Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

AAS22-P01 Room:Convention Hall Time:May 21 17:00-18:30

SMILES L2 Product improvements in v2.X updates

MITSUDA, Chihiro[1*], SUZUKI, Makoto[2], MANAGO, Naohiro[2], NAITO, Yoko[3], TAKAHASHI, Chikako[1], IMAI, Koji[4], HAYASHI, Hiroo[5], SHIOTANI, Masato[5], SANO, Takuki[2], TANIGUCHI, Hirotomo[1], Masahiro Takayanagi[2]

[1]Fujitsu FIP Corporation, [2]Japan aerospace exploration agency, [3]Graduate School of Science, Kyoto Univ., [4]TOME R&D Inc., [5]RISH, Kyoto Univ

In this presentation, we will introduce about processing status of level 2 products of JEM/SMILES. Latest product v2.1 was already released for RA researchers), and it will be released to the general users in spring, 2012.

The SMILES (Superconducting Submillimeter-Wave Limb-Emission Sounder) has 4K-cooled superconducting mixers and had observed atmospheric spectra with high sensitivity for about half a year from Oct. 12, 2009. SMILES observes three submillimeter bands defined as band A, B, and C. Frequency coverages are 624.32-625.52 GHz, 625.12-626.32 GHz and 649.12-650.32 GHz, respectively. Standard L2 products are O_3, HCl, ClO, HNO_3, CH_3CN, HOCl, HO_2, BrO and O_3-isotioes (^{17}OOO, $O^{17}OO$, ^{18}OOO) in the stratosphere.

In Sep., 2010, version 2.0 products were released for RA researchers. Objective of v2.0 product is to reduce temperature bias. In the stratosphere, temperature of SMILES v1.3 is 2% higher than other satellite observation like as TIMED/SABER, AURA/MLS, and assimilated data like as GEOS-5. This is the largest issue in v1.X series since temperature is a basic parameter which characterizes the atmospheric structure. Temperature bias may suggest biases of other products.

The new products used latest L1B 007 which includes gain nonlinearity effect of receivers. The bias of temperature in upper stratosphere is successfully suppressed. In addition, we stopped temperature retrieval above 40km and refer MLS temperature product (v2.2) with applying migrating tidal model. HCl profiles in mesosphere became constant. This feature is suggested by Cl chemistry. V2.1 which was released in Jan. 2012 is miner update version for HOCl. HOCl lines are located near $O_{3\ (v1,3)}$ and ^{18}OOO. In this version, some parameters of these lines were changed and residual spectra were compressed. HOCl difference between SMILES and WACCM around 30km was suppressed.

Keywords: International Space Station, Kibo, O3, Data Processing, retrieval

AAS22-P02 Room:Convention Hall Time:May 21 17:00-18:30

Validation of the SMILES Level 2 version 2.1 ozone data by using ozonesonde measurements

IMAI, Koji[1*], FUJIWARA, Masatomo[2], SUZUKI, Makoto[3], MANAGO, Naohiro[3], SANO, Takuki[3], MITSUDA, Chihiro[4], NAITO, Yoko[5], SHIOTANI, Masato[6]

[1]TOME R&D Inc., [2]Faculty of Environmental Earth Science, Hokkaido University, [3]Institute for Space and Astronautical Sciences, Japan Aerospace Exploration Agency, [4]Fujitsu FIP Corporation, [5]Graduate School of Science, Kyoto University, [6]Research Institute for Sustainable Humanosphere

Superconducting Submillimeter-Wave Limb-Emission Sounder (SMILES) onboard International Space Station has provided global measurements of ozone (O3) profiles in the middle atmosphere from 12 October 2009 to 21 April 2010. We present validation studies of the SMILES version 2.1 ozone product in the altitude range from 16 km to 30 km using ozonesonde measurements.

A total of 225 ozonesonde profiles from 33 ozonesonde stations worldwide are compared with a total of 471 coincident SMILES ozone profiles. The agreement between the SMILES and the ozonesonde measurements is within 5% and better at higher latitudes in the altitude range from 26 km to 30 km.

Keywords: International Space Station, Kibo, SMILES, O3, ozone

Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

AAS22-P03 Room:Convention Hall Time:May 21 17:00-18:30

Validation of the SMILES Level 2 version 2.1 stratospheric ozone

IMAI, Koji[1*], SHIOTANI, Masato[5], SUZUKI, Makoto[2], MANAGO, Naohiro[2], SANO, Takuki[2], MITSUDA, Chihiro[3], NAITO, Yoko[4]

[1]TOME R&D Inc., [2]Institute for Space and Astronautical Sciences, Japan Aerospace Exploration Agency, [3]Fujitsu FIP Corporation, [4]Graduate School of Science, Kyoto University, [5]Research Institute for Sustainable Humanosphere

Superconducting Submillimeter-Wave Limb-Emission Sounder (SMILES) onboard International Space Station has provided global measurements of ozone (O3) profiles in the middle atmosphere from 12 October 2009 to 21 April 2010. We present validation studies of the SMILES version 2.1 ozone product in the stratosphere using other data sources: satellite data and chemical-climate models. The SMILES ozone data agree with most of other satellites data within 10- 15% at an altitude between 20 km and 50 km.

Keywords: International Space Station, Kibo, SMILES, O3, ozone

Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

AAS22-P04 Room:Convention Hall Time:May 21 17:00-18:30

Analysis of Arctic stratospheric minor gases related to ozone depletion observed with JEM/SMILES in 2009/2010

TACHIBANA, Yuji[1*], SAITOH, Naoko[1], KASAI, YASUKO[2]

[1]Center for Environmental Remote Sensing, Chiba University, [2]National Institute of Information and Communications Technology

The Superconducting Submillimeter-Wave Limb-Emission Sounder (SMILES) is a sensor equipped in the Japanese Experiment Module "KIBO" on board the International Space Station (ISS), which has unprecedented high sensitivity with superconducting technology. SMILES had observed atmospheric minor constituents in the stratosphere and mesosphere from November 2009 to April 2010 with more than ten times the precision of other existing sensors. We analyzed SMILES L2 research products provided by the National Institute of Information and Communications Technology ("L2r") to discuss the relationship between temperature and stratospheric minor gases related to ozone depletion in the Arctic winter of 2009/2010.

Analysis of the SMILES L2r temperature data from 60 to 65^{o}N showed that the lowest temperatures occurred in a region centered at 30^{o}E at 24 km in January. The lowest temperature region shifted downward to 20 km in February. Here, we compared the SMILES L2r temperature data with the Goddard Earth Observing System Model Version 5 (GEOS-5) temperature data to assess the data quality of the L2r temperature product. Temperature data derived from Band B of SMILES had no distinct bias to the GEOS-5 temperature data, and those from Band A of SMILES were 5-10 times higher than the corresponding GEOS-5 temperature data.

Nitric acid concentrations were low in the lowest temperature region at 24 km in early and mid-January; in the same region, HCl concentrations decreased, ClO concentrations increased, and ozone concentrations slightly decreased. Similar feature was also seen at 20 km in late January and early February. These results suggest that Polar Stratospheric Clouds (PSCs) that were mainly composed of nitric acid were formed under cold conditions, and heterogeneous reactions on the surface of the PSCs particles occurred in these regions.

We calculated Nitric Acid Trihydrate (NAT) saturation temperature ("T_{NAT}") at each measurement location by using SMILES L2r nitric acid data. In the region where temperatures were lower than the calculated T_{NAT}, the amount of nitric acid was low, and the concentrations of HCl and ClO dramatically decreased and increased, respectively. However, changes in concentrations of nitric acic, HCl, and ClO were also seen in relatively warm region with temperatures higher than T_{NAT}; for more detailed analysis, we have to evaluate the quality of the L2r nitric acid data through comparisons with other independent data.

Keywords: stratospheirc minor gases, ozone depletion, remote sensing

Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

AAS22-P05 Room:Convention Hall Time:May 21 17:00-18:30

Validation of stratospheric and mesospheric HCl (L2r product) measured by SMILES

YOKOYAMA, Kengo[1*], TAKESHI Manabe[1], YASUKO Kasai[2], HIDEO Sagawa[2], KODAI Suzuki[3]

[1]Osaka Prefecture University, [2]NICT, [3]University of Tokyo

SMILES (Superconducting Submillimeter-Wave Limb-Emission Sounder) was attached to the ISS (Inter-national Space Station) / JEM (Japanese Experiment Module) to focus on molecules related to ozone destruction which includes hydrogen chloride (HCl). The period of observation covers October 2009 to April 2010. SMILES observes two HCl isotopes, H35Cl and H37Cl, in different SMILES frequency bands. The observation frequency of SMIELS includes three bands around 625 and 649 GHz (called Band A, Band B and Band C). H37Cl and H35Cl are observed in the Band A (624.32-625.62 GHz) and B (625.12-626.32 GHz) of the AOS (Acousto-Optic Spectrometer), respectively. The altitude distributions of the volume mixing ratio of HCl (called Level-2 product) are derived from the measured spectra separately for H37Cl and H35Cl.

HCl is estimated to comprise 95% of total stratospheric chlorine (Cl) and it is a reservoir molecule in the chlorine chemistry relating to the ozone depletion in the stratosphere. We can predict the future distribution of ozone as the results of researching the global distribution of halogen molecules including HCl.

Several instruments including Aura/MLS (Microwave Limb Sounder) and ACE/FTS (Fourier Transform Spectrometer) have observed the global distribution of HCl before SMILES observation. But these measurement results show a difference of 0.2 ppbv at about 53 km [S.A. Montzka et al 2011]. This research shows the comparison and validation between SMILES HCl (Level-2 Research product version 2.1.5) profiles and Aura/MLS and ACE/FTS. The L2r HCl profiles retrieved from the band A agreed with those from Aura/MLS at the altitudes from 25 km to 50 km , but the difference of the HCl profiles between L2r and Aura/MLS becomes larger at the altitude higher than 50 km. We confirmed the same tendency for the comparison between the L2r HCl profiles retrieved from the band B and Aura/MLS.

Keywords: HCl, SMILES

Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

AAS22-P06 Room:Convention Hall Time:May 21 17:00-18:30

HCl/Cly ratios of just before the breakup of the Antarctic vortex as observed by SMILES/MLS/AC FTS

SUGITA, Takafumi[1*], KASAI, YASUKO[2], TERAO, Yukio[1], HAYASHIDA, Sachiko[3]

[1]National Institute for Environmental Studies, [2]National Institute of Information and Communications Technology, [3]Nara Women's University

The International Space Station (ISS) / Japanese Exposure Module (JEM) borne instrument, the Superconducting Submillimeter-Wave Limb-Emission Sounder (SMILES), was successfully launched by the Japanese H-II Transfer Vehicle (HTV) on 11 September 2009 to measure chemical species in the stratosphere. We focus on inorganic chlorine species measured inside the Antarctic vortex in late spring when it is just before the breakup. At that time and location, the hydrogen chloride (HCl) is generally a main component of the total inorganic chlorine (Cly) in the lower stratosphere.

On 19-24 November 2009, SMILES measured southern latitudes up to 66 degrees. We will use the first public release of the dataset both for the operational and the research products. High HCl values up to 2.8 ppbv were observed near 460 K potential temperature levels (at altitude of 18 km). This characteristic agrees well with that observed in the past spring inside the Antarctic vortex. Comparisons with other satellite instruments, Microwave Limb Sounder (MLS) and Atmospheric Chemistry Experiment Fourier transform spectrometer (ACE-FTS), were also made at the same time and location. The results have shown the validity of the SMILES HCl data quantitatively. This also confirms the high HCl/Cly ratios inside the Antarctic vortex just before the breakup of the vortex. Then, such a feature in the recent past was examined using the MLS data between 2004 and 2011. It is found that this feature is rather regular in this late spring period in the Antarctic. Implication for this is to suggest that the future trend of Cly in the stratosphere can be deduced at this time and location by utilizing some aircraft or balloon measurements of HCl even below 20 km, as if no satellite measurement of HCl in the upper stratosphere in the future.

Keywords: stratosphere, antarctic, polar vortex, inorganic chlorine

Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

AAS22-P07 Room:Convention Hall Time:May 21 17:00-18:30

Mesospheric O3 observed by ISS/JEM/SMILES

SANO, Takuki[1*], MANAGO, Naohiro[1], SUZUKI, Makoto[1], MITSUDA, Chihiro[2], TAKAHASHI, Chikako[2], IMAI, Koji[3], AKIYOSHI, Hideharu[4], SAKAZAKI, Takatoshi[5], FUJIWARA, Masatomo[5], NAITO, Yoko[6], NISHI, Noriyuki[6], TAKAHASHI, Kenshi[7], HAYASHI, Hiroo[7], SHIOTANI, Masato[7]

[1]Institute of Space and Astronautical Science, JAXA, [2]Fujitsu FIP Corporation, [3]Tome R&D Inc., [4]Center for Global Environmental Research, NIES, [5]Graduate School of Environmental Science, Hokkaido University, [6]Graduate School of Science, Kyoto University, [7]Research Institute for Sustainable Humanosphere, Kyoto University

The Superconducting Sub-millimeter Limb-emission Sounder (SMILES) onboard Japan Experiment Module (JEM) of the International Space Station (ISS) have observed atmospheric minor constituents related with ozone chemistry, such as O_3, HCl, ClO, HO_2, HOCl, BrO, with high sensitivity. Especially, O_3, HCl and ClO can be detected with altitude up to the mesosphere (around 80km). In comparison with the stratosphere, "in situ" photochemistry controls concentration of minor constituents, so that we can examine current understanding of whole atmospheric chemical reactions by the direct comparison with SMILES observational data and results from numerical model calculations. In this study, we report the characteristics of mesospheric ozone observed with SMILES, some results of comparative validation with past satellite data and numerical model calculations, and diurnal variation of mesospheric ozone.

In the atmospheric chemistry studies, numerical models calculation are the powerful tools for understanding of observation data and future forecasting, but we have to notice that the rates of chemical reactions which these models based on may have 30-50% of error, because these coefficients are extrapolated to stratosphere / mesosphere from the results from laboratory experiments. Therefore, the observation results of mesospheric minor constituents with 10-20% of error, such as SMILES data, can review the whole of past science of atmospheric chemistry with unprecedented accuracy.

Mesospheric ozone have been observed with ACE-FTS onboard Scisat-1, SABER onboard TIMED, and MLS onboard EOS-Aura. In this study, we have compared SMILES data with ACE-FTS and SABER (MLS data exists only for sunrise and sunset localtime, so they cannot be used for this comparison), as well as reproduction results of meteorological field from numerical model (SD-WACCM) calculation. As a result of this comparison, SMILES data relatively agreed with the results from SD-WACCM and 1.27micron-channel of SABER.

It is known that mesospheric ozone distribution has diurnal variation, such as time-variable characteristics after sunset, from numerical model calculations. Though the quality of past ground-based and space-borne observation data are not enough for discussing these diurnal variation. Thank to the unique orbital characteristics, diurnal variation can be plotted from about 45-day data of SMILES observation. The diurnal vatiation of mesospheric ozone will be discussed in combination with the mixing ratio of water vapor, so we also report these results.

Keywords: SMILES, Mesosphere, Atmospheric minor constituents, Ozone, Diurnal variation, Satellite observation

Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

AAS22-P08 Room:Convention Hall Time:May 21 17:00-18:30

Analysis on the seasonality of the QBO influence on the global circulation by making time-lagged composites

Kayo Sakurai[1], NAITO, Yoko[1*], YODEN, Shigeo[1]

[1]Graduate School of Science, Kyoto University

1. Introduction

The QBO (quasi-biennial oscillation) is a phenomenum which is dominant in the equatorial storatosphere, and has influence on the extratropical circulation by modifiying meridional circulation and propagation of the planetary waves (Baldwin et al., 2001). In most of the previous works studying such influences of the QBO, composites for each month have been made according to the QBO phase in the ralevant month. In these cases, it is hard to make discussion about continuity of the features obtained for a sequential months. In the present study, therefore, we make time-lagged composite analysis in which the QBO phase in a fixed month is used to make composites for sequential months in order to investigate seasonality of the influence of the QBO on the global circulation.

The ERA40 data (1958-2002) are used in the analysis.

2. Time-lagged composite analysis

After Wallace et al. (1993), the phase of the QBO is defined with the phase angle of PC (principal conponent) 1 and PC 2 obtained from the EOF (empirical orthogonal function) analysis on the zonal wind in the equatorial lower stratosphere. The probability density function of the phase angles in June for 44 years shows bimodal structure: less frequent around -pi/2 and pi/2 and more frequent around 0 and pi. We fix a key month to June in defining two groups "Westery" and "Easterly", and make composites for sequential months before and after the key month.

3. Results

In the present analysis, a composite obtained for six months before the key month is different from that obtained for six months after the key day, for example.

By extending the period of composite to several years before and after the key month, it is shown that descending of the easterly or westerly winds in the equatorial stratosphere as the QBO starts in a specified phase (in September-October or in December-January, respectively) of the SAO (semiannual oscillation) in the upper stratosphere. It is also shown that the descending speed of the easterly or westerly winds has semiannual variation (fast in May and October).

The composites of the EP (Eliassen-Palm) flux and the residual meridional circulation show variations which are well corresponding to the variation of the desceinding speed.

References

Wallace et al., 1993 : J.Atmos.Sci., 50, 1751-1762
Baldwin et al., 2001 : Rev.Geophys., 39, 179-229

Keywords: stratosphere, QBO, SAO, dynamics

Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

AAS22-P09 Room:Convention Hall Time:May 21 17:00-18:30

Observation of ClO at the lower stratosphere by JEM/SMILES

MITSUDA, Chihiro[1*], SUZUKI, Makoto[2], MANAGO, Naohiro[2], IMAI, Koji[3], SANO, Takuki[2], Douglas E. Kinnison[4], AKIYOSHI, Hideharu[5], NAITO, Yoko[6], SHIOTANI, Masato[7]

[1]Fujitsu FIP Corporation, [2]Japan aerospace exploration agency, [3]TOME R&D Inc., [4]National Center for Atmospheric Research, [5]National Institute for Environmental Studies, [6]Graduate School of Science, Kyoto Univ., [7]RISH, Kyoto Univ.

In the chemistry of stratospheric, it is well known that the inorganic chlorine species such as ClO, HCl, HOCl, $ClONO_2$ and Cl-atom play major role. However, precision and/or accuracy of satellite observations for the inorganic chlorine species have been not sufficient for quantitative discussions of inorganic chlorine chemistry. In this paper, we report observed results of ClO in the lower stratosphere by using SMILES.

ISS/JEM/SMILES realized low-noise observation at the 650 GHz frequency region by using 4K-cooled superconducting SIS mixer. As a result, ClO was observed with high precision much better than previous observations (Aura/MLS and Odin/SMR).

Aura/MLS have been measuring ClO with a 0.1 ppbv precision at 25-50km altitude. Theoretical ClO precision of SMILES has been reported to be about 0.01 pptv at 30 km. This value can be verified from bin-width of histogram of nighttime ClO, since the ClO value during nighttime should be zero below 35km at the background atmosphere. We obtained actual bin-width, or ClO random error, to be 0.015 pptv, which is slightly larger than the theoretical value. It has been estimated that the additional random error might come from IFOV pointing error, temperature retrieval error, or baseline fitting error.

In tropical region (N10-S10), difference between day and night profiles was 79 pptv at 25 km. This result agreed quite well with reproductive calculated value (nearby 80 pptv) by using Chemical Transport Model (SD-WACCM). On the other hand, in middle latitude (N30-50) during Mar. 13-25, 2010, SMILES value were 71 pptv at 22km, and 35 pptv at 19 km. These value were significantly larger that reported as 10 pptv by airplane and balloon observation in 1986. SMILES mid-latitude value is about 3-7 times higher than the past observation, however, agrees with reproductive calculated value like as tropical region. These discrepancy in the mid-latitude between SMILES and past observation can be explained partly by the historical increase of total Clx from 2.4 pptv in 1968 to the present value, $>$3.0 ppbv.

Keywords: SMILES, International space station, ClO, stratosphere

Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

AAS22-P10 Room:Convention Hall Time:May 21 17:00-18:30

Chemistry within 2009/10 Arctic polar vortex observed by ISS/JEM/SMILES

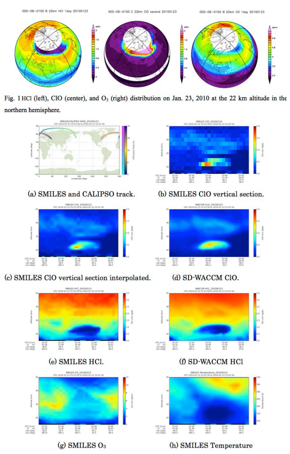
SUZUKI, Makoto[1*], MANAGO, Naohiro[1], MITSUDA, Chihiro[2], IMAI, Koji[3], SANO, Takuki[1], AKIYOSHI, Hideharu[4], NAITO, Yoko[5], SHIOTANI, Masato[6], Douglas Kinnison[7]

[1]JAXA/ISAS, [2]Fujitsu FIP, [3]Tome R&D Inc., [4]NIES, [5]Kyoto U., [6]Kyoto U./RISH, [7]UCAR

Superocnducting Submillimeter-Wave Limb-Emission Sounder (SMILES) is a 4K cooled limb sounding instrument in the 625-650 GHz frequency region, onboard International Space Station (ISS). SMILES was jointly developed by Japan Aerospace Exploration Agency (JAXA) and National Institute of Information and Communications Technology (NICT). SMILES operated from Oct. 12, 2009 to Apr. 23, 2010, when sub-mm local oscillator was suddenly terminated operation by failure. SMILES measured O3, H35Cl, H37Cl, ClO, HOCl, HO2, BrO, HNO3, CH3CN and O3 isotopes (17OOO, 18OOO, and O17OO). Precision (random error) of SMILES ClO product is about 0.01 ppb which is about 1/10 of Aura/MLS. SMILES measured 45 degree leftward from ISS forward direction, which gave latitudinal coverage of SMILES, 38S-65N.

It is well known that the chlorine chemistry (ClOx) becomes dominant when the heterogeneous processes occurred during the polar winter season. SMILES observed O3, HCl, and ClO during 2009/10 arctic winter season, as shown in Fig. 1. HCl is about 1.6 ppbt at outside polar vortex and it is almost entirely converted to the ClO (1.6 to 2.0 ppbt). O3 destruction has occurred as much as 20% (from 4 ppmv to 3.2 ppmv) after 3 weeks of heterogeneous chemical process.

Fig. 2 (a) shows trajectory of observation points of SMILES (large circles) from 15:23UT to 15:47 in Jan. 23, 2009, and CALIPSO observation points which passed north of Europe. Fig. 2(b) shows SMILES ClO vertical section. Figs. 2(c) and (d) shows horizontaly and vertically interpolated ClO of SMILES and SD-WACCM (specified dynamics-WACCM, reproduction run using GEOS-5 meteoroogical data), where slight difference is pbvious at the region observed in 15:38-15:40UTC at 20-22 km. Figs. 2 (e) and (f) shows those of HCl observed by SMILES and calculated by SD-WACCM, and HCl has been converted fully to the reactive inorganic species. Figs. 2 (g) and (h) show O3 and temperature observed by SMILES.



Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

AAS22-P11 Room:Convention Hall Time:May 21 17:00-18:30

Mesospheric HO2 and O3 Distribution in Tropical Region Measured by SMILES and Their Relation to Transient Luminous Event

SATO, Mitsuteru[1*], SUZUKI, Makoto[2], MITSUDA, Chihiro[3], SHIOTANI, Masato[4], SAKAZAKI, Takatoshi[5], FUJIWARA, Masatomo[6], AKIYOSHI, Hideharu[7], Douglas Kinnison[8]

[1]Faculty of Science, Hokkaido University, [2]ISAS/JAXA, [3]Fujitsu FIP Corporation, [4]RISH, Kyoto University, [5]Graduate School of Environmental Earth Science, Hokkaido University, [6]Faculty of Environmental Earth Science, Hokkaido University, [7]National Institute for Environmental Studies, [8]NCAR

Based on the chemical simulation of the lightning-associated Transient Luminous Events (TLEs) such as sprites and elves, it is reported that the number density of NOx, HOx and O3 in the stratosphere and mesosphere can be drastically changed after the occurrence of TLEs. Though it is reported that the occurrence of TLEs mainly centers on the tropical region and that these TLEs may affect chemistry in the tropical stratosphere and mesosphere, no qualitative analysis has been performed so far. In order to identify the chemical impact of TLEs, we analyzed the O3 and HO2 data obtained by ISS/SMILES. Based on the initial analysis, we identified that the number density of HO2 increased over the tropical continents and that the number density is about 2 times bigger than that estimated by the three-dimensional photochemical model (SD-WACCM). At the presentation, we will show more detailed HO2, O3 distributions and time variations.

Keywords: lightning, sprite, HO2, O3, SMILES

Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

AAS22-P12 Room:Convention Hall Time:May 21 17:00-18:30

Sudden Stratospheric Warming event and its impact on mesospheric compositions in 2009-2010 Arctic Winter by JEM/SMILES

MAHANI, Mona E.[1*], Daniel Kreyling[2], Hideo Sagawa[1], Isao Murata[1], Yasumasa Kasaba[1], Yasuko Kasai[2]

[1]Tohoku University, [2]National Institute of Information an Communications Technology (NICT)

The final target of this research is to find out the potential response of the atmospheric compositions affected by Sudden Stratospheric Warming (SSW) in the upper stratosphere and mesosphere. A SSW is a dramatic middle atmosphere event where the polar vortex of westerly (eastward) winds in the winter hemisphere abruptly (i.e. over the course of a few days) slows down (Minor warming) or even reverses direction (Major warming). During such events, the polar stratosphere exhibits a warming of tens of degrees over a few days and polar mesospheric cooling has also been observed during SSWs. Over the past decades, satellite instruments have observed the impact of SSW events on minor constituents like carbon monoxide (CO), ozone (O3), nitrous oxide (N2O) and water vapor (HO2). It is now clear that SSWs are dynamical disturbances affecting the entire middle and upper atmosphere, in addition to perturbing the tropospheric circulation (Kvissel, O.-K., et al., 2011).

We investigated the impact of SSW in the strato/mesosphere using newly obtained data with SMILES (Superconducting sub-Millimeter Limb Emission Sounder). SMILES is a highly sensitive radiometer with a few to several tens percent of precision from upper troposphere to the mesosphere. SMILES was developed by the Japanese Aerospace eXploration Agency (JAXA) and the National Institute of Communications and Technology (NICT) located at the Japanese Experiment Module (JEM) on board the International Space Station (ISS). From October 2009 to April 2010, SMILES has successfully measured the vertical distributions and the diurnal variations of various atmospheric species in the latitude range of 38S to 65N.

The analysis of temperature and ozone for the SSW during 1st January - 31 March 2010 was performed. Ozone increasing from January to March in the stratosphere has been confirmed. In the mesosphere, the diurnal variation structure of ozone was illustrated due to the variation in SMILES solar zenith angle. Night time ozone enhancement in the mesosphere has already been approved during this period, with respect to the temperature. SMILES observation approved the occurrence of SSW event in the end of January 2010 and the end of March 2010. SMILES observation of latitudinal, diurnal and seasonal variation of ozone in the mesosphere will be investigated in detail with the focus on discovering the impact of SSW on the mesospheric temperature and minor constituents such as O3, HCl and HO2.

Keywords: sudden stratospheric warming, SMILES, atmospheric compositions, ozone, mesosphere, diurnal variation

AAS22-P13 Room:Convention Hall Time:May 21 17:00-18:30

Predictability variations in a stratosphere-troposphere coupled system associated with winter polar vortex conditions

NOGUCHI, Shunsuke[1*], YODEN, Shigeo[1], TAGUCHI, Masakazu[2], Hitoshi Mukougawa[3], HIROOKA, Toshihiko[4]

[1]School of Science, Kyoto University, [2]Aichi University of Education, [3]DPRI, Kyoto University,, [4]School of Science, Kyushu University

Predictabilities of sudden stratospheric warming (SSW) events have been examined by the use of operational ensemble one-month forecast data produced by the Japan Meteorological Agency (JMA) (e.g., Mukougawa et al. 2005; Hirooka et al. 2007). However, they are case studies limited to a few SSW events.

In this study, intraseasonal and interannual variations in predictability of temperature inside the polar vortex in the northern hemispheric winter are investigated for seven winters of 2001/02 to 2007/8 by the use of the JMA forecast data. The ensemble one-month forecast is performed every Wednesday and Thursday from a control initial condition and several couples of perturbed conditions with both signs. In total, 26 or 50 ensemble members are taken for a week with a time-lagged (one-day) ensemble technique. The seven-winter period includes four SSW events and some minor ones.

Several measures on the predictability of the ensemble forecasts are introduced to study the predictability variations associated with dynamical conditions of the polar vortex, which are related to SSW events or vortex intensification events. Predictability limit is defined using the root mean square error as the time when it first surpasses one half of the climatological standard deviation in winter for a statistical analysis of its seasonal variation. On average, the predictability limit in the stratosphere is longer (about 10 days) than that in the troposphere (about 5 days). Its seasonal variation is large in the middle stratosphere; relatively long in early and late winter, whereas relatively short in midwinter.

The occurrence of some SSW events is well predicted by a large part of the ensemble members with a lead time of one week or so, whereas that in some other cases is more difficult to predict. We also have some examples of the predictions of an SSW event but no realization in the real atmosphere: the real world is in the other tail of the probability distribution of the ensemble forecasts of an SSW event. The occurrence or non-occurrence of such extreme events is discussed with probability distribution functions that have large non-Gaussian nature.

Keywords: stratospheric circulation, predictability, sudden warming, ensemble one-month prediction

Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

AAS22-P14 Room:Convention Hall Time:May 21 17:00-18:30

Evaluation of the molecular diffusion process in the stratosphere

SUGAWARA, Satoshi[1*], ISHIDOYA, Shigeyuki[2]

[1]Miyagi Univ. of Education, [2]AIST

It has been shown that the gravitational separation effect can be detected in the stratosphere from nitrogen, oxygen, and argon isotopic ratios and Ar/N2 ratio observed by balloon experiments. The gravitational separation has a possibility to be a new tracer of stratospheric circulation. In this study, theoretical model simulations are performed to validate an existence of the gravitational separation in stratosphere, as well as to evaluate the magnitude of isotopic discrimination of the atmospheric major components driven by molecular diffusion including the thermal diffusion. 2-D model of the middle atmosphere, SOCRATES, used in this study has a high altitude domain up to 120 km and includes molecular diffusion process above the mesosphere. In an original setting of SOCRATES, the thermal diffusion is calculated only for hydrogen atom in the mesosphere. We expanded a model domain affected by the molecular diffusion process to the stratosphere, and calculated the ratio of 32O2 and 34O2 concentrations. The molecular diffusion flux is calculated by applying a theory in Banks and Kockarts (1973). Thermal diffusion factor for the mixture of 32O2 and 34O2 is assumed to be 0.01 by considering the value previously reported in Grew and Ibbs (1952). We repeated model simulations with and without ordinary molecular diffusion and/or thermal diffusion, and compared the distributions of oxygen isotopic ratios. As a result, it is concluded that the magnitude of gravitational separation in stratosphere will be significant enough to be detected by the isotopic measurements. However, simulated magnitudes of the gravitation separation are considerably smaller than observed values. Possible effects of the thermal diffusion on isotopic ratio will be also discussed.

Keywords: stratosphere, molecular diffusion

Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

AAS22-P15 Room:Convention Hall Time:May 21 17:00-18:30

Ozone variations over the northern subtropical region revealed by ozonesonde observations in Hanoi

OGINO, Shin-Ya[1*], FUJIWARA, Masatomo[2], SHIOTANI, Masato[3], HASEBE, Fumio[2], MATSUMOTO, Jun[4], HA Hoang Thi Thuy[5], THANH Nguyen Thi Tan[5]

[1]JAMSTEC, [2]Hokkaido University, [3]Kyoto University, [4]Tokyo Metropolitan University, [5]Aero-Meteorological Observatory, Hanoi

We have conducted continuous monthly ozonesonde observations and campaign intensive observations with a few-day interval every winter at Hanoi (21N, 106E), Vietnam since September 2004. By using the obtained data, seasonal and subseasonal variations in ozone mixing ratio (OMR) are investigated and the cause of the variations are discussed. A relative standard deviation (RSD), which is defined as a standard deviation divided by the mean value, is employed to evaluate the amplitude of variation in order to eliminate the rapid increase of the mean OMR with height.

In the lower and middle stratosphere (above about 20 km height), a clear seasonal variation is found with larger values in spring and summer and with smaller values in winter which is consistent with the well-known features of seasonal variation shown by previous studies.

A seasonal cycle with a winter minimum and a spring-summer maximum is also found in the UTLS region (10–20 km) with the larger RSD of 20-30%. Backward trajectory analysis shows that the winter minimum is due to the low OMR air mass transport form the tropical troposphere. This feature is commonly seen through the UTLS region in winter. On the other hand, the variation from spring to summer seem different between above and below the tropopause level at around 17 km. Below the tropopause level (upper troposphere around 14 km), the OMR peaks in late spring (May). This peak is consistent with the air mass transport from the mid-latitude stratosphere to the deep troposphere due to tropopause foldings. Above the tropopause level (lower stratosphere around 18 km), the OMR peaks in summer (July to August). This peak seems to be caused directly by the anti-cyclonic circulation associated with the Tibetan High, which is different from the upper tropospheric increase due to the tropopause folding. In mid-summer, the well-developed tongue-shape structure with high OMR air masses moves over Hanoi. As a result, the maximum OMR is considered to appear at around 18 km height in summer over Hanoi.

In the lower troposphere, the OMR has a clear maximum in March to April at about 3 km height. The maximum seems to propagate downward from 3 km height to the surface ozone maximum in May. The relation with surface ozone enhancement due to biomass burning is suggested, although the feature with downward propagation is inconsistent with the surface source. A tropopause folding is another candidate for producing the spring ozone maximum at 3 km.

Subseasonal variations in OMR show large amplitude in the UTLS region (around 15 km) and in the boundary layer (below 1 km) with the RSD of larger than 40¥%, which is comparable to that of mean seasonal variation of OMR. It is shown that the OMR variations in the UTLS region during the every winter campaigns have a negative correlation with the meridional wind. This relation indicates that the low OMR observed at Hanoi has been transported from the equatorial region, which is confirmed by backward trajectory analyses. This result supports the interpretation that the OMR winter minimum in UTLS is caused by the low OMR air mass transport from the equatorial region where the mean ozone concentration is low.

The mean OMR values during the winter campaigns suggest an existence of significant year-to-year variability in OMR at Hanoi. In January 2006, the convective center accompanied by the anti-cyclonic circulation as Rossby response moved westward due to the La Nina condition, which result in the more frequent arrival of low OMR air masses transported from the equatorial region to Hanoi. There is a possibility that a similar large-scale circulation change associated with the ENSO variation can strongly affect the ozone and other quantities over Hanoi.

Keywords: ozone, Stratosphere troposphere exchange, Indochina Peninsula, tropopause folding, Rossby wave breaking, biomass burning

Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

AAS22-P16 Room:Convention Hall Time:May 21 17:00-18:30

Analysis of an Extratropical Cyclone and Tropopause Inversion Layer using a Meso-scale Model

TAKESHITA, Megumi[1*], OTSUKA, Shigenori[1], YODEN, Shigeo[1]

[1]Graduate School of Science, Kyoto University

Tropopause Inversion Layer (TIL) is a persistent layer with high static stability (Birner, 2002). Formation mechanisms of the TIL are not well understood, though mechanisms which may contribute the formation have been proposed, such as a dynamical mechanism due to local vertical convergence associated with a synoptic vortex (Wirth, 2003) and a radiative forcing mechanism due to heating by ozone and cooling by water vapor (Randel et al., 2007). Most of the studies so far used some idealized simulations and numerical experiments with realistic conditions have not been conducted yet.

We perform numerical experiments on a life cycle of an observed extratropical cyclone with Non-Hydrostatic Model (NHM) of Japan Meteorological Agency (JMA), which is originally used for operational numerical weather predictions. The model we modified has 200 layers in the vertical from the surface to 25 km in altitude, and the horizontal domain is 4140 km x 4000 km around Japan with a horizontal resolution of 20 km. The time integration period is 72 hours from 19th to 22nd in February, 2009, during which a typical event of explosive cyclogenesis was observed. For the initial and boundary conditions, we use NCEP/FNL data.

The TIL obtained in the control run has similar characteristics as observation, including dependence on local relative vorticity (Birner et al., 2002): stronger TIL in negative vorticity areas and weaker TIL in positive vorticity areas. But the dependence is clear only at the developing and mature stages of the cyclone, which suggests that the evolution of the cyclone plays an important role in the formation of the TIL. In the model, stronger TIL tends to appear in the areas where stronger gravity waves exist. To see the effects of gravity waves on the TIL, vertical convergence at the tropopause is analyzed. The histograms of maximum buoyancy frequency square within the TIL ($N^2{}_{max}$) show that the regions of vertical convergence show higher $N^2{}_{max}$, whereas those of vertical divergence show lower $N^2{}_{max}$. This tendency is clearer in the regions of negative relative vorticities at the tropopause. By taking account of the fact that the gravity wave activities associated with the cyclone and the jet streak seems to be enhanced during the developing and mature stages of the cyclone, the vertical convergence by gravity waves associated with synoptic weather systems can be a key in the formation of the negative correlation between the strength of the TIL and the local relative vorticity at the tropopause.

In experimental runs, water vapor is removed above 300 hPa level (EXP300) and 500 hPa level (EXP500) in the initial conditions in order to investigate the temperature response to the radiative forcing by water vapor perturbations around the tropopause. The explosive development of the extratropical cyclone is not different from the control run very much, but the TIL becomes stronger in EXP300 and weaker in EXP500. The vertical profiles of static stability in EXP300 become sharper due to the shaper vertical water vapor profile with sudden decrease of water vapor just below the tropopause (that is, 300 hPa level in EXP300). Quantitative analyses on the formation of the TIL are performed in detail to see the relative importance of dynamical and radiative forcing mechanisms.

Keywords: tropopause inversion layer, extratropical cyclone, gravity wave

Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

AAS22-P17 Room:Convention Hall Time:May 21 17:00-18:30

Chemical Reactions in the Stratosphere Induced by Transient Astronomical Ionizing Events

SEKIGUCHI, Kentaro[1*], Yoichi NAKAI[1], Takashi IMAMURA[2], Hideharu AKIYOSHI[2], Yuko MOTIZUKI[1]

[1]RIKEN, [2]National Institute for Environmental Studies

Issues on terrestrial consequences of astronomical ionizing events (such as solar energetic particle events or supernovae) have motivated researchers both in astronomy and aeronomy. We focus especially on the influences of such events on the concentration change of nitric oxides (NOx) and ozone in the stratosphere, and start to do a new simulation study at the frontier of atmospheric chemistry, chemical physics, astronomy, and climate-change research. In this research area, Thomas et al. recently performed a two-dimensional photochemical transport model calculation and reported that gamma-ray bursts could induce ozone depletion (at most 20 - 30 % depletion) in the stratosphere [1,2]. In their photochemical model, they did not explicitly consider intermediate ions to avoid heavy calculations of the ion-molecule reactions. Instead, they used reported parameters of initial nitric oxide (NOx) increase per ion pairs generated by the irradiation.

In our approach, first we directly solve differential equations of ion-molecule reactions and analyze the influence of each reaction on the concentration change of NOx species. After we find adequate values of NOx concentration change we use them as input parameters for large-scale simulation. In the future we plan to realize a three-dimensional large-scale simulation with a chemistry climate model that is more advanced than the simulation by Thomas et al. For the first step of our study, we build a zero-dimensional model where the geographical height (altitude) is the only parameter (so-called BOX model).

Due to solar energetic particle events, showers of photons (X ray and gamma ray) and high energy (>100 MeV) particles (protons, neutrons) come down to the atmosphere, and due to near-earth supernovae, showers of photons (X ray and gamma ray whose energy are less than about 1 MeV) come. These high-energy particles/photons ionize and dissociate N_2 and O_2 in the stratosphere. On this radiolytic processes of N_2 and O_2, we used the G values of radiolysis [3] to obtain the yield of product ions (N^+, O^+, N_2^+, O_2^+, e^-) and radicals ($N(^4S)$, $N(^2D)$, $N(^2P)$, $O(^3P)$, $O(^1D)$). G value is the number of product atoms or molecules per 100eV energy absorbed by the reactant system. We can roughly say that the product species generated by radiolysis of light atoms are defined only by the absorbed energy, which allow us to use G values. With this treatment we can estimate rate constants without considering the details of initial multi-step scattering processes. The ions and radicals generated by the radiolytic process react and form positive and negative ions for example, NO^+, O_4^+ ,O^-, and O_2^-. We include more than 100 chemical reactions (including ozone-destroying NOx, HOx, and halogens) at this stage and used the software for complex chemical kinetics, FACSIMILE (mcpa corp.)

In the present study, we assumed large solar-proton events (for example, see [4]) as input irradiation of the astronomical events, and represented the temporal variation of the irradiation with a step-function as Thomas et al. did in their calculations. We set the values of the fluence and duration at $1.0*10^9$ cm^{-2} and 24 hours, respectively. We did calculations with parameters (temperature and initial concentrations of chemical species) corresponding to altitudes between upper (50 km) and lower (25 km) stratosphere.

We discuss NOx concentration change and primary reaction paths, and their altitude dependence.

References

[1] B.C.Thomas, A. L. Melott, C. H. Jackman, C. M. Laird, M. V. Medvedev, R. S. Stolarski, N. Gehels, J. K. Cannizzo, D. P. Hogan, and L. M. Ejzak, Astrophys. J. 634, 509 (2005).

[2] L. M. Ejzak, A. L. Melott, M. V. Medvedev, and B.C.Thomas, Astrophys. J. 654, 373 (2007).

[3] C. Willis, A. W. Boyd, Int. J. Radiat. Chem. 8, 71 (1976).

[4] B. C. Thomas, C. H. Jackman, and A. L. Melott, Geophys. Res. Lett. 34, L06810 (2007).

Keywords: Solar energetic particle events, Supernovae, Ozone depletion

Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

AAS22-P18 Room:Convention Hall Time:May 21 17:00-18:30

A proposal of the SPARC Reanalysis/Analysis Intercomparison Project (S-RIP)

FUJIWARA, Masatomo[1*], Saroja Polavarapu[2], David Jackson[3]

[1]EES, Hokkaido Univ., [2]Environment Canada, [3]UKMO

Available global reanalysis data sets (8 currently) will be investigated for the major middle atmospheric diagnostics under the collaboration between the SPARC community and the reanalysis centers. The purposes of this project are to have a good communication platform between the SPARC community and the reanalysis centers, to understand the current reanalysis products, and to contribute to future reanalysis improvements in the middle atmosphere region. The project will have three major components: (1) the management team which deals with the overall coordination including the SPARC-reanalysis center connection, (2) the scientific working group which suggests the diagnostics covered and has the responsibility for editing and writing the final report, and (3) all SPARC-related researchers who make the data analysis, write journal papers, and contribute to the final report. The project will hold two or three dedicated workshops, where analysis results are discussed among the SPARC community and the reanalysis centers, and produce the final report as a SPARC report, which reviews the then past and near-future publications. The project duration is expected to be 3-5 years for the first phase. This project will be officially proposed at the SPARC SSG meeting in February 2012.