

Modeling the Diurnal Change of Cloud Cover Using Multiple Global Models and ISCCP/TRMM Data Sets

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Clouds are important components of radiation budget of the earth. Precipitation and cloudiness show highest amplitude of variation at time period of one day. In this study it is shown that 1 to 5 day forecasting of the diurnal cycle of clouds can be greatly improved using a multimodel superensemble (SE) (Krishnamurti et al. 1999). Further, a unified cloud parameterization scheme (Unf) is developed based on the idea of SE. This scheme, when implemented in the Florida State University (FSU) global spectral model (GSM) improves the diurnal cycle of clouds and radiation budget of the earth to a large extent. All the results are verified against the International Satellite Cloud Climatology Project (ISCCP) DX1 infrared (Schiffer and Rossow 1983) and Clouds and the Earth's Radiant Energy System (CERES) data sets.

Four versions of the FSU atmospheric GSM were used with four different cloud parameterization schemes at T126L28 resolution ($\sim 0.94^\circ$ and 28 vertical sigma layers). 5-day long forecasts were made starting at 12 GMT of 1 January 2000 to 31 March 2000. Superensemble forecasts from these models were created for the last 10 days using training statistics of the first 81 days. The Unf used the statistics of the 4 versions of the models from 1 January 2000 to 28 February 2000. The model forecasts with this new scheme were made for 1 to 31 March 2000.

The total diurnal cycle of low, middle and high clouds over the entire tropical ($0-360^\circ\text{E}$, $30^\circ\text{S}-30^\circ\text{N}$) land and ocean is shown in Fig 1 for day-4 of forecasts. Low clouds over the tropics show a peak at 12 hours local time over land and at 09 hours local time over ocean. Most of the member models have great difficulty in predicting the phase and amplitude of low clouds both over land and ocean. The Unf and the SE greatly improved the error of the diurnal cycle of low clouds over land and ocean.

Middle clouds show a peak at 03 hours over land and at 00 hours over ocean. Only one member model is able to show this phase and amplitude of middle clouds somewhat correctly (Fig 1c, d). The RMS error of the total diurnal cycle was reduced by 3 to 5 times with the use of the Unf and the SE.

High clouds show peak at 21 hours over land and at 15 hours over ocean (Fig 1e, f). All the models and their ensemble mean (EM) were unable to forecast the phase and amplitude of high clouds. The phase error of the models were large over ocean as compared to over land. The skills of the Unf and the SE were much higher compared to all the member models and their EM.

Phase and relative amplitude of high clouds from ISCCP, EM, Unf and SE over the Amazon region is shown in Fig 2 for day-4 of forecasts in vector representation. It can be noticed that both the phase and amplitude of the diurnal cycle were improved using the Unf and the SE. The domain average absolute phase error for the EM is 2.9 hours, and that for the Unf and SE are 1.8 and 2.0 hours respectively.

These results show that SE can improve the diurnal cycle of cloud covers to a great

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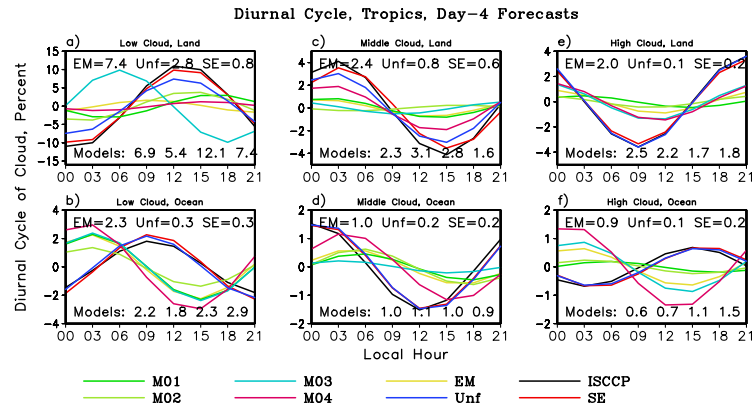


Figure 1: Diurnal cycle of low, middle and high cloud cover over the Tropics (0° – 360° E, 30° S– 30° N) from ISCCP and day-4 forecasts from the member models, ensemble mean (EM), unified scheme (Unified) and the superensemble (SE) during 22–31 March 2000. RMS error (in percent) of the total diurnal cycle for EM, Unified and SE are indicated at the top of the panels, and those for the member models are shown at the bottom of the panels.

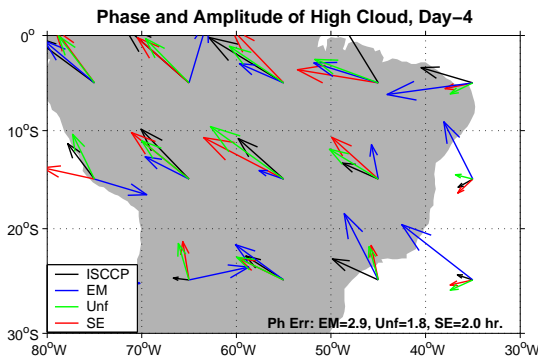


Figure 2: Phase and amplitude of the diurnal cycle of high cloud cover over the Amazon region from ISCCP and day-4 forecasts from the ensemble mean (EM), unified scheme (Unf) and the superensemble (SE) during 22–31 March 2000. A northward arrow represents a phase at 00 hours and eastward arrow represents a phase at 09 hours.

extent. The newly developed unified cloud scheme also shows much higher skill in predicting the phase and amplitude of diurnal cycle of clouds. This scheme should be tested in real time numerical weather prediction models.

References

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