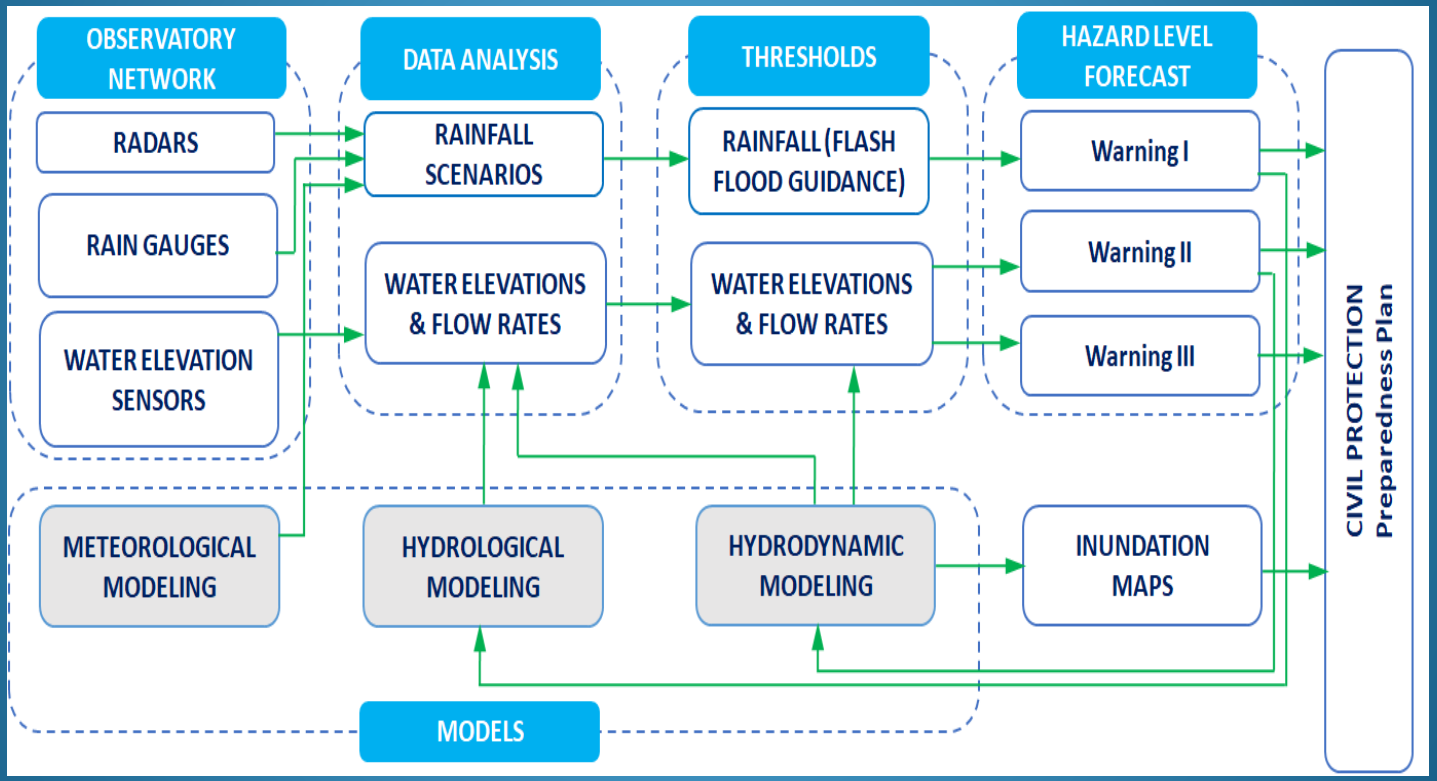
The need for an efficient early warning system for flash floods in the Prefecture of Attica. 31-10-2018



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Outline of the presentation: The 4 main questions

Question 1	Do we need an EWS in Attica? A first answer based on flood incidences and their consequences
Question 2	Do we really need an EWS in Attica, even when there are structural works?
Question 3	Which should be the main characteristics of an EWS in Attica?
Question 4	What else is needed for a successful EWS in Attica? Information, education and training on floods!

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We answer these questions

- With reference to the case of the FF in Mandra on the 15th of November 2017.

- Using:
  - ✓ research work in the LAH, mainly hydrodynamic modeling and questionnaires (after the FF in Mandra), and
  - ✓ literature and published information in the media.

- Knowing that we can face floods using:
  - ✓ Structural (infrastructure) works; in the mountainous areas and flood plain.
  - ✓ Non-structural measures, such as operation of flood forecasting and early warning systems (EWS), preparation of hazard maps, especially for 'hot spots', and evacuation plans.

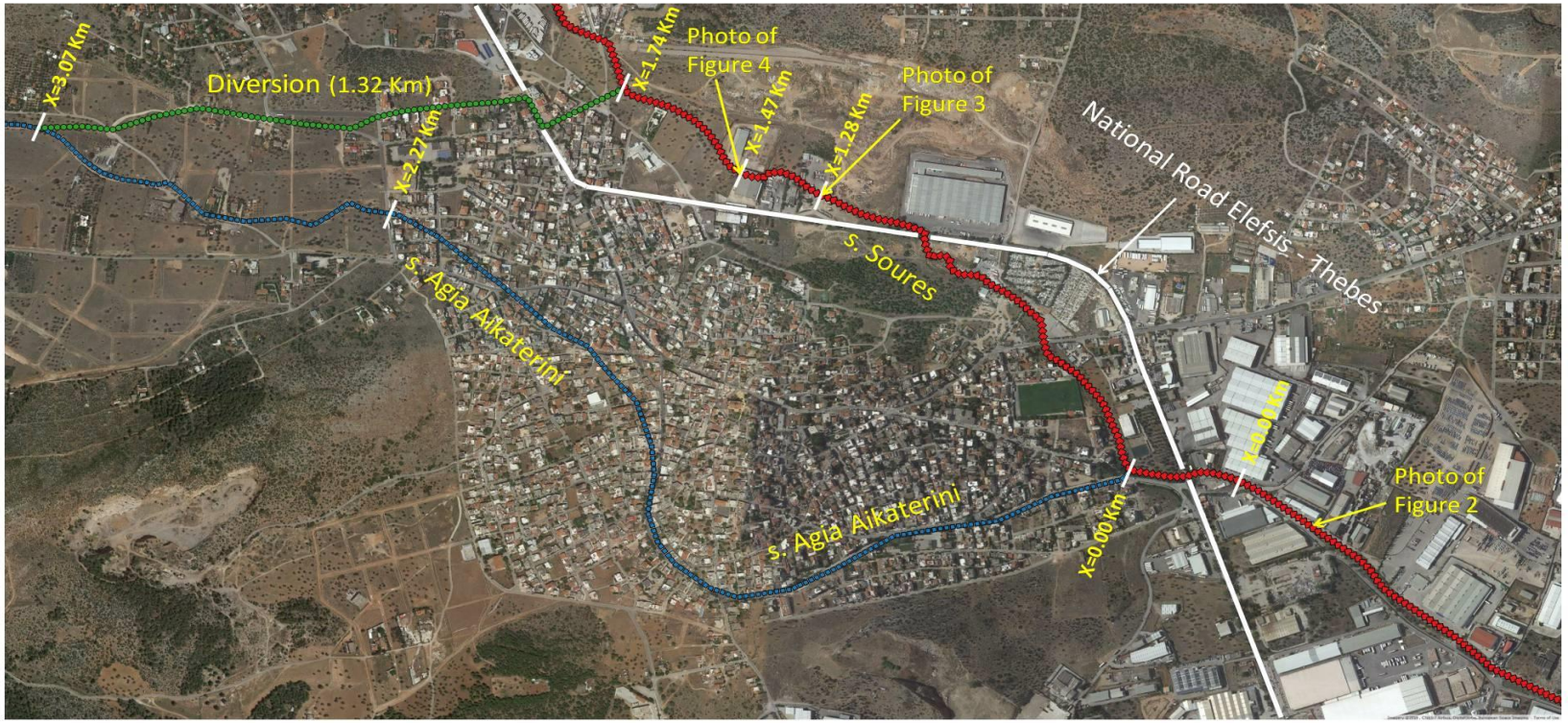
Question 1
Do we need an EWS in Attica?
Yes (based on flood incidences and their consequences)

Floods in Attica-The case of Mandra FF

- Region of Attica. Characterized by a relatively large number of floods over a long period of time. In the Greek mythology, according to which the Ogygian flood in the 10th millennium BCE is said to have covered the whole world and was so devastating that Attica remained without kings until the reign of Cecrops.
- In the period 1880–2010: 545 events, 686 human casualties and extensive damage in the country;
- Seasonality patterns. More events clustering in November.
- Highest numbers of events and casualties occurred in Attica!
- Recent example: The FF in Mandra on the 15th of November 2017
  - The third most disastrous 'November' flood in Attica following the floods of Western suburbs of Athens in 1961 (43 deaths) and 1977 (37 deaths), which occurred 11 years after the 'warning flood' (2 deaths) in the same area in January 1996.
  - The Emergency Plan of Action Operations Update issued by the International Federation of Red Cross and Red Crescent Societies (IFRC) 'The majority of the population was affected by the floods. The most immediate impact is the loss of life. A total of 23 deaths have been reported, and 24 injured. Secondly, basements and ground floors of buildings in the city were also seriously impacted; officials estimated 80 per cent of the city area had been affected, except for some located on the hills'.

Question 2
Do we really need an EWS in Attica, even when there exist structural works?

2.1 Final design of the structural works in Mandra (T=50 years)



1. Regulation of s. Soures; L=1.74 km, Q=91-125 m^3/s, A=24.0-34.4 m^2.
2. Partial diversion of s. Agia Aikaterini; L=1.52 km, Q=47 m^3/s, A=12.5-24.0 m^2 to s. Soures.
3. Downstream of its diversion location, the s. Agia Aikaterini continues to flow through the town of Mandra via an existing, enclosed rectangular conduit (L=2.27 km, Q=10 m^3/s and A=3.4 m^2.

Q2: Do we really need an EWS in Attica, even when there exist structural works?

2.2 The 3 problems of the FF in Mandra (1)

Problems during the flood

1. Problem 1. Practically, **no structural works existed** (in the mountains and flood plain). Moreover, '… private constructions were erected over the two major filled-in streams while the necessary **water drainage pipes were either too small** or they were not built at all'; in some cases A about 2.0 m^2.

Q2: Do we really need an EWS in Attica, even when there exist structural works?

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2.3 The 3 problems of the FF in Mandra (2)

Problem 2. **Extreme rainfall.**

Press Bulletin of the National Observatory of Athens (NOA) on the 20th of November (Weather radar XPol of the Institute for Environmental Research and Sustainable Development) measured on the 15th of November a zone of very intensive rainfall over the greater area of Mandra of a total height higher than 200 mm in 6 hours!
This value is well above any expected FFG (Flash Flood Guidance) in any region and certainly would have triggered a warning of an operating EWS.

Problem 3. **Extremely local rainfall.** Almost impossible to measure it!

There were no rain gauges in the catchment area (practically, to verify the measurement of the radar) and no water level sensors in the two streams. Moreover, according to NOA the rainfall heights in the neighboring meteorological stations of Elefsis, Vilia and Agioi Theodoroi were measured equal to 35 mm, 35 mm and 22 mm, respectively; in other words, the FF in Mandra was a very local event, like the majority of FFs worldwide.

2.4 If there were structural works in Mandra?

First question: Would the presence of the structural works have reduced the effects of flood?

Based on preliminary estimations by hydrologists:

1. The peak values of the hydrographs at the upstream ends of the two streams > 200 m^3/s; they correspond to T=150-200 years or even higher.

2. These are much higher than the hydraulic capacity of the technical works of the final design.

In any case:
1.The presence of the structural works would have certainly reduced the inundation area (provided that there were no other constructions in the streams that reduced their cross-sectional area).
2. Flood would have occurred (we have to live with floods).

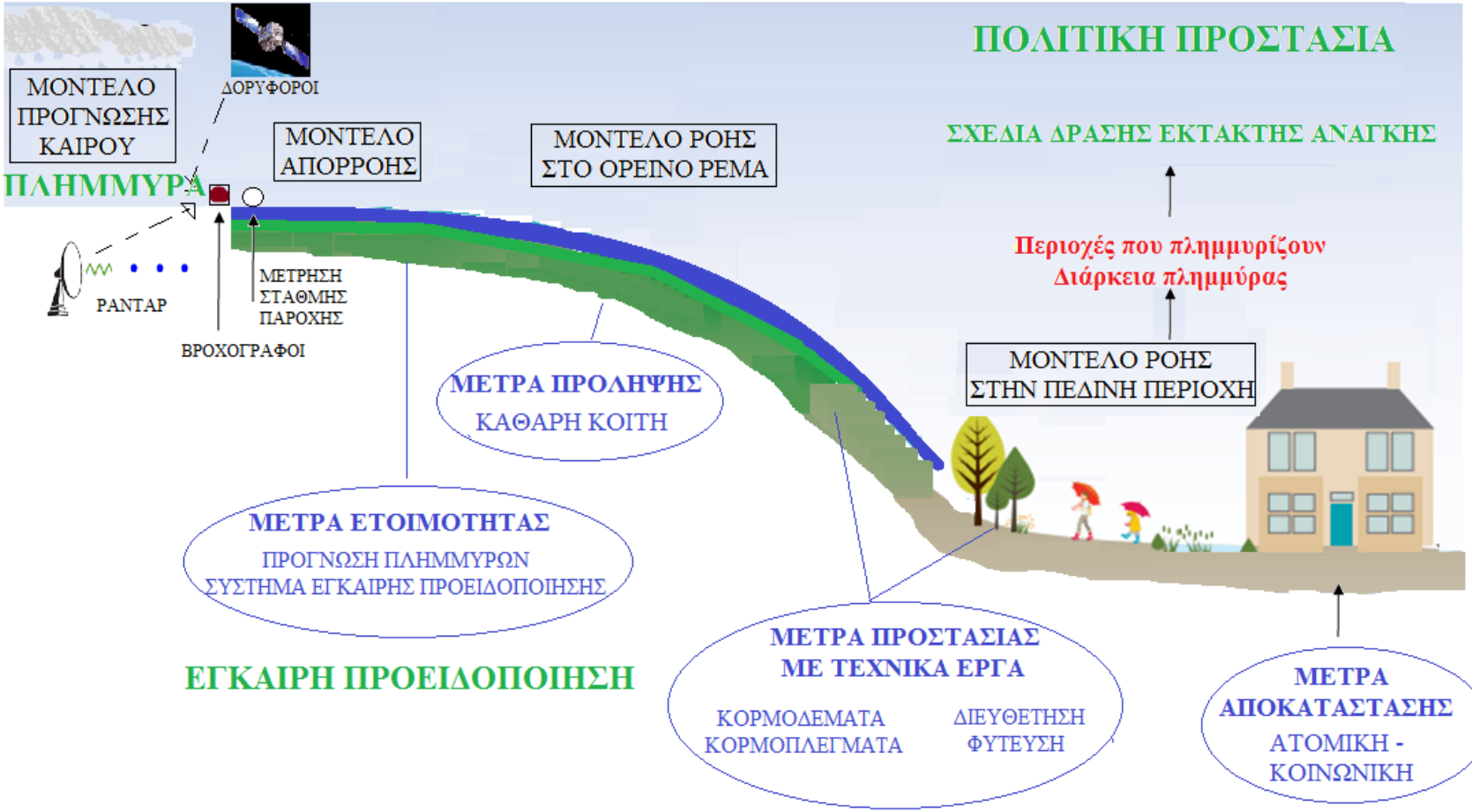
2.5 Do we really need an EWS in Attica, even when there exist structural works? Repeat question 2

Second question: Could we have avoided the disaster, if an EWS was in operation linked with a preparedness plan?

- ✓ The available times in Mandra are very small (<20 minutes).
- ✓ According to the Federal Emergency Management Agency (FEMA) "Seconds May Matter in Flash Flood Warning". Therefore, the answer to this question is certainly positive, even the EWS is not a perfect one.
- ✓ A warning by the EWS a few minutes before the arrival of the flood wave of the s. Agia Aikaterini in the town would probably have permitted the people to perform the most important first step of the simplest preparedness plan 'Move quickly to higher ground. Save yourself, not your belongings. The most important thing is your safety'. Moreover, it would have allowed the closing of the National Road Elefsis-Thebes at its entrance in the south-eastern part of the town, which would have possibly reduced the largest number of victims that was observed in the upstream northern part of the National Road that replaced s. Soures during flood passage.
- ✓ Thus: Yes, we need an EWS.

Question 3
Which should be the main characteristics of an EWS in Attica?

3.1 The main environmental processes the main 3 models of the EWS and the subsequent flood protection measures



Q3: Which should be the main characteristics of an EWS in Attica?

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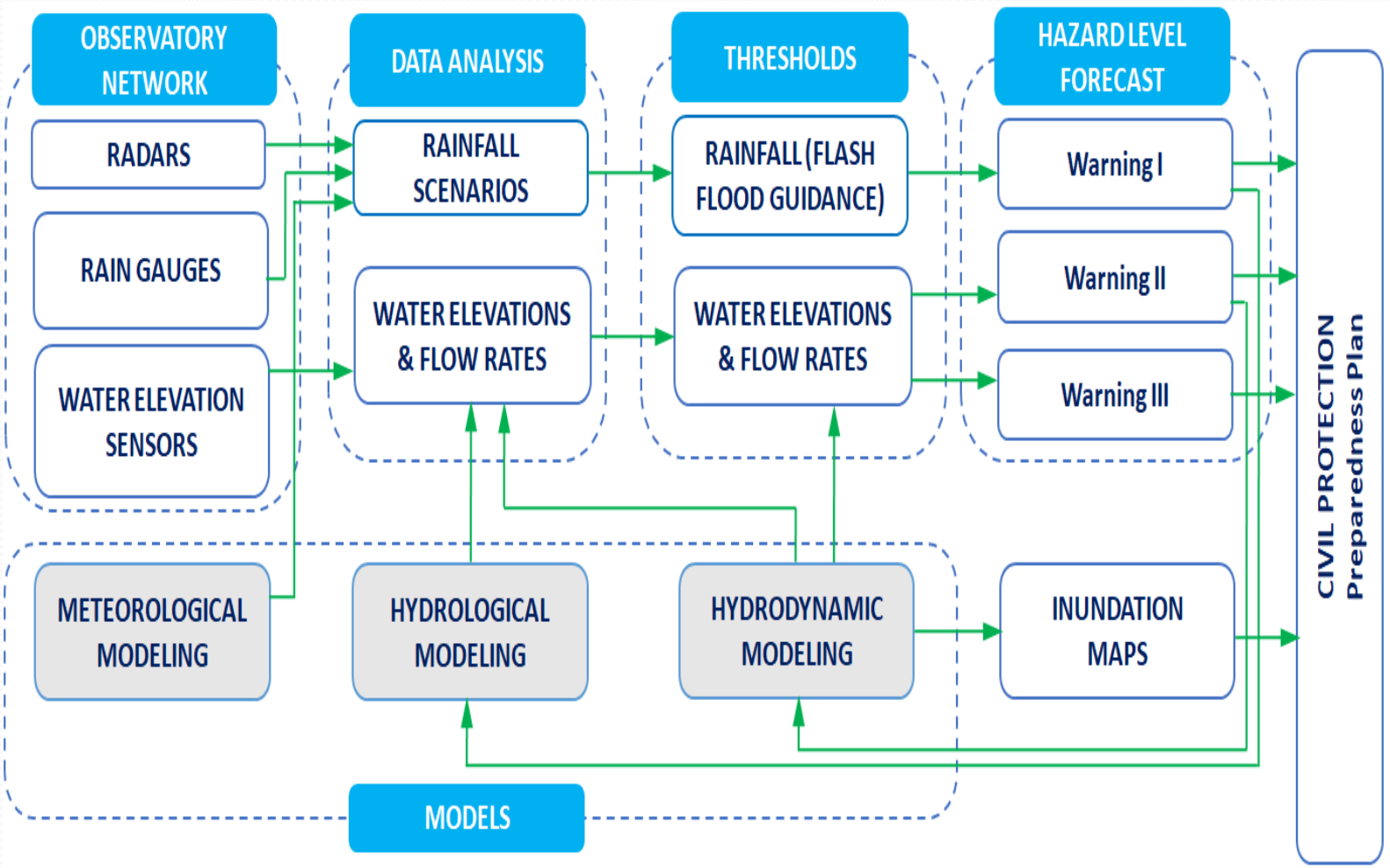
3.2 The procedure of the EWS



Q3: Which should be the main characteristics of an EWS in Attica?

3.3 The main components of the EWS

Main components of the EWS:

- ✓ the observatory network for collecting environmental data that include rainfall and stream flow information, upon which to base warnings, and
- ✓ the IT infrastructure that allows for the collection and analysis of network data, warning preparation, and communication channels for distributing warning and other information to constituents.

The EWS should be operated in small time steps of 5-10 minutes to be able to cope with fast FFs!

Q3: Which should be the main characteristics of an EWS in Attica?

3.4 The operation of the EWS and the level of warnings

Every time step.

- ✓ Rainfall data from the radars are collected and compared with predictions of meteorological models; then, a precipitation analysis - forecast is performed by nowcasting methods to produce rainfall scenarios that allow their direct comparison with rainfall thresholds, for example FFG values. In case the rainfall threshold is exceeded, the first level of 'warning' is issued and hydrological modeling calculations are performed for all rainfall scenarios to determine the corresponding runoff and flow rates.
- ✓ These flow rates are compared with discharge thresholds, for example flow-rates for T=5 years; in case these thresholds are exceeded, the second and most important level of 'warning' is issued.
- ✓ For FF of relatively long lead times (>40 minutes), hydrodynamic modeling calculations can be performed for all scenarios to determine the flow rates and the water levels at specific locations of the streams and compare them with corresponding thresholds; when thresholds are exceeded the third level of 'warning' is issued.
- ✓ The threshold values for water elevations and flow rates are calculated via hydrodynamic models.

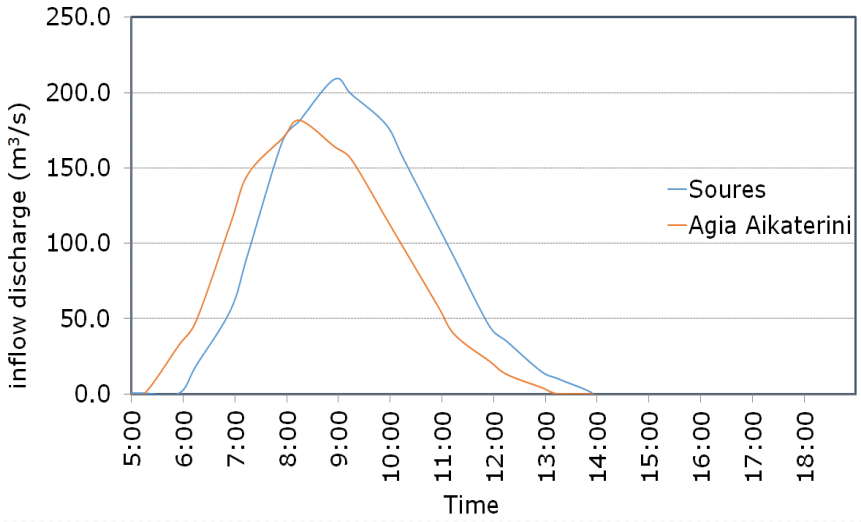
Q3: Which should be the main characteristics of an EWS in Attica?

3.5 The main 3 models of the EWS for FF

✓ Meteorological models. Specialized scientists: Meteorologists.

✓ Hydrological models.
Specialized scientists: Hydrologists.

The inlet hydrograph for Mandra (Tsakiris, 2017)



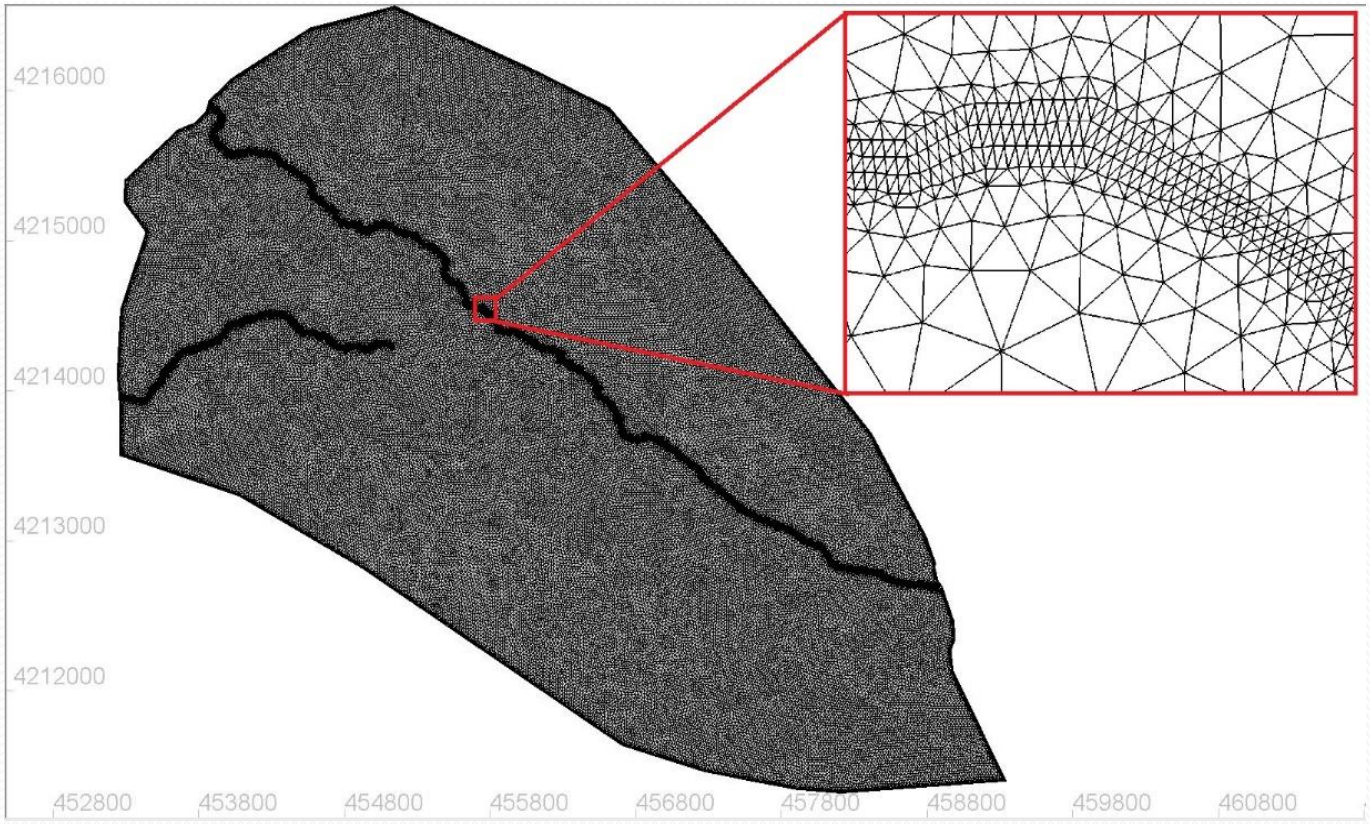
✓ Hydrodynamic models. Specialized scientists: Hydraulic Engineers.

Output of each model is input to the next model!

Interdisciplinary subject involving many specializations, such as transportation engineers, geologists, risk analysis experts, environmental engineers, architecs and many others. Thus: a cooperation is required!

Q3: Which should be the main characteristics of an EWS in Attica?

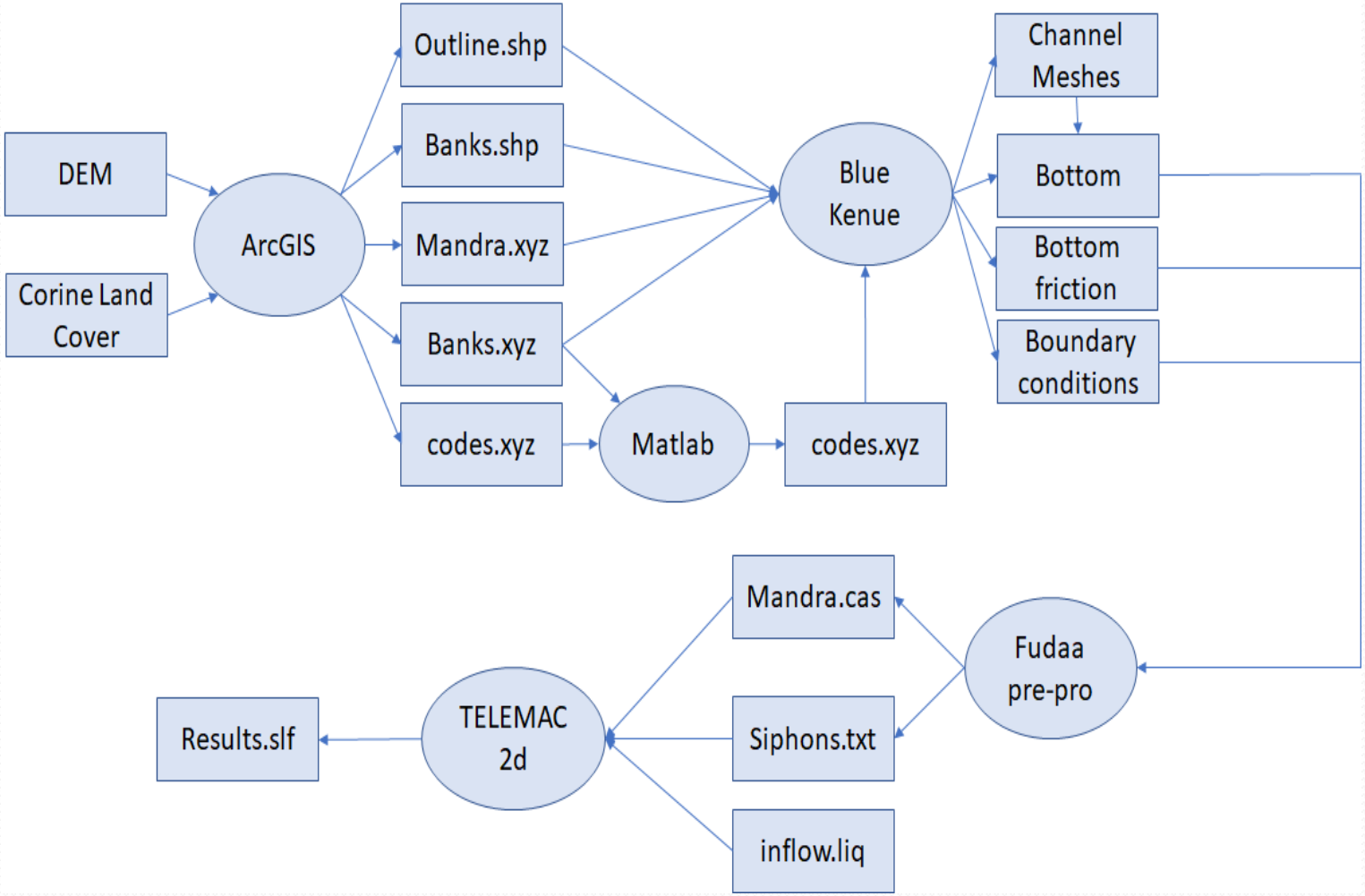
3.6 The hydrodynamic model (TELEMAC 2D)



The finite element mesh of TELEMAC-2D model

Q3: Which should be the main characteristics of an EWS in Attica?

3.7 The calculation procedure in TELEMAC 2D



Q3: Which should be the main characteristics of an EWS in Attica?

3.7 Taking into account all technical works

No (-)	Technical work (Type)	Upstream Location (m)	Width or Diameter (m)	Height (m)	Length (m)
TW1	Twin-pipe	3890	2x4.0	1.35	25.0
TW2	Culvert	3740	3.0	1.5	35.0
TW3	Culvert	2013	2.0	1.0	27.0
TW4	Twin-channel	1202	2x4.0	1.25	61.0
TW5	Twin-pipe	1010	2x0.8		38.0
TW6	Culvert	760	3.5	2.0	15.0
TW7	Pipe	514	1.2		14.0
TW8	Pipe	444	1.2		13.0
TW9	Culvert	349	5.0	1.90	15.0
TW10	Culvert	-120	5.5	4.5	18.0
TW11	Twin-channel	-268	2x4.0	3.0	185.0
TW12	Twin-channel	-850	2x4.0	3.0	16.0
TW13	Twin-channel	-962	2x4.0	3.0	31.0
TW14	Twin-channel	-1340	2x4.0	3.0	200.0
TW15	Twin-channel	-1940	2x4.0	3.0	497
TW16	Bridge	-1680	30.0	6.0	33.0
TW17	Culvert	4550	3.0	1.35	10
TW18	Pipe	2230	2.0	1.7	2319

Important notes

- ✓ Hydrodynamic modeling is generally complicated.
- ✓ Hydrodynamic models cannot be used as black box models.
- ✓ The presence of solids should be taken into account (not in the present work).
- ✓ The presence of buildings should be taken into account accurately (not in the present work).

Q3: Which should be the main characteristics of an EWS in Attica?

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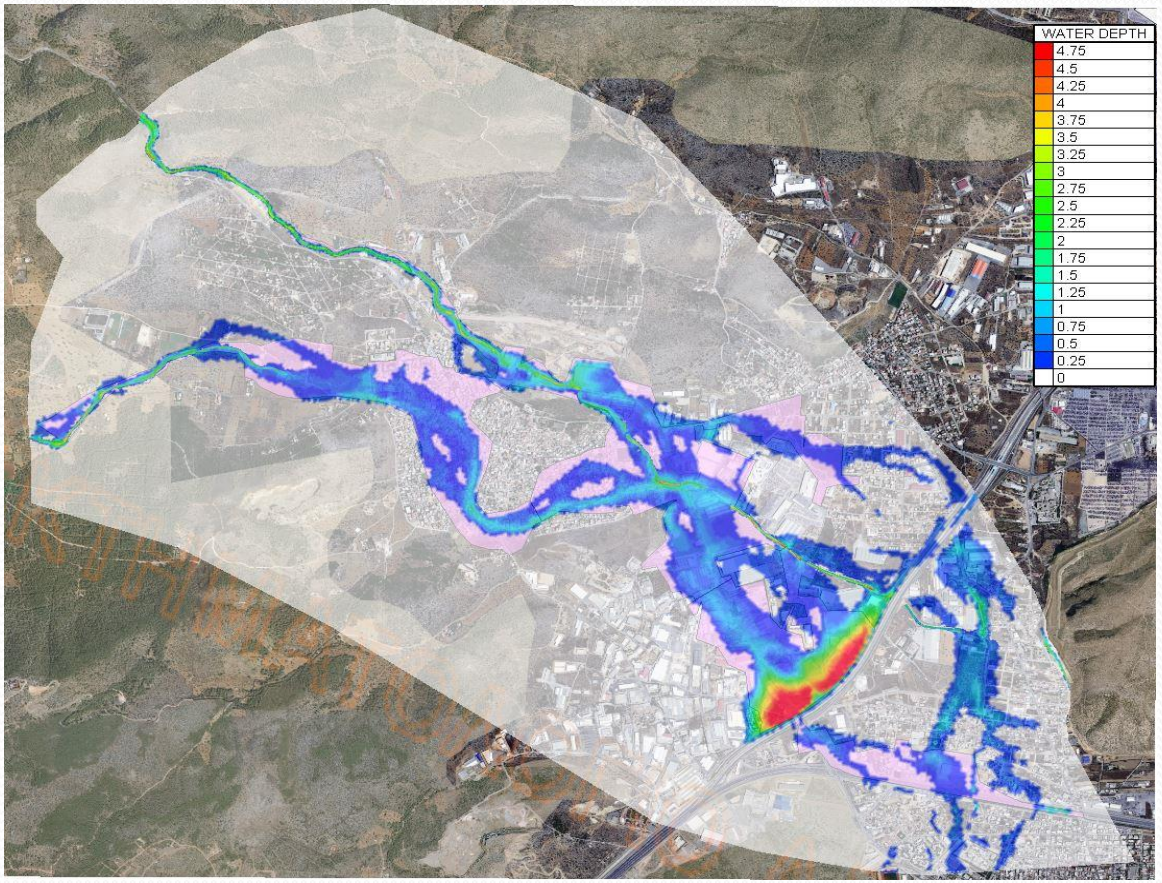
3.8 Results: Inundation area incl. hot spots



Comparison of model with observation: Initial results!
Identification of hot spots can help the Civil protection (evacuation plan).

Q3: Which should be the main characteristics of an EWS in Attica?

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Question 4

What else is needed for a successful EWS in Attica?

Information, education and training on floods!

Information, education and training on floods!

Based on preliminary results of questionnaires in Mandra (63 questionnaires)

INFORMATION-EDUCATION

- People think that the main cause of floods is the lack of structure works (92%).
- People informed on floods. 52 %: bad-very bad; 38% is good-very good.
- People prefer to be informed on what to do in case of floods by internet, seminars and personal communication.
- 92 % think that a preparedness exercise is useful.

PREPARDNESS

- 89 % were not prepared to face the flood of 2017.
- 67 % feel that they are not prepared to face a flood.

WARNING

- People prefer public announcement by the local authorities.

CONCLUSIONS

1. Based on flood incidences and their consequences an EWS is needed in Attica.

2. An EWS in indeed needed, even if the structural works have been constructed according to the final study.

3. The EWS must satisfy a series of characteristics and involve a significant number of specialized scientists; a co-operation is needed.

4. The EWS can be successful only when the people are informed, educated and trained on floods!