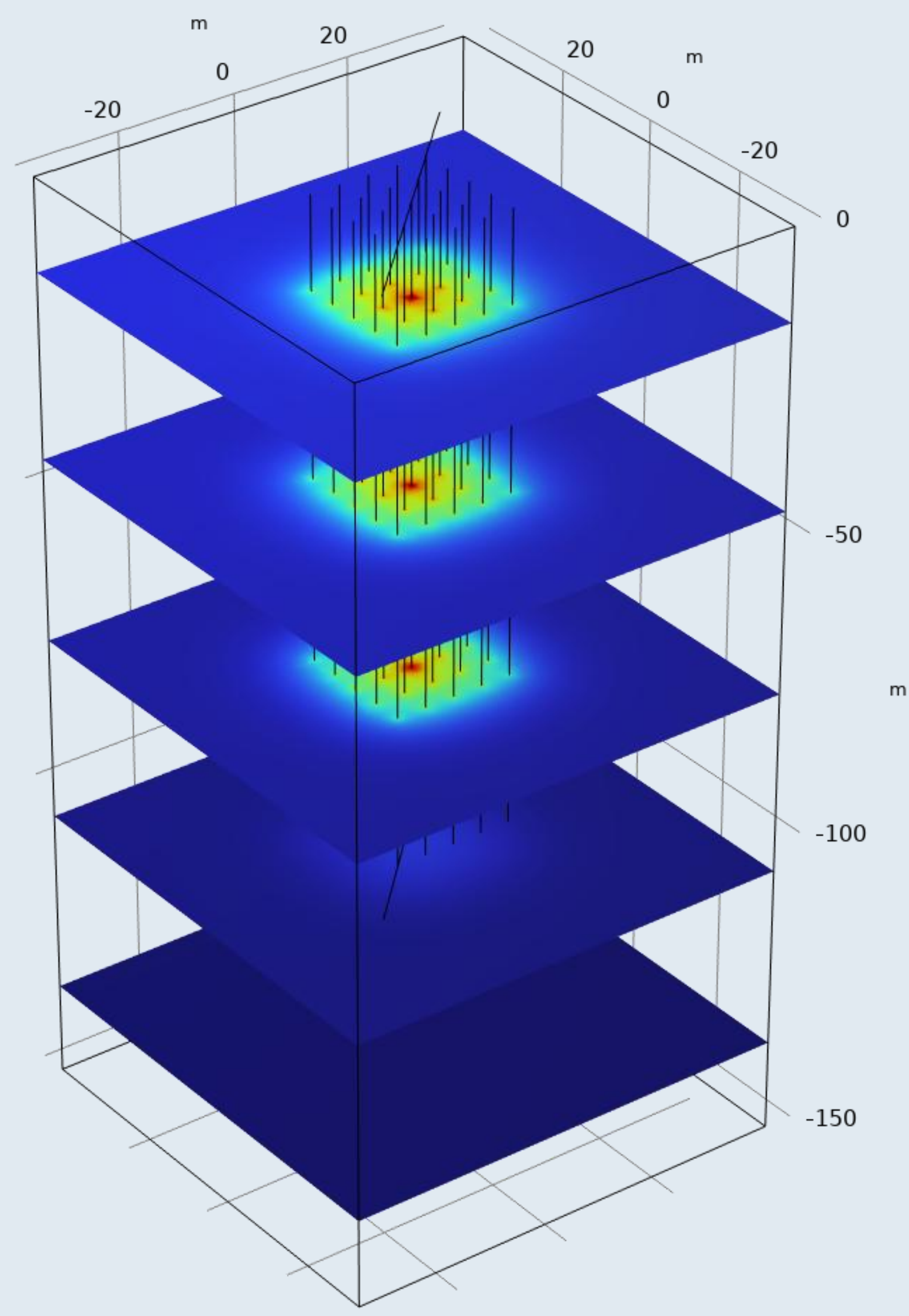




# Design-Driven Seasonal BTES Configurations Using COMSOL Multiphysics®

For the same heat input and site area, borefield layout determines whether the BTES develops a concentrated thermal core or a more uniform storage volume.

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## Abstract

Borehole Thermal Energy Storage can balance the seasonal mismatch between renewable or waste-heat availability and heating demand. However, its thermal performance depends not only on the total injected energy, but also on borehole spacing, type, and spatial arrangement. Poor configuration can produce excessive local temperatures, strong thermal gradients, and underutilised ground volume.

This study develops a COMSOL-based framework for comparing hybrid BTES configurations under the same site and heat-input constraints. The objective is to determine which borefield arrangement is most suitable for concentrated high-temperature charging, balanced performance, or uniform seasonal heat storage.

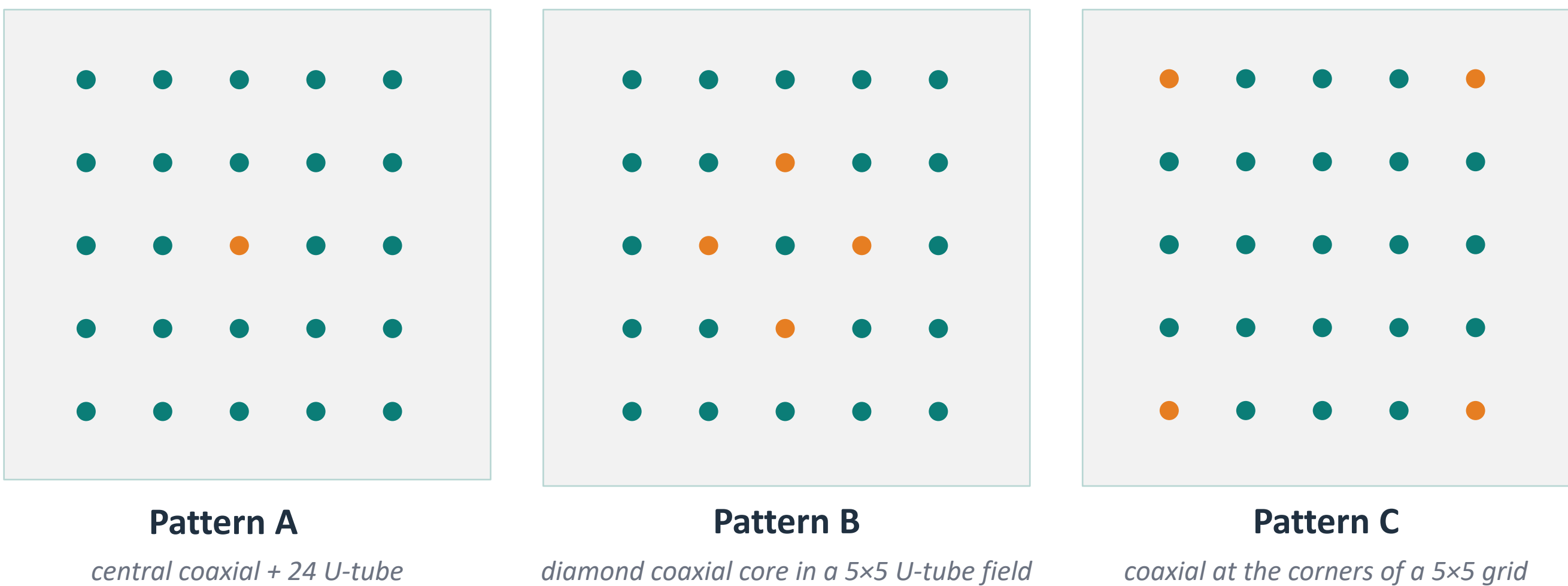


FIGURE 1. Three hybrid BTES configurations investigated under identical borefield dimensions, charging duration, and total heat input.

## Methodology

A transient model was developed in COMSOL Multiphysics® 6.3 by coupling simplified one-dimensional boreholes with a three-dimensional ground domain. The reference system consists of a (5 x 5) borefield with 100 m-deep boreholes, 5 m spacing, and a one-year charging period. A total heat-injection rate of 65 kW was applied, with the thermal loading distributed between coaxial (40 W/m) and U-tube (25 W/m) boreholes.

Three hybrid configurations were compared (Figure 1) under identical total heat input. Performance was evaluated using peak temperature, centre and outer probe temperatures, spatial uniformity, thermal gradients, and borefield-volume utilisation.

## Results & Design Implication

The same total heat input produced distinct thermal responses across the three configurations.

- Pattern A developed the highest local temperature and the strongest thermal gradients.
- Pattern B retained a concentrated heated core but extended the thermal plume over a larger part of the borefield.
- Pattern C produced the smoothest temperature field and the smallest centre-to-outer temperature difference, indicating more uniform use of the available ground volume.

The preferred configuration therefore depends on whether the design objective is high peak temperature, an intermediate compromise, or uniform seasonal heat storage.

- No single configuration is universally optimal. BTES layout should therefore be selected according to the intended operating objective: peak-temperature charging, a compromise between concentration and uniformity, or distributed long-term seasonal storage.

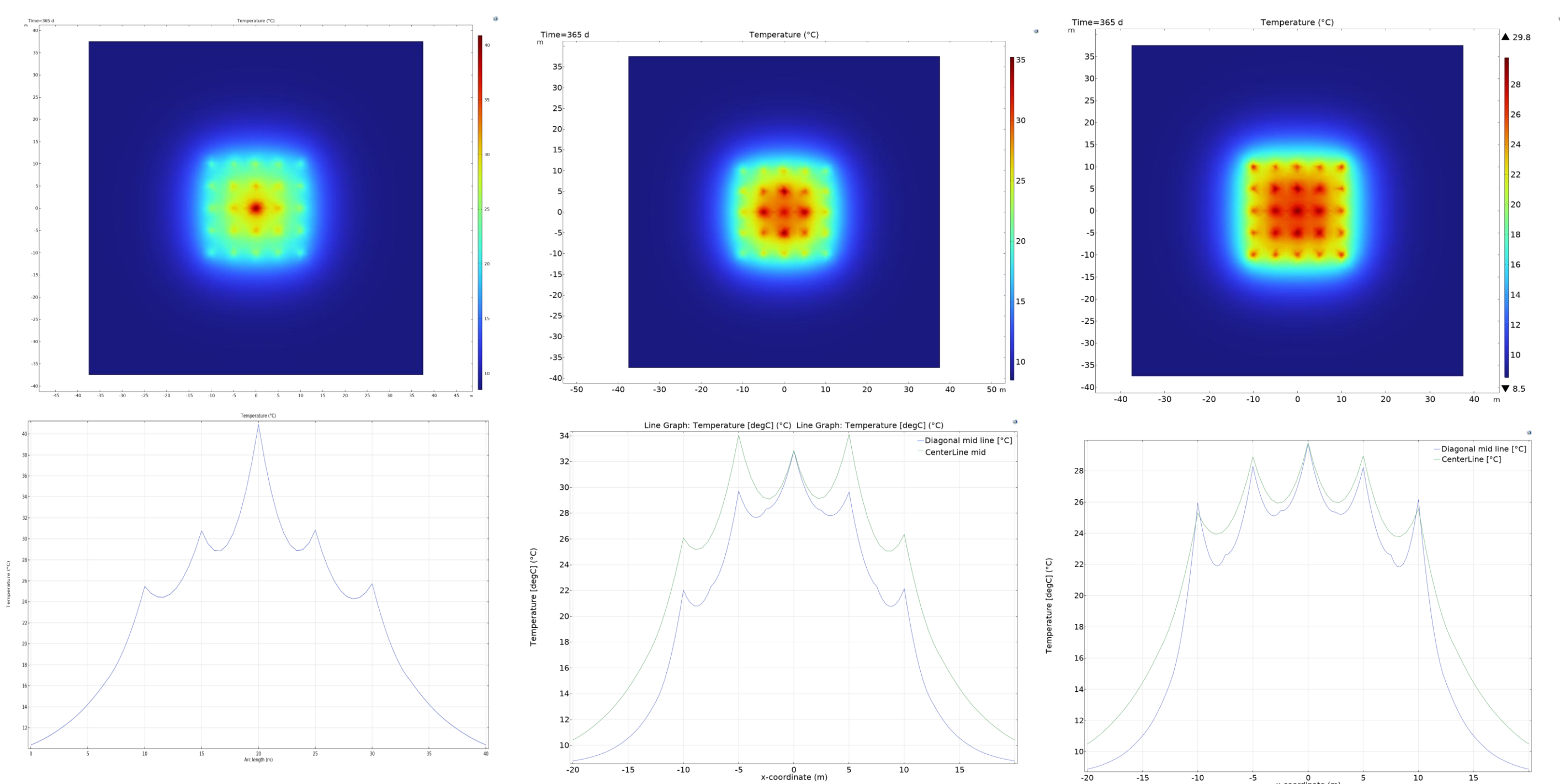


FIGURE 2. From left to right Pattern A, Pattern B, and Pattern C; Mid-depth lateral temperature field, and Temperature distribution along diagonal and center line, t=365[d]

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