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Machine Learning Platform at MET Norway

Abdelkader Mezghani

WeADL 2023 Workshop

The workshop is organized under the umbrella of WeaMyL, project funded by the EEA and Norway Grants under the RO-NO-2019-0133. Contract: No 26/2020











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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





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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.











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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

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











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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

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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



Legend person system

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Zoom on the components of the WeaMyL System



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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 ...

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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 ...

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MET Norway's Privacy Policy

Dataset	Size Last Modif	ied
WeaMyL		
Satellite/		
Radar/		
Observation/		
Model/		

12 MET Norway Thredds Service at Norwegian Meteorological Institute see Info Documentation

Accessing the predicted data ...

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MET Norway's Privacy Policy

Dataset	Size Last Modified
Model	
version2/	
version1/	
version0/	
test/	

Accessing the observations ...

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O A https://thredds.met.no/thredds/catalog/remotesensing/reflectivity-nordic/catalog.html

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MET Norway's Privacy Policy

Dataset	Size	Last Modified
Radar reflectivity archive (Nordic)		
latest/		
<u>2023/</u>		
<u>2022/</u>		
<u>2021/</u>		
<u> </u>		
2019/		











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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
- <u>Marshall–Palmer relation</u> (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

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ML model version 0

Learning function : $f_{o}(G_{t-5}) = G_{t}$













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ML model version 1

Learning function:
$$f_{I}(G_{t-20}, G_{t-15}, G_{t-10}, G_{t-5}) = G_{t}$$





16.03.2021 T6.40





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ML Model version 2 16.03.2021 T6.40 Learning functions : $f_{2.5} (G_{t-20}, G_{t-15}, G_{t-10}, G_{t-5}) = G_{t}$ $f_{2,15} (G_{t-25}, G_{t-20}, G_{t-15}, G_{t-10}) = G_{t+5}$ $f_{2.15} (G_{t-20}, G_{t-15}, G_{t-10}, G_{t-5}) = G_{t+10}$ 16.03.2021 T6.45 16.03.2021 T6.50 $f_{2.25} (G_{t-25}, G_{t-20}, G_{t-15}, G_{t-10}) = G_{t+15}$ Model 1.0.0 - 5 mn 16.03.2021 T6.15 16.03.2021 T6.20 16.03.2021 T6.25 16.03.2021 T6.30 16.03.2021 Model 1.1.1 – 15 mn 16.03.2021 T6.55 Model 1.2.0 – 25 mn 20

06/09/2023

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XNow model

- XNow Xception-based ensemble of N model(s) trained on a dataset containing N days of radar data ٠ (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. ٠
- ٠
- 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) ٠
 - 2.0.5 (3 models trained on 45 days of historical data)
 - 3.0.0 (3 models trained on 102 days of historical data) ٠

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.

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Model Evaluation

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WeaMyL ML working environment

- Python programming language
- Bash scripting language
- Required packages :
 - TensorFlow,
 - xarray,
 - numpy,
 - netCDF4 python library
 - \circ etc.

• CDO (Climate Data Operator) to manipulate netCDF files

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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

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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

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Output as netCDF4 files

\$ is 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-1000.20220316T065500Z_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

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



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How to access and visualise the results

- 1. Access the data for both observations and predictions from MET Norway TDS
 - <u>https://thredds.met.no/thredds/catalog/remotesensing/reflectivity-nordic/catalog.html</u>
 - <u>https://thredds.met.no/thredds/catalog/weamyl/Model/catalog.html</u>
- 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

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Visualise the results

Godiva web-browser





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