Package ‘solrad’

November 5, 2018

Title Calculating Solar Radiation and Related Variables Based on Location, Time and Topographical Conditions

Description For surface energy models and estimation of solar positions and components with varying topography, time and locations. The functions calculate solar top-of-atmosphere, open, diffuse and direct components, atmospheric transmittance and diffuse factors, day length, sunrise and sunset, solar azimuth, zenith, altitude, incidence, and hour angles, earth declination angle, equation of time, and solar constant. Details about the methods and equations are explained in Seyednasrollah, Bijan, Mukesh Kumar, and Timothy E. Link. 'On the role of vegetation density on net snow cover radiation at the forest floor.' Journal of Geophysical Research: Atmospheres 118.15 (2013): 8359-8374, <doi:10.1002/jgrd.50575>.

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Altitude

Description

This function solar altitude angle (in degrees) for a given day of year and location.

Usage

Altitude(DOY, Lat, Lon, SLon, DS)

Arguments

<table>
<thead>
<tr>
<th>DOY</th>
<th>Day of year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lat</td>
<td>Latitude in degrees</td>
</tr>
<tr>
<td>Lon</td>
<td>Longitude in degrees</td>
</tr>
<tr>
<td>SLon</td>
<td>Standard longitude (based on time zone) in degrees</td>
</tr>
<tr>
<td>DS</td>
<td>Daylight saving in minutes</td>
</tr>
</tbody>
</table>
Examples

#Calculating solar altitude angle for two consecutive days

DOY <- seq(0, 2, .05)

alpha <- altitudeHdoyL lat = T5L lon=PL slon=PL ds=6PI

#Note: only the difference between Lon and Slon matters not each value

plot(DOY, alpha)


<table>
<thead>
<tr>
<th>AST</th>
<th>Apparent Solar Time</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Description

This function returns the apparent solar time (in minutes) for a given day of year and location.

Usage

AST(DOY, Lon, Slon, DS)

Arguments

- **DOY**: Day of year
- **Lon**: Longitude in degrees
- **Slon**: Standard longitude (based on time zone) in degrees
- **DS**: Daylight saving in minutes

Examples

#Calculating apparent solar time for two consecutive days

DOY <- seq(0, 2, .05)

ast <- AST(DOY, Lon=0, Slon=0, DS=60)

#Note: only the difference between Lon and Slon matters not each value

plot(DOY, ast)
Azimuth | Solar Azimuth Angle

Description

This function returns solar azimuth angle (in degrees) for a given day of year and location. The solar azimuth angle is the angle of sun’s ray measured in the horizontal plane from due south.

Usage

Azimuth(DOY, Lat, Lon, SLon, DS)

Arguments

- **DOY** | Day of year
- **Lat** | Latitude (in degrees)
- **Lon** | Longitude in degrees
- **SLon** | Standard longitude (based on time zone) in degrees
- **DS** | Daylight saving in minutes

Examples

# Calculating solar azimuth angle for two consecutive days on 45 degree lat and 10 degree lon

DOY <- seq(8, 2, .05)

Az <- Azimuth(DOY, Lat = 45, Lon=10, SLon=10, DS=0)

# Note: only the difference between Lon and SLon matters not each value

plot(DOY, Az)

DayLength | Day Length

Description

This function estimates day length (in hours) for a given day of year and latitude.

Usage

DayLength(DOY, Lat)
**DayOfYear**

**Arguments**

- **DOY**  
  Day of year

- **Lat**  
  Latitude (in degrees)

**Examples**

```r
# Calculating day length for 365 day of the year for 45 degree latitude
DOY <- 1:365
Lat = 45
dl <- DayLength(DOY, Lat)
plot(DOY, dl)
```

---

### Description

This function returns a continuous day of year value (as integer value 1:365) for a given date-time in "POSIXlt" "POSIXct" format.

**Usage**

```r
DayOfYear(DateTime)
```

**Arguments**

- **DateTime**  
  DateTime object

**Examples**

```r
# Calculating day of year for now
DayOfYear(Sys.time())
```
Declination  

**Declination Angle**

**Description**

This function calculates solar declination angle for a given day of year.

**Usage**

Declination(DOY)

**Arguments**

- **DOY**  
  Day of year

**Examples**

```r
# Calculating solar declination angle for 365 day of the year

DOY <- 1:365

delta <- Declination(DOY)

plot(DOY, delta)
```

---

**DiffuseRadiation**  

**Solar Diffuse Radiation on a Surface**

**Description**

This function returns solar diffuse radiation (in W/m²) for a given day of year, location and topography.

**Usage**

DiffuseRadiation(DOY, Lat, Lon, SLon, DS, Elevation, Slope)

**Arguments**

- **DOY**  
  Day of year
- **Lat**  
  Latitude (in degrees)
- **Lon**  
  Longitude in degrees
- **SLon**  
  Standard longitude (based on time zone) in degrees
- **DS**  
  Daylight saving in minutes
- **Elevation**  
  Elevation of the site in meters
- **Slope**  
  Site slope in degrees
DiffusionFactor

Examples

#Calculating atmospheric transmittance coefficient for two consecutive days on 45 degree
# latitude and 10 degree longitude and at 100 m altitude.

DOY <- seq(0, 2, .05)

Sdifopen <- DiffuseRadiation(DOY, Lat = 45, Lon=10, SLon=10, DS=0, Elevation = 100, Slope = 0)
#Note: only the difference between Lon and SLon matters not each value

plot(DOY, Sdifopen)

DiffusionFactor | Atmospheric Diffusion Factor

Description

This function returns atmospheric diffusion factor for a given day of year, location and topography.

Usage

DiffusionFactor(DOY, Lat, Lon, SLon, DS, Elevation)

Arguments

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DOY</td>
<td>Day of year</td>
</tr>
<tr>
<td>Lat</td>
<td>Latitude (in degrees)</td>
</tr>
<tr>
<td>Lon</td>
<td>Longitude in degrees</td>
</tr>
<tr>
<td>SLon</td>
<td>Standard longitude (based on time zone) in degrees</td>
</tr>
<tr>
<td>DS</td>
<td>Daylight saving in minutes</td>
</tr>
<tr>
<td>Elevation</td>
<td>Elevation of the site in meters</td>
</tr>
</tbody>
</table>

Examples

#Calculating atmospheric diffusion factor for two consecutive days on 45 degree
# latitude and 10 degree longitude and at 100 m altitude.

DOY <- seq(0, 2, .05)

td <- DiffusionFactor(DOY, Lat = 45, Lon=10, SLon=10, DS=0, Elevation = 100)
#Note: only the difference between Lon and SLon matters not each value

plot(DOY, td)
**DirectRadiation**

*Solar Direct Beam Radiation on Surface*

**Description**

This function returns solar open direct beam radiation (in W/m²) for a given day of year, location and topography.

**Usage**

```
DirectRadiation(DOY, Lat, Lon, SLon, DS, Elevation, Slope, Aspect)
```

**Arguments**

- **DOY**: Day of year
- **Lat**: Latitude (in degrees)
- **Lon**: Longitude in degrees
- **SLon**: Standard longitude (based on time zone) in degrees
- **DS**: Daylight saving in minutes
- **Elevation**: Elevation of the site in meters
- **Slope**: Site slope in degrees
- **Aspect**: Site aspect with respect to the south in degrees

**Examples**

```r
#Calculating atmospheric transmittance coefficient for two consecutive days on 45 degree latitude and 10 degree longitude and at 100 m altitude.

DOY <- seq(0, 2, .05)

Sopen <- OpenRadiation(DOY, Lat = 45, Lon=10, SLon=10, DS=0, Elevation = 100)

#Note: only the difference between Lon and SLon matters not each value

plot(DOY, Sopen)
```
**EOT**

*Equation of time*

**Description**

This function approximates the value of equation of time for a given day of year.

**Usage**

```
EOT(DOY)
```

**Arguments**

- **DOY**
  
  Day of year

**Examples**

```
#Calculating equation of time for 365 day of the year
DOY <- 1:365
eot <- EOT(DOY)
plot(DOY, eot)
```

---

**Extraterrestrial**

*Solar Extraterrestrial Radiation*

**Description**

This function calculates solar extraterrestrial radiation (in W/m2) for a given day of year.

**Usage**

```
Extraterrestrial(DOY)
```

**Arguments**

- **DOY**
  
  Day of year
**Examples**

```r
#Calculating solar extraterrestrial radiation for 365 day of the year
DOY <- 1:365
Sextr <- Extraterrestrial(DOY)
plot(DOY, Sextr)
```

---

**Extraterrestrial**

*Normal Extraterrestrial Solar Radiation*

**Description**

This function calculates extraterrestrial solar radiation normal to surface (in W/m2) for a given day of year, location and topography.

**Usage**

```r
ExtraterrestrialNormal(DOY, Lat, Lon, SLon, DS, Slope, Aspect)
```

**Arguments**

- **DOY**: Day of year
- **Lat**: Latitude (in degrees)
- **Lon**: Longitude in degrees
- **SLon**: Standard longitude (based on time zone) in degrees
- **DS**: Daylight saving in minutes
- **Slope**: Site slope in degrees
- **Aspect**: Site aspect with respect to the south in degrees

**Examples**

```r
#Calculating solar incidence angle for two consecutive days on 45 degree latitude and 10 degree longitude
DOY <- seq(0, 2, .05)
SextrNormal <- ExtraterrestrialNormal(DOY, Lat = 45, Lon=10, SLon=10, DS=0, Slope = 10, Aspect = 0)
#Note: only the difference between Lon and SLon matters not each value
plot(DOY, SextrNormal)
```
HourAngle

Solar Hour Angle

Description
This function returns solar hour angle for a given day of year, and location.

Usage
HourAngle(DOY, Lon, SLon, DS)

Arguments
- DOY: Day of year
- Lon: Longitude in degrees
- SLon: Standard longitude (based on time zone) in degrees
- DS: Daylight saving in minutes

Examples

#Calculating solar hour angle for two consecutive days
DOY <- seq(0, 2, .05)

h <- HourAngle(DOY, Lon=0, SLon=0, DS=60)
#Note: only the difference between Lon and SLon matters not each value
plot(DOY, h)

Incidence

Solar Incidence Angle

Description
This function returns solar incidence angle (in degrees) for a given day of year and location and site slope and aspect. The solar incidence angle is the angle between sun’s ray and the normal on a surface.

Usage
Incidence(DOY, Lat, Lon, SLon, DS, Slope, Aspect)
Arguments

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DOY</td>
<td>Day of year</td>
</tr>
<tr>
<td>Lat</td>
<td>Latitude (in degrees)</td>
</tr>
<tr>
<td>Lon</td>
<td>Longitude in degrees</td>
</tr>
<tr>
<td>SLon</td>
<td>Standard longitude (based on time zone) in degrees</td>
</tr>
<tr>
<td>DS</td>
<td>Daylight saving in minutes</td>
</tr>
<tr>
<td>Slope</td>
<td>Site slope in degrees</td>
</tr>
<tr>
<td>Aspect</td>
<td>Site aspect with respect to the south in degrees</td>
</tr>
</tbody>
</table>

Examples

```r
calculating solar incidence angle for two consecutive days on 45 degree latitude and
# 10 degree longitude

DOY <- seq(0, 2, .05)

theta <- incidenceHDOYL lat = 45L lon = 10L slon = 10L DS = 0L Slope = 10L Aspect = 0L
# Note: only the difference between lon and slon matters not each value

plot(DOY, theta)
```

---

LST

Local Standard Time

Description

This function returns local standard time (in minutes) given a day of the year value.

Usage

LST(DOY)

Arguments

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DOY</td>
<td>Day of year</td>
</tr>
</tbody>
</table>

Examples

```r
# Calculating local standard time for two consecutive days

DOY <- seq(0, 2, .05)

lst <- LST(DOY)

plot(DOY, lst)
```
**OpenRadiation**

---

**Open Sky Solar Radiation**

Description

This function returns open sky solar radiation (in W/m²) for a given day of year and location.

Usage

```
openradiationHdoyL latL lonL slonL dsL elevationI
```

Arguments

- **doy** Day of year
- **lat** Latitude (in degrees)
- **lon** Longitude in degrees
- **slon** Standard longitude (based on time zone) in degrees
- **ds** Daylight saving in minutes
- **elevation** Elevation of the site in meters

Examples

Calculating open sky solar radiation for two consecutive days on 45 degree latitude and 10 degree longitude and at 100 m altitude.

```r
doy <- seq(0, 2, .05)
Sopen <- openradiation(doy, Lat = 45, Lon = 10, Slon = 10, DS = 0, Elevation = 100)
```

Note: only the difference between Lon and Slon matters not each value

```r
plot(doy, Sopen)
```

---

**Solar**

Calculating Solar Variables

Description

This function calculates solar variables including radiation components, solar angles and positions and day length.

Usage

```
Solar(DOY, Lat, Lon, Slon, DS, Elevation, Slope, Aspect)
```
#### Arguments

- **DOY**: Day of year
- **Lat**: Latitude (in degrees)
- **Lon**: Longitude in degrees
- **SLon**: Standard longitude (based on time zone) in degrees
- **DS**: Daylight saving in minutes
- **Elevation**: Elevation of the site in meters
- **Slope**: Site slope in degrees
- **Aspect**: Site aspect with respect to the south in degrees

#### Examples

```r
# Calculating solar variables and angles

DOY <- seq(0, 2, .05)
solar <- solarHdoyL lat = T5L lon=1PL slon=1PL ds=PL elevation = 1PPPL slope = 1PL aspect = PI

# Note: only the difference between Lon and SLon matters not each value

par(mfrow=c(3,1))
plot(DOY, solar$Altitude, ylim = c(-90,90))
plot(DOY, solar$Azimuth, col= 'red')

plot(DOY, solar$Sdiopen)
lines(DOY, solar$Sdifopen, col='red')
```

---

### Description

This constant value returns solar constant in Watt per meter squared

### Usage

```r
SolarConstant
```

### Format

An object of class *numeric* of length 1.

### Examples

```r
# Printing Solar Constant

print(SolarConstant)
```
Sunrise

Sunrise Time

Description
This function estimates sunrise time (in continuous hour values) for a given day of year and latitude.

Usage
Sunrise(DOY, Lat)

Arguments
- DOY: Day of year
- Lat: Latitude (in degrees)

Examples
#Calculating sunrise time for 365 day of the year for 45 degree latitude
DOY <- 1:365
Lat = 45
sunrise <- Sunrise(DOY, Lat)
plot(DOY, sunrise)

Sunset

Sunset Time

Description
This function estimates sunset time (in continuous hour values) for a given day of year and latitude.

Usage
Sunset(DOY, Lat)

Arguments
- DOY: Day of year
- Lat: Latitude (in degrees)
Examples

#Calculating sunset time for 365 day of the year for 45 degree latitude

DOY <- 1:365

Lat = 45

sunset <- sunsetHdoyL latI

plot(HdoyL sunsetI)

Transmittance   Atmospheric Transmittance

Description

This function returns atmospheric transmittance coefficient for a given day of year and location.

Usage

Transmittance(DOY, Lat, Lon, SLon, DS, Elevation)

Arguments

DOY      Day of year
Lat      Latitude (in degrees)
Lon      Longitude in degrees
SLon     Standard longitude (based on time zone) in degrees
DS       Daylight saving in minutes
Elevation Elevation of the site in meters

Examples

#Calculating atmospheric transmittance coefficient for two consecutive days on 45 degree
# latitude and 10 degree longitude and at 100 m altitude.

DOY <- seq(0, 2, .05)

tb <- Transmittance(DOY, Lat = 45, Lon=10, SLon=10, DS=0, Elevation = 100)

#Note: only the difference between Lon and SLon matters not each value

plot(DOY, tb)
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