Package 'landsat'

August 25, 2023

Type Package

Title Radiometric and Topographic Correction of Satellite Imagery

Version 1.1.2

Date 2023-08-01

Author Sarah Goslee [aut, cre]

Maintainer Sarah Goslee <sarah.goslee@usda.gov>

Depends R (>= 3.2.0), sp (>= 2.0)

Imports stats, graphics, methods, lmodel2, mgcv

Suggests sf

Description Processing of Landsat or other multispectral satellite imagery. Includes relative normalization, image-based radiometric correction, and topographic correction options. The original package description was published as Goslee (2011) <doi:10.18637/jss.v043.i04>, and details of the topographic corrections in Goslee (2012) <doi:10.14358/PERS.78.9.973>.

License GPL (>= 2)

LazyLoad yes

BugReports https://github.com/phiala/landsat/issues

NeedsCompilation no

Repository CRAN

Date/Publication 2023-08-24 22:20:06 UTC

R topics documented:

Index   **29**

BSL   *Bare Soil Line*

Description

Finds Bare Soil Line (BSL) and maximum vegetation point.

Usage

```
BSL(band3, band4, method = "quantile", ulimit = 0.99, llimit = 0.005, maxval = 255)
```

Arguments

band3	File name or image file (matrix, data frame, or SpatialGridDataFrame) for Landsat band 3 DN (red).
band4	File name or image file (matrix, data frame, or SpatialGridDataFrame) for Landsat band 4 DN (NIR).
method	Either "quantile" or "minimum" – describes way in which soil line is identified.
ulimit	Upper limit for quantile of band ratios (ulimit < 1).
llimit	Lower limit for quantile of band ratios (llimit > 0).
maxval	Maximum value for band data; default of 255 for Landsat 5 and 7.

Details

Finding the BSL requires identifying the lowest NIR values for each level of red. The quantile method takes the lowest set of points, those with a NIR/red ratio less than the llimit-th quantile. The minimum value method takes the lowest NIR value for each level of red. However they are found, these points with low NIR for their red values are used in a major axis regression to find the Bare Soil Line. This function also identifies the full canopy point (maximum vegetation), by using the ulimit to identify the top points, with NIR/red ratio greater than the ulimit-th quantile, and with high NIR values. Red or NIR values of 255 (saturated sensor) are omitted when calculating the BSL.

Value

BSL	Regression coefficients for the Bare Soil Line
top	band 3 and band 4 values for the full canopy point

Author(s)

Sarah Goslee

References

Maas, S. J. & Rajan, N. 2010. Normalizing and converting image DC data using scatter plot matching. Remote Sensing 2:1644-1661.

Examples

```
data(nov3)
data(nov4)
nov.bsl <- BSL(nov3, nov4)
plot(as.vector(as.matrix(nov3)), as.vector(as.matrix(nov4)))
abline(nov.bsl$BSL, col="red")
points(nov.bsl$top[1], nov.bsl$top[2], col="green", cex=2, pch=16)
```

---

clouds	*Create a cloud mask from Landsat bands 1 and 6.*

Description

Uses Landsat band 1 and band 6 to identify clouds and create a cloud mask.

Usage

```
clouds(band1, band6, level = 0.0014, buffer=5)
```

Arguments

band1	File name or image file (matrix, data frame, or SpatialGridDataFrame) for Landsat band 1.
band6	File name or image file (matrix, data frame, or SpatialGridDataFrame) for Landsat band 6.
level	Threshold level for cloud/noncloud decision. The default threshold is appropriate for reflectance and temperature values, and must be adjusted for use with DN.
buffer	Pixel buffer size to expand around thresholded cloud areas.

Details

Clouds are reflective (high) in band 1 and cold (low) in band 6, so the ratio of the two bands is high over clouds. The ratio must be adjusted for data type, whether reflectance, radiance, or DN.

Value

Returns a cloud mask in the same format as band1. Clouds are 1; noncloud areas are NA. Cloud areas are expanded by buffer pixels to ensure that cloud edges are captured.

Author(s)

Sarah Goslee

References

This function is loosely based on: Martinuzzi, S., Gould, W.A., Ramos Gonzales, O.M. 2007. Creating Cloud-Free Landsat ETM+ Data Sets in Tropical Landscapes: Cloud and Cloud-Shadow Removal. USDA Forest Service General Technical Report IITF-GTR-32.

Examples

```
data(july1)
data(july61)
july.cloud <- clouds(july1, july61)

par(mfrow=c(1,2))
image(july1)
image(july.cloud)
```

---

ddate	*Decimal Date*

Description

Convert a vector containing year, month, day or individual year, month, day arguments into a decimal date in years.

Usage

```
ddate(year, month, day)
```

Arguments

year	Either a numeric year OR a vector in the form of c(year, month, day). The latter option is so that ddate() can be conveniently used with apply().
month	If year is a single value, must contain the number of the month.
day	If year is a single value, must contain the number of the day.

Details

ddate() will accept a vector with the three date components so that it can be conveniently used with apply() on a data frame containing columns for year, month and day.

Value

The decimal date in years.

Author(s)

Sarah Goslee

Examples

```
ddate(2001, 5, 15)
```

---

dem   *Digital Elevation Model*

Description

A 30-meter resolution elevation model in SpatialGridDataFrame format that matches the Landsat images nov and july.

Usage

```
data(dem)
```

Details

Elevations are in meters.

Source

Digital Elevation Models for the United States are available from the United States Geologic Survey, http://www.usgs.gov

Examples

```
data(dem)
dem.slopeasp <- slopeasp(dem)

par(mfrow=c(1,3))
image(dem)
image(dem.slopeasp$slope)
image(dem.slopeasp$aspect)
```

DOS   *Dark Object Subtraction*

Description

Calculates calibration value for the Dark Object Subtraction (DOS) method of radiometric correction.

Usage

```
DOS(sat = 5, scattering.coef = c(-4, -2, -1, -0.7, -0.5), SHV, SHV.band, gain,
offset, Grescale, Brescale, sunelev, edist, Esun = c(198.3, 179.6, 153.6,
103.1, 22, 8.34), blackadjust = 0.01)
```

Arguments

sat	Landsat satellite platform: 5 for TM; 7 for ETM+; 8 for OLI.
scattering.coef	
	Atmospheric scattering coefficient; defaults are from Chavez 1988.
SHV	Starting Haze Value
SHV.band	Band from which the Starting Haze Value was obtained.
gain	Band-specific sensor gain. Require either gain and offset or Grescale and Brescale to convert DN to radiance.
offset	Band-specific sensor offset. Require either gain and offset or Grescale and Brescale to convert DN to radiance.
Grescale	Band-specific sensor $G\_rescale$ (gain). Require either gain and offset or Grescale and Brescale to convert DN to radiance.
Brescale	Band-specific sensor $B\_rescale$ (bias). Require either gain and offset or Grescale and Brescale to convert DN to radiance.
sunelev	Sun elevation in degrees
edist	Earth-Sun distance in AU.
Esun	Exo-atmospheric solar irradiance, as given by Chander et al. 2009 or others.
blackadjust	By default, implements 1% adjustment value to compensate for lack of perfectly dark pixels.

Details

The Dark Object Subtraction method assumes that the darkest parts of an image (water, artificial structures) should be black if not for the effects of atmospheric scatter. Corrections to make it possible to use the black value from one band to correct the remaining bands.

Value

DNfinal.mean	The Dark Object Subtraction value for the complete set of scattering coefficients (Table X in Chavez 1989).
DNfinal.approx	
	The same table as DNfinal.mean, but using a numerical approximation across the band wavelength instead of the mean wavelength.

Author(s)

Sarah Goslee

References

Chavez, Jr., P. S. 1988. An improved dark-object subtraction technique for atmospheric scattering correction of multispectral data. Remote Sensing of Environment 24:459-479.

Chavez, Jr., P. S. 1989. Radiometric calibration of Landsat Thematic Mapper multispectral images. Photogrammetric Engineering and Remote Sensing 55: 1285-1294.

See Also

[radiocorr](#)

Examples

```
data(july1)
data(july3)

# One approach to choosing a Starting Haze Value is to take
# the lowest DN value with a frequency greater than some
# predetermined threshold, in this case 1000 pixels.
SHV <- table(july1@data[,1])
SHV <- min(as.numeric(names(SHV)[SHV > 1000]))
# this is used as Lhaze in the radiocorr function

# G_rescale, B_rescale, sun elevation comes from metadata for the SHV band
july.DOS <- DOS(sat=7, SHV=SHV, SHV.band=1, Grescale=0.77569,
Brescale=-6.20000, sunelev=61.4,
edist=ESdist("2002-07-20"))$DNfinal.mean

# DOS() returns results for the complete set of scattering coefficients
# need to choose the appropriate one based on general atmospheric conditions
### -4.0: Very Clear SHV <= 55
### -2.0: Clear SHV 56-75
###  -1.0: Moderate SHV 76-95
### -0.7: Hazy SHV 96-115
### -0.5: Very Hazy SHV >115
# for july, SHV == 70, so use -2.0: Clear
july.DOS <- july.DOS[ , 2]

# Use DOS value as Lhaze in radiocorr() for DOS correction to reflectance
```

```
july3.DOSrefl <- radiocorr(july3, Grescale=0.77569, Brescale=-6.20000,
sunelev=61.4, edist=ESdist("2002-07-20"), Esun=1533,
Lhaze=july.DOS[3], method="DOS")
```

ESdist   *Earth-Sun distance for a given date.*

Description

Calculates the estimated Earth-Sun distance in Astronomical Units (AU) for a given date.

Usage

```
ESdist(adate)
```

Arguments

adate   date in "YYYY-MM-DD" format

Value

Returns estimated Earth-Sun distance in AU.

Author(s)

Sarah Goslee

Examples

```
ESdist("2010-08-30")
```

---

georef   *Simple image-matching georeferencing function.*

Description

Finds best fit between target image and tofix image by minimizing RMSE between the two. The tofix image is moved one pixel at a time horizontally or vertically. Simple automated georeferencing is adequate for some image-processing tasks.

Usage

```
georef(target, tofix, maxdist = 1000, startx = 0, starty = 0)
```

Arguments

target	A georeferenced base image; can be matrix, dataframe or SpatialGridDataFrame.
tofix	The image to be georeferenced; can be matrix, dataframe or SpatialGridDataFrame.
maxdist	The greatest distance to move the tofix image. If this is exceeded, the function will stop.
startx	Shift the tofix image this many pixels in the x direction before beginning, to avoid local minimum.
starty	Shift the tofix image this many pixels in the y direction before beginning, to avoid local minimum.

Details

This function offers a simplistic approach to georeferencing using an iterative algorithm that at each step moves the tofix image one pixel in the direction that produces the greatest reduction in RMSE. When RMSE no longer decreases or maxdist is reached, the algorithm stops, assuming that the tofix image now matches the reference target image. This algorithm can produce local minima. Results should always be checked visually.

Note: this algorithm is only effective with images larger than the samples included with this package. The July and November images are already georectified, but this function will show them as needing considerable adjustment. Images of at least 1000x1000 pixels are necessary for adequate results.

Value

shiftx	The x-direction shift to get the best match (lowest RMSE).
shifty	The y-direction shift to get the best match (lowest RMSE).
initrmse	Initial RMSE between target and tofix images.
currrmse	Lowest RMSE, after shiftx and shifty pixel adjustments. Will be 9999 if maxdist is exceeded.

Author(s)

Sarah Goslee

See Also

geoshift

Examples

```
# to use for georeferencing
data(nov3)
data(july3)
july.shift <- georef(nov3, july3, maxdist=50) # match july to november
july3.corr <- geoshift(july3, padx=50, pady=50, july.shift$shiftx, july.shift$shifty)

# only need to run georef once for a particular date
```

```
# use the same correction for all bands
data(july4)
july4.corr <- geoshift(july4, padx=50, pady=50, july.shift$shiftx, july.shift$shifty)
```

---

geoshift   *Shift and pad an image*

Description

Shifts an image vertically or horizontally and adds a padded border.

Usage

```
geoshift(mat, padx, pady, shiftx, shifty, nodata = NA)
```

Arguments

mat	A matrix, data frame or SpatialGridDataFrame
padx	Number of pixels to add as padding in the x direction on each side of the image (along the x-axis). Should be larger than the number of pixels to shift to avoid data loss.
pady	Number of pixels to add as padding in the y direction on each side of the image (along the y-axis). Should be larger than the number of pixels to shift to avoid data loss.
shiftx	Number of pixels to shift (positive or negative) in the x direction (along the x-axis).
shifty	Number of pixels to shift (positive or negative) in the y direction (along the y-axis).
nodata	Value to use for missing data.

Details

This function can be used to correct spatially-referenced images that are off by a few pixels in the x or y directions. It does not warp an image, only slide it. Adding padding to the outside edge makes it possible to match several images even if they are not stored with georeferecing information. geoshift() can be used in conjunction with georef() to automatically match up geospatial images. Note: directions are relative to the image as displayed by the image() command, and not the underlying matrix representation.

Value

Returns data in the same format as the function was given: matrix, data frame, or SpatialGrid-DataFrame.

Author(s)

Sarah Goslee

See Also

[georef](#)

Examples

```
testmat <- matrix(1:9, 3, 3)
geoshift(testmat, 5, 10, 0, 0)
geoshift(testmat, 5, 10, 2, 2)

# to use for georeferencing
data(nov3)
data(july3)
july.shift <- georef(nov3, july3, maxdist=50) # match july to november
july3.corr <- geoshift(july3, padx=50, pady=50, july.shift$shiftx, july.shift$shifty)

# only need to run georef once for a particular date
# use the same correction for all bands
data(july4)
july4.corr <- geoshift(july4, padx=50, pady=50, july.shift$shiftx, july.shift$shifty)
```

---

histmatch	*Histogram matching of an image*

Description

Force image x to match target image by matching their histograms.

Usage

```
histmatch(master, tofix, mask, minval = 0, maxval = 255, by = 1)
```

Arguments

master	The target image, in SpatialGridDataFrame, data frame, matrix or vector format.
tofix	The image to be normalized, in any format.
mask	Areas to be omitted, if any, such as a cloud mask. Only NA values within the mask will be used.
minval	Lower bound of the possible range of values in target and tofix images.
maxval	Upper bound of the possible range of values in target and tofix images.
by	Step size to use in constructing histograms. Should be appropriate for minval and maxval of the images.

Details

The histogram of the tofix image will be forced to match that of the target image.

Value

recode   The transformation table used to match the histograms.

newimage   The transformed image, in the same format in which tofix was provided.

Author(s)

Sarah Goslee

See Also

relnorm

Examples

```
## Not run:
data(nov3)
data(july3)
par(mfrow=c(2,2))
image(nov3)
image(july3)

nov3.newR <- relnorm(master=july3, tofix=nov3)
image(nov3.newR$newimage)

nov3.newH <- histmatch(master=july3, tofix=nov3)
image(nov3.newH$newimage)

## End(Not run)
```

---

july   *Sample Landsat ETM+ data*

Description

SpatialGridDataFrame containing a 300 x 300 pixel subset (1500 x 1500 m) of the Landsat ETM+
image for path 15, row 32, obtained on 20 July 2002. Each band, including both thermal bands, is
contained in a separate file.

Usage

```
data(july1)
```

Format

Images are in SpatialGridDataFrame format. More information is available in the documentation for the sp package.

Details

Date: 2002-07-20
Satellite: Landsat ETM+ (7)
Sun elevation: 61.4
Sun azimuth: 125.8

_____

band	Grescale	Brescale
1	0.77569	-6.20
2	0.79569	-6.40
3	0.61922	-5.00
4	0.63725	-5.10
5	0.12573	-1.00
7	0.04373	-0.35

Source

Landsat images can be obtained from the United States Geological Survey at http://landsat.usgs.gov

Examples

```
data(july3)
image(july3)
```

---

lssub	*Subset a geotiff image.*

Description

Uses GDAL tools to reproject (optional) and subset a geotiff given the center point and the desired size.

Usage

```
lssub(filename, outname, centerx, centery, centerepsg, widthx, widthy)
```

Arguments

filename	Filename (and path) to a geotiff image.
outname	Filename (and path) for subset image.
centerx	x coordinate of new center point.
centery	y coordinate of new center point.
centerepsg	Projection of the center point coordinates as 5-digit EPSG code. If missing, assume that point and geotiff have the same projection.
widthx	Desired width of subset image.
widthy	Desired height of subset image.

Details

The new image will be a subset of size (widthx, widthy) with center point (centerx, centery), with the same pixel size. If the center point coordinates are in a different projection than the original image, they will be reprojected.

Value

The new image is exported as a geotiff. Nothing is returned within R.

Note

Requires gdalinfo and gdaltransform to be available to the operating system. Only known to work on linux. This function was written to speed processing of multiple files for a specific project, and may be dropped in future releases of the landsat package. On my computer, lssub() is over an order of magnitude faster than reading the image into R, subsetting it, and writing out the result.

Author(s)

Sarah Goslee

Examples

```
## Not run: lssub("/data/gis/testimage.tif", "/data/gis/subimage.tif", centerx = 260485,
centery = 4527220, centerepsg = 26918, widthx = 50, widthy = 50)
## End(Not run)
```

---

minnaert	*Whole-image and pixel-based Minnaert topographic correction of remote sensing data.*

Description

Adds several modified Minnaert corrections to the capabilities of topocorr().

Usage

```
minnaert(x, slope, aspect, sunelev, sunazimuth, na.value = NA, GRASS.aspect=FALSE,
IL.epsilon=0.000001, slopeclass = c(1, 5, 10, 15, 20, 25, 30, 45), coverclass)
```

Arguments

x	Image to be corrected, in matrix, data frame, or SpatialGridDataFrame format.
slope	Slope image of same size and resolution as x.
aspect	Aspect image of same size and resolution as x.
sunelev	Sun elevation in degrees.
sunazimuth	Sun azimuth in degrees.
na.value	Value to use for missing data.
GRASS.aspect	Whether aspect is measured according to GRASS defaults (counterclockwise from east) or is measured clockwise from north. If GRASS.aspect=TRUE, aspect is converted to clockwise from north before analysis.
IL.epsilon	If IL == 0 (Illumination), some methods will give a topographically-corrected value of Inf due to division by zero. If desired, adding a small increment to zero values eliminates this.
slopeclass	The classes into which the slope will be divided before calculating k separately for each class.
coverclass	If present, TRUE/FALSE vector indicating which pixels to use when calculating k. This allows k to be determined separately for different cover classes.

Details

Calculates the Minnaert k coefficients for the whole image and for the individual slope classes.

Value

allcoef	The Minnaert k for the entire image. This is the value used in topocorr() (though the latter may have been truncated).
classcoef	A data frame containing the slope class midpoints, number of pixels per class, and k for that class (for the desired cover class, if specified).
xout	A topographically-corrected image in the same format as x.
xout	A topographically-corrected image in the same format as x.

Author(s)

Sarah Goslee

References

Lu, D., Ge, H., He, S., Xu, A., Zhou, G., and Du, H. 2008. Pixel-based Minnaert correction method for reducing topographic effects on a Landsat 7 ETM+ image. Photogrammetric Engineering and Remote Sensing 74:1343-1350.

See Also

topocorr

Examples

```
# require slope and aspect for topographic correction
data(dem)
dem.slopeasp <- slopeasp(dem)

# use cosine method of topographic correction
data(july4)
july4.minpix <- minnaert(july4, dem.slopeasp$slope, dem.slopeasp$aspect,
sunelev=61.4, sunazimuth=125.8, slopeclass=c(1, 5, 10, 15, 50))
july4.minpix$classcoef # all coefficients
```

---

movingwindow   *Simple moving window function.*

Description

Very simple function to apply a kernel to a matrix across a moving window.

Usage

```
movingwindow(x, kernel, na.rm=TRUE)
```

Arguments

x	A matrix.
kernel	The kernel to be applied to the matrix, for example a Sobel kernel.
na.rm	NA handling option to be passed to sum(). If TRUE, NA will be returned if any value under the kernel is NA or NaN, otherwise NA values will be omitted.

Details

This function is used in the calculation of slope and aspect by slopeasp().

Value

Returns the transformed matrix.

Note

Should be rewritten in C for greater efficiency.

Author(s)

Sarah Goslee

See Also

[slopeasp](#)

Examples

```
data(dem)
dem.smoothed <- movingwindow(dem, matrix(c(1,1,1,1,0,1,1,1,1), 3, 3)/8)

par(mfrow=c(1,2))
image(dem)
image(dem.smoothed)
```

---

nov   *Sample Landsat ETM+ data*

Description

SpatialGridDataFrame containing a 300 x 300 pixel subset (1500 x 1500 m) of the Landsat ETM+ image for path 15, row 32, obtained on 25 November 2002. Each band, including both thermal bands, is contained in a separate file.

Usage

```
data(nov1)
```

Format

Images are in SpatialGridDataFrame format. More information is available in the documentation for the sp package.

Details

Date: 2002-11-25
Satellite: Landsat ETM+ (7)
Sun elevation: 26.2
Sun azimuth: 159.5

———

band	Grescale	Brescale
1	0.77569	-6.20
2	0.79569	-6.40
3	0.61922	-5.00
4	0.63725	-5.10
5	0.12573	-1.00
7	0.04373	-0.35

Source

Landsat images can be obtained from the United States Geological Survey at http://landsat.usgs.gov

Examples

```
data(nov3)
image(nov3)
```

PIF   *Pseudo-Invariant Features*

Description

Pseudo-invariant features identification for relative radiometric normalization.

Usage

```
PIF(band3, band4, band7, level = 0.99)
```

Arguments

band3	Landsat band 3, as a filename to be imported, a matrix, data frame, or Spatial-GridDataFrame.
band4	Landsat band 4, as a filename to be imported, a matrix, data frame, or Spatial-GridDataFrame.
band7	Landsat band 7, as a filename to be imported, a matrix, data frame, or Spatial-GridDataFrame.
level	Threshold level for identifying PIFs. (0 < level < 1)

Details

Pseudo-invariant features (PIFs) are areas such as artificial structures that can reasonably be expected to have a constant reflectance over time, rather than varying seasonally as vegetation does. Differences in PIF reflectance between dates can be assumed to be due to varying atmospheric conditions.

Value

Returns a PIF mask in the same format as the input files, with 1 for pseudo-invariant features and 0 for background data.

Author(s)

Sarah Goslee

References

Schott, J. R.; Salvaggio, C. & Volchok, W. J. 1988. Radiometric scene normalization using pseudoinvariant features. Remote Sensing of Environment 26:1-16.

See Also

RCS

Examples

```
# identify pseudo-invariant feature
data(july3)
data(july4)
data(july7)
july.pif <- PIF(july3, july4, july7)

# use PIFs to related nov to july Landsat data for band 3
# properly, would also remove cloudy areas first
data(nov3)
# use major axis regression: error in both x and y
nov.correction <- lmodel2:::lmodel2(july3@data[july.pif@data[,1] == 1, 1] ~
nov3@data[july.pif@data[,1] == 1, 1])$regression.results[2, 2:3]
nov3.corrected <- nov3
nov3.corrected@data[,1] <- nov3@data[,1] * nov.correction[2] + nov.correction[1]
```

---

radiocorr	*Radiometric correction of Landsat data*

Description

Implements several different methods for absolute radiometric correction of satellite data.

Usage

```
radiocorr(x, gain, offset, Grescale, Brescale, sunelev, satzenith = 0, edist,
Esun, Lhaze, method = "apparentreflectance")
```

Arguments

x	Image to be corrected, in matrix, data frame, or SpatialGridDataFrame format.
gain	Band-specific sensor gain. Require either gain and offset or Grescale and Brescale to convert DN to radiance.
offset	Band-specific sensor offset. Require either gain and offset or Grescale and Brescale to convert DN to radiance.
Grescale	Band-specific sensor Grescale (gain). Require either gain and offset or Grescale and Brescale to convert DN to radiance.

Brescale	Band-specific sensor Brescale (bias). Require either gain and offset or Grescale and Brescale to convert DN to radiance.
sunelev	Sun elevation in degrees
satzenith	Satellite sensor zenith angle (0 for Landsat)
edist	Earth-Sun distance in AU.
Esun	Exo-atmospheric solar irradiance, as given by Chandler et al. 2009 or others.
Lhaze	Haze value, such as SHV from DOS() function. Not needed for apparent reflectance.
method	Radiometric correction method to be used. There are currently four methods available: "apparentreflectance", "DOS" (Chavez 1989), "COSTZ" (Chavez 1996), "DOS4" (SWS+2001).

Details

Uses one of four image-based radiometric correction methods to adjust a satellite image to compensate for atmospheric conditions.

Value

Returns a radiometrically-corrected image in the same format as x.

Author(s)

Sarah Goslee

References

Chavez, Jr., P. S. 1989. Radiometric calibration of Landsat Thematic Mapper multispectral images. Photogrammetric Engineering and Remote Sensing 55:1285-1294.

Chavez, Jr., P. S. 1996. Image-based atmospheric corrections revisited and improved. Photogrammetric Engineering and Remote Sensing 62:1025-1036.

Song, C.; Woodcock, C. E.; Seto, K. C.; Lenney, M. P. & Macomber, S. A. 2001. Classification and change detection using Landsat TM data: when and how to correct atmospheric effects? Remote Sensing of Environment 75:230-244.

See Also

[DOS](DOS)

Examples

```
data(july1)
data(july3)

# One approach to choosing a Starting Haze Value is to take the lowest DN value
# with a frequency greater than some predetermined threshold, in this case 1000 pixels.
SHV <- table(july1@data[,1])
```

```
SHV <- min(as.numeric(names(SHV)[SHV > 1000]))
# this is used as Lhaze in the radiocorr function

# Grescale, Brescale, sun elevation comes from metadata for the SHV band
july.DOS <- DOS(sat=7, SHV=SHV, SHV.band=1, Grescale=0.77569, Brescale=-6.20000,
sunelev=61.4, edist=ESdist("2002-07-20"))$DNfinal.mean

# DOS() returns results for the complete set of scattering coefficients
# need to choose the appropriate one based on general atmospheric conditions
### -4.0: Very Clear SHV <= 55
### -2.0: Clear SHV 56-75
###  -1.0: Moderate SHV 76-95
### -0.7: Hazy SHV 96-115
### -0.5: Very Hazy SHV >115
# for july, SHV == 70, so use -2.0: Clear
july.DOS <- july.DOS[ , 2]

# Use DOS value as Lhaze in radiocorr() for DOS correction to reflectance
july3.DOSrefl <- radiocorr(july3, Grescale=0.77569, Brescale=-6.20000,
sunelev=61.4, edist=ESdist("2002-07-20"), Esun=1533,
Lhaze=july.DOS[3], method="DOS")
```

RCS	*Radiometric Control Sets*

Description

The Radiometric Control Sets method of relative radiometric correction for Landsat data.

Usage

```
RCS(data.tc, level = 0.01)
```

Arguments

data.tc	The output of tasscap().
level	Threshold level to use (0 < level < 1).

Details

Radiometric Control Sets (RCSs) are areas such as artificial structures and large bodies of water that can reasonably be expected to have a constant reflectance over time, rather than varying seasonally as vegetation does. Differences in RCS reflectance between dates can be assumed to be due to varying atmospheric conditions. Pixels with low greenness and either high or low brightness are identified.

Value

Returns an RCS mask file in the format of the original data (vector, matrix, data frame or Spatial-GridDataFrame, as preseved by tasscap()) with 1 for RCS pixels and 0 for background.

Author(s)

Sarah Goslee

References

Hall, F.; Strebel, D.; Nickeson, J. & Goetz, S. 1991. Radiometric rectification: toward a common radiometric response among multidate, multisensor images. Remote Sensing of Environment 35:11-27.

See Also

[PIF](#), [tasscap](#)

Examples

```
# identify radiometric control set
data(july1)
data(july2)
data(july3)
data(july4)
data(july5)
data(july7)
july.tc <- tasscap("july", 7)
july.rcs <- RCS(july.tc)

# use RCS to relate nov to july Landsat data for band 3
# properly, would also remove cloudy areas first
data(nov3)
# use major axis regression: error in both x and y
nov.correction <- lmodel2:::lmodel2(july3@data[july.rcs@data[,1] == 1, 1] ~
nov3@data[july.rcs@data[,1] == 1, 1])$regression.results[2, 2:3]
nov3.corrected <- nov3
nov3.corrected@data[,1] <- nov3@data[,1] * nov.correction[2] + nov.correction[1]
```

---

relnorm   *Relative normalization of an image*

Description

Use regression methods to adjust distribution of values in image tofix to match those in the master image.

Usage

```
relnorm(master, tofix, mask, method = "MA", nperm = 1000)
```

Arguments

master	The target image, in SpatialGridDataFrame, data frame, matrix or vector format.
tofix	The image to be normalized, in any format.
mask	Areas to be omitted, if any, such as a cloud mask. Only NA values within the mask will be used.
method	Regression method to be used. OLS: Ordinary Least Squares; MA: Major Axis (recommended); SMA: Standard Major Axis.
nperm	Number of permutations to use for significance testing.

Details

The regression coefficients from tofix ~ master will be used to match the distribution of values of tofix to those in the master image.

Value

regression.results	
	The regression results from lmodel2
newimage	The transformed image, in the same format in which tofix was provided.

Author(s)

Sarah Goslee

See Also

histmatch

Examples

```
## Not run:
data(nov3)
data(july3)
par(mfrow=c(2,2))
image(nov3)
image(july3)

nov3.newR <- relnorm(master=july3, tofix=nov3)
image(nov3.newR$newimage)

nov3.newH <- histmatch(master=july3, tofix=nov3)
image(nov3.newH$newimage)

## End(Not run)
```

| slopeasp | *Calculate slope and aspect from elevation data.* |

Description

Uses gridded elevation data to calculate slope and aspect, by default using a 3x3 region. The horizontal resolution and vertical resolution must be in the same units.

Usage

```
slopeasp(x, EWres, NSres, EWkernel, NSkernel, smoothing=1)
```

Arguments

x	gridded elevation data, either as a SpatialGridDataFrame, dataframe, or matrix.
EWres	East-West grid resolution. May be omitted if x is a SpatialGridDataFrame and the horizontal units are the same as the vertical units.
NSres	North-South grid resolution. May be omitted if x is a SpatialGridDataFrame and the horizontal units are the same as the vertical units.
EWkernel	The kernel to use when calculating the East-West component of slope. If missing, a 3x3 kernel will be used.
NSkernel	The kernel to use when calculating the North-South component of slope. If missing, a 3x3 kernel will be used.
smoothing	A positive integer describing the additional smoothing to be applied, if any. smoothing=1 (default) means no smoothing will be used.

Details

By default, a 3x3 Sobel filter is used (as is standard in many GIS packages). A larger Sobel filter or a different filter will give varying results. This filter provides the third-order finite difference weighted by reciprocal of distance method proposed by Unwin (1981).

Value

slope	The slope of the DEM, in degrees
aspect	The aspect of the DEM, beginning with north and moving clockwise, and with aspect = 0 where slope = 0.

Author(s)

Sarah Goslee

References

Unwin, D. 1981. Introductory Spatial Analysis. London: Methuen. Clarke, K.C.and Lee, S.J. 2007. Spatial resolution and algorithm choice as modifiers of downslope flow computed from Digital Elevation Models. Cartography and Geographic Information Science 34:215-230.

See Also

[movingwindow](), [topocorr]()

Examples

```
data(dem)
dem.slopeasp <- slopeasp(dem)

par(mfrow=c(1,3))
image(dem)
image(dem.slopeasp$slope)
image(dem.slopeasp$aspect)
```

---

tasscap   *Tasseled Cap for Landsat data*

Description

Tasseled cap transformation for Landsat TM, ETM+, or OLI.

Usage

```
tasscap(basename, sat = 7)
```

Arguments

basename	Base filename (string) to which band numbers are appended, eg "july" for files named "july1", "july2", "july3", etc. Data should be at-sensor reflectance.
sat	Landsat satellite platform: 5 for TM; 7 for ETM+; 8 for OLI.

Details

For Landsat TM, the coefficients are to be applied to "reflectance factors", which appear to be the DN. For ETM+ and OLI, the coefficients are for top-of-atmosphere reflectance. For both TM and ETM+, the bands to be provided are 1, 2, 3, 4, 5, and 7. For OLI, the bands needed are 2 through 7. Future updates will allow use of a raster stack rather than separate objects.

Value

If the input files are matrices or data frames, returns a data frame with three columns, one for each component. If the input files are SpatialGridDataFrames, returns a list with one element for each component. In either case three components are returned: Brightness, Greenness, Wetness.

Author(s)

Sarah Goslee

References

Original papers:

Baig, M. H. A., Zhang, L., Shuai, T. & Tong, Q. 2014. Derivation of a tasselled cap transformation based on Landsat 8 at-satellite reflectance. Remote Sensing Letters 5:423-431.

Crist, E. P. 1985. A TM tasseled cap equivalent transformation for reflectance factor data. Remote Sensing of Environment 17:301-306.

Crist, E. & Kauth, R. 1986. The tasseled cap de-mystified. Photogrammetric Engineering and Remote Sensing 52:81-86.

Huang, C., Wylie, B., Yang, L., Homer, C. & Zylstra, G. 2002. Derivation of a tasseled cap transformation based on Landsat 7 at-satellite reflectance. International Journal of Remote Sensing 23:1741-1748.

Examples

```
data(july1)
data(july2)
data(july3)
data(july4)
data(july5)
data(july7)
july.tc <- tasscap("july", 7)
```

---

thermalband	*Thermal band to temperature conversion.*

Description

Converts Landsat thermal band DN (TM or ETM+ band 6-1 and 6-2) to temperature using default coefficients from Chander et al. 2009.

Usage

```
thermalband(x, band)
```

Arguments

x	Landsat band 6 Digital Number (DN) in matrix, data frame or SpatialGrid-DataFrame format.
band	6 for TM; 61 or 62 for the appropriate ETM+ bands. Any other value will fail.

Value

Returns a temperature image in the same format as x.

Author(s)

Sarah Goslee

References

Coefficients from Chander, G., Markham, B.L., Helder, D.L. 2009. Summary of current radiometric calibration coefficients for Landsat MSS, TM, ETM+, and EO-1 ALI sensors. Remote Sensing of Environment 113:893-903.

Examples

```
data(nov61)
nov.temp1 <- thermalband(nov61, 61)
image(nov.temp1)
```

---

topocorr	*Topographic correction of remote sensing data.*

Description

Implements several different methods for topographic correction of remote sensing data.

Usage

```
topocorr(x, slope, aspect, sunelev, sunazimuth, method = "cosine", na.value = NA,
GRASS.aspect=FALSE, IL.epsilon=0.000001)
```

Arguments

x	Image to be corrected, in matrix, data frame, or SpatialGridDataFrame format.
slope	Slope image of same size and resolution as x.
aspect	Aspect image of same size and resolution as x.
sunelev	Sun elevation in degrees.
sunazimuth	Sun azimuth in degrees.
method	Topographic correction method to be used. There are currently eight methods available: "cosine", "improvedcosine", "minnaert", "ccorrection" (first four from Riano et al. 2003), "minslope" (Minnaert with slope correction, also from Riano et al. 2003), "gamma" (from Richter et al. 2009), "SCS" (Gu and Gillespie 1998, Gao and Zhang 2009), "illumination" (uncorrected illumination).
na.value	Value to use for missing data.
GRASS.aspect	Whether aspect is measured according to GRASS defaults (counterclockwise from east) or is measured clockwise from north. If GRASS.aspect=TRUE, aspect is converted to clockwise from north before analysis.
IL.epsilon	If IL == 0 (Illumination), some methods will give a topographically-corrected value of Inf due to division by zero. If desired, adding a small increment to zero values eliminates this.

Details

Uses one of the available topographic correction methods to compensate for the effects of slope and aspect on reflectance from the land surface.

Value

Returns a topographically-corrected image in the same format as x.

Author(s)

Sarah Goslee

References

Gao, Y. & Zhang, W. 2009. LULC classification and topographic correction of Landsat-7 ETM+ imagery in the Yangjia River Watershed: the influence of DEM resolution. Sensors 9:1980-1995.

Gu, D. & Gillespie, A. 1998. Topographic normalization of Landsat TM images of forest based on subpixel sun-canopy-sensor geometry. Remote Sensing of Environment 64:166-175.

Riano, D., Chuvieco, E., Salas, J. & Aguado, I. 2003. Assessment of different topographic corrections in Landsat-TM data for mapping vegetation types. IEEE Transactions on Geoscience and Remote Sensing 41:1056-1061.

Richter, R., Kellenberger, T. & Kaufmann, H. 2009. Comparison of topographic correction methods. Remote Sensing 1:184-196.

See Also

slopeasp

Examples

```
# require slope and aspect for topographic correction
data(dem)
dem.slopeasp <- slopeasp(dem)

# use cosine method of topographic correction
data(july3)
july3.topo <- topocorr(july3, dem.slopeasp$slope, dem.slopeasp$aspect,
sunelev=61.4, sunazimuth=125.8)
```

Index