Evaluating the Newly Implemented NCEP Cloud/Radiative Parameterizations with CERES

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Introduction

The recent release of NASA CERES data provides a timely opportunity for validating the newly implemented cloud/radiation physics in the NCEP operational global forecast system. NCEP replaced the original diagnostic cloud parameterization with a prognostic cloud condensate formulation in the May 2001. Radiative transfer calculations now incorporate optical thickness from the predicted cloud condensate path. Radiative fluxes from CERES measurements and cloud properties, such as ice/liquid water path are now can be utilized for comparison with model outputs. Estimated surface fluxes from CERES observations are also relevant for evaluating NCEP surface fluxes.

Operational Algorithms

The major implementations for NCEP Global Spectral Model (GSM) on May 15, 2001 includes:

* Prognostic cloud condensate (liquid/ice)

* Cloud optical properties in radiation calculated from cloud liquid/ice path

* Convective detainment is a source of cloud condensate.

* Cumulus cloud produces momentum mixing.

* Cumulus cloud top randomly chosen from a range of values bounded by the sounding profile.

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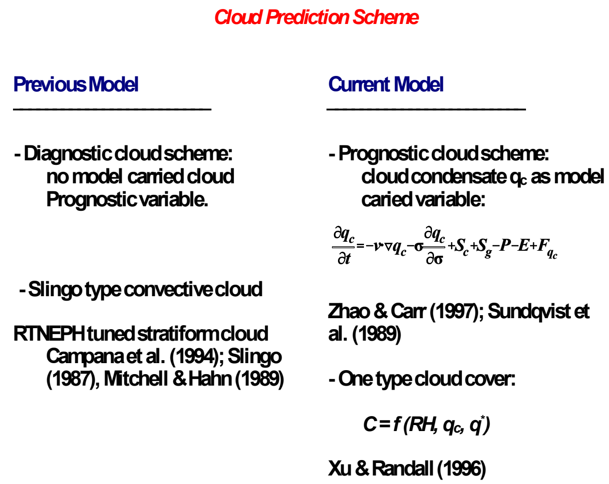


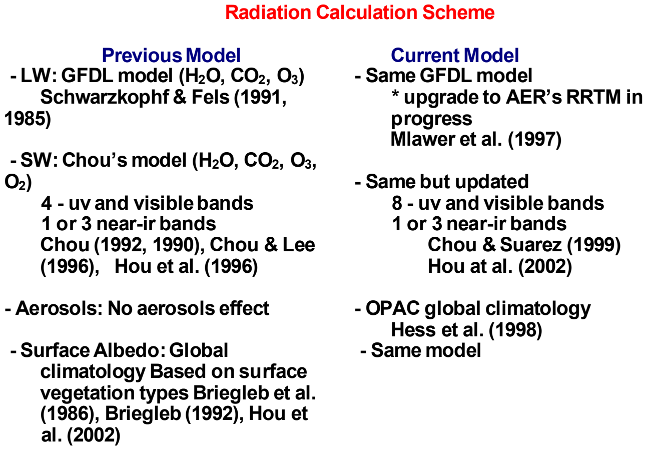
Cloud Prediction Scheme

Previous Model	**Current Model**
- Diagnostic cloud scheme: no model carried cloud Prognostic variable.	- Prognostic cloud scheme: cloud condensate q_c as model caried variable: $\frac{\partial q_c}{\partial t} = -v \cdot \nabla q_c - \sigma \frac{\partial q_c}{\partial \sigma} + S_c + S_g - P - E + F_{q_c}$
- Slingo type convective cloud	Zhao & Carr (1997); Sundqvist et al. (1989)
RTNEPH tuned stratiform cloud Campana et al. (1994); Slingo (1987), Mitchell & Hahn (1989)	- One type cloud cover: $C = f(RH, q_c, q^*)$ Xu & Randall (1996)

Table 1

Table 1 outlines the differences between the previous and current cloud schemes

Table 2 outlines the differences between the previous and current radiation schemes.



Radiation Calculation Scheme

Previous Model	**Current Model**
- LW: GFDL model (H_2O, CO_2, O_3) Schwarzkophf & Fels (1991, 1985)	- Same GFDL model * upgrade to AER's RRTM in progress Mlawer et al. (1997)
- SW: Chou's model (H_2O, CO_2, O_3, O_2) 4 - uv and visible bands 1 or 3 near-ir bands Chou (1992, 1990), Chou & Lee (1996), Hou et al. (1996)	- Same but updated 8 - uv and visible bands 1 or 3 near-ir bands Chou & Suarez (1999) Hou at al. (2002)
- Aerosols: No aerosols effect	- OPAC global climatology Hess et al. (1998)
- Surface Albedo: Global climatology Based on surface vegetation types Briegleb et al. (1986), Briegleb (1992), Hou et al. (2002)	- Same model

Table 2

Results

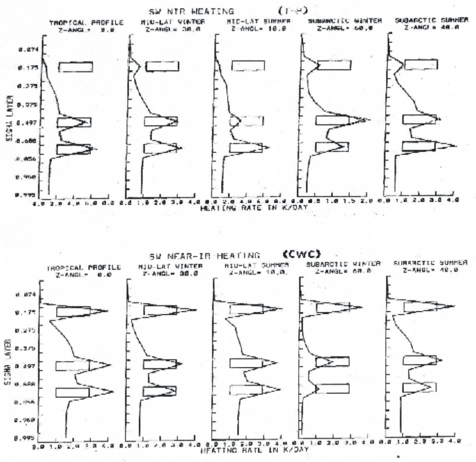


Fig. 1

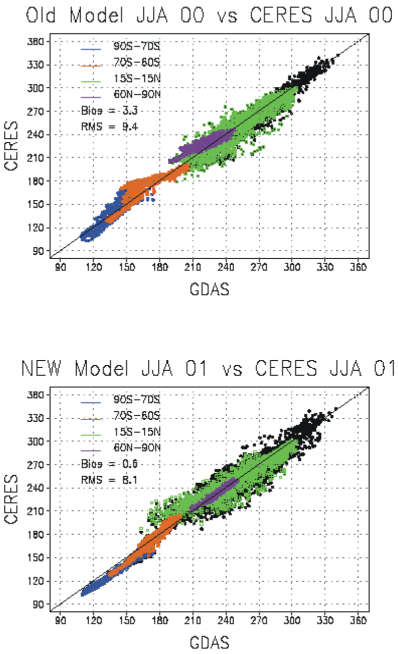


Fig. 2

The new algorithm has substantially reduced the warm bias of the temperature near surface, and the cold bias in the stratosphere. Fig. 1, shows the five heating profiles using the McClatchey atmosphere. The upper panels are from the previous algorithm, the lower panels are from the current algorithm. The rectangular boxes represents the cloud decks. It is apparent that the new algorithm performs much realistic heating profiles, in particular associated with the clouds.

Fig. 2 shows the comparison with NASA CERES ERBE-like OLR for the seasonal mean of June through August. The scatter plots compare the previous algorithm (upper panel for the year of 2000) and the new algorithm with the (lower panel for the year of 2001), in W/M2. OLR is modulated by clouds. Using the previous diagnostic cloud algorithm, a number of empirical coefficients are used for various latitudinal zones. It is apparent from the upper panel scatter plot

that the each coefficient is only effective within a small region, as one can tell that the slopes of each region deviates significantly from the unity. However, the new algorithm shows a clear coherence for all the latitudes except the high clouds in the tropical regions. The erroneous regional stratification in the mid-high latitudes are virtually eliminated. T he improvement also manifested in the global mean bias, which bias was reduced from 3..4 W/M^2 to 2.1 W/M^2, a reduction of ~ 40%.

Fig3. Shows the TOA agreement of reflected solar radiation between GSM and CERES for the monthly mean of June 2001. As OLR, the result shows a general agreement with the minor bias of 1.5 W/M**2. The result is a significantly

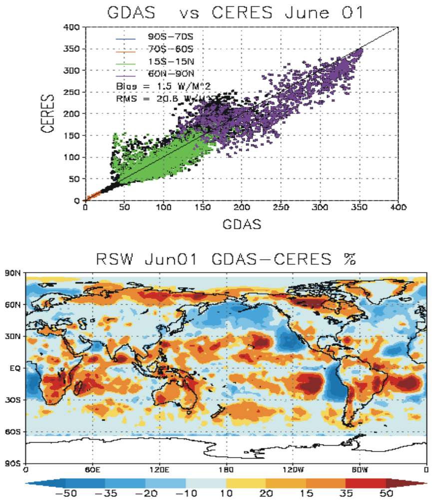


Fig. 3

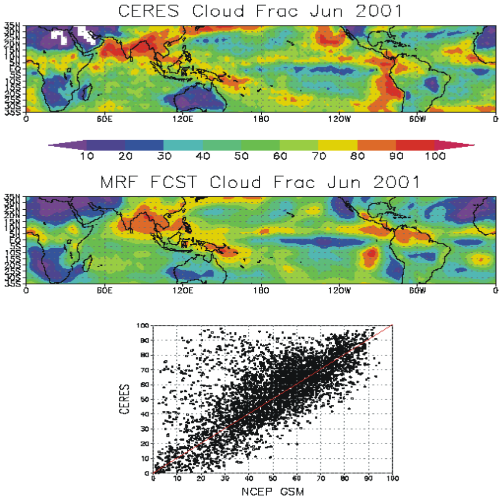


Fig. 4

improvement over the the previous model, such as used for NCEP/NCAR Reanalysis, in such case, the global mean bias is more than 30 W/m**2.

Still the regional difference can be large, in particular in the regions of marine stratus off the west coast of continents, where, in general the model underestimates for more than 20%. In contrast, over some land area, such as Australia, south Africa and eastern South America, the model overestimates significantly.

Fig. 4 shows the comparison of cloud fraction. The top panel is from CERES/Terra using VIRS on TRMM. The mid panel is from 6-hour model forecasts using the new algorithm, and the scatter plot is on the bottom panel. Since using TRMM VIRS, this comparison is limited to the tropics, which cloud variability is the largest. Still, GSM cloudiness correlated well with CERES, which is evident from the geographical distributions. It also appears, from the scatter plot, that the model underestimates in many regions. As discussed in the TOA reflected shortwave radiation, GSM underestimates at the regions of marine stratus clouds.

Similarly, the agreement on the surface fluxes are also improved substantially**.** Not shown, but compared are the surface downward longwave radiation between GSM and the climatology derived from NASA Langley Research Center surface radiation budget data set for the month of June. We see a fair well agreement both on geographical distributions and scatter plots. Larger differences occurs in the western Pacific, may caused by cloud heights.

Summary

In summary, the new implementation on NCEP GSM model physics in cloud and radiation parameterizations leads to improvement on model tropical storm forecasts, tropical circulation forecasts, and hemisphere circulation forecasts (more in summer than winter). Also improved are overall model radiative fluxes: at TOA, model fluxes, which are within or close to the uncertainties of the observations; at SFC, model fluxes are close to the uncertainties of the retrieval algorithms (but regional differences still large). Other improvement includes overall model cloud distributions as compared to RTNEPH and CERES data. Further improvement of tropical cloud prediction and cloud radiative properties, , however, requires more model cloud/radiation diagnostic parameters for comparison to the ever-increasing amount of observations.

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