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RESINA
Fast Simulation-Based Prediction for Pilot Design

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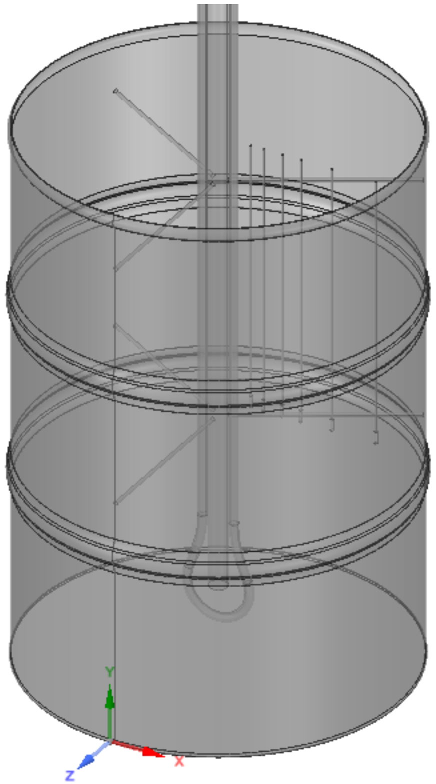
Why We Use Simulation

Simulation helps us design the pilot, estimate performance, and compare materials and operating conditions more efficiently while maintaining good accuracy.

- We are developing a pilot system.
- Simulations help us understand how the pilot system may perform.
- Detailed CFD simulations are accurate, but time-consuming.
- A reduced-order model (ROM) provides faster predictions.



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How the Model Works

The goal is to keep the accuracy of detailed simulations while making results much faster to use.

Detailed simulation → **Learn from data** → **Fast prediction**

- Full CFD simulations are powerful, but slow.
- The model was trained on 800 simulation cases.
- After training, it can estimate new temperature fields much more quickly.

Why it is useful

Faster design studies
Compare many cases without running a full simulation every time.

Lower computing cost
Use detailed simulations for training, then reuse the learned model.

Easier communication
Share the big picture without showing all the equations and specialist details.

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From a Huge Temperature Map to 4 Key Modes

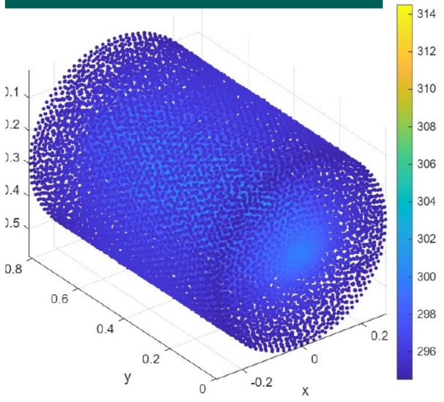
Instead of tracking every point separately, the model keeps only the main modes that explain nearly all of the variation.

What happens behind the scenes

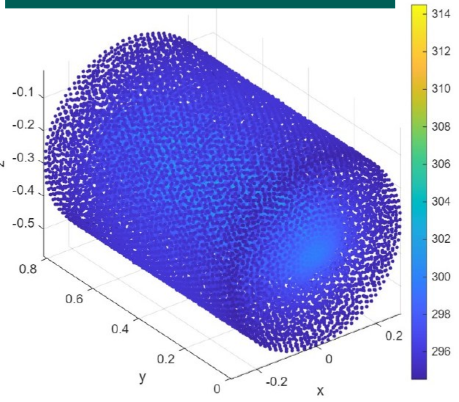
1. The original field contains about 267,000 temperature values.
2. The method finds the strongest recurring temperature patterns.
3. Only 4 modes were enough to capture almost all of the variation seen in the dataset.

267,462 values → 4 main modes

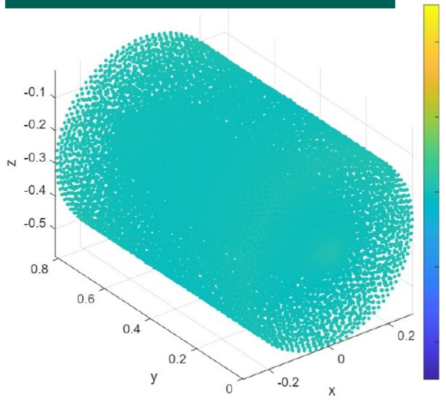
CFD results



Compact reconstruction



Error< 2×10^{-4}



Example: original result, compact reconstruction, and difference map

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How Close Are the ROM Predictions

For cases inside the studied design space, the simplified model stays very close to the full simulation results.

Simple reading of the results

Typical field error

< 0.15 ˚C

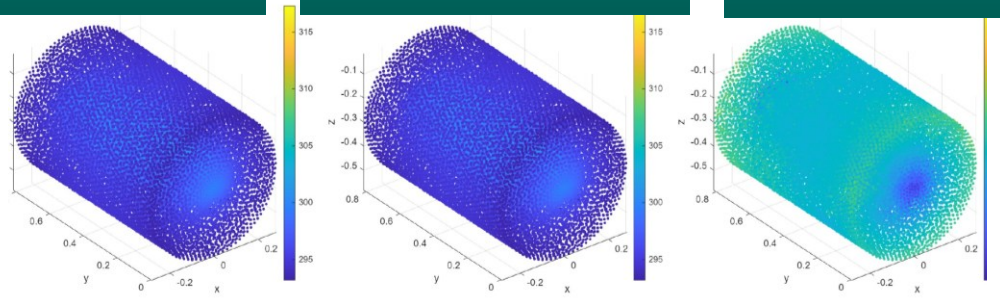
This means the ROM usually reproduces the detailed result very closely.

Best use case
Quick screening and comparison of cases that are similar to the training data.

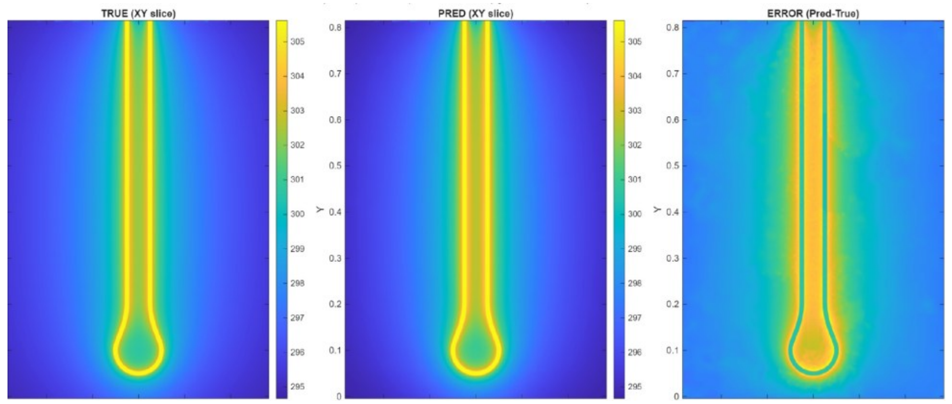
Caution: larger errors mainly appeared when predicting far outside the training range.

Temperature distribution

CFD | Prediction | Error < 0.15˚C



3D Example Comparison



2D Slice Example Comparison

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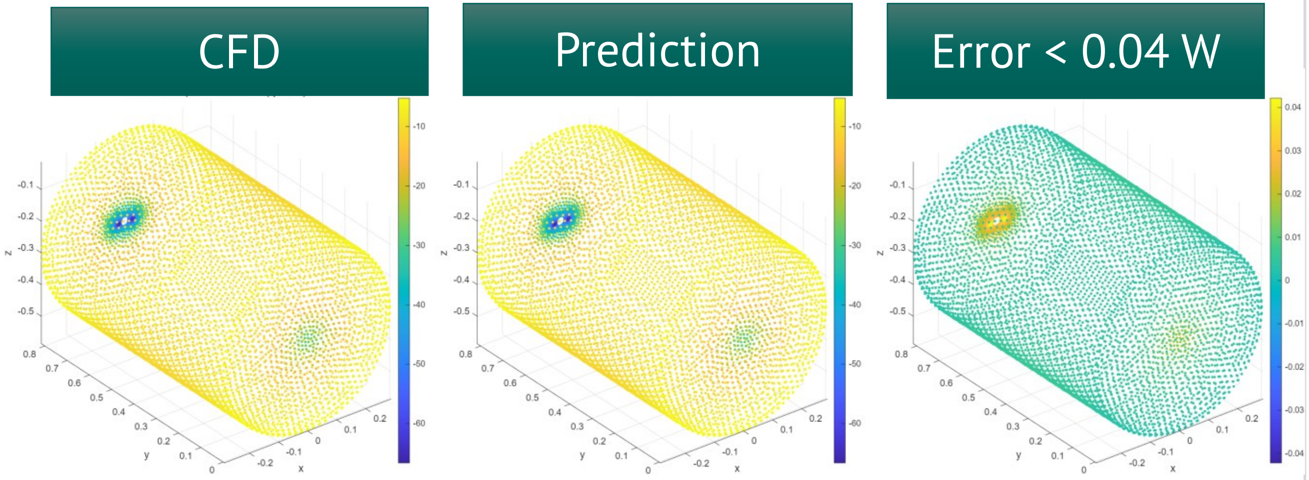
Example Results for Heat Transfer Rate

These examples show the detailed simulation, the ROM prediction, and the remaining difference between them.



Another 3D comparison from the original study

What These Visuals Show

- The ROM reproduces the main temperature shapes well.
- The difference plots are small for cases inside the trained range.
- That makes the model useful for rapid screening and design exploration.
- Full simulations are still important for edge cases and for generating new training data.

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Thank You!

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