Package ‘sad’

November 6, 2020

Title Verify the Scale, Anisotropy and Direction of Weather Forecasts

Version 0.1.3

Description Implementation of the wavelet-based spatial verification method of Buschow and Friederichs "SAD: Verifying the Scale, Anisotropy and Direction of precipitation forecasts" (2020, submitted to QJRMS). Forecasts and Observations are transformed by a decimated or redundant dual-tree complex wavelet transform to analyze the spatial scale, degree of anisotropy and preferred direction in each field. These structural attributes are compared by a series of scores. An experimental algorithm for the correction of these errors is included as well.

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Imports emdist

Depends dualtrees

Encoding UTF-8

LazyData false

RoxygenNote 6.1.1

NeedsCompilation no

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Repository CRAN

Date/Publication 2020-11-06 16:30:02 UTC

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getpareto

**Description**

Determine the set of pareto optimal forecasts in a matrix of scores

**Usage**

getpareto(scores)

**Arguments**

- **scores**
  a matrix of negatively oriented scores where the rows correspond to different forecasts and the columns denote different scores.

**Details**

The Pareto set contains all those forecasts for which no other forecast is better in every respect. In this function, we assume that all scores are negatively oriented, "better" therefore means lower values.

**Value**

a vector of indices indicating all members of the pareto set.

**Note**

This function becomes very memory hungry if you have more than 1000 forecasts, be careful.

hemd

**histogram emd**

**Description**

Earth Mover's Distance between two histograms, given as vectors

**Usage**

hemd(h1, h2, mids = NULL)

**Arguments**

- **h1, h2**
  vectors of non-negative numbers representing two histograms
- **mids**
  the bin mids corresponding to the histograms. Can also be given via the names of h1.
prepare_sad

Value

the value of the EMD

Description

remove small values, apply log-transform, smooth borders, handle boundary conditions

Usage

prepare_sad(x, xmin = 0.1, log = TRUE, rsm = 0, Nx = NULL, Ny = NULL, boundaries = "pad")

Arguments

x         a list of 2 or more 2D matrices with equal sizes and no missing or infinite values, as required by as.sadforecast
xmin      values smaller than xmin are set to zero
log       logical, do you want to log-transform the data? (recommended for precipitation)
$rsm$     number of pixels which are linearly smoothed at the edge
$Nx$      size to which the data is extended in x-direction
$Ny$      size to which the data is extended in y-direction
boundaries how to handle the boundary conditions, either "pad", "mirror" or "periodic"

Details

the positions within the extended field where the original field resides are output as attributes "px", "py" of the result. The other input parameters are saved as attributes of the result as well.

Value

an object of class sadforecast which has been prepared in the desired way.

Examples

data(rrain)
ra <- list(rrain[2,4,,], rrain[3,9,,])
ra <- prepare_sad(ra, rsm=0, Nx=256, boundaries="mirror", log=FALSE)
plot(ra)
**raincols**

**Description**

Eight shades of blue used in plot.sadforecast

**Usage**

raincols

**Format**

An object of class character of length 8.

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**rrain**

**Random Rain**

**Description**

Randomly simulated synthetic rain fields with Matern covariances

**Usage**

data(rrain)

**Format**

A 4x10x128x128 matrix

**Details**

These fields were used in Buschow et al. (2019) <doi:10.5194/gmd-12-3401-2019>. The first array corresponds to the four model configurations from that paper (different roughness nu and scale sc), the second dimension contains ten realizations for each model.

**Source**

simulated using the 'RandomFields' package, code available at <10.5281/zenodo.3257511>

**Examples**

data(rrain)
sadcorrect

correct structure errors

Description

use the inverse 'dtcwt' to correct errors in scale, anisotropy and direction

Usage

sadcorrect(x, xmin = 0.1, log = TRUE, rsm = 0, Nx = NULL, Ny = NULL, J = NULL, boundaries = "pad", direction = TRUE)

Arguments

- **x**: a list of equally sized matrices, the first element is assumed to be the observation
- **xmin**: values smaller than xmin are set to zero
- **log**: logical, do you want to log-transform the data? (recommended for precipitation)
- **rsm**: number of pixels which are linearly smoothed at the edge
- **Nx**: size to which the data is extended in x-direction, has to be a whole power of 2
- **Ny**: size to which the data is extended in y-direction, has to be a whole power of 2
- **J**: largest scale considered
- **boundaries**: how to handle the boundary conditions, either "pad", "mirror" or "periodic"
- **direction**: if TRUE, scale and direction are corrected, otherwise only scale

Details

The algorithm performs the following steps:

1. remove values below xmin
2. if log=TRUE log-transform all fields
3. set all fields to zero mean, unit variance
4. apply dtcwt to all fields
5. loop over forecasts and scales. If direction=TRUE loop over the six directions. Multiply forecast energy at each location by the ratio of total observed energy to total forecast energy at that scale (and possibly direction)
6. apply idtcwt to all forecasts
7. reset means and variance of the forecasts to their original values
8. if log=TRUE invert the log-transform
9. return the list of corrected fields

Value

an object of class sadforecast
Examples

data( rrain )
ra <- as.sadforecast( list( rrain[2,1,,], rrain[3,1,,], rrain[3,2,,], rrain[3,3,,] ) )
ra_c <- sadcorrect( ra, rsm=10 )
plot(ra_c)

sadforecast

class for a list of forecasts

Description

check that a list of forecasts fulfills all requirements to be verified by our method

Usage

as.sadforecast(x)

## S3 method for class 'sadforecast'
plot(x, mfrow = NULL, col = NULL, ...)

Arguments

x a list of 2 or more 2D matrices with equal sizes and no missing or infinite values
mfrow vector with the number of rows and columns you would like in the plot
col color scale for the plot
... further arguments passed to image

Details

as.sadforecast does nothing except check that everything is as it should be, add the attributes that can be changed by prepare_sad and provide a method for quick plots of the data.

Value

an object of class sadforecast

Examples

data( rrain )
ra <- list( rrain[1,1,,], rrain[4,5,,], rrain[2,7,,] )
ra <- as.sadforecast(ra)
plot(ra)
sadverif  

dual-tree verification

Description
verify the scale, anisotropy and direction of a number of forecasts

Usage
sadverif(x, dec = TRUE, xmin = 0.1, log = TRUE, a = 1, nbr = 33,  
          rsm = 0, Nx = NULL, Ny = NULL, J = NULL, boundaries = "pad",  
          return_specs = FALSE)

## S3 method for class 'sadverif'
plot(x, ...)

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

Arguments

x  
a list of equally sized matrices, the first element is assumed to be the observation
dec  
logical, do you want to use the decimated transform
xmin  
values smaller than xmin are set to zero
log  
logical, do you want to log-transfrom the data? (recommended for precipitation)
a  
relative weight of directional errors compared to scale errors in semdd
nbr  
number of breaks for the scale histograms, has no effect if dec=TRUE
rsm  
number of pixels which are linearly smoothed at the edge
Nx  
size to which the data is extended in x-direction
Ny  
size to which the data is extended in y-direction
J  
largest scale considered
boundaries  
how to handle the boundary conditions, either "pad", "mirror" or "periodic"
return_specs  
if TRUE, the spatial mean spectra are returned as well
...  
 further arguments, currently ignored.
object  
object of class sadverif

Details
each element of x is transformed via dtcwt from the 'dualtrees' package. Scores and centres based
on the mean spectra are calculated. If dec=FALSE, scale histograms and the corresponding score
hemd are calculated as well.
Value

an object of class sadverif, containing the following elements

settings a dataframe containing the parameters that were originally passed to dtverif

centres a matrix containing the anisotropy rho, angle phi, and central scale z derived from the mean spectra. Rain area and sum are included as well.

detscores a matrix containing the differences in centre components, the direction/anisotropy score dxy, the emd between direction-averaged spectra (semd) and the emd between the directional spectra (semdd). If dec=FALSE, the emd between the scale histograms, hemd, is included as well.

time the time the calculation took in seconds

if there is more than one forecast, the ensemble scores SpEn and (if available), hemd are computed as well, treating all forecasts as members of the ensemble to be verified.

References


Examples

```r
oldpar <- par(no.readonly=TRUE)
on.exit(par(oldpar))
data(rrain)
ra <- as.sadforecast( list( rrain[1,1,,], rrain[1,2,,], rrain[2,1,,], rrain[3,1,,]) )
plot(ra)
verif <- sadverif( ra, log=FALSE, xmin=0 )
summary(verif)
par( mfrow=c(2,2) )
plot( verif )
```

```
semd
spectral emd
```

Description

earth mover’s distance between dual-tree wavelet spectra

Usage

```r
semd(dt1, dt2, a = 1, dir = TRUE)
```

Arguments

dt1, dt2 forecast and observed spectrum

a ratio between scale- and directional component

dir whether or not to include direction information
**semld**

**Value**

a single value, the emd. If `dir=FALSE`, the value is signed, indicating the direction of the scale error.
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