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AAS22-01 会場:201B 時間:5 月 21 日 09:00-09:15

超伝導サブミリ波リム放射サウンダ(SMILES)から得られた観測結果の概要
Overview of observational results from the Superconducting Submillimeter-Wave Limb-Emission Sounder (SMILES)

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

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

キーワード: 中層大気, オゾン化学, 大気力学, 衛星観測, 国際宇宙ステーション
Keywords: Middle Atmosphere, Ozone Chemistry, Atmospheric Dynamics, Satellite Measurement, International Space Station

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AAS22-02 会場:201B 時間:5 月 21 日 09:15-09:30

QBO と SAO に関連したオゾン分布 — SMILES による観測とナッジング CTM による評価
Ozone distribution related to the QBO and the SAO — Observation by the SMILES and estimation by a nudging CTM

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QBO (準二年周期振動) と SAO (半年周期振動) の位相によって変動する、赤道域成層圏のオゾン分布について、力学的・化学的効果の定量的評価を試みる。解析には SMILES による観測と MIROC CCM をベースにしたナッジング CTM による数値計算のデータを併用する。

赤道域成層圏におけるオゾン混合比の分布は、成層圏の中ほど (高度 30 km 付近) に極大を持ち、上部成層圏では高度とともに値が小さくなる。この上部成層圏における緯度方向の分布は、基本的には赤道付近に極大を一つ持つ構造となっていることが多いが、QBO と SAO の位相によっては、緯度方向に極大を二つ持ち赤道上に極小を持つダブルピーク構造が見られる時期もある。

Randel and Wu (1996) に指摘され ”rabbit ears” と呼ばれたこのダブルピーク構造は、SMILES による観測では月平均場でなく日々のマッピングデータにおいても明瞭に見ることができる。また、SAO の位相によって現れたり消えたりすることも SMILES 観測データでは確かめることができた。

本講演ではさらに、ナッジング CTM から得られた力学・化学の各項のデータを解析することで、移流などの力学的効果や生成消滅反応などの化学的効果がどの程度このダブルピーク構造の出現に寄与しているかを定量的に評価する。

キーワード: 成層圏, QBO, SAO, オゾン, 力学, 化学
Keywords: stratosphere, QBO, SAO, ozone, dynamics, chemistry

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AAS22-03 会場:201B 時間:5 月 21 日 09:30-09:45

SMILES 観測で明らかになった中層大気オゾンの日変動
Diurnal ozone variations in the middle atmosphere as revealed with SMILES observations

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

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

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

キーワード: 中層大気, オゾン, 日変化
Keywords: Middle atmosphere, diurnal ozone variations

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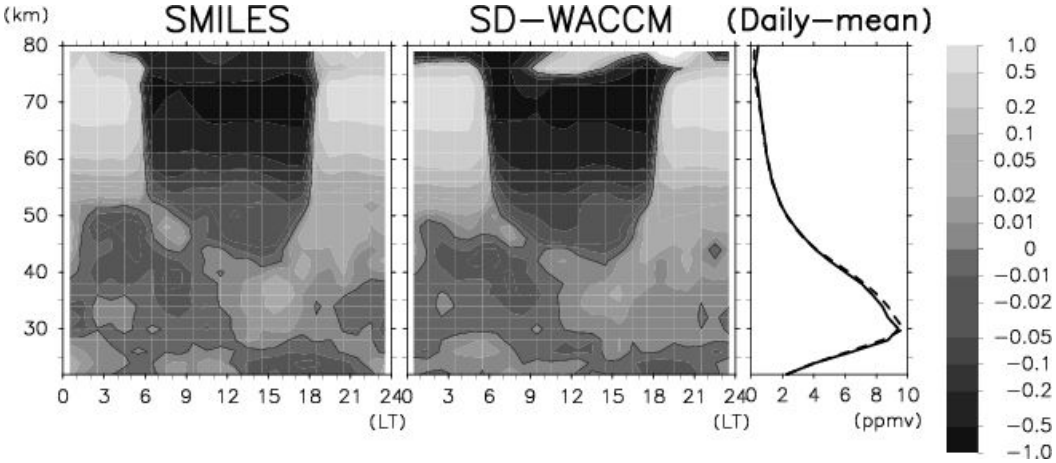

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AAS22-04 会場:201B 時間:5 月 21 日 09:45-10:00

SMILES で観測された成層圏における反応 ClO + HO2 –> HOCl + O2 について
On the reaction ClO + HO2 –> HOCl + O2 based upon SMILES observation

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

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

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

キーワード: 成層圏, 無機塩素系化学種
Keywords: stratosphere, inorganic chlorine

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AAS22-05 会場:201B 時間:5 月 21 日 10:00-10:15

SMILES 気候値の作成と SPARC/DI における活動
SMILES climatology and activity in SPARC DI

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

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

キーワード: SMILES, サブミリ波サウンダ, 成層圏, 中間圏, 大気微量成分
Keywords: SMILES, Sub-mm sounder, Stratosphere, Mesosphere, Atmospheric composition

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AAS22-06 会場:201B 時間:5 月 21 日 10:15-10:30

成層圏大気主成分の重力分離とその物質循環研究への応用の可能性
Gravitational Separation : A New Tracer of Stratospheric Circulation

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大気中の酸素（O2）濃度（δ (O2/N2)）、窒素（N2）および O2 の安定同位体比（δ 15N of N2、δ 18O of O2）の高精度観測から、成層圏における大気主成分の重力分離の検出が示唆されている（Ishidoya et al., 2006, 2008a, b）。本報告では、新たに分析した成層圏大気の Ar/N2 比（δ (Ar/N2)）および質量数 40 と 36 の Ar の同位体比（δ 40Ar）から示唆された重力分離検出の証拠について報告するとともに、2006 年以降に新たに採取した試料のデータを加えて得られた成層圏大気の O2 濃度の長期トレンドと、重力分離と成層圏大気の平均年代との比較から成層圏大気輸送の変動について新たな知見が得られる可能性について述べる。成層圏大気のδ (O2/N2)、δ 15N of N2、およびδ 18O of O2 の分析は、三陸上空において 1999 年 5 月 31 日、2000 年 8 月 28 日、2001 年 5 月 30 日、2002 年 9 月 4 日、2004 年 9 月 6 日、2006 年 6 月 3 日および 2007 年 6 月 4 日に採取した試料と、大樹町上空において 2010 年 8 月 22 日に採取した試料について行った。また 1995 年 6 月 8 日の三陸上空試料に関してδ 15N とδ 18O の分析を、2007 年 6 月 4 日の三陸上空試料に関してはδ (Ar/N2) およびδ 40Ar の分析も行った。サンプラーは大気球によって打ち上げられ、圏界面直上から高度約 35km までの 11 高度の大気採取に成功した。採取した大気試料は研究室に持ち帰り、質量分析計によってδ (O2/N2)、δ 15N 、δ 18O、δ (Ar/N2) およびδ 40Ar を分析した。

三陸および大樹町上空におけるδ (O2/N2)、δ 15N 、およびδ 18O はいずれも高度増加に伴い値が減少していた。この値の減少は、δ 15N とδ 18O の変動量が分子拡散による重力分離と対流による混合を考慮した定常鉛直 1 次元モデルによる計算結果と整合的なこと、またδ 18O/ δ 15N の比が重力分離から予測される 2 にほぼ等しいことから、成層圏における大気成分の重力分離によって引き起こされていることが示唆される。2007 年 6 月 4 日の三陸上空大気試料のδ (Ar/N2)/δ 15N およびδ 40Ar/δ 15N の比はそれぞれ 11.8 ± 1.4 および 4.2 ± 0.6 であり、重力分離から予想される値と整合的であった。本研究では、過去の研究で疑われていた、サンプラーの空気取入口が日射により加熱されることに起因する熱拡散効果で予想される両者の値が 16.0 ± 0.1 および 2.7 ± 0.1 であり重力分離とは異なることを実験的に確認し、δ 15N とδ 18O の観測値が純粋な重力分離を反映したものであることを明らかにした。

三陸および大樹町上空の成層圏におけるδ (O2/N2) の観測値に重畳している重力分離効果を、3x Δδ 15N の値をδ (O2/N2) の観測値から差し引くことで補正し（＊本研究では O2/N2 として質量数 32/29 の比を測定。Δは成層圏と対流圏の観測値の差を示す）、その高度約 20km 以上での平均値を時系列でプロットした結果から、対流圏に追随した中部成層圏でのδ (O2/N2) の明らかな経年減少が示された。δ (O2/N2) と CO2 濃度の両者から推定される中部成層圏と対流圏上部の空気塊の年代差は共に約 4 年と整合的であった。

重力分離の指標として定義したδ値（δ 15N+δ 18O/2）の、三陸および大樹町上空における観測期間平均の高度分布からの偏差（Δδ）と、CO2 濃度から計算した成層圏大気の平均年代（CO2 age）の、高度約 20 km 以上での平均値は、負相関に近い関係を示した。2 次元モデル（SOCRATES）では高度に対するδ値の変化が緯度によって異なることが計算されており、Δδの年々変化は成層圏における緯度方向の輸送の変動を表す可能性がある。またモデルでは緯度によりδ値と CO2 age の関係が異なることも示されており、今後、1985 年からの三陸上空成層圏大気の保存試料を分析し、両者の関係をより詳細に検討することで、Brewer-Dobson 循環の長期変動に関する情報が得られることが期待される。

キーワード: 成層圏大気重力分離, 成層圏大気輸送新トレーサー, 成層圏大気酸素濃度の経年減少, 重力および熱的効果による分子拡散
Keywords: gravitational separation in the stratosphere, a new tracer of stratospheric circulation, decrease of stratospheric O2 concentration, molecular diffusion by gravity and thermal effect

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2010-2011 冬季における寒冷な極域成層圏と惑星波の下向き伝播
Stratospheric cooling and downward planetary-wave propagation in the lowermost stratosphere during the 2010-11 winter

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

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

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

キーワード: 成層圏極渦強化イベント, 西太平洋パターン, 惑星波の下向き伝播
Keywords: Polar vortex intensification, Western Pacific pattern, downward planetary wave propagation

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AAS22-08 会場:201B 時間:5 月 21 日 11:00-11:15

対流圏から下部熱圏域の力学的結合 -2009 年 1 月成層圏突然昇温の GAIA データ解析-
Coupling of atmospheric dynamics from the troposphere to the lower thermosphere - Analysis of GAIA data in 2009-Jan. SSW-

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本研究の目的は、Ground-to-topside model of the Atmosphere and Ionosphere for Aeronomy (GAIA) モデル [Miyoshi et al., 2011] の結果を用いて、2009 年 1 月に発生した成層圏突然昇温の前後に対流圏・成層圏・中間圏・熱圏下部の間に生じた力学的な相互作用を明らかにすることである。そのために、GAIA の下層大気部分に気象庁再解析データを入れた計算を行った。さらに、2009 年 1 月の突然昇温前後に熱圏下部までの大気に生じる波動・循環の変化について変形オイラー方程式を用いて解析を行った。

その結果、成層圏の昇温やその後の運動の変化に作用する力学的な効果は緯度によって異なることが分かった。これらは主に下部中間圏まで伝播した波数 2 のプラネタリー波の緯度方向の構造の違い、子午面循環の違いなどに起因するものである。また、2009 年 1 月の突然昇温時には、北半球環状モードが中間圏から対流圏上部に向かって下方伝播していることが分かり、その伝播の構造も緯度ごとに異なることが明らかとなった。

北極振動は SSW と関連しているとされる。本研究で SSW は中間圏にて駆動されることが明らかになったことから、北極振動も中間圏の影響を受けていることになる。北極振動と冬の寒さが関連していることから、中間圏の大気ダイナミックスは寒い冬を作り出す原因をなしている可能性がある。

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

キーワード: 成層圏突然昇温, 中間圏, 対流圏, 北極振動, GAIA モデル
Keywords: stratspheric sudden warming, mesosphere, troposphere, arctic oscillation, GAIA model

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AAS22-09 会場:201B 時間:5 月 21 日 11:15-11:30

2002 年 9 月の南半球成層圏突然昇温の予測可能性
Predictability of the major stratospheric sudden warming in the Southern Hemisphere for September 2002

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

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

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

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

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AAS22-10 会場:201B 時間:5 月 21 日 11:30-11:45

オゾン回復と二酸化炭素増加に対する中層大気の力学的応答
On the dynamical responses in the middle atmosphere to ozone recovery and CO_2 increase

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

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

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

キーワード: 残差循環, 大気波動, 将来予測
Keywords: residual circulation, atmospheric waves, future prediction

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AAS22-11 会場:201B 時間:5 月 21 日 11:45-12:00

３つの化学輸送モデルを用いた成層圏オゾンデータ同化システムの相互比較
Intercomparison of the stratospheric ozone data assimilation among three CTMs based on observation system experiments

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

1. MLS assimilation

- The model-bias deteriorated the assimilation performance through the amplifying the growth of errors and preventing that of the ensemble spread. Both of these caused an underestimation of the forecast error covariance.
- An ozone bias causes a temperature bias through the radiation process. Therefore, in the stratosphere, reduction of the ozone bias by the assimilation of MLS ozone profiles greatly led to a reduction of temperature bias.
- In contrast, in the upper stratosphere and mesosphere, where the ozone concentration is mainly controlled chemically, the MLS assimilation did not work effectively. In this altitude range, the ozone spread rapidly converges to a photochemical equilibrium value. As a result, LETKF underestimated the forecast error of ozone because of the small ensemble spread relative to the observation error. In order to avoid the underestimation of forecast error, including some other chemical species into the assimilation will be needed to perturb the chemical equilibrium.
- In the troposphere, MLS ozone assimilation did not improve tropospheric ozone profiles because of the lack of data in the middle and lower troposphere and the large uncertainties of the data in the upper troposphere. The error in total ozone was not sufficiently reduced by the MLS data assimilation because of the uncorrected bias in tropospheric ozone. This is evident in the CCSRNIES model, which showed a large bias in ozone in the troposphere. Further, the MLS ozone assimilation for total ozone in CHASER was less effective than that in CCSRNIES and MRI, because in CHASER the ozone concentration above 70 hPa was fixed to the climatology.

2. OMI-TOMS assimilation

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

3. MLS and OMI-TOMS assimilation

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

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

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AAS22-12 会場:201B 時間:5 月 21 日 12:00-12:15

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

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

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

キーワード: Tropical Tropopause Layer, GPS Radio Occultation, Temperature Trend, Global Warming
Keywords: Tropical Tropopause Layer, GPS Radio Occultation, Temperature Trend, Global Warming

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AAS22-13 会場:201B 時間:5 月 21 日 13:45-14:00

インドネシア海洋大陸上空熱帯対流圏界層における相対湿度と巻雲の関係
Relationship between relative humidity and cirrus clouds in the tropical tropopause layer over Indonesia

稲飯 洋一 [1*], 柴田 隆 [2], 藤原 正智 [3], 長谷部 文雄 [3], Holger Voemel[4]
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The relationship between relative humidity and cirrus clouds in the tropical tropopause layer (TTL) is investigated using balloon-borne cryogenic frost-point hygrometers (CFH) and quasi-collocated measurements of space-borne Cloud-Aerosol Lidar with Orthogonal Polarization (CALIOP) at two stations in Indonesia in January 2007 and 2008: Biak (1.17S, 136.06E) facing the western Pacific and Kototabang (0.20S, 100.32E) facing the eastern Indian Ocean. High supersaturations have been measured inside cirrus clouds. At Kototabang, thin layers of high supersaturation, up to ~160%, are often observed co-existing with cirrus clouds at altitudes of 15-18 km. At Biak, relative humidity over ice (RHi) inside the TTL cirrus is around 100% or less without large supersaturation layers, and most clouds are limited to altitudes below 16 km. Analysis of background meteorological fields and convective activity suggests that high supersaturations in cirrus clouds in this study are produced away from deep convective regions and where a well-developed transition layer exists between convective and highly stratified regions.

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AAS22-14 会場:201B 時間:5 月 21 日 14:00-14:15

ケルビン波に伴う熱帯対流圏界面付近のオゾン変動と乱流混合について
On the turbulent mixing and ozone variations around the tropical tropopause associated with Kelvin waves

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

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

キーワード: 乱流, 赤道波, オゾン
Keywords: turbulence, equatorial wave, ozone

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AAS22-P01 会場:コンベンションホール 時間:5 月 21 日 17:00-18:30

SMILES L2 プロダクト v2.X での改訂状況
SMILES L2 Product improvements in v2.X updates

光田 千紘 [1*], 鈴木 睦 [2], 眞子 直弘 [2], 内藤 陽子 [3], 高橋 千賀子 [1], 今井 弘二 [4], 林 寛生 [5], 塩谷 雅人 [5], 佐野 琢己 [2], 谷口 弘智 [1], 高柳 昌弘 [2]
MITSUDA, Chihiro[1*], SUZUKI, Makoto[2], MANAGO, Naohiro[2], NAITO, Yoko[3], TAKAHASHI, Chikako[1], IMAI, Koji[4], HAYASHI, Hiroo[5], SHIOTANI, Masato[5], SANO, Takuki[2], TANIGUCHI, Hirotomo[1], Masahiro Takayanagi[2]

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

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

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

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

キーワード: 国際宇宙ステーション, きぼう, オゾン, データ処理, リトリーバル
Keywords: International Space Station, Kibo, O3, Data Processing, retrieval

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AAS22-P02 会場:コンベンションホール 時間:5 月 21 日 17:00-18:30

SMILES レベル 2 バージョン 2.1 オゾンとオゾンゾンデの比較結果について
Validation of the SMILES Level 2 version 2.1 ozone data by using ozonesonde measurements

今井 弘二 [1*], 藤原 正智 [2], 鈴木 睦 [3], 眞子 直弘 [3], 佐野 琢己 [3], 光田 千紘 [4], 内藤 陽子 [5], 塩谷 雅人 [6]
IMAI, Koji[1*], FUJIWARA, Masatomo[2], SUZUKI, Makoto[3], MANAGO, Naohiro[3], SANO, Takuki[3], MITSUDA, Chihiro[4], NAITO, Yoko[5], SHIOTANI, Masato[6]

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

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

キーワード: 国際宇宙ステーション, きぼう, オゾン
Keywords: International Space Station, Kibo, SMILES, O3, ozone

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AAS22-P03 会場:コンベンションホール 時間:5 月 21 日 17:00-18:30

SMILES レベル 2 バージョン 2.1 成層圏オゾンの検証結果について
Validation of the SMILES Level 2 version 2.1 stratospheric ozone

今井 弘二 [1*], 塩谷 雅人 [5], 鈴木 睦 [2], 眞子 直弘 [2], 佐野 琢己 [2], 光田 千紘 [3], 内藤 陽子 [4]
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Superconducting Submillimeter-Wave Limb-Emission Sounder (SMILES) onboard International Space Station has provided global measurements of ozone (O3) profiles in the middle atmosphere from 12 October 2009 to 21 April 2010. We present validation studies of the SMILES version 2.1 ozone product in the stratosphere using other data sources: satellite data and chemical-climate models. The SMILES ozone data agree with most of other satellites data within 10- 15% at an altitude between 20 km and 50 km.

キーワード: 国際宇宙ステーション, きぼう, オゾン
Keywords: International Space Station, Kibo, SMILES, O3, ozone

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JEM/SMILES による 2009/2010 年冬春季北極成層圏オゾン破壊関連物質の解析
Analysis of Arctic stratospheric minor gases related to ozone depletion observed with JEM/SMILES in 2009/2010

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国際宇宙ステーション「きぼう」日本実験棟に搭載された超伝導サブミリ波リム放射サウンダ（SMILES; Superconducting Submillimeter-Wave Limb-Emission Sounder）は、超伝導技術を搭載したこれまでにない高感度なセンサーであり、2009 年 11 月から 2010 年 4 月までの約半年間にわたり、成層圏および中間圏の大気微量成分を従来のセンサーと比べて十倍程度高い精度で観測した。本研究では、情報通信研究機構が提供する SMILES 研究プロダクト（L2r プロダクト）を用いて、2009/2010 年の北極成層圏のオゾン破壊関連物質と気温との関係を解析した。

まず、SMILES で観測された北緯 60〜65 °の気温データの解析から、1 月は高度 24 km の東経 30 度を中心とした領域で最も低温になっており、2 月はその低温領域が高度 20 km に下がっていたことがわかった。SMILES の気温データの信頼性を確認するために、対応する GEOS-5（The Goddard Earth Observing System Model Version 5）の気温データと比較したところ、SMILES のバンド B から導出された気温は GEOS-5 の気温に対して明確なバイアスはなく、一方、SMILES のバンド A から導出された気温は 5〜10 K 程度 GEOS-5 の気温データよりも高く導出されていることがわかった。

1 月初中旬の高度 24 km では、最も低温となっている領域で HNO_3 濃度が少なくなっており、同じ領域で HCl 濃度は減少し、ClO 濃度は増加し、O_3 濃度は減少していた。1 月下旬から 2 月の高度 20 km においても、同様の傾向が見られた。これらの領域では、低温条件下で HNO_3 を主成分とする PSCs が形成され、PSCs 粒子上で不均一反応が起こっていたと考えられる。

さらに、気温と各微量成分との関係を詳細に調べるため、NAT 飽和温度 (T_{NAT}) を SMILES の HNO_3 データを用いて計算した。その結果、気温が T_{NAT} 以下になっているところで、HNO_3 濃度が少なくなっており、HCl 濃度、ClO 濃度はそれぞれ急激に減少、増加していることがわかった。しかしながら、気温が T_{NAT} 以上のところでも HNO_3、HCl、ClO 濃度の増減が見られるデータがあった。これらについて詳細を解析するために、まず SMILES L2r の HNO_3 のデータ質を他の独立なデータで検証する必要があると考える。

キーワード: 成層圏大気微量成分, オゾン破壊, リモートセンシング
Keywords: stratospheirc minor gases, ozone depletion, remote sensing

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SMILES で観測された成層圏及び中間圏 HCl (L2r プロダクト) の検証
Validation of stratospheric and mesospheric HCl (L2r product) measured by SMILES

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オゾン層破壊に関与している物質を観測するために，SMILES (Superconducting Submillimeter-Wave Limb-Emission Sounder / 超伝導サブミリ波リム放射サウンダ) は国際宇宙ステーション (ISS) に搭載された．観測は 2009 年 10 月から 2010 年 4 月まで実施された．SMILES は塩化水素 (HCl) の同位体 (H35Cl，H37Cl) を異なる周波数帯で観測している．観測周波数領域は 3 つのバンド帯からなっている．バンド A (624.32 - 625.52 GHz) で H37Cl，バンド B (625.12 - 626.32 GHz) で H35Cl を観測する．HCl の体積混合比は各周波数帯から別々に求めた．

地球大気成層圏 (50 km 以上) において，95%の塩素 (Cl) が HCl として大気中に存在している．また，塩素系化合物の中において， HCl はオゾン層破壊に Cl のリザーバとして関与している．このため，大気中の HCl を含む塩素系化合物の全球分布の定量的な観測は，今後の ClOx によるオゾン層の破壊状況を予測する上で重要になる．

SMILES の観測以前，Aura/MLS(Microwave Limb Sounder)，ACE/FTS(Fourier Transform Spectrometer，赤外領域観測) といった観測機器が HCl を測定してきた．しかし，これらの結果は高度約 53km において 0.2 ppbv 程度のずれがある [S.A. Montzka et al 2011]．本研究では，SMILES のバンド A・B から求めた HCl (Level-2 Research プロダクト version 2.1.5) と Aura/MLS 及び ACE/FTS の観測結果との検証を行なった．ここでは，Aura./MLS との検証結果について簡潔に述べる．SMILES のバンド A の観測結果と Aura/MLS の結果を比較した場合，高度 25 km から 50 km において相対誤差が 10 %以内に収まっている．しかし，高度 50 km 以上では Aura/MLS の観測結果は高度方向に上昇しているのに対して，SMILES の観測結果は高度方向に一様な 3.0 ppbv を示している．また，SMILES のバンド B と Aura/MLS との比較においても同様の結果となった．

キーワード: サブミリ波, HCl, SMILES
Keywords: HCl, SMILES

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SMILES/MLS/ACE-FTS による南極極渦崩壊前の HCl/Cly 比
HCl/Cly ratios of just before the breakup of the Antarctic vortex as observed by SMILES/MLS/ACE-FTS

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成層圏での無機塩素化合物（HCl, $ClONO_2$, ClO など、総量を Cly）は対流圏起源のフロンガス等が成層圏において種々の光化学反応過程を経ることにより生じる。現在、その最大濃度は 3 から 3.5 ppbv 程度と推定される。今後はゆるやかに減少し、2050 年頃には 1980 年頃のレベル（2 ppbv）へ戻ると期待されており、それに伴い全球規模でオゾン全量の回復が進むものと考えられている。本研究では下部成層圏において Cly の殆どが HCl で構成される極めて特有な南極極渦内の 11 月（通年、極渦崩壊の少し前にあたる）に焦点をあて、そのような化学・力学的ふるまいを念頭においた上で各衛星データの質評価・相互比較を行う。国際宇宙ステーション「きぼう」搭載の超伝導サブミリ波リム放射サウンダ（SMILES）は 2009 年 10 月から翌年 4 月まで HCl や ClO 測定を含む高精度大気微量成分観測を成功させた。発表では第 1 回目となる一般公開バージョン（operational と research プロダクト）を利用する。また同時期に観測が存在する米国 MLS および加 ACE-FTS からのデータも併せて解析に利用する。これまでの解析結果から、高度 18 km（温位 460 K）において、2.8 ppbv 程度の高い HCl 混合比となっていることを極渦内の観測から明らかにした。また、お互いの衛星観測はデータのばらつきや測定誤差の範囲内で良く一致していた。さらに極渦内のその高い HCl/Cly 比の年々の挙動についても近年の MLS データを用いた解析を実施した。その結果、11 月下旬の極渦内ではどの年も高い HCl 濃度となっていたことが分かった。このことから、Cly トレンド把握には上部成層圏（Cly の殆どが HCl）以外にも、この解析で用いられた南極極渦内の下部成層圏でも現実的であると言える。

キーワード: 成層圏, 南極, 極渦, 無機塩素化合物
Keywords: stratosphere, antarctic, polar vortex, inorganic chlorine

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JEM/SMILES による中間圏 O3 の観測結果
Mesospheric O3 observed by ISS/JEM/SMILES

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ISS/JEM/SMILES は、オゾン層化学に関係する O_3, HCl, ClO, HO_2, HOCl, BrO などについて、これまでの衛星観測と比べ大幅に高い感度での測定を行なった。なかでも O_3, HCl, ClO については高度 80km 程度までの中間圏において観測を行うことができた。成層圏と対比して、中間圏ではより一層、その場での光化学反応が微量成分濃度を支配しており、SMILES データとモデル計算結果と比較することにより、大気化学全般における化学反応の現在の知識の妥当性を確認することが可能と考えられる。本研究では、(1) SMILES 中間圏 O_3 データの特徴、(2) 既存衛星データ・モデル計算結果との比較検証、(3) SMILES から得られた中間圏 O_3 の日変化、について報告する。

大気の研究において、モデル計算は観測結果の解釈や将来予測のための非常に強力な手段であるが、その基礎となる化学反応速度は、成層圏・中間圏への外挿のため± 30-50%の誤差を持っていることに注意が必要である。従って、SMILES のように± 10-20%精度で中間圏の微量成分濃度を観測することは、既存の大気化学に関する知識体系をこれまでに無い精緻さでの再点検を可能とする。

中間圏 O_3 は、SciSAT-1 衛星/ACE-FTS, TIMED 衛星/SABER, Aura/MLS などで観測されている。本研究では、日の出・日没時のみのデータである ACE-FTS を除く衛星データ及び気象場の再現計算を行なったモデル計算 (SD-WACCAM) と SMILES データとを比較した。その結果、SD-WACCM 及び SABER 1.27 μ m と比較的 良い一致を得た。

中間圏 O_3 は、日の出後の特徴的な時間変化などの日変化がモデル計算から知られているが、これまで地上観測あるいは衛星観測からは日変化に関する議論は十分に行えていなかった。SMILES データでは、ISS 軌道の特徴から 45 日程度で日変化をプロットすることができる。中間圏 O_3 の日変化は H_2O 混合比と共に議論することが可能であり、その結果についても報告する。

キーワード: SMILES, 中間圏, 大気微量成分, オゾン, 日変化, 衛星観測
Keywords: SMILES, Mesosphere, Atmospheric minor constituents, Ozone, Diurnal variation, Satellite observation

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全球的なQBO影響の季節性に関する解析 — 時間ずらしコンポジット法による解析
Analysis on the seasonality of the QBO influence on the global circulation by making time-lagged composites

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1. はじめに

QBO（準二年周期振動）は赤道成層圏で顕著な現象であるが, 子午面循環やプラネタリー波の伝播の変調を介して中高緯度へも影響している (Baldwin et al.,2001). このような QBO 影響を調べたこれまでの研究では, 各月のコンポジットのグループ分けにその月の赤道風を基準に用いることがほとんどであったが, この場合, 得られたシグナルの連続性は保証されない. そこで本研究では, 基準となる月を固定してその前後の各月のグループ分けを行う時間ずらしコンポジット法を用い, 季節とともに変化する全球的な QBO 影響を解析する.

用いるデータは ERA40 (1958-2002 年) である.

2. 時間ずらしコンポジット法

まず, Wallace et al. (1993) を参考に, 赤道成層圏中・下層における帯状流の EOF 第 1 モード・第 2 モードの時間関数がなす位相角で QBO の位相を定義する. 各月の位相を見ると, 6 月の位相の分布が -pi/2 付近と pi/2 付近で疎, 0 付近と pi 付近で密になっていることがわかる. そこで本研究では, どの月の解析においてもこの 6 月の位相を基準に, 「西風」と「東風」の二つのグループに分けることにする.

3. 解析結果

従来の基準によるコンポジット解析とは異なり, 本研究の解析で得られる結果は同じ 12ヵ月の繰り返しとはならない.

赤道帯状流のコンポジットとその差を, 基準の月から前後 2 年半ずつの期間に亘って描くと, QBO にともなう偏差が約 2 年かけてゆっくり下降する様子が見られるほか, 下降が成層圏上層の SAO (半年周期振動) の特定位相 (西風は 9-10 月頃, 東風は 12-1 月頃) をきっかけに始まっていることがわかる. また, 下降速度が 5 月頃と 10 月頃に速いという半年周期の変動を示していることも見てとれる.

Eliassen-Palm フラックスや残差子午面循環についても時間ずらしコンポジットをしたところ, この下降速度の変動によく対応した変動を見せていることがわかった.

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キーワード: 成層圏, QBO, SAO, 力学
Keywords: stratosphere, QBO, SAO, dynamics

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JEM/SMILES で観測された成層圏下部 ClO 分布
Observation of ClO at the lower stratosphere by JEM/SMILES

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

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

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

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

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

キーワード: SMILES, 国際宇宙ステーション, 一酸化塩素, 成層圏
Keywords: SMILES, International space station, ClO, stratosphere

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ISS/JEM/SMILES により 2009/10 年の北極域 Vortex 中での化学反応について
Chemistry within 2009/10 Arctic polar vortex observed by ISS/JEM/SMILES

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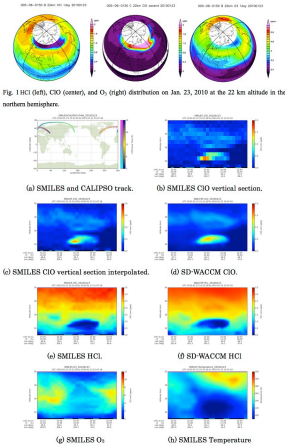
Superocnducting Submillimeter-Wave Limb-Emission Sounder (SMILES) is a 4K cooled limb sounding instrument in the 625-650 GHz frequency region, onboard International Space Station (ISS). SMILES was jointly developed by Japan Aerospace Exploration Agency (JAXA) and National Institute of Information and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

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

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



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AAS22-P11 会場:コンベンションホール 時間:5 月 21 日 17:00-18:30

SMILES で観測された熱帯域中間圏 HO2, O3 分布と高高度放電発光現象との関連
Mesospheric HO2 and O3 Distribution in Tropical Region Measured by SMILES and Their Relation to Transient Luminous Event

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世界で発生する 80%の雷放電は熱帯・亜熱帯域に集中しているが，それらの雷放電が大量の NOx を生成し対流圏における大気化学に大きく寄与していると推定されている。一方，雷放電に伴う成層圏・中間圏・熱圏下部での高高度放電発光現象（スプライト，エルブスなど）も，雷放電の発生分布に従い熱帯・亜熱帯域の大陸上空で頻発していることが明らかになりつつある。近年では，スプライトの発生によって成層圏・中間圏・熱圏下部での化学反応に対し局所的に大きな影響を与え，結果として大気組成が変化しているとする数値シミュレーション結果が示されている。例えば高度 60 km では，スプライト発生から 1 時間後には NO の数密度が約 6 桁，NO2 が約 2 桁，O3 が約 1 桁，OH が約 3 桁それぞれ増加することが示されている。また HO2 に関しては，高度 60 km では時間経過と共に数密度は大きく変化しないが，成層圏界面付近の高度 50 km では 1 桁増加，また高度 70 km 付近では約 1/2 に減少することが示されている。~50 flash/s という雷放電の発生頻度に較べると，~1 event/min というスプライトの平均的発生頻度は低いが，スプライトの発生が集中する熱帯・亜熱帯域上空の中間圏・熱圏下部では，広域的な化学組成にまで影響が及んでいる可能性もある。このため，スプライトが与える大気化学組成変化に対する影響を定量的に明らかにすることを目的として，高度 80 km までの O3 および HO2 を高精度に測定できる JEM/SMILES の観測データを解析した。特に，SMILES のデータに，高高度放電発光現象との関係がある異常な O3, HO2 の値が含まれていないかに着目し解析を実施した。その結果，これまでの予備的な解析から，高度 75-80 km において SMILES HO2 の値は，赤道域 (南緯 30 度-北緯 30 度) において 3 次元光化学モデル計算 (SD-WACCM) の，ほぼ 2 倍の異常な値を示すことが明らかとなった。これは，北緯 30 度以北および南緯 30 度以南では認められない。さらに，HO2 の世界分布を推定した結果，主に大陸上で混合比が上昇していることも確認された。一般には，雷放電および高高度放電発光現象の発生頻度は熱帯・亜熱帯域で高いことから，これらの事象が高高度放電発光現象に起因して生じているのではないかと示唆される。講演では，より詳細な数密度分布と時間変化について報告する。

キーワード: 雷放電, スプライト, HO2, O3, SMILES
Keywords: lightning, sprite, HO2, O3, SMILES

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

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

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

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

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

キーワード: sudden stratospheric warming, SMILES, atmospheric compositions, ozone, mesosphere, diurnal variation
Keywords: sudden stratospheric warming, SMILES, atmospheric compositions, ozone, mesosphere, diurnal variation

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AAS22-P13 会場:コンベンションホール 時間:5 月 21 日 17:00-18:30

成層圏-対流圏結合系における冬季極渦変動に伴う予測可能性変動について
Predictability variations in a stratosphere-troposphere coupled system associated with winter polar vortex conditions

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

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

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

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

キーワード: 成層圏循環, 予測可能性, 突然昇温, １ヶ月アンサンブル予報
Keywords: stratospheric circulation, predictability, sudden warming, ensemble one-month prediction

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成層圏大気中の分子拡散の評価
Evaluation of the molecular diffusion process in the stratosphere

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

キーワード: 成層圏, 分子拡散
Keywords: stratosphere, molecular diffusion

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AAS22-P15 会場:コンベンションホール 時間:5 月 21 日 17:00-18:30

ハノイのオゾンゾンデ観測に基づく北半球亜熱帯域におけるオゾン変動
Ozone variations over the northern subtropical region revealed by ozonesonde observations in Hanoi

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

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

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

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

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

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

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

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メソモデルで再現された温帯低気圧と対流圏界面逆転層に関する解析
Analysis of an Extratropical Cyclone and Tropopause Inversion Layer using a Meso-scale Model

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対流圏界面逆転層（TIL）は，対流圏界面直上で全球的に見られる，厚さ約 2 km の持続的な温度逆転層である（Birner, 2002）．TIL は対流圏-成層圏の物質輸送や波の伝播に影響を与えるため，近年観測および理論研究が盛んに行われている．TIL の形成には，力学過程（Wirth, 2003）および放射過程（Randel et al.,2007）が寄与することが示されているが，どのような過程が支配的であるかはまだ明らかでない．また，理論的な先行研究のほとんどは理想化された数値モデルを用いており，水蒸気を含むメソモデルのような現実的なモデルによるシミュレーションはまだ行われない．

本研究では，温帯の TIL の形成メカニズムを解明するため，先行研究よりも現実的で高解像度の 3 次元領域気象モデルを用いた事例解析を行った．使用したモデルは気象庁非静力学モデルである．水平解像度は 20 km，鉛直解像度は対流圏界面付近で 125 m であり，初期値・境界値には NCEP-FNL を用いた．現実的な総観規模擾乱と TIL の関係を調べるため，日本付近で急速に発達した低気圧を対象とした事例解析を行った．計算期間は 2009 年 2 月 19 日 12 UTC から 21 日 12 UTC までの 48 時間であり，低気圧は 36 時間目付近で最盛期を迎えた．

コントロールランにおいて再現された TIL は，観測研究によって記述されている TIL の特徴が確認でき，TIL の渦度依存性（Birner et al., 2002）も再現されていた．すなわち，対流圏界面付近の局所的な相対渦度が負の領域で TIL が強く，正の領域で TIL が弱い．ただし，この依存性は低気圧の発達期・最盛期にのみ明瞭であった．また，その原因を明らかにするため，モデル領域内で強い TIL が比較的強い重力波発生領域に多く出現していることに着目し，重力波の解析を行った．その結果，重力波による強い収束領域において強い（TIL における浮力振動数の 2 乗の最大値 N^2_{max} が大きい）TIL の出現頻度が高かった．また，この傾向は正渦度領域よりも負渦度領域において強かった．さらに，この傾向が全計算期間（48 時間）のうち低気圧の発達期・最盛期にのみ明瞭に見られること，および低気圧の発達に伴い西風ジェットの出口や低気圧上空において重力波が盛んに放射されていたことから，総観規模擾乱に伴う重力波による鉛直収束が，TIL の強さと局所的な相対渦度の負の相関の形成に重要な役割を果たしていると考えられる．

なお，本研究では水蒸気の放射効果による TIL 形成への寄与を調べるために，対流圏界面付近の水蒸気を段階的に減らした感度実験も行った．感度実験は，300 hPa より上空の水蒸気を除いたラン（EXP300）と 500 hPa より上空の水蒸気を除いたラン（EXP500）であり，形成された TIL は EXP300，コントロールラン，EXP500 の順に強かった．EXP300 において TIL が強かったのは，対流圏界面の直下にあたる 300 hPa 付近で水蒸気が急激に減少したために，放射冷却を通じて静的安定度の鉛直プロファイルの勾配が大きくなったためと考えられる．また，水蒸気の放射効果による TIL への寄与は，低気圧の発達する時間スケールにおいては，力学過程に比べて小さいことを示した．

キーワード: 対流圏界面逆転層, 温帯低気圧, 重力波
Keywords: tropopause inversion layer, extratropical cyclone, gravity wave

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高エネルギー粒子・光子が成層圏大気に引き起こす化学反応のシミュレーション
Chemical Reactions in the Stratosphere Induced by Transient Astronomical Ionizing Events

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突発的な天体爆発現象（太陽高エネルギー粒子現象や超新星爆発）が地球環境に与える影響の研究は、宇宙からの視点と地球からの視点が交差する境界領域にあり、最近大きな注目を集めている。我々は特に、これらの天体イベントが成層圏において引き起こす窒素酸化物 (NOx) とオゾンの濃度変動を明らかにするために、大気化学、気候変動、原子分子物理、天文学の知見を動員した新しい計算シミュレーションに着手した。この領域で先駆的な研究を行っている Thomas らは最近、ガンマ線バーストの影響に関して二次元の光化学輸送モデルを用いた数値シミュレーションを行い、成層圏におけるオゾン量の減少（20-30 %にも及ぶ）を報告している [1,2]。彼らが用いたモデルでは、過重な計算を避けるために中間生成物としてのイオンが関わる反応については露わに考慮せず、電離イオン対が生成される際の NOx 濃度変動に関しては既報のパラメータを用いている。

我々は、まず電離・解離過程とそれに続くイオン分子反応の連立微分方程式を直接解き、個々のイオン分子反応の NOx 濃度変動への寄与を分析し、得られた妥当な NOx 濃度変動を大規模計算への入力パラメータとするアプローチを考えている。将来的には Thomas らの計算よりさらに詳細な三次元の化学気候モデルシミュレーションにつなげる予定である。本講演では、その第一段階として、地上からの高度以外に緯度・経度の変数を持たないゼロ次元のモデル（いわゆるボックスモデル）の結果について報告する。

大規模太陽フレアに伴う太陽高エネルギー粒子現象では、フレアからの X 線、γ 線光子と共に、100 MeV を越える高エネルギー粒子（陽子・中性子）が、太陽系近傍の超新星爆発からは 1 MeV 程度以下の γ 線、X 線光子が地球大気に降り注ぐ。これらの高エネルギー粒子・光子は、成層圏において酸素、窒素（O_2, N_2）を電離・解離する。今回の我々の計算では、電離によって生成するイオン（N^+, O^+, N_2^+, O_2^+, e^-）や解離によって生成するラジカル（$N(^4S)$, $N(^2D)$, $N(^2P)$, $O(^3P)$, $O(^1D)$ ）の量は、放射線過程の G 値 [3] を用いて見積った。G 値とは、系に与えられたエネルギー 100 eV 当たりに生じる生成物の個数で、単位は [atoms or molecules / 100 eV] である。電離放射線によって大気中に生成される化学種は、おおまかには物質が放射線から吸収するエネルギーだけで決まると考えてよく（軽元素からなる物質の場合）、それが G 値を使う根拠になっている。この扱いによって多段階の散乱過程の詳細には立ち入らずに、電離・解離の速度定数を設定することができる。放射線によって生じたイオンやラジカルは、引き続いて起こる化学反応によって各種の正負イオン（NO^+, O_4^+, O^-, O_2^- 等）を生成する。現時点で総数 100 以上の化学反応（オゾン破壊の NOx サイクル、HOx サイクル、ハロゲンサイクルを含む) を取り入れ、反応速度式を表す連立微分方程式の数値積分には、FACSIMILE (MCPA. Corp) という複合化学反応専用ソフトウェアを用いた。

本講演では、天体現象からの入射エネルギーのインプットとして、巨大な太陽高エネルギー粒子現象（例えば [4]）を想定し、まず Thomas らと同様に矩形波を用いて近似した（フルエンス 1.0 × 10^9 cm^{-2} , パルス幅 24 時間）。大気の温度と化学種の初期濃度としては、下部成層圏および上部成層圏におけるいくつかの代表的高度を設定した。計算結果を基に、NOx 濃度変動のタイムスケール、主要な反応経路、高度依存性について議論する。

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SPARC 再解析比較プロジェクト（S-RIP）の提案
A proposal of the SPARC Reanalysis/Analysis Intercomparison Project (S-RIP)

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