A51E-0734 The Accuracy of Solar Irradiance Calculations Used in Medium Range Forecast Models

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1. Introduction

Recent research has shown that radiative transfer parameterization errors can have an adverse effect on mesoscale numerical weather forecasts of the atmospheric boundary layer (ABL) wind, temperature, and mixing depth. (Zamora et al., 2003). Typically, mesoscale model forecasts of wind, temperature, and mixed layer depth are used by air quality specialists to forecast chemical concentrations of atmospheric pollutants.

During the New England Air Quality Study 2002 (NEAQS 2002) The National Oceanic and Atmospheric Administration Environmental Technology Laboratory (NOAA/ETL) made detailed observations of the solar and infrared radiative fluxes at the Thompson Farm, air chemistry site located near Durham, NH. In this poster we compare the observed solar irradiance for a five day high ozone event beginning at 0000 UTC, August 11, 2002 with real-time forecast values from the NOAA Forecast Systems Laboratory (FSL) coupled weather-chemistry forecast model and the National Centers for Environmental Prediction (NCEP) Eta model.

2. Numerical Models

The coupled chemistry model was run twice daily using 27 km grid spacing. The Dudhia cloud radiation parameterization was used along with the Burk-Thompson 1.5 order ABL scheme. Radiation was calculated at 30 minute intervals. The Grell convective parameterization was used along with the Reisner 1 mixed cloud physics package. In this poster we compare the Thompson Farm solar irradiance observations with output from the 24-h simulations initialized at 0000 UTC for both the MM5 and the NCEP 12-km Eta forecasts.

3. Results

The Thompson Farm observations and the MM5 forecast values for August 11-15, 2002 are shown in Figure 1. The observations indicate that clear sky conditions prevailed over most of the period. Cloud cover was observed late in the afternoon of 13 August and at midday on 15 August. We also note that the peak solar irradiance values observed each day decreased as the event progressed.

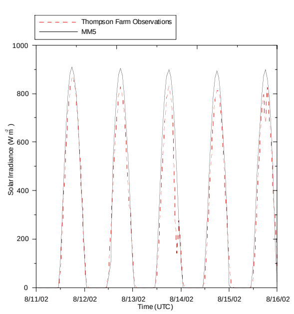

Figure 1. Solar Radiative Flux observed at Thompson Farm and MM5 Forecast values, for August 11-15, 2002.

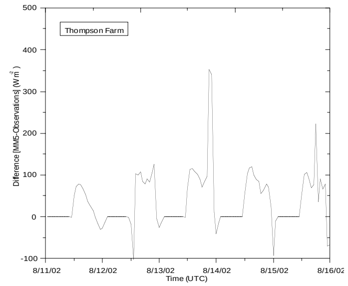

Figure 2. Difference [MM5 – Observations] for Thompson Farm, August 11-15, 2002.

The differences between the observations and the MM5 forecast irradiances (Fig. 2) average ~100-110 $W\ m^{-2}$ on all days of the event. The largest discrepancies are found when clouds were not produced in the MM5 forecast. Similar differences between MM5 and the observations were found during the Nashville Southern Oxidant Studies (SOS99). The differences between MM5 and the observations near sunset and sunrise are in part caused by calculating the solar irradiance at 30 minute intervals in the model cycle.

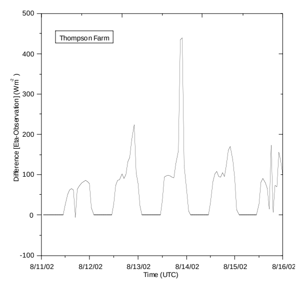

Figure 3. Difference [Eta – Observations] for Thompson Farm, August 11-15, 2002.

During the clear sky periods the Eta forecast irradiances are also greater than those observed at Thompson Farm (Fig. 3). The magnitude is slightly smaller than the difference between the MM5 values and the observations. The differences between the Eta forecast values and the observations are ~90-100 $W\ m^{-2}$. Both the Eta and MM5 models estimated the solar irradiance using the method described by Lacis and Hanson (1974). Both models produced similar results in the clear sky cases suggesting that a crucial attenuation process has not been represented in the solar irradiance parameterization.

The evaluation of the Lacis and Hanson solar radiation parameterization for the Nashville SOS99 air quality events found that the parameterization performed poorly when the observed aerosol optical depths (AOD) exceeded 0.1. Numerous studies have shown that during the summer months both the Southern states and the East Coast of the U.S are frequently impacted by industrial pollution plumes that contain large amounts of sulfate and organic aerosols.

At the Thompson Farm site we measured AOD at 412, 500, 675, and 862 nm using a sun photometer. The combination of the AOD measurements and the solar irradiance observations allowed us to quantify the impact of aerosol optical depths exceeding 0.1 on the quality of Lacis and Hanson based solar irradiance estimates.

Figure 4 shows that the AOD at 500 nm exceeded 0.1 on all days of the event. The highest AOD occurred on 14 August coinciding with the peak surface ozone measured at the Thompson Farm site.

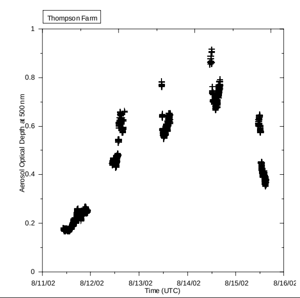

Figure 4. Aerosol optical depths at 500 nm observed at Thompson Farm 11-16 August 2002.

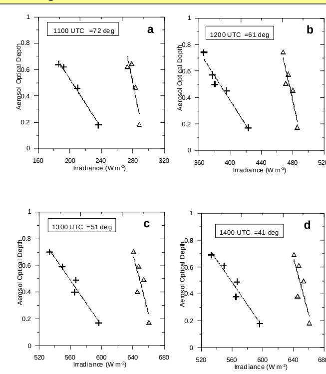

Figure 5. Correlation between AODs and the observed (crosses) and the Eta modeled (triangles) irradiances for zenith angles of 71,61,51, and 41 degrees at Thompson Farm for 11-16 August 2002.

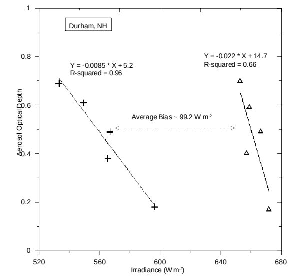

Figure 6. Correlation between AODs and the observed (crosses) and MM5 modeled (triangles) irradiances for 41 degree zenith angles at Thompson Farm for 11-16 August 2002.

Figures 5 and 6 show that the decrease in the incoming observed solar irradiance can be correlated with the increase in the AOD. In contrast the Eta and MM5 forecast irradiances show little or no correlation with the increase in AOD. The correlation between the observed irradiance and AOD suggest that for each 0.1 increase in AOD the solar irradiance decreases by ~ 12 $W\ m^{-2}$.

• Concluding Remarks

These results suggest that solar irradiance estimated using the Lacis and Hanson parameterization can contain significant uncertainty when the AODs exceed 0.1. The errors in the incoming solar irradiance can impact the performance of the numerical model by changing the models surface energy balance. Typically, models respond by increasing the amount of turbulent mixing in the planetary boundary layer leading to an over-prediction of mixed layer depth. Photolysis calculations in air quality models can also be compromised by errors in the incoming solar irradiance.

Our study suggests that a more comprehensive method of estimating solar irradiance in both MM5 and the NCEP Eta model is needed when the air mass over the region of interest contains significant aerosol loading. Recently, NCEP began testing a version of the Chou (1992) solar irradiance scheme in the Eta model. We are currently evaluating the performance of the method using data gathered this past summer by ETL at Concord, NH.

5. References

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Lacis, A. A. and J. E. Hansen, 1974: A parameterization for the absorption of solar radiation in the Earth's atmosphere. *J. Atmos. Sci*., 33, 3077-3107.

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