LSCE, Cast3M code

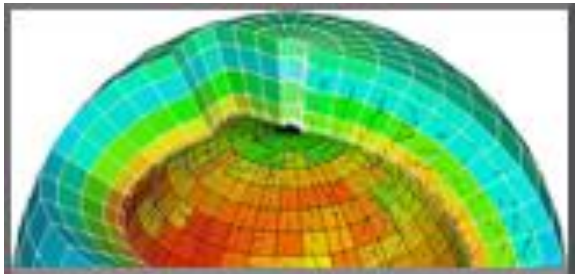
C. Grenier, N. Roux, E. Mouche

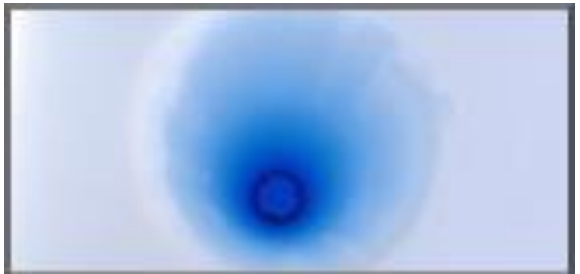
F. Costard

LSCE (Laboratoire des Sciences du Climat et de l'Environnement)

GEOPS, Univ. Orsay

LSCE activities


Modélisation du Climat et des Cycles Biogéochimiques


Dynamique et Archives du Climat


Composition Atmosphérique et Flux de Surface


Transferts et Traceurs dans l'Environnement


ICOS


Intéractions Homme-Climat-Environnement

Cast3M (www-cast3m.cea.fr)

- Finite Element code developed at CEA (French Atomic Energy Commission) for Nuclear Reactor applications (mechanics, fluid mechanics, heat transfer …)
- Since the end of the 90s, equations of transfer in porous media included with MHFE and FV numerical schemes
  - Flow (Darcy, Richards, two phase)
  - Transport (Lagrangian, Eulerian)
- Reference code for Nuclear waste storage applications

Coupled TH model, Cast3M code

– Water budget

$$\left(S_w \frac{\partial \epsilon \rho_w}{\partial \rho}\right)\frac{\partial p}{\partial t} = \nabla.\left[\rho_w K_w \vec{\nabla} p\right] + \nabla.\left[\rho_w K_w \vec{\nabla} z\right] - \left(\epsilon(\rho_w - \rho_i)\frac{\partial S_w}{\partial T}\right)\frac{\partial T}{\partial t}$$

– Heat budget

$$\left(\rho_w S_w C_w \epsilon + \rho_i S_i C_i \epsilon + (1-\epsilon)\rho_s C_s + \epsilon \rho_i L \frac{\partial S_i}{\partial T}\right)\frac{\partial T}{\partial t} = \nabla.(\lambda_t \nabla T) + \nabla.\left[\rho_w c_w T.\vec{\nabla} p + \rho_w c_w T.\vec{\nabla} z\right]$$

Coupled TH model, Cast3M code

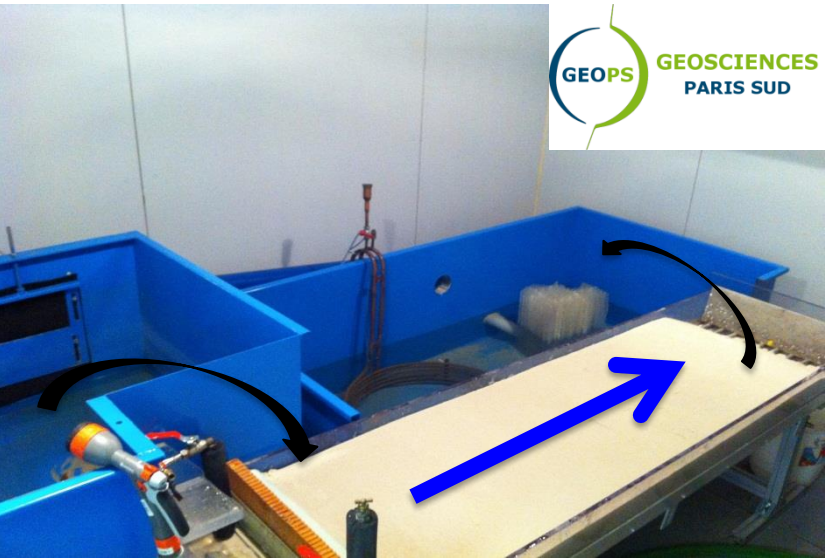
- Time discretization: ***fully implicit*** and constant time step
- ***Picard scheme*** (interate between both equations until distance between two successive p and T fields are below threshold)
- ***Under-relaxation*** scheme to stabilize resolution of heat equation
- ***FV*** were preferred proving more robust than MHFE

Cold regions hydrology at LSCE

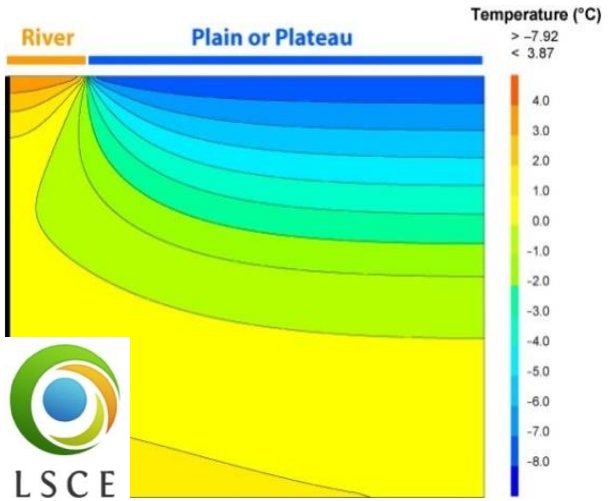
- On the longer term
  - Include Richards equations
    - How good Richards compares with three-phase (air, liquid water, ice)?
  - Support studies involving water bodies in Yakutia (2D / 3D)
  - Consider evolution of thermokarstic systems (geometrical changes)

Study of river taliks & their evolution in the context of climate change (N. Roux phD work)

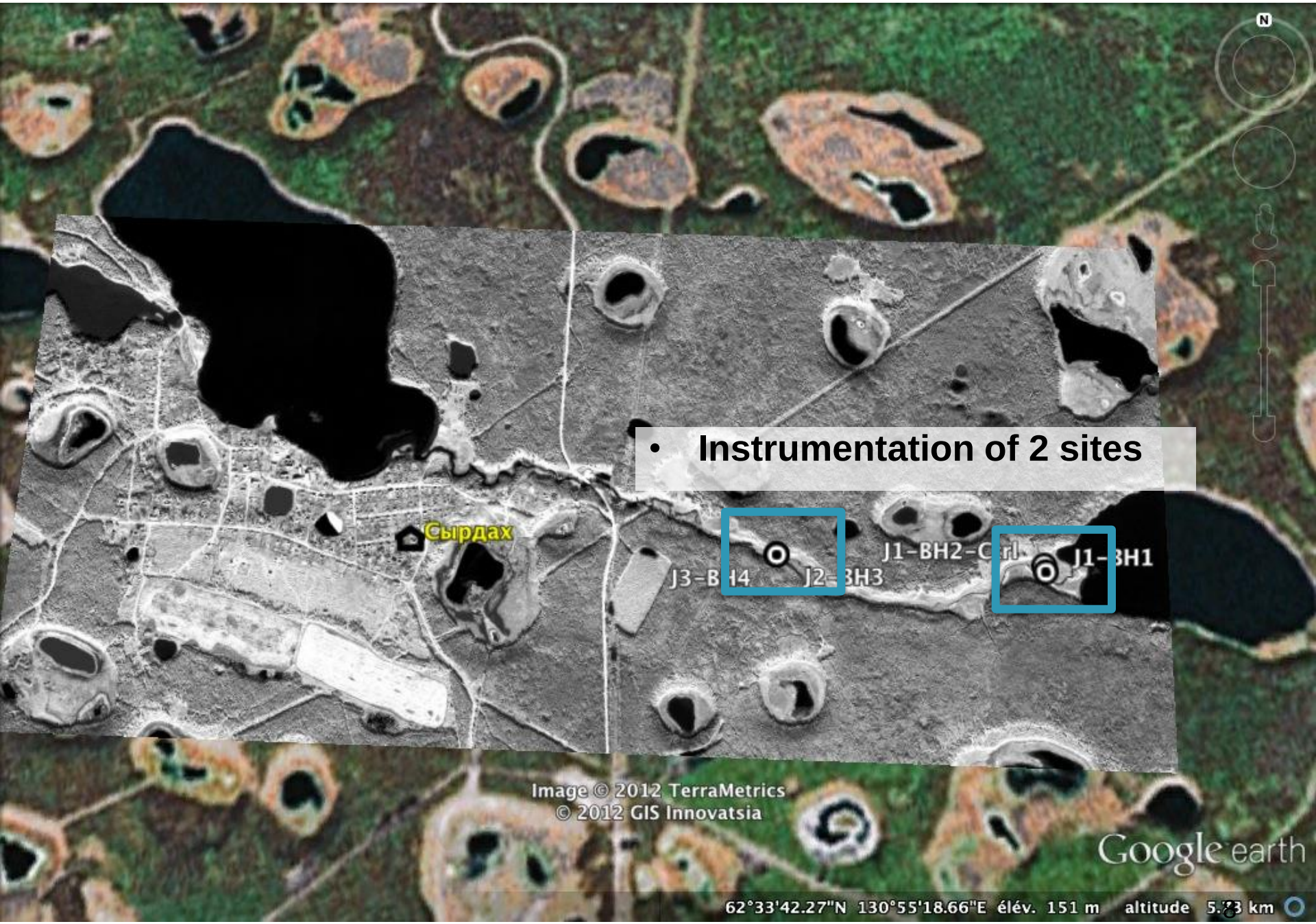
- Collaboration Univ. Orsay and Permafrost Institute (Yakutsk, Siberia)
- Approach coupling
  - Field work (Lena river and Alas valley in Yakutia, Sibéria),
  - Numerical simulation,
  - Analogical simulation in cold room.

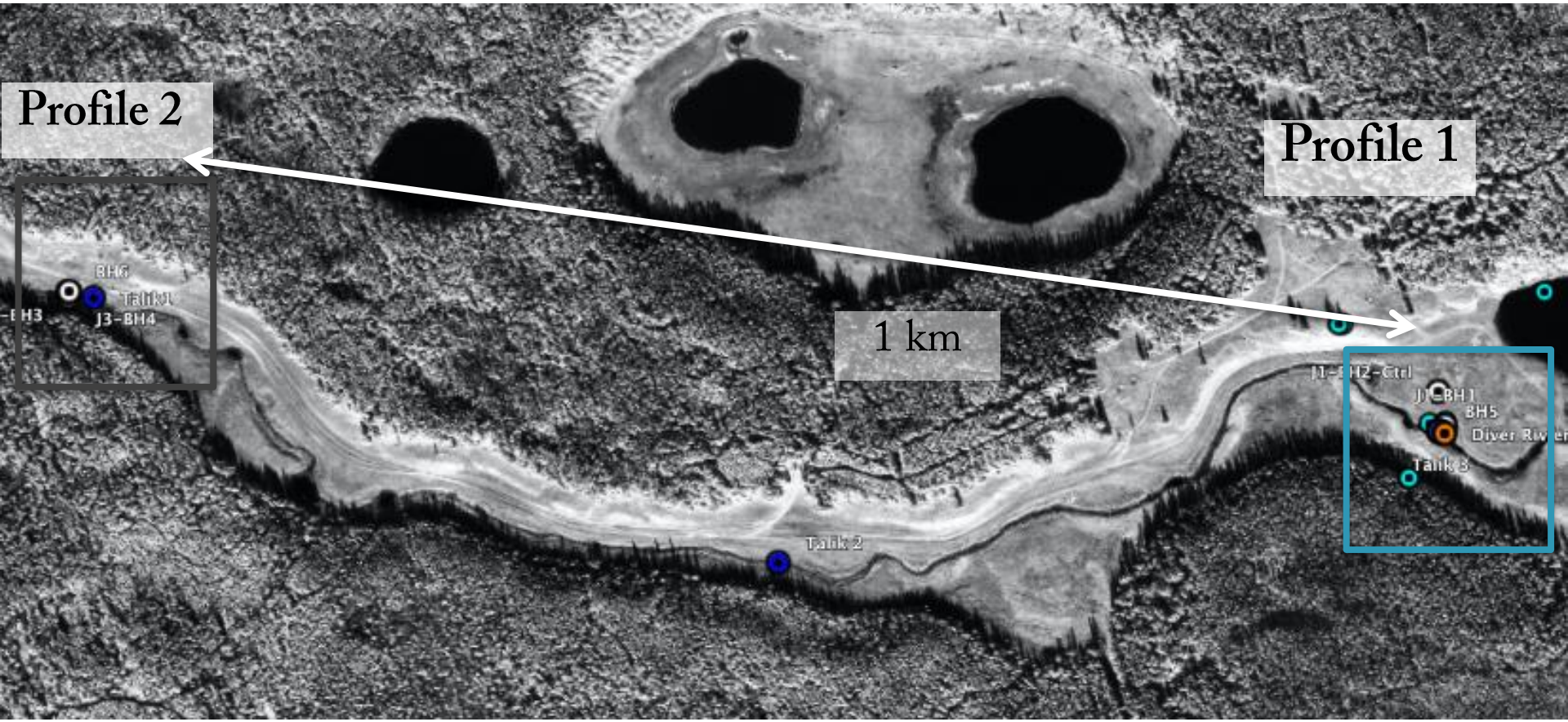


GEOPS GEOSCIENCES PARIS SUD

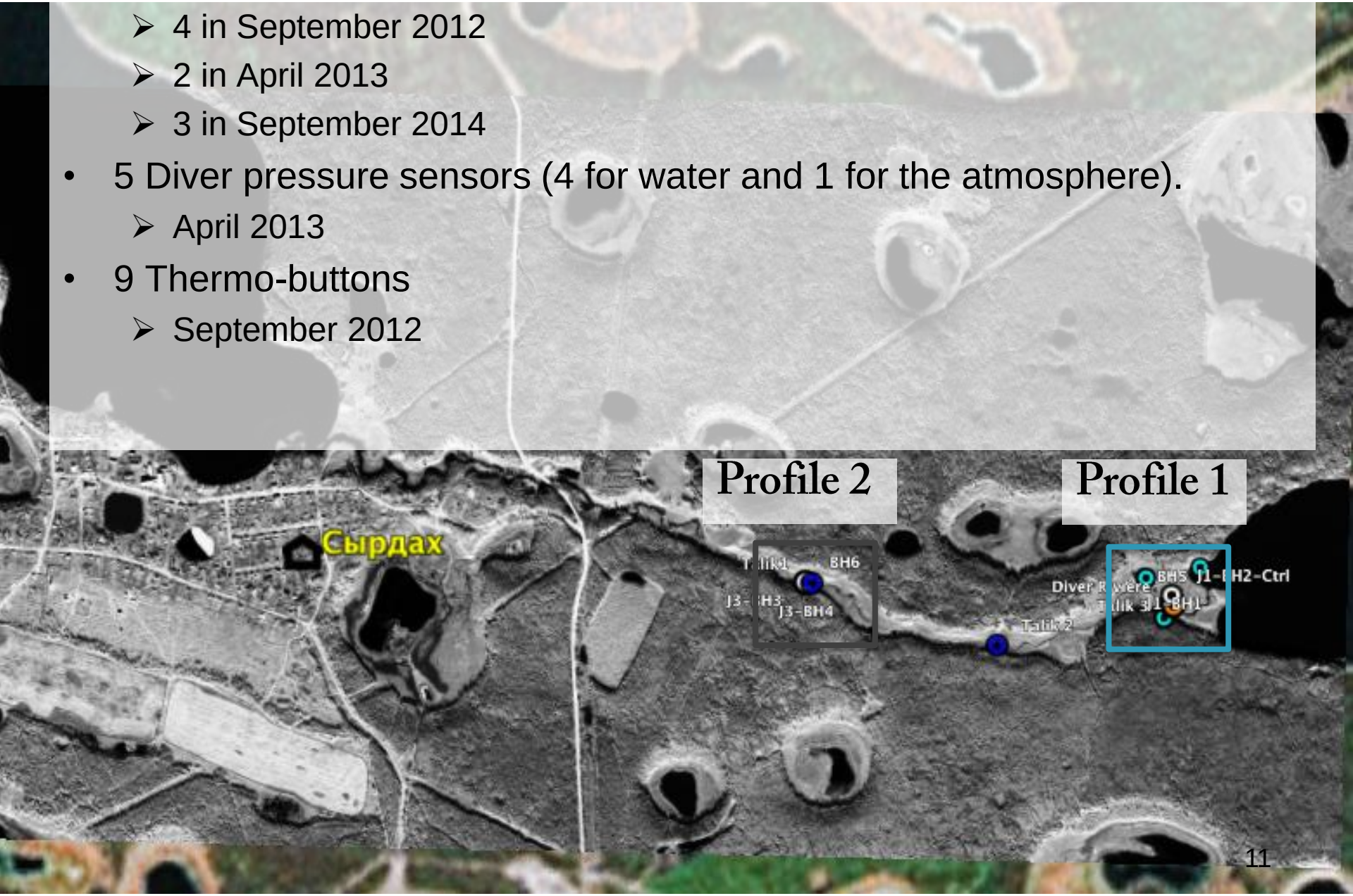


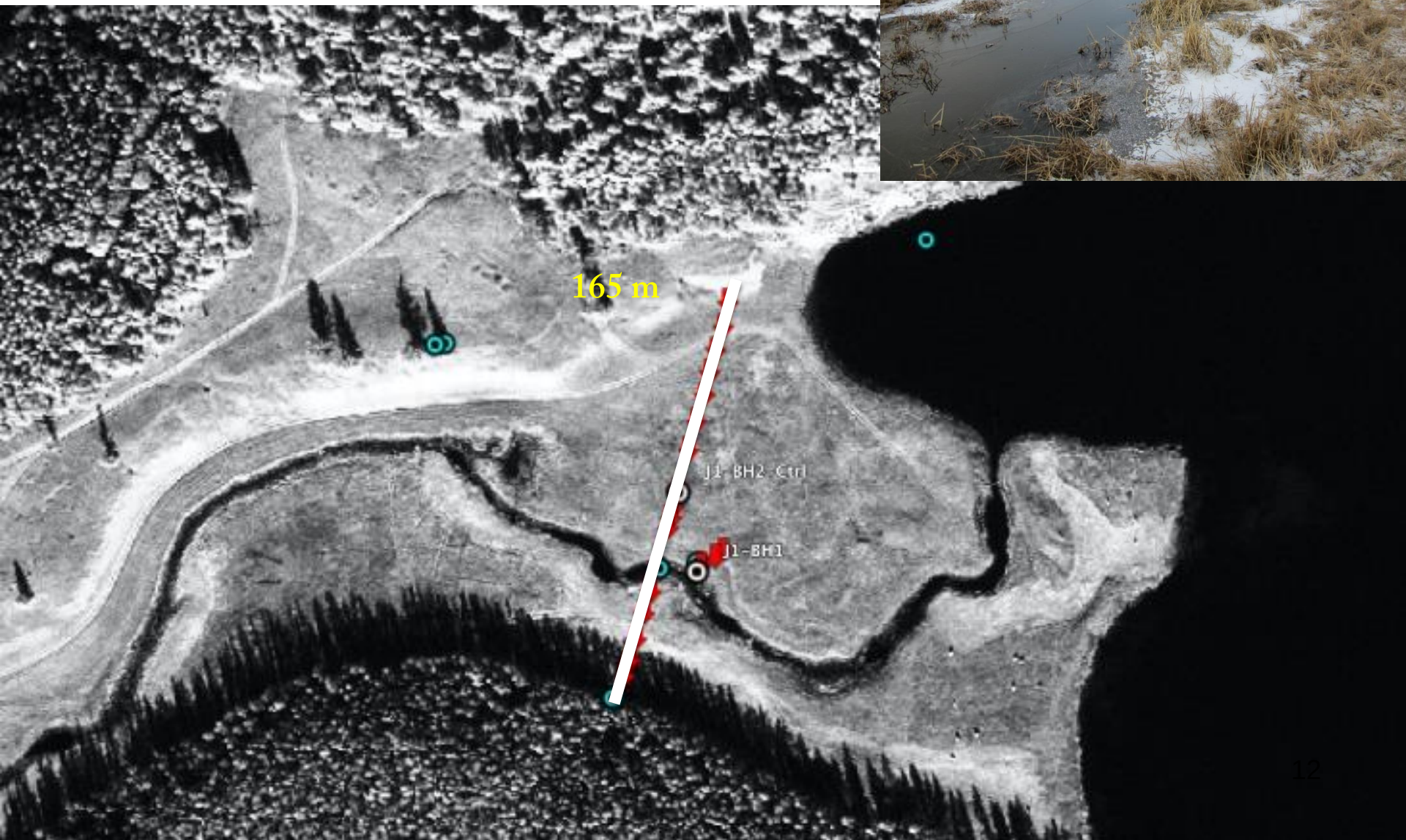
LSCE

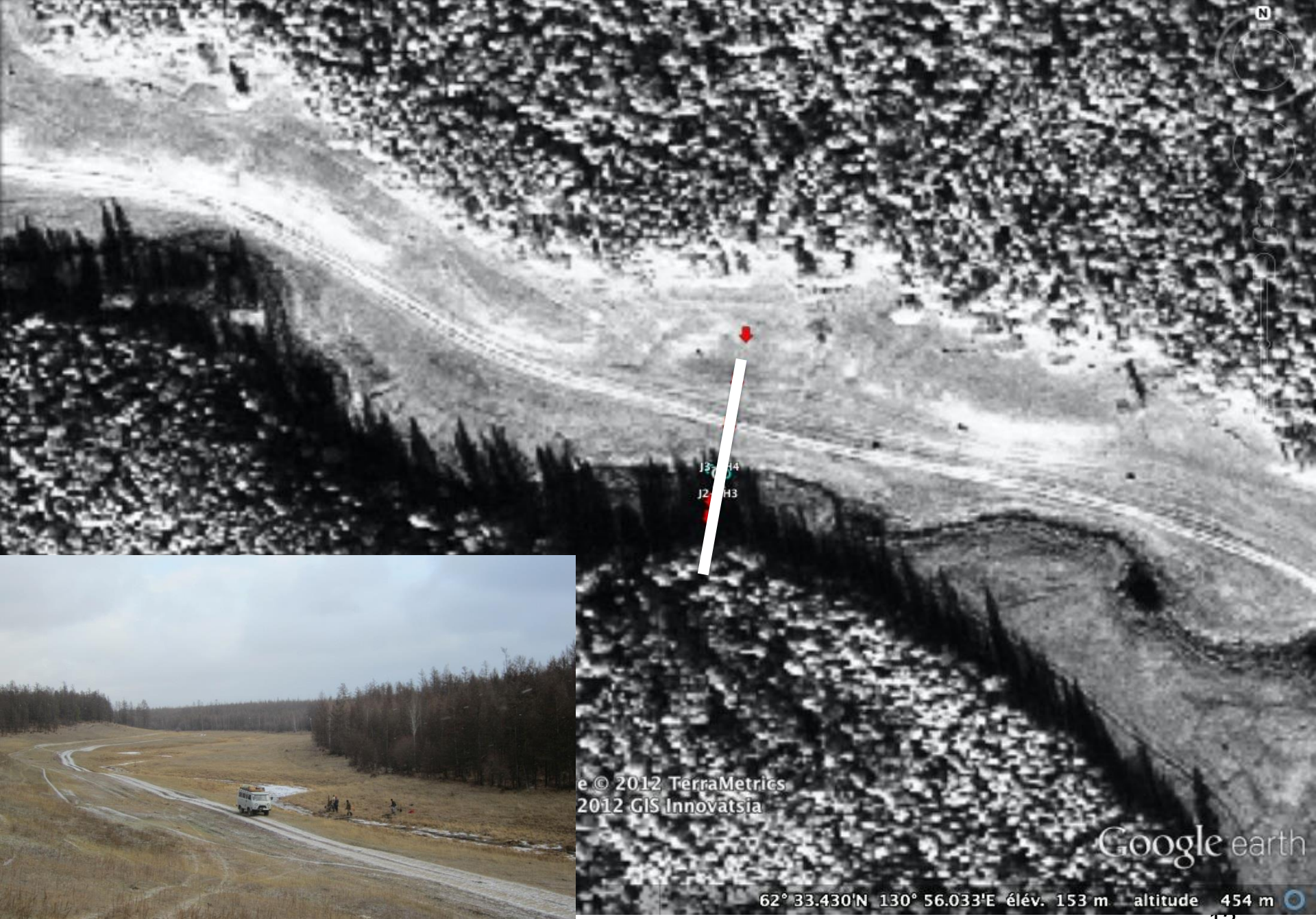

• Instrumentation of 2 sites
Сырдах
J3-BH4
J2-BH3
J1-BH2-Grl
J1-BH1
Image © 2012 TerraMetrics
© 2012 GIS Innovatsia
Google earth
62°33'42.27"N 130°55'18.66"E élév. 151 m altitude 5.23 km

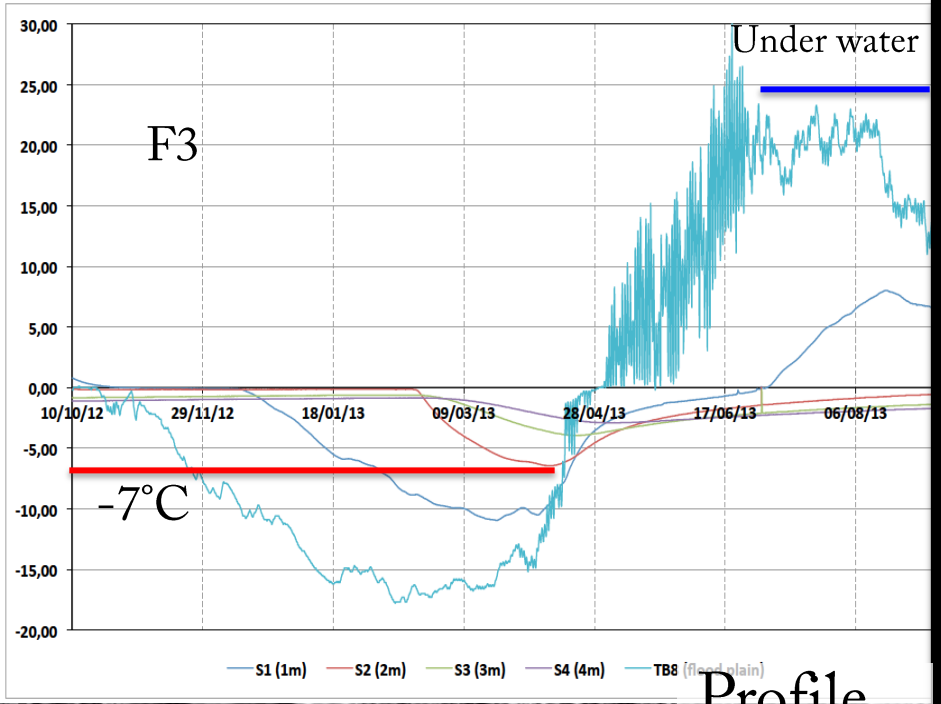

Profile 2
Profile 1
1 km
BH6
J3-BH4
Tank 2
Tank 3
BH5

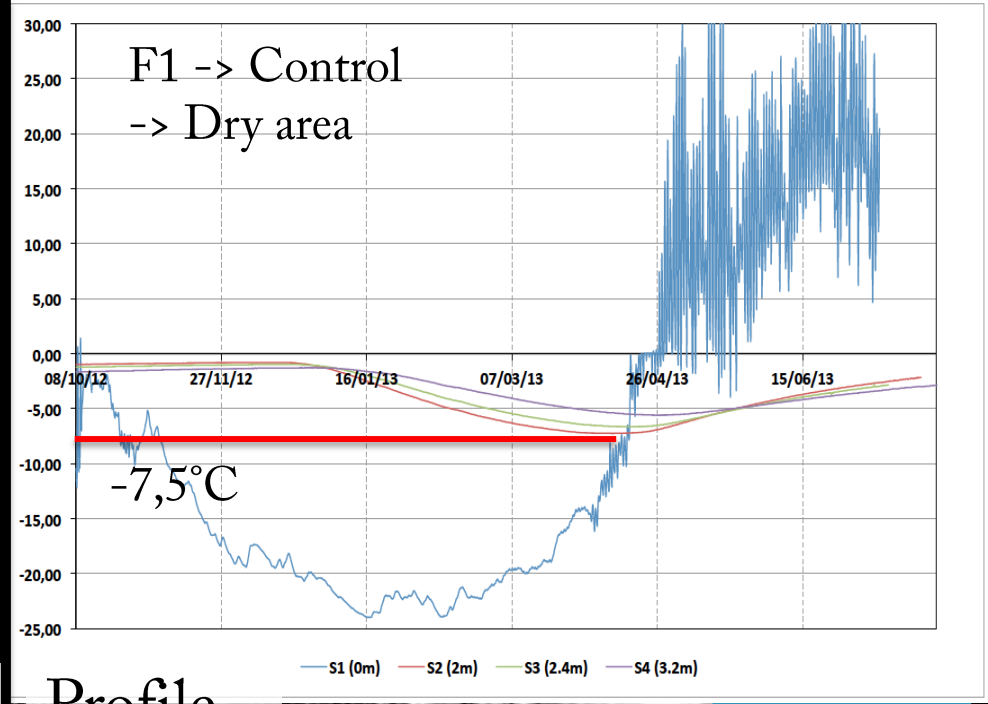
- Installation of 9 (10) HOBOs dataloggers.
  - 4 in September 2012
  - 2 in April 2013
  - 3 in September 2014
- 5 Diver pressure sensors (4 for water and 1 for the atmosphere).
  - April 2013
- 9 Thermo-buttons
  - September 2012




165 m
J1-BH2 Ctrl
J1-BH1


e © 2012 TerraMetrics
2012 GIS Innovatsia
Google earth
62° 33.430'N 130° 56.033'E élév. 153 m altitude 454 m





Profile 2

Profile 1