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A novel Tikhonov-based approach for harmonized high-accuracy retrieval of methane columns and profiles from NDACC FTIR network measurements. Application to global validation of ENVISAT/SCIAMACHY biases

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The first goal of this paper is to present an original approach for retrieval of methane columns and profiles from ground-based mid-infrared solar FTIR routine measurements performed within the Network for the Detection of Atmospheric Composition Change (NDACC). It is based on an altitude constant Tikhonov first order (L1) regularization, applied to inversion of methane profiles given in units of percentage of the volume mixing ratios at each layer altitude. A mathematical presentation of this regularization matrix can be found in Sussmann and Borsdorff (2007, equations B3 and B4 therein). We show that this approach is ideally suited to achieve a harmonized retrieval for a set of different, globally distributed FTIR stations, since it is extraordinarily simple and robust. This is because it is directly related to the well tested classical retrieval approach of simple volume mixing ratio profile scaling (via one altitude constant scaling factor), but allows for some additional flexibility in the shape of the retrieved profiles. This helps to get the total columns better integrated, even in the presence of spectral perturbations (e.g., from clouds). The amount of flexibility of the retrieved profile shape (relative to the a priori profile) can easily be tuned empirically versus one figure of merit, like minimum diurnal variation of the retrieved columns, or targeting at minimum profile oscillations within the retrieved ensemble. Sensitivity studies will be presented showing the optimization procedure and an error characterization of the new retrieval.

Based on this approach and in order to guarantee a station-to-station consistency of <1 % for satellite validation we performed a general harmonization effort for 13 selected globally distributed NDACC FTIR stations. Station-to-station biases are eliminated by using identical micro-windows, spectroscopic line lists, retrieval parameters, sources of ancillary data like pressure-temperature profiles, and water vapor data for deriving dry air columns. Furthermore, a geophysically consistent set of priori profiles for the retrievals at all stations was established.

Global satellite measurements of column-averaged methane have recently shown a step forward in data quality via year 2003 and 2004 retrievals from two different processors, namely IMAP-DOAS ver. 49 and WFM-DOAS ver. 1.0 (Frankenberg et al., 2008; Buchwitz et al., 2008). Accuracy and precision have approached the order of 1 %, and can be considered for inverse modelling of sources and sinks. This means at the same time that the quality requirements for ground-based validation data have become higher. This has been addressed by our harmonization effort described above. Our network validation study utilizes the validation strategy developed during the first validation of ENVISAT/SCIAMACHY column-averaged methane by FTIR (Sussmann et al., 2005). The outcome of the new study is the accurate determination of the satellite-ground station biases as a function of latitude on global scale.

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