Why Analyze Solar?

- To choose croplands
- To select building sites
- To estimate potential for solar energy
The Power of the Sun

- On average, 1,000 watts of solar energy falls on each square meter of the earth out of 174 petawatts that strikes the earth.

- Actual insolation depends on a number of factors...
  - Latitude
  - Time of day
  - Terrain angle (slope)
  - Terrain direction (aspect)
  - Shadows from objects like trees and buildings
  - Air quality
  - Clouds
Oblique Sunlight

- The lower the sun is in the sky, the less energy falls on a fixed area of the earth. By comparison, only a quarter as much energy falls on a square mile when the sun is 30° above the horizon as does when the sun is overhead. This is an important factor in solar analysis (and it explains the seasons).

![Diagram showing the effect of oblique sunlight on energy distribution.](image)
ArcMap Solar Radiation Tools

- Within the Spatial Analyst toolbox

- Three tools...
  - Points solar radiation: insolation at a point
  - Solar radiation graphics: hemispherical sunmap, skymap, and viewshed map
  - Area solar radiation: insolation for an area.
Area Solar Radiation

- Starts with a raster digital elevation model
- Requires input of a number of parameters...
  - Analysis duration: hours, day range, month, year
  - Analysis spatial resolution
  - Others
  - Most defaults are acceptable
- Produces radiation rasters representing...
  - Direct energy in watt hours per square meter (wh/M²)
  - Diffuse, whole sky energy (wh/M²)
  - Sunlight duration (hours)
Example Analysis

Question at hand: Which downtown rooftops are better locations for photovoltaic panels? Pick one day. In practice, analyze over a year.

Criterion: Rooftops with more insolation are better.

Inputs...
- LIDAR digital surface model
- Analysis parameters

Outputs...
- Whole-sky/global energy raster (wh/M²)
- Direct sunlight duration (hours)
Process

- Get LIDAR for analysis area from Milwaukee Co. GIS site.
- Open ArcToolbox and select Spatial Analyst Tools>Solar Radiation>Area Solar Radiation
- Fill in parameters (a model/macro helps)
  - Name output raster including optionals at bottom
  - Select time duration (day number is counted from January 1, time is local solar time)
- Click OK
- Display and analyze rasters.
Step 1 - Get LIDAR

Get Milwaukee County LIDAR DSM (for example).

- Start ArcMap with a blank map.
- Add data from ‘GIS Servers’ > ‘Add ArcGIS Server’
- Choose ‘Use GIS Services’ in dialog
- Enter ‘http://maps.milwaukee county.org/arcgis/services’
- Select ‘arcgis on maps.milwaukee county.org’
- Choose ‘LIDAR’ folder then ‘DSM5ft’
- Zoom to analysis area
Step 2-Select Area

- Export the target area
  - Zoom to analysis area.
  - Right click the LIDAR layer and export data frame into a geo-database. Add as a layer.
  - Remove original LIDAR layer.
Step 3 - Open Solar Tool

1. Select Spatial Analyst extension in ArcMap 'Customize' menu.
2. Open ArcToolbox and expand 'Spatial Analyst Tools'.
3. Select 'Solar Radiation'.
4. Double-click 'Area Solar Radiation'.
5. 'Points Solar Radiation' works in a similar way.
6. 'Solar Radiation Graphics' creates viewshed and skymaps.
Step 4-Run Analysis

- Fill in parameters or build model/macro.
  - ‘Show Help’ is helpful.
  - Drag DSM from table of contents as input raster.
  - Name the output global radiation raster in your GDB.
  - Pick time configuration of ‘Within a day’.
  - Set start and end times in local solar time expressed in 24-hour time.
  - Set hour interval to define integration period. Two hours is reasonable.
  - Check ‘Create outputs for each interval’. This generates a raster summing the energy or duration within the interval. A six-hour analysis with a two hour interval generates an output raster with three bands.
  - Click ‘Optional outputs’ and name ‘Output direct duration hours’ in your GDB.
  - Other defaults are acceptable.
  - Click ‘OK’ and watch progress bar. A message appears when tool finishes.
  - Larger areas, higher resolution, and more outputs can add substantial time to the analysis.
Step 5-Use Analysis

- ‘Add Data’ to display output found in your GDB.
- ‘Outputs for each interval’ display as multi-band rasters. Select bands individually from your GDB as needed.
- The outputs are rasters so all raster tools apply. For example…
  - Set a threshold value to narrow candidate rooftops
  - Use raster math to combine rasters.
To Learn More

- Good process outline from Yale Center for Earth Observation:

- ESRI product description:
  http://webhelp.esri.com/arcgisdesktop/9.3/index.cfm?
  TopicName=Understanding_solar_radiation_analysis
Ready to Try?