A process oriented evaluation of clouds simulated by the LMDZ5 GCM using A-train high spatial resolution observations (CALIPSO-PARASOL-CERES)

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Abstract

The representation of clouds in climate models is largely driven by model parameterizations. This study focuses on the ability of the LMDZ5 GCM version 5.0 to simulate climatology and the climate response of the tropical cloud system, using the A-train constellation of instruments. We evaluate the climatology of the tropical cloud system in LMDZ5A and LMDZ5B, with and without the new boundary layer and low level cloud scheme. LMDZ5B simulates a new boundary layer and low level cloud scheme, improving boundary layer clouds. This study of instantaneous cloud properties at high spatial and temporal resolution enables to evaluate the ability of models to reproduce the instantaneous relation between cloud properties and to constrain cloud description at the process scale in climate models.

Keywords

LMDZ5; tropical boundary layer; low level clouds; A-train observations; CALIPSO, PARASOL, CERES

Evaluation of Cloud Properties using Monthly Mean Statistics

Classical study of cloud properties using monthly mean climatologies

First conclusions:
1. Error compensation between the monthly mean vertically integrated values of cloud cover and cloud optical depth
2. The horizontal extent of high level clouds are mostly determined by the model, not by radiative processes or cloud feedbacks.
3. LMDZ5B leads to significant improvements compared to LMDZ5A, but still underestimates cloud fraction.

Can we use the A-train to learn more about clouds in climate models?

How do Cloud Fraction and Cloud Reflectance vary instantaneously?

The added value of evaluating the model using instantaneous cloud properties

Instantaneous and Monthly Correlation between Cloud Fraction and Cloud Optical Depth

The relationship between Cloud Fraction and Cloud Optical Depth is significantly dependent on the spatial-temporal resolution of observations.

- Monthly correlation CF - CRef: High correlation but the cloud optical depth increases with cloud fraction.
- Instantaneous correlation CF - CRef: High correlation and the cloud optical depth decreases with cloud fraction.

Evaluation of Tropical Clouds using Instantaneous Clouds Properties

Instantaneous Relation between Cloud Vertical Distribution and Cloud Optical Depth

Evaluation of Monthly Mean Zonal Cloud Properties

Evaluation of Monthly Mean Cloud Properties in the tropical oceans in circulation regimes

Evaluation of Monthly Mean Cloud Vertical Distribution in the tropical oceans in circulation regimes

Conclusions

A high spatial resolution allows high resolution of cloud properties containing information at the cloud scale. It shows how the cloud properties (cloud cover, cloud optical depth and cloud vertical distribution) vary over time scales and over climatic regimes in the tropical oceans.

- Monthly correlation: the cloud optical depth increases as the cloud fraction increases.
- The correlation between the cloud optical depth and cloud fraction is high but decreases over time scales and over climatic regimes.
- The model evaluated here finds difficulties in reproducing instantaneous cloud properties.
- A high cloud optical depth decreases when the cloud extends horizontally. This is underemphasized in the observations.
- The model simulates the cloud optical depth increases with cloud fraction.

Focus on tropical boundary layer clouds

Cloud Optical Depth and Cloud Top Altitude

- Model bias: High optical thin clouds, low optical thick clouds are not well simulated.

Cloud Optical Depth increases with cloud thickness.

Cloud Fraction

- Model needs more liquid water to assimilate thin clouds.

- Model needs higher cloud water content and cloud optical depth.

References
