# Package 'esd4all'

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**Title** esd4all

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**Depends** clim.pact, cyclones, akima, ncdf, sgeostat, fields, spam, R (>= 2.2.0)

**Description** functions for post-processing and gridding
empirical-statistical downscaled climate scenarios.

**License** GPL (>= 2)

**URL** http://www.r-project.org http://cran.r-project.org
http://noserc.met.no/grtools/esd4all.html

**ZipData** no

**Repository** CRAN

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constructESD *Empirical-Statistical Downsacling For All.*

## Description

R-package for processing results from empirical-statistical downscaling (ESD).

The code has been taylored to post-process data derived through the clim.pact (http://cran.r-project.org/web/packages/clim.pact/index.html) and met.no.REB packages (the latter is not posted on CRAN). The package uses the same ESD data as displayed in Google.Earth (http://eklima.met.no/metno/esd/esd.google.earthTemp.kmz).

The R-package assumes that the ESD involves a fairly large multi-model ensemble, typically involving 40-50 different simulations. Each simulation produces one time series for each location, typically over the period 1900-2100. The time series are the seasonal mean temperature (e.g. winter, spring, summer and autumn).

More details about the nature of the data can be found in met.no Notes 03/2009 (http://met.no/Forskning/Publikasjoner/?module=Files;action=File.getFile;ID=2319) and 15/2009 (http://met.no/Forskning/Publikasjoner/?module=Files;action=File.getFile;ID=2631).

data(esdsummary) retrieves ESD data generated by esdsummary() in the met.no-package. These data consist of coefficients of the best-fit polynomials to the 5-, and 95- percentiles as well as the mean of the set of time series (1900-2100) of downscaled multi-model ensemble (CMIP3). data(grm.coef) gieves the coefficients $c_i$ from the geographical regression model (GRM) for the 5th-order polinomial fits to the trends. The 3D matrix holds the Estimate Std. Error t value Pr(>|t|) from the summary of the linear model - see R-script in exampls for more details.

constructESD constructs time series of the 5-, and 95- percentiles as well as the mean (1900-2100) of downscaled GCM (e.g from the CMIP3 data set). These reconstructions are constructed from coefficients describing the best-fit polynomials:

$$y(t) = c_0 + c_1 t + c_2 t^2 + c_3 t^3 + c_4 t^4 + c_5 t^5,$$

where t is the time.

pdfESD produces a pdf (Gaussian) of the seasonal temperature downscaled from the multi-model ensemble at a given location. Note, this pdf is not necessarily the same as the true pdf for the real temperature.

mapESDlocs produces a map showing the locations for which there are multi-model ESD results in the esd4all package.

queryLocations returns the name of the locations of the ESD locations.

get5mintopo retrieves a 5-minute resolution data file of the topography over Internet and saves the data locally in a suitable format for the use in the esd4all package.

fortegn a utility used internally - returns -1 or +1.

geo.inf is a function that uses a geographical regression model (GRM) to grid the results, and then adds the residuals through interpolation (kriging or 2D splines). This is an internal function.

gridESD is the main function that grids the coefficients used to describe the best-fit polynomials providing smooth approximations of the time series for 5- and 95-percentiles and the ensemble mean. The function uses geo.inf.

gridded.c is produced by gridESD. In the CRAN-version (1.0-3), a reduced version of this gridded data set is used due to size limitations, but a fuller version is available from http://noserc.met.no/grtools/esd4all.html.

mapESDquants constructs map of derived quantiles.

mapESDprobs construct map of the fraction of GCMs with value below/higher then threshold.

esdsummary contains coefficients describing the polynomials of the 5th and 95th percentiles as well as ensemble mean of ESD analysis for a large number of locations around the world, seen in http://eklima.met.no/metno/esd/esd.google.earthTemp.kmz. The list is created using esd2google in met.no.REB, available at http://noserc.met.no/grtools/reb.html.

gridded.c contains results from gridding the coefficients (stored in esdsummary) over northern Europe.

ESDinGoogle views the ESD results in GoogleEarth

ESDdetails provides details about the ESD results and explains how the figures should be interpreted. ESDreference provides a link to a proper reference for the ESD - Benestad, R.E. (2005) Climate change scenarios for northern Europe from multi-model IPCC AR4 climate simulations GRL, 32 doi:10.1029/2005GL023401 No. 17, L17704.

rda2cdf reads the gridded data in an rda-file and saves these as a netCDF file.

figures Makes figures showing maps of the 95-percentile for summer (JJA) mean temperature and probability of below freezing mean winter (DJF) temperatures.

## Usage

```
constructESD(location,plot=TRUE,
             get.data="data(esdsummary,envir=environment())",
             gridded="data(gridded.c,envir=environment())",
             mfrow=c(2,2))
pdfESD(location,plot=TRUE,get.data="data(esdsummary,envir=environment())",
       gridded="data(gridded.c,envir=environment())",year=2050,
       ref=NULL,mfrow=c(2,2),what="pdf")
mapESDlocs(get.data="data(esdsummary,envir=environment())")
queryLocations(nr=NULL,get.data="data(esdsummary,envir=environment())")
get5mintopo(browser = "firefox", url ="http://marine.rutgers.edu/po/tools/gridpak/etopo5.nc")
fortegn(a,b)
geo.inf(g.obj,do.km=TRUE,x.scale=1000,
                    predict=TRUE,krig=TRUE,krig.Nx=NULL,krig.Ny=NULL,
                    x.rng=c(-10,32),y.rng=c(44,70),plot=FALSE,
                    krig.package="fields",
                    use.previous.estimates=TRUE,linear.intp=TRUE)
KrigFields(resid,lon.grd,lat.grd)
KrigSgeostat(resid,lon.grd,lat.grd,do.km)
gridESD(get.data = "data(esdsummary,envir=environment())",
                 plot = FALSE, x.rng = c(-30, 50), y.rng = c(40, 72),
                 x.scale = 1000, do.km = TRUE, krig = TRUE, new = TRUE,
                 krig.Nx = 30, krig.Ny = 30, use.previous.estimates =
                 TRUE, linear.intp = TRUE, krig.package = "fields",
                 fname = "gridded.c.rda")
```

```
mapESDquants(what="q95",season=3,year=2050,ref=NULL,
                          get.data1="data(gridded.c,envir=environment())",
                          get.data2="data(esdsummary,envir=environment())",
                          plot=TRUE)
mapESDprobs(thresh=0,season=1,year=2050,ref=NULL,
             get.data="data(gridded.c,envir=environment())",plot=TRUE)
data(esdsummary)
data(gridded.c)
data(gridded.ealat.c)
data(gridded.africa.c)
data(grm.coef)
data(grm.coef.africa)
data(grm.coef.ealat)
ESDinGoogle(browser = "firefox", url="http://eklima.met.no/metno/esd/esd.google.earthTemp.kmz")
ESDdetails(browser = "firefox", url="http://met.no/Forskning/Publikasjoner/")
rda2cdf(get.data="data(gridded.c,envir=environment())")
figures(get.data="data(gridded.c,envir=environment())",
                    season.1=3,season.2=1,year=2050,thresh=0,what="q95")
reduce.rda.size(get.data="data(gridded.c,envir=environment())",reduce.res=TRUE,
                           Nx=100,Ny=100)
```

## Arguments

| | |
|---|---|
| location | A string containing the name of site or a list with longitude and latitude (in that order) for reconstruction from gridded data. |
| plot | flag: TRUE or FALSE |
| get.data | Method for getting the data |
| gridded | Method for getting gridded data |
| year | Scenario year |
| nr | Station number |
| browser | Preferred browser |
| url | URLs of on-line reports or KML-files. |
| g.obj | List object holding ESD data for a number of sites. Used for gridding. |
| do.km | FLAG: TRUE use km rather than lon-lat coordinates. |
| x.scale | Spatila scale: 1000 implies units of km. |
| predict | FLAG: TRUE or FALSE |
| krig | FLAG: FALSE implies a bi-linear interpolation rather than kriging. Two kriging options are avialble, specified by the argument krig.package. Past tests have revealed some problems with the kriging options, however. |
| krig.package | Specify package for kriging analysis: "fields" or "sgeostat" |
| x.rng | x range for selection of sites in gridding |
| y.rng | y range for selection of sites in gridding |
| use.previous.estimates | FLAG: TRUE for avoiding repeating lengthy calculations |

| | |
|---|---|
| linear.intp | used for the linear argument in interp |
| ref | Reference year |
| fname | File name for gridded.c. |
| what | Specification of type |
| a | A value: a < b returns -1 in fortegn |
| b | A value: a < b returns -1 in fortegn |
| reduce.res | TRUE: use interp to reduce the spatial resolution, otherwise save only the land points. |
| mfrow | see par. |
| krig.Nx | To specify coarser grid for residual gridding |
| krig.Ny | To specify coarser grid for residual gridding |
| new | FALSE: try to continue on a previous job |
| season | Season |
| season.1 | Season |
| season.2 | Season |
| get.data1 | Method for getting the data |
| get.data2 | Method for getting the data |
| thresh | Threshold value for estimating probabilities |
| resid | List object holding the residuals from GRM |
| lon.grd | longitude coordinates of grid |
| lat.grd | Latitude coordinates of grid |
| Nx | number of points in x-dimensions |
| Ny | number of points in y-dimensions |

## Author(s)

R.E. Benestad

## Examples

```
## Not run:
ESDinGoogle()
data(esdsummary)
mapESDlocs()
queryLocations() -> a
constructESD(a[1]) -> b
pdfESD(a[1])
mapESDquants() -> map.q95
mapESDprobs() -> map.pr.T.lt.0

# How to generate the gridded data
dsjobs(ele=101,scen="sresa1b")
bestESD()                     # to weed out multiple locations
allESD(path="ESD/")           # to weed out multiple locations
```

```
esd2google() -> esdsummary     # summarise all the ESD results
catESDsummary(esdsummary) -> esdsummary.tidy
gridded.c <- gridESD(get.data=esdsummary.tidy, x.rng=c(-12,45),y.rng=c(35,72),new=TRUE)
gridded.africa.c <- gridESD(get.data=esdsummary.tidy,x.rng=c(-20,50),y.rng=c(-40,37),new=TRUE)
gridded.ealat.c <-
gridESD(get.data=esdsummary.tidy,x.rng=c(15,190),y.rng=c(60,80),new=TRUE)

#How to create the figures in publications:
figures(get.data="data(gridded.ealat.c,envir=environment())",year=2100,
        what="mean",thresh=-10,season.1=1)
file.rename("Gridded_ESD-q95map.nc","EALAT_ESD-meanmap-2100.nc")
file.rename("Gridded_ESD-p0map.nc","EALAT_ESD-p-10map-2100.nc")
figures(get.data="data(gridded.ealat.c,envir=environment())",
        what="mean",thresh=-10,season.1=1)
file.rename("Gridded_ESD-q95map.nc","EALAT_ESD-meanmap-2050.nc")
file.rename("Gridded_ESD-p0map.nc","EALAT_ESD-p-10map-2050.nc")
figures(get.data="data(gridded.ealat.c,envir=environment())",year=2000,
        what="mean",thresh=-10,season.1=1)
file.rename("Gridded_ESD-q95map.nc","EALAT_ESD-meanmap-2000.nc")
file.rename("Gridded_ESD-p0map.nc","EALAT_ESD-p-10map-2000.nc")

constructESD(list(90,70),gridded="data(gridded.ealat.c,envir=environment())")
pdfESD(list(90,70),gridded="data(gridded.ealat.c,envir=environment())")

figures(get.data="data(gridded.africa.c,envir=environment())",
        season.1=3,season.2=3,thresh=35)
file.rename("Gridded_ESD-q95map.nc","Africa_ESD-q95map-2500.nc")
file.rename("Gridded_ESD-p0map.nc","Africa_ESD-p35map-2500.nc")
figures(get.data="data(gridded.africa.c,envir=environment())",
        season.1=3,season.2=3,thresh=35,year=2010)
file.rename("Gridded_ESD-q95map.nc","Africa_ESD-q95map-2000.nc")
file.rename("Gridded_ESD-p0map.nc","Africa_ESD-p34map-2000.nc")
figures(get.data="data(gridded.africa.c,envir=environment())",
        season.1=3,season.2=3,thresh=35,year=2100)
file.rename("Gridded_ESD-q95map.nc","Africa_ESD-q95map-2100.nc")
file.rename("Gridded_ESD-p0map.nc","Africa_ESD-p34map-2100.nc")

figures(year=2100)
file.rename("Gridded_ESD-q95map.nc","Europe_ESD-q95map-2100.nc")
file.rename("Gridded_ESD-p0map.nc","Europe_ESD-p0map-2100.nc")
figures(year=2000)
file.rename("Gridded_ESD-q95map.nc","Europe_ESD-q95map-2000.nc")
file.rename("Gridded_ESD-p0map.nc","Europe_ESD-p0map-2000.nc")
figures()
file.rename("Gridded_ESD-q95map.nc","Europe_ESD-q95map-2050.nc")
file.rename("Gridded_ESD-p0map.nc","Europe_ESD-p0map-2050.nc")


# Maps for EALAT book:

figures(get.data="data(gridded.ealat.c,envir=environment())",year=1975,
        what="mean",thresh=-10)
file.rename("Gridded_ESD-q95map.nc","EALAT_ESD-meanmap-1975.nc")
```

```
file.rename("Gridded_ESD-p0map.nc","EALAT_ESD-p-10map-1975.nc")
figures(get.data="data(gridded.ealat.c,envir=environment())",year=2085,
        what="mean",thresh=-10)
file.rename("Gridded_ESD-q95map.nc","EALAT_ESD-meanmap-2085.nc")
file.rename("Gridded_ESD-p0map.nc","EALAT_ESD-p-10map-2085.nc")

# Generate tables for adjusted R-squared statistics for the geographical
# regression model
library(esd4all)
data(gridded.c)
R2 <- attributes(gridded.c)$GRM.R2
dim(R2) <- c(6,12); R2 <- t(R2)
colnames(R2) <- paste("c",0:5,sep="_")
rownames(R2) <- paste(rep(c("mean","q05","q95"),4),
                      c(rep("DJF",3),rep("MAM",3),rep("JJA",3),rep("SON",3)))
print(R2)


# The papers used ferret (ferret.wrc.noaa.gov/) to make the final plots
# based on the netCDF files created...



# The following lines were used to reduce the matrix of coefficients for
# the CRAN-version of the esd4all-package:


reduce.rda.size(Nx=50,Ny=50) -> gridded.c
save(file="gridded.c.reduced.rda",gridded.c)
reduce.rda.size(get.data="data(gridded.ealat.c,envir=environment())",Nx=50,Ny=50)->
   gridded.ealat.c
save(file="gridded.ealat.c.reduced.rda",gridded.ealat.c)
reduce.rda.size(get.data="data(gridded.africa.c,envir=environment())",Nx=50,Ny=50)->
   gridded.africa.c
save(file="gridded.africa.c.reduced.rda",gridded.africa.c)

## End(Not run)
```

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