```r
library(nlme)
library(stargazer)

data(ests_out)
tmp <- filter(ests_out, seg == '303') %>%
  select(z_cmax, long, lat)

modnl <- gls(z_cmax ~ 1, data = tmp)
mod1 <- gls(z_cmax ~ 1, correlation = corSpher(form = ~ long + lat, nugget = TRUE),
  data = tmp)
mod2 <- gls(z_cmax ~ 1, correlation = corLin(form = ~ long + lat, nugget = TRUE),
  data = tmp)
mod3 <- gls(z_cmax ~ 1, correlation = corRatio(form = ~ long + lat, nugget = TRUE),
  data = tmp)
mod4 <- gls(z_cmax ~ 1, correlation = corGaus(form = ~ long + lat, nugget = TRUE),
  data = tmp)
mod5 <- gls(z_cmax ~ 1, correlation = corExp(form = ~ long + lat, nugget = TRUE),
  data = tmp)

# AIC(modnl, mod1, mod2, mod3, mod4, mod5)

stargazer(modnl, mod1, mod2, mod3, mod4, mod5,
  title = 'Comparison of regression models with different correlation structures for grid lo
  column.labels = c('null', 'Spher', 'Lin', 'Ratio', 'Gaus', 'Exp'),
  model.numbers = F
  )
```

Table 1: Comparison of regression models with different correlation structures for grid locations.

	Dependent variable:					
	z_cmax					
	null	Spher	Lin	Ratio	Gaus	Exp
Constant	2.382***	2.355***	2.271***	2.356***	2.364***	2.349***
	(0.070)	(0.136)	(0.506)	(0.219)	(0.144)	(0.177)
Observations	31	31	31	31	31	31
Log Likelihood	−16.082	−7.722	−9.699	−8.044	−7.326	−8.639
Akaike Inf. Crit.	36.165	23.445	27.399	24.088	22.652	25.279
Bayesian Inf. Crit.	38.967	29.050	33.003	29.693	28.256	30.883
Note:						*p<0.1; **p<0.05; ***p<0.01

```r
data(choc_light)
data(irl_light)
data(tb_light)

choc_light <- select(choc_light, z_c_all, light, seg, Longitude, Latitude) %>%
  mutate(bay = 'choc')
irl_light <- select(irl_light, z_c_all, light, seg, Longitude, Latitude) %>%
  mutate(bay = 'irl')
tb_light <- select(tb_light, z_c_all, light, seg, Longitude, Latitude) %>%
  mutate(bay = 'tb')

all_light <- rbind(choc_light, irl_light, tb_light) %>%
  mutate(bay = factor(bay))

znl <- lme(z_c_all ~ 0 + bay, random = ~ 1 | bay, data = all_light)
zm1 <- lme(z_c_all ~ 0 + bay, random = ~ 1 | bay,
  correlation = corGaus(form = ~ Latitude + Longitude | bay, nugget = TRUE),
  data = all_light)


lnl <- lme(light ~ 0 + bay, random = ~ 1 | bay, data = all_light)
lm1 <- lme(light ~ 0 + bay, random = ~ 1 | bay,
  correlation = corGaus(form = ~ Latitude + Longitude | bay, nugget = TRUE),
  data = all_light)
```

```r
summary(zm1)
```

```
## Linear mixed-effects model fit by REML
##  Data: all_light
##         AIC       BIC   logLik
##   -1060.961 -1027.886 537.4807
##
## Random effects:
##  Formula: ~1 | bay
##         (Intercept)  Residual
## StdDev:  0.05965811 0.3734619
##
## Correlation Structure: Gaussian spatial correlation
##  Formula: ~Latitude + Longitude | bay
##  Parameter estimate(s):
##      range     nugget
## 0.02545925 0.03293515
## Fixed effects: z_c_all ~ 0 + bay
##            Value  Std.Error DF  t-value p-value
## baychoc 2.020700 0.10997963  0 18.37340     NaN
```

```
## bayirl  1.101049 0.09641191  0 11.42026     NaN
## baytb   1.162806 0.08121930  0 14.31687     NaN
##  Correlation:
##        baychc bayirl
## bayirl 0
## baytb  0      0
##
## Standardized Within-Group Residuals:
##        Min         Q1        Med         Q3        Max
## -3.9370251 -0.3373829  0.3062355  0.8650886  5.7771938
##
## Number of Observations: 836
## Number of Groups: 3
```

```
summary(lm1)
```

```
## Linear mixed-effects model fit by REML
##  Data: all_light
##        AIC      BIC    logLik
##   5099.712 5132.787 -2542.856
##
## Random effects:
##  Formula: ~1 | bay
##         (Intercept) Residual
## StdDev:    1.595389 9.987022
##
## Correlation Structure: Gaussian spatial correlation
##  Formula: ~Latitude + Longitude | bay
##  Parameter estimate(s):
##      range     nugget
## 0.02741658 0.12826392
## Fixed effects: light ~ 0 + bay
##            Value Std.Error DF   t-value p-value
## baychoc 48.07661  3.011848  0 15.962492     NaN
## bayirl  17.66437  2.591238  0  6.816959     NaN
## baytb   42.06220  2.201927  0 19.102454     NaN
##  Correlation:
##        baychc bayirl
## bayirl 0
## baytb  0      0
##
## Standardized Within-Group Residuals:
##         Min          Q1         Med          Q3         Max
## -2.93104423 -0.43027644  0.06738397  0.47640757  3.90853899
##
## Number of Observations: 836
```

```
## Number of Groups: 3
```

```
stargazer(znl, zm1, lnl, lm1,
  title = 'Inter-bay differences for median depth of colonization and light requirements. Nu
  column.labels = c('null', 'Gaus', 'null', 'Gaus'),
  model.numbers = F
  )
```

Table 2: Inter-bay differences for median depth of colonization and light requirements. Null models do not include a grouped correlation structure.

	Dependent variable:			
	z_c_all		light	
	null	Gaus	null	Gaus
baychoc	2.242	2.021	50.758	48.077
	(0.059)	(0.110)	(1.528)	(3.012)
bayirl	1.054	1.101	17.932	17.664
	(0.075)	(0.096)	(1.946)	(2.591)
baytb	1.210	1.163	41.577	42.062
	(0.057)	(0.081)	(1.474)	(2.202)
Observations	836	836	836	836
Log Likelihood	−303.580	537.481	−3,011.239	−2,542.856
Akaike Inf. Crit.	617.160	−1,060.961	6,032.477	5,099.712
Bayesian Inf. Crit.	640.785	−1,027.886	6,056.103	5,132.787
Note:				*p<0.1; **p<0.05; ***p<0.01

```
library(multcomp)
summary(glht(zm1, linfct = mcp(bay = 'Tukey')))

##
##   Simultaneous Tests for General Linear Hypotheses
##
## Multiple Comparisons of Means: Tukey Contrasts
##
##
## Fit: lme.formula(fixed = z_c_all ~ 0 + bay, data = all_light, random = ~1 |
##     bay, correlation = corGaus(form = ~Latitude + Longitude |
```

```
##     bay, nugget = TRUE))
##
## Linear Hypotheses:
##                 Estimate Std. Error z value Pr(>|z|)
## irl - choc == 0 -0.91965    0.14626  -6.288   <1e-05 ***
## tb - choc == 0  -0.85789    0.13672  -6.275   <1e-05 ***
## tb - irl == 0    0.06176    0.12606   0.490    0.876
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## (Adjusted p values reported -- single-step method)
```

```
summary(glht(lm1, linfct = mcp(bay = 'Tukey')))
```

```
##
##   Simultaneous Tests for General Linear Hypotheses
##
## Multiple Comparisons of Means: Tukey Contrasts
##
##
## Fit: lme.formula(fixed = light ~ 0 + bay, data = all_light, random = ~1 |
##     bay, correlation = corGaus(form = ~Latitude + Longitude |
##     bay, nugget = TRUE))
##
## Linear Hypotheses:
##                 Estimate Std. Error z value Pr(>|z|)
## irl - choc == 0  -30.412      3.973  -7.654   <1e-04 ***
## tb - choc == 0    -6.014      3.731  -1.612     0.24
## tb - irl == 0     24.398      3.400   7.175   <1e-04 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## (Adjusted p values reported -- single-step method)
```