Package 's2dverification'

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Type Package

Title Set of common tools for model diagnostics.

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Description Set of tools to assess the performance of a model through the computation of typical prediction scores against one or more observational datasets or reanalyses (a reanalysis being a physical extrapolation of observations that relies on the equations from a model, not a pure observational dataset).

License GPL-3

Depends R (>= 2.14.1), ncdf4, GEOmap, geomapdata, mapproj, maps,abind, parallel, bigmemory

LazyData yes

Encoding UTF-8

R topics documented:

s2dverification-package *Prediction Model Score*

Description

This package contains a set of tools to score prediction models by comparing experimental data with observational data.

Details

Package:	s2dverification
Type:	Package
Version:	2.2.0
Date:	2014-12-16
License:	GPLv3

First, data has to be loaded from the repository with the function Load().
It is needed to specify a variable to load, names for the experimental and observational datasets to load the data from and the starting dates, among other arguments.
This will automatically provide two matrices with the observational and experimental data.
From then on you can compute the anomalies, climatologies, etc.

Author(s)

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References

Please, for more information load the package and check the help for each function, or check the wiki page on common diagnostics.

ACC *Computes Anomaly Correlation Coefficient (Spatial Correlation)*

Description

Matrix var_exp & var_obs should have dimensions (nexp/nobs, nsdates, nltimes, nlat, nlon) or (nexp/nobs, nsdates, nmember, nltimes, nlat, nlon) ACC computes the Anomaly Correlation Coefficient for the ensemble mean of each jexp in 1:nexp and each jobs in 1:nobs which gives nexp x nobs

ACC for each startdate and each leadtime. A domain can be selected by providing the list of longitudes/latitudes (lon/lat) of the grid together with the corner of the domain: lonlatbox = c(lonmin, lonmax, latmin, latmax)

Usage

```
ACC(var_exp, var_obs, lon = NULL, lat = NULL, lonlatbox = NULL,
    conf = TRUE, conftype = "parametric")
```

Arguments

var_exp	Matrix of experimental data with dimensions: c(nexp, nsdates, nltimes, nlat, nlon)
var_obs	Matrix of observational data, same dimensions as var_exp except along the first dimension and the second if it corresponds to the member dimension.
lon	Array of longitudes of the var_exp/var_obs grids, optional.
lat	Array of latitudes of the var_exp/var_obs grids, optional.
lonlatbox	Domain to select : c(lonmin, lonmax, latmin, latmax), optional.
conf	TRUE/FALSE confidence intervals or significance level provided or not
conftype	"parametric" provides a confidence interval for the ACC computed by a Fisher transformation and a significance level for the ACC from a one-sided student-T distribution "bootstrap" provides a confidence interval for the ACC and MACC computed from bootstrapping on the members with 100 drawings with replacement. To guarantee the statistical robustness of the result, make sure that your experiments/oservations/startdates/ leadtimes always have the same number of members

Value

ACC	If conf set as TRUE, Matrix with dimensions : c(nexp, nobs, nsdates, nleadtimes, 4) The fifth dimension of length 4 corresponds to the lower limit of the 95% confidence interval, the ACC, the upper limit of the 95% confidence interval and the 95% significance level. If conf set as FALSE, Anomaly Correlation Coefficient with dimensions : c(nexp, nobs, nsdates, nleadtimes).
MACC	Mean Anomaly Correlation Coefficient with dimensions : c(nexp, nobs, nleadtimes)

Author(s)

History: 0.1 - 2013-08 (V. Guemas, <virginie.guemas@ic3.cat>) - Original code 1.0 - 2013-09 (N. Manubens, <nicolau.manubens@ic3.cat>) - Formatting to CRAN 1.1 - 2013-09 (C. Prodhomme, <chloe.prodhomme@ic3.cat>) - optimization

1.2 - 2014-08 (V. Guemas, <virginie.guemas@ic3.cat>) - Bug-fixes : handling of NA & selection of domain + Simplification of code 1.3.0 - 2014-08 (V. Guemas, <virginie.guemas@ic3.cat>) - Boostrapping over members 1.3.1 - 2014-09 (C. Prodhomme, chloe.prodhomme@ic3.cat) - Add comments and minor style changes

Examples

```
startDates <- c('19851101', '19901101', '19951101', '20001101', '20051101')
sampleData <- Load('tos', c('i00k'), c('ERSST'), startDates, nleadtime = 124,
                   leadtimemin = 1, leadtimemax = 4, output = 'lonlat',
                   latmin = 30, latmax = 45, lonmin = 0, lonmax = 40)
sampleData$mod <- Season(sampleData$mod, 4, 11, 12, 2)
sampleData$obs <- Season(sampleData$obs, 4, 11, 12, 2)
clim <- Clim(sampleData$mod, sampleData$obs)
ano_exp <- Ano(sampleData$mod, clim$clim_exp)
ano_obs <- Ano(sampleData$obs, clim$clim_obs)
acc <- ACC(Mean1Dim(sampleData$mod, 2),
           Mean1Dim(sampleData$obs, 2))
PlotACC(acc$ACC, startDates)
```

Alpha *Estimates AutoCorrelation At Lag 1 following Guemas et al, BAMS, 2013b*

Description

This function, relying on the `FitAcfCoef()` function, estimates the autocorrelation at lag 1 of the xdata array following the method described in Guemas V., Auger L., Doblas-Reyes F., JAMC, 2013. After applying a linear detrending and/or a filtering of any frequency peak if requested, the sample autocorrelation is estimated. Then the theoretical autocorrelation of an AR1 is fitted to the sample autocorrelation using the Cardano's formula (see `FitAcfCoef()`) to obtain the autocorrelation at lag 1. This method assumes xdata is an AR1 process.

Usage

```
Alpha(xdata, detrend = FALSE, filter = FALSE)
```

Arguments

`xdata`	Timeseries from which the autocorrelation at lag 1 is requested.
`detrend`	TRUE applies a linear detrending to xdata prior to the estimation of the autocorrelation at lag 1.
`filter`	TRUE applies a filtering of any frequency peak prior to the estimation of the autocorrelation at lag 1.

Value

Autocorrelation at lag 1

Author(s)

History:
0.1 - 2012-06 (V. Guemas, <virginie.guemas@ic3.cat>) - Original code 1.0 - 2013-09 (N. Manubens, <nicolau.manubens@ic3.cat>) - Formatting to CRAN

Examples

```
startDates <- c('19851101', '19901101', '19951101', '20001101', '20051101')
sampleData <- Load('tos', c('i00k'), c('ERSST'), startDates, nleadtime = 124,
                   leadtimemin = 1, leadtimemax = 60, output = 'areave',
                   latmin = 30, latmax = 45, lonmin = 0, lonmax = 40)
alpha <- Alpha(sampleData$mod[1, 1, , 1])
print(alpha)
```

Ano *Computes Forecast or Observed Anomalies*

Description

This function computes anomalies from any experimental or observational matrix output from `Load()` and their climatologies output from `Clim()`.

Usage

```
Ano(var, clim)
```

Arguments

`var`	Model or observational data: c(nmod/nexp/nobs, nmemb/nparam, nsdates, nltime) up to c(nmod/nexp/nobs, nmemb/nparam, nsdates, nltime, nlevel, nlat, nlon)
`clim`	Climatologies from clim: c(nmod/nexp/nobs, nltime) up to c(nmod/nexp/nobs, nltime, nlevel, nlat, nlon) or c(nmod/nexp/nobs, nmemb/nparam, nltime) up to c(nmod/nexp/nobs, nmemb/nparam, nltime, nlevel, nlat, nlon) or c(nmod/nexp/nobs, nmemb/nparam, nsdates, nltime) up to c(nmod/nexp/nobs, nmemb/nparam, nsdates, nltime, nlevel, nlat, nlon) depending on the options provided to `Clim()`

Value

Matrix with same dimensions as var

Author(s)

History: 0.1 - 2012-03 (V. Guemas, <virginie.guemas@ic3.cat>) - Original code 1.0 - 2013-09 (N. Manubens, <nicolau.manubens@ic3.cat>) - Formatting to R CRAN

Examples

```
startDates <- c('19901101', '19951101', '20001101')
sampleData <- Load('tos', c('i00k'), c('ERSST'), startDates, nleadtime = 124,
                   leadtimemin = 1, leadtimemax = 60, output = 'areave',
                   latmin = 30, latmax = 45, lonmin = 0, lonmax = 40)
clim <- Clim(sampleData$mod, sampleData$obs)
ano_exp <- Ano(sampleData$mod, clim$clim_exp)
```

```
ano_obs <- Ano(sampleData$obs, clim$clim_obs)
runmean_nb_months <- 12
dim_to_smooth <- 4  # Smooth along lead-times
smooth_ano_exp <- Smoothing(ano_exp, runmean_nb_months, dim_to_smooth)
smooth_ano_obs <- Smoothing(ano_obs, runmean_nb_months, dim_to_smooth)
PlotAno(smooth_ano_exp, smooth_ano_obs, startDates,
        toptitle = paste('smoothed anomalies'), ytitle = c('K', 'K', 'K'),
        legends = 'ERSST', biglab = FALSE, fileout = 'tos_ano.eps')
```

`Ano_CrossValid` *Computes Anomalies in Cross-Validation Mode*

Description

This function computes anomalies from experimental and observational matrices output from `load()` by subtracting the climatologies computed in a cross-validation mode and with a per-pair method.

Usage

```
Ano_CrossValid(var_exp, var_obs, memb = TRUE)
```

Arguments

`var_exp`	Model data: c(nmod/nexp, nmemb/nparam, nsdates, nltime) up to c(nmod/nexp, nmemb/nparam, nsdates, nltime, nlevel, nlat, nlon)
`var_obs`	Observational data: c(nobs, nmemb, nsdates, nltime) up to c(nobs, nmemb, nsdates, nltime, nlevel, nlat, nlon)
`memb`	memb: TRUE/FALSE (1 climatology for each member/1 climatology averaging all the members). Default = TRUE.

Value

`$ano_exp`	Matrix with same dimensions as var_exp
`$ano_obs`	Matrix with same dimensions as var_obs

Author(s)

History: 0.1 - 2011-12 (V. Guemas, <virginie.guemas@ic3.cat>) - Original code 1.0 - 2013-09 (N. Manubens, <nicolau.manubens@ic3.cat>) - Formatting to CRAN

Examples

```
startDates <- c('19901101', '19951101', '20001101')
sampleData <- Load('tos', c('i00k'), c('ERSST'), startDates, nleadtime = 124,
                   leadtimemin = 1, leadtimemax = 60, output = 'areave',
                   latmin = 30, latmax = 45, lonmin = 0, lonmax = 40)
anomalies <- Ano_CrossValid(sampleData$mod, sampleData$obs)
PlotAno(anomalies$ano_exp, anomalies$ano_obs, startDates,
        toptitle = paste('anomalies'), ytitle = c('K', 'K', 'K'),
        legends = 'ERSST', biglab = FALSE, fileout = 'tos_ano_crossvalid.eps')
```

Clim *Computes Per-pair/Kharin/FALSEuckar Climatologies*

Description

This function computes climatologies from the experimental and observational matrices output from `Load()` using one of the following methods: 1) per-pair method (Garcia-Serrano and Doblas-Reyes, CD, 2012) 2) Kharin method (Karin et al, GRL, 2012) 3) Fuckar mathod (Fuckar et al, GRL, 2014)

Usage

```
Clim(var_exp, var_obs, memb = TRUE, kharin = FALSE, NDV = FALSE)
```

Arguments

`var_exp`	Model data: c(nmod/nexp, nmemb/nparam, nsdates, nltime) up to c(nmod/nexp, nmemb/nparam, nsdates, nltime, nlevel, nlat, nlon)
`var_obs`	Observational data: c(nobs, nmemb, nsdates, nltime) up to c(nobs, nmemb, nsdates, nltime, nlevel, nlat, nlon)
`memb`	memb: TRUE/FALSE (1 climatology for each member). Default = TRUE.
`kharin`	TRUE/FALSE (if Kharin method is applied or not). Default = FALSE.
`NDV`	TRUE/FALSE (if Fuckar method is applied or not). Default = FALSE.

Value

`clim_exp`	Matrix with same dimensions as var_exp
`clim_obs`	Matrix with same dimensions as var_obs

Author(s)

History: 0.9 - 2011-03 (V. Guemas, <virginie.guemas@ic3.cat>) - Original code 1.0 - 2013-09 (N. Manubens, <nicolau.manubens@ic3.cat>) - Formatting to R CRAN

Examples

```
startDates <- c('19901101', '19951101', '20001101')
sampleData <- Load('tos', c('i00k'), c('ERSST'), startDates, nleadtime = 124,
                   leadtimemin = 1, leadtimemax = 60, output = 'areave',
                   latmin = 30, latmax = 45, lonmin = 0, lonmax = 40)
clim <- Clim(sampleData$mod, sampleData$obs)
PlotClim(clim$clim_exp, clim$clim_obs,
         toptitle = paste('sea surface temperature climatologies'),
         ytitle = 'K', monini = 11, listexp = c('CMIP5 IC3'),
         listobs = c('ERSST'), biglab = FALSE, fileout = 'tos_clim.eps')
```

ColorBar *Draws Color Bar*

Description

Creates a horizontal or vertical colorbar to introduce in multipanels.

Usage

```
ColorBar(brks, cols = NULL, vert = TRUE, subsampleg = 1, cex = 1)
```

Arguments

brks	Levels.
cols	List of colours, optional.
vert	TRUE/FALSE for vertical/horizontal colorbar.
subsampleg	Supsampling factor of the interval between ticks on the colorbar. Default: 1 = every level
cex	Multiplicative factor to increase the ticks size, optional.

Author(s)

History: 0.1 - 2012-04 (V. Guemas, <virginie.guemas@ic3.cat>) - Original code 0.2 - 2013-04 (I. Andreu-Burillo, <isabel.andreu-burillo@ic3.cat>) - vert option 1.0 - 2013-09 (N. Manubens, <nicolau.manubens@ic3.cat>) - Formatting to CRAN 1.1 - 2013-09 (c. Prodhomme <chloe.prodhomme@ic3.cat>) - add cex option

Examples

```
cols <- c("dodgerblue4", "dodgerblue1", "forestgreen", "yellowgreen", "white",
          "white", "yellow", "orange", "red", "saddlebrown")
lims <- seq(-1, 1, 0.2)
ColorBar(lims, cols)
```

Consist_Trend *Computes Trends Using Only Model Data For Which Observations Are Available*

Description

Computes trends by least square fitting together with the associated error interval for both the observational and model data. Provides also the detrended observational and modeled data. The trend is computed along the second dimension, expected to be the start date dimension (the user is supposed to perform an ensemble averaging operation with Mean1Dim() prior to using Consist_trend()).

Usage

```
Consist_Trend(var_exp, var_obs, interval = 1)
```

Arguments

var_exp	Ensemble mean of model hindcasts with dimensions: c(nmod/nexp, nsdates, nltime) up to c(nmod/nexp, nsdates, nltime, nlevel, nlat, nlon)
var_obs	Ensemble mean of observational data with dimensions: c(nobs, nsdates, nltime) up to c(nobs, nsdates, nltime, nlevel, nlat, nlon) Dimensions 2 to 6 should be the same as var_exp.
interval	Number of months/years between 2 start dates. Default = 1. The trends will be provided respectively in field unit per month or per year.

Value

$trend	Trends of model and observational data with dimensions: c(nmod/nexp + nobs, 3, nltime) up to c(nmod/nexp + nobs, 3, nltime, nlevel, nlat, nlon) The length 3 dimension corresponds to the lower limit of the 95% onfidence interval, the slope of the trends and the upper limit of the 95% confidence interval.
$detrendedmod	Same dimensions as var_exp with linearly detrended values of var_exp along the second = start date dimension.
$detrendedobs	Same dimensions as var_exp with linearly detrended values of var_obs along the second = start date dimension.

Author(s)

History: 0.1 - 2011-11 (V. Guemas, <vguemas@ic3.cat>) - Original code 1.0 - 2013-09 (N. Manubens, <nicolau.manubens@ic3.cat>) - Formatting to R CRAN

Examples

```
startDates <- c('19901101', '19951101', '20001101')
sampleData <- Load('tos', c('i00k'), c('ERSST'), startDates, nleadtime = 124,
                   leadtimemin = 1, leadtimemax = 60, output = 'areave',
                   latmin = 30, latmax = 45, lonmin = 0, lonmax = 40)

clim <- Clim(sampleData$mod, sampleData$obs)
ano_exp <- Ano(sampleData$mod, clim$clim_exp)
ano_obs <- Ano(sampleData$obs, clim$clim_obs)
runmean_months <- 12
dim_to_smooth <- 4  # Smooth along lead-times
smooth_ano_exp <- Smoothing(ano_exp, runmean_months, dim_to_smooth)
smooth_ano_obs <- Smoothing(ano_obs, runmean_months, dim_to_smooth)
dim_to_mean <- 2  # Mean along members
years_between_startdates <- 5
trend <- Consist_Trend(Mean1Dim(smooth_ano_exp, dim_to_mean),
                       Mean1Dim(smooth_ano_obs, dim_to_mean),
                       years_between_startdates)
```

```
PlotVsLTime(trend$trend, toptitle = "trend", ytitle = "K/(5 years)",
            monini = 11, limits = c(-0.8, 0.8), listexp = c('CMIP5 IC3'),
            listobs = c('ERSST'), biglab = FALSE, hlines = c(0),
            fileout = 'tos_consist_trend.eps')
PlotAno(InsertDim(trend$detrendedmod,2,1), InsertDim(trend$detrendedobs,2,1),
        startDates, "Detrended tos anomalies", ytitle = 'K',
        legends = 'ERSST', biglab = FALSE, fileout = 'tos_detrended_ano.eps')
```

`Corr` *Computes Correlation Skill Measure (Temporal Correlation Along Start Dates)*

Description

Matrix var_exp & var_obs should have the same dimensions except along posloop dimension where the length can be different, with the number of experiments/ models for var_exp (nexp) and the number of obserational datasets for var_obs (nobs). Corr computes the correlation skill of each jexp in 1:nexp against each jobs in 1:nobs which gives nexp x nobs correlation skill measures for each other grid point of the matrix (each latitude/longitude/level/leadtime). The correlations are computed along the poscor dimension which should correspond to the startdate dimension. If compROW is given, the correlations are computed only if rows along the compROW dimension are complete between limits[1] and limits[2], that mean with no NA between limits[1] and limits[2]. This option can be activated if the user wishes to account only for the forecasts for which observations are available at all leadtimes. Default: limits[1] = 1 and limits[2] = length(compROW dimension). The confidence interval is computed by a Fisher transformation. The significance level relies on a one-sided student-T distribution. We can modifiy the treshold of the test modifying siglev (default value=0.95)

Usage

```
Corr(var_exp, var_obs, posloop = 1, poscor = 2, compROW = NULL, limits = NULL, siglev = 0.95)
```

Arguments

`var_exp`	Matrix of experimental data.
`var_obs`	Matrix of observational data, same dimensions as var_exp except along posloop dimension, where the length can be nobs instead of nexp.
`posloop`	Dimension nobs and nexp.
`poscor`	Dimension along which correlation are to be computed (the dimension of the start dates).
`compROW`	Data taken into account only if (compROW)th row is complete. Default = NULL.
`limits`	Complete between limits[1] & limits[2]. Default = NULL.
`siglev`	Significance level according. Default = 0.95.

Value

Matrix with dimensions : c(length(posloop) in var_exp, length(posloop) in var_obs, 4, all other dimensions of var_exp & var_obs except poscor). The third dimension of length 4 corresponds to the lower limit of the 95% confidence interval, the correlation, the upper limit of the 95% confidence interval and the 95% significance level given by a one-sided T-test.

Author(s)

History: 0.1 - 2011-04 (V. Guemas, <vguemas@ic3.cat>) - Original code 1.0 - 2013-09 (N. Manubens, <nicolau.manubens@ic3.cat>) - Formatting to R CRAN 1.1 - 2014-10 (M. Menegoz, <martin.menegoz@ic3.cat>) - Adding siglev argument

Examples

```
startDates <- c('19851101', '19901101', '19951101', '20001101', '20051101')
sampleData <- Load('tos', c('i00k'), c('ERSST'), startDates, nleadtime = 124,
                   leadtimemin = 1, leadtimemax = 60, output = 'areave',
                   latmin = 30, latmax = 45, lonmin = 0, lonmax = 40)
clim <- Clim(sampleData$mod, sampleData$obs)
ano_exp <- Ano(sampleData$mod, clim$clim_exp)
ano_obs <- Ano(sampleData$obs, clim$clim_obs)
runmean_months <- 12
dim_to_smooth <- 4  # Smooth along lead-times
smooth_ano_exp <- Smoothing(ano_exp, runmean_months, dim_to_smooth)
smooth_ano_obs <- Smoothing(ano_obs, runmean_months, dim_to_smooth)
dim_to_mean <- 2  # Mean along members
required_complete_row <- 3  # Discard start dates which contain any NA lead-times
leadtimes_per_startdate <- 60
corr <- Corr(Mean1Dim(smooth_ano_exp, dim_to_mean),
             Mean1Dim(smooth_ano_obs, dim_to_mean),
             compROW = required_complete_row,
             limits = c(ceiling((runmean_months + 1) / 2),
                        leadtimes_per_startdate - floor(runmean_months / 2)))
PlotVsLTime(corr, toptitle = "correlations", ytitle = "correlation",
            monini = 11, limits = c(-1, 2), listexp = c('CMIP5 IC3'),
            listobs = c('ERSST'), biglab = FALSE, hlines = c(-1, 0, 1),
            fileout = 'tos_cor.eps')
```

Enlarge *Extends The Number Of Dimensions of A Matrix*

Description

Extends the number of dimensions of var to numdims (the added dimensions have length 1).

Usage

```
Enlarge(var, numdims)
```

Arguments

var	Matrix to be extended.
numdims	Output number of dimensions.

Value

Extended matrix.

Author(s)

History: 0.1 - 2011-03 (V. Guemas, <virginie.guemas@ic3.cat>) - Original code 1.0 - 2013-09 (N. Manubens, <nicolau.manubens@ic3.cat>) - Formatting to R CRAN

Examples

```
data <- array(1, c(2, 2, 3))
print(dim(Enlarge(data, 5)))
```

Eno *Computes Effective Sample Size With Classical Method*

Description

Computes the effective number of independant data along the posdim dimension of a matrix. This effective number of independant date may be required to perform statistical/inference tests. Based on eno function from Caio Coelho from rclim.txt.

Usage

```
Eno(obs, posdim)
```

Arguments

obs	Matrix of any number of dimensions up to 10.
posdim	Dimension along which to compute the effective sample size.

Value

Same dimensions as var but without the posdim dimension.

Author(s)

History: 0.1 - 2011-05 (V. Guemas, <virginie.guemas@ic3.cat>) - Original code 1.0 - 2013-09 (N. Manubens, <nicolau.manubens@ic3.cat>) - Formatting to R CRAN

Examples

```
startDates <- c('19851101', '19901101', '19951101', '20001101', '20051101')
sampleData <- Load('tos', c('i00k'), c('ERSST'), startDates, nleadtime = 124,
                   leadtimemin = 1, leadtimemax = 60, output = 'lonlat',
                   latmin = 30, latmax = 45, lonmin = 0, lonmax = 40)
sampleData$mod <- Season(sampleData$mod, 4, 11, 1, 12)
eno <- Eno(sampleData$mod[1, 1, , 1, , ], 1)
PlotEquiMap(eno, sampleData$lon, sampleData$lat)
```

EnoNew *Computes Effective Sample Size Following Guemas et al, BAMS, 2013b*

Description

This function computes the equivalent number of independent data in the xdata array following the method described in Guemas V., Auger L., Doblas-Reyes F., JAMC, 2013. The method relies on the Trenberth (1984) formula combined with a reduced uncertainty of the estimated autocorrelation function compared to the original approach.

Usage

```
EnoNew(xdata, detrend = FALSE, filter = FALSE)
```

Arguments

xdata	Timeseries from which the equivalent number of independent data is requested
detrend	TRUE applies a linear detrending to xdata prior to the estimation of the equivalent number of independant data.
filter	TRUE applies a filtering of any frequency peak prior to the estimation of the equivalent number of independant data.

Author(s)

History:
0.1 - 2012-06 (V. Guemas, <virginie.guemas@ic3.cat>) - Original code 1.0 - 2013-09 (N. Manubens, <nicolau.manubens@ic3.cat>) - Formatting to CRAN

Examples

```
startDates <- c('19851101', '19901101', '19951101', '20001101', '20051101')
sampleData <- Load('tos', c('i00k'), c('ERSST'), startDates, nleadtime = 124,
                   leadtimemin = 1, leadtimemax = 60, output = 'lonlat',
                   latmin = 30, latmax = 45, lonmin = 0, lonmax = 40)
eno <- EnoNew(sampleData$mod[1, 1, , 1, 10, 15])
print(eno)
```

`Filter` *Filter Frequency Peaks From An Array*

Description

This function filters from the xdata array, the signal of frequency freq.
The filtering is performed by dichotomy, seeking for the frequency around freq and the phase that maximizes the signal to subtract to xdata.
The maximization of the signal to subtract relies on a minimization of the mean square differences between xdata and a cosine of given frequency and phase.

Usage

```
Filter(xdata, freq)
```

Arguments

`xdata`	Array to be filtered.
`freq`	Frequency to filter.

Value

Filtered Array

Author(s)

History:
0.1 - 2012-02 (V. Guemas, <virginie.guemas@ic3.cat>) - Original code 1.0 - 2012-02 (N. Manubens, <nicolau.manubens@ic3.cat>) - Formatting to CRAN

Examples

```
startDates <- c('19901101', '19951101', '20001101')
sampleData <- Load('tos', c('i00k'), c('ERSST'), startDates, nleadtime = 124,
                   leadtimemin = 1, leadtimemax = 60, output = 'areave',
                   latmin = 30, latmax = 45, lonmin = 0, lonmax = 40)

ensmod <- Mean1Dim(sampleData$mod, 2)
for (jstartdate in 1:3) {
  spectrum <- Spectrum(ensmod[1, jstartdate, ])
  for (jlen in 1:dim(spectrum)[1]) {
    if (spectrum[jlen, 2] > spectrum[jlen, 4]) {
      ensmod[1, jstartdate, ] <- Filter(ensmod[1, jstartdate, ],
                                        spectrum[jlen, 1])
    }
  }
}
PlotAno(InsertDim(ensmod, 2, 1), sdates = startDates, fileout =
        'filtered_ensemble_mean.eps')
```

FitAcfCoef *Fits an AR1 AutoCorrelation Function Using the Cardano Formula*

Description

This function finds the minimum point of the fourth order polynom (a - x)2 + 0.25(b - x2)2 written to fit the two autoregression coefficients a and b.
Thanks to the Cardano formula, provided a and b in [0 1], the problem is well posed, delta > 0 and there is only one solution to the minimum.

This function is called in Alpha() to minimize the mean square differences between the theoretical autocorrelation function of an AR1 and the first guess of estimated autocorrelation function estacf, using only the first two lags.

Usage

```
FitAcfCoef(a, b)
```

Arguments

a	Coefficient a : first estimate of the autocorrelation at lag 1
b	Coefficient b : first estimate of the autocorrelation at lag 2

Value

Best estimate of the autocorrelation at lag 1

Author(s)

History:
0.1 - 2012-06 (L. Auger, <ludovic.auger@meteo.fr>) - Original code 1.0 - 2013-09 (N. Manubens, <nicolau.manubens@ic3.cat>) - Formatting to CRAN

Examples

```
series <- GenSeries(1000, 0.35, 2, 1)
estacf <- acf(series[951:1000], plot = FALSE)$acf
alpha <- FitAcfCoef(max(estacf[2], 0), max(estacf[3], 0))
print(alpha)
```

FitAutocor *Fits an AR1 Autocorrelation Function Using Dichotomy*

Description

This function fits the theoretical autocorrelation function of an AR1 to the first guess of estimated autocorrelation function estacf containing any number of lags. The fitting relies on a dichotomial minimisation of the mean square differences between both autocorrelation functions. It returns the autocorrelation at lag 1 of the fitted AR1 process.

Usage

```
FitAutocor(estacf, window = c(-1, 1), prec = 0.01)
```

Arguments

estacf	First guess of the autocorrelation function
window	Interval in which the autocorrelation at lag 1 should be found.
prec	Precision to which the autocorrelation function at lag 1 is to be estimated.

Value

Best estimate of the autocorrelation at lag 1

Author(s)

History:
0.1 - 2012-02 (V. Guemas, <virginie.guemas@ic3.cat>) - Original code 1.0 - 2013-09 (N. Manubens, <nicolau.manubens@ic3.cat>) - Formatting to CRAN

Examples

```
series <- GenSeries(1000, 0.35, 2, 1)
estacf <- acf(series[951:1000], plot = FALSE)$acf
alpha <-  FitAutocor(estacf, c(-1, 1), 0.01)
print(alpha)
```

GenSeries *Generates An AR1 Time Series*

Description

This functions generates AR1 processes containing n data, with alpha as autocorrelation at lag 1, and mean and standard deviation provided by the mean and std arguments.

Usage

```
GenSeries(n, alpha, mean, std)
```

Arguments

n	Length of the timeseries to be generated.
alpha	Autocorrelation at lag 1.
mean	Mean of the data.
std	Standard deviation of the data.

Value

AR1 timeseries

Author(s)

History:
0.1 - 2012-04 (L. Auger, <ludovic.auger@meteo.fr>) - Original code 1.0 - 2012-04 (N. Manubens, <nicolau.manubens@ic3.cat>) - Formatting to CRAN

Examples

```
series <- GenSeries(1000, 0.35, 2, 1)
plot(series, type = 'l')
```

Histo2Hindcast *Chunks Long Simulations For Comparison With Hindcasts*

Description

This function reorganizes a long run (historical typically) with only one start date into chunks corresponding to a set of start dates. The expected input structure is the one output from Load() with 4 to 7 dimensions.

Usage

```
Histo2Hindcast(varin, sdatesin, sdatesout, nleadtimesout)
```

Arguments

varin	Input model or observational data: c(nmod/nexp/nobs, nmemb/nparam, nsdates, nltimes) up to c(nmod/nexp/nobs, nmemb/nparam, nsdates, nltimes, nlevel, nlat, nlon)
sdatesin	Start date of the input matrix 'YYYYMMDD'.
sdatesout	List of start dates of the output matrix c('YYYYMMDD', 'YYYYMMDD', ...).
nleadtimesout	Number of leadtimes in the output matrix.

Value

A matrix with the same number of dimensions as the input one, the same dimensions 1 and 2 and potentially the same dimensions 5 to 7. Dimensions 3 and 4 are set by the arguments sdatesout and nleadtimesout.

Author(s)

History: 0.1 - 2012-11 (V. Guemas, <vguemas@ic3.cat>) - Original code 1.0 - 2013-09 (N. Manubens, <nicolau.manubens@ic3.cat>) - Formatting to CRAN

Examples

```
startDates <- c('19901101')
sampleData <- Load('tos', c('i00k'), c('ERSST'), startDates, nleadtime = 124,
                   leadtimemin = 1, leadtimemax = 60, output = 'areave',
                   latmin = 30, latmax = 45, lonmin = 0, lonmax = 40)
start_dates_out <- c('19901101', '19911101', '19921101', '19931101', '19941101')
leadtimes_per_startdate <- 12
experimental_data <- Histo2Hindcast(sampleData$mod, startDates[1],
                                    start_dates_out, leadtimes_per_startdate)
observational_data <- Histo2Hindcast(sampleData$obs, startDates[1],
                                     start_dates_out, leadtimes_per_startdate)
PlotAno(experimental_data, observational_data, start_dates_out,
        toptitle = paste('anomalies reorganized into shorter chunks'),
        ytitle = 'K', fileout='tos_histo2hindcast.eps')
```

IniListDims *Creates A List Of Integer Ranges*

Description

This function generates a list of arrays where those arrays contain integers from 1 to various numbers. This list of arrays is used in the other functions as a list of indices of the elements of the matrices.

Usage

```
IniListDims(dims, lenlist)
```

Arguments

dims	The dimensions of a matrix for which we need the possible indices for each dimension. For exemple, if the dimensions sent are c(3,2,5), the following list of arrays will be generated: list(c(1:3), c(1:2), c(1:5))
lenlist	lenlist is the length of the list because the list will be complemented above length(dims) by arrays of length 1. For example, if lenlist is set to 7, the previous list of arrays will be extended to: list(c(1:3), c(1:2), c(1:5), 1, 1, 1, 1)

Value

A list with lenlist elements, each with arrays with integers from 1 to the numbers in dims array and with only 1 for the dimensions above length(dims).

Author(s)

History: 0.1 - 2011-04 (V. Guemas, <virginie.guemas@ic3.cat>) - Original code 1.0 - 2013-09 (N. Manubens, <nicolau.manubens@ic3.cat>) - Formatting to R CRAN

Examples

```
indices <- IniListDims(c(2, 2, 4, 3), 6)
print(indices)
```

InsertDim *Adds A Dimension To A Matrix*

Description

Add one dimension to the matrix var in position posdim with length lendim and which correspond to lendim repetitions of the var matrix.

Usage

```
InsertDim(var, posdim, lendim)
```

Arguments

var	Matrix to which a dimension should be added.
posdim	Position of the new dimension.
lendim	Length of the new dimension.

Value

Matrix with the added dimension.

Author(s)

History: 0.1 - 2011-03 (V. Guemas, <virginie.guemas@ic3.cat>) - Original code 1.0 - 2013-09 (N. Manubens, <nicolau.manubens@ic3.cat>) - Formatting to R CRAN

Examples

```
a <- array(rnorm(15), dim = c(3, 1, 5, 1))
print(dim(a))
print(dim(a[, , , ]))
print(dim(InsertDim(InsertDim(a[, , , ], 2, 1), 4, 1)))
```

LeapYear *Checks Whether A Year Is Leap Year*

Description

This function tells whether a year is leap year or not.

Usage

```
LeapYear(year)
```

Arguments

year	The year to tell whether is leap year or not.

Value

Boolean telling whether the year is a leap year or not.

Author(s)

History: 0.1 - 2011-03 (V. Guemas, <vguemas@ic3.cat>) - Original code 1.0 - 2013-09 (N. Manubens, <nicolau.manubens@ic3.cat>) - Formatting to CRAN

Examples

```
print(LeapYear(1990))
print(LeapYear(1991))
print(LeapYear(1992))
print(LeapYear(1993))
```

Load *Loads Experimental And Observational Data*

Description

This function loads monthly or daily data from a set of specified experimental datasets together with observational data that date corresponds the experimental data. See parameters 'storefreq', 'sampleperiod', 'exp' and 'obs'. Load() arranges the data into two arrays with a similar format with the following dimensions: 1- The number of experimental datasets determined by the user through the argument 'exp' for the experimental data array or the number of observational datasets available for validation for the observational array determined as well by the user through the argument 'obs'. 2- The greatest number of members across all experiments in the experimental data array or across all observational datasets in the observational data array. 3- The number of starting dates determined by the user through the 'sdates' argument (we need to store data of each prediction of the model in each starting date). 4- The greatest number of lead-times. 5- The number of latitudes of the zone we want to consider. 6- The number of longitudes of the zone we want to consider. Dimensions 5 and 6 are optional and their presence depends on the type of the specified variable (global mean or 2-dimensional) and on the selected output type (area averaged time series, latitude averaged time series, longitude averaged time series or 2-dimensional time series). In the case of loading an area average the dimensions of the arrays will be only the first 4.

Only a specified variable and a set of starting dates is loaded from each experiment. See parameters 'var' and 'sdates'. Afterwards, observational data that matches every starting date and lead-time of every experimental dataset is fetched in the file system (so, if two predictions at two different start dates overlap, some observational values will be loaded more than once). If no data is found in the file system for an experimental or observational array point it is filled with an NA value.

If the specified output is 2-dimensional or latitude- or longitude-averaged time series all the data is interpolated into a common grid. If the specified output type is area averaged time series the data is averaged on the individual grid of each dataset but can also be averaged after interpolating into a common grid. See parameters 'grid' and 'method'. Once the two arrays are filled by calling this function, other functions in the s2dverification package that receive as inputs data formatted in this data structure can be executed (e.g: `Clim()` to compute climatologies, `Ano()` to compute anomalies, ...).

Load() has many additional parameters to disable values and trim dimensions of selected variable, even masks can be applied to 2-dimensional variables. See parameters 'nmember', 'nmemberobs', 'nleadtime', 'leadtimemin', 'leadtimemax', 'sampleperiod', 'lonmin', 'lonmax', 'latmin', 'latmax', 'maskmod', 'maskobs', 'varmin', 'varmax'.

The parameters 'exp' and 'obs' are lists of dataset identifiers. To fetch the data in the repository associated to each dataset, Load() reads a configuration file which associates each pair of (dataset ID, variable name) to a corresponding path pattern in which the dataset and variable data is stored. These patterns can contain wildcards and variables tags that will be replaced automatically by Load() with starting date, member number, variable name, etc. Furthermore, each pair can be associated not only to a path but also to other values such as grid type, maximum or minimum allowed values, etc., that make Load() capable of loading data stored in multiple formats and naming conventions. See '?LoadConfigurationFile' and parameters 'configfile', 'suffixexp' and 'suffixobs' for more information. OPeNDAP URLs are also supported.

All in all, Load() can load 2-dimensional or global mean variables in any of the following formats: - experiments: · file per ensemble per starting date (YYYY, MM and DD somewhere in the path) · file per member per starting date (YYYY, MM, DD and MemberNumber somewhere in the path, exps with different numbers of members supported) (YYYY, MM and DD specify the starting dates of the predictions) - observations: · file per ensemble per month (YYYY and MM somewhere in the path) · file per member per month (YYYY, MM and MemberNumber somewhere in the path, obs with different numbers of members supported) · file per dataset (No constraints in the path but the time axes in the file have to be properly defined) (YYYY and MM correspond to the actual month data in the file) In all the formats the data can be stored in a daily or monthly frequency, or a multiple of these (see parameters 'storefreq' and 'sampleperiod'). The only supported file format is NetCDF.

The Load() function returns a named list whith four components: 'mod', 'obs', 'lat' and 'lon'. 'mod' is the array that contains the experimental data. 'obs' is the array that contains the observational data. 'lat' and "lon" are the latitudes and longitudes of the grid into which the data is interpolated (0 if the loaded variable is a global mean or the output is an area average).

Usage

```
Load(var, exp = NULL, obs = NULL, sdates, nmember = NULL, nmemberobs = NULL, nleadtime = NULL, le
```

Arguments

var	Name of the variable to load. Must have matching entries in the list of global mean or in the list of 2-dimensional variables in the configuration file. Also must have matching entries together with each dataset specified in 'exp' and 'obs' in any of the experimental dataset tables and in any of the observational dataset tables. This parameter is mandatory. Ex: 'tas'
exp	Vector of experimental dataset IDs. Each must have matching entries together with the variable name specified in 'var' in any of the experimental datasets tables in the configuration file. IMPORTANT: Place first the experiment with the largest number of members and, if possible, with the largest number of leadtimes. If not possible, the arguments 'nmember' and/or 'nleadtime' should be filled to not miss any member or leadtime. If 'exp' is not specified or set to NULL, observational data is loaded for each start-date for a period of time as long as the time period between the first specified start date and the current date. Ex: c('ecmwf', 'i00k')
obs	Vector of observational dataset IDs. Each must have matching entries together with the variable name specified in 'var' in any of the observational datasets tables in the configuration file. IMPORTANT: Place first the observation with the largest number of members. If not possible, the argument 'nmemberobs' should be filled to not miss any member. If 'obs' is not specified or set to NULL, no observational data is loaded. Ex: c('ERSST', 'ERAint')
sdates	Vector of starting dates of the experimental runs to be loaded following the pattern 'YYYYMMDD'. This argument is mandatory. Ex: c('19601101', '19651101', '19701101')
nmember	Vector with the numbers of members to load from the specified experimental datasets in 'exp'. If not specified, the number of members of the first experimental dataset is detected and replied to all the experimental datasets. If a single

value is specified it is replied to all the experimental datasets. Data for each member is fetched in the file system. If not found is filled with NA values. An NA value in the 'nmember' list is interpreted as "fetch as many members as the greatest number of members among experimental datasets". Note: It is recommended to specify the number of members of the first experimental dataset if it is stored in file per member format because there are known issues in the automatic detection of members if the path to the dataset in the configuration file contains Shell Globbing wildcards such as '*'. Ex: c(4, 9)

`nmemberobs` Vector with the numbers of members to load from the specified observational datasets in 'obs'. If not specified, the number of members of the first observational dataset is detected and replied to all the observational datasets. If a single value is specified it is replied to all the observational datasets. Data for each member is fetched in the file system. If not found is filled with NA values. An NA value in the 'nmemberobs' list is interpreted as "fetch as many members as the greatest number of members among observational datasets". Note: It is recommended to specify the number of members of the first observational dataset if it is stored in file per member format because there are known issues in the automatic detection of members if the path to the dataset in the configuration file contains Shell Globbing wildcards such as '*'. Ex: c(1, 5)

`nleadtime` Largest number of lead-times among experimental datasets. Takes by default the number of lead-times of the first experimental dataset in 'exp'. If 'exp' is NULL this argument won't have any effect (see Load() description).

`leadtimemin` Only lead-times higher or equal to 'leadtimemin' are loaded. Takes by default value 1.

`leadtimemax` Only lead-times lower or equal to 'leadtimemax' are loaded. Takes by default the same value as 'nleadtime'.

`storefreq` Frequency at which the data to be loaded is stored in the file system. Can take values 'monthly' or 'daily'. By default it takes 'monthly'. Note: Data stored in other frequencies with a period which is divisible by a month can be loaded with a proper use of 'storefreq' and 'sampleperiod' parameters. It can also be loaded if the period is divisible by a day and the observational datasets are stored in a file per dataset format or 'obs' is empty.

`sampleperiod` To load only a subset between 'leadtimemin' and 'leadtimemax' with the period of subsampling 'sampleperiod'. Takes by default value 1 (all lead-times are loaded). See 'storefreq' for more information.

`lonmin` If a 2-dimensional variable is loaded, values at longitudes lower than 'lonmin' aren't loaded. Must take a value in the range [0, 360] (if negative longitudes are found in the data files these are translated to this range). It is set to 0 if not specified. If 'lonmin' > 'lonmax', data across Greenwich is loaded.

`lonmax` If a 2-dimensional variable is loaded, values at longitudes higher than 'lonmax' aren't loaded. Must take a value in the range [0, 360] (if negative longitudes are found in the data files these are translated to this range). It is set to 360 if not specified. If 'lonmin' > 'lonmax', data across Greenwich is loaded.

`latmin` If a 2-dimensional variable is loaded, values at latitudes lower than 'latmin' aren't loaded. Must take a value in the range [-90, 90]. It is set to -90 if not specified.

latmax — If a 2-dimensional variable is loaded, values at latitudes higher than 'latmax' aren't loaded. Must take a value in the range [-90, 90]. It is set to 90 if not specified.

output — This parameter determines the format in which the data is arranged in the output arrays. Can take values 'areave', 'lon', 'lat', 'lonlat'. 'areave': Time series of area-averaged variables over the specified domain. 'lon': Time series of meridional averages as a function of longitudes. 'lat': Time series of zonal averages as a function of latitudes. 'lonlat': Time series of 2d fields. Takes by default the value 'areave'. If the variable specified in 'var' is a global mean, this parameter is forced to 'areave'. All the loaded data is interpolated into the grid of the first experimental dataset except if 'areave' is selected. In that case the area averages are computed on each dataset original grid. A common grid different than the first experiment's can be specified through the parameter 'grid'. If 'grid' is specified when selecting 'areave' output type, all the loaded data is interpolated into the specified grid before calculating the area averages.

method — This parameter determines the interpolation method to be used when regridding data (see 'output'). Can take values 'bilinear', 'bicubic', 'conservative', 'distance-weighted'. Takes by default the value 'conservative'.

grid — A common grid can be specified through the parameter 'grid' when loading 2-dimensional data. Data is interpolated into this grid whichever 'output' type is specified. If the selected output type is 'areave' and a 'grid' is specified, the area averages are calculated after interpolating to the specified grid. If not specified and the selected output type is 'lon', 'lat' or 'lonlat', this parameter takes as default value the grid of the first experimental dataset, which is read from the configuration file. The grid must be supported by 'cdo' tools: rNXxNY or tTRgrid. Ex: 'r96x72'

maskmod — List of masks to be applied to the data of each experimental dataset respectively, if a 2-dimensional variable is specified in 'var'. Each mask is a matrix with dimensions c(longitudes, latitudes) with the same size as the common grid or with the same size of the associated experimental dataset if 'areave' output type is specified and no common 'grid' is specified. A value of 1 at a point of the mask keeps the original value at that point whereas a value of 0 disables it (replaces by an NA value). By default all values are kept (all ones). Warning: list() compulsory even if loading 1 experimental dataset only! Ex: list(array(1, dim = c(num_lons, num_lats)))

maskobs — List of masks to be applied to the data of each observational dataset respectively, if a 2-dimensional variable is specified in 'var'. Each mask is a matrix with dimensions c(longitudes, latitudes) with the same size as the common grid or with the same size of the associated observational dataset if 'areave' output type is specified and no common 'grid' is specified. A value of 1 at a point of the mask keeps the original value at that point whereas a value of 0 disables it (replaces by an NA value). By default all values are kept (all ones). Warning: list() compulsory even if loading 1 observational dataset only! Ex: list(array(1, dim = c(num_lons, num_lats)))

configfile — Path to the s2dverification configuration file from which information on location in file system (and other) of datasets is retreived. By default the configuration

file used at IC3 is used (it is included in the package). Check the IC3's configuration file or a template of configuration file in the folder 'inst/config' in the package. Check further information on the configuration file mechanism in '?LoadConfigurationFile'.

`suffixexp` Vector of suffixes used to build the dataset path of the experimental datasets respectively. Some times paths to datasets can vary depending on slight differences in model adjustments, which leads to an addition of a suffix in the common path pattern for the rest of experimental datasets. In such situation 'suffixexp' can help. Each pair of experimental dataset ID and variable name can have a suffix associated in the configuration file. If only one suffix is specified all experimental datasets will take the same suffix. An NA value in the list of suffixes is interpreted as "take the suffix specified in the configuration file". Ex: c('_f6h', '_3hourly')

`suffixobs` Vector of suffixes used to build the dataset path of the observational datasets respectively. Some times paths to datasets can vary depending on slight differences in postprocessings or reanalises adjustments, which leads to an addition of a suffix in the common path pattern for the rest of observational datasets. In such situation 'suffixobs' can help. Each pair of observational dataset ID and variable name can have a suffix associated in the configuration file. If only one suffix is specified all observational datasets will take the same suffix. An NA value in the list of suffixes is interpreted as "take the suffix specified in the configuration file". Ex: c('_f6h', '_3hourly')

`varmin` Loaded experimental and observational data values smaller than 'varmin' will be disabled (replaced by NA values). Takes by default the value specified in the configuration file.

`varmax` Loaded experimental and observational data values greater than 'varmax' will be disabled (replaced by NA values). Takes by default the value specified in the configuration file.

`silent` Parameter to show (FALSE) or hide (TRUE) information messages. Warnings will be displayed even if 'silent' is set to TRUE. Takes by default the value 'FALSE'.

`ncores` Number of parallel processes created to perform the fetch and computation of data. These processes will use shared memory in the processor in which Load() is launched. By default the number of logical cores in the machine will be detected and as many processes as logical cores there are will be created. A value of 1 won't create parallel processes. Note: Each parallel process creates other blocking processes each time they need to compute an interpolation via 'cdo'.

Details

The two output matrices have between 2 and 6 dimensions: 1) Number of experimental/observational datasets. 2) Number of members. 3) Number of startdates. 4) Number of leadtimes. 5) Number of latitudes (optional). 6) Number of longitudes (optional). but the two matrices have the same number of dimensions and only the first two dimensions can have different lengths depending on the input arguments.

For a detailed explanation of the process, read the documentation attached to the package or check the comments in the code.

Value

$mod	Model outputs. If output = 'areave', matrix with dimensions c(nmod/nexp, nmemb/nparam, nsdates, nltime) If output = 'lat', matrix with dimensions c(nmod/nexp, nmemb/nparam, nsdates, nltime, nlat) If output = 'lon', matrix with dimensions c(nmod/nexp, nmemb/nparam, nsdates, nltime, nlon) If output = 'lonlat', matrix with dimensions c(nmod/nexp, nmemb/nparam, nsdates, nltime, nlat, nlon)
$obs	Observations. Matrix with same dimensions as '$mod' except along the first two. If output = 'areave', matrix with dimensions c(nobs, nmemb, nsdates, nltime) If output = 'lat', matrix with dimensions c(nobs, nmemb, nsdates, nltime, nlat) If output = 'lon', matrix with dimensions c(nobs, nmemb nsdates, nltime, nlon) If output = 'lonlat', matrix with dimensions c(nobs, nmemb, nsdates, nltime, nlat, nlon)
$lat	Latitudes of the output grid (default: model grid of the first experiment). If 'areave' is selected or a global mean variable is specified, takes value 0.
$lon	Longitudes of the output grid (default: model grid of the first experiment). If 'areave' is selected or a global mean variable is specified, takes value 0.

Author(s)

History: 0.1 - 2011-03 (V. Guemas, <virginie.guemas@ic3.cat>) - Original code 1.0 - 2013-09 (N. Manubens, <nicolau.manubens@ic3.cat>) - Formatting to CRAN 1.2 - 2015-02 (N. Manubens, <nicolau.manubens@ic3.cat>) - Generalisation + parallelisation

Examples

```
startDates <- c('19901101', '19951101', '20001101')
sampleData <- Load('tos', c('i00k'), c('ERSST'), startDates, nleadtime = 124,
                   leadtimemin = 1, leadtimemax = 60, output = 'areave',
                   latmin = 30, latmax = 45, lonmin = 0, lonmax = 40)
PlotAno(sampleData$mod, sampleData$obs, startDates,
        toptitle = "Mediterannean SST", ytitle = 'K',
        fileout = 'tos_load_data.eps')
```

LoadConfigurationFile *Load Dataset Location Data Into An Environment*

Description

This function loads all the data contained in the configuration file specified as parameter 'configfile' in the function Load() of s2dverification. Extends the environment given as parameter with the variables and functions needed for the configuration file mechanism to work. This function is called from inside the Load() function. There is no need to call it manually.

Two examples of configuration files can be found inside the 'inst/config/' folder in the package: IC3.conf: configuration file used at IC3. Contains location data on several datasets and variables. template.conf: very simple configuration file intended to be used as pattern when starting from scratch.

How the configuration file works: ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

It contains two lists and five tables. Each of these have a header that starts with '!!'. These are key lines and should not be removed or reordered. Lines starting with '#' and blank lines will be ignored.

The first list should contain all the supported 2-dimensional variables. The second list should contain all the supported global mean variables. Regular expressions[1] can be used in these lists to match more than one variable name.

The first table contains information about experiments (which are stored in a file per ensemble format). The second table contains information about file-per-member experiments (which are stored in a file per ensemble format). The third table contains information about observations (which are stored in a single file per month for the whole ensemble). The fourth table contains information about the file-per-member observations (which are stored in one file per month for each member). The fifth table contains information about the file-per-dataset observations (which contain all the dataset values in a single file).

Each table entry is a list of comma-separated elements. The two first are part of a key that is associated to a value formed by the other elements. The key elements are a dataset identifier and a variable name. The value elements are the dataset main path, dataset file path, grid (unless it is an observation table entry), the variable name inside the .nc file, a default suffix (explained below) and a minimum and maximum vaues beyond which loaded data is deactivated.

Given a dataset name and a variable name, a full path is obtained concatenating the main path and the file path with a slash (/) in between. Also the grid (in the case it is an experiment), the nc variable name, the suffixes and the limit values are obtained.

Any of the elements in the keys can contain regular expressions that will cause matching for sets of dataset names or variable names.

The dataset path and file path can contain shell globbing expressions[2] that will cause matching for sets of paths when fetching the file in the full path. The full path can point to an OPeNDAP URL.

Any of the elements in the value can contain variables that will be replaced to an associated string. Variables can be defined only immediately above any of the tables header. The pattern of a variable definition is VARIABLE_NAME = VARIABLE_VALUE and can be accessed from within the table values or from within the variable values as $VARIABLE_NAME$ For example: FILE_NAME = tos.nc !!table_of_experiments ecmwf, tos, /path/to/dataset, $FILE_NAME$ There are some reserved variables that will offer information about the store frequency, the current startdate Load() is fetching, etc: $START_DATE$, $STORE_FREQ$ for file-per-member datasets: $MEMBER_NUMBER$ for observations: $YEAR$, $MONTH$, DAY Additionally, from an element in an entry value you can access the other elements of the entry as: EXP_NAME, VAR_NAME, EXP_MAIN_PATH, EXP_FILE_PATH, $GRID$, VAR_NAME, $SUFFIX$, VAR_MIN, VAR_MAX and in an observation as: OBS_NAME, VAR_NAME, OBS_MAIN_PATH, OBS_FILE_PATH, VAR_NAME, $SUFFIX$, VAR_MIN, VAR_MAX

The variable $SUFFIX$ is useful because it can be used to take part in the main or file path. For example: '/path/to$SUFFIX$/dataset'. It will be replaced by the value in the column that corresponfs to the suffix unless the user specifies a different suffix via the parameter 'suffixexp' or 'suffixobs'.

This way the user is able to load two variables with the same name in the same dataset but with slight modifications, with a suffix anywhere in the path to the data that advices of this slight modification.

The entries in a table will be grouped in 4 levels of specificity: 1- General entries: · the key dataset name and variable name are both a regular expression matching any sequence of characters (.*) that will cause matching for any pair of dataset and variable names Example: .*, .*, /dataset/main/path, file/path, grid, nc_var_name 2- Dataset entries: · the key variable name matches any sequence of characters Example: ecmwf, .*, /dataset/main/path, file/path, grid, nc_var_name 3- Variable entries: · the key dataset name matches any sequence of characters Example: .*, tos, /dataset/main/path, file/path, grid, nc_var_name 4- Specific entries: · both key values are specified Example: ecmwf, tos, /dataset/main/path, file/path, grid, nc_var_name

Given a pair of dataset name and variable name for which we want to know the full path, all the rules that match will be applied from more general to more specific. If there is more than one entry per group that match a given key pair, these will be applied in the order of appearance in the configuration file (top to bottom).

An asterisk (*) in any value element will be interpreted as 'leave it as is or take the default value if yet not defined'. The default values are defined in the following reserved variables: $DEFAULT_EXP_MAIN_PATH$, $DEFAULT_EXP_FILE_PATH$, $DEFAULT_GRID$, $DEFAULT_NC_VAR_NAME$, $DEFAULT_OBS_MAIN_PATH$, $DEFAULT_OBS_FILE_PATH$ Trailing asterisks in an entry are not mandatory. For example ecmwf, .*, /dataset/main/path, *, *, *, *, *, * will have the same effect as ecmwf, .*, /dataset/main/path

A double quote only (") in any key or value element will be interpreted as 'fill in with the same value as the entry above'.

The pattern to obtain the full path by concatenating the dataset main path and the dataset file path can be adjusted in the variables EXP_FULL_PATH and OBS_FULL_PATH, which are defined by default as EXP_FULL_PATH = EXP_MAIN_PATH/EXP_FILE_PATH OBS_FULL_PATH = OBS_MAIN_PATH/OBS_FILE_PATH

[1] http://tldp.org/LDP/abs/html/globbingref.html [2] https://stat.ethz.ch/R-manual/R-devel/library/base/html/regex.html

Usage

```
LoadConfigurationFile(environment)
```

Arguments

`environment`	R environment to extend with the configuration file mechanism variables and functions.

Value

Extended environment with the configuration file mechanism variables and functions.

Author(s)

History: 0.1 - 2014-12 (N. Manubens, <nicolau.manubens@ic3.cat>) - First version

Examples

```
configfile <- system.file("config", "template.conf", package = "s2dverification")
LoadConfigurationFile(environment())
```

`LoadDataFile` *Load Data From File Into Environment*

Description

This function receives a 'work piece', a named list which contains information on a data file to be loaded. It can be run in 'explore' mode or in 'load' mode. When running in 'explore' mode, the metadata of the file is read and the sizes of the dimensions in the file are returned in a named list: 'nmemb': Number of members 'nltime': Number of lead-times 'lon': Longitudes in the file 'lat': Latitudes in the file When running in 'load' mode it loads and performs any requested computations in additional parameters in the 'work piece', such as interpolating, slicing, ..., and finally stores it in a shared memory matrix pointed by the parameter 'out_pointer' in the 'work piece'.

Usage

```
LoadDataFile(work_piece, explore_dims = FALSE, silent = FALSE)
```

Arguments

`work_piece`	Named list with information on the file to load or explore and additional parameters. The needed variables in the work piece are: - In explore mode: · dataset_type: 'exp'/'obs' · filename: full path to the data file · namevar: name of the variable in the nc file · is_2d_var: TRUE/FALSE · grid: common grid into which interpolate or NULL if no interpolation · remap: interpolation method ('remapbil'/'remapdis'/'remapcon'/'remapbic') · lon_limits: c(lon_min, lon_max) · lat_limits: c(lat_min, lat_max) · is_file_per_member: TRUE/FALSE - In load mode: · dataset_type: 'exp'/'obs' · filename: full path to the data file · namevar: name of the variable in the nc file · is_2d_var: TRUE/FALSE · grid: common grid into which interpolate or NULL if no interpolation · remap: interpolation method ('remapbil'/'remapdis'/'remapcon'/'remapbic') · lon_limits: c(lon_min, lon_max) · lat_limits: c(lat_min, lat_max) · is_file_per_dataset: TRUE/FALSE · startdates: in the case that filename points to a whole dataset file, the list of starting dates to load must be specified. c('sdate1', 'sdate2', ...) · out_pointer: big.matrix descriptor pointing to the array (transformed into a matrix) where to keep the data · dims: named list with dimension sizes of the original array into which the data is kept. Names must be c(['nlon'], ['nlat'], 'nltime', 'nmember', 'nsdates', 'ndat'). · indices: vector of initial positions corresponding to each dimension in 'dims' where to store data in the original array. First two indices ('nlon', 'nlat') can be missing. · nmember: number of members expected to be loaded · mask: complete (untrimmed + interpolated if needed) mask to activate/deactivate data points, with dimensions c('lon', 'lat') · leadtimes: vector of time indices to be loaded from the file · var_limits: c(var_min, var_max)

explore_dims	Run in dimension explore mode (TRUE) or in load and calculation mode (FALSE). Takes by default the value FALSE (calculation mode).
silent	Parameter to allow (FALSE) or deactivate (TRUE) printing of explanatory messages. When deactivated any warning messages will still be displayed. Takes by default the value FALSE (verbose mode).

Value

When called in 'explore' mode, a named list is returned with the found lengths for members, leadtimes and the latitudes and longitudes already trimmed and reordered if needed. The names are 'nmemb', 'nltime', 'lon', 'lat'. If it is a file from a file-per-member dataset, the number of files that match the filename replacing the $MEMBER$ part by an asterisk is returned (which is the supposed number of members). There are known issues with this method of detection. See documentation on parameter 'nmember' and 'nmemberobs' in Load() function. When called in 'calculation' mode, TRUE is returned if the file was found and FALSE is returned otherwise.

Author(s)

History: 0.1 - 2015-01 (N. Manubens, <nicolau.manubens@ic3.cat>) - First version

Examples

```
#LoadDataFile(list(dataset_type = 'exp', filename = '/path/to/file.nc', namevar = 'tos', is_2d_var = TRUE, g
```

Mean1Dim *Averages A Matrix Along A Dimension*

Description

Averages the matrix var along the posdim dimension between limits [1] and limits [2] if limits argument is provided by the user.

Usage

```
Mean1Dim(var, posdim, narm = TRUE, limits = NULL)
```

Arguments

var	Matrix to average.
posdim	Dimension to average along.
narm	Ignore NA (TRUE) values or not (FALSE).
limits	Limits to average between.

Value

Matrix with one dimension less than the input one containing the average along posdim dimension.

Author(s)

History: 0.1 - 2011-04 (V. Guemas, <virginie.guemas@ic3.cat>) - Original code 1.0 - 2013-09 (N. Manubens, <nicolau.manubens@ic3.cat>) - Formatting to R CRAN

Examples

```
a <- array(rnorm(24), dim = c(2, 3, 4))
print(a)
print(Mean1Dim(a, 2))
```

MeanListDim *Averages A Matrix Along Various Dimensions*

Description

Averages the matrix var along a set of dimensions given by the argument dims.

Usage

```
MeanListDim(var, dims, narm = TRUE)
```

Arguments

var	Matrix to average.
dims	List of dimensions to average along.
narm	Ignore NA (TRUE) values or not (FALSE).

Value

Matrix with as many dimensions less than the input matrix as provided by the list dims and containing the average along this list of dimensions.

Author(s)

History: 0.1 - 2011-04 (V. Guemas, <vguemas@ic3.cat>) - Original code 1.0 - 2013-09 (N. Manubens, <nicolau.manubens@ic3.cat>) - Formatting to R CRAN

Examples

```
a <- array(rnorm(24), dim = c(2, 3, 4))
print(a)
print(Mean1Dim(a, 2))
print(MeanListDim(a, c(2, 3)))
```

`Plot2VarsVsLTime` *Plot Two Scores With Confidence Intervals In A Common Plot*

Description

Plots two input variables having the same dimensions in a common plot. One plot for all experiments. Input variables should have dimensions (nexp/nmod, nltime).

Usage

```
Plot2VarsVsLTime(var1, var2, toptitle = "", ytitle = "", monini = 1,
                 freq = 12, nticks = NULL, limits = NULL,
                 listexp = c("exp1", "exp2", "exp3"),
                 listvars = c("var1", "var2"), biglab = FALSE, hlines = NULL,
                 leg = TRUE, siglev = FALSE, sizetit = 1,
                 fileout = "output_plot2varsvsltime.eps", show_conf = TRUE)
```

Arguments

`var1`	Matrix of dimensions (nexp/nmod, nltime).
`var2`	Matrix of dimensions (nexp/nmod, nltime).
`toptitle`	Main title, optional.
`ytitle`	Title of Y-axis, optional.
`monini`	Starting month between 1 and 12. Default = 1.
`freq`	1 = yearly, 12 = monthly, 4 = seasonal, ... Default = 12.
`nticks`	Number of ticks and labels on the x-axis, optional.
`limits`	c(lower limit, upper limit): limits of the Y-axis, optional.
`listexp`	List of experiment names, up to three, optional.
`listvars`	List of names of input variables, optional.
`biglab`	TRUE/FALSE for presentation/paper plot. Default = FALSE.
`hlines`	c(a, b, ...) Add horizontal black lines at Y-positions a, b, ... Default: NULL.
`leg`	TRUE/FALSE if legend should be added or not to the plot. Default = TRUE.
`siglev`	TRUE/FALSE if significance level should replace confidence interval. Default = FALSE.
`sizetit`	Multiplicative factor to change title size, optional.
`fileout`	Name of output ps file.
`show_conf`	TRUE/FALSE to show/not confidence intervals for input variables.

Details

Examples of input: ————————

RMSE error for a number of experiments and along lead-time: (nexp, nltime)

Author(s)

History: 1.0 - 2013-03 (I. Andreu-Burillo, <isabel.andreu-burillo@ic3.cat>) - Original code

Examples

```
startDates <- c('19851101', '19901101', '19951101', '20001101', '20051101')
sampleData <- Load('tos', c('i00k'), c('ERSST'), startDates, nleadtime = 124,
                   leadtimemin = 1, leadtimemax = 60, output = 'areave',
                   latmin = 30, latmax = 45, lonmin = 0, lonmax = 40)
clim <- Clim(sampleData$mod, sampleData$obs)
ano_exp <- Ano(sampleData$mod, clim$clim_exp)
ano_obs <- Ano(sampleData$obs, clim$clim_obs)
runmean_months <- 12
dim_to_smooth <- 4  # Smooth along lead-times
smooth_ano_exp <- Smoothing(ano_exp, runmean_months, dim_to_smooth)
smooth_ano_obs <- Smoothing(ano_obs, runmean_months, dim_to_smooth)
dim_to_mean <- 2  # Mean along members
required_complete_row <- 3  # Discard start dates that contain NA along lead-times
leadtimes_per_startdate <- 60
rms <- RMS(Mean1Dim(smooth_ano_exp, dim_to_mean),
           Mean1Dim(smooth_ano_obs, dim_to_mean),
           compROW = required_complete_row,
           limits = c(ceiling((runmean_months + 1) / 2),
                      leadtimes_per_startdate - floor(runmean_months / 2)))
smooth_ano_exp_m_sub <- smooth_ano_exp - InsertDim(Mean1Dim(smooth_ano_exp, 2,
                        narm = TRUE), 2, dim(smooth_ano_exp)[2])
spread <- Spread(smooth_ano_exp_m_sub, c(2, 3))
Plot2VarsVsLTime(InsertDim(rms[, , , ], 1, 1), spread$sd,
                 toptitle = 'RMSE and spread', monini = 11, freq = 12,
                 listexp = c('CMIP5 IC3'), listvar = c('RMSE', 'spread'),
                 fileout = 'plot2vars.eps')
```

PlotACC *Plot Plumes/Timeseries Of Anomaly Correlation Coefficients*

Description

Plots plumes/timeseries of ACC from a matrix with dimensions (output from ACC()): c(nexp, nobs, nsdates, nltime, 4) with the fourth dimension of length 4 containing the lower limit of the 95% confidence interval, the ACC, the upper limit of the 95% confidence interval and the 95% significance level given by a one-sided T-test.

Usage

```
PlotACC(ACC, sdates, toptitle = "", sizetit = 1, ytitle = "", limits = NULL,
        legends = NULL, freq = 12, biglab = FALSE, fill = FALSE, linezero = FALSE,
        points = TRUE, vlines = NULL, fileout = "output_PlotACC.eps")
```

Arguments

ACC	ACC matrix with with dimensions: c(nexp, nobs, nsdates, nltime, 4) with the fourth dimension of length 4 containing the lower limit of the 95% confidence interval, the ACC, the upper limit of the 95% confidence interval and the 95% significance level.
sdates	List of startdates: c('YYYYMMDD','YYYYMMDD').
toptitle	Main title, optional.
sizetit	Multiplicative factor to scale title size, optional.
ytitle	Title of Y-axis for each experiment: c("","), optional.
limits	c(lower limit, upper limit): limits of the Y-axis, optional.
legends	List of flags (characters) to be written in the legend, optional.
freq	1 = yearly, 12 = monthly, 4 = seasonal, ... Default: 12.
biglab	TRUE/FALSE for presentation/paper plot, Default = FALSE.
fill	TRUE/FALSE if filled confidence interval. Default = FALSE.
linezero	TRUE/FALSE if a line at y=0 should be added. Default = FALSE.
points	TRUE/FALSE if points instead of lines. Default = TRUE. Must be TRUE if only 1 leadtime.
vlines	List of x location where to add vertical black lines, optional.
fileout	Name of the output eps file.

Author(s)

History: 0.1 - 2013-08 (V. Guemas, <virginie.guemas@ic3.cat>) - Original code 1.0 - 2013-09 (N. Manubens, <nicolau.manubens@ic3.cat>) - Formatting to CRAN

Examples

```
startDates <- c('19851101', '19901101', '19951101', '20001101', '20051101')
sampleData <- Load('tos', c('i00k'), c('ERSST'), startDates, nleadtime = 124,
                   leadtimemin = 1, leadtimemax = 4, output = 'lonlat',
                   latmin = 30, latmax = 45, lonmin = 0, lonmax = 40)
sampleData$mod <- Season(sampleData$mod, 4, 11, 12, 2)
sampleData$obs <- Season(sampleData$obs, 4, 11, 12, 2)
clim <- Clim(sampleData$mod, sampleData$obs)
ano_exp <- Ano(sampleData$mod, clim$clim_exp)
ano_obs <- Ano(sampleData$obs, clim$clim_obs)
acc <- ACC(Mean1Dim(sampleData$mod, 2),
           Mean1Dim(sampleData$obs, 2))
PlotACC(acc$ACC, startDates, toptitle = "Anomaly Correlation Coefficient")
```

PlotAno *Plot Raw Or Smoothed Anomalies*

Description

Plots timeseries of raw or smoothed anomalies of any index output from Load() or Ano() or or Ano_CrossValid() or Smoothing() and organized in matrices with dimensions: c(nmod/nexp, nmemb/nparam, nsdates, nltime) for the model data c(nobs, nmemb, nsdates, nltime) for the observational data

Usage

```
PlotAno(exp_ano, obs_ano = NULL, sdates, toptitle = c("", "", "", "", "", "",
        "", "", "", "", "", "", "", "", "", ""), ytitle = c("", "", "", "", "",
        "", "", "", "", "", "", "", "", "", ""), limits = NULL,
        legends = NULL, freq = 12, biglab = FALSE, fill = TRUE, memb = TRUE,
        ensmean = TRUE, linezero = FALSE, points = FALSE, vlines = NULL,
        fileout = c("output1_plotano.eps", "output2_plotano.eps",
        "output3_plotano.eps", "output4_plotano.eps", "output5_plotano.eps"),
        sizetit = 1)
```

Arguments

exp_ano	Matrix containing the experimental data: c(nmod/nexp, nmemb/nparam, nsdates, nltime).
obs_ano	Optional matrix containing the observational data: c(nobs, nmemb, nsdates, nltime)
sdates	List of starting dates: c('YYYYMMDD','YYYYMMDD').
toptitle	Main title for each experiment: c("","), optional.
ytitle	Title of Y-axis for each experiment: c("","), optional.
limits	c(lower limit, upper limit): limits of the Y-axis, optional.
legends	List of observational dataset names, optional.
freq	1 = yearly, 12 = monthly, 4 = seasonal, ... Default: 12.
biglab	TRUE/FALSE for presentation/paper plot. Default = FALSE.
fill	TRUE/FALSE if the spread between members should be filled. Default = TRUE.
memb	TRUE/FALSE if all members/only the ensemble-mean should be plotted. Default = TRUE.
ensmean	TRUE/FALSE if the ensemble-mean should be plotted. Default = TRUE.
linezero	TRUE/FALSE if a line at y=0 should be added. Default = FALSE.
points	TRUE/FALSE if points instead of lines should be shown. Default = FALSE.
vlines	List of x location where to add vertical black lines, optional.
fileout	Name of the output eps file for each experiment: c("",").
sizetit	Multiplicative factor to scale title size, optional.

Author(s)

History: 0.1 - 2011-03 (V. Guemas, <virginie.guemas@ic3.cat>) - Original code 1.0 - 2013-09 (N. Manubens, <nicolau.manubens@ic3.cat>) - Formatting to CRAN

Examples

```
startDates <- c('19901101', '19951101', '20001101')
sampleData <- Load('tos', c('i00k'), c('ERSST'), startDates, nleadtime = 124,
                   leadtimemin = 1, leadtimemax = 60, output = 'areave',
                   latmin = 30, latmax = 45, lonmin = 0, lonmax = 40)
clim <- Clim(sampleData$mod, sampleData$obs)
ano_exp <- Ano(sampleData$mod, clim$clim_exp)
ano_obs <- Ano(sampleData$obs, clim$clim_obs)
runmean_nb_months <- 12
dim_to_smooth <- 4  # Smooth along lead-times
smooth_ano_exp <- Smoothing(ano_exp, runmean_nb_months, dim_to_smooth)
smooth_ano_obs <- Smoothing(ano_obs, runmean_nb_months, dim_to_smooth)
PlotAno(smooth_ano_exp, smooth_ano_obs, startDates,
        toptitle = paste('smoothed anomalies'), ytitle = c('K', 'K', 'K'),
        legends = 'ERSST', biglab = FALSE, fileout = 'tos_ano.eps')
```

PlotClim *Plots Climatologies*

Description

Plots climatologies as a function of the forecast time for any index output from `Clim()` and organized in matrix with dimensions: c(nmod/nexp, nmemb/nparam, nltime) or c(nmod/nexp, nltime) for the experiment data c(nobs, nmemb, nltime) or c(nobs, nltime) for the observational data

Usage

```
PlotClim(exp_clim, obs_clim = NULL, toptitle = "", ytitle = "", monini = 1,
         freq = 12, limits = NULL, listexp = c("exp1", "exp2", "exp3"),
         listobs = c("obs1", "obs2", "obs3"), biglab = FALSE, leg = TRUE,
         fileout = "output_plotclim.eps", sizetit = 1)
```

Arguments

`exp_clim`	Matrix containing the experimental data with dimensions: c(nmod/nexp, nmemb/nparam, nltime) or c(nmod/nexp, nltime)
`obs_clim`	Matrix containing the observational data (optional) with dimensions: c(nobs, nmemb, nltime) or c(nobs, nltime)
`toptitle`	Main title, optional
`ytitle`	Title of Y-axis, optional.
`monini`	Starting month between 1 and 12. Default = 1.

freq	1 = yearly, 12 = monthly, 4 = seasonal, ... Default = 12.
limits	c(lower limit, upper limit): limits of the Y-axis, optional.
listexp	List of experiment names, optional.
listobs	List of observational dataset names, optional.
biglab	TRUE/FALSE for presentation/paper plot. Default = FALSE.
leg	TRUE/FALSE to plot the legend or not.
fileout	Name of the output eps file.
sizetit	Multiplicative factor to scale title size, optional.

Author(s)

History: 0.1 - 2011-03 (V. Guemas, <virginie.guemas@ic3.cat>) - Original code 1.0 - 2013-09 (N. Manubens, <nicolau.manubens@ic3.cat>) - Formatting to CRAN

Examples

```
startDates <- c('19901101', '19951101', '20001101')
sampleData <- Load('tos', c('i00k'), c('ERSST'), startDates, nleadtime = 124,
                   leadtimemin = 1, leadtimemax = 60, output = 'areave',
                   latmin = 30, latmax = 45, lonmin = 0, lonmax = 40)
clim <- Clim(sampleData$mod, sampleData$obs)
PlotClim(clim$clim_exp, clim$clim_obs, toptitle = paste('climatologies'),
         ytitle = 'K', monini = 11, listexp = c('CMIP5 IC3'),
         listobs = c('ERSST'), biglab = FALSE, fileout = 'tos_clim.eps')
```

PlotEquiMap *Maps A Two-Dimensional Variable On A Cylindrical Equidistant Projection*

Description

Map a two dimensional matrix with (longitude, latitude) dimensions on a cylindrical equidistant latitude and longitude projection.

Usage

```
PlotEquiMap(var, lon, lat, toptitle = "", sizetit = 1, units = "",
            brks = NULL, cols = NULL, square = TRUE,
            filled.continents = TRUE, contours = NULL, brks2 = NULL,
            dots = NULL, axelab = TRUE, labW = FALSE, intylat = 20, intxlon = 20,
            drawleg = TRUE, subsampleg = 1, numbfig = 1, colNA = "white")
```

Arguments

var	Matrix to plot with (longitude, latitude) dimensions.
lon	Array of longitudes.
lat	Array of latitudes.
toptitle	Title, optional.
sizetit	Multiplicative factor to increase title size, optional.
units	Units, optional.
brks	Colour levels, optional.
cols	List of colours, optional.
square	Field coloured with squares (TRUE) for each grid cell or spatial smoothing (FALSE). Default: TRUE.
filled.continents	Continents filled in grey (TRUE) or represented by a black line (FALSE). Default = TRUE. Filling unavailable if crossing Greenwich. Filling unavailable if square = FALSE.
contours	Matrix to be added to the plot and shown with contours. Default = NULL.
brks2	Contour levels, optional.
dots	Matrix with TRUE / FALSE flags to add black dots over the maps (to show where a score is significant for example). Option only available if square = TRUE.
axelab	TRUE/FALSE, label the axis. Default = TRUE.
labW	Label the longitude axis with W instead of minus. Default = FALSE.
intylat	Interval between latitude ticks on y-axis. Default = 20deg.
intxlon	Interval between longitude ticks on x-axis. Default = 20deg.
drawleg	Draw a colorbar. Can be FALSE only if square = FALSE. Must be FALSE if numbfig > 1. Default = TRUE.
subsampleg	Supsampling factor of the interval between ticks on colorbar. Default = 1 = every colour level.
numbfig	Number of figures in the final multipanel.
colNA	Color used to represent NA. Default = 'white'

Author(s)

History: 0.1 - 2011-11 (V. Guemas, <virginie.guemas@ic3.cat>) - Original code 0.2 - 2013-04 (R. Saurral <ramiro.saurral@ic3.cat>) - LabW 1.0 - 2013-09 (N. Manubens, <nicolau.manubens@ic3.cat>) - Formatting to R CRAN

Examples

```
startDates <- c('19901101', '19951101', '20001101')
sampleData <- Load('tos', c('i00k'), c('ERSST'), startDates, nleadtime = 124,
                   leadtimemin = 1, leadtimemax = 60, output = 'lonlat',
                   latmin = 30, latmax = 45, lonmin = 0, lonmax = 40)
PlotEquiMap(sampleData$mod[1, 1, 1, 1, , ], sampleData$lon, sampleData$lat,
            toptitle = 'Predicted sea surface temperature for Nov 1960 from 1st Nov',
            sizetit = 0.5)
```

PlotSection *Plots A Vertical Section*

Description

Plot a (longitude,depth) or (latitude,depth) section.

Usage

```
PlotSection(var, horiz, depth, toptitle = "", sizetit = 1, units = "",
            brks = NULL, cols = NULL, axelab = TRUE, intydep = 200,
            intxhoriz = 20, drawleg = TRUE)
```

Arguments

var	Matrix to plot with (longitude/latitude, depth) dimensions.
horiz	Array of longitudes or latitudes.
depth	Array of depths.
toptitle	Title, optional.
sizetit	Multiplicative factor to increase title size, optional.
units	Units, optional.
brks	Colour levels, optional.
cols	List of colours, optional.
axelab	TRUE/FALSE, label the axis. Default = TRUE.
intydep	Interval between depth ticks on y-axis. Default: 200m.
intxhoriz	Interval between longitude/latitude ticks on x-axis. Default: 20deg.
drawleg	Draw colorbar. Default: TRUE.

Author(s)

History: 0.1 - 2012-09 (V. Guemas, <virginie.guemas@ic3.cat>) - Original code 1.0 - 2013-09 (N. Manubens, <nicolau.manubens@ic3.cat>) - Formatting to CRAN

Examples

```
sampleData <- sampleDepthData
PlotSection(sampleData$mod[1, 1, 1, 1, , ], sampleData$lat, sampleData$depth,
            toptitle = 'temperature 1995-11 member 0')
```

PlotStereoMap *Maps A Two-Dimensional Variable On A Polar Stereographic Projection*

Description

Map a two dimensional matrix with (longitude, latitude) dimensions on a polar stereographic projection.

Usage

```
PlotStereoMap(var, lon, lat, latlims = c(60,90), toptitle = "", sizetit = 1,
              units = "", brks = NULL, cols = NULL, filled.continents = FALSE,
              dots = NULL, intlat = 10, drawleg = TRUE, subsampleg = 1,
              colNA = "white")
```

Arguments

var	Matrix to plot with (longitude, latitude) dimensions.
lon	Array of longitudes.
lat	Array of latitudes.
latlims	Latitudinal limits of the figure. Example : c(60, 90) for the North Pole c(-90,-60) for the South Pole
toptitle	Title, optional.
sizetit	Multiplicative factor to increase title size, optional.
units	Units, optional.
brks	Colour levels, optional.
cols	List of colours, optional.
filled.continents	Continents filled in grey (TRUE) or represented by a black line (FALSE). Default = FALSE.
dots	Matrix with TRUE / FALSE flags to add black dots over the maps (to show where a score is significant for example).
intlat	Interval between latitude circles. Default = 10deg.
drawleg	Draw a colorbar.
subsampleg	Supsampling factor of the interval between ticks on colorbar. Default = 1 = every colour level.
colNA	Color used to represent NA. Default = 'white'

Author(s)

History: 1.0 - 2014-07 (V. Guemas, <virginie.guemas@ic3.cat>) - Original code

PlotVsLTime *Plots A Score Along The Forecast Time With Its Confidence Interval*

Description

Plots The Correlation (Corr()) or the Root Mean Square Error (RMS()) between the forecasted values and their observational counterpart or the slopes of their trends (Trend()) or the InterQuartile Range, Maximum-Mininum, Standard Deviation or Median Absolute Deviation of the Ensemble Members (Spread()), or the ratio between the Ensemble Spread and the RMSE of the Ensemble Mean (RatioSDRMS()) along the forecast time for all the input experiments on the same figure with their confidence intervals.

Usage

```
PlotVsLTime(var, toptitle = "", ytitle = "", monini = 1, freq = 12,
nticks = NULL, limits = NULL, listexp = c("exp1", "exp2", "exp3"),
listobs = c("obs1", "obs2", "obs3"), biglab = FALSE, hlines = NULL, leg = TRUE,
siglev = FALSE, fileout = "output_plotvsltime.eps", sizetit = 1, show_conf = TRUE)
```

Arguments

var	Matrix containing any Prediction Score with dimensions: (nexp/nmod, 3/4 ,nltime) or (nexp/nmod, nobs, 3/4 ,nltime)
toptitle	Main title, optional.
ytitle	Title of Y-axis, optional.
monini	Starting month between 1 and 12. Default = 1.
freq	1 = yearly, 12 = monthly, 4 = seasonal, ... Default = 12.
nticks	Number of ticks and labels on the x-axis, optional.
limits	c(lower limit, upper limit): limits of the Y-axis, optional.
listexp	List of experiment names, optional.
listobs	List of observation names, optional.
biglab	TRUE/FALSE for presentation/paper plot. Default = FALSE.
hlines	c(a,b, ..) Add horizontal black lines at Y-positions a,b, ... Default = NULL.
leg	TRUE/FALSE if legend should be added or not to the plot. Default = TRUE.
siglev	TRUE/FALSE if significance level should replace confidence interval. Default = FALSE.
fileout	Name of the output eps file.
sizetit	Multiplicative factor to change title size, optional.
show_conf	TRUE/FALSE to show/not confidence intervals for input variables.

Details

Examples of input:

Model and observed output from `Load()` then `Clim()` then `Ano()` then `Smoothing()`: (nmod, nmemb, nsdate, nltime) and (nobs, nmemb, nsdate, nltime) then averaged over the members `Mean1Dim(var_exp/var_obs, p` (nmod, nsdate, nltime) and (nobs, nsdate, nltime) then passed through `Corr(exp, obs, posloop = 1, poscor = 2)` or `RMS(exp, obs, posloop = 1, posRMS = 2)`: (nmod, nobs, 3, nltime) would plot the correlations or RMS between each exp & each obs as a function of the forecast time.

Author(s)

History: 0.1 - 2011-03 (V. Guemas, - Original code <virginie.guemas@ic3.cat>) 0.2 - 2013-03 (I. Andreu-Burillo, - Introduced parameter - <isabel.andreu-burillo@ic3.cat>) - sizetit 0.3 - 2013-10 (I. Andreu-Burillo, - Introduced parameter - <isabel.andreu-burillo@ic3.cat>) - show_conf 1.0 - 2013-11 (N. Manubens, <nicolau.manubens@ic3.cat>) - Formatting to CRAN

Examples

```
startDates <- c('19851101', '19901101', '19951101', '20001101', '20051101')
sampleData <- Load('tos', c('i00k'), c('ERSST'), startDates, nleadtime = 124,
                   leadtimemin = 1, leadtimemax = 60, output = 'areave',
                   latmin = 30, latmax = 45, lonmin = 0, lonmax = 40)
clim <- Clim(sampleData$mod, sampleData$obs)
ano_exp <- Ano(sampleData$mod, clim$clim_exp)
ano_obs <- Ano(sampleData$obs, clim$clim_obs)
runmean_months <- 12
dim_to_smooth <- 4  # Smooth along lead-times
smooth_ano_exp <- Smoothing(ano_exp, runmean_months, dim_to_smooth)
smooth_ano_obs <- Smoothing(ano_obs, runmean_months, dim_to_smooth)
dim_to_mean <- 2  # Mean along members
required_complete_row <- 3  # Discard startdates for which there are NA leadtimes
leadtimes_per_startdate <- 60
corr <- Corr(Mean1Dim(smooth_ano_exp, dim_to_mean),
             Mean1Dim(smooth_ano_obs, dim_to_mean),
             compROW = required_complete_row,
             limits = c(ceiling((runmean_months + 1) / 2),
                        leadtimes_per_startdate - floor(runmean_months / 2)))
PlotVsLTime(corr, toptitle = "correlations", ytitle = "correlation",
            monini = 11, limits = c(-1, 2), listexp = c('CMIP5 IC3'),
            listobs = c('ERSST'), biglab = FALSE, hlines = c(-1, 0, 1),
            fileout = 'tos_cor.eps')
```

`RatioRMS` *Computes The Ratio Between The RMSE Scores of 2 Experiments.*

Description

Matrix var_exp1 / var_exp2 / var_obs should have the same dimensions. The ratio RMSE(var_exp1, var_obs) / RMSE(var_exp2, var_obs) is output. The p-value is provided by a two-sided Fischer test.

Usage

```
RatioRMS(var_exp1, var_exp2, var_obs, posRMS = 1)
```

Arguments

var_exp1	Matrix of experimental data 1.
var_exp2	Matrix of experimental data 2, same dimensions as var_exp1.
var_obs	Matrix of observational data, same dimensions as var_exp1.
posRMS	Dimension along which the RMSE are to be computed = the position of the start dates.

Value

Matrix with the same dimensions as var_exp1/var_exp2/var_obs except along posRMS where the dimension has length 2. The dimension 2 corresponds to the ratio between the RMSE (RMSE1/RMSE2) and the p.value of the two-sided Fisher test with Ho: RMSE1/RMSE2 = 1.

Author(s)

History: 0.1 - 2011-11 (V. Guemas, <vguemas@ic3.cat>) - Original code 1.0 - 2013-09 (N. Manubens, <nicolau.manubens@ic3.cat>) - Formatting to R CRAN

Examples

```
startDates <- c('19901101', '19951101', '20001101')
sampleData <- Load('tos', c('i00k'), c('ERSST'), startDates, nleadtime = 124,
                   leadtimemin = 1, leadtimemax = 60, output = 'lonlat',
                   latmin = 30, latmax = 45, lonmin = 0, lonmax = 40)
leadtimes_dimension <- 4
initial_month <- 11
mean_start_month <- 12
mean_stop_month <- 2
sampleData$mod <- Season(sampleData$mod, leadtimes_dimension, initial_month,
                         mean_start_month, mean_stop_month)
sampleData$obs <- Season(sampleData$obs, leadtimes_dimension, initial_month,
                         mean_start_month, mean_stop_month)
clim <- Clim(sampleData$mod, sampleData$obs)
ano_exp <- Ano(sampleData$mod, clim$clim_exp)
ano_obs <- Ano(sampleData$obs, clim$clim_obs)
rrms <- RatioRMS(Mean1Dim(ano_exp[ , 1:3, , , , ], 1)[, 1, , ],
                 Mean1Dim(ano_exp[ , 4:5, , , , ], 1)[, 1, , ],
                 Mean1Dim(ano_obs, 2)[1, , 1, , ], 1)
PlotEquiMap(rrms[1, , ], sampleData$lon, sampleData$lat,
            toptitle = 'Ratio RMSE')
```

RatioSDRMS *Computes The Ratio Between the Ensemble Spread and the RMSE of the Ensemble Mean*

Description

Matrices var_exp & var_obs should have dimensions between c(nmod/nexp, nmemb/nparam, nsdates, nltime) and c(nmod/nexp, nmemb/nparam, nsdates, nltime, nlevel, nlat, nlon) The ratio between the standard deviation of the members around the ensemble mean in var_exp and the RMSE between var_exp and var_obs is output for each experiment and each observational dataset. The p-value is provided by a one-sided Fischer test.

Usage

```
RatioSDRMS(var_exp, var_obs)
```

Arguments

var_exp	Model data: c(nmod/nexp, nmemb/nparam, nsdates, nltime) up to c(nmod/nexp, nmemb/nparam, nsdates, nltime, nlevel, nlat, nlon)
var_obs	Observational data: c(nobs, nmemb, nsdates, nltime) up to c(nobs, nmemb, nsdates, nltime, nlevel, nlat, nlon)

Value

Matrix with dimensions c(nexp/nmod, nobs, 2, nltime) up to c(nexp/nmod, nobs, 2, nltime, nlevel, nlat, nlon) dimensions. The dimension 2 corresponds to the ratio (SD/RMSE) and the p.value of the one-sided Fisher test with Ho: SD/RMSE = 1.

Author(s)

History: 0.1 - 2011-12 (V. Guemas, <virginie.guemas@ic3.cat>) - Original code 1.0 - 2013-09 (N. Manubens, <nicolau-manubens@ic3.cat>) - Formatting to CRAN

Examples

```
startDates <- c('19851101', '19901101', '19951101', '20001101', '20051101')
sampleData <- Load('tos', c('i00k'), c('ERSST'), startDates, nleadtime = 124,
                   leadtimemin = 1, leadtimemax = 60, output = 'areave',
                   latmin = 30, latmax = 45, lonmin = 0, lonmax = 40)
rsdrms <- RatioSDRMS(sampleData$mod, sampleData$obs)
rsdrms2 <- array(dim = c(dim(rsdrms)[1:2], 4, dim(rsdrms)[4]))
rsdrms2[, , 2, ] <- rsdrms[, , 1, ]
rsdrms2[, , 4, ] <- rsdrms[, , 2, ]
PlotVsLTime(rsdrms2, toptitle = "Ratio ensemble spread / RMSE", ytitle = "",
            monini = 11, limits = c(-1, 1.3), listexp = c('CMIP5 IC3'),
            listobs = c('ERSST'), biglab = FALSE, siglev = TRUE,
            fileout = 'tos_rsdrms.eps')
```

`Regression` *Computes The Regression Of A Matrix On Another Along A Dimension*

Description

Computes the regression of the input matrice vary on the input matrice varx along the posREG dimension by least square fitting. Provides the slope of the regression, the associated confidence interval, and the intercept. Provides also the vary data filtered out from the regression onto varx. The confidence interval relies on a student-T distribution.

Usage

```
Regression(vary, varx, posREG = 2)
```

Arguments

`vary`	Matrix of any number of dimensions up to 10.
`varx`	Matrix of any number of dimensions up to 10. Same dimensions as vary.
`posREG`	Position along which to compute the regression.

Value

`$regression`	Matrix with same dimensions as varx and vary except along posREG dimension which is replaced by a length 4 dimension, corresponding to the lower limit of the 95% confidence interval, the slope, the upper limit of the 95% confidence interval and the intercept.
`$filtered`	Same dimensions as vary filtered out from the regression onto varx along the posREG dimension.

Author(s)

History: 0.1 - 2013-05 (V. Guemas, <virginie.guemas@ic3.cat>) - Original code 1.0 - 2013-09 (N. Manubens, <nicolau.manubens@ic3.cat>) - Formatting to CRAN

Examples

```
startDates <- c('19901101', '19951101', '20001101')
sampleData <- Load('tos', c('i00k'), c('ERSST'), startDates, nleadtime = 124,
                   leadtimemin = 1, leadtimemax = 4, output = 'lonlat',
                   latmin = 30, latmax = 45, lonmin = 0, lonmax = 40)
sampleData$mod <- Season(sampleData$mod, 4, 11, 12, 2)
sampleData$obs <- Season(sampleData$obs, 4, 11, 12, 2)
reg <- Regression(Mean1Dim(sampleData$mod, 2),
                  Mean1Dim(sampleData$obs, 2), 2)
PlotEquiMap(reg$regression[1, 2, 1, , ], sampleData$lon, sampleData$lat,
            toptitle='Regression of the prediction on the observations',
            sizetit = 0.5)
```

RMS *Computes Root Mean Square Error Skill Measure*

Description

Matrix var_exp & var_obs should have the same dimensions except along posloop dimension where the length can be different, with the number of experiments/ models for var_exp (nexp) and the number of obserational datasets for var_obs (nobs). RMS computes the Root Mean Square Error skill of each jexp in 1:nexp against each jobs in 1:nobs which gives nexp x nobs RMSE skill measures for each other grid point of the matrix (each latitude/longitude/level/leadtime). The RMSE are computed along the posRMS dimension which should correspond to the startdate dimension. If compROW is given, the RMSE are computed only if rows along the compROW dimension are complete between limits[1] and limits[2], that mean with no NA between limits[1] and limits[2]. This option can be activated if the user wishes to account only for the forecasts for which observations are available at all leadtimes. Default: limits[1] = 1 and limits[2] = length(compROW dimension). The confidence interval relies on a chi2 distribution.

Usage

```
RMS(var_exp, var_obs, posloop = 1, posRMS = 2, compROW = NULL, limits = NULL)
```

Arguments

var_exp	Matrix of experimental data.
var_obs	Matrix of observational data, same dimensions as var_exp except along posloop dimension, where the length can be nobs instead of nexp.
posloop	Dimension nobs and nexp.
posRMS	Dimension along which RMSE are to be computed (the dimension of the start dates).
compROW	Data taken into account only if (compROW)th row is complete. Default = NULL.
limits	Complete between limits[1] & limits[2]. Default = NULL.

Value

Matrix with dimensions: c(length(posloop) in var_exp, length(posloop) in var_obs, 3, all other dimensions of var_exp & var_obs except posRMS). The dimension 3 corresponds to the lower limit of the 95% confidence interval, the RMSE and the upper limit of the 95% confidence interval.

Author(s)

History: 0.1 - 2011-05 (V. Guemas, <vguemas@ic3.cat>) - Original code 1.0 - 2013-09 (N. Manubens, <nicolau.manubens@ic3.cat>) - Formatting to R CRAN

Examples

```
startDates <- c('19851101', '19901101', '19951101', '20001101', '20051101')
sampleData <- Load('tos', c('i00k'), c('ERSST'), startDates, nleadtime = 124,
                   leadtimemin = 1, leadtimemax = 60, output = 'areave',
                   latmin = 30, latmax = 45, lonmin = 0, lonmax = 40)
clim <- Clim(sampleData$mod, sampleData$obs)
ano_exp <- Ano(sampleData$mod, clim$clim_exp)
ano_obs <- Ano(sampleData$obs, clim$clim_obs)
runmean_months <- 12
dim_to_smooth <- 4  # Smooth along lead-times
smooth_ano_exp <- Smoothing(ano_exp, runmean_months, dim_to_smooth)
smooth_ano_obs <- Smoothing(ano_obs, runmean_months, dim_to_smooth)
dim_to_mean <- 2  # Mean along members
required_complete_row <- 3  # Discard start-dates for which some leadtimes are missing
leadtimes_per_startdate <- 60
rms <- RMS(Mean1Dim(smooth_ano_exp, dim_to_mean),
           Mean1Dim(smooth_ano_obs, dim_to_mean),
           compROW = required_complete_row,
           limits = c(ceiling((runmean_months + 1) / 2),
                      leadtimes_per_startdate - floor(runmean_months / 2)))
PlotVsLTime(rms, toptitle = "Root Mean Square Error", ytitle = "K",
            monini = 11, limits = NULL, listexp = c('CMIP5 IC3'),
            listobs = c('ERSST'), biglab = FALSE, hlines = c(0),
            fileout = 'tos_rms.eps')
```

RMSSS *Computes Root Mean Square Skill Score*

Description

Matrices var_exp & var_obs should have the same dimensions except along posloop where the length can be different, with the number of experiments/ models for var_exp (nexp) and the number of obserational datasets for var_obs (nobs). RMSSS computes the Root Mean Square Skill Score of each jexp in 1:nexp against each jobs in 1:nobs which gives nexp x nobs RMSSS for each other grid point of the matrix (each latitude/longitude/level/leadtime). The RMSSS are computed along the posRMS dimension which should correspond to the startdate dimension. The p-value is provided by a one-sided Fisher test.

Usage

```
RMSSS(var_exp, var_obs, posloop = 1, posRMS = 2)
```

Arguments

var_exp	Matrix of experimental data.
var_obs	Matrix of observational data, same dimensions as var_exp except along posloop dimension, where the length can be nobs instead of nexp.
posloop	Dimension nobs and nexp.

posRMS Dimension along which the RMSE are to be computed (the dimension of the start dates).

Value

Matrix with dimensions : c(length(posloop) in var_exp, length(posloop) in var_obs, 2, all other dimensions of var_exp & var_obs except posRMS). The dimension 2 corresponds to the RMSSS and the p.value of the one-sided Fisher test with Ho: RMSSS = 0.

Author(s)

History: 0.1 - 2012-04 (V. Guemas, <vguemas@ic3.cat>) - Original code 1.0 - 2013-09 (N. Manubens, <nicolau.manubens@ic3.cat>) - Formatting to R CRAN

Examples

```
startDates <- c('19851101', '19901101', '19951101', '20001101', '20051101')
sampleData <- Load('tos', c('i00k'), c('ERSST'), startDates, nleadtime = 124,
                   leadtimemin = 1, leadtimemax = 60, output = 'areave',
                   latmin = 30, latmax = 45, lonmin = 0, lonmax = 40)
clim <- Clim(sampleData$mod, sampleData$obs)
ano_exp <- Ano(sampleData$mod, clim$clim_exp)
ano_obs <- Ano(sampleData$obs, clim$clim_obs)
rmsss <- RMSSS(Mean1Dim(ano_exp, 2), Mean1Dim(ano_obs, 2))
rmsss2 <- array(dim = c(dim(rmsss)[1:2], 4, dim(rmsss)[4]))
rmsss2[, , 2, ] <- rmsss[, , 1, ]
rmsss2[, , 4, ] <- rmsss[, , 2, ]
PlotVsLTime(rmsss, toptitle = "Root Mean Square Skill Score", ytitle = "",
            monini = 11, limits = c(-1, 1.3), listexp = c('CMIP5 IC3'),
            listobs = c('ERSST'), biglab = FALSE, hlines = c(-1, 0, 1),
            fileout = 'tos_rmsss.eps')
```

---

sampleDepthData *Sample of Experimental Data for Forecast Verification In Function Of Latitudes And Depths*

Description

This data set provides data in function of latitudes and depths for the variable 'tos', i.e. sea surface temperature, from the decadal climate prediction experiment run at IC3 in the context of the CMIP5 project. Its name within IC3 local database is 'i00k'.

Usage

```
data(sampleDepthData)
```

Format

The data set provides with a variable named 'sampleDepthData'.

sampleDepthData$exp is an array that contains the experimental data and the dimension meanings and values are: c(# of experimental datasets, # of members, # of starting dates, # of lead-times, # of depths, # of latitudes) c(1, 5, 3, 60, 7, 21)

sampleDepthData$obs should be an array that contained the observational data but in this sample is not defined (NULL).

sampleDepthData$depths is an array with the 7 longitudes covered by the data.

sampleDepthData$lat is an array with the 21 latitudes covered by the data.

`sampleMap` *Sample of Observational and Experimental Data for Forecast Verification In Function Of Longitudes And Latitudes*

Description

This data set provides data in function of longitudes and latitudes for the variable 'tos', i.e. sea surface temperature, over the mediterranean zone from the decadal climate prediction experiment run at IC3 in the context of the CMIP5 project. Its name within IC3 local database is 'i00k'. The observational dataset used for verification is the 'ERSST' observational dataset, in this example.

The data is provided through a variable named 'sampleMap' and is structured as expected from the 'Load()' function in the 's2dverification' package if was called as follows:

sampleMap <- Load('tos', c('i00k'), c('ERSST'), c('19851101', '19901101', '19951101', '20001101', '20051101'), nleadtime = 124, leadtimemin = 1, leadtimemax = 60, sampleperiod = 1, output = 'lonlat', latmin = 30, latmax = 45, lonmin = 0, lonmax = 40)

Check the documentation on 'Load()' in the package 's2dverification' for more information.

Usage

```
data(sampleMap)
```

Format

The data set provides with a variable named 'sampleMap'.

sampleMap$mod is an array that contains the experimental data and the dimension meanings and values are: c(# of experimental datasets, # of members, # of starting dates, # of lead-times, # of latitudes, # of longitudes) c(1, 5, 5, 60, 13, 36)

sampleMap$obs is an array that contains the observational data and the dimension meanings and values are: c(# of observational datasets, # of members, # of starting dates, # of lead-times, # of latitudes, # of longitudes) c(1, 1, 5, 60, 13, 36)

sampleMap$lat is an array with the 13 latitudes covered by the data.

sampleMap$lon is an array with the 36 longitudes covered by the data.

sampleTimeSeries *Sample of Observational and Experimental Data for Forecast Verification As Area Averages*

Description

This data set provides area averaged data for the variable 'tos', i.e. sea surface temperature, over the mediterranean zone from the decadal climate prediction experiment run at IC3 in the context of the CMIP5 project. Its name within IC3 local database is 'i00k'. The observational dataset used for verification is the 'ERSST' observational dataset, in this example.

The data is provided through a variable named 'sampleTimeSeries' and is structured as expected from the 'Load()' function in the 's2dverification' package if was called as follows:

sampleTimeSeries <- Load('tos', c('i00k'), c('ERSST'), c('19851101', '19901101', '19951101', '20001101', '20051101'), nleadtime = 124, leadtimemin = 1, leadtimemax = 60, sampleperiod = 1, output = 'areave', latmin = 30, latmax = 45, lonmin = 0, lonmax = 40)

Check the documentation on 'Load()' in the package 's2dverification' for more information.

Usage

```
data(sampleTimeSeries)
```

Format

The data set provides with a variable named 'sampleTimeSeries'.

sampleTimeSeries$mod is an array that contains the experimental data and the dimension meanings and values are: c(# of experimental datasets, # of members, # of starting dates, # of lead-times) c(1, 5, 5, 60)

sampleTimeSeries$obs is an array that contains the observational data and the dimension meanings and values are: c(# of observational datasets, # of members, # of starting dates, # of lead-times) c(1, 1, 5, 60)

sampleTimeSeries$lat is an array with the 13 latitudes covered by the data that was area averaged to calculate the time series.

sampleTimeSeries$lon is an array with the 36 longitudes covered by the data that was area averaged to calculate the time series.

Season *Computes Seasonal Means*

Description

Computes seasonal means on timeseries organized in a matrix of any number of dimensions up to 10 dimensions where the time dimension is one of those 10 dimensions.

Usage

```
Season(var, posdim = 4, monini, moninf, monsup)
```

Arguments

var	Matrix containing the timeseries along one of its dimensions.
posdim	Dimension along which to compute seasonal means = Time dimension
monini	First month of the time-series: 1 to 12.
moninf	Month when to start the seasonal means: 1 to 12.
monsup	Month when to stop the seasonal means: 1 to 12.

Value

Matrix with the same dimensions as var except along the posdim dimension which length corresponds to the number of seasons. Partial seasons are not accounted for.

Author(s)

History: 0.1 - 2011-03 (V. Guemas, <virginie.guemas@ic3.cat>) - Original code 1.0 - 2013-09 (N. Manubens, <nicolau.manubens@ic3.cat>) - Formatting to CRAN

Examples

```
startDates <- c('19901101', '19951101', '20001101')
sampleData <- Load('tos', c('i00k'), c('ERSST'), startDates, nleadtime = 124,
                   leadtimemin = 1, leadtimemax = 60, output = 'areave',
                   latmin = 30, latmax = 45, lonmin = 0, lonmax = 40)
leadtimes_dimension <- 4
initial_month <- 11
mean_start_month <- 12
mean_stop_month <- 2
season_means_mod <- Season(sampleData$mod, leadtimes_dimension, initial_month,
                           mean_start_month, mean_stop_month)
season_means_obs <- Season(sampleData$obs, leadtimes_dimension, initial_month,
                           mean_start_month, mean_stop_month)
PlotAno(season_means_mod, season_means_obs, startDates,
        toptitle = paste('winter (DJF) temperatures'), ytitle = c('K'),
        legends = 'ERSST', biglab = FALSE, fileout = 'tos_season_means.eps')
```

SelIndices *Slices A Matrix Along A Dimension*

Description

This function allows to select a subensemble from a matrix of any dimensions, providing the dimension along which the user aims at cutting the input matrix and between which indices.

Usage

```
SelIndices(var, posdim, limits)
```

Arguments

var	A matrix of any dimensions.
posdim	The dimension along which a submatrix should be selected.
limits	The lower and upper indice of the selection along the posdim dimension.

Value

The sliced matrix.

Author(s)

History: 0.1 - 2011-04 (V. Guemas, <virginie.guemas@ic3.cat>) - Original code 1.0 - 2013-09 (N. Manubens, <nicolau.manubens@ic3.cat>) - Formatting to CRAN

Examples

```
a <- array(rnorm(24), dim = c(2, 3, 4, 1))
print(a)
print(a[, , 2:3, ])
print(dim(a[, , 2:3, ]))
print(SelIndices(a, 3, c(2, 3)))
print(dim(SelIndices(a, 3, c(2, 3))))
```

Smoothing *Smoothes A Matrix Along A Dimension*

Description

Smoothes a matrix of any number of dimensions up to 10 dimensions along one of its dimensions

Usage

```
Smoothing(var, runmeanlen = 12, numdimt = 4)
```

Arguments

var	Matrix to be smoothed along one of its dimension (typically the forecast time dimension).
runmeanlen	Running mean length in number of sampling units (typically months).
numdimt	Dimension to smooth.

Value

Matrix with same the dimensions as var but smoothed along the numdimt dimension.

Author(s)

History: 0.1 - 2011-03 (V. Guemas, <virginie.guemas@ic3.cat>) - Original code 1.0 - 2013-09 (N. Manubens, <nicolau.manubens@ic3.cat>) - Formatting to R CRAN

Examples

```
startDates <- c('19901101', '19951101', '20001101')
sampleData <- Load('tos', c('i00k'), c('ERSST'), startDates, nleadtime = 124,
                   leadtimemin = 1, leadtimemax = 60, output = 'areave',
                   latmin = 30, latmax = 45, lonmin = 0, lonmax = 40)
clim <- Clim(sampleData$mod, sampleData$obs)
ano_exp <- Ano(sampleData$mod, clim$clim_exp)
ano_obs <- Ano(sampleData$obs, clim$clim_obs)
runmean_months <- 12
dim_to_smooth <- 4  # Smooth along lead-times
smooth_ano_exp <- Smoothing(ano_exp, runmean_months, dim_to_smooth)
smooth_ano_obs <- Smoothing(ano_obs, runmean_months, dim_to_smooth)
PlotAno(smooth_ano_exp, smooth_ano_obs, startDates,
        toptitle = "Smoothed Mediterranean mean SST", ytitle = "K",
        fileout = "tos_smoothed_ano.eps")
```

Spectrum *Estimates Frequency Spectrum*

Description

This function estimates the frequency spectrum of the xdata array together with its 95% and 99% significance level. The output is provided as a matrix with dimensions c(number of frequencies, 4). The column contains the frequency values, the power, the 95% significance level and the 99% one. The spectrum estimation relies on a R built-in function and the significance levels are estimated by a Monte-Carlo method.

Usage

```
Spectrum(xdata)
```

Arguments

xdata	Array of which the frequency spectrum is required

Value

Frequency spectrum with dimensions c(number of frequencies, 4). The column contains the frequency values, the power, the 95% significance level and the 99% one.

Author(s)

History:
0.1 - 2012-02 (V. Guemas, <virginie.guemas@ic3.cat>) - Original code 1.0 - 2013-09 (N. Manubens, <nicolau.manubens@ic3.cat>) - Formatting to CRAN

Examples

```
startDates <- c('19901101', '19951101', '20001101')
sampleData <- Load('tos', c('i00k'), c('ERSST'), startDates, nleadtime = 124,
                   leadtimemin = 1, leadtimemax = 60, output = 'areave',
                   latmin = 30, latmax = 45, lonmin = 0, lonmax = 40)

ensmod <- Mean1Dim(sampleData$mod, 2)
for (jstartdate in 1:3) {
  spectrum <- Spectrum(ensmod[1, jstartdate, ])
  for (jlen in 1:dim(spectrum)[1]) {
    if (spectrum[jlen, 2] > spectrum[jlen, 4]) {
      ensmod[1, jstartdate, ] <- Filter(ensmod[1, jstartdate, ],
                                        spectrum[jlen, 1])
    }
  }
}
PlotAno(InsertDim(ensmod, 2, 1), sdates = startDates, fileout =
        'filtered_ensemble_mean.eps')
```

Spread — *Computes InterQuartile Range, Maximum-Minimum, Standard Deviation and Median Absolute Deviation of the Ensemble Members*

Description

Computes the InterQuartile Range, the Maximum minus Mininum, the Standard Deviation and the Median Absolute Deviation along the list of dimensions provided by the posdim argument (typically along the ensemble member and start date dimension). The confidence interval is computed by bootstrapping.

Usage

```
Spread(var, posdim = 2, narm = TRUE)
```

Arguments

var	Matrix of any number of dimensions up to 10.
posdim	List of dimensions along which to compute IQR/MaxMin/SD/MAD.
narm	TRUE/FALSE if NA removed/kept for computation. Default = TRUE.

Details

Example: ——— To compute IQR, Max-Min, SD & MAD accross the members and start dates of var output from `Load()` or `Ano()` or `Ano_CrossValid()`, call: spread(var, posdim = c(2, 3), narm = TRUE)

Value

Matrix with the same dimensions as var except along the first posdim dimension which is replaced by a length 3 dimension, corresponding to the lower limit of the 95% confidence interval, the spread and the upper limit of the 95% confidence interval for each experiment/leadtime/latitude/longitude.

`$iqr`	InterQuartile Range.
`$maxmin`	Maximum - Minimum.
`$sd`	Standard Deviation.
`$mad`	Median Absolute Deviation.

Author(s)

History: 0.1 - 2011-03 (V. Guemas, <virginie.guemas@ic3.cat>) - Original code 1.0 - 2013-09 (N. Manubens, <nicolau.manubens@ic3.cat>) - Formatting to CRAN

Examples

```
startDates <- c('19901101', '19951101', '20001101')
sampleData <- Load('tos', c('i00k'), c('ERSST'), startDates, nleadtime = 124,
                   leadtimemin = 1, leadtimemax = 60, output = 'areave',
                   latmin = 30, latmax = 45, lonmin = 0, lonmax = 40)
clim <- Clim(sampleData$mod, sampleData$obs)
ano_exp <- Ano(sampleData$mod, clim$clim_exp)
runmean_months <- 12
dim_to_smooth <- 4  # Smooth along lead-times
smooth_ano_exp <- Smoothing(ano_exp, runmean_months, dim_to_smooth)
smooth_ano_exp_m_sub <- smooth_ano_exp - InsertDim(Mean1Dim(smooth_ano_exp, 2,
                        narm = TRUE), 2, dim(smooth_ano_exp)[2])
spread <- Spread(smooth_ano_exp_m_sub, c(2, 3))
PlotVsLTime(spread$iqr,
            toptitle = "Inter-Quartile Range between ensemble members",
            ytitle = "K", monini = 11, limits = NULL,
            listexp = c('CMIP5 IC3'), listobs = c('ERSST'), biglab = FALSE,
            hlines = c(0), fileout = 'tos_iqr.eps')
PlotVsLTime(spread$maxmin, toptitle = "Maximum minus minimum of the members",
            ytitle = "K", monini = 11, limits = NULL,
            listexp = c('CMIP5 IC3'), listobs = c('ERSST'), biglab = FALSE,
            hlines = c(0), fileout = 'tos_maxmin.eps')
PlotVsLTime(spread$sd, toptitle = "Standard deviation of the members",
            ytitle = "K", monini = 11, limits = NULL,
            listexp = c('CMIP5 IC3'), listobs = c('ERSST'), biglab = FALSE,
            hlines = c(0), fileout = 'tos_sd.eps')
PlotVsLTime(spread$mad, toptitle = "Median Absolute Deviation of the members",
            ytitle = "K", monini = 11, limits = NULL,
```

```
listexp = c('CMIP5 IC3'), listobs = c('ERSST'), biglab = FALSE,
hlines = c(0), fileout = 'tos_mad.eps')
```

Trend *Computes Trends*

Description

Computes the trend along the posTR dimension of the matrix var by least square fitting, and the associated an error interval. Provide also the detrended data. The confidence interval relies on a student-T distribution.

Usage

```
Trend(var, posTR = 2, interval = 1)
```

Arguments

var	Matrix of any number of dimensions up to 10.
posTR	Position along which to compute the trend.
interval	Number of months/years between 2 points along posTR dimension. Default = 1. The trend would be provided in number of units per month or year.

Value

$trend	Same dimensions as var except along the posTR dimension which is replaced by a length 3 dimension, corresponding to the lower limit of the 95% confidence interval, trends and the upper limit of the 95% confidence interval for each point of the matrix along all the other dimensions.
$detrended	Same dimensions as var with linearly detrended var along the posTR dimension.

Author(s)

History: 0.1 - 2011-05 (V. Guemas, <virginie.guemas@ic3.cat>) - Original code 1.0 - 2013-09 (N. Manubens, <nicolau.manubens@ic3.cat>) - Formatting to CRAN

Examples

```
startDates <- c('19851101', '19901101', '19951101', '20001101', '20051101')
sampleData <- Load('tos', c('i00k'), c('ERSST'), startDates, nleadtime = 124,
                   leadtimemin = 1, leadtimemax = 60, output = 'areave',
                   latmin = 30, latmax = 45, lonmin = 0, lonmax = 40)
months_between_startdates <- 60
trend <- Trend(sampleData$obs, 3, months_between_startdates)
PlotVsLTime(trend$trend, toptitle = "trend", ytitle = "K / (5 year)",
            monini = 11, limits = c(-1,1), listexp = c('CMIP5 IC3'),
            listobs = c('ERSST'), biglab = FALSE, hlines = 0,
            fileout = 'tos_obs_trend.eps')
```

```
PlotAno(trend$detrended, NULL, startDates,
        toptitle = 'detrended anomalies (along the startdates)', ytitle = 'K',
        legends = 'ERSST', biglab = FALSE, fileout = 'tos_detrended_obs.eps')
```

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