

Metview Interactive Tutorial



Development Section
ECMWF

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This tutorial was tested with Metview version 4.4.6 but should work for all 4.4.x versions, apart from the features of the new user interface, which are only available in version 4.4.6.

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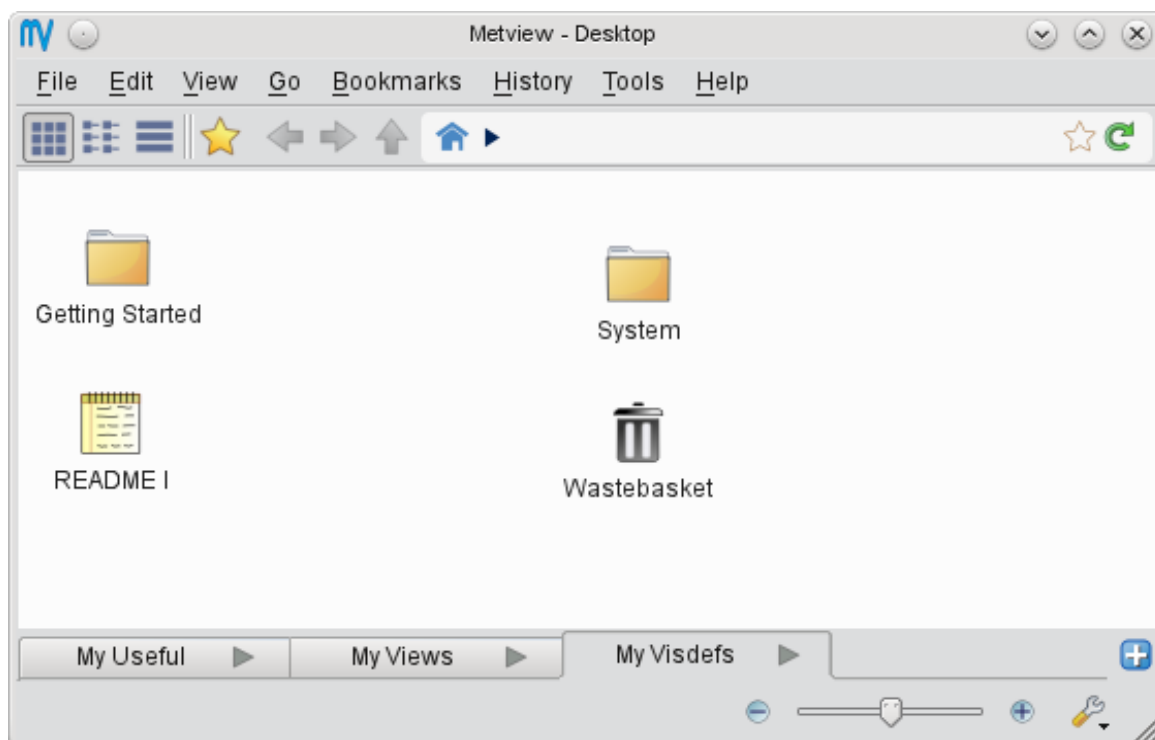
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PART 1 - INTRODUCTION

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
```

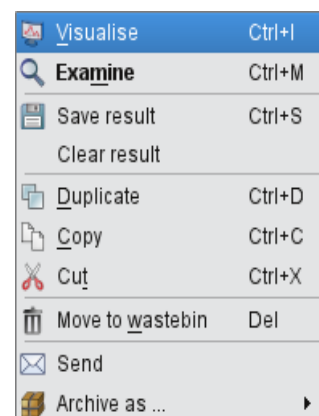
Otherwise you can download this file from the [Metview Training Course](#) website.

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

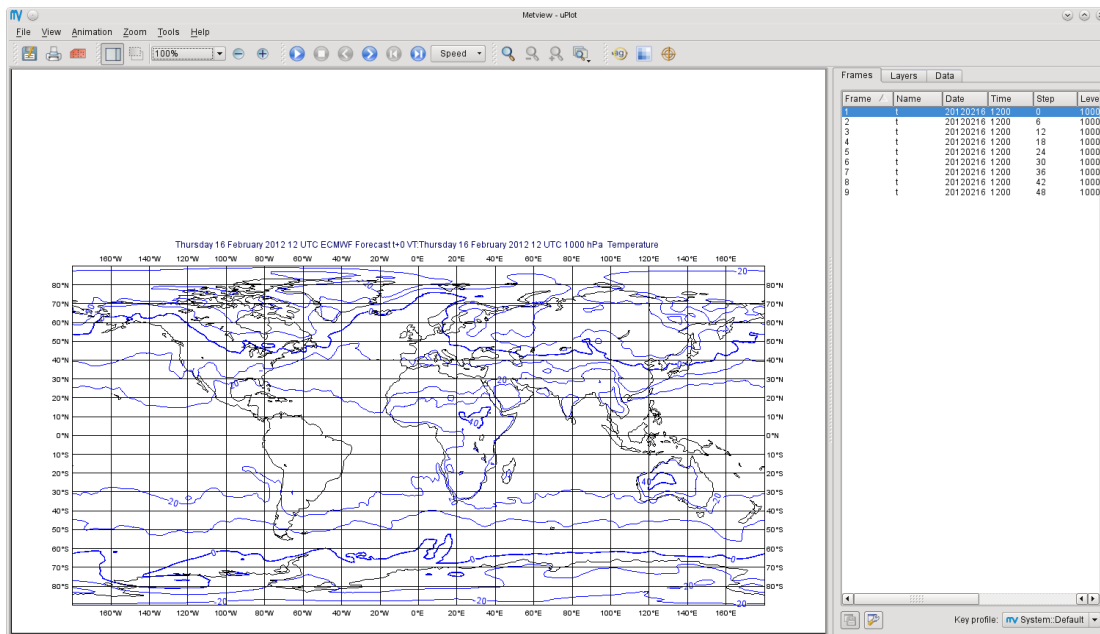


*If it does not appear immediately, press F5 (or **View | Reload**).*

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.

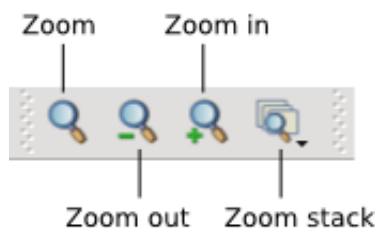


Antialiasing



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

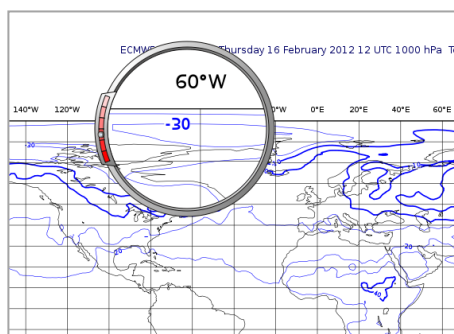


The above diagram shows the **Zoom** toolbar at the top of the **Display Window**. Click the **Zoom** button to enter 'zoom mode'. Now you can select an area by dragging with the left mouse button. You can zoom in as many times as you like. In order to 'undo' or 'redo' a zoom, click the **Zoom out** 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.

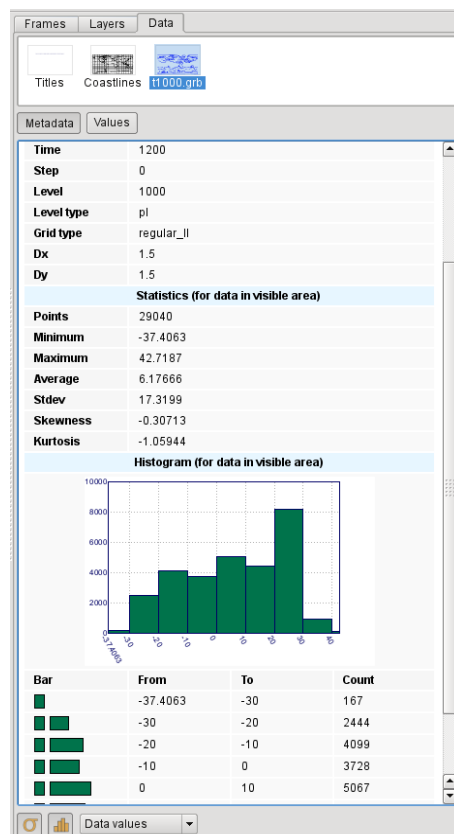
Frame	Name	Date	Time	Step	Level
1	t	20120216	1200	0	1000
2	t	20120216	1200	6	1000
3	t	20120216	1200	12	1000
4	t	20120216	1200	18	1000
5	t	20120216	1200	24	1000
6	t	20120216	1200	30	1000
7	t	20120216	1200	36	1000
8	t	20120216	1200	42	1000
9	t	20120216	1200	48	1000

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.

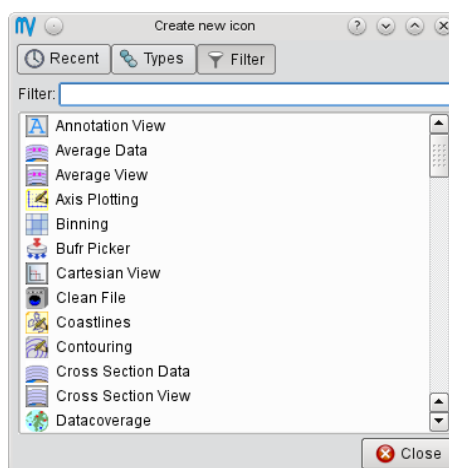
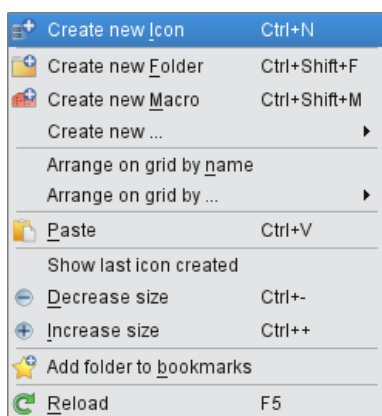
We will investigate these features in more detail later, but for now close the **Display Window**.



Creating and Editing an Icon

Let's customise the coastline plotting attributes.

First, create a new *Coastlines* icon. You can right-click within the **Metview desktop** to obtain a context menu from where the option **Create new icon** is available (shortcut: CTRL-N).



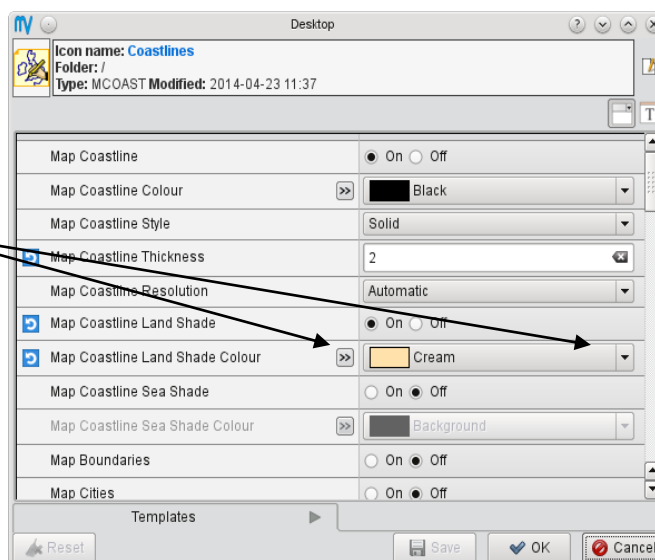
This brings up a dialog from where you can find the *Coastlines* icon; either double-click the icon, or drag it onto the **desktop** to create a new instance. Close the dialog.

Edit the newly-created icon by either double-clicking on it or else right-click, **edit** (double-clicking an icon performs the **edit** action for most icon types). 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: an undo button now appears beside this parameter
Map Coastline Land Shade	On
Map Coastline Land Shade Colour	Cream

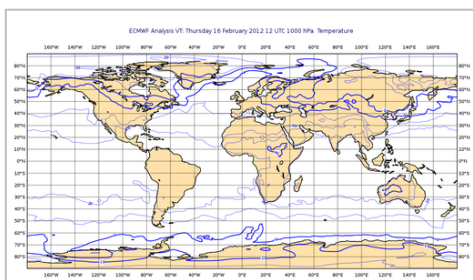
For colour-based parameters, there are two small arrows - the one on the right reveals a drop-down list of predefined colours (use this one); then one on the left reveals an advanced colour selection tool.

After making these changes, click the **Ok** 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. You can close the **Display Window** again.

Modifying a Default Icon

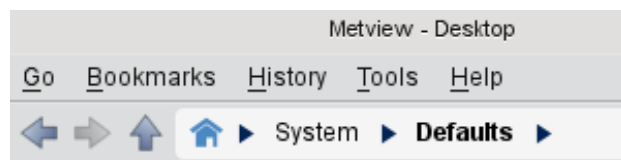
As an exercise, we will now make this set of coastline attributes the default in all Metview plots.

- 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, select it and press the Del button on the keyboard; alternatively, right-click, **Move to wastebin**. Both will move the icon(s) to the wastebin. The wastebin can be emptied in order to permanently delete the icon(s).

Standard shortcuts are available for copying, cutting and pasting icons. Alternatively, 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

Navigate back to your main Metview folder - Metview provides several ways to do this; for now, click on the Home icon in the navigation bar.



Now visualise the data again - your new default coastline attributes are automatically applied.

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 **Save** in the icon editor, the changes will be saved, whilst keeping the editor open for further editing. This allows you to more quickly test your changes. Drop the new icon into your plot to see its effect.

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).

To create a new subfolder, you could bring up the **Create new icon** dialog, but there is a faster way - right-click on an empty part of the Metview desktop and select **Create new folder**. A new folder called *Folder* will be created. Click on its title and rename it '*course*' (all lower-case).

Select your data icon and any Coastlines icons, and drag them into the *course* folder icon. Enter the new folder and check that your icons are there.

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 press F5 to rescan for new files. **You will not need these until Part 3.**

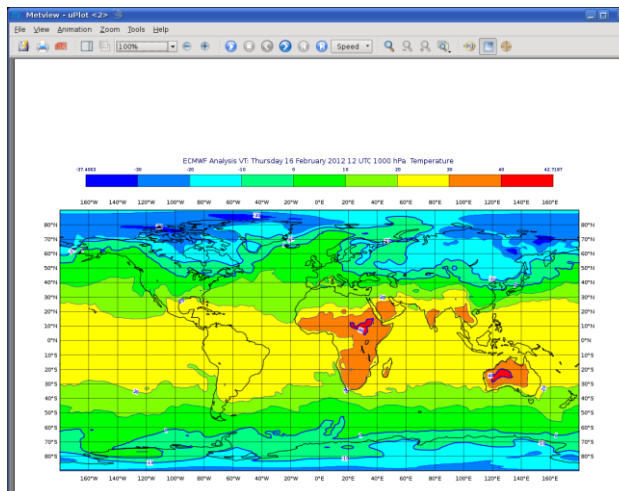
If you have extra time, explore *Extra_tasks_Part_1*. It might be useful to open this folder in a new tab (available from the right-click context menu).

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 (CTRL-N).

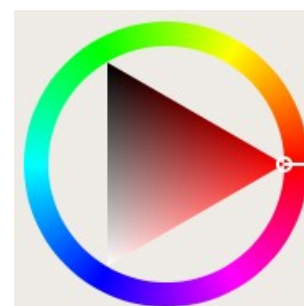


Edit it, setting the following parameters:

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**, drag with the middle mouse button or use the Copy and Paste shortcuts), 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
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!

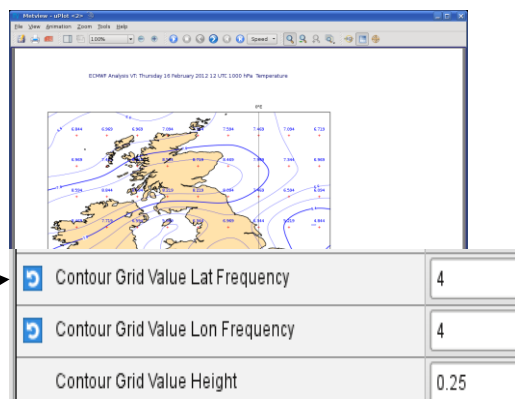
In Part 5 we will see a technique that will allow you to shade both hot and cold extremes without shading the 'normal' values in-between.

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 **blue 'revert' button** next to the parameter.

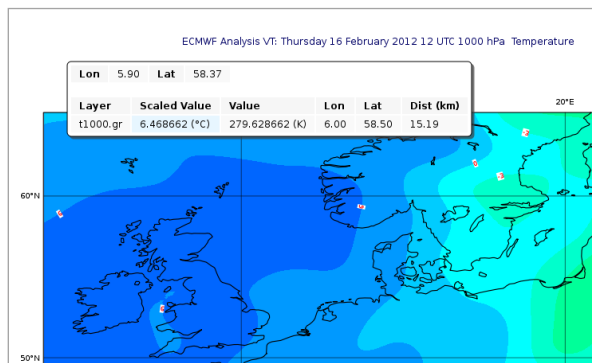
This button does two things: it indicates that a parameter has been altered from its default, and it restores the parameter to its default when clicked.



Cursor Data



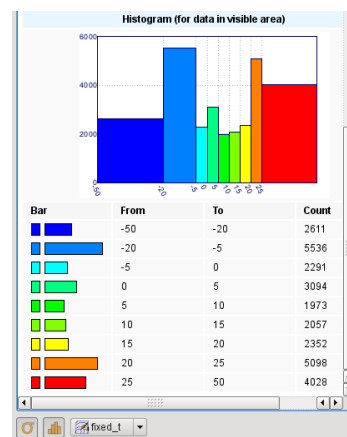
For a closer inspection of data values in a plot without having to apply a special contour icon, the cursor data tool can be used. When activated, the cursor data box follows the mouse cursor around the plot, displaying data for the nearest grid point(s). To 'dock' the data box, left-click; to 'undock', 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 area of the plot. The meta-data is updated to include only the data points which are visible.



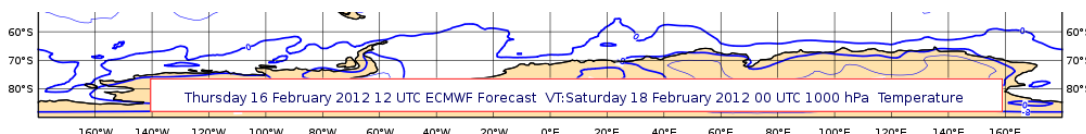
Plot Titles

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.

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 keys¹ (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	
Grid: <grib_info key='iDirectionIncrementInDegrees'/> x <grib_info key='jDirectionIncrementInDegrees'/> degrees	









If you have extra time, explore *Extra_tasks_Part_2*.

¹ https://software.ecmwf.int/grib_api

PART 3 - DATA

Data Sources

Now open the *data_sources* folder, either in a new tab or in a new window (using the right-click context menu). 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	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. Right-click and **Examine** the icon to see the data tabulated 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:

Black	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 generated some log message, probably when you visualised the BUFR data or performed the MARS retrieval. Each icon has its own text output which can be viewed by selecting **Log** from the icon's right-click menu. This is only enabled when there is output for that icon, and is reset when the icon's contents change. Have a look at the log messages for the *Mars Retrieval icon* (ensure that you have retrieved data first).

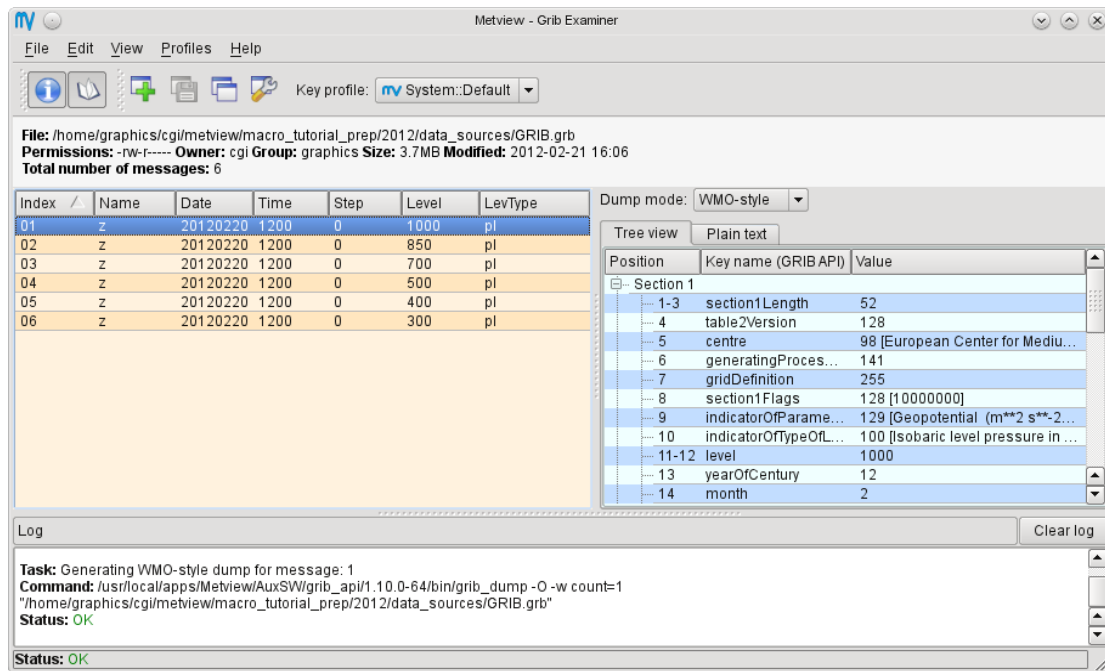
You can view a complete history of output from all icons by selecting **Log** from the **Tools** menu in any **Metview desktop**.

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 modes**). 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 line²), 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 **Create New... Link to File** and type `/scratch/ectrain/trx/mv_data/ztuv.grb` into the **File name** box (or navigate there and select the file with the mouse). Note that the text label under the new icon is in italics, and there is an arrow in the bottom-left corner - these indicate that this is a link. The padlock in the bottom-right corner tells us that this file is read-only. 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.



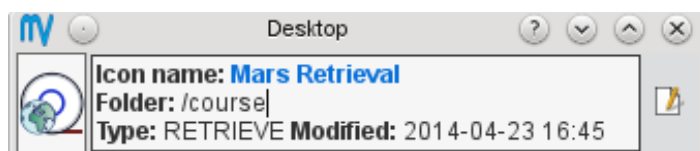
ztuv.grb

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. 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 the button to the right of the information panel; click it and change the name of the icon 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 and rename it *fc_an_diff*. Edit it and ensure that the first **FORMULA** option (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. Use this icon to filter the data in *BUFR.buf*. 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*, preferably in a new window. 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
<i>shading_only_t</i>	Contouring for temperature fields using shading and no isolines.	Visualise your <i>t_an</i> data filter icon and drag this visdef into the plot. Scroll through the fields.
<i>shading_20_levels</i>	General contour shade icon with 20 automatically computed levels.	Visualise your <i>t_an</i> data filter icon and drag this visdef into the plot.
<i>hatch_shading</i>	Contouring using hatch shading.	Visualise your <i>t_an</i> data filter icon and drag this visdef into the plot. This can be a useful contouring method for black and white publications.
<i>pos, neg</i>	Contour shading.	We will use these in Part 5.
<i>histogram_legend</i>	Changes the legend into a histogram format.	Visualise your <i>t_an</i> data filter icon and drag <i>shading_only_t</i> into the plot. Now drag this visdef to change the legend style.
<i>land_sea_shading</i>	Shades land and sea.	This can be dragged onto any geographical plot at any time.
<i>boundaries</i>	Plots country boundaries.	This can be dragged onto any geographical plot at any time.
<i>high_winds</i>	Wind arrows only above	Visualise <i>ztuv.grb</i> and select the

	10m/s. No thinning is applied, so the arrows will be more dense.	first wind field. Drag this icon into the plot.
<i>wind_flags</i>	Wind flags only above 5 m/s.	Same as above.
<i>coloured_wind</i>	Wind arrows coloured according to the wind speed.	Same as above.
<i>t_symbols_K</i>	Symbol plotting in degrees K.	Visualise <i>geopoints.gpt</i> from the <i>data_sources</i> folder and drag this visdef into the plot. The data are in degrees Kelvin.
<i>t_symbols_C</i>	Symbol plotting in degrees Celsius.	Create a new <i>Simple Formula</i> icon and use it to convert the geopoints data into degrees Celsius: ' F+x ' FORMULA , subtract 273.15 from the geopoints icon. Visualise your new icon and drag this visdef into the plot. The data are in degrees Celsius.
<i>t_symbols_auto</i>	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.
<i>graph_curve</i>	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.

We will first use a *Geographical View* icon to save a geographical area that we can reuse.

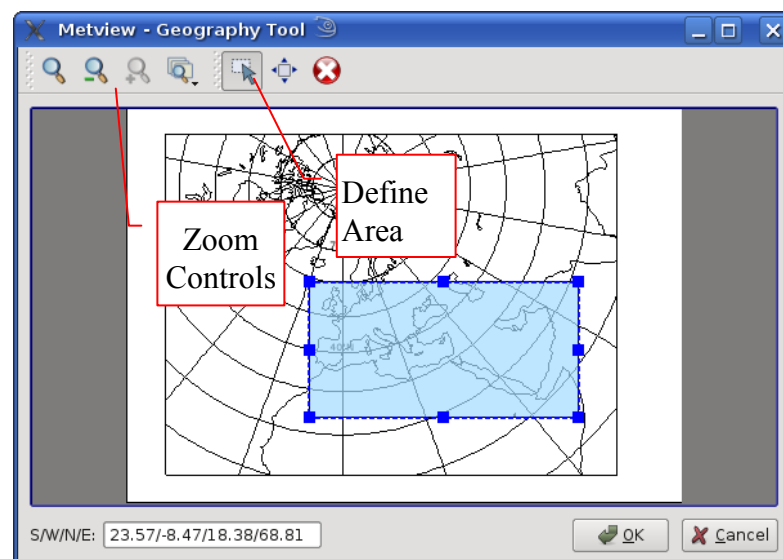
Create a new *Geographical View* icon. Take this opportunity to explore the different ways to find it in the **Create new icon** dialog. First, note that there are three ways to find icons: **Recent**, **Types** and **Filter**. From the Filter mode, type `geo` to start the search - this should be enough to find *Geographical View*. Now try the **Types** mode, and set **Type** to **Views**. This shows all the available **view** icons. The **Recent** mode gives access to the last few icon types you have created.

Whichever method you choose, create a new *Geographical View* icon 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 next to the **Area** parameter (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.

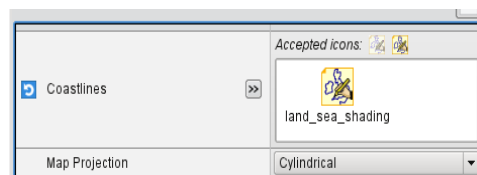
Try using this icon in two different ways:

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 24).

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.

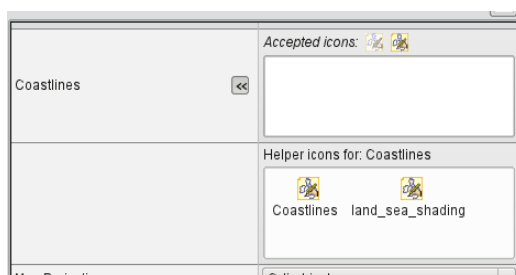


You can use your own *Coastlines* icons in this icon field: edit your *Geographical View* icon, right-click on the embedded *Coastlines* icon (if there is one) and select **remove**. Now drag the *land_sea_shading* icon from the *visdefs* desktop into the now-empty **Coastlines** icon field. Click **Apply**,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

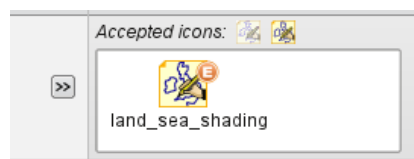
This method allows you to share a single *Coastlines* icon between multiple view icons; update the *Coastlines* icon and all the views will pick up the changes automatically.

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* from your desktop 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.

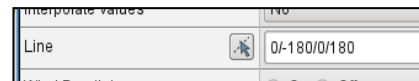
This is an alternative way to share embedded icons. Note that this *Coastlines* icon is *embedded* in the *Geographical View* icon (notice the 'E' symbol on the icon); it is not a link to an icon you can see on a Metview desktop, but is contained entirely within the *Geographical View* icon. If you move the *Geographical View* icon, the embedded *Coastlines* icon will move with it.



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). Save your changes in the *Cross Section View* icon and use it to re-visualise the data with this new cross section.



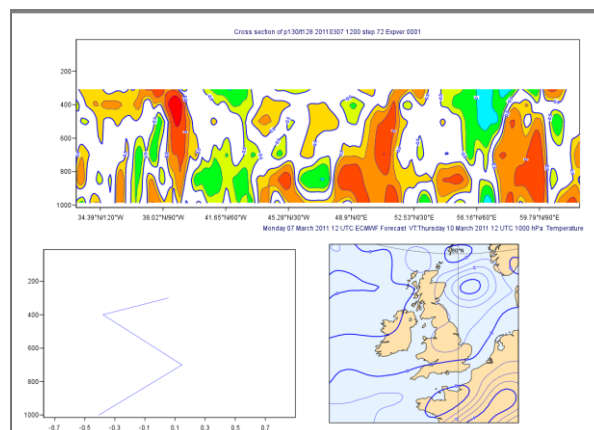
Note that you can still drag any valid contour icons you may have into the **Display Window** when visualising a cross section.

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:

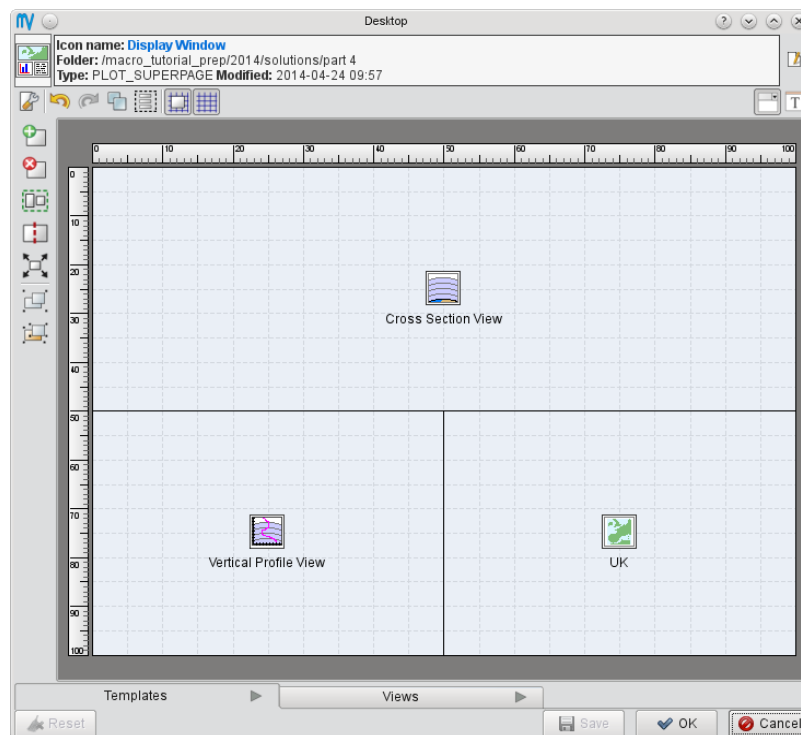


Create a new *Display Window* icon and **edit** it.

Click on the **Add new frame** button to create the first frame. By default, this contains just a single plot scene which uses a *Geographic View*. Now click **Expand selected frames** to make it fill the whole area.

Now divide it up into three areas as follows. Click **Split selected frames** and select **2x1** in order to obtain two vertically stacked frames. With the lower frame selected, click **Split selected frames** and select **1x2**.

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 *Geographic 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 scenes 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 one is used. You can also right-click on a scene and choose “Select as active scene” from the context menu.

Storing and Reusing Icons

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

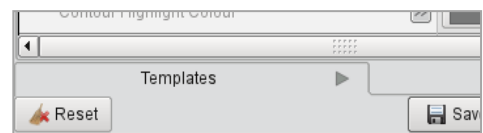
One way to store icons is to put them into an **icon drawer**. These are visible as a tabbed area at the bottom of every desktop. These sets of icons are available no matter which folder you are in, providing quick access to frequently-used icons. A few sample drawers are provided, and you can add your own.



Click the '+' button to the right of the drawers to create a new icon drawer; rename it **Custom**. It will be placed alphabetically in your set of drawers.

Drag any useful icons you have into your new drawer (click on the drawer first to open it). 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**.

For another approach, note that each icon editor has a *Template Drawer* at the bottom. This facility is useful when you have a *subset* of parameters that you frequently wish to use, for example you often want black isolines (but want to change other parameters). Create a new *Contouring* icon and rename it *Black Contours*. Set **Contour Line Colour** and **Contour Highlight Colour** to Black and save the icon. Edit another *Contouring* icon (old or new) and click on the **Templates** tab in the editor to open the drawer. Drag your *Black Contours* icon into this **Templates** drawer. It will now be available whenever you edit *any* *Contouring* icon (and you can now delete the original *Black Contours* icon). You can now drag *Black Contours* into the main editor window to add its settings to the currently-edited icon; it only changes the two parameters that are set and does not touch the rest. More options are available from the context menu of the *Black Contours* icon.



Other uses of this approach could be to add grid-value plotting to a *Contouring* icon or land-sea shading to a *Coastlines* icon.

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*.

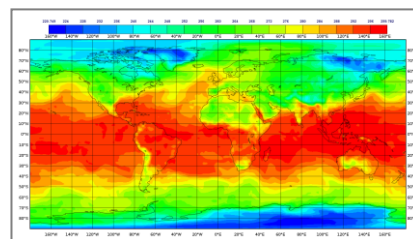
NetCDF data

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

Create a new *NetCDF Visualiser* icon. 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

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.

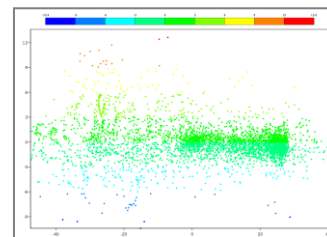


ASCII Table data

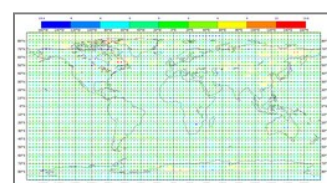
To see how to plot ASCII data which is arranged in columns (e.g. a CSV file), have a quick look at *ASCII Table.csv* in the *data_sources* folder – it is a standard comma-separated file. Create a new *Table Visualiser* icon and rename it *fc_anoms_vis_xy*. Edit it and drop the *ASCII Table.csv* icon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



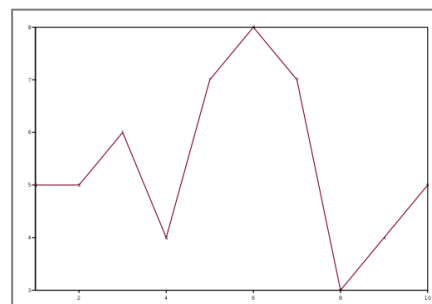
The data file also contains latitudes and longitudes; copy *fc_anoms_vis_xy* and rename it *fc_anoms_vis_geo*. Edit this icon to produce a map plot – you will need to set **Table Plot Type** to Geo Points, and then modify other parameters in order to get a plot.



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

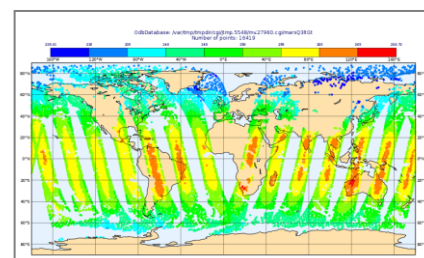
Metview can be used to quickly plot data that is not stored in files by using the *Input Visualiser* icon. Create one and edit it; keep **Input Plot Type** as Xy Points and enter lists of slash-separated numbers into the fields **Input X Values**, **Input Y Values** and, optionally, **Input Values**. 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

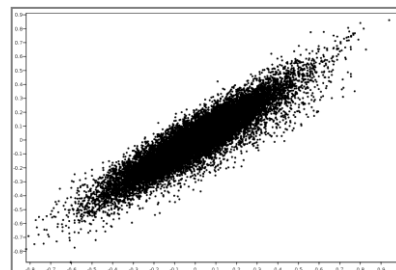
ODB data also requires a visualiser icon; create a new *ODB Visualiser* icon, rename it *odb_tb_plot* and edit it. Drop the *ODB Database* icon into the **ODB Data** field. Most of the default parameters are already suitable for this ODB – just edit the one field:



Odb Where	vertco_reference_1@body = 5
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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>

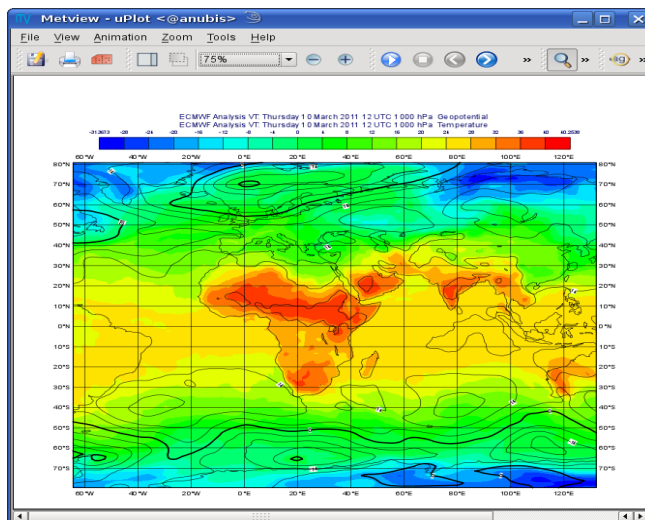
Icon Drop Rules

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.

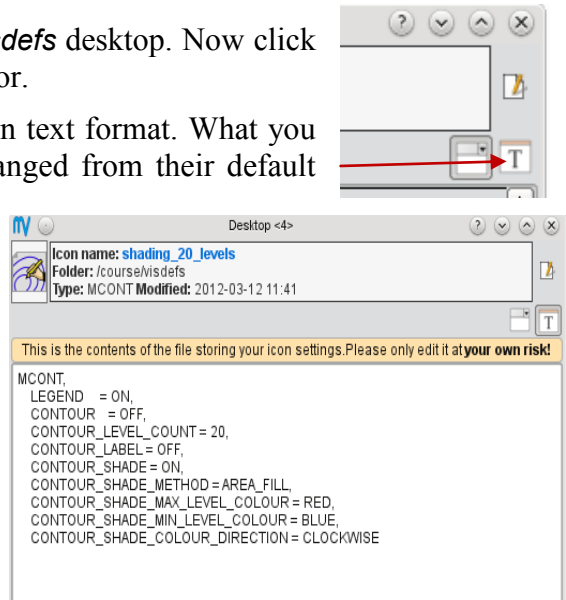
Icons Revealed

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

Edit the *shading_20_levels* icon from the *visdefs* desktop. Now click the 'T' icon in the top-right corner of the editor.

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 buttons 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 *Contouring* 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:

Metview Interactive Tutorial

```
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 are also some hidden ‘dot’ files which store information about icon position and view settings, which can be listed by adding the `-a` option:

```
ls -la
```

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*.

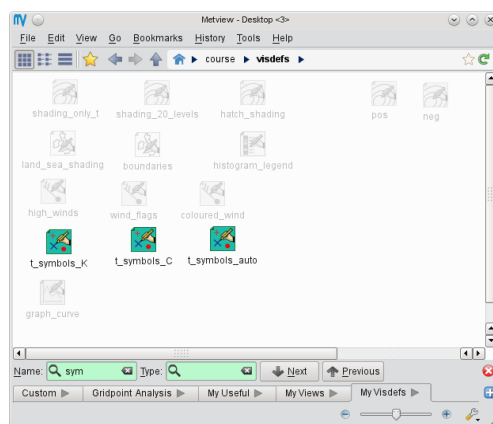
PART 6 - METVIEW TOOLS AND APPLICATIONS

Desktop

Spend some time trying the different ways to find icons in the **Create new icon** dialog.

Bookmark the visdefs folder so you can get to it quickly. How many ways can you find to add it to the bookmarks?

Metview's user interface features a filtering facility for finding icons in cluttered desktops. Go to the visdefs folder and press CTRL-F to bring up the Find bar. Start typing in either the **name** or the **type** edit boxes to start the filtering process.



Try the different ways of viewing a folder using the **View Mode** icons in the toolbar.



Hover the mouse cursor over an icon to see additional information in the status bar at the bottom.

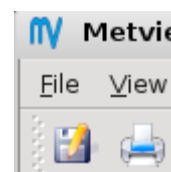
Try changing the size of the icons using the controls at the bottom-right of the desktop.



Icons can be dragged anywhere! Drag an icon into another tab, or into a bookmarked folder to move it there.

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

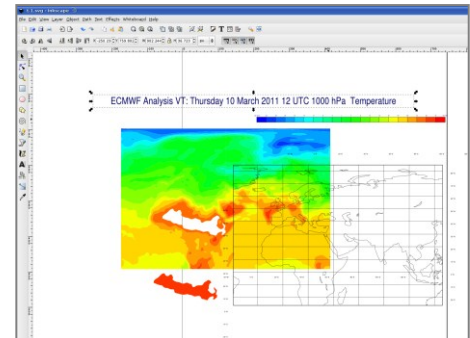


the filename, as this will be added automatically. The **Output formats** option allows you to specify multiple formats – Metview can efficiently generate multiple output formats in one go.

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 entry).

Name	CPU %	Memory	Time	PID
Data Cache	< 1%	6.1 M	09m	28367
Display Manager	< 1%	7.2 M	09m	28375
Macro Editor	< 1%	16.4 M	14m	27983
Mars	< 1%	8.1 M	00m	28839
mars@28910	3 %	15.1 M	00m	28910
Process monitor	< 1%	42.5 M	01m	28804
User Interface	< 1%	63.8 M	14m	27953

Often, Metview processes are run so quickly that you barely see them in the **Process 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

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 more modules in the **Data Processing** type in the **Create new icon** dialog. 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.

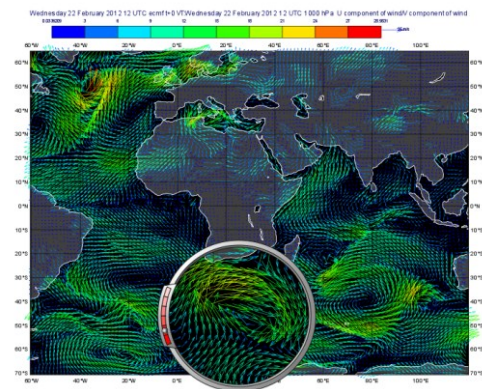
Note that this set of icons also contains the means to convert between GRIB and Geopoints formats.

Coloured Wind Fields

Create a new *Wind Plotting* icon and set the following parameters in order to colour the arrows according to the wind speed:

Legend	On
Wind Thinning Factor	1
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	Speed

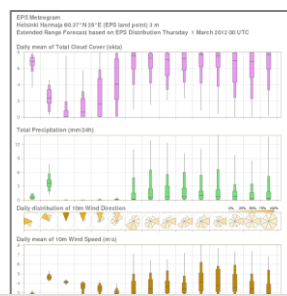
Visualise *ztuv.grb* and move to a wind field. Drop the new *Wind Plotting* icon into the plot window. This plot is clearer if dark grey land/sea shading is used.



Meteograms

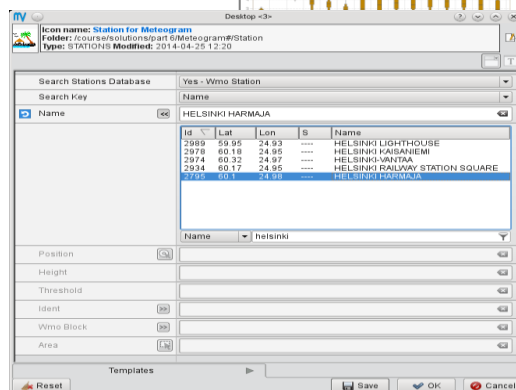
Also available is the *Meteogram* icon (only available at ECMWF). This icon uses an embedded *Stations* icon; use it, but edit it before using it. This will allow you to explore the *Stations* editor; this provides access to thousands of WMO stations.

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



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.

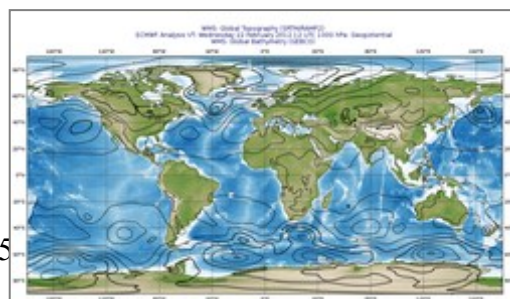


The *Shell Script* icon allows you to enter shell commands such as 'ls'. You can run the commands directly from the editor, in which case the output will appear in the Output area at the bottom, or else you can right-click **execute** and look at the icon's output messages.

The *Notes* icon stores plain text, so you can use this to make notes. General text files copied into a Metview folder will appear as *Notes* icons.

WMS (Web Map Service) Client

Metview includes a WMS client. 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>

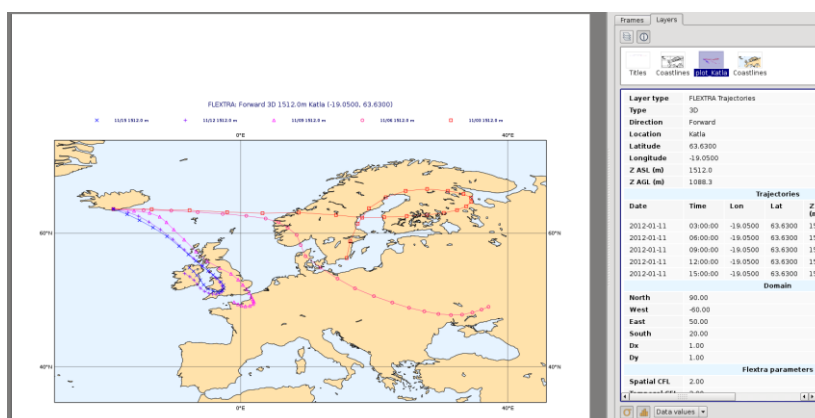
ODB

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*.