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Numerical Weather Prediction

Verification of Probabilistic Precipitation Forecasts in Metropolitan Zone of Valley of Mexico Using the ECMWF Ensemble Prediction System

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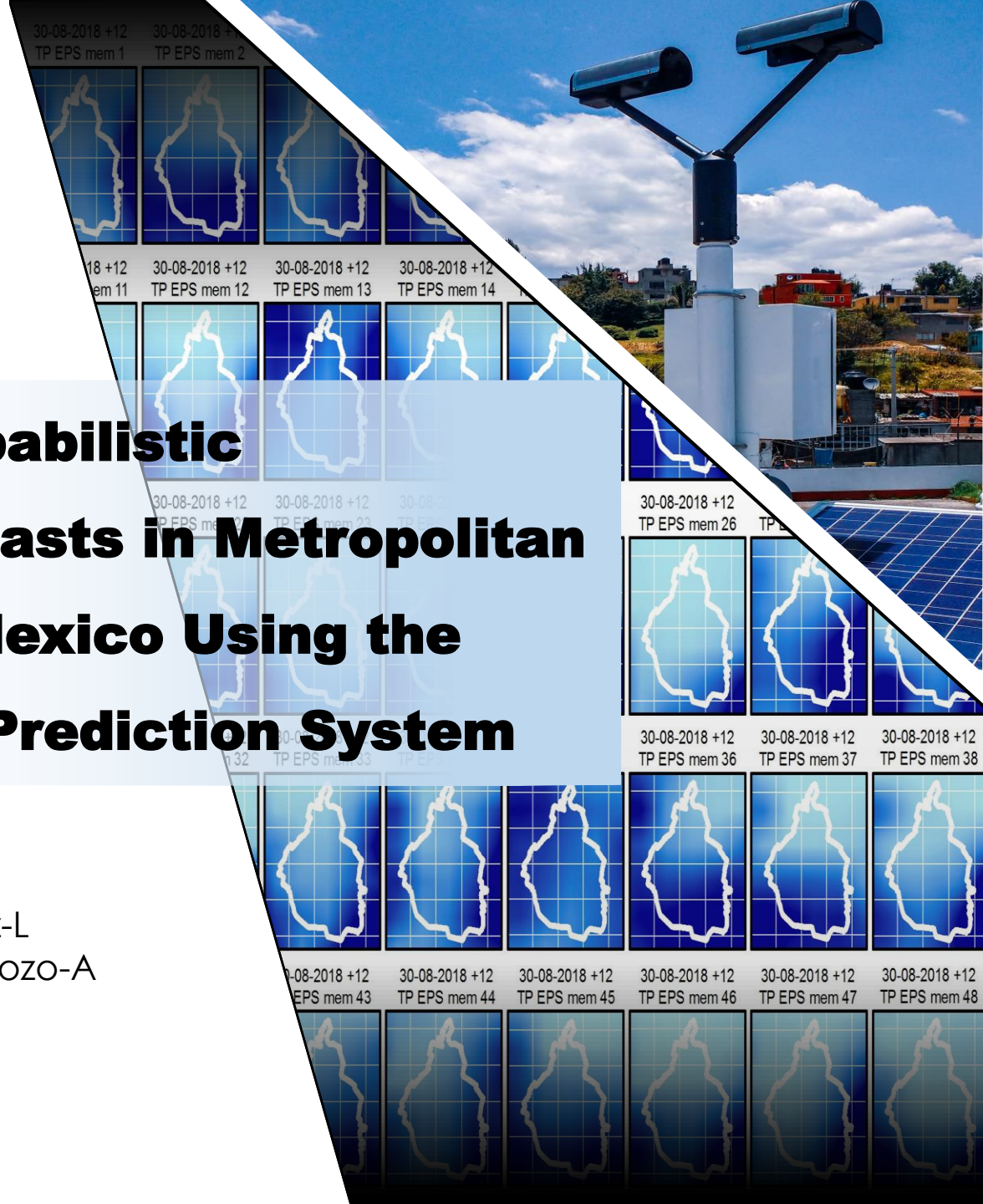
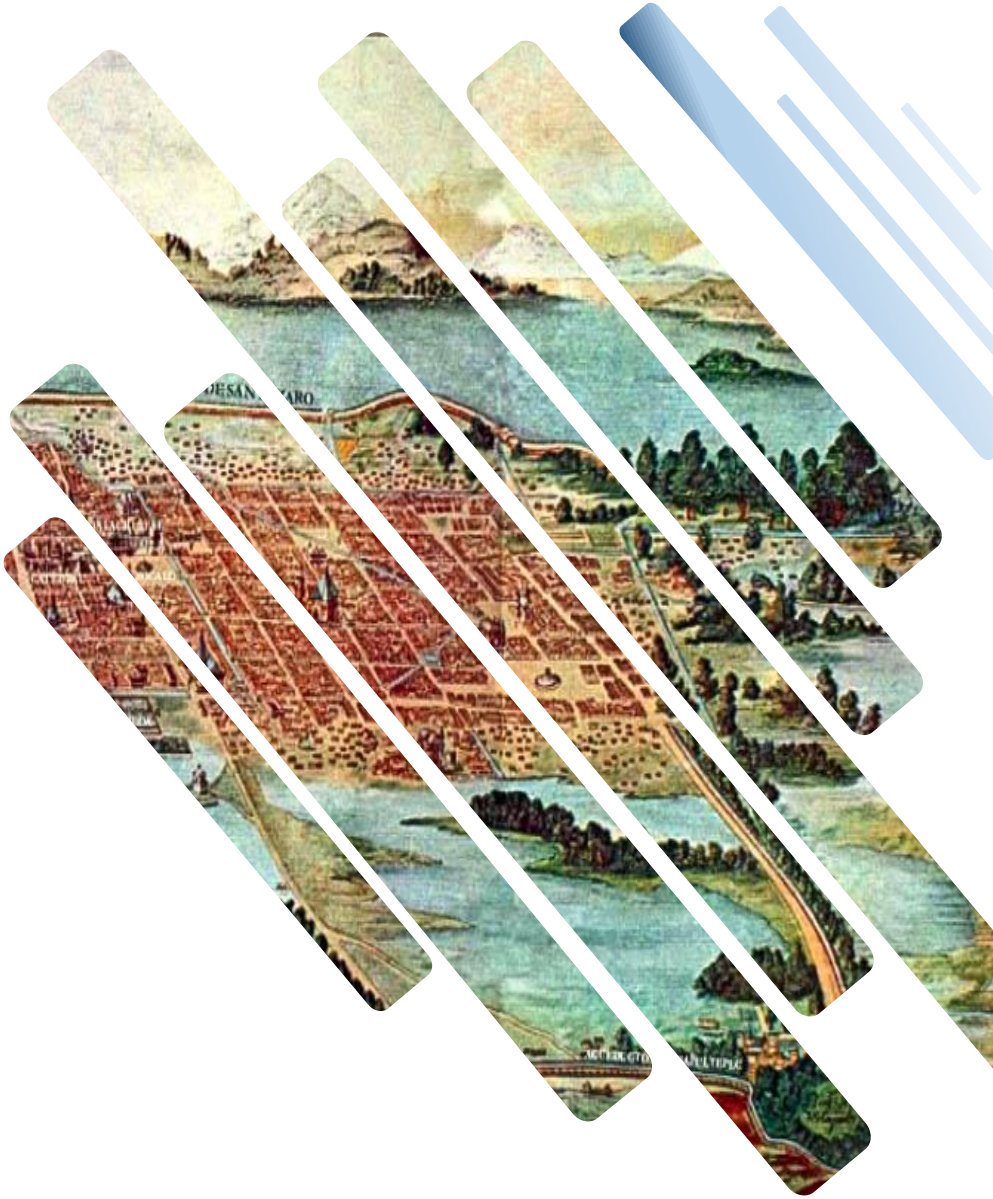
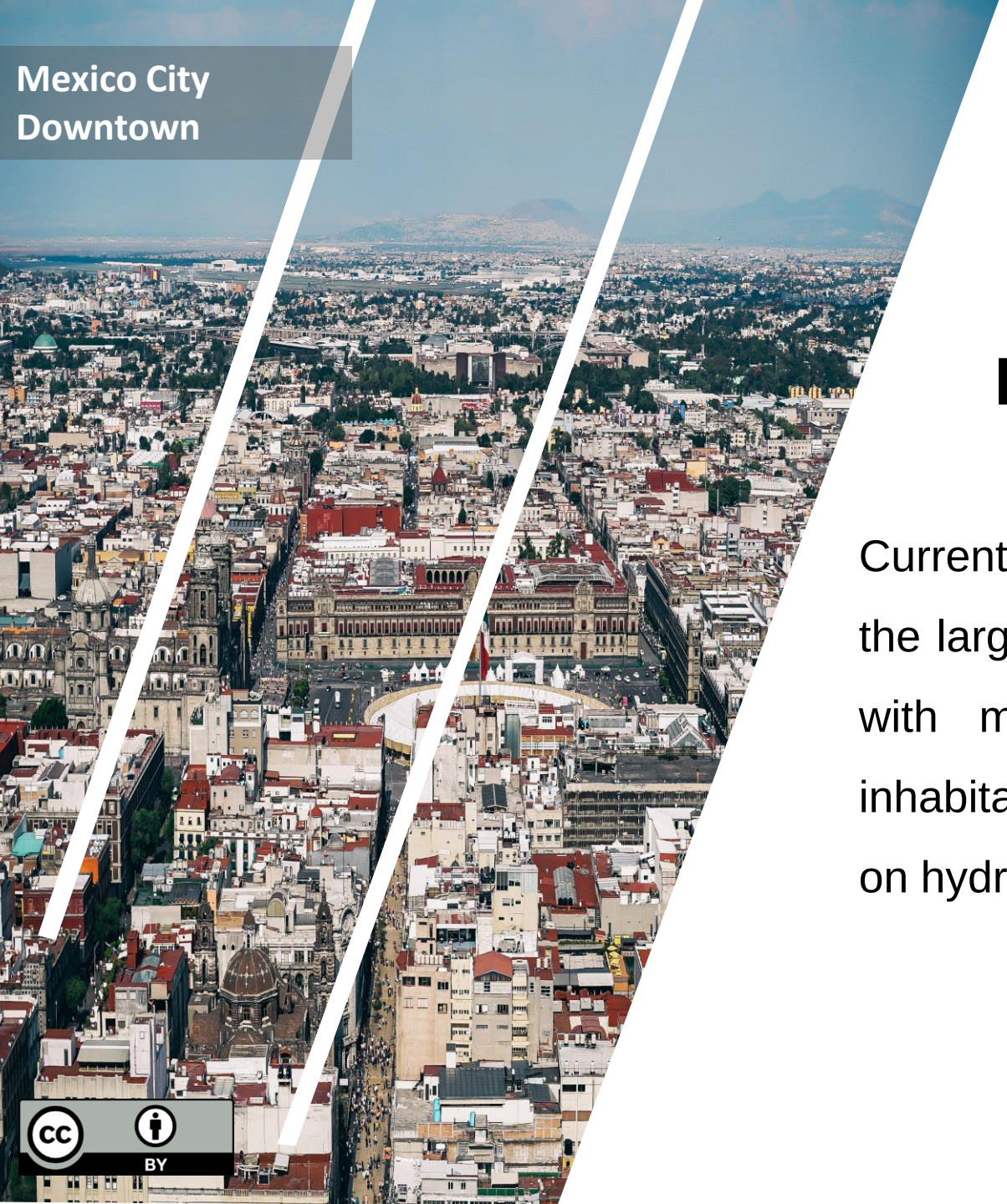


CONTENTS





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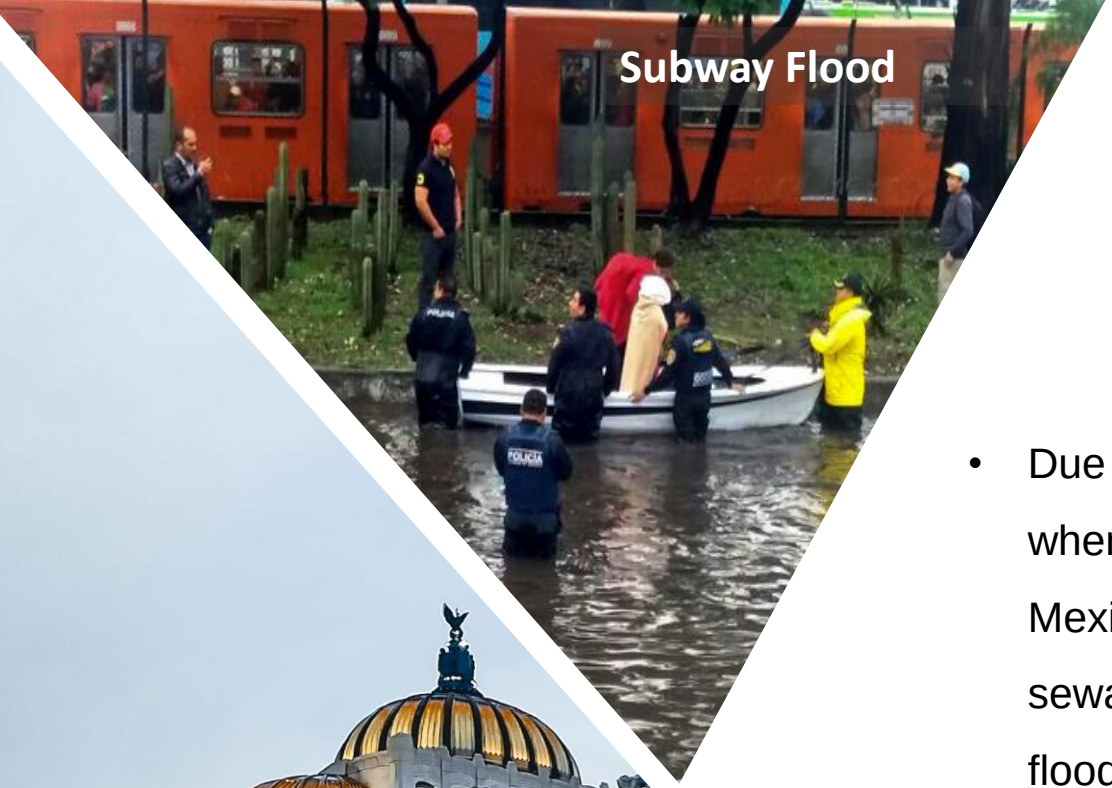
INTRODUCTION

Currently, Mexico City is one of the largest metropolis of the world with more than 22 million of inhabitants and serious difficulties on hydraulic infrastructure.



Subway Flood

“Palacio de Bellas Artes”

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PROBLEMS

- Due to its hydrological characteristics when located within a closed basin, Mexico city depends entirely on the sewage system to prevent and mitigate floods.
- Rainfall not infiltrated into the drainage system flows down the streets and carries sediment, rocks, garbage, cars, and even houses.

MAIN OBJECTIVES & MOTIVATION

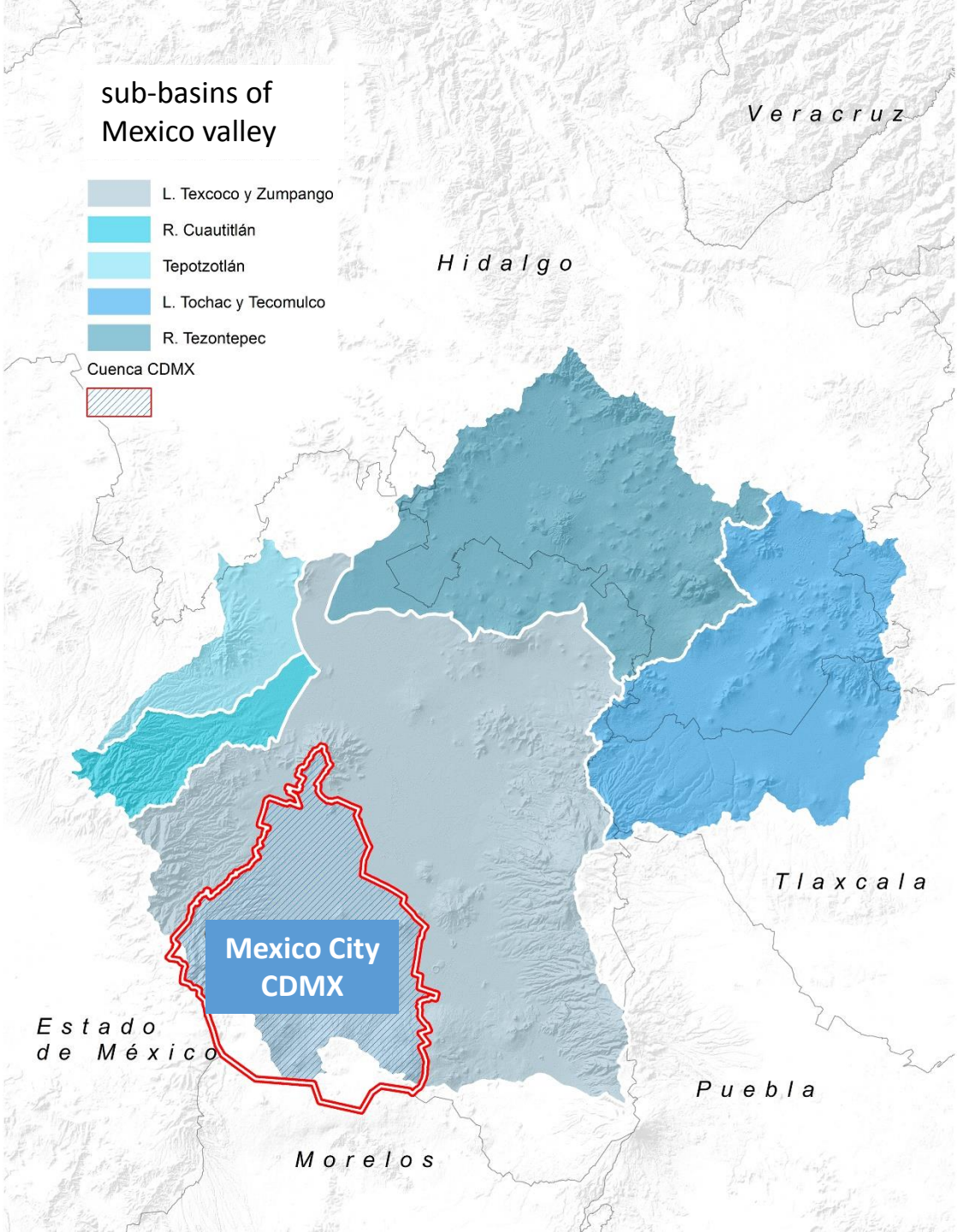
- Proposal of a flood warning system for Mexico City.

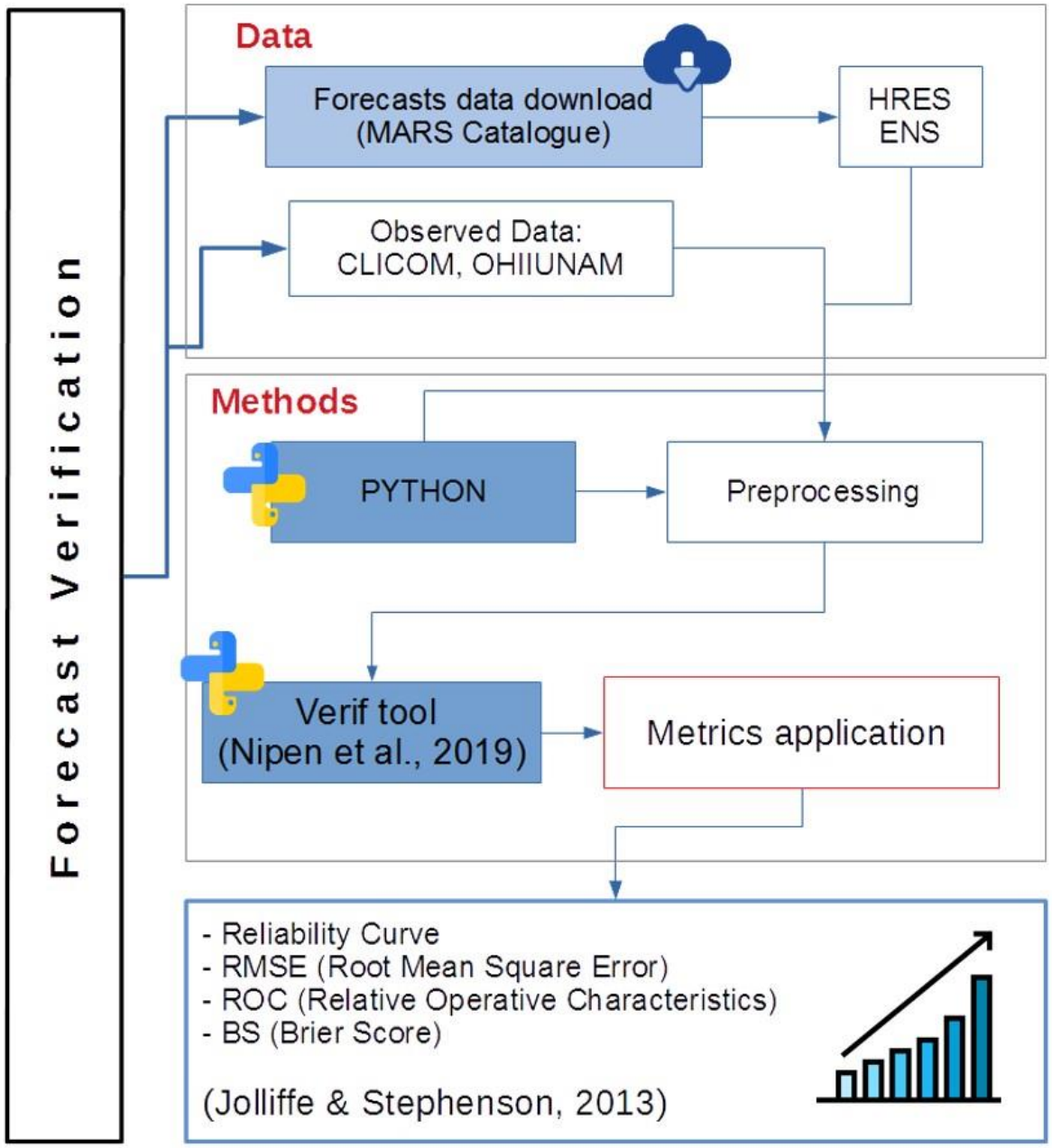
- Verification of ECMWF ensemble forecast (EPS) against observed rainfall data for two study cases: Mexico Valley Basin and Mexico City.

STUDY AREA

The difference in heights within the state of Mexico causes it to occur from a humid climate in the mountainous area, to a dry and hot one in the lower areas of the valley.

The annual average rainfall varies in a range of 600 to 1500 millimeters, generally being distributed in the months of May to October (MJJASON).





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METHODS & DATA

RAINFALL DATA

Study case 1: Mexico Valley Basin (CVM)

ECMWF forecasts:

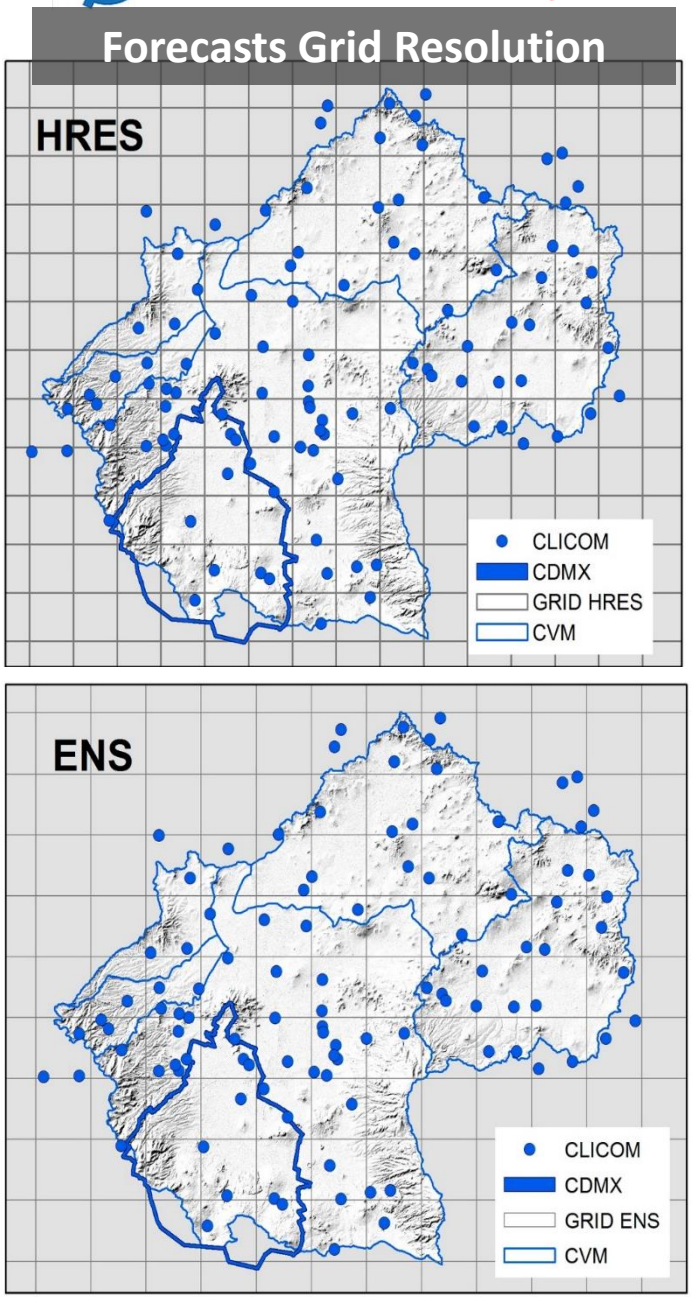
Historical and operational data products:

- HRES (High resolution Forecast, Deterministic);
- ENS (Ensemble Forecast, 50 members) and EMEAN (ensemble mean);
- Time step T = 24 hours.
- Parameter: total precipitation (tp, 228.18) at surface level (sf) and for a base time of 12:00 UTC in GRIB format.

Observed Data:

- 103 weather stations (CLICOM, clicom-mex.cicese.mx) with daily data (accumulated over 24 hours).

The stations were processed and selected based on the established analysis period (2007-2014) and considering good coverage and spatial distribution within the basin.



RAINFALL DATA

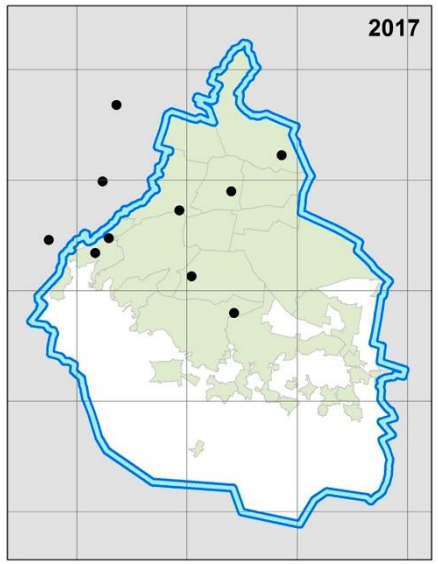
Study case 2: Mexico City (CDMX)

ECMWF forecasts:

Historical and operational data products:

- HRES (High resolution Forecast, Deterministic);
- ENS (Ensemble Forecast, 50 members) and EMEAN (ensemble mean);
- Lead time T = 0 + 90 hours
- Time step = 6 hours
- Parameter: total precipitation (tp, 228.18) at surface level (sf) and for a base time of 12:00 UTC in GRIB format.

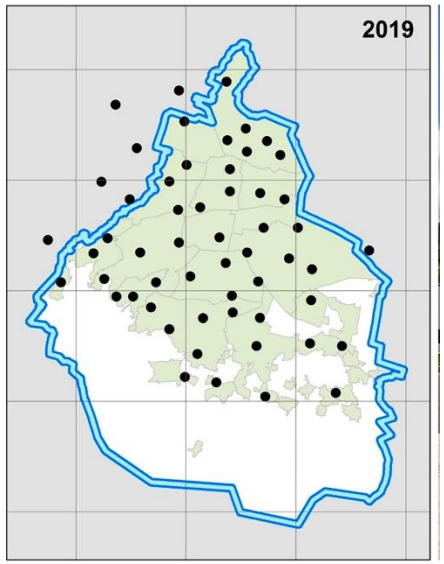
Disdrometer



Observed Data:

- 51 weather stations. OHIIUNAM's individual stations work independently and are made up of a disdrometer to measure rainfall at 1-minute time scale (https://www.oh-iiunam.mx/).

Figure shows the distribution of the OHIIUNAM stations for analysis period: 2017 – 2019 (MJJASON) along with the ECMWF ENS grid (0.125°).



OHIIUNAM Gauge Stations

RESULTS & DISCUSSION

- Forecast Verification for the study cases: Mexico Valley Basin and Mexico City.

- Application of quality indices.

1951 flood

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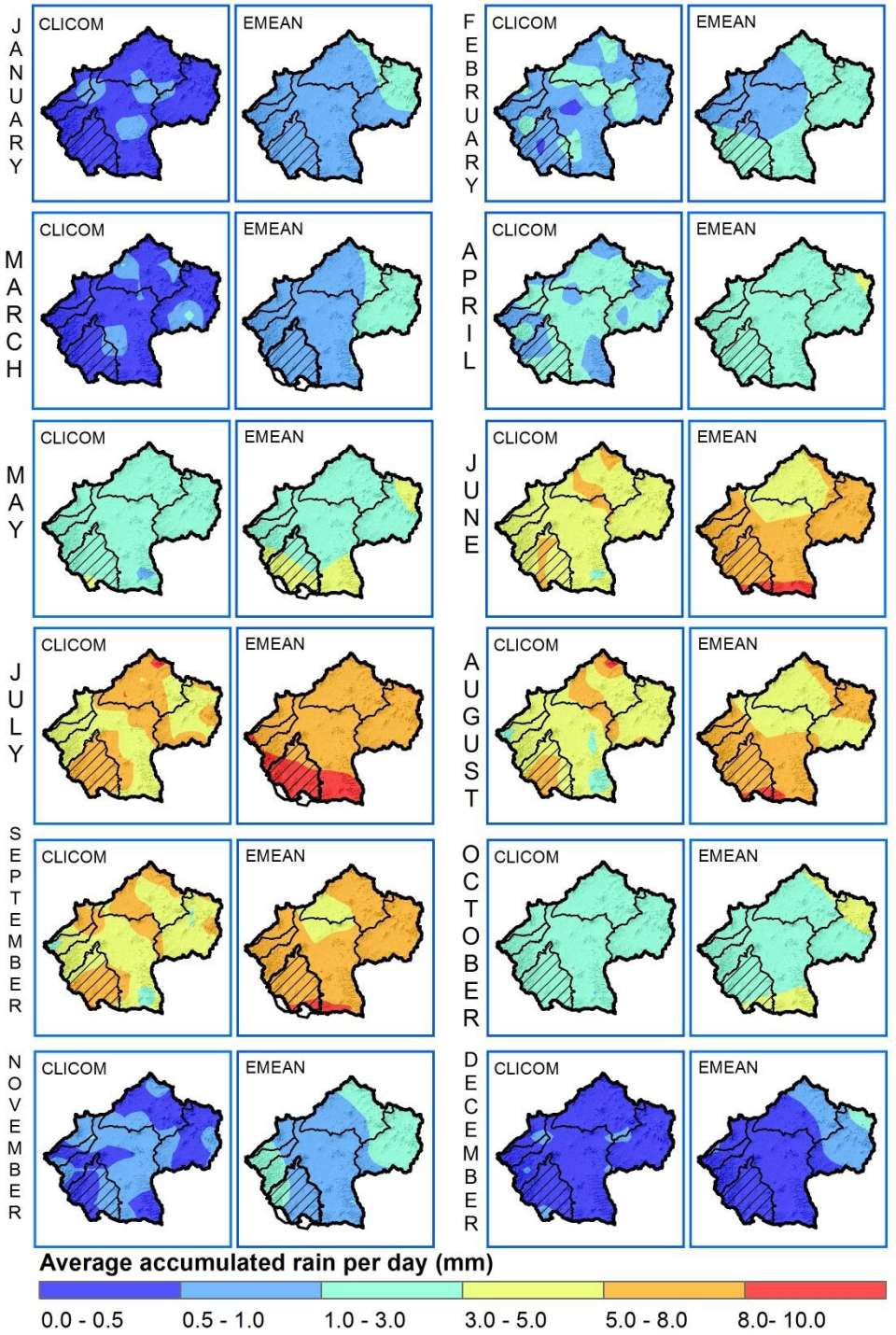
FORECASTS VERIFICATION IN MEXICO VALLEY BASIN

Preliminary comparison

Average rainfall of 24 hours (CLICOM System) per month for the period 2007-2014 against the ensemble mean (EMEAN).

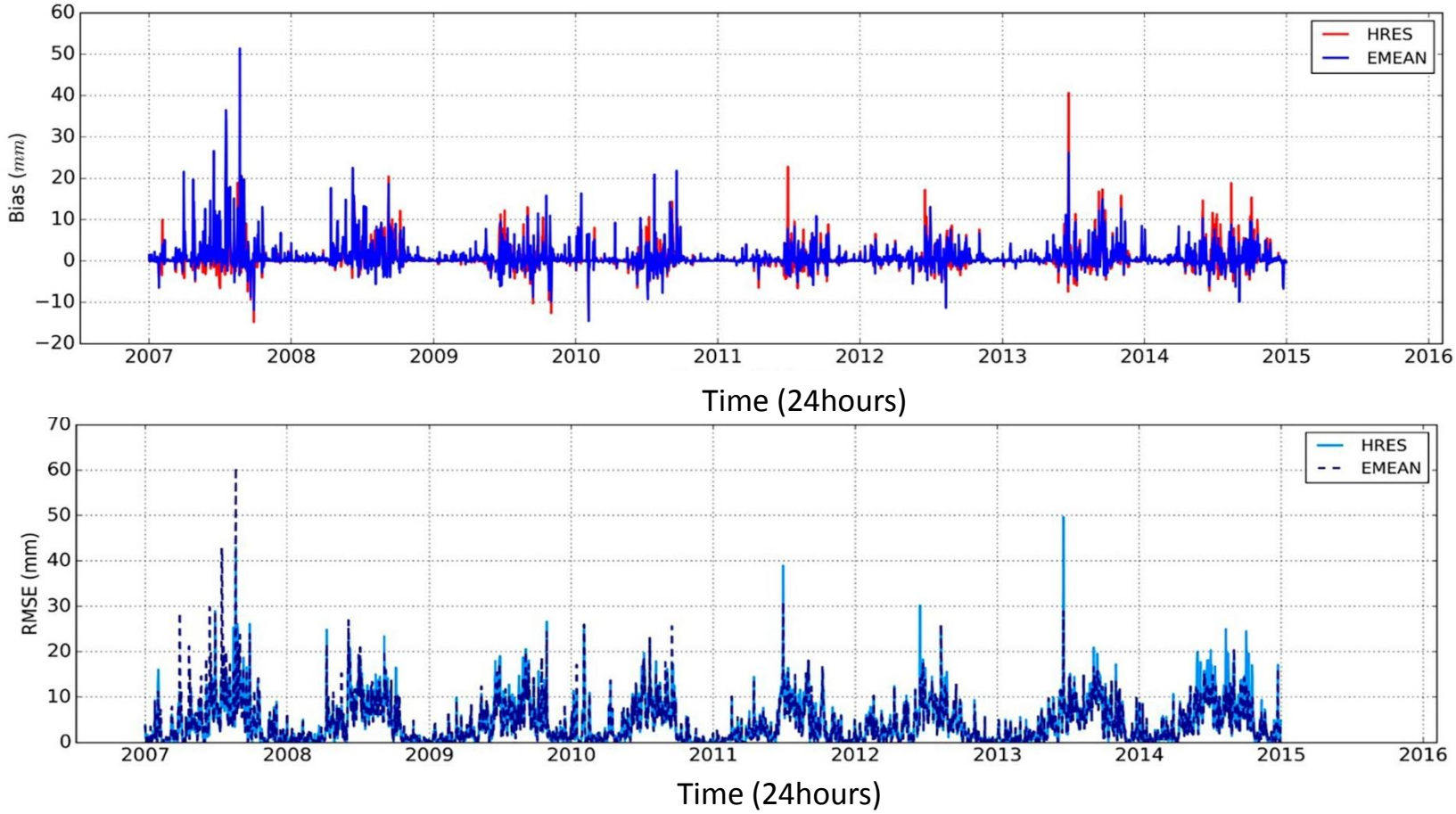
The results of this comparison show the same trend of rain month by month according to the observed data, which corroborates a good consistency of the forecast, especially since the months of highest rainfall “MJJASON” are properly identified.

However, EMEAN tends to over-forecast the rain; especially small events located in the range of 0 to 3 mm in 24 hours.



FORECASTS VERIFICATION IN MEXICO

VALLEY BASIN: BIAS, RMSE



Bias is greater during the rainy season indicating over forecast when BIAS> 0 and under forecast of events when BIAS <0. The biggest errors appear in the rainy season (May - November); which corroborates greater uncertainty in the forecast of extreme events.

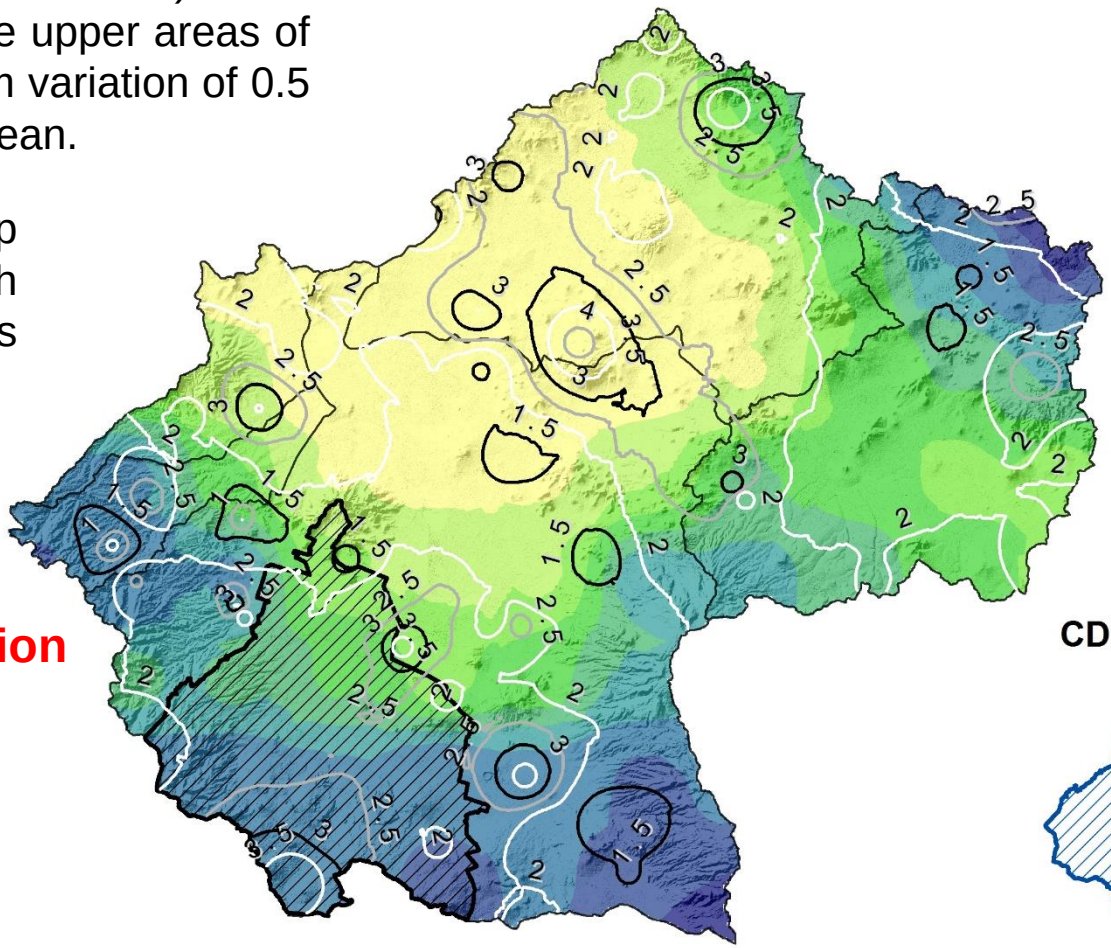
EMEAN performed better than HRES

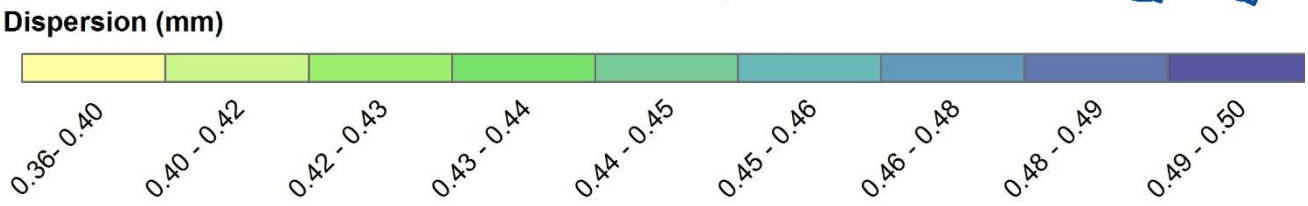
DISPERSION

The dispersion (standard deviation) of the ensemble is greater in the upper areas of the basin with a maximum variation of 0.5 mm with respect to the mean.

The dispersion map indicate that in areas with highest rainfall there is greater uncertainty.

Average dispersion in 24 hours





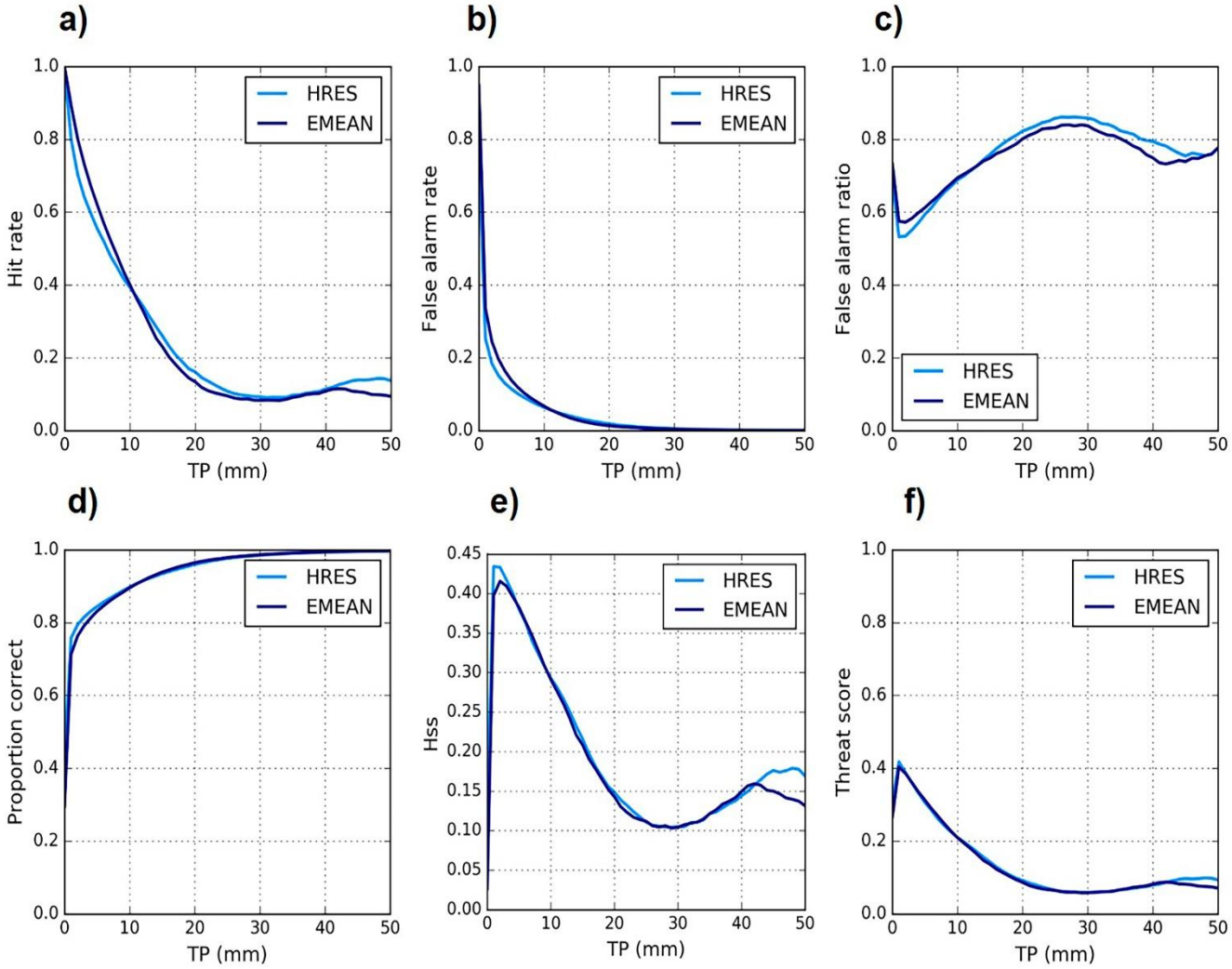
FORECASTS VERIFICATION IN MEXICO

VALLEY BASIN: Quality metrics

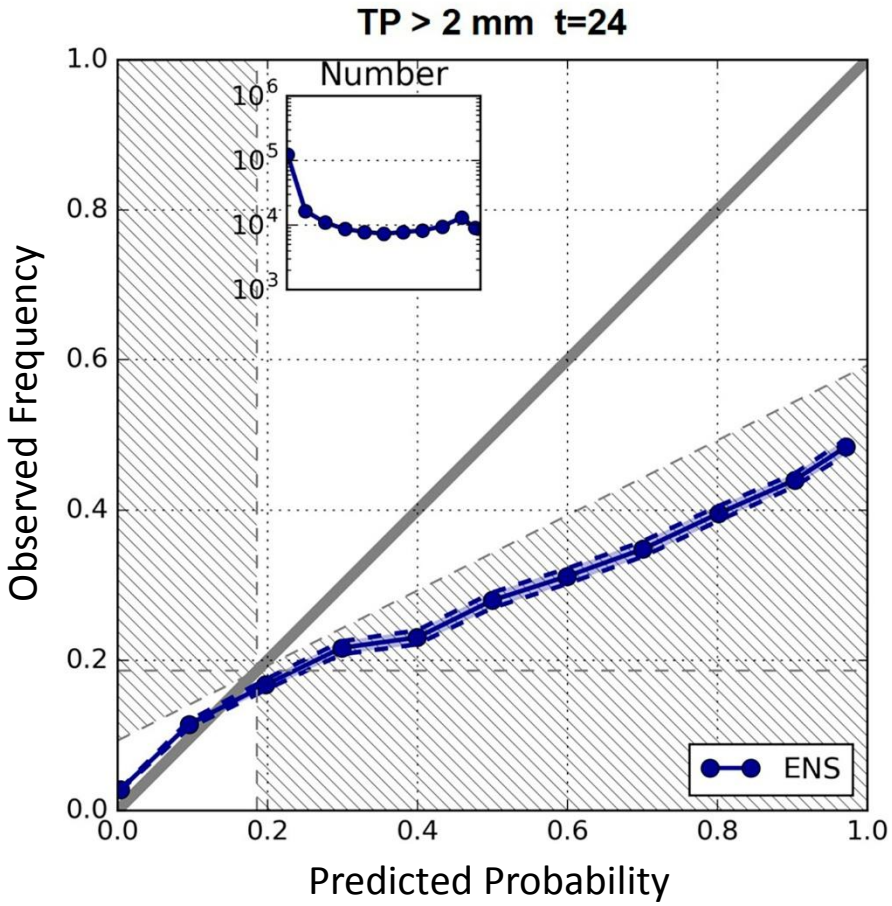
Accumulated rainfall in 24 hours

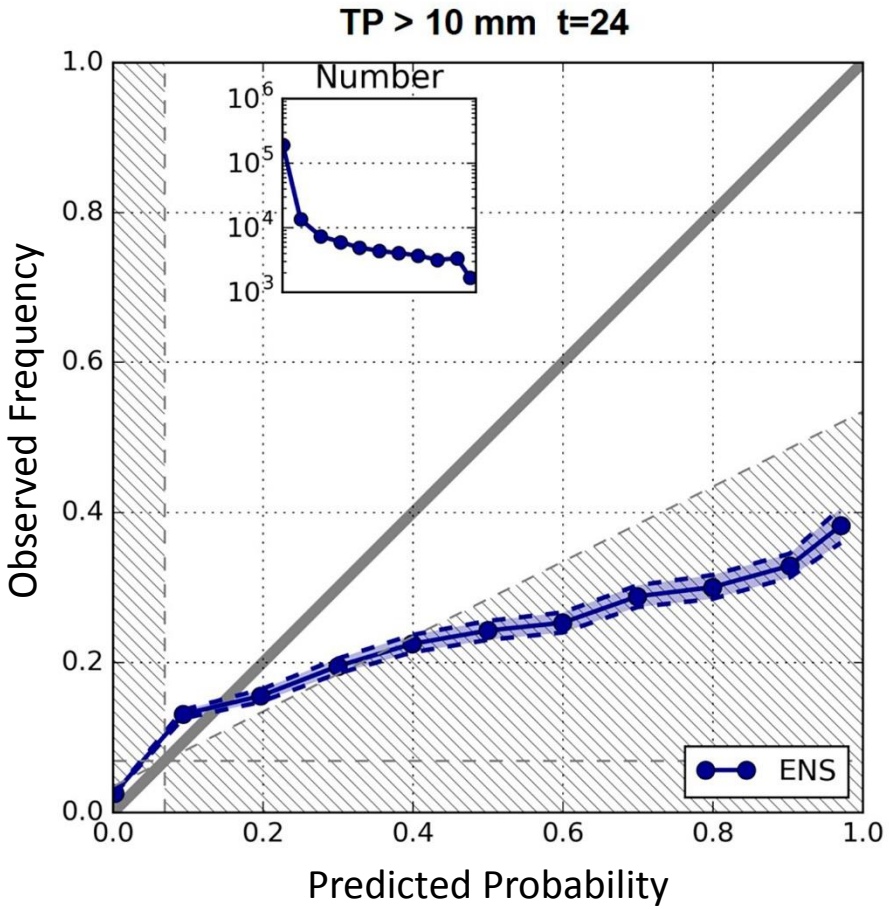
Results establish that the ability of the forecasts to detect events of interest is greater for events from 0 to 10 mm. The probability of false alarm indicates that the number of false alarms is greater for small events (TP <10 mm); which means that, for minor rains, the events are over-predicted (b).

HSS index showed that the forecast performance is higher for events from 2 to 10 millimeters. Finally, the forecast of extreme events is poor.



FORECASTS VERIFICATION IN MEXICO VALLEY BASIN: RELIABILITY CURVE





Reliability diagram for the probabilistic forecast for t = 24 hours and thresholds of 2 and 10 mm of accumulated precipitation. The data are biased, since it is presented over forecasting of events associated with higher probabilities.

FORECASTS VERIFICATION

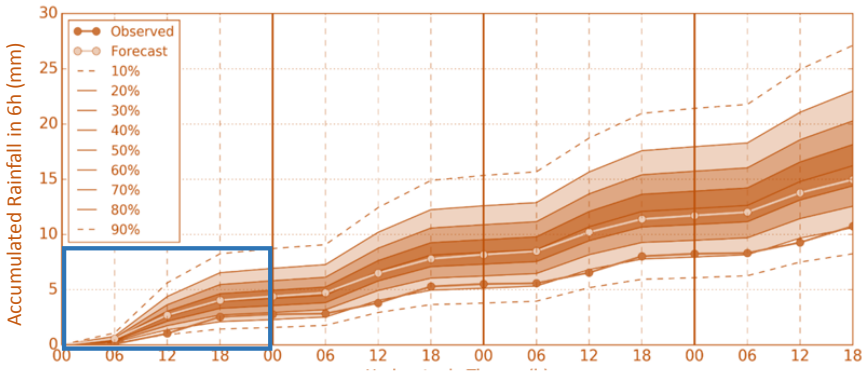
IN MEXICO CITY: Meteogram

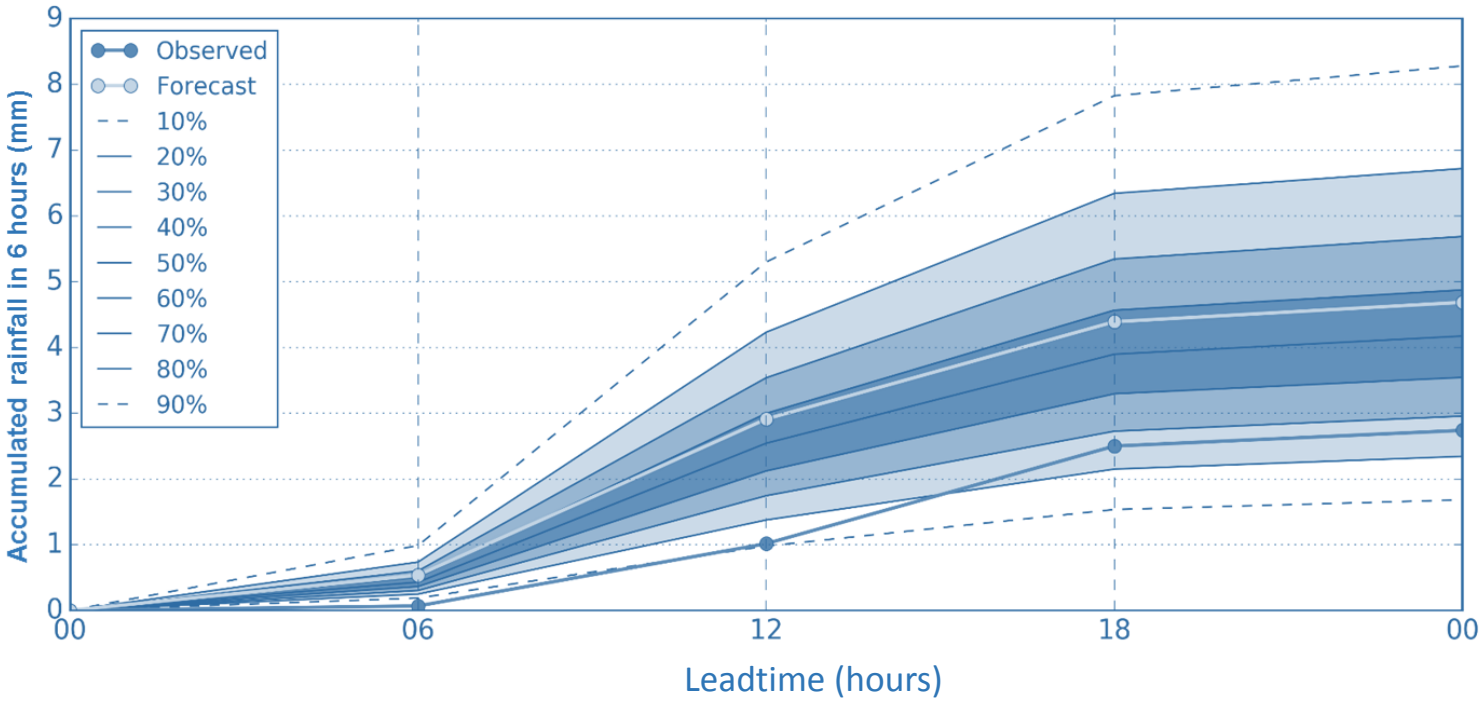
Average rainfall meteogram for Mexico City; result of the comparison of the OHIIUNAM point stations with respect to the ECMWF forecast grid.

Observed rainfall falls within the 20% - 30% percentile of the probability distribution and is generally below the EMEAN line; which is indicative of over-prediction of events.

Forecast is fairly accurate for a 36-hour leadtime.

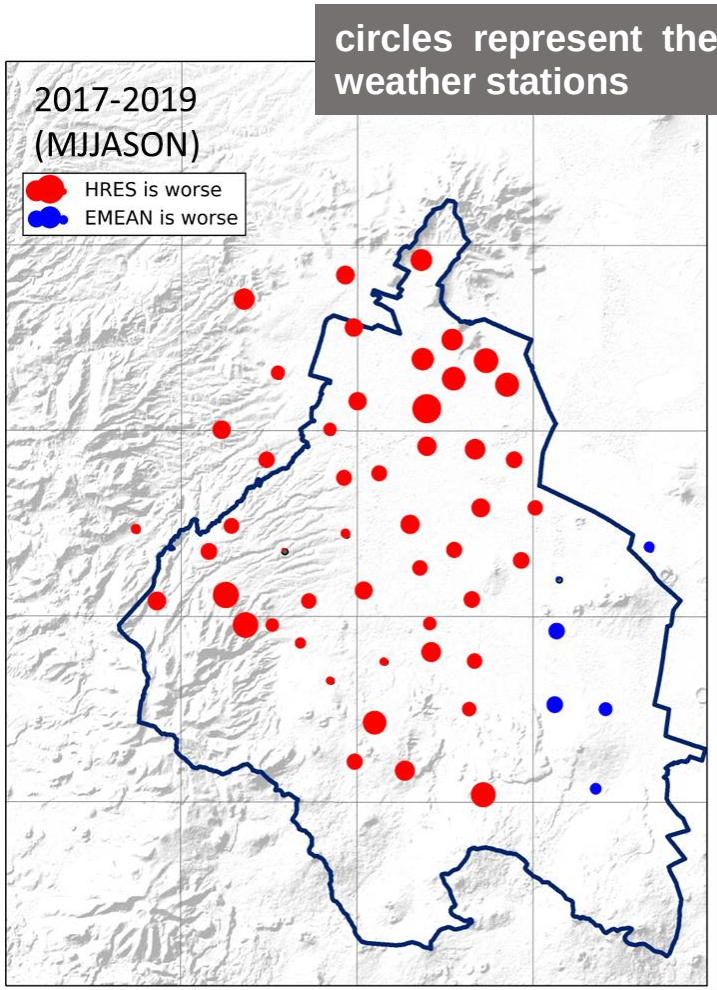
METEOGRAM
OBSERVED,ENS and EMEAN
Accumulated rainfall in 6 hours
2017-2019 (MJJASON)

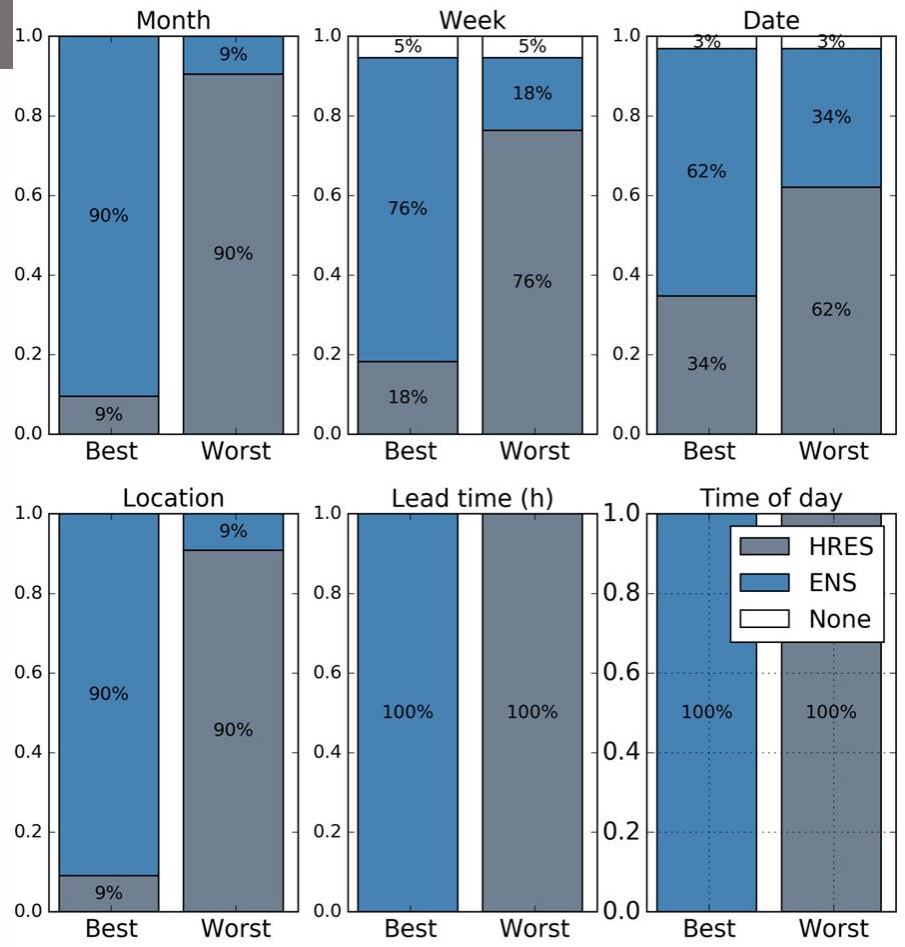




FORECASTS VERIFICATION IN MEXICO CITY:

Impact map RMSE, Pearson Correlation





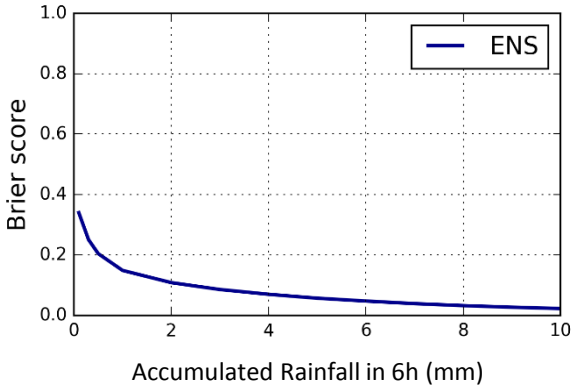
Spatial results of the root mean square error. The bigger the circle, the worse the result

Pearson correlation results for different time windows.

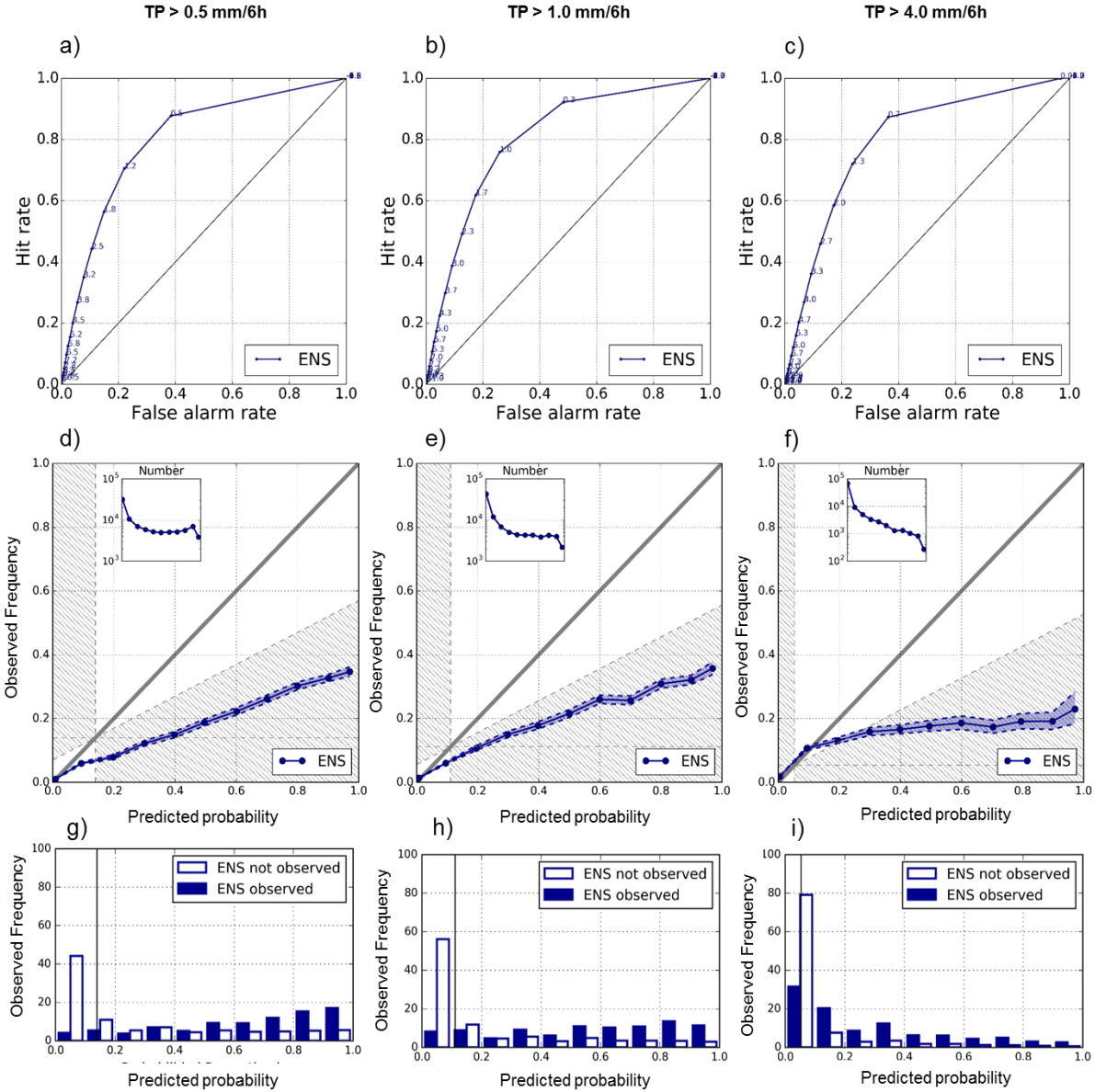
FORECASTS VERIFICATION IN MEXICO CITY: ROC, Reliability and Discrimination Diagrams, Brier Score

The ROC curves demonstrate that there is a better resolution and reliability for forecasting 1 mm in 6 hours rainfall.

The average forecast is greater than the observed average



Better results of the index while precipitation increases. ENS is more accurate if accumulated rainfall greater than 1 millimeter is considered.



CONCLUSIONS

1. In this analysis, only meteorological uncertainty was evaluated considering simply rainfall prediction.

2. In general, the ensemble mean (EMEAN) performs better than the deterministic forecast (HRES), which is indicative of a good forecast system.

3. Application of quality indices (POD, FAR, HSS, PC, PODF, TS) resulted in a greater reliability of the forecast for events in the range of 2 to 10 mm of accumulated precipitation in 24 hours.

4. Bias is greater (BIAS> 0) for the rainy season (MJJASON), which means more uncertainty.

5. The probability distribution given by the ensemble constitutes a good representation of the possible scenarios of the atmosphere along the time horizon.

6. There is a good discrimination of observed and unobserved events of accumulated precipitation of 1 mm in 6 hours. On the other hand, the reliability diagram does not show a good resolution, which translates into low forecast reliability.

“EPS are an excellent tool for predicting rain and therefore floods”

FUTURE LINES INVESTIGATION

1. Forecast calibration to improve reliability.
2. Use the ensembles for rain simulation using a 2D hydrodynamic model.
3. Generation of probabilistic flood maps.

Thank You

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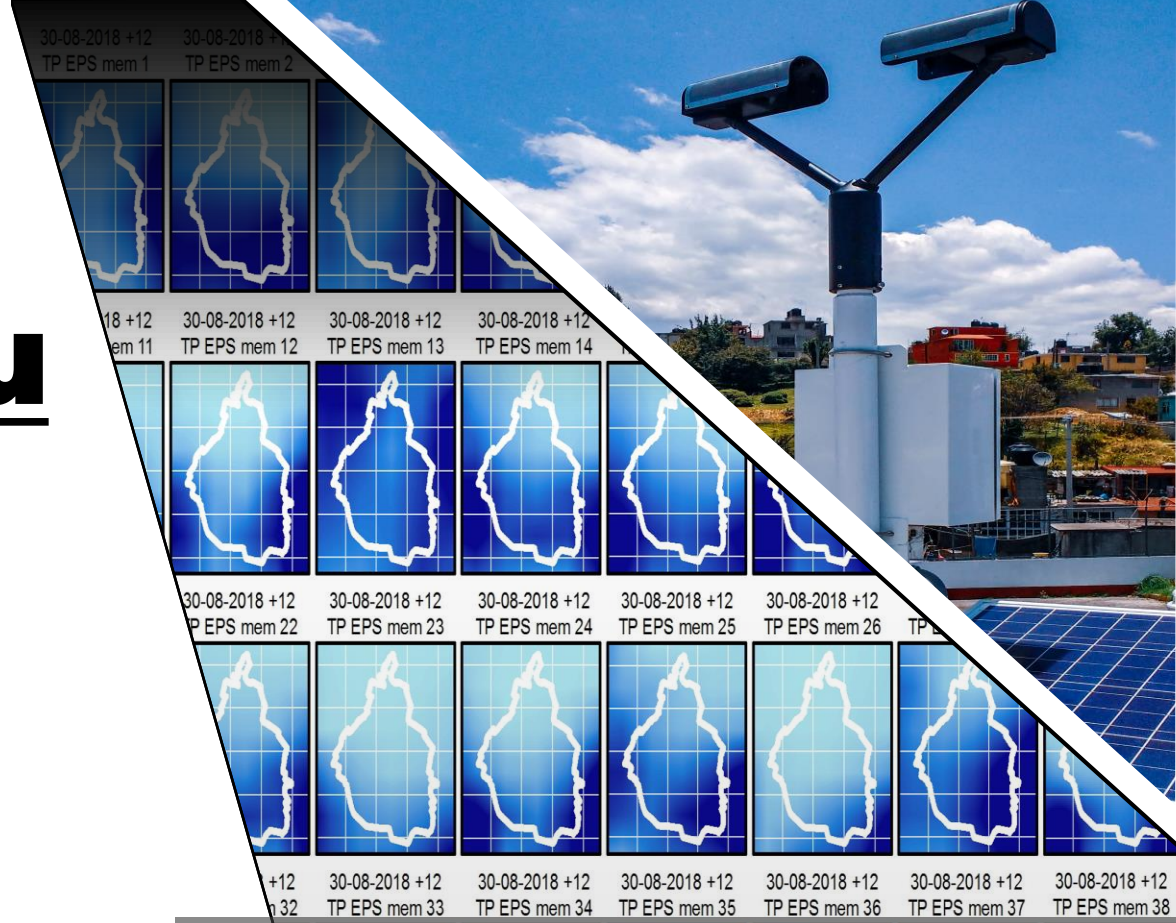

ACKNOWLEDGEMENTS:

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Jolliffe, I. T., & Stephenson, D. B. (2013). Forecast Verification A Practitioner ́s Guide in Atmospheric Science. Journal of Chemical Information and Modeling (Vol. 53). Sussex: Wiley. https://doi.org/10.1017/CBO9781107415324.004