COST ACTION TU1405

European network for shallow geothermal energy applications in buildings and infrastructures (GABI)

UNIVERSITY OF CAMBRIDGE

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EUROPEAN COOPERATION IN SCIENCE AND TECHNOLOGY

WG1 – Ground investigation methods

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WG1 OBJECTIVES

WG1 SCIENTIFIC PROGRAM

WG1 WORKPLAN

WG1 COMPOSITION

GABI - Primary objective:

Build a new European network of researchers and engineers to address the challenges of thermoactive geostructures in terms of thermal and mechanical design.

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WG1 OBJECTIVES

- Improve the knowledge on soil thermal characterization (for SGE) at an European level
- State of the art (field and laboratory tests)
- Comparison of different thermal ground investigation methods and different techniques and practices across Europe
- Influence of thermal properties on the performance of geothermal systems (structural effects, energy efficiency….)
- Analysis of scale effects
- Integrated methodologies
- Advances in soil constitutive models taking into account thermal and hydraulic effects (THM analysis)
- Best practice rules for thermal investigation

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WG1 SCIENTIFIC PROGRAM

- Reviewing and comparing ground thermal characterization methods
- Soil thermal conductivity heat models (influence on water content, saturation degree, particle size distribution, void ratio….)
- Compilation of data and information provided by Cost partner countries. Different soil and climate conditions. Different geothermal applications
- Carrying out specific ground tests in the aim of STSM
- Numerical and constitutive modelling of thermo-hydro-mechanical soil behaviour (soil thermal expansion models, dependence of strength on temperature…)
- Assessment of the importance of mechanical effects in SGE
- Assessment of the importance of flow effects in SGE
- Multiphysical soil properties

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WG1 SCIENTIFIC PROGRAM

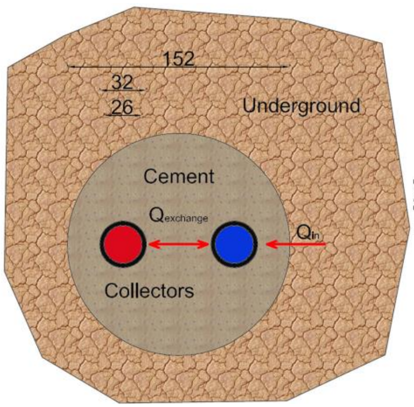
- **Thermal tests**
  - In situ tests
  - Laboratory tests
- **Numerical models**
  - Conduction analyses
  - Thermo-hydro-mechanical (THM) models
  - Plastic, viscous behaviour
  - Advection analyses
  - Saturation
- **Monitoring thermoactive geostructures systems**
  - Temperature fields
  - Mechanical effects

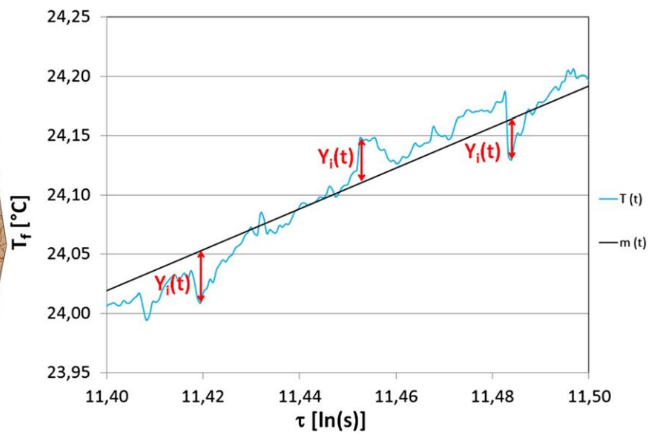
Soil testing

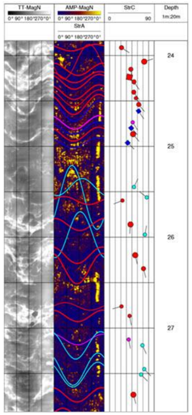
In situ testing

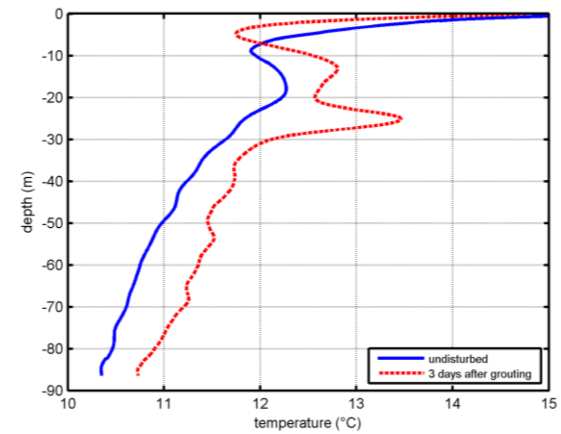
TRT- thermal response tests (standard and distributed):

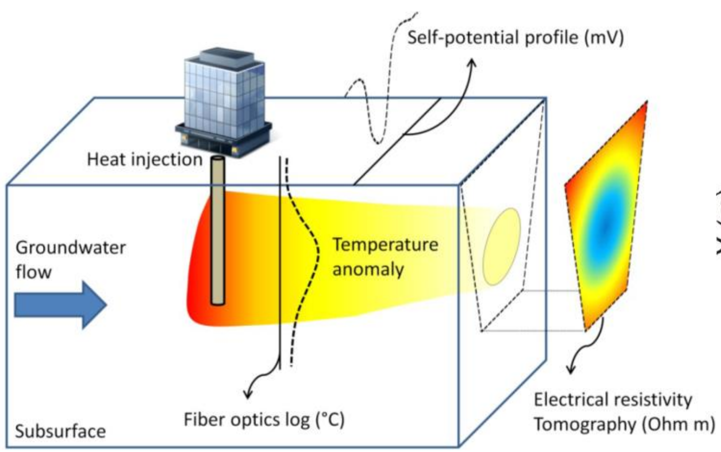
In and Out temperature and continuous measures in boreholes (distributed fiber optics).

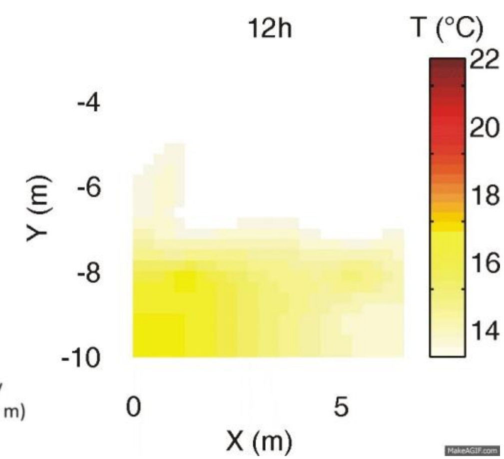












Spatial distribution of temperature:

Emerging geophysical technologies to measure the temperature in the subsurface in a fully non-invasive manner

Hermans et al. (2014), Energies, 7(8).

Soil testing

Laboratory testing

Characterize multiphysical soil behavior (thermal behaviour , thermo-hydraulic behaviour, thermo-hydro-mechanical behaviour).

Evaluate its influence on the thermoactive geostrucutures design (effects induced by the temperature cycles)

Thermal conduction parameters

Standard tests

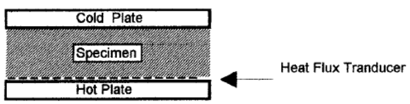


FIG. 1 Apparatus with One Heat Flux Transducer and One Specimen

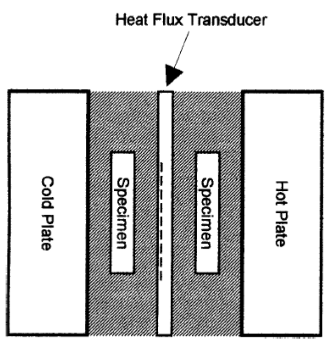
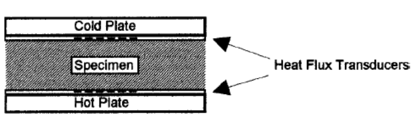


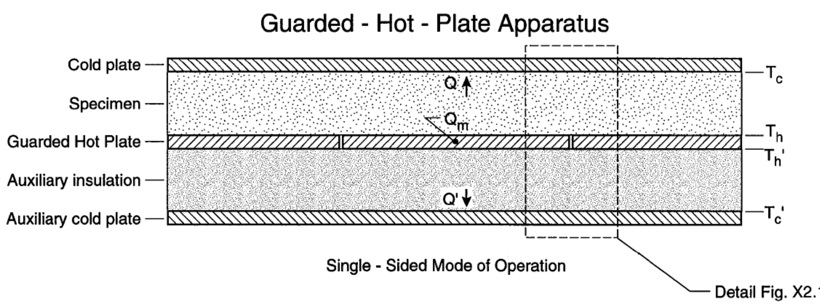
FIG. 2 Apparatus with One Heat Flux Transducer and Two Specimens



Designation: C518 – 10

Designation: C1114 – 06

C1044 – 12



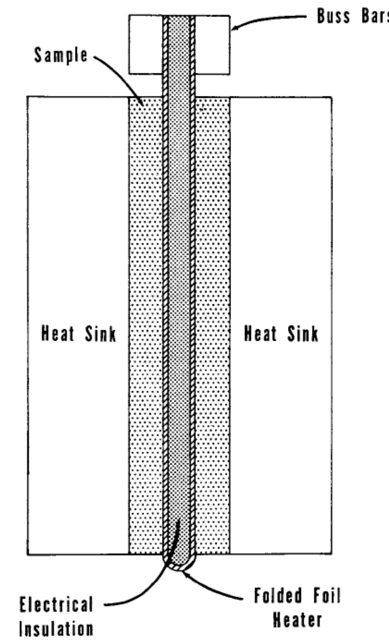


FIG. A1.1 Schematic of the Thin-Foil Heater

Standard Practice for Using a Guarded-Hot-Plate Apparatus or Thin-Heater Apparatus in the Single-Sided Mode[1]

Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Thin-Heater Apparatus[1]

Soil testing

Laboratory testing

Reliability of laboratory tests versus in-situ

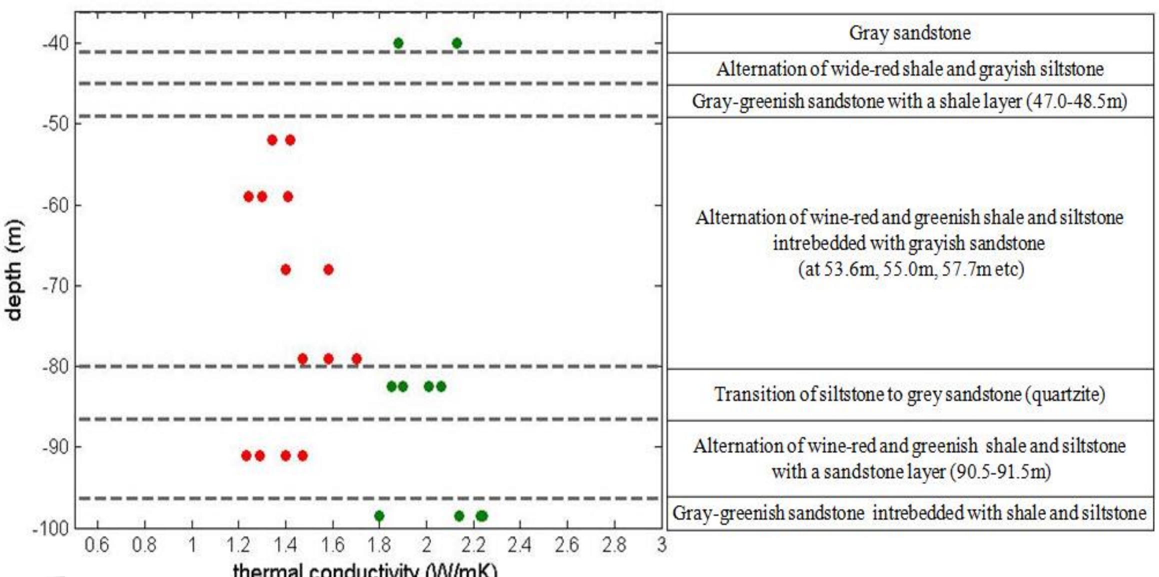
1. Collection of cuttings during drilling for every 5m

2. Preparation of dry samples (oven for more than 24h)

3. Measurement of thermal conductivity, needle probe procedure

$$\Delta T = \frac{Q}{4\pi \cdot \lambda_{meas}} \Delta \ln(t)$$

$$\lambda_{meas} = \lambda_{cutt}^{1-n} \cdot \lambda_{air}^{n}$$



B1	Geosolid 235	λ=2.35 W/mK
B3	Geosolid 235	λ=2.35 W/mK
B4	Admixture with graphite	λ=2.46 W/mK

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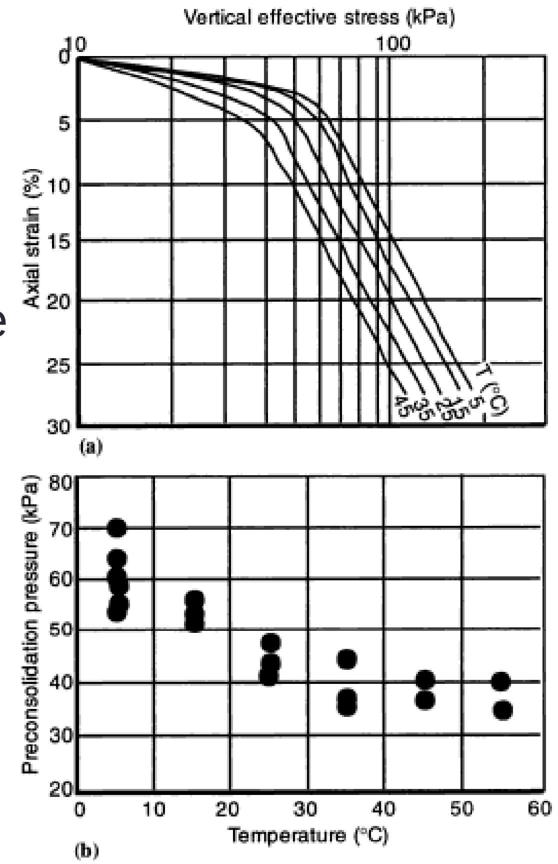
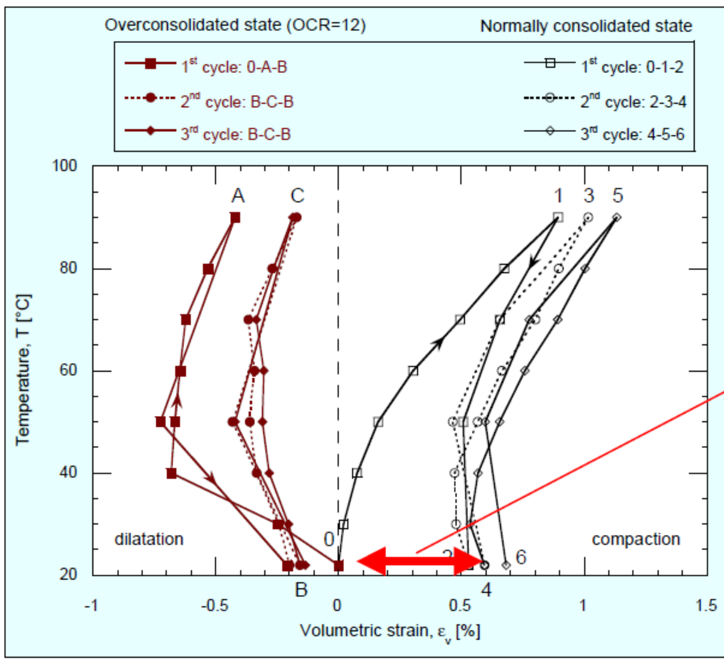
Soil testing

Laboratory testing

Testing in Non-isothermal Conditions

To investigate the effect of temperature on mechanical and hydraulic soil behaviour.





Heating-Cooling cycles

Irreversible thermal strains: Thermo-Plasticity

Thermal cycle on Kaolin clay under constant isotropic compression

(after Cekerevac & Laloui, 2005)

Laloui & François (2008)

Several studies on temperature effects in soft clays compressibility (Marques et al., 2002).

"*With increasing temperature the soil becomes more compressible in overconsolidated domain and the entire compression curve moves towards lower effective stresses*"

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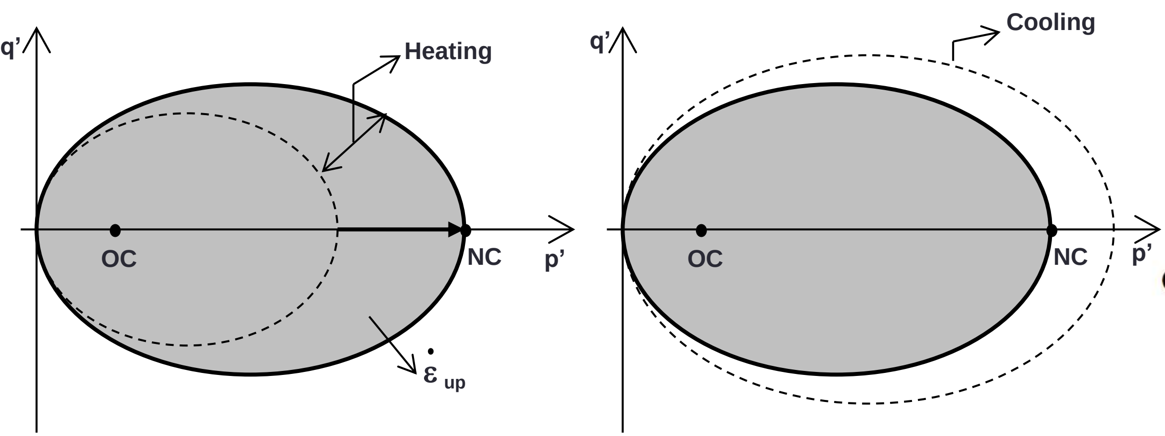
WG1 SCIENTIFIC PROGRAM

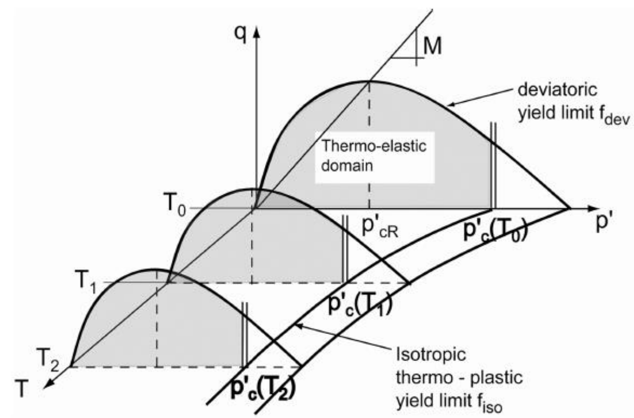
Numerical models

Constitutive models



$$p'_c = p'_c(s,T)\exp\left(\beta\,\varepsilon_v^p\right)$$

Advanced Constitutive Model for Environmental Geomechanics – Temperature (ACMEG – T Model)
François & Laloui (2008), *Int. J. Numer. Anal. Meth. Geomech.*



Thermo-hydro-mechanical (THM) coupled analysis

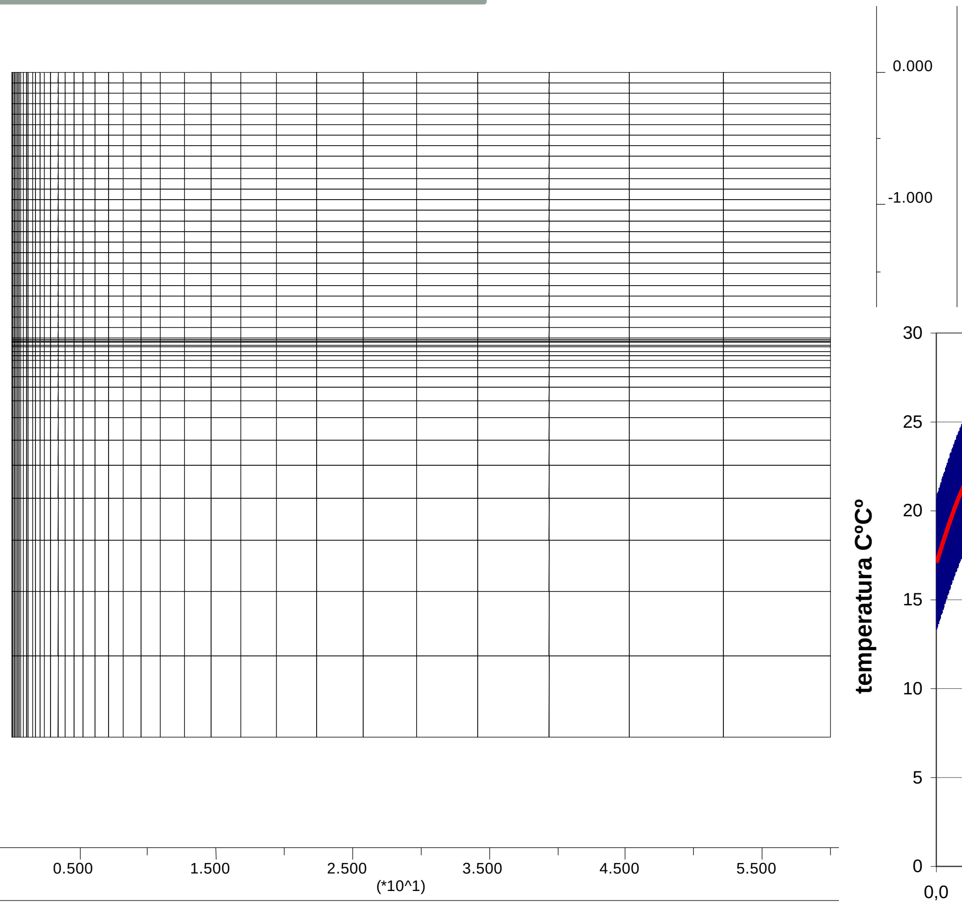
Simple and advanced thermoplastic models

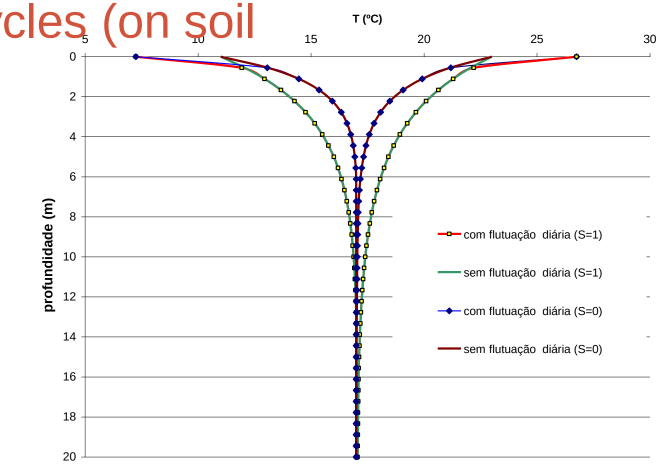
Importance of partial saturation

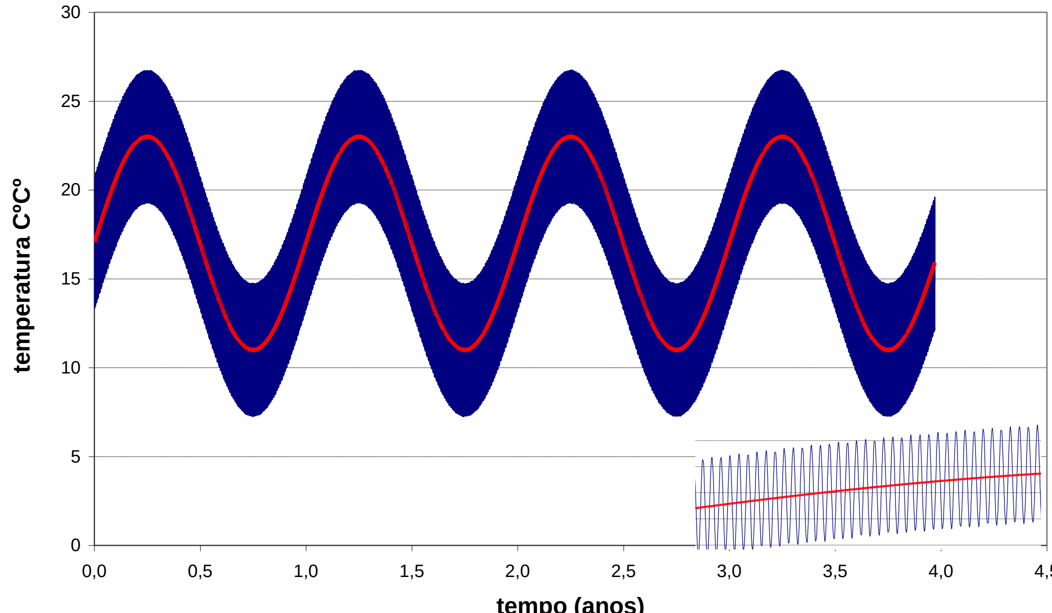
Numerical models

Coupled analyses

Effects induced by the thermal cycles (on soil and thermoactive structure)







Lisboa, Portugal
Clique em um mês para obter mais detalhes. Os detalhes dos dias, para o mês selecionado, aparecem abaixo.

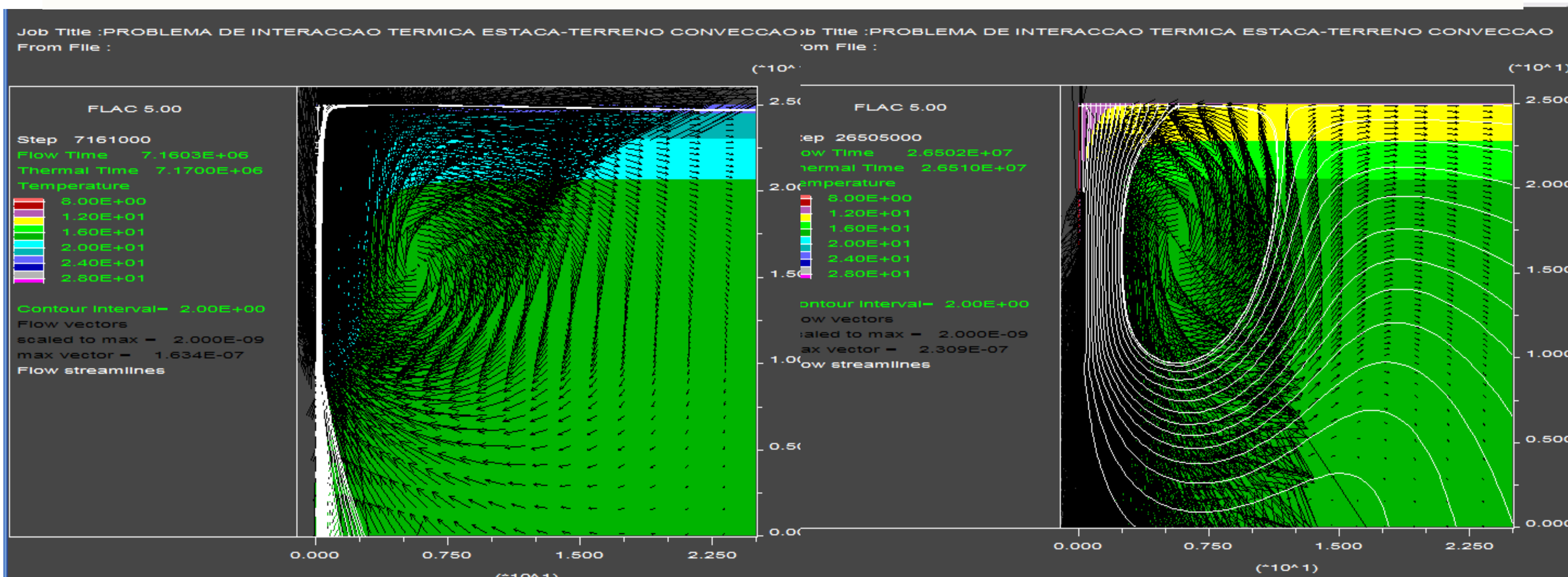
	Jan	Fev	Mar	Abr	Mai	Jun	Jul	Ago	Set	Out	Nov	Dez
Máximas	14°C	16°C	17°C	19°C	22°C	24°C	27°C	28°C	26°C	22°C	18°C	14°C
Mínimas	8°C	9°C	9°C	11°C	13°C	16°C	17°C	17°C	17°C	14°C	11°C	9°C
Média	11°C	12°C	14°C	15°C	17°C	20°C	22°C	23°C	22°C	18°C	14°C	12°C
Precip.	109 mm	112 mm	69 mm	64 mm	38 mm	20 mm	5 mm	5 mm	25 mm	81 mm	114 mm	109 mm

Numerical models

Advection analyses

Hydrostatic water pressure conditions (influence of permeability change)

Advection currents induced by the change of water density with temperature



Negligible influence on the temperature distribution
and on the thermal fluxes for k=1e-8 – 1 e-

(Vieira and Maranha, 2012)

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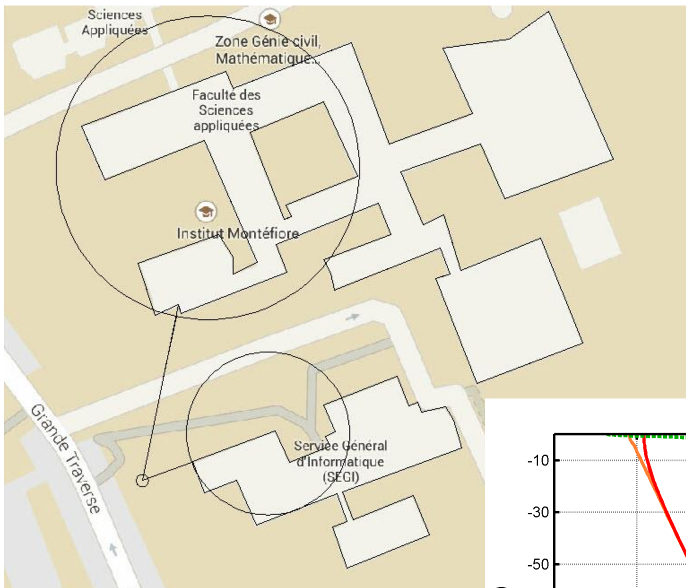
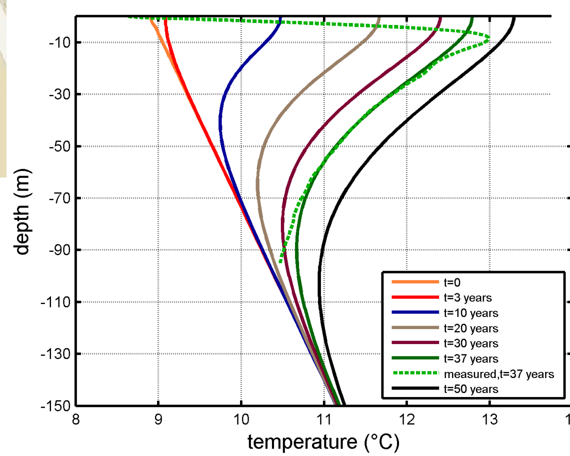
Soil testing

Numerical analyses

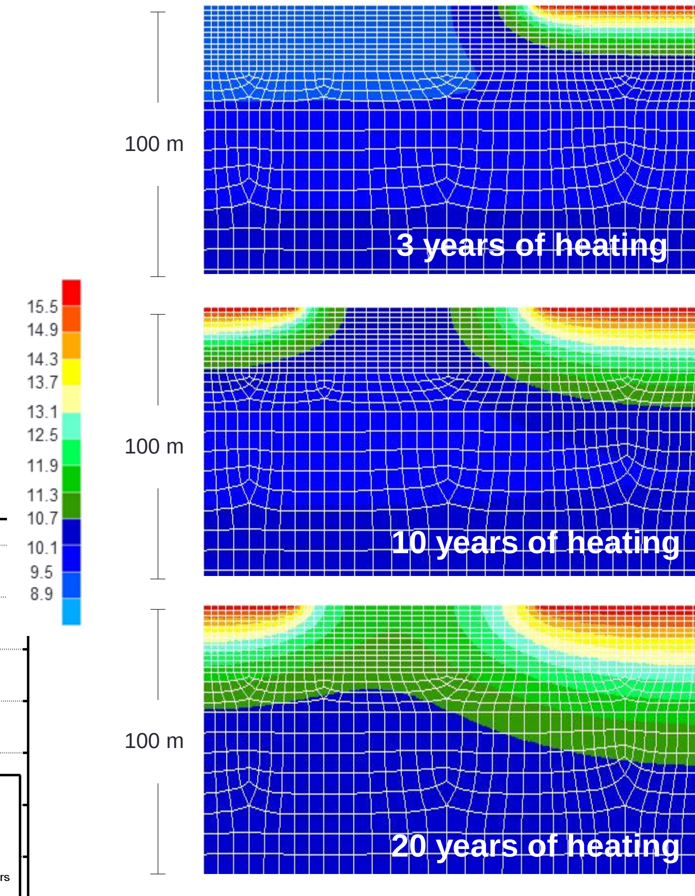
Interactions between BHES with structures:



- 2D axisymmetric model
- Simulating heat loss through SEGI and Montéfiore



Undisturbed ground temperature



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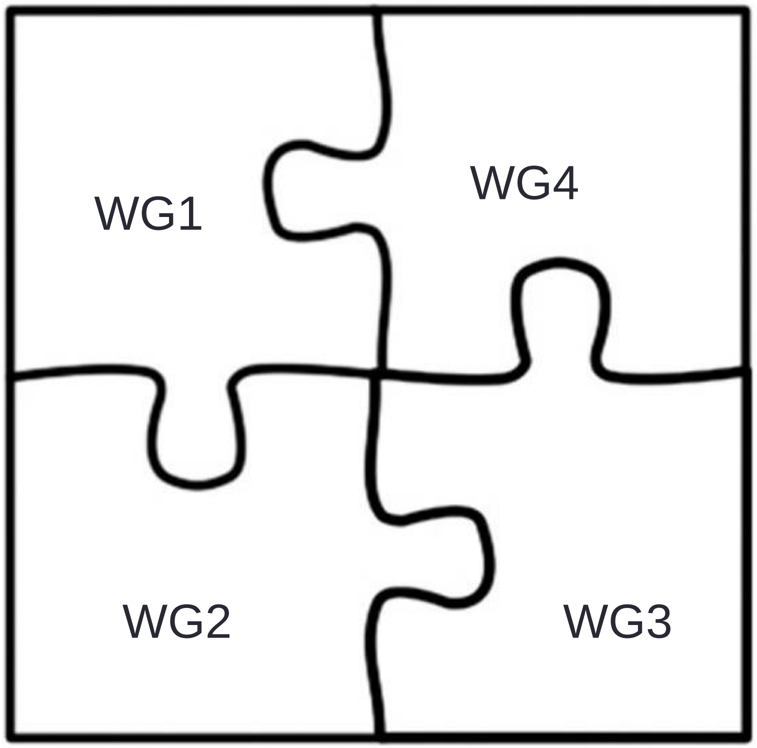
WG1 WORKPLAN

Cooperation with other working groups



WG1 – thermal ground investigation methods
WG2 – energy performance assessment
WG3 – sustainability and urban planning
WG4 – thermoactive geostructure design

In close cooperation with WG4. The structural and thermal performance of thermoactive geostructures (interaction effects soil/structure).

Other research themes….

Furthermore, it will be necessary to interact with WG2 and WG3. Energy performance and sustainability analysis depend on the soil behaviour. The results of experiments and of real case studies…

The synergy with the WG2 and the WG3 is essential in order to have a full understanding of the system's performance.

Sharing of databases….

cost
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WG1 WORKPLAN

Deliverables

•The key tools for disseminating the scientific achievements are the joint publications in peer-reviewed journals, book chapters, workshops and communications to international conferences.

•Mailing lists for the committees and members of WGs will allow information exchange at each level.

•Technical news and highlights will be delivered in the Action periodic newsletter.

•Training will be covered by schools plus lectures given by leading scientists during the Action meetings.

•Non-technical articles, press releases and invitations for media exposure (when appropriate) will contribute to dissemination to the general public.

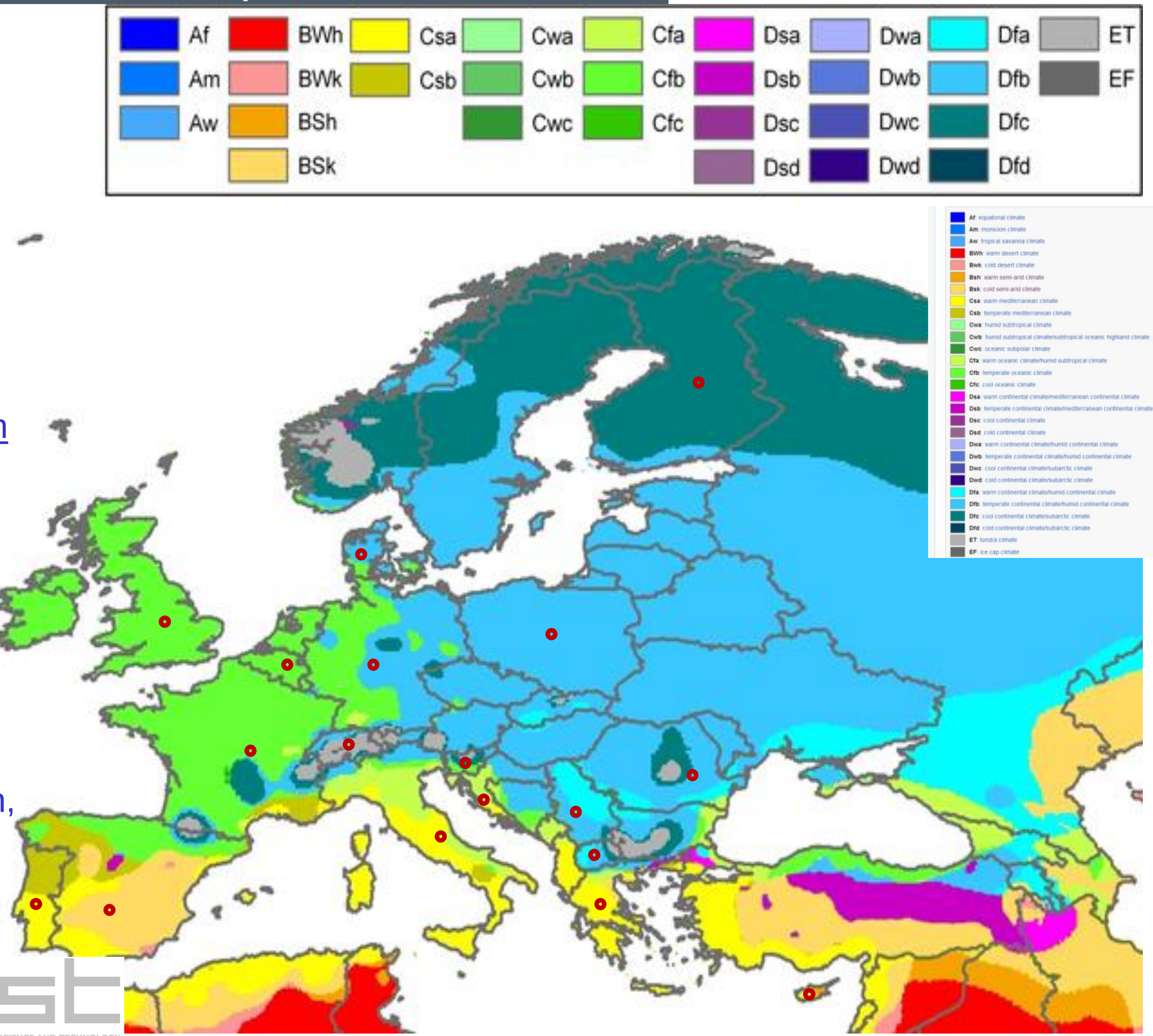
•The annual reports will cover the dissemination activities.

•These reports are in fact dissemination tools themselves and will be made publicly available through the Action website.

•The dissemination plan can be updated if necessary in order to strengthen specific methods, as well as to introduce new measures. Moreover, the outreach strategy will be adapted to arising needs, like that to improve internal and external communication processes.

Cost action Composition

https://commons.wikimedia.org/wiki/File:Europe_Koppen_Map.png



19 countries involved in the Action:

Belgium, Bulgaria, Croatia, Cyprus, Denmark, Finland, France, Germany, Greece, Italia, Poland, Portugal, Romania, Serbia, Slovenia, Spain, Switzerland, United Kingdom, FYR Macedonia

Cost action: WG1 Composition

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