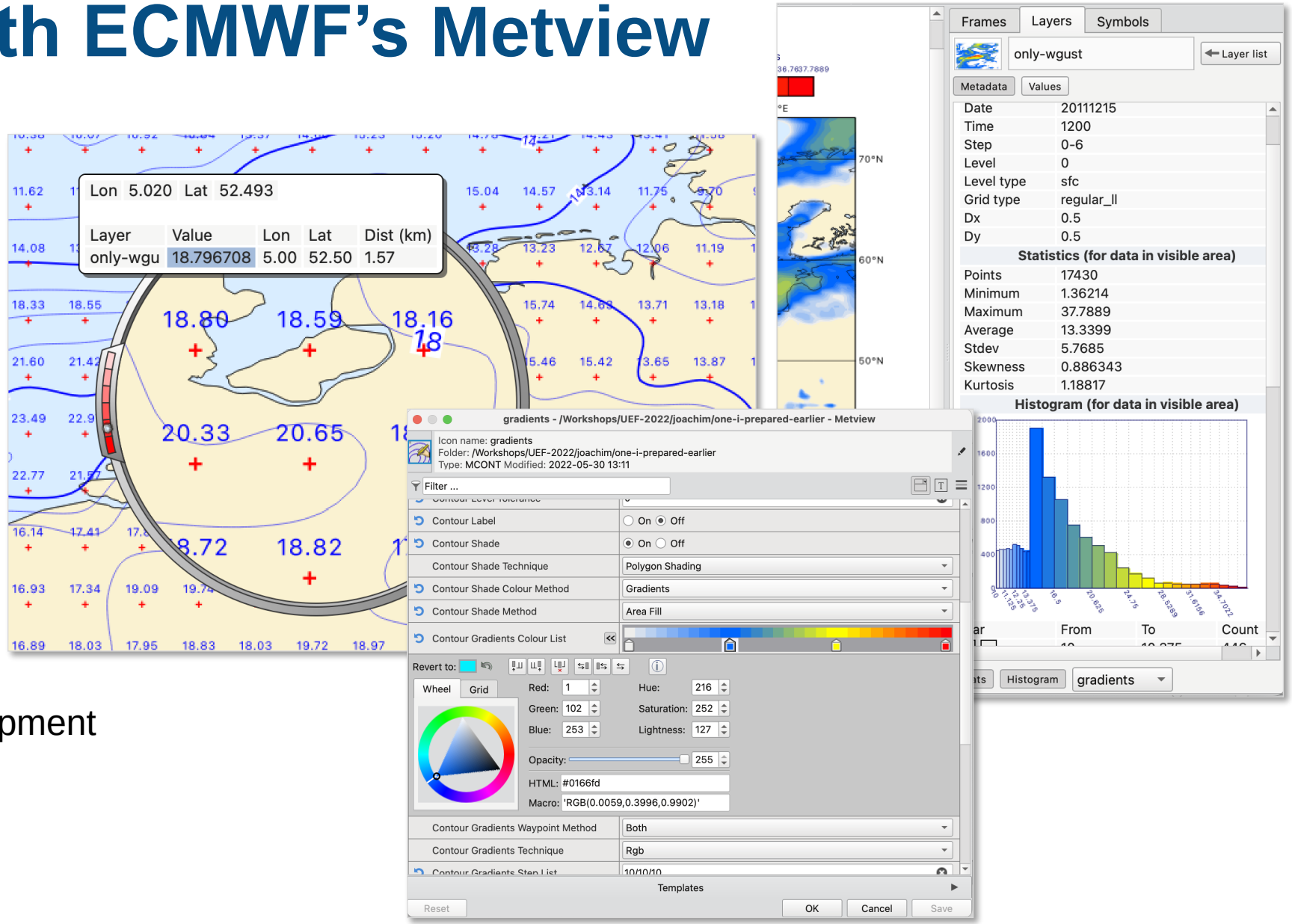
Interactive data visualization and pre-processing with ECMWF's Metview software

June 8, 2022

Iain Russell

Development Section, ECMWF

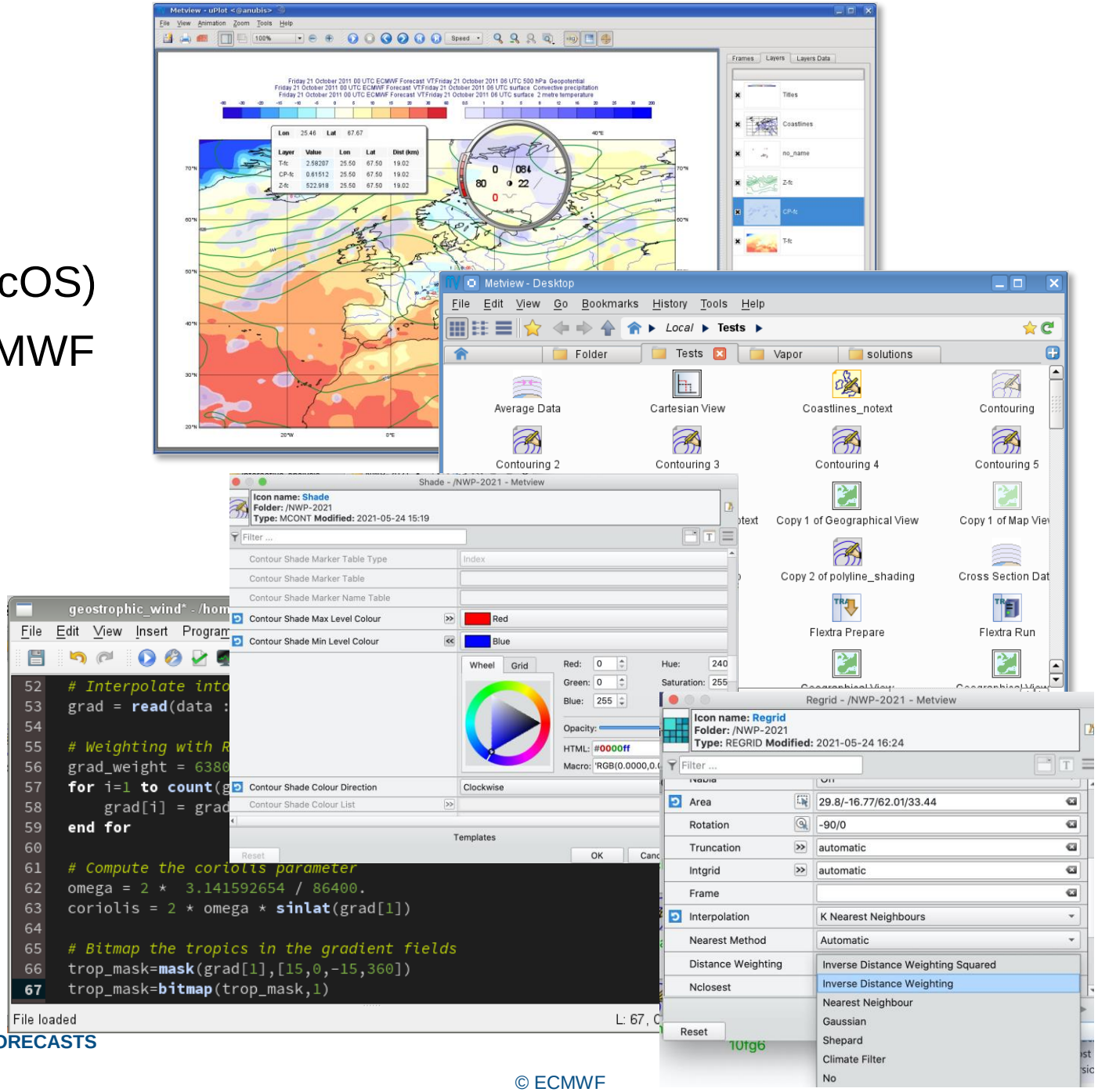


Thanks to the Metview development team over the years!

ECMWF

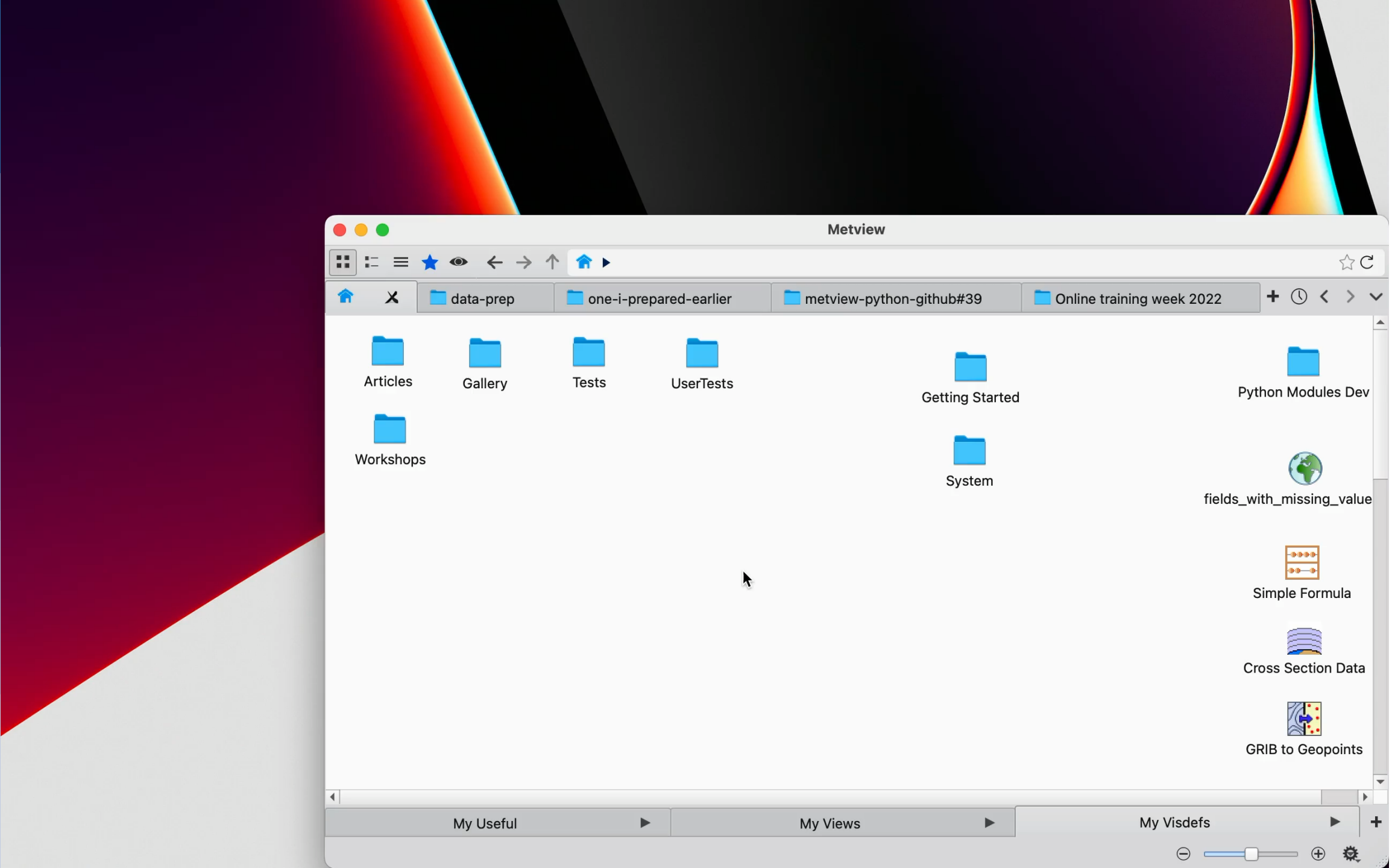
What is Metview?

- Workstation software, runs on UNIX, from laptops to supercomputers (including macOS)
- Developed at ECMWF, built on other ECMWF libraries
- Open source, Apache 2.0 license
- Data access
- Data processing
- Data visualisation
- Icon based user interface
- Powerful scripting languages - Python and Macro

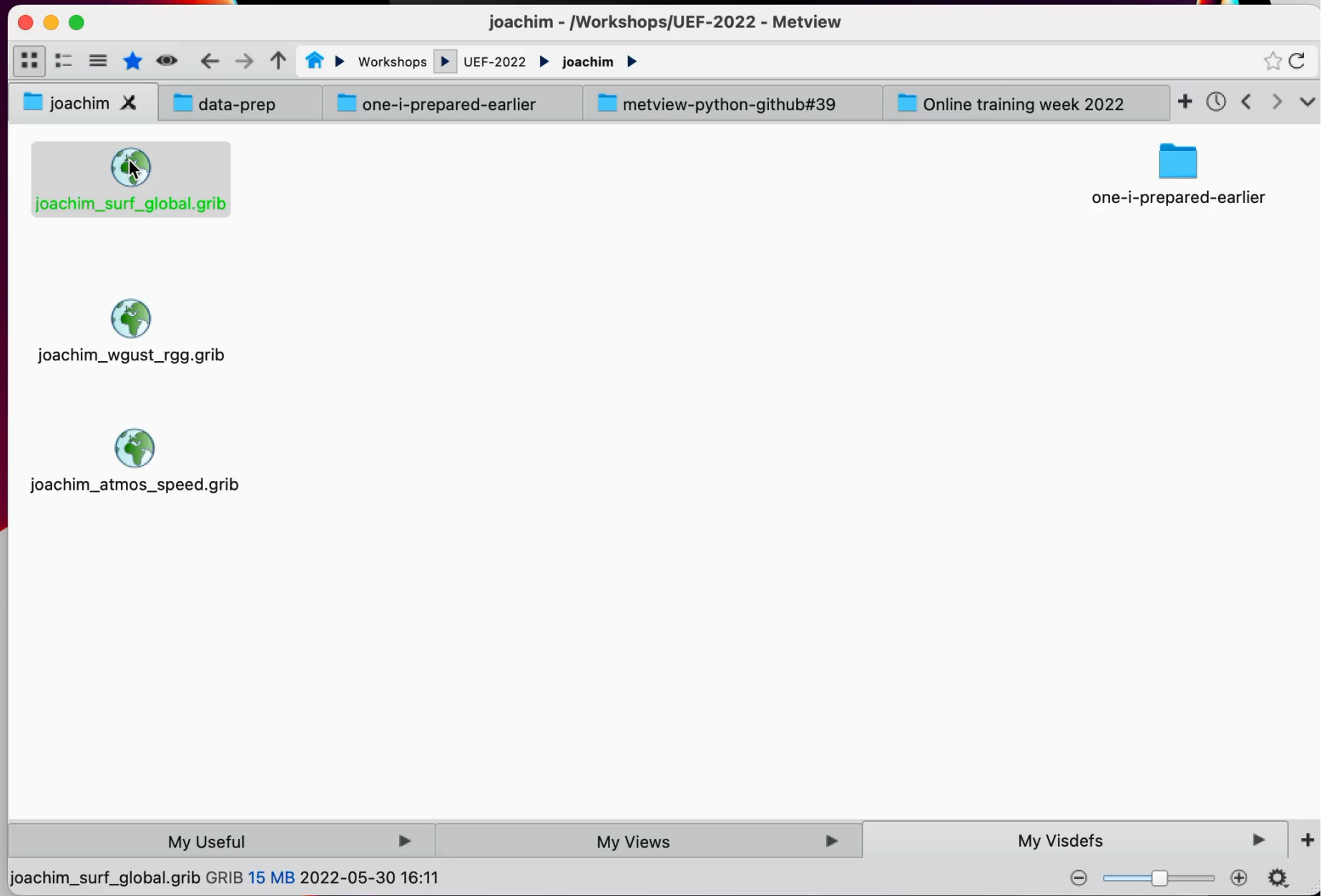


Interactive visualisation

- Navigate folders and initial data inspection


Metview
data-prep
one-i-prepared-earlier
metview-python-github#39
Online training week 2022
Articles
Gallery
Tests
UserTests
Workshops
Getting Started
System
Python Modules Dev
fields_with_missing_value
Simple Formula
Cross Section Data
GRIB to Geopoints
My Useful
My Views
My Visdefs

- Visualise using default styling


joachim - /Workshops/UEF-2022 - Metview
Workshops
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joachim
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data-prep
one-i-prepared-earlier
metview-python-github#39
Online training week 2022
joachim_surf_global.grib
one-i-prepared-earlier
joachim_wgust_rgg.grib
joachim_atmos_speed.grib
My Useful
My Views
My Visdefs
joachim_surf_global.grib GRIB 15 MB 2022-05-30 16:11

- Create a contouring icon and use ecCharts default style

Metview - uPlot

Fit to Window | Speed | Frames | Layers | Symbols

joachim - /Workshops/UEF-2022 - Metview

Workshops > UEF-2022 > joachim

joachim | data-prep | one-i-prepared-earlier | metview-python-github#39 | Online training week 2022

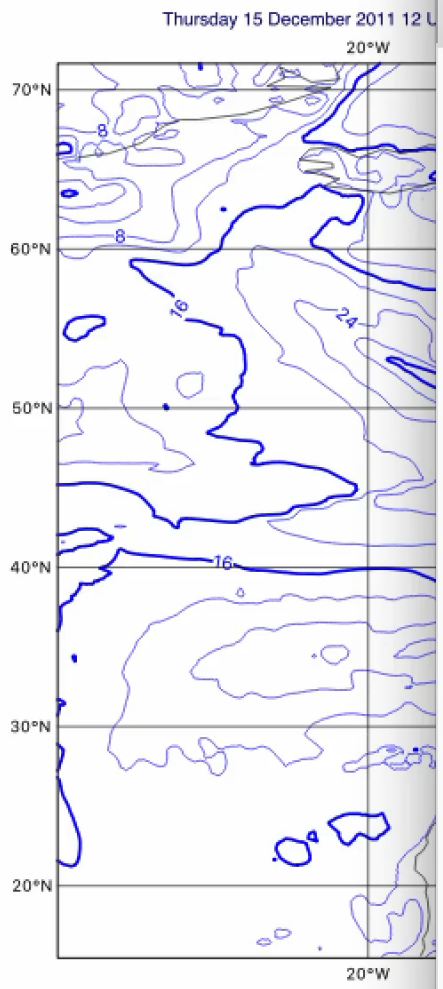
joachim_surf_global.grib

joachim_wgust_rgg.grib

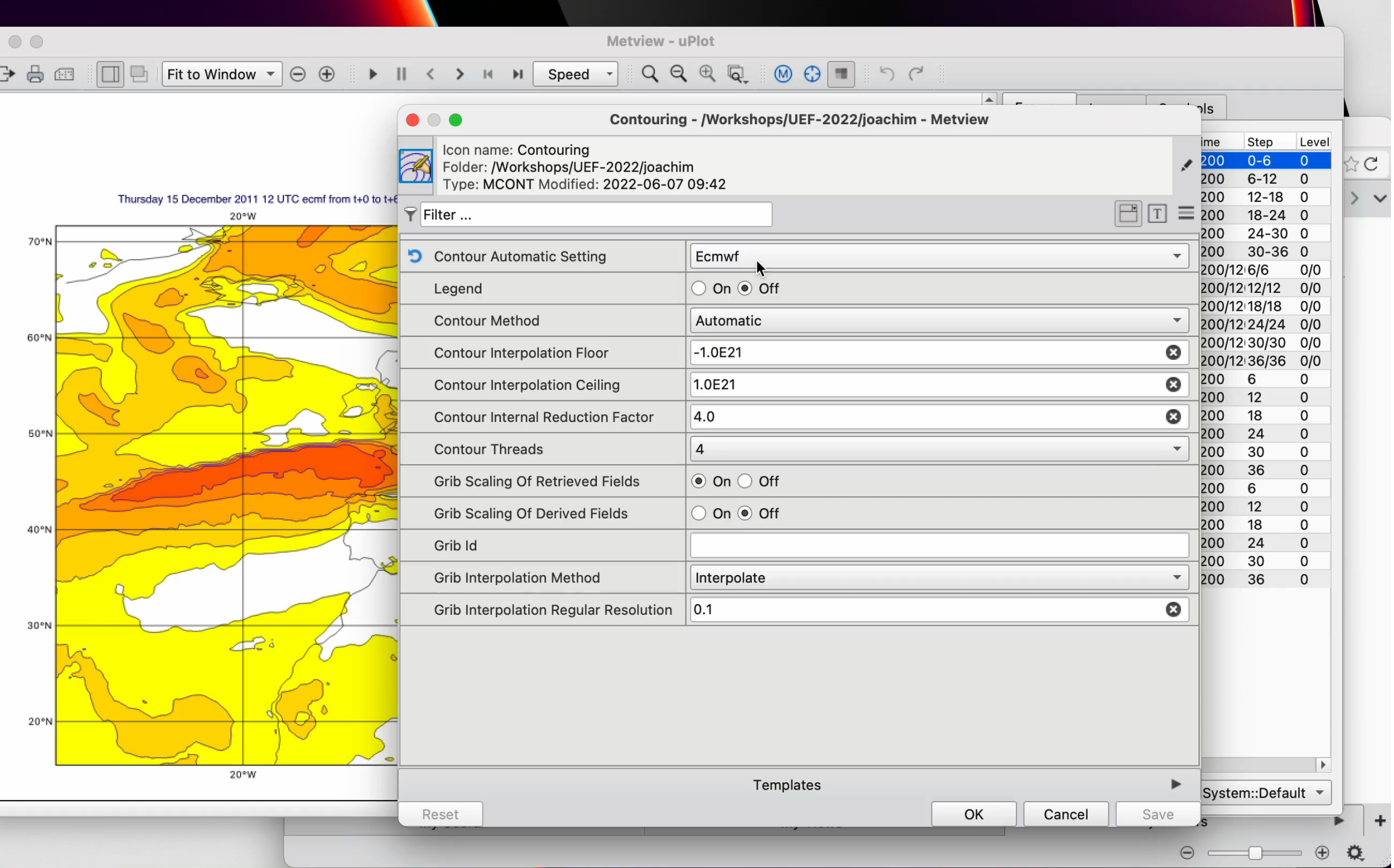
joachim_atmos_speed.grib

one-i-prepared-earlier

My Useful | My Views | My Visdefs



- Check out the style browser


Metview - uPlot
Fit to Window
Speed
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Icon name: Contouring
Folder: /Workshops/UEF-2022/joachim
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Filter ...
Contour Automatic Setting
Ecmwf
Legend
On Off
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Automatic
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-1.0E21
Contour Interpolation Ceiling
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Contour Internal Reduction Factor
4.0
Contour Threads
4
Grib Scaling Of Retrieved Fields
On Off
Grib Scaling Of Derived Fields
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Grib Id
Grib Interpolation Method
Interpolate
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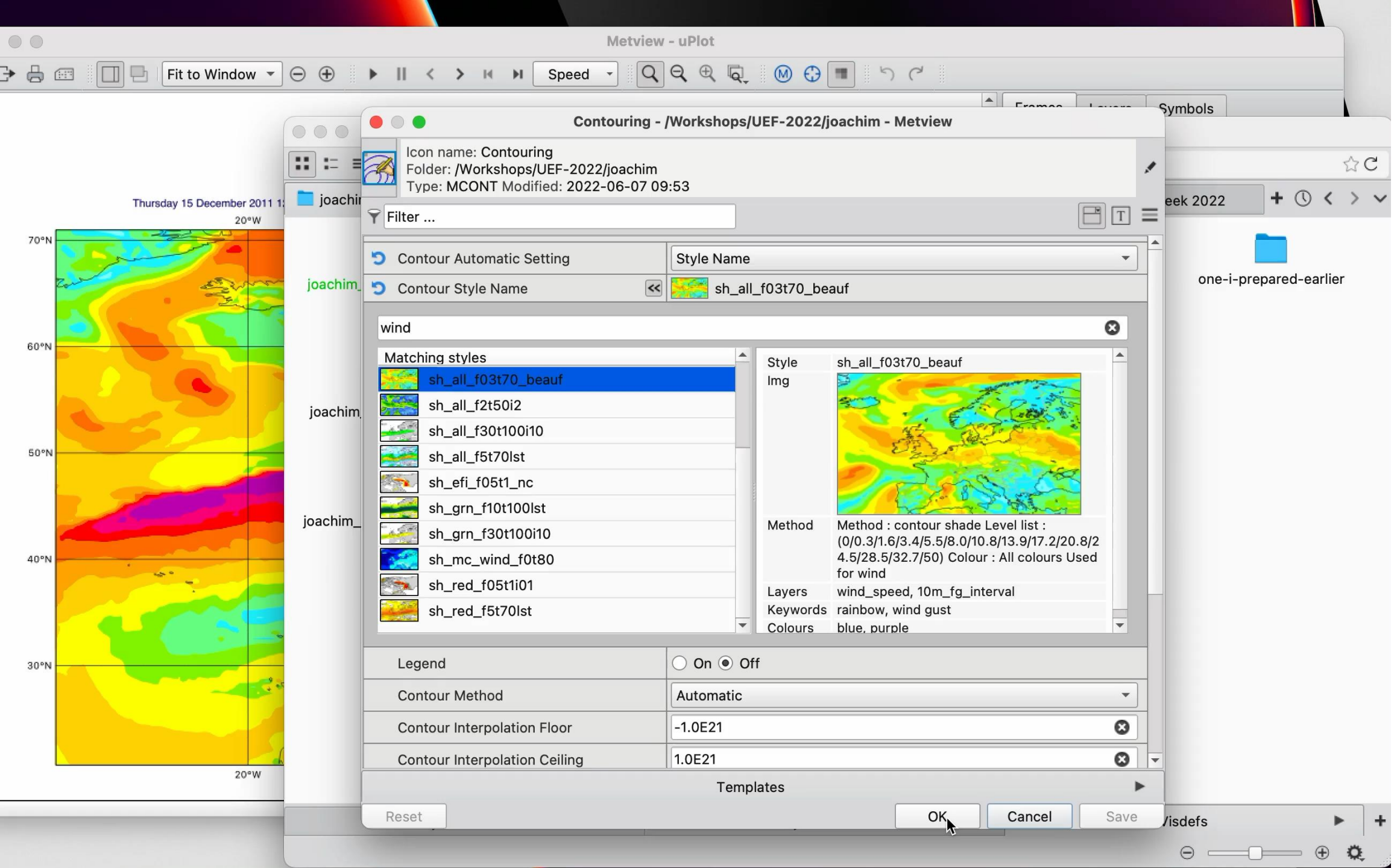
0.1
Templates
Reset
OK
Cancel
Save
Thursday 15 December 2011 12 UTC ecmf from t+0 to t+6
20°W
70°N
60°N
50°N
40°N
30°N
20°N
Step
Level
System::Default

- Store that icon for re-use


Metview - uPlot
Fit to Window
Speed
Symbols
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Contour Style Name
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wind
Matching styles
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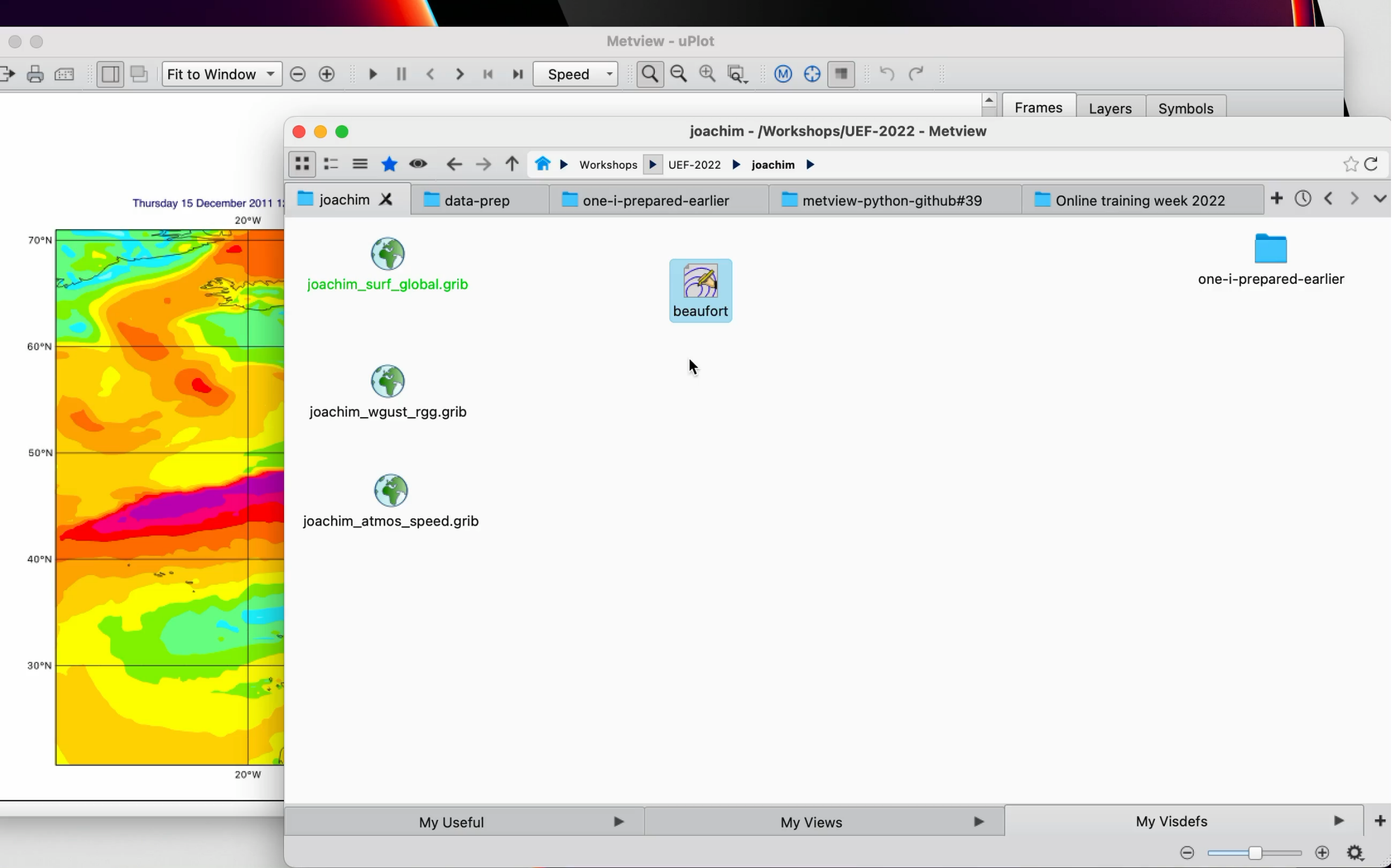
sh_all_f30t100i10
sh_all_f5t70lst
sh_efi_f05t1_nc
sh_grn_f10t100lst
sh_grn_f30t100i10
sh_mc_wind_f0t80
sh_red_f05t1i01
sh_red_f5t70lst
Style
sh_all_f03t70_beauf
Img
Method
Method : contour shade Level list : (0/0.3/1.6/3.4/5.5/8.0/10.8/13.9/17.2/20.8/24.5/28.5/32.7/50) Colour : All colours Used for wind
Layers
wind_speed, 10m_fg_interval
Keywords
rainbow, wind gust
Colours
blue, purple
Legend
On
Off
Contour Method
Automatic
Contour Interpolation Floor
-1.0E21
Contour Interpolation Ceiling
1.0E21
Templates
Reset
OK
Cancel
Save
Thursday 15 December 2011
20°W
70°N
60°N
50°N
40°N
30°N
20°W
one-i-prepared-earlier

- Create our own simple colour scheme


Metview - uPlot
Fit to Window
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Frames
Layers
Symbols
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UEF-2022
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joachim_wgust_rgg.grib
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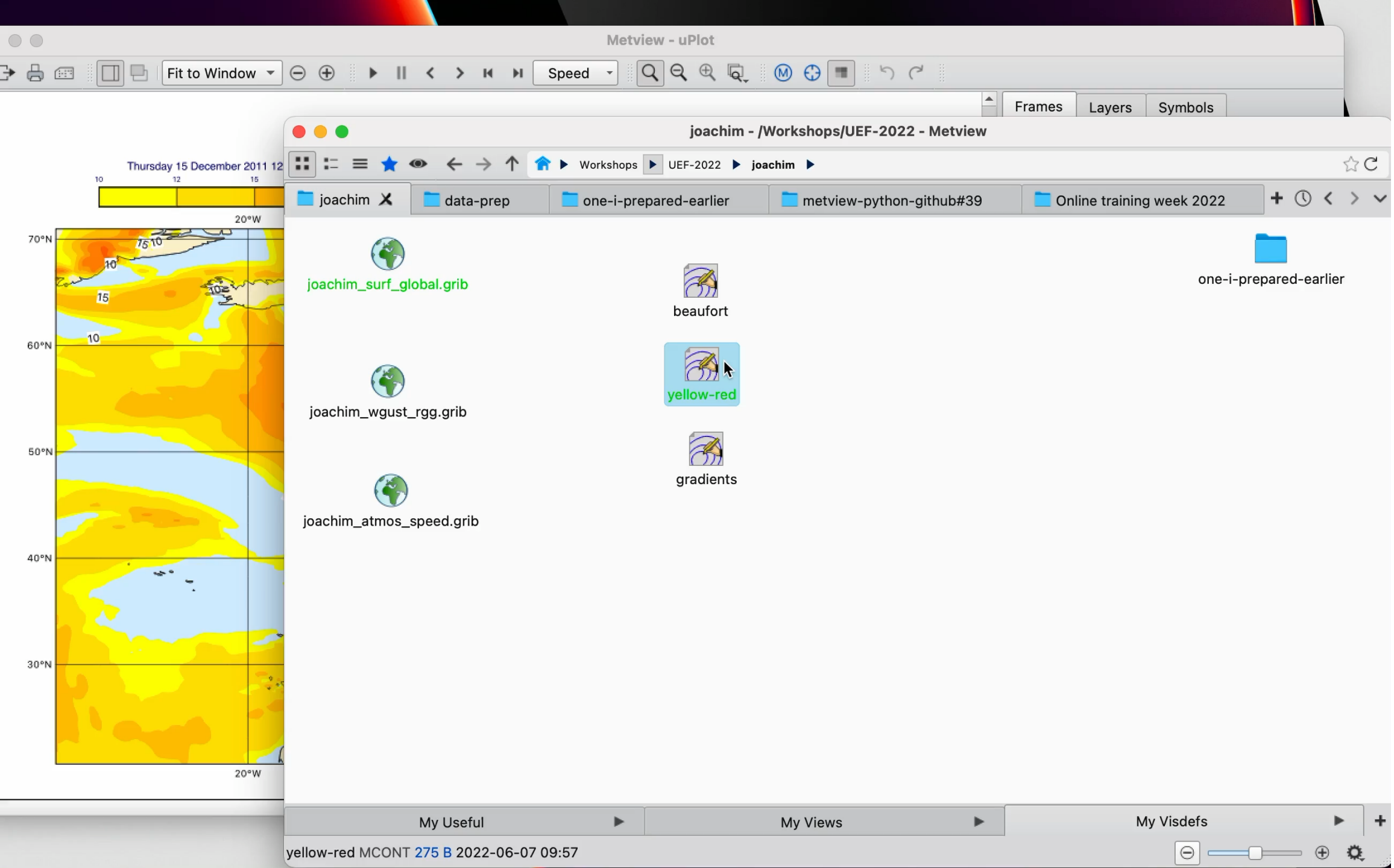
Thursday 15 December 2011
20°W
70°N
60°N
50°N
40°N
30°N
20°W
My Useful
My Views
My Visdefs

- Create out own multi-stage colour palette


Metview - uPlot
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Layers
Symbols
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one-i-prepared-earlier
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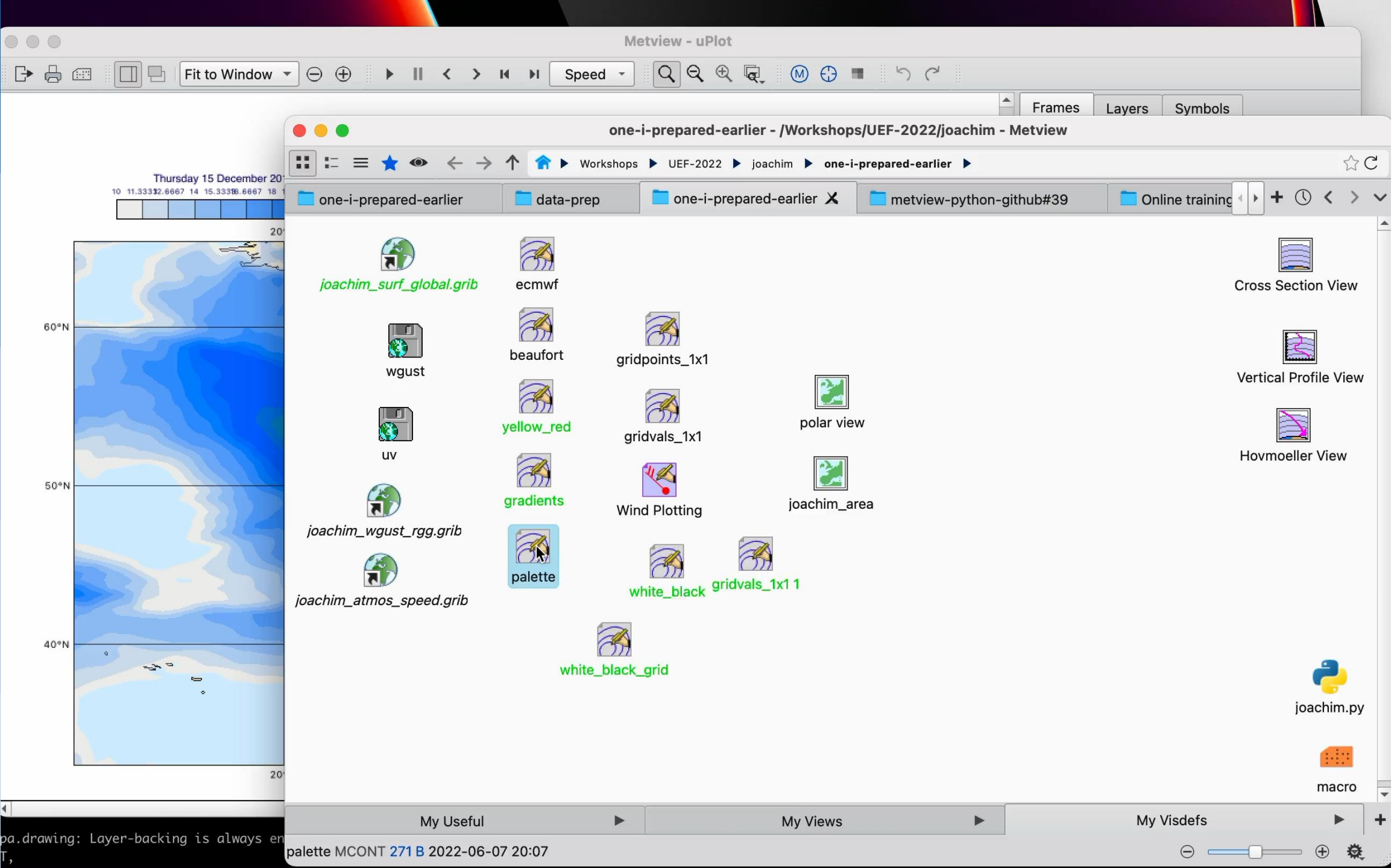
yellow-red
gradients
joachim_atmos_speed.grib
My Useful
My Views
My Visdefs
yellow-red MCONT 275 B 2022-06-07 09:57

- Check out the palette browser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Layers
Symbols
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UEF-2022
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yellow_red
gridvals_1x1
polar view
uv
gradients
Wind Plotting
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joachim_wgust_rgg.grib
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white_black
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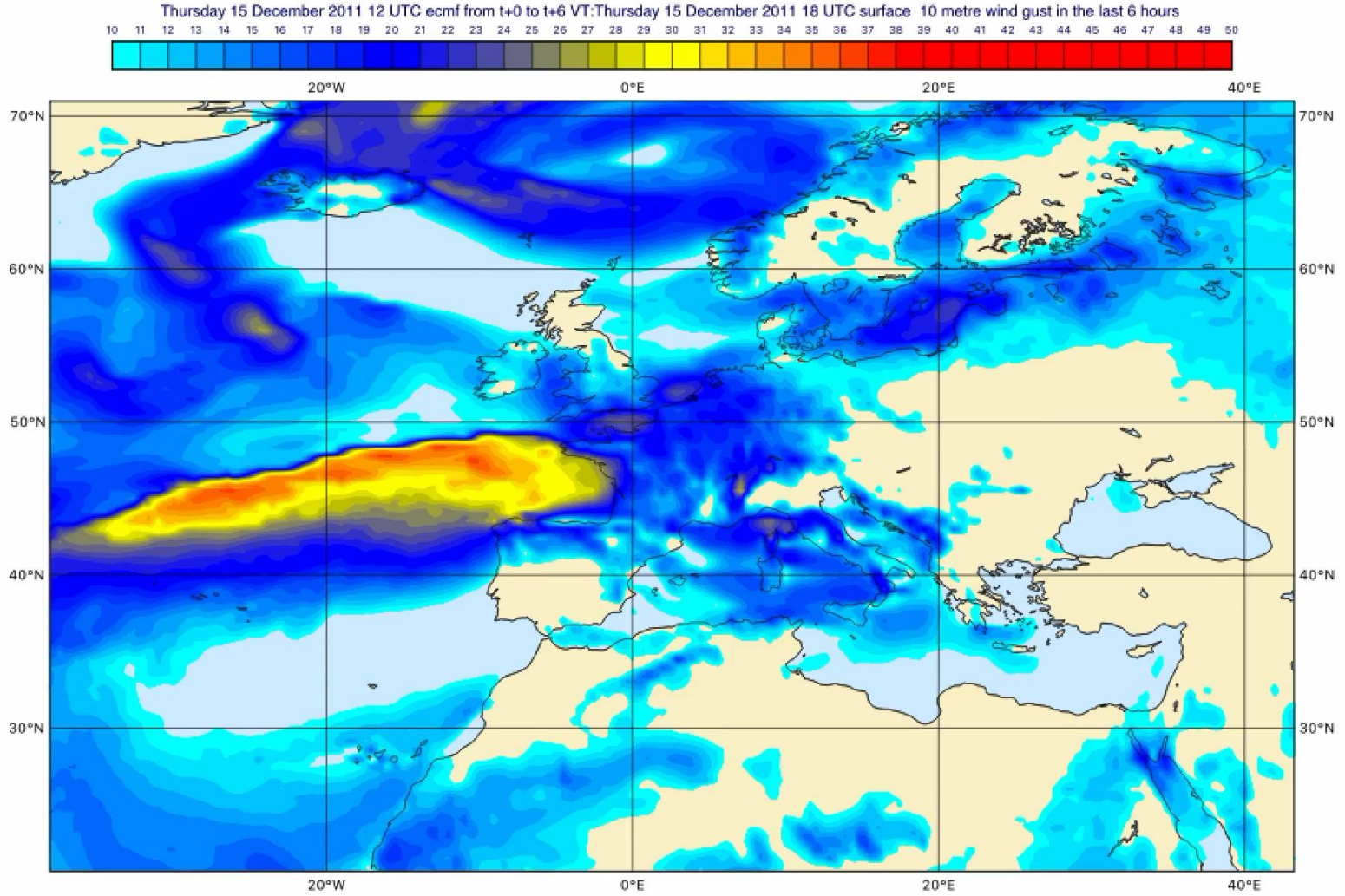
white_black_grid
Cross Section View
Vertical Profile View
Hovmoeller View
joachim.py
macro
My Useful
My Views
My Visdefs
palette MCONT 271 B 2022-06-07 20:07
Thursday 15 December 20
60°N
50°N
40°N

- Interactive inspection of statistics

Metview - uPlot

Fit to Window | Speed



Frames | Layers | Symbols

Frame	Name	Date	Time	Step	Level
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6	10fg6	2011121	1200	6-12	0
10	10fg6	2011121	1200	12-18	0
14	10fg6	2011121	1200	18-24	0
18	10fg6	2011121	1200	24-30	0
22	10fg6	2011121	1200	30-36	0
3	10u/10v	2011121	1200/12	6/6	0/0
7	10u/10v	2011121	1200/12	12/12	0/0
11	10u/10v	2011121	1200/12	18/18	0/0
15	10u/10v	2011121	1200/12	24/24	0/0
19	10u/10v	2011121	1200/12	30/30	0/0
23	10u/10v	2011121	1200/12	36/36	0/0
1	msl	2011121	1200	6	0
5	msl	2011121	1200	12	0
9	msl	2011121	1200	18	0
13	msl	2011121	1200	24	0
17	msl	2011121	1200	30	0
21	msl	2011121	1200	36	0
4	tp	2011121	1200	6	0
8	tp	2011121	1200	12	0
12	tp	2011121	1200	18	0
16	tp	2011121	1200	24	0
20	tp	2011121	1200	30	0
24	tp	2011121	1200	36	0

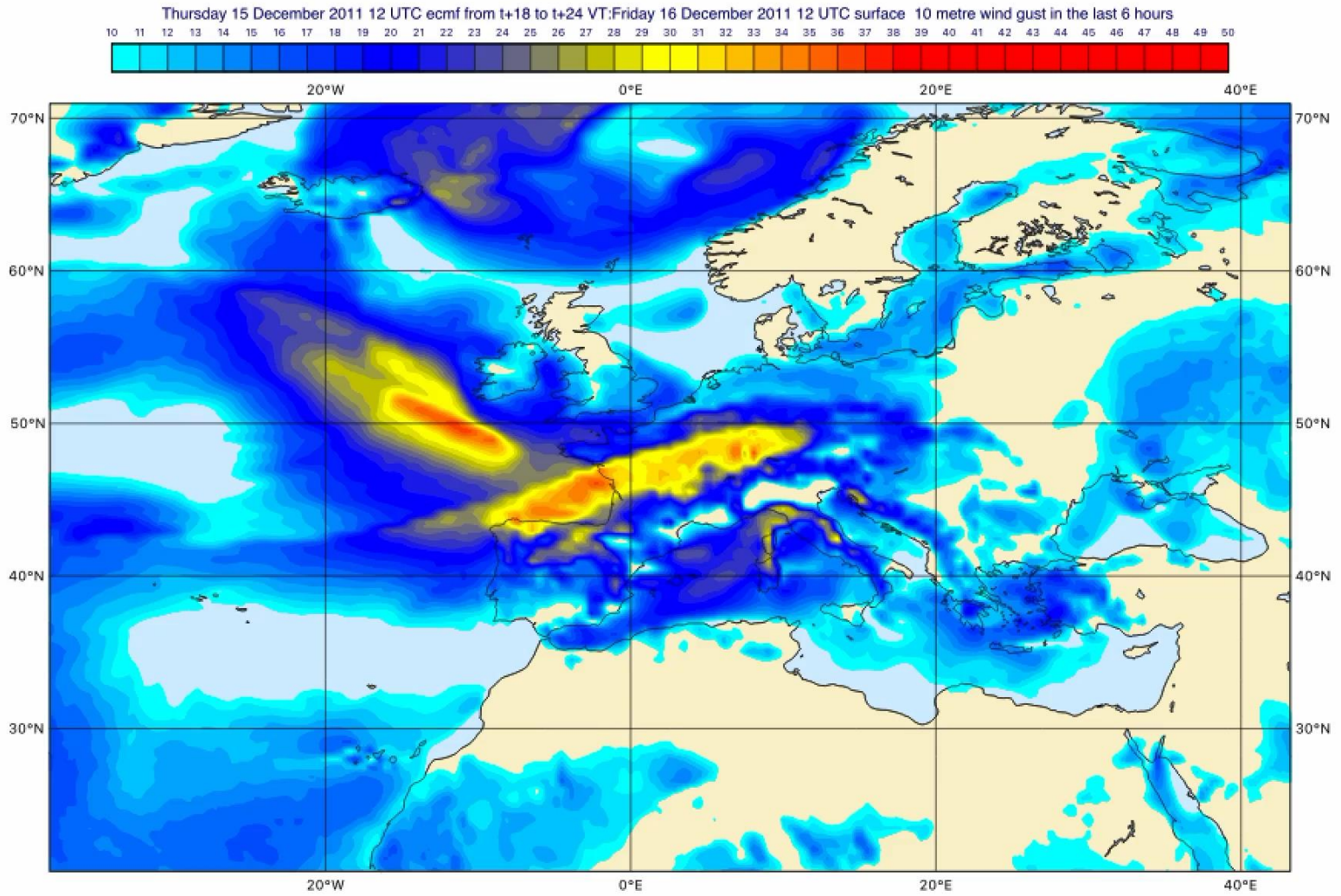
Key profile: System::Default

My Useful | My Views | My Visdefs

- Interactive inspection of point data

Metview - uPlot

Fit to Window | Speed



Frames | Layers | Symbols

Frame	Name	Date	Time	Step	Level
2	10fg6	2011121	1200	0-6	0
6	10fg6	2011121	1200	6-12	0
10	10fg6	2011121	1200	12-18	0
14	10fg6	2011121	1200	18-24	0
18	10fg6	2011121	1200	24-30	0
22	10fg6	2011121	1200	30-36	0
3	10u/10v	2011121	1200/12	6/6	0/0
7	10u/10v	2011121	1200/12	12/12	0/0
11	10u/10v	2011121	1200/12	18/18	0/0
15	10u/10v	2011121	1200/12	24/24	0/0
19	10u/10v	2011121	1200/12	30/30	0/0
23	10u/10v	2011121	1200/12	36/36	0/0
1	msl	2011121	1200	6	0
5	msl	2011121	1200	12	0
9	msl	2011121	1200	18	0
13	msl	2011121	1200	24	0
17	msl	2011121	1200	30	0
21	msl	2011121	1200	36	0
4	tp	2011121	1200	6	0
8	tp	2011121	1200	12	0
12	tp	2011121	1200	18	0
16	tp	2011121	1200	24	0
20	tp	2011121	1200	30	0
24	tp	2011121	1200	36	0

Key profile: System::Default

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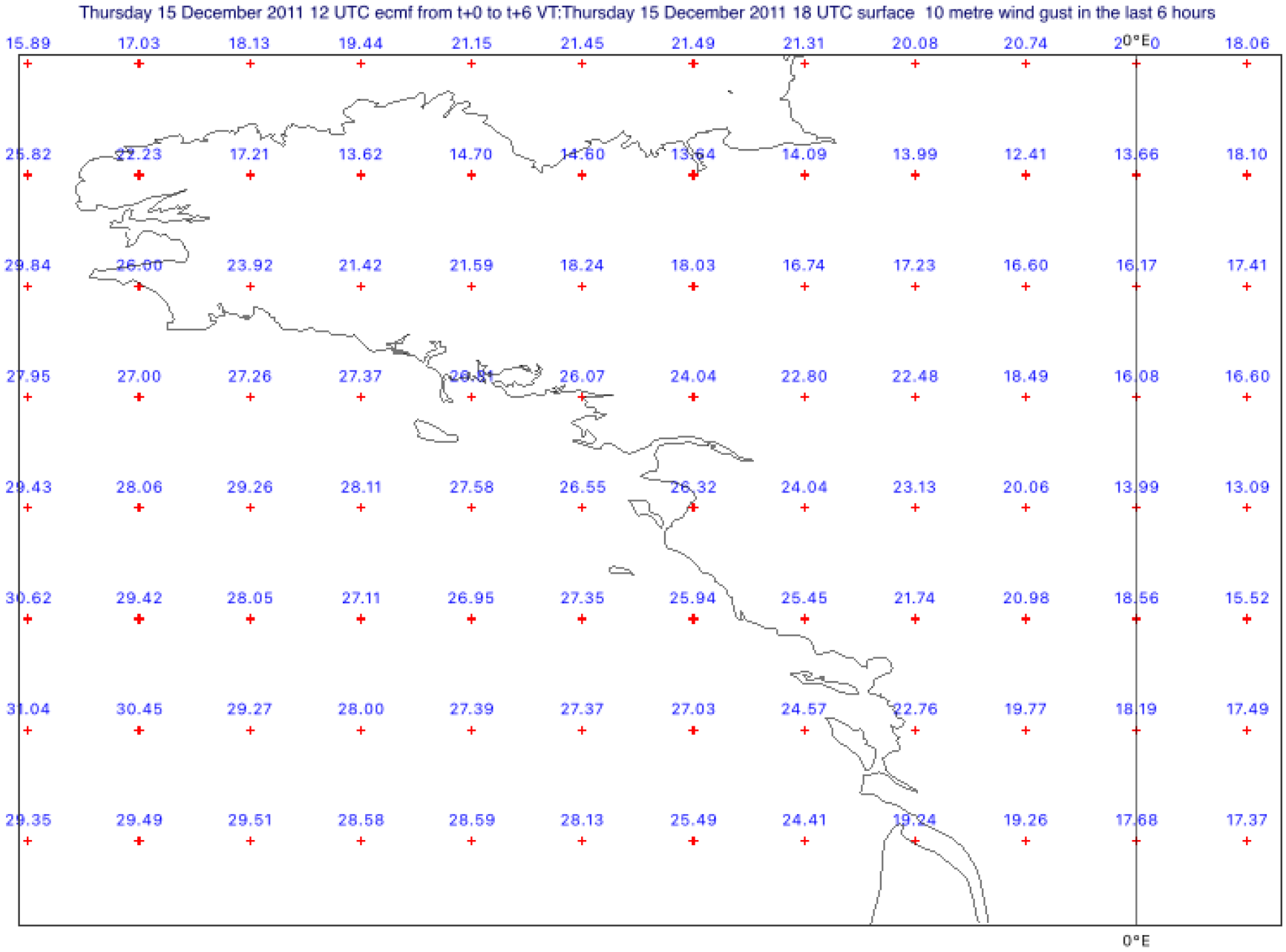
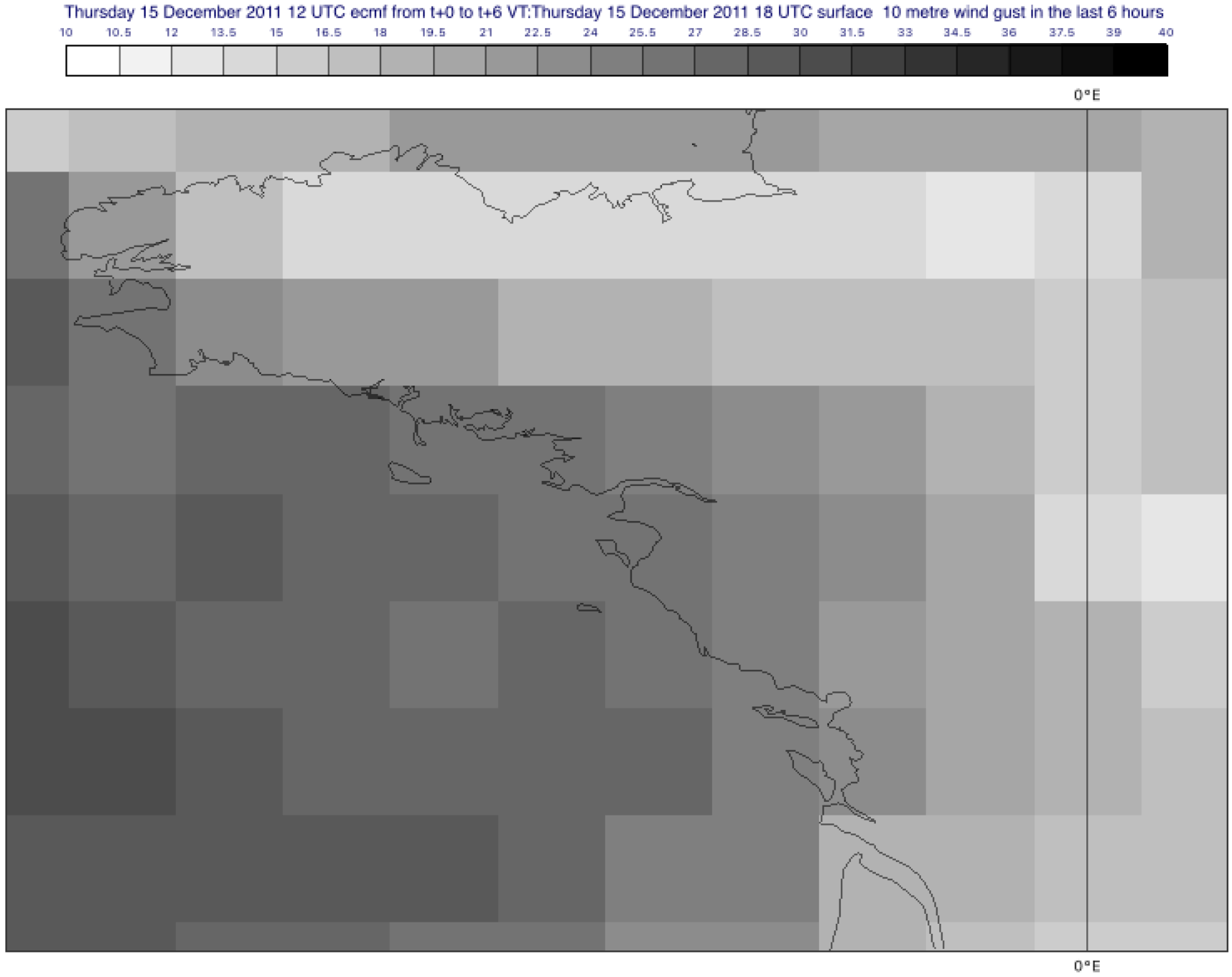
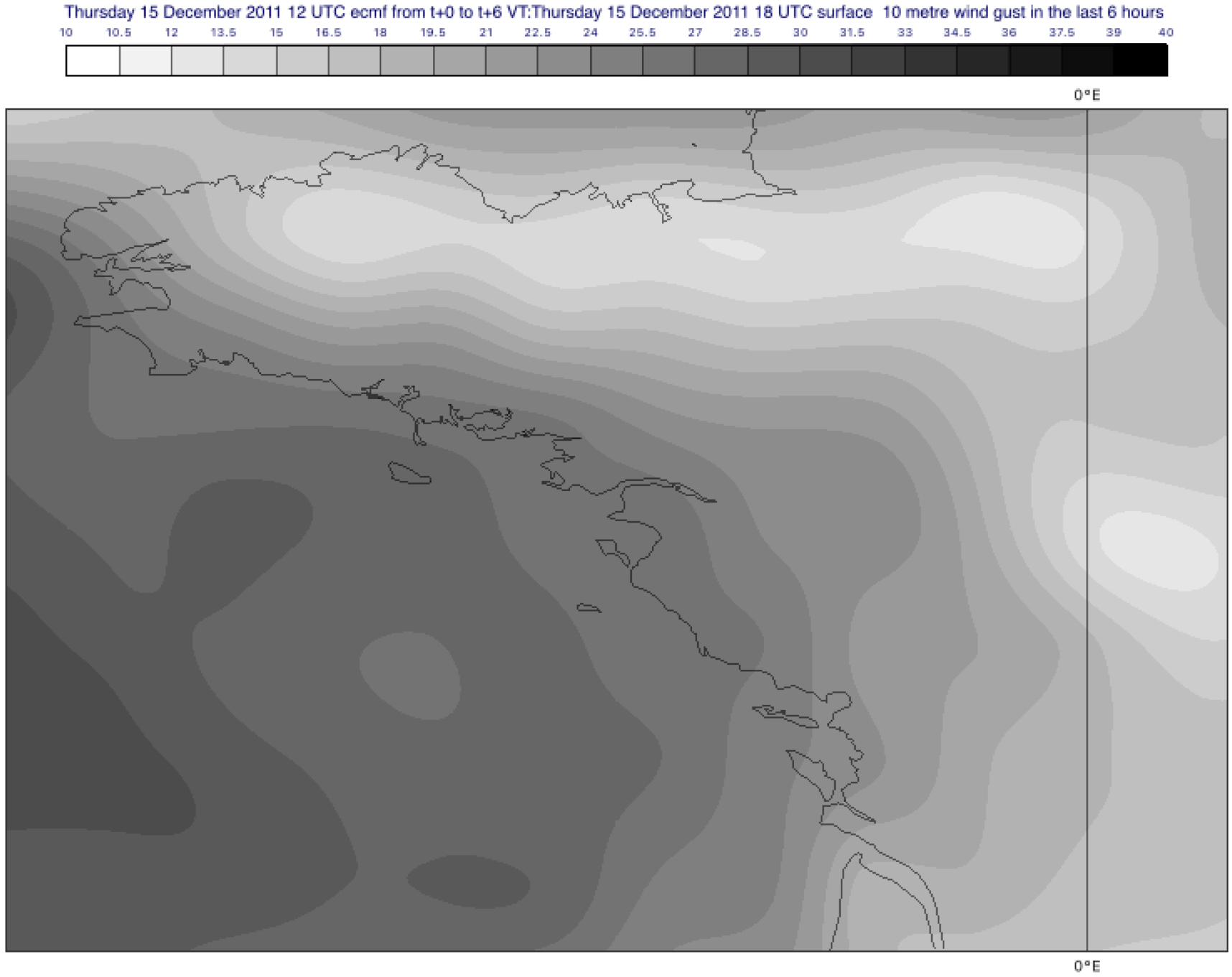
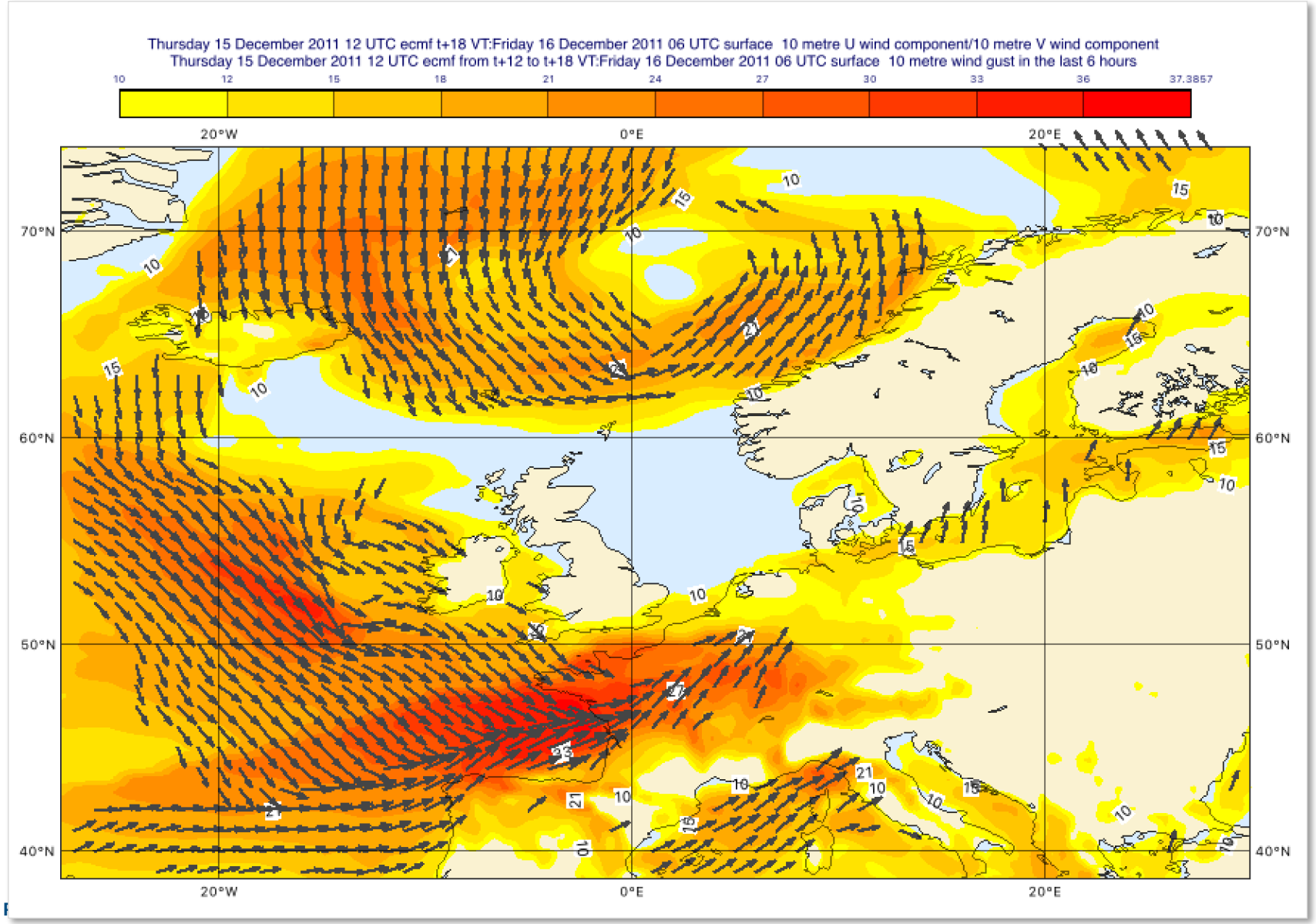

Thursday 15 December 2011 12 UTC ecmf from t+0 to t+6 VT:Thursday 15 December 2011 18 UTC surface 10 metre wind gust in the last 6 hours
15.89 17.03 18.13 19.44 21.15 21.45 21.49 21.31 20.08 20.74 20°E 18.06
25.82 22.23 17.21 13.62 14.70 14.60 13.64 14.09 13.99 12.41 13.66 18.10
29.84 26.60 23.92 21.42 21.59 18.24 18.03 16.74 17.23 16.60 16.17 17.41
27.95 27.00 27.26 27.37 26.07 24.04 22.80 22.48 18.49 16.08 16.60
29.43 28.06 29.26 28.11 27.58 26.55 26.32 24.04 23.13 20.06 13.99 13.09
30.62 29.42 28.05 27.11 26.95 27.35 25.94 25.45 21.74 20.98 18.56 15.52
31.04 30.45 29.27 28.00 27.39 27.37 27.03 24.57 22.76 19.77 18.19 17.49
29.35 29.49 29.51 28.58 28.59 28.13 25.49 24.41 19.24 19.26 17.68 17.37
0°E

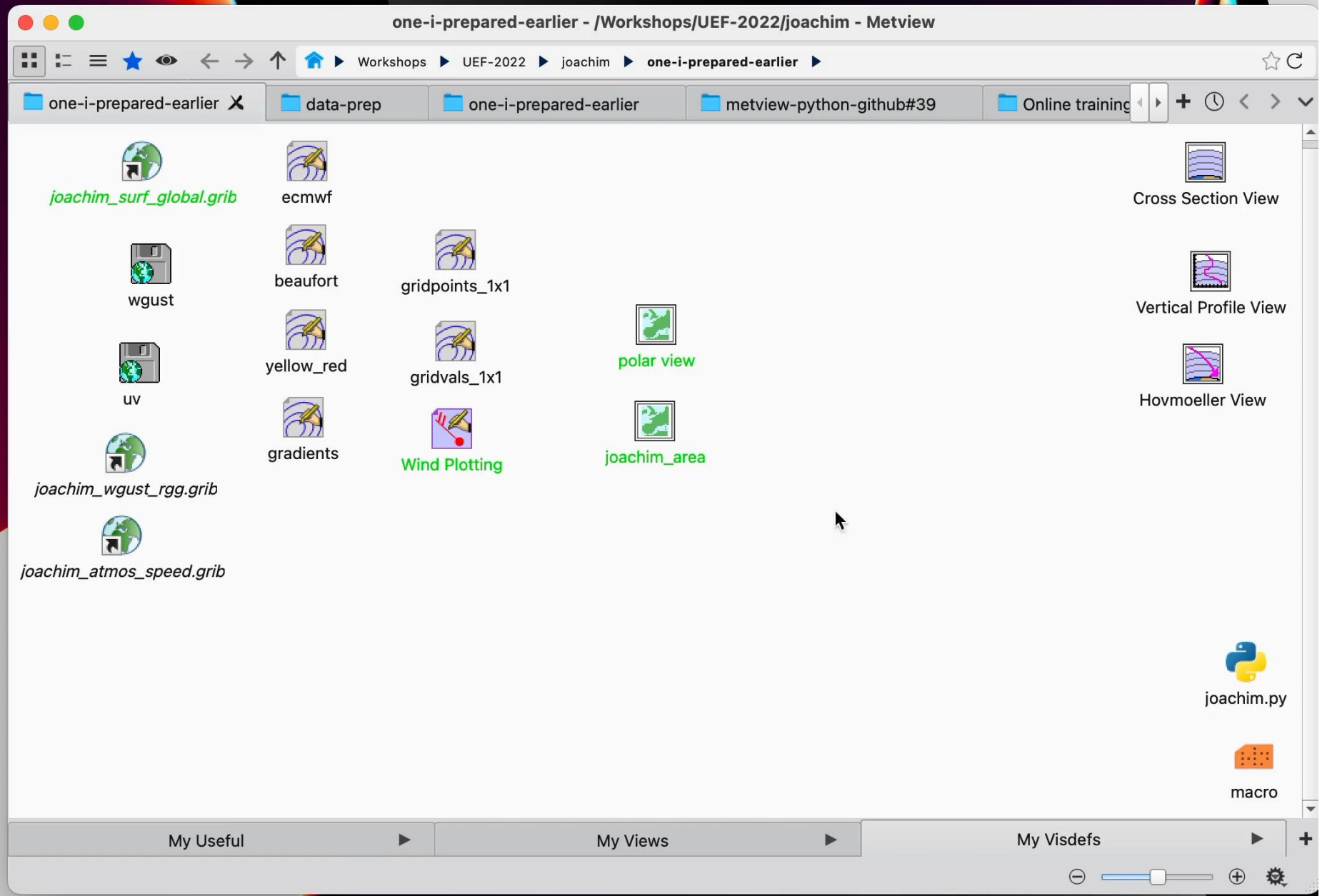

Thursday 15 December 2011 12 UTC ecmf from t+0 to t+6 VT:Thursday 15 December 2011 18 UTC surface 10 metre wind gust in the last 6 hours
10 10.5 12 13.5 15 16.5 18 19.5 21 22.5 24 25.5 27 28.5 30 31.5 33 34.5 36 37.5 39 40
0°E
0°E


Thursday 15 December 2011 12 UTC ecmf from t+0 to t+6 VT:Thursday 15 December 2011 18 UTC surface 10 metre wind gust in the last 6 hours
10 10.5 12 13.5 15 16.5 18 19.5 21 22.5 24 25.5 27 28.5 30 31.5 33 34.5 36 37.5 39 40
0°E
0°E

- Overlay data to give more information



- Generate Python code


one-i-prepared-earlier - /Workshops/UEF-2022/joachim - Metview
Workshops
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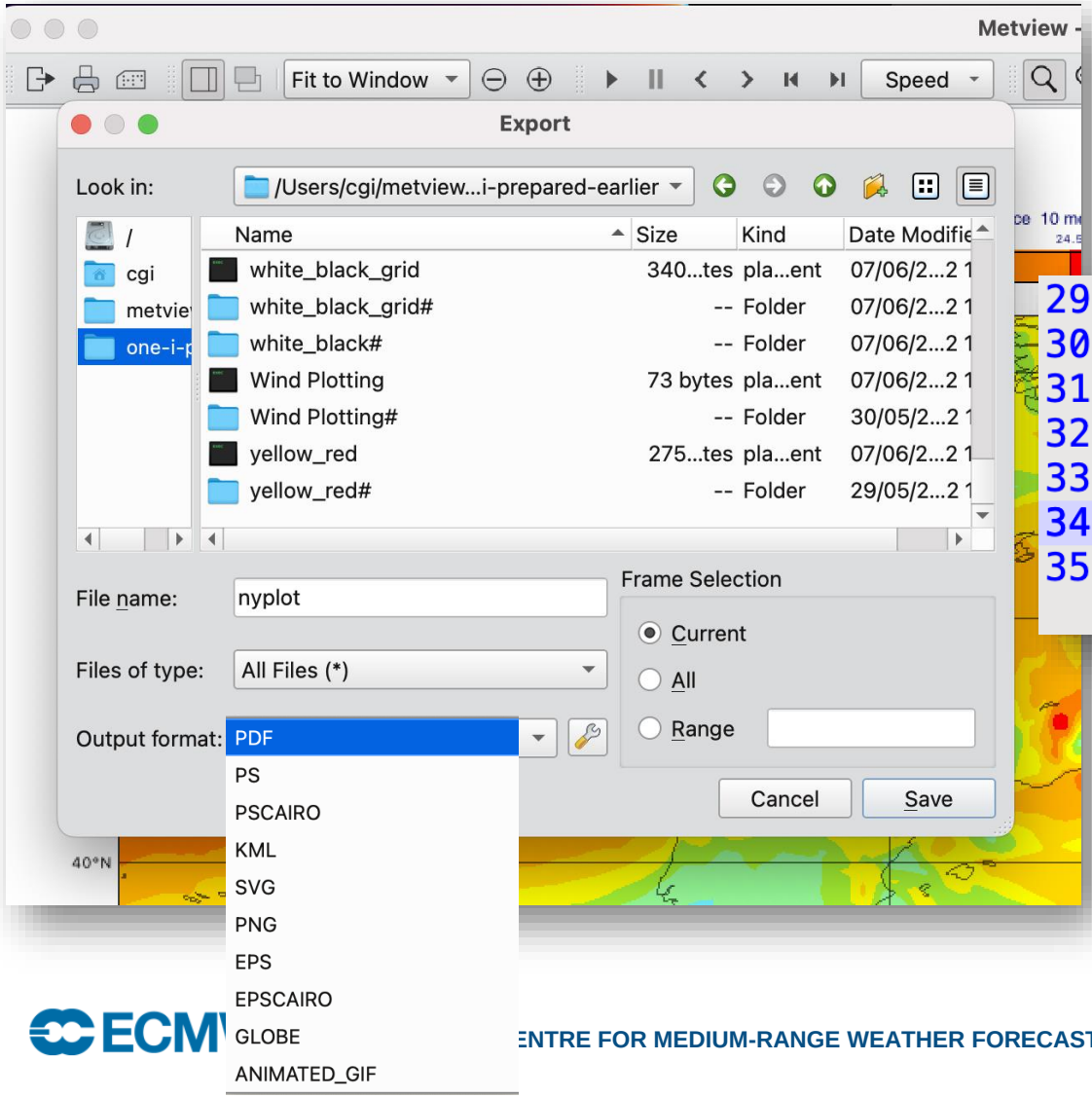
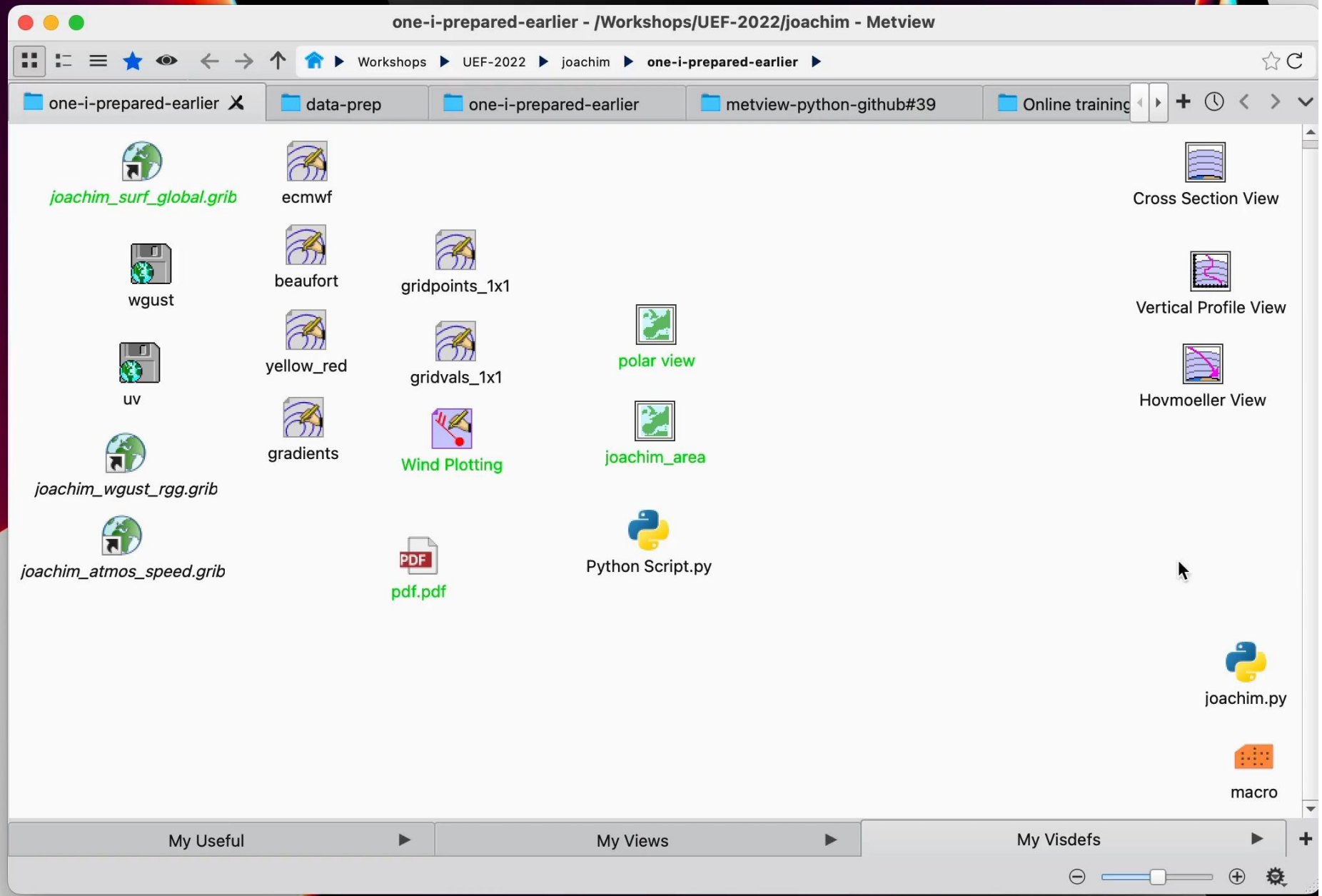
- Export to pdf or other formats via UI and Python call




```
joachim_area = mv.geoview(
    map_area_definition = "corners",
    area                = [21.78,-55.18,74.11,27.81]
    )

mv.setoutput(mv.pdf_output())
mv.plot(joachim_area, wgust, yellow_red)
```

- Inspect the atmosphere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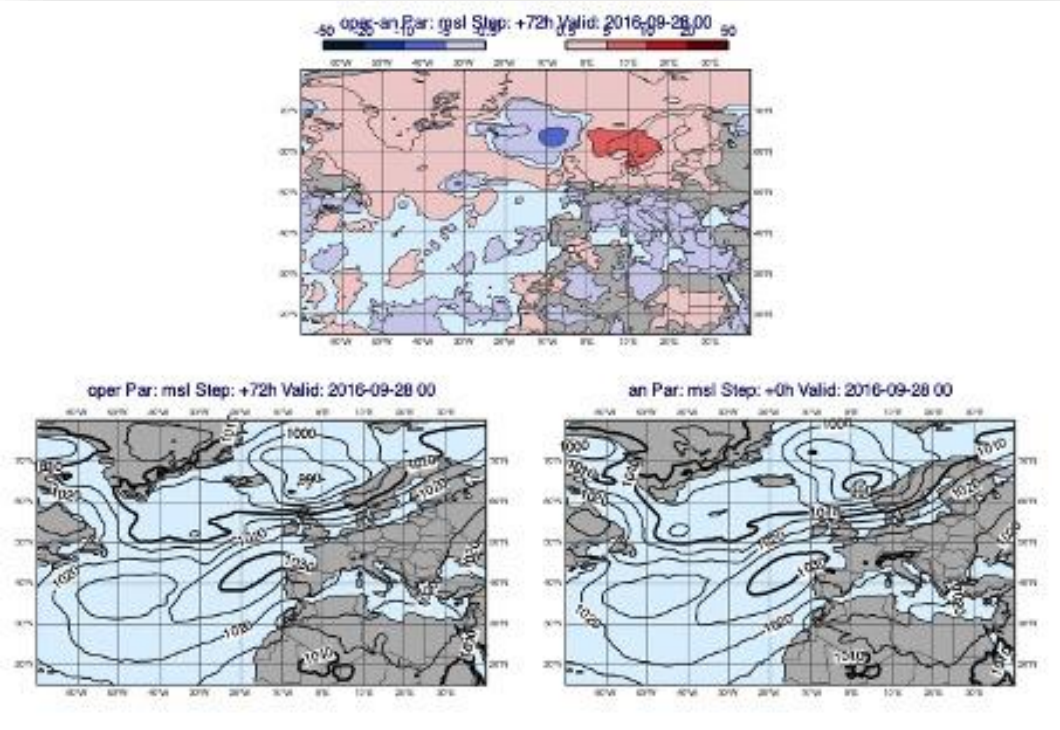
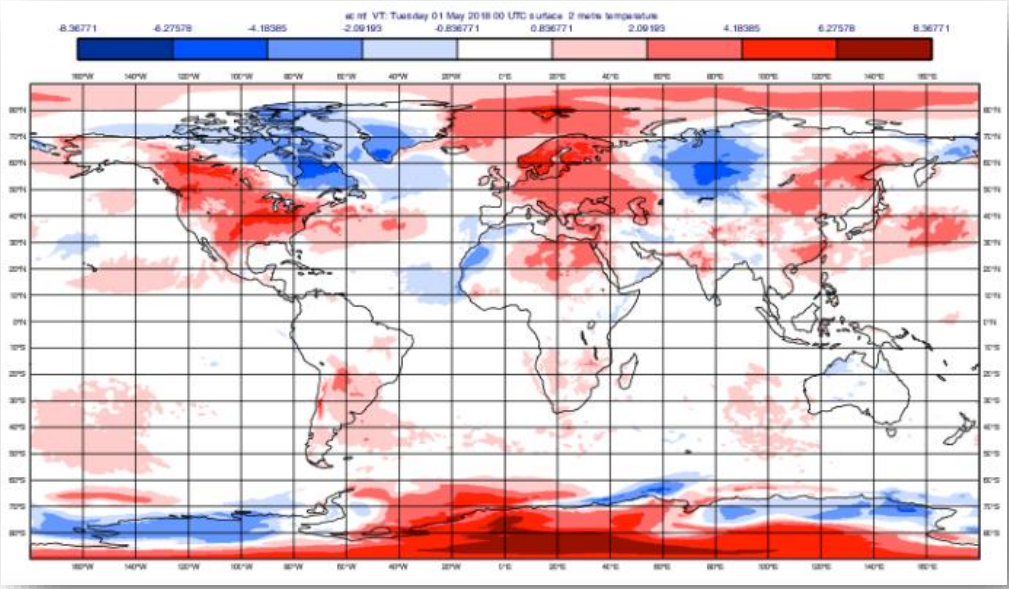
joachim_atmos_speed.grib
PDF
pdf.pdf
Python Script.py
joachim.py
macro
My Useful
My Views
My Visdefs

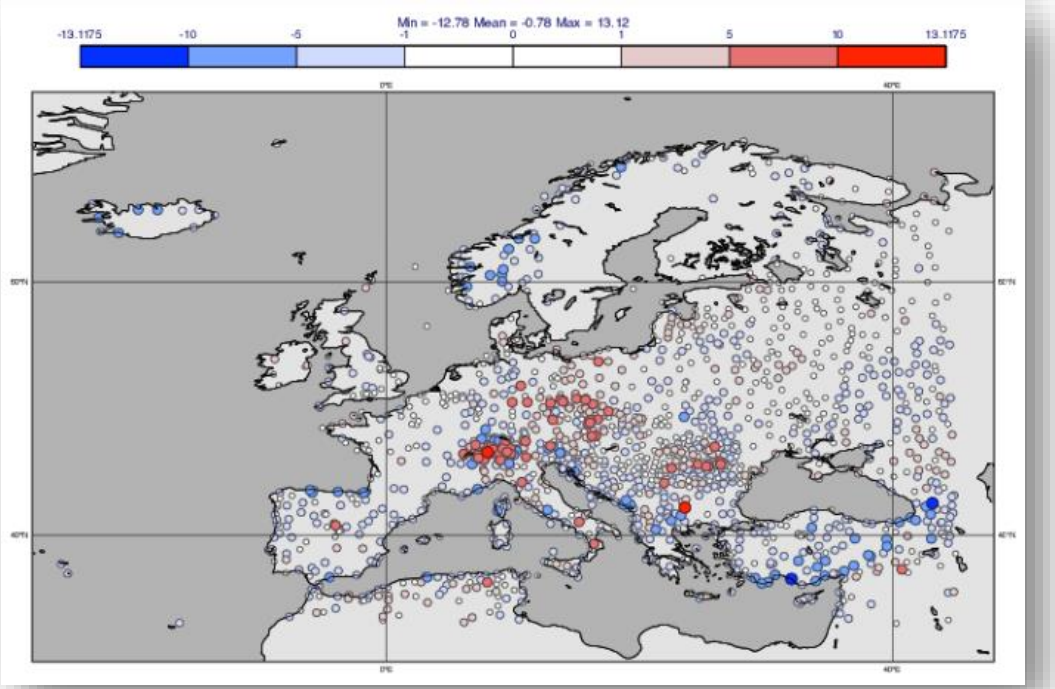
Data pre-processing

Pre-processing

- Basic maths, e.g. anomalies:
  - forecast-analysis
  - forecast-observation

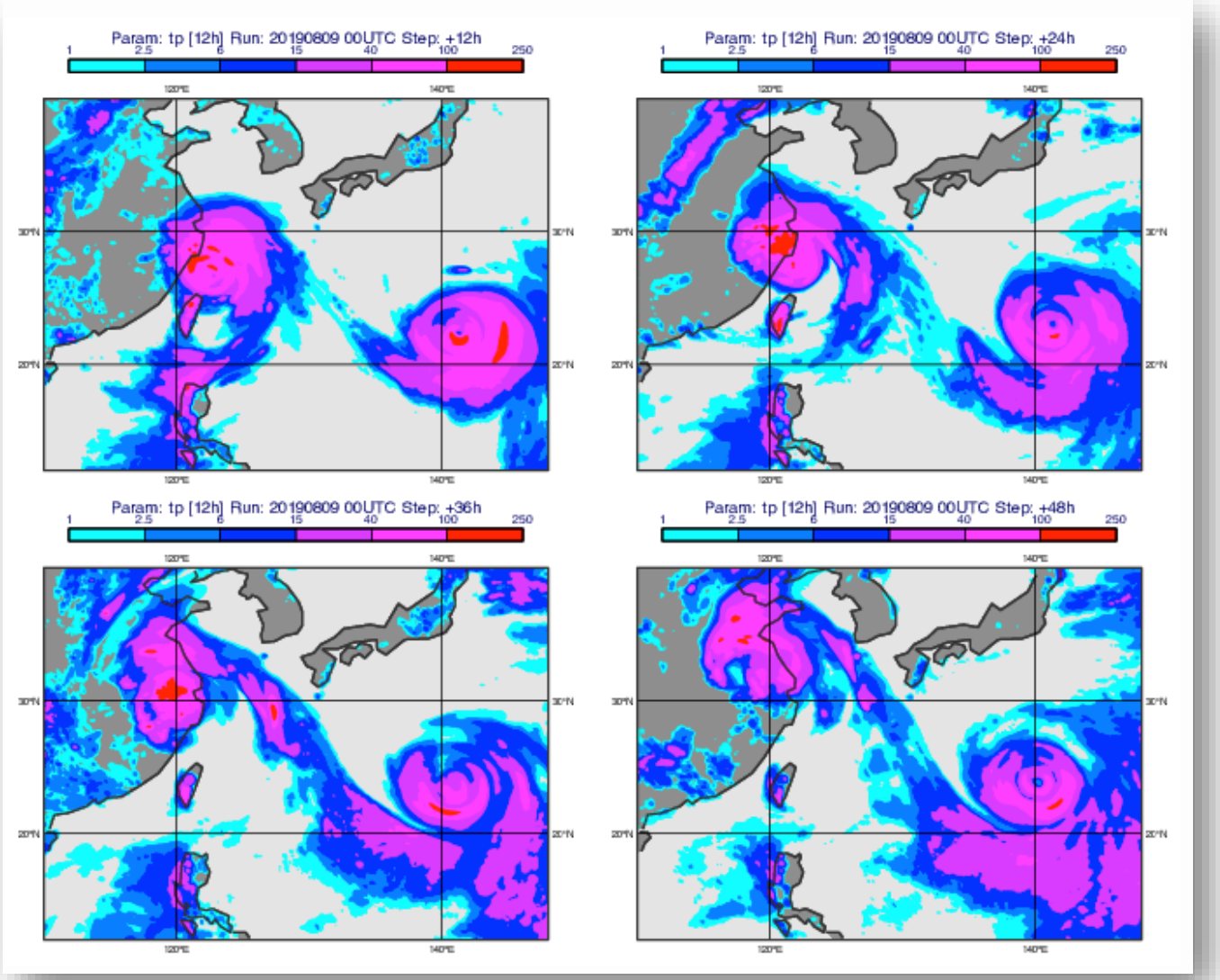






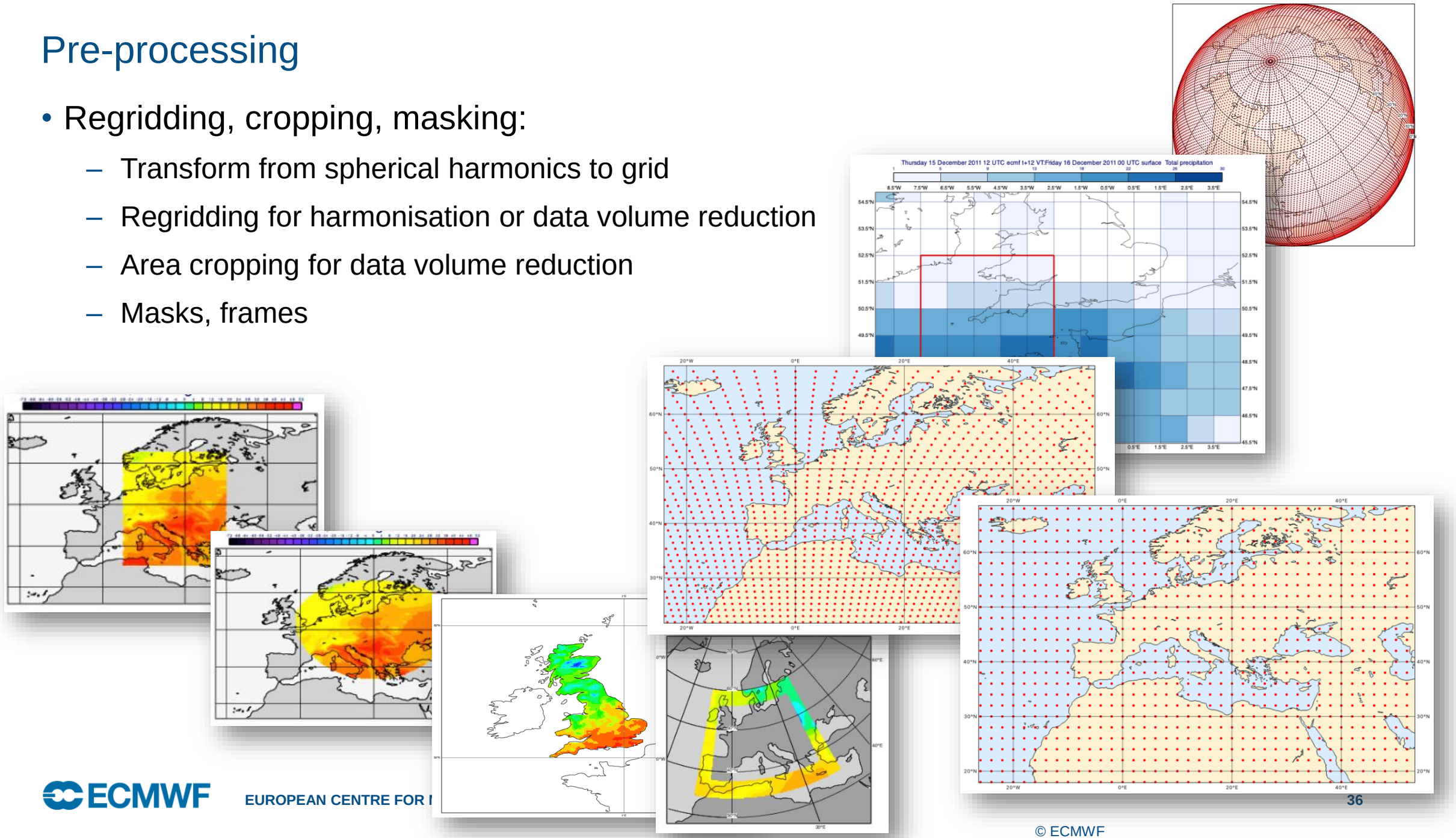
Pre-processing

- Precipitation:
  - De-accumulation
  - Model output can contain accumulated precipitation, e.g. 12-hour forecast contains all precip accumulated over 12 hours
  - Must ‘de-accumulate’ it to see amounts over shorter intervals



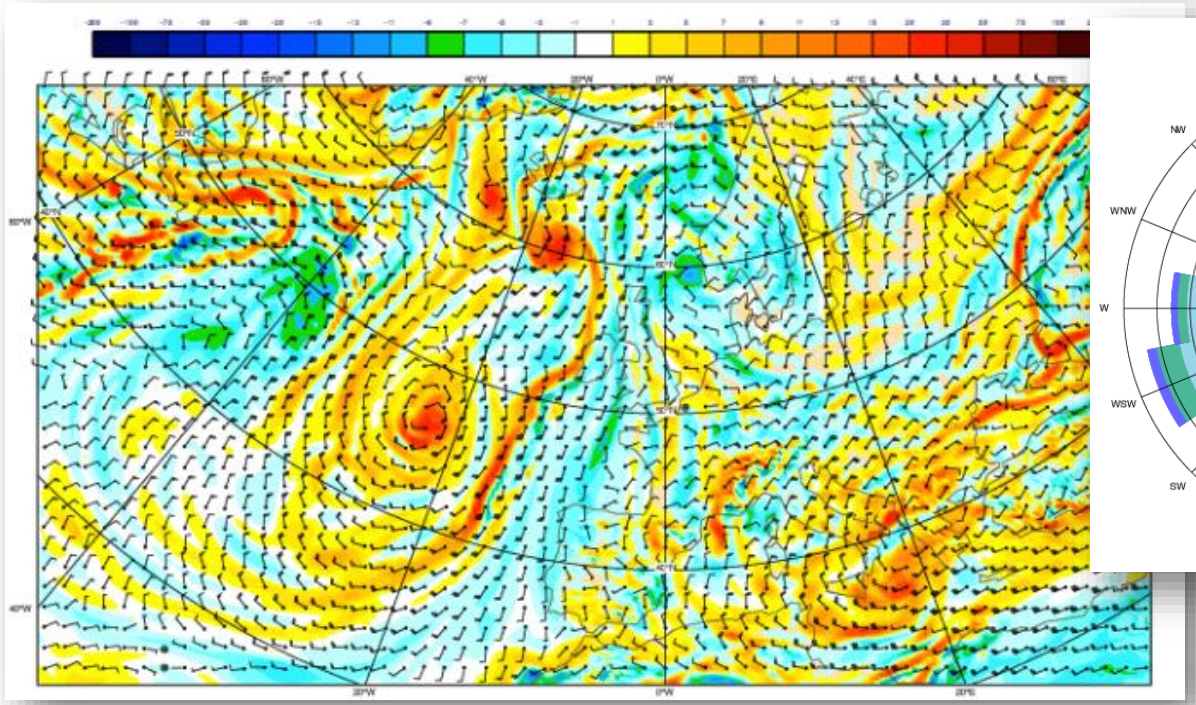
Pre-processing

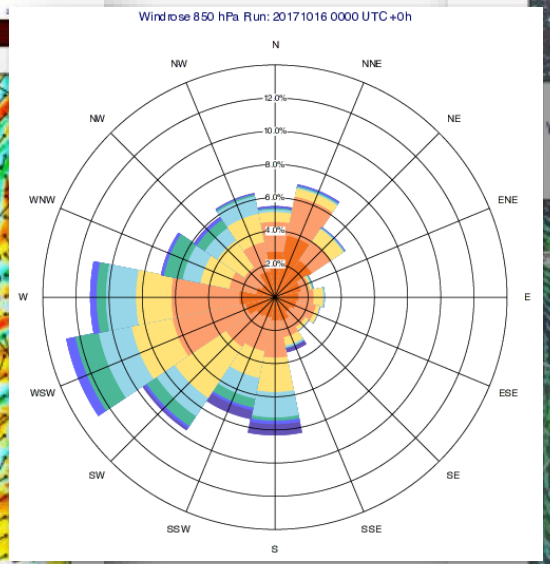
- Regridding, cropping, masking:
  - Transform from spherical harmonics to grid
  - Regridding for harmonisation or data volume reduction
  - Area cropping for data volume reduction
  - Masks, frames

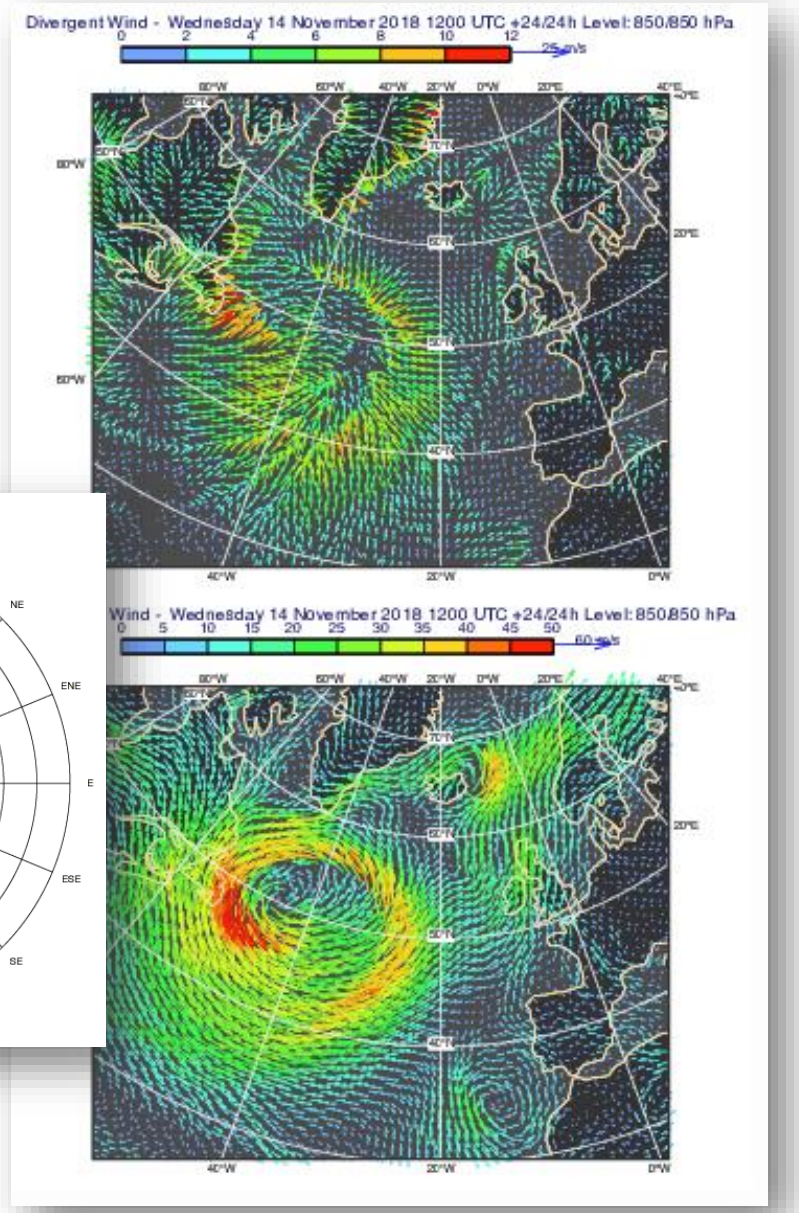


Pre-processing

- Wind:
  - Computation of U/V wind from vorticity and divergence
  - Computation of wind speed from U/V
  - Computation of rotational and divergent wind

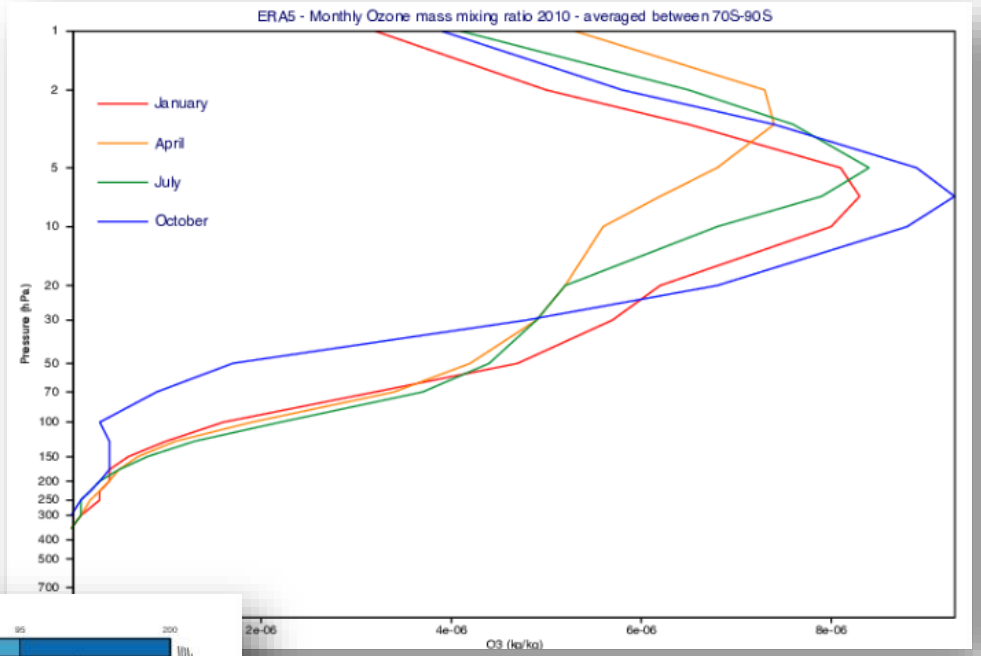


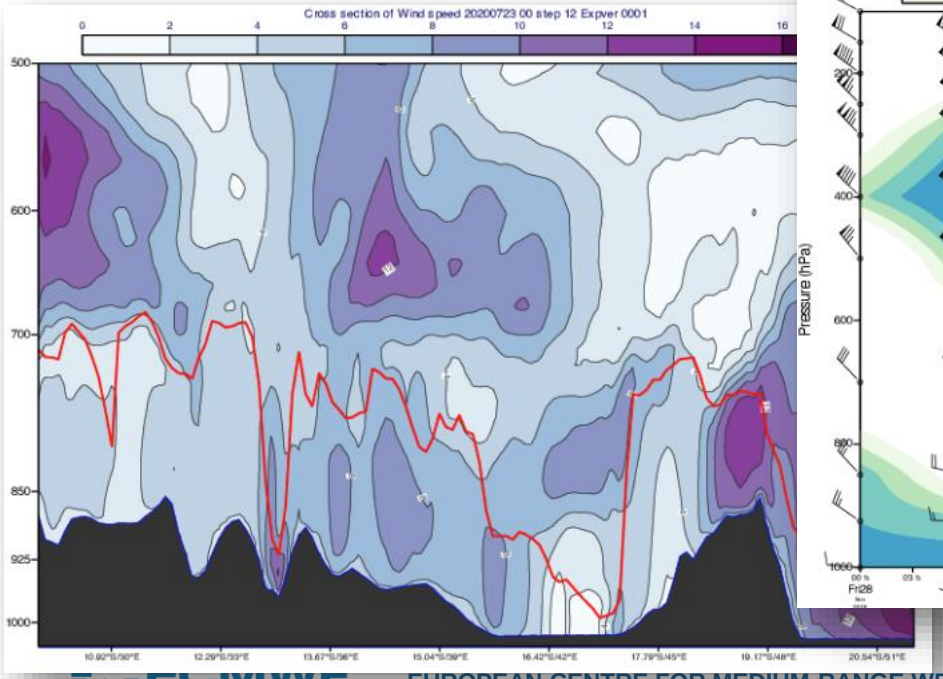


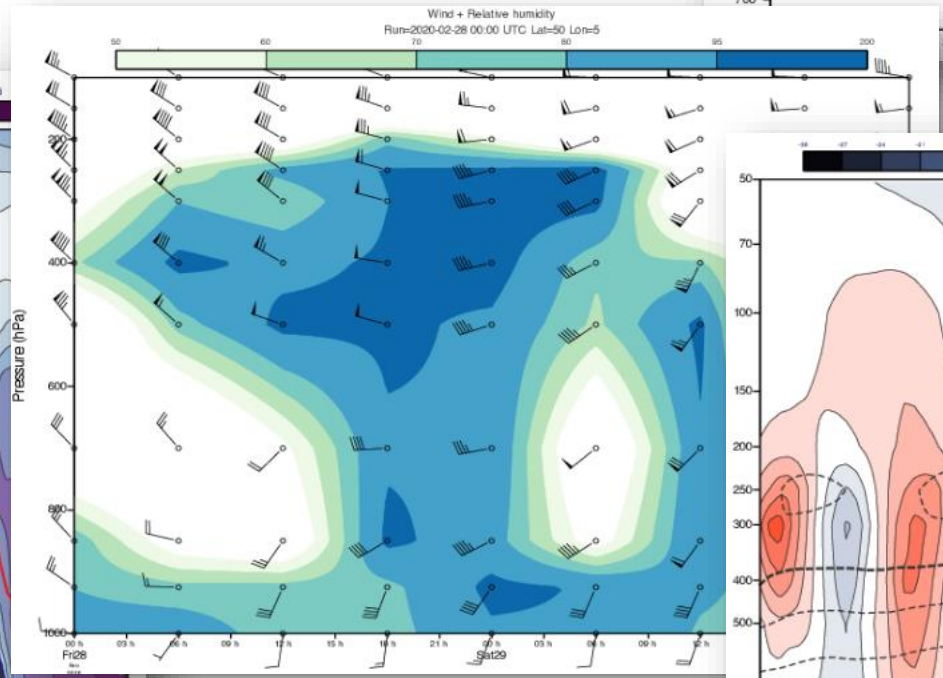


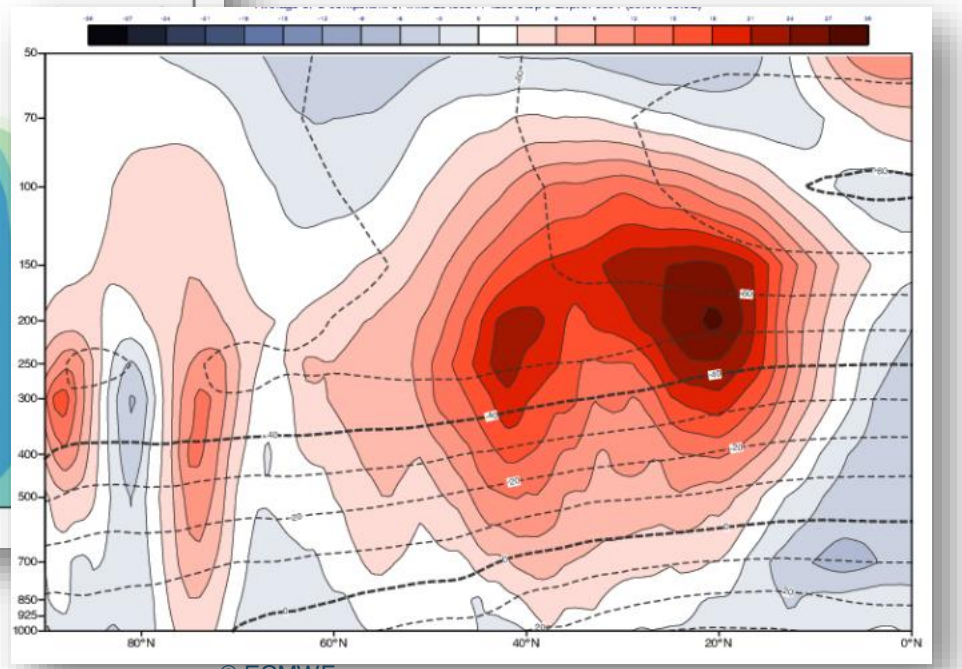
Pre-processing

- Slicing:
  - Vertical profiles
  - Cross sections
  - Time/height diagrams
  - Directional averaging, e.g. zonal means





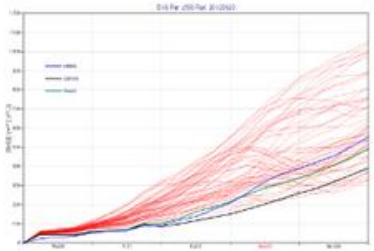




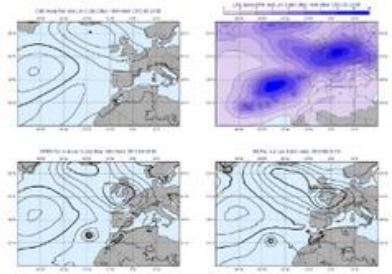
Pre-processing

- Plenty more, including ensemble data

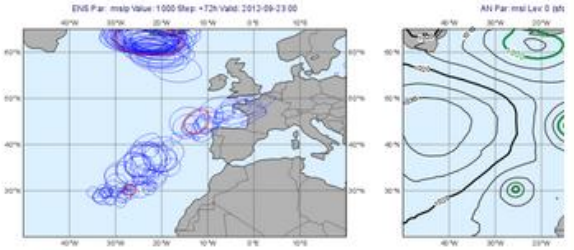
Ensembles



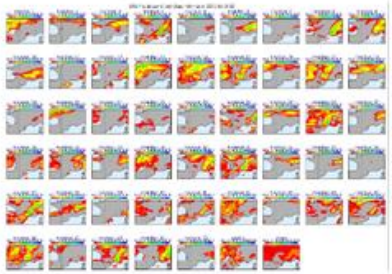
RMSE curves Z500 for ensemble



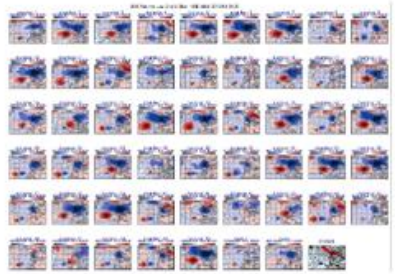
MSLP ensemble mean and spread compared to analysis



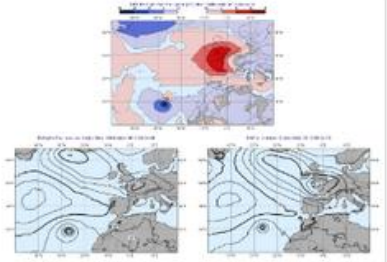
MSLP ensemble spaghetti plot



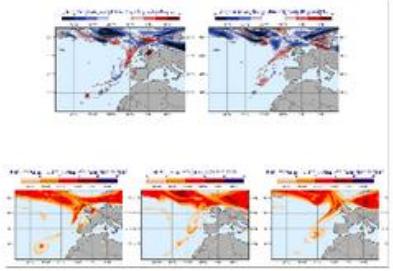
Ensemble stamp map total precipitation over France



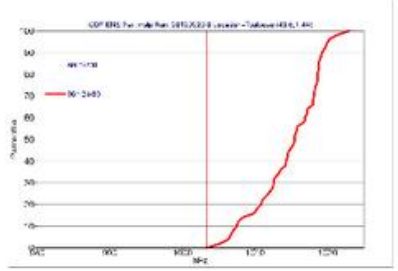
Ensemble difference stamp map of z500



Comparing MSLP of perturbed ensemble membe

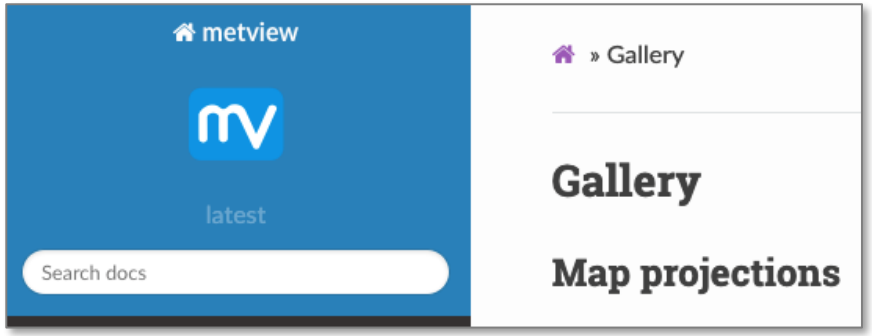


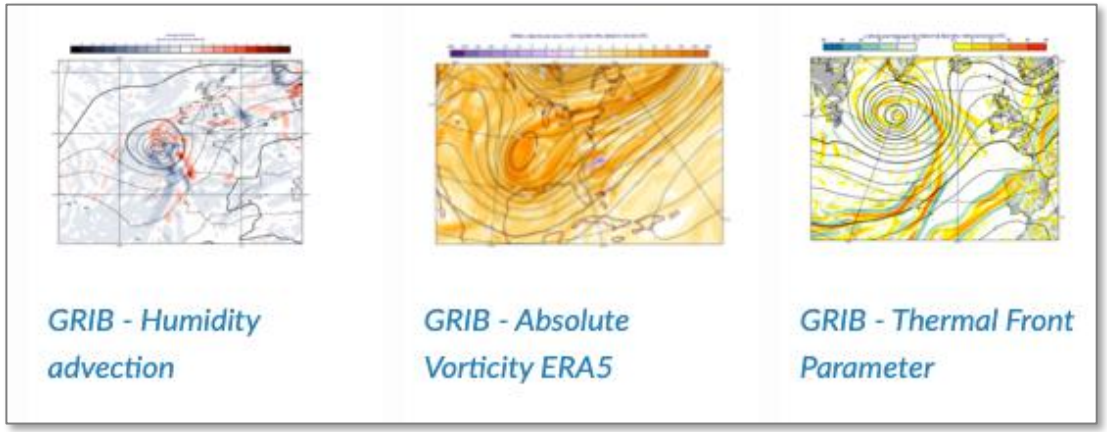
Difference maps of two ensemble members to analysis

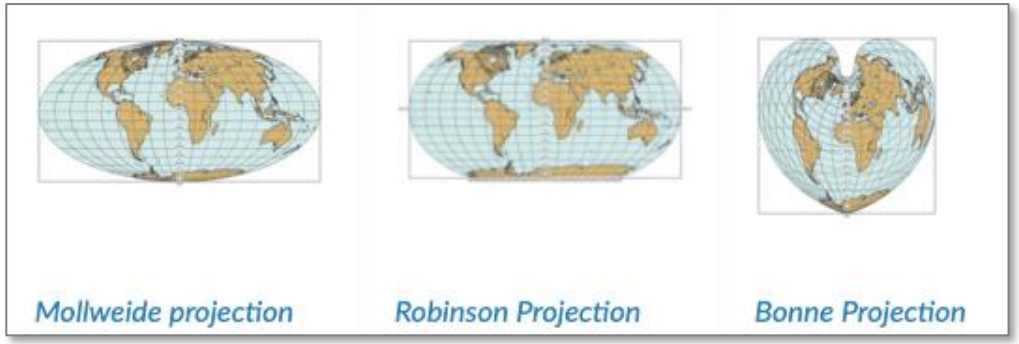


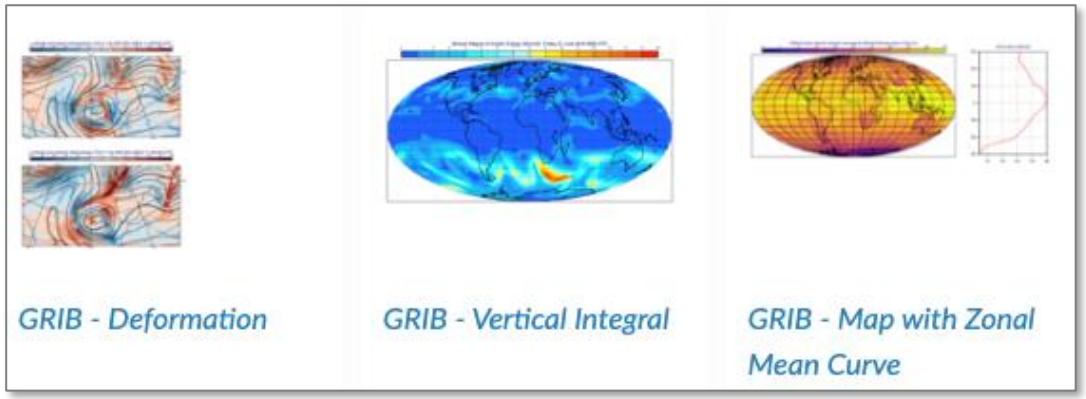
Cumulative distribution function MSLP for ensemble forecast at Toulouse, France

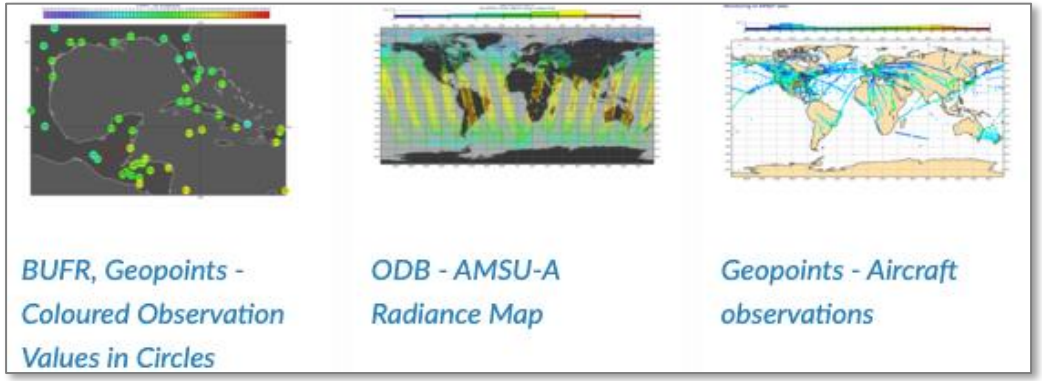
Get inspiration (and code)

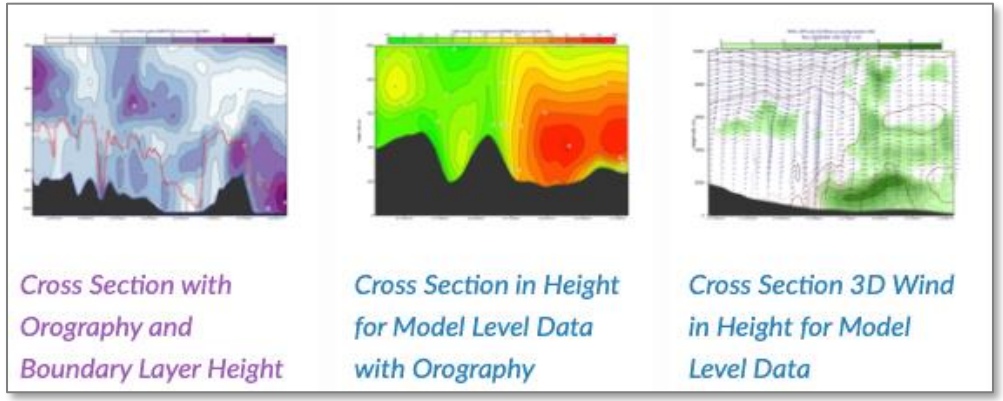












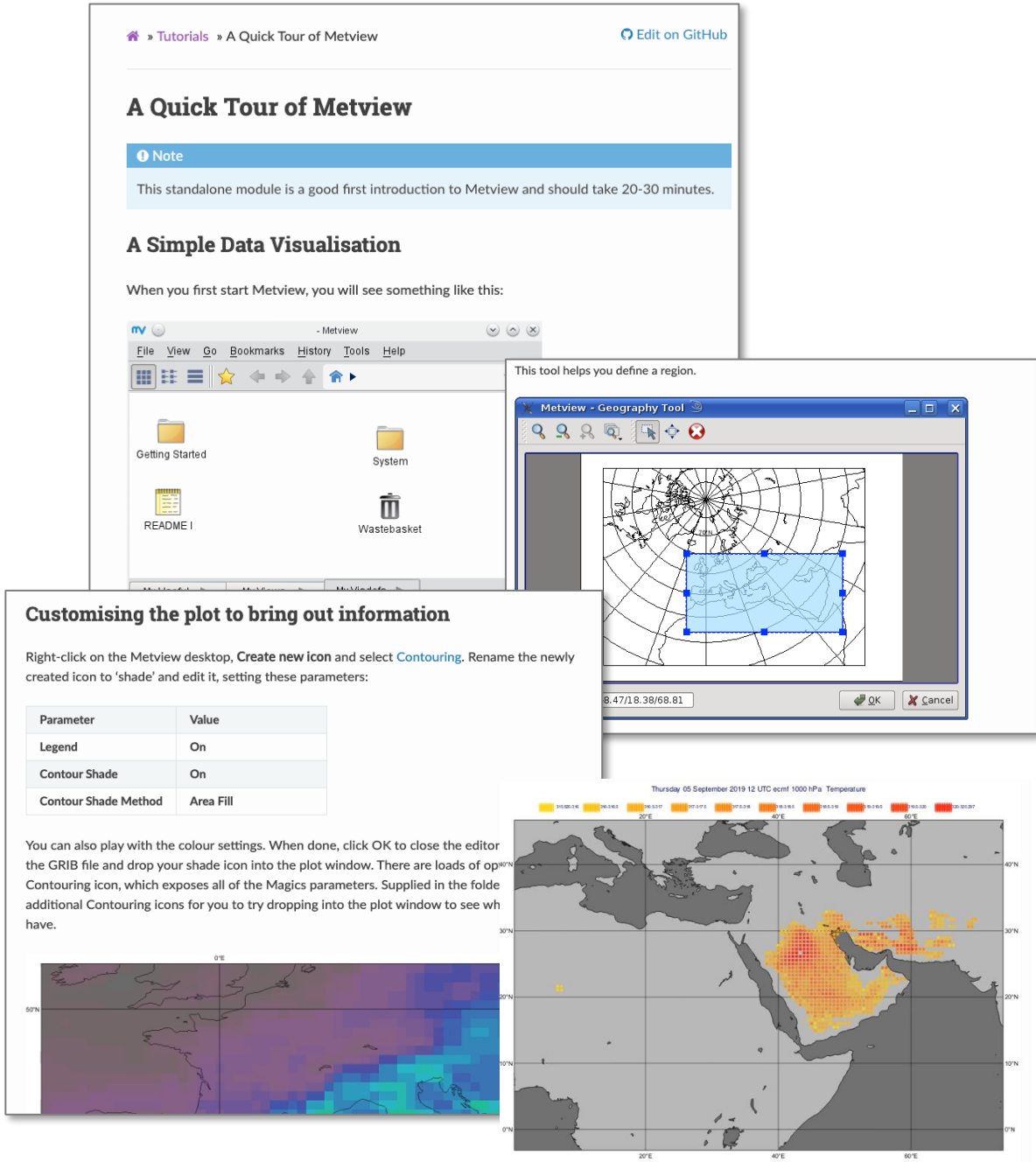
Metview availability – outside ECMWF

- Available for Linux and macOS
- Install from binaries
  - openSUSE, Fedora
- Conda (via conda-forge)

```
conda install metview          -c conda-forge
conda install metview-batch    -c conda-forge
conda install metview-python   -c conda-forge
```

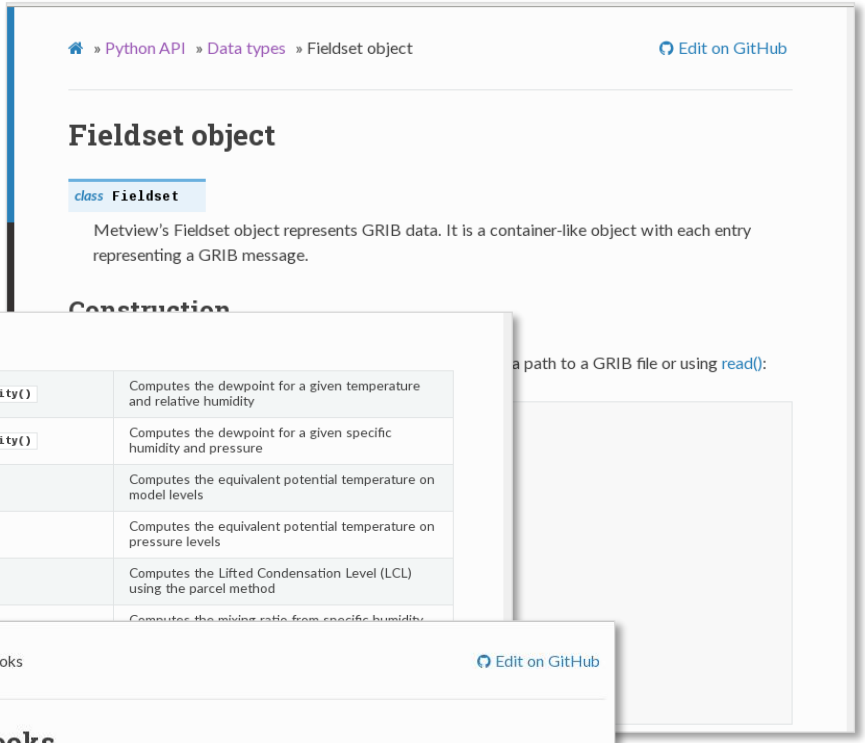
- Homebrew packages coming soon!
- Build from source
- Build from bundle
- The Metview Python interface can to be installed separately if not in conda:

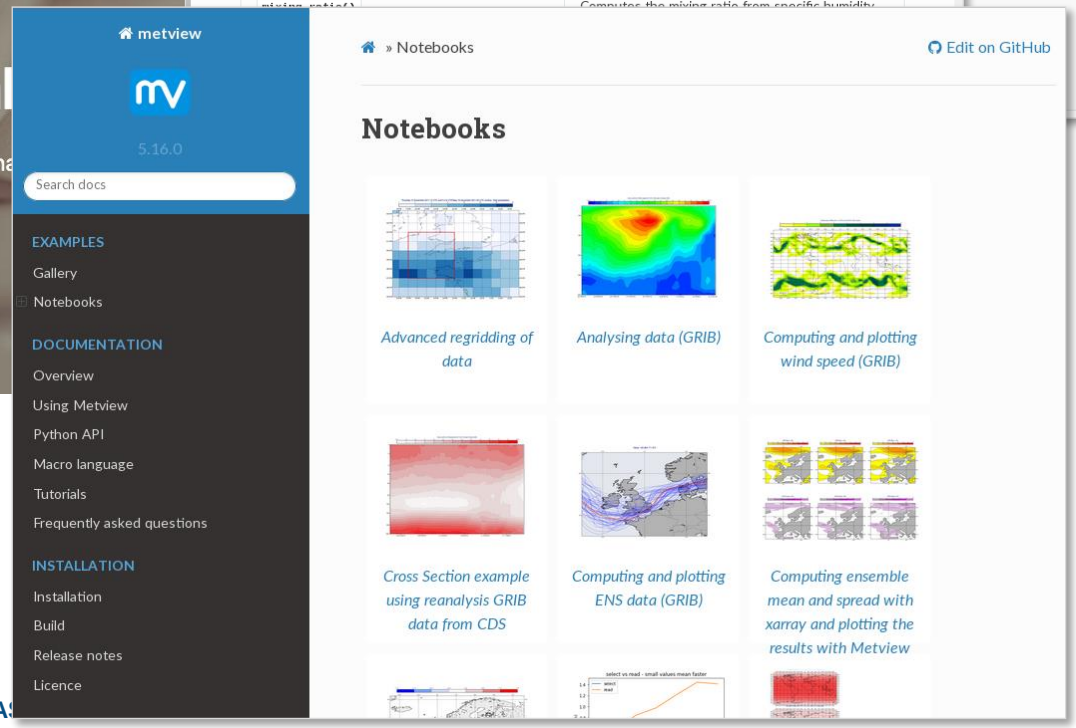
```
pip install metview
```



For more information…

- Ask for help:
  - https://confluence.ecmwf.int/site/support
- Visit our web pages:
  - https://metview.readthedocs.io/en/latest/index.html

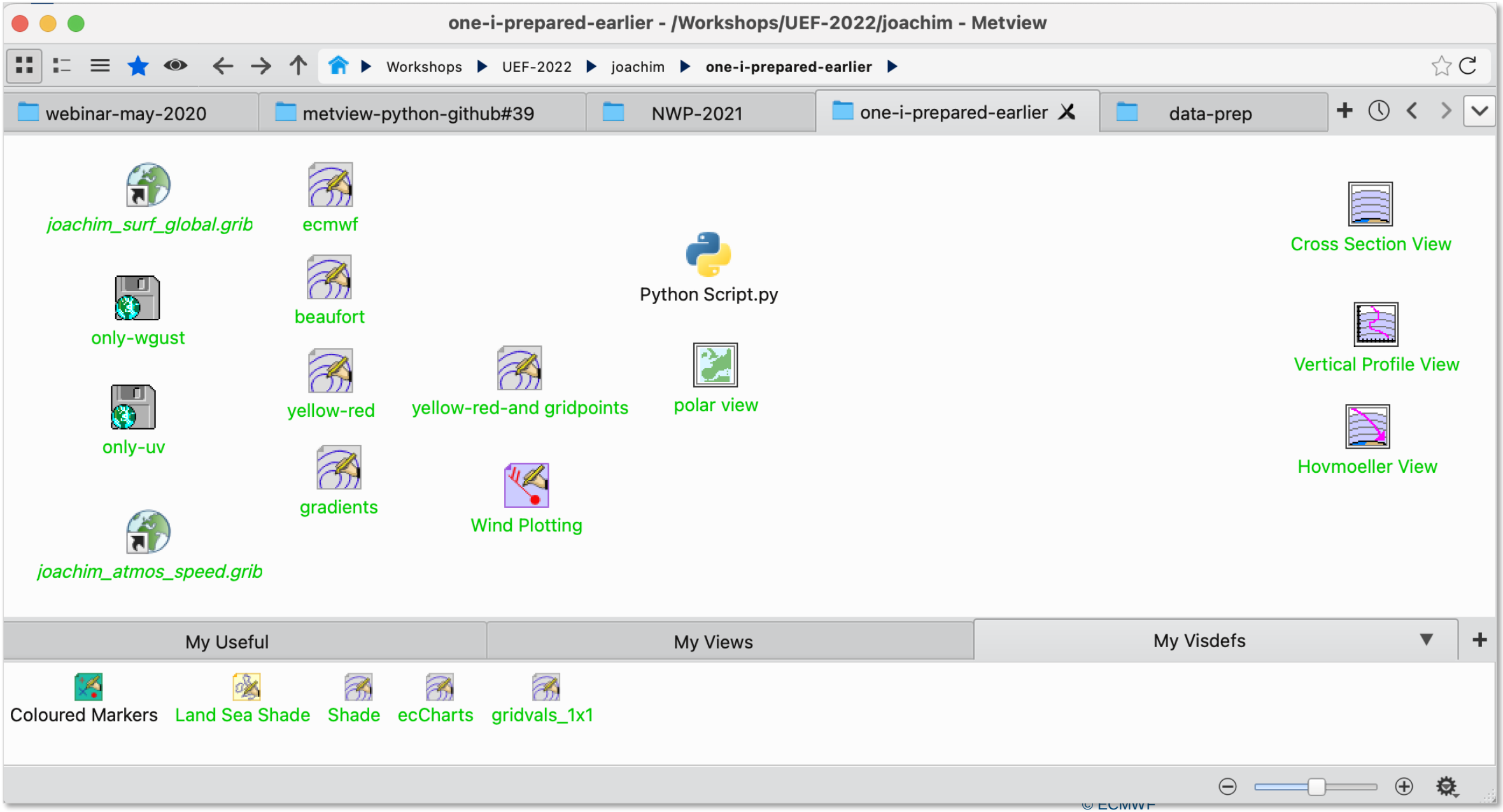




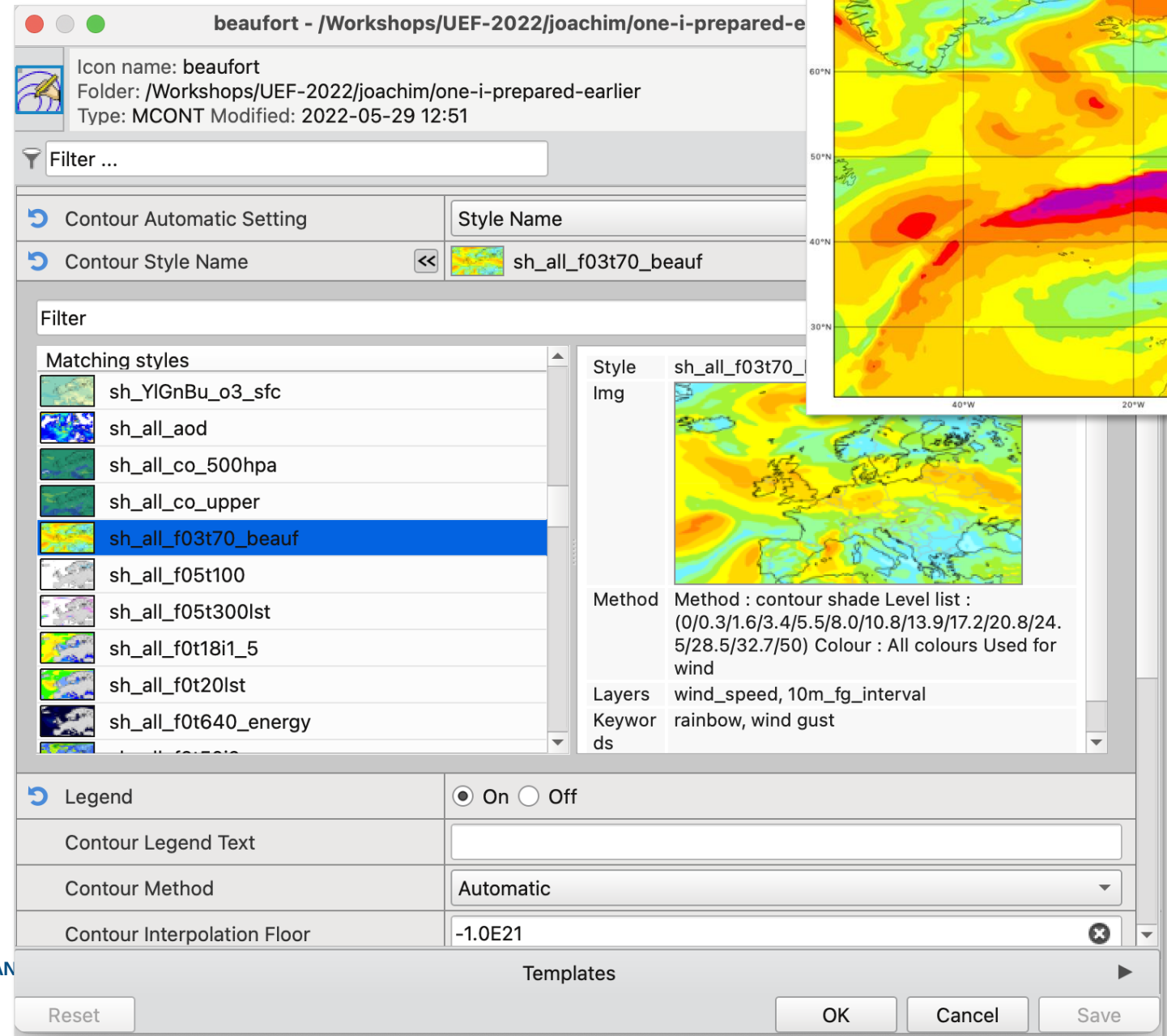
Questions?

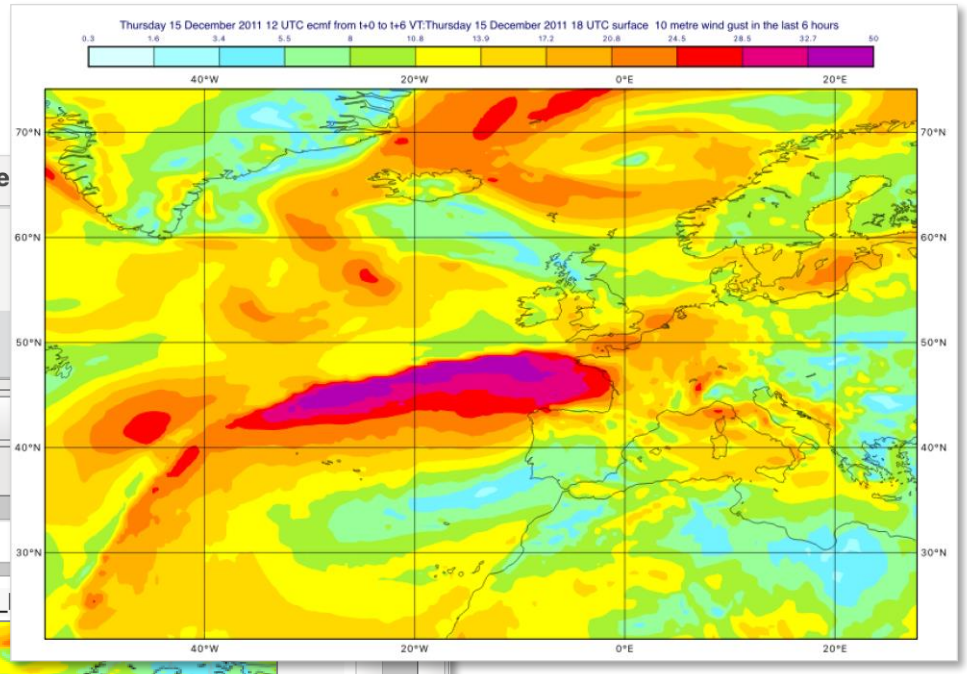
- Backups in case the videos do not work!

Main UI

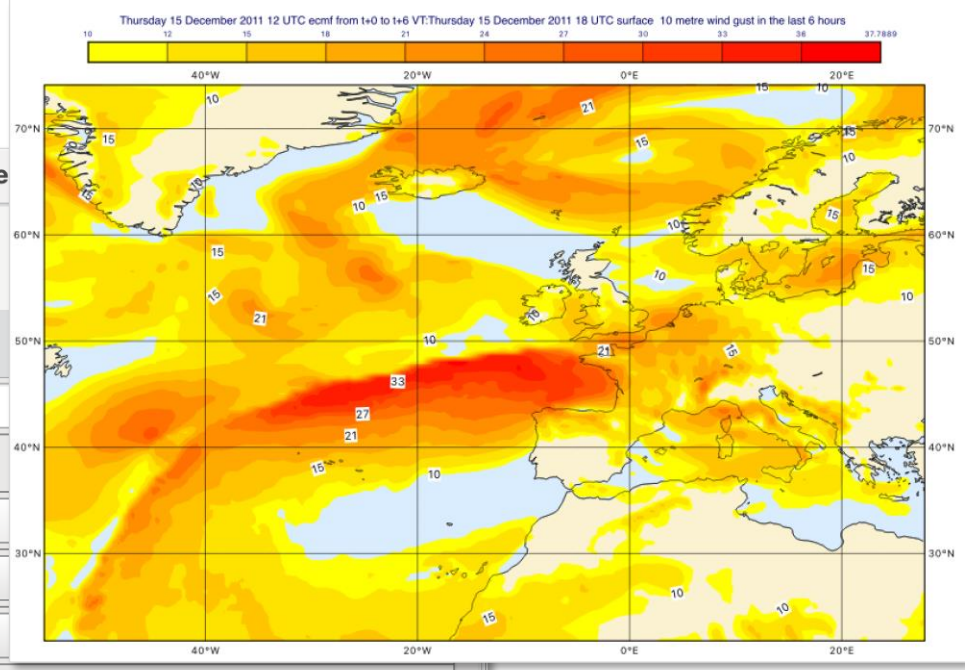

one-i-prepared-earlier - /Workshops/UEF-2022/joachim - Metview
Workshops
UEF-2022
joachim
one-i-prepared-earlier
webinar-may-2020
metview-python-github#39
NWP-2021
one-i-prepared-earlier
data-prep
joachim_surf_global.grib
ecmwf
only-wgust
beaufort
Python Script.py
Cross Section View
Vertical Profile View
only-uv
yellow-red
yellow-red-and gridpoints
polar view
gradients
Wind Plotting
Hovmoeller View
joachim_atmos_speed.grib
My Useful
My Views
My Visdefs
Coloured Markers
Land Sea Shade
Shade
ecCharts
gridvals_1x1

Contour icon editor – style browser





Contour icon editor – custom style



yellow-red - /Workshops/UEF-2022/joachim/one-i-prepare

Icon name: yellow-red
Folder: /Workshops/UEF-2022/joachim/one-i-prepared-earlier
Type: MCONT Modified: 2022-05-29 12:56

Filter ...

Contour Label Frequency	2
Contour Shade	On / Off
Contour Shade Technique	Polygon Shading
Contour Shade Colour Method	Calculate
Contour Shade Method	Area Fill
Contour Shade Max Level Colour	Red
Contour Shade Min Level Colour	Yellow

Wheel | Grid

Red: 255 Hue: 60
Green: 255 Saturation: 255
Blue: 0 Lightness: 128

Opacity: 255

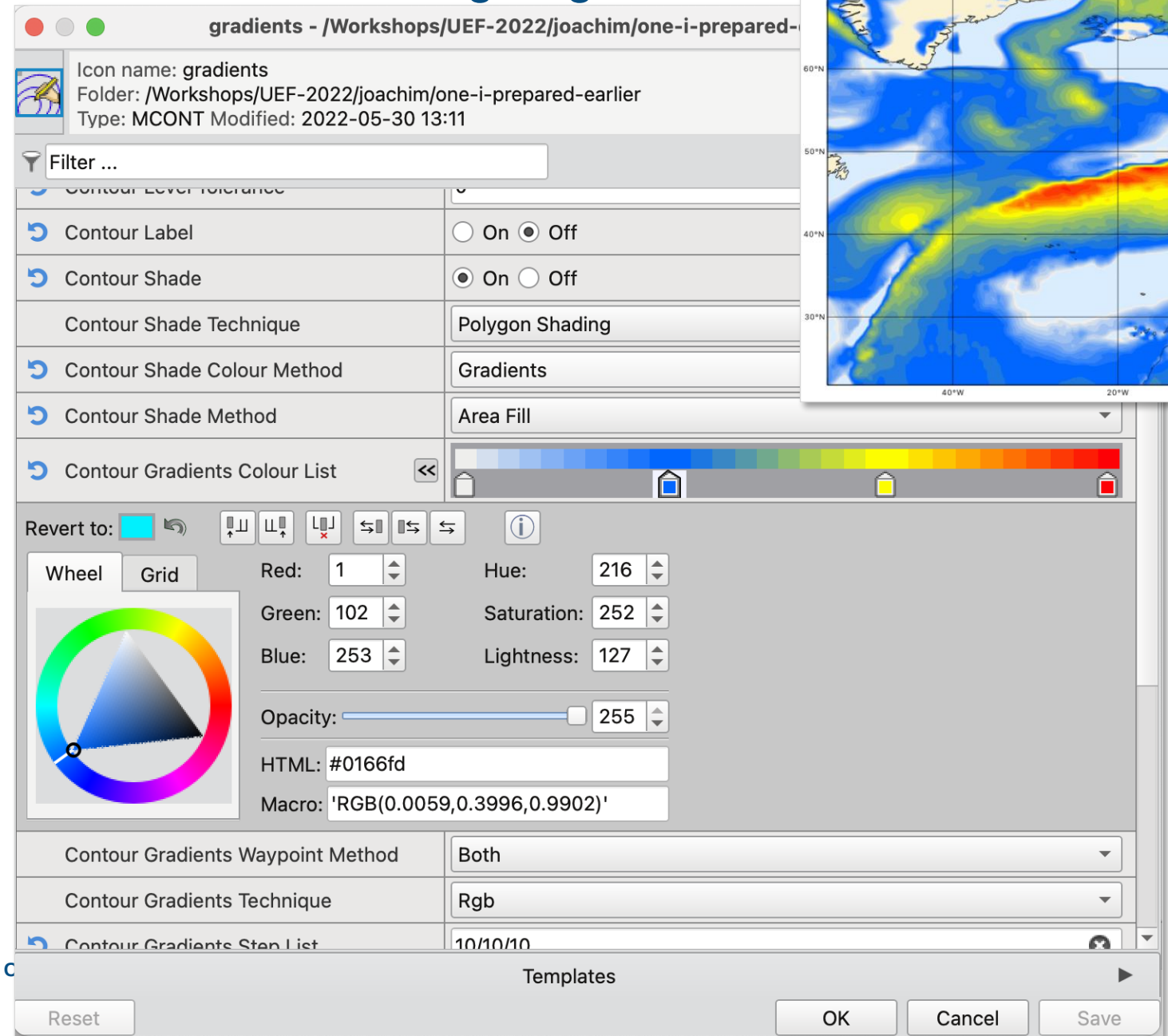
HTML: #ffff00
Macro: 'RGB(1.0000,1.0000,0.0000)'

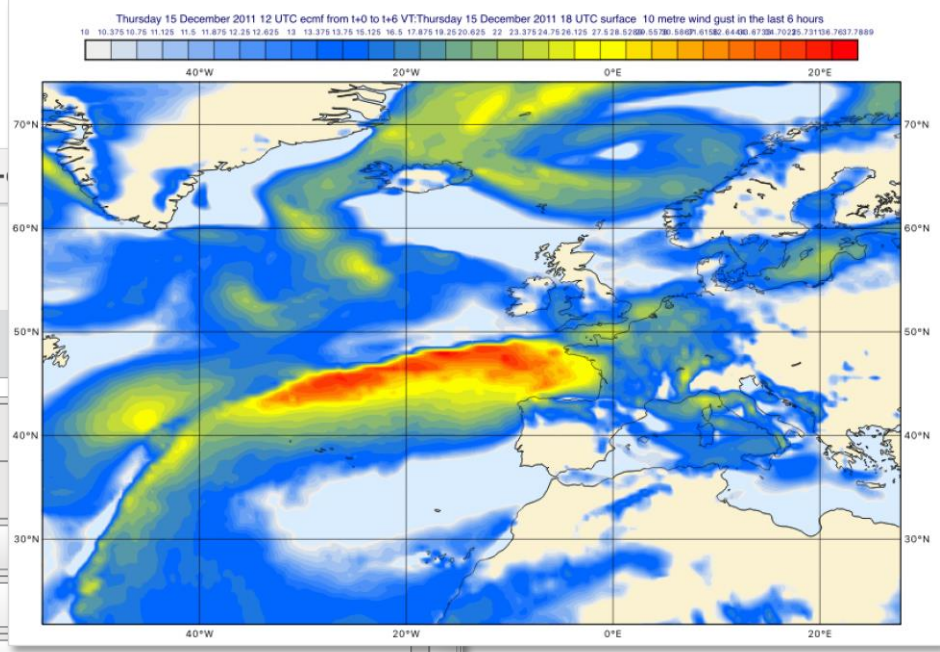
Contour Shade Colour Direction	Clockwise
Contour Legend Text	
Contour Method	Automatic

Templates

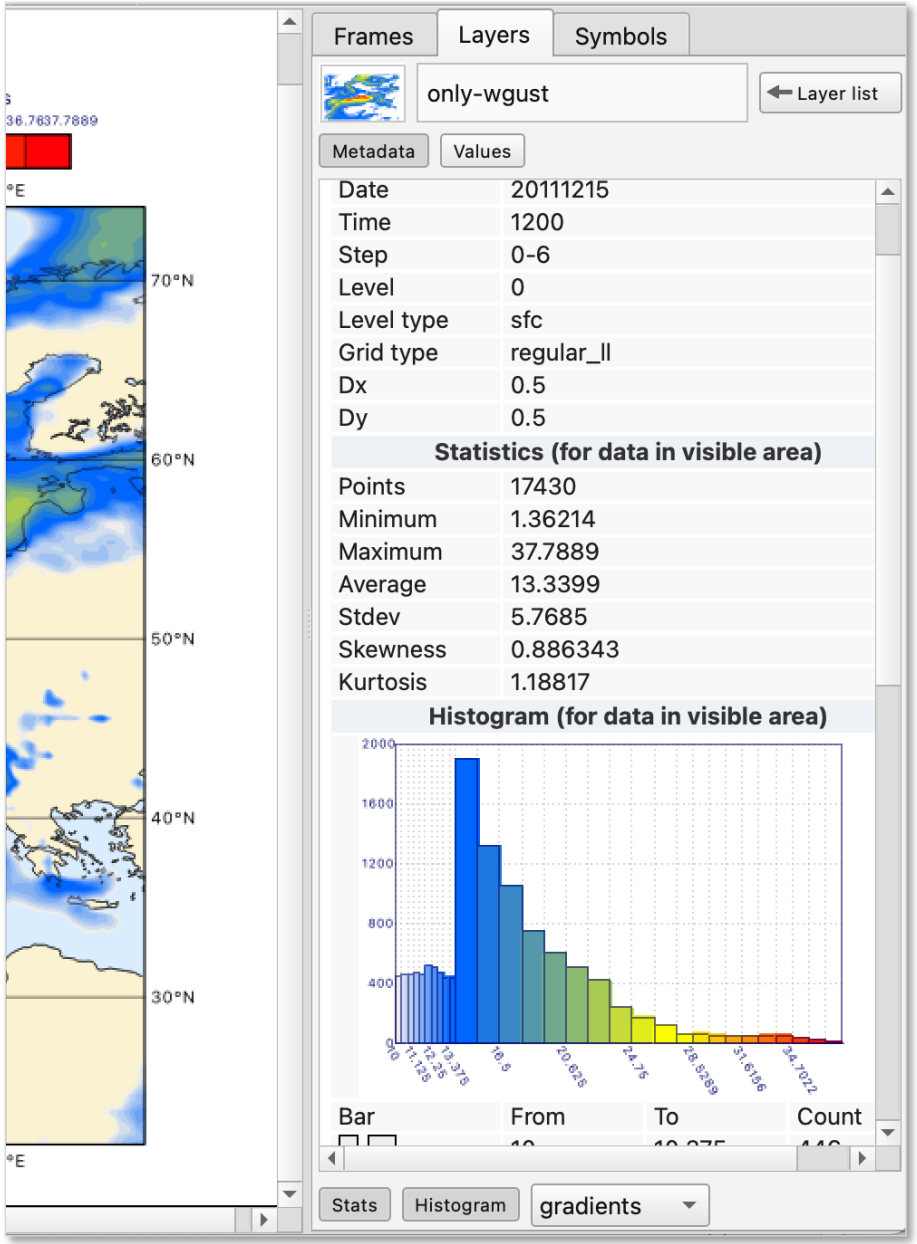
Reset OK Cancel Save

Contour icon editor – advanced editing of gradients

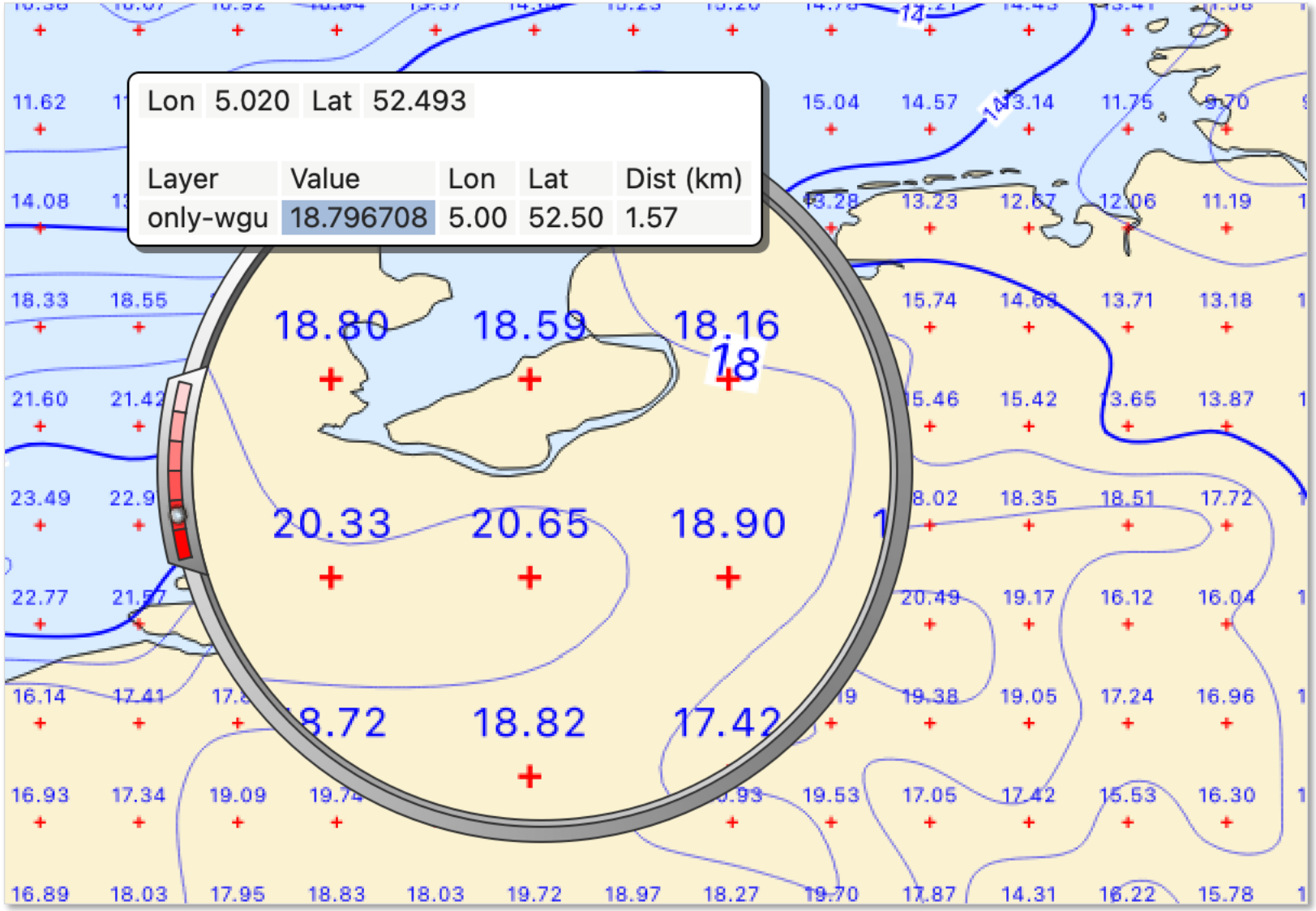




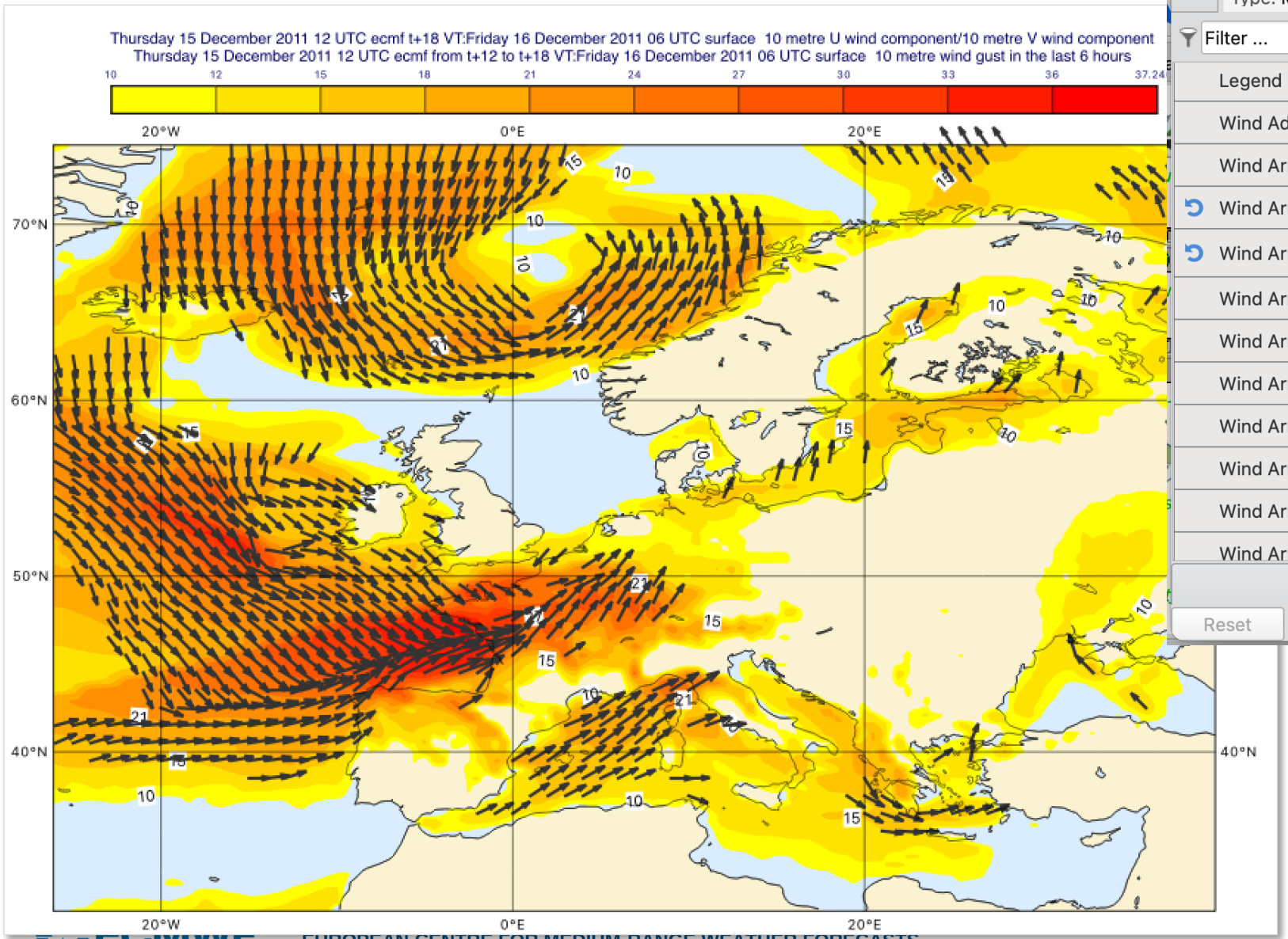
Metadata, histogram in sidebar

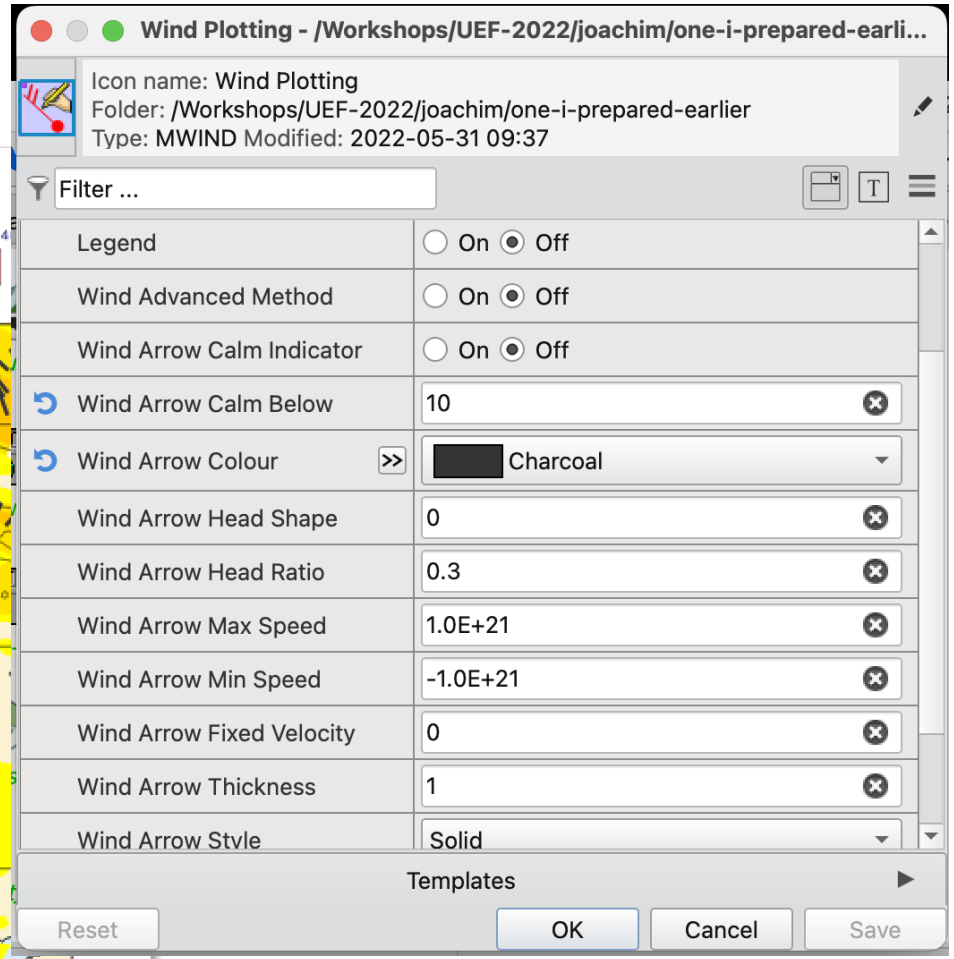


Point inspection



Add a wind layer



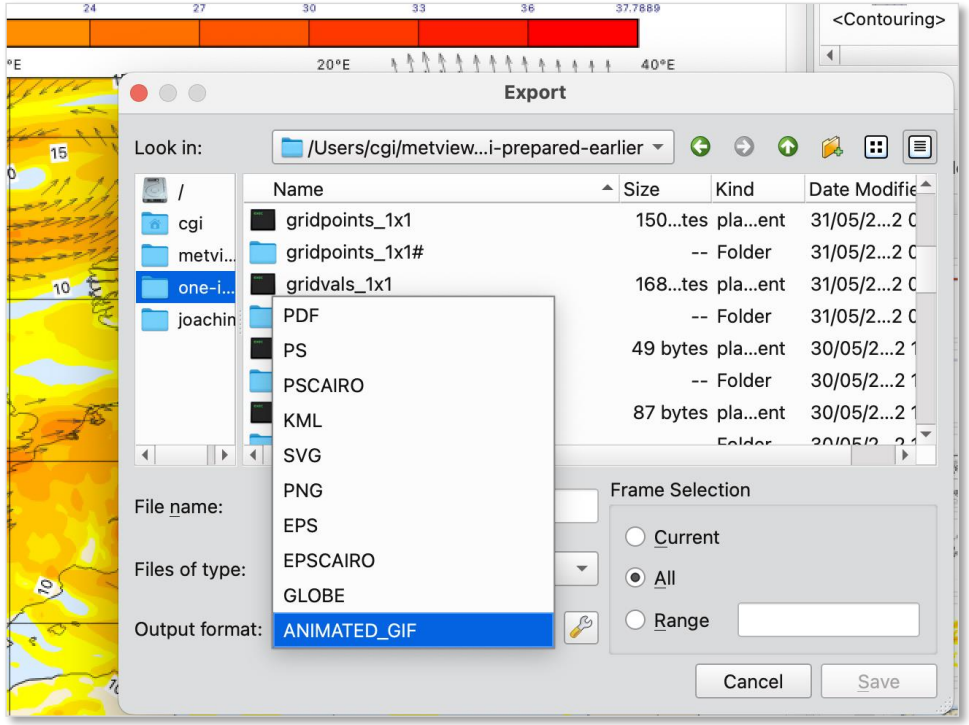


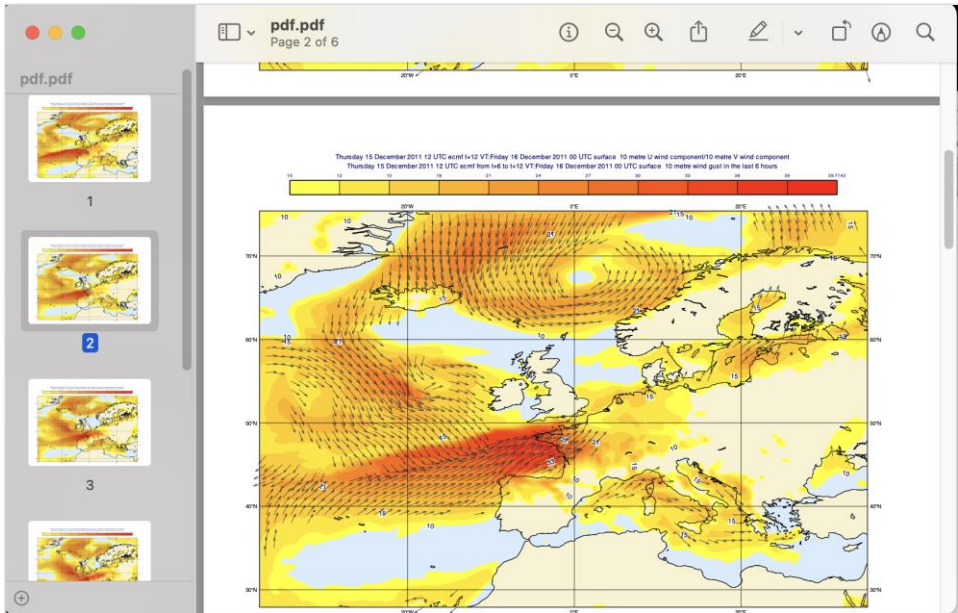
Export to PDF/PNG, Generate Python code

joachim.py - /Users/cgi/metview/Workshops/UEF-2022/joachim/one-i-prepared-earlier/joachim.py

```
 5
 6 wgust = mv.read(
 7     param = "10fg6",
 8     data  = joachim_surf_grib
 9     )
10
11
12 beaufort = mv.mcont(
13     contour_automatic_setting = "style_name",
14     contour_style_name        = "sh_all_f03t70_beauf",
15     legend                    = "on"
16     )
17
18
19 polar_view = mv.geoview(
20     map_projection = "polar_stereographic"
21     )
22
23 mv.plot(polar_view, wgust, beaufort)
```

beaufort





Set up a vertical cross section while looking at data