Package ‘water’

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Title Actual Evapotranspiration with Energy Balance Models

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Description Tools and functions to calculate actual Evapotranspiration using surface energy balance models.

Depends R (>= 3.4), raster (>= 2.5), sp (>= 1.2), rgdal (>= 1.2)

Imports

License GPL (>= 2)

URL http://midraed.github.io/water

BugReports https://github.com/midraed/water/issues

LazyData true

Suggests knitr, rmarkdown

VignetteBuilder knitr

Encoding UTF-8

RoxygenNote 6.0.1

NeedsCompilation no

Repository CRAN

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R topics documented:

`albedo` *Calculates Broadband Albedo from Landsat data*

Description

Broadband surface Albedo is estimated considering the integration of all narrowband at-surface reflectances following a weighting function with empirical coefficients (Tasumi et al., 2007).

Usage

```
albedo(image.SR, aoi, coeff = "Tasumi", sat = "auto")
```

Arguments

image.SR	surface reflectance image with bands B, R, G, NIR, SWIR1, SWIR2
aoi	area of interest to crop images, if waterOptions("autoAoi") == TRUE will look for any object called aoi on .GlobalEnv
coeff	coefficient to transform narrow to broad band albedo. See Details.
sat	"L7" for Landsat 7, "L8" for Landsat 8 or "auto" to guess from filenames

Details

There are differents models to convert narrowband data to broadband albedo. You can choose coeff="Tasumi" to use Tasumi et al (2008) coefficients, calculated for Landsat 7; coeff="Liang" to use Liang Landsat 7 coefficients or "Olmedo" to use Olmedo coefficients for Landsat 8.

Author(s)

Guillermo Federico Olmedo

Fonseca-Luengo, David

References

R. G. Allen, M. Tasumi, and R. Trezza, "Satellite-based energy balance for mapping evapotranspiration with internalized calibration (METRIC) - Model" Journal of Irrigation and Drainage Engineering, vol. 133, p. 380, 2007
M. Tasumi, Allen, R. G., and Trezza, R. 2007. "Estimation of at-surface reflection albedo from satellite for routine operational calculation of land surface energy balance". J. Hydrol. Eng.
Liang, S. (2000). Narrowband to broadband conversions of land surface albedo: I. Algorithms. Remote Sensing of Environment, 76(1), 213-238.

See Also

Other net radiation related functions: LAI, METRICtopo, SWtrasmisivity, incLWradiation, incSWradiation, netRadiation, outLWradiation, soilHeatFlux, solarAngles, surfaceTemperature

---

calcAnchors *Select anchors pixels for H function*

Description

automatically search end members within the satellite scene (extreme wet and dry conditions).

Usage

```
calcAnchors(image, Ts, LAI, albedo, Z.om, n = 1, aoi,
  anchors.method = "flexible", WeatherStation, plots = TRUE,
  deltaTemp = 5, minDist = 500, WSbuffer = 30000, verbose = FALSE)
```

Arguments

`image`	top-of-atmosphere landsat reflectance image
`Ts`	land surface temperature in K. See surfaceTemperature()
`LAI`	rasterLayer with Leaf Area Index. See LAI()
`albedo`	broandband surface albedo. See albedo()
`Z.om`	momentum roughness lenght. See momentumRoughnessLength()
`n`	number of pair of anchors pixels to calculate
`aoi`	area of interest to limit the search. If waterOptions(autoAOI) == TRUE, It'll use aoi object from .GlobalEnv
`anchors.method`	method for the selection of anchor pixels. "random" for random selection of hot and cold candidates according to CITRA-MCB method, or "best" for selecting the best candidates. And "flexible" for method with soft limits to the anchor pixel conditions.
`WeatherStation`	Optional. WeatherStation data at the satellite overpass. Should be a waterWeatherStation object calculated using read.WSdata and MTL file.
`plots`	Logical. If TRUE will plot position of anchors points selected. Points in red are selected hot pixels, blue are the cold ones and the black represents the position of the Weather Station
`deltaTemp`	deltaTemp for method "CITRA-MCBs" or "CITRA-MCBr"
`minDist`	minimun distance allowed for two anchor pixels of the same type (in meters).
`WSbuffer`	maximun distante to the Weather Station (in meters).
`verbose`	Logical. If TRUE will print aditional data to console

Author(s)

Guillermo Federico Olmedo

de la Fuente-Saiz, Daniel

References

CITRA y MCB (com pers)

See Also

Other sensible heat flux functions: `calcH`, `momentumRoughnessLength`

calcH — *Iterative function to estimate H and R.ah*

Description

generates an iterative solution to estimate r.ah and H because both are unknown at each pixel.

Usage

```
calcH(anchors, method = "mean", Ts, Z.om, WeatherStation, ETp.coef = 1.05,
  Z.om.ws = 0.03, mountainous = FALSE, DEM, Rn, G, verbose = FALSE,
  maxit = 20)
```

Arguments

anchors	anchors points. Can be the result from calcAnchors() or a spatialPointDataframe o Dataframe with X, Y, and type. type should be "cold" or "hot"
method	Method when using more than 1 pair of anchor pixels. method = "mean" will use the mean value for the cold pixels vs the mean value for the hot pixels.
Ts	Land surface temperature in K. See surfaceTemperature()
Z.om	momentum roughness lenght. See momentumRoughnessLength()
WeatherStation	WeatherStation data at the satellite overpass. Can be a waterWeatherStation object calculated using read.WSdata and MTL file
ETp.coef	ETp coefficient usually 1.05 or 1.2 for alfalfa
Z.om.ws	momentum roughness lenght for WeatherStation. Usually a value of 0.03 might be reasonable for a typical agricultural weather station sited over vegetation that is about 0.3 m tall. For clipped grass, use 0.015 m
mountainous	Logical. If TRUE heat transfer equation will be adjusted for mountainous terrain
DEM	Digital Elevation Model in meters.
Rn	Net radiation. See netRadiation()
G	Soil Heat Flux. See soilHeatFlux()
verbose	Logical. If TRUE will print information about every iteration to console
maxit	Maximun number of iteration. Default 20.

Details

Sensible heat flux is the rate of heat loss to the air by convection and conduction, due to a temperature difference.This parameter is computed using the following one-dimensional, aerodynamic,temperature gradient based equation for heat transport, this method is difficult to solve because there are two unknowns, rah and dT. To facilitate this computation, METRIC utilize the two "anchor" pixels and solve for dT that satisfies eq. given the aerodynamic roughness and wind speed at a given height. Aerodynamic resistance, and heat transfer is impacted by buoyancy of heated, light air at the surface, especially when H is large. Therefore, correction to rah is needed to account for buoyancy effects. However, H is needed to make this correction. An iterative solution for both H and rah is used.

Author(s)

Guillermo Federico Olmedo

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References

R. G. Allen, M. Tasumi, and R. Trezza, "Satellite-based energy balance for mapping evapotranspiration with internalized calibration (METRIC) - Model" Journal of Irrigation and Drainage Engineering, vol. 133, p. 380, 2007

Allen, R., Irmak, A., Trezza, R., Hendrickx, J.M.H., Bastiaanssen, W., Kjaersgaard, J., 2011. Satellite-based ET estimation in agriculture using SEBAL and METRIC. Hydrol. Process. 25, 4011-4027. doi:10.1002/hyp.8408

See Also

Other sensible heat flux functions: `calcAnchors`, `momentumRoughnessLength`

`calcRadiance` *Calculates radiance*

Description

This function calculates radiance

Usage

```
calcRadiance(image.DN, sat = "auto", MTL)
```

Arguments

`image.DN`	raw image in digital numbers
`sat`	"L7" for Landsat 7, "L8" for Landsat 8 or "auto" to guess from filenames
`MTL`	Landsat Metadata File

Author(s)

Guillermo Federico Olmedo

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References

R. G. Allen, M. Tasumi, and R. Trezza, "Satellite-based energy balance for mapping evapotranspiration with internalized calibration (METRIC) - Model" Journal of Irrigation and Drainage Engineering, vol. 133, p. 380, 2007
LPSO. (2004). Landsat 7 science data users handbook, Landsat Project Science Office, NASA Goddard Space Flight Center, Greenbelt, Md., (http://landsathandbook.gsfc.nasa.gov/) (Feb. 5, 2007)

See Also

Other remote sensing support functions: `calcSR`, `calcTOAr`, `cfmask`, `loadImageSR`, `loadImage`

`calcSR` *Calculates surface reflectance for L7*

Description

Calculates surface reflectance from top of atmosphere radiance using the model developed by Tasumi et al. (2008) and Allen et al. (2007), which considers a band-by-band basis.

Usage

```
calcSR(image.TOAr, sat = "auto", aoi, incidence.hor, WeatherStation,
  surface.model)
```

Arguments

`image.TOAr`	raster stack. top of atmosphere reflectance image
`sat`	"L7" for Landsat 7, "L8" for Landsat 8 or "auto" to guess from filenames
`aoi`	area of interest to crop images, if waterOptions("autoAoi") == TRUE will look for any object called aoi on .GlobalEnv
`incidence.hor`	solar incidence angle, considering plain surface
`WeatherStation`	Weather Station data
`surface.model`	rasterStack with DEM, Slope and Aspect. See surface.model()

Author(s)

Guillermo Federico Olmedo

Fonseca-Luengo, David

References

Tasumi M.; Allen R.G. and Trezza, R. At-surface albedo from Landsat and MODIS satellites for use in energy balance studies of evapotranspiration Journal of Hydrolog. Eng., 2008, 13, (51-63)

R. G. Allen, M. Tasumi, and R. Trezza, "Satellite-based energy balance for mapping evapotranspiration with internalized calibration (METRIC) - Model" Journal of Irrigation and Drainage Engineering, vol. 133, p. 380, 2007

See Also

Other remote sensing support functions: `calcRadiance`, `calcTOAr`, `cfmask`, `loadImageSR`, `loadImage`

`calcTOAr` *Calculates Top of atmosphere reflectance*

Description

This function calculates the TOA (Top Of Atmosphere) reflectance considering only the image metadata.

Usage

```
calcTOAr(image.DN, sat = "auto", aoi, incidence.rel, MTL)
```

Arguments

`image.DN`	raw image in digital numbers
`sat`	"L7" for Landsat 7, "L8" for Landsat 8 or "auto" to guess from filenames
`aoi`	area of interest to crop images, if waterOptions("autoAoi") == TRUE will look for any object called aoi on .GlobalEnv
`incidence.rel`	solar incidence angle, considering the relief
`MTL`	Landsat Metadata File

Author(s)

Guillermo Federico Olmedo

Fonseca-Luengo, David

References

R. G. Allen, M. Tasumi, and R. Trezza, "Satellite-based energy balance for mapping evapotranspiration with internalized calibration (METRIC) - Model" Journal of Irrigation and Drainage Engineering, vol. 133, p. 380, 2007

LPSO. (2004). Landsat 7 science data users handbook, Landsat Project Science Office, NASA Goddard Space Flight Center, Greenbelt, Md., (http://landsathandbook.gsfc.nasa.gov/) (Feb. 5, 2007)

See Also

Other remote sensing support functions: `calcRadiance`, `calcSR`, `cfmask`, `loadImageSR`, `loadImage`

`cfmask` *mask clouds*

Description

This function mask clouds and other values using the cfmask

Usage

```
cfmask(path = getwd(), image, cfmask, keep = 0, buffer = 60)
```

Arguments

`path`	folder where band files are stored
`image`	L8 raw image
`cfmask`	Raster layer with the cfmask
`keep`	values in cfmask to preserve in the final output
`buffer`	buffer width around excluded values, numeric > 0. Unit is meter if x has a longitude/latitude CRS, or mapunits in other cases

Author(s)

Guillermo Federico Olmedo

See Also

Other remote sensing support functions: `calcRadiance`, `calcSR`, `calcTOAr`, `loadImageSR`, `loadImage`

checkSRTMgrids — *Check needed SRTM grids from image extent*

Description

Check needed SRTM grids from image extent

Usage

```
checkSRTMgrids(raw.image)
```

Arguments

`raw.image`	image to calculate extent

Author(s)

Guillermo Federico Olmedo

See Also

Other support functions: `createAoi`, `prepareSRTMdata`

createAoi — *Create aoi polygon from topleft and bottomright coordinates*

Description

An AOI (Area of Interest) is created based on two points (topleft and bottomright) using a coordinate reference system.

Usage

```
createAoi(topleft, bottomright, EPSG)
```

Arguments

`topleft`	a vector with topleft x,y coordinates
`bottomright`	a vector with bottomright x,y coordinates
`EPSG`	Coordinate reference system EPSG code

Value

object of class SpatialPolygons

Author(s)

Guillermo Federico Olmedo

Fonseca-Luengo, David

See Also

Other support functions: checkSRTMgrids, prepareSRTMdata

Examples

```
tl <- c(493300, -3592700)
br <- c(557200, -3700000)
aoi <- createAoi(topleft = tl, bottomright=br, EPSG=32619)
plot(aoi)
```

---

dailyET — *Calculates daily ET using Penman Monteith hourly formula for every hour*

Description

Calculates daily ET using Penman Monteith hourly formula for every hour

Usage

```
dailyET(WeatherStation, DOY, height, lat, long, elev, ET = "ETr",
  long.z = WeatherStation$long, date = "auto", MTL)
```

Arguments

WeatherStation	a data frame with all the needed fields (see example)
DOY	day of year
height	weather station sensors height in meters
lat	latitude in decimal degrees of the weather station
long	longitude in decimal degrees of the weather station
elev	elevation in meters of the weather station
ET	"ETo" for short crops, similar to clipped, cool-season grass; or "ETr" for tall crops, similar to 0.5 m tall full-cover alfalfa.
long.z	longitude for local time
date	if date == "auto" will use a MTL file provided or present in the working folder to select the date.
MTL	Metadata file. If not provided will look for one on working directory. If provided or present will calculate weather conditions on satellite overpass.

Value

ET daily in mm.h-1

Author(s)

Guillermo Federico Olmedo

References

Allen 2005 ASCE

Examples

```
csvfile <- system.file("extdata", "apples.csv", package="water")

WeatherStation <- read.WSdata(WSdata = csvfile, date.format = "%d/%m/%Y",
lat=-35.42222, long= -71.38639, elev=201, height= 2.2, cf=c(1,0.2777778,1,1))

dailyET(WeatherStation = WeatherStation, lat=-35.422, long=-71.386, elev=124,
ET="ETo")
```

DEM_Talca *SRTM DEM from east of Talca, Chile*

Description

A RasterLayer object with a a Digital Elevation Model.

Usage

```
DEM_Talca
```

Format

An object of class `RasterLayer` of dimension 417 x 508 x 1.

Details

Original data is float. Example data is integer.

Data available from the U.S. Geological Survey.

Source

http://www.usgs.gov/

ET24h — *Calculates daily ET from a surface energy balance and Weather Station*

Description

Calculates daily ET from a surface energy balance and Weather Station

Usage

```
ET24h(Rn, G, H, Ts, WeatherStation, ETr.daily, C.rad = 1)
```

Arguments

`Rn`	Net radiation. See netRadiation()
`G`	Soil Heat Flux. See soilHeatFlux()
`H`	Sensible Heat Flux. See calcH()
`Ts`	Land surface temperature. See surfaceTemperature()
`WeatherStation`	WeatherStation data at the flyby from the satellite. Can be a waterWeatherStation object calculate using read.WSdata and MTL file
`ETr.daily`	hourly ETr for every hour of the day. See dailyET()
`C.rad`	correction term used in sloping terrain to correct for variation in 24 h versus instantaneous energy availability. See Allen (2007)

Author(s)

Guillermo Federico Olmedo

References

R. G. Allen, M. Tasumi, and R. Trezza, "Satellite-based energy balance for mapping evapotranspiration with internalized calibration (METRIC) - Model" Journal of Irrigation and Drainage Engineering, vol. 133, p. 380, 2007

getDataWS — *Export data.frame from waterWeatherStation Object*

Description

Export weather conditions at satellite flyby from waterWeatherStation object

Usage

```
getDataWS(WeatherStation)
```

Arguments

`WeatherStation`	waterWeatherStation object. See read.WSdata()

Author(s)

Guillermo Federico Olmedo

`hourlyET` *Calculates ET using Penman Monteith hourly formula*

Description

Calculates ET using Penman Monteith hourly formula

Usage

```
hourlyET(WeatherStation, hours, DOY, long.z = WeatherStation$long,
  ET.instantaneous = FALSE, ET = "ETr", height = 2, lat, long, elev)
```

Arguments

`WeatherStation`	a data frame with all the needed fields (see example)
`hours`	time of the day in hours in 24hs format
`DOY`	day of year
`long.z`	longitude for local time
`ET.instantaneous`	Logical. True if you want to calculate instantaneous ET instead of hourly ET. See Details.
`ET`	"ETo" for short crops, similar to clipped, cool-season grass; or "ETr" for tall crops, similar to 0.5 m tall full-cover alfalfa.
`height`	weather station sensors height in meters
`lat`	latitude of weather station in decimal degrees. Negative values for south latitude
`long`	longitude of weather station in decimal degrees. Negative values for west longitude
`elev`	elevation of weather station in meters

Details

The only difference on instantaneous ET is how the hour is interpreted. On FALSE, and for example at 11:00, ET is calculated between 10:00 and 11:00, on TRUE Et is calculated at 11:00 hs.

Value

ET hourly in mm.h-1

Author(s)

Guillermo Federico Olmedo

References

Allen 2005 ASCE

Examples

```
WeatherStation  <- data.frame(wind=4.72,
                              RH=59,
                              temp=24.3,
                              radiation=675,
                              height=2.2,
                              lat=-35.37,
                              long=71.5946,
                              elev=124)
  hourlyET(WeatherStation, hours=10.5, DOY=363, long.z=71.635)
```

---

incLWradiation *Calculates long wave incoming radiation*

Description

This function estimates the long wave incoming radiation using the Stefan-Boltzmann equation. In addition, empirical equation of Bastiaanssen (1995) with coefficients developed by Allen (2000) are used to estimate the effective atmospheric emissivity.

Usage

```
incLWradiation(WeatherStation, DEM, solar.angles, Ts)
```

Arguments

`WeatherStation`	Weather Station data
`DEM`	digital elevation model in meters.
`solar.angles`	rasterStack with latitude, declination, hour.angle, incidence.hor and incidence.rel. See solarAngles()
`Ts`	Land surface temperature. See surfaceTemperature()

Author(s)

Guillermo Federico Olmedo

Fonseca-Luengo, David

References

R. G. Allen, M. Tasumi, and R. Trezza, "Satellite-based energy balance for mapping evapotranspiration with internalized calibration (METRIC) - Model" Journal of Irrigation and Drainage Engineering, vol. 133, p. 380, 2007

Bastiaanssen W. Regionalization of surface flux densities and moisture indicators in composite terrain: A remote sensing approach under clear skies in Mediterranean climates. Ph.D. dissertation, CIP Data Koninklijke Bibliotheek, Den Haag, The Netherlands, 1995, p273

Allen R. RAPID long-wave radiation calculations and model comparisons Internal report, University of Idaho, Kimberly, Idaho, 2000

See Also

Other net radiation related functions: `LAI`, `METRICtopo`, `SWtrasmisivity`, `albedo`, `incSWradiation`, `netRadiation`, `outLWradiation`, `soilHeatFlux`, `solarAngles`, `surfaceTemperature`

`incSWradiation` *Calculates Incoming Solar Radiation*

Description

This function calculates incoming solar radiation from surface model and solar angles.

Usage

```
incSWradiation(surface.model, solar.angles, WeatherStation)
```

Arguments

`surface.model`	rasterStack with DEM, Slope and Aspect. See surface.model()
`solar.angles`	rasterStack with latitude, declination, hour.angle, incidence.hor and incidence.rel. See solarAngles()
`WeatherStation`	Weather Station data

Author(s)

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References

R. G. Allen, M. Tasumi, and R. Trezza, "Satellite-based energy balance for mapping evapotranspiration with internalized calibration (METRIC) - Model" Journal of Irrigation and Drainage Engineering, vol. 133, p. 380, 2007

See Also

Other net radiation related functions: `LAI`, `METRICtopo`, `SWtrasmisivity`, `albedo`, `incLWradiation`, `netRadiation`, `outLWradiation`, `soilHeatFlux`, `solarAngles`, `surfaceTemperature`

`L7_Talca` *Landsat 7 scene from east of Talca, Chile*

Description

A RasterStack object with a Landsat 7 ETM+ subset image. Band names are stored in layer names. Images are USGS L1 raw data.

Usage

```
L7_Talca
```

Format

An object of class `RasterBrick` of dimension 417 x 508 x 7.

Details

Metadata for this image is also provided as system file. You can load it with: system.file("extdata", "L7.MTL.txt", package="water")

Data available from the U.S. Geological Survey.

Source

http://www.usgs.gov/

LAI — *Estimate LAI from Landsat Data*

Description

This function implements empirical models to estimate LAI (Leaf Area Index) for satellital images. Models were extracted from METRIC publications and other works developed on different crops.

Usage

```
LAI(method = "metric2010", image, aoi, L = 0.1)
```

Arguments

`method`	Method used to estimate LAI from spectral data.
`image`	image. top-of-atmosphere reflectance for method=="metric" | method=="metric2010" | method=="MCB"; surface reflectance for method = "turner". Digital counts for method = "vineyard".
`aoi`	area of interest to crop images, if waterOptions("autoAoi") == TRUE will look for any object called aoi on .GlobalEnv
`L`	L factor used in method = "metric" or "metric2010" to estimate SAVI, defaults to 0.1

Details

LAI is computed using the top-of atmosphere (at-satellite) reflectance value. LAI and other indices such NDVI, SAVI are used to predict characteristics of vegetation, depending on preferences of the user. Available methods are: "metric", "metric2010", "MCB", "vineyard" and "turner".

Author(s)

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References

R. G. Allen, M. Tasumi, and R. Trezza, "Satellite-based energy balance for mapping evapotranspiration with internalized calibration (METRIC) - Model" Journal of Irrigation and Drainage Engineering, vol. 133, p. 380, 2007
Carrasco-Benavides, M., Ortega-Farias, S., Lagos, L., Kleissl, J., Morales-Salinas, L., & Kilic, A. (2014). Parameterization of the Satellite-Based Model (METRIC) for the Estimation of Instantaneous Surface Energy Balance Components over a Drip-Irrigated Vineyard. Remote Sensing, 6(11), 11342-11371. http://doi.org/10.3390/rs61111342
Johnson, L. F. (2003). Temporal Stability of the NDVI-LAI Relationship in a Napa Valley Vineyard, 96-101. http://doi.org/10.1111/j.1755-0238.2003.tb00258.x Turner, D. P., Cohen, W. B., Kennedy,

R. E., Fassnacht, K. S., & Briggs, J. M. (1999). Relationships between leaf area index and Landsat TM spectral vegetation indices across three temperate zone sites. Remote Sensing of Environment, 70(1), 52–68. http://doi.org/10.1016/S0034-4257(99)00057-7

See Also

Other net radiation related functions: `METRICtopo`, `SWtrasmisivity`, `albedo`, `incLWradiation`, `incSWradiation`, `netRadiation`, `outLWradiation`, `soilHeatFlux`, `solarAngles`, `surfaceTemperature`

`loadImage` *Load Landsat data from folder*

Description

This function loads Landsat bands from a specific folder.

Usage

```
loadImage(path = getwd(), sat = "auto", aoi)
```

Arguments

`path`	folder where band files are stored
`sat`	"L7" for Landsat 7, "L8" for Landsat 8, "MODIS" for MODIS or "auto" to guess from filenames
`aoi`	area of interest to crop images, if waterOptions("autoAoi") == TRUE will look for any object called aoi on .GlobalEnv

Author(s)

Guillermo Federico Olmedo

Fonseca-Luengo, David

References

R. G. Allen, M. Tasumi, and R. Trezza, "Satellite-based energy balance for mapping evapotranspiration with internalized calibration (METRIC) - Model" Journal of Irrigation and Drainage Engineering, vol. 133, p. 380, 2007

See Also

Other remote sensing support functions: `calcRadiance`, `calcSR`, `calcTOAr`, `cfmask`, `loadImageSR`

loadImageSR — *Load Landsat 8 surface reflectance data from folder*

Description

This function loads Landsat bands from a specific folder.

Usage

```
loadImageSR(path = getwd(), aoi)
```

Arguments

`path`	folder where band files are stored
`aoi`	area of interest to crop images, if waterOptions("autoAoi") == TRUE will look for any object called aoi on .GlobalEnv

Author(s)

Guillermo Federico Olmedo

See Also

Other remote sensing support functions: `calcRadiance`, `calcSR`, `calcTOAr`, `cfmask`, `loadImage`

METRIC.EB — *Estimates Energy Balance using METRIC2010 Model*

Description

Estimates Energy Balance using METRIC2010 Model

Usage

```
METRIC.EB(image.DN, image.SR, WeatherStation, MTL, sat = "auto", thermalband,
  plain = TRUE, DEM, aoi, G.method = "Tasumi", alb.coeff = "Tasumi",
  LST.method = "SC", LAI.method = "metric2010", L = 0.1,
  Zom.method = "short.crops", anchors.method = "CITRA-MCB", anchors,
  n = 1, ETp.coef = 1.05, Z.om.ws = 0.0018, verbose = FALSE,
  extraParameters = vector())
```

Arguments

image.DN	raw imagen in digital counts to evaluate
image.SR	L8 ONLY. Surface reflectance imagen. water package does not include a model to calculate surface reflectance for Landsat 8 images. Landsat 8 users should download precalculated surface reflectances from espa website (espa.cr.usgs.gov).
WeatherStation	Weather Station data, can be a waterWeatherStation object
MTL	Landsat metadata file
sat	Landsat satellite version. "L7" or "L8"
thermalband	Landsat low gain thermalband
plain	Logical. If TRUE surface is assumed plain
DEM	Digital Elevation Model of the study area. Not needed if plain = TRUE
aoi	SpatialPolygon object with limits of Area of interest
G.method	method used for the G estimation. Currently implemeted are "Tasumi" for Tasumi,2003 or "Bastiaanssen" for Bastiaanssen, 2000
alb.coeff	coefficient to transform narrow to broad band albedo. See Details.
LST.method	Method for land surface temperature estimation. "SC" for single channel or "SW" for split window algorithm. "SW" is only available for L8. See `water::surfaceTemperature`
LAI.method	Method used to estimate LAI from spectral data. See Details.
L	L value for SAVI calculation
Zom.method	method selected to calculate momentum roughness length. Use "short.crops" for short crops methods from Allen et al (2007); "custom" for custom method also in Allen et al (2007); Or "Perrier" to use Perrier equation as in Santos et al (2012) and Pocas et al (2014).
anchors.method	method for the automatic selection of the anchor pixels.
anchors	data.frame or SpatialPointsDataFrame with the anchor pixels. The data frame must include a "type" column with "hot" and "cold" values.
n	number of pair of anchors pixels to calculate
ETp.coef	ETp coefficient usually 1.05 or 1.2 for alfalfa
Z.om.ws	momentum roughness lenght for WeatherStation. Usually 0.0018 or 0.03 for long grass
verbose	Logical. If TRUE will print aditional data to console
extraParameters	Extra parameters for the non default methods. i.e. Zom.method = "Perrier", needs two extra parameters: fLAI, h. See help(momentumRoughnessLength).

Details

There are differents models to convert narrowband data to broadband albedo. You can choose alb.coeff ="Tasumi" to use Tasumi et al (2008) coefficients, calculated for Landsat 7; alb.coeff ="Liang" to use Liang Landsat 7 coefficients or "Olmedo" to use Olmedo coefficients for Landsat 8.

Extra Parameters

Extra Paramenters for functions inside METRIC.EB() include: * for momentumRoughness when Zom.method = "Perrier": fLAI, h. * for calcAnchors(): minDist, WSbuffer, deltaTemp

Author(s)

Guillermo F Olmedo, <guillermo.olmedo@gmail.com>

References

R. G. Allen, M. Tasumi, and R. Trezza, "Satellite-based energy balance for mapping evapotranspiration with internalized calibration (METRIC) - Model" Journal of Irrigation and Drainage Engineering, vol. 133, p. 380, 2007 González, Arturo & Hay, Christopher & Kjaersgaard, Jeppe & Neale, Christopher. (2015). Use of Remote Sensing to Generate Crop Coefficient and Estimate Actual Crop Evapotranspiration. 10.13031/aim.20152190105.

See Also

Other METRIC model functions: METRIC.G, METRIC.Rn

Examples

```
### Data preparation
library(water)
aoi <- createAoi(topleft = c(500000, -3644000), bottomright = c(526000, -3660000))
raw_data_folder <- system.file("extdata", package="water")
image <- loadImage(path=raw_data_folder, aoi=aoi, sat="L8")
image.SR <- loadImageSR(path=raw_data_folder, aoi=aoi)
csvfile <- system.file("extdata", "INTA.csv", package="water")
MTLfile <- system.file("extdata", "LC82320832016040LGN00_MTL.txt", package="water")
## Not run:
WeatherStation <- read.WSdata(WSdata = csvfile,
                              datetime.format =  "%Y/%m/%d %H:%M",
                              columns = c("datetime", "temp",
                                          "RH", "pp", "radiation", "wind"),
                              lat=-33.00513, long= -68.86469, elev=927, height= 2,
                              MTL=MTLfile)

### LSEB with default methods and no extra parameters
Energy.Balance <- METRIC.EB(image.DN = image, image.SR = image.SR,
                            plain=TRUE, aoi=aoi, n = 5, WeatherStation = WeatherStation,
                       ETp.coef = 1.2, sat="L8", alb.coeff = "Olmedo", LST.method = "SW",
                            LAI.method = "metric2010", Z.om.ws = 0.03, MTL = MTLfile)


### LSEB with "Perrier" method for Zom and extra parameters
Energy.Balance <- METRIC.EB(image.DN = image, image.SR = image.SR,
                            plain=TRUE, aoi=aoi, n = 5, WeatherStation = WeatherStation,
                       ETp.coef = 1.2, sat="L8", alb.coeff = "Olmedo", LST.method = "SW",
                       LAI.method = "metric2010", Zom.method = "Perrier", Z.om.ws = 0.03,
                            MTL = MTLfile, extraParameters = c(fLAI = 0.5, h = 1.8) )
```

```
## End(Not run)
```

METRIC.G *Estimates Net Radiation as in METRIC Model*

Description

Estimates Net Radiation as in METRIC Model

Usage

```
METRIC.G(image.DN, WeatherStation = WeatherStation, Rn, plain = TRUE, DEM,
  aoi)
```

Arguments

`image.DN`	raw imagen in digital counts to evaluate
`WeatherStation`	Weather Station data, can be a waterWeatherStation object
`Rn`	RasterLayer with Net Radiation data in W/m2
`plain`	Logical. If TRUE surface is assumed plain
`DEM`	Digital Elevation Model of the study area. Not needed if plain = TRUE
`aoi`	SpatialPolygon object with limits of Area of interest

Author(s)

Guillermo F Olmedo, `<guillermo.olmedo@gmail.com>`

References

R. G. Allen, M. Tasumi, and R. Trezza, "Satellite-based energy balance for mapping evapotranspiration with internalized calibration (METRIC) - Model" Journal of Irrigation and Drainage Engineering, vol. 133, p. 380, 2007

See Also

Other METRIC model functions: `METRIC.EB`, `METRIC.Rn`

METRIC.Rn — *Estimates Net Radiation as in METRIC Model*

Description

Estimates Net Radiation as in METRIC Model

Usage

```
METRIC.Rn(image.DN, WeatherStation, MTL, sat = "auto", thermalband,
  alb.coeff = "Tasumi", LAI.method = "metric2010", plain = TRUE, DEM, aoi)
```

Arguments

`image.DN`	raw imagen in digital counts to evaluate
`WeatherStation`	Weather Station data, can be a waterWeatherStation object
`MTL`	Landsat metadata file
`sat`	Landsat satellite version. "L7" or "L8"
`thermalband`	Landsat low gain thermalband
`alb.coeff`	coefficient to transform narrow to broad band albedo. See Details.
`LAI.method`	Method used to estimate LAI from spectral data. See Details.
`plain`	Logical. If TRUE surface is assumed plain
`DEM`	Digital Elevation Model of the study area. Not needed if plain = TRUE
`aoi`	SpatialPolygon object with limits of Area of interest

Author(s)

Guillermo F Olmedo, <guillermo.olmedo@gmail.com>

References

R. G. Allen, M. Tasumi, and R. Trezza, "Satellite-based energy balance for mapping evapotranspiration with internalized calibration (METRIC) - Model" Journal of Irrigation and Drainage Engineering, vol. 133, p. 380, 2007

See Also

Other METRIC model functions: `METRIC.EB`, `METRIC.G`

`METRICtopo` *Calculates surface model used in METRIC*

Description

DEM map is used to generate the surface representation of the image through of aspect and slope maps. This procedure helps to avoid differences in the surface temperature (and finally Evapotranspiration) caused by different incidence angles and/or elevations in mountainous areas.

Usage

```
METRICtopo(DEM)
```

Arguments

`DEM`	raster with Digital elevation model

Author(s)

Guillermo Federico Olmedo

Fonseca-Luengo, David

References

R. G. Allen, M. Tasumi, and R. Trezza, "Satellite-based energy balance for mapping evapotranspiration with internalized calibration (METRIC) - Model" Journal of Irrigation and Drainage Engineering, vol. 133, p. 380, 2007

See Also

Other net radiation related functions: `LAI`, `SWtrasmisivity`, `albedo`, `incLWradiation`, `incSWradiation`, `netRadiation`, `outLWradiation`, `soilHeatFlux`, `solarAngles`, `surfaceTemperature`

`momentumRoughnessLength` *Calculates Momentum Roughness Length*

Description

this function estimates Momentum Roughness Length (Zom) from the average vegetation height around the weather station.

Usage

```
momentumRoughnessLength(method = "short.crops", LAI, NDVI, albedo, a, b, fLAI,
  h, mountainous = FALSE, surface.model)
```

Arguments

`method`	method selected to calculate momentum roughness length. Use "short.crops" for short crops methods from Allen et al (2007); "custom" for custom method also in Allen et al (2007); Or "Perrier" to use Perrier equation as in Santos et al (2012) and Pocas et al (2014).
`LAI`	rasterLayer with Leaf Area Index. See LAI(). Only needed for method = "short.crops"
`NDVI`	rasterLayer with Normalized Difference Vegetation Index. Only needed for method = "custom"
`albedo`	broadband surface albedo. See albedo()
`a`	"a" coefficients for Allen (2007) custom function to estimate Momentum roughness length. Only needed for method = "custom"
`b`	"b" coefficients for Allen (2007) custom function to estimate Momentum roughness length. Only needed for method = "custom"
`fLAI`	proportion of LAI lying above h/2. Only needed for method = "Perrier"
`h`	crop height in meters. Only needed for method = "Perrier"
`mountainous`	empirical adjustment for effects of general terrain roughness on momentum and heat transfer. See Allen (2007)
`surface.model`	surface model with a RasterLayer called "Slope" needed is mountainous = TRUE. See surface.model()

Details

According Allen et al,. 2010 Zom is a measure of the form drag and skin friction for the layer of air that interacts with the surface.

Author(s)

Guillermo Federico Olmedo

de la Fuente-Saiz, Daniel

References

R. G. Allen, M. Tasumi, and R. Trezza, "Satellite-based energy balance for mapping evapotranspiration with internalized calibration (METRIC) - Model" Journal of Irrigation and Drainage Engineering, vol. 133, p. 380, 2007

Pocas, I., Paco, T.A., Cunha, M., Andrade, J.A., Silvestre, J., Sousa, A., Santos, F.L., Pereira, L.S., Allen, R.G., 2014. Satellite-based evapotranspiration of a super-intensive olive orchard: Application of METRIC algorithms. Biosystems Engineering 128, 69-81. doi:10.1016/j.biosystemseng.2014.06.019

Santos, C., Lorite, I.J., Allen, R.G., Tasumi, M., 2012. Aerodynamic Parameterization of the Satellite-Based Energy Balance (METRIC) Model for ET Estimation in Rainfed Olive Orchards of Andalusia, Spain. Water Resour Manage 26, 3267-3283. doi:10.1007/s11269-012-0071-8

See Also

Other sensible heat flux functions: `calcAnchors`, `calcH`

`netRadiation` *Estimates net radiation*

Description

This function estimates net radiation considering a surface radiation balance. Equations use the information from the image, in addition of measurements of actual vapor pressure and altitude.

Usage

```
netRadiation(LAI, albedo, Rs.inc, Rl.inc, Rl.out)
```

Arguments

`LAI`	raster layer with leaf area index. See LAI()
`albedo`	broadband surface albedo. See albedo()
`Rs.inc`	incoming short-wave radiation
`Rl.inc`	incomin long-wave radiation
`Rl.out`	outgoing long-wave radiation

Author(s)

Guillermo Federico Olmedo

Fonseca-Luengo, David

References

R. G. Allen, M. Tasumi, and R. Trezza, "Satellite-based energy balance for mapping evapotranspiration with internalized calibration (METRIC) - Model" Journal of Irrigation and Drainage Engineering, vol. 133, p. 380, 2007

See Also

Other net radiation related functions: `LAI`, `METRICtopo`, `SWtrasmisivity`, `albedo`, `incLWradiation`, `incSWradiation`, `outLWradiation`, `soilHeatFlux`, `solarAngles`, `surfaceTemperature`

outLWradiation — *Calculates Long wave outgoing radiation*

Description

This function estimates the long wave outgoing radiation using the Stefan-Boltzmann equation.

Usage

```
outLWradiation(LAI, Ts)
```

Arguments

LAI	raster layer with leaf area index. See LAI()
Ts	Land surface temperature. See surfaceTemperature()

Author(s)

Guillermo Federico Olmedo

Fonseca-Luengo, David

References

R. G. Allen, M. Tasumi, and R. Trezza, "Satellite-based energy balance for mapping evapotranspiration with internalized calibration (METRIC) - Model" Journal of Irrigation and Drainage Engineering, vol. 133, p. 380, 2007

See Also

Other net radiation related functions: LAI, METRICtopo, SWtrasmisivity, albedo, incLWradiation, incSWradiation, netRadiation, soilHeatFlux, solarAngles, surfaceTemperature

plot.waterLSEB — *Plot method for waterLSEB S3 class*

Description

Plot method for waterLSEB S3 class

Usage

```
## S3 method for class 'waterLSEB'
plot(x, ...)
```

Arguments

x	waterLSEB object.
...	further arguments passed to or from other methods.

Author(s)

Guillermo Federico Olmedo

See Also

Other LSEB objects related functions: print.waterLSEB, writeRaster.waterLSEB

---

plot.waterWeatherStation

Plot method for waterWeatherStation S3 class

Description

Plot method for waterWeatherStation S3 class

Usage

```
## S3 method for class 'waterWeatherStation'
plot(x, hourly = FALSE, sat = TRUE, date, ...)
```

Arguments

x	waterWeatherStation object. See read.WSdata()
hourly	If TRUE will plot only hourly data, instead of all data from the waterWeatherStation object
sat	If TRUE, and if the waterWeatherStation object was created using a Landsat Metadata File, will plot only data from day of the satellite overpass
date	When sat = FALSE, the date to plot in a multi-day object
...	additional parameters to pass to plot()

Author(s)

Guillermo Federico Olmedo

See Also

Other Weather station related functions: print.waterWeatherStation, read.WSdata2, read.WSdata

prepareSRTMdata — *Create a mosaic with SRTM grid from image extent*

Description

Create a mosaic with SRTM grid from image extent

Usage

```
prepareSRTMdata(path = getwd(), format = "tif", extent)
```

Arguments

path	folder where SRTM files are stored
format	format of SRTM grid files
extent	minimal extent of mosaic

Author(s)

Guillermo Federico Olmedo

See Also

Other support functions: checkSRTMgrids, createAoi

print.waterLSEB — *Print method for waterLSEB S3 class*

Description

Print method for waterLSEB S3 class

Usage

```
## S3 method for class 'waterLSEB'
print(x, ...)
```

Arguments

x	waterLSEB object.
...	further arguments passed to or from other methods.

Author(s)

Guillermo Federico Olmedo

See Also

Other LSEB objects related functions: plot.waterLSEB, writeRaster.waterLSEB

---

print.waterWeatherStation
Print method for waterWeatherStation S3 class

Description

Print method for waterWeatherStation S3 class

Usage

```
## S3 method for class 'waterWeatherStation'
print(x, ...)
```

Arguments

x	waterWeatherStation object. See read.WSdata()
...	additional parameters to pass to print()

Author(s)

Guillermo Federico Olmedo

See Also

Other Weather station related functions: plot.waterWeatherStation, read.WSdata2, read.WSdata

---

read.WSdata *Prepares weather station data*

Description

Prepares weather station data

Usage

```
read.WSdata(WSdata, ..., height = 2.2, lat, long, elev, columns = c(date =
  1, time = 2, radiation = 3, wind = 4, RH = 6, temp = 7, rain = 8),
  date.format = "%Y-%m-%d", time.format = "%H:%M:%S",
  datetime.format = "%Y-%m-%d %H:%M:%S", tz = "", cf = c(1, 1, 1),
  MTL)
```

Arguments

`WSdata`	csv file with weather station data or data.frame
`...`	additional parameter to pass to read.csv()
`height`	weather station sensors height in meters
`lat`	latitude of weather station in decimal degrees. Negative values for south latitude
`long`	longitude of weather station in decimal degrees. Negative values for west longitude
`elev`	elevation of weather station in meters
`columns`	vector with the column numbers in WSdata for the date, time, radiation, wind, RH, temperature and rain. If date and time are in the same column, the column number has to be the same. Names in this vector are ignored and are presented on Usage and examples only as a reference.
`date.format`	date format. See strptime format argument.
`time.format`	time format. See strptime format argument.
`datetime.format`	datetime format. See strptime format argument.
`tz`	timezone of the weather station dates. If not present assumes the same timezone as the computer running the code. See strptime for details.
`cf`	conversion factor to convert radiation, wind, and temperature to W/m2; m/s and Celsius. See Details.
`MTL`	Metadata file. If not provided will look for one on working directory. If provided or present will calculate weather conditions on satellite overpass.

Details

For cf, if your data is in W/m2, km/h and Celsius (radiation, wind, temperature), cf should be: cf = c(1,0.2777778,1)

Value

waterWeatherStation object, with data.frames with all data, hourly data and conditions at satellite flyby.

Author(s)

Guillermo Federico Olmedo

References

Landsat 7 Metadata example file available from the U.S. Geological Survey. Weather Station example file courtesy of CITRA, Universidad de Talca, Chile

See Also

`read.WSdata2` for the equivalent using read.csv2()

Other Weather station related functions: `plot.waterWeatherStation`, `print.waterWeatherStation`, `read.WSdata2`

Examples

```
csvfile <- system.file("extdata", "apples.csv", package="water")
MTLfile <- system.file("extdata", "L7.MTL.txt", package="water")
WS <- read.WSdata(WSdata = csvfile, date.format = "%d/%m/%Y",
                  lat=-35.42222, long= -71.38639, elev=201, height= 2.2,
                  columns=c("date" = 1, "time" = 2, "radiation" = 3,
                  "wind" = 4, "RH" = 6, "temp" = 7, "rain" = 8),
                  MTL = MTLfile)
print(WS)
plot(WS, alldata=FALSE)
plot(WS, alldata=TRUE)
```

`read.WSdata2` *Prepares weather station data 2*

Description

Prepares weather station data 2

Usage

```
read.WSdata2(WSdata, ..., height = 2.2, lat, long, elev, columns = c(date =
  1, time = 2, radiation = 3, wind = 4, RH = 6, temp = 7, rain = 8),
  date.format = "%d/%m/%Y", time.format = "%H:%M:%S",
  datetime.format = "%Y-%m-%d %H:%M:%S", tz = "", cf = c(1, 3.6, 1,
  1), MTL)
```

Arguments

`WSdata`	csv file with weather station data
`...`	additional parameter to pass to read.csv()
`height`	weather station sensors height in meters
`lat`	latitude of weather station in decimal degrees. Negative values for south latitude
`long`	longitude of weather station in decimal degrees. Negative values for west longitude
`elev`	elevation of weather station in meters
`columns`	columns order of needed data. Vector containing "date", "time", "radiation", "wind", "RH", "temp" and "rain". Other values are ignored. If you have a column with date and time in the same column, you can include "datetime" and "date" and "time" are no longer needed.
`date.format`	date format. See strptime format argument.
`time.format`	time format. See strptime format argument.
`datetime.format`	datetime format. See strptime format argument.

`tz`	timezone of the weather station dates. If not present assumes the same timezone as the computer running the code. See strptime for details.
`cf`	conversion factor to convert radiation, wind, and temperature to W/m2; m/s and Celsius. See Details.
`MTL`	Metadata file. If not provided will look for one on working directory. If provided or present will calculate weather conditions on satellite flyby.

Details

For cf, if your data is in W/m2, km/h and Celsius (radiation, wind, temperature), cf should be: cf = c(1,0.2777778,1)

Author(s)

Guillermo Federico Olmedo

See Also

Other Weather station related functions: `plot.waterWeatherStation`, `print.waterWeatherStation`, `read.WSdata`

`soilHeatFlux` *Estimates Soil Heat Flux*

Description

This function implements models to estimate soil heat flux for different surfaces and considering different inputs.

Usage

```
soilHeatFlux(image, Ts, albedo, LAI, Rn, aoi, method = "Tasumi")
```

Arguments

`image`	surface reflectance image
`Ts`	Land surface temperature. See surfaceTemperature()
`albedo`	broadband surface albedo. See albedo()
`LAI`	raster layer with leaf area index. See LAI()
`Rn`	Net radiation. See netRadiation()
`aoi`	area of interest to crop images, if waterOptions("autoAoi") == TRUE will look for any object called aoi on .GlobalEnv
`method`	method used for the G estimation. Currently implemeted are "Tasumi" for Tasumi,2003 or "Bastiaanssen" for Bastiaanssen, 2000

Author(s)

Guillermo Federico Olmedo

Fonseca-Luengo, David

References

R. G. Allen, M. Tasumi, and R. Trezza, "Satellite-based energy balance for mapping evapotranspiration with internalized calibration (METRIC) - Model" Journal of Irrigation and Drainage Engineering, vol. 133, p. 380, 2007

See Also

Other net radiation related functions: `LAI`, `METRICtopo`, `SWtrasmisivity`, `albedo`, `incLWradiation`, `incSWradiation`, `netRadiation`, `outLWradiation`, `solarAngles`, `surfaceTemperature`

`solarAngles` *Calculates solar angles*

Description

Metadata, aspect and slope maps are combined to estimate solar angles for the entire image.

Usage

```
solarAngles(surface.model, MTL, WeatherStation)
```

Arguments

`surface.model`	rasterStack with DEM, Slope and Aspect. See surface.model()
`MTL`	Landsat Metadata File
`WeatherStation`	Weather Station data

Details

Narrowband transmittances,are calculated considering some radiation transfer models operated over a wide range of climates and locations across the world, this parameter vary with the cosine of the solar angle, atmospheric pressure and precipitable water vapor in the atmosphere, so the author must obtain accurate values of these three parameters.

Author(s)

Guillermo Federico Olmedo

Fonseca-Luengo, David

Fernando Fuentes Peñailillo

References

R. G. Allen, M. Tasumi, and R. Trezza, "Satellite-based energy balance for mapping evapotranspiration with internalized calibration (METRIC) - Model" Journal of Irrigation and Drainage Engineering, vol. 133, p. 380, 2007

See Also

Other net radiation related functions: `LAI`, `METRICtopo`, `SWtrasmisivity`, `albedo`, `incLWradiation`, `incSWradiation`, `netRadiation`, `outLWradiation`, `soilHeatFlux`, `surfaceTemperature`

`surfaceTemperature` *Estimates Land Surface Temperature from Landsat Data*

Description

Surface temperature is estimated using a modified Plank equation considering empirical constants for Landsat images. In addition, this model implements a correction of thermal radiance following to Wukelic et al. (1989).

Usage

```
surfaceTemperature(image.DN, sat = "auto", LAI, aoi, method = "SC",
  WeatherStation, thermalband)
```

Arguments

`image.DN`	raw image in digital numbers
`sat`	"L7" for Landsat 7, "L8" for Landsat 8 or "auto" to guess from filenames
`LAI`	raster layer with leaf area index. See LAI()
`aoi`	area of interest to crop images, if waterOptions("autoAoi") == TRUE will look for any object called aoi on .GlobalEnv
`method`	"SC" for single channel or "SW" for split window algorithm. "SW" is only available for L8
`WeatherStation`	Weather Station data
`thermalband`	Satellite thermal band. For L8 this should be band 10. Deprecated argument

Author(s)

Guillermo Federico Olmedo

Fonseca-Luengo, David

References

R. G. Allen, M. Tasumi, and R. Trezza, "Satellite-based energy balance for mapping evapotranspiration with internalized calibration (METRIC) - Model" Journal of Irrigation and Drainage Engineering, vol. 133, p. 380, 2007

Wukelic G. E.; Gibbons D. E.; Martucci L. M. & Foote, H. P. Radiometric calibration of Landsat thematic mapper thermal band Remote Sensing of Environment, 1989, 28, (339-347)

Jimenez-Munoz, J. C., Sobrino, J. A., Skokovic, D., Mattar, C., & Cristobal, J. (2014). Land surface temperature retrieval methods from landsat-8 thermal infrared sensor data. IEEE Geoscience and Remote Sensing Letters, 11(10), 1840–1843. http://doi.org/10.1109/LGRS.2014.2312032

See Also

Other net radiation related functions: `LAI`, `METRICtopo`, `SWtrasmisivity`, `albedo`, `incLWradiation`, `incSWradiation`, `netRadiation`, `outLWradiation`, `soilHeatFlux`, `solarAngles`

`SWtrasmisivity` *Calculates short wave transmisivity*

Description

Short wave transmisivity is estimated for broad-band considering an extended equation developed by Allen (1996), based from Majumdar et al.(1972), using coefficients developed by ASCE-EWRI (2005).

Usage

```
SWtrasmisivity(Kt = 1, ea, dem, incidence.hor)
```

Arguments

`Kt`	unitless turbidity coefficient 0<Kt<=1.0, where Kt=1.0 for clean air and Kt=0.5 for extremely turbid, dusty, or polluted air
`ea`	near-surface vapor pressure (kPa)
`dem`	digital elevation model
`incidence.hor`	solar incidence angle, considering plain surface

Author(s)

Guillermo Federico Olmedo

Fonseca-Luengo, David

References

R. G. Allen, M. Tasumi, and R. Trezza, "Satellite-based energy balance for mapping evapotranspiration with internalized calibration (METRIC) - Model" Journal of Irrigation and Drainage Engineering, vol. 133, p. 380, 2007

Majumdar, N.; Mathur, B. & Kaushik, S. Prediction of direct solar radiation for low atmospheric turbidity Solar Energy, Elsevier, 1972, 13, 383-394

ASCE-EWRI The ASCE Standardized Reference Evapotranspiration Equation Report of the ASCE-EWRI Task Committee on Standardization of Reference Evapotranspiration, 2005

See Also

Other net radiation related functions: `LAI`, `METRICtopo`, `albedo`, `incLWradiation`, `incSWradiation`, `netRadiation`, `outLWradiation`, `soilHeatFlux`, `solarAngles`, `surfaceTemperature`

`waterOptions` *Global options for water package*

Description

This function is based on raster::rasterOptions by Robert Hijmans.

Usage

```
waterOptions(overwrite, writeResults, outputFolder, SRTMrepo, autoAoi,
  default = FALSE)
```

Arguments

`overwrite`	Logical. If TRUE and writeResults is TRUE it will overwrite results. If FALSE, results are save with a name with name_datetime.
`writeResults`	Logical. If TRUE it'll write result to disk. This is slower but if FALSE you can have out-of-memory problems.
`outputFolder`	Name of a folder to save files, relative to workind folder.
`SRTMrepo`	A folder where SRTM grids are stored, to create DEM. See prepareSRTMdata()
`autoAoi`	Logical. If TRUE it'll look for a object called aoi on .GlobalEnv and use it as aoi. See createAoi()
`default`	Logical. If TRUE will revert all options to defaults values

Value

list of the current options (invisibly). If no arguments are provided the options are printed.

Author(s)

Guillermo F Olmedo, <guillermo.olmedo@gmail.com>

References

Robert J. Hijmans (2015). raster: Geographic Data Analysis and Modeling. R package version 2.4-18. http://CRAN.R-project.org/package=raster

---

`writeRaster.waterLSEB` *writeRaster method for waterLSEB S3 class*

Description

writeRaster method for waterLSEB S3 class

Usage

```
## S3 method for class 'waterLSEB'
writeRaster(x, ...)
```

Arguments

`x`	waterLSEB object.
`...`	additional parameters to pass to writeRaster()

Author(s)

María Victoria Munafó

See Also

Other LSEB objects related functions: `plot.waterLSEB`, `print.waterLSEB`

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