PRIMER ENCUENTRO UNESCO:
ENERGIA GEOTERMICA
EN EUROPA Y EN LAS AMERICAS

Comsol Multyphysics

Daniel Balzan Alzate

Estudiante Ingeniería Ambiental UdeM

María Isabel Vélez

Estudiante Maestría INRS-ETE

United Nations
Educational, Scientific and
Cultural Organization

UNIVERSIDAD DE MEDELLIN

UNIVERSIDAD DE MEDELLIN

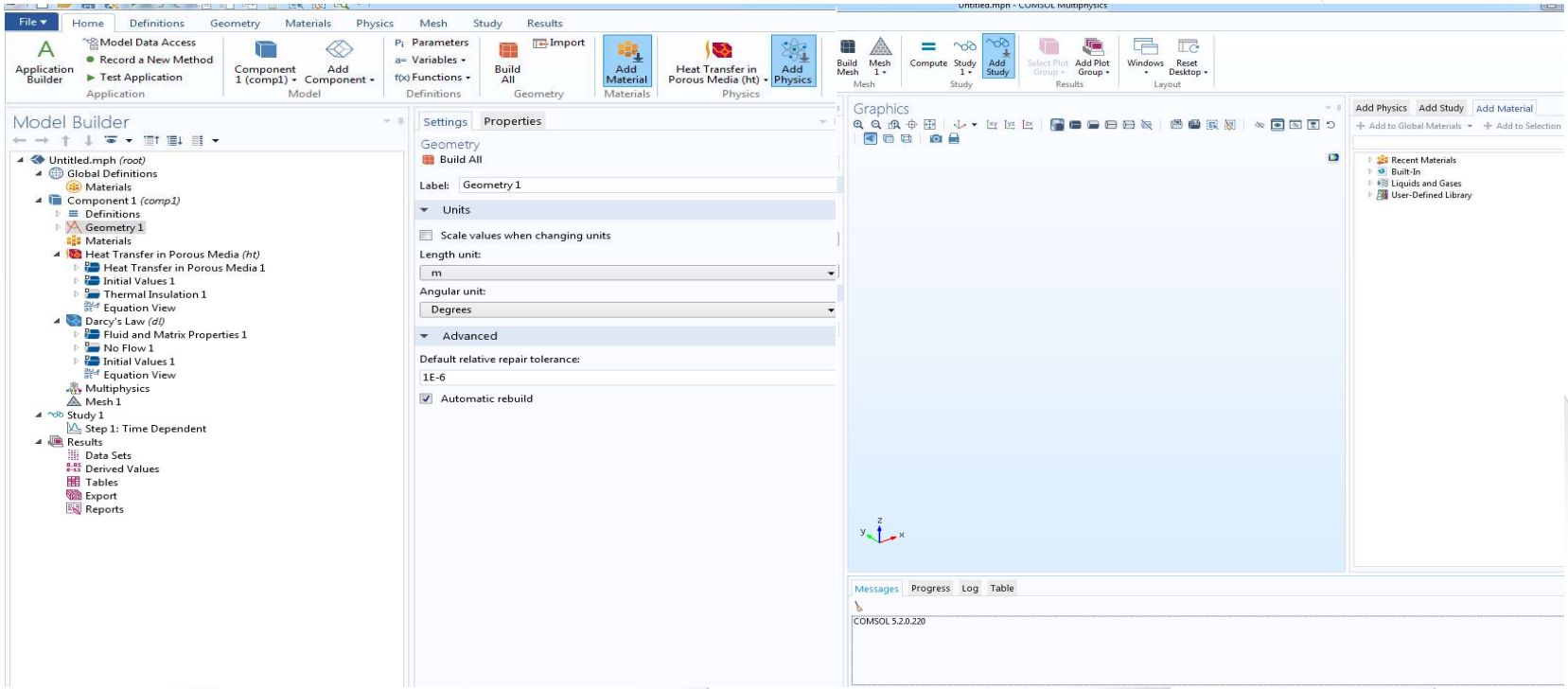
Content

- Introduction
- Heat transfer in porous medium
  - Numerical model
  - Analytical model
- Heat transfer in fractured porous medium
  - Numerical model
  - Analytical model
- Conclusion

UNIVERSIDAD DE MEDELLIN

Introduction

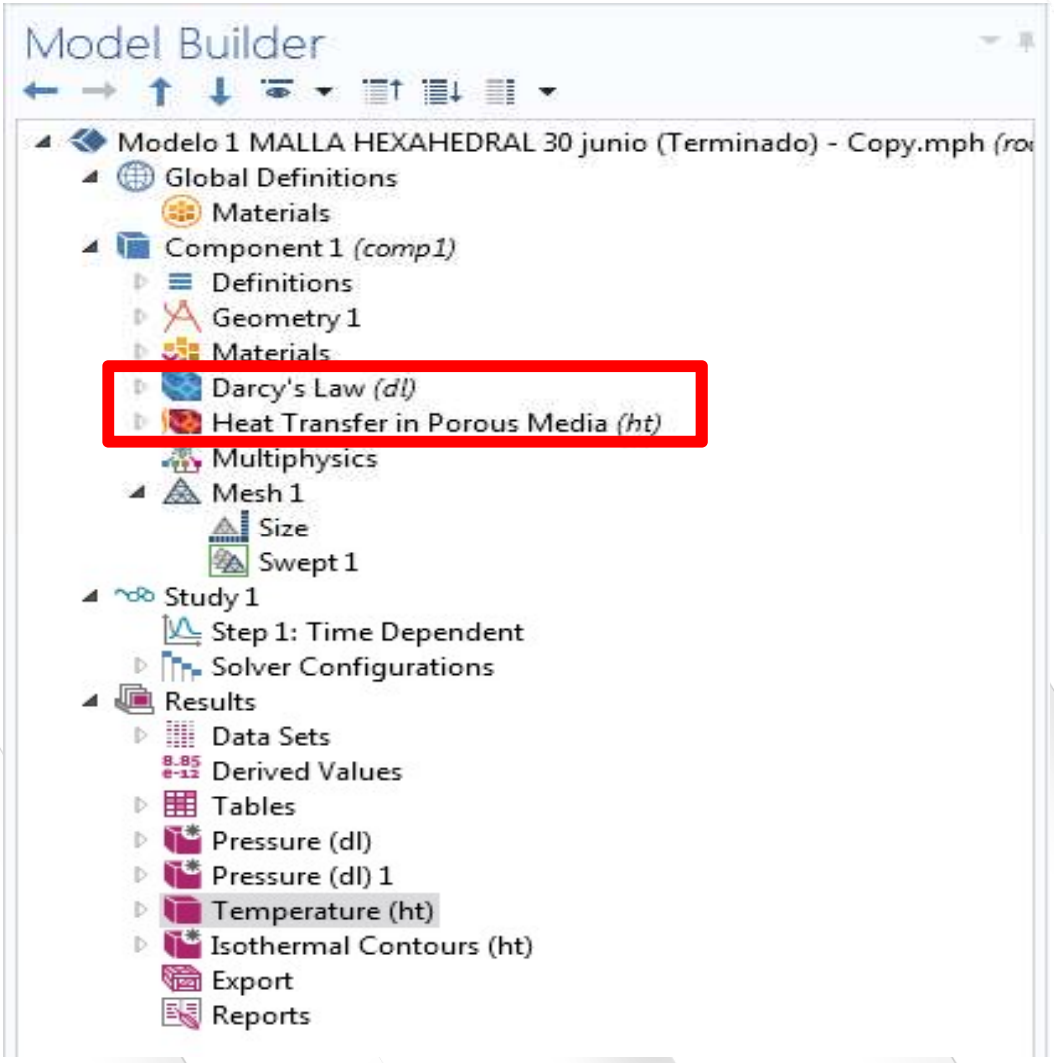
- **Comsol's user interface**



UNIVERSIDAD DE MEDELLIN

Introduction

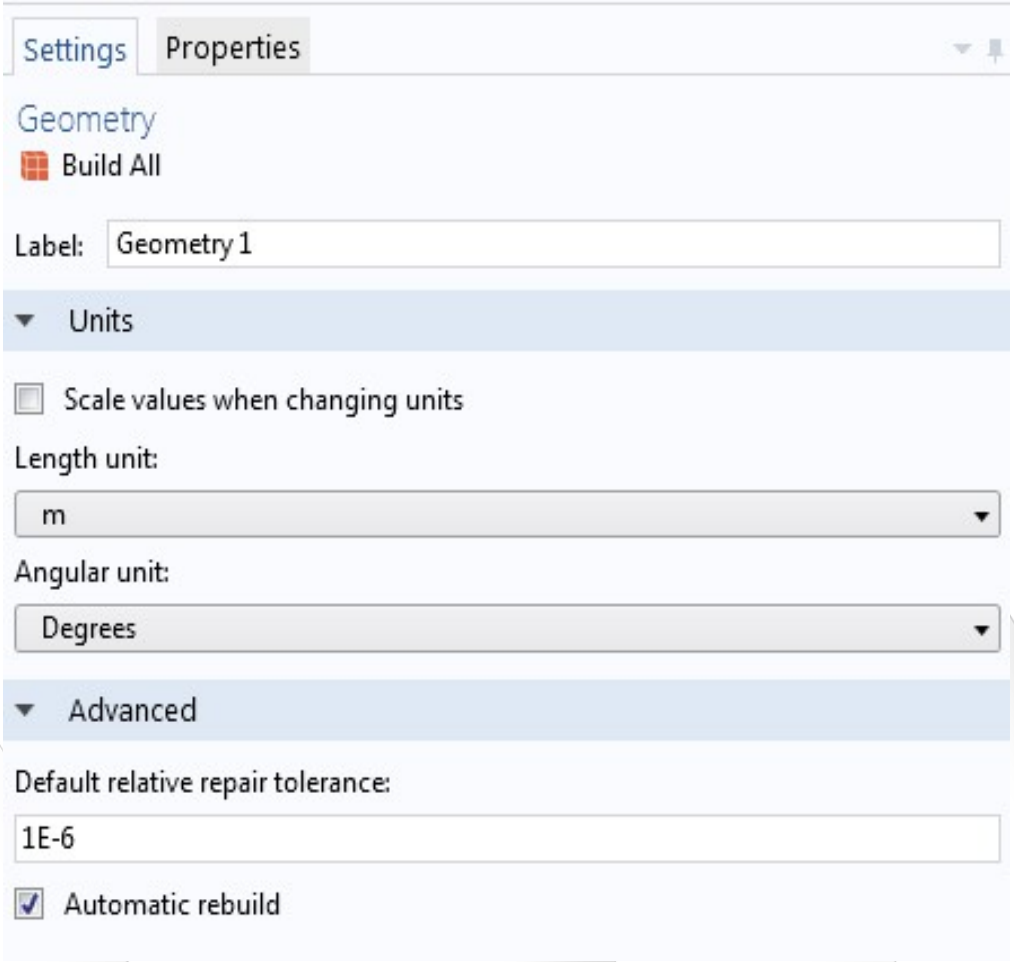
- **Model Builder**



UNIVERSIDAD DE MEDELLIN

Introduction

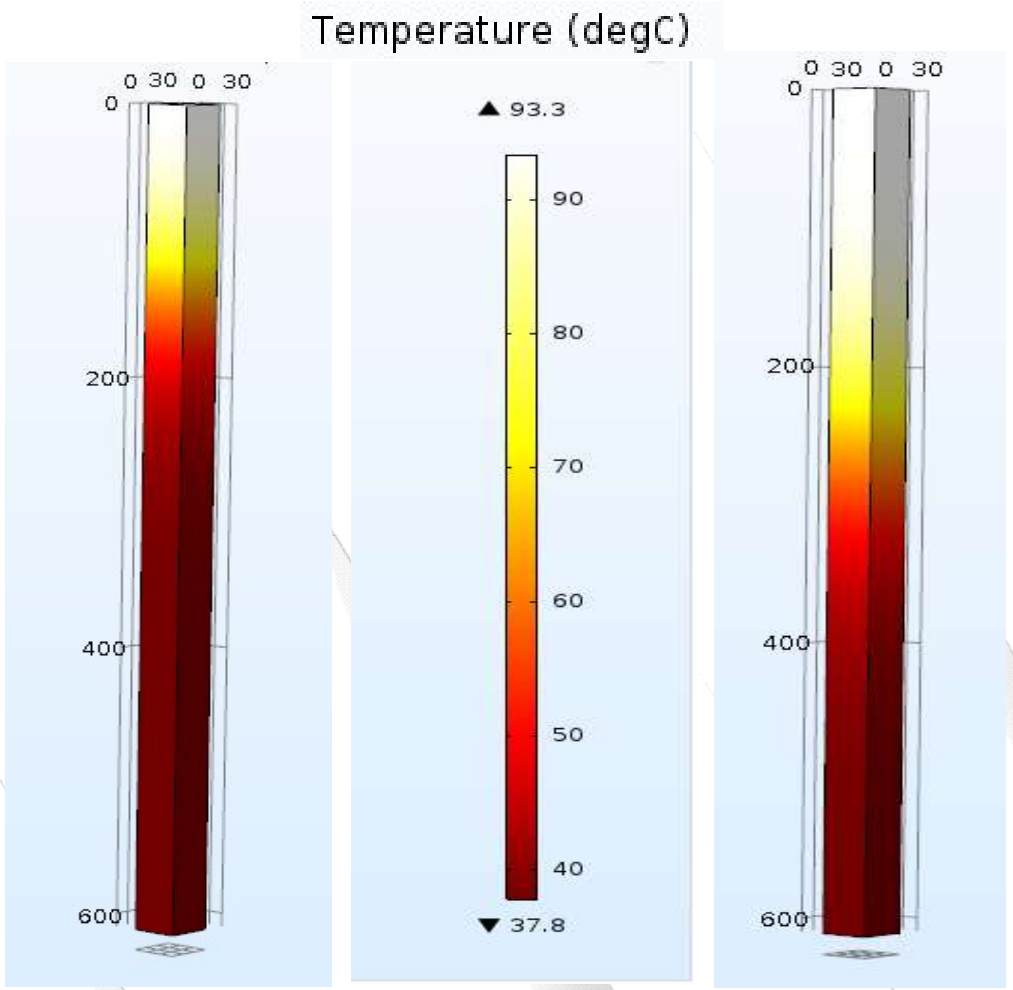
- **Parameter assignment**



UNIVERSIDAD DE MEDELLIN

Heat transfer in porous medium

- Heat transfer by conduction, advection and mechanical dispersion
- Temperature evaluated at:
  - 2148 days
  - 4262 days

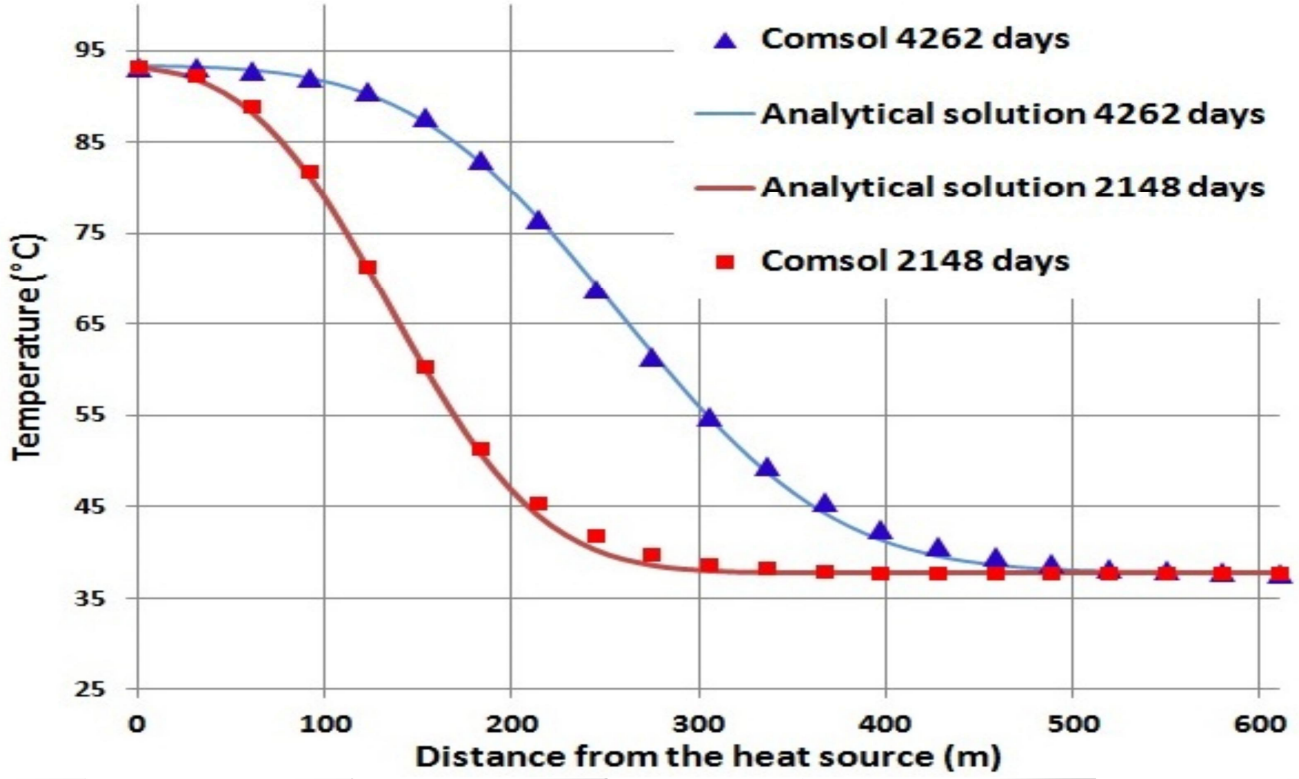


2148 days 4262 days

UNIVERSIDAD DE MEDELLIN

Heat transfer in porous medium

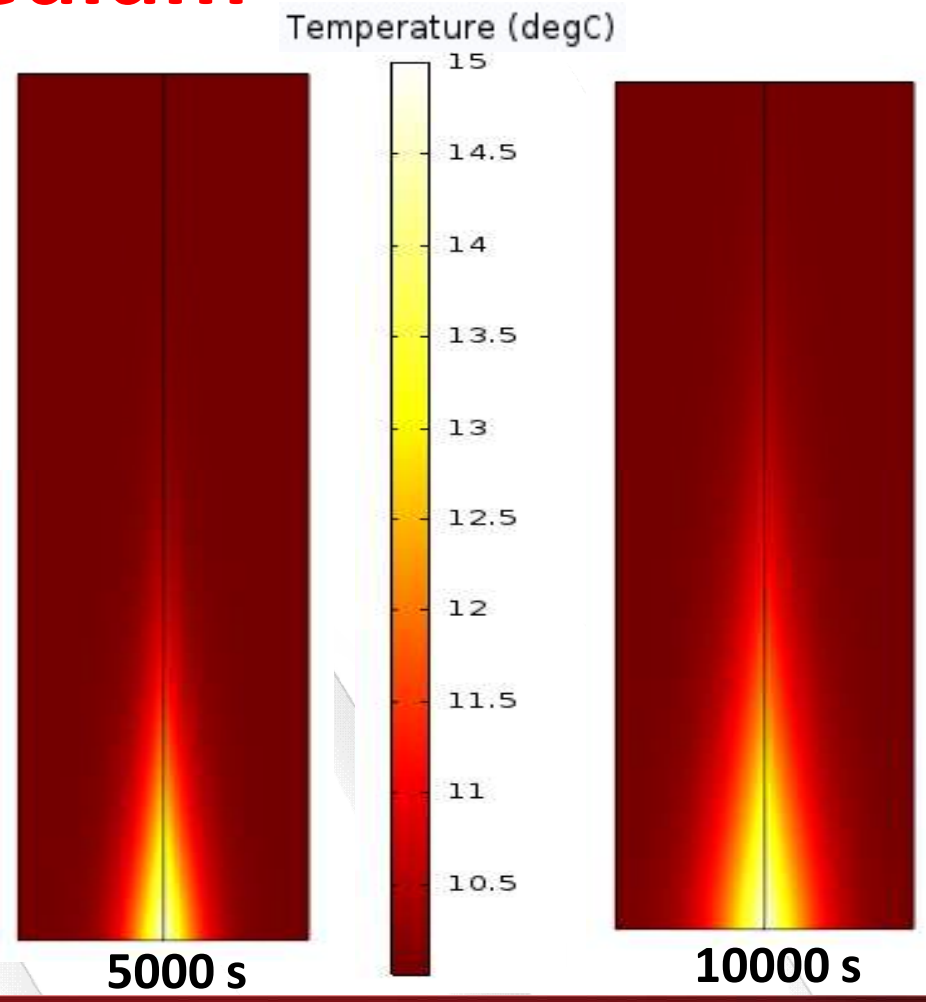
- **Analytical and numerical results**



UNIVERSIDAD DE MEDELLIN

Heat transfer in fractured porous medium

- Heat transfer by conduction into the matrix and advection along the fracture (no mechanical dispersion)
- Temperature evaluated at 5000 s and 10000 s



UNIVERSIDAD DE MEDELLIN

Heat transfer in fractured porous medium

- **Fracture is represented by an equivalent porous medium (EPM)**
  - **Mesh size limitation (2D and smaller domain)**
  - **Equivalent hydraulic conductivity for the fracture zone:**

$$K_f = \frac{\gamma(2b)^2}{12\mu}$$

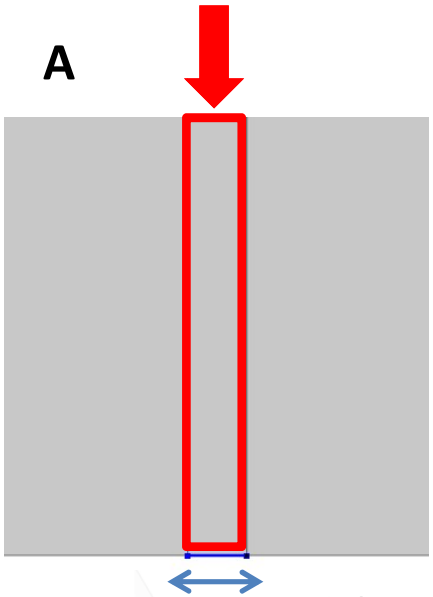
- K_f : **Fracture zone hydraulic conductivity (m/s)**
- b : **Fracture aperture (m)**
- μ : **Water dynamic viscosity (Pa·s)**
- γ : **Water specific weight (N/m^3)**

UNIVERSIDAD DE MEDELLIN

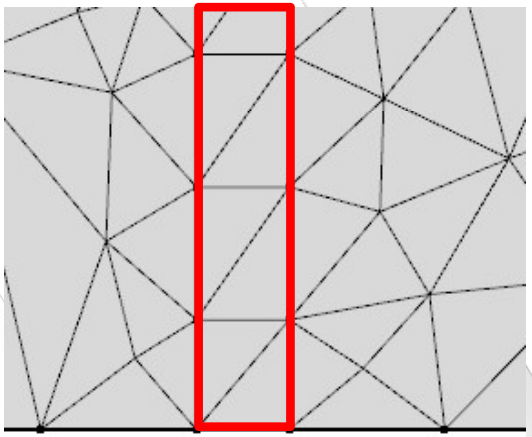
Heat transfer in fractured porous medium

- Temperature boundary condition is applied to a line
- Refined mesh close to the fracture

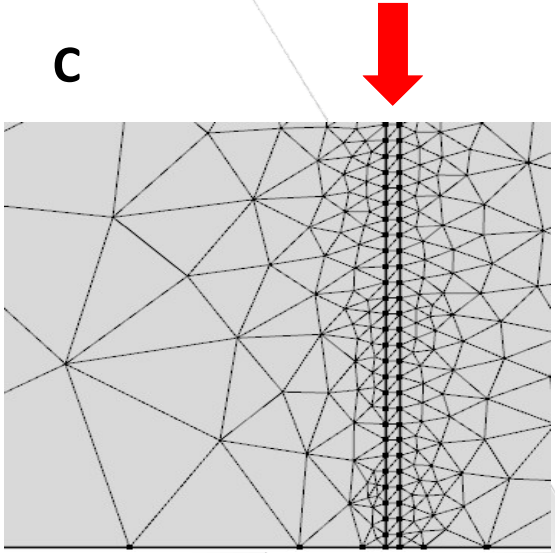
A



B



C

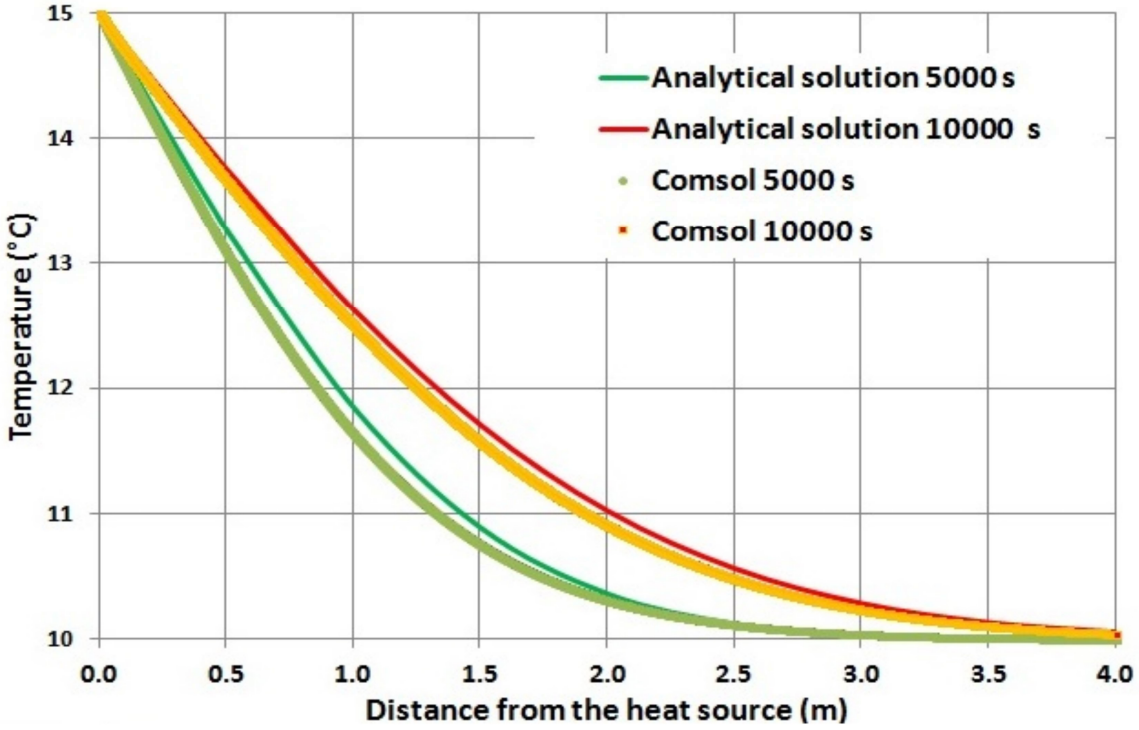


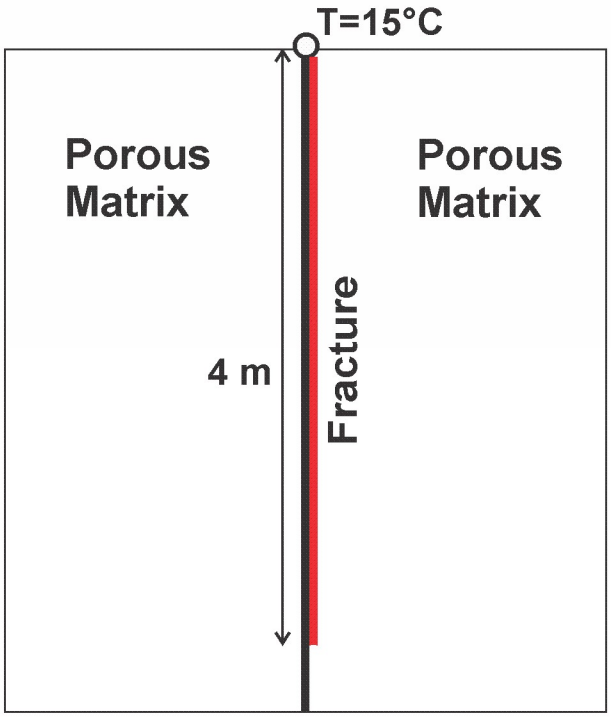
Fracture zone width: $3x10^{-4}$ m
where constant temperature is applied

UNIVERSIDAD DE MEDELLIN

Heat transfer in fractured porous medium

- Temperature along the fracture

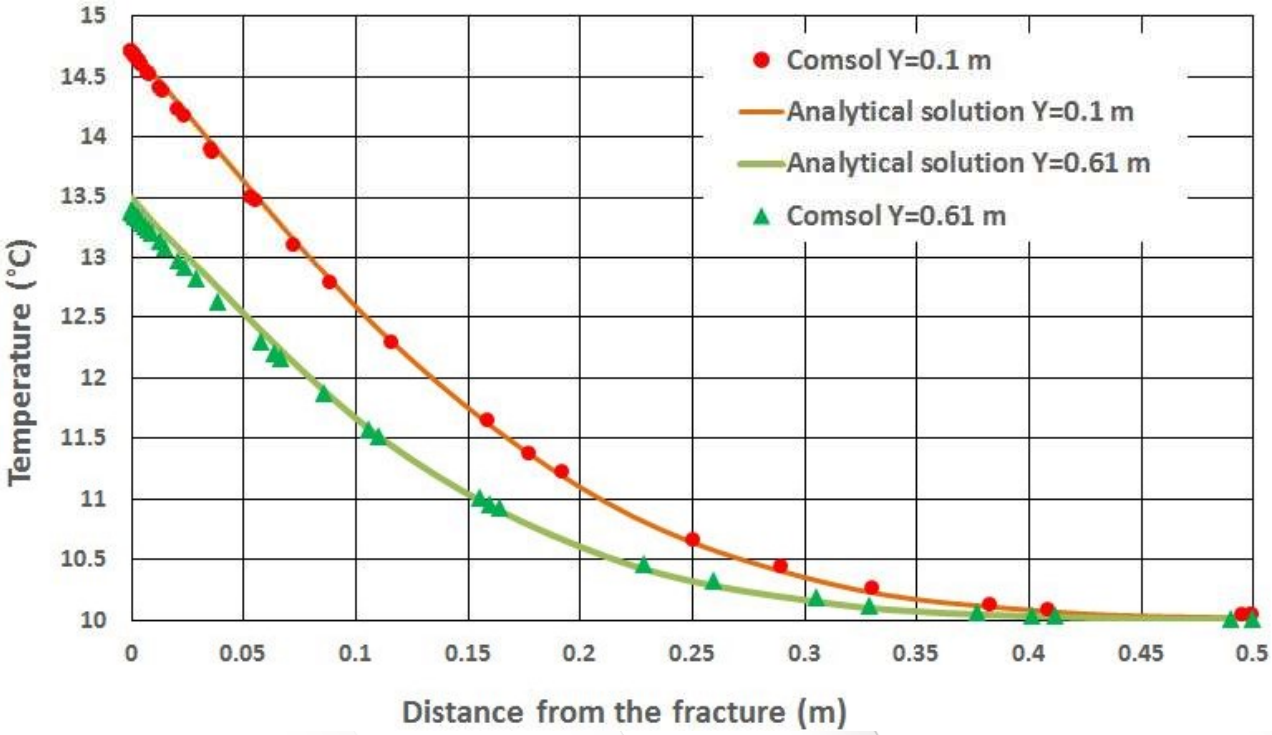


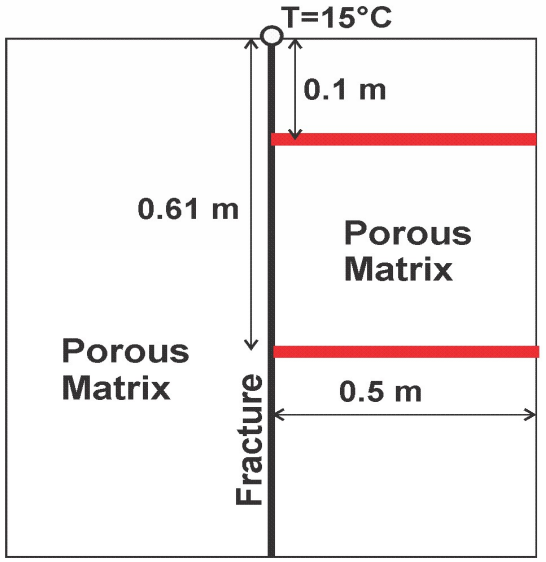


UNIVERSIDAD DE MEDELLIN

Heat transfer in fractured porous medium

- **Temperature in the porous matrix**

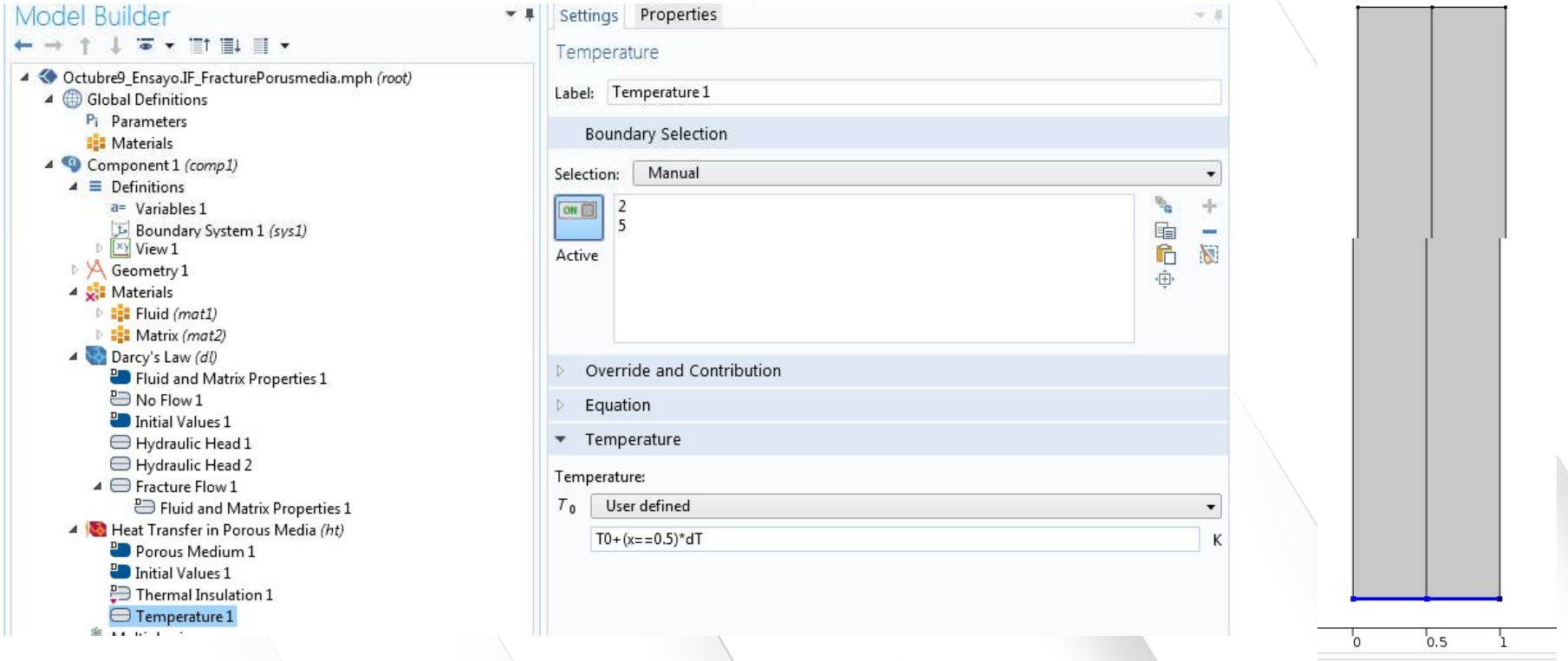




UNIVERSIDAD DE MEDELLIN

Heat transfer in fractured porous medium

- **Temperature boundary condition to the discrete fracture**



UNIVERSIDAD DE MEDELLIN

Conclusions

- Good numerical approximations for heat transfer in the porous medium and along a fracture were obtained
- A limitation of the heat transfer in porous medium Comsol module has been identified
  - Among the boundary condition options, there is not the possibility to set a temperature boundary condition to a point
  - The discrete fracture is independent of the matrix (nodes are not common or superposed, as in HGS)

Gracias

UNIVERSIDAD DE MEDELLIN