INTER-HEMISPHERIC DIFFERENCES IN PMSE: ARE THEY DUE TO DIFFERENCES IN MESOPAUSE TEMPERATURES?

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Abstract

Recent observations using the Peruvian\U.S. Profiler at Machu Picchu Base in Antarctica show that PMSE are vastly weaker in the southern hemisphere relative to the north. The difference in average echo strength in the two hemispheres is of the order 23-33 dB. Since the PMSE occurrence is closely associated with the extremely low temperatures that are a well-know feature of the high-latitude summer mesopause region, the most obvious explanation for this discrepancy is that the mesopause temperatures are warmer in the southern hemisphere than they are in the north.

Introduction

By far, the most intriguing discovery that has emerged from the Machu Picchu Radar on King George Island in Antarctica is that Polar Summer Mesospheric Echoes, or PMSE-- which are a strong and ubiquitous feature of the high-latitude summertime mesopause in the northern hemisphere--are much weaker and more sporadic in the southern hemisphere. Indeed, we find that PMSE in the southern hemisphere are some three hundred to three thousand times weaker in the southern hemisphere than they are at nearly-equivalent latitudes in the northern hemisphere [Balsley et al., 1993,1995].

Clearly, there must be a major difference in one or more of the mean mesopause state variables in the two hemispheres to produce such a surprising difference. We outline here the possibility that the mean mesopause temperature is a few Kelvin warmer at high southern latitudes. This suggestion is based on PMSE research in the northern hemisphere, which shows that PMSE occurrence is at least partially controlled by a mean "threshold" temperature [Balsley et al., 1983; von Zahn, 1989]. Provided that the southern hemisphere mesopause temperatures are warmer, this difference would then be manifested by greatly reduced PMSE intensities in the south.

Furthermore, since the high-latitude summer mesopause low temperatures arise from adiabatic cooling resulting from a strong atmospheric upwelling, it is reasonable to expect that upwelling in the south is reduced relative to the north. Reduced upwelling also results in a weaker meridional outflow circulation. And both reduced upwelling and meridional flow could be a consequence of reduced middle-atmospheric gravity-wave dissipation. Finally, a lower level of middle-atmospheric gravity waves would suggest that there would be fewer gravity waves propagating upward from the troposphere.

Experimental evidence for a warmer southern mesopause

Direct evidence for differences in summertime mesopause temperatures in the northern and southern hemispheres is patchy at best. Labitzke and Barnett [1981] report that monthly mean radiance data from the Nimbus 6 satellite indicates a warmer mesopause in the south relative to the north. And monthly mean summer temperatures at 80 km between 75° and 80° latitude extracted from Barnett and Corney [1985] suggest that there are measurable differences on the order of a few Kelvin. Finally, Thomas [1995] has reported differences in polar cap mean mesopause temperatures, with temperatures in the southern hemisphere being some 4 K warmer than their northern counterparts.

With regard to differences in the mean flow and wave activity in the two high latitude mesopause regions, the best information to date comes from Vincent [1994]. Vincent reports that both the mean meridional wind magnitude and the gravity wave activity are reduced in the southern hemisphere relative to the north. The gravity wave activity is down by a factor of two, while the mean meridional outflow is reduced by roughly 50%.

Further evidence is provided by satellite observations of Polar Mesospheric Clouds (PMCs) [see Thomas, 1991 and references cited therein]. PMCs have occurrence statistics very similar to those of PMSEs: they are observed near the high-latitude mesopause in both hemispheres in summer. Observations of hemispheric differences in PMC characteristics show that southern PMCs are weaker, and are more confined to high latitudes. Both of these differences could well arise from reduced meridional outflow and concomitant warmer temperature in the south.

Conclusion

Although evidence for a warmer southern mesopause is--at this point--speculative, there are a variety of independent observations of other hemispheric properties that are consistent with this possibility.

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