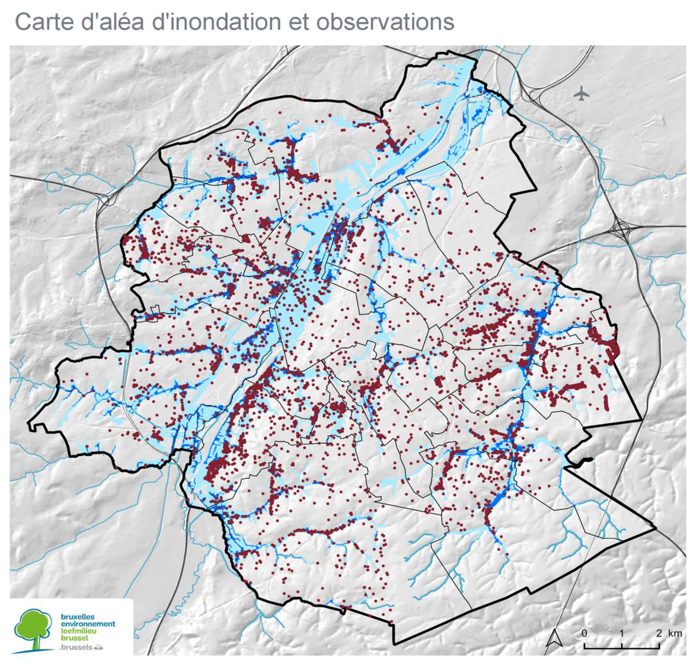
Nowcasting of rainfall return periods by municipality: a pragmatic tool for warning of pluvial flooding

Brussels is a 47% sealed territory, equipped with a combined sewerage system and storm water basins (totalizing 2l/m2 for the entire territory) dimensioned based on rainfall with a return period of 10 years. When rainfall is intense (generally during convective events) and exceeds these return periods, numerous flooding problems related to drainage appear. These are mainly sewage backups in cellars. Water backups on roads in the low-lying areas of the territory are also observed.



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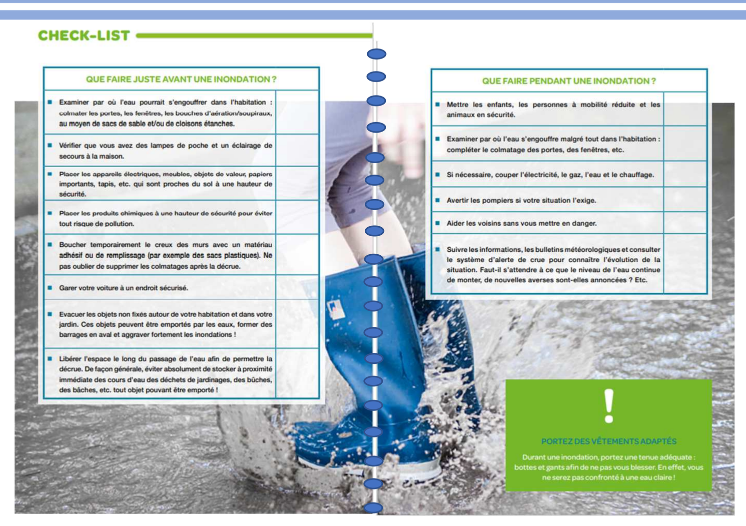
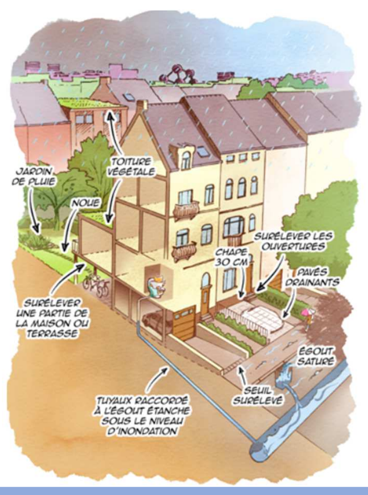
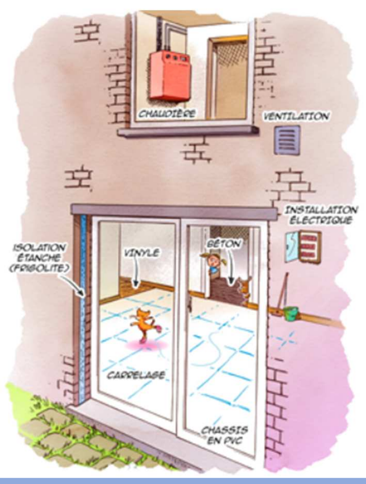
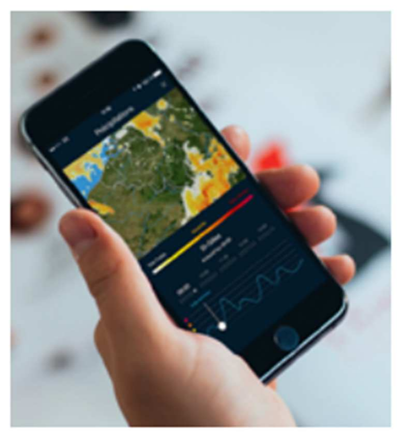


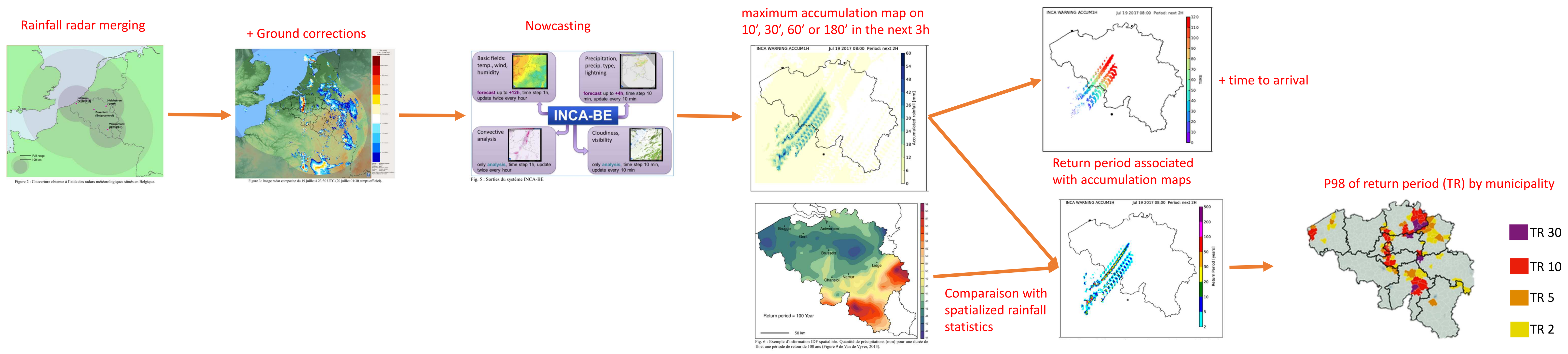




In order to reduce the vulnerability of the territory to these pluvial floods, awareness-raising actions and advisory services exist. Additional constraints in the rules of construction are being developed in sensitive areas. To these protection and prevention actions must be added preparation actions. The generation of flood warnings is an essential element. It will allow to set up the safeguard measures in time, by the municipal services but also by the inhabitants themselves.

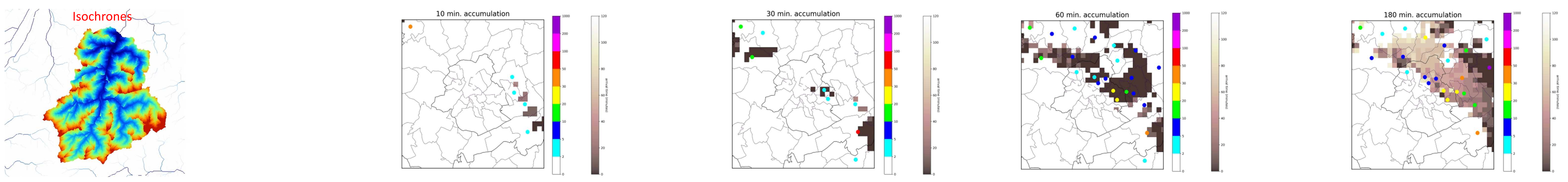


The principle of these alerts is based on the exceeding of a rainfall return time threshold, or in other words "in case of exceptional rainfall, the consequences are likely to be exceptional as well". The sewerage system being dimensioned for rainfall with a return time of 10 years, when the return time of a rainfall exceeds this return time, the risk of flooding will appear, and will increase with the level of rarity of the expected rainfall. This is a simple and fast way (no hydrological and hydraulic simulations to be done) to warn about the risk of pluvial flooding. The calculations are based on rainfall nowcasting at 3h, extrapolating the evolution of rainfall observed on the radar and corrected by ground data. The maximum rainfall accumulation over the given time interval (10, 30, 60 and 180 minutes) is calculated over the prediction horizon (and including the rainfall that has already occurred). The maximum accumulation per given time interval is then converted to return time, using local IDF statistics (also spatialized). The time to the arrival of the critical rainfall is also calculated at each pixel.

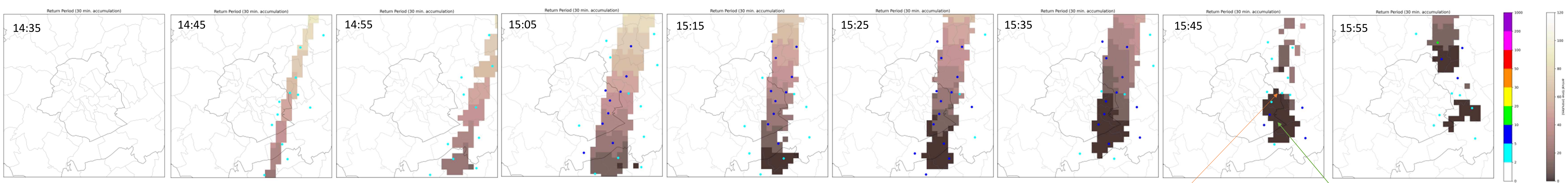


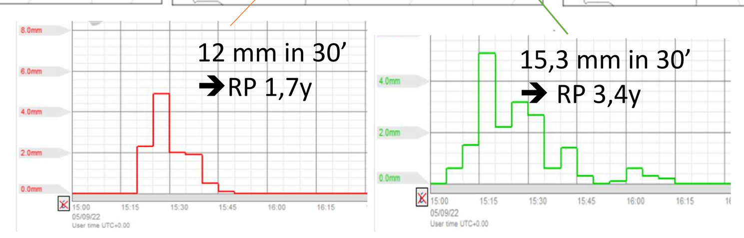
The next step is to generate alerts by management zones. The selected zones are the municipalities, but we could also subdivide the municipalities by watershed if the size of a municipality is important regarding the spatial granularity of the predictions (including spatial uncertainties). It is also prudent to include a buffer around these zones to account for the spatial uncertainty of rainfall predictions. Within these zones, zonal statistics of predicted return times are performed. We selected the 98th percentile as a good indicator of risk within the zone. This allows us to exclude extreme values for only a few pixels within the zone, while focusing on intense rainfall nuclei.

The critical rain duration to consider in the return time calculations is specific for each plot as it depends on its position in the watershed. The critical rain duration will correspond approximately to the concentration time, specific to each plot. The calculations are made for 4 accumulation periods: 10 minutes, 30 minutes, 1h and 3h. In Brussels, the 10- and 30-minutes rain duration are the most relevant for most of the floodable areas (pluvial hazard), considering the reactivity of the waterproofed catchment areas equipped with sewers.

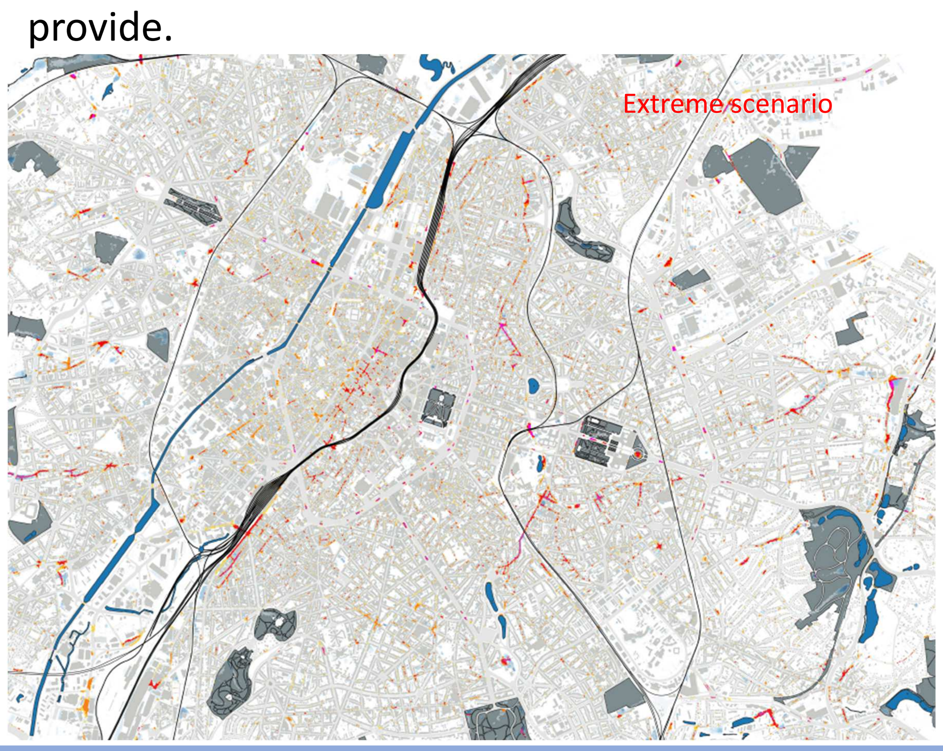


The system has been running internally for several months. We have already noted some points of improvement. The main difficulty comes from the spatial detail that we wish to have, which is often incompatible with the spatial predictions of the models, in particular for convective rainfall that we are trying to alert: stripping in the propagation of rainfall, storm position evolving from one simulation to another, spatial shift between radar and ground observations (wind), rapid evolution of the intensity of thunderstorm nuclei, sensitivity to corrective factors resulting from ground observations... The prediction is therefore quite uncertain, up to a few minutes before the event. It remains a pre-warning system.





Pre-computed flood hazard maps for different return periods could also be used to evaluate the potential consequence of the rainfall in terms of flooded area, although other factors such as the amount of previous rainfall that already partly saturates the network and its temporal dynamics should also be considered. But obviously we will not be able to go as far with this pre-warning tool as a complete hydrological and hydraulic live modeling would provide.



Prediction (left) 80 minutes in advance compared to radar observation (right)