インドネシア上空成層圏において観測された大気主成分の拡散分離
Diffusive separation of major atmospheric components in the stratosphere over Indonesia

*石戸谷 重之[1]、菅原 敏[2]、青木 周司[3]、森本 真司[3]、中澤 高清[3]、豊田 栄[4]、池田 忠作[5]、本田 秀之[5]、稲飯 洋一[6]、長谷部 文雄[6]、Putri Fanny[7]、後藤 大輔[8]、村山 昌平[1]
*Shigeyuki Ishidoya[1], Satoshi Sugawara[2], Shuji Aoki[3], Shinji Morimoto[3], Takakiyo Nakazawa[3], Sakae Toyoda[4], Chusaku Ikeda[5], Hideyuki Honda[5], Yoichi Inai[6], Fumio Hasebe[6], Fanny A. Putri[7], Daisuke Goto[8], Shohei Murayama[1]

1.産業技術総合研究所、2.宮城教育大学、3.東北大学、4.東京工業大学、5.宇宙航空研究開発機構、6.北海道大学、7.インドネシア国立航空宇宙研究所、8.国立極地研究所
1.National Institute of Advanced Industrial Science and Technology (AIST), 2.Miyagi University of Education, 3.Tohoku University, 4.Tokyo Institute of Technology, 5.Japan Aerospace Exploration Agency (JAXA), 6.Hokkaido University, 7.Lembaga Penerbangan dan Antariksa Nasional (LAPAN), 8.National Institute of Polar Research

In the atmosphere over the turbopause (about 100 km), the mole fraction of heavier molecules decreases with increasing altitude due to diffusive separation in Earth's gravitational field. Recently, Ishidoya et al. (2013) reported such gravitational separation of the atmosphere is also found in the middle to lower stratosphere (about 15-35 km) over Japan from high precision measurements of the composition of the atmospheric major components. To investigate whether gravitational separation is also detectable over the equatorial region or not, we carried out collection of the stratospheric air using a balloon-borne cryogenic air sampler over Biak, Indonesia during February 22-28, 2015. For the observation, we used a Joule-Thomson minicooler, developed by Morimoto et al. (2009), as the cryogenic air sampler, and succeeded to collect 8 air samples at heights of 17-29 km. The collected air samples were analyzed for delta(Ar/N_2), delta(O_2/N_2), delta^{15}N of N_2, delta^{18}O of O_2 and delta^{40}Ar by using a mass spectrometer (Ishidoya and Murayama, 2014), and the measured values showed small but significant decrease with altitude probably due to gravitational separation. The amount of gravitational separation, evaluated as delta values for the mass number difference of 1 (e.g. delta for $^{15}N^{14}N/^{14}N^{14}N$), is found to be 11 per meg at the height of 29 km. Based on the observed gravitational separation and a 1-dimensional steady state eddy diffusion/molecular diffusion model, we estimated 1-dimensional vertical eddy diffusion coefficients (K_z) over the equatorial region. By using the average K_z from the surface to the middle stratosphere, we calculated a timescale of the vertical diffusion for a length scale from the surface to the middle stratosphere assuming simple Fickian diffusion. We found that the calculated timescale agrees with the elapsed time since the stratospheric air passed an upper boundary of the tropical tropopause layer (TTL), estimated from tape recorder signals of stratospheric water vapor (Mote et al., 1996), which is significantly smaller than the mean age of air estimated from CO_2 concentration (CO_2 age). This discrepancy may be due to insensitivity of gravitational separation to mixing processes in Brewer-Dobson circulation, of which variations change the mean age of air significantly.

References

Ishidoya, S. et al. (2013) Gravitational separation in the stratosphere –a new indicator of atmospheric circulation. *Atmos. Chem. Phys.*, 13, 8787–8796, www.atmos-chem-phys.net/13/8787/2013/, doi:10.5194/acp-13-8787-2013.

Ishidoya, S. & Murayama, S. (2014) Development of high precision continuous measuring system of the atmospheric O_2/N_2 and Ar/N_2 ratios and its application to the observation in Tsukuba, Japan. *Tellus B*, 66, 22574, http://dx.doi.org/ 10.3402/tellusb.v66.22574.

Morimoto et al. (2009) A new compact air sampler and its application in stratospheric greenhouse gas observation at Syowa station, Antarctia. *J. Atmos. Oceanic and Technol.*, 26 10.1175/2009JTECHA1283.1.
Mote, P. W. et al. (1996) An atmospheric tape recorder: The imprint of tropical tropopause temperatures on stratospheric water vapor. *J. Geophys. Res.*, 101, 3989-4006.

キーワード：大気成分重力分離、クライオジェニックサンプラー、インドネシア上空成層圏
Keywords: gravitational separation of atmospheric components, cryogenic air sampler, stratosphere over Indonesia

