An introduction to the ATM99 model in R

Overview

The ATM99 model predicts conversion of animal manure or other high-moisture organic wastes to methane (CH_4) and carbon dioxide (CO_2) under anaerobic conditions. The name comes from **a**naerobic **t**ransformation **m**odel, and 99 represents the unlimited number of microbial groups that can be included. With multiple microbial groups and group-specific parameters describing kinetics and yield, the model can predict realistic short- and long-term responses to temperature change. Although it was storage of organic waste (animal manure) in unheated tanks that drove the initial development of the model, with its flexibility it is well-suited to simulate biogas production from organic waste in anaerobic digesters, particularly in the presence of temperature variation.

Installation

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```
ff <- list.files('../R', full.names = TRUE)
for (i in ff) source(i)
ls()
```

```
##  [1] "atm"          "atm_regular"  "atm_variable" "ff"           "H2SO4_titrat" "i"            "logi
## [11] "pH_fun"       "pred1"        "rates"        "SO4_fun"      "temp_C_fun"
```

A simple example

By default, the `atm()` function simulates degradation of animal manure from a 33 m^3 storage tank with a 30 day emptying interval. Fresh slurry is added continuously at a rate of 1000 kg d^{-1}. Default values are included for all arguments, including the first two, which set the length of the simulation (365 d) and the time interval in the output (1 d).

```
pred1 <- atm()
```

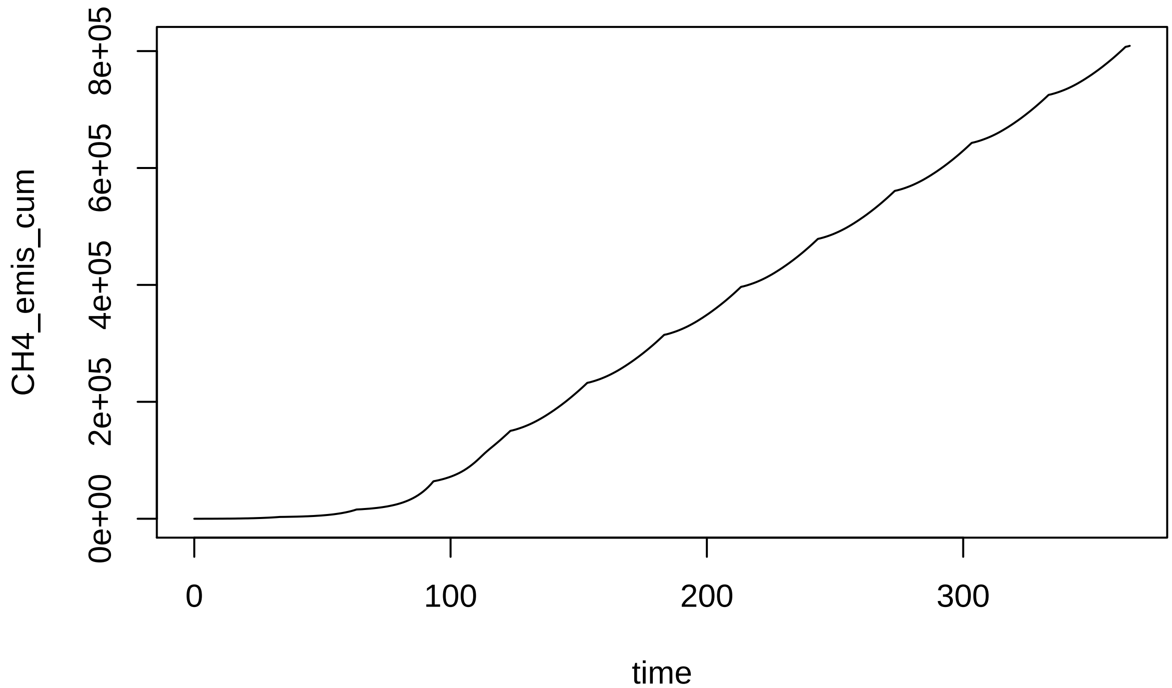
Output is, by default, a data frame with predicted variables over time. Typically the primary variable of interest is CH_4 emission, which is returned as a total (g) and rate, overall or normalized to COD or VS mass:

```
names(pred1[grepl('^CH4', names(pred1))])
```

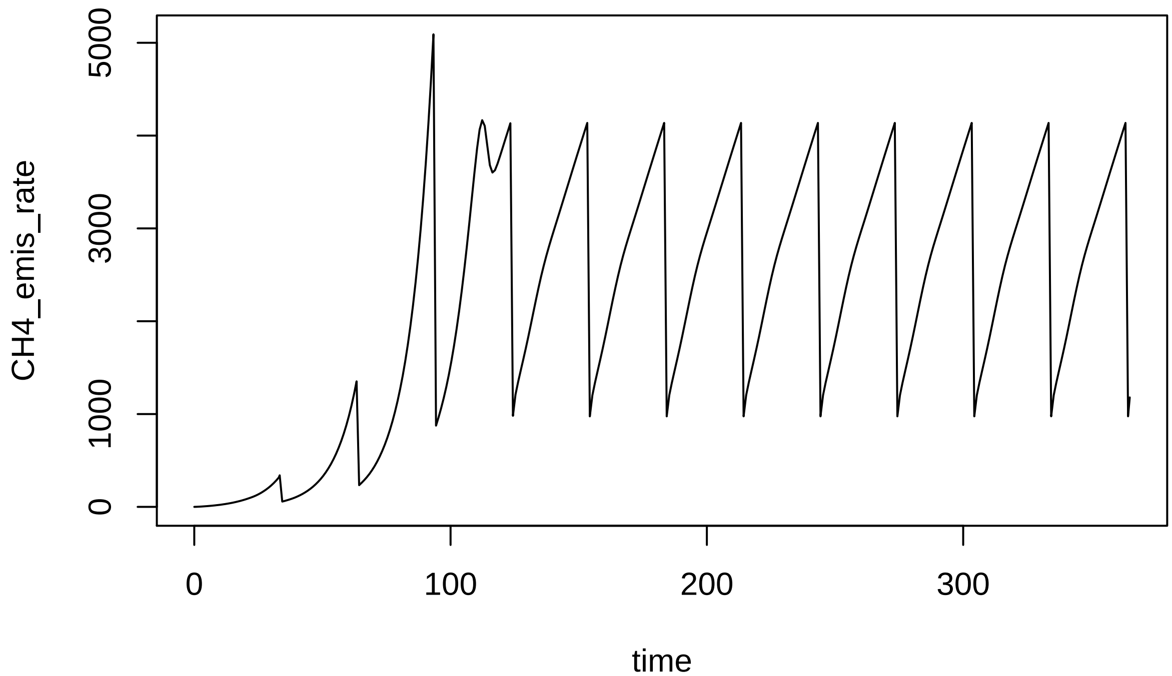
```
##  [1] "CH4_emis_cum"         "CH4_emis_rate"        "CH4_emis_rate_slurry" "CH4_flux"             "CH4
##  [7] "CH4_emis_rate_VS"     "CH4_emis_cum_COD"     "CH4_emis_cum_dCOD"    "CH4_emis_cum_VS"
```

Total cumulative emission (g) and emission rate (g/d) are plotted below.

```
plot(CH4_emis_cum ~ time, data = pred1, type = 'l')
```

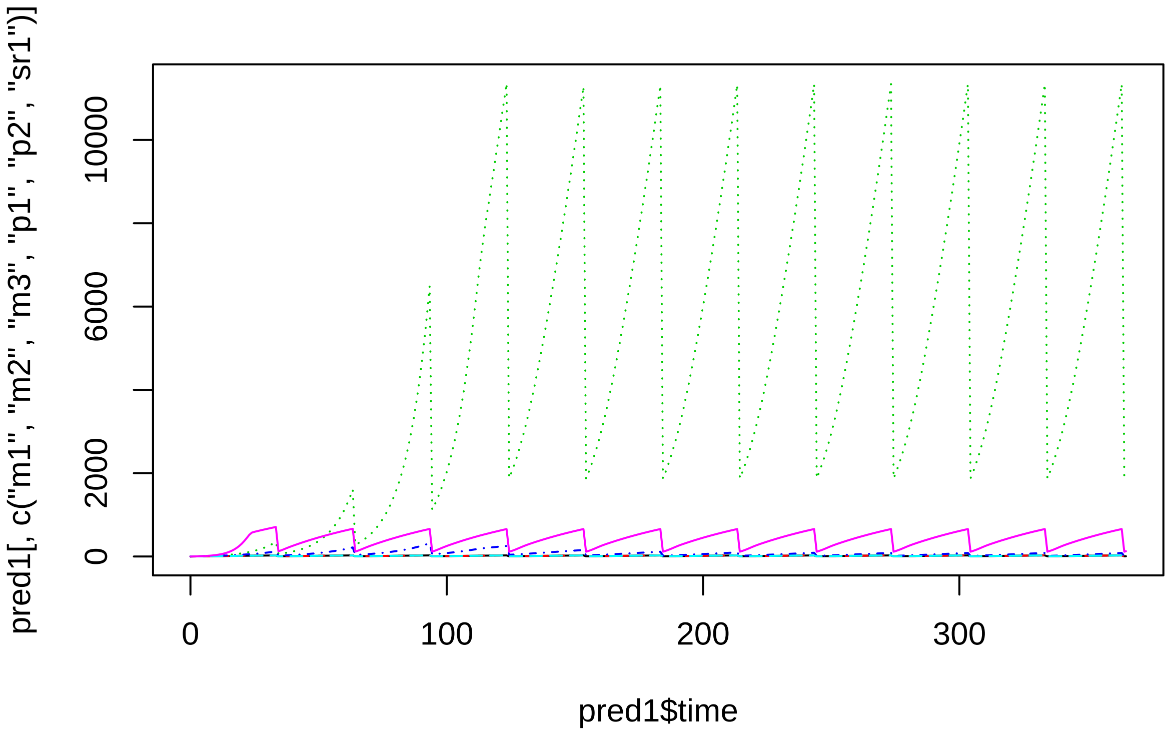



```r
plot(CH4_emis_rate ~ time, data = pred1, type = 'l')
```



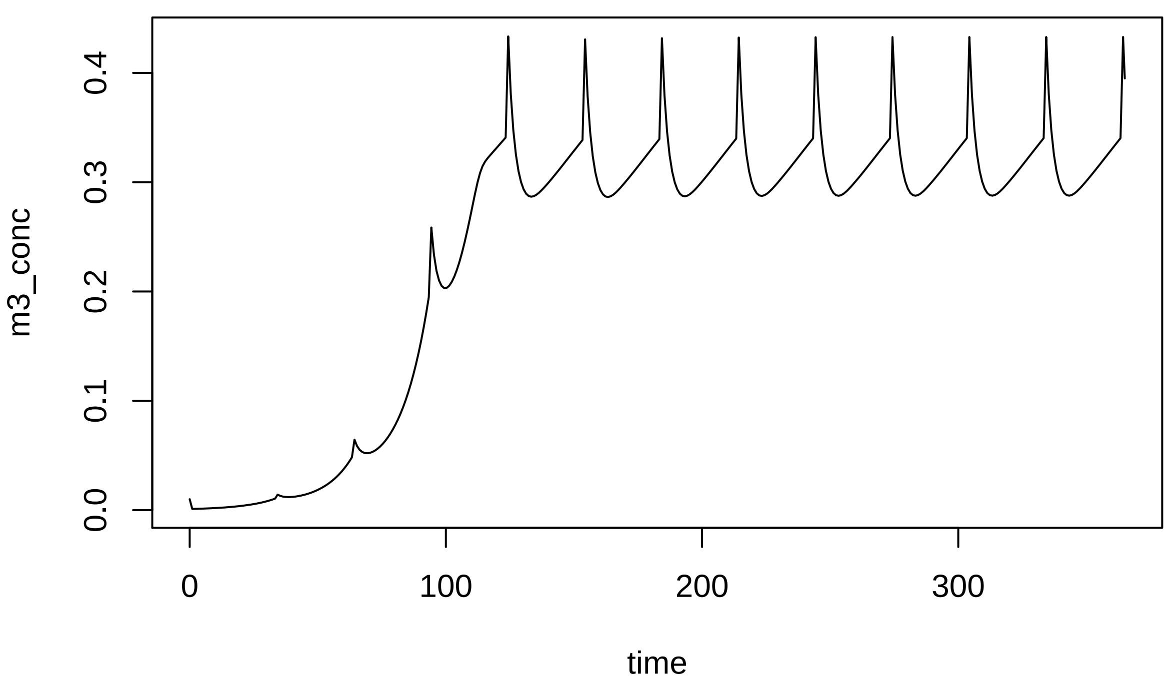
Microbial biomass (g) is given in columns with the names set in the `grp_pars` argument.

```r
matplot(pred1$time, pred1[, c('m1', 'm2', 'm3', 'p1', 'p2', 'sr1')], type = 'l')
```



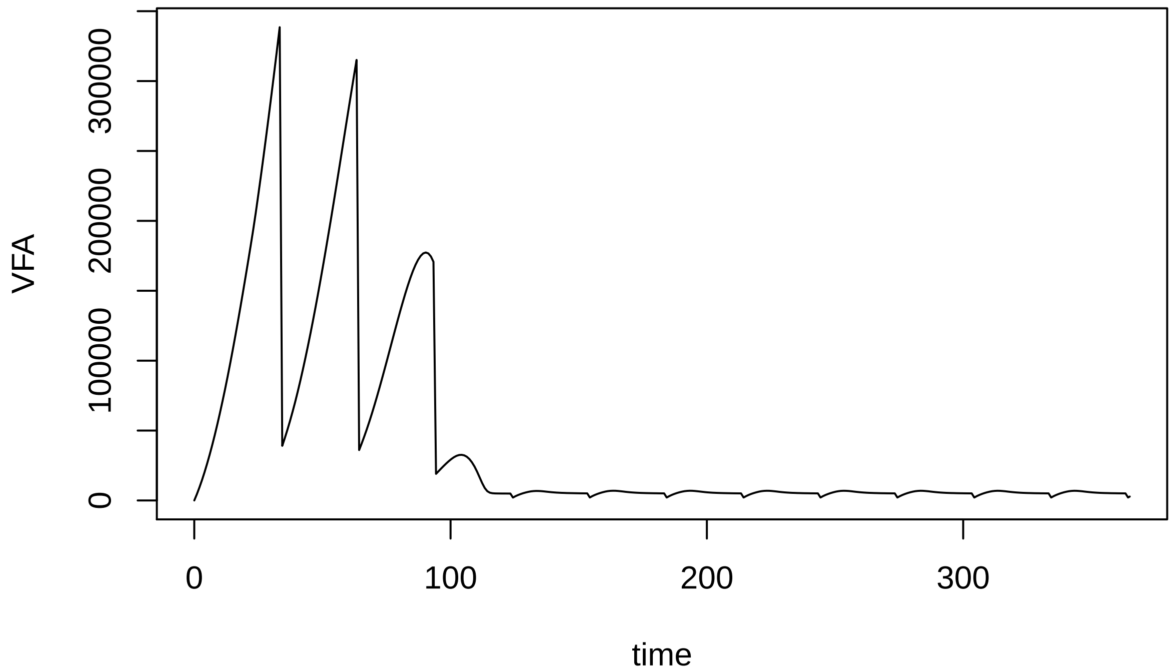
Because of a default temperature of 23 (NTS: why so high???) methanogen `m3` dominates. Biomass concentrations (g/kg) may be more informative.

```
plot(m3_conc ~ time, data = pred1, type = 'l')
```



Dynamics in production of CH_4 are often related to VFA accumulation, and VFA mass (g) and concentration (g/kg) can be extracted.

```
plot(VFA ~ time, data = pred1, type = 'l')
```




```r
plot(VFA_conc ~ time, data = pred1, type = 'l')
```