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The Global Search for Abiogenic GHGs, via Methane Isotopes and Ethane

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The importance of Methane as an anthropogenic Green House Gas (GHG) is well recognized in the scientific community, and is second only to Carbon Dioxide in terms of influence on the Earth's radiation budget (Parker, et al, 2011) suggesting that the ability to apportion the source of the methane (whether it is biogenic, abiogenic or thermogenic) has never been more important. It has been proposed (Etiope, 2009) that it may be possible to distinguish between a biogenic methane source (e.g. bacteria fermentation) and an abiogenic source (e.g. gas seepage or fugitive emissions) via the retrieval of the abundances of methane isotopes (12CH4 and 13CH4) and through the ratio of ethane (C2H6) to methane (CH4) concentrations. Using ultra fine spectroscopy (<0.2cm-1 spectral resolution) from Fourier Transform Spectrometers (FTS) based on the SCISAT-1 (ACE-FTS) and GOSAT (TANSO-FTS) we are developing a retrieval scheme to map global emissions of abiogenic and biogenic methane, and provide insight into how these variations in methane might drive atmospheric chemistry, focusing on the lower levels of the atmosphere.

Using HiTran2012 simulations, we show that it is possible to distinguish between methane isotopes using the FTS based instruments on ACE and GOSAT, and retrieve the abundances in the Short Wave Infra-red (SWIR) at 1.65μm, 2.3μm, 3.3μm and Thermal IR, 7.8μm wavebands for methane, and the 3.3μm and 7μm wavebands for ethane. Initially we use the spectral line database HITRAN to determine the most appropriate spectral waveband to retrieve methane isotopes (and ethane) with minimal water vapour, CO_2 and NO_2 impact. Following this, we have evaluated the detectability of these trace gases using the more sophisticated Radiative Transfer Models (RTMs) SCIATRAN, the Oxford RFM and MODTRAN 5 in the SWIR, in order to determine the barriers to retrieving methane isotopes in both ACE (limb profile) and GOSAT (nadir measurements) instruments, including a preliminary investigation into the effects of clouds, aerosols, surface reflectance on the retrieval of methane isotopes.

The aim of these RTM simulations is to further narrow down the spectral regions (originally identified in the HITRAN assessment) where methane isotopes can/may be retrieved from orbit. The key outputs from the RTM study are absorption and radiance data, which allow us to identify the cleanest methane regions, and the likely SNR achievable in these regions.

Finally we show some of the results of a study where we compare the output from each of the RTMs used in this study (SCIATRAN, ORFM and MODTRAN), in order to gain some confidence and insight into the strengths and weaknesses of the RTM outputs, using MODTRAN as a benchmark.

References:

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