Spectroscopy for satellite remote sensing of greenhouse gases: Recent advances and outstanding challenges

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Satellite observations can complement measurements from ground-based networks and airborne campaigns to provide new insights into the spatial and temporal distribution of trace gases that are key to our understanding of atmospheric chemistry and Earth's climate. However, obtaining the trace gas information from satellite radiance measurements requires processing of the radiances using retrieval algorithms. The accuracy of remotely sensed quantities from such algorithms depends directly on the accuracy of the forward model used in the algorithm.

Retrievals of well-mixed greenhouse gases place particularly stringent demands on the accuracy of the forward model, since the variations of these gases in the atmosphere are small compared to the background. Systematic errors in the forward model can lead to regional-scale and/or time-dependent biases in the retrieval products, which in turn can lead to biases in estimates of sources and sinks that are derived from these products. Here, we present recent work on spectroscopy for the 0.76 mm O_2 A-band and the 1.61 and 2.06 mm CO_2 bands utilized by the NASA Orbiting Carbon Observatory missions (OCO-2 and OCO-3) and discuss future directions relevant for these and other greenhouse gas missions.

Efforts are underway to incorporate advanced line-shape formulations and to derive improved experimental line parameters. Advances in spectroscopy are included in the OCO forward model by updating look-up tables for molecular absorption coefficients (ABSCO tables). Recent updates to OCO ABSCO tables include results from a new multispectrum analysis of O_2 spectra acquired over a wide range of temperature and pressure, where details of the line-shape profile, the extent of line-mixing and the collision-induced absorption were determined in a self-consistent model [Drouin et al., 2017]. Updates also include results of new multispectrum analyses of the 1.61 mm and 2.06 mm CO_2 bands with improved constraints on the temperature dependence for these bands [Devi et al., 2016; Benner et al. 2016]. We present results of validation of these spectroscopic updates using ground-based atmospheric spectra and retrievals from the Total Carbon Column Observing Network (TCCON) site in Lamont, Oklahoma [Oyafuso et al., 2017] as well as satellite-based spectra and retrievals from OCO-2. In addition to showing the reduction in residuals and retrieval biases associated with the updates, we will discuss outstanding issues and potential paths to resolving these.

Odorants and Broadband Rotational Spectroscopy: What can we learn?

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Our sense of smell is usually referred to as the least known among all our senses. Several theories have been proposed over the years trying to explain how we smell but none of them provide a comprehensive understanding of the fundamentals of olfaction. Detailed information on how the interactions between odorants and olfactory receptors occur at the molecular level is still lacking. To achieve a better understanding on the molecular mechanisms involved in olfaction, we are investigating several odorants and their interactions with water and mimics of amino acid residues in olfactory receptors using broadband rotational spectroscopy. In this talk we will present an overview of our recent work on odorants and their clusters. Our results provide information on the intra- and intermolecular interactions determining structure and conformation, and highlight the relevant role of secondary interactions.

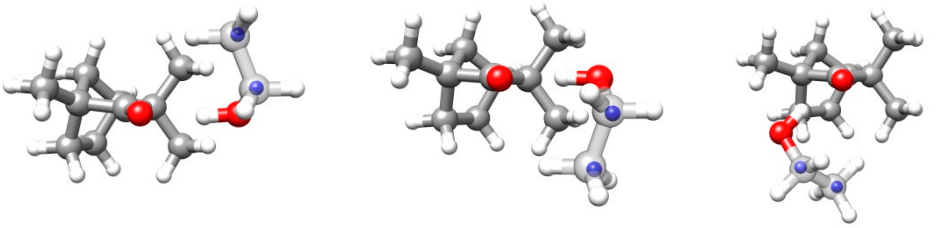

Figure 1. Observed conformers of the fenchone–ethanol complex.