Improvement of cloud fraction scheme via radiative budget analysis
R.-S. Park
Korea Institute of Atmospheric Prediction Systems (KIAPS)

Introduction

- Diagnosing the downward solar radiation at the surface could be the first step to analyze an accuracy of a global forecasting model in a physical aspect because it is the main and only source of energy generating physical phenomena.
- Recently, the underestimation of downward solar radiation flux at the surface was reported in our global forecasting model and this can be a starting point to improve our global forecasting model.
- In this study, the underestimation of downward solar radiation at the surface was analyzed in several aspects of physical processes. Based on this analysis, the shallow convective scheme and prognostic cloud fraction scheme were modified in order to reduce its bias.

Diagnostics of radiative budget

- The reduction of downward solar radiation with the update of physics packages

Describing cloud fraction schemes

- Diagnostic cloud fraction scheme
  \[ CF = \alpha_{cq} \cdot \rho \]  (based on Guiterre and Issac (2007))
- Prognostic cloud fraction scheme
  \[ q_{cld} = q_{cld}^{IV} + 9q_{cld}^{VC} + 9q_{cld}^{V} + 9q_{cld}^{DIC} \]  (Park et al., 2016)

Diagnosing clouds

- Inconsistency of cloud fractions simulated by diagnostic and prognostic cloud fraction schemes (DIAGC and PROGC) at the high altitude and the Arctic regions

Cloud water vs cloud fraction

- Cloud formation analysis via selections of cloud fraction schemes and radiative budget

Budget analysis of low level clouds via prognostic cloud fraction scheme

- Overestimated cloud fractions over Arctic regions and at high altitudes are due to the cloud formation in supersaturated clouds. \[ \rho_{cld} - \rho_{cld}^{sat} \]

Results and Discussion

- Applying an weighting factor with hydrometers when \( q_{2+q} \cdot 3 \times 2e^{-4} \text{ kg/kg} \) in supersaturated cloud
  \[ \alpha_{cld} = 1 - \alpha_{cld}^{sat} - \rho_{cld}^{sat} - \rho_{cld}^{sat} \]
  \( \alpha_{cld} \): cloud formation by condensation
  \( q_{2+q} \): cloud liquid water (kg/kg)
  \( q_{cld} \): cloud ice water (kg/kg)

Modification of cloud fraction schemes in supersaturated clouds

- Global mean of downward solar radiation at the surface 178(CERES), 169(PROGC), and 175(PROGC-mod) W/m²

Summary and Conclusion

- Downward solar radiation in different physics packages were diagnosed and its reduction was perceived.
- Overestimated cloud fractions were issued as a main reason for the underestimated downward solar radiation at the surface.
- Based on the diagnostics, the formation process of clouds by condensation in supersaturated clouds were modified.
- Via the modification, the downward solar radiation budget was improved.