the determination of cloud content especially of cirrus clouds is gaining high interest. The greatest challenges for such measurements are being used from ground level up to the lower stratosphere with appropriate precision and accuracy the low concentration and varying environment pressure. Such purpose instrument was probably presented first by our research group [1-2]. The development of the system called WaSUL-Hygro and some measurement results will be introduced.
The measurement system is based on photoacoustic spectroscopy and contains two measuring cells, one is used to measure water vapor concentration which is typically sampled by a sideward or backward inlet, while the second one measures total water content (water vapor plus ice crystals) after evaporation in a forward facing sampler. The two measuring cells are simultaneously illuminated through with one distributed feedback diode laser (1371 or 1392 nm). Two early versions have been used within the CARIBIC project.
During the recent years, efforts were made to turn the system into a more reliable and robust one [3]. The first important development was the improvement of the wavelength stabilization method of the applied laser. As a result the uncertainty of the wavelength is less than 40fm, which corresponds to less than 0.05% of PA signal uncertainty. This PA signal uncertainty is lower than the noise level of the system itself. The other main development was the improvement of the concentration determination algorithm. For this purpose several calibration and data evaluation methods were developed, the combination of the latest ones have made the system traceable to the humidity generator applied during the calibration within 1.5% relative deviation or within noise level, whichever is greater.
The improved system was several times blind tested at the Environmental Simulation Facility (Forschungszentrum Jülich, Germany) in pressure and humidity ranges possible in in-service aircraft operation (150-950 mbar and 1-15000 ppmV). Furthermore, the system was tested and compared to other instruments in three flight campaigns based on a research aircraft (Learjet 36A). The test results both in the laboratory and both in the field shows that the developed system is a promising tool for further airborne environment research.

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