The Hydrological Observatory of Mexico City (OH-IIUNAM): A unique setup for hydrological research within large urban environments

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1. INTRODUCTION

As the global population steadily migrates from rural to urban regions. As the urban built environment grows in terms of population and urbanization, especially in developing countries, the quantity and quality of infrastructure needed to monitor and anticipate natural hazards is essential to ensure a sound urban governance. One of the most damaging natural hazards that cities are facing, is associated to the direct and indirect impacts provoked by severe rainstorms. The hydrology of urban areas represents a scientific challenge given the substantial modification of its water-land-atmosphere continuum [1, 2]. As land use and cover undergo through the urbanization process, hydrological systems are profoundly altered [3, 4] and hydro-meteorological hazards are likely to exert greater impacts to society.

The hydrological response of urban landscapes is characterized by a faster transformation of rainfall into runoff when compared to natural and rural watersheds. Because of this, higher temporal and spatial resolution of rainfall measurements are required for urban hydrology [5]. Nevertheless, conventional rain gauge networks or radars cannot provide rainfall information at these hyper-resolutions, either because of coarse data acquisition timesteps by sensors or simply because of the network's sparse spatial coverage [6].

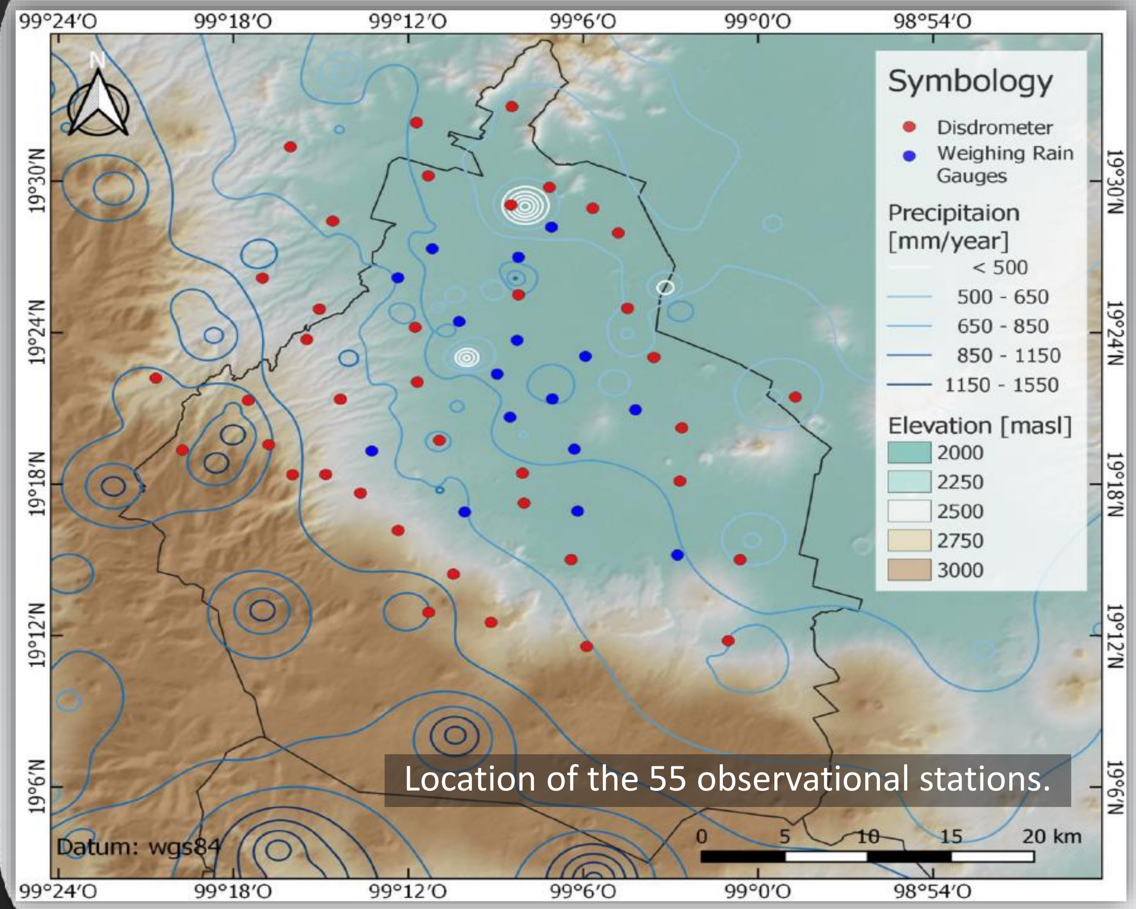
In response to these challenges, novel observational systems capable of monitoring hydrometeorological conditions, predicting their impacts in near real-time, and communicating their potential derived hazards to society in due time must be developed.

2. AIMS

The principal aim of the Hydrological Observatory of Mexico City (OH-IIUNAM, its spanish acronym) is to show an innovate way to leverage high-resolution state-of-the-art commercial sensors, low-cost data acquisition, communication technologies and cloud computing to enable the observation, backcasting and forecasting of hydrological processes in a large urban environment such as Mexico city. To specific aims are:

- Develop a hydrological observation network.
- Acquisition, transmission and publication of hydrological data in real-time.
- Identify the topics on the scientific research agenda to improve urban hydrological characterization

3. STUDY AREA



Location of the 55 observational stations.

The OH-IIUNAM was developed by the Institute of Engineering from the National Autonomous University of Mexico.

Integrated by:

55 precipitation sensors widely spread across the metropolitan area of Mexico city.

This is the world's most dense network of disdrometers in an urban setting.

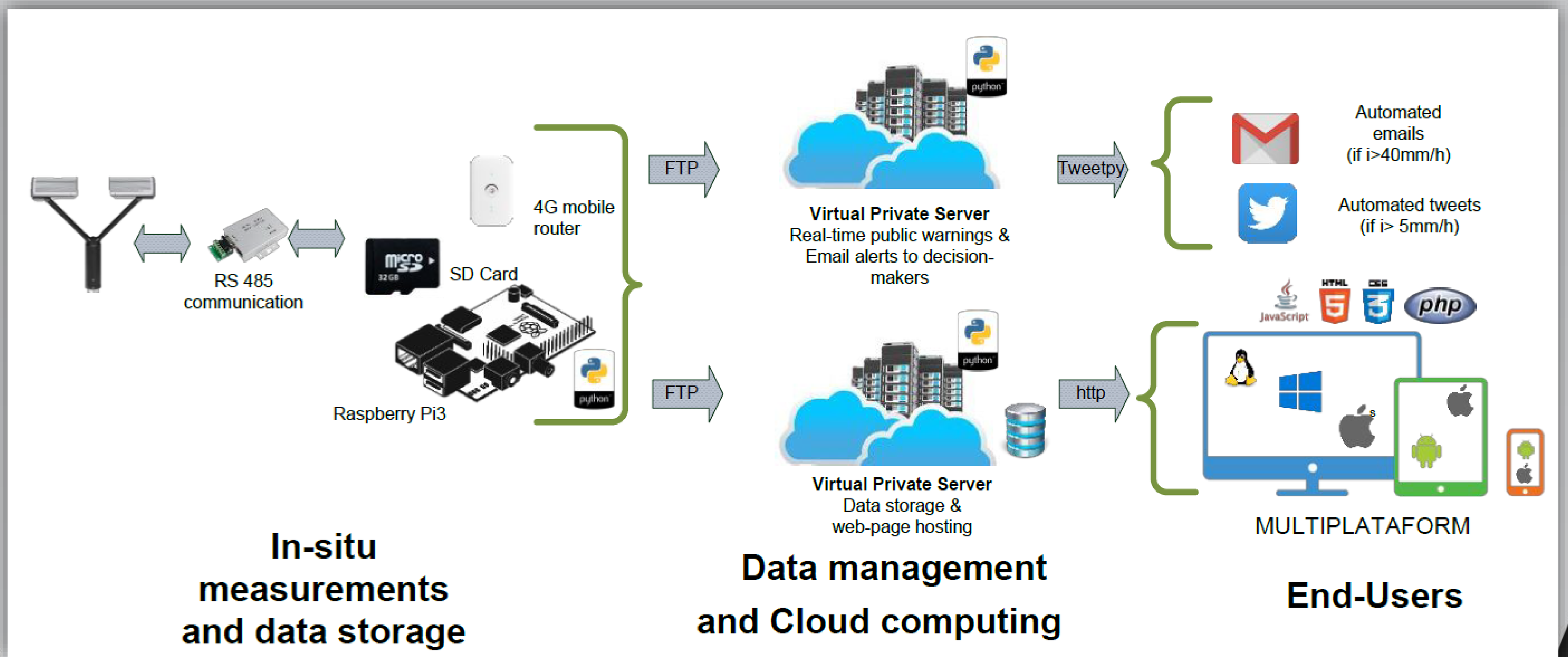
4. THE OH-IIUNAM

Equipment

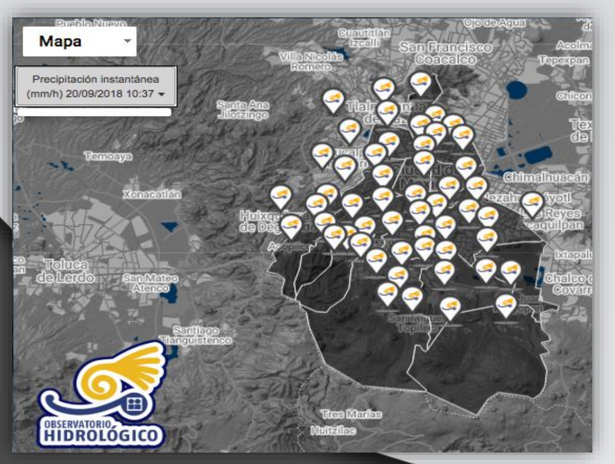
39 laser-optical disdrometers

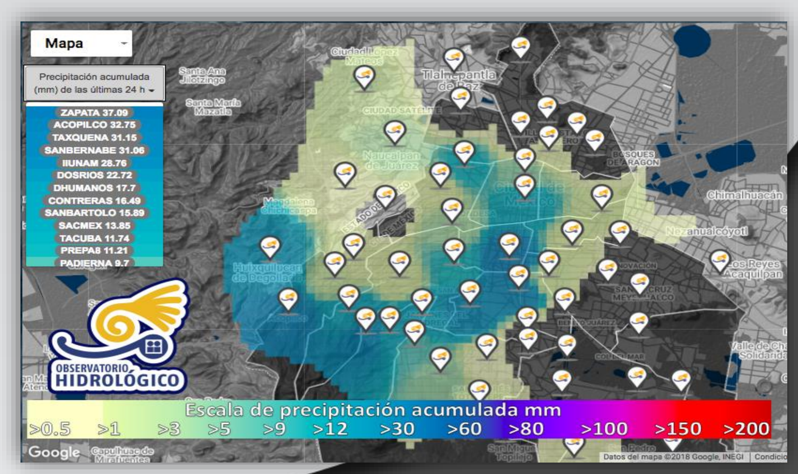
16 weighing rain gauges

Metodology: System Architecture / Hardware and Software



In website (www.oh-iiunam.mx) information can be consulted and downloaded.





5. A RESEARCH AGENDA FOR URBAN HYDROLOGY

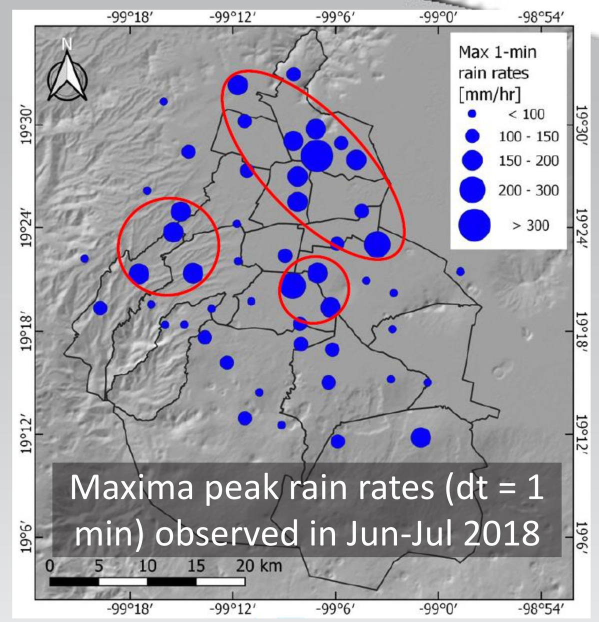
Precipitation characterization and classification

How does the spatial variability of rainfall behave over different timescales?

The spatial distribution of precipitation occurring over Mexico City is directly correlated to its topography. Topographic highs along the southwestern of the city exhibit annual rain depths two-to-three times higher than those observed in the flat ones, however convective storms in specific areas of the city can be much more intense than the orographic ones.

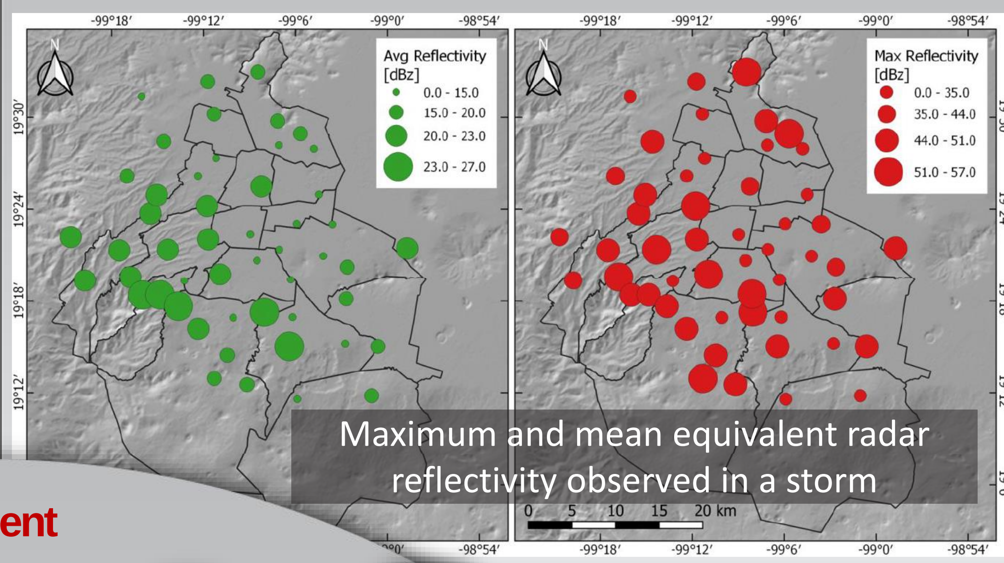
What is the dominant type of precipitation across Mexico City?

In flatter areas, where the contribution of orographic rainfall can be neglected, single storm events can be primarily classified into stratiform and convective systems.



Maxima peak rain rates (dt = 1 min) observed in Jun-Jul 2018

Precipitation modelling



Maximum and mean equivalent radar reflectivity observed in a storm

Are stochastic rainfall models constrained in highly convective regions?

Stochastic rainfall temporal disaggregation models widely used for flood risk estimation can be largely constrained due to the extent of the study area and its storm classification characteristics. As the contribution of convective storms becomes more relevant in the hydrology of an urban region, it is crucial to include as many model testing sites as possible.

Can deterministic rainfall models be revisited and applied for forecasting purposes?

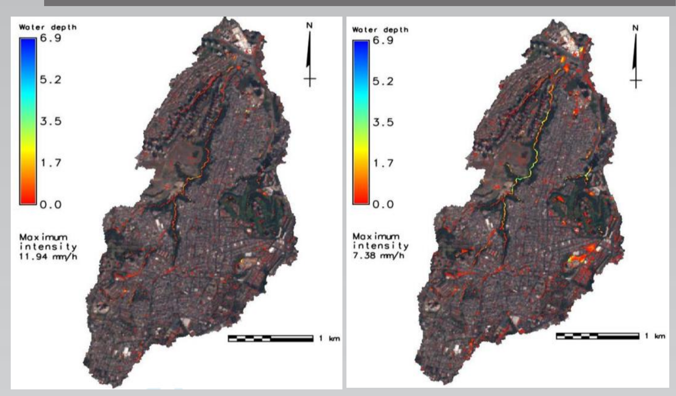
Due to the characteristics of convective storms, new approaches for rainfall modelling using deterministic and numerical models should be explored Furthermore, Lagrangian rainfall models could be used for short-term forecasting purposes.

Urban hydrological processes and infrastructure design

How sensitive is the urban hydrological response to spatial and temporal rainfall variability?

Hydrological models can present highly variable outputs due to its sensitivity to rainfall inputs. Likewise, every single storm is dependent in terms of coverage area, initial position and subsequent movement, determining the drivers of flood peak magnitude and lag time.

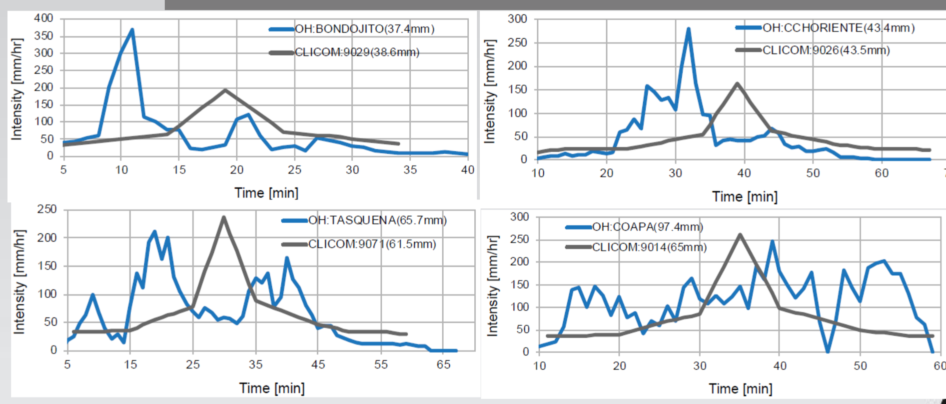
Hydrodynamic simulation at the Rio Hondo catchment comparison (OH-IIUNAM, GPM)



Is urban water infrastructure adequately designed?

Conventional methods for hydrological design are based on the temporal disaggregation of maxima daily values derived from empirical frequency distributions. However, the runoff storm caused by a short but very intense convective storm and highly impervious surface may not be captured at all.

Comparison of design hyetographs from the conventional rain gauge network and OH-IIUNAM



6. CONCLUSIONS

The key contribution of this work was the design and implementation of a scalable, easy to use, interoperable rainfall observational network within a large urban region that encompasses scientific research, hydraulic infrastructure operation and prevention of hydrometeorological risks to society.

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