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Treat the missing data as parameters to be estimated.

Goal: Find $\pi(\alpha, \beta, \sigma, \{\mathbf{x}\}_{unobs}, \{\mathbf{y}\}_{unobs} \mid \{\mathbf{x}\}_{obs}, \{\mathbf{y}\}_{obs})$

$$
\begin{aligned}
x_1 &\sim U\left(min\{\mathbf{x}\}_{obs}, max\{\mathbf{x}\}_{obs}\right) \\
y_1 &\sim U\left(min\{\mathbf{y}\}_{obs}, max\{\mathbf{y}\}_{obs}\right) \\
x_2 &\sim U\left(min\{\mathbf{x}\}_{obs}, max\{\mathbf{x}\}_{obs}\right) \\
y_2 &\sim U\left(min\{\mathbf{y}\}_{obs}, max\{\mathbf{y}\}_{obs}\right) \\
\begin{bmatrix}\mathbf{x}_t \\ \mathbf{y}_t\end{bmatrix} &\sim N\left((2-\beta)\begin{bmatrix}x_{t-1} \\ y_{t-1}\end{bmatrix} + (\beta - 1 - 2k\beta)\begin{bmatrix}x_{t-2} \\ y_{t-2}\end{bmatrix}, \sigma^2 I\right), \qquad t \in \{3:500\} \\
\sigma &\sim IG\,(1,1) \\
\beta &\sim N\left(0, 10^2\right) \\
\alpha = \beta k &\sim N\left(0, 10^2\right)
\end{aligned}
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To estimate the parameters, we use Adaptive Metropolis-Within-Gibbs