Widening of the cold point tropopause and implications for stratospheric composition

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The tropical belt has expanded over the past few decades with potentially important implications for tropospheric circulation systems and precipitation patterns. While most existing studies of the tropical widening focus on the troposphere, possible implication for the cold point and the tropical tropopause layer (TTL), which serve as main gateway for trace gases entering the stratosphere, are still unclear.

We investigate changes of the upper TTL based on the Lagrangian approach and determine the Lagrangian cold point (LCP) for 1979-2011 from ERA-Interim based trajectory calculations. The LCP distribution shows strong latitudinal variations with season and year. We define the width of the cold points (or final dehydration points) as the latitudinal extent of the LCP distribution and derived a mean width of 28°. Compared to existing diagnostics focusing on lower parts of the atmosphere and encompassing the complete width of the circulation cell, our measure of the width of the upward mass transport is relatively narrow. However, the cold point width shows a variability that is similar to some of the upper tropospheric metrics of the tropical widening. At the same time, the cold point width is connected to stratospheric signals such as the quasi-biennial oscillation.

Based on the long-term LCP time series, we detect a significant broadening of the Lagrangian cold point of 1.2° per decade and demonstrate that this is caused by changes in the transport patterns and not by changes in the overall temperature distribution. We investigate how the cold point width is related to the lowest temperatures that air masses experience on their way to the stratosphere and show that the positive trend in the first drives a positive trend in the latter. The diagnosed expansion of the cold point of 1.2° per decade is in good agreement with most other diagnostics, confirming that the tropical widening is a phenomenon also apparent at the gateway to the stratosphere, impacting cold point and dehydration patterns and thus stratospheric water vapour.

Key words: Tropical widening, Lagrangian cold point, final dehydration point