Latitudinal distributions of gravitational separation and mean age of the stratospheric air observed using a balloon-borne cryogenic air sampler

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We have collected the stratospheric air samples over Japan, the Arctic, Antarctica and equatorial regions at height levels from 10 to 35 km since 1985 by using two kinds of cryogenic air samplers on board a scientific balloon (Honda et al., 1996; Morimoto et al. 2009). The air samples were analyzed for atmospheric greenhouse gases and related air components, and we reported many findings such as spatiotemporal variations in the stratospheric CO2 concentration and gravitational separation of major atmospheric components (e.g. Aoki et al., 2003; Ishidoya et al., 2013). Recently, many studies have focused on “mean age” of stratospheric air derived from clock tracers such as CO2 and SF6 to evaluate changes in the Brewer-Dobson circulation (BDC) responding to climate change (e.g. Engel et al., 2009; Ray et al., 2014). However, as Ray et al. (2014) reported, it is difficult to separate the competing effects on the mean age between mean circulation and mixing only from CO2 and SF6 ages since the mean age becomes younger and older by an enhancement of mean circulation and mixing, respectively, as the consequences of accelerating of BDC. In this regard, gravitational separation of stratospheric air, observed firstly by our observations, is expected to be an additional tool to constrain detail changes in BDC. Both the age and gravitational separation are unaffected by any chemical processes ideally, however the cause of gravitational separation, mass-dependent molecular diffusion superimposed on mass-independent atmospheric transport, is fundamentally different from the cause of age. Therefore, competing effects on gravitational separation between mean circulation and mixing are also expected to be different from those on age. In this study, we present latitudinal distributions of gravitational separation and CO2 age and discuss the advantages of the simultaneous analyses of age and gravitational separation to the stratospheric circulation study.

References

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