

As the referee provided a detailed review for the initial screening review, most of the referee's comments were addressed prior to the submission of the manuscript. We detail the changes that have been made in accordance to the referee's wishes.

1)

Introduction

The sentence: "They found that warmer stratospheric temperatures in the winter hemisphere, an indicator of increased planetary wave activity, could be associated with warm anomalies of the summer mesospheric temperatures in the opposite hemisphere.", has been added to explain the Karlsson et al observations.

Page 1, 1st paragraph:

Indeed, the referee is correct that the dissipation of energy and the deposition of momentum, and I have changed line 2 on page 2 to read "dissipate their energy and deposit their momentum..." to reflect that.

We believe that paragraph 1 of the text is in keeping with the referee's comments. In the absence of waves, there would be a geostrophic zonal flow driven by the radiative temperature/pressure gradients and the Coriolis force. The wave momentum deposition produces a drag force on the zonal flow that produces a residual circulation, and the ensuing vertical motions that drive the temperature away from radiative equilibrium. While in steady state there is no net force, and $du/dt=0$, one can speak of the gravity-wave drag force as a force decelerating the zonal winds (as indeed, any time one speaks of a force it is proper to speak of the acceleration or deceleration it produces). In addition, any change in the zonal momentum flux will create accelerations or decelerations of the zonal wind field. This is, in fact, what is stated in lines 2-4 on page 2: "This input of momentum decelerates the zonal winds and establishes a pole-to-pole circulation in the mesosphere". To express this in a manner that may be more acceptable to the referee, this has been changed to: "This input of momentum creates a drag force on the zonal wind that establishes a pole-to-pole circulation in the mesosphere"

Page 1 2nd paragraph

I think there is perhaps a misunderstanding regarding statements concerning the direction of the momentum deposited in the mesosphere. We were very specifically speaking of the mesosphere and merely used the direction of the mean flow as reference, since the cardinal direction changes winter to summer. Thus, the drag force, and hence the strength of the residual meridional circulation, is greater as more net-momentum in the direction opposite to the mean flow is deposited in the mesosphere. Of course above the mesopause, in the lower thermosphere, the summer wind reversal means that the gravity waves represent an acceleration force and the meridional circulation weakens and ultimately reverses. The statement has now been changed to read simply: "The strength of this inter-hemispheric circulation, and thus the degree of heating or cooling at the polar mesopause, depends upon the net amount gravity-wave momentum flux deposited in the mesosphere".

In a similar fashion, there does not seem to be a conflict regarding the comments on the second paragraph on this page. It is stated that "stronger stratospheric zonal winds result in a more complete filtering of the waves, giving a higher net momentum flux", whereas the referee states "a weaker mean wind will reduce the GW momentum flux that reaches higher altitudes and vice versa". I believe that the two statements are, in

fact, the “vice versa” of each other! To make this clear, the statement has been changed to read: Hence, stronger stratospheric zonal winds result in a more complete filtering of the waves, giving a higher net gravity-wave momentum flux and a stronger residual circulation, and vice versa (Holton, 1982, 1983).

The statement regarding the confirmation of the proposed mechanisms through the simplistic model of Koernish and Becker, with the appropriate reference, have been added.

2)

While the effect of the QBO is weaker in the southern hemisphere, as shown by Baldwin and Dunkerton 1998, it must be remembered that the mechanism proposed does not require the vortex to break down, only that the winds be changed by the phase of the QBO. Baldwin and Dunkerton show that the winds from 30-60 are faster during the westerly phase of the QBO. Although the effect is about half the size of that observed in the northern hemisphere, and it occurs at lower latitudes, it does occur over the entire winter period. Thus, it is this effect to which we are referring. Synoptic waves could also play a part, although I am not familiar with a reference showing that effect. However, to accommodate the referee's comments we will use the term "synoptic and planetary waves" when referring to the southern hemisphere. The term "planetary waves" had been used with regard to Karlsson's work which examined weak and strong EP fluxes in the southern hemisphere, but referred to the collected activity as "planetary waves".

In this work we have shown that the northern hemisphere mesospheric temperatures are directly correlated both with the QBO phase and the southern extra-tropical stratospheric temperatures (a proxy for planetary wave activity). At the suggestion of the referees, a test of this proxy was done by examining the average speed difference in the zonal winds between 40 and 60 S during the warm and cold mesospheric temperature anomalies. Although it is not the fully correlation analysis between the equatorial winds and the zonal winds and temperatures at different latitudes requested here, we believe that it does satisfy the main points of that request without repeating earlier studies.

The Baldwin and Dunkerton (1998) study has shown a clear relationship between the phase of the equatorial QBO and the speed of the southern hemisphere zonal wind, and that analysis was performed as both a function of the time of the year and the zonal wind strength between the equator and the pole. Thus, a repeat of that analysis in this work would seem unwarranted.