Improvement of cloud fraction scheme via radiative budget analysis

R.-S. Park

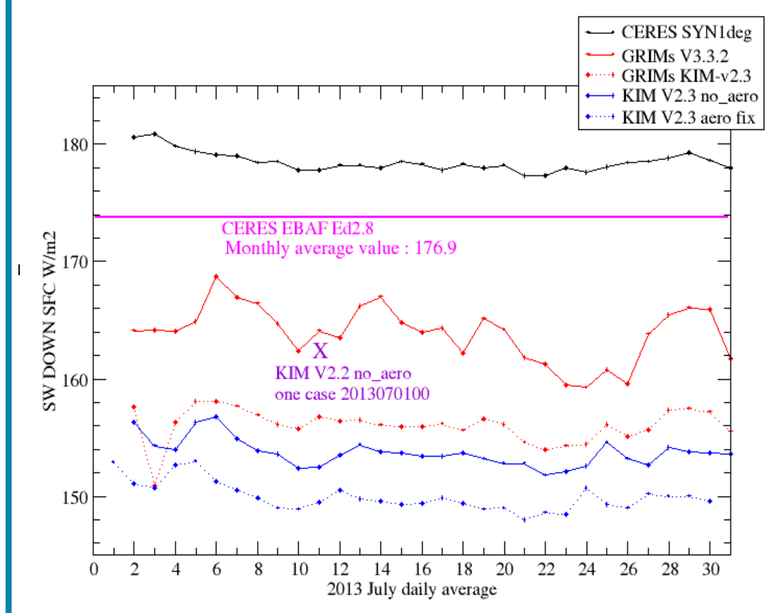
Korea Institute of Atmospheric Prediction Systems (KIAPS)

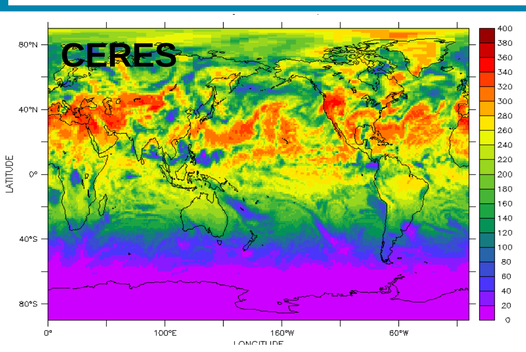
Introduction

- 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 flux 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.

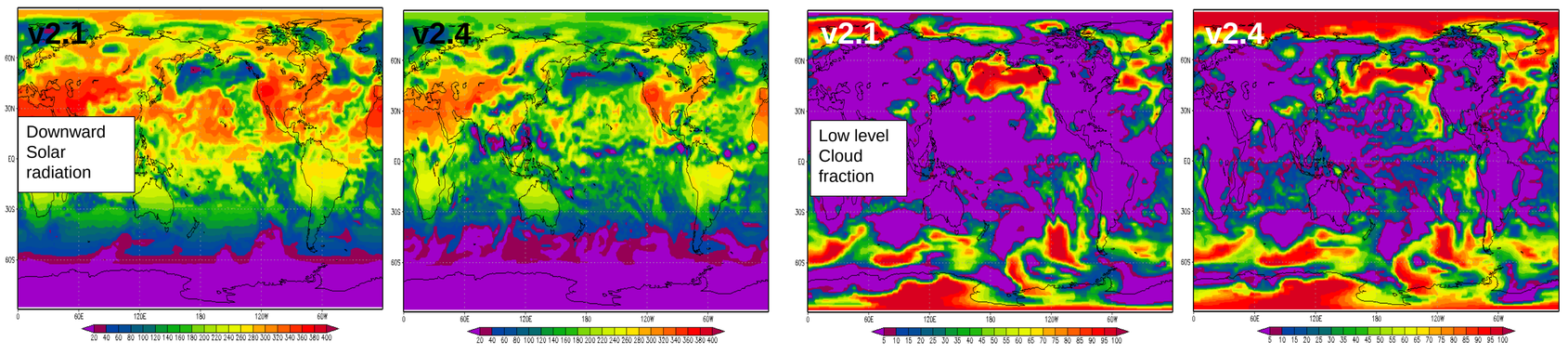
Diagnostics of radiative budget

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





- The increase of low level cloud fraction with the update of physics packages
- High correlation between changes of cloud fraction and downward solar radiation
- Purpose: Modifications of prognostic cloud fraction scheme to improve the downward solar radiative fluxes based on the above diagnostics of solar radiation and physics schemes



Results and Discussion

Describing cloud fraction schemes

- Diagnostic cloud fraction scheme

$CF = \alpha(q_c)^{\beta}$: based on Gultepe and Issac (2007)

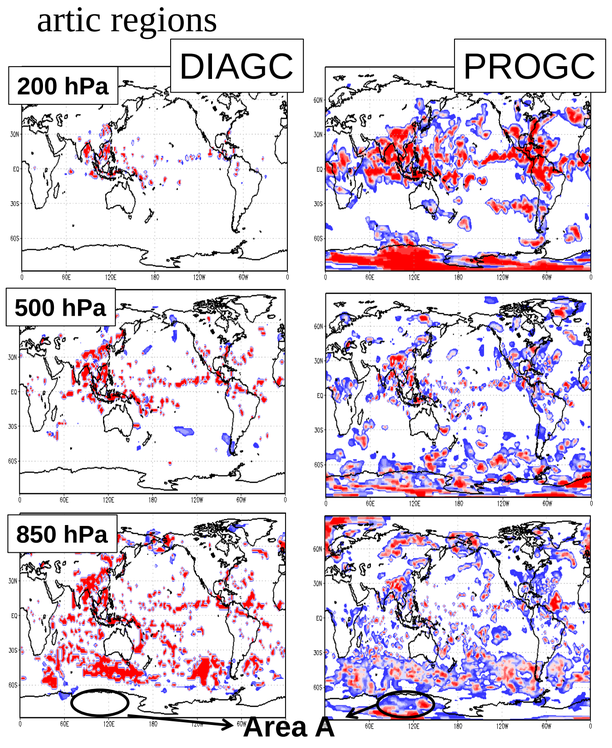
- Prognostic cloud fraction scheme

$$\frac{\partial C}{\partial t} = A(C) + S(C)_{cv} + S(C)_{BL} + S(C)_{C} - D(C)$$

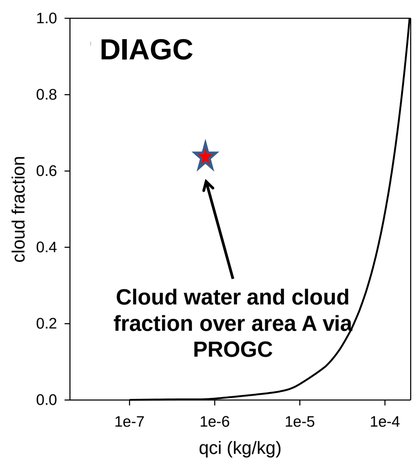
(Park et al., 2016)

Diagnosing cloud fractions

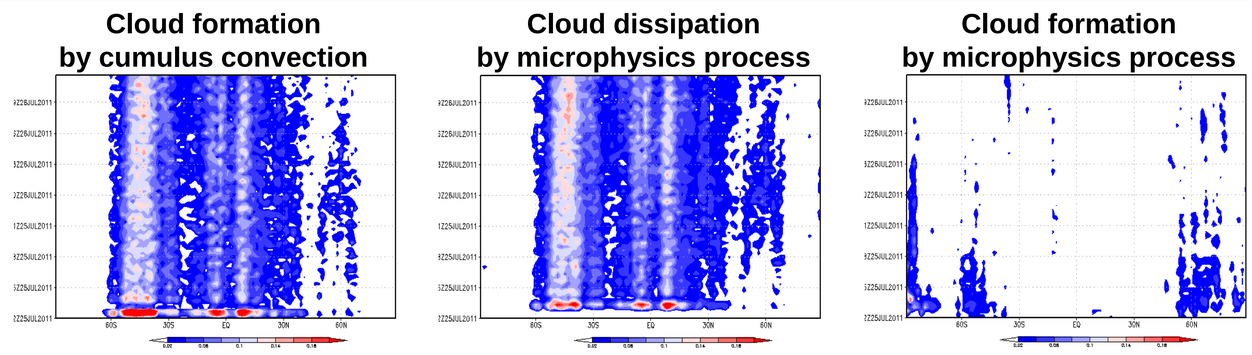
- Inconsistency of cloud fractions simulated by diagnostic and prognostic cloud fraction schemes (DIAGC and PROGC) at the high altitude and the artic regions



Cloud water vs cloud fraction



Budget analysis of low level clouds via prognostic cloud fraction scheme



- Overestimated cloud fractions over artic regions and at high altitudes are due to the cloud formation in supersaturated clouds. $cld_{st}(t) = \{1 - cld(t-1)\}$

In a condition of "saturated water vapor < water vapor (at T)"

Modification of cloud fraction scheme in supersaturated clouds

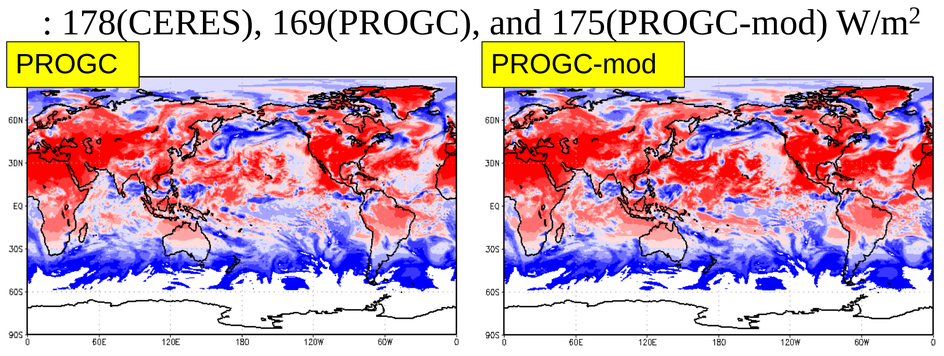
- Applying an weighting factor with hydrometeors when q2+q3 < 2.e-4 kg/kg in supersaturated cloud

$$cld_{st}(t) = 1 - cld(t-1) \Rightarrow cld_{st}(t) = \{1 - cld(t-1)\}\frac{q2+q3}{2.e^{-4}}$$

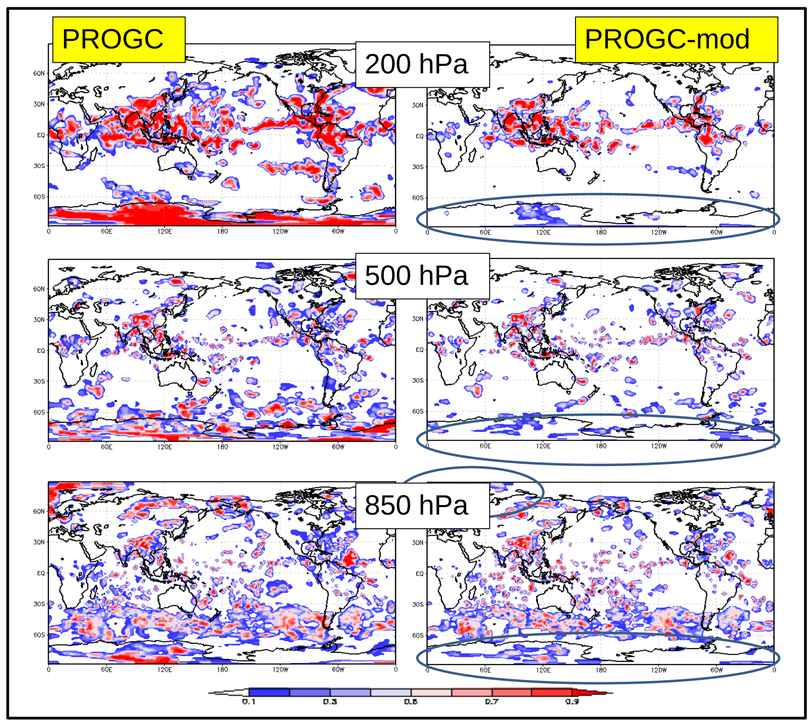
cld_{st}: cloud formation by condensation
q2: cloud liquid water (kg/kg) / q3: cloud ice water (kg/kg)

Improvement of downward solar radiation budget

- Global mean of downward solar radiation at the surface : 178(CERES), 169(PROGC), and 175(PROGC-mod) W/m^2



Improvement of cloud fractions



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.

2017 KIAPS International Symposium will be held during Oct. 2017 at the Seoul, Korea.
- Web: http://www.kiaps.org
- Email: rs.park@kiaps.org