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Using satellite rainfall estimations for the definition of heavy rainfall statistics on two Caribbean watersheds

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HAL Authorization

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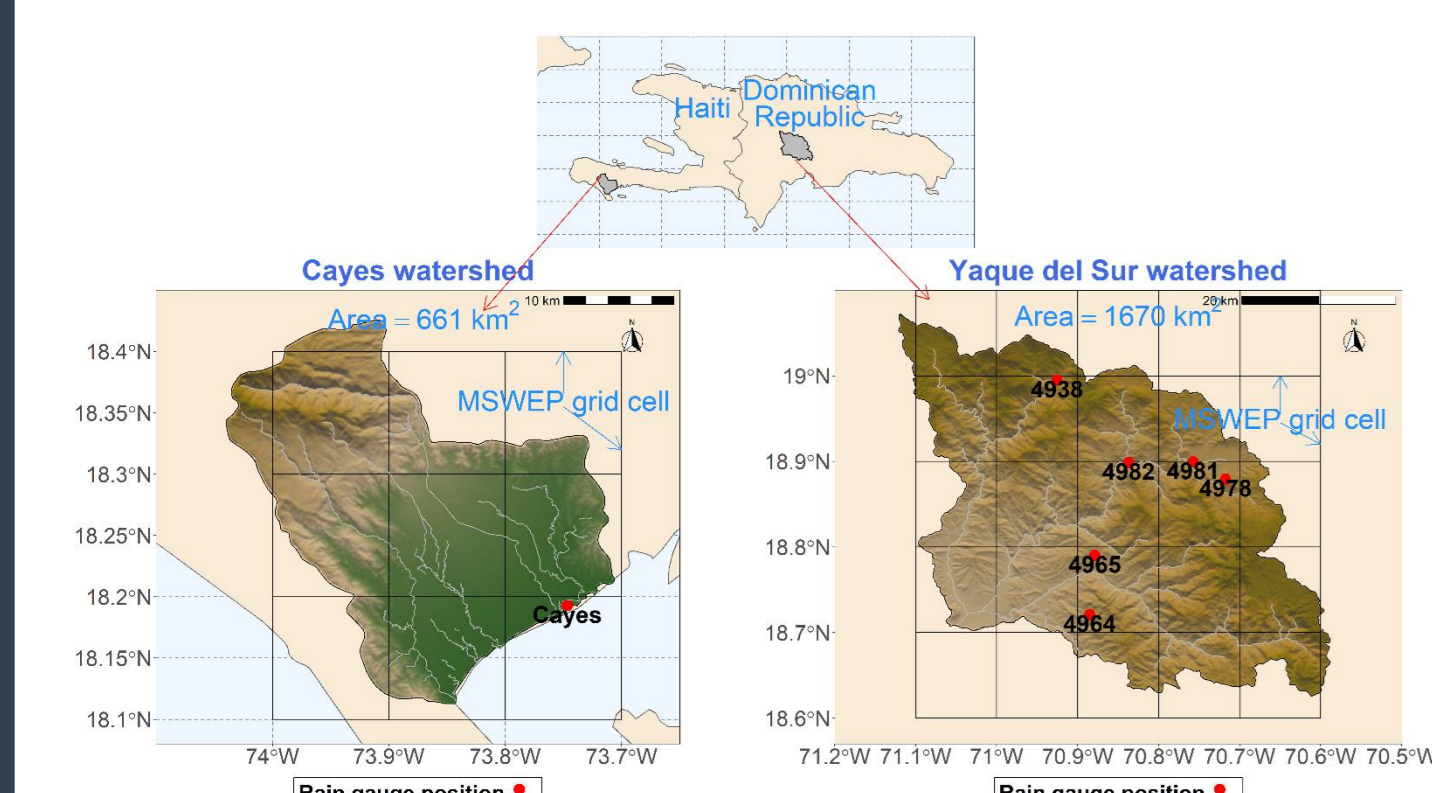
1 Introduction and context

1.1 - Introduction

The Hispaniola Island (divided into two countries : Haiti to the west and the Dominican Republic to the east) is highly vulnerable to flooding hazards. In addition, most urban areas lack a hydro-meteorological reference allowing to anticipate the damages that can be generated by different types of intense events.

In this context, this work aims to evaluate a method designed to define heavy rainfall statistics by coupling Stochastic Storm Transposition (Wright *et al.*, 2017, 2013) and MSWEP satellite rainfall estimates (Beck *et al.*, 2017) on two watersheds: the Cayes watershed in Haiti and the Yaque del Sur watershed in Dominican Republic. This method will be compared to classical GEV fitting on observed rainfall data.

1.2 - Studied catchments



1. The Cayes watershed has an area of 661 km² with relatively flat relief in its downstream part and an upstream part where rainfall is particularly high on the island.
2. The Yaque del Sur (YDS) watershed drains 1670 km² with elevation ranging from 367 to 3093 m.

Fig. 1. Elevation of two studied watersheds (DEM used : SRTM 90 m).

1.3 - Data used

1. MSWEP dataset - merging satellite, gauges and reanalysis data - is available from 1979 to 2017 with a spatio-temporal resolution of 0.1° (≈11 km) / 3 h (Beck *et al.*, 2017).
2. 7 daily rainfall series available from 1980 to 2010: 6 for the Yaque del Sur catchment and 1 for the Cayes Catchment.

2 Method

2.1 - Heavy rainfall statistics at rain gauges and MSWEP pixels

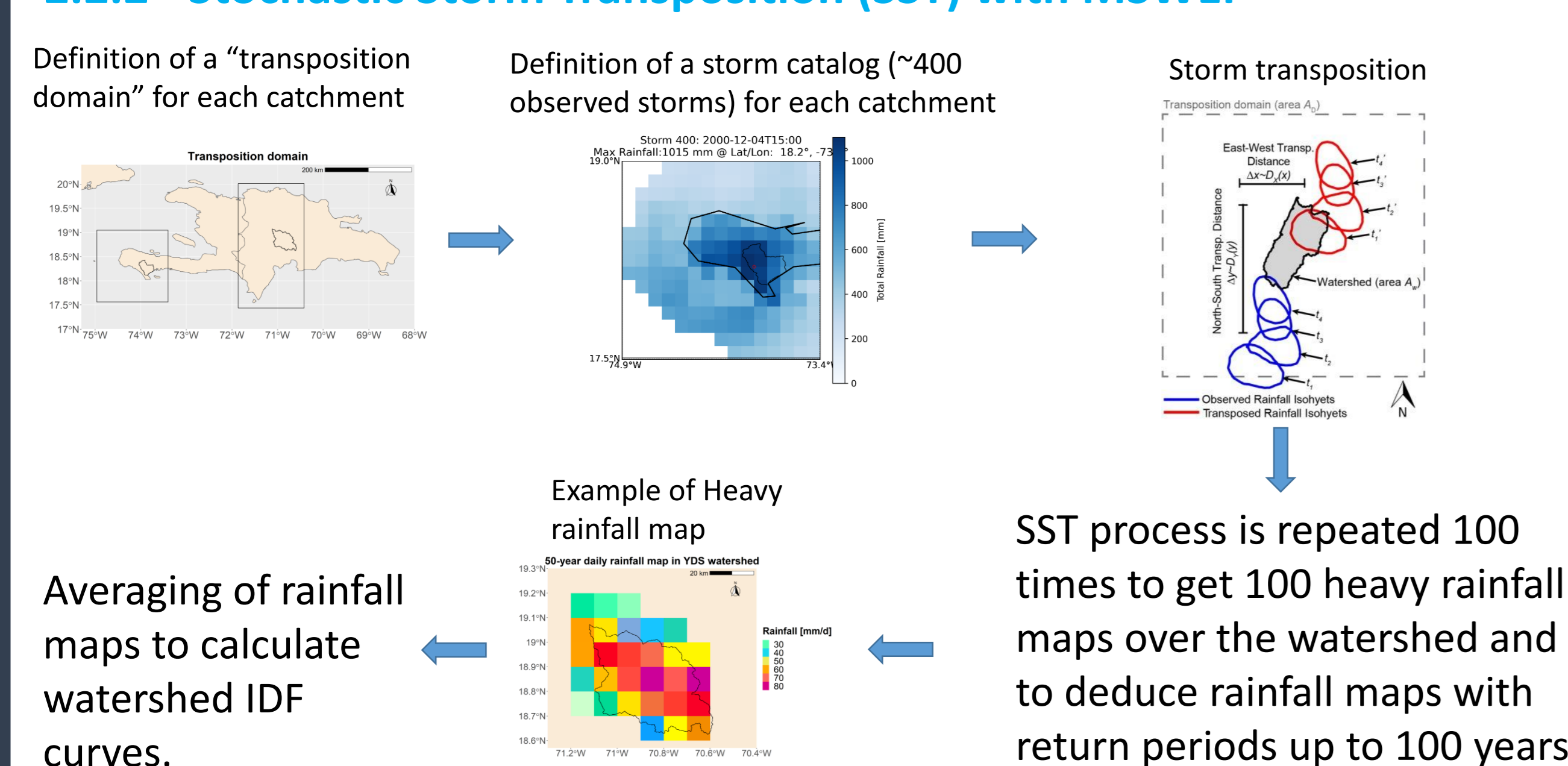
- ❖ Identification of the annual maximum of each daily rain gauges precipitation series and their corresponding MSWEP pixels
- ❖ Fitting of a GEV distribution on each annual maximum series

2.2 - Heavy rainfall statistics at the catchment scale

2.2.1 - Classical heavy rainfall statistics using Thiessen polygons

- ❖ Estimation of catchment precipitation series using Thiessen polygons
- ❖ Identification of the annual maximum for each catchment precipitation series
- ❖ Fitting of a GEV distribution on each annual maximum

2.2.2 - Stochastic Storm Transposition (SST) with MSWEP



3 Heavy rainfall statistics at rain gauges and MSWEP pixels

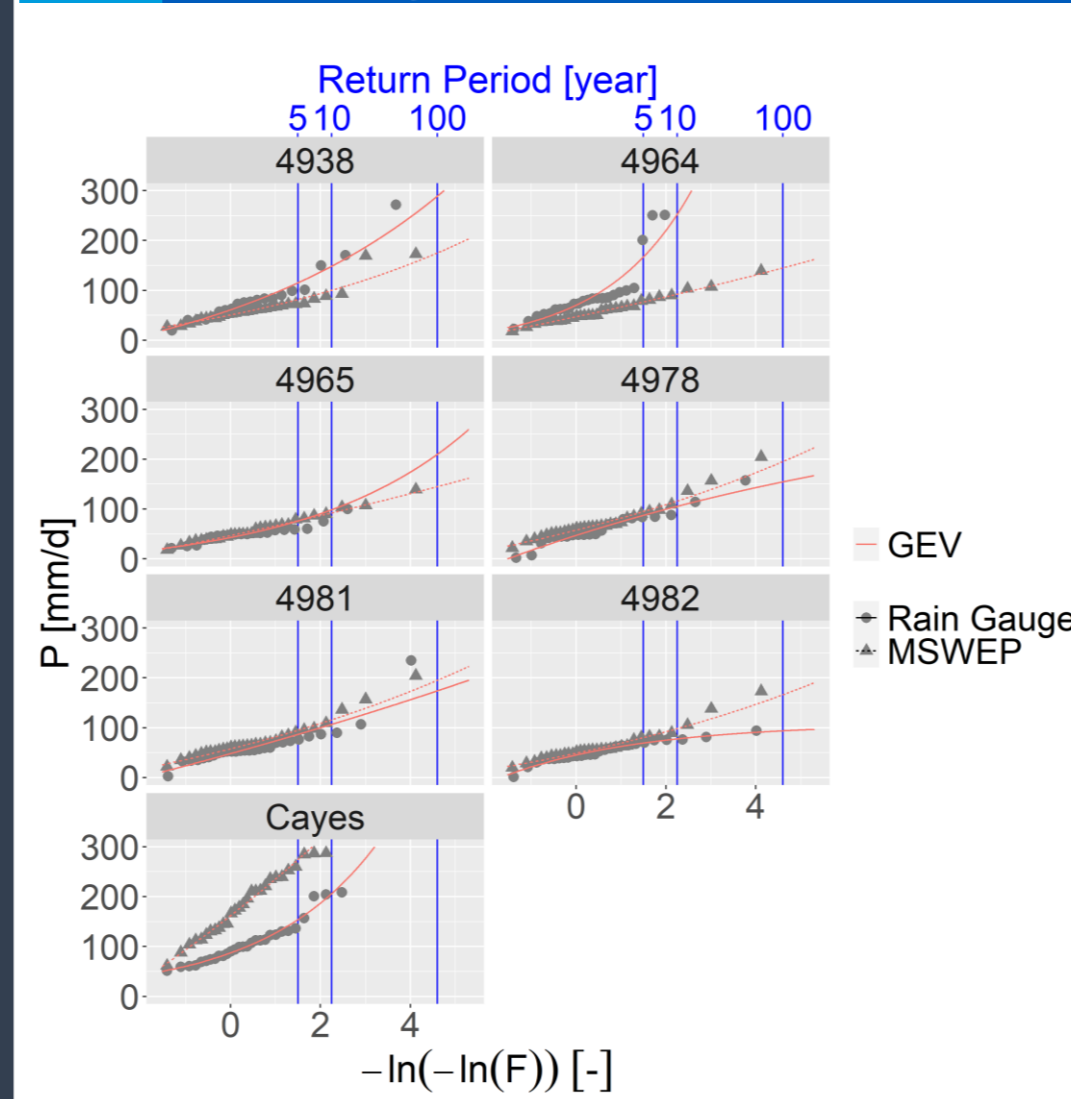


Fig. 2. GEV fitting on 7 rain gauge series and their corresponding MSWEP pixels.

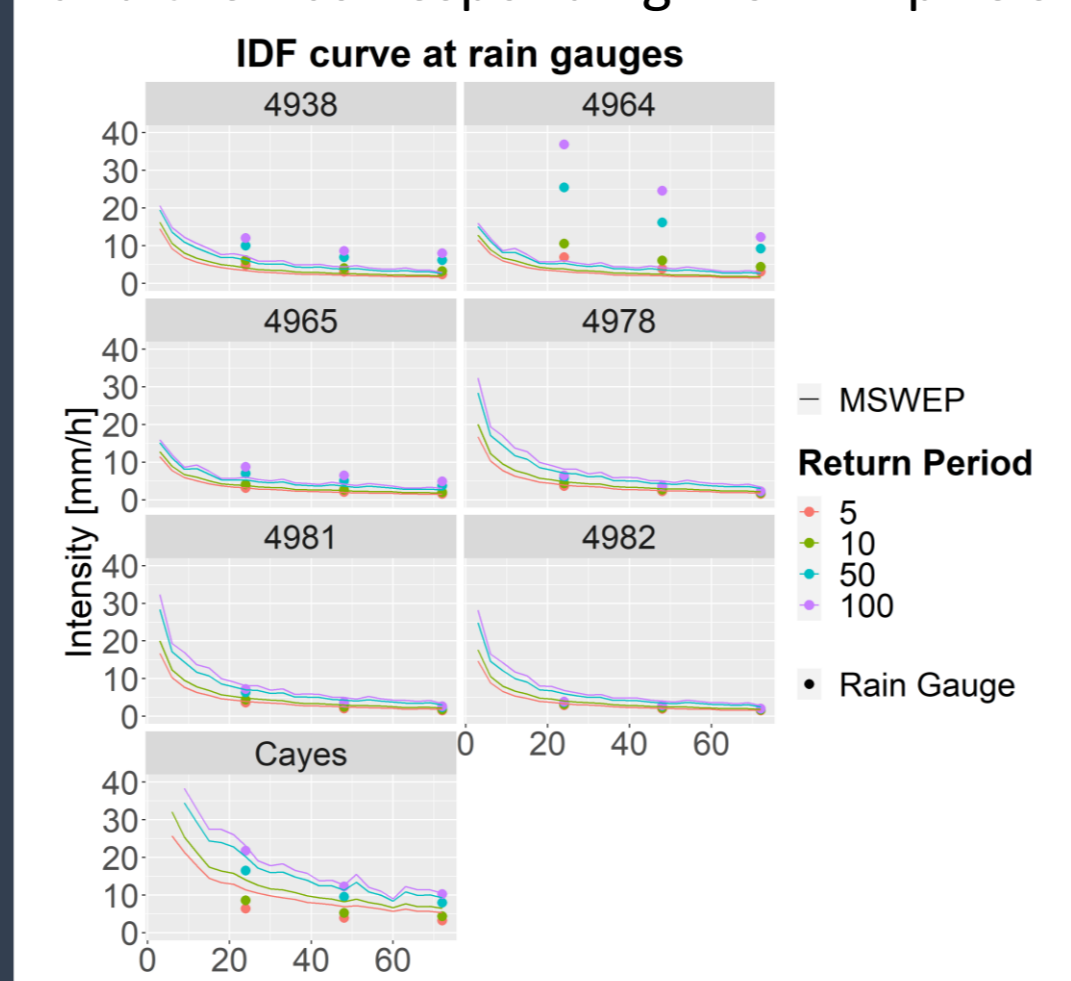
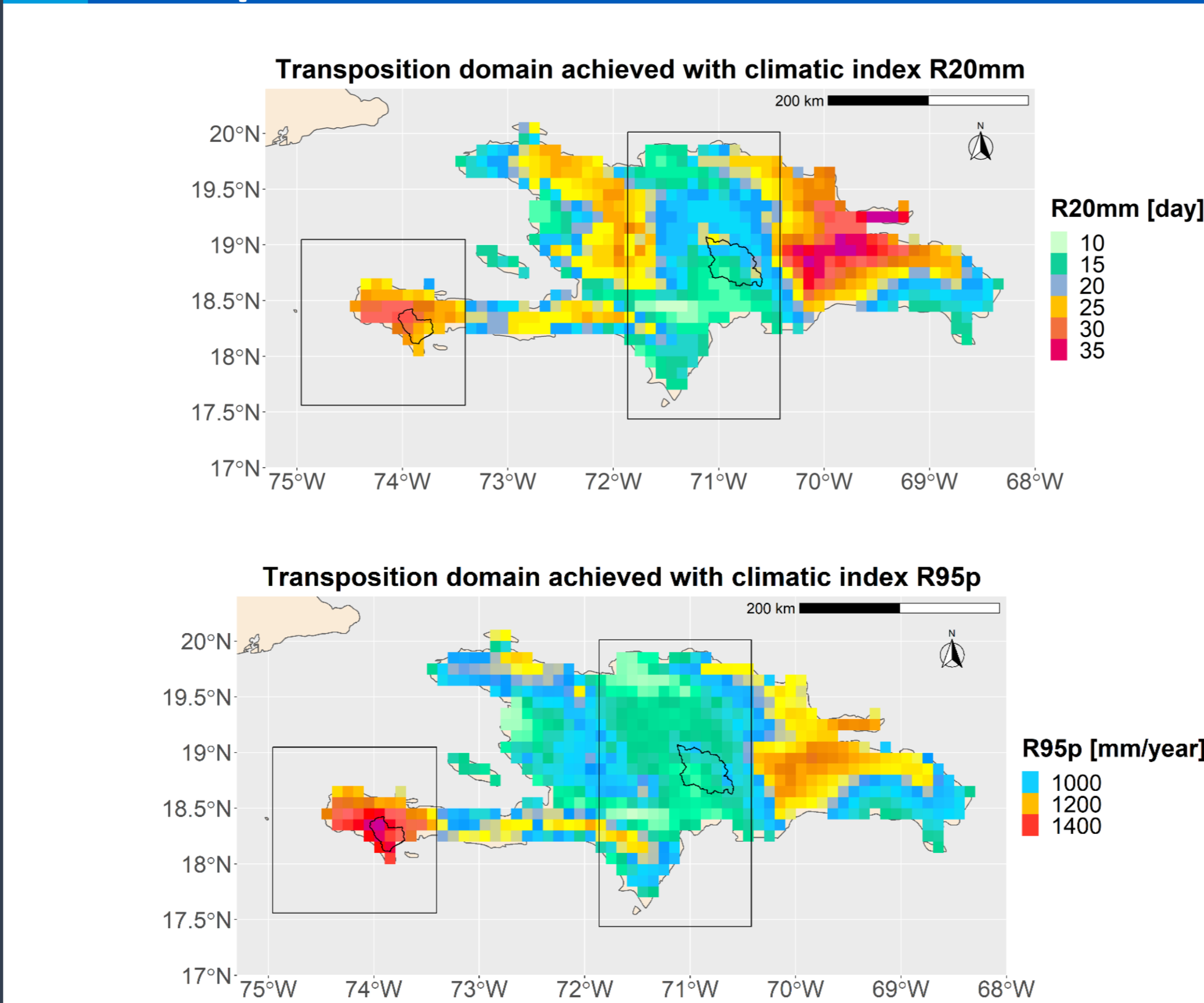


Fig. 3. IDF curves on 7 rain gauge series and their corresponding MSWEP pixels.

- ❖ MSWEP "annual maximum rainfall (P)" is close to that of the rain gauges in YDS watershed.
- ❖ P (annual maximum rainfall) > P₁₀ (10-year rainfall) seem overestimated by MSWEP for the 3 rain gauges (4978, 4981 and 4982) in the eastern part of the YDS watershed.
- ❖ P > P₁₀ seem underestimated by MSWEP for the 3 rain gauges (4938, 4964 and 4965) in the western part of the YDS watershed.
- ❖ P is strongly overestimated by MSWEP in the Cayes watershed.

- ❖ Heavy rainfall statistics from MSWEP are relatively realistic for areas with few reliable measurements.
- ❖ MSWEP severely underestimates heavy rainfall statistics from rain gauges 4938 and 4964 in YDS watershed.
- ❖ MSWEP overestimates low return period rainfall of the Cayes watershed rain gauge

4 Transposition domain of SST method



- ❖ The transposition domain is an area where the heavy rainfall climatology is assumed to be homogeneous.
- ❖ Both statistical indices R20mm (annual count of days when precipitation ≥ 20mm) and R95p (annual total precipitation when precipitation > 95th percentiles) are used to delimit the two transposition domains.

5 Heavy rainfall statistics at the catchment scale

5.1 - SST heavy rainfall map of two studied watersheds

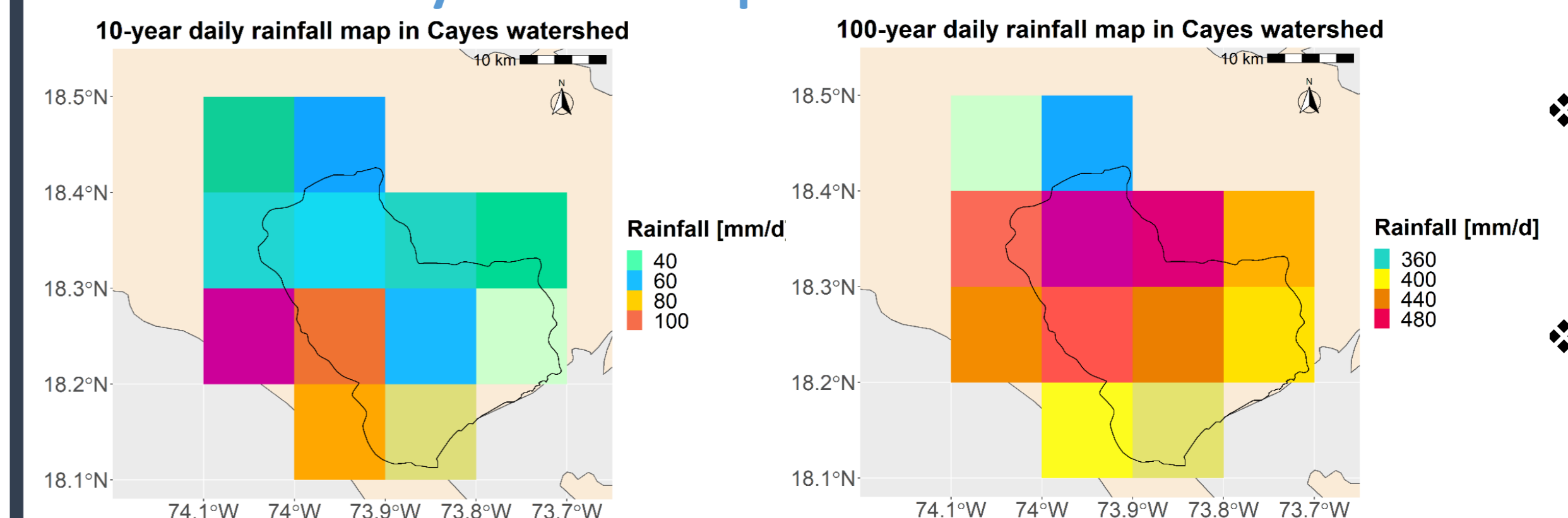


Fig. 6. Spatial distribution of the 10-year return period daily rainfall in the Cayes watershed.

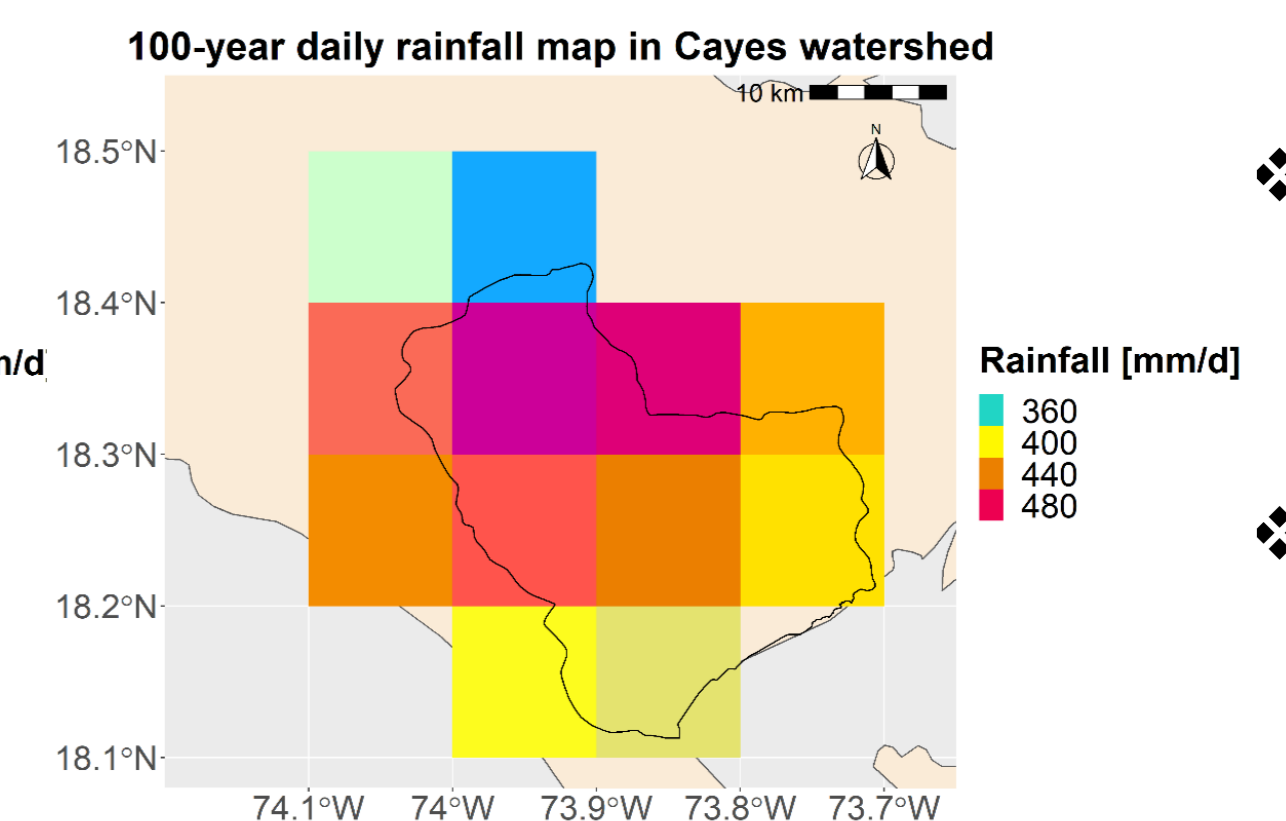


Fig. 7. Spatial distribution of the 100-year return period daily rainfall in the Cayes watershed.

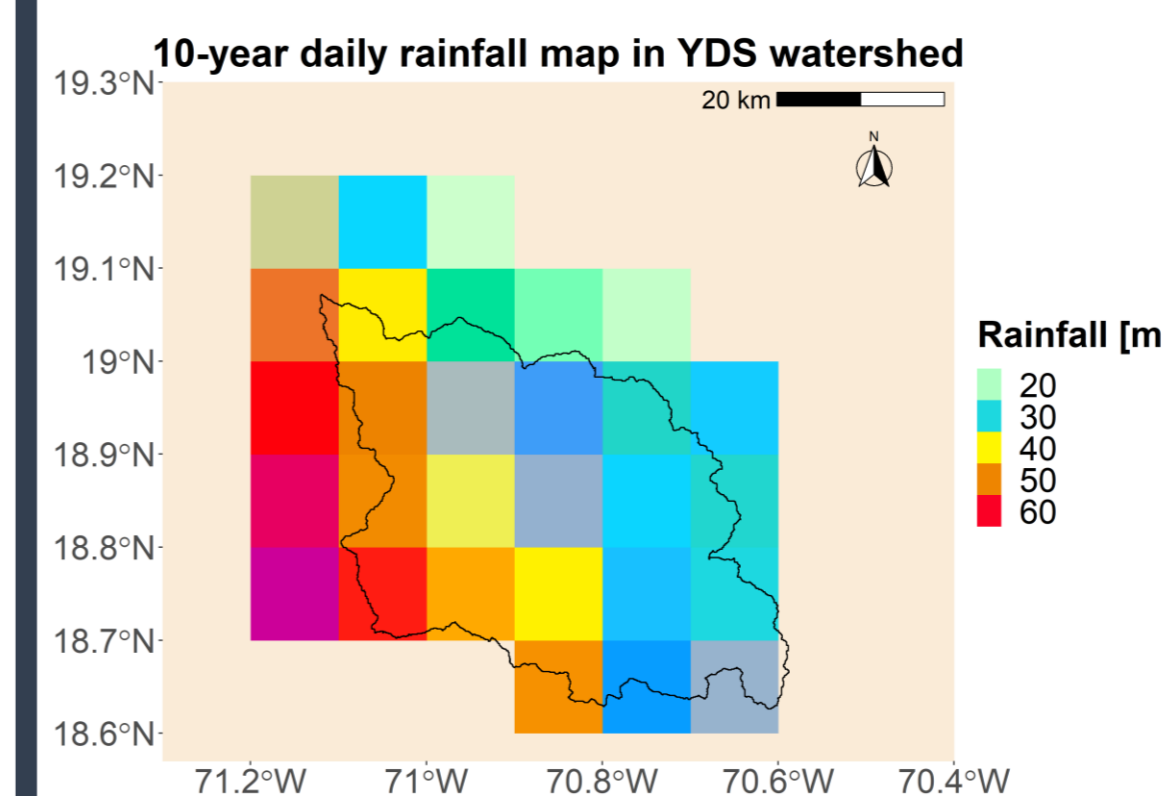


Fig. 8. Spatial distribution of the 10-year return period daily rainfall in the YDS watershed.

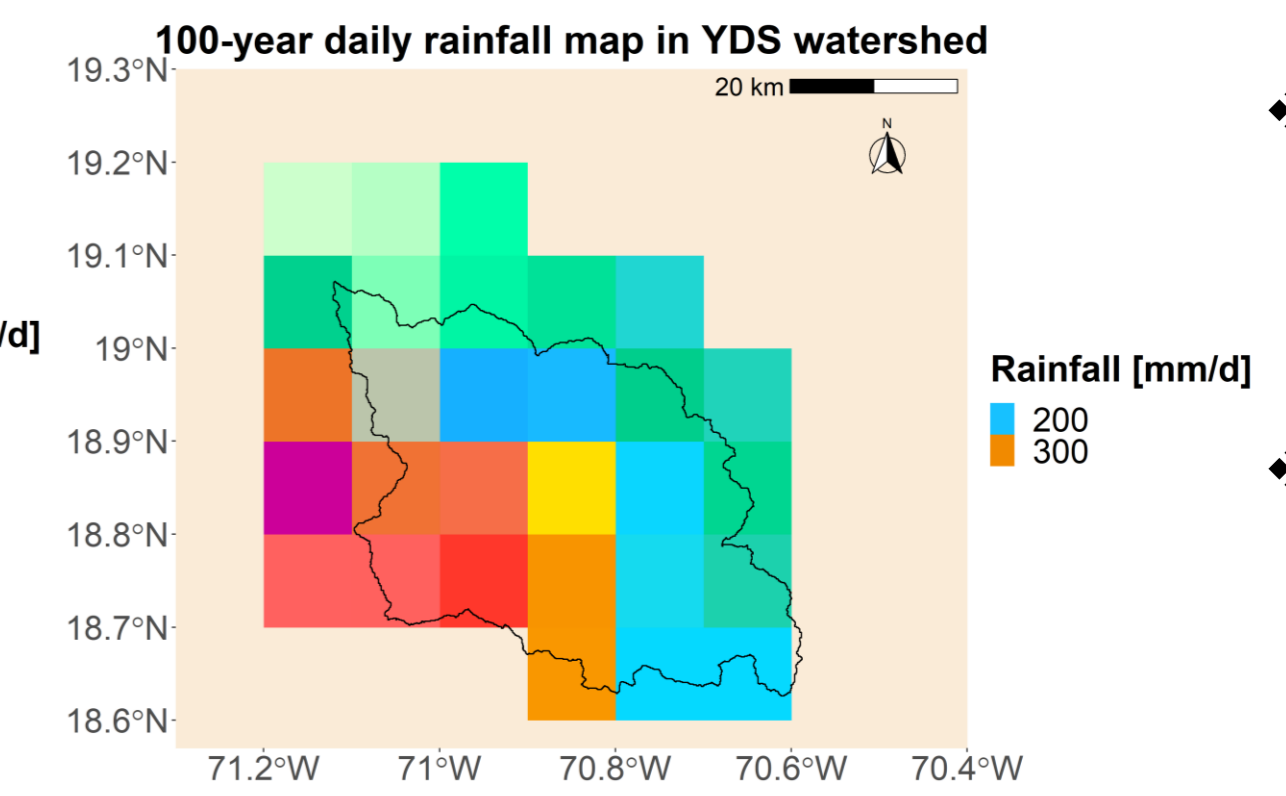


Fig. 9. Spatial distribution of the 100-year return period daily rainfall in the YDS watershed.

- ❖ Average daily rainfall with a 10-year return period (P₁₀) is 70 mm/d in the Cayes watershed.
- ❖ Average daily rainfall with a 100-year return period (P₁₀₀) is 425 mm/d in the Cayes watershed.

- ❖ Average daily rainfall with a 10-year return period (P₁₀) is 40 mm/d in the YDS watershed.
- ❖ Average daily rainfall with a 100-year return period (P₁₀₀) is 200 mm/d in the YDS watershed.

5.2 - IDF curve at the catchment scale

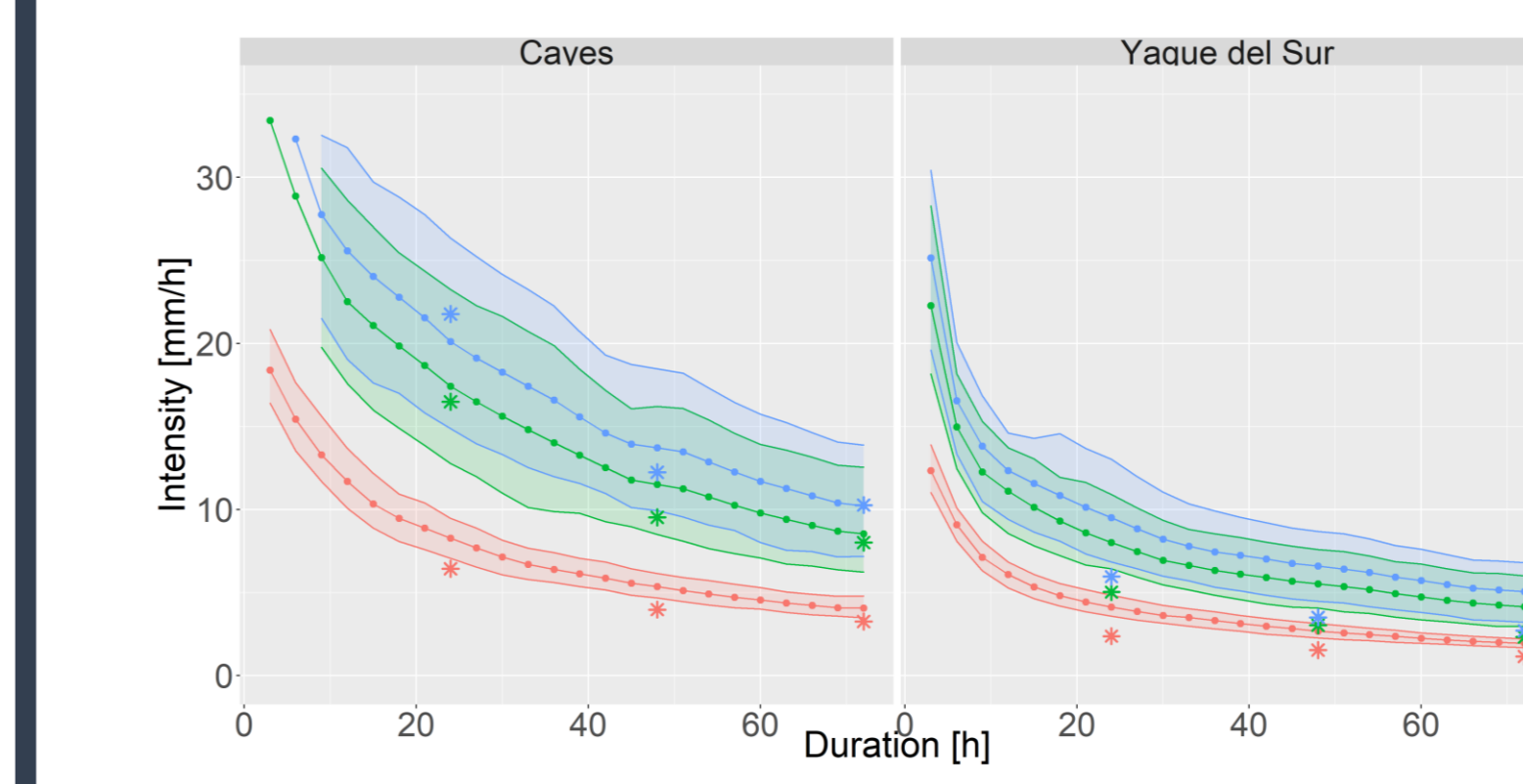


Fig. 10. Representation of the IDF curves averaged over the Cayes and the YDS watersheds.

- ❖ Rainfall intensities obtained with MSWEP + SST and Thiessen + GEV methods are similar for the Cayes watershed.
- ❖ Rainfall intensities obtained with MSWEP + SST are significantly higher than those obtained with Thiessen + GEV fitting on the rain gauge series for the YDS watershed.
- ❖ Thiessen catchment rainfall series in YDS watershed has smoothed rainfall peaks and therefore underestimates the rainfall intensities obtained with GEV fitting over catchment series.

6 Conclusions and perspectives

- ❖ Heavy rainfall statistics obtained with MSWEP dataset and rain gauge observations for the GEV method are similar on the two studied catchments, except for the highest annual maxima, no definite trend of over or underestimation.
- ❖ Results obtained by using MSWEP rainfall data as inputs of the SST method seem relevant.
- ❖ This study highlights the potential of using satellite rainfall such as MSWEP to determine heavy rainfall statistics in watersheds with few or no rainfall measurements such as ungauged Haitian watersheds.
- ❖ Further studies need to be performed on well instrumented watersheds to fully document the strengths and weaknesses of this new SST method in our study region (Greater Antilles).

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