THERMAL SIMULATIONS OF THE MERCEDES WCD TANK: INSULATION IS MANDATORY

Luís Filipe Mendes

September 2025
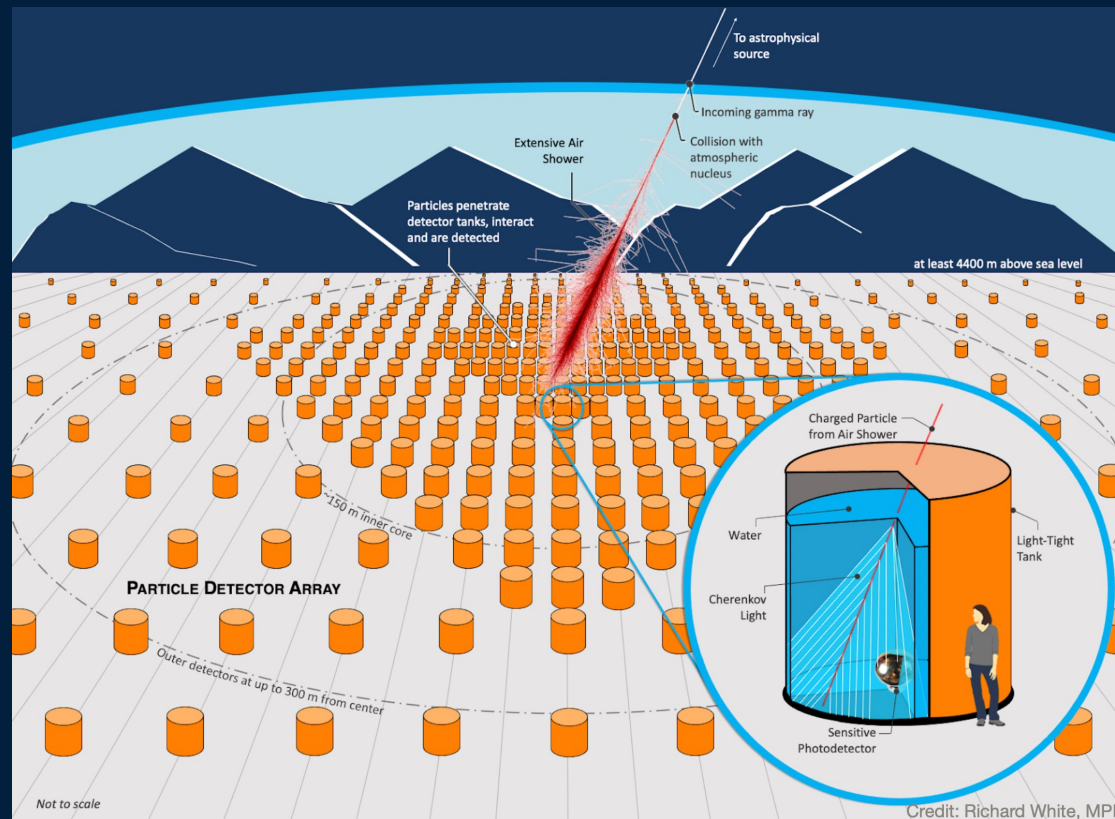
OUTLINE

1. Freezing danger

2. Heat transfer with the tank

3. Simulation model

4. Some results

Technical note

1. FREEZING DANGER

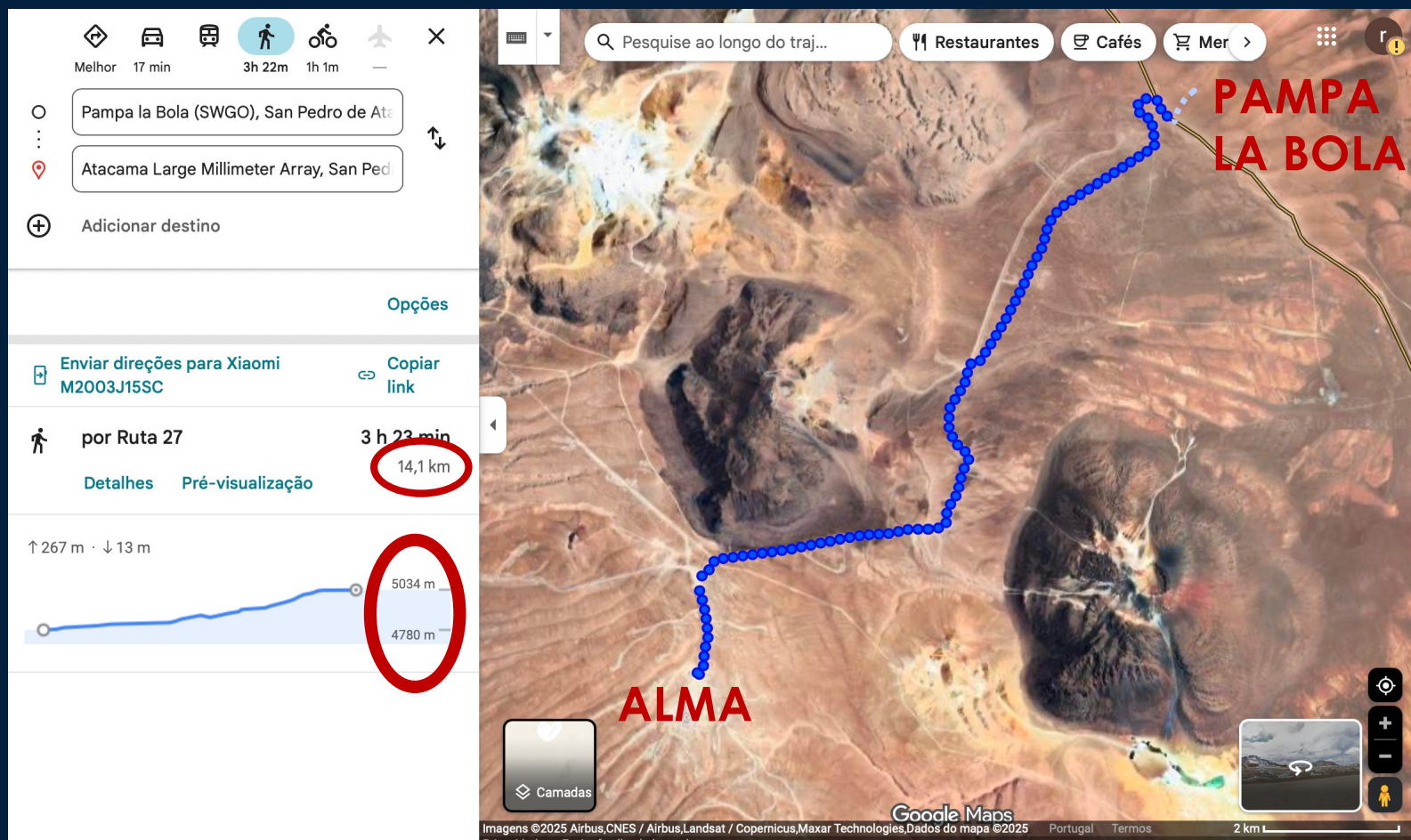As in Piere Auger observatory, SWGO tanks will be exposed, not buried

Credit: Richard White, MPIK

The climate at Pampa la Bola (SWGO site) is very harsh

Alma observatory site

https://public.nrao.edu/telescopes/alma/

The climate at Pampa la Bola (SWGO site) is very harsh

https://www.google.com/maps/

4

We have no images to show, but we have personal testimonies from 2025 about water tanks at ALMA that were destroyed by ice formation — an event we were almost certain could happen
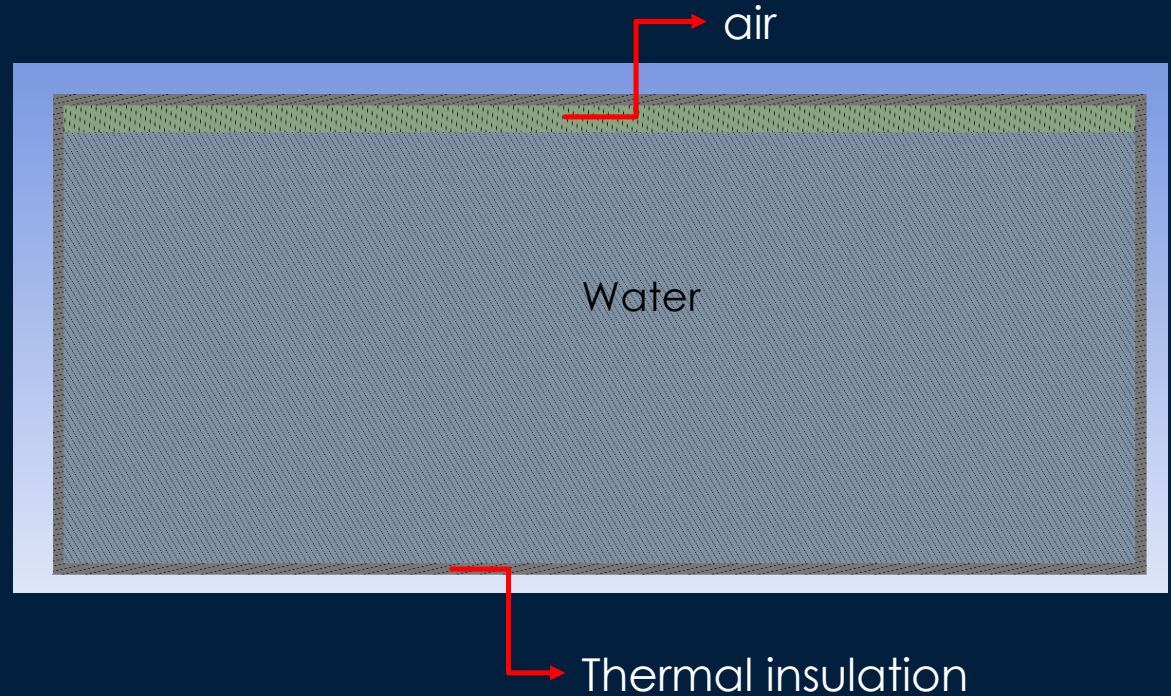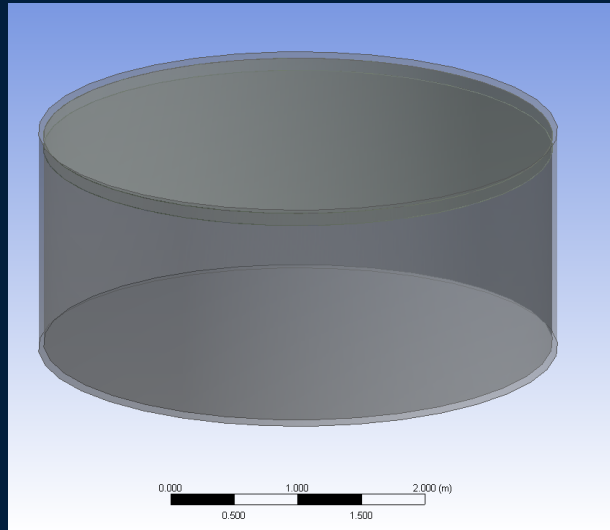

Daily temperature
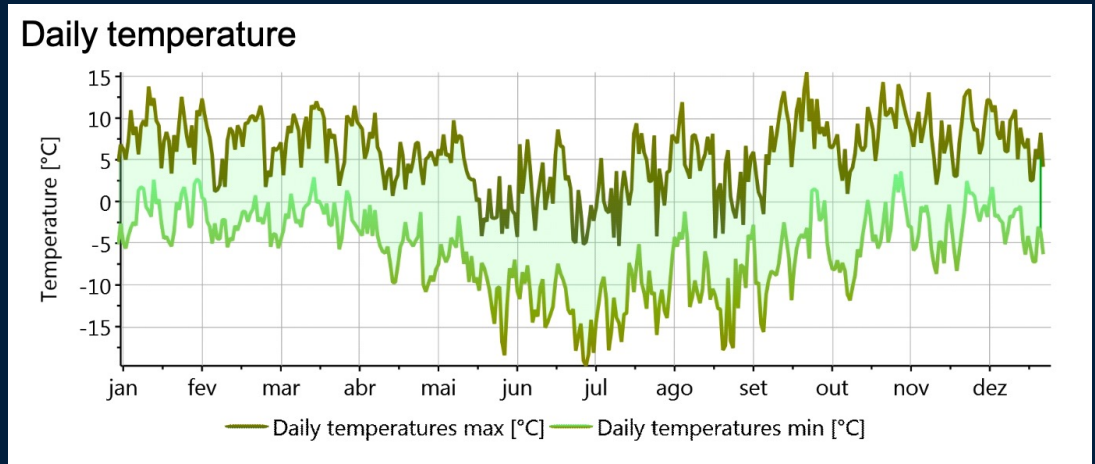
METEONORM – Pampa la Bola
Extreme year: interval of confidence of 95%

This issue cannot be addressed with conjectures, extrapolation from different sizes/locations or with oversimplified models

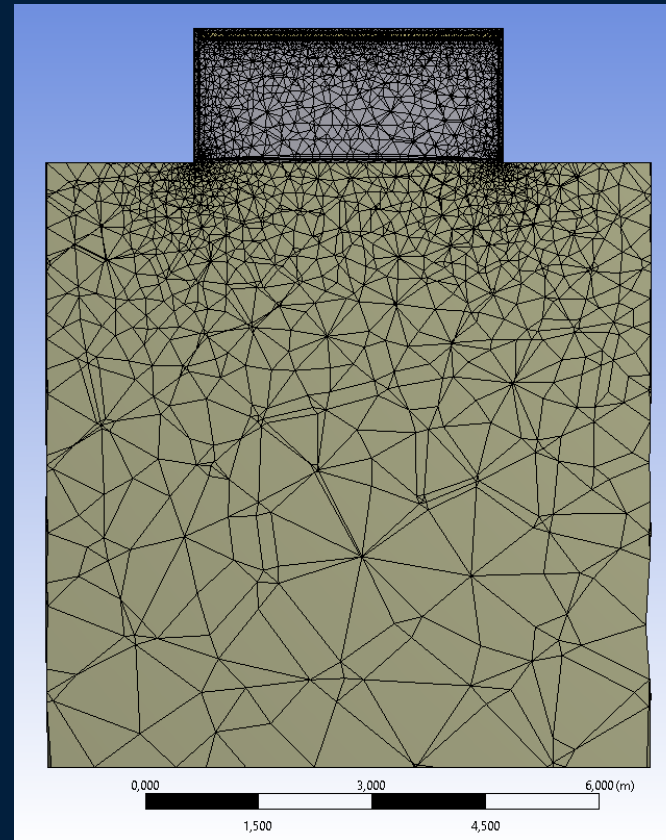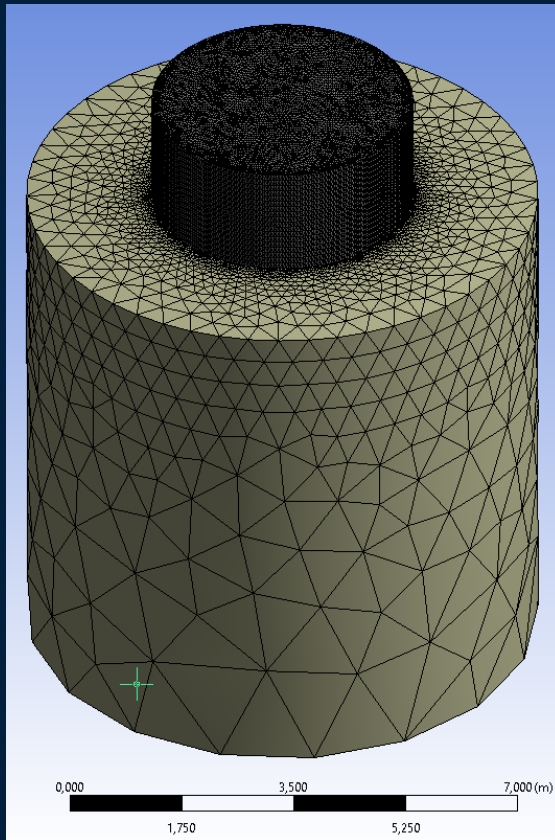# 2. HEAT TRANSFER WITH THE TANK

Soil
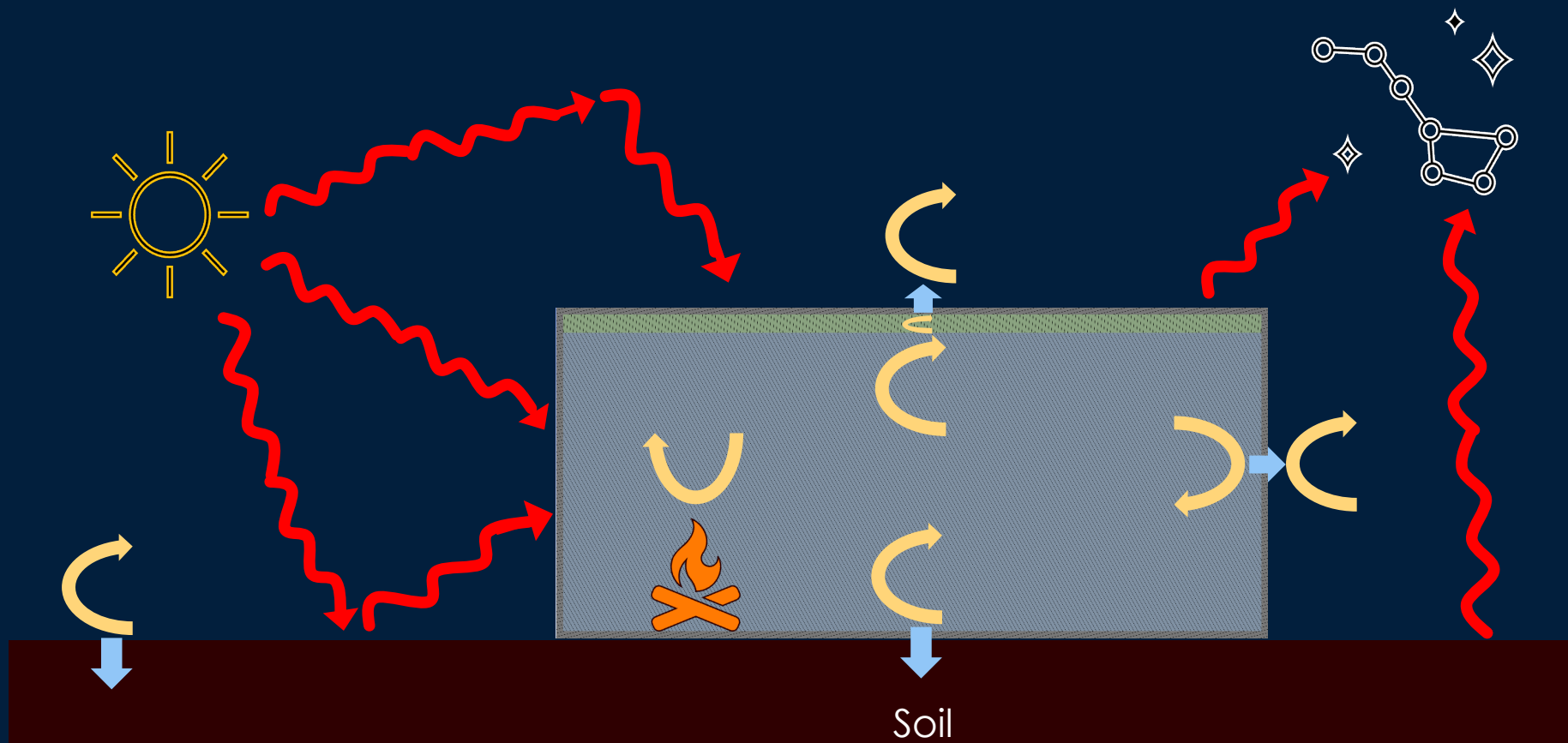
3. Simulation Model

Dimensions:
- Diameter: 4 m
- Height: 1.75 m
- Water Height: 1.60 m
- Thermal insulation thickness: adjustable (4 cm in this figure)

$10^5 - 10^6$ cells

detailed model, with fluid velocity fields calculation and with solar ray tracing (ANSYS – FLUENT)
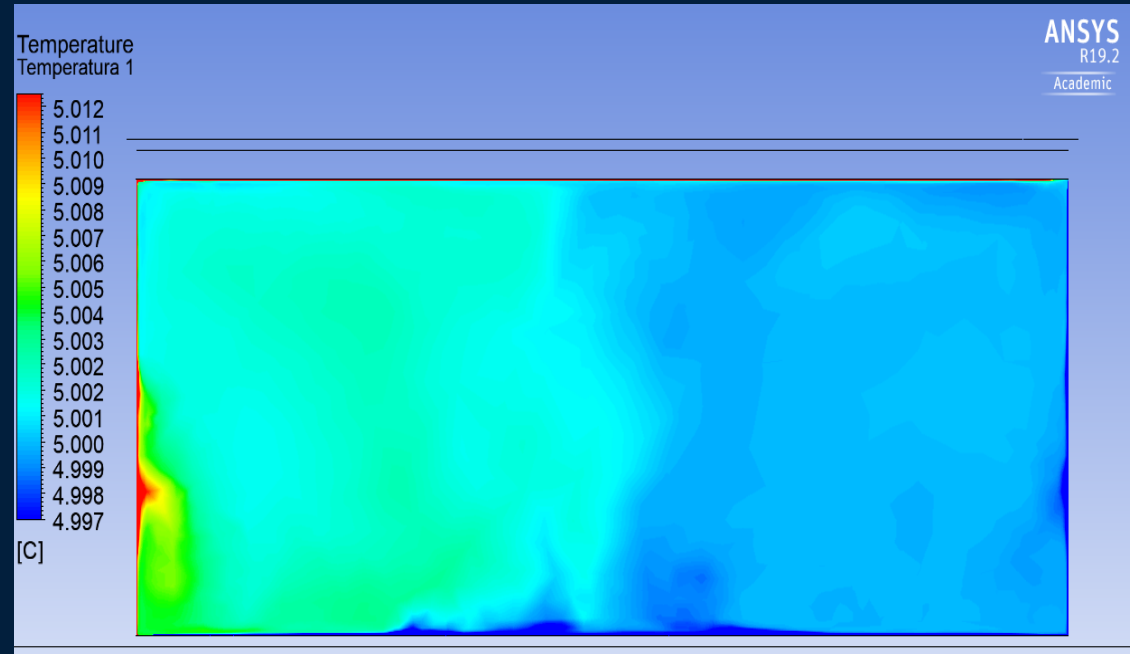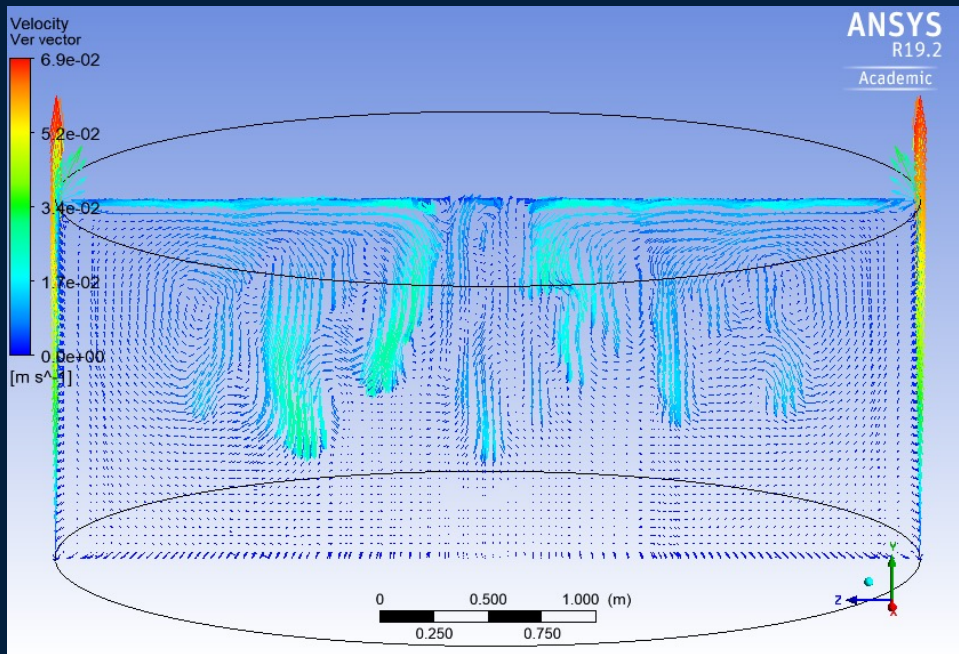
- allows up to a few hours of simulated time

- 1 year of simulated time would need to run for *30 years*

  CPU: intel core i5 @3.5 GHz, 2 cores

Several simplifications were introduced:

- Every simplification was validated against previous, less simplified versions

- Simplifications were accepted when deviations remain below 0.05 °C/month

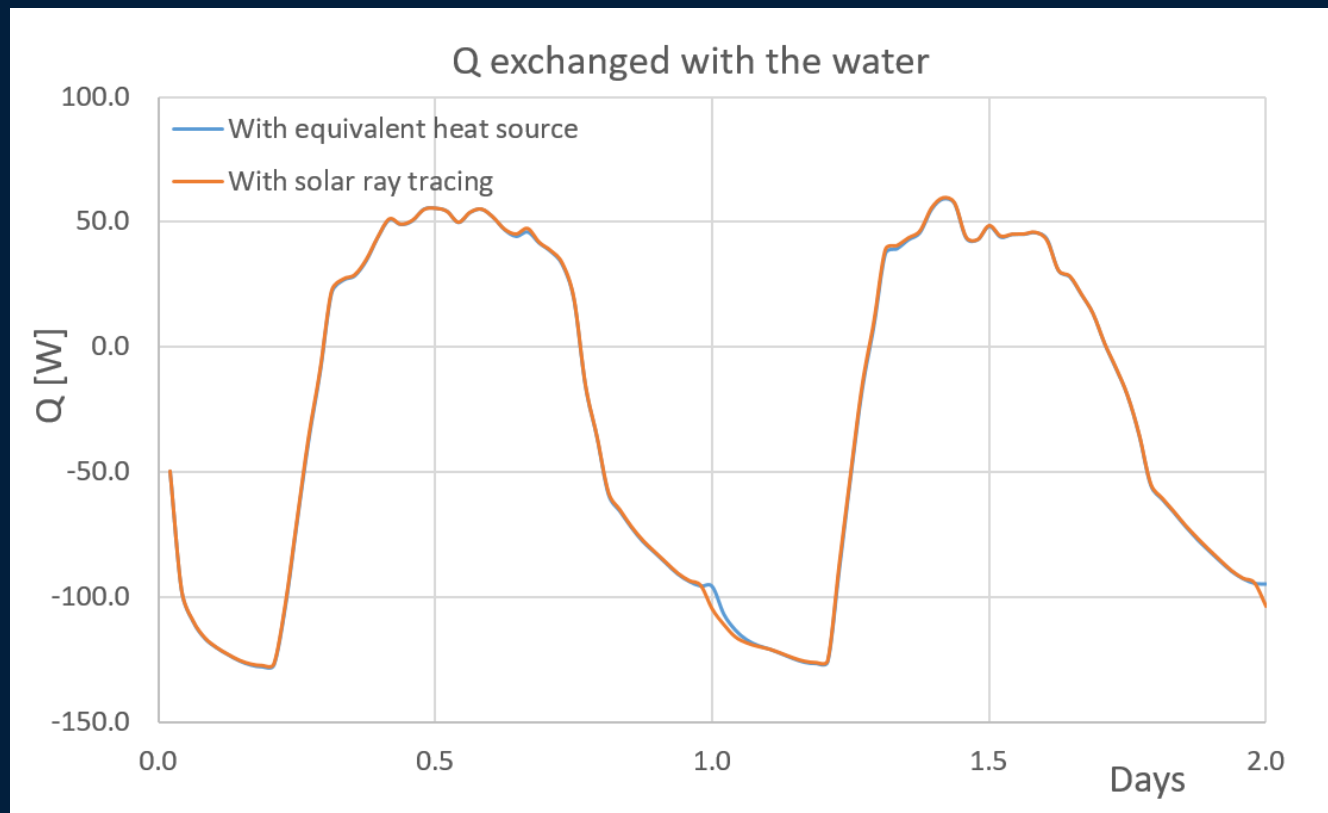# For example

The water volume remains fully mixed, with temperature gradients being negligible across the tank and never exceeding ~ 0.2°C, even near heat exchange surfaces → no need to compute the velocity field

Or,

Calculating the solar loads separately and subsequently applying them as equivalent heat sources to the model doesn't change the results
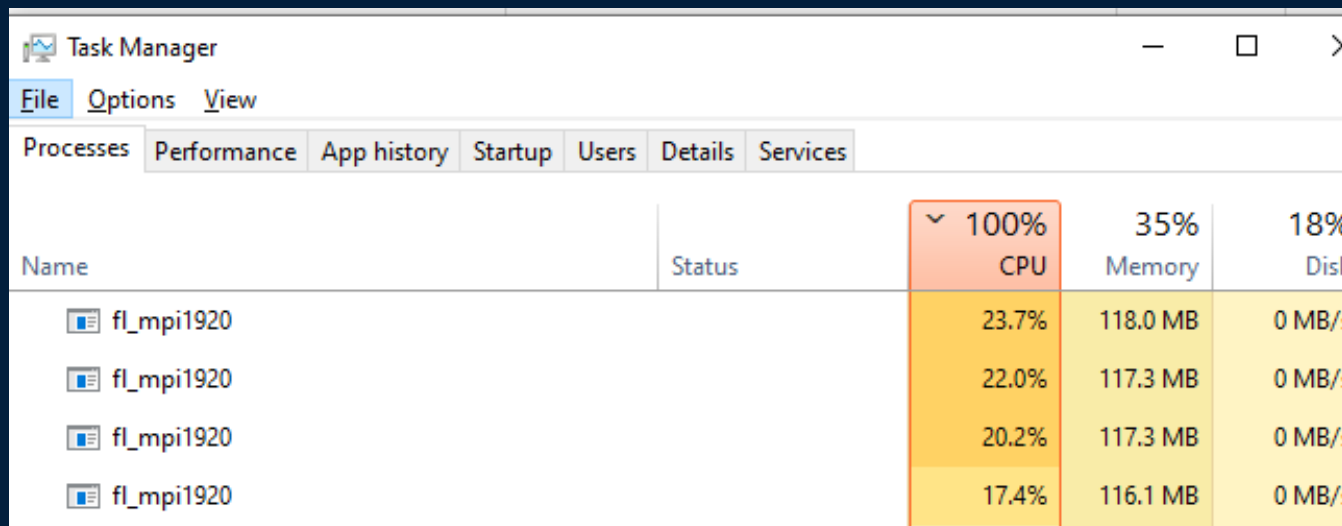

ΔT_{water} (1 month)=0.008 °C

IN THE END,

For tanks with configurations similar to the Mercedes WCD, it was possible to find a simplified model that accounts for all relevant heat exchange processes while enabling feasible annual simulations:

- 1 year of simulated time is computationally reduced to 6.5 h of simulation runtime
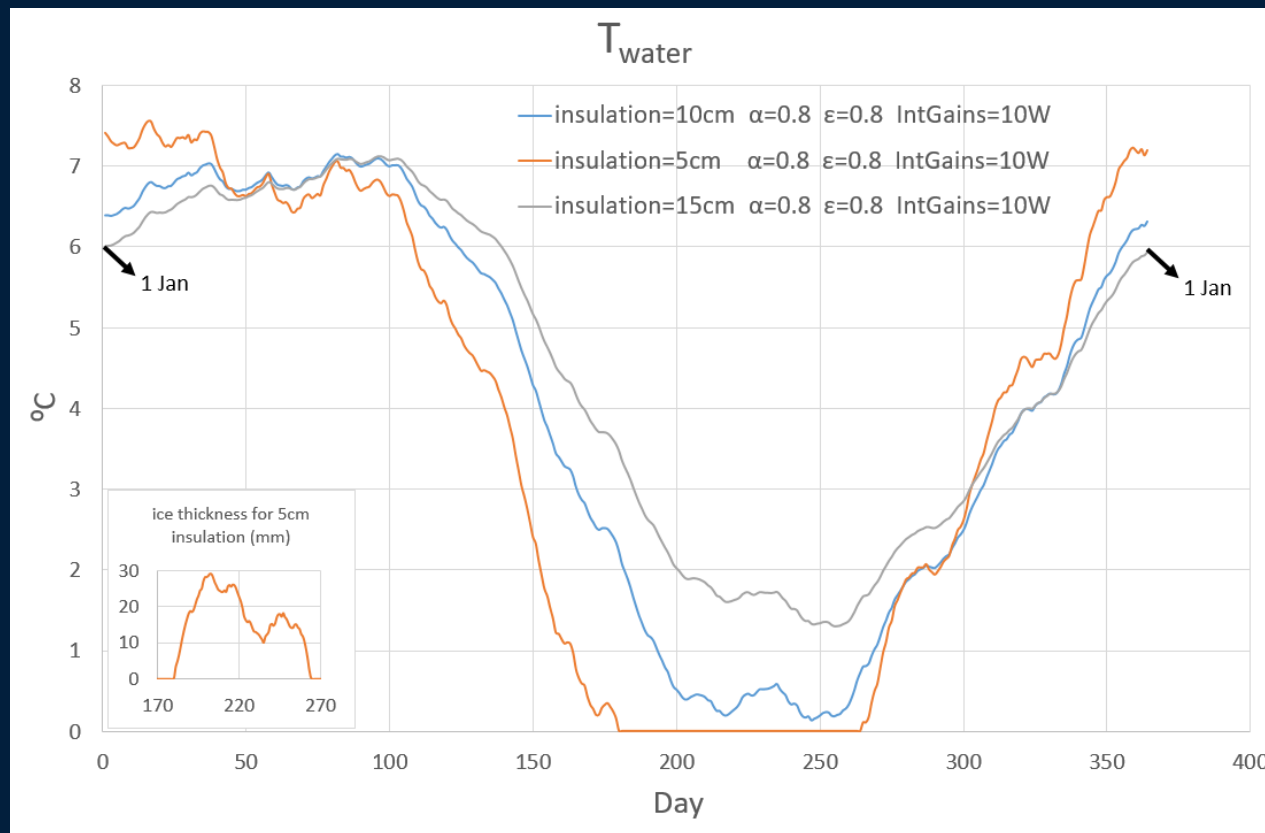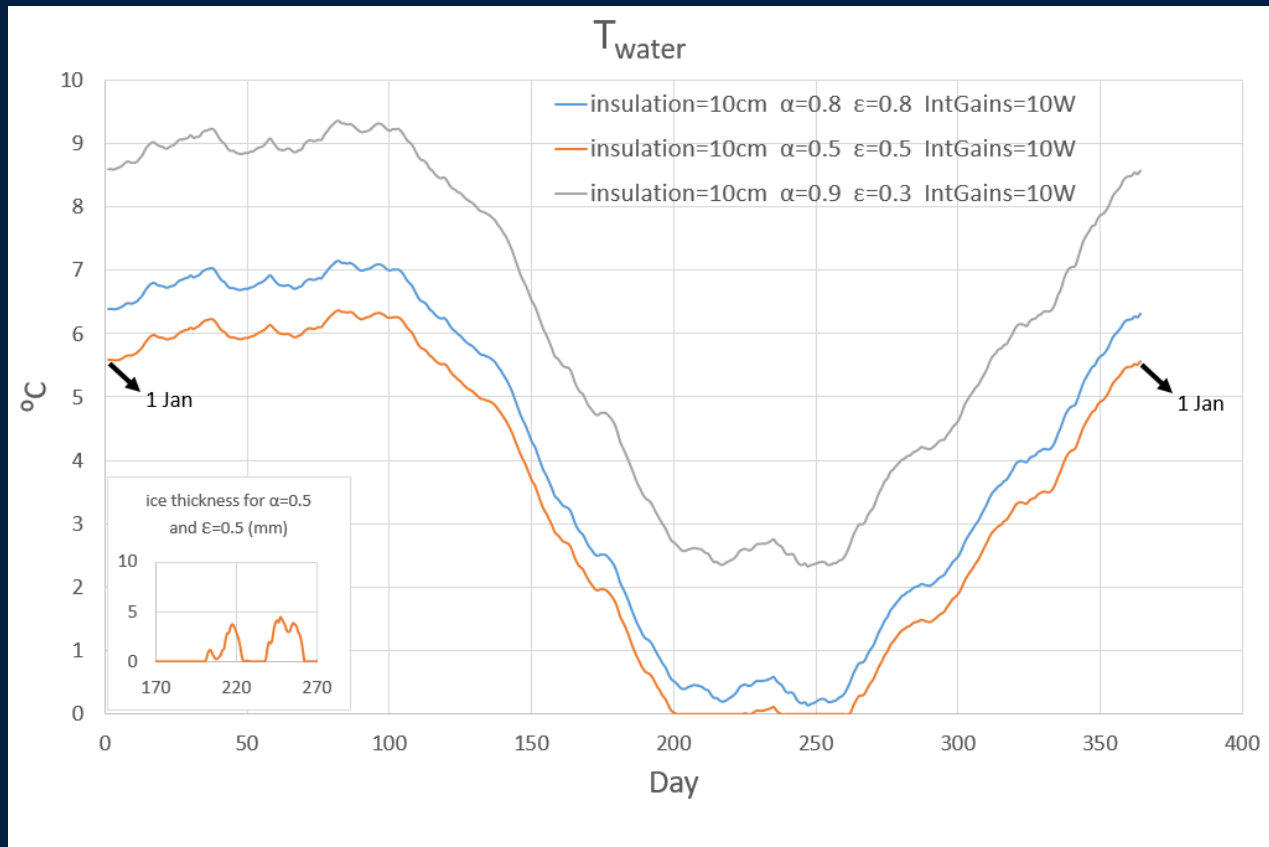

CPU: intel core i5 @3.5 GHz, 2 cores

5. SOME RESULTS

Effect of the insulation thickness

Effect of the surface optical properties (α and ε)

Effect of the internal gains
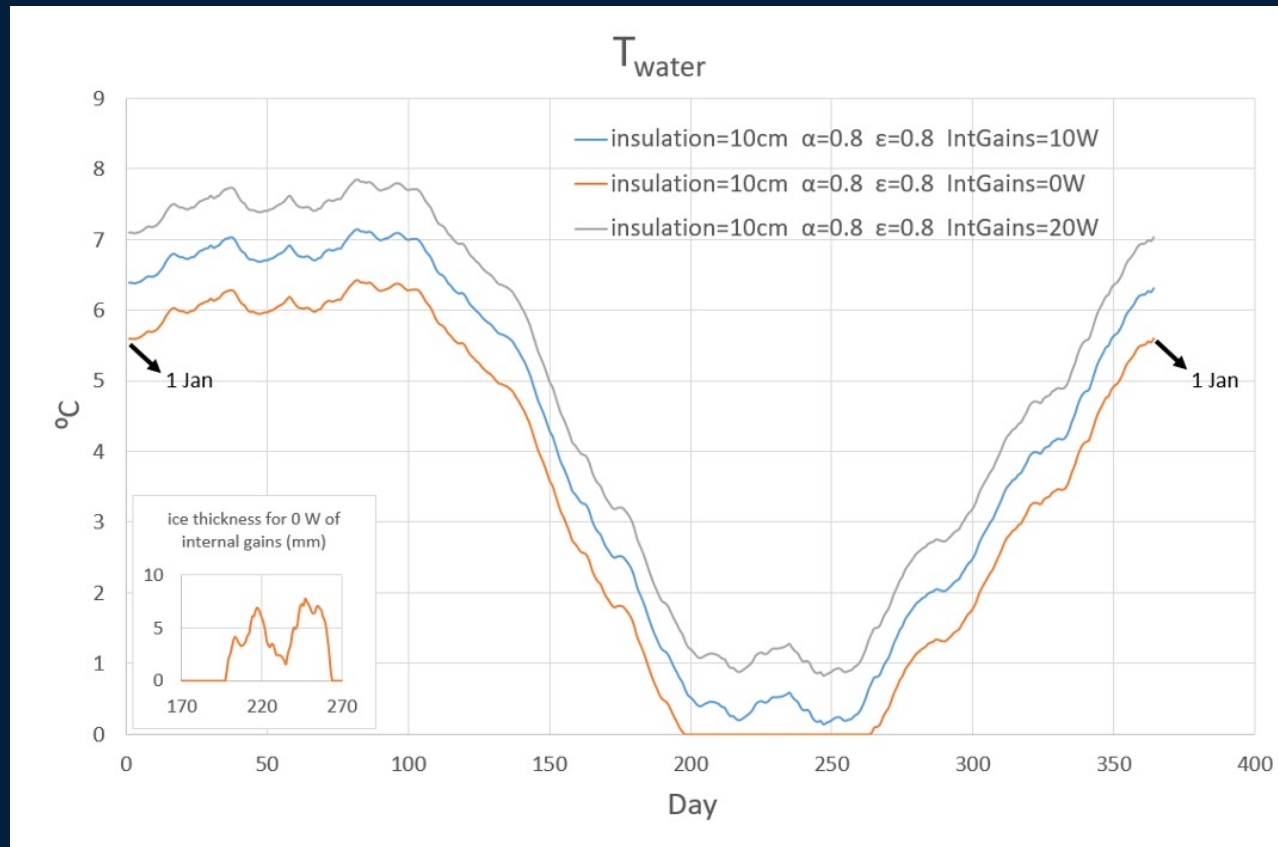
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Detailed thermal simulation model for tanks with the Mercedes WCD geometry

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