

```

library(nlme)
library(stargazer)

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

modn1 <- 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(modn1, mod1, mod2, mod3, mod4, mod5)

stargazer(modn1, mod1, mod2, mod3, mod4, mod5,
  title = 'Comparison of regression models with different correlation structures for grid locations',
  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.

	<i>Dependent variable:</i>					
	z_cmax					
	null	Spher	Lin	Ratio	Gaus	Exp
Constant	2.382*** (0.070)	2.355*** (0.136)	2.271*** (0.506)	2.356*** (0.219)	2.364*** (0.144)	2.349*** (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

```

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))

zn1 <- 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 = FALSE),
  data = all_light)
zm2 <- lme(z_c_all ~ 0 + bay, random = ~ 1 | bay,
  correlation = corGaus(form = ~ Latitude + Longitude | bay, nugget = TRUE),
  data = all_light)

ln1 <- 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 = FALSE),
  data = all_light)
lm2 <- lme(light ~ 0 + bay, random = ~ 1 | bay,
  correlation = corGaus(form = ~ Latitude + Longitude | bay, nugget = TRUE),
  data = all_light)

```

```

summary(zm1)

## Linear mixed-effects model fit by REML
## Data: all_light
##           AIC           BIC    logLik
##    -87.99629  -59.64608  49.99814
##
## Random effects:
## Formula: ~1 | bay
##           (Intercept) Residual
## StdDev:   0.04474165  0.2800867

```

```

##
## Correlation Structure: Gaussian spatial correlation
## Formula: ~Latitude + Longitude | bay
## Parameter estimate(s):
##      range
## 0.007992795
## Fixed effects: z_c_all ~ 0 + bay
##              Value Std.Error DF  t-value p-value
## baychoc 2.124354 0.05637388  0 37.68330    NaN
## bayirl  1.073833 0.06374245  0 16.84643    NaN
## baytb   1.199982 0.04764828  0 25.18416    NaN
## Correlation:
##      baychc bayirl
## bayirl 0
## baytb  0      0
##
## Standardized Within-Group Residuals:
##      Min      Q1      Med      Q3      Max
## -5.6196257 -0.5367480  0.2614813  0.9666520  7.3331159
##
## Number of Observations: 836
## Number of Groups: 3

summary(lm1)

## Linear mixed-effects model fit by REML
## Data: all_light
##      AIC      BIC    logLik
## 5680.798 5709.149 -2834.399
##
## Random effects:
## Formula: ~1 | bay
##      (Intercept) Residual
## StdDev:      1.335232  8.35838
##
## Correlation Structure: Gaussian spatial correlation
## Formula: ~Latitude + Longitude | bay
## Parameter estimate(s):
##      range
## 0.007154898
## Fixed effects: light ~ 0 + bay
##              Value Std.Error DF  t-value p-value
## baychoc 51.19770  1.640932  0 31.20037    NaN

```

```
## bayirl 17.83239 1.889493 0 9.43766 NaN
## baytb 41.65458 1.408418 0 29.57544 NaN
## Correlation:
##      baychc bayirl
## bayirl 0
## baytb 0      0
##
## Standardized Within-Group Residuals:
##      Min      Q1      Med      Q3      Max
## -3.791201263 -0.554951340 -0.005255754 0.506392145 4.296715152
##
## Number of Observations: 836
## Number of Groups: 3
```

```
stargazer(znl, zm1, zm2, lnl, lm1, lm2,
  title = 'Inter-bay differences for median depth of colonization and light requirements',
  column.labels = c('null', 'Gaus', 'Gaus, nug', 'null', 'Gaus', 'Gaus, nug'),
  model.numbers = F
)
```

```
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 = FALSE))
##
## Linear Hypotheses:
##      Estimate Std. Error z value Pr(>|z|)
## irl - choc == 0 -1.05052    0.08509 -12.345 <1e-04 ***
## tb - choc == 0 -0.92437    0.07381 -12.523 <1e-04 ***
## tb - irl == 0 0.12615    0.07958 1.585 0.251
## ---
## Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## (Adjusted p values reported -- single-step method)
```

Table 2: Inter-bay differences for median depth of colonization and light requirements. Null models do not include a grouped correlation structure. Gaussian models with and without nuggets for the spatial correlation structures are also shown.

	<i>Dependent variable:</i>					
	null	z_c_all Gaus	Gaus, nug	null	light Gaus	Gaus, nug
baychoc	2.242 (0.059)	2.124 (0.056)	2.021 (0.110)	50.758 (1.528)	51.198 (1.641)	48.077 (3.012)
bayirl	1.054 (0.075)	1.074 (0.064)	1.101 (0.096)	17.932 (1.946)	17.832 (1.889)	17.664 (2.591)
baytb	1.210 (0.057)	1.200 (0.048)	1.163 (0.081)	41.577 (1.474)	41.655 (1.408)	42.062 (2.202)
Observations	836	836	836	836	836	836
Log Likelihood	−303.580	49.998	537.481	−3,011.239	−2,834.399	−2,542.856
Akaike Inf. Crit.	617.160	−87.996	−1,060.961	6,032.477	5,680.798	5,099.712
Bayesian Inf. Crit.	640.785	−59.646	−1,027.886	6,056.103	5,709.149	5,132.787

Note:

*p<0.1; **p<0.05; ***p<0.01

```
summary(glht(zm2, 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 = FALSE))
##
## Linear Hypotheses:
## Estimate Std. Error z value Pr(>|z|)
## irl - choc == 0 -33.365 2.503 -13.332 <1e-04 ***
## tb - choc == 0 -9.543 2.162 -4.413 <1e-04 ***
## tb - irl == 0 23.822 2.357 10.108 <1e-04 ***
## ---
## Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## (Adjusted p values reported -- single-step method)
```

```
summary(glht(lm2, 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	0.239
## 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)
```