Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

AAS22-01 Room:301B Time:May 20 09:00-09:15

Interhemispheric differences in the roles of SAO in mid- and high latitudes

Kota Okamoto[1*], Kaoru Sato[1]

[1]The University of Tokyo

Previous studies showed the existence of the climatological upwelling in the subtropical stratopause region. It is known that the seasonal variation in the subtropical upwelling is closely related to the equatorial semiannual oscillation (SAO). The SAO and the residual circulation in the middle atmosphere are driven by atmospheric waves such as planetary waves and gravity waves. This study shows a dynamical link between the SAO and the subtropical upwelling in the austral and boreal winter from statistical analysis using a reanalysis (MERRA) data. All years (1979-2010) are divided into two groups, strong SAO years and weak SAO years, defined by the zonal wind at the equatorial stratopause. For the austral winter (July), the composite analysis shows the strong connection between the interannual variability of the SAO, the subtropical upwelling, and the planetary wave activity at lower stratosphere. Since interannual variations of the SAO and planetary wave activity affect the subtropical momentum deposition in the mesosphere, the variation in the upwelling is controlled by the SAO and planetary wave activity. In contrast, the planetary wave activity is not correlated to the subtropical upwelling for the boreal winter (January), although the SAO and the upwelling are negatively correlated. The interhemispheric difference is attributable to the difference in the property of the planetary wave. Transient planetary waves are dominant for the austral winter, while stationary component is dominant for the boreal winter.

Keywords: equatorial semiannual oscillation, residual circulation, planetary waves

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

AAS22-02 Room:301B Time:May 20 09:15-09:30

Propagation characteristics of gravity waves in the austral winter using the AIRS high resolution data

Chikara Tsuchiya[1*], SATO, Kaoru[1], ALEXANDER, M. Joan[2], HOFFMANN, Lars[3]

[1]Graduate School of Science, the University of Tokyo, [2]NorthWest Research Associates, [3]Forschungszentrum Julich

Atmospheric Infrared Sounder (AIRS) on Aqua with horizontal resolution of 13.5 km at nadir has an ability to analyze gravity waves with a long vertical and short horizontal wavelength. Wave events from mountains (Eckermann et al., 2007) and convection (Grimsdell et al., 2010) with large amplitudes have been studied, although waves from jet-front system have not yet.

In the austral winter, it is expected that AIRS data can resolve (a) waves from the jet-front system, (b) waves travelling latitudinally (Sato et al., 2009), and (c) waves from small islands with a sharp mountain (Alexander et al., 2009). The momentum transport by waves of (b) and (c) that has not been included by gravity wave parameterizations so far is thought to play an essential role to improve the strength and seasonality of the polar night jet (McLandress et al., 2012).

In this study, the AIRS high resolution temperature data (Hoffmann and Alexander, 2009) from June to August 2004 was used. To reduce the noise, temperature anomalies at the height of 30 - 48 km were averaged. Then, the S-transform which is a one-dimensional wavelet transform was applied to data series cross (along) the satellite orbit. This procedure provides amplitudes, horizontal wavelengths, and wave vector directions of wave events with a direction up to 45 degrees from the cross (along) track direction. Finally, data that was considered from the noise is excluded.

A reanalysis data MERRA was used. To diagnose the occurrence of fronts at the lower troposphere, the frontogenesis function at 600 hPa was estimated.

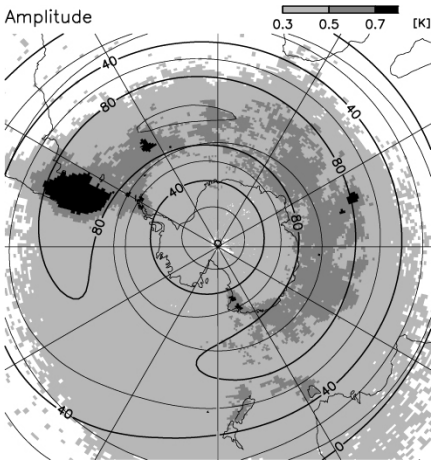
The figure shows the amplitude of wave events averaged over the analyzed period. Large values are observed in regions of Andes, Antarctic Peninsula, islands, and over the Southern Ocean.

From the analysis of the frontogenesis function, two thirds of event grids with amplitude larger than 0.5 K are accompanied with fronts. It is thought that the jet-front system is a key for the generation of observed waves.

Grid numbers in the polar night jet were categorized with the wave vector direction and latitudinal westerly wind gradient at 30 hPa, U_y. Waves dominantly have a direction to the south in regions of $U_y < 0$, although grid numbers of waves directing northward are larger than southward where $U_y > 0$. It is consistent with the previous study that waves with no meridional wavenumber at initial propagate to the jet axis due to the latitudinal wind gradient (Sato et al., 2009).

Momentum flux with events near islands and that in the other regions will be quantitatively compared each other. To clarify the generation mechanism of observed waves, the relation to the tropospheric jet and to the development of synoptic-scale storms will be discussed.

Keywords: stratosphere, gravity waves, jet-front system, satellite data, S-Transform



Japan Geoscience Union Meeting 2013
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AAS22-03 Room:301B Time:May 20 09:30-09:45

Circulation changes in the mesosphere during stratospheric sudden warming events

IIDA, Chihiro[1], Toshihiko Hirooka[2*], EGUCHI, Nawo[3]

[1]Graduate School of Science, Kyushu University, [2]Faculty of Science, Kyushu University, [3]Research Institute for Applied Mechanics, Kyushu University

Recent satellite observations show the appearance of easterly winds in the upper mesosphere just before the occurrence of the stratospheric sudden warming (SSW) event in the upper stratosphere in January 2009 (Manney et al. 2009). This is considered to be strong manifestation of stratosphere-mesosphere dynamical coupling; in order to understand this phenomenon, the accumulation of detailed investigation of SSW events would be necessary for the region throughout the atmosphere up to the mesopause level. In this study, we make dynamical analyses for wind and temperature fields up to the mesopause level during the recent SSW events by the use of Aura MLS data since 2004. It is found that easterly winds in the mesosphere do not always appear before SSW easterlies of the upper stratosphere. For the appearance of preceding easterlies in the upper mesosphere, wave driving due to internally formed or refracted large-scale waves is necessary in that region; the enhancement of such waves seems to be owing to changing background wind structure of the lower mesosphere prior to the SSW occurrence.

Keywords: stratospheric sudden warming, mesospheric circulation, MLS data

Japan Geoscience Union Meeting 2013
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AAS22-04 Room:301B Time:May 20 09:45-10:00

A role of eddy on the tropospheric circulation trend corresponding to the stratospheric ozone reduction in boreal summer

Tetsu Nakamura[1*], Koji Yamazaki[2], Hideharu Akiyoshi[3]

[1]National Institute of Polar Research, [2]Hokkaido Univ., [3]National Institute for Environmental Studies

The tropospheric responses to changes in the stratospheric ozone radiative heating are examined by assessing influences of long-term trends in the stratospheric ozone on the troposphere. A linear trend analysis was applied to five reanalysis data sets and five chemistry climate models (CCMs) for boreal summer (June-July-August) in ozone depleting period (1981-2000). Sensitivity simulations of depleting ozone using CCMs show poleward shifts of the subtropical jet and expansion of the Hadley cell as well as reanalyses show. Anomalous radiative heating associated with the decrease of the ozone induces the negative potential vorticity (PV) anomalies near tropopause. Steady responses to the ozone radiative heating anomalies evaluated by the PV inversion technique show the poleward shift of the subtropical jet but have small amplitudes in the lower to middle troposphere. Eddy feedback associated with changes in the basic state due to PV anomalies is examined by idealized experiment using dry general circulation model (GCM). In the upper troposphere, wave forcing accelerates the zonal wind north of the jet and decelerates south of the jet. Then, the deceleration forcing south of the jet drives anomalous residual mean circulation in the lower latitudes corresponding to the expansion of the Hadley cell in the middle troposphere. The Coriolis force associated with the anomalous residual mean circulation expand the zonal wind anomalies around the jet from the upper troposphere to the lower troposphere. The results suggest an important role of the stratospheric ozone on the tropospheric climate changes via modifying the eddy activity in the troposphere.

Keywords: stratospheric ozone, chemistry climate model, long-term trend

Japan Geoscience Union Meeting 2013
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AAS22-05 Room:301B Time:May 20 10:00-10:15

Long-term trend in the stratospheric quasibiennial oscillation and tropical mean upwelling

Yoshio Kawatani[1*], Kevin Hamilton[2]

[1]JAMSTEC, [2]IPRC Univ. Hawaii

The zonal-mean zonal circulation in the tropical stratosphere is dominated by the quasibiennial oscillation (QBO) between prevailing easterlies and westerlies with periods of about 28 months. The vertical structure of the QBO in the lowermost stratosphere is linked to the mean upwelling there, which itself is a key factor in determining stratospheric composition. We report on an analysis of near-equatorial radiosonde observations for 1953-2012 and reveal a previously unknown long-term trend of weakening amplitude in the QBO of zonal flow in the tropical lower stratosphere. The trend is particularly notable at 70 hPa (˜19 km), where amplitudes dropped by roughly 1/3 over the period. This trend is also apparent in the global warming simulations of the four models in the Coupled Model Intercomparison Project Phase 5 (CMIP5) that realistically simulate the QBO. This effect is most reasonably explained as resulting from a trend of increased mean tropical upwelling in the lower stratosphere. Almost all comprehensive climate models have projected an intensifying tropical upwelling in global warming scenarios, but attempts to estimate changes in the upwelling by using observational data have yielded ambiguous, inconclusive, and/or contradictory results. Discovery of a significant trend in the lower stratosphere QBO amplitude provides strong support for the existence of a long-term trend of enhanced upwelling near the tropical tropopause and this trend can be considered a subtle, but robust, indicator of the response of the climate system to anthropogenic forcing over recent decades.

Keywords: QBO, Brewer-Dobson circulation

Japan Geoscience Union Meeting 2013
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AAS22-06 Room:301B Time:May 20 10:15-10:30

Gravity waves associated with an extratropical cyclone and possible role in the formation of tropopause inversion layer

Shigenori Otsuka[1], Shigeo Yoden[2*]

[1]RIKEN Advanced Institute for Computational Science, [2]Division of Earth and Planetary Sciences, Graduate School of Science, Kyoto Univeersity

We perform a numerical simulation on the generation of gravity waves associated with an extratropical cyclone and investigate its possible role in the formation of tropopause inversion layer (TIL), which is a persistent layer with high static stability (Birner, 2002). We use a JMA regional non-hydrostatic model (NHM), which 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 explosive cyclogenesis was observed. For the initial and boundary conditions, we use NCEP FNL.

An arc-shaped wave packet propagating northward from a jet streak associated with the extratropical cyclone is identified during its developing stage, and the wave packet satisfies the dispersion relation of inertia-gravity wave with a period of about 300 minutes. Histograms of N^2 at the TIL classified by d^2w/dz^2 and dw/dz at the TIL show that enhancement of d^2w/dz^2 by vertically-propagating gravity waves have a significant impact on the strength of the TIL. The effect of gravity waves on the TIL is clearer in the regions where relative vorticity at the tropopause is negative. This result implies that gravity waves may have an important role in making the negative correlation between the strength of the TIL and relative vorticity at the tropopause.

Keywords: gravity waves, extratropical cyclone, tropopause, inversion layer, numerical simulation

Japan Geoscience Union Meeting 2013
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AAS22-07 Room:301B Time:May 20 10:30-10:45

Impacts of increase in greenhouse gases and ozone depletion and recovery on the Brewer-Dobson circulation

Makoto Deushi[1*], Kiyotaka Shibata[1]

[1]Meteorological Research Institute

In this study, present and future changes in stratospheric transport characteristics are examined using multi decadal simulations carried out with a chemistry-climate model (CCM) developed at the Meteorological Research Institute (MRI-CCM). We performed a reference run from 1960 to 2100 under a prescribed forcing in which both the greenhouse gases (GHGs) and ozone depleting substances (ODSs) vary transiently in time. In addition, we also performed two sensitivity runs in which either GHGs or ODSs held fixed at 1960 levels. We compared the two sensitivity runs with the reference run to separate effects of the ODS and GHG forcings on the stratospheric transport characteristics.

In the late 21st century, increasing of GHGs induces stronger stratospheric residual circulation with enhanced eddy horizontal transport in the mid-latitudes stratosphere. The eddy transport is especially enhanced in the northern hemisphere. In the beginning of the 21st century, when the large ozone depletion is simulated in the Antarctic, annually-averaged residual circulation and mean N_2O transport for the reference run become significantly stronger not only in the Antarctic lower stratosphere but in the southern upper stratosphere.

Keywords: climate projections, stratospheric transport, chemistry-climate model

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AAS22-08 Room:301B Time:May 20 11:00-11:15

Volatility and conposition of aerosol in tropical stratosphere and TTL

Masahiko Hayashi[1*], Takashi Shibata[2], Keiichiro Hara[1]

[1]Faculty of Science, Fukuoka Univ., [2]Graduate school of Nagoya Univ.

1. Introduction

Global circulation of atmosphere transports ozone, water vapor, methane and other constituents. Air flow from Tropical Tropopause Layer (TTL) to stratosphere passes cold tropopause. Water vapor condenses on ice nucleus and form large scale cirrus in the TTL because of cold conditions, and dehydrated air flows into the stratosphere. On the other hand, super saturation over ice was sometimes observed in TTL. Then, it is important to know aerosol compositions and their ability as ice nuclei in the TTL to understand the budget of water vapor in the atmosphere. So, we performed balloon borne observations at Biak, Indonesia in January 2011, 2012, and 2013 in order to understand aerosol size distribution and constituents in the stratosphere and TTL over western Pacific region.

2. Observation

We planned to estimate aerosol compositions from volatility observations, using dual OPCs. One of OPCs observes size distributions under ambient condition, and other one observes size distributions under heated condition through thermo denuder. OPC have ten size thresholds, 0.3, 0.4, 0.5, 0.66, 0.8, 1.2, 2.0, 3.4, 7.0, and 11.4 um in diameter for spherical particle with refractive index of 1.40. Air sampling rate is 3.0 liter/minute. Thermo denuder was constructed with a stainless steel pipe with diameter of 5 or 8 mm and a mantle heater with heating length of 50cm. Temperature of the mantle heater was controlled at 100 to 300 degree Celsius with step of 50 degrees. Laboratory experiments for test particles under 1 atm were examined and volatile temperature under TTL and stratosphere were estimated to be 100 degree Celsius for sulfuric acid, 150 or 200 degrees for ammonium sulfate and/or ammonium bi-sulfate, and more than 300 degrees for sea salt.

Dual OPCs were launched from the observatory of LAPAN in Biak Indonesia (1^o10'S ,133^o6'E) on Jan 10th, 2011 (200^oC), on Jan. 10th (200^oC), 11th (150^oC), 12th (100^oC) in 2012, and on Jan. 9th (200^oC), 10th (300^oC),,11th (250^oC)in 2013.

3. Results

a) Volcanic aerosols

An enhanced aerosol layer with concentrations of several 10s thousands particles/g-air for 0.3 um diameter was found around cold point tropopause and also found non-volatile particles with about 1 um in 2011. These layers are inferred to be volcanic layer by eruption of Mt. Merapi in November 2010. Aerosol layers with enhanced sub-micrometer aerosol concentration were also observed in the stratosphere, around 20 km, in 2012. The enhancement may be caused by eruption of Mt. Nebro in June 2011.

b) Composition of aerosols in TTL and stratosphere inferred from volatility

Major constituent of aerosol in TTL was inferred to be partially neutralized sulfuric acid, and non-volatile constituent was also included about 5 % in number concentration with 0.3-0.8 um. Cloud layers associated with convective clouds include more non-volatile constituent than in normal TTL. It is inferred that major components of stratospheric aerosol layer was sulfuric acid and also includes non-volatile constituents less than 5 % in number concentration of sub-micron particles. These results suggest that non-volatile constituent, sea salt, transported into TTL by convective clouds and transported to stratosphere through TTL.

Keywords: Tropical Tropopause Layer, aerosol, volatility, cirrus

Japan Geoscience Union Meeting 2013
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AAS22-09 Room:301B Time:May 20 11:15-11:30

Cirrus cloud particles in the tropical tropopsuse layer observed by HYVIS

Mayuko Sakurai[1*], Takashi Shibata[1], SHIMIZU, Kensaku[2], SUGIDACHI, Takuji[3], KOMALA, Ninong[4]

[1]Nagoya University, [2]Meisei Electric Co., Ltd., [3]Hokkaido University, [4]LAPAN

Water vapor in lower stratosphere has influence on sea surface temperature and stratospheric ozone. Its sources are transportation from the troposphere to the stratosphere by Brewer Dobson circulation and oxidation of methane in stratosphere. In lower stratosphere, the transportation is dominant.

The air transported from the troposphere to the stratosphere pass through the Tropical Tropopause Layer; TTL. TTL is the cold area, where cirrus clouds are formed frequently, and the air passing through TTL is dehydrated. Therefore formations of cirrus clouds determine the water vapor concentration in lower stratosphere. In addition, cirrus clouds have an effect on earth radiation budget. Number concentration and shape of cloud particles are the basic information about microphysical characteristic and radiation budget of cirrus clouds.

In this study, we studied the microphysical characteristic of cirrus cloud by observations by HYdrometeor VIdeoSonde (HYVIS, manufactured by Meisei electric co., ltd.). Balloon born HYVIS collects cloud particles on transparent film, takes images of cloud particles from behind the film, transmits the images by radio waves to the ground. This device measures changes of shape and the number of cloud particles with through the balloon ascending. The HYVIS used in this study force to introduce air. We can calculate sampling air volume by actual area and aspiration rate, and it is possible to estimate the number concentration.

Some other observations had been performed as the part of SOWER campaign at Biak (1.17 degrees South, 136.06 degrees East), Indonesia in 5-14th January 2013.

We conducted a wide variety of simultaneous observations such as lidar, Cryogenic Frostpoint Hygrometer (CFH), Optical Particle Counter (OPC), and Electrochemical Concentration Cell (ECC) ozonezonde. We launched HYVIS once in a day from 7th to 9th January 2013. The maximum duration of operation is 75 minutes. HYVIS can reach stratosphere within this duration.

The result of HYVIS observation launched at 18:46LT on 9th January shows that the size of particle and number dentistry were much smaller than typical value. The diameter of the most of the particles was 6-20 micrometers and the estimated number density of cloud particle was 10ˆ[4]-2x10ˆ[5]/m[3]. The shape of the cloud particles was almost sphere. The columnar, needle, plate-like shape particles were rarely observed. The large particles whose diameter is larger than 40 micrometers were not detected.

Ten hours before launching of the HYVIS, the clouds top hights observed by lidar was constantly 17.5 km. After launching HYVIS, due to the occurrence of thick clouds, lidar observation could not detect up to the cloud top. On the other hand, HYVIS observed cloud particles at the altitude higher than 19km. The simultaneous lidar observation detected the relatively high number density cirrus clouds from 8-17.5km altitudes. Therefore, it may be caused by the contamination of balloon or ropes when the HYVIS passed through the thick clouds.

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AAS22-10 Room:301B Time:May 20 11:30-11:45

Development of a balloon-borne chilled-mirror hygrometer for climate monitoring

Takuji Sugidachi[1*], Masatomo Fujiwara[1], SHIMIZU, Kensaku[2], IBATA, Kazumasa[3], KANAI, Yoshiyuki[3]

[1]Hokkaido University, [2]MEISEI ELECTRIC CO., LTD, [3]Azbil Corporation

Atmospheric water vapor plays important roles in the global climate system. In upper troposphere and lower stratosphere, it contributes strongly to the radiative balance and influences variability of ozone layer through its photochemical nature. Accurate monitoring of water vapor is crucial for improving our understanding of climate change. Chilled mirror hygrometers have been used as transfer standard in laboratories and metrology labs, because this type of hygrometers can measure water vapor consentration with high accuracy. We have converted FINEDEW^{TM} (Azbil Corporation), which is a chilled mirror hygrometer for industrial application, into a hygrometer for upper air observation. Because the FINEDEW^{TM} uses a two-stage Peltier cooler, it does not need cryogen and thus is easy to handle. We have conducted flight tests in Japan and Indonesia to evaluate the performance. The results showed that this hygrometer has ability to measure atmospheric water vapor from the surface to the lower stratosphere. Also, simultaneous soundings with the Cryogenic Frostpoint Hygrometer (CFH) showed good agreement at least in the whole troposphere. With some more improvements, it is considered that our hygrometer will contribute to the monitoring of water vapor in the stratosphere as well as the tropsphere.

Keywords: Water vapor, Climate, Ozone layer

Japan Geoscience Union Meeting 2013
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AAS22-11 Room:301B Time:May 20 11:45-12:00

A CCM experiment on the effects of solar proton events on HNO3 and O3 in the polar middle and lower atmosphere

Hideharu Akiyoshi[1*], Yousuke Yamashita[2], Masanao Kadowaki[3], Kentaro SEKIGUCHI[4], Yoichi Nakai[4], Takashi Imamura[1], Yuko MOTIZUKI[4]

[1]NIES, [2]JSPS postdoctral researcher, [3]AORI, University of Tokyo, [4]RIKEN

Changes in nitric acid concentration and ozone concentration in the polar atmosphere due to solar proton events are investigated using a chemistry-climate model (CCM). The CCM used in this study is the MIROC3.2-CCM that has been developed in NIES, incorporating stratospheric chemical module into the MIROC3.2-GCM, which was used for the future projection of climate by IPCC. The CCM experiments assume ten times NOx concentration of the climate value in the polar region of 60-90N and 60-90S and at the altitudes of 35-55km for the initial condition. Then the calculation is performed for three years in the atmospheric composition for the year 1900. The results are compared with those from the run without the NOx increase. The results indicate that the sedimentation of polar stratospheric clouds (PSCs) is a key process for the increase in nitric acid in the polar troposphere. For a more realistic simulation, we are developing a chemical box model which includes ion reactions in the atmosphere as well as neutral chemical reactions. The estimation of the NOx and Ox increases after solar proton events will be used for the initial condition of CCM calculation.

Keywords: solar proton event, ozone, nitric acid, polar region, chemistry-climate model

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

AAS22-12 Room:301B Time:May 20 12:00-12:15

Observation of O3, ClO, HOCl, HO2, and BrO by JEM/SMILES

Makoto Suzuki[1*], Naohiro Manago[2], Koji Imai[1], Takuki Sano[1], Chihiro Mitsuda[3], Yoko Naito[4], Hideharu Akiyoshi[5], Hiroyuki Ozeki[7], Eriko Nishimoto[6], Masato Shiotani[6]

[1]ISAS, [2]Chiba U./CeRES, [3]FIP, [4]Kyoto U., [5]NIES, [6]Kyoto U./RISH, [7]Toho U.

SMILES; Superconducting Submillimeter-Wave Limb Emission Sounder is a 4 K cooled 625-650 GHz limb sounder to observe O3, HCl, ClO, HO2, HOCl, BrO, HNO3, and O3 isotopes. SMILES had been operated on the International Space Station from Oct. 12, 2009 to Apr. 21, 2010. ?Since ISS is 51 degree inclined orbit, 30-45 days SMILES zonal mean could provide diurnal variation of chemical species in the stratosphere and mesosphere. Diurnal variation of O3, ClO, HOCl, HO2, and BrO are compared with two nudged CGCM calculations (SD-WACCM; Specified-dynamics WACCM, and MIROC) and satellite observations.

Diurnal variation of O3 agreed with SD-WACCM over 50-82 km, but small peak in the morning (7 am local time) is apparent for the SMILES but not for the SD-WACCM at 70 km.

Diurnal variation of ClO agreed quite well between SMILES L2 ver. 2.2 and SD-WACCM from 19 to 76 km altitude region. But nighttime ClO value of SMILES L2 ver. 2,2 above 50 km is less than SD-WACCM (70%), which is not clearly explained by the SMILES retrieval issue or our current knowledge of chemical kinetics.

Diurnal variation of HOCl also agreed quite nicely from 31 to 76 km. The nighttime build up of HOCl observed SMILES at 44-68 km are nicely reproduced by the SD-WACCM calculation using JPL2006 chemical kinetics dataset.

HO2 diurnal variation also agreed with SD-WACCM from 24 to 72 km. Above 76 km, SMILES L2 ver. 2.2 needs modification of a priori and its co-variance, and we will get better agreement with model calculations. SMILES L2 ver. 2.2 also shows night time bias due to AOS (Acousto-Optics Spectrometer) characteristics.

Keywords: Ozone layer, Chlorine species, Bromine species, sub-mm, International Space Station, mesosphere

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AAS22-13 Room:301B Time:May 20 12:15-12:30

Atmospheric response during annular solar eclipse of 15 January 2010

Koji Imai[1*], Hideharu Akiyoshi[2], Yousuke Yamashita[2], Makoto Suzuki[1], Masato Shiotani[3]

[1]Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, [2]National Institute for Environmental Studies, [3]Research Institute for Sustainable Humanosphere, Kyoto University

A solar eclipse is a rare, natural, global and unique perturbation experiment. The rapid changes in light intensity provide us with an excellent opportunity to prove atmospheric photochemistry, dynamic processes and the other academic fields. The longest solar eclipse of this millennium occurred on 15 January 2010, and we first grasped the variations of vertical profiles of the middle atmospheric trace gasses using high sensitivity measurements of the Superconducting Submillimeter-Wave Limb-Emission Sounder (SMILES). The observation data shows the day-night transition. Also, we simulated the event using the MIROC3.2-CTM which is one of the chemistry and transport models (CTM) developed from the chemical module of the Center for Climate System Research/National Institute for Environmental Studies(CCSR/NIES) CCM. In this presentation, we will show the impact on the atmospheric response to the abrupt change in solar forcing during the event and the inter-comparisons between the SMILES measurements and the CTM results. The study provides a striking demonstration of the dynamics of photochemical processes in the middle-atmosphere.

Keywords: middle atmosphere, stratosphere, ozone, solar eclipse, SMILES, international space station

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AAS22-P01 Room:Convention Hall Time:May 20 18:15-19:30

ENSO-induced changes in the Northern winter stratosphere revisited

Masakazu Taguchi[1*]

[1]Aichi University of Education

Using the JRA-25/JCDAS reanalysis and JMA hindcast (HC) data, this study re-examines the ENSO-induced changes in the Northern winter stratosphere.

This study seeks to better understand the observed changes in the time mean states and variability (such as occurrence of stratospheric sudden warmings, or SSWs): it is widely accepted that the polar vortex is weaker and warmer on average for warm ENSO years than for cold years, whereas occurrence of highly disturbed situations of the vortex such as SSWs is more frequent (or as frequent) for cold ENSO years. For this purpose, we utilize the reanalysis and also the HC data. The HC experiments were conducted by the JMA using March, 2011 version of the 1-month ensemble prediction system. The ensemble predictions were made from each of the 10th, 20th, and last day of each month for 1979-2009, with an ensemble size of five.

In the analysis data (real world), we first confirm the existing results that the polar vortex changes in the time mean states and variability with ENSO. Then, we find that the frequent occurrence of disturbed situations for cold ENSO years is mainly contributed by a couple of SSWs (e.g., those in 1984/85 and 2005/06 winters). These SSWs occur with moderate upward propagation and marked poleward propagation of wave activity under the easterly condition of the QBO.

In the HC data, we further show that, when initialized about 10 to 20 days before the SSWs, the data only roughly reproduce such propagation features and underestimate (or miss) the deceleration of the polar night jet. These features of the wave propagation are therefore the key for the HC data to well reproduce the SSWs, and hence the ENSO induced changes in the stratospheric variability as observed.

Keywords: stratosphere, ENSO-induced changes, stratospheric sudden warming, QBO

Japan Geoscience Union Meeting 2013
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AAS22-P02 Room:Convention Hall Time:May 20 18:15-19:30

Observation of aerosol profiles using balloon separated Unmanned Arial Vehicle at Syowa Station, East Antarctica

Masahiko Hayashi[1*], HIGASHINO, Shin-ichiro[2], UMEMOTO, Shiina[1], OZUKA, Keiichi[1], SHIGYO, Izumi[1], NISHIMURA, Motoki[2], NAGASAKI, Shuji[2]

[1]Fukuoka Univ., [2]Kyushu Univ.

Boundary regions in the upper atmosphere play important roles in the global budget of material and energy. It is difficult to perform in-situ observations and sample recovery in/from the regions. There are some platforms for them, airplane, balloon, rocket and so on. They require heavy loads and/or cost for observations.

Small Unmanned Aerial Vehicle (UAV) is one of the most cheap and mobile platforms. Recent developments of electronic devices, microcomputer, and navigation system have been drastic and it supports to develop many types of small UAV. On the other hand, a small rubber balloon is very cheap and useful to lift instruments to upper atmosphere. We started to develop new type of platform, combined a balloon and an UAV. In the first stage, an UAV is hanged and lifted by a rubber balloon to the stratosphere. Aerosol instruments borne in UAV observe aerosol concentration and collect sample during ascending. At the top altitude, planned to separate position, UAV cut hanging rope and return to ground base with instruments and sample by self-control with micro-computer system.

We performed aerosol observations upto 10 km a.s.l. at Syowa Station (69.0 oS, 39.6 oE) in January 2013, as one program of the 54th Japanese Antarctic Research Expedition. Five successful flight were carried out and observe vertical profiles of aerosol concentration ranging from 0.3 to 11.4 um in diameter, and collect sample up to 8 km a.s.l.. Tropopause is locate around 8 to 10 km a.s.l over Syowa Station in summer season.

We are planning to develop more advanced platform, using balloon, parachute, and UAV, which can realize observation up to 30 km.

We will report details of the developed new type of platform and preliminary results of aerosol observations at Syowa Station.

Keywords: balloon seperated UAV, stratospheric aerosol, Antarctica

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Updates of JEM/SMILES L2Product v2.4: improvements of mesospheric O3 and HCl profiles

Chihiro Mitsuda[1*], Makoto Suzuki[2], Naohiro Manago[3], Eriko Nishimoto[2], Yoko Naito[4], Chikako Takahashi[1], Koji Imai[5], Takuki Sano[2], Masato Shiotani[6]

[1]Fujitsu FIP Corporation, [2]Japan aerospace exploration agency, [3]Center of Environmental Remote Sensing, Chiba Univ., [4]Graduate School of Science, Kyoto Univ., [5]TOME R&D Inc., [6]Research Institute for Sustainable Humanosphere, Kyoto Univ.

The SMILES (Superconducting Submillimeter-Wave Limb-Emission Sounder) , an instrument for a joint mission of Japan Aerospace Exploration Agency and National Institute of Information and Communications Technology, had observed atmospheric submillimeter spectra from 2009/10/12 to 2010/4/21 from the International Space Station (ISS). The SMILES has 4K-cooled superconducting mixers and had performed the observation with high sensitivity and stability. Standard L2 products are O3 and some molecules related O3 chemistry, such as HCl, ClO, HNO3, CH3CN, HOCl, HO2, BrO and O3-isotopes (17OOO, O17OO, 18OOO) and v2.1 are released for non-limited users in spring, 2012. About O3, the most sensitive SMILES product, validation study with comparing other satellite data and numerical modes is already advanced [Imai et al., 2012, submitted to JGR]. Additionally, ISS, attached SMILES, has a solar asynchronous orbit and SMILES data are used diurnal variation studies [e.g. Sakazaki et al., 2013, JGR].

Latest L2 Product v2.4 is scheduled to be released in spring, 2013. It is a one of the goals of updates after v2.1 to improve upper mesospheric profiles.

In v2.1, the recommended altitude range of O3 for scientific use is 16 - 73 km since profiles vibrate in upper altitude range. It is because retrieval settings are not suitable. A priori profile of O3 is monthly climatology based on AURA/MLS v2.2 for 2005-2007. However, a priori profile above 75 km is not suitable since it is outside of useful altitude range. In v2.4, retrieval altitude range is expanded up to 120 km, and a prior profile and error are adjusted. As a result, noise in the mesosphere is reduced, and SMILES profiles has sub-peak in upper mesosphere which is observed by other satellite like SABER [Smith et al., 2013, submitted to JGR].

In HCl case, retrieval altitude range was expanded up to 100 km like O3. Additionally, about 2% of vibration near 50 km is suppressed. There are 2 factors. One is to revise AOS response function which is one of instrument functions by SMILES instrument team. Accuracy of signal extraction was improved by changing analysis method and vibration of HCl was reduced to 1 %. The other is to update inversion algorithm. Although optimal estimation method was used, Tikhonov reguralization method was also newly added. Thereby, HCl profiles become smooth.

Keywords: SMILES, JEM, Ozone, mesosphere, ISS

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Analysis of Arctic stratospheric minor gases related to ozone depletion by coupled use of JEM/SMILES and ACE-FTS

Yuji Tachibana[1*], SAITOH, Naoko[1], Takafumi Sugita[2], KASAI, Yasuko[3]

[1]Center for Environmental Remote Sensing, Chiba University, [2]National Insitutute for Environmental Studies, [3]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 which included ClO which was not able to be observed by high sensitivity until now in the stratosphere and mesosphere from October 12, 2009 to April 21, 2010 with more than ten times the precision of other existing sensors. The Atmospheric Chemistry Experiment - Fourier Transform Spectrometer (ACE-FTS), which is on board SCISAT-1, has been observing atmospheric minor constituents in the upper troposphere and stratosphere from March 11, 2004 by solar occultation technique. We have analyzed SMILES Level 2 (L2) research products and ACE-FTS to discuss the relationship between temperature and stratospheric minor gases related to ozone depletion and time variation of Cl Partitioning in the Arctic winter of 2009/2010.

Analysis of the SMILES L2r ClO profile and the ACE-FTS HCl, NOy, ClONO2 and N2O profiles from 50 to 65N showed that differences in ClO, HCl and ClONO2 concentrations between inner polar vortex and outer polar vortex was the largest from 18 to 28 km in January and February 2010. We calculated ice frost point (Tice) at each measurement location. In the region where a temperature was lower than the calculated Tice plus 15 K, concentrations of HCl, ClONO2 and NOy dramatically decreased; decrease in the concentrations was the largest at equivalent latitudes higher than 70. It is suggested that the decrease in HCl, ClONO2 and NOy was caused by PSC formation and heterogeneous reaction on the surface. We analyzed correlations between N2O and other minor constituents. A compact correlation between them was seen in November 2009. On the other hand, the correlation in January and February had a different characteristic. This suggests that changes in concentrations of these minor constituents was caused by chemical factors, not by dynamical factors. We analyzed a time-series of Cl Partitioning by using ClO and HOCl observed by SMILES and HCl and ClONO2 observed by ACE-FTS in inner polar vortex in 2009/2010. The concentrations did not change in November 2009. In the beginning of January 2010, the concentrations of HCl and ClONO2 decreased. In the middle of January, the concentration of ClO dramatically increased. In the end of January, the concentration of ClO dramatically decreased and the concentrations of HCl and ClONO2 increased. In February and March, the concentration of ClONO2 was higher than that in November 2009. In the presentation, we show more detailed analysis of Cl Partitioning in 2009/2010 observed by SMILES and ACE-FTS.

Keywords: startospheric minor gases, ozone depletion, remote sensing

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Correlation among water vapor and ozone as observed from Aura/MLS

Vivek Panwar[1*], H. Hashiguchi[1], M. K. Yamamoto[1], S. K. Dhaka[2]

[1]Research Institute of Sustainable Humanosphere, Kyoto University, Japan, [2]Department of Physics and Electronics, Rajdhani College, University of Delhi, India

We present a relationship between water vapor mixing ratio (WV) and ozone mixing ratio (O3) measured by Aura/MLS in the tropical upper troposphere and lower stratosphere during 2005-10. Seasonal variability is analyzed in WV and O3 using MLS data. During summer (April-September) WV and O3 scatter plots are used to examine the relationship between them at different pressure levels. Around 100 hPa and above, it seems that there is an increasing linear tendency between WV and O3 with a high correlation coefficient. However, during winter (October-March) it seems that there is an association between WV and O3 but comparatively lesser than summer. From the scatter plots of WV and O3, it appears that during convection WV is injected from troposphere to lower stratosphere in the tropical region. However, the increasing amount of O3 and WV just above tropopause appears that it is dynamically controlled during summer. The O3 values are in general high during summer as compared to winter and are larger by a factor of ˜2 while at 68hPa WV values are high during winter by a factor ˜1-2. The temperature during summer show high values as compared to winter above tropopause. Our analysis suggests that there is a need to study jointly O3 and WV that would help in better understanding the transport in the TTL region and above.

Keywords: Tropical Tropopause Layer, Water Vapor, Ozone

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Validation of ozone and chlorine compounds data observed by SMILES

Koji Imai[1], Makoto Suzuki[1], Takuki Sano[1*], Chihiro Mitsuda[2], Naohiro Manago[3], Yoko Naito[4], Hideharu Akiyoshi[5], Masato Shiotani[6]

[1]Japan Aerospace Exploration Agency, [2]Fujitsu FIP Corporation, [3]Center for Environmental Remote Sensing, Chiba University, [4]Graduate School of Science, Kyoto University, [5]National Institute for Environmental Studies, [6]Research Institute for Sustainable Humanosphere

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 and 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 ozone and chlorine compounds in stratosphere and mesosphere observed with SMILES instrument. Some results of comparative validation with past satellite data and numerical model calculations, and their characterisics of diurnal variation are also presented.

Keywords: stratosphere, mesosphere, diurnal variation, ozone, limb sounding, submillimeter wave

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Characteristic of Vertical Wavenumber Spectra in The Lower Stratosphere Observed with COSMIC GPS Radio Occultation

Noersomadi Noersomadi[1], Toshitaka Tsuda[2*]

[1]National Institute of Aeronautic and Space (LAPAN), Indonesia, [2]RISH Kyoto University

Vertical wavenumber spectra of atmospheric temperature perturbations in the lower stratosphere were analyzed by using COSMIC GPS Radio Occultation data. This study used high resolution profiles from January 2007 to December 2009 derived from the Full Spectrum Inversion retrieval method (Tsuda, et.al., 2011). The height range between 20 to 27 km was selected considering the atmospheric conditions are relatively stable over the entire latitude range. We investigated latitude variations of spectra over two longitude regions; 90 to 150 and 170 to 230 degree east, considering land and ocean distributions. The logarithmic spectral slope of temperature perturbations in the equator region agrees with the model spectrum throughout the year showing saturated gravity wave due to convective activity. It has been depicted an annual variation in the spectral slope at mid latitude in northern hemisphere, which is close to -3 in winter and gradual (-2.4 to -2.7) in summer. It also found an annual variation at mid latitude in southern hemisphere, which behaves differently from northern hemisphere, showing a latitudinal drift of the region southward (from 20S to 60S) from May through October. These variations are related with jet stream as described from zonal wind data. We calculated the moving average of z-score value that showed good correlation between temperature variance, spectral slope, and zonal wind.

Keywords: vertical wavenumber spectra, temparature perturbations

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Global Structure of Brunt Vaisala Frequency as revealed COSMIC GPS Radio Occultation

Noersomadi Noersomadi[1], Toshitaka Tsuda[2*]

[1]National Institute of Aeronautic and Space (LAPAN), Indonesia, [2]RISH Kyoto University

COSMIC GPS RO data were utilized to investigate the atmospheric stability through deriving Brunt Vaisala frequency (N^2) from temperature profiles. N^2 is calculated using 100 m height difference and averaged into 1 km resolution. Height versus latitude section of N^2 showed the sharpness of tropopause layer. It depicted a very stable condition of the stratosphere layer. The deviation of N^2 in the equator region pronounced clearly relation with QBO phase. Time variations of the structure of N^2 in the stratosphere of polar region between northern hemisphere (NH) and southern hemisphere (SH) are quiet different. An annual oscillation is described in the SH showing the polar night jet during winter season, whereas in winter season of NH the atmospheric stability are influenced by sudden stratosphere warming. An annual oscillation is also depicted in the equator region through time versus longitude diagram of N^2 at 17 km that represent the fluctuation of tropopause layer. Time longitude diagram over 30N latitude at 15 km for the global region showed eastward propagation of atmospheric waves.

Keywords: Brunt Vaisala frequency, COSMIC, GPS RO