# The Doppler Absorption in the Thermal Infrared Radiation Parameterization of JMA Global Spectrum Model



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In longwave(LW) radiation scheme of the atmospheric numerical model, the stratosphere and the troposphere cannot be treated in the same manner. As an altitude becomes higher in the stratosphere, the dominant absorption line profile changes from a Lorentz line shape(collisional broadening) to a Doppler line shape(Doppler broadening). The operational global NWP model of Japan Meteorological Agency(JMA-GSM0103) does not sufficiently take account of the latter absorption type. The calculation method of the transmission function is based on the statistical band model(Goody,1952), where a Lorentz line shape is assumed. The Doppler effect is simply included by retaining a finite absorption under low pressure conditions where the pure Lorentz absorption would be normally negligible. GSM0103 has great error in temperature in the stratospheric region (shown later), and this insufficient treatment of the Doppler absorption in the LW radiation scheme is thought to be as one of its cause.

New parameterization is being developed in order to introduce the Doppler absorption properly. It is based on the LW radiation scheme of the NASA Goddard Space Flight Center (Chou et al.,2002) and the Doppler effect is considered by using the transmittance tables precomputed with the accutate line-by-line(LBL) culculation considering the Doppler broadening. Transmission of an atmospheric path can be calculated by reffering to these tables with an effective pressure and temperature computed by weighting the absorber amount along a path (2-parameter scaling method).

Cooling rates by LW radiation are computed by this new parameterization and the one used in GSM0103. Fig.1 and 2 respectively show the results for the mid-latitude summer and the tropical atmosphere taken from McClatchey et al.(1972), which are devided into 40-layers of GSM0103 in calculation. The figures indicate that (1) the cooling in the upper stratosphere is increased because of introducing the Doppler absorption properly, (2) the cooling in the middle stratosphere is decreased, and (3) the cooling in the troposphere is also improved in terms of better agreement with the LBL results. It is supposed that (2) is due to the increase of the upward flux in the stratosphere with the change in the troposphere((3)).

Next, this parameterization is examined by the one month forecast experiment using JMA's global model. Fig.3 shows the one month mean error in zonal-mean temperature in July 2001. The revised version is the same as the GSM0103 except for the parameterization of the Doppler effect in the LW radiation scheme. The great contrast between positive error(above the 3-hPa level) and negative error(below it) computed by the original GSM0103 is eliminated, and the magnitude of that negative error is reduced in the new version. This impact is consistent with the above-mentioned (1) and (2). While the error is increased in some regions of the troposphere by the reflection of the above (3), this implies the necessity to improve the other physical processes in the troposphere, including cloud-radiation interaction process.

References

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McClatchey,R.A.,R.W.Fenn,J.E.A.Selby,F.E.Volz and J.S.Garing,1972: Optical properties of the atmosphere, 3rd ed.,AFCRL Envirn.Res.Papers No.**411**,108pp.

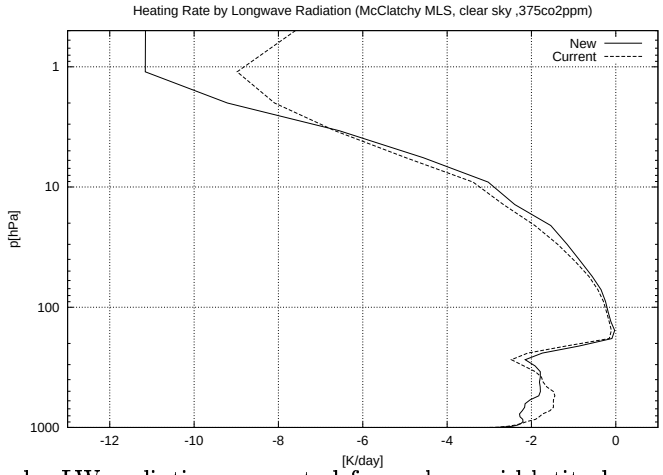


Fig.1: The heating rate by LW radiation computed for a clear mid-latitude summer atmosphere by the new parameterization(solid line) and the one used in GSM0103(dashed line)

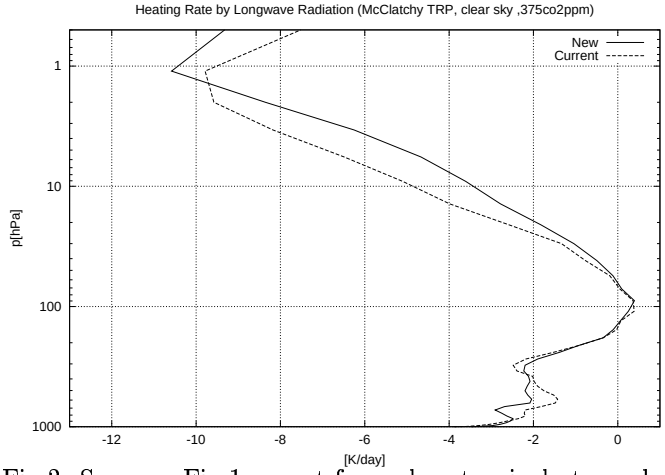


Fig.2: Same as Fig.1 except for a clear tropical atmosphere

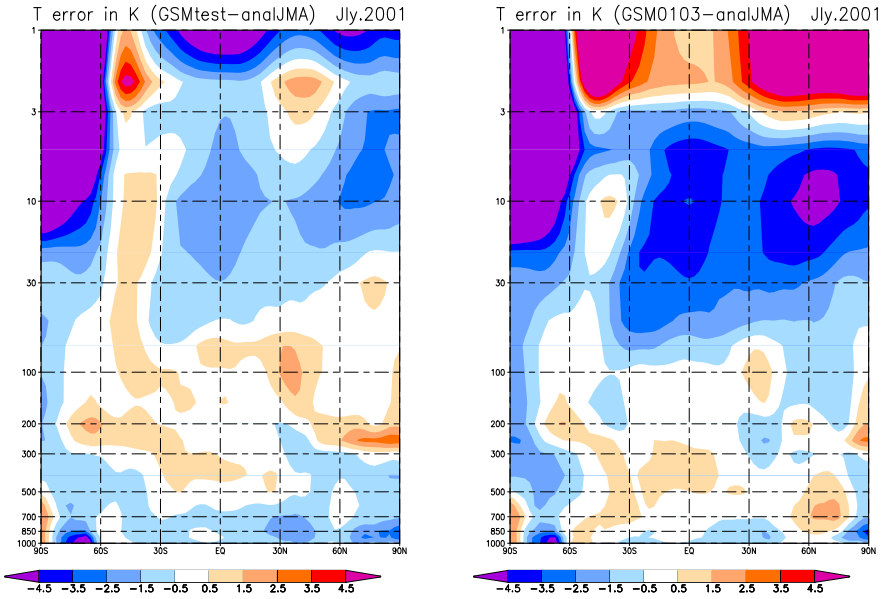


Fig.3: The one-month mean forecast error of zonal-mean temperature in July 2001. The current JMA-GSM0103(right) and the revised version using the new parameterization(left).