Japan Geoscience Union Meeting 2014
(28 April - 02 May 2014 at Pacifico YOKOHAMA, Kanagawa, Japan)

AAS21-01 Room:313 Time:April 30 09:00-09:15

A Study on the Structure of Instability in the Mesosphere Using a High Resolution General Circulation Model

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It is well known that in the winter mesosphere, a necessary condition of barotropic and/or baroclinic instability, i.e., negative latitudinal gradient of potential vorticity (PV), is frequently satisfied. This study examines dynamical mechanism of the formation of such instability condition in boreal winter using high-resolution general circulation model data. This model does not include gravity wave (GW) parameterizations and hence all GWs are resolved, allowing us to analyze GWs directly. This is a strong advantage of our study because GWs are quite important for the momentum budget in the mesosphere. First, the 2-d TEM analysis was made. It is shown that the negative PV gradient is regarded as an enhanced PV maximum. This maximum is due to the poleward shift of the westerly jet in associated with strong EP-flux divergence caused by planetary waves from the troposphere. Strong GW drag slightly above the westerly jet shifts poleward as well, which can be understood by a selective GW-filtering mechanism. It seems that this GW-drag shift induces strong upwelling in the middle latitudes and adiabatically cools the middle mesosphere. Resultant enhanced static stability is the main cause of the PV maximum in the upper mesosphere. Because of the dominance of planetary waves during this event, this process may not be zonally uniform. Thus, the 3-d analysis was made using recent theoretical formula by Kinoshita and Sato (2013). As expected, the GW drag is distributed depending on the longitude. The zonal structure of PV maximum is consistent with the GW drag distribution. An interesting fact is that the spatial distribution of GW drag is not largely correlated with that of the zonal wind at the same level but highly correlated with that in the stratosphere. This result indicates that the mesosphere reflects the zonal structure of the stratosphere via the selective GW filtering.

AAS21-02 Room:313 Time:April 30 09:15-09:30

Dynamical mechanism of multiple tropopause structure observed over Syowa Station

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Multiple tropopauses which are determined following the definition by the World Meteorological Organization (WMO) were detected in winter at Syowa Station (69.0S, 39.6E). It is shown that the multiple tropopause structures were observed along with a descent of the first (i.e., lowest) tropopause five times in the autumn period from 1 April and 16 May 2013. A detailed analysis using data from the PANSY radar and radiosonde observations was performed for a typical case in 8-11.

The mechanism of the multiple tropopause structure was analyzed using the PANSY radar and radiosonde observations. It is shown that the multiple tropopause structure was regarded as strong temperature fluctuations with a vertical length of about 3 km. Moreover, it is seen that the temperature fluctuations were out of phase with vertical wind fluctuations observed by the PANSY radar by 90o. This feature is consistent with the linear inertia-gravity wave theory. Thus, it is likely that the multiple tropopause structure above the first tropopause was due to the temperature fluctuations associated with an inertia-gravity waves (IGW) having a vertical length of about 3 km. The hodograph analysis also indicates that the multiple tropopause structure above the first tropopause is due to a monochromatic IGW.

To examine the dynamical mechanism and there-dimensional structure of this phenomenon, a numerical simulation was performed by NICAM without using any gravity wave parameterization. The model simulation period is from 0000 UTC 7 April 2013 to 0000 UTC 12 April 2013.

A close look at the time-height cross section of the zonal wind velocity and the static stability over Syowa Station indicates that the multiple tropopause structures together with the descent of the first tropopauses and associated wind disturbances were successfully simulated. A polar front jet strongly meanders in the time period from 8 April to 10 April and a tropopause folding structure is developed near Syowa Station. This means that the descent of the first tropopause was likely caused by the passage of a developing tropopause folding over Syowa Station. The IGW parameters were also consistent with those estimated by the hodograph analysis using the PANSY radar data.

Next, possible sources of the IGWs observed over Syowa Station were examined using data from the NICAM simulation. As a result, it was shown that wave packets observed over Syowa Station include gravity waves both excited by the steep topographic effect and the spontaneous adjustment process.

This mechanism is quite different from mechanisms which previous studies examined in the monsoon region or midlatitude, which is closely related to stratosphere-troposphere exchange (e.g. Randel et al. 2007). It is suggested this enable us to interpret a part of a significant seasonal sensitivity in the poles discussed by Anel et al. (2008). The static stability in the winter lower stratosphere in the Antarctic is particularly weaker than in other latitudes (Gettleman et al., 2011). It is likely because ozone heating is absent due to polar night. Based on the radiosonde observations, Tomikawa et al. (2009) also shows that the static stability in the lower stratosphere over Syowa Station is minimized in April through July. Temperature fluctuations associated with gravity waves are observed as fluctuations of the static stability. Thus, when the background static stability is sufficiently weak such as in the polar lower stratosphere, the temperature fluctuations associated with gravity waves can make local minima of the static stability which are detected as thermal tropopauses. Therefore, it is likely that multiple tropopause events due to IGWs are considered to occur frequently in the Arctic / Ataractic region in winter.

Keywords: Tropopause, Multiple tropopause, Gravity wave

AAS21-03 Room:313 Time:April 30 09:30-09:45

Tropical non-migrating tides appearing in a high vertical resolution GCM

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Atmospheric tides are global scale waves with periods that are harmonics of a solar day. They are primarily excited in the troposphere and the stratosphere, and then, propagate upward. Tides are generally classified into two components: migrating (Sun-synchronous) and non-migrating (non-Sun-synchronous) tides. Although migrating tides were examined by many previous studies, a much fewer studies considered non-migrating tides particularly in the troposphere and the stratosphere. The purpose of this study is to reveal the horizontal and vertical structure of non-migrating tides and its seasonal variations in the region from the troposphere to the mesosphere, as well as to clarify the underlying physical processes.

In this study, data from a high-resolution (T213L256) global spectral climate model (Watanabe et al., 2008) are analyzed. This model covers quite a wide height range from the ground surface to the upper mesosphere (80 km in altitude), enabling us to investigate the full tidal coupling between the lower and upper atmosphere. Also, the vertical resolution is ~300 m in the vertical, which is almost sufficient to simulate realistic propagation and momentum deposition of gravity waves including tides. We compared the model data with data from COSMIC GPS-RO measurements and TIMED/SABER satellite measurements, and confirmed that the model captures the observed characteristics at least qualitatively.

In the model data, we clearly see that non-migrating tides are mainly excited over the two large continents: over Africa and South America. The excited tides are propagating three-dimensionally like internal inertia-gravity waves. During the propagation, tides with small wavenumbers are filtered out by background zonal wind (e.g., stratospheric semiannual oscillation (SAO)). Thus, both excitation and filtering processes are important for understanding the tidal variability.

Keywords: nonmigrating tides, KANTO, SABER, COSMIC

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AAS21-04 Room:313 Time:April 30 09:45-10:00

Stratospheric Geoengineering

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Overview of stratospheric geoengineering simulations proposed by GeoMIP (Geoengineering Model Intercomparison Project) will be presented with emphasis on impact of anthropogenic stratospheric aerosols on stratospheric ozone and surface UV.

Keywords: geoengineering, stratosphere, aerosol

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AAS21-05 Room:313 Time:April 30 10:00-10:15

Influence of topography onto the temperature variation around the tropical tropopause layer

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The tropical tropopause layer (TTL) is a region where the tropospheric air passes through before entering the stratosphere. Since this region is very cold, the air from the troposphere is dehydrated around here. It is known the Kelvin wave around the TTL affects the big temperature variation and strong dehydration. We investigated the temperature variations around the TTL using the Nonhydrostatic Icosahedral Atmospheric Model (NICAM) on December 2006 (Miura et al. 2007). We found that the temperature variations associated with Kelvin waves are very large over the mountain regions. The amplitude is about 2-times larger than that over the ocean even on the same latitude. We think this result would be a new scientific discovery from simulations or finding of unknown biases of simulations. In this study, we investigate the influence of the topography on the temperature variations around the TTL using the NICAM, re-analysis, satellite, and radiosonde data. We used the Constellation Observing System for Meteorology, Ionosphere, and Climate (COSMIC) data as a satellite data in December, January and February from 2006 to 2010 in order to investigate the temperature variations. The large temperature variations (standard deviation) were found over the mountain regions. This result satisfies the 90% statistical significance level, but the number of data samples is a few. We investigated some reanalysis data having different horizontal resolutions. The standard deviations of the TTL temperature near mountains became large as the horizontal resolution of the model became high. We checked a reanalysis data of the Year of Tropical Convection (YOTC) data from ECMWF with a horizontal resolution of 0.125 degree. When Kelvin waves passed through over the Western Pacific, the amplitude of temperature was large about 2 K over the mountain regions. The power spectrum in the mountains between 7 days and 12 days was actually larger comparing with the ocean. We compared the two local radiosonde data in Jambi and Kototabang (near mountains region). We found that there was no clear difference of temperature variation. Although the temperature variations at Kototabang were slightly large, it is associated with local diurnal variations but not the wave activities. In this study, we found large temperature variation over the mountain in the observational data and numerical models. We would discuss present results and the possibility of this work.

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AAS21-06 Room:313 Time:April 30 10:15-10:30

Constructing the Middle-Atmosphere Version of Non-hydrostatic Global Atmospheric Model NICAM

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Atmospheric gravity wave, which is generated by topography, convective activity, frontal system, jet, and/or so on, affects the formation of the basic state in the troposphere and middle atmosphere through wave convergence. It is difficult for a GCM (general circulation model) to explicitly simulate processes of generation, propagation and convergence of the gravity wave, and gravity wave drag scheme is often used in such a model. Watanabe et al. [2008] successfully simulated realistic gravity wave and basic state of the middle atmosphere using high resolution GCM (60 km in horizon and 300 m in vertical) without gravity wave drag scheme. However, propagation characteristics of the gravity wave cannot be appropriately simulated by the GCM based on the hydrostatic system, since dispersion relationship of the gravity wave is different between the hydrostatic and non-hydrostatic system. In addition, GCM cannot explicitly simulate convection, which is one of the source of the gravity wave.

We are constructing the middle-atmosphere version of the non-hydrostatic global atmospheric model, NICAM (Non-hydrostatic Icosahedral Atmospheric Model). Horizontal resolution of the NICAM is 220 km, 56 km, or 14 km. We adopt hybrid-z∗system as a vertical coordinate, in which the horizontal surface is almost flat in the middle atmosphere. Vertical level is located up to 80 km with the uniform interval in the middle atmosphere; the vertical interval is 2 km (61 layers), 1 km (91 layers), 500 m (162 layers), or 300 m (261 layers). We do not use gravity wave drag scheme and cumulus convection scheme. Other configurations are almost same as those in the standard NICAM, which is mainly used for the tropospheric research.

In this presentation, we will show initial results of the performance in the reproducibility of the basic state. Overall, zonal mean structure of the temperature and zonal wind are well simulated in both the troposphere and the middle atmosphere. Though axis of the polar night jet is biased poleward, it is somewhat improved as the vertical resolution is increased. Higher vertical resolution also brings better performance in the strength of the easterly jet in the summer hemisphere and in the QBO-like structure in the tropical lower stratosphere. In the winter hemisphere, cold bias is found around the pole in the upper stratosphere and the mesosphere, and too strong polar night jet is found. At present, the simulation tends to be numerically more unstable as the horizontal and/or vertical resolutions are increased. We will show the above points and wake up debate about the potential of the non-hydrostatic atmospheric model for future research of the whole atmosphere.

Keywords: nonhydrostatic global atmospheric model, atmospheric gravity wave, middle atmosphere, tropical convection

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AAS21-07 Room:313 Time:April 30 11:00-11:15

Physical interpretation on the mechanisms of spontaneous gravity wave radiation using the renormalization group method

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Gravity waves (GWs) are categorized into orographic ones and non-orographic ones. The mechanisms for non-orographic GW radiation are not clear, because the dynamics is quite nonlinear and complicated unlike orographic GWs. Recently it has been revealed that GWs are spontaneously radiated from an approximately-balanced flow, especially in the jet/front systems (e.g., O ' Sullivan and Dunkerton 1995). The balanced adjustment theory proposed by Plougonven and Zhang (2007) is considered to be the most likely to describe the spontaneous radiation. However, their theory does not give physical interpretations on GW sources and radiation mechanisms. In this study, we derived a new theory and made physical interpretations.

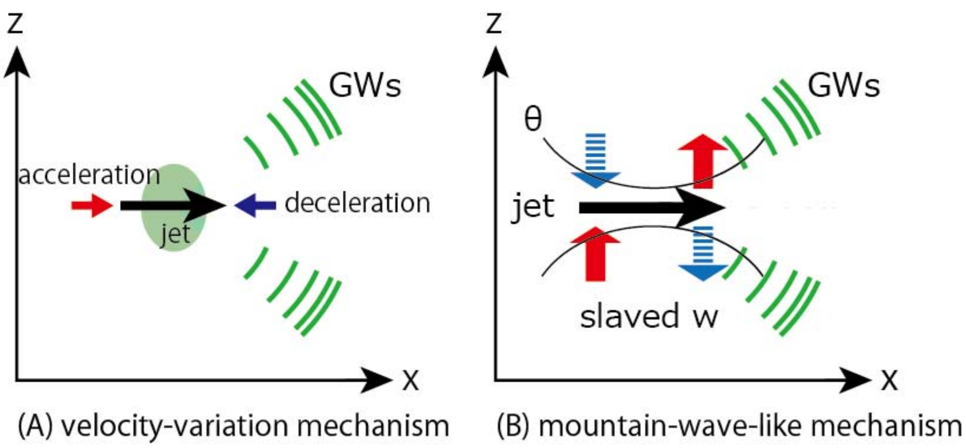
Using the renormalization group (RG) method (Chen et al. 1996), which is a singular perturbation method, the interaction between the vortical flow and the Doppler-shifted GWs which both have slow time-scales is formulated for the hydrostatic Boussinesq equations on the f plane. In general, the RG method enables us to extract slowly-varying components systematically and naturally from the system containing multiple timescale motions. The derived time evolution equations (RG equations, referred to as RGEs) describe the spontaneous radiation of GWs from the components slaved to the vortical flow through a quasi-resonance together with the GW radiation reaction on the large-scale vortical flow. The quasi-resonance occurs when the space and time scales of slaved components are comparable to those of GWs (quasi-resonance condition).

The RGEs are validated using numerical simulations of the vortex dipole by Japan Meteorological Agency Nonhydrostatic Model. The flow near the dipole center is quite strong due to the confluence, which is similar to a localized jet stream in the atmosphere. GW distribution obtained by the RGE integration accords well with the numerical simulation. This result supports the validity of our theory.

The main GW sources in the vortex dipole can be classified into two groups by using the RGEs. The GW sources in the first group are the slaved components produced by the horizontal divergence of acceleration of the vortical flow near the dipole center (Fig. A). The acceleration can be regarded as the sum of Coriolis and pressure gradient forces. This fact indicates that the GW sources express the horizontal compression of fluid. The horizontal compression can produce vertical motion, which radiates GWs when its space and time scales satisfy the quasi-resonance condition. This radiation mechanism corresponds to the velocity-variation mechanism proposed by Viúdez (2007).

The slaved component in the other group is mainly produced by the vortical flow over the deformed potential temperature surfaces (Fig. B). The deformation of potential temperature surfaces can be attributed to the Bernoulli effect due to the strong vortical flow near the dipole center. The vortical flow over the deformed potential surfaces can produce vertical motion, which radiates GWs when its space and time scales satisfy the quasi-resonance condition. In other words, the deformed potential temperature surfaces act like a mountain as in the radiation process of orographic GWs. This radiation mechanism corresponds to the mountain-wave-like mechanism proposed by McIntyre (2009).

Keywords: gravity wave, jet stream, spontaneous radiation, renormalization, wave, singular perturbation method



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AAS21-08 Room:313 Time:April 30 11:15-11:30

QBO-like oscillation in a radiative-convective equilibrium state obtained with a two-dimensional moist convection model

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Quasi-Biennial Oscillation (QBO) is a prominent internal variations in the equatorial stratosphere due to the interactions between a mean zonal wind and waves that propagate upward in the stratosphere. Over two decades ago, Held et al. (1993) investigated radiative-convective equilibrium states with a two-dimensional explicit moist convection model and obtained a QBO-like oscillation. Their model contains the fundamental dynamical processes of the QBO, though it is a highly-idealized two-dimensional model for a periodic domain without Coriolis effects. In this study, we re-examine the QBO-like oscillation found by H93 with a long enough integration period over two years, by using Advanced Research WRF Modeling System. We also investigate the sensitivity of the QBO-like oscillation in regards of different factors such as domain size, resolution and boundary conditions (e.g., prescribed zonal wind at the top and sea surface temperature).

The control experiment has a similar configuration to that of Held et al.; 640km domain width with a resolution of 5km, 130 vertical levels up to 26km. Convective parameterization is turned off in all simulations and only a cloud microphysics scheme is used. Other physics options are standard ones for short- and long-wave radiations, surface fluxes, planetary boundary layer, turbulence and diffusion, and Rayleigh damping near the top boundary. After spin up, the mean zonal wind shows a clear QBO-like oscillation with a period of 120.6 days. Unlike the observed QBO, the oscillation has a clear signal in the troposphere, in which moist convections dominate and gravity waves are generated. Such convectively generated gravity waves propagate into the stratosphere to produce the QBO-like oscillation in the stratosphere. On the other hand, intensity and propagation of organized convective systems, including zonal mean precipitation, are modulated in accordance with the oscillation of mean zonal wind in the troposphere.

Keywords: QBO, radiative-convective equilibrium, wave-mean flow interaction, two-dimensional moist convection model, stratosphere-troposphere dynamical coupling

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AAS21-09 Room:313 Time:April 30 11:30-11:45

Interannual changes of the semiannual oscillation induced by stratospheric sudden warming events

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The semiannual oscillation (SAO) is observed in circulation changes in the equatorial middle atmosphere, which consist of two separate maxima centered near the stratopause (SSAO) and the upper mesosphere (MSAO) with an approximate out-of-phase relathionship between the two [e.g., Andrews et al., 1987]. The SSAO has eastely and westerly maxima at solstices and equinoxes, respectively, while the MSAO shows an out-of-phase change with the SSAO. It is known that somewhat different consideration must be made between the SSAO and the MSAO for their forcing mechanisms, and it seems to be also true of their interannual changes. In this study, we make global gridpoint data for geopotential and temperature fields up to the mesopause level derived from Aura MLS data, to make dynamical analyses for equatorial zonal wind and temperature changes since August 2004 to present. It is found that the strength of both the SSAO and MSAO might be modulated by stratospheric sudden warming (SSW) events in boreal winter solstices. In the equatorial regions, enhanced poleward flows of the residual meridional circulation associated with SSW events lead to temperature perturbations consisting of a cooling in the stratosphere and a warming in the mesosphere. Such temperature perturbations may bring about opposite changes in the SSAO and the MSAO through the thermal wind balance at the equator, leading to their amplifications.

Keywords: semiannual oscillation, stratospheric sudden warming, MLS data

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AAS21-10 Room:313 Time:April 30 11:45-12:00

Recent variability and zonal asymmetry in upper troposphere and lower stratosphere observed with GPS radio occultation m

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Tropical upper troposphere and lower stratosphere (UTLS) variability and zonal asymmetry are explored using global positioning system radio occultation (GPS-RO) measurements. GPS-RO offers global monitoring of fine structures of the UTLS temperature variability. GPS-RO continuous measurements from CHAMP (2001-2006) and COSMIC (2006-2013) for about 13 years allows us to study the interannual variability, trends (over the last decade) and its fine zonal structures. The warming of UTLS temperatures between 100 and 50 hPa, warming of tropopause and decrease in its height have been observed over the last decade. The possible reasons for such changes linking to the recent moderate volcanic eruptions and dynamical changes involving changes in sea surface temperature and Brewer Dobson circulation will discussed. The variability and structure observed in GPS-RO will be compared with existing conventional radiosonde and reanalysis datasets.

Keywords: UTLS Temperature, Zonal Assymetry, GPS Radio Occultation, Moderate Volcanic Eruptions, Dynamical Changes

AAS21-11 Room:313 Time:April 30 12:00-12:15

The role of the mid-latitude oceanic front in the ozone-induced climate change in the Southern Hemisphere

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The Southern Hemisphere Annular Mode (SAM) is the dominant mode of low-frequency atmospheric variability in the extratropical Southern Hemisphere, exerting substantial impacts on regional distributions of temperature and precipitation. Its multi-decadal trend in the troposphere observed in late 20th century has been related to the lower-stratospheric changes induced by the ozone depletion. Known as a manifestation of meridional shift of the eddy-driven polar-front jet (PFJ), which is collocated with the storm-track, the SAM variability may be sensitive to the near-surface baroclinicity associated with the midlatitude oceanic frontal zone.

In the present study, aqua-planet atmospheric general circulation model experiments are conducted with two different zonally symmetric profiles of sea-surface temperature (SST) whose frontal gradient in midlatitudes is retained or eliminated. A comparison of the tropospheric response to the assigned stratospheric ozone depletion between the two SST profiles reveals critical importance of the frontal SST gradient for the intensified stratospheric polar vortex, which is due to the ozone depletion, in triggering and keeping positive phase of the tropospheric SAM in late spring through summer.

We also reveal that the SAM trend in late 20th century simulated in CMIP3/5 models is sensitive to the position and intensity of the mid-latitude oceanic frontal zone. Specifically, a model that simulates the zonal-mean frontal zone at higher latitude tends to simulate the maximum positive trends in the zonal-mean westerlies and midlatitude precipitation also at higher latitudes than another model with the oceanic frontal zone at lower latitude. This relationship is more obvious in a subset of the models with the relatively strong oceanic fronts.

Keywords: Ozone hole, Annular mode, Oceanic front

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AAS21-12 Room:313 Time:April 30 12:15-12:30

Global response to the major volcanic eruptions in 9 reanalysis datasets

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The global climate response to the eruptions of Mount Agung in 1963, El Chichón in 1982 and Mount Pinatubo in 1991 is investigated using 9 reanalysis datasets (ERA-40, ERA-Interim, JRA-25/JCDAS, JRA-55, MERRA, NCEP/NCAR, NCEP/DOE, NCEP-CFSR, and 20CR). Multiple linear regression is applied to the zonal and monthly mean time series of key dynamical variables by considering the components of linear trends, seasonal variations, the Quasi-Biennial Oscillation (QBO), solar cycle, and El Nino Southern Oscillation (ENSO). The residuals are used to define the volcanic signals. Latitude-altitude distributions of the volcanic signals and of the regression coefficients are compared and discussed among the different reanalyses. In response to the Mount Pinatubo eruption most reanalyses show statistically significant negative and positive temperature anomalies in the tropical troposphere and in the tropical lower stratosphere, respectively. The signals are similar for the El Chichón eruption, with a statistically insignificant tropospheric response. The response to the Mount Agung eruption is asymmetric about the equator with significant warming in the Southern Hemisphere midlatitude upper troposphere to lower stratosphere. This work is a contribution to the SPARC Reanalysis Intercomparison Project (S-RIP).

Keywords: volcanic eruption, climate, reanalysis, stratosphere, troposphere

AAS21-13 Room:313 Time:April 30 12:30-12:45

Simulation of stratospheric aerosol changes after the Pinatubo eruption

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An explosive volcanic eruption can inject a large amount of SO_2 into the stratosphere, which is oxidized to form sulfate aerosol. Such aerosol has an impact on the Earth's radiative budget by enhancing back-scattering of the solar radiation, and causes stratospheric ozone depletion through heterogeneous chemical reactions. This study investigates spatiotemporal changes in the volcanic aerosol after the 1991 Pinatubo eruption. We particularly focus on impacts of (1) heating due to volcanic ash, (2) injection height, and (3) temporal evolution of the aerosol radius, on transport and distribution of the volcanic aerosol. We conducted a control simulation and three sensitivity simulations using the MIROC-ESM-CHEM chemistry — climate model. In the control simulation, 20 Mt of the SO_2 and 30 Mt of the ash were injected into the altitudes between 16 km and 18 km over the Mt. Pinatubo on June 15th 1991. The radius of stratospheric sulfate aerosol is prescribed by the data estimated from SAGE II in the control simulation. The first sensitivity simulation injected only the SO_2 into the altitudes between 16 km and 18 km. The second sensitivity simulation injected the SO_2 into the altitudes between 17 km and 26 km. In the third sensitivity simulation, the radius of the sulfate aerosol was fixed to 0.08 μm. The control simulation reproduced a general feature of the observed aerosol optical depth (AOD) derived from SAGE II and AVHRR, although the simulated residence time of the aerosol is longer than the observed one. The sensitivity simulations show the following: (1) heating due to the ash causes an anomalous upward and equatorward transport of the volcanic aerosol during 4 — 5 days after the eruption, (2) the SO_2 injection into the altitudes of 17 — 26 km does not represent the anomalous transport due to the heating which is caused by long-wave absorption of the ash , (3) the temporal evolution of the aerosol radius slightly facilitates the removal of the aerosol from the stratosphere.

Keywords: stratospheric aerosol, volcanic eruption, chemistry-climate model

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Recent Results for Middle Atmospheric Sciences using Data from SMILES

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The Superconducting Submillimeter-Wave Limb-Emission Sounder (SMILES) aboard the Japanese Experiment Module (JEM) of the International Space Station (ISS) made atmospheric measurements of minor species in the stratosphere and mesosphere for about six months from October 2009 to April 2010. Data for scientific community are now provided from DARTS (Data ARchives and Transmission System) of ISAS/JAXA (http://darts.isas.jaxa.jp/iss/smiles/). In this talk, we will present recent results from the SMILES measurements in association with middle atmospheric chemistry and dynamics. The main topics to be highlighted are as follows.

[Diurnal ozone variations in the stratosphere] The SMILES observations have revealed the global pattern of diurnal ozone variations throughout the stratosphere. The peak-to-peak difference in the stratospheric ozone mixing ratio reaches 8% over the course of a day, suggesting careful consideration when merging ozone data from different satellite measurements (Sakazaki et al., 2013).

[Ozonesonde bias suggested from comparisons with SMILES] The SMILES ozone data have been extensively compared with other satellite data sources (Imai et al., 2013a). Further comparisons of SMILES ozone profiles with those from ozonesondes show that the agreement was generally good, but at low latitudes the SMILES ozone data showed larger values than those at middle and high latitudes. To explain this bias, we examined an issue of the ozonesonde's response time, and found a negative bias in ozonesonde measurements more than 7% at 20 km in the equatorial latitude (Imai et al., 2013b).

[Mesospheric ozone variations during the solar eclipse] During the annular solar eclipse on 15 January 2010, SMILES successfully captured temporal changes in ozone concentration. We found that in the lower mesosphere ozone amounts get closer to the normal nighttime average, and the mechanism is detailed with use of an atmospheric chemistry box model (Imai et al., 2014).

Keywords: Middle Atmosphere, Ozone, Satellite Observation

AAS21-15 Room:313 Time:April 30 14:30-14:45

Stratospheric ClO observation by JEM/SMILES

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SMILES operated on the ISS from Oct. 12, 2009 to Apr. 21, 2010. Since the detector (Superconductor-Insulator-Superconductor: SIS mixer) was cooled down to 4K, SMILES showed system noise figure, Tsys ˜250K, or spectral noise floor ˜0.4K, which gave one order better signal to noise ratio compared to previous sub-mm observations from space (Aura/MLS and Odin/SMR).

Aura/MLS have been measuring ClO with a 0.1 ppbv precision at 25-50km altitude. Theoretical 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, which should be almost 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, a priori pressure error, or baseline fitting error.

In tropical region (N10-S10), difference between day and night profiles was 792 pptv at 25km. 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 712 pptv at 22km, and 352 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: Chlorine monoxide, Stratosphere, International Space Station, submm, ozone, SMILES

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Correlation between O_3 and HCl in the lower stratosphere as observed by SMILES

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Ozone (O_3) in the upper troposphere (UT) has an effect on radiative forcing. One of poorly constrained source of tropospheric O_3 is the stratosphere. Marcy et al. (Science, 2004) have suggested that measurements of HCl in the UT can be used to calculate how much O_3 was transported from the lower stratosphere (LS). Using the correlation between O_3 and HCl in the LS, a fraction of the source of the stratosphere has been quantified from measurements in the UT. To perform such a study, it is important to establish the O_3/HCl correlations in the LS. Here, we will present the O_3/HCl correlations as observed by the Superconducting Submillimeter-Wave Limb-Emission Sounder (SMILES) on board the International Space Station (ISS) (Kikuchi et al., JGR, 2010). We first focus on latitudes between 30^oS and 66^oS in periods of November 2009, February 2010, and April 2010, when SMILES mainly covered the Southern Hemisphere (S.H.). Both the slope and intercept of the O_3/HCl correlation in the S.H. Feb. are larger than those in Nov. (outside the Antarctic vortex). This is probably due to mixing of air inside and outside the Antarctic vortex, where the enhanced HCl values were observed only inside the vortex (The break-up of the vortex occurred in Dec. 2009 in the LS). Then, hemispheric contrasts in spring and fall will also be presented. In the S.H. Nov. (late spring), the slope is larger than that in the N.H. Apr. (30-66^oN). Also, in the S.H. Apr. (fall), the slope is larger than that in the N.H. Oct. (30-66^oN). Although, the reason for these larger slopes in the S.H. is not known, the O_3/HCl correlations obtained from SMILES give recent references for the mid to high latitude LS in both the hemispheres.

Keywords: SMILES, ISS, ozone, chlorine

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Reincrease of total columns of HCl and HF observed with FTIR at Tsukuba

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The vertical column densities of HCl and HF have been observed with high-resolution Fourier transform spectrometer at Tsukuba, Japan since 1998. SFIT1 spectral fitting program was used to derive the vertical column densities.

HCl and HF are the reservoir species of Chlorine and Fluorine, respectively. Chlorofluorocarbons are the main sources of both of them.

Daily averaged HCl column increased from 1999 to 2001, decreased from 2003 to 2006 and again increased after 2007. Daily averaged HF column increased from 1999 to 2002, level off from 2003 to 2006 and again increased after 2007. The trend fitting shows -1.8%/yr (2001-2006) and +1.0%/yr (2007-2013) for HCl, and +0.3%/yr (2001-2006) and +2.5%/yr (2007-2013) for HF.

The reason why HCl and HF increase again has not been investigated yet but this increase may lead to the delay of ozone recovery. One possible reason is the change of atmospheric circulation. Simulation result of chemical transport model with observed meteorological data (ERA-interim) shows stop of decrease of HCl at around 2008 while the result without observed meteorological data shows continuous decrease. Another possible reason is the increase in emissions of HCFCs and HFCs which increased the input of Cl and F to the stratosphere but there is no observational evidence.

Keywords: FTIR, Trace Species, CFCs

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The impact of altitude mis-estimation caused by Vaisala RS80 pressure bias on ozone and temperature profile data

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Non-biased meteorological data are necessary for studies for detecting long-term climate change. Vaisala RS80 radiosonde is widely used for operational and scientific observations. It has been known, however, that the RS80 has pressure bias. The pressure bias affects height information of the profile in a traditional way where the geometric height (or geopotential height in some cases) is calculated from the hydrostatics equation. In addition, the pressure measurements affect the mixing ratio values of any chemical species because the calculation needs air pressure value. The RS80 pressure bias is estimated to be -0.3 $\pm$0.2 hPa, -0.4 $\pm$0.1 hPa, and -0.4 $\pm$0.1 hPa (1σ) at 20 km, 25 km, and 30 km, respectively from the observations using RS80 together with global positioning system (GPS) sensor in the Soundings of Ozone and Water in the Equatorial Region (SOWER) project during from December 2004 to January 2010. Since ozone mixing ratio and temperature are also measured simultaneously, the impact of the mis-estimated altitude on observed profiles of ozone and temperature was evaluated. The net biases of -1.3 $\pm$1.4%, -0.5 $\pm$0.7%, and 3.1 $\pm$1.9% (1σ) at 20 km, 25 km, and 30 km, respectively for ozone mixing ratio and that of -0.1 $\pm$0.2 K, -0.2 $\pm$0.3 K, and -0.4 $\pm$0.7 K (1σ) at 20 km, 25 km, and 30 km, respectively for temperature are estimated as impacts from RS80 pressure bias. Those ozone and temperature biases can result in artificial variation in the long-term meteorological records when there is a radiosonde change from or to RS80. Especially, sign-reversed biases of ozone and temperature appear as artificial variations when the instrument is changed from RS80 to non-pressure-biased radiosonde (for example GPS sonde).

Keywords: sonde observation, observational bias, stratospheric ozone, stratospheric temperature, stratospheric long-term variation

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Total ozone reduction over Rio Gallegos (Argentina) in November 2009 simulated by MIROC3.2 Chemical Transport Model

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de Laat et al. (Geophys. Res. Lett., 2010) reported three weeks of reduced total ozone columns over the southern tip of South America in November 2009. The duration of the low total ozone was unusual for the regions. Ozone vertical profile measurements at Rio Gallegos, Argentina (51S, 69W) by ozone LIDAR suggest that the isentropic surfaces of 675K and 475K over Rio Gallegos was inside the Antarctic polar vortex around 13-14 November and 22-23 November respectively thus the low total ozone lasted for three weeks (Wolfram et al, 5th SPARC General Assembly, Queenstown, New Zealand, 2014). MIROC 3.2 Chemical Transport Model with a horizontal resolution of T42 (corresponding to 2.8 degree by 2.8 degree in grids) simulates this long term reduced total ozone over Rio Gallegos. The dynamical and chemical fields around the Antarctica in November 2009 are analyzed. Investigations of these fields for the other past years and comparisons with those in 2009 will be performed.

Keywords: Argentina, ozone hole, CTM, polar vortex, SATREPS, November 2009

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Relationship between total ozone and wave activities in Antarctic region

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It is well known that the formation, development and inter-annual variation of the ozone hole are related to the dynamics in winter polar stratosphere. Stratospheric sudden warming was detected in the Southern Hemisphere in 2002 for the first time and then the ozone hole area (defined by the area inside 220DU) was reduced to less than 5 million square kilometers. A similar reduction of ozone hole was also simulated by CCSR/NIES CCM with CCMVal-REF2 scenario, in which the wave number 2 was unusually developed.

These suggest a possibility that ozone hole may suddenly be reduced in a specific year by the dynamics in the future, apart from the effect of the decrease in chlorine and bromine concentration in the atmosphere due to the halogen regulation. Thus, in order to speculate ozone hole trend and the variability in the course of the long-term climate change of the future, it is needed to clarify the relationship between wave activity and ozone hole in the past. Relationships among the ozone hole indices (maximum ozone hole area and minimum total ozone), wave activity and temperature in the Southern Hemisphere were investigated using observation data and chemical transport model output.

Keywords: stratospheric ozone, dynamics, chemical transport model