# Modelling of methane emission from stored digestate

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STØTTET AF
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# Methane emission from agricultural residues

- Agriculture contributes more than **¼ of Danish greenhouse gases** (GHG)
- Nearly ½ of agricultural methane is from **manure storage**
- The national inventory shows **no improvement** in the past 30 years

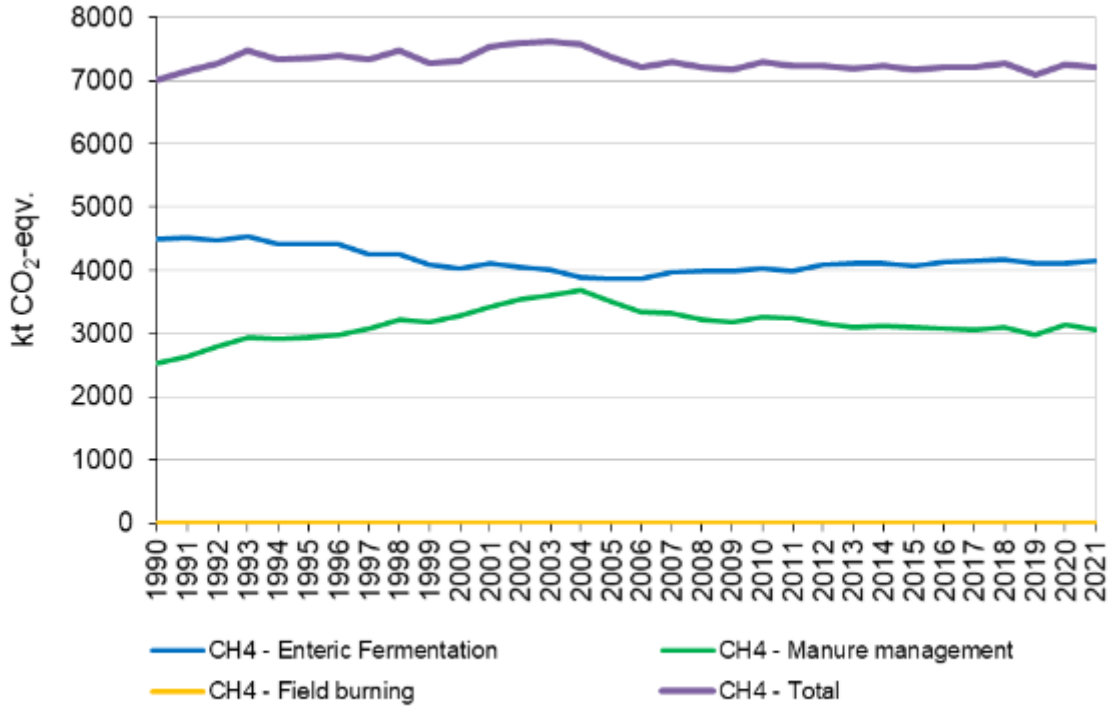



Figure 5.1b Danish agricultural $CH_4$ emissions 1990 – 2021.

From 2023 Danish national inventory report
https://dce2.au.dk/pub/SR541.pdf

# The Klimagylle project

**Description**

- Aim is to develop a method for predicting management effects on methane emission from stored digestate using the best available modeling tools
- Two main components: emission **measurement** and emission **modeling**
- This presentation focuses on modeling

**Project participants**

- Lars Viladsgaard Toft, Andreas Gravholt, Michael Holm | **SEGES**
- Pernille Lund Kasper | **DTI**
- Henrik Bjarne Møller, Cristiane Romio, Sasha Hafner | **Aarhus University**

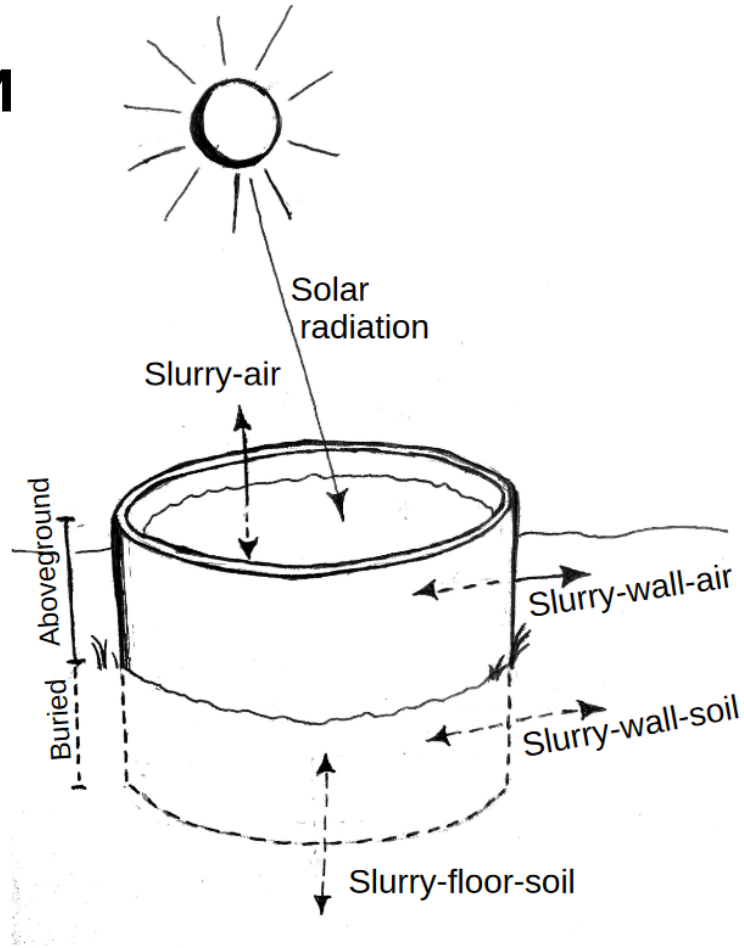
# Measurements: 4 digestate storage tanks

| Tank ID | Maximum volume ($m^3$) | Digestate load* (t) | Volatile solids (VS) load* (t) | Peak temperature† (°C, (month)) | Measured $CH_4$ emission* (t) | Measured $CH_4$ emission* (kg/t) |
|---|---|---|---|---|---|---|
| AD1 | 5000 | 4000 | 220 | 25.9 (9) | 7.5 | 1.9 |
| AD2 | 2500 | 2000 | 100 | 21.6 (8) | 5.9 | 3.0 |
| AD3 | 1500 | 1600 | 80 | 24.4 (7) | 2.3 | 1.4 |
| AD4 | 1500 | 2200 | 80 | 23.1 (8) | 6.1 | 2.8 |

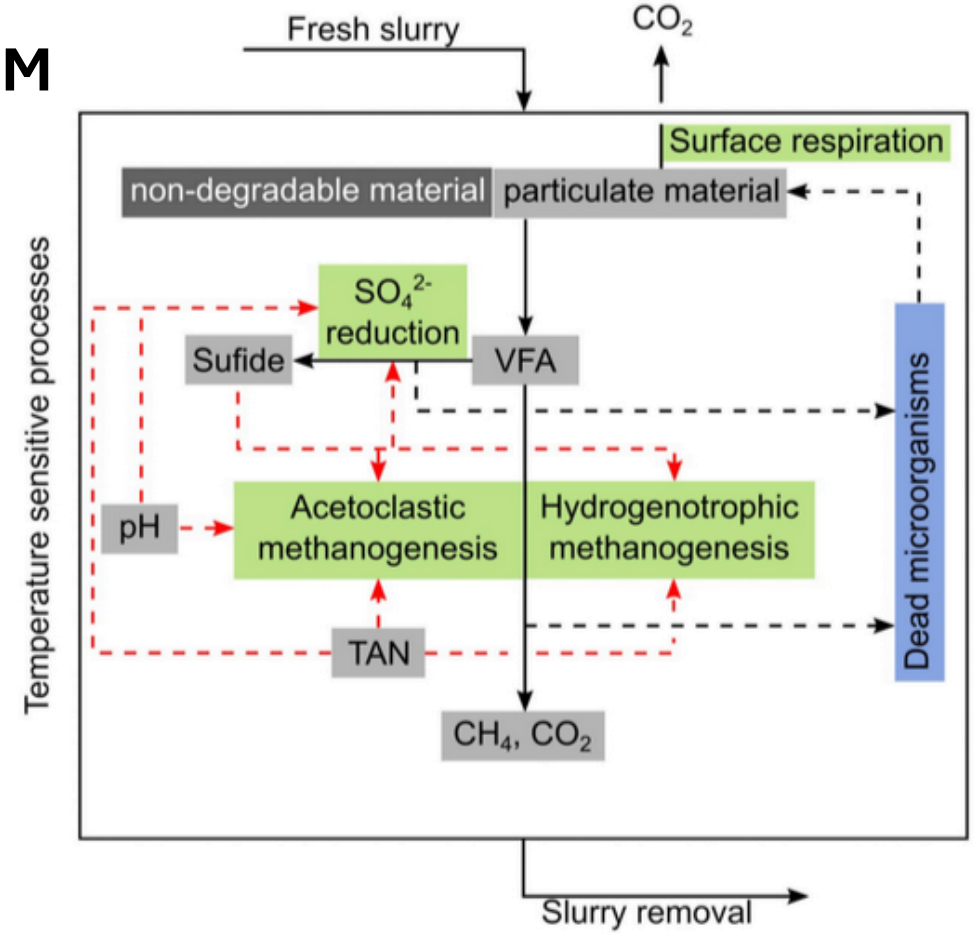
*Annual, †monthly average

# Methods – coupling two models

**STM**




**ABM**




https://doi.org/10.1016/j.softx.2023.101354

https://doi.org/10.1371/journal.pone.0252881

# Model details

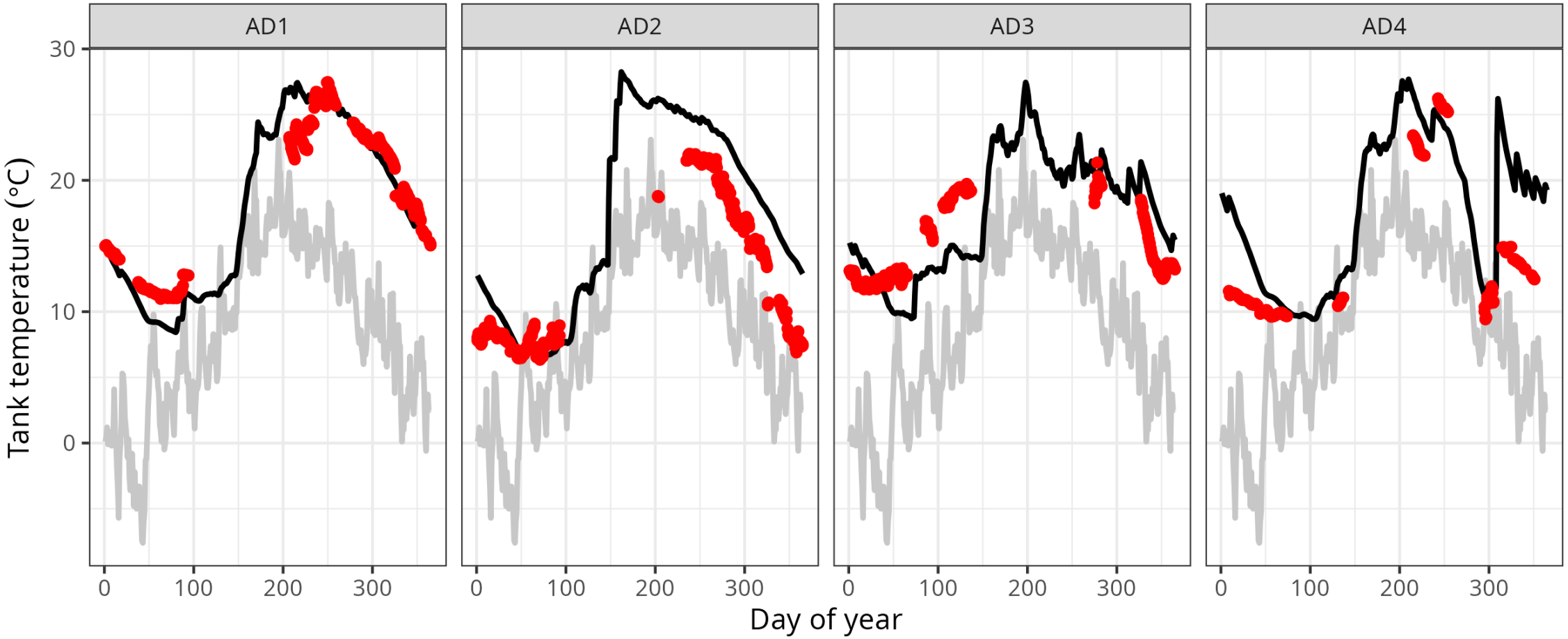
**Temperature by STM**

- Simple lumped parameter heat transfer model
- Inputs: tank dimensions, daily air temperature and solar radiation, tank loading and emptying schedule
- Parameters: heat transfer resistance values, absorptivity, physical constants
- Open-source: https://github.com/AU-BCE-EE/STM

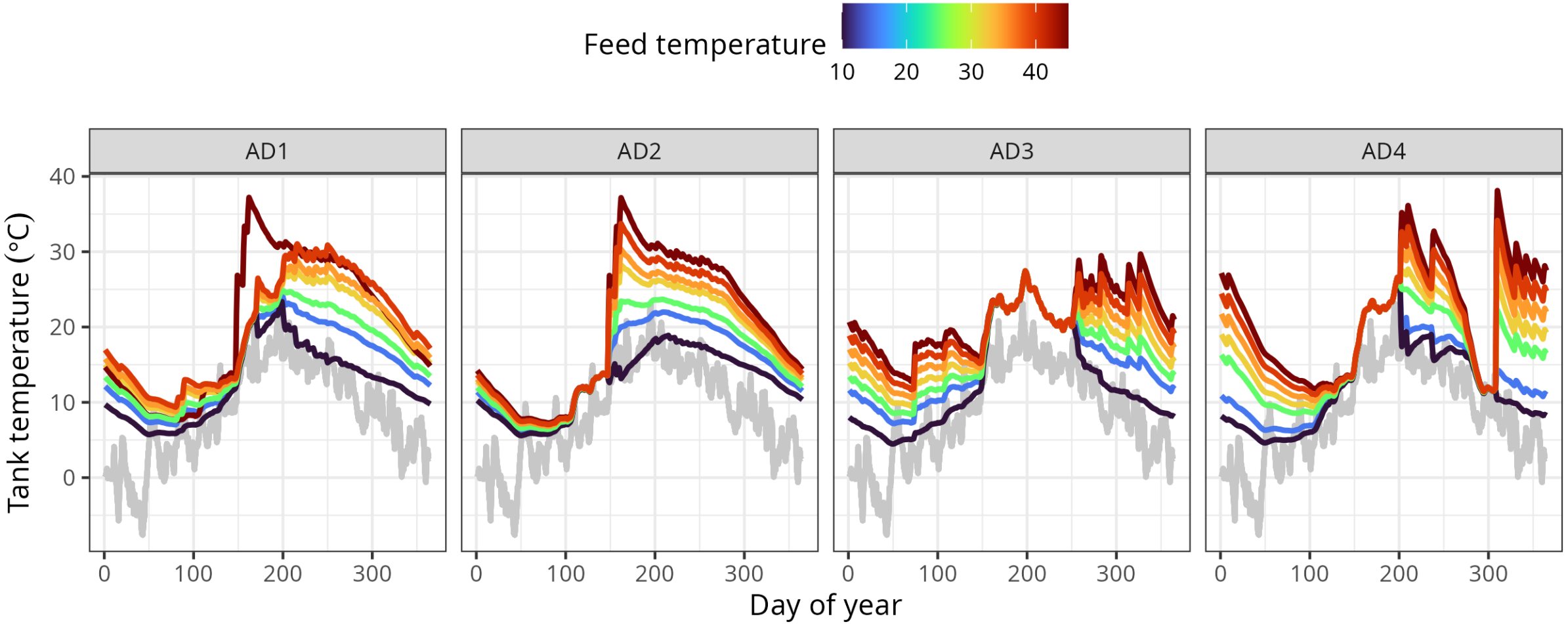
**Microbiology and $CH_4$ by ABM**

- Model of microbial growth and activity
- Inputs: daily digestate temperature, tank loading and emptying schedule, substrate concentration
- Parameters: methanogens, hydrolysis rate, microbial growth rates, …
- Open-source: https://github.com/AU-BCE-EE/ABM

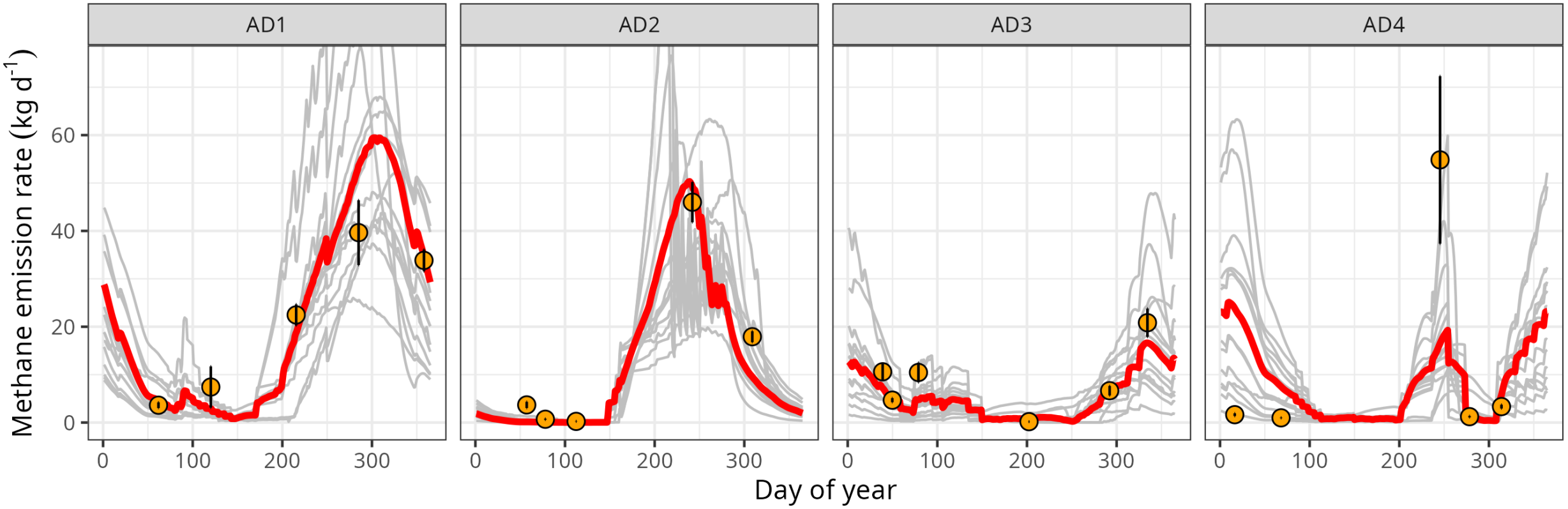
# Temperature predictions – STM evaluation



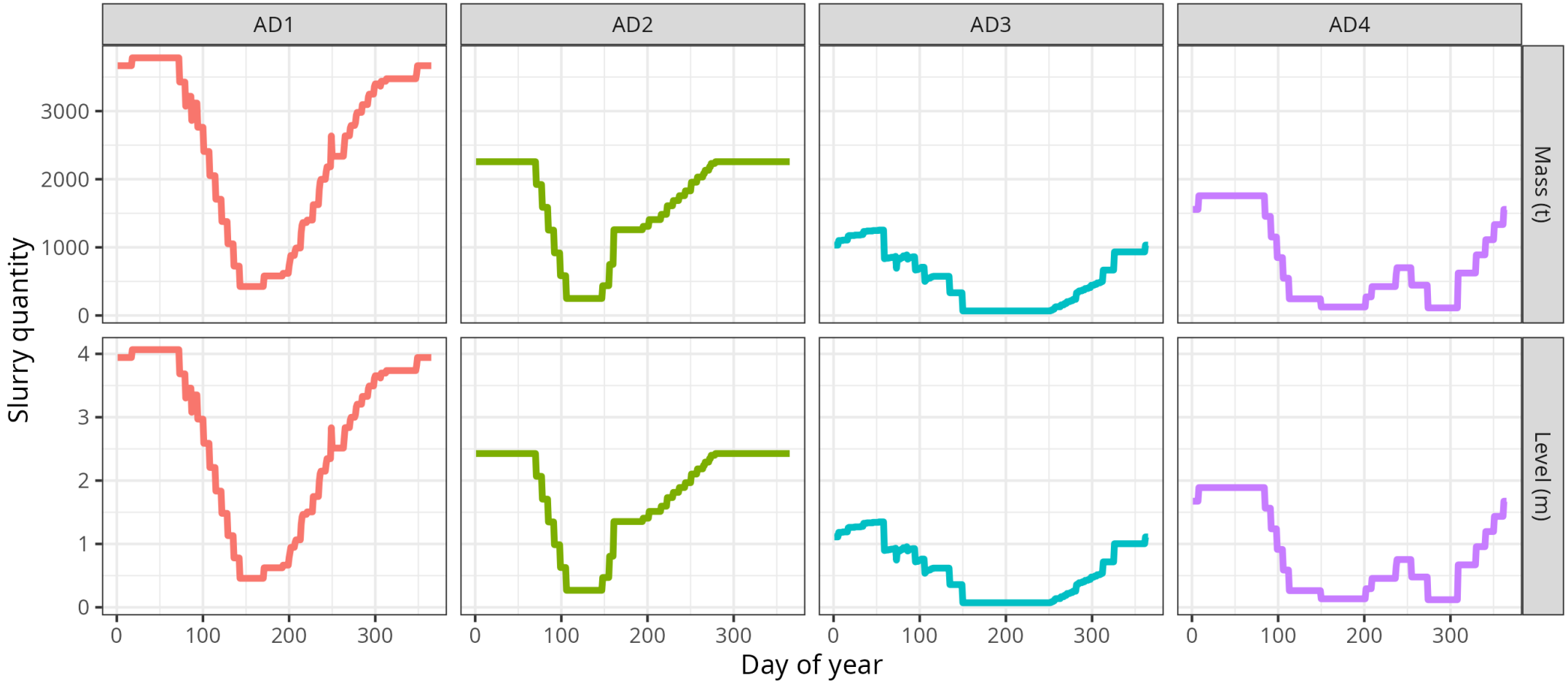
# Delivery temperature effect



# Methane emission – ABM evaluation



# Timing of loading and emptying important



# Methane emission control

1

Particulate organic substrates

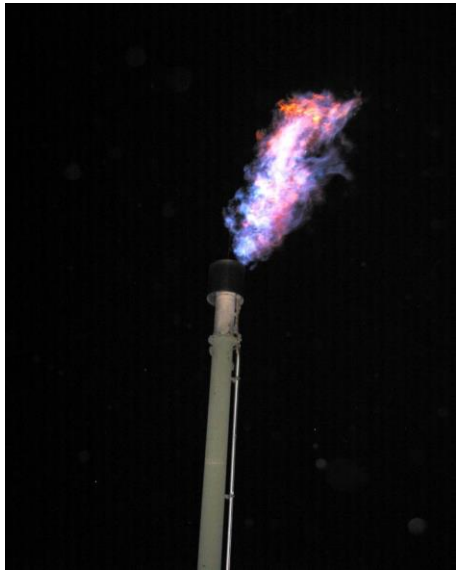
2

Hydrolysis and fermentation


VFAs

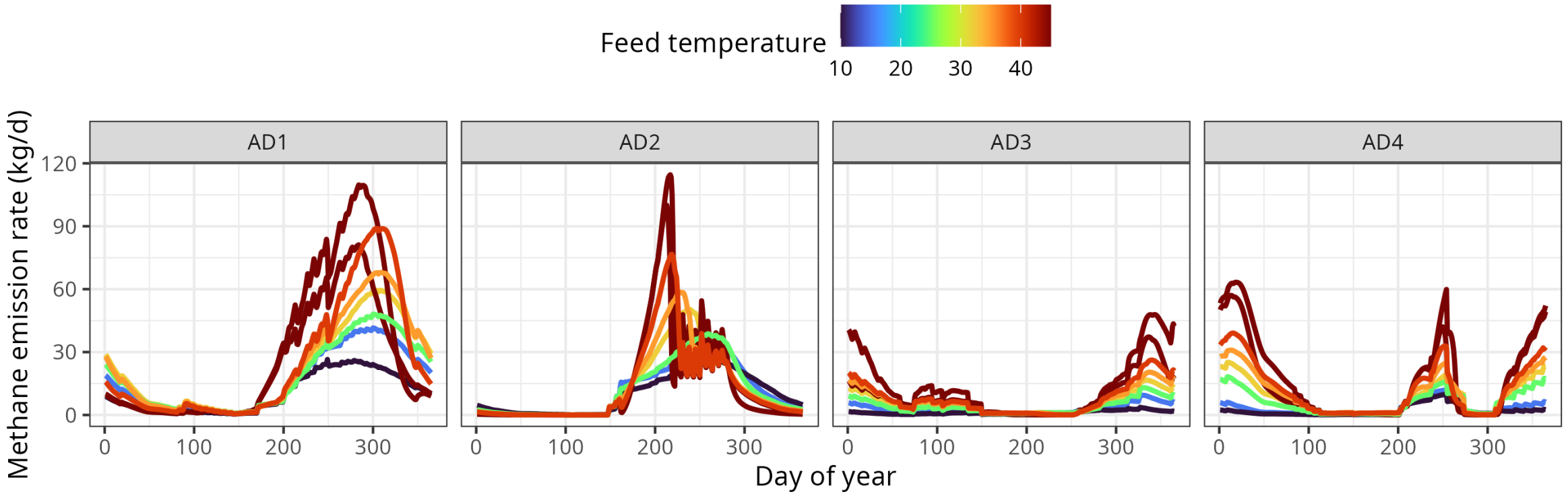
3

Methanogenesis

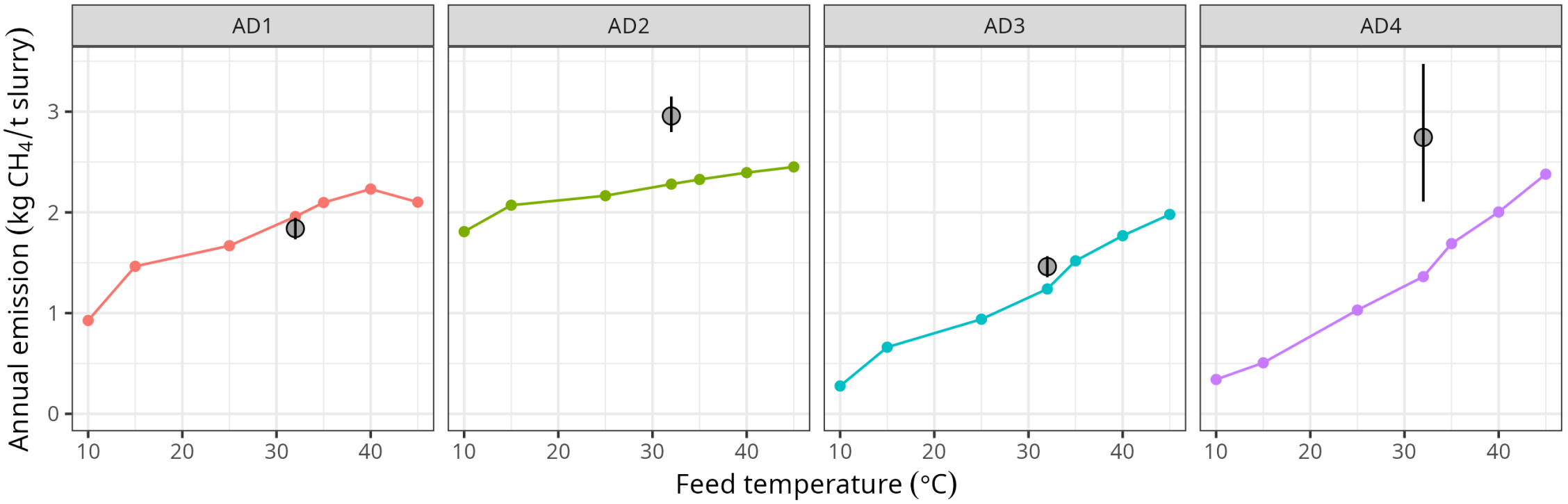


$CH_4$ and $CO_2$

# Effect of delivery temperature on emission



# Temperature sensitivity



# Summary and context

- We coupled a heat transfer model and microbiology model to predict effects of management on methane emission from stored digestate
- Evaluation with measured emission shows models provide plausible or even reasonably accurate estimates
- But uncertainty is substantial, due in part to multiple potential bottlenecks for methane production
- Coupled models can quantify interactions that affect emission and sensitivity to e.g., digestate delivery temperature x loading timing
- Unexpected responses to management are likely

# Thank you for your attention!

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