The vertical distribution of temperature trends indicates mainly warming (variable magnitude) in the troposphere and strong cooling (variable magnitude) in the stratosphere over most LTP. In addition, results indicate a variability of the height of the ZTL over the defined LTP even in the longer 25-year trends. The ZTL has a tendency to decrease over the temporal change of trends. The general tendency suggest that the ZTL decreases in height with strong cooling in the stratosphere, mainly in the later 20 and 25-year trends. However over some 20-year trends the ZTL doesn’t appear on the magnitude of the cooling in the trends above the ZTL or the magnitude of the warming in the trends below the ZTL. The reduced RATPAC dataset global average trends ZTL varies over a range of ~75-150 hPa and for the 25-year globally averaged LTP over a range of ~90-250 hPa. RATPAC-A does not show a significant departure from the reduced RATPAC results, however Fig. 2 shows results from the Ex Tropics(c) and (f) and it indicates significant cooling over 20 or 25-year periods appear only after trends ending in ~1993. Results indicate the variability of the ZTL independent of the tropopause. RATPAC data may not show the atmosphere differently to understand trend. Instead of the tropopause, certain studies may need to use a variable boundary such as the ZTL. It is possible that causes of ZTL variability may be related to ozone depletion and recovery, water vapor variability or variability in the solar spectral output to name a few. However, a comprehensive study into the effects of these parameters over LTP would be necessary to confirm this hypothesis and in some cases vertical profiles of these forcings are not available.

**References**


**Future Work**

Our **Significance Examples** are not an exhaustive list, but does communicate the importance of understanding variability in the ZTL and temperature trend profiles. Future work will include: analysis of the ZTL with all available radiosonde datasets to include error analysis in the creation of the ZTL analysis over different regions of the globe. Additional future work will include the necessary collaboration to create a new MSU channel to compare the ZTL region with satellite trends. We propose a new channel created from different scan angles of MSU channel 4(LS), sensing the lower region of the lower stratosphere (LST).

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**Significance Examples**

Here we present examples how understanding the variability in the ZTL and the vertical temperature trend profile may impact climate studies.

**Trend Analysis Combining MSU MT and LS channels**

[7] developed a method to analyze lower tropospheric temperature trends by combining MSU channel 2(MT) and channel 4(LS). Their method uses 25-year trends from radiosonde data to create coefficients that may be used with MSU data.

Note from Figs 1 and 2 that the majority of the ZTL variability is between 100mb and 200mb. This coincides with the tropopause layer that has the greatest contribution from both channels. We determined that the greatest errors using this method were seen during the stratosphere where the LST channel does not represent the MT channel layer above a chosen tropopause. This occurs when there is strong cooling in the stratosphere coincident with the predominate level of zero trend (ZTL) above the troposphere. We did not find this conclusion in any 25-year LTP in global or tropospheric averaged data, but in future studies this may be changed in terms of regions or periods (less than 25 years) may be introducing significant unaccounted errors.[8]

**Atmospheric Amplification Theory**

Determing if tropical surface warming trends with height with the tropopause with a maximum trend in the middle to upper troposphere (Atmospheric Amplification)[9] could yield different results using different trends periods. Using Fig 5(b) as an example: Tropical (30N-30S) 25-year LTP trends.

- This temperature trend profile could give results showing atmospheric amplification with maximum warming around 300-400mb and warming until ZTL, close to 100mb.
- This temperature trend profile may show any warming in the profile and the trends decrease after the 200mb, but not the tropopause.
- This temperature trend profile may show two maximum levels (~850mb and 300-400mb) and then decreasing thru the ZTL (~150mb) to the tropopause (100mb)

**Validating Climate Models - ZTL**

[10] shows simulated 1979-1999 temperature trends from four different global climate models (see [11], figure 1). Each of these models depicted a ZTL at 100mb for the Tropics (30N-30S). Using Fig 2(b), Tropical (30N-30S) 20-year trends as a comparison indicates a difference trend ending in 1999. Fig 2(b) (red line) indicates a ZTL at or below 250mb, tropical observations maximum warming (or close to it). The authors note that this is an example and a detailed comparison needs to be accomplished; however, this comparison shows that the ZTL could be used as a novel tool to validate climate model output.