Methods

Table 1: Simulation mis-specification design matrix. Outer dimensions describe the unique correct models (6) while inner dimensions (18) describe the unique mis-specifications run for each simulation.

Covariance Matrix	**Autocorrelation**	**Matern Correlation**	**Phylogenetic Correlation**
Type	Mis-specification		
LMM	Data Model iid Mis-specified Covariance	Data Model iid Mis-specified Covariance	Data Model iid Mis-specified Covariance
GLMM	Data Model iid Mis-specified Covariance	Data Model iid Mis-specified Covariance	Data Model iid Mis-specified Covariance

Table 2: Linear Model Simulation: data generating models, parameter values, and mis-specifications.

	Data Generating Model	Parameters	Data Fitting Model
Correct	$X_i \sim N(0,1)$ $\mu_{i,j} = X_i\beta$ $y_{i,j} \sim N(\mu_{i,j}, \sigma_y)$	$\beta = (4,-5)$ $\sigma_y = 1$	$X_i \sim N(0,1)$ $\mu_{i,j} = X_i\beta$ $y_{i,j} \sim N(\mu_{i,j}, \sigma_y)$
Mis-specified	$X_i \sim N(0,1)$ $\mu_{i,j} = X_i\beta$ $y^{'}_{i,j} \sim N(\mu_{i,j}, exp(\sigma_y))$		$X_i \sim N(0,1)$ $\mu_{i,j} = X_i\beta$ $y^{'}_{i,j} \sim N(\mu_{i,j}, \sigma_y)$

Table 3: Temporal Model Simulation: data generating models, parameter values, and mis-specifications.

	Linear Mixed Model			**Generalized Linear Mixed Model**		
	Data Generating Model	Parameters	Data Fitting Model	Data Generating Model	Parameters	Data Fitting Model
Correct	$\mu_i = u_{i-1} + a$ $u_i \sim N(\mu_i, \sigma_u)$ $y_i \sim N(u_i, \sigma_y)$	$a = 2$ $u[1] = 0$ $\sigma_u = 1$ $\sigma_y = 1$	$\mu_i = u_{i-1} + a$ $u_i \sim N(\mu_i, \sigma_u)$ $y_i \sim N(u_i, \sigma_y)$	$\mu_i = u_{i-1} + a$ $u_i \sim N(\mu_i, \sigma_u)$ $y_i \sim Gamma(\frac{1}{CV}^2, e^{u_i} CV^2)$	$a = .02$ $u[1] = 0$ $\sigma_u = 0.1$ $CV = 0.3$	$\mu_i = u_{i-1} + a$ $u_i \sim N(\mu_i, \sigma_u)$ $y_i \sim Gamma(\frac{1}{CV}^2, e^{u_i} CV^2)$
Mis-specified	Missing Random Effects $\mu_i = u_{i-1} + a$ $u_i \sim N(\mu_i, \sigma_u)$ $y_i \sim N(u_i, \sigma_y)$		$y_i \sim N(a(1:n), \sigma_y)$	Missing Random Effects $\mu_i = u_{i-1} + a$ $u_i \sim N(\mu_i, \sigma_u)$ $y_i \sim Gamma(\frac{1}{CV}^2, e^{u_i} CV^2)$		$y_i \sim Gamma(\frac{1}{CV}^2, e^{a} CV^2)$
	Mis-specified Data Model $\mu_i = u_{i-1} + a$ $u_i \sim N(\mu_i, \sigma_u)$ $\sigma_y^2 = c(rep(35, n/4), rep(0.5, n/4),$ $rep(35, n/4), rep(0.5, n/4)$ $y_i^{'} \sim N(u_i, \sigma_y)$		$\mu_i = u_{i-1} + a$ $u_i \sim N(\mu_i, \sigma_u)$ $y_i^{'} \sim N(u_i, \sigma_y)$	Misp-specified Data Model $\mu_i = u_{i-1} + a$ $u_i \sim N(\mu_i, \sigma_u)$ $y_i \sim Gamma(\frac{1}{CV}^2, e^{u_i} CV^2)$		$\mu_i = u_{i-1} + a$ $u_i \sim N(\mu_i, \sigma_u)$ $y_i \sim N(u_i, \sigma_y)$
	Mis-specifed Random Effects $\mu_i = u_{i-1} + a$ $u_i \sim N(\mu_i, \sigma_u)$ $y_i \sim N(u_i, \sigma_y)$		$\mu_i = u_{i-1}$ $u_i \sim N(\mu_i, \sigma_u)$ $y_i \sim N(u_i, \sigma_y)$	Mis-specified Random Effects $u_i^{'} = u_{i-1} + Gamma(0.5, 20)$ $y_i^{'} \sim Gamma(\frac{1}{CV}^2, e^{u_i^{'}} CV^2)$		$\mu_i = u_{i-1} + a$ $u_i \sim N(\mu_i, \sigma_u)$ $y_i^{'} \sim Gamma(\frac{1}{CV}^2, e^{u_i} CV^2)$

Table 4: Spatial Model Simulation: data generating models, parameter values, and mis-specifications.

	Linear Mixed Model			**Generalized Linear Mixed Model**		
	Data Generating Model	Parameters	Data Fitting Model	Data Generating Model	Parameters	Data Fitting Model
Correct	$\omega \sim GMRF(Q[\kappa, \sigma_\omega^2])$ $\eta_i = \beta_0 + \omega_i$ $y \sim N(\eta, \sigma_y)$	$\beta_0 = 2$ $\sigma_y^2 = 1$ $\phi = 50$ $\kappa = \sqrt{8}/\phi$ $\sigma_\omega^2 = 2$	$\omega \sim GMRF(Q[\kappa, \sigma_\omega^2])$ $\eta_i = \beta_0 + \omega_i$ $y \sim N(\eta, \sigma_y)$	$\omega \sim GMRF(Q[\kappa, \sigma_\omega^2])$ $\eta_i = exp(\beta_0 + \omega_i)$ $y \sim Pois(\eta, \sigma_y)$	$\beta = 2$ $\phi = 30$ $\kappa = \sqrt{8}/\phi$ $\sigma_\omega^2 = 0.25$	$\omega \sim GMRF(Q[\kappa, \sigma_\omega^2])$ $\eta_i = exp(\beta_0 + \omega_i)$ $y \sim Pois(\eta, \sigma_y)$
Mis-specified	Missing Random Effects $\omega \sim GMRF(Q[\kappa, \sigma_\omega^2])$ $\eta_i = \beta_0 + \omega_i$ $y \sim N(\eta, \sigma_y)$		$\eta_i = \beta_0$ $y \sim N(\eta, \sigma_y)$	Missing Random Effects $\omega \sim GMRF(Q[\kappa, \sigma_\omega^2])$ $\eta_i = exp(\beta_0 + \omega_i)$ $y \sim Pois(\eta)$		$\eta_i = exp(\beta_0)$ $y \sim Pois(\eta)$
	Mis-specified Data Model $\omega \sim GMRF(Q[\kappa, \sigma_\omega^2])$ $\eta_i = \beta_0 + \omega_i$ $y \sim N(\eta, \sigma_y)$		$\omega \sim GMRF(Q[\kappa, \sigma_\omega^2])$ $\eta_i = \beta_0 + \omega_i$ $\sigma_y = exp(N(0, 1))$ $y \sim N(\eta, \sigma_y)$	Mis-specified Data Model $\omega \sim GMRF(Q[\kappa, \sigma_\omega^2])$ $\eta_i = exp(\beta_0 + \omega_i)$ $y^{'} \sim B(1, 0.7) * Pois(\eta)$		$\omega \sim GMRF(Q[\kappa, \sigma_\omega^2])$ $\eta_i = exp(\beta_0 + \omega_i)$ $y \sim Pois(\eta)$
	Mis-specified Random Effects Model $\omega \sim GMRF(Q[\kappa, \sigma_\omega^2])$ $\eta_i = \beta_0 + exp(\omega_i)$ $y^{'} \sim N(\eta, \sigma_y)$		$\omega \sim GMRF(Q[\kappa, \sigma_\omega^2])$ $\eta_i = \beta_0 + \omega_i$ $y^{'} \sim N(\eta, \sigma_y)$	Mis-specified Random Effects Model		

Table 5: Phylogenetic Model Simulation: data generating models, parameter values, and mis-specifications.

	Linear Mixed Model			**Generalized Linear Mixed Model**		
	Data Generating Model	Parameters	Data Fitting Model	Data Generating Model	Parameters	Data Fitting Model
Correct	$tree \sim randomTree(n)$ $\Sigma = BM(tree, a, r, \sigma_u^2)$ $u \sim MVNORM(\Sigma)$ $X_i \sim Unif(-0.5, 0.5)$ $\eta = X\beta + u$ $y \sim Normal(\eta, \sigma_y)$	$a = 0$ $r = 0$ $\sigma_u^2 = 2$ $\beta = (0, 1)$ $\sigma_y = 1$	$tree \sim randomTree(n)$ $\Sigma = BM(tree, a, r, \sigma_u^2)$ $u \sim MVNORM(\Sigma)$ $X_i \sim Unif(-0.5, 0.5)$ $\eta = X\beta + u$ $y \sim Normal(\eta, \sigma_y)$	$tree \sim randomTree(n)$ $\Sigma = BM(tree, a, r, \sigma_u^2)$ $u \sim MVNORM(\Sigma)$ $\eta = exp(\beta_0 + u)$ $y \sim NegBinom(\mu = \eta, size = \theta)$	$a = 0$ $r = 0$ $\sigma_u^2 = 1$ $\beta_0 = 3$ $\theta = 0.5$	$tree \sim randomTree(n)$ $\Sigma = BM(tree, a, r, \sigma_u^2)$ $u \sim MVNORM(\Sigma)$ $\eta = exp(\beta_0 + u)$ $y \sim NegBinom(\mu = \eta, size = \theta)$
Mis-specified	Missing Random Effects $tree \sim randomTree(n)$ $\Sigma = BM(tree, a, r, \sigma_u^2)$ $u \sim MVNORM(\Sigma)$ $X_i \sim Unif(-0.5, 0.5)$ $\eta = X\beta + u$ $y \sim Normal(\eta, \sigma_y)$		$X_i \sim Unif(-0.5, 0.5)$ $\eta = X\beta$ $y \sim Normal(\eta, \sigma_y)$	Missing Random Effects $tree \sim randomTree(n)$ $\Sigma = BM(tree, a, r, \sigma_u^2)$ $u \sim MVNORM(\Sigma)$ $\eta = exp(\beta_0 + u)$ $y \sim NegBinom(\mu = \eta, size = \theta)$		$\eta = exp(\beta_0)$ $y \sim NegBinom(\mu = \eta, size = \theta)$
	Mis-specified Data Model $tree \sim randomTree(n)$ $\Sigma = BM(tree, a, r, \sigma_u^2)$ $u \sim MVNORM(\Sigma)$ $X_i \sim Unif(-0.5, 0.5)$ $\eta = X\beta + u$ $y \sim Normal(\eta, \sigma_y)$		$tree \sim randomTree(n)$ $\Sigma = BM(tree, a, r, \sigma_u^2)$ $u \sim MVNORM(\Sigma)$ $X_i \sim Unif(-0.5, 0.5)$ $\eta = exp(X\beta + u)$ $y \sim Normal(\eta, \sigma_y)$	Misp-specified Data Model $tree \sim randomTree(n)$ $\Sigma = BM(tree, a, r, \sigma_u^2)$ $u \sim MVNORM(\Sigma)$ $\eta = exp(\beta_0 + u)$ $y \sim NegBinom(\mu = \eta, size = \theta)$		$tree \sim randomTree(n)$ $\Sigma = BM(tree, a, r, \sigma_u^2)$ $u \sim MVNORM(\Sigma)$ $\eta = exp(\beta_0 + u)$ $y \sim Poisson(\mu = \eta)$
	Mis-specifed Random Effects $tree \sim randomTree(n)$ $\Sigma = BM(tree, a, r, \sigma_u^2)$ $u \sim MVNORM(\Sigma)$ $X_i \sim Unif(-0.5, 0.5)$ $\eta = X\beta + exp(u)$ $y^{'} \sim Normal(\eta, \sigma_y)$		$tree \sim randomTree(n)$ $\Sigma = BM(tree, a, r, \sigma_u^2)$ $u \sim MVNORM(\Sigma)$ $X_i \sim Unif(-0.5, 0.5)$ $\eta = X\beta + u$ $y^{'} \sim Normal(\eta, \sigma_y)$	Mis-specified Random Effects $tree \sim randomTree(n)$ $\Sigma = OU(tree, a = 1, r = -2, \sigma_u^2)$ $u^{'} \sim MVNORM(\Sigma)$ $\eta^{'} = exp(\beta_0 + u^{'})$ $y^{'} \sim NegBinom(\mu = \eta^{'}, size = \theta)$		$tree \sim randomTree(n)$ $\Sigma = BM(tree, a = 0, r = 0, \sigma_u^2)$ $u \sim MVNORM(\Sigma)$ $\eta = exp(\beta_0 + u)$ $y^{'} \sim NegBinom(\mu = \eta, size = \theta)$

Results

LM

Table 6: Linear Model. Type I error rates at the 0.05 significance level evaluated for each method for theoretical and estimated residuals.

test	residual type	Pearson	one-step cdf	one-step Generic	one-step Gaussian	full Gaussian	Conditional ecdf, Not Rotated
Kolmogorov-Smirnov	theoretical	0.048	0.048	0.048	0.048	0.048	0.044
	estimated	0.000	0.000	0.000	0.000	0.000	0.000

Table 7: Linear Model. Power at the 0.95 significance level evaluated for each method for theoretical and estimated residuals.

test	residual type	Pearson	one-step cdf	one-step Generic	one-step Gaussian	full Gaussian	Conditional ecdf, Not Rotated
Kolmogorov-Smirnov	theoretical	1.000	1.000	1.000	1.000	1.000	1.000
	estimated	0.963	0.963	0.963	0.963	0.963	0.961

Temporal Correlation - LMM

Table 8: LMM Temporal Correlation Model. Type I error rates and Power evaluated for each analytical and simulation method for theoretical residuals. Results are partitioned out by model mis-specification (from left to right) and residual type (top to bottom).

		Type I Error	Power		
test	method	Correct	A: iid	B: Heterosck.	C: Missing Drift
Anderson-Darling	Pearson	0.061	1.000	1.000	1.000
Anderson-Darling	one-step cdf	0.046	1.000	1.000	1.000
Anderson-Darling	one-step Generic	0.046	1.000	1.000	1.000
Anderson-Darling	one-step Gaussian	0.046	1.000	1.000	1.000
Anderson-Darling	full Gaussian	0.046	1.000	1.000	1.000
Anderson-Darling	MCMC	0.048	1.000	1.000	0.050
Anderson-Darling	Process osa	1.000	NA	1.000	1.000
Anderson-Darling	Process ecdf	0.306	NA	0.320	0.329
Anderson-Darling	Unconditional ecdf, Rotated	0.335	1.000	1.000	1.000
Anderson-Darling	Unconditional ecdf, Not Rotated	0.993	1.000	1.000	1.000
Anderson-Darling	Conditional ecdf, Rotated	0.352	1.000	1.000	1.000
Anderson-Darling	Conditional ecdf, Not Rotated	0.228	1.000	1.000	1.000
Kolmogorov- Smirnov	Pearson	0.056	1.000	1.000	1.000
Kolmogorov- Smirnov	one-step cdf	0.041	1.000	0.889	1.000
Kolmogorov- Smirnov	one-step Generic	0.042	1.000	0.867	1.000
Kolmogorov- Smirnov	one-step Gaussian	0.042	1.000	0.867	1.000
Kolmogorov- Smirnov	full Gaussian	0.042	1.000	0.867	1.000
Kolmogorov- Smirnov	MCMC	0.041	1.000	0.814	0.047
Kolmogorov- Smirnov	Process osa	1.000	NA	1.000	1.000
Kolmogorov- Smirnov	Process ecdf	0.047	NA	0.043	0.048
Kolmogorov- Smirnov	Unconditional ecdf, Rotated	0.060	1.000	1.000	1.000
Kolmogorov- Smirnov	Unconditional ecdf, Not Rotated	0.987	1.000	0.960	1.000
Kolmogorov- Smirnov	Conditional ecdf, Rotated	0.065	1.000	1.000	1.000
Kolmogorov- Smirnov	Conditional ecdf, Not Rotated	0.057	1.000	1.000	1.000
Autocorrelation	Pearson	0.047	1.000	0.000	1.000
Autocorrelation	one-step cdf	0.051	1.000	0.000	0.100
Autocorrelation	one-step Generic	0.052	1.000	0.000	0.104
Autocorrelation	one-step Gaussian	0.052	1.000	0.000	0.100
Autocorrelation	full Gaussian	0.052	1.000	0.000	0.100
Autocorrelation	MCMC	0.048	1.000	0.000	0.069
Autocorrelation	Process osa	0.069	NA	0.000	0.069
Autocorrelation	Process ecdf	0.048	NA	0.050	0.050
Autocorrelation	Unconditional ecdf, Rotated	0.043	0.982	0.000	0.132
Autocorrelation	Unconditional ecdf, Not Rotated	1.000	0.984	0.923	1.000
Autocorrelation	Conditional ecdf, Rotated	0.053	0.983	0.110	0.985
Autocorrelation	Conditional ecdf, Not Rotated	0.049	0.983	0.000	0.986

Table 9: LMM Temporal Correlation Model. Type I error rates and Power evaluated for each analytical and simulation method for estimated residuals. Results are partitioned out by model mis-specification (from left to right) and residual type (top to bottom).

		Type I Error	Power		
test	method	Correct	A: iid	B: Heterosck.	C: Missing Drift
Anderson-Darling	Pearson	0.002	1.000	0.010	0.000
Anderson-Darling	one-step cdf	0.030	1.000	0.016	1.000
Anderson-Darling	one-step Generic	0.024	1.000	0.016	0.995
Anderson-Darling	one-step Gaussian	0.022	1.000	0.014	0.996
Anderson-Darling	full Gaussian	0.027	1.000	0.022	0.997
Anderson-Darling	MCMC	0.053	1.000	0.117	0.051
Anderson-Darling	Process osa	1.000	NA	1.000	0.999
Anderson-Darling	Process ecdf	0.015	NA	0.285	0.996
Anderson-Darling	Unconditional ecdf, Rotated	0.315	1.000	0.912	0.999
Anderson-Darling	Unconditional ecdf, Not Rotated	0.315	1.000	0.453	1.000
Anderson-Darling	Conditional ecdf, Rotated	0.015	1.000	0.780	0.000
Anderson-Darling	Conditional ecdf, Not Rotated	0.010	1.000	0.672	0.000
Kolmogorov- Smirnov	Pearson	0.129	1.000	0.668	1.000
Kolmogorov- Smirnov	one-step cdf	0.000	1.000	0.362	1.000
Kolmogorov- Smirnov	one-step Generic	0.000	1.000	0.365	1.000
Kolmogorov- Smirnov	one-step Gaussian	0.000	1.000	0.365	1.000
Kolmogorov- Smirnov	full Gaussian	0.000	1.000	0.370	1.000
Kolmogorov- Smirnov	MCMC	0.054	1.000	0.467	0.051
Kolmogorov- Smirnov	Process osa	1.000	NA	1.000	1.000
Kolmogorov- Smirnov	Process ecdf	0.357	NA	0.998	1.000
Kolmogorov- Smirnov	Unconditional ecdf, Rotated	0.001	1.000	0.141	1.000
Kolmogorov- Smirnov	Unconditional ecdf, Not Rotated	0.996	1.000	0.964	1.000
Kolmogorov- Smirnov	Conditional ecdf, Rotated	0.077	1.000	0.183	1.000
Kolmogorov- Smirnov	Conditional ecdf, Not Rotated	0.129	1.000	0.657	1.000
Lilliefors	Pearson	0.051	0.130	0.992	0.022
Lilliefors	one-step cdf	0.048	0.130	0.980	1.000
Lilliefors	one-step Generic	0.052	0.130	0.980	0.036
Lilliefors	one-step Gaussian	0.053	0.130	0.980	0.036
Lilliefors	full Gaussian	0.052	0.130	0.982	0.034
Lilliefors	MCMC	0.050	0.130	0.870	0.054
Lilliefors	Process osa	0.057	NA	0.219	0.035
Lilliefors	Process ecdf	0.074	NA	0.626	0.099
Lilliefors	Unconditional ecdf, Rotated	0.169	0.204	0.971	0.140
Lilliefors	Unconditional ecdf, Not Rotated	0.528	0.278	0.836	1.000
Lilliefors	Conditional ecdf, Rotated	0.047	0.210	0.980	0.083
Lilliefors	Conditional ecdf, Not Rotated	0.051	0.289	0.995	0.078
Autocorrelation	Pearson	0.001	1.000	0.000	0.000
Autocorrelation	one-step cdf	0.003	1.000	0.000	0.001
Autocorrelation	one-step Generic	0.003	1.000	0.000	0.000
Autocorrelation	one-step Gaussian	0.003	1.000	0.000	0.000
Autocorrelation	full Gaussian	0.003	1.000	0.000	0.000
Autocorrelation	MCMC	0.027	1.000	0.104	0.059
Autocorrelation	Process osa	0.064	NA	0.217	0.000
Autocorrelation	Process ecdf	0.974	NA	0.897	0.000
Autocorrelation	Unconditional ecdf, Rotated	0.006	1.000	0.177	0.000
Autocorrelation	Unconditional ecdf, Not Rotated	1.000	1.000	0.905	1.000
Autocorrelation	Conditional ecdf, Rotated	0.001	1.000	0.043	0.045
Autocorrelation	Conditional ecdf, Not Rotated	0.001	1.000	0.048	0.051

Temporal Correlation - GLMM

Table 10: GLMM Temporal Correlation Model. Type I error rates and Power evaluated for each analytical and simulation method for theoretical residuals. Results are partitioned out by model mis-specification (from left to right) and residual type (top to bottom).

		Type I Error	Power		
test	method	Correct	A: iid	B: Gamma - Normal	C: Misp Cov
Anderson-Darling	Pearson	0.976	1.000	1.000	1.000
Anderson-Darling	one-step cdf	0.097	1.000	0.961	1.000
Anderson-Darling	one-step Generic	0.041	1.000	0.959	1.000
Anderson-Darling	MCMC	0.048	1.000	0.684	0.063
Anderson-Darling	Process osa	0.091	NA	0.919	1.000
Anderson-Darling	Process ecdf	0.329	NA	0.318	0.335
Anderson-Darling	Unconditional ecdf, Rotated	0.819	1.000	0.997	0.741
Anderson-Darling	Unconditional ecdf, Not Rotated	0.994	1.000	1.000	1.000
Anderson-Darling	Conditional ecdf, Rotated	0.318	1.000	1.000	1.000
Anderson-Darling	Conditional ecdf, Not Rotated	0.227	1.000	1.000	1.000
Kolmogorov- Smirnov	Pearson	0.875	1.000	1.000	1.000
Kolmogorov- Smirnov	one-step cdf	0.077	1.000	0.874	1.000
Kolmogorov- Smirnov	one-step Generic	0.033	1.000	0.880	1.000
Kolmogorov- Smirnov	MCMC	0.056	1.000	0.581	0.055
Kolmogorov- Smirnov	Process osa	0.080	NA	0.793	1.000
Kolmogorov- Smirnov	Process ecdf	0.049	NA	0.054	0.044
Kolmogorov- Smirnov	Unconditional ecdf, Rotated	0.724	1.000	0.852	0.553
Kolmogorov- Smirnov	Unconditional ecdf, Not Rotated	0.990	1.000	1.000	1.000
Kolmogorov- Smirnov	Conditional ecdf, Rotated	0.071	1.000	1.000	1.000
Kolmogorov- Smirnov	Conditional ecdf, Not Rotated	0.049	1.000	1.000	1.000
Autocorrelation	Pearson	0.217	1.000	1.000	1.000
Autocorrelation	one-step cdf	0.054	0.995	0.331	0.000
Autocorrelation	one-step Generic	0.053	0.993	0.092	0.000
Autocorrelation	MCMC	0.048	1.000	0.027	0.120
Autocorrelation	Process osa	0.051	NA	0.237	0.000
Autocorrelation	Process ecdf	0.051	NA	0.055	0.052
Autocorrelation	Unconditional ecdf, Rotated	0.486	0.920	0.091	0.100
Autocorrelation	Unconditional ecdf, Not Rotated	1.000	0.976	0.992	1.000
Autocorrelation	Conditional ecdf, Rotated	0.045	0.933	0.585	0.903
Autocorrelation	Conditional ecdf, Not Rotated	0.051	0.975	1.000	0.986

Table 11: GLMM Temporal Correlation Model. Type I error rates and Power evaluated for each analytical and simulation method for estimated residuals. Results are partitioned out by model mis-specification (from left to right) and residual type (top to bottom).

		Type I Error	Power		
test	method	Correct	A: iid	B: Gamma - Normal	C: Misp Cov
Anderson-Darling	Pearson	0.619	0.911	0.001	1.000
Anderson-Darling	one-step cdf	0.115	0.830	0.289	0.025
Anderson-Darling	one-step Generic	0.039	0.886	0.020	0.020
Anderson-Darling	MCMC	0.043	0.841	0.057	0.051
Anderson-Darling	Process osa	0.069	NA	0.155	0.954
Anderson-Darling	Process ecdf	0.111	NA	0.813	0.162
Anderson-Darling	Unconditional ecdf, Rotated	0.148	0.890	0.974	0.353
Anderson-Darling	Unconditional ecdf, Not Rotated	0.307	0.869	0.457	0.366
Anderson-Darling	Conditional ecdf, Rotated	0.001	0.909	0.238	0.073
Anderson-Darling	Conditional ecdf, Not Rotated	0.000	0.861	0.226	0.041
Kolmogorov- Smirnov	Pearson	0.878	0.986	0.982	1.000
Kolmogorov- Smirnov	one-step cdf	0.115	0.958	0.797	0.002
Kolmogorov- Smirnov	one-step Generic	0.000	0.965	0.795	0.002
Kolmogorov- Smirnov	MCMC	0.037	0.958	0.086	0.047
Kolmogorov- Smirnov	Process osa	0.088	NA	0.386	1.000
Kolmogorov- Smirnov	Process ecdf	0.006	NA	0.730	0.829
Kolmogorov- Smirnov	Unconditional ecdf, Rotated	0.658	0.945	0.608	0.316
Kolmogorov- Smirnov	Unconditional ecdf, Not Rotated	0.995	0.954	0.999	0.990
Kolmogorov- Smirnov	Conditional ecdf, Rotated	0.878	0.950	0.977	0.022
Kolmogorov- Smirnov	Conditional ecdf, Not Rotated	0.924	0.951	0.979	0.040
Lilliefors	Pearson	0.993	0.983	0.966	1.000
Lilliefors	one-step cdf	0.184	0.779	0.956	0.126
Lilliefors	one-step Generic	0.049	0.779	0.961	0.123
Lilliefors	MCMC	0.036	0.779	0.162	0.048
Lilliefors	Process osa	0.055	NA	0.675	0.090
Lilliefors	Process ecdf	0.108	NA	0.983	0.396
Lilliefors	Unconditional ecdf, Rotated	0.596	0.791	0.983	0.148
Lilliefors	Unconditional ecdf, Not Rotated	0.651	0.865	0.957	0.529
Lilliefors	Conditional ecdf, Rotated	0.053	0.800	0.697	0.115
Lilliefors	Conditional ecdf, Not Rotated	0.051	0.870	0.696	0.075
Autocorrelation	Pearson	0.005	1.000	0.021	0.034
Autocorrelation	one-step cdf	0.001	1.000	0.107	0.004
Autocorrelation	one-step Generic	0.000	1.000	0.122	0.005
Autocorrelation	MCMC	0.045	1.000	0.087	0.033
Autocorrelation	Process osa	0.008	NA	0.208	0.073
Autocorrelation	Process ecdf	0.345	NA	0.530	0.991
Autocorrelation	Unconditional ecdf, Rotated	0.400	0.882	0.180	0.041
Autocorrelation	Unconditional ecdf, Not Rotated	1.000	0.999	1.000	0.997
Autocorrelation	Conditional ecdf, Rotated	0.000	0.880	0.035	0.000
Autocorrelation	Conditional ecdf, Not Rotated	0.000	0.999	0.036	0.000

Spatial

Table 12: LMM Spatial Model. Type I error rates and Power evaluated for each analytical and simulation method for theoretical residuals. Results are partitioned out by model mis-specification (from left to right) and residual type (top to bottom).

		Type I Error	Power		
test	method	Correct	A: iid	B: Misp Data	C: Misp Cov
Anderson-Darling	Pearson	0.044	0.999	1.000	1.000
Anderson-Darling	one-step cdf	0.009	0.999	1.000	0.883
Anderson-Darling	one-step Generic	0.011	0.999	1.000	0.778
Anderson-Darling	one-step Gaussian	0.011	0.999	1.000	0.889
Anderson-Darling	full Gaussian	0.011	0.999	1.000	0.889
Anderson-Darling	MCMC	0.050	0.999	1.000	0.761
Anderson-Darling	Process osa	0.890	NA	1.000	0.982
Anderson-Darling	Process ecdf	0.136	NA	0.149	0.124
Anderson-Darling	Unconditional ecdf, Rotated	0.225	1.000	1.000	0.974
Anderson-Darling	Unconditional ecdf, Not Rotated	0.762	1.000	1.000	1.000
Anderson-Darling	Conditional ecdf, Rotated	0.338	1.000	1.000	1.000
Anderson-Darling	Conditional ecdf, Not Rotated	0.216	1.000	1.000	1.000
Kolmogorov- Smirnov	Pearson	0.046	0.992	0.977	1.000
Kolmogorov- Smirnov	one-step cdf	0.012	0.992	0.978	0.536
Kolmogorov- Smirnov	one-step Generic	0.012	0.992	0.973	0.538
Kolmogorov- Smirnov	one-step Gaussian	0.012	0.992	0.973	0.538
Kolmogorov- Smirnov	full Gaussian	0.012	0.992	0.973	0.538
Kolmogorov- Smirnov	MCMC	0.038	0.992	0.948	0.487
Kolmogorov- Smirnov	Process osa	0.455	NA	0.998	0.830
Kolmogorov- Smirnov	Process ecdf	0.055	NA	0.054	0.044
Kolmogorov- Smirnov	Unconditional ecdf, Rotated	0.016	0.996	0.992	0.649
Kolmogorov- Smirnov	Unconditional ecdf, Not Rotated	0.687	0.992	0.901	1.000
Kolmogorov- Smirnov	Conditional ecdf, Rotated	0.050	0.998	0.998	1.000
Kolmogorov- Smirnov	Conditional ecdf, Not Rotated	0.039	0.992	0.980	1.000
Autocorrelation	Pearson	0.059	0.998	0.148	0.958
Autocorrelation	one-step cdf	0.050	0.998	0.027	0.175
Autocorrelation	one-step Generic	0.050	0.998	0.012	0.334
Autocorrelation	one-step Gaussian	0.050	0.998	0.011	0.314
Autocorrelation	full Gaussian	0.050	0.998	0.011	0.314
Autocorrelation	MCMC	0.043	0.998	0.001	0.147
Autocorrelation	Process osa	0.069	NA	0.106	0.255
Autocorrelation	Process ecdf	0.081	NA	0.097	0.101
Autocorrelation	Unconditional ecdf, Rotated	0.045	0.996	0.013	0.130
Autocorrelation	Unconditional ecdf, Not Rotated	0.999	0.998	0.923	0.982
Autocorrelation	Conditional ecdf, Rotated	0.062	0.995	0.055	0.363
Autocorrelation	Conditional ecdf, Not Rotated	0.054	0.998	0.057	0.515

Table 13: LMM Spatial Model. Type I error rates and Power evaluated for each analytical and simulation method for estimated residuals. Results are partitioned out by model mis-specification (from left to right) and residual type (top to bottom).

		Type I Error	Power		
test	method	Correct	A: iid	B: Misp Data	C: Misp Cov
Anderson-Darling	Pearson	0.002	0.033	0.054	0.197
Anderson-Darling	one-step cdf	0.038	0.021	0.055	0.181
Anderson-Darling	one-step Generic	0.043	0.037	NA	NA
Anderson-Darling	one-step Gaussian	0.041	0.033	0.055	0.189
Anderson-Darling	full Gaussian	0.042	0.040	0.055	0.188
Anderson-Darling	MCMC	0.053	0.035	0.062	0.222
Anderson-Darling	Process osa	0.477	NA	0.767	0.774
Anderson-Darling	Process ecdf	0.006	NA	0.000	0.078
Anderson-Darling	Unconditional ecdf, Rotated	0.304	0.256	0.999	0.976
Anderson-Darling	Unconditional ecdf, Not Rotated	0.111	0.137	0.992	0.965
Anderson-Darling	Conditional ecdf, Rotated	0.025	0.253	0.995	0.880
Anderson-Darling	Conditional ecdf, Not Rotated	0.016	0.154	0.993	0.874
Kolmogorov- Smirnov	Pearson	0.139	0.004	0.985	0.935
Kolmogorov- Smirnov	one-step cdf	0.019	0.004	0.982	0.871
Kolmogorov- Smirnov	one-step Generic	0.013	0.004	NA	NA
Kolmogorov- Smirnov	one-step Gaussian	0.013	0.004	0.982	0.868
Kolmogorov- Smirnov	full Gaussian	0.013	0.004	0.981	0.896
Kolmogorov- Smirnov	MCMC	0.039	0.004	0.983	0.846
Kolmogorov- Smirnov	Process osa	0.469	NA	0.671	0.708
Kolmogorov- Smirnov	Process ecdf	0.575	NA	1.000	0.954
Kolmogorov- Smirnov	Unconditional ecdf, Rotated	0.026	0.002	0.931	0.851
Kolmogorov- Smirnov	Unconditional ecdf, Not Rotated	0.329	0.004	0.983	0.939
Kolmogorov- Smirnov	Conditional ecdf, Rotated	0.090	0.007	0.925	0.925
Kolmogorov- Smirnov	Conditional ecdf, Not Rotated	0.146	0.002	0.986	0.940
Lilliefors	Pearson	0.054	0.124	0.999	0.916
Lilliefors	one-step cdf	0.054	0.124	0.999	0.943
Lilliefors	one-step Generic	0.048	0.122	NA	NA
Lilliefors	one-step Gaussian	0.048	0.124	0.999	0.947
Lilliefors	full Gaussian	0.048	0.124	0.998	0.954
Lilliefors	MCMC	0.067	0.124	0.999	0.860
Lilliefors	Process osa	0.055	NA	0.527	0.586
Lilliefors	Process ecdf	0.117	NA	0.072	0.187
Lilliefors	Unconditional ecdf, Rotated	0.145	0.191	1.000	0.971
Lilliefors	Unconditional ecdf, Not Rotated	0.153	0.168	1.000	0.982
Lilliefors	Conditional ecdf, Rotated	0.076	0.184	1.000	0.925
Lilliefors	Conditional ecdf, Not Rotated	0.064	0.172	0.999	0.927
Autocorrelation	Pearson	0.004	0.998	0.753	0.854
Autocorrelation	one-step cdf	0.045	0.998	0.737	0.859
Autocorrelation	one-step Generic	0.046	0.998	NA	NA
Autocorrelation	one-step Gaussian	0.046	0.998	0.738	0.861
Autocorrelation	full Gaussian	0.046	0.998	0.758	0.880
Autocorrelation	MCMC	0.038	0.998	0.753	0.864
Autocorrelation	Process osa	0.048	NA	0.137	0.120
Autocorrelation	Process ecdf	0.249	NA	0.050	0.077
Autocorrelation	Unconditional ecdf, Rotated	0.039	0.998	0.826	0.851
Autocorrelation	Unconditional ecdf, Not Rotated	0.998	0.998	0.864	0.982
Autocorrelation	Conditional ecdf, Rotated	0.004	0.998	0.826	0.849
Autocorrelation	Conditional ecdf, Not Rotated	0.004	0.998	0.860	0.850

Table 14: GLMM Spatial Model. Type I error rates and Power evaluated for each analytical and simulation method for theoretical residuals. Results are partitioned out by model mis-specification (from left to right) and residual type (top to bottom).

		Type I Error	Power		
test	method	Correct	A: iid	B: Misp Data	C: Misp Cov
Anderson-Darling	Pearson	0.099	0.995	1.000	0.099
Anderson-Darling	one-step cdf	0.040	0.991	1.000	0.140
Anderson-Darling	one-step Generic	0.037	0.991	1.000	0.130
Anderson-Darling	MCMC	0.060	0.991	1.000	0.082
Anderson-Darling	Process osa	0.880	NA	1.000	0.924
Anderson-Darling	Process ecdf	0.161	NA	0.139	1.000
Anderson-Darling	Unconditional ecdf, Rotated	0.197	1.000	0.966	0.392
Anderson-Darling	Unconditional ecdf, Not Rotated	0.541	0.998	1.000	0.550
Anderson-Darling	Conditional ecdf, Rotated	0.325	1.000	1.000	0.344
Anderson-Darling	Conditional ecdf, Not Rotated	0.139	0.997	1.000	0.129
Kolmogorov- Smirnov	Pearson	0.085	0.979	1.000	0.085
Kolmogorov- Smirnov	one-step cdf	0.040	0.916	1.000	0.084
Kolmogorov- Smirnov	one-step Generic	0.037	0.916	1.000	0.083
Kolmogorov- Smirnov	MCMC	0.044	0.912	0.986	0.061
Kolmogorov- Smirnov	Process osa	0.447	NA	0.928	0.482
Kolmogorov- Smirnov	Process ecdf	0.060	NA	0.061	1.000
Kolmogorov- Smirnov	Unconditional ecdf, Rotated	0.062	0.944	0.812	0.128
Kolmogorov- Smirnov	Unconditional ecdf, Not Rotated	0.469	0.911	1.000	0.467
Kolmogorov- Smirnov	Conditional ecdf, Rotated	0.064	0.938	1.000	0.074
Kolmogorov- Smirnov	Conditional ecdf, Not Rotated	0.052	0.912	1.000	0.057
Autocorrelation	Pearson	0.064	0.988	0.094	0.064
Autocorrelation	one-step cdf	0.055	0.990	0.000	0.620
Autocorrelation	one-step Generic	0.055	0.989	0.001	0.618
Autocorrelation	MCMC	0.071	0.988	0.000	0.265
Autocorrelation	Process osa	0.070	NA	0.045	0.059
Autocorrelation	Process ecdf	0.077	NA	0.085	0.050
Autocorrelation	Unconditional ecdf, Rotated	0.020	0.975	0.003	0.518
Autocorrelation	Unconditional ecdf, Not Rotated	0.986	0.984	0.588	0.988
Autocorrelation	Conditional ecdf, Rotated	0.053	0.978	0.047	0.064
Autocorrelation	Conditional ecdf, Not Rotated	0.063	0.985	0.060	0.062

Table 15: GLMM Spatial Model. Type I error rates and Power evaluated for each analytical and simulation method for estimated residuals. Results are partitioned out by model mis-specification (from left to right) and residual type (top to bottom).

		Type I Error	Power		
test	method	Correct	A: iid	B: Misp Data	C: Misp Cov
Anderson-Darling	Pearson	0.005	0.829	0.007	0.003
Anderson-Darling	one-step cdf	0.027	0.751	0.221	0.049
Anderson-Darling	one-step Generic	0.036	0.759	0.129	0.038
Anderson-Darling	MCMC	0.049	0.753	0.096	0.045
Anderson-Darling	Process osa	0.488	NA	0.520	0.505
Anderson-Darling	Process ecdf	0.005	NA	0.047	0.006
Anderson-Darling	Unconditional ecdf, Rotated	0.237	0.996	0.041	0.301
Anderson-Darling	Unconditional ecdf, Not Rotated	0.094	0.981	0.145	0.079
Anderson-Darling	Conditional ecdf, Rotated	0.047	0.990	0.008	0.047
Anderson-Darling	Conditional ecdf, Not Rotated	0.009	0.970	0.005	0.006
Kolmogorov- Smirnov	Pearson	0.253	0.984	1.000	0.555
Kolmogorov- Smirnov	one-step cdf	0.006	0.820	0.931	0.001
Kolmogorov- Smirnov	one-step Generic	0.007	0.820	0.745	0.001
Kolmogorov- Smirnov	MCMC	0.038	0.820	0.089	0.022
Kolmogorov- Smirnov	Process osa	0.471	NA	0.866	0.476
Kolmogorov- Smirnov	Process ecdf	0.658	NA	0.442	0.997
Kolmogorov- Smirnov	Unconditional ecdf, Rotated	0.018	0.872	0.131	0.002
Kolmogorov- Smirnov	Unconditional ecdf, Not Rotated	0.063	0.814	0.807	0.010
Kolmogorov- Smirnov	Conditional ecdf, Rotated	0.086	0.880	0.999	0.366
Kolmogorov- Smirnov	Conditional ecdf, Not Rotated	0.144	0.813	1.000	0.473
Lilliefors	Pearson	0.062	0.972	1.000	0.129
Lilliefors	one-step cdf	0.047	0.309	0.996	0.044
Lilliefors	one-step Generic	0.047	0.270	0.994	0.039
Lilliefors	MCMC	0.046	0.318	0.074	0.042
Lilliefors	Process osa	0.054	NA	0.738	0.044
Lilliefors	Process ecdf	0.217	NA	0.941	0.793
Lilliefors	Unconditional ecdf, Rotated	0.124	0.822	0.746	0.147
Lilliefors	Unconditional ecdf, Not Rotated	0.096	0.694	0.998	0.081
Lilliefors	Conditional ecdf, Rotated	0.172	0.840	1.000	0.267
Lilliefors	Conditional ecdf, Not Rotated	0.153	0.696	1.000	0.292
Autocorrelation	Pearson	0.001	0.988	0.001	0.348
Autocorrelation	one-step cdf	0.079	0.990	0.009	0.829
Autocorrelation	one-step Generic	0.079	0.989	0.008	0.824
Autocorrelation	MCMC	0.062	0.989	0.024	0.298
Autocorrelation	Process osa	0.063	NA	0.032	0.050
Autocorrelation	Process ecdf	0.480	NA	0.046	0.060
Autocorrelation	Unconditional ecdf, Rotated	0.050	0.984	0.081	0.744
Autocorrelation	Unconditional ecdf, Not Rotated	0.990	0.990	0.234	0.990
Autocorrelation	Conditional ecdf, Rotated	0.001	0.986	0.003	0.317
Autocorrelation	Conditional ecdf, Not Rotated	0.001	0.989	0.004	0.335

Phylogenetic

Table 16: LMM Phylogenetic Model. Type I error rates and Power evaluated for each analytical and simulation method for theoretical residuals. Results are partitioned out by model mis-specification (from left to right) and residual type (top to bottom).

		Type I Error	Power		
test	method	Correct	A: iid	B: Misp Data	C: Misp Cov
Anderson-Darling	Pearson	0.055	1.000	1.000	1.000
Anderson-Darling	one-step cdf	0.052	1.000	0.980	0.989
Anderson-Darling	one-step Generic	0.047	1.000	0.924	0.937
Anderson-Darling	one-step Gaussian	0.047	1.000	0.986	0.994
Anderson-Darling	full Gaussian	0.047	1.000	0.986	0.994
Anderson-Darling	MCMC	0.042	1.000	0.916	0.905
Anderson-Darling	Process osa	0.040	NA	0.957	0.964
Anderson-Darling	Process ecdf	0.333	NA	0.346	0.343
Anderson-Darling	Unconditional ecdf, Rotated	0.335	1.000	0.997	0.999
Anderson-Darling	Unconditional ecdf, Not Rotated	0.759	1.000	1.000	1.000
Anderson-Darling	Conditional ecdf, Rotated	0.327	1.000	1.000	1.000
Anderson-Darling	Conditional ecdf, Not Rotated	0.229	1.000	1.000	1.000
Kolmogorov- Smirnov	Pearson	0.047	1.000	1.000	1.000
Kolmogorov- Smirnov	one-step cdf	0.043	1.000	0.738	0.750
Kolmogorov- Smirnov	one-step Generic	0.042	1.000	0.739	0.752
Kolmogorov- Smirnov	one-step Gaussian	0.042	1.000	0.740	0.752
Kolmogorov- Smirnov	full Gaussian	0.042	1.000	0.740	0.752
Kolmogorov- Smirnov	MCMC	0.042	1.000	0.758	0.737
Kolmogorov- Smirnov	Process osa	0.041	NA	0.708	0.712
Kolmogorov- Smirnov	Process ecdf	0.062	NA	0.051	0.053
Kolmogorov- Smirnov	Unconditional ecdf, Rotated	0.052	1.000	0.835	0.840
Kolmogorov- Smirnov	Unconditional ecdf, Not Rotated	0.679	1.000	1.000	1.000
Kolmogorov- Smirnov	Conditional ecdf, Rotated	0.058	1.000	1.000	1.000
Kolmogorov- Smirnov	Conditional ecdf, Not Rotated	0.043	1.000	1.000	1.000
Autocorrelation	Pearson	0.045	0.999	0.850	0.872
Autocorrelation	one-step cdf	0.041	0.999	0.622	0.621
Autocorrelation	one-step Generic	0.042	0.999	0.321	0.326
Autocorrelation	one-step Gaussian	0.042	0.999	0.434	0.442
Autocorrelation	full Gaussian	0.042	0.999	0.434	0.442
Autocorrelation	MCMC	0.051	0.999	0.337	0.329
Autocorrelation	Process osa	0.050	NA	0.457	0.450
Autocorrelation	Process ecdf	0.048	NA	0.052	0.052
Autocorrelation	Unconditional ecdf, Rotated	0.045	0.992	0.093	0.087
Autocorrelation	Unconditional ecdf, Not Rotated	0.999	0.997	0.979	0.983
Autocorrelation	Conditional ecdf, Rotated	0.049	0.996	0.408	0.400
Autocorrelation	Conditional ecdf, Not Rotated	0.051	0.997	0.354	0.363

Table 17: LMM Phylogenetic Model. Type I error rates and Power evaluated for each analytical and simulation method for estimated residuals. Results are partitioned out by model mis-specification (from left to right) and residual type (top to bottom).

		Type I Error	Power		
test	method	Correct	A: iid	B: Misp Data	C: Misp Cov
Anderson-Darling	Pearson	0.000	0.034	0.221	0.201
Anderson-Darling	one-step cdf	0.068	0.038	0.610	0.610
Anderson-Darling	one-step Generic	0.037	0.034	0.016	0.006
Anderson-Darling	one-step Gaussian	0.029	0.029	0.447	0.430
Anderson-Darling	full Gaussian	0.028	0.028	0.451	0.436
Anderson-Darling	MCMC	0.038	0.038	0.216	0.215
Anderson-Darling	Process osa	0.044	NA	0.237	0.231
Anderson-Darling	Process ecdf	0.051	NA	0.582	0.624
Anderson-Darling	Unconditional ecdf, Rotated	0.290	0.293	0.999	1.000
Anderson-Darling	Unconditional ecdf, Not Rotated	0.261	0.165	0.967	0.963
Anderson-Darling	Conditional ecdf, Rotated	0.004	0.293	0.538	0.504
Anderson-Darling	Conditional ecdf, Not Rotated	0.003	0.151	0.530	0.496
Kolmogorov- Smirnov	Pearson	0.638	0.005	0.991	0.993
Kolmogorov- Smirnov	one-step cdf	0.046	0.005	0.979	0.972
Kolmogorov- Smirnov	one-step Generic	0.013	0.005	0.987	0.981
Kolmogorov- Smirnov	one-step Gaussian	0.013	0.005	0.987	0.981
Kolmogorov- Smirnov	full Gaussian	0.013	0.005	0.986	0.980
Kolmogorov- Smirnov	MCMC	0.043	0.005	0.446	0.416
Kolmogorov- Smirnov	Process osa	0.012	NA	0.528	0.553
Kolmogorov- Smirnov	Process ecdf	0.166	NA	0.995	0.996
Kolmogorov- Smirnov	Unconditional ecdf, Rotated	0.014	0.007	0.973	0.969
Kolmogorov- Smirnov	Unconditional ecdf, Not Rotated	0.536	0.004	0.996	0.995
Kolmogorov- Smirnov	Conditional ecdf, Rotated	0.538	0.006	0.989	0.986
Kolmogorov- Smirnov	Conditional ecdf, Not Rotated	0.629	0.005	0.992	0.992
Lilliefors	Pearson	0.049	0.122	0.995	0.994
Lilliefors	one-step cdf	0.075	0.122	0.987	0.987
Lilliefors	one-step Generic	0.042	0.122	0.993	0.991
Lilliefors	one-step Gaussian	0.042	0.122	0.997	0.995
Lilliefors	full Gaussian	0.042	0.122	0.997	0.995
Lilliefors	MCMC	0.044	0.122	0.524	0.474
Lilliefors	Process osa	0.042	NA	0.584	0.624
Lilliefors	Process ecdf	0.093	NA	0.733	0.759
Lilliefors	Unconditional ecdf, Rotated	0.154	0.220	0.998	0.999
Lilliefors	Unconditional ecdf, Not Rotated	0.172	0.206	0.998	1.000
Lilliefors	Conditional ecdf, Rotated	0.059	0.230	0.595	0.577
Lilliefors	Conditional ecdf, Not Rotated	0.048	0.201	0.605	0.578
Autocorrelation	Pearson	0.935	0.999	0.798	0.805
Autocorrelation	one-step cdf	0.019	0.999	0.391	0.387
Autocorrelation	one-step Generic	0.021	0.999	0.473	0.478
Autocorrelation	one-step Gaussian	0.021	0.999	0.484	0.488
Autocorrelation	full Gaussian	0.021	0.999	0.484	0.485
Autocorrelation	MCMC	0.035	0.999	0.292	0.278
Autocorrelation	Process osa	0.036	NA	0.244	0.265
Autocorrelation	Process ecdf	0.161	NA	0.226	0.216
Autocorrelation	Unconditional ecdf, Rotated	0.021	0.999	0.357	0.344
Autocorrelation	Unconditional ecdf, Not Rotated	1.000	0.999	0.972	0.977
Autocorrelation	Conditional ecdf, Rotated	0.883	0.999	0.369	0.339
Autocorrelation	Conditional ecdf, Not Rotated	0.902	0.999	0.424	0.407

Table 18: GLMM Phylogenetic Model. Type I error rates and Power evaluated for each analytical and simulation method for theoretical residuals. Results are partitioned out by model mis-specification (from left to right) and residual type (top to bottom).

		Type I Error	Power		
test	method	Correct	A: iid	B: Misp Data	C: Misp Cov
Anderson-Darling	Pearson	1.000	1.000	1.000	1.000
Anderson-Darling	one-step cdf	0.053	0.991	1.000	0.339
Anderson-Darling	one-step Generic	0.035	0.985	0.999	0.330
Anderson-Darling	MCMC	0.067	0.989	0.748	0.149
Anderson-Darling	Process osa	0.040	NA	0.989	0.087
Anderson-Darling	Process ecdf	0.334	NA	0.330	0.358
Anderson-Darling	Unconditional ecdf, Rotated	0.671	0.999	0.711	0.561
Anderson-Darling	Unconditional ecdf, Not Rotated	0.603	0.999	0.925	0.945
Anderson-Darling	Conditional ecdf, Rotated	0.351	0.999	1.000	1.000
Anderson-Darling	Conditional ecdf, Not Rotated	0.131	0.999	1.000	1.000
Kolmogorov- Smirnov	Pearson	1.000	1.000	1.000	1.000
Kolmogorov- Smirnov	one-step cdf	0.049	0.849	0.992	0.339
Kolmogorov- Smirnov	one-step Generic	0.037	0.844	0.986	0.330
Kolmogorov- Smirnov	MCMC	0.055	0.848	0.545	0.158
Kolmogorov- Smirnov	Process osa	0.042	NA	0.848	0.088
Kolmogorov- Smirnov	Process ecdf	0.051	NA	0.048	0.055
Kolmogorov- Smirnov	Unconditional ecdf, Rotated	0.588	0.972	0.644	0.489
Kolmogorov- Smirnov	Unconditional ecdf, Not Rotated	0.549	0.843	0.844	0.925
Kolmogorov- Smirnov	Conditional ecdf, Rotated	0.161	0.975	1.000	0.992
Kolmogorov- Smirnov	Conditional ecdf, Not Rotated	0.035	0.855	1.000	0.931
Autocorrelation	Pearson	0.211	0.670	0.211	0.622
Autocorrelation	one-step cdf	0.063	0.895	0.436	0.208
Autocorrelation	one-step Generic	0.054	0.903	0.428	0.222
Autocorrelation	MCMC	0.044	0.904	0.315	0.054
Autocorrelation	Process osa	0.044	NA	0.236	0.046
Autocorrelation	Process ecdf	0.045	NA	0.052	0.047
Autocorrelation	Unconditional ecdf, Rotated	0.070	0.460	0.090	0.071
Autocorrelation	Unconditional ecdf, Not Rotated	0.874	0.880	0.891	0.205
Autocorrelation	Conditional ecdf, Rotated	0.042	0.460	0.060	0.188
Autocorrelation	Conditional ecdf, Not Rotated	0.038	0.878	0.054	0.680

Table 19: GLMM Phylogenetic Model. Type I error rates and Power evaluated for each analytical and simulation method for estimated residuals. Results are partitioned out by model mis-specification (from left to right) and residual type (top to bottom).

		Type I Error	Power		
test	method	Correct	A: iid	B: Misp Data	C: Misp Cov
Anderson-Darling	Pearson	0.999	1.000	0.000	1.000
Anderson-Darling	one-step cdf	0.043	0.013	0.422	0.025
Anderson-Darling	one-step Generic	0.027	0.011	0.053	0.031
Anderson-Darling	MCMC	0.030	0.011	0.076	0.044
Anderson-Darling	Process osa	0.050	NA	0.041	0.075
Anderson-Darling	Process ecdf	0.007	NA	0.236	0.000
Anderson-Darling	Unconditional ecdf, Rotated	0.260	0.835	0.005	0.259
Anderson-Darling	Unconditional ecdf, Not Rotated	0.179	0.633	0.048	0.121
Anderson-Darling	Conditional ecdf, Rotated	0.045	0.811	0.008	0.181
Anderson-Darling	Conditional ecdf, Not Rotated	0.024	0.634	0.004	0.060
Kolmogorov- Smirnov	Pearson	1.000	1.000	1.000	1.000
Kolmogorov- Smirnov	one-step cdf	0.002	0.330	0.814	0.000
Kolmogorov- Smirnov	one-step Generic	0.005	0.524	0.006	0.008
Kolmogorov- Smirnov	MCMC	0.024	0.328	0.051	0.009
Kolmogorov- Smirnov	Process osa	0.029	NA	0.016	0.066
Kolmogorov- Smirnov	Process ecdf	0.980	NA	0.042	1.000
Kolmogorov- Smirnov	Unconditional ecdf, Rotated	0.397	0.528	0.863	0.097
Kolmogorov- Smirnov	Unconditional ecdf, Not Rotated	0.275	0.322	0.907	0.060
Kolmogorov- Smirnov	Conditional ecdf, Rotated	0.055	0.513	1.000	0.012
Kolmogorov- Smirnov	Conditional ecdf, Not Rotated	0.156	0.319	1.000	0.001
Lilliefors	Pearson	1.000	1.000	0.992	1.000
Lilliefors	one-step cdf	0.037	0.623	0.620	0.038
Lilliefors	one-step Generic	0.039	0.647	0.121	0.059
Lilliefors	MCMC	0.053	0.634	0.051	0.046
Lilliefors	Process osa	0.066	NA	0.103	0.076
Lilliefors	Process ecdf	0.661	NA	0.273	0.550
Lilliefors	Unconditional ecdf, Rotated	0.443	0.792	0.267	0.185
Lilliefors	Unconditional ecdf, Not Rotated	0.087	0.772	0.699	0.075
Lilliefors	Conditional ecdf, Rotated	0.132	0.776	0.989	0.112
Lilliefors	Conditional ecdf, Not Rotated	0.216	0.780	1.000	0.062
Autocorrelation	Pearson	0.214	0.670	0.899	0.057
Autocorrelation	one-step cdf	0.047	0.890	0.498	0.029
Autocorrelation	one-step Generic	0.044	0.884	0.514	0.024
Autocorrelation	MCMC	0.038	0.884	0.077	0.040
Autocorrelation	Process osa	0.049	NA	0.344	0.076
Autocorrelation	Process ecdf	0.724	NA	0.318	0.663
Autocorrelation	Unconditional ecdf, Rotated	0.067	0.573	0.320	0.039
Autocorrelation	Unconditional ecdf, Not Rotated	0.885	0.889	0.833	0.253
Autocorrelation	Conditional ecdf, Rotated	0.100	0.566	0.832	0.042
Autocorrelation	Conditional ecdf, Not Rotated	0.132	0.888	0.585	0.036

Table 20: Overview of issues and recommendations for common classes of models. Correlation and distributions refer to predicted data from a fitted model, against which observed points are compared. A linear rotation refers to a multiplication of the simulated and observed data by a Cholesky decomposition of the estimated covariance matrix of the observed data, z'=Lz, as available in DHARMa.

Model class	Case studies	Issues and causes	Recommendation
Linear model	Linear model	No issues	Pearson residuals
Generalized linear model (GLM)	Skewed Gamma	Non-normality resulting from response variable. Quantile residuals are needed if not approximately normal.	Quantile residual
Linear mixed model (LMM), Multivariate model	Random walk, Spatial LMM, Multinomial	Linear correlations caused by non-independence in observations.	Use a method that linearly decorrela order to transform to a unit iid no OSA Full Gaussian, OSA one-step sian, or simulation residuals with rot
Generalized linear mixed model (GLMM)	Spatial Poisson, Repeated measures Tweedie	Non-normality and non-linear correlations caused by response variable and non-independence in observations.	Needs non-linear decorrelation and tiles. Needs non-linear decorrelatio quantiles. Best approach depends o study and sample size.