Development of a Principal Components-Based Radiative Transfer Model and its Application to IASI CH_4 Retrievals

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ABSTRACT

Methane (CH_4) retrievals in the thermal infrared (TIR) can be computationally demanding: spaceborne instruments such as IASI produce a considerable volume of spectral data of high quality demanding accurate radiative transfer modelling (RTM). This, together with the large number of species to consider in the CH_4 retrieval spectral region dictate that the modelling needs to be carried out on a fine spectral and vertical grid, and these constraints lead to substantial processing time when using full-physics RTMs. Fast RTM alternatives such as RTTOV exist, but they are often impossible or difficult to customize when it comes to aspects such as the atmospheric species considered, spectroscopy, vertical discretization, and spectral resolution.

In order to perform faster CH_4 retrievals from IASI data, an algorithm based on the Principal Component-based Radiative Transfer Model (PCRTM) approach (Liu et al.[1]) has been developed. The main idea behind the PCRTM method is to compress the spectral information in a limited number of Principal Components (PC) and parameterize the PC scores based on a relatively small number of monochromatic radiative transfer simulations, resulting in a significant reduction of the necessary computations. The model produces the top-of-atmosphere (TOA) IASI channel radiances as well as the Jacobians for all species of interest in the spectral region used for the retrieval (1190 – 1350 cm^{-1}). PCRTM is a great framework to develop a customized, accurate and fast RTM, based on full-physics radiative transfer calculations.

In this work, we will detail the general approach taken for the development of a PCRTM for the specific spectral region of CH_4 in the TIR, how the Jacobians were derived, its implementation in an optimal estimation inversion scheme for CH_4, and the various techniques that were tested to find an optimal set of wavenumbers at which the radiative transfer calculations should be carried out for the parameterization of the PC scores for the IASI channel radiances and Jacobians. We will compare the TOA radiances and Jacobians produced by the customized PCRTM and the full-physics RTM on which it was based, as well as the retrieved quantities from the CH_4 retrieval scheme driven by both RTMs.

[1] Xu Liu, William L. Smith, Daniel K. Zhou, and Allen Larar, "Principal component-based radiative transfer model for hyperspectral sensors: theoretical concept," Appl. Opt. 45, 201-209 (2006)