Package 'rkt'

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Type Package

Title Mann-Kendall Test, Seasonal and Regional Kendall Tests

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Description Contains function rkt which computes the Mann-Kendall test (MK) and the Seasonal and the Regional Kendall Tests for trend (SKT and RKT) and Theil-Sen's slope estimator.

License GPL-2

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Contents

rkt-package *Mann-Kendall Test, Seasonal and Regional Kendall Tests*

Description

Contains function rkt which computes the Mann-Kendall test (MK) and the Seasonal and the Regional Kendall Tests for trend (SKT and RKT) and Theil-Sen's slope estimator.

Details

Package:	rkt
Type:	Package
Version:	1.7
Date:	2026-08-25
License:	GPL-2

This function computes the Mann-Kendall test (MK) and the Seasonal and the Regional Kendall Tests for trend (SKT and RKT) and Sen's slope estimator.
MK, SKT and RKT are tests for monotonic trend in time series based on the Kendall rank correlation.
SKT and RKT are intrablock tests in which test statistics are computed for each season or month (SKT) or for each site (RKT) and combined in an overall test.
In RKT, seasonality can be accounted for by using a blocking variable combining both sites and seasons, such as (site * 12 + month).
When a covariable is defined, this function also computes partial RKT and SKT.
To allow for non-regular sampling dates, input data should be vectors, not time series.
If there are no block definition nor ties, exact probability can be optionally calculatesd by recurrence relation.

Author(s)

Maintainer: Aldo Marchetto <aldo.marchetto@cnr.it>

References

Helsel D.R., Frans L.M. 2006 The regional Kendall test for trend: Environmental Science and Technology **40**, 4066–4073

Helsel D.R., Mueller D.K., Slack J.R. 2006 *Computer program for the Kendall family of trend tests* U.S. Geological Survey Scientific Investigations Report 2005-5275, 4 pp.

Hirsch R.M., Slack J.R., Smith R.A. Techniques of trend ananlyis for monthly water quality data. Water Resources Research **18**, 107-121

Hirsch R.M., Slack J.R. 1984 A nonparametric test for seasonal data with serial dependance. Water Resources Research **20**, 727-732

Libiseller C., Grimvall A. 2002 Perfomance of partial Mann-Kendall tests for trend detection in the presence of covariates. Environmetrics **13**, 71-84

Mann H.B. 1945. Nonparametric tests against trend. Econometrica **13**, 245-249

Kaarsemaker L., Wijngaarden A. van 1953 Tables for use in rank correlation. Report R73 of the Computation Depattment of the Mathematical Centre, Amsterdam

Best, D.J., Gipps, P.G. 1974 Algorithm AS 71: The Upper Tail Probabilities of Kendall's Tau. Journal of the Royal Statistical Society. Series C (Applied Statistics), 23: 98-100

Marchetto A., Rogora M., Arisci S. 2013 Trend analysis of atmospheric deposition data: a comparison of statistical approaches. Atmospheric Environment **64**, 95-102

Examples

```
#
# monthly data, using covariate and intra-block correction
#
data(pie1)
ex<-rkt(pie1$Year,pie1$SO4,pie1$Month,pie1$mm,TRUE)
print(ex)
#
# weekly data, no intrablock correction
#
data(pie1w)
ex<-rkt(pie1w$Date,pie1w$SO4)
print(ex)
#
# monthly data, hydrological years (oct-sep) as in USGS program
#
data(pie1)
ex<-rkt(pie1$Year+floor(pie1$Month/10),pie1$SO4,pie1$Month,,TRUE)
print(ex)
#
```

`pblocks` *exact probability for SKT/RKT with blocks (seasons/sites)*

Description

upper tail exact probability for a positive value of S in presence of up to 6 blocks. With more blocks exact probability is not useful, as the normal approximation is precise even with as low as 3 points for 12 seasons (see Hirscvh 1982). Block lenght can be different among blocks. The

exact probability is obtained following Hirsch (1982), by enumerating all possible permutations and combinations of Si (the S of a single block) for all the blocks, summing the Si's, multiplying the independent probabilities, and adding the probabilities of all of the Si sequences that sum to each particular value of S. pblocks function is called by rkt. rkt will double the retruned value to obtain the 2-sided probability.

Usage

```
pblocks(BL,S)
```

Arguments

BL	a vector of 6 integers representing the length of the blocks, in decreasing order; if there are less than 6 blocks, the remaining values should be set to zero.
S	the value of S of the SKT/RKT test

Value

the upper tail exact probability of S, based on the block length.

Note

used by rkt

Author(s)

Aldo Marchetto

References

Hirsch R.M., Slack J.R., Smith R.A. 1982. Techniques of trend ananlyis for monthly water quality data. Water Resources Research **18**, 107-121

See Also

rkt

Examples

```
pblocks(c(4,4,4,0,0,0),4)
```

pie1 *Example data for rkt function*

Description

Bulk open field deposition collected in Val Sessera (Italy) in 1998-2010, volume weighted monthly averages.

Usage

```
data(pie1)
```

Format

A data frame with 156 observations on the following 5 variables.

`Year` sampling year

`Month` sampling month

`mm` amount of precipitation (mm)

`SO4` sulphate concentration (mg/L)

`NO3` nitate concentration (mg N/L)

Details

SO4 shows a highly significant decreasing trend, NO3 shows a moderately significant decreasing trend and mm no significant trend

Source

Marchetto A., Rogora M. & Arisci S. 2013 Trend analysis of atmospheric deposition data: a comparison of statistical approaches. Atmospheric Environment **64**, 95-102

Rogora M., Mosello R., Arisci S., Brizzio M., Barbieri A., Balestrini R., Waldner P., Schmitt M., Stahli M.,Thimonier A., Kalina M., Puxbaum H., Nickus U., Ulrich E., Probst A. 2006 An overview of atmospheric deposition chemistry over the Alps: Present status and long-term trends. Hydrobiologia **562**, 17–40

Examples

```
data(pie1)
rkt(pie1$Year,pie1$SO4,pie1$Month,pie1$mm,TRUE)
```

pie1w *Example data for rkt function*

Description

Bulk open field deposition collected in Val Sessera (Italy) in 1998-2007. Raw weekly data.

Usage

```
data(pie1)
```

Format

A data frame with 718 observations on the following 4 variables.

`Date` sampling date (year+decimals)

`mm` amount of precipitation (mm)

`SO4` sulphate concentration (mg/L)

`NO3` nitate concentration (mg N/L)

Details

SO4 shows a decreasing trend NO3 and mm show no significant trend

Source

Marchetto A., Rogora M. & Arisci S. 2013 Trend analysis of atmospheric deposition data: a comparison of statistical approaches. Atmospheric Environment **64**, 95-102

Rogora M., Mosello R., Arisci S., Brizzio M., Barbieri A., Balestrini R., Waldner P., Schmitt M., Stahli M.,Thimonier A., Kalina M., Puxbaum H., Nickus U., Ulrich E., Probst A. 2006 An overview of atmospheric deposition chemistry over the Alps: Present status and long-term trends. Hydrobiologia **562**, 17–40

Examples

```
data(pie1w)
rkt(pie1w$Date,pie1w$SO4)
```

print.rkt *print Method for class rkt*

Description

The results of the test(s) and the slope are printed

Usage

```
## S3 method for class 'rkt'
print(x, ...)
```

Arguments

x	an object of class rkt, i.e. the output of the rkt function
...	any additional argument

Value

NULL

Author(s)

Aldo Marchetto <aldo.marchetto@cnr.it>

Examples

```
data(pie1)

ex<-rkt(pie1$Year,pie1$SO4,pie1$Month,pie1$mm,TRUE)
print(ex)
```

rkt *Mann Kendall test and Seasonal and Regional Kendall tests (SKT/RKT)*

Description

Computes the Mann-Kendall test (MK) and the Seasonal and the Regional Kendall Tests for trend (SKT and RKT) and Theil-Sen's slope estimator.
When a covariable is defined, this function also computes partial RKT and SKT.
To allow for non-regular sampling dates, input data should be vectors, not time series.

Usage

```
rkt(date, y, block, cv, correct = F, rep = "e", exactp=F, maxp=50)
```

Arguments

date	a mandatory vector of numerical data representing dates, as years or years+decimal. If correction for intra-block correlation is required, dates will be truncated to the year, and no more than one value per block per year will be considered. If two equal dates (or truncated dates) are found, the behaviour of the program is determined by rep
y	a mandatory vector of measured data. In this vector, missing data are allowed.
block	an optional vector of positive integer numbers representing blocks, i.e. sites, seasons or months, or a code combining both sites and seasons/months. If no blocks are defined, the result will be the Mann-Kendall test.
cv	an optional vector containing a covariable, such as river flow or deposition amount. In this vector, missing data are allowed, however all case for which covariable value is missing are deleted from the analysis. As a consequence, if a covariable with missing data is passed to this function, the Kendall score, tau and p-value will be different than without covariable.
correct	a boolean value. If correct is FALSE, no correction for correlation between blocks is performed. If correct is TRUE, dates are truncated and the correction for correlation between blocks is performed. Note that the truncation is performed in any case, while the correction is performed only if there are more than one block, and more than nine years of data. Default value is FALSE.
rep	a character value. If rep is set to "a", data sharing the same date (or truncated date if correct is TRUE) are averaged. If rep is set to "m", their median is used. For any other value of rep, an error is produced if two or more data share the same date (or truncated date if correct is TRUE). The latter is the default behaviour of the program.
exactp	an boolean value. If exactp is TRUE, there are no ties in y, less than 7 blocks and the number of data is not greater than maxp, upper tail exact probability is calculated using the recurrence relation as described in AS 71 (Best & Gipps, 1974). Other options included in AS 71 were not used, as with modern computers the recurrence relation procedure take a few second, even with 50 data points. For longer time series, the normal approximation can be used. In case blocks were defined, the procedure described by Hirsch (1982) is used. Block length may be different among blocks. For more than 6 blocks, only the normal approximation can be used. The 2-sided probability is obtained by duplicating the upper-tail probability, but avoiding p greater than 1.
maxp	a numeric value, defining the maximum numer of data points for the calculation of exact probability. Beware that with maxp larger than 50, calculation time may became very long.

Details

The MK test for trend analysis was first proposed by Mann (1945).
Hirsch et al. (1982) derived SKT for trend analysis of monthly data in a single site using seasons as the blocking variable, and Helsel and Franse (2006) extended it to a regional test using sites as the blocking variable (RKT).
The correction for correlation among blocks was introduced by Hirsch & Slack (1984), and the

partial test was proposed by Libiseller & Grimvall (2002).
At least 4 data are required for each block.
Correction for correlation between blocks is not performed if less than 10 years of data are available.
If correct is FALSE, data are not required to be sampled monthly or yearly.

Value

A list with class rkt is returned with the following components:

`sl`	two sided p-value by normal approximation
`S`	Kendall's score
`B`	Theil-Sen's slope for MK, Seasonal (or Regional) Kendall Slope estimator for SKT and RKT
`varS`	variance of S
`sl.corrected`	two sided p-value, after correction for intra-block correlation
`varS.corrected`	variance of S, after correction for intra-block correlation
`partial.S`	partial Kendall's score, if a covariable is present
`partial.sl`	two sided p-value of the partial test, if a covariable is present
`partial.varS`	partial variance of S, if a covariable is present
`partial.sl.corrected`	two sided p-value of the partial test, after correction for intra-block correlation, if a covariable is present
`partial.varS.corrected`	partial variance of S, after correction for intra-block correlation, if a covariable is present
`tau`	Kendall tau, corrected for ties
`exact_p`	Upper tail exact probability, if there are no ties, no more than 100 data points and exactp is TRUE

Note

All items are returned in any case. When a test is not performed, relative items are set to NA.
To consider data sharing the same dates as ties in the time domain, please use Kendall function in the Kendall package.
For time series with multiple detection limits, please refer to the NADA package.
Thanks to Peter Waldner (WSL, Switzerland), Claudia von Bromssen (SLU, Sweden) and Andrea Blomenhofer (LFU, Germany) for their contribution.

Author(s)

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References

Helsel D.R., Frans L.M. 2006 The regional Kendall test for trend: Environmental Science and Technology **40**, 4066–4073

Helsel D.R., Mueller D.K., Slack J.R. 2006 *Computer program for the Kendall family of trend tests* U.S. Geological Survey Scientific Investigations Report 2005-5275, 4 pp.

Hirsch R.M., Slack J.R., Smith R.A. 1982. Techniques of trend ananlyis for monthly water quality data. Water Resources Research **18**, 107-121

Hirsch R.M., Slack J.R. 1984 A nonparametric test for seasonal data with serial dependance. Water Resources Research **20**, 727-732

Libiseller C., Grimvall A. 2002 Perfomance of partial Mann-Kendall tests for trend detection in the presence of covariates. Environmetrics **13**, 71-84

Mann H.B. 1945. Nonparametric tests against trend. Econometrica **13**, 245-249

Kaarsemaker L., Wijngaarden A. van 1953 Tables for use in rank correlation. Report R73 of the Computation Depattment of the Mathematical Centre, Amsterdam

Best, D.J., Gipps, P.G. 1974 Algorithm AS 71: The Upper Tail Probabilities of Kendall's Tau. Journal of the Royal Statistical Society. Series C (Applied Statistics), 23: 98-100

Marchetto A., Rogora M., Arisci S. 2013 Trend analysis of atmospheric deposition data: a comparison of statistical approaches. Atmospheric Environment **64**, 95-102

See Also

print.rkt

Examples

```
#
# monthly data
#
data(pie1)
ex<-rkt(pie1$Year,pie1$SO4,pie1$Month,pie1$mm,TRUE)
print(ex)

#
# weekly data, no intrablock correction
#
data(pie1w)
ex<-rkt(pie1w$Date,pie1w$SO4)
print(ex)

#
```

```
# monthly data, hydrological years (oct-sep) as in USGS program
#
data(pie1)
ex<-rkt(pie1$Year+floor(pie1$Month/10),pie1$SO4,pie1$Month,,TRUE)
print(ex)

#
# weekly data transformed into seasonal data by averaging
# exact probability calculated
#
data(pie1w)
ex<-rkt(floor(pie1w$Date),pie1w$NO3,floor((pie1w$Date-floor(pie1w$Date))*4)+1,rep="a",exactp=TRUE)
print(ex)
```

`sign1` *modified sign() fucntion for SKT taking into account missing data*

Description

differ from sign as it return 0 when x is NA

Usage

```
sign1(x)
```

Arguments

x	any number

Value

1 if x > 0 -1 if x < 0 0 if x = 0 or x = NA

Note

used by rkt

Author(s)

Aldo Marchetto

References

Hirsch R.M. & Slack J.R. 1984. A nonparametric test for seasonal data with serial dependance. Water Resources Research, 20: 727-732

See Also

rkt

Examples

```
a<-1
sign1(a)
a<-NA
sign1(a)
```

---

tauprob *exact probability for Mann Kendall test*

Description

upper tail exact probability for a positive value of S. The exact probability is obtained following a slightly modified AS67 algorithm (Best and Gibbs, 1974). Only positive vales of S are accepted and the exact probability is obtained using the recurrence relation. Other options included in AS 67 were not used, as with modern computers the recurrence relation procedure take a few second, even with 50 data points. For longer time series, the normal approximation can be used. tauprob function is called by rkt. rkt will double the upper tail probability to obtain 2-sided probability.

Usage

```
tauprob(N,S)
```

Arguments

N	the number of data used for the test
S	the value of S of the Mann Kendall test

Value

the exact upper-tail probability of S

Note

used by rkt

Author(s)

Aldo Marchetto

References

Best, D.J., Gipps, P.G. 1974 Algorithm AS 71: The Upper Tail Probabilities of Kendall's Tau. Journal of the Royal Statistical Society. Series C (Applied Statistics), 23: 98-100

See Also

rkt

Examples

```
tauprob(12,30)
```

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