Evaluation of the Performance of the Physics Routines in an Operational Prediction Model

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Introduction

A number of high-resolution forecast models are currently being used to make routine forecasts of cloud properties and the surface radiation budget over the Atmospheric Radiation Measurement (ARM) Southern Great Plains (SGP) site. Such model output has the potential to aid our study of the climate in this region. However, the accuracy of these predictions remains to be ascertained. In this study, Eta model predictions of radiation properties are evaluated by comparison with data measured at the ARM SGP site.

The Eta Model

The Eta forecast model is run operationally twice a day at the National Centers for Environmental Prediction (NCEP). Model output from January to June of 1997 was analyzed. During that time, the model's horizontal domain covered most of North America with a grid spacing of 48 km. There were 38 vertical levels defined in pressure coordinates from the surface to about 22 km. The model had a time step of 2 min. and was run to provide hourly forecasts for a 48-hour period. An explicit cloud prediction scheme and a radiation package were included in the model. Changes and corrections to the model are made approximately annually, so the precise version described here is no longer operational. The most recent update to the Eta model occurred in February 1998.

Method

Downward solar flux, downward infrared (IR) flux, surface temperature, and water vapor path values predicted by the Eta model were compared to measurements from the ARM SGP site (Table 1). For the ARM measurements, data were used from the central Cloud and Radiation Testbed (CART) facility in Lamont, Oklahoma, located at (36.62°N, 97.50°W). Data for the Eta model grid points nearest Lamont were used for comparison. This grid point fell at (36.70°N, 97.55°W), or approximately 12 km northwest of the ARM facility.

Continuous time series for each variable were created from the Eta output by splicing together predictions for hours 6 through 17 from each forecast and filling in any remaining gaps using data for other forecast times. Time series of ARM data were made by calculating hourly averages of the measured quantities. Hours for which the measurements were missing or known to be unreliable were eliminated from both the ARM and Eta time series. The data sets were converted to series of daily mean values and 30-day running means. For solar fluxes, only daylight hours were included in the calculation of daily and 30-day running means. Data for complete 24-hour days were used to compute the means of other variables.

Table 1. Statistics for daily-averaged values

	Mean	Std. Dev.	No. Pts.	Corr. Coeff.
Eta Downward Solar Flux[(a)] (Wm^{-2})	435.8	121.9	170	
ARM Downward Solar Flux[(a)] (Wm^{-2})	336.0	147.4	170	0.9766
Eta Downward IR Flux (Wm^{-2})	296.2	54.6	171	
ARM Downward IR Flux (Wm^{-2})	314.1	49.6	171	0.9986
Eta Surface Temperature (°C)	10.5	9.8	170	
ARM Surface Temperature (°C)	11.0	8.9	170	0.9915
Eta Water Vapor Path (cm)	1.45	0.77	101	
ARM Water Vapor Path (cm)	1.69	0.91	101	0.9968
(a) Only daylight hours were included in solar daily averages.				

Results

The total downward solar fluxes predicted by the Eta model and measured at the ARM site are shown in Figure 1. A steady positive bias of about 100 Wm^{-2} is apparent in the predicted values. The effect of clouds is evident in the high frequency oscillations.

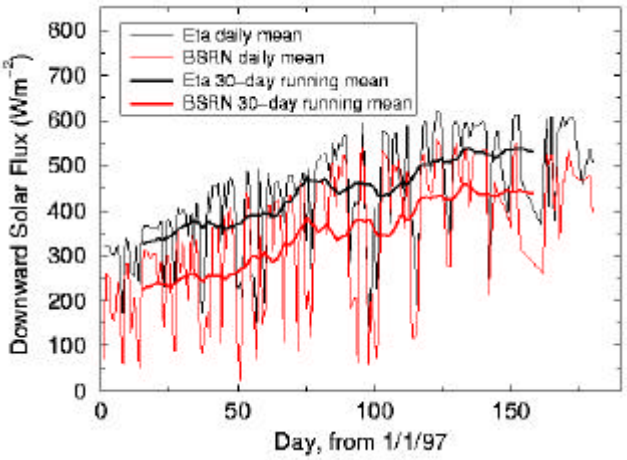

Figure 1. Comparison of total downward solar flux predicted by the Eta model and measured by the baseline surface radiation network Eppley precision spectral pyranometer. (For a color version of this figure, please see *http://www.arm.gov/docs/documents/technical/conf_9803/hinkelman-98.pdf*.)

The predicted and measured total downward infrared fluxes are presented in Figure 2. Although the predicted values appear to track the measurements well, the 30-day running means reveal a negative bias of about 20 Wm^{-2} in the Eta predictions.

Despite the excess solar radiation in the Eta model, the predicted and measured surface (2 m) temperatures, shown in Figure 3, were found to agree well except for a slight negative (positive) bias in winter (summer) for the Eta model.

Figure 4 shows a comparison of predicted and measured column water vapor. Predicted data are negatively biased by about 0.2 cm. This could explain part of the deficiency in downward IR flux predicted by the Eta model.

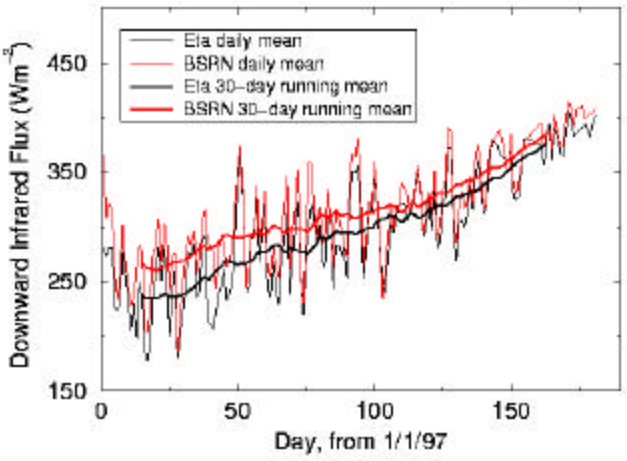

Figure 2. Comparison of total downward infrared flux predicted by the Eta model and measured by the baseline surface radiation network infrared pyrgeometer. (For a color version of this figure, please see *http://www.arm.gov/docs/documents/technical/conf_9803/hinkelman-98.pdf*.)

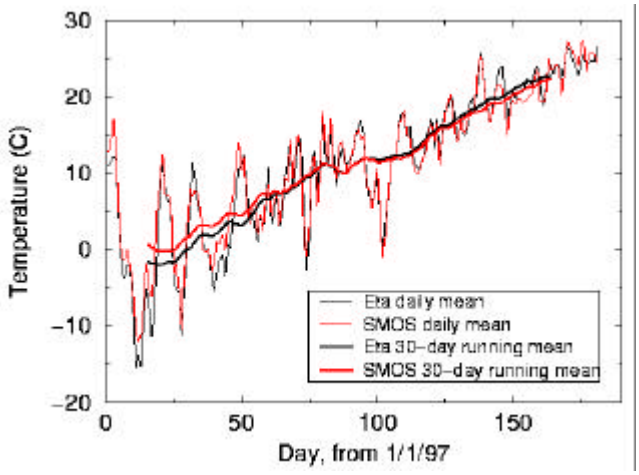

Figure 3. Comparison of (2 m) surface temperature predicted by the Eta model and measured by the surface meteorological observing system. (For a color version of this figure, please see *http://www.arm.gov/docs/documents/technical/conf_9803/hinkelman-98.pdf*.)

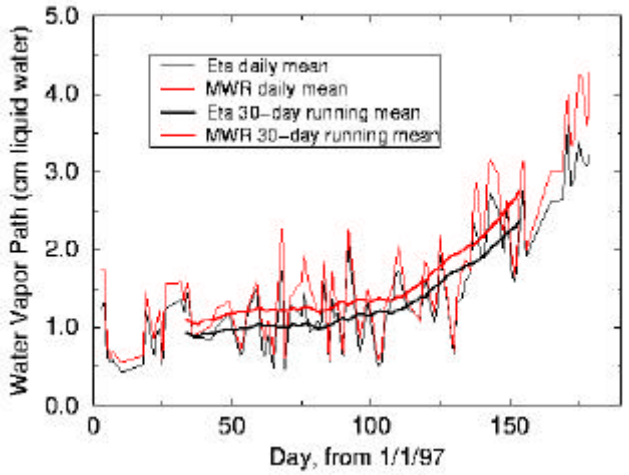

Figure 4. Comparison of column water vapor predicted by the Eta model and measured by the microwave radiometer. (For a color version of this figure, please see *http://www.arm.gov/docs/documents/technical/conf_9803/hinkelman-98.pdf*.)

Conclusion

Eta downwelling solar radiation has a large positive bias. Eta downwelling IR radiation has a small negative bias. Some of the error in the predicted IR downward flux may be explained by underprediction of the total column water vapor by the model. Despite the discrepancies in predicted radiative fluxes, the predicted surface temperatures appear largely correct.

Future Plans

The accuracy of cloud prediction by the Eta model, in terms of both the presence, height, and amount of clouds, will be investigated next. In addition to yielding information on the performance of the model's cloud prediction routine, this should provide insight into the source of the radiation budget errors. The radiative transfer algorithms in the Eta model will be examined in order to determine why the high solar flux seems not to affect other model parameters. The latent and sensible heat fluxes calculated by the Eta model will also be examined.