Thermodynamic correction of particle concentrations measured by underwing probes on fast flying aircraft

Ralf Weigel, Peter Spichtinger, Christoph Mahnke, Marcus Klingebiel, Armin Afchine, Andreas Petzold, Martina Krämer, Anja Costa, Sergej Molleker and Stephan Borrmann

Johannes Gutenberg-University, Mainz, Germany
Max-Planck-Institute for Chemistry, Mainz, Germany
Research Center Jülich, Germany

Abstract:

Particle concentration measurements with underwing probes on aircraft are impacted by air compression in a region upstream of the instrument body as a function of flight velocity. In particular for fast-flying aircraft the necessity arises to account for compression of the air sample volume. In the compression region where the detection of particles occurs (i.e. under factual measurement conditions), pressure and temperature of the air sample are increased compared to ambient (undisturbed) conditions in certain distance away from the aircraft. Hence, a correction procedure is needed to invert measured particle number concentrations to ambient conditions that is commonly applicable for different instruments to gain comparable results.

From measurements during two missions in 2014 (ML-CIRRUS and ACRDIDICON) with the German Gulfstream G-550 (HALO - High Altitude LOng range) research aircraft we develop a procedure to correct the measured particle concentration to ambient conditions using a thermodynamic approach.
The correction procedure will be introduced, its derivation from thermodynamic assumptions will be explained and its resulting effectiveness on measurement data will be presented with respect to hitherto existing and applied correction procedures. The applicability of the thermodynamic correction will be demonstrated to hold for optical array probes, relatively independent on the individual aerodynamic design of the instrument or the position at the underwing hardpoint of a fast flying aircraft such as *HALO*.