ATARRI - Outline of BSC Virtual Trainings on Dust Modelling

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Contents

1. Background
2. Audience survey
3. VT Session outline
    1. Introduction to existing dust products and data structures
    2. Data visualisation
    3. Comparison of forecasts with remote sensing observations
    4. Evaluation of forecasts using AERONET and in-situ observations
4. Learning Environment
5. Dates

Background

- Continuation of trainings on dust modelling (practical component).
  - Part of Task 3.2 VT5 Virtual training (M15-M17)
- Trainings to cover:
  - description and usage of current BSC-CNS forecast products
  - best practices
  - tools for model evaluation
- Survey held on 11/2024 to identify needs of trainees (reopened on 10/2025 to record new responses).
  - Audience background.
  - Familiarity with dust modelling.
  - Practical skills.

Survey

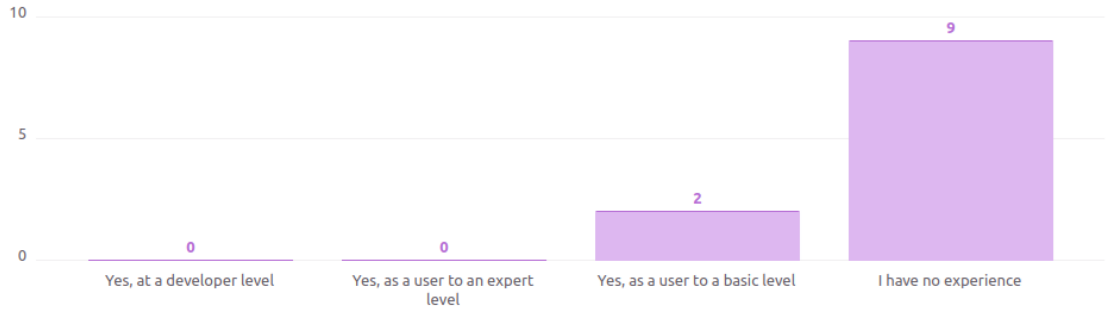
3 What is your motivation to learn aspects of dust modelling?

11 out of 11 people answered this question.

Choices	Responses	Percentages
Run tailored simulations for your area of interest	7	63.6%
Compare and evaluate with in-situ or satellite observations	10	90.9%
Test and improve dust models	4	36.4%
Integrate dust modelling capacities in other models	2	18.2%
other	0	0%

4 Do you have any experience with atmospheric composition models?

11 out of 11 people answered this question.

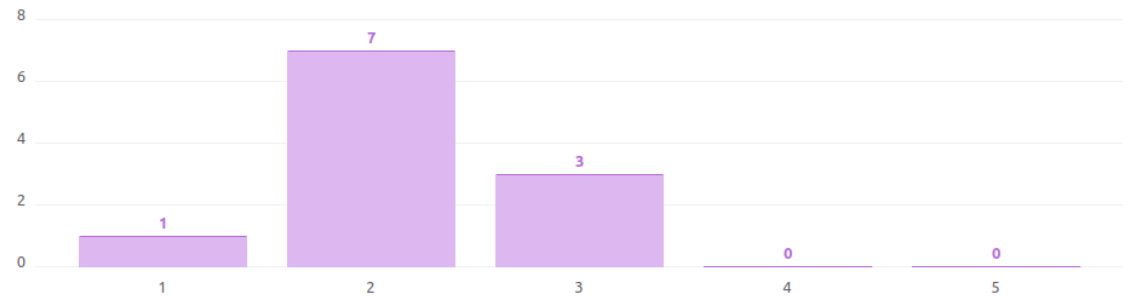


Survey

6 On a scale of 1 to 5, how familiar are you with the concepts of dust modelling?

11 out of 11 people answered this question.

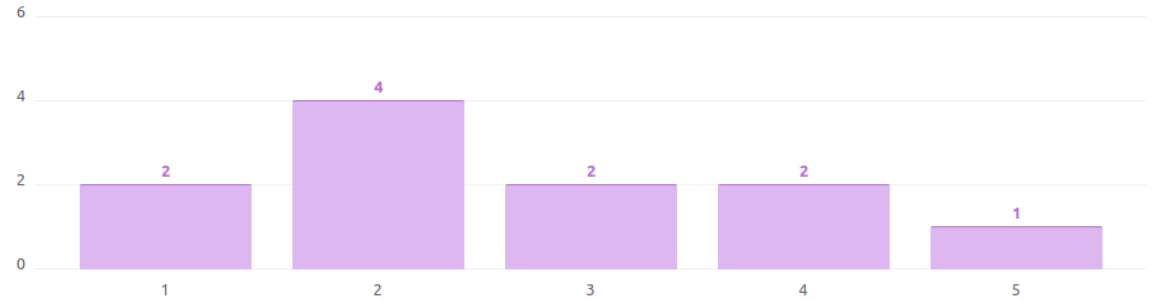
2.18	2	0.6
Mean	Median	Standard deviation



12 How would you evaluate your programming skills in Python?

11 out of 11 people answered this question.

2.64	2	1.29
Mean	Median	Standard deviation



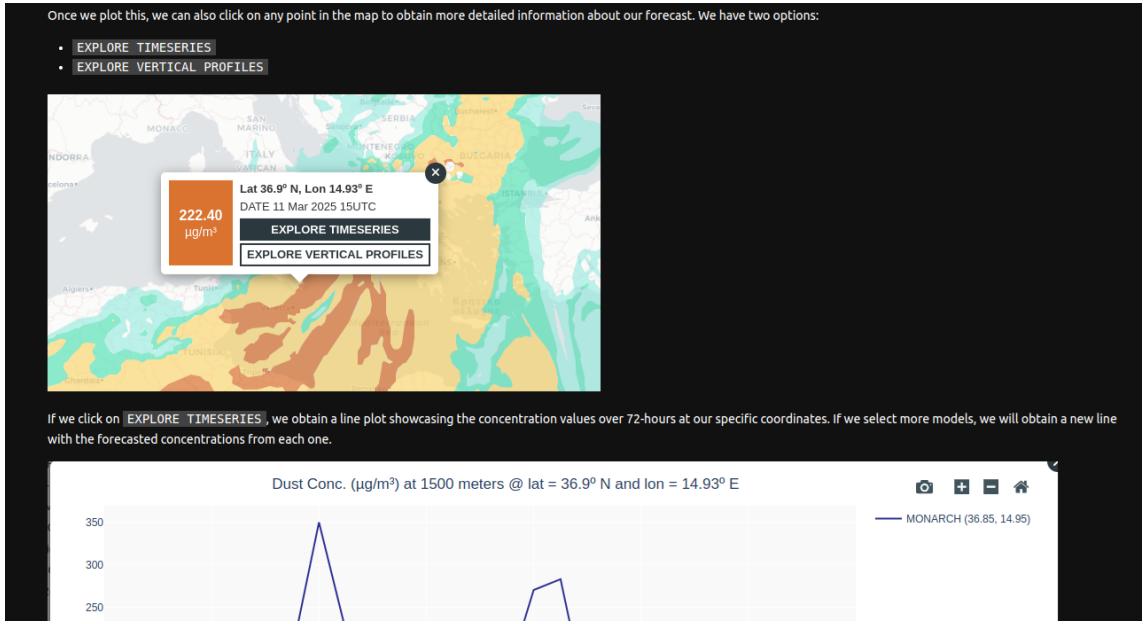
General outline

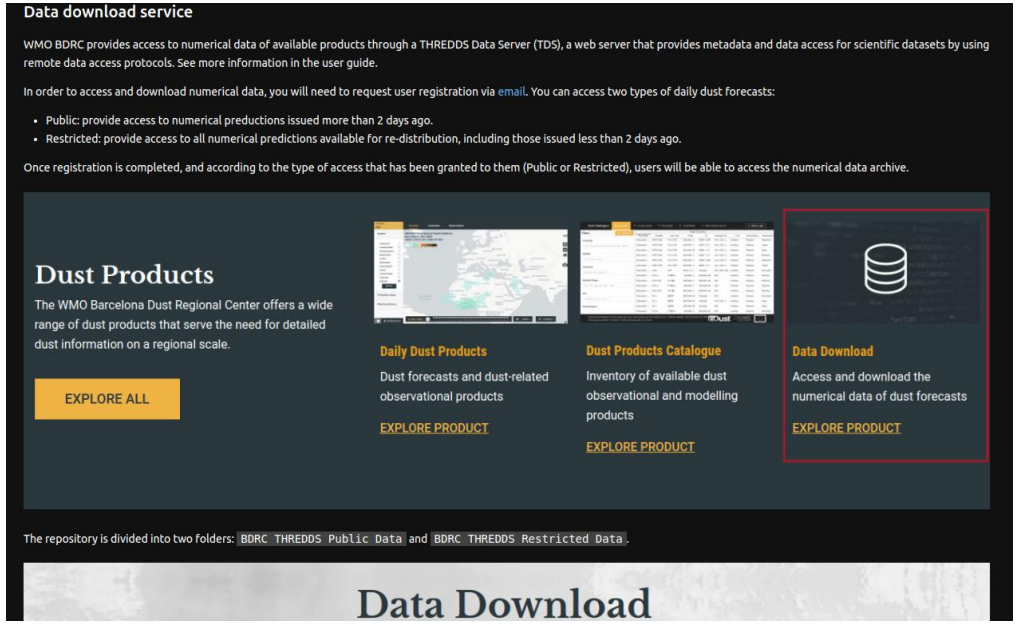
- Main folder structure:
  - `/home/jupyter-user/atarri/`: Location where users have a copy of their own material and tools to follow along the training.
  - `/shared/`: Partition available to store dust models, observational datasets and processed data.
- Each `/home/jupyter/atarri/` folder contains three subfolder types:
  - Virtual Trainings: Content and code to analyse dust models inside Jupyter Notebooks.
  - Auxiliary folders: Scripts, outputs, functions, etc.
  - Tools: Copy of the MAPIES and Providentia tools.
- Notebooks supported by tool-specific conda environments.
- Exercises based around the analysis of a dust event over Cyprus (03/03/2025 - 08/03/2025).

VT1: Introduction to existing dust products and data structures

Learning objectives:

- Understand current dust products and tools available in the Barcelona Dust Regional Centre (BDRC) website.
- Learn to load and manage MONARCH data in Python.
- Understand the structure of MONARCH netcdf files via the use of relevant Python libraries.
- Develop the ability to visualise basic data features and trends in dust model output.





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```
    # Store results in dictionary with level as column name
    stats_dict[str(level)] = {
        "Mean (µg/m³)": mean,
        "Median (µg/m³)": median,
        "Max (µg/m³)": max_value,
        "Min (µg/m³)": min_value,
    }
```

Once this is done, we can convert the dictionary to a data frame, and use some styling options to represent the summary table as follows:

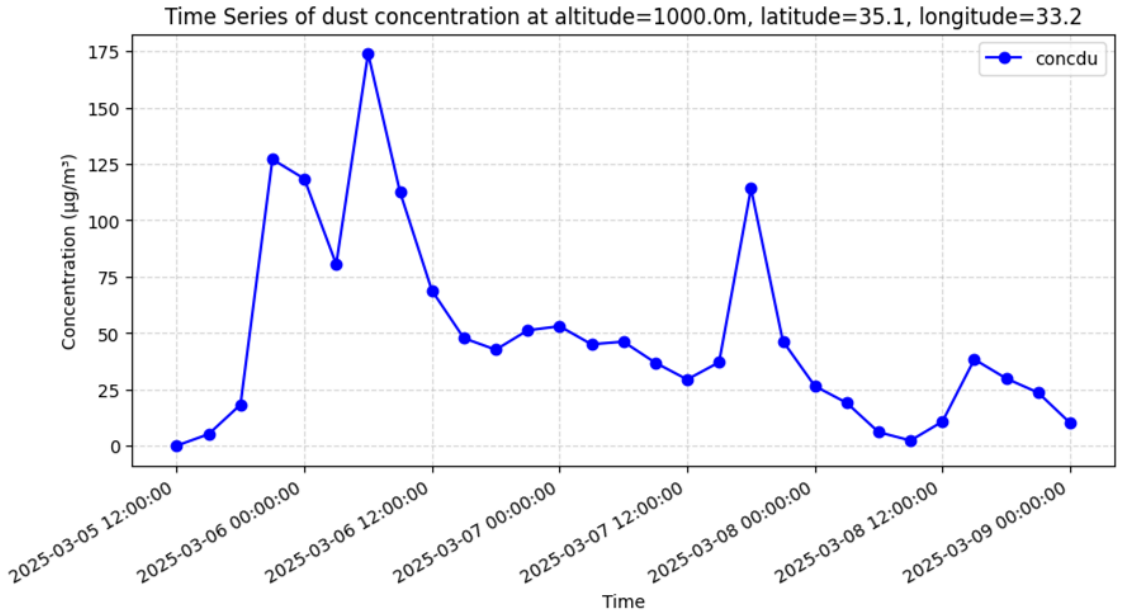
```
[25]: df_stats = pd.DataFrame(stats_dict)

styled_df = df_stats.style.set_table_styles(
    [{'selector': 'th', 'props': [('border', '1px solid black')]},
     {'selector': 'td', 'props': [('border', '1px solid black')]},
     {'selector': 'table', 'props': [('border-collapse', 'collapse')]}
)

styled_df
```

[25]:

	500	1000	2000	4000
Mean (µg/m³)	22.193788	31.849194	102.923060	73.555100
Median (µg/m³)	15.007632	19.824402	41.259423	42.420314
Max (µg/m³)	116.393430	117.507838	749.075582	281.911298
Min (µg/m³)	0.000000	0.000000	0.000000	0.000000



VT2: Data visualisation

Learning objectives:

- Create different features for map plots.
- Create animated plots to show changes over time.
- Plot altitude-temporal vertical sections with MONARCH model data.
- Learn to create cross-sectional views using latitude and longitude data with MetPy.

To reduce cluttering in our plotting lines, we will store `lat`, `lon` and `time` into variables. For `time`, we will extract the value so it is readable later on.

[6]:
```
od_lat = od_ds["lat"]
od_lon = od_ds["lon"]
od_time = od_ds["time"].isel(time=0).values
```

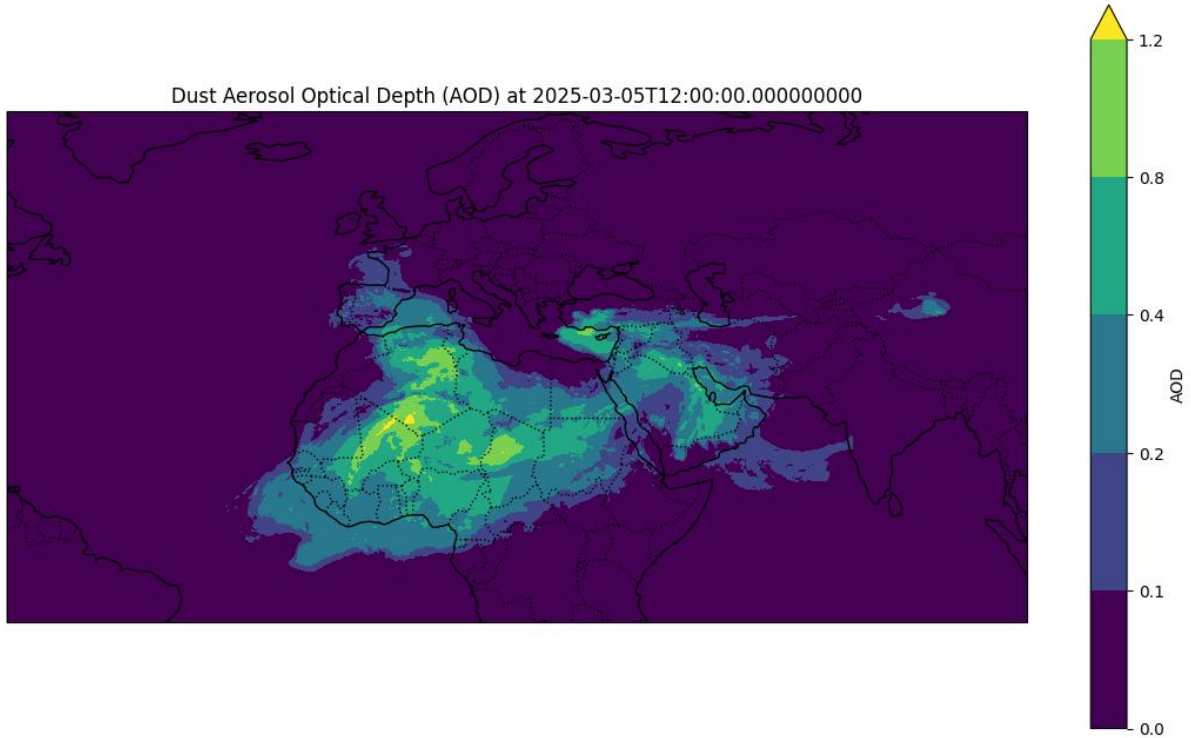
Finally, we use `matplotlib` to plot AOD at a specific timestep, using longitude and latitude as inputs. We will also add a dynamic title by incorporating our time value. By adding `cartopy`, we can add more detail to our map, such as setting coastlines and country borders. We will also use our `get_custom_norm()` function to set customised AOD ranges in our map display.

[7]:
```
od_ranges = [0, 0.1, 0.2, 0.4, 0.8, 1.2]
```

[8]:
```
# Create the plot
fig, ax = plt.subplots(figsize=(14, 8), subplot_kw={"projection": ccrs.PlateCar

# Get the norm using the helper function
od_norm = get_custom_norm(od_ranges)

# Plot the data
p = ax.pcolormesh(od_lon,
                  od_lat,
                  od_select_ds,
```



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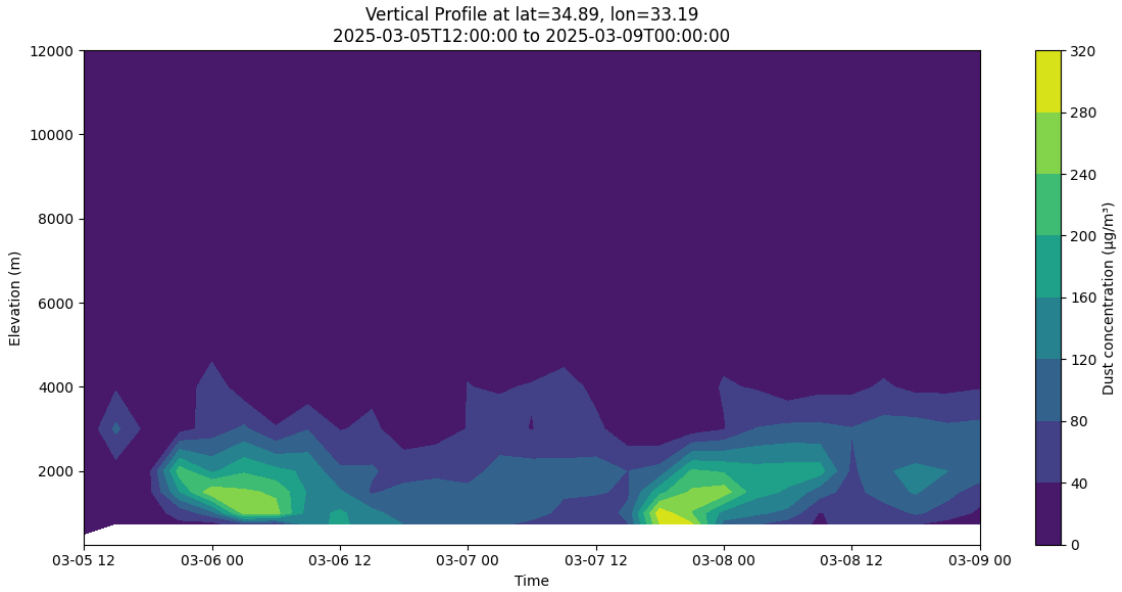
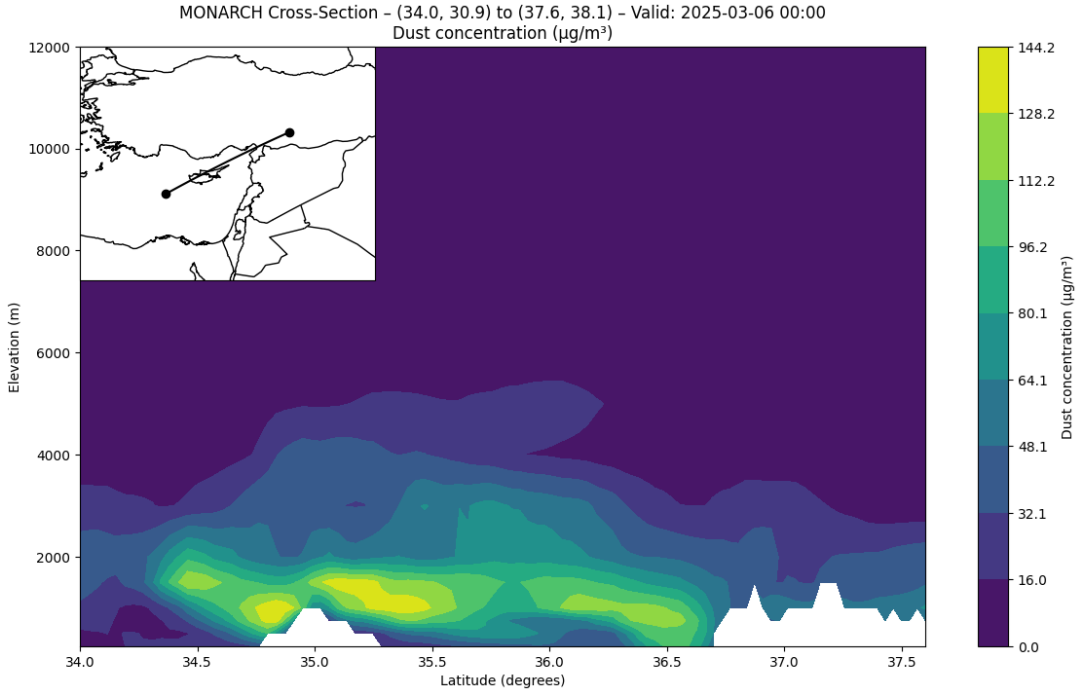
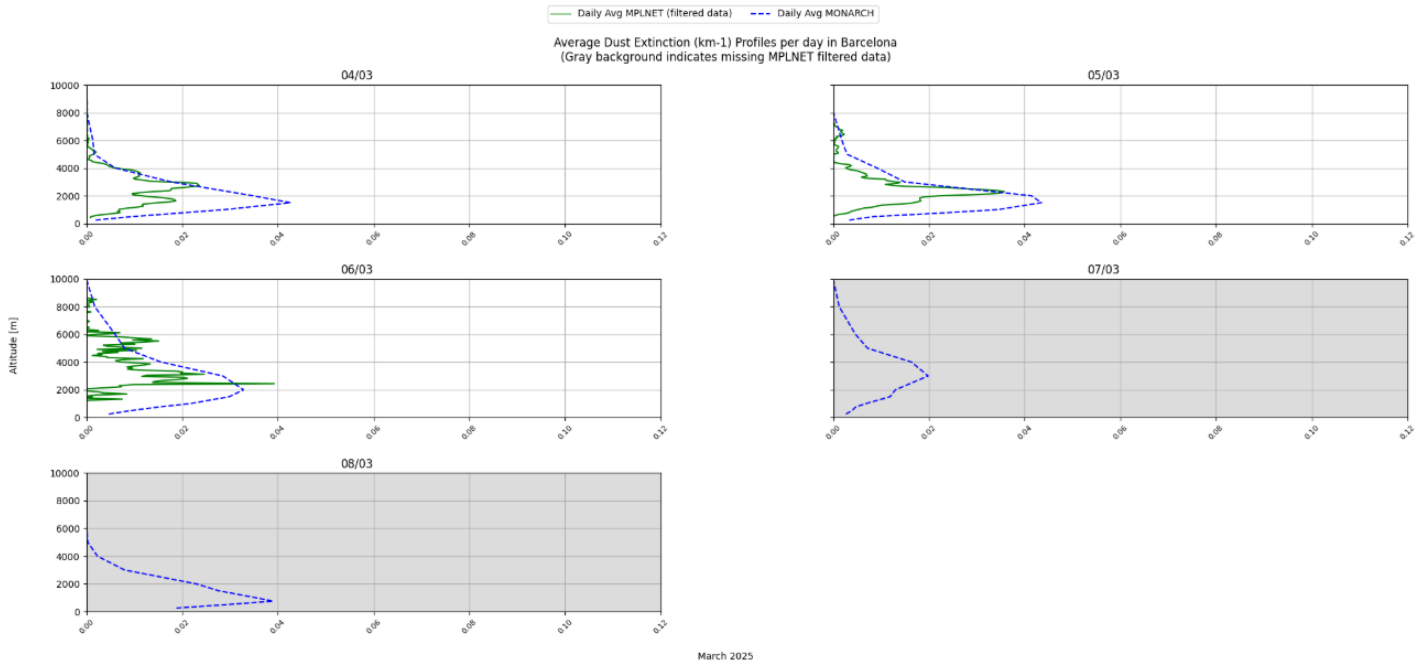




VT3: Comparison of forecasts with remote sensing observations

Learning objectives:

- Understand how to pre-process and format MPLNET data for data comparison.
- Learn how to calculate dust extinction from MPLNET and MONARCH data files.
- Create comparison plots to analyse MPLNET data and MONARCH models.
- Learn how to apply MAPIES tools and functions to process and plot VIIRS satellite data, and compare it against MONARCH dust models.



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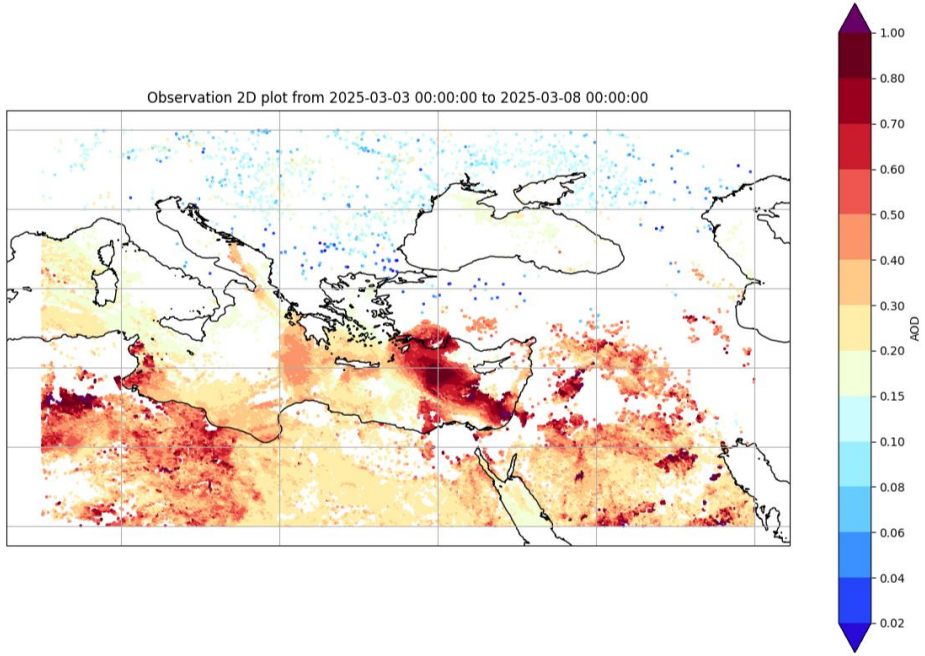
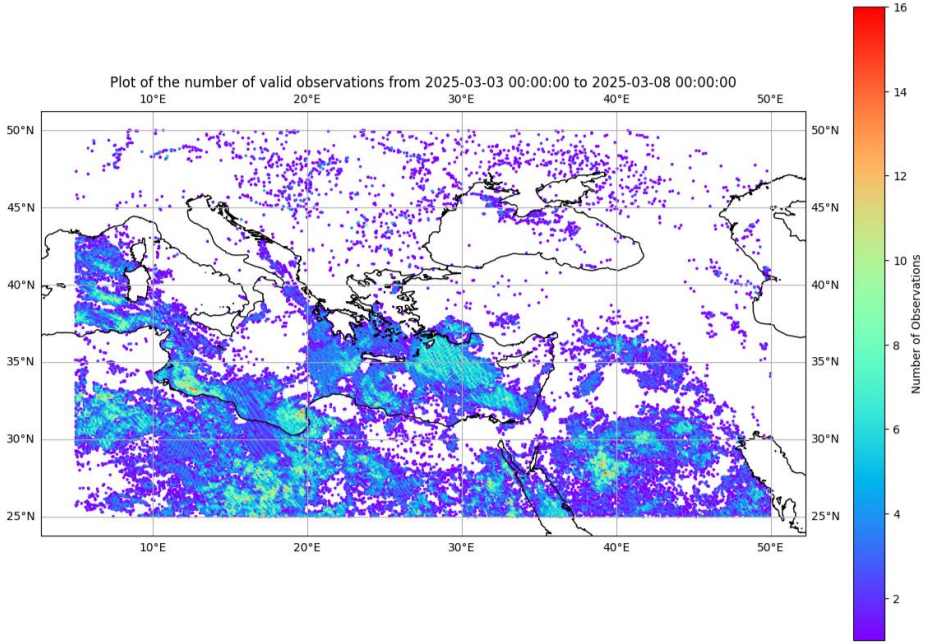
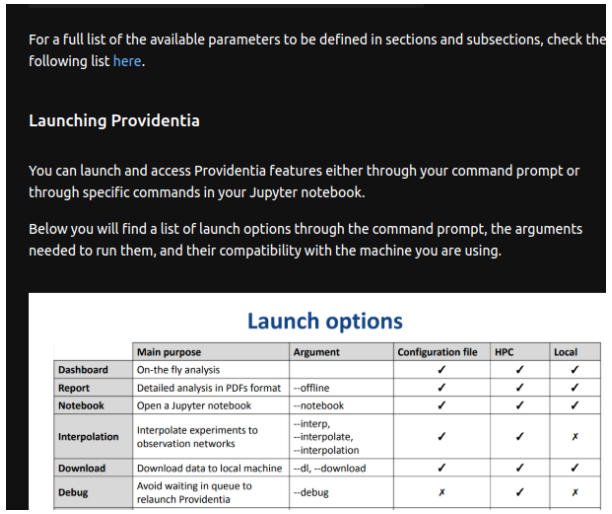




VT4: Evaluation of forecasts using AERONET and in-situ observations

Learning objectives:

- Learn about Providentia: what it is, how it works, and how to employ the different functionalities from Interpolation, Dashboard, and Library Mode.
- Use Interpolation mode to spatially and temporally interpolate AOD from AERONET observations and MONARCH data.
- Successfully launch and use Providentia Dashboard mode to visually evaluate MONARCH dust optical depth at 550nm with AERONET aerosol optical depth at 550nm.
- Apply functions from Providentia Library mode to evaluate MONARCH coarse dust optical depth at 500nm with AERONET aerosol optical depth at 500nm.



For a full list of the available parameters to be defined in sections and subsections, check the following list here.

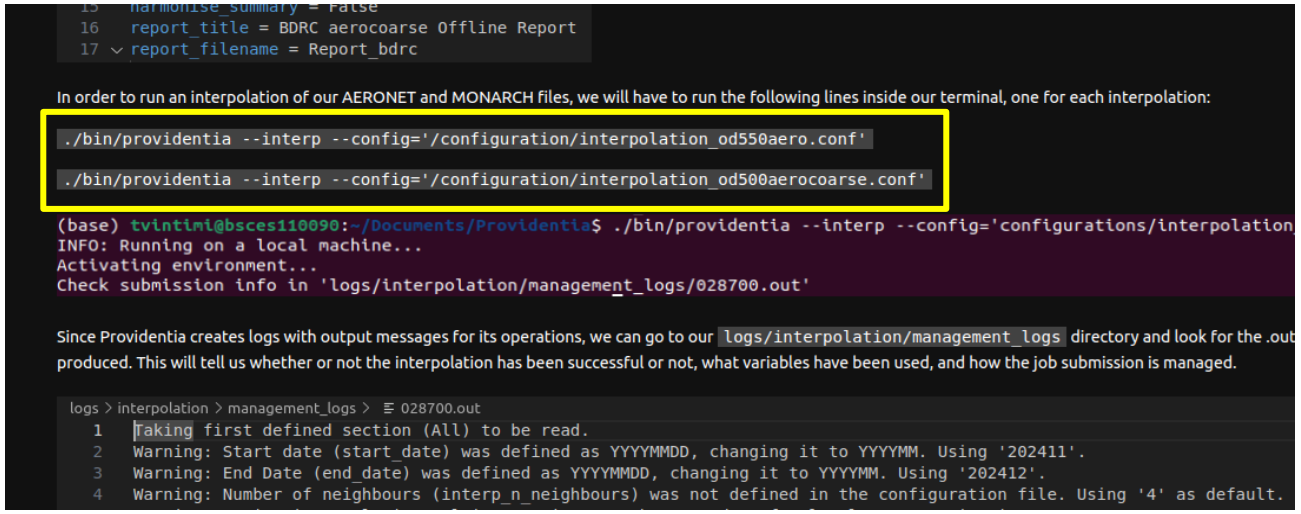
Launching Providentia

You can launch and access Providentia features either through your command prompt or through specific commands in your Jupyter notebook.

Below you will find a list of launch options through the command prompt, the arguments needed to run them, and their compatibility with the machine you are using.

Launch options

	Main purpose	Argument	Configuration file	HPC	Local
Dashboard	On-the fly analysis		✓	✓	✓
Report	Detailed analysis in PDFs format	--offline	✓	✓	✓
Notebook	Open a Jupyter notebook	--notebook	✓	✓	✓
Interpolation	Interpolate experiments to observation networks	--interp, --interpolate, --interpolation	✓	✓	✗
Download	Download data to local machine	--dl, --download	✓	✓	✓
Debug	Avoid waiting in queue to relaunch Providentia	--debug	✗	✓	✗



```
16  report_title = BDRC aerocoarse Offline Report
17  report_filename = Report_bdrc
```

In order to run an interpolation of our AERONET and MONARCH files, we will have to run the following lines inside our terminal, one for each interpolation:

```
./bin/providentia --interp --config='/configuration/interpolation_od550aero.conf'

./bin/providentia --interp --config='/configuration/interpolation_od500aerocoarse.conf'
```

```
(base) tvintimi@bsces110090:~/Documents/Providentia$ ./bin/providentia --interp --config='configurations/interpolation
INFO: Running on a local machine...
Activating environment...
Check submission info in 'logs/interpolation/management_logs/028700.out'
```

Since Providentia creates logs with output messages for its operations, we can go to our `logs/interpolation/management_logs` directory and look for the .out produced. This will tell us whether or not the interpolation has been successful or not, what variables have been used, and how the job submission is managed.

logs > interpolation > management_logs > 028700.out

```
1  Taking first defined section (All) to be read.
2  Warning: Start date (start_date) was defined as YYYYMMDD, changing it to YYYYMM. Using '202411'.
3  Warning: End Date (end_date) was defined as YYYYMMDD, changing it to YYYYMM. Using '202412'.
4  Warning: Number of neighbours (interp_n_neighbours) was not defined in the configuration file. Using '4' as default.
```

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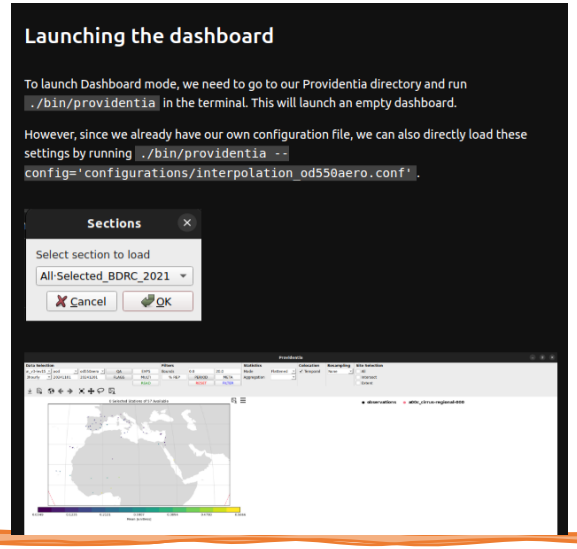

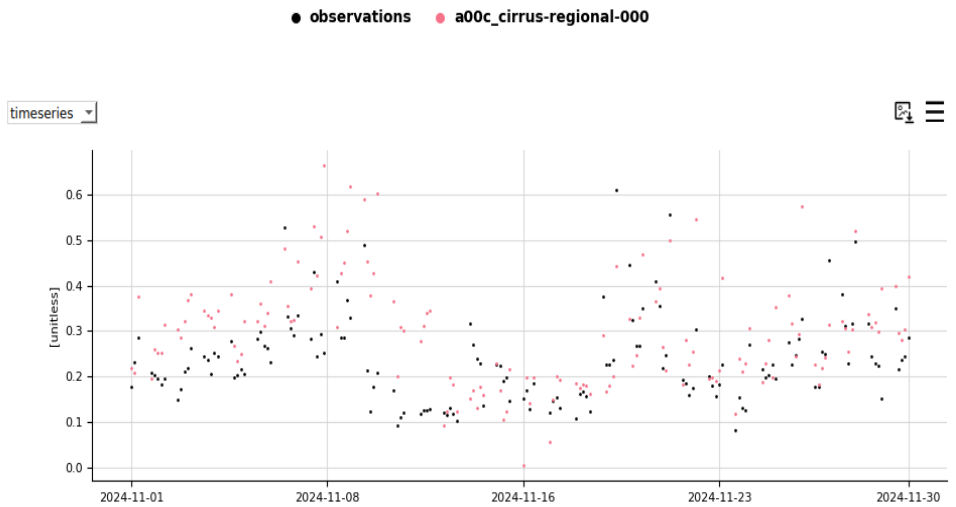

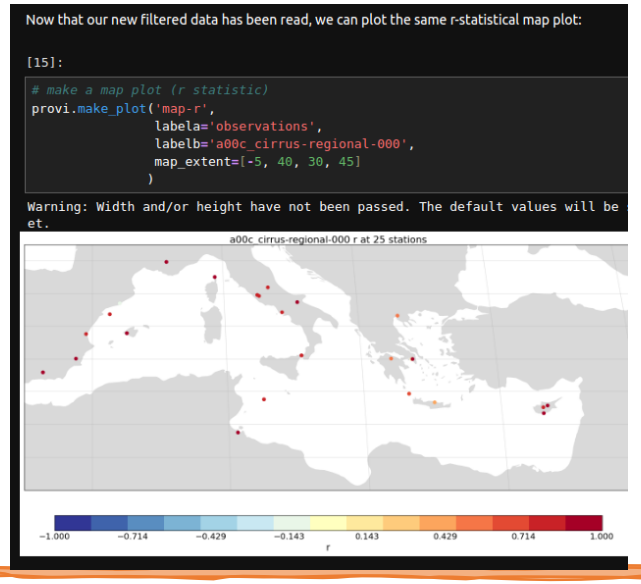

Learning environment

- We are running a JupyterHub hosted at BSC, where we have centralised access to all our material.
- All trainees will be given their own credentials to access the platform.
  - You will receive your credentials by email prior to the start of the first session.
- Good internet access is required. The platform can be accessed on any operating system.
- JupyterHub will run throughout the duration of the trainings.

Dates

VT Session	Date
Introduction to existing dust products and data structures	December 10, 2025
Data visualisation	January 14, 2025
Comparison of forecasts with remote sensing observations	February 04, 2026
Evaluation of forecasts using AERONET and in-situ observations	February 25, 2026

Funded by the European Union

THANK YOU

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