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Fractionation in airborne O_2/N_2-Measurements: Scaled Laboratory Tests

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Measurements of atmospheric O_2 in combination with CO_2-measurements in the atmosphere, allow the partitioning of global oceanic and terrestrial sinks of anthropogenic CO_2. Airborne measurements are an important complement to the global network of surface sampling stations, since they provide access to different temporal and spatial scales, which serve as a testbed for atmospheric transport models. Measuring atmospheric variations of O_2/N_2 on a ppm level relative to the large background concentration of 21% O_2 makes atmospheric oxygen measurements very challenging and requires dealing with a number of gas-handling issues. Most importantly, the diffusive separation of O_2 and N_2 (fractionation) induced by gradients in pressure, temperature and humidity needs to be limited to levels below the relevant variations of O_2/N_2 in the air. During airborne experiments, thermal fractionation can be caused by adiabatic heating (ram-heating) at the aircraft's inlet due to deceleration of the sample at the air intake. This effect depends on the geometry and size of the inlet as well as on intake flow and airplane velocity.

In this study, we present results of a down-scaled wind tunnel experiment in the lab, using Reynolds numbers similar to the real situation of a sample air inlet mounted on an aircraft. This allowed determining the fractionation effect for a range of different aircraft velocities. A simplified calculation based on computational fluid dynamics (CFD) modeling is used to fit the data and to up-scale the fractionation to the real flight case. Our results show that fractionation signals are not necessarily negligible in comparison to atmospheric signals; hence thermal fractionation at the inlet can cause problems. Depending on inlet size and geometry it is necessary to use active flow control in order to provide for isokinetic sampling of the air at different heights.