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The SPARC water vapour assessment II: Assessment of water vapour isotopologue measurements by ACE-FTS and Odin-SMR

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In this study, we focus on two currently operational satellite instruments (ACE-FTS on SCISAT and SMR on Odin) capable of obtaining stratospheric water vapour isotopologue amounts. Isotopologues are molecules of identical chemical but different isotopic composition. Knowledge of the isotopic composition of water vapour in the atmosphere is useful for the understanding and quantification of processes affecting water vapour amounts in the atmosphere. In many studies, isotopologue amounts are primarily discussed as δ values, which are defined relative to a standard. For $H_2^{18}O$, that is:

$$\delta^{18}O = ((VMR_{H_2^{18}O}/VMR_{H_2^{16}O})/(VMR_{H_2^{18}O}/VMR_{H_2^{16}O})_{VSMOW}) - 1) * 1000\text{‰} \quad (1)$$

with VSMOW as Vienna Standard Mean Ocean Water. We present results for the the water vapour isotopologues $H_2^{18}O$ and $H_2^{17}O$ in the stratosphere and lower mesosphere using δ^{18}O and δ^{17}O in the comparison.

The first satellite instrument in this study is ACE-FTS on SCISAT, which is a infrared Fourier Transform Spectrometer with a high spectral resolution of 0.02 cm^{-1} and a spectral range from 750 to 4400 cm^{-1}. It measures using solar occultation viewing geometry. SCISAT is in a high inclination orbit at an altitude of 650 km. It was launched in August 2003 and has been performing routine measurements since February 2004.

The second instrument is SMR on Odin, which measures millimeter wave emissions from the atmosphere with an 1.1 m telescope in the 486 to 581 GHz range with four tunable radiometers. Odin was launched in February 2001 into a quasi-polar sun-synchronous orbit at about 600 km altitude. Spectral regions for the target trace gases are selected for SMR using different measurement modes and thus not all retrieved species are measured simultaneously.

In order to perform the comparison between ACE-FTS and SMR, a maximum temporal difference of 5 hours and a maximum spatial difference of 1000 km were selected as collocation criteria. We followed the respective data quality recommendations for each data set. To avoid comparisons of air masses inside and outside the polar vortex, we used sPV (scaled potential vorticity) from the GEOS-5 data assimilation system interpolated to the location and time of each of the observations.

As only few datasets for $H_2^{18}O$ and $H_2^{17}O$ are available, we also included qualitative comparison with older and/or non-coincident datasets. These are the ATMOS Space Shuttle missions and the balloon-borne datasets FIRS-2 and JPL Mark IV. In the case of JPL Mark IV, measurements were obtained after the launch of ACE-FTS, but they don't satisfy any normal coincidence criterion.

We find that ACE-FTS and SMR agree well for δ^{18}O, while stratospheric δ^{17}O remains to be a challenging data product.