

共同研究課題

超高層大気イメージングシステムデータベースのアーカイブ

研究代表者： 塩川和夫（名古屋大学太陽地球環境研究所）
研究分担者： 小川忠彦（名古屋大学太陽地球環境研究所）
大塚雄一（名古屋大学太陽地球環境研究所）
大山伸一郎（名古屋大学太陽地球環境研究所）

1. 研究目的

「超高層大気イメージングシステム(Optical Mesosphere Thermosphere Imagers - OMTIs)」は、平成8年度に導入され、高感度全天カメラ、掃天フォトメータ、ファブリ・ペロー分光計、及び分光温度計から構成されている。この機器群で高度90-300kmの夜間大気光を観測することにより、大気の密度変化の2次元分布、風速、温度を同時に複数高度で計測することができる。本データベースでは、これらの観測から得られる超高層大気変動のデータをデータベース化して公開することにより、大気重力波や熱圏波動の研究を全国の研究者と協力して推進する。

2. データベース作成の概要

太陽地球環境研究所では、超高層大気イメージングシステムを用いて総合的な大気観測を行い、中間圏、熱圏、電離圏の大気力学過程の解明に大きく貢献してきた。平成22年8月現在で、北海道陸別観測所、滋賀県信楽町（京都大学信楽MU観測所）、鹿児島県佐多岬、コトタバン（インドネシア）、チュンマイ（タイ）、レズリュートベイ、アサバスカ（カナダ）、パラツンカ、マガダン（ロシア）、トロムソ（ノルウェー）で、これらの機器による無人自動観測を定常的に行っている。これらの観測点からカメラ13台、フォトメータ3台、ファブリ・ペロー干渉計4台、分光温度計4台、のデータが定常的に得られる。これらの機器から毎日得られるデータから、クイックルックのためのサマリープロットを作成し、ホームページで公開していく。デジタルデータは、リクエストに応じて公開していく。これらのデータアーカイブ作業のために、アルバイト職員を1名、雇用している。これらの観測・共同研究は、ジオスペース研究センターの第1期及び第2期のプロジェクト2の一環として行われている。自動観測で得られるデータをデータベース化し、そのクイックルックプロットを逐次作成・整理しておくことによって、初めて処理に時間のかかる画像データを簡単に扱えるようになる。このデータベース化は非常に重要で、これにより、自動観測の不具合の早期発見だけでなく、大量の画像データを用いた統計的な解析や、人工衛星データとの比較、低緯度オーロラ・大規模TID・プラズマバブル構造などの特異な現象の発見、などの研究が可能になる。

3. 共同研究の成果、公表状況

中間圏大気重力波、電離圏の中規模・大規模伝搬性電離圏擾乱、低緯度オーロラ、極冠域パッチ現象、赤道域プラズマバブル、などの研究にこのデータベースは広く利用されている。2001年以降の研究論文のリストを以下に示す。

査読付き論文リスト (2001年以降)

1. Shiokawa, K., T. Kadota, M. K. Ejiri, Y. Otsuka, Y. Katoh, M. Satoh, and T. Ogawa, Three-channel imaging Fabry-Perot interferometer for midlatitude airglow measurement, *Appl. Opt.*, 40, 4286-4296, 2001.
2. Shiokawa, K., T. Ogawa, H. Oya, F. J. Rich, and K. Yumoto, A stable auroral red (SAR) arc observed over Japan after an interval of very weak solar wind, *J. Geophys. Res.*, 106, 26,091-26,101, 2001.
3. Saito, A., M. Nishimura, M. Yamamoto, M. Kubota, K. Shiokawa, Y. Otsuka, T. Tsugawa, S. Fukao, T. Ogawa, M. Ishii, T. Sakanoi, and S. Miyazaki, Traveling ionospheric disturbances detected in the FRONT campaign, *Geophys. Res. Lett.*, 28, 689-692, 2001.
4. Sahai, Y., K. Shiokawa, Y. Otsuka, C. Ihara, T. Ogawa, K. Igarashi, S. Miyazaki, and T. Saito, Imaging observations of mid-latitude ionospheric disturbances during the geomagnetic storm on February 12, 2000, *J. Geophys. Res.*, 106, 24,481-24,492, 2001.
5. Ejiri, M. K., K. Shiokawa, T. Ogawa, T. Nakamura, R. Maekawa, T. Tsuda, and M. Kubota, Observations of small-scale gravity waves near the mesopause obtained from four all-sky CCD imagers and the MU radar, *J. Geophys. Res.*, 106, 22,793-22,799, 2001.
6. Nakamura, T., T. Tsuda, R. Maekawa, M. Tsutsumi, K. Shiokawa, and T. Ogawa, Seasonal variation of gravity waves with various temporal and horizontal scales in the MLT region observed with radar and airglow imaging, *Adv. Space Res.*, 27, 1737-1742, 2001.
7. Ogawa, T., N. Balan, Y. Otsuka, K. Shiokawa, C. Ihara, T. Shimomai, and A. Saito, Observations and modeling of 630 nm airglow and total electron content associated with traveling ionospheric disturbances over Shigaraki, Japan, *Earth Planets Space*, 54, 45-56, 2002.
8. Shiokawa, K., Y. Otsuka, M. K. Ejiri, Y. Sahai, T. Kadota, C. Ihara, T. Ogawa, K. Igarashi, S. Miyazaki, and A. Saito, Imaging observations of the equatorward limit of midlatitude traveling ionospheric disturbances, *Earth Planets Space*, 54, 57-62, 2002.
9. Shiokawa, K., Y. Otsuka, T. Ogawa, N. Balan, K. Igarashi, A. J. Ridley, D. J. Knipp, A. Saito, and K. Yumoto, A large-scale traveling ionospheric disturbance during the magnetic storm of September 15, 1999, *J. Geophys. Res.*, 107(A6), 10.1029/2001JA000245, 2002.
10. Shiokawa, K., Y. Katoh, M. Satoh, T. Ogawa, M. Taguchi, and H. Yamagishi, A new auroral spectrometer using an acousto-optic tunable filter, *Advances in Polar Upper Atmosphere Research*, National Institute of Polar Research, Japan, No.16, 146-156, 2002.
11. Ejiri, M. K., K. Shiokawa, T. Ogawa, M. Kubota, T. Nakamura, and T. Tsuda, Dual-site imaging observations of small-scale wave structures through OH and OI nightglow emissions, *Geophys. Res. Lett.*, 29, No.10, 10.1029/2001GL014257, 2002.

12. Iwagami, N., T. Shibaki, T. Suzuki, Y. Yamada, H. Onishi, Y. Takahashi, H. Yamamoto, H. Sekiguchi, K. Mori, Y. Sano, M. Kubota, Y. Murayama, M. Ishii, K.-I. Oyama, R. Yoshimura, M. Shimoyama, Y. Koizumi, K. Shiokawa, N. Takegawa, and T. Nakamura, The WAVE2000 campaign: Overview and preliminary results, *J. Atmos. Solar-Terr. Phys.*, 64, 1095-1104, 2002.
13. Otsuka, Y., K. Shiokawa, T. Ogawa, and P. Wilkinson, Geomagnetic conjugate observations of equatorial airglow depletions *Geophys. Res. Lett.*, 29, No.15, 43-1-4, 10.1029/2002GL015347, 2002.
14. Gavrilov, N. M., K. Shiokawa, and T. Ogawa, Seasonal variations of medium-scale gravity wave parameters in the lower thermosphere obtained from spectral airglow temperature imager observations at Shigaraki, Japan, *J. Geophys. Res.*, 107(D24), 4755, doi:10.1029/2001JD001469, 2002.
15. Shiokawa, K., M. K. Ejiri, T. Ogawa, Y. Yamada, H. Fukunishi, K. Igarashi, and T. Nakamura, A localized structure in OH airglow images near the mesopause region, *J. Geophys. Res.*, 108(D2), 4048, doi:10.1029/2002JD002462, 2003.
16. Shiokawa, K., C. Ihara, Y. Otsuka, and T. Ogawa, Statistical study of nighttime medium-scale traveling ionospheric disturbances using midlatitude airglow images, *J. Geophys. Res.*, 108(A1), 1052, doi:10.1029/2002JA009491, 2003.
17. Shiokawa, K., Y. Otsuka, C. Ihara, T. Ogawa, and F. J. Rich, Ground and satellite observations of nighttime medium-scale traveling ionospheric disturbance at midlatitude, *J. Geophys. Res.*, 108(A4), 1145, doi:10.1029/2002JA009639, 2003.
18. Shiokawa, K., T. Kadota, Y. Otsuka, T. Ogawa, T. Nakamura, and S. Fukao, A two-channel Fabry-Perot interferometer with thermoelectric-cooled CCD detectors for neutral wind measurement in the upper atmosphere, *Earth Planets Space*, 55, 271-275, 2003.
19. Shiokawa, K., Y. Otsuka, T. Ogawa, S. Kawamura, M. Yamamoto, S. Fukao, T. Nakamura, T. Tsuda, N. Balan, K. Igarashi, G. Lu, A. Saito, and K. Yumoto, Thermospheric wind during a storm-time large-scale traveling ionospheric disturbance, *J. Geophys. Res.*, 108(A12), 1423, doi:10.1029/2003JA010001, 2003.
20. Otsuka, Y., T. Kadota, K. Shiokawa, T. Ogawa, S. Kawamura, S. Fukao, and S.-R. Zhang, Optical and radio measurements of a 630-nm airglow enhancement propagating over Japan on September 9, 1999, *J. Geophys. Res.*, 108 (A6), 1252, doi:10.1029/2002JA009594, 2003.
21. Ejiri, M. K., K. Shiokawa, T. Ogawa, K. Igarashi, T. Nakamura, and T. Tsuda, Statistical study of short-period gravity waves in OH and OI nightglow images at two separated sites, *J. Geophys. Res.*, 108 (D21), 4679, doi:10.1029/2002JD002795, 2003.
22. Shiokawa, K., Y. Otsuka, T. Ogawa, H. Takahashi, T. Nakamura, and T. Shimomai, Comparison of OH rotational temperatures measured by the Spectral Airglow Temperature Imager (SATI) and by a tilting-filter photometer, *J. Atmos. Solar-Terr. Phys.*, 66, 891-897, 2004.
23. Shiokawa, K., Y. Otsuka, T. Ogawa, and P. Wilkinson, Time evolution of high-altitude plasma bubbles imaged at geomagnetic conjugate points, *Ann. Geophys.*, 22, 3137-3143, 2004.
24. Fujii, J., T. Nakamura, T. Tsuda, and K. Shiokawa, Comparison of winds measured by MU radar and Fabry-Perot interferometer and effect of OI5577 airglow height variations, *J. Atmos. Solar-Terr. Phys.*, 66, 573-583, 2004.
25. Takahashi, H., T. Nakamura, K. Shiokawa, T. Tsuda, L. M. Lima, and D. Gobbi, Atmospheric densi

- ty and pressure inferred from the meteor diffusion coefficient and airglow O2b temperature in the MLT region, *Earth Planets Space*, 56, 249-258, 2004.
26. Suzuki, S., K. Shiokawa, Y. Otsuka, T. Ogawa, and P. J. Wilkinson, Statistical characteristics of gravity waves observed by an all-sky imager at Darwin, Australia, *J. Geophys. Res.*, 109, D20S07, doi:10.1029/2003JD004336, 2004.
 27. Otsuka, Y., K. Shiokawa, T. Ogawa, and P. Wilkinson, Geomagnetic conjugate observations of medium-scale traveling ionospheric disturbances at midlatitude using all-sky airglow imagers, *Geophys. Res. Lett.*, L15803, doi:10.1029/2004GL020262, 2004.
 28. Otsuka, Y., K. Shiokawa, T. Ogawa, T. Yokoyama, M. Yamamoto, and S. Fukao, Spatial relationship of equatorial plasma bubbles and field-aligned irregularities observed with an all-sky airglow imager and the Equatorial Atmosphere Radar, *Geophys. Res. Lett.*, 31, L20802, doi:10.1029/2004GL020869, 2004.
 29. Iwagami, N., S. Ohtsuki, M. Akojima, M. Kubota, Y. Murayama, S. Kawamura, R. Yoshimura, T. Nakamura, H. Yamamoto, H. Sekiguchi, N. Kimura, K. Shiokawa, T. Okada, K. Ishisaka, Y. Ashihara, Y. Kaiho, M. Abo, T. Abe, Y. Koizumi, and K.-I. Oyama, Waves in airglow structures experiment 2004: Overview and preliminary results, *Adv. Space Res.* vol.35, no.11, 1964-1970, 2005.
 30. Shiokawa, K., T. Ogawa, and Y. Kamide, Low-latitude auroras observed in Japan: 1999-2004, *J. Geophys. Res.*, 110, A05202, doi:10.1029/2004JA010706, 2005.
 31. Shiokawa, K., Y. Otsuka, T. Tsugawa, T. Ogawa, A. Saito, K. Ohshima, M. Kubota, T. Maruyama, T. Nakamura, M. Yamamoto, and P. Wilkinson, Geomagnetic conjugate observation of nighttime medium-scale and large-scale traveling ionospheric disturbances: FRONT3 campaign, *J. Geophys. Res.*, 110, A05303, doi:10.1029/2004JA010845, 2005.
 32. Ogawa, T., E. Sagawa, Y. Otsuka, K. Shiokawa, T. J. Immel, S. B. Mende, and P. Wilkinson, Simultaneous ground- and satellite-based airglow observations of geomagnetic conjugate plasma bubbles in the equatorial anomaly, *Earth Planets Space*, 57, 385-392, 2005.
 33. Takahashi, H., C. M. Wrasse, D. Gobbi, T. Nakamura, K. Shiokawa, and L. M. Lima, Airglow OH emission height inferred from the OH temperature and meteor trail diffusion coefficient, *Adv. Space Res.*, vol.35, No.11, 1940-1944, 2005.
 34. Onoma, F., Y. Otsuka, K. Shiokawa, T. Ogawa, M. Yamamoto, S. Fukao, and S. Saito, Relationship between propagation direction of gravity waves in OH and OI airglow images and VHF radar echo occurrence during the SEEK-2 campaign, *Ann. Geophys.*, 23, 2385-2390, 2005.
 35. Ogawa, T., Y. Otsuka, F. Onoma, K. Shiokawa, and M. Yamamoto, The first coordinated observations of mid-latitude E-region quasi-periodic radar echoes and lower thermospheric 557.7-nm airglow, *Ann. Geophys.*, 23, 2391-2399, 2005.
 36. Nakata, H., I. Nagashima, K. Sakata, Y. Otsuka, Y. Akaike, T. Takano, S. Shimakura, K. Shiokawa, and T. Ogawa, Observations of equatorial plasma bubbles using broadcast VHF radio waves, *Geophys. Res. Lett.*, 32, L17110, doi:10.1029/2005GL023243, 2005.
 37. Murata, K. T., K. Yamamoto, D. Matsuoka, E. Kimura, H. Matsumoto, M. Okada, T. Mukai, J. B. Sigwarth, S. Fujita, T. Tanaka, K. Yumoto, T. Ogino, K. Shiokawa, N. A. Tsyganenko, J. L. Green, and T. Nagai, Development of the virtual Earth's magnetosphere system (VEMS), *Adv. Polar Upp*

- er Atmos. Res., 19, 135-151, 2005.
38. Shiokawa, K., Y. Otsuka, and T. Ogawa, Quasiperiodic southward moving waves in 630-nm airglow images in the equatorial thermosphere, *J. Geophys. Res.*, 111, A06301, doi:10.1029/2005JA011406, 2006.
 39. Shiokawa, K., S. Suzuki, Y. Otsuka, T. Ogawa, T. Nakamura, M. G. Mlynczak, and J. M. Russell II, A multi-instrument measurement of a mesospheric front-like structure at the equator, *J. Meteor. Soc. Japan*, Vol. 84A, pp. 305-316, 2006.
 40. Kubota, M., S. Kawamura, M. Abo, Y. Koizumi, Y. Murayama, M. Yamamori, K. Shiokawa, Y. Otsuka, M. Uchiumi, K. Igarashi, T. Abe, K.-I. Oyama, and N. Iwagami, A fast-propagating, large-scale atmospheric gravity wave observed in the WAVE2004 campaign, *J. Geophys. Res.*, 111, D21110, doi:10.1029/2005JD006788, 2006.
 41. Hosokawa, K., K. Shiokawa, Y. Otsuka, A. Nakajima, T. Ogawa, and J. D. Kelly, Estimating drift velocity of polar cap patches with all-sky airglow imager at Resolute Bay, Canada, *Geophys. Res. Lett.*, vol. 33, L15111, doi:10.1029/2006GL026916, 2006.
 42. Shiokawa, K., S. Suzuki, Y. Otsuka, T. Ogawa, T. Nakamura, and T. Horinouchi, An intense gravity wave near the mesopause region observed by a Fabry-Perot interferometer and an airglow imager, *J. Geophys. Res.*, 112, D07106, doi:10.1029/2006JD007385, 2007.
 43. Shiokawa, K., G. Lu, Y. Otsuka, T. Ogawa, M. Yamamoto, N. Nishitani, and N. Sato, Ground observation and AMIE-TIEGCM modeling of a storm-time traveling ionospheric disturbance, *J. Geophys. Res.*, 112, A05308, doi:10.1029/2006JA011772, 2007.
 44. Shiokawa, K., Y. Otsuka, S. Suzuki, T. Katoh, Y. Katoh, M. Satoh, T. Ogawa, H. Takahashi, D. Gobbi, T. Nakamura, B. P. Williams, C.-Y. She, M. Taguchi, and T. Shimomai, Development of airglow temperature photometers with cooled-CCD detectors, *Earth Planets Space*, 59, 585-599, 2007.
 45. Suzuki, S., K. Shiokawa, Y. Otsuka, T. Ogawa, K. Nakamura, and T. Nakamura, A concentric gravity wave structure in the mesospheric airglow images, *J. Geophys. Res.*, 112, D02102, doi:10.1029/2005JD006558, 2007.
 46. Sakaguchi, K., K. Shiokawa, A. Ieda, Y. Miyoshi, Y. Otsuka, T. Ogawa, M. Connors, E. F. Donovan, and F. J. Rich, Simultaneous ground and satellite observations of an isolated proton arc at subauroral latitudes, *J. Geophys. Res.*, 112, A04202, doi:10.1029/2006JA012135, 2007.
 47. Otsuka, Y., F. Onoma, K. Shiokawa, T. Ogawa, M. Yamamoto, and S. Fukao, Simultaneous observations of nighttime medium-scale traveling ionospheric disturbances and E region field-aligned irregularities at midlatitude, *J. Geophys. Res.*, 112, A06317, doi:10.1029/2005JA011548, 2007.
 48. Suzuki, S., K. Shiokawa, Y. Otsuka, T. Ogawa, M. Kubota, M. Tsutsumi, T. Nakamura, and D. C. Fritts, Gravity wave momentum flux in the upper mesosphere derived from OH airglow imaging measurements, *Earth Planets Space*, 59, 421-428, 2007.
 49. Shiokawa, K., T. Tsugawa, Y. Otsuka, T. Ogawa, G. Lu, A. Saito, and M. Yamamoto, Optical and radio observations and AMIE/TIEGCM modeling of nighttime traveling ionospheric disturbances at mid-latitudes during geomagnetic storms, *AGU monograph on Mid-Latitude Ionospheric Dynamics and Disturbances*, 271-281, 2008.
 50. Shiokawa, K., Y. Otsuka, N. Nishitani, T. Ogawa, T. Tsugawa, T. Maruyama, S. E. Smirnov, V. V.

- Bychkov, and B. M. Shevtsov, Northeastward motion of nighttime medium-scale traveling ionospheric disturbances at middle latitudes observed by an airglow imager, *J. Geophys. Res.*, 113, A12312, doi:10.1029/2008JA013417, 2008.
51. Sakaguchi, K., K. Shiokawa, Y. Miyoshi, Y. Otsuka, T. Ogawa, K. Asamura, and M. Connors, Simultaneous appearance of isolated auroral arcs and Pc 1 geomagnetic pulsations at subauroral latitudes, *J. Geophys. Res.*, 113, A05201, doi:10.1029/2007JA012888, 2008.
 52. Suzuki H., K. Shiokawa, M. Tsutsumi, T. Nakamura and M. Taguchi, Atmospheric gravity waves identified by ground-based observations of the intensity and rotational temperature of OH airglow, *Polar Science*, 2, 1-8, 2008.
 53. Koustov, A., K. Hosokawa, N. Nishitani, T. Ogawa, and K. Shiokawa, Rankin Inlet PolarDARN radar observations of duskward moving Sun-aligned optical forms, *Ann. Geophys.*, 26, 2711-2723, 2008.
 54. Miyoshi, Y., K. Sakaguchi, K. Shiokawa, D. Evans, J. Albert, M. Connors, and V. Jordanova, Precipitation of radiation belt electrons by EMIC waves, observed from ground and space, *Geophys. Res. Lett.*, 35, doi:10.1029/2008GL035727, 2008.
 55. Ogawa, T., Y. Otsuka, K. Shiokawa, T. Tsugawa, A. Saito, K. Hoshino, K. Matunaga, M. Kubota, and M. Ishii, Medium-scale traveling ionospheric disturbances and plasma bubbles observed by an all-sky airglow imager at Yonaguni, Japan, *Terr. Atmos. Ocean Sci.*, 20, 287-295, 2009.
 56. Suzuki, S., K. Shiokawa, K. Hosokawa, K. Nakamura, and W. K. Hocking, Statistical characteristics of polar cap mesospheric gravity waves observed by an all-sky airglow imager at Resolute Bay, Canada, *J. Geophys. Res.*, 114, A01311, doi:10.1029/2008JA013652, 2009.
 57. Hosokawa, K., K. Shiokawa, Y. Otsuka, and T. Ogawa, J. P. St-Maurice, G. J. Sofko, and D. A. Andre, Spatial relationship of polar cap patches and field-aligned irregularities observed with an all-sky airglow imager at Resolute Bay and the PolarDARN Rankin Inlet radar, *J. Geophys. Res.*, 114, A03306, doi:10.1029/2008JA013707, 2009.
 58. Otsuka, Y., K. Shiokawa, T. Ogawa, T. Yokoyama, and M. Yamamoto, Spatial relationship of nighttime medium-scale traveling ionospheric disturbances and F-region field-aligned irregularities observed with two spaced all-sky airglow imagers and the MU radar, *J. Geophys. Res.*, in press, doi:10.1029/2008JA013902, 2009.
 59. Ogawa, T., N. Nishitani, Y. Otsuka, K. Shiokawa, T. Tsugawa, and K. Hosokawa, Medium-scale traveling ionospheric disturbances observed with the SuperDARN Hokkaido radar, all-sky imager and GPS network, and their relation to concurrent sporadic-E irregularities, *J. Geophys. Res.*, 114, A03316, doi:10.1029/2008JA013893, 2009.
 60. Hosokawa, K., T. Kashimoto, S. Suzuki, K. Shiokawa, Y. Otsuka and T. Ogawa, Motion of polar cap patches: A statistical study with all-sky airglow imager at Resolute Bay, Canada, 114, A04318, doi:10.1029/2008JA014020, *J. Geophys. Res.*, 2009.
 61. Hosokawa, K., T. Tsugawa, K. Shiokawa, Y. Otsuka, T. Ogawa, and M. R. Hairston, Unusually elongated, bright airglow plume in the polar cap F region: Is it a tongue of ionization?, *Geophys. Res. Lett.*, 36, L07103, doi:10.1029/2009GL037512, 2009.
 62. Suzuki, S., K. Shiokawa, Y. Otsuka, T. Ogawa, T. Nakamura, and A.Z. Liu, Characteristics of equatorial gravity waves derived from mesospheric airglow imaging observations, *Ann. Geophys.*, 27, 16

25-1629, 2009.

63. Ogawa, T., Y. Otsuka, K. Shiokawa, T. Tsugawa, A. Saito, K. Hoshino, K. Matunaga, M. Kubota, and M. Ishii, Medium-scale traveling ionospheric disturbances and plasma bubbles observed by an all-sky airglow at Yonaguni, Japan, *Terr. Atmos. Ocean Sci.*, 20, 287-295, doi:10.3319/TAO.2007.12.06.02(F3C), 2009.
64. Suzuki, S., K. Hosokawa, T. F. Shibata, K. Shiokawa, Y. Otsuka, N. Nishitani, T. Ogawa, A. V. Koustov, and B. M. Shevtsov, Coordinated observations of nighttime medium-scale traveling ionospheric disturbances in 630-nm airglow and HF radar echoes at midlatitudes, *J. Geophys. Res.*, 114, A07312, doi:10.1029/2008JA013963, 2009.
65. Koustov, A., N. Nishitani, K. Shiokawa, S. Suzuki, and B.M. Shevtsov, Joint observations of a traveling ionospheric disturbance with the Paratunka OMTI camera and the Hokkaido HF radar, *Ann. Geophys.*, 27, 2399–2406, 2009.
66. Hosokawa, K., J. P. St-Maurice, G. J. Sofko, K. Shiokawa, Y. Otsuka, T. Ogawa, Reorganization of polar cap patches through shears in the background plasma convection, *J. Geophys. Res.*, 115, A01303, doi:10.1029/2009JA014599, 2009.
67. Jayachandran, P. T., K. Hosokawa, J. W. MacDougall, S. Mushini, R. B. Langley, and K. Shiokawa, GPS total electron content variations associated with a polar cap arc, *J. Geophys. Res.*, 114, A12304, doi:10.1029/2009JA014916, 2009.
68. Shiokawa, K., K. Hosokawa, K. Sakaguchi, A. Ieda, Y. Otsuka, T. Ogawa and M. Connors, The Optical Mesosphere Thermosphere Imagers (OMTIs) for network measurements of aurora and airglow, *Future Perspectives of Space Plasma and Particle Instrumentation and International Collaborations*, AIP Conference proceedings, edited by M. Hirahara, Y. Miyoshi, N. Terada, I. Shinohara, and T. Mukai, AIP Conference proceedings, pp.212-215, doi:10.1063/1.3169292, 2009.
69. Shiokawa, K., Y. Otsuka, and T. Ogawa, Propagation characteristics of nighttime mesospheric and thermospheric waves observed by optical mesosphere thermosphere imagers at middle and low latitudes, *Earth Planets Space*, 61, 479-491, 2009.

4. ホームページのアドレス

<http://stdb2.stelab.nagoya-u.ac.jp/omti/>