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Quantification of the water vapor greenhouse effect: setup and first results of the Zugspitze radiative closure experiment

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Uncertainties in the knowledge of atmospheric radiative processes are among the main limiting factors for the accuracy of current climate models. Being the primary greenhouse gas in the Earth's atmosphere, water vapor is of crucial importance in atmospheric radiative transfer. However, water vapor absorption processes, especially the contribution attributed to the water vapor continuum, are currently not sufficiently well quantified. The aim of this study is therefore to obtain a more exact characterization of the water vapor radiative processes throughout the IR by means of a so-called radiative closure study at the Zugspitze/Schneefernerhaus observatory and thereby validate the radiative transfer codes used in current climate models.

For that purpose, spectral radiance is measured at the Zugspitze summit observatory using an AERI-ER thermal emission radiometer (covering the far- and mid-infrared) and a solar absorption FTIR spectrometer (covering the near-infrared), respectively. These measurements are then compared to synthetic radiance spectra computed by means of the Line-By-Line Radiative Transfer Model (LBLRTM, Clough et al., 2005), a high resolution model widely used in the atmospheric science community. This line-by-line code provides the foundation of RRTM, a rapid radiation code (Mlawer et al., 1997) used in various weather forecast models or general circulation models like ECHAM. To be able to quantify errors in the description of water vapor radiative processes from spectral residuals, i.e. difference spectra between measured and calculated radiance, the atmospheric state used as an input to LBLRTM has to be constrained precisely. This input comprises water vapor columns, water vapor profiles, and temperature profiles measured by an LHATPRO microwave radiometer along with total column information on further trace gases (e.g. CO_2 and O_3) measured by the solar FTIR.

We will present the setup of the Zugspitze radiative closure experiment. Due to its high-altitude location and the available permanent instrumentation, the Zugspitze observatory meets the necessary requirements to determine highly accurate water vapor continuum absorption parameters in the far- and mid-infrared spectral range from a more extensive set of closure measurements compared to previous campaign-based studies. Furthermore, we will present a novel radiometric calibration strategy for the solar FTIR spectral radiance measurements based on a combination of the Langley method and measurements of a high-temperature blackbody source that allows for the determination of continuum absorption parameters in the near-infrared spectral region, where previously no precise measurements under atmospheric conditions were available. This improved quantification of water vapor continuum absorption parameters allows us to further validate the current standard continuum model MT_CKD (Mlawer et al., 2012).

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