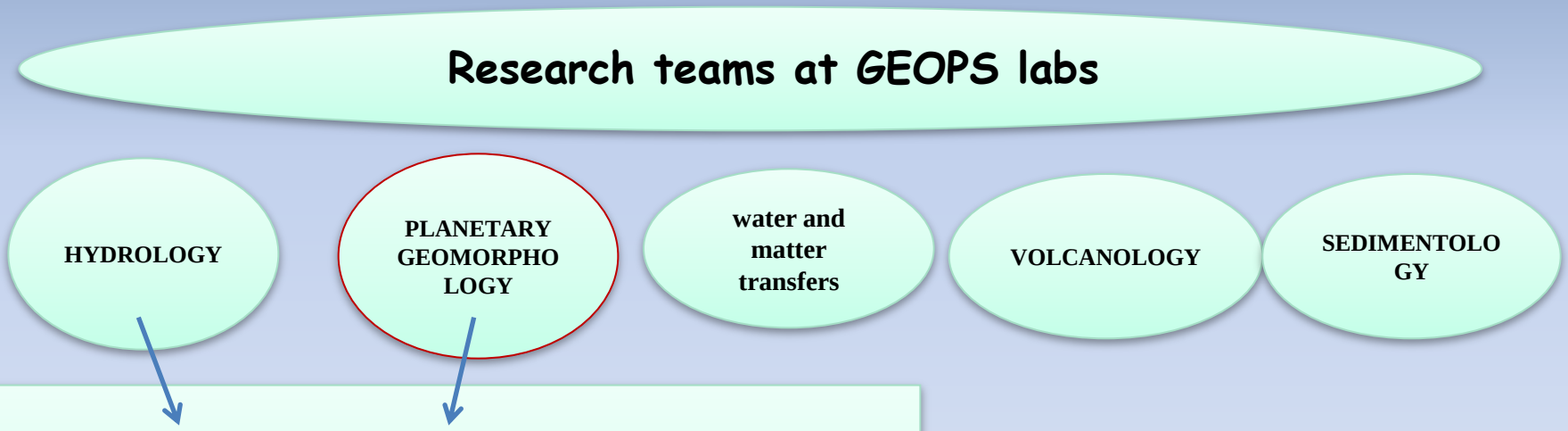
Cold room facility at Orsay (GEOPS)

François Costard
GEOPS, University Paris 11 & CNRS, France

GEOPS

- GEOPS is a Earth Sciences interdisciplinary laboratory from University Paris Sud 11 and CNRS
- 60 permanent people (33 researchers +24 ing-Tech)
- « Young » lab (created in July 2004)
- Average age : 43 years old
- 9 mass spectrometers

Research team « Arctic Environment » since 2010 - GEOPS



ARCTIC ENVIRONMENT

Researchers: Costard F., A. Sejourne; Dupeyrat L., Marlin C., Saintenoy A., Pessel M. Gargani J.

PhD students : Delangle E., M Quenet, N. Roux.

GEOPS GEOSCIENCES PARIS SUD

Main topics of our team:

- Impact of the recent global warming on thermal process (fluvial thermal erosion and thermokarst)
  - heat transfert modelling (hiérarchisation of parameters)
  - erosion rate (field measurments)

- Heat exchange between water and permafrost for arctic and subarctic environment (rivers, lacs)

- On going research programs :
  - Fluvial dynamic of the Lena river
  - Thermokarst evolution → Antoine Sejourné
  - Talik evolution → Nicolas Roux and Ch. Grenier

Methodoloy used since 1992

Field data

IGEOPS- LGP

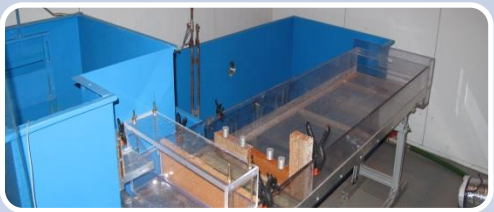
Sibérie, Spitsberg

Observations

Mesures (météo, T air-eau-pergélisol, débits, physico-chimie, piézométrie, GPR, nivellement)

Prélèvements

Laboratory



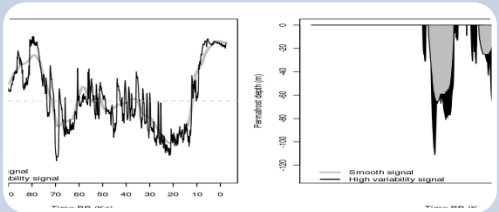
GEOPS- M2C

Chenal hydraulique en chambre froide

GPR,

scanner laser (ERM)

Numerical modeling



GEOPS, LSCE

Modélisation

Approche comparative Terre Mars

Chgt. phase

grande échelle, passé présent et futur,

J. Aguirre-Puente

L. Dupeyrat

Ch. Grenier

Physical modeling: cold room facility overview

2 cold chambers (-40°C; -20°C

Hydraulic channel: talik simulation

Laser scaning

Ice wedge simulation

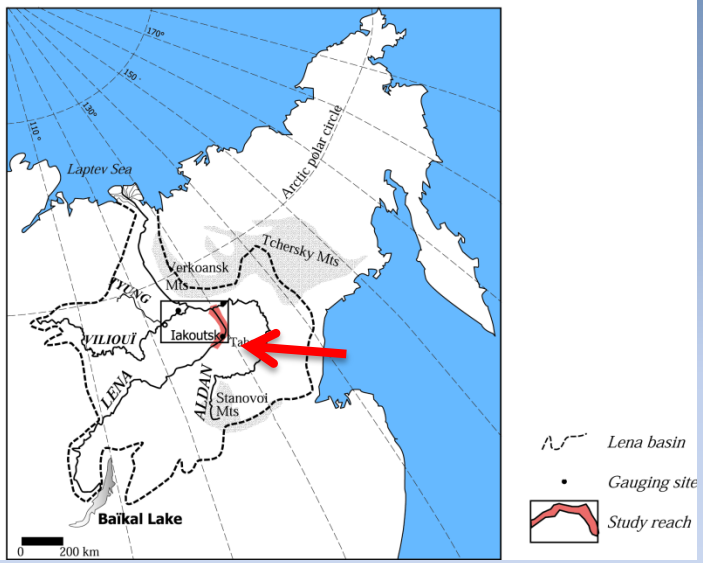
Thermokarst lakes in Yakoutia

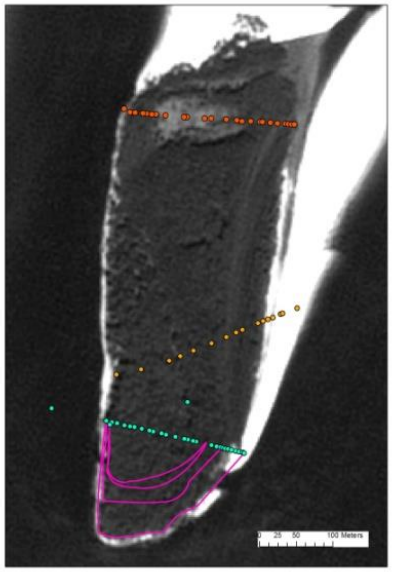
Researcher : A. Sejourne geologist

- Méthode:
  - Etude de terrain 2010 & 2012
  - Image haute résolution GeoEye (50 cm/pixel)
- Développement cyclique annuel de 1-2 m [*Séjourné et al., en révision*]
- En relation avec le climat

Thermocirque actif

Impact of the global warming on the Dynamic of the Lena ice break ups
Program CLIMAFLU (2008-2011)





Erosion rate : 20 – 43 m.yr^{-1}

Measuments each year on the field

Data loggers

Objective

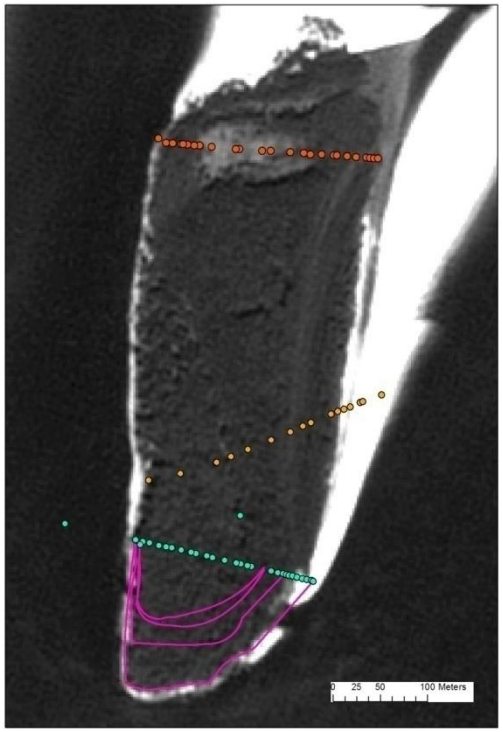
Dynamic and impact of the ice breakups on the Lena river :

1. *general lack of data and detail records about the impact of the breakup for most Siberian rivers*

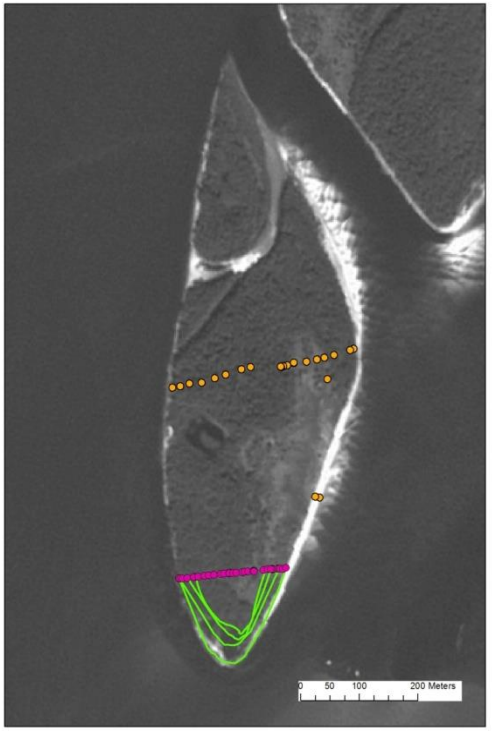
2. *many questions remain open about the initial stages of the ice breakups :*

    - *timing of the submersion of the islands,*
    - *inter-annual variability of the ice breakups*
    - *impact on erosion rate of frozen islands*
    - *What are the main parameters controlling the erosion of islands ?*
    - *duration of the active fluvial thermal erosion during the breakup*

3 instrumental sites

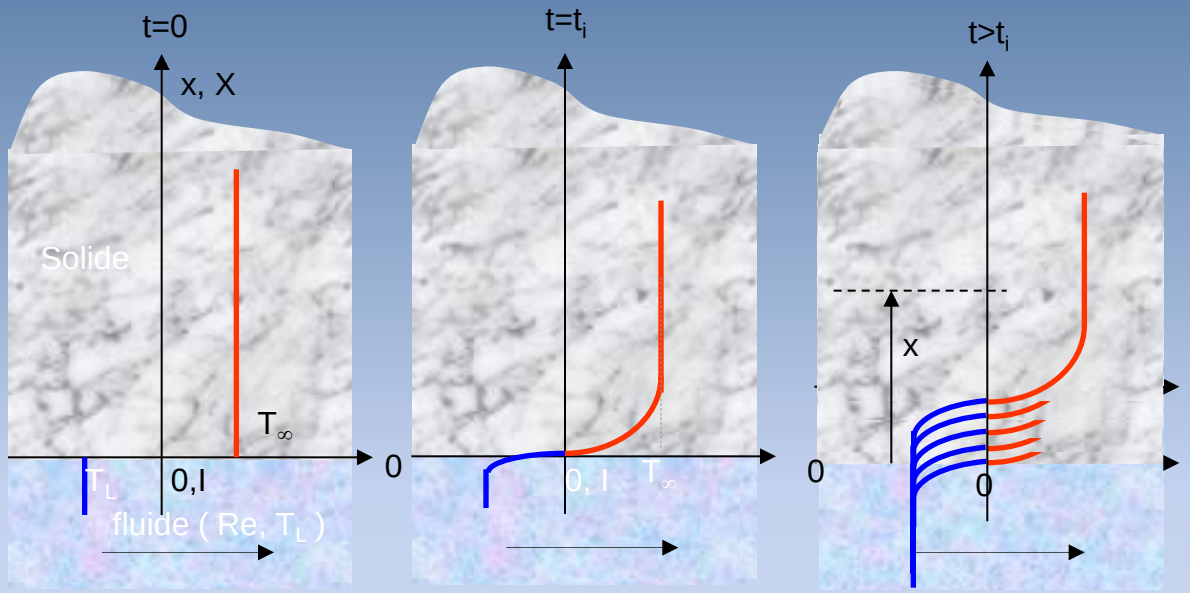


Timoshka



Eselyak

MODELE D'ABLATION A TAUX CONSTANT



Contact solide-fluide
Solide isotherme T_∞

Début de la fonte du solide : l'interface a atteint la température de fusion .

Fonte du solide

On suppose que :

$$V_a = \frac{\partial s}{\partial t} = cte$$

Profil thermique T(X,t) dans le solide n'est pas fonction du temps

T(X,t) subit une simple translation de $V_a t$

Vitesse d'ablation

$$V_a = \frac{h(T_L - T_f)}{\rho L + \rho C_p (T_f - T_\infty)}$$

Profil thermique dans le solide

$$T(X,t) = (T_f - T_\infty)\exp\left(-\frac{\rho C_p V_a}{k} X\right) + T_\infty$$

Position instantanée de l'interface

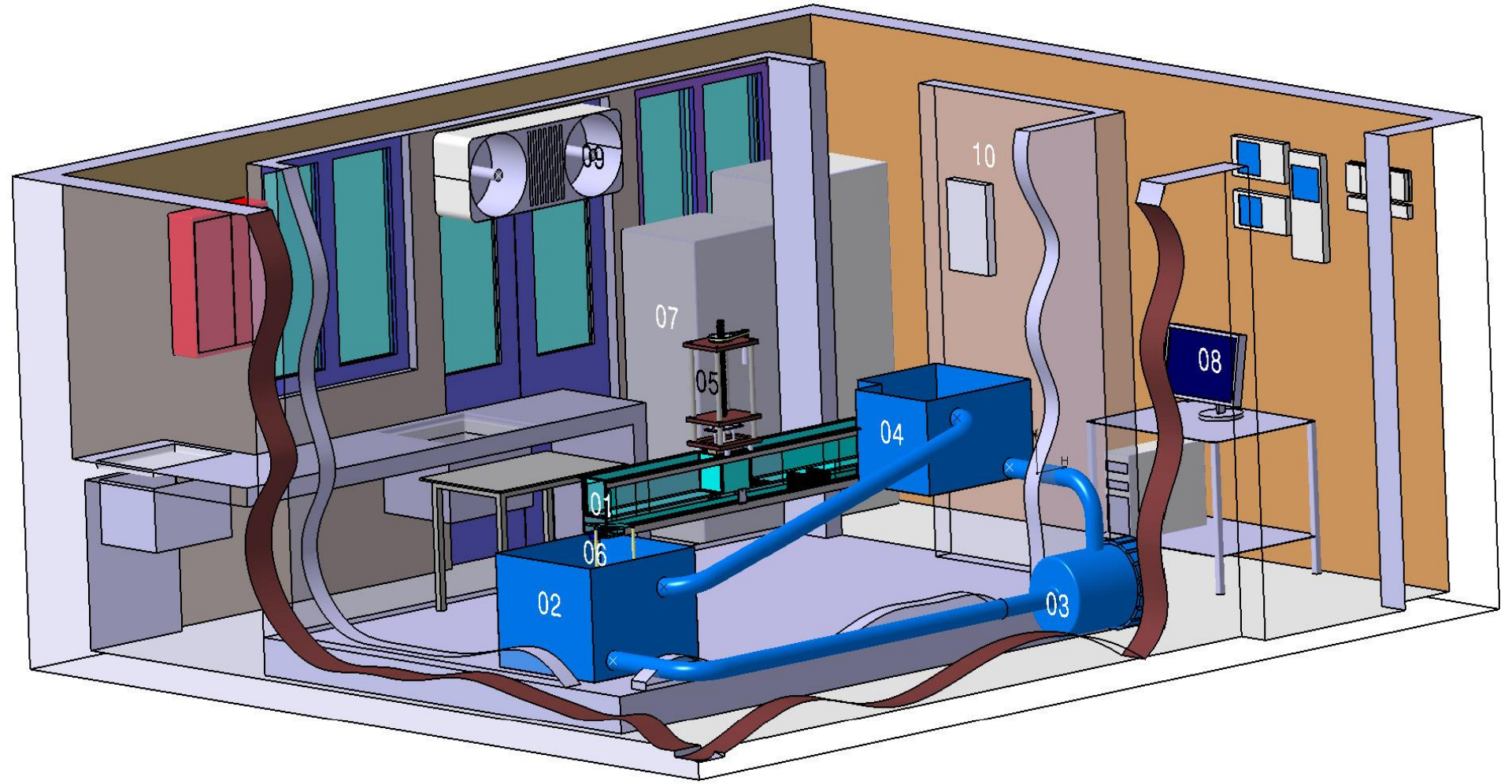
$$s(t) = \frac{h(T_L - T_f)}{\rho L + \rho C_p (T_f - T_\infty)} t$$

Aguirre-Puente et al., JGR, 1999

Dupeyrat et al. PPP 2011
Randriamazaoro et al. ESPL 2007

GEOSCIENCES PARIS SUD

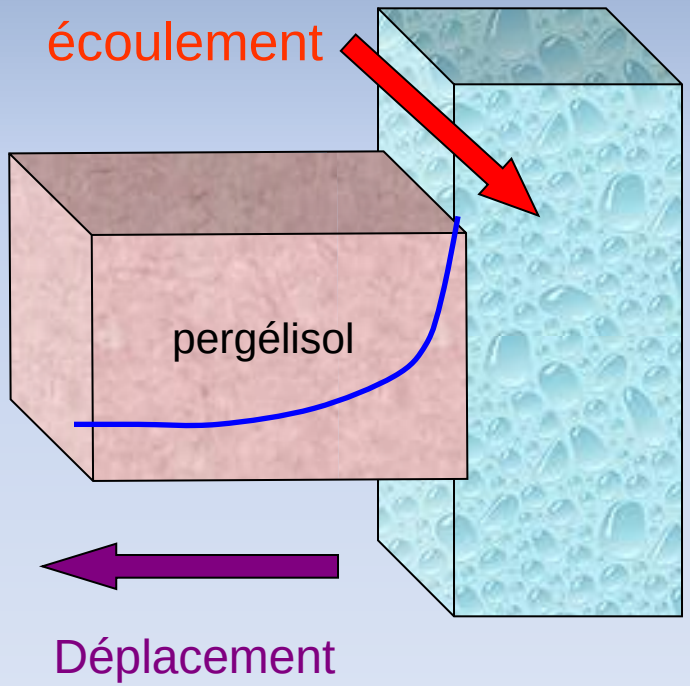
Hydraulic flume in a cold room

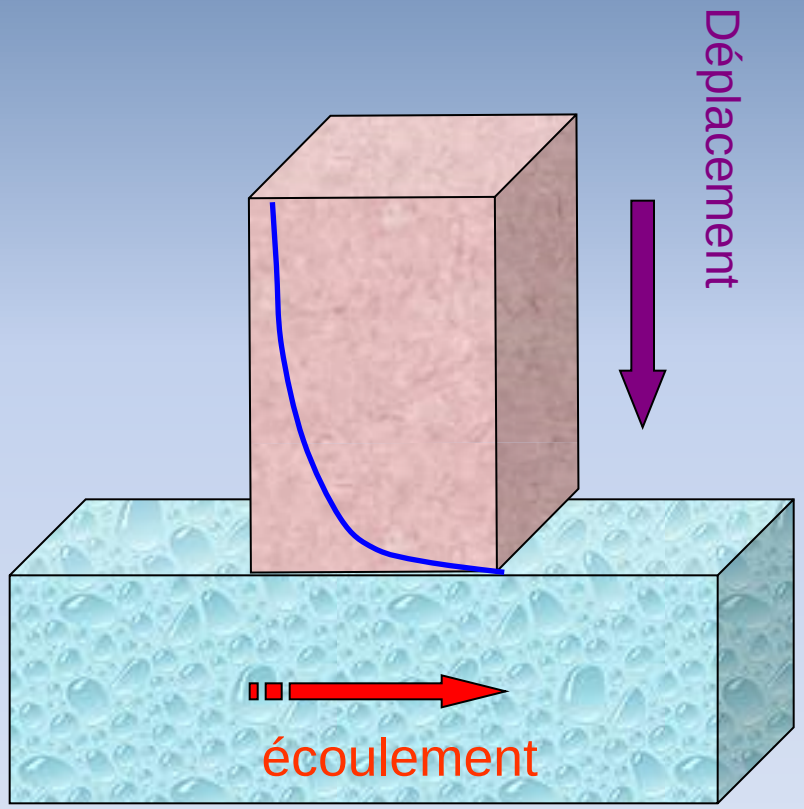


Du terrain au modèle analogique

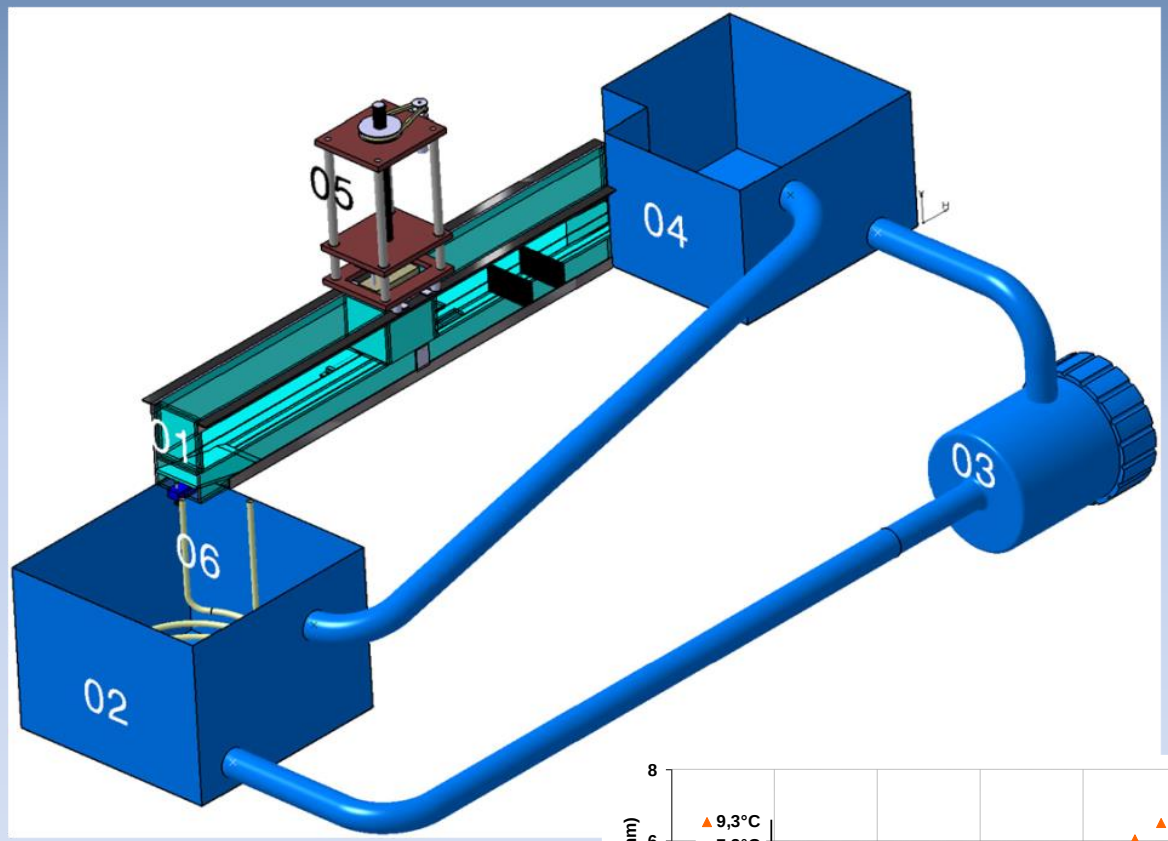
Cas d'une rivière

Modèle expérimental

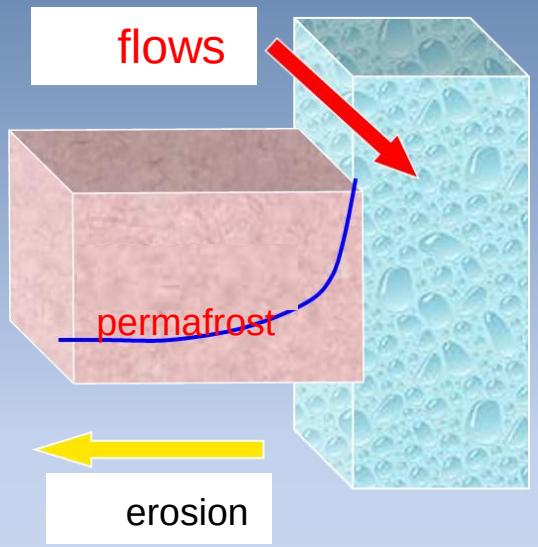


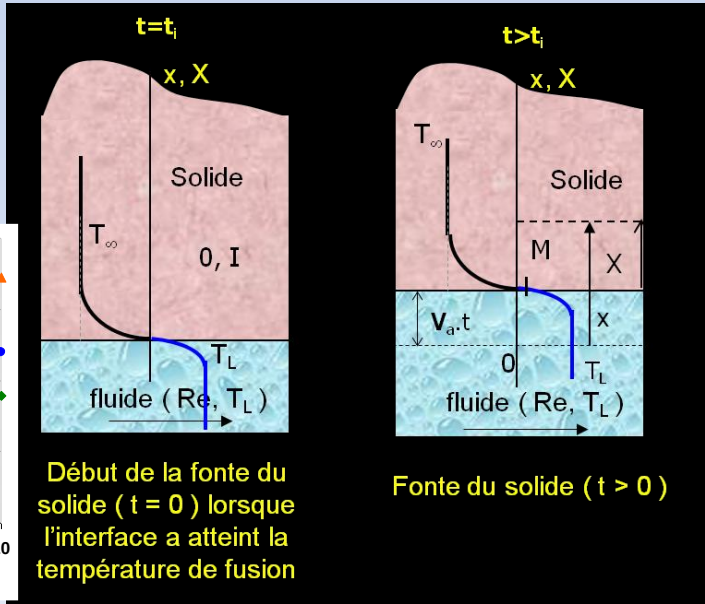


Hydraulic flume in a cold room



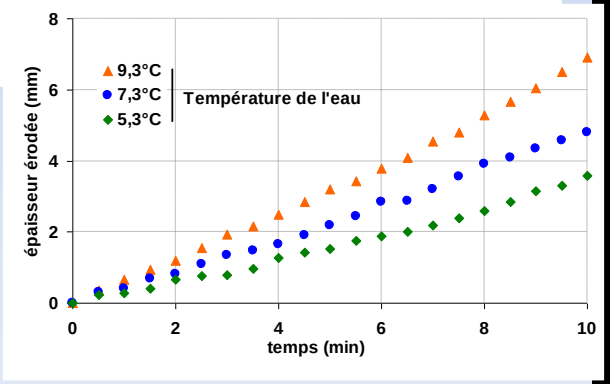
Ablation model



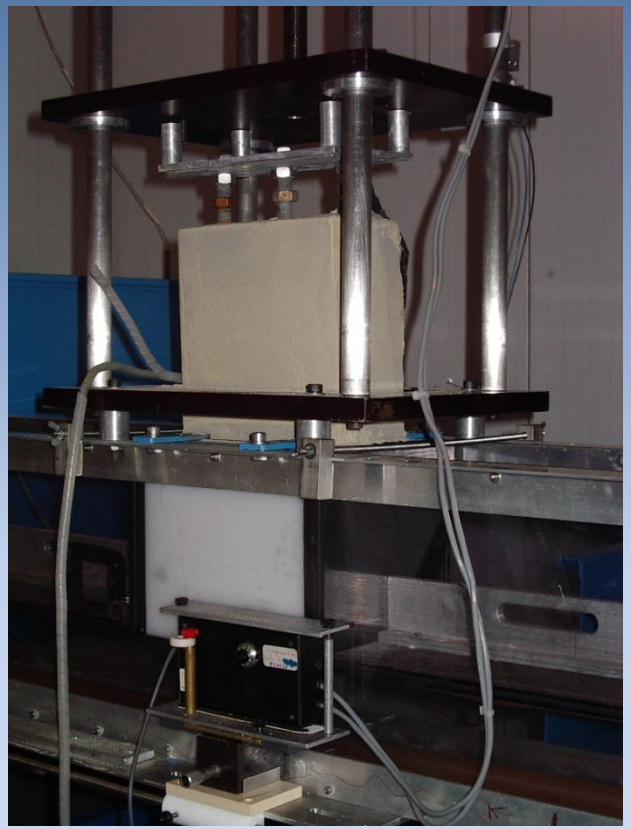


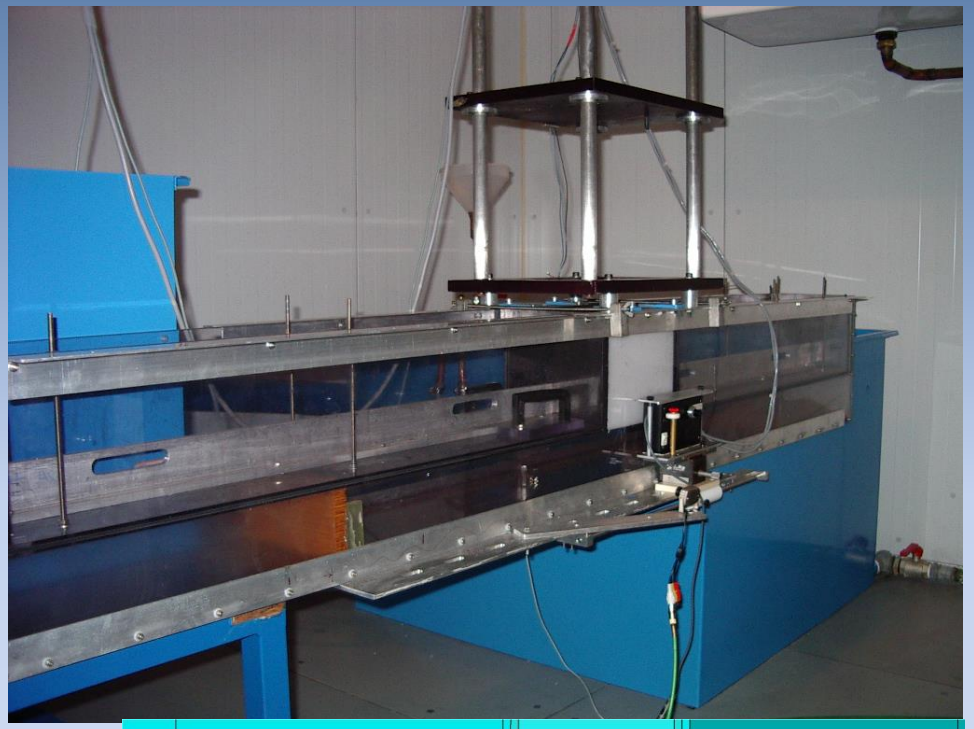
Début de la fonte du solide (t = 0) lorsque l'interface a atteint la température de fusion

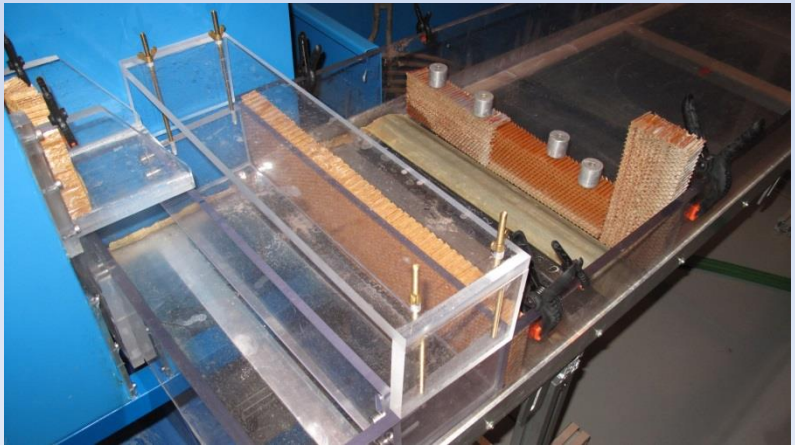
Fonte du solide (t > 0)

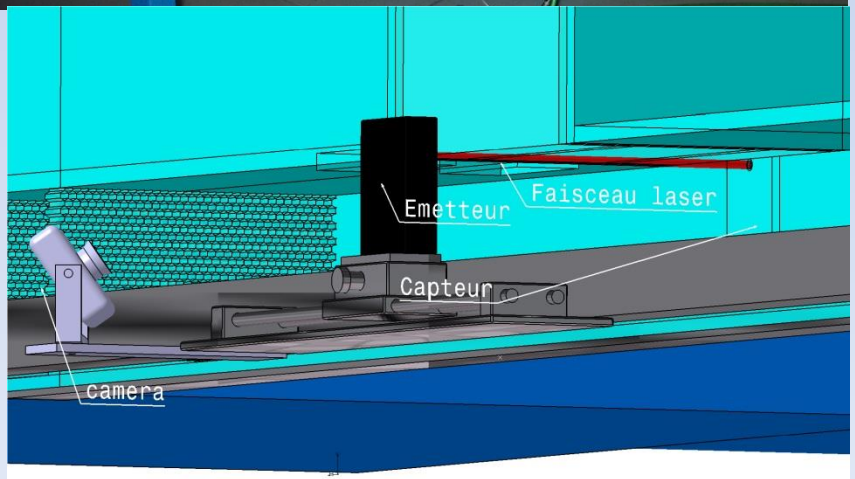


Dupeyrat et al. PPP 2011
Randriamazaoro et al. ESPL 2007

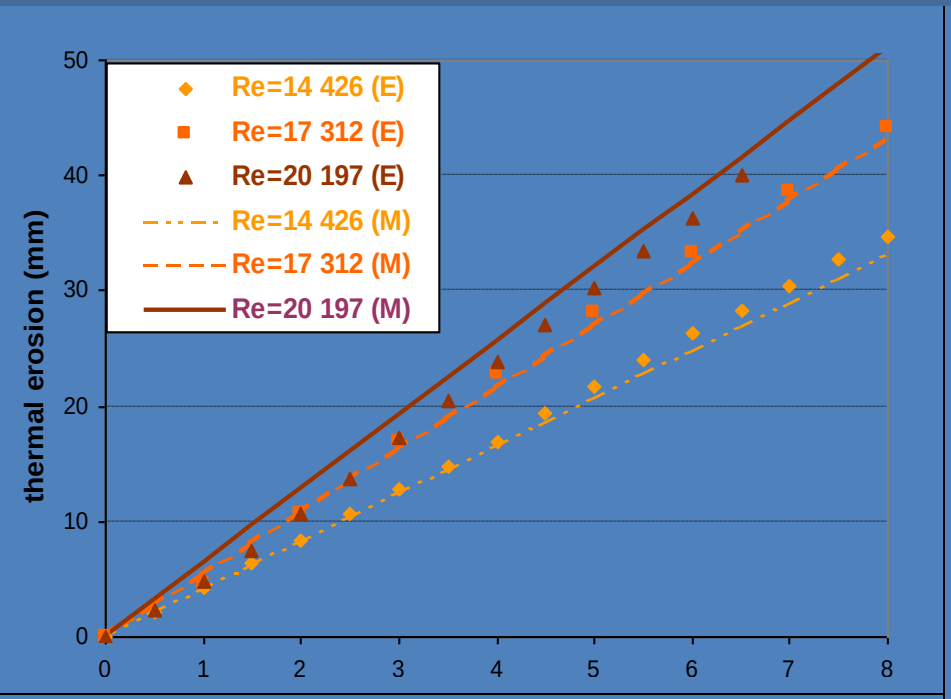


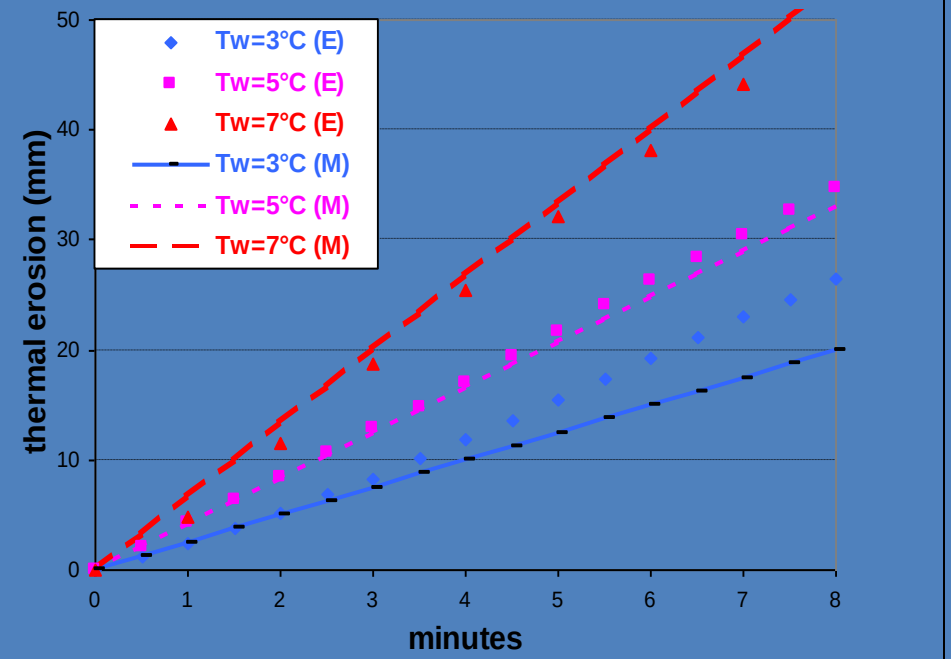


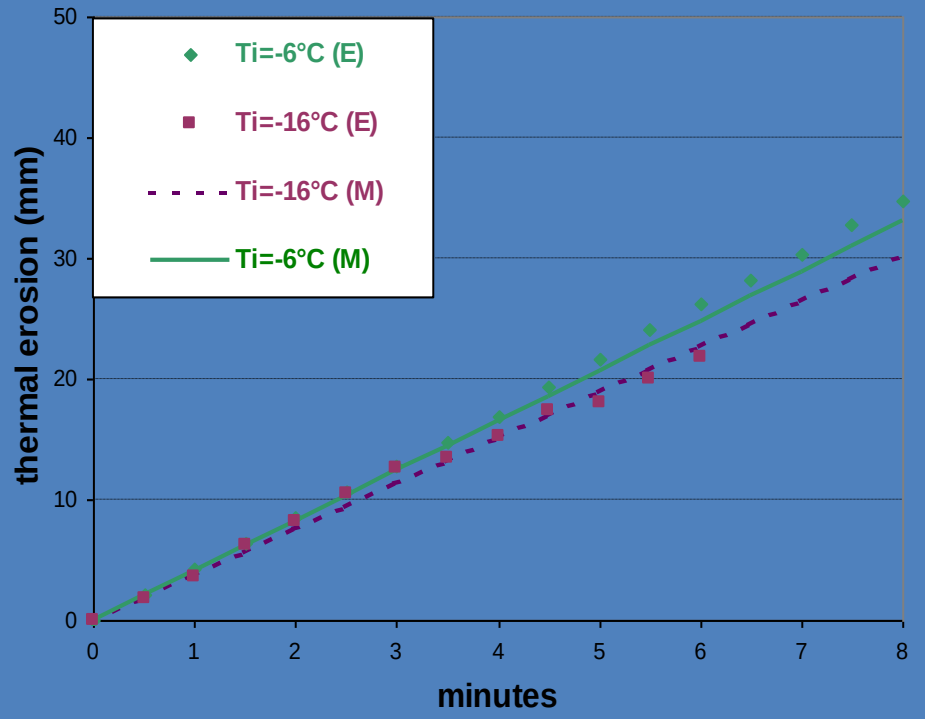



Emetteur
Faisceau laser
Capteur
camera

Hiérarchisation des paramètres





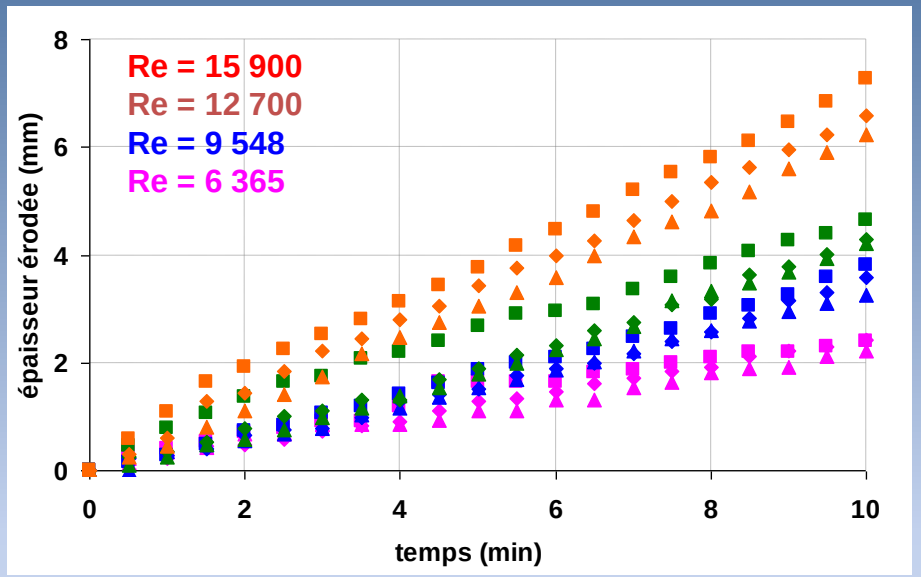


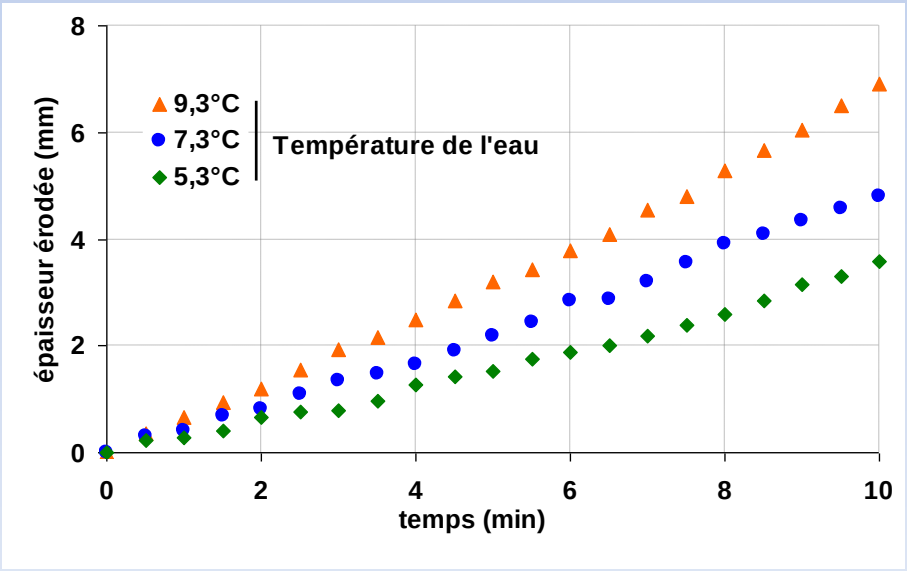
Ablation model applied to the thermal erosion

For one month, ablation rates equal :

- 20 m for pure ice
- 30 m for ice content , w=80%
- 40 m for ice content w=40%

water T = +15°C
permafrost T = -7°C



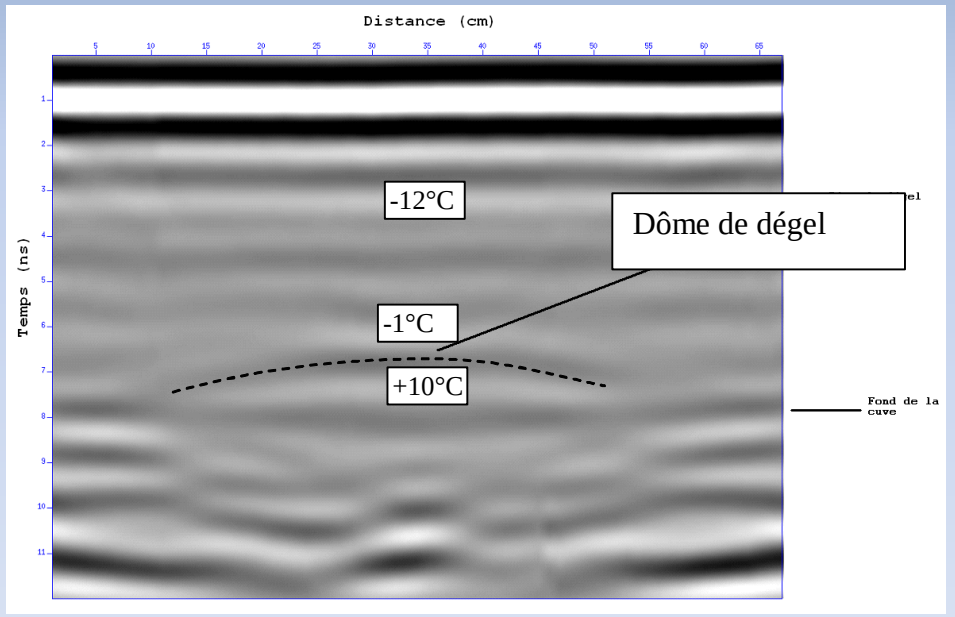


An increase of 2°C of the water stream temperature increase the erosion rate by 26%

Randriamazaoro et al., 2007

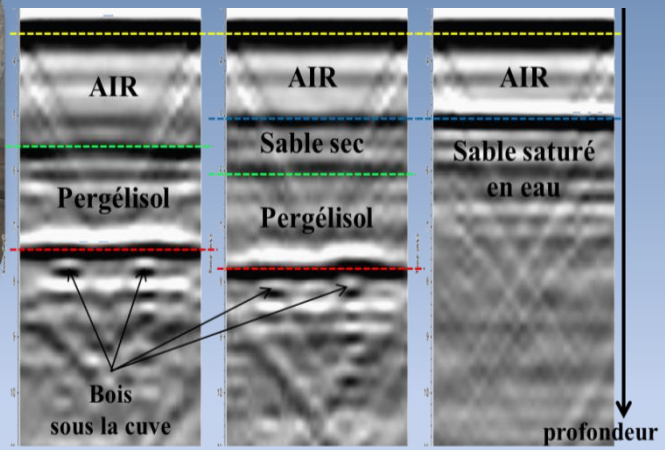
Detection of the 0^0C isotherm in a $1m^3$ permafrost with a Ground Penetrating Radar (800 MHz)

A. Saintenoy et al



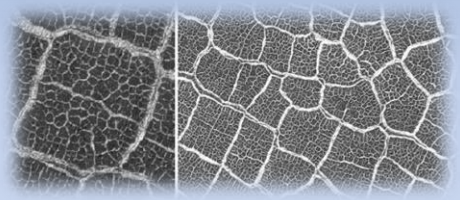
TEST of the WISDOM radar (EXOMARS mission ESA)

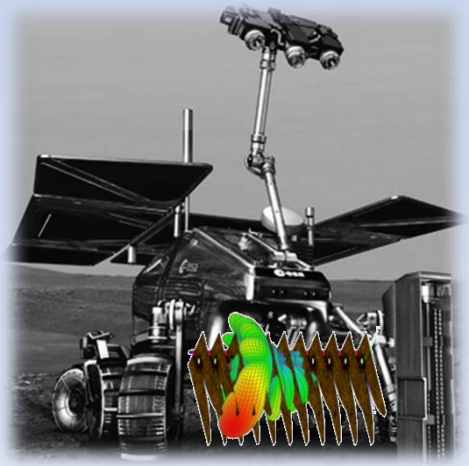
Confrontation avec le radar MALA

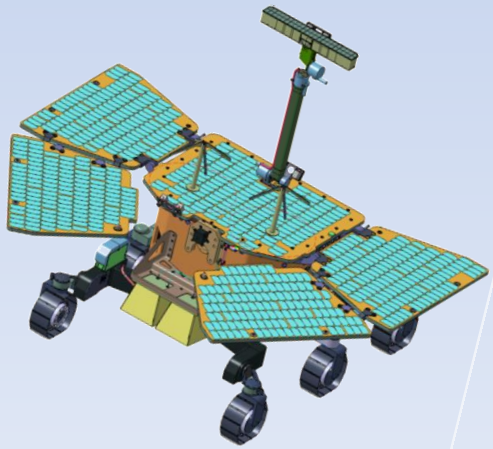


+ Estimation de la permittivité des strates

Fractures (fentes en coin) à la surface de Mars
(contraction du sol sous le froid et au gel-dégel)







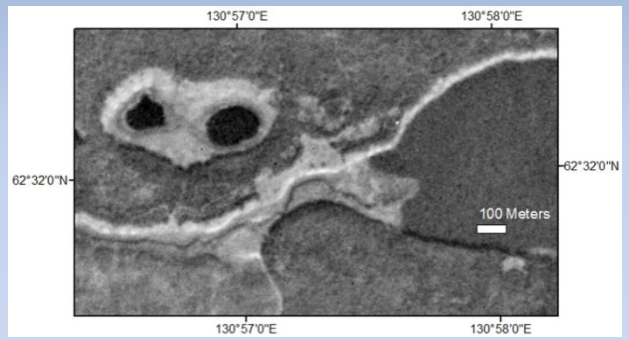
Marc BIANCHERI-ASTIER (MCF) – Albane SAINTENOY (MCF) – François COSTARD (DR)

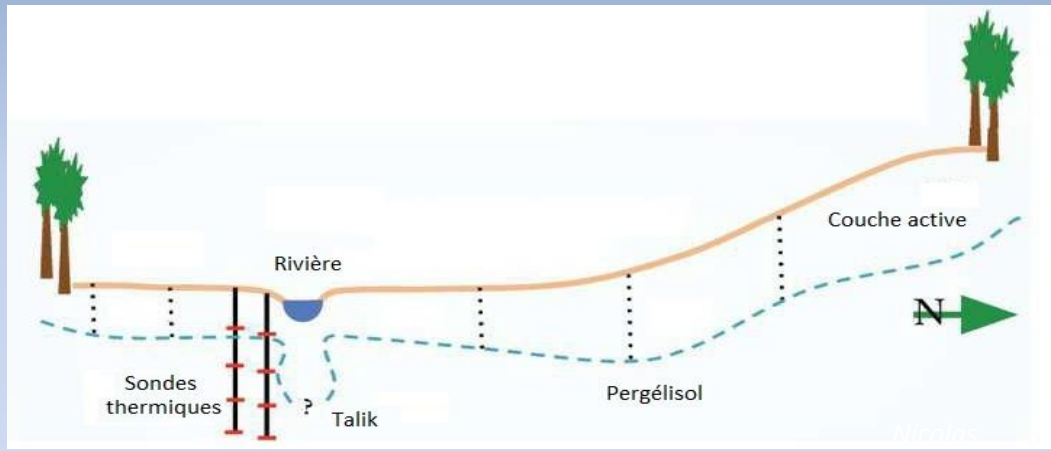
Modeling of taliks under small rivers
with LSCE: Ch. Grenier and N. Roux (PhD)

Approche :

- étude terrain (vallées d'Alas en Yakoutie, Sibérie),
- simulation numérique,
- simulation analogique en chambre froide.

Roux et al. PPP, submitted

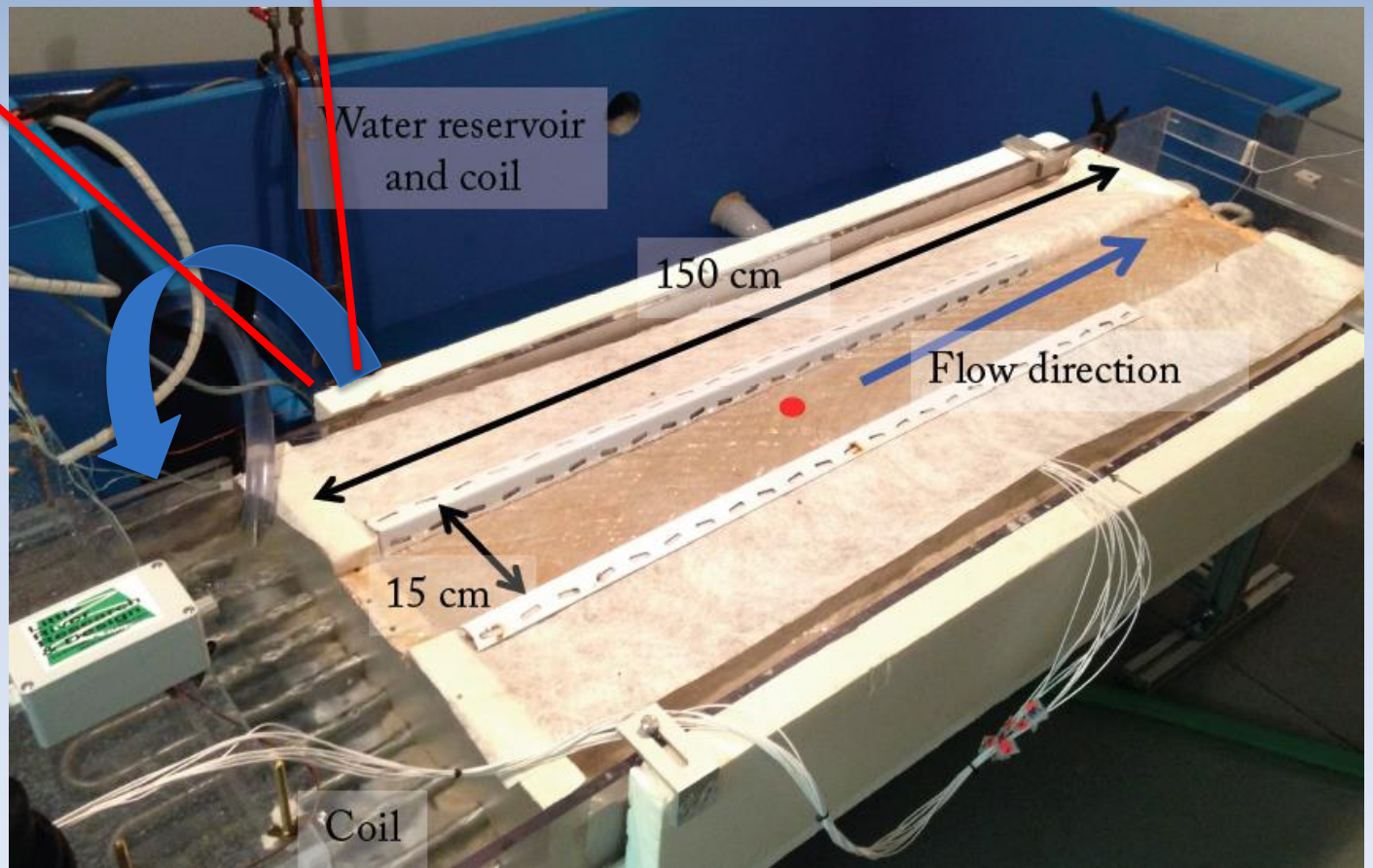
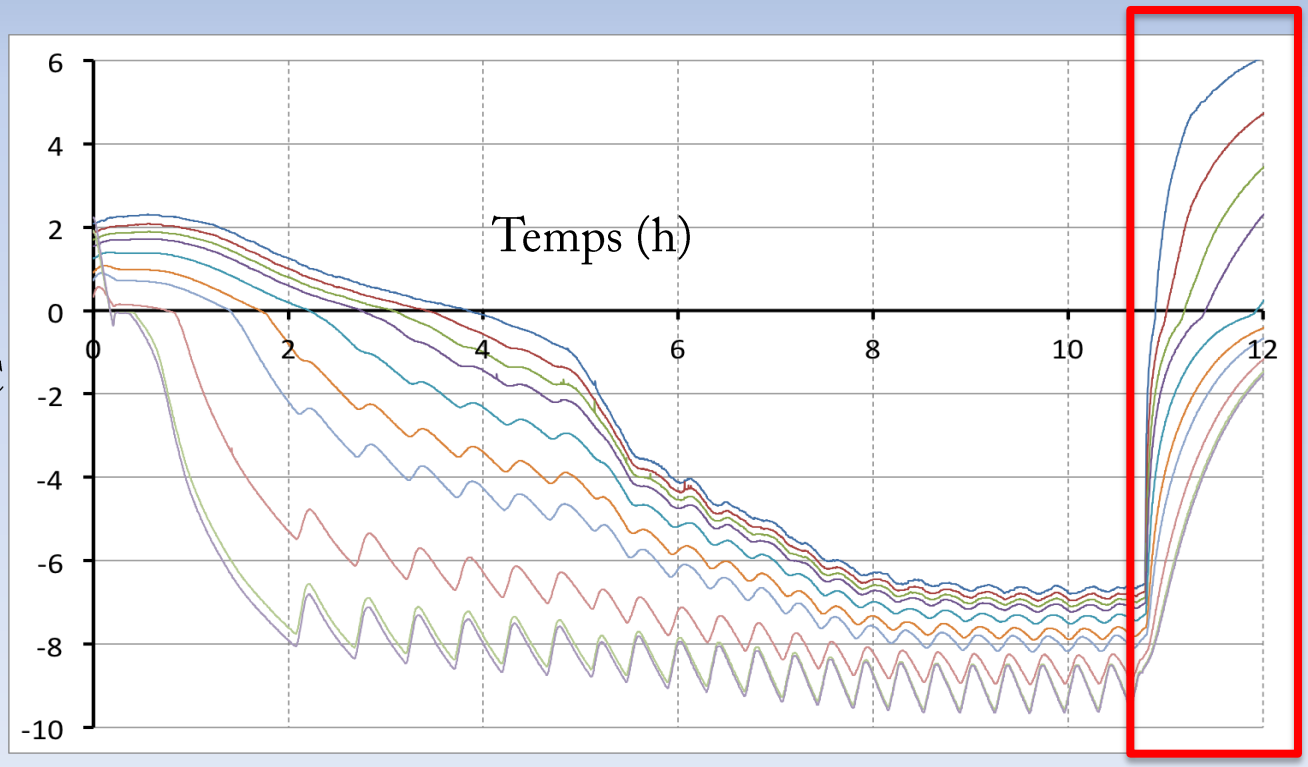




Site instrumenté

Nicolas Roux

SIBELCO
FRANCE


Water reservoir and coil
150 cm
Flow direction
15 cm
Coil

T (air) = 7° C