Machine Learning Platform at MET Norway

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WeADL 2023 Workshop

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the WeaMyL project aims to

- enhance national nowcasting warning systems by the use of machine learning (ML) techniques applied on radar, satellite and ground based observations,

- automate the nowcasting warning systems by creating a ML driven platform for early forecast of severe phenomena

- Website: https://weamyl.met.no

Outline

- What is the Machine Learning driven Platform?
- Who is intended for?
- Components of the ML Platform
- How it is linked to other WeaMyL components?
- Deployment of the Machine Learning Platform.

Machine Learning driven Platform

- MET has developed the machine learning platform
- MET Norway has not developed the machine learning algorithm
- MET has provided expertise to the ML model

→ develop nowcasting warning systems by creating a ML-driven platform to allow for early forecast of severe phenomena

End users

Research meteorologists

- Run the machine learning algorithm on demand
- Search annotated events from the Atlas and evaluate the ML models

Operational meteorologists,

- Check the latest forecast issued from the automatic ML jobs
- Review the latest warnings
- Give the earlier warnings hit rate grades

Flowchart of the main components of the Annotated Atlas

Components of the Machine Learning Platform

- Front-end
  - Thredds data server
  - Open Geoweb
- Back-end
  - Machine Learning algorithm
  - PPI jobs

Flowchart of the main components of the ML platform

Front-Ends of the WeaMyL System

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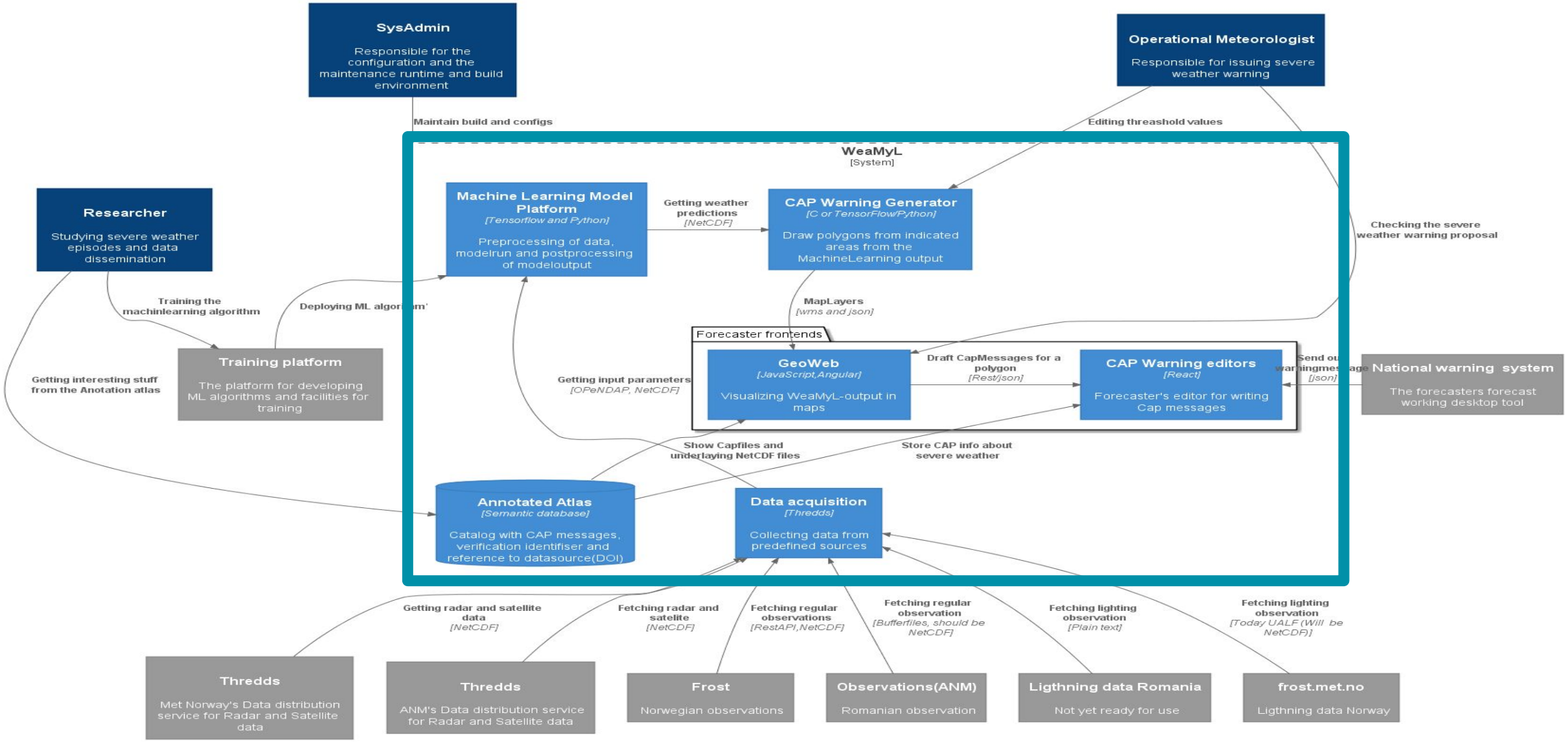
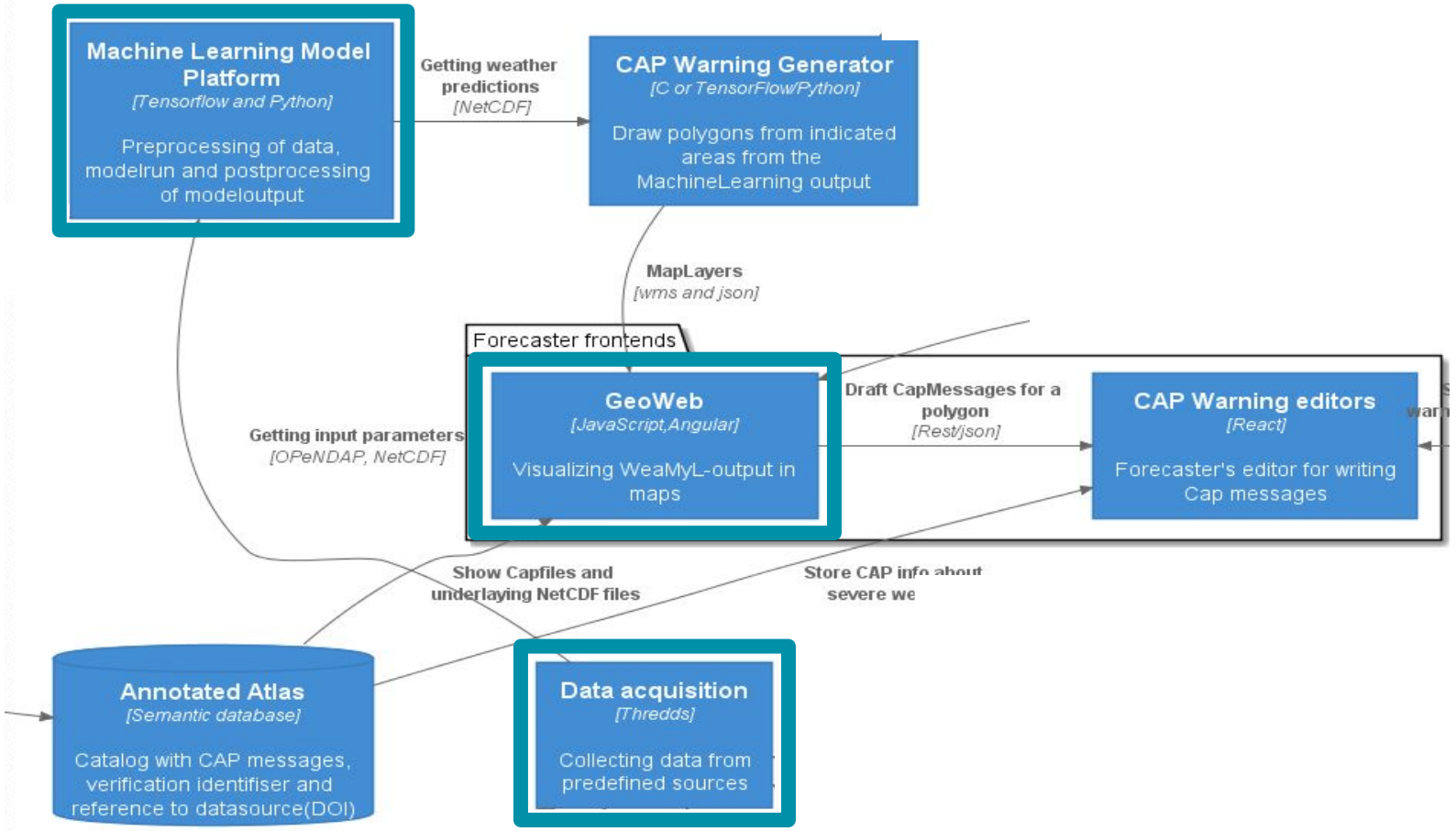
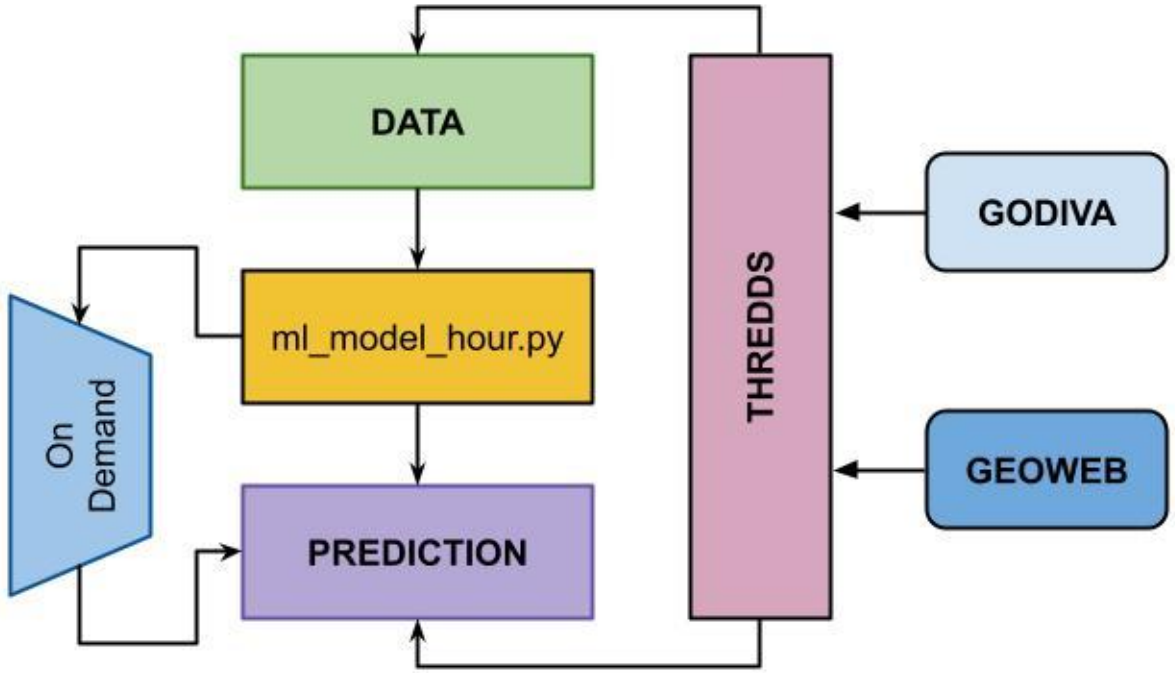


Zoom on the components of the WeaMyL System



WeaMyL ML platform



Simplified flowchart of the machine learning platform

```
# run a virtual environment using conda
$ source conda.sh

# Activate a working environment
$ conda activate production-10-2022

# (production-10-2022)
abdelkaderm@ppi-blogin-a1:~$

# Run python scripts with different inputs

## Automatic jbs
$ python ML_model_hour.py 'latest'

## On demand jobs
$ python ML_model_hour.py '20220628T1000'
```

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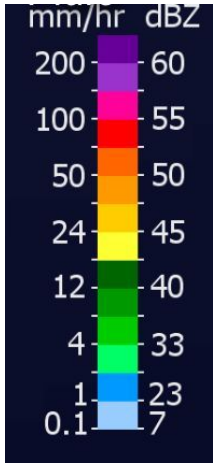
How to access the data from MET Norway TREDDS Data Server?

e.g. recorded and predicted reflectivity factor …

Equivalent Reflectivity Factor (Z)

- *Equivalent Reflectivity factor Z (in dBZ) reflecting the amount of transmitted power returned to the radar receiver after hitting precipitation - composite means compiling all returns from all elevation scans.'*
- *Precipitation targets produce a range of dBZ values to more than 60 dBZ ~ 200 mm/h in extremely heavy rain and/or hail*
- known as Marshall–Palmer relation which is an empirical relationship of the form $Z = aR^b$



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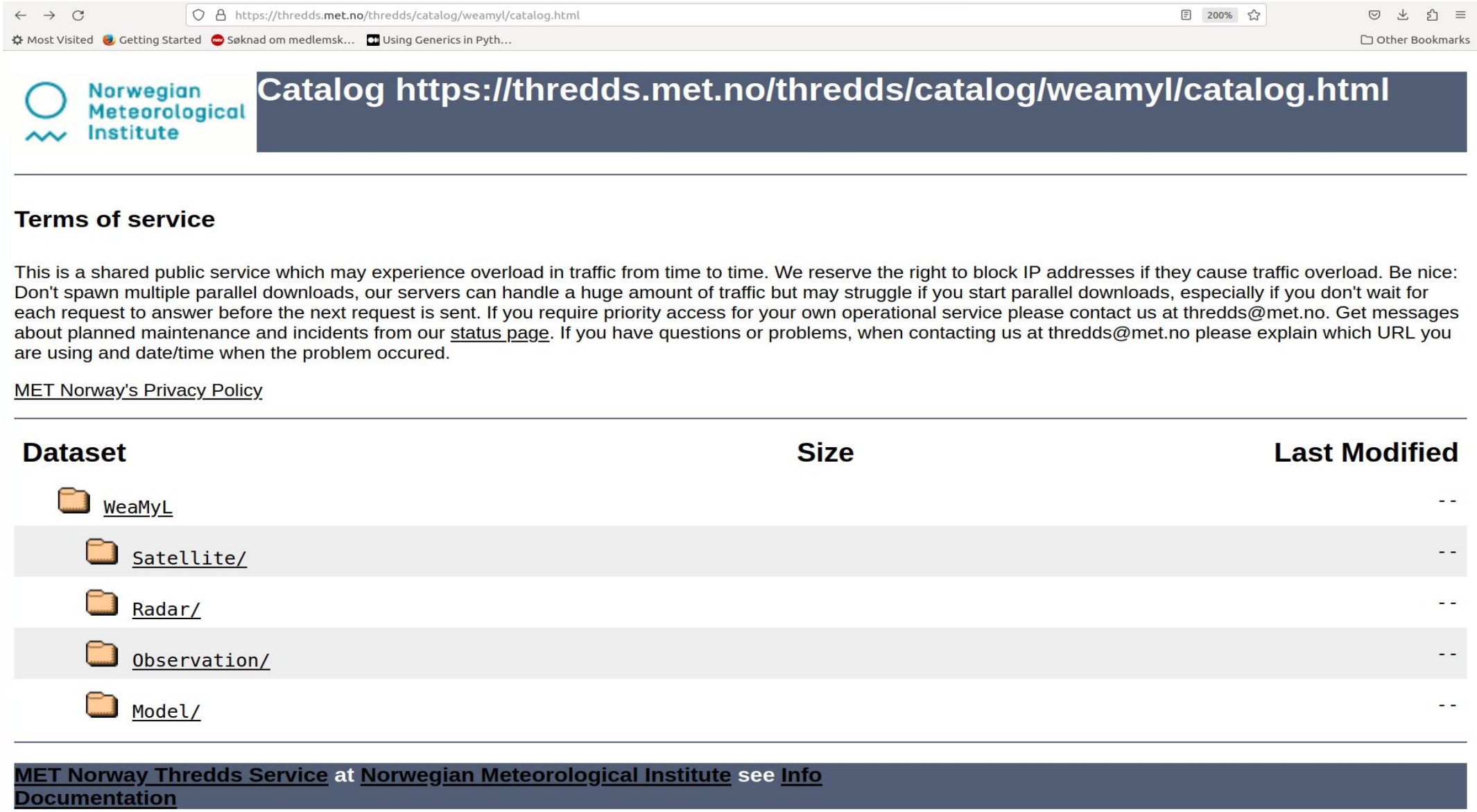
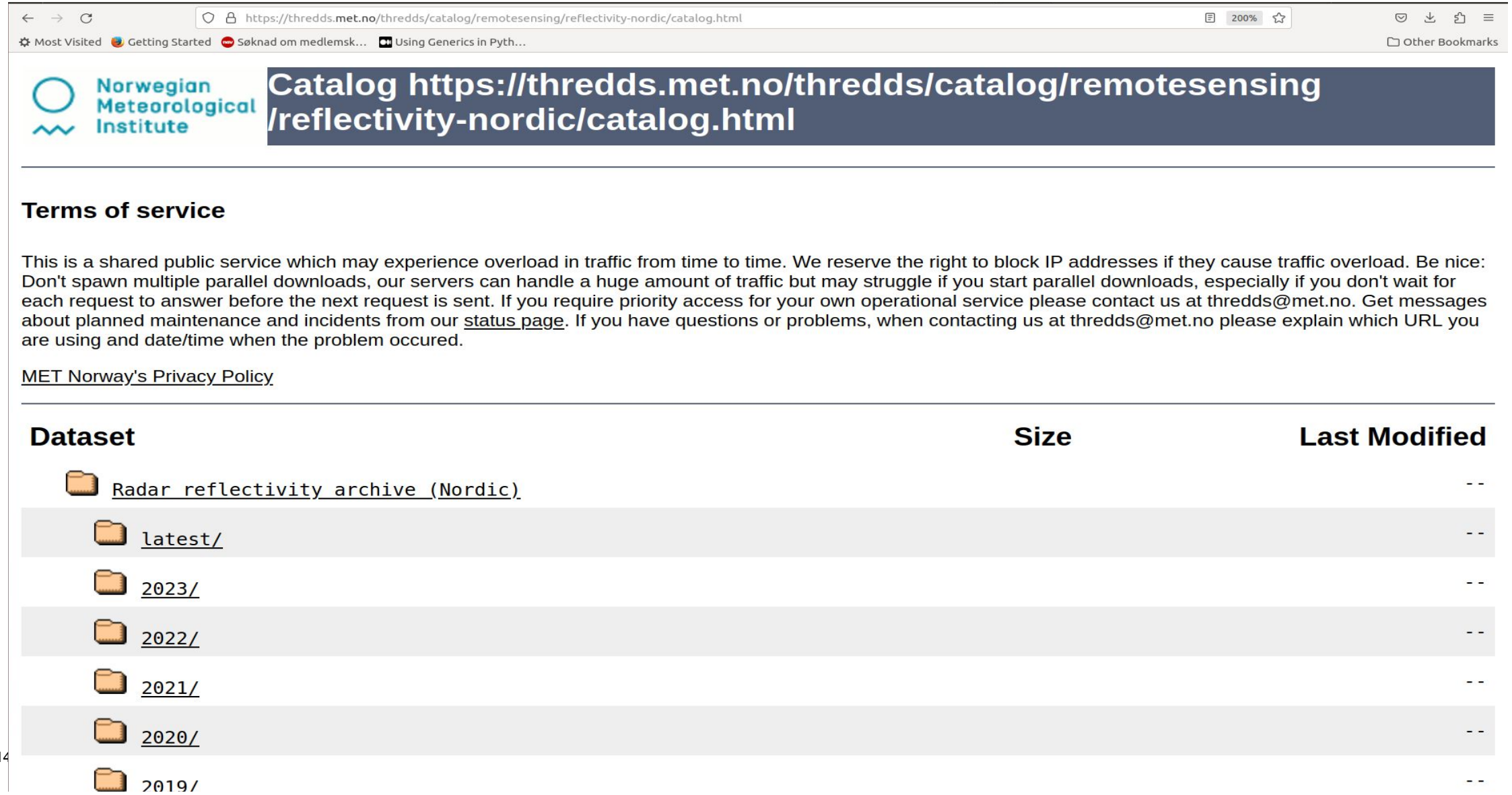
Accessing the project folder …



Accessing the predicted data …

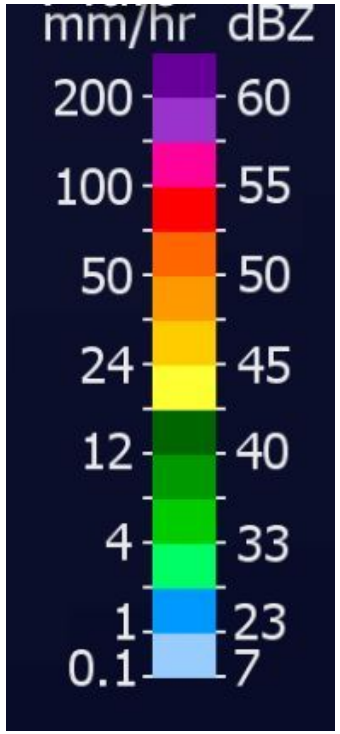
Accessing the observations …



Composite Reflectivity factor as input to ML

- *Equivalent Reflectivity factor Z (in dBZ) reflects the transmitted power which is returned to the radar receiver after hitting water particles (precipitation)*
- Composite means *compiling all returns from all elevation scans to get a best estimate*
- Marshall–Palmer relation (1984) which is an empirical relationship of the form $Z = aR^{b,}$

  where R is the rainfall rate
- *Precipitation targets produce a range of reflectivity values to more than 60 dBZ ~ 200 mm/h in extremely heavy rain and/or hail* known



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How to visualise the recorded and predicted/forecasted data?

e.g. data : recorded and predicted composite reflectivity factor

tool : Open Geoweb application

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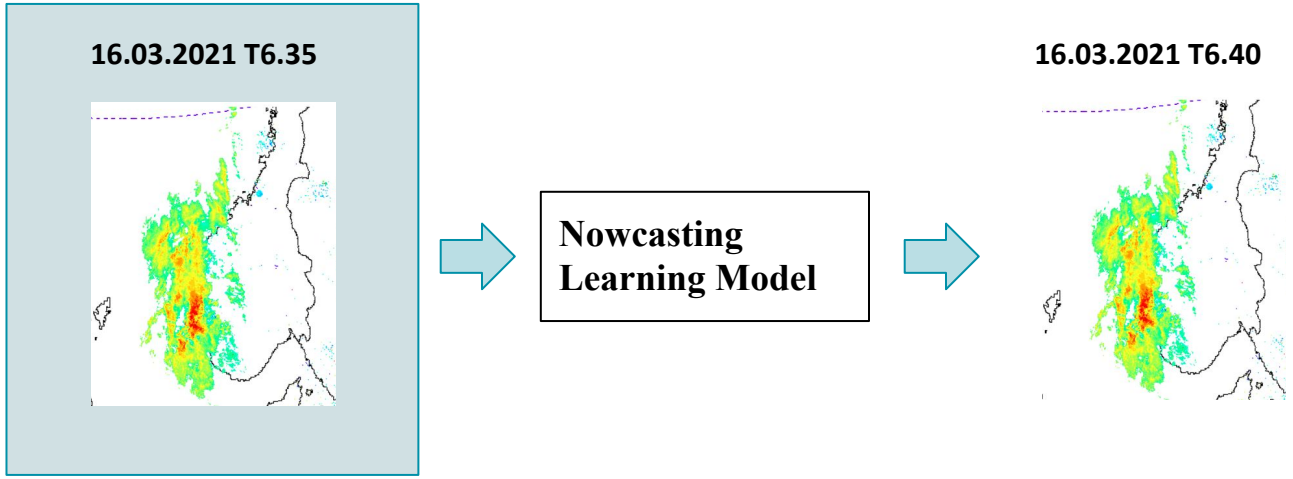
Machine learning model versions

- version 0
- version 1
- version 2

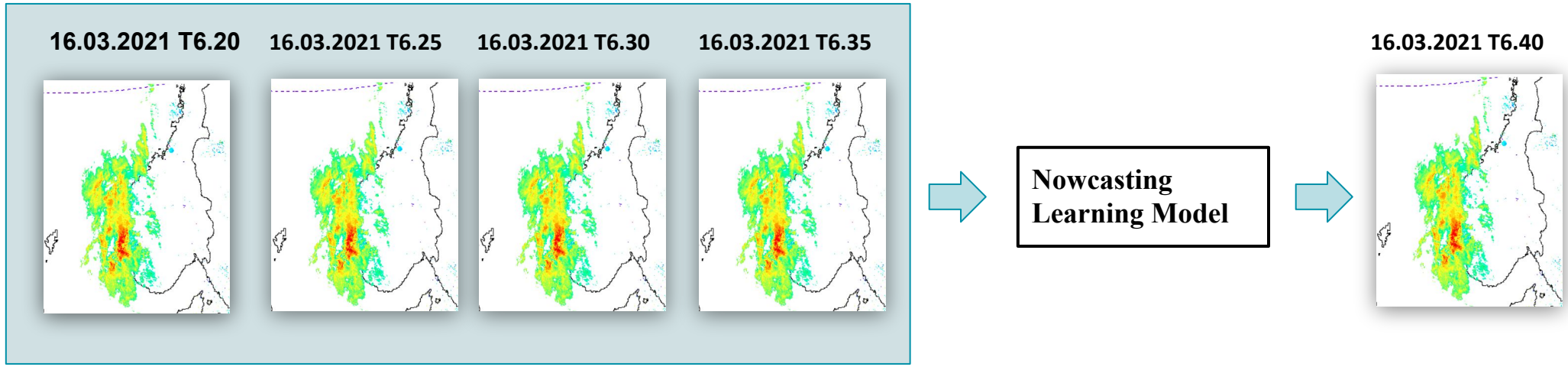
ML model version 0

$$Learning\ function: \quad f_o\,(G_{t-5}) = G_t$$



ML model version 1

$$Learning\ function: \quad f_1(G_{t-20}, G_{t-15}, G_{t-10}, G_{t-5}) = G_t$$



ML Model version 2

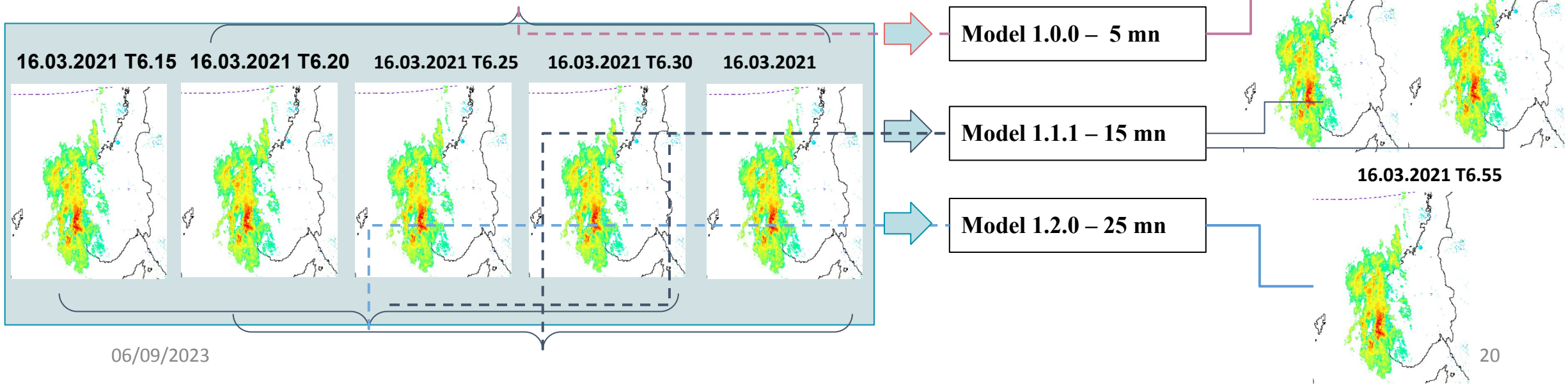
Learning functions :

$$f_{2,5}\,(G_{t-20},G_{t-15},G_{t-10},G_{t-5}) = G_{t}$$

$$f_{2,15}\,(G_{t-25},G_{t-20},G_{t-15},G_{t-10}) = G_{t+5}$$

$$f_{2,15}\,(G_{t-20},G_{t-15},G_{t-10},G_{t-5}) = G_{t+10}$$

$$f_{2,25}\,(G_{t-25},G_{t-20},G_{t-15},G_{t-10}) = G_{t+15}$$



XNow model

- XNow - Xception-based ensemble of N model(s) trained on a dataset containing N days of radar data (thredds.met.no).
- Each model has been trained on a region of approximately 300km x 300km surrounding Oslo for predicting the composite reflectivity values in the future using current radar values and an improved loss function.
- The day used for illustrating the predictions has not been used for training.
- Different versions
    - 1.0.0 (1 model trained on 45 days of historical data)
    - 2.0.0 (3 models),
    - 2.0.3 (3 models trained on 45 days of historical data)
    - 2.0.5 (3 models trained on 45 days of historical data)
    - 3.0.0 (3 models trained on 102 days of historical data)

I. A. Socaci, G. Czibula, V. -S. Ionescu and A. Mihai, "XNow: A deep learning technique for nowcasting based on radar products' values prediction," *2020 IEEE 14th International Symposium on Applied Computational Intelligence and Informatics (SACI)*, Timisoara, Romania, 2020, pp. 000117-000122, doi: 10.1109/SACI49304.2020.9118849.

Model Evaluation

WeaMyL ML working environment

- Python programming language
- Bash scripting language
- Required packages :
  - TensorFlow,
  - xarray,
  - numpy,
  - netCDF4 python library
  - etc.
- CDO (Climate Data Operator) to manipulate netCDF files

PPI Job (shell script)

```
# Activate the tensorflow environment
source /modules/rhel8/conda/install/etc/profile.d/conda.sh
conda activate TensorFlowGPU-03-2022
# Input of starting forecasting time in the format
TIME='20220316T0640000Z'
or
TIME='latest'

# time steps of 5 min ahead
NSTEPS='24'
# Run the ML script
python3 multiple_ml_models.py $TIME $NSTEPS
```

Basic call

```
$ sh ML_model_hour_job_PPI_20220316.sh
Calling WeaMyL ML platform …
Generated time: 2022-03-16 T06:40:00 …. with ML model 1.0.0
Generated time: 2022-03-16 T06:45:00 …. with ML model 1.1.0
Generated time: 2022-03-16 T06:50:00 …. with ML model 1.1.0
Generated time: 2022-03-16 T06:55:00 …. with ML model 1.2.0
……..
……..
Generated time: 2022-03-16 T08:20:00 …. with ML model 1.0.0
Generated time: 2022-03-16 T08:25:00 …. with ML model 1.1.0
Generated time: 2022-03-16 T08:30:00 …. with ML model 1.1.0
Generated time: 2022-03-16 T08:35:00 …. with ML model 1.2.0
```

Output as netCDF4 files

```
$ ls weamyl/weamyl_model/tmp/*20220316*_v2.nc
yrwms-nordic.mos.pcappi-0-dbz.noclass-clfilter-novpr-clcorr-block.nordiclcc-1000.20220316T064000Z_v2.nc
yrwms-nordic.mos.pcappi-0-dbz.noclass-clfilter-novpr-clcorr-block.nordiclcc-1000.20220316T064500Z_v2.nc
yrwms-nordic.mos.pcappi-0-dbz.noclass-clfilter-novpr-clcorr-block.nordiclcc-1000.20220316T065000Z_v2.nc
yrwms-nordic.mos.pcappi-0-dbz.noclass-clfilter-novpr-clcorr-block.nordiclcc-1000.20220316T065500Z_v2.nc
……..
……
yrwms-nordic.mos.pcappi-0-dbz.noclass-clfilter-novpr-clcorr-block.nordiclcc-1000.20220316T082000Z_v2.nc
yrwms-nordic.mos.pcappi-0-dbz.noclass-clfilter-novpr-clcorr-block.nordiclcc-1000.20220316T082500Z_v2.nc
yrwms-nordic.mos.pcappi-0-dbz.noclass-clfilter-novpr-clcorr-block.nordiclcc-1000.20220316T083000Z_v2.nc
yrwms-nordic.mos.pcappi-0-dbz.noclass-clfilter-novpr-clcorr-block.nordiclcc-1000.20220316T083500Z_v2.nc


$ cdo -mergetime *20220316*v2.nc ../output/version2/test_v2_20220316.nc
```

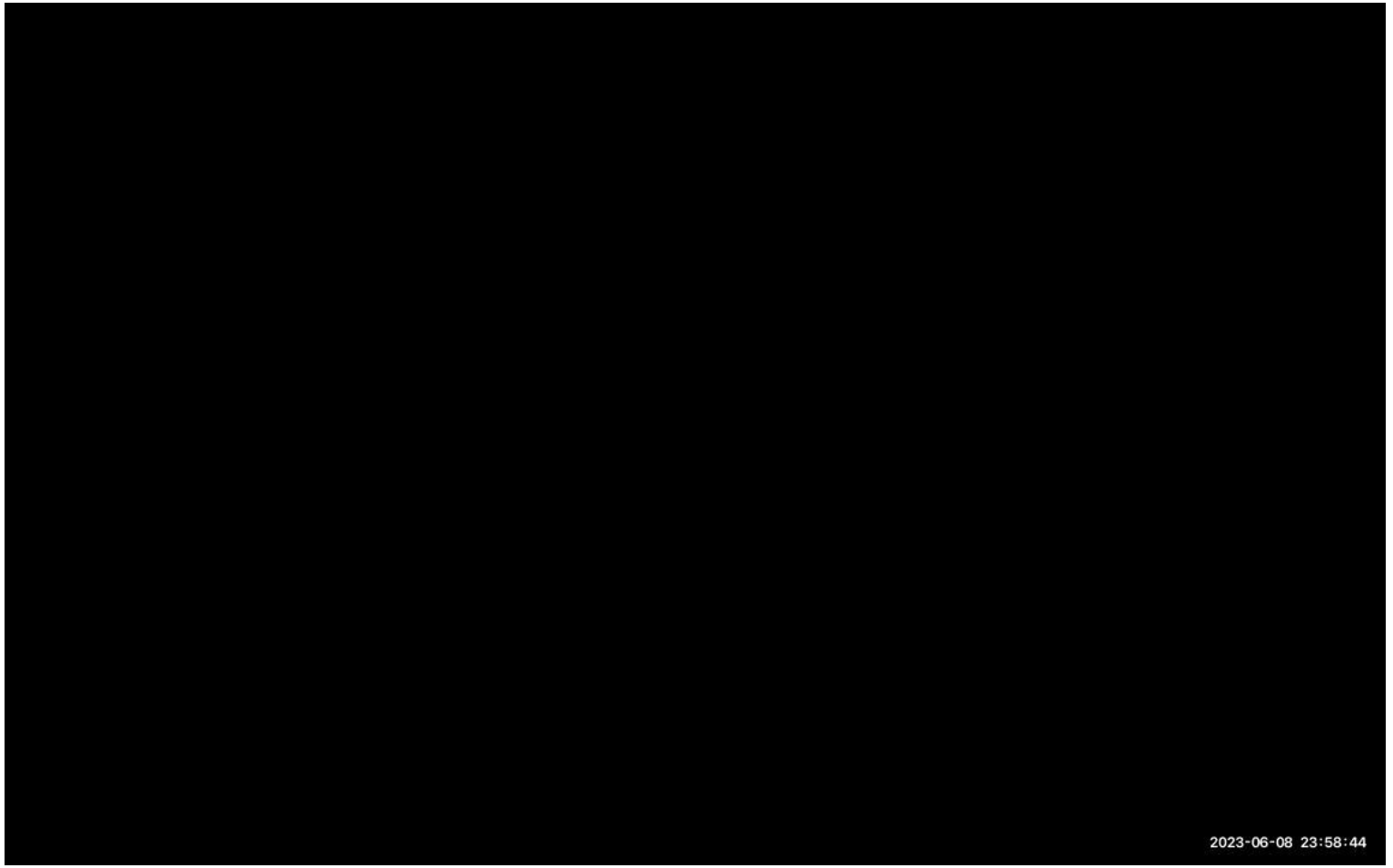
How to access and visualise the results

1. Access the data for both observations and predictions from MET Norway TDS
   - https://thredds.met.no/thredds/catalog/remotesensing/reflectivity-nordic/catalog.html
   - https://thredds.met.no/thredds/catalog/weamyl/Model/catalog.html
2. Quick animation to visualise the results using Godiva2 web-browser
3. Visualise and make a comparison between observations and predictions using
   - OpenGeoWeb https://demo.OpenGeoWeb.com

Visualise the results

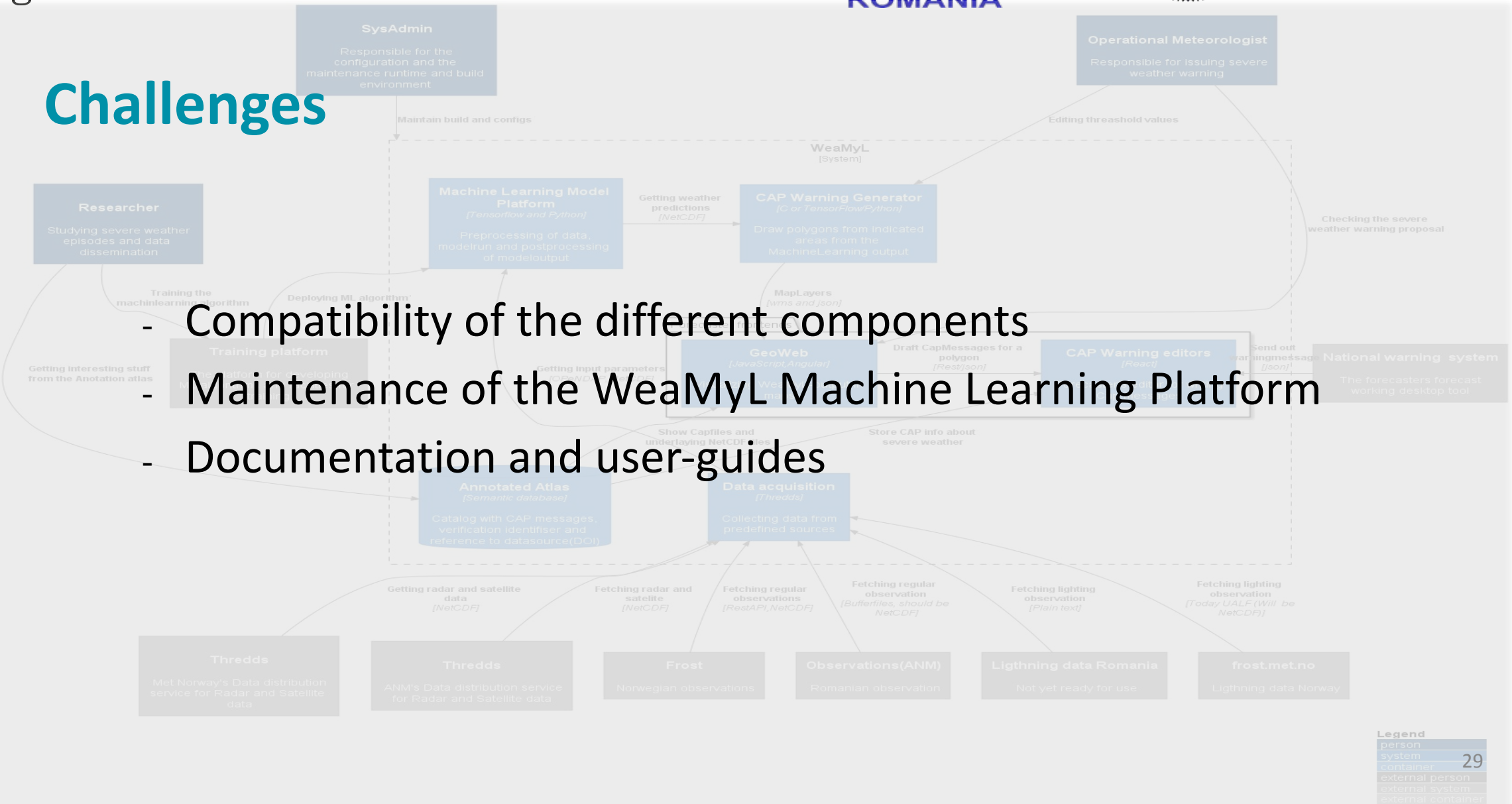
Godiva

web-browser



Challenges

- Compatibility of the different components
- Maintenance of the WeaMyL Machine Learning Platform
- Documentation and user-guides



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