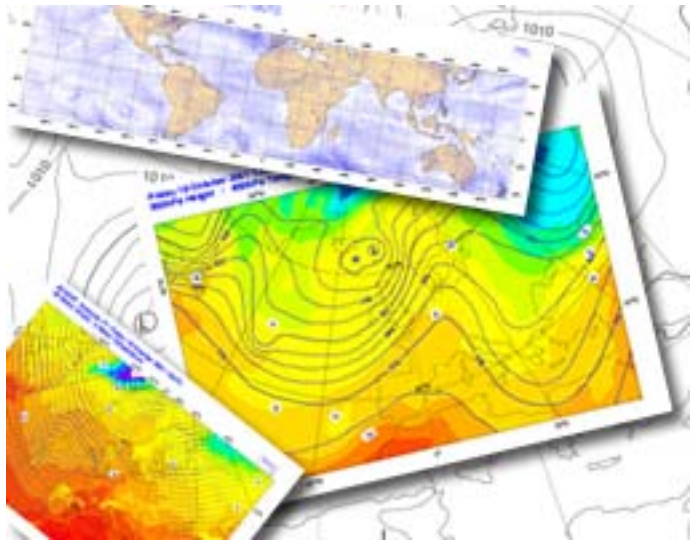
The challenges of the ECMWF graphics packages



Sylvie Lamy-Thépaut

Graphics Section

ECMWF

Outline

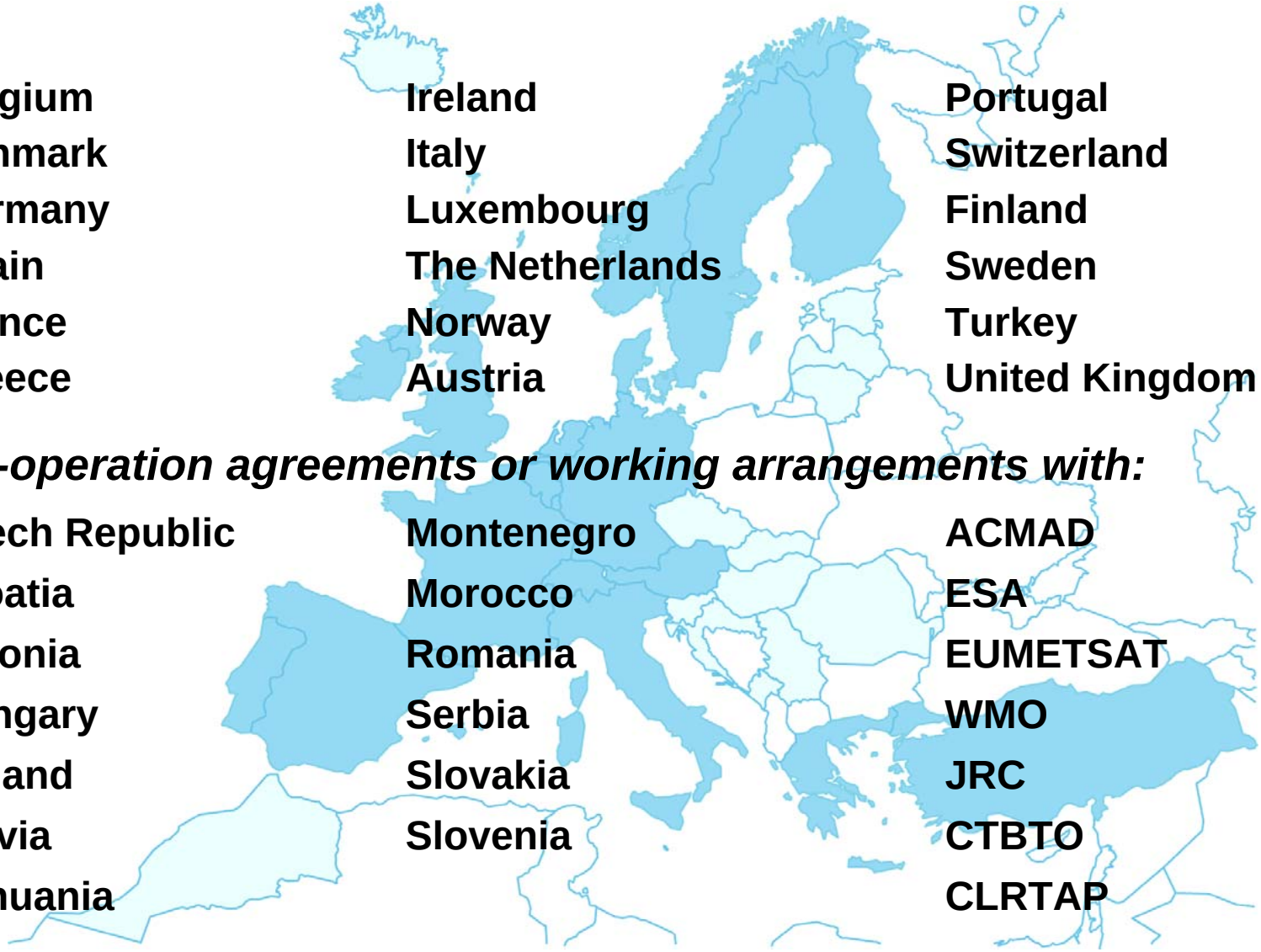
- **Who are we?**
  - **ECMWF**
  - **The Graphics Section**
- **What are our Missions?**
  - **Magics**
  - **Metview**
  - **Wrep : our new web project**
- **What are our Challenges?**
  - **Web applications**
  - **New sources of data**
  - **High Volume of data**
  - **Modern Interactive Desktops**

What is ECMWF?

- **European Centre for Medium Range Weather Forecasts**
- **We provide operational medium- and extended-range forecasts and a state-of-the-art super-computing facility for scientific research.**
- **Supported by 31 States**
- **220 Employees**
- **Founded 33 years ago**

- **Based in Reading, west of London, United Kingdom.**

Supporting States and Co-operation

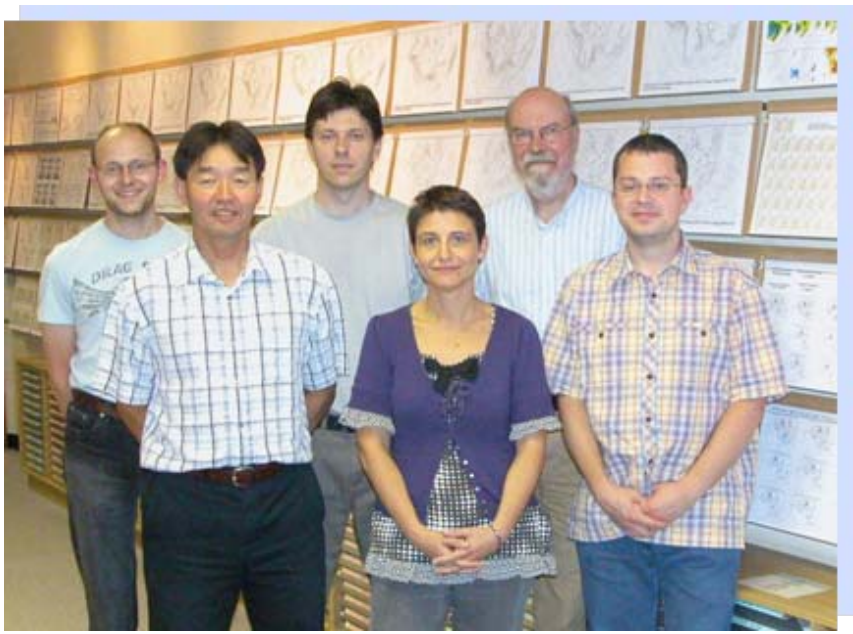


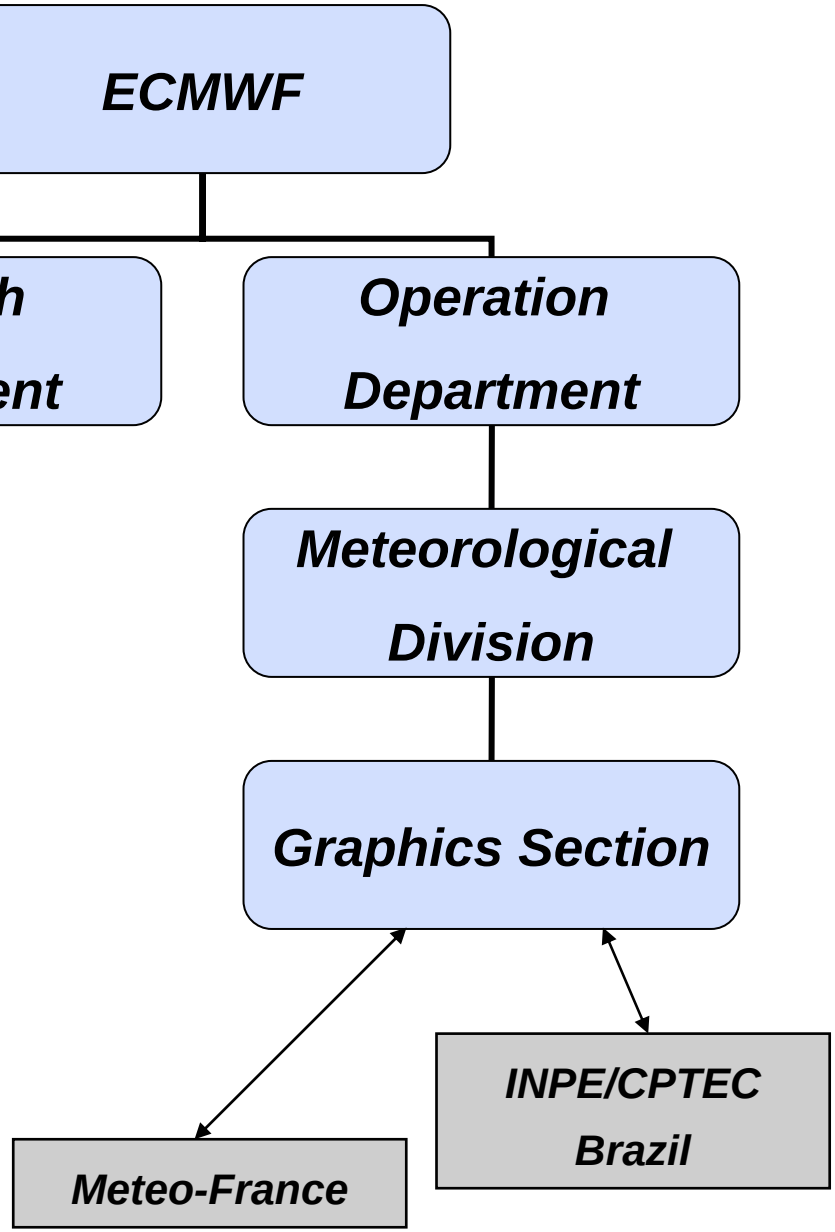
Belgium	Ireland	Portugal
Denmark	Italy	Switzerland
Germany	Luxembourg	Finland
Spain	The Netherlands	Sweden
France	Norway	Turkey
Greece	Austria	United Kingdom

Co-operation agreements or working arrangements with:

Czech Republic	Montenegro	ACMAD
Croatia	Morocco	ESA
Estonia	Romania	EUMETSAT
Hungary	Serbia	WMO
Iceland	Slovakia	JRC
Latvia	Slovenia	CTBTO
Lithuania		CLRTAP

Who are We?



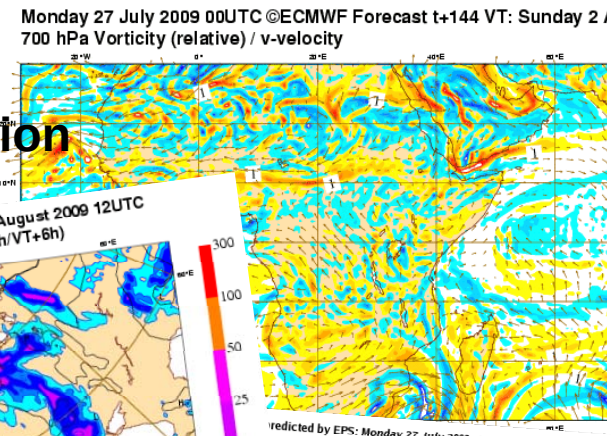

ECMWF
Research Department
Operation Department
Meteorological Division
Graphics Section
Meteo-France
INPE/CPTEC Brazil

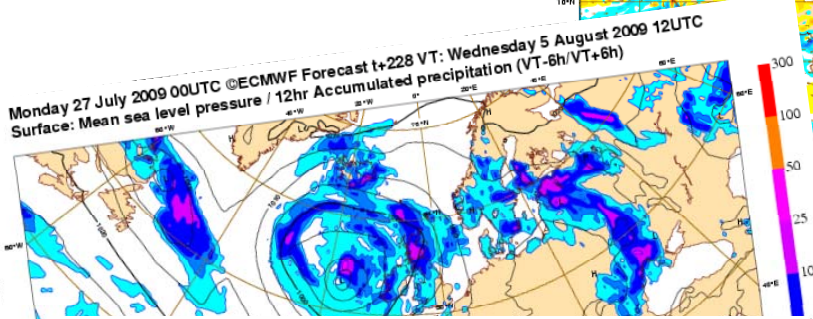
What are our Missions?

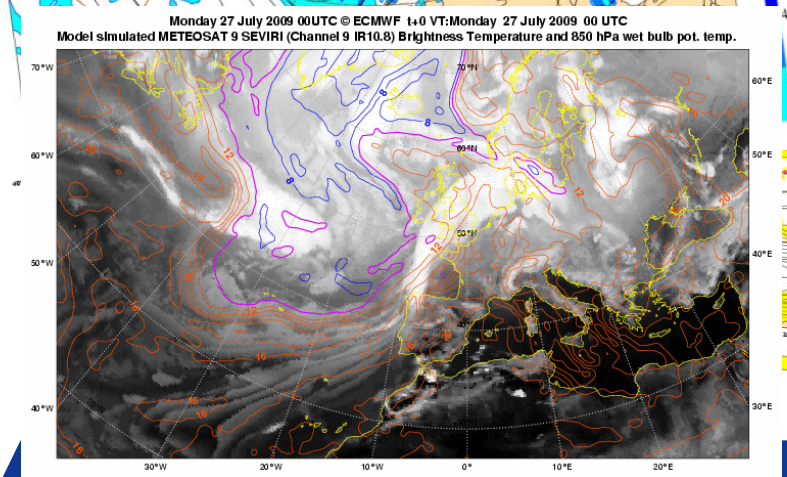
- **We are here to help researchers and analysts to access, manipulate and visualise a wide variety of meteorological data.**
- **We develop and maintain :**
  - **A graphical package with various APIs : Magics**
  - **A desktop based application : Metview.**
- **We participate in the new web project**
  - **Easy description and production of plots.**
- **To do that, we use**
  - **Unix platforms**
  - **Mostly C++ language**
  - **Perforce for versioning**
  - **Eclipse**

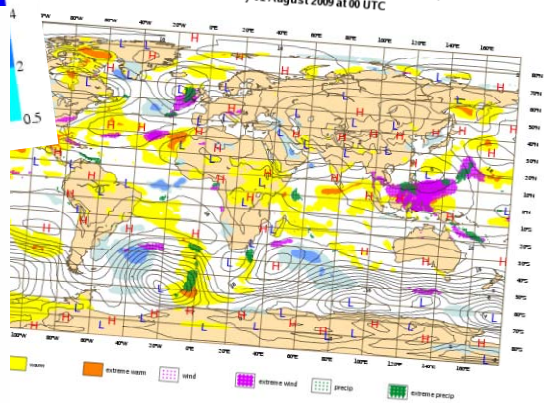
Magics: Our Graphical package

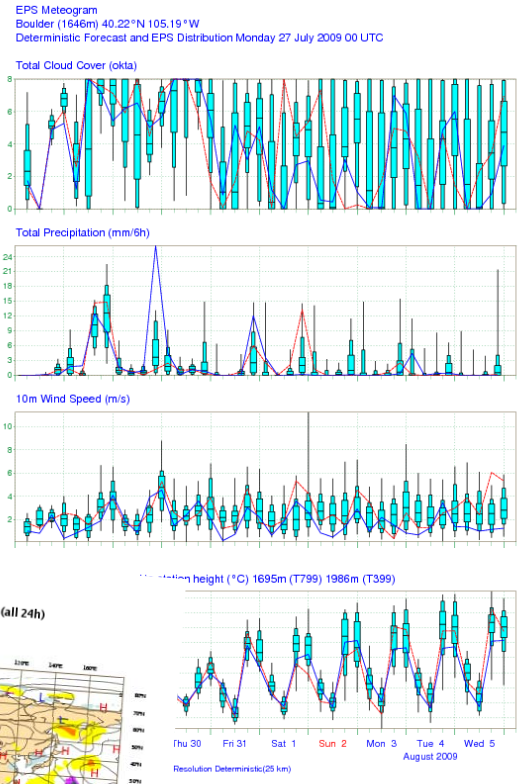
- **Magics is meteorologically-oriented**
  - **GRIB**
  - **BUFR**
  - **Specific Visualisation**











Magics

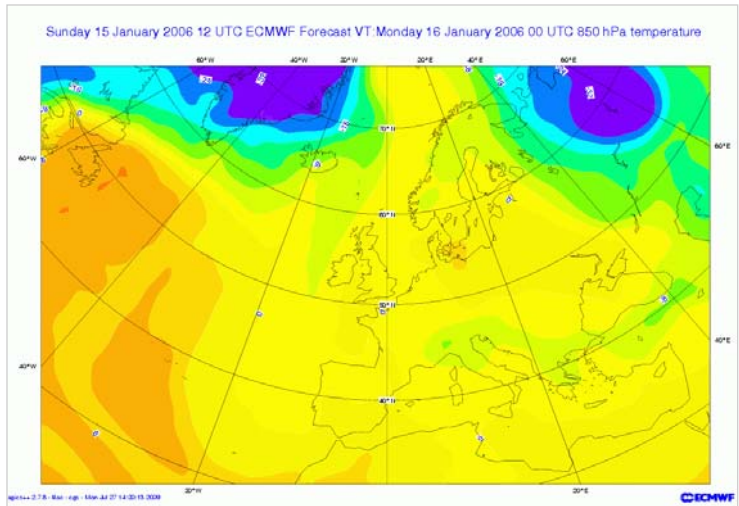
t_shaded_z_isolines.f - /var/tmp/cgs/perforce/magplus/docs/general/

File Edit Search Preferences Shell Macro Windows Help

/var/tmp/cgs/perforce/magplus/docs/general/t_shaded_z_isolines.f byte 1850 of 2053 L: 47 C: 15

```
      program t_shaded_z_isolines

c     define our colour palette for the shading
      parameter (nlev=20)
      character*25 ctab
      dimension  ctab  (nlev)
      data       ctab  /'blue_purple',....'magenta'/

c     open magics and set the output file type/name
c     note that 'ps' is the default so we don't need to
c     specify it here.
      call popen
      call psetc ('output_format',  'ps')
      call psetc ('output_name',    't_shaded_z_isolines')


c     area specification (south, west, north, east )
      call psetc ('subpage_map_projection', 'polar_stereographic')
      call psetr ('subpage_lower_left_latitude',    23.0)
      call psetr ('subpage_lower_left_longitude',  -33.0)
      call psetr ('subpage_upper_right_latitude',   51.0)
      call psetr ('subpage_upper_right_longitude',  72.0)

c     first, load and plot the temperature data, shaded
c     pass the data to magics
      call psetc ('grib_input_file_name', '../data/t850_fc_12.grib')
      call pgrib



c     define and plot the contour
      call psetc  ('contour',                      'off')
      call psetr  ('contour_shade_min_level',       -40.)
      call psetr  ('contour_shade_max_level',        44.)
      call psetc  ('contour_level_selection_type', 'interval')
      call psetr  ('contour_interval',              4.0)
      call psetc  ('contour_shade_colour_method',  'list')
      call pset1c ('contour_shade_colour_list',     ctab, nlev)
      call psetc  ('contour_shade',                'on')
      call psetc  ('contour_shade_technique',      'polygon_shading')
      call psetc  ('contour_shade_method',         'area_fill')
      call psetc  ('contour_hilo',                 'off')
      call pcont

c     plot the title text and the coastlines
      call psetr ('character_height', 0.25)
      call ptext

c     set up the coastline attributes
      call psetc ('map_coastline_colour', 'black')
      call psetc ('map_grid_colour',      'black')
      call pcoast

      call pclose

      stop
      end
```

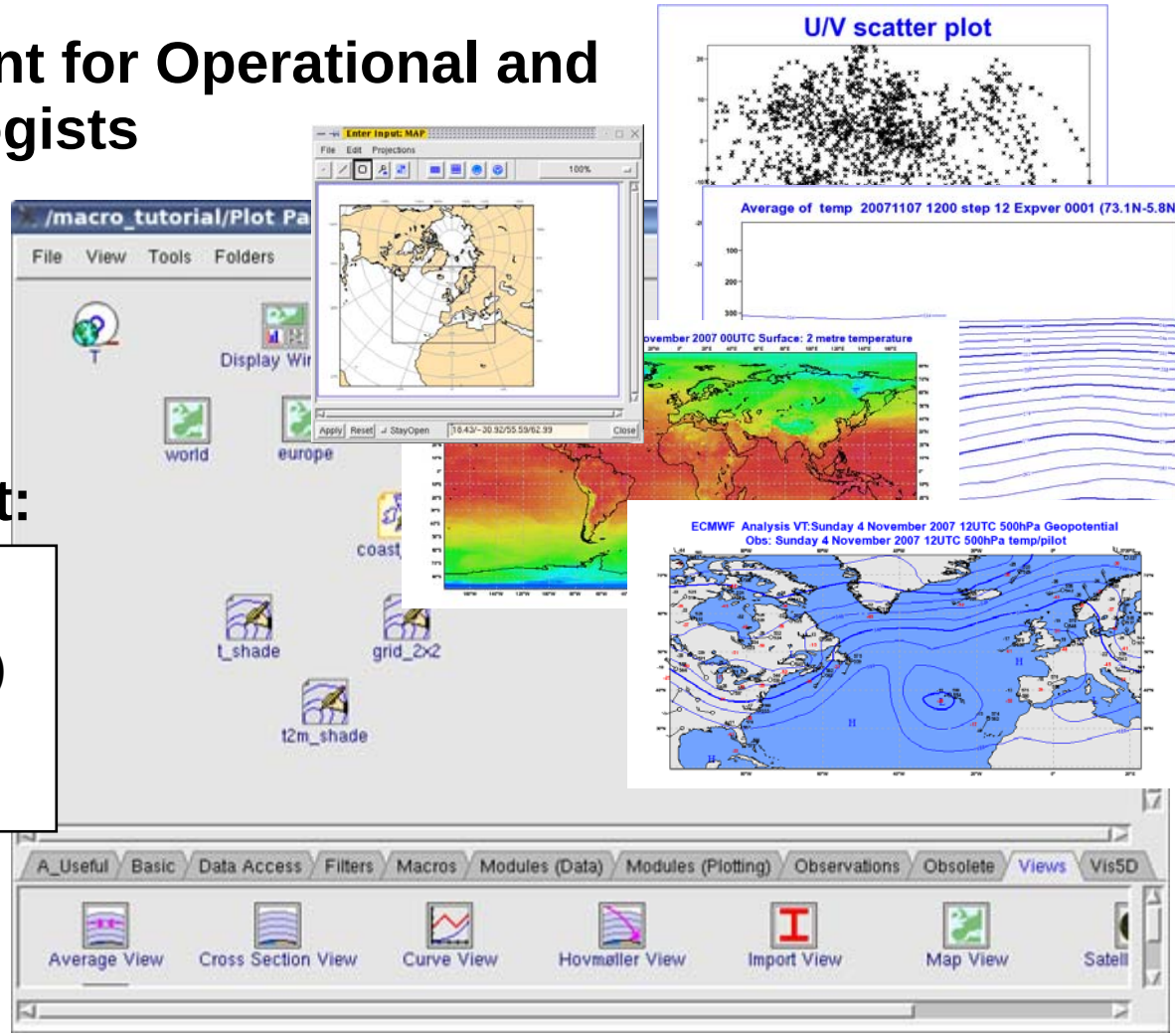
- **Magics provides a simple API**
  - **-Large set of parameters**
  - **-Small number of FORTRAN callable subroutines**



Metview: Our meteorological workstation

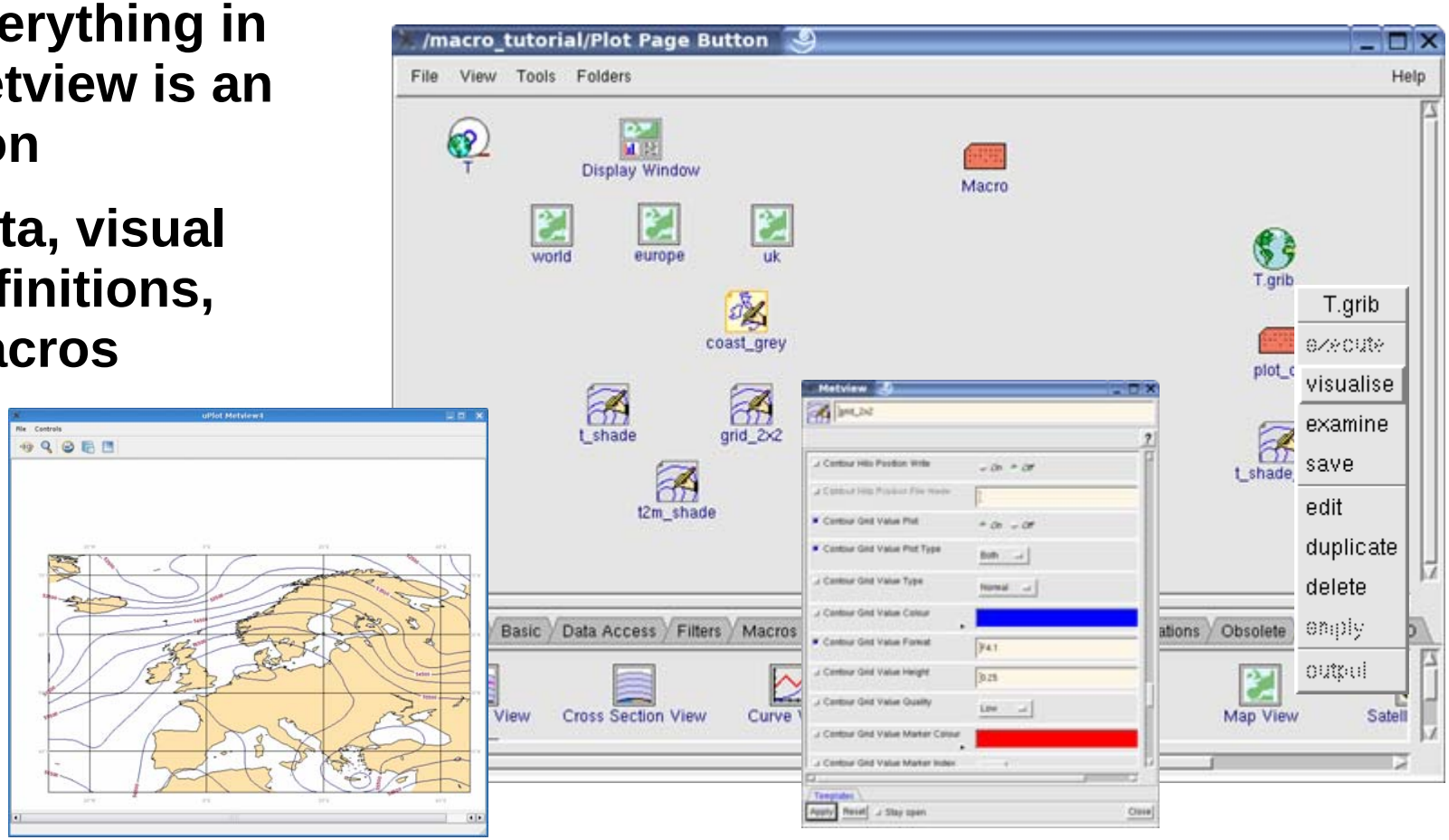
- **Working environment for Operational and Research Meteorologists**

- **Co-operative project:**
  - *ECMWF*
  - *INPE/CPTEC (Brazil)*
  - *Meteo-France*



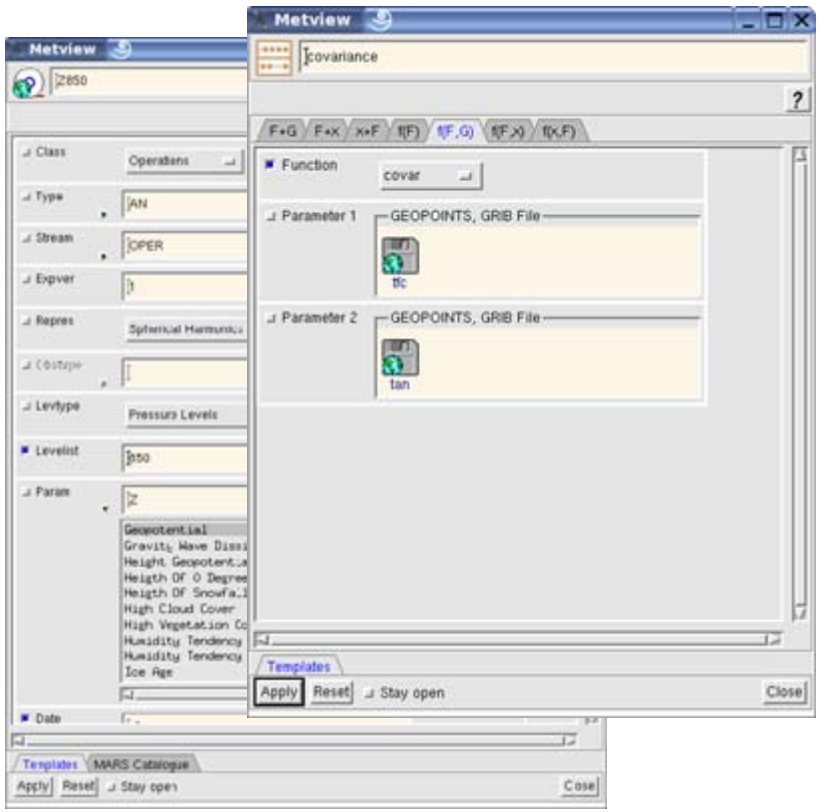
Metview - Interactive

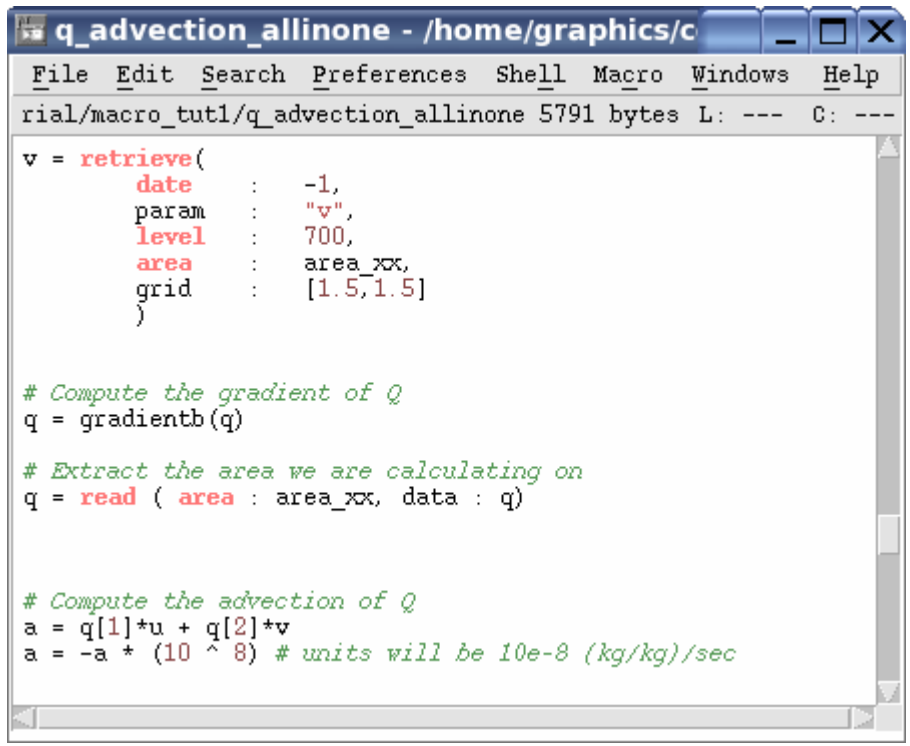
- **Icon-based interface (drag and drop)**
- **Everything in Metview is an Icon**
- **Data, visual definitions, macros**



Metview - Data Processing

- **Meteorological Data Access and Processing Package**
- **GRIB, BUFR, MARS, ODB, geopoints, …**

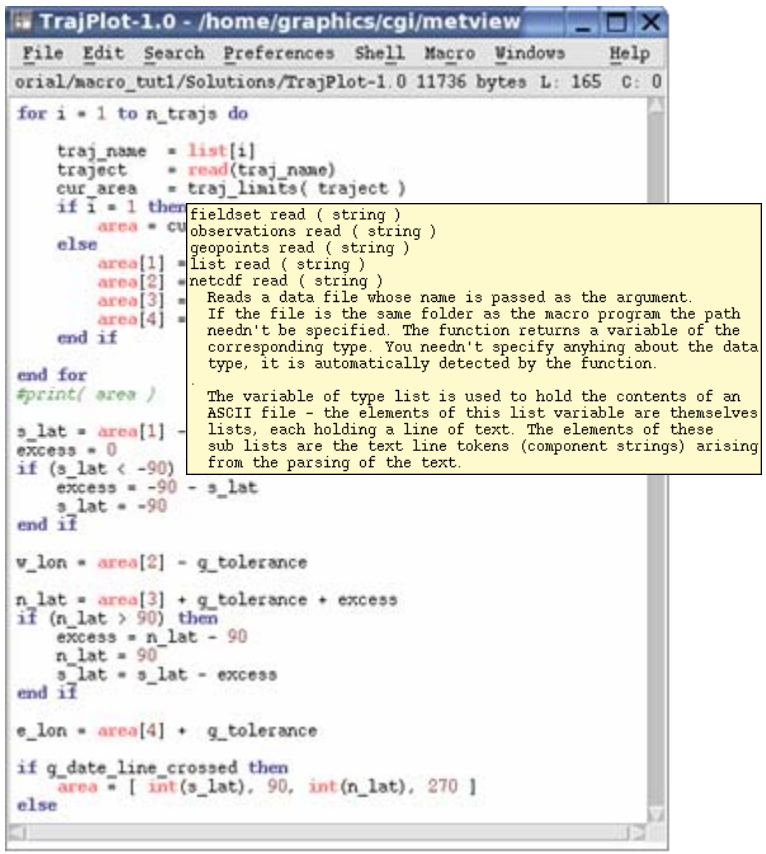





```
v = retrieve(
        date    :   -1,
        param   :   "v",
        level   :   700,
        area    :   area_xx,
        grid    :   [1.5,1.5]
        )


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

# Extract the area we are calculating on
q = read ( area : area_xx, data : q)



# Compute the advection of Q
a = q[1]*u + q[2]*v
a = -a * (10 ^ 8) # units will be 10e-8 (kg/kg)/sec
```

Metview – Macro Language

- **Macro language**
  - **powerful meteorologically oriented language**



- ✓Simple script language
- ✓Extensive list of operators/functions
- ✓Macro programs: interactive or batch mode
- ✓Automatically convert icons to equivalent macro code
- ✓Macro editor – built-in or selected by user
- ✓NEdit: enhanced Macro editor

Our Challenges

- **Magics and Metview have now been up and running for the last 15 years!**
- **They both needed some re-engineering to meet the new users requirements**
  - **New high resolution models**
  - **More satellite observation**
  - **More exchange of data**
  - **New web interfaces**
  - **New ways to export data for later visualisation (Google-Earth)**
- **The next generation is coming:**

Magics++ and Metview 4

Magics++

- **Magics++ is object-oriented :**

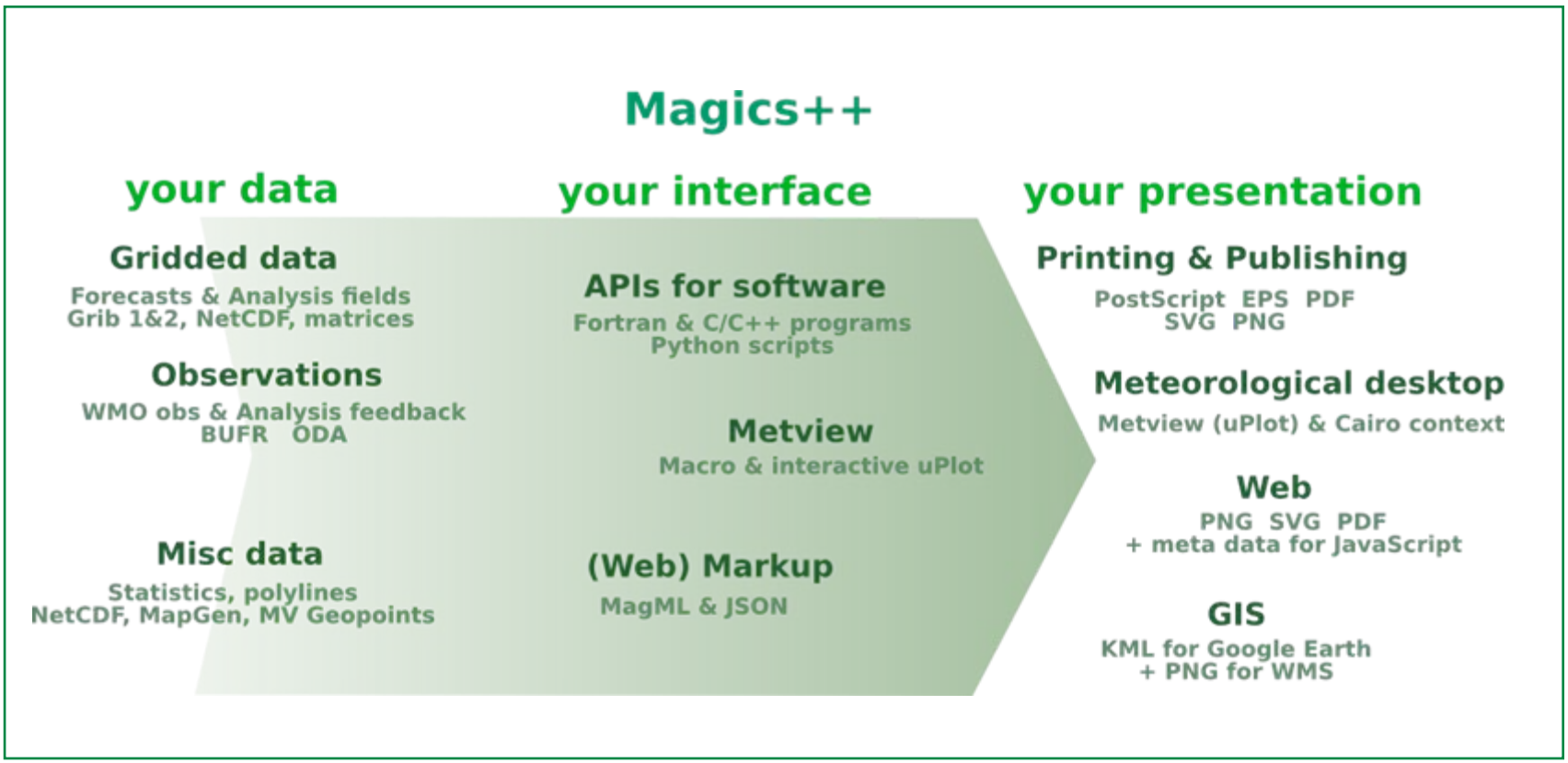
  Its object-oriented architecture allows easy integration of new data formats, new outputs, and new visualisations.

- **Magics++ is meteorologically oriented, but it is not a standalone application…**
- **Magics++ is the visualisation component of a more complex framework.**
  - **Desktop applications, WMS …**

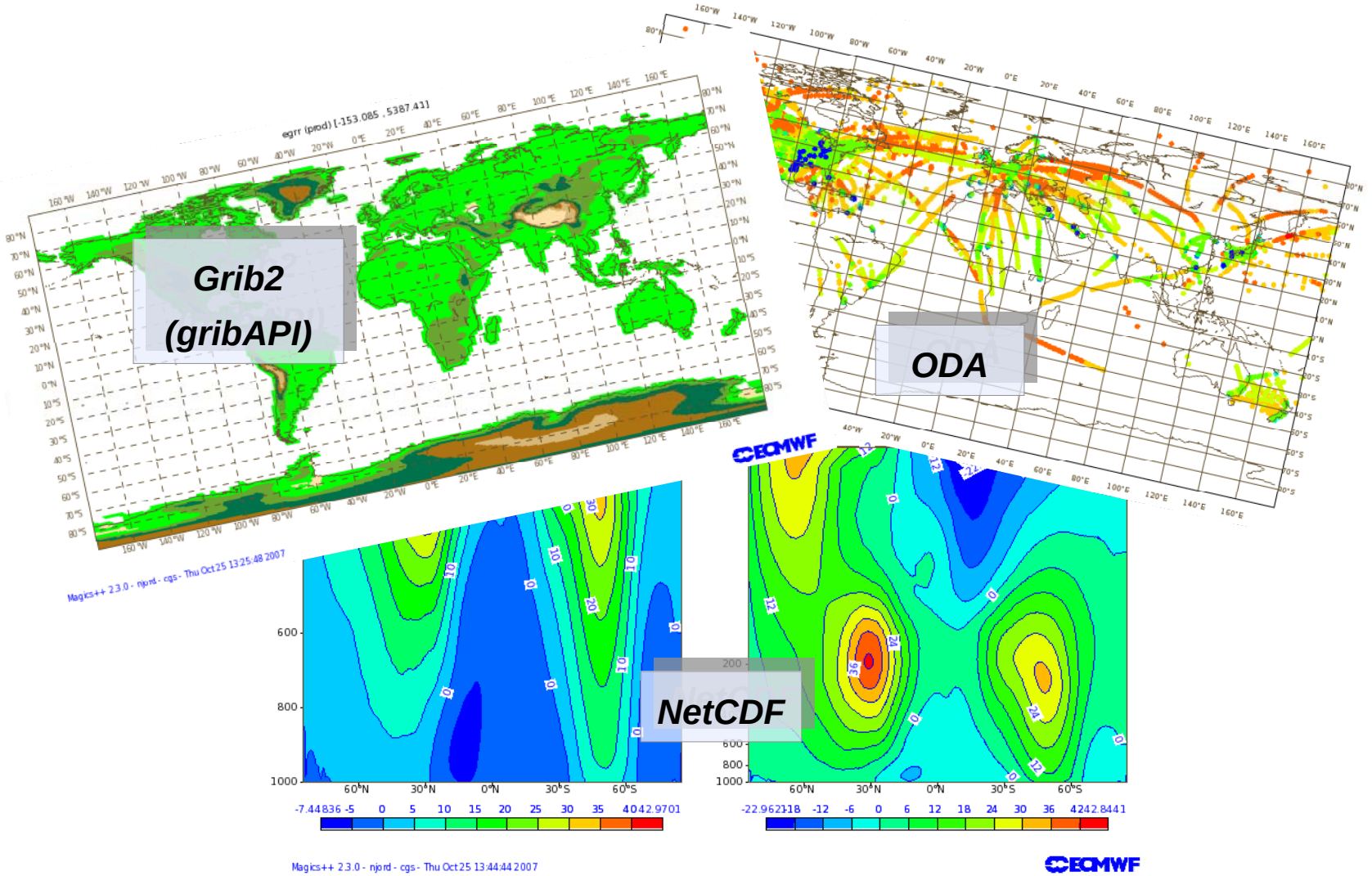
The new design of Magics++ will allow it to be used in the new generation of meteorological workstations:

Desktop or Web-oriented!

Magics++

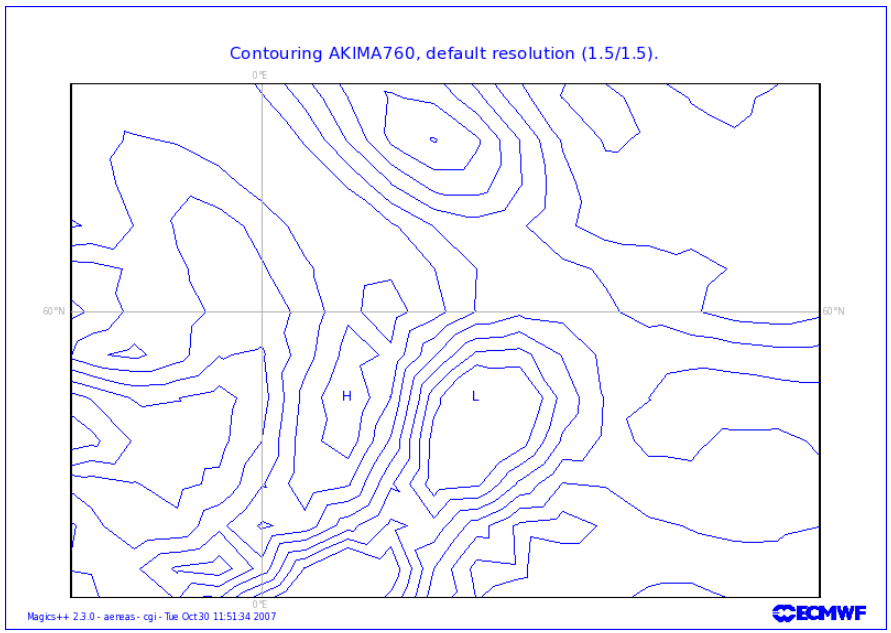

Magics++
your data
Gridded data
Forecasts & Analysis fields
Grib 1&2, NetCDF, matrices
Observations
WMO obs & Analysis feedback
BUFR ODA
Misc data
Statistics, polylines
NetCDF, MapGen, MV Geopoints
your interface
APIs for software
Fortran & C/C++ programs
Python scripts
Metview
Macro & interactive uPlot
(Web) Markup
MagML & JSON
your presentation
Printing & Publishing
PostScript EPS PDF
SVG PNG
Meteorological desktop
Metview (uPlot) & Cairo context
Web
PNG SVG PDF
+ meta data for JavaScript
GIS
KML for Google Earth
+ PNG for WMS

Magics++: new data inputs

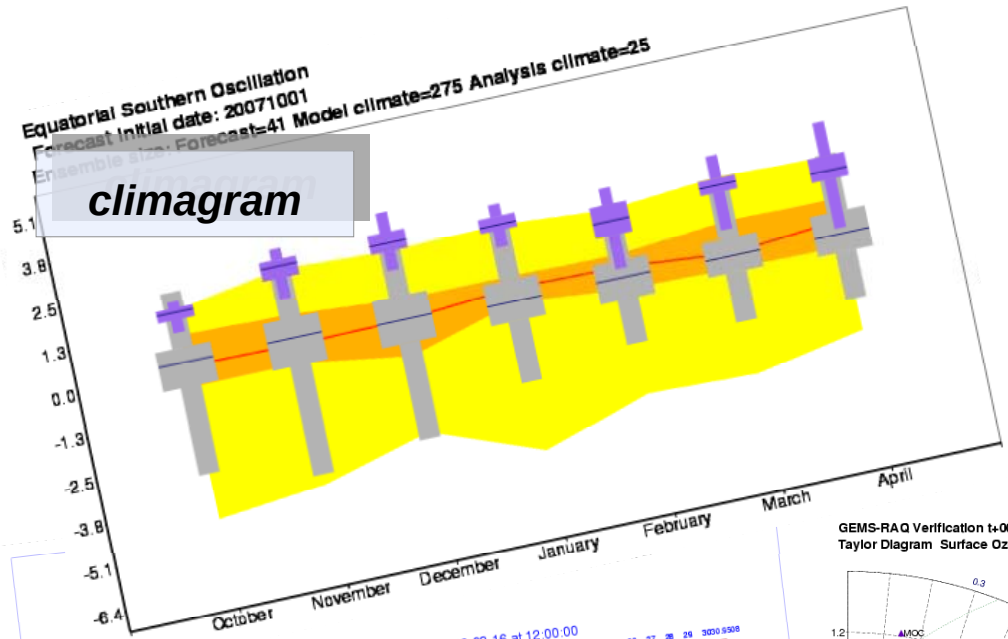


Magics++: new contouring

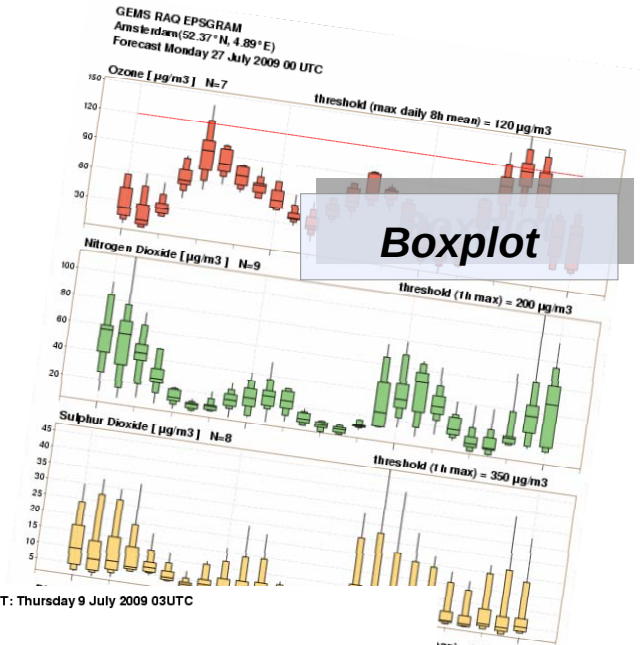
- **Algorithms developed by Hiroshi Akima - documented in the ACM Transactions on Mathematical Software**
- **New contouring has no license restrictions and we have full control of the code**
- **INPE/CPTEC (Brazil) has successfully implemented a C++ version**
- **Algorithms handle gridded and scattered data**
- **Accuracy is configurable by the user, although Magics++ will always choose sensible automatic values by default**



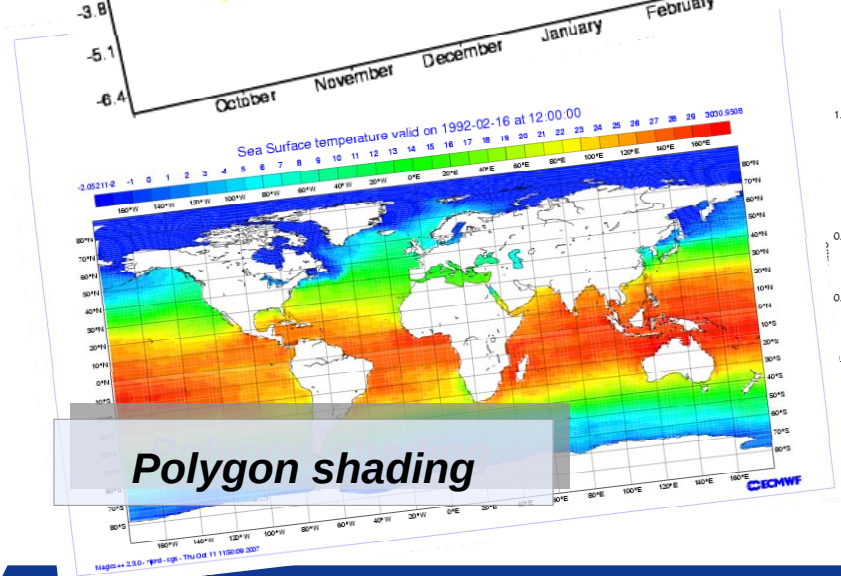
Magics++: new visualisations and projections



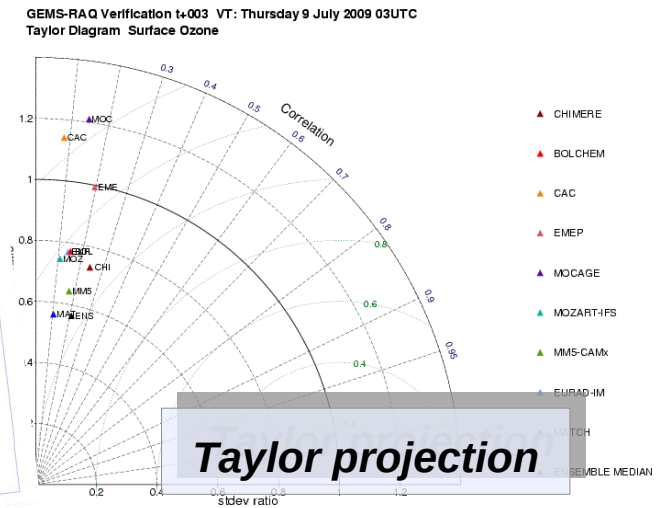
climagram



Boxplot



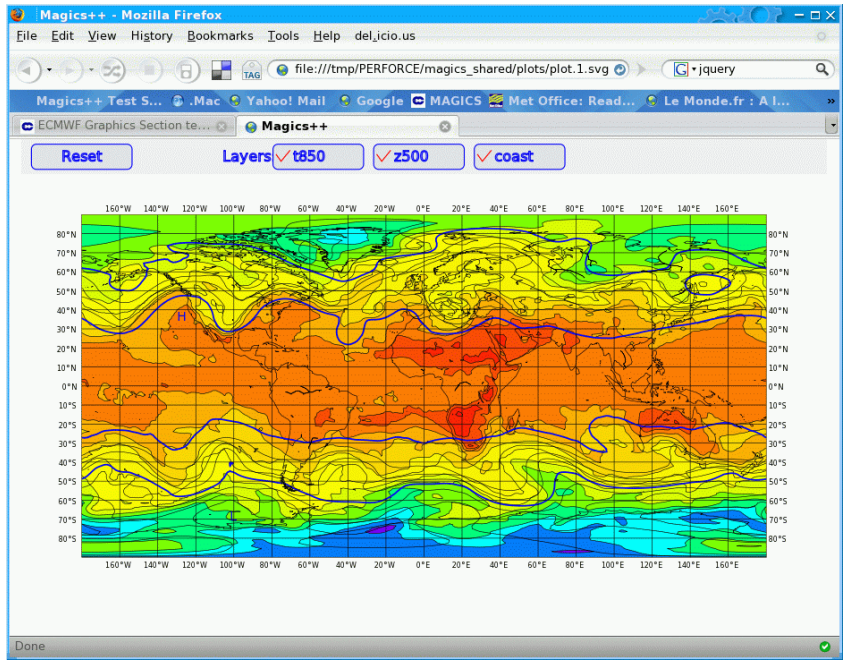
Polygon shading



Taylor projection

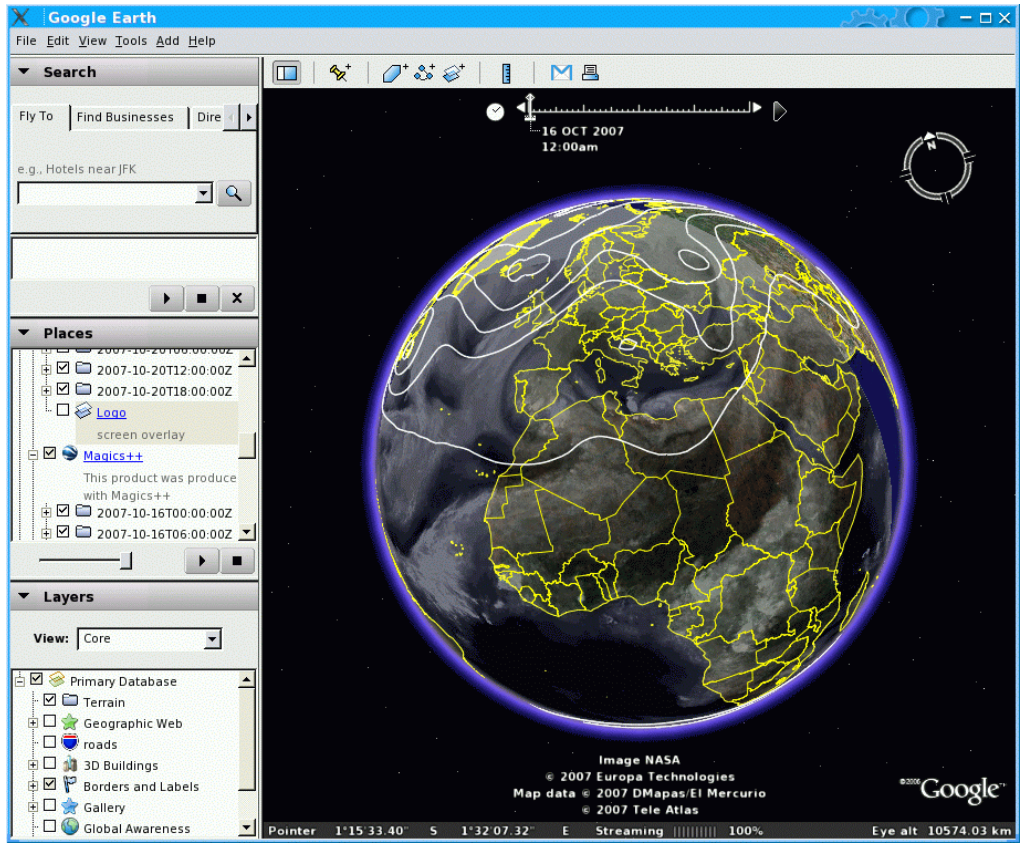
Magics++: new outputs

- **Magics++ produces better publication-quality plots by supporting PNG, EPS and by optimizing PostScript output**
- **Magics++ uses Cairo to generate PNG and PDF**
- **We wrote our own SVG driver to have full control on the output.**
- **We are also thinking in creating our own meta internal format for speeding the web production.**



Magics++: KML/KMZ output

- Generates OGC compliant KML 2.2
- Very different to other 2D outputs
- Generates time series



Magics++: ready for the web

- **It is a new software: can handle web requirements**
  - **Produces wide range of web formats: PNG, PDF, SVG, KML**
  - **Generates metadata info regarding the data displayed and legend**
  - **Generates simple JavaScript codes to enable map navigation**
- **An XML based interface: MagML**
  - **The XML convention makes it easy to use in a web context**
  - **A MagML interpreter can be easily embedded in a complex web project allowing the generation of plot on demand**
  - **The MagML syntax is similar to the Metview icons convention**
- **A JSON Interface tailored for the needs of our new web project.**

Magics++: our programming experience

- **Autotools (configure) based installation enables easier spread of Magics++**
  - **Users are more confident to update**
  - **Debian and Fedora community have or plan to package Magics++**

- **C++ proved again to be a good choice**
  - **Already used in Metview for 15 years**
  - **Fast, clear structured object-oriented code**
  - **Only issue: compiler support**

- **Backwards compatibility**
  - **Important in an operational environment**
  - **Can limit new developments**

Metview in the age of web services

Now that there is the ability of powerful web services, where does a meteorological workstation, such as Metview, come in?

- **The increasing amount of data to be processed does still need processing speed best achieved by an optimized software**
- **While maps allow visualisation on the web a workstation can give more tools to analyse and work with data itself**
- **The tool, once installed, is always available and independent of network and other services**
- **We also need a tool to design the products for the web at the first place!!!**

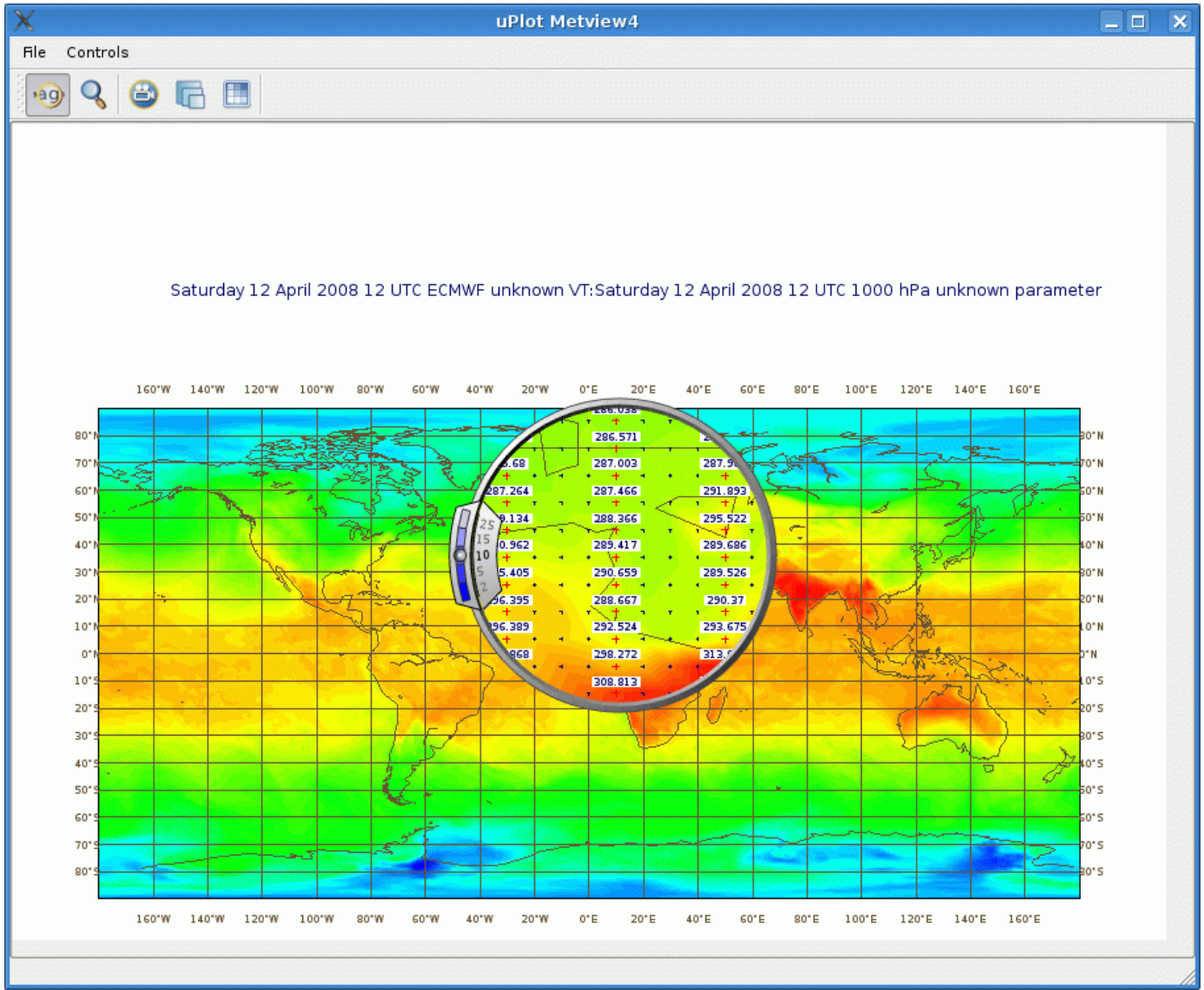
Metview 4: new development choices

- **Replace MAGICS with Magics++**
  - Offers all features of Magics++
- **Replacement of Motif with Qt**
- **Continue to use OpenGL API**
  - Efficient
  - Well established
- **Use autotools for installation**
- **Offer tools for:**
  - post-processing & visualisation of model analysis and forecasts
  - observation monitoring
  - development of web products
  - model verification

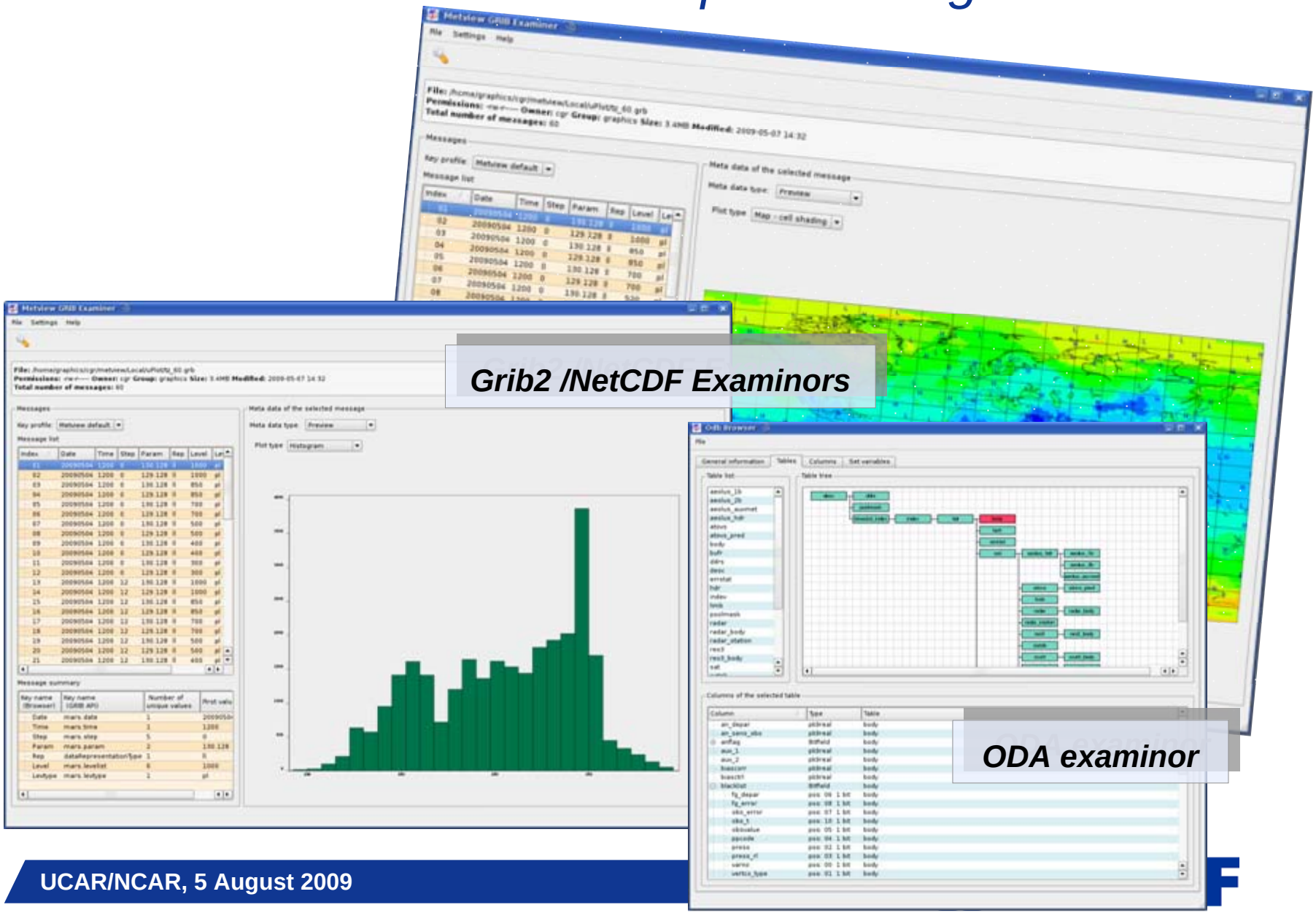
Metview 4: plans

- A new visualisation module to take advantage of all the benefits provided by Magics++
- More functionality to handle NetCDFs
- Revisit our macro language
- More facilities to handle satellite data
- MagML integration
- OGC service client (and server?)
- Full 64 bit memory support
- Better installation tools (Autotools)

MV4 : magnification tool to explore data



MV4 :examiners to explore large dataset



The Web era

Re-engineering the Web system with a view to providing a resilient service with interactive features such as zooming and on-demand production of customised plots for members states…

- **Our current web has been available since January 2002**
- **The number of products on web continues to grow in response to user requests (currently more than half a million single gif images on the web site)**
- **The users expectations of web services are increasing**
  - **High availability**
  - **more interactivity: zoom, pan, click**
- **We need to plan for emerging standards (e.g. OGC/GIS/INSPIRE)**

Magics++/Metview: on the server side

- **Easy description of products**
  - **MagML ot JSON (both being Metview like)**
- **Generation of JavaScript for navigation, zooming, panning..**
- **Generation of metadata for title, legend…**

- **Use of the macro language to perform computations on fields.**
  - **Threshold computation for probabilities maps.**
  - **Accumulation for rainfall.**
- **Use of HADOOP to store the data**

Mozilla Firefox

File Edit View History Bookmarks Tools Help del.icio.us

http://wrep.ecmwf.int/demo/

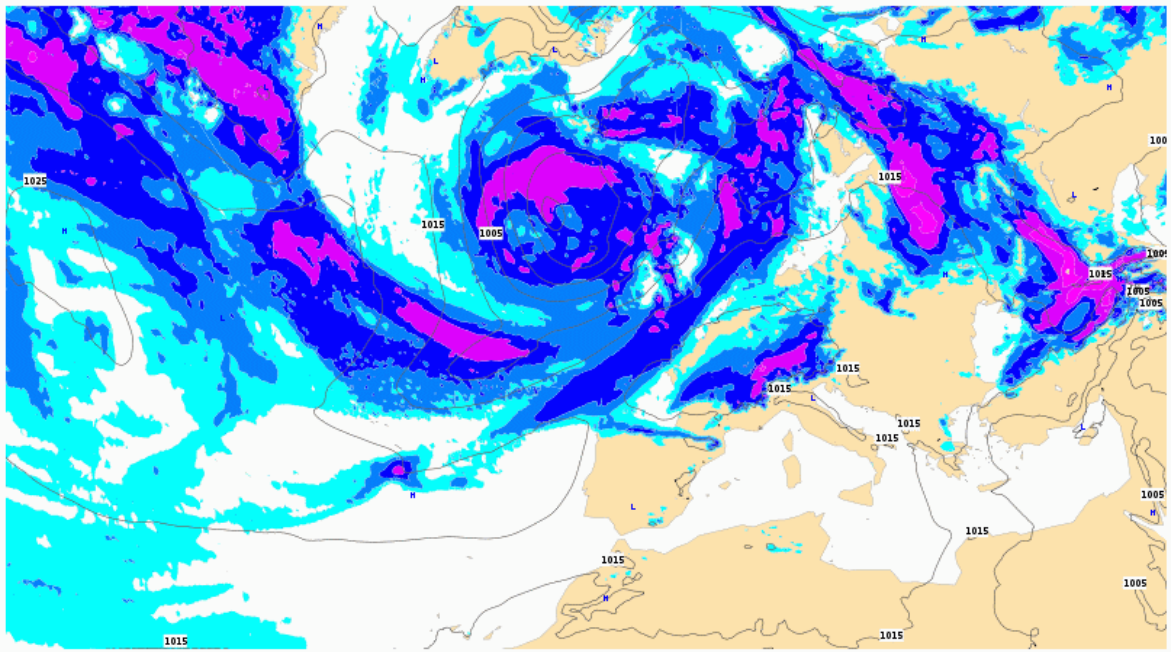
Unidata Program Center | GIS/OGC - Home | http://wrep....f.int/demo/

wave_mwp_wd

Map (click on it)

OpenLayers demo

undefined

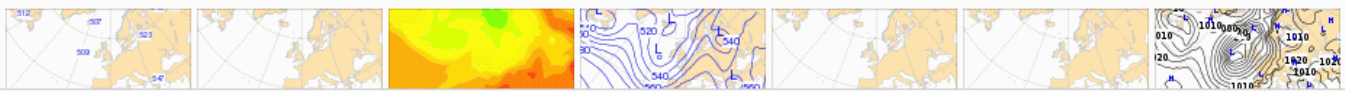


Layers

- msl_for_prep_msl
- tp_for_prep_mslp
- coast_for_prep_msl

Lat: -45.8140735694823, Lon: 163.805, Nearest value: pending

Contours (click on one of them)



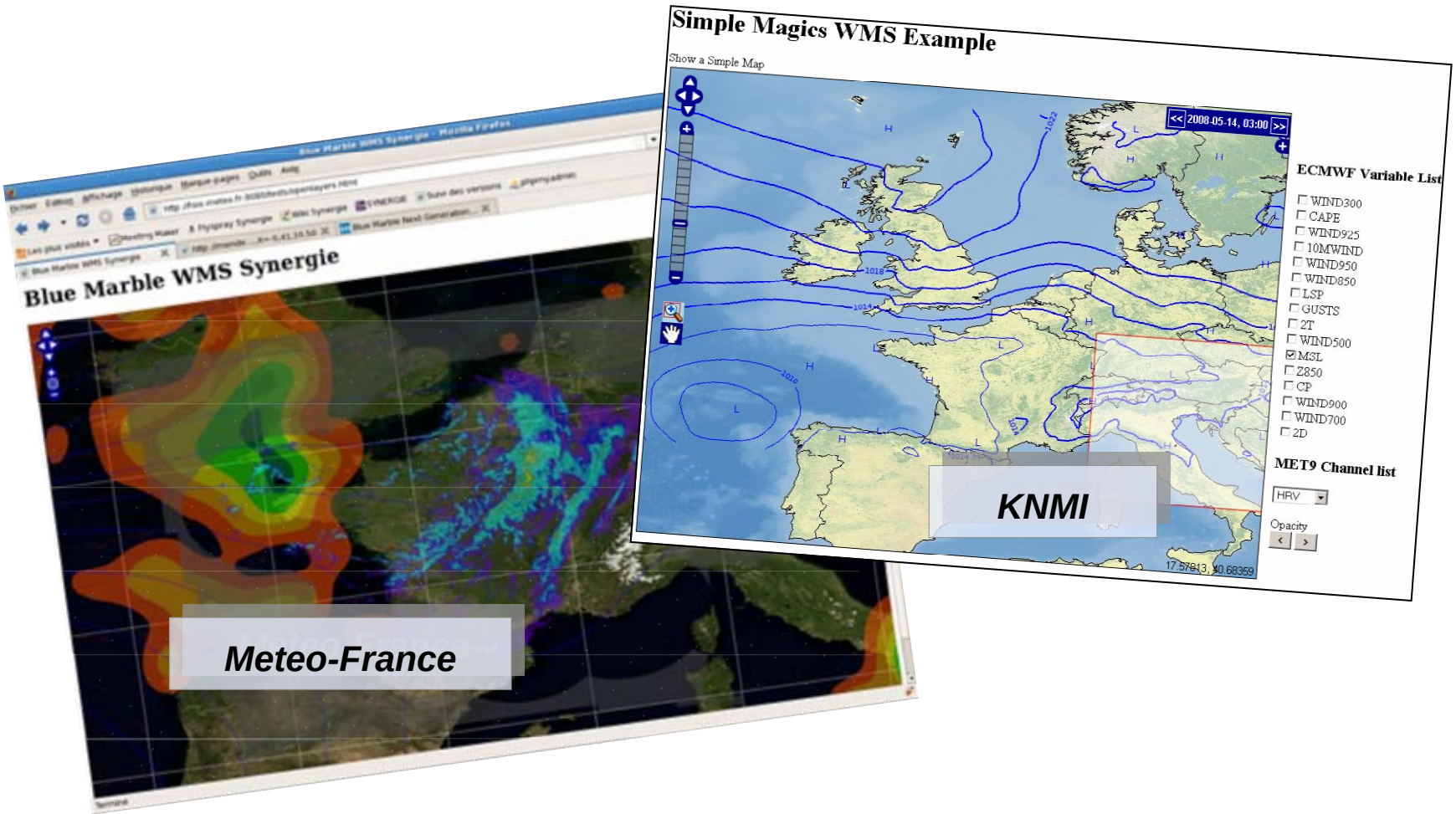
Done

Magics++ : on the WMS Server side

- **Easy description of layers**
- **Fast visualisation**
- **High quality graphics**

- **Definition and use of projection needs to be assessed**
  - **E.g. definition of polar stereographic projections**
- **How should WMS served maps be updated?**
  - **On request, once or periodically**
- **Work after this will aim at catalogue and feature services**

Magics++ : on the WMS Server side

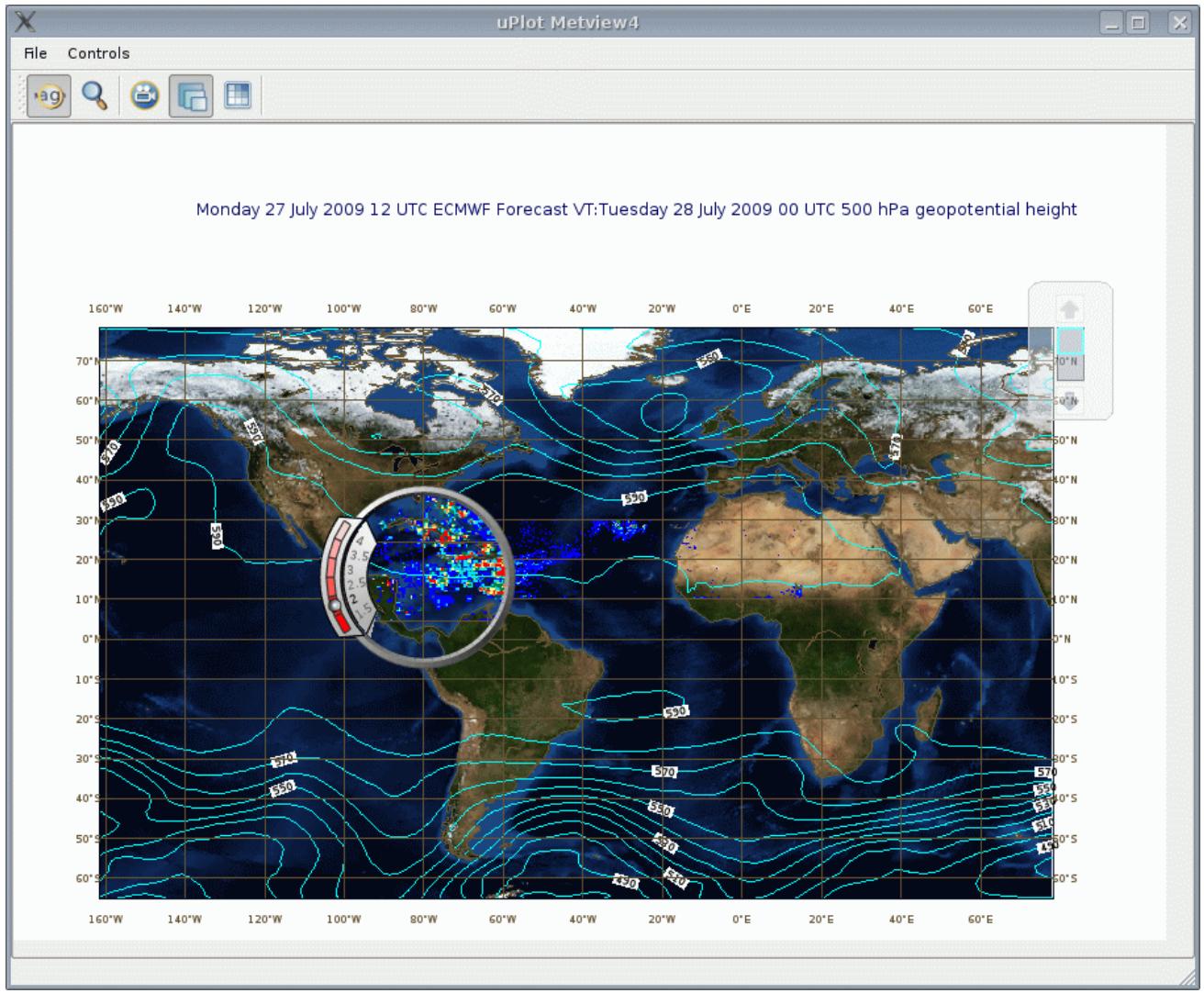


Metview 4 : on the WMS Client side

- **The Metview architecture makes the integration of new data layers easy.**
- **The new WebClient icon allows the users to access and overlay data from external WMS.**

- **Reliability of an external WMS?**
- **Where to find the rules to overlay?**

Metview 4


uPlot Metview4
File
Controls
Monday 27 July 2009 12 UTC ECMWF Forecast VT:Tuesday 28 July 2009 00 UTC 500 hPa geopotential height

OGC standards and web services

- **ECMWF is committed to investigating the use of OGC standards and (web) services**
- **We hosted jointly with Met Office and Météo France a Workshop in Nov 2008**
- **ECMWF wants to take an active role in the OGC Meteorology DWG**
- **Any implementations need to be tested with external partners to ensure interoperability**

2nd workshop on the use of GIS/OGC standards in meteorology

- **23 – 25 November 2009 Toulouse France**

- **To review the use of OGC standards in geo-sciences in Europe and worldwide.**

More information at
http://www.meteo.fr/cic/meetings/gis-ogc/

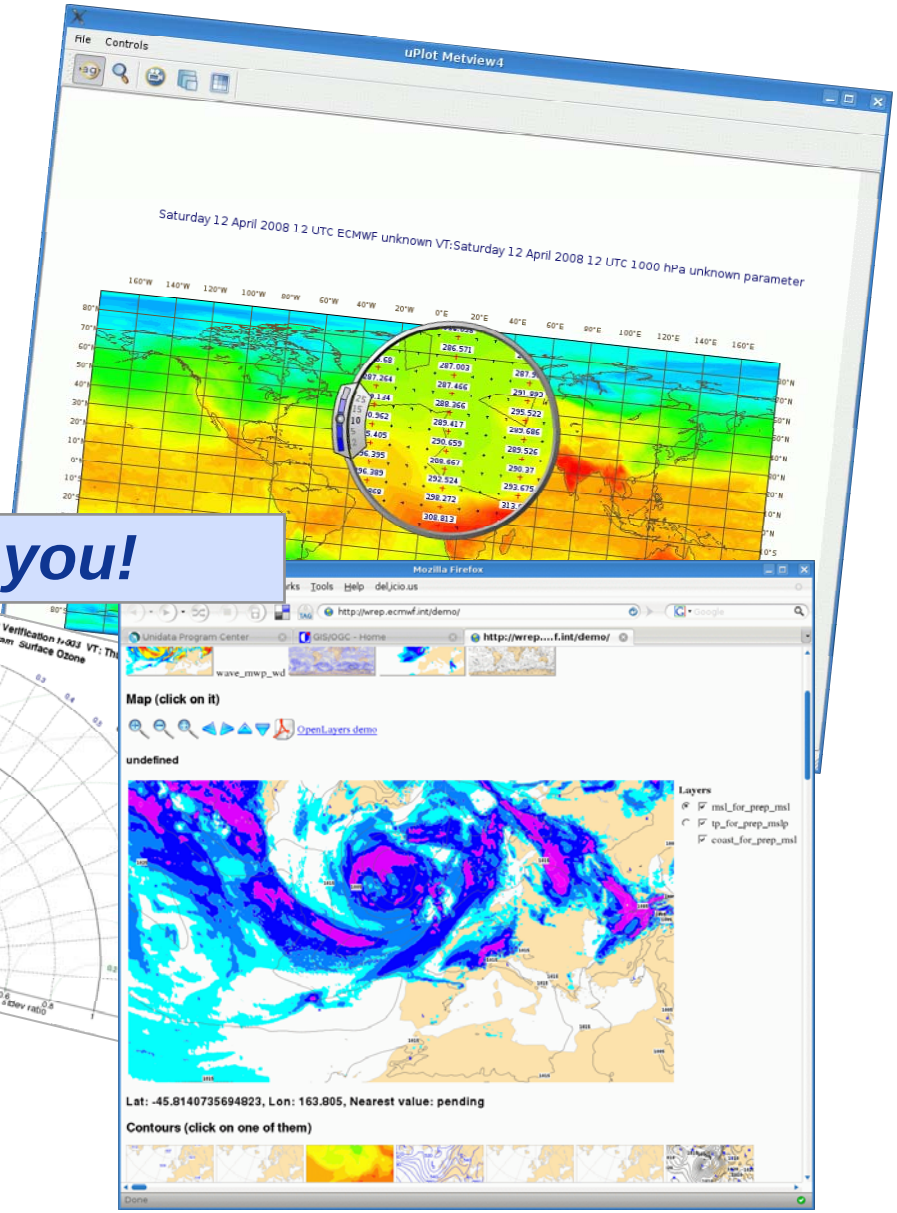
12th Workshop on Meteorological Operational Systems

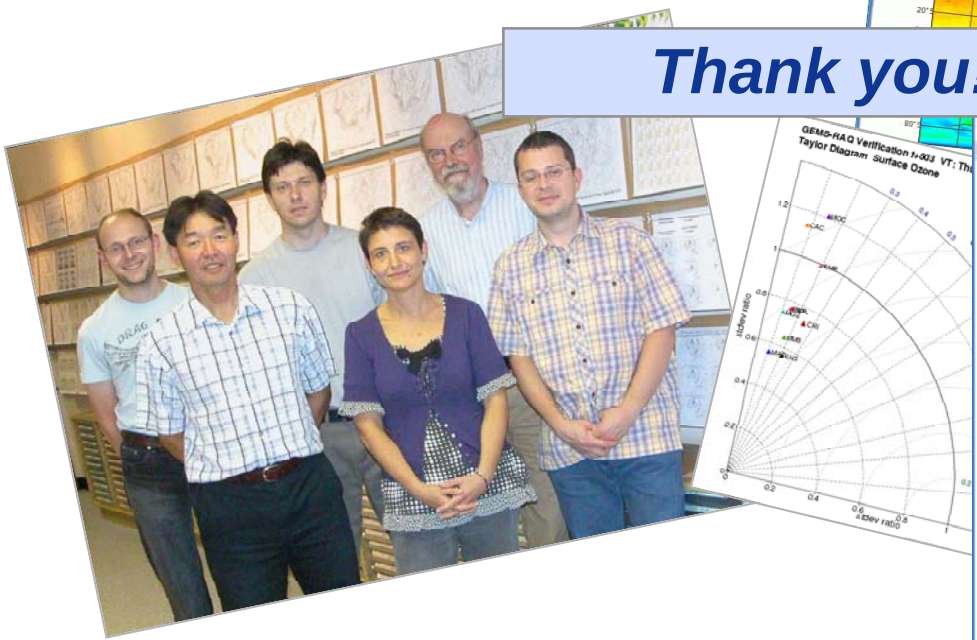
- **2nd – 6th November 2009 at ECMWF, Reading, UK**

- **Speakers are invited to report on "new trends in meteorological visualisation applications"**

More information at

www.ecmwf.int/newsevents/meetings/workshops/2009/MOS_12/


uPlot Metview4
File
Controls
Saturday 12 April 2008 12 UTC ECMWF unknown VT:Saturday 12 April 2008 12 UTC 1000 hPa unknown parameter
Mozilla Firefox
Map (click on it)
OpenLayers demo
undefined
Layers
Lat: -45.8140735694823, Lon: 163.905, Nearest value: pending
Contours (click on one of them)



Thank you!