Improvements in super-cooled liquid water simulations of low-level mixed-phase clouds over the Southern Ocean using a single-column box model

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A high-resolution global atmospheric model, NICAM (Nonhydrostatic ICosahedral Atmospheric Model), exhibited underestimation biases in low-level mixed-phase clouds in the midlatitudes and polar regions. Ice-cloud microphysics used in a single-moment bulk cloud microphysics scheme (NSW6) was evaluated and improved using a singlecolumn box model by reference to a double-moment bulk cloud microphysics scheme (NDW6). Budget analysis indicated that excessive action of the Bergeron-Findeisen and riming processes crucially reduced supercooled liquid water. In addition, the rapid production of rain directly reduced cloud water and indirectly reduced cloud water through the production of snow and graupel by riming. These biases in growth rates were found to originate from the number concentration diagnosis used in NSW6. The diagnosis based on the midlatitude cloud systems assumption was completely different from the one for low-level mixed-phase clouds. To alleviate underestimation biases, rain production, heterogeneous ice nucleation, vapor deposition by snow and graupel, and riming processes were revised. Either change in cloud microphysics alleviated the underestimation biases without parameter tuning. Finally, the lifetime of cloud layers
simulated by NSW6 was reasonably prolonged.

Keywords: supercooled liquid water, mixed-phase clouds, cloud microphysics

