Gravitational separation of atmospheric major components in the stratosphere

Shigeyuki Ishidoya[1]; Satoshi Sugawara[2]; Shinji Morimoto[3]; Shuji Aoki[4]; Takakiyo Nakazawa[5]

[1] CAOS, Tohoku University; [2] Miyagi Univ. Ed.; [3] National Institute of Polar Research; [4] CAOS, Graduate School of Sci., Tohoku Univ.; [5] CAOS, Tohoku Univ.

Recently, precise vertical profiles of O2/N2 ratio, delta15N of N2 and delta18O of O2 in the stratosphere were observed (Ishidoya et al., 2006). The results showed that their values decrease with increasing height, suggesting a mass-dependent gravitational separation of atmospheric components. They also found the averaged stratospheric O2/N2 ratio at heights above 20-25 km over Japan, corrected for gravitational separation, decreased secularly. As an indicator of the gravitational separation, 'delta' was defined by an average value of delta15N of N2 and delta18O/2 of O2. The delta values over Kiruna, Sweden, which were observed inside the polar vortex, were lower than those over Sanriku, Japan and Syowa, Antarctica. At heights below 20-25 km, the mean age of air (CO2 age) increased with height, and the ages were older over Kiruna than over Sanriku and Syowa. These characteristics were negatively correlated with those of the delta values. At heights above 20-25 km, the CO2 age at various times and locations were constant with height, while the delta values decreased gradually with height. These facts suggested that the information on increasing gravitational separation with height was useful in understanding the vertical component of the meridional circulation in the stratosphere. For example, observed latitudinal differences of the delta values suggested the effect of descending air was more significant over Kiruna than over Sanriku. We also obtained a compact relationship between the delta values and the N2O concentration. The variation in the delta values with height was found to be weaker in region with the N2O concentrations between 45 and 125 ppb than in other regions, which might suggest that the vertical mixing or replacement of air occurred in this region.