Equatorial Atmospheric Kelvin Waves during 2014-2016 El Niño episodes andtheir effect on Stratospheric QBO

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Equatorial atmospheric Kelvin waves are investigated during positive El Niño Southern Oscillation (ENSO) episodes using temperature data retrieved from GPS Radio Occultation (RO) observations of FORMOSAT-3/COSMIC 5 during the period from August 2006 to April 2016. Enhanced Kelvin wave activity is observed during the El Niño episodes of 2010 and 2014-2016 and it is also observed that the Kelvin wave amplitudes correlate with the Niño 3.4 index and also with outgoing longwave radiation and trade wind index. This study indicates that the enhanced equatorial atmospheric Kelvin wave activity might be produced by geophysical processes that were involved in the onset and development of the El Niño episode. Further, easterly winds above the tropopause during this period favoured the vertically upward propagation of these waves that induced a fast descending westerly regime by the end of 2010 but showing different behaviors during 2014-2016 period.The current study presents observational evidence of enhanced Kelvin wave activity during El Niño that has affected the stratospheric quasi-biennial oscillation (QBO) through wave-mean flow interactions. Detailed comparison between the ENSO episodes of 2010 and 2014-2016 will be investigated in this study.

Keywords: El Niño Southern Oscillation , quasi-biennial oscillation (QBO)

Analysis of the Distribution and Controlling Factors in the Atmospheric Gravity Wave Potential Energy

Analysis of the Distribution and Controlling Factors in the Atmospheric Gravity Wave Potential Energy

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In the past years, global morphology and climatology of gravity waves have been widely studied and the effects of topography and convection systems have been evaluated, but the complete gravity wave distribution could not be explained by these effects. To find the missing controlling factors, a series of synoptic scale analyses is performed in the present study to investigate relationships between synoptic scale factors and potential energy (E_p) associated with gravity waves. Global distribution of E_p during a 12-year period from 2002 to 2013 is derived using temperature profiles retrieved from observations of Sounding of the Atmosphere using Broadband Emission Radiometry (SABER) instrument onboard the Thermosphere Ionosphere Mesosphere Energetics and Dynamics (TIMED) satellite. Synoptic scale factors obtained from ECMWF Interim reanalysis data are employed to investigate the correlation between synoptic systems and E_p. It is found that E_p values are high around extratropical cyclones over mid-latitudes (30° –60°) and around the Intertropical Convergence Zone (ITCZ) over low-latitudes (10° –30°). E_p values are low around subtropical highs over both mid- and low-latitudes. This is the first time that a synoptic scale analysis of E_p distribution is performed, and the influence of synoptic scale factors on E_p confirmed.

キーワード：gravity waves、potential energy、synoptic scale factors、TIMED/SABER
Keywords: gravity waves, potential energy, synoptic scale factors, TIMED/SABER

昭和基地レイリー/ラマンライダーライダー観測を用いた高度15-70kmの重力波活動の高度・季節変動の研究

Study of vertical / seasonal variation of gravity wave in the height range of 15-70km over Syowa Station in Antarctica using Rayleigh/Raman lidar

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下層大気で発生した重力波は上方伝播し、中層大気へ運動量・エネルギーを輸送する。その効果は、中層大気の水平平均風を変化させ、大規模子午面循環を引き起こし、中層大気の鉛直気温プロファイルを大きく変化させることが定性的に理解されている[Lindzen, 1981; Holton, 1982; Matsuno, 1982]。しかし、現在でも重力波の水平平均風への定量的寄与は理解が不十分である。そのため、国立極地研究所は南極昭和基地(69°S, 40°E)にレイリー/ラマン(RR)ライダーを設置し、2011年2月から高度約5-80kmの気温観測を行い、重力波による気温擾乱を観測している。2014年10月終わりまでに350晩以上の観測を行っており現在も観測を継続している。
本研究では、昭和基地上空の高度15-70kmの月平均ポテンシャルエネルギー（*Ep*）を2011年5月から2013年10月まで（11、12、1月を除く）求めた。高度35-70kmの活動度は、昭和基地に近いDavis基地(69°S, 78°E)でレイリーライダー観測を行った先行研究[Alexanderetal.2011]と類似した冬極大の季節変動が見られた。同様に高度35km以下でも晩秋(5月)に活動度が上昇するのが見られた。しかし、高度35-70 kmと異なり晩冬(9月)に活動度が下がらなかった。月平均*Ep*の高度変化については期間全体を通して、高度30 km以上では高度と共に指数関数的に増加し（増加率はおおむねexp(z/2H); H~7 km はスケールハイト）、高度30 km以下では25 km付近に極小、20 km付近に極大を持つことがわかった。しかし、2012年10月の月平均*Ep*プロファイルはこれとは異なり、高度40-45kmに極小を持つ高度変化を示していた。全球気象再解析データ（NASA/MERRA）による昭和基地上空の東西風の季節変化と、観測で得られた月平均Epの高度分布の関係を調べた結果、2012年10月のプロファイルが異なる理由は、東西風が弱い高度域が下りてくる速度が他の年に比べて早かったことが原因だと考えられる。

キーワード：重力波、中層大気、ライダー
Keywords: gravity wave, middle atmosphere, lidar

GAIA モデルを用いた成層圏突然昇温後に伴う下部熱圏温度全球平均値下降現象に於ける潮汐波の鉛直熱輸送寄与の評価

Evaluation of Global Mean Temperature Cooling in lower thermosphere just after Stratospheric Sudden Warming due to Tidal wave's vertical thermal advection using GAIA model

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日本気象学会2015春季大会に於いて宮原三郎九州大学名誉教授と陳穎雯JAMSTEC博士研究員は「成層圏突然昇温（SSW）に伴う下部熱圏全球平均温度変動:Kyushu-GCMによる解析」について報告した．その解析結果によるとSSW直後の下部熱圏全球平均温度下降の５０％程度はsemi-diurnal tide(東西波数２)波動擾乱の鉛直熱輸送によると示された．
Kyushu-GCM は高度150 km までの大循環モデルである．更に上層の下部熱圏で前述の解析結果を検証するために高度500km までを表現できるGAIA(75層)モデルを用いて潮汐波擾乱によるSSW後の下部熱圏全球平均温度下降に対する寄与について解析を行なった．高度200kmまでの温度下降は semi-diurnal tide(東西波数2)擾乱による冷却が卓越しておりKyushu-GCMの場合と同様のことを結論付けることができる．
併し高度200km以上になるとsemi-diurnal tide 擾乱は冷却に働くがdiurnal tide(東西波数1)擾乱は加熱に働く．Migrating tide擾乱全体でも加熱に働き、SSW直後の下部熱圏全球平均温度下降を潮汐擾乱の鉛直熱輸送では説明できない．Non-Migrating Tide は冷却にも加熱にも寄与していない．Waltersheid (1981)は内部重力波擾乱の鉛直熱輸送により冷却効果が下部熱圏で働いていることを理論的に示した．
従って高度200 km 以上では下部熱圏全球平均温度下降は多くの重力波によるものである可能性を示唆している．GAIA(75層)は鉛直解像度が Kyushu-GCM(250層)に比べ低いので大会会場では GAIA(150層)の解析結果についても報告する予定である．

キーワード：成層圏突然昇温、大気潮汐波、GAIA model
Keywords: Stratospheric Sudden Warming, Atmospheric Tidal Wave, GAIA model

インドネシアに設置された2台の流星レーダーを用いた運動量フラックスの測定法について
Measurement of momentum flux Using two meteor radars in Indonesia

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Two nearly identical meteor radars were operated at Koto Tabang (0.20°S, 100.32°E), western Sumatra, and Biak (1.17°S, 136,10°E), western Papua in Indonesia, separated by approximately 4,000 km in longitude on the equator. The zonal and meridional momentum flux, $u'w'$ and $v'w'$, where u, v and w are the eastward, northward and vertical wind velocity components, respectively, were estimated at 86 to 94 km altitudes using the meteor radar data by applying a method proposed by Hocking [2005]. The observed $u'w'$ at the two sites agreed reasonably well at 86, 90 and 94 km during the observation periods when the data acquisition rate was sufficiently large enough. Variations of $v'w'$ was consistent between 86, 90 and 94 km altitudes at both sites. The climatological variation of the monthly averaged $u'w'$ and $v'w'$ was investigated using the long-term radar data at Koto Tabang from November 2002 to November 2013. The seasonal variations of $u'w'$ and $v'w'$ showed a repeatable semiannual and annual cycles, respectively. $u'w'$ showed eastward values in February-April and July-September, and $v'w'$ was northward in June to August at 90-94 km, which were generally anti-phase with the mean zonal and meridional winds, having the same periodicity. Our results suggest the usefulness of the Hocking method.

キーワード：流星レーダー、運動量フラックス、中間圏・下部熱圏、Hocking法、赤道、半年周期変動
Keywords: Meteor radar, Momentum flux, Mesosphere and lower thermosphere, Hocking method, Equator, Semi-annual variation

ポーカーフラット及びトロムソMFレーダーで観測された中間圏重力波の半日周期変動
Tidal modulation of mesospheric gravity waves observed with MF radar at Poker Flat, and Tromsø

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アラスカ・ポーカーフラット及びノルウェー・トロムソに設置されたMFレーダーにより中間圏から下部熱圏における中性風速データが1990年代後半以降観測されている。本研究では10年間（1999〜2008年）の上記観測データを用いて、短周期重力波活動の半日周期変動と半日潮汐波を含む背景場の関係について詳細に調べる。
まず、これまで行ってきた解析と同様、水平風速データから重力波と潮汐波の抽出を行う。ここで、潮汐波は30分平均データ5日間分からトレンドを除き、8，12，24時間周期の正弦波をフィッティングして振幅と位相を30分ごとに求めた。一方、1〜4時間周期を持つ擾乱を短周期重力波として解析した。潮汐波とGW-KEの半日周期成分の1日コンポジット解析を各月ごとに10年分計算した結果、ポーカーフラットでは11〜12月において半日潮汐が東風時、1，2，5〜8月では東風から西風に変わる時、トロムソでは11〜2月において半日潮汐が西風時、5〜9月では東風時にGW-KEが最大となることがわかった（IUGG2015）。この現象の物理メカニズムを考察した結果、夏季のポーカーフラットで見られた関係以外、重力波のクリティカルレベルフィルタリングによる減衰・砕波により説明できることが示された。今後は、夏季のポーカーフラットで見られたGW-KEと半日潮汐との位相関係及び、GW-KEの日周期成分においてクリティカルレベルフィルタリングでは説明できない現象ついてさらに解析を進め、物理メカニズムを議論したい。

キーワード：大気重力波、大気潮汐、中間圏
Keywords: Atmospheric Gravity Wave, Atmospheric Tide, Mesosphere

Recent Progress on Advanced Ionospheric Probe Onboard FORMOSAT-5 Satellite

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Advanced Ionospheric Probe (AIP) is a piggyback science payload developed by National Central University for FORMOSAT-5 satellite since 12 January 2012. The AIP is an all-in-one plasma sensor to measure ionospheric plasma concentrations, velocities, or temperatures in a time-sharing way. Meanwhile, the AIP is capable of measuring ionospheric plasma irregularities with sampling rate up to 8,192 Hz over a wide range of spatial scales. Electroformed gold grids used in the AIP can reduce quasi-hysteresis effect on current-voltage curves in a plasma injection test and approximate ideal electrical potential surfaces for accurate data available in the future. The AIP flight model has passed through preliminary and critical design review, functional and environmental tests, and then was delivered to the NSPO on 8 October 2013. It is scheduled to launch into a low Earth orbit on a Falcon 9 rocket manufactured by Space Exploration Technologies Corp. from Vandenberg Air Force Base in the 2nd quarter 2016 to carry out a two-year scientific mission on space weather and seismic precursors. At the beginning the AIP will be routinely operated within ±75° latitude in the night-side sector to meet a 5-W limit in average power per orbit due to high power consumption and a heat dissipation issue. Up to 1.5 gigabits per day in data storage, the AIP is capable to perform 8,192 electric current readings per second with duty cycle under 10% to resolve fine structure of equatorial ionospheric plasma irregularities within ±18° latitude.

Keywords: AIP, FORMOSAT-5, Ionosphere

Conjugate observations of low-latitude travelling ionospheric disturbances by a 630-nm airglow imager at Indonesia and the CHAMP satellite

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We report the first comparison of ground and satellite measurements of equatorial travelling ionospheric disturbances (TIDs) by using a 630-nm airglow imager and the CHAMP satellite. The airglow images are obtained at Kototabang (KTB), Indonesia (geographic coordinates: 0.2S, 100.3E, geomagnetic latitude: 10.6S), during a 7-year period from October 2002 to October 2009. Only three TID events with ground and satellite conjugate measurements are found on April 30, 2006 (event 1), September 28, 2006 (event 2) and April 12, 2004 (event 3). All three events were southward-moving structures in 630-nm airglow images. The events 1 and 2 are single pulse with horizontal scales of ~500-1000 km. The event 3 show three wave fronts with horizontal scale size of 500-700 km. For event 2, the neutral density shows in-phase variations with the airglow intensity. However for events 1 and 3, they are out of phase. The relation between electron density and airglow intensity is out of phase for event 1, while their relationship are unclear for event 2 and 3, suggesting that ionospheric plasma variation is not the cause of the observed TID. If the TIDs are caused by gravity waves in the thermosphere, in and out of phase relationships between neutral density at an altitude of 400 km at CHAMP and airglow layer at 250 km, should depend on the vertical wavelength of the gravity wave, which is highly affected by background wind. We estimate possible vertical wavelengths for those events to explain the observed phase relationships between neutral density and airglow intensity.

Keywords: Travelling Ionospheric Disturbances, CHAMP, Airglow Imager

The Occultation TEC Assimilated to NCAR/TIE-GCM to Simulate the Ionosphere During the Storm Time

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We will construct a data assimilation model with the Thermosphere-Ionosphere Electrodynamics General Circulation Model (TIE-GCM) for the ionosphere by assimilating the FORMOSAT-3 occultation total electron contents (OTEC). The TIE-GCM was developed by NCAR/HAO is a self-consistently electrodynamics coupled thermosphere and ionosphere model subjected by a few parameters with the lower and upper boundary conditions to describe the dynamics of the ionosphere and the thermosphere. The measured occultation total electron contents (OTEC) along the light path from GPS to LEO satellites could be assimilated with the TIE-GCM as a realistic model for the space weather in the ionosphere. We assimilated the FORMOSAT-3 OTEC data with TIE-GCM to optimize the parameters for atmospheric tides at lower boundary used in the model that improved the simulation of the electron density distribution in geomagnetic quiet days. The assimilated OTEC data during the geomagnetic storm time will optimize the sensitive physical control parameters of the model such as hemispheric particle participation power (HP), polar cap potential drop (CP). We simulate the ionosphere in storm time in the day Sep. 09, 2011 with the assimilated data with 3 hours per cycle. The optimized time dependent parameters, HP and CP, used in TIE-GCM will be compared with the values in the geophysical indices database (GPI).

共鳴散乱ライダーで得られた中間圏下部熱圏における大気温度の時間-高度変動特性（36°N, 140°E）
Time and height variability of temparature in Mesosphere and Lower Thermosphere region based on resonance scattering lidar measurement at NIPR (36°N, 140°E)

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The National Institute of Polar Research (NIPR) is leading a six year prioritized project of the Antarctic research observations since 2010. One of the sub-projects is entitled ‘the global environmental change revealed through the Antarctic middle and upper atmosphere’. As a part of the sub-project, a Rayleigh/Raman lidar (RR lidar) was installed at Syowa, Antarctica (69S, 39E) in January, 2011. The operation has been conducted since February 2011 and the RR lidar has kept measuring temperature profiles continuously between approximately 10 and 80 km for almost 3 years. In order to extend the height coverage to include mesosphere and lower thermosphere region, a new resonance scattering lidar system with tunable wavelengths is developed at NIPR in Tachikawa (35.7N, 139.4E).
The lidar transmitter is based on injection-seeded, pulsed alexandrite laser for 768-788 nm (fundamental wavelengths) and a second- harmonic generation (SHG) unit for 384-394 nm (second harmonic wavelengths). The laser wavelengths are tuned into the resonance wavelengths by a wavemeter that is calibrated and validated using a wavelength-stabilized He-Ne laser and a potassium vapor cell for doppler-free spectroscopy. This lidar has capabilities to measure density variations of minor constituents such as atomic iron (Fe, 386 nm), atomic potassium (K, 770 nm), calcium ion (Ca+, 393 nm), and nitrogen ion (N2+, 390, 391 nm) and temperature profiles in the mesosphere and lower thermosphere (MLT) region. It can also estimate temperature profiles from the upper Storatosphere to the lower mesosphere using signals of Rayleigh scattering.
In this presentation, we will presnet time and height variability of temparature in the MLT region based on campaign observation in winter 2015-2016 focusing on Sudden Stratospheric Warming (SSW) impact on dyanmics in the MLT region. In addition, the obtained temperature profiles are validated by comparisons to those obatined from satellites data such as Aura/MLS. In addition, dynamical and/or chemical response to SSW and sporadic E-layer in MLT region are discussed using neutral Fe atom density data.

キーワード：中間圏ー下部熱圏、大気温度、成層圏突然昇温
Keywords: the Mesosphere and Lower Theremosphere, Temperature, Sudden Stratospheric Warming

共鳴散乱ライダーによるCa+密度観測で見られた電離圏E領域プラズマ中の微細構造

Fine structures in the E-region plasma density of the ionosphere observed by a Ca^+ resonance scattering lidar observation

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The National Institute of Polar Research (NIPR) is developing a new resonance scattering lidar with multiple wavelengths to install and operate it at Syowa, Antarctica. The lidar will observe temperature profiles and variations of minor constituents such as Fe, K, Ca^+, and aurorally excited N_2^+ in the mesosphere and lower thermosphere. In August 2014, it received the first light from Ca^+ in a sporadic E layer. After that, we increase the resolution of the Ca+ observation and have succeeded in getting the Ca^+ profile with time/height resolution of 5 sec/15 m. As a result of the high resolution observations, fine structures in a sporadic E layer with a vertical width of only 1 -2 km have become detectable clearly. In this presentation, we will show the observed fine structures and discuss atmospheric instabilities in the E-region plasma.

キーワード：共鳴散乱ライダー、カルシウムイオン、微細構造、スポラディックE層、中性大気・プラズマ相互作用
Keywords: resonance scattering lidar, Ca+, fine structure, Sporadic E layer, interaction of neutral and plasma atmospheres

First nadir imaging of medium-scale traveling ionospheric disturbances by the spectrographic imager on International Space Station

First nadir imaging of medium-scale traveling ionospheric disturbances by the spectrographic imager on International Space Station

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Medium-scale traveling ionospheric disturbances (MSTIDs) at mid-latitudes are wave-like structures of the ionosphere, which has been mainly observed by ground-based instruments. It is more challenging to observe MSTIDs from the space while it can clarify spatiotemporal characteristics of MSTIDs. In this presentation, we show the first result of nadir imaging of MSTIDs by the Visible and near-Infrared Spectral Imager (VISI). VISI is one of the instruments of the ISS-IMAP (International Space Station-Ionosphere, Mesosphere, upper Atmosphere, and Plasmasphere mapping) mission, which is designed to measure three nightglow emissions; O (630nm), OH Meinel band (730 nm), and O2 atmospheric band (762 nm), with two field of views (+/-45 deg. to nadir). Using 630-nm airglow data of an ionospheric observation mode, MSTIDs structures were successfully detected on May 22, 2014. Horizontal wavelengths of the MSTIDs were 200-500km, which agreed with those observed by ground-based instruments. The peak-to-peak amplitude of MSTIDs observed by the forward (backward) field of views were about 40% (60%) of the background. The difference of the ratios indicates the geomagnetic field-aligned structure of the MSTIDs.

キーワード：nadir imaging、630nm airglow、medium scale traveling ionospheric disturbance
Keywords: nadir imaging, 630nm airglow, medium scale traveling ionospheric disturbance

HFドップラーにより観測された異なる高度での地震に伴う電離圏変動
Coseismic ionospheric disturbances at different altitudes observed with HF Doppler

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Many studies have reported that ionospheric disturbances occur after large earthquakes. One of the main causes for these disturbances is acoustic wave excited by Rayleigh wave propagated on the ground from the epicenter. The acoustic wave perturbes ionospheric electron density in propagating the ionosphere. Several observations, such as GPS, HF Doppler, the ionogram, observed the ionospheric perturbations at appropriate altitudes for each observations. However, there are few reports for the direct demonstration of vertical propagation of acoustic waves using the single observation. Here, we have observed ionospheric disturbances at the different altitude simultaneously using HF Doppler system (HFD). In this system, radio waves at four different frequencies are observed, implying that the ionospheric perturbations at up to four different altitudes are observed by this system. In examining earthquakes occurred around Japan since 2003, we have found 3 events in which the ionospheric perturbations were observed with the multiple frequencies. From their wave forms, the higher components of the perturbations decay as the altitude is higher. In conjunction with the seismometer data observed below the reflection point of the HFD radio waves, the amplification ratio of the atmospheric wave from ground to the ionosphere have calculated in 3 bands (10.0-25.6, 25.6-45.5, and 45.5-76.9 mHz). Theoretical amplification ratio were also calculated based on energy conservation law, considering absorption by viscosity, thermal conductivity, and relaxation losses of atmosphere (Chum et al., 2012). In comparison of the theoretical amplification ratio, that determined by HFD is rather smaller. However, their height profiles are qualitatively consistent each other; higher frequency components are more greatly damped in at high altitude. There might be the reasons for this difference; attenuations of wave energy that is not considered, differences between model parameters and real values, and lesser conversion efficiency when ground motions excite infrasound waves.

キーワード：電離圏変動、地震、HFドップラー、音波
Keywords: Ionospheric perturbation, earthquake, HF Doppler, acoustic wave

Plasma Depletion Bays in the Equatorial Ionosphere Observed by TIMED and FORMOSAT3/COSMIC during 2007-2015

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An interesting new feature of three Northern (one Southern) ionospheric plasma depletion bays over the magnetic equator is for the first time found in airglow emissions of 135.6 nm by TIMED/GUVI in May (January) of 2007. Electron density profiles derived from FORMOSAT3/COSMIC are further used to study diurnal, altitude, seasonal, longitudinal, and solar activity variations of the plasma depletion bays. Results show that the plasma depletion bays become the most prominent at 250-300 km altitude around the midnight during the low solar activity year. The three (one) bays appear between 60W-180E (80W-150W) during April-September, especially May (October-March). Model simulations suggest that the trans-equatorial neutral wind in the thermosphere should play an important role.

Keywords: FORMOSAT3/COSMIC, TIMED/GUVI, IONOSPHERE

Seasonal variation of the equatorial wind jet at 250 km and 400 km: GOCE and CHAMP observations

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By using long-term in-situ wind observations from the GOCE satellite at 250 km, and the CHAMP satellite at ~400 km, this study examine the seasonal variation of the equatorial wind jet previously reported using short-term CHAMP and DE-2 satellite observations. The results show that the wind jet exists at both altitudes, and experiences similar seasonal variations. The wind jet is found to be strongest around the September equinox, and disappears around the June solstice at both altitudes. The jet shows little solar cycle and geomagnetic activity dependence. These seasonal variations are interpreted in the framework of ion-neutral interaction.

Keywords: wind jet, thermosphere wind, ion-neutral coupling

地磁気日変化振幅に見られる電離圏電場の長期変動

Long-term variation of ionospheric electric fields as seen in the amplitude of geomagnetic solar quiet daily variation

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地磁気日変化(Sq)は、電離圏E領域を流れる大規模電離圏電流によって引き起こされる。その電離圏電流は、正午付近の中緯度では負、赤道域では正の地磁気南北成分磁場をそれぞれ作る。オームの法則によれば、このSq磁場変動をもたらす物理パラメータは、電離圏電気伝導度、分極電場、そしてダイナモ電場からなる。したがって、Sq磁場変動の長期変動特性を調べることは、電離圏、および超高層大気の長期変動を理解する上で重要である。これまで観測とモデリングに基づくSq磁場変動の長期変動に関する多くの研究がなされてきたが、長期でかつ全球的な電離圏伝導度値の情報が不足していたために、全球にわたるSq電離圏電場の長期変動特性の実態はよくわかっていない。そこで本研究では、1958年から2015年までの地磁気と電離圏電気伝導度モデル値を用いて、全球のSq電離圏電場の長期変動特性(季節変動、太陽活動、長期トレンド)を調べ、電離圏と超高層大気の長期変動メカニズムを解明することを目的とする。ここでは、京大地磁気センターが管理するデータベースに登録されている地磁気Kp指数、および地磁気1時間値を使用した。また、Sq電場の太陽活動依存性を調べるために、月平均太陽F10.7指数を参照した。そして、高度80 km –150 kmの範囲を積分した2次元電気伝導度モデル値をSq電場の導出の際に用いた。まず、各日のKp指数で4を超えない日を地磁気静穏日と同定し、その日に該当する中緯度から赤道域の地磁気データを選定した。同定された地磁気静穏日のおのおのの地磁気東西、南北成分について、真夜中の値からのずれをSq場による変動とみなし、それらを各時間について1ヶ月平均をした。最終的にオームの法則からSq場の東西、南北の磁場振幅と2次元電気伝導度からSq場の電離圏電場を導出した。その結果、グアム(赤道域)と女満別(中緯度)における正午付近のSq場の磁場変動と電離圏電気伝導度の長期変動は、1958年から2015年の間、明瞭な季節変化と11年太陽活動周期性を示した。そして、両者ともに太陽活動期において増加する傾向が見られた。Sq場の磁場変動の季節変化のパターンは、地磁気の成分によって異なっており、南北成分は、春分の時期に最大となるが、東西成分は、秋分の時期に最大になる。このような季節変動特性は、電離圏電気伝導度には見られなかった。一方、Sq場の電離圏東西、南北電場もまた明瞭な季節変化と11年太陽活動周期性を示したが、東西成分の電場は、緯度によって太陽活動依存性が異なっていた。それは、赤道域のグアムでは太陽活動と正の相関を示したが、中緯度域の女満別は、太陽活動極小期に東西電場の調度が増加するという反相関の関係にあった。このような傾向が全ての観測点において見られるかどうかを調べるために、20年以上の連続した地磁気データが存在する83の地磁気観測点におけるデータ解析を行った。その結果、太陽F10.7指数と東西電場の間のラグなしの相関係数の全球分布は、地理経度に関係なく、赤道域では正の値を、中緯度では負の値を示していた。よって、この結果から正午付近におけるSq場の電離圏東西電場の太陽活動依存性が全球的に見て赤道域と中緯度域と異なると言える。今後は、全ての地方時において太陽活動とSq電場との相関関係を調べ、太陽活動期にSqの東西電場強度の減少要因を明らかにする予定である。

キーワード：地磁気日変化、太陽活動、電離圏電場、季節変化、超高層大気、赤道域
Keywords: Geomagnetic solar quiet daily variation, Solar activity, Ionospheric electric field, Seasonal variation, Upper atmosphere, Equatorial region

Coherent seasonal, annual, and quasi-biennial variations in ionospheric tidal/SPW amplitudes

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In this study, we examine the coherent spatial and temporal modes dominating the variation of selected ionospheric tidal and stationary planetary wave signatures from 2007 - 2013 FORMOSAT-3/COSMIC total electron content observations using Multi-dimensional Ensemble Empirical Mode Decomposition (MEEMD) from the Hilbert-Huang Transform. We examine the DW1, SW2, DE3, and SPW4 components, which are driven by a variety of in-situ and vertical coupling sources. The intrinsic mode functions (IMFs) resolved by MEEMD analysis allows for the isolation of the dominant modes of variability for prominent ionospheric tidal / SPW signatures in a manner not previously used, allowing the effects of specific drivers to be examined individually.
The time scales of the individual IMFs isolated for all tidal/SPW signatures correspond to a semiannual variation at EIA latitudes maximizing at the equinoxes, as well as annual oscillations at the EIA crests and troughs. All tidal / SPW signatures show one IMF isolating an ionospheric quasi-biennial oscillation (QBO) in the equatorial latitudes maximizing around January of odd numbered years. This TEC QBO variation is in phase with a similar QBO variation isolated in both the GUVI zonal mean column O/N2 density ratio as well as the F10.7 solar radio flux index around solar maximum, while showing temporal variation more similar to that of GUVI O/N2 during the time around the 2008/2009 extended solar minimum. These results point to both quasi-biennial variations in solar irradiance as well as thermosphere / ionosphere composition as a generation mechanism for the ionospheric QBO.

Keywords: Thermosphere, Ionosphere, Tides, QBO

The ionospheric characteristics over the northern equatorial anomaly crest during the prolonged solar minimum period

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In this study we have analyzed the diurnal, monthly, seasonal, and annual variation in NmF2, hmF2, foE, B0, scale height at F2 layer peak height (H_m), total electron content (TEC), and ionospheric equivalent slab thickness (tau symbol) over the northern crest equatorial anomaly area at solar minimum during 1995-1996 and 2008-2009. We collected the data from an ionosode station located at Chung-Li Observation (121.1.oE, 25.0oN) and GPS receiver (TWTF) located at Tao-Yuan (121.09oE, 24.57oN). The result shows the first maximum value for NmF2 and TEC occurred a time delay in 2008 comparison with values in 1995. The result of foE depicts a lower value during 2008-2009 than variation in 1995-1996. The variation of hmF2 in 2008-2009 was lower than values in 1995-1996. The ionospheric equivalent slab thickness during 0600-1200 LT was higher in 2008-2009 than values in 1995-1996, particularly in summer season. Furthermore, a comprehensive discussion of the physics processes for the variation of ionosphere during the prolonged low solar activity period.

Keywords: ionospheric physics, solar activity, ionospheric dynamics

LF帯標準電波を用いた2011年東北地方太平洋沖地震後のD領域電離圏擾乱
D-region ionospheric disturbances after the 2011 off the Pacific coast of Tohoku Earthquake using LF transmitter signals

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So far, a lot of studies for the F-region ionosphere associated with earthquakes have been reported, although few studies for the D-region ionosphere have reported. It is difficult to observe the D-region electron density because of high collision frequency between plasma and the neutral atmosphere. In this study, we investigate the D-region disturbances associated with the 2011 off the Pacific coast of Tohoku Earthquake using intensity and phase of LF transmitter signals. The phase was converted to reflection height based on Earth-ionosphere waveguide mode theory. The reflection height corresponds to electron density in the D-region. The propagation paths are Saga-Rikubetsu (RKB) and BPC(China)-RKB. As a result, clear oscillations of the intensity over both propagation paths were simultaneously observed about 6 minutes and 12 seconds after the earthquake onset. The both periods of the intensity and reflection height oscillations were about 100 s. The one-to-one corresponding between the intensity and reflection height was not seen clearly. The changes of the intensity and reflection height for the oscillations were about 0.1 dB and 50 - 65 m, respectively. The time difference between the earthquake onset and the oscillations was consistent with the propagation time of the Rayleigh waves (seismic waves) propagating from the epicenter to the LF propagation paths along the Earth surface, plus the propagation time of acoustic waves propagating from the ground to 70 km altitude vertically. Thus, the LF oscillations may be caused by the acoustic waves excited by the Rayleigh waves.

The photochemical model of atomic oxygen ions retrieving from ground-based observation of airglow

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To study the chemistry and composition of the upper atmosphere, we can utilize airglow emissions from the photochemical reactions of the ions in this region. When the atomic oxygen ions, which are distributed in the ionospheric F region, experience an energy level transition, visible light with a wavelength of 630 nm is released. We used the photometer system built by our team to perform ground-based observations of airglow over the sky of Taiwan at The Lulin Observatory (23°28′07″N, 120°52′25″E) during nighttime. We combined the mean values of our observations every 10 minutes with a photo chemistry model based on the formula derived from the theory of R. Link and L. L. Cogger. With this method, we can estimate how the density of oxygen atomic ions varies with time and altitude. This system will be used for long term observations to study the seasonal variation of upper atmosphere composition.

Keywords: photochemical, airglow, ionosphere

