Clase 16 de mayo

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```
library(faux)
```

```
## Warning: package 'faux' was built under R version 4.1.3
```

```
##
## ************
## Welcome to faux. For support and examples visit:
## https://debruine.github.io/faux/
## - Get and set global package options with: faux_options()
## ************
```

```
set.seed(123)
df <- rnorm_multi(n = 120,
            mu = c(7, 100),
            sd = c(1.5, 25),
            varnames = c('DE', 'DDF'),
            r = 0.7)
```

Modelo

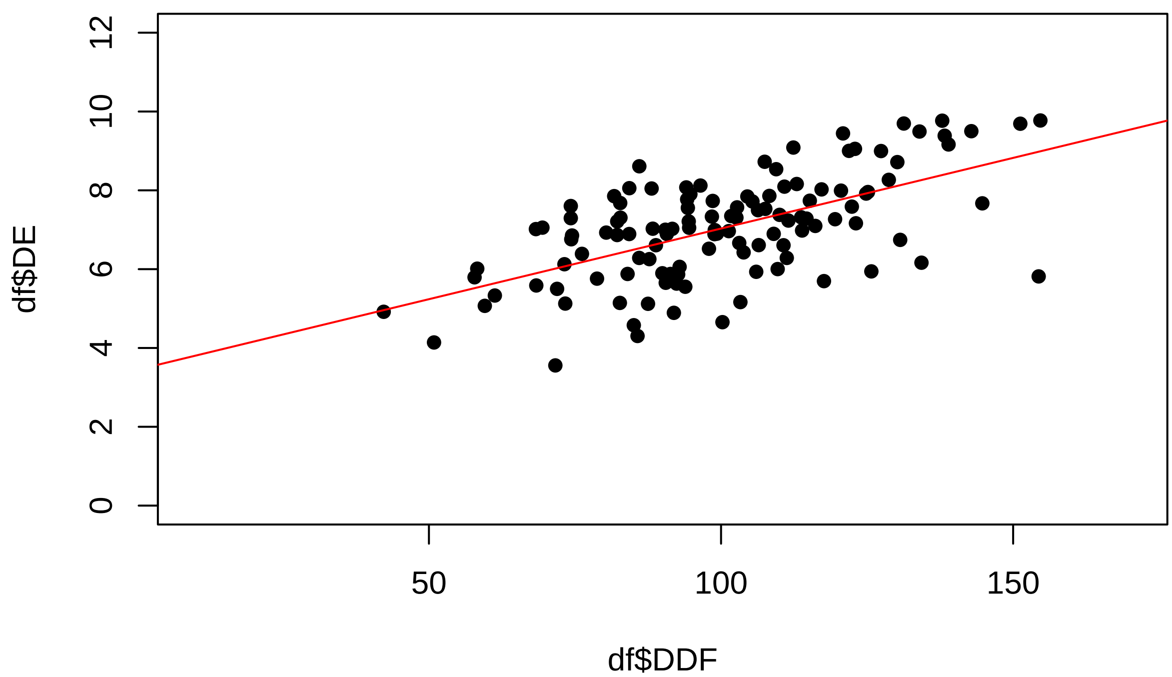
```
mod_lm <- lm(DE ~ DDF, data = df)
summary(mod_lm)
```

```
##
## Call:
## lm(formula = DE ~ DDF, data = df)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -3.1641 -0.5972  0.1889  0.7415  2.0820
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept) 3.444790   0.441990   7.794 2.83e-12 ***
## DDF         0.035857   0.004298   8.342 1.57e-13 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
```

```
## Residual standard error: 1.049 on 118 degrees of freedom
## Multiple R-squared:  0.371,  Adjusted R-squared:  0.3656
## F-statistic: 69.59 on 1 and 118 DF,  p-value: 1.573e-13
```

$$Y_{DE} = 3.444 + 0.036X$$

```
plot(df$DDF, df$DE, pch = 16, ylim = c(0,12), xlim = c(10,170))
abline(mod_lm, col = 'red')
```



Funcion que permite calcular el intercepto

```
fab <- function(x, y){
  n <- length(x) # Largo de x -> n
  b <- (sum(x * y) - n * mean(x) * mean(y)) / (sum(x**2) - n * (mean(x))**2)
  a <- mean(y) - b * mean(x)
  return(data.frame(Intercepto = a, Pendiente = b))
}
```

```
fab(df$DDF, df$DE)
```

```
##   Intercepto  Pendiente
## 1    3.44479 0.03585671
```

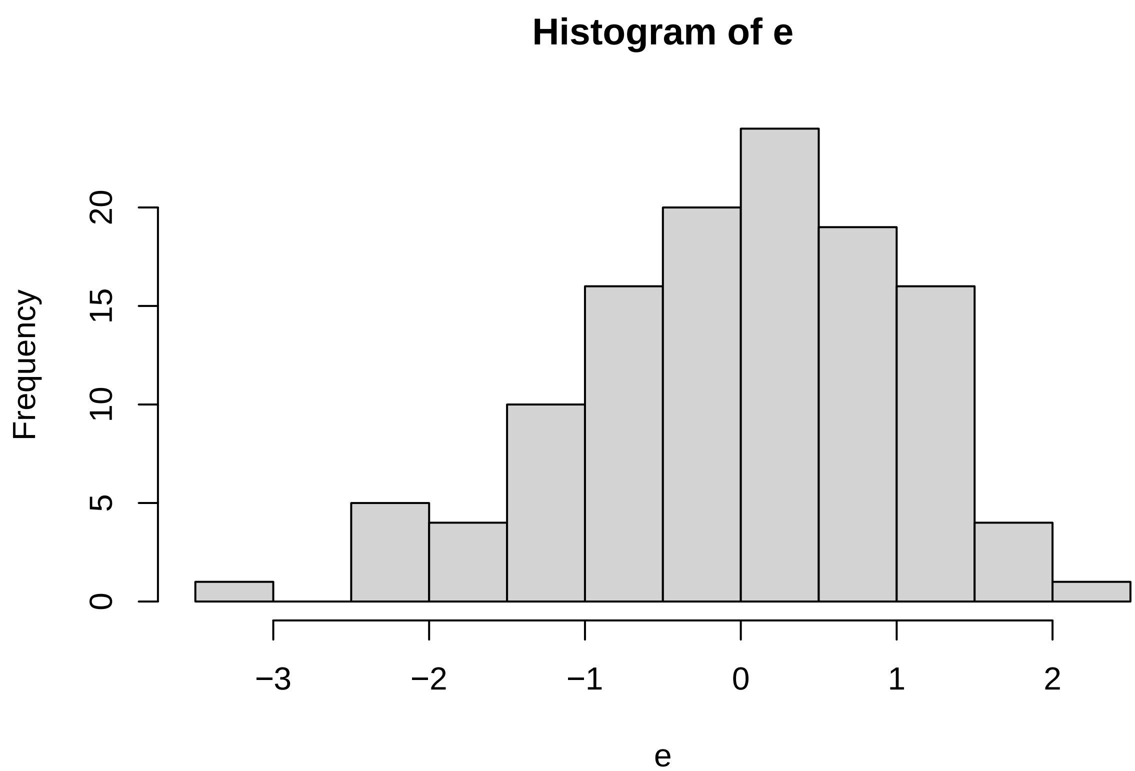
```r
e <- mod_lm$residuals; sum(e)
```

```
## [1] 1.814521e-15
```

```r
S <- sum(e**2); S
```

```
## [1] 129.7903
```

```r
hist(e)
```



Pruebas de normalidad

```r
shapiro.test(e)
```

```
##
##  Shapiro-Wilk normality test
##
## data:  e
## W = 0.9737, p-value = 0.01876
```

```r
nortest::sf.test(e)
```

```
##
##  Shapiro-Francia normality test
##
## data:  e
## W = 0.97495, p-value = 0.02561
```

```r
nortest::ad.test(e)
```

```
##
##  Anderson-Darling normality test
##
## data:  e
## A = 0.78207, p-value = 0.04124
```

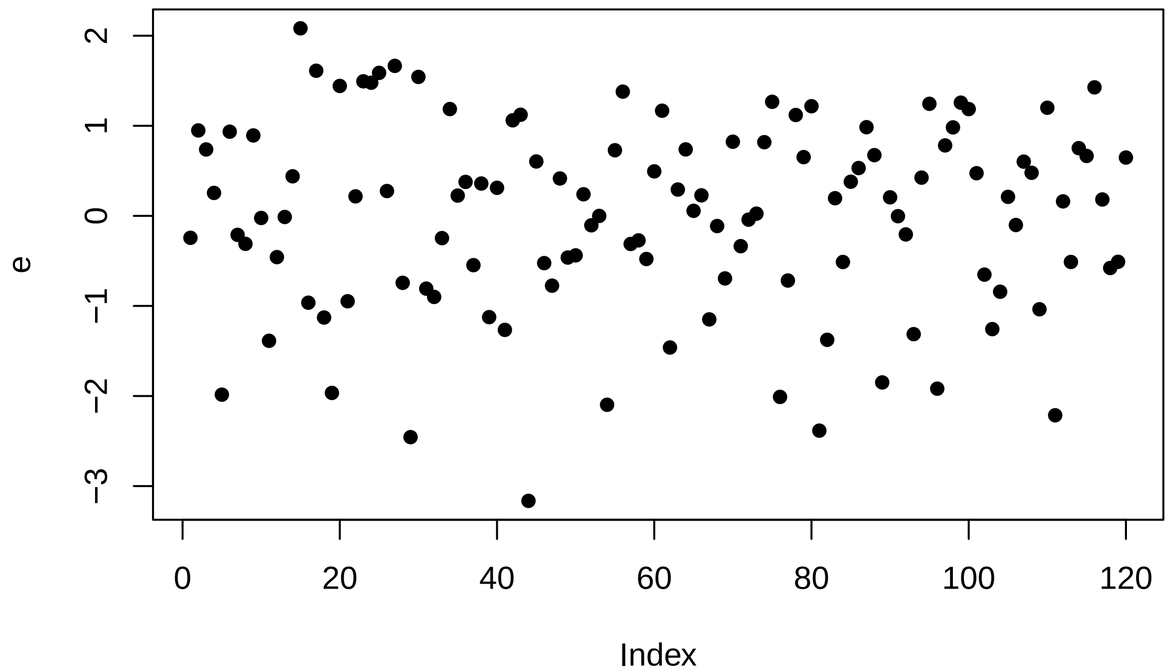
```r
nortest::cvm.test(e) # Check
```

```
##
##  Cramer-von Mises normality test
##
## data:  e
## W = 0.10993, p-value = 0.08105
```

Homoseasticidad

Revisando homogeniedad de varianzas

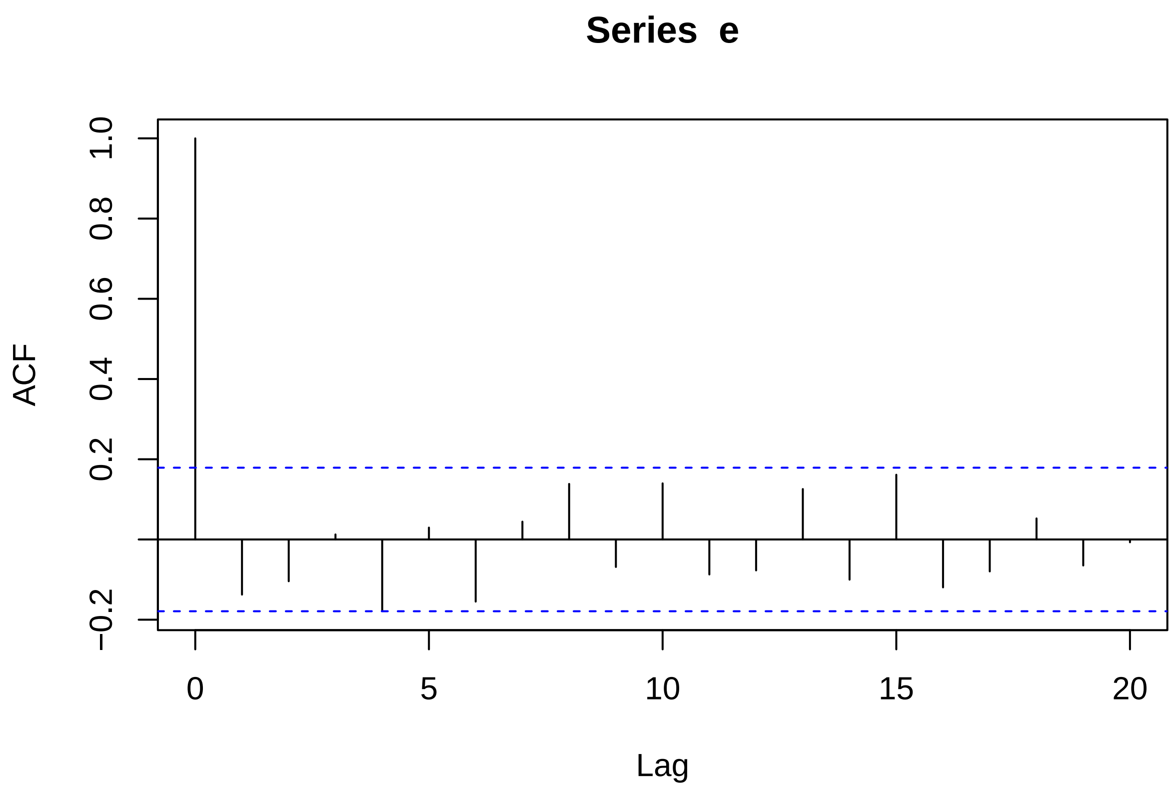
```r
plot(e, pch = 16)
```



Revisando el supuesto de independencia (Temporal)

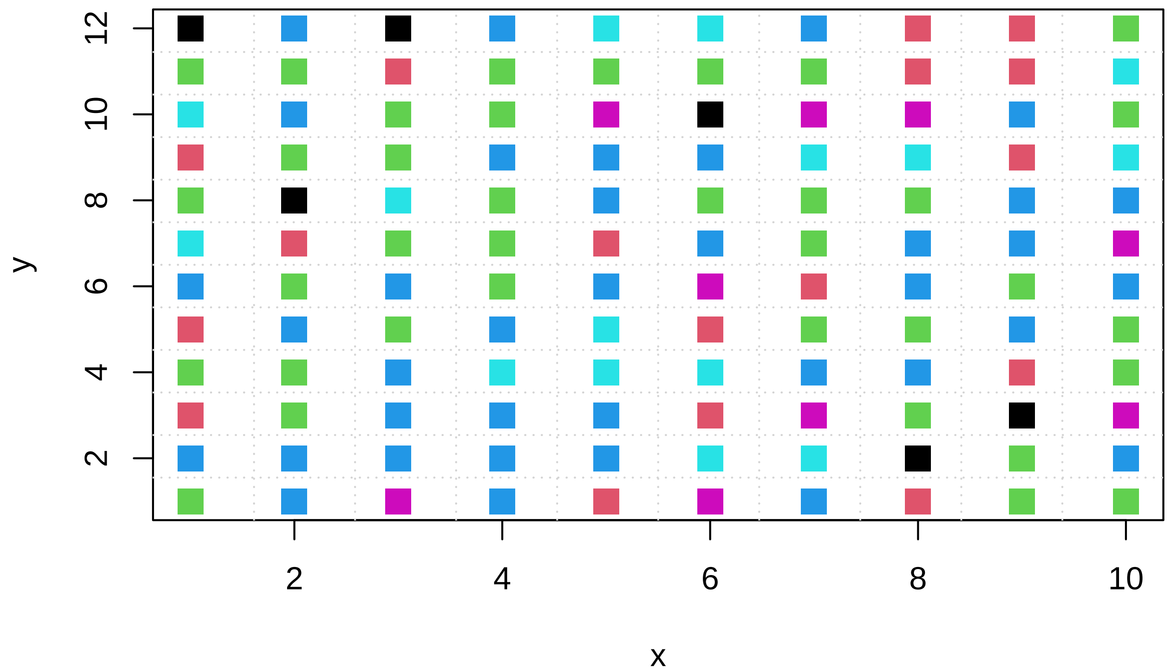
función de autocorrelación

```
acf(e)
```

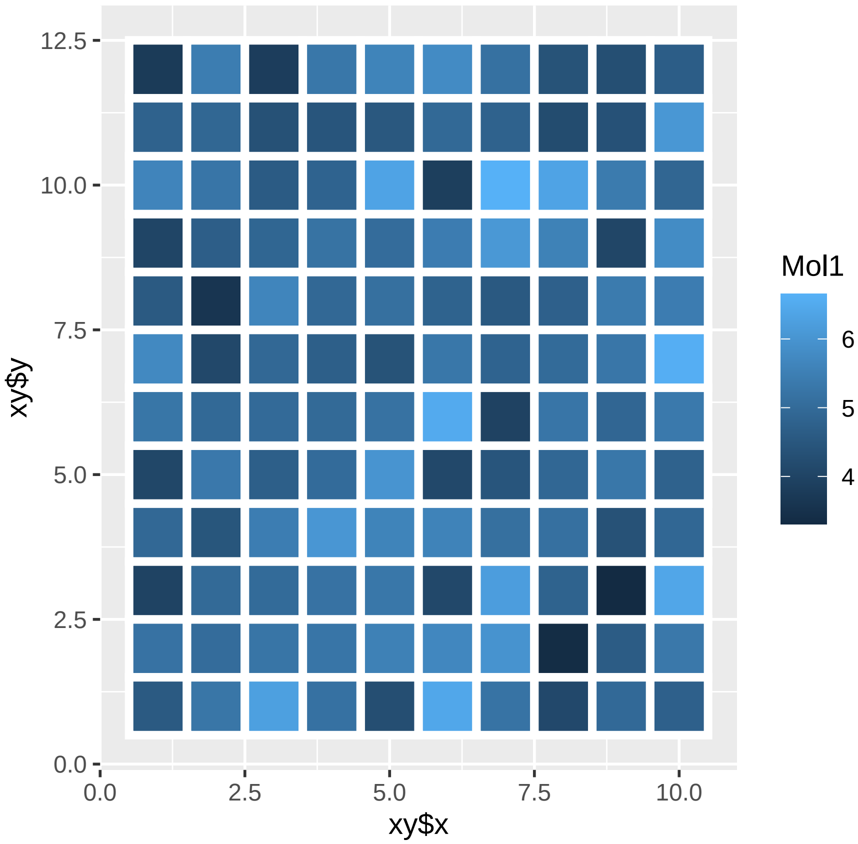



```
library(faux)
set.seed(123)
df2 <- rnorm_multi(n = 120,
            mu = c(5, 10),
            sd = c(0.8, 1.2),
            varnames = c('Mol1', 'Mol2'),
            r = 0.7)

df2$Mol3 <- sort(df2$Mol2)
df2$Accesion <- sample(gl(3,40,120, labels = c('A1', 'A2', 'A3')))
```

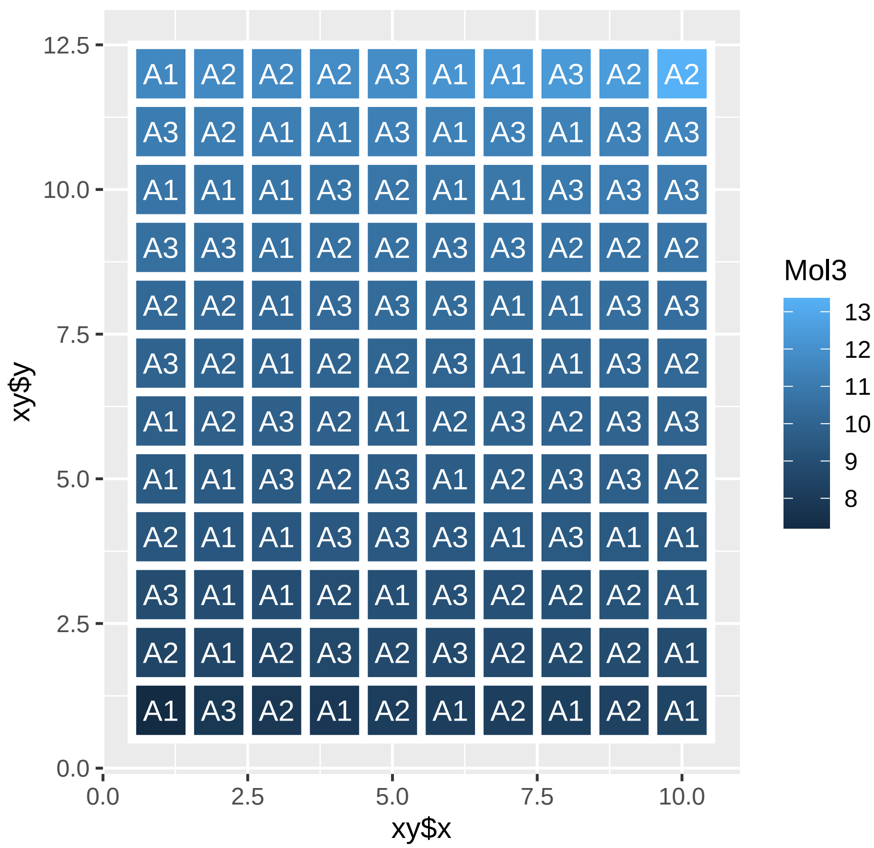
```
xy <- expand.grid(x = seq(1,10),
                  y = seq(1,12))
color = cut(df2$Mol1, breaks = 6)
plot(xy, pch = 15, col = color, cex = 1.8)
grid(10,12)
```




```
library(ggplot2)

ggplot(df2, aes(x = xy$x, y = xy$y, fill = Mol1)) +
  geom_tile(color = "white",
            lwd = 1.5,
            linetype = 1) +
  coord_fixed()
```




```
library(ggplot2)

ggplot(df2, aes(x = xy$x, y = xy$y, fill = Mol3)) +
  geom_tile(color = "white",
            lwd = 1.5,
            linetype = 1) +
  geom_text(aes(label = Accesion), color = "white", size = 4)+
  coord_fixed()
```



$$H_0 : \mu_{A1} = \mu_{A2} = \mu_{A3} H_a : At\ least\ one\ is\ different$$

Análisis de varianza

```
mod_aov <- aov(Mol3 ~ Accesion, data = df2)
aa <-summary(mod_aov)
ifelse(aa[[1]][1,5] < 0.05, 'Rechazo Ho', 'No rechazo Ho')
```

```
## [1] "No rechazo Ho"
```

```
dist_matrix <- as.matrix(dist(cbind(xy$x,xy$y)))
dim(dist_matrix)
```

```
## [1] 120 120
```

```
inv_matrix <- 1/dist_matrix
diag(inv_matrix) <- 0
head(inv_matrix)
```

```
##           1         2         3         4         5         6         7
## 1 0.0000000 1.0000000 0.5000000 0.3333333 0.2500000 0.2000000 0.1666667
```

```
## 2 1.0000000 0.0000000 1.0000000 0.5000000 0.3333333 0.2500000 0.2000000
## 3 0.5000000 1.0000000 0.0000000 1.0000000 0.5000000 0.3333333 0.2500000
## 4 0.3333333 0.5000000 1.0000000 0.0000000 1.0000000 0.5000000 0.3333333
## 5 0.2500000 0.3333333 0.5000000 1.0000000 0.0000000 1.0000000 0.5000000
## 6 0.2000000 0.2500000 0.3333333 0.5000000 1.0000000 0.0000000 1.0000000
##           8         9        10        11        12        13        14
## 1 0.1428571 0.1250000 0.1111111 1.0000000 0.7071068 0.4472136 0.3162278
## 2 0.1666667 0.1428571 0.1250000 0.7071068 1.0000000 0.7071068 0.4472136
## 3 0.2000000 0.1666667 0.1428571 0.4472136 0.7071068 1.0000000 0.7071068
## 4 0.2500000 0.2000000 0.1666667 0.3162278 0.4472136 0.7071068 1.0000000
## 5 0.3333333 0.2500000 0.2000000 0.2425356 0.3162278 0.4472136 0.7071068
## 6 0.5000000 0.3333333 0.2500000 0.1961161 0.2425356 0.3162278 0.4472136
##          15        16        17        18        19        20        21
## 1 0.2425356 0.1961161 0.1643990 0.1414214 0.1240347 0.1104315 0.5000000
## 2 0.3162278 0.2425356 0.1961161 0.1643990 0.1414214 0.1240347 0.4472136
## 3 0.4472136 0.3162278 0.2425356 0.1961161 0.1643990 0.1414214 0.3535534
## 4 0.7071068 0.4472136 0.3162278 0.2425356 0.1961161 0.1643990 0.2773501
## 5 1.0000000 0.7071068 0.4472136 0.3162278 0.2425356 0.1961161 0.2236068
## 6 0.7071068 1.0000000 0.7071068 0.4472136 0.3162278 0.2425356 0.1856953
##          22        23        24        25        26        27        28
## 1 0.4472136 0.3535534 0.2773501 0.2236068 0.1856953 0.1581139 0.1373606
## 2 0.5000000 0.4472136 0.3535534 0.2773501 0.2236068 0.1856953 0.1581139
## 3 0.4472136 0.5000000 0.4472136 0.3535534 0.2773501 0.2236068 0.1856953
## 4 0.3535534 0.4472136 0.5000000 0.4472136 0.3535534 0.2773501 0.2236068
## 5 0.2773501 0.3535534 0.4472136 0.5000000 0.4472136 0.3535534 0.2773501
## 6 0.2236068 0.2773501 0.3535534 0.4472136 0.5000000 0.4472136 0.3535534
##          29        30        31        32        33        34        35
## 1 0.1212678 0.1084652 0.3333333 0.3162278 0.2773501 0.2357023 0.2000000
## 2 0.1373606 0.1212678 0.3162278 0.3333333 0.3162278 0.2773501 0.2357023
## 3 0.1581139 0.1373606 0.2773501 0.3162278 0.3333333 0.3162278 0.2773501
## 4 0.1856953 0.1581139 0.2357023 0.2773501 0.3162278 0.3333333 0.3162278
## 5 0.2236068 0.1856953 0.2000000 0.2357023 0.2773501 0.3162278 0.3333333
## 6 0.2773501 0.2236068 0.1714986 0.2000000 0.2357023 0.2773501 0.3162278
##          36        37        38        39        40        41        42
## 1 0.1714986 0.1490712 0.1313064 0.1170411 0.1054093 0.2500000 0.2425356
## 2 0.2000000 0.1714986 0.1490712 0.1313064 0.1170411 0.2425356 0.2500000
## 3 0.2357023 0.2000000 0.1714986 0.1490712 0.1313064 0.2236068 0.2425356
## 4 0.2773501 0.2357023 0.2000000 0.1714986 0.1490712 0.2000000 0.2236068
## 5 0.3162278 0.2773501 0.2357023 0.2000000 0.1714986 0.1767767 0.2000000
## 6 0.3333333 0.3162278 0.2773501 0.2357023 0.2000000 0.1561738 0.1767767
##          43        44        45        46        47        48        49
## 1 0.2236068 0.2000000 0.1767767 0.1561738 0.1386750 0.1240347 0.1118034
## 2 0.2425356 0.2236068 0.2000000 0.1767767 0.1561738 0.1386750 0.1240347
## 3 0.2500000 0.2425356 0.2236068 0.2000000 0.1767767 0.1561738 0.1386750
## 4 0.2425356 0.2500000 0.2425356 0.2236068 0.2000000 0.1767767 0.1561738
## 5 0.2236068 0.2425356 0.2500000 0.2425356 0.2236068 0.2000000 0.1767767
## 6 0.2000000 0.2236068 0.2425356 0.2500000 0.2425356 0.2236068 0.2000000
##          50        51        52        53        54        55        56
## 1 0.1015346 0.2000000 0.1961161 0.1856953 0.1714986 0.1561738 0.1414214
## 2 0.1118034 0.1961161 0.2000000 0.1961161 0.1856953 0.1714986 0.1561738
## 3 0.1240347 0.1856953 0.1961161 0.2000000 0.1961161 0.1856953 0.1714986
## 4 0.1386750 0.1714986 0.1856953 0.1961161 0.2000000 0.1961161 0.1856953
## 5 0.1561738 0.1561738 0.1714986 0.1856953 0.1961161 0.2000000 0.1961161
## 6 0.1767767 0.1414214 0.1561738 0.1714986 0.1856953 0.1961161 0.2000000
```

```
##          57        58        59         60        61        62        63
## 1 0.1280369 0.1162476 0.1059998 0.09712859 0.1666667 0.1643990 0.1581139
## 2 0.1414214 0.1280369 0.1162476 0.10599979 0.1643990 0.1666667 0.1643990
## 3 0.1561738 0.1414214 0.1280369 0.11624764 0.1581139 0.1643990 0.1666667
## 4 0.1714986 0.1561738 0.1414214 0.12803688 0.1490712 0.1581139 0.1643990
## 5 0.1856953 0.1714986 0.1561738 0.14142136 0.1386750 0.1490712 0.1581139
## 6 0.1961161 0.1856953 0.1714986 0.15617376 0.1280369 0.1386750 0.1490712
##          64        65        66        67        68        69         70
## 1 0.1490712 0.1386750 0.1280369 0.1178511 0.1084652 0.1000000 0.09245003
## 2 0.1581139 0.1490712 0.1386750 0.1280369 0.1178511 0.1084652 0.10000000
## 3 0.1643990 0.1581139 0.1490712 0.1386750 0.1280369 0.1178511 0.10846523
## 4 0.1666667 0.1643990 0.1581139 0.1490712 0.1386750 0.1280369 0.11785113
## 5 0.1643990 0.1666667 0.1643990 0.1581139 0.1490712 0.1386750 0.12803688
## 6 0.1581139 0.1643990 0.1666667 0.1643990 0.1581139 0.1490712 0.13867505
##          71        72        73        74        75        76        77
## 1 0.1428571 0.1414214 0.1373606 0.1313064 0.1240347 0.1162476 0.1084652
## 2 0.1414214 0.1428571 0.1414214 0.1373606 0.1313064 0.1240347 0.1162476
## 3 0.1373606 0.1414214 0.1428571 0.1414214 0.1373606 0.1313064 0.1240347
## 4 0.1313064 0.1373606 0.1414214 0.1428571 0.1414214 0.1373606 0.1313064
## 5 0.1240347 0.1313064 0.1373606 0.1414214 0.1428571 0.1414214 0.1373606
## 6 0.1162476 0.1240347 0.1313064 0.1373606 0.1414214 0.1428571 0.1414214
##          78         79         80        81        82        83        84
## 1 0.1010153 0.09407209 0.08770580 0.1250000 0.1240347 0.1212678 0.1170411
## 2 0.1084652 0.10101525 0.09407209 0.1240347 0.1250000 0.1240347 0.1212678
## 3 0.1162476 0.10846523 0.10101525 0.1212678 0.1240347 0.1250000 0.1240347
## 4 0.1240347 0.11624764 0.10846523 0.1170411 0.1212678 0.1240347 0.1250000
## 5 0.1313064 0.12403473 0.11624764 0.1118034 0.1170411 0.1212678 0.1240347
## 6 0.1373606 0.13130643 0.12403473 0.1059998 0.1118034 0.1170411 0.1212678
##          85        86        87         88         89         90         91
## 1 0.1118034 0.1059998 0.1000000 0.09407209 0.08838835 0.08304548 0.11111111
## 2 0.1170411 0.1118034 0.1059998 0.10000000 0.09407209 0.08838835 0.11043153
## 3 0.1212678 0.1170411 0.1118034 0.10599979 0.10000000 0.09407209 0.10846523
## 4 0.1240347 0.1212678 0.1170411 0.11180340 0.10599979 0.10000000 0.10540926
## 5 0.1250000 0.1240347 0.1212678 0.11704115 0.11180340 0.10599979 0.10153462
## 6 0.1240347 0.1250000 0.1240347 0.12126781 0.11704115 0.11180340 0.09712859
##          92        93        94        95         96         97         98
## 1 0.1104315 0.1084652 0.1054093 0.1015346 0.09712859 0.09245003 0.08770580
## 2 0.1111111 0.1104315 0.1084652 0.1054093 0.10153462 0.09712859 0.09245003
## 3 0.1104315 0.1111111 0.1104315 0.1084652 0.10540926 0.10153462 0.09712859
## 4 0.1084652 0.1104315 0.1111111 0.1104315 0.10846523 0.10540926 0.10153462
## 5 0.1054093 0.1084652 0.1104315 0.1111111 0.11043153 0.10846523 0.10540926
## 6 0.1015346 0.1054093 0.1084652 0.1104315 0.11111111 0.11043153 0.10846523
##           99        100        101        102        103        104        105
## 1 0.08304548 0.07856742 0.10000000 0.09950372 0.09805807 0.09578263 0.09284767
## 2 0.08770580 0.08304548 0.09950372 0.10000000 0.09950372 0.09805807 0.09578263
## 3 0.09245003 0.08770580 0.09805807 0.09950372 0.10000000 0.09950372 0.09805807
## 4 0.09712859 0.09245003 0.09578263 0.09805807 0.09950372 0.10000000 0.09950372
## 5 0.10153462 0.09712859 0.09284767 0.09578263 0.09805807 0.09950372 0.10000000
## 6 0.10540926 0.10153462 0.08944272 0.09284767 0.09578263 0.09805807 0.09950372
##          106        107        108        109        110        111        112
## 1 0.08944272 0.08574929 0.08192319 0.07808688 0.07432941 0.09090909 0.09053575
## 2 0.09284767 0.08944272 0.08574929 0.08192319 0.07808688 0.09053575 0.09090909
## 3 0.09578263 0.09284767 0.08944272 0.08574929 0.08192319 0.08944272 0.09053575
## 4 0.09805807 0.09578263 0.09284767 0.08944272 0.08574929 0.08770580 0.08944272
```

```
## 5 0.09950372 0.09805807 0.09578263 0.09284767 0.08944272 0.08543577 0.08770580
## 6 0.10000000 0.09950372 0.09805807 0.09578263 0.09284767 0.08276059 0.08543577
##          113        114        115        116        117        118        119
## 1 0.08944272 0.08770580 0.08543577 0.08276059 0.07980869 0.07669650 0.07352146
## 2 0.09053575 0.08944272 0.08770580 0.08543577 0.08276059 0.07980869 0.07669650
## 3 0.09090909 0.09053575 0.08944272 0.08770580 0.08543577 0.08276059 0.07980869
## 4 0.09053575 0.09090909 0.09053575 0.08944272 0.08770580 0.08543577 0.08276059
## 5 0.08944272 0.09053575 0.09090909 0.09053575 0.08944272 0.08770580 0.08543577
## 6 0.08770580 0.08944272 0.09053575 0.09090909 0.09053575 0.08944272 0.08770580
##          120
## 1 0.07035975
## 2 0.07352146
## 3 0.07669650
## 4 0.07980869
## 5 0.08276059
## 6 0.08543577
```

```
ape::Moran.I(mod_aov$residuals, inv_matrix)
```

```
## $observed
## [1] 0.3257745
##
## $expected
## [1] -0.008403361
##
## $sd
## [1] 0.009053756
##
## $p.value
## [1] 0
```

continuando... con los modelos de regresión espacial

Modelo autorregresivo puro

```
library(spatialreg)
```

```
## Warning: package 'spatialreg' was built under R version 4.1.3
```

```
## Loading required package: spData
```

```
## Warning: package 'spData' was built under R version 4.1.3
```

```
## To access larger datasets in this package, install the spDataLarge
## package with: `install.packages('spDataLarge',
## repos='https://nowosad.github.io/drat/', type='source')`
```

```
## Loading required package: Matrix
```

```
## Loading required package: sf
```

```
## Warning: package 'sf' was built under R version 4.1.3

## Linking to GEOS 3.9.1, GDAL 3.2.1, PROJ 7.2.1; sf_use_s2() is TRUE

## Registered S3 method overwritten by 'spdep':
##   method   from
##   plot.mst ape
```

```
library(spdep)
```

```
## Warning: package 'spdep' was built under R version 4.1.3

## Loading required package: sp

## Warning: package 'sp' was built under R version 4.1.3

##
## Attaching package: 'spdep'

## The following objects are masked from 'package:spatialreg':
##
##     get.ClusterOption, get.coresOption, get.mcOption,
##     get.VerboseOption, get.ZeroPolicyOption, set.ClusterOption,
##     set.coresOption, set.mcOption, set.VerboseOption,
##     set.ZeroPolicyOption
```

```
library(sp)
XY <- as.matrix(xy)
contnb <- dnearneigh(coordinates(XY),0,380000,longlat = F)
dlist <- nbdists(contnb, XY)
dlist <- lapply(dlist, function(x) 1/x)
Wve <- nb2listw(contnb,glist=dlist,style = "W")
mod_map <- spautolm(Mol3 ~ 1, data = df2, listw = Wve)
summary(mod_map)
```

```
##
## Call: spautolm(formula = Mol3 ~ 1, data = df2, listw = Wve)
##
## Residuals:
##       Min        1Q    Median        3Q       Max
## -2.310980 -0.344036 -0.018235  0.370445  2.842945
##
## Coefficients:
##             Estimate Std. Error z value Pr(>|z|)
## (Intercept)  10.1932     3.8049   2.679 0.007385
##
## Lambda: 0.98197 LR test value: 85.62 p-value: < 2.22e-16
## Numerical Hessian standard error of lambda: 0.018086
##
## Log likelihood: -139.3803
## ML residual variance (sigma squared): 0.56491, (sigma: 0.75161)
## Number of observations: 120
## Number of parameters estimated: 3
## AIC: 284.76
```

$$Y_{Mol3} = \alpha + \lambda WY + \epsilon$$

$$Y_{Mol3} = 10.1932 + 0.98197 WY_{Mol3}$$

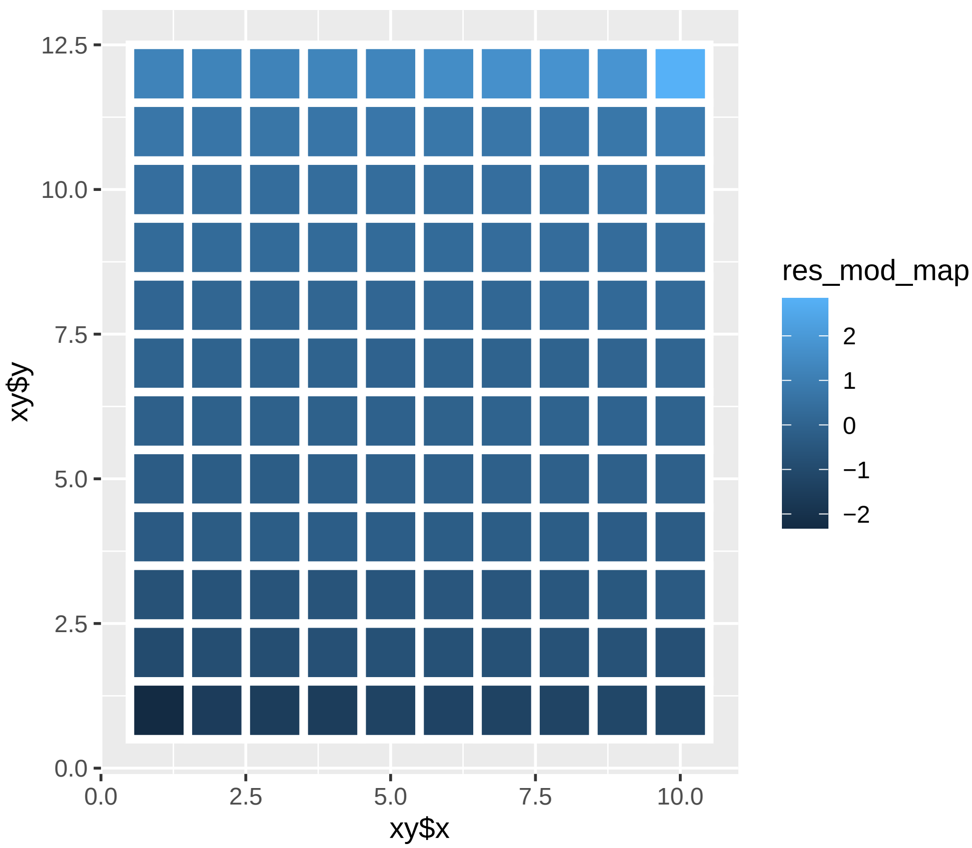
$$H_0 : \lambda = 0 H_a : \lambda \neq 0$$

Se rechaza la H_0

```
res_mod_map <- mod_map$fit$residuals
ape::Moran.I(res_mod_map, inv_matrix)
```

```
## $observed
## [1] 0.2906574
##
## $expected
## [1] -0.008403361
##
## $sd
## [1] 0.008993576
##
## $p.value
## [1] 0
```

```
ggplot(df2, aes(x = xy$x, y = xy$y, fill = res_mod_map)) +
  geom_tile(color = "white",
            lwd = 1.5,
            linetype = 1) +
  coord_fixed()
```




```
pH <- sort(rnorm(120, 5.5, 0.2))
```

Nuedo modelo

$$Y_{mol3} = \alpha + \lambda WY + \beta X_{pH} + \epsilon$$

Modelo con variables explicativas

Modelo espacial en rezago

```
mod_2 <- 0
```

Asignación

- Correr el modelo espacial en rezago
- Buscar librería (Tip spatialreg, 'spatial lag model')

Regresión Lineal Estándar (SLM - OLS)

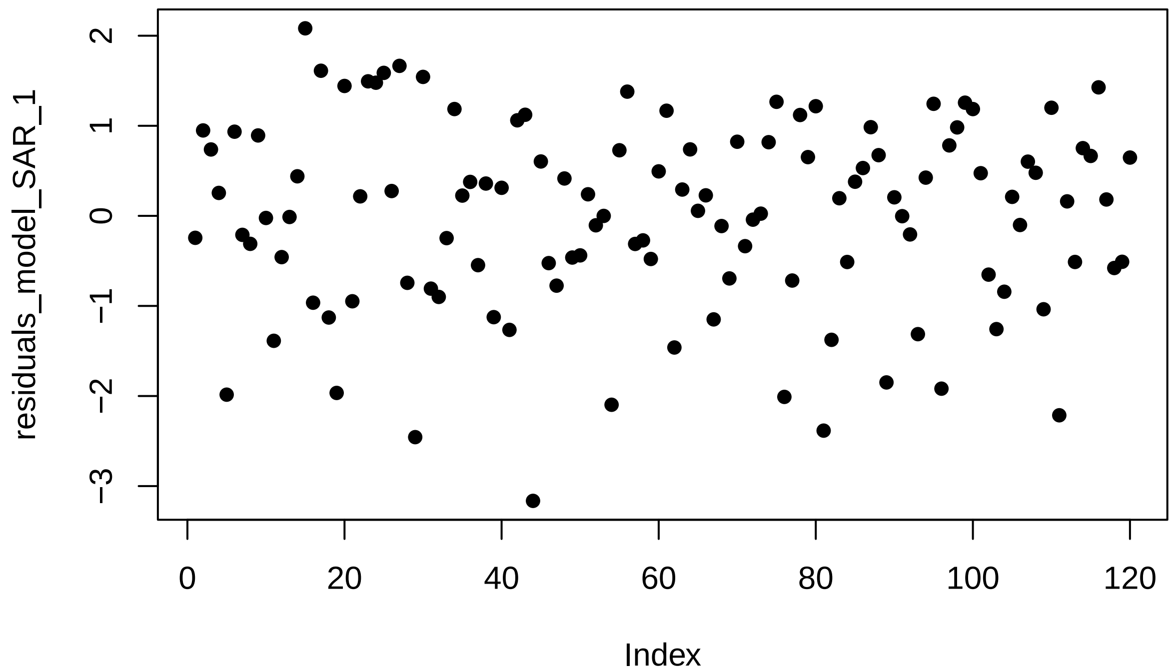
```r
model_SAR_1<-lm(DE ~ DDF, data = df)
summary(model_SAR_1)
```

```
##
## Call:
## lm(formula = DE ~ DDF, data = df)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -3.1641 -0.5972  0.1889  0.7415  2.0820
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept) 3.444790   0.441990   7.794 2.83e-12 ***
## DDF         0.035857   0.004298   8.342 1.57e-13 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1.049 on 118 degrees of freedom
## Multiple R-squared:  0.371,  Adjusted R-squared:  0.3656
## F-statistic: 69.59 on 1 and 118 DF,  p-value: 1.573e-13
```

```r
residuals_model_SAR_1<-residuals(model_SAR_1)
shapiro.test(residuals_model_SAR_1)
```

```
##
##  Shapiro-Wilk normality test
##
## data:  residuals_model_SAR_1
## W = 0.9737, p-value = 0.01876
```

```r
plot(residuals_model_SAR_1, pch = 16)
```



Modelo de Error espacial (SEM)

```
sem1<-errorsarlm(DE ~ DDF, data = df, listw = Wve)
summary(sem1)
```

```
##
## Call:errorsarlm(formula = DE ~ DDF, data = df, listw = Wve)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -3.14929 -0.58177  0.18387  0.73513  2.09598
##
## Type: error
## Coefficients: (asymptotic standard errors)
##              Estimate Std. Error z value  Pr(>|z|)
## (Intercept) 3.4254726  0.4356813  7.8623 3.775e-15
## DDF         0.0360561  0.0042771  8.4301 < 2.2e-16
##
## Lambda: -0.30341, LR test value: 0.17082, p-value: 0.67938
## Asymptotic standard error: 0.66617
##     z-value: -0.45545, p-value: 0.64879
## Wald statistic: 0.20743, p-value: 0.64879
##
```

```
## Log likelihood: -174.8929 for error model
## ML residual variance (sigma squared): 1.0789, (sigma: 1.0387)
## Number of observations: 120
## Number of parameters estimated: 4
## AIC: 357.79, (AIC for lm: 355.96)
```

Spatial lag model

```r
fit.lag<-lagsarlm(DE ~ DDF, data = df, listw = Wve)
summary(fit.lag)
```

```
##
## Call:lagsarlm(formula = DE ~ DDF, data = df, listw = Wve)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -3.16655 -0.59639  0.19013  0.74301  2.07985
##
## Type: lag
## Coefficients: (asymptotic standard errors)
##             Estimate Std. Error z value Pr(>|z|)
## (Intercept) 3.285996   3.818043  0.8606   0.3894
## DDF         0.035863   0.004273  8.3928   <2e-16
##
## Rho: 0.022424, LR test value: 0.0013794, p-value: 0.97037
## Asymptotic standard error: 0.53356
##     z-value: 0.042027, p-value: 0.96648
## Wald statistic: 0.0017663, p-value: 0.96648
##
## Log likelihood: -174.9776 for lag model
## ML residual variance (sigma squared): 1.0816, (sigma: 1.04)
## Number of observations: 120
## Number of parameters estimated: 4
## AIC: 357.96, (AIC for lm: 355.96)
## LM test for residual autocorrelation
## test value: 2.1435, p-value: 0.14318
```

- ¿Este modelo me quita la dependencia espacial?

el p-valor >0.05 NO hay dependencia especial.

Bibliografia

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https://rspatial.org/raster/analysis/7-spregression.html

https://crd230.github.io/lab8.html#Spatial_lag_model

https://cran.r-project.org/web/packages/spatialreg/spatialreg.pdf