# Methane emissions from wetlands
# A microbial model.

Sarah Chadburn
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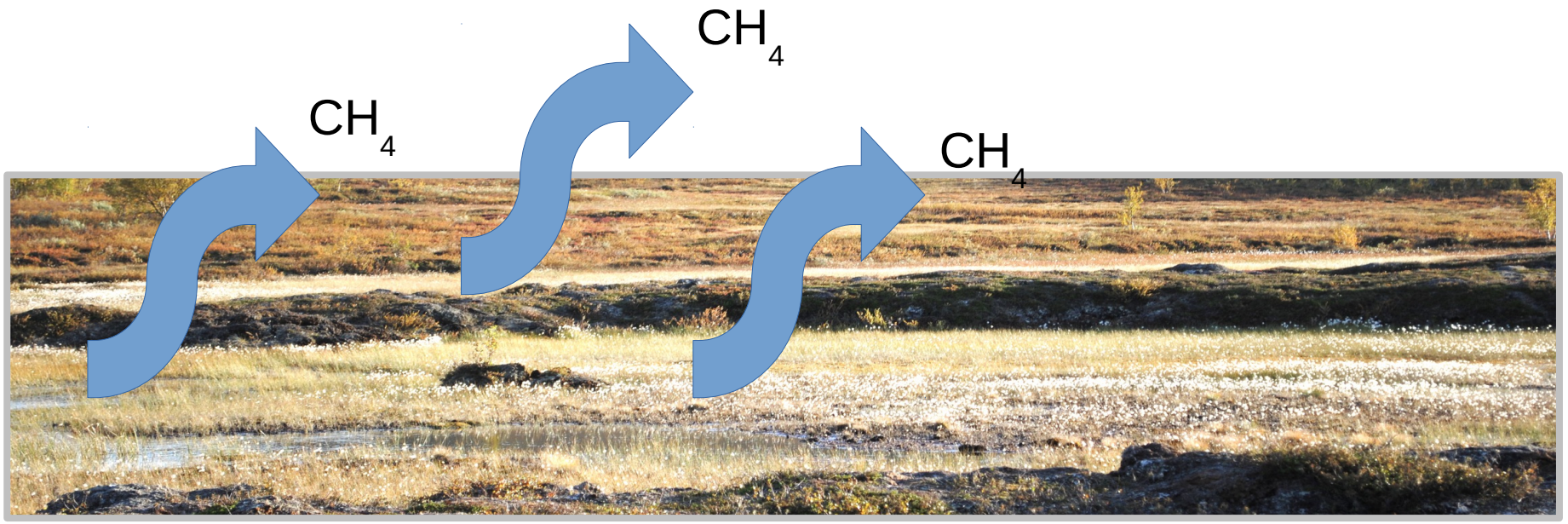
+ many many others.

# Methane from wetlands

- Greenhouse gas → ~180 $TgCH_4/yr$ (~ 4 GtC in $CO_2$)
- Essential to include in climate projections



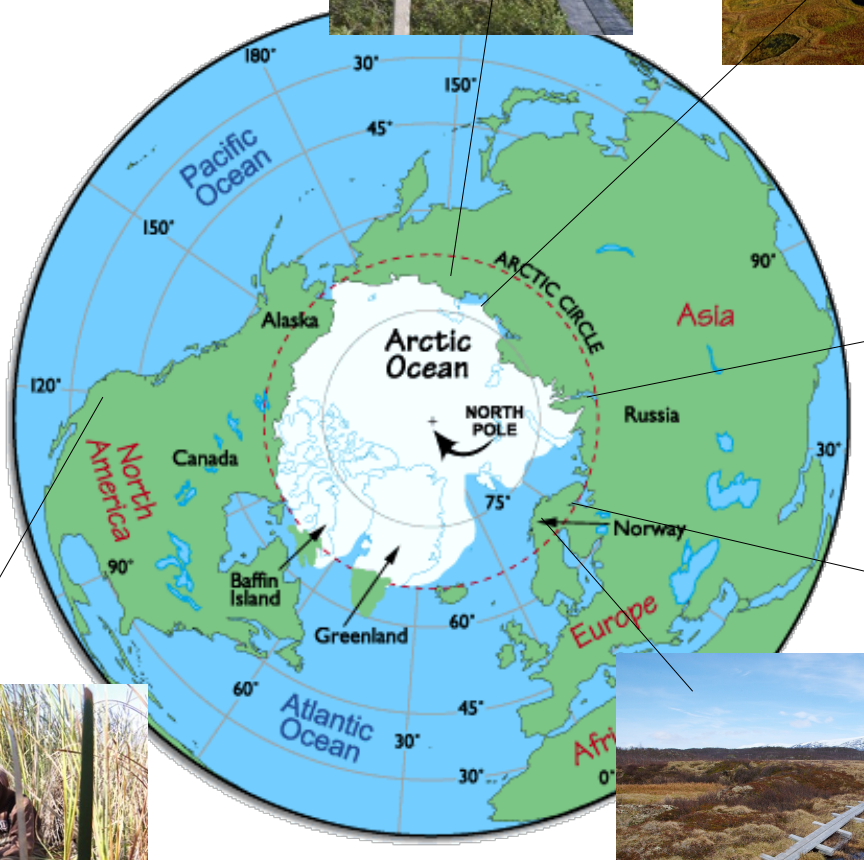
# Measuring Methane

Eddy covariance +
Other concurrently
measured variables.

Great opportunity
for modelling

Kytalyk

Samoylov




Seida

Lompolojankka

Abisko

Twitchell

# Modelling Methane

- $CH_4 \sim C \exp(qT_{soil})$ *if the water table is at the surface*
- $CH_4 = 0$ *otherwise*

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- $CH_4 \sim C \exp(qT_{soil})$ *if the water table is at the surface*
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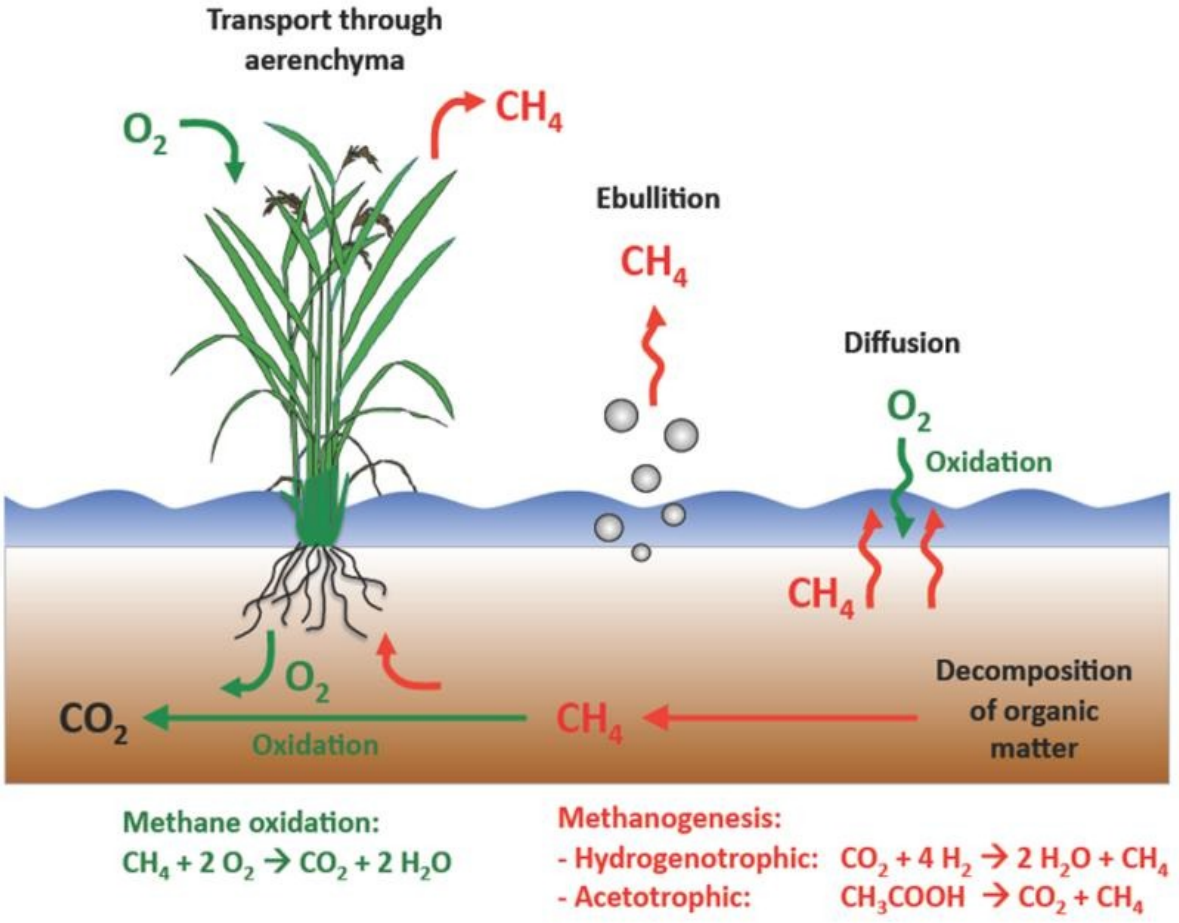
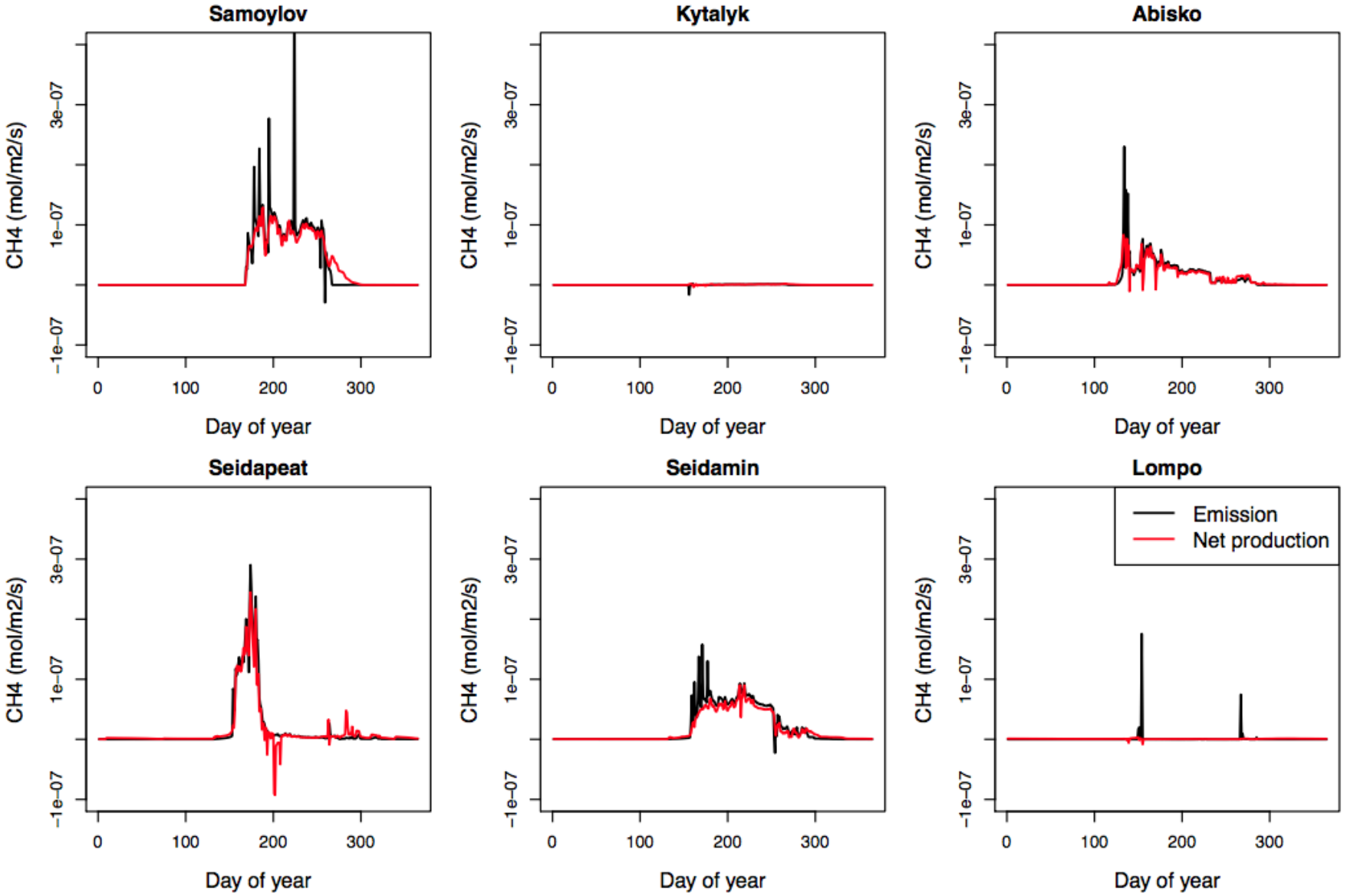
- Some land surface models (e.g. CLM) simulate transport and oxidation.



# Modelling Methane

- Transport is second order effect. CLM simulations:



# Modelling Methane

Key is to get net *production* right.

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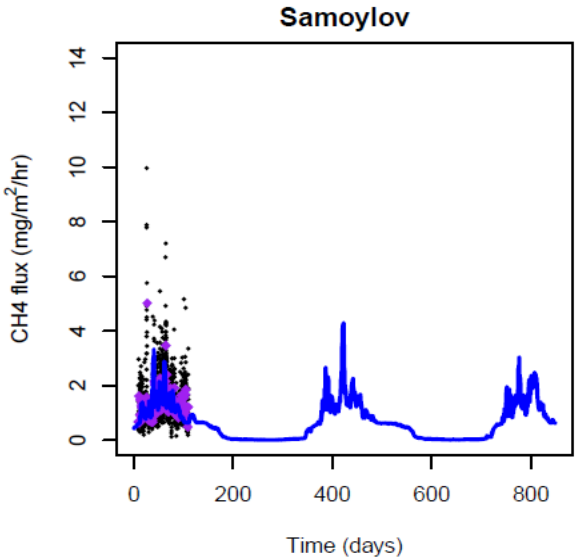
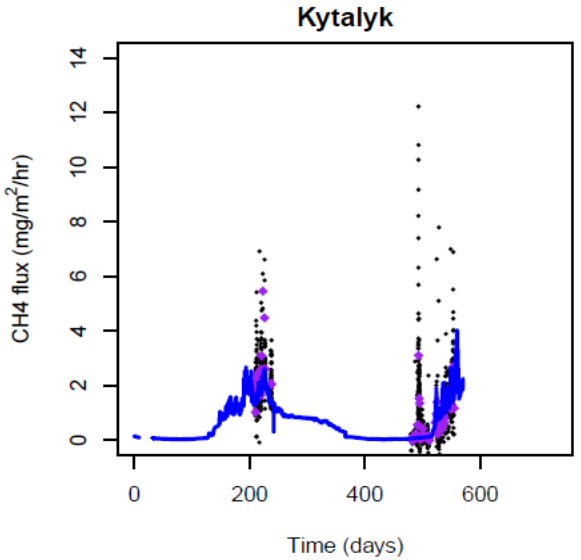
Simple scheme: $CH_4 \sim C \exp(qT_{soil})$

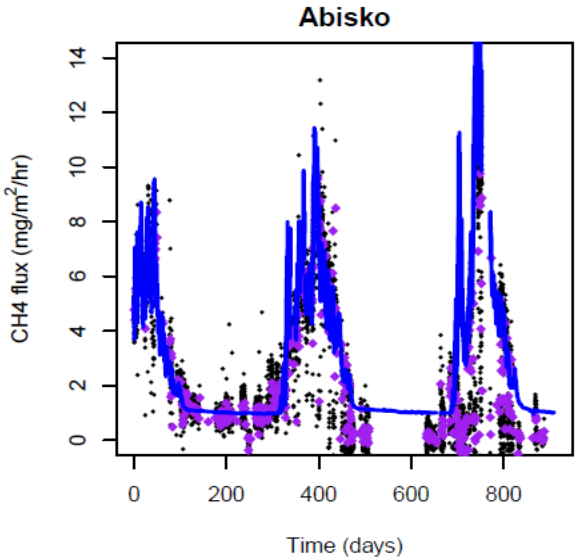
# Recreating the observations with the simple model: Cold sites

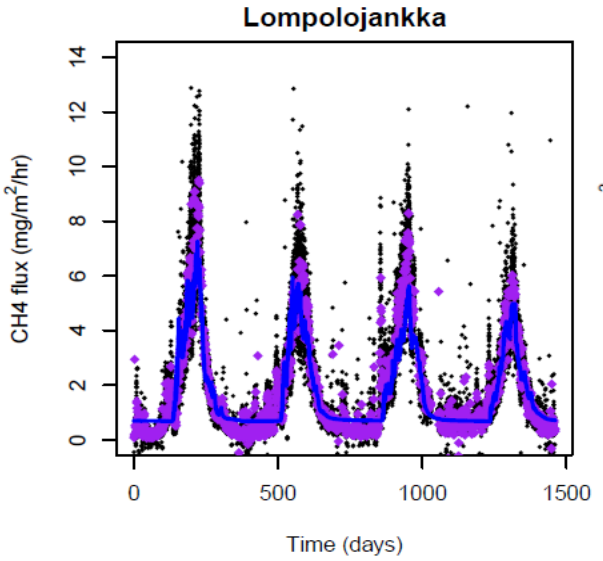
## Large q (equiv. $Q_{10}$ = 5.2)

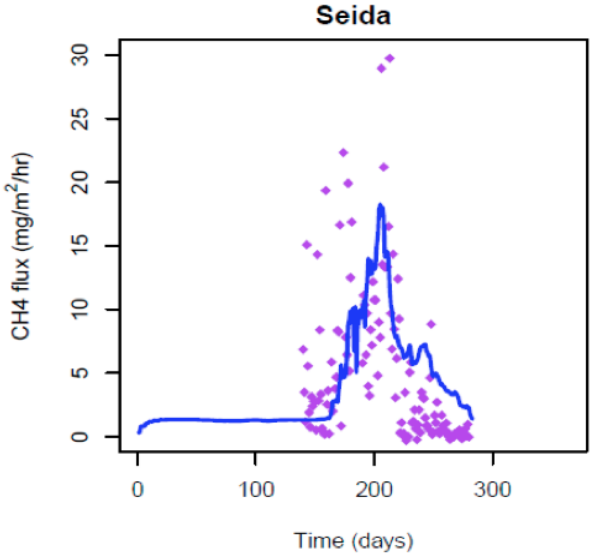
Observations (half-hourly)
Observations (daily)
Model

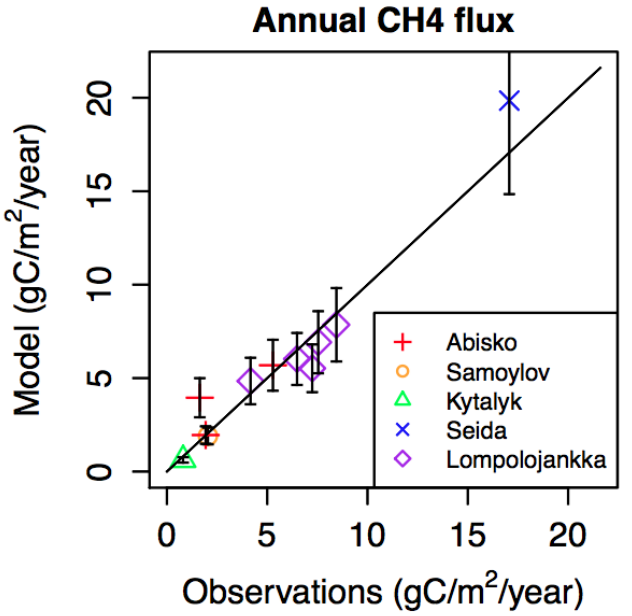


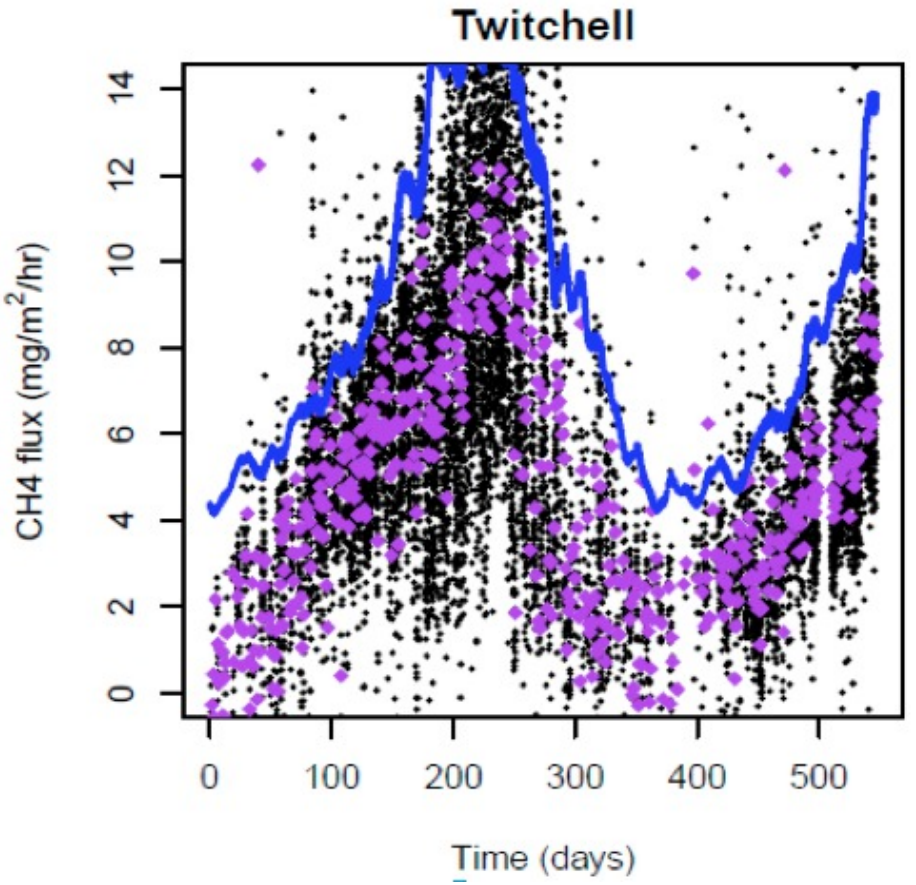



# Twitchell marsh - a warmer site

Use same parameters as for cold sites
Methane emission much higher than observed

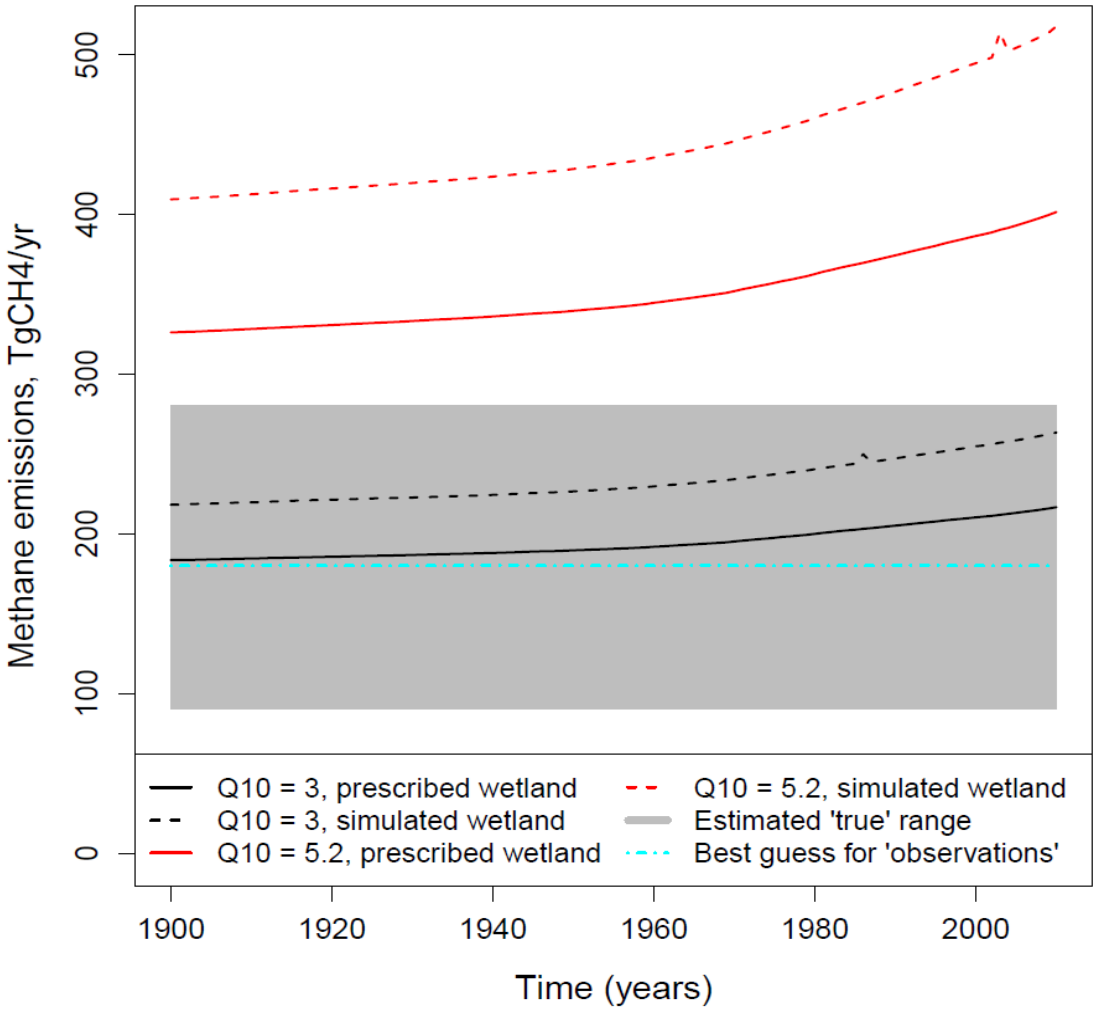
$CH_4 \sim C \exp(qT_{soil})$

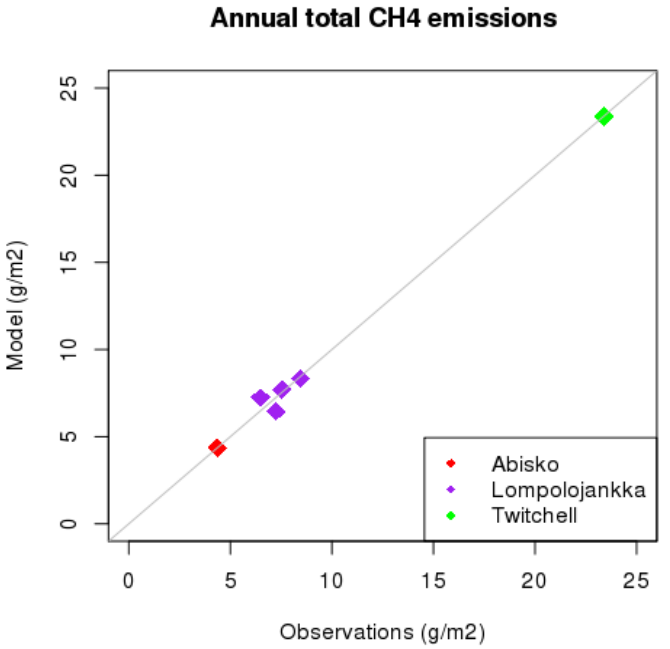


# Testing parameters in JULES

$$CH_4 \sim C \exp(qT_{soil})$$

- Smaller q (equiv. $Q_{10}$ = 3) obtained by fitting annual means.
- Global total much improved.

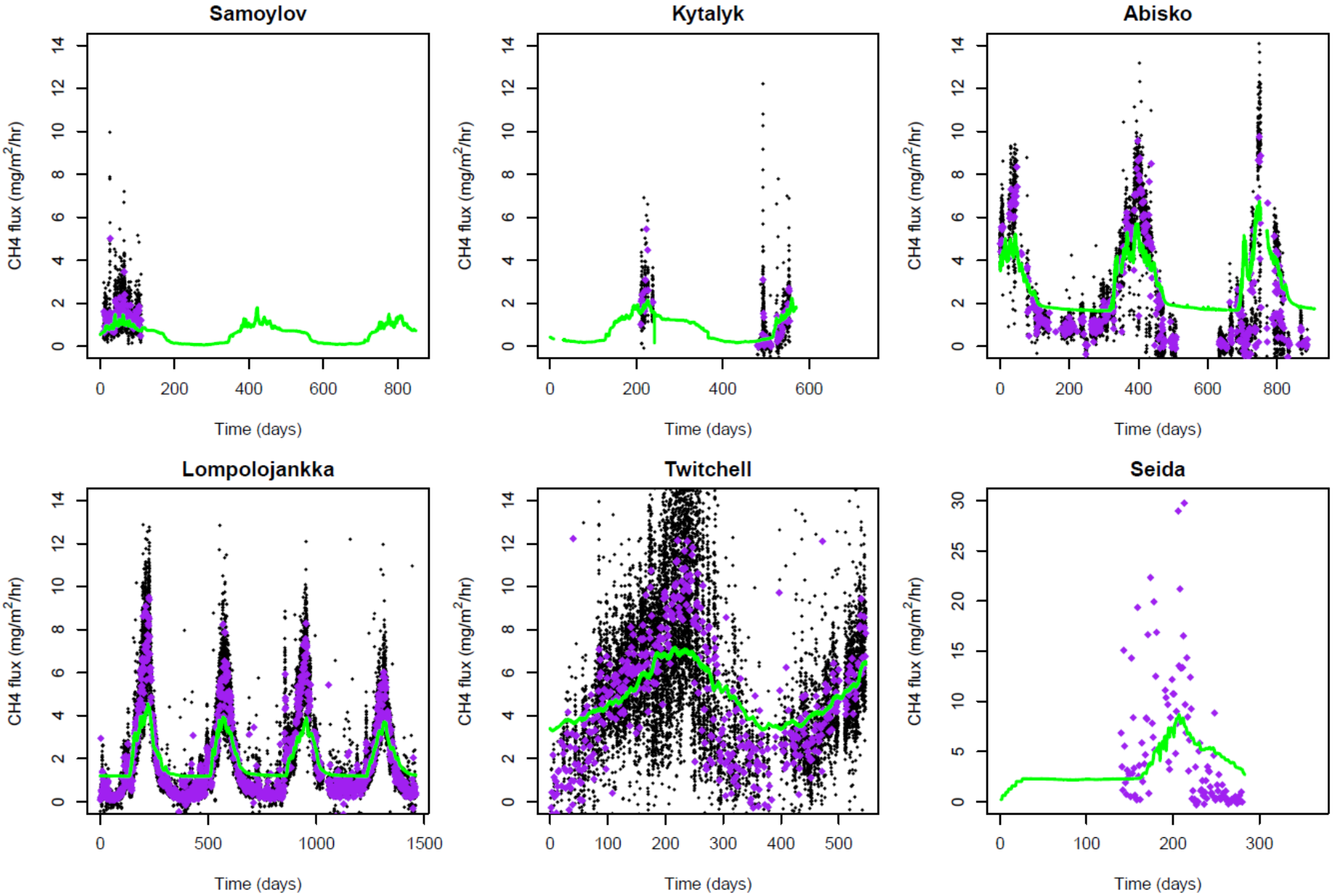


# Comparing new parameters with observations

- Seasonal cycle is much too small.

Observations (half-hourly)
Observations (daily)
Model



# Introducing microbes

**Enzymes**

*Soil organic carbon → Acetate, dissolved substrates*

$C \exp(qT_{soil})$

Microbes feed on dissolved substrates.

# Seasonal cycle

**Enzymes**

*Soil organic carbon* → *Acetate, dissolved substrates*

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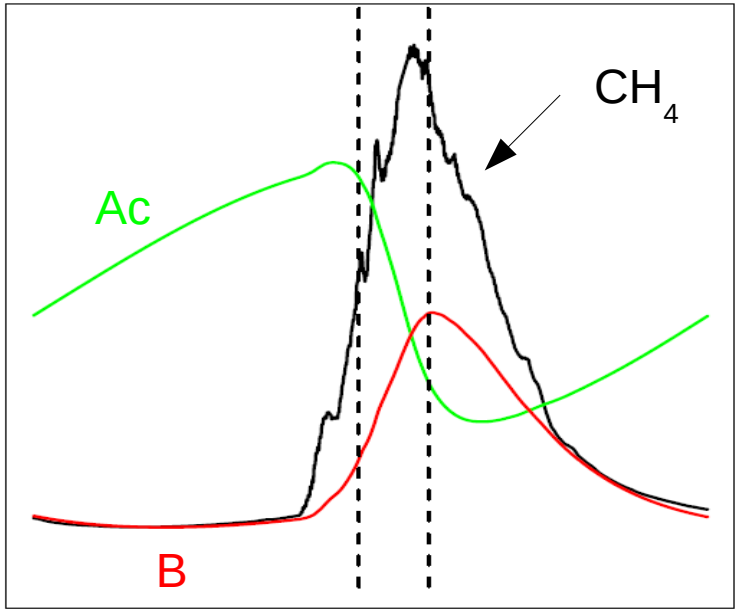
Microbes (B) go dormant in winter, substrate (Ac) accumulates → accelerated growth in summer.



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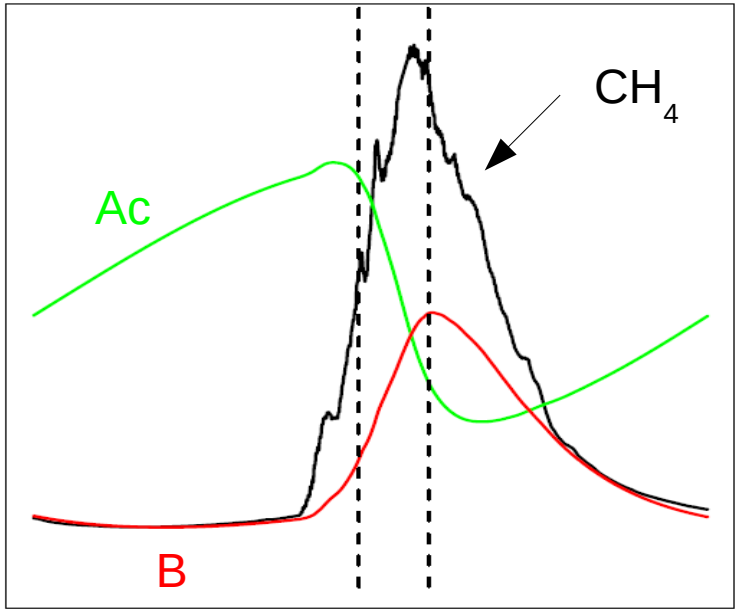
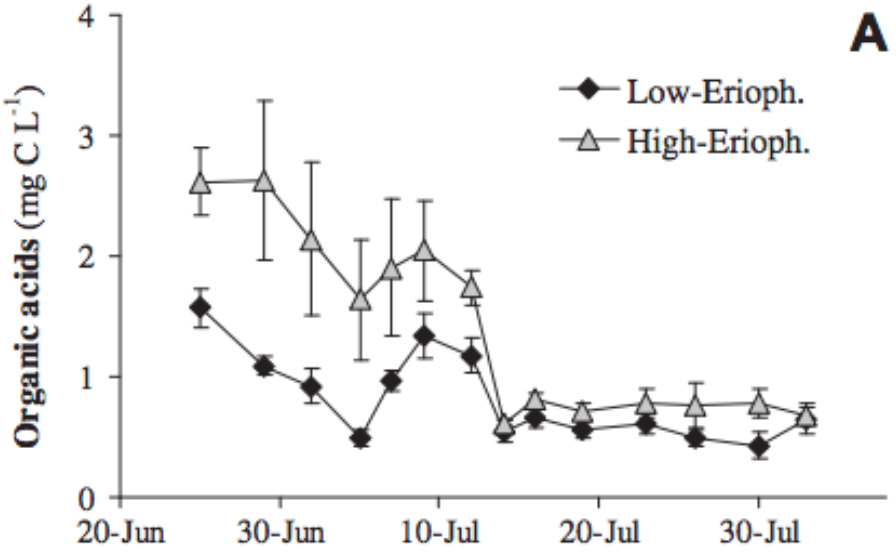



Strom et al. *Soil Biology and Biochemistry* **45** 61-70 (2012)

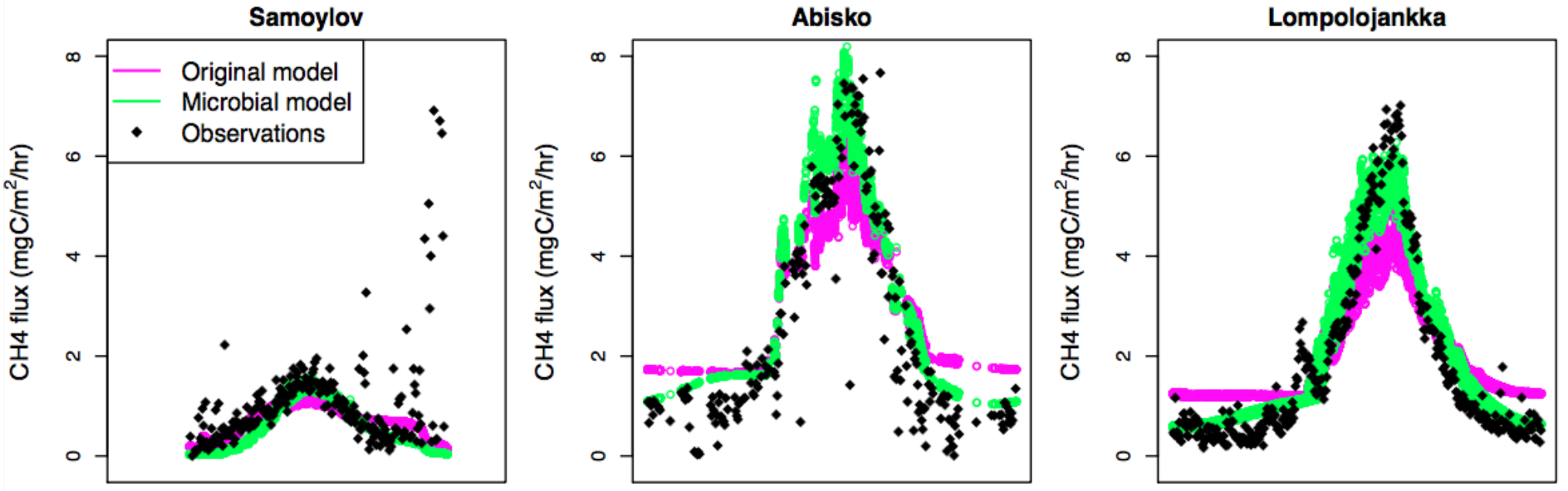
# Microbial model

**Enzymes**

*Soil organic carbon* → *Acetate, dissolved substrates*

$C \exp(qT_{soil})$

In equilibrium, *annual* CH4 emission is the same as the simple model. *Seasonal cycle* is amplified.



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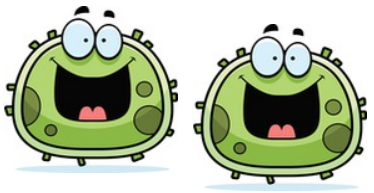

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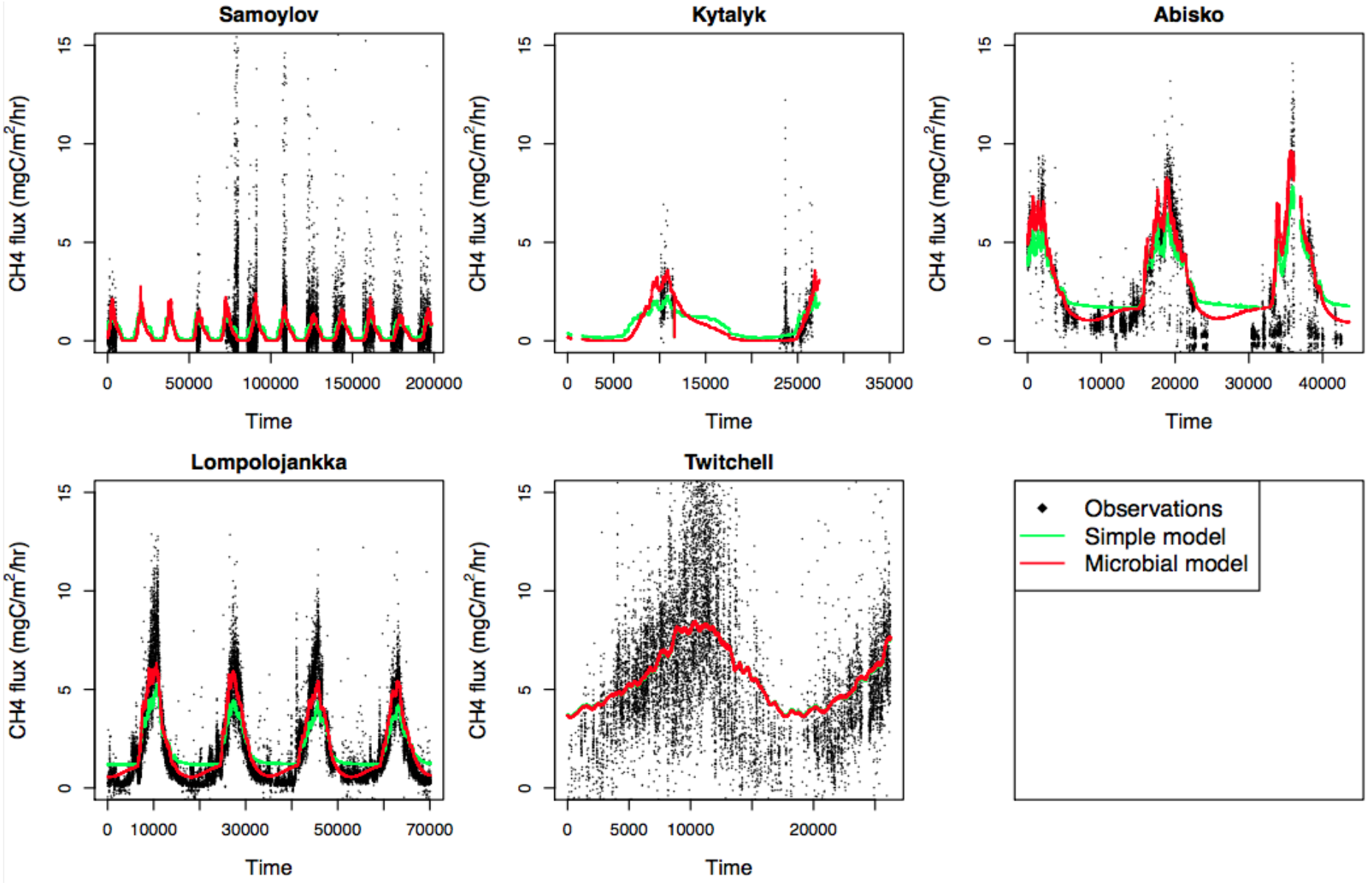

# Conclusions

- Priority: model *$CH_4$ production* before including transport processes.
- *Microbes* drive the seasonal cycle of $CH_4$ emissions and explain the high ‘observed $Q_{10}$’.

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# Future

- Put the microbial model in JULES.
- Develop a similar model for the aerobic case.

**This will have huge consequences for carbon dynamics globally.**

# Thanks for listening!

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Chadburn, et al. *Biogeosciences* **14**, 5143-5169 (2017)