Package ‘nixmass’

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R topics documented:

hsdata ................................................................. 2
nixmass ............................................................. 3
plot.nixmass ......................................................... 5
summary.nixmass ................................................... 5
swe.delta.snow .................................................... 6
swe.gu19 ............................................................ 7
swe.jo09 ............................................................. 8
swe.pi16 ............................................................. 9
swe.st10 ............................................................ 10

Index 12
 hsdata  

Daily snow depth data for a northern alpine station

Description

Gapless daily snow depth observations for a winter season from 1.8. - 31.7. from a station situated in the northern eastern alps at an altitude of 600 m. For anonymization the years are intentionally set to 1900 - 1901.

This data series is free of gaps with a minimum of 0 and a maximum of 1.3 meters. It is intended to be used as is as input data for the package nixmass to calculate snow water equivalent and bulk snow density with the delta.snow method and several empirical regression models from the literature.

Usage

data("hsdata")

Format

A data.frame named data with columns date and hs. The date column contains character strings of the format "YYYY-MM-DD" and is of class character. The hs column holds daily observed snow depths in meters and is of class numeric.

Examples

```r
## Load example data
data("hsdata")

## explore dataset
head(hsdata)
plot(hsdata$hs, type="o")

## compute snow water equivalents
o <- nixmass(hsdata, model="delta.snow",verbose=TRUE)
plot(o)

o1 <- nixmass(hsdata, alt=600, region.jo09 = 6, region.gu19 = "central",
               snowclass.st10 = "alpine", verbose = FALSE)
plot(o1)
summary(o1)
```
**nixmass**  
*SWE modeling with the delta.snow process based model and several empirical regression models.*

**Description**

Snow Water Equivalent (SWE) is modeled either exclusively from daily snow depth changes or statistically depending on snow depth, altitude, date and climate class.

**Usage**

```r
nixmass(data, model = c("delta.snow","jo09","pi16","st10","gu19"),
        alt, region.jo09, region.gu19, snowclass.st10, verbose = FALSE)
```

**Arguments**

- `data`: A data.frame of daily observations with two columns named `date` and `hs` referring to day and snow depth at that day. Values in the date column must be of class character with format `YYYY-MM-DD`. Values in the `hs` column must be snow depth values of class numeric ≥ 0 in m. No gaps or NA are allowed.

- `model`: Defines model for SWE computation. Can be one, several or all of "delta.snow","jo09","pi16","st10","gu19". If no model is given, all models are computed.

- `alt`: Must be given if one of model is "jo09". Station elevation in meters

- `region.jo09`: Must be given if one of model is "jo09". This must be an integer number between 1 and 7 of the Swiss region where the station belongs to, according to Fig. 1 in the original reference.

- `region.gu19`: If model contains "gu19" this must be one of "italy", "southwest", "central" or "southeast" as described in the original reference.

- `snowclass.st10`: Must be given if one of model is "st10". Must be one of the following character strings: "alpine","maritime","prairie","tundra","taiga" as outlined in the original reference.

- `verbose`: Logical. Should additional information be given during runtime?

**Details**

`nixmass` This function is a wrapper for the computation of SWE with different models. The process based model `delta.snow` can be chosen, as well as different empirical regression models of Jonas, Pistocchi, Sturm and Guyennon. For the "delta.snow" model and the ones of "Pistocchi" and "Guyennon", the needed parameters and coefficients from the original references are set as default. They can however be changed according to results from other datasets. For the other models of "Jonas" and "Sturm" regression coefficients are fixed.

The computation is quite fast and there does not exist any restriction regarding the length of the data. However, if many years have to be modeled at once, it is recommended to split the computation into single years, separated by zero snow depth values.
Value

A list of class "nixmass" with components:

- `swe` Contains a list of numerical vectors. Each entry refers to SWE values computed with the selected model(s).
- `date` Character vector of date strings in the format `YYYY-MM-DD`.
- `hs` Vector of snow depth values used to compute SWE.

Author(s)

Harald Schellander, Michael Winkler

References


Examples

```r
## Load example data with realistic snow depth values
## from a station at 600 meters in the northern Alps
## Note that the winter season is set to an arbitrary date
## to mask its origin
data(hsdata)
o <- nixmass(hsdata, model="delta.snow",verbose=TRUE)
plot(o)
o1 <- nixmass(hsdata, alt=600, region.jo09=6, region.gu19 = "central",
             snowclass.st10 = "alpine", verbose = FALSE)
plot(o1)
summary(o1)
```
plot.nixmass

Plot modeled SWE values of a nixmass object.

Description
Plot modeled SWE values of a nixmass object.

Usage
## S3 method for class 'nixmass'
plot(x, title = NULL, ...)

Arguments
x       nixmass object.
title       Main plot title.
...       Further graphical parameters may also be supplied as arguments. See plot.

Value
Does not return anything. A plot is produced.

summary.nixmass
Print summary of a nixmass object.

Description
Print summary of a nixmass object.

Usage
## S3 method for class 'nixmass'
summary(object, ...)

Arguments
object       nixmass object.
...       additional arguments affecting the summary produced.

Value
Summary information of SWE values calculated with selected models is printed to the screen.
Description
Model daily values of Snow Water Equivalent (SWE) solely from daily differences of snow depth.

Usage
swe.delta.snow(data, rho.max=401.2588, rho.null=81.19417, c.ov=0.0005104722,
k.ov=0.37856737, k=0.02993175, tau=0.02362476, eta.null=8523356,
timestep=24, verbose=FALSE)

Arguments
data A data.frame with at least two columns named date and hs. They should contain date and corresponding daily observations of snow depth $hs \geq 0$ measured at one site. The unit must be meters (m). No gaps or NA are allowed.
rho.max Maximum density of an individual snow layer produced by the deltasnow model [kg/m3], $rho.max > 0$
rho.null Fresh snow density for a newly created layer [kg/m3], $rho.null > 0$
c.ov Overburden factor due to fresh snow [-], $c.ov > 0$
k.ov Defines the impact of the individual layer density on the compaction due to overburden [-], $k.ov \in [0, 1]$.
k Exponent of the exponential-law compaction [m3/kg], $k > 0$.
tau Uncertainty bound [m], $tau > 0$.
eta.null Effective compactive viscosity of snow for "zero-density" [Pa s].
timestep Timestep between snow depth observations in hours. Default is 24 hours, i.e. daily snow depth observations.
verbose Should additional information be given during runtime? Can be TRUE or FALSE.

Details
swe.delta.snow computes SWE solely from daily changes of snow depth at an observation site. Compression of a snow layer without additional load on top is computed on the basis of Sturm and Holmgren (1998), who regard snow as a viscous fluid:

$$\rho_i(t_{i+1}) = \rho_i(t_i) \star (1 + (SWE \star g)/\eta_0 \star exp^{-k2*\rho_i(t_i)})$$

with $\rho_i(t_{i+1})$ and $\rho_i(t_i)$ being tomorrow’s and today’s respective density of layer i, the gravitational acceleration $g = 9.8 m/s^2$, viscosity $\eta_0$ [Pa] and factor $k2[m^3 kg^{-1}]$, determining the importance of today’s for tomorrow’s density.

Value
A vector with daily SWE values in mm.
Author(s)

Harald Schellander, Michael Winkler

References

Gruber, S. (2014) "Modelling snow water equivalent based on daily snow depths", Masterthesis, Institute for Atmospheric and Cryospheric Sciences, University of Innsbruck.


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swe.gu19

Statistical SWE modeling based on a quadratic dependance on the day-of-year

Description

This model parameterizes bulk snow density with day-of-the-year as the only input similar to swe.pi16 but adds a quadratic dependance. It was calibrated for the regions of the whole Italian alps, and the subregions South-West, Central and South-East. By setting the coefficients of the empirical regression it can however be used with results from other datasets.

Usage

swe.gu19(data, region.gu19, n0=NA ,n1=NA, n2=NA)

Arguments

data A data.frame of daily observations with two columns named date and hs referring to day and snow depth at that day. The date column must be a character string with the format YYYY-MM-DD. The hs column must be snow depth values ≥ 0 in m.

region.gu19 Must be one of the italian subalpine regions italy, southwest, central or southeast, defined in the original reference (see details), or myregion, in which case the coefficients n0, n1 and n2 have to be set.

n0,n1,n2 Values n0, n1 and n2 refer to Intercept, slope and quadratic dependence of an empirical regression between densities and the day-of-year (see details)
Details

`swe.gu19` Similar to the model of Pistocchi (2016), this function uses only the day-of-year (DOY) as parameterization for bulk snow density and hence SWE. In contrast to the latter, here, a quadratic term for DOY was added, to reflect non-linearity in the snow bulk density variability. The datums in the input data.frame are converted to DOY as days spent since November 1st. Regression coefficients depend on regions defined in Guyennon et al. (2019), which are `italy` for the Italian Alps, `southwest` for the South-western Italian Alps, `central` for the Central Italian Alpes or `southeast` for the South-western Italian Alps.

If `region.gu19` is set to `myregion`, the coefficients no, n1 and n2 must be set to values, obtained from a regression between densities and day-of-year from another dataset. It has to have the form density ~ DOY + DOY^2, where DOY is the day-of-year as defined in the original reference. Non computable values are returned as NA.

Value

A vector with daily SWE values in mm.

References


`swe.jo09` Statistical SWE modeling depending on month and climatic region in Switzerland

Description

Snow Water Equivalent (SWE) is modeled statistically depending on snow depth, altitude, date and region in Switzerland.

Usage

`swe.jo09(data, alt, region.jo09)`

Arguments

data A data.frame of daily observations with two columns named `date` and `hs` referring to day and snow depth at that day. The date column must be a character string with the format YYYY-MM-DD. The `hs` column must be snow depth values ≥ 0 in m.

alt station elevation in meters

region.jo09 Integer number of the Swiss region where the station belongs to, according to Fig. 1 in the original reference. Must be one of 1,2,3,4,5,6,7.
Details

This model parametrizes bulk snow density using snow depth, season (i.e. month), site altitude and site location. The location is implemented by a density offset according to the region in Switzerland, where the station belongs to. Non computable values are returned as NA.

Value

A list with SWE values for each region in mm.

References


swe.pi16

Statistical SWE modeling depending on the day-of-year

Description

This model parameterizes bulk snow density with day-of-the-year as the only input. It was calibrated for the region of South Tyrol, Italy, and is therefore called ST model in the original reference.

Usage

`swe.pi16(data, rho_0=200, K=1)`

Arguments

- `data` A data.frame of daily observations with two columns named `date` and `hs` referring to day and snow depth at that day. The date column must be a character string with the format `YYYY-MM-DD`. The `hs` column must be snow depth values ≥ 0 in m.
- `rho_0` Intercept of the linear regression between observed snow depths and SWE values. `rho_0` is set to 200 as default, which is the value from the original reference. It can however be set to any value according to regression modeling with other datasets.
- `K` Slope of the linear regression between observed densities and the day-of-year as defined in the original reference. `K` is set to 1 as default, which is the value from the original reference. It can however be set to any value according to regression modeling with other datasets.
Details

`swe.pi16` This function uses only the day-of-year (DOY) as parameterization for bulk snow density and hence SWE. Here, the datums in the input data.frame are converted to DOY as defined in the original reference: negative values between 1.10. and 31.12. DOY=-92 at 1.10. In leap years 31.12. has DOY = 0, in non-leap years 31.12. has DOY = -1 with no day being 0. Non computable values are returned as NA.

Value

A vector with daily SWE values in mm.

References


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`swe.st10`  
*Statistical SWE modeling depending on day of year and a climatic region*

Description

The *Sturm* model parametrizes bulk snow density with day of the year and a `snowclass.st10`. It was trained on historical snow depth - density - SWE data from the United States, Canada, and Switzerland.

Usage

`swe.st10(data,snowclass.st10)`

Arguments

- `data`  
  A data.frame of daily observations with two columns named `date` and `hs` referring to day and snow depth at that day. The date column must be a character string with the format `YYYY-MM-DD`. The hs column must be snow depth values $\geq 0$ in m.

- `snowclass.st10`  
  Must be one of the following character strings: "alpine","maritime","prairie","tundra","taiga".

Details

`swe.st10` This model converts snow depth to SWE using snow depth, day of year and station location (from which a climate class of snow can be inferred. The day of year (DOY) is the day-number of in the season 1.10. - 30.6. The 1.10. refers to DOY = -92. The 1.2. would be DOY = 32, while 15.11. would be DOY = -47. The `snowclass.st10` must be one out of the character strings "alpine","maritime","prairie","tundra" and "taiga". For the Alps probably "alpine" would be the most appropriate climate classification. Non computable values are returned as NA.
**Value**

A vector with daily SWE values in mm.

**References**

Index

* doy
  swe.gu19, 7
  swe.pi16, 9

* modeling
  nixmass, 3
  swe.delta.snow, 6
  swe.gu19, 7
  swe.jo09, 8
  swe.pi16, 9
  swe.st10, 10

* snow depth
  nixmass, 3
  swe.delta.snow, 6
  swe.gu19, 7
  swe.jo09, 8
  swe.pi16, 9
  swe.st10, 10

* statistical
  nixmass, 3
  swe.gu19, 7
  swe.jo09, 8
  swe.pi16, 9
  swe.st10, 10

* swe
  nixmass, 3
  swe.delta.snow, 6
  swe.gu19, 7
  swe.jo09, 8
  swe.pi16, 9
  swe.st10, 10

  delta.snow, 3
  Guyennon, 3
  hsdata, 2
  Jonas, 3
  nixmass, 2, 3

  Pistocchi, 3
  plot, 5
  plot.nixmass, 5

  Sturm, 3
  summary.nixmass, 5
  swe.delta.snow, 6
  swe.gu19, 7
  swe.jo09, 8
  swe.pi16, 7, 9
  swe.st10, 10