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Trends in the mesopause region temperature and our present understanding—an update

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Abstract

A comprehensive review of the long-term changes and trends in the thermal structure of the mesosphere and lower thermosphere (MLT) region has been provided by Beig et al. [Beig, G., Keckhut, P., Lowe, R.P., Roble, R.G., Mlynczak, M.G., Scheer, J., Fomichev, V.I., Offermann, D., French, W.J.R., Shepherd, M.G., Semenov, A.I., Remsberg, E.E., She, C.Y., Lübken, F.J., Bremer, J., Clemesha, B.R., Stegman, J., Sigernes, F., Fadnavis, S., 2003. Review of mesospheric temperature trends. Rev. Geophys. 41 (4), 1015, doi: 10.1029/2002RG000121] in which results and analysis reported until about early 2002 were included. Since then not much new information on the temperature trends has been added. Nevertheless, some new results along with some modified results by revisiting the older data sets have been reported in recent time. Our understanding on the nature of temperature trends in the MLT region is relatively better understood now and model agreements with some of the specific observed feature are better reproduced in recent time. This paper briefly summarizes the progress made over the recent past in the field of mesopause region temperature trends and provide an update to Beig et al. (2003). Some new information is also added in recent time on the seasonal trend variability in temperature of the mesopause region which is also discussed in this article. Finally the new insight into the probable mechanisms to understand the observed trends along with future scope of the work in this field is outlined.

Keywords: Mesosphere; Mesopause; Temperature trends; Airglow; Energetics

1. Introduction

It is generally thought that life on Earth is more directly affected by climate change near the surface than in the middle and upper atmosphere. However, the radiative effects of an increase in the greenhouse gases, particularly CO_2, become more pronounced at higher altitudes (decrease in optical depth) rather than the lower heights. As a result, the chemical composition and thermal structure of the mesosphere may be altered substantially by human activities, which, through feedbacks, could affect the lower atmosphere. However, to date there is no data set from which the mesospheric energy budget can be confidently derived on a global basis, and thus we know very little concerning the relative importance of the various sources and sinks of energy and their overall role in determining the structure and variability of the mesosphere (Beig et al., 2003). We do not even know basic properties; such as if the mesosphere is in global mean radiative equilibrium on monthly to seasonal timescales, as is the stratosphere (Mlynczak et al., 1999). However, the major radiative, chemical, and dynamical processes that govern the energy balance in the mesosphere are thought to be well-known. Analysis of the energy budget produced by the extended Canadian Middle Atmosphere Model (Fomichev et al., 2002) revealed radiative processes to be dominant throughout the middle and upper atmosphere. The pattern is considerably more complicated in the mesosphere and lower thermosphere region between 70 and 120 km. The Thermosphere–Ionosphere–Mesosphere Energetics and Dynamics (TIMED) Mission, and the significant ground-based program that accompanies

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it, is likely to provide this essential understanding of the energy budget of this critical region of Earth's atmosphere.

Nevertheless, during the last decade, there has been an ever-growing impetus for temperature trend investigations in mesopause region, now that it has been established that the secular increases in greenhouse gases at the ground should have a substantial impact on the radiative-chemical–dynamical equilibrium of the middle atmosphere. In the past, a number of authors have discussed global change and temperature in relation to observations or models (Roble, 1995; Thomas, 1996; Danilov, 1997; etc.). Russian data sets are probably the longest temperature series available for the entire MLT region (Semenov et al., 2002). The problem of MLT region temperature trends is being taken more seriously during the past few years. As a result of which, a joint working group on trends under the auspices of International Association of Geomagnetism and Aeronomy (IAGA) and International Commission on Middle Atmosphere (ICMA) has constituted the mesospheric temperature trend assessment (MTTA) panel with the objective of dealing with issues related to MLT temperature trends. The effort of MTTA has resulted in a first comprehensive review and the status report of observational and model results for temperature trends in this region which was published recently (Beig et al., 2003). This paper is considered as the vital baseline paper in this field. Thereafter, a few papers dealing with long-term changes and trends in MLT temperature have also been published. It is also becoming increasingly clear that the similarity among the trend results derived for different stations becomes more obvious after the solar cycle-related variation has been removed from the original signal (Golitsyn et al., 2006). The article present an update to the above mentioned baseline paper on the mesopause region temperature trends and discusses some new directions and future roadmap.

2. Results

This paper addresses the results pertaining to the region 80–100 km, normally referred as mesopause region. Fig. 1 shows the summary of the annual mean long-term temperature trends (K/decade) as reported in the recent literature for the mesopause region during the past 2–3 decades. As stated earlier, we discuss here only those results in detail which were either not included or could not be reported until the time of the publication of the baseline review paper (Beig et al., 2003). Hence for other results, which are reported in Figs. 1 and 2 but not discussed here in detail, reader is referred to Beig et al. (2003).

2.1. Northern hemisphere

Fig. 1 shows the annual mean long-term temperature trends (K/decade) as reported in the recent literature for the mesopause region during the past 2–3 decades for the northern hemisphere. It is an update to Beig et al. (2003). In recent time, the latest publication on this subject is by

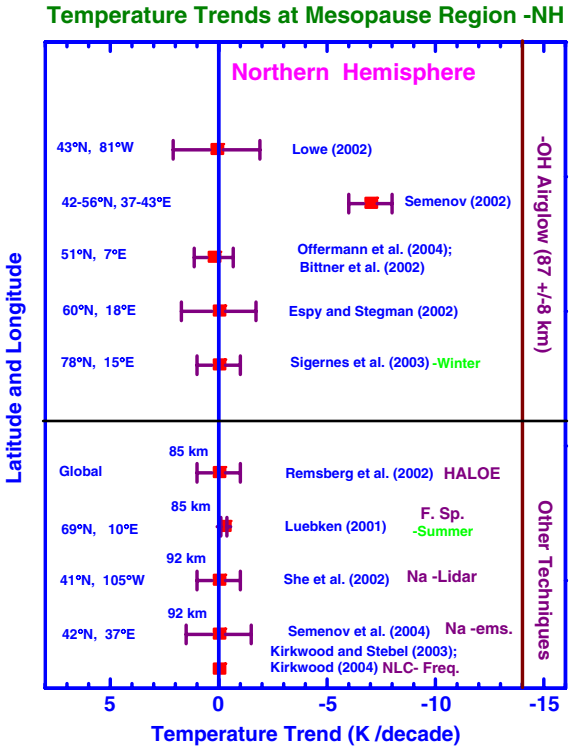

Fig. 1. Annual mean long-term temperature trends (K/decade) as reported in the recent literature for the mesopause region during the past 2–3 decades for the northern hemisphere. An update to Beig et al. (2003).

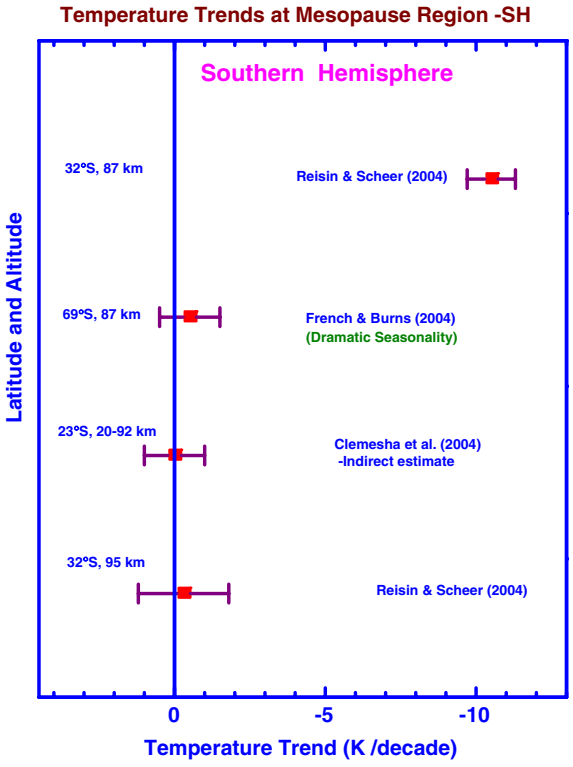

Fig. 2. Annual mean long-term temperature trends (K/decade) as reported in the recent literature for the mesopause region during the past 2–3 decades for the southern hemisphere. An update to Beig et al. (2003).