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Recent new evidences of deep convective vertical transport of water vapor through the tropopause

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A few years ago, we identified a deep convective transport mechanism (storm top gravity wave breaking) of water vapor through the tropopause so that tropospheric water substance can be injected into the lower stratosphere via this pathway. The main evidence we presented previously was taken from the lower resolution geostationary and a few polar orbiting satellite images of the storm anvil top cirrus plumes. Recent observations turn out more supporting evidences for this important vertical transport mechanism. There are now many higher resolution satellite images, mainly from MODIS instrument, that show more definitely the existence of these plumes, many of which would probably unseen by lower resolution GOES images.

Furthermore, movies taken by a building top webcam also demonstrate that the jumping cirrus phenomenon, first identified by T. Fujita in 1980s, is quite common in active thunderstorm cells, quite contrary to previous belief that it is a rare occurrence. We have used a cloud model to demonstrate that the jumping cirrus is exactly the gravity wave breaking phenomenon that transports water vapor through the tropopause.

Finally, the recent measurements of the heavy water to normal water ratio (HDO/H2O) clearly indicate that the ratio is much highly than that would be if the transport of water from the troposphere to the stratosphere is via slow ascent. The only explanation that can be used to interpret this observation is that water substance is transported through the tropopause via rapid vertical motion, i.e., deep convection.

We will present satellite images, surface-based thunderstorm movies and the chemical measurements to demonstrate that the deep convective transport of water substance (and possibly other trace chemicals) through the tropopause is a very common phenomenon and may be one of the most importance pathways of vertical transport

between the troposphere and stratosphere.