PHYS.ORG

Meteorology meets metrology

December 2 2014

View along HALO's wing (with the aerosol instruments) above the Amazon rainforest. Credit: Buchholz/PTB

Barely has the research aircraft HALO entered the kilometre-high clouds towering above the Brazilian rainforest than the researchers find themselves in a complete haze, but they can rely on the measuring instruments that are working at full capacity. HAI – a new, highly accurate hygrometer of the Physikalisch-Technische Bundesanstalt

(PTB) – is aboard.

The shooting star among hygrometers has been developed only recently by metrologists (metrology = the science of measurement) especially for use on board aircraft and in the clouds, but it has already been used in four research campaigns and has already clocked up more than 300 hours of active use. It is the only device worldwide that can determine precisely and simultaneously how much of the water present in the atmosphere is in the form of vapour, condensation, droplets or ice. These data help us understand natural and anthropogenic cloud formation processes and how they influence the climate. HAI is robust enough for field use at strongly varying temperatures and pressures and it is also coupled to the international humidity scale. Furthermore, it requires no time-consuming calibration. Its unique features combine applied climate research with metrology's most demanding requirements.

HAI is an acronym that stands for Hygrometer for Atmospheric Investigations. Its latest assignment (within the scope of the ACRIDICON-CHUVA mission) took it on a large-scale expedition in which approx. 60 scientists from Germany, Israel and Brazil were involved. On board HALO, one of the most modern measurement aircraft for atmospheric research – operated by the Deutsches Luft- und Raumfahrtzentrum (DLR – the national aeronautics and space research centre of the Federal Republic of Germany) – HAI again and again flew into the clouds rising above the Amazon rainforest to collect samples. The researchers wanted to find out, among other things, which influence air pollution above cities or slash-and-burn areas have on the formation of clouds.

Water is the most important greenhouse gas and plays various roles in climate development. Clouds shade and cool down the surface of the Earth; at the same time, they act as an insulation layer, keeping the terrestrial thermal radiation from escaping into space. The total global water cycle is based on the humidity present in the air heating up and cooling down again. Furthermore, humidity values serve as a correction coefficient in many other atmospheric measurements. Water is the most influential greenhouse gas, this is a fact. But putting a figure on its influence in order to set up models on climate development is a very difficult task. Depending on how high the clouds are as well as on their exact composition (they can consist of vapour, droplets and ice in varying amounts), they can have very diverse effects. Also, the measurement of the different phases of water is a complex task as its state of matter may already be influenced decisively the moment the sample is taken: for example, water vapour can already condensate to droplets on its way to the measuring instrument due to cooling while the sample is being collected.

Scientists from PTB have solved this problem by means of the HAI multi-phase water sensor. HAI simultaneously determines how much water vapour and how much condensed water is present in the air; a robust, open and aerodynamic measuring cell located outside the aircraft body directly measures the gaseous water vapour content of the air flowing through it. Another two-channel measuring unit is located inside the aircraft, at the end of a heated sample collection tube where two sensors working independently of each other measure the total water content of the sample. The difference between the total water content measured and the result of the measurement carried out in the gaseous phase allow the content of condensed water to be determined simultaneously.

HAI is based on a special variant of TDLAS (Tunable Diode Laser Absorption Spectroscopy) which is self-calibrating. The previously required time-consuming calibration, which was excessively difficult to carry out accurately and frequently enough in the field, has, thus, become obsolete. In addition, HAI, in combination with HALO, is the first airborne fast hygrometer in use that is directly traced back to the metrological humidity scale. Contrary to most other hygrometers, it provides results with low and clearly defined measurement uncertainty, in accordance with strict metrological requirements.

More information: V. Ebert, M. Kraemer, A. Afchine B. Buchholz, "HAI: A novel airborne multi-channel hygrometer for fast multi-phase H2O quantification: Performance of the HAI instrument during the first flights on the German HALO aircraft," American Geosciences Union Fall meeting, 15-19 December 2014, Moscone Center, San Francisco, CA, USA, Session In Situ and Spaceborne Observations of Atmospheric Water Vapor and Temperature II, paper A54C-06, agu.confex.com/agu/fm14/meetingapp.cgi#Paper/19528

B. Buchholz, A. Afchine, M. Krämer, V. Ebert, "Fast, multi-phase H2O measurements on board of HALO: Results from the novel HAI instrument during the first field campaigns." *Geophysical Research Abstracts* Vol. 16, EGU2014-9241, 2014, EGU General Assembly 2014

For more information about the ABRIDICON-CHUVA mission, please visit:
www.mpic.de/forschung/partikel … acridicon-chuva.html

Provided by Physikalisch-Technische Bundesanstalt