FINAL REPORT PROGRAM LEFE

Program LEFE/ MANU	**I2ADMET** : Artificial Intelligence methods for the detection of rainfall texture objects in Numerical Weather Prediction (NWP) outputs	**Year 2019**

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Context

Operational weather forecasting at Météo-France aims at anticipating high-impact weather such as heavy precipitating events and thunderstorms. Around hundred high-resolution NWP forecasts are issued daily, and must be exploited by forecasters in real time. Faced with this huge amount of information there is thus a need to develop innovative tools in order to extract the relevant signal and facilitate the human expertise.

Objectives / scientific questions

The main approach followed in this project is the automatic detection of large-scale homogeneous precipitation patterns in NWP forecasts, according to their spatial organization (hereafter called « texture »). Several machine learning and deep learning algorithms commonly used for pattern recognition have been applied to perform the segmentation of rainfall forecasts in three categories, corresponding to no precipitation, continuous precipitation and intermittent precipitation.

Main results

A database consisting of several hundreds of kilometric rainfall forecasts from the French Arome model has been designed, with the corresponding groundtruth per-pixel handmade texture labels. Logistic regression, random forests and a convolutional neural networks (CNN) based on the U-Net architecture have been trained and evaluated on this database.

While continuous rainfall is properly identified by all methods, the accuracy of intermittent rainfall detection depends on the method and the best results are obtained using random forests and CNN.

Since the development of training databases is time-consuming, the capacity of algorithms trained on a specific dataset to generalise on precipitation outputs from different versions of the Arome model (including in particular a change of model grid spacing) and on rainfall observations has also been examined. This transfer of knowledge is shown to work quite well in most cases.

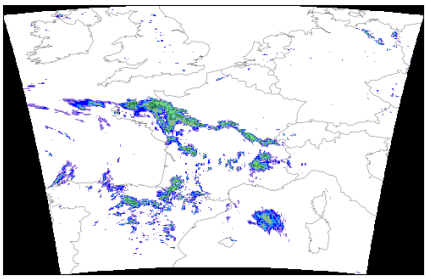

Fig1 : One-hour accumulated rainfall forecast from the French Arome model (in mm), valid on June 03 2018 at 18 UTC.

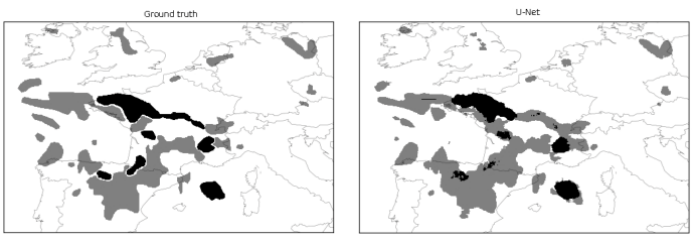

Fig 2 : The corresponding groundtruth texture labels for continuous and intermittent rainfall in black and grey respectively (left), and the corresponding segmentation results using the U-Net (right).

Figure 2 illustrates the ability of the U-Net algorithm to accurately segment the rainfall forecast of Figure 1 in three categories. Both continuous (black) and intermittent (grey) rainfall patterns detected by the U-Net are in good agreement with the manually-labeled groundtruth.

Future of the project : This project has shown the potential of Artificial Intelligence and in particular convolutional neural networks for weather objets detection. Based on these encouraging results the U-Net is currently being adapted to detect a wide variety of objects with different shapes and scales, such as weather fronts, tropical cyclones and damaging thunderstorms. With GPUs now available on the new HPC at Météo-France, the transfer of these object post-processing from research to operations will be considered in the short term.
The use of AI for enhancing NWP in cases of high-impact weather will also be further explored. It is the purpose of the POESY project submitted to ANR AAP 2021.

Nombre de publications, de communications et de thèses

Publication

Y. Hamidi, L. Raynaud, L. Rottner and P. Arbogast : Texture-based segmentation of high-resolution precipitation forecasts with machine-learning methods. *Q. J. R. Meteorol. Soc., Volume 146, Issue 732,* October 2020 Part A, 3014-3028, https://doi.org/10.1002/qj.3823

Communications

Hamidi et al., Object-processing of high-resolution precipitation forecasts based on intensity and texture segmentation ; AMS 99th Annual Meeting, Phoenix, USA, January 2019

Hamidi et al., La détection et la caractérisation automatiques de la texture des précipitations, Rencontres R&D 2019, Météo-France, Journée spéciale Intelligence Artificielle, Juin 2019

L. Raynaud, Object-based processing of high-resolution precipitation forecasts, from detection to practical applications, AGU Fall Meeting, San Francisco, USA, December 2019

L. Raynaud, Automatic detection of weather events in high-resolution NWP outputs, invited presentation at ECMWF-ESA Workshop on Machine Learning for Earth System Observation and Prediction, virtual event, 5-8 October 2020.

PhD-thesis of Yamina Hamidi, University Toulouse 3 Paul Sabatier, defended on 30th november 2020.