Operational Flood Forecasting and Diachronic Flood Mapping

for a Flash-Flood-Prone Mediterranean Basin: the UNICORN–Mandra Pilot

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1. Introduction & Motivation

Flash floods in small Mediterranean catchments are highly dangerous due to short response times, intense convective rainfall, and urbanisation.

The Mandra basin, western Attica, Greece, is a representative high-risk case.

⚠ Mandra flood, 15 November 2017 — 24 fatalities, >100 M€ damage, deadliest flood in Greece in 40+ years

Before UNICORN, NOA/BEYOND FloodHub already provided near-real-time flood monitoring for Mandra, using 5 min station observations and a pre-run HEC-HMS/HEC-RAS scenario library to retrieve flood-extent and depth maps.

UNICORN upgraded the system with:

- 48 h WRF-ARW-driven flood-forecasting module
- Sentinel-1 diachronic flood-mapping service

2. Study Area

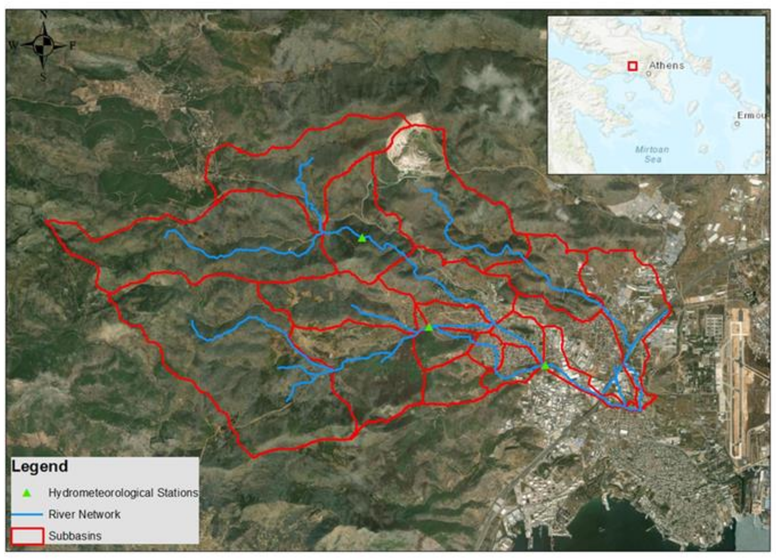


Fig. 1. Mandra basin (57 km²), sub-basin delineation, stream network, urban perimeter, and locations of the three NOA/BEYOND telemetric stations.

- ~57 km² basin in western Attica
- Urban, industrial, peri-urban, and forested areas
- Post-fire monitoring via FireHub
- 3 stations for rainfall, water level, and temperature

3. Pre-existing NRT FloodHub System

Station observations and crowdsourced water-level records are compared with a pre-run scenario library to retrieve the closest flood scenario.

Station observations (5-min update) → Best-match scenario retrieval → Flood extent & depth maps

- Scenario library: HEC-HMS (hydrological) + HEC-RAS (hydraulic), pre-run offline
- Scenario dimensions: return period T (50–1000 yr), rainfall duration d (3–12 h), antecedent wetness conditions (CN I/II/III)
- Platform: FloodHub web portal, auto-updating every 5 min

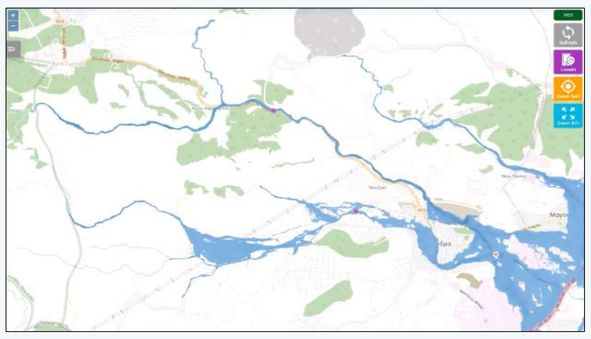
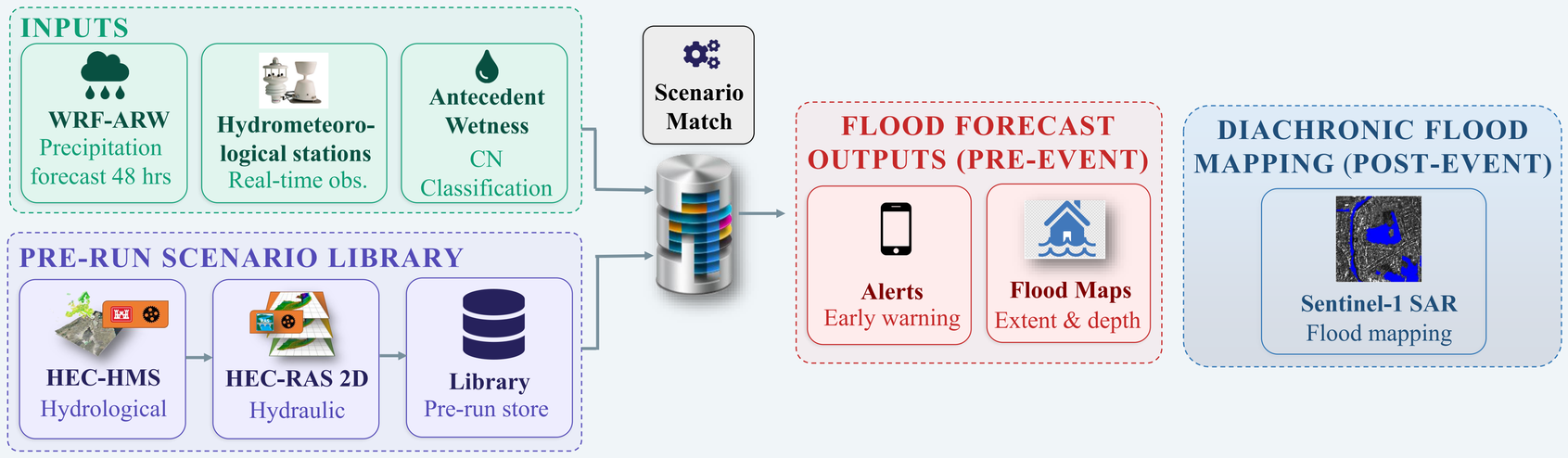


Fig. 2. Existing operational near-real-time NOA/BEYOND FloodHub platform

4. UNICORN Operational Additions

UNICORN extended the existing FloodHub system with two new operational components integrated into the same platform: platform:

FLOOD FORECASTING MODULE (PRE-EVENT)	DIACHRONIC FLOOD MAPPING (POST-EVENT)
48-h flood forecast via WRF-ARW scenario retrieval	Automated Sentinel-1 SAR flood mapping



5. Forecasting Workflow

- The service selects the best-fit pre-run scenario from the library.
- The retrieval is driven by WRF-ARW precipitation forecasts processed through the scenario-matching algorithm.

INPUT: WRF-ARW precipitation forecasts (2 km grid, 48 h horizon) + station rainfall observations.

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STEP 1: Extract basin rainfall descriptors from WRF.

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STEP 2: Compute rolling windows (3, 6, 9, 12 h) - (mean, P90, and Max).

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STEP 3: Use P90 rainfall to match forecast intensity to IDF return period.

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STEP 4: Antecedent wetness conditions classification (CN I / II / III) from 5-day cumulative station rainfall.

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STEP 5: Retrieve best-fit pre-run HEC-HMS / HEC-RAS scenario from library (T × d × CN combination).

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OUTPUT: 48 h flood extent and depth maps through FloodHub.

6. Best-Match Scenario Logic

The Python scenario-matching algorithm converts WRF GRIB2 rainfall forecasts into one library index:

T × d × CN

- **Return period selection**: smallest T whose IDF intensity exceeds forecast intensity (P90 / duration).
- **Severity** metric: use **P90 percentile** rainfall to capture localised extremes.
- **Episode ranking**: for each duration, highest T → highest P90 → highest mean rainfall → earliest timing.
- **Final choice**: most severe case across all durations

7. Sentinel-1 Diachronic Flood Mapping

A fully automated SAR processing chain monitors historical and ongoing flood events using Sentinel-1A/C GRD data.

S1 GRD acquire (CDSE auto-fetch) → Thermal noise removal + border denoising → Orbit correction (POEORB) → Radiometric calibration → Multi-looking → Terrain-flattening (2 m DEM) → Terrain-correction + geocoding → dB conversion → Random Forest classification (water / non-water) → Flood extent + archive update

Limitation: Sentinel-1 revisit time (~3-6 days) may miss the exact peak-flood timing for flash flood events.

8. FloodHub Platform Architecture

Operational FloodHub platform (floodhub.beyond-eocenter.eu/forecast)

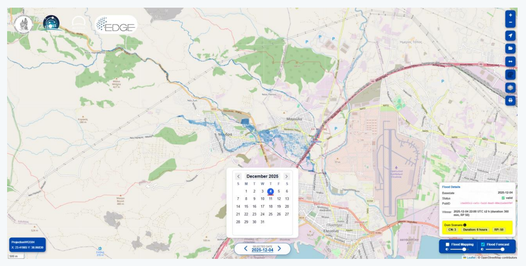
DATA INGESTION
WRF-ARW
Station API
Sentinel-1 (CDSE)

DATA STORAGE
PostgreSQL/PostGIS
Open Data Cube
Scenario library

SERVICES
REST API
WMS / WMTS / WCS
Scenario matching

WEB PORTAL
Vue.js + Leaflet
Forecasting tab
Mapping tab

Fig. 3. FloodHub forecasting tab showing scenario matrix (CN × T × d) and flood extent map.

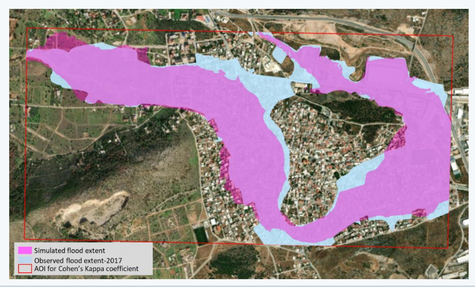


9. Results & Validation

Initial validation covered Storm Byron (04.12.2026) and the 15 November 2017 major Mandra flood event.

Metric	Value	Context
WRF precipitation (Storm Byron): observed 106.8 mm, modelled 99.5 mm	**RB −6.8%**	Acceptable NWP bias
WRF RMSE (Storm Byron event)	**7.3 mm/day**	Precipitation forecast
Rainfall-runoff Storm Byron (Komvos station)	**RSR ≈0.58**	HEC-HMS performance
Flood extent (15 Nov 2017, urban)	**κ ≈0.85**	Sentinel-1 vs. HEC-RAS
Scenario coverage (CN × T × d)	**72 scenarios**	Library completeness

Fig. 4. Simulated (HEC-RAS) vs. Sentinel-1-derived flood extent for the 2017 event in the Mandra urban area. Cohen's kappa ≈ 0.85.



10. Conclusions

- FloodHub was upgraded with an operational 48 h forecasting module for the Mandra basin.
- No online HEC-HMS or HEC-RAS runs are required. Scenario retrieval is immediate.
- The best-match algorithm provides conservative and robust episode selection.
- IDF mapping ensures that the retrieved scenario covers or exceeds forecast severity.
- Sentinel-1 SAR enables cloud-independent post-event delineation and supports archive.
- Initial validation is encouraging:
  - RSR ≈ 0.58 for Storm Byron
  - Cohen's kappa ≈ 0.85 for the 2017 Mandra flood extent

Acknowledgment

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https://unicorn-project.com

Key References

[1] Iliopoulou et al. (2024) — Stochastic regionalization of rainfall intensity, duration, and return-period relationships over Greece, supporting IDF-based design rainfall and forecast-severity classification. [2] Papaioannou et al. (2018) — Operational scenario-based flood-risk framework for ungauged urban areas using IDF rainfall, SCS-CN hydrology, and HEC-RAS 2D inundation mapping [3] Tsouni et al. (2026) The innovative BEYOND/FloodHub real-time flood monitoring and early warning system based on modelling, multi-source EO and crowdsourced data, IGARSS 2026