Examining the state of the tropopause during Rossby wave breaking events using COSMIC

Alexia Prosperi1, Chengji Liu2, Elizabeth Barnes2
Valparaiso University, Valparaiso, Indiana1; Colorado State University, Fort Collins, Colorado2

Introduction
Rossby waves are instrumental to atmospheric dynamics and their breaking can transport and mix the air around the tropopause. Here, we examine the structure of the tropopause throughout the lifecycle of Rossby wave breaking to quantify their potential impacts on the frequency of double tropopauses using COSMIC GPS radio occultation profiles. While the identification of double tropopauses is not new, this work links large-scale dynamical processes to the fine-scale structure of the tropopause using high-resolution observations by COSMIC.

Motivation
Double tropopauses (TPs) are related to stronger mixing at the tropopause. This stronger mixing can cause increased amounts of ozone being mixed into the troposphere, which impacts plants and humans.

This research examines Rossby wave breaking as a potential driver of double tropopauses, and quantifies the differences between cyclonic and anticyclonic wave breaking.

Cyclonic wave breaking events are less likely to occur with a warming climate (Barnes and Polvani, 2013). Therefore, determining whether cyclonic and anticyclonic events are similar or different is important for understanding future mixing and transport at the tropopause.

Methods
COSMIC profiles are taken from near the earth’s surface to approximately 800 km. For this research, the area between 0 and 30 km was the focus.

The World Meteorological Organization (WMO) definition of the tropopause was used.

To select Rossby wave breaking events, an algorithm developed by Chengji Liu was used (Liu et al., 2014). Once the potential vorticity (PV) contour of a Rossby wave overturns, it is considered a breaking event if a longitudinal line crosses the PV contour three times.

7 dates for both cyclonic and anticyclonic wave breaking events were examined.

Tropopause coordinates were used in order to show tropopause structure more clearly. These plots show tropopause vs. height coordinates.

Results

Temperature anomalies during a cyclonic wave breaking event on 01/02/09. The black dashed line indicates the day of the event.

Temperature anomalies during an anticyclonic wave breaking event on 01/14/09. The black dashed line indicates the day of the event.

Composite of fraction of double TPs during cyclonic events

Composite of fraction of double TPs during anticyclonic events

Conclusions
- There are differences in tropopause structure during anticyclonic and cyclonic wave breaking events.
- Double tropopauses occur more often in the cyclonic lobe of cyclonic wave breaking events and the anticyclonic lobe of anticyclonic wave breaking events.
- After a Rossby wave breaking event, the cyclonic lobe cools and the anticyclonic lobe warms at the tropopause for both cyclonic and anticyclonic wave breaking events.
- Before an anticyclonic wave breaking event, the anticyclonic lobe is anomalously warm at the tropopause. This may indicate the anticyclonic lobe developing before the cyclonic lobe.

Acknowledgements
This work has been supported by the National Science Foundation Research Experiences for Undergraduates Site in Climate Science at Colorado State University under the cooperative agreement No. AGS-146170 and by the Climate and Large-Scale Dynamics Program of the National Science Foundation under grant 1419818.

Special thanks to the ESMEI organization.

For more information, contact me: alexia.prosperi@gmail.com