Japan Geoscience Union Meeting 2012
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AAS22-01 Room:201B Time:May 21 09:00-09:15

Overview of observational results from the Superconducting Submillimeter-Wave Limb-Emission Sounder (SMILES)

SHIOTANI, Masato[1*]

[1]Research Institute for Sustainable Humanosphere, Kyoto University

The Superconducting Submillimeter-Wave Limb-Emission Sounder (SMILES) was developed to be aboard the Japanese Experiment Module (JEM) on the International Space Station. It is a cooperative project of the Japan Aerospace Exploration Agency (JAXA) and the National Institute of Information and Communications Technology (NICT). The key concept of SMILES is its high-sensitivity measurement of minor species in the middle atmosphere by a receiver using superconductor-insulator-superconductor (SIS) mixers which are cooled to 4.5 K by a mechanical cryocooler. SMILES was successfully launched on September 11, 2009, and started atmospheric observations on October 12. Unfortunately, SMILES observations had been suspended since April 21, 2010 due to the failure of a critical component in the submillimeter local oscillator. Furthermore, the cooler stopped its operation due to the failure of the JEM thermal control system on June 5, 2010.

The mission objectives are as follows: i) To demonstrate a 4-K mechanical cooler and superconducting mixers in the environment of outer space for submillimeter limb-emission sounding in the frequency bands of 624.32-626.32 GHz and 649.12-650.32 GHz and ii) To measure atmospheric minor constituents in the middle atmosphere globally (O3, HCl, ClO, HO2, HOCl, BrO, O3 isotopes, HNO3, CH3CN, etc.) in order to get a better understanding of factors and processes controlling the stratospheric ozone amounts and those related to climate change. Though future states of the ozone layer have been investigated using coupled chemistry-climate model, there are still considerable uncertainties in factors affecting ozone levels, especially the bromine budget and inorganic chlorine chemistry. The SMILES mission can contribute to the detailed halogen chemistry by providing useful constraints for these issues. In this presentation, we will give a brief description of the SMILES observations, and on the basis of the version 2.1 level 2 data which is released to the public this spring, we will present some results that demonstrate SMILES abilities to observe the atmospheric minor constituents in the middle atmosphere.

Keywords: Middle Atmosphere, Ozone Chemistry, Atmospheric Dynamics, Satellite Measurement, International Space Station

AAS22-02 Room:201B Time:May 21 09:15-09:30

Ozone distribution related to the QBO and the SAO — Observation by the SMILES and estimation by a nudging CTM

NAITO, Yoko[1*], AKIYOSHI, Hideharu[3], SHIOTANI, Masato[2]

[1]Graduate School of Science, Kyoto University, [2]Research Institute for Sustainable Humanosphere, [3]National Institute for Environmental Studies

An attempt is made to estimate dynamical and chemical effects on the variation of the ozone distribution in the equatorial stratosphere according to the phases of the QBO (quasi-biennial oscillation) and the SAO (semiannual oscillation). Both of the data from the observation by the SMILES and the data from the simulation by a nudging CTM based on the MIROC CCM are analyzed.

The distribution of ozone mixing ratio in the equatorial stratosphere has a maximum in the mid-stratosphere (about 30 km), and the value decreases with height in the upper stratosphere. The latitudinal distribution in the upper stratosphere basically shows a single-peak structure with a maximum around the equator, while sometimes exhibits a double-peak structure with two maxima according to the phases of the QBO and the SAO.

Such a double-peak structure, called as ”rabbit ears” by Randel and Wu (1996), is clearly displayed in the daily mapped data from the SMILES observation. The SMILES observation also showed that the double-peak structure appears and disappears according to the phase of the SAO.

Furthermore in the present talk, a quantitative estimation will be made on contributions of both dynamical effects such as the advection and the chemical effects such as the production/destruction of ozone to form the double-peak structure.

Keywords: stratosphere, QBO, SAO, ozone, dynamics, chemistry

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AAS22-03 Room:201B Time:May 21 09:30-09:45

Diurnal ozone variations in the middle atmosphere as revealed with SMILES observations

SAKAZAKI, Takatoshi[1*], FUJIWARA, Masatomo[1], SHIOTANI, Masato[2], SUZUKI, Makoto[3], AKIYOSHI, Hideharu[4], Douglas Kinnison[5]

[1]Graduate School of Environmental Science, Hokkaido University, [2]RISH/Kyoto Univesity, [3]ISAS/JAXA, [4]National Institute for Environmental Studies, [5]National Center for Atmospheric Research

Diurnal ozone variations in the middle atmosphere are controlled by both photochemistry and dynamics. The global and quantitative understanding of diurnal ozone variations is crucial for trend analysis, intercomparison of different satellite observations made at different local times, validation of CCMs and so on. Previous studies mainly used in situ observations such as ozone lidars for detecting the diurnal variability; in contrast, global observations have been only possible by the two non-Sun-synchronous satellite observations, i.e., UARS/MLS and TIMED/SABER. However, the results from the two satellite observations are not consistent quantitatively at some altitude levels in the stratosphere. The Superconducting Submillimeter-Wave Limb-Emission Sounder (SMILES) onboard the International Space Station is another non-Sun-synchronous satellite, which achieved global observations of minor constituents in the middle atmosphere with a very high accuracy during the period from October 2009 to April 2010. The purpose of this study is to obtain a global picture of diurnal ozone variations in the middle atmosphere, by using SMILES data as well as other satellite and CCM data sets.

We analyze ozone mixing ratio from four different observation/model data sets: (1) SMILES Version 2.0 data, (2) TIMED/SABER Version 1.07 data from the 9.6 micro-meter band, (3) SD-WACCM data, (4) CCSR/NIES Nudging CTM. These data are analyzed for the period of the SMIELS observations. For the non-Sun-synchronous SMILES (SABER) observations, 30 (60) days are needed to cover a whole diurnal cycle. In order to avoid sampling issues due to the background ozone changes, the 30-day (60-day) running mean has been subtracted from the original data for data (1, 3-4) (data (2)) in advance. Then, every 5 degrees in latitude and every ~3 km in altitude, the residuals from the running mean are binned and averaged in 1-hour local-time bins, which are considered as diurnal variations in this study.

Figure 1 shows vertical distributions of diurnal ozone variations averaged for 10S-10N, as derived from SMILES and SD-WACCM data. The diurnal variations shown here are the relative values to the daily-mean for the analysis period shown also in Figure 1. We discover that the results from the two data sets agree quite well. The results from SABER observations show a roughly similar phase pattern as in Figure 1 but with much larger amplitudes (approximately twice) at 30-50 km. These findings suggest that SMILES has allowed us to obtain the global picture of diurnal ozone variations for the first time. In other words, diurnal ozone variations in CCMs (e.g., SD-WACCM) have been validated for the first time. The observed results are summarized and interpreted as follows. At 20-30 km, the diurnal harmonic component is dominant with the amplitude of 2-3%. Its phase shows a downward progression with altitude. An analysis of dynamical fields (temperature and winds from MERRA) suggests that this diurnal component is mainly controlled by the vertical transport associated with diurnal tides. At 30-40 km, ozone minimizes after dawn and increases toward the maximum in the afternoon. The amplitude is 2-5%. The dawn minimum is caused by the depletion of odd oxygen associated with the NOx chemistry, while the afternoon maximum is caused by the production of odd oxygen through the photolysis of molecular oxygen as suggested by Pallister and Tuck (1983). At 40-50 km, we observe similar diurnal variations seen at 30-40 km and additional minimum of ~5% about at noon. This additional minimum is probably caused by the depletion of odd oxygen due to the HOx chemistry as also suggested by Pallister and Tuck (1983). Finally, above 50 km, the ozone shows a simple day/night contrast with an amplitude of ~100% at maximum. This is caused by the high [O]/[O3] ratio in the upper atmosphere; i.e., the odd oxygen resides as atomic oxygen so that ozone shows a strong depletion during the day.

Keywords: Middle atmosphere, diurnal ozone variations

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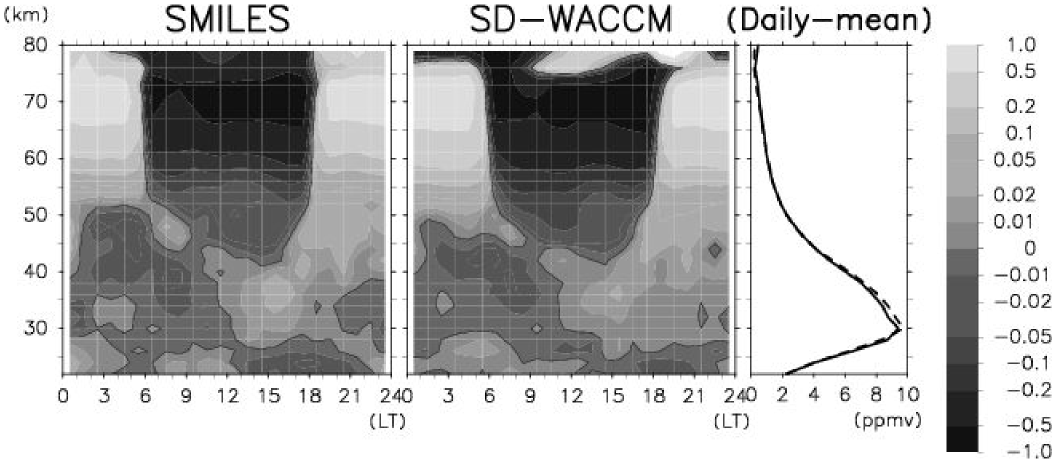

AAS22-04 Room:201B Time:May 21 09:45-10:00

On the reaction ClO + HO2 –> HOCl + O2 based upon SMILES observation

MANAGO, Naohiro[1*], SUZUKI, Makoto[1], SANO, Takuki[1], MITSUDA, Chihiro[2], IMAI, Koji[3], TAKAHASHI, Kenshi[4], SHIOTANI, Masato[4]

[1]ISAS/JAXA, [2]Fujitsu FIP Corp., [3]TOME R&D Inc., [4]RISH/Kyoto Univ.

SMILES (Superconducting Submillimeter-Wave Limb Emission Sounder) is an instrument to measure global distribution of minor species in the middle atmosphere by limb observation. It was attached to the Japanese Experiment Module (JEM) on the International Space Station (ISS) and obtained a half year's worth of data between mid October, 2009 and mid April, 2010. SMILES has an advantage in low system noise realized by cooling the receiver to 4 degrees kelvin with a mechanical cooler, and it enables to measure distribution of trace gases such as O3, HCl, ClO, HO2 and HOCl with high sensitivity.

It is a well-known fact that inorganic chlorine play an important role in the stratospheric chemistry. However, it is not fully understood quantitatively due to the limited precision of parameters such as the abundance of HCl, total abundance of inorganic chlorine, the ratio between HCl and other inorganic chlorine, the ratio between ClO and HOCl, and so on.

In this research, we estimated the reaction rate of ClO + HO2 –> HOCl + O2 with steady-state approximation. By using SMILES L2 ver.2.1 for the HOCl concentration and MODTRAN5 to calculate the photodissociation rate of HOCl, we obtained reaction rates similar to the JPL 2006 value at the altitude range of 30 - 40 km.

Keywords: stratosphere, inorganic chlorine

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AAS22-05 Room:201B Time:May 21 10:00-10:15

SMILES climatology and activity in SPARC DI

KASAI, YASUKO[1*], SAGAWA, Hideo[1], Daniel Kreyling[1], SUZUKI, Kodai[2], SATO, Tomohiro[3], Joachim Urban[4]

[1]NICT, [2]University of Tokyo, [3]Tokyo Institute of Technology, [4]Chalmers University of Technology

The Superconducting Submillimeter-Wave Limb-Emission Sounder (SMILES) on the Japanese Experiment Module (JEM) in the International Space Station (ISS) was successfully observed the altitude profiles of minor atmospheric compositions with new super-sensitive 4K heterodyne receiver system, which provide lower noise spectrum one order magnitude than Aura/MLS and Odin/SMR, from international space station (ISS) during 12 October 2009 and 21 April 2010. The atmospheric compositions SMILES observed were O3, H35Cl, H37Cl, ClO, HOCl, HO2, BrO, HNO3, CH3CN, Ozone isotopes, upper tropospheric humidity, ice cloud in the middle atmosphere. The wind velocities and temperature were also retrieved. ISS platform give us many unique observation characteristics, and one of them is a diurnal variation of the observation of atmospheric composition with non sun-synchronous orbit. SMILES is the co-development project between JAXA and NICT.

We would like to report a SMILES climatology for the diurnal variation for short-lived species in the stratosphere and mesosphere, and current status of our activity in SPARC data initiative. We used the SMILES L2 research product version 2.1.5 for the climatology. The status of the SMILES L2 research product version 2.1.5, including intensive error analysis, comparison/validation will be also present.

Keywords: SMILES, Sub-mm sounder, Stratosphere, Mesosphere, Atmospheric composition

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AAS22-06 Room:201B Time:May 21 10:15-10:30

Gravitational Separation : A New Tracer of Stratospheric Circulation

ISHIDOYA, Shigeyuki[1*], SUGAWARA, Satoshi[2], MORIMOTO, Shinji[3], AOKI, Shuji[4], NAKAZAWA, Takakiyo[4], Hideyuki Honda[5], MURAYAMA, Shohei[1]

[1]AIST, [2]Miyagi University of Education, [3]National Institute of Polar Research, [4]Tohoku University, [5]Japan Aerospace Exploration Agency

As a basic knowledge of the atmospheric science, it has been believed that the gravitational separation of the atmospheric components can be found in the atmosphere above the turbopause. Demolishing this scientific common sense, we have detected a significant gravitational separation of major atmospheric components in the stratosphere for the first time based on the high-precision measurements of the stable isotopic ratios of N2, O2 and Ar as well as the concentrations of O2 and Ar in the atmosphere. Observed relationships between them are identical to those expected from the gravitational separation, however, they are clearly different from those expected from the thermally-driven fractionation related to air-sampling procedures. From the comparison of stratospheric O2/N2 ratio with and without correction for the gravitational separation, it is indicated that the consideration of the gravitational separation is indispensable to derive reliable information from measured values of the concentration and the isotopic ratio of atmospheric components. It is also suggested that the simultaneous observation of the gravitational separation and the CO2 age in the stratosphere could provide useful information to clarify year-to-year variations of Brewer-Dobson circulation due to climate change associated with the global warming.

Keywords: gravitational separation in the stratosphere, a new tracer of stratospheric circulation, decrease of stratospheric O2 concentration, molecular diffusion by gravity and thermal effect

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AAS22-07 Room:201B Time:May 21 10:45-11:00

Stratospheric cooling and downward planetary-wave propagation in the lowermost stratosphere during the 2010-11 winter

NISHII, Kazuaki[1*], Hisashi Nakamura[1], Yvan J. Orsolini[2]

[1]RCAST, University of Tokyo, [2]Norwegian Institute for Air Research

Dynamical cooling in the polar stratosphere is induced by weakening of E-P flux convergence (i.e. anomalous divergence) in the stratosphere. As the E-P flux convergence is mainly contributed to by upward planetary-wave (PW) propagation from the troposphere, the intensity of its propagation is well correlated with E-P flux convergence and the polar stratospheric temperature. Several studies (Orsolini et al. 2009, QJRMS; Nishii et al. 2010, GRL) pointed out a tropospheric blocking high over the western Pacific, whose circulation pattern has projection onto the Western Pacific (WP) teleconnection pattern, tend to weaken the upward PW propagation and to lower the polar stratospheric temperature. In this study, we investigate a possibility that downward PW propagation in the lowermost stratosphere also causes the E-P flux divergence in the polar stratosphere and leads to stratospheric cooling.

Based on prominent negative events of vertical 100-hPa E-P flux averaged over the mid- to high-latitudes in the northern hemisphere, we performed composite analyses for each term of a transformed Eulerian mean (TEM) equation. Downward E-P flux in the lowermost stratosphere and divergence of E-P flux in the stratosphere are observed around the reference date, which is followed by persistent cooling of the polar stratosphere more than two weeks. About one week before the reference date, enhanced upward E-P flux and its convergence lead to deceleration of upper stratospheric zonal wind. This deceleration results in weakening of vertical sheer of zonal wind at the level, which hints at a turning surface for vertically-propagating PWs there (Harnik 2009, JGR). Our results are mostly consistent with Harnik (2009, JGR) who showed that a short pulse of upward-propagating PW forms a turning surface in the upper stratosphere, where the PW is reflected back.

By taking above results into consideration, we analyzed the prolonged cold 2010-11 winter. We found that while three cooling events in December and January were accompanied by tropospheric WP pattern events, cooling in February was led by downward-propagating PW events. Cooling in March is accompanied both by WP and downward-propagating PW events.

Keywords: Polar vortex intensification, Western Pacific pattern, downward planetary wave propagation

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AAS22-08 Room:201B Time:May 21 11:00-11:15

Coupling of atmospheric dynamics from the troposphere to the lower thermosphere - Analysis of GAIA data in 2009-Jan. SSW-

OCHI, Kenta[1*], FUJITA, Shigeru[1], MIYOSHI, Yasunobu[2], FUJIWARA, Hitoshi[3], JIN, Hidekatsu[4], SHINAGAWA, Hiroyuki[4]

[1]Meteorological College, [2]Department of Earth and Planetary Sciences, Faculty of Sciences, Kyushu University, [3]Faculty of Science and Technology, Seikei University, [4]National Institude of Information and Communications Technology

In order to reveal mechanical interactions among dynamics in the troposphere, in the stratosphere, in the mesosphere, and in the lower thermosphere during the stratospheric sudden warming (SSW) in Jan. 2009, we analyze global atmospheric circulation and its disturbances appearing in the Ground-to-topside model of the Atmosphere and Ionosphere for Aeronomy (GAIA) data [Miyoshi et al., 2011]. We put the JMA/JRA data in the lower atmosphere part of GAIA. Finally, the GAIA data are interpreted by using results from a simplified transformed Euler equation.

It is concluded that the dynamical effects caused by the heating and disturbances in the SSW depend on latitudes. This dependence is derived mainly from latitudinal and meridional non-uniform structures of the m=2 planetary wave which propagates up to the lower mesosphere. It is also revealed that, during the 2009-Jan. event, a symmetric atmospheric circulation in the northern hemisphere appears first in the mesosphere and propagates down to the upper troposphere. The downward propagation of the circulation exhibits latitudinal variations in its structure.

The Arctic Oscillation (AO) is related to the SSW. As the present study manifested that the SSW is initiated in the mesosphere, the AO is controlled by the mesospheric dynamics. Because the AO is assumed to be related with the cold winter, it may be concluded that the mesospheric dynamics plays an important role in generating a cold winter.

Miyoshi, Y., H. Fujiwara, H. Jin, H. Shinagawa, H. Liu, and K. Terada (2011), Model study on the formation of the equatorial mass density anomaly in the thermosphere, J. Geophys. Res., 116, A05322, doi:10.1029/2010JA016315.

Keywords: stratspheric sudden warming, mesosphere, troposphere, arctic oscillation, GAIA model

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AAS22-09 Room:201B Time:May 21 11:15-11:30

Predictability of the major stratospheric sudden warming in the Southern Hemisphere for September 2002

TAGUCHI, Masakazu[1*]

[1] Aichi University of Education

A lot of attention has been drawn to dynamically coupled variability between the extratropical troposphere and stratosphere including stratospheric sudden warmings (SSWs) as an outstanding example. Existing studies have investigated such variability through diagnostic analyses of observational (reanalysis) and model simulation data as well as numerical experiments. Extensive studies using forecast data have been recently made in terms of predictability of SSWs. However, predictability of SSWs of a wavenumber 2 type (vortex split) has been relatively unexplored. This study seeks to investigate predictability of the major SSW in the Southern Hemisphere for September, 2002 using hindcast experiment data of one-month ensemble predictions conducted by Japan Meteorological Agency (JMA).

We use the JRA/JCDAS reanalysis data as a reference for the real world. We compare, to the reanalysis data, the JMA hindcast experiment data of one-month ensemble predictions. The experiment covers the period from 1979 to 2009. The predictions are initialized on the 10th, 20th, and last day of each month, with an ensemble size of 5. The polar night jet reverses its direction in late September of 2002, with an easterly wind peak on 9/27, accompanied by increased wave activity entering the stratosphere. We mainly focus on the predictions from (A) 8/31, (B) 9/10, and (C) 9/20 of 2002 to investigate these variations.

Our comparison between the reanalysis and prediction data shows the following features: Predictions initialized later forecast the wind variability better. The predictions of A and B do not at all show zonal wind reversals, whereas some of C do; The predictability of the zonal wind well corresponds to that of wave activity in the lower stratosphere. The predictions B underestimate the magnitude of the increased wave activity, whereas those C does the persistence; The predictability of the wave activity is further related to that of upper tropospheric anomalies. A blocking ridge over the South Atlantic, contributing to the increase in the wave activity, is likely the key for the above features.

We will also examine SSWs of the wave 2 type (2009 and 1989 cases) in the Northern Hemisphere.

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AAS22-10 Room:201B Time:May 21 11:30-11:45

On the dynamical responses in the middle atmosphere to ozone recovery and CO_2 increase

OKAMOTO, Kota[1*], Rolando R. Garcia[2], SATO, Kaoru[1]

[1]The University of Tokyo, [2]National Center for Atmospheric Research

Observational evidences have shown the stratospheric ozone decrease in the past decades. A preceding paper to the present study, Smith et al. [2010], examined the response of the mesospheric circulation and temperature to the past ozone loss using data from the Whole Atmosphere Community Climate Model (WACCM) developed by National Center for Atmospheric Research. They found a strong negative trend in the strength of the mesospheric residual flow driven by gravity waves in the Southern Hemisphere (SH) during early summer. The resultant temperature trend through the adiabatic process is positive in the polar mesosphere and negative in the polar lower thermosphere. The mechanism can be explained as follows: Ozone depletion leads a cooling trend in the lower stratosphere. The increase of positive temperature gradient is accompanied by westerly wind even in the early summer. The early summer westerly wind reduces the net eastward gravity wave drag in the mesosphere by wave filtering in the lower stratosphere. The residual flow from the summer to winter hemispheres is then weakened to modify the temperature responses around the polar mesopause.

On the other hand, many chemistry-climate models have simulated the disappearance of the ozone hole by the mid-21st century. One of the purposes of the present study is to investigate how the dynamical response changes in the ozone recovery period in the WACCM simulation for the 21st century. We have investigated linear trends of temperature, zonal wind, and residual circulation in the early SH summer in the period of 2005-2050 simulated by WACCM. Antarctic ozone recovery leads to temperature increase in early summer in the lower stratosphere which weakens westerly winds in the stratosphere. This mean zonal wind change modifies the filtering of gravity waves propagating into the mesosphere. The penetrating gravity waves accelerate the mesospheric equatorward flow which is followed by the accelerated upwelling below the mesopause in the southern polar region. These results support the mechanism of Smith et al. [2010].

In addition to ozone changes, the CO_2 emission scenarios are included in the WACCM simulation. The CO_2 variation also influences the background temperature fields by modification of radiation balance. We compared three simulations with different CO_2 scenarios to examine dynamical responses to them in the period of 2050-2100. An interesting feature appears around the winter stratopause. In the simulations, the winter polar stratosphere has warming trend against our intuition for CO_2 increase which has cooling effect on the stratosphere. The warming trend is caused by the acceleration trend of the Brewer-Dobson circulation due to the increasing trend of the amount of the E-P flux convergence in the upper stratosphere. At the same time, the westerly in the polar stratosphere is weaker in the future through the thermal wind balance. The wind profile filters the gravity wave propagation into the mesosphere. As a result of reduction of the net westward gravity wave drag, the mesospheric meridional circulation is decelerated. The winter polar mesospheric temperature then decreases by the decrease of adiabatic heating due to weakened downwelling. Combination of the cooling in the polar mesosphere and warming in the polar stratosphere lowers the stratopause height defined as the vertical temperature maximum.

Keywords: residual circulation, atmospheric waves, future prediction

AAS22-11 Room:201B Time:May 21 11:45-12:00

Intercomparison of the stratospheric ozone data assimilation among three CTMs based on observation system experiments

NAKAMURA, Tetsu[1*], AKIYOSHI, Hideharu[1], DEUSHI, Makoto[2], MIYAZAKI, Kazuyuki[3], Kobayashi Chiaki[2], SHIBATA, Kiyotaka[2], IWASAKI, Toshiki[4]

[1]NIES, [2]MRI, [3]JAMSTEC, [4]Tohoku University

The impact of the model performance on the stratospheric ozone analysis is investigated using three different models with a common chemistry-meteorology coupling data assimilation framework. To develop a system for assimilation of meteorological field variables with ozone, we used a local ensemble transform Kalman filter (LETKF) with the CCSRNIES chemistry-climate model (CCM), the MRI CCM, and the CHASER chemical transport model (CTM). For the assimilation, we used ozone profiles provided by Aura/Microwave Limb Sounder (MLS) and total ozone provided by the Ozone Monitoring Instrument-Total Ozone Mapping Spectrometer (TOMS). We also used meteorological field variables of reanalysis data (JMA Climate Data Assimilation System), assimilated by LETKF or nudged, to drive the models. As a result, we found the effects of model bias in ozone on their assimilation performance as follows:

1. MLS assimilation

- The model-bias deteriorated the assimilation performance through the amplifying the growth of errors and preventing that of the ensemble spread. Both of these caused an underestimation of the forecast error covariance.

- An ozone bias causes a temperature bias through the radiation process. Therefore, in the stratosphere, reduction of the ozone bias by the assimilation of MLS ozone profiles greatly led to a reduction of temperature bias.

- In contrast, in the upper stratosphere and mesosphere, where the ozone concentration is mainly controlled chemically, the MLS assimilation did not work effectively. In this altitude range, the ozone spread rapidly converges to a photochemical equilibrium value. As a result, LETKF underestimated the forecast error of ozone because of the small ensemble spread relative to the observation error. In order to avoid the underestimation of forecast error, including some other chemical species into the assimilation will be needed to perturb the chemical equilibrium.

- In the troposphere, MLS ozone assimilation did not improve tropospheric ozone profiles because of the lack of data in the middle and lower troposphere and the large uncertainties of the data in the upper troposphere. The error in total ozone was not sufficiently reduced by the MLS data assimilation because of the uncorrected bias in tropospheric ozone. This is evident in the CCSRNIES model, which showed a large bias in ozone in the troposphere. Further, the MLS ozone assimilation for total ozone in CHASER was less effective than that in CCSRNIES and MRI, because in CHASER the ozone concentration above 70 hPa was fixed to the climatology.

2. OMI-TOMS assimilation

- Assimilation of OMI-TOMS total ozone data modified the ozone concentration profiles thorough the forecast error covariance, with the result that the modeled total ozone was close to the observation. In this study, we used a simplified method for vertical localization in which the localization distances were set to zero. It might be necessary to choose the localization distance more carefully to improve the assimilation performance. For example, applying a vertical localization using averaging kernel may be effective.

3. MLS and OMI-TOMS assimilation

- Assimilation of both MLS and OMI-TOMS data greatly reduced biases in the ozone profiles in both the stratosphere and the troposphere, resulting in a good assimilation performance for total ozone. Biases in total ozone were nearly zero, and the RMSE was smaller than the SCIAMACHY observation error in the NH and tropics. The biases between the CCSRNIES and MRI models showed little difference, although bias of CCSRNIES without assimilation was larger than that of MRI.

Keywords: stratospheric ozone, chemistry transport model, a local ensemble transform Kalman filter, data assimilation

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AAS22-12 Room:201B Time:May 21 12:00-12:15

Warming trends in the tropical tropopause layer estimated from GPS radio occultation in 2001-2010

MEHTA, Sanjay[1*], Toshitaka Tsuda[1], Masatomo Fujiwara[2]

[1]RISH, Kyoto University, Japan, [2]Hokkaido University, Sapporo, Japan

This study investigated the long term changes in the tropical tropopause layer (TTL) temperature using GPS radio occultation (RO) data form the German CHAMP satellite mission for the period May 2001-December 2007 and US?Taiwanese COSMIC six satellite mission for the period May 2006 - December 2010 in the latitude belt 15 S-15 N. Although continuous GPS RO data is only available for about 10 years, yet it has emerged as potential data to study the interannual changes of the TTL. The radiosonde data for period 1980-2010 in in the latitude belt 15S-15N is also used to compare the result. The TTL is the layer in the tropics between the level of main convective outflow level and the cold point tropopause (CPT), about 12-19 km. However, we use temperatures between altitudes 8-30 km which account both tropospheric (below the TTL) and stratospheric (above the TTL) processes besides TTL. The linear regression analysis was applied to the deseasonalized monthly mean temperature time series for each 1-km altitude bin for the periods 1980-2000 and 2001-2010 separately. The regression analysis included the components representing quasi-biennial oscillation (QBO), El Nino Sothern Oscillation (ENSO) and 11-year solar cycle for the period 2001-2010 as well as volcanic aerosols for the period 1980-2000. The analysis reveals dominance of the QBO (1-3 K/QBO index) in the upper part and above the TTL with maxima at the equator, particularly for the period during Northern Hemispheric (NH) autumn and winter during 2010-2010. The dominance of the ENSO is also seen within the TTL and below it (~ 0.5-1.0 K/ENSO index) with maxima at the equator, particularly during NH spring and summer during 2001-2010. Solar cycle effect was found to be negligible during 2001-2010.The troposphere below the TTL show warming trend (0.1-0.3 K/decade), while the TTL and above it shows cooling trend (0.2-1.2 K/decade) during 1980-2000. The TTL shows slow warming trend (0.5-1.0 K/decade) during 2001-2010 in contrast to period 1980-2000. The warming in the TTL could be possibly attributed due to increasing greenhouse gases.

Keywords: Tropical Tropopause Layer, GPS Radio Occultation, Temperature Trend, Global Warming

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AAS22-13 Room:201B Time:May 21 13:45-14:00

Relationship between relative humidity and cirrus clouds in the tropical tropopause layer over Indonesia

INAI, Yoichi[1*], SHIBATA, Takashi[2], FUJIWARA, Masatomo[3], HASEBE, Fumio[3], Holger Voemel[4]

[1]Tohoku Univ., [2]Nagoya Univ., [3]Hokkaido Univ., [4]DWD, Germany

The relationship between relative humidity and cirrus clouds in the tropical tropopause layer (TTL) is investigated using balloon-borne cryogenic frost-point hygrometers (CFH) and quasi-collocated measurements of space-borne Cloud-Aerosol Lidar with Orthogonal Polarization (CALIOP) at two stations in Indonesia in January 2007 and 2008: Biak (1.17S, 136.06E) facing the western Pacific and Kototabang (0.20S, 100.32E) facing the eastern Indian Ocean. High supersaturations have been measured inside cirrus clouds. At Kototabang, thin layers of high supersaturation, up to ~160%, are often observed co-existing with cirrus clouds at altitudes of 15-18 km. At Biak, relative humidity over ice (RHi) inside the TTL cirrus is around 100% or less without large supersaturation layers, and most clouds are limited to altitudes below 16 km. Analysis of background meteorological fields and convective activity suggests that high supersaturations in cirrus clouds in this study are produced away from deep convective regions and where a well-developed transition layer exists between convective and highly stratified regions.

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On the turbulent mixing and ozone variations around the tropical tropopause associated with Kelvin waves

KOISHI, Kazunari[1*], Masato Shiotani[1], Junko Suzuki[2]

[1]Research Institute for Sustainable Humanosphere, Kyoto University, [2]Japan Agency for Marine-Earth Science and Technology

We investigated the observed variations of ozone around the tropical tropopause in relation to large-scale waves both in the altitude and isentropic coordinates with ozonesondes provided by SHADOZ (Southern Hemisphere ADditional Ozonesondes) for period 1998-2009. Because ozone near this level can be used for the tracer of atmospheric motion, we regarded an ozone enhancement as the signal of a turbulent mixing. Global-model outputs (often >1.5 km) have difficulty analyzing the fine structure of ozone and temperature. Hence this study presents observed variations using ozonesondes (<0.2 km). Based on the signals of Kelvin waves (an eastward-traveling component of equatorial waves) which is filtered in the spectral-frequency domain using reanalysis data (ERA-Interim), we clarified the dependency of the observed profiles to phase evolution of the large-scale wave. In the phase-height cross sections or, in other words, the longitude-height cross sections for eastward-traveling Kelvin waves, the composite temperature and ozone profiles showed clear in-phase relationship. The phase line of temperature and ozone anomalies tilted eastward, indicating the undulation of isentropic surfaces associated with Kelvin waves. Finally, to avoid the influence of vertical advection accompanied by the waves, the ozone variation in the phase-isentrope cross sections were shown. The temperature anomalies still showed the phase progression associated with Kelvin waves. As for the ozone anomalies, however, the phase progression almost disappeared, but the enhancement of ozone was seen in the warm phase around 420 K level. Focusing on the positive ozone anomalies around 420 K level, the enhancement of ozone corresponded to the transition from warm to cold temperature anomalies. This suggests that the turbulent mixing may occur in the shear zone particularly for the warm anomaly. These observational results imply the connection between small-scale mixing and large-scale waves. May be there is the large shear zone near the maximum of temperature. Further research which is focused on the wave properties and the structure of temperature and wind is required.

Keywords: turbulence, equatorial wave, ozone