

Gravitational Separation : A New Tracer of Stratospheric Circulation

ISHIDOYA, Shigeyuki^{1*}, SUGAWARA, Satoshi², MORIMOTO, Shinji³, AOKI, Shuji⁴, NAKAZAWA, Takakiyo⁴, Hideyuki Honda⁵, MURAYAMA, Shohei¹

¹AIST, ²Miyagi University of Education, ³National Institute of Polar Research, ⁴Tohoku University, ⁵Japan Aerospace Exploration Agency

As a basic knowledge of the atmospheric science, it has been believed that the gravitational separation of the atmospheric components can be found in the atmosphere above the turbopause. Demolishing this scientific common sense, we have detected a significant gravitational separation of major atmospheric components in the stratosphere for the first time based on the high-precision measurements of the stable isotopic ratios of N₂, O₂ and Ar as well as the concentrations of O₂ and Ar in the atmosphere. Observed relationships between them are identical to those expected from the gravitational separation, however, they are clearly different from those expected from the thermally-driven fractionation related to air-sampling procedures. From the comparison of stratospheric O₂/N₂ ratio with and without correction for the gravitational separation, it is indicated that the consideration of the gravitational separation is indispensable to derive reliable information from measured values of the concentration and the isotopic ratio of atmospheric components. It is also suggested that the simultaneous observation of the gravitational separation and the CO₂ age in the stratosphere could provide useful information to clarify year-to-year variations of Brewer-Dobson circulation due to climate change associated with the global warming.

Keywords: gravitational separation in the stratosphere, a new tracer of stratospheric circulation, decrease of stratospheric O₂ concentration, molecular diffusion by gravity and thermal effect