Twenty years of hydrological observations at Fiumarella of Corleto basin: experimental data, analysis and modeling

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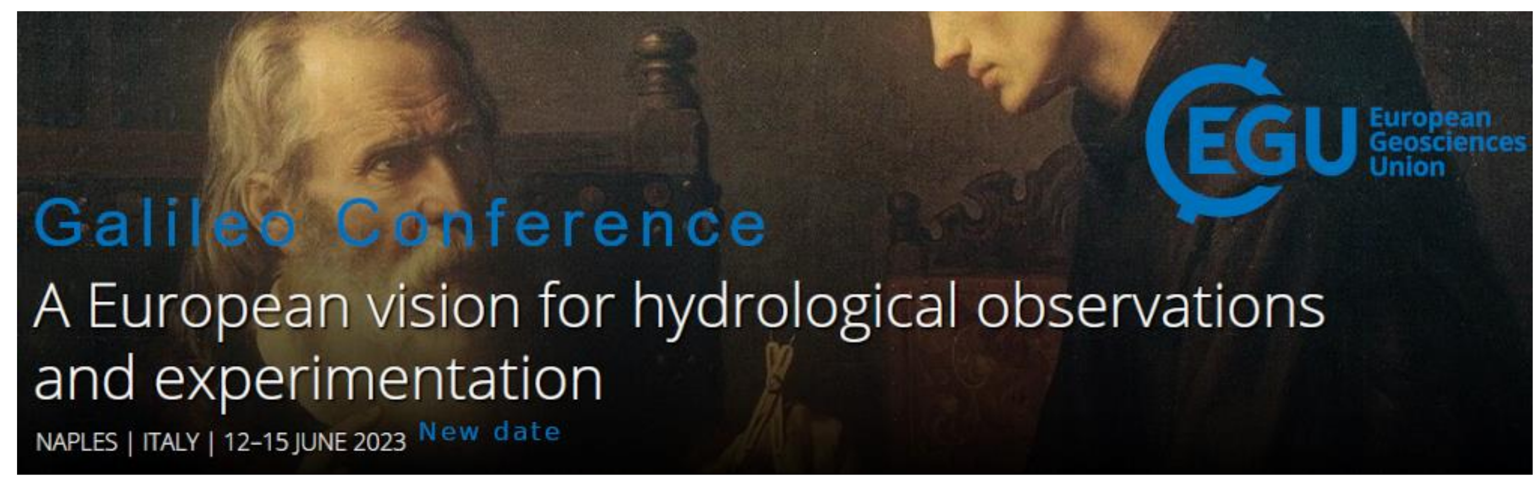
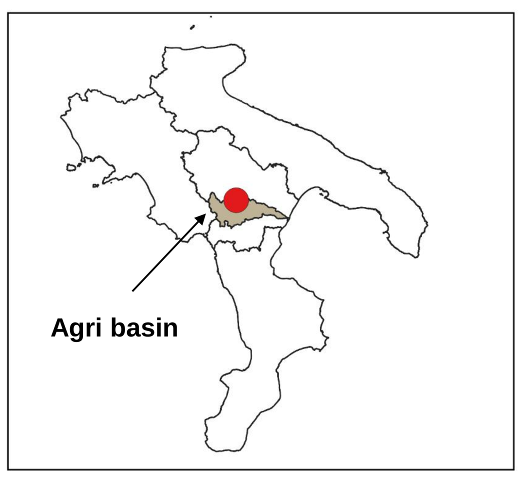


1. Introduction

Hydrological observations provided by in situ monitoring networks are essential to better understand hydrological processes and to improve water resource management. In this contribution, we describe the monitoring activities conducted from 2002 at "Fiumarella of Corleto" basin (Basilicata region, Southern Italy), with reference to two different spatial scales: the entire basin (32.5 km^2) and the sub-basin (0.65 km^2).

2. Study Area

The experimental basin "Fiumarella of Corleto" is a tributary of the Sauro river (Agri basin). This basin has the specificity of being made up of two sides with somewhat different geomorphological and land use characteristics: the left side is characterized by soils for agricultural use while the right side is covered by predominantly woodland vegetation.



- Elevation range: 660 – 1500 m a.s.l.
- Mean precipitation: ~600 mm/year
- Mean temperature: ~10 °C
- Mean river discharge: ~1 m^3/s

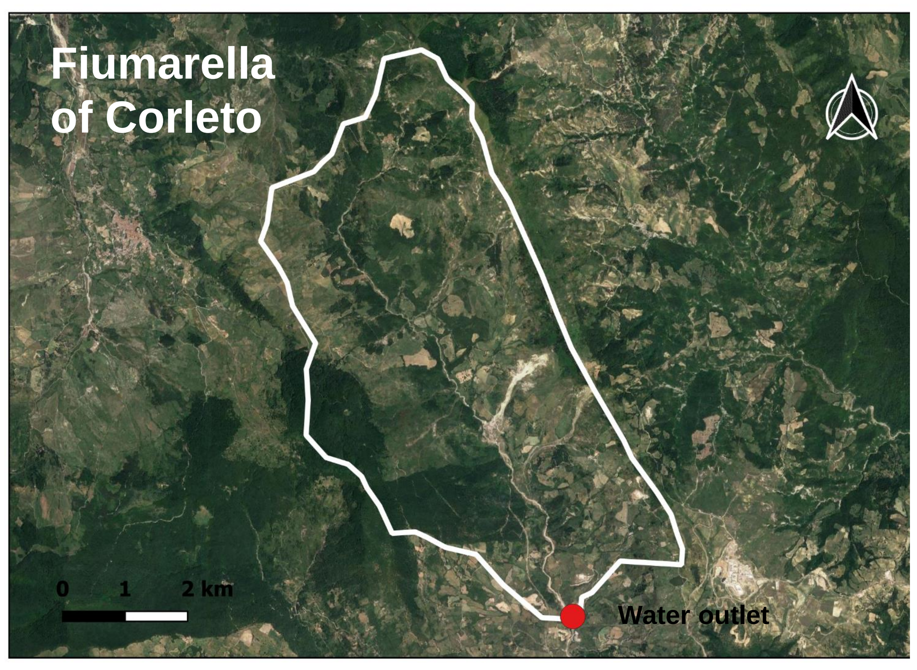


Figure 1 Location of Fiumarella of Corleto basin.

3.Monitoring

Basin pedology was investigated through field campaigns and laboratory measurements the main soil-land units of the basin (Romano et al., 2002 and Santini et al., 1999). For the zones without available information, the data was integrated with the HYPRES (HYdraulic PRoperties of European Soil) database that defines also the hydraulic characteristics. In addition to this, a high-resolution (1x1 m) DSM of the basin was derived using LiDAR to provide a detailed characterization of the morphology of the two slopes.

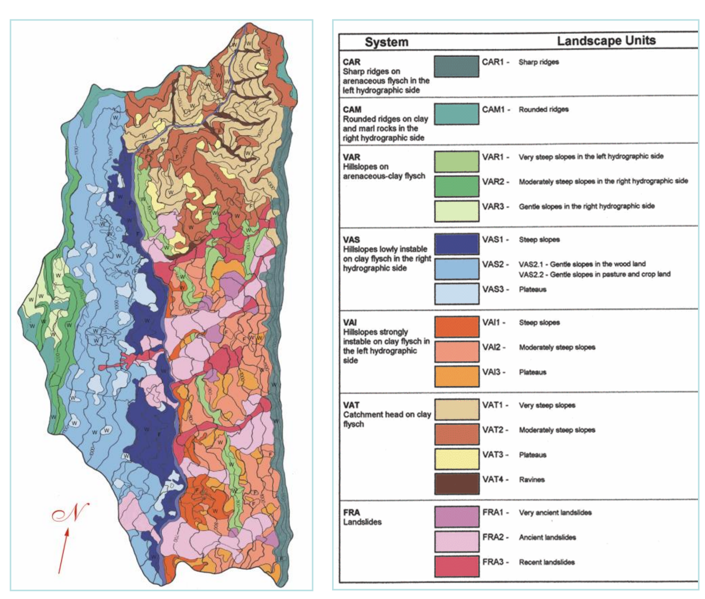


Figure 2 Soil-Landscape Units.

From 2002, the basin is equipped with three meteorological and hydrological measurement stations:

- Station n°1 is able to acquire all the main meteorological and climatic quantities with a Meteo-Hydrological system, powered by the electric line.
- Station n°2 is made up of a tilting bowl rain gauge and an ultrasound hydrometric level sensor (1 cm resolution), powered by solar panels.
- Station n°3 is made up of a tilting bowl rain gauge, powered by solar panels.

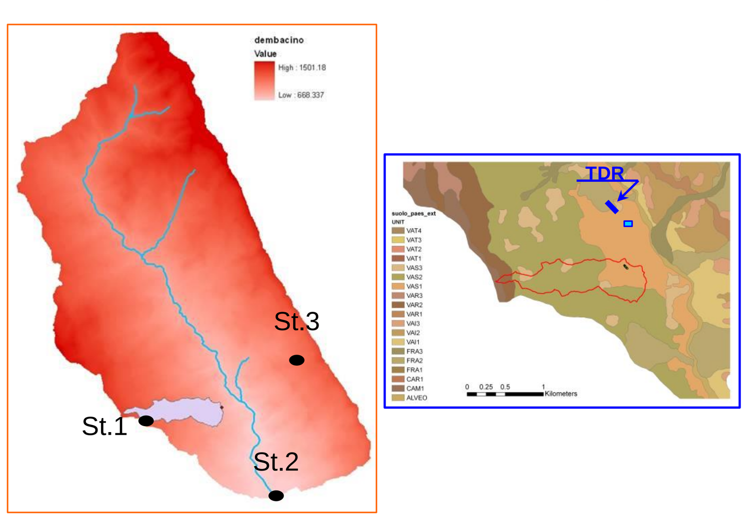


Figure 3 Location of three automated stations and sub-basin.

Meteo-hydrology quantity	Time resolution (min)	Measurement start date	Instrument location
Soil Moisture	60	February 2006	
Precipitation	10	September 2002	(1)-(2)-(3)
Snowy precipitation	10	September 2002	(1)
Hydrometer level	15	September 2002	(2)
Temperature	60	September 2002	(1)
Incident solar radiation	60	November 2004	(1)
Air relative humidity	60	November 2004	(1)
Atmospheric pressure	60	November 2004	(1)
Wind direction	10	November 2004	(1)
Wind speed	10	November 2004	(1)

Table 1 Meteo-hydrological variables available at different stations.

Figure 4 Station n°1 Meteo-Hydrological.

Figure 5 Station n°2 Hydrometer and Rain-Gauge.

Figure 6 System of station n°3 Rain-Gauge.

Figure 7 Outlet section of sub-basin.

From 2006, a TDR100 system connected to 22 probes located at 11 different sampling sites was used to monitor soil moisture in the sub-basin. The system was set up along a transect measuring approximately 60 meters in length, with probes located at two different depths of 30 and 60 cm.

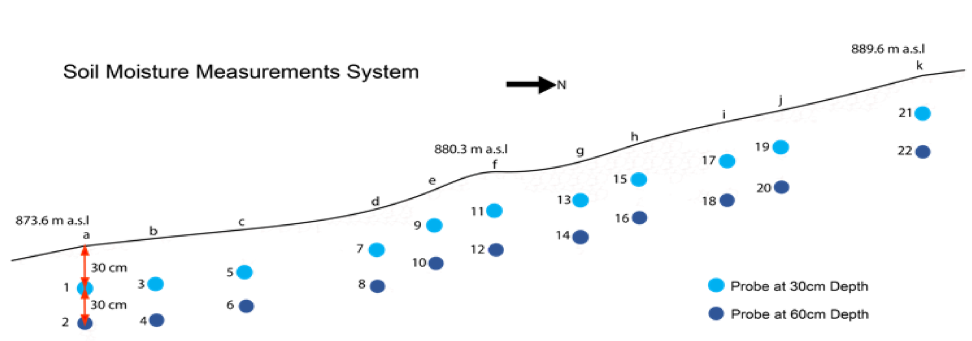


Figure 8 Soil Moisture Measurements System (TDR).

4. Data and Analysis

Temperatures, rainfall and discharge collected from stations were used to characterize the hydrological behavior of the two drainage areas in Fiumarella of Corleto basin for 20 years. Peak flow analyses were performed to define lag-time, soil moisture conditions before flood events evidencing the different hydrological responses of both basin and sub-basin. Hydrological process signatures were calculated using the Matlab Toolbox Streamflow Signatures in Hydrology (TOSSH) developed by Gnann et al., 2021.

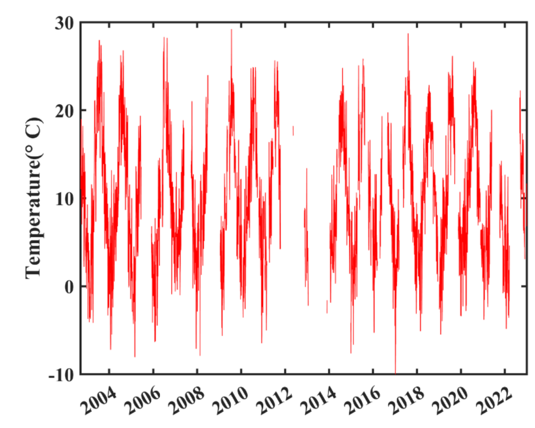


Figure 9 Average Temperature

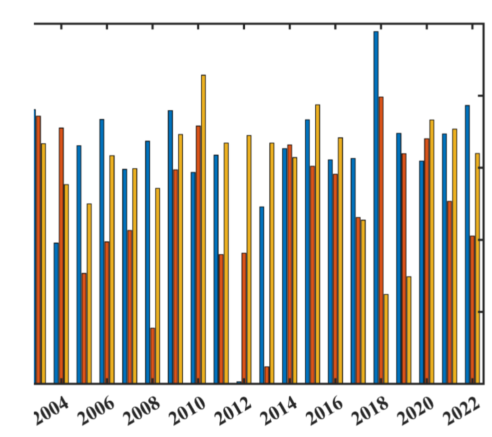


Figure 10 Annual rainfall for each station

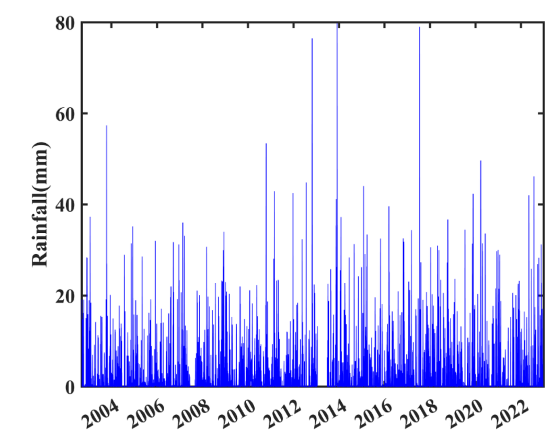


Figure 11 Average precipitation records

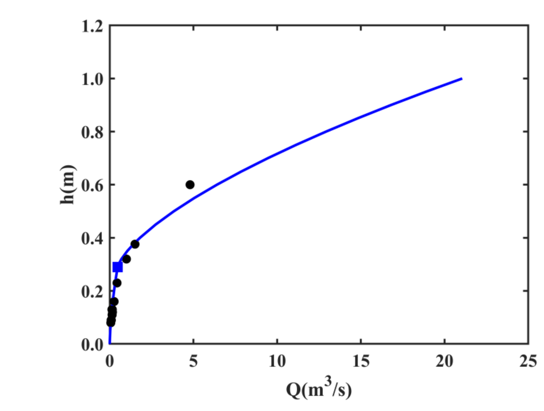


Figure 12 Rating curve at basin water outlet

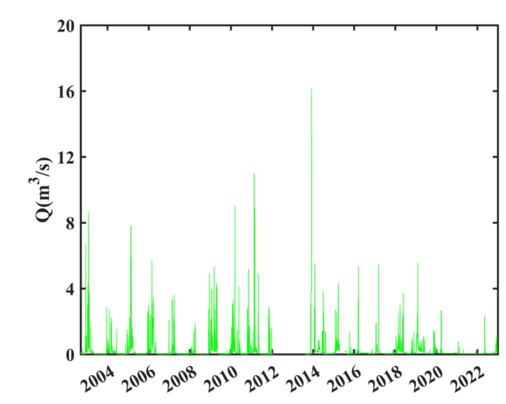


Figure 13 Daily discharge records

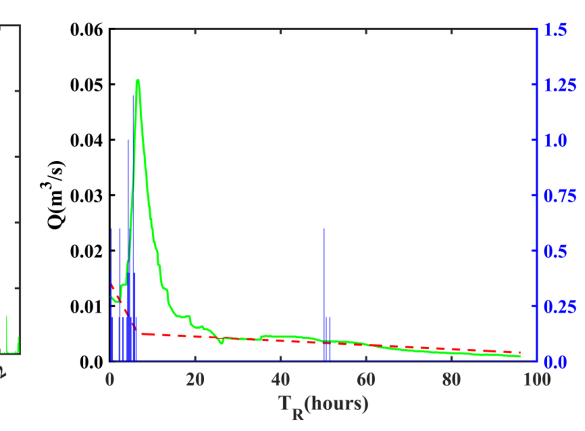


Figure 14 Baseflow separation

CATEGORY	SIGNATURES	DESCRIPTION	VALUES
Water balance	AC	Flow auto-correlation (-)	0.66
	FDC_slope	Slope of the flow duration curve (-)	-7.79
	Q_mean	Mean daily discharge (m^3/s)	0.28
	QCoV	Coefficient of variation	3.07
Low flow	BFI	Baseflow index (-)	0.26
	Q5	5-th streamflow percentile (m^3/s)	3.79E-04
	low_Q_dur	Low flow duration	26.7
	low_Q_freq	Low flow frequency	0.57
High flow	Q95	95-th streamflow percentile (m^3/s)	0.87
	high_Q_dur	High flow duration	7.94
	high_Q_freq	High flow frequency	0.18

Table 2 Main hydrological signatures calculated.

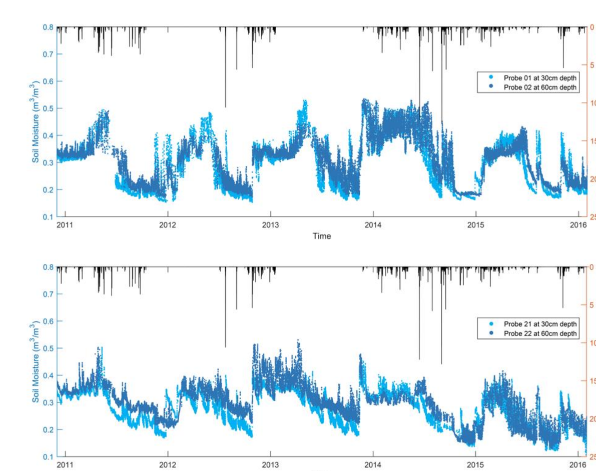


Figure 15 Example of soil moisture time-series (Su et al., 2020)

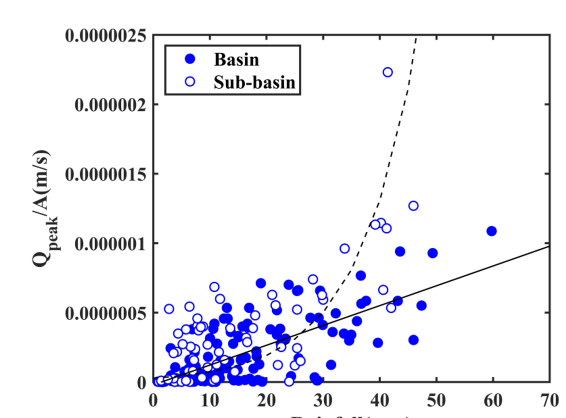


Figure 16 Trend of the ratio between the peak flows and the area of the reference basin as a function of the rainfall height.

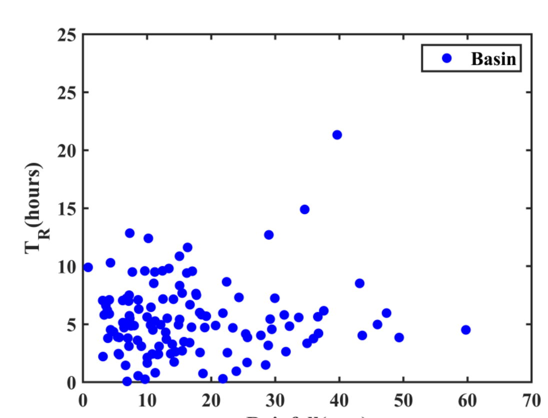


Figure 17 Basin Lag-Time.

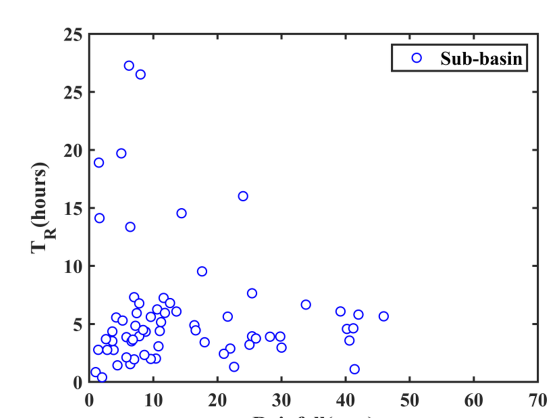


Figure 18 Sub-Basin Lag-Time.

5. Modeling

DREAM semi-distributed hydrological model (Manfreda et al., 2005) was used to to simulate different hydrological responses of the basin, exploring single and multi-criteria calibration approaches. For this purpose, we use genetic algorithm (GA) and different single and multiobjective approaches that optimizes total flow, base flow and water balance in lumped and distributed configurations. Generally, we obtained satisfactory results in representing flow regimes with Nash-Sutcliffe (NSE) and Kling-Gupta efficiency values between 0,50-0,65 and 0,50-0,80 respectively (Dal Sasso et al., 2022).

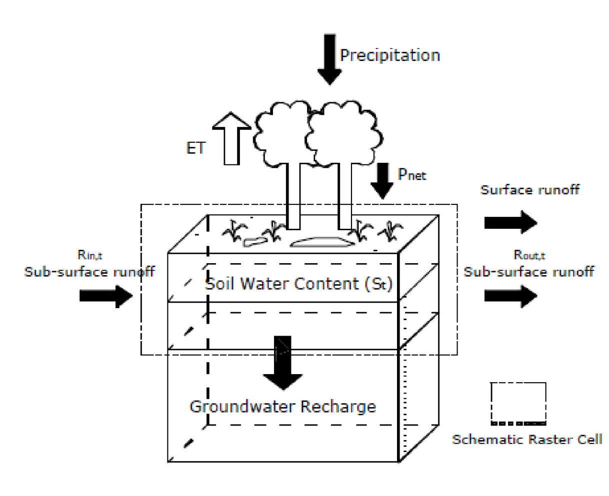


Figure 19 DREAM model conceptual scheme. Taken from Manfreda et al. (2005)

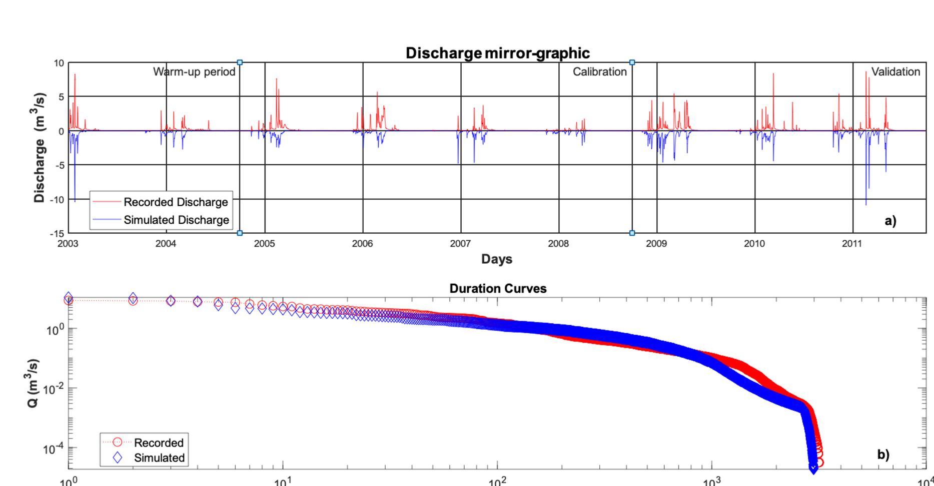


Figure 20 Example of application of DREAM Model (Dal Sasso et al., 2022)

6. Concluding Remarks

- Importance of the availability of long time series of hydrological data for calibrating hydrological models
- Importance of monitoring systems to observe hydrological processes at scale of interest
- Need to identify new criteria for efficiently modeling moving across scales

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