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

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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

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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

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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.

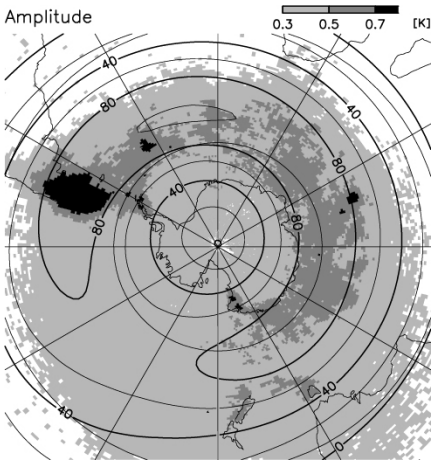
The figure shows the amplitude of wave events averaged over the analyzed period. Large values are observed in regions of Andes, Antarctic Peninsula, islands, and over the Southern Ocean.

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

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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

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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

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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

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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

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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

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

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

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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

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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

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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

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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

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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]

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

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

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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

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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