NAME

caltra - calculate air parcel trajectories

SYNOPSIS

caltra *startdate enddate startfile filename* [*optional arguments*]

DESCRIPTION

Calculate trajectories for the air parcels starting at the positions specified in *startfile.* The trajectories cover the time period from *startdate* to *enddate* and the trajectories are saved in the output file *filename.* Forward and backward trajectories can be calculated according to the order of the start and end date.

PARAMETERS

startdate
: start time of the air parcels in the format YYYYMMDD_HH(MM) (e.g. 20100101_00 or 20100101_0030 for 1 January 2010, 00 UTC and 00:30 UTC). Note that the minutes (MM) are optional.

enddate
: end time of the air parcels (same format as the *startdate*). If the end time is after the start time, forward trajectories are calculated; otherwise, i.e. for end date before the start date, backward trajectories result.

startfile
: file with the starting positions of the trajectories (possibly created with **create_strartf**). Different formats for the "startfile" are supported (see **reformat** for details). If no format specifier (appendix .[1234]) is given, a simple (longitude,latitude,pressure) list is expected.

filename
: output trajectory file with trajectories. Different formats are supported (see **reformat** for details).

OPTIONAL

-j
: Jumping flag: if a trajectory crosses the lower boundary, it is raised a little and hence is allowed to move on. Otherwise, i.e. no "-j" flag set, the trajectory would stick at the same position. The default is that "-j" is **not** set.

-i hours
: time increments (in hours) for input P and S files. If not explicitely specified, this is determined from the P and S files in the current directory.

-t min
: time step (in minutes) for trajcetory calculation. Per default, the time step is 1/12 the time increment of the input files. For instance, 6-h input P and S files result in a time step of 5 min. The time step must be consisten with the output interval (see next optional parameter "-o").

-o hours
: Output interval (in minutes) of the air parcel positions. Per default it is the same as the time increment between the input P and S files (see option "-i"). Note that the output interval must be a multiple of the time step for trajectory calculation (see optional argument "-t").

-p
: Periodicity flag. If set, a periodic domain is assumed in zonal direction. Per default, the flag is **not** set.

-changet
: flag whether the times of the P and S files should be changed or not before a calculation; the default is that the times are **not** changed.

-noclean
: flag whether parameter and criterion files should be kept; this is particularly helpful for debugging.

-timecheck
: enforce a time check on the data file

EXAMPLES

[1] caltra 19891020_00 19891020_18 startf OUT.1

Calculate forward trajectories from 20/10/1989 00 UTC to 20/10/1989 18 UTC. The starting starting positions are given on the file "startf" as a list of (longitude,latitude,pressure) values. The output trajectories are written to the file "OUT.1", where the appendix 1 denotes ASCII format..B

[2] caltra 19891020_18 19891020_00 startf OUT.1
As in example 1, but backward trajectories from 20/10/1989 18 UTC to 20/10/1989 00 UTC.

[3] caltra 19891020_00 19891020_18 startf OUT -j
As in example [1], but with jumping flag set: if a trajectory crosses the lower boundary (topography), it is raised a little and then is allowed to move on.

[4] caltra 19891020_00 19891020_18 startf OUT -j -o 15 -t 15
As in example [3], but the output interval is set to 15 min with the optional argument "-o". Note that the output interval (15 min) must be a multiple of the time step, which is here set explicitely to 15 min with "-t".

[5] caltra 19891020_0130 19891020_1730 startf1 OUT -j -o 15 -t 15 -changet
Start from non-analysis time 01:30 UTC to non-analysis time 17:30 UTC. Furthermore, the times on the prinmary netCDF files are changed accordingly.

AUTHOR

Written by Michael Sprenger and Heini Wernli (January 2011)

NAME

datelist - handling of datelists

SYNOPSIS

datelist *filename mode [parameters]*

DESCRIPTION

A date list is a file of dates in the format {YYYYMMDD_HH}, e.g. 19900101_00 for 00 UTC, 1 January 1990. This command offers several ways how to create date lists and to work with them.

PARAMETERS

filename name of the date list file. If the name **'stdout'** or **'screen'** is given, the output will be directed to standardoutput: no file will be created.

mode one of several modes (see below).

CREATING DATE LISTS

-create stardate enddate
create a datelist from startdate (in format {YYYYMMDD_HHMM}) to enddate; the time interval is per default 6 h (see option -interval). If the start and end date do not match with the analysis times, the date list will contain the enclosing analysis times: for instance, for **-create 20100201_04 20100201_19** the date list will contain the following dates: 20100201_00, 20100201_06, 20100201_12, 20100201_18, 20100202_00.

-indir dirname
search for dates (in format {YYYYMMDD_HH}) in the direcory given with {dirname} - the dates are written in ascending order to the datelist file and repeating dates are removed.

-interval value
change the interval to {value} hours, instead of the default 6 hours.

INFO ABOUT DATE LISTS

-ndates
write the number of dates in the list

-timerange
write the time range {last date} - {first date} [in hours].

-isin date
check whether the date is in the list (1) or not (0).

STEPPING THROUGH DATE LISTS

-first
write the first date of the date list

-last write the last date of the date list

-next date
find the date {date} in the list and write the **next** date to screen; if no next date is in the list, i.e. the end of the list is reached, 'nil' will be returned.

-prev date
find the date {date} in the list and write the **previous** date to screen; if no previous date is in the list, i.e. the beginning of the list is reached, 'nil' will be returned.

COMPARING DATE LISTS

-overlap file1 file1
determine the overlap of two date lists.

-onlyin1 file1 file1
determine the dates which only occur in date list 1, but not in datelist 2

-onlyin2 file1 file1
determine the dates which only occur in date list 2, but not in datelist 1

Examples

[1] datelist screen -indir ./

look for dates in the current directory and write them to screen

[2] datelist dates -create 19890101_00 20110101_00 -interval 2

creates dates from 00 UTC, 1 January 1989 to 00 UTC, 1 January 2011 with an interval of 2 hours. The output will be written to the file 'dates'.

AUTHOR

Written by Michael Sprenger and Heini Wernli (January 2011)

NAME

difference - calculate the difference of two trajecrtory files

SYNOPSIS

difference *inpfil1 inpfile2 outfile field [-single|-max]*

DESCRIPTION

Calculate the difference of two trajectory files "inpfile1" and "inpfile2" and write it to a new trajectory file "outfile". The difference is calculated of the field "field", which must be available on both input files. If the field "LATLON" is specified, the spherical distance between the two trajectories is taken. Furthermore, with "-single" the difference is written at all times, with "-max" only the time of maximum difference is written.

PARAMETERS

inpfile1 first trajectory file

inpfile2 second trajectory file

outfile output trajectory file - note that this is not a standard trajectory file which can be further processed! The position of both trajectories are listed and also the field for both trajectories and their difference.

field Name of field for which the difference should be calculated. It must be available in both trajectory files. IF "LATLON" is specified, the spherical distance between the trajectory positions is calculated.

OPTIONAL PARAMETERS

-single the difference is written to "outfile" for all trajectory times

-max the difference is written to "outfile" only for the trajectory time with maximum difference.

EXAMPLES

[1] difference tra1 tra2 out LATLON -single

gives the speherical distance (LATLON) between trajectories in "tra1" and "tra2". The difference is written for all trajectory times.

[2] difference tra1 tra2 out TH -max

gives the difference of potential temperature (TH) between trajectory file "ra1" and "tra2" and writes the maximum difference ("-max") to the output file "out".

AUTHOR

Written by Michael Sprenger and Heini Wernli (January 2011)

extract

extract - extract columns, times, single trajectories and starting positions

SYNOPSIS

extract *inptra outtra mode*

DESCRIPTION

Extract columns, times, single trajectories or starting positions from an input trajectory file *inptra* and write output to a new trajectory file *outtra.* The different extraction modes are specified with *mode.* Note: the time, longitude, latitude and pressure need not be extracted beacuse they are an integral part of every trajectory file - they are extracted by default.

EXTRACTION MODE

-var extract columns of a trajectory file; the columns can be listed by name (e.g. -var TH PV RH) or a range of columns can be specified by the "to" operator (e.g. -var TH to PV). The two modes can also be combined: "-var TH to PV RH" extracts all columns between TH and PV, and additionally RH.

-time
extract trajectory times; the times can be given as a list of times (e.g. -time 6 12) or as a time range (e.g. -time 6 to 18).

-tra extract single trajectories; the index of the trajectories can be specified as a list (e.g. -tra 10 12 14) or as a range of trajectories (e.g. -tra 10 to 20).

-startf
extract list (longitude, latitude, pressure) of starting positions ofvthe trajectory file (corresponding to time 0).

-index
extract single trajectories - the trajectory indices (from 1 to #trajectories) are given on a file (e.g. -index filename).

-boolean
extract single trajectories - the trajectory are specified on a boolean (0/1) file (e.g. -boolean filename).

-pattern
extract all trajectories which match the pattern given; the pattern is a list of numbers. It is then checked whether these numbers occur in a trajectory (all at one time).

EXAMPLES

[1] extract inptra outtra -time 6 to 36 72
read input trajectory file "inptra", extract times 6 to 36 and additionally time 72, and write output to trajectory file "outtra".

[2] extract inptra outtra -index indfile
reads input trajectories from "inptra" and write all trajectories to "outtra" which are listed in the file "indfile". In "infile" the indices of selected trajectories are listed line-by-line.

[3] extract inptra outtra -pattern -999.99
extracts all trajectories which have a missing data (-999.99) entry.

[4] extract inptra outtra -pattern 0.00 -44.25 -28.47 140
extracts all trajectories which have the numbers '0.00 -44.25 -28.47 140' in their list. This options is convenient to search for specific times and positions, and then to see the complete trajectory.

AUTHOR

Written by Michael Sprenger and Heini Wernli (January 2011)

NAME

gettidiff - get the difference (in hours) between two dates

SYNOPSIS

gettidiff *date1 date2*

DESCRIPTION

Get the time difference (in hours) between two dates (in form YYYYMMDD_HH(MM), i.e. the minutes are optional): date1 - date2. The output is in format HH or HH.MM

PARAMETERS

date1 first date (in form YYYYMMDD_HH(MM))

date2 second date (in form YYYYMMDD_HH(MM))

EXAMPLES

[1] gettidiff 20110102_18 20110205_00

gives the time difference between 20110102_18 and 20110205_00; the result is -798 h.

AUTHOR

Written by Michael Sprenger and Heini Wernli (January 2011)

NAME

getvars - get a list of a fields on a netCDF file

SYNOPSIS

getvars *filename*

DESCRIPTION

Get a list of all fields on a netCDF file - the names of the fields are listed line-by-line.

PARAMETERS

filename name of the netCDF file (e.g. P20110102_00).

EXAMPLES

[1] getvars P20110102_00

gives a list of all fields on the netCDF file P20110102_00; the results is: time, Q, LWC, IWC, T, U, V, OMEGA, PS, SLP

AUTHOR

Written by Michael Sprenger and Heini Wernli (January 2011)

NAME

Lagranto - calculate trajectories for ECMWF analyses and forecasts

SYNOPSIS

lagrantohelp [topic|tutorial|reference|future] - show this man page or the one corresponding to a specific topic. All *underlined* names in this document have their own man page. If "tutorial" is chosen, a detailed tutorial for Lagranto is opened. For "reference" a PDF document with all man pages is opened. Finally, with option "future" plans for additional features will be listed.

DESCRIPTION

Lagranto is a software tool (UNIX shell-scripts and Fortran programs) to analyze Lagrangian aspects of atmospheric phenomena. It requires a time-series of 3-dimensional wind fields (and if necessary further variables) on netCDF files.

CORE PROGRAMS

create_startf	create starting files
caltra	calculate trajectory positions
trace	trace meteorological fields along trajectories
select	select trajectories based on several criteria
density	create netCDF files with trajectory densities

TRAJECTORY TOOLS

extract	extract single trajectories, times or columns from a trajectory file
list2lsl	transform a (longitude,latitude,pressure) list into a trajectory file
lsl2list	transform a trajectory file into a (longitude,latitude,pressure) list
mergetra	merge two trajectory files
reformat	change the format of a trajectory file
timeres	change the time resolution of a trajectory file with interpolation
trainfo	write some information about a trajectory file
difference	calculate the difference between two trajectory files

NETCDF TOOLS

changecst	change the constants filename on a netCDF file
changet	change the time on a netCDF file
getmima	get the minimum and maximum value of a field on a netCDF file
getvars	get a list of fields on a netCDF file

GENERAL TOOLS

newtime	get a new date from an initial date and an offset in hours
gettidiff	get the time difference between two dates

VISUALISATION

Lagranto comes with two packages for visualisation of trajectories: one based on Matlab (www.mathworks.com) and one based on NCL (www.ncl.ucar.edu). Examples are provided in folder "figure" of the Lagranto installation.

AUTHOR

Written by Michael Sprenger and Heini Wernli (January 2011)

NAME

list2lsl - convert a list of longitude, latitude and pressure into a trajectory file.

SYNOPSIS

list2lsl *inpfile outfile [optional arguments]*

DESCRIPTION

Convert an input file "inpfile" wqith a list of longitude, latitude and pressure into a trajectory file.

PARAMETERS

inpfile input file (a list of longitude, latitude and pressure)

outfile output trajectory file

OPTIONAL PARAMETERS

-ref refdate

set the reference date of the trajectory file to "refdate", e.g. "-ref 20110102_00".

-time value

set the time of the trajectory file to "value" (in format HH.MM): e.g. "-time 6" sets the time to 6 h.

EXAMPLES

[1] list2lsl listfile trafile -refdate 20110101_00 -time 6

converts the list "listfile" into a trajectory file "trafile", where the reference date is 20110101_00 and the time is 6 h.

AUTHOR

Written by Michael Sprenger and Heini Wernli (January 2011)

NAME

lsl2list - convert a trajectory file into a list of longitude, latituden and pressure

SYNOPSIS

lsl2list *inpfile outfile*

DESCRIPTION

Convert an input trajectory file "inpfile" into a list of longitude, latitude and pressure; all times are included in this list.

PARAMETERS

inpfile input trajectory file

outfile output file (a list of longitude, latitude and pressure)

EXAMPLES

lsl2list trafile listfile

converts all entries of the trajectory file "trafile" into a listfile with longitude, latitude and pressure.

AUTHOR

Written by Michael Sprenger and Heini Wernli (January 2011)

NAME

mergetra - combine two trajectory files

SYNOPSIS

mergetra *inpfile1 inpfile2 outfile*

DESCRIPTION

Combines two input trajectory files "inpfile1" and "inpfile2" and writes a new combined trajectory file "outfile". Three different modes for combination are supported (see below).

PARAMETERS

inpfile1 first input trajectory file

inpfile2 second input trajectory file

outfile output trajectory file

MODES FOR COMBINATION

Three different combination modes are supported. They are tested for sequentially and the first mode which is accepted, based on the criteria listed below, is performed. The three modes are:

- column

The input files have the same trajectory times, longitudes, latitudes and pressures, and both files contain the same number of trajectories. The new trajectory file contains all columns from both input files, duplicate columns only included once, e.g. if "inpfile1" has columns "time,lon,lat,p,TH,PV" and "inpfile2" columns "time,lon,lat,p,PV,Q", the output file will have "time,lon,lat,p,TH,PV,Q".

- append

The input files have the same trajectory times and the same columns, but differ in the number of trajectories. Then the second file is appended to the first one and written as a new trajectory file.

- times

The input files differ only in the time values, e.g. the first file might contain times -96 h to 0 h and the second the times from 0 h to 96 hours. Then the new combined file will contain the time -96 h to 96 h. Note that duplicate times are eliminated. Furthermore, the output times are sorted in increasing order.

EXAMPLES

[1] mergetra file1 file2 newfile

combines the two trajectory files "file1" and "file2" and writes a new trajectory file; the mode for combination is automatically detected.

AUTHOR

Written by Michael Sprenger and Heini Wernli (January 2011)

NAME

newtime - get a new date string from an initial date and an offset in hours

SYNOPSIS

newtime *date offset*

DESCRIPTION

Given an initial date string in format "YYYYMMDD_HH" and an offset in hours, create a new date string - agin in the form "YYYYMMDD_HH".

PARAMETERS

date initial date in form "YYYYMMDD_HH", e.g. 20110102_18 for 18 UTC, 2nd January 2011.

offset Offset in hours; the offset can be positive (into the future) or negative (into the past).

EXAMPLES

[1] newtime 20110101_00 45

gives 20110102_21, the datestring 45 h after 20110101_00.

AUTHOR

Written by Michael Sprenger and Heini Wernli (January 2011)

NAME

reformat - convert trajectory files between different formats

SYNOPSIS

reformat *inpfile outfile*

DESCRIPTION

Convert a Lagranto trajectory file *inpfile* from one format to another format; the new file is written to *outfile.* The formats are specified with an appendix to the filename, e.g. "trajectory.1" specifies format 1. If no appendix is given, format 1 is chosen.

PARAMETERS

inpfile input trajectory file

outfile output trajectory file (can be the same as inpfile).

FORMATS

Formats must be specified with an appendix to the filename. If no appendix is given, format 1 is chosen.

.1 ASCII file; the trajectories are sorted according to their starting positions. Different trajectories are separated by a blank line. This format is the only one supported by the Matlab and NCL visualisation scripts (see **lagrantohelp/visualisation).**

.2 ASCII file; the trajectories are sorted according to their times. Different times are separated with a blank line.

.3 unformatted Fortran; this is the most efficient format, but least portable one.

.4 netCDF; portable and compact data format.

EXAMPLES

[1] reformat trainp.1 trainp.4

Convert the input trajectory file in format 1 (ASCII) to format 4 (netCDF).

AUTHOR

Written by Michael Sprenger and Heini Wernli (January 2011)

NAME

select - select trajectories

SYNOPSIS

select *inptra outtra criterion*

DESCRIPTION

Select trajectories from the input trajectories in "inptra" based upon meteorological conditions specified in "criterion" (to be described below). The selected trajectories are then written to a new trajectory file "outtra".

PARAMETERS

inptra input trajectory file

outtra output trajectory file

criterion specification of the selection criterion; the specification is either an explicit criterion or a file containing the specification. Each selection criterion has the following form:
COMMAND : **FIELD** : **ARGUMENTS** : **[TIME].**
Several selection criteria can be combined with logical operator & (AND) and | (OR), the AND having higher priority than the OR.

OPTIONAL ARGUMENTS

-noclean
keep temporary files for debugging.

-boolean
Write a boolean list (0/1) instead of a trajectory file; the file has #trajectories entries, each line corresponding to an input trajectory /1=trajectory selected, 0=not selected).

-index
Write an index list instead of a trajectory file: the index of all selected trajectories is written to the output file - the index ranges from 1 to #trajectories.

-count
Write only the number of selected trajectories to the output file.

-startf
Write only the starting positions of selected trajectories to the output file.

-regionf filename
change the region file from its default value "regionf" to a new file name: the syntax is "-regionf filename".

COMMAND

- GT
greater than: e.g. **GT:PV:2** selects trajectories with first potential vorticity (PV) larger than 2 PVU.

- LT less than: e.g. **LT:RH:70** selects trajectories with first relative humidity (RH) below 70 %.

- IN within: e.g. **IN:lon:30,40** selects trajectories with first longitude between 30 and 40 deg.

- OUT
outside: e.g. **OUT:lat:-30,30** selects trajectories with first latitude outside -30 and 30 deg - neglecting an equatoriual/subtropical band.

- EQ
equal: e.g. **EQ:p:460** selects trajectories with first pressure equal to 460 hPa.

- TRUE
check whether value is different from zero (logical TRUE): e.g. **TRUE:CYCL::ALL(ANY)** checks whether the trajectory passes through a cycclone, which is marked as 0/1 field, at any time. Note that the command 'TRUE' has no arguments of its own!

- FALSE

check whether value is equal to zero (logical FALSE): e.g. **FALSE:CYCL::ALL(ALL)** checks whether the trajectory never passes through a cycclone, which is marked as 0/1 field. Note that the command 'TRUE' has no arguments of its own!

- ALL, ANY, NONE

these are special commands which only apply for the TRIGGER field. Further explanations are given below in section TRIGGER.

FIELD

- VALUE

take value of the field: e.g. **GT:PV(VALUE):2** selects the trajectories with first potential vorticity (PV) value greater than 2 PVU. This selection criterion is equivalent to **GT:PV:2,** i.e. the VALUE argument is taken as default.

- MEAN

take the mean over the selected times: e.g. **GT:RH(MEAN):70:ALL** selects all trajectories for which the mean relative humidity (RH) over all times (ALL) is greater than 70 %.

- VAR

take the variance over the selected times: e.g. **GT:lat(VAR):10:ALL** selects all trajectories for which the variance of latitude (lat) over all times (ALL) is greater than 10.

- MIN

take the minimum of the selected times: e.g. **LT:p(MIN):300:ALL** select all trajectories which have a minium pressure (p) less than 300 hPa over all times (ALL).

- MAX

take the maximum of the selected times: e.g. **LT:p(MAX):300:ALL** select all trajectories which have a maximum pressure (p) less than 300 hPa over all times (ALL).

- SUM

take the sum over the selected times: e.g. **GT:LHR(SUM):2:ALL** selects all trajectories for which the sum over all latent heating rates (LHR) over all times (ALL) is greater than 2 K.

- CHANGE

take change between two times: e.g. **GT:p(CHANGE):600:FIRST,LAST** selects all trajectories wich have a pressure difference |p(FIRST)-p(LAST)| greater than 600 hPa between the first and last time or vice versa. Note that the change can be positive or negative, i.e. it is not clear whether it is ascent or descent.

- DIFF

take difference between two times: e.g. **GT:p(DIFF):600:FIRST,LAST** selects all trajectories wich have a pressure difference p(FIRST)-p(LAST) greater than 600 hPa between the first and last time - corresponding to an ascending air stream. Correspondingly **GT:p(DIFF):600:LAST,FIRST** finds a descending air stream.

TIME MODE

The command are applied to a set of trajectory times; if no time is specified, the the command is only applied to the first time. Most generally, the time mode consists of two parts: time list(time mode), where the first specifies a list of times and the second how to apply the criterion to the selected times.

- FIRST

first time: e.g. **IN:lat:-20,20:FIRST** selects all trajectories with first latitude between 20 S to 20 N, i.e. wich start in an equatorial band.

- LAST

last time: e.g. **IN:lat:-20,20:LAST** selects all trajectories with last latitude between 20 S to 20 N, i.e. which end in an equatorial band.

- T1,T2,T3

an explict list of times: e.g. **IN:lat:-20,20:6,12** selects all trajectories which are in the equatorial band at times 6 h and 12 h. The criterion must apply at both times (see below ALL, ANY, NONE).

- T1 to T2

a time range: e.g. **IN:lat:-20,20:6 to 18** selects all trajectories which are in the equatorial band from 6 h to 18 h. The criterion must apply at all times between 6 h and 18 h (see below ALL, ANY, NONE).

- ALL

all times: e.g. **IN:lat:-20,20:ALL** selects all trajectories which stay at all times in the equatorial band. This time mode is the same as **ALL(ALL),** i.e. all times are selected and the criterion must apply to all times. With **IN:lat:-20,20:12-24(ALL)** the criterion must apply for all times between 12 h and 24 h.

- ANY

any times: e.g. **IN:lat:-20,20:ALL(ANY)** selects all trajectories which stay at any times in the equatorial band. Note that with the first "ALL" the times are selected, i.e. all times in this case, and with the second "ANY" it is specified that the criterion must only apply to at least one of the selected times.

- NONE

at no time: e.g. **IN:lat:-20,20:ALL(NONE)** selects all trajectories which never stay in the equatorial band. **OUT:lat:-20,20:FIRST(NONE)** selects the trajectories which are not outside the equatorial time at the first time: they must be inside.

- TRIGGER

the trajectory is automatically selected, but the trigger column is updated. A selection of trajectories might then e accomplished based on this trigger column: e.g **GT:p:700:1(TRIGGER)** would set the trigger 1 for all trajectory times where the pressure (p) is greater than 700 hPa. Similarly, **GT:p:800:1(TRIGGER) & GT:lat:50:2(TRIGGER)** would set the trigger 1 for all times where the pressure (p) is larger than 800 hPa and set the trigger 2 for all times where the latitude (lat) is larger than 50 degrees north. Note, that both eents might apply: then the rsulting trigger is 3. The triggers are internally saved as the bits of an integer variable, i.e. trigger 1 corresponds to value 1=2ˆ0, trigger 2 to 2=2ˆ1, trigger 3 to 4=2ˆ2...

LOGICAL OPERATORS

- & logical and: e.g. **GT:lat:34:FIRST & GT:lon:50:FIRST** selects the trajectories to the north of 34 N and to the east of 50 E at first time. Several selection criteria can be combined with '&'.

- | logical or: e.g. **GT:lat:34:FIRST | GT:lon:50:FIRST** selects the trajectories to the north of 34 N or to the east of 50 E at first time. Several selection criteria can be combined with '|'. Note that locical OR has a lower priority than logical AND, i.e. in an expression like T1 | T2 & T3 first the expression T2 & T3 is evaluated and only then logically OR-combined with T1.

IMPLICIT FIELDS

Implicit variables can be used in the selection criteria, although they do not explicitely appear as a column in the trajectory file. They are calculated on-the-fly during the selection.

- DIST

length of the trajectory (in km), integrated along great circle sections between the trajectory vertices: e.g. **GT:DIST:1000:LAST** tests whether the total path length of the trajectory (DIST) exceeds 1000 km.

- DIST0

distance of the trajectory (in km) from its starting position: e.g. **GT:DIST0:1000:18,24(ANY)** tests whether the air parcel is more than 1000 km away from its starting position, either at time 18 h or at time 24 h.

- INPOLYGON

specification of a polygon: e.g. **TRUE:INPOLYGON:filename:ALL(ANY)** selects all trajectories which pass through the polygon specified in "filename". The polygon is specified as described in **create_startf** (see comments there). With **FALSE:INPOLYGON:filename:ALL(ALL)** all trajectories are selected which never pass through the polygon. Note that for every call of **select** only one polygon can be used in the criteria!

- INBOX

specification of a longitude/latitude rectangle <lonw,lone,lats,latn>: e.g. **TRUE:INBOX:20,40,30,60:ALL(ANY)** selects all trajectories which pass through the longitude/latitude rectangle with lower-left corner at 20 E / 30 N and the upper-right corner at 40 E / 60 N. Correspondingly, with **TRUE:INBOX:20,40,30,60:ALL(NONE)** the trajectories are selected which never pass through the rectangle.

- INCIRCLE

specification of circle around a specified point: e.g. **TRUE:INCIRCLE:40,50,500:LAST** select all trajectories which have their final position (LAST) in the circle centred at 40 E / 50 N and with a radius of 500 km.

- INREGION

specification of target regions in a region file (default "regionf") - please consider the documentation of "create_startf" for details concerning the format of the region file. As an example, if a region 1 is defined on the region file, the criterion **TRUE:INREGION:1:18** selects all trejactories which are within region 1 at time 18 h.

SPECIAL CRITERIA

Special criteria are and can be implemented into **select.** The call to the special criteria is of the following form: **SPECIAL:command:parameters,** where "command" is a command string (e.g. WCB) and "parameters" is a list of parameter values.

- WCB

identification of Warm Conveyor Belts (WCB): e.g. **SPECIAL:WCB:300,0,24** selects trajectories which ascend more than 300 hPa between time 0 and 24 h. Note, the ascent is determined as min{p(0...24)}-p(0), i.e. the first pressure p(0) is fixed whereas the lowest pressure can occur at any time between 0...24 h.

TRIGGER FIELD

A trigger (or flag) field can be defined in select. This special column of the trajectory file allows to mark specified events for each trajectory and its times. As an example, you would like to select all trajectories which are below 700 hPa at a certain time and have relative humidity above 80 % **at the same times:** Then you could set a first trigger for the pressure criterion and a second one for the relative humidity, and then you would check for the simultaneous occurence of the two triggers. More specifically,

GT:p:700:1(TRIGGER) & GT:RH:80:2(TRIGGER)

this will define the triggers for the two events. Note that both events might be fulfilled, in which case both triggers are set. The value of the trigger is: 1 if only the first criterion is fulfilled (binary 01); 2 if only the second is fulfilled (binary 10) and 3 if both are fulfilled (binary 11).

ALL:TRIGGER:1,2:ALL(ANY)

this will select all trajectories for which both triggers 1 and 2 are set - they can be set at any time of all the trajectory times; if, for instance, you would like to test whether the two triggers are set at the two times 6 and 12, the command would be **ALL:TRIGGER:1,2:6,12(ALL).**

ALL:TRIGGER:1,2:ALL(ANY)

will only check whether one of the two triggers 1 and 2 is set

NONE:TRIGGER:1,2:ALL(ANY)

will check whether none of the two triggers 1 and 2 is set

IMPLEMENTING COMPLEX CRITERIA

New special criteria can easily be implemented into the code - to this aim the following steps must be taken:

[1] <special.f>

in directory "${LAGRANTO}/select/" must be modified. Take the example "WCB" to see how the Fortran code must be changed.

[2] <install.sh select>

must be invoked to recompile the program "select". For successful compilation, the executable "select" will be listed.

Type <select -special> to get a list of all special commands and a detailed description.

EXAMPLES

[1] select trainp traout 'GT:PV:2:LAST'

selects all trajectories with PV>2 PVU for the last time step. The input trajectories are given in trainp, the selected ones are written to traout. If the two filenames are the same, the input file is over-written.

[2] select trainp traout 'IN:lat:-20,20:6,12'

selects all trajectories which are in the equatorial band at times 6 h and 12 h. The criterion must apply at both times.

[3] select trainp traout 'GT:lat:34:FIRST & GT:lon:50:FIRST'

selects the trajectories to the north of 34 N and to the east of 50 E at first time. Several selection criteria can be combined with '&'.

[4] select trainp traout 'LT:p(MIN):300:ALL'

select all trajectories which have a minium pressure (p) less than 300 hPa over all times (ALL).

AUTHOR

Written by Michael Sprenger and Heini Wernli (January 2011)

NAME

timeres - change the time resolution of a trajectory

SYNOPSIS

timeres *inpfile outfile -[h|min] value [-cubic|-linear]*

DESCRIPTION

Change the time resolution of an input trajectory file "inpfile" through interpolation and write a new trajectory file "outfile". The new time resolution "value" is given either in hours "-h" or in minutes "-min". The interpolation is performed on the trajectory file either in linear mode ("-linear") or in cubic spline mode ("-cubic"). The default is "-cubic".

PARAMETERS

inpfile input trajectory file

outfile output trajectory file (can be the same as inpfile).

-h value new time resolution in hours (e.g. "-h 1").

-min value new time resolution in minutes (e.g. "-min 15").

-linear linear interpolation between two trajectory times; note that this mode conserves the sign between two trajectory times - possibly of important for specific humidity, relative humidity,...

-linear subic spline interpolation between two trajectory times; note that this mode conserves can change the sign between two trajectory times!

EXAMPLES

[1] timeres trafile trafile -min 15 -linear

changes the time resolution to 15 minutes, using linear interpolation, and overwrites the old trajectory file.

AUTHOR

Written by Michael Sprenger and Heini Wernli (January 2011

NAME

tracal - simple calculations with trajectory files

SYNOPSIS

tracal *inpfile outfile expression*

DESCRIPTION

Simple calculation on the input trajectory file *inpfile* ; the output is written to the output trajectory file *outfile* and the expression for the calculation is given in *expression.*

PARAMETERS

inpfile input trajectory file

outfile output trajectory file (can be the same as inpfile).

expression arithmetic expression, e.g. 'DIFF=PS-p' to get difference between surface pressure (PS) and the pressure height of the trajectory (p). Note that the variable names must exactly match to the column names in the trajectory file. The mathematical expression can contain previously defined variables, numbers (e.g., 1.5 or 1.5e-6), arithmetic operators (+, -, *, /, ^), and a number of mathematical functions (sin, cos, tan, sqrt, exp, log, ln, abs, ang, real, imag, conjg, complex). The expression can also use nested levels of parentheses for grouping. There are two predefined variables that are available to the user â the constant pi=3.14159265358979 and the imaginary unit i.

EXAMPLES

[1] tracal inp out 'agl=z-zb'

caculates the difference between air parcel height (z) and surface height (zb). The result is saved in an new column (agl).

AUTHOR

Written by Michael Sprenger and Heini Wernli (August 2012); the evaluation of the arithmetic expression is based on the string manipulation routines by 'Dr. George Benthien' (http://gbenthien.net/index.html).

NAME

trace - trace meteorological fields along trajectories

SYNOPSIS

trace *inpfile outfile* [*optional arguments*]

DESCRIPTION

Trace meteorological fields along the trajectories given in the input file *inpfile* and write a new trajectory file *outfile tracing file* (default: tracevars). Partly they can be computed "online" (see ONLINE CALCULATIONS below), normally they are availbale on the primary and secondary P and S files.

PARAMETERS

inpfile input trajectory file; the appendix determines the format (see **reformat** for details).

outfile output trajectory file; the appendix determines the format (see **reformat** for details).

TRACING FILE

Normally the meteorological fields for tracing are listed in a file with name **tracevars .** The name of the tracing file can be changed with the optional argument "-v" (see below). The format of the tracing file is as follows:

Format

field[:shift] scale computation prefix

Shifts (optional)

- field:+100km[lat] - get field at trajectory position + 100 km shifted to north. A shift to south is obtained with field:-100km[lat].
- field:+100km[lon] - get field at trajectory position + 100 km shifted to east. A shift to west is obtained with field:-100km[lon].
- field:+2[dlat] - get field at trajectory position + 2 grid spacings dlat shifted to north. A shift to south is obtained with field:-2[dlat].
- field:+2[dlon] - get field at trajectory position + 2 grid spacings dlon shifted to east. A shift to west is obtained with field:-2[dlon].
- field:+50hPa - get field at trajectory position + 50 hPa shifted in vertical. A shift to lower pressures is obtained with field:-50hPa.
- field:+1dp - get field at trajectory position + 1 grid spacing DP shifted in vertical. A shift to lower pressures is obtained with field:-1dp. Note that DP is not fixed but varies with height.
- field:+6h - get field at trajectory position, but 6 h in the future. Shifts to the past are poeeible with field:-6h. In addition to hours (h), the time shift can be specified in minutes (min).

Examples

- TH 1. 0 S : trace potential temperature (TH), scale it with 1 (no scaling); it is available on the S file (no computation is needed: 0).
- Q 1000. 0 P : trace specific humidity (Q), scale it with 1000 to have g/kg; it is available on the P file (no computation is needed: 0).
- RH 1. 1 * : trace relative humidity (RH), no scaling is needed (1.); relative humidity is not available on either P or S file and must be computed (1).
- TH:100hPa 1. 0 S : As in the first example, but now the potential temperature is taken 100 hPa below the air parcel position.

OPTIONAL ARGUMENTS

-i hours time increments (in hours) for input P and S files. If not explicitely specified, this is determined from the P and S files i n the current directory.

-v varfile Change the name of the tracing file from its default value "tracevars" to "varfile".

-f field scale Trace field (with scaling scale) along the trajectories; the computation flag and the prefix for the data file is automatically set. This options allows the quick tracing of a field, without specifying a tracing file.

-changet flag whether the times of the P and S files should be changed or not before a calculation; the default is that the times are **not** changed.

-noclean flag whether parameter and criterion files should be kept; this is particularly helpful for debugging.

-timecheck enforce a time check for the data file

SPECIAL INTERPOLATION MODES

-nearest Do no interpolation between grid points; just take the nearest neighbor! This option is useful, if a discrete input field is given (e.g. labels), where interpolated values are meaningless.

-circle_avg radius
calculate area-weighted average over all grid points within a circle of the specified radius [km]. e.g. -circle_avg 200; note that the tracing of fields within a circle is quite slow.

-circle_max radius
calculate maximum within a circle of a radius [km]. e.g. -circle_max 200

-circle_min radius
calculate minimum within a circle of a radius [km]. e.g. -circle_min 200

-clustering special mode to trace strat/trop label; the labels are attributed according to the program (tropopause), which clusters the atmosphere into five distinct classes according to the definition of the tropopause: PV (2 PVU) and potential temperature (380 K). The clustering mode is a refined version of the nearest mode, where all surrounding eight grid points vote for the final value.

ONLINE CALCULATIONS

If the computation flag in the tracing file is set to 1, a meteorological field is calculated based upon the already traced fields and/or based on the fields on the primary and secondary P and S files. The following fields are implemented for online calculations:

- TH
potential temperature (in K).

- RHO
density (in kg/m^-3).

- RH
relative humidity (in %).

- THE
equivalent-potential temperature (in K).

- LHR
latent heating rate (K per input time step, typically K/6h).

- D[U,V,T,TH]DX
horizontal derivative d[U,V,T,TH]/dx in west-east direction along pressure surfaces - zonal distance in m. U=zonal wind component (m/s), V=meridional wind component (m/s), T=temperature (deg C or K), TH=potential temperature (K).

- D[U,V,T,TH]DY
horizontal derivative d[U,V,T,TH]/dy in south-north direction along pressure surfaces -meridional distance in m.

- D[U,V,T,TH]DP
vertical derivative d[U,V,T,TH]/dp - pressure p in Pa.

- NSQ
squared Brunt-Vaisala frequence (in m^-2).

- RELVORT
relative vorticity (in s^-1) - RELVORT = DVDX - DUDY.

- ABSVORT
absolute vorticity (in s^-1) - ABSVORT = DVDX - DUDY + F, F being the Coriolis parameter.

- DIV
horizontal divergence of the velocity field (in s^-1) - DIV = DUDX + DVDY.

- DEF
horizontal deformation of the velocity field (in s^-1) - DEF = SQRT((DVDX + DUDY)^2 + (DUDX-DVDY)^2).

- PV Ertel potential vorticity (in PVU) - PV = g * (ABSVORT * DTHDP + DUDP * DTHDY - DVDP * DTHDX).

- RI Richardson number - RI = NSQ / (DUDP^2 + DVDP^2).

- TI tubulence indicator according to Ellrod & Knapp - TI = DEF * SQRT(DUDP^2 + DVDP^2) * (RHO * G).

- DIR
wind direction relative to zonal flow: (U,V)=(1,1) -> 45 deg; (U,V)=(1,-1) -> -45 deg; (U,V)=(-1,-1) -> -135 deg; (U,V)=(-1,1) -> 135 deg. A westerly flow has 0 deg, a southerly flow 90 deg, and a northerly one -90 deg.

- DIST0
spherical distance (in km) from starting position.

- DIST
length of the trajectory (in km): integrated along great circle sections between the trajectory vertices.

- HEAD
heading of the trajectory: (DX,DY)=(1,1) -> 45 deg; (DX,DY)=(1,-1) -> -45 deg; (DX,DY)=(-1,-1) -> -135 deg; (DX,DY)=(-1,1) -> 135 deg. A path increment to east has heading of 0 deg; to the north 90 deg; to the south -90 deg; and to the west -180 deg.

EXAMPLES

[1] trace TRAJECTORY.1 TRAJECTORY.1 -changet
Read the trajectory file TRAJECTORY.1, trace all fields in the file "tracevars" along the trajectories and overwrite the existing trajectory file. In preparation, all times on the P and S files are changed prior to the tracing.

[2] trace INPTRA.1 OUTTRA.1 -f PV 1.
Trace PV (with scaling factor 1.) along the trajectories in trajectory file "INPTRA.1" and write a new trajectory file "OUTTRA.1".

[3] trace INPTRA.1 OUTTRA.1 -f PV:-100HPA 1.
As in example [2], but the PV is taken at a position 100 hPa higher (lower pressure) than the air parcel's position.

[4] trace INPTRA.1 OUTTRA.1 -f DIST0 1.
Get the spherical distance (in km) of the air parcel from its starting position.

AUTHOR

Written by Michael Sprenger and Heini Wernli (January 2011).

NAME

trainfo - write meta-information for a trajectory file

SYNOPSIS

trainfo *trafile* [*option*].

DESCRIPTION

Write meta-information for a trajectory file *trafile* to screen. If no option is given, all meta-information is written, otherwise the specific piece of information is passed with *option.*

PARAMETERS

trafile
name of the input trajectory file

OPTIONAL ARGUMENTS

- dim
dimensions of the trajectory file: #tra, #ntimes, #ncolumns.

- ntra
number of trajectories.

- ntim
number of times.

- ncol
number of columns (including time, longitude, latitude, pressure).

- vars
list of field names (columns) on the trajectory file.

- refdate
reference date in format (YYYYMMDD_HHMM).

- times
list of times (relative to the referencec date). Times are given in format: HH.MM.

- startdate
starting date for the trajectory calculation (in format YYYYMMD_HHMM).

- enddate
end date for the trajectory calculation (in format YYYYMMD_HHMM).

- timerange
time range (in minutes) of the trajectories.

- list list all trajectories.

EXAMPLES

[1] trainfo file dim
Given a trajectory file with name "file", write the three dimensions of the file to screen. The dimensions are: number of trajectories, number of times and number of columns.

AUTHOR

Written by Michael Sprenger and Heini Wernli (January 2011)

NAME

wrfmap - transform between geographical and WRF coordinates

SYNOPSIS

wrfmap *[-create filename* **|** *-ll2xy coords* **|** *-xy2ll coord]*

DESCRIPTION

Create a mapping netCDF file *wrfmap.nc* which contains the forward and the backward coordinate transformation. The forward transformation is from WRF grid indices (x/y) to geographical longitude/latitude, the backward transformation the other way round. If the mapping file *wrfmap.nc* exists, the tool allows to transform between the two coordinates.

PARAMETERS

-create filename create the mapping file wrfmap.nc based on the WRF output file *filename.* The WRF output file must contain the fields XLAT and XLONG which give for each grid point of the WRF domain the corresponding longitude and latitude. This forward transfoation fields are written as LON and LAT to wrfmap.nc. For the reverse transformation, two additional fields X and Y are calculated and written, which give for each possible longitude/latitude the corresponding grid point (x/y) in the WRF domain.

-ll2xy [lon lat **|** *inpfile outfile]*
write the x/y coordinates for either the single position lon/lat to screen, or for all coordinates on the input file 'inpfile' to 'outfile'. The input and output file can be trajectory files, in which case the column headers are accordingly adapted to x/y or lon/lat.

-xy2ll [x y **|** *inpfile outfile]*
write the lon/lat coordinates for either the single position x/y to screen, or for all coordinates on the input file 'inpfile' to 'outfile'. The input and output file can be trajectory files, in which case the column headers are accordingly adapted to x/y or lon/lat.

EXAMPLES

[1] wrfmap -create wrfout_d01_2011-08-26_12:00:00
Take the netCDF file 'wrfout_d01_2011-08-26_12:00:00' from WRF and write the forward and backward mapping fields to netCDF file 'wrfmap.nc'

[2] wrfmap -ll2xy -70 56
Get the grid indices for (lon=-70/lat=56) and write them to screen.

[3] wrfmap -xy2ll traj.1 traj.1
Take the trajectory file 'traj.1' and convert all grid coordinates x/y into lon/lat coordinates. The output will overwrite the input file.

AUTHOR

Written by Michael Sprenger and Heini Wernli (January 2013)