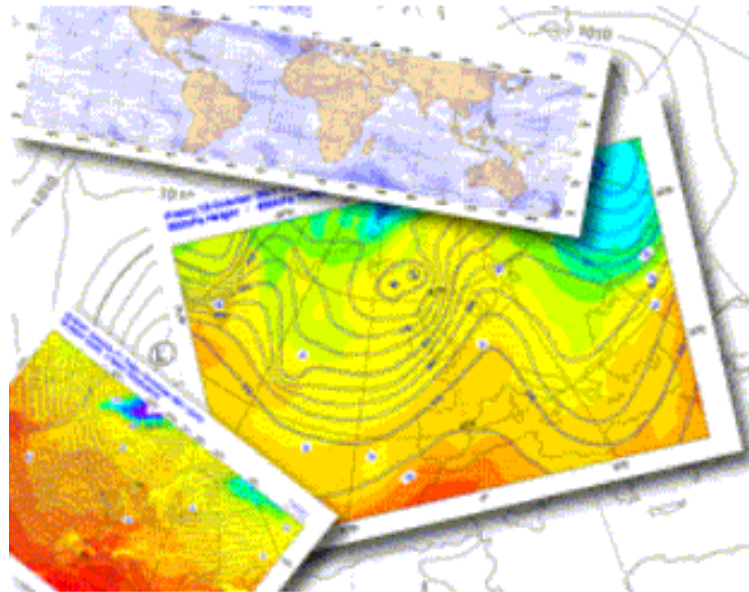


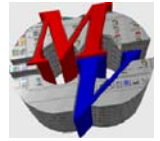
# Metview – Macro Language



**Iain Russell,**

**ECMWF**

# Macro Introduction



- **Designed to perform data manipulation and plotting from within the Metview environment**

```
basic - /home/graphics/cgi/metview/macro_tutorial_prep/for_overheads/
File Edit Search Preferences Shell Macro Windows Help
/home/graphics/cgi/metview/macro_tutorial_prep/for_overheads/basic 215 bytes L: 13 C: 0

# Load the forecast and analysis data files

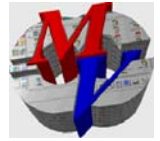
analysis_grib = read("analysis.grib")
forecast_grib = read("forecast.grib")

# Compute and plot the difference

fa_diff = forecast_grib - analysis_grib

plot (fa_diff)
```

# Macro Introduction



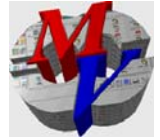
- **Able to describe complex sequences of actions**

```
basic - /home/graphics/cgi/metview/macro_tutorial_prep/for_overheads/
File Edit Search Preferences Shell Macro Windows Help
/home/graphics/cgi/metview/macro_tutorial_prep/for_overheads/basic 471 bytes L: 28 C: 0

# loop through dates - every 2 days

for d = 2003-09-01 to 2003-09-10 by 2 do
  rd = retrieve_data (d)      # user-defined function
  modify_data (rd)           # user-defined function
  plot_data_ps (rd)          # user-defined function
end for
```

# Macro Introduction



- **Easy as a script language - no variable declarations or program units; typeless variables**

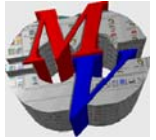
```
/home/graphics/cgi/metview/macro_tutorial_prep/for_overheads/basic 853 bytes L: 36 C: 0

# Load various data files

fs_rain    = read ("rain.grib")           # loads as a fieldset
geo_rain   = read ("rain_points.txt")    # loads as geopoints
ncdf_rain  = read ("rain.netcdf")        # loads as netcdf

print(type(fs_rain))                     # output: "fieldset"
print(type(geo_rain))                    # output: "geopoints"
print(type(ncdf_rain))                    # output: "netcdf"
```

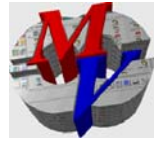
# Macro Introduction



- **Complex as a programming language - support for variables, flow control, functions, I/O and error control**

```
home/graphics/cgi/metview/macro_tutorial_prep/for_overheads/basic 979 bytes L: 45 C: 0  
  
home = getenv("HOME")  
path = home & "/metview/test_data.grib"  
  
if (not(exist(path))) then  
    fail("file does not exist")  
end if
```

# Macro Introduction



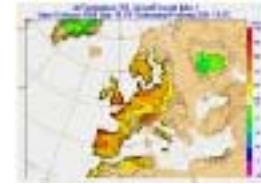
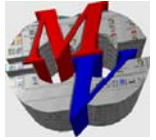
- Interfaces with user's FORTRAN programs

```
/home/graphics/cgi/metview/macro_tutorial_prep/macro_tut1/gradientb.f 3154 bytes L: 12 C: 0
C
C  "GRADIEN" COMPUTES
C
C  THIS PROGRAM IS A MO
C  "GRADIEN" TO TAKE 1
C
PROGRAM GRADIEN
PARAMETER (ISIZE=
DIMENSION ISEC0(2
DIMENSION ISEC1(1

***  GET FIRST ARGUMEN
CALL MGETG(IGRIB1

graphics/cgi/metview/macro_tutorial_prep/for_overheads/basic 1181 bytes L: 55 C: 27
extern gradientb(f:fieldset) "gradientb"
# Retrieve the specific humidity
q = retrieve (
    date      : -1,
    param     : "q",
    level     : 700,
    grid      : [1.5,1.5]
)
# Compute the gradient of Q
q = gradientb(q)
```

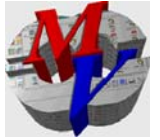
# Uses of Macro Language



- **Generate visualisation plots directly**
- **Generate a derived data set to drop in plot or animation windows or to input to other applications**
- **Provide a user interface for complex tasks**
- **Incorporate macros in scheduled tasks - thus use Metview in an operational environment, run in batch mode**

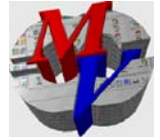
# Data For Tutorial

---

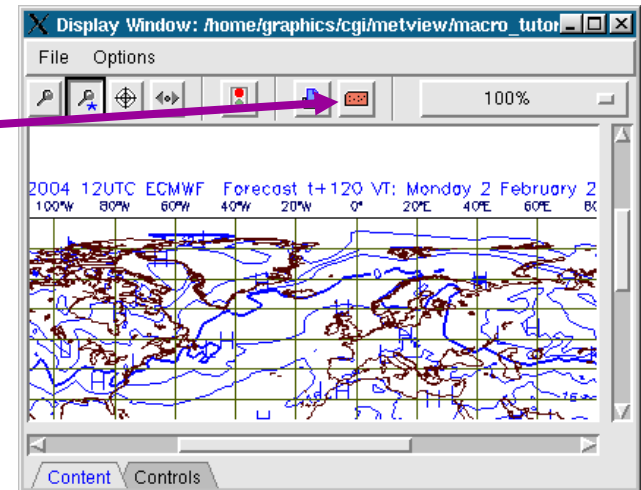


- `cd ~/metview`
- `~trx/mv2007/get_macro_data`

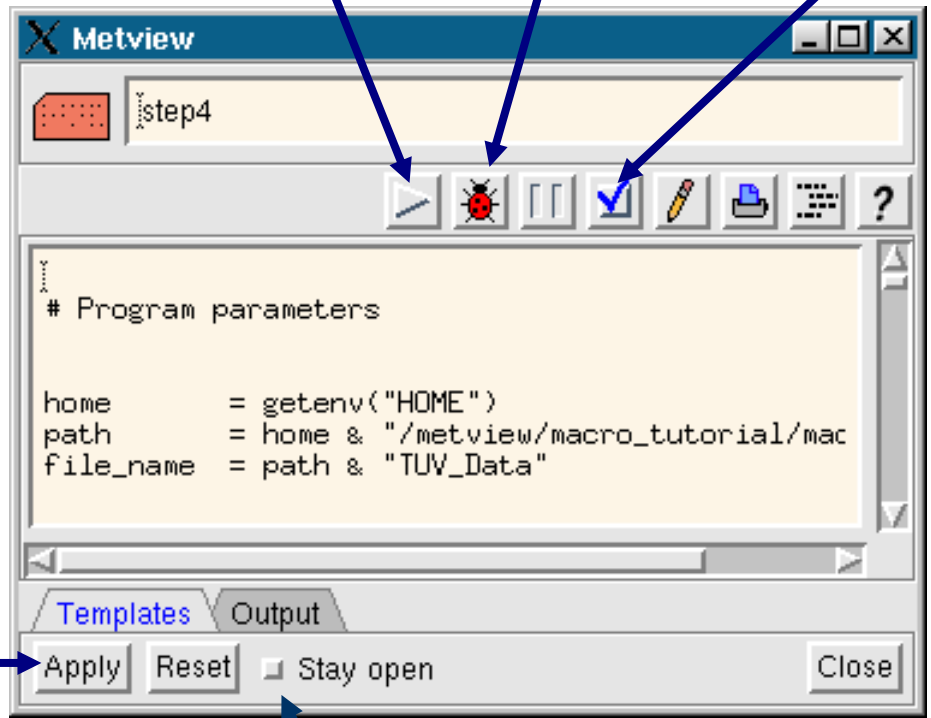
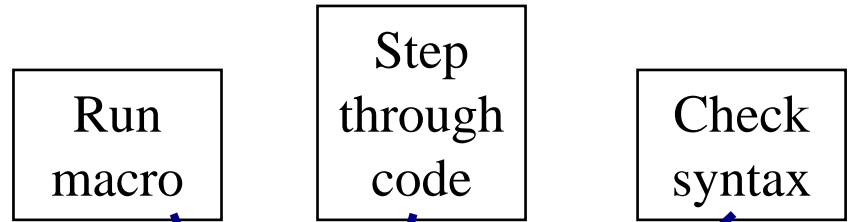
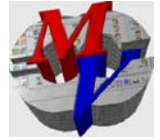
# Creating a Macro Program



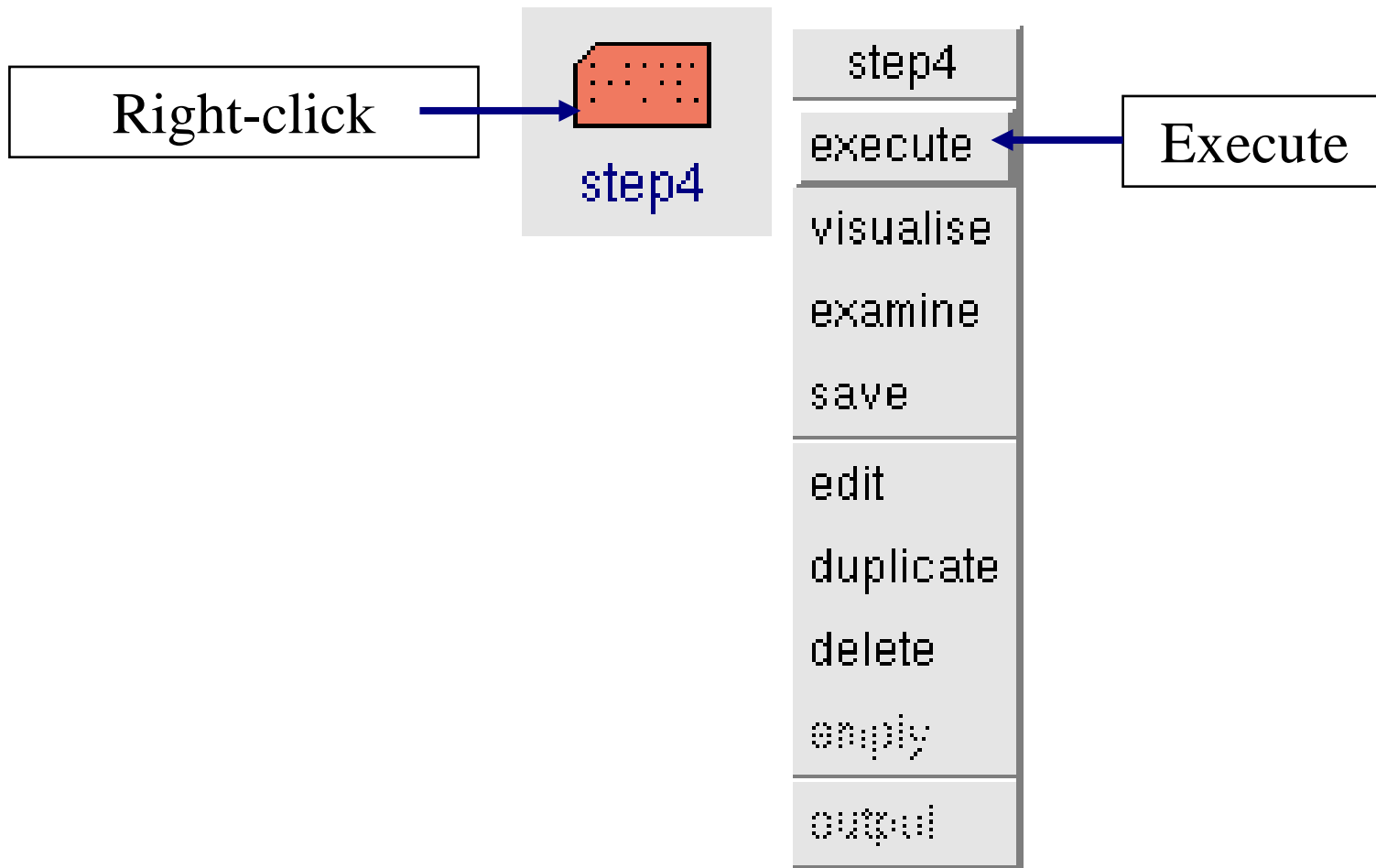
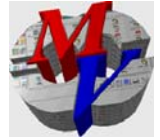
- **Save visualisation as Macro - limited in scope**
- **Drop icons inside Macro Editor, add extra bits**
- **Write from scratch (the more macros you write, the more you recycle those you have done, lessening the effort)**



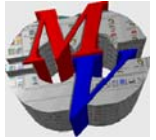
# The Macro Editor



# Executing Macros Another Way



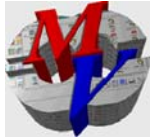
# Macro Documentation



- <http://www.ecmwf.int/>
  - ◆ [publications/manuals/metview](#)
    - ➔ [manual/mvug\\_user.pdf](#)
    - [manual/mvug\\_new](#)
    - [manual/mvug\\_export.pdf](#)
  - ➔ or
  - ➔ [manual/index.html](#)

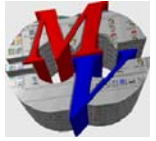
# Tutorial Contents

---



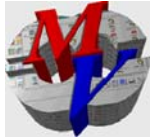
- **Steps 1-4 : Basic intro - input, basic contours, plot window, variables and functions**
- **Steps 5-7 : Outputs other than on-screen**
- **Step 8 : Macro run mode control**
- **Steps 9-10 : User Interfaces in Macro**
- **Step 11 : Macro in Batch**
- **Steps 12a,b,c : Using functions in Macro (libraries)**
- **Embedding FORTRAN in Macro**

# Fortran in Macro - Introduction



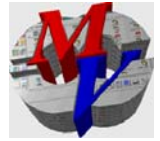
- **Very powerful feature of the macro language.**
- **Extends immensely its scope, allows efficient use of existing resources.**
- **FORTTRAN programs used in tasks which can not be achieved by macro functions, e.g. calculations using gridpoint positions. Or use existing FORTRAN code to save time.**
- **FORTTRAN-Metview macro interface supports input data of type GRIB, number, string and vector. BUFR, images and matrices are waiting implementation.**

# Fortran in Macro – General Approach



- **Embed FORTRAN source code in the macro source file**
    - ◆ **OR**
  - **Compile FORTRAN program separately or take an existing executable**
- 
- **FORTRAN program is treated as another macro function**
  - **Specify some MARS retrievals to provide input fieldsets, use FORTRAN function to provide derived field(s);**

# Fortran in Macro – General Approach



- Embed the FORTRAN code in the macro program using the **inline** keyword

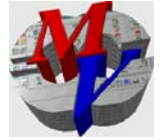
```
File Edit Search Preferences Shell Macro Windows Help
/metview/macro_tutorial/prep/gradient_ex 325 bytes L: 17 C: 0
extern gradientb(f:fieldset) "fortran" inline

    PROGRAM GRADIENTB
    PARAMETER (ISIZE=50000)
    ...
    ...
C    GET FIRST ARGUMENT AS A FIELDSET.
    CALL MGETG(IGRIB1, ICNT)
    ...
    ...
end inline

#-----
q = retrieve( param : "q",
              ... )

q = gradientb(q)
```

# Fortran in Macro – General Approach



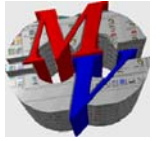
- **OR** specify location of the FORTRAN executable to the macro program

```
basic (modified) - /home/graphics/cgi/metview/macro_tutorial_prep/
File Edit Search Preferences Shell Macro Windows Help
hics/cgi/metview/macro_tutorial_prep/for_overheads/basic 1181 bytes L: 55 C: 27
extern gradientb(f:fieldset) "gradientb"

# Retrieve the specific humidity
q = retrieve (
    date      : -1,
    param     : "q",
    level     : 700,
    grid      : [1.5,1.5]
)

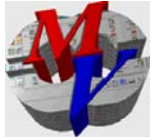
# Compute the gradient of Q
q = gradientb(q)
```

# Fortran in Macro – General Approach



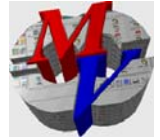
- **Use suite of FORTRAN routines to get the input arguments, decode GRIB headers, save and set results, - these are the “interface routines”.**
- **Schematically, the FORTRAN program dealing with a GRIB file is composed of**
  - ◆ **a section where input is read and output prepared**
  - ◆ **a loop where fields are loaded, expanded, validated, processed and saved**
  - ◆ **a section where output is set**

# Fortran in Macro – A Simple Example



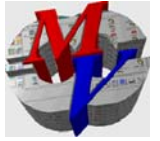
- **Advection of scalar field requires FORTRAN program to obtain the gradient of the field.**
- **Assume you will have a FORTRAN program called `gradientb` returning the gradient of a fieldset in two components (then advection is trivial). First concentrate on the writing of the macro program itself.**
- **Examine macro provided, which computes advection of specific humidity  $q$  at 700 hPa**
- **Examine FORTRAN source code provided, which computes gradient of a field**

# Fortran in Macro – A Simple Example



- **Note interface routines, prefixed by "M" (MGETG, MNEWG, MLOADG, MSAVEG, MSETG). Most of the FORTRAN code is standard to process a GRIB fieldset.**
- **User routine GRAD() calculates gradient of input fieldset in two components:**
  - ◆ **saved separately and coded as wind components -**
  - ◆ **each can be accessed separately in the macro for the calculation of the advection.**
- **Two methods for making the program visible to macros:**

# Fortran in Macro – Embedding the FORTRAN Program



- **Method 1**: write the FORTRAN code inline – i.e., inside the macro code itself:

```
extern gradientb(f:fieldset) "fortran" inline
```

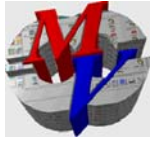
```
PROGRAM GRADIENTB
```

```
CALL MGETG(IGRIB1,ICNT)
```

```
. . .
```

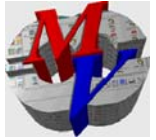
```
end inline
```

# Fortran in Macro – Embedding the FORTRAN Program



- **This can be written directly into the macro that will use it or else in a separate file.**
- **If written to a separate file, it can be accessed with the `include` macro command.**
- **If named correctly, it can be placed in the Macro folder of the Metview system folder (`~uid/metview/Metview/Macros`). In this case, the calling macro does not need any extra lines in order to use this function.**

# Fortran in Macro – Embedding the FORTRAN Program



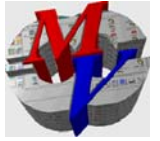
- **Method 2**: compile and link the FORTRAN program separately. Then:
- a) inform the macro program where to find the FORTRAN executable:

```
extern gradientb(f:fieldset)
```

```
"/home/xy/xyz/metview/fortran/gradientb"
```

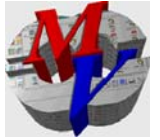
- or b) place the executable in the Macro folder of the Metview system folder (~uid/metview/Metview/Macros)
  - ◆ No need to specify this location to the macro

# Fortran in Macro – Embedding the FORTRAN Program



- **Finally, save the macro and execute to obtain the desired result.**
- **The procedure above is fairly general and with minor changes, can be adapted to other tasks just by replacing the processing routine.**

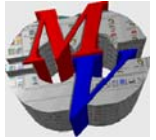
# Macro Essentials - Variables



- No need for declaration
- Dynamic typing

```
a = 1          # type(a) = 'number'  
a = 'hello'    # type(a) = 'string'  
a = [4, 5]     # type(a) = 'list'
```

# Macro Essentials - Variables



- **Scope and Visibility**

- ◆ **Variables inside functions are local**

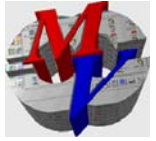
- ◆ **Functions cannot see 'outside' variables**

```
x = 9                # cannot see y here

function func
    y = 10           # cannot see x here
end func

                    # cannot see y here
```

# Macro Essentials - Variables



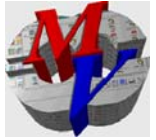
- **Scope and Visibility**

- ◆ ... unless a variable is defined to be 'global'

```
global g1 = 9           # cannot see y1 here
function func
    y1 = 10 + g1        # can see g1 here
end func

                        # cannot see y1 here
```

# Macro Essentials - Variables



- **Scope and Visibility**

- ◆ ... a better solution is to pass a parameter
- ◆ ... that way, the function can be reused in other macros

```
x = 9

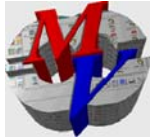
func(x)      # x is passed as a parameter

function func (t : number) #t adopts value of x

    y1 = 10 + t          # y1 = 10 + 9

end func
```

# Macro Essentials - Variables



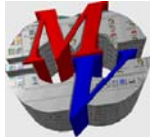
- Destroying variables automatically
  - ◆ When they go out of scope

```
function plot_a
  a = retrieve(...)
  plot(a)
end plot_a
```

```
# Main routine
```

```
plot_a() # a is created and destroyed
```

# Macro Essentials - Variables



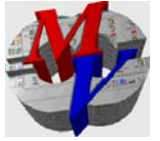
- Destroying variables manually

- ◆ Set to zero

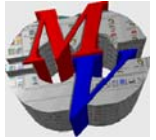
```
a = retrieve(...)  
plot(a) # we have finished with 'a' now  
a = 0  
b = retrieve(...)  
plot(b)
```

# Macro Essentials – Loops, Tests & Functions

---



- **The for, while, repeat, loop statements**
  - ◆ **See ‘Metview Macro Syntax’ handout**
  
- **The if/else, when, case statements**
  - ◆ **See ‘Metview Macro Syntax’ handout**
  
- **Function declarations**
  - ◆ **See ‘Metview Macro Syntax’ handout**



- **Multiple versions**

- ◆ **Can declare multiple functions with the same name, but with different parameter number/types.**

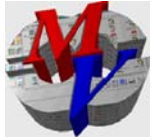
```
function fn_test ()
```

```
function fn_test (param1: string)
```

```
function fn_test (param1: number)
```

- ◆ **Correct one will be chosen according to the supplied parameters**

# Macro Essentials - Strings



- `'Hello'` is the same as `"Hello"`
- Concatenate strings with strings, numbers and dates using the `'&'` operator

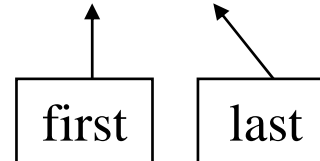
eg. `"part1_" & "part2_" & 3`

produces `"part1_part2_3"`

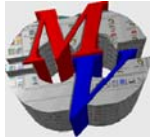
- Obtain substrings with `substring()`

e.g. `substring ("Metview", 2, 4)`

produces `"etv"`



# Macro Essentials - Strings



- Split a string into parts using `parse()`
- Creates a list of substrings

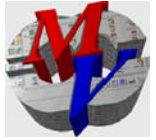
```
n = parse("z500.grib", ".")
```

```
print ("name = ", n[1], " extension = ", n[2])
```

◆ prints the following string :

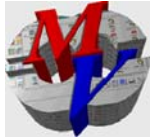
`name = z500 extension = grib`

# Macro Essentials - Dates



- Dates defined as a built-in type - year, month, day, hour, minute and second.
- Dates can be created as literals using :
  - ◆ `yyyy-mm-dd`
  - ◆ `yyyy-DDD`
  - ◆ where : yr, yyyy - 4 digit yr, mm - 2 digit month, dd - 2 digit day, DDD - 3 digit Julian day.
- The time can be added using :
  - ◆ `HH:MM` or `HH:MM:SS`
  - ◆ Eg `start_date = 2003-03-20 12:01`

# Macro Essentials - Dates



- **Function `date()` creates dates from numbers:**

`d1 = date(20050129)`

`today = date(0)`

`yesterday = date(-1)`

- **Hour, minute and second components are zero.**

- **To create a full date, use decimal dates:**

`d = date(20050129.5)`

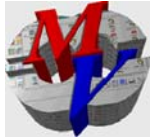
or

`d = 2002-01-29 + 0.5`

or

`d = 2002-01-29 + hour(12)`

# Macro Essentials - Dates

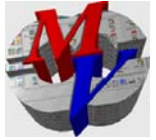


- **Note that numbers passed to Metview modules are automatically converted to dates:**

```
r = retrieve(date : -1, ...)
```

```
r = retrieve(date : 19970101, ...)
```

# Macro Essentials - Dates



- **Loops on dates using a for loop:**

```
for d = 2007-01-01 to 2007-03-01 do
    ...
end for
```

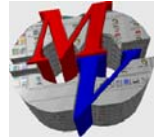
---

```
for d = 2007-01-01 to 2007-03-01 by 2 do
    ...
end for
```

---

```
for d = 2007-01-01 to 2007-03-01 by hour(6) do
    x = retrieve(
        date : yyyyymmdd(d),    # extract date
        time : hhmm(d),        # extract time
        ...
    )
end for
```

# Macro Essentials - Lists



- **Ordered, heterogeneous collection of values. Not limited in length. List elements can be of any type, including lists. Lists are built using square brackets, and can be initialised with `nil`:**

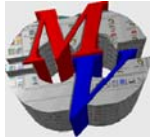
```
l = [3,4,"foo","bar"]
```

```
l = nil
```

```
l = l & [2,3,[3,4]]
```

```
l = l & ["str1"] & ["str2"]
```

```
europe = [35,-12.5,75,42.5] # S, W, N, E
```



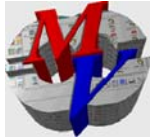
- **Accessing List Elements**

```
mylist = [10,20,30,40]
```

```
a = mylist[1]      # a = 10
```

```
b = mylist[2,4]   # b = [20,30,40] (m to n)
```

```
c = mylist[1,4,2] # c = [10,30] (step 2)
```



- Useful List Functions

```
num_elements = count (mylist)
```

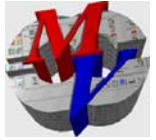
```
sorted = sort (mylist)
```

```
# can provide custom sorting function
```

```
if (2 in mylist) then
```

```
...
```

```
end if
```



- **Definition**

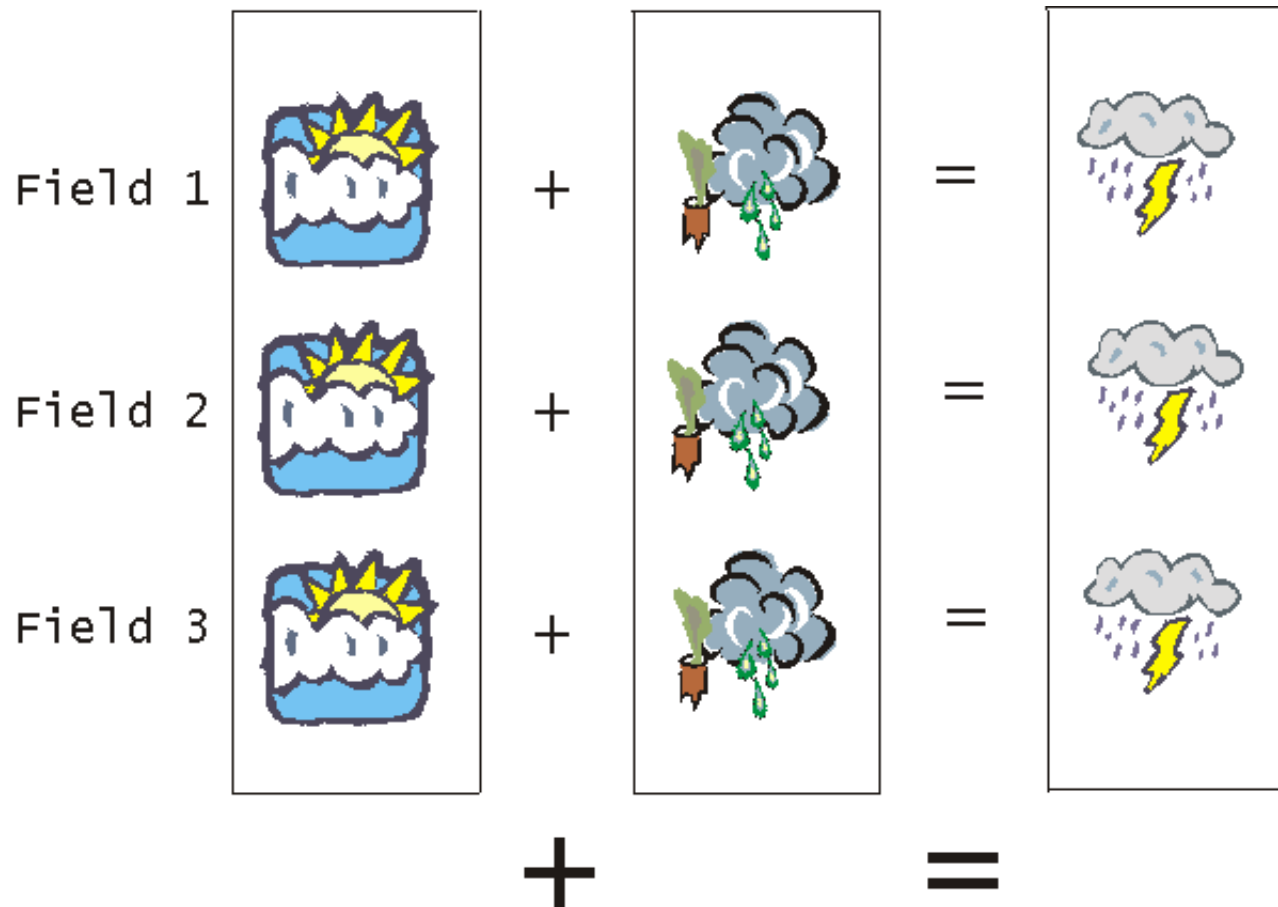
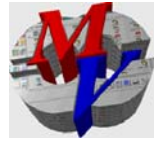
- ◆ **Entity composed of several meteorological fields, (e.g. output of a MARS retrieval).**

- **Operations and functions of fieldsets**

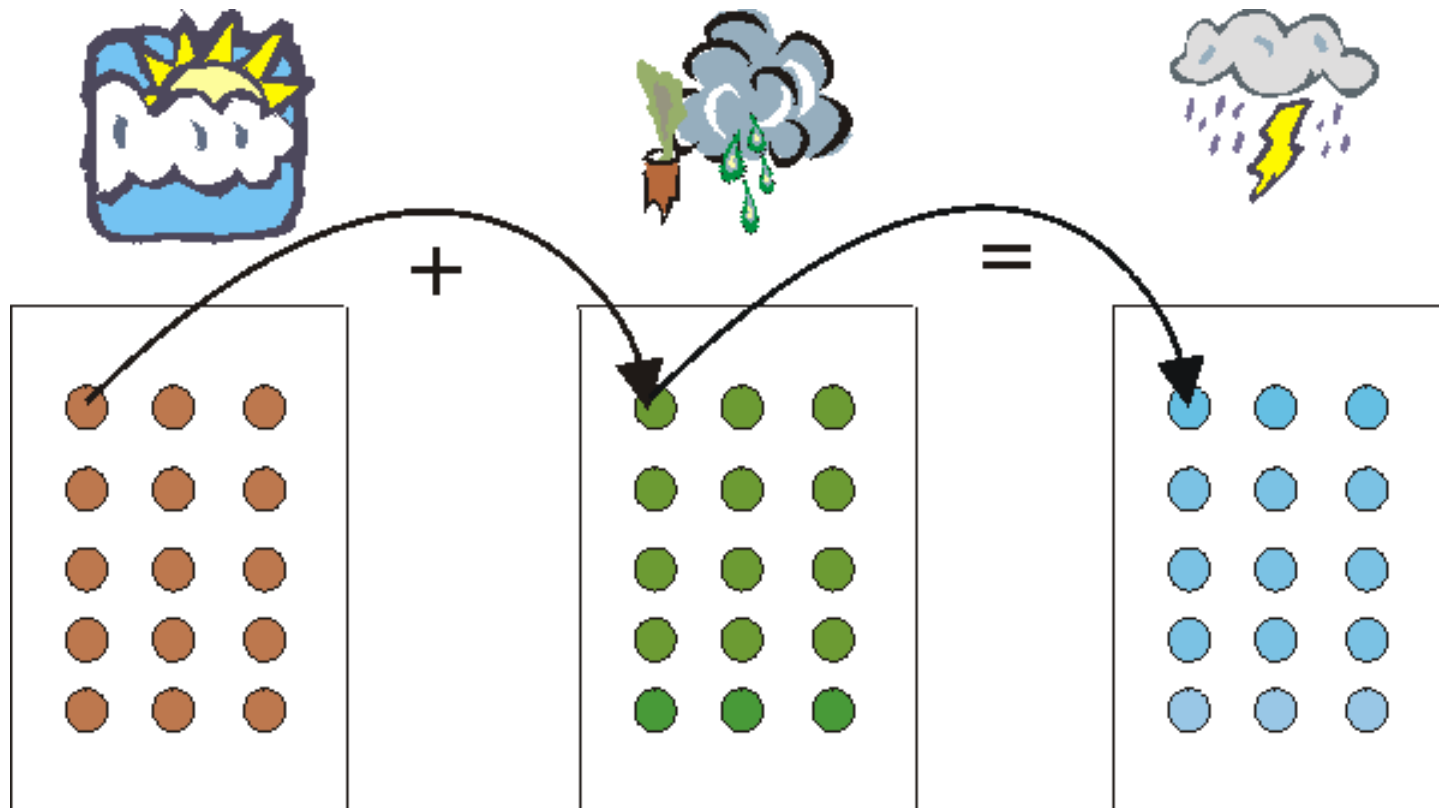
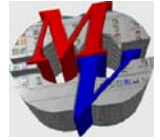
- ◆ **Operations on two fieldsets are carried out between each pair of corresponding values within each pair of corresponding fields. The result is a new fieldset.**

`result = fieldset_1 + fieldset_2`

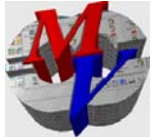
# Macro Essentials - Fieldsets



# Macro Essentials - Fieldsets



# Macro Essentials - Fieldsets



- **Operations and functions of fieldsets**

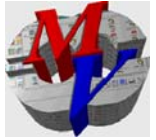
- ◆ **Can also combine fieldsets with scalars:**

$$Z = X - 273.15$$

**Gives a fieldset where all values are 273.15 less than the original (Kelvin to Celcius)**

- ◆ **Functions such as log:**

$$Z = \log(X)$$



- **Operations and functions of fieldsets**

- ◆ **Boolean operators such as > or <= produce 0 when the comparison fails, or 1 if it succeeds:**

$$Z = X > 0$$

**Gives a fieldset where all values are either 1 or 0**

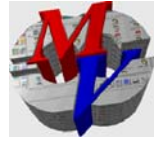
- can be used as a mask to multiply by
- `bitmap()` can be used to invalidate values

**e.g.**

```
t2m_masked = t2m * landseamask
```

```
t2m_masked = bitmap (t2m_masked, 0)
```

# Macro Essentials - Fieldsets



- suppose that fieldset 'fs' contains 5 fields:

- ◆ `accumulate(fs)`

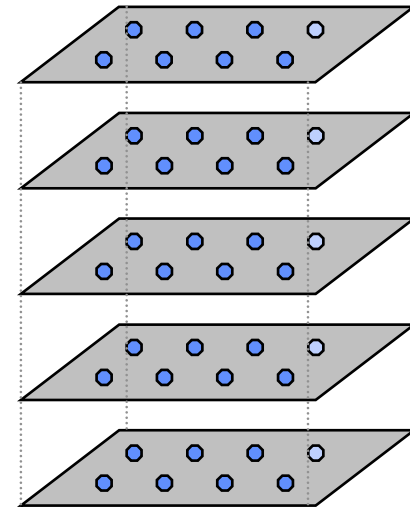
- returns a list of 5 numbers, each is the sum of all the values in that field

- ◆ `sum(fs)`

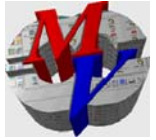
- returns a single field where each value is the sum of the 5 corresponding values in the input fields

- ◆ Many, many more – see the user guide

- e.g. `mean()`, `maxvalue()`, `stdev()`, `coslat()`



# Macro Essentials - Fieldsets



- **Building up fieldsets**

- ◆ `fieldset & fieldset , fieldset & nil`

- ◆ **merge several fieldsets. The output is a fieldset with as many fields as the sum of all fieldsets.**

```
fs = nil
```

```
for d = 2006-01-01 to 2006-12-31 do
```

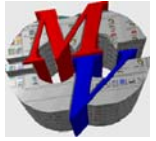
```
  x = retrieve(date : d, ...)
```

```
  fs = fs & x
```

```
end for
```

- ◆ **This is useful to build a fieldset from nothing.**

# Macro Essentials - Fieldsets



- **Extracting fields from fieldsets**

- fieldset [number]

- fieldset [number,number]

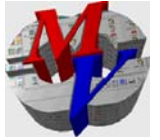
- fieldset [number,number,number]

- **Examples :**

```
y = x[2]           # copies field 2 of x into y
```

```
y = x[3,8]        # copies fields 3,4,5,6,7 and 8
```

```
y = x[1,20,4]     # copies fields 1, 5, 9, 13 and 17
```

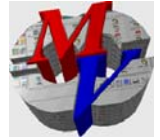


- Writing Fieldsets as Text

- ◆ Easy to save in Geopoints format (see next slide)

```
for i = 1 to count (fields) do
  gpt = grib_to_geo (data : fields[i])
  write ('field_' & i & '.gpt', gpt)
end for
```

# Macro Essentials - Geopoints



- Hold spatially irregular data
- ASCII format file

*#GEO*

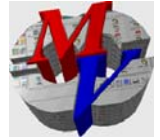
PARAMETER = 2m Temperature

lat	long	level	date	time	value
-----	------	-------	------	------	-------

*#DATA*

36.15	-5.35	850	19970810	1200	300.9
34.58	32.98	850	19970810	1200	301.6
41.97	21.65	850	19970810	1200	299.4

# Macro Essentials - Geopoints



- **Alternative format: XYV**

*#GEO*

*#FORMAT XYV*

PARAMETER = 2m Temperature

long	lat	value
------	-----	-------

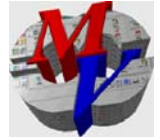
*#DATA*

-5.35	36.15	300.9
-------	-------	-------

32.98	34.58	301.6
-------	-------	-------

21.65	41.97	299.4
-------	-------	-------

# Macro Essentials - Geopoints



- **Alternative format: XY\_VECTOR**

*#GEO*

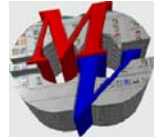
*#FORMAT XY\_VECTOR*

lat	lon	height	date	time	u	v
-----	-----	--------	------	------	---	---

*#DATA*

80	10	0	20030617	1200	-4.9001	-8.3126
80	5.5	0	20030617	1200	-5.6628	-7.7252
70	11	0	20030617	1200	-6.42549	-7.13829

# Macro Essentials - Geopoints



- **Alternative format: POLAR\_VECTOR**

*#GEO*

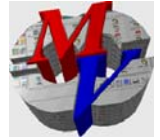
*#FORMAT POLAR\_VECTOR*

lat lon height date time speed direction

*#DATA*

50.97	6.05	0	20030614	1200	23	90
41.97	21.65	0	20030614	1200	4	330
35.85	14.48	0	20030614	1200	12	170

# Macro Essentials - Geopoints



- **Operations on geopoints**

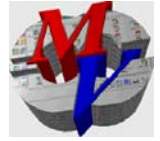
- ◆ **Generally create a new set of geopoints, where each value is the result of the operation on the corresponding input value**

- ◆ `geo_new = geo_pts + 1`

- Means "add 1 to each geopoint value, creating a new set of geopoints".

( 3 ,	4 ,	5 ,	6 ,	7 ,	8 )
↓	↓	↓	↓	↓	↓
( 4 ,	5 ,	6 ,	7 ,	8 ,	9 )

# Macro Essentials - Geopoints



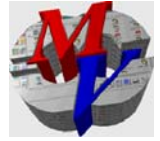
- **Operations on geopoints**

- ◆ `geo_gt_5 = geo_pts > 5`

- Means "create a new set of geopoints of 1 where input value is greater than 5, and 0 where it is not".

( 3 ,	4 ,	5 ,	6 ,	7 ,	8 )
↓	↓	↓	↓	↓	↓
( 0 ,	0 ,	0 ,	1 ,	1 ,	1 )

# Macro Essentials - Geopoints



## ● Filtering geopoints

◆ `result = filter (geo_pts, geo_pts > 5)`

◆ `result = filter (geo_pts, geo_gt_5)`

Equivalent

→ Means “extract from the first set of geopoints the points where the corresponding point in the second parameter is non-zero”.

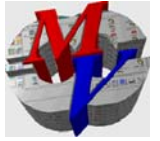
→ Means "create a new set of geopoints consisting only of those points whose value is greater than 5".

`geo_pts` : ( 3 , 4 , 5 , 6 , 7 , 8 )

`geo_gt_5` : ( 0 , 0 , 0 , 1 , 1 , 1 )

`result` : ( 6 , 7 , 8 )

# Macro Essentials - Geopoints



- **Example of functions on geopoints**

- ◆ `count (geopoints)`

- Returns the number of points

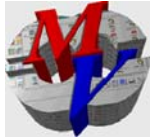
- ◆ `distance (geopoints, number, number)`

- Returns the set of distances from the given location

- ◆ `mean (geopoints)`

- Returns the mean value of all the points

# Macro Essentials - Geopoints



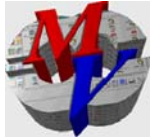
- **Combining Fieldsets And Point Data**

- ◆ **Point data is stored in *geopoints* variables**

- ◆ **Combination of geopoints and fieldsets is done automatically by Metview Macro :**

- - for each geopoint, find the corresponding value in the fieldset by interpolation
- - now combine corresponding values (add, subtract etc.)
- - the result is a new geopoints variable
- - only considers the first field in a fieldset

# Macro Essentials - Definitions



- A collection of named items (members)
- Eg

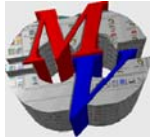
```
a = (x : 1, y : 2) # create definition
```

```
c = a.x           # get value of 'x'
```

or

```
c = a["x"]
```

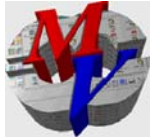
# Macro Essentials - Definitions



- **Icon-functions take definitions:**

```
acoast = pcoast(  
    map_coastline_resolution      :    "high",  
    map_coastline_colour         :    "black",  
    map_grid_colour              :    "black",  
    map_grid_longitude_increment :    10,  
    map_label_colour             :    "black",  
    map_coastline_land_shade     :    "on",  
    map_coastline_land_shade_colour:  "cream"  
)
```

# Macro Essentials - Definitions



```
param_def = ( param : "Z",  
              type  : "FC",  
              date  : -1,  
              step  : 24 )
```

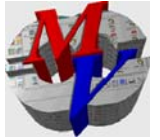
```
# retrieve as LL grid or not according to user
```

```
# choice
```

```
if (use_LL = "yes") then  
  param_def.grid = [1.5,1.5]  
end if
```

```
Z_ret = retrieve (param_def)
```

# Macro Essentials - Definitions

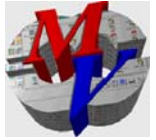


```
common_input = ( levtype : "PL",  
                 levelist : 850,  
                 date : -1,  
                 time : 12,  
                 grid : [2.5,2.5],  
                 type : "AN" )
```

```
Uan = retrieve ( common_input,  
                param : "U" )
```

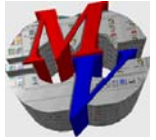
```
Van = retrieve ( common_input,  
                param : "V" )
```

# Macro Essentials – Data Input



- For GRIB files, `read()` reads the data into a fieldset
- For BUFR files, `read()` reads the data into an observations variable (usually convert to geopoints before using)
- For geopoints, `read()` reads the data into a geopoints variable
- For other ASCII data, `read()` reads the data into a list, where each element is a string containing a line of the text file. Use string functions `parse()` and `substring()` to separate elements further.

# Macro Essentials – Data Output



- **Use the `write()` function**

- using filename, subsequent calls overwrite

- using file handler, subsequent calls append

- **Can also use `append()`**

- **Automatic file format**

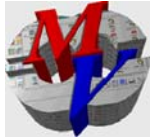
**fieldset**      ->      **GRIB file**

**observations** ->      **BUFR file**

**geopoints**      ->      **geopoints file**

**string**      ->      **ASCII file (custom formats)**

# Macro Documentation



- <http://www.ecmwf.int/>
  - ◆ [publications/manuals/](#)
    - [metview/manual/mvug\\_\[export/user/new\].pdf](#)
    - or
    - [metview/manual/index.html](#)
- [http://www.ecmwf.int/services/computing/training/material/com\\_mv.html](http://www.ecmwf.int/services/computing/training/material/com_mv.html)
  - ◆ **Material from this course will soon appear there!**
- **Ask!**
  - ◆ [metview@ecmwf.int](mailto:metview@ecmwf.int)