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TSUNAMI RISKS TO THE EASTERN MEDITERRANEAN COASTAL ZONE

Partners:

- LP 1 - UNIVERSITY OF THE AEGEAN
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INTRODUCTION

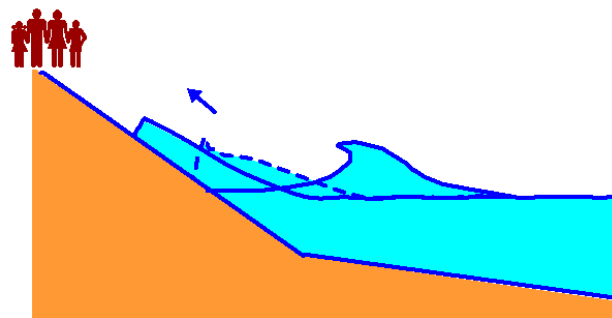
The recent catastrophic giant tsunami that was generated by the December 26, 2004 earthquake offshore western Sumatra has raised a number of urgent issues regarding tsunamis. In particular, the Indian Ocean event pointed out dramatically that we have little knowledge on tsunamis and on their potential impact on human habitat, and also that the international community lacks a clear strategy of how to deal with these events. This holds also for the countries facing the Mediterranean Sea.

The international scientific community has to contribute to the simulation of the tsunami generation, propagation and coastal inundation processes, and to the planning of the mitigation of the tsunami effects on the coastal communities.

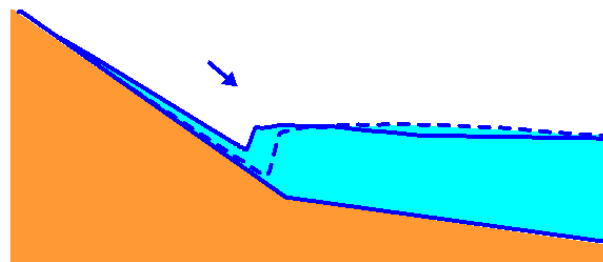
A tsunami is different from normal waves on the ocean. Normal ocean and wind swell waves may cause motion in the water to depths of 150 m. In contrast, the passage of a tsunami involves the movement of water all the way to the seafloor. Tsunami can be caused by under-sea events like earthquakes, landslides, volcanic eruptions or even ocean meteorite impacts. A tsunami is a series of sea waves, the first of which may not be the highest. The waves are of extremely long length and period. Tsunami waves move outwards, away from their source. As a tsunami crosses a deep ocean, the length from crest to crest may be as much as 150 km but the height may be less than a metre. Tsunami waves may therefore be unnoticed by ships or from the air, reaching speeds up to 1000 km/h. As a tsunami leaves the deep water of the open ocean and travels into the shallower water near the coast, the tsunami slows. As the tsunami's speed diminishes, its height grows. This is called shoaling. A tsunami that is unnoticeable at sea may grow to be several metres or more in height near the coast. Depending on whether the first part of a tsunami to reach the shore is a crest or a trough, it may appear as a rapidly rising or falling tide. In instances where the leading edge of the tsunami wave is its trough, the sea will recede from the coast before the wave's arrival. If the seafloor slope is shallow, this recession can exceed many hundreds of metres. Local details of the shape of the seafloor may also cause the tsunami to appear as a series of breaking waves.

The sequence of a tsunami hitting a coastal area involves various processes from the generation of the tsunami wave, to its propagation, to the coastal-zone hydrodynamic processes including surf- and swash zone processes, to the processes involving interaction between tsunami wave and built and natural environments, and to

inundation of land areas. Because of the runup-rundown processes (Figure 1) tsunamis can be deadly when they hit coastal areas. The death toll can reach tens, even hundreds of thousands. Damage to the built and natural environments can reach enormous levels.



Shoaling, Breaking and runup



Rundown

Fig. 1. Sketch of a tsunami sequence in the coastal zone.

The first to assess vulnerabilities and risks is to identify the threats. In the case of a tsunami crashing into a shore area with its towns and built and natural environments, the full spectrum of threats may be considered in four major categories:

1. Threats related to coastal hydrodynamics including inundation;
2. Threats related to sediment-transport, morphology and floating-debris processes;
3. Threats related to scour/erosion and liquefaction processes; and
4. Threats related to hydrodynamic loading on coastal and on-land structures.

Each category of threat may be broken down into specific processes as follows.

Major processes related to threats due to coastal hydrodynamics including inundation are:

- Tsunami-wave breaking processes;
- Runup and rundown processes; and
- Inundation processes.

Likewise, major processes related to threats due to sediment transport, morphology and floating-debris are:

- Sediment transport processes under tsunami waves;
- Morphology under tsunami waves;
- Processes related to bars, beaches, dunes, overtopping/breaches; and
- Processes related to floating-debris flow

Similarly, major processes related to threats due to scour/erosion and liquefaction processes are:

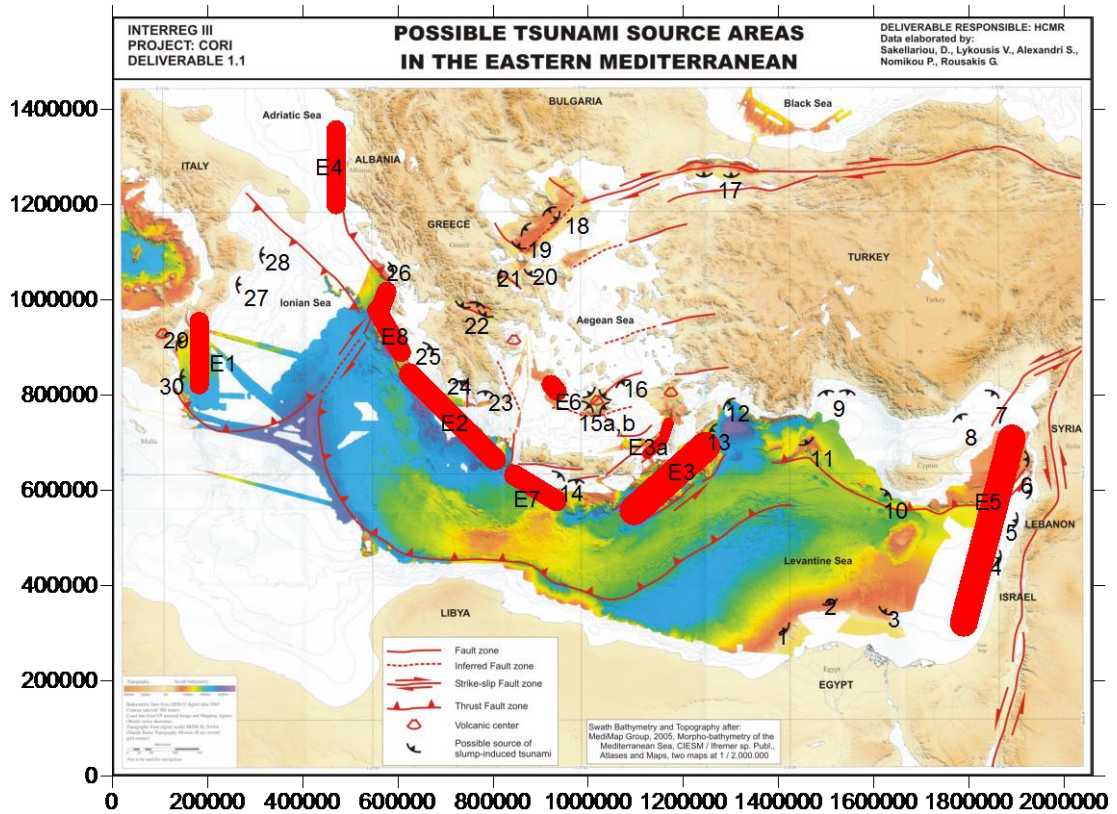
- Scour processes around bridge piers, piles, wind-mill mono towers, supporting pile elements of offshore platforms, pipelines, cables and similar objects lying on the seabed, vertical sea walls, quay walls, sheet-piled structures, vertical-wall breakwaters, tsunami attenuation structures, on-land structures, rubble-mound structures; and
- Seabed/structure failure due to liquefaction processes under tsunami waves.

Finally, major processes related to threats due to hydrodynamic loading on coastal and on-land structures are:

- Processes related to hydrodynamic forces on cylindrical structures;
- Processes related to hydrodynamic forces on vertical walls;
- Processes related to hydrodynamic forces on rubble mound structures;

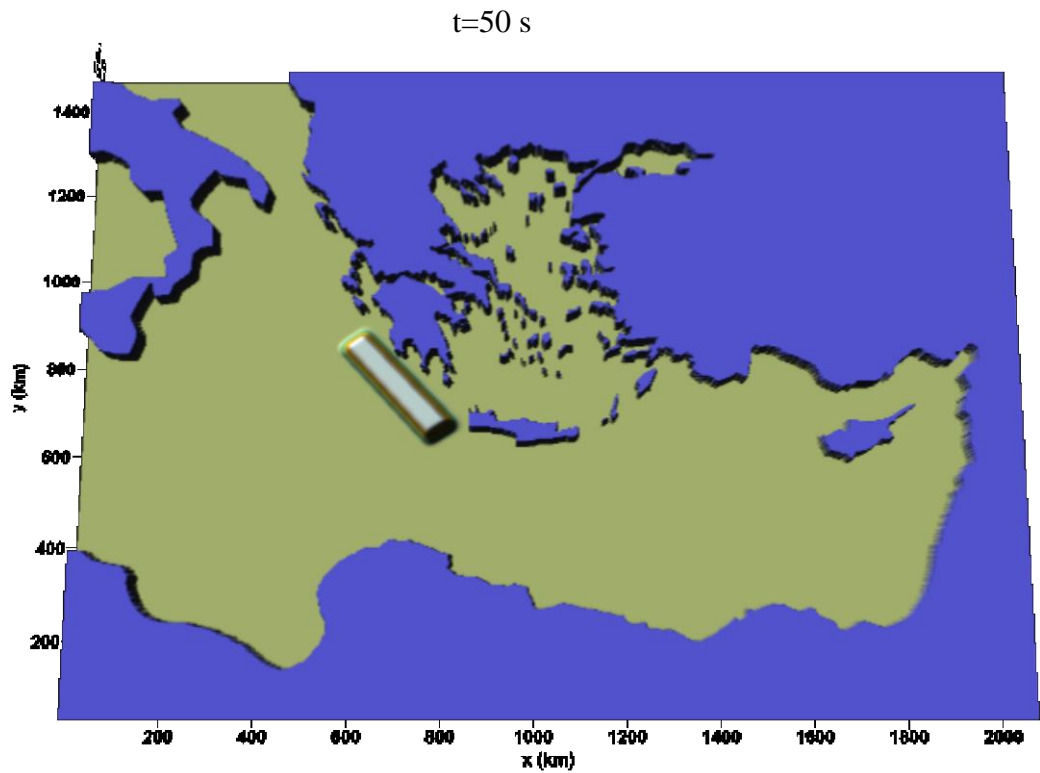
MODEL RESULTS and VULNERABILITY MAPS

In this project we concentrate on the use of scenarios to study the basic features of tsunami propagation in the Eastern Mediterranean region. We consider the following 40 zones (sources). For the numerical simulation of tsunamis an advanced is applied for all the 40 tsunamigenic sources.

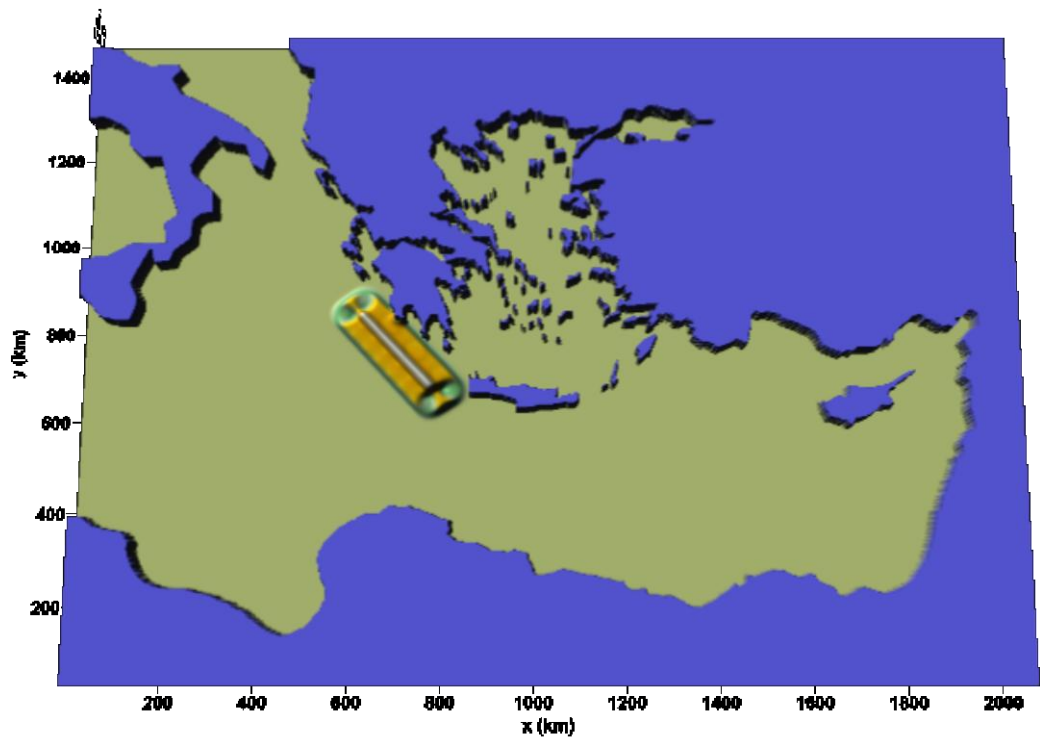


Summarization of the tsunamigenic zones in the Eastern Mediterranean adopted for the present study. The codes indicate the 40 zones which correspond to the 40 runs of the numerical model.

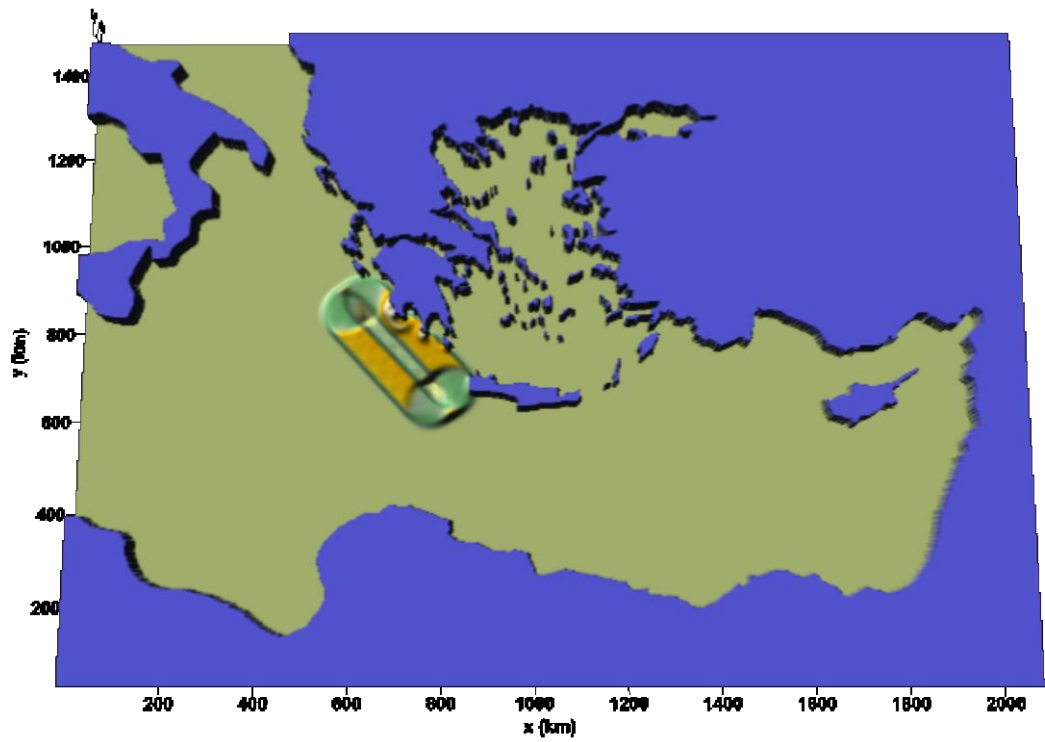
In the next figures the generation and propagation of the tsunami of the case E2 is shown.



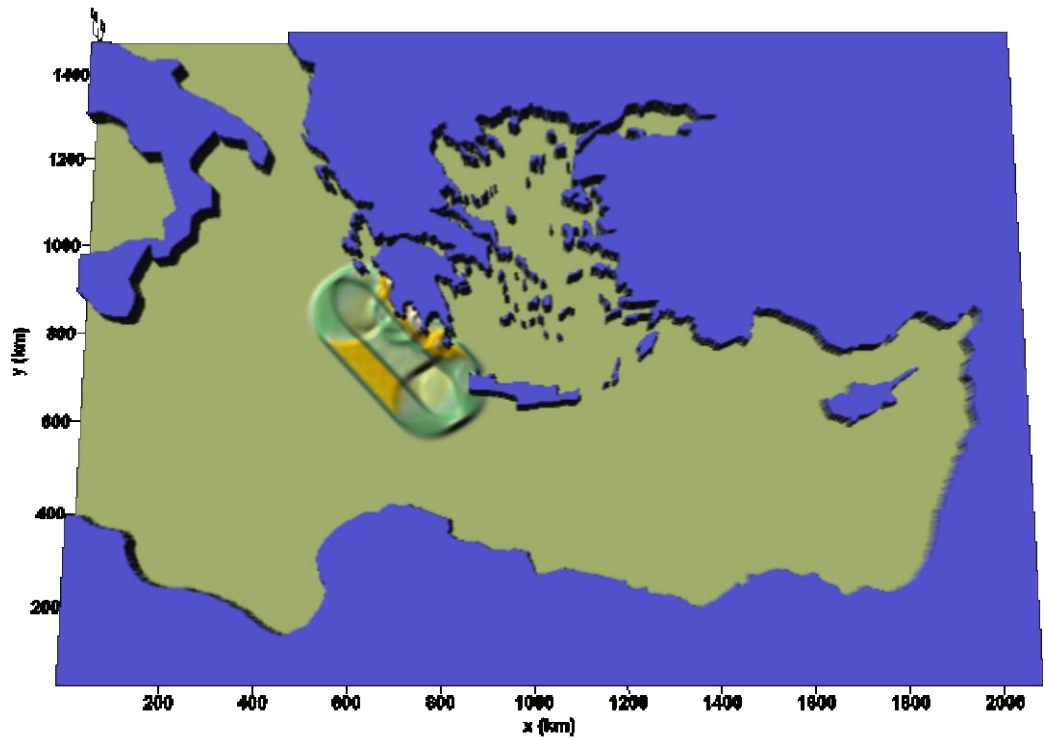
Snapshot of the tsunami elevation fields computed for the case E2; t=50 s.



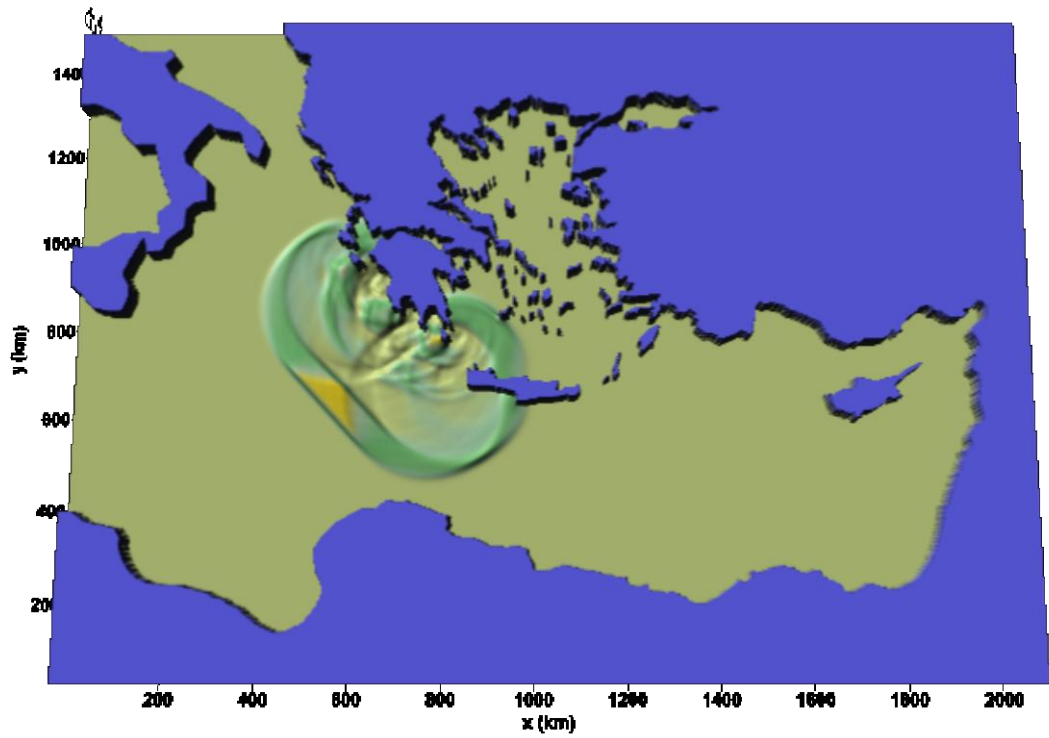
Snapshot of the tsunami elevation fields computed for the case E2; t=250 s



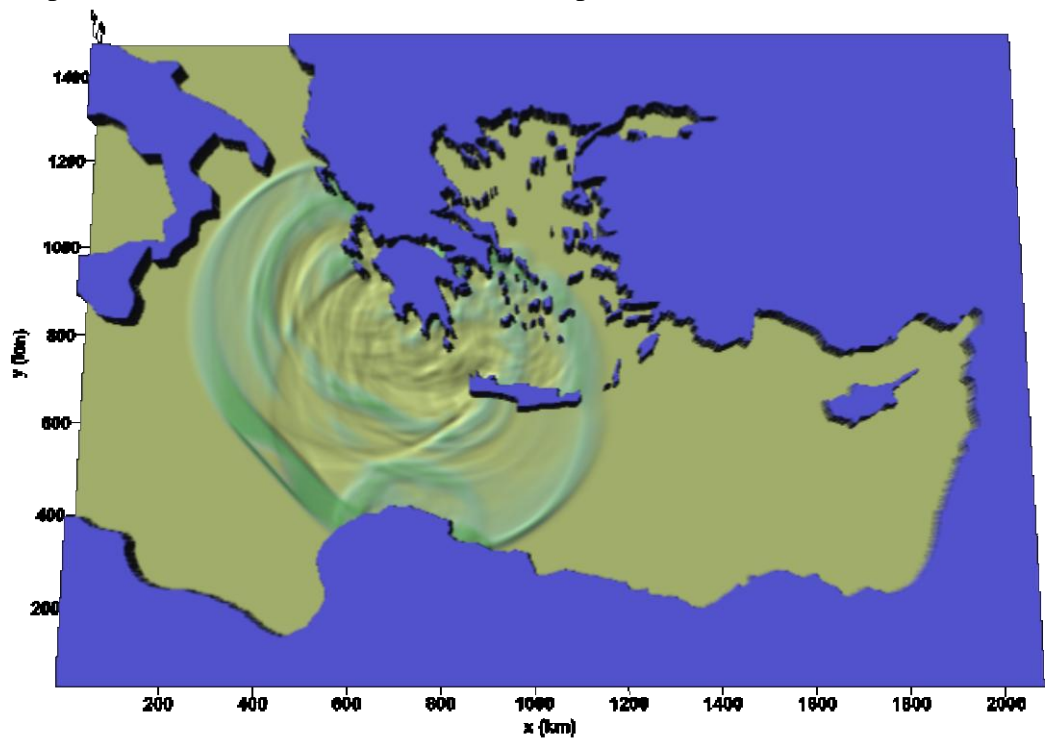
Snapshot of the tsunami elevation fields computed for the case E2; $t=550$ s



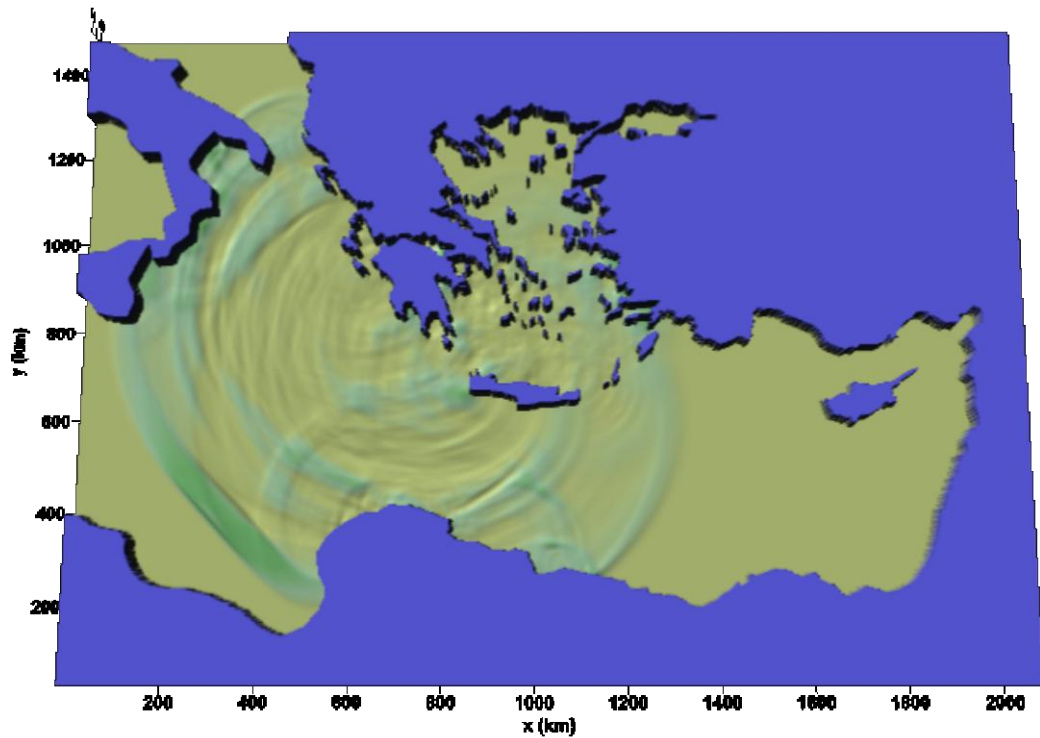
Snapshot of the tsunami elevation fields computed for the case E2; $t=850$ s



Snapshot of the tsunami elevation fields computed for the case E2; $t=2000$ s

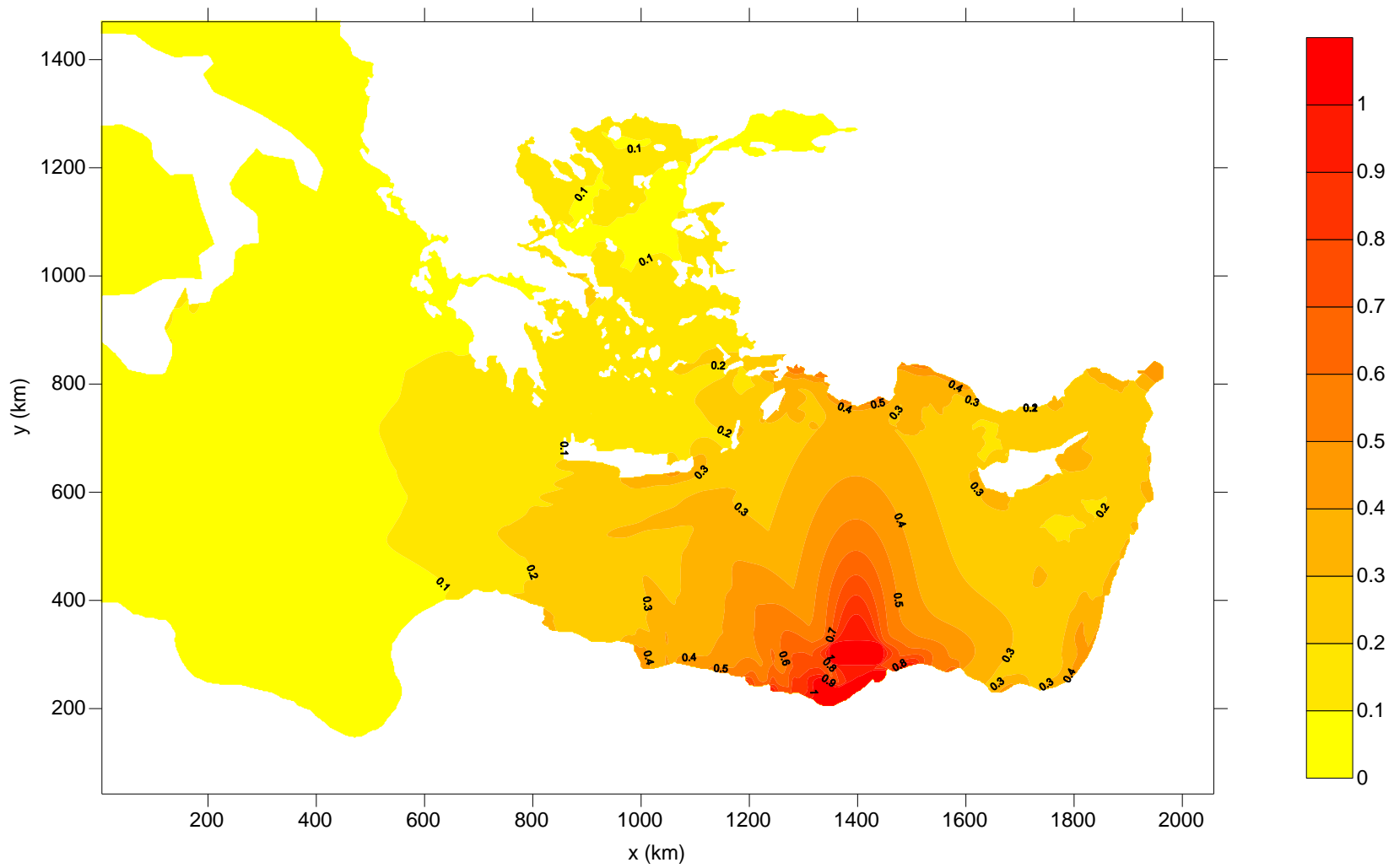


Snapshot of the tsunami elevation fields computed for the case E2; $t=4000$ s

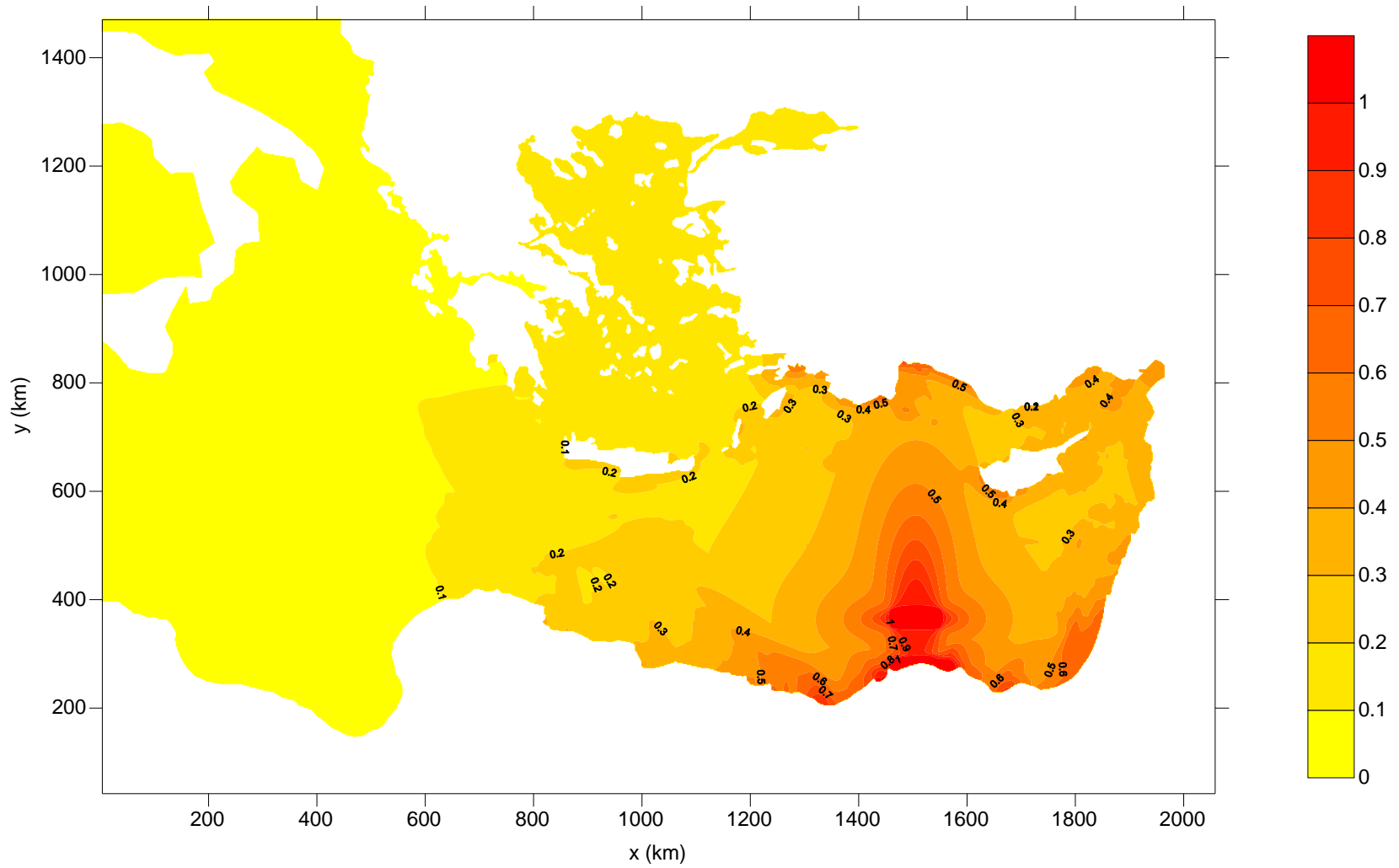


Snapshot of the tsunami elevation fields computed for the case E2; $t=6000$ s

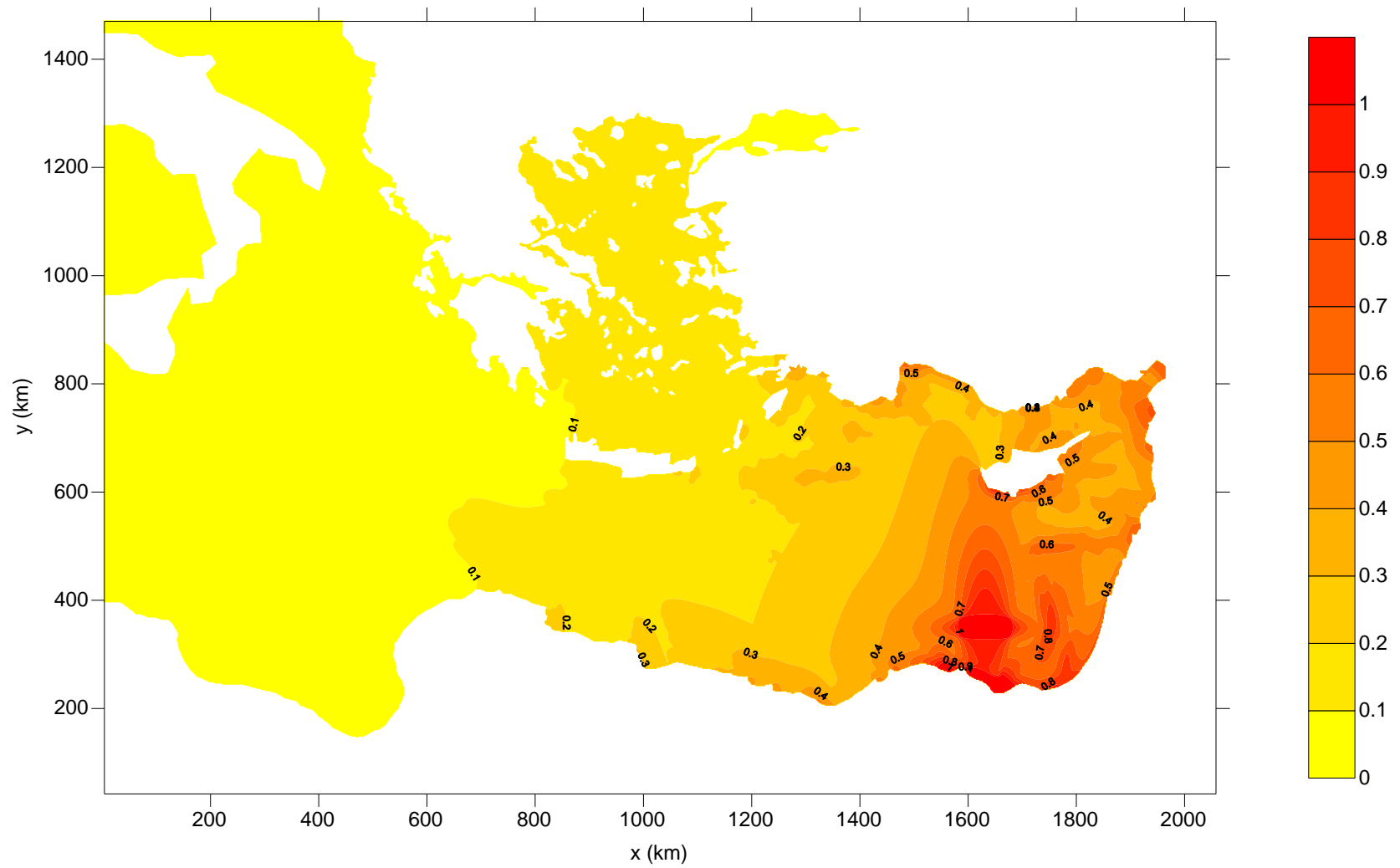
In the following figures the results of numerical model runs, regarding the coastal impact of the worst case scenarios, are presented for the 40 cases. The figures also show the expected maximum wave height in the coastal zone and consist the vulnerability maps for Eastern Mediterranean.



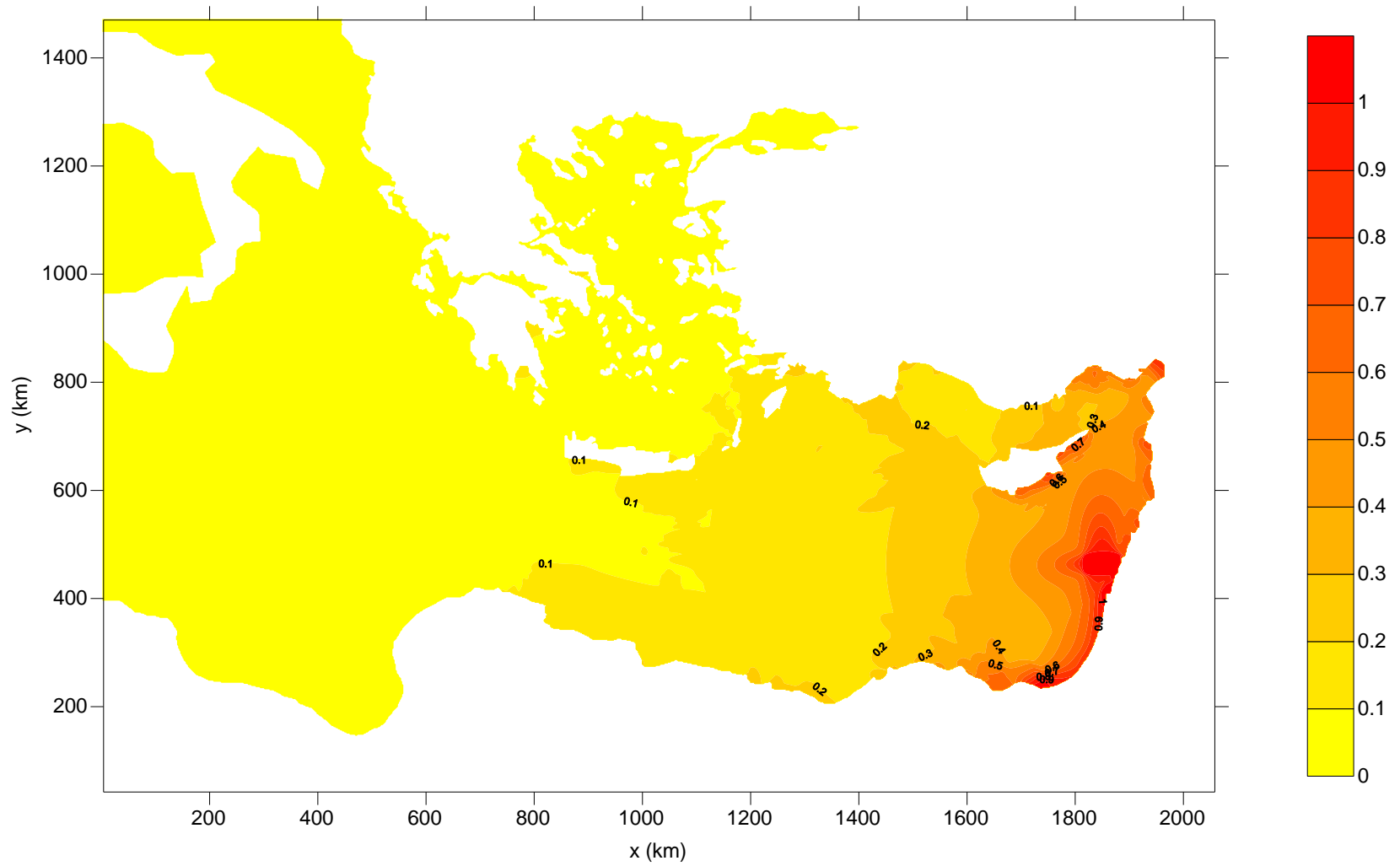
Extreme water elevation field computed for the case 1.



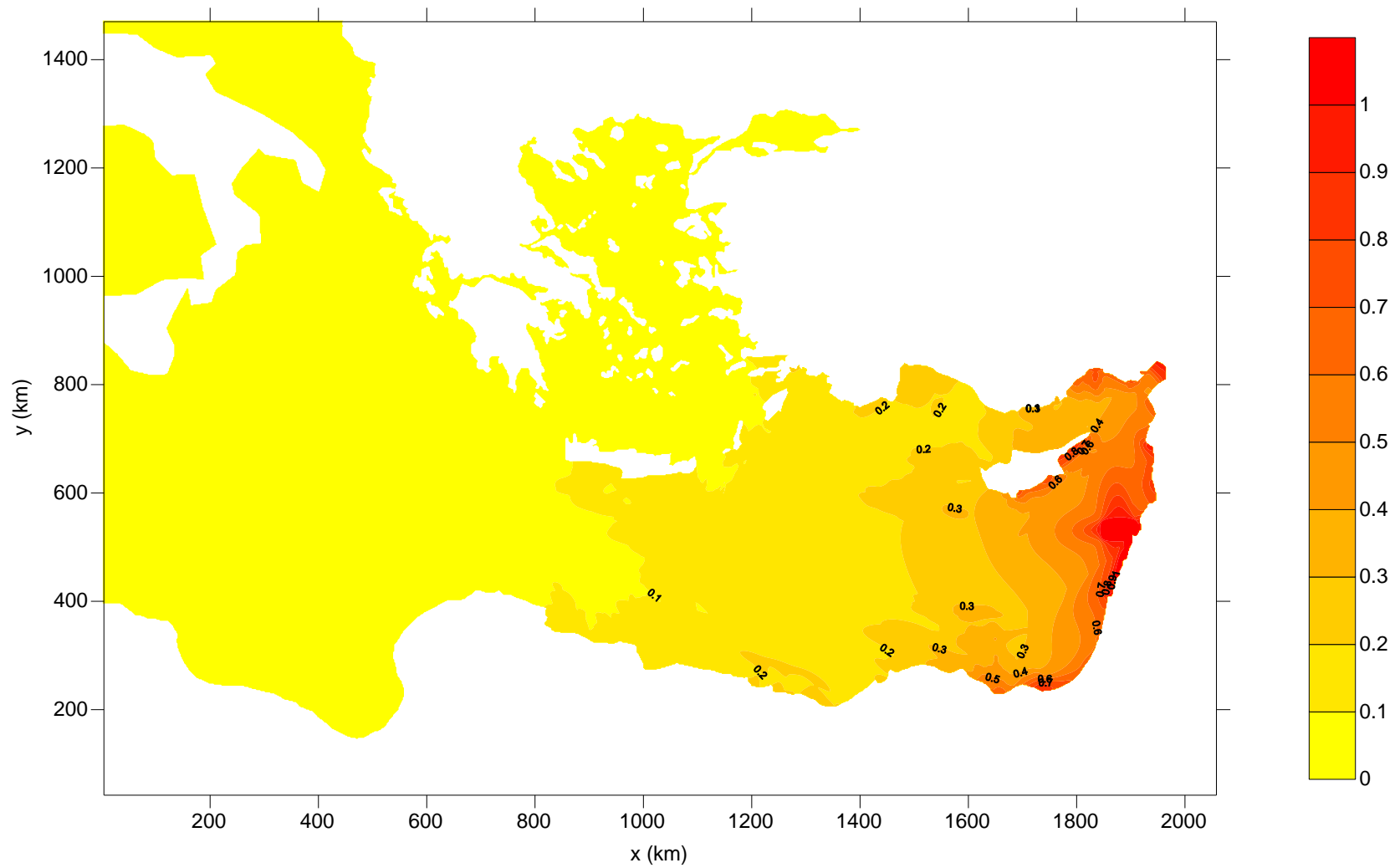
Extreme water elevation field computed for the case 2.



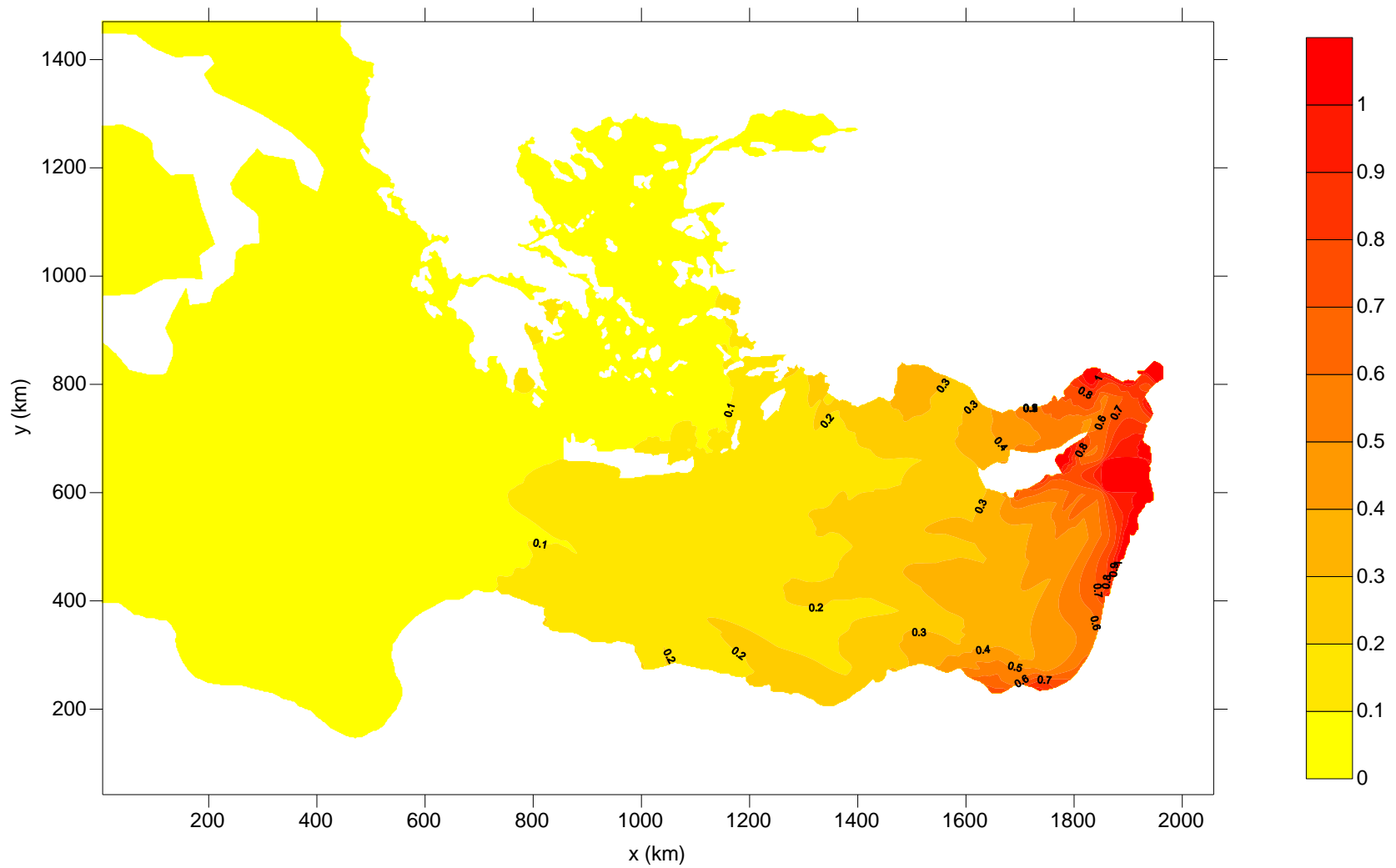
Extreme water elevation field computed for the case 3.



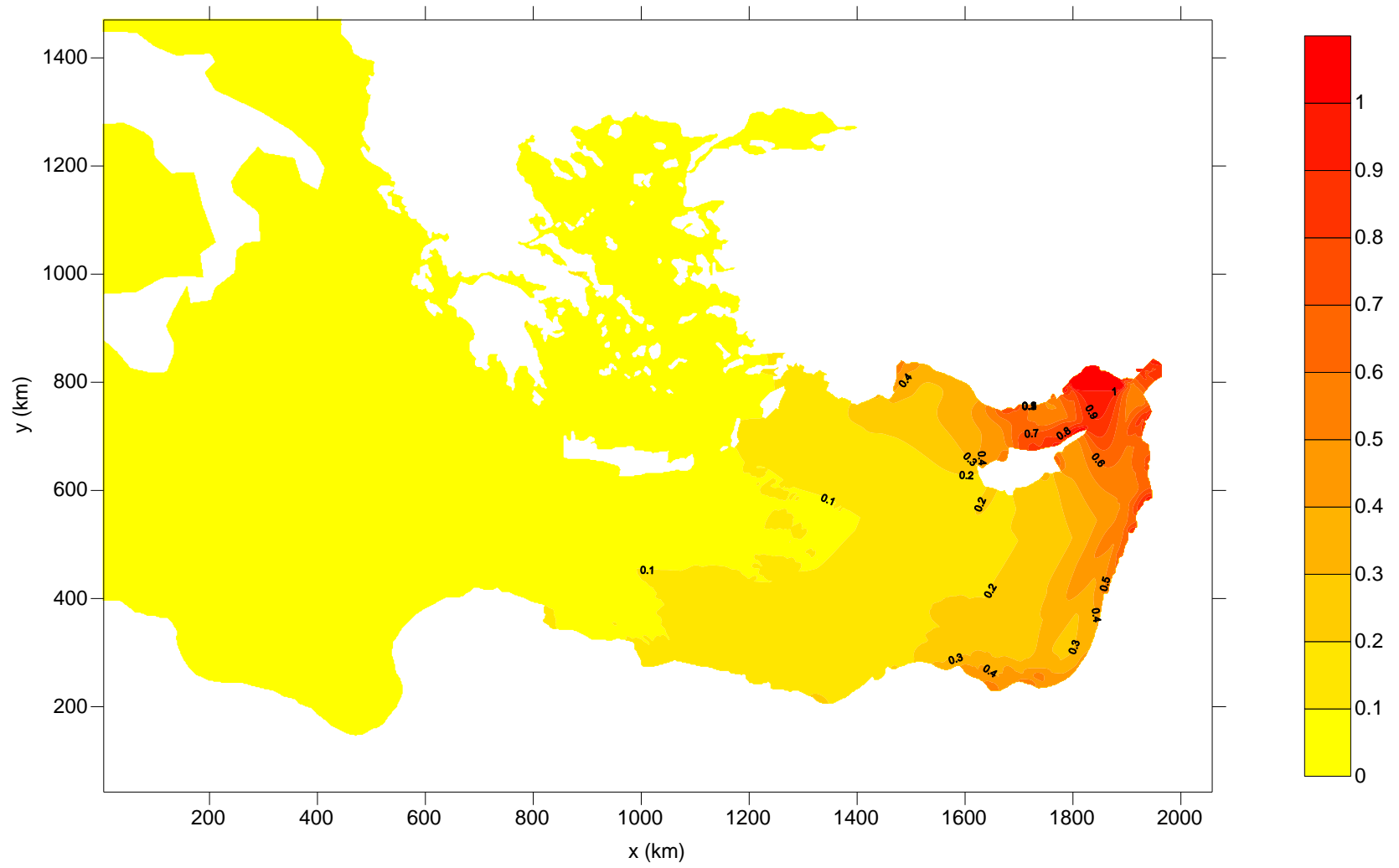
Extreme water elevation field computed for the case 4.



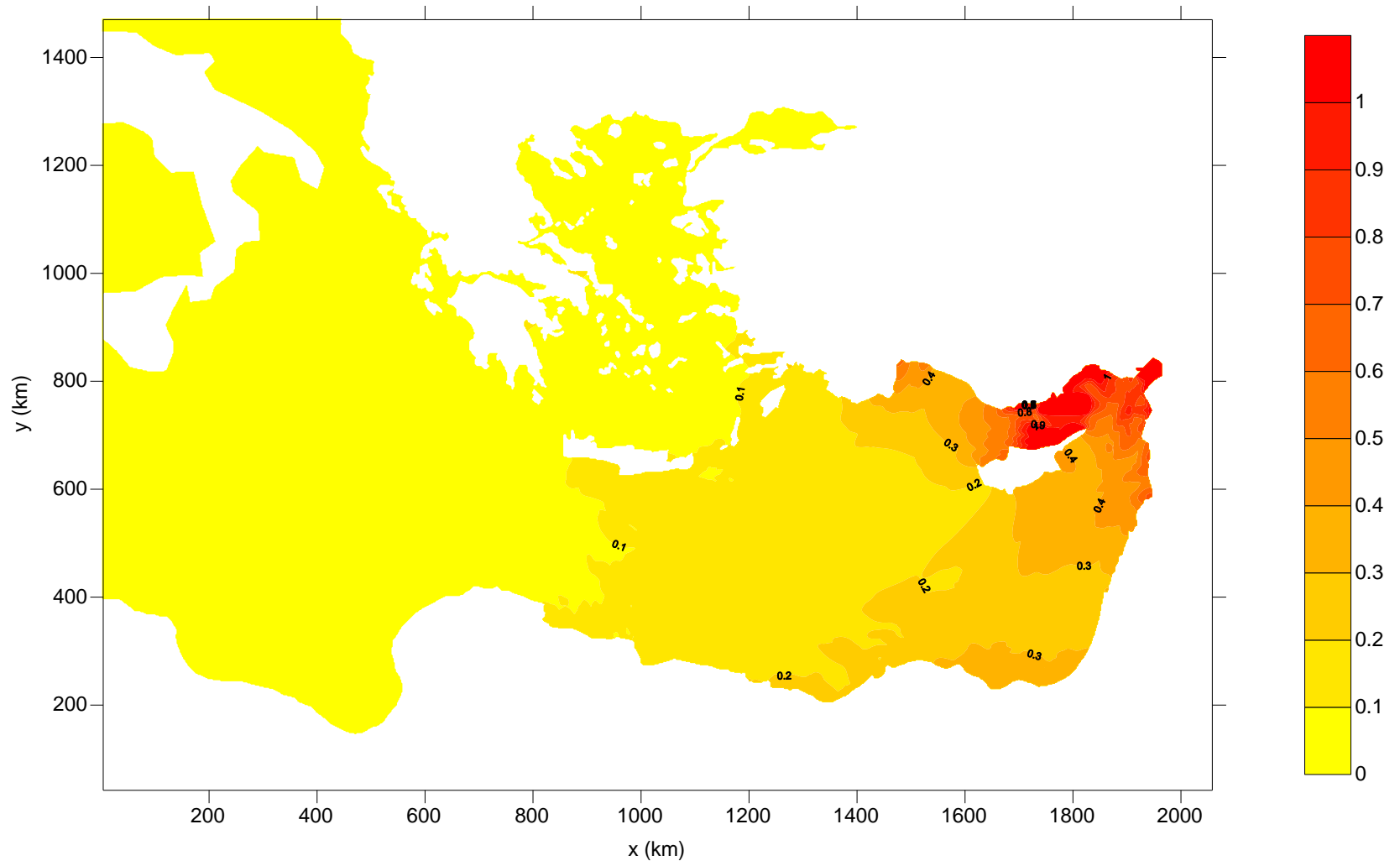
Extreme water elevation field computed for the case 5.



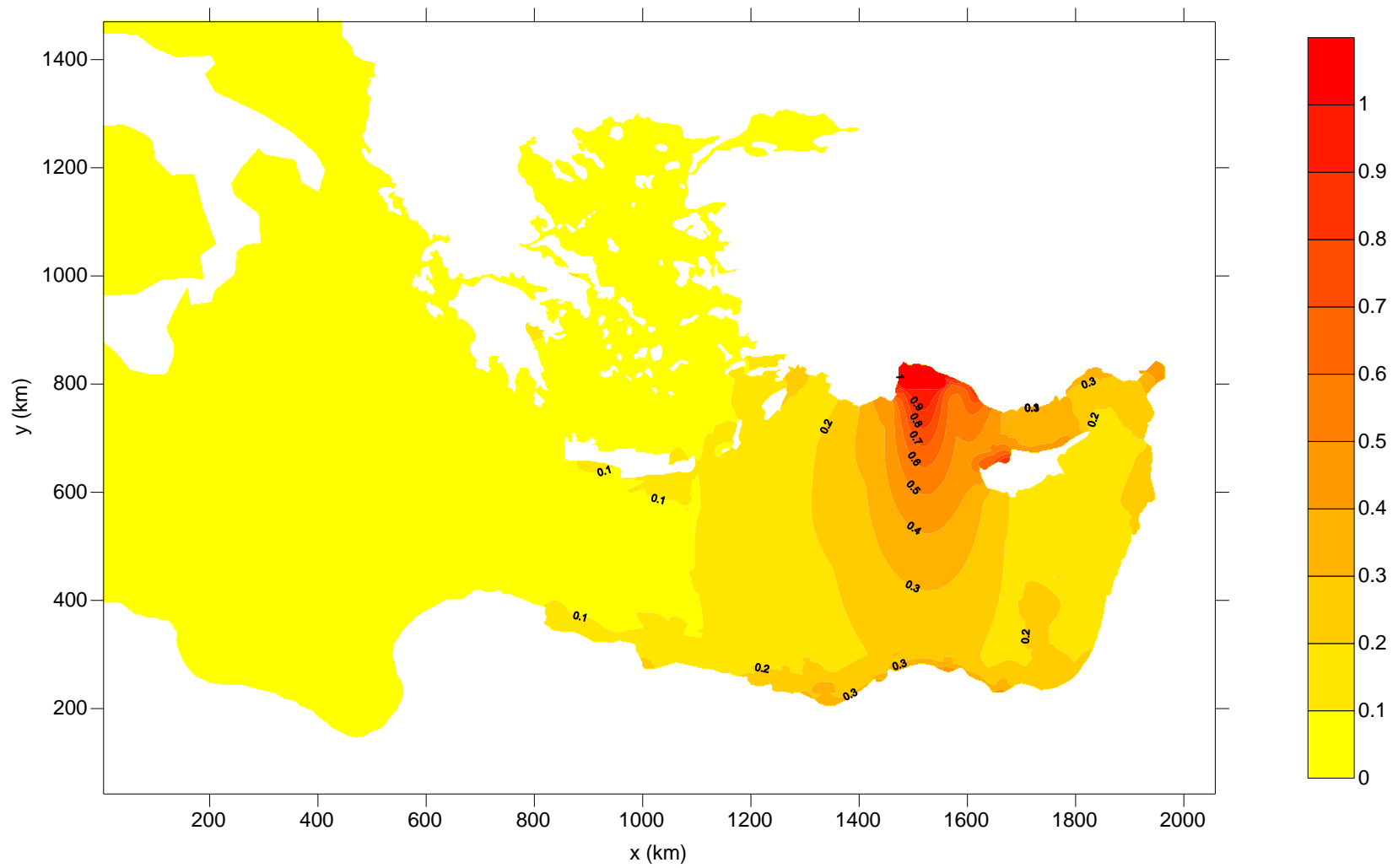
Extreme water elevation field computed for the case 6.



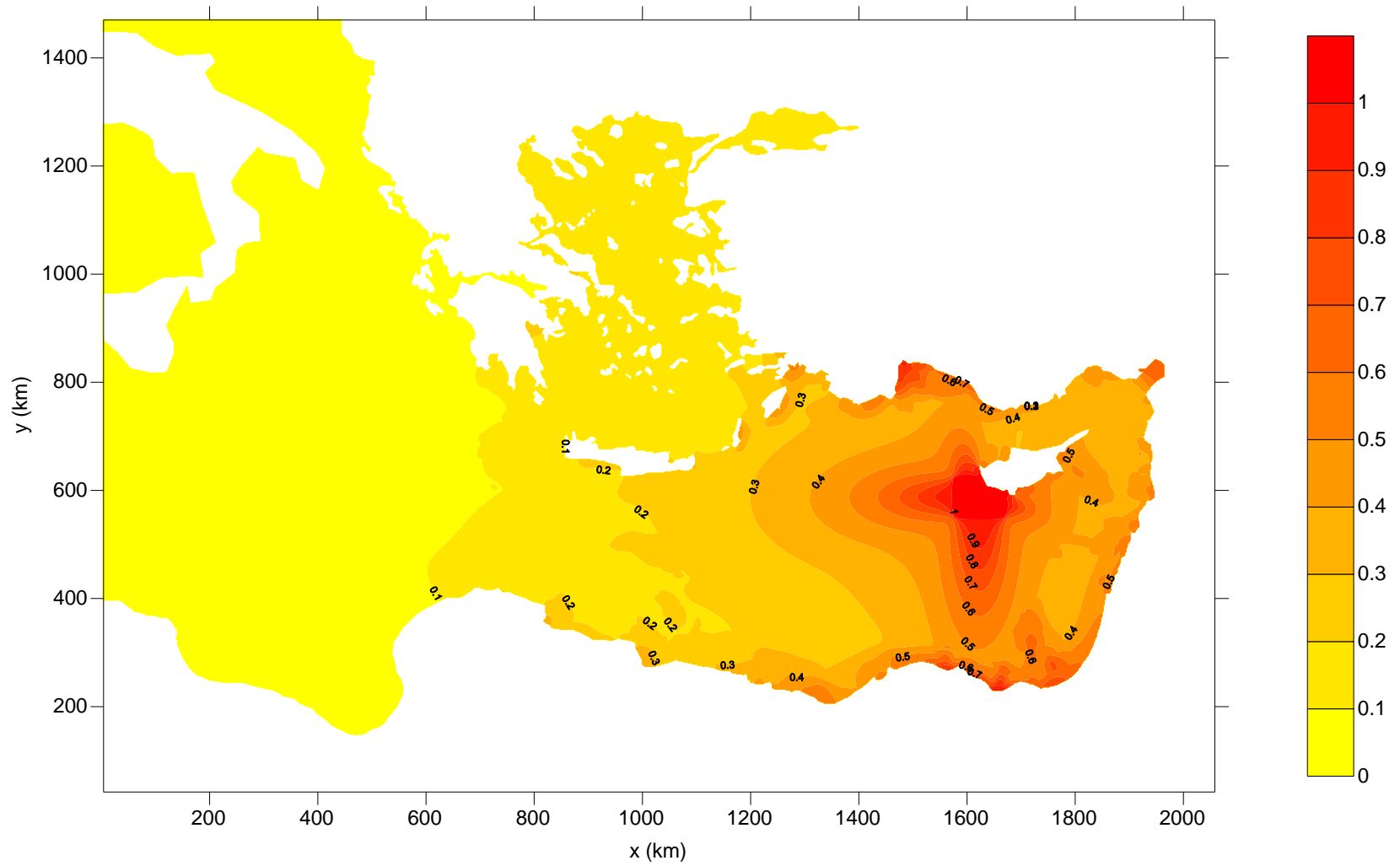
Extreme water elevation field computed for the case 7.



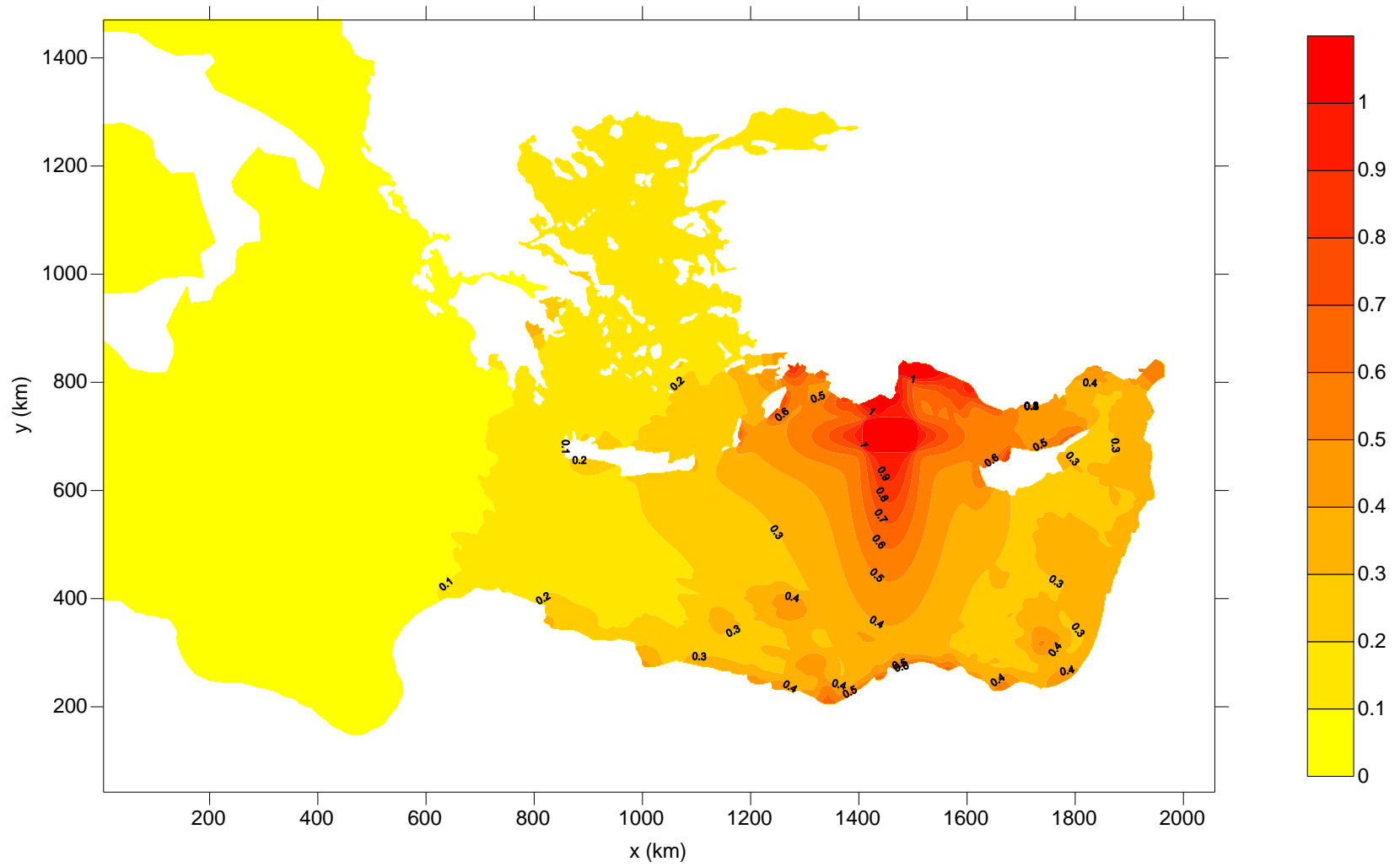
Extreme water elevation field computed for the case 8.



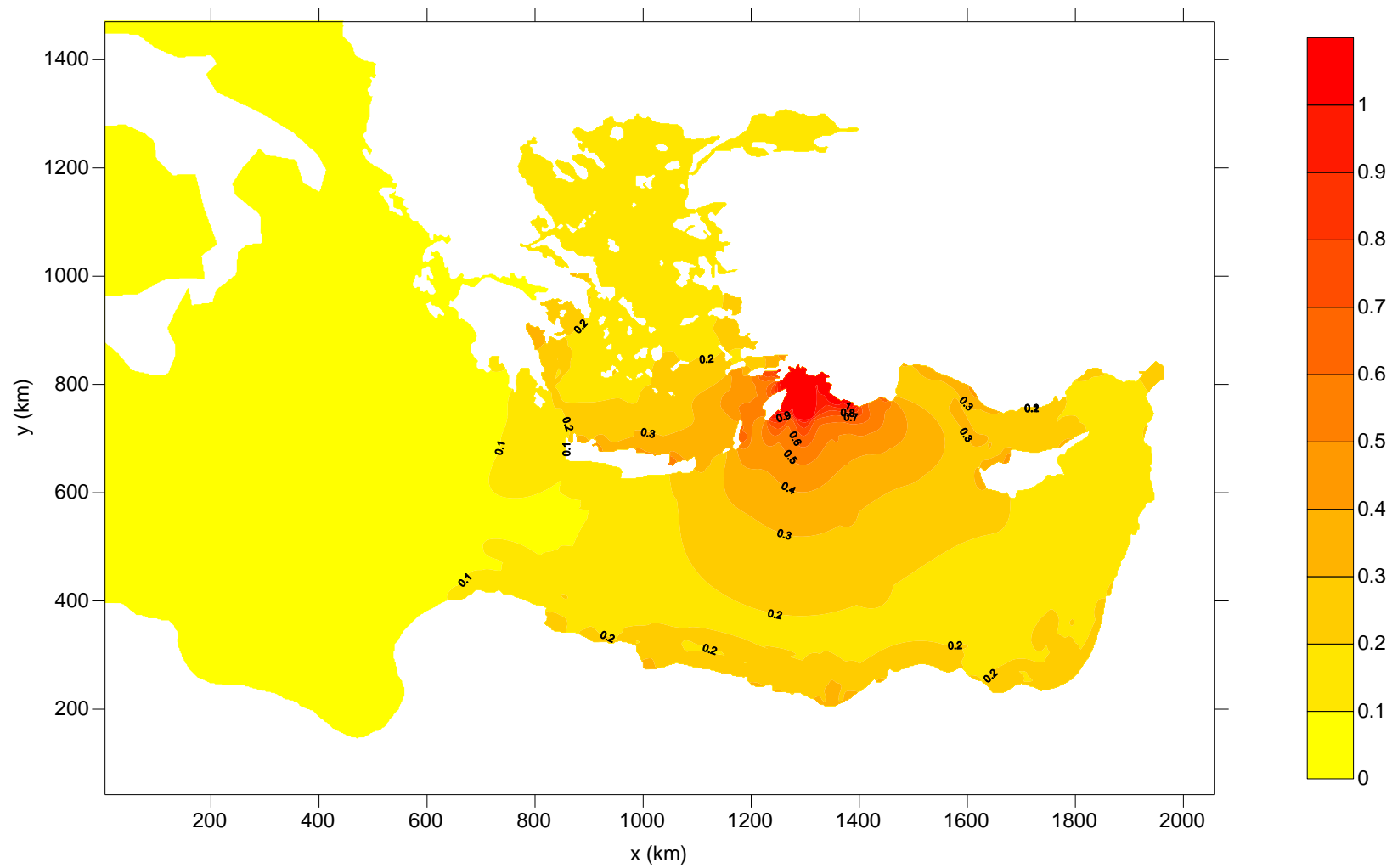
Extreme water elevation field computed for the case 9.



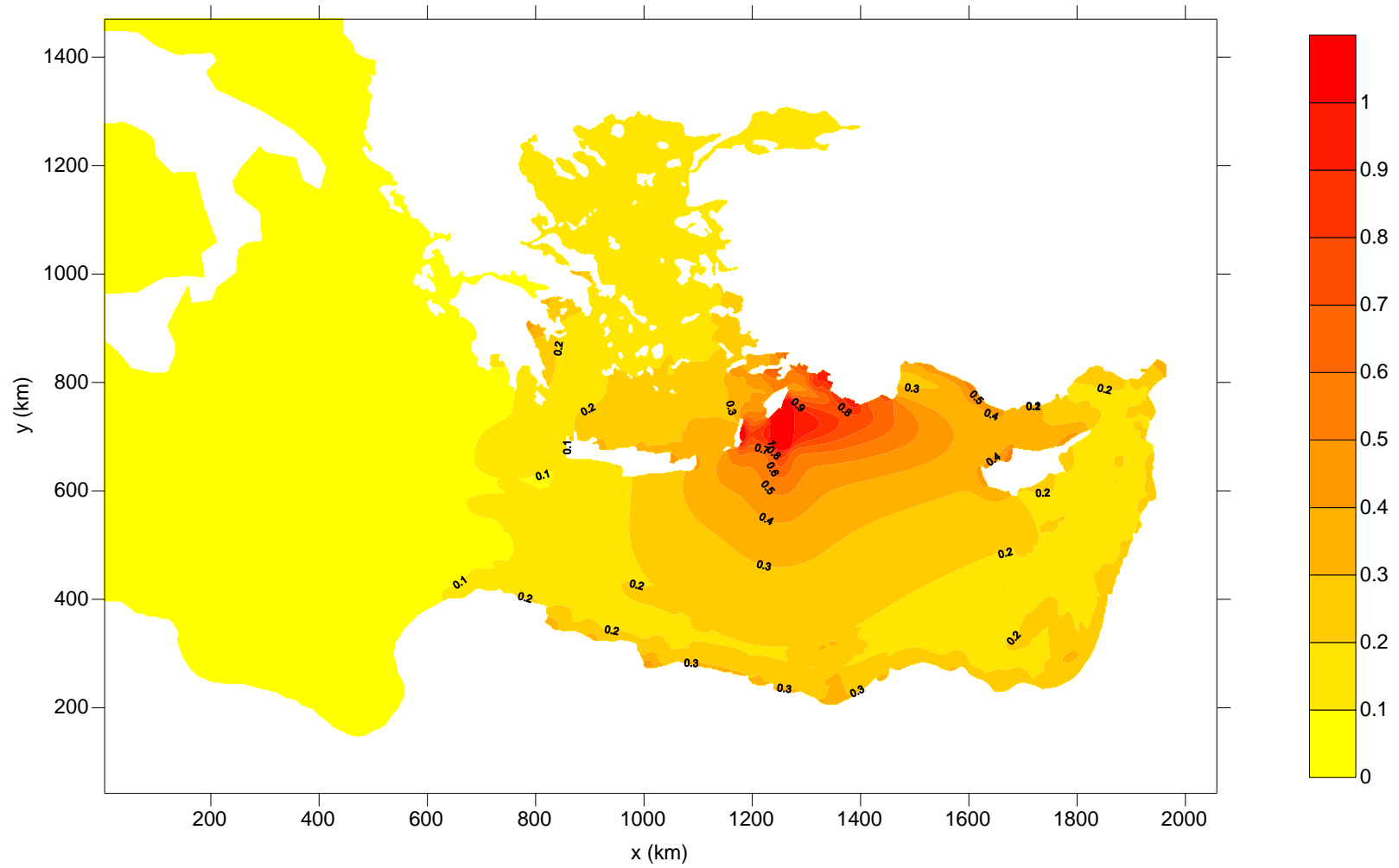
Extreme water elevation field computed for the case 10.



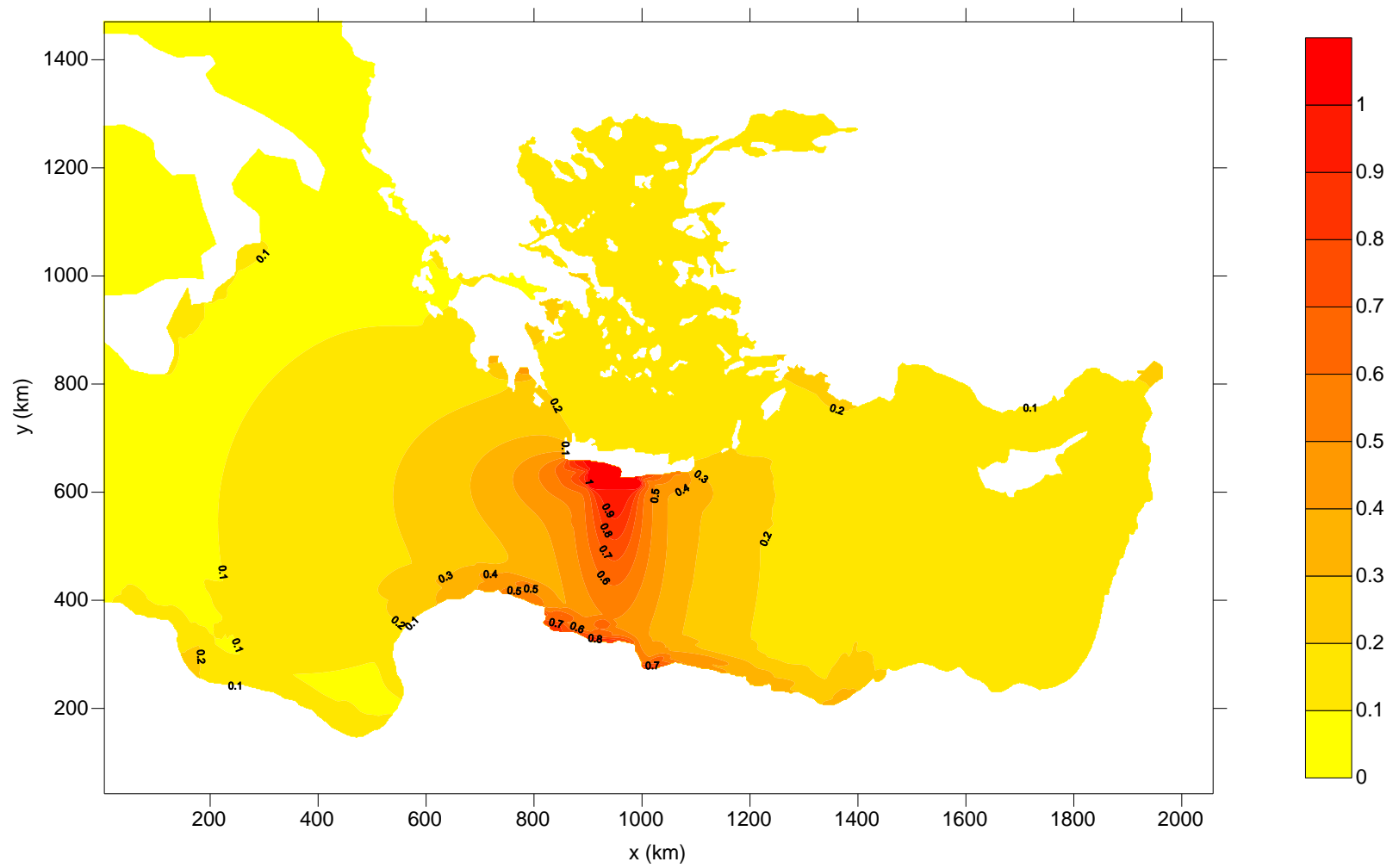
Extreme water elevation field computed for the case 11.



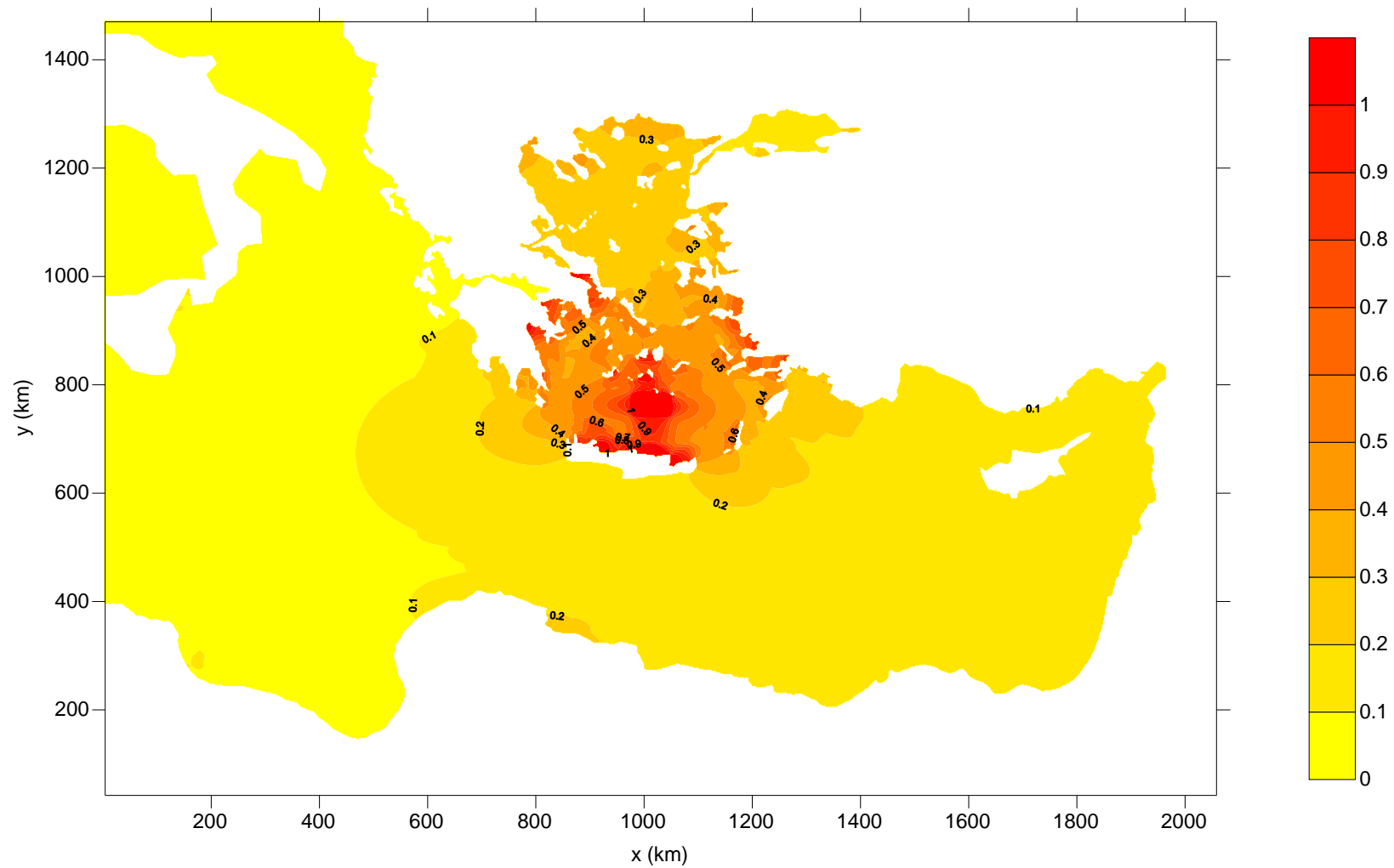
Extreme water elevation field computed for the case 12.



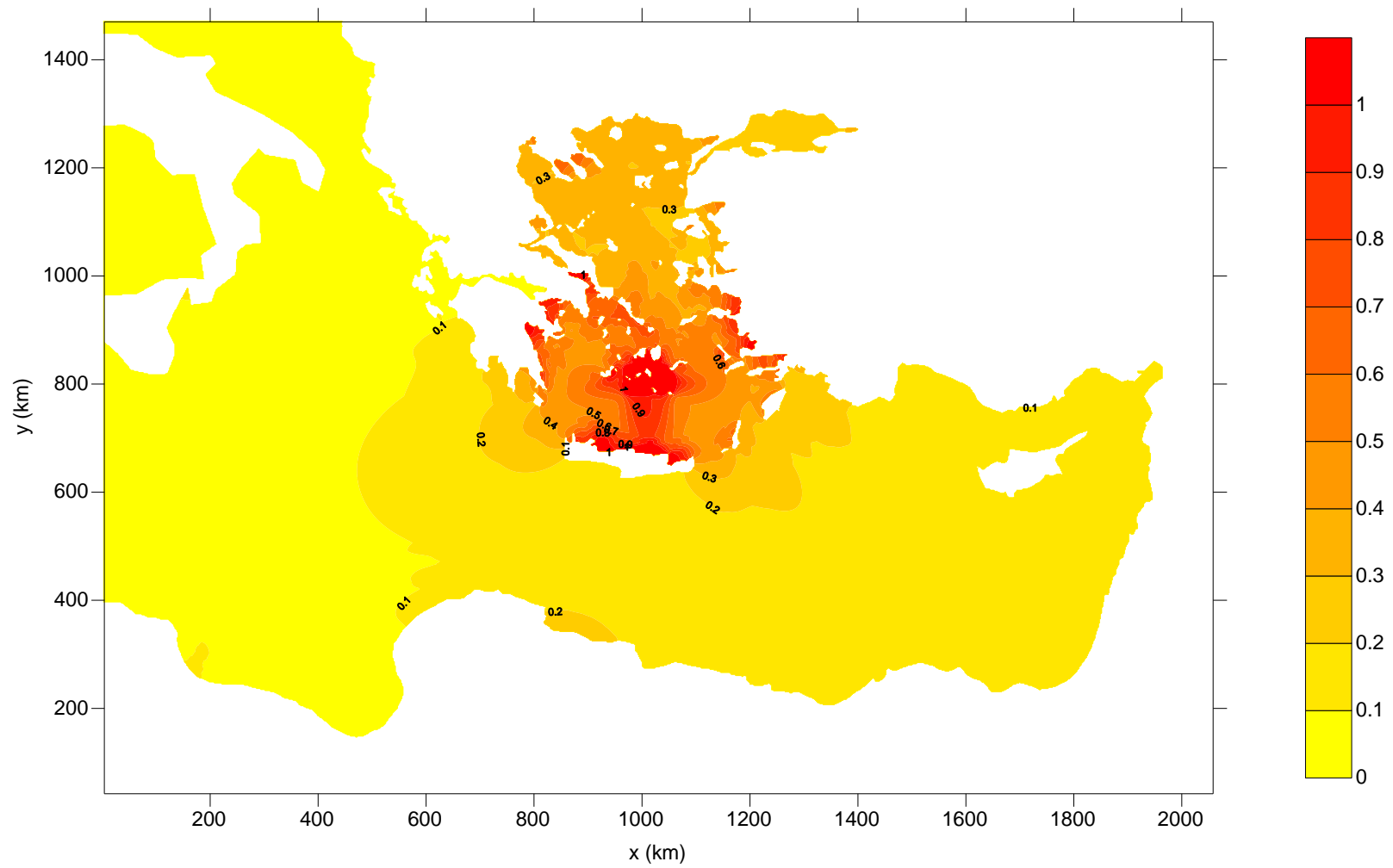
Extreme water elevation field computed for the case 13.



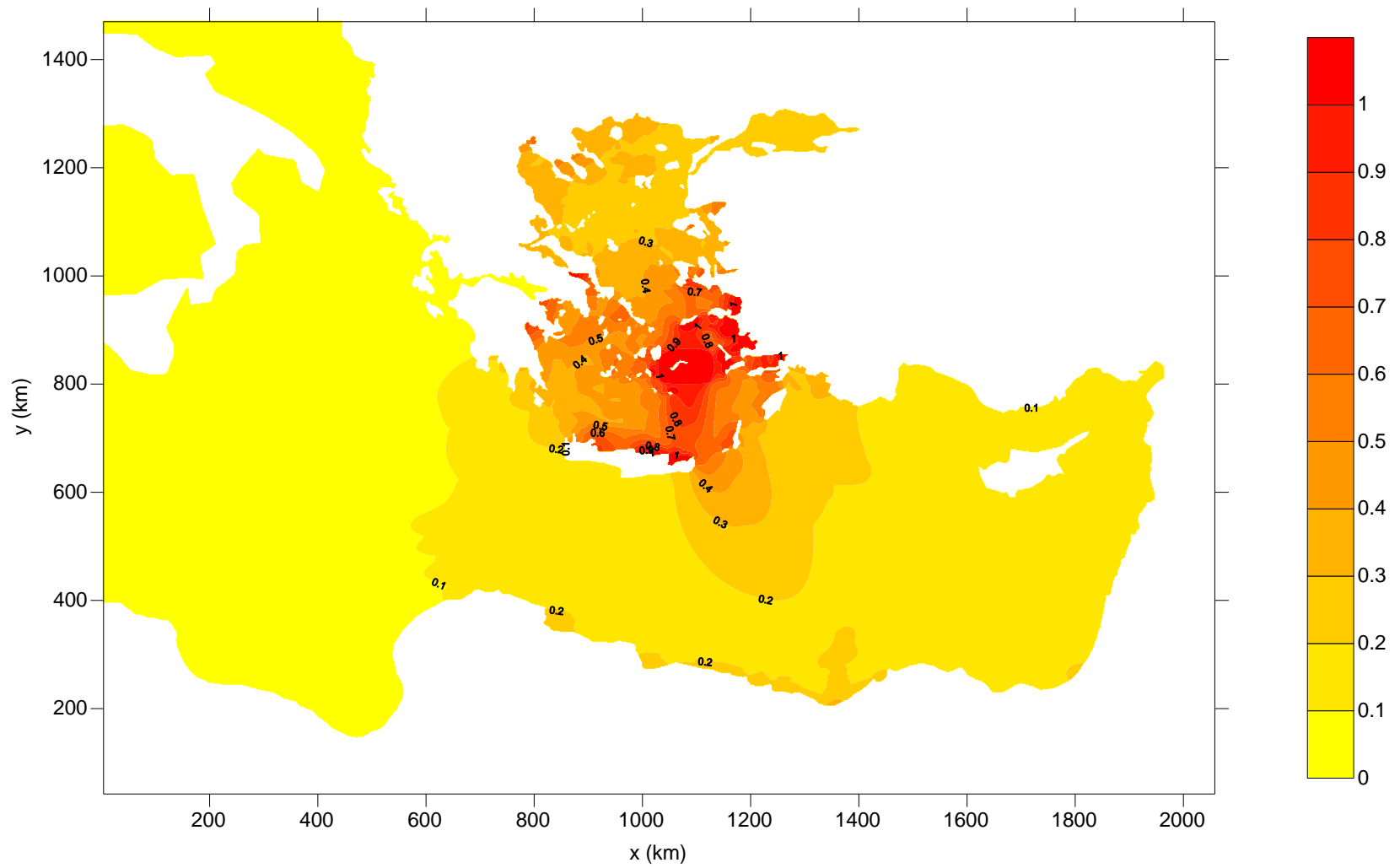
Extreme water elevation field computed for the case 14.



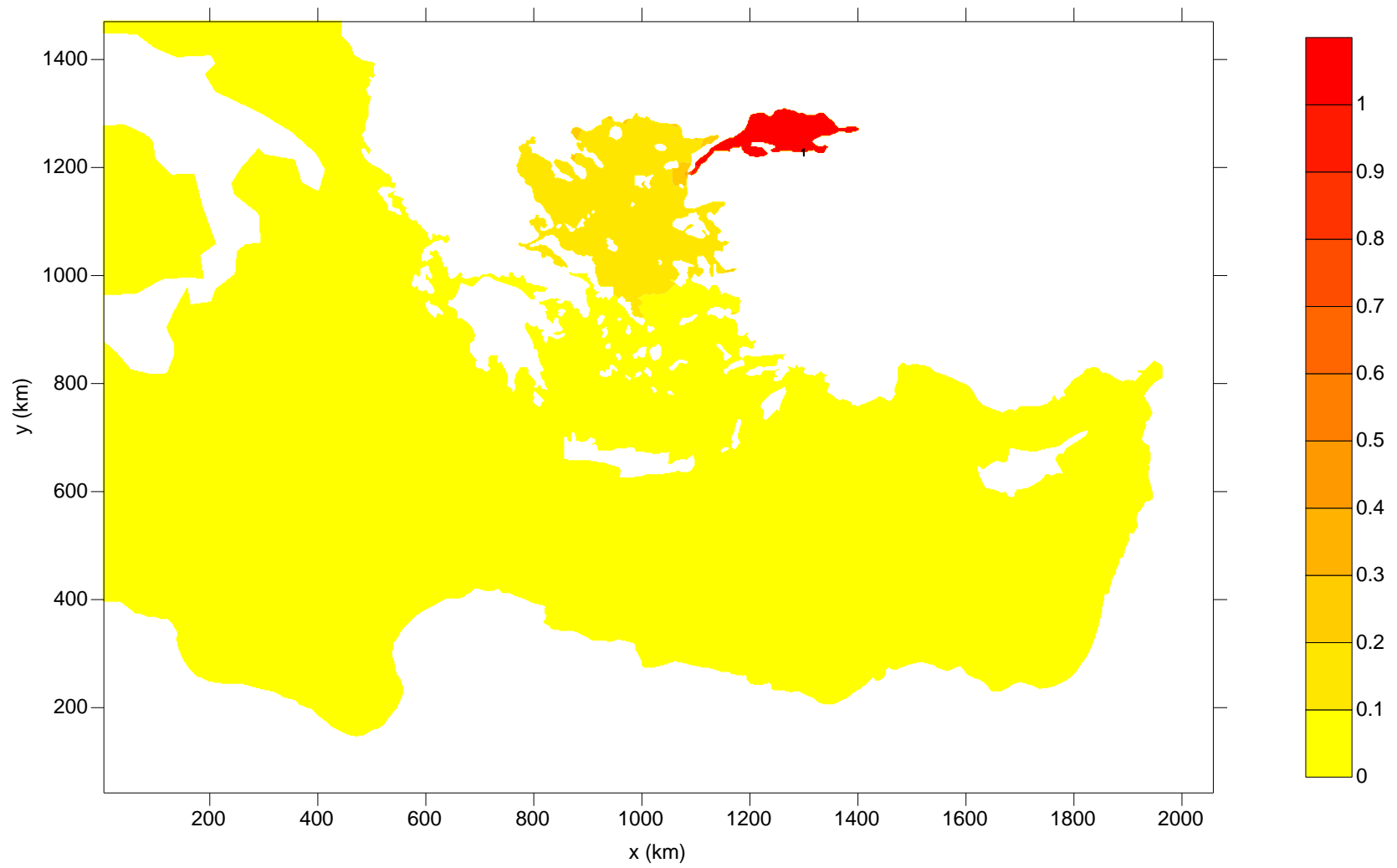
Extreme water elevation field computed for the case 15a.



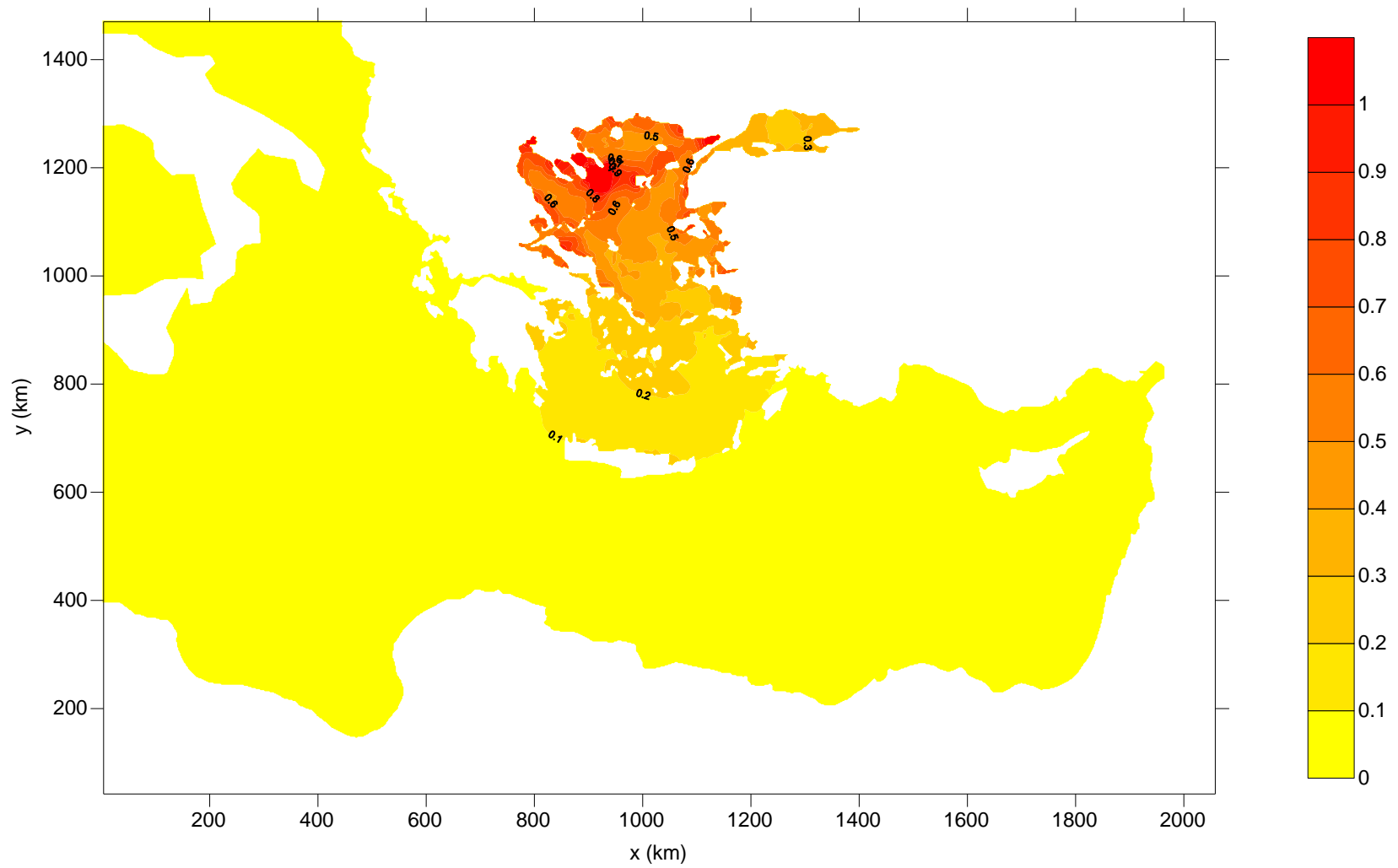
Extreme water elevation field computed for the case 15b.



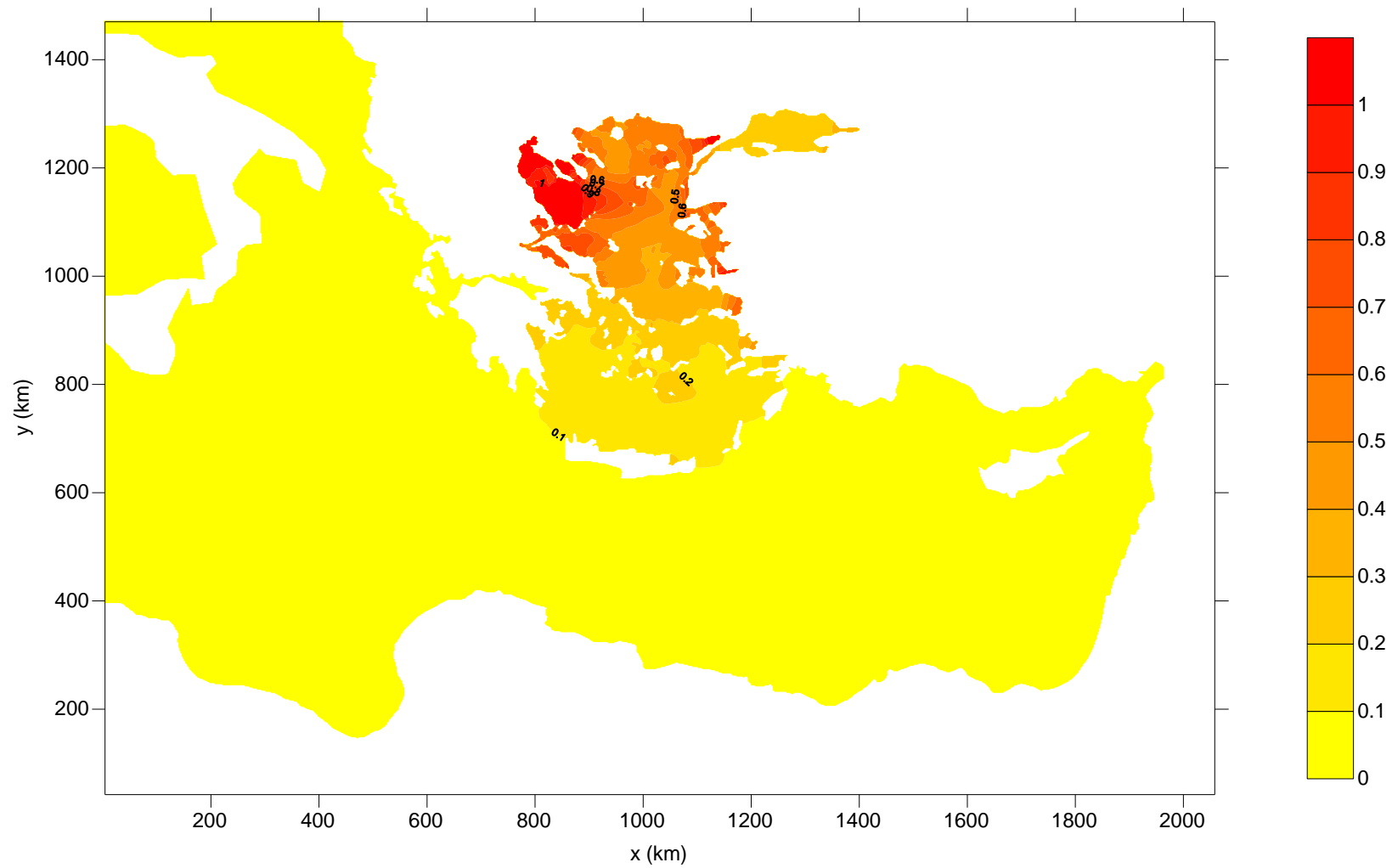
Extreme water elevation field computed for the case 16.



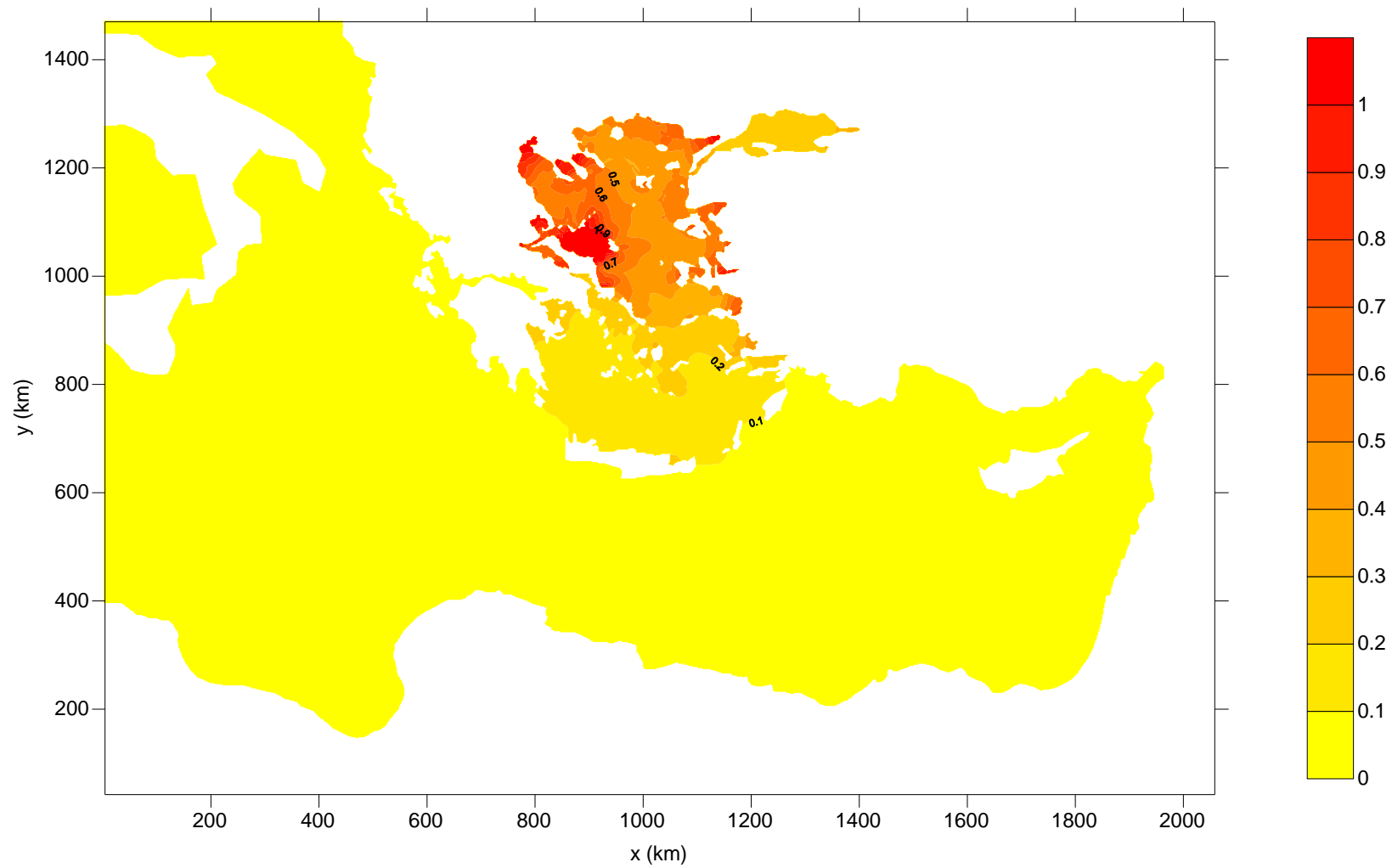
Extreme water elevation field computed for the case 17.



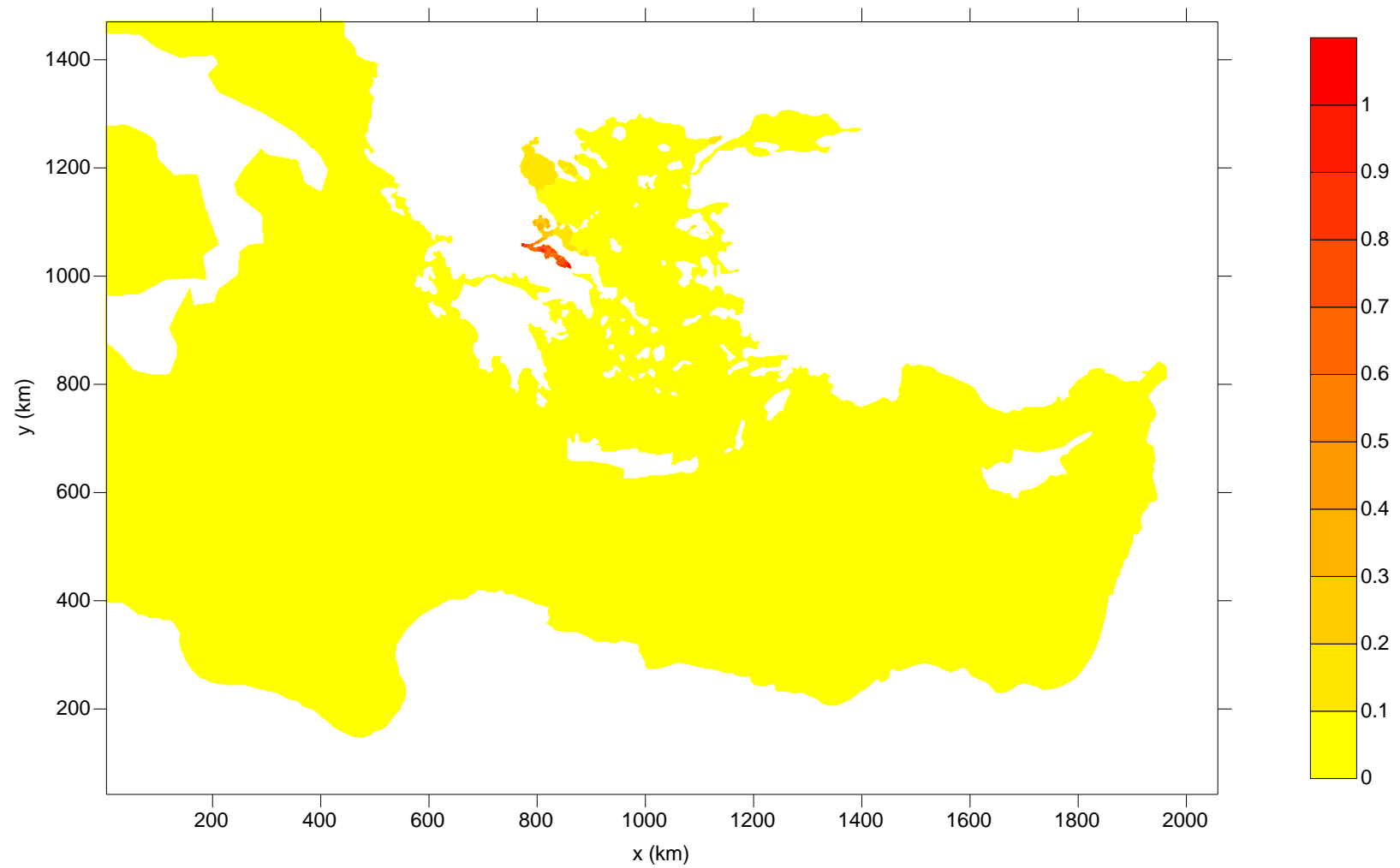
Extreme water elevation field computed for the case 18.



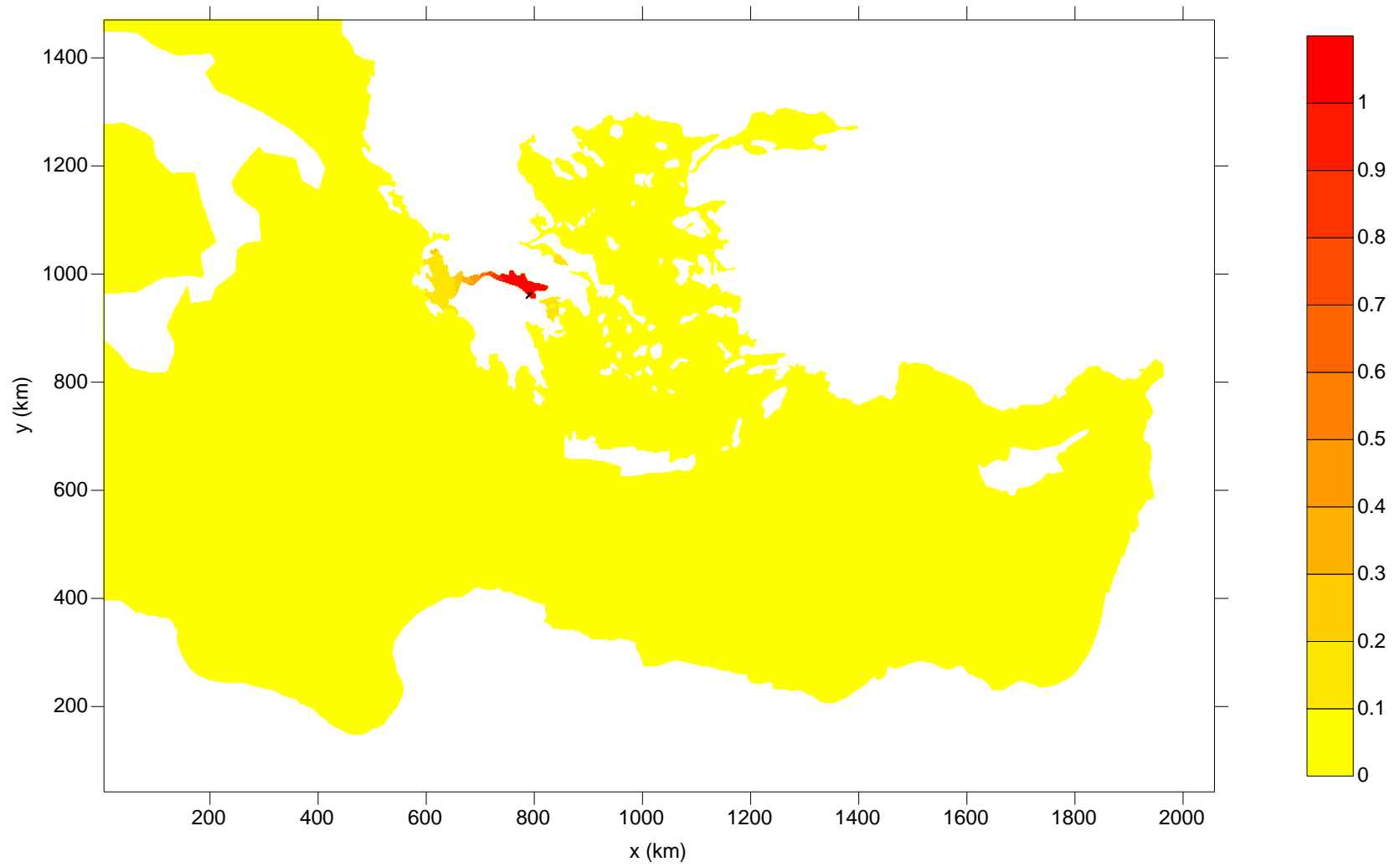
Extreme water elevation field computed for the case 19.



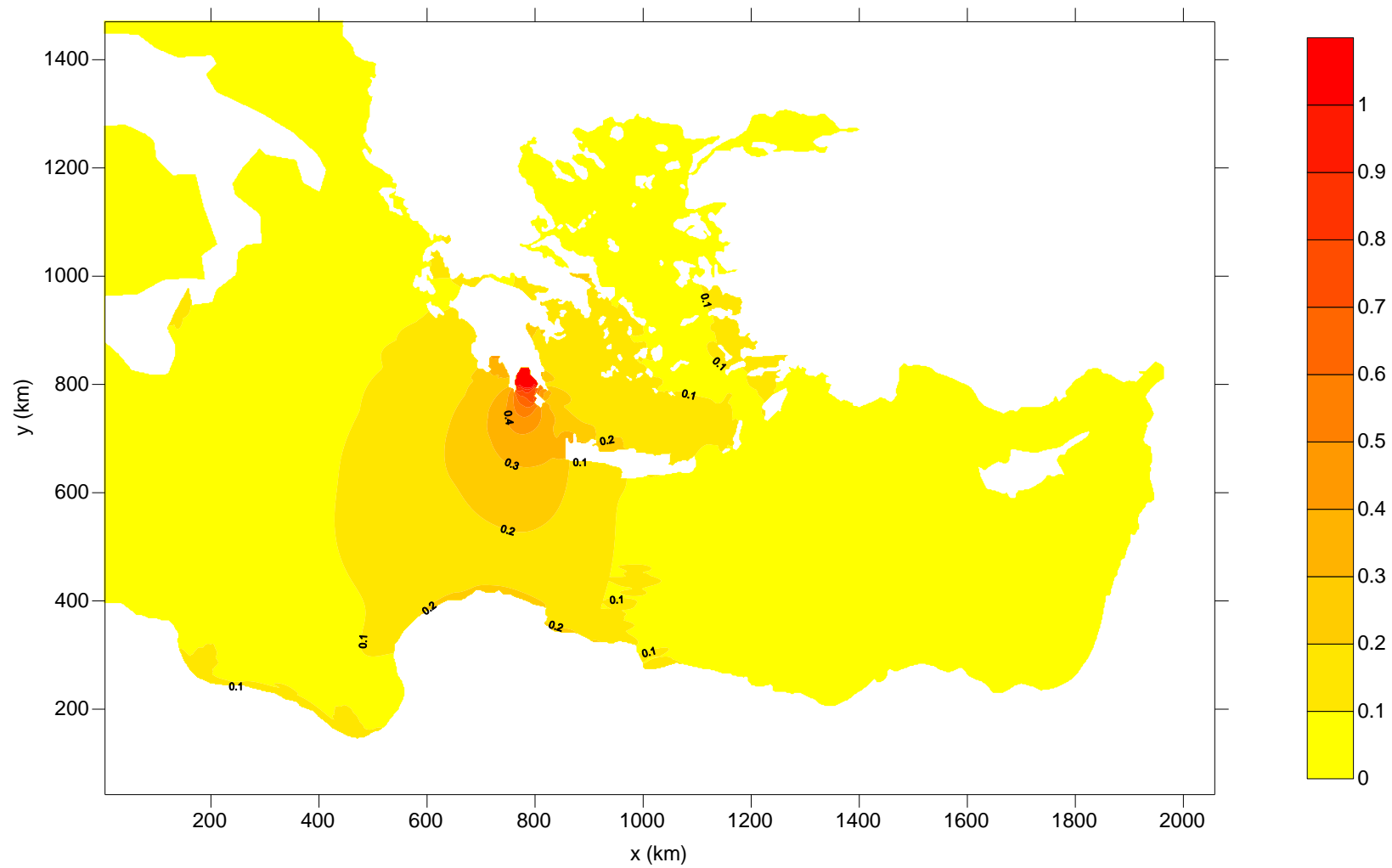
Extreme water elevation field computed for the case 20.



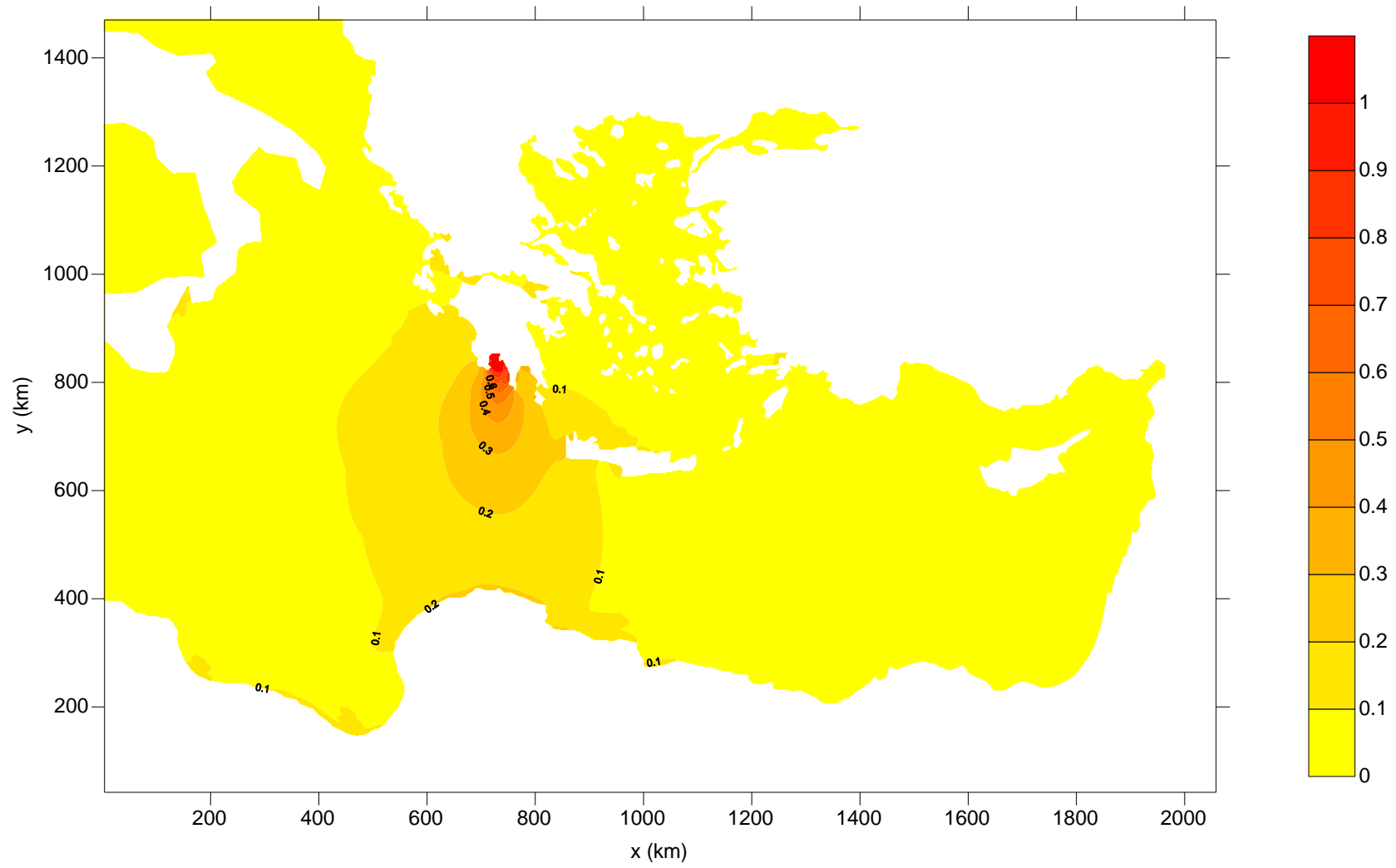
Extreme water elevation field computed for the case 21.



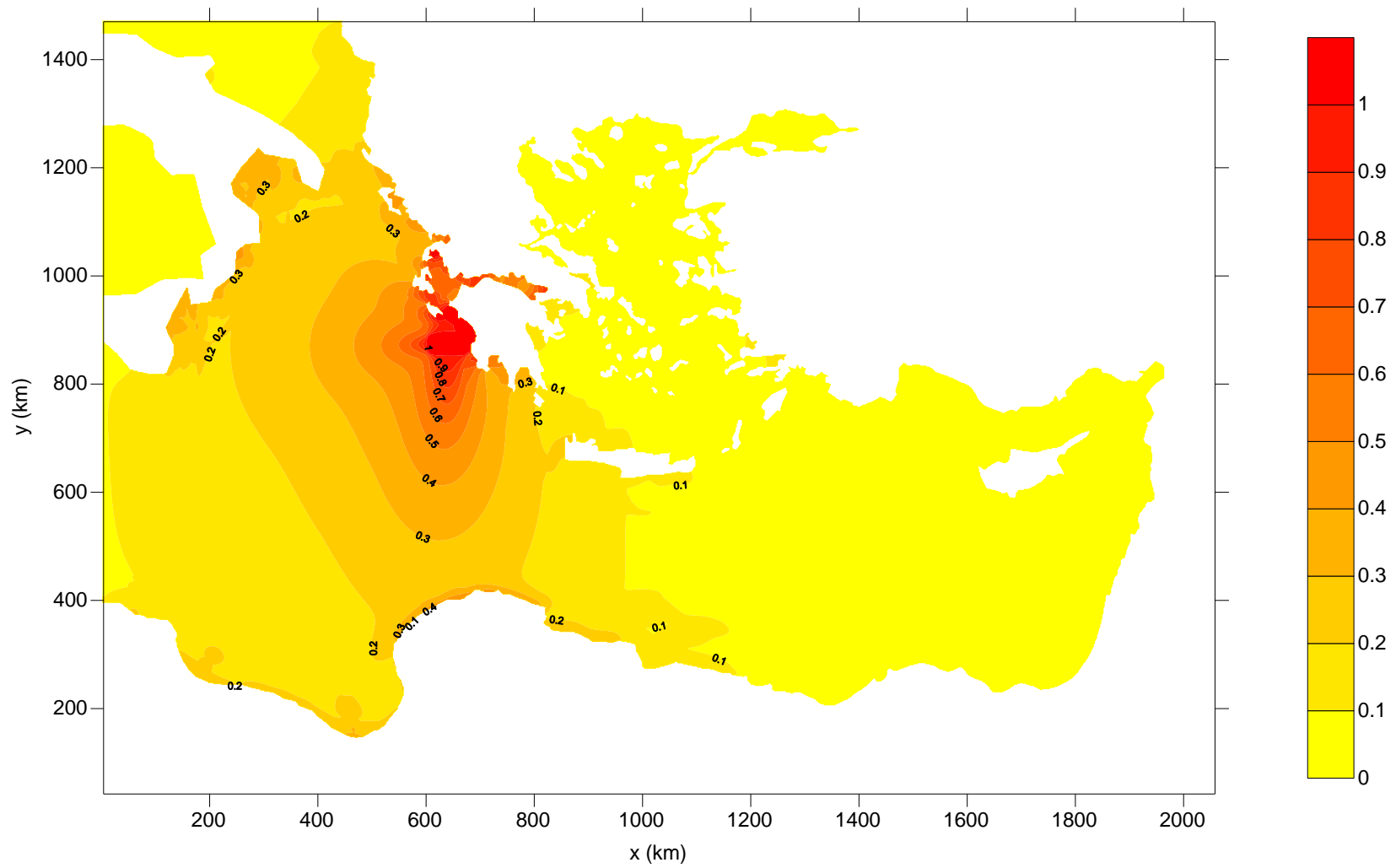
Extreme water elevation field computed for the case 22.



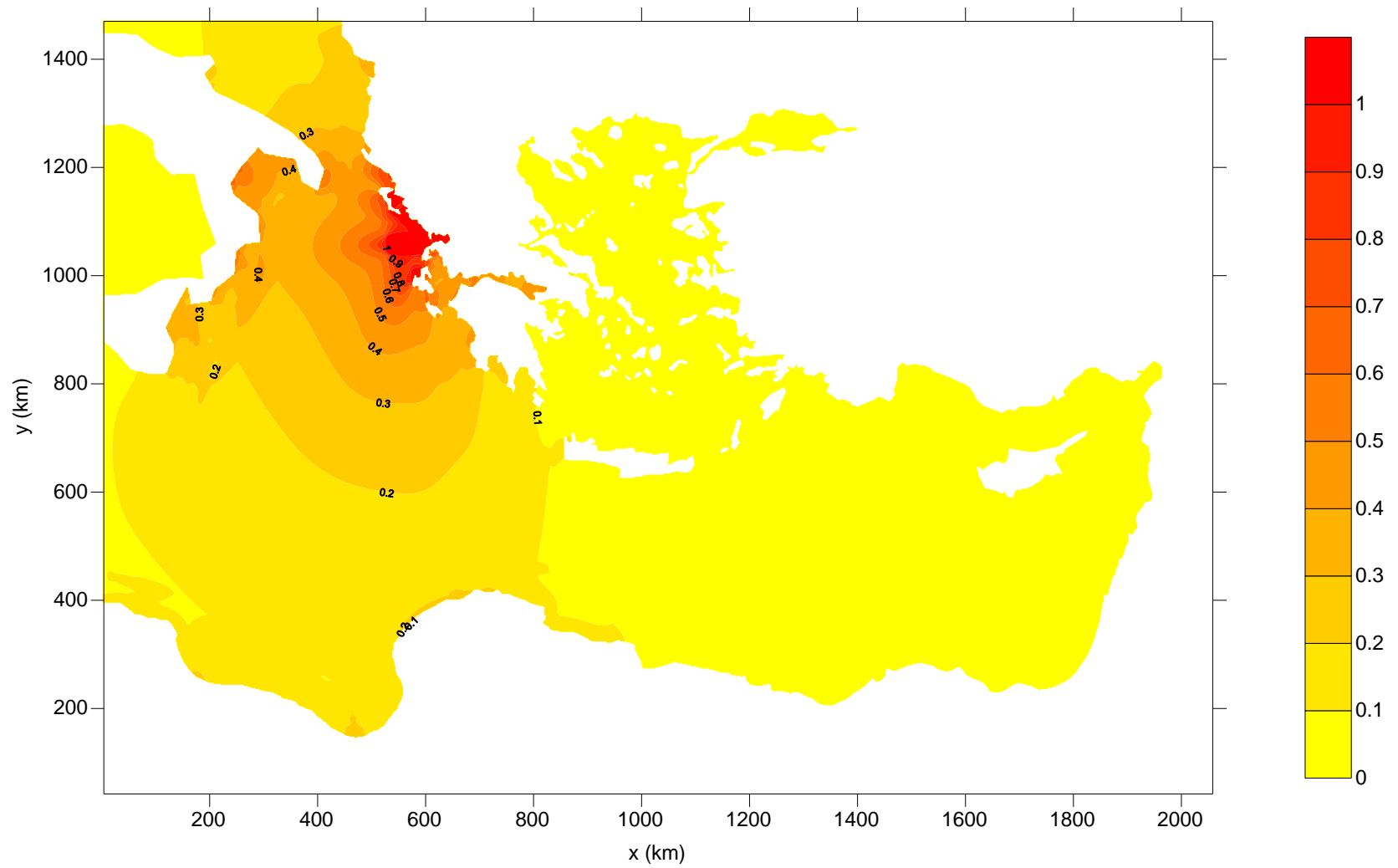
Extreme water elevation field computed for the case 23.



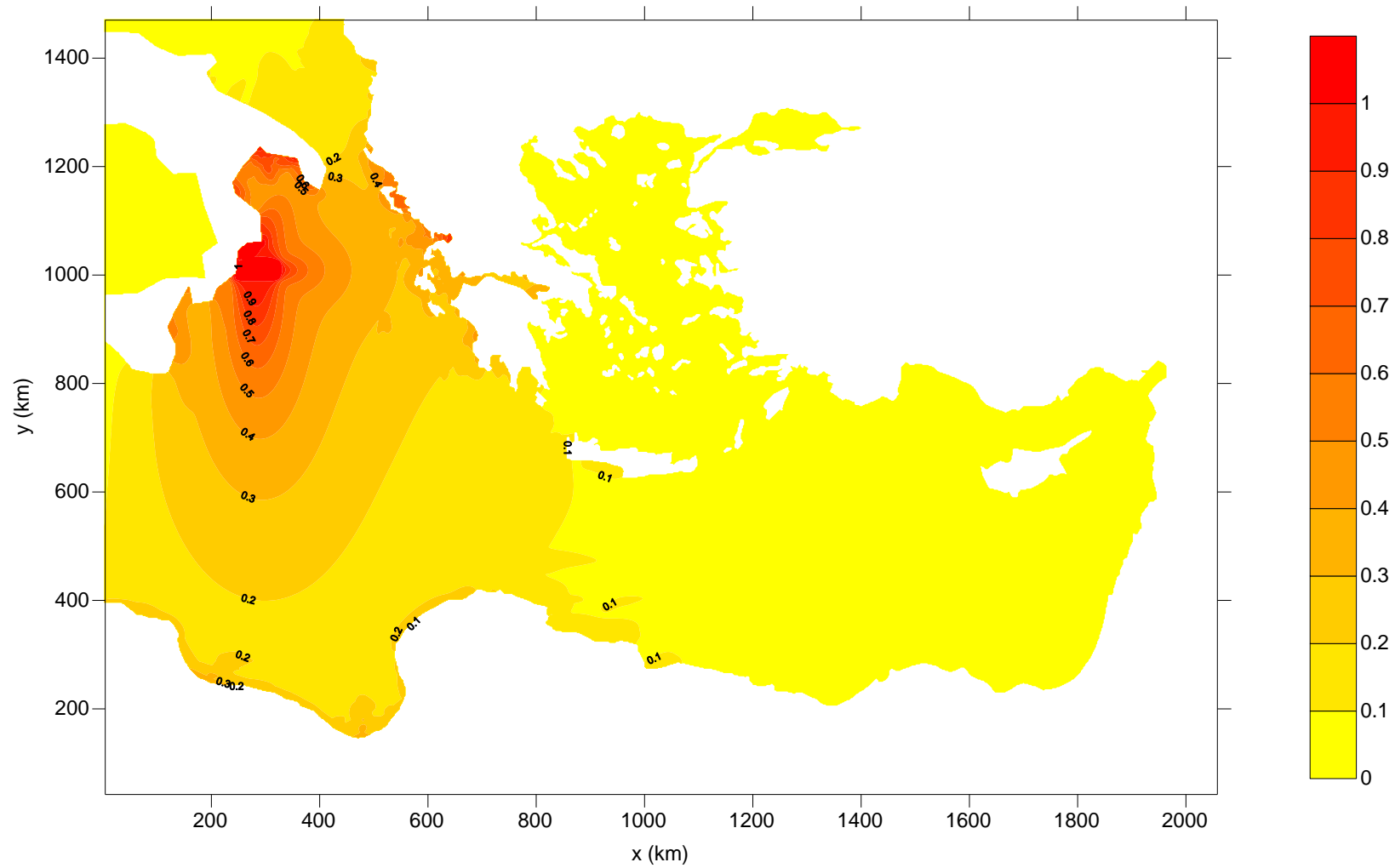
Extreme water elevation field computed for the case 24.



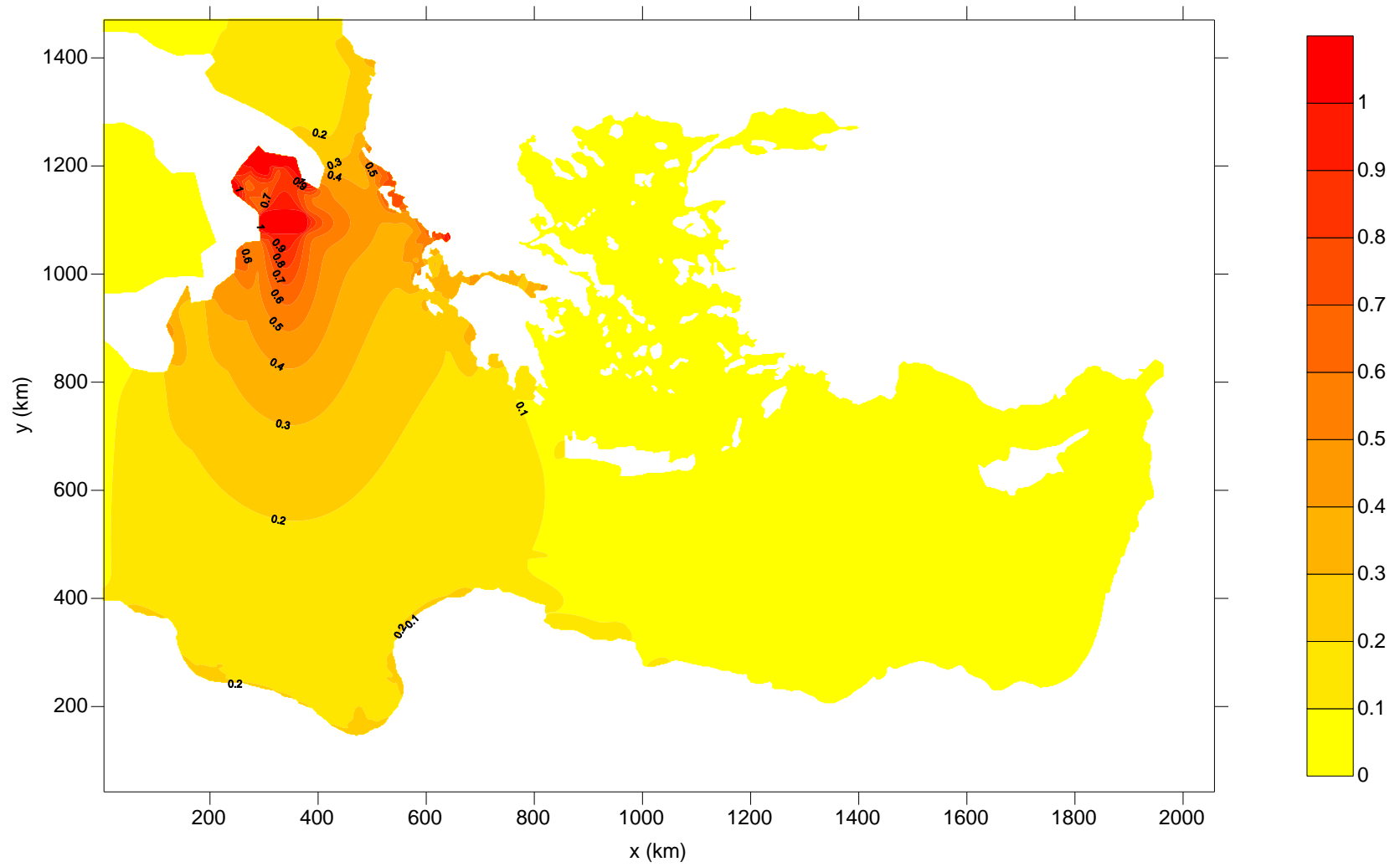
Extreme water elevation field computed for the case 25.



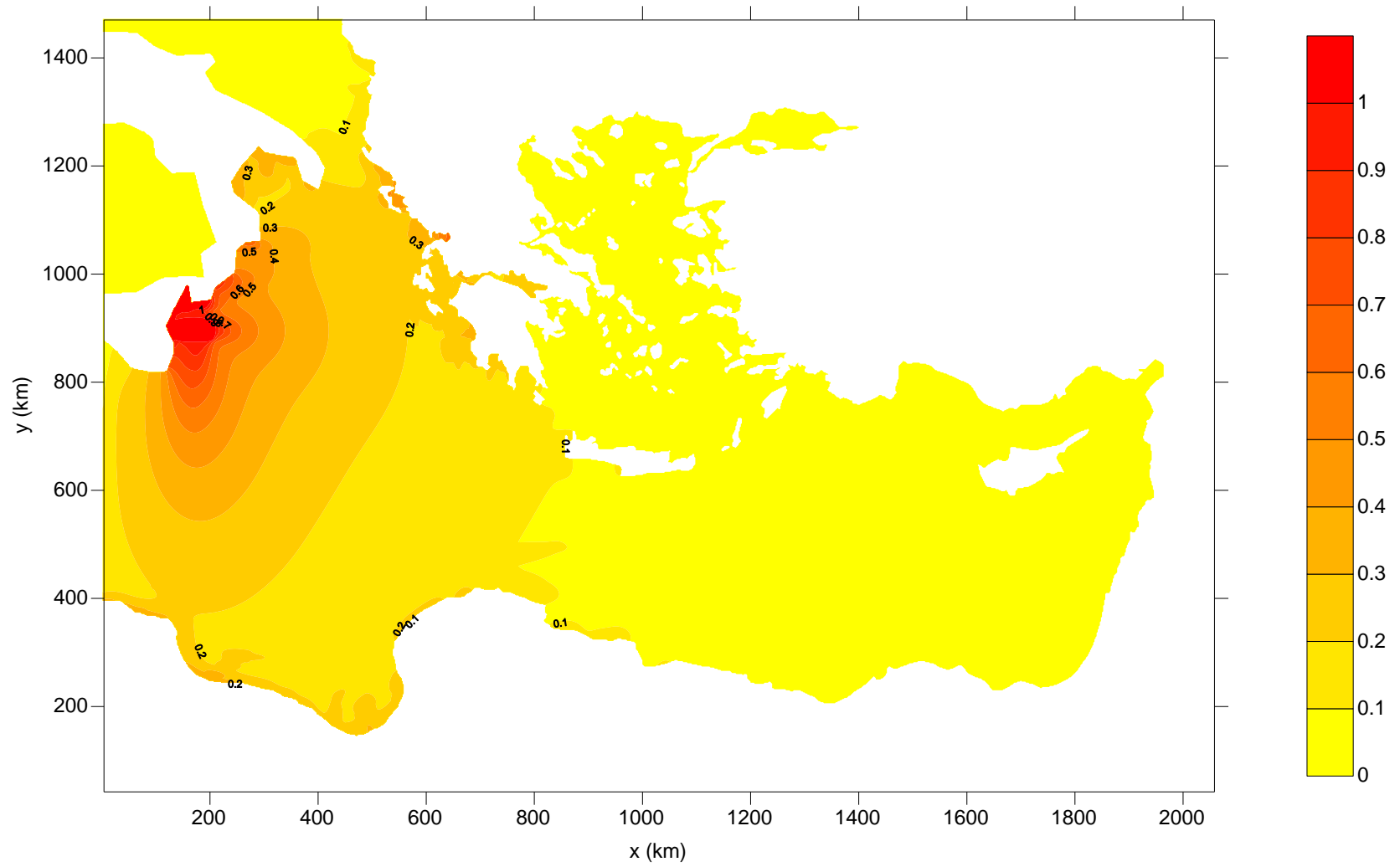
Extreme water elevation field computed for the case 26.



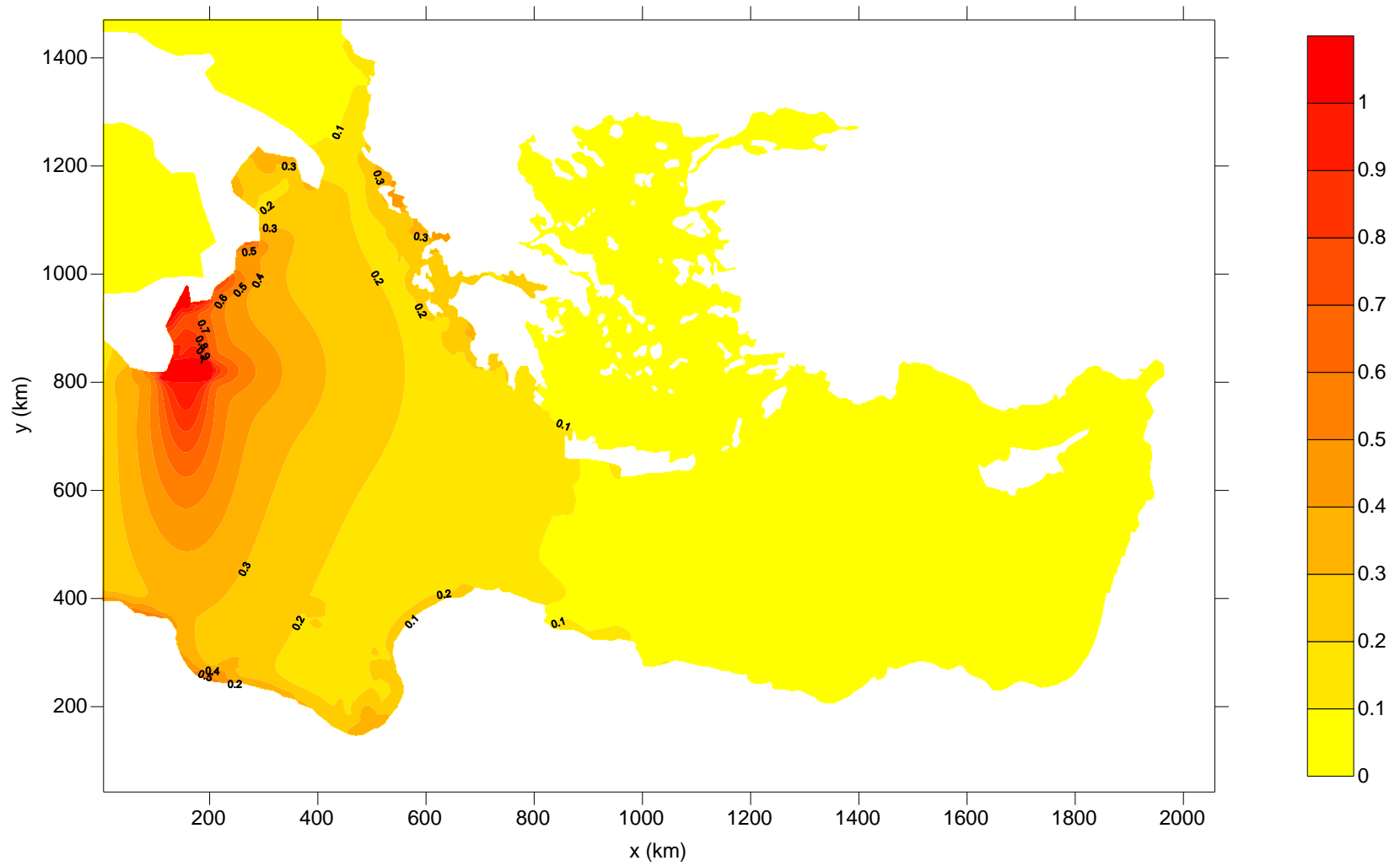
Extreme water elevation field computed for the case 27.



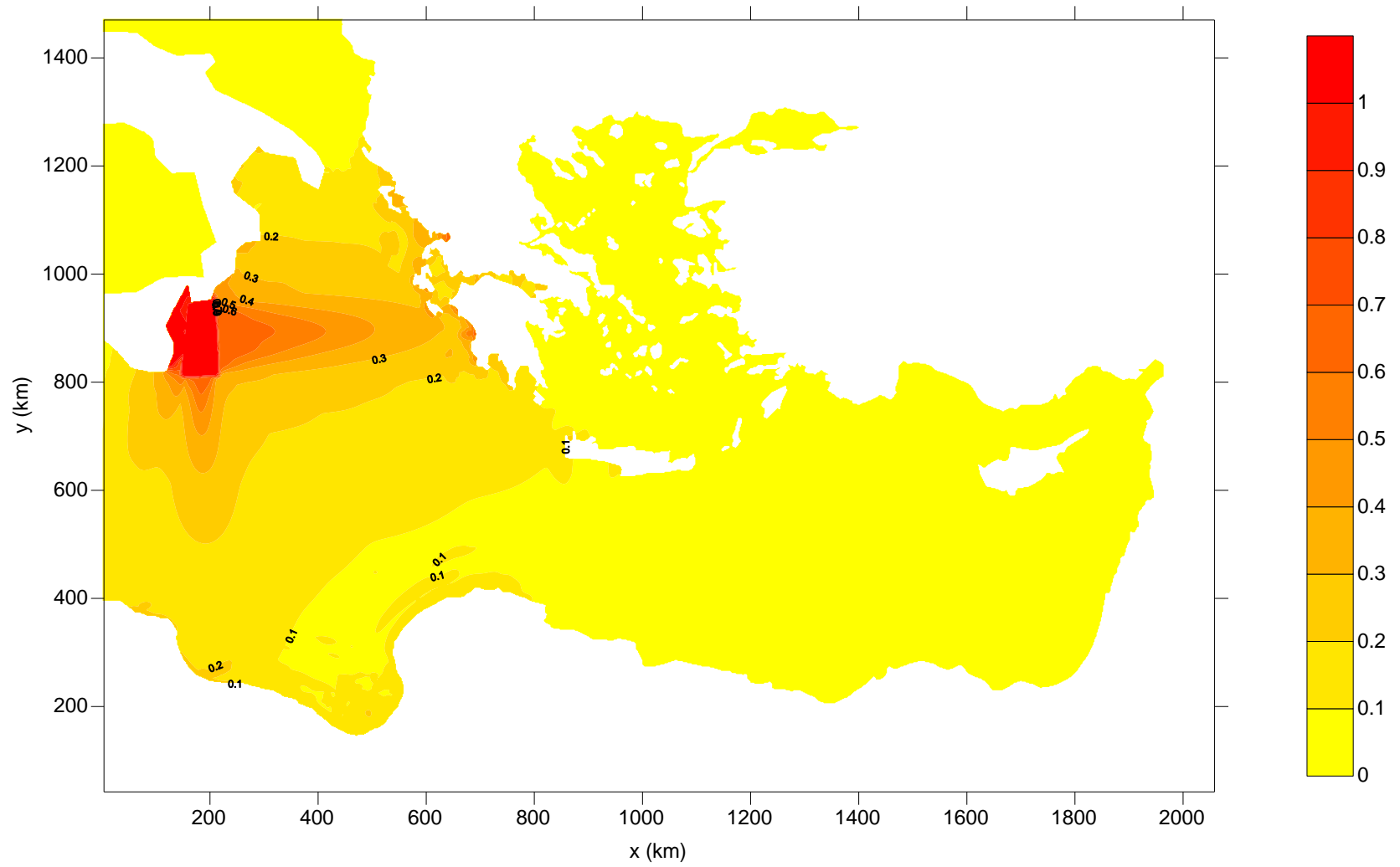
Extreme water elevation field computed for the case 28.



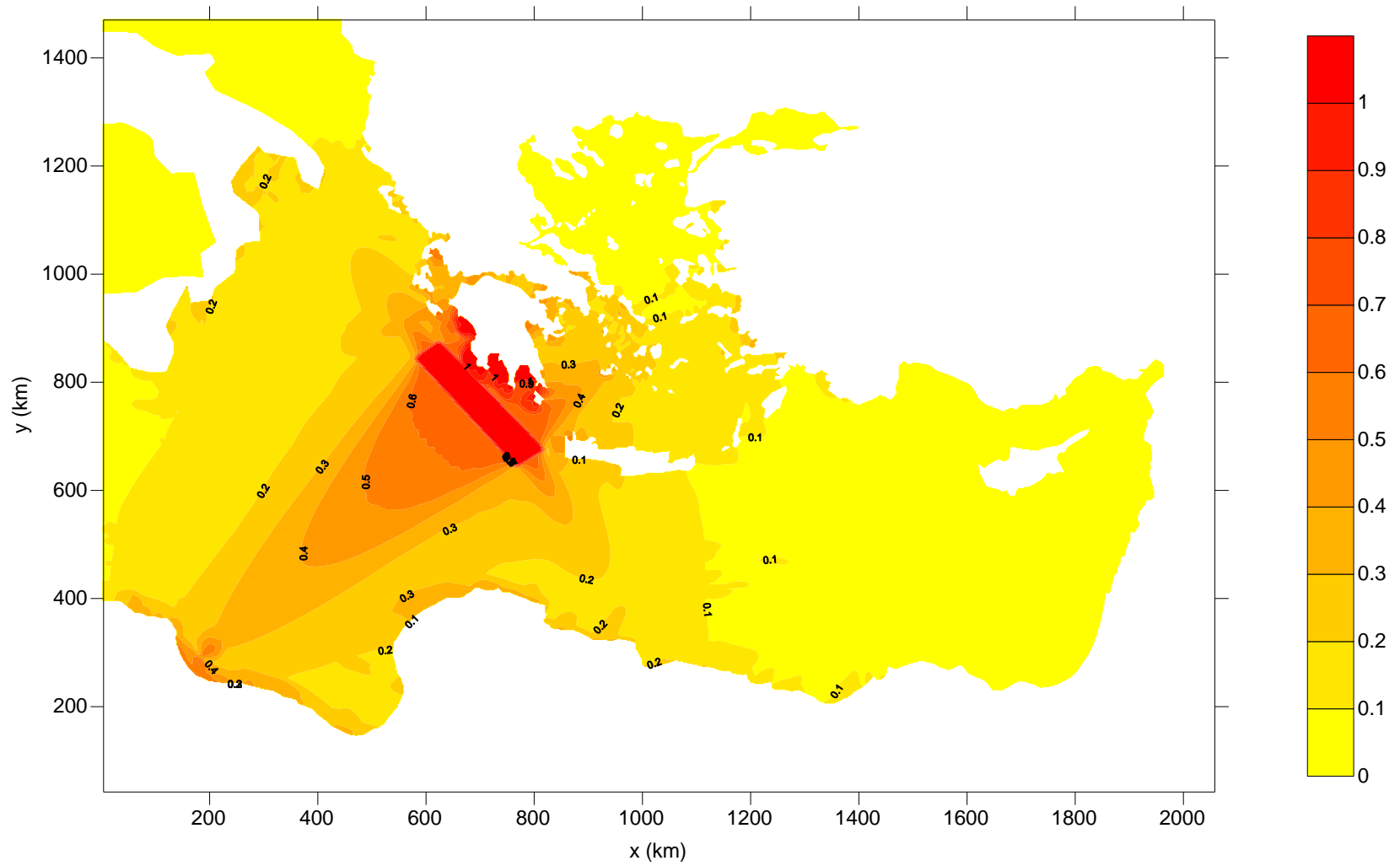
Extreme water elevation field computed for the case 29.



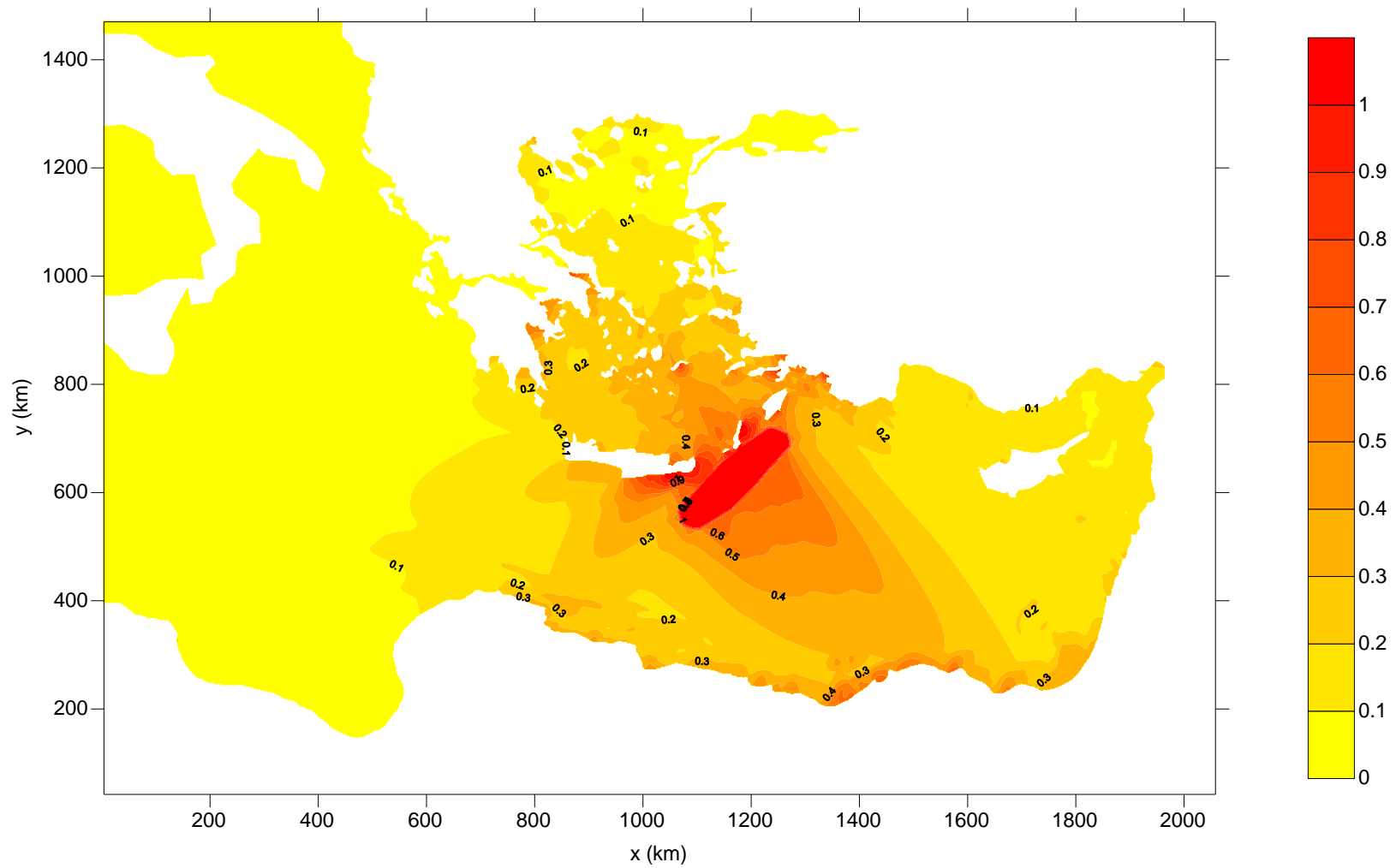
Extreme water elevation field computed for the case 30.



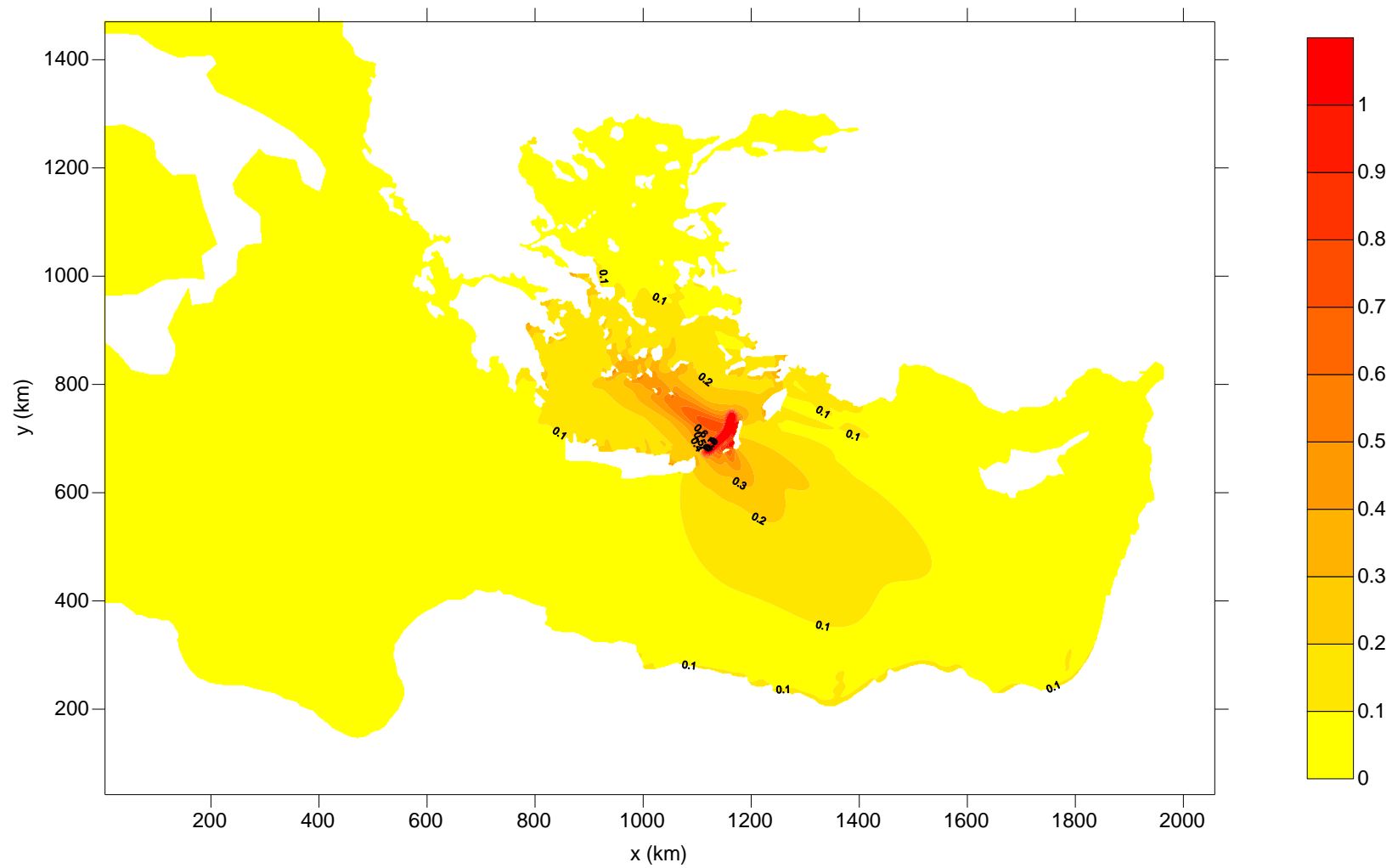
Extreme water elevation field computed for the case E1.



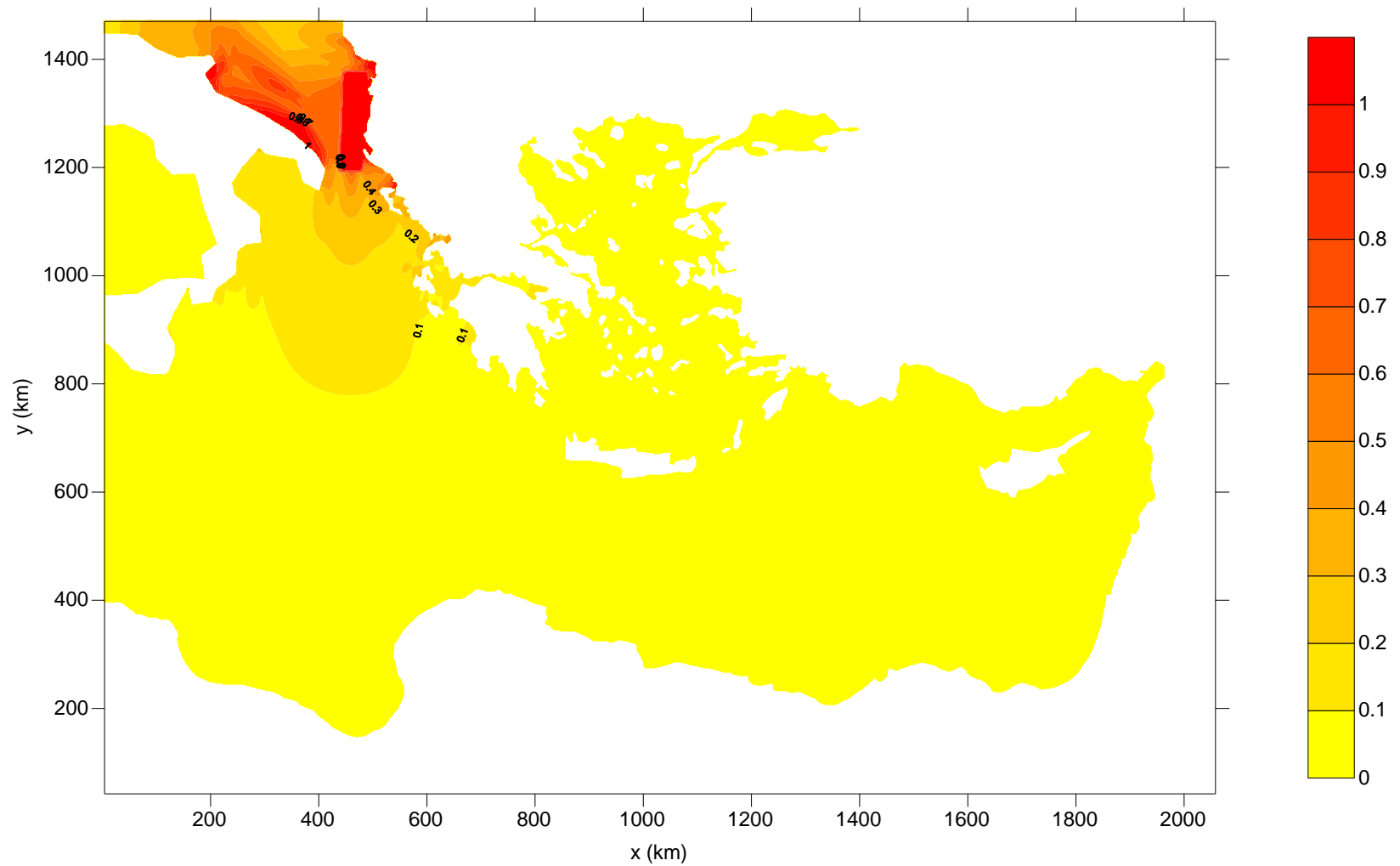
Extreme water elevation field computed for the case E2.



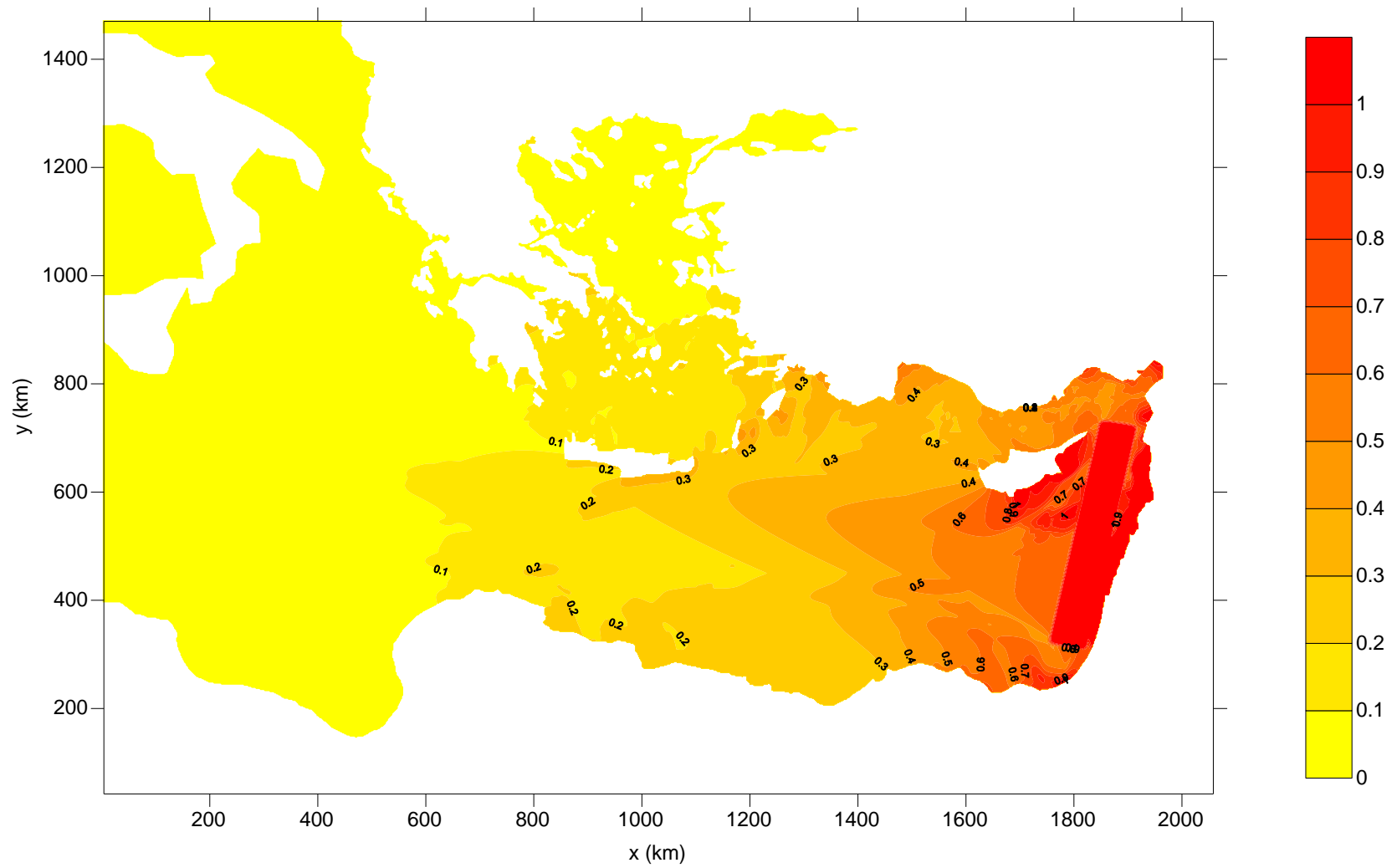
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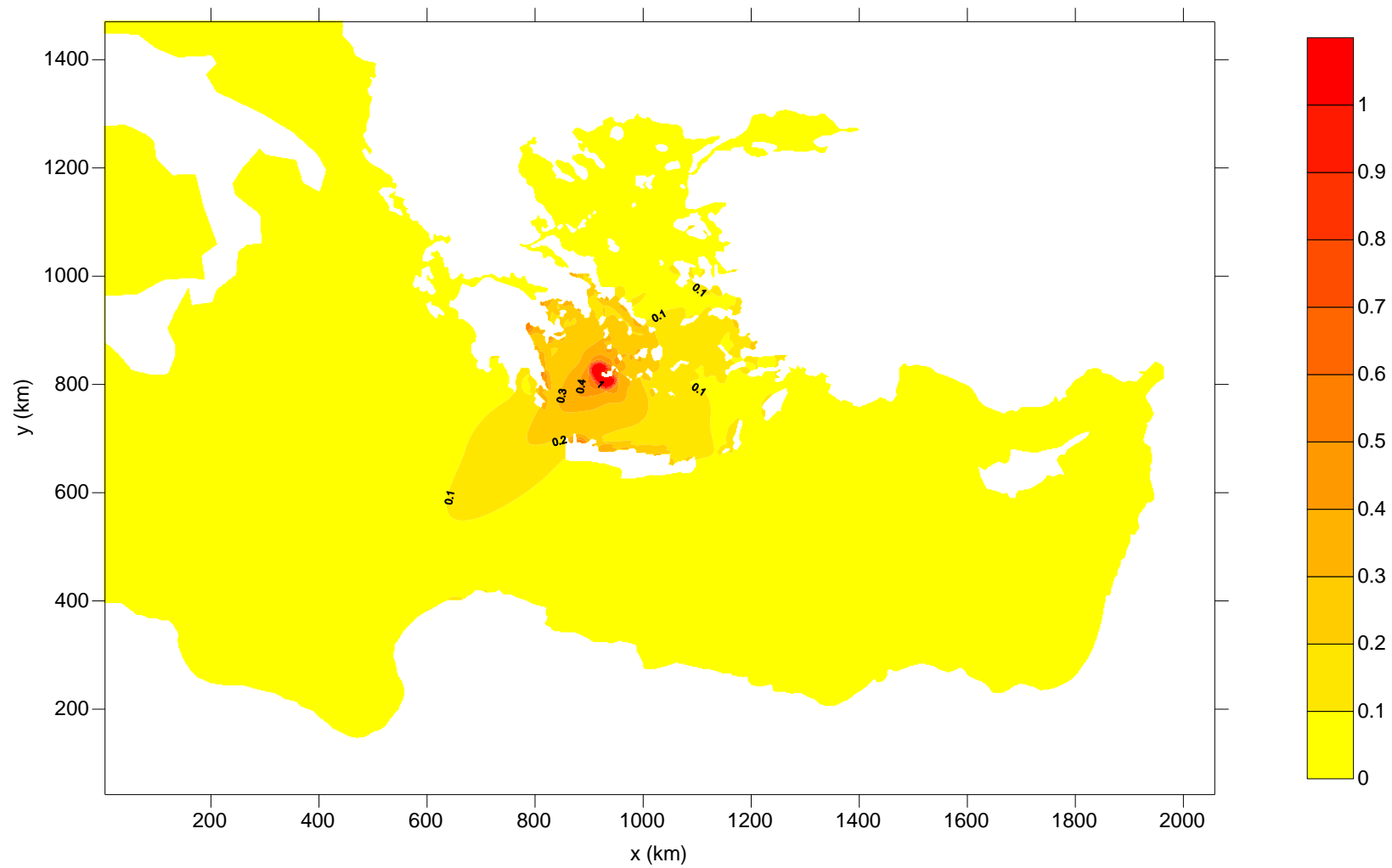
Extreme water elevation field computed for the case E3α.



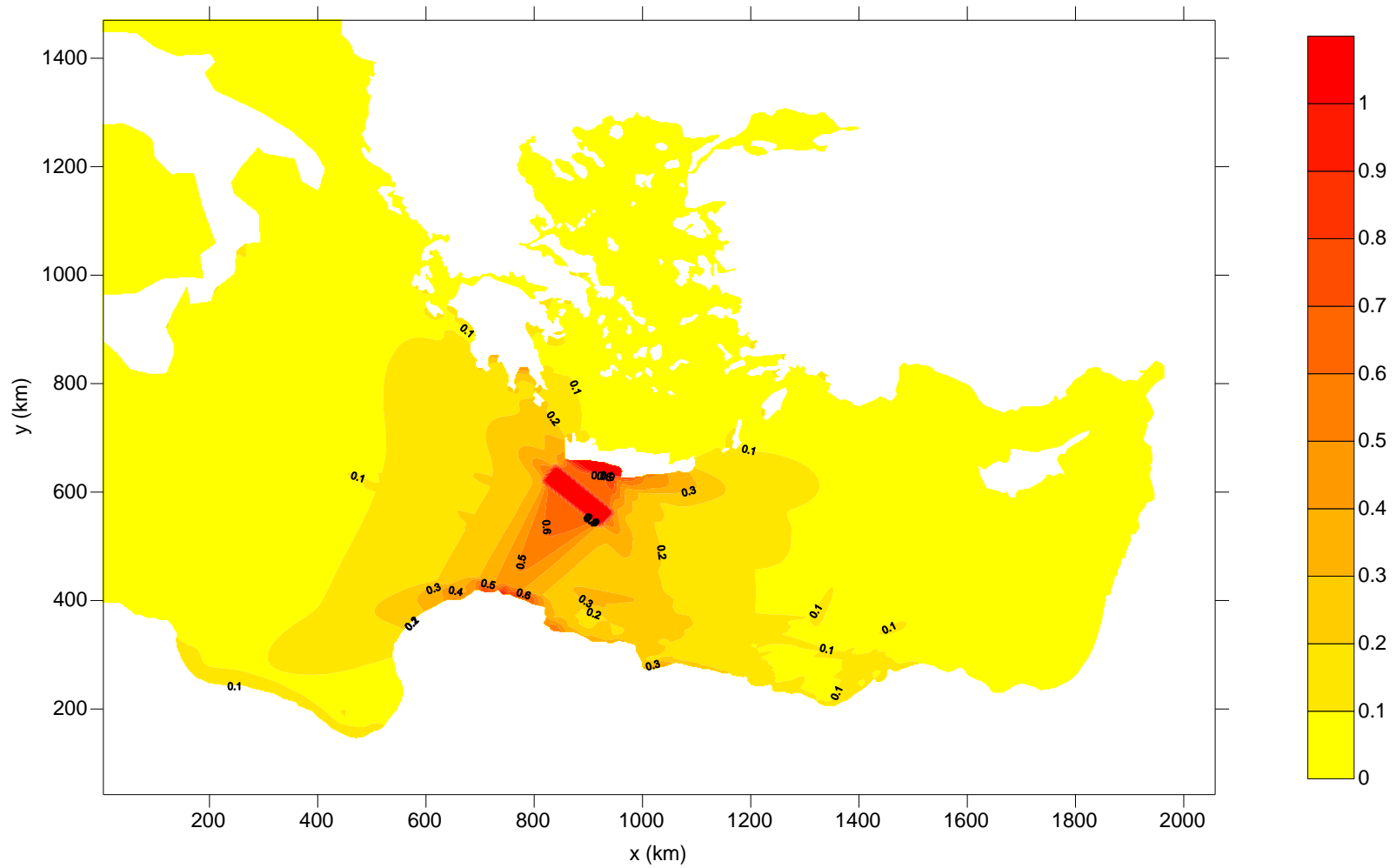
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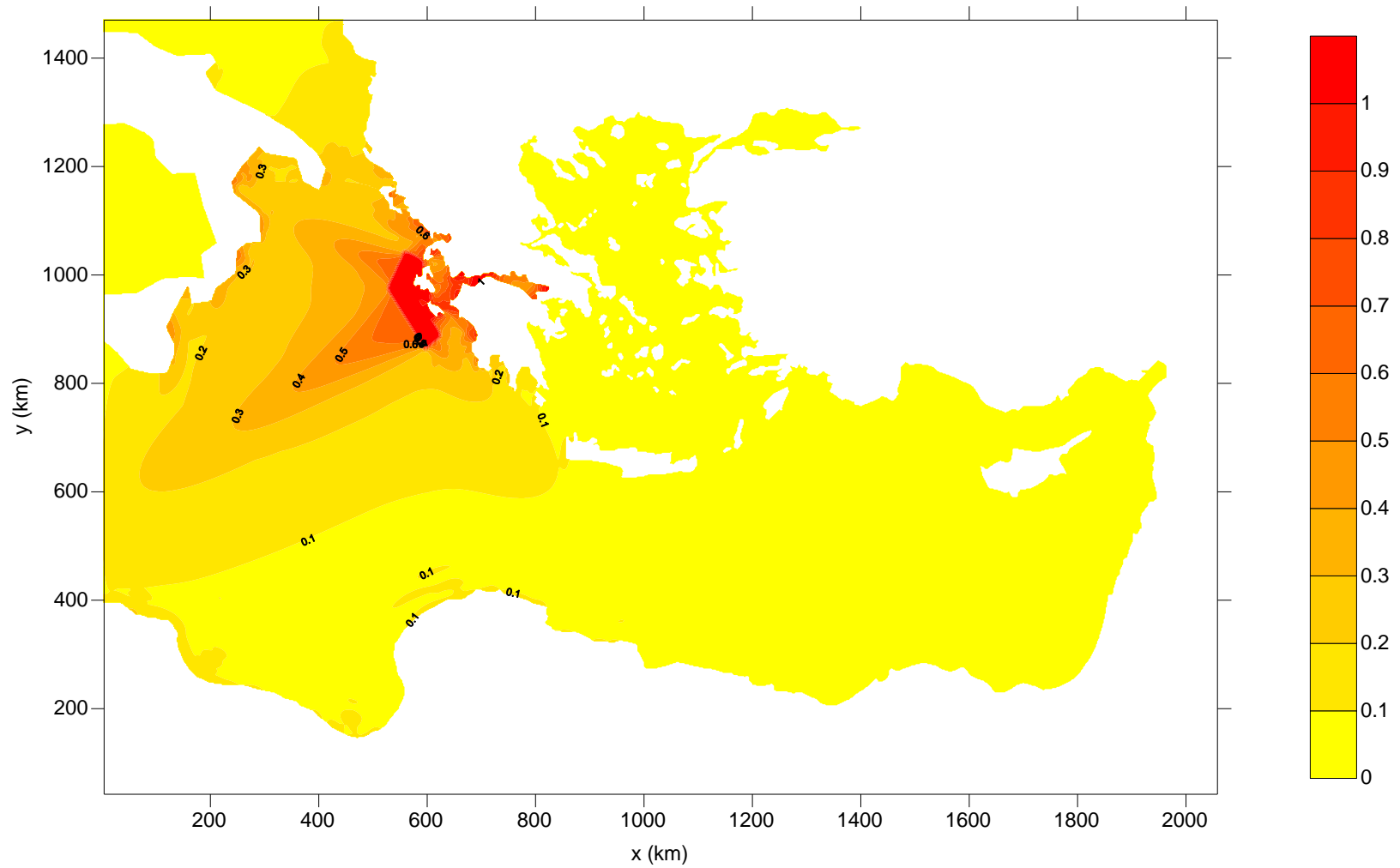
Extreme water elevation field computed for the case E5.



Extreme water elevation field computed for the case E6.



Extreme water elevation field computed for the case E7.



Extreme water elevation field computed for the case E8.

