Application of RRTM longwave radiation to NCEP GFS

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The longwave (LW) radiative transfer parameterization used in the current NCEP operational Global Forecast System (GFS) atmospheric model was developed at the Geophysical Fluid Dynamics Laboratory (GFDL) (Schwarzkopf and Fels, 1991). Recently, a Rapid Radiative Transfer Model for longwave radiation (RRTM) has been developed at Atmospheric and Environmental Research, Inc. (AER) (Mlawer et al. 1997). The radiative transfer calculation in RRTM is highly accurate with very high computational efficiency, especially in a large model with high vertical resolution. In a 64-layer model test, the RRTM runs in about one half the time as the operational code does. In addition to the major atmospheric absorbing gases included in the operational LW scheme, such as carbon dioxide, water vapor, and ozone, the RRTM also contains numerous minor species such as nitrous oxide, methane, and up to four types of halocarbons. In water vapor continuum absorption calculations, the operational model uses coefficients derived by Roberts et al. (1976), while RRTM uses a more advanced CKD_2.4 model (Clough et al. 1992).

Comparisons of clear-sky cooling rates between the two parameterizations for typical atmospheric profiles show that, in general, differences between the two radiation schemes are relatively small, except in the upper stratosphere, where RRTM produces more cooling effect than the operational LW model. Since December 24, 2002 we have been running a parallel T254-L64 GFS experiment with RRTM. Figure 1 shows comparison of 500 mb geopotential height anomaly correlation scores of 5-day model forecasts between operational model (PP1) and the parallel model (PP2). Zonally averaged 5-day forecast temperature biases (not shown) indicate that RRTM improves tropospheric temperature bias while enhancing the cold bias in the stratosphere. Two five-year climate runs on a T62-L64 model were also conducted for the two LW radiation schemes. Table 1 shows outgoing LW radiation at the top of the model atmosphere (TOA) for the two LW radiation parameterizations and the five-year climatological average from ERBE observations. It shows that the RRTM produces a closer agreement between simulations and observations than the operational model. Comparison of OLR fluxes at the TOA among the two radiation parameterizations and ERBE observation for a five-year average over the months of July and January (not shown) shows that RRTM improves OLR distribution over tropical and summer mid-latitude regions.

Table 1. Five-year averaged monthly OLR (W/m**2) comparisons among the operational LW scheme, the RRTM, and the observations from ERBE data.

Month	Operational-LW	RRTM-LW	ERBE
JAN	241.06	235.90	232.48
APR	242.64	237.45	234.47
JUL	247.89	242.96	239.40
OCT	241.06	235.90	235.30

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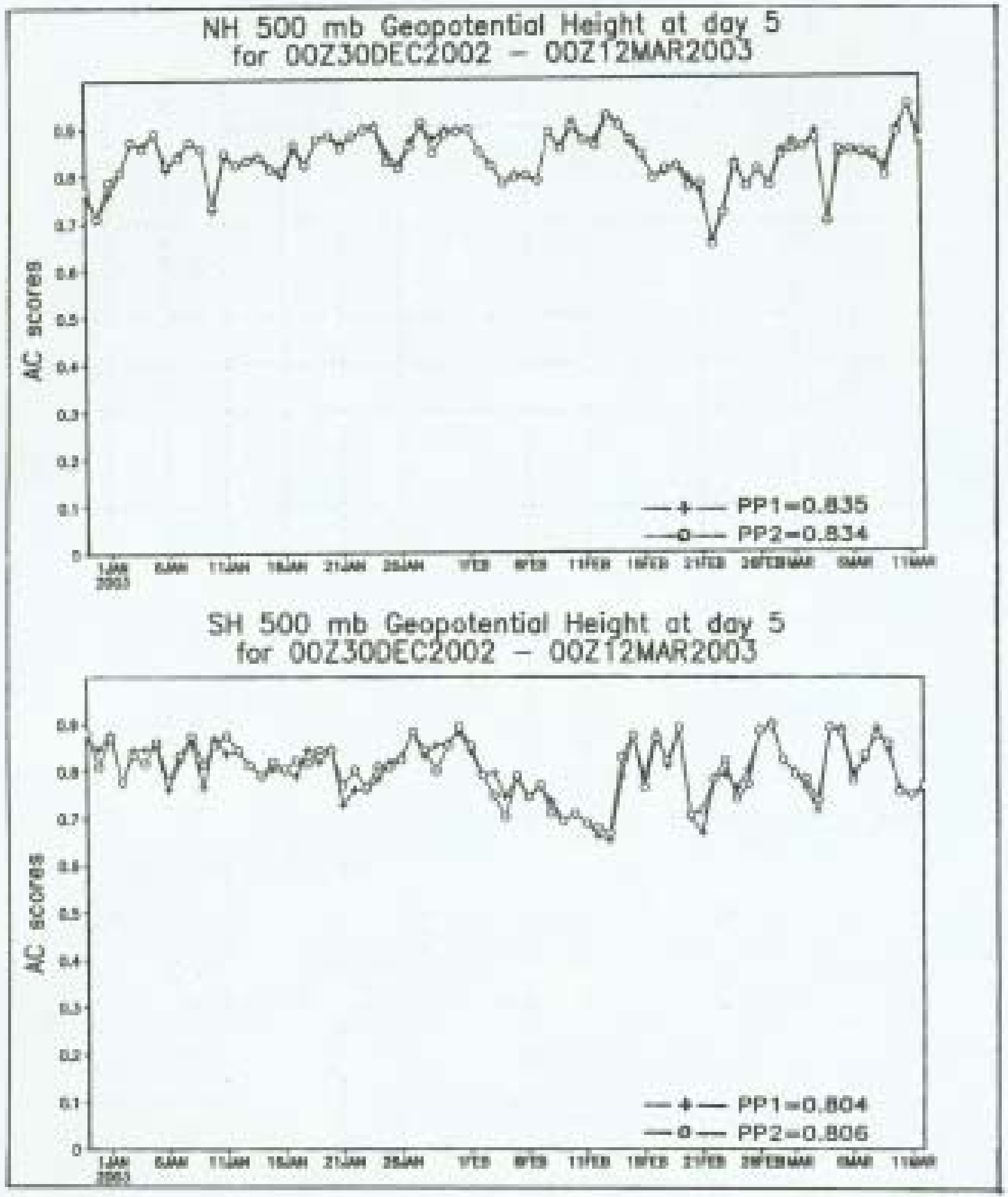

Figure 1. 500-mb geopotential height anomaly correlation scores of 5-day model forecasts. The upper panel is for northern hemisphere and the lower for southern hemisphere.

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