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

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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

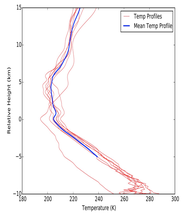
COSMIC profiles are taken from near the earth's surface to approximately 800 km. For this research, the area between 0 and 30 km was the focus.

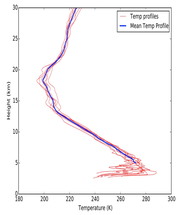
The World Meteorological Organization (WMO) definition of the tropopause was used.

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.

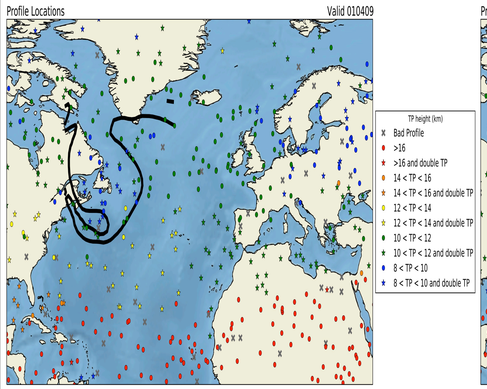
Tropopause coordinates were used in order to show tropopause structure more clearly. These plots show tropopause vs. height coordinates.



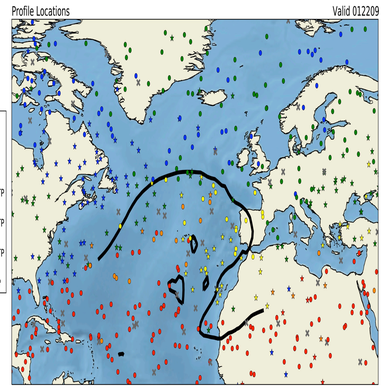


Results

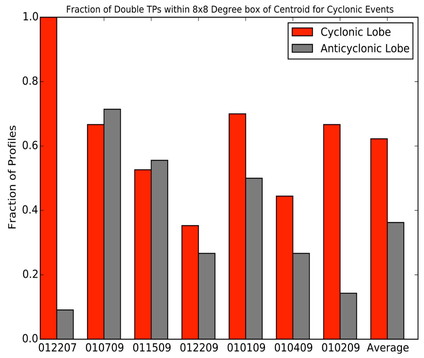
Cyclonic wave breaking event on 01/02/09



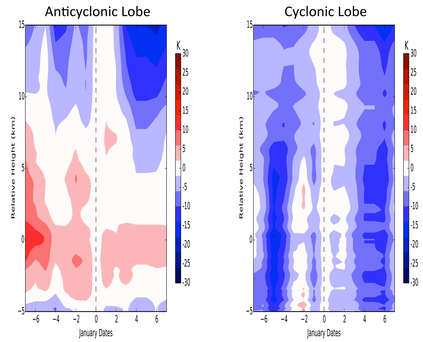
Anticyclonic wave breaking event on 01/14/09



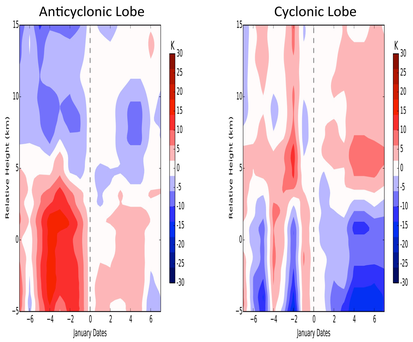
Composite of fraction of double TPs during cyclonic events



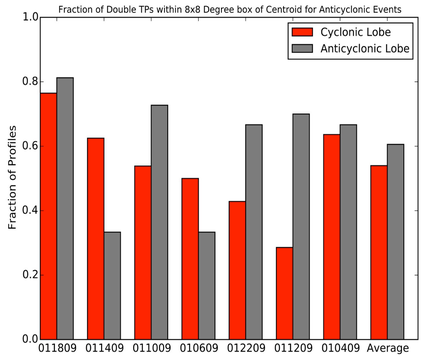
Temperature anomalies during a cyclonic wave breaking event on 01/02/09. The black dashed line indicates the day of the event.



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 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.

Limitations

The location of the profiles varies from day to day. This results in a differing amount of profiles within each lobe of a certain event. Because of this, the conclusion from each individual date can only be as good as the number of profiles within the lobes.

An 8x8 box was used to calculate averages within each lobe. However, using a box size this large could result in profiles from the opposite lobe being examined. A box size with smaller dimensions created situations where only one profile was included in the average so the sample size was small.

Future Work

More cases over an area expanded to include the entire Northern Hemisphere.

Calculating statistics.

Developing a method to follow a PV contour in order to use the profiles within that area to calculate diagnostics.

Comparing COSMIC to reanalysis data to determine if the high resolution of COSMIC allows the structure of the tropopause to be more accurately examined.

References

Barnes, E.A., and L. Polvani, 2013: Response of the midlatitude jets, and of their variability, to increased greenhouse gases in the CMIP5 models. *J. Climate*, **26**, 7117-7135, doi: 10.1175/JCLI-D-12-00536.1.

Liu, C., X. Ren, and X. Yang (2014), Mean flow-storm track relationship and Rossby wave breaking in two types of El-Niñ˜ o, *Adv. Atmos. Sci.*, *31*(1), 197–210.

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