A New Ice Fall Speed Considering Rimming and its Test in GFDL AM3

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In mixed-phase clouds, riming changes ice particle properties, such as density, shapes, and fall speed. Using the liquid water content (LWC), ice water content (IWC), and radial velocity prepared by Mace et al. (2006) based on long term ARM in situ and remote sensing data, a new ice fall speed formula has been derived and tested in GFDL AM3.

\[ R_i = \frac{LWC}{IWC + 3.29 IWC^{0.57} V_R - 19.3 IWC^{0.77}} \]

\[ V_R = V_R \times IWC \times (1 - R) + V_i \times IWC \times R \]

Figure 1: (a) Comparison of derived ice fall speed using Hansell and Donner (1998) formula with observed radial velocity; (b) Same as (a), but for the new fall speed considering the rimming effect; (c) Same as (a), but for a more general parameterization as indicated in Fig. 2 and Fig. 3.

Implementation

![Implementation Diagram]

Figure 2: Implementation of the generalized formulas used in the new scheme.

![Graph]

Figure 3: (a) Coefficients of A-D relationship of the new scheme vary with T and R. (b) Changes found (black) to 1 (violet). (d) Same as (a), but for the M-D. (c) Same as (d), but for V_R. (d) Same as (c), but for V_R. (e) Change from (c), (black) to 50°C (violet). (f) Same as (e), but for V_R. (g) Change from (d), (black) to 50°C (violet). (h) Same as (g), but for V_R.

Figure 4: 1st row: Annual mean (2003-2007) NWC observed by CloudSat at 225 km and the errors using v=2.5 m/s. 2nd row: GCM annual mean LWC at 225 km and the errors using v=2.5 m/s. 3rd row: Same as 2nd row, but for the run using v=1.0 m/s. 4th row: Same as 3rd row, but for the run using v=2.5 m/s.

Figure 5: Annual mean precipitation difference between 5-year AM2 climatological SST simulation and 20-year GCIP precipitation for 1st run (left) and 2nd run (middle). (right).

Figure 6: Relative ice cloud occurrence (time contour) obtained by T. (upper panel) and IWC (lower panel) and mean fall speed (color shading) for the ocean at 50°S processed by Dong and Mace (2009). (d) Same as (a), but for the AM3 R run (c) AM3 v=2.5 m/s. (d) AM3 v=1.0 m/s.

Figure 7: PDF distribution of observed and modeled ice fall speed (upper panel) and IWC (middle and lower panels) at 50°S for v=1.0 m/s (left) and v=2.5 m/s (right).

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References: