USDA UV-B Monitoring and Research Program

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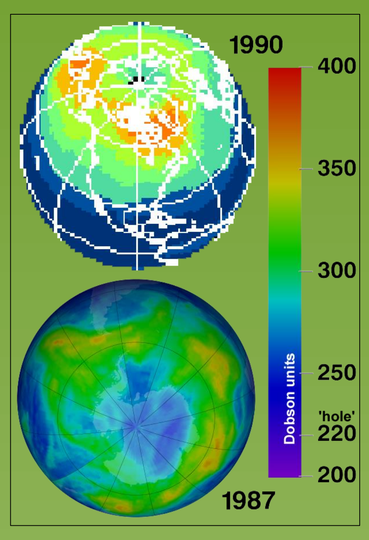
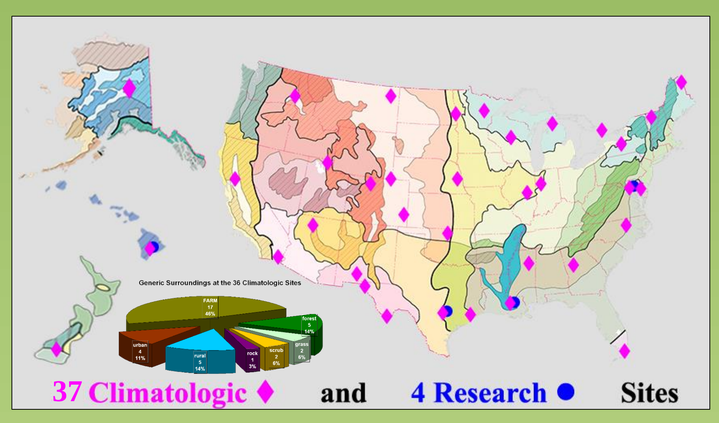
abstract

After the discovery of the persistent 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 UV-B (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 37 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 (23 years and growing) of UV-B irradiance necessary to assess trends.





monitoring network

Instrumentation

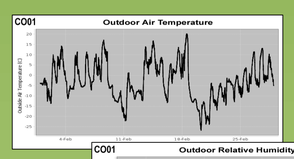
Each of the 37 network sites shown on the map below has:

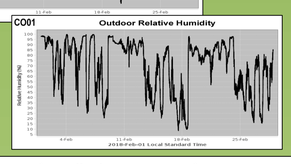
UV datalogger - samples every 20 seconds and stores a three-minute average

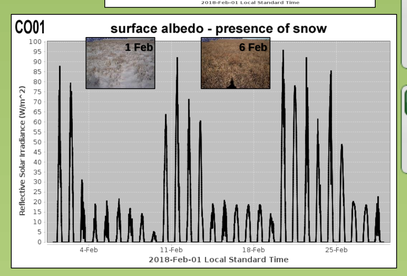
- UltraViolet Multi-Filter Rotating Shadowband Radiometer (UV-MFRSR) nominal 300, 305, 311, 317, 325, 332 and 368 nm at 2 nm FWHM of the total horizontal, direct normal, and diffuse horizontal irradiance
- PAR (photosynthetically active radiation) Quantum sensor (400 to 700 nm)
- *Barometer at 14 sites (per requests from researchers)*
- *UV-A biometer at 7 sites for early research with NASA*

VIS datalogger - samples every 15 seconds and stores a three-minute average

- 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
- UVB-1 broadband radiometer (280 to 320 nm)
- temperature and humidity probe
- downward-looking photometer for surface reflectance (presence/absence of snow)

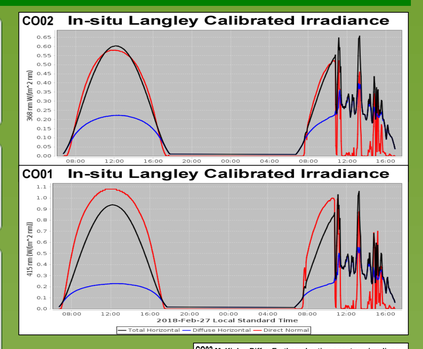


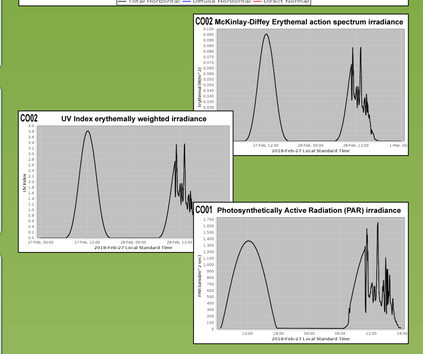


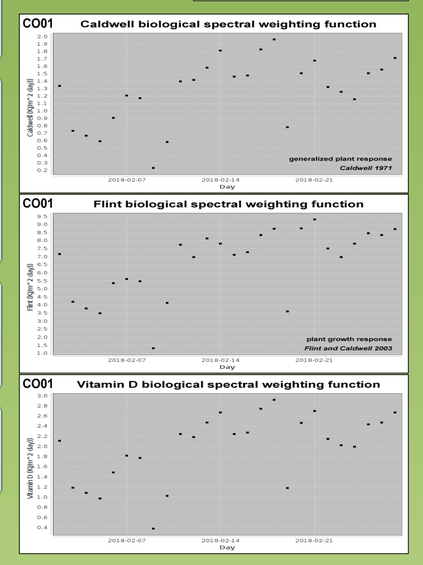


products

- **Spectral Irradiance Data Download**
  - In Situ calibrated
  - MLO calibrated
  - Historical Lamp calibrated
- **Weighted Irradiance Data Download**
  - Erythemal
  - PAR
- **Derived Products Download**
  - UV Index
  - Synthetic Spectra
  - Instantaneous Optical Depths
  - Average Optical Depths
  - UV Irradiance Estimator
- **Climatology Products**
  - Daily Sums
  - Hourly Sums
  - Spatio-Temporal Distribution of UV-B
  - US Merged Irradiance Statistics
  - Sums US Contour Maps
- **Instrument Characteristics Download**
  - Filter Function Corrections
  - Angular Cosine Corrections
  - Langley Voltage Offsets
  - Serial Number Deployment History
  - Site Location Deployment History
- **Anciliary Measurements Download**
  - Internal Head Temperature
  - Air Temp, Humidity, Reflective Solar Irradiance
  - Barometer
  - Electronic Offset(Bias)
  - Cosine Corrected Voltages
  - UVA (uncalibrated)
- **Quality Control Information**
  - Data Processing Procedures
  - Data Corrections
  - Quality Control Abbreviations
- **Data Requests**
  - FTP Access
  - Usage Statistics

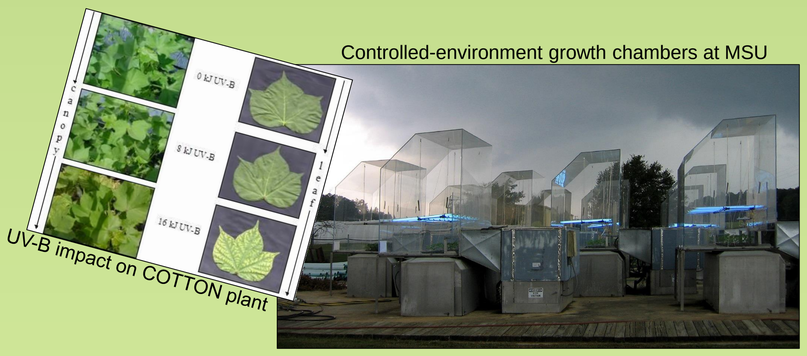




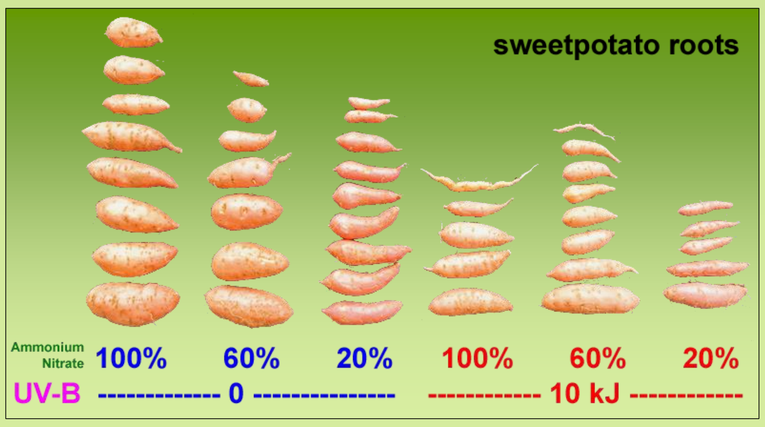


effects studies

UVMRP works with researchers at Mississippi State University (MSU) 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, which include, but are not limited to: cotton, corn, soybean, wheat, rice, and sweetpotato. By understanding both compounding and antagonistic effects of multiple stress factors, research will help develop solutions that could enable producers to cope with these effects and ensure future crop quality and productivity. Results from these greenhouse experiments are used in the development of quantitative algorithms that are incorporated into the climate-crop simulation model for the integrated agricultural impact assessment system.

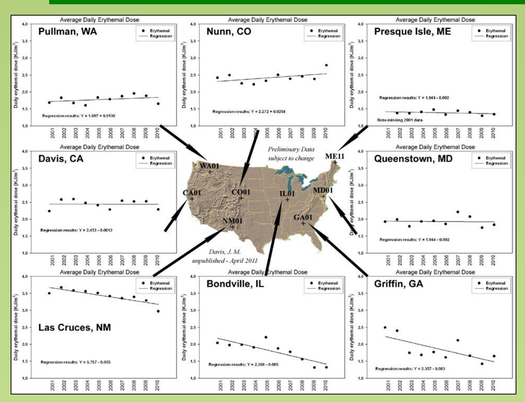


Controlled-environment growth chambers at MSU



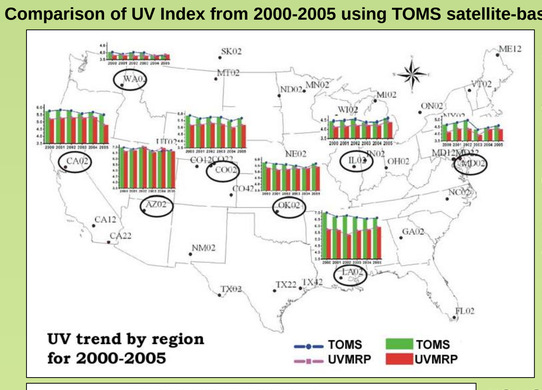
Effect of ambient and elevated UV-B radiation and nitrogen-deficiency on sweetpotato cultivars Beauregard, Hatteras and Louisiana 1188. Most plant parameters measured [photosynthesis, chlorophyll fluorescence, stomatal conductance, transpiration rate, water-use efficiency, growth and development (leaf area, leaf thickness, vine length, total dry weight, number of roots), combined response index (CRI) and UV-B sensitivity index (USI)] showed reduction and loss of yield due to dysfunction of photosynthesis, with cultivar Beauregard more sensitive to UV-B than cultivars Hatteras and Louisiana 1188. Elevated UV-B inhibited the growth of sweetpotato, but no significant interactive effect between nitrogen and UV stressors was found, though optimal nitrogen did offset some UV-B stress.

UV climatology

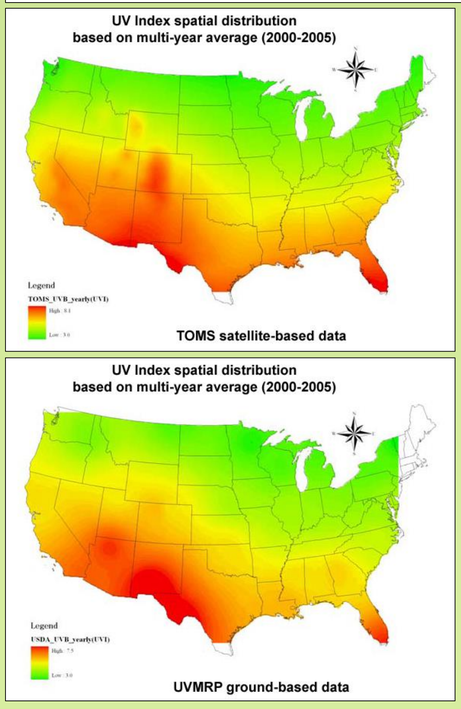


Average Daily Erythemal Dose in KJ/m^2 from 2001-2010 using measurements from UV-MFRSR. The individual 3-minute-average filter measurements are used in the UVMRP's Synthetic Spectrum Program, which integrates over the erythemal portion of the UV spectrum and weights the irradiances with the erythemal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

Comparison of UV Index from 2000-2005 using TOMS satellite-based data and UVMRP ground-based data



The difference between TOMS and UVMRP UV Index (UVI) data sets were analyzed for spatiotemporal trends from 2000 to 2005 for both monthly and yearly timeframes. In general, these two data sources present a high degree of correlation (e.g., correlation coefficients are 98% and above), however, the TOMS UVI is 2%-15% larger than the UVMRP UVI. Such difference is mainly due to how UV-B radiation is normally reflected, scattered, and absorbed before reaching the land surface.

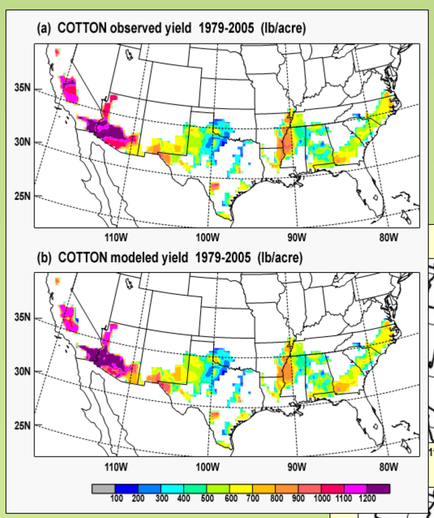


TOMS data, being satellite-based remotely sensed, is less impacted by cloud cover, precipitation, humidity, ozone, and aerosols in the air, whereas UVMRP ground-based measurements are significantly affected by cloud cover, precipitation, and temperature, as well as aerosols, ozone, and many other factors.

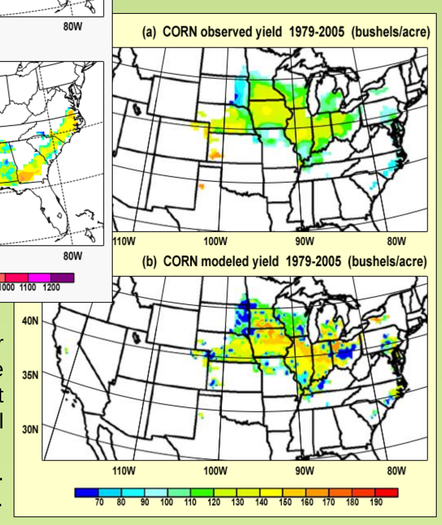
In general, the UVI annual mean based on TOMS data is always higher than that based on UVMRP measurements (i.e., 0.21-0.64 units). UVMRP measurements may be better applied for time series analyses due to the capability to conduct intensive point measurements. TOMS data may be more applicable to explore the regional patterns of UVI distribution due to higher spatial resolution and sensitivity to topography. While east coast USA experienced increased UV-B that was mainly due to changes of the total ozone and aerosol, west coast USA experienced decreased UV-B that was mainly due to changes of total cloud.

climate-crop model

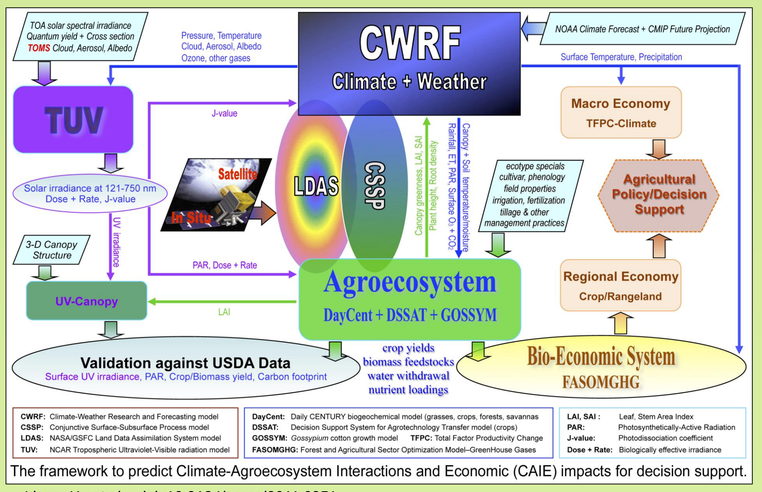
Understanding agricultural response to climate and environmental change is critical for providing decision support to stakeholders, such as agricultural producers, land managers, and policy makers. UVMRP is working with collaborators at the University of Maryland (UMD) to develop a comprehensive computational model 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).



Left: 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. *observed yield on the upper map*. simulated yield on the lower map.



Right: maps of **CORN** yields over the 14-state corn belt for the years 1979 to 2005, to show that the accuracy of the CAIE model is -/+10% throughout the region. *observed yield on the upper map*. simulated yield on the lower map.



The framework to predict Climate-Agroecosystem Interactions and Economic (CAIE) impacts for decision support.

Liang, X., et al. doi: 10.2134/agronj2011.0251

http://uvb.nrel.colostate.edu/