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COMITÉ FRANÇAIS DE MÉCANIQUE  
DES SOLS ET DE GÉOTECHNIQUE

LA CONGÉLATION \_

ARTIFICIAL FREEZING OF SOILS, *IN CIVIL ENGINEERING*

**SOIL FREEZING AND MONITORING**

CFMS SCIENTIFIC AND TECHNICAL DAY \_ NOVEMBER 17<sup>TH</sup> 2023  
ESTHER HUGUENOT – MEDERIC PIEDEVACHE – SOLEXPERTS FRANCE

**SOLEXPERTS**

# Overview

- **Solexperts : 10 years on freezing monitoring experience**
- **Overview of Solexperts instruments dedicated for freezing control**
- **Setting up data monitoring**
- **Knowledge acquired through these projects**



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# Solexperts : 10 years on freezing monitoring experience

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## The company

- More than 75 years of experience in projects worldwide with geotechnical and hydrogeological instrumentation and field tests
- Our workshop has its own means of production to manufacture any device quickly and made-to-measure



# Solexperts : 10 years on freezing monitoring experience

## International projects

- Amsterdam (NL)
- Zurich (CH)
- Cigar Lake (CA)
- Rastatt (DE)
- Albula (CH)
- Usolski (RU)
- Napoli (IT)



# Solexperts : 10 years on freezing monitoring experience

## Grand Paris Express

- Porte de Clichy (L14, 2015)
- Puits d'essai Aulnay sous Bois (2016)
- Mairie d'Aubervilliers (L12, 2018)
- Saint Ouen (L14, 2018)
- Lot T2A – Gare du Vert de Maisons (L15, 2021)
- Lot T3A – Gare Issy RER (L15, 2022)



2020 Porte de Clichy Aubervilliers



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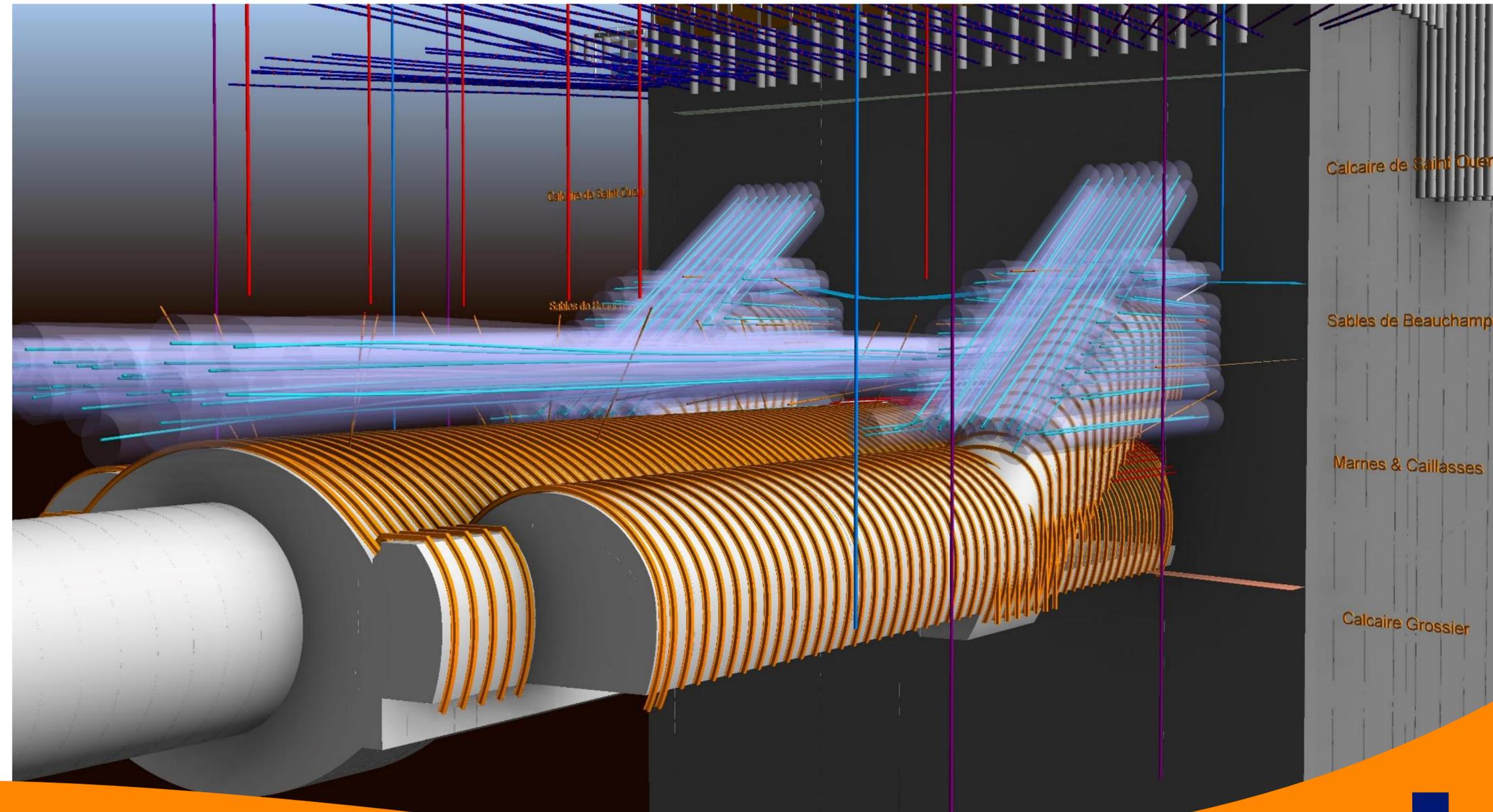
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# Overview of Solexperts instruments dedicated for freezing control

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## 3 entities to watch

- 3D-View of freezing boreholes for cavern and galleries digging at Le Vert de Maisons Station



# Overview of Solexperts instruments dedicated for freezing control

## Objective : Controlling brine temperature into pipes

- Sensors thin enough to fit in immersion sleeve (6.5 mm ID)
- Wide temperature range (up to  $-200^{\circ}\text{C}$ )
- High accuracy ( $\pm 0.3^{\circ}\text{C}$ )
- Correctly insulated from outside temperature
- Wire resistant to extreme temperature and ice crushing



# Overview of Solexperts instruments dedicated for freezing control

## Objective : Estimating ice expansion on the ground

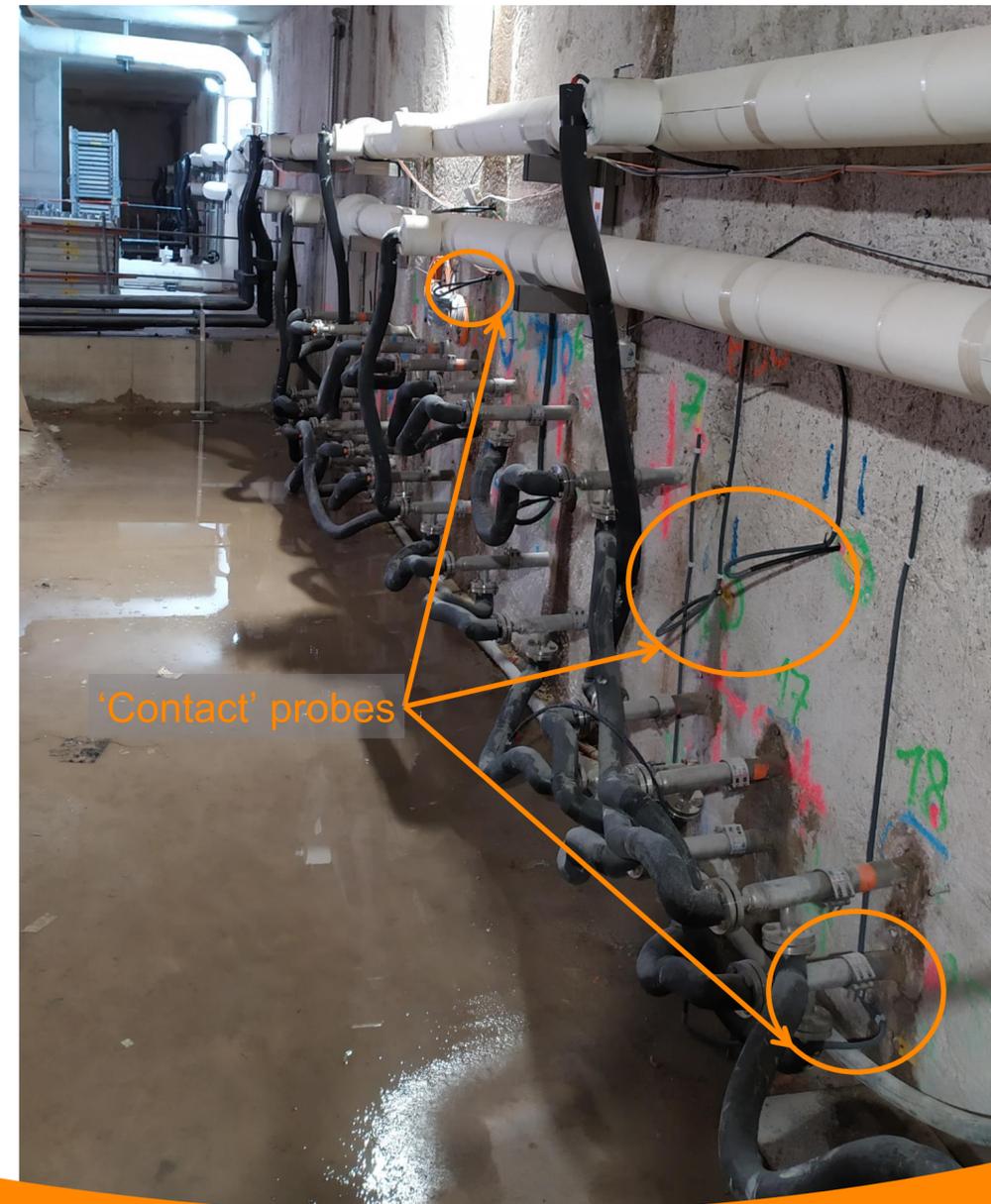
- Temperature sensors connected together
- Waterproof and small diameter (20mm)
- Sensor distribution adaptable according to the zone of interest
- Thermometric chain installed in horizontal or vertical orientation



# Overview of Solexperts instruments dedicated for freezing control

**Objective: Measuring temperature at ground/diaphragm wall interface**

- 1 m drilling through diaphragm wall
- Make sure that sensor goes correctly to the right place
- Same exigences regarding ice crushing





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# Setting up data monitoring

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## Data collecting chain



Sensors



## Data acquisition



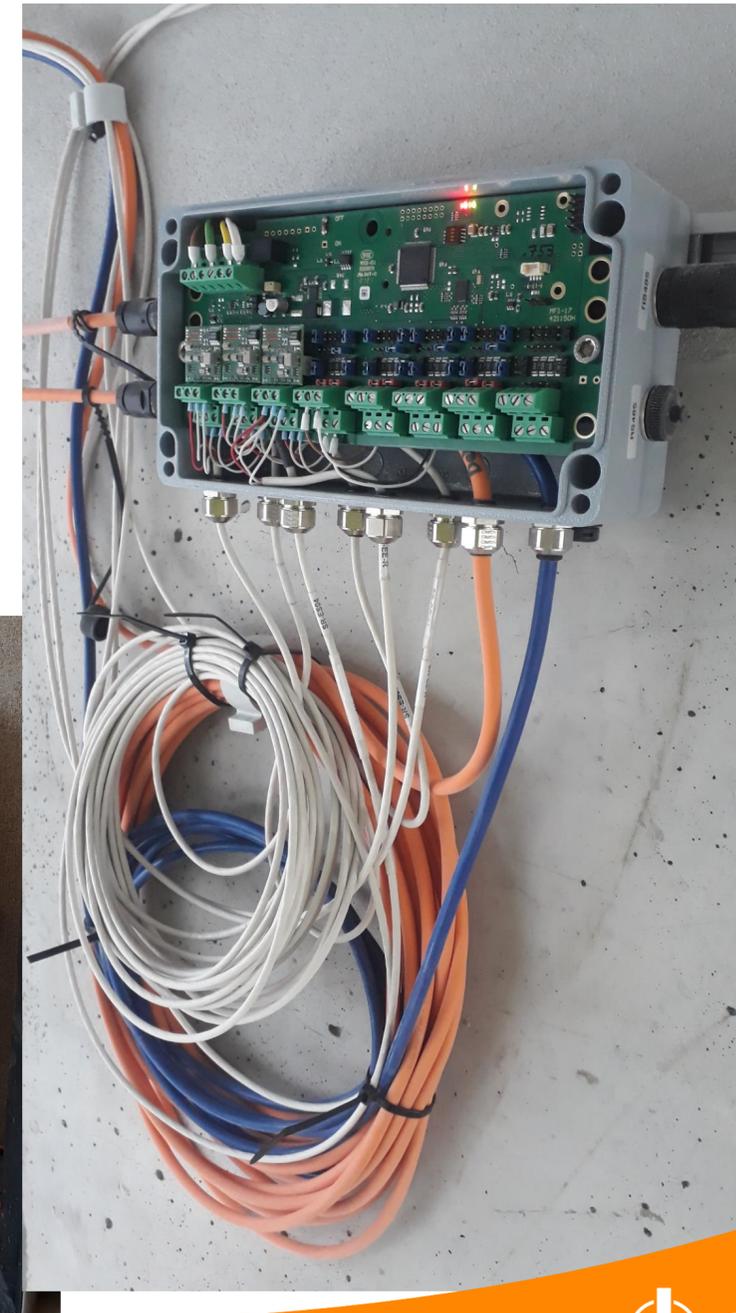
To web-visualisation



# Setting up data monitoring

## Data acquisition system

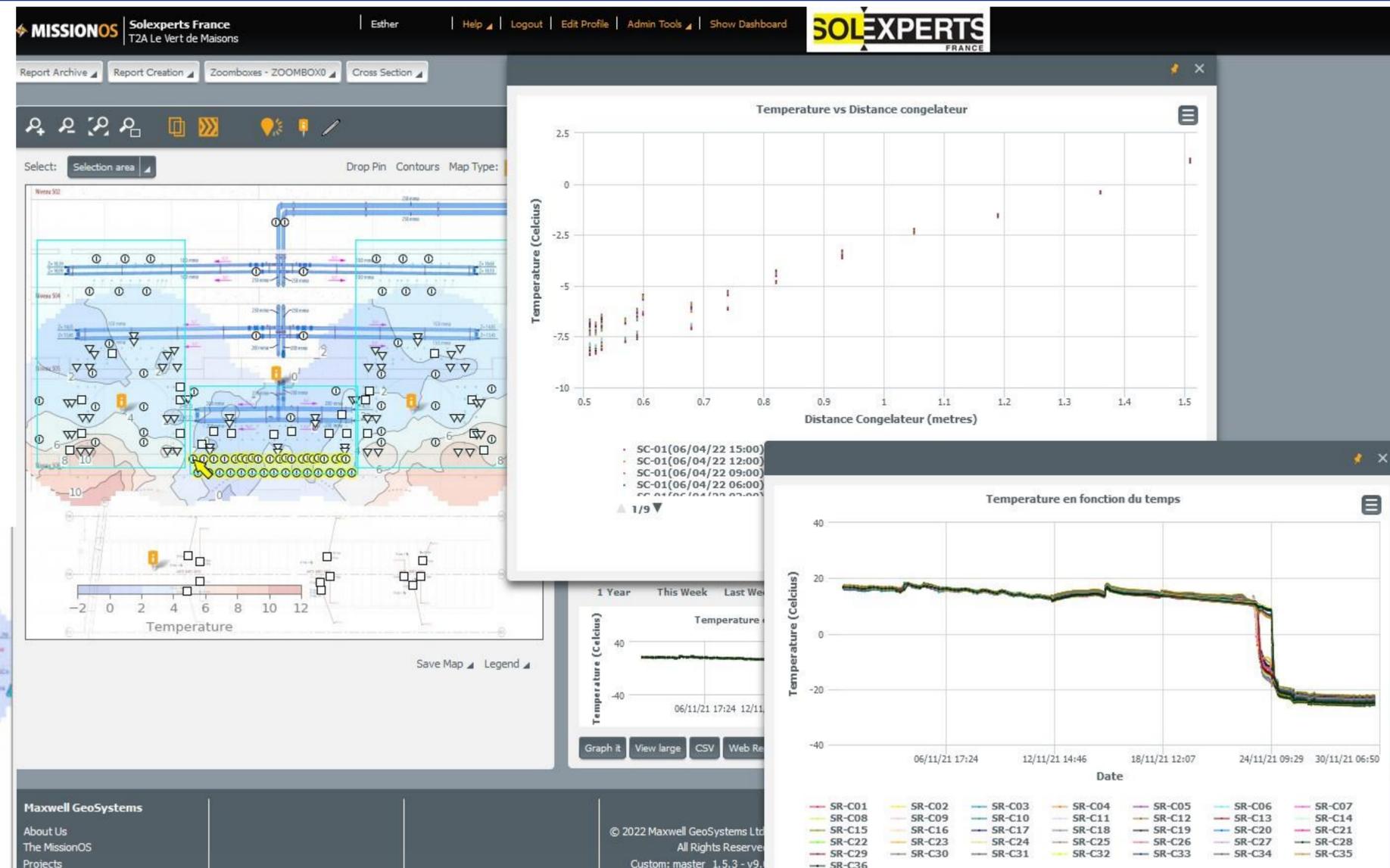
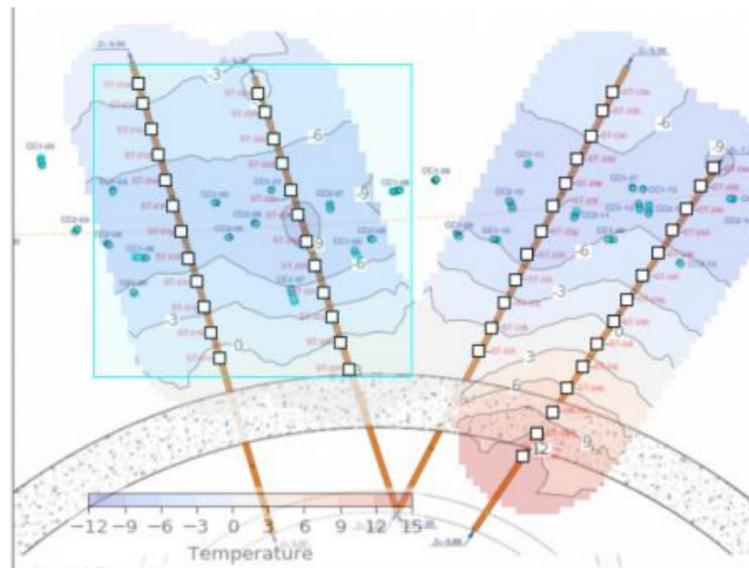
- Use of one or multiple automated acquisition computer
- Acquisition interface close to the zone of interest to limit the number of cables on worksite
- Incorporating phasing into production layouts to optimize instrumentation
- Fast acquisition (less than 30 secondes for 200 sensors)
- Consecutive data transfert to web-vizualisation



# Setting up data monitoring

## Web Vizualisation

- Web portal accessible by the construction company, the project manager and the owner
- Time based or space-based graph
- Gradient map
- Automatic daily export
- Email/SMS alert





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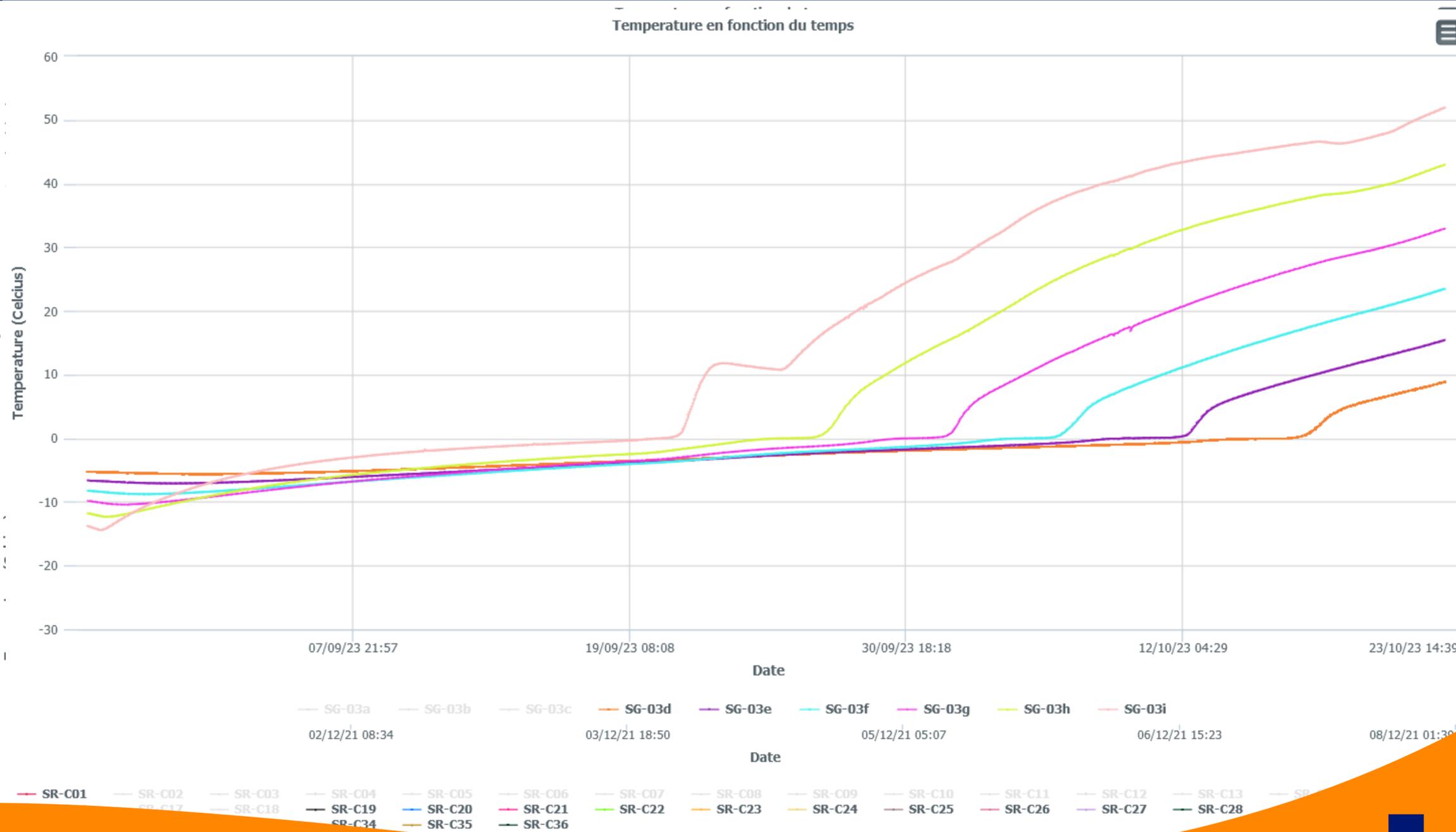
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**Knowledge acquired  
through these projects**

# Knowledge acquired through these projects

## Always think about :

- What do you want to measure ?
- Where is the sensor ?
- What is around the sensor ?  
/Can the environment change the measurement ?
- Is the sensor able to measure what you expect ?
- Why the result is different ?



# Knowledge acquired through these projects

## Sensor protection

- Borehole are not waterproof
- Need to had tubes to protect the probes





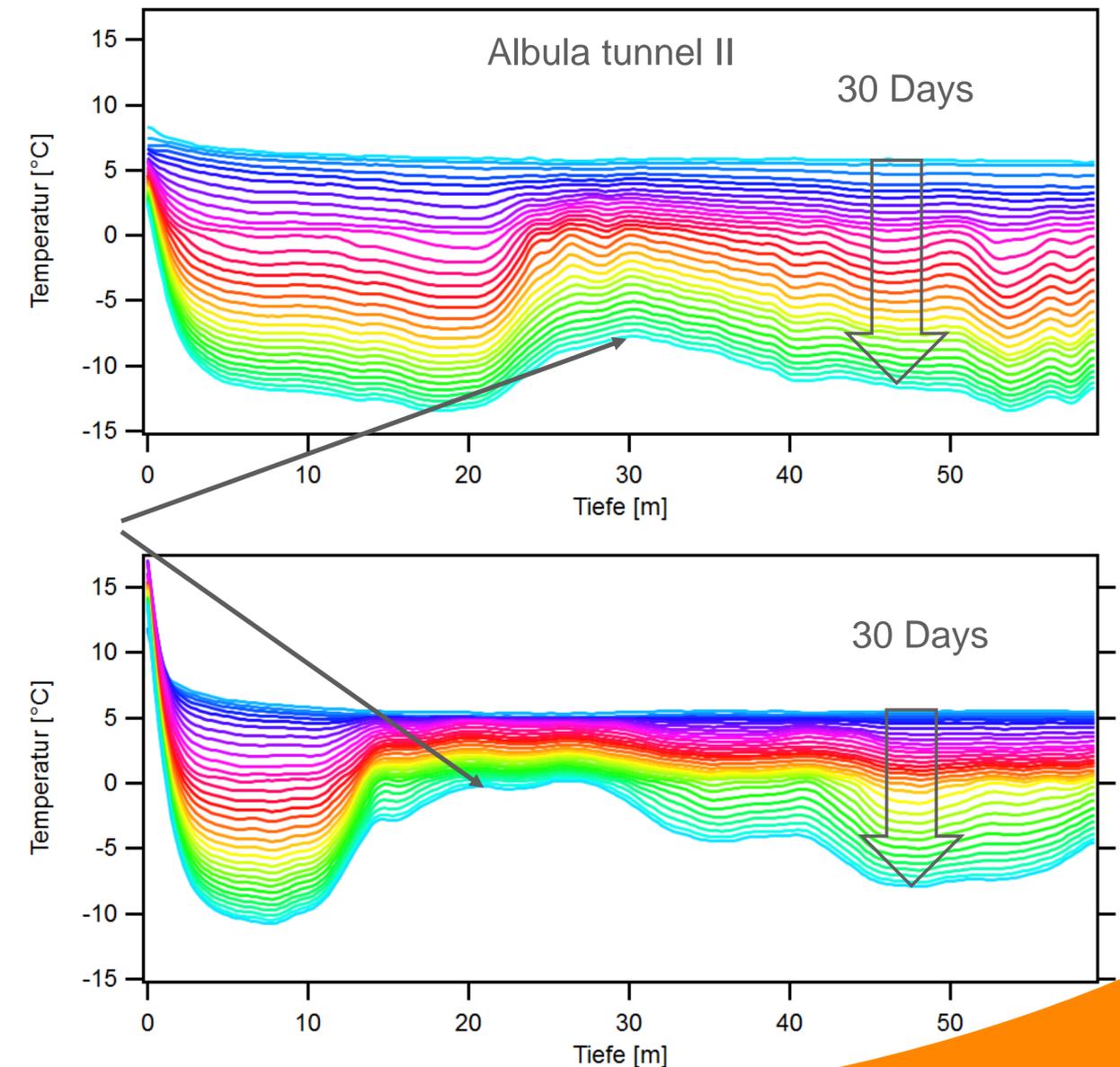
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# Conclusion and alternatives

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- Monitoring is essential to manage ground freezing projects
- Because of harsh conditions, necessity to well protect sensors with a compromise protection/contact with the ground
- A good alternative : Fiber Optic
- Easy to identify small-scale anomalies but with several requirements :
  - Temperature control via reference sensors
  - Meticulous spatial identification
  - Limited adaptability to phasing



Thank You

Questions ?

