

# MONITORING OF PHYSICAL TENDENCIES

Tomislav Kovacic

## General description

### Introduction

The main idea of monitoring the physical tendencies is to find out those cases when they cause blow up of the model or just a bad score. The monitoring system consists of three parts, these are: computation of frequency distributions, finding the points with absolute values of physical tendencies exceeding prescribed threshold value and output of 1D profiles at those points.

### Physical tendencies in the ARPAGE-ALADIN model

The description of the physical parameterisations in the ARPAGE-ALADIN model is given in model documentation (Gerard, 2001). Here, only those aspects of it will be presented which are connected with implementation of diagnostic of physical tendencies.

The effect of physical processes is introduced in the model by addition of physical tendencies to the time changes of the model variables. A physical tendency for each variable is a sum of effects of all parameterised physical processes.

Calculations of the physical parameterisations take place in the part of the model where the calculations in the grid points are made, and this is a subroutine *CPG*. *CPG* calls the subroutine *MF\_PHYS* which contains all calculations of physical parameterisations and physical tendencies. These calculations are made by calls to subroutines *APLPAR*, *CPFHPFS* and *CPTEND*. At the end of the calls to these subroutines following physical tendencies are available:

U component of wind tendency (PTENDU),

V component of wind tendency (PTENDV),

enthalpy tendency (ZTENDH),

specific moisture tendency (ZTENDQ),

specific content of ice tendency (ZTENDQI),

specific content of liquid water tendency (ZTENDQL).

The names in the brackets are those used in *MF\_PHYS*.

The monitoring and diagnostics of physical tendencies is done on these six tendencies.

## Frequency distribution

The first stage in recognising the unusual cases is to find statistical characteristic of physical tendencies. As for our purpose only those cases with great absolute values of physical tendencies are interesting, frequency distributions of absolute values of physical tendencies are the statistical characteristic we are interested in.

As values of the physical tendencies spread over several decimal orders of magnitude, decimal logarithms of their absolute values must be used for frequency distribution curve. This defines the variable  $x$  for which the frequency distribution curve is calculated as

$$x = \log_{10} \left( \left| \frac{\partial \varphi}{\partial t} \right| \right)$$

where  $\varphi$  is any variable of the model.

If  $x_1$  is the lowest value and  $x_N$  the highest value of  $x$  we define the WIDTH of frequency distribution as

$$WIDTH = x_N - x_1$$

This interval is divided in equal classes. We define precision of classes as

$$\log_{10}(PREC) = \log_{10}(x_{i+1}) - \log_{10}(x_i)$$

$(PREC-1)*100$  gives percent of maximal change of tendency within the classe. Number of classes is given with

$$NWIDTH = \frac{WIDTH}{\log_{10}(PREC)}$$

There is a one class more for all values  $x$  greater then  $x_N$ .

Computation of frequency distributions will not be used in operational work of the model, but only for finding threshold values for high values of tendencies.

Extraction of points with physical tendencies exceeding the threshold value

On the bases of frequency distributions for all tendencies, for each one of them, we can chose a threshold values and find those points in the 3D space of the model whert at least one of tendencies eqceedes its thrershold value. Such points will be saved for each time step and analysed later. This diagnostics will be used in operational work of the model.

Extraction of profiles

For further investigation of physical parametrisations, the 1D vertical profiles at the geographical position of extracted points are extracted for all those fields needed for SCM (Single Column Model).

## Application in the code

### The namelist NAMCHET

The ways of usage of the system for monitoring of physical tendencies is controlled by variables put in the namelist NAMCHET, which is declared in header file namchet.h. It is declared as follows

```
NAMELIST /NAMCHET/ LCTFREQ, LCTCOORD, LCTPROF, CTHRVALS, WIDTH, APREC, &  
& STARTCLASS, NPROFMAX
```

The variables included in the namelist are declared in module YOMCHET and their meanings and default values are explained here.

LCTFREQ is a logical variable. When its value is .TRUE. the calculation of frequency distributions is enabled. For each time step the frequency distributions will be calculated and written to the file CHET.FREQ.lfa .

LCTCOORD is a logical variable. When its value is .TRUE. searching for points with at least one of phys. tend. exceeding the threshold value is enabled. At each time step these points will be written to the file CHET.COORD.lfa

LCTPROF is a logical variable. When its value is .TRUE. It enables the extraction of 1-D vertical profiles at points with at least one tendency exceeding its threshold values. The profiles are extracted for each time step and written to the file ChetProfile.p-*nnnn*, where *p* stays for the point number and *nnnn* for the number of the time step.

CTHRVALS is a character array with descriptions of threshold values for physical tendencies. A description of threshold value consists of two fields. The first field is for entering the tendency name, and the second field is for precision. The lengths of fields are given with parameters NAMELENGTH and NCTHLEN, which are defined in module YOMCHET. Present values are 20 and 7. If the name is shorter than length of its field, field must be filled with blanks to reach its given length. The position of description in the array is essential because each tendency has fixed index in array.

WIDTH is a real variable containing the number of decimal orders over which the values of the physical tendencies are spread (see A.3.).

APREC is a real variable that contains the antilogarithm of class width on log-scale (see PREC in A.3.), it defines a precision of dividing the data in classes.

STARTCLASS is a real array and it contains the values of tendencies at the upper limit of the first class, the value at lower limit is zero. The position in the array is essential because each tendency has fixed index in array. Although all variables have same number of decimal orders and precision, their values can be shifted several orders of magnitude one to another, as they are themselves not of the same order.

NPROFMAX is an integer variable in which the maximal number of SCM profiles is written. The number of profiles must be limited because in the case that some tendencies have too low thresholds too many output files are produced vesting a space on disk. In the case when the number of points in which threshold was exceeded is greater then this limit the execution of program is aborted, and threshold values in namelist must be increased.

The indices of the tendencies in the arrays are following:

Phys. tend. of U component of wind	1
Phys. tend. of V component of wind	2
Phys. tend. of enthalpy	3

Phys. tend. of specific moisture	4
Phys. tend. of ice specific contend	5
Phys. tend. of water specific contend	6

This indeces have name KVAR when they are used as the arguments of subroutines.

The default values for the variables in the namelist NAMCHET are listed here

```

LCTFREQ= .FALSE.

LCTCOOR= .FALSE.

LCTPROF= .FALSE.

CTHRVALS(1)= 'PTENDU      2.6E-3'
CTHRVALS(2)= 'PTENDV      2.6E-3'
CTHRVALS(3)= 'PTENDH      2.369 '
CTHRVALS(4)= 'PTENDQ      8.2E-7'
CTHRVALS(5)= 'PTENDQI     8.2E-7'
CTHRVALS(6)= 'PTENDQL     8.2E-7'

WIDTH= 8.0_JPRB

APREC= 1.1_JPRB

STARTCLASS(1)= 1.0E-9_JPRB
STARTCLASS(2)= 1.0E-9_JPRB
STARTCLASS(3)= 1.0E-6_JPRB
STARTCLASS(4)= 1.0E-13_JPRB
STARTCLASS(5)= 1.0E-13_JPRB
STARTCLASS(6)= 1.0E-13_JPRB

NPROFMAX= 10

```

## Module YOMCHET

All global data needed for monitoring of physical tendencies are contained in this module. Two new data types are introduced to keep all information about physical tendencies in one global variable *GCHET*.

New types *TYPE\_CHET* and *TY\_PHYS\_TEND\_PT*

A new type *TYPE\_CHET*, with the structure shown bellow, contains all the information about physical tendencies.

**TYPE** *TYPE\_CHET*

```

LOGICAL                :: LCHET

LOGICAL                :: LCOORD

LOGICAL                :: LGPROF

CHARACTER(4)          :: CEXPNM

CHARACTER(NAMELENGTH), POINTER, &
& DIMENSION(:)        :: CVARNA

INTEGER_M             :: NVPHT

INTEGER_M             :: NWIDTH

INTEGER_M             :: NPHTEXTH

REAL_B                :: ATIMEST

REAL_B                :: APREC

REAL_B                :: AWIDTH

REAL_B,POINTER, &
& DIMENSION(:,:)     :: ACLASS

REAL_B,POINTER, &
& DIMENSION(:,:)     :: FQDIST

REAL_B,POINTER, &
& DIMENSION(:,:)     :: ACUMFQ

REAL_B,POINTER, &
& DIMENSION(:)       :: TENDTHRESH

TYPE(TY_PHYS_TEND_PT), POINTER, &
& DIMENSION(:)       :: APOINT

```

**END TYPE TYPE\_CHET**

The meaning of the components of TYPE\_CHET is as follows:

LCHET : switch for freq. distr. calculations, it is assigned the value  
of LCTFREQ from NAMCHET, and has the same  
meaning.

LCOORD : switch for extraction of points, it is assigned the value of

LCTCOOR from NAMCHET, and has the same meaning.

LGPROF : switch for extraction of profiles, it is assigned the value of

LCTCOOR from NAMCHET, and has the same meaning.

CEXPNM : the name of the ARPAGE/ALADIN job, the same as

CNMEX from module YOMSSA

CVARNA : the array with names of variables, used for output. Its

values are assigned in SUCHED, and can be a default name

or the name from CTHRVALS variable from namelist

NVPHT : number of variables for which phys. tendency diagnostics

is done, it is set in SUQCHET

NWIDT : number of classes for frequency distributions (see A.3)

NPHTEXTH : number of points with phys. tend. exceeding the threshold

ATIMEST : the time step

APREC : precision (see A.3)

AWIDTH : number of decimal orders of magnitude for interval in

which frequency distribution is calculated (see A.3)

FQDIST : array with frequency distributions of phys. tend.

ACUMFQ : array with cumulative frequency distribution

APOINT : array with points where threshold value is exceeded

The points with absolute values of tendencies exceeding a threshold value are described with structure given with the type TY\_PHYS\_TEND\_PT, and its definition is given below:

**TYPE** TY\_PHYS\_TEND\_PT

REAL\_B :: ALAT ! latitude in radians

REAL\_B :: ALONG ! longitude in radians

REAL\_B :: HEIGHT ! height in meters

REAL\_B :: TEND\_VAL ! value of exceeded tendency

INTEGER\_M :: NCHETLONG ! the index of point in the work space

**END TYPE** TY\_PHYS\_TEND\_PT

The global variable GCHET

The global variable *GCHET* of type *TYPE\_CHET* is the central point in monitoring of physical tendencies. The job done by all subroutines in monitoring of phys. tend. is mainly to something with its components.

Set up and reset, *SUCHET* and *RESETCHE*

*SUCHET*

Subroutine *SUCHET* prepares the global variable *GCHET* for computations. It first initialises namelist *NAMCHET* variables assigning them default values and then reads namelist. After that, values of *GCHET*'s components are assigned, and pointers are allocated.

It is called from *SUOYOMA*, and must be called before time step loop.

*RESETCHE*

Subroutine *RESETCHE* resets some of the *GCHET*'s component for calculations in a next time step. It is called from *CNT4*.

Frequency distribution, *CPCHET* and *WRITECHET*

*CPCHET*

Within subroutine *CPCHET* frequency distributions for six physical tendencies are calculated. It calls *CPCHET\_1*, which calculates frequency distribution for each physical tendency

.Arguments of *CPCHET* are:

*KPROMA* : horizontal dimension

*KSTART* : first element of work

*KPROF* : last element of work.

*KFLEV* : number of levels in grid point space

*PTENDU* : "U"-wind tendency due to physics.

*PTENDV* : "V"-wind tendency due to physics.

*PTENDH* : Enthalpy tendency.

*PTENDQ* : Moisture tendency.

*PTENDQI* : Ice tendency.

*PTENDQL* : Liquid water tendency.

*CPCHET\_1*

Subroutine *CPCHET\_1* calculates frequency distribution for one physical tendency. It is called from *CPCHET*

Arguments of *CPCHET\_1* are:

*KVAR* : index of physical tendency (see B.1)

*KPROMA* : horizontal dimension

*KSTART* : first element of work

*KPROF* : last element of work.

*KFLEV* : number of levels in grid point space

*PTEND* : array with physical tendency for chosen variable (*KVAR*).

## WRITECHET

Subroutine WRITECHET writes frequency distributions to the file CHET.FREQ.lfa. It is called from subroutine CNT4, from the main time loop.

Argument of WRITECHET is:

KTSNO : number of the time step

Extraction of points, CHETEXTH

Within CHETEXTH points in which at least one of total tendencies exceeds its threshold value are found and written to file. This is achieved by calls to subroutine CHETEXTH\_1 for the each one of total tendencies

Arguments of CHETEXTH:

KPROMA : horizontal dimension

KSTART : first element of work

KPROF : last element of work.

KFLEV : number of levels in grid point space

KTSNO : time-step number

PTENDU : "U"-wind tendency due to physics.

PTENDV : "V"-wind tendency due to physics.

PTENDH : Enthalpy tendency.

PTENDQ : Moisture tendency.

PTENDQI : Ice tendency.

PTENDQL : Liquid water tendency.

PHI : geopotential height on interlayers at time t.

PHIF : geopotential height on layers at time t.

Extraction of points, CHETEXTH\_1

Subroutine CHETEXTH\_1 searches over all points of working space for points where tendency that is passed as an argument exceeds its threshold value. The points are stored in GCHET%APOINT, and written to file CHET.KOORD.lfa.

Arguments of CHETEXTH\_1:

KVAR : index of physical tendency

KPROMA : horizontal dimension

KSTART : first element of work

KPROF : last element of work.

KFLEV : number of levels in grid point space



PTEND : array with physical tendency, must be that one to which

belongs index KVAR

Extraction of profiles, PROFILECHET

Subroutine PROFILECHET writes to the file *ChetProfile.p+nnnn* all values in the column over the geographical coordinates of the point needed for run of SCM (Single Column Model). PROFILECHET is called from the subroutine MF\_PHYS, and aborts the program execution if the number of points exceeds NPROFMAX (B.1).

Arguments of PROFILECHET are two numerous to be listed here. They are mainly the same as those of WRITEPYSIO, except for second to tenth argument in WRITEPYSIO, which are not needed in PROFILECHET, the first argument, although it 's name is different in two subroutines, has the same meaning, it is a horizontal dimension.

Modification of WRITEPHYSIO

A part of subroutine WRITEPHYSIO was extracted to new subroutine WRITEPROFILE. And at that place a call to WRITEPROFILE is inserted.

WRITEPROFILE

Subroutine WRITEPROFILE extracts from the models 3D fields 1D fields for SCM calculations. The names of files have the form *CDNAME.p+nnnn*, where *p* stays for the point number and *nnnn* for the number of the time step and *CDNAME* is an argument of subroutine.

First six arguments are:

CDNAME : the first part of the output file name

KLON : position of the nearest grid point in horizontal direction

PLAT\_MODELE : latitude of the geographical point

PLON\_MODELE : longitude of the geographical point

PD : orthodromic distance to the nearest grid point

PHOUR : time since the beginning of the prediction in hours.

Other arguments are the same as the corresponding arguments in WRITEPHYSIO.

Output files

All output files are written in the LFA format.

10.1 Description of the file CHET.FREQ.lfa

CLASSES1

CLASSES2

...

...

...

CLASSES6

FREQUENCY DISTRIBUTIONS FOR TIME STEP 1

FREQUENCY DISTRIBUTIONS FOR TIME STEP 2

...

...

...

FREQUENCY DISTRIBUTIONS FOR TIME STEP last step

CLASSES<sub>i</sub> are written in subroutine SYCHET, and frequency distributions in

WRITECHET.

CLASSES<sub>i</sub> are written for each variable, and each is a series of NWIDT numbers which are the values of tendency at the limits of classes.

The FREQUENCY DISTRIBUTIONS FOR TIME STEP has following fields:

INDEXP

TIME\_STEP

FREQUENCY DISTRIBUTION 1

FREQUENCY DISTRIBUTION 2

...

...

...

FREQUENCY DISTRIBUTION last tendency

INDEXP is the name of experiment, it to CNMEXP

TIME\_STEP is the time step length in seconds

The FREQUENCY DISTRIBUTION contains frequency distribution for one tendency, at the given time step. It is a series of NWIDT+1 numbers, that are frequencies for each class, and one more, the frequency for tendencies greater then value at the limit of the highest class.

10. 2 Description of file the file CHET.COORD.lfa

INDEXP

TIME\_STEP

POINTS AT TIME STEP 1

POINTS AT TIME STEP 2

...

...

...

POINTS AT TIME STEP last time step

INDEXP is the name of experiment, it to CNMEXP

TIME\_STEP is the time step length in seconds

POINTS AT TIME STEP is a series of points:

POINT 1

POINT 2

...

...

...

POINT n

POINT has following structure :

DESCRIPTOR

LONGITUDE

LATITUDE

HEIGHT OVER SEA

HEIGHT OVER OROGRAPHY

TIME STEP NUMBER

TENDENCY VALUE

DESCRIPTOR is a character string with tendency name and number of class to which belongs the value of tendency

Modification in SUOYOMA, CNT4 and MF\_PHYS

In SUOYOMA the call to SUCHET is added.

In CNT4 calls to WRITECHET and RESECHET are added.

In MF\_PHYS CP calls to CHET, CHETEXTH and PROFILECHET are added.