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IMAGE
PROCESSING
LABORATORY

nowcAstIng

Nowcasting of fog using AI (NAI) techniques
using satellite observations.



nowcAstIng

A toolbox for developing fog ML models

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Outline:

- **nowcAstIng toolbox**
- **Current work**

nowcAstIng NWC SAF toolbox

The toolbox is proposing NWC SAF cloud products along with METAR reports to develop fog nowcasting ML models. Satellite radiances are also accessible for EUMETSAT registered users.

The users can develop, train and reuse their models for a particular airport.

The objective is to exploit the information coming from satellite, along with METAR reports, to nowcast fog some hours in the future

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A toolbox for developing fog nowcasting ML models

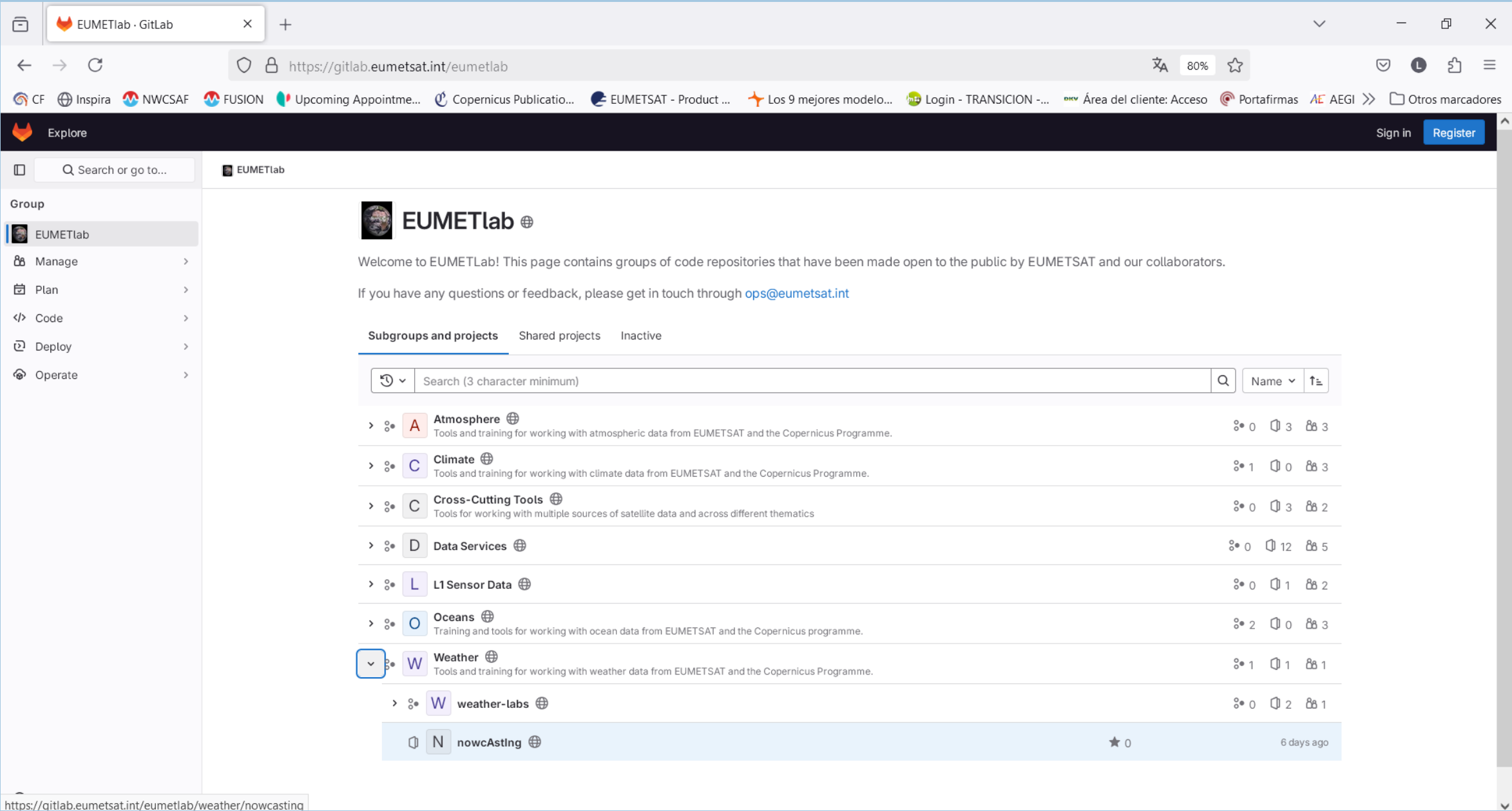
<https://gitlab.eumetsat.int/eumetlab/weather/nowcasting>



nowcAstIng is available on EUMETLab.

The toolbox is released with a capacity-building approach under the umbrella of the EUMETSATs’ EUMETLab. You can clone it from:

<https://gitlab.eumetsat.int/eumetlab/weather/nowcasting.git>





nowcAstIng is released under MIT License.

The nowcAstIng targeted user are Machine Learning practitioners, Academia and NMS. These communities are encouraged to fork the project, give feedback and contribute. The nowcAstIng toolbox is in the format of a Jupyter notebook collection.

EUMETlab / Weather / nowcAst X

https://gitlab.eumetsat.int/eumetlab/weather/nowcasting

CF Inspira NWCSAF FUSION Upcoming Appointme... Copernicus Publicatio... EUMETSAT - Product ... Los 9 mejores modelo... Login - TRANSICION - ... Área del cliente: Acceso Portafirmas Otros marcadores

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Deploy >

Operate >

Monitor >

Analyze >

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main nowcasting

History Find file Code

Calibration added to model storage

jllisov authored 6 days ago

c89c4756

| Name | Last commit | Last update |
|----------|-------------------------------------|---------------|
| Airports | project migration from AEMET gitlab | 1 year ago |
| data | GOES East projection fixed | 1 week ago |
| dock | LEVD airport added | 2 weeks ago |
| img | fixing previous commit | 11 months ago |
| info | project migration from AEMET gitlab | 1 year ago |
| lib | GOES East projection fixed | 1 week ago |
| metrics | new metrics for LEPA NN | 9 months ago |
| models | refactor | 9 months ago |

https://gitlab.eumetsat.int/eumetlab/weather/nowcasting/-/commit/c89c4756dd263703fdf06011b69aea51bf14d11b

Star 0

Project information

103 Commits

1 Branch

0 Tags

README

MIT License

Created on August 23, 2023



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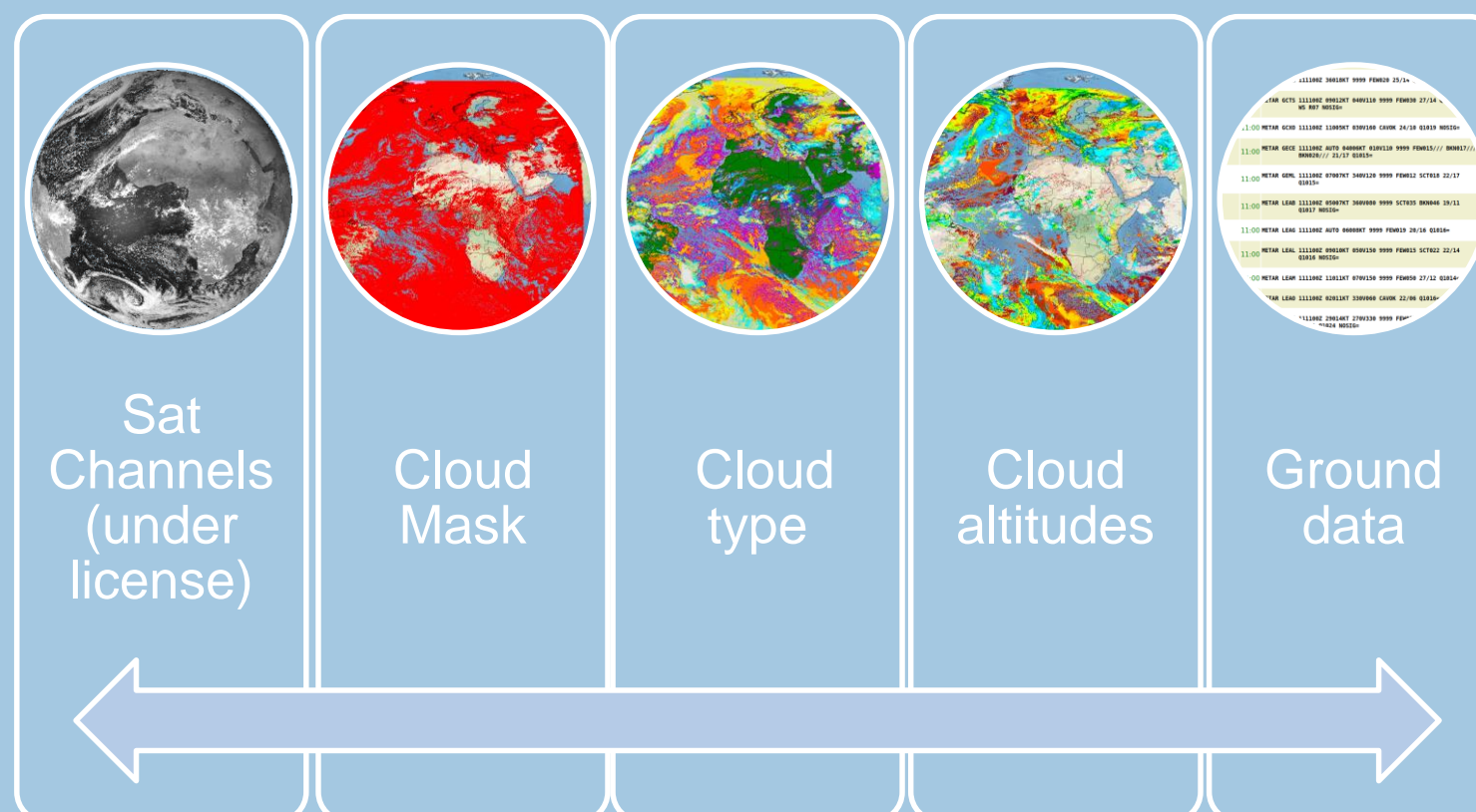
nowcAstIng targets to co-development.

The nowcAstIng targeted user are Machine Learning practitioners, Academia and NMS. **These communities are encouraged to fork the project, give feedback and contribute.**

The nowcAstIng toolbox is in the format of a Jupyter notebook collection, allowing:

1. To download the NWC SAF clouds (and sat channels under license) and collocate them with METAR reports
2. To get insight on the fog formation ;
3. To establish baseline models ;
4. To develop ML models to forecast the occurrence of fog ;
5. To store their models for operational reuse.

The data proposed to feed the ML models are NWC SAF cloud and METAR data.





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Photo: [Andrew Malone via Wikimedia Commons](#)

The set of notebooks is
proposing an example of fog
forecasting ML model
construction.

The notebooks
one by one:



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The first notebook gives a general description:

It explains the proposed data to train the model: NWC SAF cloud products, Information extracted from METAR reports and some geophysical calculated variables (as solar elevation...). The first notebook includes an index pointing the user to each chapter of the course.

The toolbox download the data, store them, and make them accessible via xarray objects. The xarray Datasets follow CF convention.

Filter files by name

| Name | Last Modified |
|---------------|---------------|
| fourthro... | 10 months ago |
| grid_sear... | 10 months ago |
| grid_sear... | 10 months ago |
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| LEZG_clo... | 12 months ago |

BOOSTDEVLEMD.ipynb × BOOSTDEVLEZG.ipynb × FormationLEPA.ipynb × indexFog.ipynb model.png × +

Markdown ▾

Notebook Python 3 (ipykernel)

Data download >>

Introduction

nowcAstIng

nowcA_{st}I^{ng} is a Python-based capacity-building resource for the use of the NWC SAF products to feed ML models. This course is focused in fog forecast. The notebooks guide the user to prepare the datacubes (with Satellite Cloud and METAR reports), and explore some statistical techniques.

The training course covers [DATA DOWNLOAD](#), [DATA EXPLORATION](#), [DATA COLLOCATION](#), [BASELINE MODELS](#) and [NEURAL NETWORKS](#) allowing the user to develop and test their own models in a specific notebook: [DEV](#)

This course is based on [Jupyter notebooks](#), which allow for a high-level of interactive learning, as code, text description and visualisation is combined in one place. We recommend the use of jupyter-lab.

Learning Outcomes

First notebook: Introduction



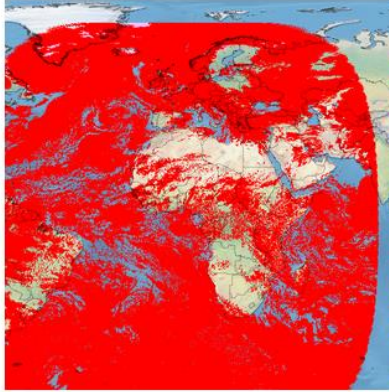
The first notebook also explains the learning outcome: at the end of the series the user:

- Will be familiarized with the content of NWC SAF GEO Cloud Products.
- Will be more familiar with information extracted from METAR reports.
- Will know how to merge both data: clouds and METAR.
- Will see an example of Naïve Bayes implementation.
- Will see an example of a NN basic implementation for a particular airport.
- Will learn how to store and compare its own ML models

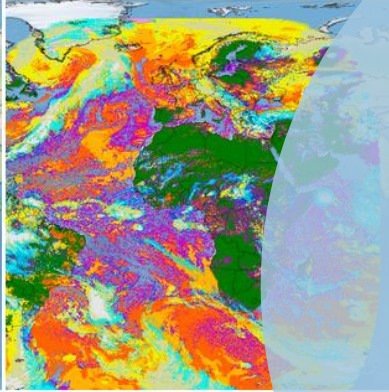
| Name | Last Modified |
|--------------|----------------|
| fourthro... | 10 months ago |
| grid_sear... | 10 months ago |
| grid_sear... | 10 months ago |
| grid_sear... | 10 months ago |
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| grid_sear... | 10 months ago |
| grid_sear... | 10 months ago |
| grid_sear... | 10 months ago |
| GRU.ipynb | 7 months ago |
| Importan... | 5 months ago |
| Importan... | 5 months ago |
| Importan... | 2 months ago |
| indexFog... | 11 minutes ago |
| LEZG_clo... | 12 months ago |
| LEZG.df2 | 6 days ago |
| LICENSE... | last year |
| LSTM4_le... | 11 months ago |

Data


The proposed NWC SAF data are CMA, CT, CTTH from the NWC SAF in combination with METAR reports, and some calculated variables. When running, the software will download a tile of the NWC SAF products around the chosen airport and stack them along the time axis in a single netcdf. A similar approach is taken for METAR reports: the software will download the METAR reports for the chosen period fill gaps and store them in a single netcdf. Bellow you can find some images:




NWC SAF Cloud Mask (CMA)



NWC SAF Cloud Type (CT)



NWC SAF Cloud Top Temperature Height (CTTH)



METAR reports

First notebook: Introduction

Data origin

The second notebook gives some general ideas and explains how to download the data for a particular airport. It also makes some considerations on data attribution and where to get credentials to access the data.

The software downloads the data and pack the downloaded in two individual netCDF CF files for reusing. The data are exposed as xarray Datasets.

The screenshot displays a Jupyter Notebook environment with a file explorer on the left and a code editor on the right. The file explorer shows a list of files, including 'dataStor...', 'DEV.ipynb', 'DEV2.ipynb', and several 'Ensembl...' files. The code editor shows the following code:

```
endts = datetime.datetime(2022, 12, 3)
# The ICAO code of the airport
ICAO = "LEPA"
# Then construct your connection

LEVC_METAR = airport.Dock_connection(ICAO, startts, endts)

Beginning...
METAR Dataset loaded...

Now you have the METAR data loaded and you can do a first interaction with it. Please run the bellow cell.
```

The output of the code is shown in the cell below:

```
[2]: LEVC_METAR.Dataset
```

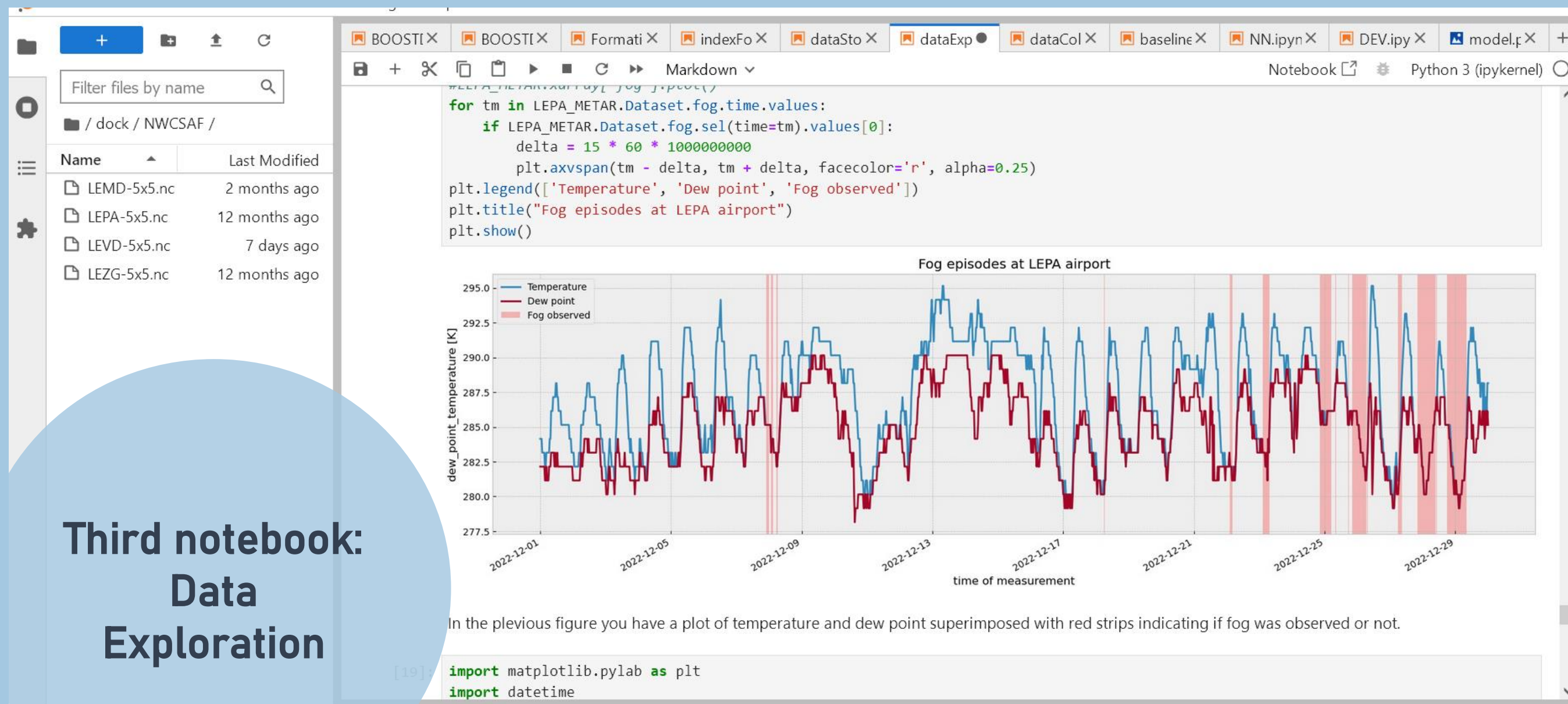
The output is a `xarray.Dataset` object with the following dimensions and coordinates:

- Dimensions: (time: 97, station: 1)
- Coordinates: time (time) datetime64[ns] 2022-12-01 ... 2022-12-03, station (station) object 'LEPA'
- Data variables: valid (station, time) object ..., vis (station, time) float32 ..., temp (station, time) float32 ..., dewpt (station, time) float32 ...

A large blue circle is overlaid on the right side of the notebook, containing the text:

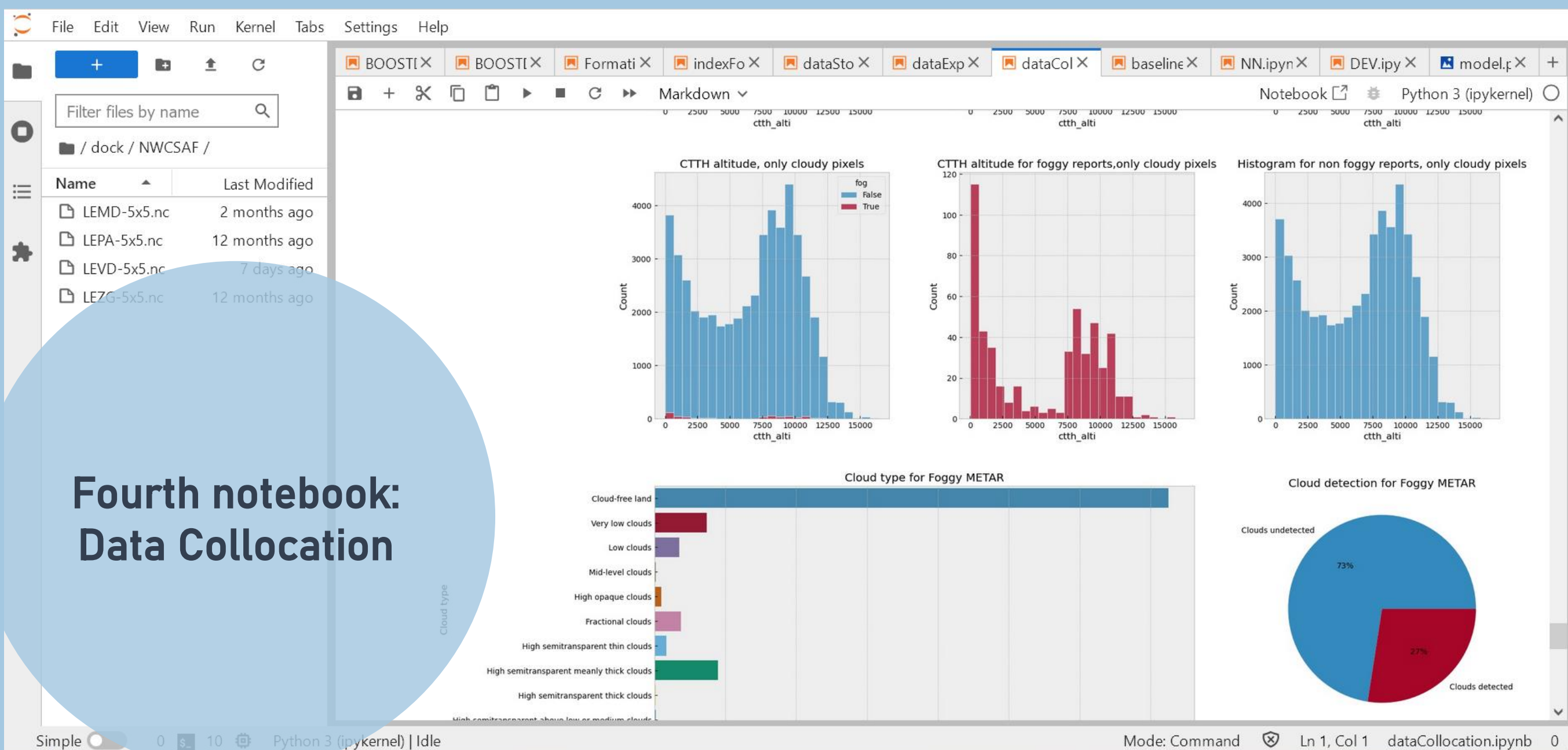
Second notebook: Data Download

The third notebook teaches how to connect with the stored data, how to plot some basic graph. The objective is to gain insight on the data characteristics



Third notebook: Data Exploration

The fourth notebook teaches how to collocate the data for simultaneous exploitation. The satellite cloud data are a cube of small stamps with a very long time axis, on the other hand the METAR data are a long time series with different time steps. The notebook teaches how to select the central pixel of the stamps and how to deal with the METAR data. Two methods are provided: `.resample()` and `.interpolate()` for METAR data



In the fifth notebook, how to build some baseline models, including Naïve Bayes, is explained. These models will be the reference for the actual models.

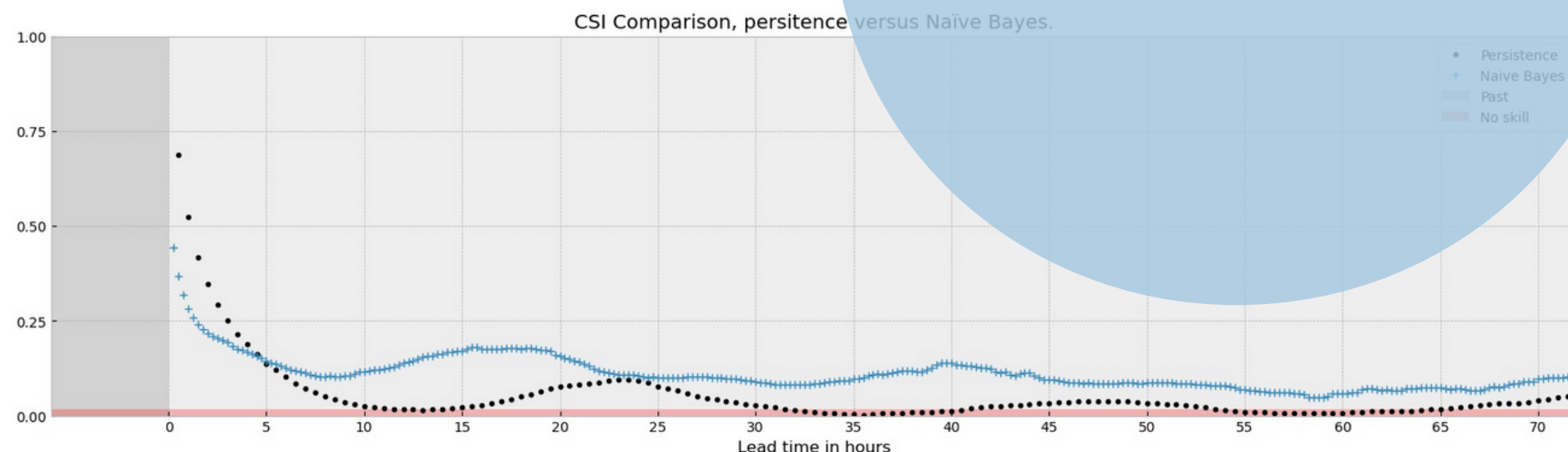
Through the toolbox the users models and their performance are stored on disk, you don't need to retrain the model each time you need to make a prediction.

Fifth notebook: Baselines

```
plt.xlim(left=-6)
plt.xlim(right=72)
plt.ylim(bottom=0)
plt.ylim(top=1)

ax.legend(["Persistence", "Naive Bayes", "Past", "No skill"])

plt.show()
```



In the previous plots we have plotted the two baselines. A good model should outperform both of them: It should have higher CSI than the persistence for less than 5 hours and higher CSI than Naïve Bayes for lead time longer than 5 hours. Finding such kind of model for LEPA airport is the objective of the next notebooks. We will test first a Feed Forward Neural Network and after we will expl



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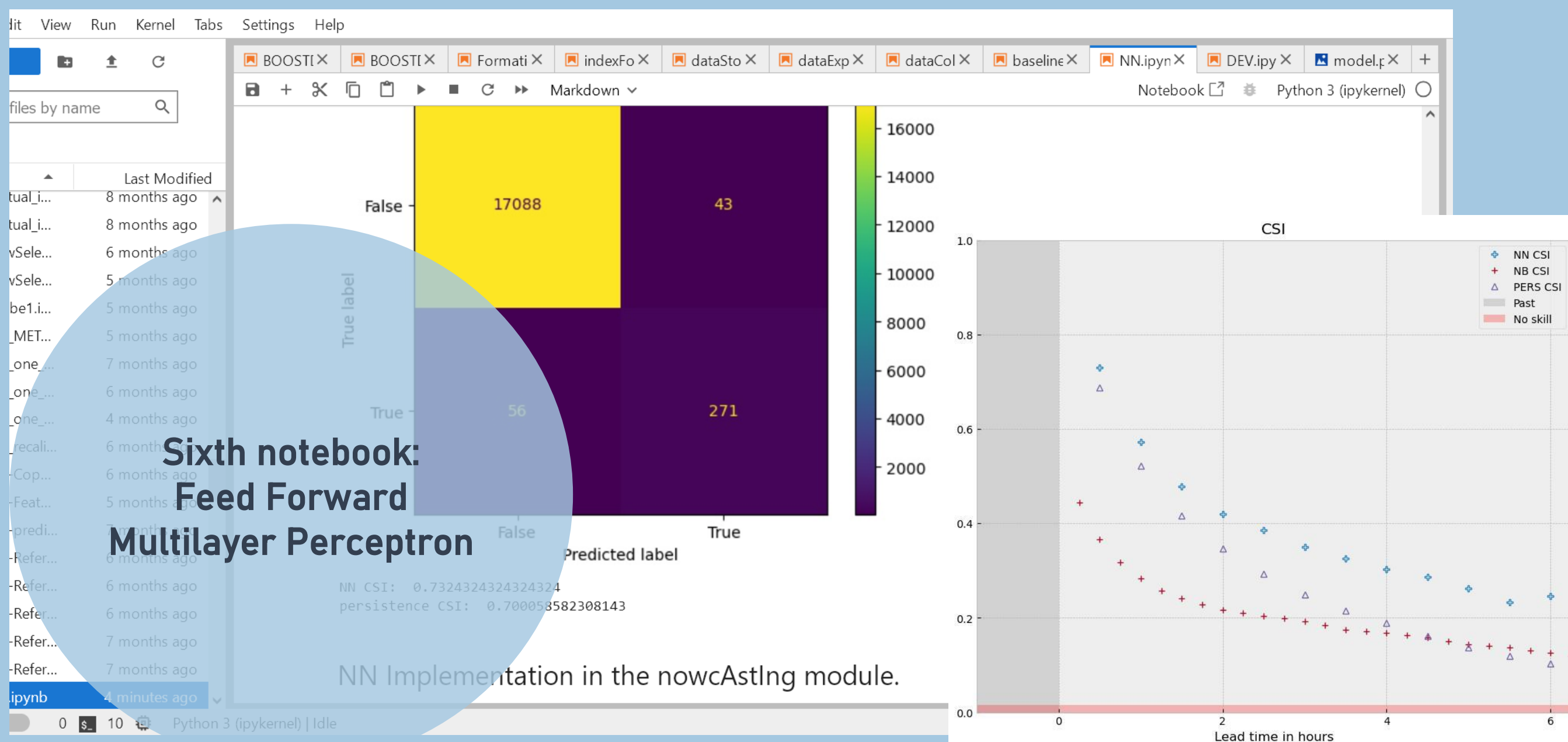
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In the sixth notebook, Deep Learning basis are explained. We use a Feed Forward Multilayer perceptron (stored also as a class of the toolbox). Special attention is given to the loss function.

This model has proved to outperform the baselines for LEPA airport .





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The seventh notebook provides a host class to test own models.
The name of the class is DEEPmodel, it takes as parameters a long list of "configurable" parameters: a tag, the ICAO code of the airport, the data, the model architecture, the list of predictors, the learning rate...

This allow to develop and intercompare different models. The code is prepared to run either on CPU or GPU.

File Edit View Run Kernel Tabs Settings Help

BOOSTIX BOOSTIX FormatiX indexFoX dataStoX dataExpX dataColX baselineX NN.ipynX DEV.ipynX model.cX

Filter files by name

Name Last Modified

- DEV.ipynb 10 hours ago
- DEV2.ipynb 5 months ago
- Ensembl... 5 months ago
- Ensembl... 6 months ago
- Ensembl... 8 months ago
- Ensembl... 5 months ago
- environ... 6 months ago
- feature_i... 5 months ago
- feature_i... 5 months ago
- FF_diff.txt 11 months ago
- FF.txt 11 months ago
- FFCSI_dif... 11 months ago
- FFCSI_fo... 11 months ago
- FFCSIPO... 11 months ago
- FFCSIPO... 11 months ago
- FirstInt.py 4 months ago
- FocalLos... 10 months ago
- foo 10 months ago
- forest de 6 months ago

Loading the minimal parameters...

```
[ ]: import nowcAstIng as nwc

hidden_size = 15
num_layers = 3
input_size = features.shape[1] # number of variables
output_size = len_out

net = RNN(input_size, hidden_size, num_layers, output_size).to(device)

model = nwc.DEEPModel(tag='RNN', ICAO='LEPA', NET=net)
model.load()
```

Loading the data and calculating

```
[ ]: # You give now some data

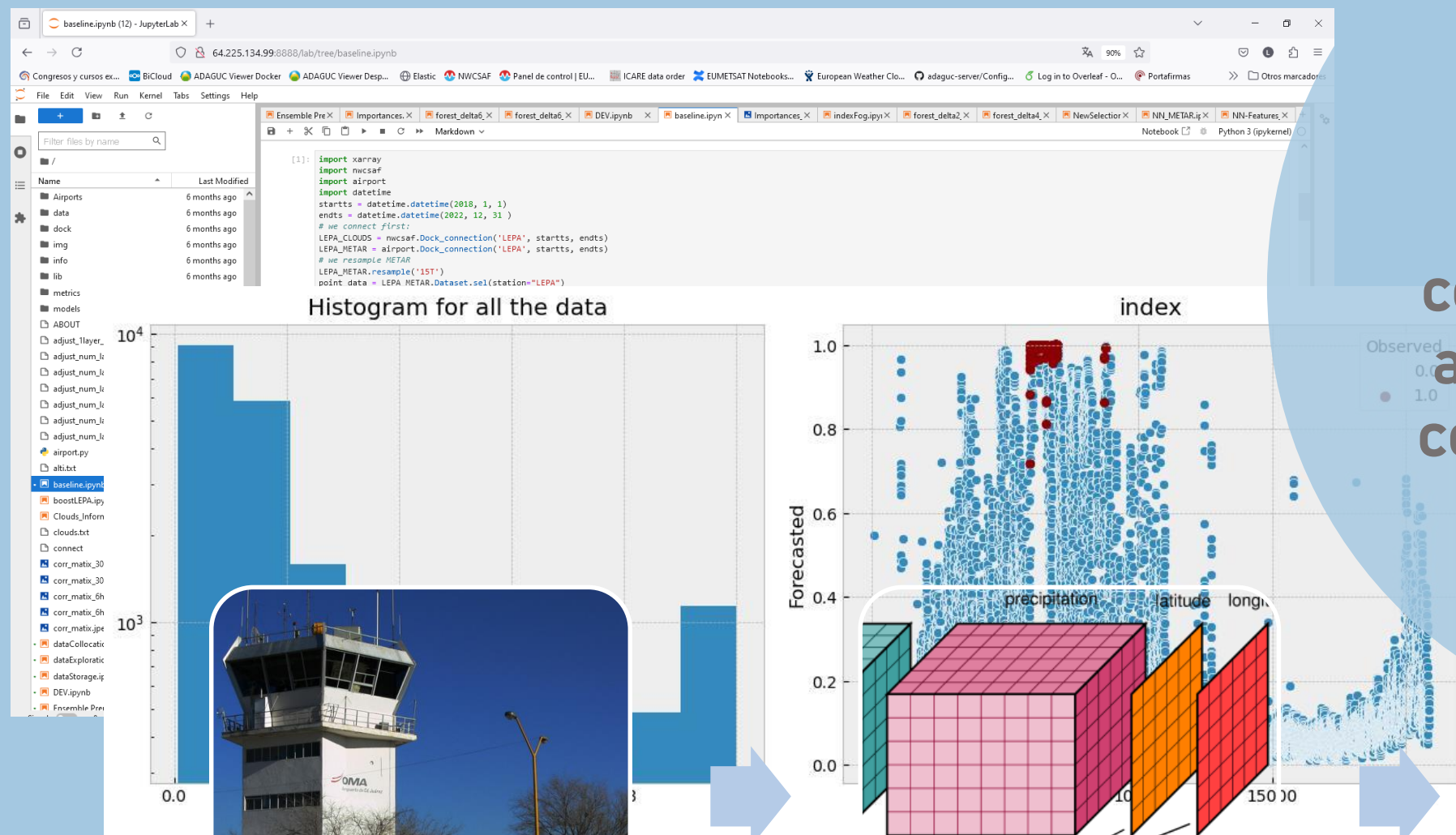
data = {'cma': True, 'ctth_pres': 24800, "ctth_tempe": 270, 'dewpt': 283.1499938964844, 'fog': False,
        'low_lev_inv': True, 'solar_elev': 2.770315058421099, 'station_pressure': 102732.6484375,
        'temp': 284.1499938964844, 'wind_dir': 320.0, 'wind_speed': 1.5433319807052612}

print("#####")
print("##### FORECAST: #####")
model.predict(data)
```

[]: # You can give a list of data

**Seventh notebook:
Developing own
models**

Summary



We provide the toolbox to the community through a jupyter notebook collection, allowing:

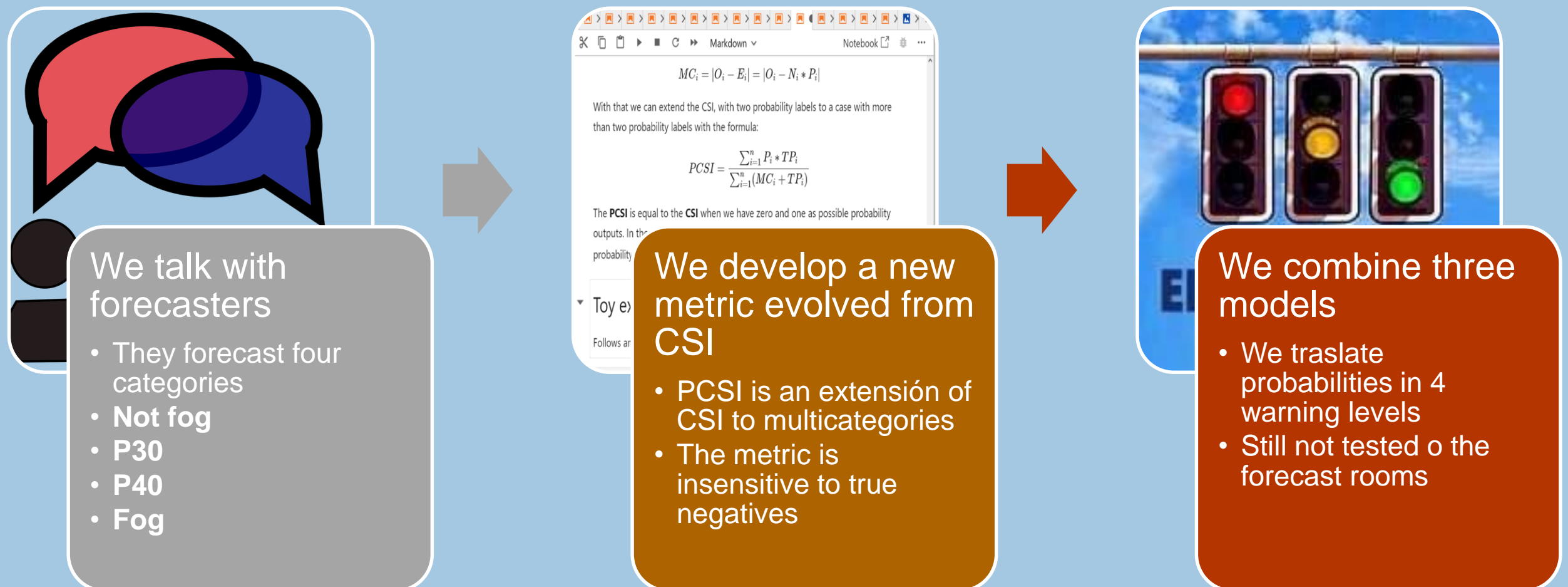
To choose a location

To download the data

To develop and test their own models

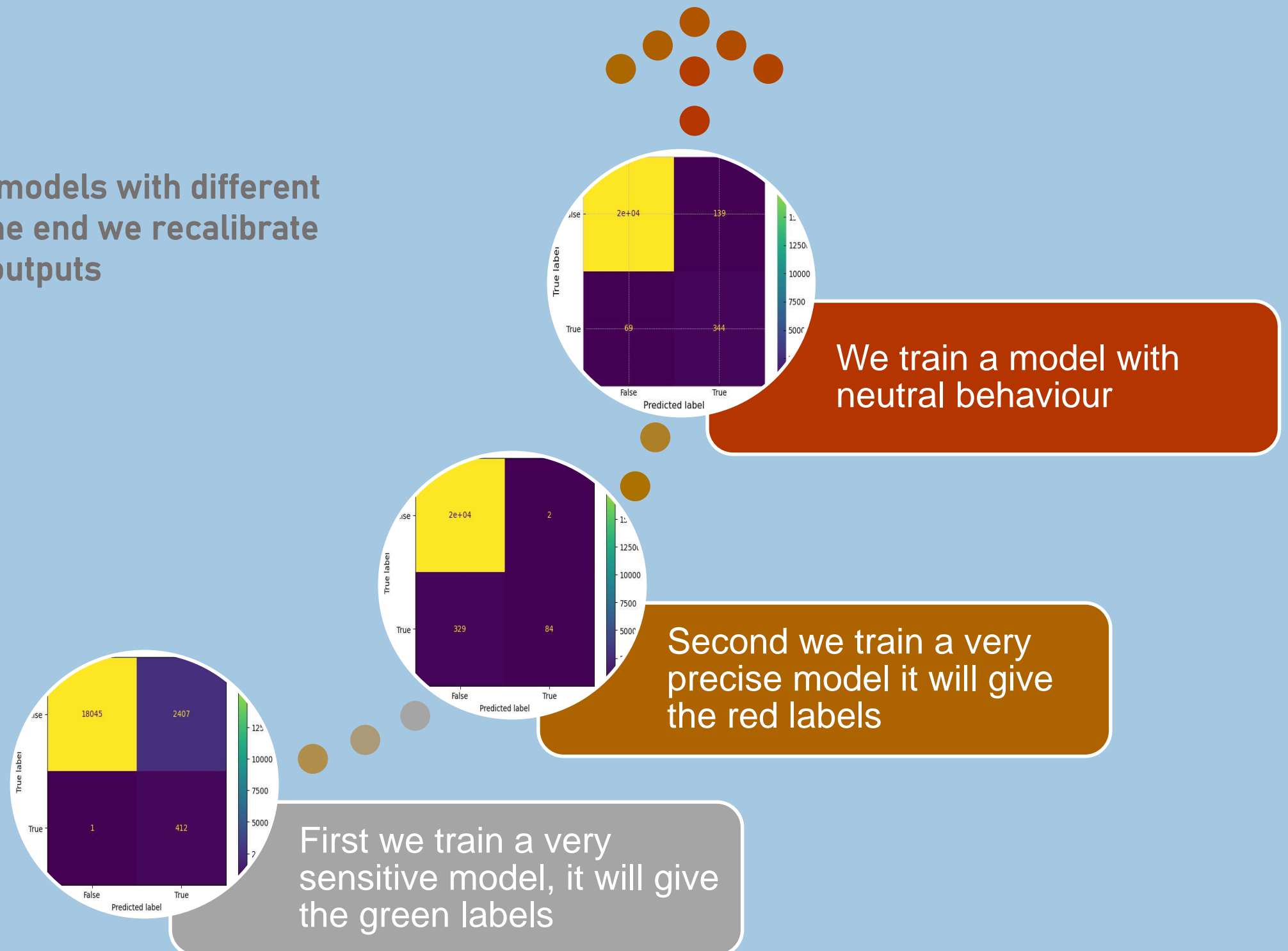
Dev>Ops

AEMET is in the process of testing in operations .



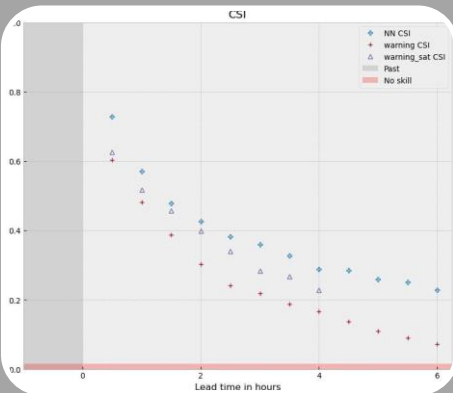
Dev>Ops

We combine three models with different behaviour and at the end we recalibrate the outputs



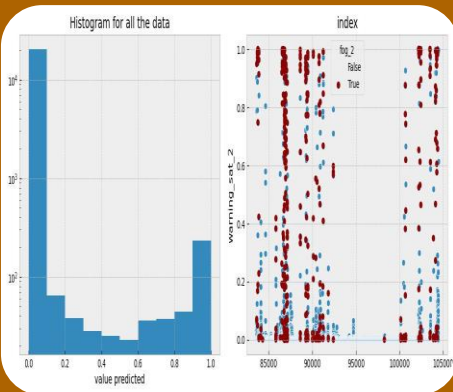
We are facing the problem with a boosting approach.

Dev>Ops



We are nowcating all time step at once

- The overall performance increases with radiances
- The model is more performant nowcasting time steps one by one



The model goes beyond persistence

- The model is able to nowcast fog with clear vibility
- The model is able to nowcast notfog in foggy situations

| | | | | |
|----|----|----|----|----|
| 1 | 3 | 6 | 10 | 15 |
| 2 | 5 | 9 | 14 | 19 |
| 4 | 8 | 13 | 18 | 22 |
| 7 | 12 | 17 | 21 | 24 |
| 11 | 16 | 20 | 23 | 25 |

Spatial and temporal info

- We are including the 4 previous time steps of the variables
- For spatial we are just including means and standard deviations of the spatial variables

Final valoration:





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Thank you for the attention!



Foto [Bernd](#) [Dittrich](#) at [Unsplash](#)

jlisov@aemet.es

NowcastIng of fog using AI (NAI) techniques using satellite observations

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Special thanks to Carla Barroso from EUMETSAT
NWC SAF home page: <http://nwc-saf.eumetsat.int>