Package 'sarp.snowprofile'

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Title Snow Profile Analysis for Snowpack and Avalanche Research

Description Analysis and plotting tools for snow profile data produced from manual snowpack observations and physical snowpack models. The functions in this package support snowpack and avalanche research by reading various formats of data (including CAAML, SMET, generic csv, and outputs from the snow cover model SNOWPACK), manipulate the data, and produce graphics such as stratigraphy and time series profiles. Package developed by the Simon Fraser University Avalanche Research Program <http://www.avalancheresearch.ca>.
Graphics apply visualization concepts from Horton, Nowak, and Haegeli (2020, <doi:10.5194/nhess-20-1557-2020>).

URL http://www.avalancheresearch.ca

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Contents

`assignDatetags` *Assign layers in simulated snow profiles to precomputed datetags*

Description

This routine assigns each layer of simulated snow profiles to precomputed datetags. Conceptually, each datetag represents a date when the surface layers get buried by new snow. To assign layers to datetags, the routine chooses the closest datetag that is older than the layer formation date. This routine needs precomputed datetags, which are currently computed based on precipitation patterns by functions in other packages. Once layers are assigned to datetags, layers from different locations or times can easily be grouped by their datetags.

Usage

```
assignDatetags(
  x,
  potentialDatetags,
  vdate = NULL,
  adjust_bdates = FALSE,
  computeBDate = TRUE,
  checkMonotonicity = ifelse(computeBDate, TRUE, FALSE),
  ...
)
```

```
## S3 method for class 'snowprofileSet'
assignDatetags(
  x,
  potentialDatetags,
  vdate = NULL,
  adjust_bdates = FALSE,
  computeBDate = TRUE,
  checkMonotonicity = ifelse(computeBDate, TRUE, FALSE),
  ...
)

## S3 method for class 'snowprofile'
assignDatetags(
  x,
  potentialDatetags,
  vdate = NULL,
  adjust_bdates = FALSE,
  computeBDate = TRUE,
  checkMonotonicity = ifelse(computeBDate, TRUE, FALSE),
  ...
)

## S3 method for class 'snowprofileLayers'
assignDatetags(
  x,
  potentialDatetags,
  vdate,
  adjust_bdates = FALSE,
  computeBDate = TRUE,
  checkMonotonicity = ifelse(computeBDate, TRUE, FALSE),
  ...
)
```

Arguments

`x`	a snowprofileSet, snowprofile or snowprofileLayers object
`potentialDatetags`	a character or Date array of all potential datetags of the season. This array is currently provided by `sarp.2021.herla.snowprofilevalidation::derivePotentialDatetags()` only.
`vdate`	date when the profile and layer information is valid (i.e., `profile$date`)
`adjust_bdates`	boolean switch to compute bdates that are more similar to human interpretation. Deprecated and not recommeneded, see Details.
`computeBDate`	compute burial dates (`bdates`) from layer deposition dates?
`checkMonotonicity`	check ascending order of layers. This acts as a check for whether multiple layers objects are stacked, which is not allowed.

... passed on to subsequent methods

Details

As a side effect and to issue warnings when layers might not be assigned to meaningful datetags, the routine also computes the exact burial dates (bdates) of layers, which is the ddate of the overlying layer. For snowpack simulations with thin layer resolution, this approach yields very similar ddates and bdates for most layers, since most layers form and instantly get buried by another layer of the same storm. Before implementing the aforementioned approach of pre-computing datetags based on weather patterns, this routine attempted to make bdates more similar to human interpretation by adjusting bdates, so that (similar) layers with the same ddate (i.e., same storm) inherit the same bdate (similar means: identical gtype & hardness). This feature is still available by setting adjust_bdates to TRUE, which is not recommended, though.

Value

The input object will be returned with the columns datetag and bdate added to the profile layers

Methods (by class)

- assignDatetags(snowprofileSet): for snowprofileSets
- assignDatetags(snowprofile): for snowprofiles
- assignDatetags(snowprofileLayers): for snowprofileLayers

Author(s)

fherla

See Also

deriveBDate, guessDatetagsSimple

Examples

```
## TODO: create a meaningful example!
```

---

char2numAspect *Conversion of character Aspects to numeric Aspects*

Description

Convert character aspects (of snow profile locations) to numeric values. For example, Aspect "N" (north) becomes 0 degrees azimuth.

Usage

```
char2numAspect(charAspect)
```

Arguments

charAspect	Character string of aspect location, i.e., one of • c("N", "NE", "NNE", "ENE", "E", "ESE", "SE", "SSE", "S", "SSW", "SW", "WSW", "W", "WNW", "NW")

Value

Float value of numeric aspect location, North = 0 degree, S = 180 degree

Author(s)

fherla

Examples

```
char2numAspect("W")
char2numAspect("WNW")

char2numAspect(c("N", NA, "NA", "NE"))
```

---

char2numHHI *Conversion of Hand Hardness Index (HHI)*

Description

Convert character hand hardness index (HHI) of snow layers to numeric values. For example, hand hardness Fist becomes 1, Ice becomes 6.

Usage

```
char2numHHI(charHHI)
```

Arguments

charHHI	Character string of hand hardness level, i.e., one of • Fist 'F', 4 Fingers '4F', 1 Finger '1F', Pencil 'P', Knife 'K', or Ice 'I' • intermediate values allowed, e.g. 'F+', '1F-', 'F-4F'

Value

Float value of numeric hand hardness level between 1 and 6.

Author(s)

fherla

Examples

```
char2numHHI('F+')
char2numHHI('F-')
char2numHHI('F-4F')

## not meaningful:
this_throws_error <- TRUE
if (!this_throws_error) {
char2numHHI('F-P')
}
```

`codes_pro` *PRO field code lookup*

Description

Named list of SNOWPACK PRO field codes used by snowprofilePro and writePro.

Usage

```
codes_pro
```

Format

An object of class `list` of length 20.

Value

A named list of character codes.

`computeRTA` *Compute Relative Threshold Sum approach (RTA)*

Description

The function can compute the RTA index for layers and for interfaces. The calculation follows the example in Monti (2013), referenced below. The six individual relative lemons are computed as follows. To compute the RTA index for layers, the layer properties are combined with the interface properties of the weakest interface below or above the layer. To compute the RTA index for interfaces, the interface properties are combined with the weakest layer properties below or above the interface. The six properties considered in the index are

- grain size, hardness, grain type (layer properties)
- difference of grain sizes and hardness (at the interface)
- depth (at the top interface of the layer)

Instead of implementing a static threshold for the depth weighting, the depth is scaled with a weibull function that is corrected for potential crusts and their stabilizing effects (Monti and Mitterer, personal communication).

Note that due to the crust correction, the results from this function will only be correct if applied to profiles that have not yet been resampled (such as by functions from sarp.snowprofile.alignment: `resampleSP`, `resampleSPpairs`, `dtw`, `averageSP`).

The RTA index ranges between `[0, 1]`, with the weakest layer/interface euqal to 1. Values > 0.8 indicate layers/interfaces with a poor structural stability.

Usage

```
computeRTA(x, target = c("interface", "layer"))

## S3 method for class 'snowprofileSet'
computeRTA(x, target = c("interface", "layer"))

## S3 method for class 'snowprofile'
computeRTA(x, target = c("interface", "layer"))
```

Arguments

`x`	a snowprofile or snowprofileSet. Profile layer properties must be known for all layers (i.e., no NAs in gtype, hardness, gsize allowed!)
`target`	Do you want to compute the index for the layers or for the layer interfaces? defaults to both.

Value

The input object will be returned with the new layer properties `rta`/`rta_interface` describing the RTA index added to the profile layers.

Methods (by class)

- `computeRTA(snowprofileSet)`: for snowprofileSets
- `computeRTA(snowprofile)`: for snowprofiles

Author(s)

fherla

References

Monti, F., & Schweizer, J. (2013). A relative difference approach to detect potential weak layers within a snow profile. Proceedings of the 2013 International Snow Science Workshop, Grenoble, France, 339–343. Retrieved from https://arc.lib.montana.edu/snow-science/item.php?id=1861

See Also

computeTSA

Examples

```
## apply function to snowprofileSet
profileset <- computeRTA(SPgroup)

## apply function to snowprofile and plot output
sp <- computeRTA(SPpairs$B_modeled1)
plot(sp, TempProfile = FALSE, main = "RTA")
lines(sp$layers$rta*5, sp$layers$height - 0.5*sp$layers$thickness, type = "b", xlim = c(0, 5))
lines(sp$layers$rta_interface*5, sp$layers$height, type = "b", xlim = c(0, 5), col = "red")
abline(h = sp$layers$height, lty = "dotted", col = "grey")
abline(v = 0.8*5, lty = "dashed")
```

---

computeSLABrho *Compute mean density of slab*

Description

For each layer, compute the average density of all layers above, i.e. <rho>_slab.

Usage

```
computeSLABrho(profile)
```

Arguments

profile	snowprofile object

Value

snowprofile object with added layers column $slab_rho. Note that topmost layer is always NA.

Author(s)

fherla

---

computeSLABrhogs *Compute 'density over grain size' averaged over slab*

Description

For each layer, compute the average density over grain size of all layers above, i.e. <rho/gs>_slab. This variable has been found to characterize the cohesion of slabs: new snow slabs tend to consist of low density & large grains, and more cohesive slabs of older snow tend to consist of higher density & smaller grains (Mayer et al, 2022 in review).

Usage

```
computeSLABrhogs(profile, implementation = c("pub", "literal")[1])
```

Arguments

profile	snowprofile object
implementation	"pub" for <rho/gs>_slab, "literal" for 'mean density of slab over mean grain size of slab' <rho>_slab / <gs>_slab.

Value

snowprofile object with added layers column $slab_rhogs. Note that topmost layer is always NA.

Author(s)

fherla

---

computeTSA *Compute Threshold Sum Approach (TSA, lemons, yellow flags, 'Nieten')*

Description

This routine computes the traditional lemons (German 'Nieten') based on absolute thresholds. Since the thresholds are defined in Monti (2014) with different thresholds for manual versus observed profiles, this routine switches between the appropriate thresholds based on the $type field of the input profile. While manual and whiteboard profiles get one set of thresholds, modeled, vstation, and aggregate type profiles get another set.

Usage

```
computeTSA(x, target = c("interface", "layer"))

## S3 method for class 'snowprofileSet'
computeTSA(x, target = c("interface", "layer"))

## S3 method for class 'snowprofile'
computeTSA(x, target = c("interface", "layer"))
```

Arguments

x	a snowprofile or snowprofileSet
target	Do you want to compute the index for the layers or for the layer interfaces? defaults to both.

Value

New layer properties tsa/tsa_interface describing the threshold sums are added to the profile layers. The TSA sums up to 6 indicators, whereas >= 5 indicators indicate structurally unstable layers/interfaces.

Methods (by class)

- computeTSA(snowprofileSet): for snowprofileSets
- computeTSA(snowprofile): for snowprofiles

Author(s)

fherla

References

Schweizer, J., & Jamieson, J. B. (2007). A threshold sum approach to stability evaluation of manual snow profiles. Cold Regions Science and Technology, 47(1–2), 50–59. https://doi.org/10.1016/j.coldregions.2006.08.011

Monti, F., Schweizer, J., & Fierz, C. (2014). Hardness estimation and weak layer detection in simulated snow stratigraphy. Cold Regions Science and Technology, 103, 82–90. https://doi.org/10.1016/j.coldregions.2014.03.00

See Also

computeRTA

Examples

```
## apply function to snowprofileSet
profileset <- computeTSA(SPgroup)

## apply function to snowprofile and plot output
sp <- computeTSA(SPpairs$B_modeled1)
plot(sp, TempProfile = FALSE, main = "TSA")
lines(sp$layers$tsa/6*5,
      sp$layers$height - 0.5*sp$layers$thickness, type = "b", xlim = c(0, 5))
lines(sp$layers$tsa_interface/6*5, sp$layers$height, type = "b", xlim = c(0, 5), col = "red")
abline(h = sp$layers$height, lty = "dotted", col = "grey")
abline(v = 5/6*5, lty = "dashed")
```

---

deriveBDate *Derive burial dates from deposition dates in simulated profiles*

Description

This routine derives burial dates (bdate) from deposition dates (ddate). Optionally, burial dates can be adjusted to align more closely with human interpretation (see Details in guessDatetagsSimple).

Usage

```
deriveBDate(x, adjust_bdates = TRUE, ...)

## S3 method for class 'snowprofileSet'
deriveBDate(x, adjust_bdates = TRUE, ...)

## S3 method for class 'snowprofile'
deriveBDate(x, adjust_bdates = TRUE, checkMonotonicity = FALSE, ...)

## S3 method for class 'snowprofileLayers'
deriveBDate(x, adjust_bdates = TRUE, checkMonotonicity = TRUE, ...)
```

Arguments

x	a snowprofileSet, snowprofile or snowprofileLayers object
adjust_bdates	boolean switch to compute bdates similar to human interpretation.
...	passed on to subsequent methods
checkMonotonicity	check ascending order of layers. This acts as a check for whether multiple layers objects are stacked, which is not allowed.

Value

The input object will be returned with the column bdate added to the profile layers

Methods (by class)

- deriveBDate(snowprofileSet): for snowprofileSets
- deriveBDate(snowprofile): for snowprofiles
- deriveBDate(snowprofileLayers): for snowprofileLayers

Author(s)

fherla

---

deriveDatetag *Derive datetag from deposition dates in simulated profiles*

Description

This routine is deprecated; use guessDatetagsSimple, deriveBDate, and/or assignDatetags instead. This routine derives the datetags of simulated snow profile layers from deposition dates. Datetags usually are deposition dates for crust layers, and burial dates for other weak layers (e.g., SH, FC). If no datetags can be derived, a datetag column of NAs will nevertheless be added to the snowprofile layers. The routine also adds a bdate column for burial dates that are calculated along the way.

Usage

```
deriveDatetag(x, adjust_bdates = TRUE, ...)

## S3 method for class 'snowprofileSet'
deriveDatetag(x, adjust_bdates = TRUE, ...)

## S3 method for class 'snowprofile'
deriveDatetag(x, adjust_bdates = TRUE, ...)

## S3 method for class 'snowprofileLayers'
deriveDatetag(x, adjust_bdates = TRUE, checkMonotonicity = TRUE, ...)
```

Arguments

x	a snowprofileSet, snowprofile or snowprofileLayers object
adjust_bdates	boolean switch to compute bdates similar to human interpretation. see Details.
...	passed on to subsequent methods
checkMonotonicity	check ascending order of layers. This acts as a check for whether multiple layers objects are stacked, which is not allowed.

Details

bdates are computed by taking the ddate of the overlying layer. For snowpack simulations with thin layer resolution, this approach yields very similar ddates and bdates for most layers, since most layers form and instantly get buried by another layer of the same storm. To make bdates more similar to human interpretation, bdates can be adjusted, so that (similar) layers with the same ddate (i.e., same storm) inherit the same bdate (similar means: identical gtype & hardness).

Value

The input object will be returned with the columns datetag and bdate added to the profile layers

Methods (by class)

- deriveDatetag(snowprofileSet): for snowprofileSets
- deriveDatetag(snowprofile): for snowprofiles
- deriveDatetag(snowprofileLayers): for snowprofileLayers

Note

Deprecated; use guessDatetagsSimple and/or assignDatetags instead.

Author(s)

fherla

`export.snowprofileCsv` *Export or write a snowprofile object to a CSV table*

Description

Export or write a snowprofile object to a CSV table

Usage

```
export.snowprofileCsv(
  profile,
  filename = stop("filename must be provided"),
  sep = ",",
  export.all = "Layers",
  variables = NA
)
```

Arguments

`profile`	snowprofile object
`filename`	character string, e.g. 'path/to/file.csv'
`sep`	csv column separator as character string
`export.all`	one of `TRUE`, `FALSE`, `'Layers'`: export all variables of the snowprofile object to the csv table? If `'Layers'`, then all layer variables of the snowprofile will be exported.
`variables`	A tag-value list of the format, e.g. height = 'height_top', to specify column names of specific variables, to customize column order, and/or to include specific profile meta data if `export.all == 'Layers'` (e.g. easily include the meta data `station_id`). Note that the tags of the tag-value list need to correspond to elements of the snowprofile object.

Details

Note that existing files with the specified filename will be **overwritten** without warning!

Value

Writes csv file to disk, no return value in R

Author(s)

fherla

See Also

snowprofileCsv

Examples

```
## export an entire snowprofile object:

export.snowprofileCsv(SPpairs$A_manual, filename = file.path(tempdir(), 'file.csv'),
                      export.all = TRUE)


## export only the layer properties of a snowprofile object,
#  and change the column order with few column names:
#  All layer variables will be exported, but the three ones provided in 'variables'
#  will be the first three columns of the csv table, and their column names will be changed
#  accordingly.

export.snowprofileCsv(SPpairs$A_manual, filename = file.path(tempdir(), 'file.csv'),
                      export.all = 'Layers',
                      variables = list(height = 'height_top', hardness = 'hardness',
                                       gtype = 'gt1'))


## export all layer properties of a snowprofile object plus the station ID:

export.snowprofileCsv(SPpairs$A_manual, filename = file.path(tempdir(), 'file.csv'),
                     export.all = 'Layers', variables = list(station_id = 'station_id'))

## check the content of the exported csv file:
csv_content <- read.csv(file.path(tempdir(), 'file.csv'))
head(csv_content)

## or re-import the csv file as snowprofile object:
csv_snowprofile <- snowprofileCsv(file.path(tempdir(), 'file.csv'))
print(csv_snowprofile)
```

`findPWL` *Find layers of interest (e.g. PWLs) in snowprofile(Layers)*

Description

Find one or more layers of interest, such as persistent weak layers (PWL) in a snowprofile or snowprofileLayers object based on combinations of grain type, datetag, grain size, and stability indices (TSA/ RTA/ critical crack length/ p_unstable) of the layer. The routine can also be used for searching for crusts (or any other grain types).

Usage

```
findPWL(
  x,
  pwl_gtype = c("SH", "DH"),
  pwl_date = NA,
```

```
  date_variable = c("ddate", "datetag")[1],
  date_range = c(-5, 0),
  date_range_earlier = as.difftime(date_range[1], units = "days"),
  date_range_later = as.difftime(date_range[2], units = "days"),
  bdate_range = c(-1, 1),
  bdate_range_earlier = as.difftime(bdate_range[1], units = "days"),
  bdate_range_later = as.difftime(bdate_range[2], units = "days"),
  threshold_gtype = pwl_gtype,
  threshold_gsize = NA,
  threshold_TSA = NA,
  threshold_RTA = NA,
  threshold_SK38 = NA,
  threshold_RC = NA,
  threshold_PU = NA
)

labelPWL(x, ...)
```

Arguments

x	snowprofile or snowprofileLayers object
pwl_gtype	a vector of grain types of interest
pwl_date	a date of interest given as character ('YYYY-MM-DD') or as POSIXct; set to NA to ignore dates. If given as POSIXct, time comparison between layer dates and pwl_date will consider the times of day (i.e., hours, etc). Otherwise only consider year/month/days.
date_variable	Which layer dates do you want to consider? deposition and burial dates (ddate), or pre-computed datetags (datetag, see assignDatetags for more information)?
date_range	a numeric array of length 2 that defines a date search window around pwl_date. This date range is applied to ddates (deposition dates), or if these are not available to datetags.
date_range_earlier	a difftime object of date_range[1] (must be negative).
date_range_later	a difftime object of date_range[2] (must be positive).
bdate_range	a numeric array of length 2 that defines a date search window around pwl_date. This date range is applied to bdates (burial dates)
bdate_range_earlier	a difftime object of bdate_range[1] (must be negative).
bdate_range_later	a difftime object of bdate_range[2] (must be positive).
threshold_gtype	specific grain types that are only deemed a PWL if they pass one or multiple thresholds (see next parameters)
threshold_gsize	a threshold grain size in order to deem threshold_gtype a PWL; set to NA to ignore grain sizes.

threshold_TSA	a threshold TSA value (see computeTSA) in order to deem threshold_gtype a PWL; set to NA to ignore TSA.
threshold_RTA	a threshold RTA value (see computeRTA) in order to deem threshold_gtype a PWL; set to NA to ignore RTA.
threshold_SK38	a threshold SK38 in order to deem threshold_gtype a PWL; set to NA to ignore this threshold.
threshold_RC	a threshold critical crack length in order to deem threshold_gtype a PWL; set to NA to ignore this threshold.
threshold_PU	a threshold value for p_unstable in order to deem threshold_gtype a PWL; set to NA to ignore this threshold.
...	passed on to findPWL

Details

In case date considerations are included in your search, either one of the date window conditions needs to be satisfied to return a given layer:

- ddate or datetag within date_range, **or**
- bdate within bdate_range

If the input object contains deposition dates (ddate, mostly in simulated profiles), but no bdates, they are computed via deriveBDate; otherwise the date window is applied to the datetag (mostly for manual profiles).

If you apply thresholds to your search, only layers are returned that satisfy *at least one* of the provided thresholds.

The labelPWL wrapper function is primarily used by sarp.snowprofile.alignment::averageSP.

Value

findPWL: An index vector of PWLs that match the desired requirements

labelPWL: The input object with an extra boolean column appended to the layer object, called $layerOfInterest.

Functions

- findPWL(): Find layers of interest (e.g., PWLs) in snowprofile or snowprofileLayers
- labelPWL(): Label layers of interest (e.g., weak layers) in snowprofile

Author(s)

fherla

Examples

```
## get index vector:
findPWL(SPpairs$A_modeled)

## get layers subset:
SPpairs$A_manual$layers[findPWL(SPpairs$A_manual), ]
SPpairs$A_manual$layers[findPWL(SPpairs$A_manual, threshold_gsize = 2.2,
                        threshold_gtype = c("FC", "FCxr")), ]
## all (SH, DH), and (FC, FCxr) >= 1 mm grain size:
SPpairs$A_modeled$layers[findPWL(SPpairs$A_modeled, pwl_gtype = c("SH", "DH", "FC", "FCxr"),
                                 threshold_gsize = 1, threshold_gtype = c("FC", "FCxr")), ]
## use TSA threshold:
SPpairs$A_modeled <- computeTSA(SPpairs$A_modeled)
SPpairs$A_modeled$layers[findPWL(SPpairs$A_modeled, pwl_gtype = c("SH", "DH", "FC", "FCxr"),
                                   threshold_TSA = 4, threshold_gtype = c("FC", "FCxr")), ]

## searching for a specific pwl_date:
## let's construct one layer and an array of pwl_dates
tl <- snowprofileLayers(height = 1, gtype = "SH",
                        ddate = as.POSIXct("2020-12-15"),
                        bdate = as.POSIXct("2020-12-20"))
pwl_dates <- paste0("2020-12-", seq(14, 22))
## which pwl_date will 'find' that layer?
sapply(pwl_dates, function(dt) length(findPWL(tl, pwl_date = dt)) > 0)
## same example, but with bdate being NA:
tl <- snowprofileLayers(height = 1, gtype = "SH",
                        ddate = as.POSIXct("2020-12-15"),
                        bdate = as.POSIXct(NA), dropNAs = FALSE)
sapply(pwl_dates, function(dt) length(findPWL(tl, pwl_date = dt)) > 0)

## pwl_date example with proper profile:
potentialDatetags <- sort(unique(as.Date(SPpairs$A_modeled$layers$ddate)))
sp <- suppressWarnings(assignDatetags(SPpairs$A_modeled, potentialDatetags))
sp$layers
pwl_dates <- paste0("2019-02-", seq(18, 26))
names(pwl_dates) <- pwl_dates
## which pwl_date will 'find' the two layers with (b)date labels?
list(pwl_date = lapply(pwl_dates, function(dt) {
  sp$layers[findPWL(sp, pwl_gtype = c("SH", "FC"), pwl_date = dt),
            c("height", "gtype", "ddate", "bdate")]
}))

## same example as above, but including TSA threshold:
sp <- computeTSA(sp)
## the SH layer has TSA 5, the FC layer has TSA 4:
list(pwl_date = lapply(pwl_dates, function(dt) {
  sp$layers[findPWL(sp, pwl_gtype = c("SH", "FC"), pwl_date = dt, threshold_TSA = 5),
            c("height", "gtype", "ddate", "bdate")]
}))
## --> no more FC layer in output since its TSA value is below the threshold!

## can also be used to search for crusts:
```

```
SPpairs$A_manual$layers[findPWL(SPpairs$A_manual, pwl_gtype = "MFcr"), ]
```

`format_snowprofileLayers` *Format snowprofileLayers*

Description

Calculate missing data.frame columns based on the given ones, if possible.

Usage

```
format_snowprofileLayers(
  obj,
  target = "all",
  hs = NA,
  maxObservedDepth = NA,
  validate = TRUE,
  dropNAs = TRUE
)
```

Arguments

`obj`	snowprofileLayers object
`target`	string, indicating which fields are auto-filled ('all', 'height', 'depth', 'thickness', 'none')
`hs`	total snow height (cm) if not deductible from given fields
`maxObservedDepth`	the observed depth of the profile from the snow surface downwards. Will only be used, if no `height` or `thickness` exist in `obj`, or if `hs` is not given.
`validate`	Validate `obj` with validate_snowprofileLayers?
`dropNAs`	Do you want to drop all columns consisting of NAs only?

Value

copy of obj with auto-filled columns

`getColoursDensity` *Gets colours for plotting snow density values*

Description

Gets colours for plotting snow density values in snowprofiles. Colours are consistent with niViz at https://niviz.org

Usage

```
getColoursDensity(Values, Resolution = 101, Verbose = FALSE)
```

Arguments

`Values`	Density values (kg/m3)
`Resolution`	Resolution of colour scale. Default is 100.
`Verbose`	Switch for writing out value and html colour tuplets for debugging.

Value

Array with HTML colour codes

Author(s)

phaegeli

See Also

getColoursGrainSize, getColoursGrainType, getColoursHardness, getColoursLWC, getColoursSnowTemp

Examples

```
Density <- seq(0,700, by=10)
plot(x = rep(1,length(Density)), y = Density, col = getColoursDensity(Density), pch = 19, cex = 3)
```

`getColoursGrainSize` *Gets colours for plotting grain size values*

Description

Gets colours for plotting grain size values in snowprofiles. Colours are consistent with niViz at https://niviz.org

Usage

```
getColoursGrainSize(Values, Resolution = 101, Verbose = FALSE)
```

Arguments

`Values`	Liquid water content values
`Resolution`	Resolution of colour scale. Default is 100.
`Verbose`	Switch for writing out value and html colour tuplets for debugging.

Value

Array with HTML colour codes

Author(s)

phaegeli

See Also

getColoursDensity, getColoursGrainType, getColoursHardness, getColoursLWC, getColoursSnowTemp

Examples

```
GrainSize <- seq(0,6, by=0.1)
plot(x = rep(1,length(GrainSize)), y = GrainSize,
     col = getColoursGrainSize(GrainSize), pch = 19, cex = 3)
```

getColoursGrainType *Gets colours for plotting snow grain types*

Description

Grain colours are defined in the grainDict data.frame and the definitions can be changed with setColoursGrainType

Usage

```
getColoursGrainType(Grains, grainDict. = grainDict)
```

Arguments

Grains	grain type (character or list of characters)
grainDict.	lookup table to use. Note, the easiest and best way to do this is via setColoursGrainType. This input variable here is only a hack to change the grainDict explicitly when calling plot.snowprofile via Col, and beforehand computing Col = Col <- sapply(Profile$layers$gtype, function(x) getColoursGrainType(x, grainDict = setColoursGrainType('sarp-reduced'))); This is only necessary in specific environments (e.g. a shiny app)

Value

Array with HTML colour codes

Author(s)

phaegeli, shorton, fherla

See Also

setColoursGrainType, getColoursDensity, getColoursGrainSize, getColoursHardness, getColoursLWC, getColoursSnowTemp

Examples

```
Grains <- c('PP', 'DF', 'RG', 'FC', 'FCxr', 'DH', 'SH', 'MF', 'MFcr', 'IF')
Colours <- getColoursGrainType(Grains)
Colours

plot(1:length(Grains), col = Colours, pch = 20, cex = 3)
text(1:length(Grains), 1:length(Grains), Grains, pos = 1)
```

`getColoursHardness` *Gets colours for plotting snow hardness values*

Description

Gets colours for plotting snow hardness values in snowprofiles.

Usage

```
getColoursHardness(Values, Resolution = 101, Verbose = FALSE)
```

Arguments

`Values`	Hardness values
`Resolution`	Resolution of colour scale. Default is 100.
`Verbose`	Switch for writing out value and html colour tuplets for debugging.

Value

Array with HTML colour codes

Author(s)

phaegeli

See Also

getColoursDensity, getColoursGrainSize, getColoursGrainType, getColoursLWC, getColoursSnowTemp

Examples

```
Hardness <- c(1:5)
plot(x = rep(1,length(Hardness)), y = Hardness,
     col = getColoursHardness(Hardness), pch = 19,cex = 3)
```

`getColoursLWC` *Gets colours for plotting LWC values*

Description

Gets colours for plotting LWC values in snowprofiles. Colours are consistent with niViz at https://niviz.org

Usage

```
getColoursLWC(Values, Resolution = 101, Verbose = FALSE)
```

Arguments

`Values`	Liquid water content values
`Resolution`	Resolution of colour scale. Default is 100.
`Verbose`	Switch for writing out value and html colour tuplets for debugging.

Value

Array with HTML colour codes

Author(s)

phaegeli

See Also

getColoursDensity, getColoursGrainSize, getColoursGrainType, getColoursHardness, getColoursSnowTemp

Examples

```
LWC <- seq(0,6, by = 0.1)
plot(x = rep(1,length(LWC)), y = LWC, col = getColoursLWC(LWC), pch = 19, cex = 3)
```

getColoursPercentage *Gets colours for plotting the snow layer property 'percentage'*

Description

Gets colours for plotting the snow layer property 'percentage', as used for example for distributions from 0–1.

Usage

```
getColoursPercentage(
  Values,
  Resolution = 101,
  Min = 0,
  Max = 1,
  ClrRamp = c("Blues", "Greys", "Greys_transparent")[1]
)
```

Arguments

Values	of the 'percentage' variable
Resolution	Resolution of colour scale. Default is 100.
Min	Minimum values of the percentage (for colouring)
Max	Maximum –=–
ClrRamp	Three different colourmaps can be chosen from: "Blues", "Greys", "Greys_transparent"

Value

Array with HTML colour codes

Author(s)

fherla

See Also

getColoursGrainSize, getColoursGrainType, getColoursHardness, getColoursLWC, getColoursSnowTemp, getColoursStability

Examples

```
prct <- seq(0, 1, by=0.1)
plot(x = rep(1,length(prct)), y = prct,
     col = getColoursPercentage(prct), pch = 19, cex = 3)

plot(x = rep(1,length(prct)), y = prct,
     col = getColoursPercentage(prct, ClrRamp = "Greys"), pch = 19, cex = 3)
```

`getColoursSnowTemp` *Gets colours for plotting snow temperature values*

Description

Gets colours for plotting snow temperature values in snowprofiles. Colours are consistent with niViz at https://niviz.org

Usage

```
getColoursSnowTemp(Values, Resolution = 101, Verbose = FALSE)
```

Arguments

`Values`	Snow temperature values
`Resolution`	Resolution of colour scale. Default is 100.
`Verbose`	Switch for writing out value and html colour tuplets for debugging.

Value

Array with HTML colour codes

Author(s)

phaegeli

See Also

getColoursDensity, getColoursGrainSize, getColoursGrainType, getColoursHardness, getColoursLWC

Examples

```
SnowTemp <- c(-25:0)
plot(x = rep(1,length(SnowTemp)), y = SnowTemp,
     col = getColoursSnowTemp(SnowTemp), pch = 19,cex = 3)
```

`getColoursStability` *Gets colours for plotting snow stability indices*

Description

Gets colours for plotting snow stability indices in snowprofiles.

Usage

```
getColoursStability(
  Values,
  StabilityIndexThreshold = 0.77,
  StabilityIndexRange = c(0, 1),
  invers = FALSE,
  Resolution = 100
)
```

Arguments

`Values`	Stability index values
`StabilityIndexThreshold`	A scalar threshold that defines the transition from medium to poor stability. The color scheme will be adjusted so that this threshold becomes apparent from the colours.
`StabilityIndexRange`	The range the index spans, e.g. for TSA `[0, 6]`, for RTA and p_unstable `[0, 1]`, for critical crack length `[0, 3]`, etc..
`invers`	Indices like TSA/ RTA/ p_unstable increase the poorer layer stability gets. For indices with revers behaviour (e.g.,, critical crack length) switch this flag to `TRUE`.
`Resolution`	Resolution of colour scale. Default is 100.

Value

Array with HTML colour codes

Author(s)

fherla

See Also

getColoursGrainSize, getColoursGrainType, getColoursHardness, getColoursLWC, getColoursSnowTemp, getColoursPercentage

Examples

```
p_unstable <- seq(0, 1, by=0.1)
plot(x = rep(1,length(p_unstable)), y = p_unstable,
     col = getColoursStability(p_unstable), pch = 19, cex = 3)

critical_crack_length <- c(seq(0.2, 0.8, by=0.1), 1.5, 2.5)
plot(x = rep(1,length(critical_crack_length)), y = critical_crack_length, pch = 19, cex = 3,
     col = getColoursStability(critical_crack_length, StabilityIndexThreshold = 0.4,
                               StabilityIndexRange = c(0, 3), invers = TRUE))
```

---

grainDict *A data.frame storing the grain type colours*

Description

The colours can be changed by calling the function setColoursGrainType, see examples below.

Usage

```
grainDict
```

Format

A data.frame

Examples

```
print(grainDict)

## change colours for subsequent plots:
grainDict <- setColoursGrainType('sarp-reduced')
```

---

guessDatetagsSimple *Guess datetags from deposition dates in simulated profiles*

Description

This routine provides a simple heuristic for assigning datetags to layers. Datetags usually are deposition dates for crust layers, and burial dates for other weak layers (e.g., SH, FC). If no datetags can be derived, a datetag column of NAs will be added. Burial dates (`bdate`) are computed via deriveBDate.

Usage

```
guessDatetagsSimple(x, adjust_bdates = TRUE, ...)

## S3 method for class 'snowprofileSet'
guessDatetagsSimple(x, adjust_bdates = TRUE, ...)

## S3 method for class 'snowprofile'
guessDatetagsSimple(x, adjust_bdates = TRUE, checkMonotonicity = FALSE, ...)

## S3 method for class 'snowprofileLayers'
guessDatetagsSimple(x, adjust_bdates = TRUE, checkMonotonicity = TRUE, ...)
```

Arguments

x	a snowprofileSet, snowprofile or snowprofileLayers object
adjust_bdates	boolean switch to compute bdates similar to human interpretation. see Details.
...	passed on to subsequent methods
checkMonotonicity	check ascending order of layers. This acts as a check for whether multiple layers objects are stacked, which is not allowed.

Value

The input object will be returned with the columns `datetag` and `bdate` added to the profile layers

Methods (by class)

- `guessDatetagsSimple(snowprofileSet)`: for snowprofileSets
- `guessDatetagsSimple(snowprofile)`: for snowprofiles
- `guessDatetagsSimple(snowprofileLayers)`: for snowprofileLayers

Author(s)

fherla

---

hasUnobservedBasalLayer

Check whether a profile is observed down to ground or not

Description

Check whether a profile is observed down to ground or not

Usage

```
hasUnobservedBasalLayer(x)
```

Arguments

x	a snowprofile, or snowprofileLayers object

Value

boolean TRUE/FALSE

`importRDefaultPackages` *Import R_DEFAULT_PACKAGES*

Description

Import R_DEFAULT_PACKAGES

Usage

```
importRDefaultPackages()
```

`insertUnobservedBasalLayer` *Insert a special layer at the bottom to indicate a snow profile that's unobserved from a specific point down to the ground internal function, not exported. used in snowprofileLayers*

Description

Insert a special layer at the bottom to indicate a snow profile that's unobserved from a specific point down to the ground internal function, not exported. used in snowprofileLayers

Usage

```
insertUnobservedBasalLayer(object, basal_offset, setBasalThicknessNA = FALSE)
```

Arguments

object	snowprofileLayers object
basal_offset	a positive numeric scalar indicating the thickness of the basal unobserved layer(s)
setBasalThicknessNA	boolean TRUE/FALSE indicating whether the thickness of the inserted layer should be basal_offset or NA. Setting the thickness to NA corresponds to setting a flag that the depth of the profile (i.e., the unobserved basal layers) is unknown. This often happens in manual profiles which only observe the uppermost meter (or so) of the snowpack

Value

same object with basal layer inserted as individual row in the data.frame

Author(s)

fherla

`is.snowprofile` *Check class snowprofile*

Description

Check if object is of class snowprofile

Usage

```
is.snowprofile(x)
```

Arguments

x	object to test

Value

boolean

`is.snowprofileInstabilitySigns` *Check class snowprofileInstabilitySigns*

Description

Check if object is of class snowprofileInstabilitySigns

Usage

```
is.snowprofileInstabilitySigns(x)
```

Arguments

x	object to test

Value

boolean

is.snowprofileLayers *Check class snowprofileLayers*

Description

Check if object is of class snowprofileLayers

Usage

```
is.snowprofileLayers(x)
```

Arguments

x	object to test

Value

boolean

is.snowprofileSet *Check class snowprofileSet*

Description

Check if object is of class snowprofileSet

Usage

```
is.snowprofileSet(x)
```

Arguments

x	object to test

Value

boolean

is.snowprofileTests *Check class snowprofileTests*

Description

Check if object is of class snowprofileTests

Usage

```
is.snowprofileTests(x)
```

Arguments

x	object to test

Value

boolean

new_snowprofile *Low-level constructor function for a snowprofile object*

Description

Low-cost, efficient constructor function to be used by users who know what they're doing. If that's not you, use the high-level constructor snowprofile.

Usage

```
new_snowprofile(
  station = character(),
  station_id = character(),
  datetime = as.POSIXct(NA),
  latlon = as.double(c(NA, NA)),
  elev = double(),
  angle = double(),
  aspect = double(),
  hs = double(),
  maxObservedDepth = double(),
  type = character(),
  band = character(),
  zone = character(),
  comment = character(),
  hn24 = double(),
  hn72 = double(),
  ski_pen = double(),
```

```
  layers = snowprofileLayers(),
  tests = snowprofileTests(),
  instabilitySigns = snowprofileInstabilitySigns()
)
```

Arguments

station	character string
station_id	character string
datetime	date and time as class POSIXct in most meaningful timezone (timezone can be converted very easily: e.g. `print(profile$datetime, tz = 'EST')`.
latlon	2-element vector latitude (first), longitude (second)
elev	profile elevation (m)
angle	slope angle (degree)
aspect	slope aspect (degree)
hs	total snow height (cm); if not provided, the field will be derived from the profile layers.
maxObservedDepth	equivalent to hs for full profiles that go down to the ground. for test profiles that only observe the upper part of the snowpack this value refers to the maximum depth of the profile observation.
type	character string, must be either 'manual', 'modeled', 'vstation', 'aggregate', or 'whiteboard'
band	character string describing elevation band as ALP, TL, BTL (alpine, treeline, below treeline)
zone	character string describing the zone or region of the profile location (e.g., BURN-ABY_MTN)
comment	character string with any text comments
hn24	height of new snow within 24 h
hn72	height of new snow within 72 h
ski_pen	skier penetration depth (m)
layers	snowprofileLayers object
tests	snowprofileTests object
instabilitySigns	snowprofileInstabilitySigns object

Value

snowprofile object

numberOfPWLsPerVerticalLevel *Count number of PWLs per vertical level*

Description

This is a wrapper function to bin several weak layers (or crusts) into vertical levels. The layers to be binned can be controlled with a provided index vector for full customization.

Usage

```
numberOfPWLsPerVerticalLevel(x, pwl_idx, depth_breaks = c(0, 30, 80, 150, Inf))
```

Arguments

x	snowprofile or snowprofileLayers object
pwl_idx	an index vector that corresponds to the layers of interest. Tip: this can also be a call to findPWL, see examples.
depth_breaks	a vector of break points referring to absolute depth values. Inf is a placeholder for max depth.

Value

This function returns a table object

Author(s)

fherla

Examples

```
SH_idx <- findPWL(SPpairs$C_day1, pwl_gtype = "SH")
numberOfPWLsPerVerticalLevel(SPpairs$C_day1, SH_idx)

numberOfPWLsPerVerticalLevel(SPpairs$C_day2, findPWL(SPpairs$C_day2))
```

`plot.snowprofile` *Plot hardness profile*

Description

Plot hardness profile

Usage

```
## S3 method for class 'snowprofile'
plot(
  x,
  TempProfile = TRUE,
  xlimTemp = NULL,
  Col = "auto",
  TopDown = "auto",
  axes = TRUE,
  xlab = "",
  emphasizeLayers = FALSE,
  emphasis = "95",
  failureLayers = FALSE,
  failureLayers.cex = 1,
  failureLayers.col = "red",
  nYTicks = 4,
  ymax = max(c(x$maxObservedDepth, x$hs), na.rm = TRUE),
  ytick.las = 1,
  alignWithBottomUpPlot = FALSE,
  highlightUnobservedBasalLayers = TRUE,
  label.datetags = FALSE,
  ...
)
```

Arguments

`x`	snowprofile object
`TempProfile`	draw unscaled temperature profile (default = TRUE)? Temperature data needs to be included in the snowprofile object either under `x$layers$temperature`, or in a separate `x$temperatureProfile` data.frame providing a vertical grid independent from the snow layers.
`xlimTemp`	the x limits in degrees Celsius for the temperature profile (if left empty it scales to the range of temperature values)
`Col`	vector of colours corresponding to the grain types in the profile (defaults to a lookup table)
`TopDown`	Option to plot by depth instead of height with zero depth on top of plot (default = FALSE)

axes	Should axes be printed?
xlab	x-axis label, defaults to an empty string
emphasizeLayers	index OR character vector (grain types) of layers to be emphasized (i.e. all other layers become slightly transparent)
emphasis	2 digit quoted number between '01'-'99' to control the degree of emphasis; the higher the stronger
failureLayers	height vector of failure layers that will be indicated with an arrow
failureLayers.cex	factor to shrink or enlarge the arrow
failureLayers.col	color of arrow, can also be a vector of same length as failureLayers to color different arrows differently
nYTicks	number of tick marks at yaxis
ymax	the maximum ylim value
ytick.las	orientation of y-axis labels
alignWithBottomUpPlot	useful when aligning the yaxis grids of bottom up profileSet plots and top down hardness plots.
highlightUnobservedBasalLayers	draw sine wave at lowest observed layer to highlight unobserved layers below
label.datetags	label the datetags of the snowprofile layers? (Won't produce a pretty plot, but give you some more information for analysis)
...	other parameters to barplot

See Also

plot.snowprofileSet

Examples

```
plot(SPpairs$A_manual)
plot(SPpairs$A_manual, Col = 'black')
plot(SPpairs$A_manual, emphasizeLayers = c(5, 11),
     failureLayers = SPpairs$A_manual$layers$height[5], failureLayers.cex = 1.5)
plot(SPpairs$A_manual, emphasizeLayers = 'SH')
plot(SPpairs$A_manual, TopDown = TRUE)
plot(SPpairs$A_modeled, TempProfile = TRUE, xlimTemp = c(-30,10))

# highlight unobserved basal layers:
plot(snowprofile(layers = snowprofileLayers(depth = c(40, 25, 0),
                                            hardness = c(2, 3, 1),
                                            gtype = c('FC', NA, 'PP'),
                                            hs = 70,
                                    maxObservedDepth = 50)), TopDown = TRUE, ymax = 80)
```

`plot.snowprofileSet` *Plot a single layer property in multiple profiles side-by-side*

Description

A flexible function to plot multiple snowprofiles either in a timeseries or various types of groups.

Usage

```
## S3 method for class 'snowprofileSet'
plot(
  x,
  SortMethod = c("time", "time_daily", "unsorted", "hs", "elev", "presorted"),
 ColParam = c("gtype", "hardness", "density", "temp", "gsize", "ssi", "p_unstable",
    "crit_cut_length", "rta", "percentage", "lwc"),
  TopDown = FALSE,
  DateStart = NA,
  DateEnd = NA,
  Timeseries_labels = c("weekly", "monthly", "daily", "daily HH:MM", NA),
  ylim = NULL,
  OutlineLyrs = FALSE,
  emphasizeLayers = NULL,
  colAlpha = NA,
  colEmphasis = NA,
  OutlineProfile = NULL,
  HorizGrid = TRUE,
  VerticalGrid = TRUE,
  yaxis = TRUE,
  main = NA,
  ylab = NA,
  xlab = NA,
  box = TRUE,
  xticklabels = FALSE,
  xtick.las = 2,
  ytick.las = 1,
  yPadding = 10,
  xPadding = 0.5,
  hardnessResidual = 1,
  hardnessScale = 1,
  xOffset = -0.5,
  xScale = 1,
  k = NULL,
  offset = as.Date(NA),
  add = FALSE,
  tz = "UTC",
  ...
)
```

Arguments

x	An object of class snowprofileSet
SortMethod	How to arrange profiles along the x-axis. Options include timeseries (default = 'time', or 'time_daily'), in existing order of Profiles list ('unsorted'), sorted by HS ('hs'), or elevation ('elev')
ColParam	What parameter to show with colour. So far the following types are available: "gtype", "hardness", "density", "temp", "gsize", "ssi", "p_unstable", "crit_cut_length", "rta", "percentage", "lwc".
TopDown	Option to plot by depth instead of height with zero depth on top of plot (default = FALSE)
DateStart	Start date for timeseries plots (SortMethod = 'time'). If not provided, the function takes the date range from Profiles (default = NA).
DateEnd	End date for timeseries plots (SortMethod = 'time'). If not provided, the function takes the date range from Profiles (default = NA).
Timeseries_labels	Label Saturdays "weekly", "monthly", "daily", "daily HH:MM", or NA
ylim	Vertical range of plot
OutlineLyrs	Switch for outlining layers (default = FALSE)
emphasizeLayers	emphasize layers with different transparency than others, or a different color altogether? then set this argument to TRUE if you want to emphasize all labeled layers of interest (aka weak layers), or provide a named list with arguments to a function call to findPWL to define which layers to emphasize. Set either colAlpha or colEmphasis to make the emphasis apparent.
colAlpha	the transparency setting for all layers (except the ones to be emphasized if you want to emphasize any). This can be useful for example if you want to overplot the grain type sequences with another variable, e.g. a percentage from a distribution.
colEmphasis	the color of the layers to be emphasized (only if you want a different color than defined by ColParam)
OutlineProfile	vector of profile indices that will be outlined to highlight them
HorizGrid	Draw horizontal grid at layer heights (default = TRUE)
VerticalGrid	Draw vertical grid at xticks (default = TRUE)
yaxis	draw a y-axis? (either FALSE, TRUE draws yaxis left, "right" draws yaxis on the right plot side) *Note* that in case of "right" you need to adjust par(mar = ...), disable ylab and manually draw an xlab with mtext.
main	Main title
ylab	y-axis label; disable ylab by providing an empty string (i.e., ylab = '')
xlab	x-axis label; disable xlab by providing an empty string (i.e., xlab = '')
box	Draw a box around the plot (default = TRUE)
xticklabels	Label the profiles with their "names", "originalIndices" (prior to sorting), "dates", "datetimes", or a custom character array

xtick.las	Orientation of labels if xticklabels is specified.
ytick.las	Orientation of y-axis labels
yPadding	Padding between ylim and limits of data, default = 10. Note that R will still put padding by default. If you want to prohibit that entirely, specify xaxs ='i', or yaxs = 'i'.
xPadding	Padding between xlim and limits of data, default = 0.5. Note that R will still put padding by default. If you want to prohibit that entirely, specify xaxs = 'i', or yaxs = 'i'. For xPadding, you can provide either a scalar, or a length 2 numeric for left and right hand side, respectively.
hardnessResidual	Value within [0, 1] to control the minimum horizontal space of each layer that will be colored irrespective of the layer's hardness. A value of 1 corresponds to no hardness being shown.
hardnessScale	A scaling factor that exaggerates the hardness profile to subsequent cells on the x-axis. Useful for time series of sparse profile observations. Note that this scaling factor is unused when hardnessScale = 1 and that it gets more influential the smaller hardnessScale gets. Also note, that a hardnessScale > 1 can lead to profiles overlapping.
xOffset	offsets the profile location on the x-axis
xScale	stretches the horizontal space of each profile. This should ideally be 1, but if you have a 3-hourly profile resolution and want the plot to display without data gaps, you can set this to 3. Warning: Please note, that this may lead to unnoticed profile overlap if not calibrated properly!
k	a sorting vector if SortMethod = "presorted".
offset	Provide a Date or POSIXct offset if you want to offset the vertical snow height/depth axis so that the offset date aligns with snow depth/height 0.
add	add the plot to an existing plot, or create new plot?
tz	timezone of your snowprofileSet (for DateStart and DateEnd filtering)
...	Additional parameters passed to plot()

Details

The routine allows you to plot coloured sequences only, or to include hardness profile information as well. See parameter hardnessResidual and the examples for more details. To change the font size of labels etc, use par() with the parameters cex.lab, cex.axis, etc.

Author(s)

shorton, fherla, phaegeli

See Also

plot.snowprofile, SPgroup

Examples

```
## Standard profile timeline (e.g. https://niviz.org)
plot(SPtimeline)                            # hourly timeseries
plot(SPtimeline, SortMethod = "time_daily")   # daily timeseries

## Change time series date(time) labels:
plot(SPtimeline, Timeseries_labels = "daily", xtick.las = 1)
plot(SPtimeline, Timeseries_labels = "daily 00:00", xtick.las = 1)
plot(SPtimeline,
     xticklabels = c("one", "two", "three", "", "", "",
                     "seven", "", "nine", "", "eleven"),
     Timeseries_labels = NA, xtick.las = 1)

## Deal with data gaps originating from discontinuous timeseries
## hourly timeseries, representing raw data
plot(SPtimeline_3hourly,
     xOffset = 0, Timeseries_labels = "daily")
## hourly timeseries, stretched to fill missing hours for a continuous plot
plot(SPtimeline_3hourly, xScale = 3,
     xOffset = 0, Timeseries_labels = "daily")

## Group of profiles with same timestamp
plot(SPgroup, SortMethod = 'unsorted')  # sorted in same order as list
plot(SPgroup, SortMethod = 'hs') # sorted by snow height
plot(SPgroup, SortMethod = 'elev') # sorted by elevation

## Colour layers by other properties
plot(SPtimeline, ColParam = 'density')

## Align layers by depth instead of height
plot(SPtimeline, TopDown = TRUE)

## Timelines with specific date ranges
plot(SPtimeline, DateEnd = '2017-12-17')
plot(SPtimeline, DateStart = '2017-12-15', DateEnd = '2017-12-17')
plot(SPtimeline, DateStart = "2017-12-16 19:00",
     Timeseries_labels = "daily 00:00", xtick.las = 1)

## Show hardness profile, too:
plot(SPtimeline, hardnessResidual = 0.1, hardnessScale = 10)

## Additional examples of plot dimensions and labelling
## Label the indices of the profiles in the list:
plot(SPgroup, SortMethod = 'elev', xticklabels = "originalIndices")
##  ... and with minimized axis limits and their station ID names:
plot(SPgroup, SortMethod = 'elev',
     xticklabels = sapply(SPgroup, function(x) x$station_id),
     yPadding = 0, xPadding = 0, xaxs = 'i', yaxs = 'i')
##  sorted by depth, and without box:
plot(SPgroup, SortMethod = 'hs', TopDown = TRUE, box = FALSE)

## Apply a date offset to investigate which layers formed around that day of interest:
```

```
pwl_exists <- sapply(SPgroup, function(sp)
  {length(findPWL(sp, pwl_date = "2019-01-21", pwl_gtype = c("SH", "DH"),
                  date_range_earlier = as.difftime(2, unit = "days"))) > 0})
k <- order(pwl_exists, decreasing = TRUE)
plot(SPgroup, SortMethod = 'presorted', k = k, xticklabels = "originalIndices",
     offset = as.Date("2019-01-21"), xlab = "<-- Jan 21 PWL exists | does not exist -->")
abline(v = max(which(pwl_exists[k]))+0.5, lty = "dashed")

## Emphasize specific layers
## (i) all labeled layers of interest:
SPgroup <- snowprofileSet(lapply(SPgroup, labelPWL))  # label layers with default settings
plot(SPgroup, SortMethod = "hs", emphasizeLayers = TRUE, colAlpha = 0.3)
## (ii) specific individual layers:
plot(SPgroup, SortMethod = "hs",
     emphasizeLayers = list(pwl_gtype = c("SH", "DH"), pwl_date = "2019-01-21"),
     colAlpha = 0.3, colEmphasis = "black")
```

`print.snowprofile` *Print snowprofile object*

Description

Print snowprofile object

Usage

```
## S3 method for class 'snowprofile'
print(x, pretty = TRUE, nLayers = NA, ...)
```

Arguments

`x`	snowprofile object
`pretty`	pretty print the object (data.frame-like instead of list-like)
`nLayers`	only print the first few layers (cf., head)
`...`	passed to print.default

Value

object gets printed to console

Examples

```
## pretty print
SPpairs$A_manual
## or alternatively:
print(SPpairs$A_manual)
```

```
## reduce number of layers printed:
print(SPpairs$A_manual, nLayers = 6)

## print profile non-pretty (i.e., like the data is stored):
print(SPpairs$A_manual, pretty = FALSE)
```

`rbind.snowprofile` *Convert snowprofile into data.frame with columns for metadata*

Description

Convert snowprofile object into data.frame with a row for each layer and additional columns with metadata

Usage

```
## S3 method for class 'snowprofile'
rbind(..., deparse.level = 1)
```

Arguments

`...`	Object of class snowprofile
`deparse.level`	Argument for generic rbind method

Details

Metadata columns are calculated with summary.snowprofile

Value

data.frame

Author(s)

shorton

See Also

summary.snowprofile, rbind.snowprofileSet

Examples

```
Profile <- SPgroup[[1]]
ProfileTable <- rbind(Profile)
head(ProfileTable)
```

`rbind.snowprofileSet` *Concatenate snowprofileSet into a large data.frame with a row for each layer*

Description

A wrapper to apply rbind.snowprofile to each profile in a snowprofileSet then concatenate

Usage

```
## S3 method for class 'snowprofileSet'
rbind(..., deparse.level = 1)
```

Arguments

`...`	Object of class snowprofileSet
`deparse.level`	Argument for generic rbind method

Details

Returns a large data.frame with a row for each layer and additional columns with metadata (calculated with summary.snowprofile)

Value

data.frame

Author(s)

shorton

See Also

summary.snowprofile, rbind.snowprofile

Examples

```
## Create rbind table
ProfileTable <- rbind(SPgroup)
head(ProfileTable)

## Filter by layer properties
SHlayers <- subset(ProfileTable, gtype == 'SH')
summary(SHlayers)
plot(elev ~ gsize, SHlayers)
```

readSmet *Parse a SMET file*

Description

Read contents of a SMET file https://models.slf.ch/docserver/meteoio/SMET_specifications.pdf

Usage

```
readSmet(Filename, HeaderOnly = FALSE)
```

Arguments

Filename	Path to a smet file
HeaderOnly	Read only Header information and return as Data.Frame?

Value

List containing metadata and data

Author(s)

shorton

See Also

writeSmet, snowprofileSno, snowprofilePrf, snowprofilePro

Examples

```
## Path to example smet
Filename <- system.file('extdata', 'example.smet', package = 'sarp.snowprofile')
Wx = readSmet(Filename)
str(Wx)

Header <- readSmet(Filename, HeaderOnly = TRUE)
Header
```

`reformat_snowprofile` *Reformat a malformatted snowprofile object*

Description

Reformat a malformatted snowprofile object. A malformatted object may use field names that deviate from our suggested field names (e.g., `grain_type` instead of `gtype`), or it may use data types that are different than what we suggest to use (e.g., `ddate` as type `Date` instead of `POSIXct`). Basically, if your snowprofile object fails the test of validate_snowprofile due to the above reason this function should fix it.

Usage

```
reformat_snowprofile(profile, currentFields = NULL, targetFields = NULL)
```

Arguments

`profile`	snowprofile object
`currentFields`	array of character strings specifying the current field names that you want to change
`targetFields`	array of same size than `currentFields` specifying the new field names

Examples

```
## check the malformatted profile:
this_throws_error <- TRUE
if (!this_throws_error) {
validate_snowprofile(SPmalformatted[[1]])
}
## i.e., we see that elev and ddate are of wrong data type,
## and a warning that grain_type is an unknown layer property.

## reformat field types, but not the field name:
betterProfile <- reformat_snowprofile(SPmalformatted[[1]])
## i.e., no error is raised anymore, but only the grain_type warning

## so let's reformat also the field names:
optimalProfile <- reformat_snowprofile(SPmalformatted[[1]], "grain_type", "gtype")



## reformat a list of profiles with the same configuration:
SPmalformatted_reformatted <- lapply(SPmalformatted, reformat_snowprofile,
                                     currentFields = "grain_type", targetFields = "gtype")

## the malformatted profile set finally is correctly formatted:
lapply(SPmalformatted_reformatted, validate_snowprofile)
```

`scanProfileDates` *Read profile dates from prf/pro file*

Description

Before reading entire SNOWPACK output it can be helpful to scan the profile timestamps first

Usage

```
scanProfileDates(Filename, tz = "UTC")
```

Arguments

`Filename`	filename
`tz`	time zone (default = 'UTC')

Value

vector of as.POSIXct timestamps

Author(s)

shorton

See Also

snowprofilePrf, snowprofilePro

Examples

```
## Path to example prf file
Filename <- system.file('extdata', 'example.prf', package = 'sarp.snowprofile')

## Scan dates in file
Dates <- scanProfileDates(Filename)
print(Dates)
```

sd_sample_uncorrected *fast uncorrected sample standard deviation https://en.wikipedia.org/wiki/Standard_deviation#Rapid_calculation_methods*

Description

fast uncorrected sample standard deviation https://en.wikipedia.org/wiki/Standard_deviation#Rapid_calculation_methods

Usage

```
sd_sample_uncorrected(x, xbar = mean(x), na.rm = FALSE)
```

Arguments

x	a numeric vector
xbar	arithmetic mean of x
na.rm	remove any NAs before computation of standard deviation?

Value

uncorrected sample standard deviation (i.e., a numeric scalar)

Author(s)

fherla

setColoursGrainType *Set colour scale for grain types*

Description

Currently, you can choose between 'iacs', 'iacs2', 'sarp', or 'sarp-reduced'.

Usage

```
setColoursGrainType(ScaleName)
```

Arguments

`ScaleName`	Name of graintype colour scale • `iacs`: scale defined by the *International Classification of Seasonal Snow on the Ground* • `iacs2`: scale defined by the *International Classification of Seasonal Snow on the Ground* with a dark red colour for MFcr layers so that MF and MFcr layers can be better distinguished. • `sarp`: hazard adjusted colours for grain types based on Horton et al. (2020) • `sarp-reduced`: hazard adjusted colours for groups of grain types based on Horton et al. (2020)

Value

data.frame containing the new colour values stored in `grainDict`

References

Horton, S., Nowak, S., and Haegeli, P.: Enhancing the operational value of snowpack models with visualization design principles, Nat. Hazards Earth Syst. Sci., 20, 1557–1572, doi:10.5194/nhess-2015572020, 2020.

See Also

grainDict, getColoursGrainType

Examples

```
## Current/default grain type colours
grainDict
plot(SPpairs$A_manual, main = 'Snow profile with default colours')

## Change to IACS colours
grainDict <- setColoursGrainType('IACS')
grainDict
plot(SPpairs$A_manual, main = 'Snow profile with IACS colours')

## Change to IACS colours with adjusted MFcr (darkred)
grainDict <- setColoursGrainType('IACS2')
grainDict
plot(SPpairs$A_manual, main = 'Snow profile with IACS colours and adjusted darkred MFcr')

## Change to SARP colours
grainDict <- setColoursGrainType('SARP')
grainDict
plot(SPpairs$A_manual, main = 'Snow profile with SARP colours')

## Change to reduced SARP colours
grainDict <- setColoursGrainType('SARP-reduced')
grainDict
plot(SPpairs$A_manual, main = 'Snow profile with a reduced set of SARP colours')
```

`simplifyGtypes` *Simplify detailed grain types to parent classes*

Description

The IACS records grain types in major and minor classes, e.g. precipitation particles PP can be subclassified into stellar dendrites PPsd. Some of these subclasses are not supported in this R package and so this function simplifies the unsupported gran type subclasses into their supported main classes. If a given grain type cannot be simplified, a NA value is returned for it.

Usage

```
simplifyGtypes(gtypes, supported_gtypes = grainDict$gtype)
```

Arguments

`gtypes`	an array of character grain types following IACS standards
`supported_gtypes`	an array of supported grain types that will determine the simplification

Value

the modified input array

Author(s)

fherla

Examples

```
## create an array of gtypes
gtypes <- c('FCxr', 'RGxf', 'PPsd', 'PP', 'IFrc', "KKfx")

## sinplify gtypes to supported_gtypes:
simplifyGtypes(gtypes)
```

`snowprofile` *High-level constructor for a snowprofile object*

Description

Conveniently create a snowprofile object. Calls low-level constructor (only available internally: new_snowprofile), asserts correctness through a snowprofile validator function (validate_snowprofile) and yields meaningful error messages. Use low-level constructor if you generate many (!) profiles.

Usage

```
snowprofile(
  station = as.character(NA),
  station_id = as.character(NA),
  datetime = as.POSIXct(NA),
  latlon = as.double(c(NA, NA)),
  elev = as.double(NA),
  angle = as.double(NA),
  aspect = as.double(NA),
  hs = as.double(NA),
  maxObservedDepth = as.double(NA),
  type = "manual",
  band = as.character(NA),
  zone = as.character(NA),
  comment = as.character(NA),
  hn24 = as.double(NA),
  hn72 = as.double(NA),
  ski_pen = as.double(NA),
  layers = snowprofileLayers(dropNAs = FALSE, validate = FALSE),
  tests = snowprofileTests(dropNAs = FALSE),
  instabilitySigns = snowprofileInstabilitySigns(dropNAs = FALSE),
  validate = TRUE,
  dropNAs = TRUE
)
```

Arguments

`station`	character string
`station_id`	character string
`datetime`	date and time as class POSIXct in most meaningful timezone (timezone can be converted very easily: e.g. `print(profile$datetime, tz = 'EST')`.
`latlon`	2-element vector latitude (first), longitude (second)
`elev`	profile elevation (m)
`angle`	slope angle (degree)
`aspect`	slope aspect (degree)

hs	total snow height (cm); if not provided, the field will be derived from the profile layers.
maxObservedDepth	equivalent to hs for full profiles that go down to the ground. for test profiles that only observe the upper part of the snowpack this value refers to the maximum depth of the profile observation.
type	character string, must be either 'manual', 'modeled', 'vstation', 'aggregate', or 'whiteboard'
band	character string describing elevation band as ALP, TL, BTL (alpine, treeline, below treeline)
zone	character string describing the zone or region of the profile location (e.g., BURN-ABY_MTN)
comment	character string with any text comments
hn24	height of new snow within 24 h
hn72	height of new snow within 72 h
ski_pen	skier penetration depth (m)
layers	snowprofileLayers object
tests	snowprofileTests object
instabilitySigns	snowprofileInstabilitySigns object
validate	Validate the object with validate_snowprofile?
dropNAs	Do you want to drop non-mandatory snowprofile and snowprofileLayers fields that are NA only?

Value

snowprofile object

Author(s)

shorton, fherla

See Also

summary.snowprofile, plot.snowprofile, snowprofileLayers, snowprofileTests, snowprofileInstabilitySigns, SPpairs

Examples

```
## Empty snowprofile:
snowprofile()

## Test profile:
testProfile <- snowprofile(station = 'SARPstation', station_id = 'SARP007',
                           datetime = as.POSIXct('2019/04/01 10:00:00', tz = 'Etc/GMT+7'),
                             latlon = c(49.277223, -122.915084), aspect = 180,
```

```
                          layers = snowprofileLayers(height = c(10, 25, 50),
                                                     hardness = c(3, 2, 1),
                                                     gtype = c('FC', NA, 'PP')))
summary(testProfile)
plot(testProfile)
```

`snowprofileCaaml` *Read a Caaml file into a snowprofile object*

Description

Note, that this function only provides a starting point for loading caaml files into R. Currently, caaml files exported from niviz.org, or snowpilot.org should be compatible with this routine. However, this routine only extracts some metadata and some of the most important layer characteristics. While a temperature profile (that is independent from the layers) is extracted, no other variables that can be written into a caaml file are currently being read (such as stability test results, etc).

Usage

```
snowprofileCaaml(
  caamlFile,
  sourceType = NA,
  readStabilityTests = TRUE,
  validate = TRUE
)
```

Arguments

`caamlFile`	'path/to/file.caaml'
`sourceType`	choose 'manual', 'modeled', 'vstation', 'aggregate' or 'whiteboard'; while this routine has some functionality built in to detect sourceTypes under certain circumstances, it needs to be provided in most cases.
`readStabilityTests`	boolean (this is still beta version and can throw errors sometimes)
`validate`	Should the resulting snowprofile object be validated by validate_snowprofile?

Details

- There is still a bug related to non-numeric aspects (e.g., E instead of 90).
- The snowprofileCsv function provides a lot more flexibility to read in data, if you can choose the format of your underlying data. Don't hesitate to reach out though if your caaml files throw errors and you need help! If you extend this routine, please also reach out and let us know, so we can update this package with your code extensions.

Value

snowprofile object

Author(s)

fherla

Examples

```
## load example caaml file that ships with package:
caamlFile <- system.file('extdata', 'example.caaml', package = 'sarp.snowprofile')

## read caaml file:
profile <- snowprofileCaaml(caamlFile, sourceType = 'vstation')

## other file with slighlty different xml namespace, structure, etc (including stability test):
caamlFile2 <- system.file('extdata', 'example2.caaml', package = 'sarp.snowprofile')
profile2 <- snowprofileCaaml(caamlFile2, sourceType = 'manual')
```

---

snowprofileCsv *Read csv file into a snowprofile object*

Description

Read csv file into a snowprofile object

Usage

```
snowprofileCsv(
  path,
  header = TRUE,
  sep = ",",
  use.swisscode = FALSE,
  height = "height",
  gtype = "gtype",
  hardness = "hardness",
  ...,
  crust.val = 2,
  tz = "UTC"
)
```

Arguments

path	'path/to/file.csv'
header	is there a header line in the csv file to explain the column names? If not, specify a character vector of column names in the correct order.
sep	csv column separator as string
use.swisscode	boolean; are grain types given as (numeric) swisscode (TRUE) or as character strings (FALSE)? If TRUE, grain types can be given as three-digit code (gt1|gt2|gt3), or as one-digit code specifying the primary grain type *if* another column is provided that specifies crusts. See Details and Examples for more information.

`height`	character string referring to the csv column of the top layer interfaces
`gtype`	character string referring to the csv column of the grain types
`hardness`	character string referring to the csv column of the layer hardnesses
`...`	provide name-value pairs of additional csv columns (in the form `gsize = 'csv-GrainSize-ColName'`), e.g. • profile specific info: `station`, `station_id`, `datetime`, `latlon`, `elev`, `angle`, `aspect`, `type` (see snowprofile) • layer specific info: deposition date, grain size, ssi, ... (see snowprofileLayers)
`crust.val`	If a column 'crust' is provided, what value of 'crust' defines MFcr? Mostly, either 2 (default) or 1. See Details.
`tz`	time zone (default = 'UTC')

Details

The minimum information required to construct a valid snowprofile object is `height`, `gtype` and `hardness`. Currently, substituting `height` with a depth vector is not supported.

If profile specific information is provided in the csv table, it can only be included into the snowprofile object through the exact field names (see above). However, layer specific information can be named arbitrarily (except for the three required fields).

Regarding **swisscode**: The SNOWPACK documentation specifies that MFcr are encoded as (gt1|gt2|gt3) = (7|x|2), i.e. gt1 == 7 and gt3 == 2. This is also how this routine handles the grain type encoding per default. However, some csv tables might be provided using swisscode encoding and providing gt1, gt2, and gt3 as individual one-digit columns. In those cases, gt3 could be defined as a boolean (0 or 1), where gt1 == 7 and gt3 == 1 represent crusts, instead of the aforementioned standard definition of gt1 == 7 and gt3 == 2. To handle these cases, `crust.val` can be set to 1, instead of its default `crust.val = 2`.

Value

snowprofile object

Author(s)

fherla

See Also

snowprofileCsv_advanced

Examples

```
## imagine a csv table with a very straightforward format,
## similar to the following data.frame:
(DF <- data.frame(height = c(50, 80, 100), gtype = c('FC', 'RG', 'PP'), hardness = c(1, 3, 2)))
## write DF to a temporary file:
write.csv(DF, file = file.path(tempdir(), 'file.csv'))
```

```
## read this file very easily by
profile <- snowprofileCsv(file.path(tempdir(), 'file.csv'))
profile


## imagine a csv table that requires a bit more customization,
## similar to the following data.frame:
(DF <- data.frame(ID = rep(1234, times = 3), layer_top = c(10.5, 15, 55.0), gt1 = c(5, 7, 2),
                gs = c(5.0, 1.5, 1.0), crust = c(0, 1, 0), hardness = c('F', 'P', '4F+')))
write.csv(DF, file = file.path(tempdir(), 'file.csv'))

profile <- snowprofileCsv(file.path(tempdir(), 'file.csv'), height = 'layer_top', gtype = 'gt1',
                          use.swisscode = TRUE, gsize = 'gs', crust.val = 1)
profile
## Note that the csv column 'crust', which specifies whether a MF layer is actually
#  a MFcr layer, is already named correctly (i.e., 'crust'). If it were named 'freeze-crust',
#  we would need to add to the function call: `crust = 'freeze-crust'`.
# Also note, that we need to provide `crust.val = 1`, since we're not using the standard definition
# of swisscode MFcr encoding (see Details).

## let's assume you want to read the csv file an customize some names, e.g. GrainSIZE:
profile <- snowprofileCsv(file.path(tempdir(), 'file.csv'), height = 'layer_top', gtype = 'gt1',
                          use.swisscode = TRUE, GrainSIZE = 'gs')
profile

## Note that generally in a snowprofile object layer properties can be custom named,
#  meta information, e.g. station_id, can not! I.e. you need to use the prescribed names.
```

`snowprofileCsv_advanced` *Read routine for advanced csv tables containing various snowprofile information*

Description

This routine reads blocks of snowprofile metadata, layers, tests, and stability signs. Columns contain different variables, rows different observations. While metadata only contains one row, layers, tests, and signs consist of potentially multiple rows. Within each block of information, mind the correct alignment of rows. Missing values (i.e., NA) need to be left blank or called `NA`. See the examples below including the example file shipped with the package.

Usage

```
snowprofileCsv_advanced(
  csvFile,
  meta = c("uid", "hs", "maxObservedDepth", "comment"),
```

```
  layers = c("depth", "height", "gtype", "hardness", "datetag", "gsize", "gtype_sec",
     "layer_comment"),
  tests = c("test", "result", "fract_char", "score", "test_depth", "test_comment"),
   instabilitySigns = c("instabilitySign_type", "instabilitySign_present",
     "instabilitySign_comment"),
   sep = ",",
   elev.units = "ft",
   tz = "UTC"
)
```

Arguments

csvFile	'path/to/file.csv'
meta	column names of block metadata
layers	column names of block snowprofileLayers
tests	column names of block snowprofileTests
instabilitySigns	column names of block snowprofileInstabilitySigns
sep	csv column separator
elev.units	if set to "ft", the routine will convert to "m". Set to "m" (or anything else) if it should be unchanged
tz	time zone (default = 'UTC')

Author(s)

fherla

Examples

```
## load example csv file that ships with package:
csvFile <- system.file('extdata', 'example_adv.csv', package = 'sarp.snowprofile')

profile <- snowprofileCsv_advanced(csvFile, meta = c("uid", "hs", "maxObservedDepth", "comment",
                                                     "datetime", "zone", "station",
                                                "station_id", "aspect", "elev", "angle"))

plot(profile)
```

---

snowprofileInstabilitySigns

Constructor for a snowprofileInstabilitySigns object

Description

Create a snowprofileInstabilitySigns object. Instability signs can for example be whumpfs, cracking, natural avalanches, skier accidental release, ski cutting, etc. For more information, see Canadian Avalanche Association. (2016). Observation Guidelines and Recording Standards for Weather, Snowpack, and Avalanches. Revelstoke, BC, Canada.

Usage

```
snowprofileInstabilitySigns(
 signsFrame = data.frame(type = as.character(NA), present = as.character(NA), comment =
   as.character(NA)),
 dropNAs = TRUE
)
```

Arguments

`signsFrame`	a data.frame listing snowpack stability signs. Rows correspond to individual observations of instability signs and columns describe at least the fields `c("type", "present")`. • type: Sc, Sa, Na, whumpf, crack, ... • present: Was the instability sign present (TRUE), not present (FALSE), or unknown (NA), for example – natural avalanches occurred (i.e., Na TRUE), did not occur (i.e., Na FALSE), no observations were carried out (i.e., Na NA) – skiing the slope led to an avalanche (i.e., Sa TRUE) – ski cutting did not release avalanche (i.e., Sc FALSE) – etc
`dropNAs`	Should empty, non-mandatory columns be dropped from the final snowprofileInstabilitySigns object?

Details

Note: This class might be a temporary solution to digitize instability signs observed in proximity to snowprofiles. The information contained here, might be ported to a more general field observations class that is both independent from snowprofile objects and that is more in line with existing field observation standards.

Value

snowprofileInstabilitySigns object

Author(s)

fherla

See Also

snowprofile, snowprofileLayers, snowprofileTests

Examples

```
## create a data.frame with instability sign observations
(signsFrame <- data.frame(type = c("Na", "whumpf", "cracking", "Sa"),
                          present = c(FALSE, TRUE, FALSE, FALSE)))

## create snowprofileInstabilitySigns object
instabilitySigns <- snowprofileInstabilitySigns(signsFrame)

## create snowprofile object containing instability signs and check resulting object:
snowprofile(instabilitySigns = instabilitySigns)
```

---

snowprofileLayers *Constructor for a snowprofileLayers object*

Description

Helper function to conveniently create a snowprofileLayers object, i.e. data.frame with mandatory column fields height (or depth) that provides vertical position of layers. Layers need to be ordered in a sequential manner, and the routine will rearrange the layers so that the last row of the resulting dataframe corresponds to the snow surface. If the vertical location of the layers is given by depth, make sure to provide `hs` if it's known. Otherwise, provide the field `maxObservedDepth` or layer thicknesses. Providing only depth will issue a warning and set the corresponding lowest layer thickness to NA. The resulting dataframe will contain all three fields `height`, `depth`, and `thickness`, which will be auto-filled if not provided (see format_snowprofileLayers). If the columns that describe layer properties are not of equal lengths, their values will be recycled (default data.frame mechanism). Instead of individual layer characteristics, a data.frame can be provided, which will be converted into a snowprofileLayers class. The constructor asserts correctness of the layers object by a call to validate_snowprofileLayers.

Usage

```
snowprofileLayers(
  height = as.double(NA),
  temperature = as.double(NA),
  density = as.double(NA),
  lwc = as.double(NA),
  gsize = as.double(NA),
  gsize_max = as.double(NA),
  gsize_avg = as.double(NA),
  gtype = as.factor(NA),
  gtype_sec = as.factor(NA),
  hardness = as.double(NA),
  ddate = as.POSIXct(NA),
  bdate = as.POSIXct(NA),
  datetag = as.Date(NA),
  ssi = as.double(NA),
```

```
  sphericity = as.double(NA),
  v_strain_rate = as.double(NA),
  crit_cut_length = as.double(NA),
  tsa = as.double(NA),
  tsa_interface = as.double(NA),
  rta = as.double(NA),
  rta_interface = as.double(NA),
  layerOfInterest = as.logical(NA),
  comment = as.character(NA),
  ...,
  hs = as.double(NA),
  maxObservedDepth = as.double(NA),
  layerFrame = NA,
  validate = TRUE,
  dropNAs = TRUE
)
```

Arguments

height	height vector (cm) referring to the top layer interface. Instead of height, depth can also be given and should be accompanied by an array specifying the thickness of the layers, or alternatively, the total snow depth hs and/or the maximum observed depth maxObservedDepth should be provided. Note, that also the depth refers to the top layer interface. **See examples!**
temperature	snow temperature (deg C)
density	layer density (kg/m3)
lwc	liquid water content (%)
gsize	grain size (mm)
gsize_max	maximum grain size (mm)
gsize_avg	average grain size (mm)
gtype	grain type (character or factor)
gtype_sec	secondary grain type (character or factor)
hardness	numeric hand hardness (use char2numHHI to convert from character hardness)
ddate	deposition date of layer (POSIXct format). WARNING: if you provide character format, the time zone of your computer system will be assumed.
bdate	burial date of layer (POSIXct format). WARNING: if you provide character format, the time zone of your computer system will be assumed.
datetag	of layer (i.e., usually corresponds to ddate for 'MFcr', and to bdate for all other grain types.)
ssi	snow stability index (numeric)
sphericity	between 0 and 1
v_strain_rate	viscous deformation rate (s^-1)
crit_cut_length	critical crack length (m)

tsa	threshold sum approach for structural instability (also called lemons); valid for the layer, i.e., the weakest interface adjacent to the layer. see computeTSA.
tsa_interface	same as tsa, but valid for top interface of corresponding layer
rta	relative threshold sum approach (following Monti et al 2013, ISSW paper); valid for the layer, i.e., the weakest interface adjacent to the layer. see computeRTA.
rta_interface	same as rta, but valid for top interface of corresponding layer
layerOfInterest	a boolean column to label specific layers of interest, e.g. weak layers. see labelPWL.
comment	character string
...	columns to include in the layers object. Note, that they need to correspond to the according height/depth array. e.g. hardness (can use character hardness or numeric hardness via char2numHHI), ddate (class POSIX), bdate (class Date) gtype (character or factor), density, temperature, gsize, lwc, gsize_max, gtype_sec, ssi, depth, thickness
hs	total snow height (cm), if not deductible from height vector. Particularly important when only a depth grid is provided!
maxObservedDepth	the observed depth of the profile from the snow surface downwards. Will only be used, if no height, thickness, or hs is given.
layerFrame	a data.frame that's converted to a snowprofileLayers class if no other layer characteristics are provided
validate	Validate obj with validate_snowprofileLayers?
dropNAs	Do you want to drop all columns consisting of NAs only?

Value

snowprofileLayers object as data.frame with strings as factors

Author(s)

shorton, fherla

See Also

snowprofile

Examples

```
## Empty layers object:
snowprofileLayers()


## simple layers example that recycles the hardness 1F+: with warning issued!
## Try what happens if you provide ddate as character array without a timezone.
snowprofileLayers(height = c(10, 25, 50),
                  hardness = char2numHHI('1F+'),
```

```
                  gtype = c('FC', NA, 'PP'),
                  ddate = as.POSIXct(c(NA, NA, "2020-02-15 10:45:00"),
                                     tz = "Etc/GMT+7"))

## create snowprofileLayers object from data.frame
## and feed it into a snowprofile object:
df <- data.frame(height = c(10, 25, 50),
                  hardness = c(2, 3, 1),
                  gtype = c('FC', NA, 'PP'),
                  stringsAsFactors = TRUE)

spL <- snowprofileLayers(layerFrame = df)
(sp <- snowprofile(layers = spL))


##### Create top-down recorded snowprofileLayers ####
## check out how the fields 'hs' and 'maxObservedDepth' are auto-filled in the
## resulting snowprofile object!
## 1.) Specify depth and hs:
## In that case the routine will assume that the deepest layer extends down to the ground
(sp1 <- snowprofile(layers = snowprofileLayers(depth = c(40, 25, 0),
                                               hardness = c(2, 3, 1),
                                               gtype = c('FC', NA, 'PP'),
                                               hs = 50)))
## note that sp and sp1 are the same profiles:
all(sapply(names(sp$layers), function(cols) {sp$layers[cols] == sp1$layers[cols]}), na.rm = TRUE)

## 2.) Specify depth, hs and thickness or maxObservedDepth:
## This will include a basal layer of NAs to fill the unobserved space down to the ground.
(sp2 <- snowprofile(layers = snowprofileLayers(depth = c(40, 25, 0),
                                               hardness = c(2, 3, 1),
                                               gtype = c('FC', NA, 'PP'),
                                               hs = 70,
                                               maxObservedDepth = 50)))

## 3.) Specify depth and maxObservedDepth:
## This will include a basal layer of NAs which is 1 cm thick to flag the unknown basal layers.
(sp3 <- snowprofile(layers = snowprofileLayers(depth = c(40, 25, 0),
                          hardness = c(2, 3, 1),
                          gtype = c('FC', NA, 'PP'),
                          gsize = c(2, NA, NA),
                          maxObservedDepth = 50)))

## 4.) Specify depth and thickness:
## This is equivalent to the example spL3 above!
## This will include a basal layer of NAs which is 1 cm thick to flag the unknown basal layers.
(sp4 <- snowprofile(layers = snowprofileLayers(depth = c(40, 25, 0),
                          thickness = c(10, 15, 25),
                          hardness = c(2, 3, 1),
                          gtype = c('FC', NA, 'PP'))))

## 5.) Specify only depth: issues warning!
(sp5 <- snowprofile(layers = snowprofileLayers(depth = c(40, 25, 0),
```

```
                        hardness = c(2, 3, 1),
                        gtype = c('FC', NA, 'PP'))))

## plot all 5 top.down-recorded profiles:
set <- snowprofileSet(list(sp1, sp2, sp3, sp4, sp5))
plot(set, SortMethod = "unsorted", xticklabels = "originalIndices",
     hardnessResidual = 0.1, hardnessScale = 1.5, TopDown = TRUE,
     main = "TopDown Plot")

plot(set, SortMethod = "unsorted", xticklabels = "originalIndices",
     hardnessResidual = 0.1, hardnessScale = 1.5, TopDown = FALSE,
     main = "BottomUp Plot")
```

`snowprofilePrf` *Construct snowprofile object from PRF file*

Description

Read .prf files from SNOWPACK model output

Usage

```
snowprofilePrf(Filename, ProfileDate = NA, tz = "UTC")
```

Arguments

`Filename`	path to prf file
`ProfileDate`	read a single profile from file (default = NA will read all profiles)
`tz`	time zone (default = 'UTC')

Details

Several SNOWPACK model output formats exist see SNOWPACK documentation

Definitions of PRF files are provided at https://snowpack.slf.ch/doc-release/html/prf_format.html

PRF files typically contain profiles from the same station at multiple time steps. If a specific `ProfileDate` is provided a single snowprofile object is returned (search available dates with `scanProfileDates`), otherwise all profiles are read and a list of snowprofile objects is returned.

Value

a single snowprofile object of list of multiple snowprofile objects

Author(s)

shorton

See Also

snowprofilePro, scanProfileDates, snowprofileSno

Examples

```
## Path to example prf file
Filename <- system.file('extdata', 'example.prf', package = 'sarp.snowprofile')

## Scan dates in file
Dates <- scanProfileDates(Filename)
print(Dates)

## Read a single profile by date and plot
ProfileDate <- Dates[3]
Profile <- snowprofilePrf(Filename, ProfileDate = ProfileDate)
plot(Profile)

## Read entire time series and plot
Profiles <- snowprofilePrf(Filename)
plot(Profiles, main = 'Timeseries read from example.prf')
```

---

snowprofilePro *Construct snowprofile object from PRO file*

Description

Read .pro files from SNOWPACK model output

Usage

```
snowprofilePro(
  Filename,
  ProfileDate = NA,
  tz = "UTC",
  remove_soil = TRUE,
  consider_SH_surface = TRUE,
  suppressWarnings = FALSE
)
```

Arguments

Filename	path to pro file
ProfileDate	read specific profiles from file either by individual date or a vector of dates (default = NA will read all profiles)
tz	time zone (default = 'UTC')
remove_soil	if soil layers are present in PRO file, remove them from snowprofile objects?

`consider_SH_surface`
: boolean switch to read the special PRO field 0514–SH at surface (this will produce NA for many unknown layer properties except gsize, density, hardness, gtype, height)

`suppressWarnings`
: boolean switch

Details

Several SNOWPACK model output formats exist see SNOWPACK documentation

Definitions of PRO files are provided at https://snowpack.slf.ch/doc-release/html/pro_format.html and an example file is available at niViz

PRO files typically contain profiles from the same station at multiple time steps. If a specific `ProfileDate` is provided a single snowprofile object is returned (search available dates with `scanProfileDates`), otherwise all profiles are read and a list of snowprofile objects is returned.

Value

a single snowprofile object or a snowprofileSet (list of multiple snowprofile objects) depending on whether multiple or single dates are being read. If several ProfileDates are being given, but only one of the dates contains snow, a snowprofileSet of length 1 is returned.

Author(s)

shorton, dmauracher

See Also

snowprofilePrf, scanProfileDates, snowprofileSno

Examples

```
## Path to example pro file
Filename <- system.file('extdata', 'example.pro', package = 'sarp.snowprofile')

## Download example pro file from niViz
#Filename <- tempfile(fileext = '.pro')
#download.file('https://niviz.org/resources/example.pro', Filename)

## Scan dates in file
Dates <- scanProfileDates(Filename)
print(Dates)

## Read a single profile by date and plot
ProfileDate <- Dates[3]
Profile <- snowprofilePro(Filename, ProfileDate = ProfileDate)
plot(Profile)

## Read entire time series and plot
Profiles <- snowprofilePro(Filename)
```

```
plot(Profiles, main = 'Timeseries read from example.pro')

## Read several specific dates and plot
specificDates <- Dates[2:3]
Profiles <- snowprofilePro(Filename, ProfileDate = specificDates)
plot(Profiles)
```

`snowprofileSet` *Constructor for class snowprofileSet*

Description

Constructor for class snowprofileSet

Usage

```
snowprofileSet(x = list())
```

Arguments

`x`	list of snowprofile objects

Value

a snowprofileSet

See Also

snowprofile, summary.snowprofileSet

`snowprofileSno` *Construct snowprofile object from SNO file*

Description

Read .sno files from SNOWPACK model input/output

Usage

```
snowprofileSno(Filename)
```

Arguments

`Filename`	path to sno file

Details

Several SNOWPACK model output formats exist see SNOWPACK documentation

Definitions of SNO files are provided at https://snowpack.slf.ch/doc-release/html/smet.html

Value

a snowprofile object

Author(s)

shorton

See Also

snowprofilePro, snowprofilePrf, snowprofileCsv

Examples

```
## Path to example prf file
Filename <- system.file('extdata', 'example.sno', package = 'sarp.snowprofile')

## Read snowprofile object
Profile <- snowprofileSno(Filename)

## Note: plot.snowprofile won't work because sno files don't have harndess

## Plot a temperautre profile
plot(snowprofileSet(list(Profile)), ColParam = 'temp')
```

---

snowprofileTests *Constructor for a snowprofileTests object*

Description

Create a snowprofileTests object.

Usage

```
snowprofileTests(
  testsFrame = data.frame(type = as.character(NA), result = as.character(NA), score =
    as.double(NA), fract_char = as.character(NA), depth = as.double(NA), comment =
     as.character(NA)),
  dropNAs = TRUE
)
```

Arguments

`testsFrame` a data.frame listing snowpack stability tests. Rows correspond to individual tests and columns describe at least the fields `c("type", "result", "fract_char", "score", "depth")`.

- Test **type** and **result** yield the standard 'data code' for reporting snowpack tests according to the OGRS (see Details). Following type and result combinations are allowed:
  - STV, STE, STM, STH, STN, and mixed forms STE-M, STM-H
  - CTV, CTE, CTM, CTH, CTN, and mixed forms CTE-M, CTM-H
  - DTV, DTE, DTM, DTH, DTN, and mixed forms DTE-M, DTM-H
  - ECTPV, ECTP, ECTN, ECTX
  - RB, PST, DT tests are currently not supported.
- **score**: numeric, number of taps (for CT, ECT)
- **fract_char** corresponds to the fracture character, e.g., SP, SC, PC, RP, BRK, ...
- **depth**: vertical location of corresponding snowpack layer (from surface)
- potential test comment column

`dropNAs` Should empty, non-mandatory columns be dropped from the final snowprofileTests object?

Details

For more information, see Canadian Avalanche Association. (2016). Observation Guidelines and Recording Standards for Weather, Snowpack, and Avalanches (OGRS). Revelstoke, BC, Canada.

Value

snowprofileTests object

Author(s)

fherla

See Also

snowprofile, snowprofileLayers, snowprofileInstabilitySigns

Examples

```
## create a data.frame with test observations
(testsFrame <- data.frame(type = c("CT", "ST", "ECT"),
                          result = c("E-M", "M", "P"),
                          score = c(10, NA, 12),
                          fract_char = c("SP", NA, NA),
                          depth = c(40, 40, 40),
                          comment = c("some comment on first test", "", "")))

## create snowprofileTests object
```

```
tests <- snowprofileTests(testsFrame)

## create snowprofile object containing test results and check resulting object:
snowprofile(tests = tests)
```

SPgroup *Example group of snowprofiles from a mountain drainage*

Description

A list of 12 snowprofile objects.

Usage

```
SPgroup
```

Format

A list with 12 entries, that are of class snowprofile

See Also

SPpairs, SPtimeline, plot.snowprofileSet

Examples

```
plot(SPgroup, SortMethod = 'unsorted', xticklabels = "originalIndices")
plot(SPgroup, SortMethod = 'hs', xticklabels = "originalIndices")
```

SPmalformatted *Malformatted example profiles*

Description

A list with two entries, each containing a snowprofile object. Both are malformatted, check out the examples in validate_snowprofile and reformat_snowprofile to learn how to fix it.

Usage

```
SPmalformatted
```

Format

A list with several entries, that are of class snowprofile

See Also

validate_snowprofile, reformat_snowprofile, SPpairs, SPgroup, SPtimeline

---

`SPpairs` *Pairs of example snowprofiles*

Description

A list with several entries, each containing a snowprofile object. Pairs of similar profiles are grouped by their names.

Usage

```
SPpairs
```

Format

A list with several entries, that are of class snowprofile

See Also

SPgroup, SPtimeline

Examples

```
## Each name refers to one snowprofile:
names(SPpairs)

opar <- par(no.readonly = TRUE)
par(mfrow = c(1, 2))
plot(SPpairs$A_manual, main = 'SPpairs$A_manual')
plot(SPpairs$A_modeled, main = 'SPpairs$A_modeled')
par(opar)
```

`SPtimeline` *Timeseries of snowprofiles #'*

Description

Timeseries of snowprofiles #'

Usage

```
SPtimeline
```

Format

A list with several entries, that are of class snowprofile

See Also

SPgroup, SPpairs

Examples

```
summary(SPtimeline)
plot(SPtimeline)
```

`SPtimeline_3hourly` *Timeseries of snowprofiles in 3 hour resolution #'*

Description

Timeseries of snowprofiles in 3 hour resolution #'

Usage

```
SPtimeline_3hourly
```

Format

A list with several entries, that are of class snowprofile

See Also

SPtimeline

Examples

```
summary(SPtimeline_3hourly)
plot(SPtimeline_3hourly)
```

`summary.snowprofile` *Summary of a single snowprofile*

Description

Summary of a single snowprofile

Usage

```
## S3 method for class 'snowprofile'
summary(object, fast = FALSE, ...)
```

Arguments

`object`	snowprofile object
`fast`	boolean switch for twice as fast computation. downside: keep only length-1 meta data, i.e., discard latlon, or nlayers..
`...`	additional arguments for generic method

Details

Creates a one row data.frame where each column contains metadata.

Metadata is determines as elements of the snowprofile object list that are length = 1. An exception is made for latlon where separate columns for lat and lon are produces.

A derived value `nLayers` is derived by counting the number of rows in $layers.

Value

data.frame

Author(s)

shorton

See Also

summary.snowprofileSet

Examples

```
Profile <- SPgroup[[1]]
names(Profile)
summary(Profile)
lapply(SPgroup, summary)
```

summary.snowprofileSet *Summarize multiple snowprofiles*

Description

Wrapper for summary.snowprofile, which only returns metadata for a single snowprofile object. summary.snowprofileSet provides metadata for multiple snowprofiles, which is useful for subsetting.

Usage

```
## S3 method for class 'snowprofileSet'
summary(object, fast = TRUE, ...)
```

Arguments

object	list of snowprofile objects
fast	boolean switch to speed up computations, see summary.snowprofile
...	additional arguments for generic method

Value

data.frame

Author(s)

shorton

See Also

summary.snowprofile, rbind.snowprofileSet

Examples

```
## Extract metadata for a group of profiles
Metadata <- summary(SPgroup)
head(Metadata)

## Subsetting profiles with Metadata
Alpine <- SPgroup[Metadata$elev > 2000]
summary(Alpine)
Shallow <- SPgroup[Metadata$hs < 150]
summary(Shallow)
Week2 <- SPtimeline[summary(SPtimeline)$date > '2017-12-15']


## time comparison of fast--slow implementation
```

```
## expect 20 sec runtime
# rbenchmark::benchmark(fast = {Metadata <- summary(SPgroup, fast = TRUE)},
#                       slow = {Metadata <- summary(SPgroup, fast = FALSE)},
#                       replications = 10**3)
```

---

swisscode *Numerical, Swiss Grain Type Code*

Description

A character array of grain types that can be translated into a numerical code by their indices.

Usage

```
swisscode
```

Format

A character array

Examples

```
print(swisscode)

## see numerical code for each grain type:
rbind(swisscode, seq(length(swisscode)))
```

---

validate_snowprofile *Validate correctness of snowprofile object*

Description

Validator function that checks if snowprofile standards are being met and raises an error if mandatory fields are missing or data types are incorrect. The function raises a warning when unknown field names are encountered.

Usage

```
validate_snowprofile(object, silent = FALSE)
```

Arguments

object	a snowprofile object to be validated
silent	remain silent upon error (i.e., don't raise error, but only print it)

Value

Per default an error is raised when discovered, if `silent = TRUE` the error is only printed and the error message returned (Note: a warning is never returned but only printed!). If the function is applied to multiple objects, the function returns `NULL` for each object if no error is encountered (see examples below).

See Also

reformat_snowprofile

Examples

```
## Validate individual snowprofile and raise an error
## in case of a malformatted profile:

## (1) no error
validate_snowprofile(SPgroup[[1]])

## (2) malformatted profile --> error
this_throws_error <- TRUE
if (!this_throws_error) {
validate_snowprofile(SPmalformatted[[1]])
}

## Validate a list of snowprofiles and raise an error
## when the first error is encountered:
## (i.e., stop subsequent execution)

## (1) no error
lapply(SPgroup, validate_snowprofile)

## (2) malformatted profile --> error
if (!this_throws_error) {
lapply(SPmalformatted, validate_snowprofile)
}

## Validate a list of snowprofiles and continue execution,
## so that you get a comprehensive list of errors of all profiles:
if (!this_throws_error) {
errorlist <- lapply(SPmalformatted, validate_snowprofile, silent = TRUE)
errorlist[sapply(errorlist, function(item) !is.null(item))] # print profiles that caused errors
}
```

`validate_snowprofileLayers`

Validate correctness of snowprofileLayers object

Description

Validator function that checks if class standards are being met and raises an error if not.

Usage

```
validate_snowprofileLayers(object, silent = FALSE)
```

Arguments

object	to be tested
silent	remain silent upon error (i.e., don't throw error, but only print it)

Value

Per default an error is raised when discovered, if `silent = TRUE` the error is only printed and the error message returned.

---

writePro *Write snowprofileSet to a PRO file*

Description

Write SNOWPACK PRO files from a snowprofileSet.

Usage

```
writePro(
  profiles,
  filename,
  meta = NaN,
  header_comment = "time of creation and SNOWPACK version unknown"
)
```

Arguments

profiles	snowprofileSet object to write.
filename	output file path ending in `.pro`.
meta	optional profile metadata (defaults to `summary(profiles, fast = TRUE)` when omitted).
header_comment	character string added to the file header.

Value

Writes a PRO file to disk; returns `NULL` invisibly.

See Also

snowprofilePro

Examples

```
## Path to example pro file
Filename <- system.file('extdata', 'example.pro', package = 'sarp.snowprofile')

## Read entire time series and plot
Profiles <- snowprofilePro(Filename)
plot(Profiles, main = 'Timeseries read from example.pro')

## Write to file
tmppath = tempfile(pattern = "written_", fileext = ".pro")
writePro(Profiles, tmppath)

## Re-read from tempfile
Profiles2 <- snowprofilePro(tmppath)
(testbool <- all(Profiles[[1]]$layers == Profiles2[[1]]$layers))
if (!testbool) stop("error in writePro re-reading!")
```

---

writeSmet *Write a SMET file*

Description

Write data into a SMET file https://models.slf.ch/docserver/meteoio/SMET_specifications.pdf

Usage

```
writeSmet(smet, filename)
```

Arguments

smet	A data structure that resembles a smet file (i.e., list containing metadata and a data.frame, see example in readSmet)
filename	Filepath to be written

Value

Generates smet file

Author(s)

fherla, shorton

See Also

readSmet, snowprofileSno, snowprofilePrf, snowprofilePro

Examples

```
## First read example smet file provided in package
(Wx = readSmet(system.file('extdata', 'example.smet', package = 'sarp.snowprofile')))

## Then write Wx to a new temp file and show the file
writeSmet(Wx, filename = file.path(tempdir(), 'file.smet'))
file.show(file.path(tempdir(), 'file.smet'))

## Check whether it can be read back in
(WxNew <- readSmet(file.path(tempdir(), 'file.smet')))
```

[.snowprofileSet *Extract method*

Description

Extract method

Usage

```
## S3 method for class 'snowprofileSet'
x[i]
```

Arguments

x	object from which to extract element(s) or in which to replace element(s).
i	indices specifying elements to extract or replace

Value

snowprofileSet object

Index