10\_gls\_models

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Quick summary table…more detailed output of the model summaries and ACF/PACF plots follow in the rest of the document:

|  |  |  |
| --- | --- | --- |
| NO3- model | Covariance | AIC |
| **Simple**: gls(dailyNO3 ~ site.ID\*year, na.action = na.omit, data = mean\_daily |  | 11938.37 |
| **Compound Symmetry:** gls(dailyNO3 ~ site.ID\*year, na.action = na.omit, data = mean\_daily, correlation = corCompSymm(form = ~ julian)) | Rho: -9.866e-07 | 11940.37 |
| **CorAR1 structure:** gls(dailyNO3 ~ site.ID\*year, na.action = na.omit, data = mean\_daily, correlation = corAR1(form = ~ julian|site.ID/year)) | Phi1: 0.9431369 | 8256.072 |
| fDOM model | Covariance | AIC |
| **Simple**: gls(dailyfDOM ~ site.ID\*year, na.action = na.omit, data = mean\_daily |  | 18992.24 |
| **Compound Symmetry:** gls(dailyfDOM ~ site.ID\*year, na.action = na.omit, data = mean\_daily, correlation = corCompSymm(form = ~ julian)) | Rho: 0 | 18994.24 |
| **CorAR1 structure:** gls(dailyfDOM ~ site.ID\*year, na.action = na.omit, data = mean\_daily, correlation = corAR1(form = ~ julian|site.ID/year)) | Phi1: 0.9431369 | 17236.82 |
| SPC model | Covariance | AIC |
| **Simple**: gls(dailySPC ~ site.ID\*year, na.action = na.omit, data = mean\_daily |  | 22425.38 |
| **Compound Symmetry:** gls(dailySPC ~ site.ID\*year, na.action = na.omit, data = mean\_daily, correlation = corCompSymm(form = ~ julian)) | Rho: 2.167e-19 | 22427.38 |
| **CorAR1 structure:** gls(dailySPC ~ site.ID\*year, na.action = na.omit, data = mean\_daily, correlation = corAR1(form = ~ julian|site.ID/year)) | Phi1: 0.9749659 | 16750.35 |
| Turb model | Covariance | AIC |
| **Simple**: gls(dailySPC ~ site.ID\*year, na.action = na.omit, data = mean\_daily |  | 21132.81 |
| **Compound Symmetry:** gls(dailySPC ~ site.ID\*year, na.action = na.omit, data = mean\_daily, correlation = corCompSymm(form = ~ julian)) | Rho: 0 | 21134.81 |
| **CorAR1 structure:** gls(dailySPC ~ site.ID\*year, na.action = na.omit, data = mean\_daily, correlation = corAR1(form = ~ julian|site.ID/year)) | Phi1: 0.6012503 | 20226.75 |

#load libraries

library(here)

## here() starts at /Users/jakecavaiani/Documents/Storms\_clean\_repo

library(tidyverse)

## ── Attaching packages ─────────────────────────────────────── tidyverse 1.3.1 ──

## ✓ ggplot2 3.3.5 ✓ purrr 0.3.4  
## ✓ tibble 3.1.6 ✓ dplyr 1.0.7  
## ✓ tidyr 1.1.3 ✓ stringr 1.4.0  
## ✓ readr 1.4.0 ✓ forcats 0.5.1

## ── Conflicts ────────────────────────────────────────── tidyverse\_conflicts() ──  
## x dplyr::filter() masks stats::filter()  
## x dplyr::lag() masks stats::lag()

library(nlme)

##   
## Attaching package: 'nlme'

## The following object is masked from 'package:dplyr':  
##   
## collapse

library(forecast)

## Registered S3 method overwritten by 'quantmod':  
## method from  
## as.zoo.data.frame zoo

##   
## Attaching package: 'forecast'

## The following object is masked from 'package:nlme':  
##   
## getResponse

library(stats)  
library(readr)  
library(ggplot2)  
library(plotly)

##   
## Attaching package: 'plotly'

## The following object is masked from 'package:ggplot2':  
##   
## last\_plot

## The following object is masked from 'package:stats':  
##   
## filter

## The following object is masked from 'package:graphics':  
##   
## layout

library(GGally)

## Registered S3 method overwritten by 'GGally':  
## method from   
## +.gg ggplot2

library(ggpmisc)

## Loading required package: ggpp

##   
## Attaching package: 'ggpp'

## The following object is masked from 'package:ggplot2':  
##   
## annotate

library(ggpubr)

##   
## Attaching package: 'ggpubr'

## The following object is masked from 'package:forecast':  
##   
## gghistogram

library(ggExtra)  
library(lubridate)

##   
## Attaching package: 'lubridate'

## The following objects are masked from 'package:base':  
##   
## date, intersect, setdiff, union

library(nlme)  
library(MuMIn)  
library(multcomp)

## Loading required package: mvtnorm

## Loading required package: survival

## Loading required package: TH.data

## Loading required package: MASS

##   
## Attaching package: 'MASS'

## The following object is masked from 'package:plotly':  
##   
## select

## The following object is masked from 'package:dplyr':  
##   
## select

##   
## Attaching package: 'TH.data'

## The following object is masked from 'package:MASS':  
##   
## geyser

# NO3 simple model

no3.mod.gls <- gls(dailyNO3 ~ site.ID\*year,   
 na.action = na.omit,   
 data = mean\_daily)  
summary(no3.mod.gls) # AIC is 11938.37

## Generalized least squares fit by REML  
## Model: dailyNO3 ~ site.ID \* year   
## Data: mean\_daily   
## AIC BIC logLik  
## 11938.37 12010.13 -5956.186  
##   
## Coefficients:  
## Value Std.Error t-value p-value  
## (Intercept) -330.312 579.6639 -0.569834 0.5689  
## site.IDFRCH 1113.935 855.2601 1.302451 0.1929  
## site.IDMOOS 1418.306 858.2591 1.652538 0.0986  
## site.IDPOKE -4286.582 1218.2334 -3.518687 0.0004  
## site.IDSTRT -2959.577 1130.8402 -2.617149 0.0089  
## site.IDVAUL -17452.576 1040.5199 -16.772938 0.0000  
## year 0.178 0.2870 0.618444 0.5364  
## site.IDFRCH:year -0.552 0.4235 -1.303660 0.1925  
## site.IDMOOS:year -0.705 0.4250 -1.658793 0.0973  
## site.IDPOKE:year 2.122 0.6032 3.518667 0.0004  
## site.IDSTRT:year 1.463 0.5598 2.613225 0.0090  
## site.IDVAUL:year 8.636 0.5152 16.764921 0.0000  
##   
## Correlation:   
## (Intr) st.IDFRCH st.IDMOOS st.IDPOKE st.IDSTRT st.IDVAUL  
## site.IDFRCH -0.678   
## site.IDMOOS -0.675 0.458   
## site.IDPOKE -0.476 0.322 0.321   
## site.IDSTRT -0.513 0.347 0.346 0.244   
## site.IDVAUL -0.557 0.378 0.376 0.265 0.286   
## year -1.000 0.678 0.675 0.476 0.513 0.557   
## site.IDFRCH:year 0.678 -1.000 -0.458 -0.322 -0.347 -0.378   
## site.IDMOOS:year 0.675 -0.458 -1.000 -0.321 -0.346 -0.376   
## site.IDPOKE:year 0.476 -0.323 -0.321 -1.000 -0.244 -0.265   
## site.IDSTRT:year 0.513 -0.347 -0.346 -0.244 -1.000 -0.286   
## site.IDVAUL:year 0.557 -0.378 -0.376 -0.265 -0.286 -1.000   
## year s.IDFRCH: s.IDMOOS: s.IDPOKE: s.IDSTRT:  
## site.IDFRCH   
## site.IDMOOS   
## site.IDPOKE   
## site.IDSTRT   
## site.IDVAUL   
## year   
## site.IDFRCH:year -0.678   
## site.IDMOOS:year -0.675 0.458   
## site.IDPOKE:year -0.476 0.323 0.321   
## site.IDSTRT:year -0.513 0.347 0.346 0.244   
## site.IDVAUL:year -0.557 0.378 0.376 0.265 0.286   
##   
## Standardized residuals:  
## Min Q1 Med Q3 Max   
## -2.88615102 -0.56989874 0.06311857 0.61126156 6.86078895   
##   
## Residual standard error: 6.006299   
## Degrees of freedom: 1856 total; 1844 residual

#ACF plot function assumes no skipped time points. GLS removed missing values. Need to fill in the residual series to account for missing value  
E <- residuals(no3.mod.gls, type="normalized")  
I1 <- !is.na(mean\_daily$dailyNO3)  
Efull <- vector(length=length(mean\_daily$dailyNO3))  
Efull <- NA  
Efull[I1] <- E  
par(mfrow=c(2,1))  
acf(Efull, na.action=na.pass)  
pacf(Efull, na.action=na.pass)

Chart, histogram

Description automatically generated

Chart

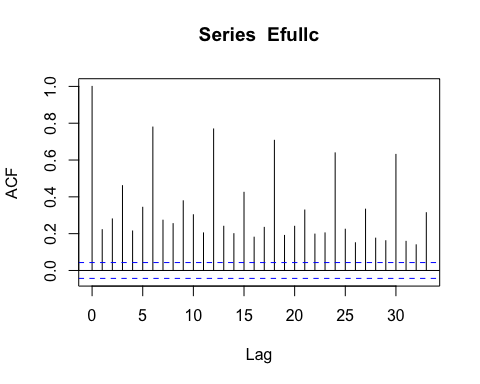
Description automatically generated

## Compound symmetry

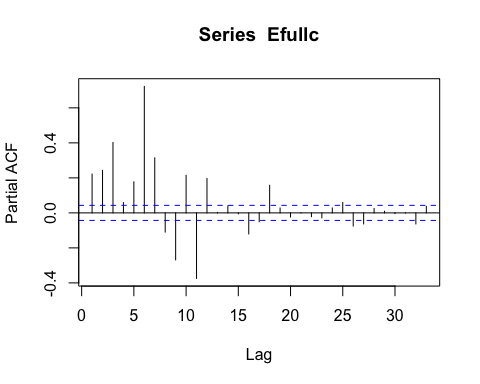
## Compound symmetry  
no3.mod.cs <- gls(dailyNO3 ~ site.ID\*year,   
 na.action = na.omit,   
 data = mean\_daily,   
 correlation = corCompSymm(form = ~ julian))  
  
summary(no3.mod.cs) # covariance ~ 0 # AIC is 11940.37

## Generalized least squares fit by REML  
## Model: dailyNO3 ~ site.ID \* year   
## Data: mean\_daily   
## AIC BIC logLik  
## 11940.37 12017.65 -5956.186  
##   
## Correlation Structure: Compound symmetry  
## Formula: ~julian   
## Parameter estimate(s):  
## Rho   
## -9.866646e-07   
##   
## Coefficients:  
## Value Std.Error t-value p-value  
## (Intercept) -330.312 579.6639 -0.569834 0.5689  
## site.IDFRCH 1113.935 855.2601 1.302451 0.1929  
## site.IDMOOS 1418.306 858.2591 1.652538 0.0986  
## site.IDPOKE -4286.582 1218.2334 -3.518687 0.0004  
## site.IDSTRT -2959.577 1130.8402 -2.617149 0.0089  
## site.IDVAUL -17452.576 1040.5199 -16.772938 0.0000  
## year 0.178 0.2870 0.618444 0.5364  
## site.IDFRCH:year -0.552 0.4235 -1.303660 0.1925  
## site.IDMOOS:year -0.705 0.4250 -1.658793 0.0973  
## site.IDPOKE:year 2.122 0.6032 3.518667 0.0004  
## site.IDSTRT:year 1.463 0.5598 2.613225 0.0090  
## site.IDVAUL:year 8.636 0.5152 16.764921 0.0000  
##   
## Correlation:   
## (Intr) st.IDFRCH st.IDMOOS st.IDPOKE st.IDSTRT st.IDVAUL  
## site.IDFRCH -0.678   
## site.IDMOOS -0.675 0.458   
## site.IDPOKE -0.476 0.322 0.321   
## site.IDSTRT -0.513 0.347 0.346 0.244   
## site.IDVAUL -0.557 0.378 0.376 0.265 0.286   
## year -1.000 0.678 0.675 0.476 0.513 0.557   
## site.IDFRCH:year 0.678 -1.000 -0.458 -0.322 -0.347 -0.378   
## site.IDMOOS:year 0.675 -0.458 -1.000 -0.321 -0.346 -0.376   
## site.IDPOKE:year 0.476 -0.323 -0.321 -1.000 -0.244 -0.265   
## site.IDSTRT:year 0.513 -0.347 -0.346 -0.244 -1.000 -0.286   
## site.IDVAUL:year 0.557 -0.378 -0.376 -0.265 -0.286 -1.000   
## year s.IDFRCH: s.IDMOOS: s.IDPOKE: s.IDSTRT:  
## site.IDFRCH   
## site.IDMOOS   
## site.IDPOKE   
## site.IDSTRT   
## site.IDVAUL   
## year   
## site.IDFRCH:year -0.678   
## site.IDMOOS:year -0.675 0.458   
## site.IDPOKE:year -0.476 0.323 0.321   
## site.IDSTRT:year -0.513 0.347 0.346 0.244   
## site.IDVAUL:year -0.557 0.378 0.376 0.265 0.286   
##   
## Standardized residuals:  
## Min Q1 Med Q3 Max   
## -2.8861524 -0.5698990 0.0631186 0.6112619 6.8607923   
##   
## Residual standard error: 6.006296   
## Degrees of freedom: 1856 total; 1844 residual

Ecs <- residuals(no3.mod.cs, type="normalized")  
I1 <- !is.na(mean\_daily$dailyNO3)  
Efullc <- vector(length=length(mean\_daily$dailyNO3))  
Efullc <- NA  
Efullc[I1] <- Ecs  
acf(Efullc, na.action=na.pass)



pacf(Efullc, na.action=na.pass)



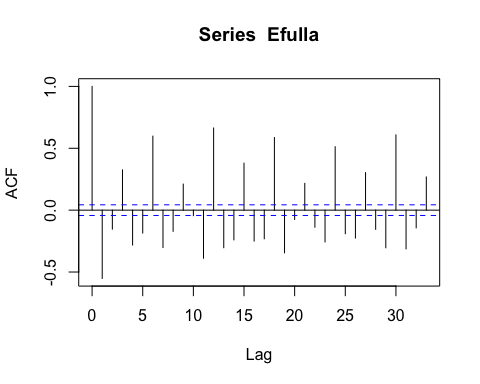
### CorAR1 structure

#errors structured as AR1  
no3.mod.ar1 <- gls(dailyNO3 ~ site.ID\*year,   
 na.action = na.omit,   
 data = mean\_daily,   
 correlation = corAR1(form = ~ julian|site.ID/year))  
  
summary(no3.mod.ar1) # Phi1 = 0.9431369 # AIC is 8256.072

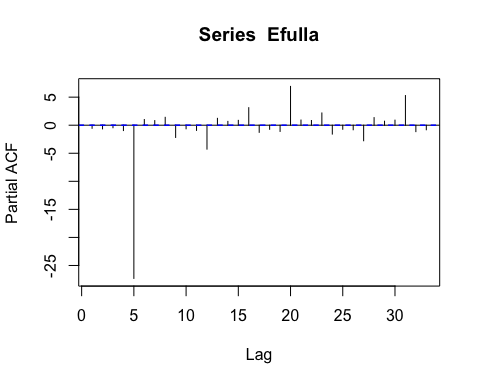
## Generalized least squares fit by REML  
## Model: dailyNO3 ~ site.ID \* year   
## Data: mean\_daily   
## AIC BIC logLik  
## 8256.072 8333.347 -4114.036  
##   
## Correlation Structure: ARMA(1,0)  
## Formula: ~julian | site.ID/year   
## Parameter estimate(s):  
## Phi1   
## 0.9431369   
##   
## Coefficients:  
## Value Std.Error t-value p-value  
## (Intercept) -671.039 2983.447 -0.2249206 0.8221  
## site.IDFRCH 2603.924 4276.654 0.6088695 0.5427  
## site.IDMOOS 1095.052 4222.695 0.2593255 0.7954  
## site.IDPOKE -4334.266 6045.457 -0.7169460 0.4735  
## site.IDSTRT -3452.959 5524.525 -0.6250238 0.5320  
## site.IDVAUL -16616.097 5513.149 -3.0139030 0.0026  
## year 0.346 1.477 0.2343345 0.8148  
## site.IDFRCH:year -1.290 2.118 -0.6091118 0.5425  
## site.IDMOOS:year -0.544 2.091 -0.2603287 0.7946  
## site.IDPOKE:year 2.146 2.993 0.7169833 0.4735  
## site.IDSTRT:year 1.707 2.735 0.6240652 0.5327  
## site.IDVAUL:year 8.222 2.729 3.0124774 0.0026  
##   
## Correlation:   
## (Intr) st.IDFRCH st.IDMOOS st.IDPOKE st.IDSTRT st.IDVAUL  
## site.IDFRCH -0.698   
## site.IDMOOS -0.707 0.493   
## site.IDPOKE -0.494 0.344 0.349   
## site.IDSTRT -0.540 0.377 0.382 0.267   
## site.IDVAUL -0.541 0.378 0.382 0.267 0.292   
## year -1.000 0.698 0.707 0.494 0.540 0.541   
## site.IDFRCH:year 0.698 -1.000 -0.493 -0.344 -0.377 -0.378   
## site.IDMOOS:year 0.707 -0.493 -1.000 -0.349 -0.382 -0.382   
## site.IDPOKE:year 0.494 -0.344 -0.349 -1.000 -0.267 -0.267   
## site.IDSTRT:year 0.540 -0.377 -0.382 -0.267 -1.000 -0.292   
## site.IDVAUL:year 0.541 -0.378 -0.382 -0.267 -0.292 -1.000   
## year s.IDFRCH: s.IDMOOS: s.IDPOKE: s.IDSTRT:  
## site.IDFRCH   
## site.IDMOOS   
## site.IDPOKE   
## site.IDSTRT   
## site.IDVAUL   
## year   
## site.IDFRCH:year -0.698   
## site.IDMOOS:year -0.707 0.493   
## site.IDPOKE:year -0.494 0.344 0.349   
## site.IDSTRT:year -0.540 0.377 0.382 0.267   
## site.IDVAUL:year -0.541 0.378 0.382 0.267 0.292   
##   
## Standardized residuals:  
## Min Q1 Med Q3 Max   
## -2.660892820 -0.522474137 0.003078766 0.582382448 6.413645254   
##   
## Residual standard error: 6.576789   
## Degrees of freedom: 1856 total; 1844 residual

# ~t|g  
# t is the time covariate   
# g is the group factor and when a grouping factor is present in the form argument, the correlation structure is assumed to apply only to observations within the same grouping level and observations with different grouping levels are assumed to be uncorrelated

Ear1<-residuals(no3.mod.ar1, type="normalized")  
I1<-!is.na(mean\_daily$dailyNO3)  
Efulla<-vector(length = length(mean\_daily$dailyNO3))  
Efulla<-NA  
Efulla[I1]<-Ear1  
acf(Efulla, na.action=na.pass)



pacf(Efulla, na.action=na.pass)



# fDOM simple model

fDOM.mod.gls <- gls(dailyfDOM ~ site.ID\*year,   
 na.action = na.omit,   
 data = mean\_daily)  
summary(fDOM.mod.gls) # AIC is 18992.24

## Generalized least squares fit by REML  
## Model: dailyfDOM ~ site.ID \* year   
## Data: mean\_daily   
## AIC BIC logLik  
## 18992.24 19064.7 -9483.121  
##   
## Coefficients:  
## Value Std.Error t-value p-value  
## (Intercept) 4444.666 2994.577 1.484239 0.1379  
## site.IDFRCH 24795.810 4437.418 5.587891 0.0000  
## site.IDMOOS 15040.672 4116.115 3.654095 0.0003  
## site.IDPOKE 4148.580 6289.814 0.659571 0.5096  
## site.IDSTRT -5290.483 5422.126 -0.975721 0.3293  
## site.IDVAUL -9697.656 5366.560 -1.807053 0.0709  
## year -2.172 1.483 -1.464522 0.1432  
## site.IDFRCH:year -12.271 2.197 -5.585156 0.0000  
## site.IDMOOS:year -7.416 2.038 -3.638682 0.0003  
## site.IDPOKE:year -2.064 3.114 -0.662661 0.5076  
## site.IDSTRT:year 2.621 2.684 0.976513 0.3289  
## site.IDVAUL:year 4.878 2.657 1.835847 0.0665  
##   
## Correlation:   
## (Intr) st.IDFRCH st.IDMOOS st.IDPOKE st.IDSTRT st.IDVAUL  
## site.IDFRCH -0.675   
## site.IDMOOS -0.728 0.491   
## site.IDPOKE -0.476 0.321 0.346   
## site.IDSTRT -0.552 0.373 0.402 0.263   
## site.IDVAUL -0.558 0.377 0.406 0.266 0.308   
## year -1.000 0.675 0.728 0.476 0.552 0.558   
## site.IDFRCH:year 0.675 -1.000 -0.491 -0.321 -0.373 -0.377   
## site.IDMOOS:year 0.728 -0.491 -1.000 -0.346 -0.402 -0.406   
## site.IDPOKE:year 0.476 -0.321 -0.346 -1.000 -0.263 -0.266   
## site.IDSTRT:year 0.552 -0.373 -0.402 -0.263 -1.000 -0.308   
## site.IDVAUL:year 0.558 -0.377 -0.406 -0.266 -0.308 -1.000   
## year s.IDFRCH: s.IDMOOS: s.IDPOKE: s.IDSTRT:  
## site.IDFRCH   
## site.IDMOOS   
## site.IDPOKE   
## site.IDSTRT   
## site.IDVAUL   
## year   
## site.IDFRCH:year -0.675   
## site.IDMOOS:year -0.728 0.491   
## site.IDPOKE:year -0.476 0.321 0.346   
## site.IDSTRT:year -0.552 0.373 0.402 0.263   
## site.IDVAUL:year -0.558 0.377 0.406 0.266 0.308   
##   
## Standardized residuals:  
## Min Q1 Med Q3 Max   
## -7.3862546 -0.4992402 -0.1262554 0.4964870 18.0953215   
##   
## Residual standard error: 31.00563   
## Degrees of freedom: 1959 total; 1947 residual

#ACF plot function assumes no skipped time points. GLS removed missing values. Need to fill in the residual series to account for missing value  
E <- residuals(fDOM.mod.gls, type="normalized")  
I1 <- !is.na(mean\_daily$dailyfDOM)  
Efull <- vector(length=length(mean\_daily$dailyfDOM))  
Efull <- NA  
Efull[I1] <- E  
par(mfrow=c(2,1))  
acf(Efull, na.action=na.pass)  
pacf(Efull, na.action=na.pass)

Chart, histogram

Description automatically generatedChart

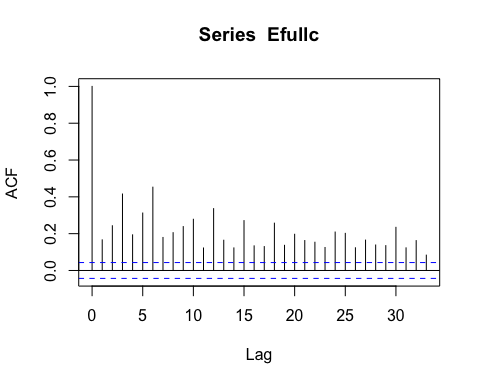
Description automatically generated

## Compound symmetry

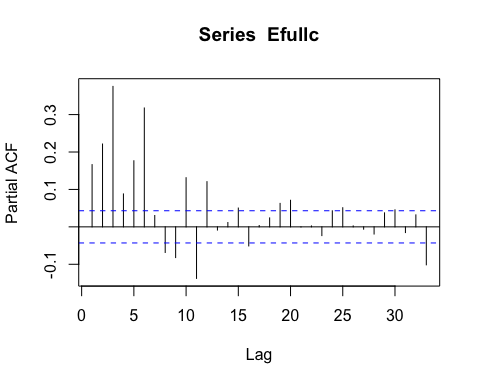
## Compound symmetry  
fDOM.mod.cs <- gls(dailyfDOM ~ site.ID\*year,   
 na.action = na.omit,   
 data = mean\_daily,   
 correlation = corCompSymm(form = ~ julian))  
  
summary(fDOM.mod.cs) # covariance ~ 0 # AIC is 18994.24

## Generalized least squares fit by REML  
## Model: dailyfDOM ~ site.ID \* year   
## Data: mean\_daily   
## AIC BIC logLik  
## 18994.24 19072.28 -9483.121  
##   
## Correlation Structure: Compound symmetry  
## Formula: ~julian   
## Parameter estimate(s):  
## Rho   
## 0   
##   
## Coefficients:  
## Value Std.Error t-value p-value  
## (Intercept) 4444.666 2994.577 1.484239 0.1379  
## site.IDFRCH 24795.810 4437.418 5.587891 0.0000  
## site.IDMOOS 15040.672 4116.115 3.654095 0.0003  
## site.IDPOKE 4148.580 6289.814 0.659571 0.5096  
## site.IDSTRT -5290.483 5422.126 -0.975721 0.3293  
## site.IDVAUL -9697.656 5366.560 -1.807053 0.0709  
## year -2.172 1.483 -1.464522 0.1432  
## site.IDFRCH:year -12.271 2.197 -5.585156 0.0000  
## site.IDMOOS:year -7.416 2.038 -3.638682 0.0003  
## site.IDPOKE:year -2.064 3.114 -0.662661 0.5076  
## site.IDSTRT:year 2.621 2.684 0.976513 0.3289  
## site.IDVAUL:year 4.878 2.657 1.835847 0.0665  
##   
## Correlation:   
## (Intr) st.IDFRCH st.IDMOOS st.IDPOKE st.IDSTRT st.IDVAUL  
## site.IDFRCH -0.675   
## site.IDMOOS -0.728 0.491   
## site.IDPOKE -0.476 0.321 0.346   
## site.IDSTRT -0.552 0.373 0.402 0.263   
## site.IDVAUL -0.558 0.377 0.406 0.266 0.308   
## year -1.000 0.675 0.728 0.476 0.552 0.558   
## site.IDFRCH:year 0.675 -1.000 -0.491 -0.321 -0.373 -0.377   
## site.IDMOOS:year 0.728 -0.491 -1.000 -0.346 -0.402 -0.406   
## site.IDPOKE:year 0.476 -0.321 -0.346 -1.000 -0.263 -0.266   
## site.IDSTRT:year 0.552 -0.373 -0.402 -0.263 -1.000 -0.308   
## site.IDVAUL:year 0.558 -0.377 -0.406 -0.266 -0.308 -1.000   
## year s.IDFRCH: s.IDMOOS: s.IDPOKE: s.IDSTRT:  
## site.IDFRCH   
## site.IDMOOS   
## site.IDPOKE   
## site.IDSTRT   
## site.IDVAUL   
## year   
## site.IDFRCH:year -0.675   
## site.IDMOOS:year -0.728 0.491   
## site.IDPOKE:year -0.476 0.321 0.346   
## site.IDSTRT:year -0.552 0.373 0.402 0.263   
## site.IDVAUL:year -0.558 0.377 0.406 0.266 0.308   
##   
## Standardized residuals:  
## Min Q1 Med Q3 Max   
## -7.3862546 -0.4992402 -0.1262554 0.4964870 18.0953215   
##   
## Residual standard error: 31.00563   
## Degrees of freedom: 1959 total; 1947 residual

Ecs <- residuals(fDOM.mod.cs, type="normalized")  
I1 <- !is.na(mean\_daily$dailyfDOM)  
Efullc <- vector(length=length(mean\_daily$dailyfDOM))  
Efullc <- NA  
Efullc[I1] <- Ecs  
acf(Efullc, na.action=na.pass)



pacf(Efullc, na.action=na.pass)



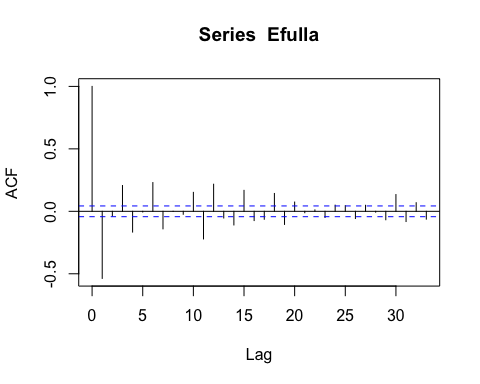
### CorAR1 structure

#errors structured as AR1  
fDOM.mod.ar1 <- gls(dailyfDOM ~ site.ID\*year,   
 na.action = na.omit,   
 data = mean\_daily,   
 correlation = corAR1(form = ~ julian|site.ID/year))  
  
summary(fDOM.mod.ar1) # Phi1 = .790946 # AIC is 17236.82

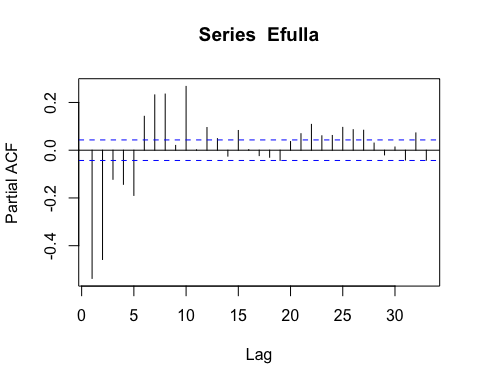
## Generalized least squares fit by REML  
## Model: dailyfDOM ~ site.ID \* year   
## Data: mean\_daily   
## AIC BIC logLik  
## 17236.82 17314.86 -8604.412  
##   
## Correlation Structure: ARMA(1,0)  
## Formula: ~julian | site.ID/year   
## Parameter estimate(s):  
## Phi1   
## 0.790946   
##   
## Coefficients:  
## Value Std.Error t-value p-value  
## (Intercept) 1896.109 8480.571 0.2235827 0.8231  
## site.IDFRCH 30954.044 12447.863 2.4866954 0.0130  
## site.IDMOOS 19696.289 11741.067 1.6775553 0.0936  
## site.IDPOKE 7973.976 17424.844 0.4576211 0.6473  
## site.IDSTRT -1525.288 15385.075 -0.0991407 0.9210  
## site.IDVAUL -6721.586 15289.224 -0.4396290 0.6603  
## year -0.910 4.199 -0.2166478 0.8285  
## site.IDFRCH:year -15.320 6.163 -2.4856587 0.0130  
## site.IDMOOS:year -9.721 5.814 -1.6721000 0.0947  
## site.IDPOKE:year -3.958 8.627 -0.4587816 0.6464  
## site.IDSTRT:year 0.757 7.617 0.0993551 0.9209  
## site.IDVAUL:year 3.404 7.569 0.4497421 0.6529  
##   
## Correlation:   
## (Intr) st.IDFRCH st.IDMOOS st.IDPOKE st.IDSTRT st.IDVAUL  
## site.IDFRCH -0.681   
## site.IDMOOS -0.722 0.492   
## site.IDPOKE -0.487 0.332 0.352   
## site.IDSTRT -0.551 0.376 0.398 0.268   
## site.IDVAUL -0.555 0.378 0.401 0.270 0.306   
## year -1.000 0.681 0.722 0.487 0.551 0.555   
## site.IDFRCH:year 0.681 -1.000 -0.492 -0.332 -0.376 -0.378   
## site.IDMOOS:year 0.722 -0.492 -1.000 -0.352 -0.398 -0.401   
## site.IDPOKE:year 0.487 -0.332 -0.352 -1.000 -0.268 -0.270   
## site.IDSTRT:year 0.551 -0.376 -0.398 -0.268 -1.000 -0.306   
## site.IDVAUL:year 0.555 -0.378 -0.401 -0.270 -0.306 -1.000   
## year s.IDFRCH: s.IDMOOS: s.IDPOKE: s.IDSTRT:  
## site.IDFRCH   
## site.IDMOOS   
## site.IDPOKE   
## site.IDSTRT   
## site.IDVAUL   
## year   
## site.IDFRCH:year -0.681   
## site.IDMOOS:year -0.722 0.492   
## site.IDPOKE:year -0.487 0.332 0.352   
## site.IDSTRT:year -0.551 0.376 0.398 0.268   
## site.IDVAUL:year -0.555 0.378 0.401 0.270 0.306   
##   
## Standardized residuals:  
## Min Q1 Med Q3 Max   
## -7.09848338 -0.46541829 -0.09615328 0.47689502 17.34201486   
##   
## Residual standard error: 32.25249   
## Degrees of freedom: 1959 total; 1947 residual

# ~t|g  
# t is the time covariate   
# g is the group factor and when a grouping factor is present in the form argument, the correlation structure is assumed to apply only to observations within the same grouping level and observations with different grouping levels are assumed to be uncorrelated

Ear1<-residuals(fDOM.mod.ar1, type="normalized")  
I1<-!is.na(mean\_daily$dailyfDOM)  
Efulla<-vector(length = length(mean\_daily$dailyfDOM))  
Efulla<-NA  
Efulla[I1]<-Ear1  
acf(Efulla, na.action=na.pass)



pacf(Efulla, na.action=na.pass)



# SPC simple model

SPC.mod.gls <- gls(dailySPC ~ site.ID\*year,   
 na.action = na.omit,   
 data = mean\_daily)  
summary(SPC.mod.gls) # AIC is 22425.38

## Generalized least squares fit by REML  
## Model: dailySPC ~ site.ID \* year   
## Data: mean\_daily   
## AIC BIC logLik  
## 22425.38 22498.23 -11199.69  
##   
## Coefficients:  
## Value Std.Error t-value p-value  
## (Intercept) -4338.86 6086.912 -0.7128172 0.4760  
## site.IDFRCH -3672.07 8368.332 -0.4388055 0.6608  
## site.IDMOOS -3457.21 8310.832 -0.4159886 0.6775  
## site.IDPOKE 9320.91 12804.046 0.7279660 0.4667  
## site.IDSTRT -10739.61 11046.868 -0.9721856 0.3311  
## site.IDVAUL 32290.00 10913.946 2.9585996 0.0031  
## year 2.19 3.014 0.7249916 0.4685  
## site.IDFRCH:year 1.82 4.144 0.4401960 0.6598  
## site.IDMOOS:year 1.73 4.115 0.4209248 0.6739  
## site.IDPOKE:year -4.60 6.340 -0.7252596 0.4684  
## site.IDSTRT:year 5.34 5.469 0.9763819 0.3290  
## site.IDVAUL:year -15.85 5.403 -2.9334091 0.0034  
##   
## Correlation:   
## (Intr) st.IDFRCH st.IDMOOS st.IDPOKE st.IDSTRT st.IDVAUL  
## site.IDFRCH -0.727   
## site.IDMOOS -0.732 0.533   
## site.IDPOKE -0.475 0.346 0.348   
## site.IDSTRT -0.551 0.401 0.404 0.262   
## site.IDVAUL -0.558 0.406 0.408 0.265 0.307   
## year -1.000 0.727 0.732 0.475 0.551 0.558   
## site.IDFRCH:year 0.727 -1.000 -0.533 -0.346 -0.401 -0.406   
## site.IDMOOS:year 0.732 -0.533 -1.000 -0.348 -0.404 -0.408   
## site.IDPOKE:year 0.475 -0.346 -0.348 -1.000 -0.262 -0.265   
## site.IDSTRT:year 0.551 -0.401 -0.404 -0.262 -1.000 -0.307   
## site.IDVAUL:year 0.558 -0.406 -0.409 -0.265 -0.307 -1.000   
## year s.IDFRCH: s.IDMOOS: s.IDPOKE: s.IDSTRT:  
## site.IDFRCH   
## site.IDMOOS   
## site.IDPOKE   
## site.IDSTRT   
## site.IDVAUL   
## year   
## site.IDFRCH:year -0.727   
## site.IDMOOS:year -0.732 0.533   
## site.IDPOKE:year -0.475 0.346 0.348   
## site.IDSTRT:year -0.551 0.401 0.404 0.262   
## site.IDVAUL:year -0.558 0.406 0.409 0.265 0.307   
##   
## Standardized residuals:  
## Min Q1 Med Q3 Max   
## -3.8632025 -0.2231021 -0.0126838 0.2396526 6.2069423   
##   
## Residual standard error: 63.07071   
## Degrees of freedom: 2019 total; 2007 residual

#ACF plot function assumes no skipped time points. GLS removed missing values. Need to fill in the residual series to account for missing value  
E <- residuals(SPC.mod.gls, type="normalized")  
I1 <- !is.na(mean\_daily$dailySPC)  
Efull <- vector(length=length(mean\_daily$dailySPC))  
Efull <- NA  
Efull[I1] <- E  
par(mfrow=c(2,1))  
acf(Efull, na.action=na.pass)  
pacf(Efull, na.action=na.pass)

Chart, histogram

Description automatically generatedChart, histogram

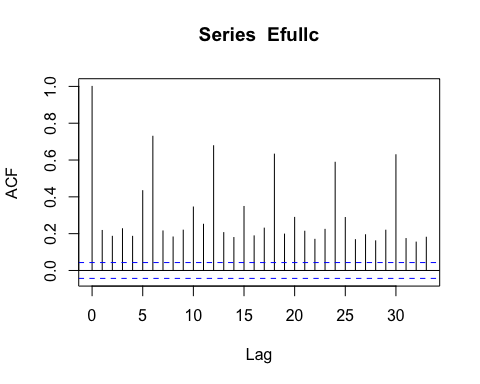
Description automatically generated

## Compound symmetry

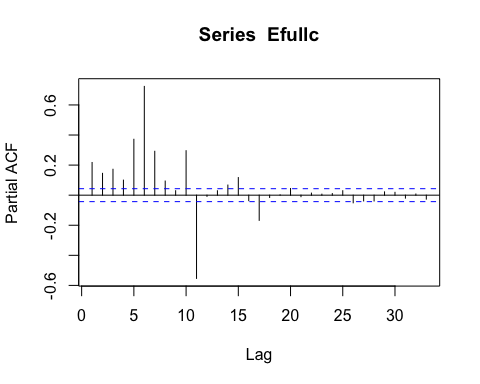
## Compound symmetry  
SPC.mod.cs <- gls(dailySPC ~ site.ID\*year,   
 na.action = na.omit,   
 data = mean\_daily,   
 correlation = corCompSymm(form = ~ julian))  
  
summary(SPC.mod.cs) # covariance ~ 2.16733e-19 # AIC is 22427.38

## Generalized least squares fit by REML  
## Model: dailySPC ~ site.ID \* year   
## Data: mean\_daily   
## AIC BIC logLik  
## 22427.38 22505.84 -11199.69  
##   
## Correlation Structure: Compound symmetry  
## Formula: ~julian   
## Parameter estimate(s):  
## Rho   
## 2.16733e-19   
##   
## Coefficients:  
## Value Std.Error t-value p-value  
## (Intercept) -4338.86 6086.912 -0.7128172 0.4760  
## site.IDFRCH -3672.07 8368.332 -0.4388055 0.6608  
## site.IDMOOS -3457.21 8310.832 -0.4159886 0.6775  
## site.IDPOKE 9320.91 12804.046 0.7279660 0.4667  
## site.IDSTRT -10739.61 11046.868 -0.9721856 0.3311  
## site.IDVAUL 32290.00 10913.946 2.9585996 0.0031  
## year 2.19 3.014 0.7249916 0.4685  
## site.IDFRCH:year 1.82 4.144 0.4401960 0.6598  
## site.IDMOOS:year 1.73 4.115 0.4209248 0.6739  
## site.IDPOKE:year -4.60 6.340 -0.7252596 0.4684  
## site.IDSTRT:year 5.34 5.469 0.9763819 0.3290  
## site.IDVAUL:year -15.85 5.403 -2.9334091 0.0034  
##   
## Correlation:   
## (Intr) st.IDFRCH st.IDMOOS st.IDPOKE st.IDSTRT st.IDVAUL  
## site.IDFRCH -0.727   
## site.IDMOOS -0.732 0.533   
## site.IDPOKE -0.475 0.346 0.348   
## site.IDSTRT -0.551 0.401 0.404 0.262   
## site.IDVAUL -0.558 0.406 0.408 0.265 0.307   
## year -1.000 0.727 0.732 0.475 0.551 0.558   
## site.IDFRCH:year 0.727 -1.000 -0.533 -0.346 -0.401 -0.406   
## site.IDMOOS:year 0.732 -0.533 -1.000 -0.348 -0.404 -0.408   
## site.IDPOKE:year 0.475 -0.346 -0.348 -1.000 -0.262 -0.265   
## site.IDSTRT:year 0.551 -0.401 -0.404 -0.262 -1.000 -0.307   
## site.IDVAUL:year 0.558 -0.406 -0.409 -0.265 -0.307 -1.000   
## year s.IDFRCH: s.IDMOOS: s.IDPOKE: s.IDSTRT:  
## site.IDFRCH   
## site.IDMOOS   
## site.IDPOKE   
## site.IDSTRT   
## site.IDVAUL   
## year   
## site.IDFRCH:year -0.727   
## site.IDMOOS:year -0.732 0.533   
## site.IDPOKE:year -0.475 0.346 0.348   
## site.IDSTRT:year -0.551 0.401 0.404 0.262   
## site.IDVAUL:year -0.558 0.406 0.409 0.265 0.307   
##   
## Standardized residuals:  
## Min Q1 Med Q3 Max   
## -3.8632025 -0.2231021 -0.0126838 0.2396526 6.2069423   
##   
## Residual standard error: 63.07071   
## Degrees of freedom: 2019 total; 2007 residual

Ecs <- residuals(SPC.mod.cs, type="normalized")  
I1 <- !is.na(mean\_daily$dailySPC)  
Efullc <- vector(length=length(mean\_daily$dailySPC))  
Efullc <- NA  
Efullc[I1] <- Ecs  
acf(Efullc, na.action=na.pass)



pacf(Efullc, na.action=na.pass)



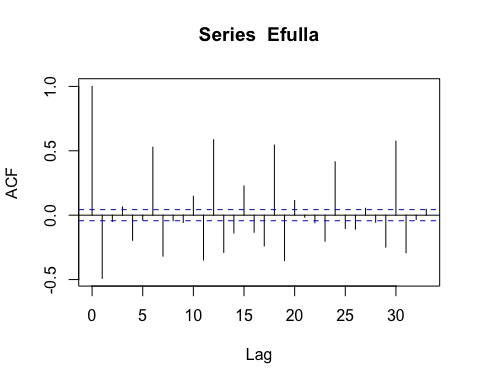
### CorAR1 structure

#errors structured as AR1  
SPC.mod.ar1 <- gls(dailySPC ~ site.ID\*year,   
 na.action = na.omit,   
 data = mean\_daily,   
 correlation = corAR1(form = ~ julian|site.ID/year))  
  
summary(SPC.mod.ar1) # Phi1 = 0.9749659 # AIC is 16750.35

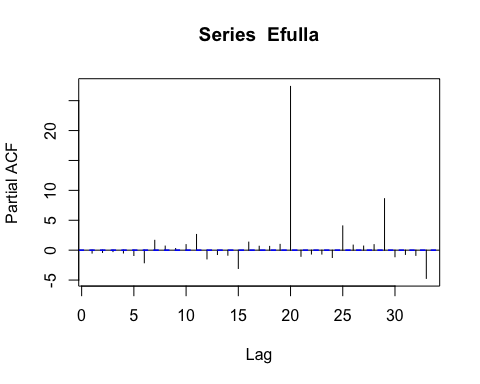
## Generalized least squares fit by REML  
## Model: dailySPC ~ site.ID \* year   
## Data: mean\_daily   
## AIC BIC logLik  
## 16750.35 16828.81 -8361.177  
##   
## Correlation Structure: ARMA(1,0)  
## Formula: ~julian | site.ID/year   
## Parameter estimate(s):  
## Phi1   
## 0.9749659   
##   
## Coefficients:  
## Value Std.Error t-value p-value  
## (Intercept) 369.77 40752.53 0.0090736 0.9928  
## site.IDFRCH -9135.22 57699.15 -0.1583250 0.8742  
## site.IDMOOS -11261.27 57416.84 -0.1961318 0.8445  
## site.IDPOKE -7289.02 80958.72 -0.0900338 0.9283  
## site.IDSTRT -17549.16 75840.74 -0.2313949 0.8170  
## site.IDVAUL -46810.33 75832.62 -0.6172849 0.5371  
## year -0.15 20.18 -0.0072335 0.9942  
## site.IDFRCH:year 4.53 28.57 0.1585253 0.8741  
## site.IDMOOS:year 5.60 28.43 0.1968247 0.8440  
## site.IDPOKE:year 3.63 40.08 0.0905055 0.9279  
## site.IDSTRT:year 8.71 37.55 0.2319872 0.8166  
## site.IDVAUL:year 23.31 37.54 0.6209398 0.5347  
##   
## Correlation:   
## (Intr) st.IDFRCH st.IDMOOS st.IDPOKE st.IDSTRT st.IDVAUL  
## site.IDFRCH -0.706   
## site.IDMOOS -0.710 0.501   
## site.IDPOKE -0.503 0.356 0.357   
## site.IDSTRT -0.537 0.380 0.381 0.270   
## site.IDVAUL -0.537 0.380 0.381 0.271 0.289   
## year -1.000 0.706 0.710 0.503 0.537 0.537   
## site.IDFRCH:year 0.706 -1.000 -0.501 -0.356 -0.380 -0.380   
## site.IDMOOS:year 0.710 -0.501 -1.000 -0.357 -0.381 -0.381   
## site.IDPOKE:year 0.503 -0.356 -0.357 -1.000 -0.271 -0.271   
## site.IDSTRT:year 0.537 -0.380 -0.381 -0.271 -1.000 -0.289   
## site.IDVAUL:year 0.537 -0.380 -0.381 -0.271 -0.289 -1.000   
## year s.IDFRCH: s.IDMOOS: s.IDPOKE: s.IDSTRT:  
## site.IDFRCH   
## site.IDMOOS   
## site.IDPOKE   
## site.IDSTRT   
## site.IDVAUL   
## year   
## site.IDFRCH:year -0.706   
## site.IDMOOS:year -0.710 0.501   
## site.IDPOKE:year -0.503 0.356 0.357   
## site.IDSTRT:year -0.537 0.380 0.381 0.271   
## site.IDVAUL:year -0.537 0.380 0.381 0.271 0.289   
##   
## Standardized residuals:  
## Min Q1 Med Q3 Max   
## -3.86889941 -0.23335187 -0.01955058 0.19940182 5.04694235   
##   
## Residual standard error: 68.71386   
## Degrees of freedom: 2019 total; 2007 residual

# ~t|g  
# t is the time covariate   
# g is the group factor and when a grouping factor is present in the form argument, the correlation structure is assumed to apply only to observations within the same grouping level and observations with different grouping levels are assumed to be uncorrelated

Ear1<-residuals(SPC.mod.ar1, type="normalized")  
I1<-!is.na(mean\_daily$dailySPC)  
Efulla<-vector(length = length(mean\_daily$dailySPC))  
Efulla<-NA  
Efulla[I1]<-Ear1  
acf(Efulla, na.action=na.pass)



pacf(Efulla, na.action=na.pass)



# turb simple model

turb.mod.gls <- gls(dailyTurb ~ site.ID\*year,   
 na.action = na.omit,   
 data = mean\_daily)  
summary(turb.mod.gls) # AIC is 21132.81

## Generalized least squares fit by REML  
## Model: dailyTurb ~ site.ID \* year   
## Data: mean\_daily   
## AIC BIC logLik  
## 21132.81 21205.75 -10553.41  
##   
## Coefficients:  
## Value Std.Error t-value p-value  
## (Intercept) 2294.729 4275.741 0.536686 0.5915  
## site.IDFRCH 6197.680 5837.428 1.061714 0.2885  
## site.IDMOOS 3306.893 5837.076 0.566532 0.5711  
## site.IDPOKE -6471.945 8985.983 -0.720227 0.4715  
## site.IDSTRT 5461.272 7745.901 0.705053 0.4809  
## site.IDVAUL -30553.768 7666.483 -3.985369 0.0001  
## year -1.132 2.117 -0.534911 0.5928  
## site.IDFRCH:year -3.059 2.890 -1.058296 0.2900  
## site.IDMOOS:year -1.627 2.890 -0.562920 0.5736  
## site.IDPOKE:year 3.206 4.449 0.720603 0.4712  
## site.IDSTRT:year -2.700 3.835 -0.704199 0.4814  
## site.IDVAUL:year 15.139 3.796 3.988640 0.0001  
##   
## Correlation:   
## (Intr) st.IDFRCH st.IDMOOS st.IDPOKE st.IDSTRT st.IDVAUL  
## site.IDFRCH -0.732   
## site.IDMOOS -0.733 0.537   
## site.IDPOKE -0.476 0.349 0.349   
## site.IDSTRT -0.552 0.404 0.404 0.263   
## site.IDVAUL -0.558 0.409 0.409 0.265 0.308   
## year -1.000 0.732 0.733 0.476 0.552 0.558   
## site.IDFRCH:year 0.732 -1.000 -0.537 -0.349 -0.404 -0.408   
## site.IDMOOS:year 0.733 -0.537 -1.000 -0.349 -0.404 -0.409   
## site.IDPOKE:year 0.476 -0.349 -0.349 -1.000 -0.263 -0.265   
## site.IDSTRT:year 0.552 -0.404 -0.404 -0.263 -1.000 -0.308   
## site.IDVAUL:year 0.558 -0.409 -0.409 -0.265 -0.308 -1.000   
## year s.IDFRCH: s.IDMOOS: s.IDPOKE: s.IDSTRT:  
## site.IDFRCH   
## site.IDMOOS   
## site.IDPOKE   
## site.IDSTRT   
## site.IDVAUL   
## year   
## site.IDFRCH:year -0.732   
## site.IDMOOS:year -0.733 0.537   
## site.IDPOKE:year -0.476 0.349 0.349   
## site.IDSTRT:year -0.552 0.404 0.404 0.263   
## site.IDVAUL:year -0.558 0.409 0.409 0.265 0.308   
##   
## Standardized residuals:  
## Min Q1 Med Q3 Max   
## -0.95440900 -0.33291259 -0.15258787 -0.03580911 15.49227183   
##   
## Residual standard error: 44.30391   
## Degrees of freedom: 2031 total; 2019 residual

#ACF plot function assumes no skipped time points. GLS removed missing values. Need to fill in the residual series to account for missing value  
E <- residuals(turb.mod.gls, type="normalized")  
I1 <- !is.na(mean\_daily$dailyTurb)  
Efull <- vector(length=length(mean\_daily$dailyTurb))  
Efull <- NA  
Efull[I1] <- E  
par(mfrow=c(2,1))  
acf(Efull, na.action=na.pass)  
pacf(Efull, na.action=na.pass)

A picture containing text, device, screenshot

Description automatically generatedChart

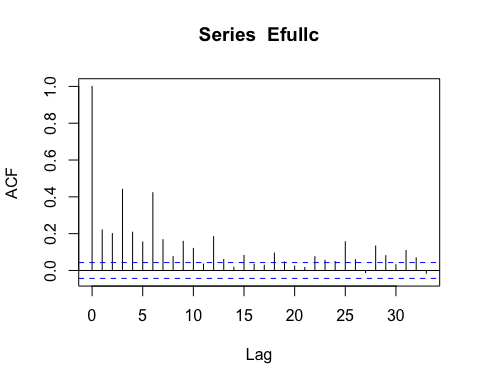
Description automatically generated

## Compound symmetry

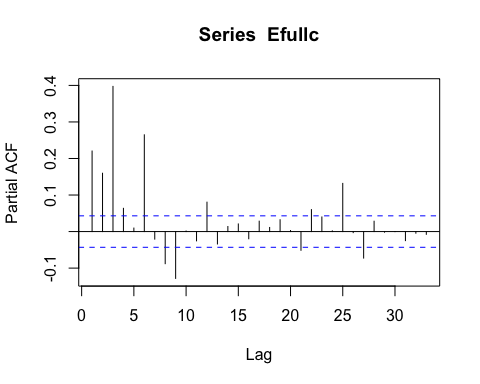
## Compound symmetry  
turb.mod.cs <- gls(dailyTurb ~ site.ID\*year,   
 na.action = na.omit,   
 data = mean\_daily,   
 correlation = corCompSymm(form = ~ julian))  
  
summary(turb.mod.cs) # covariance 0 # AIC is 21134.81

## Generalized least squares fit by REML  
## Model: dailyTurb ~ site.ID \* year   
## Data: mean\_daily   
## AIC BIC logLik  
## 21134.81 21213.36 -10553.41  
##   
## Correlation Structure: Compound symmetry  
## Formula: ~julian   
## Parameter estimate(s):  
## Rho   
## 0   
##   
## Coefficients:  
## Value Std.Error t-value p-value  
## (Intercept) 2294.729 4275.741 0.536686 0.5915  
## site.IDFRCH 6197.680 5837.428 1.061714 0.2885  
## site.IDMOOS 3306.893 5837.076 0.566532 0.5711  
## site.IDPOKE -6471.945 8985.983 -0.720227 0.4715  
## site.IDSTRT 5461.272 7745.901 0.705053 0.4809  
## site.IDVAUL -30553.768 7666.483 -3.985369 0.0001  
## year -1.132 2.117 -0.534911 0.5928  
## site.IDFRCH:year -3.059 2.890 -1.058296 0.2900  
## site.IDMOOS:year -1.627 2.890 -0.562920 0.5736  
## site.IDPOKE:year 3.206 4.449 0.720603 0.4712  
## site.IDSTRT:year -2.700 3.835 -0.704199 0.4814  
## site.IDVAUL:year 15.139 3.796 3.988640 0.0001  
##   
## Correlation:   
## (Intr) st.IDFRCH st.IDMOOS st.IDPOKE st.IDSTRT st.IDVAUL  
## site.IDFRCH -0.732   
## site.IDMOOS -0.733 0.537   
## site.IDPOKE -0.476 0.349 0.349   
## site.IDSTRT -0.552 0.404 0.404 0.263   
## site.IDVAUL -0.558 0.409 0.409 0.265 0.308   
## year -1.000 0.732 0.733 0.476 0.552 0.558   
## site.IDFRCH:year 0.732 -1.000 -0.537 -0.349 -0.404 -0.408   
## site.IDMOOS:year 0.733 -0.537 -1.000 -0.349 -0.404 -0.409   
## site.IDPOKE:year 0.476 -0.349 -0.349 -1.000 -0.263 -0.265   
## site.IDSTRT:year 0.552 -0.404 -0.404 -0.263 -1.000 -0.308   
## site.IDVAUL:year 0.558 -0.409 -0.409 -0.265 -0.308 -1.000   
## year s.IDFRCH: s.IDMOOS: s.IDPOKE: s.IDSTRT:  
## site.IDFRCH   
## site.IDMOOS   
## site.IDPOKE   
## site.IDSTRT   
## site.IDVAUL   
## year   
## site.IDFRCH:year -0.732   
## site.IDMOOS:year -0.733 0.537   
## site.IDPOKE:year -0.476 0.349 0.349   
## site.IDSTRT:year -0.552 0.404 0.404 0.263   
## site.IDVAUL:year -0.558 0.409 0.409 0.265 0.308   
##   
## Standardized residuals:  
## Min Q1 Med Q3 Max   
## -0.95440900 -0.33291259 -0.15258787 -0.03580911 15.49227183   
##   
## Residual standard error: 44.30391   
## Degrees of freedom: 2031 total; 2019 residual

Ecs <- residuals(turb.mod.cs, type="normalized")  
I1 <- !is.na(mean\_daily$dailyTurb)  
Efullc <- vector(length=length(mean\_daily$dailyTurb))  
Efullc <- NA  
Efullc[I1] <- Ecs  
acf(Efullc, na.action=na.pass)



pacf(Efullc, na.action=na.pass)



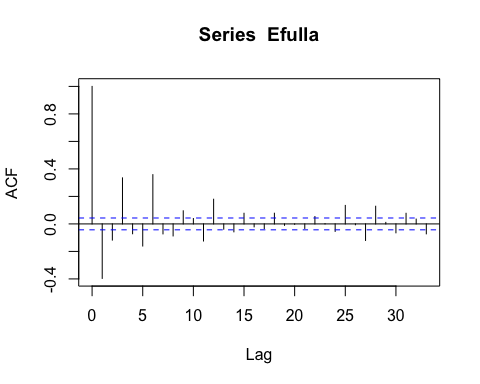
### CorAR1 structure

#errors structured as AR1  
turb.mod.ar1 <- gls(dailyTurb ~ site.ID\*year,   
 na.action = na.omit,   
 data = mean\_daily,   
 correlation = corAR1(form = ~ julian|site.ID/year))  
  
summary(turb.mod.ar1) # Phi1 = 0.6012503 # AIC is 20226.75

## Generalized least squares fit by REML  
## Model: dailyTurb ~ site.ID \* year   
## Data: mean\_daily   
## AIC BIC logLik  
## 20226.75 20305.29 -10099.37  
##   
## Correlation Structure: ARMA(1,0)  
## Formula: ~julian | site.ID/year   
## Parameter estimate(s):  
## Phi1   
## 0.6012503   
##   
## Coefficients:  
## Value Std.Error t-value p-value  
## (Intercept) 1656.175 8301.739 0.1994974 0.8419  
## site.IDFRCH 6987.731 11390.256 0.6134832 0.5396  
## site.IDMOOS 4065.402 11382.368 0.3571667 0.7210  
## site.IDPOKE -5144.451 17240.972 -0.2983852 0.7654  
## site.IDSTRT 5461.033 15057.765 0.3626722 0.7169  
## site.IDVAUL -27932.387 14891.978 -1.8756667 0.0608  
## year -0.816 4.111 -0.1986023 0.8426  
## site.IDFRCH:year -3.450 5.640 -0.6117574 0.5408  
## site.IDMOOS:year -2.003 5.636 -0.3553228 0.7224  
## site.IDPOKE:year 2.549 8.536 0.2985742 0.7653  
## site.IDSTRT:year -2.700 7.455 -0.3622375 0.7172  
## site.IDVAUL:year 13.841 7.373 1.8773330 0.0606  
##   
## Correlation:   
## (Intr) st.IDFRCH st.IDMOOS st.IDPOKE st.IDSTRT st.IDVAUL  
## site.IDFRCH -0.729   
## site.IDMOOS -0.729 0.532   
## site.IDPOKE -0.482 0.351 0.351   
## site.IDSTRT -0.551 0.402 0.402 0.265   
## site.IDVAUL -0.557 0.406 0.407 0.268 0.307   
## year -1.000 0.729 0.729 0.482 0.551 0.557   
## site.IDFRCH:year 0.729 -1.000 -0.532 -0.351 -0.402 -0.406   
## site.IDMOOS:year 0.729 -0.532 -1.000 -0.351 -0.402 -0.407   
## site.IDPOKE:year 0.482 -0.351 -0.351 -1.000 -0.265 -0.268   
## site.IDSTRT:year 0.551 -0.402 -0.402 -0.266 -1.000 -0.307   
## site.IDVAUL:year 0.558 -0.406 -0.407 -0.268 -0.307 -1.000   
## year s.IDFRCH: s.IDMOOS: s.IDPOKE: s.IDSTRT:  
## site.IDFRCH   
## site.IDMOOS   
## site.IDPOKE   
## site.IDSTRT   
## site.IDVAUL   
## year   
## site.IDFRCH:year -0.729   
## site.IDMOOS:year -0.729 0.532   
## site.IDPOKE:year -0.482 0.351 0.351   
## site.IDSTRT:year -0.551 0.402 0.402 0.266   
## site.IDVAUL:year -0.558 0.406 0.407 0.268 0.307   
##   
## Standardized residuals:  
## Min Q1 Med Q3 Max   
## -0.92179050 -0.33002405 -0.14450159 -0.03262132 15.49850064   
##   
## Residual standard error: 44.32925   
## Degrees of freedom: 2031 total; 2019 residual

# ~t|g  
# t is the time covariate   
# g is the group factor and when a grouping factor is present in the form argument, the correlation structure is assumed to apply only to observations within the same grouping level and observations with different grouping levels are assumed to be uncorrelated

Ear1<-residuals(turb.mod.ar1, type="normalized")  
I1<-!is.na(mean\_daily$dailyTurb)  
Efulla<-vector(length = length(mean\_daily$dailyTurb))  
Efulla<-NA  
Efulla[I1]<-Ear1  
acf(Efulla, na.action=na.pass)



pacf(Efulla, na.action=na.pass)

