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	**Compound Symmetry**	**Autocorrelation**	**Matern Correlation**
Type	Mis-specification		
LMM	Data Model Missing RE Mis-specified RE	Data Model Missing RE Mis-specified RE	Data Model Missing RE Mis-specified RE
GLMM	Data Model Missing RE Mis-specified RE	Data Model Missing RE Mis-specified RE	Data Model Missing RE Mis-specified RE

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: Mixed Model Simulation: data generating models, parameter values, and mis-specifications.

Data Generating Model	Parameters	Data Fitting Model
Linear Mixed Model		
Correct		
$X_i \sim Unif(-0.5, 0.5)$ $u_j \sim N(0, \sigma_u)$ $\mu_{i,j} = X_i\beta + u_j$ $y_{i,j} \sim N(\mu_{i,j}, \sigma_y)$	$\beta = (4, -8)$ $\sigma_u = 2$ $\sigma_y = 0.5$	$X_i \sim Unif(-0.5, 0.5)$ $u_j \sim N(0, \sigma_u)$ $\mu_{i,j} = X_i\beta + u_j$ $y_{i,j} \sim N(\mu_{i,j}, \sigma_y)$
Mis-specified		
Correct $X_i \sim Unif(-0.5, 0.5)$ $u_j \sim N(0, \sigma_u)$ $\mu_{i,j} = X_i\beta + u_j$ $y_{i,j} \sim N(\mu_{i,j}, \sigma_y)$		Missing Random Effect $X_i \sim Unif(-0.5, 0.5)$ $\mu_{i,j} = X_i\beta$ $y_{i,j} \sim N(\mu_{i,j}, \sigma_y)$ Missing Covariate $u_j \sim N(0, \sigma_u)$ $\mu_{i,j} = \beta + u_j$ $y_{i,j} \sim N(\mu_{i,j}, \sigma_y)$
Lognormal Random Effect $X_i \sim Unif(-0.5, 0.5)$ $u_j \sim N(0, \sigma_u)$ $\mu'_{i,j} = X_i\beta + e^{u_j}$ $y'_{i,j} \sim N(\mu'_{i,j}, \sigma_y)$		Correct $X_i \sim Unif(-0.5, 0.5)$ $\mu_{i,j} = X_i\beta + u_j$ $y'_{i,j} \sim N(\mu_{i,j}, \sigma_y)$

Data Generating Model	Parameters	Data Fitting Model
Generalized Linear Mixed Model		
Correct		
$u_j \sim N(0, \sigma_u)$ $\mu_{i,j} = exp(\beta + u_j)$ $y_{i,j} \sim NBinom(\mu_{i,j}, size)$	$\beta = log(2)$ $size = 1$ $\sigma_u = 1$	$u_j \sim N(0, \sigma_u)$ $\mu_{i,j} = exp(\beta + u_j)$ $y_{i,j} \sim NBinom(\mu_{i,j}, size)$
Mis-specified		
Correct $u_j \sim N(0, \sigma_u)$ $\mu_{i,j} = exp(\beta + u_j)$ $y_{i,j} \sim NBinom(\mu_{i,j}, size)$		Missing Random Effect $\mu_{i,j} = exp(\beta)$ $y_{i,j} \sim NBinom(\mu_{i,j}, size)$ Mis-specified Distribution (Poisson) $u_j \sim N(0, \sigma_u)$ $\mu_{i,j} = exp(\beta + u_j)$ $y_{i,j} \sim Poisson(\mu_{i,j})$
Gamma Random Effect $u_j \sim Gamma(1, 1)$ $\mu'_{i,j} = exp(\beta + u_j)$ $y'_{i,j} \sim NBinom(\mu_{i,j}, size)$		Correct $u_j \sim N(0, \sigma_u)$ $\mu_{i,j} = exp(\beta + u_j)$ $y_{i,j} \sim NBinom(\mu_{i,j}, size)$

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

Data Generating Model	Parameters	Data Fitting Model
Linear Mixed Model		
Correct		
$\mu_i = u_{i-1} + a$ $u_i \sim N(\mu_i, \sigma_u)$ $y_i \sim N(u_i, \sigma_y)$	$a = 2$ $u[1] = 0$ $\sigma_u = 1$ $\sigma_y = 1$	$\mu_i = u_{i-1} + a$ $u_i \sim N(\mu_i, \sigma_u)$ $y_i \sim N(u_i, \sigma_y)$
Mis-specified		
Correct $\mu_i = u_{i-1} + a$ $u_i \sim N(\mu_i, \sigma_u)$ $y_i \sim N(u_i, \sigma_y)$		Missing Random Effect $y_i \sim N(a(1:n), \sigma_y)$ Missing Drift Term $\mu_i = u_{i-1}$ $u_i \sim N(\mu_i, \sigma_u)$ $y_i \sim N(u_i, \sigma_y)$
Heteroscedasticity $\mu_i = u_{i-1} + a$ $u_i \sim N(\mu_i, \sigma_u)$ $\sigma_y = \sqrt{(1:\frac{n}{2})^{1.3}}$ $y_i^{'} \sim N(u_i, \sigma_y)$		Correct $\mu_i = u_{i-1} + a$ $u_i \sim N(\mu_i, \sigma_u)$ $y_i^{'} \sim N(u_i, \sigma_y)$
Lognormal Random Effect $\mu_i = u_{i-1} + a$ $u_i \sim N(\mu_i, \sigma_u)$ $y_i^{'} \sim N(e^{u_i}, \sigma_y)$		Correct $\mu_i = u_{i-1} + a$ $u_i \sim N(\mu_i, \sigma_u)$ $y_i^{'} \sim N(u_i, \sigma_y)$

Data Generating Model	Parameters	Data Fitting Model
Generalized Linear Mixed Model		
Correct		
$\mu_i = u_{i-1} + a$ $u_i \sim N(\mu_i, \sigma_u)$ $y_i \sim Gamma(\frac{1}{CV}^2, e^{u_i} CV^2)$	$a = .02$ $u[1] = 0$ $\sigma_u = 0.5$ $CV = 0.15$	$\mu_i = u_{i-1} + a$ $u_i \sim N(\mu_i, \sigma_u)$ $y_i \sim Gamma(\frac{1}{CV}^2, e^{u_i} CV^2)$
Mis-specified		
Correct $\mu_i = u_{i-1} + a$ $u_i \sim N(\mu_i, \sigma_u)$ $y_i \sim Gamma(\frac{1}{CV}^2, e^{u_i} CV^2)$		Mising Random Effect $y_i \sim Gamma(\frac{1}{CV}^2, e^{a} CV^2)$ Missing Drift Term $\mu_i = u_{i-1}$ $u_i \sim N(\mu_i, \sigma_u)$ $y_i \sim Gamma(\frac{1}{CV}^2, e^{u_i} CV^2)$
Gamma Random Effect $u_i = u_{i-1} + Gamma(0.5, 20)$ $y_i^{'} \sim Gamma(\frac{1}{CV}^2, e^{u_i} CV^2)$		Mis-specified Distribution Normal $\mu_i = u_{i-1} + a$ $u_i \sim N(\mu_i, \sigma_u)$ $y_i \sim N(u_i, \sigma_y)$ Correct $\mu_i = u_{i-1} + a$ $u_i \sim N(\mu_i, \sigma_u)$ $y_i \sim Gamma(\frac{1}{CV}^2, e^{u_i} CV^2)$

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

Data Generating Model	Parameters	Data Fitting Model
Linear Mixed Model		
Correct		
$\omega \sim GMRF(Q[\kappa, \sigma_\omega^2])$ $\eta_i = \beta_0 + \omega_i$ $y \sim N(\eta, \sigma_y)$	$\beta_0 = 4$ $\sigma_y^2 = 1$ $\phi = 30$ $\kappa = \sqrt{8}/\phi$ $\sigma_\omega^2 = 1$	$\omega \sim GMRF(Q[\kappa, \sigma_\omega^2])$ $\eta_i = \beta_0 + \omega_i$ $y \sim N(\eta, \sigma_y)$
Mis-specified		
Correct $\omega \sim GMRF(Q[\kappa, \sigma_\omega^2])$ $\eta_i = \beta_0 + \omega_i$ $y \sim N(\eta, \sigma_y)$		Missing Random Effect $\eta_i = \beta_0$ $y \sim N(\eta, \sigma_y)$ Lognormal Error $\omega \sim GMRF(Q[\kappa, \sigma_\omega^2])$ $\eta_i = \beta_0 + \omega_i$ $\sigma_y = exp(N(0,1))$ $y \sim N(\eta, \sigma_y)$
Lognormal Random Effect $\omega \sim GMRF(Q[\kappa, \sigma_\omega^2])$ $\eta_i = \beta_0 + exp(\omega_i)$ $y^{'} \sim N(\eta, \sigma_y)$		Correct $\omega \sim GMRF(Q[\kappa, \sigma_\omega^2])$ $\eta_i = \beta_0 + \omega_i$ $y^{'} \sim N(\eta, \sigma_y)$

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

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 Generic	one-step Gaussian	full Gaussian	cdf	Unconditional ecdf, Not Rotated	Conditional ecdf, Not Rotated
Anderson Darling	theoretical	0.047	0.047	0.047	0.047	0.047	0.226	0.223
	estimated	0.023	0.027	0.038	0.028	0.023	0.206	0.201
Kolmogorov-Smirnov	theoretical	0.048	0.048	0.048	0.048	0.048	0.041	0.044
	estimated	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Lilliefors	estimated	0.052	0.052	0.052	0.052	0.052	0.148	0.145

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 Generic	one-step Gaussian	full Gaussian	cdf	Unconditional ecdf, Not Rotated	Conditional ecdf, Not Rotated
LN-error								
Anderson Darling	theoretical	1	1	1	1	1	1	1
	estimated	0.134	0.01	0.136	0.127	0.092	0.998	0.995
Kolmogorov-Smirnov	theoretical	1	1	1	1	1	1	1
	estimated	0.963	0.963	0.963	0.963	0.963	0.962	0.961
Lilliefors	estimated	0.999	0.998	0.999	0.999	0.995	1	1

Compound Symmetry - LMM

Table 8: Compound Symmetry - LMM. 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 Generic	one-step Gaussian	full Gaussian	cdf	MCMC	Unconditional ecdf, Rotated	Unconditional ecdf, Not Rotated	Conditional ecdf, Rotated	Conditional ecdf, Not Rotated
AOV Equal Means	theoretical	0.054	0.066	0.066	0.066	0.066	0.046	0.061	1.000	0.056	0.053
	estimated	0.000	0.068	0.068	0.068	0.070	0.041	0.068	1.000	0.000	0.000
Levene's Equal Variances	theoretical	0.032	0.035	0.035	0.035	0.035	0.032	0.043	0.060	0.032	0.035
	estimated	0.033	0.038	0.038	0.038	0.037	0.033	0.040	0.045	0.036	0.033
Anderson Darling	theoretical	0.047	0.042	0.042	0.042	0.045	0.046	0.357	0.954	0.357	0.216
	estimated	0.015	0.050	0.039	0.046	0.041	0.049	0.315	0.088	0.269	0.153
Kolmogorov-Smirnov	theoretical	0.048	0.039	0.039	0.039	0.041	0.046	0.063	0.920	0.051	0.038
	estimated	0.000	0.022	0.022	0.022	0.022	0.043	0.037	0.476	0.002	0.000
Lilliefors	estimated	0.053	0.058	0.058	0.058	0.057	0.067	0.165	0.843	0.180	0.135

Table 9: Compound Symmetry - LMM. Power at the 0.95 significance level evaluated for each method for theoretical and estimated residuals.

test	residual type	Pearson	one-step Generic	one-step Gaussian	full Gaussian	cdf	MCMC	Unconditional ecdf, Rotated	Unconditional ecdf, Not Rotated	Conditional ecdf, Rotated	Conditional ecdf, Not Rotated
A: Missing RE											
AOV Equal Means	theoretical	1	1	1	1	1	1	1	1	1	1
	estimated	1	1	1	1	1	1	1	1	1	1
Levene's Equal Variances	theoretical	0.032	0.872	0.032	0.032	0.176	0.236	0.803	0.837	0.812	0.827
	estimated	0.033	0.033	0.033	0.033	0.033	0.033	0.215	0.031	0.214	0.026
Anderson Darling	theoretical	1	1	1	1	1	1	1	1	1	1
	estimated	0.073	0.079	0.071	0.089	0.056	0.068	0.107	0.074	0.116	0.068
Kolmogorov-Smirnov	theoretical	1	1	1	1	1	1	1	1	1	1
	estimated	0.464	0.464	0.464	0.464	0.464	0.464	0.393	0.465	0.393	0.461
Lilliefors	estimated	0.836	0.836	0.836	0.836	0.836	0.836	0.754	0.84	0.777	0.842
B: Missing X											
AOV Equal Means	theoretical	0	0	0	0	0	0	0	0.969	0	0
	estimated	0	0	0	0	0	0.04	0	0.973	0	0
Levene's Equal Variances	theoretical	0	0	0	0	0	0	0	0.132	0	0
	estimated	0	0	0	0	0	0	0	0	0	0
Anderson Darling	theoretical	1	1	1	1	1	1	1	0.925	1	1
	estimated	0.056	0.089	0.084	0.082	0.094	0.064	0.153	0.047	0.087	0.059
Kolmogorov-Smirnov	theoretical	1	1	1	1	1	1	1	0.812	1	1
	estimated	0.165	0.322	0.321	0.321	0.322	0.197	0.306	0.004	0.117	0.163
Lilliefors	estimated	0.751	0.624	0.624	0.624	0.624	0.634	0.488	0.099	0.59	0.731
C: Misp RE											
AOV Equal Means	theoretical	1	0.049	0.049	0.049	0.048	0.05	0.044	0.993	1	0.999
	estimated	0	0.059	0.059	0.059	0.059	0.047	0.054	0.989	0	0
Levene's Equal Variances	theoretical	0.032	0.035	0.035	0.035	0.036	0.032	0.041	0.056	0.808	0.819
	estimated	0.033	0.036	0.036	0.036	0.037	0.033	0.042	0.035	0.036	0.035
Anderson Darling	theoretical	0.997	0.05	0.05	0.05	0.055	0.055	0.309	1	0.999	0.999
	estimated	0.021	0.04	0.036	0.042	0.043	0.044	0.305	0.117	0.248	0.163
Kolmogorov-Smirnov	theoretical	0.993	0.055	0.055	0.055	0.057	0.051	0.058	1	0.995	0.993
	estimated	0	0.013	0.013	0.013	0.013	0.043	0.015	0.199	0.001	0
Lilliefors	estimated	0.047	0.055	0.055	0.055	0.054	0.062	0.161	0.479	0.174	0.133

Table 10: Compound Symmetry - LMM. Type I error rates at the 0.10 significance level evaluated for each method for theoretical and estimated residuals.

test	residual type	Pearson	one-step Generic	one-step Gaussian	full Gaussian	cdf	MCMC	Unconditional ecdf, Rotated	Unconditional ecdf, Not Rotated	Conditional ecdf, Rotated	Conditional ecdf, Not Rotated
AOV Equal Means	theoretical	0.104	0.117	0.117	0.117	0.114	0.109	0.111	1.000	0.106	0.109
	estimated	0.000	0.132	0.132	0.132	0.133	0.089	0.120	1.000	0.000	0.000
Levene's Equal Variances	theoretical	0.060	0.075	0.075	0.075	0.073	0.060	0.083	0.099	0.076	0.062
	estimated	0.065	0.069	0.069	0.069	0.069	0.065	0.085	0.088	0.071	0.070
Anderson Darling	theoretical	0.083	0.091	0.091	0.091	0.093	0.098	0.395	0.980	0.388	0.250
	estimated	0.046	0.095	0.087	0.097	0.103	0.093	0.341	0.169	0.296	0.180
Kolmogorov-Smirnov	theoretical	0.077	0.084	0.084	0.084	0.086	0.098	0.109	0.949	0.093	0.076
	estimated	0.002	0.062	0.062	0.062	0.062	0.089	0.066	0.577	0.002	0.002
Lilliefors	estimated	0.114	0.109	0.109	0.109	0.114	0.132	0.265	0.888	0.257	0.200

Table 11: Compound Symmetry - LMM. Power at the 0.90 significance level evaluated for each method for theoretical and estimated residuals.

test	residual type	Pearson	one-step Generic	one-step Gaussian	full Gaussian	cdf	MCMC	Unconditional ecdf, Rotated	Unconditional ecdf, Not Rotated	Conditional ecdf, Rotated	Conditional ecdf, Not Rotated
A: Missing RE											
AOV Equal Means	theoretical	1	1	1	1	1	1	1	1	1	1
	estimated	1	1	1	1	1	1	1	1	1	1
Levene's Equal Variances	theoretical	0.06	0.895	0.06	0.06	0.241	0.278	0.851	0.878	0.86	0.884
	estimated	0.065	0.065	0.065	0.065	0.065	0.065	0.318	0.071	0.32	0.063
Anderson Darling	theoretical	1	1	1	1	1	1	1	1	1	1
	estimated	0.14	0.15	0.148	0.157	0.143	0.128	0.172	0.156	0.201	0.142
Kolmogorov-Smirnov	theoretical	1	1	1	1	1	1	1	1	1	1
	estimated	0.569	0.569	0.569	0.569	0.569	0.569	0.504	0.568	0.509	0.566
Lilliefors	estimated	0.887	0.887	0.887	0.887	0.887	0.887	0.828	0.893	0.845	0.879
B: Missing X											
AOV Equal Means	theoretical	0	0	0	0	0	0	0	0.982	0	0
	estimated	0	0	0	0	0	0.092	0.001	0.981	0	0
Levene's Equal Variances	theoretical	0	0	0	0	0	0	0.001	0.173	0	0
	estimated	0	0	0	0	0	0	0	0	0	0
Anderson Darling	theoretical	1	1	1	1	1	1	1	0.953	1	1
	estimated	0.106	0.184	0.169	0.154	0.167	0.125	0.238	0.096	0.146	0.115
Kolmogorov-Smirnov	theoretical	1	1	1	1	1	1	1	0.875	1	1
	estimated	0.291	0.446	0.446	0.446	0.447	0.326	0.442	0.012	0.242	0.279
Lilliefors	estimated	0.824	0.727	0.727	0.727	0.726	0.737	0.615	0.172	0.7	0.821
C: Misp RE											
AOV Equal Means	theoretical	1	0.088	0.088	0.088	0.082	0.094	0.083	0.994	1	0.999
	estimated	0	0.114	0.114	0.114	0.114	0.103	0.12	0.995	0	0
Levene's Equal Variances	theoretical	0.06	0.073	0.073	0.073	0.072	0.06	0.08	0.104	0.853	0.852
	estimated	0.065	0.07	0.07	0.07	0.07	0.065	0.08	0.073	0.085	0.07
Anderson Darling	theoretical	0.998	0.108	0.108	0.108	0.11	0.113	0.354	1	0.999	0.999
	estimated	0.048	0.078	0.08	0.085	0.071	0.099	0.34	0.161	0.28	0.186
Kolmogorov-Smirnov	theoretical	0.997	0.102	0.102	0.102	0.106	0.093	0.115	1	0.996	0.997
	estimated	0.003	0.035	0.035	0.035	0.035	0.075	0.041	0.266	0.003	0.003
Lilliefors	estimated	0.108	0.114	0.115	0.115	0.114	0.111	0.249	0.558	0.242	0.21

Compound Symmetry - GLMM

Table 12: Compound Symmetry - GLMM. 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 Generic	cdf	MCMC	Unconditional ecdf, Rotated	Unconditional ecdf, Not Rotated	Conditional ecdf, Rotated	Conditional ecdf, Not Rotated
AOV Equal Means	theoretical	0.101	0.039	0.040	0.049	0.025	0.909	0.039	0.045
	estimated	0.000	0.026	0.028	0.039	0.019	0.924	0.000	0.000
Levene's Equal Variances	theoretical	0.911	0.052	0.052	0.032	0.890	0.088	0.040	0.020
	estimated	0.911	0.048	0.048	0.029	0.899	0.075	0.019	0.010
Anderson Darling	theoretical	1.000	0.039	0.038	0.052	0.444	0.492	0.376	0.121
	estimated	0.985	0.037	0.025	0.055	0.174	0.050	0.216	0.056
Kolmogorov-Smirnov	theoretical	1.000	0.038	0.039	0.044	0.294	0.424	0.086	0.035
	estimated	1.000	0.002	0.001	0.017	0.063	0.000	0.006	0.000
Lilliefors	estimated	1.000	0.024	0.023	0.030	0.136	0.050	0.120	0.054

Table 13: Compound Symmetry - GLMM. Power at the 0.95 significance level evaluated for each method for theoretical and estimated residuals.

test	residual type	Pearson	one-step Generic	cdf	MCMC	Unconditional ecdf, Rotated	Unconditional ecdf, Not Rotated	Conditional ecdf, Rotated	Conditional ecdf, Not Rotated
A: Missing RE									
AOV Equal Means	theoretical	0.947	0.939	0.939	0.925	0.891	0.931	0.872	0.932
	estimated	0.947	0.935	0.935	0.924	0.896	0.924	0.9	0.922
Levene's Equal Variances	theoretical	0.911	0.479	0.524	0.513	0.366	0.553	0.392	0.567
	estimated	0.911	0.184	0.185	0.146	0.234	0.132	0.221	0.121
Anderson Darling	theoretical	1	0.711	0.715	0.716	0.938	0.859	0.944	0.856
	estimated	0.997	0.027	0.028	0.027	0.43	0.178	0.425	0.198
Kolmogorov-Smirnov	theoretical	1	0.575	0.575	0.563	0.684	0.56	0.699	0.565
	estimated	1	0.009	0.009	0.008	0.054	0.007	0.053	0.011
Lilliefors	estimated	1	0.094	0.096	0.124	0.354	0.199	0.358	0.212
B: NB - Pois									
AOV Equal Means	theoretical	0.065	0.032	0.041	0	0.085	0.93	0.089	0.11
	estimated	0	0.03	0.033	0	0.073	0.935	0.001	0.005
Levene's Equal Variances	theoretical	0.442	0.598	0.59	0.547	0.858	0.328	0.441	0.561
	estimated	0.382	0.625	0.611	0.555	0.919	0.342	0.438	0.527
Anderson Darling	theoretical	1	0.99	0.991	0.976	0.946	0.84	1	0.998
	estimated	0.912	0.762	0.803	0.799	0.994	0.515	0.998	0.981
Kolmogorov-Smirnov	theoretical	1	0.917	0.908	0.881	0.804	0.74	0.953	0.901
	estimated	1	0.866	0.863	0.865	0.871	0.796	0.948	0.891
Lilliefors	estimated	1	0.46	0.631	0.626	0.843	0.49	0.955	0.908
C: Misp RE									
AOV Equal Means	theoretical	0.852	0.029	0.038	0.047	0.043	0.822	0.817	0.884
	estimated	0	0.03	0.039	0.044	0.024	0.844	0.002	0
Levene's Equal Variances	theoretical	0.837	0.051	0.048	0.045	0.767	0.205	0.485	0.549
	estimated	0.837	0.057	0.051	0.051	0.79	0.093	0.031	0.027
Anderson Darling	theoretical	1	0.274	0.278	0.074	0.857	0.953	0.995	0.979
	estimated	1	0.035	0.038	0.041	0.279	0.076	0.237	0.071
Kolmogorov-Smirnov	theoretical	1	0.209	0.218	0.055	0.787	0.941	0.953	0.932
	estimated	1	0.005	0.002	0.016	0.099	0.021	0.004	0
Lilliefors	estimated	1	0.043	0.041	0.04	0.226	0.156	0.131	0.067

Table 14: Compound Symmetry - GLMM. Type I error rates at the 0.10 significance level evaluated for each method for theoretical and estimated residuals.

test	residual type	Pearson	one-step Generic	cdf	MCMC	Unconditional ecdf, Rotated	Unconditional ecdf, Not Rotated	Conditional ecdf, Rotated	Conditional ecdf, Not Rotated
AOV Equal Means	theoretical	0.152	0.086	0.090	0.090	0.042	0.937	0.089	0.079
	estimated	0.000	0.084	0.091	0.085	0.046	0.945	0.004	0.000
Levene's Equal Variances	theoretical	0.948	0.098	0.097	0.075	0.935	0.152	0.083	0.058
	estimated	0.948	0.094	0.092	0.070	0.926	0.147	0.061	0.022
Anderson Darling	theoretical	1.000	0.095	0.095	0.102	0.529	0.584	0.432	0.160
	estimated	0.988	0.070	0.063	0.092	0.225	0.088	0.263	0.092
Kolmogorov-Smirnov	theoretical	1.000	0.089	0.089	0.092	0.398	0.509	0.157	0.095
	estimated	1.000	0.005	0.005	0.051	0.106	0.002	0.016	0.001
Lilliefors	estimated	1.000	0.053	0.054	0.075	0.233	0.100	0.185	0.095

Table 15: Compound Symmetry - GLMM. Power at the 0.90 significance level evaluated for each method for theoretical and estimated residuals.

test	residual type	Pearson	one-step Generic	cdf	MCMC	Unconditional ecdf, Rotated	Unconditional ecdf, Not Rotated	Conditional ecdf, Rotated	Conditional ecdf, Not Rotated
A: Missing RE									
AOV Equal Means	theoretical	0.962	0.963	0.963	0.949	0.923	0.948	0.925	0.95
	estimated	0.962	0.957	0.957	0.954	0.932	0.944	0.931	0.948
Levene's Equal Variances	theoretical	0.948	0.586	0.631	0.622	0.462	0.648	0.493	0.662
	estimated	0.948	0.287	0.286	0.25	0.357	0.232	0.325	0.233
Anderson Darling	theoretical	1	0.792	0.792	0.791	0.953	0.884	0.959	0.881
	estimated	0.999	0.054	0.064	0.063	0.463	0.204	0.455	0.238
Kolmogorov-Smirnov	theoretical	1	0.655	0.655	0.661	0.775	0.654	0.766	0.653
	estimated	1	0.015	0.015	0.019	0.094	0.018	0.094	0.02
Lilliefors	estimated	1	0.157	0.159	0.183	0.456	0.261	0.467	0.269
B: NB - Pois									
AOV Equal Means	theoretical	0.114	0.061	0.071	0.004	0.135	0.951	0.138	0.163
	estimated	0	0.056	0.058	0.003	0.112	0.96	0.002	0.011
Levene's Equal Variances	theoretical	0.536	0.7	0.681	0.644	0.907	0.441	0.54	0.658
	estimated	0.493	0.719	0.703	0.652	0.947	0.49	0.518	0.636
Anderson Darling	theoretical	1	0.996	0.995	0.987	0.967	0.893	1	0.999
	estimated	0.958	0.847	0.882	0.879	0.997	0.602	1	0.986
Kolmogorov-Smirnov	theoretical	1	0.963	0.96	0.931	0.871	0.814	0.975	0.94
	estimated	1	0.916	0.911	0.922	0.924	0.879	0.971	0.93
Lilliefors	estimated	1	0.587	0.74	0.733	0.908	0.628	0.972	0.938
C: Misp RE									
AOV Equal Means	theoretical	0.884	0.066	0.079	0.092	0.072	0.856	0.848	0.903
	estimated	0	0.076	0.102	0.087	0.049	0.881	0.007	0
Levene's Equal Variances	theoretical	0.882	0.095	0.091	0.088	0.822	0.26	0.575	0.631
	estimated	0.882	0.105	0.099	0.088	0.828	0.145	0.067	0.047
Anderson Darling	theoretical	1	0.403	0.42	0.133	0.899	0.97	0.998	0.985
	estimated	1	0.08	0.067	0.09	0.33	0.112	0.278	0.103
Kolmogorov-Smirnov	theoretical	1	0.326	0.332	0.114	0.846	0.967	0.97	0.954
	estimated	1	0.011	0.005	0.036	0.152	0.032	0.01	0
Lilliefors	estimated	1	0.082	0.088	0.087	0.31	0.208	0.213	0.117

Temporal Correlation - LMM

Table 16: Temporal Correlation - LMM. 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 Generic	one-step Gaussian	full Gaussian	cdf	MCMC	Unconditional ecdf, Rotated	Unconditional ecdf, Not Rotated	Conditional ecdf, Rotated	Conditional ecdf, Not Rotated
Anderson Darling	theoretical	0.061	0.046	0.046	0.046	0.046	0.048	0.341	0.993	0.342	0.234
	estimated	0.002	0.024	0.037	0.031	0.029	0.042	0.310	0.308	0.017	0.009
Kolmogorov-Smirnov	theoretical	0.056	0.042	0.042	0.042	0.041	0.041	0.051	0.988	0.067	0.065
	estimated	0.128	0.000	0.000	0.000	0.000	0.055	0.000	0.995	0.078	0.126
Lilliefors	estimated	0.052	0.052	0.053	0.052	0.048	0.050	0.165	0.540	0.065	0.055
Autocorrelation	theoretical	0.047	0.052	0.052	0.052	0.051	0.048	0.047	1.000	0.057	0.048
	estimated	0.001	0.003	0.003	0.003	0.003	0.026	0.004	1.000	0.000	0.001

Table 17: Temporal Correlation - LMM. Power at the 0.95 significance level evaluated for each method for theoretical and estimated residuals.

test	residual type	Pearson	one-step Generic	one-step Gaussian	full Gaussian	cdf	MCMC	Unconditional ecdf, Rotated	Unconditional ecdf, Not Rotated	Conditional ecdf, Rotated	Conditional ecdf, Not Rotated
A: Missing RE											
Autocorrelation	theoretical	1	1	1	1	1	1	0.983	0.98	0.983	0.98
	estimated	1	1	1	1	1	1	1	1	1	1
Anderson Darling	theoretical	1	1	1	1	1	1	1	1	1	1
	estimated	1	1	1	1	1	1	1	1	1	1
Kolmogorov-Smirnov	theoretical	1	1	1	1	1	1	1	1	1	1
	estimated	1	1	1	1	1	1	1	1	1	1
Lilliefors	estimated	0.13	0.13	0.13	0.13	0.13	0.13	0.195	0.274	0.205	0.275
B: Heterosck.											
Autocorrelation	theoretical	0	0	0	0	0.005	0	0	0.002	0.008	0
	estimated	0	0	0	0	0	0.208	0	0	0	0
Anderson Darling	theoretical	1	1	1	1	1	1	1	1	1	1
	estimated	0.014	0.01	0.01	0.009	0.003	0.998	0.979	0.962	0.978	0.965
Kolmogorov-Smirnov	theoretical	1	1	1	1	1	1	1	1	1	1
	estimated	0.012	0.291	0.291	0.291	0.291	0.998	0.822	0.884	0.014	0.01
Lilliefors	estimated	1	1	1	1	1	1	1	1	1	1
C: Missing Drift											
Autocorrelation	theoretical	1	0.104	0.1	0.1	0.1	0.069	0.143	0.998	0.984	0.986
	estimated	0	0	0	0	0.001	0.057	0	1	0.038	0.043
Anderson Darling	theoretical	1	1	1	1	1	0.05	1	1	1	1
	estimated	0	0.998	0.993	0.997	1	0.049	0.998	1	0	0
Kolmogorov-Smirnov	theoretical	1	1	1	1	1	0.047	1	1	1	1
	estimated	1	1	1	1	1	0.049	1	1	1	1
Lilliefors	estimated	0.022	0.037	0.037	0.034	1	0.055	0.11	1	0.085	0.078
D: Misp RE											
Autocorrelation	theoretical	1	0.754	0.967	0.967	0.432	0.068	0.276	0.948	0.982	0.98
	estimated	0	0.024	0.03	0.036	0.024	0.057	0.015	1	0.037	0.052
Anderson Darling	theoretical	1	1	1	1	1	1	1	1	1	1
	estimated	0	0.038	0.106	0.148	0.823	0.055	0.994	0.308	0	0
Kolmogorov-Smirnov	theoretical	1	1	1	1	1	1	1	1	1	1
	estimated	1	0.974	0.974	0.976	0.998	0.043	0.893	0.999	1	1
Lilliefors	estimated	0.905	1	1	0.997	0.999	0.045	1	0.711	0.08	0.081

Table 18: Temporal Correlation - LMM. Type I error rates at the 0.10 significance level evaluated for each method for theoretical and estimated residuals.

test	residual type	Pearson	one-step Generic	one-step Gaussian	full Gaussian	cdf	MCMC	Unconditional ecdf, Rotated	Unconditional ecdf, Not Rotated	Conditional ecdf, Rotated	Conditional ecdf, Not Rotated
Anderson Darling	theoretical	0.107	0.094	0.094	0.094	0.094	0.090	0.377	0.997	0.385	0.271
	estimated	0.008	0.058	0.070	0.069	0.062	0.099	0.346	0.398	0.029	0.011
Kolmogorov-Smirnov	theoretical	0.103	0.084	0.084	0.084	0.084	0.080	0.094	0.993	0.117	0.104
	estimated	0.245	0.001	0.001	0.001	0.001	0.095	0.006	0.997	0.148	0.241
Lilliefors	estimated	0.105	0.100	0.100	0.100	0.100	0.097	0.252	0.635	0.124	0.103
Autocorrelation	theoretical	0.099	0.098	0.098	0.098	0.099	0.085	0.102	1.000	0.105	0.111
	estimated	0.001	0.007	0.007	0.007	0.006	0.071	0.023	1.000	0.001	0.001

Table 19: Temporal Correlation - LMM. Power at the 0.90 significance level evaluated for each method for theoretical and estimated residuals.

test	residual type	Pearson	one-step Generic	one-step Gaussian	full Gaussian	cdf	MCMC	Unconditional ecdf, Rotated	Unconditional ecdf, Not Rotated	Conditional ecdf, Rotated	Conditional ecdf, Not Rotated
A: Missing RE											
Autocorrelation	theoretical	1	1	1	1	1	1	0.987	0.984	0.988	0.985
	estimated	1	1	1	1	1	1	1	1	1	1
Anderson Darling	theoretical	1	1	1	1	1	1	1	1	1	1
	estimated	1	1	1	1	1	1	1	1	1	1
Kolmogorov-Smirnov	theoretical	1	1	1	1	1	1	1	1	1	1
	estimated	1	1	1	1	1	1	1	1	1	1
Lilliefors	estimated	0.319	0.319	0.319	0.319	0.319	0.319	0.368	0.544	0.416	0.529
B: Heterosck.											
Autocorrelation	theoretical	0	0	0	0	0.044	0	0	0.03	0.063	0
	estimated	0	0	0	0	0	0.244	0	0	0	0
Anderson Darling	theoretical	1	1	1	1	1	1	1	1	1	1
	estimated	0.038	0.029	0.031	0.031	0.022	0.998	0.981	0.965	0.978	0.965
Kolmogorov-Smirnov	theoretical	1	1	1	1	1	1	1	1	1	1
	estimated	0.161	0.696	0.697	0.697	0.697	0.998	0.913	0.95	0.118	0.17
Lilliefors	estimated	1	1	1	1	1	1	1	1	1	1
C: Missing Drift											
Autocorrelation	theoretical	1	0.17	0.168	0.167	0.164	0.14	0.235	1	0.988	0.987
	estimated	0	0	0	0	0.001	0.104	0	1	0.093	0.101
Anderson Darling	theoretical	1	1	1	1	1	0.093	1	1	1	1
	estimated	0	1	1	1	1	0.102	1	1	0	0
Kolmogorov-Smirnov	theoretical	1	1	1	1	1	0.086	1	1	1	1
	estimated	1	1	1	1	1	0.103	1	1	1	1
Lilliefors	estimated	0.063	0.082	0.083	0.087	1	0.103	0.163	1	0.153	0.155
D: Misp RE											
Autocorrelation	theoretical	1	0.834	0.99	0.99	0.57	0.149	0.367	0.949	0.982	0.98
	estimated	0	0.049	0.055	0.059	0.042	0.098	0.034	1	0.086	0.1
Anderson Darling	theoretical	1	1	1	1	1	1	1	1	1	1
	estimated	0	0.094	0.218	0.255	0.84	0.116	0.994	0.387	0	0
Kolmogorov-Smirnov	theoretical	1	1	1	1	1	1	1	1	1	1
	estimated	1	0.99	0.99	0.992	1	0.087	0.953	1	1	1
Lilliefors	estimated	0.944	1	1	0.997	1	0.089	1	0.785	0.143	0.172

Temporal Correlation - GLMM

Table 20: Temporal Correlation - GLMM. 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 Generic	cdf	MCMC	Unconditional ecdf, Rotated	Unconditional ecdf, Not Rotated	Conditional ecdf, Rotated	Conditional ecdf, Not Rotated
Anderson Darling	theoretical	0.951	0.041	0.040	0.068	0.614	0.980	0.359	0.229
	estimated	0.831	0.026	0.022	0.055	0.204	0.346	0.175	0.115
Kolmogorov-Smirnov	theoretical	0.857	0.041	0.039	0.058	0.520	0.968	0.055	0.044
	estimated	0.787	0.000	0.001	0.048	0.419	0.912	0.001	0.001
Lilliefors	estimated	0.968	0.052	0.056	0.056	0.298	0.252	0.149	0.121
Autocorrelation	theoretical	0.140	0.033	0.036	0.039	0.068	0.900	0.054	0.041
	estimated	0.040	0.028	0.027	0.044	0.069	0.818	0.009	0.006

Table 21: Temporal Correlation - GLMM. Power at the 0.95 significance level evaluated for each method for theoretical and estimated residuals.

test	residual type	Pearson	one-step Generic	cdf	MCMC	Unconditional ecdf, Rotated	Unconditional ecdf, Not Rotated	Conditional ecdf, Rotated	Conditional ecdf, Not Rotated
A: Missing RE									
Autocorrelation	theoretical	0.972	0.973	0.979	0.98	0.884	0.93	0.88	0.932
	estimated	0.972	0.979	0.98	0.98	0.879	0.97	0.889	0.968
Anderson Darling	theoretical	0.995	0.984	0.985	0.985	0.993	0.989	1	0.99
	estimated	0.905	0.853	0.866	0.87	0.928	0.906	0.934	0.914
Kolmogorov-Smirnov	theoretical	0.983	0.972	0.97	0.97	0.971	0.967	0.975	0.97
	estimated	0.964	0.939	0.934	0.934	0.936	0.935	0.933	0.936
Lilliefors	estimated	0.99	0.572	0.537	0.537	0.816	0.794	0.811	0.788
B: Gamma - Normal									
Autocorrelation	theoretical	0.765	0.066	0.213	0.038	0.105	0.808	0.185	0.212
	estimated	0.025	0.062	0.07	0.091	0.144	0.879	0.034	0.027
Anderson Darling	theoretical	1	0.974	0.977	0.924	0.985	0.998	1	1
	estimated	0.017	0.016	0.04	0.098	0.948	0.579	0.863	0.829
Kolmogorov-Smirnov	theoretical	1	0.901	0.893	0.839	0.852	0.995	1	1
	estimated	0.681	0.624	0.619	0.51	0.494	0.983	0.61	0.676
Lilliefors	estimated	0.959	0.932	0.939	0.839	0.961	0.904	0.97	0.967
C: Missing Drift									
Autocorrelation	theoretical	0.944	0.033	0.031	0.047	0.05	0.936	0.905	0.958
	estimated	0.021	0.011	0.011	0.032	0.033	0.946	0.001	0
Anderson Darling	theoretical	1	0.221	0.214	0.044	0.783	0.985	1	1
	estimated	0.821	0.068	0.066	0.039	0.573	0.703	0.167	0.091
Kolmogorov-Smirnov	theoretical	1	0.174	0.159	0.042	0.727	0.971	1	1
	estimated	0.782	0.099	0.087	0.049	0.713	0.964	0.002	0.002
Lilliefors	estimated	0.965	0.046	0.049	0.045	0.563	0.5	0.149	0.112
D: Misp RE									
Autocorrelation	theoretical	0.943	0.001	0.001	0.026	0.015	0.256	0.888	0.935
	estimated	0.112	0.048	0.043	0.217	0.06	0.124	0.041	0.036
Anderson Darling	theoretical	1	0.008	0.009	0.064	0.172	1	0.993	0.987
	estimated	1	0.025	0.033	0.65	0.405	0.363	0.277	0.174
Kolmogorov-Smirnov	theoretical	1	0.009	0.011	0.056	0.122	0.999	0.939	0.934
	estimated	1	0.001	0.001	0.641	0.34	0.534	0.004	0
Lilliefors	estimated	0.973	0.042	0.044	0.082	0.201	0.169	0.174	0.136

Table 22: Temporal Correlation - GLMM. Type I error rates at the 0.10 significance level evaluated for each method for theoretical and estimated residuals.

test	residual type	Pearson	one-step Generic	cdf	MCMC	Unconditional ecdf, Rotated	Unconditional ecdf, Not Rotated	Conditional ecdf, Rotated	Conditional ecdf, Not Rotated
Anderson Darling	theoretical	0.972	0.084	0.081	0.114	0.696	0.987	0.403	0.264
	estimated	0.847	0.057	0.053	0.091	0.251	0.432	0.213	0.134
Kolmogorov-Smirnov	theoretical	0.900	0.073	0.068	0.111	0.605	0.979	0.114	0.089
	estimated	0.838	0.001	0.001	0.090	0.512	0.936	0.003	0.006
Lilliefors	estimated	0.981	0.117	0.111	0.099	0.408	0.341	0.217	0.197
Autocorrelation	theoretical	0.187	0.079	0.078	0.098	0.118	0.928	0.091	0.090
	estimated	0.055	0.065	0.065	0.087	0.140	0.887	0.018	0.018

Table 23: Temporal Correlation - GLMM. Power at the 0.90 significance level evaluated for each method for theoretical and estimated residuals.

test	residual type	Pearson	one-step Generic	cdf	MCMC	Unconditional ecdf, Rotated	Unconditional ecdf, Not Rotated	Conditional ecdf, Rotated	Conditional ecdf, Not Rotated
A: Missing RE									
Autocorrelation	theoretical	0.984	0.987	0.989	0.99	0.915	0.958	0.923	0.961
	estimated	0.984	0.988	0.989	0.989	0.914	0.987	0.919	0.985
Anderson Darling	theoretical	0.996	0.989	0.989	0.989	0.995	0.992	1	0.993
	estimated	0.931	0.881	0.894	0.905	0.95	0.924	0.948	0.925
Kolmogorov-Smirnov	theoretical	0.989	0.981	0.979	0.979	0.979	0.977	0.983	0.977
	estimated	0.976	0.948	0.942	0.942	0.944	0.944	0.941	0.947
Lilliefors	estimated	0.997	0.663	0.622	0.622	0.856	0.834	0.845	0.83
B: Gamma - Normal									
Autocorrelation	theoretical	0.804	0.102	0.283	0.059	0.196	0.848	0.239	0.279
	estimated	0.041	0.124	0.137	0.149	0.224	0.913	0.045	0.048
Anderson Darling	theoretical	1	0.989	0.992	0.952	0.988	0.999	1	1
	estimated	0.042	0.037	0.081	0.142	0.953	0.644	0.866	0.831
Kolmogorov-Smirnov	theoretical	1	0.933	0.933	0.884	0.891	0.999	1	1
	estimated	0.804	0.736	0.721	0.613	0.56	0.989	0.715	0.788
Lilliefors	estimated	0.974	0.957	0.965	0.897	0.971	0.928	0.983	0.979
C: Missing Drift									
Autocorrelation	theoretical	0.962	0.075	0.074	0.093	0.093	0.96	0.943	0.981
	estimated	0.03	0.026	0.027	0.07	0.061	0.969	0.005	0.005
Anderson Darling	theoretical	1	0.33	0.316	0.094	0.825	0.993	1	1
	estimated	0.842	0.13	0.132	0.097	0.624	0.759	0.189	0.116
Kolmogorov-Smirnov	theoretical	1	0.264	0.249	0.099	0.786	0.986	1	1
	estimated	0.832	0.196	0.177	0.083	0.766	0.973	0.003	0.007
Lilliefors	estimated	0.982	0.094	0.106	0.088	0.665	0.593	0.22	0.18
D: Misp RE									
Autocorrelation	theoretical	0.96	0.011	0.012	0.054	0.027	0.356	0.925	0.956
	estimated	0.169	0.104	0.105	0.282	0.103	0.206	0.086	0.085
Anderson Darling	theoretical	1	0.034	0.031	0.106	0.273	1	0.996	0.99
	estimated	1	0.069	0.074	0.671	0.462	0.449	0.32	0.206
Kolmogorov-Smirnov	theoretical	1	0.036	0.031	0.11	0.208	1	0.955	0.944
	estimated	1	0.005	0.006	0.648	0.404	0.603	0.005	0
Lilliefors	estimated	0.989	0.089	0.094	0.146	0.294	0.253	0.259	0.204

Spatial

Table 24: Spatial Model. Type I error rates and Power evaluated for each analytical and simulation method for theoretical residuals using the KS normality test. 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: Missing RE	B: Lognorm error	C: Misp RE
GOF.ad	Pearson	0.044	0.914	1.000	1.000
GOF.ad	one-step Generic	0.028	0.913	1.000	0.936
GOF.ad	one-step Gaussian	0.028	0.914	1.000	0.952
GOF.ad	full Gaussian	0.028	0.914	1.000	0.952
GOF.ad	cdf	0.029	0.914	1.000	0.951
GOF.ad	MCMC	0.063	0.914	1.000	0.347
GOF.ad	Unconditional ecdf, Rotated	0.264	0.991	1.000	0.985
GOF.ad	Unconditional ecdf, Not Rotated	0.539	0.963	1.000	0.999
GOF.ad	Conditional ecdf, Rotated	0.338	0.989	1.000	1.000
GOF.ad	Conditional ecdf, Not Rotated	0.216	0.963	1.000	1.000
GOF.ks	Pearson	0.046	0.733	1.000	1.000
GOF.ks	one-step Generic	0.037	0.733	1.000	0.706
GOF.ks	one-step Gaussian	0.037	0.733	1.000	0.706
GOF.ks	full Gaussian	0.037	0.733	1.000	0.706
GOF.ks	cdf	0.037	0.733	1.000	0.711
GOF.ks	MCMC	0.061	0.733	1.000	0.153
GOF.ks	Unconditional ecdf, Rotated	0.036	0.791	1.000	0.751
GOF.ks	Unconditional ecdf, Not Rotated	0.438	0.725	1.000	0.999
GOF.ks	Conditional ecdf, Rotated	0.050	0.809	1.000	1.000
GOF.ks	Conditional ecdf, Not Rotated	0.039	0.732	1.000	1.000
SAC	Pearson	0.059	0.944	0.059	0.618
SAC	one-step Generic	0.056	0.944	0.002	0.234
SAC	one-step Gaussian	0.056	0.944	0.004	0.288
SAC	full Gaussian	0.056	0.944	0.004	0.288
SAC	cdf	0.056	0.944	NA	0.232
SAC	MCMC	0.068	0.944	0.000	0.117
SAC	Unconditional ecdf, Rotated	0.052	0.917	0.004	0.062
SAC	Unconditional ecdf, Not Rotated	0.945	0.925	0.182	0.871
SAC	Conditional ecdf, Rotated	0.062	0.917	0.063	0.160
SAC	Conditional ecdf, Not Rotated	0.054	0.923	0.054	0.200

Table 25: Spatial Model. Type I error rates and Power evaluated for each analytical and simulation method for estimated residuals using the KS normality test. 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: Missing RE	B: Lognorm error	C: Misp RE
GOF.ad	Pearson	0.008	0.027	0.064	0.011
GOF.ad	one-step Generic	0.038	0.029	NA	NA
GOF.ad	one-step Gaussian	0.038	0.025	0.079	0.039
GOF.ad	full Gaussian	0.034	0.025	0.101	0.048
GOF.ad	cdf	0.043	0.028	0.091	0.095
GOF.ad	MCMC	0.048	0.025	0.077	0.045
GOF.ad	Unconditional ecdf, Rotated	0.286	0.270	0.997	0.786
GOF.ad	Unconditional ecdf, Not Rotated	0.143	0.194	0.998	0.743
GOF.ad	Conditional ecdf, Rotated	0.059	0.297	0.997	0.292
GOF.ad	Conditional ecdf, Not Rotated	0.033	0.164	0.996	0.270
GOF.ks	Pearson	0.110	0.001	1.000	0.566
GOF.ks	one-step Generic	0.005	0.001	NA	NA
GOF.ks	one-step Gaussian	0.005	0.001	1.000	0.252
GOF.ks	full Gaussian	0.005	0.001	1.000	0.284
GOF.ks	cdf	0.018	0.001	1.000	0.283
GOF.ks	MCMC	0.034	0.001	1.000	0.158
GOF.ks	Unconditional ecdf, Rotated	0.008	0.000	0.995	0.152
GOF.ks	Unconditional ecdf, Not Rotated	0.061	0.001	1.000	0.426
GOF.ks	Conditional ecdf, Rotated	0.090	0.000	0.998	0.503
GOF.ks	Conditional ecdf, Not Rotated	0.105	0.001	1.000	0.572
GOF.lf	Pearson	0.071	0.065	1.000	0.389
GOF.lf	one-step Generic	0.063	0.065	NA	NA
GOF.lf	one-step Gaussian	0.063	0.065	1.000	0.478
GOF.lf	full Gaussian	0.063	0.065	1.000	0.478
GOF.lf	cdf	0.075	0.065	1.000	0.489
GOF.lf	MCMC	0.044	0.065	1.000	0.214
GOF.lf	Unconditional ecdf, Rotated	0.176	0.159	1.000	0.740
GOF.lf	Unconditional ecdf, Not Rotated	0.121	0.147	1.000	0.838
GOF.lf	Conditional ecdf, Rotated	0.098	0.156	1.000	0.412
GOF.lf	Conditional ecdf, Not Rotated	0.079	0.137	1.000	0.434
SAC	Pearson	0.022	0.944	0.111	0.182
SAC	one-step Generic	0.047	0.944	NA	NA
SAC	one-step Gaussian	0.047	0.944	0.106	0.255
SAC	full Gaussian	0.047	0.944	0.099	0.268
SAC	cdf	0.047	0.944	0.105	0.242
SAC	MCMC	0.060	0.944	0.111	0.211
SAC	Unconditional ecdf, Rotated	0.052	0.923	0.152	0.210
SAC	Unconditional ecdf, Not Rotated	0.951	0.936	0.148	0.935
SAC	Conditional ecdf, Rotated	0.022	0.914	0.140	0.177
SAC	Conditional ecdf, Not Rotated	0.021	0.942	0.154	0.180

Table 26: 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.