"Use of Comsol as a Tool in the Design of an Inclined Multiple Borehole Heat Exchanger"

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Objectives

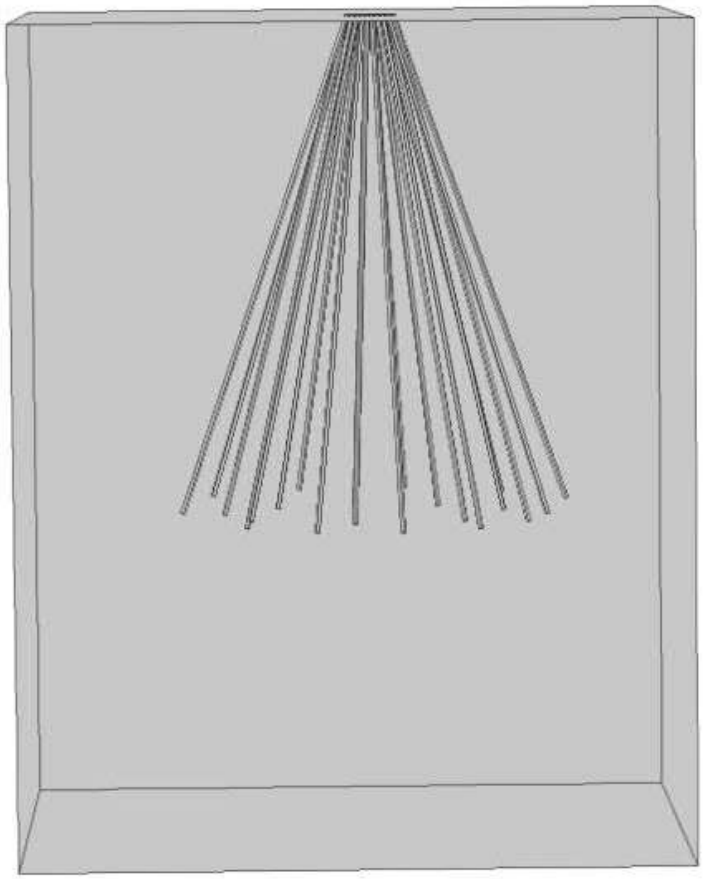
- Find a way to correctly design and analyze borehole fields with inclined boreholes.
- Analyze the temperature distribution in the ground and in the heat carrying fluid over time.
- Compare the Comsol Multiphysics model with available software in the ground source cooling/heating field.

Introduction

- Part of my Master thesis on Ground source cooling combined with free cooling.
- New way to size systems with an inclined multiple borehole heat exchanger
- Takes the 3-dimensional heat transfer into account
- Applications: Can be used when designing systems that uses multiple boreholes for cooling, heating and storage purposes.

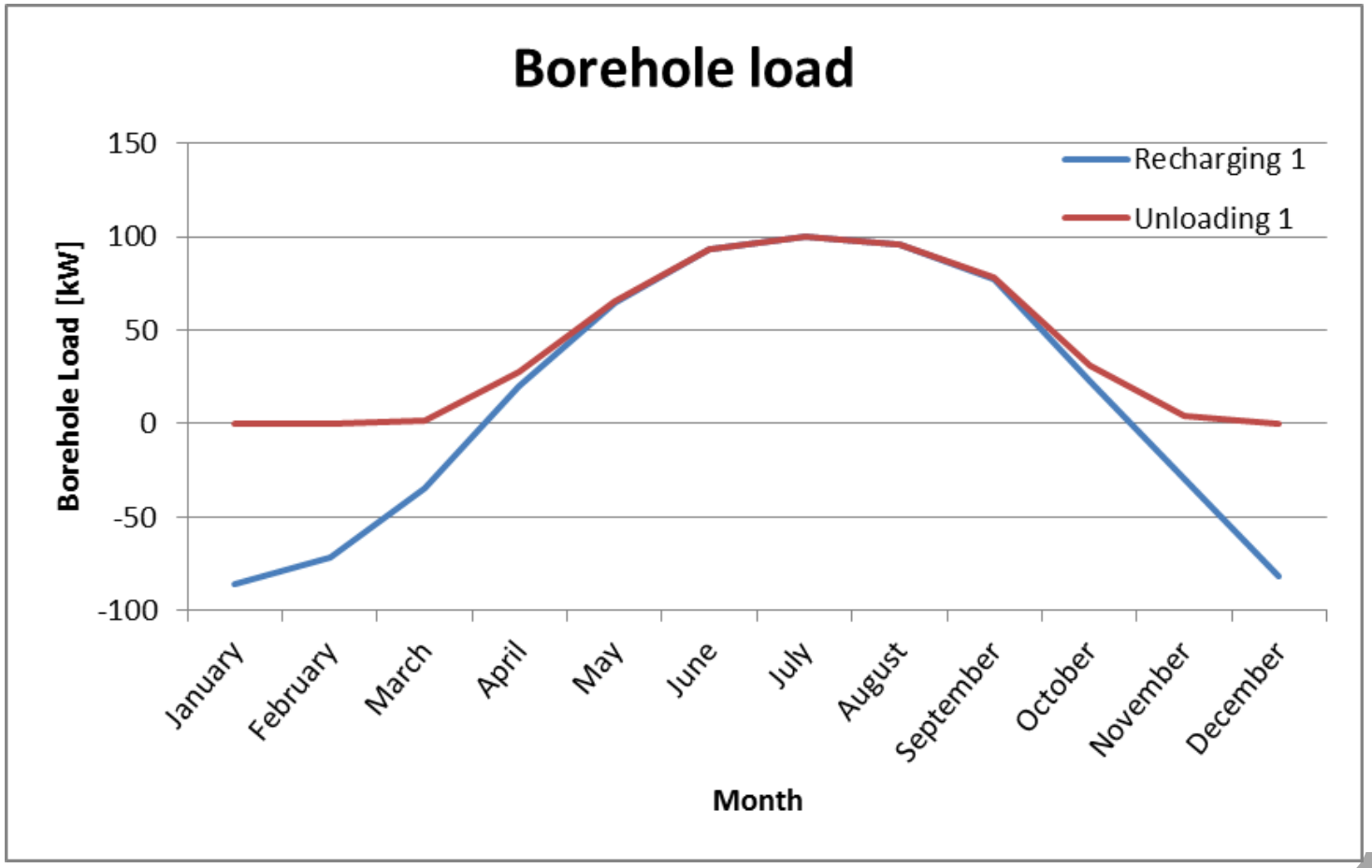
Methodology

- Used Comsol Multiphysics Heat Transfer Module.
- 20 year simulation period with 30 day time step.
- 20 Boreholes, 140 mm diameter, fan shaped pattern.
- Tetrahedral Mesh (107 000 cells)
- Initial/boundary conditions:
  - Ground temperature: Uniform (6.6 °C) and Gradient.
  - Constant boundary temperature.
  - Surface boundary temperature varies according to climate.
  - Heat load applied uniformly on the borehole surfaces.



Borehole Load

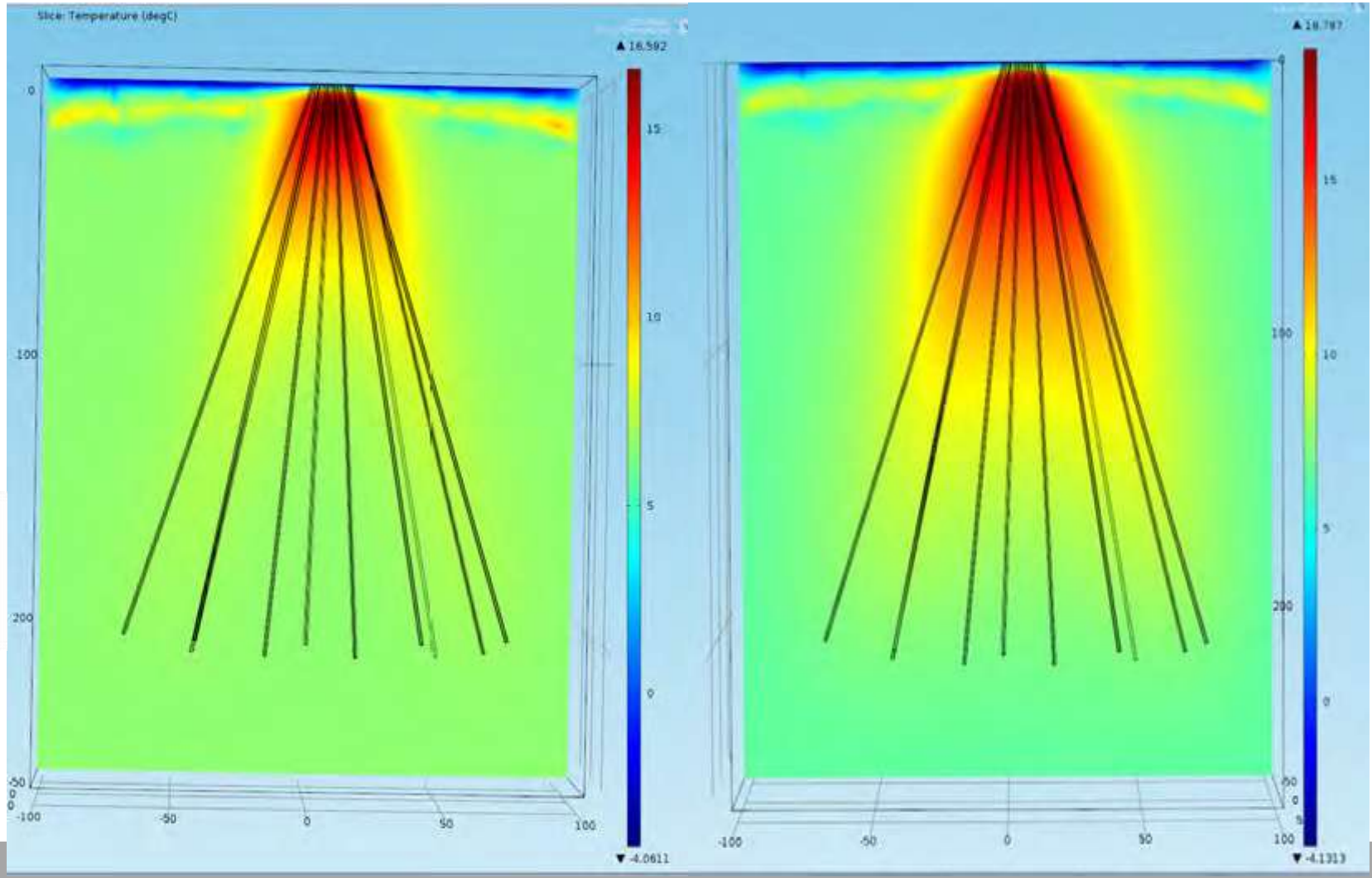
- Recharging and Unloading



Ground Temperature

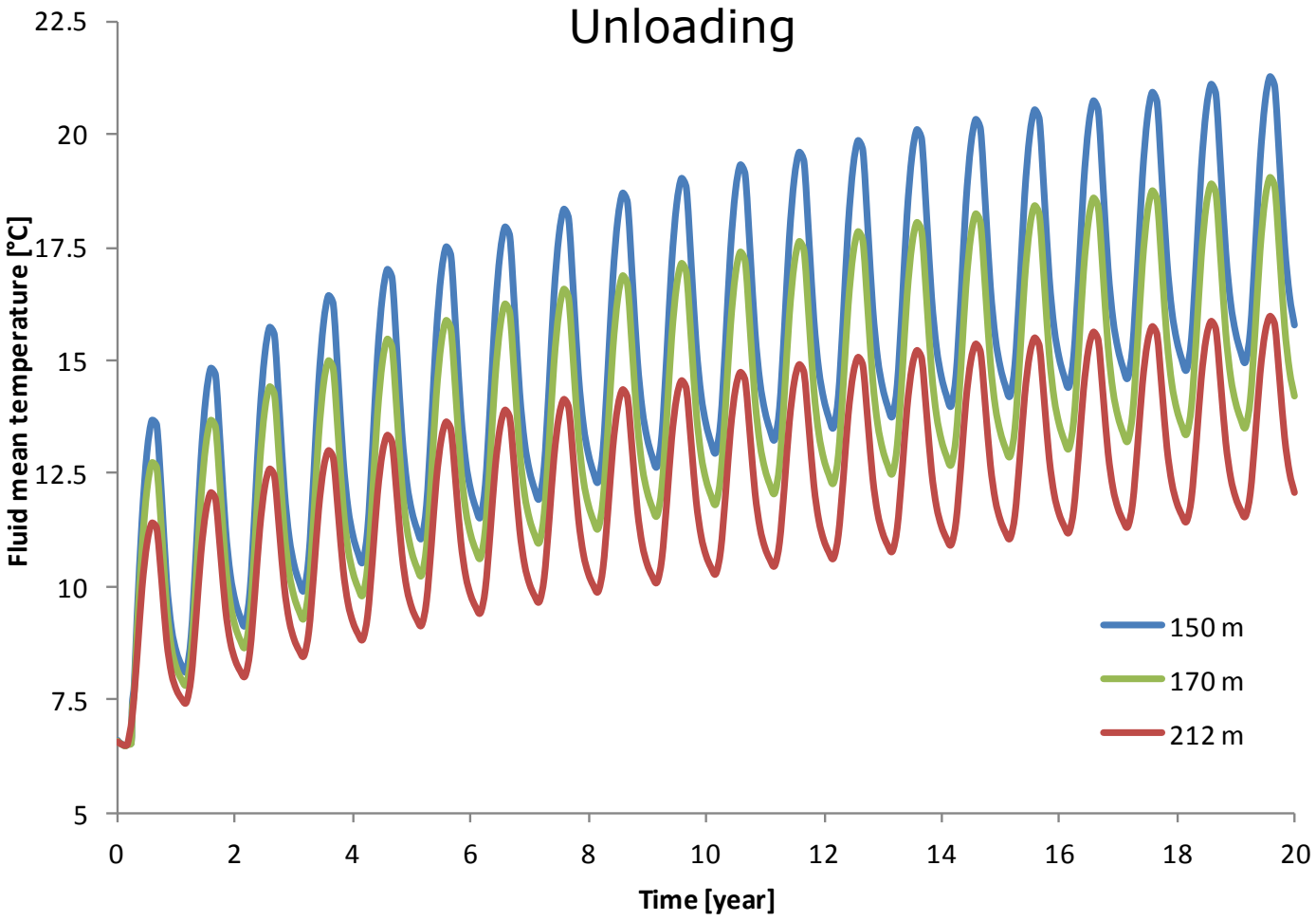
5 years

20 Years



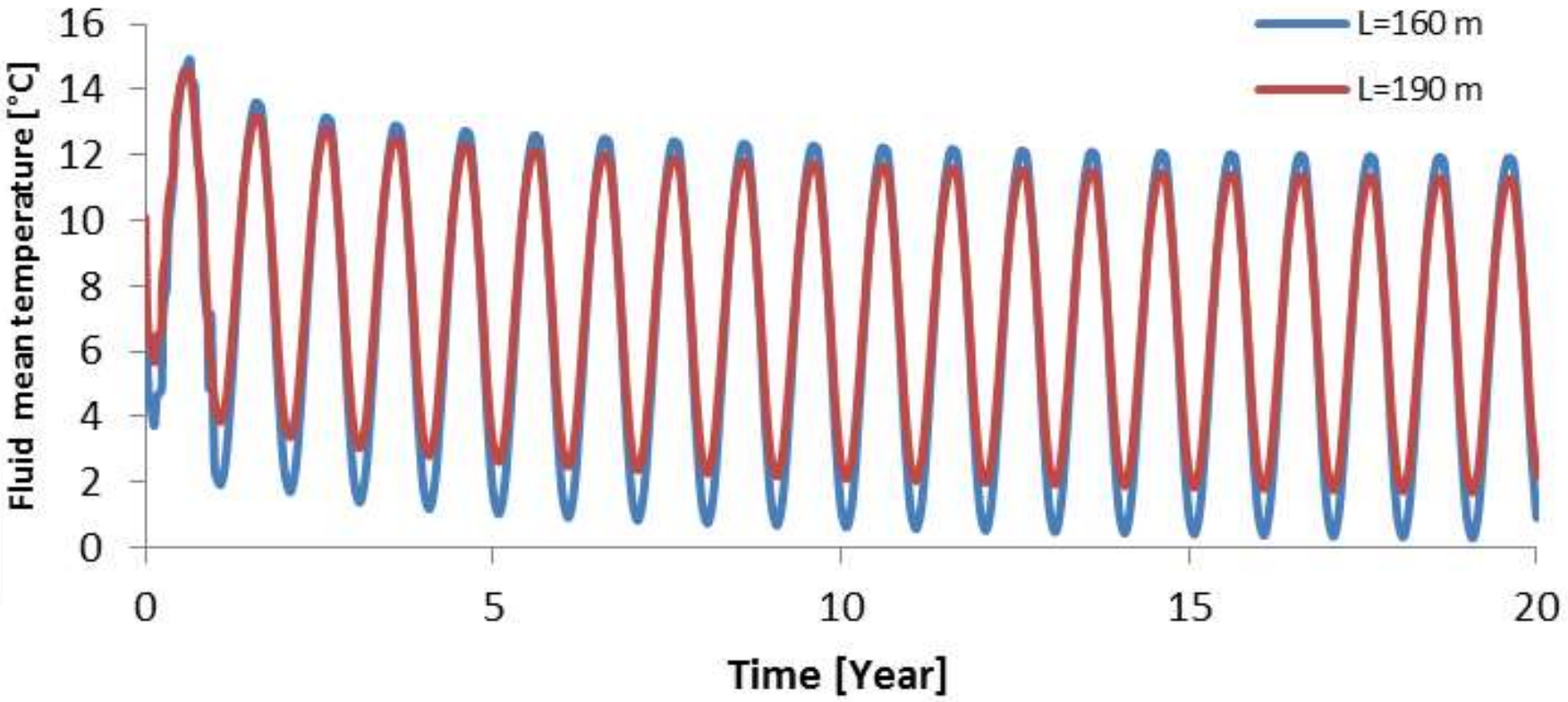
Fluid Temperatures

Calculated from the borehole wall temperature using the thermal resistance.



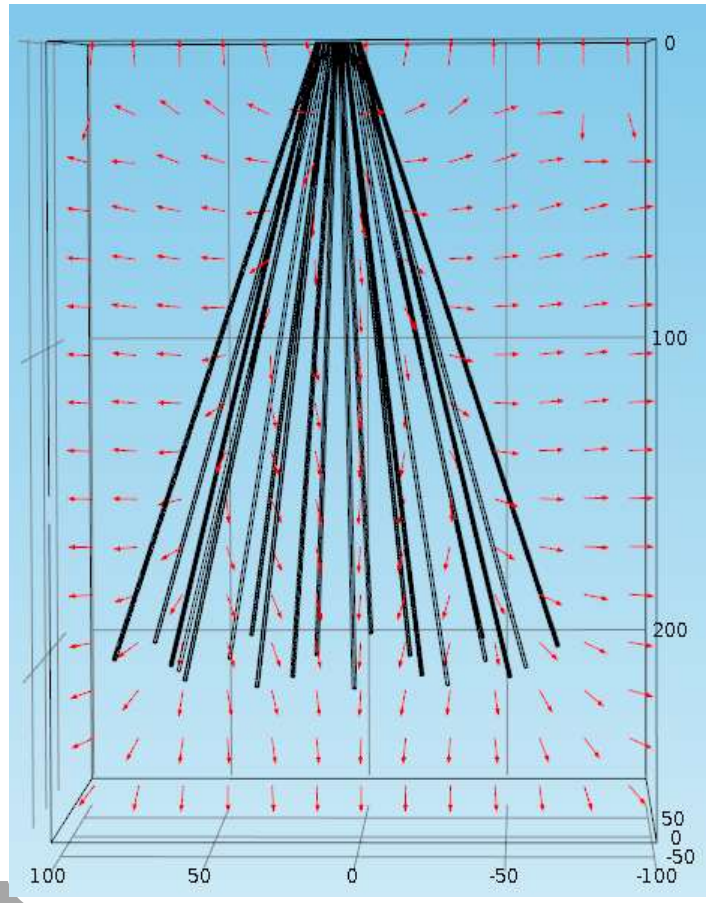
Fluid Temperatures

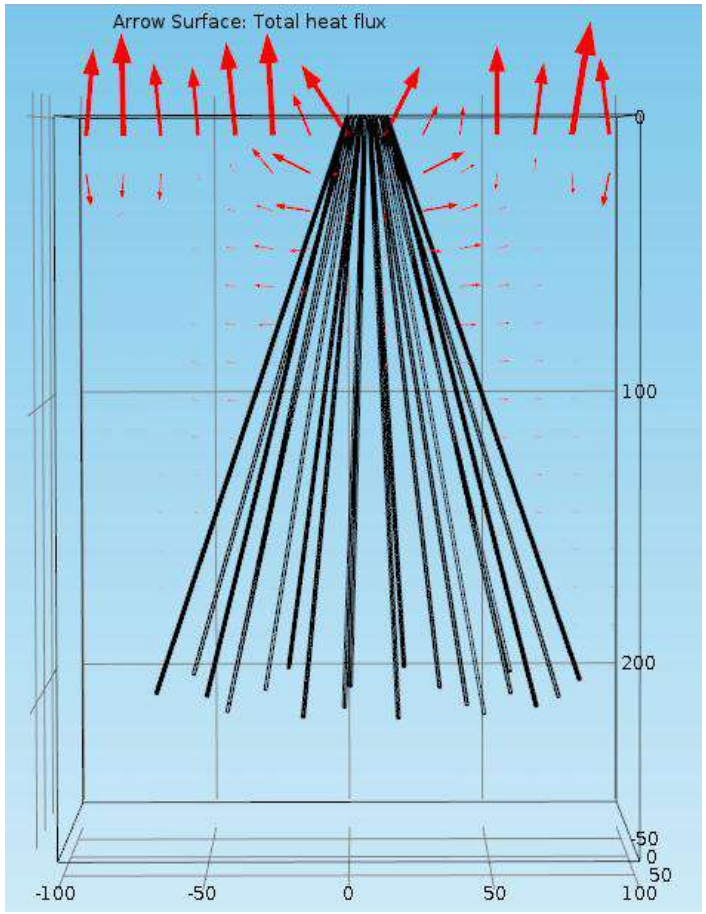
Recharging



Heat Flow Direction

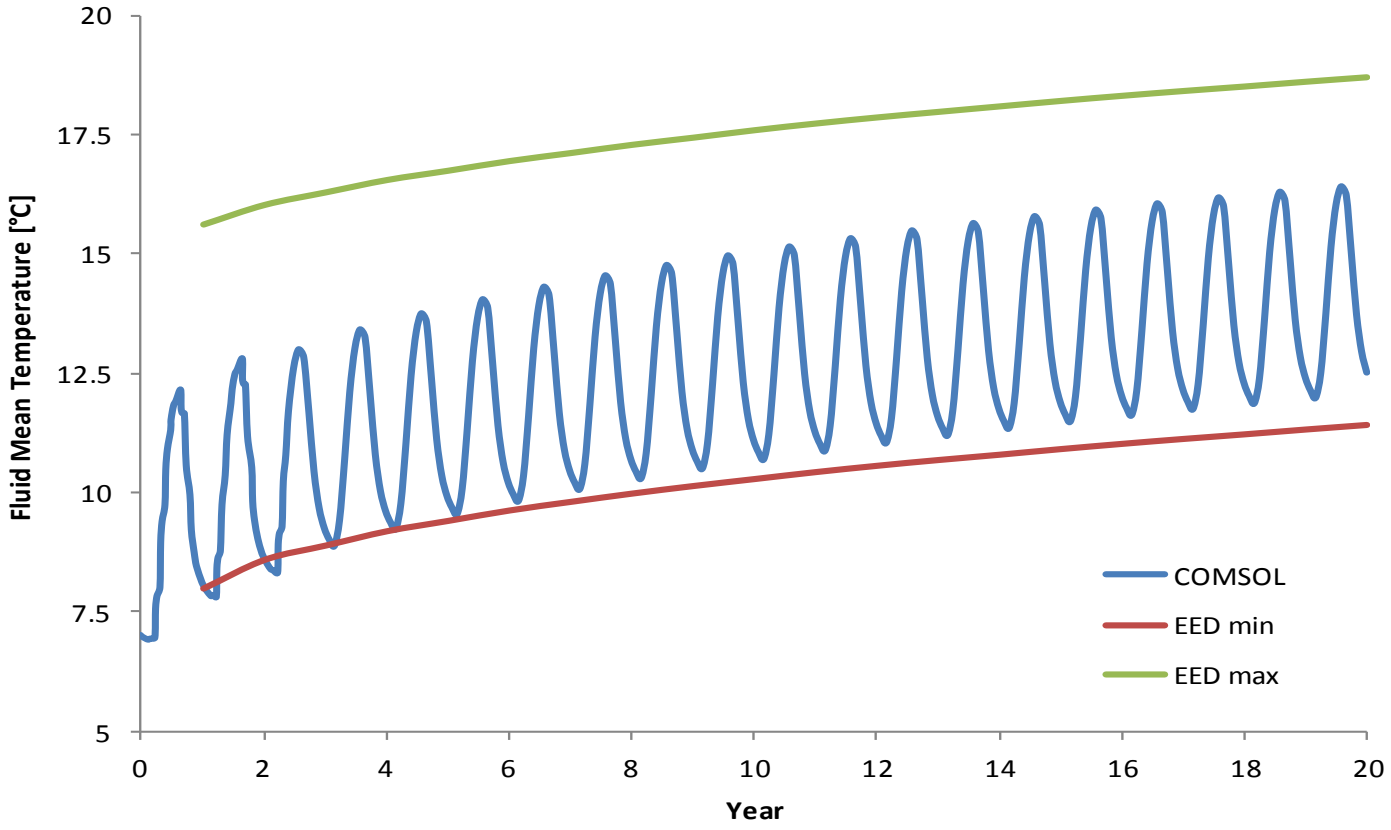
- Why is it important to take 3-dimensional heat transfer into account?





Software Comparison

- Comsol Multiphysics vs EED (Earth Energy Designer)
- Unloading case with ground temperature gradient
- Could lead to oversized system (higher investment cost)



Conclusions

- Comsol Multiphysics is a satisfactory tool when designing inclined borehole fields since
  - It can model any borehole geometry
  - It takes three-dimensional heat transfer into account
- Modeling showed that a high temperature area was formed at the top of the boreholes, giving rise to vertical heat transfer.
- Differences in results between Comsol and other software when similar conditions are used.

Thank you

- Questions?

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