Calculating Solar Radiation Using Solar Analyst

One important contribution to the understanding of a landscape is the incoming solar radiation, or insolation, that is available at the surface. While one could use the global average of 1366 watts/m^2, actual values are generally much lower. On a global scale the controlling variables are the latitude, distance from the sun, and time of year. At the local level elevation, slope and aspect are major factors in determining the amount of energy available. You will need ArcGIS version 9.2 or greater with the Spatial Analysis extension.

The Solar Analyst module in ArcGIS can be used to calculate Watt-Hours/$meter^2$ at the surface at the local scale. Inputs to this process are a digital elevation model (DEM), the latitude of the scene center, and the date and time that you wish to accumulate insolation. You can specify a portion of a day, or a range of days such as a week or month.

For purposes of this document, we will use the Solar Analyst to accumulate the energy striking the surface for the one hour prior to the acquisition of a Landsat image. You could then compare the amount of energy available at the surface, to the brightness-temperature derived from the Landsat thermal band. Alternatively you could adjust the parameters to compare the amount of energy available over a growing season, to the local land cover.

Required inputs

The most important requirement is an accurate, georeferenced DEM dataset. If you do not have one for your study area, use the DEM FAQ on this site to help you locate one. Make note of the scene center latitude. The Solar Analyst module may not determine this automatically when the dataset is opened.

For this example, the other required inputs are the Julian date and the local time of day of image acquisition. As a reminder, the Julian day of year is simply the sequential number from 1 to 365 (or 366 if a leap year). You can use the Julian Data Calendar, found in the CEO Tools folder on the workstation desktop, to calculate this. Local time of day is a function of latitude. The Landsat orbit is designed to cross the equator at approximately noon local time. An orbit takes approximately 90 minutes, or 45 minutes from pole to pole. A rough estimate of the local time is fine.

Create new data layers

Begin this process by loading ArcGIS and activating the Spatial Analysis extension if necessary. Add your DEM to the new empty map. Open ArcToolbox and select **Spatial Analyst Tools | Solar Radiation | Area Solar Radiation**.

You will input or adjust the following values:

- Select the DEM for the Input Raster.
- Enter the name **WattsTot** for the Output global radiation raster.
- Latitude should be prefilled from the DEM; if not, enter the latitude of the scene center
- Set the Sky size/Resolution to 1600
- For Time configuration select “Within a day”

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- Day number of the year is the Julian date of the image
- End time is the time of image acquisition derived earlier in Local Solar Time
- Start time is one hour prior to image acquisition using Local Solar Time.

> **Note**: This will create a new ArcGRID data layer for the total watts/m^2 for the surface. If you are interested in its two components, *direct* and *diffuse* energy, do the following. Scroll down to the Optional outputs section and click on the down arrow to open this section. You can create data layers for direct radiation and diffuse radiation using filenames **WattsDir** and **WattsDiff** respectively.

After reviewing all of the parameters click **OK**. This process may take several hours to complete. When this is complete you will have up to three new ArcGRID layers in your map.

> There are several radiation parameters that use the default values for a generally clear sky. These could be modified as part of a future research project, or if the scene conditions warrant a change. Variables include *Transmittivity* (0.5) and *Diffuse proportion* (0.3). The *Uniform Sky* model could be changed to the *Standard Overcast Sky* model. Also the *Zenith* and *Azimuth* divisions have been set to 8. See the help section of the Area Solar Radiation window in ArcGIS for more information.

Data conversion

After viewing these new data, you may need or want to convert them to ERMapper files. The easiest way to do this is to use ENVI to open the ArcGRID layer and then save it directly into ERMapper format. From the ENVI main menu select **File | Open External File | IP Software | ESRI GRID**. Navigate to the ArcGRID directory and load the "hdr.adf" file. After viewing the file in ENVI save this in ERMapper format via **File | Save File As | ERMapper**. Select the input file then navigate to your directory and save each grid as a new ERMapper raster dataset using filenames **Watts_Tot.ers, Watts_Dir.ers** and **Watts_Diff.ers** for the total, direct and diffuse radiation layers respectively.

Alternatively you can use ArcGIS to export these to ERDAS Imagine files then open them in ERMapper. Right click on a GRID and select **Data | Export Data**. Make sure the output format selected is "IMAGINE Image". Export each of the Watt GRIDS. Open each Imagine file in ERMapper and save these as new ERMapper raster datasets using the filenames **Watts_Tot.ers, Watts_Dir.ers** and **Watts_Diff.ers** for the total, direct and diffuse radiation layers respectively. The Data Type must be set to IEEE4Byte.