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3<sup>rd</sup> - 5<sup>th</sup> July 2018  
PAU, FRANCE

DE LA RECHERCHE À L'INDUSTRIE  
**cea den**

# FROM PIEZOMETRIC MONITORING TO GROUNDWATER FLOODING RISK MANAGEMENT

DTN/SMTA/LMTE

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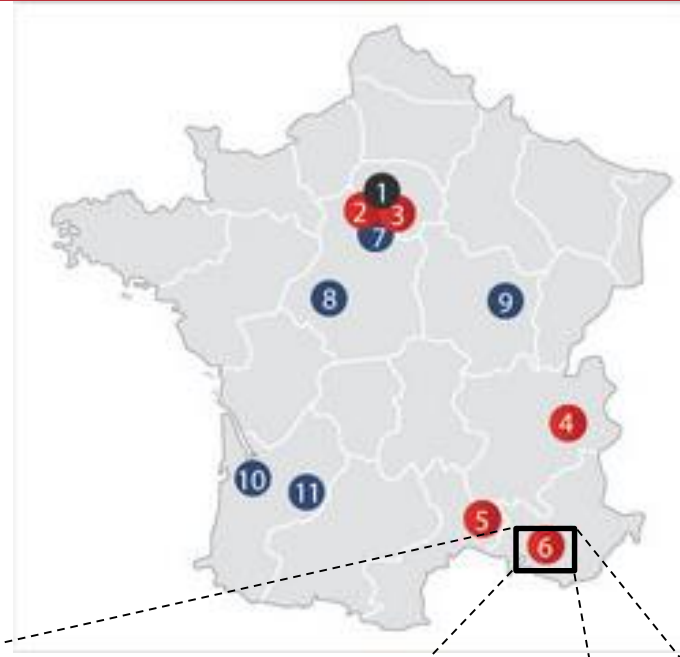


# 1. GENERAL PRESENTATION

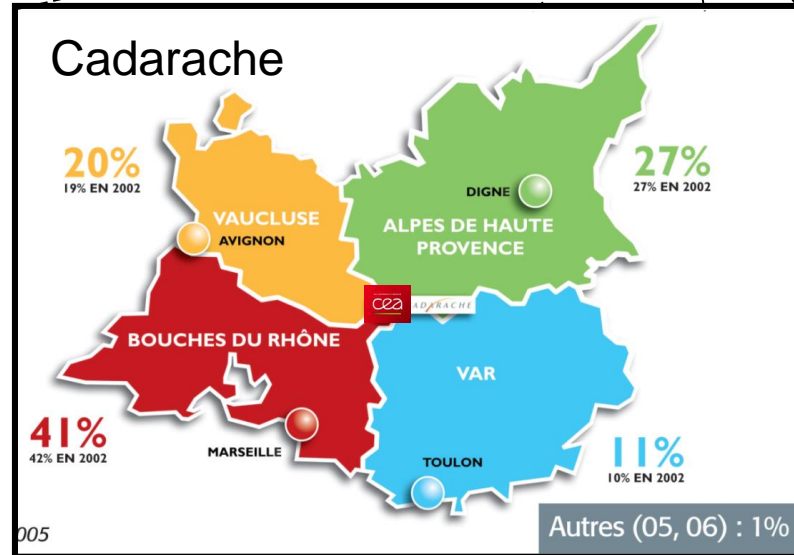
## 1.1 THE CEA IN FRANCE



- 16 000 employees
- 1 500 PhD students
- 4.2 M d'€ of annual budget
- 684 patents in 2017



- Headquarters
- Civil nuclear Center (DEN)
- Military nuclear Center (DAM)

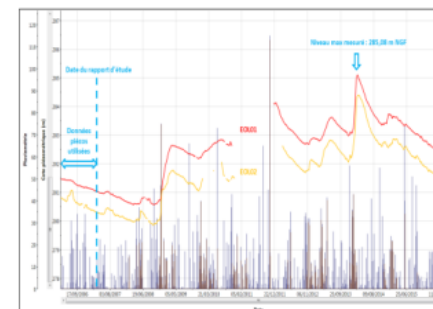


**Surface** : 16 km<sup>2</sup> (~ 9 km<sup>2</sup> fenced)  
**Facilities** : 21 INB  
 1 INBS  
 ~ 20 ICPE  
**Staff** : 5000 people

### LMTE : Reference laboratory in hydrogeology for all the CEA Nuclear Energy Division (DEN) facilities

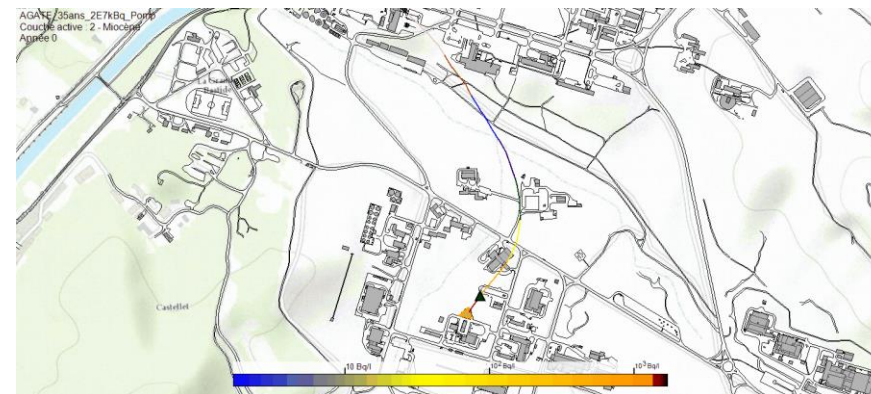
- **Management of the piezometric park and hydrodynamic monitoring:**

- Drilling
- Piezometer diagnostic, rehabilitation, fillers
- Piezometric data acquisition and management
- Groundwater data control and verification



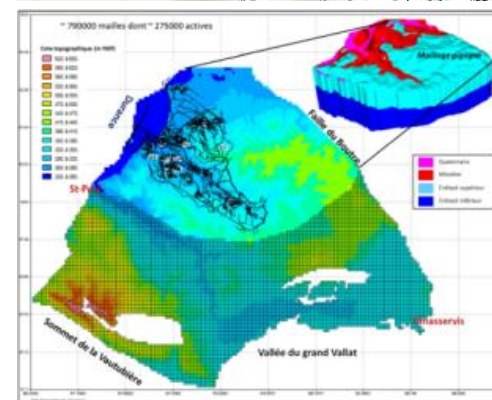
- **Operational studies and expertise:**

- Flow modelling (substances transfer by groundwater)
- Groundwater flooding risk (for both fast and slow hydrodynamic aquifers)
- Liquefaction risks in case of earthquakes
- Sizing of drainage device



- **R&D program in hydrogeology:**

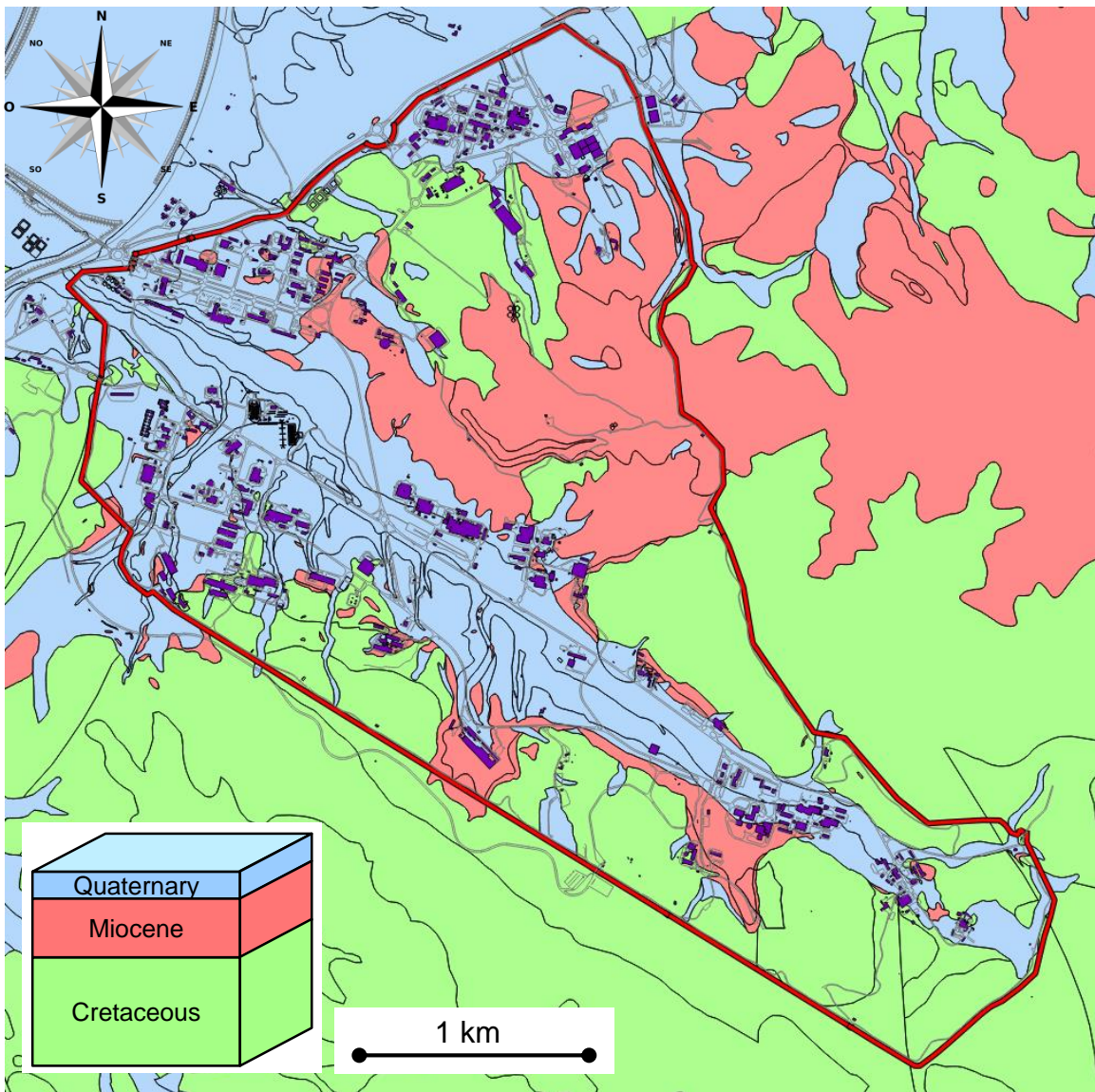
- Flow modelling developments
- Benchmark of hydrogeology simulation tools : MARTHE, MODFLOW-MT3D, FEFLOW, HYTEC...
- Crisis tool design (GRENA, PERISCOP)
- Geochemistry studies (radionuclides behaviour)





# 1. GENERAL PRESENTATION

## 1.3 SIMPLIFIED HYDROGEOLOGICAL CONTEXT OF THE CADARACHE CENTER



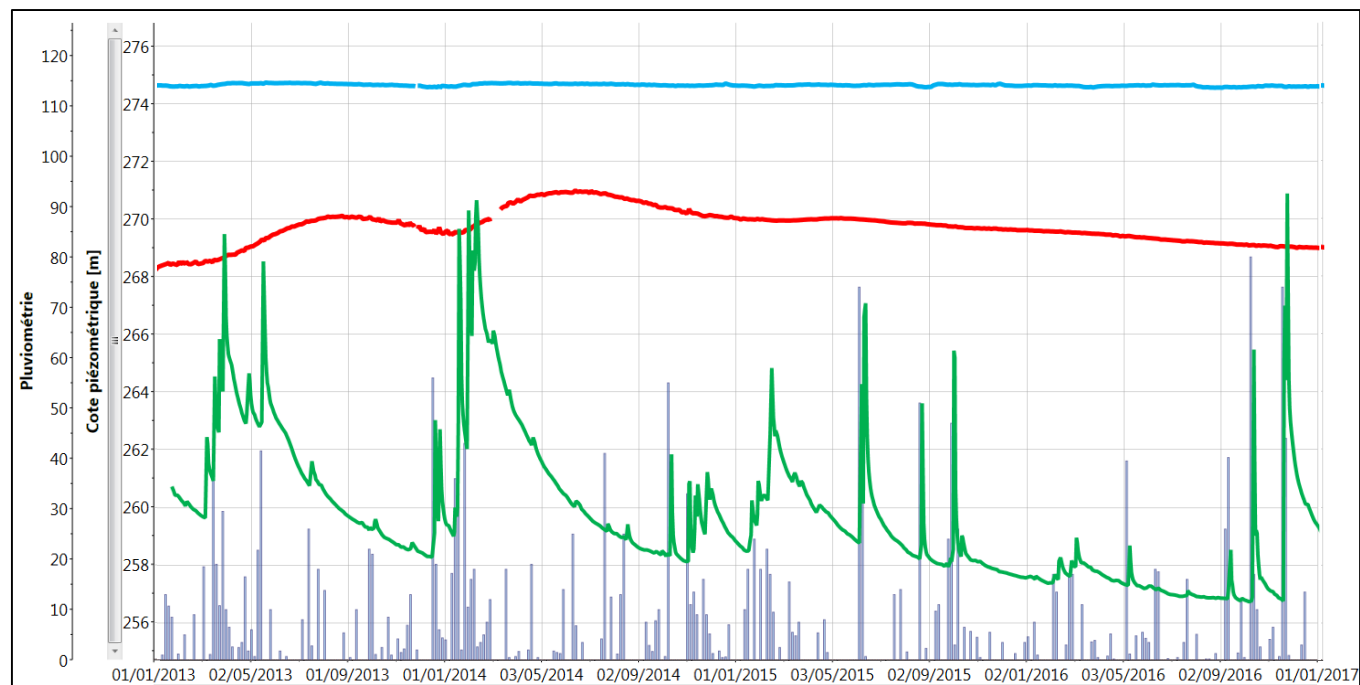
Alluvial deposits (Quaternary)



Sandstone (Miocene)



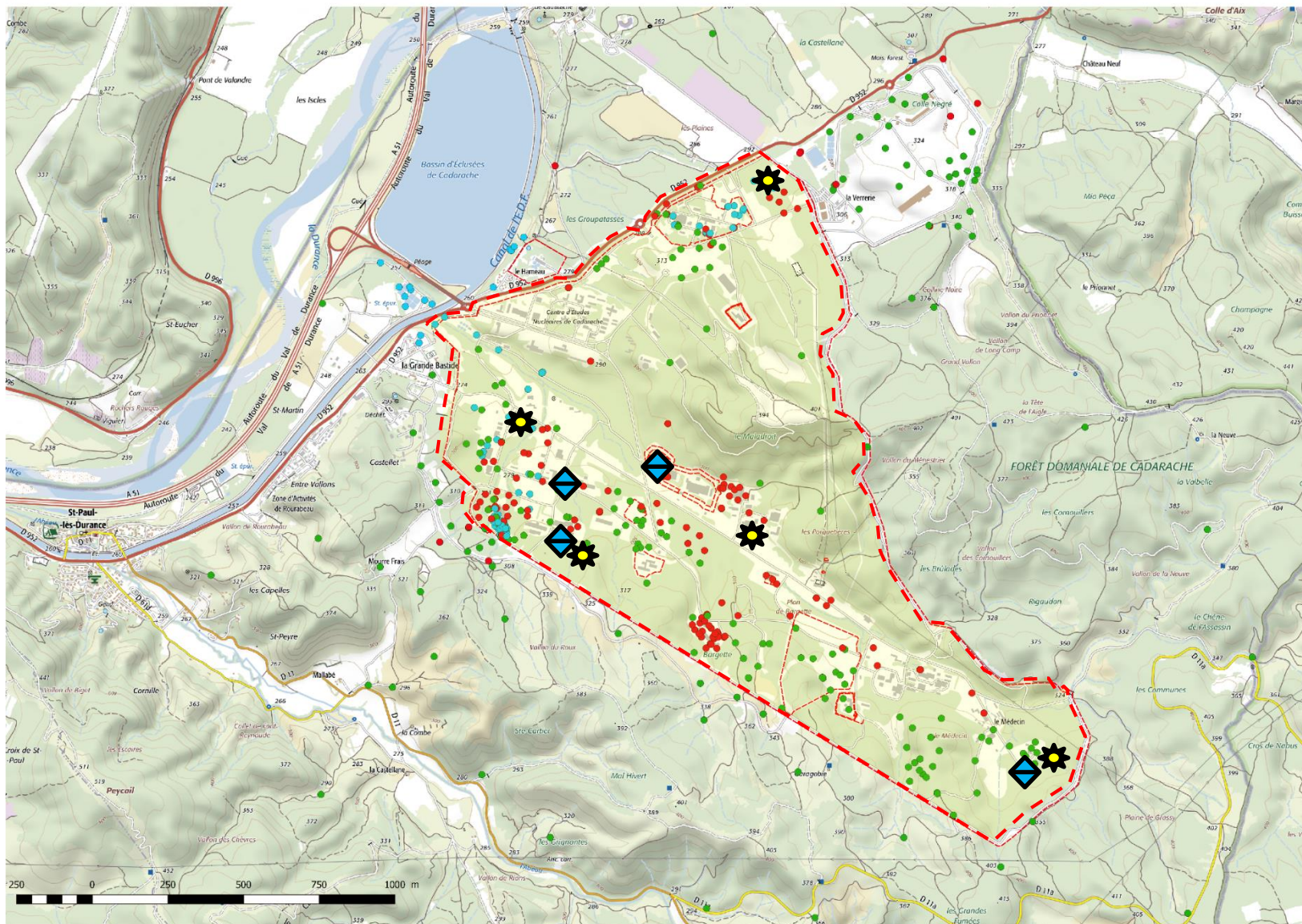
Limestone (Cretaceous)





# 2. GROUNDWATER HYDRODYNAMIC MONITORING

## 2.1 HYDROGEOLOGICAL MONITORING NETWORK OF THE CADARACHE CENTER



+ 400 piezometers (180 with pressure sensor)

● Quaternaire

● Miocène

● Crétacé



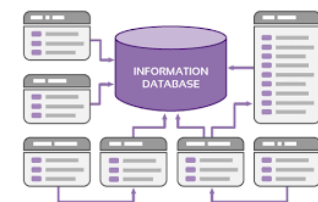
4 CPT stations (with remote transmission)



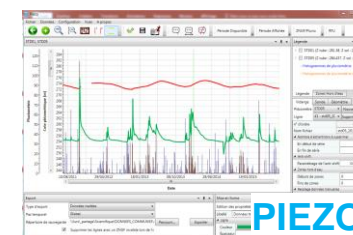
5 weather stations  
(with remote transmission)



Large piezometric and weather data base



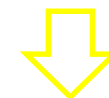
LMTE develop its own tools



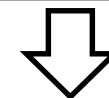




1) Manual readings import



2) Raw fluctuation data import between manual readings



3) Barometric corrections



4) Anomaly evaluation

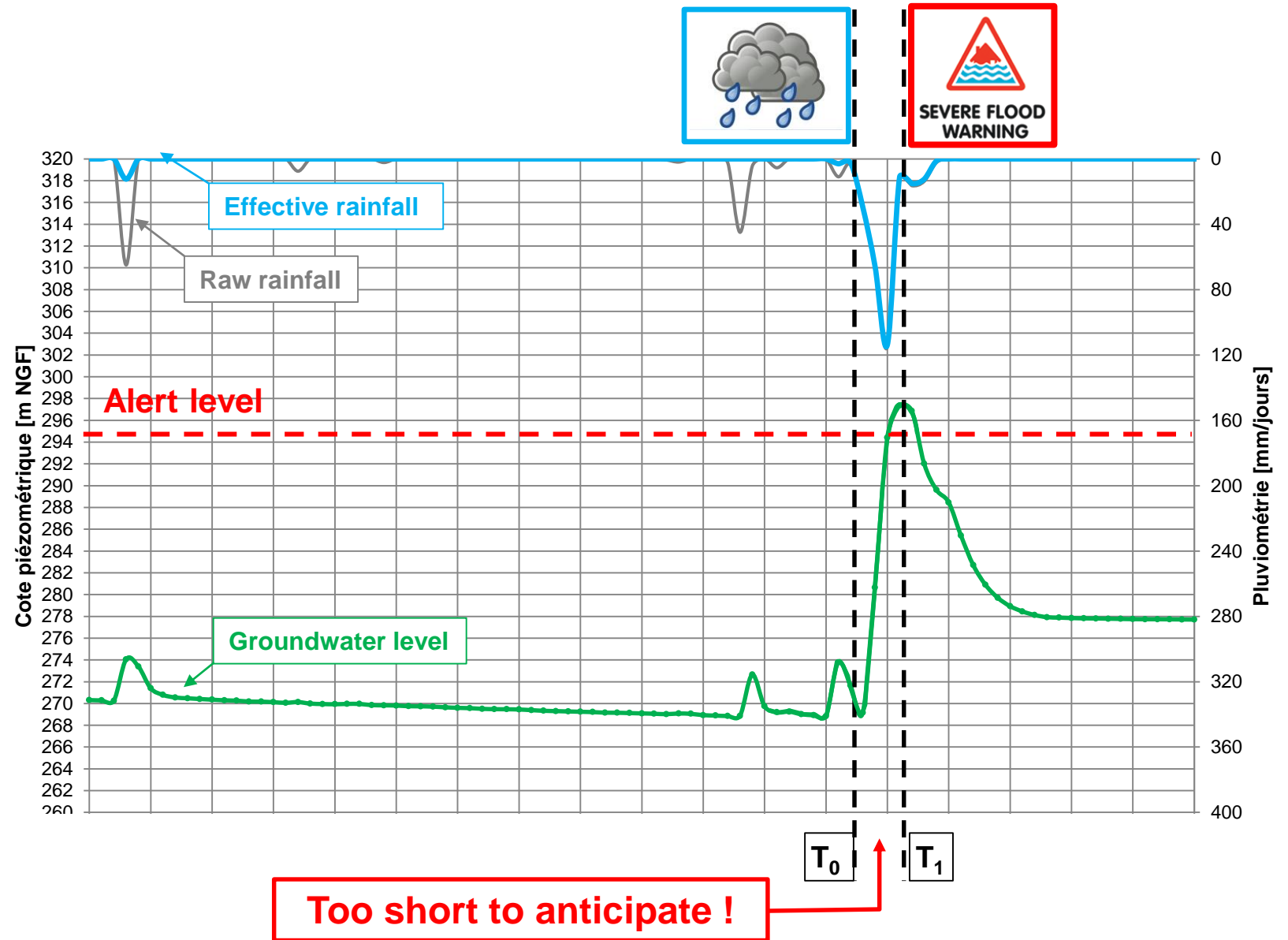
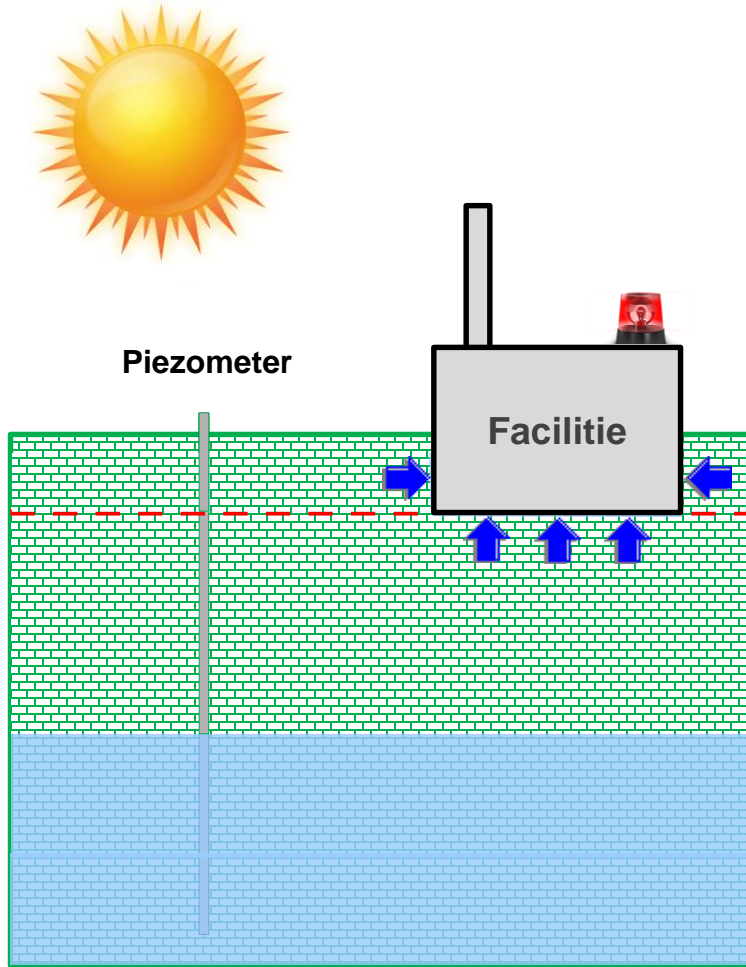


5) Drift correction



## 2. GROUNDWATER HYDRODYNAMIC MONITORING

### 2.3 SCENARIO OF A EXTREME FLOOD BY GROUNDWATER RISING (WITHOUT PERISCOPE)





# 2. GROUNDWATER HYDRODYNAMIC MONITORING

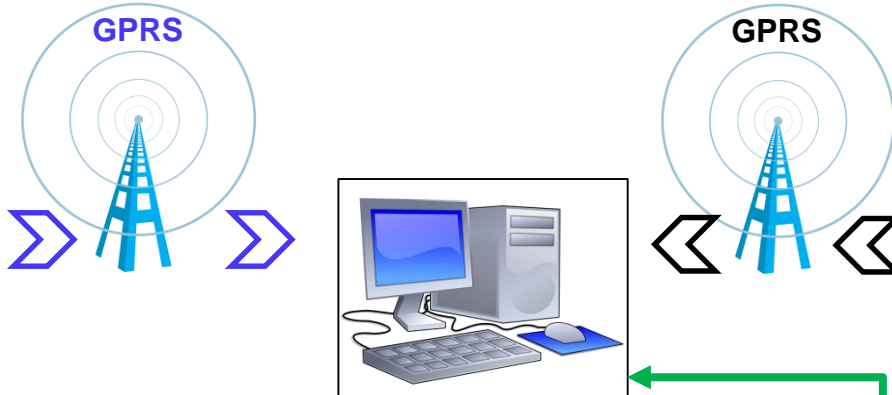
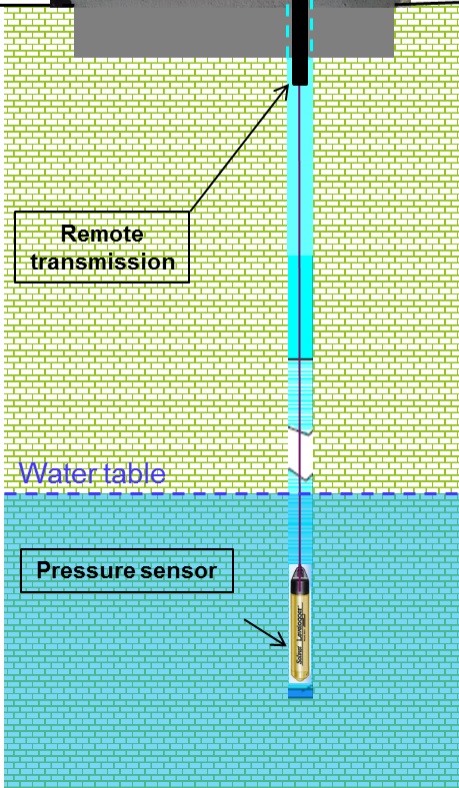
## 2.4 « PERISCOPE » TOOL : FLOOD PLATFORM ORGANISATION

Piezometric data  
(in real time)

Rain gauge Piezometer

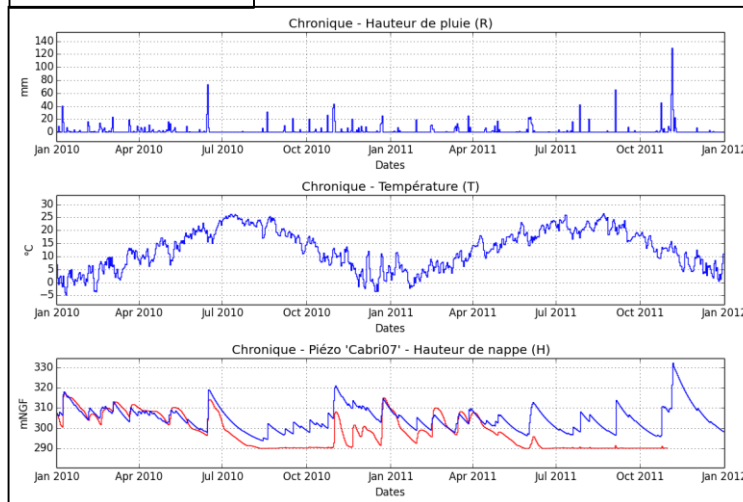


Ground level



Monitoring and simulation

MECK  
(rain/level Model)



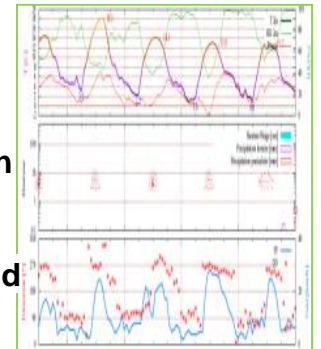
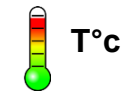
4.5 days forecast of the water table

Weather data

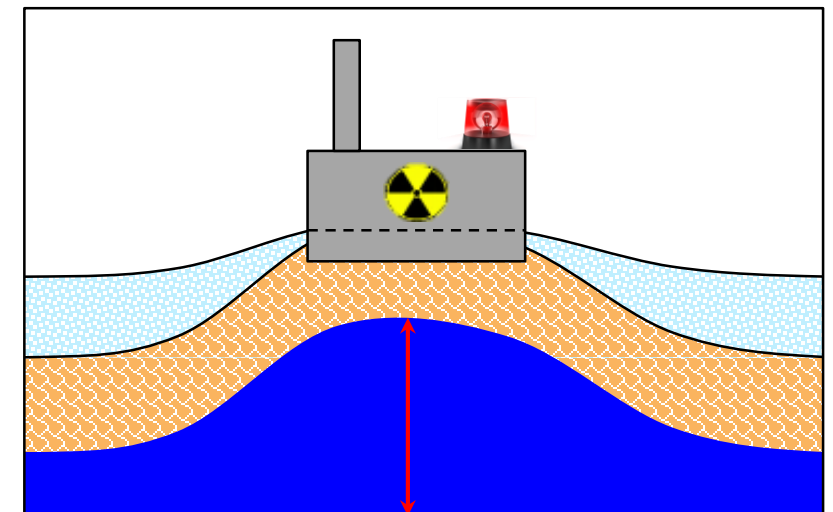
Real time data



PREVI-MISTRAU tool  
4.5 days prediction

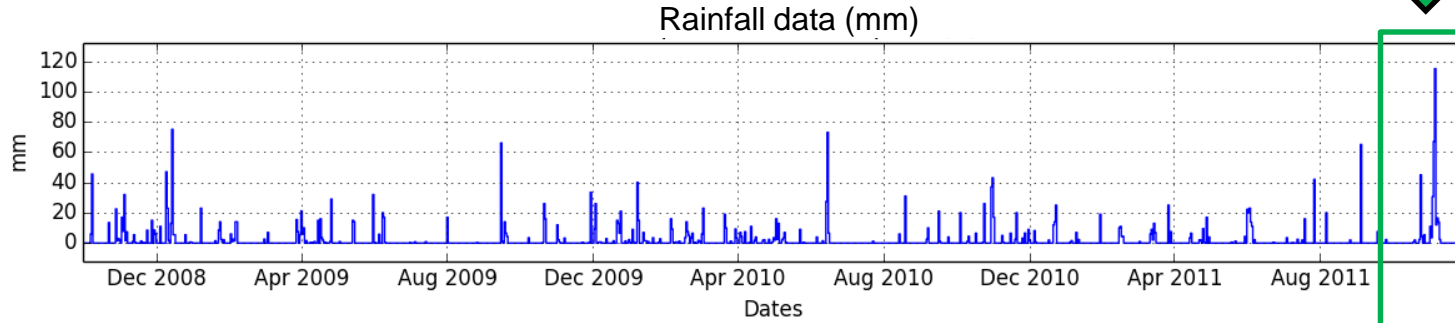
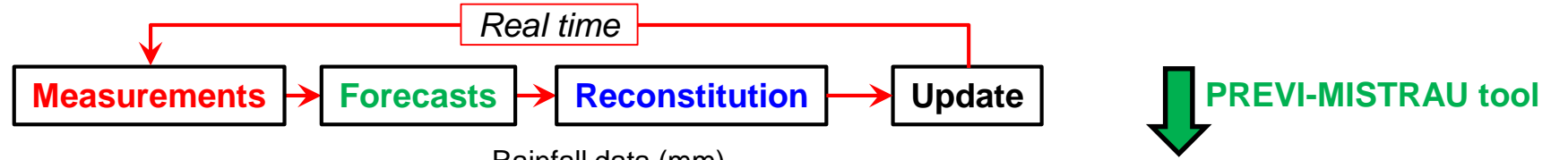


**ALERT**

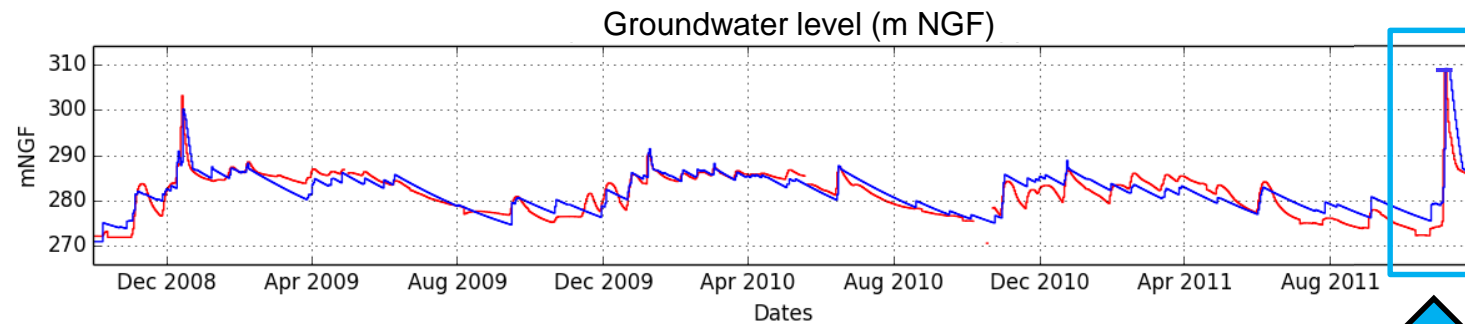
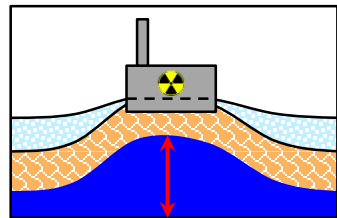
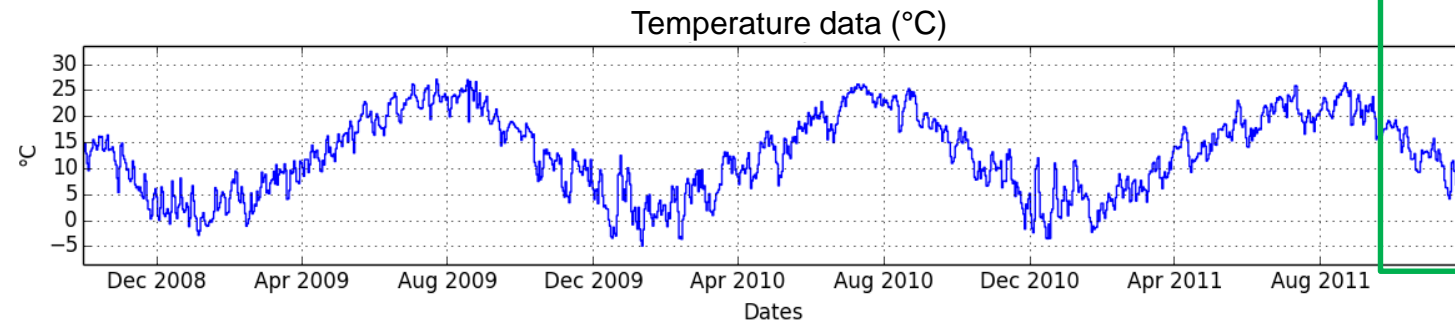


# 2. GROUNDWATER HYDRODYNAMIC MONITORING

## 2.5 « PERISCOPE » TOOL : GENERAL PERFORMANCES



4.5 days  
Weather data forecasted  
(ETP computation)

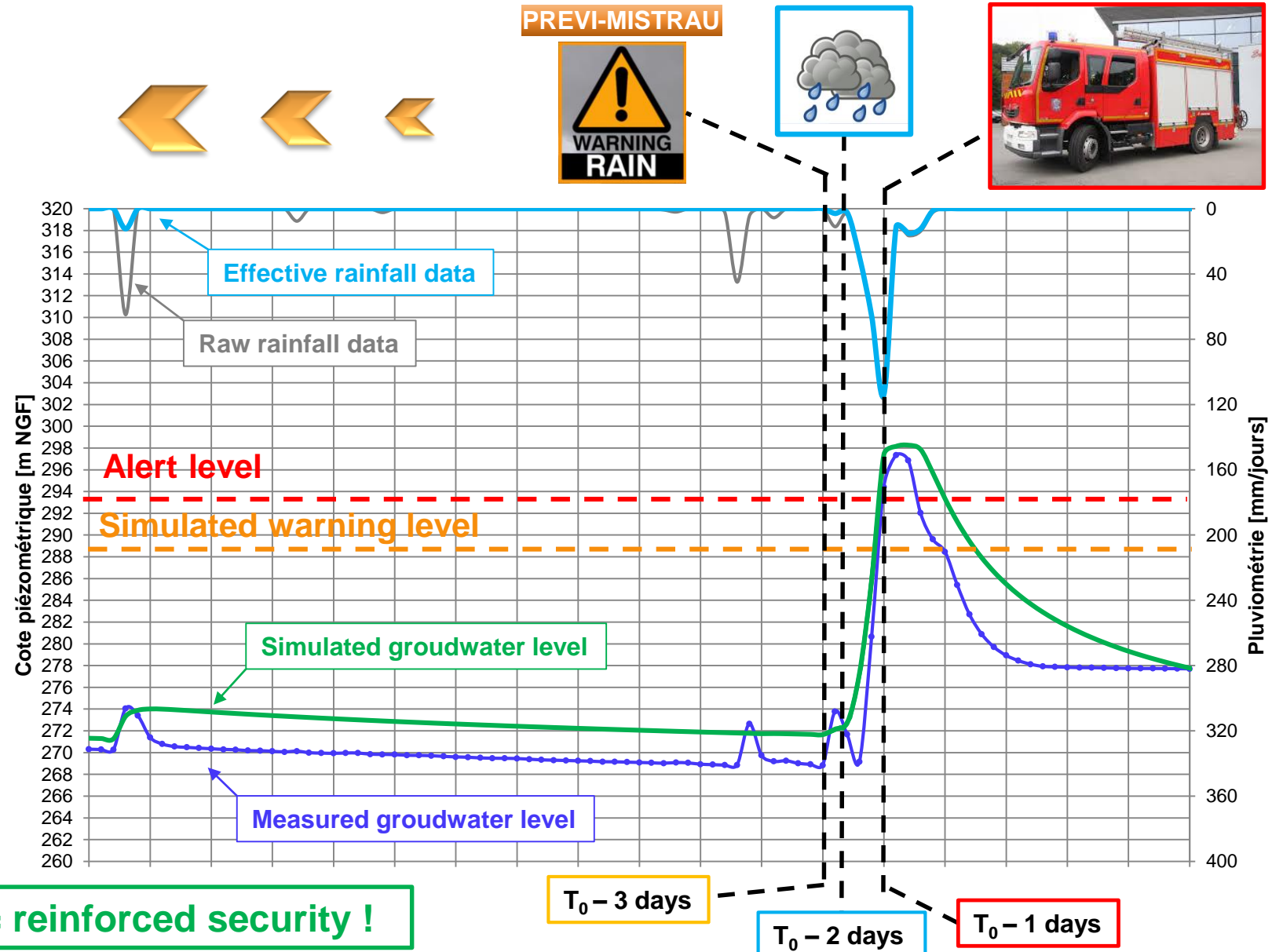
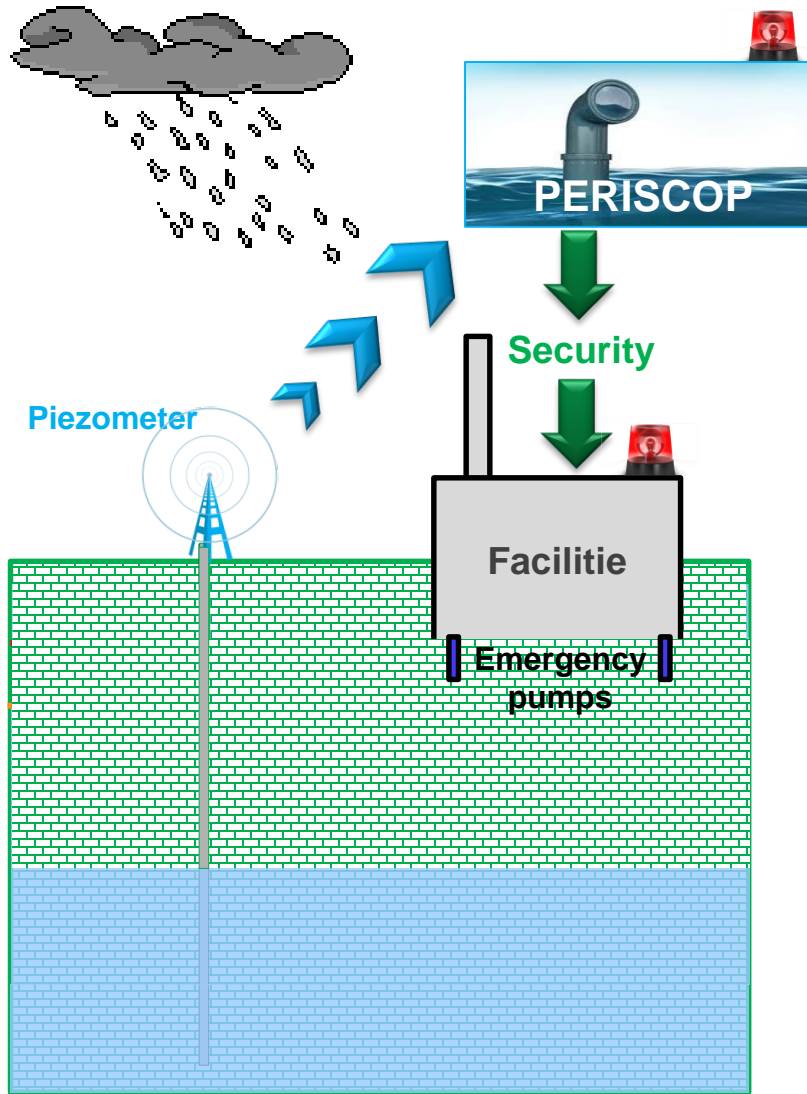


Max piezometric  
level simulated



# 2. GROUNDWATER HYDRODYNAMIC MONITORING

## 2.6 SCENARIO OF A EXTREME FLOOD BY GROUNDWATER RISING (WITH PERISCOPE)



**Flood anticipated = reinforced security !**





Thank you for your attention !

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