THREE YEARS OF SCIAMACHY CARBON DIOXIDE AND METHANE COLUMN-AVERAGED DRY AIR MOLE FRACTION MEASUREMENTS

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ABSTRACT

Carbon dioxide (CO_2) and methane (CH_4) are the two most important anthropogenic greenhouse gases. The near-infrared nadir spectra of reflected solar radiation measured by SCIAMACHY on-board ENVISAT contain information on the vertical columns of these gases which we retrieve using a new version of the scientific algorithm WFM-DOAS (version 1.0). Our main data products are column-averaged dry air mole fractions (XCO_2 in ppm and XCH_4 in ppb) determined by simultaneous measurements of the dry air mass obtained from oxygen (O_2) for carbon dioxide and CO_2 for methane. The SCIAMACHY data set is unique because of the high sensitivity of the near-infrared measurements with respect to concentration changes in the atmospheric boundary layer. This sensitivity is a pre-requisite to get information on regional surface sources and sinks which are currently only poorly constrained globally by atmospheric measurements. We present a short overview about the processed data set covering the time period 2003-2005.

1. INTRODUCTION

The carbon gases carbon dioxide (CO_2) and methane (CH_4) are the two most important anthropogenic greenhouse gases and contribute to global climate change. The near-infrared nadir spectra of reflected solar radiation measured by SCIAMACHY [1] on-board ENVISAT contain information on the vertical columns of these gases which we retrieve using the scientific algorithm WFM-DOAS [2, 3, 4]. Here we present an overview of the latest retrieval results of column-averaged dry air mole fractions for the years 2003-2005 obtained from the newest version WFM-DOAS v1.0 [9, 10] with which major problems of the previous versions (large scaling factor for XCO_2 v0.4 and SZA-dependent bias of XCH_4 v0.5) have been solved. In Section 2 we shortly summarize the main results based on annual averages and the first ever animations of global greenhouse gas distributions measured from space. For details concerning the new three years carbon dioxide and methane data set and the algorithm changes we refer to [9] (CO_2) and [10] (CH_4).

2. RESULTS

We have processed all available SCIAMACHY spectra (Level 1b version 5 converted to Level 1c using the standard calibration options) for the time period 2003-2005 using the improved retrieval algorithm WFM-DOAS version 1.0. The resulting annual composite averages for carbon dioxide and methane are shown in Fig. 1. In order to separate out ground scenes affected by clouds, low sun or those exhibiting a poor fit result for whatever reasons, only those ground scenes satisfying certain quality criteria marking successful measurements are considered [9, 10]. Because of the higher accuracy and precision requirements for carbon dioxde only the measurements over land are shown.

The qualitative seasonal results presented in Figs. 2 and 3 are taken from the first ever animations showing the global distribution of the greenhouse gases carbon dioxide and methane [6] (also available from `http://www.iup.uni-bremen.de/sciamachy/NIR_NADIR_WFM_DOAS/index.html`) which are based on monthly mean data using interpolation and extrapolation to fill some data gaps.

2.1. Carbon dioxide

Carbon dioxide (CO_2) columns are retrieved from a small spectral fitting window (1558-1594 nm) located in SCIAMACHY channel 6. Oxygen (O_2) columns from channel 4 (755-775 nm) are retrieved to compute the column-averaged dry air mole fraction XCO_2.

Fig. 2 shows how our planet is ”breathing”. Each year huge amounts of CO_2 are taken up by the growing vegetation in spring and summer (resulting in lower (decreasing) atmospheric CO_2 levels) and are to a large extent released again during the following autumn and winter (resulting in higher (increasing) atmospheric CO_2) when part of the vegetation dies and decays. Also visible are the rising CO_2 levels with time, primarily due to burning of fossil fuels, resulting in somewhat higher CO_2 levels end of 2005 compared to the beginning of 2003. This global increase can also be seen in the annual carbon dioxide averages shown in Fig. 1.

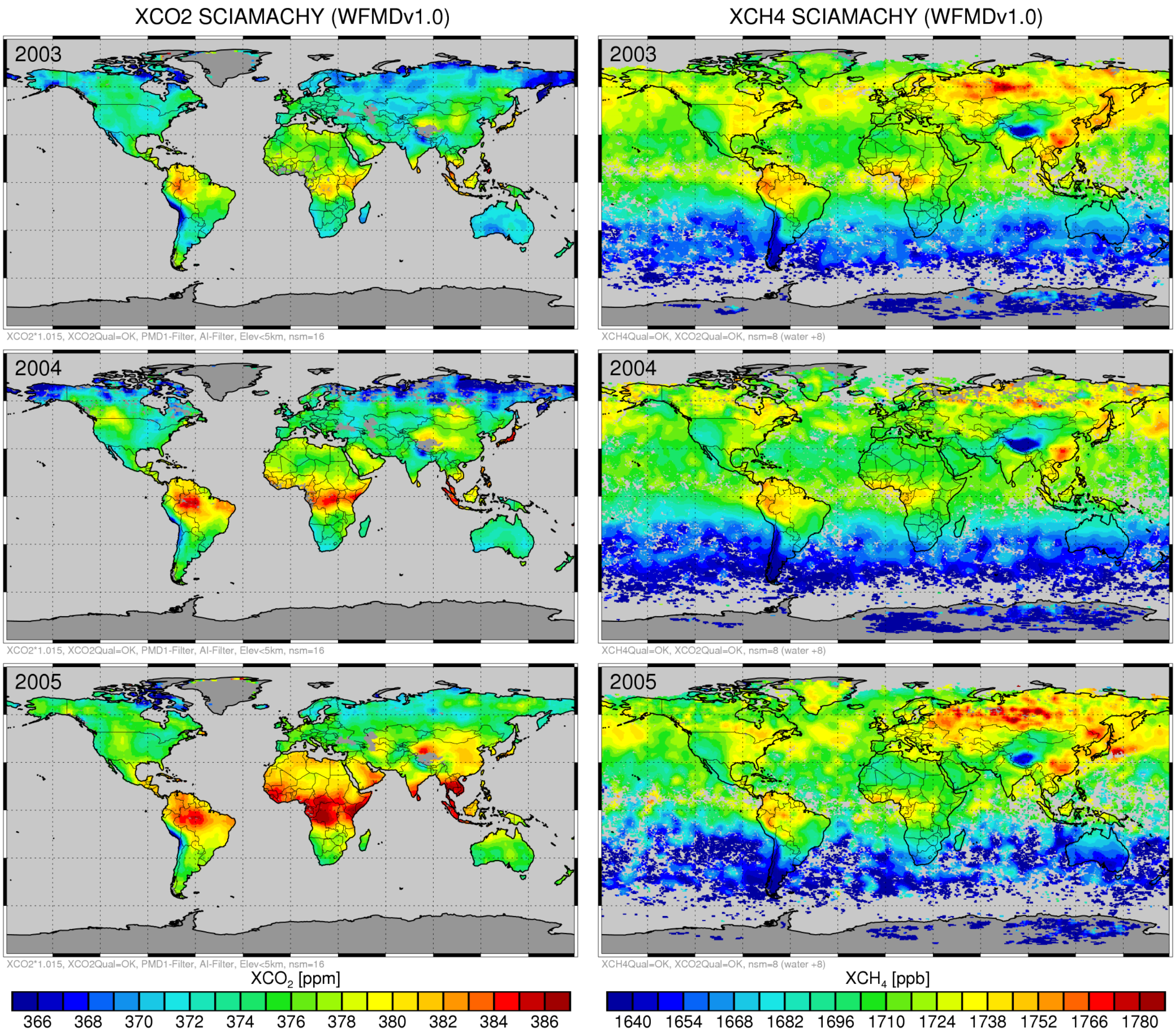

Figure 1. Three years of SCIAMACHY carbon dioxide (left) and methane (right) column-averaged dry air mole fractions as retrieved by WFM-DOAS version 1.0 (WFMDv1.0). Because of the higher accuracy and precision requirements for carbon dioxde only the measurements over land are shown.

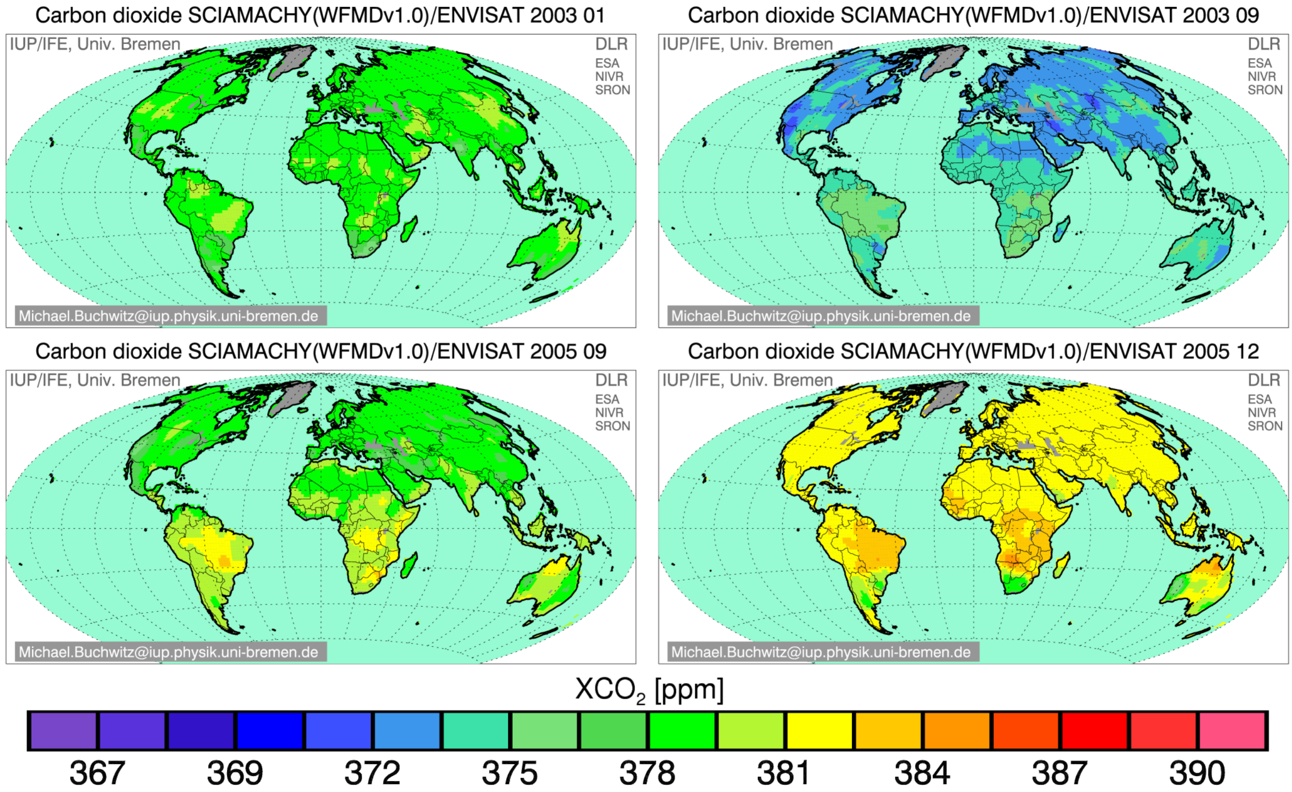

Figure 2. Snapshots of the carbon dioxide animation showing the breathing of our planet and the global increase with time.

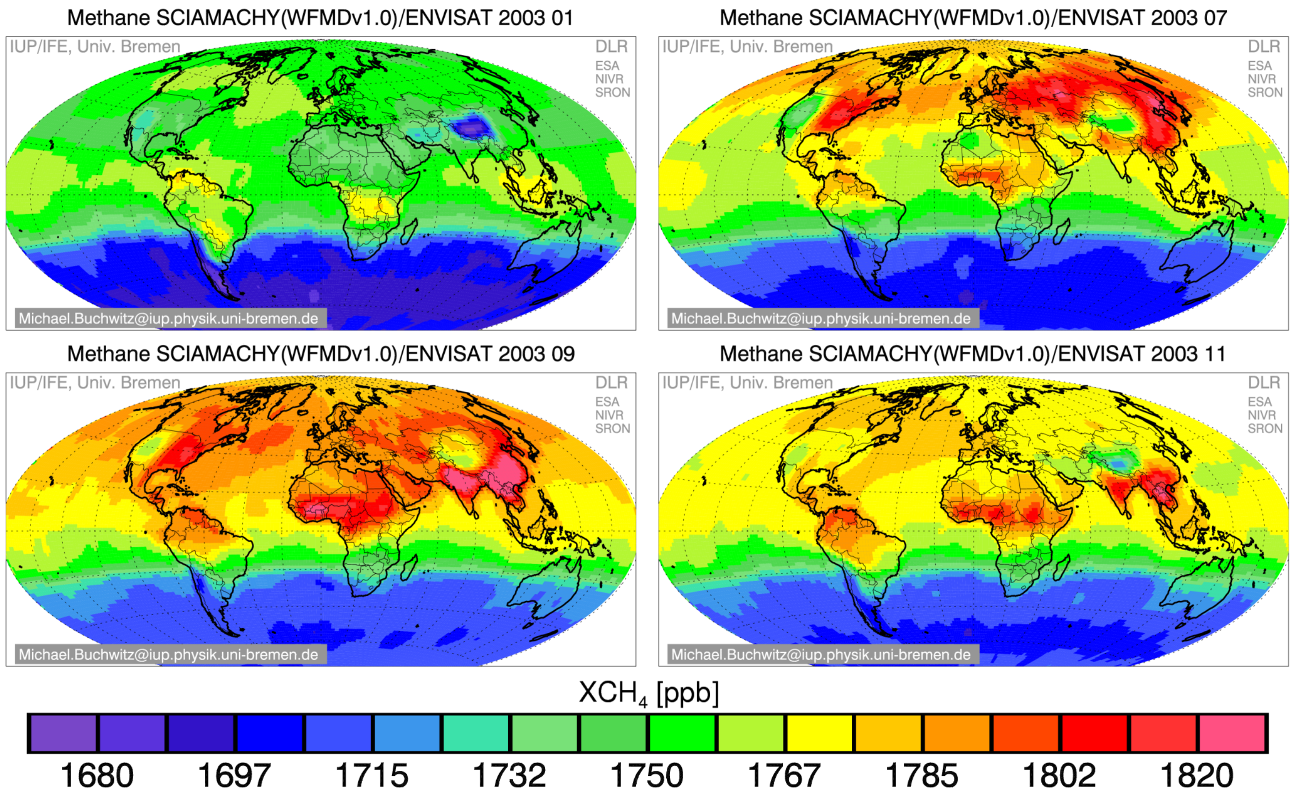

Figure 3. The same as Fig. 2 but for methane showing the interhemispheric gradient and major methane source regions.

2.2. Methane

Methane columns are retrieved from a small spectral fitting window (1630-1671 nm) located in SCIAMACHY channel 6. CO_2 from channel 6 is used as a proxy for the light path and the simultaneously retrieved CO_2 column is used to estimate the air column necessary to compute the column-averaged dry air mole fraction XCH_4. The advantage of using CO_2 is a significant better cancellation of systematic light path related retrieval errors (aerosols, albedo, residual clouds) because of similar radiative transfer in the neighboring fitting windows of CH_4 and CO_2.

As one can see in Figs. 1 and 3, the interhemispheric gradient is clearly visible and major methane source regions like rice paddies in China and Siberian wetlands can be identified. Additionally, unexpected high amounts of methane over tropical rain forests are observed by SCIAMACHY [7, 3, 10] pointing to the possibility of a not yet known source of methane or to a significantly underestimated known source. One explanation for the high tropical methane retrieved by SCIAMACHY could be the recently discovered methane emission of living plants [8].

3. SUMMARY

We have presented an overview about the current status of the retrieval of carbon dioxide and methane from SCIAMACHY near-infrared nadir spectra using the WFM-DOAS algorithm. The new CH_4 and CO_2 version 1.0 data products will be released soon. Comparisons with FTS and global model simulations will be presented in [9, 10].

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