7B.5 A TWO-COLUMN MODEL USING THE WEAK TEMPERATURE GRADIENT APPROXIMATION

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Abstract

We extend the single column model with fixed atmospheric temperature of Sobel and Bretherton (2000) into a two-column, nonrotating radiative-convective model which uses the Weak Temperature Gradient (WTG) approximation to determine the flow field. The free-tropospheric temperature profiles of the two columns are assumed identical and steady, and the temperature equation under the WTG approximation is used diagnostically to calculate the vertical velocities. These vertical velocities and the continuity equation are then used to calculate the horizontal velocities. No horizontal momentum equation is used. The mean free-tropospheric temperature profile is determined implicitly by the requirement that the mass budget of the model be closed.

This model is compared to the two-column model of Nilsson and Emanuel (1999) which uses a linear, nonrotating horizontal momentum equation and the same underlying radiative-convective code as the WTG model. The Nilsson-Emanuel model is modified, for the comparison, by replacing the uniform vertical viscosity coefficient with a variable coefficient that is maximum in the boundary layer and decreases to zero in the free troposphere. Simulations are performed with fixed sea surface temperature (SST) for a range of SSTs. The comparison of the two models provides a direct test of the WTG approximation in a context with complete vertical structure and some important interactive physical processes, although the horizontal structure is severely truncated. The vertical velocity and precipitation fields simulated in the two models are very similar, as long as the SSTs in the two columns differ by about 2C or more. For smaller SST differences, technical difficulties related to the implicit determination of the temperature cause significant errors in the shapes of the WTG vertical velocity profiles, though the temperature and precipitation fields are reasonably well simulated even in these cases. The mean temperature profile in the WTG model has an offset relative to the Nilsson-Emanuel model for given SST but its dependence on SST is otherwise similar.

The agreement between the two models improves as horizontal domain size increases. This is due to the viscosity's being restricted to the PBL, and is in contrast to related calculations published elsewhere in which the viscosity is uniform throughout the troposphere.

A complete manuscript (Shaevitz and Sobel 2002) is on the web, see below.

References

Nilsson, J. and K. A. Emanuel, 1999: Equilibrium atmospheres of a two-column radiative convective model. *Q. J. R. Meteor. Soc.*, **125**, 2239-2264.

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Sobel, A. H., and C. S. Bretherton, 2000: Modeling tropical precipitation in a single column. *J. Climate*, **13**, 4378-4392.

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