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The gradient genesis of the stratospheric trace species in the subtropics and around the polar vortex

K. Miyazaki (1) and T. Iwasaki (2)
(1) Frontier Research Center for Global Change, (2) Tohoku University

This study is to examine the formation and decay mechanisms of the meridional gradients of the stratospheric trace species in the subtropics and around the polar vortex. For this purpose, we proposed and used a gradient genesis equation on the basis of the mass-weighted isentropic zonal means. The gradient genesis is mainly decomposed into the stretching and shearing deformation terms of mean-meridional flows, similar to the frontogenesis analysis, and the stairstep and smoothing effects of eddy transports. These terms help to understand physical meanings of the gradient genesis. The gradient genesis analysis is applied to N_2O data as a tracer, obtained from a global chemical transport model. The analysis indicated that the mean vertical transport increases the meridional tracer gradient from the subtropics to mid- latitudes through the shearing deformation, particularly related to the overturning of the Brewer-Dobson circulation. The mean meridional transport advects the subtropical tracer edge toward the mid latitudes, while the stairstep effect almost compensates for the reduction in the gradient due to the mean meridional transport around the subtropics. The subtropical tracer edge has gradient maxima twice in early spring and autumn in the middle stratosphere, and it was found that the evolution mechanisms of the subtropical tracer gradient are different between these two seasons. The autumnal edge is principally formed by the shearing deformation, while the stairstep effect also influences the generation of the springtime edge. Around the Antarctic polar vortex, the stretching deformation of the mean-meridional circulation mainly generates a strong tracer gradient.