# USDA UV-B Monitoring and Research Program

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## Abstract

This poster reports recent advances within the three main research areas of the USDA UV-B Monitoring and Research Program (UVMRP). For the monitoring network, we present a UV climatology study that explores long-term trends of erythemal irradiance at eight locations across the U.S. For the effects work, we show the interaction of UV-B radiation and nitrogen-deficiency on two sweetpotato cultivars. For the climate-crop model, we compare observed cotton yields in the U.S. with those simulated by the newly developed regional crop model.

## Introduction

After the discovery of the regularly occurring springtime Antarctic ozone 'hole' in 1985 and subsequently an intermittent minor Arctic 'hole' in 1990, the U.S. Department of Agriculture (USDA) became concerned that the decreasing stratospheric ozone over North America could potentially cause increases of crop- and biosphere-damaging levels of ultraviolet radiation. In January 1991 and March 1992 the USDA sponsored workshops to explore the need for a national UV monitoring network, since US weather stations do not collect UV irradiance. Later in 1992, the USDA initiated and funded the UV-B Monitoring and Research Program (UVMRP), headquartered at Colorado State University (CSU) in Fort Collins, Colorado, USA, to provide information on the geographical distribution and temporal trends of ultraviolet-B radiation throughout the United States.

Specifically the UVMRP:

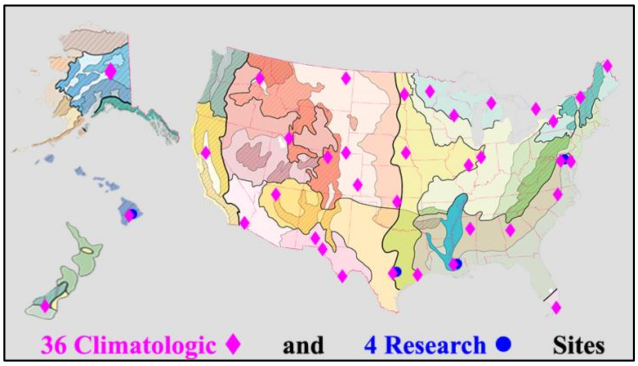
1. continuously collects ambient ground-level solar radiation data, including UV-B and PAR (photosynthetically active radiation) from 36 climatological and 4 long-term research sites distributed throughout agricultural regions, representative of many North American ecoregions;
2. provides this data and data products in near real time via its web page to the agricultural community and other users;
3. in collaboration with universities and researchers nationwide, conducts impact studies on the response of crops, forests, plants, ecosystems, humans, animals, and aquatic systems to UV-B radiation and other environmental stress factors;
4. collaborates on developing the Climate-Agroecosystem- UV Interactions and Economic (CAIE) system, a comprehensive climate-crop model that assists with predicting effects (such as biological and economic) of climate change on agriculture for the benefit of policymakers; and
5. maintains long-term records (21 years and growing) of UV-B irradiance necessary to assess patterns or trends.

## Monitoring Network - Instrumentation

Each of the 36 network sites shown on the map below has:

1. UV datalogger - samples every 20 seconds and stores a three-minute average for these four instruments:
2. UltraViolet Multi-Filter Rotating Shadowband Radiometer (UV-MFRSR) nominal 300, 305, 311, 317, 325, 332 and 368 nm at 2 nm FWHM (full-width half-maximum) of the total horizontal, direct normal, and diffuse horizontal irradiance,
3. PAR Quantum sensor (400 to 700 nm),
4. Barometer at 14 sites (per requests from researchers),
5. UV-A biometer at 7 sites for research with NASA.

1. VIS datalogger - samples every 15 seconds and stores a three-minute average for these four instruments:
2. Visible Multi-Filter Rotating Shadowband Radiometer (Vis-MFRSR) nominal SiC, 415, 500, 610, 665, 860 and 940 nm at 10 nm FWHM of the total horizontal, direct normal, and diffuse horizontal irradiance,
3. UVB-1 broadband radiometer (280 to 320 nm),
4. temperature and humidity probe,
5. downward-looking photometer for surface reflectance (presence/absence of snow).




## UV Climatology

Figure 1 (on next page) shows Average Daily Erythemal Dose in KJ/m$^2$ from 2001-2010 using measurements from UV-MFRSR. The individual 3-minute-average filter measurements are used in the UVMRP's Synthetic Spectrum Program, which integrates over the erythemal portion of the UV spectrum and weights the irradiances with the erythemal response function. Daily sums are accumulated and averaged over the year to obtain an average daily value for each of the years plotted.

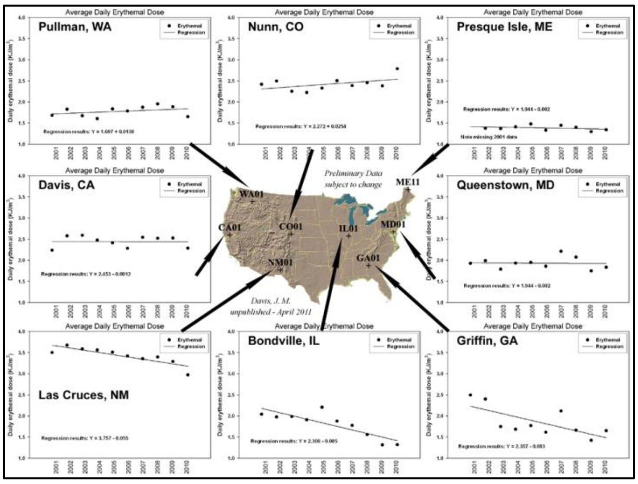



**Figure 1.** Average Daily Erythemal Dose in KJ/m$^2$ from 2001-2010 for eight sites of the UVMRP Network.

### Effects Studies

UVMRP works with researchers at Mississippi State University to evaluate both isolated and interactive effects of elevated UV-B and other environmental stress factors (such as water, temperature, and nutrients) on growth and development of economically important crops, such as cotton, corn, soybean, wheat, rice, and sweetpotato (Figure 2). Such research will help develop solutions that would enable producers to cope with these effects and ensure future crop quality and productivity. Results from these experiments are used to develop quantitative algorithms for the climate-crop simulation model of the integrated agricultural impact assessment system.

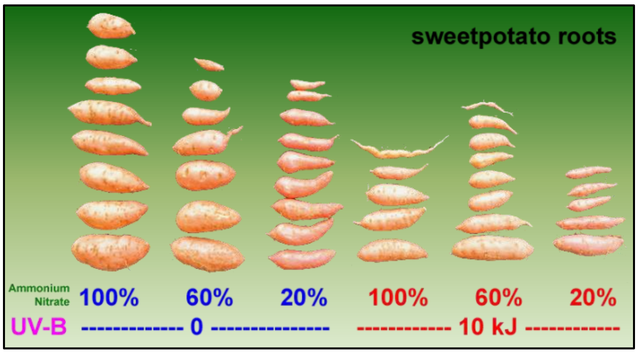



**Figure 2.** Effect of ambient and elevated UV-B radiation and nitrogen-deficiency on sweetpotato cultivars Beauregard, Hatteras and Louisiana 1188. Elevated UV-B inhibited the growth of sweetpotato, but no significant interactive effect between nitrogen and UV stressors was found, and optimal nitrogen did offset some UV-B stress.

### Climate-Crop Model

Understanding agricultural response to climate and environmental change is critical for providing decision support to stakeholders, such as agricultural producers, land managers, and policy makers. UVMRP is working with collaborators at the University of Maryland (UMD) to develop a comprehensive computational model (Figures 3 and 4) that will couple state-of-the-art algorithms for simulating climate, crop, and grassland dynamics to study their interactions and the economic impacts stemming from crop responses to a wide range of environmental stress factors (including UV-B radiation).

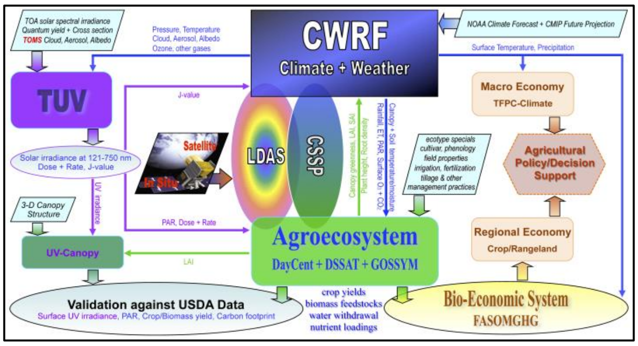



**Figure 3.** The framework of algorithms to predict Climate-Agroecosystem Interactions and Economic (CAIE) impacts for decision support.

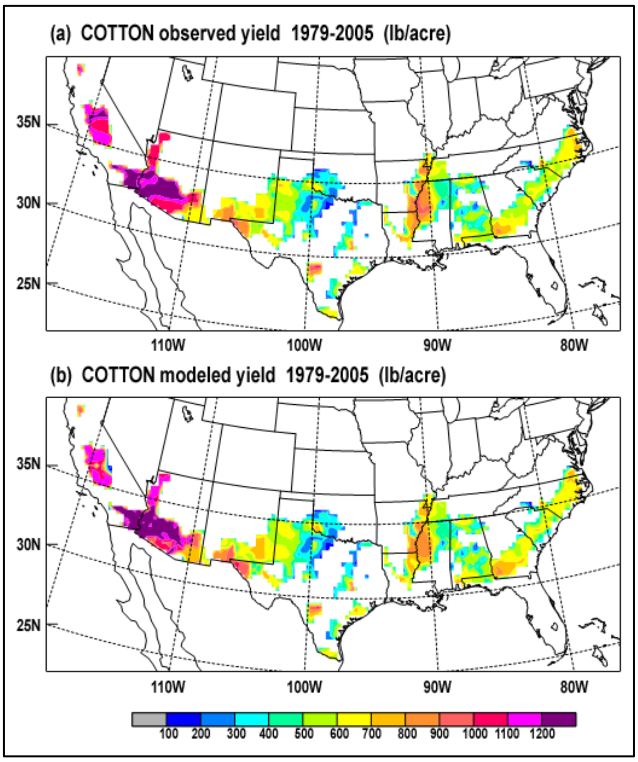



**Figure 4.** Maps of cotton yields over 18-state cotton belt for the years 1979 to 2005, to show that the accuracy of the CAIE model is -/+10% throughout the region.

### References

Chen, Z., effects studies–sweetpotato, Master's Degree thesis defense (successful), unpublished

Davis, J., UV climatology, private communication, unpublished

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