Neural Network Based Models for the Retrieval of Methane Concentration Vertical Profiles from Remote Sensing Data

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Keywords: neural networks, greenhouse gas, inverse problem.

Methane (CH4) and carbon dioxide (CO2) are the most important anthropogenic greenhouse gases. Recent studies have shown that atmospheric methane concentrations have increased by approximately 150% since pre-industrial times. This corresponds to a radiative forcing of 0.48Wm−2, which amounts to 20% of the total radiative forcing due to well-mixed greenhouse gases. More than half of the present-day methane emissions are of anthropogenic origin and the most important sources are fossil-fuel production, domestic ruminants, rice cultivation and waste handling. CH4 absorbs the rising radiation from the earth-atmosphere system on the near infrared spectral range and play an important role in the greenhouse effect and in the climatic change over the globe (IPCC, 2001).

Within the context above, it is becoming increasingly relevant to develop novel and better techniques to estimate concentration profiles of atmospheric constituents like methane. In this sense, a good alternative is the use of satellite remote sensing data. CH4 retrieval feasibility and sensitivity studies have already been performed for the Atmospheric Infrared Sounder (AIRS), see (Christi & Stephens, 2004) and (Engelen & Stephens, 2004), and the Scanning Imaging Absorption Spectrometer for Atmospheric Chartography (SCIAMACHY), see (Buchwitz et al., 2004) and (Buchwitz et al., 2005).

In this article we discuss a neurocomputing approach to deal with this kind of inverse problem. In a first step, we investigated the performance of the radiative transfer model (forward model) to be used in the inversion process. The forward model used here is the SCIATRAN code, developed by the University of Bremen (IFE/IUP) to simulate radiances from SCIAMACHY satellite spectrometer (Rozanov et al., 2002). Based on these studies we decided to exploit the Sciamachy data near-infrared channel 8 in order to do the CH4 profile inversion as related above. In a second step, we developed a neural network for reconstructing methane vertical column densities from remote sensing data. To this end, we employed synthetic radiances simulated by SCIATRAN for the learning process of the neural network. Finally, we validated our approach using a set of more than a hundred test cases, with and without noise in the radiance data.

Three architectures of neural networks were applied to the inverse problem of retrieval of methane vertical concentration profiles from remote sensing data. Overall, the use of neural networks was able to solve this difficult inverse problem even when the data were contaminated with noise. A comparison among different ANN architectures was accomplished but it was not possible to detect great discrepancies in the performance of them. Some modifications could be implemented in order to improve the neural network performance. The use of noisy data in the training data is an obvious one. The incorporation of real satellite radiances is another. From this preliminary exercise, two advantages of the use of neural networks became clear: after the training phase, the reconstruction algorithm is much faster than the classical inversion methods; and it is an intrinsically parallel approach that can be very easily implemented in a parallel environment.

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