SEVERE WEATHER IDENTIFICATION USING POLARIMETRIC RADAR AND MACHINE LEARNING TECHNIQUES

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Objective

Severe Weather Events (SWE) identification in Southern Brazil, using a polarimetric weather radar data with Machine Learning (ML) techniques.

Introduction

This work presents our experience with radar data analysis for single and dual polarimetric systems, using machine learning techniques to explore complex data and obtain an overview and better understanding of the observed phenomena.

In less than 5 years, in Brazil we increased our radar coverage, from 23 single polarization weather radars to 15 more new dual polarization radars, mainly S-Band, with a concentration in the southern region, an area prone to severe weather, mostly related to Mesoscale Convective Systems. Weather radars in the south of Brazil play an important role in quantitative precipitation estimation and severe weather monitoring and forecasting. The major economical activity in this region is agro-industry and en-ergy production, responsible for more than 35% of hydropower energy generation used in the country, directly dependent on precipitation dis-tribution, water availability and severe storms impacts.

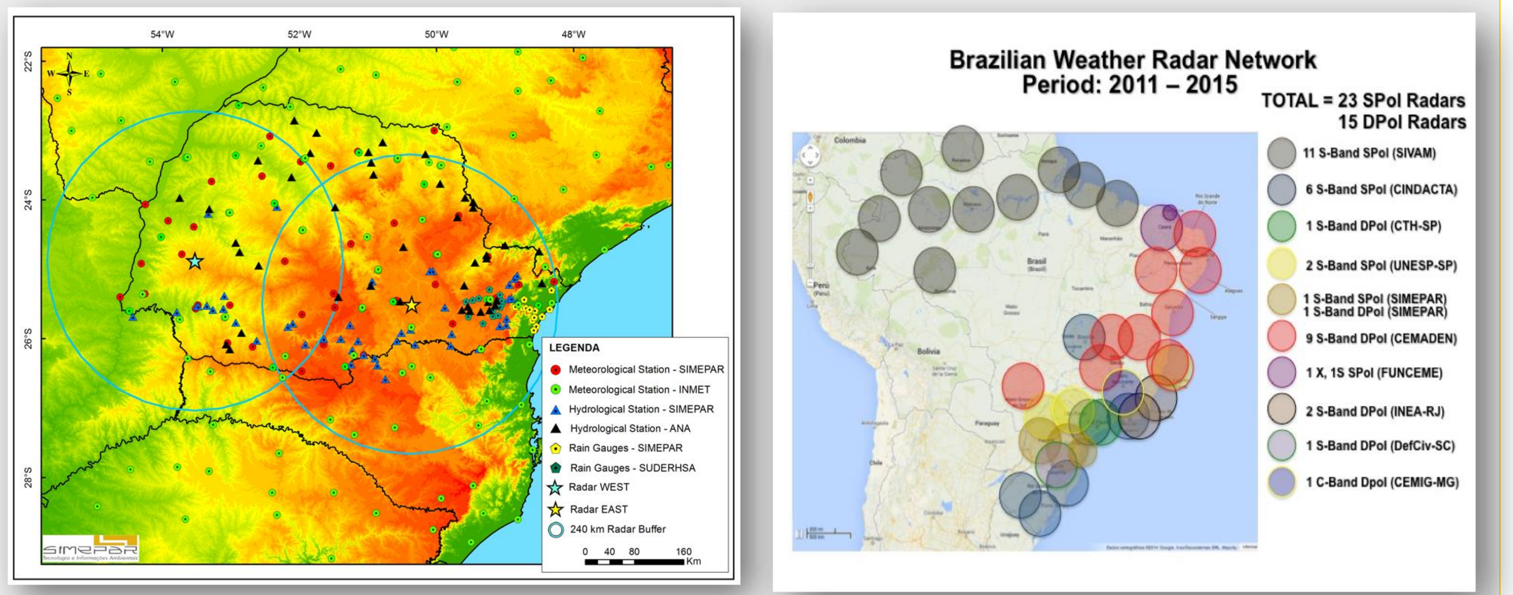

Fig. 1: Brazilian weather radar network (left); and Hydrometeorological System in Parana State, with 2 S-Band weather radars, 1 Single Pol and 1 Dual Pol (right).

Data

- **Radar:** Volumetric scans from polarimetric weather radar.
- **Atmospheric electric discharges:** Total lightning data from Earth Networks Total Lightning Network (ENTLN).
- **Period:** January 2015 to July 2016

Methodology

The polarimetric moments used were Z, ZDR, KDP and RHOHV and radar products such as height of the maximum reflectivity (HMAX), and azimuthal, vertical and radial shear.

a) A damage occurred on 12/28/2015. This SWE had a precipitation of 61 mm in 4 hours, causing several floods.

b) Damage caused by a tornado on 03/22/2016 (Cândido Randon city).

c) Tornado on 03/22/2016 (Cândido Randon city)

d) A funnel cloud occurred on 13 july 2015.

Fig. 2: Some examples of studied SWE

Machine Learning (ML) is an Artificial Intelligence subarea. Multilayer Perceptron (MLP) and Support Vector Machine (SVM) are one of the most used ML techniques. MLP and SVM were trained with radar data input, to provide M-MLP and M-SVM identification models, respectively.

To validate the regions where the occurrence of SWE is unknown the M-ENTLN model was obtained by using ENTLN total lightning data, that means a SWE identification by using high total-lightning density or lightning jumps.

Results

Table 1 shows the correct identification by models only in the previously identified regions. And all regions identified are compared in table 2.

Table 1: Correct identification by M-MLP, M-SVM in in training, test and general data set.

Model	Training set	Test set	General set
M-MLP	78,78 %	90%	81,40%
M-SVM	90 %	100 %	93,02%

Table 2: Identification by M-MLP and M-SVM models compared to M-ENTLN.

Set	Model	Model and M-ENTLN	Only M-ENTLN
Training	M-MLP	75 %	32,5%
	M-SVM	75 %	23,94 %
Test	M-MLP	57,37 %	30,88 %
	M-SVM	55,42 %	23,33 %
General	M-MLP	68,58 %	32,02 %
	M-SVM	67,84 %	23,76 %

Figures 3, 4 and 5 show examples of model identification, in a reflectivity PPI. The black dots represent the points identified by the models, and the circle indicates known SWE.

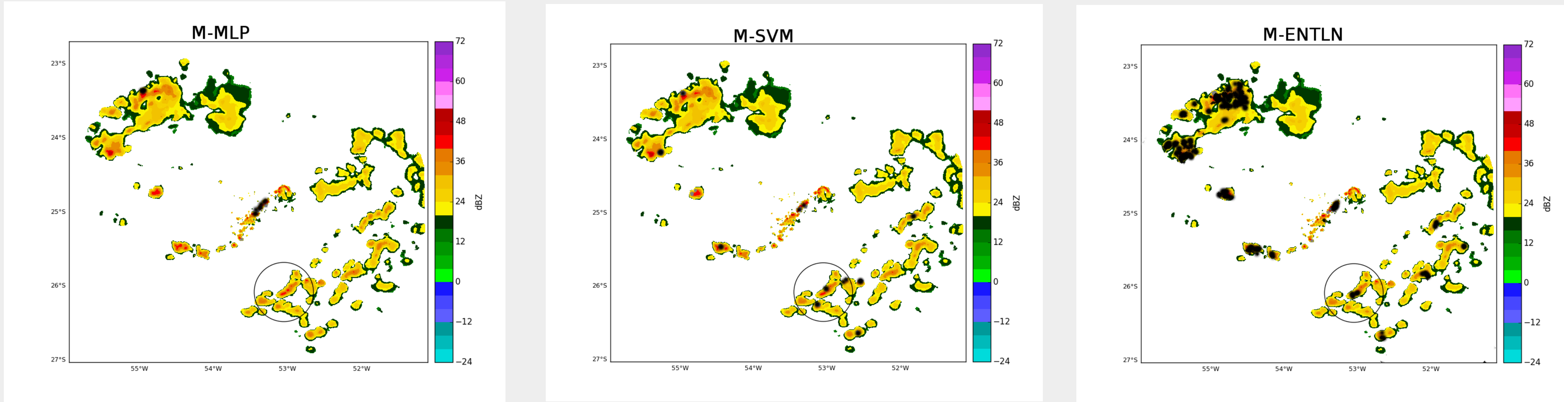

Figure 3: Output from models M-MLP, M-SVM and M-ENTLN on 12/28/2015, 09:15 PM (SWE in Fig 2(a).

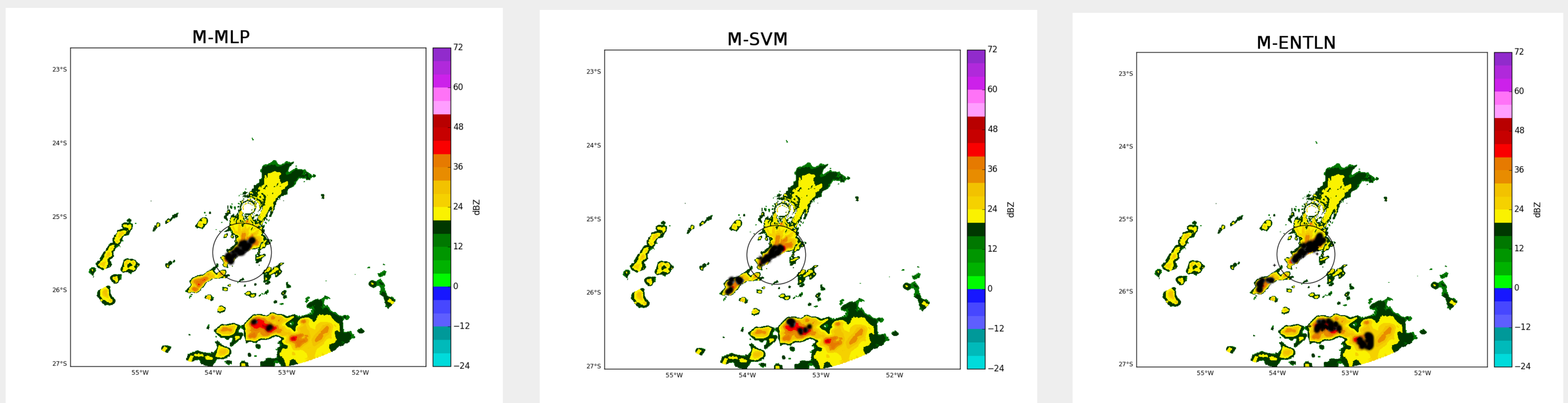

Figure 4: Output from models M-MLP, M-SVM and M-ENTLN on 03/22/2016, related Fig, 2(b) and Fig. 2(c).

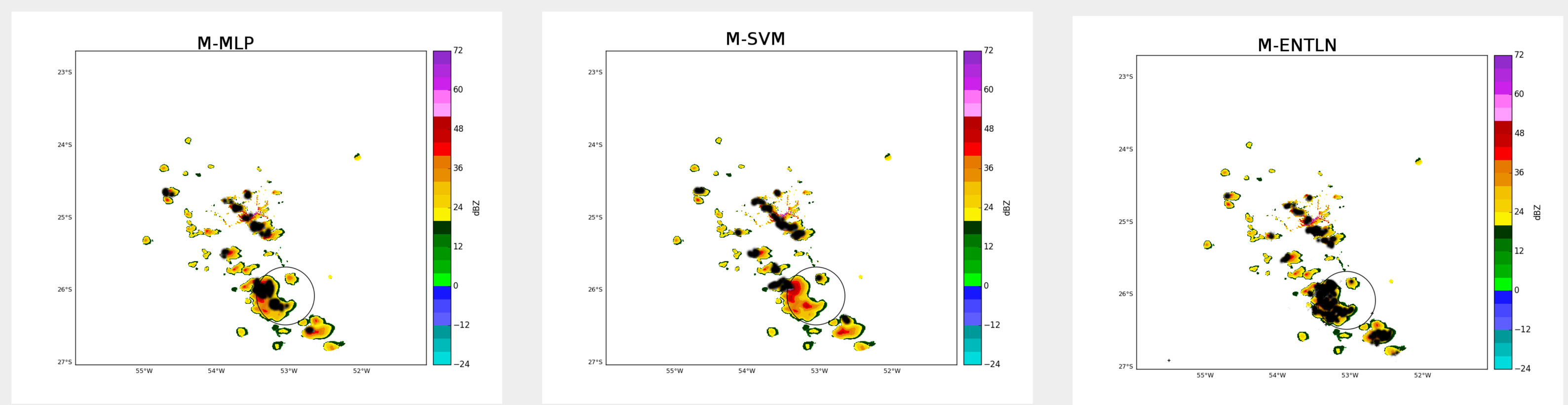

Figure 5: Output from models M-MLP, M-SVM and M-ENTLN on 07/13/2015, related Fig 2(d).

Comments and Conclusions

The performance of the models may be directly related to the inaccuracy of location information, time and duration of events, but 80% of the events were fully identified during the 30 minutes preceding the SWE. In addition, some regions which were not previously identified as SWE, were indicated by the models as possible occurrence of severe weather. In regions where the models were not applied during training, a comparison was made with total lightning data. This comparison showed good correlation between the identified regions and high values of total lightning data or lighntning jump. In this way, this study is efficient as a tool to support the decision, by meteorologists, in the identification and prediction of SWE. In order to improve these results, will be investigate the regions with no previous classification of SWE but which were identified as possible severe events.

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