Diagnosis of stratocumulus and deep convective clouds simulated by the NCEP/GFS using satellite and ground-based measurements

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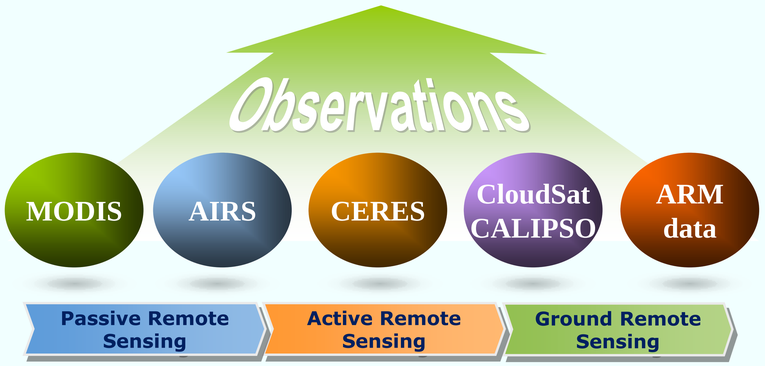
Introduction

❖ **Cloud properties, cloud vertical structure, and deep convective clouds are important for meteorological studies due to their impact on both the Earth's radiation budget and adiabatic heating.**

❖ **The objectives of this study are to diagnose the performance of NCEP Global Forecast System (GFS) model cloud simulations and to identify possible causes of the discrepancies in cloud fields and to examine individual factors that affect the development of deep convective clouds using different types of observational datasets.**

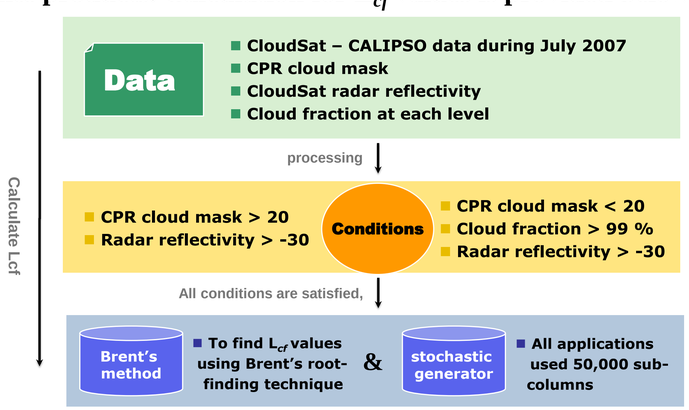
Data & Methodology

Evaluation of GFS clouds



➢ **We test an alternative cloud parameterization scheme (Slingo 1987 and Gordon 1992; SG scheme) that requires inputs of atmospheric dynamic and thermodynamic variables.**

➢ **We evaluate the impact of cloud overlapping on cloud fraction by applying a linear combination of maximum and random overlapping assumptions with a de-correlation length (L_{cf}) determined from satellite products. Calculation for L_{cf} values is provided below.**



Results

a) Low cloud fraction

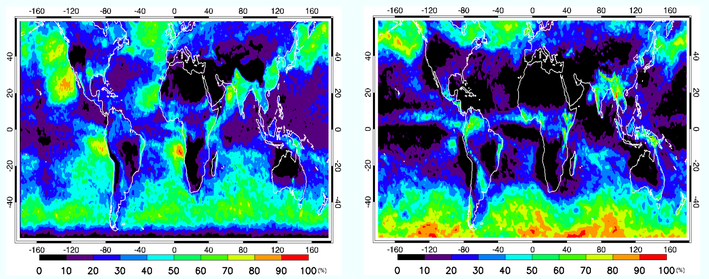


Fig. 1. Low cloud fractions from the CL algorithm (left) and the GFS model (right) in July 2008.

b) Comparison with SGP data

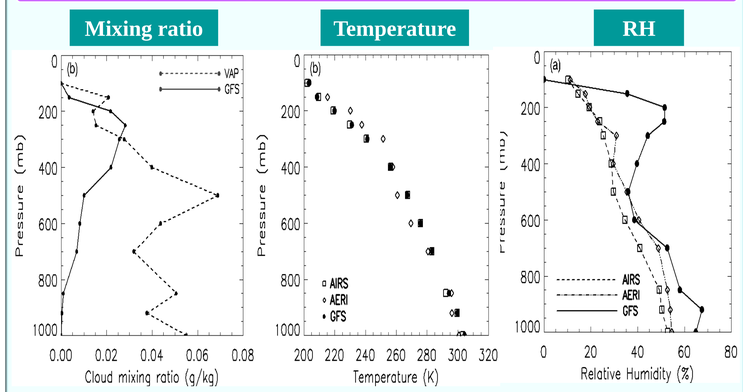


Fig. 2. Cloud water mixing ratio from ARM/VAP and the GFS model (left); Comparisons of temperature (middle) and relative humidity (right) values in July 2008 from AIRS, AERI, and GFS.

c) Comparison of cloud fraction

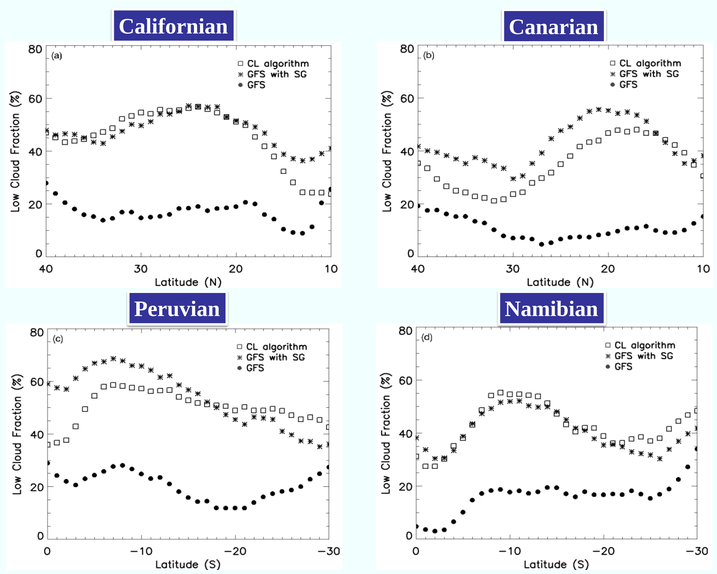


Fig. 3. Latitudinal variations of zonal-mean low cloud fractions from the CL algorithm, the GFS model using the SG scheme, and the GFS model in its original form. Californian (10° - 40°N, 160° - 110°W), Peruvian (0° - 30°S, 110° - 75°W), Namibian (0° - 30°S, 30°W - 10°E), and Canarian (10° - 40°N, 60° - 20°W).

d) L_{cf} and cloud fractions with L_{cf}

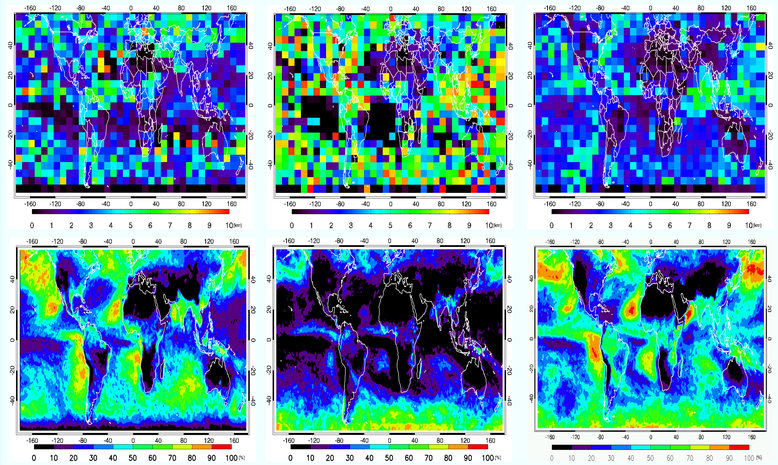


Fig. 4 Upper panels: geographic distributions of median values of L_{cf} for high clouds (left), mid clouds (middle), low clouds (right) using a stochastic cloud generator and the C-C data collected in July 2007. Lower panel: Comparison of cloud fractions derived from the CL algorithm using MODIS data (left), the GFS cloud fraction with L_{cf} based on observations (middle) and the GFS model with SG scheme (right) for low clouds in July 2007.

e) Deep convective clouds (DCC)

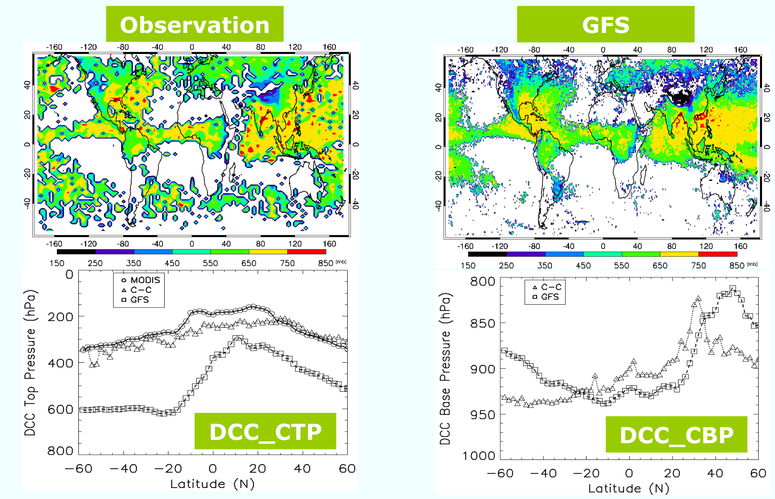


Fig. 5. Comparisons of DCC cloud depth from CloudSat -CALIPSO data (upper left) and the GFS model (upper right) and latitudinal variations of zonal-mean cloud top pressure from MODIS, CloudSat -CALIPSO data, the GFS model (bottom left) and cloud base pressure from CloudSat -CALIPSO data,and the GFS model (bottom right) during June-July-August 2007.

Summary

➢ **Low clouds simulated by the GFS bear similar gross pattern but large discrepancies for marine stratocumulus clouds over the eastern tropical oceans. Underestimation of cloud mixing ratio is the main cause of the bias.**

➢ **Application of the SG scheme to the GFS model results in more marine stratocumulus clouds and low-level clouds. Use of de-correlation length from satellite observations help improve the agreement in total column cloud amounts.**

➢ **For DCCs, the GFS model produces sound gross spatial patterns, but there tends to be weak convection strength for deep convection in the model simulations.**

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