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Analysis of the carbon dioxide in the upper troposphere and lower stratosphere by the data from GOSAT TANSO-FTS TIR

Akihiro Honda[1]* , Nawo Eguchi[2] , Naoko Saitoh[3] and Yousuke Niwa[4]

1: Interdisciplinary Graduate School of Engineering and Sciences, Kyushu University,
2: Research Institute for Applied Mechanics, Kyushu University,
3: Center for Environmental Remote Sensing, Chiba University,
4: Center for Global Environmental Research, National Institute for Environmental Studies

Mail to : honda@riam.kyushu-u.ac.jp

九州大学 KYUSHU UNIVERSITY

1. INTRODUCTION

Stratospheric cooling was reported, it could be caused by increasing the carbon dioxide (CO_2), which is a major greenhouse gas. While, the concentration of CO_2 in the stratosphere is not well understood, nor are the exchange processes between the upper troposphere and lower stratosphere (UT/LS ; 250-100hPa). The present study investigated the intra-seasonal, seasonal and inter-annual variations of CO_2 to understand the CO_2 concentration at UT/LS and the Stratosphere and Troposphere exchange process.

2. ANALYSIS DATA

We used the vertical profile data (Level 2) of CO_2 derived from thermal infrared (TIR) region (Band 4: 5.5 - 14.3 μm) of the TANSO-FTS on board GOSAT. The analysis period is four years from 1 January 2010 to 31 December 2013. We adapted the bias correction values derived from Saitoh et al. [AMT, 2016] which validated the TIR CO_2 profiles at UT/LS region with the Comprehensive Observation Network for TRace gases by AIrLiner (CONTRAIL). For reference, the atmospheric transport model, NIES-TM (ver.5) [Saeki et al., 2013] and the NICAM–TM [Niwa et al., 2011; 2017] were used.

*GOSAT TANSO-FTS : Greenhouse gases Observing SATellite, Thermal And Near infrared Sensor for carbon Observation - Fourier Transform Spectrometer [Yokota et al., 2009]

*NICAM-TM : Nonhydrostatic Icosahedral Atmospheric Model - based Transport Model

3. RESULTS

Seasonal variation of CO_2 concentration

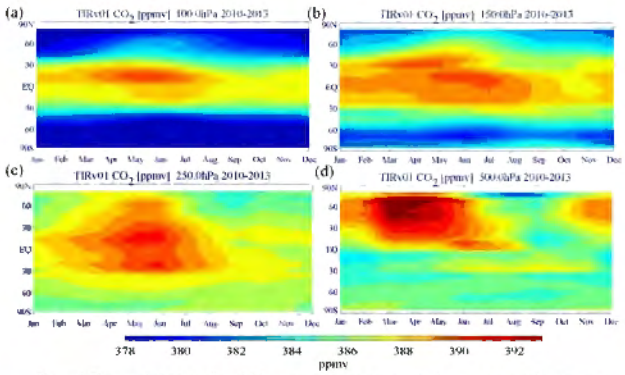

Figure 1. Time and latitude section of CO_2 concentration averaged over four years subtracting the growth rate from January 2010 to December 2013 at (a)100 hPa, (b)150 hPa, (c)250 hPa , and (d)500 hPa.

GOSAT TANSO-FTS TIR vs NICAM-TM

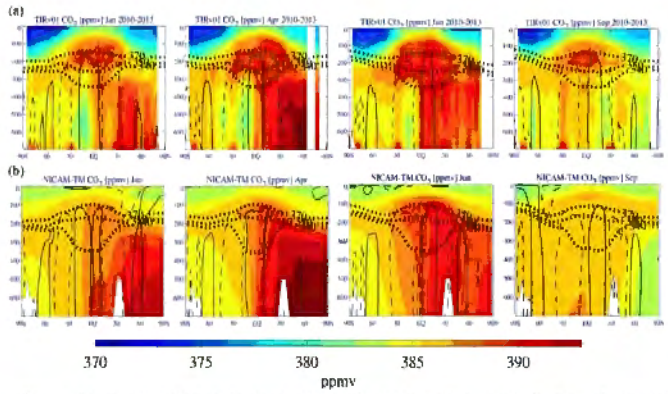

Figure 2. Latitude and pressure section of CO_2 concentration averaged over four years January, April, June and September (a) GOSAT and (b) NICAM-TM data. The dotted lines show the potential temperature (340, 350 and 370 K) and the thick and dashed lines show upward and downward vertical velocity (±1.0 Pa/ s), respectively.

Inter-annual variation of CO_2 concentration

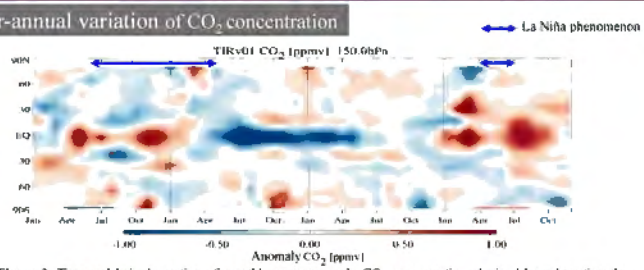

Figure 3. Time and latitude section of monthly mean anomaly CO_2 concentration obtained by subtracting the growth rate at each latitude and 4-year average at 150 hPa from 1 January 2010 to 31 December 2013. The blue arrows show La Niña periods.

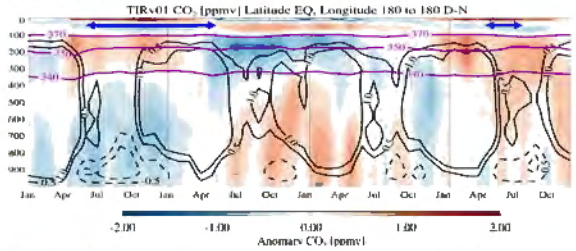

Figure 4. Time and pressure section of monthly mean anomaly CO_2 concentration at EQ. The purple lines show the potential temperature (K), 340, 350 and 370K, and the black solid and dashed lines represent vertical wind (m/s) obtained from ECMWF ERA Interim.

Intra-seasonal variation CO_2 concentration

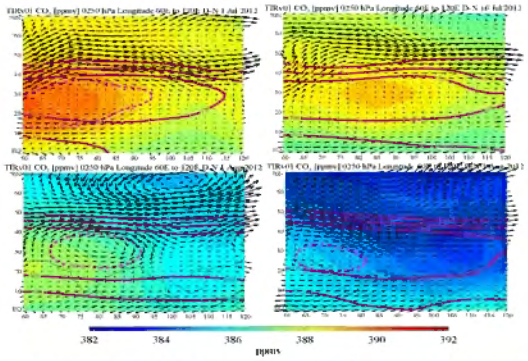

Figure 5. A horizontal map of 5 days mean CO_2 concentration obtained by subtracting the growth rate at each latitude in (a)1 July, (b)16 July, (c)1 August and (d)16 August 2012 at 250 hPa. Black arrows indicate horizontal wind, the red line indicate potential temperature [K] and the purple broken line indicates the geopotential height [m] from ECMWF ERA-Interim.

4. SUMMARY

- The seasonal variation of CO_2 concentration, showed that the maximum peak existed after a few month with respect to the peak at the middle troposphere (Figure 1).
- In the NICAM-TM results, the extension of high CO_2 concentration at UT toward southern hemisphere were not clearly seen rather than the in TANSO-FTS (Figure 2).
- The inter-annual variation of CO_2 concentration at UT/LS was affected by the ENSO cycle; the higher (lower) concentration were seen during La Nina (Normal / El Nino) period (Figures 3 and 4).
- The intra-seasonal variations over Asian Summer Monsoon region were associated with both the vertical and horizontal transportations due to the deep convection and the Asian monsoon anticyclonic circulation, respectively.

References:

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