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Modernizing Greece's flood defenses: learning from past disasters and leveraging advanced hydrological tools

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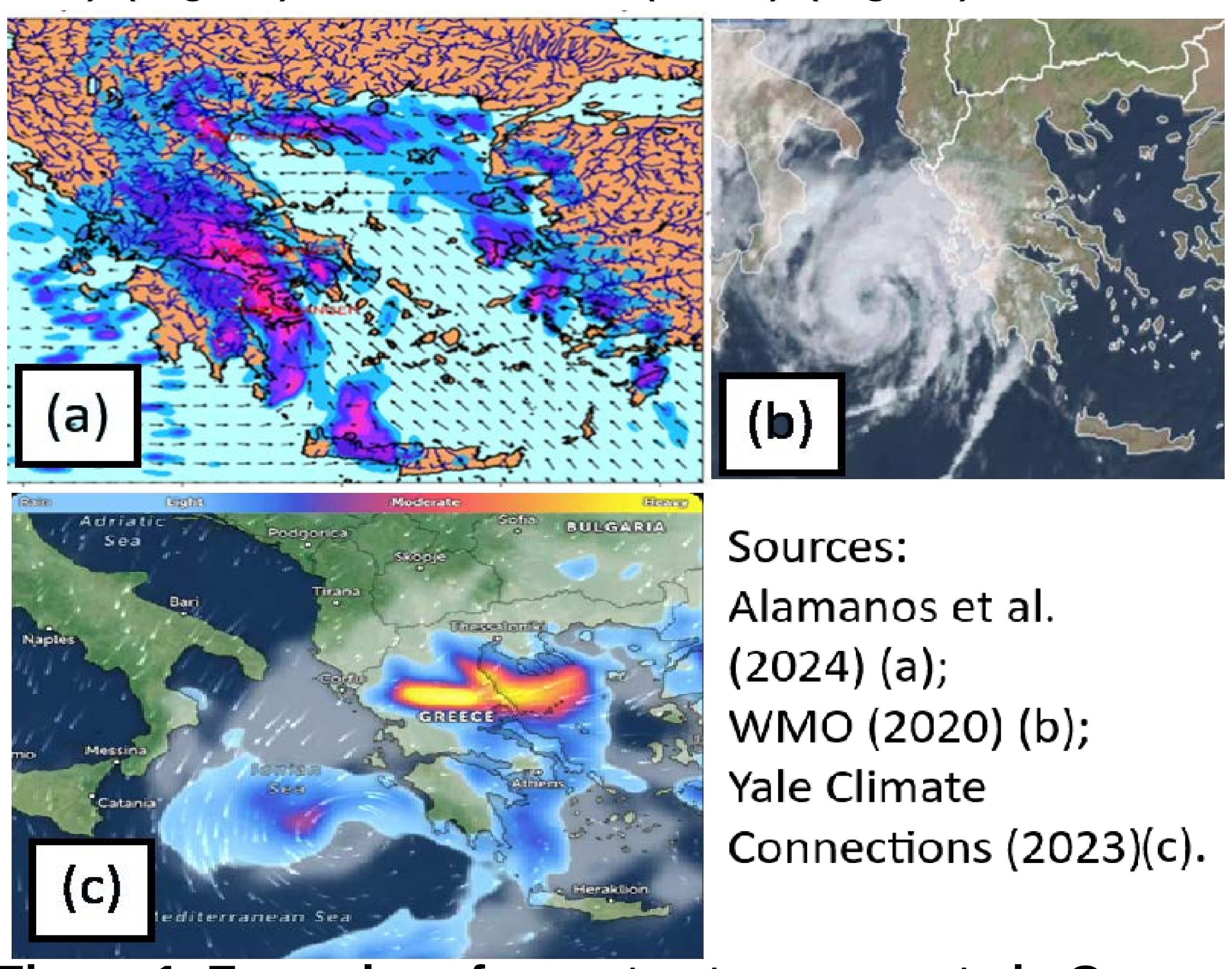
INTRODUCTION & AIM

Climate change is intensifying the hydrological cycle, leading to more frequent and severe flood events worldwide. In Greece, recent disasters have exposed the vulnerability of aging infrastructure: bridges, drainage networks, flood protection structures, and river buffer zones seem to fail repeatedly because they were designed to outdated rainfall patterns. Examples: Storm Girionis (2019) (Fig.1a), Cyclone Ianos (2020) (Fig.1b), Storm Daniel (2023) (Fig.1c).



Sources: Alamanos et al. (2024) (a); WMO (2020) (b); Yale Climate Connections (2023)(c).

Figure 1. Examples of recent extreme events in Greece.

METHOD

Based on our experience with previous Greek case studies, hydraulic simulation models, and hydro-dynamic representations of flood events under the aforementioned hazards, we see the need to underscore two factors:

1) The role of Intermittent Streams & Ephemeral Rivers (IRES): Responsible for the several flooding cases (see example Figure for the case of Kineta, 2019) (Alamanos et al., 2024).

This indicates the need to map IRES, as they are not mapped in Greece, and usually not considered in flood protection plans, however, as proved, these can cause severe damages, under all scenarios.

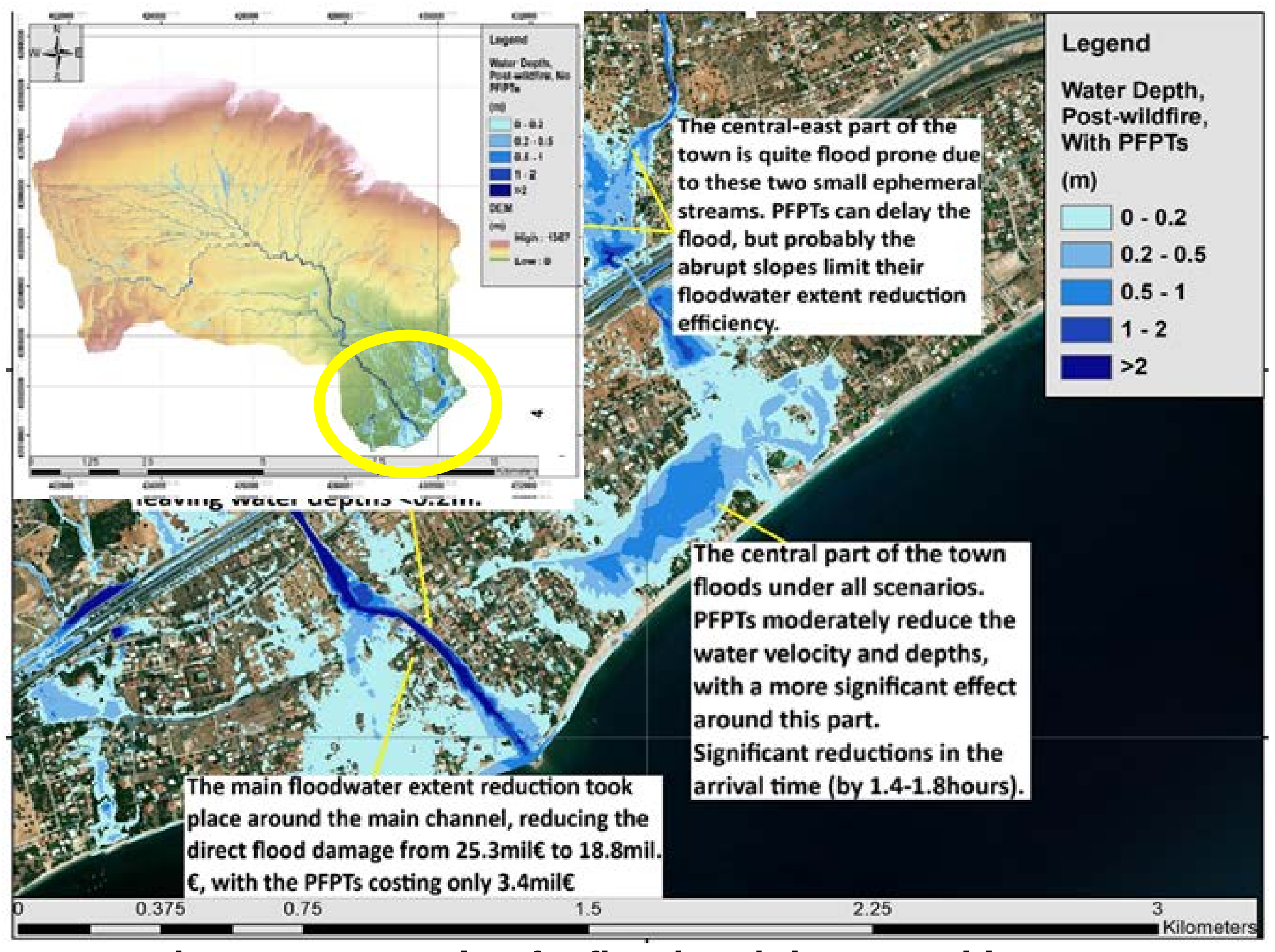


Figure 2. Example of a flood mainly caused by IRES.

2) The need for proper design-storm tools, adapted to such extreme phenomena. To enhance the suggested redesign of critical infrastructure, we developed a novel Python-based tool that automates the generation of design storm hyetographs from watershed shapefiles using Greece's official gridded intensity-duration-frequency (IDF) parameters, as provided by the Greek Ministry of Environment.

RESULTS & DISCUSSION

The developed tool Catchment2Storm overlays a user-defined catchment shapefile onto the national IDF grid, calculates area-weighted IDF parameters for each intersected sub-area, and synthesizes a complete hyetograph. The storm is reduced spatially using the Area-Reduction-Coefficient φ (Phi), and is temporally rearranged using the Alternating Block Method (ABM), resulting in a realistic design storm profile. The Catchment2Storm can provide a ready-to-use hyetograph for any user-specified return period, storm duration, and time interval (Alamanos & Papaioannou, 2025).

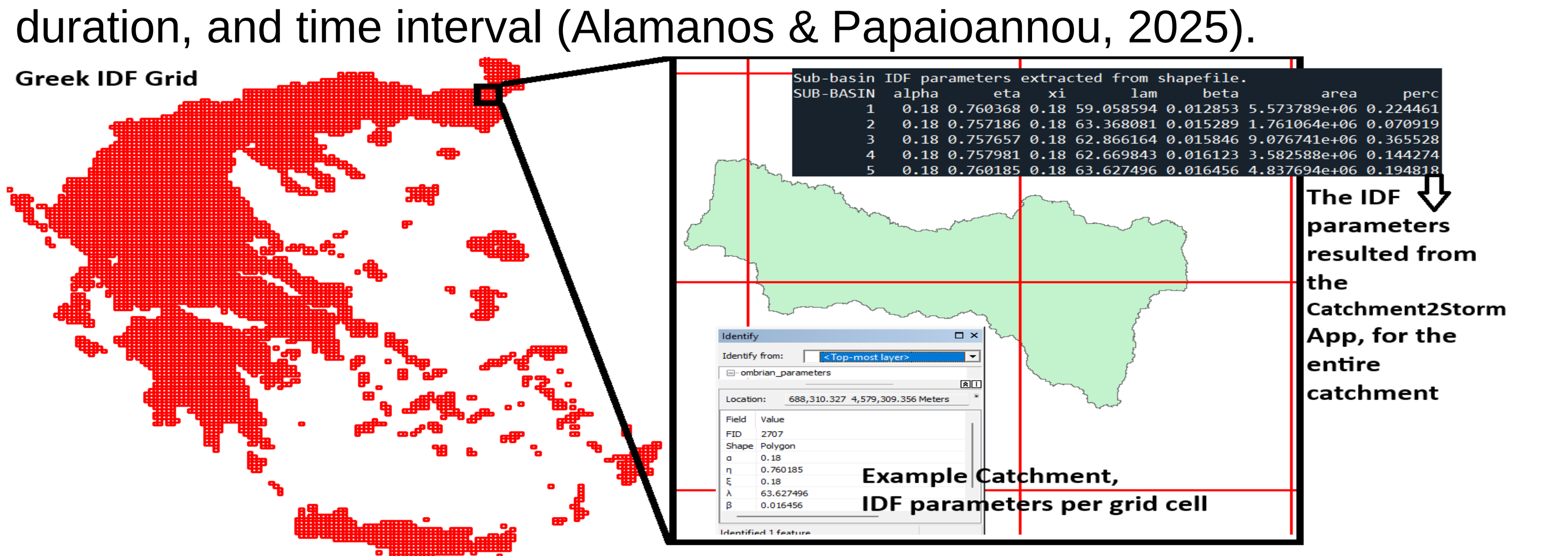


Figure 3. An example catchment, overlaying with the official Greek IDF Grid, where each cell has its own set of IDF parameters. The users do not have to open any spatial files, like in this figure. Instead, they can just load their catchment's shapefile in the Catchment2Storm App. They will get (as a first output) the (black) set of IDF parameters for their catchment.

Final outputs include a plot of the hyetograph, an Excel summary, and CSV tables formatted for direct use in HEC-HMS and HEC-RAS hydrologic and hydraulic models. We have applied the Catchment2Storm tool to all Greek sub-catchments, (N=10,773), using a batch-run approach in Python, which also summarized key metrics for different hyetographs.

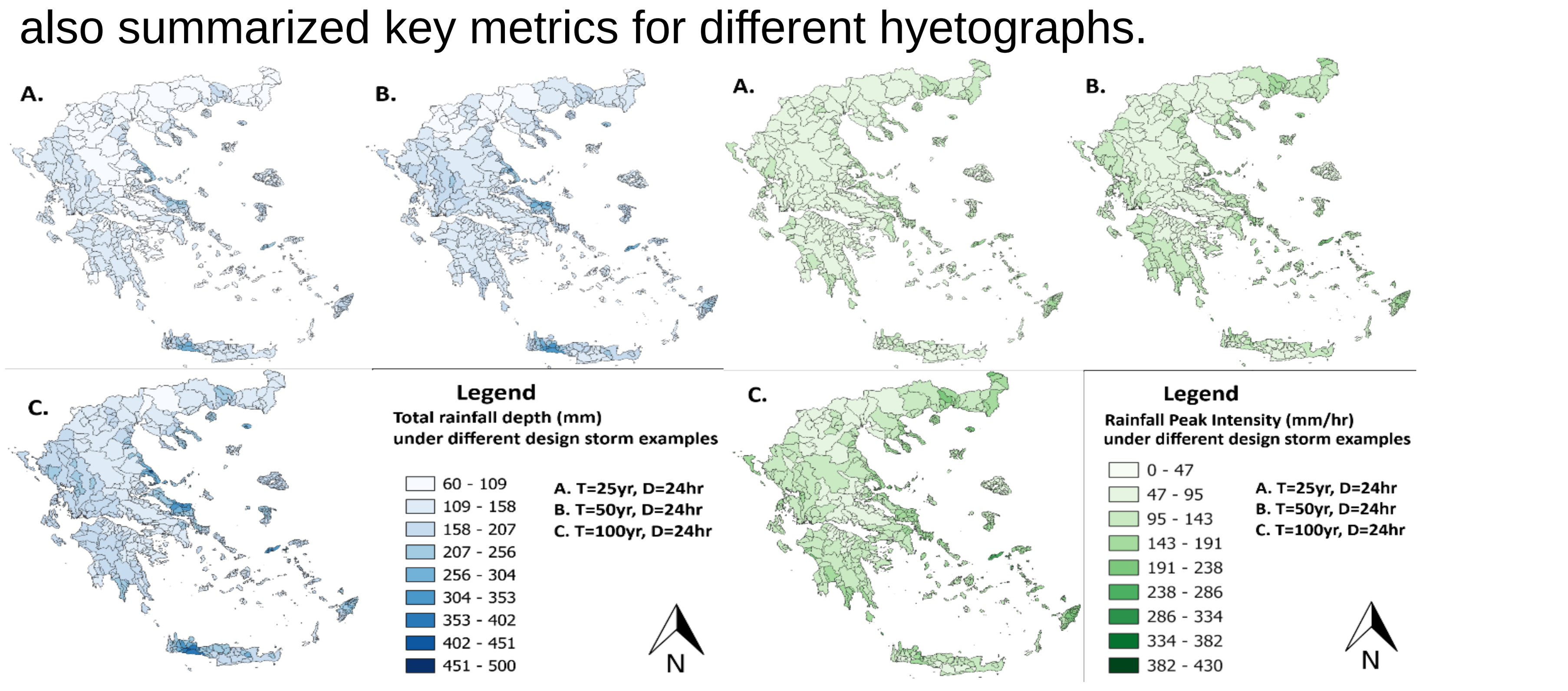


Figure 4. Indicative summary metrics of the design storms produced at the national scale. Left: Total rainfall depth (sum of the design storm precipitation). Right: Rainfall peak intensity (max intensity of the design storms).

CONCLUSION

To build resilience, flood protection design must be updated to reflect current and future climates, and this must be reflected to our workflows and regulations:

- Map Intermittent Rivers and Ephemeral Streams (IRES) and integrate them in flood protection planning. We showed that these have been mainly responsible for several events, leading to 'surprising' floods.
- The Catchment2Storm tool can streamline the traditionally complex and often manual process of generating design storms by automating geospatial analysis and storm synthesis directly from national IDF data.

FUTURE WORK / REFERENCES

- Alamanos, A., Papaioannou G., Varlas, G., Markogianni, V., Plataniotis, A., Papadopoulos, A., Dimitriou, E. & Koundouri, P. (2024). Designing post-fire flood protection techniques for a real event in Central Greece. *Prevention and Treatment of Natural Disasters,* 3(2). https://doi.org/10.54963/ptnd.v3i2.303
- Alamanos, A.; Papaioannou, G. A National-Scale IDF-Based Design Storm Hyetograph Inventory: Applying the Catchment2Storm Tool in Greece. In Proceedings of the 9th International Electronic Conference on Water Sciences Recent Advances in Water Sciences under a Variable and Changing Environment; Online, November 11 2025. https://sciforum.net/paper/view/26230
- WMO (2020). https://www.abc.net.au/news/2020-09-18/greece-braces-for-rare-mediterranean-hurricane/12678326
- Yale Climate Connections (2023). https://yaleclimateconnections.org/2023/09/fire-to-flood-greeces-destructive-roller-coaster-ride/