1 Materials and Methods

1.1 Taxon occurrence information

1.2 Supertree inference

1.3 Model specification

Define y as a $N \times T$ matrix of the observed 0/1 occurrence of species i at time t, and z as a $N \times T$ matrix of the "true" 0/1 occurrence of species i at time t. The observation presence of a taxon $y_{i,t}$ is modeled as following a Bernoulli distribution defined

$$y_{i,t} \sim \text{Bernoulli}(\rho_t z_{i,t}) \tag{1}$$

where ρ is a length T vector of the probability that a species is observed at time t given that it is present at time t ($\rho_t = \Pr(y_{\_t} = 1 | x_{\_t} = 1)$).

Observation probability ρ_t is modeled as Bernoulli distributed variable with probability equal to the inverse logit transformed length T vector ρ' (Eq. 2). The elements of ρ' are modeled as exchangeable draws from a Normal distribution with location $\rho^{''}$ and scale $\sigma_{\rho'}$; these are given weakly informative Normal and half-Cauchy priors, respectively.

$$\begin{aligned}
\rho_t &\sim \text{Bernoulli}\left(\text{logit}^{-1}(\rho'_t)\right) \\
\rho'_t &\sim \mathcal{N}(\rho^{''}, \sigma_{\rho'}) \\
\rho^{''} &\sim \mathcal{N}(0, 1) \\
\sigma_{\rho'} &\sim \text{C}^{+}(1)
\end{aligned} \tag{2}$$

The "true" presence/absence states of taxa z are modeled as a logistic regression (Eq. 3) where the probability of being present ($z = 1$) is a function of individual-level and group-level effects. The intercept of this regression α is a length T vector which varies by time t (Eq. 4). Individual-level covariates are a $N \times D$ matrix x whose regression coefficients are the length D column vector β. These regression coefficients are given independent weakly informative Normally distributed priors.

$$\begin{aligned}
z_{i,t} &\sim \text{Bernoulli}\left(\text{logit}^{-1}(\alpha_t + x_i \beta)\right) \\
\beta &\sim \mathcal{N}(0, 1)
\end{aligned} \tag{3}$$

The value of α_t is itself defined as a regression (Eq. 4). The intercept of the this group-level regression is defined as μ. The effect of plant regime p is modeled as the length P vector ϕ whose elemnts are draws from a Normal distribution with a location of 0 and scale of σ_{ϕ}. The group-level covariates corresponding to global climate values of interest is defined as the $T \times U$ matrix u where γ is a length U column vector of regression coefficients. Finally σ_{μ} is positive real value. μ, the elements of γ, σ_{μ}, and σ_{ϕ} are all given weakly informative independent priors (Eq. 4).

$$
\begin{aligned}
\alpha_t &\sim \mathcal{N}(\mu + \phi_{p[t]} + u_t \gamma, \sigma_{\mu}) \\
\phi_p &\sim \mathcal{N}(0, \sigma_{\phi}) \\
\mu &\sim \mathcal{N}(0, 5) \\
\gamma &\sim \mathcal{N}(0, 1) \\
\sigma_{\mu} &\sim \mathrm{C}^{+}(1) \\
\sigma_{\phi} &\sim \mathrm{C}^{+}(1)
\end{aligned}
\tag{4}
$$