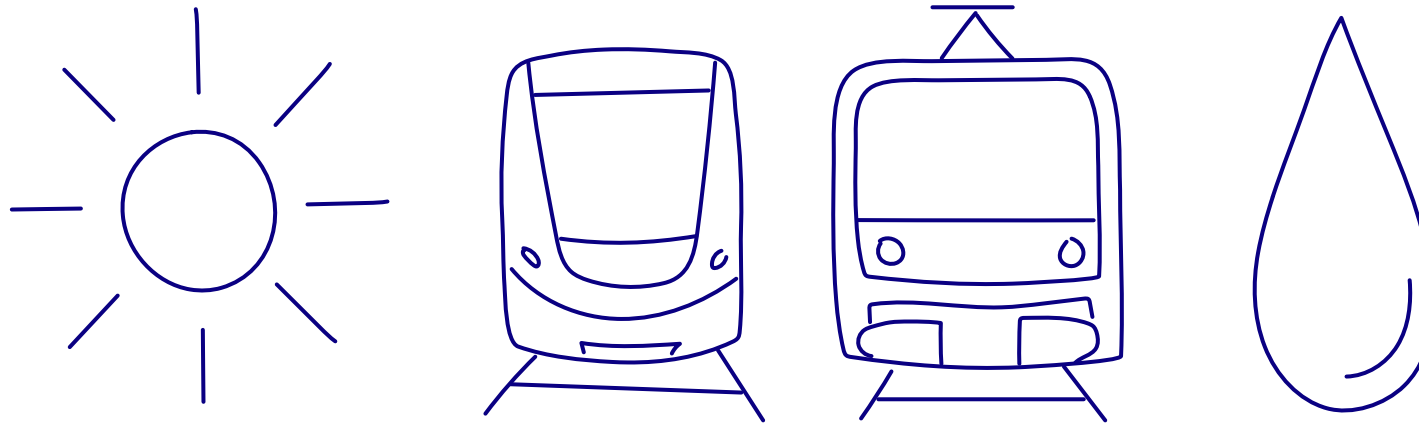




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RATP: Paris metro and RER's climate change adaptation plan

PWI Seminar – Resiliency in Rail Infrastructure :
International experience on climate change adaptation



Institution for
Railway Engineering

GRUPE
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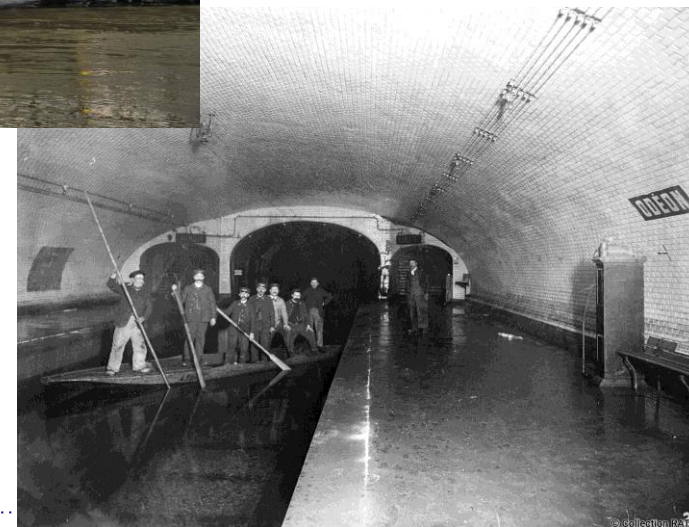
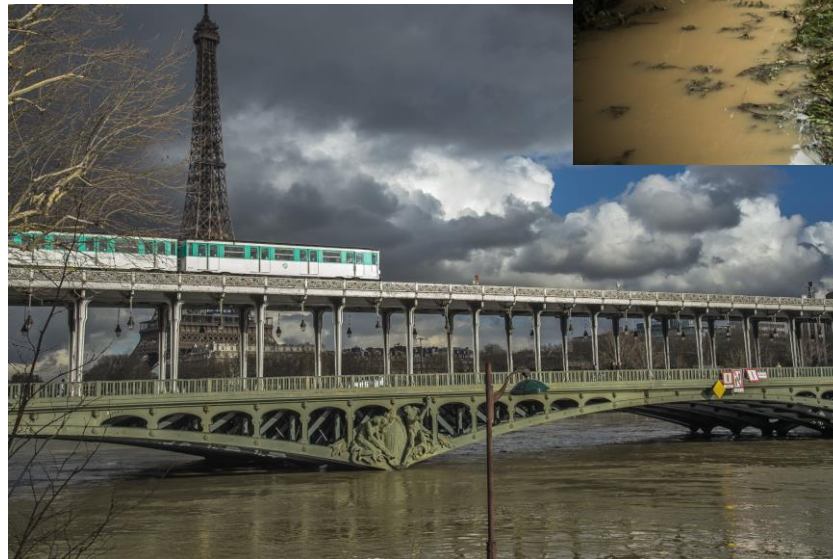
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**What we are
facing in the
Paris region**

Climate change is already visible

What we've already seen...

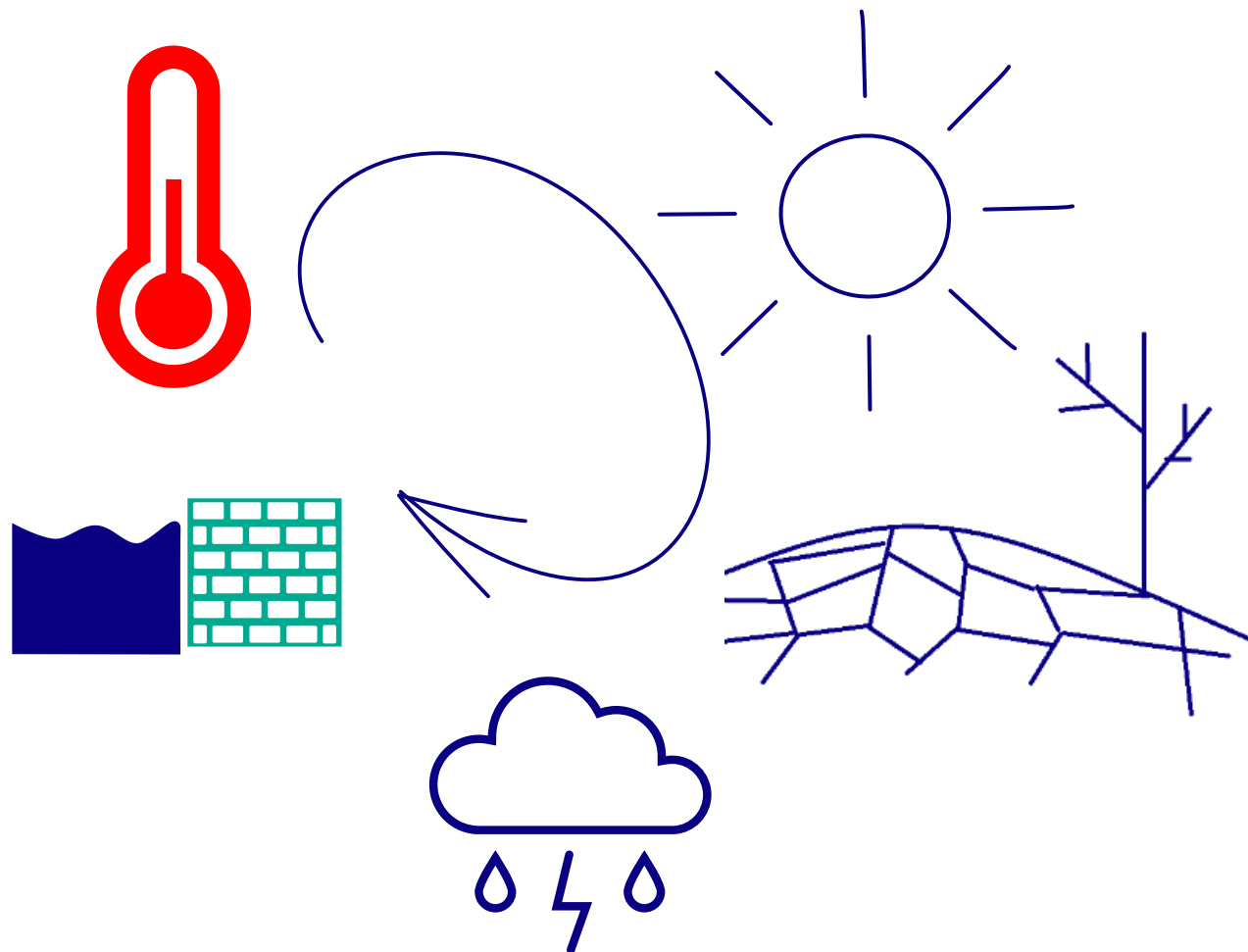
- **Heat waves** in July 2019 and July 2022 leading to **speed restrictions on all aerial parts of all our railway lines**
- **Heavy rainfalls** leading to :
 - **Landslides of embankments** in Courcelle (RER B) and Orlyval in June 2018
 - **Flooding of station entries or technical rooms** nearly every year since 2016
- Decennial **Seine river floods** in 2016 and 2018... and the centennial Seine river flood of 1910...



Adapting to a temperature increase of +4°C by 2100

What is to come (in the worst case)...

- ↳ **Mean daily temperature : +4°C**
- ↳ **Heat waves : + 30 days/year**
- ↳ Tropical nights : + 35 days/year
- ↳ **Summer drought : + 10 days/year**
- ↳ **Heavy rainfall episodes : + 2 days/year...** and an increase in the intensity of these episodes
- ↳ **Frequency of Seine and Marne river floods :**
 - + 20 % decennial
 - + 40% centennial

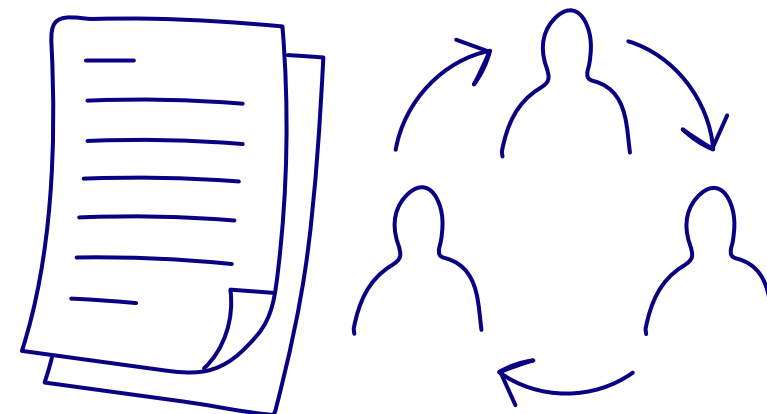


Adapting to a temperature increase of +4°C by 2100

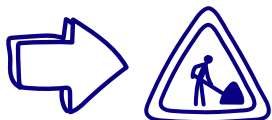
Systematic review of the technical and operational impacts of the different climatic phenomena

- Railway and station infrastructure and equipment
- Rolling stock
- Traffic and operating conditions
- Passengers
- Working conditions of the personnel
- Information systems and telecommunications...

... based on **expert opinions, technical and environmental specifications, experience feedback** from previous climatic events, literature review and benchmarks...



What are the associated risks ? What are our existing countermeasures ?



What needs to be done to improve them (if necessary) ?

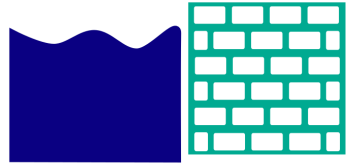


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**What we are
already doing**

River flood



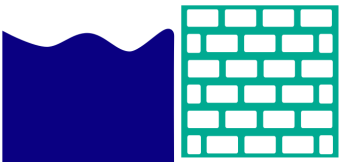
A specific general instruction and a business continuity plan approved by the Paris Region's Prefect... and partially tested yearly

Dealing with surface waters...

- Concrete walls, flood stop boards, tunnel doors, leakproof trapdoors, concrete coverings...



River flood

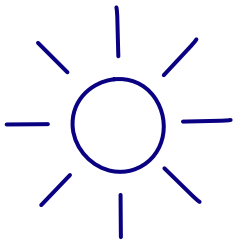


Dealing with phreatic groundwater infiltration / seepage...

- Pumping stations with secured power supply
- Watertight doors
- Emergency dewatering mobile unit and portable power plants
- Emergency spare pumps in « sensitive » pumping stations

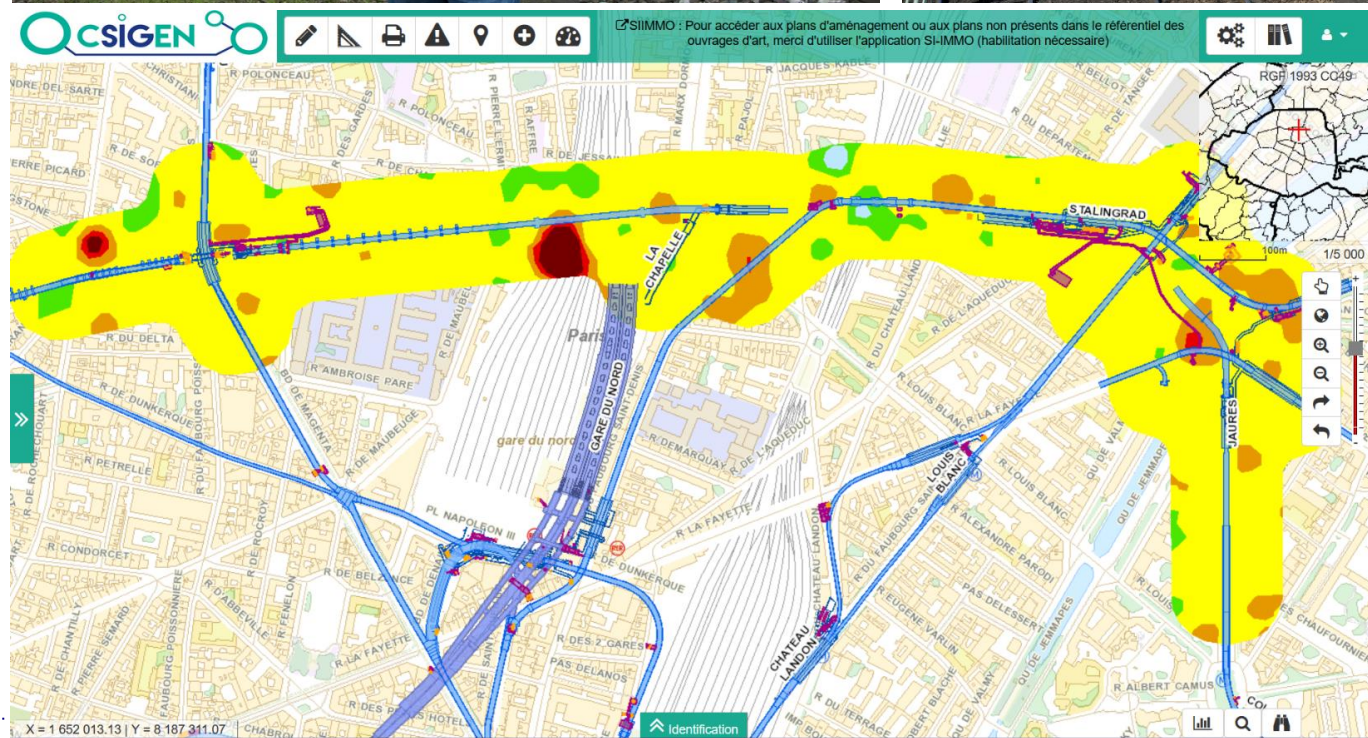


Heatwaves / Drought

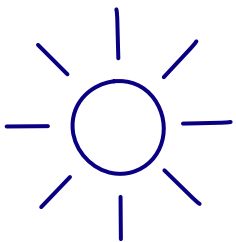


Enhanced maintenance / surveillance measures :

- Railway track and catenary/counterweight inspection visits in specific zones
- Regular visits of key points / sensitive premises : signalling, OCC's UPS and HVAC...
- Targeted cleaning of some air shafts (to avoid fire outbreak)...
- InSAR interferometry data automated analysis through artificial intelligence processes (to monitor ground subsidence risk and structural instability)



Heatwaves / Drought



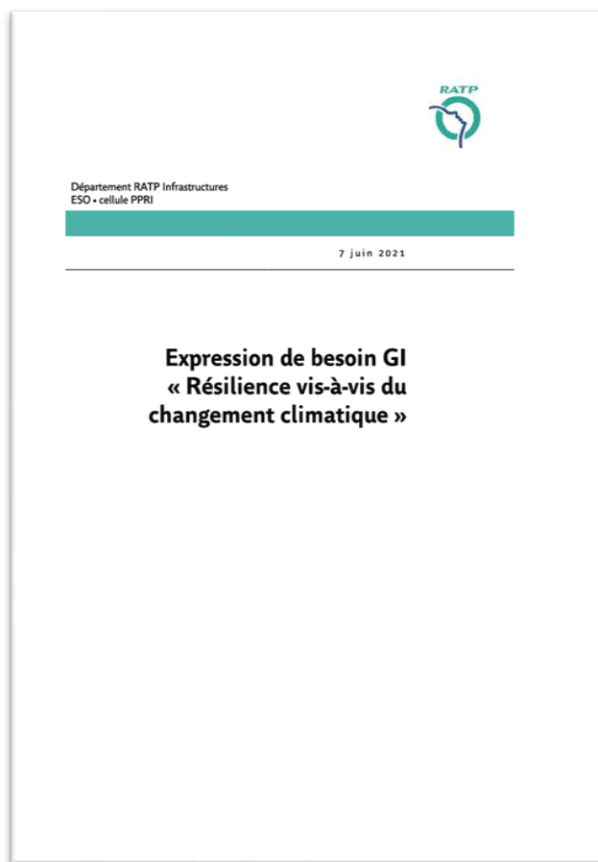
« Modification » of existing assets

→ Athermic film-coatings installed on elevator glass shafts exposed to sunrays...

Regular exercises or situation scenarios

→ “Paris at 50°C”...

Review of design specifications

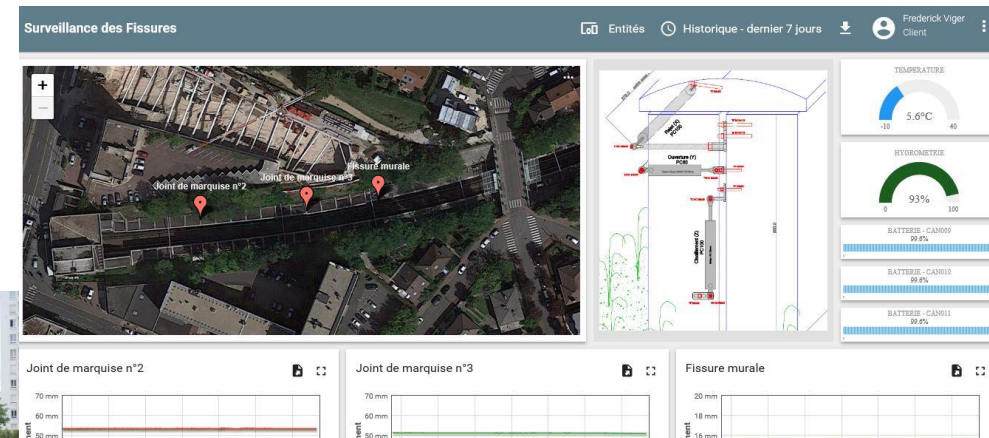
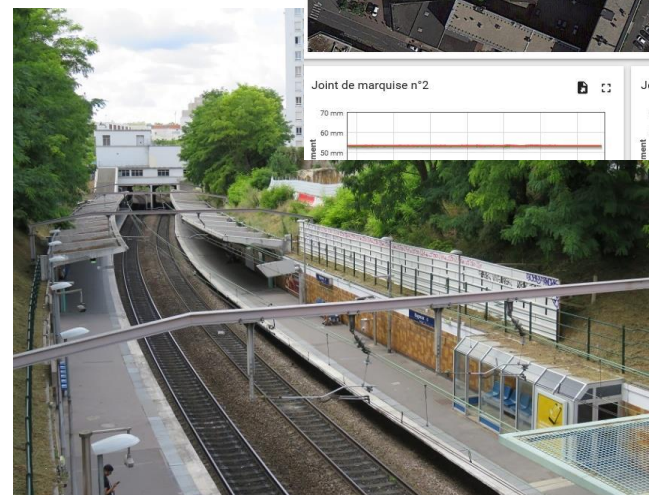
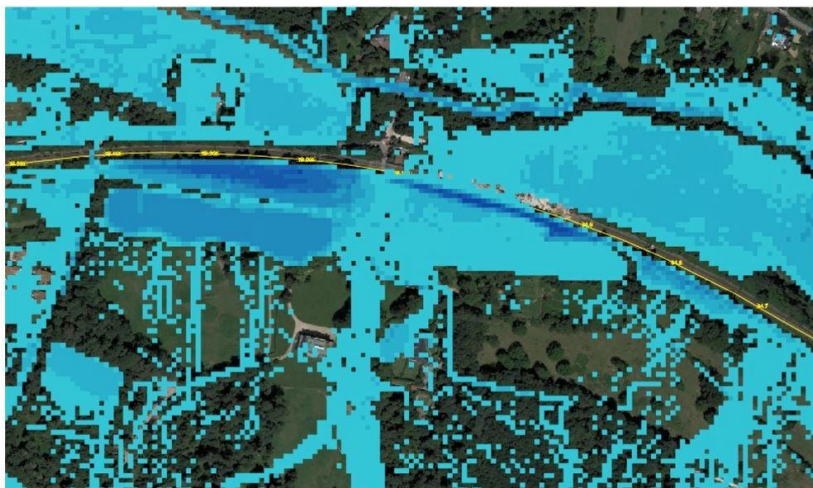


Heavy rainfalls



Enhanced knowledge / surveillance measures :

- **Hydrological studies** to evaluate the sensibility of earthworks & station entrances as well as the design of drainage water facilities ⇒ Targeted reinforced inspections
- **IoT monitoring** of “sensitive” earthworks and civil engineering works
- **Probe drillings** in our tunnels to detect cavities (karstic vughs...)



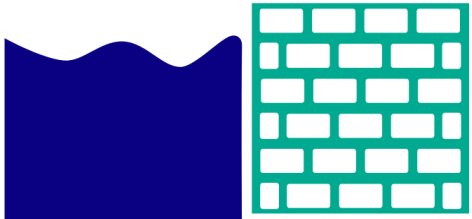


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**New countermeasures
being deployed**

River flood

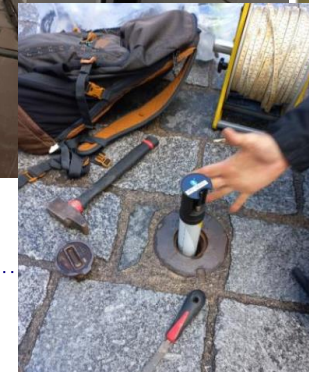


Surface waters

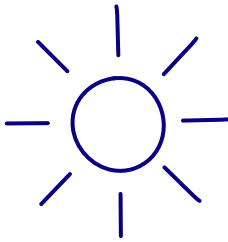
- Progressive move towards reusable or passive protections
- Improvements of storage zones, accommodation and foodservice for assembly personnel

Phreatic groundwater

- Design of secondary partitioning doors to avoid cross-contamination between metro lines
- Waterflow real-time monitoring of « sensitive » pumping stations & Groundwater real-time monitoring by piezometers equipped with IoT
- Targeted reinforcement of the dewatering capacity of some pumping stations

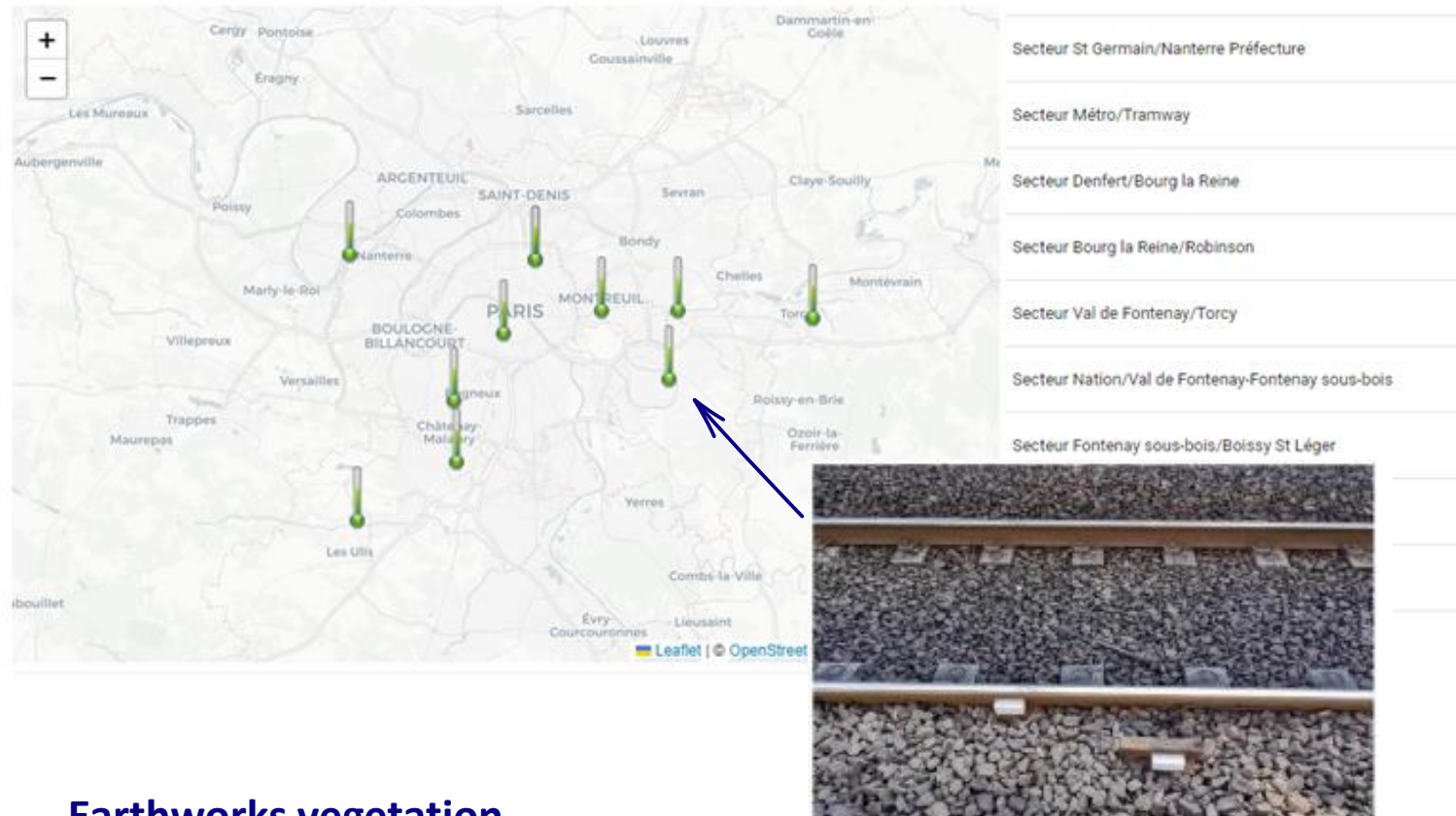


Heatwaves / Drought



Railway track surveillance

- **Rail temperature sensors** dispatched in different locations of our network and linked to a **predictive model** enabling to discriminate different homogeneous temperature zones (HTZ)
⇒ **Targeted temperature speed restrictions when given temperature thresholds are exceeded**
- Additional surveillance to avoid track buckling or wov on specific zones
 - **CWR zones with super reinforced ballast sections (S&C on timber sleepers)** : additional controls
 - **Zones of recent major renovation or renewal works:** cameras for real-time monitoring of the tracks & S&C
- **Specific surveillance of clay and marl zones...**



Earthworks vegetation

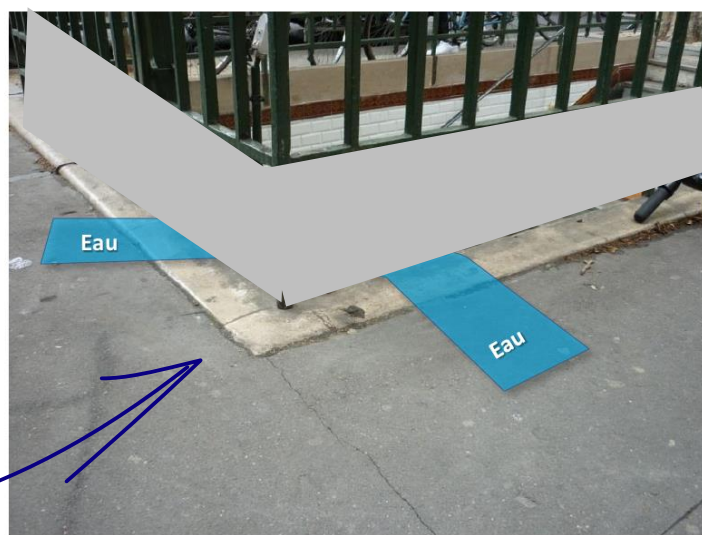
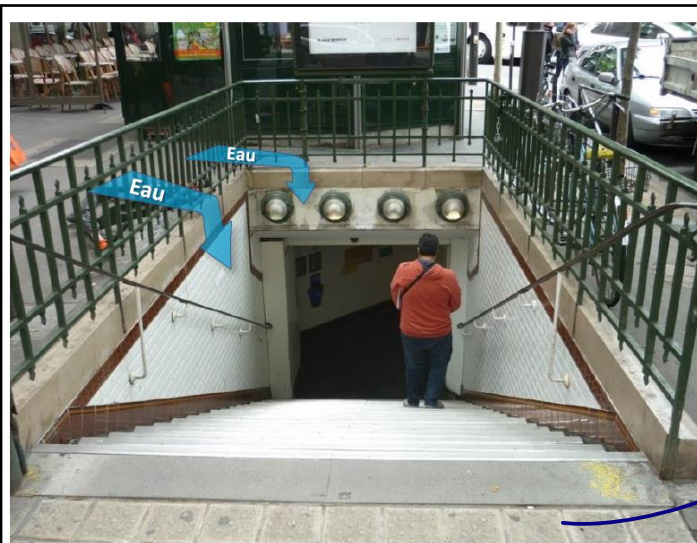
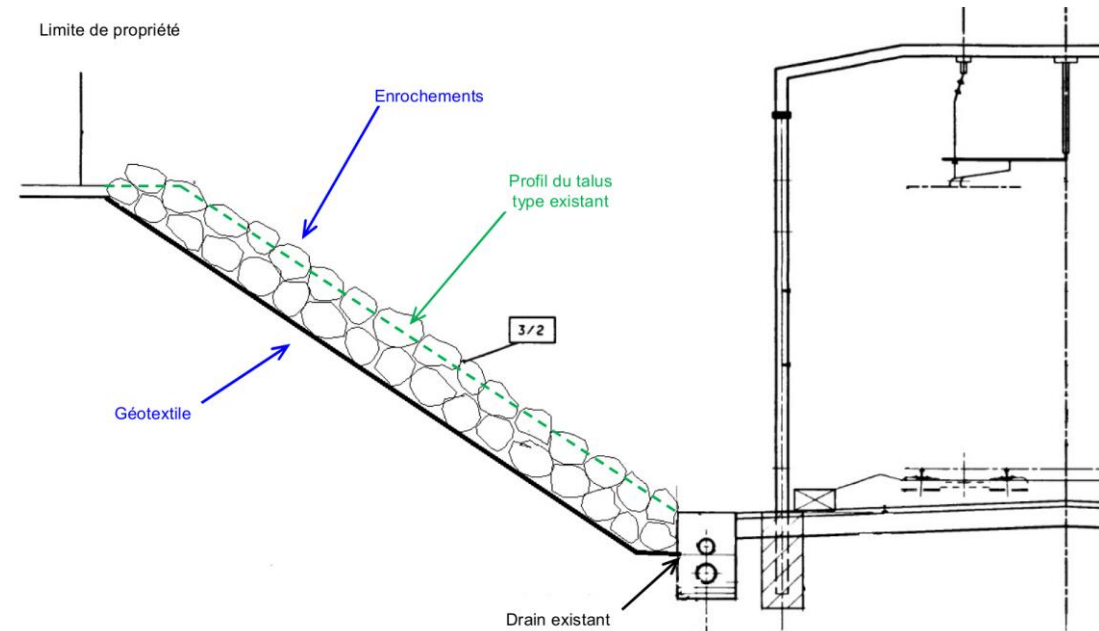
- **Identification and testing of vegetation less sensitive to drought and heavy rainfalls** to avoid superficial instabilities of embankments...

Heavy rainfalls



Adressing the identified vulnerabilities

→ **Civil engineering and water drainage improvement works** around earthworks and around station entrances





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And there's plenty more to come in the future...

Volunteerism for climatic events crisis management through a specific app, Installation of insulating mats under the railway platform in marl & clay zones, Launch of CURATE research project...

Thank you⁺⁺

e : david.courteille@ratp.fr

