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

MSD04-01 会場:101A 時間:5 月 24 日 09:00-09:30

EISCAT 及び EISCAT 3D を用いた最先端ジオスペース及び大気科学研究に向けて
Toward cutting edge of geospace and atmospheric sciences with EISCAT and EISCAT_3D

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The European Incoherent Scatter(EISCAT) radar system in northern Scandinavia and Svalbard has been playing a pivotal role in advancing cutting edge sciences in various areas including atmospheric, ionospheric and geospace studies, space weather and global change. Affiliated in the EISCAT scientific association in 1996, Japanese science community has jointly contributed to achieve further understanding of the magnetosphere-ionosphere-thermosphere coupling processes using the integrated ground-based instruments and rocket/satellite simultaneous observations with EISCAT radars. In this paper, an overview on several key scientific issues will be presented in order to stimulate further discussions for the new EISCAT_3D project more productive.

キーワード: 欧州非干渉散乱レーダー, 次期レーダー計画, ジオスペース科学, 大気科学, 最先端科学
Keywords: EISCAT, EISCAT 3D, geospace science, atmospheric science, cutting-edge sciences

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MSD04-02 会場:101A 時間:5 月 24 日 09:30-10:00

The AMISR Radars
The AMISR Radars

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The planned EISCAT_3D radar system is, in many ways, an extension of the AMISR radar systems developed for the U.S. National Science Foundation. Like 3D, AMISR is a phased array with pulse-to-pulse steering capability, flexible waveform capabilities, and similar scientific goals. This talk will present a survey of the capabilities of AMISR as well as some data examples from that system. Special emphasis will also be given to the new capabilities of the EISCAT_3D radar and many of the interesting scientific contributions that should result from its use.

キーワード: incoherent scatter radar, phased array
Keywords: incoherent scatter radar, phased array

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MSD04-03 会場:101A 時間:5 月 24 日 10:00-10:15

3 次元電離圏と結合したアルヴェーン波の反射過程
Scale-dependent reflection process of shear Alfven wave coupling to the 3D-ionospheric current system

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Interaction between shear Alfven wave and 3-dimensional ionosphere coupling to the auroral acceleration region (AAR) is discussed. In the conventionally established global M-I coupling process via shear Alfven wave, the ionosphere had been treated as a height-integrated conducting layer. This assumption can be validated under the condition that the ionospheric potential structure has no altitudinal dependence. However as shown by Lesserd and Knudsen [2002], the small scale shear Alfven wave (of which scale length is several km) incident from the magnetosphere to the ionosphere is almost absorbed into the ionosphere for any realistic condition of ionospheric conductances. Furthermore, existence of AAR also brings about scale-dependent reflection process of shear Alfven wave when the scale length is smaller than the resistive scale length (that is roughly 1000km for typical ionospheric conditions).

Composite effect of AAR and 3-dimensional current closure is very important because it is closely related to the physics of confinement of Hall current divergence in the ionosphere. From theoretical analysis, we found that characteristic scale length of effective conducting layer is controlled by the ratio of Pedersen to parallel conductivity. When the horizontal scale length of FAC is smaller than this characteristic scale, an effective ionospheric conductivity becomes small and FAC only closed via small fraction of ionospheric current. This means that the FAC closure is accomplished at the upper ionospheric E-layer or F-layer not at the all over the E-layer.

Our results strongly suggest that in a large scale M-I coupling process that is larger than ˜1000 km, the confinement of Hall current divergence in the ionosphere is controlled by the ratio of Alfven conductance to Pedersen conductivity but for small scale M-I coupling smaller than 1000 km is effectively confined in the ionosphere, which means the polarization electric field is efficiently produced for generation of Cowling effect.

キーワード: アルヴェーン波, 3 次元電離圏, 磁気圏電離圏結合
Keywords: Alfven wave, 3 dimensional ionosphere, Magnetosphere-Ionosphere coupling

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MSD04-04 会場:101A 時間:5 月 24 日 10:15-10:30

A study of electro-dynamical coupling between E and F regions
A study of electro-dynamical coupling between E and F regions

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Electro-dynamical coupling between E and F regions is one of important subjects for the ionospheric study. Recently, horizontal structures of sporadic E layer (Es) is required to be observed in order to understand effects of Es on generation and propagation of Medium-Scale Traveling Ionospheric Disturbances (MSTIDs), which are wavy structures of the plasma density in the F region. Whereas MSTIDs have been considered to be generated by atmospheric gravity waves, recent studies suggest that electro-dynamical process including polarization electric fields could play an important role in generating nighttime MSTIDs. The Perkins instability, which is a plasma instability operating at mid-latitudes, could explain most of features of the observed MSTIDs, but two major discrepancies between the observations and theory for the Perkins instability are pointed out. First, the growth rate predicted by the theory is too small (on the order of 10^{-4} s^{-1}) to explain the observations. Second, the instability theory cannot explain the equatorward and westward propagation of the MSTIDs. According to the Perkins instability theory, the structures generated by this instability should propagate at the same velocity as the background ExB drift, which is almost always to the east. However, this propagation direction is opposite to that of the observed MSTIDs. These two discrepancies could be resolved by considering E- and F-region coupling processes. However, horizontal structures of Es with scale-sizes of several hundred kilometers corresponding to the horizontal wavelength of the nighttime MSTIDs have not been revealed due to the limitation of instruments. EISCAT_3D is expected to observe the horizontal structures of Es and reveal the E- and F-region electro-dynamical coupling operating in the MSTID generation and propagation.

キーワード: EISCAT_3D, EISCAT, MSTID, sporadic E, ionospheric disturbance
Keywords: EISCAT_3D, EISCAT, MSTID, sporadic E, ionospheric disturbance

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MSD04-05 会場:101A 時間:5 月 24 日 10:30-10:45

EISCAT レーダーによる電離圏電気伝導度の同時スキャン観測
EISCAT simultaneous scanning observations of ionospheric parameters

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Akimasa Ieda[1*], Shin-ichiro Oyama[1], Aoi Nakamizo[1], Ryoichi Fujii[1]

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We compare ionospheric parameters along the same grate circle observed by two radars. The two European incoherent scatter (EISCAT) radars are located at Tromso (67 MLAT) and Longyearbyen (75 MLAT). This observation was planned to inter-calibrate the two radars and then to study the latitudinal profiles of the ionospheric parameters including conductance. The radars scan the ionosphere along a great circle with the elevation angles larger than 23 and 30 deg for Tromso and Longyearbyen radars, respectively. The radars are separated by 996 km along a great circle, which is nearly meridian. The midpoint of the two radar sites is geodetic (lon, lat) = (18.0, 73.9) deg. The two radars observe the midpoint at 300 km altitude with the elevation angle of 30 deg. This operation was conducted between 11-19 UT (12-20 LT) on March 30, 2012, including 1625 UT when the solar zenith angle is the same at the two radar sites. We will discuss the results after additional operations planned in March 2013.

キーワード: 電離圏電気伝導度, 電離圏, 欧州非干渉散乱レーダー
Keywords: ionospheric conductivity, ionosphere, EISCAT, incoherent scatter radar

Japan Geoscience Union Meeting 2013
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MSD04-06 会場:101A 時間:5 月 24 日 11:00-11:30

EISCAT_3D-N: A proposal to the Research Council of Norway to finance EISCAT_3D
EISCAT_3D-N: A proposal to the Research Council of Norway to finance EISCAT_3D

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I describe in this presentation the proposal of the Department of Physics and Technology of the University of Tromso in Norway to the Research Council of Norway to partially fund the construction of EISCAT_3D (E3D). E3D is an international project on The European Strategy Forum on Research Infrastructures (ESFRI) roadmap. E3D will be a world-class radar facility for investigations of the geospace environment. It will replace the present EISCAT facilities in northern Norway, Sweden and Finland. E3D will use the incoherent scattering (IS) technique to make 3-dimensional vector measurements across a wide field of view of key parameters in the auroral atmosphere by taking advantage of technological advances in radio, radar, computing, and signal analysis. E3D will have 20 times better sensitivity and one order of magnitude better resolution than all other radar facilities in the world. E3D will allow us to understand the flows, sources, sinks, and interactions of energy, momentum and mass in the auroral atmosphere. E3D will provide synergies towards relevant areas of increasing socioeconomic importance; including atmospheric precursors of climate change and vulnerability of modern technological infrastructures due to space weather and space debris. E3D can study auroral particle precipitation that depletes ozone in the stratosphere, and atmospheric tides and sudden stratospheric warming events that bring disturbances to the ionosphere from below. Real-time measurements from E3D will be provided to monitoring services dealing with space weather and space debris, a key focus of ESA's Space Situational Awareness (SSA) programme. E3D will also contribute to science and engineering education at all levels. The project will create opportunities to national industry and services of the member countries in communications hardware and software and information technologies. This E3D project is backed by all major universities in Norway (Tromso, Bergen, Oslo, UNIS and NTNU), Andoya Rocket Range, and the Norwegian Space Centre).

キーワード: Incoherent Scatter Radar, Ionosphere physics, Polar ionosphere, Space weather
Keywords: Incoherent Scatter Radar, Ionosphere physics, Polar ionosphere, Space weather

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MSD04-07 会場:101A 時間:5 月 24 日 11:30-12:00

EISCAT_3D in Sweden: national science targets, roadmap and funding plan

EISCAT_3D in Sweden: national science targets, roadmap and funding plan

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EISCAT_3D will be a multistatic radar capable of imaging volumes in the Earth's atmosphere and geospace. Presently, five radar sites are foreseen to be located in northern Scandinavia, including one site with a 10 MW transmitter. EISCAT_3D is designed to use several different measurement techniques never before combined together in a single radar system: volumetric imaging, aperture synthesis imaging, multistatic imaging, scanning, tracking and adaptive experiments, and the possibility for continuous monitoring of the ionosphere and neutral atmosphere.

EISCAT_3D is on the roadmap of the European Strategy Forum on Research Infrastructures (ESFRI) since 2008. It is identified as a major step in the development of EISCAT, which must be taken to stay on the scientific forefront. The planning of EISCAT_3D is currently financed by the EU Commission and the Swedish Research Council (VR). This presentation gives an overview of the Swedish science targets, roadmap and funding plan to support the EISCAT_3D construction, as proposed to VR by the Swedish scientific community on March 26, 2013.

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MSD04-08 会場:101A 時間:5 月 24 日 12:00-12:15

極域下部熱圏中性風の研究への期待
Study of the lower thermospheric wind dynamics

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The lower thermospheric wind dynamics has been paid attention for several decades to understand the Magnetosphere-Ionosphere-Thermosphere coupling. In particular, it has been an issue how the lower thermosphere will response to the solar wind energy input. IS radar measurements of the polar lower thermosphere begun about 40 years ago by a pioneer work of Brekke et al. [JGR, 78, 8235, 1973], and significant number of studies have been published since then. However, our understanding of the lower thermosphere is still limited. One of reasons is that the lower thermosphere is significantly influenced by atmospheric waves propagating from below. Thus, the day-to-day variability is very prominent. Owing to high running cost, long run of IS radar had not been conducted a decade ago. In 2007-2008, EISCAT Svalbard radar was operated almost continuously for 1 year. However, only about 20 % of the data sets can be used for deriving the ion velocity vector. If we have wind velocity datasets on daily basis like meteor and MF radars usually made for the mesospheric wind measurements, our understanding of the lower thermosphere wind dynamics will be much more progressed. EISCAT 3D can make it possible. I will overview works of the lower thermospheric wind and propose what kind of run we desire.

キーワード: EISCAT 3D, 下部熱圏, 北極域
Keywords: EISCAT 3D, Lower thermosphere, polar region

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MSD04-09 会場:101A 時間:5 月 24 日 12:15-12:30

EISCAT_3D による下層大気の３次元風速分布観測に向けて
Toward EISCAT_3D observation of three-dimensional wind velocity in the

古本 淳一[1*], 山本 衛[1], 橋口 浩之[1], 津田 敏隆[1]
Jun-ichi Furumoto[1*], Mamoru Yamamoto[1], Hiroyuki Hashiguchi[1], Toshitaka Tsuda[1]

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Both of IS and ST radars is the high-power atmosphere radars at the VHF- or UHF- frequencies. In the IS radar measurement, clear-air echoes in the troposphere and stratosphere is able to detect, although most of research are not interested in measurements. This paper introduces the MST radar technique to IS radar measurement for lower atmosphere measurements. The radar imaging technique originally developed for turbulence technique will be helpful for measurement of upper atmosphere measurement also. This paper discusses the feasibility of various MST radar techniques to EISCAT_3D.
Keywords: EISCAT_3D

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MSD04-10 会場:101A 時間:5 月 24 日 12:30-12:45

大気大循環モデルによる下部熱圏中性風の運動量収支見積もり
The momentum balance of the neutral atmosphere in the lower thermosphere estimated by a GCM.

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The polar lower thermosphere neutral winds show significant variations due to the energy inputs from the solar UV/EUV flux and from the magnetosphere. The EISCAT radar observation revealed that the neutral wind at an altitude of 118 km exceeds 500m/s during strong energy input. They estimated the momentum balance of the neutral wind and concluded that the major driving force was the horizontal pressure gradient force induced by the Joule heating. However the direct observation of the neutral density and pressure were not performed. The absence of these parameters may cause a serious error in the momentum balance of the neutral wind. In this study, we examined mechanism for the generation of high speed neutral wind in the lower thermosphere using a whole atmosphere general circulation model. We performed a series of GCM experiments under various conditions (Cross polar potential: 30, 90 120 and 150kV). We obtained the enhancement of the neutral wind with the magnitude of 500 m/s under the disturbed condition. This enhancement of the neutral wind obtained in this study is comparable to the observed. Analysis of the momentum balance of the neutral wind indicates that the fluctuations of the wind under the quiet and disturbed condition are mainly caused by the pressure gradient force which is generated by the Joule heating. In particular, the enhancement of the wind under the disturbed condition coincides with the increase of the pressure gradient force. We also found that the molecular diffusion was not negligibly small and attenuated the high speed neutral wind under the disturbed condition

キーワード: 運動量収支, ジュール加熱, 数値シミュレーション
Keywords: momentum balance, Joule heating, Numerical simulation

Japan Geoscience Union Meeting 2013
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MSD04-11 会場:101A 時間:5 月 24 日 14:30-14:45

南東方向に動くカスプオーロラに伴うメソスケールフローのダイナミクス
Mesoscale flow dynamics related to a southeastward-moving auroral transient in the cusp

田口 聡 [1*], 小川 泰信 [2], 細川 敬祐 [1]
Satoshi Taguchi[1*], Yasunobu Ogawa[2], Keisuke Hosokawa[1]

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In this paper we focus on a mesoscale phenomenon that moves in the southeastward direction on the poleward side of the stable cusp precipitation region, using data from a high-sensitivity all-sky imager and the EISCAT radar at Longyearbyen, Svalbard. During an interval of weakly southward IMF on 13 January 2013 EISCAT northwestward-directed low-elevation measurement detected an enhanced southeastward flow accompanied by the clear increase both in the ion and electron temperatures. The all-sky imager shows that a mesoscale aurora form is detached from the poleward boundary of the stable cusp precipitation region at ~1130 MLT, and that it moves rapidly in the direction expected from the radar observation. When this aurora form reaches the local noon, it slows down, and then diminishes. We present detailed characteristics of the mesoscale flow dynamics related to this auroral form, and discuss whether or not this phenomenon can fall in the category of the usual poleward-moving auroral form.
Keywords: aurora, cusp, particle precipitation, plasma flow, solar wind magnetosphere interaction

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MSD04-12 会場:101A 時間:5 月 24 日 14:45-15:00

オーロラ活動に伴う高エネルギー電子の降り込み；EISCAT 観測
Sub-relativistic electron precipitation associated with the diffuse aurora; EISCAT observations

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The diffuse/pulsating aurora are caused by precipitations of tens keV electrons, and the whistler chorus wave-particle interactions have been expected to be a possible candidate for the pitch angle scattering. The numerical simulation on the wave-particle interactions predicts that sub-relativistic electrons of more than 100 keV should precipitate simultaneously with tens keV electrons because the whistler mode waves can resonate with higher energy electrons at high-latitude along the magnetic field line. Therefore, if precipitations of sub-relativistic electrons are confirmed associated with the diffuse/pulsating aurora, it is evidence that whistler mode chorus cause diffuse/pulsating aurora. In November 2012, we conducted the European Incoherent Scatter (EISCAT) observations at Tromso, Norway to measure the electron density above 60 km associated with the diffuse/pulsating aurora. The EISCAT VHF radar observations confirmed that the electron density enhancements at 80 km due to ~200 keV electron precipitations. The pulsating aurora was observed in the equatorward side of the EISCAT. In this presentation, we will compare the electron density profile measured by EISCAT with the computer simulation on the precipitated electrons by whistler mode chorus and discuss the possible mechanism of the density enhancement at 80 km.

キーワード: オーロラ, 波動粒子相互作用, EISCAT
Keywords: aurora, wave-particle interactions, EISCAT

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MSD04-13 会場:101A 時間:5 月 24 日 15:00-15:15

オーロラ高速撮像の科学
The science of high-speed imaging of aurora

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Pulsations, irregularly switching on and off in the brightness with typical durations of an order of 2 to 20 s, are a fundamental characteristic of post-midnight aurora. Although the pulsating aurora is weak compared with those of quiet arcs or breakups, a cutting-edge sensitive high-speed camera is now capable of detecting the faint aurora with more than several hundred frames per second. In fact, it has been found that a fastest-ever-observed fluctuation is superimposed on a pulsating aurora, which is more than an order of magnitude faster than well-known 3 Hz modulation [1]. The generation mechanism remains unknown, and two different possibilities of the modulation source arise at the equatorial magnetosphere and at the magnetosphere-ionosphere coupled region. The new science of high-speed imaging of aurora will be discussed, including the latest results obtained from the high-speed imaging of aurora at subauroral latitude (AUGO2, Alberta), combined with earlier results obtained at high latitude (PFRR, Alaska) [2, 3].

[1] Kataoka, R., et al. (2012), Pulsating aurora beyond the ultra-low-frequency range, J. Geophys. Res, 117, A08336.

[2] Kataoka, R., et al. (2011b), Ground-based multispectral high-speed imaging offlickering aurora, Geophys. Res. Lett., 38, L14106.

[3] Kataoka, R., et al. (2011a), Turbulent microstructures and formation of folds inauroral breakup arc, J. Geophys. Res., 116, A00K02.

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MSD04-14 会場:101A 時間:5 月 24 日 15:15-15:30

磁気圏電離圏結合モデルによるオーロラアークの非線型発展
Magnetosphere-ionosphere coupling model for evolution of auroral arcs

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Our recent modeling studies on evolution of auroral arcs and the related nonlinear wave activities are presented. The model basically treats Alfven wave dynamics driven by the magnetosphere-ionosphere coupling process and covers a narrow dipole flux tube in the auroral region. The magnetospheric plasma is described by the reduced-MHD equations of electric and magnetic perturbations in a background convection field. The ionospheric plasma motion is described by the compressible two-fluid equations and is characterized by the Pedersen and Hall currents. The field-aligned current of the Alfven wave flows into the ionosphere, producing an internal uniformity of plasma density or conductivity, which in turn triggers new wave propagation to the magnetosphere. The three-dimensional simulations reproduce auroral structuring such as splitting of arc and vortices, along with field line oscillatory behaviors. In this talk, we introduce results of these simulations and provide implications to future planning observations as EISCAT-3D.
Keywords: magnetosphere-ionosphere coupling, auroral arc, Alfven wave

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MSD04-15 会場:101A 時間:5 月 24 日 15:30-15:45

観測ロケットキャンペーンに関連したEISCAT_3Dへの期待
Expectation of EISCAT_3D observation for the sounding rocket campaign

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Takumi Abe[1*]

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[1]Japan Aerospace Exploration Agency

The Institute of Space and Astronautical Science (ISAS) of Japan Aerospace Exploration Agency (JAXA) has continued to launch the sounding rockets for a study of the upper atmospheric physics not only inside Japan but in Scandinavian country. The purpose of Japanese sounding rocket experiments in the high latitude region is mainly to investigate various polar upper atmospheric phenomena related to the auroral activity. In such experiments, simultaneous observations by the ground-based instruments are indispensable to make a comprehensive measurement of the science target, and have been conducted so far as the international collaboration. Among them, EISCAT radar plays a primary role and has provided essential support for the sounding rocket campaign. We strongly expect that further powerful support will be provided by EISCAT_3D. In this presentation, our expectation for significant contribution of EISCAT_3D to the sounding rocket campaign in Scandinavian countries will be given.

One of the noticeable performances of EISCAT_3D is three-dimensional measurement capability of the upper atmosphere, by which essential information on the upper atmosphere near the rocket trajectory can be provided with a sufficiently small spatial resolution. In particular, two-dimensional information on the observation is expected to be available in the vicinity of the rocket position, while it was basically one-dimensional information until now. It will be possible to make a direct and essential comparison between the sounding rocket and radar observations.

We also expect the high spatial resolution data provided by EISCAT_3D, which is essential for the detailed comparison between the sounding rocket observation and the ground-based measurement. In addition, it is very important to know the latest condition of the upper atmosphere for the rocket trajectory in advance, when we determine whether the launch condition is satisfied. This capability is particularly important when the science target is small scale phenomena. Furthermore, if space-time ambiguity is resolved due to simultaneous multiple beam capability of EISCAY_3D, major obstacle for upper atmospheric research by the sounding rocket can be overcome.

Thus, when observations of the polar upper atmosphere by EISCAT_3D are available, significance of the ground-based support for the sounding rocket experiment will be much increased.

Keywords: Sounding rocket, coordinated observation, ground-based support, ionosphere, lower thermosphere

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MSD04-16 会場:101A 時間:5 月 24 日 15:45-16:00

EISCAT_3D レーダーで推進する EISCAT-日本国際共同研究
EISCAT-Japan collaborative studies drived by EISCAT_3D radars

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Hiroshi Miyaoka[1*], Satonori Nozawa[2], Yasunobu Ogawa[1], Shin-ichiro Oyama[2], Takuji Nakamura[1], Ryoichi Fujii[2], Craig Heinselman[3]

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The EISCAT(European Incoherent SCATter) Scientific Association is an international research organization, which operates incoherent scatter radars at 931MHz, 224MHz and 500MHz in northern Scandinavia and Svalbard for studies of physical and environmental processes in the middle/upper atmosphere and near-Earth space. Since 1996, National Institute of Polar Research, in collaboration with STEL of Nagoya University has promoted the EISCAT project for the user community in Japan to use the EISCAT facility for their scientific subjects.

EISCAT_3D is the major upgrade of the existing EISCAT radars in the northern Scandinavia. With a multi-static phased array system composed of one central active (transmit-receive) site and several receive-only sites, the EISCAT_3D system is expected to provide us 10 times higher temporal and spatial resolution and capabilities than the present radars.

In this presentation, we will overview our scientific activity and achievements with the EISCAT facility and our strategic plan of national funding for EISCAT_3D-J as well as the science targets which we expect to be unraveled by EISCAT_3D.

キーワード: 非干渉散乱レーダー, 欧州非干渉散乱レーダー科学協会, 電離圏, 熱圏, 中間圏, 三次元イメージング観測
Keywords: Incoherent scatter radar, EISCAT, Ionosphere, Thermosphere, Mesosphere, 3D imaging observation

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RISR と OMTI による極冠オーロラの観測
An Observation of Polar Cap Aurora with RISR and OMTI: A Feasibility Study for EISCAT_3D

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One of the primary scientific objectives of the planned EISCAT_3D would be ”3D imaging of aurora”, especially 3D imaging of dynamically moving auroral arcs at the time of substorm expansion phase onset. In order to discuss the specification of the EISCAT_3D system, we have to know how such an effort of 3D imaging of aurora is being made by using currently-working IS radar systems. For this purpose, we introduce an event of isolated auroral arc in the polar cap region which was simultaneously observed by an all-sky imager of OMTIs (Optical Mesosphere Thermosphere Imagers) and RISR (Resolute Bay Incoherent Scatter Radar) at Resolute Bay, Canada (74.7 N, 265.0 E, 82.9 MLAT) in winter/2009. By using the data during this event, we visualized the plasma structure near the arc in 3D fashion. In particular, we tried to reproduce the 3D structure of electric field and corresponding electric current through a quantitative estimation of horizontal plasma velocity along the arc. As a result, ion velocity around the arc was found to show a shear reversal flow across the arc at 200-400 km altitudes; -1500 m/s on the dusk-side of the arc and 1000 m/s on the other side of the arc. This reversed flow corresponds to an electric field (i.e., Pedersen current) structure converging towards the center of the arc. Such a converging Pedersen current is consistent with upward field-aligned currents (FACs) within the arc which are possibly carried by precipitating electrons leading to the generation of the arc. Possible 3D structure of electric field and electric current including FAC around the arc will be discussed as a feasibility study for the EISCAT_3D system.

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一般化オーロラトモグラフィの EISCAT_3D プロジェクトへの応用
Application of Generalized Auroral Computed Tomography to the EISCAT_3D project

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Aurora Computed Tomography (ACT) is a method for retrieving three-dimensional (3-D) distribution of auroral luminosity from auroral images obtained simultaneously by the multi-point observation. As a next step of the ACT, we have developed Generalized - Aurora Computed Tomography (G-ACT) that reconstructs the energy and spatial distributions of precipitating electrons from multi-instrument data, such as ionospheric electron density from the EISCAT radar, cosmic noise absorption (CNA) from imaging riometer, as well as the auroral images. This method is compatible with 3-D ionospheric data observed by the EISCAT_3D radar, because the tomography method essentially assumes that the observational data are the projection of the 3-D data.

In this study, we examine how the G-ACT method can contribute to the EISCAT_3D project by numerical simulation. We first obtained auroral images observed by ALIS (Aurora Large Imaging System) and the electron density distribution observed with the EISCAT_3D radar by assuming spatial and energy distribution of incident electrons and then applied the G-ACT to these data. The results showed a possibility that the G-ACT can interpolate the electron density distribution observed with the EISCAT_3D radar at a higher spatial resolution. On the other hand, the 3-D aurora distribution reconstructed from only optical images was improved by a use of the EISCAT 3-D data. Furthermore, we suggest where new imagers should be installed for simultaneous observation with the EISCAT_3D radar.

キーワード: オーロラトモグラフィ, EISCAT_3D, 逆問題, 3 次元構造, オーロライメージャ, 電離圏電子密度
Keywords: aurora tomography, EISCAT_3D, inverse problem, 3 dimensional structure, aurora imager, ionospheric electron density

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EISCAT レーダートロムソ観測所における 2013 年 3 月までの STEL 光学観測結果と EISCAT_3D への貢献
Report of the STEL optical observation at the Tromsoe EISCAT radar site by March 2013 and the contributions to EISCAT_3D

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太陽地球環境研究所（Solar-Terrestrial Environment Laboratory; STEL）は欧州非干渉散乱（European Incoherent Scatter; EISCAT）レーダーがあるノルウェーのトロムソ（北緯 69.6°、東経 19.2°）で 10 年以上に渡り光学観測を実施してきた。トロムソは欧米・アジア諸国が様々な光学・電波観測装置を設置し、EISCAT レーダーを軸とした国際共同観測研究を展開する世界最大級の観測拠点である。2013 年 1 月現在、我々はトロムソ観測所に以下に述べる 5 台の光学観測装置を設置し、10 月から翌 3 月の約半年間、自動観測とともに共同研究者からの要請に応じた観測モードで運用を行っている。尚、これら光学観測装置以外にナトリウムライダーが 2010 年 10 月から稼働している。これについては別に報告する。

1. 3 波長フォトメータ
1997 年 1 月に最初のキャンペーン観測を実施後、2001 年 10 月に自動運用を開始した本装置は現在 3 つの光学フィルター（427.8 nm, 630.0 nm, 557.7 nm）を持ち、20Hz サンプリングでデータを取得する。2010 年 10 月に運用・データの自動処理システムを更新した。常に磁力線方向に固定した観測を行い、EISCAT UHF レーダーの主要観測モードの一つである CP-1 モード（同じく磁力線方向にアンテナ方向を固定した観測）とほぼ同じ空間を同時に観測することができる。

2. 天候・オーロラ観測用デジタルカメラ
対流圏高度の雲の発生状況を把握することは、光学観測データの解析にとって必須事項である。光学フィルターを通した単色画像では天候を判別しにくく、デジタルカメラで撮影されるカラー画像がより適している。そこで 2001 年 10 月からデジタルカメラによる自動観測を開始した。撮影画像は天候確認だけでなく、磁力線付近のオーロラ微細構造などオーロラ形態情報の提供も兼ねている。

3. プロトン全天カメラ
2006 年 10 月から自動運用を開始した本装置は、下向き沿磁力線電流の発生領域における電離圏応答を捉えることを目的に設置された。上向き沿磁力線電流の発生領域（オーロラアーク発生領域に相当）に近接するオーロラ発光が弱く、電離圏電子密度が周辺より極端に低い領域には、下向き沿磁力線電流と磁場に垂直な電場が発生すると考えられている。これら電流回路の連続性を維持するために下向き沿磁力線電場が形成され、磁気圏からのプロトン降込みが誘導される結果、プロトン発光（486.1 nm）が期待される。これまでの観測で数例だがこの仮説を裏付ける観測結果が取得されている。

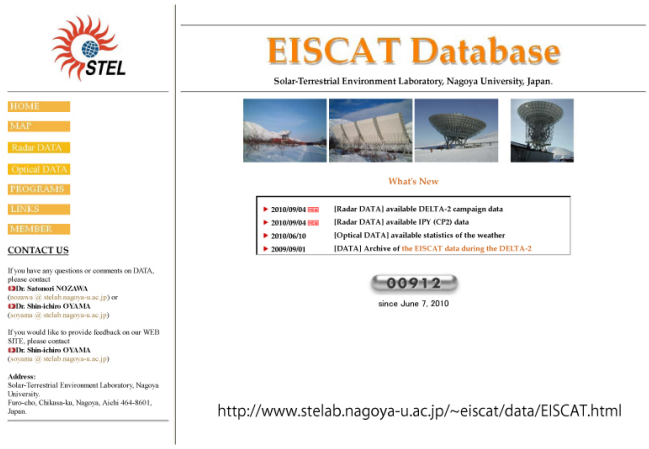
4. 多波長全天カメラ
オーロラや大気光を観測する目的で 2009 年 1 月に設置された本装置は、6 種類の光学フィルターが装着されたホイールを備え、積分時間や観測波長の順番などを任意に設定できる自動観測プログラムによって制御されている。現在保有する光学フィルターの波長は、557.7 nm、630.0 nm、OH バンド、589.3 nm、572.5 nm、732.0 nm である。

5. ファブリペロー干渉計（Fabry-Perot interferometer: FPI）
多波長全天カメラ（上記 4）と同時にトロムソ観測所に設置された本装置は、視野角約 4° の狭視野タイプの装置であり、3 種類の光学フィルターを装着したホイールを持つ。装置上部にはスカイスキャナーと呼ばれる回転モーター付ミラーがあり、観測プログラムでホイールとスカイスキャナーを制御することで、観測波長やその選択順序と積分時間、視線方向を科学目的に合わせて任意に設定することができる。観測される物理量は中性大気の風速と温度である。

これらの光学観測装置は、EISCAT レーダーをはじめ様々な観測装置との共同観測実験に利用されてきた。最初の装置が自動観測を始めて以来、稼働期間は太陽活動周期の 1 サイクルに近く、超高層大気の長期変動研究やイベント解析を行う上で貴重なデータセットが整備された。これまでに蓄積された観測データのクイックルックはウェブページで公開されている（www.stelab.nagoya-u.ac.jp/~eiscat/data/EISCAT.html）。今後も全装置の自動観測を継続し、太陽活動極大期に計画されている様々な観測実験に参画し、国内外の共同研究者の研究活動に寄与していく。特に EISCAT_3D との同時観

測は、時間的・空間的に激しく変化するオーロラ現象の理解を進める上で重要なデータセットを提供できると期待される。本発表では、観測状況を報告するとともに EISCAT_3D との同時観測について議論する。

キーワード: オーロラ, 大気光, 光学装置, 電離圏, 熱圏, 極域
Keywords: Aurora, Airglow, Optical instrument, Ionosphere, Thermosphere, Polar region



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極域電離圏における N2+発光とイオン上昇流のれいめい衛星-EISCAT レーダー同時観測
Coordinated observation between Reimei and EISCAT radar of N2+ emission and ion upflow in the polar topside ionosphere

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The upflow and outflow of heavy ions, such as N2+ and NO+, has been examined with immense interests since it is considered that heavy ions hardly escape from terrestrial gravity. It is considered that the generation process of N2+ outflow is the charge exchange between O+ and N2 at topside ionosphere. Recently, optical measurement data taken by a satellite showed N2+ 1st negative band emissions in the sunlit region suggesting the existence of N2+ upflow. To clarify the process of ion upflow, we carried out the coordinated observations between the Reimei satellite and the EISCAT/ESR radar during the winter solstice periods from 2005 to 2012, except for 2011 due to the problem on Reimei attitude system.

The field-of-view (FOV) of the multi-spectral auroral camera (MAC) on Reimei was directed toward the earth's limb in order to observe the height profile of N2+ emission intensity produced by resonant scattering. In this case, the altitude resolution and range in the image data obtained with Reimei/MAC are approximately 5 km and 300 km, respectively. N2+ emission image was taken with every 1 second. On the other hand, ion upflow speeds near the FOV of MAC are simultaneously observed by the EISCAT/ESR radar with the fast scan mode or fixed mode toward the magnetic zenith. In the scan mode, the azimuthal scan range is 120 degrees centering the geomagnetic north direction, and time resolution is about 3 min.

Using the Reimei data, we examined the relationship among N2+ 1st negative and OI green line emissions, ion upflow and geomagnetic activity. We found good correlation between N2+ emission intensities at 300 and 400km altitude and Kp indices. At these altitudes, N2+ emission intensities were 100-600R greater than OI intensities when Kp was greater than 3+. This suggests that N2+ density increase, or ion upflow occurs in the topside/upper ionosphere when geomagnetic activity increased.

From the statistical analysis based on the coordinated measurement data between Reimei and EISCAT/ESR radar, we found no significant relationship between ion up/down flow and and N2+ emission. Considering the fact that the dayside heating region (cusp/cleft and auroral oval) is expected to be shifted toward lower-latitudes, far from the ESR-site during the disturbed conditions, it is suggested that N2+ enhancement measured by Reimei was not generated locally at the field line threading Reimei, but may be transported from the dayside heating region. In this presentation, we will present the recent results on the coordinated observations, and give the future subject for the EISCAT-3D project.

キーワード: れいめい, EISCAT, イオン上昇流, オーロラ, 電離圏
Keywords: Reimei, EISCAT, ion upflow, aurora, ionosphere

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EISCAT_3D を用いたイオン上昇流/流出の研究
Study on ion upflow and outflow with EISCAT_3D

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An important phenomenon of magnetosphere-ionosphere coupling is the formation of upwelling ions in the topside polar ionosphere. These upflows can be a significant loss of atmospheric gasses into interplanetary space and a significant source of magnetospheric plasma, which may also affect the dynamics of the magnetosphere. Key processes for upward ion flows in the topside ionosphere are suggested to be frictional heating, ambipolar diffusion driven by a heated electron gas, and transverse ion acceleration produced by plasma waves. It is critical to determine the relative importance of the different mechanisms in operation and to understand the 3D distribution and composition of the upflowing ions and neutrals. Moreover, there are several transitions of upflowing ions, for examples, from chemical to diffusion dominance at 500-800 km altitude, from subsonic to supersonic flow at 1000-2000 km altitude, and from collisional to collisionless region at 1500-2500km altitude. EISCAT_3D is one of the most suitable measurements to investigate such transitions because of its wider height coverage (up to about 2000 km) along the field line. EISCAT_3D will have more transmitter power density and higher sensitivity than those of the current Tromso UHF radar, and will give information of accurate thermal ion velocity, upward flux, and ion composition (O+, H+, and hopefully NO+). In this paper, potential investigations of ion upflow and outflow using the EISCAT_3D are shown, and desirable specifications of the EISCAT_3D are discussed.

キーワード: 極域電離圏, EISCAT_3D, イオン流出
Keywords: Polar ionosphere, EISCAT_3D, ion outflow

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EISCAT トロムソサイトにおける Na 共鳴散乱ライダーと EISCAT レーダーの連携観測
Coordinated observations with Na resonance scattering lidar and EISCAT radar at the EISCAT Tromsoe site

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Takuo Tsuda[1*], Satonori Nozawa[2], Nobuo Matuura[2], Masaki Tsutsumi[1], Yasunobu Ogawa[1], Shin-ichiro Oyama[2], Toru Takahashi[2], Taku D Kawahara[3], Tetsuya Kawabata[2], Norihito Saito[4], Satoshi Wada[4], Takuji Nakamura[1], Ryoichi Fujii[2]

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We have been operating a sodium (Na) resonance scattering lidar at the EISCAT Tromsoe site (69.6N, 19.2E) since 2010, in cooperation with the EISCAT radar. The Na resonance scattering lidar is capable to measure neutral temperature, neutral wind velocity, and sodium density. On the other hand, as a well-known fact, the EISCAT radar is a powerful tool for ionospheric measurements. Thus coordinated observations with the Na resonance scattering lidar and EISCAT radar will be an important key to resolve the atmosphere-ionosphere coupling process. In this presentation, we introduce the Na resonance scattering lidar observations at the EISCAT Tromsoe site, and then report some recent results, such as sporadic Na/E-layer event which is an aspect of ion-neutral dynamical and chemical interactions. Hopefully these results would be good examples to discuss possibilities of further collaborative observations using the Na resonance scattering lidar and the EISCAT/EISCAT 3D.
Keywords: Na resonance scattering lidar, EISCAT/EISCAT_3D, Tromsoe, Sporadic Na layer, Sporadic E layer

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EISCAT_3D と GCM シミュレーションによる極域超高層大気の研究
Polar aeronomy with EISCAT_3D and GCM simulations

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The EISCAT radar system has had great contributions to probing the polar upper atmosphere in collaboration with observations from optical and radar instruments, magnetometers, rockets, and satellites more than 30 years. For the next stage, the EISCAT radar system seems to be still expected to undertake a role of the research center for the auroral atmosphere. The global warming and the resultant cooling in the upper atmosphere are one of the most important issues for aeronomy in the 21st century. In order to understand the long-term variations of the upper atmosphere, continuity of observations is necessary and the EISCAT observations will have great contributions to the topics. Challenges to unknown phenomena are also important for the new EISCAT radar system (EISCAT_3D). For example, the EISCAT_3D system and some instruments installed around the site will capture the turbulence which would be generated by breaking of atmospheric waves. This comprehensive monitoring of the atmospheric phenomena and space weather will enable us to predict the weather in the upper atmosphere with GCM simulations. In this presentation, we will show our research activity to date and future research plans with EISCAT_3D and GCM simulations.

キーワード: 極域, 超高層大気, レーダー, GCM
Keywords: polar region, upper atmosphere, radar, GCM