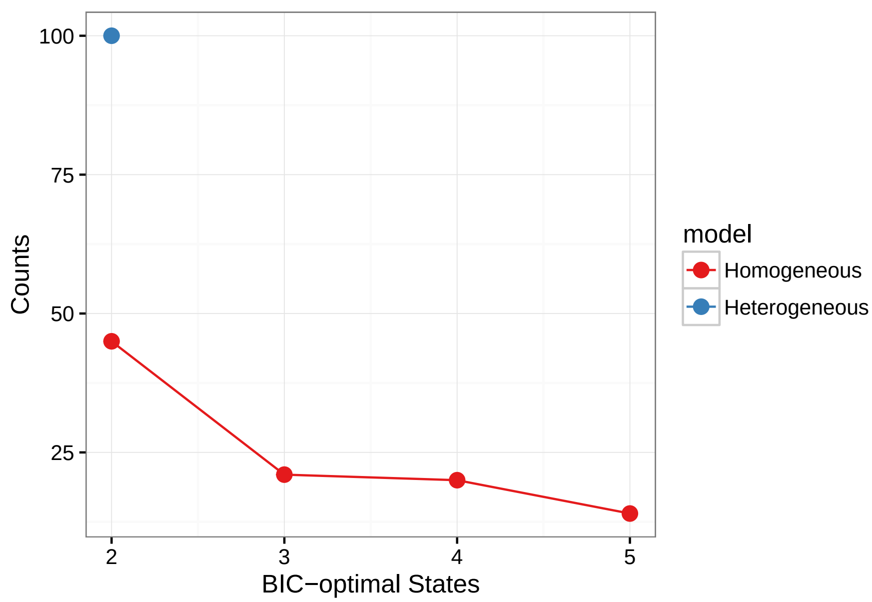


Figure 1: BIC-optimal state frequency for 2-6 state HMMs with and without covariate transition on 100 two-state hidden Markov models with covariate transitioning simulations.

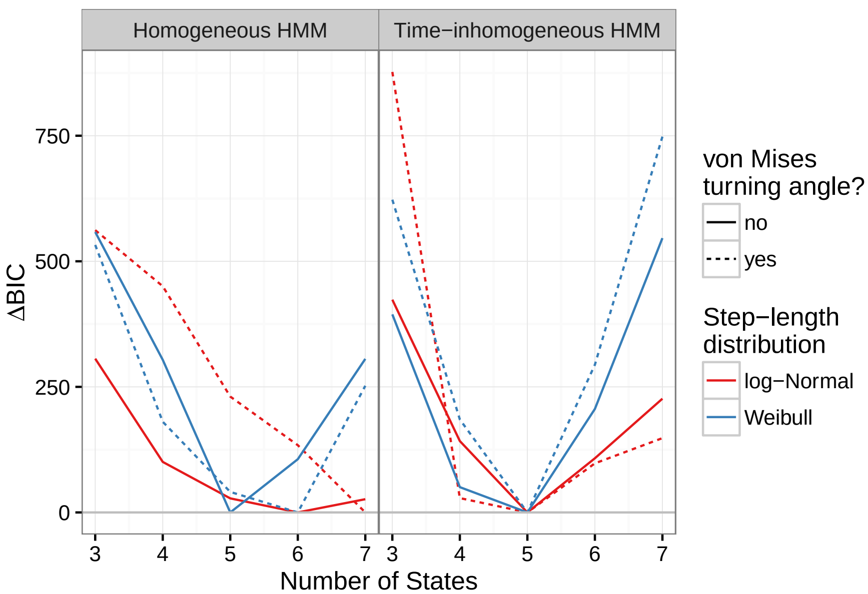


Figure 2: Adjusted Bayesian information criterion values for 3-7 state HMMs with different step-length distributions, with and without temporal transitions and turning angles.

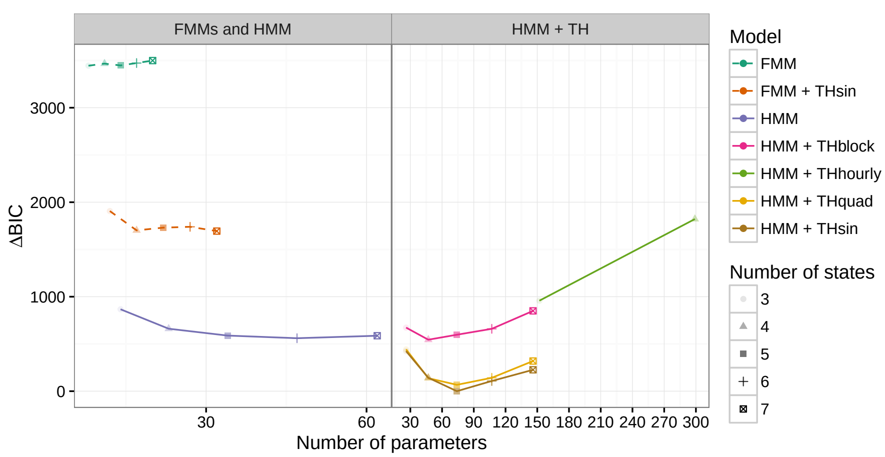


Figure 3: Adjusted BIC by number of free parameters for HMM model types. The left panel shows FMM, FMM with a sin prior and HMM. The right panel shows HMMs with different temporal transitions.

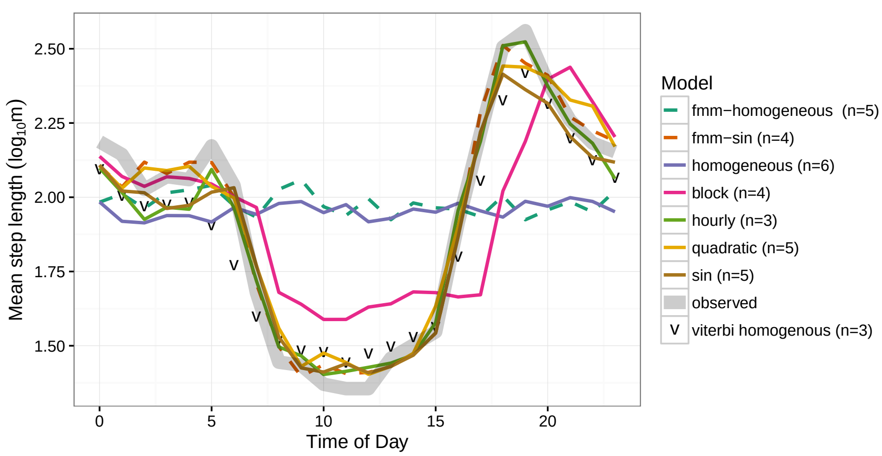


Figure 4: Average step length by time of day observed (gray highlight), three-state HMM Viterbi predictions (V points), and all transitions type HMMs predictions (out of sample) with their respective BIC-optimal states.

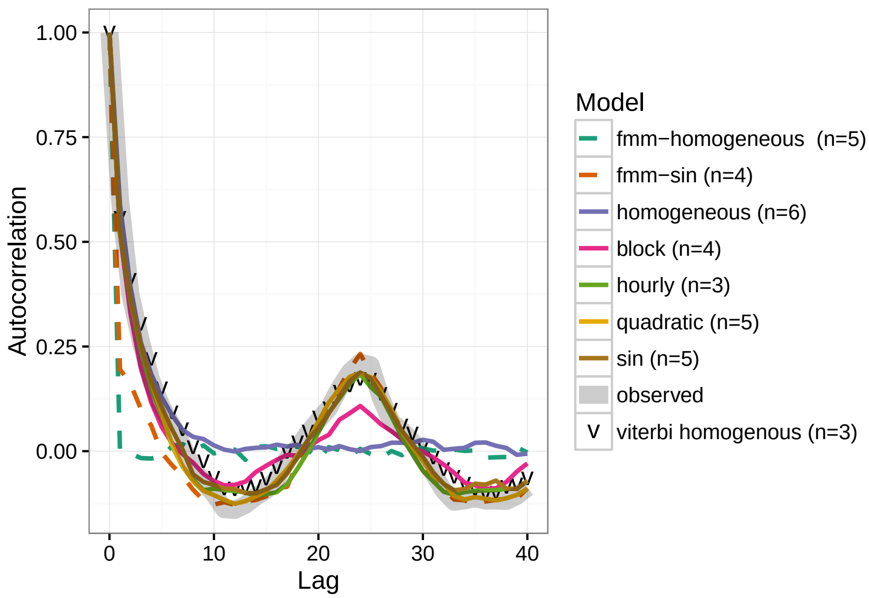


Figure 5: Autocorrelation of observed (gray highlight), three-state HMM Viterbi predictions (V points), and all transitions type HMMs predictions (out of sample) with their respective BIC-optimal states

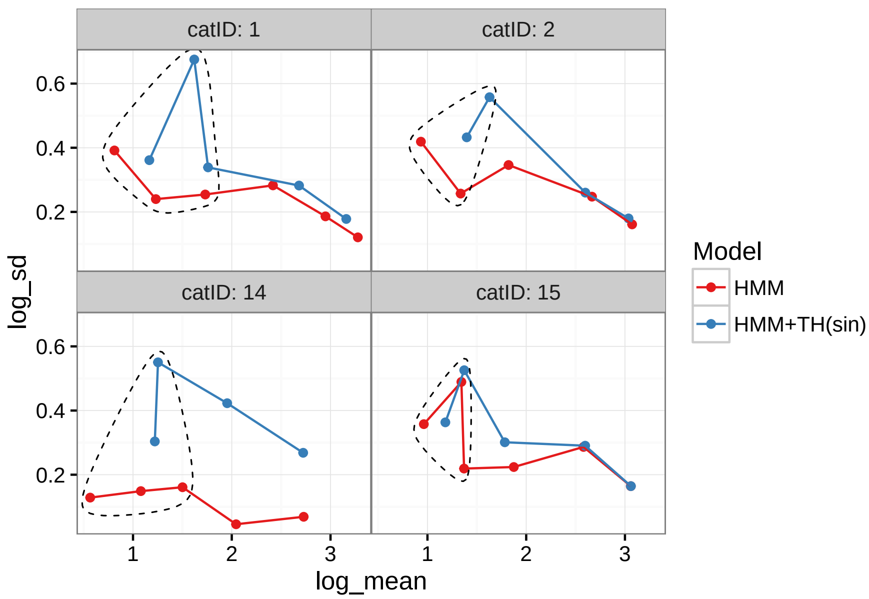
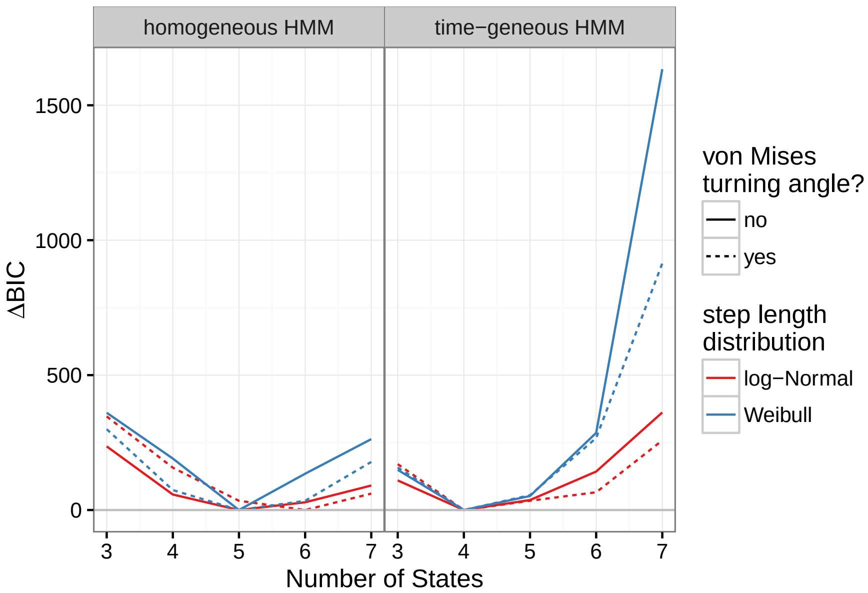
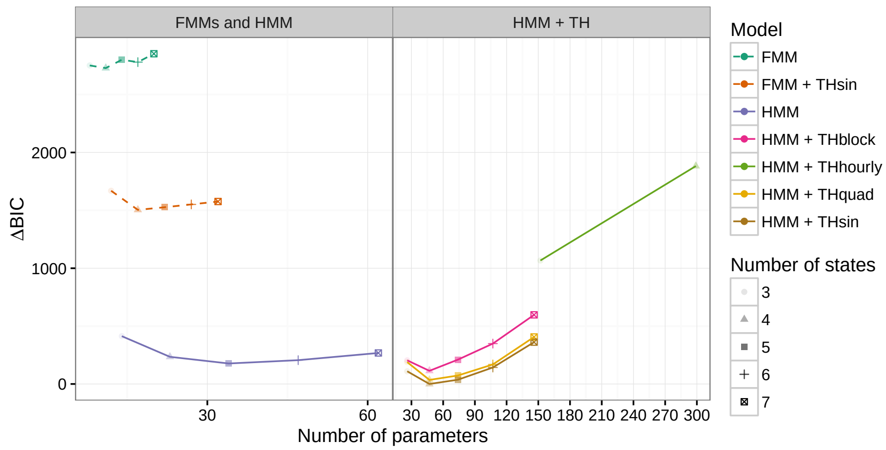


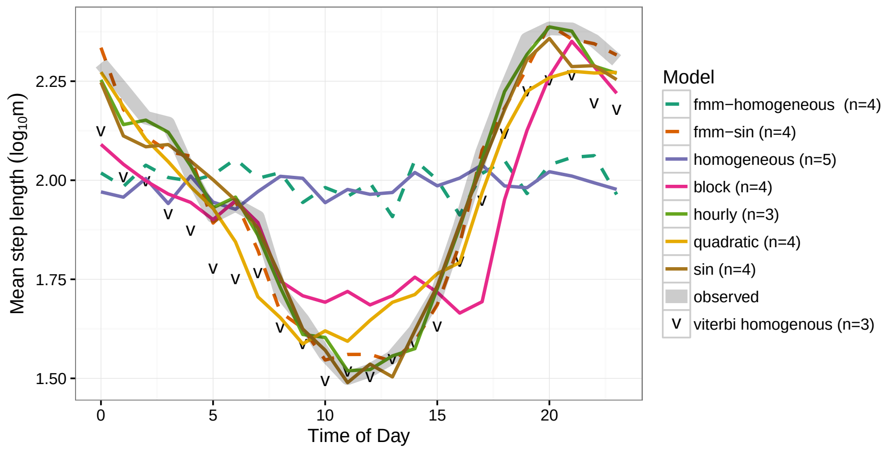
Figure 6: State identification plot with log mean and standard deviation of BIC-optimal HMM and HMM with sinusoidal transition.

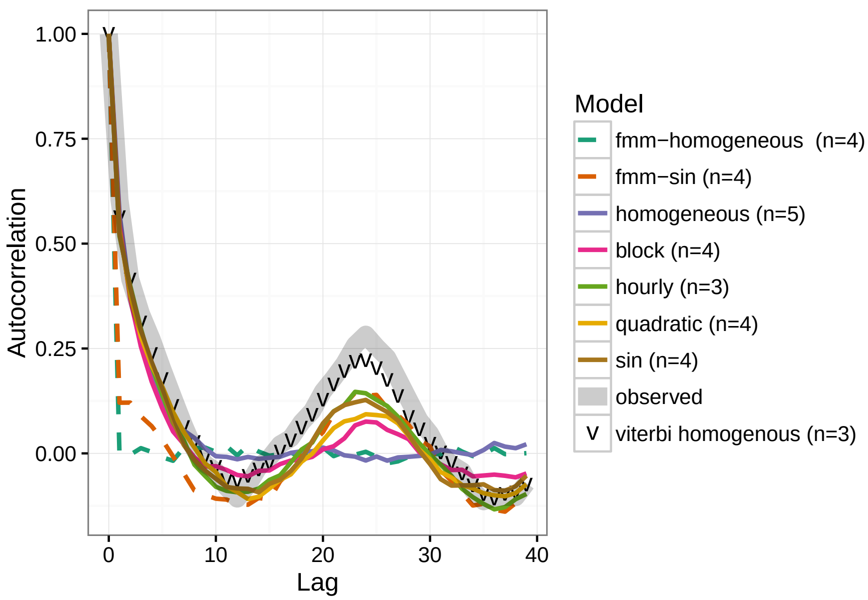
1 Additional files



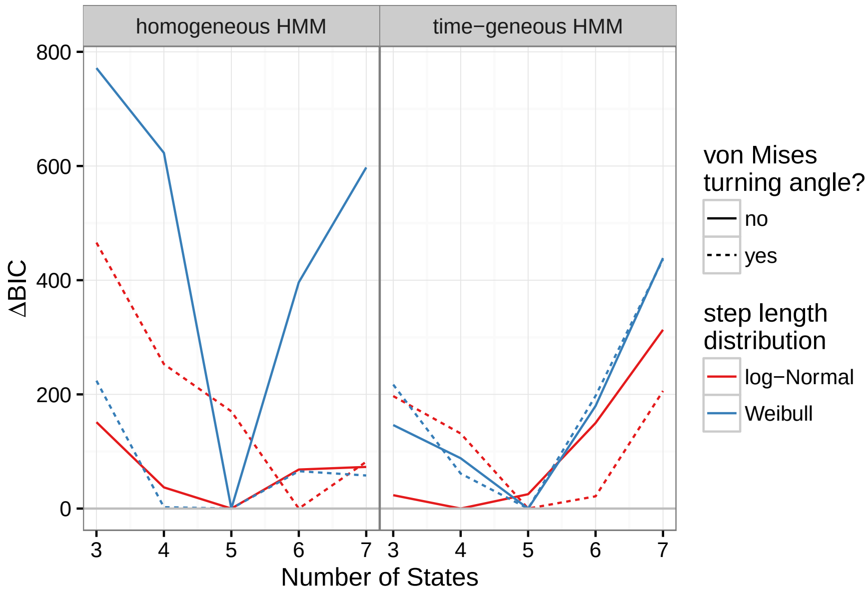


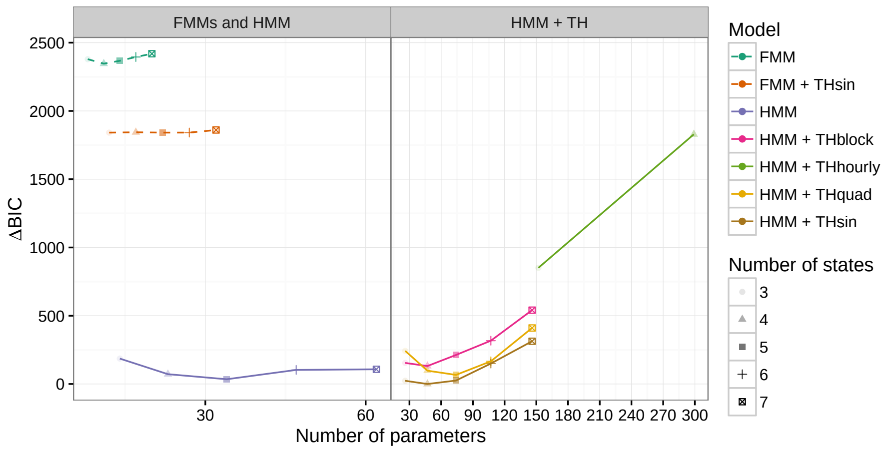
FMMs and HMM
HMM + TH
Model
FMM
FMM + THsin
HMM
HMM + THblock
HMM + THhourly
HMM + THquad
HMM + THsin
Number of states
3
4
5
6
7
ΔBIC
2000
1000
0
30
60
30 60 90 120 150 180 210 240 270 300
Number of parameters

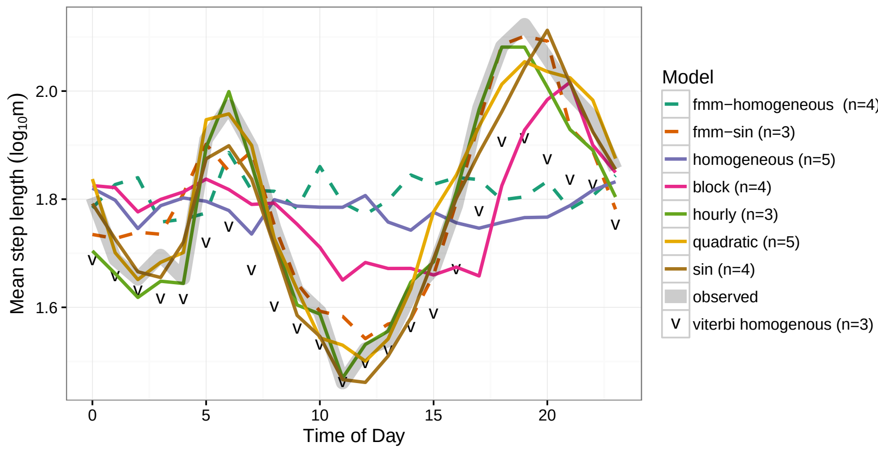

Model
fmm−homogeneous (n=4)
fmm−sin (n=4)
homogeneous (n=5)
block (n=4)
hourly (n=3)
quadratic (n=4)
sin (n=4)
observed
viterbi homogenous (n=3)
Mean step length ($\log_{10}$m)
Time of Day
2.25
2.00
1.75
1.50
0
5
10
15
20



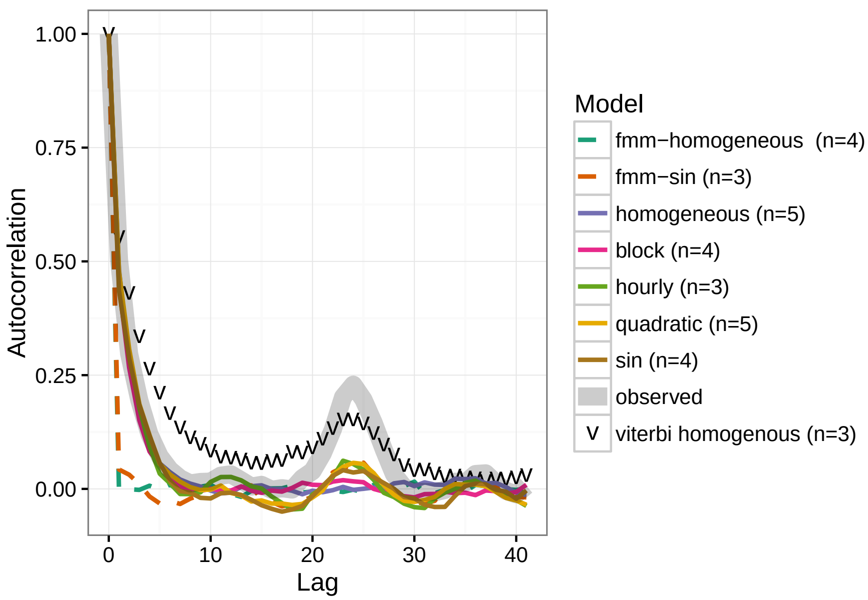
Autocorrelation
1.00
0.75
0.50
0.25
0.00
0
10
20
30
40
Lag
Model
fmm−homogeneous (n=4)
fmm−sin (n=4)
homogeneous (n=5)
block (n=4)
hourly (n=3)
quadratic (n=4)
sin (n=4)
observed
viterbi homogenous (n=3)

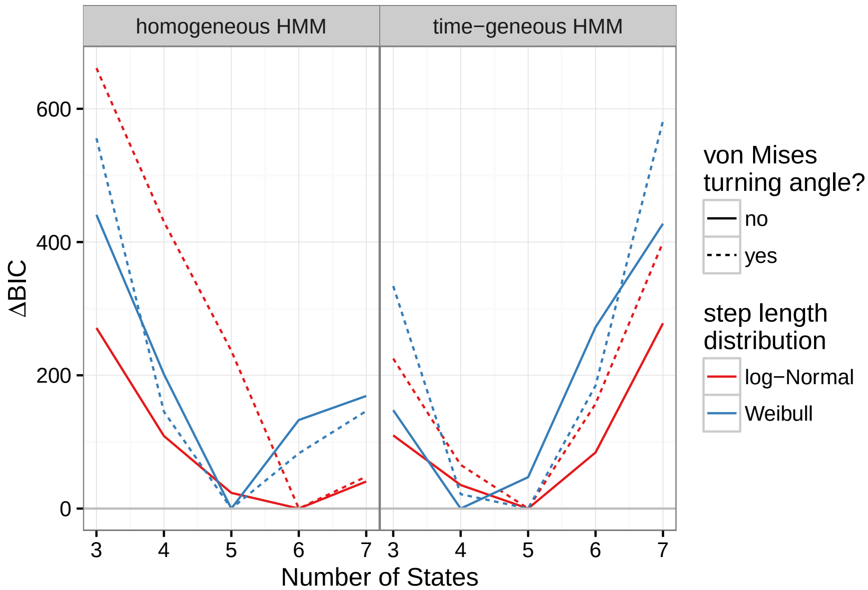

homogeneous HMM
time−geneous HMM
800
600
400
200
0
ΔBIC
3
4
5
6
7
Number of States
von Mises
turning angle?
no
yes
step length
distribution
log−Normal
Weibull

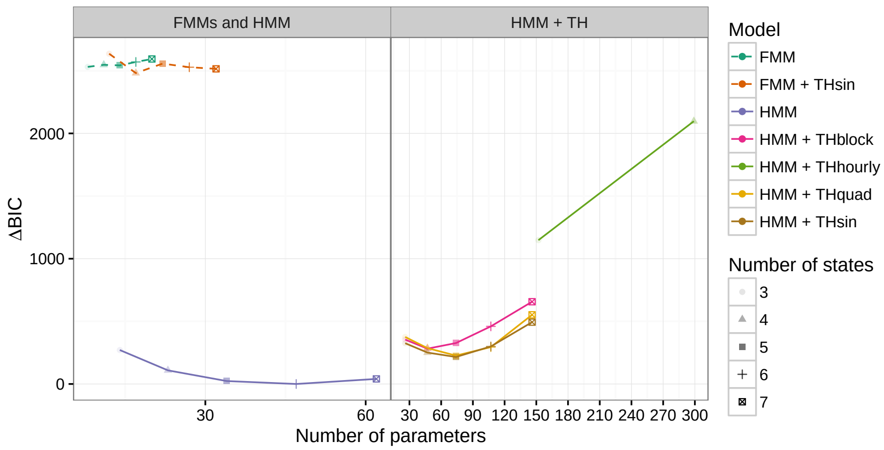

FMMs and HMM
HMM + TH
2500
2000
1500
1000
500
0
ΔBIC
30
60
30 60 90 120 150 180 210 240 270 300
Number of parameters
Model
FMM
FMM + THsin
HMM
HMM + THblock
HMM + THhourly
HMM + THquad
HMM + THsin
Number of states
3
4
5
6
7



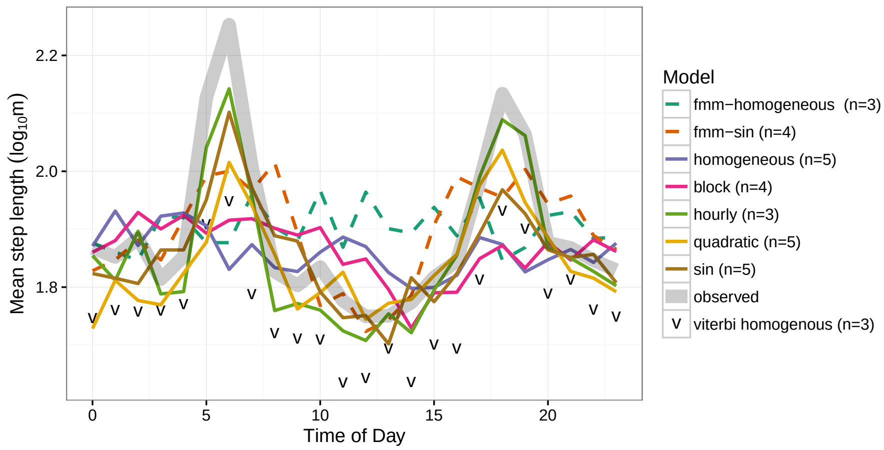
Mean step length ($\log_{10}$m)
2.0
1.8
1.6
0
5
10
15
20
Time of Day
Model
fmm−homogeneous (n=4)
fmm−sin (n=3)
homogeneous (n=5)
block (n=4)
hourly (n=3)
quadratic (n=5)
sin (n=4)
observed
viterbi homogenous (n=3)

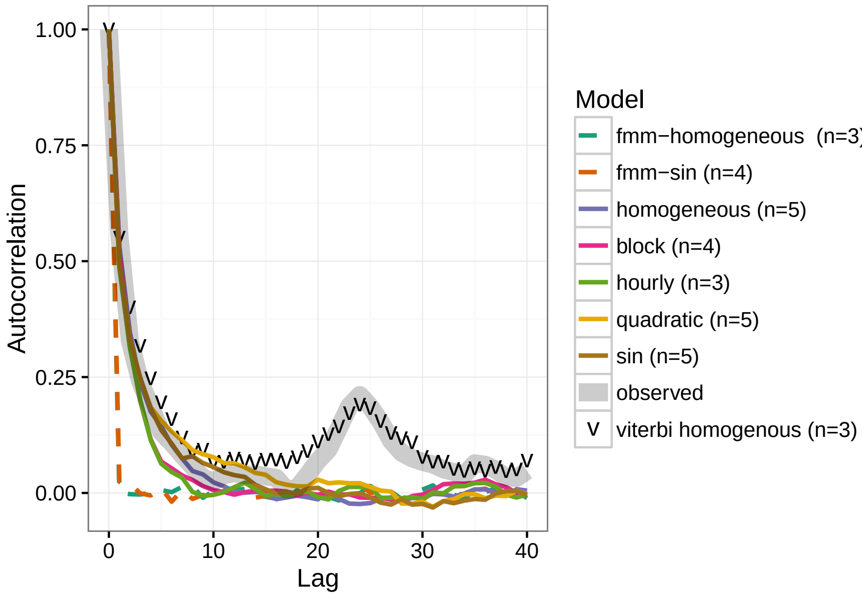

1.00
0.75
0.50
0.25
0.00
Autocorrelation
0
10
20
30
40
Lag
Model
fmm−homogeneous (n=4)
fmm−sin (n=3)
homogeneous (n=5)
block (n=4)
hourly (n=3)
quadratic (n=5)
sin (n=4)
observed
viterbi homogenous (n=3)


homogeneous HMM
time−geneous HMM
ΔBIC
600
400
200
0
3
4
5
6
7
Number of States
von Mises turning angle?
no
yes
step length distribution
log−Normal
Weibull



FMMs and HMM
HMM + TH
ΔBIC
2000
1000
0
30
60
30 60 90 120 150 180 210 240 270 300
Number of parameters
Model
FMM
FMM + THsin
HMM
HMM + THblock
HMM + THhourly
HMM + THquad
HMM + THsin
Number of states
3
4
5
6
7


Mean step length ($\log_{10}$m)
2.2
2.0
1.8
0
5
10
15
20
Time of Day
Model
fmm−homogeneous (n=3)
fmm−sin (n=4)
homogeneous (n=5)
block (n=4)
hourly (n=3)
quadratic (n=5)
sin (n=5)
observed
v viterbi homogenous (n=3)


1.00
0.75
0.50
0.25
0.00
Autocorrelation
0
10
20
30
40
Lag
Model
fmm−homogeneous (n=3)
fmm−sin (n=4)
homogeneous (n=5)
block (n=4)
hourly (n=3)
quadratic (n=5)
sin (n=5)
observed
viterbi homogenous (n=3)