# Comparisons of USDA UV-MFRSR UV irradiance measurements with TOMS satellite retrievals and DISORT under various cloud and aerosol conditions


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## Program Objectives

The USDA UVB Radiation Monitoring Program is a program of the US Department of Agriculture's Cooperative State Research, Education and Extension Service (CSREES). The program was initiated in 1992, through a grant to Colorado State University, to provide information on the geographical distribution and temporal trends of UVB (ultraviolet -B) radiation in the United States. This information is critical to the assessment of the potential impacts of increasing ultraviolet radiation levels on agricultural crops and forests. Specifically the monitoring program:

·Provides information to the agricultural community and others about the climatological and geographical distribution of UVB irradiance;

·Furnishes the basic information necessary to support evaluations of the potential damage effects of UVB to agricultural crops and forests;

·Supplies ground truth for satellite measurements and basic information or radiation transfer model calculations.

## The Climatological Network

The climatology network of the USDA UV-B Monitoring Program is designed to provide an adequate density of measurement sites to establish the spatial and temporal characteristics of UVB irradiance. The network follows a grid-based design which divides the country into 26 regions of approximately equal-area. Sites are located primarily in rural areas, with particular consideration given to agricultural and forested regions. Initial site locations were also chosen to evaluate their suitability as research sites which will use high resolution spectroradiometers. All thirty sites have been instrumented with both broadband meters and shadowbanded multi-filter instruments and all sites follow a standardized measurement protocol. For more information about the climatological network please check http://uvb.nrel.colostate.edu.

## Research Activities

Focused towards challenging our current understanding of factors that control UV-B irradiance and towards improving the quality of UV-B monitoring instrumentation and data;
Focused towards understanding the response of plants and livestock to UV-B and other environmental stress factors like high temperature, drought, etc., and developing the genetic research to identify crop variants resistant to these stressors;
Provide key opportunities for collaborative research and provide calibration benchmarks for the USDA climatological network as well as other US Global Change agencies involved in UV-B research.

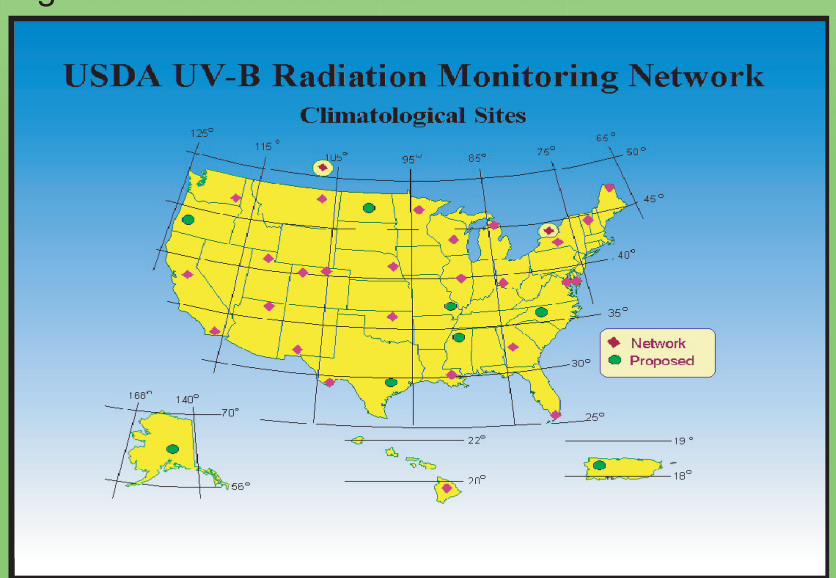


*Figure 1* **Typical climatological site**


## ABSTRACT

An array of widely spaced ground-based radiometers gives frequent, accurate point measurements of UV irradiances but lack the broad spatial coverage necessary for UV climatologies and precision of single-platform satellite retrievals from NASA TOMS (Herman et al.,1999). Comparison of irradiances from the two methods can increase the accuracy of the satellite UV retrievals, especially in the presence of absorbing aerosols and broken clouds. Irradiances under a wide variety of sky conditions from the 7 channel UV Multi-filter Rotating Shadowband Radiometer (UV-MFRSR) are compared with UV retrievals from TOMS as well as those using a radiative transfer model (DISORT). The UV-MFRSR makes direct-beam measurement which allow aerosol optical depth determination, in-situ-Langley calibration, and direct to diffuse ratios. The USDA UVB Monitoring Program operates 27 sites in the US and 2 in Canada with next-day download of total, direct, and diffuse irradiances at 300, 305, 311, 317, 325, 332, and 368 nm on TOMS global retrievals of column ozone, UV, and aerosol index.


## Methodology

We first looked for sites which had stable detectors as judged by a time series of the the Langley voltage intercepts (Bigelow and Slusser, 2000), shown in Figure 3. Oklahoma and New Mexico were chosen. A clear day was chosen based on a good Langley plot (Harrison and Michalsky, 1994). Irradiances for the 325 channel were computed every 5 degrees SZA using DISORT (Madronich, 1993; Stamnes et al., 1988) using the spectral response functions measured by the Central UV Calibration Facility (CUCF). Numerous repeat SRFs have been performed by the CUCF which demonstrate that the SRFs do not change (see Figure 2 for a typical repeat charaterization). The model was run with no aerosol and then using the measured aerosol optical depth assuming a single scattering albedo of 0.95. The ratio of model to measured total horizontal irradiances is shown in Figure 4 (NM) and Figure 5 (OK).

Next the USDA measurements at 325 nm were compared with TOMS retrioevals (Herman et al., 1999). USDA measurements made within one hour before and after the TOMS overpass were averaged to account for the pixel size (~50 km x 50 km) and the effect due to clouds. Figure 6 shows the ratio of TOMS retrievals to averaged USDA measurements for NM and Figure 7 shows the same for OK. The NM comparisons show some scatter but virtually no bias. The OK comparisons show a slight (~5%) bias high for the TOMS retrievals.

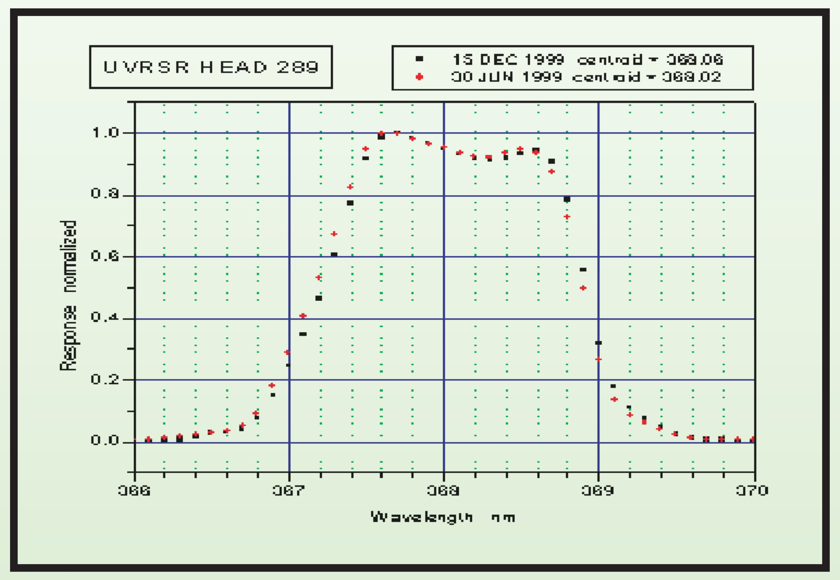


*Figure 2* **Repeat spectral response function by CUCF**

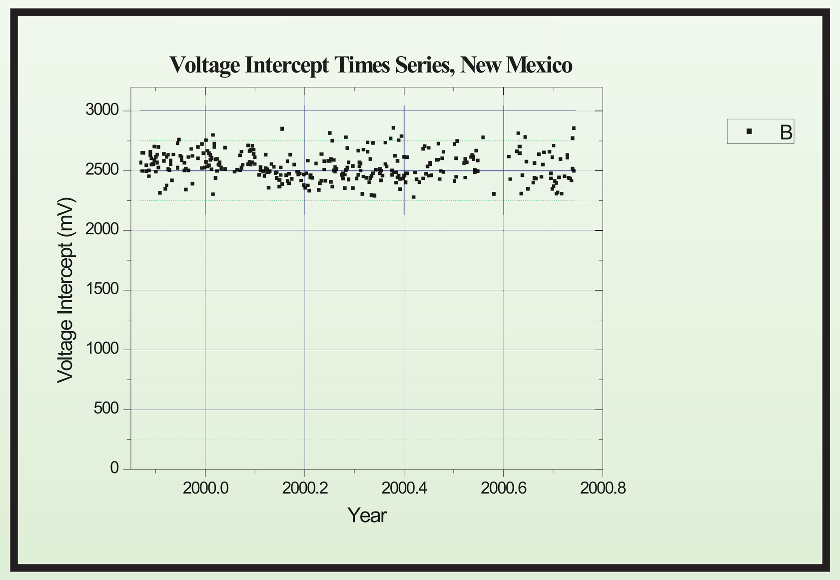


*Figure 3* **Langley time series for NM**

## Conclusions

By including aerosols in the RT model the measured clear sky irradiances agree to within 2% of the measured USDA irradiances over a large range of SZAs. TOMS UV retrievals agree well with measured USDA irradiances averaged +/- 1 hour from the TOMS overpass at NM, but overestimate the UV at OK. Since NM is generally less turbid than OK, it is likely that at least some of the TOMS overestimate is due to aerosols. The effect of broken clouds on TOMS UV retrievals is improved by time averaging ground-based radiometer data. More work is planned using 3 minute cloud optical depths to characterize the cloud field that TOMS "sees".


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## Acknowlegements

This study was supported by the USDA CSREES (Agreements 98-34263-6888 and 99-34263-8566), NASA (Contract number NCC5-288).


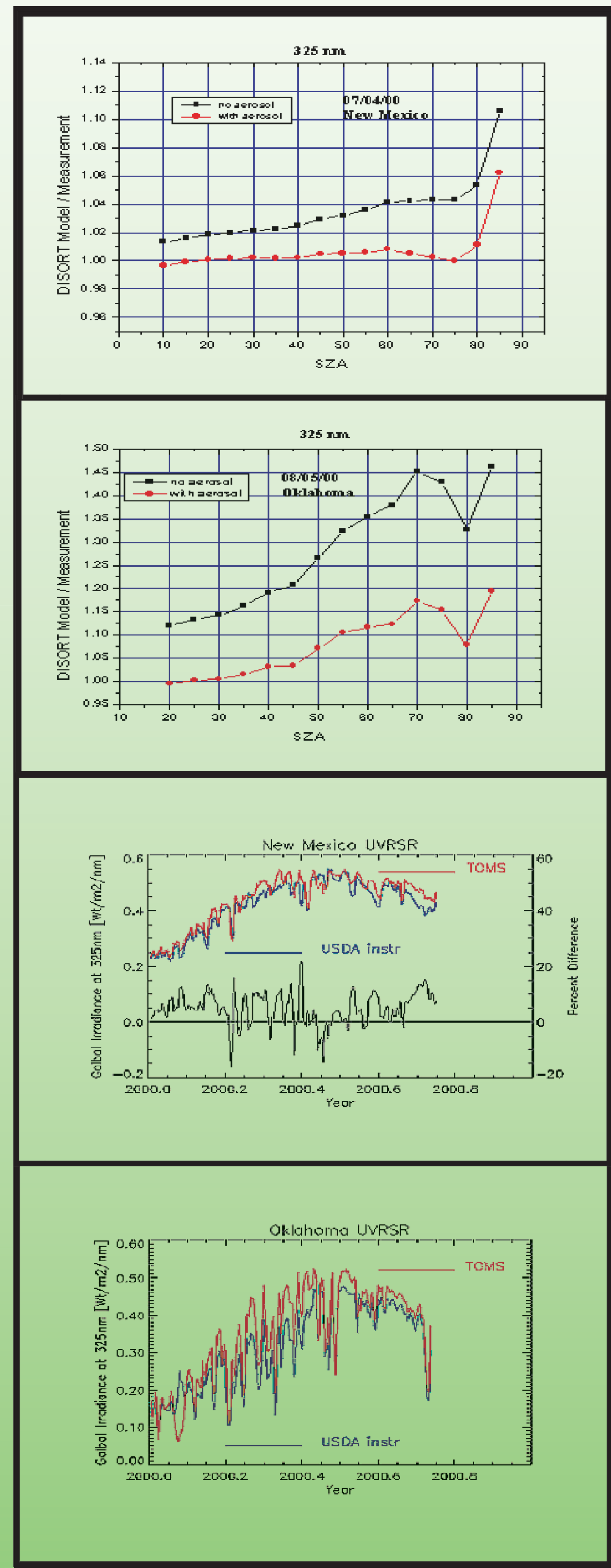


***Figure 4-7 from top to bottom***

4. Ratio of DISORT to measurements, NM
5. Ratio of DISORT to measurements, OK
6. Ratio of TOMS to measurements, NM
7. Ratio of TOMS to measurements, OK