Metview ODB Tutorial

Meteorological Visualisation Section
Operations Department
ECMWF

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This tutorial was tested with Metview version 4.1.1
and will not work for previous versions.

Table of Contents

PREPARATIONS

Please note that this tutorial was designed to be used only at the ECMWF.

Before you start the tutorial you need to execute the following preparatory steps:

1. Start **Metview 4** with the following command:

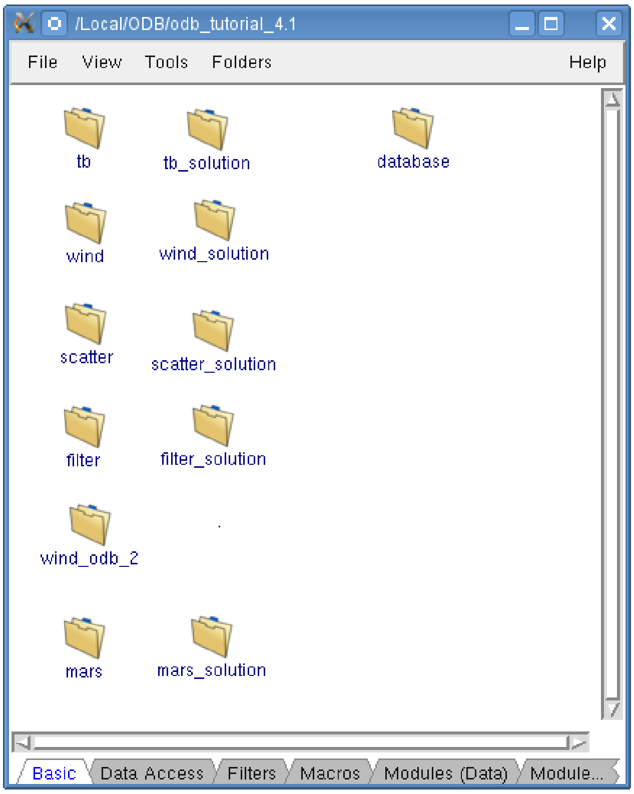
   metview4_new -slog &

   The optional -slog switch will enable Metview to print detailed logging information to the standard output.

2. Type the following command in a terminal window:

   cp -R /scratch/graphics/cgr/odb_tutorial_4.1 ~/metview

The directory that you just copied into your Metview environment contains all the icons for the tutorial and the solutions of the exercises, as well. In your main Metview folder now you should find an 'odb_tutorial_4.1' folder with the following contents (double-click to open).



PART 1 - THE ODB DATABASE ICON

In this exercise we will learn about the *ODB Database* icon and see how to examine its meta-data content.

The ODB Database Icon

Open folder 'database' inside your 'odb_tutorial_4.1' folder (double-click or right-click, **edit)**. Here you will find all the *ODB Database* icons used in the tutorial.

These icons represent ODB databases residing on our file system. More precisely, in our case, these are only symbolic links to the databases to save disk space. Symbolic links can be really useful for working with the usually quite large ODB databases.

> About symbolic links:
> To create a symbolic link right-click in the Metview desktop with no icons selected and choose **new link**… from the menu and type your database path into the **Selection** box. Please note that the text label under symbolic link icons is in italics.

Remarks

- *ODB database* icons, like any other Metview icons, can be dragged and dropped between Metview folders. However, if the icon is not a symbolic link the whole data structure, which is usually very big, is copied/moved over during such an operation, so it might take a significant amount of time. On the contrary, for a symbolic link the link itself is copied over during a drag and drop operation so it is safe to use.

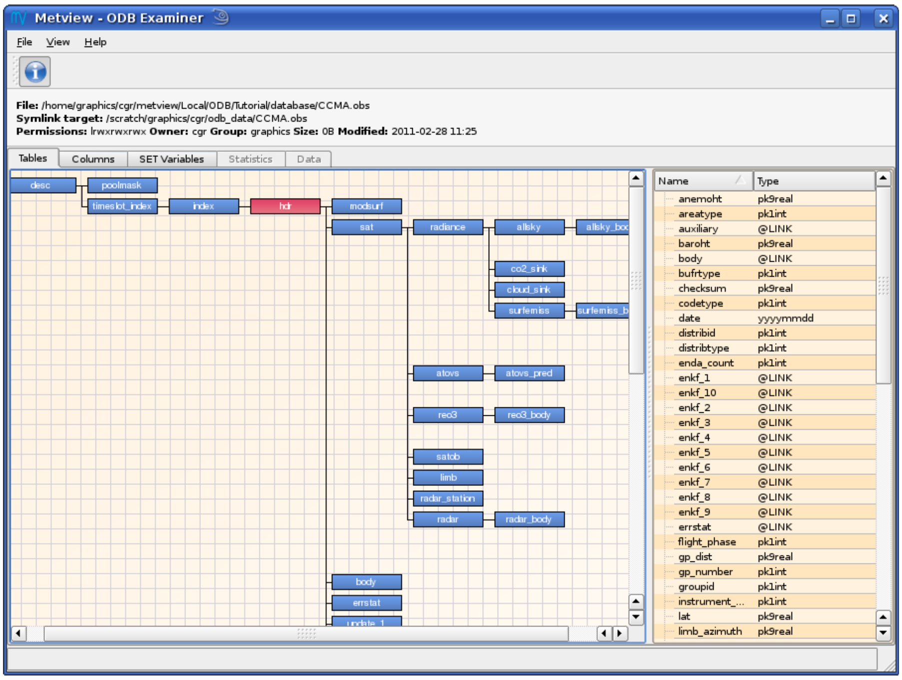
The ODB Binary Representations

In the framework of the Observation Handling and Monitoring project a new binary representation was developed for ODB to enable MARS archiving. This new format is referred to as ODB-2, while the previous one as ODB-1. The ODB-2 format currently comes only with a "flat" structure (i.e. with one single table) and represented by a single file instead of the usual CCMA/ECMA, etc. directory structures.

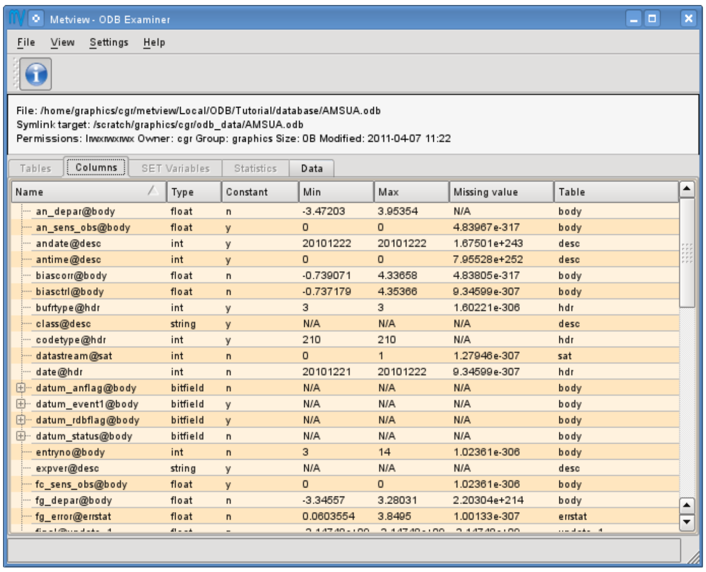
Metview uses the same icon for both ODB formats, hiding the differences between them and providing the users with an interface which is **format transparent**. However, please note that wind plotting presently requires different approaches for the ODB-1 and ODB-2 formats, respectively (see *PART 3* and *PART 7* for details on the differences).

The ODB Examiner

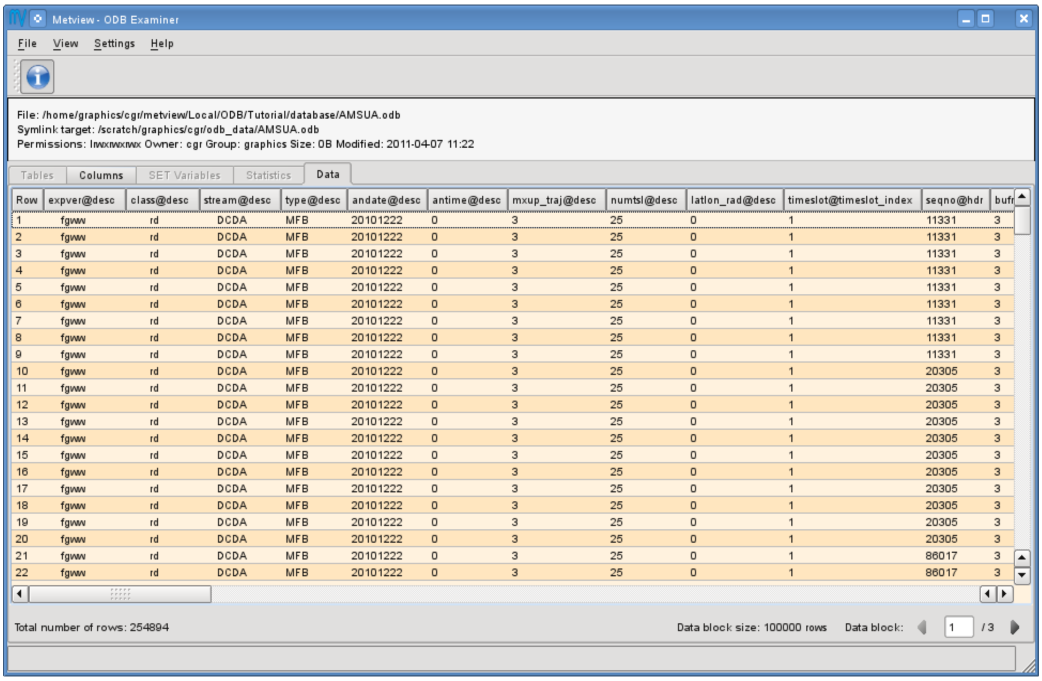
Right-click on your 'CCMA.obs' *ODB Database* icon and select **examine** from the icon menu. This will start the **ODB Examiner** application that displays the meta-data of the database. By default you should see the **Tables** tab of the interface showing the ODB table hierarchy. This hierarchy only exists only for the ODB-1 format (so we can see that our 'CCMA.obs' icon represents an ODB-1 database). By clicking on a table name the columns belonging to the selected table are displayed in the right hand side of the interface. There are two more tabs in the interface: the **Columns** tab showing the list of all the available columns and the **SET Variables** tab providing the users with the list of pre-defined ODB variables. Explore these tabs and then close the **ODB Examiner**.



Now right click and **examine** icon 'AMSUA.odb'. It points to an ODB-2 database (just like icon 'AIREP.odb'). Since there is no table hierarchy to be shown the list of all the available columns is displayed by default (**Columns** tab).

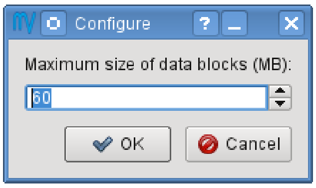


The data values stored in the ODB can be also inspected in the **ODB Examiner** (this feature is currently working only for ODB-2). Just click on the **Data** tab to see the data values. If there are too many values to be shown the **ODB Examiner** displays the data items in blocks. The actual size of the data blocks (in terms of rows) can be seen at the bottom of the interface next to the data block navigation buttons. Data blocks were introduced to reduce memory usage since the **ODB Examiner** has to keep in memory all the values shown in the **Data** tab.



Remarks

- The **ODB Examiner** contains a file information panel at the top showing the full icon path. If the icon is a symbolic link this panel also shows the location in the file system where the link points to.
- Each column in the **Data** tab can be sorted by clicking on the column heading. However, please note that sorting is enabled only if all the available data values can be displayed at once, i.e. no data blocks are to be used. By default the **ODB Examiner** starts splitting the data into data blocks if more than 60 MB is needed to store the data values in memory. You can override this default value in the **Configure** dialog available from the **Settings** menu in the menu bar.



PART 2 - SYMBOL PLOTTING ON MAPS

In this exercise we will retrieve and plot the brightness temperature values for channel 5 from our 'AMSUA.odb' database. Please open folder 'tb' inside folder 'odb_tutorial_4.1' to start the work.

The ODB Visualiser Icon

The simplest way to plot ODB data in Metview is to use the *ODB Visualiser* icon. It performs the query, defines which ODB columns should be interpreted as latitude, longitude and value(s) and specifies the plot type (symbol or wind plotting), as well. You can find this icon in the **Modules (Plotting)** icon drawer.

Create a new *ODB Visualiser* icon by dragging it into your folder and rename it 'tb_plot'.

First, open its editor and set **ODB Plot Type** to 'Geo Points' to indicate that we want to plot the values on a map.

Second, drop your 'AMSUA.odb' database icon into the **Odb Data** field. This specifies the database for which the query will be performed.

Third, we need to specify the ODB/SQL query and the way the columns are interpreted to generate the plot. We want to perform the following query:

```
SELECT
      lat@hdr,
      lon@hdr,
      obsvalue@body
WHERE
      vertco_reference_1@body = 5
```

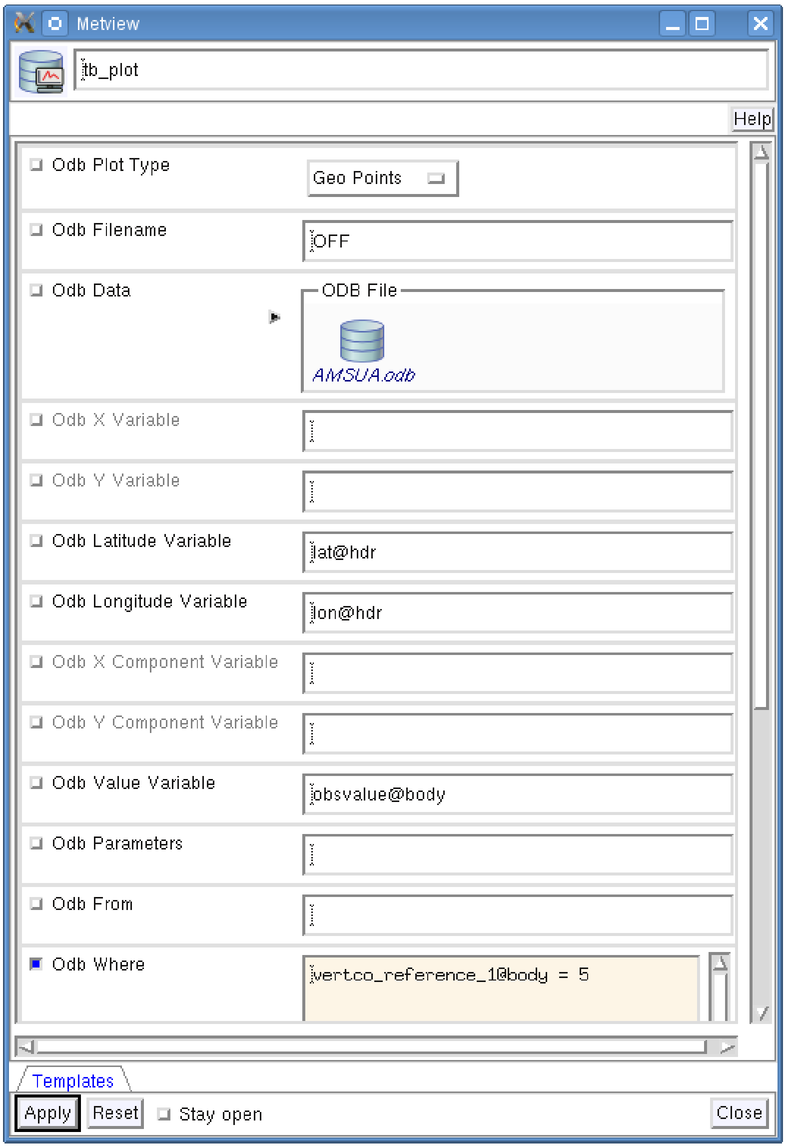
In the *ODB Visualiser* interface this query cannot be typed in directly but has to be split into the following individual items:

- **Odb Latitude Variable**: specifies the name of the column holding the latitude data in the SELECT statement (here `lat@hdr`).
- **Odb Longitude Variable**: specifies the name of the column holding the longitude data in the SELECT statement (here `lon@hdr`)
- **Odb Value Variable**: specifies the name of the column holding the value data in the SELECT statement (here `obsvalue@body`)
- **Odb Where**: specifies the WHERE statement. In our example it is as follows:

```
vertco_reference_1@body = 5
```

Last, we have to specify the units of the geographical co-ordinates (here `lat@hdr` and `lon@hdr`) in the **Odb Coordinates Unit** field. It is necessary since Metview requires geographical co-ordinates in degrees, but there is no general way to find out their units in an ODB database. Instead an explicit declaration is needed from the users. Our database stores co-ordinates in degrees. So, to correctly interpret our co-ordinate values **Odb Coordinates Unit** should be set to 'Degrees' (which is the default value so we do not need to change it).

Having finished the modifications your icon editor should look like this:



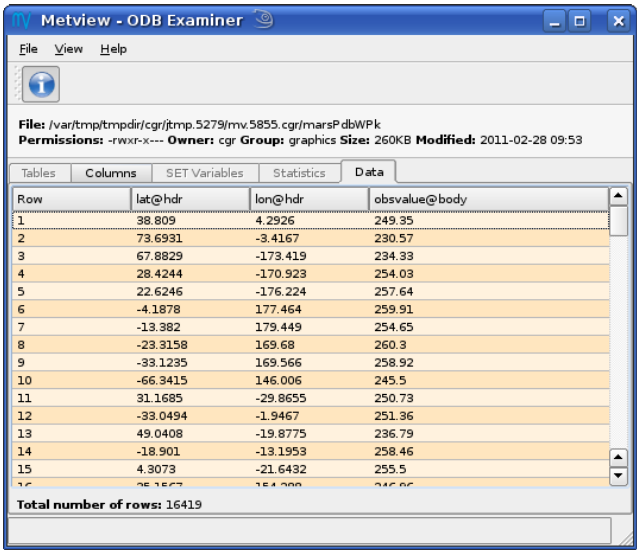
Remarks

- The ODB database for which the query is performed can be alternatively specified by the database path via the **Odb Filename** input field. Please note that the typed-in database path is only used by Metview if no database icon is present.
- The maximum number of rows accepted in the ODB retrieval is specified in the **Odb Nb Rows** input field. By default (**-1**) there is no upper limit for the number of rows.

- If column `latlon_rad@desc` is available in an ODB (it is defined for our 'AMSUA.odb' database) it tells us the geographical co-ordinate units. Its 0 value indicates degrees while 1 means radians (you can use the **ODB Examiner** to check this value for our database). Besides, it is worth mentioning that all ODBs retrieved from MARS, as a generic rule, use degrees as geographical co-ordinate units.

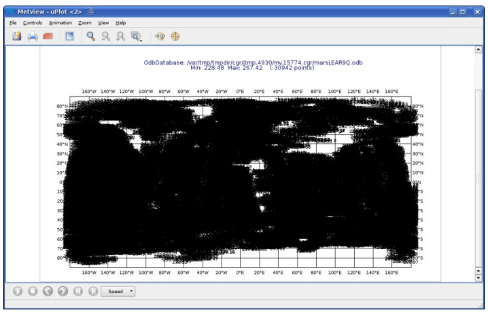
Running the Query

Save your *ODB Visualiser* icon (**Apply**) then right-click and **execute** to run the query. Within a few seconds the icon should turn green indicating that the retrieval was successful and has been cached. Now your icon behaves exactly like an *ODB Database* icon. Right-click **examine** to look at its content. You can see that the resulting ODB contains only three columns: `lat@hdr`, `lon@hdr`, `obsvalue@body`. By clicking on the **Data** tab you can even see the data values.

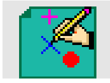


Visualising the Output

Right-click and **visualise** the icon to plot the retrieved data (please note that you can directly visualise the icon by skipping the **execute** step). This will bring up the Metview **Display Window** using the default visualisation assigned to symbol plotting. By default the data values are plotted to the map. Unfortunately, it is not the desired visualisation in our case (we cannot even see the satellite tracks) so we will further customise the plot.



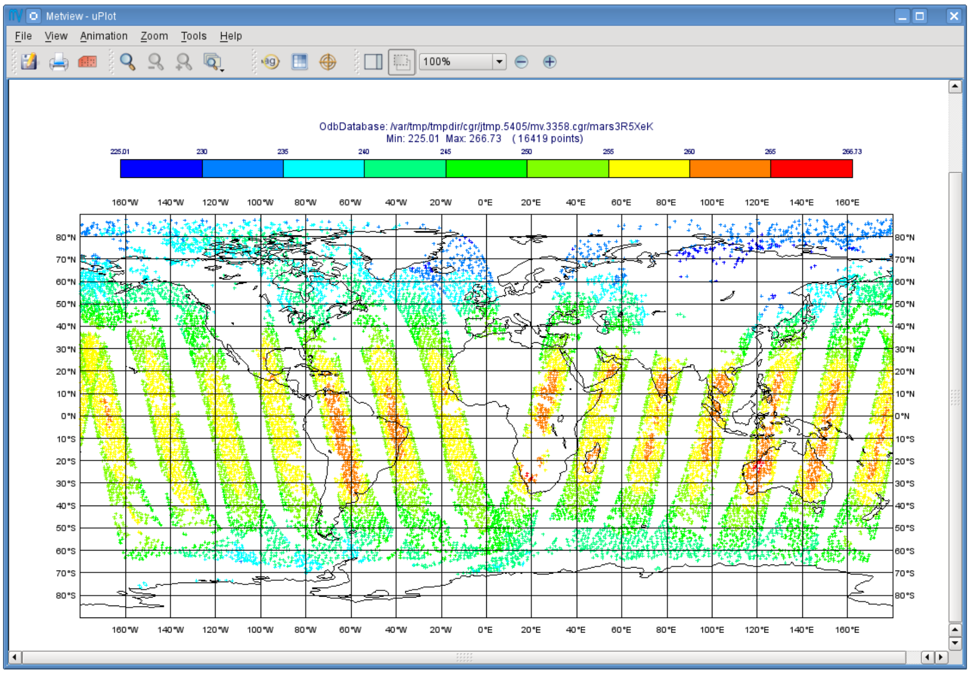
We will change the plot by using markers instead of numbers and change the colour, as well. Let's create a new *Symbol Plotting* icon (it can be found in the **Visual Definitions** icon drawer, you may need to scroll the drawers to the right).



Rename it 'symbol' then edit it, by setting the following parameters:

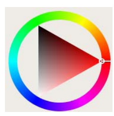
Legend	On
Symbol Type	Marker
Symbol Table Mode	Advanced
Symbol Advanced Table Max Level Colour	Red
Symbol Advanced Table Min Level Colour	Blue
Symbol Advanced Table Colour Direction	Clockwise
Symbol Advanced Table Marker List	3
Symbol Advanced Table Height List	0.15

Now drop this icon into the plot to see the effect of the changes.

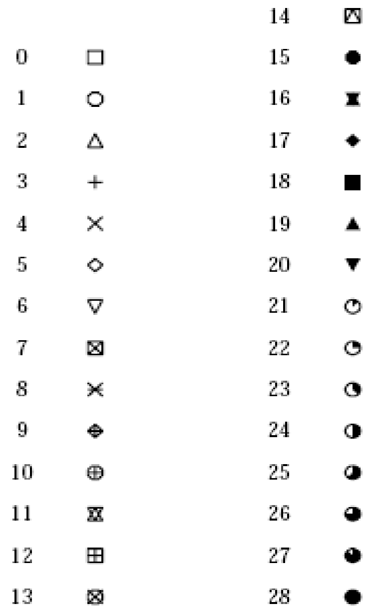


We used the **Symbol Table Mode** in our icon and set it to 'Advanced' which enabled us to automatically define intervals with a separate maker type, colour and size. These settings work in a similar way as in the *Contouring* icon.

Our palette was automatically generated from a colour wheel by interpolating in clockwise direction between **Symbol Advanced Table Min Level Colour** and **Symbol Advanced Table Max Level Colour**.



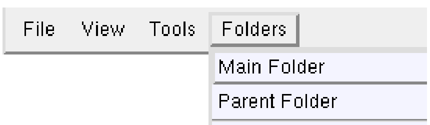
The identifiers of the available symbol markers are summarised in the table below. Please note that the rendering speed of the markers can be significantly different and using a simpler symbol (in terms of rendering) can greatly reduce the plotting time. For example, the usage of marker 3 (plus sign) can result in much faster plot generation than that of marker 15 (filled circle).



Changing the Default Symbol Plotting Icon

Since the visual change is so useful (and the rendering process is much faster, as well) we will now make the settings of our 'symbol' icon the defaults for symbol plotting in Metview.

- Open your main Metview folder (select item 'Main Folder' from the **Folders** menu in the menu bar of the **Metview Desktop**)



- Open the subfolder called 'System' and then subfolder 'Defaults'.
- Do one of the following: edit the *Symbol Plotting* icon in the 'Defaults' folder to specify your new settings or else delete it and copy your 'symbol' icon into this folder then rename it 'Symbol Plotting'

> For information: To delete an icon, right-click, **delete**; to move an icon between folders, drag it with the left mouse button; to copy an icon between folders, drag it with the middle mouse button.

- Save your changes and visualise your *ODB Visualiser* icon again - your new default symbol plotting attributes are automatically applied.

Now close your 'Defaults' folder.

Having a Histogram in the Legend

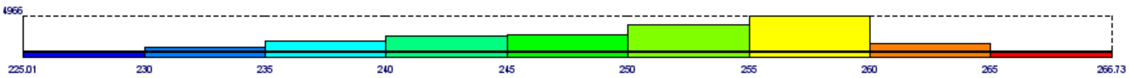
So far we have used the default legend settings, which resulted in a continuous legend. Now we will change our legend so that it could display a histogram showing the data distribution across the data intervals used in the symbol plotting.

Let's create a new *Legend* icon (it can be found in the **Visual Definitions** icon drawer).

Edit it, by setting the following parameter:

Legend Display Type	Histogram

Now drop the icon into the plot to see how the legend has been changed: it now contains an additional area holding the histogram.



Fixing the Symbol Plotting Intervals

Now zoom in and out of different areas. What happens to the palette - does it stay constant? The default behaviour is to create 10 interval levels *within the range of data actually plotted*. As the area changes, so does the range of values being plotted.

Let's create a palette which will not be altered when we change the area. Copy your 'symbol' icon (either right-click + **duplicate**, or drag with the middle mouse button), and rename the copy 'symbol_fixed' by clicking on its title. Edit the icon and make the following changes:

Symbol Advanced Table Selection Type	Interval
Symbol Advanced Table Min Value	220
Symbol Advanced Table Max Value	270
Symbol Advanced Table Interval	5

Now when you apply this icon you will see that the palette is fixed wherever you zoom.

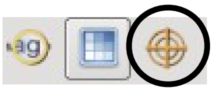
Changing the Title

The title of the ODB plot was automatically generated. It contains the database name (in this case it is a temporary file, the result of the query) and some statistics. To use a custom title we need a *Text Plotting* icon (it can be found in the **Visual Definitions** icon drawer).

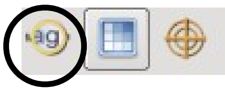
This time you do not need to create a new icon since there is one called ‘title’ already prepared for you. Edit this icon to see how the title is constructed. Then simply drag it into the **Display Window** and see how your title has been changed.

Inspecting the Data Values

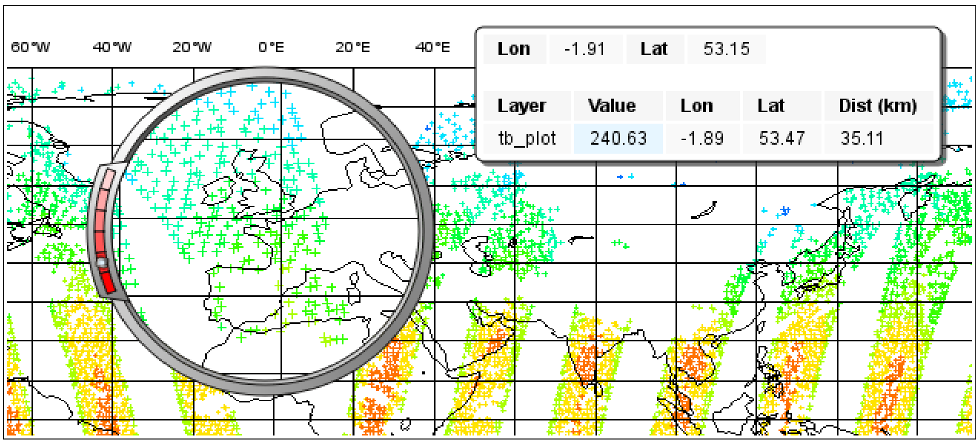
Data values at the cursor position can be inspected with the **Cursor Data Tool,** which can be activated by pressing on the gun-sight icon in the toolbar of the **Display Window**. The **Cursor Data Tool** displays the co-ordinates of the current cursor position and the information for the nearest data point to this position.



You may find hard to use the **Cursor Data Tool** for ODB since it is complicated to properly position the cursor in data dense regions in the plot. To overcome this difficulty you need to launch the **Magnifier** by pressing on the magnifier icon in the toolbar and navigate it to your area of interest in the plot.



Now if you move the cursor inside the magnifying glass it is significantly easier to distinguish the individual data points since you navigate the cursor inside a closed-up region.



PART 3 - WIND PLOTTING ON MAPS

In this exercise we will retrieve and plot wind vectors for aircraft data above 250 hPa using the *ODB Visualiser* icon.

Please note that the *ODB Visualiser* icon needs to retrieve both wind components within a single ODB/SQL query. This type of query is working fine for ODB-1 databases. However, it is working for ODB-2 databases only if the wind components are stored in different columns (but this is not the general case). Therefore we will demonstrate wind plotting here with an ODB-1 database ('CCMA.obs') and show an alternative way for ODB-2 data in *PART 7* of the tutorial.

Writing a Wind Data Query

In our 'CCMA.obs' database the u and v wind component values are stored in the same column (`obsvalue`) strictly following each other. It means that a u value is always followed by a v value in the database. To gain access for the u and v values independently we need a way somehow to refer to the next row in the database. This can be done by adding the `#1` suffix to the column names in question. So our query to retrieve wind vectors for aircraft data above 250 hPa can be written as:

```
SELECT
        lat@hdr,
        lon@hdr,
        obsvalue@hdr,
        obsvalue@hdr#1
FROM  hdr, body
WHERE
        obstype@hdr = 2 and
        varno@body = 3 and
        varno@body#1 = 4 and
        vertco_reference_1@body < 25000
```

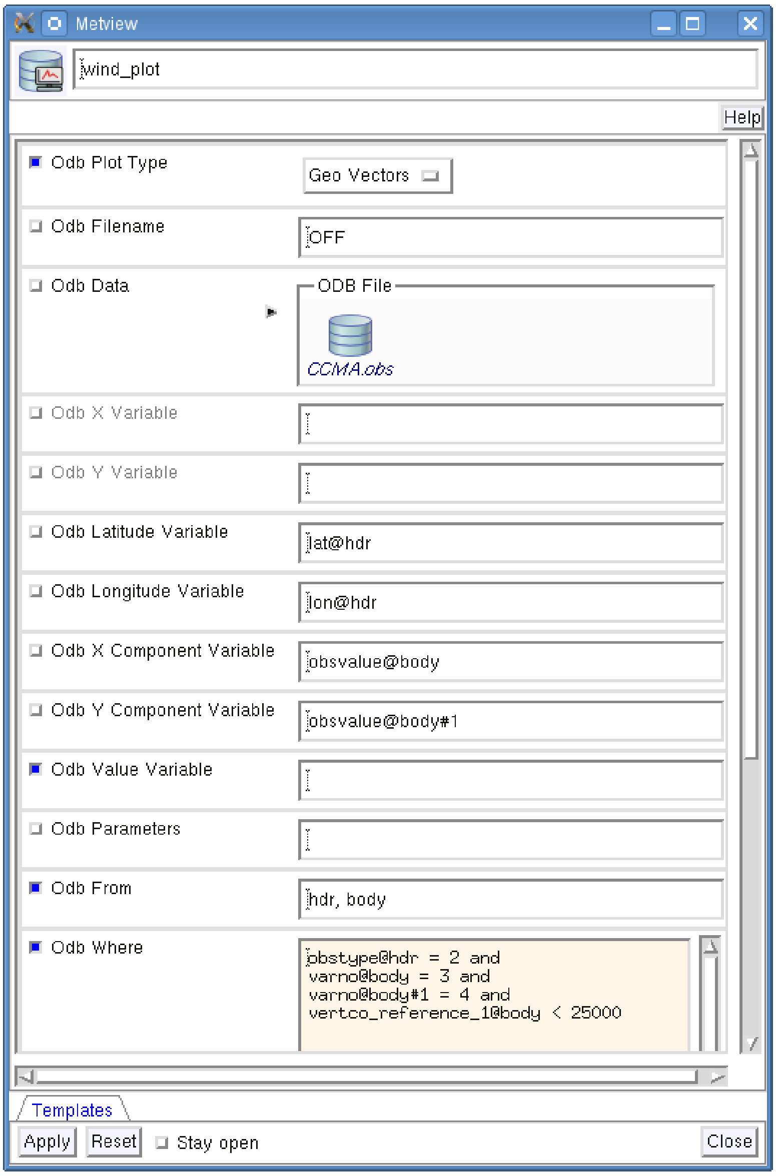
Here the u wind component data is specified by `obsvalue@body` (with `varno@body=3`) while the v wind component data comes from the next row specified by `obsvalue@body#1` (with `varno@body#1=4`).

Creating an ODB Visualiser Icon

Now open folder 'wind' inside your 'odb_tutorial_4.1' folder. Create a new *ODB Visualiser* icon and rename it 'wind_plot'. Open its editor and set **ODB Plot Type** to 'Geo Vectors' to indicate that we want to plot vectors on a map.

Then, change the icon to perform the query specified above for the 'CCMA.obs' icon located in this folder. This can be done in a similar fashion to our symbol plotting example in *PART 2*

. The main difference is that this time we plot wind data, so we need to work with the u and v wind components instead of scalar data values.



First, drop your 'CCMA.obs' *ODB Database* icon into the **Odb Data** field. This defines the database for which the query will be performed.

Second, we need to specify the query by setting the following individual items:

- **Odb Latitude Variable**: specifies the name of the column holding the latitude data in the SELECT statement (here `lat@hdr`)
- **Odb Longitude Variable**: specifies the name of the column holding the longitude data in the SELECT statement (here `lon@hdr`)
- **Odb X Component Variable**: specifies the name of the column holding the u wind component data in the SELECT statement (here `obsvalue@body`)
- **Odb Y Component Variable**: specifies the name of the column holding the v wind component data in the SELECT statement (here `obsvalue@body#1`)

- **Odb Value Variable**: specifies the name of the column whose values willl be used to generate the colour palette for the wind plotting. We leave this item empty because it instructs Metview to use the wind speed for this purpose.
- **Odb From**: specifies the FROM statement (it is only needed for ODB-1 databases).
- **Odb Where**: specifies the WHERE statement. In our example it is as follows:

```
obstype@hdr = 2 and
varno@body = 3 and
varno@body#1 = 4 and
vertco_reference_1@body < 25000
```

Last, **Odb Coordinates Unit** has to be set to 'Radians' since our database stores geographical co-ordinates in radians.

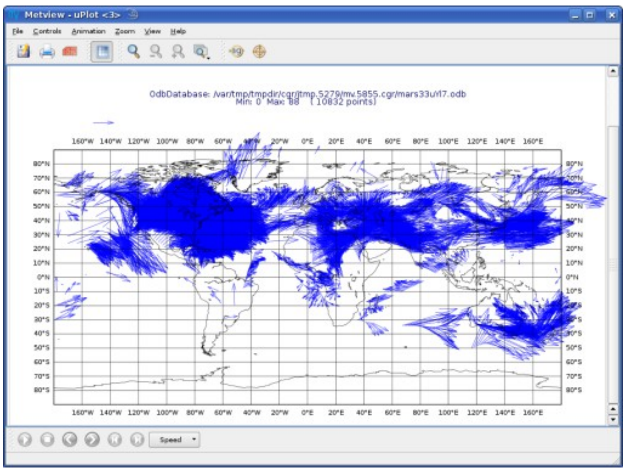
Having finished editing your icon editor it should look like the picture on the previous page.

Running the Query

Save your *ODB Visualiser* icon (**Apply**) then right-click and **execute** to run the query. Within a few seconds the icon should turn green indicating that the retrieval was successful and has been cached. Now your icon behaves exactly like an *ODB Database* icon. Right-click **examine** to look at its content.

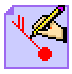
Visualising the Output

Right-click and **visualise** the icon to plot the retrieved data (please note that you can directly visualise this icon by skipping the **execute** step). This will bring up the Metview **Display Window** using the default visualisation assigned to wind plotting (your default settings might be different to the one used to generate this plot).



We will change the plot by applying a colour palette according to the wind speed and change the wind arrow size and thinning, as well.

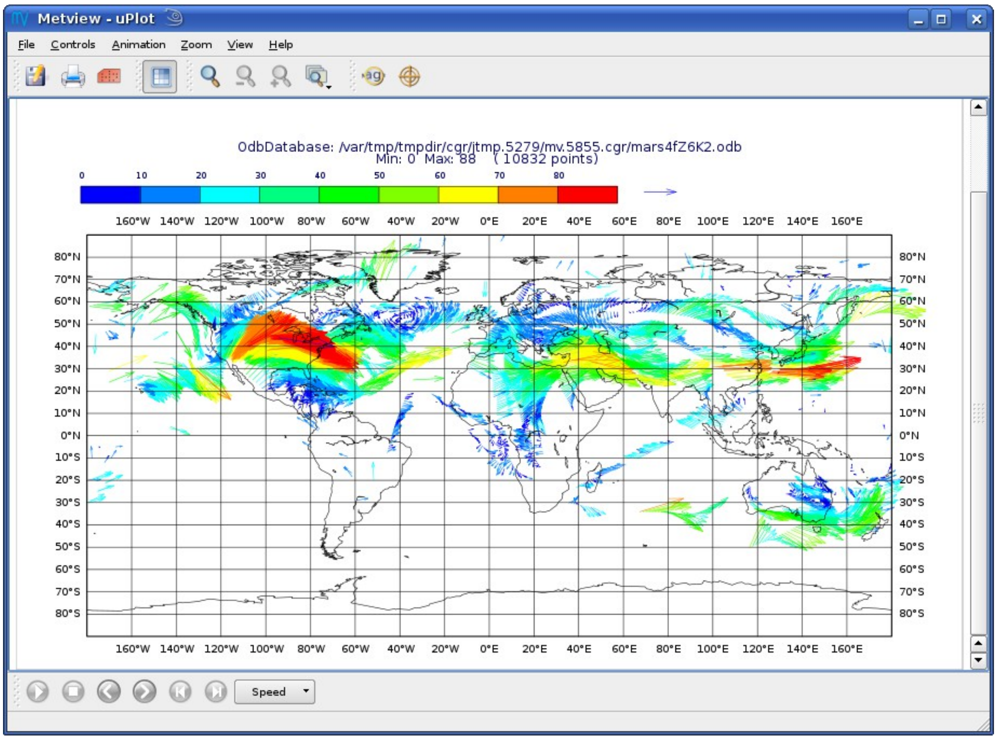
Let's create a new *Wind Plotting* icon (it can be found in the **Visual Definitions** icon drawer, you may need to scroll the drawers to the right).



Rename it 'colour_wind' then edit it, by setting the following parameters:

Wind Field Type	Arrows
Wind Advanced Method	On
Wind Arrow Unit Velocity	50.
Wind Thinning Factor	1.0
Wind Advanced Colour Max Level Colour	Red
Wind Advanced Colour Min Level Colour	Blue
Wind Advanced Colour Direction	Clockwise

Now drop this icon into the plot to see the effect of the changes.



We used the **Wind Advanced Method** in our icon that enabled us to automatically define wind speed intervals and assign a nice palette to them. These settings work in a similar way to the *Contouring* icon. Please note that our palette was automatically generated from a colour wheel by interpolating in clockwise direction between **Wind Advanced Colour Min Level Colour** and **Wind Advanced Colour Max Level Colour**.

Fixing the Wind Speed Intervals

If you zoom in and out of different areas you can see that the palette does not stay constant. The default behaviour is to create 10 interval levels *within the range of data actually plotted*. As the area changes, so does the range of values being plotted.

Now we will create a palette which will not be altered when we change the area. Copy the *Wind Plotting* icon (either right-click + **duplicate**, or drag with the middle mouse button), and rename the copy 'fixed_wind' by clicking on its title. Edit the icon and make the following changes:

Wind Advanced Colour Selection Type	Interval
Wind Advanced Colour Min Value	0
Wind Advanced Colour Max Value	90
Wind Advanced Colour Level Interval	5

Now when you apply this icon you will see that the palette is fixed wherever you zoom.

Changing the Title

To change the automatically generated ODB title you need to simply drag an already prepared *Text Plotting* icon called 'title' into the **Display Window.**

PART 4 - SCATTER PLOTS

In this exercise we will generate scatter plots for the analysis and first guess departures values of brightness temperature. As in the previous exercises we will use channel 5 from our 'AMSUA.odb' database. Please open folder 'scatter' inside folder 'odb_tutorial_4.1' to start the work.

About Scatter Plots

Scatter plots are used to display values in a Cartesian co-ordinate system for two variables for a set of data. In such plots the data is visualised as a collection of points where one variable specifies the positions on the horizontal axis and the other variable specifies the positions on the vertical axis. In our case column `fg_depar@body` defines the data for the horizontal axis and column `an_depar@body` defines the data for the vertical axis.

Creating an ODB Visualiser Icon

Create a new *ODB Visualiser* icon and rename it 'scatter_plot' then open its editor.

First, set **ODB Plot Type** to 'Xy Points' to indicate that we want to plot symbols in a Cartesian view.

Second, drop your 'AMSUA.odb' *ODB Database* icon into the **Odb Data** field. This specifies the database for which the query will be performed.

Last, we need to specify the ODB/SQL query and the way the columns are to be interpreted to generate the plot. We want to perform the following query:

```
SELECT
      fg_depar@body,
      an_depar@body,
WHERE
      vertco_reference_1@body = 5
```

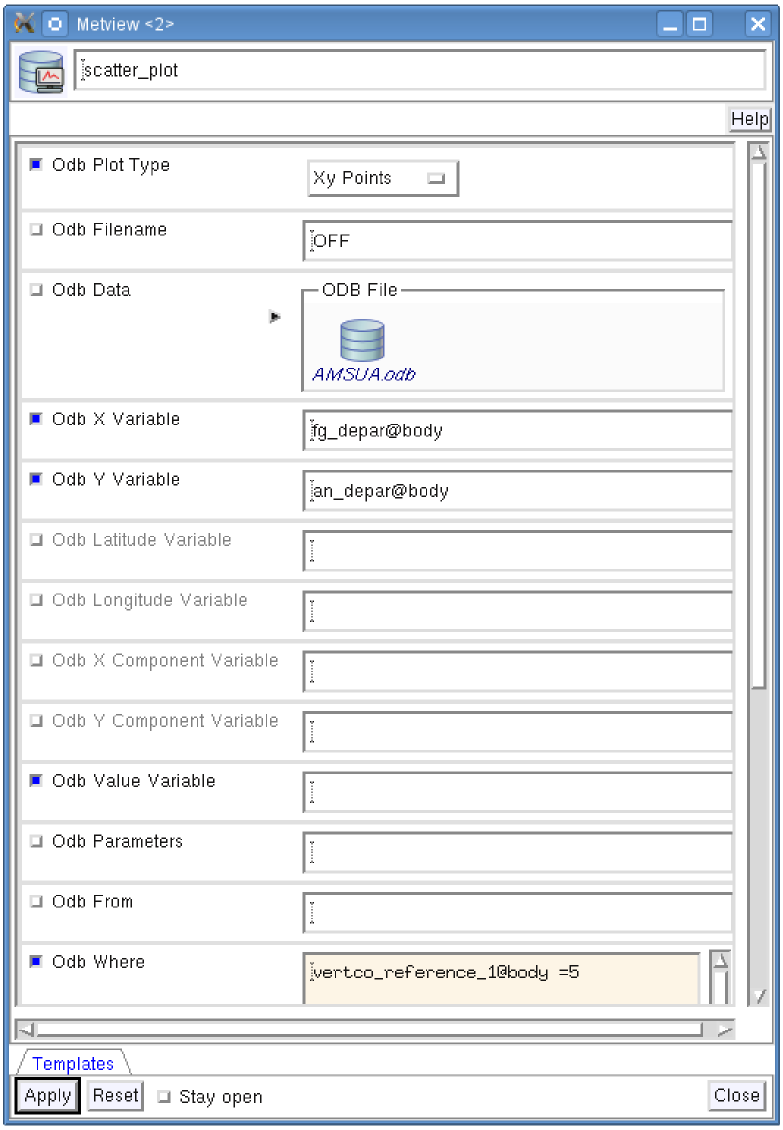
In the *ODB Visualiser* interface this query cannot be typed in directly but has to be split into the following individual items:

- **Odb X Variable**: specifies the name of the column holding the x data in the SELECT statement (here `fg_depar@body`).
- **Odb Y Variable**: specifies the name of the column holding the y data in the SELECT statement (here `an_depar@body`).
- **Odb Value Variable**: specifies the name of the column whose values will be used to generate the colour palette for the scatter plot. We will leave this item empty because we do not want to use this feature in this example.

- **Odb Where**: specifies the WHERE statement. In our example it is as follows:

```
vertco_reference_1@body = 5
```

Having finished the modifications your icon editor should look like this:

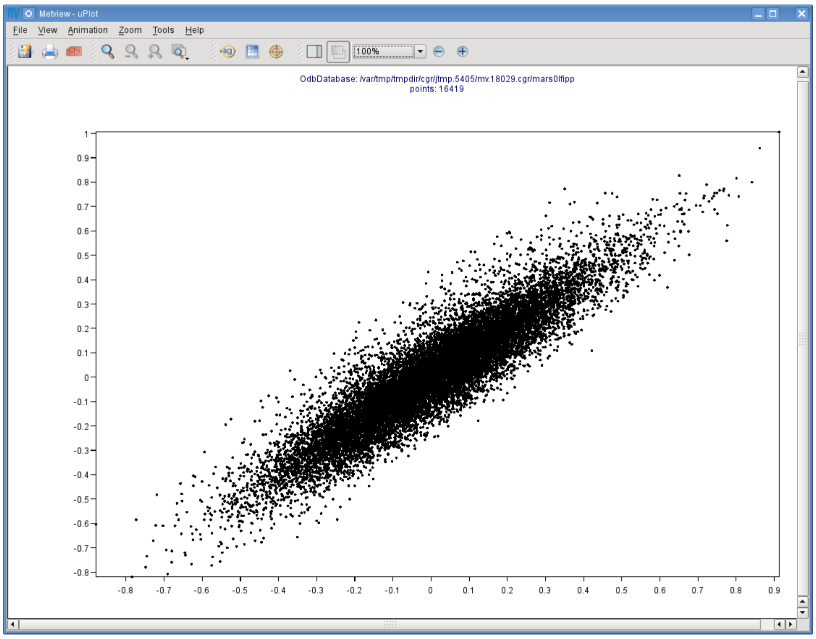


Running the Query

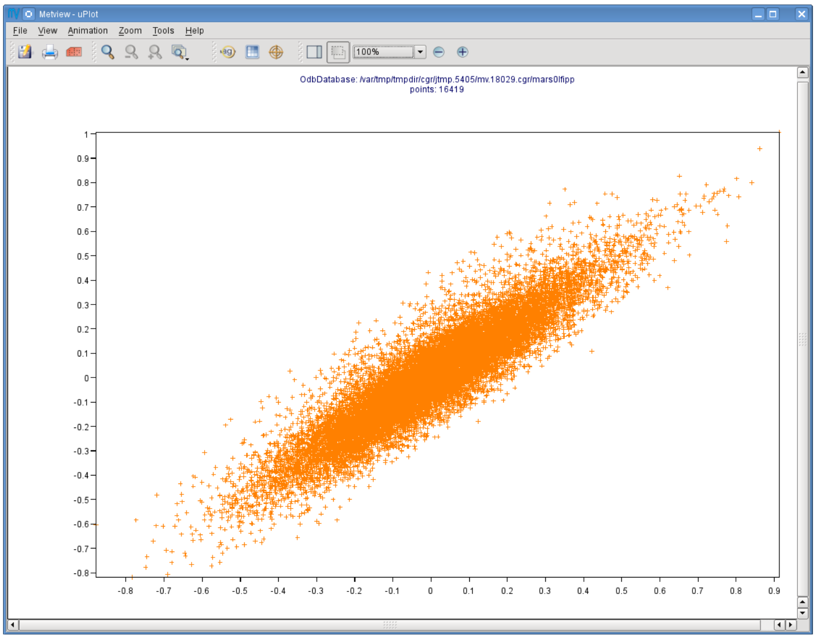
Save your *ODB Visualiser* icon (**Apply**) then right-click and **execute** to run the query. Within a few seconds the icon should turn green indicating that the retrieval was successful and has been cached. Now your icon behaves exactly like an *ODB Database* icon. Right-click **examine** to look at its content.

Visualising the Output

Right-click and **visualise** the icon to plot the data (please note that you can directly visualise this icon by skipping the **execute** step). This will bring up the Metview **Display Window** using the default visualisation (black circles) assigned to this kind of plots.



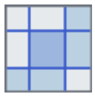
We can change the symbol (its type, colour and size) used for the plot with a *Symbol Plotting* icon. This time you do not need to create a new icon since there is one called 'scatter_symbol' already prepared for you. Edit this icon to see its settings then simply drag it into the **Display Window** and see how your plot has been changed.



Defining Binning

The main problem with our scatter plot is that it has dense regions where the data distribution is really hard to see. To overcome this difficulty we will create a density map out of our scatter plot. We can achieve it by turning our scattered dataset into a gridded dataset via binning. Binning means that we split the scatter plot area into grid cells by defining bins along the horizontal and vertical axes. Then for each cell we assign the number of points it contains as a grid value.

We will define the properties of the binning via the *Binning* icon.



Let's create a new *Binning* icon (it can be found in the **Visual Definitions** icon drawer, you may need to scroll the drawers to the right). Rename it 'bin_100' then edit it, by setting the following parameters:

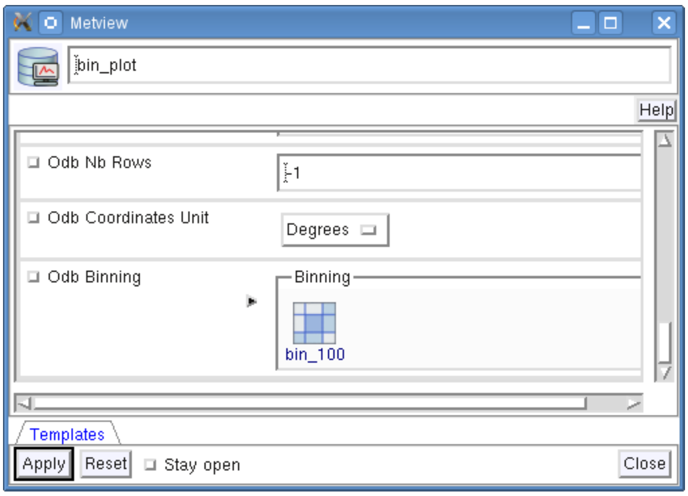
Binning X Count	100
Binning Y Count	100

With these settings we will split the data value range for both the x and y axes into 100 bins to generate the gridded dataset.

Now we will create a new *ODB Visualiser* icon to be used with our *Binning* icon. Copy your 'scatter_plot' icon (either right-click + **duplicate**, or drag with the middle mouse button), and rename the copy 'bin_plot' by clicking on its title. Edit the icon and make the following changes:

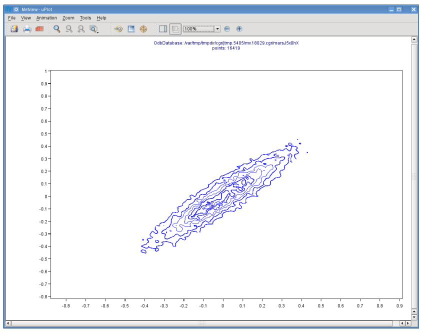
Set **ODB Plot Type** to 'Xy_Binning' to indicate that we want to generate a new dataset with binning and want to plot it in a Cartesian view.

Then, drop your 'bin_100' *Binning* icon into the **Odb Binning** field as the picture below illustrates it.



Visualising the Binned Dataset

Right-click and **visualise** icon 'bin_plot' to retrieve the data, perform the binning and plot the resulting dataset. This will bring up the Metview **Display Window** using the default contouring visualisation assigned to gridded datasets (your default contouring settings might be different to the one used to generate this plot).



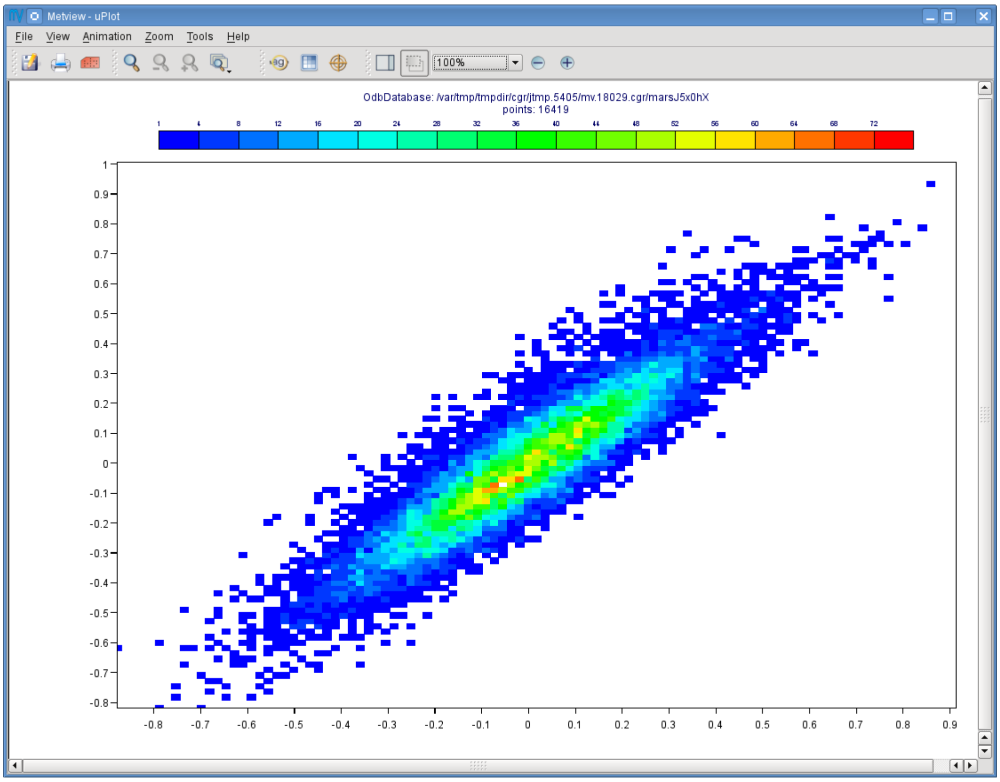
Unfortunately isolines is not the desired visualisation type in our case (our data is not smooth enough) so we need to further customise the contouring settings. The best choice for us is to use **grid shading** since it applies shading for the grid cells themselves and we get the correct representation of our grid in the plot. (Please note that grid shading is different to cell shading, since the latter always involves an interpolation to define a new set of grid cells that the shading is applied for.)

Let's create a new *Contouring* icon (it can be found in the **Visual Definitions** icon drawer, you may need to scroll the drawers to the right).

Rename it ‘bin_grid_shade’ then edit it, by setting the following parameters:

Legend	On
Contour	Off
Contour Level Selection Type	Count
Contour Reference Level	0.
Contour Min Level	1.
Contour Shade Min Level	1.
Contour Level Count	20
Contour Shade	On
Contour Shade Technique	Grid Shading
Contour Shade Method	Area Fill
Contour Shade Max Level Colour	Red
Contour Shade Min Level Colour	Blue
Contour Shade Colour Direction	Clockwise

Now drop this icon into the plot to see the effect of the changes.

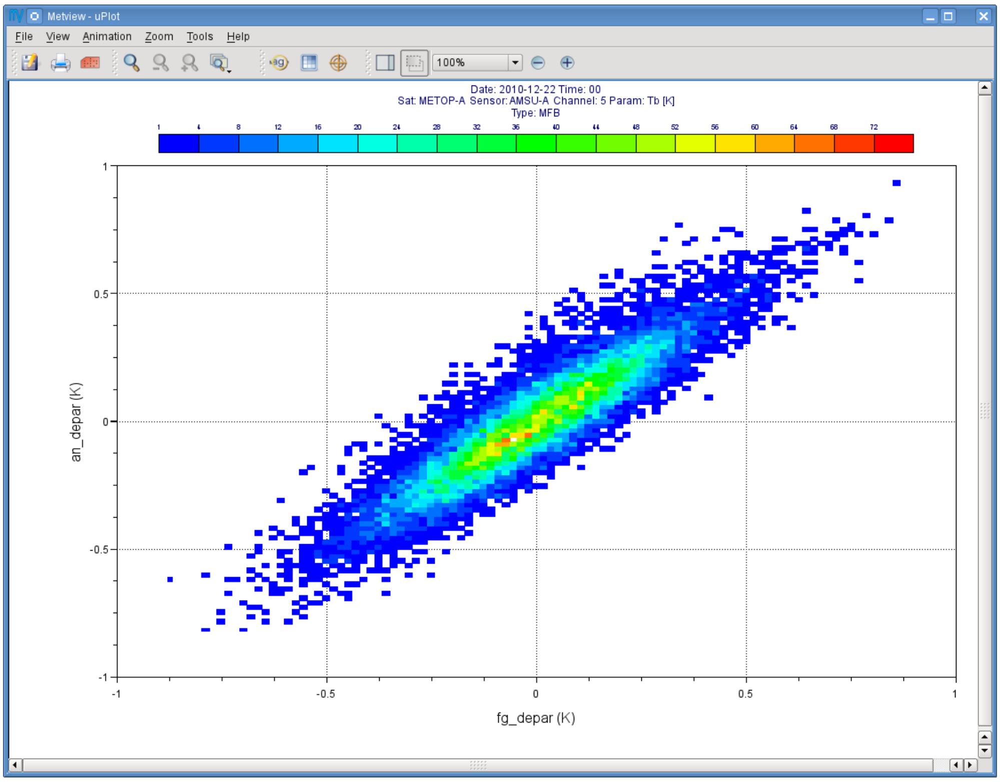


In our *Contouring* icon we set the minimum value to '1.' to exclude grid cells containing no points at all and used 20 intervals between the minimum and the maximum to define the colour palette. Please note that our palette was automatically generated from a colour wheel by interpolating in clockwise direction between **Contour Shade Min Level Colour** and **Contour Shade Max Level Colour**.

Changing the View

We will further customise the plot by changing the axis value ranges and adding axis labels and grid-lines to it. To change these properties we need a *Cartesian View* icon (it can be found in the **Visual Definitions** icon drawer).

This time you do not need to create a new icon since there is one called 'scatter_view' already prepared for you. Edit this icon to see how the view is constructed (please note that the axis properties are defined via the embedded *Horizontal Axis* and *Vertical Axis* icons). Then simply drag it into the **Display Window** and see how your plot has been changed.



Changing the Title

To change the automatically generated ODB title you need to simply drag an already prepared *Text Plotting* icon called 'title' into the **Display Window.**

PART 5 - PLOTTING WITH MACRO

In this example we will write the macro equivalent of the exercise we solved in *PART 2* : we would like to retrieve and plot the brightness temperature for channel 5 for our ‘AMSUA.odb’ database. We will work in folder 'tb' again.

Basics

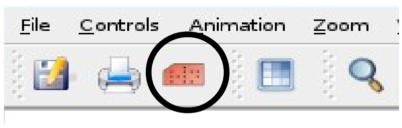
The implementation of ODB data plotting in Metview macro follows the same principles as in the interactive mode. In macro we work with the macro command equivalents of the ODB icons we have seen so far:

- *ODB Database* icon: its corresponding macro command is **read**.
- *ODB Visualiser* icon: its corresponding macro command is **odb_visualiser**.

Another feature is that multi-line text, which we used for the WHERE statement in the *ODB Visualiser* icon, should be specified as a set of concatenated strings in macro. This technique is worth using if we do not want to put the (otherwise long) ODB queries into one line.

Automatic macro generation

The quickest way to generate a macro is to simply save a visualisation on screen as a *Macro* icon. Visualise your ODB data again, drop the symbol plotting and title icons into the plot and click on the macro icon in the tool bar of the **Display Window**.



Now a new *Macro* icon called 'MacroFramework*N*' is generated in your folder. Right-click **visualise** this icon. Now you should see your original plot reproduced.

Please note that this macro is to be used primarily as a framework. Depending on the complexity of the plot macros generated in this way may not work as expected and in such cases you may need to fine-tune them manually. So, we will use an alternative way and **write our macro in the macro editor**.

Step 1 - Writing a macro

Since we already have all the icons for our example we will not write the macro from scratch but instead we drop the icons into the **Macro editor** and just re-edit the automatically generated code.

Create a new *Macro* icon (it can be found in the **Macros** icon drawer) and rename it 'step1'. When you open the **Macro editor** (right-click **edit**) you can see that the first line contains `#Metview Macro`. Having this special comment in the first line helps Metview to identify the file as a macro, so we want to keep this comment in the first line.

Now position the cursor in the editor a few lines below the line of `#Metview Macro`. By doing so we specified the position where the icon-drop generated code will be placed. Then drop your 'tb_plot' *ODB Visualiser* icon into the **Macro editor**. You should see something like this (after removing the comment lines starting with `# Importing`):

```
#Metview Macro

amsua_2e_db = read("AMSUA.odb")

tb_plot = odb_visualiser(
      odb_where  : " vertco_reference_1@body = 5 ",
      odb_data   :  amsua_2e_odb
      )
```

You only have to add the following command to the macro to plot the result:

```
plot(tb_plot)
```

Now, if you execute this macro (right-click **execute** or click on the **Play** button in the **Macro editor**) you should see a **Display Window** popping up with your default symbol plotting visualisation.

Step 2 – Adding More Features

Duplicate the 'step1' *Macro* icon (right-click **duplicate)** and rename the duplicate 'step2'. In this step we will add our symbol plotting and title icons to the macro.

Position the cursor above the `plot` command in the **Macro editor** and drop your 'symbol_fixed' icon into it. Repeat this with the 'title' icon. Then modify the plot command by adding these new arguments after the `tb_plot` variable:

```
plot(tb_plot,symbol_fixed,title)
```

Now, if you run this macro you should see your modified plot in the **Display Window**.

Remarks

- The macro equivalent of the wind plotting exercise in *PART 3* and that of the scatter plot exercise in *PART 4* can be written in a very similar way to what was shown above for symbol plotting. The solutions can be found and studied in folder ‘wind_solution’ and 'scatter_solution', respectively.

PART 6 - THE ODB FILTER ICON

In this exercise we will learn about the *ODB Filter* icon.

In the previous exercises we saw how to visualise ODB data with the *ODB Visualiser* icon. This icon is working well for visualisation, however, it is not suitable for performing general retrievals (with more than four columns) and does not allow direct access to the retrieved values (for data processing in macro). To achieve these goals we need to use the *ODB Filter* icon which is able to perform arbitrary ODB queries and save the results as new ODBs on output.

The Exercise

As a demonstration of the *ODB Filter* icon we will compute and plot the analysis increments in observation space for the brightness temperature. Like in *PART 2* we will work again with channel 5 from our 'AMSUA.odb' database. Because our database does not contain the analysis increment we will compute it as the difference of the analysis departure and the first guess departure. First, we will write and perform the query needed for the exercise via the *ODB Filter* icon, then we will write a macro to do the computations and plot the final result.

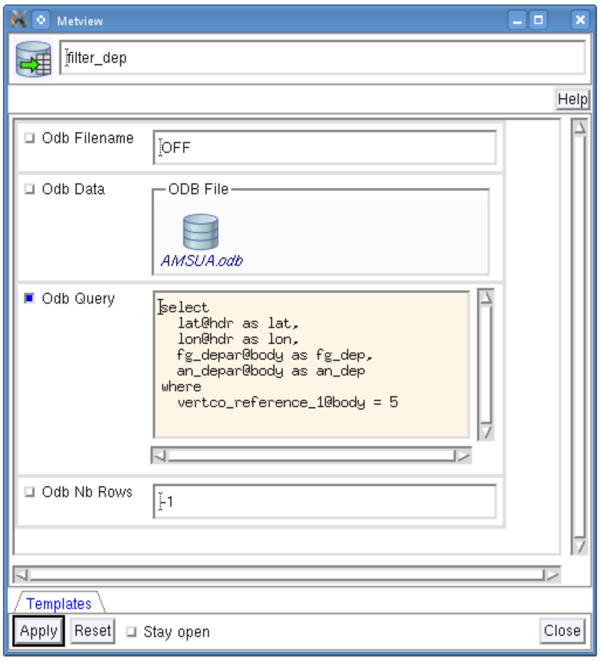
The ODB Filter Icon

Open folder 'filter' inside your 'odb_tutorial_4.1' folder. Create a new *ODB Filter* icon (you can find it in the **Filters** icon drawer) and rename it 'filter_dep'. Open its editor and perform the following steps:

- Drop your 'AMSUA.odb' *ODB Database* icon into the **Odb Data** field. This specifies the database for which the query will be performed.
- Type in the following ODB/SQL query in the **Odb Query** multi-line text input field.

```
select
      lat@hdr as lat,
      lon@hdr as lon,
      fg_depar@body as fg_dep,
      an_depar@body as an_dep
where
     vertco_reference_1@body = 5
```

Now your icon editor should look like this:

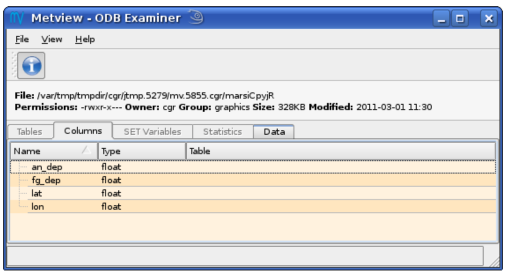


Remarks

- It is advised to use the full column names in the query because this fully complies with the SQL standards and newer versions of ODB require this as well.
- We used aliases (e.g. `as lat`) since it highly simplifies the referencing to the columns in the visualisation and macro processing.
- The ODB database for which the query is performed can be alternatively specified by the database path via the **Odb Filename** input field. Please note that the typed-in database path is only used by Metview if no database icon is present.
- The maximum number of rows accepted in the ODB retrieval is specified in the **Odb Nb Rows** input field. By default (**-1**) there is no upper limit for the number of rows.

Running the Query

Save your *ODB Filter* icon (**Apply**) then right-click and **execute** to run the query. Within a few seconds the icon should turn green indicating that the retrieval was successful and has been cached. Now your icon behaves exactly like an *ODB Database* icon. Right-click **examine** to look at its content.



Now you can see that as we defined it in the query the resulting ODB contains only four columns: `lat`, `lon`, `fg_dep` and `an_dep`.

Writing a Macro

Now we will write a macro to compute the analysis increment and visualise it.

Create a new *Macro* icon and rename it 'step1'. Open the **Macro editor** (right-click **edit**) and move the cursor somewhere below the `#Metview Macro` line at the top. Then drop your 'filter_dep' icon into the editor. You should see something like this (after removing the comment lines starting with `# Importing`):

```
#Metview Macro

amsua_2e_odb= read("AMSUA.odb")

filter_dep = odb_filter(
      odb_query  : "select " &
        "  lat@hdr as lat, " &
        "  lon@hdr as lon, " &
        "  fg_depar@body as fg_dep, " &
        "  an_depar@body as an_dep " &
        "where " &
        "  vertco_reference_1@body = 5 ",
       odb_data  :    amsua_2e_odb
     )
```

This piece of code performs the query and stores the result in an ODB database which is now represented by the `filter_dep` macro variable. Metview offers the `values` built-in macro function to read ODB column data into vectors. We need all the four columns for the computations and the visualisation, so we read them all one by one:

```
lat = values(filter_dep,"lat")
lon = values(filter_dep,"lon")
fg_dep = values(filter_dep,"fg_dep")
an_dep = values(filter_dep,"an_dep")
```

Having each ODB column stored in a vector we compute the analysis increment as the difference between the analysis departure and the first guess departure. First, we allocate a vector to store the result:

```
num=count(lat)
incr = vector(num)
```

then compute the difference between the all the elements of the `an_dep` and `fg_dep` vectors:

```
incr  = an_dep -fg_dep
```

The last step is the visualisation of the result. The simplest way is to build a geopoints object out of the needed vectors (these are `lat`, `lon` and `incr`, respectively) and pass it to the `plot` command:

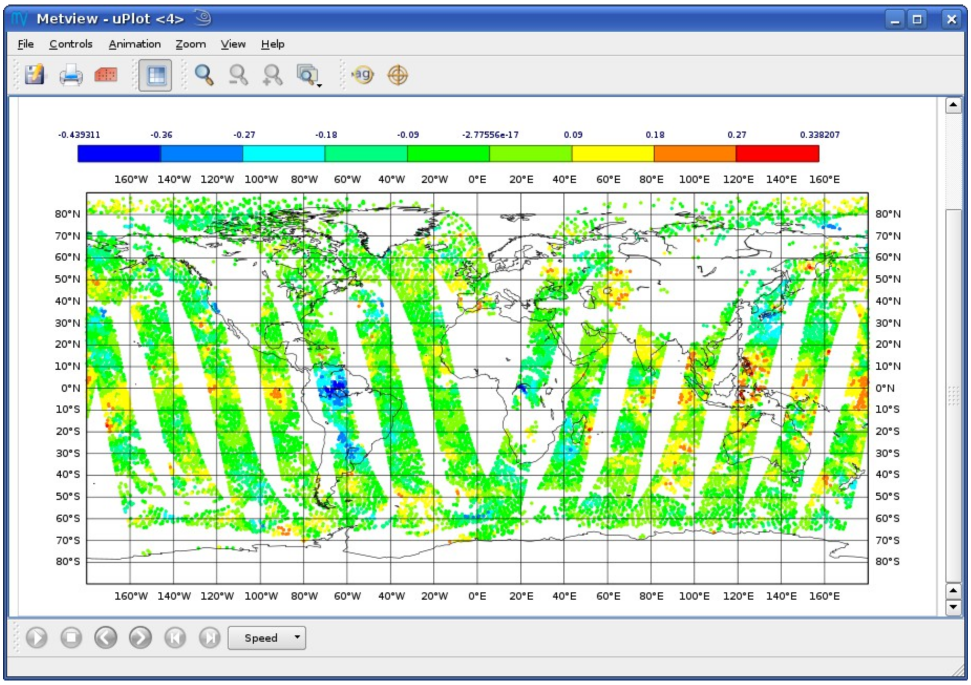
```
geo=create_geo(num,"xyv")
geo=set_latitudes(geo,lat)
```



```
geo=set_longitudes(geo,lon)
geo=set_values(geo,incr)

plot(geo)
```

Now, if you execute this macro (right-click **execute** or click on the **Play** button in the **Macro editor**) you should see a **Display Window** popping up with this result (your plot might look different depending on your default symbol plotting settings):



Enhancing the Plot

In our plot the large increments (in terms of absolute value) are not clearly highlighted because the plot is dominated by the bright green colour assigned to the near-zero values. To enhance the plot we would like to apply another colour palette by using:

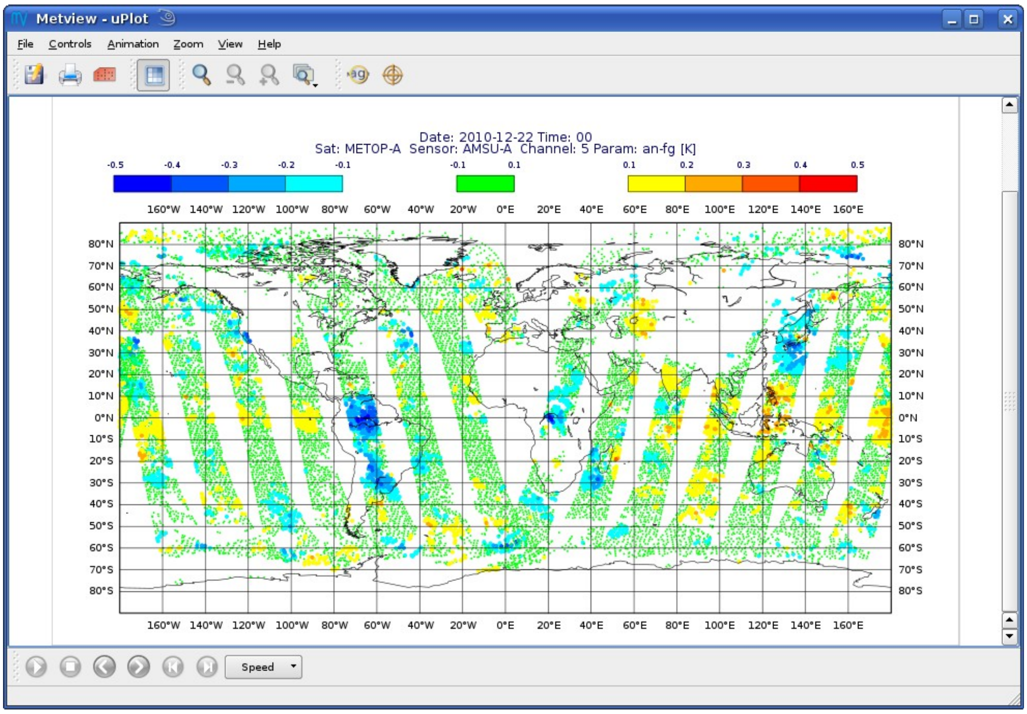
- green colour and small symbols for the values between -0.1 and 0.1
- blue palette for the negative values below -0.1
- red-to-yellow palette for the positive values above 0.1

It is complicated to create such a colour palette with one *Symbol Plotting* icon but we can overcome this difficulty by using three *Symbol Plotting* icons instead. This time you do not have to create these icons since they are already prepared for you.

Now visualise your plot again. Find the 'sym_small, 'sym_neg' and 'sym_pos' *Symbol Plotting* icons in the folder and select them together - either drag a rectangle around them, or click on each whilst holding down `SHIFT`. Then drag them together into the plot.

In the last step drag the 'title' *Text Plotting* icon into the plot, as well.

You will see an enhanced plot as shown below:



Modifying the Macro

We are satisfied with the new colour palette and with the title as well, so in the last step of the exercise we will add these new settings to our macro.

Duplicate the 'step1' macro icon (right-click **Duplicate)** and rename the duplicate 'step2'. Position the cursor above the `plot` command in the **Macro editor** and drop your 'sym_small', 'sym_neg', 'sym pos' and 'title' icons into it (you can drop them together or one by one).

Then modify the plot command by adding these new arguments after the `geo` variable:

```
plot(geo,sym_neg,sym_small,sym_pos,title)
```

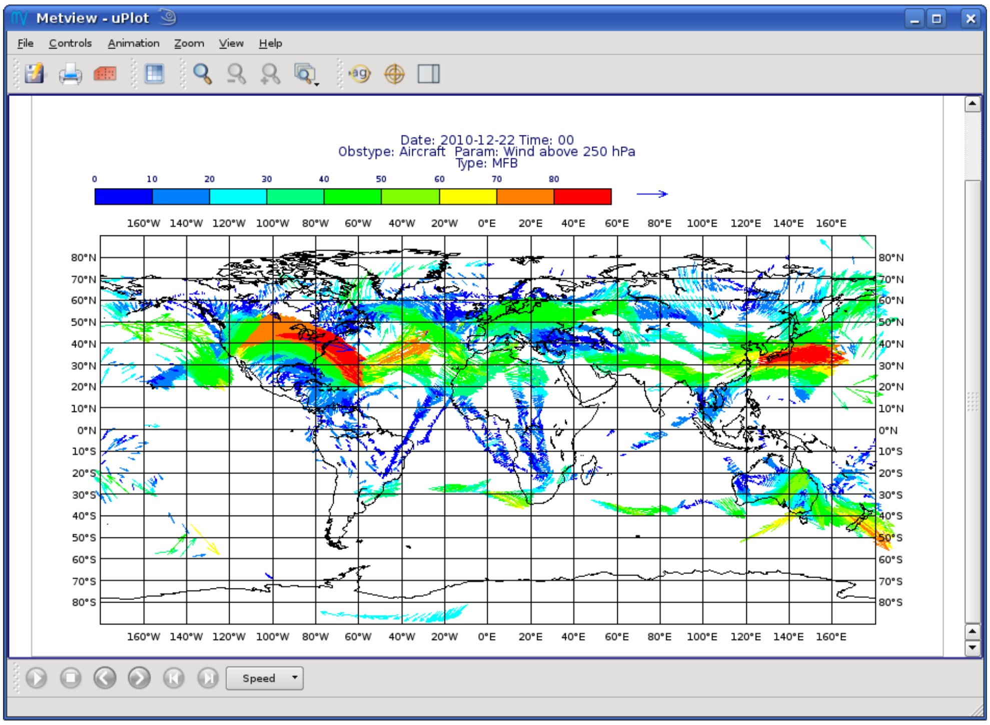
Now, if you visualise the macro you should see your modified plot in the **Display Window**.

Part 7 - Wind Plotting with ODB-2 Data

In this exercise we will present an example macro to show how to plot ODB-2 wind data if both the wind components are stored in the same column in the database. We will demonstrate this plotting technique on aircraft wind data above 250 hPa from our ‘AIREP.odb’ ODB-2 database.

Running the Macro

Open folder 'wind_odb2' inside your 'odb_tutorial_4.1' folder. You will find here the ‘AIREP.odb’ *ODB Database* icon and a macro called ‘plot_wind’. If you right click and **visualise** the macro it will retrieve and plot the wind data from the database. You should see a **Display Window** popping up with the result (your plot might look different depending on your default wind plotting settings):



This result was achieved by executing the following steps in the macro:

- Perform two queries: one for the u and one for the v wind component.
- Get the data values from the two resulting ODBs as vectors.
- Build an **xy_vector** geopoints object out of this data
- Visualise the geopoints object

Explaining the Macro

Open the **Macro editor** for our macro (right-click **edit**) to study its source code.

The macro starts the `#Metview Macro` declaration. Then we load our database into a macro object.

```
mydb= read("AIREP.odb")
```

We perform two ODB/SQL queries for this database via the `odb_filter` command. The first query retrieves the u wind component while the second query retrieves the v wind component. As a result we have two ODB objects: `filter_u` containing columns `lat`, `lon` and `u`, and `filter_v` containing columns `lat`, `lon` and `v`. Since the u and v wind data come strictly after each other in the database we can be sure that the two ODBs have the same number of rows and their `lat` and `lon` columns are identical.

```
filter_u = odb_filter(
      odb_query  : "select " &
        "  lat@hdr as lat, " &
        "  lon@hdr as lon, " &
        "  obsvalue@body as u, " &
        "where " &
        "  obstype@hdr = 2 and " &
        "  varno@body = 3 and "
        "  vertco_reference_1@body > 25000 ",
       odb_data  :     myodb
)

filter_v = odb_filter(
      odb_query  : "select " &
        "  lat@hdr as lat, " &
        "  lon@hdr as lon, " &
        "  obsvalue@body as v, " &
        "where " &
        "  obstype@hdr = 2 and " &
        "  varno@body = 4 and "
        "  vertco_reference_1@body > 25000 ",
       odb_data  :     myodb
)
```

In the next step we extract the `lat`, `lon`, `u` and `v` ODB columns into vectors via the `values()` macro function.

```
lat = values(filter_u,"lat")
lon = values(filter_u,"lon")
u = values(filter_u,"u")
v = values(filter_v,"v")
```

Having each necessary ODB column stored in a vector we build an **xy_vector** geopoints object out of them.


```
geo=create_geo(count(lat),"xy_vector")
geo=set_latitudes(geo,lat)
geo=set_longitudes(geo,lon)
geo=set_values(geo,u)
geo=set_value2s(geo,v)
```

In the last step we specify our wind plotting visual definition

```
colour_wind = mwind( … )
```

then our title

```
title = mtext( … )
```

and visualise the geopoints object itself

```
plot(geo,colour_wind,title)
```

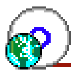
PART 8 - MARS RETRIEVALS

In this exercise we will introduce how to retrieve ODB data from MARS in Metview.

> Please note that the examples presented in this chapter are not guaranteed to work for you since the MARS ODB archive is still under development and subject to changes.

The MARS Retrieval Icon

In Metview we can access ODB from MARS by using the standard *MARS Retrieval* icon. This icon is located in the **Data Acces** icon drawer.



Now create a new *MARS Retrieval* icon by dragging it into your folder and rename it 'mars_hirs'. We will edit this icon in order to retrieve HIRS data available for yesterday at 00 UT and also use the filter option to select only a subset of the archived columns. Our retrieval can be written as follows:

```
retrieve,
class       = od,
type        = MFB,
stream      = DA,
expver      = 1,
obsgroup    = hirs,
date        = -1,
time        = 00,
filter      = "select lat,lon, obsvalue, vertco_reference_1”
```

Now edit your *MARS Retrieval* icon so that it could perform this retrieval.

Remarks

- Please be aware that the **Obsgroup** parameter in the icon editor does not contain the string “hirs”. Instead it offers a list of numerical IDs. The ID of HIRS is 2.

Running the Retrieval

Save your *MARS Retrieval* icon (**Apply**) then right-click and **execute** to run the query. Within a few seconds the icon should turn green indicating that the retrieval was successful and has been cached.

Working with the Retrieved Data

Now your icon behaves exactly like an *ODB Database* icon and all the relevant techniques introduced in the previous Chapters (*PART 1 - PART 7)* can be used with it. It means that you can examine, visualise and manipulate the data it holds.

- To examine: just right-click **examine** to look at its content.
- To visualise: you need to use an *ODB Visualiser* icon (see *PART 2*). There is one, called 'plot_hirs', already prepared for you in the folder. It is to plot the observation values for channel 5 on a map. Just edit this icon and drop your *MARS Retrieval* icon into the **ODB Data** field. Save the icon (**Apply**) then right-click and **visualise** to generate the plot.
- To manipulate: you need to write a macro (please read the next section about how to do it).

Macro Usage

The usage of ODB MARS retrievals in Metview macro follows the same principles as in the interactive mode. In macro we work with the macro command equivalent of the *MARS Retrieval* icon which is **retrieve**.

Now we will write a simple macro to retrieve our HIRS ODB data from MARS and compute and print the minimum, maximum and mean of the observed data values.

Create a new *Macro* icon and rename it 'step1'. Open the **Macro editor** (right-click **edit**) and move the cursor somewhere below the `#Metview Macro` line at the top. Then drop your 'mars_hirs' icon into the editor. You should see something like this (after removing the comment lines starting with `# Importing`):

```
#Metview Macro

mars_hirs = retrieve(
      type : "mfb",
      repres : "bu",
      obsgroup : "hirs",
      time : 00,
      resol : "",
      filter : "select lat, lon, obsvalue, vertco_reference_1"
)
```

This piece of code performs the retrieval and stores the result in an ODB database which is now represented by the `mars_hirs` macro variable.

In the next step we will use the `values` built-in macro function to read the ODB data values into a vector.

```
val = values(mars_hirs,"obsvalue@body")
```


The last step is to compute some statistics for vector `val` and print them the into the standard output.

```
min_v=minvalue(val)
max_v=maxvalue(val)
mean_v=mean(val)
print("min: ",min_v," max: ",max_v," mean: ",mean_v)
```

Now, if you execute this macro (right-click **execute** or click on the **Play** button in the **Macro editor**) you should see the following text appearing in the standard output:

```
min: 191.710006714 max: 301.720001221 mean: 238.441305601
```

Further Macro Examples

There are two more macro examples in the folder to show you how to use ODB MARS retrievals in Metview macro:

- macro_filter: it shows how to manipulate ODB MARS data with the `odb_filter` function (see *PART 6*) to derive new datasets.
- macro_plot: it shows how to plot data from an ODB MARS retrieval. It is basically the macro equivalent of the 'plot_hirs' *ODB Visualiser* icon.

