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How probable was the flood inundation in Mandra? A preliminary urban flood inundation analysis

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1. Abstract

A recent flash flood event in the Mandra region west of Athens, Greece, turned urban roads into fast-flowing rivers, and caused many fatalities and economic damages. After this incident a great dispute arose whether the devastating results were due to the extreme nature of the storm event or to the poor flood protection works. In this study, we present a preliminary analysis of the urban flood inundation at the wider area by taking into account the uncertainty introduced by the input discharge, topography and hydraulic characteristics. Finally, we discuss how hydraulic works could reduce the severity of the event.

2. Location of Mandra

Mandra is a small industrial city with equivalent population up to 13000 people. The city is located in a watershed area of 75km^2 and is crossed by two ephemeral streams, which are named Soures and Agia Aikaterini. The extended urban expansion of Mandra in the last two decades, seems to change the topography and geometry of the existed watercourses. Soures watercourse flows as open channel and after its conjunction with Agia Aikaterini stream is treated in an open channel constructed by concrete. Upstream of conjunction Agia Aikaterini stream flows in an underground pipe through the hole city and at the point it reaches the city's boundaries, it turns to open channel flow.

3.The event

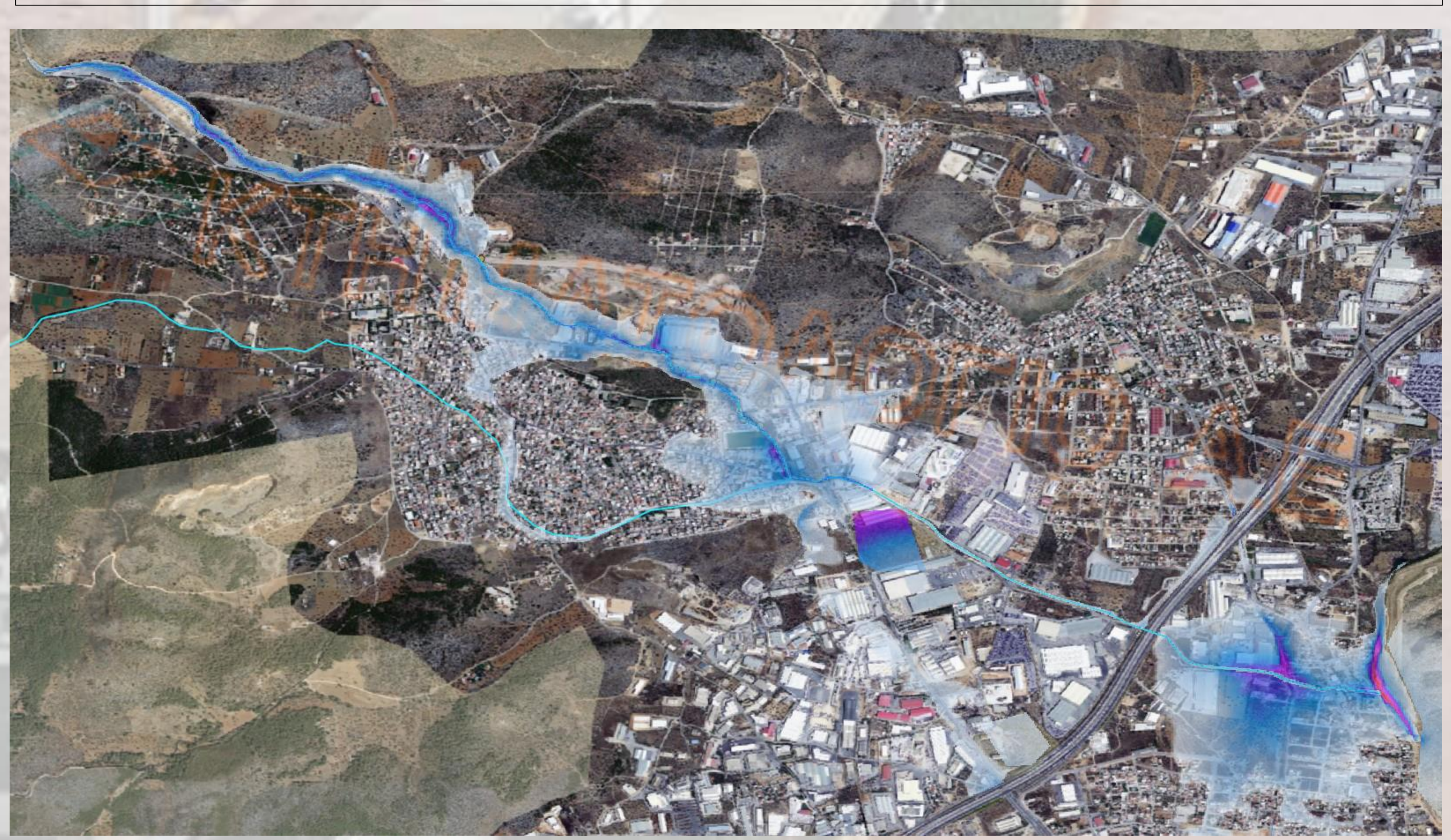
A flash flood occurred on the 15th of November, in the early morning the two streams inundated and each one's banks were heavily eroded. Therefore, a high sediment transportation is noticed, (including larger gravels than usual). This sediment transportation left some "footprints" as the water was flowing throughout the city.

4. Considerations

Our thought was to exploit this "footprint" in order to validate the 2-D flood model in terms of a justified discharge that matches the observed inundation. In an early stage of this analysis, we choose to use a steady state flow regime since it was difficult to find and handle trustworthy data for the validation.
Furthermore, we decide to isolate the Soures stream and its watershed. This consideration takes advantage of a short simulation time, a negligible loss of precision and a strong basis for the analysis.
Taking everything into account, we track the maximum water depth in seven certain points of the flooded area. Note that these seven points are selected so as they are only affected by the Soures stream flow.

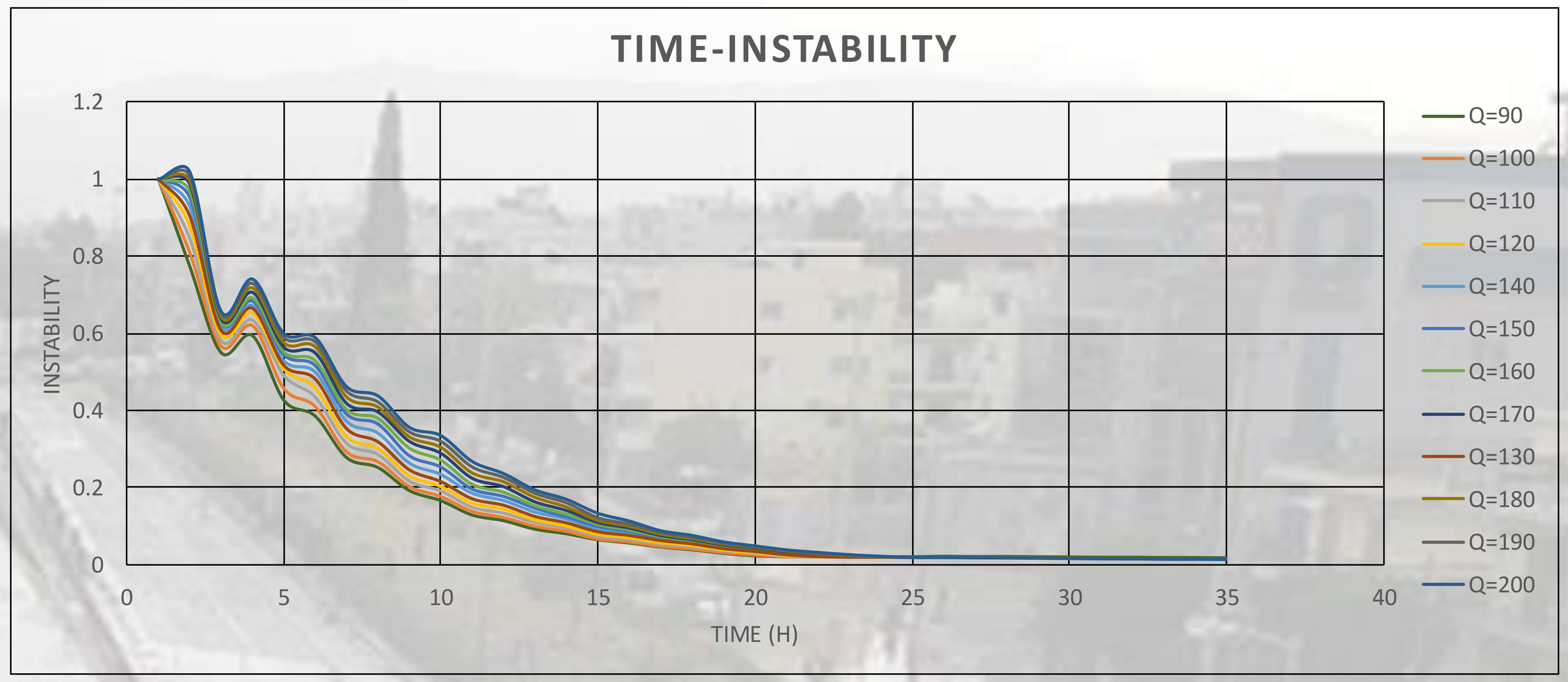
5. Simulation

Comparing results between simulation with the quasi 2-D CFD software LISFLOOD-FP v5.9.6 and satellite reception of mapped flood extend at the area of Soures stream influence, we notice an adequate fit to the observed inundation.



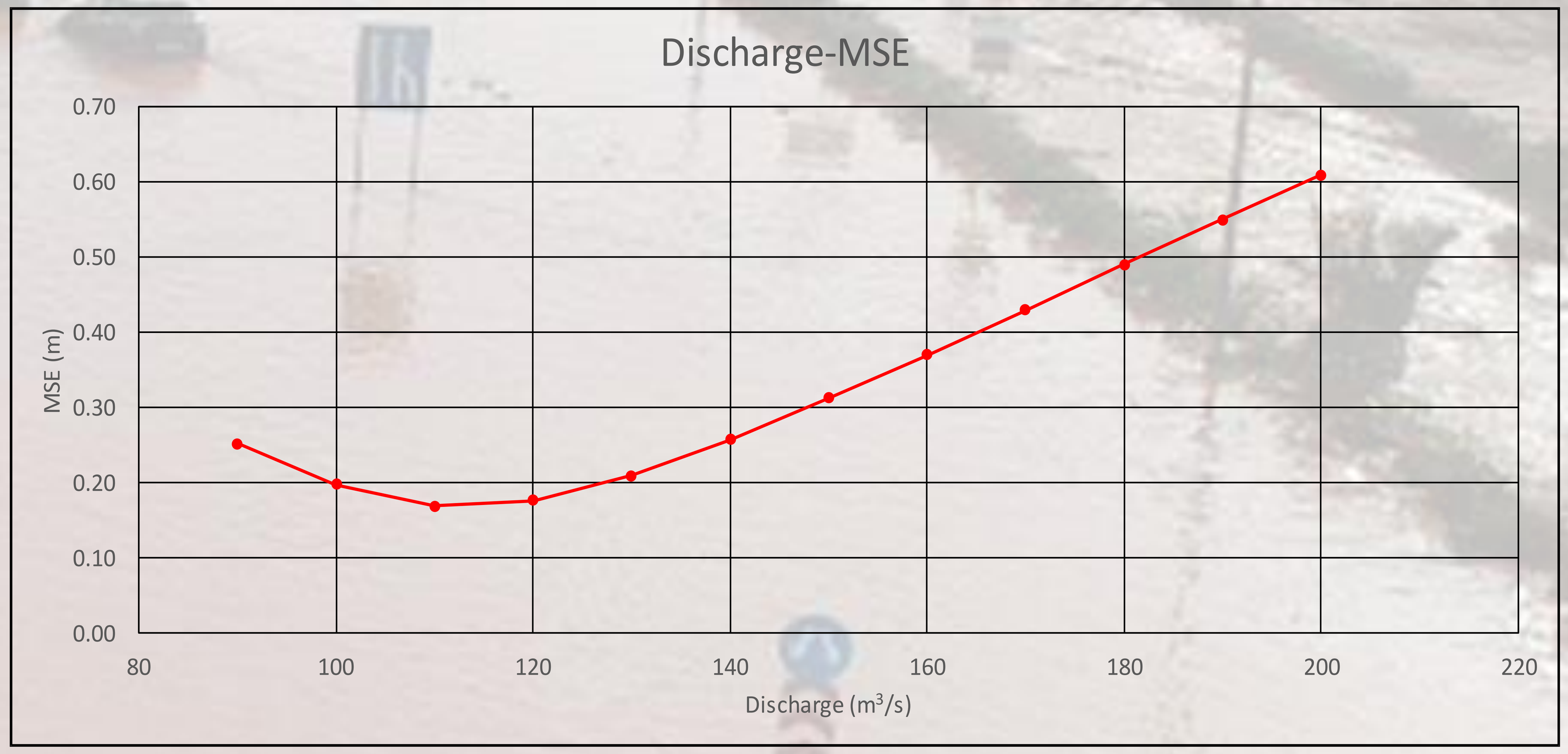
6. Model

Looking for the time demanded for the simulation of the steady flow, we drew up the following Figure that shows the percentage of instability with respect to time. The accuracy is predefined at 10cm. We considered 35 hours to be an adequate time for every single simulation.



7. Results

Every single discharge is assessed through comparison among the 7 pre-specified points and the water depth of simulation at each point. We used the mean square error method as a common comparative measure. Through the following Figure we were able to drew some conclusions about the steady flow estimate in between 110-120m^3/s. Finally we considered that the steady state flow and the maximum observed water depth were mostly affected only by the Soures stream.



8. Discussion

The estimated peak flow of 120 m^3/s is reasonable, taking into account the characteristics of the upstream catchment and the approximate reproduction of the storm event, based on inverse analysis of the observed flood event at the neighboring basin of Sarantapotamos. In particular, the stream of Soures drains a mountainous area of about 35 km^2, dominated by high-permeable formations (limestones). Due to the relatively small extent of the basin, it is quite realistic employing the rational method for extracting the average rainfall intensity over the basin and for a duration equal to its response time, which produced the evaluated discharge. In this context, considering a runoff coefficient of about 0.25, we get a rainfall intensity of about 50 mm/h. On the other hand, under such extreme flood conditions, the time of concentration of the catchment is expected to be around two hours.
We remark that the concept of the varying time of concentration, as result of the dependence of runoff velocity to the effective rainfall (Michailidi et al., 2018), is of key importance, and may partially explain the extent of the catastrophic flood event.
In the catchment of Sarantapotamos, for d = 2 hours we estimated an intensity up to 38 mm/h (Ntigkakis et al., 2018), corresponding to a return period of about 200 years. However, the rainfall event at this basin was somehow milder than in the Soures basin, thus the increased intensity of 50 mm/h for two-hour duration seems quite realistic.

9.References

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