Using Remote Sensing Data to Improve Geographic Assessments of UV-B Radiation from a Sparse Ground Monitoring Network

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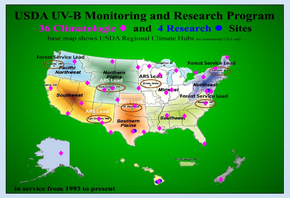
Objectives

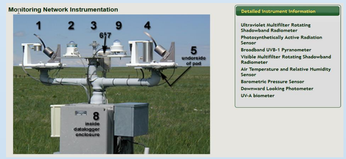
- Produce a data product that allows users to acquire time series of the distribution of UV-B radiation across the continental USA, based upon measurements from the UVMRP.
- Provide data in a format that is GIS ready.
- Users will be able to use the data product to produce time series of UV-B at any location.
- The data product will be useful for characterizing the UV-B climate, in terms of basic statistics (eg. mean, min, max, std), geographic distributions, and temporal changes at daily, weekly, seasonal, and annual time scales.

Methods

Ground Surface Monitoring Network

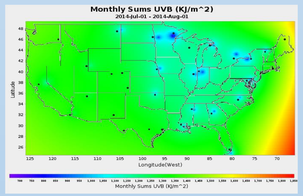
The UVMRP, operating since 1993, is the only network providing nationwide surface monitoring of UV-B irradiance.

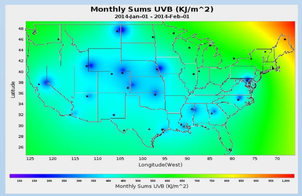




Data Products include downloadable daily sums and hourly sums of UV radiation for each monitoring station, as well as contour maps of these sums as well as monthly sums based upon simple spatial interpolation.

Since the monitoring network is relatively sparse, it is difficult to provide realistic interpolations for areas located between stations, thereby making the extraction of data for any such locations problematic. Here are example results of simple interpolation:





Satellite Data

- The Ozone Monitoring Instrument (OMI) is a nadir-viewing near-UV/Visible spectrometer on board NASA's Aura satellite, which is the atmospheric chemistry mission of the NASA EOS.
- Aura, launched in 2004, flies in formation about 15 minutes behind the Aqua, satellite, both orbiting the earth in a polar Sun-synchronous pattern providing global daily coverage. Scenes are taken at solar noon.
- The OMI was developed by scientists in the Netherlands and Finland.
- A variety of derived data products are produced including ozone, top of atmosphere and surface UV-B in four wave bands, UV-A, cloud cover, and erythemal dose.
- Nadir ground pixel size is 13x12km, with a swath width of at least 725km.
- Level 3 products use the best data to create 0.25 x 0.25, 0.5 x 0.5 and 1 x 1 degree grids.
- On this project we used the Level 3 1 x 1 degree gridded data of surface UV-B (OMUVBd).
- Data are available for download from the NASA Mirador site at the Goddard Space Flight Center.

Data Processing

UVMRP Data

A computer program was developed to produce data files of the UVMRP day-long sums (KJ/m2/day), and mid-day, morning and afternoon dose rates (W/m^2) each monitoring site for 2005-2014. These data files are used as input to the data fusion program.

OMI Satellite Data

- OMI data are daily UV irradiances in four wavelengths (305, 310, 324, and 380 nm).
- The data are hdf5 files, contained within NetCDF files.
- GDAL (Geospatial Data Abstraction Library) is used to translate from HDF5 to IDRISI .rst format.
- The .rst files are imported into Terrset (formerly IDRISI) and resampled to geographic coordinates on a 1x1 degree lat-long grid covering the USA.
- A computer program (maketotal.f) computes total UVB, Flint weighted, Caldwell weighted, and erythemal weighted UV-B from the OMI data in the four wavelengths .
- This program uses a reference solar spectrum (radiance by nm) to estimate spectrum-wide UVB from radiances at the four wavelengths.
- Another program (composite.f) temporally composites the daily data to weekly data.

- The data products were organized into folders and subfolders according to years, level of processing, and data types.
- Step-by-step instruction sheets (tutorials) were created.
- Graduate student interns (funded by **ColoradoView**) carried out the downloading and data processing and learned much about the basics of acquiring and processing remote sensing data.
- Each year resulted in over 18,000 files of 90MB produced (times 10 years). The final lat-long data set amounted to >5900 files, and 2920 raster grids per year (8 bands x 365 days).

Interpolation and Data-Fusion Program

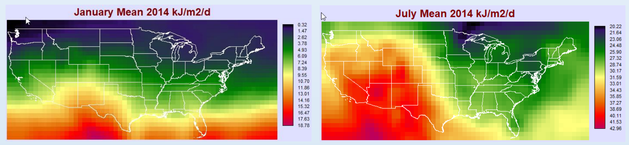
- The computer program pptmap.f develops regressions between UVMRP data and OMI data for each grid-cell. For each grid-cell, the slope of the regression line, which is the change in UVMRP data relative to OMI data from neighborhood stations, is used to estimate what UVMRP values would be at neighborhood stations based on OMI differences between the target grid-cell and the stations
- Once the station data in a local region around a grid-cell adjusted for OMI differences relative to the target grid-cell, the program spatially interpolates values for each grid-cell. Inverse distance weighting or Gaussian distance weighting can be used.
- If inverse distance weighting is used, the interpolated map data will almost exactly agree with the UVMRP station data in the grid-cells where the stations are located.

Analyses

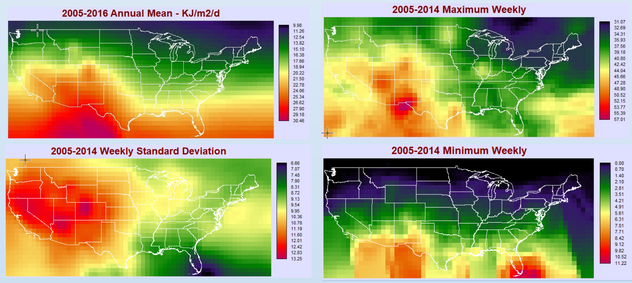
Analyses are carried out using Terrset - software for image processing, GIS, and spatial modeling
developed at Clark Labs. Terrset grew out of the IDRISI software as it expanded to include modeling tools.

Results

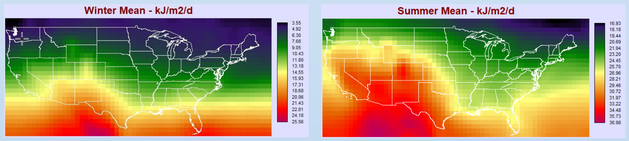
Monthly Means (weekly, daily as well)



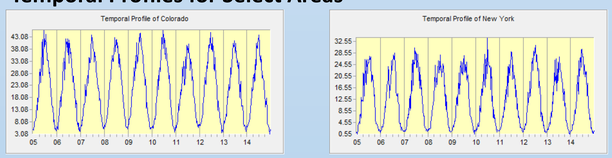
Annual Statistics



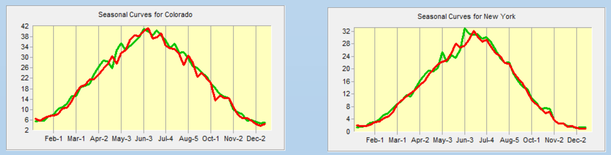
Seasonal Statistics



Temporal Profiles for Select Areas

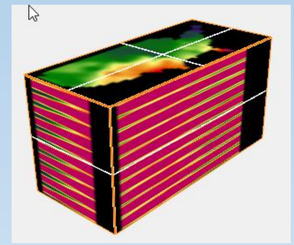


Seasonal Curves for Select Areas



Visualization Cube

X-Longitude, Y-Latitude, Z-Time
Each surface is a cross-section
Can be animated over time
Image on top changes during the animation



Longitudal cross-section
X-latitude, Y-time
Color-UVB

Latitudinal cross-section
X-longitude, Y-Time, Color-UVB