

# Package ‘vineyard’

September 26, 2019

**Type** Package

**Title** Bud Break, Phenological and Yield Models for Vineyards

**Version** 0.1.0

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**Description** Late frosts are a significant risk to grape production in frost-prone viticultural regions. Increasing air temperature because of climate change is likely to advance grape bud break and last frost events in spring. So far, it is unclear whether one trend will be more pronounced than the other, and hence, whether the risk of late frost damage will increase or decrease. The aim of this package is to provide tools for investigating e.g. the future frost risk in winegrowing regions by assessing the effect of simulated future climate conditions on the timing of bud break and last frost date. Late frost risk can be assessed by the implementation of phenological models for bud break of the grapevine.

**License** What license is it under?

**Encoding** UTF-8

**LazyData** true

**RoxygenNote** 6.1.1

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DD.double.cumulative	<i>Compute the cumulative degree days by the double (lower and upper) temperature threshold</i>
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**Description**

Implementation to compute the cumulative degree days by the double (lower and upper) temperature threshold by Molitor et al., (2014).

**Usage**

```
DD.double.cumulative(data, t.mean.col, a, b)
```

**Arguments**

- data           input data in xts format.
- t.mean.col    numeric, column position in data for the daily mean air temperature vector in Celsius degrees.
- a             numeric, threshold temperature (in Celsius degrees) for vine growth.
- b             numeric, upper threshold temperature (in Celsius degrees) for vine growth.

**Value**

list per year for the input data plus an additional column with the cumulative degree days (in Celsius degrees) for vine growth. The output for each year is a "xts" time series object.

**References**

Daniel Molitor, Jürgen Junk, Danièle Evers, Lucien Hoffmann, and Marco Beyer (2014). A high-resolution cumulative degree day-based model to simulate phenological development of grapevine. Am. J. Enol. Vitic., (65:1):72–80.

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DD.double.phenology	<i>Cumulative degree days (CDD) by the double (lower and upper) threshold algorithm for phenology</i>
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### Description

Implementation to compute the cumulative degree days by the double (lower and upper) threshold algorithm by Molitor et al. (2010) for phenology.

### Usage

```
DD.double.phenology(cdd.dtt, chs.mean)
```

### Arguments

cdd.dtt	cumulative degree days (in Celsius degrees) for vine growth in xts format as provided by "DD.double.treshold.cumulative" function.
chs.mean	numeric, mean cumulative heat sum for bud break (in Celsius degrees).

### Value

the cumulative degree days (in Celsius degrees) for vine growth plus an additional column with the cumulative degree days (in Celsius degrees) for phenology.

### References

Daniel Molitor, Jürgen Junk, Danièle Evers, Lucien Hoffmann, and Marco Beyer (2014). A high-resolution cumulative degree day-based model to simulate phenological development of grapevine. *Am. J. Enol. Vitic.*, (65:1):72–80.

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DD.double.threshold	<i>Compute the degree days by the double (lower and upper) temperature thresholds</i>
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### Description

Implementation to compute the degree days by the double (lower and upper) temperature thresholds by Molitor et al., (2014).

### Usage

```
DD.double.threshold(t.mean, a, b)
```

**Arguments**

t.mean	daily mean air temperature vector in Celsius degrees.
a	numeric, lower threshold temperature (in Celsius degrees) for vine growth.
b	numeric, upper threshold temperature (in Celsius degrees) for vine growth.

**Value**

a vector with the degree days (in Celsius degrees) for vine growth.

**References**

Daniel Molitor, Jürgen Junk, Danièle Evers, Lucien Hoffmann, and Marco Beyer (2014). A high-resolution cumulative degree day-based model to simulate phenological development of grapevine. *Am. J. Enol. Vitic.*, (65:1):72–80.

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DD.LUH.cumulative	<i>Compute cumulative degree days by the lower, upper and heat temperature thresholds</i>
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**Description**

Implementation to compute cumulative degree days by the lower, upper and heat temperature threshold by Molitor et al., (2014).

**Usage**

```
DD.LUH.cumulative(data, t.mean.col, a, b, c)
```

**Arguments**

data	input data in xts format.
t.mean.col	numeric, column position in data for the daily mean air temperature vector in Celsius degrees.
a	numeric, threshold temperature (in Celsius degrees) for vine growth.
b	numeric, upper threshold temperature (in Celsius degrees) for vine growth.
c	numeric, heat threshold temperature (in Celsius degrees) for vine growth.

**Value**

list per year for the input data plus an additional column with the cumulative degree days (in Celsius degrees) for vine growth. The output for each year is a "xts" time series object.

**References**

Daniel Molitor, Jürgen Junk, Danièle Evers, Lucien Hoffmann, and Marco Beyer (2014). A high-resolution cumulative degree day-based model to simulate phenological development of grapevine. *Am. J. Enol. Vitic.*, (65:1):72–80.

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DD.LUH.phenology	<i>Cumulative degree days (CDD) by the lower, upper and heat thresholds algorithm for phenology</i>
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### Description

Implementation to compute the cumulative degree days by the lower, upper and heat threshold algorithm by Molitor et al. (2010) for phenology.

### Usage

```
DD.LUH.phenology(cdd.LUHtt, chs.mean)
```

### Arguments

cdd.LUHtt	cumulative degree days (in Celsius degrees) for vine growth in xts format as provided by "DD.LUH.cumulative" function.
chs.mean	numeric, mean cumulative heat sum for bud break (in Celsius degrees).

### Value

the cumulative degree days (in Celsius degrees) for vine growth plus an additional column with the cumulative degree days (in Celsius degrees) for phenology.

### References

Daniel Molitor, Jürgen Junk, Danièle Evers, Lucien Hoffmann, and Marco Beyer (2014). A high-resolution cumulative degree day-based model to simulate phenological development of grapevine. *Am. J. Enol. Vitic.*, (65:1):72–80.

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DD.LUH.threshold	<i>Compute the degree days by a lower, upper and heat threshold temperatures</i>
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### Description

Implementation to compute the degree days by a lower, upper and heat threshold temperatures by Molitor et al., (2014).

### Usage

```
DD.LUH.threshold(t.mean, a, b, c)
```

**Arguments**

t.mean	daily mean air temperature vector in Celsius degrees.
a	numeric, lower threshold temperature (in Celsius degrees) for vine growth.
b	numeric, upper threshold temperature (in Celsius degrees) for vine growth.
c	numeric, heat threshold temperature (in Celsius degrees) for vine growth.

**Value**

a vector with the degree days (in Celsius degrees) for vine growth.

**References**

Daniel Molitor, Jürgen Junk, Danièle Evers, Lucien Hoffmann, and Marco Beyer (2014). A high-resolution cumulative degree day-based model to simulate phenological development of grapevine. *Am. J. Enol. Vitic.*, (65:1):72–80.

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DD.single.cumulative	<i>Compute the cumulative degree days by the single temperature threshold</i>
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**Description**

Implementation to compute the cumulative degree days by the single temperature threshold by Molitor et al., (2014).

**Usage**

```
DD.single.cumulative(data, t.mean.col, a)
```

**Arguments**

data	input data in xts format.
t.mean.col	numeric, column position in data for the daily mean air temperature vector in Celsius degrees.
a	numeric, threshold temperature (in Celsius degrees) for vine growth.

**Value**

list per year for the input data plus an additional column with the cumulative degree days (in Celsius degrees) for vine growth. The output for each year is a "xts" time series object.

**References**

Daniel Molitor, Jürgen Junk, Danièle Evers, Lucien Hoffmann, and Marco Beyer (2014). A high-resolution cumulative degree day-based model to simulate phenological development of grapevine. *Am. J. Enol. Vitic.*, (65:1):72–80.

---

DD.single.phenology	<i>Cumulative degree days (CDD) by the single threshold algorithm for phenology</i>
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**Description**

Implementation to compute the cumulative degree days by the single threshold algorithm by Molitor et al. (2010) for phenology.

**Usage**

```
DD.single.phenology(cdd.stt, chs.mean)
```

**Arguments**

cdd.stt	cumulative degree days (in Celsius degrees) for vine growth in xts format as provided by "DD.single.treshhold.cumulative" function.
chs.mean	numeric, mean cumulative heat sum for bud break (in Celsius degrees).

**Value**

the cumulative degree days (in Celsius degrees) for vine growth plus an additional column with the cumulative degree days (in Celsius degrees) for phenology.

**References**

Daniel Molitor, Jürgen Junk, Danièle Evers, Lucien Hoffmann, and Marco Beyer (2014). A high-resolution cumulative degree day-based model to simulate phenological development of grapevine. *Am. J. Enol. Vitic.*, (65:1):72–80.

---

DD.single.threshold	<i>Compute degree days by the single temperature threshold</i>
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**Description**

Implementation to compute degree days by the single temperature threshold by Molitor et al., (2014).

**Usage**

```
DD.single.threshold(t.mean, a)
```

**Arguments**

t.mean	daily mean air temperature vector in Celsius degrees.
a	numeric, threshold temperature (in Celsius degrees) for vine growth.

**Value**

a vector with the degree days.

**References**

Daniel Molitor, Jürgen Junk, Danièle Evers, Lucien Hoffmann, and Marco Beyer (2014). A high-resolution cumulative degree day-based model to simulate phenological development of grapevine. *Am. J. Enol. Vitic.*, (65:1):72–80.

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DD.single.triangle	<i>Degree days by the single triangle algorithm for bud break</i>
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**Description**

Implementation to compute the degree days by the single triangle algorithm by Nendel (2010) for bud break.

**Usage**

```
DD.single.triangle(t.zero, t.min, t.mean, t.max)
```

**Arguments**

t.zero	numeric, threshold temperature (in Celsius degrees) for vine growth.
t.min	daily minimum air temperature vector in Celsius degrees.
t.max	daily maximum air temperature vector in Celsius degrees.

**Value**

a vector with the degree-days (in Celsius degrees) for vine growth.

**References**

Nendel, Class (2010). Grapevine bud break prediction for cool winter climates. *Int. J. Biometeorol.*, 54, 231–241.



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DD.single.triangle.budbreak

*Cumulative degree days (CDD) by the single triangle algorithm for bud break*

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### Description

Implementation to compute the cumulative degree days by the single triangle algorithm by Nendel (2010) for bud break.

### Usage

```
DD.single.triangle.budbreak(cdd, start.date)
```

### Arguments

cdd	cumulative degree days (in Celsius degrees) for vine growth in xts format as provided by "DD.single.triangle.cumulative" function.
start.date	numeric, calculated optimum starting date in day of year.

### Value

the cumulative degree days (in Celsius degrees) for vine growth plus an additional column with the cumulative degree days (in Celsius degrees) for bud break.

### References

Nendel, Class (2010). Grapevine bud break prediction for cool winter climates. Int. J. Biometeorol., 54, 231–241.

---

DD.single.triangle.cumulative

*Cumulative degree days (CDD) by the single triangle algorithm*

---

### Description

Implementation to compute the cumulative degree days by the single triangle algorithm by Nendel (2010).

### Usage

```
DD.single.triangle.cumulative(data, t.zero, t.min.col, t.mean.col,
  t.max.col)
```

**Arguments**

<code>data</code>	input data in xts format.
<code>t.zero</code>	numeric, threshold temperature (in Celsius degrees) for vine growth.
<code>t.min.col</code>	numeric, column position in data for the daily minimum air temperature vector in Celsius degrees.
<code>t.mean.col</code>	numeric, column position in data for the daily mean air temperature vector in Celsius degrees.
<code>t.max.col</code>	numeric, column position in data for the daily maximum air temperature vector in Celsius degrees.
<code>start.date</code>	numeric, calculated optimum starting date in day of year.

**Value**

list per year for the input data plus an additional column with the cumulative degree days (in Celsius degrees) for vine growth. The output for each year is a "xts" time series object.

**References**

Nendel, Class (2010). Grapevine bud break prediction for cool winter climates. *Int. J. Biometeorol.*, 54, 231–241.

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FillNA

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*Fill NA data in time series*


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**Description**

Fill NA data in time series

**Usage**

```
FillNA(x)
```

**Arguments**

`x` the input time series as xts object.

**Value**

a time series with the NAs replaced by data according to the `na.locf` zoo function.

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GrowthStage_CDD	<i>Cumulative degree days and growth stages</i>
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### Description

A sample dataset containing the cumulative degree days (CDD) with optimized lower, upper, and heat threshold triplets (5, 20, 22°C) per growth stages according to Table 4 from Molitor et al. (2014).

### References

Daniel Molitor, Jürgen Junk, Danièle Evers, Lucien Hoffmann, and Marco Beyer. A high-resolution cumulative degree day-based model to simulate phenological development of grapevine. *Am. J. Enol. Vitic.*, (65:1):72–80, 2014.

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Id.na	<i>Find indexes for NA data in time series</i>
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---

### Description

Find indexes for NA data in time series

### Usage

Id.na(x)

### Arguments

x                      the input time series as xts object.

### Value

a vector with the index for NA data in the time series.

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Phenology.stages	<i>Compute phenological stages</i>
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### Description

Implementation to compute phenological stages by Molitor et al., (2014).

### Usage

```
Phenology.stages(cdd.phen, ref.data, stage)
```

### Arguments

cdd.phen	list, cumulative degree days (in Celsius degrees) for vine growth in xts format as provided by e.g. "DD.single.treshold.phenology" function.
ref.data	data.frame, reference dataset to define the phenological stages e.g. "Growth-Stage_CDD" dataset.
stage	vector, growth stage(s) for which the phenology should be computed.

### Value

list per year, with each list containing a data.frame with the phenological stages for vine growth.

### References

Daniel Molitor, Jürgen Junk, Danièle Evers, Lucien Hoffmann, and Marco Beyer (2014). A high-resolution cumulative degree day-based model to simulate phenological development of grapevine. Am. J. Enol. Vitic., (65:1):72–80.

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plot.na	<i>Plot NA data in time series</i>
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### Description

Plot NA data in time series

### Usage

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

### Arguments

x	the input time series as xts object.
ids.na	the vector which contains indexes for NA data as provided by the Id.na function.

**Value**

plots with the NAs highlighted.

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Raw2xts	<i>Raw data to xts object</i>
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**Description**

Raw data to xts object

**Usage**

Raw2xts(data)

**Arguments**

data                      the dataframe to convert to xts time series.

**Value**

the xts object for the input dataframe.

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Remich	<i>Sample time series of meteorological data for Remich station.</i>
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**Description**

A sample dataset containing time series of meteorological data for Remich station located in the Grand-Duchy of Luxembourg obtained by the Institut Viti-vinicole in Remich. The data covers the period from 1970 to 2017 at daily time interval.

**References**

<https://agriculture.public.lu/de/weinbau-oenologie.html>

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