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Formation of the Double Tropopause in midlatitudes: an analysis using both observations and models

Tanya Peevey (1,2), Paul Konopka (1), Cameron Homeyer (2), and Rolf Mueller (1)
(1) Forschungzentrum Juelich GmbH, IEK-7, Juelich, Germany (t.peevey@fz-juelich.de), (2) National Center for Atmospheric Research, Boulder, Colorado, USA

The double tropopause (DT) is defined using the thermal definition of the tropopause, is found in the upper troposphere lower stratosphere (UTLS) region of the atmosphere, and forms primarily poleward of the subtropical jets. Studies have shown that this thermal structure is associated with the poleward transport of upper tropospheric air into the lower stratosphere during Rossby wave breaking events. The potential for subsequent mixing of radiatively important species in the lower stratosphere highlights the potential importance of the DT in further understanding the dynamics and structure of the UTLS.

A few recent studies have drawn attention to this by showing that our knowledge of the DT is not complete. These efforts specifically show that the origin of air within the DT is still under debate since there are currently three different answers to the same question: low latitudes, midlatitudes and high latitudes. Additionally, one of these studies also shows that the DT can not form with out the tropopause inversion layer (TIL) and that as the strength of the TIL increases so does the DT frequency of occurrence. This is interesting because those results emphasis a current gap in knowledge in our understanding of the DT and, consequently, the UTLS. The focus of this work is to address some of these current open questions.

This study utilizes both observations from HIRDLS, a satellite instrument funded by NASA, and model output from CLaMS, a Lagrangian model developed at Forschungzentrum Juelich. Initially the DT is analysed within the baroclinic system to understand its relationship to the TIL. Results from a case study, which examines a baroclinic disturbance over the Pacific Ocean, shows that as the disturbance develop the DT extends equatorward as the TIL forms and increases in strength. The work presented here explores this further by investigating the movement of air within the DT as it expands and contracts meridionally during the growth and decay of this system using CLaMS and HIRDLS data. This is done by examining horizontal and vertical changes in the mean age of air and both tropospheric and stratospheric tracers, such as CO and O_3, within the system as it grows and dissipates. Other synoptic-scale systems in the midlatitudes are also examined in a similar way using the same data sets to gain a more extensive understanding of the DT-TIL relationship and, potentially, the variations in the origin of air within the DT.