Extreme Rainfall from Tropical Cyclones Described Through the Metastatistical Extreme Value Distribution

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Storm surges

Heavy rainfall

Strong wind

In the following, we will focus on

HEAVY RAINFALL

(Some) impacts of heavy rainfall

NEGATIVE

Flooding/flash flooding

Landslides

Waterborne diseases

POSITIVE

Drought mitigation

Reservoir replenishment

IMPORTANCE
of accurate extreme value estimation

The Metastatistical Extreme Value Distribution (MEVD)

(*Marani and Ignaccolo*, 2015; *Zorzetto et al.*, 2016)

$$\zeta_M(x) = \frac{1}{M} \sum_{j=1}^{M} [F(x; \boldsymbol{\theta_j})]^{n_j}$$

In its single-component…

(*Miniussi et al.*, 2020)

$$\zeta(x) = \frac{1}{M} \sum_{j=1}^{M} [F_{nTC}(x; \boldsymbol{\theta_j})]^{n_j^{nTC}} \cdot [F_{TC}(x; \boldsymbol{\theta})]^{n_j^{TC}}$$
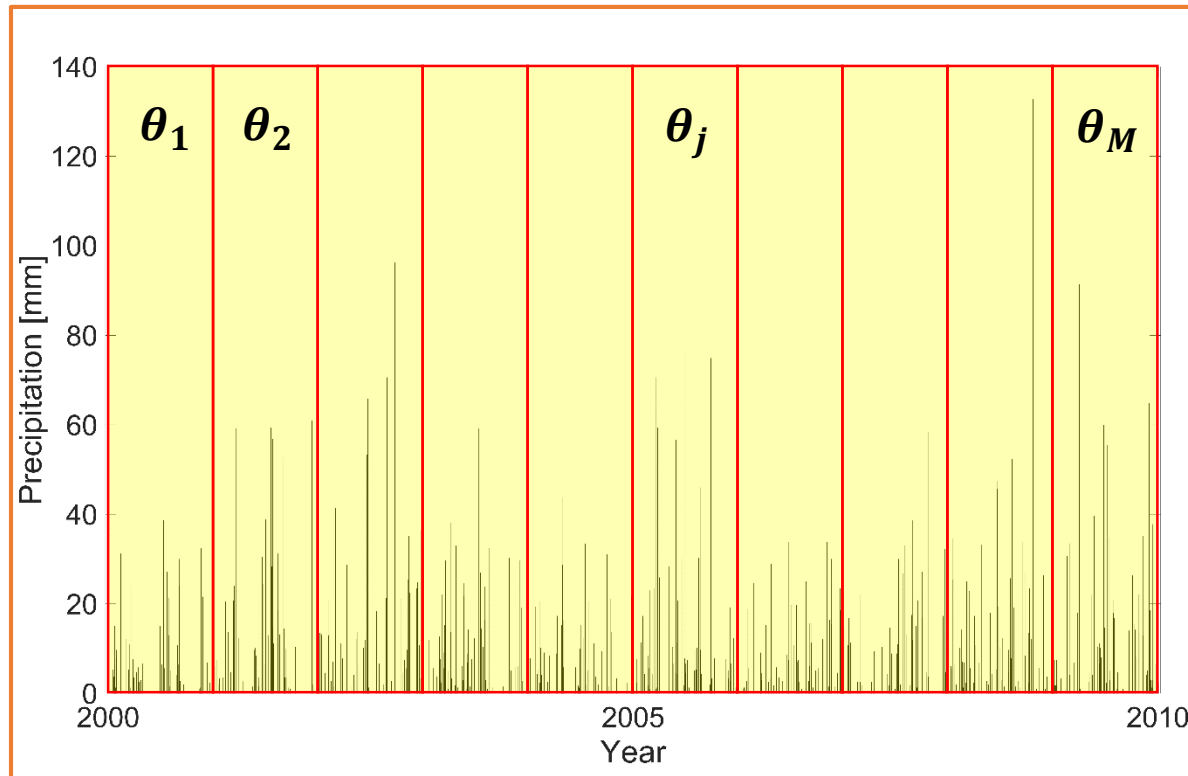
…and mixed formulation

- $F_{nTC}(x; \boldsymbol{\theta_j})$: distribution of the ordinary non-TC events in year *j*

- $F_{TC}(x; \boldsymbol{\theta})$: distribution of the ordinary TC events in the whole sample

- n_j^{nTC} (n_j^{TC}) : number of non-TC (TC) events in year *j*
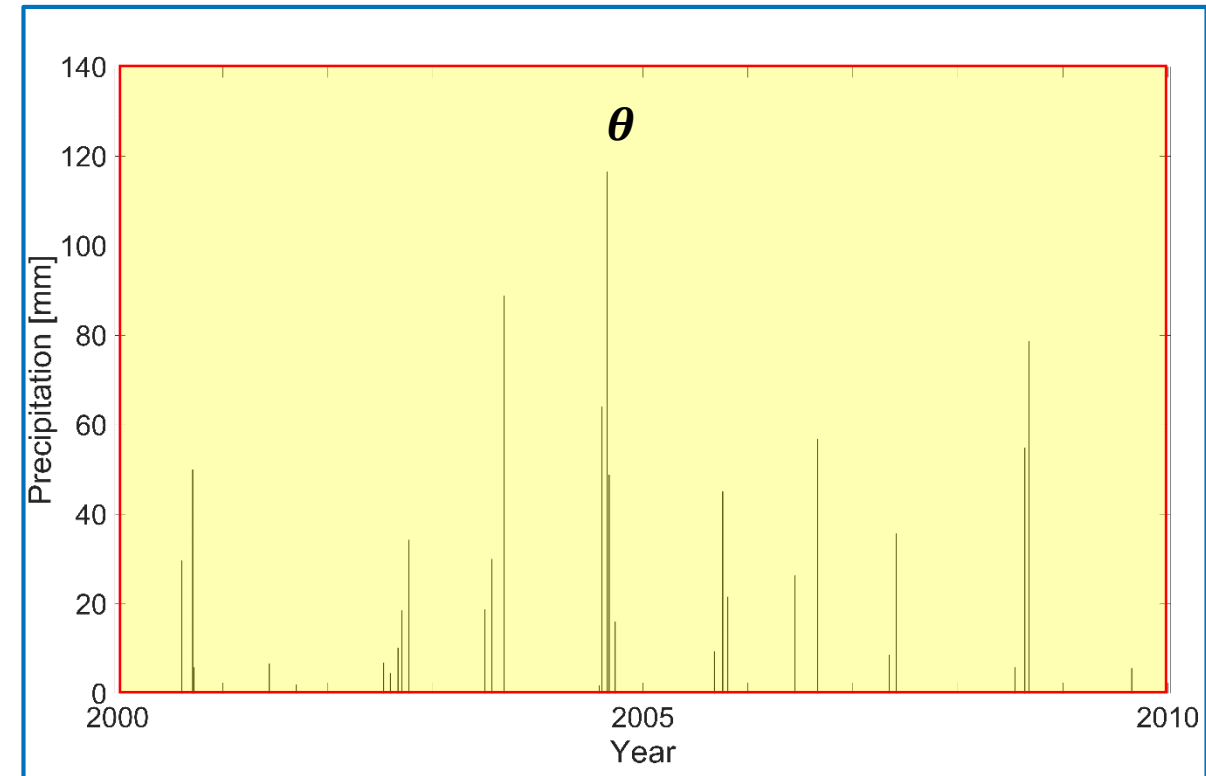
- M   : length of the series

The mixed MEVD

$$\zeta(x) = \frac{1}{M}\sum_{j=1}^{M} \boxed{[F_{nTC}(x;\boldsymbol{\theta_j})]^{n_j^{nTC}}} \cdot \boxed{[F_{TC}(x;\boldsymbol{\theta})]^{n_j^{TC}}}$$
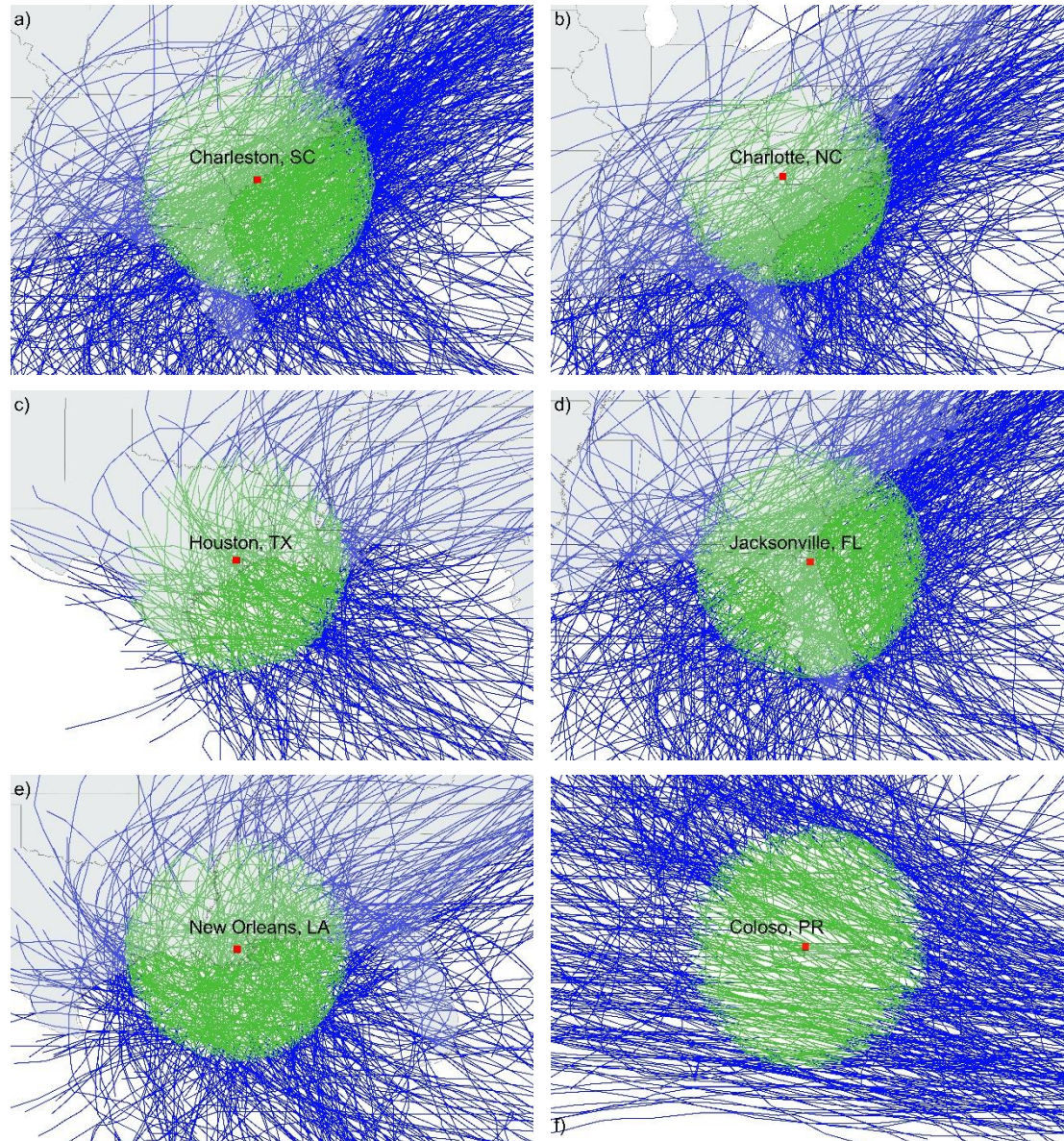
Non-TC rainfall

TC-induced rainfall

M = 10 years
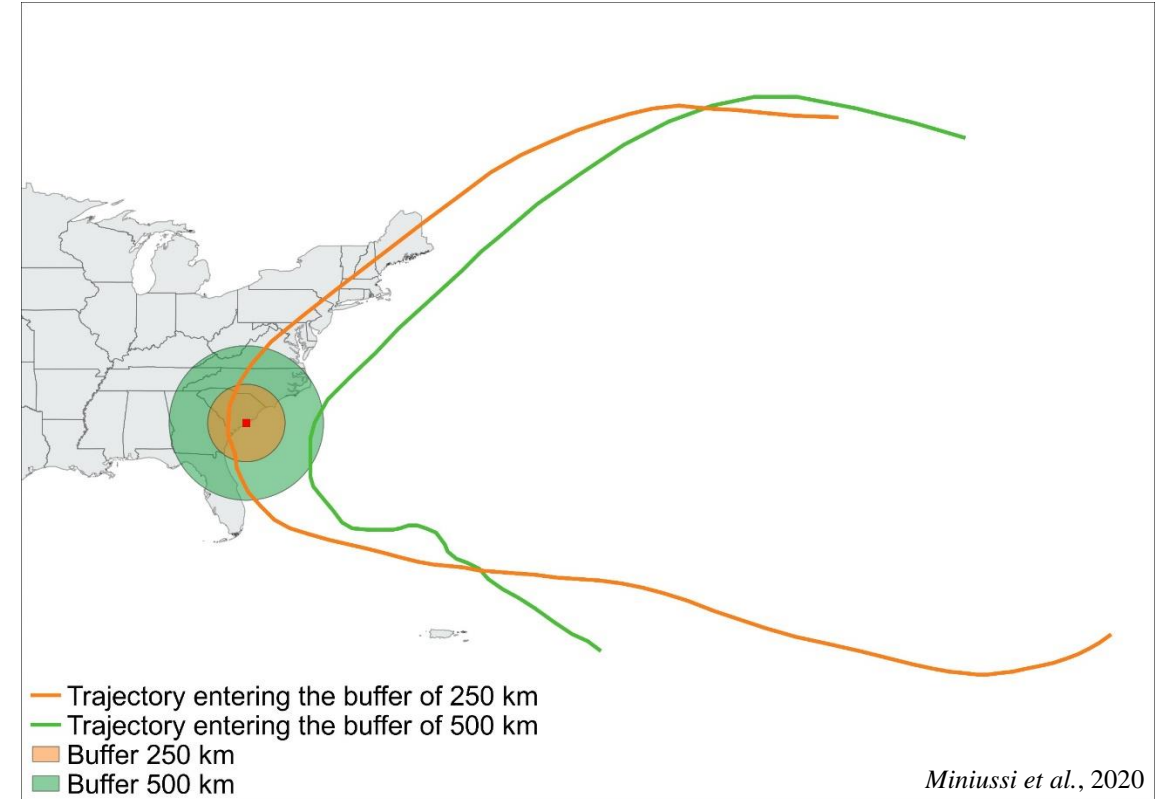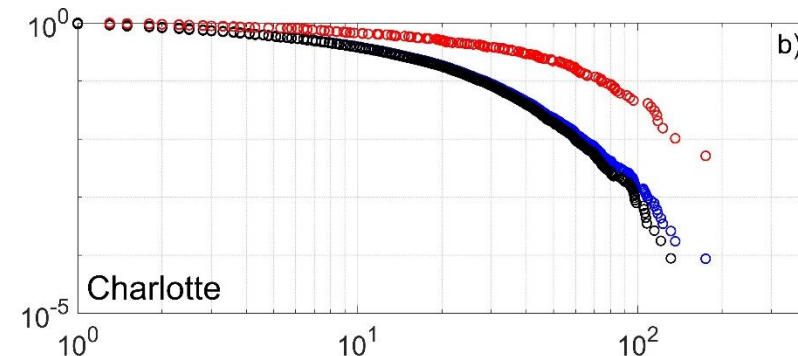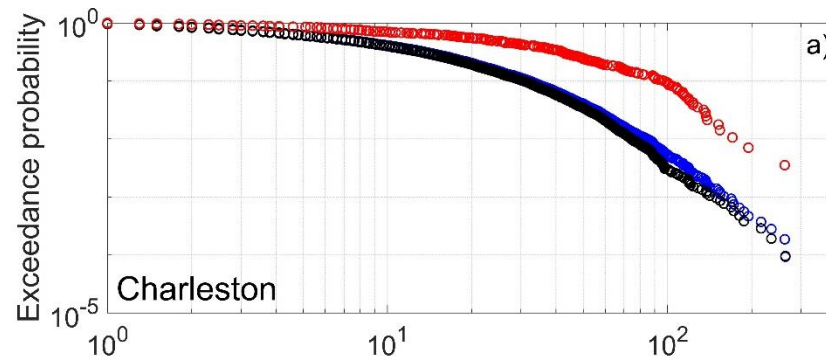
M = 10 years

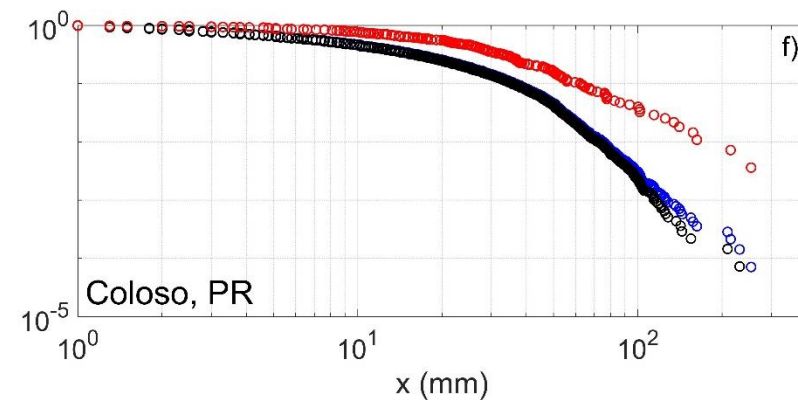Buffers for identifying trajectories of TCs influencing rainfall

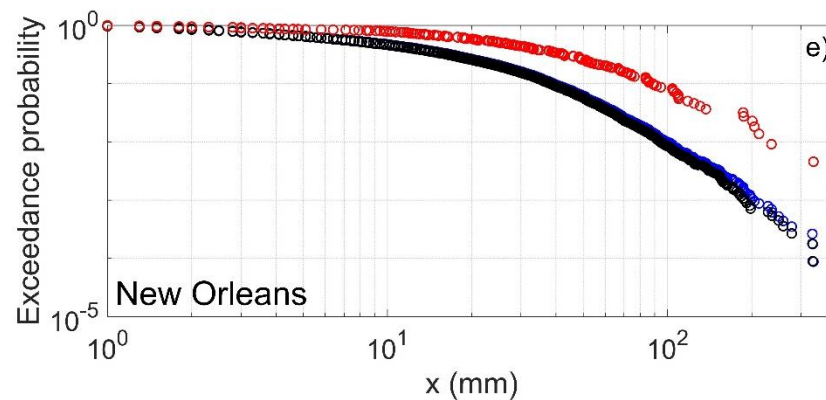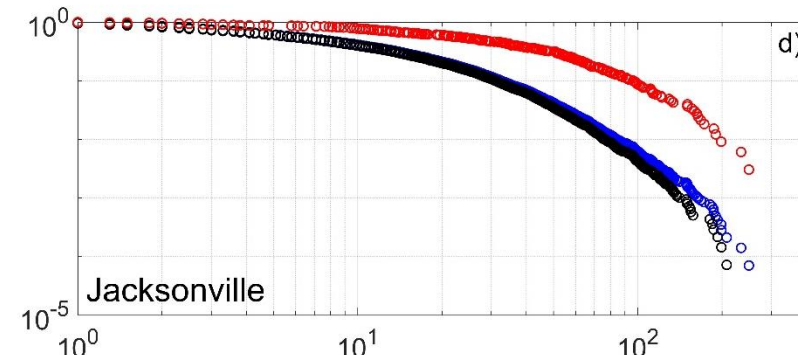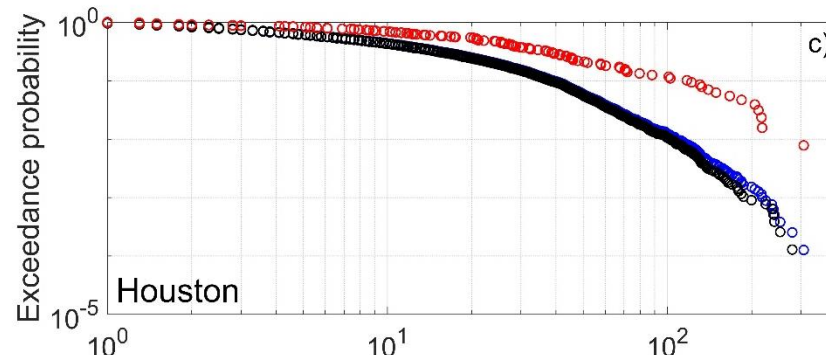*Miniussi et al.*, 2020

Can mixtures of distributions improve the accuracy in the estimation of extreme values of rainfall?

Miniussi et al., 2020

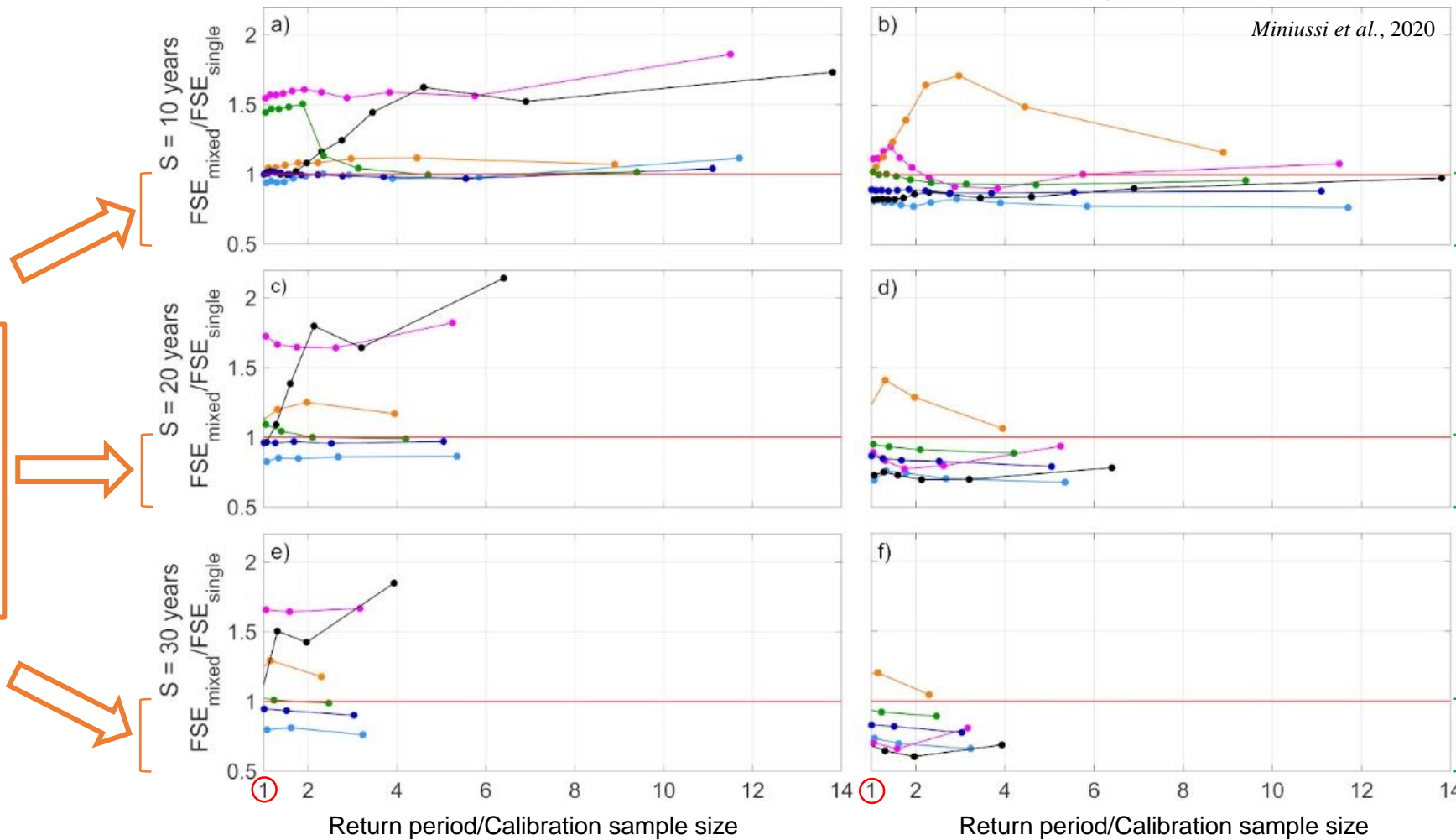YES! ⟹ The use of a mixed-MEVD is justified

Single-component or mixed MEVD?

FSE: Fractional Standard Error
S: Calibration sample size

Does the temporal scale matter?

Daily rainfall   3-days rainfall

Miniussi et al., 2020

No consistent outperformance of one method

5 cases out of 6 benefit from the mixed MEVD (FSE ratio < 1)

Conclusions

1. The MEVD naturally incorporates different phenomena (e.g., non-TC and TC-induced rainfall)

2. The mixed-MEVD reduces the estimation error in most of the cases analyzed

3. The time scale for which the advantage becomes consistently more relevant is 3 days

Some MEVD references:

- Marani M. and M.Ignaccolo (2015). A metastatistical approach to rainfall extremes. *Adv Wat Res*, 7.
- Hosseini S.R., M.Scaioni and M.Marani (2020). Extreme Atlantic hurricane probability of occurrence through the Metastatistical Extreme Value Distribution. *Geophys Res Lett*, 47.
- Miniussi A., M.Marani and G.Villarini (2020). Metastatistical Extreme Value Distribution applied to floods across the continental United States. *Adv Wat Res*, 136.
- Miniussi A., G.Villarini and M.Marani (2020). Analyses through the Metastatistical Extreme Value Distribution identify contributions of Tropical Cyclones to rainfall extremes in the Eastern United States. *Geophys Res Lett*, 47.
- Zorzetto E., G.Botter and M.Marani (2016). On the emergence of rainfall extremes from ordinary events. *Geophys Res Lett*, 43.
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- Zorzetto E. and M.Marani (2020). Extreme value metastatistical analysis of remotely sensed rainfall in ungauged areas: Spatial downscaling and error modelling. *Adv Wat Res*, 135.