Boundary Hunting in the Tropics

Geographical Variability of the Width of the Tropical Belt

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A number of recent studies have found evidence for a widening of the earth's tropical belt[2]. Most studies focus on the annual mean zonal mean tropical belt width. The purpose of this research is to determine the geographical variability of the width of the tropical belt. We study how well defined the boundaries of the tropical belt are in both hemispheres as a function of longitude and season. The sharpness of the tropical boundaries as a function of longitude can provide information, which is otherwise hidden in zonal averages. Localized widening of the tropical belt is expected to have a bigger climatic impact for a very sharp tropical boundary encompassing a drastic distinction between the biomes of the tropics versus the subtropics. In contrast, a less sharp or even ill-defined boundary will likely lead to more fickle changes in climate and gradual changes in the biodiversity of the two regions in focus. An improved understanding of the morphology of the tropical belt can help us determine climatic changes surrounding the edges of the tropics. For all figures present, monthly mean ECMWF interim reanalysis data (ERA-interim) from 1979-2012 was used.

Hunting for the Tropopause

Figure 2

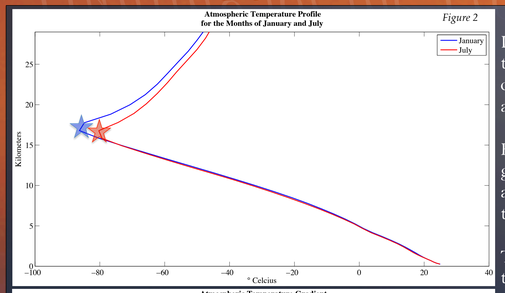
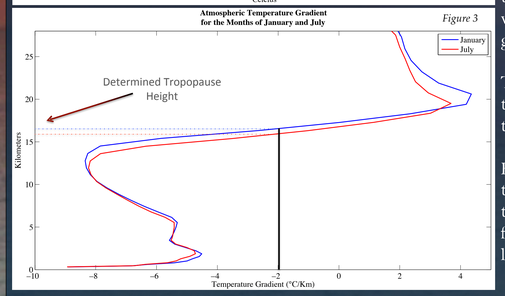


Figure 3



In the tropics and subtropics, the tropopause is the second coldest place in the atmosphere.

* * *

By observing the temperature gradient, we can pin-point the altitude of the tropopause in the atmosphere. (figure 2)

* * *

The WMO defines the tropopause as the point at which the temperature gradient reaches -2 °C/km*

* * *

This can be found by taking the first derivative of the temperature profile. (figure 3)

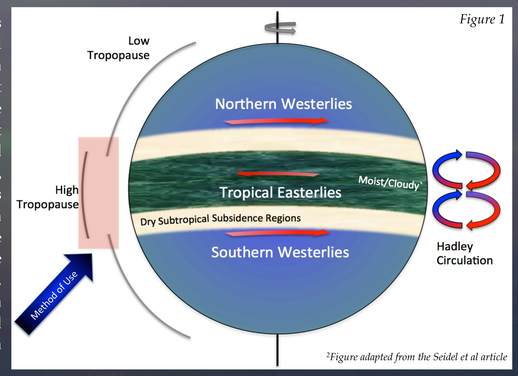
* * *

By finding the -2 °C/km threshold, we can determine the altitude of the tropopause for all longitudes and latitudes. (figure 3)

The Tropics and Subtropics:

The boundary that separates the two biomes is not well defined, and depending on discipline has different meanings. Astronomically the edge of belt is defined at ~23.5 degrees north and ~23.5 degrees south, however, the above weather patterns just described extend much further, sometimes twice the distance, than that of these two astronomical definitions. Hydrologically, the tropics can be defined based on the varied amounts of precipitation found between the two sub-regions, created by the Hadley circulation. The distinct subtropical jet stream can also be used to determine the boundaries of the belt. The method used in this project is based on the "tropopause break" to determine the transition between the two zones as well as measure the sharpness of this transition. The tropopause break is an atmospheric structure in which the area between the troposphere and stratosphere rapidly increases in altitude. The hastiness of this altitude shift will be referred to as the gradient strength and it is through this that abrupt versus gradual shifts in biomatic zones can be concluded from.

Figure 1



[2]*Figure adapted from the Seidel et al article*

Hunting for the Tropical Belt

Figure 4

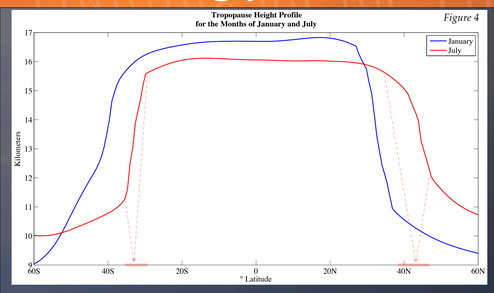


Figure 5

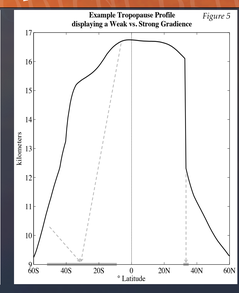
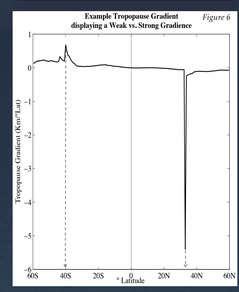


Figure 6



Once the tropopause is found and profiled, as in the plot above, the analysis can begin in order to find the edges of the tropical belt.

* * *

The gradient is found of the tropopause profile, to determine the latitude coordinate of the edge, as well as quantify its strength.

* * *

A well defined tropical bound has a very large spike in the gradient whereas a less well defined bound is more noisy with a small deviation from the background. (figure 6)

Figure 7

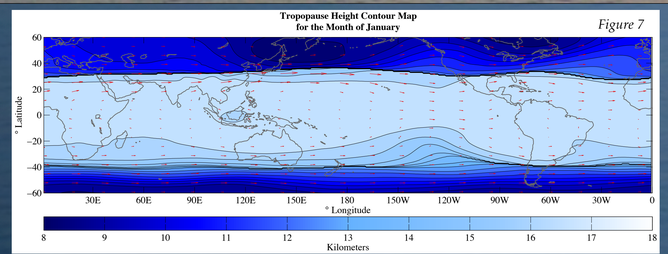
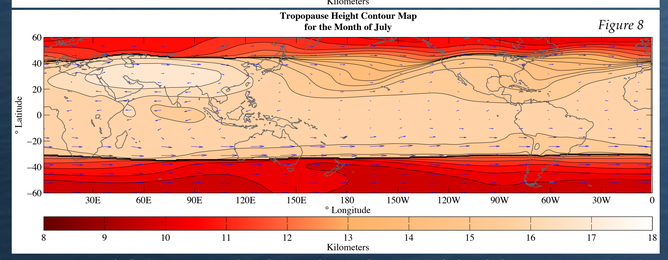


Figure 8



These contours of the tropopause height emphasize how well defined the tropopause break is in some regions and how it is less well defined in others.

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Wind is plotted to help give insight into how well defined the edges of the belt are.

Figure 9

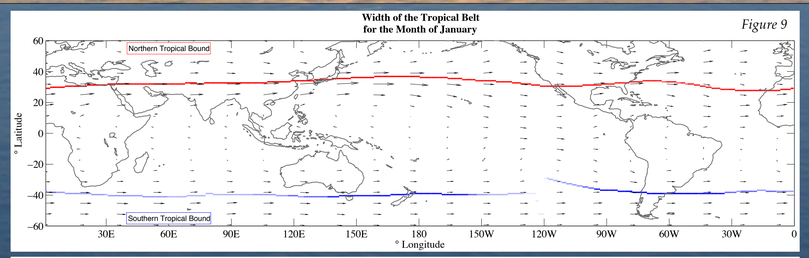
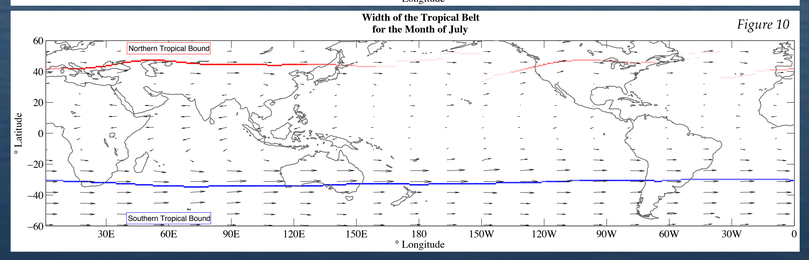


Figure 10



From figures 7 and 8, the strength of the gradient is quantified and colorized—deeper color meaning stronger gradient.

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Note that the breaks in the pacific regions in each hemispheres respective summer season.

Figure 11

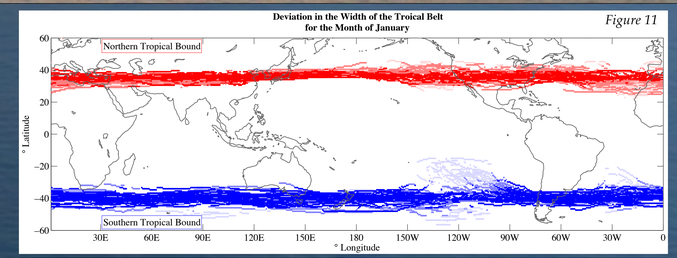
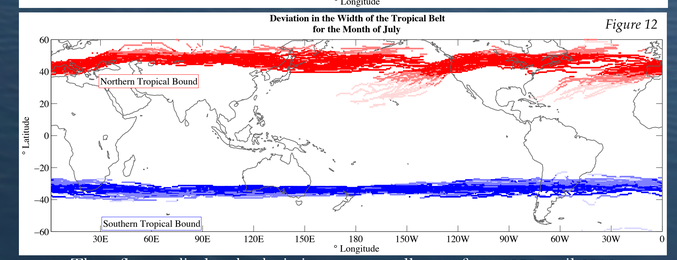


Figure 12



These figures display the deviation amongst all years from 1979 until 2012.

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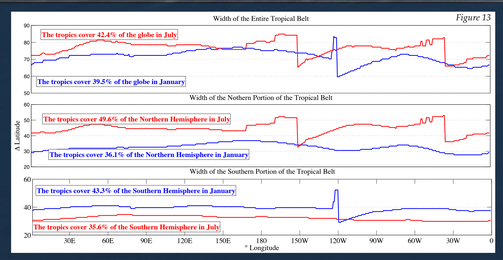
Dark color indicates a range from ±1 standard deviation value from the mean, a light color is within the range of ±2 standard deviations, and even lighter are the outliers outside either range.

Figure 13



This final plot displays the width of the overall tropical belt (measured in latitudes) as well as the width of each individual portion of the belt – the Northern and Southern portions.

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Also included are the percentages covered of the globe or each respective hemisphere.

Summary and Conclusion

The purpose of this project was to study geographical variability of the width of the tropical belt and quantify the strength of the transition between tropical and subtropical regions. This was done by analyzing the respective latitudes and the gradient strength of the atmospheric phenomenon known as the tropopause break. It was found that during each hemisphere's respective summer season the tropical belt edge over the Pacific and Atlantic oceans can display a tendency to be very fickle and thus poorly defined. For all times of the year, however, it is shown that the tropopause break over land has the tendency to create a well defined and sharp tropical edge.

Acknowledgements and References

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ERA-interim data were provided by ECMWF through NCAR.

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[1]Davis, Nicholas A., and Thomas Birner. "Seasonal to Multidecadal Variability of the Width of the Tropical Belt." Journal of Geophysical Research: Atmospheres 118.14 (2013): 7773-787. Print.

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[2]Seidel, El Al. "Widening of the Tropical Belt in a Changing Climate." Nature 1 (2008): 21-24. Nature Geoscience. Nature Publishing Group, Jan. 2008. Web.