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# Temperature trends in the mesosphere

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We have performed trend studies in the mesosphere in the period 1961-2009 with LIMA (Leibniz-Institute Middle Atmosphere model) which is based on ECMWF below approximately 40 km and adapts temporal variations of $CO_2$ and $O_3$ according to observations. There is general agreement between LIMA and observations. Temperatures in the mesosphere/lower thermosphere vary non-uniformly with time, mainly due to the influence of ozone. We have therefore separated the influence of $CO_2$(t) and $O_3$(t) when determining trends. It is important to distinguish between trends on pressure altitudes, $z_p$, and geometric altitudes, $z_{geo}$, where the latter includes the effect of shrinking due to cooling at lower heights. Maximum total temperature trends reach approximately -1,3 K/dec at $z_p$ $\sim$60 km and -1.8 K/dec at $z_{geo}$ $\sim$70 km, respectively. Carbon dioxide is the main driver of these trends in the mesosphere, whereas ozone contributes approximately one third, both on geometric and pressure heights. Depending on the time period chosen, the ozone effect on trends can be significantly smaller or larger. Temperature trends on geometric and pressure altitudes can differ by as much as -0.9 K/dec in the mesosphere. The altitudes of pressure levels in the mesosphere decrease up to several hundred meters. The shift maximizes at mesopause levels where it accumulates to more than 1 km. Most of the shrinking occurs in the mesosphere and a smaller fraction ($\sim$20%) in the stratosphere. For the first time, we have performed long term runs with LIMA applying the 20th Century Reanalysis from NCEP/NCAR dating back to 1871. Again, trends are non-uniform with time. Since the late 19th century temperatures in the mesosphere have dropped by approximately 5–7 K on pressure altitudes, and up to 10–12 K on geometric altitudes. This is much more then typical trends in the troposphere and stratosphere. It is therefore justified to summarize that the mesosphere (at least in summer and at middle latitudes) reacts substantially more sensitive to climate change compared to lower altitudes.