Assessment of terrigenous sediment input into Plastiras lake (Greece) as deduced from UAS and multibeam surveys: insights from the "IANOS" Medicane effect

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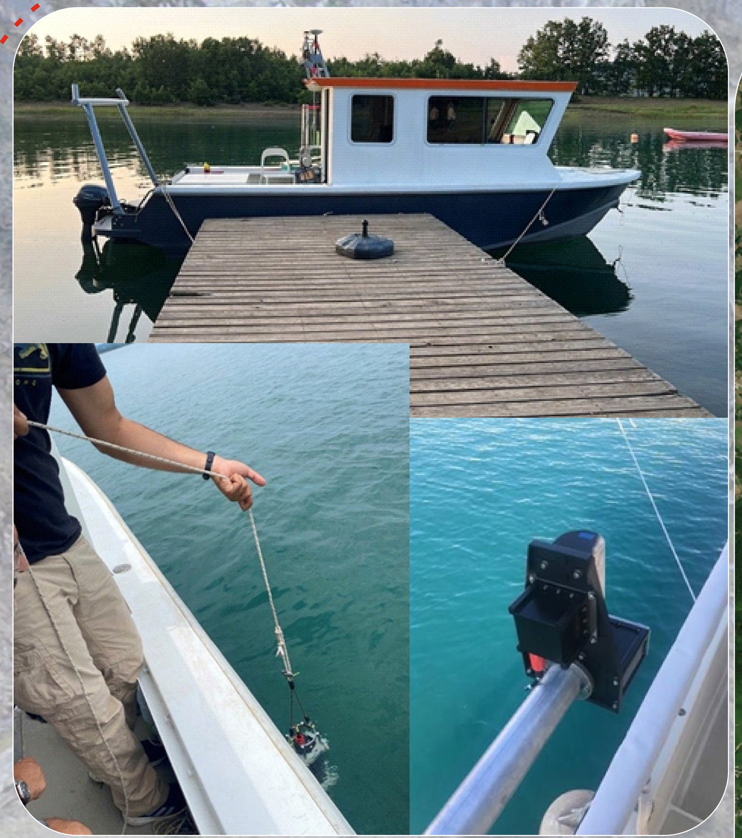
ABSTRACT

Plastiras artificial lake is formed upstream of an 83 m-high arched dam, at an altitude of 795.20 m above msl. A hydroelectric power plant constructed back in 1959, started functioning in 1960 with an average annual electricity production of 180 GWh. Moreover, its water provides potable supply, after treatment, to surrounding towns and essential agricultural irrigation to 140,000 acres of land. The 23.5 km² lake and its surroundings are extensively used for environmental recreational activities and the local ecosystem is sensitive to human activities and environmental factors.

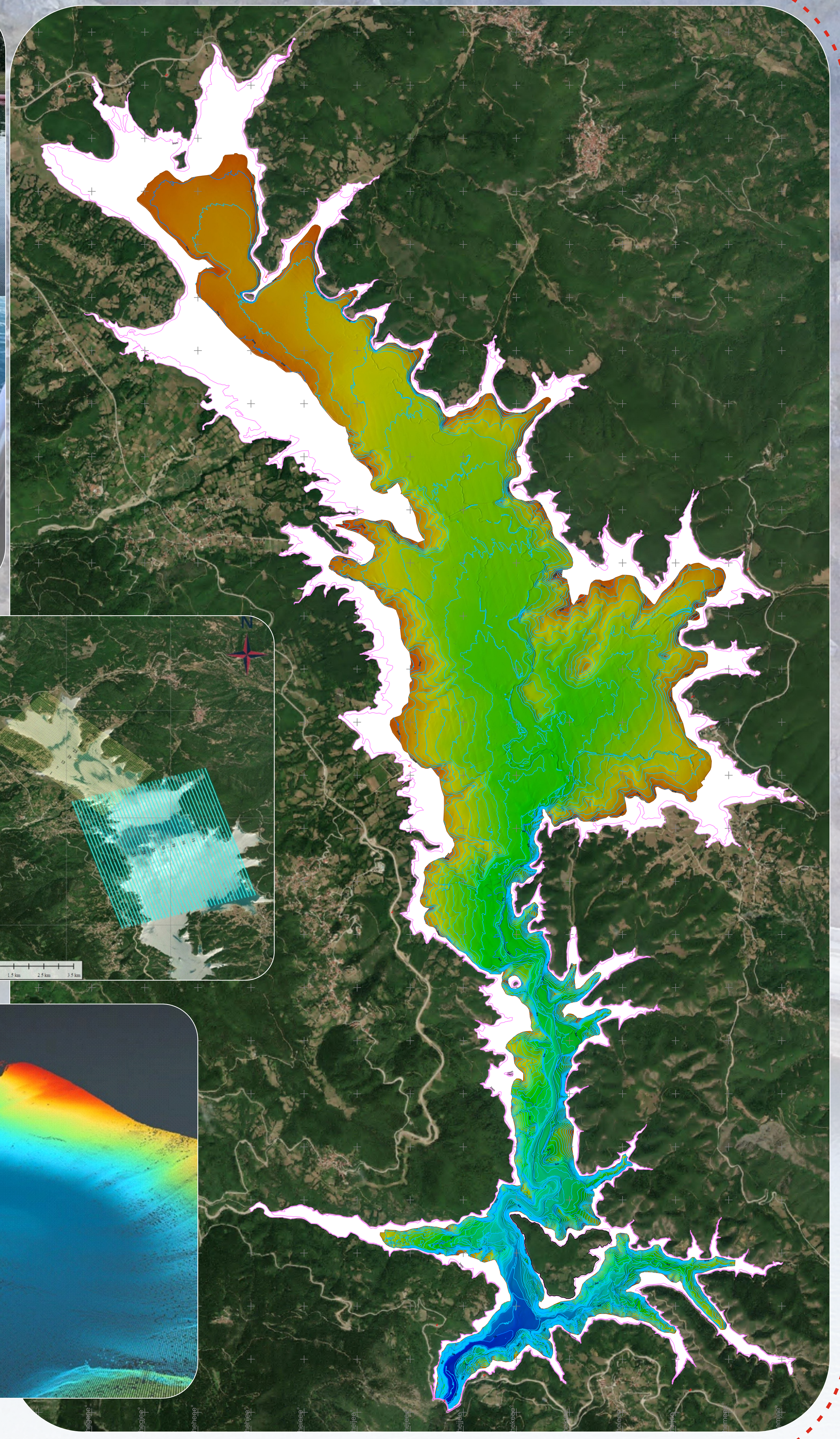
Recently the region was affected by two extreme weather events, in 2020 and 2023, evidently causing extensive mass wasting phenomena in the surrounding drainage basins and torrent discharge points into the lake. Especially after the "IANOS" Medicane (September 17-18, 2020), a systematic monitoring of the lake and its drainage was decided. A synergy of methodologies with state-of-the-art equipment was used, to evaluate the volumes of terrigenous sediment brought into the lake, drastically reducing the water storage capacity of the dam. The reference dataset was a single and multibeam survey carried out back in 2009, accompanied by a photogrammetric mapping of the lake coast at the maximum lake water level.

Our 2023 surveys encompass more than 14,000 images which were acquired with a Trinity F90 UAS, flying at a relative height of 160 meters, covering a 200-meter-wide zone around the coast of the lake, with a 70% overlap between the images. Image capturing of the latter took place during the lowest lake water level so that most of this zone would be revealed from the water's surface. The establishment of 15 Ground Control Points (GCPs) at certain locations around the lake increased the spatial credibility of the extracted 2.5 cm resolution Digital Terrain Model. For co-registration reasons, the same GCPs were also used as references during the multibeam survey, which was conducted at transects parallel and vertical to the shoreline routes, 20-90 meters apart, pending on the lake depth, to achieve a complete swath coverage of the lake bottom. The multibeam-sounding survey was carried out at near maximum lake water level, with continuous hourly monitoring of the water level and the water speed of sound.

Both methodologies resulted in point-clouds which were unified, and a DTM of the entire lake bottom was constructed, representing the full extent of the water body during the highest water level. The latter was compared to the 2010 dataset and a significant change in the water volume was detected reaching almost 4 million m3. This is clearly related to the volume of sediments brought into the lake, by both sediment gravity flows entering the lake especially within the torrent inlets along the west coast while finer suspended sediment mostly settles in the deepest areas towards the dam.

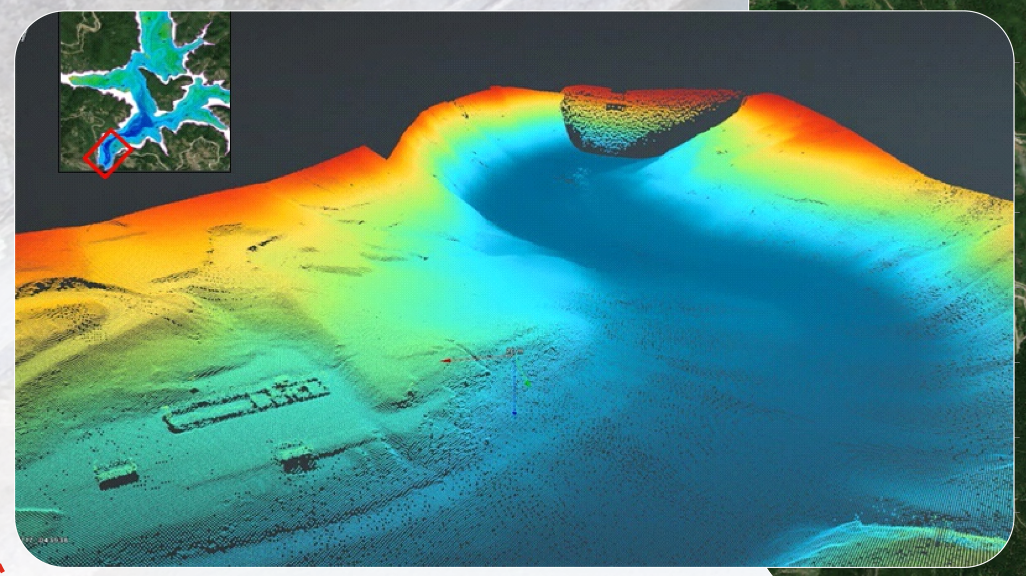


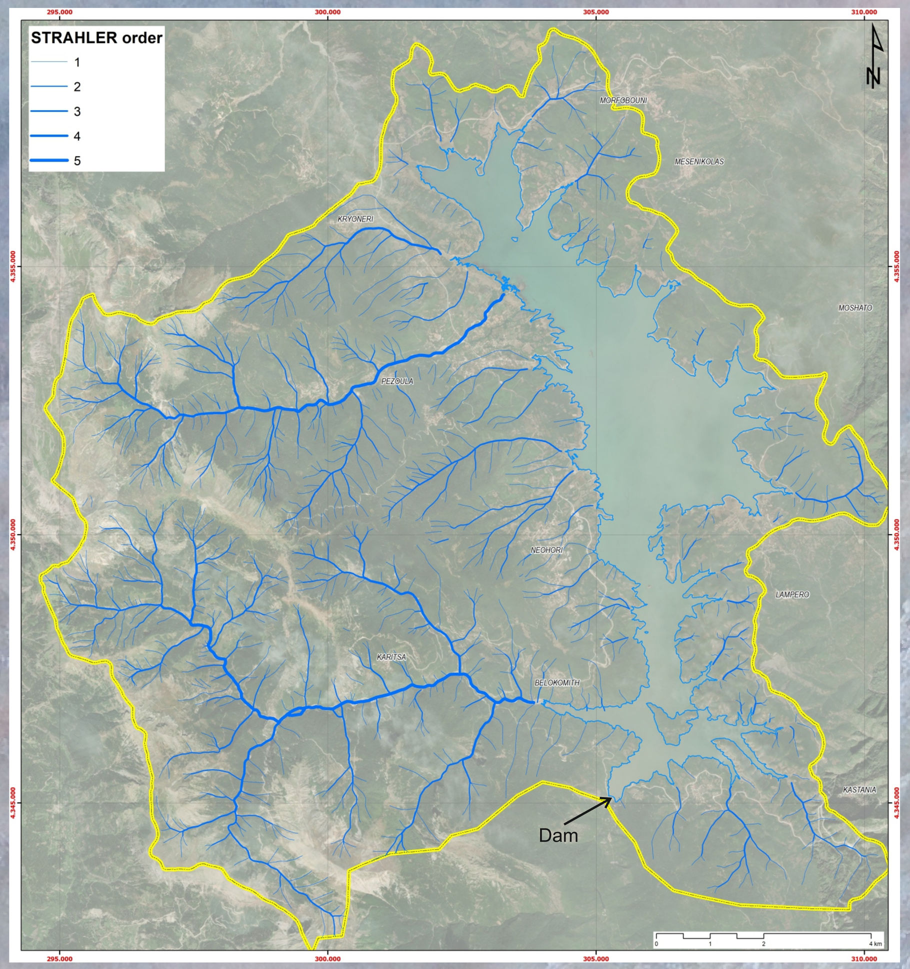
The equipment for the offshore, lake bottom data collection, included a multi-beam sounding device carried by a vessel, conducting transects parallel to the main lake axis (right inset).



The deeper parts of the lake bottom morphology were mapped, based on the point cloud, which was created after processing the multi-beam survey data. A high detail map was generated (right inset) and used for detecting lake bottom changes for the last decade.

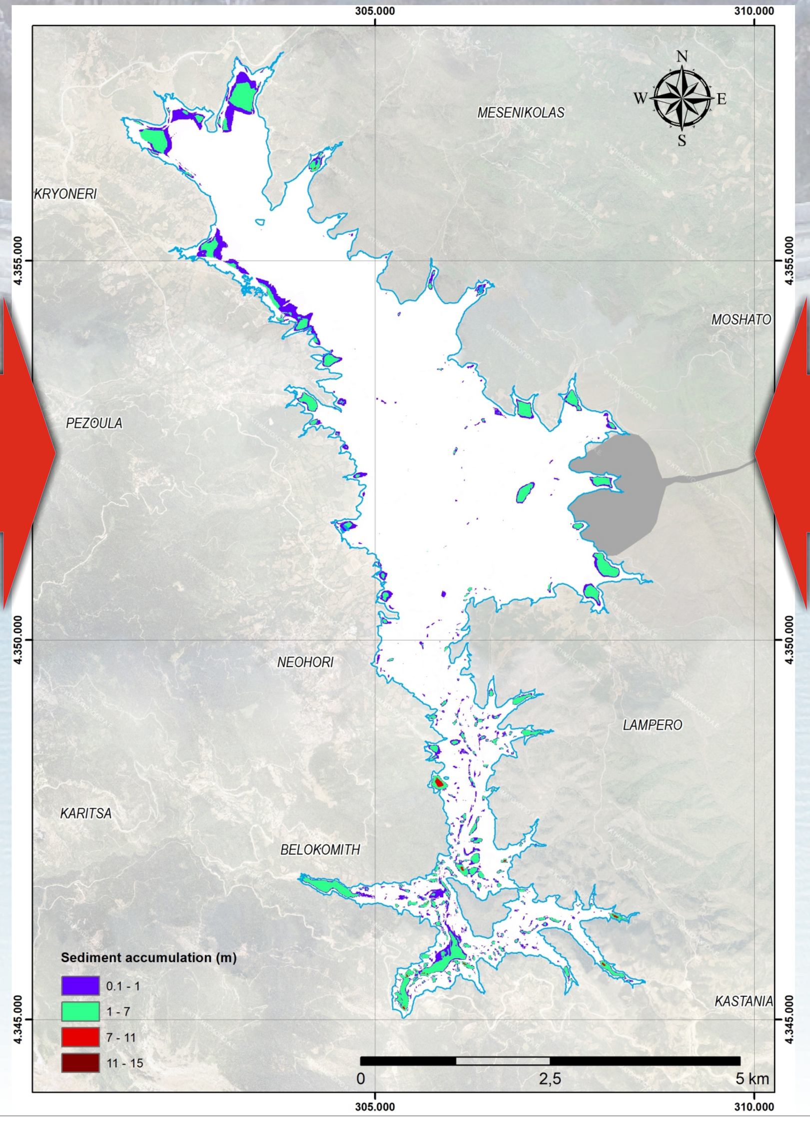
The high-resolution offshore data processing revealed -among others- a submerged bridge and buildings as well as the underwater part of the dam, which could be visualized in 3D oblique views (inset below).

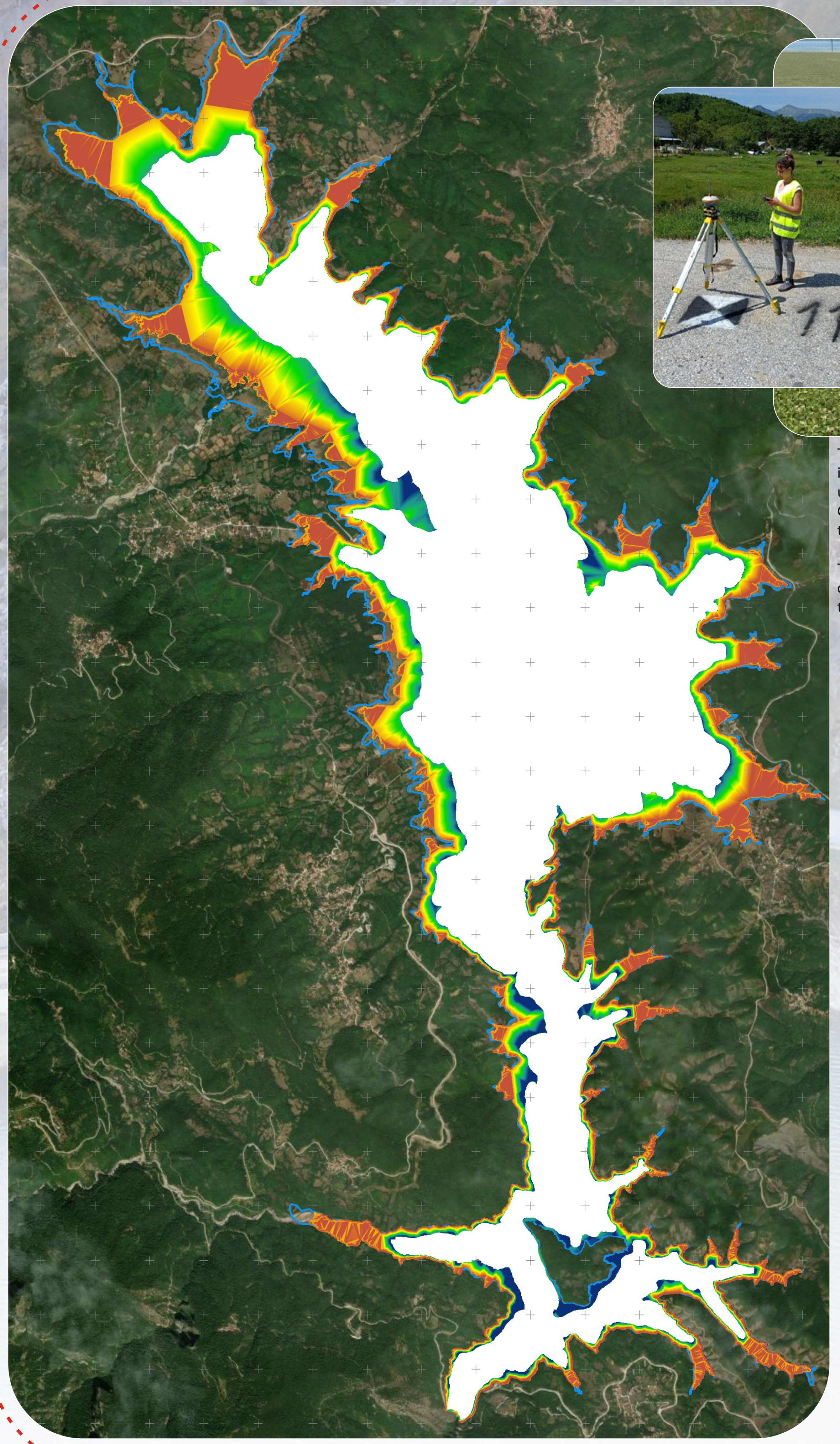




The drainage network that ends up in the artificial lake is characterized by asymmetry, as it is longer and more dense at the western part of the hydrologic basin (see above).

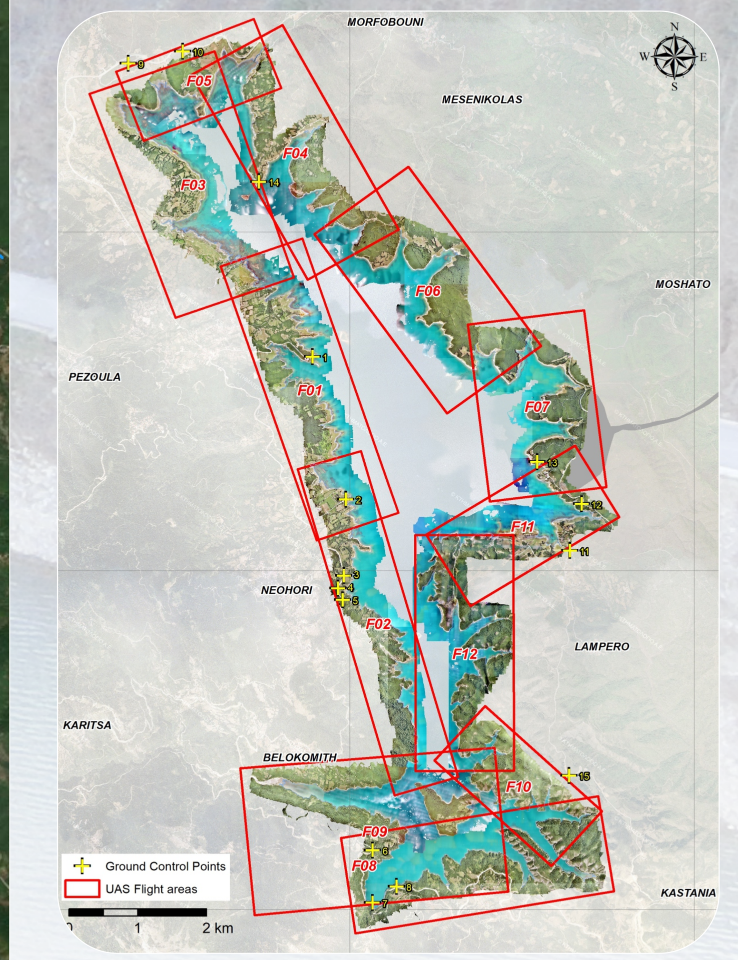
The combination of offshore and onshore point cloud data, led to a unified morphology of the lake bottom, which was compared to a similar one, constructed with slightly different methodology during 2010. This comparison revealed the locations where sediment thickness occurred, mainly after the severe Ïanos" Medicane, during 2020 (see below).

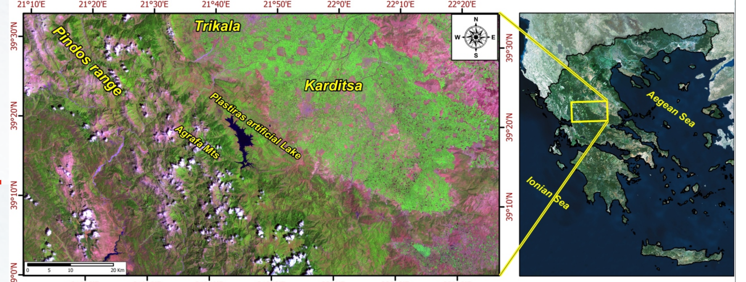




The equipment for the onshore data collection included a fixed wing UAS (upper inset), which covered the entire coastal area, acquiring thousands of aerial images used for constructing high-resolution DTMs and ortho-mosaics (inset below). Also, GCPs were established around the lake with GNSS used either for post-processing of the aerial data and for combining the offshore data as well .

The image data were used afterwards within the photogrammetry processing for constructing a point cloud for the onshore part of the lake coast (left inset), where the vessel could not flow during the low water level period.





Landsat-7ETM+ image of Central Greece (542/RGB), acquired on 13/5/2009, showing the Plastiras artificial lake surrounded by mountainous environment. The map on the right shows the study area location within the mainland Greece.

Photography encouraged

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