

# State Space Reporting Delay

## Terms

$N_{t,\infty}$  = total observed cases from time  $t$  onward (cases that occurred at time  $t$  and were observed at some point?)

$N_{t,T}$  = cases that occurred on time  $t$  and were observed by time  $T$

$n_{t,d}$  = cases that occurred on time  $t$  and were observed exactly  $d$  days later

We see that

$$N_{t,T} = \sum_{i=0}^{\min(T-t,D)} n_{t,i}$$

$$N_{t,\infty} = \sum_{i=0}^{\infty} n_{t,i} = \sum_{i=0}^D n_{t,i}$$

where  $D$  is the maximum observed delay value

Good?

## State Space Reporting Delay

$$X_t \sim N(X_{t-1}, \sigma_X^2)$$

$$\lambda_t \sim N(X_t, \sigma_\lambda^2)$$

$$N_{t,\infty} | \lambda_t \sim \text{Pois}(\exp(\lambda_t))$$

$$N_{t,T} | N_{t,\infty}, \lambda_t \sim \text{Binom}(N_{t,\infty}, q_{T-t})$$

(OR?:

$$(n_{t,0}, \dots, n_{t,T}) | N_{t,\infty}, \lambda_t \sim \text{Multinomial}(N_{t,\infty}, p)$$

)

where

$$q_{T-t} = \sum_{i=1}^{T-t} p_{t,i}$$

and

$$(p_{t,1}, p_{t,2}, \dots, p_{t,D}) \sim \text{Dirichlet}(\alpha_1, \alpha_2, \dots, \alpha_D)$$

```
library('nimble')
```

```
## nimble version 0.6-7 is loaded.
## For more information on NIMBLE and a User Manual,
## please visit http://R-nimble.org.
##
## Attaching package: 'nimble'
```

```
## The following object is masked from 'package:stats':
##
##      simulate
```

```
set.seed(1)

## define the model
stateSpaceCode <- nimbleCode({
  a ~ dunif(-0.9999, 0.9999)
  b ~ dnorm(0, sd = 1000)
  sigPN ~ dunif(1e-04, 1)
  sigOE ~ dunif(1e-04, 1)
  x[1] ~ dnorm(b/(1 - a), sd = sigPN/sqrt((1-a*a)))
  y[1] ~ dt(mu = x[1], sigma = sigOE, df = 5)
  for (i in 2:t) {
    x[i] ~ dnorm(a * x[i - 1] + b, sd = sigPN)
    y[i] ~ dt(mu = x[i], sigma = sigOE, df = 5)
  }
})

## define data, constants, and initial values
data <- list(
  y = c(0.213, 1.025, 0.314, 0.521, 0.895, 1.74, 0.078, 0.474, 0.656, 0.802)
)
constants <- list(
  t = 10
)
inits <- list(
  a = 0,
  b = .5,
  sigPN = .1,
  sigOE = .05
)

## build the model
stateSpaceModel <- nimbleModel(stateSpaceCode,
                               data = data,
                               constants = constants,
                               inits = inits,
                               check = FALSE)
```

```
## defining model...
```

```
## building model...
```

```
## setting data and initial values...
```

```
## running calculate on model (any error reports that follow may simply reflect missing values in model)
## checking model sizes and dimensions... This model is not fully initialized. This is not an error. To
## model building finished.
```

```
bootstrapFilter <- buildBootstrapFilter(stateSpaceModel, nodes = 'x')
compiledList <- compileNimble(stateSpaceModel, bootstrapFilter)
```

```
## compiling... this may take a minute. Use 'showCompilerOutput = TRUE' to see C++ compiler details.
## compilation finished.
```