Metview Interactive Tutorial

Meteorological Visualisation Section
Operations Department
ECMWF

11/03/2013

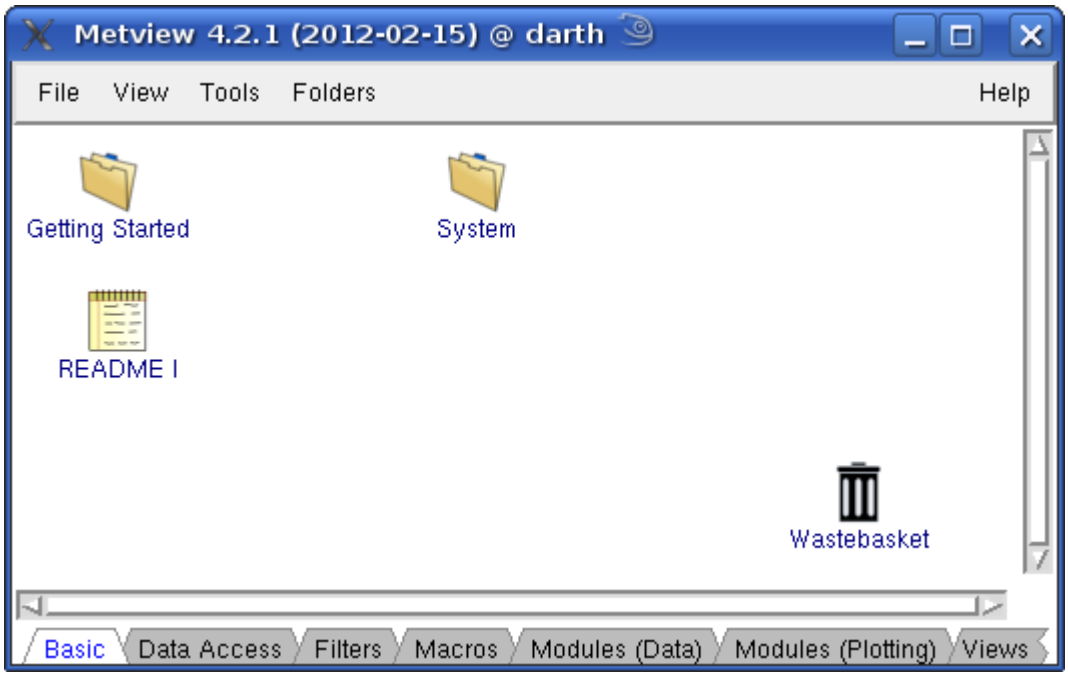
This tutorial was tested with Metview version 4.3.7
but should work for all 4.3.x versions.

European Centre for Medium-Range Weather Forecasts
Shinfield Park, Reading, RG2 9AX, United Kingdom

PART 1 - INTRODUCTION

A Simple Data Visualisation

When you first start Metview, you will see something like this:



This sort of window is called a **Metview desktop**.

Copy a GRIB data file into your Metview directory (`~/metview`); if you are attending the training course at ECMWF, then type the following command in a terminal window:

```
cp ~trx/mv_data/t1000.grb ~/metview
```

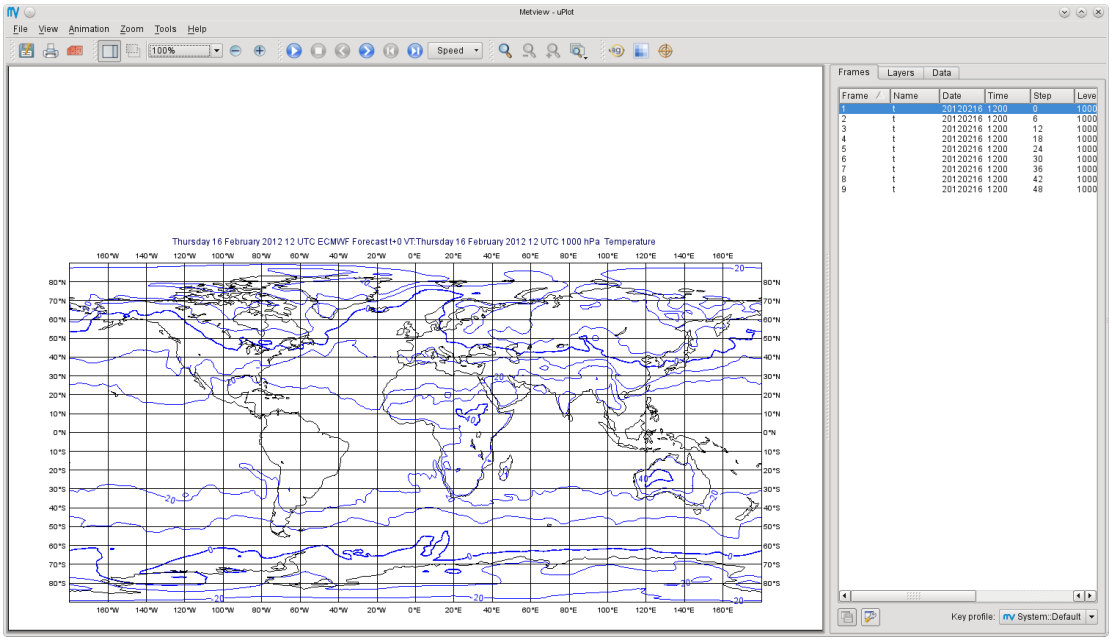
Otherwise you can download this file from the Metview Training Course website.

You should now see a new GRIB icon in your Metview window:

If it does not appear immediately, right-click on the **Metview Desktop** and select **Rescan folder**.

When you right-click on an icon, a context-sensitive menu appears.

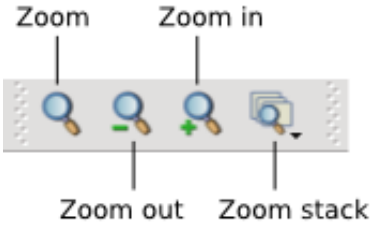
To visualise this data, right-click on its icon and select **visualise**. You will now see the **Display Window**. Its toolbars can all be moved, docked, undocked and hidden to suit your preferences.



Antialiasing

To the right of the zoom buttons should be the **Antialias** button. When active, a smoothing is applied to the lines in the plot – it is worth doing although it comes at the cost of a small amount of plotting speed. This setting will be remembered the next time you visualise data. Note that the antialiasing is not carried through to the various export image formats (see later) – it is active only in the interactive window.

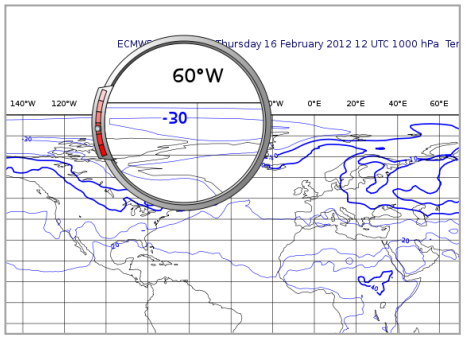
Zooming in a Plot



The above diagram shows the **Zoom** toolbar at the top of the **Display Window**. Click the **Zoom** button to enter 'zoom mode'. Now you can select an area by dragging with the left mouse button. You can zoom in as many times as you like. In order to 'undo' or 'redo' a zoom, click the **Zoom out** or **Zoom in** buttons respectively. The **Zoom stack** provides quick visual access to the current zoom history. Notice that when a new area is selected, the contours are recalculated - you see more detail as you zoom into a smaller area; you may also see more detailed coastlines.

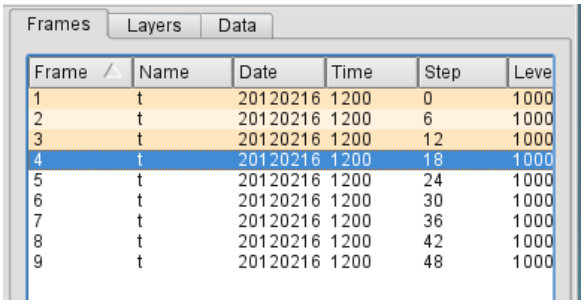
Using the Magnifier

The **Magnifier** button in the toolbar toggles the magnifier tool on and off. Unlike **Zoom**, this is a purely graphical enlargement of the plot. It is used mainly to inspect small text such as contour labels. The magnifying glass can be moved and resized using the mouse, and the magnification scale on its left-hand side can also be adjusted.



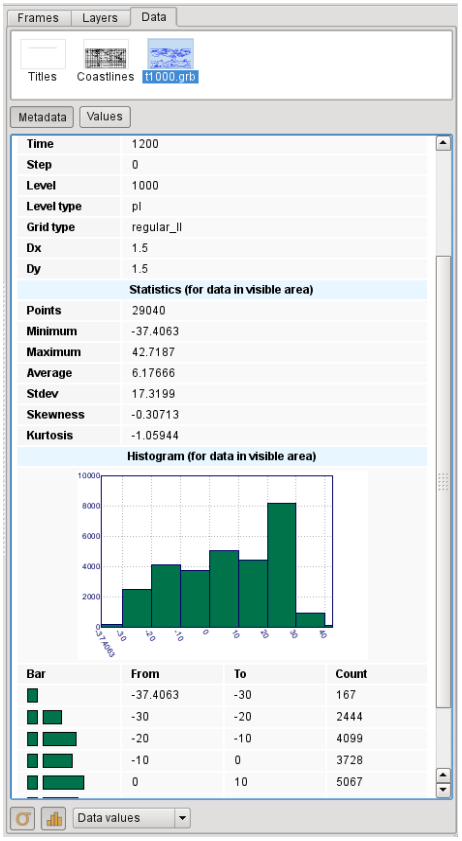
Animation Steps

The **Frames** tab to the right of the plot shows us that our GRIB file contains multiple fields. You can move between fields by clicking within this tab, by using the animation control buttons or by using the cursor keys. Note that each plot is computed only when you select a field. Generated plots are cached, indicated in the **Frames** tab through shading. This can quicken their rendering when the plots are complex. Note that modifying the plot in any way (such as zooming) clears the cache.



Frame	Name	Date	Time	Step	Leve
1	t	20120216	1200	0	1000
2	t	20120216	1200	6	1000
3	t	20120216	1200	12	1000
4	t	20120216	1200	18	1000
5	t	20120216	1200	24	1000
6	t	20120216	1200	30	1000
7	t	20120216	1200	36	1000
8	t	20120216	1200	42	1000
9	t	20120216	1200	48	1000

Layer Meta-data



There are three tabs in this panel - **Frames**, **Layers** and **Data**. We will look at **Layers** soon, but for now select the **Data** tab.

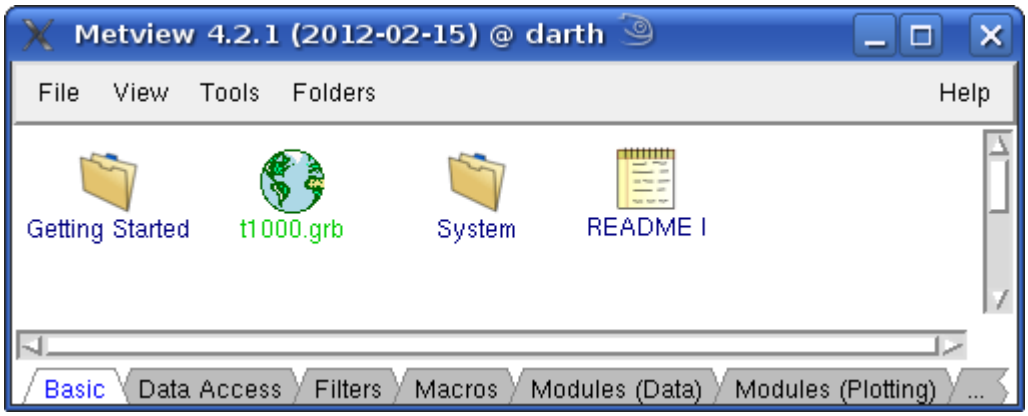
This reveals a page of meta-data for the current layer, including a histogram.

We will investigate these features in more detail later, but for now close the **Display Window**.

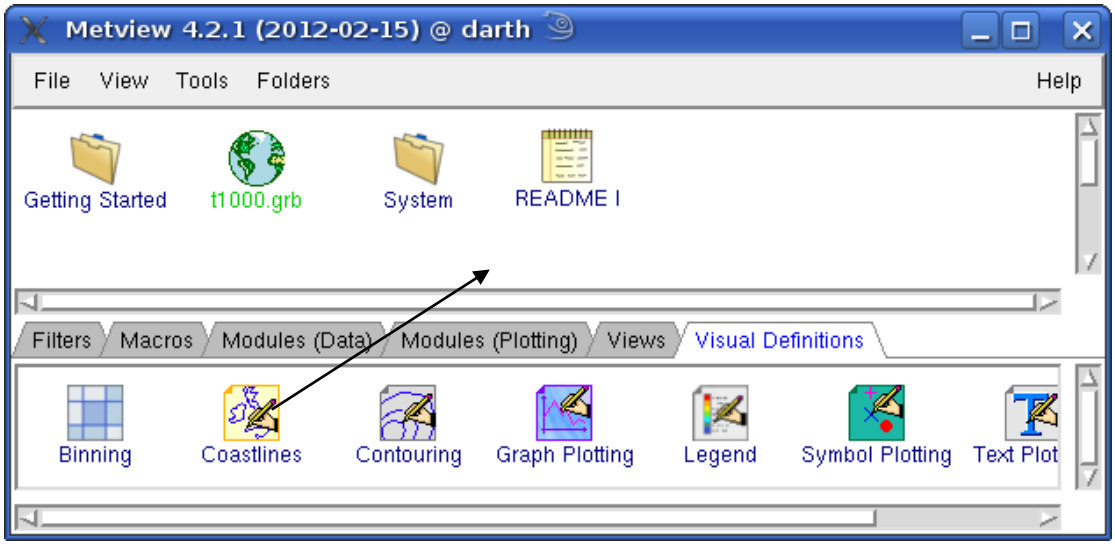
Creating and Editing an Icon

Let's customise the coastline plotting attributes.

First, create a new *Coastlines* icon. You can find a set of 'default' icons in the *icon drawers* at the bottom of the **Metview desktop**. Each holds a set of icons corresponding to a given category, such as **Basic** or **Data Access**.



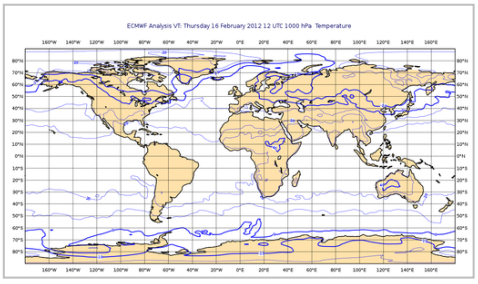
By clicking on the rightmost tab, scroll along until you see the **Visual Definitions** drawer. Open it by clicking on it.



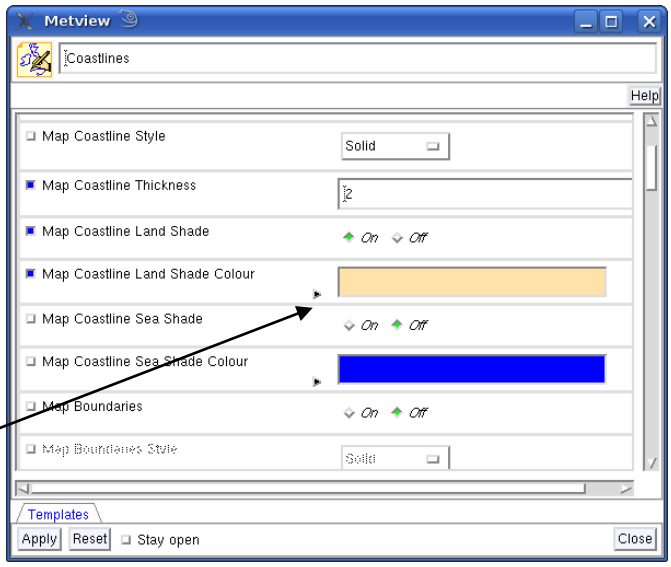
Drag the *Coastlines* icon onto the desktop area - a copy is made. You can close the drawer by clicking on its tab again.

Edit the icon by either double-clicking on it or else right-click, **edit** (double-clicking an icon always performs the **edit** action). This brings up the *icon editor* for coastline plotting. All user-selectable parameters for plotting coastlines are here. Set the following parameters:

Map Coastline Thickness	2 **Note**: you must hit `return` after editing a raw text field like this
Map Coastline Land Shade	On
Map Coastline Land Shade Colour	Cream



For colour-based parameters, there is a small arrow in the editor - click it to reveal a list of possible colours. After making these changes, click the **Apply** button to save and exit the editor.



Visualise the data again, and drag your new *Coastlines* icon into the **Display Window**.

Your *Coastlines* icon can be dragged into any plot, and later we'll see how to store useful icons so that they can be easily accessed from anywhere.

Modifying Layers

Now look at the **Layers** tab again. Drag the shaded *Coastlines* layer so that it is above the *t1000.grb* layer – a quick way to mask out the sea points! Imagine looking down through the layers from the top to the bottom in order to understand how they work. You can also select the *Coastlines* layer and change its transparency value. You can also toggle layers on and off using the checkboxes next to them. Note that these adjustments are not carried through to the various export image formats (see later).

Future versions of Metview will incorporate more advanced plot-editing facilities available directly from the **Layers** tab.

Modifying a Default Icon

As an exercise, we will now make this set of coastline attributes the default in all Metview plots.

- Open the folder called *System*.
- Now open the subfolder *Defaults*.
- Do one of the following: edit the *Coastlines* icon in the *Defaults* directory, or else delete it and copy your new *Coastlines* icon into the *Defaults* directory.

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. **Note:** on some systems, the middle mouse button cannot be used for dragging (this affects other applications, not just Metview). The alternative is to drag while holding down both the left and right buttons simultaneously.

Now visualise the data again - your new default coastline attributes are automatically applied. Close the *Defaults* folder to avoid accidentally changing more defaults!

Exploring the Coastlines Icon

Whilst we are looking at the *Coastlines* icon, we should explore some more aspects of it. We already have land shading, so let's add sea shading. In your main Metview folder (not the *Defaults* folder), copy your *Coastlines* icon (either right-click +

duplicate, or drag with the middle mouse button) and rename the copy, by clicking on its title, to *land_sea_shade*.

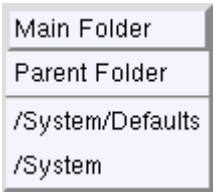
Edit this icon and activate its land and sea shading, setting the colour to whatever you like. Note that if you click **Stay Open** in the icon editor, then **Apply** will save the changes whilst keeping the editor open for further editing. This allows you to more quickly test your changes.

Make a copy of this icon, rename it *land_sea_shade_with_features* and try activating various features such as boundaries and rivers.

If you prefer the look of either of your new icons, then try making it the default (note: the default icon must always be called *Coastlines*).

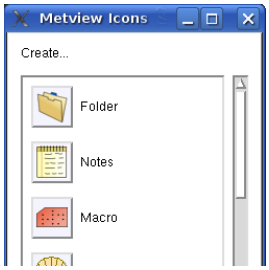
Organising Your Files

Before going further, organise your work into a new folder.



First, find your 'main' Metview folder (where you have the GRIB file). Notice the **Folders** menu on the menu bar, which gives access to the main folder, the parent folder and the most recently accessed folders.

To create a new subfolder, you could drag the *Folder* icon from the **Basic** drawer at the bottom of the **Metview desktop**. However, we will now see the other way to create new icons.



Ensure that no icon is selected on the desktop, then right-click and choose **New Icon…** This is the **desktop menu**. The *Folder* icon is the first in the list - click it to create a new folder. Click on its title and rename it '*course*' (all lower-case).

Open the new folder (double-click or right-click, **edit**) and drag your data icon into the new desktop in order to move it there. Also move your Coastline icons there. You may close any other Metview desktops that are open. If you close all the Metview desktops, then Metview will terminate and you will have to restart it.

Type the following command in a terminal window (or download the files):

```
~trx/mv_data/get_data
```

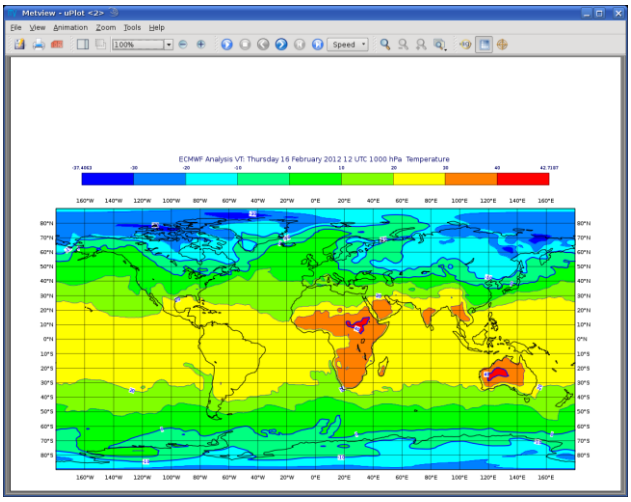
You should now see some new folders within your *course* desktop (*data_sources*, *visdefs*, *solutions* and *extra_tasks*). You may have to wait a few seconds, or else choose **Rescan folder** from the **Desktop Menu**. You will not need these until Part 3.

If you have extra time, explore *Extra_tasks_Part_1*.

PART 2 - VISUALISING YOUR DATA

Modifying the Contouring

Now we will shade our temperature field so that we can see the different levels more clearly.



Create a new Contouring icon by taking a copy from the **Visual Definitions** drawer at the bottom of your Metview desktop.

Edit it, setting the following parameters:

Contour Shade	On
Contour Shade Method	Area Fill
Contour Shade Max Level Colour	Red
Contour Shade Min Level Colour	Blue
Contour Shade Colour Direction	Clockwise

Apply the changes, visualise the data icon again (*t1000.grb*) and drag the contouring icon into the **Display Window**.

Our palette is automatically generated from a colour wheel. Try setting **Contour Shade Colour Direction** to Anti Clockwise to see the difference in the generated palette.

Creating a Legend

Create a legend by changing the first parameter in the Contour editor and dragging the icon into the **Display Window** again:

Legend	On

Fixing the Contour Levels

Now zoom in and out of different areas. What happens to the palette - does it stay constant? The default behaviour is to create contours at 10 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 the *Contouring* icon (either right-click + **duplicate**, or drag with the middle mouse button), and rename the copy '*fixed_t*' by clicking on its title. Edit the icon and make the following changes:

Contour Level Selection Type	Level List
Contour Level List	-5/0/5/10/15/20/25 **Note**: you must hit `return` after editing a raw text field like this
Contour Shade Colour Direction	Clockwise

Now when you apply this icon you will see that the palette is fixed wherever you zoom. There will probably be parts of the plot which are not filled; this is because our range of contour levels does not cover the whole range of values in the data. Change the list of contour levels so that the whole plot will be covered - you only need to add one number to each end of the level list to do this (or else change the current numbers at the ends of the list).

Plotting Extreme Values

You may be interested only in a certain range of values. This is easily done by modifying the contour parameters. Make a copy of *fixed_t* and call it *fixed_t_cold*.

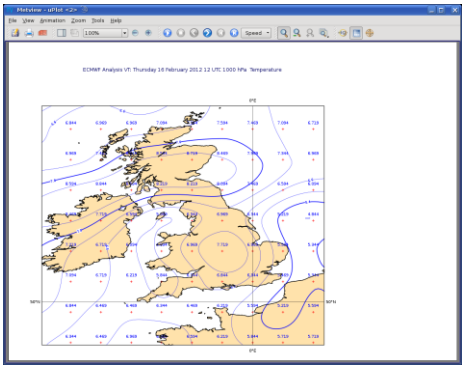
Modify the level list so that it contains a set of temperature values which only go up to 5 degrees C. Also change the colour scale so that the colours range from one shade of blue to another shade of blue. Now only the cold temperatures are plotted. If you have land and sea shading enabled, you will also be able to see this where there is no temperature shading.

You may turn off the isolines by setting **Contour** to Off.

Now we will create a similar plot, but this time with isolines at all levels, but shading only at the cold temperatures. Copy your *fixed_t_cold* icon and rename the copy *fixed_t_cold_plus_isolines* (for example!). Turn the isoline plotting back on, and add some positive values to the level list (e.g. –100/-20/-15/-10/-5/0/5/10/15/20/25/100). Isolines will be plotted at all these levels. To restrict the shading to a certain range, set **Contour Shade Max Level** to 5. Try out this new contouring icon!

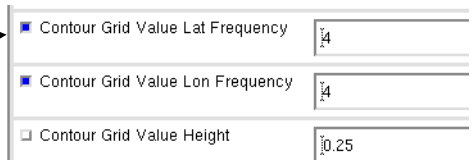
In Part 5 we will see a technique that will allow you to shade both hot and cold extremes without shading the 'normal' values in-between.

Plotting Grid Values



We will now plot grid values. Create a new *Contour* icon and rename it *grid_4x4*. Edit it and find the set of parameters close to the bottom of the editor which control the plotting of grid values. Activate grid value plotting, set it to plot **both** values and markers, and set the lat/long frequency each to 4.

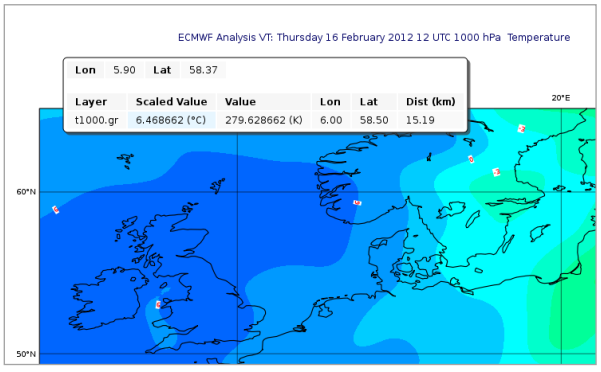
If you zoom into smaller areas, you may want to see every grid point - duplicate *grid_4x4* and call it *grid_1x1*. Set the lat/long frequency to 1 - one fast way to do this is to click on the **small blue button** next to the parameter.



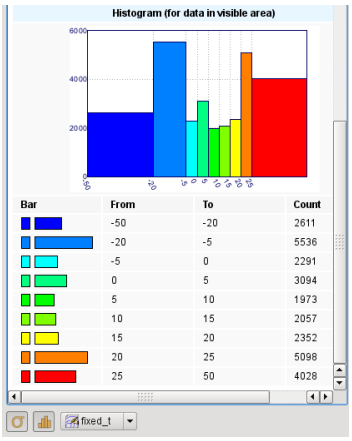
This button does two things: it indicates that a parameter has been altered from its default, and it restores the parameter to its default when clicked.

Cursor Data

For a closer inspection of data values in a plot without having to apply a special contour icon, the cursor data tool can be used. When activated, the cursor data box follows the mouse cursor around the plot, displaying data for the nearest grid point(s). To 'dock' the data box, left-click; to 'undock', left-click again and the box will retain its current offset from the cursor. The cursor data tool is available regardless of whether grid value plotting is on or not.



Layer Meta-data



With your GRIB data displayed with one of the shaded contour icons, look again at the layer meta-data (right-hand side of the window, **Data** tab). There is a button at the bottom which allows you to choose to view the histogram using the current contour settings instead of the default. Try it! Drop different contour icons into the plot to see what happens.

Now zoom into a smaller are of the plot. The meta-data is updated to include only the data points which are visible.

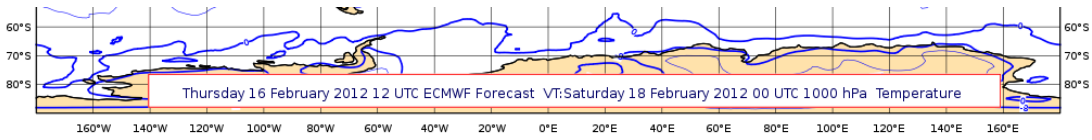
Plot Titles

Metview provides some control over the plot titles. For most data, the automatic title provides most of the useful information that describes it. We will now see how to modify the title specification and create our own titles.

Create a new *Text Plotting* icon (copy from the **Visual Definitions** drawer).

Separate lines of user text can be added to the automatic title. Try adding a couple of lines of your own text to the title, also making sure to change the parameter **Text Line Count** (drop the icon into your plot to see the result). Now replace the automatic title (line 1) with some of your own text. Change the text colour.

Now we will change the positioning of the title as in the next screenshot.



Create a new *Text Plotting* icon and rename it *positional_title*. Explore the parameters to create an automatic title which is displayed clearly at the bottom of the plot. You will need to use the parameters **Text Mode** and **Text Box Blanking**, among others. Units are cm from the bottom-left of the page.

You may manually override the exact details that go into the title by creating a user text title which includes *meta-field* references. We will use just a subset of these for this exercise. A meta-field is a special text string used for extracting meta-data from a field. For GRIB data we use GRIB_API keys[1] (we will investigate these in more detail later).

Create a new *Text Plotting* icon and rename it *custom_grib_title*. Set the following parameters to see how you can add information to the title from the GRIB header:

Text Line Count	2
Text Line 2	

[1] https://software.ecmwf.int/grib_api

Grid: <grib_info key='iDirectionIncrementInDegrees'/> x <grib_info key='jDirectionIncrementInDegrees'/> degrees

Storing and Reusing Icons

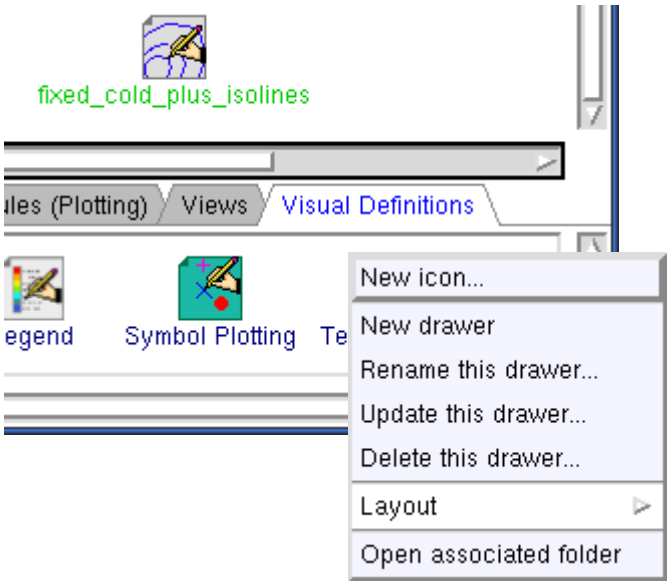
Metview has a number of ways to store useful icons so that they can be easily accessed.

First, each icon editor has a *Template Drawer* at the bottom. Edit a new Contour icon and click on the **Templates** tab in the editor to open the drawer. There is a selection of ready-made contour icons here. Drag ***Black Contours*** into the main editor in order to apply it. You can drag multiple icons into the editor at once.

Investigate the right-click menu on the template icons.

You can drag any of your own Contour icons into this drawer; they will now be available whenever you edit a Contour icon.

Another way to store icons is to either put them in an existing icon drawer, or else create your own. These drawers are available from all Metview desktops. Close the **Display Window** if it is open. Right-click inside an empty part of a drawer to get the drawer menu. Create a new drawer and rename it **Custom**. When you create a new drawer it appears in the right-most end; however, when you restart Metview, it will be placed alphabetically.



Drag any useful icons you have into your new drawer. They will now be available from any Metview desktop - just drag your icon from your drawer onto the desktop in order to create a copy. Alternatively, drag an icon from your drawer straight into the **Display Window**.

If you have extra time, explore *Extra_tasks_Part_2*.

PART 3 - DATA

Data Sources

Now open the *data_sources* folder. You will see a set of icons representing different data types. They are described in the following table.

Icon	Data Type(s) Returned	Description
 GRIB Data	GRIB	A GRIB file. Contains gridded field data.
 BUFR Data	BUFR	A BUFR data file. Contains observation data.
 Geopoints Data	Geopoints	An ASCII text file containing scattered point data.
 MARS Retrieval	GRIB / BUFR	Retrieves data from the MARS data archive. Contains no data itself.
 Lat / Long Matrix	GRIB	Text file format for gridded data. Converted internally into GRIB format.
	NetCDF	A binary file for storing multi-dimensional arrays of data.
 ASCII Table	Table	An ASCII file with data arranged with one column per variable (e.g. CSV).
 ODB Database	ODB	An ODB database storing observation data.

You have already seen GRIB data in earlier exercises.

Visualise the BUFR data file. Zoom in on an area. Notice that you see more observations as you zoom into smaller areas. If you need to read the text more clearly, use the **Magnify** tool!

Visualise the geopoints data file. By default, the numerical values are displayed, and no thinning is applied (we will see how to change the plotting attributes in Part 4). Use the **Zoom** and **Magnify** tools to examine the data in smaller areas. Double-click the icon or right-click **edit** in order to see the text file behind this data.

Edit the *Lat Long Matrix* icon - this is a text file format. When you **visualise** the data, Metview converts it internally into GRIB format. This is one way to allow Metview to handle gridded data which is not in GRIB format - convert it to this text format instead.

We will get to the remaining file formats a little later. Visualisation of some of these data types (netCDF, ASCII Tables and ODB) can require an extra step – this will be covered in Part 4.

Icon Feedback

The *Mars Retrieval* icon gives us the opportunity to explore another feature of Metview. The colour of an icon's text label tells us which state it is in:

Blue	No operation executed since last save (default)
Orange	Operation in progress, e.g. waiting for data retrieval from database
Green	Operation successfully executed, data may be cached for some icons
Red	Operation failed, e.g. due to invalid input parameters

Visualise the *Mars Retrieval* icon and watch as the colour of its text label changes. If you edit the icon (e.g. change **Param** to U/V), the colour will be reset.

Icon Output

By now you should have seen a popup window giving some information, either when you visualised the BUFR data or performed the MARS retrieval. Each icon has its own text output which can be viewed by selecting **output** from the icon's right-click menu. This is only enabled when there is output for that icon. Have a look at the output for the *Mars Retrieval icon* (ensure that you have retrieved data first).

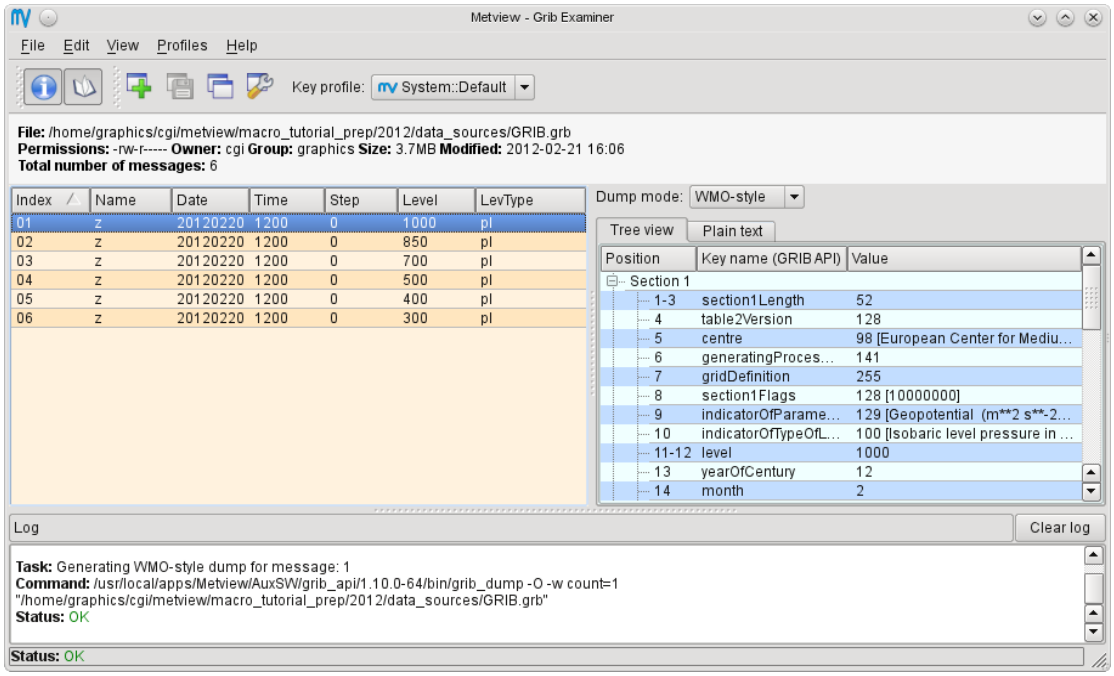
You can view a complete history of output from all icons by selecting **Messages…** from the **File** menu in any **Metview desktop**.

For an even more detailed output, you can start Metview on the command line with the '`-slog`' option - this will write lots of information to your terminal window. This information can be useful when reporting a problem to the Metview team! '`metview -h`' gives a list of all useful command line options and environment variables.

Examining Data

Metview allows a deeper examination of some data types.

Right-click **examine** the GRIB file. In this case we have 6 fields (messages) in the file, each represented by a row in the message list on the left-hand side. The right-hand side shows detailed meta-information for the selected message, presented in a number of different ways (try changing between **Tree view** and **Plain text**; try different **Dump mode**s). You can sort the fields by clicking on the different column headers. The GRIB examiner can be customised – see the extra tasks for this chapter, as this is an advanced topic.



Examine the BUFR data to see what the observation messages look like. You can also examine the ODB, netCDF and geopoints icons. ASCII Table data currently does not have a custom examiner, but upon examination it will be opened in a text editor.

Creating Links to External Data

By default, Metview can only see files under the `$HOME/metview` directory. You can select a different home directory for Metview (`-u` option on the Metview startup command line[2]), but you can also create links to external data files - this can be useful if you have large data files which would exceed the quota in your home directory.

[2] Type '`metview -h`' in order to get a complete list of startup options and relevant environment variables which affect the operation of Metview.

One way is to do this from a shell command line (`ln` command), but Metview can also create these links for you.

Return to your *course* folder. With no icon selected, right-click and choose **New link…** and type `/scratch/ectrain/trx/mv_data/ztuv.grb` into the **Selection** box. Note that the text label under the new icon is in italics - this indicates that this is a link. This file contains analysis and 1, 2, 3, 4 and 5-day forecasts for geopotential, temperature and wind at various pressure levels – **visualise** it to see for yourself.

You can create links to individual files or complete folders. This facility can be used to share folders between users.

Filtering GRIB Data

Metview provides powerful data filtering capabilities. Let's take our *ztuv.grb* file and extract the forecast and analysis data separately from it.

Create a new *GRIB Filter* icon from the **Filters** drawer (or use the **desktop menu** / **New Icon…**). This time we'll rename it from within the icon editor (just to show an alternative way to rename an icon). Edit the icon, and notice that its name appears at the very top of the editor. This is an editable field, so change it to *t_3day_fc* - we will use this icon to extract only the 3-day forecast data for temperature.

First, we specify the input data. Drag the *ztuv.grb* icon into the **Data** field of the editor. This is an *icon field* – an area where you can drop other icons. Now set the following parameters to extract just the 3-day (72-hour) temperature forecast:

Type	FC or Forecast
Param	T or Temperature
Step	72

Visualise this icon and verify that it returns only the data we expect.

Now create a new *GRIB Filter* icon, rename it *t_an* and use it to extract only the temperature analysis data:

Type	AN or Analysis
Param	T or Temperature

Simple Data Manipulations

Now we would like to compute the difference between the forecast and the analysis. Create a new *Simple Formula* icon (**Macros** drawer) and rename it *fc_an_diff*. Edit it and ensure that the first tab (F+G) is selected. Drag the

t_3day_fc icon into the **Parameter 1** icon box, and *t_an* into **Parameter 2**. Ensure the **Operator** is set to minus ('-'). **Apply** to save the changes, and **visualise** this new icon. It will read the data from its two input icons and return the difference. If you close the **Display Window** and then re-visualise the icon, it will be faster because the data will have been cached (green icons).

Open the *visdefs* folder and drag the *pos* and *neg* icons together into the **Display Window** in order to easily differentiate between positive and negative differences.

Notice that we are not just subtracting one field from another - each input icon contains data from multiple levels (1000hPa, 850hPa, 700hPa, 500hPa, 400hPa and 300hPa) - we call such a collection a **fieldset**. When we perform the subtraction, we subtract each field in *t_an* from the field in the corresponding position in *3_day_fc*, giving us a new fieldset - scroll through the resulting fields to check.

Although simple operations such as this can easily be performed using icons, the Metview Macro language provides a more powerful and flexible solution for calculations more complex than this.

Filtering Observation Data

Create a new *Observation Filter* icon from the **Filters** drawer. Use this icon to filter the data in *BUFR.bufr*. Experiment with the **Location Filter** parameter, and extract just a selected area or line of data (format is S/W/N/E, but we'll soon see a better way to enter coordinates). Try returning its output as geopoints (**Geographical Points** in the option list); by default, Temperature is the parameter which is extracted (012004).

ODB data

ODB stands for **Observational DataBase** and is developed at ECMWF to manage very large observational data volumes through the ECMWF IFS/4DVAR-system. The data structure of an ODB database can be seen as a table of variables called columns.

Right-click **examine** the *ODB Database* icon to see a list of the variables in the data. The Data tab provides access to the actual data itself.

ODB data can be filtered using ODB/SQL queries. The supplied *ODB Filter* icon contains an ODB/SQL query to retrieve certain columns of data. Edit it - note that this pre-prepared icon is using the *ODB Database* icon. Look at the ODB Query field to get an idea of what data will be filtered. Now close the editor and **examine** the icon to see the filtered subset of data it has produced.

If you have extra time, explore *Extra_tasks_Part_3*.

PART 4 - VISUAL DEFINITIONS, VIEWS AND LAYOUTS

Visual Definitions

So far we have been using *Contour* icons to change the plotting attributes of fields. In general, we call a set of plotting parameters a **visual definition** (*visdef*); a *Contour* icon is a visual definition for contour plotting, a *Wind* icon is a visual definition for wind plotting, etc. We will now look at a small selection of visdefs in order to see what is possible with Metview.

Open the folder *visdefs*. This contains a set of pre-prepared visual definition icons for you to play with. You can edit each icon and quickly scan down the left-hand side for the blue buttons in order to see which parameters have been changed from their default values. Here are some suggestions for investigating the icons:

Name	Purpose	Suggestion
shading_only_t	Contouring for temperature fields using shading and no isolines.	Visualise your *t_an* data filter icon and drag this visdef into the plot. Scroll through the fields.
shading_20_levels	General contour shade icon with 20 automatically computed levels.	Visualise your *t_an* data filter icon and drag this visdef into the plot.
hatch_shading	Contouring using hatch shading.	Visualise your *t_an* data filter icon and drag this visdef into the plot. This can be a useful contouring method for black and white publications.
pos, neg	Contour shading.	We will use these in Part 5.
histogram_legend	Changes the legend into a histogram format.	Visualise your *t_an* data filter icon and drag *shading_only_t* into the plot. Now drag this visdef to change the legend style.
land_sea_shading	Shades land and sea.	This can be dragged onto any geographical plot at any time.
boundaries	Plots country boundaries.	This can be dragged onto any geographical plot at any time.
high_winds	Wind arrows only above 10m/s. No thinning is	Visualise *ztuv.grb* and select the first wind field. Drag this icon into

	applied, so the arrows will be more dense.	the plot.
wind_flags	Wind flags only above 5 m/s.	Same as above.
coloured_wind	Wind arrows coloured according to the wind speed.	Same as above.
t_symbols_K	Symbol plotting in degrees K.	Visualise *geopoints.gpt* from the *data_sources* folder and drag this visdef into the plot. The data are in degrees Kelvin.
t_symbols_C	Symbol plotting in degrees Celsius.	Create a new *Simple Formula* icon and use it to convert the geopoints data into degrees Celsius: '**F+x**' tab, subtract 273.15 from the geopoints icon. Visualise your new icon and drag this visdef into the plot. The data are in degrees Celsius.
t_symbols_auto	Symbol plotting with automatic range calculation	Visualise some geopoints data and drop this visdef into the plot. The level list is computed automatically from the data and will change if you zoom.
graph_curve	Graph plotting	We will use this later.

Views

A fundamental concept in Metview is the **view**. A **view** specifies the following things in a Metview plot:

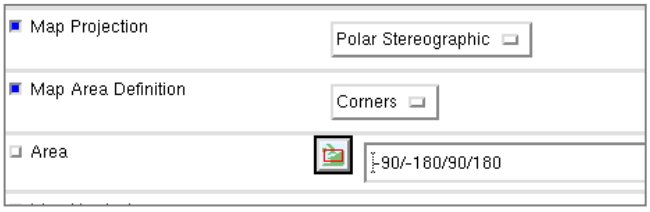
- what type of visualisation (e.g. geographical map, cross section, vertical profile)
- parameters specific to that plot type (e.g. geographical area, cross section line)
- the plot position within the page (several plots can share a page)
- how to overlay different data in the same plot (covered later in this course)
- how to draw the frame around the plot

Without a view specification, Metview would not plot anything; if you do not provide a view, then Metview will use a sensible default view.

The Geographical View

This is the default view for plotting geographic-based data.

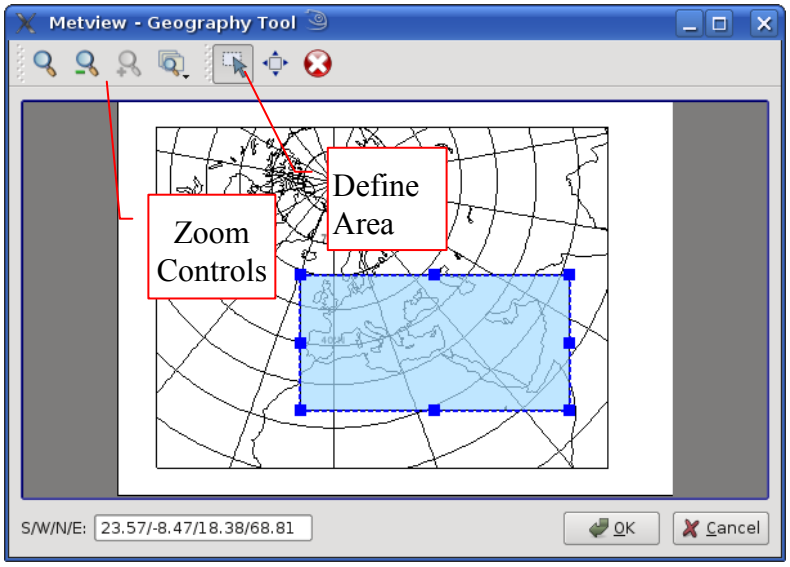
In Metview 4, the Geographical View *icon replaces Metview 3's* Map View *icon. While existing* Map View *icons will still work, some functionality will be restricted, such as overlay control.*



We will first use a *Geographical View* icon to save a geographical area that we can reuse. Create a new *Geographical View* icon (**Views** drawer) and rename it to the name of a country/region of your choice. Edit the icon, change the **Map Projection** to Polar Stereographic, the **Map Area Definition** to Corners and click on the **Geography Tool** button (shown in the picture above).

The Geography Tool

This tool helps you define a region.



Use the **Zoom** tools to enlarge the European area and use the **Area** tool to select your region of choice. Click **Ok** to save your selection - your choices will now be updated in the *Geographic View* editor. Click **Apply** in the *Geographical View* editor to save everything.

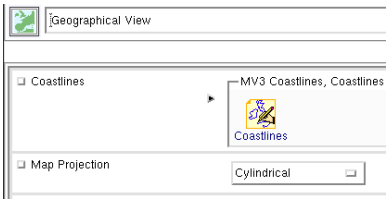
Try using this icon in two different ways:

1. Visualise the *Geographical View* icon and drag a data icon into the **Display Window**

2. Visualise a data icon and drag the *Geographical View* icon into the **Display Window**

It is possible to create *Geographical View* icons for each region you are interested in and store them for regular use (see *Storing and Reusing Icons* on page 14).

Embedded Icons

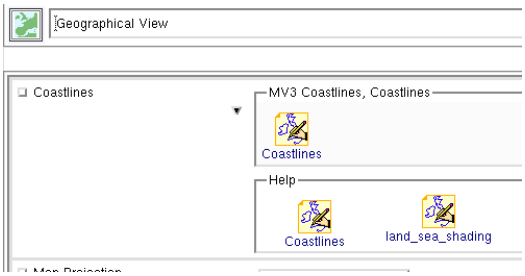


Notice that a *Geographical View* icon editor contains a place for an embedded *Coastlines* icon. If you drop a *Coastlines* icon here and apply the changes, then the *Geographical View* icon will use your new coastlines.

You can use your own *Coastlines* icons in this icon field: edit your *Geographical View* icon, right-click on the embedded *Coastlines* icon (if there is one) and select **remove**. Now drag the *land_sea_shading* icon from the *visdefs* desktop into the now-empty **Coastlines** icon field. Click **Apply**, then visualise your *Geographical View* icon.

Your *Geographical View* icon now contains a ***link*** to the coastlines icon - if you change the *land_sea_shading* icon, then those changes will be reflected the next time you visualise your *Geographical View*; if you edit the coastlines icon within the *Map View* icon editor, those changes will be applied to the *land_sea_shading* icon.

This method allows you to share a single *Coastlines* icon between multiple view icons; update the *Coastlines* icon and all the views will pick up the changes automatically.

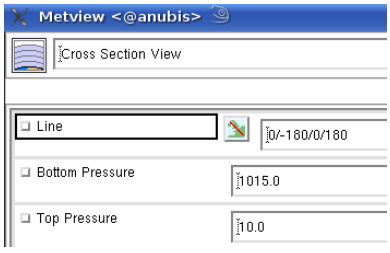


Another way to share embedded icons is to use the **icon help drawer**. Click the arrow beside the *Coastlines* icon to open this drawer. Drag *land_sea_shading* into it. **Apply**.

Now create a new *Geographical View* icon and edit it. Open the **Coastlines** help drawer and drag *land_sea_shading* into the icon field. Your *Geographical View* is now using a ***copy*** of this *Coastlines* icon. This is an alternative way to share embedded icons.

The Cross Section View

Now create a new *Cross Section View* icon. Visualise it and drop the *t_an* filter icon into the **Display Window**. A default cross section is generated. This is an alternative way to **view** your data - instead of a geographical plot for instance.



Edit the *Cross Section View* icon and change the transect line - click on the **Geography Tool** button to bring up an editor (or type the coordinate by hand).

Click **Apply** in the *Cross Section View* icon and use it to re-visualise the data with this new cross section.

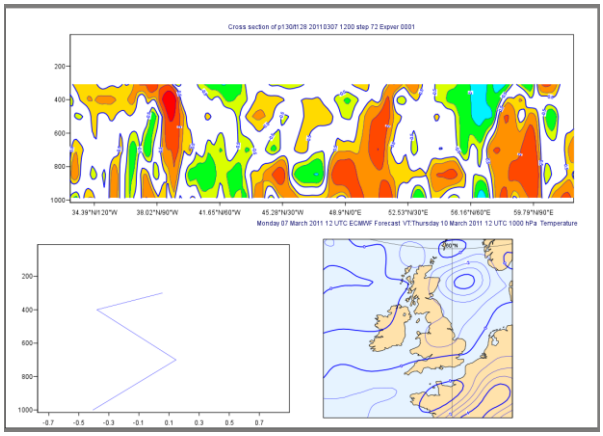
Note that you can still drag any valid contour icons you may have into the **Display Window** when visualising a cross section.

The Vertical Profile View

Now create a new *Vertical Profile View* icon. Visualise it and drop the *t_an* filter icon into the **Display Window**. This view shows a vertical profile at a point (or averaged over an area). Experiment with this icon in a similar way to how you did with the *Cross Section View* icon.

Plot Layout in Metview

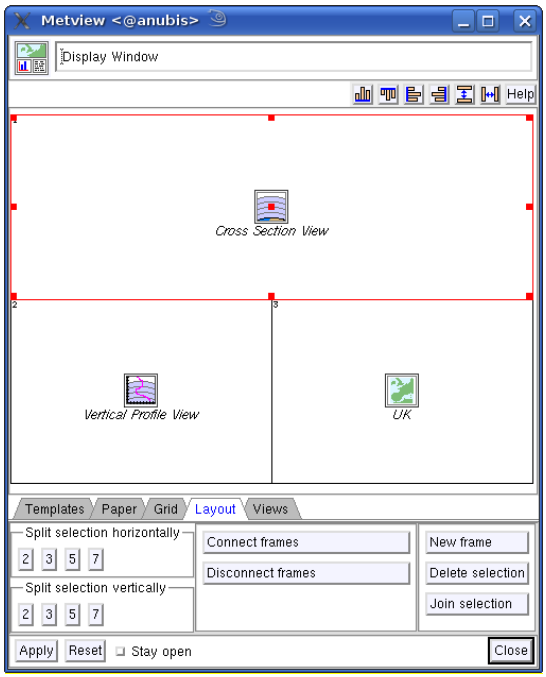
Sophisticated layouts are possible in Metview, with multiple plots on a single page as shown below:



Create a new *Display Window* icon (**Basic** drawer) and **edit** it. This icon defines a page, which by default contains just a single plot scene which uses a *Geographic View*.

First, let's split the page into two so that we have a top half and a bottom half. Click on the **Layout** tab at the bottom to reveal the layout controls. Click **Split selection vertically (2)**. Now select just the bottom half (it will have a red border around it when you have done this) and click **Split selection horizontally (2)**.

Now we will give a different **view** to each scene. Drag a *Cross Section View* icon (either one you previously created or else a new one) into the top scene. Drag a *Vertical Profile View* icon into the bottom-left scene. Drag a *Map View* of your choice into the bottom-right scene. Your **Display Window** editor should look like this:



Apply your changes and **Visualise** this icon. Drag the *fc_an_diff* computation icon into all three of the scene in the **Display Window**. Now apply some visdefs: from the visdefs desktop, drag *pos* and *neg* (together) into the cross section scene and *graph_curve* into the vertical profile scene. Your result should look something like the plot at the start of this section.

If you look at the **Frames** and, more interestingly, the **Layers** tabs, you will see that they are linked to only one of these scenes at a time. Try using the **Active scene** control to change which on is used. You can also right-click on a scene and choose "Select as active scene" from the context menu.

If you have extra time, explore *Extra_tasks_Part_4*.

PART 5 – VISUALISERS, DROPS, OVERLAY AND ICONS

Visualiser Icons

Some formats, such as GRIB, are easy to visualise in Metview - just right-click **visualise**. This is because they are quite constrained in their contents and have enough standardised meta-data for a program to understand how they should be plotted. Some other formats, such as netCDF and tables of ASCII data are not easily interpreted for automatic plotting (which variables/columns should be selected and what do they represent?). Metview introduces the concept of the *Visualiser icon*.

Visualisers are new to Metview 4.

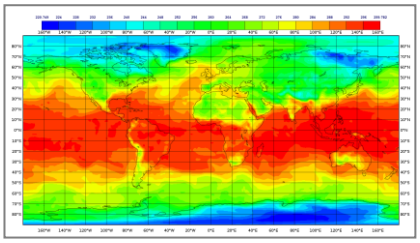
NetCDF data

Examine the *NetCDF* icon in the *data_sources* folder to get an idea of its structure.

Create a new *NetCDF Visualiser* icon (**Modules (Plotting)** drawer). Edit it and drop the *NetCDF* icon into the **NetCDF Data** field. Set the following parameters:

Netcdf Plot Type	Geo Matrix
Netcdf Latitude Variable	latitude
Netcdf Longitude Variable	longitude
Netcdf Value Variable	v2d

Apply to save the changes, and **visualise** this new icon. See how the settings in the visualiser icon correspond to the variable names in the data. Now visualise another field from the same file. Use the *shading_20_levels* icon on the plot.

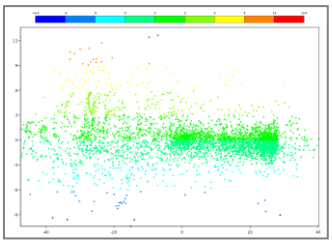


ASCII Table data

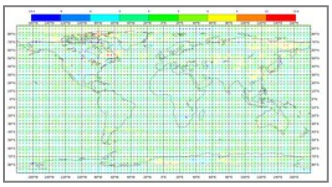
To see how to plot ASCII data which is arranged in columns (e.g. a CSV file), have a quick look at *ASCII Table.csv* in the *data_sources* folder – it is a standard comma-separated file. Create a new *Table Visualiser* icon and rename it *fc_anoms_vis_xy*. Edit it and drop the *ASCII Table.csv* icon into the **Table Data** field. Set the following parameters:

Table Plot Type	Xy Points
Table X Variable	an
Table Y Variable	fc-an
Table Value Variable	fc-an

Visualise to get a scatterplot and drop the *t_symbols_auto* icon from the *visdefs* folder into the plot. You could also plot *an* against *fc*.



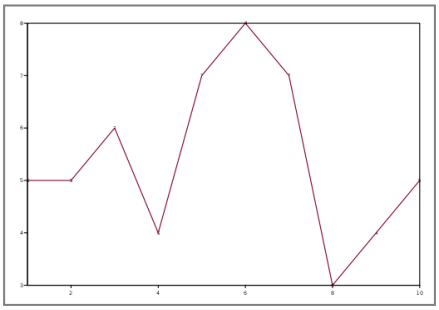
The data file also contains latitudes and longitudes; copy *fc_anoms_vis_xy* and rename it *fc_anoms_vis_geo.* Edit this icon to produce a map plot – you will need to set **Table Plot Type** to Geo Points, and then modify other parameters in order to get a plot.



The *Table Visualiser* icon also provides a number of options to enable the parsing of various forms of ASCII table, e.g. space-separated, combined delimiters, etc.

Lists of data values

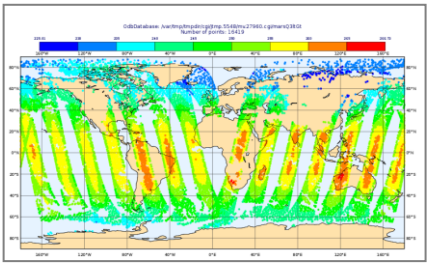
Metview can be used to quickly plot data that is not stored in files by using the *Input Visualiser* icon. Take a copy from the **Modules (Plotting)** drawer and edit it; keep **Input Plot Type** as Xy Points and enter lists of slash-separated numbers into the fields **Input X Values**, **Input Y Values** and, optionally, **Input Values**. Apply, then **visualise** the icon. By default, it will plot your data points as unconnected symbols. To connect them with a curve, drop the *graph_curve* icon from the *visdefs* folder into the plot.



When used as part of a macro script, this technique can be used to easily visualise computed data points not stored in files.

ODB data

ODB data also requires a visualiser icon; create a new *ODB Visualiser* icon, rename it *odb_tb_plot* and edit it. Drop the ODB Database icon into the **ODB Data** field.

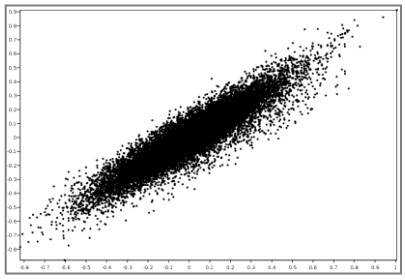


Most of the default parameters are already suitable for this ODB – just edit the one field:

Odb Where	vertco_reference_1@body = 5

Now visualise the icon and drop the *t_symbols_auto* icon from the *visdefs* folder into the plot.

A scatterplot can also be generated from the data. Copy your existing icon and rename the copy *odb_scatter_plot*. Modify its settings like this:



Odb Plot Type	Xy Points
Odb X Variable	fg_depar@body
Odb y Variable	an_depar@body
Odb Value Variable	<leave blank>

This will produce an x/y scatterplot visualisation; you can drop the *t_symbols_auto* icon into it. The 'extra tasks' shows an advanced form of visualising plots such as this.

A complete separate tutorial on ODB usage in Metview is available from Metview's tutorial web page:

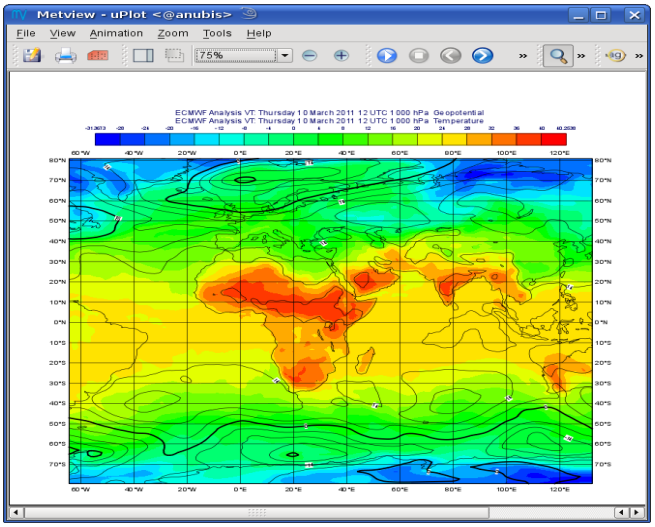
https://software.ecmwf.int/metview/Tutorials

Icon Drop Rules

Visualise *fc_an_diff* – this was the difference field we created earlier.

From the *visdefs* desktop, drag the *pos* icon into the **Display Window** – this shades the positive values. Now drag the *neg* icon into the **Display Window** – this shades the negative values. But it replaces the *pos* shading! How do we get both together? Select both the *pos* and *neg* icons and drag them *together* into the **Display Window**.

Now let's see how to overlay two different data units. Create a copy of the *t_an* filter icon, rename it *z_an* and set **Param** to Z so that we will filter just geopotential data. Visualise *t_an*, then drop *z_an* into the **Display Window**. We now have two contoured fields in our plot, but we would like different visdefs for each one. If we drop a contour visdef into the **Display Window**, it will be applied to each contour plot in the window (try it). How do we bypass this behaviour?



One way is through dropping a visdef *with* a data icon. Close the **Display Window** and we'll start again. Create a simple contour icon for the geopotential (*z_an*) data with black contour lines and no shading (you can use the *Black Contours* icon from the **Templates** drawer in the icon editor to help with this). Visualise *t_an* and drop the *shading_20_levels* icon from the *visdefs* desktop into the Display Window. Now select both *z_an* and your new black contours icon and drop them into the **Display Window** *together*. If you like, you can also filter the U/V data and drop this into the **Display Window** too – it will be unaffected by the *Contour* icons since it is a wind field.

VisDef Drop Rules:

a visdef dropped in a scene applies to all compatible Data and removes any existing similar visdef
a visdef dropped jointly with Data remains attached to Data and has no effect on other Data or visdefs!
two visdefs of the same type dropped jointly act as a single visdef and apply to all compatible Data (e.g. pos+neg contouring)

Data Overlay

Metview's *overlay settings* determine which data are overlaid on the same plot as each other. For instance, we have already produced a plot with temperature and geopotential overlaid together. Metview has some default rules, which can be overridden using an **Overlay Control** parameter in the view icons.

You have already seen what Metview does with data contained in a single data icon, which is Rule 1:

Multiple data contained in a single icon or file (data unit) are never overlaid

In practice, this means that a GRIB file with 5 fields is visualised as 5 separate plots which you can scroll through.

If you wish to overlay data, then you must provide separate data icons for each 'layer'. Then we are subject to Rule 2:

Multiple data provided in several data icons are overlaid according to user or system defined overlay controls.

Let's experiment in order to see how to work this.

Create a new *Geographic View* icon, and rename it *overlay_test*. First, visualise it; then drop *t_an* and then *t1000.grb* onto it. Give one of them black contours so you can tell them apart. They are overlaid, because that is the default. The **Frames** tab will help you see this too.

Now, edit *overlay_test* and scroll down to **Overlay Control**, change it to Never, and apply.

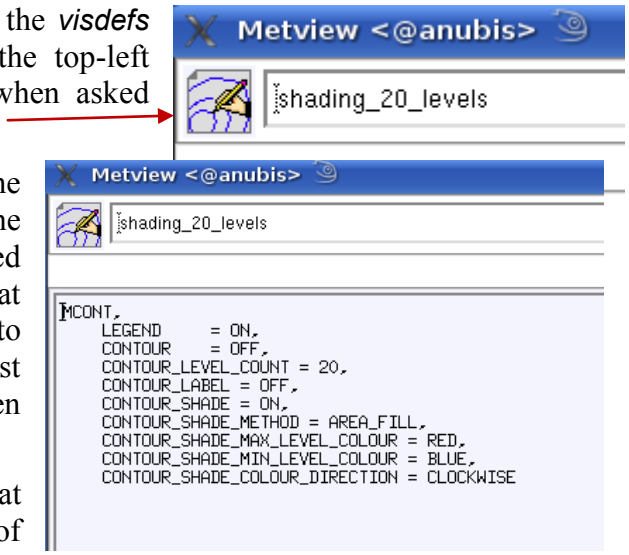
Now repeat the previous exercise, and see what happens when we try to plot data from two different icons. The fields from the two icons are plotted in sequence with no overlay.

Repeat again, but this time with **Overlay Control** set to By Date. In this mode, two fields from different sources will only be overlaid if they are valid at the same date and time.

Icons Revealed

So, when you create a new *Contour* icon, what is actually behind it? Answer: a text file! The easiest way to see this is to use a 'hidden' feature of the icon editors.

Edit the *shading_20_levels* icon from the *visdefs* desktop. Now click on the icon in the top-left corner of the editor, and click **OK** when asked whether to Apply.



You can now see the 'contents' of the icon in text format. What you see are the parameters which have been changed from their default settings (the ones that would have the blue squares next to them in the icon editor). This is one fast way to see which parameters have been set in an icon.

It may also be reassuring to know that visdef files are not large! All of Metview's icons are similar to this; the only files which are likely to be large are data files and output files (such as PostScript, PNG, etc).

So, when you create a new *Contour* icon, what are you actually creating on the file system? Note first that Metview's 'Main' folder is located at `$HOME/metview` unless you started Metview with the `-u` option.

From a terminal window command line, go to the `visdefs` directory and list it:

```
cd ~/metview/course/visdefs
ls -l
```

Among the files listed will be `shading_20_levels`. `shading_20_levels` contains exactly the text you have just seen from within the icon editor. You can check this with your favourite text editor, e.g.

```
nedit shading_20_levels
```

There is, however, also a hidden file called `.shading_20_levels`:

```
ls -la
nedit .shading_20_levels
```

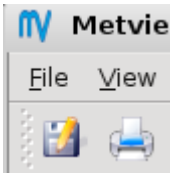
This contains some meta-information about the icon, such as its class, and its position on the desktop.

Some icons also have a directory with a hash (#) symbol at the end - if we had embedded icons within it (in the same way that a *Geographic View* icon has an embedded *Coastlines* icon), then they would appear inside this directory.

If you have extra time, explore *Extra_tasks_Part_5*.

PART 6 - METVIEW TOOLS AND APPLICATIONS

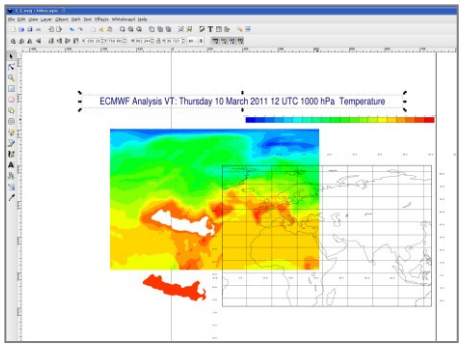
Exporting Plots from Metview



The **Display Window** has buttons for both exporting a plot to file, and for printing a plot. The **Export** button produces a dialog which allows you to specify a path and filename – you should omit the extension from the filename, as this will be added automatically. The **Output formats** option allows you to specify multiple formats – Metview can efficiently generate multiple output formats in one go.

Frame Selection specifies whether to print all of the frames in the **Display Window** (including the ones you have to scroll to) or just the one that is visible.

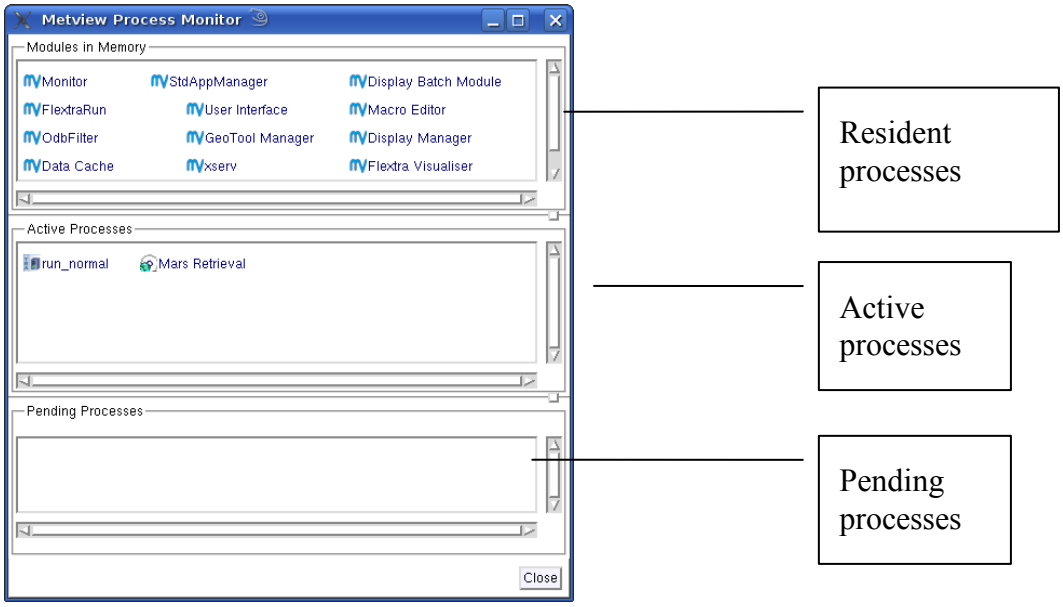
One of the supported formats is KML/KMZ, used by Google Earth. Try exporting a plot in this format. If you have saved it to a directory within ~/metview then you should see a KML icon which you can **visualise**. Otherwise you can start `google-earth` from the command line with the path to the KML/KMZ output file as its argument.



Export a plot in SVG format, then **examine** the resulting SVG icon. This will open the file in the vector graphics editor Inkscape, from where you can manually adjust the plot.

Task Monitoring

Metview has a built-in task monitor, available from the **Tools** menu on the menu bar (**Process Monitor…**). This tool allows you to see which processes Metview is currently running. It also allows some control, such as the ability to abort processes (right-click menu on each process's icon).



From bottom to top: the **pending processes** pane contains the processes that are queued, waiting for execution. The **active processes** pane contains the processes that are currently being executed. The **resident processes** pane contains the Metview modules that have been successfully started and are residing in memory.

Often, Metview processes are run so quickly that you barely see them in the **Monitor**. However, data retrievals and complex computations can take longer. Experiment with this tool; keep it running while you perform some computations or visualise some data.

Metview Applications

Explore some of Metview's applications. This is really a 'play with Metview' session, but here are some suggestions. Choose the ones that interest you most, or explore by yourself!

First, create a new folder called *mv_apps* and work in there in order to keep things tidy.

Data Processing

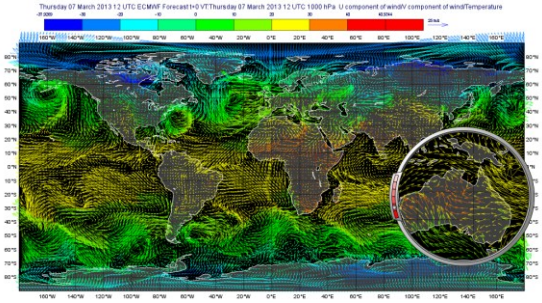
From the **Modules (Data)** icon drawer, create a new *Average Data* icon. Edit it, open the icon help drawer for the **Data** parameter and use the suggested MARS retrieval icon. Set **Area** to some area of interest. **Apply**, then **visualise** the icon. The application behind this icon computes a vertical average cross section. Metview supplies a default *Average View* when visualising it.

Investigate the *Hovmøller Data* icon.

Investigate the **Modules (Data)** icon drawer and use its icons in a similar way - most of them have useful icons in their icon help drawers. Not every icon field needs to be filled, but data fields do. Note that some icons (such as *Rotational or Divergent Wind*) produce results encoded in spherical harmonics – these cannot be visualised directly and therefore have to be passed through a *GRIB Filter* icon with the **Grid** parameter set to something like 1.5/1.5.

Note that this drawer also contains the means to convert between GRIB and Geopoints formats.

Coloured Wind Fields



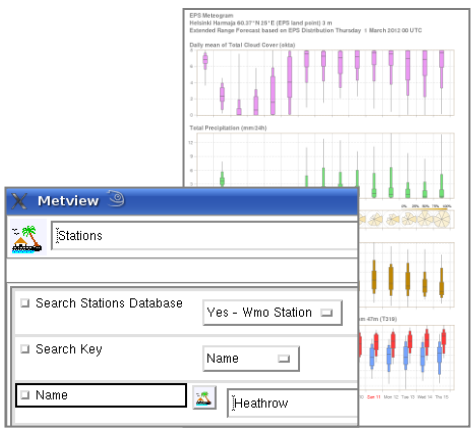
From the **Modules (Plotting)** drawer, create a new *Grib Vectors* icon. This icon can be used to a) combine 2 fields that Metview would not normally plot as a vector quantity and b) to specify a third field (e.g. temperature) which can be used to compute the colours of the wind arrows. We will use it now in its second context. Edit the icon and, with the help boxes, use the supplied help MARS Retrieval icons for the **U Component**, **V Component** and **Colouring Field**. Visualise the icon. If you do not have MARS access, you can use three GRIB Filter icons to separately filter U, V and T from *ztuv.grb* instead.

Now create a new *Wind Plotting* icon and set the following parameters:

Legend	On
Wind Advanced Method	On
Wind Advanced Colour Max Level Colour	Red
Wind Advanced Colour Min Level Colour	Blue
Wind Advanced Colour Direction	Clockwise
Wind Advanced Colour Parameter	Parameter

Drop this icon into the plot window. **Wind Advanced Colour Parameter** can be set to Speed in order to use the wind speed to compute the colour scale. This plot is clearer if dark grey land/sea shading is used.

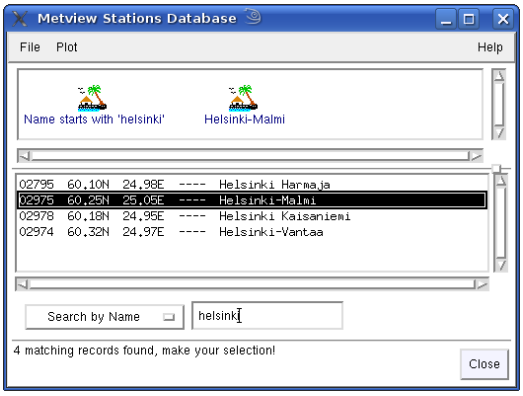
Meteograms



Also available is the *Meteogram* icon (only available at ECMWF). This icon uses an embedded *Stations* icon; use it, but edit it before using it. This is will

allow you to explore the **Stations** tool; this provides access to thousands of WMO stations.

Edit the embedded *Stations* icon and click on the button next to the **Name** parameter. This brings up the **Stations** tool.



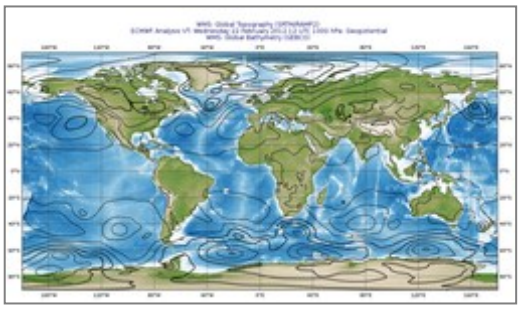
This tool allows you to search for stations in various ways. For instance, type 'helsinki' into the search box to find all stations whose names start with that string. Select one, and **Close** the tool.

When you **visualise** the *Meteogram* icon, it will send a request to ECMWF's server which will generate a meteogram plot.

The *Shell Script* icon allows you to enter shell commands such as 'ls'. You can run the commands directly from the editor, in which case the output will appear in the Output area at the bottom, or else you can right-click **execute** and look at the icon's output messages.

The *Notes* icon stores plain text, so you can use this to make notes.

WMS (Web Map Service) Client



Metview includes a WMS client, whose icon can be found in the **Data Access** drawer. This provides access to catalogues of geographical plots from any institute that provides them. The *Solutions* folder for this part provides some pre-defined WMS icons. Start by visualising one – the plot will be requested from an external server and so may take a few seconds. If you edit one of the icons you will see the layers available from that service.

This is a big topic, and it has its own ECMWF Newsletter article and tutorial:

https://software.ecmwf.int/metview

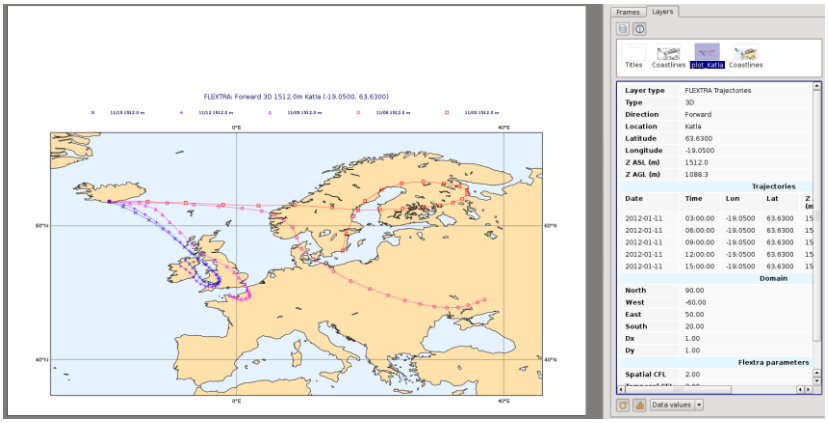
ODB

An ECMWF Newsletter article and a complete separate tutorial on ODB usage in Metview is available from Metview's web pages:

https://software.ecmwf.int/metview

Trajectories (FLEXTRA)

FLEXTRA is an established trajectory model used by growing scientific community. Metview has a set of icons for interacting with FLEXTRA at all stages: preparing the data, running the model and visualising the output.



Visualise the *FLEXTRA Plot* icon from the *Solutions* folder (it will automatically execute the *FLEXTRA Run* icon). The computations will take a minute or so; their input is a set of GRIB files stored on the file system. **Examine** the *FLEXTRA Run* icon to see the model output.

For more information on using FLEXTRA within Metview, please see the tutorial, available at:

https://software.ecmwf.int/metview

If you have extra time, explore *Extra_tasks_Part_6*.