Ecu_RK_3b.R

Antares

2019-04-10

```r
#===============================================================
# PROCEDIMIENTO PARA ESTIMAR EL CARBONO ORGANICO EN LOS SUELOS=====
# ============= DE ECUADOR (KG/M2) Y (TN/HA) =====================
#===============================================================

# MODELO EMPLEADO REGRESION - KRIGING.
# CANTIDAD DE PERFILES DE SUELOS PARA CALIBRACION:12924.
# CANTIDAD DE PERFILES DE SUELOS DEJADOS PARA VALIDACIO: 1000.

# Establecemos el directorio de trabajo.

setwd("C:/Marsev/Ecuador/")

#load("C:/Marsev/Ecuador/Ecuador_mg_vs_resobaja.Rdata")

# Cargamos las librerias o paquetes requeridos.

library(raster)
```

```
## Loading required package: sp
```

```r
library(car)
```

```
## Loading required package: carData
```

```r
library(rgdal)
```

```
## rgdal: version: 1.4-3, (SVN revision 828)
##  Geospatial Data Abstraction Library extensions to R successfully loaded
##  Loaded GDAL runtime: GDAL 2.2.3, released 2017/11/20
##  Path to GDAL shared files: C:/Users/Antares/Documents/R/win-library/3.5/rgdal/gdal
##  GDAL binary built with GEOS: TRUE
##  Loaded PROJ.4 runtime: Rel. 4.9.3, 15 August 2016, [PJ_VERSION: 493]
##  Path to PROJ.4 shared files: C:/Users/Antares/Documents/R/win-library/3.5/rgdal/proj
##  Linking to sp version: 1.3-1
```

```r
library(gstat)
library(caret)
```

```
## Loading required package: lattice
```

```
## Loading required package: ggplot2
```

```r
library(reshape)
library(sp)
library(lattice)
library(ggplot2)
library(automap)
library(Metrics)
```

```
##
```

```
## Attaching package: 'Metrics'

## The following objects are masked from 'package:caret':
##
##     precision, recall
```

```r
# Cargamos las funciones requeridas.

load("DSM_supportfunctions.RData")

dummyRaster <- function(rast){
  rast <- as.factor(rast)
  result <- list()
  for(i in 1:length(levels(rast)[[1]][[1]])){
    result[[i]] <- rast == levels(rast)[[1]][[1]][i]
    names(result[[i]]) <- paste0(names(rast),
                                 levels(rast)[[1]][[1]][i])
  }
  return(stack(result))
}

# Cargamos los datos del splines.

dat <- read.csv("Ecu_cali7.csv")

# Observamos los nombres de los campos o columnas.

# names(dat)

# Transformamos a factor las covariables categoricas.

dat$Bioclivs <- as.factor(dat$Bioclivs)
dat$Climavs <- as.factor(dat$Climavs)
dat$Cobervs <- as.factor(dat$Cobervs)
dat$Pisosvs <- as.factor(dat$Pisosvs)
dat$Suelosvs <- as.factor(dat$Suelosvs)

# Vemos estrucura de los datos.

# str(dat)

# Convertimos las columnas de covariables categoricas a dummy,
# el resultado es una matrix:

dat_Bioclivs_du <- model.matrix(~Bioclivs -1, data = dat)
dat_Climavs_du <- model.matrix(~Climavs -1, data = dat)
dat_Cobervs_du <- model.matrix(~Cobervs -1, data = dat)
dat_Pisosvs_du <- model.matrix(~Pisosvs -1, data = dat)
dat_Suelosvs_du <- model.matrix(~Suelosvs -1, data = dat)

dat_Bioclivs_du <- as.data.frame(dat_Bioclivs_du)
dat_Climavs_du <- as.data.frame(dat_Climavs_du)
dat_Cobervs_du <- as.data.frame(dat_Cobervs_du)
dat_Pisosvs_du <- as.data.frame(dat_Pisosvs_du)
dat_Suelosvs_du <- as.data.frame(dat_Suelosvs_du)
```

```r
dat <- cbind(dat, dat_Bioclivs_du, dat_Climavs_du, dat_Cobervs_du, dat_Pisosvs_du, dat_Suelosvs_du)

# Observamos los nombres de los campos o columnas.

names(dat)
```

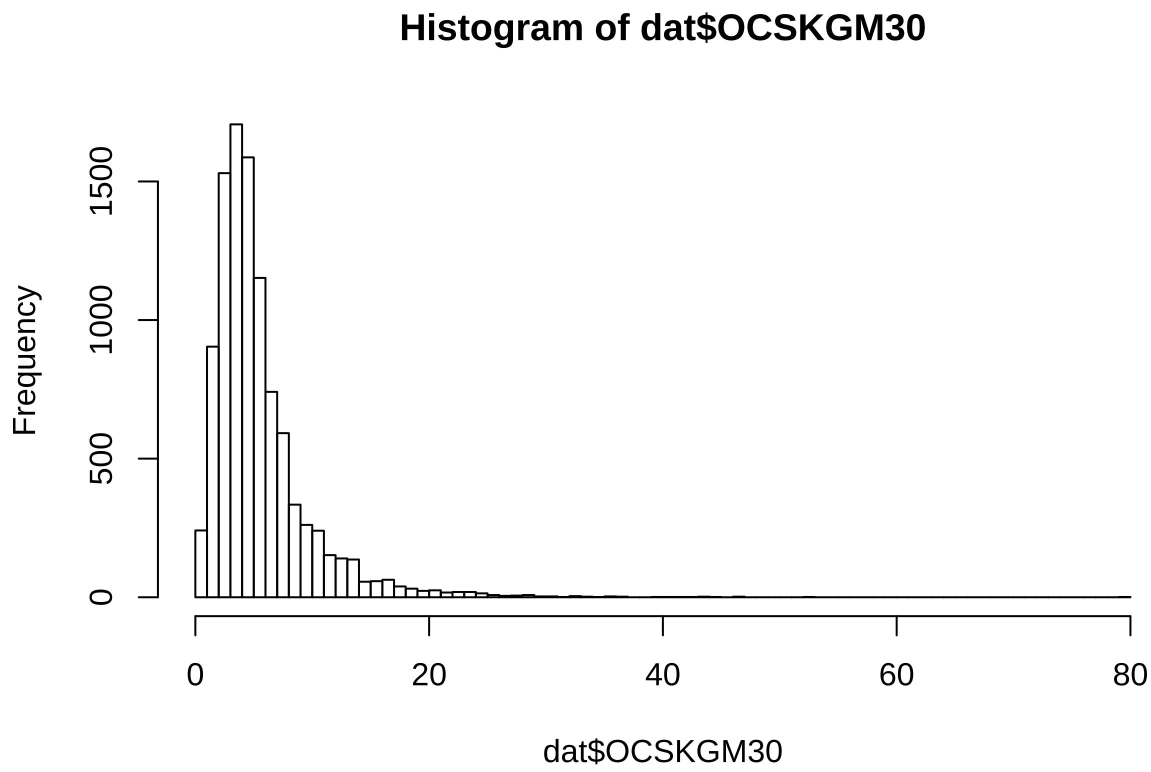
```
##   [1] "ID1"                              "ID"
##   [3] "LATITUDE"                         "LONGITUDE"
##   [5] "OCSKGM30"                         "DEM"
##   [7] "Analytical"                       "Slope"
##   [9] "Aspect"                           "Crosssecti"
##  [11] "Longitudin"                       "Covergence"
##  [13] "Closeddepr"                       "Flowaccumu"
##  [15] "Topographi"                       "LSFactor"
##  [17] "Channelnet"                       "VerticalDistanceToChannelNetwork"
##  [19] "ValleyDepth"                      "RelativeSlopePosition"
##  [21] "DEMSRE3a"                         "etmnts3a"
##  [23] "evmmod3a"                         "evsmod3a"
##  [25] "g01igb3a"                         "g02esa3a"
##  [27] "g02igb3a"                         "g03esa3a"
##  [29] "g04esa3a"                         "g04igb3a"
##  [31] "g05esa3a"                         "g06esa3a"
##  [33] "g10igb3a"                         "g11esa3a"
##  [35] "g11igb3a"                         "g12igb3a"
##  [37] "g13esa3a"                         "g14esa3a"
##  [39] "g18esa3a"                         "gacgem3a"
##  [41] "gachws3a"                         "galhws3a"
##  [43] "ganhws3a"                         "garhws3a"
##  [45] "gcmhws3a"                         "geaisg3a"
##  [47] "gflhws3a"                         "gglhws3a"
##  [49] "glcesa3a"                         "glcjrc3a"
##  [51] "glphws3a"                         "glvhws3a"
##  [53] "glwwwf3a"                         "gphhws3a"
##  [55] "gplhws3a"                         "grghws3a"
##  [57] "gumhws3a"                         "gvrhws3a"
##  [59] "inmsre3a"                         "inssre3a"
##  [61] "l02igb3a"                         "l04igb3a"
##  [63] "l05igb3a"                         "l06igb3a"
##  [65] "l07igb3a"                         "l08igb3a"
##  [67] "l09igb3a"                         "l10igb3a"
##  [69] "l11igb3a"                         "l12igb3a"
##  [71] "l13igb3a"                         "l14igb3a"
##  [73] "l3pobi3b"                         "lammod3a"
##  [75] "lasmod3a"                         "opisre3a"
##  [77] "px1wcl3a"                         "px2wcl3a"
##  [79] "px3wcl3a"                         "px4wcl3a"
##  [81] "slpsrt3a"                         "tdhmod3a"
##  [83] "tdlmod3a"                         "tdmmod3a"
##  [85] "tdsmod3a"                         "tnhmod3a"
##  [87] "tnlmod3a"                         "tnmmod3a"
##  [89] "tnsmod3a"                         "twisre3a"
##  [91] "tx1mod3a"                         "tx2mod3a"
##  [93] "tx3mod3a"                         "tx4mod3a"
```

```
##  [95] "tx5mod3a"                            "tx6mod3a"
##  [97] "Bioclivs"                            "Climavs"
##  [99] "Cobervs"                             "Ecosivs"
## [101] "Geolovs"                             "Geomovs"
## [103] "Pisosvs"                             "Suelosvs"
## [105] "Bioclivs1"                           "Bioclivs2"
## [107] "Bioclivs3"                           "Bioclivs4"
## [109] "Climavs1"                            "Climavs2"
## [111] "Climavs3"                            "Climavs4"
## [113] "Climavs5"                            "Climavs6"
## [115] "Climavs7"                            "Climavs8"
## [117] "Climavs9"                            "Cobervs2"
## [119] "Cobervs3"                            "Cobervs4"
## [121] "Cobervs5"                            "Cobervs6"
## [123] "Cobervs7"                            "Pisosvs1"
## [125] "Pisosvs2"                            "Pisosvs3"
## [127] "Pisosvs4"                            "Pisosvs7"
## [129] "Pisosvs9"                            "Suelosvs1"
## [131] "Suelosvs2"                           "Suelosvs3"
## [133] "Suelosvs4"                           "Suelosvs5"
## [135] "Suelosvs6"                           "Suelosvs7"
## [137] "Suelosvs8"                           "Suelosvs9"
## [139] "Suelosvs10"                          "Suelosvs11"
```

```r
# Vemos un resumen de los datos de carbono organico de los perfiles de suelos en kg/m2.

summary(dat$OCSKGM30)
```

```
##     Min.  1st Qu.   Median     Mean  3rd Qu.     Max.
##  0.02302  2.89453  4.39886  5.48640  6.63229 79.58376
```

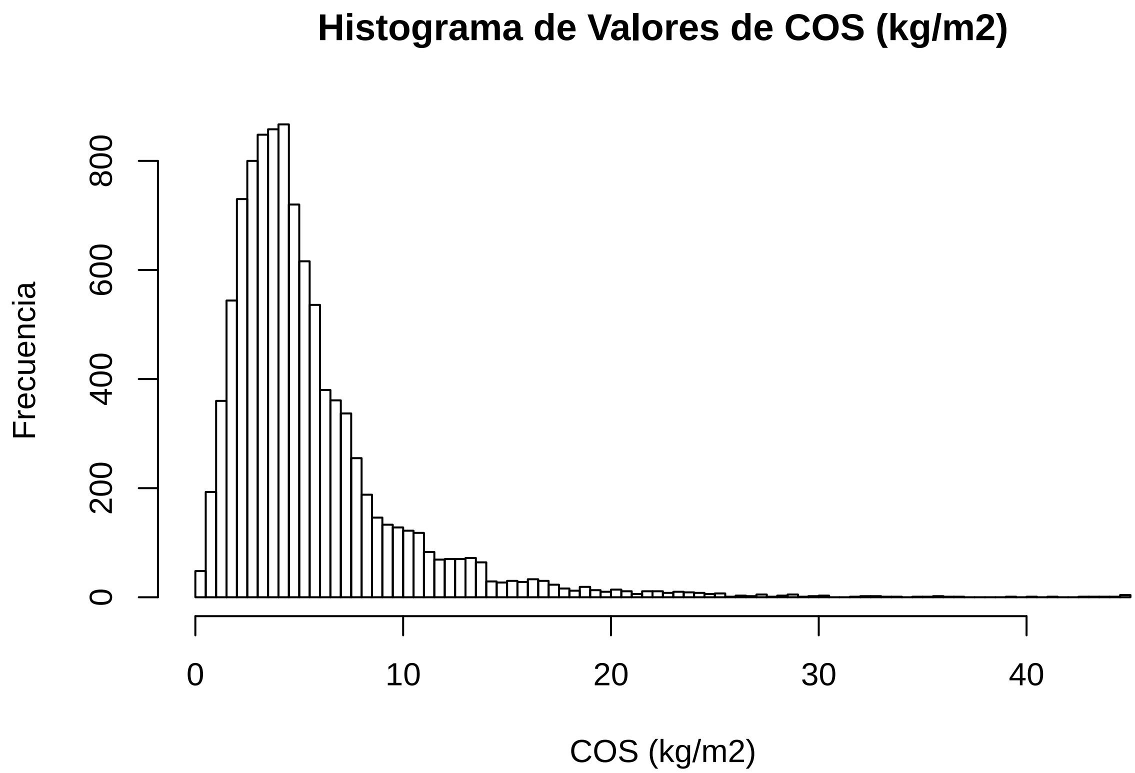
```r
# Diseñamos un histogramos de los datos de carbono organico de los perfiles de suelos.

hist(dat$OCSKGM30, breaks = 100)
```




```r
# Modificamos valores atipicos.

dat$OCSKGM30[dat$OCSKGM30 > 45] <- 45

# Vemos un resumen de los datos de carbono organico de los perfiles de suelos en kg/m2.

summary(dat$OCSKGM30)
```

```
##     Min.  1st Qu.   Median     Mean  3rd Qu.     Max.
##  0.02302  2.89453  4.39886  5.48203  6.63229 45.00000
```

```r
# Disenamos un histogramos de los datos de carbono organico de los perfiles de suelos.

hist(dat$OCSKGM30, breaks = 100, main = "Histograma de Valores de COS (kg/m2)", ylab = 'Frecuencia', xla
     sub='Histograma sobre datos de COS de perfiles de suelos.' )
```

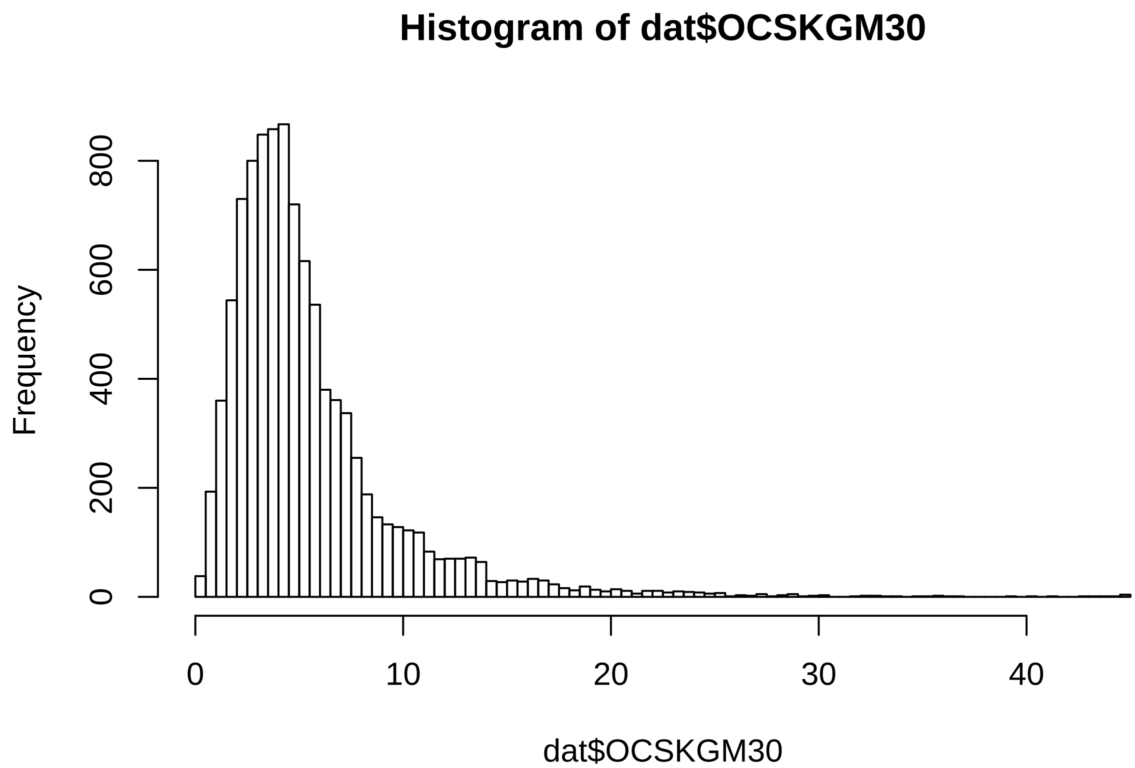


Histograma sobre datos de COS de perfiles de suelos.

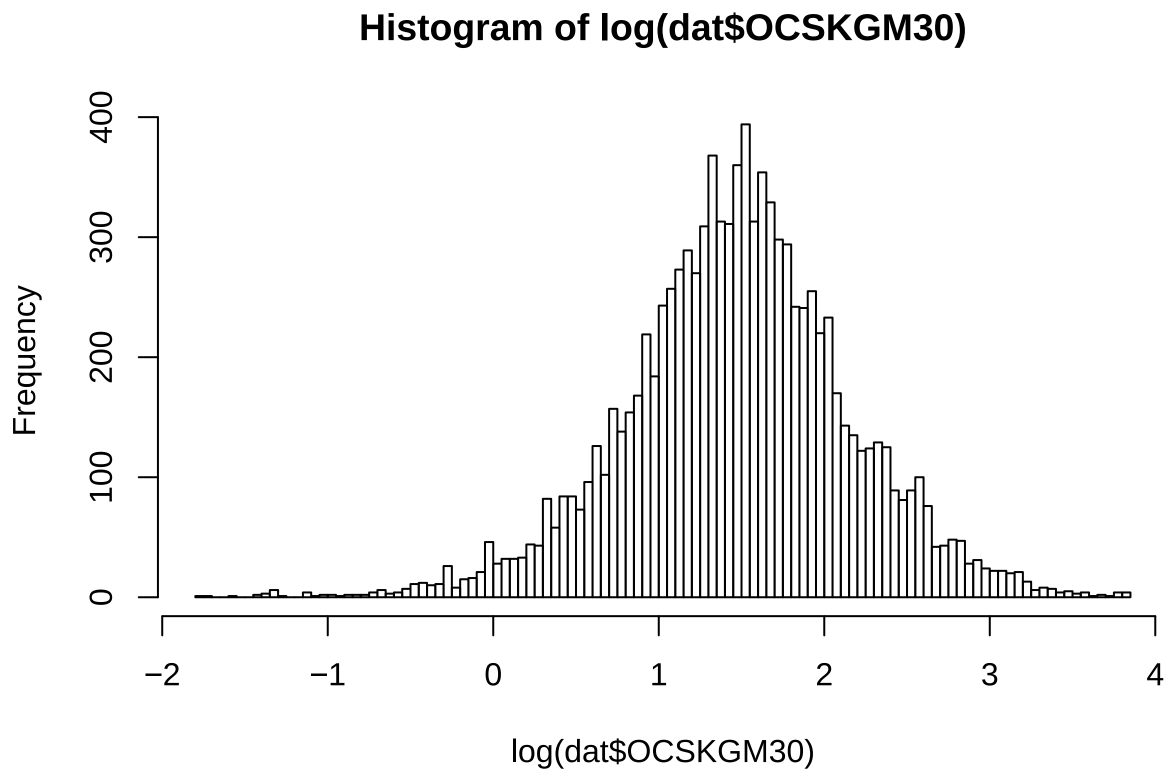
```
# Removemos valores atipicos, segun Bonferroni.

dat <- dat[-c(4496, 2510, 2220, 6999, 9201, 8716, 2214, 2031, 3002, 3869),]

# Vemos un resumen de los datos de carbono organico de los perfiles de suelos en kg/m2.

summary(dat$OCSKGM30)
```

```
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##  0.1655  2.9013  4.3989  5.4873  6.6323 45.0000
```

```
# Disenamos un histogramos de los datos de carbono organico de los perfiles de suelos.

hist(dat$OCSKGM30, breaks = 100)
```




```r
# Vemos la estructura de los datos.

# str(dat)

# Transfomamos a log y diseñamos un histogramos de los datos de COS de los perfiles de suelos.

hist(log(dat$OCSKGM30), breaks=100)
```




```r
## Recreamos el objeto con la ubicacion de los puntos

dat_sp <- dat
coordinates(dat_sp) <- ~ LONGITUDE + LATITUDE

### Analisis de correlacion

# names(dat_sp@data)
COR <- cor(as.matrix(dat_sp@data[,3]), as.matrix(dat_sp@data[,-c(1:3, 95, 96, 97, 101, 102)]))
COR
```

```
##           DEM  Analytical      Slope     Aspect Crosssecti Longitudin
## [1,] 0.208929 -0.01369506 0.05634872 0.02661526  0.0944178   0.147155
##      Covergence  Closeddepr  Flowaccumu Topographi   LSFactor Channelnet
## [1,] 0.09215387 -0.06614235 -0.03510654 -0.1537406 -0.0678515 0.08534772
##      VerticalDistanceToChannelNetwork ValleyDepth RelativeSlopePosition
## [1,]                        0.3741556  -0.1803803              0.355123
##       DEMSRE3a   etmnts3a  evmmod3a    evsmod3a    g01igb3a   g02esa3a
## [1,] 0.2105132 0.03984657 0.1475343 -0.05230708 -0.07836442 0.03834311
##         g02igb3a   g03esa3a    g04esa3a   g04igb3a   g05esa3a   g06esa3a
## [1,] -0.07736351 0.02763012 -0.03925473 -0.1048521 0.08657251 0.05915097
##       g10igb3a    g11esa3a   g11igb3a   g12igb3a     g13esa3a   g14esa3a
## [1,] -0.103391 -0.06309548 -0.1066508 -0.1067288 -0.004986846 -0.1429939
##          g18esa3a  gacgem3a    gachws3a   galhws3a  ganhws3a   garhws3a
## [1,] -0.002570222 0.1095029 -0.09087424 0.05191342 0.2407074 -0.0926822
##         gcmhws3a   geaisg3a     gflhws3a    gglhws3a   glcesa3a
## [1,] -0.03091354 -0.1154044 -0.008979239 -0.09756214 -0.1080372
```

```
##         glcjrc3a   glphws3a    glvhws3a    glwwwf3a    gphhws3a
## [1,] 0.001386801 -0.0885956 -0.05393139 -0.02290974 -0.06567279
##         gplhws3a   grghws3a  gumhws3a    gvrhws3a  inmsre3a  inssre3a
## [1,] -0.07246678 -0.1632326 0.1569082 -0.07845569 0.1837037 0.1925178
##        l02igb3a    l04igb3a   l05igb3a    l06igb3a    l07igb3a   l08igb3a
## [1,] 0.08800435 -0.01624081 0.07691153 -0.0447614 -0.09222192 0.03296024
##         l09igb3a  l10igb3a    l11igb3a    l12igb3a    l13igb3a    l14igb3a
## [1,] -0.07807656 0.1140745 -0.03794976 -0.06704101 -0.07830182 -0.08818114
##        l3pobi3b   lammod3a  lasmod3a    opisre3a  px1wcl3a   px2wcl3a
## [1,] -0.1309477 0.04271475 0.1048257 -0.01459334 0.1067635 0.07436161
##        px3wcl3a   px4wcl3a  slpsrt3a   tdhmod3a   tdlmod3a   tdmmod3a
## [1,] 0.07609933 0.07338385 0.1487879 -0.3683897 -0.2501556 -0.3766725
##         tdsmod3a   tnhmod3a   tnlmod3a   tnmmod3a   tnsmod3a   twisre3a
## [1,] -0.01636793 -0.2272885 -0.1775566 -0.2068962 0.06277568 -0.2425156
##        tx1mod3a   tx2mod3a  tx3mod3a   tx4mod3a   tx5mod3a   tx6mod3a
## [1,] -0.3867905 -0.4121598 -0.362301 -0.3476275 -0.3676105 -0.3586784
##           Ecosivs     Geolovs     Geomovs Bioclivs1   Bioclivs2  Bioclivs3
## [1,] -0.003836575 -0.04858467 -0.02815205 0.1822291 -0.02969367 -0.1848079
##        Bioclivs4  Climavs1    Climavs2    Climavs3    Climavs4   Climavs5
## [1,] -0.02582213 0.1267681 -0.08554551 -0.08056989 -0.09176811 -0.1248557
##      Climavs6   Climavs7    Climavs8   Climavs9  Cobervs2    Cobervs3
## [1,] 0.161981 0.06076828 -0.08873329 0.05683279 0.0343383 -0.03353496
##        Cobervs4     Cobervs5    Cobervs6    Cobervs7    Pisosvs1  Pisosvs2
## [1,] 0.03273343 -0.003925262 -0.03322118 -0.04611703 -0.01916704 0.1556606
##      Pisosvs3   Pisosvs4   Pisosvs7   Pisosvs9   Suelosvs1 Suelosvs2
## [1,] 0.178582 0.04207305 0.01095232 -0.1793011 -0.04141558 0.4049269
##       Suelosvs3  Suelosvs4  Suelosvs5  Suelosvs6   Suelosvs7   Suelosvs8
## [1,] -0.0759617 -0.1284575 0.01885043 -0.1214687 -0.06770708 -0.02046923
##        Suelosvs9  Suelosvs10  Suelosvs11
## [1,] 0.002592527 -0.02810099 -0.07658166
```

```r
x <- subset(melt(COR), value != 1 | value != NA)
x <- x[with(x, order(-abs(x$value))),]
#as.character(x$X2[1:10])

# Vemos las primeras 10 covariables de mayor correlacion con el COS.

x[1:10,]
```

```
##     X1                             X2      value
## 87   1                       tx2mod3a -0.4121598
## 121  1                      Suelosvs2  0.4049269
## 86   1                       tx1mod3a -0.3867905
## 79   1                       tdmmod3a -0.3766725
## 13   1 VerticalDistanceToChannelNetwork  0.3741556
## 77   1                       tdhmod3a -0.3683897
## 90   1                       tx5mod3a -0.3676105
## 88   1                       tx3mod3a -0.3623010
## 91   1                       tx6mod3a -0.3586784
## 15   1            RelativeSlopePosition  0.3551230
```

```r
idx <- as.character(x$X2[1:25])
idx
```

```
##  [1] "tx2mod3a"                         "Suelosvs2"
##  [3] "tx1mod3a"                         "tdmmod3a"
```

```
##  [5] "VerticalDistanceToChannelNetwork" "tdhmod3a"
##  [7] "tx5mod3a"                         "tx3mod3a"
##  [9] "tx6mod3a"                         "RelativeSlopePosition"
## [11] "tx4mod3a"                         "tdlmod3a"
## [13] "twisre3a"                         "ganhws3a"
## [15] "tnhmod3a"                         "DEMSRE3a"
## [17] "DEM"                              "tnmmod3a"
## [19] "inssre3a"                         "Bioclivs3"
## [21] "inmsre3a"                         "Bioclivs1"
## [23] "ValleyDepth"                      "Pisosvs9"
## [25] "Pisosvs3"
```

```r
# Creamos el archivo de datos para emplear en la regresion lineal multiple.

dat2 <- dat[c('OCSKGM30', idx, 'LATITUDE', 'LONGITUDE')]

# Observamos los nombres de los campos o columnas.

#names(dat2)

dat2[dat$OCSKGM30 == 0, 1] <- NA

## Modelo de Regresion lineal multiple.

modelo.MLR <- lm(log(OCSKGM30) ~ . -LATITUDE-LONGITUDE, data = dat2)

# Vemos un resumen de los resultados del modelo de regresion lineal multiple.

summary(modelo.MLR)
```

```
##
## Call:
## lm(formula = log(OCSKGM30) ~ . - LATITUDE - LONGITUDE, data = dat2)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -2.86687 -0.31757  0.04076  0.35801  2.38386
##
## Coefficients:
##                                   Estimate Std. Error t value Pr(>|t|)
## (Intercept)                      3.760e+00  3.543e-01  10.611  < 2e-16
## tx2mod3a                        -3.250e-02  4.469e-03  -7.271 3.82e-13
## Suelosvs2                        3.553e-01  1.721e-02  20.643  < 2e-16
## tx1mod3a                        -2.515e-04  3.466e-03  -0.073  0.94216
## tdmmod3a                        -2.309e-02  7.292e-03  -3.167  0.00155
## VerticalDistanceToChannelNetwork  2.277e-04  3.787e-05   6.012 1.89e-09
## tdhmod3a                        -1.944e-02  3.099e-03  -6.272 3.71e-10
## tx5mod3a                        -1.138e-03  3.787e-03  -0.301  0.76377
## tx3mod3a                        -9.507e-03  4.717e-03  -2.016  0.04386
## tx6mod3a                         2.161e-02  3.365e-03   6.423 1.40e-10
## RelativeSlopePosition            3.072e-01  7.500e-02   4.096 4.24e-05
## tx4mod3a                        -7.014e-03  4.293e-03  -1.634  0.10229
## tdlmod3a                         1.114e-02  2.486e-03   4.482 7.46e-06
## twisre3a                        -7.165e-04  5.298e-04  -1.352  0.17629
## ganhws3a                         1.279e-03  1.931e-04   6.624 3.68e-11
```

```
## tnhmod3a                           -5.563e-02  6.609e-03  -8.417  < 2e-16
## DEMSRE3a                            5.567e-04  2.150e-04   2.589  0.00964
## DEM                                -1.047e-03  2.177e-04  -4.809 1.54e-06
## tnmmod3a                            8.216e-03  5.067e-03   1.622  0.10492
## inssre3a                            1.914e-02  1.252e-02   1.529  0.12631
## Bioclivs3                          -9.057e-03  1.852e-02  -0.489  0.62474
## inmsre3a                            5.214e-03  3.352e-03   1.556  0.11985
## Bioclivs1                           4.538e-02  1.697e-02   2.673  0.00752
## ValleyDepth                         1.651e-05  1.609e-05   1.026  0.30490
## Pisosvs9                           -1.452e-01  2.235e-02  -6.495 8.70e-11
## Pisosvs3                            1.230e-01  4.035e-02   3.048  0.00231
##
## (Intercept)                        ***
## tx2mod3a                           ***
## Suelosvs2                          ***
## tx1mod3a
## tdmmod3a                           **
## VerticalDistanceToChannelNetwork ***
## tdhmod3a                           ***
## tx5mod3a
## tx3mod3a                           *
## tx6mod3a                           ***
## RelativeSlopePosition              ***
## tx4mod3a
## tdlmod3a                           ***
## twisre3a
## ganhws3a                           ***
## tnhmod3a                           ***
## DEMSRE3a                           **
## DEM                                ***
## tnmmod3a
## inssre3a
## Bioclivs3
## inmsre3a
## Bioclivs1                          **
## ValleyDepth
## Pisosvs9                           ***
## Pisosvs3                           **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.5705 on 10101 degrees of freedom
## Multiple R-squared:  0.298,  Adjusted R-squared:  0.2963
## F-statistic: 171.5 on 25 and 10101 DF,  p-value: < 2.2e-16
```

```
# Analisis de varianza.

anova(modelo.MLR)
```

```
## Analysis of Variance Table
##
## Response: log(OCSKGM30)
##                                    Df Sum Sq Mean Sq   F value    Pr(>F)
## tx2mod3a                            1  745.9  745.86 2291.3286 < 2.2e-16
## Suelosvs2                           1  291.8  291.77  896.3471 < 2.2e-16
```

```
## tx1mod3a                             1    1.6    1.57    4.8342 0.0279235
## tdmmod3a                             1    4.7    4.68   14.3817 0.0001501
## VerticalDistanceToChannelNetwork     1   23.5   23.49   72.1620 < 2.2e-16
## tdhmod3a                             1  104.0  104.02  319.5491 < 2.2e-16
## tx5mod3a                             1   17.4   17.39   53.4108 2.911e-13
## tx3mod3a                             1    0.1    0.15    0.4536 0.5006617
## tx6mod3a                             1    7.3    7.26   22.3150 2.345e-06
## RelativeSlopePosition                1   22.5   22.50   69.1320 < 2.2e-16
## tx4mod3a                             1    0.1    0.13    0.4077 0.5231504
## tdlmod3a                             1   41.8   41.77  128.3207 < 2.2e-16
## twisre3a                             1    0.7    0.70    2.1359 0.1439195
## ganhws3a                             1    8.7    8.70   26.7201 2.397e-07
## tnhmod3a                             1   39.7   39.72  122.0136 < 2.2e-16
## DEMSRE3a                             1   51.3   51.35  157.7358 < 2.2e-16
## DEM                                  1    6.5    6.52   20.0209 7.744e-06
## tnmmod3a                             1    4.5    4.50   13.8329 0.0002009
## inssre3a                             1    0.1    0.08    0.2444 0.6210258
## Bioclivs3                            1    0.5    0.51    1.5600 0.2116923
## inmsre3a                             1    0.8    0.85    2.6050 0.1065574
## Bioclivs1                            1    3.5    3.52   10.8117 0.0010120
## ValleyDepth                          1    2.8    2.85    8.7511 0.0031014
## Pisosvs9                             1   12.9   12.91   39.6628 3.144e-10
## Pisosvs3                             1    3.0    3.02    9.2925 0.0023069
## Residuals                        10101 3288.0    0.33
##
## tx2mod3a                         ***
## Suelosvs2                        ***
## tx1mod3a                         *
## tdmmod3a                         ***
## VerticalDistanceToChannelNetwork ***
## tdhmod3a                         ***
## tx5mod3a                         ***
## tx3mod3a
## tx6mod3a                         ***
## RelativeSlopePosition            ***
## tx4mod3a
## tdlmod3a                         ***
## twisre3a
## ganhws3a                         ***
## tnhmod3a                         ***
## DEMSRE3a                         ***
## DEM                              ***
## tnmmod3a                         ***
## inssre3a
## Bioclivs3
## inmsre3a
## Bioclivs1                        **
## ValleyDepth                      **
## Pisosvs9                         ***
## Pisosvs3                         **
## Residuals
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```r
## Hacemos seleccion de variables por stepwise

modelo.MLR.step <- step(modelo.MLR, direction="both")
```

```
## Start:  AIC=-11340.09
## log(OCSKGM30) ~ (tx2mod3a + Suelosvs2 + tx1mod3a + tdmmod3a +
##     VerticalDistanceToChannelNetwork + tdhmod3a + tx5mod3a +
##     tx3mod3a + tx6mod3a + RelativeSlopePosition + tx4mod3a +
##     tdlmod3a + twisre3a + ganhws3a + tnhmod3a + DEMSRE3a + DEM +
##     tnmmod3a + inssre3a + Bioclivs3 + inmsre3a + Bioclivs1 +
##     ValleyDepth + Pisosvs9 + Pisosvs3 + LATITUDE + LONGITUDE) -
##     LATITUDE - LONGITUDE
##
##                                    Df Sum of Sq    RSS    AIC
## - tx1mod3a                          1     0.002 3288.0 -11342
## - tx5mod3a                          1     0.029 3288.0 -11342
## - Bioclivs3                         1     0.078 3288.1 -11342
## - ValleyDepth                       1     0.343 3288.4 -11341
## - twisre3a                          1     0.595 3288.6 -11340
## <none>                                          3288.0 -11340
## - inssre3a                          1     0.761 3288.8 -11340
## - inmsre3a                          1     0.788 3288.8 -11340
## - tnmmod3a                          1     0.856 3288.9 -11340
## - tx4mod3a                          1     0.869 3288.9 -11339
## - tx3mod3a                          1     1.323 3289.3 -11338
## - DEMSRE3a                          1     2.182 3290.2 -11335
## - Bioclivs1                         1     2.327 3290.3 -11335
## - Pisosvs3                          1     3.025 3291.0 -11333
## - tdmmod3a                          1     3.264 3291.3 -11332
## - RelativeSlopePosition             1     5.461 3293.5 -11325
## - tdlmod3a                          1     6.540 3294.6 -11322
## - DEM                               1     7.529 3295.5 -11319
## - VerticalDistanceToChannelNetwork  1    11.767 3299.8 -11306
## - tdhmod3a                          1    12.805 3300.8 -11303
## - tx6mod3a                          1    13.429 3301.4 -11301
## - Pisosvs9                          1    13.731 3301.7 -11300
## - ganhws3a                          1    14.282 3302.3 -11298
## - tx2mod3a                          1    17.211 3305.2 -11289
## - tnhmod3a                          1    23.060 3311.1 -11271
## - Suelosvs2                         1   138.715 3426.7 -10924
##
## Step:  AIC=-11342.09
## log(OCSKGM30) ~ tx2mod3a + Suelosvs2 + tdmmod3a + VerticalDistanceToChannelNetwork +
##     tdhmod3a + tx5mod3a + tx3mod3a + tx6mod3a + RelativeSlopePosition +
##     tx4mod3a + tdlmod3a + twisre3a + ganhws3a + tnhmod3a + DEMSRE3a +
##     DEM + tnmmod3a + inssre3a + Bioclivs3 + inmsre3a + Bioclivs1 +
##     ValleyDepth + Pisosvs9 + Pisosvs3
##
##                                    Df Sum of Sq    RSS    AIC
## - tx5mod3a                          1     0.031 3288.0 -11344
## - Bioclivs3                         1     0.080 3288.1 -11344
## - ValleyDepth                       1     0.341 3288.4 -11343
## - twisre3a                          1     0.599 3288.6 -11342
## <none>                                          3288.0 -11342
```

```
## - inssre3a                        1     0.759 3288.8 -11342
## - inmsre3a                        1     0.788 3288.8 -11342
## - tnmmod3a                        1     0.856 3288.9 -11342
## - tx4mod3a                        1     0.869 3288.9 -11341
## + tx1mod3a                        1     0.002 3288.0 -11340
## - tx3mod3a                        1     1.325 3289.3 -11340
## - DEMSRE3a                        1     2.181 3290.2 -11337
## - Bioclivs1                       1     2.362 3290.4 -11337
## - Pisosvs3                        1     3.023 3291.0 -11335
## - tdmmod3a                        1     3.498 3291.5 -11333
## - RelativeSlopePosition           1     5.462 3293.5 -11327
## - tdlmod3a                        1     6.557 3294.6 -11324
## - DEM                             1     7.528 3295.5 -11321
## - VerticalDistanceToChannelNetwork  1    11.806 3299.8 -11308
## - tdhmod3a                        1    12.805 3300.8 -11305
## - tx6mod3a                        1    13.457 3301.5 -11303
## - Pisosvs9                        1    13.803 3301.8 -11302
## - ganhws3a                        1    14.300 3302.3 -11300
## - tx2mod3a                        1    19.361 3307.4 -11285
## - tnhmod3a                        1    23.060 3311.1 -11273
## - Suelosvs2                       1   138.828 3426.8 -10925
##
## Step:  AIC=-11343.99
## log(OCSKGM30) ~ tx2mod3a + Suelosvs2 + tdmmod3a + VerticalDistanceToChannelNetwork +
##     tdhmod3a + tx3mod3a + tx6mod3a + RelativeSlopePosition +
##     tx4mod3a + tdlmod3a + twisre3a + ganhws3a + tnhmod3a + DEMSRE3a +
##     DEM + tnmmod3a + inssre3a + Bioclivs3 + inmsre3a + Bioclivs1 +
##     ValleyDepth + Pisosvs9 + Pisosvs3
##
##                                   Df Sum of Sq    RSS    AIC
## - Bioclivs3                       1     0.071 3288.1 -11346
## - ValleyDepth                     1     0.331 3288.4 -11345
## - twisre3a                        1     0.618 3288.7 -11344
## <none>                                        3288.0 -11344
## - inssre3a                        1     0.767 3288.8 -11344
## - inmsre3a                        1     0.809 3288.9 -11344
## - tnmmod3a                        1     0.833 3288.9 -11343
## - tx4mod3a                        1     1.159 3289.2 -11342
## + tx5mod3a                        1     0.031 3288.0 -11342
## + tx1mod3a                        1     0.003 3288.0 -11342
## - tx3mod3a                        1     1.387 3289.4 -11342
## - DEMSRE3a                        1     2.170 3290.2 -11339
## - Bioclivs1                       1     2.576 3290.6 -11338
## - Pisosvs3                        1     3.058 3291.1 -11337
## - tdmmod3a                        1     3.680 3291.7 -11335
## - RelativeSlopePosition           1     5.523 3293.6 -11329
## - tdlmod3a                        1     6.636 3294.7 -11326
## - DEM                             1     7.543 3295.6 -11323
## - VerticalDistanceToChannelNetwork  1    11.779 3299.8 -11310
## - tdhmod3a                        1    12.799 3300.8 -11307
## - Pisosvs9                        1    13.773 3301.8 -11304
## - ganhws3a                        1    14.300 3302.3 -11302
## - tx6mod3a                        1    14.535 3302.6 -11301
## - tx2mod3a                        1    19.332 3307.4 -11287
```

```
## - tnhmod3a                          1    23.311 3311.4 -11274
## - Suelosvs2                         1   138.864 3426.9 -10927
##
## Step:  AIC=-11345.77
## log(OCSKGM30) ~ tx2mod3a + Suelosvs2 + tdmmod3a + VerticalDistanceToChannelNetwork +
##     tdhmod3a + tx3mod3a + tx6mod3a + RelativeSlopePosition +
##     tx4mod3a + tdlmod3a + twisre3a + ganhws3a + tnhmod3a + DEMSRE3a +
##     DEM + tnmmod3a + inssre3a + inmsre3a + Bioclivs1 + ValleyDepth +
##     Pisosvs9 + Pisosvs3
##
##                                    Df Sum of Sq    RSS    AIC
## - ValleyDepth                       1     0.314 3288.4 -11347
## - twisre3a                          1     0.591 3288.7 -11346
## <none>                                          3288.1 -11346
## - inssre3a                          1     0.766 3288.9 -11345
## - inmsre3a                          1     0.798 3288.9 -11345
## - tnmmod3a                          1     0.862 3289.0 -11345
## - tx4mod3a                          1     1.166 3289.3 -11344
## + Bioclivs3                         1     0.071 3288.0 -11344
## + tx5mod3a                          1     0.022 3288.1 -11344
## + tx1mod3a                          1     0.005 3288.1 -11344
## - tx3mod3a                          1     1.445 3289.6 -11343
## - DEMSRE3a                          1     2.176 3290.3 -11341
## - Bioclivs1                         1     2.736 3290.8 -11339
## - Pisosvs3                          1     3.021 3291.1 -11338
## - tdmmod3a                          1     4.067 3292.2 -11335
## - RelativeSlopePosition             1     5.473 3293.6 -11331
## - tdlmod3a                          1     6.712 3294.8 -11327
## - DEM                               1     7.524 3295.6 -11325
## - VerticalDistanceToChannelNetwork  1    11.776 3299.9 -11312
## - tdhmod3a                          1    13.095 3301.2 -11308
## - Pisosvs9                          1    14.035 3302.1 -11305
## - ganhws3a                          1    14.681 3302.8 -11303
## - tx6mod3a                          1    15.398 3303.5 -11300
## - tx2mod3a                          1    19.275 3307.4 -11289
## - tnhmod3a                          1    23.433 3311.5 -11276
## - Suelosvs2                         1   138.963 3427.1 -10929
##
## Step:  AIC=-11346.81
## log(OCSKGM30) ~ tx2mod3a + Suelosvs2 + tdmmod3a + VerticalDistanceToChannelNetwork +
##     tdhmod3a + tx3mod3a + tx6mod3a + RelativeSlopePosition +
##     tx4mod3a + tdlmod3a + twisre3a + ganhws3a + tnhmod3a + DEMSRE3a +
##     DEM + tnmmod3a + inssre3a + inmsre3a + Bioclivs1 + Pisosvs9 +
##     Pisosvs3
##
##                                    Df Sum of Sq    RSS    AIC
## <none>                                          3288.4 -11347
## - twisre3a                          1     0.701 3289.1 -11347
## - inssre3a                          1     0.705 3289.1 -11347
## - inmsre3a                          1     0.779 3289.2 -11346
## - tnmmod3a                          1     0.871 3289.3 -11346
## + ValleyDepth                       1     0.314 3288.1 -11346
## - tx4mod3a                          1     1.128 3289.6 -11345
## + Bioclivs3                         1     0.054 3288.4 -11345
```

```
## + tx5mod3a                        1     0.015 3288.4 -11345
## + tx1mod3a                        1     0.002 3288.4 -11345
## - tx3mod3a                        1     1.358 3289.8 -11345
## - DEMSRE3a                        1     2.147 3290.6 -11342
## - Bioclivs1                       1     2.685 3291.1 -11340
## - Pisosvs3                        1     3.047 3291.5 -11339
## - tdmmod3a                        1     3.962 3292.4 -11337
## - RelativeSlopePosition           1     6.259 3294.7 -11330
## - tdlmod3a                        1     6.601 3295.0 -11328
## - DEM                             1     7.396 3295.8 -11326
## - tdhmod3a                        1    13.201 3301.6 -11308
## - VerticalDistanceToChannelNetwork  1    14.570 3303.0 -11304
## - ganhws3a                        1    14.867 3303.3 -11303
## - tx6mod3a                        1    15.104 3303.5 -11302
## - Pisosvs9                        1    16.627 3305.1 -11298
## - tx2mod3a                        1    19.004 3307.4 -11290
## - tnhmod3a                        1    23.120 3311.5 -11278
## - Suelosvs2                       1   138.882 3427.3 -10930
```

```r
summary(modelo.MLR.step)
```

```
##
## Call:
## lm(formula = log(OCSKGM30) ~ tx2mod3a + Suelosvs2 + tdmmod3a +
##     VerticalDistanceToChannelNetwork + tdhmod3a + tx3mod3a +
##     tx6mod3a + RelativeSlopePosition + tx4mod3a + tdlmod3a +
##     twisre3a + ganhws3a + tnhmod3a + DEMSRE3a + DEM + tnmmod3a +
##     inssre3a + inmsre3a + Bioclivs1 + Pisosvs9 + Pisosvs3, data = dat2)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -2.86564 -0.31856  0.04048  0.35757  2.38921
##
## Coefficients:
##                                    Estimate Std. Error t value Pr(>|t|)
## (Intercept)                       3.788e+00  3.528e-01  10.738  < 2e-16
## tx2mod3a                         -3.216e-02  4.209e-03  -7.642 2.34e-14
## Suelosvs2                         3.538e-01  1.713e-02  20.658  < 2e-16
## tdmmod3a                         -2.387e-02  6.842e-03  -3.489 0.000487
## VerticalDistanceToChannelNetwork  2.390e-04  3.571e-05   6.691 2.33e-11
## tdhmod3a                         -1.964e-02  3.083e-03  -6.369 1.98e-10
## tx3mod3a                         -9.518e-03  4.660e-03  -2.043 0.041117
## tx6mod3a                          2.099e-02  3.080e-03   6.813 1.01e-11
## RelativeSlopePosition             2.625e-01  5.985e-02   4.386 1.17e-05
## tx4mod3a                         -7.375e-03  3.961e-03  -1.862 0.062662
## tdlmod3a                          1.115e-02  2.475e-03   4.504 6.75e-06
## twisre3a                         -7.684e-04  5.236e-04  -1.468 0.142222
## ganhws3a                          1.296e-03  1.918e-04   6.759 1.47e-11
## tnhmod3a                         -5.454e-02  6.471e-03  -8.429  < 2e-16
## DEMSRE3a                          5.519e-04  2.149e-04   2.568 0.010229
## DEM                              -1.036e-03  2.173e-04  -4.767 1.89e-06
## tnmmod3a                          8.242e-03  5.038e-03   1.636 0.101908
## inssre3a                          1.836e-02  1.247e-02   1.472 0.141031
## inmsre3a                          5.146e-03  3.326e-03   1.547 0.121895
## Bioclivs1                         4.709e-02  1.639e-02   2.872 0.004084
```

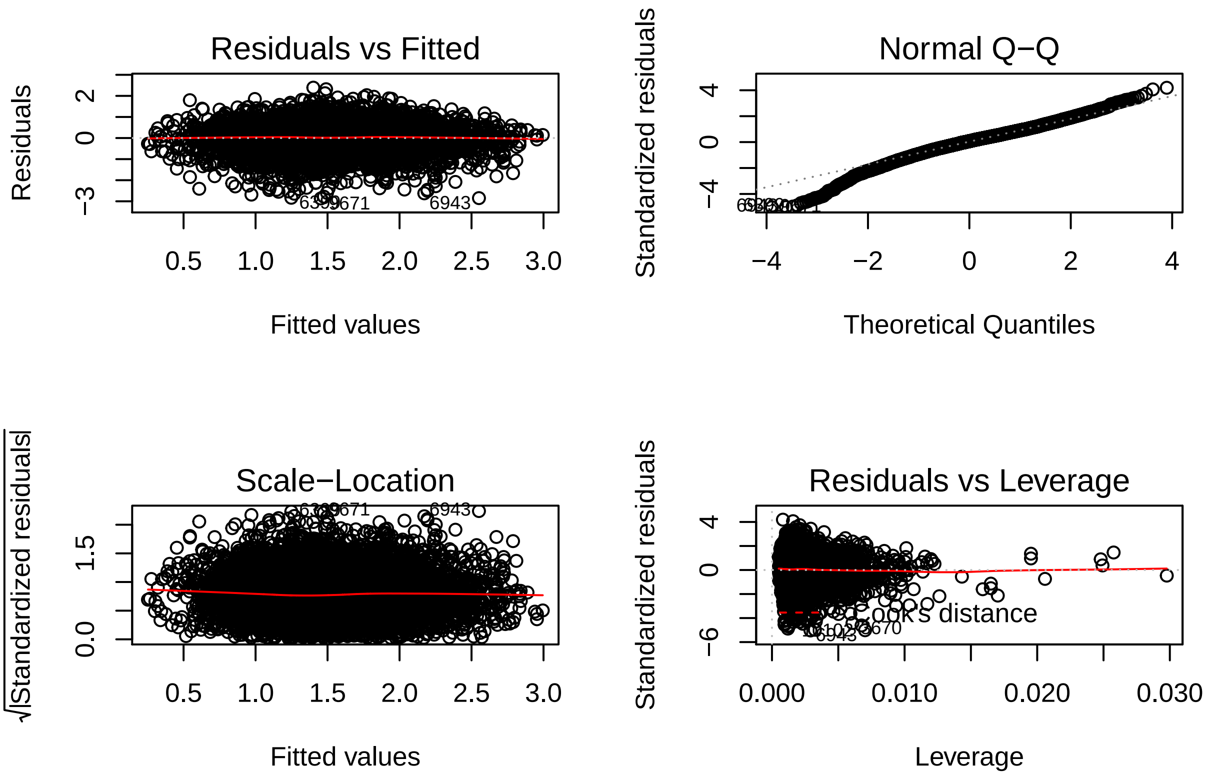
```
## Pisosvs9                          -1.519e-01  2.125e-02  -7.148 9.42e-13
## Pisosvs3                           1.231e-01  4.024e-02   3.060 0.002221
##
## (Intercept)                       ***
## tx2mod3a                          ***
## Suelosvs2                         ***
## tdmmod3a                          ***
## VerticalDistanceToChannelNetwork ***
## tdhmod3a                          ***
## tx3mod3a                          *
## tx6mod3a                          ***
## RelativeSlopePosition             ***
## tx4mod3a                          .
## tdlmod3a                          ***
## twisre3a
## ganhws3a                          ***
## tnhmod3a                          ***
## DEMSRE3a                          *
## DEM                               ***
## tnmmod3a
## inssre3a
## inmsre3a
## Bioclivs1                         **
## Pisosvs9                          ***
## Pisosvs3                          **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.5705 on 10105 degrees of freedom
## Multiple R-squared:  0.2979, Adjusted R-squared:  0.2965
## F-statistic: 204.2 on 21 and 10105 DF,  p-value: < 2.2e-16
```

```r
# Analisis de varianza.

anova(modelo.MLR.step)
```

```
## Analysis of Variance Table
##
## Response: log(OCSKGM30)
##                                     Df Sum Sq Mean Sq   F value    Pr(>F)
## tx2mod3a                             1  745.9  745.86 2291.9449 < 2.2e-16
## Suelosvs2                            1  291.8  291.77  896.5882 < 2.2e-16
## tdmmod3a                             1    6.2    6.21   19.0806 1.266e-05
## VerticalDistanceToChannelNetwork     1   23.5   23.45   72.0672 < 2.2e-16
## tdhmod3a                             1  103.9  103.91  319.3139 < 2.2e-16
## tx3mod3a                             1    0.0    0.05    0.1495 0.6989824
## tx6mod3a                             1    0.5    0.46    1.4265 0.2323601
## RelativeSlopePosition                1   29.0   28.96   88.9999 < 2.2e-16
## tx4mod3a                             1    2.5    2.47    7.5808 0.0059099
## tdlmod3a                             1   49.1   49.11  150.8953 < 2.2e-16
## twisre3a                             1    1.2    1.19    3.6494 0.0561175
## ganhws3a                             1    7.9    7.93   24.3595 8.121e-07
## tnhmod3a                             1   43.3   43.31  133.0753 < 2.2e-16
## DEMSRE3a                             1   56.1   56.13  172.4924 < 2.2e-16
## DEM                                  1    6.6    6.58   20.2212 6.975e-06
```

```
## tnmmod3a                         1    4.4    4.44   13.6571 0.0002206
## inssre3a                         1    0.1    0.07    0.2198 0.6391878
## inmsre3a                         1    0.9    0.92    2.8394 0.0920116
## Bioclivs1                        1    3.8    3.83   11.7732 0.0006033
## Pisosvs9                         1   15.7   15.69   48.2030 4.079e-12
## Pisosvs3                         1    3.0    3.05    9.3622 0.0022209
## Residuals                    10105 3288.4    0.33
##
## tx2mod3a                      ***
## Suelosvs2                     ***
## tdmmod3a                      ***
## VerticalDistanceToChannelNetwork ***
## tdhmod3a                      ***
## tx3mod3a
## tx6mod3a
## RelativeSlopePosition         ***
## tx4mod3a                      **
## tdlmod3a                      ***
## twisre3a                      .
## ganhws3a                      ***
## tnhmod3a                      ***
## DEMSRE3a                      ***
## DEM                           ***
## tnmmod3a                      ***
## inssre3a
## inmsre3a                      .
## Bioclivs1                     ***
## Pisosvs9                      ***
## Pisosvs3                      **
## Residuals
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```r
# Dividimos el area de graficos en 2 filas y 2 columnas.

par(mfrow=c(2,2))

# Hacemos los graficos del modelo de regresion lineal multiple.

plot(modelo.MLR.step)
```




```r
# Dividimos el area de graficos en 1 filas y 1 columnas.

par(mfrow=c(1,1))

#Falta de multicolinealidad en las variables x: podemos comprobar esto mediante
#el calculo de los Factores de Inflacion de la Varianza (FIVs)

vif(modelo.MLR.step)
```

```
##                           tx2mod3a                          Suelosvs2
##                           7.707706                           1.420587
##                           tdmmod3a VerticalDistanceToChannelNetwork
##                          24.949207                           7.629238
##                           tdhmod3a                           tx3mod3a
##                           6.238645                          10.418959
##                           tx6mod3a              RelativeSlopePosition
##                           7.007404                           6.775654
##                           tx4mod3a                           tdlmod3a
##                           7.884026                           7.285933
##                           twisre3a                           ganhws3a
##                           3.795768                           1.461294
##                           tnhmod3a                           DEMSRE3a
##                          45.119320                        1970.941696
##                                DEM                           tnmmod3a
##                        2014.949317                          34.898986
##                           inssre3a                           inmsre3a
```

```
##                         13.676326                          5.760323
##                         Bioclivs1                          Pisosvs9
##                          1.973250                          2.826387
##                          Pisosvs3
##                          1.251000
```

```r
#Variables problematicas tienen sqrt(FIV) > 2

sqrt(vif(modelo.MLR.step))
```

```
##                          tx2mod3a                         Suelosvs2
##                          2.776276                          1.191884
##                          tdmmod3a VerticalDistanceToChannelNetwork
##                          4.994918                          2.762108
##                          tdhmod3a                          tx3mod3a
##                          2.497728                          3.227841
##                          tx6mod3a             RelativeSlopePosition
##                          2.647150                          2.603009
##                          tx4mod3a                          tdlmod3a
##                          2.807851                          2.699247
##                          twisre3a                          ganhws3a
##                          1.948273                          1.208840
##                          tnhmod3a                          DEMSRE3a
##                          6.717092                         44.395289
##                               DEM                          tnmmod3a
##                         44.888187                          5.907536
##                          inssre3a                          inmsre3a
##                          3.698152                          2.400067
##                         Bioclivs1                          Pisosvs9
##                          1.404724                          1.681186
##                          Pisosvs3
##                          1.118481
```

```r
# Eliminamos del MRL multiple las covariables con Multicolinealidad.

modelo.MLR.step <- update(modelo.MLR.step, . ~ . - DEM -tnhmod3a -tdmmod3a -inssre3a -tx3mod3a -tnmmod3a

# Revisamos de nuevo la multicolinealidad.

sqrt(vif(modelo.MLR.step))
```

```
##                          tx2mod3a                         Suelosvs2
##                          2.319083                          1.187438
## VerticalDistanceToChannelNetwork                          tdhmod3a
##                          2.707139                          2.240357
##                          tx6mod3a             RelativeSlopePosition
##                          2.577834                          2.452224
##                          tx4mod3a                          tdlmod3a
##                          2.404800                          2.368837
##                          twisre3a                          ganhws3a
##                          1.772470                          1.197710
##                          DEMSRE3a                          inmsre3a
##                          2.822557                          1.775531
##                         Bioclivs1                          Pisosvs9
##                          1.334821                          1.632872
```

```
##                         Pisosvs3
##                         1.099501
```

```
#Vamos usar la prueba de Bonferroni para valores atipicos:

outlierTest(modelo.MLR.step)
```

```
##        rstudent unadjusted p-value Bonferonni p
## 6399  -5.099740         3.4628e-07    0.0035068
## 6943  -4.994096         6.0100e-07    0.0060863
## 9585  -4.910874         9.2091e-07    0.0093260
## 9671  -4.887380         1.0376e-06    0.0105070
## 10102 -4.746641         2.0966e-06    0.0212320
## 2219  -4.682257         2.8743e-06    0.0291080
## 7367  -4.577421         4.7636e-06    0.0482410
```

```
# Incorporamos las covariables requeridas, segun MRL Multiple.

topo <- stack('ECUtopo.tif')
namesTopo <- readRDS('namesTOPO.rds')
names(topo)
```

```
##  [1] "ECUtopo.1"  "ECUtopo.2"  "ECUtopo.3"  "ECUtopo.4"  "ECUtopo.5"
##  [6] "ECUtopo.6"  "ECUtopo.7"  "ECUtopo.8"  "ECUtopo.9"  "ECUtopo.10"
## [11] "ECUtopo.11" "ECUtopo.12" "ECUtopo.13" "ECUtopo.14" "ECUtopo.15"
```

```
names(topo) <- namesTopo
names(topo)
```

```
##  [1] "DEM"                              "AnalyticalHillshading"
##  [3] "Slope"                            "Aspect"
##  [5] "CrossSectionalCurvature"          "LongitudinalCurvature"
##  [7] "CovergenceIndex"                  "ClosedDepressions"
##  [9] "FlowAccumulation"                 "TopographicWetnessIndex"
## [11] "LSFactor"                         "ChannelNetworkBaseLevel"
## [13] "VerticalDistanceToChannelNetwork" "ValleyDepth"
## [15] "RelativeSlopePosition"
```

```
cov <- stack('ECU_worldgridsCOVS.tif')
namesCov <- readRDS('worldgridsCOVS_names.rds')
#names(cov)
names(cov) <- namesCov
#names(cov)

# Incorporamos las covariables categoricas y las adecuamos al resto.

Suelosvs <- raster('Covariables/Suelosvs.tif')
Suelosvs <- resample(Suelosvs,topo, method = 'ngb')
Bioclivs <- raster('Covariables/Bioclivs.tif')
Bioclivs <- resample(Bioclivs,topo, method = 'ngb')
Climavs <- raster('Covariables/Climavs.tif')
Climavs <- resample(Climavs,topo, method = 'ngb')
Cobervs <- raster('Covariables/Cobervs.tif')
Cobervs <- resample(Cobervs,topo, method = 'ngb')
Pisosvs <- raster('Covariables/Pisosvs.tif')
Pisosvs <- resample(Pisosvs,topo, method = 'ngb')
```

```
# Convertimos las covariables categoricas a dummy

Suelosvs_du <- dummyRaster(Suelosvs)
Bioclivs_du <- dummyRaster(Bioclivs)
Climavs_du <- dummyRaster(Climavs)
Cobervs_du <- dummyRaster(Cobervs)
Pisosvs_du <- dummyRaster(Pisosvs)

# Apilamos todas las covariables.

COV <- stack(topo, cov, Suelosvs_du, Bioclivs_du, Climavs_du, Cobervs_du, Pisosvs_du)

# Observamos los nombres de los campos o columnas.

names(COV)
```

```
##  [1] "DEM"                                "AnalyticalHillshading"
##  [3] "Slope"                              "Aspect"
##  [5] "CrossSectionalCurvature"            "LongitudinalCurvature"
##  [7] "CovergenceIndex"                    "ClosedDepressions"
##  [9] "FlowAccumulation"                   "TopographicWetnessIndex"
## [11] "LSFactor"                           "ChannelNetworkBaseLevel"
## [13] "VerticalDistanceToChannelNetwork"   "ValleyDepth"
## [15] "RelativeSlopePosition"              "cntgad3a"
## [17] "DEMSRE3a"                           "etmnts3a"
## [19] "evmmod3a"                           "evsmod3a"
## [21] "g01esa3a"                           "g01igb3a"
## [23] "g02esa3a"                           "g02igb3a"
## [25] "g03esa3a"                           "g04esa3a"
## [27] "g04igb3a"                           "g05esa3a"
## [29] "g06esa3a"                           "g07esa3a"
## [31] "g08esa3a"                           "g09esa3a"
## [33] "g10esa3a"                           "g10igb3a"
## [35] "g11esa3a"                           "g11igb3a"
## [37] "g12esa3a"                           "g12igb3a"
## [39] "g13esa3a"                           "g14esa3a"
## [41] "g15esa3a"                           "g16esa3a"
## [43] "g17esa3a"                           "g18esa3a"
## [45] "g19esa3a"                           "g20esa3a"
## [47] "g21esa3a"                           "g22esa3a"
## [49] "gabhws3a"                           "gacgem3a"
## [51] "gachws3a"                           "galhws3a"
## [53] "ganhws3a"                           "garhws3a"
## [55] "gathws3a"                           "gchhws3a"
## [57] "gclhws3a"                           "gcmhws3a"
## [59] "gcrhws3a"                           "geaisg3a"
## [61] "gflhws3a"                           "gfrhws3a"
## [63] "gglhws3a"                           "ggyhws3a"
## [65] "ghshws3a"                           "gkshws3a"
## [67] "glcesa3a"                           "glcjrc3a"
## [69] "glphws3a"                           "glvhws3a"
## [71] "glwwwf3a"                           "glxhws3a"
## [73] "gnthws3a"                           "gphhws3a"
## [75] "gplhws3a"                           "gpthws3a"
```

```
##  [77] "gpzhws3a"                           "grghws3a"
##  [79] "gschws3a"                           "gsnhws3a"
##  [81] "gsthws3a"                           "gumhws3a"
##  [83] "gvrhws3a"                           "iflgre3a"
##  [85] "inmsre3a"                           "inssre3a"
##  [87] "l01igb3a"                           "l02igb3a"
##  [89] "l03igb3a"                           "l04igb3a"
##  [91] "l05igb3a"                           "l06igb3a"
##  [93] "l07igb3a"                           "l08igb3a"
##  [95] "l09igb3a"                           "l10igb3a"
##  [97] "l11igb3a"                           "l12igb3a"
##  [99] "l13igb3a"                           "l14igb3a"
## [101] "l15igb3a"                           "l16igb3a"
## [103] "l3pobi3b"                           "lammod3a"
## [105] "lasmod3a"                           "lmbgsh3a"
## [107] "lmtgsh3a"                           "ln1dms3a"
## [109] "ln2dms3a"                           "lnmdms3a"
## [111] "opisre3a"                           "px1wcl3a"
## [113] "px2wcl3a"                           "px3wcl3a"
## [115] "px4wcl3a"                           "SLPSRT3a"
## [117] "smkisr3a"                           "tdhmod3a"
## [119] "tdlmod3a"                           "tdmmod3a"
## [121] "tdsmod3a"                           "tnhmod3a"
## [123] "tnlmod3a"                           "tnmmod3a"
## [125] "tnsmod3a"                           "twisre3a"
## [127] "tx1mod3a"                           "tx2mod3a"
## [129] "tx3mod3a"                           "tx4mod3a"
## [131] "tx5mod3a"                           "tx6mod3a"
## [133] "wmkmod3a"                           "Suelosvs1"
## [135] "Suelosvs2"                          "Suelosvs3"
## [137] "Suelosvs4"                          "Suelosvs5"
## [139] "Suelosvs6"                          "Suelosvs7"
## [141] "Suelosvs8"                          "Suelosvs9"
## [143] "Suelosvs10"                         "Suelosvs11"
## [145] "Bioclivs1"                          "Bioclivs2"
## [147] "Bioclivs3"                          "Bioclivs4"
## [149] "Climavs1"                           "Climavs2"
## [151] "Climavs3"                           "Climavs4"
## [153] "Climavs5"                           "Climavs6"
## [155] "Climavs7"                           "Climavs8"
## [157] "Climavs9"                           "Cobervs1"
## [159] "Cobervs2"                           "Cobervs3"
## [161] "Cobervs4"                           "Cobervs5"
## [163] "Cobervs6"                           "Cobervs7"
## [165] "Pisosvs1"                           "Pisosvs2"
## [167] "Pisosvs3"                           "Pisosvs4"
## [169] "Pisosvs5"                           "Pisosvs7"
## [171] "Pisosvs8"                           "Pisosvs9"
```

```r
# Seleccionamos solo las primeras 25 covariables de mayor correlacion.

COV <- COV[[idx]]

# Observamos los nombres de los campos o columnas.
```

```r
names(COV)
```

```
##  [1] "tx2mod3a"                         "Suelosvs2"
##  [3] "tx1mod3a"                         "tdmmod3a"
##  [5] "VerticalDistanceToChannelNetwork" "tdhmod3a"
##  [7] "tx5mod3a"                         "tx3mod3a"
##  [9] "tx6mod3a"                         "RelativeSlopePosition"
## [11] "tx4mod3a"                         "tdlmod3a"
## [13] "twisre3a"                         "ganhws3a"
## [15] "tnhmod3a"                         "DEMSRE3a"
## [17] "DEM"                              "tnmmod3a"
## [19] "inssre3a"                         "Bioclivs3"
## [21] "inmsre3a"                         "Bioclivs1"
## [23] "ValleyDepth"                      "Pisosvs9"
## [25] "Pisosvs3"
```

```r
# Cambiamos resolucion espacial de las covariables solo para verlos.
# En la corrida final se debe dejar en la resolucion original de 1 km.

COV <- aggregate(COV, 10)

# Adecuamos proyeccion cartograficas.
# Projectamos puntos de datos.

dat_sp@proj4string <- COV@crs
dat_sp <- spTransform(dat_sp, CRS("+init=epsg:32717"))
COV <- projectRaster(COV, crs = CRS("+init=epsg:32717"), method='ngb')

# Convertimos las covariabes a tabla de datos espaciales.

COV.sp <- as(COV, "SpatialGridDataFrame")

## Eliminamos Datos duplicados.

zerodist(dat_sp)
```

```
##       [,1] [,2]
##  [1,]    3    4
##  [2,]    3    5
##  [3,]    4    5
##  [4,]    2    7
##  [5,]   11   12
##  [6,]   11   13
##  [7,]   12   13
##  [8,]   11   14
##  [9,]   12   14
## [10,]   13   14
## [11,]   11   15
## [12,]   12   15
## [13,]   13   15
## [14,]   14   15
## [15,]   11   16
## [16,]   12   16
## [17,]   13   16
```

```
## [2124,]  9832  9833
## [2125,]  9834  9835
## [2126,]  9857  9858
## [2127,]  9841  9861
## [2128,]  9862  9863
## [2129,]  9865  9866
## [2130,]  9867  9868
## [2131,]  9854  9869
## [2132,]  9844  9870
## [2133,]  9875  9876
## [2134,]  9850  9878
## [2135,]  9885  9886
## [2136,]  9896  9897
## [2137,]  9902  9903
## [2138,]  9935  9936
## [2139,]  9929  9938
## [2140,]  9929  9939
## [2141,]  9938  9939
## [2142,]  9920  9944
## [2143,]  9948  9949
## [2144,]  9927  9961
## [2145,]  9925  9965
## [2146,]  9966  9967
## [2147,]  9960  9975
## [2148,]  9976  9977
## [2149,]  9978  9986
## [2150,]  9997  9998
## [2151,]  9925 10007
## [2152,]  9965 10007
## [2153,] 10008 10009
## [2154,] 10011 10012
## [2155,] 10014 10020
## [2156,] 10028 10029
## [2157,] 10049 10050
## [2158,] 10055 10056
## [2159,] 10055 10057
## [2160,] 10056 10057
## [2161,] 10062 10063
## [2162,] 10064 10065
## [2163,] 10062 10068
## [2164,] 10063 10068
## [2165,] 10085 10090
## [2166,] 10104 10105
## [2167,] 10107 10108
## [2168,] 10098 10109
## [2169,] 10114 10127
```

```
dat_sp <- dat_sp[dat_sp$OCSKGM30 != 0,]

# Ejecutamos estimacion del COS segun ecuacion de RLM Multiple y el kriging
# de los residuos para la parte continental del Ecuador.

start <- Sys.time()
OCS.krige <- autoKrige(formula = as.formula(modelo.MLR.step$call$formula),
```

```r
                        input_data = dat_sp,
                        new_data = COV.sp,
                        verbose = TRUE,
                        block = c(1000, 1000),
                        model = c("Sph", "Exp"))
```

```
## Warning in autoKrige(formula = as.formula(modelo.MLR.step$call$formula), :
## Removed 2169 duplicate observation(s) in input_data:

##                  coordinates   ID1                            ID
## 3      (753711.4, 10141590)   837              CG4-P158_1.28_-78.72
## 3.1    (753711.4, 10141590)   837              CG4-P158_1.28_-78.72
## 4      (753711.4, 10141590) 10089              PN2-P267_1.28_-78.72
## 2      (753723.5, 10127210)    39              CG1-P021_1.15_-78.72
## 11     (725898.1, 10116130)  1552              CL6-P127_1.05_-78.97
## 11.1   (725898.1, 10116130)  1552              CL6-P127_1.05_-78.97
## 12     (725898.1, 10116130)  1568              CL6-P143_1.05_-78.97
## 11.2   (725898.1, 10116130)  1552              CL6-P127_1.05_-78.97
## 12.1   (725898.1, 10116130)  1568              CL6-P143_1.05_-78.97
## 13     (725898.1, 10116130)  1840              CO2-P016_1.05_-78.97
## 11.3   (725898.1, 10116130)  1552              CL6-P127_1.05_-78.97
## 12.2   (725898.1, 10116130)  1568              CL6-P143_1.05_-78.97
## 13.1   (725898.1, 10116130)  1840              CO2-P016_1.05_-78.97
## 14     (725898.1, 10116130)  2001              CO9-P038_1.05_-78.97
## 11.4   (725898.1, 10116130)  1552              CL6-P127_1.05_-78.97
## 12.3   (725898.1, 10116130)  1568              CL6-P143_1.05_-78.97
## 13.2   (725898.1, 10116130)  1840              CO2-P016_1.05_-78.97
## 14.1   (725898.1, 10116130)  2001              CO9-P038_1.05_-78.97
## 15     (725898.1, 10116130)  8657              PM1-P076_1.05_-78.97
## 17     (714765.7, 10116120)  9827              PN1-P241_1.05_-79.07
## 11.5   (725898.1, 10116130)  1552              CL6-P127_1.05_-78.97
## 12.4   (725898.1, 10116130)  1568              CL6-P143_1.05_-78.97
## 13.3   (725898.1, 10116130)  1840              CO2-P016_1.05_-78.97
## 14.2   (725898.1, 10116130)  2001              CO9-P038_1.05_-78.97
## 15.1   (725898.1, 10116130)  8657              PM1-P076_1.05_-78.97
## 16     (725898.1, 10116130)  8659              PM1-P077_1.05_-78.97
## 17.1   (714765.7, 10116120)  9827              PN1-P241_1.05_-79.07
## 18     (714765.7, 10116120)  9829              PN1-P271_1.05_-79.07
## 17.2   (714765.7, 10116120)  9827              PN1-P241_1.05_-79.07
## 18.1   (714765.7, 10116120)  9829              PN1-P271_1.05_-79.07
## 21     (714765.7, 10116120)  9937              PN2-P130_1.05_-79.07
## 17.3   (714765.7, 10116120)  9827              PN1-P241_1.05_-79.07
## 18.2   (714765.7, 10116120)  9829              PN1-P271_1.05_-79.07
## 21.1   (714765.7, 10116120)  9937              PN2-P130_1.05_-79.07
## 22     (714765.7, 10116120)  9962              PN2-P155_1.05_-79.07
## 17.4   (714765.7, 10116120)  9827              PN1-P241_1.05_-79.07
## 18.3   (714765.7, 10116120)  9829              PN1-P271_1.05_-79.07
## 21.2   (714765.7, 10116120)  9937              PN2-P130_1.05_-79.07
## 22.1   (714765.7, 10116120)  9962              PN2-P155_1.05_-79.07
## 23     (714765.7, 10116120)  9964              PN2-P157_1.05_-79.07
## 17.5   (714765.7, 10116120)  9827              PN1-P241_1.05_-79.07
## 18.4   (714765.7, 10116120)  9829              PN1-P271_1.05_-79.07
## 21.3   (714765.7, 10116120)  9937              PN2-P130_1.05_-79.07
## 22.2   (714765.7, 10116120)  9962              PN2-P155_1.05_-79.07
```

```
## 2442           0          0          0
## 2450           0          0          0
## 2463           0          0          0
## 2480           0          0          0
## 2493           0          0          0
## 2504           0          0          0
## 2508           0          0          0
## 2512           0          0          0
## 2525           0          0          0
## 2533           0          0          0
## 2541           0          0          0
## 2548           0          0          0
## 2556           0          0          0
## 2568           0          0          0
## 2574           0          0          0
## 2573           0          0          0
## 2574.1         0          0          0
## 2575           0          0          0
## 2585           0          0          0
## 2574.2         0          0          0
## 2575.1         0          0          0
## 2579           0          0          0
## 2574.3         0          0          0
## 2575.2         0          0          0
## 2579.1         0          0          0
## 2591           0          0          0
## 2574.4         0          0          0
##  [ reached 'max' / getOption("max.print") -- omitted 3619 rows ]
## Checking if any bins have less than 5 points, merging bins when necessary...
##
## Selected:
##   model      psill    range
## 1   Nug 0.24464055     0.00
## 2   Exp 0.08663018 10391.67
##
## Tested models, best first:
##   Tested.models kappa      SSerror
## 2           Exp     0 4.429738e-08
## 1           Sph     0 1.033833e-07
## [using universal kriging]
```

```
print(Sys.time() - start)
```

```
## Time difference of 5.77796 mins
```

```
# Devolvemos los valores de COS a su condcion original.

RKprediction <- exp(raster(OCS.krige$krige_output[1]))
RKpredsd <- exp(raster(OCS.krige$krige_output[3]))

# Vemos el resumen estadistico de los resultados en kg/m2.

summary(RKprediction)
```

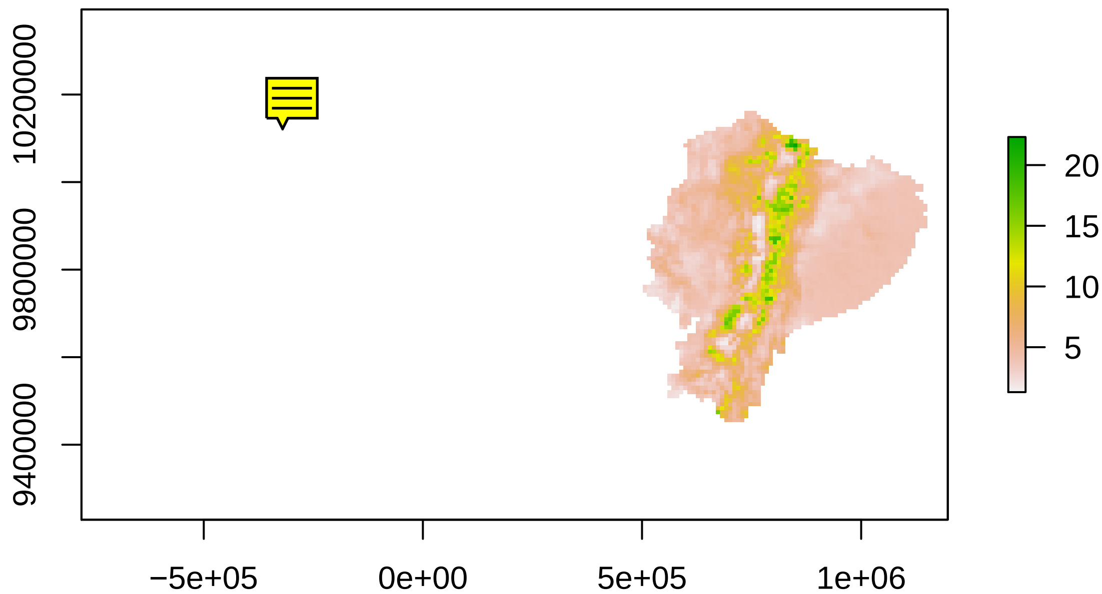
```
##                 layer
```

```
## Min.        1.296340
## 1st Qu.     3.796010
## Median      4.196352
## 3rd Qu.     6.353187
## Max.       22.313380
## NA's    16533.000000
```

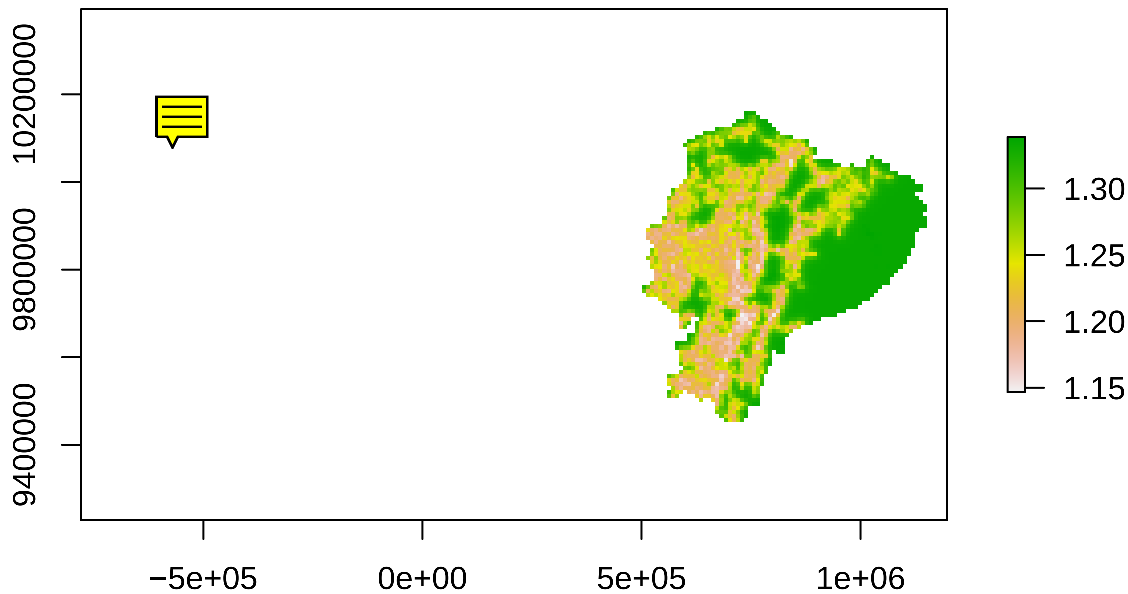
```r
summary(RKpredsd)
```

```
##                layer
## Min.        1.146581
## 1st Qu.     1.224752
## Median      1.271055
## 3rd Qu.     1.326338
## Max.        1.338849
## NA's    16533.000000
```

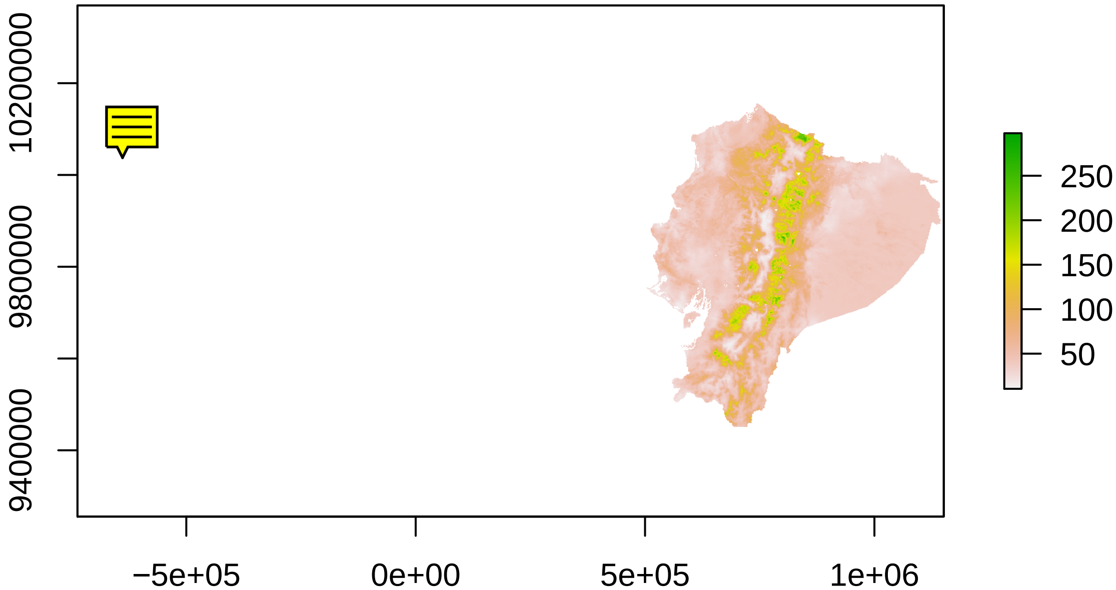
```r
# Si existen valores atipico se pueden eliminar aqui.

#values(RKprediction )[values(RKprediction ) < 0]  <- NA
#values(RKprediction )[values(RKprediction ) > 100]  <- NA
#values(RKpredsd)[values(RKpredsd ) > 10]  <- NA

# Vemos el resumen estadistico de los resultados en kg/m2.

#summary(RKprediction)
#summary(RKpredsd)

# Graficamos los resultados.

plot(RKprediction)
```



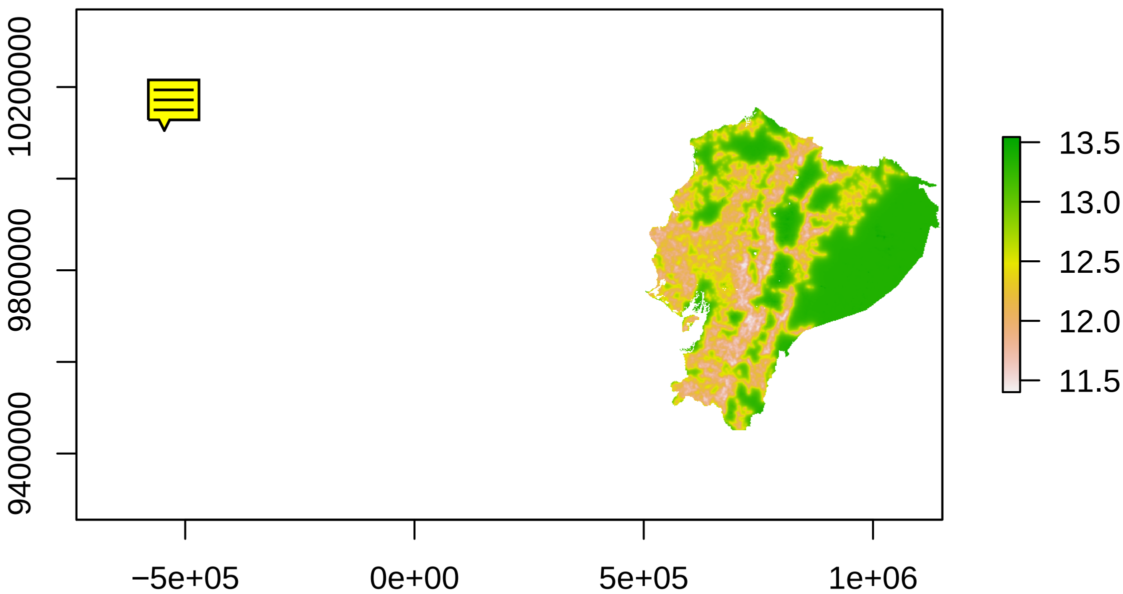

```
plot(RKpredsd)
```




```
# Reproyectamos la prediccion a geografica WGS84.

RKprediction_geo <- projectRaster(RKprediction, crs = CRS("+proj=longlat +datum=WGS84 +no_defs +ellps=W

# Guardamos los resultados en archivos tiff.

#writeRaster(RKprediction, filename = "ECU_OCS_RK_kgm2.tif")
#writeRaster(RKprediction, filename = "ECU_OCS_RK_kgm2a.asc")
#writeRaster(RKprediction_geo, filename = "ECU_OCS_RK_kgm2_geo.asc")
#writeRaster(RKprediction_geo, filename = "ECU_OCS_RK_kgm2_geot.tif")
#writeRaster(RKpredsd, filename = "ECU_OCS_RKpredsd_kgm2.tif")

# Convertimos los resultados de kg/m2 a Tn/ha.
# Importamos el raster resultados

r1 <- raster ('ECU_OCS_RK_kgm2.tif')
r2 <- r1 *10

r3 <- raster ('ECU_OCS_RKpredsd_kgm2.tif')
r4 <- r3 *10

# Graficamos los resultados en Tn/ha.

plot(r2)
```


10200000
9800000
9400000
−5e+05
0e+00
5e+05
1e+06
250
200
150
100
50

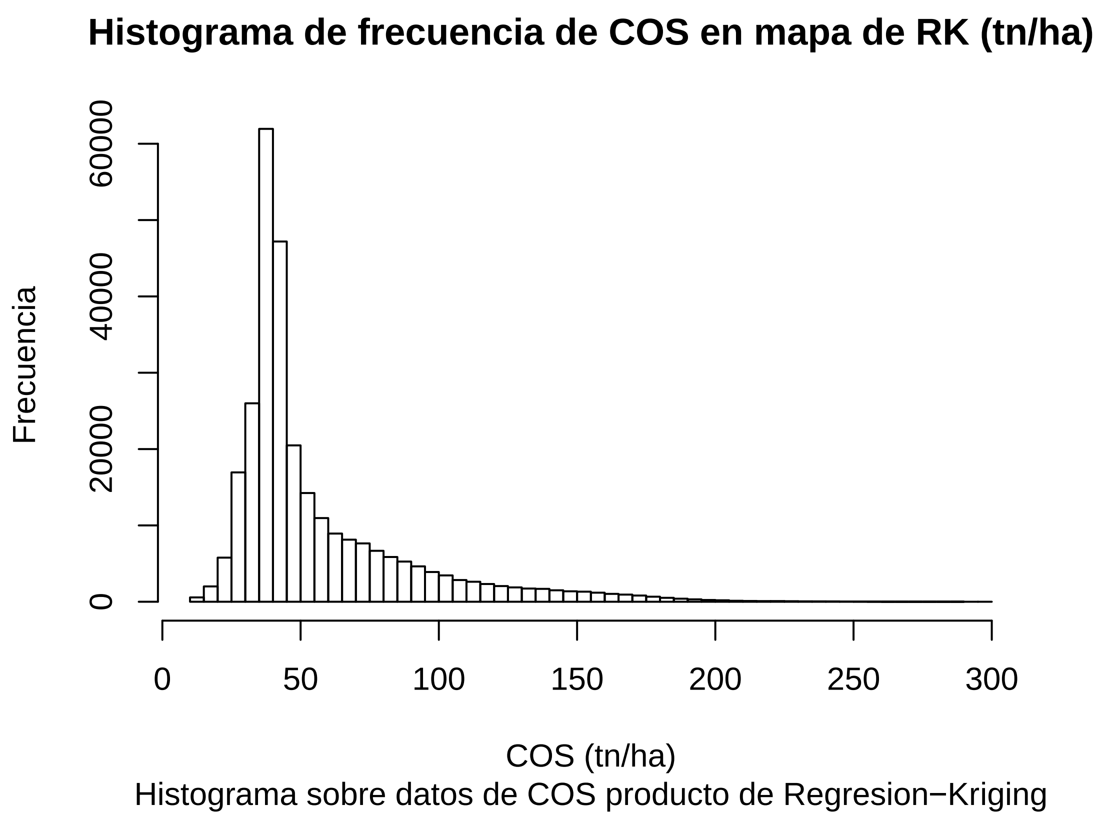
```
plot(r4)
```




```r
# Resumen del mapa de COS en tn/ha.

summary(r2)
```

```
##         ECU_OCS_RK_kgm2
## Min.       1.044161e+01
## 1st Qu.    3.759635e+01
## Median     4.226499e+01
## 3rd Qu.    6.507849e+01
## Max.       2.978068e+02
## NA's       1.398030e+06
```

```r
hist(r2, breaks = 100, main  = "Histograma de frecuencia de COS en mapa de RK (tn/ha)", xlab= 'COS (tn/l
```




```r
# Reproyectamos la prediccion a geografica WGS84.

r2_geo <- projectRaster(r2, crs = CRS("+proj=longlat +datum=WGS84 +no_defs +ellps=WGS84 +towgs84=0,0,0"
r4_geo <- projectRaster(r4, crs = CRS("+proj=longlat +datum=WGS84 +no_defs +ellps=WGS84 +towgs84=0,0,0"

# Se guarda en formato tif.
#writeRaster(r2, 'ECU_Mapa_COS_tnha.tif')
#writeRaster(r4, 'ECU_Mapa_COS_Res_tnha.tif')
#writeRaster(r4_geo, 'ECU_Mapa_COS_Res_tnha_geo.tif')
#writeRaster(r2_geo, 'ECU_Mapa_COS_tnha_geo.tif')

# Ejecutamos estimacion del COS segun ecuacion de RLM Multiple y el kriging
# de los residuos para las Islas Galapagos.

start <- Sys.time()
OCS.krige.g <- autoKrige(formula = log(OCSKGM30) ~ tx2mod3a + tdhmod3a + tx4mod3a + ganhws3a + tx6mod3a
                          DEMSRE3a + VerticalDistanceToChannelNetwork + RelativeSlopePosition + twisre3a
                       input_data = dat_sp,
                       new_data = COV.sp,
                       verbose = TRUE,
                       block = c(1000, 1000),
                       model = c("Sph", "Exp"))
```

```
## Warning in autoKrige(formula = log(OCSKGM30) ~ tx2mod3a + tdhmod3a +
## tx4mod3a + : Removed 2169 duplicate observation(s) in input_data:

##                  coordinates   ID1                                ID
```

```
## 2541           0          0          0
## 2548           0          0          0
## 2556           0          0          0
## 2568           0          0          0
## 2574           0          0          0
## 2573           0          0          0
## 2574.1         0          0          0
## 2575           0          0          0
## 2585           0          0          0
## 2574.2         0          0          0
## 2575.1         0          0          0
## 2579           0          0          0
## 2574.3         0          0          0
## 2575.2         0          0          0
## 2579.1         0          0          0
## 2591           0          0          0
## 2574.4         0          0          0
##  [ reached 'max' / getOption("max.print") -- omitted 3619 rows ]
## Checking if any bins have less than 5 points, merging bins when necessary...
##
## Selected:
##   model     psill    range
## 1   Nug 0.2431701     0.00
## 2   Exp 0.1039212 10433.87
##
## Tested models, best first:
##   Tested.models kappa      SSerror
## 2           Exp     0 7.114677e-08
## 1           Sph     0 1.906273e-07
## [using universal kriging]
```

```
print(Sys.time() - start)
```

```
## Time difference of 6.066448 mins
```

```
# Devolvemos los valores de COS a su condcion original.

RKprediction.g <- exp(raster(OCS.krige.g$krige_output[1]))
RKpredsd.g <- exp(raster(OCS.krige.g$krige_output[3]))

# Vemos el resumen estadistico de los resultados en kg/m2.

summary(RKprediction.g)
```

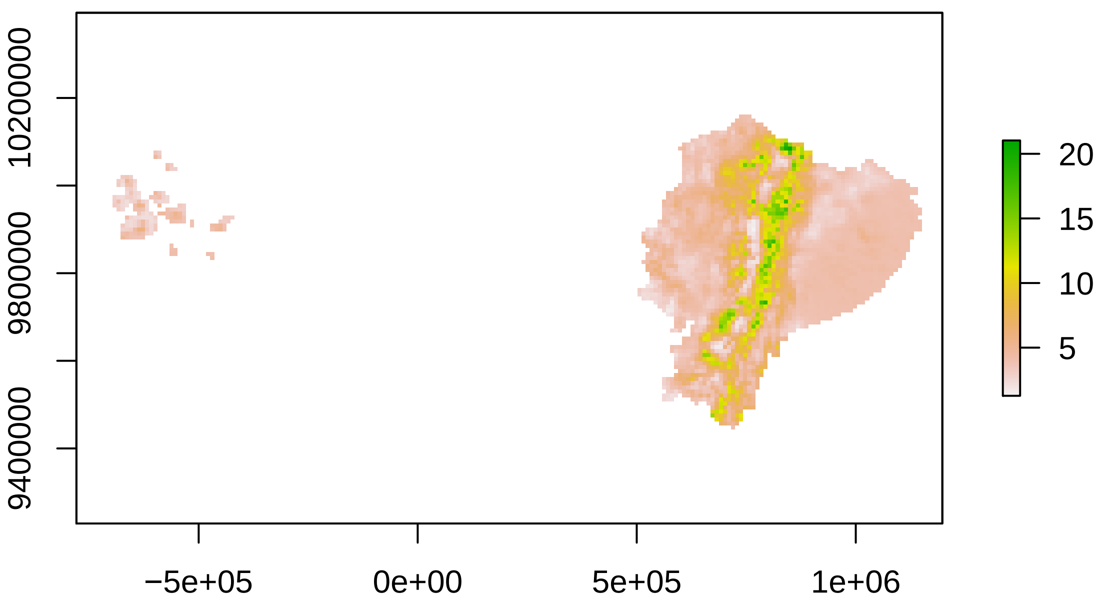
```
##                 layer
## Min.         1.271960
## 1st Qu.      3.728430
## Median       4.214753
## 3rd Qu.      6.109628
## Max.        21.034119
## NA's     16350.000000
```

```
summary(RKpredsd.g)
```

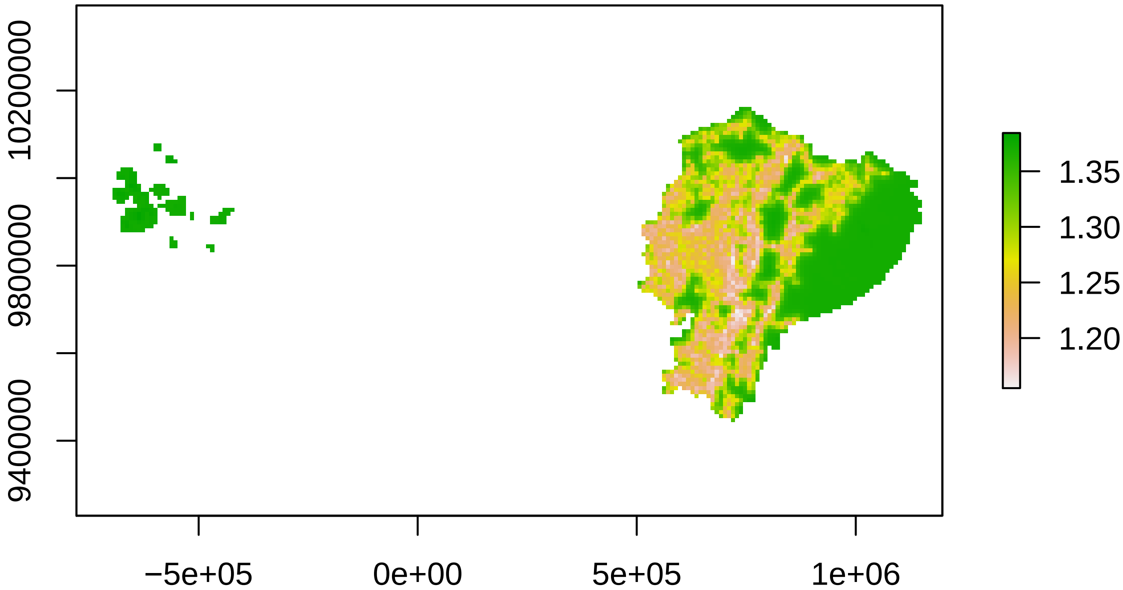
```
##                 layer
## Min.         1.154968
```

```
## 1st Qu.      1.244228
## Median       1.301377
## 3rd Qu.      1.367798
## Max.         1.384404
## NA's     16350.000000
```

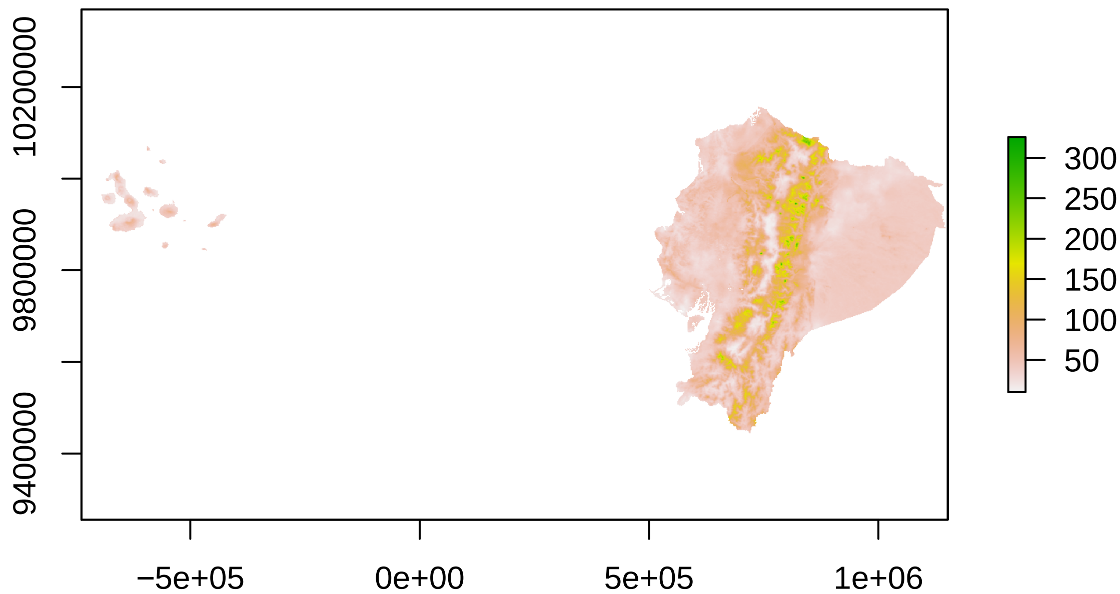
```r
# Si existen valores atipico se pueden eliminar aqui.

#values(RKprediction.g )[values(RKprediction.g ) < 0]  <- NA
#values(RKprediction.g )[values(RKprediction.g ) > 100]  <- NA
#values(RKpredsd.g)[values(RKpredsd.g ) > 10]  <- NA

# Vemos el resumen estadistico de los resultados en kg/m2.

#summary(RKprediction.g)
#summary(RKpredsd.g)

# Graficamos los resultados.

plot(RKprediction.g)
```



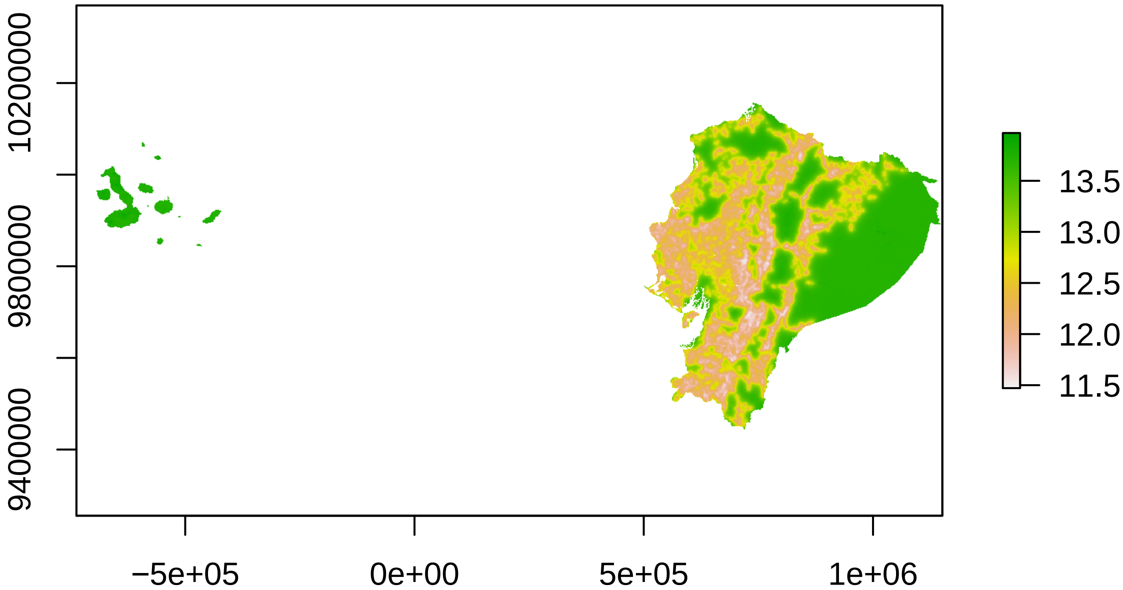

```r
plot(RKpredsd.g)
```




```r
# Guardamos los resultados en archivos tiff.

# writeRaster(RKprediction.g, filename = "ECU_OCS_RK_G_kgm2.tif")
# writeRaster(RKpredsd.g, filename = "ECU_OCS_RKpredsd_G_kgm2.tif")

# Convertimos los resultados de kg/m2 a Tn/ha.
# Importamos el raster resultados

r1.g <- raster ('ECU_OCS_RK_G_kgm2.tif')
r2.g <- r1.g *10

r3.g <- raster ('ECU_OCS_RKpredsd_G_kgm2.tif')
r4.g <- r3.g *10

# Graficamos los resultados en Tn/ha.

plot(r2.g)
```


10200000
9800000
9400000
−5e+05
0e+00
5e+05
1e+06
300
250
200
150
100
50

```
plot(r4.g)
```




```r
r2.g_geo <- projectRaster(r2.g, crs = CRS("+proj=longlat +datum=WGS84 +no_defs +ellps=WGS84 +towgs84=0,(
r4.g_geo <- projectRaster(r4.g, crs = CRS("+proj=longlat +datum=WGS84 +no_defs +ellps=WGS84 +towgs84=0,(

# Se guarda en formato tif.
#writeRaster(r2.g, 'ECU_Mapa_COS_G_tnha.tif')
#writeRaster(r4.g, 'ECU_Mapa_COS_Res_G_tnha.tif')
#writeRaster(r2.g_geo, 'ECU_Mapa_COS_G_tnha_geot.tif')
#writeRaster(r4.g_geo, 'ECU_Mapa_COS_Res_G_tnha_geo.tif')


# Estimacion de la incertidumbre segun validacion cruzada.
# Eliminamos datos duplicados.

dat_sp = dat_sp[which(!duplicated(dat_sp@coords)), ]

# Corremos la validacion cruzada.

OCS.krige.cv <- autoKrige.cv(formula = as.formula(modelo.MLR.step$call$formula),
                             input_data = dat_sp, nfold = 5)
```

```
##
  |
  |                                                                      |   0%
  |
  |================                                                      |  25%
  |
```

```
  |================================                                  |  50%
  |
  |=================================================                 |  75%
  |
  |==================================================================| 100%
```

```
# Vemos un resumen estadistico de la validacion cruzada.

summary(OCS.krige.cv)
```

```
##             [,1]
## mean_error  -2.281e-06
## me_mean     -1.544e-06
## MAE         0.394
## MSE         0.2763
## MSNE        0.969
## cor_obspred 0.6335
## cor_predres 0.005655
## RMSE        0.5257
## RMSE_sd     0.7737
## URMSE       0.5257
## iqr         0.6012
```

```
#=====================================================================================
# ============= SCRIPT PARA VALIDACION EXTERNA ========================================
# ============================== ECUADOR ==============================================
#=====================================================================================

# Para esta validacion se emplearon los 1000 puntos dejados fuera de la calibracion
# del modelo de Regresion - Kriging.

# Cargamos los datos de los perfiles de validacion.

datv <- read.csv("ecu_vali8.csv", header = TRUE, sep = ",")

# Observamos los nombres de los campos o columnas.

names(datv)
```

```
## [1] "Id1"       "Id"        "Latitude"  "Longitude" "Ocskgm30"
```

```
# Vemos un resumen de los datos de COS (Kg/m2) de los perfiles de validacion.

summary(datv$Ocskgm30)
```

```
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##  0.1376  3.0513  4.4866  5.3964  6.2934 37.7296
```

```
## Recreamos el objeto con la ubicacion de los puntos.

coordinates(datv) <- ~ Longitude + Latitude

# Adecuamos proyeccion cartograficas.
# Project point data

datv@proj4string <- CRS(projargs = "+proj=longlat +datum=WGS84 +no_defs +ellps=WGS84 +towgs84=0,0,0")
OCSKGM_RK <- raster("ECU_OCS_RK_kgm2_geot.tif")
```

```r
# Extraemos los datos de COS en kg/m2 de la capa estimada para los puntos de validacion.

datv <- extract(x = OCSKGM_RK, y = datv, sp = TRUE)

# Calculamos la diferencia entre los valores de COS medidos y los COS estims=ados.

datv$PE_RK <- datv$ECU_OCS_RK_kgm2_geot - datv$Ocskgm30

# Guardamos los resultados de esta validacion.

# write.csv(datv, "Ecu_validacion8.csv", row.names = F)

# Exponemos un resumen de los errores de prediccion.

summary(res_rk <- abs(datv$ECU_OCS_RK_kgm2_geot - datv$Ocskgm30))
```

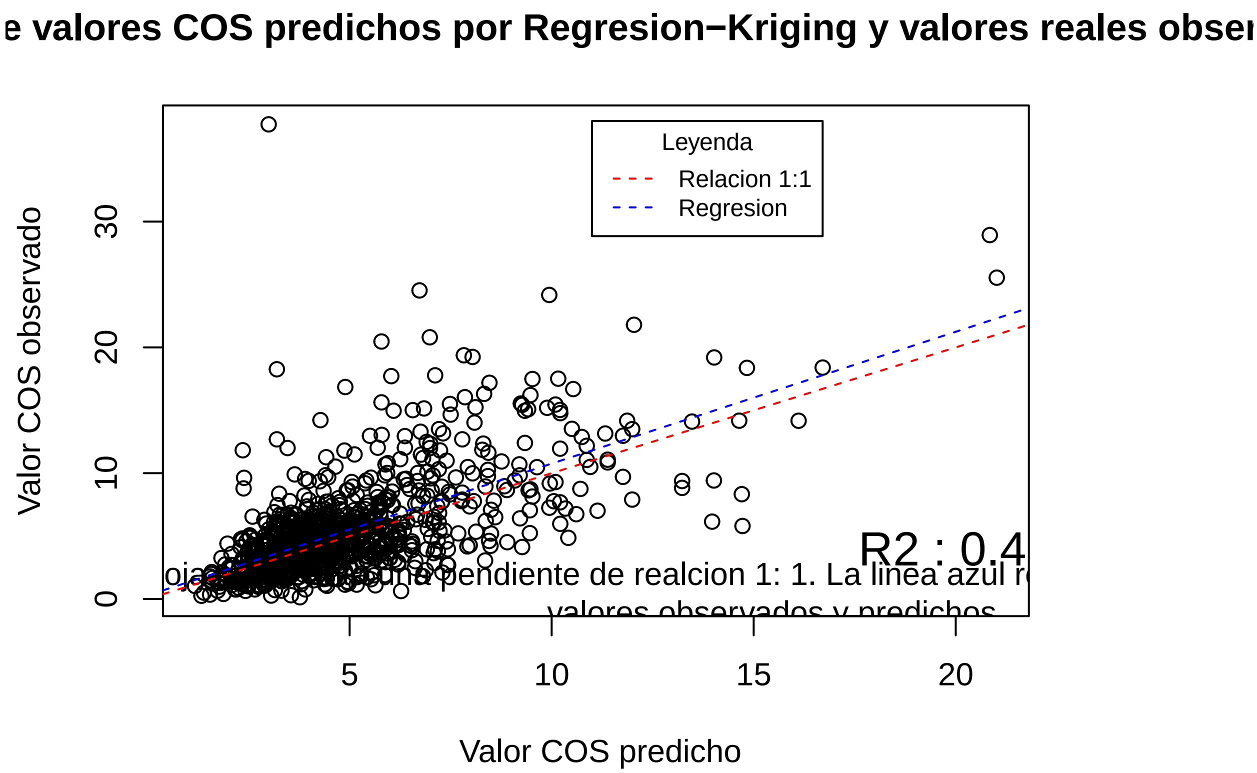
```
##     Min.  1st Qu.   Median     Mean  3rd Qu.     Max.
##  0.00027  0.56144  1.30736  1.89534  2.33010 34.73290
```

```r
# Estimacion de las medidas de calidad del mapa.

# Calculamos el cuartil 75%.

s <- quantile(res_rk,.75, na.rm=TRUE)

# Calculamos e imprimimos el error medio cuadrado entre el valor predicho
# y el valor medido.

a <-(rmse(datv$ECU_OCS_RK_kgm2_geot, datv$Ocskgm30))

# Calculamos el R2 entre los valores estimados o predichos y los medidos u observados.

g <- (cor(datv$ECU_OCS_RK_kgm2_geot, datv$Ocskgm30)^2)

# Calculamos el Error medio de todos los puntos de validacion.

ME_RK <- mean(datv$PE_RK, na.rm=TRUE)

# Calculamos el error promedio absoluto (MAE).

MAE_RK <- mean(abs(datv$PE_RK), na.rm=TRUE)

# Calculamos el cuadrado del error promedio (MSE).

MSE_RK <- mean(datv$PE_RK^2, na.rm=TRUE)

# Calculamos la raiz cuadrada del error promedio cuadrado (RMSE).

RMSE_RK <- sqrt(sum(datv$PE_RK^2, na.rm=TRUE) / length(datv$PE_RK))

# Estimamos la varianza explicada (Amount of Variance Explained (AVE)).

AVE_RK <- 1 - sum(datv$PE_RK^2, na.rm=TRUE) /
  sum( (datv$Ocskgm30 - mean(datv$Ocskgm30, na.rm = TRUE))^2,
```

```r
       na.rm = TRUE)

# Impresion de los errores.

metodo <- factor("Regresion-Kriging")
metodo <- data.frame(metodo)

resultados <- cbind(metodo, ME_RK, MAE_RK, MSE_RK, RMSE_RK, AVE_RK, s, g)
etiquetas <- c("Metodos", "ME", "MAE", "MSE", "RMSE", "AVE", "Err Q75", "R2")
names(resultados) <- etiquetas

print(resultados)
```

```
##               Metodos        ME      MAE      MSE     RMSE       AVE
## 75% Regresion-Kriging -0.517241 1.895339 8.988367 2.998061 0.3930775
##      Err Q75        R2
## 75% 2.330099 0.4120027
```

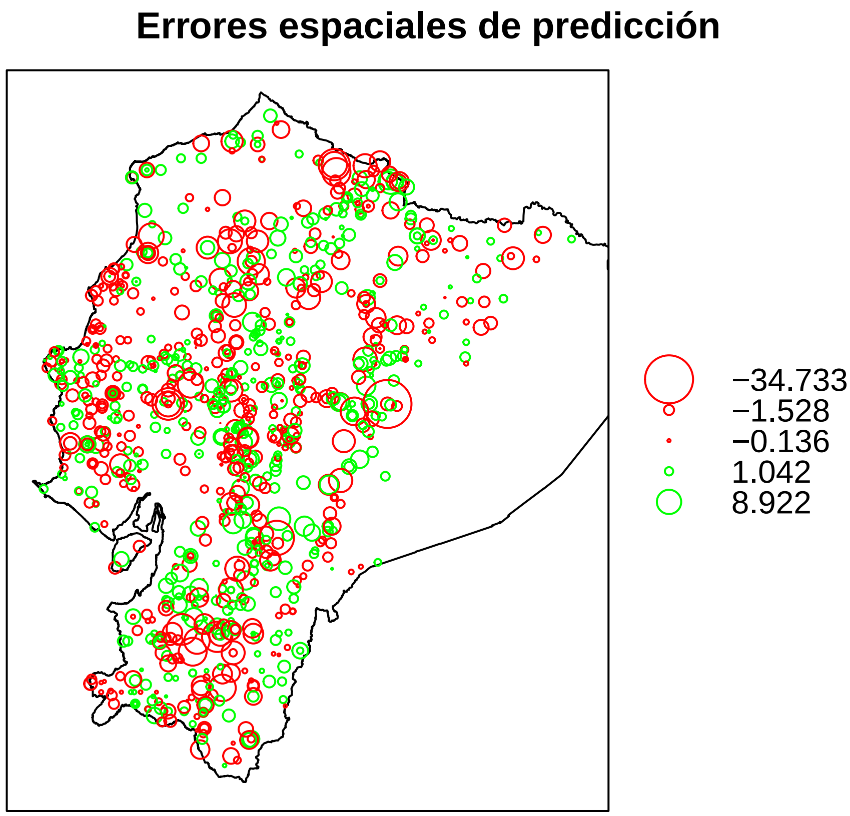
```r
# Graficamos las medidas de calidada del mapa.

# Graficamos el Scatter.

par(mfrow=c(1,1))
plot(datv$ECU_OCS_RK_kgm2_geot, datv$Ocskgm30, main="Comparacion entre valores COS predichos por Regres
     ylab='Valor COS observado', text(15,0.5, "La linea roja representa una pendiente de realcion 1: 1.
     valores observados y predichos."))


# Dibujamos una linea con relacion 1:1 color negro.

abline(0,1, lty=2, col='red')

# Establecemos una linea de regresion entre los valores estimados y los medidos color azul.

abline(lm(datv$Ocskgm30 ~ datv$ECU_OCS_RK_kgm2_geot), col = 'blue', lty=2)


legend(x = 11, y = 38,  legend = c("Relacion 1:1", "Regresion"), col = c("Red", "Blue"),
       title = "Leyenda", lty = 2, cex = 0.75)

text(20,4,"R2 : 0.41", cex = 1.5)
```




```
# Graficamos las borbujas de prediccion espacial (Spatial bubbles for prediction errors).

Ecuador <- shapefile("ecu2.shp")
```

```
## Warning in .local(x, ...): .prj file is missing
```

```
Ecuador@proj4string <- CRS(projargs = "+proj=longlat +datum=WGS84 +no_defs +ellps=WGS84 +towgs84=0,0,0")

Ecuador.sp <- as(Ecuador, "SpatialPolygonsDataFrame", filled.contour())

bubble(datv[!is.na(datv$PE_RK),], "PE_RK", pch = 21,
       col=c('red', 'green'), main = "Errores espaciales de predicción", sp.layout=list("sp.polygons", E
```




```r
# Grabamos el esapcio de trabajo.

save.image("C:/Marsev/Ecuador/Ecuador_mg_vs_resobaja.Rdata")
```