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Possibility of stratospheric hydration by overshooting analyzed with space-borne

Suginori Iwasaki (1), Takashi Shibata (2), Hiroshi Ishimoto (3), and Hisayuki Kubota (4)

(1) National Defense Academy, Yokosuka, Japan (iwasaki@nda.ac.jp), (2) Nagoya University, Nagoya, Japan., (3) Meteorological Research Institute, Tsukuba, Japan., (4) Japan Agency for Marine [U+2010] Earth Science and Technology, Yokosuka, Japan.

Overshoot, a cloud intrusion through the level of neutral buoyancy above a deep convection, is believed as one of mechanisms to hydrate or dehydrate the lower stratosphere. Because there are a few observations of overshooting, its role in the Upper Troposphere / Lower Stratosphere (UT/LS) is not well known.
The A-train is one of the most promising satellite missions to measure vertical profiles and horizontal distributions of clouds, precipitation, and temperature; hence, they can clearly measure overshooting.
First, we discuss one case study of a deep convection occurred on November 09, 2006, in the Java sea, Indonesia by using data of the A-train (the space-borne lidar CALIOP, cloud radar CloudSat, imager MODIS, and sounder AIRS-AMSU), ECMWF reanalysis, and rawinsondes, where three sondes were launched at 500 km and 6 h apart from the deep convection.
The cloud top height of the deep convection was 18.3 km and that of cirrus clouds surrounded the deep convection was 17 km. The heights of the cold point and 380 K potential temperature were about 16.5 km and 16.8 km, respectively, by interpolated AIRS-AMSU data, those estimated by ECMWF were 16.1 km and 16.7 km, and those of sonde data were about 16.3 km and 16.9 km, respectively. Since a height of 380 K is a threshold of the overworld stratosphere, this deep convection is overshooting.
The black body temperature (Tb) of the overshooting was 201 K and that of the cirrus clouds is 193 K. If the overshoot was risen from the cirrus clouds adiabatically, the air temperature of the overshoot should be 181.3 K, 20 K colder than Tb of the overshoot; hence, the air of the overshoot would be warmed by warmer air.
The ambient temperature measured with AIRS-AMSU, ECMWF and the sondes at a height between 15 and 19.5 km was less than 200 K. Since CALIOP could not measure cloud below 15.5 km high, infrared radiation from warmer clouds/precipitaion below the height could not be observed by use of MODIS. Therefore, warmer stratospheric air and the overshooting air would be mixed. There are two scenarios: one is the overshoot had been risen above a height of which temperature was warmer than 201 K and mixed with warmer stratospheric air and fallen at a height of 18.3 km. The other is the vertical distribution of potential temperature at the overshoot became complicated and warmer stratospheric air was fallen by gravity waves as shown in Figure 9 of Grosvenor et al. (2007ACP), and the air of the overshooting and the warmer stratosphere was mixed.
The particle size of the overshooting cloud is 25 μm or less by use of the radar-lidar method (Okamoto et al., 2003JGR) and its terminal velocity is 0.1 m/s or less. Suppose a life time of overshooting is 30 min (e.g., Jensen et al. 2007JGR), overshooting particles would not be removed from the overshoot; hence, stratosphere would be hydrated.
Next we show the occurrence frequency of the overshooting that would be mixed with warmer stratospheric air in our presentation.