

Sensitivity of the lower tropical stratosphere to vertical resolution in NWP models

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Operational forecast systems at ECMWF have been found to suffer from lower tropical stratosphere temperature biases which have a distinctive resolution dependency. At typical vertical resolutions (~450m or ~350m in the lower stratosphere), the model has a cold bias which gets worse with increasing horizontal resolution. Although at typical climate model resolution the problems are negligible, for high resolution NWP systems this is a serious problem. Both the cold bias and the sensitivity to horizontal resolution disappear if vertical resolution is increased sufficiently, to about 150m spacing across the tropopause. The reason for a specific threshold of 150m is not understood, although it seems to hold across a wide range of horizontal resolutions (80km to 9km).

Investigations have shown that the cold bias can also be addressed by damping small scale motions with a filter on the divergence field, such that high resolution models have a KE spectrum similar to low resolution models. It is argued that models which can resolve small scale gravity waves in the horizontal are vulnerable to numerical diffusion effects across the tropopause unless very high vertical resolution is also used. Evidence from other modelling groups suggest that although the particular form of the cold bias may be specific to the ECMWF model numerics, there is likely to be a general issue of high horizontal resolution models being sensitive to numerical issues.

Results of the impact of increased vertical resolution on forecast skill at extended and seasonal forecast ranges are also presented.

Key words: tropopause, bias, vertical resolution