Climate research with HALO over the Brazilian rainforest

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Thunderclouds over rainforests are an important element in the climate system. The German Aerospace Center (Deutsches Zentrum für Luft- und Raumfahrt; DLR) research aircraft HALO spent the period from the beginning of September to the beginning of October 2014 in Manaus, a city in the Brazilian state of Amazonas, measuring the emergence, development and properties of tropical clouds. The ACRIDICON (Aerosol, Cloud, Precipitation, and Radiation Interactions and Dynamics of Convective Cloud Systems) researchers launched the mission to better understand the microphysical mechanisms that prevail within these towering clouds and that determine their climate impact. Additionally, the researchers investigated the means by which trace substances are transported up through the clouds and how vegetation fires influence cloud properties and precipitation. The Max Planck Institute for Chemistry (MPIC) and the University of Leipzig were responsible for the scientific management of the project. In total, 23 academic institutions were involved in the HALO flight campaign. The HALO research aircraft is a joint initiative between German environmental and climate research institutions.

"DLR participated in the mission by contributing extensive trace gas, aerosol and ice particle measurements," says Hans Schlager from the DLR Institute of Atmospheric Physics, who headed the DLR research team in Brazil. "DLR focused on how the clouds transport and process the trace gases and aerosols, and how new particles emerge." For instance, new aerosols can form in the air masses flowing out from the upper reaches of thunderstorms.

A unique opportunity

The campaign had tight time constraints; indeed, the researchers only had 14 flights days in the field once preparation times had been deducted. Setting off from Manaus, a Brazilian city with over one million inhabitants, they conducted measurements in the clouds above the rainforest. Each of the measurement flights lasted roughly seven hours. Among other things, the analyses included how clouds in clean rainforest air differ from those found over polluted and deforested regions. Vegetation fires in the Amazonas region produce large quantities of smoke particles that rise high into the atmosphere, where they impact the formation of clouds and their properties. Initial analyses show that, compared with clean clouds, polluted clouds contain a higher concentration of water droplets, but that the droplets themselves are smaller.

Close to the thunderclouds

It is not standard practice for DLR test pilots to fly so close to large storm cells, sometimes even penetrating larger cloud formations. "The ACRIDICON measurement flights were the most demanding flight procedures ever completed by HALO," says Steffen Gemsa, a DLR test pilot. "Repeated flights through cumulus clouds and the outflow boundaries of high altitude tropical thunderstorms were particularly challenging." The HALO pilots performed five different scientific flight patterns, ranging from low altitude flights above the Brazilian rainforest to altitudes in excess of 15 kilometres. The research flights in Brazil frequently involved HALO withstanding atmospheric temperature differences of over 100 degrees Celsius. While 35 degrees Celsius was commonplace close to the ground, the temperature in the upper troposphere is approximately -65 degrees Celsius.

The research campaign ACRIDICON represented a unique opportunity for the researchers to conduct comprehensive aircraft measurements above the Brazilian rainforest. "The measurement flight campaign yielded a wealth of data to help us better understand the influence of aerosols and clouds on the climate," says Meinrat O. Andreae from MPIC, who headed the mission together with Ulrich Pöschl from MPIC and Manfred Wendisch from the

Institute for Meteorology (LIM) at the University of Leipzig. Scientists at the participating institutes are currently busy compiling detailed results from the mission.

The mission

The ACRIDICON research mission was conducted in close cooperation with the Brazilian project CHUVA (the Portuguese word for rain), the US-American and Brazilian measurement campaign GOAmazon (Green Ocean Amazon) and the International Amazonas research project LBA (Large Scale Biosphere-Atmosphere Experiment in Amazonia). The following institutes were directly involved in ACRIDICON-CHUVA: the Max Planck Institute for Chemistry (MPIC), the University of Leipzig, the German Aerospace Center (DLR), Forschungszentrum Jülich (FZJ), the Leibniz Institute for Tropospheric Research (TROPOS), the Karlsruhe Institute of Technology (KIT), the Physikalisch-Technische Bundesanstalt (PTB, Germany's national metrology institute), the University of Frankfurt, the University of Munich, the University of Heidelberg and the University of Mainz from Germany. The German Research Foundation (Deutsche Forschungsgemeinschaft; DFG) finances the contributions made by university partners. The Hebrew University of Jerusalem from Israel and Instituto Nacional de Pesquisas Espaciais (INPE), Universidade de São Paulo (USP), Centro Técnico Aeroespacial (CTA), Sistema de Proteção da Amazônia (SIPAM) and Instituto Nacional de Pesquisas da Amazônia (INPA) from Brazil are also involved. In total, roughly 100 scientists were in the field in Manaus, including numerous partners from Brazil and the United States. The ACRIDICON mission is funded by the Max Planck Society (Max-Planck-Gesellschaft; MPG), the German Aerospace Center (DLR) and the German Research Foundation (DFG), as well as the Karlsruhe Institute of Technology (KIT) and Forschungszentrum Jülich (FZJ).

About HALO

The HALO research aircraft is a joint initiative between German environmental and climate research institutions. HALO is funded by grants from the German Federal Ministry of Education and Research (Bundesministerium für Bildung und Forschung; BMBF), the German Research Foundation (DFG), the Helmholtz Association, the Max Planck Society (MPG), the Leibniz Association, the Free State of Bavaria, the Karlsruhe Institute of Technology (KIT), GFZ German Research Centre for Geosciences, Forschungszentrum Jülich and the German Aerospace Center (DLR).

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View from the cockpit of HALO over the Amazon region

The ACRIDICON measurement flights lasted about seven hours. Among other things, the analyses included how clouds in clean rainforest air differ from those found over polluted and deforested regions. The image shows the nose boom of the HALO (High Altitude and LOng Range) research aircraft as it approaches a disintegrating storm.

Credit: DLR (CC-BY 3.0).

HALO research aircraft

The HALO (High Altitude and LOng Range) research aircraft is based on the ultra-long-range G 550 business jet produced by Gulfstream Aerospace. With a range of more than 8000 kilometres, measurements on the scale of continents are possible; the research aircraft can reach all regions, from the poles to the tropics, and remote areas of the Pacific Ocean.

Credit: DLR (CC-BY 3.0).

Clouds tower above the rainforest

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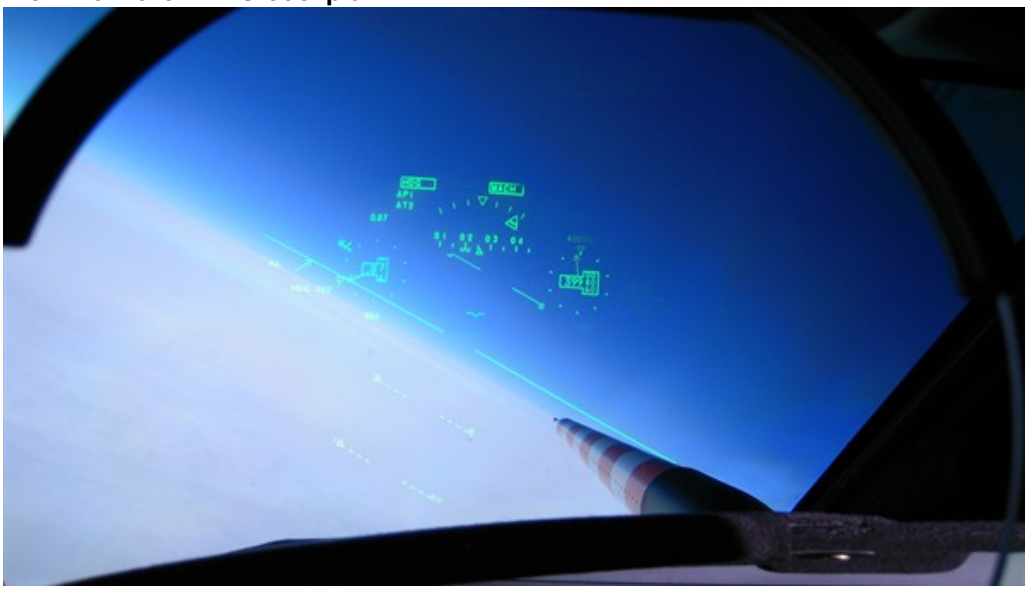
Credit: DLR (CC-BY 3.0).

View from the HALO cockpit



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