The observed variations in the isotope ratios often reveal information about the relative strengths of different sources and sinks of the trace gas in question, and about the transport processes which influence its distribution. With the magnitude of the heavy ozone isotope effect known, the isotopes can serve as tracers of transport processes which influence its distribution. The relative abundances of oxygen atoms $^{16}\text{O}$,$^{17}\text{O}$,$^{18}\text{O}$ in standard ocean water (SNOW) are approximately 1:1/500:1/2700. In this study we consider only singly substituted isotopic variants, so that asymmetric $^{16}\text{O}^{16}\text{O}^{17}\text{O}$, symmetric $^{16}\text{O}^{17}\text{O}^{17}\text{O}$, asymmetric $^{16}\text{O}^{17}\text{O}^{18}\text{O}$ and symmetric $^{16}\text{O}^{18}\text{O}^{18}\text{O}$.

**MIPAS:** The Michelson Interferometer for Passive Atmospheric Sounding is a high resolution Fourier transform spectrometer flying on Envisat satellite. MIPAS measures limb emission spectra over a wide spectral range in the middle infrared region (685-2410 cm$^{-1}$). From July 2002 until March 2004 MIPAS was operated at full spectral resolution (0.025cm$^{-1}$) with a nominal scanning sequence covering an altitude range of 6-68 km. For the high-resolution mission ESA have processed pT (pressure temperature) and six target species. However, MIPAS spectra contain also information on isotopes of ozone as well as other species.

**Retrieval Approach:** The MORSE (MIPAS Orbital Retrieval using Sequential Estimation) retrieval algorithm uses an Optimal Estimation Technique with a-priori information to constrain the retrieval [Rodgers, 2000]. The retrieval is based on the use of selected spectral intervals (microwindows) containing the best information on the target parameters [Dudhia et al., 2002] and the line-by-line radiative transfer forward model used is the RFM (Reference Forward Model). Since it is expected that there is little difference between the atmospheric $^{16}\text{O}$, isotope profiles within a10 degree latitude band, the previous MIPAS limb measurement (within the same latitude band) can provide prior information about $^{16}\text{O}$ isotope variants at the current time. Here, we use the resulting profile (and associated covariance) as the starting point for the next retrieval (Kalman filter approach). In this way the prior information enters the retrieval only once and the random error on the final profile should be greatly reduced (approximately to a tenth of an individual retrieval).

**FIRS:** The FIRS-2 is a remote-sensing Fourier transform spectrometer which observes the thermal emission of the atmosphere [Johnson et al., 1995]. It has flown from both balloon and aircraft platforms. The spectrometer resolution of 0.004 cm$^{-1}$ (unapodized) is sufficient to resolve individual rotational–translational transitions for $^{16}\text{O}^{16}\text{O}^{17}\text{O}$, $^{16}\text{O}^{16}\text{O}^{18}\text{O}$, $^{16}\text{O}^{17}\text{O}^{17}\text{O}$, $^{16}\text{O}^{17}\text{O}^{18}\text{O}$ and $^{16}\text{O}^{18}\text{O}^{18}\text{O}$. Over the range 25–35 km the average enhancements for for asymmetric, symmetric and total $^{16}\text{O}$ are 12.2±1.0%, 6.1±1.8% and 10.2±0.9%, respectively, and the average enhancements for for asymmetric, symmetric and total $^{16}\text{O}$ are 8.0±5.2%, 1.6±7.6% and 7.3±4.7%, respectively. As isotopic variations are usually small, measurements of an isotopic ratio $R$, such as $R={^{18}\text{O}}/^{16}\text{O}$, where $X$ signifies the volume mixing ratio (VMR) of X, are typically reported relative to a standard ratio $R_0$, often using delta notation: $\delta^X R = 100 \times \left( R/R_0 - 1 \right)$. Net enrichments for $^{16}\text{O}$ and $^{18}\text{O}$ are given by 2$\delta^{16}\text{O}Q_{18}$ and $2\delta^{18}\text{O}Q_{16}$ where Q stands for $^{16}\text{O}$ and $^{18}\text{O}$, respectively.

**Figure 3:** Zonal mean of asymmetric (left), symmetric (middle) and total (right) $\delta^{18}\text{O}$ and $\delta^{16}\text{O}$, respectively. Net enrichments for $^{16}\text{O}$ and $^{18}\text{O}$ are given by 2$\delta^{18}\text{O}Q_{16}$ and $2\delta^{16}\text{O}Q_{18}$ where Q stands for $^{16}\text{O}$ and $^{18}\text{O}$, respectively.

**Figure 4:** Detection of $^{18}\text{O}$ enrichment in $^{16}\text{O}$. The measurements also suggest enrichment of both $^{16}\text{O}$ and $^{18}\text{O}$ in the stratosphere (25-40 km) these measurements are in agreement with previous measurements (e.g. FIRS) and with expectations based on chemical processes. The enhancements for $^{16}\text{O}$, asymmetric and total are 12.2±1.0%, 6.1±1.8% and 10.2±0.9%, respectively, in the range 25-35 km; the enrichments for $^{16}\text{O}$, asymmetric and total are 8.0±5.2%, 1.6±7.6% and 7.3±4.3%, respectively; for $^{18}\text{O}$ are 8.0±5.2%, 1.6±7.6% and 7.3±4.7%, respectively, in this range.

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**References:**