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Measurements of atmospheric molecular hydrogen and its isotopic composition at the Cabauw tall tower in the Netherlands

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Molecular hydrogen (H2) is considered a promising energy carrier for a more sustainable energy supply system. If a transition to hydrogen fuel takes place, this may well lead to an increase of atmospheric H2 levels above present-day levels (approx. 0.5 ppm), due to leakage during H2 production, transport and storage. Concerns have been raised about potential adverse effects this may have on the atmosphere's oxidative capacity and on stratospheric ozone chemistry. Unfortunately, assessments of these effects have so far been hampered by the large quantitative uncertainties in the H2 budget, and most of the available H2 observations were made at remote locations. We aim to improve our understanding of the H2 cycle by studying its mixing ratio and isotopic composition at the more anthropogenically influenced Cabauw tall tower site.

The Cabauw tower is 213 m tall and hosts various atmospheric measurements under the name of CESAR (Cabauw Experimental Site for Atmospheric Research). It is located in a relatively rural, central part of the Netherlands, within few tens of kilometers from major urban areas. An air sampling system with inlets at 20, 60, 120 and 200 meter altitude was installed in the tower within the CHIOTTO greenhouse gas monitoring project.

H2 and CO were measured in the sampled air with an RGA-3 Reduction Gas Analyser. Three-year long timeseries of these gases were obtained for each of the different sampling altitudes with almost half-hourly resolution; for H2 this is the first quasi-continuous measurement series of vertical profiles in the boundary layer. These data allow for the characterization of seasonal and diurnal cycles, for estimates of H2:CO ratios under different traffic conditions, and for estimates of the regional soil uptake flux (Popa et al., 2011).

As the different sources and sinks of atmospheric H2 have very distinct isotopic signatures, measurements of the isotopic composition of the H2 (δD-H2) can be a useful addition for constraining source and sink terms. For more than two years, air samples from the different heights have been analyzed for δD-H2 at the IMAU isotope laboratory. The resulting data show that H2 has on average markedly higher mixing ratios and lower relative deuterium levels at the Cabauw station than at more remote stations at similar latitude from the EUROHYDROS project, a result of anthropogenic emissions of deuterium-depleted H2. Samples from the 20m level tend to have slightly higher H2 mixing ratios and lower δD-H2 than samples from higher levels taken at the same time. This indicates that the influence of local sources of H2 often dominates over the influence of local soil uptake.

References

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