POLAR MIDDLE ATMOSPHERE DYNAMICS

By

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To my family

Abstract

The dynamics of the polar mesosphere and lower thermosphere (MLT) is investigated using MF radars at Davis (69°S, 78°E), Syowa (69°S, 40°E) and Rothera (68°S, 68°W) in the Antarctic, and Poker Flat (65°N, 147°W) and Andenes (69°N, 16°E) in the Arctic. Mean winds and gravity waves are investigated on a climatological scale and also during sudden stratospheric warmings.

Mean wind climatologies in the MLT show differences that are often hemispheric in nature. For example, summer peaks in westward and equatorward winds occur earlier (closer to the solstice) in the Antarctic than in the Arctic. The greater symmetry around the solstice of phenomena such as these indicates that radiative effects may play a greater role in controlling the state of the Antarctic MLT than in the Arctic, where dynamical effects might be more important. Gravity wave observations are consistent with this theory, suggesting more wave drag may occur in the Arctic MLT.

The equatorward jet persists for about 2 weeks later in summer in the Arctic than in the Antarctic, as do satellite observations of polar mesospheric clouds (PMCs) (a temperature dependent phenomenon). It is proposed that the meridional winds can be used as a proxy for gravity wave driving and consequent adiabatic cooling in the MLT. VHF radar observations of polar mesospheric summer echoes (PMSEs) at Davis, and the satellite PMC observations, both occur at a similar time to the equatorward jet.

Seasonal variations in gravity wave activity are generally a combination of annual (with winter maxima and summer minima) and semi-annual (with maxima near the solstices and minima near the equinoxes) components. The winter maxima and spring/summer minima both occur about 3 weeks later in the Antarctic than in the

Arctic, with the difference in magnitude between these extrema being about 90% larger in the Antarctic.

The available MF radar data include six major sudden stratospheric warmings in the northern hemisphere, and the unprecedented southern event which occurred during 2002 splitting the Antarctic ozone hole apart. Three of the six northern events are relatively weak and could almost be classed as minor warmings, while the larger three are similar in strength and duration to the southern event.

Gravity wave activity reduces dramatically at Davis during the southern event, but not at Syowa (possibly due to differences in critical level filtering). The influence of major warmings on mesospheric gravity wave strength and polarisation varies significantly between locations, and individual events.

Zonal wind reversals associated with the large major warmings are all weaker and occur earlier in the mesosphere than in the stratosphere. Another hemispherically common response is zonal wave-1 planetary wave signatures in the mesospheric meridional winds (i.e., a flow over the pole). The planetary wave signatures have 14-day periodicity and are westward propagating leading up to the southern event.

The zonal winds are weaker than average during the 2002 southern winter, and also during the transition to the summer circulation. This is not seen for the large northern major warmings. There appears to be both hemispheric similarities and differences in polar middle atmosphere dynamics during stratospheric warmings, and also on a climatological scale.

Contents

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This work contains no material which has been accepted for the award of any other degree or diploma in any university or other tertiary institution and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text.

I give consent to this copy of my thesis, when deposited in the University Library, being available for loan and photocopying.

Signed: .... dated: ....

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