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## Assessment of probabilistic areal reduction factors of precipitations for the whole French territory with gridded rainfall data

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### Abstract

The purpose of our study was to develop and test a simple methodology to derive areal rainfall quantiles from point rainfall quantiles, via the concept of probabilistic areal reduction factor (ARF). This concept enables to estimate areal rainfall of a particular frequency and for a given duration from point rainfalls of the same frequency and duration. Assessing such ARF for the whole French territory is of particular interest since it should allow us to compute areal rainfall quantiles, and eventually watershed rainfall quantiles, by using already available grids of statistical point rainfall that are provided by a regionalized stochastic hourly point rainfall generator, the SHYREG method previously developed by Irstea and Météo-France for the French Ministry of ecology, sustainable development and energy (Arnaud et al., 2007).

### 1. Introduction

A stochastic hourly point rainfall generator was developed by Arnaud et al. (1999; 2007) to assess extreme rainfalls in France. Its ability to reproduce the different kinds of French climate (temperate climate for mainland France and tropical climate for the overseas French territory) and the regionalization of its parameters (Arnaud et al., 2008) enable to generate long time series of rainfall in each km<sup>2</sup> of the French territory. Being calibrated independently on numerous raingauges data, this method suffers from the limitation common to point-process rainfall generators stressed by Rodriguez-Iturbe et al. (1987) and Burlando et al. (1993): it can only reproduce point rainfall patterns and has no capacity to generate rainfall fields. Although it gives access to point rainfall quantiles everywhere in France, it can't provide areal rainfall quantiles, the estimation of the latter being however needed for the construction of design rainfall or for the diagnostic of observed events.

One means of bridging this gap between local rainfall quantiles and areal rainfall quantiles is given by the probabilistic areal reduction factor of rainfall as defined by Omolayo (1993) who suggests that to obtain the probabilistic ARF for a duration D, the T-year areal rainfall  $P_{\text{area}}$  over a region of size A should be divided by the  $w_i$ -weighted average T-year point rainfall  $P_i$  of all gauges  $i$  in the same region:

$$\text{ARF}(A,D,T) = \frac{P_{\text{area}}(A,D,T)}{\sum_i w_i \sum_i [w_i P_i(D,T)]} \quad (1)$$

Historically studied on dense network of raingauges, this factor has been computed here using rainfall fields instead of point rainfall data. This has led to a  $w_i$  weight of 1 in equation 1, for the rainfall  $P_i$  estimated in each pixel  $i$  of the rainfall field.

We have computed the probabilistic ARF thanks to two sets of rainfall fields available on the whole mainland French territory. The originality of this study is the geographical domain covered: it is the first time so far that the ARF have been studied considering the whole French territory.

## 2. Data

Two sets of rainfall fields were gracefully provided by Météo-France, the French national weather service:

- a set of hourly rainfall fields from a 10-year reference database of Quantitative Precipitation Estimation (QPE) over France (Tabary et al., 2012),
- a set of daily rainfall fields resulting from a 53-year high-resolution atmospheric reanalysis over France with the SAFRAN-gauge-based analysis system (Vidal et al., 2010).

## 3. Method

We have built samples of maximal rainfalls for each cell location (the “point” rainfalls) and for different square areas centered on each cell location (the areal rainfalls) of these gridded data. To compute rainfall quantiles, we have fitted a Gumbel law, with the L-moment method, on each of these samples. Our sampling methodology and the data used have enabled us to assess the probabilistic ARF values in mainland France for:

- different square areas,
- different rainfall durations: sub-daily to 3-day rainfall,
- different return periods: from 2 to 100-year for the SAFRAN rainfall, from 2 to 20-year for the QPE rainfall,
- different time periods: whole year, “winter” period from December to May and “summer” period from June to November,
- different climatic areas taken from Choissnel et al. (1988) and shown in Figure 1: the oceanic, the semi-oceanic, the semi-continental, the Mediterranean and the Mountain climate areas.

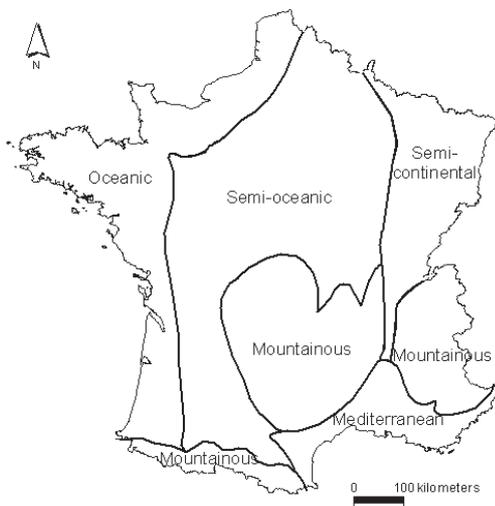


Fig 1: main climatic zones in mainland France, from Choissnel et al. (1988).

## 4. Results

The daily and hourly ARF computed in this data-intensive study have shown four main trends:

- a sensitivity to the return period as can be seen on Figure 2 that shows how the median ARF values, computed over France for the daily and hourly rainfall durations respectively, evolve with the size of the computation area and the return period;
- a sensitivity to the rainfall duration as can be seen on Figure 3 that shows how the median ARF values, computed over France for the 1-day, 2-day and 3-day durations, evolve with the size of the computation area;

- a sensitivity to the season as shown by Figure 4 that displays how the median daily ARF values computed over France for the winter and summer periods, evolve with the size of the computation area;
- a sensitivity to the geographical location as can be seen on Figure 5 that shows how the median ARF values, computed for the daily and hourly rainfall durations respectively, evolve with the size and the geographical localization of the computation area.

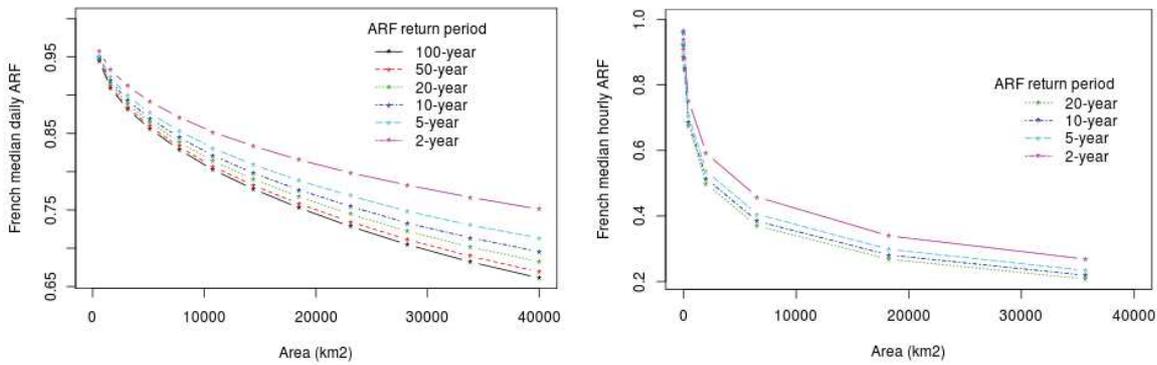


Fig 2: evolution, for different return periods, of the French median daily ARF computed with the SAFRAN annual maximal rainfall (left) and of the French median hourly ARF computed with the QPE (right) annual maximal rainfall.

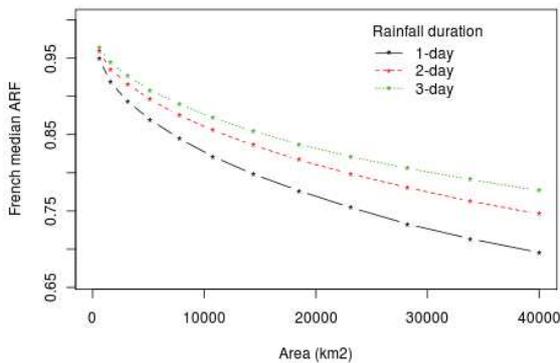


Fig 3: evolution of the 10-year French median ARF computed with the SAFRAN annual maximal rainfall for different durations.

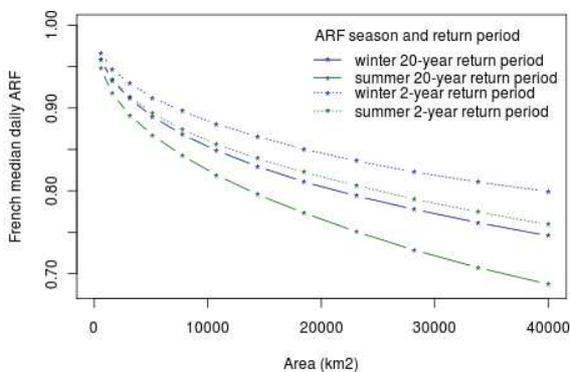


Fig 4: evolution of the French median ARF computed with the SAFRAN annual maximal rainfall for different seasons and return periods.

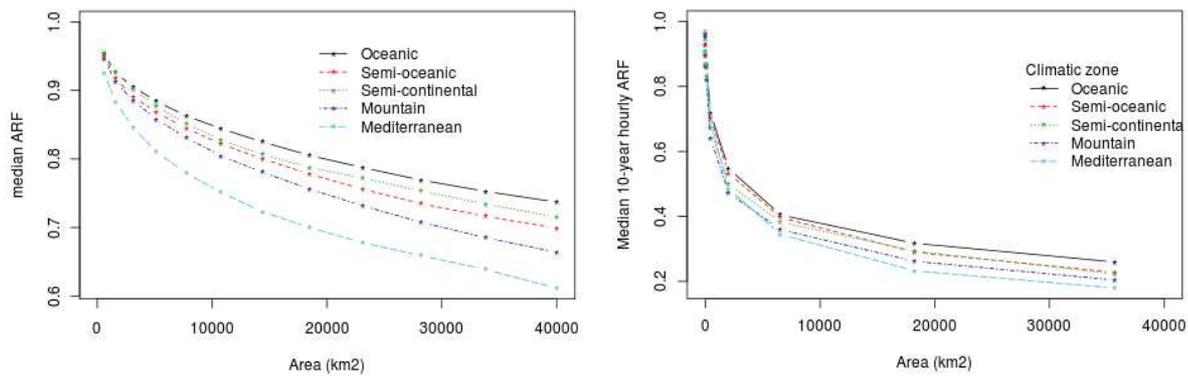


Fig 5: evolution, in the 5 main French climatic zones, of the median 10-year daily ARF computed with the SAFRAN annual maximal rainfall (left) and of the median 10-year hourly ARF computed with the QPE annual maximal rainfall (right).

Our results show that the ARF values decrease when the return period increases, ie when the severity of rainfall increases. This means that the less frequent an areal rainfall, the more it differs from the mean local rainfall quantiles of the same occurrence, computed on the same area. The ARF values also decrease when the rainfall duration decreases. This means that, for a given return period, the shorter the rainfall duration, the more an areal rainfall quantile differs from the mean local rainfall quantiles of the same occurrence, computed on the same area. We have then shown that the ARF values are smaller for the summer period than for the winter period and the summer values. This seasonal trend is in agreement with the typology of rainfall events occurring in mainland France: convective events of small spatial extent in late summer and autumn and more frontal events of wide extent in winter and spring, the former being associated with a high spatial variability of rainfall and thus leading to low values of ARF, the later with a low spatial variability and thus with high values of ARF. The geographical location of rainfall has also an impact on the values of the ARF. Regional trends can hence be observed with low daily ARF values in the Mediterranean climatic area and ARF values close to 1 for the climatic zones of Northern and Western France (oceanic to semi-continental climate). The low values of ARF in the Mediterranean climatic area reflect the high geographical variability of rainfall which characterizes this specific climate.

## 5. Conclusion

The results of this data-intensive study led for the first time on the whole French territory are in agreement with studies led abroad (e.g. Allen and DeGaetano 2005, Overeem et al. 2010) and confirm and widen the results of previous studies that were carried out in France on smaller areas and with fewer rainfall durations (e.g. Ramos et al., 2006, Neppel et al., 2003).

Having demonstrated the general trends of the probabilistic ARF of rainfall for the French mainland territory, we will be able to assess its mathematical laws. These laws will then enable us to compute areal rainfall quantiles using the grids of statistical point rainfall provided by the French regional stochastic hourly rainfall generator presented above, the SHYREG method.

## References

- Allen R., J., and DeGaetano, A. T. (2005), Areal reduction factors for two eastern United States regions with high rain-gauge density. *Journal of Hydrologic Engineering* 10(4): 327-335.
- Arnaud, P., Fine, J.-A., and Lavabre, J. (2007), An hourly rainfall generation model applicable to all types of climate. *Atmospheric Research* 85(2): 230-242.
- Neppel, L., Bouvier, C. and Lavabre, J. (2003), Areal reduction factor probabilities for rainfall in Languedoc Roussillon. *IAHS-AISH Publication* (278): 276-283.

- Omolayo, A. S. (1993), On the transposition of areal reduction factors for rainfall frequency estimation. *Journal of Hydrology* 145 (1-2): 191-205.
- Overeem, A., Buishand, T. A., Holleman, I., and Uijlenhoet R. (2010), Extreme value modeling of areal rainfall from weather radar. *Water Resources Research* 46(9): 10 p.
- Ramos, M.-H., Leblois, E., and Creutin, J.-D. (2006), From point to areal rainfall: Linking the different approaches for the frequency characterisation of rainfalls in urban areas. *Water Science and Technology*. 54(6-7): 33-40.
- Tabary, P., Dupuy, P., L'Henaff, G., Gueguen, C., Moulin, L., Laurantin, O., Merlier, C., and Soubeyroux, J. M. (2012), A 10-year (1997–2006) reanalysis of Quantitative Precipitation Estimation over France: methodology and first results. *IAHS-AISH Publication* (351) : 255-260.
- Vidal, J.-P., Martin, E., Franchistéguy, L., Baillon, M. and Soubeyroux, J.-M. (2010), A 50-year high-resolution atmospheric reanalysis over France with the Safran system. *International Journal of Climatology* 30(11): 1627-1644.