Package 'LST'

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Title Land Surface Temperature Retrieval for Landsat 8

Version 2.0.0

Description Calculates Land Surface Temperature from Landsat band 10 and 11.
Revision of the Single-
Channel Algorithm for Land Surface Temperature Retrieval From Landsat Thermal-
Infrared Data. Jimenez-
Munoz JC, Cristobal J, Sobrino JA, et al (2009). <doi:10.1109/TGRS.2008.2007125>.
Land surface temperature retrieval from LANDSAT TM 5. Sobrino JA, Jiménez-
Muñoz JC, Paolini L (2004). <doi:10.1016/j.rse.2004.02.003>.
Surface temperature estimation in Singhbhum Shear Zone of India using Landsat-7 ETM+ thermal infrared data. Srivastava PK, Majumdar TJ, Bhattacharya AK (2009). <doi:10.1016/j.asr.2009.01.023>.
Mapping land surface emissivity from NDVI: Application to European, African, and South American areas. Valor E (1996). <doi:10.1016/0034-4257(96)00039-9>.
On the relationship between thermal emissivity and the normalized difference vegetation index for natural surfaces. Van de Griend AA, Owe M (1993). <doi:10.1080/01431169308904400>.
Land Surface Temperature Retrieval from Landsat 8 TIRS—Comparison between Radiative Transfer Equation-Based Method, Split Window Algorithm and Single Channel Method. Yu X, Guo X, Wu Z (2014). <doi:10.3390/rs6109829>.
Calibration and Validation of land surface temperature for Landsat8-
TIRS sensor. Land product validation and evolution. Skoković D, Sobrino JA, Jimenez-
Munoz JC, Soria G, Julien Y, Mattar C, Cristóbal J. (2014).

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Contents

BT *At-Sensor Temperature or brightness temperature*

Description

This function calculates at-Sensor Temperature or brightness temperature

Usage

```
BT(Landsat_10, Landsat_11)
```

Arguments

`Landsat_10`	SpatRaster object, Landsat band 10
`Landsat_11`	SpatRaster object, Landsat band 11

Value

A list containing brightness temperature corresponding to Landsat band 10 and Landsat band 11

Examples

```
a <- terra::rast(ncol=100, nrow=100)
set.seed(2)
terra::values(a) = runif(10000, min=27791, max=30878)

b <- terra::rast(ncol=100, nrow=100)
set.seed(2)
terra::values(b) = runif(10000, min=25686, max=28069)

BT(Landsat_10 = a, Landsat_11 = b)
```

E_Skokovic *Land Surface Emissivity according to Skokovic et al. 2014*

Description

This function calculates Land Surface Emissivity according to Skokovic et al. 2014

Usage

```
E_Skokovic(red = red, NDVI = NDVI, band = band)
```

Arguments

red	SpatRaster object, red band of remote sensing imagery
NDVI	SpatRaster object, NDVI calculated from remote sensing imagery
band	A string specifying which Landsat 8 thermal band to use. It can be "band 10" or "band 11"

Value

SpatRaster

References

Skoković, D., Sobrino, J.A., Jimenez-Munoz, J.C., Soria, G., Julien, Y., Mattar, C. and Cristóbal, J., 2014. Calibration and Validation of land surface temperature for Landsat8-TIRS sensor. Land product validation and evolution.

Examples

```
red <- terra::rast(ncol=100, nrow=100)
set.seed(2)
terra::values(red) = runif(10000, min=0.1, max=0.4)
NDVI <- terra::rast(ncol=100, nrow=100)
set.seed(2)
terra::values(NDVI) = runif(10000, min=0.02, max=0.8)
E_Skokovic(red = red, NDVI = NDVI, band = "band 11")
```

E_Sobrino *Land Surface Emissivity according to Sobrino et al. 2008*

Description

This function calculates Land Surface Emissivity according to Sobrino et al. 2008

Usage

```
E_Sobrino(red = red, NDVI = NDVI)
```

Arguments

red	SpatRaster object, red band of remote sensing imagery
NDVI	SpatRaster object, NDVI calculated from remote sensing imagery

Value

SpatRaster

References

Sobrino, J.A., Jiménez-Muñoz, J.C., Sòria, G., Romaguera, M., Guanter, L., Moreno, J., Plaza, A. and Martínez, P., 2008. Land surface emissivity retrieval from different VNIR and TIR sensors. IEEE transactions on geoscience and remote sensing, 46(2), pp.316-327.

Examples

```
red <- terra::rast(ncol=100, nrow=100)
set.seed(2)
terra::values(red) = runif(10000, min=0.1, max=0.4)
NDVI <- terra::rast(ncol=100, nrow=100)
set.seed(2)
terra::values(NDVI) = runif(10000, min=0.02, max=0.8)
E_Sobrino(red = red, NDVI = NDVI)
```

E_Valor *Land Surface Emissivity according to Valor and Caselles 1996*

Description

This function calculates Land Surface Emissivity according to Valor and Caselles 1996

Usage

```
E_Valor(NDVI)
```

Arguments

NDVI	SpatRaster object, NDVI calculated from remote sensing imagery

Value

SpatRaster

References

Valor, E. and Caselles, V., 1996. Mapping land surface emissivity from NDVI: Application to European, African, and South American areas. Remote sensing of Environment, 57(3), pp.167-184.

Examples

```
NDVI <- terra::rast(ncol=100, nrow=100)
set.seed(2)
terra::values(NDVI) = runif(10000, min=0.02, max=0.8)
E_Valor(NDVI)
```

E_VandeGriend *Land Surface Emissivity according to Van de Griend and Owe 1993*

Description

This function calculates Land Surface Emissivity according to Van de Griend and Owe 1993

Usage

```
E_VandeGriend(NDVI)
```

Arguments

NDVI	SpatRaster object, NDVI calculated from remote sensing imagery

Value

SpatRaster

References

Van de Griend, A.A. and Owe, M., 1993. On the relationship between thermal emissivity and the normalized difference vegetation index for natural surfaces. International Journal of remote sensing, 14(6), pp.1119-1131.

Examples

```
NDVI <- terra::rast(ncol=100, nrow=100)
set.seed(2)
terra::values(NDVI) = runif(10000, min=0.02, max=0.8)
E_VandeGriend(NDVI)
```

E_Yu *Land Surface Emissivity according to Yu et al. 2014*

Description

This function calculates Land Surface Emissivity according to Yu et al. 2014

Usage

```
E_Yu(red = red, NDVI = NDVI, band = band)
```

Arguments

red	SpatRaster object, red band of remote sensing imagery
NDVI	SpatRaster object, NDVI calculated from remote sensing imagery
band	A string specifying which Landsat 8 thermal band to use. It can be "band 10" or "band 11"

Value

SpatRaster

References

Yu, X., Guo, X. and Wu, Z., 2014. Land surface temperature retrieval from Landsat 8 TIRS—Comparison between radiative transfer equation-based method, split window algorithm and single channel method. Remote sensing, 6(10), pp.9829-9852.

Examples

```
red <- terra::rast(ncol=100, nrow=100)
set.seed(2)
terra::values(red) = runif(10000, min=0.1, max=0.4)
NDVI <- terra::rast(ncol=100, nrow=100)
set.seed(2)
terra::values(NDVI) = runif(10000, min=0.02, max=0.8)
E_Yu(red = red, NDVI = NDVI, band = "band 11")
```

MWA *Mono window algorithm*

Description

This function calculates Land Surface Temperature using mono window algorithm

Usage

```
MWA(BT = BT, tau = tau, E = E, Ta = Ta)
```

Arguments

BT	SpatRaster object, brightness temperature
tau	Atmospheric transmittance
E	SpatRaster object, Land Surface Emissivity calculated according to Van de Griend and Owe 1993 or Valor and Caselles 1996 or Sobrino et al. 2008
Ta	Mean atmospheric temperature (K) of the date when Landsat passed over the study area

Value

SpatRaster

References

Qin, Z., Karnieli, A. and Berliner, P., 2001. A mono-window algorithm for retrieving land surface temperature from Landsat TM data and its application to the Israel-Egypt border region. International journal of remote sensing, 22(18), pp.3719-3746.

Examples

```
BTemp <- terra::rast(ncol=100, nrow=100)
set.seed(2)
terra::values(BTemp) = runif(10000, min=298, max=305)
E <- terra::rast(ncol=100, nrow=100)
set.seed(2)
terra::values(E) = runif(10000, min=0.96, max=0.99)
MWA(BT = BTemp, tau = 0.86, E = E, Ta = 26)
```

NDVI *NDVI*

Description

Function for NDVI calculation

Usage

```
NDVI(Red, NIR)
```

Arguments

Red	SpatRaster object, red band of remote sensing imagery
NIR	SpatRaster object, NIR band of remote sensing imagery

Value

SpatRaster

Examples

```
red <- terra::rast(ncol=100, nrow=100)
set.seed(2)
terra::values(red) = runif(10000, min=0.1, max=0.4)

NIR <- terra::rast(ncol=100, nrow=100)
set.seed(2)
terra::values(NIR) = runif(10000, min=0.1, max=0.6)

NDVI(Red = red, NIR = NIR)
```

Pv *Proportion of vegetation or fractional vegetation cover*

Description

Calculation of the proportion of vegetation or fractional vegetation cover from NDVI

Usage

```
Pv(NDVI, minNDVI, maxNDVI)
```

Arguments

NDVI	SpatRaster object, NDVI calculated from remote sensing imagery
minNDVI	= 0.2 (Ref. Sobrino et al. 2004)
maxNDVI	= 0.5 (Ref. Sobrino et al. 2004)

Value

SpatRaster

References

Sobrino, J.A., Jiménez-Muñoz, J.C. and Paolini, L., 2004. Land surface temperature retrieval from LANDSAT TM 5. Remote Sensing of environment, 90(4), pp.434-440.

Examples

```
NDVI <- terra::rast(ncol=100, nrow=100)
set.seed(2)
terra::values(NDVI) = runif(10000, min=0.02, max=0.8)
Pv(NDVI = NDVI, minNDVI = 0.2, maxNDVI = 0.5)
```

RTE *Radiative transfer equation method*

Description

This function calculates Land Surface Temperature using radiative transfer equation method

Usage

```
RTE(TIR = TIR, tau = tau, E = E, dlrad = dlrad, ulrad = ulrad, band = band)
```

Arguments

TIR	SpatRaster object, Landsat band 10 or 11
tau	Atmospheric transmittance
E	SpatRaster object, Land Surface Emissivity calculated according to Van de Griend and Owe 1993 or Valor and Caselles 1996 or Sobrino et al. 2008
dlrad	Downwelling radiance calculated from https://atmcorr.gsfc.nasa.gov/
ulrad	upwelling radiance calculated from https://atmcorr.gsfc.nasa.gov/
band	A string specifying which Landsat 8 thermal band to use. It can be "band 10" or "band 11"

Value

SpatRaster

References

Srivastava, P.K., Majumdar, T.J. and Bhattacharya, A.K., 2009. Surface temperature estimation in Singhbhum Shear Zone of India using Landsat-7 ETM+ thermal infrared data. Advances in space research, 43(10), pp.1563-1574.

Examples

```
TIR <- terra::rast(ncol=100, nrow=100)
set.seed(2)
terra::values(TIR) = runif(10000, min=27791, max=30878)
BT <- terra::rast(ncol=100, nrow=100)
set.seed(2)
terra::values(BT) = runif(10000, min=298, max=305)
E <- terra::rast(ncol=100, nrow=100)
set.seed(2)
terra::values(E) = runif(10000, min=0.96, max=0.99)
Ts_RTE <- RTE(TIR = TIR, tau = 0.86, E = E,
dlrad = 2.17, ulrad = 1.30, band = "band 11")
```

SCA *Single channel algorithm*

Description

This function calculates Land Surface Temperature using single channel algorithm

Usage

```
SCA(TIR = TIR, tau = tau, E = E, dlrad = dlrad, ulrad = ulrad, band = band)
```

Arguments

TIR	SpatRaster object, Landsat band 10 or 11
tau	Atmospheric transmittance
E	SpatRaster object, Land Surface Emissivity calculated according to Van de Griend and Owe 1993 or Valor and Caselles 1996 or Sobrino et al. 2008
dlrad	Downwelling radiance calculated from https://atmcorr.gsfc.nasa.gov/
ulrad	upwelling radiance calculated from https://atmcorr.gsfc.nasa.gov/
band	A string specifying which Landsat 8 thermal band to use. It can be "band 10" or "band 11"

Value

SpatRaster

References

Jimenez-Munoz, J.C., Cristobal, J., Sobrino, J.A., Sòria, G., Ninyerola, M. and Pons, X., 2008. Revision of the single-channel algorithm for land surface temperature retrieval from Landsat thermal-infrared data. IEEE Transactions on geoscience and remote sensing, 47(1), pp.339-349.

Examples

```
TIR <- terra::rast(ncol=100, nrow=100)
set.seed(2)
terra::values(TIR) = runif(10000, min=27791, max=30878)
E <- terra::rast(ncol=100, nrow=100)
set.seed(2)
terra::values(E) = runif(10000, min=0.96, max=0.99)
Ts_SCA <- SCA(TIR = TIR, tau = 0.86, E = E,
dlrad = 2.17, ulrad = 1.30, band = "band 11")
```

SWA *Split-window algorithm*

Description

This function calculates Land Surface Temperature using split-window algorithm

Usage

```
SWA(
  TIR_10 = TIR_10,
  TIR_11 = TIR_11,
  tau_10 = tau_10,
  tau_11 = tau_11,
  E_10 = E_10,
  E_11 = E_11
)
```

Arguments

TIR_10	SpatRaster object, Landsat band 10
TIR_11	SpatRaster object, Landsat band 11
tau_10	Atmospheric transmittance for Landsat band 10
tau_11	Atmospheric transmittance for Landsat band 11
E_10	SpatRaster object, Land Surface Emissivity for Landsat band 10 calculated according to Skokovic et al. 2014 or Yu et al. 2014
E_11	SpatRaster object, Land Surface Emissivity for Landsat band 11 calculated according to Skokovic et al. 2014 or Yu et al. 2014

Value

SpatRaster

References

Yu, X., Guo, X. and Wu, Z., 2014. Land surface temperature retrieval from Landsat 8 TIRS—Comparison between radiative transfer equation-based method, split window algorithm and single channel method. Remote sensing, 6(10), pp.9829-9852.

Examples

```
TIR_10 <- terra::rast(ncol=100, nrow=100)
set.seed(2)
terra::values(TIR_10) = runif(10000, min=27791, max=30878)
TIR_11 <- terra::rast(ncol=100, nrow=100)
set.seed(2)
terra::values(TIR_11) = runif(10000, min=25686, max=28069)
E_10 <- terra::rast(ncol=100, nrow=100)
set.seed(1)
terra::values(E_10) = runif(10000, min=0.96, max=0.99)
E_11 <-terra::rast(ncol=100, nrow=100)
set.seed(2)
terra::values(E_11) = runif(10000, min=0.96, max=0.99)
Ts_SWA <- SWA(TIR_10=TIR_10, TIR_11=TIR_11, tau_10=0.86,
tau_11=0.87, E_10=E_10, E_11=E_11)
```

Ta *Mean atmospheric temperature*

Description

This function calculates mean atmospheric temperature (Ta) using near-surface air temperature (To)

Usage

```
Ta(To = To, mod = mod)
```

Arguments

To	Near-surface air temperature (°C) of the date when Landsat passed over the study area
mod	A string specifying which model to use. It can be anyone of "USA 1976 Standard" or "Tropical Region" or "Mid-latitude Summer Region" or "Mid-latitude Winter Region"

Value

Mean atmospheric temperature (K)

References

Sekertekin, A. and Bonafoni, S., 2020. Land surface temperature retrieval from Landsat 5, 7, and 8 over rural areas: Assessment of different retrieval algorithms and emissivity models and toolbox implementation. Remote sensing, 12(2), p.294.

Examples

```
Ta(To = 26, mod = "Mid-latitude Winter Region")
```

tau *Atmospheric transmittance calculation*

Description

This function calculates Atmospheric transmittance from near-surface air temperature (To, °C) and relative humidity (RH, %) of the date when Landsat passed over the study area

Usage

```
tau(To = To, RH = To, band = band)
```

Arguments

To	Near-surface air temperature (°C) of the date when Landsat passed over the study area
RH	relative humidity (%) of the date when Landsat passed over the study area
band	A string specifying which Landsat 8 thermal band to use. It can be "band 10" or "band 11"

Value

Atmospheric transmittance

Examples

```
tau(To = 26, RH = 42, band = "band 11")
```

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