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Appendix B. Full-conditional distributions and Markov chain Monte Carlo algorithm for parameter estimation.

The model we propose is well-suited to a Bayesian analysis using Markov chain Monte Carlo (MCMC) methods. Such an approach estimates the joint posterior distribution by sampling iteratively from the full-conditional distributions. Below, we use bracket notation to denote a conditional probability distribution. For example, [x|y] indicates the conditional probability distribution of x given the parameter y. The notation "·" represents the data and other parameters in the model. The full-conditional distributions for each of the model parameters are

$$
\begin{aligned}
[\sigma_c|\cdot] &\sim \prod_t \left(p_t \times t(\mathbf{s}_{tc}|\boldsymbol{\mu}_t, \boldsymbol{\Sigma}_c, \nu_c) + (1-p_t) \times t\left(\mathbf{s}_{tc}|\boldsymbol{\mu}_t, \widetilde{\boldsymbol{\Sigma}}_c, \nu_c\right)\right) \times \text{Uniform}\left(\sigma_c|0, u_\sigma\right) \\
[a_c|\cdot] &\sim \prod_t \left(p_t \times t(\mathbf{s}_{tc}|\boldsymbol{\mu}_t, \boldsymbol{\Sigma}_c, \nu_c) + (1-p_t) \times t\left(\mathbf{s}_{tc}|\boldsymbol{\mu}_t, \widetilde{\boldsymbol{\Sigma}}_c, \nu_c\right)\right) \times \text{Uniform}\left(a_c|0, u_a\right) \\
[\rho_c|\cdot] &\sim \prod_t \left(p_t \times t(\mathbf{s}_{tc}|\boldsymbol{\mu}_t, \boldsymbol{\Sigma}_c, \nu_c) + (1-p_t) \times t\left(\mathbf{s}_{tc}|\boldsymbol{\mu}_t, \widetilde{\boldsymbol{\Sigma}}_c, \nu_c\right)\right) \times \text{Uniform}\left(\rho_c|0, u_\rho\right) \\
[\nu_c|\cdot] &\sim \prod_t \left(p_t \times t(\mathbf{s}_{tc}|\boldsymbol{\mu}_t, \boldsymbol{\Sigma}_c, \nu_c) + (1-p_t) \times t\left(\mathbf{s}_{tc}|\boldsymbol{\mu}_t, \widetilde{\boldsymbol{\Sigma}}_c, \nu_c\right)\right) \times \text{Uniform}\left(\nu_c|0, u_\nu\right) \\
[\boldsymbol{\mu}_t|\cdot] &\sim \left(\boldsymbol{\mu}_t \left| \frac{\exp\left\{\mathbf{x}'(\boldsymbol{\mu}_t)\boldsymbol{\beta} - \eta\left(\boldsymbol{\mu}_t, \boldsymbol{\mu}_{t-\Delta_t}\right)\right\}}{\int_{\mathcal{S}} \exp\left\{\mathbf{x}'(\boldsymbol{\mu})\boldsymbol{\beta} - \eta\left(\boldsymbol{\mu}, \boldsymbol{\mu}_{t-\Delta_t}\right)\right\} d\boldsymbol{\mu}}\right.\right) \times \left(\boldsymbol{\mu}_{t+\Delta_t} \left| \frac{\exp\left\{\mathbf{x}'(\boldsymbol{\mu}_{t+\Delta_t})\boldsymbol{\beta} - \eta\left(\boldsymbol{\mu}_{t+\Delta_t}, \boldsymbol{\mu}_t\right)\right\}}{\int_{\mathcal{S}} \exp\left\{\mathbf{x}'(\boldsymbol{\mu})\boldsymbol{\beta} - \eta\left(\boldsymbol{\mu}, \boldsymbol{\mu}_t\right)\right\} d\boldsymbol{\mu}}\right.\right) \\
&\quad \times \left(p_t \times t(\mathbf{s}_{tc}|\boldsymbol{\mu}_t, \boldsymbol{\Sigma}_c, \nu_c) + (1-p_t) \times t\left(\mathbf{s}_{tc}|\boldsymbol{\mu}_t, \widetilde{\boldsymbol{\Sigma}}_c, \nu_c\right)\right), \text{ for } t = \Delta_t, \ldots, T-\Delta_t \\
[\phi|\cdot] &\sim \prod_t \left(\boldsymbol{\mu}_t \left| \frac{\exp\left\{\mathbf{x}'(\boldsymbol{\mu}_t)\boldsymbol{\beta} - \eta\left(\boldsymbol{\mu}_t, \boldsymbol{\mu}_{t-\Delta_t}\right)\right\}}{\int_{\mathcal{S}} \exp\left\{\mathbf{x}'(\boldsymbol{\mu})\boldsymbol{\beta} - \eta\left(\boldsymbol{\mu}, \boldsymbol{\mu}_{t-\Delta_t}\right)\right\} d\boldsymbol{\mu}}\right.\right) \times \text{Uniform}\left(\phi|0, u_\phi\right) \\
[\boldsymbol{\beta}|\cdot] &\sim \prod_t \left(\boldsymbol{\mu}_t \left| \frac{\exp\left\{\mathbf{x}'(\boldsymbol{\mu}_t)\boldsymbol{\beta} - \eta\left(\boldsymbol{\mu}_t, \boldsymbol{\mu}_{t-\Delta_t}\right)\right\}}{\int_{\mathcal{S}} \exp\left\{\mathbf{x}'(\boldsymbol{\mu})\boldsymbol{\beta} - \eta\left(\boldsymbol{\mu}, \boldsymbol{\mu}_{t-\Delta_t}\right)\right\} d\boldsymbol{\mu}}\right.\right) \times \text{N}\left(\boldsymbol{\beta}|\boldsymbol{\mu}_\beta, \tau^2\mathbf{I}\right)
\end{aligned}
$$

The parameters σ_c, a_c, ρ_c and ν_c are estimated for each error class c; therefore, the products in their full-conditionals are only over observations $\mathbf{s}_{tc}$ within a single error class. The full-conditionals above are non-conjugate and must be sampled using Metropolis-Hastings updates. Normalizing constants cancel in the Metropolis-Hastings ratio, and thus may be omitted in the pseudocode below (e.g., the uniform prior distributions). One can implement a MCMC algorithm to estimate the parameters of the observation and process models as follows:

1. Define initial values for all model parameters: $\boldsymbol{\mu}_t^{(0)}$ for $t = 0, \ldots, T$; $\sigma_c^{(0)}$, $a_c^{(0)}$, $\rho_c^{(0)}$ and $\nu_c^{(0)}$ for c = 3, 2, 1, 0, A, and B (i.e., c indexes Argos location quality class); $\phi^{(0)}$; and $\boldsymbol{\beta}^{(0)}$. Set $k = 1$.

2. Let $\tilde{t} \in \{t_1 \ldots, t_m\}$, where $t_1, \ldots, t_m$ are the times of locations collected for a single error class. Update the observation model parameters (Eqs. 1 and 2) for the corresponding error class by:

   (a) Let

$$\mathbf{\Sigma}_c^{(k)} = \left(\sigma_c^{(k-1)}\right)^2 \left[\begin{array}{cc} 1 & \rho_c^{(k-1)}\sqrt{a_c^{(k-1)}} \\ \rho_c^{(k-1)}\sqrt{a_c^{(k-1)}} & a_c^{(k-1)} \end{array} \right]$$

   and

$$\begin{aligned} \widetilde{\mathbf{\Sigma}}_c^{(k)} &= \left(\sigma_c^{(k-1)}\right)^2 \left[\begin{array}{cc} 1 & -\rho_c^{(k-1)}\sqrt{a_c^{(k-1)}} \\ -\rho_c^{(k-1)}\sqrt{a_c^{(k-1)}} & a_c^{(k-1)} \end{array} \right], \\ &= \mathbf{H}\mathbf{\Sigma}_c^{(k)}\mathbf{H}' \end{aligned}$$

   where

$$\mathbf{H} = \left[\begin{array}{cc} 1 & 0 \\ 0 & -1 \end{array} \right].$$

   (b) Sample $\sigma_c^{(*)}$ from a proposal distribution $[\sigma_c^{(*)}|\sigma_c^{(k-1)}]$ (e.g., $\mathrm{N}\left(\sigma_c^{(*)}|\sigma_c^{(k-1)}, \tau_\sigma^2\right)$, where τ_σ^2 is a tuning parameter). If $\sigma_c^{(*)} \in [0, u_\sigma]$, calculate the Metropolis-Hastings ratio as

$$r_\sigma = \frac{\prod_{\tilde{t}} \left(p_t \times t\left(\mathbf{s}_{tc}|\boldsymbol{\mu}_t^{(k-1)}, \mathbf{\Sigma}_c^{(*)}, \nu_c^{(k-1)}\right) + (1-p_t) \times t\left(\mathbf{s}_{tc}|\boldsymbol{\mu}_t^{(k-1)}, \mathbf{H}\mathbf{\Sigma}_c^{(*)}\mathbf{H}', \nu_c^{(k-1)}\right)\right)}{\prod_{\tilde{t}} \left(p_t \times t\left(\mathbf{s}_{tc}|\boldsymbol{\mu}_t^{(k-1)}, \mathbf{\Sigma}_c^{(k)}, \nu_c^{(k-1)}\right) + (1-p_t) \times t\left(\mathbf{s}_{tc}|\boldsymbol{\mu}_t^{(k-1)}, \mathbf{H}\mathbf{\Sigma}_c^{(k)}\mathbf{H}', \nu_c^{(k-1)}\right)\right)},$$

   where

$$\mathbf{\Sigma}_c^{(*)} = \left(\sigma_c^{(*)}\right)^2 \left[\begin{array}{cc} 1 & \rho_c^{(k-1)}\sqrt{a_c^{(k-1)}} \\ \rho_c^{(k-1)}\sqrt{a_c^{(k-1)}} & a_c^{(k-1)} \end{array} \right].$$

   Note that the ratio r_σ assumes the proposal distribution is symmetric with respect to $\sigma_c^{(*)}$ and $\sigma_c^{(k-1)}$. If $r_\sigma > u$, where $u \sim \text{Uniform}(0,1)$, let $\sigma_c^{(k)} = \sigma_c^{(*)}$ and

$$\mathbf{\Sigma}_c^{(k)} = \left(\sigma_c^{(k)}\right)^2 \left[\begin{array}{cc} 1 & \rho_c^{(k-1)}\sqrt{a_c^{(k-1)}} \\ \rho_c^{(k-1)}\sqrt{a_c^{(k-1)}} & a_c^{(k-1)} \end{array} \right].$$

   Otherwise, let $\sigma_c^{(k)} = \sigma_c^{(k-1)}$ if $r_\sigma < u$, or if $\sigma_c^{(*)} \notin [0, u_\sigma]$.

   (c) Sample $a_c^{(*)}$ from a proposal distribution $[a_c^{(*)}|a_c^{(k-1)}]$ (e.g., $\mathrm{N}\left(a_c^{(*)}|a_c^{(k-1)}, \tau_a^2\right)$, where τ_a^2 is a tuning parameter). If $a_c^{(*)} \in [0, u_a]$, calculate the Metropolis-Hastings ratio as

$$r_a = \frac{\prod_{\tilde{t}} \left(p_t \times t\left(\mathbf{s}_{tc}|\boldsymbol{\mu}_t^{(k-1)}, \mathbf{\Sigma}_c^{(*)}, \nu_c^{(k-1)}\right) + (1-p_t) \times t\left(\mathbf{s}_{tc}|\boldsymbol{\mu}_t^{(k-1)}, \mathbf{H}\mathbf{\Sigma}_c^{(*)}\mathbf{H}', \nu_c^{(k-1)}\right)\right)}{\prod_{\tilde{t}} \left(p_t \times t\left(\mathbf{s}_{tc}|\boldsymbol{\mu}_t^{(k-1)}, \mathbf{\Sigma}_c^{(k)}, \nu_c^{(k-1)}\right) + (1-p_t) \times t\left(\mathbf{s}_{tc}|\boldsymbol{\mu}_t^{(k-1)}, \mathbf{H}\mathbf{\Sigma}_c^{(k)}\mathbf{H}', \nu_c^{(k-1)}\right)\right)},$$

where

$$\mathbf{\Sigma}_c^{(*)} = \left(\sigma_c^{(k)}\right)^2 \begin{bmatrix} 1 & \rho_c^{(k-1)}\sqrt{a_c^{(*)}} \\ \rho_c^{(k-1)}\sqrt{a_c^{(*)}} & a_c^{(*)} \end{bmatrix}.$$

Note that the ratio r_a assumes the proposal distribution is symmetric with respect to $a_c^{(*)}$ and $a_c^{(k-1)}$. If $r_a > u$, where $u \sim$ Uniform(0,1), let $a_c^{(k)} = a_c^{(*)}$ and

$$\mathbf{\Sigma}_c^{(k)} = \left(\sigma_c^{(k)}\right)^2 \begin{bmatrix} 1 & \rho_c^{(k-1)}\sqrt{a_c^{(k)}} \\ \rho_c^{(k-1)}\sqrt{a_c^{(k)}} & a_c^{(k)} \end{bmatrix}.$$

Otherwise, let $a_c^{(k)} = a_c^{(k-1)}$ if $r_a < u$, or if $a_c^{(*)} \notin [0, u_a]$.

(d) Sample $\rho_c^{(*)}$ from a proposal distribution $[\rho_c^{(*)}|\rho_c^{(k-1)}]$ (e.g., $\text{N}\left(\rho_c^{(*)}|\rho_c^{(k-1)}, \tau_\rho^2\right)$, where τ_ρ^2 is a tuning parameter). If $\rho_c^{(*)} \in [0, u_\rho]$, calculate the Metropolis-Hastings ratio as

$$r_\rho = \frac{\prod_{\tilde{t}}\left(p_t \times t\left(\mathbf{s}_{tc}|\boldsymbol{\mu}_t^{(k-1)}, \mathbf{\Sigma}_c^{(*)}, \nu_c^{(k-1)}\right) + (1-p_t) \times t\left(\mathbf{s}_{tc}|\boldsymbol{\mu}_t^{(k-1)}, \mathbf{H}\mathbf{\Sigma}_c^{(*)}\mathbf{H}', \nu_c^{(k-1)}\right)\right)}{\prod_{\tilde{t}}\left(p_t \times t\left(\mathbf{s}_{tc}|\boldsymbol{\mu}_t^{(k-1)}, \mathbf{\Sigma}_c^{(k)}, \nu_c^{(k-1)}\right) + (1-p_t) \times t\left(\mathbf{s}_{tc}|\boldsymbol{\mu}_t^{(k-1)}, \mathbf{H}\mathbf{\Sigma}_c^{(k)}\mathbf{H}', \nu_c^{(k-1)}\right)\right)},$$

where

$$\mathbf{\Sigma}_c^{(*)} = \left(\sigma_c^{(k)}\right)^2 \begin{bmatrix} 1 & \rho_c^{(*)}\sqrt{a_c^{(k)}} \\ \rho_c^{(*)}\sqrt{a_c^{(k)}} & a_c^{(k)} \end{bmatrix}.$$

Note that the ratio r_ρ assumes the proposal distribution is symmetric with respect to $\rho_c^{(*)}$ and $\rho_c^{(k-1)}$. If $r_\rho > u$, where $u \sim$ Uniform(0,1), let $\rho_c^{(k)} = \rho_c^{(*)}$ and

$$\mathbf{\Sigma}_c^{(k)} = \left(\sigma_c^{(k)}\right)^2 \begin{bmatrix} 1 & \rho_c^{(k)}\sqrt{a_c^{(k)}} \\ \rho_c^{(k)}\sqrt{a_c^{(k)}} & a_c^{(k)} \end{bmatrix}.$$

Otherwise, let $\rho_c^{(k)} = \rho_c^{(k-1)}$ if $r_\rho < u$, or if $\rho_c^{(*)} \notin [0, u_\rho]$.

(e) Sample $\nu_c^{(*)}$ from a proposal distribution $[\nu_c^{(*)}|\nu_c^{(k-1)}]$ (e.g., $\text{N}\left(\nu_c^{(*)}|\nu_c^{(k-1)}, \tau_\nu^2\right)$, where τ_ν^2 is a tuning parameter). If $\nu_c^{(*)} \in [0, u_\nu]$, calculate the Metropolis-Hastings ratio as

$$r_\nu = \frac{\prod_{\tilde{t}}\left(p_t \times t\left(\mathbf{s}_{tc}|\boldsymbol{\mu}_t^{(k-1)}, \mathbf{\Sigma}_c^{(k)}, \nu_c^{(*)}\right) + (1-p_t) \times t\left(\mathbf{s}_{tc}|\boldsymbol{\mu}_t^{(k-1)}, \mathbf{H}\mathbf{\Sigma}_c^{(k)}\mathbf{H}', \nu_c^{(*)}\right)\right)}{\prod_{\tilde{t}}\left(p_t \times t\left(\mathbf{s}_{tc}|\boldsymbol{\mu}_t^{(k-1)}, \mathbf{\Sigma}_c^{(k)}, \nu_c^{(k-1)}\right) + (1-p_t) \times t\left(\mathbf{s}_{tc}|\boldsymbol{\mu}_t^{(k-1)}, \mathbf{H}\mathbf{\Sigma}_c^{(k)}\mathbf{H}', \nu_c^{(k-1)}\right)\right)}.$$

Note that the ratio r_ν assumes the proposal distribution is symmetric with respect to $\nu_c^{(*)}$ and $\nu_c^{(k-1)}$. If $r_\nu > u$, where $u \sim$ Uniform(0,1), let $\nu_c^{(k)} = \nu_c^{(*)}$. Otherwise, let $\nu_c^{(k)} = \nu_c^{(k-1)}$ if $r_\nu < u$, or if $\nu_c^{(*)} \notin [0, u_\nu]$.

(f) Repeat step 2 for each error class c.

3. Sample $\phi^{(*)}$ from a proposal distribution $[\phi^{(*)}|\phi^{(k-1)}]$ (e.g., $\text{N}\left(\phi^{(*)}|\phi^{(k-1)}, \tau_\phi^2\right)$, where τ_ϕ^2

is a tuning parameter). If $\phi^{(*)} \in [0, u_\phi]$, calculate the Metropolis-Hastings ratio as

$$r_\phi = \frac{\prod_{t=0}^{T}\left(\frac{\exp\left\{\mathbf{x}'\left(\boldsymbol{\mu}_t^{(k-1)}\right)\boldsymbol{\beta}^{(k-1)} - \eta\left(\boldsymbol{\mu}_t^{(k-1)}, \boldsymbol{\mu}_{t-\Delta_t}^{(k-1)}, \phi^{(*)}\right)\right\}}{\int_{\mathcal{S}} \exp\left\{\mathbf{x}'(\boldsymbol{\mu})\boldsymbol{\beta}^{(k-1)} - \eta\left(\boldsymbol{\mu}, \boldsymbol{\mu}_{t-\Delta_t}^{(k-1)}, \phi^{(*)}\right)\right\} d\boldsymbol{\mu}}\right)}{\prod_{t=0}^{T}\left(\frac{\exp\left\{\mathbf{x}'\left(\boldsymbol{\mu}_t^{(k-1)}\right)\boldsymbol{\beta}^{(k-1)} - \eta\left(\boldsymbol{\mu}_t^{(k-1)}, \boldsymbol{\mu}_{t-\Delta_t}^{(k-1)}, \phi^{(k-1)}\right)\right\}}{\int_{\mathcal{S}} \exp\left\{\mathbf{x}'(\boldsymbol{\mu})\boldsymbol{\beta}^{(k-1)} - \eta\left(\boldsymbol{\mu}, \boldsymbol{\mu}_{t-\Delta_t}^{(k-1)}, \phi^{(k-1)}\right)\right\} d\boldsymbol{\mu}}\right)},$$

where

$$\eta\left(\boldsymbol{\mu}_t^{(k-1)}, \boldsymbol{\mu}_{t-\Delta_t}^{(k-1)}, \phi^{(*)}\right) = \frac{d\left(\boldsymbol{\mu}_t^{(k-1)}, \boldsymbol{\mu}_{t-\Delta_t}^{(k-1)}\right)}{\Delta_t \phi^{(*)}}$$

and

$$\eta\left(\boldsymbol{\mu}_t^{(k-1)}, \boldsymbol{\mu}_{t-\Delta_t}^{(k-1)}, \phi^{(k-1)}\right) = \frac{d\left(\boldsymbol{\mu}_t^{(k-1)}, \boldsymbol{\mu}_{t-\Delta_t}^{(k-1)}\right)}{\Delta_t \phi^{(k-1)}}.$$

Note that the ratio r_ϕ assumes the proposal distribution is symmetric with respect to $\phi^{(*)}$ and $\phi^{(k-1)}$. If $r_\phi > u$, where $u \sim$ Uniform(0,1), let $\phi^{(k)} = \phi^{(*)}$. Otherwise, let $\phi^{(k)} = \phi^{(k-1)}$ if $r_\phi < u$, or if $\phi^{(*)} \notin [0, u_\phi]$.

4. Sample $\boldsymbol{\beta}^{(*)}$ from a proposal distribution $[\boldsymbol{\beta}^{(*)}|\boldsymbol{\beta}^{(k-1)}]$ (e.g., $\mathrm{N}\left(\boldsymbol{\beta}^{(*)}|\boldsymbol{\beta}^{(k-1)}, \tau_\beta^2\mathbf{I}\right)$, where τ_β^2 is a tuning parameter). Calculate the Metropolis-Hastings ratio as

$$r_\beta = \frac{\prod_{t=0}^{T}\left(\frac{\exp\left\{\mathbf{x}'\left(\boldsymbol{\mu}_t^{(k-1)}\right)\boldsymbol{\beta}^{(*)} - \eta\left(\boldsymbol{\mu}_t^{(k-1)}, \boldsymbol{\mu}_{t-\Delta_t}^{(k-1)}, \phi^{(k)}\right)\right\}}{\int_{\mathcal{S}} \exp\left\{\mathbf{x}'(\boldsymbol{\mu})\boldsymbol{\beta}^{(*)} - \eta\left(\boldsymbol{\mu}, \boldsymbol{\mu}_{t-\Delta_t}^{(k-1)}, \phi^{(k)}\right)\right\} d\boldsymbol{\mu}}\right) \times \mathrm{N}\left(\boldsymbol{\beta}^{(*)}|\boldsymbol{\mu}_\beta, \tau^2\mathbf{I}\right)}{\prod_{t=0}^{T}\left(\frac{\exp\left\{\mathbf{x}'\left(\boldsymbol{\mu}_t^{(k-1)}\right)\boldsymbol{\beta}^{(k-1)} - \eta\left(\boldsymbol{\mu}_t^{(k-1)}, \boldsymbol{\mu}_{t-\Delta_t}^{(k-1)}, \phi^{(k)}\right)\right\}}{\int_{\mathcal{S}} \exp\left\{\mathbf{x}'(\boldsymbol{\mu})\boldsymbol{\beta}^{(k-1)} - \eta\left(\boldsymbol{\mu}, \boldsymbol{\mu}_{t-\Delta_t}^{(k-1)}, \phi^{(k)}\right)\right\} d\boldsymbol{\mu}}\right) \times \mathrm{N}\left(\boldsymbol{\beta}^{(k-1)}|\boldsymbol{\mu}_\beta, \tau^2\mathbf{I}\right)}.$$

Note that the ratio r_β assumes the proposal distribution is symmetric with respect to $\boldsymbol{\beta}^{(*)}$ and $\boldsymbol{\beta}^{(k-1)}$. If $r_\beta > u$, where $u \sim$ Uniform(0,1), let $\boldsymbol{\beta}^{(k)} = \boldsymbol{\beta}^{(*)}$. Otherwise, let $\boldsymbol{\beta}^{(k)} = \boldsymbol{\beta}^{(k-1)}$.

5. For each $t = \Delta_t, \ldots T - \Delta_t$ in sequence, sample $\boldsymbol{\mu}_t^{(*)}$ from a proposal distribution $[\boldsymbol{\mu}_t^{(*)}|\boldsymbol{\mu}_t^{(k-1)}]$ (e.g., $\mathrm{N}\left(\boldsymbol{\mu}_t^{(*)}|\boldsymbol{\mu}_t^{(k-1)}, \tau_\mu^2\mathbf{I}\right)$, where τ_μ^2 is a tuning parameter). If $\boldsymbol{\mu}_t^{(*)} \in \mathcal{S}$, calculate the Metropolis-Hastings ratio as

$$\begin{aligned} r_\mu &= \frac{\left[\boldsymbol{\mu}_t^{(*)}|\boldsymbol{\mu}_{t-\Delta_t}^{(k)}\right] \times \left[\boldsymbol{\mu}_{t+\Delta_t}^{(k-1)}|\boldsymbol{\mu}_t^{(*)}\right] \times \left[\mathbf{s}_{tc}|\boldsymbol{\mu}_t^{(*)}, \boldsymbol{\Sigma}_c^{(k)}, \nu_c^{(k)}\right]}{\left[\boldsymbol{\mu}_t^{(k-1)}|\boldsymbol{\mu}_{t-\Delta_t}^{(k)}\right] \times \left[\boldsymbol{\mu}_{t+\Delta_t}^{(k-1)}|\boldsymbol{\mu}_t^{(k-1)}\right] \times \left[\mathbf{s}_{tc}|\boldsymbol{\mu}_t^{(k-1)}, \boldsymbol{\Sigma}_c^{(k)}, \nu_c^{(k)}\right]} \\ &= \frac{\left(\frac{\exp\left\{\mathbf{x}'\left(\boldsymbol{\mu}_t^{(*)}\right)\boldsymbol{\beta}^{(k)} - \eta\left(\boldsymbol{\mu}_t^{(*)}, \boldsymbol{\mu}_{t-\Delta_t}^{(k)}, \phi^{(k)}\right)\right\}}{\int_{\mathcal{S}} \exp\left\{\mathbf{x}'(\boldsymbol{\mu})\boldsymbol{\beta}^{(k)} - \eta\left(\boldsymbol{\mu}, \boldsymbol{\mu}_{t-\Delta_t}^{(k)}, \phi^{(k)}\right)\right\} d\boldsymbol{\mu}}\right)}{\left(\frac{\exp\left\{\mathbf{x}'\left(\boldsymbol{\mu}_t^{(k-1)}\right)\boldsymbol{\beta}^{(k)} - \eta\left(\boldsymbol{\mu}_t^{(k-1)}, \boldsymbol{\mu}_{t-\Delta_t}^{(k)}, \phi^{(k)}\right)\right\}}{\int_{\mathcal{S}} \exp\left\{\mathbf{x}'(\boldsymbol{\mu})\boldsymbol{\beta}^{(k)} - \eta\left(\boldsymbol{\mu}, \boldsymbol{\mu}_{t-\Delta_t}^{(k)}, \phi^{(k)}\right)\right\} d\boldsymbol{\mu}}\right)} \times \end{aligned}$$

$$\frac{\left(\frac{\exp\left\{\mathbf{x}'\left(\boldsymbol{\mu}_{t+\Delta_t}^{(k-1)}\right)\boldsymbol{\beta}^{(k)}-\eta\left(\boldsymbol{\mu}_{t+\Delta_t}^{(k-1)},\boldsymbol{\mu}_t^{(*)},\phi^{(k)}\right)\right\}}{\int_{\mathcal{S}}\exp\left\{\mathbf{x}'(\boldsymbol{\mu})\boldsymbol{\beta}^{(k)}-\eta\left(\boldsymbol{\mu},\boldsymbol{\mu}_t^{(*)},\phi^{(k)}\right)\right\}d\boldsymbol{\mu}}\right)}{\left(\frac{\exp\left\{\mathbf{x}'\left(\boldsymbol{\mu}_{t+\Delta_t}^{(k-1)}\right)\boldsymbol{\beta}^{(k)}-\eta\left(\boldsymbol{\mu}_{t+\Delta_t}^{(k-1)},\boldsymbol{\mu}_t^{(k-1)},\phi^{(k)}\right)\right\}}{\int_{\mathcal{S}}\exp\left\{\mathbf{x}'(\boldsymbol{\mu})\boldsymbol{\beta}^{(k)}-\eta\left(\boldsymbol{\mu},\boldsymbol{\mu}_t^{(k-1)},\phi^{(k)}\right)\right\}d\boldsymbol{\mu}}\right)}\times$$
$$\frac{\left(p_t\times t\left(\mathbf{s}_{tc}|\boldsymbol{\mu}_t^{(*)},\boldsymbol{\Sigma}_c^{(k)},\nu_c^{(k)}\right)+(1-p_t)\times t\left(\mathbf{s}_{tc}|\boldsymbol{\mu}_t^{(*)},\mathbf{H}\boldsymbol{\Sigma}_c^{(k)}\mathbf{H}',\nu_c^{(k)}\right)\right)}{\left(p_t\times t\left(\mathbf{s}_{tc}|\boldsymbol{\mu}_t^{(k-1)},\boldsymbol{\Sigma}_c^{(k)},\nu_c^{(k)}\right)+(1-p_t)\times t\left(\mathbf{s}_{tc}|\boldsymbol{\mu}_t^{(k-1)},\mathbf{H}\boldsymbol{\Sigma}_c^{(k)}\mathbf{H}',\nu_c^{(k)}\right)\right)}$$

Note that the ratio r_μ assumes the proposal distribution is symmetric with respect to $\boldsymbol{\mu}_t^{(*)}$ and $\boldsymbol{\mu}_t^{(k-1)}$. If $r_\mu > u$, where $u \sim$ Uniform(0,1), let $\boldsymbol{\mu}_t^{(k)} = \boldsymbol{\mu}_t^{(*)}$. Otherwise, let $\boldsymbol{\mu}_t^{(k)} = \boldsymbol{\mu}_t^{(k-1)}$ if $r_\mu < u$, or if $\boldsymbol{\mu}_t^{(*)} \notin \mathcal{S}$.

6. Save $\boldsymbol{\mu}_t^{(k)}$ for $t = 0, \ldots, T$; $\sigma_c^{(k)}$, $a_c^{(k)}$, $\rho_c^{(k)}$, and $\nu_c^{(k)}$ for $c =$ 3, 2, 1, 0, A, and B; $\phi^{(k)}$; and $\boldsymbol{\beta}^{(k)}$.

7. Set $k = k + 1$ and return to step 2. The algorithm is iterated by repeating steps 2 through 7 until a sufficiently large sample has been obtained from which to approximate the posterior distribution.