# COVID-19-Spain-Analysis

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4/11/2020

This notebook reports our initial analysis of COVID-19 incidence in Spain and the climatic correlates of incidence. The data have been organized in a package for ease of access and distribution. The name of the package is `covid19env` and if necessary can be installed from the GitHub repository.

## Preliminaries

Load packages:

```
library(covid19env)
library(ggthemes)
library(gridExtra)
library(lubridate)
library(sf)
library(spdep)
library(spsur)
library(tidyverse)
#library(spatialreg)
#library(systemfit)
#library(plm)
#library(splm)
```

Load data from package `covid19env`

```
data("covid19_spain")
```

Summarize the data:

```
covid19_spain %>%
  select(-geometry) %>%
  summary()
```

```
##              province                     CCAA         ID_INE
##  Albacete        : 22   Castilla y Leon     :198   Min.   : 1.0
##  Alicante/Alacant: 22   Andalucia           :176   1st Qu.:13.0
##  Almeria         : 22   Castilla - La Mancha:110   Median :25.5
##  Araba/alava     : 22   CataluÃ±a           : 88   Mean   :25.5
##  Asturias        : 22   Galicia             : 88   3rd Qu.:38.0
##  Avila           : 22   Aragon              : 66   Max.   :50.0
##  (Other)         :968   (Other)             :374
##       Date                Cases           Incidence          Population
##  Min.   :2020-03-14   Min.   :    1.0   Min.   :  0.4536   Min.   :  88636
##  1st Qu.:2020-03-19   1st Qu.:  126.0   1st Qu.: 20.0996   1st Qu.: 331549
##  Median :2020-03-24   Median :  378.5   Median : 62.1017   Median : 684202
##  Mean   :2020-03-24   Mean   : 1073.2   Mean   :109.3028   Mean   : 974257
##  3rd Qu.:2020-03-30   3rd Qu.:  957.2   3rd Qu.:148.8700   3rd Qu.:1149460
```

```
##  Max.   :2020-04-04   Max.   :36249.0   Max.   :867.5933   Max.   :6663394
##
##      Older          Median_Age     Male2Female          Area
##  Min.   :15.16   Min.   :40.19   Min.   : 91.59   Min.   :1.979e+09
##  1st Qu.:18.02   1st Qu.:42.35   1st Qu.: 95.43   1st Qu.:6.637e+09
##  Median :19.93   Median :43.70   Median : 98.06   Median :1.001e+10
##  Mean   :21.03   Mean   :44.55   Mean   : 97.83   Mean   :1.012e+10
##  3rd Qu.:23.07   3rd Qu.:46.01   3rd Qu.:100.08   3rd Qu.:1.377e+10
##  Max.   :31.36   Max.   :50.68   Max.   :103.01   Max.   :2.179e+10
##
##     Altitude          Coast      Meteo_Station    Max_Temp        Min_Temp
##  Min.   :   5.0   Min.   :0.00   0016A  : 22   Min.   : 3.10   Min.   :-4.700
##  1st Qu.:  24.0   1st Qu.:0.00   0076   : 22   1st Qu.:13.80   1st Qu.: 3.300
##  Median : 215.5   Median :0.00   0367   : 22   Median :16.60   Median : 6.400
##  Mean   : 369.0   Mean   :0.42   1024E  : 22   Mean   :16.25   Mean   : 6.293
##  3rd Qu.: 685.0   3rd Qu.:1.00   1082   : 22   3rd Qu.:19.00   3rd Qu.: 9.100
##  Max.   :1131.0   Max.   :1.00   1111X  : 22   Max.   :25.50   Max.   :18.100
##                                  (Other):968
##    Mean_Temp     Mean_Temp_lag8   Mean_Temp_lag11  Mean_Temp_lag11w
##  Min.   : 1.00   Min.   : 5.763   Min.   : 5.364   Min.   : 4.201
##  1st Qu.: 8.90   1st Qu.:10.162   1st Qu.:10.007   1st Qu.: 9.838
##  Median :11.40   Median :11.994   Median :12.000   Median :11.764
##  Mean   :11.27   Mean   :12.207   Mean   :12.062   Mean   :11.951
##  3rd Qu.:13.60   3rd Qu.:13.981   3rd Qu.:13.718   3rd Qu.:14.006
##  Max.   :21.00   Max.   :19.887   Max.   :19.636   Max.   :19.402
##
##  Sunshine_Hours   Sunshine_Hours_lag8 Sunshine_Hours_lag11
##  Min.   : 0.000   Min.   : 0.7125     Min.   : 1.582
##  1st Qu.: 2.275   1st Qu.: 4.9594     1st Qu.: 5.145
##  Median : 6.350   Median : 6.4500     Median : 6.305
##  Mean   : 5.972   Mean   : 6.4370     Mean   : 6.317
##  3rd Qu.: 9.500   3rd Qu.: 8.0906     3rd Qu.: 7.623
##  Max.   :12.400   Max.   :10.9375     Max.   :10.136
##
##  Sunshine_Hours_lag11w Precipitation    Precipitation_lag8 Precipitation_lag11
##  Min.   : 1.115        Min.   :0.0000   Min.   :0.0000     Min.   :0.0000
##  1st Qu.: 4.766        1st Qu.:0.0000   1st Qu.:0.1250     1st Qu.:0.2727
##  Median : 6.377        Median :0.0000   Median :0.3750     Median :0.3636
##  Mean   : 6.368        Mean   :0.4491   Mean   :0.3516     Mean   :0.3682
##  3rd Qu.: 8.037        3rd Qu.:1.0000   3rd Qu.:0.5000     3rd Qu.:0.5455
##  Max.   :11.041        Max.   :1.0000   Max.   :1.0000     Max.   :1.0000
##
##  Precipitation_lag11w    Humidity     Humidity_lag8   Humidity_lag11
##  Min.   :0.0000       Min.   :20.96   Min.   :25.55   Min.   :29.44
##  1st Qu.:0.1584       1st Qu.:43.00   1st Qu.:44.94   1st Qu.:45.78
##  Median :0.3668       Median :53.57   Median :51.14   Median :50.85
##  Mean   :0.3593       Mean   :53.79   Mean   :52.03   Mean   :52.39
##  3rd Qu.:0.5489       3rd Qu.:64.49   3rd Qu.:57.74   3rd Qu.:58.18
##  Max.   :1.0000       Max.   :89.51   Max.   :76.51   Max.   :75.85
##
##  Humidity_lag11w          geometry
##  Min.   :25.39   MULTIPOLYGON :1100
##  1st Qu.:44.83   epsg:4326    :   0
##  Median :51.24   +proj=long...:   0
```

```
##  Mean   :52.20
##  3rd Qu.:59.09
##  Max.   :78.74
##
```

The dataframe is a simple features object with information at the level of the province. The dataframe includes information about the province, including its Autonomous Community (a superior jurisdiction), an identifier, dates, COVID-19 cases and incidence. The period covered is from March 14, 2020 to April 4, 2020. In addition there are some demographic controls, and various climatic variables. Of interest are the lagged variables. The lagged variables are 8-day moving averages calculated using date-minus-12-days to date-minus-5-days, to account for the latency of the infection. More information about the dataset can be obtained by typing `?covid18_spain`.

There are 50 provinces in Spain:

```
nlevels(covid19_spain$province)
```

```
## [1] 50
```

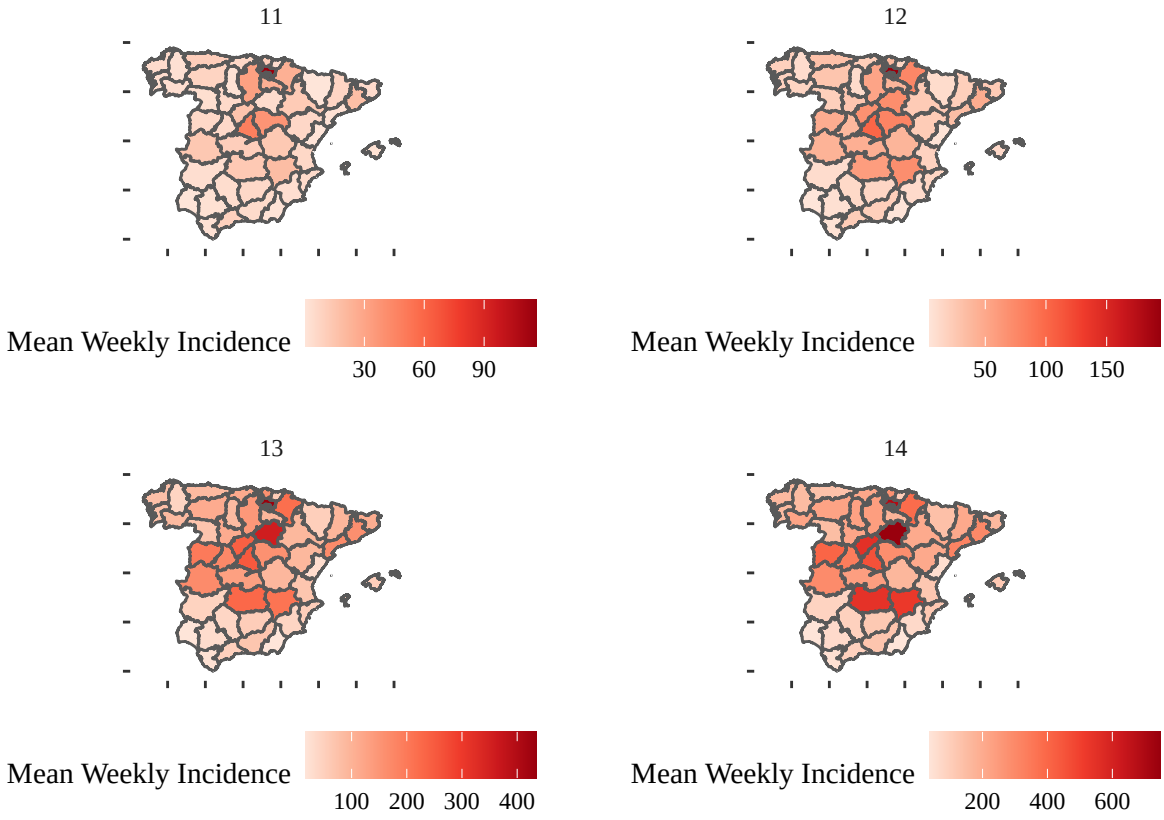
Shelter in place order in Spain went into effect on March 16, 2020. March 14 is the first day that every province had at least one reported case of COVID-19.

## Data visualization

There are 22 days in the dataset. We can summarize the incidence by week (excluding Canarias):

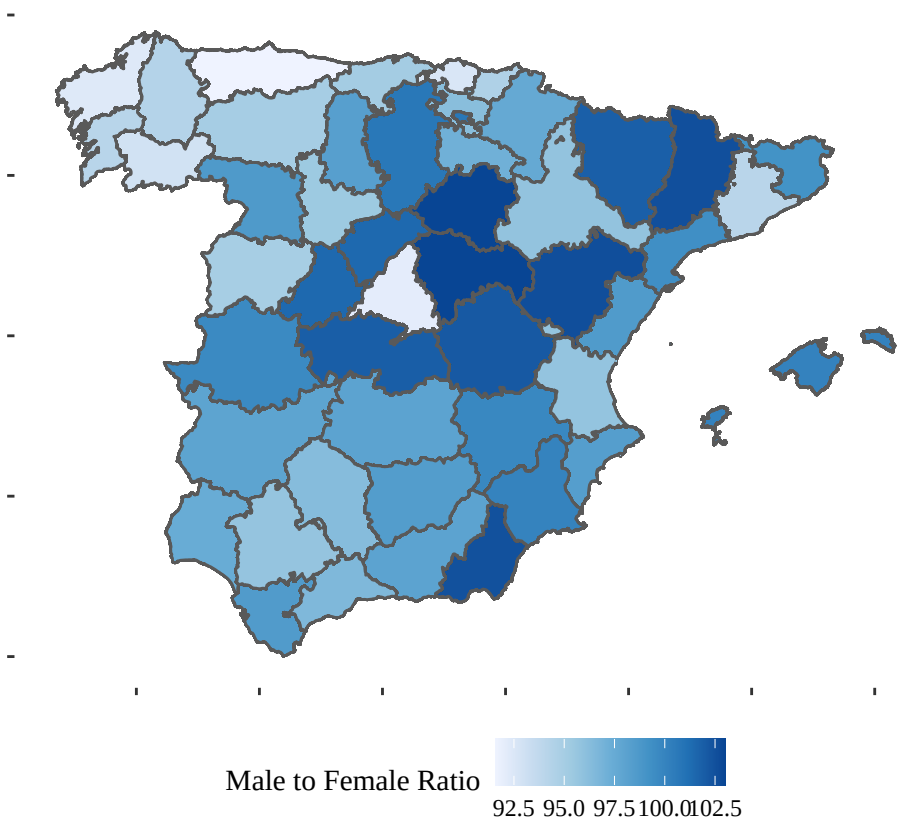
```
week11.plot <- covid19_spain %>%
  filter(CCAA != "Canarias") %>%
  group_by(province, week = isoweek(Date)) %>%
  summarise(mean_weekly_incidence = mean(Incidence)) %>%
  filter(week == 11) %>%
  ggplot() +
  geom_sf(aes(fill = mean_weekly_incidence)) +
  scale_fill_distiller(name = "Mean Weekly Incidence",
                       palette = "Reds",
                       direction = 1) +
  theme_tufte() +
  theme(axis.text = element_blank(),
        legend.position = "bottom") +
  facet_wrap(~week)

week12.plot <- covid19_spain %>%
  filter(CCAA != "Canarias") %>%
  group_by(province, week = isoweek(Date)) %>%
  summarise(mean_weekly_incidence = mean(Incidence)) %>%
  filter(week == 12) %>%
  ggplot() +
  geom_sf(aes(fill = mean_weekly_incidence)) +
  scale_fill_distiller(name = "Mean Weekly Incidence",
                       palette = "Reds",
                       direction = 1) +
  theme_tufte() +
  theme(axis.text = element_blank(),
        legend.position = "bottom") +
  facet_wrap(~week)

week13.plot <- covid19_spain %>%
```

```
  filter(CCAA != "Canarias") %>%
  group_by(province, week = isoweek(Date)) %>%
  summarise(mean_weekly_incidence = mean(Incidence)) %>%
  filter(week == 13) %>%
  ggplot() +
  geom_sf(aes(fill = mean_weekly_incidence)) +
  scale_fill_distiller(name = "Mean Weekly Incidence",
                       palette = "Reds",
                       direction = 1) +
  theme_tufte() +
  theme(axis.text = element_blank(),
        legend.position = "bottom") +
  facet_wrap(~week)

week14.plot <- covid19_spain %>%
  filter(CCAA != "Canarias") %>%
  group_by(province, week = isoweek(Date)) %>%
  summarise(mean_weekly_incidence = mean(Incidence)) %>%
  filter(week == 14) %>%
  ggplot() +
  geom_sf(aes(fill = mean_weekly_incidence)) +
  scale_fill_distiller(name = "Mean Weekly Incidence",
                       palette = "Reds",
                       direction = 1) +
  theme_tufte() +
  theme(axis.text = element_blank(),
        legend.position = "bottom") +
  facet_wrap(~week)

grid.arrange(week11.plot, week12.plot, week13.plot, week14.plot, nrow = 2)
```

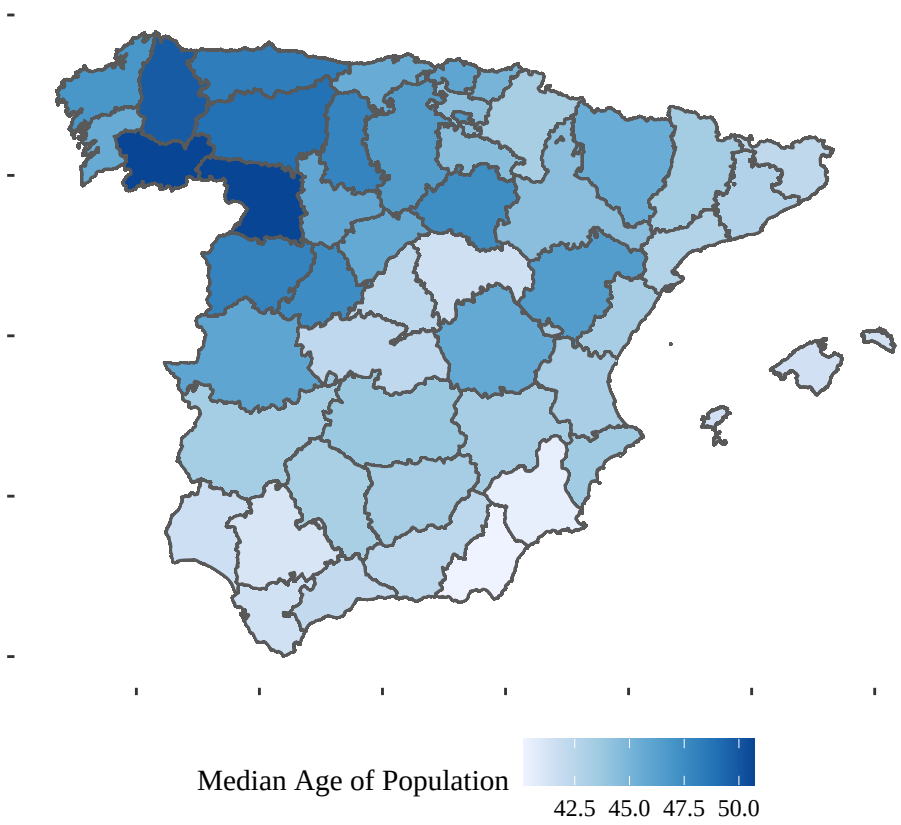



We consider two control variables: ratio of male to female in the province, and median age of the population:

```
covid19_spain %>%
  filter(CCAA != "Canarias") %>%
  ggplot() +
  geom_sf(aes(fill = Male2Female)) +
  scale_fill_distiller(name = "Male to Female Ratio",
                       palette = "Blues",
                       direction = 1) +
  theme_tufte() +
  theme(axis.text = element_blank(),
        legend.position = "bottom")
```




```
covid19_spain %>%
  filter(CCAA != "Canarias") %>%
  ggplot() +
  geom_sf(aes(fill = Median_Age)) +
  scale_fill_distiller(name = "Median Age of Population",
                       palette = "Blues",
                       direction = 1) +
  theme_tufte() +
  theme(axis.text = element_blank(),
        legend.position = "bottom")
```




We are also interested in the climatic variables. The following plot is the distribution of temperature by CCAA:

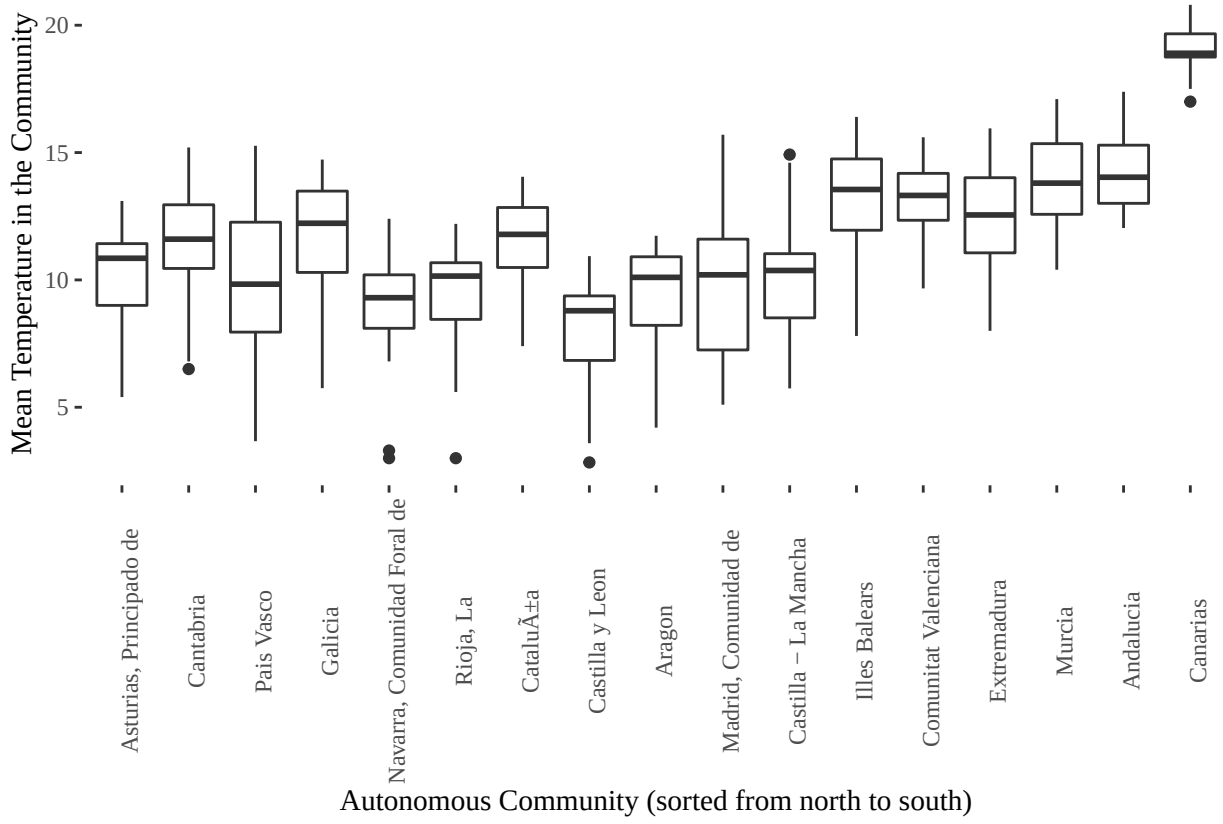
```
# Autonomous communities
ccaa.sf <- covid19_spain %>%
  filter(Date == "2020-03-14") %>%
  group_by(CCAA) %>%
  summarize(provinces = n())

# Extract coordinates of autonomous communities
ccaa.coords <- ccaa.sf %>%
  st_centroid() %>%
  st_coordinates() %>%
  as.data.frame()
```

```
## Warning in st_centroid.sf(.): st_centroid assumes attributes are constant over
## geometries of x
```

```
## Warning in st_centroid.sfc(st_geometry(x), of_largest_polygon =
## of_largest_polygon): st_centroid does not give correct centroids for longitude/
## latitude data
```

```
# Join Y coordinate to ccaa.sf
ccaa.sf <- ccaa.sf %>%
  mutate(long = ccaa.coords$Y)

# Sort autonomous communities from north to south
ccaa.levels <- ccaa.sf %>%
```

```
  arrange(desc(long)) %>% select(CCAA)

ccaa.levels <- as.character(ccaa.levels$CCAA)

# Relevel autonomous communities
covid19_spain <- covid19_spain %>%
  mutate(CCAA = factor(CCAA, levels = ccaa.levels, ordered = TRUE))

# Boxplots of temperatures
covid19_spain %>%
  st_drop_geometry() %>%
  group_by(CCAA, Date) %>%
  summarize(Mean_Temp = mean(Mean_Temp)) %>%
  ggplot(aes(x = CCAA, y = Mean_Temp)) +
  geom_boxplot() +
  theme_tufte() +
  theme(axis.text.x = element_text(angle = 90)) +
  xlab("Autonomous Community (sorted from north to south)") +
  ylab("Mean Temperature in the Community")
```




## Multivariate analysis: comparison of approaches

### Panel

1) Panel clásico
2) Panel Clásico o Dinámico

- Debe ser un modelo de efectos fijos para recoger la hetereogeneidad entre las distintas provincias (efectos)
- Debería incluir estructura dinámica ya que la serie tiene una fuerte estrutura temporal
- INCONVENIENTE: considera que la incluencia del dato del día anterior es constante (se estima un coeficiente constante)
- INCONVENIENTE: No se pueden incluir varaibles constantes en T. La hetereogeneidad entre provincias queda en el efecto fijo. No podemos por tanto incluir datos sobre estructura de la poblacion.
- INCONVENIENTE: No podemos incorporar efectos espaciales. El paquete **splm** no incluye estimación de paneles dinámicos con efectos espaciales. Tendriamos que hacerlo en matlab con los códigos de P.Elhorst.

**Spatial SUR**

2) SUR espacial

- Hay un coeficente para cada variable y cada instante de tiempo. Aunque es posible considerar coeficientes constantes para los periodos temporales que consideremos.
- La hetereoeneidad espacial debemos incorporarla mediante variables explicativas. –> Estructura de la población relacionada con COVID-19.
- Permite incluir varaibles constantes en T.
- la dinámica temporar quedará recogida mediante el término independiente y la estructura de correlaciones en los residuos. EN TODO CASO, ENTIENDO QUE NUESTRO OBJETIVO NO ES EXPLICAR ESA TENEDENCIA TEMPORAL (solo modelizarla para no incurrir en errores)

## Prepare data for SUR analysis

*El modelo debe considerar efectos del 'individuo' y del 'tiempo' (para incorporar tendencia temporal)**

```
# Definicion del panel para plm
GPanel <- plm::pdata.frame(covid19_spain %>%
                             st_drop_geometry() %>%
                             select(province,
                                    Date,
                                    Incidence,
                                    Median_Age,
                                    Male2Female,
                                    Mean_Temp_lag8,
                                    Humidity_lag8,
                                    Sunshine_Hours_lag8,
                                    Mean_Temp_lag11,
                                    Humidity_lag11,
                                    Sunshine_Hours_lag11,
                                    Mean_Temp_lag11w,
                                    Humidity_lag11w,
                                    Sunshine_Hours_lag11w),
                           c("province","Date"))
```

# Modelo SUR espacial

Construcción de W

```
# Definición matrix de contactos
Wmat <- covid19_spain %>%
  filter(Date == "2020-03-14") %>%
  as("Spatial") %>%
```

```
  poly2nb(queen = FALSE) %>%
  nb2mat(zero.policy = T)

Wmat <- (Wmat > 0) * 1

#W <- poly2nb(as(provincias.sf, "Spatial"), queen = FALSE)
#Wmat <- nb2mat(W,zero.policy = T)
#Wmat <- (Wmat>0)*1
# Conexión de las dos provincias que forman Canarias
Wmat[37, 44] <- 1
Wmat[44, 37] <- 1
# 'Paises Catalans'
n = 8
Wmat[9,n] <- 1
Wmat[n,9] <- 1
Wmat[n,47] <- 1
Wmat[47,n] <- 1
Wmat[n,43] <- 1
Wmat[43,n] <- 1
miW <- Wmat/rowSums(Wmat)
listw <- mat2listw(Wmat,style = "W")
```

Se incluyen dos variables de control para recoger la herogeneidad espacial * HM: ratio Hombres/Mujeres (signo esperado +) * EM: Edad media (signo esperado +)

Define formulas with two different lagged variables:

```
formula_lag8 <- log(Incidence) ~ log(Male2Female) +
  log(Median_Age) +
  log(Mean_Temp_lag8) +
  log(Sunshine_Hours_lag8 + 0.1) +
  log(Humidity_lag8)

formula_lag11 <- log(Incidence) ~ log(Male2Female) +
  log(Median_Age) +
  log(Mean_Temp_lag11) +
  log(Sunshine_Hours_lag11 + 0.1) +
  log(Humidity_lag11)

formula_lag11w <- log(Incidence) ~ log(Male2Female) +
  log(Median_Age) +
  log(Mean_Temp_lag11w) +
  log(Sunshine_Hours_lag11w + 0.1) +
  log(Humidity_lag11w)
```

Model with 8-day moving average of climatic variables:

```
sur.slm_lag8 <- spsur::spsurtime(formula = formula_lag8,
                                 data=GPanel,
                                 time = GPanel$Date,
                                 type = "slm",
                                 fit_method = "3sls",
                                 listw=  listw)
```

```
## Time to fit the model:  0.39  seconds
```

```r
summary(sur.slm_lag8)
```

```
## Call:
## spsur::spsurtime(formula = formula_lag8, data = GPanel, time = GPanel$Date,
##     listw = listw, type = "slm", fit_method = "3sls")
##
##
## Spatial SUR model type:  slm
##
## Equation  1
##                                  Estimate Std. Error t value  Pr(>|t|)
## (Intercept)_1                   56.590345  25.274531  2.2390 0.0254707 *
## log(Male2Female)_1              -7.257491   4.224569 -1.7179 0.0862570 .
## log(Median_Age)_1               -5.919011   2.603779 -2.2732 0.0233170 *
## log(Mean_Temp_lag8)_1           -1.471130   0.421094 -3.4936 0.0005069 ***
## log(Sunshine_Hours_lag8 + 0.1)_1  0.084006   0.155765  0.5393 0.5898443
## log(Humidity_lag8)_1             0.944923   0.483890  1.9528 0.0512497 .
## rho_1                            0.291876   0.139949  2.0856 0.0373813 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## R-squared: 0.3178
##   Equation  2
##                                  Estimate Std. Error t value  Pr(>|t|)
## (Intercept)_2                   47.94777   22.73704  2.1088   0.03532 *
## log(Male2Female)_2              -7.06368    3.88523 -1.8181   0.06948 .
## log(Median_Age)_2               -3.56330    2.28827 -1.5572   0.11988
## log(Mean_Temp_lag8)_2           -1.54689    0.38837 -3.9831 7.522e-05 ***
## log(Sunshine_Hours_lag8 + 0.1)_2  0.16203    0.16072  1.0081   0.31374
## log(Humidity_lag8)_2             0.83170    0.39156  2.1241   0.03402 *
## rho_2                            0.13439    0.13355  1.0062   0.31466
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## R-squared: 0.2951
##   Equation  3
##                                  Estimate Std. Error t value  Pr(>|t|)
## (Intercept)_3                   34.21939   20.09783  1.7026   0.08908 .
## log(Male2Female)_3              -4.42740    3.45589 -1.2811   0.20058
## log(Median_Age)_3               -2.89065    2.03158 -1.4229   0.15523
## log(Mean_Temp_lag8)_3           -1.42479    0.34690 -4.1072 4.482e-05 ***
## log(Sunshine_Hours_lag8 + 0.1)_3  0.16152    0.17799  0.9075   0.36445
## log(Humidity_lag8)_3             0.53806    0.30203  1.7815   0.07527 .
## rho_3                            0.24524    0.11390  2.1530   0.03166 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## R-squared: 0.3364
##   Equation  4
##                                  Estimate Std. Error t value Pr(>|t|)
## (Intercept)_4                   23.401417  19.868868  1.1778 0.239283
## log(Male2Female)_4              -3.279917   3.448593 -0.9511 0.341891
## log(Median_Age)_4               -1.454878   2.015831 -0.7217 0.470706
## log(Mean_Temp_lag8)_4           -1.390587   0.333572 -4.1688 3.45e-05 ***
## log(Sunshine_Hours_lag8 + 0.1)_4  0.379034   0.161033  2.3538 0.018863 *
## log(Humidity_lag8)_4             0.436363   0.263870  1.6537 0.098640 .
## rho_4                            0.294538   0.095806  3.0743 0.002193 **
```

```
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## R-squared: 0.3054
##   Equation  5
##                                  Estimate Std. Error t value  Pr(>|t|)
## (Intercept)_5                    2.049188  21.049260  0.0974  0.922475
## log(Male2Female)_5              -0.393102   3.663915 -0.1073  0.914590
## log(Median_Age)_5                0.496715   2.139421  0.2322  0.816473
## log(Mean_Temp_lag8)_5           -0.969965   0.364236 -2.6630  0.007924 **
## log(Sunshine_Hours_lag8 + 0.1)_5  0.314294   0.205808  1.5271  0.127187
## log(Humidity_lag8)_5             0.332435   0.292633  1.1360  0.256345
## rho_5                            0.422527   0.094083  4.4910 8.302e-06 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## R-squared: 0.1987
##   Equation  6
##                                  Estimate Std. Error t value  Pr(>|t|)
## (Intercept)_6                    1.374842  19.164408  0.0717 0.9428301
## log(Male2Female)_6               0.991613   3.363995  0.2948 0.7682560
## log(Median_Age)_6               -0.063457   1.947875 -0.0326 0.9740210
## log(Mean_Temp_lag8)_6           -1.147675   0.303964 -3.7757 0.0001732 ***
## log(Sunshine_Hours_lag8 + 0.1)_6  0.105686   0.190358  0.5552 0.5789407
## log(Humidity_lag8)_6             0.053383   0.223245  0.2391 0.8110815
## rho_6                           -0.013673   0.084298 -0.1622 0.8711941
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## R-squared: 0.2218
##   Equation  7
##                                   Estimate Std. Error t value  Pr(>|t|)
## (Intercept)_7                   -0.4089311 17.8694123 -0.0229   0.98175
## log(Male2Female)_7               0.8338706  3.1436392  0.2653   0.79089
## log(Median_Age)_7                0.6157758  1.8370746  0.3352   0.73758
## log(Mean_Temp_lag8)_7           -1.2788255  0.2786907 -4.5887 5.295e-06 ***
## log(Sunshine_Hours_lag8 + 0.1)_7  0.3806654  0.1810285  2.1028   0.03584 *
## log(Humidity_lag8)_7            -0.0045695  0.2137444 -0.0214   0.98295
## rho_7                            0.0397431  0.0801581  0.4958   0.62019
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## R-squared: 0.2344
##   Equation  8
##                                  Estimate Std. Error t value Pr(>|t|)
## (Intercept)_8                   -4.405281  18.086236 -0.2436 0.807635
## log(Male2Female)_8               1.619900   3.156775  0.5132 0.608010
## log(Median_Age)_8                0.694167   1.871799  0.3709 0.710859
## log(Mean_Temp_lag8)_8           -1.452958   0.267622 -5.4291 7.84e-08 ***
## log(Sunshine_Hours_lag8 + 0.1)_8  0.450326   0.171745  2.6221 0.008932 **
## log(Humidity_lag8)_8             0.108661   0.228764  0.4750 0.634942
## rho_8                            0.082296   0.079710  1.0324 0.302228
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## R-squared: 0.2703
##   Equation  9
##                                  Estimate Std. Error t value  Pr(>|t|)
## (Intercept)_9                    2.744951  17.353754  0.1582  0.874364
```

```
## log(Male2Female)_9                0.580502   3.017012  0.1924  0.847478
## log(Median_Age)_9                 0.119317   1.791143  0.0666  0.946907
## log(Mean_Temp_lag8)_9            -1.452979   0.267136 -5.4391 7.431e-08 ***
## log(Sunshine_Hours_lag8 + 0.1)_9  0.407038   0.156577  2.5996  0.009532 **
## log(Humidity_lag8)_9              0.128710   0.223574  0.5757  0.565010
## rho_9                             0.060599   0.082286  0.7364  0.461708
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## R-squared: 0.2733
##   Equation  10
##                                    Estimate Std. Error t value Pr(>|t|)
## (Intercept)_10                     2.834789  15.846039  0.1789  0.85807
## log(Male2Female)_10                0.188904   2.743175  0.0689  0.94512
## log(Median_Age)_10                 0.682894   1.644857  0.4152  0.67815
## log(Mean_Temp_lag8)_10            -1.529881   0.271088 -5.6435 2.43e-08 ***
## log(Sunshine_Hours_lag8 + 0.1)_10  0.394323   0.159585  2.4709  0.01372 *
## log(Humidity_lag8)_10              0.216856   0.232729  0.9318  0.35176
## rho_10                            -0.025740   0.084262 -0.3055  0.76009
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## R-squared: 0.3371
##   Equation  11
##                                     Estimate Std. Error t value  Pr(>|t|)
## (Intercept)_11                     2.6261320 14.6642367  0.1791   0.85792
## log(Male2Female)_11                0.7588334  2.5334638  0.2995   0.76463
## log(Median_Age)_11                 0.2663820  1.5140854  0.1759   0.86040
## log(Mean_Temp_lag8)_11            -1.5429034  0.2230854 -6.9162 1.056e-11 ***
## log(Sunshine_Hours_lag8 + 0.1)_11  0.2222326  0.0897557  2.4760   0.01353 *
## log(Humidity_lag8)_11              0.1273906  0.2029517  0.6277   0.53041
## rho_11                            -0.0018179  0.0701847 -0.0259   0.97934
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## R-squared: 0.4012
##   Equation  12
##                                    Estimate Std. Error t value  Pr(>|t|)
## (Intercept)_12                     7.118579  14.382602  0.4949 0.6207967
## log(Male2Female)_12               -0.014487   2.476846 -0.0058 0.9953348
## log(Median_Age)_12                -0.150206   1.474119 -0.1019 0.9188693
## log(Mean_Temp_lag8)_12            -1.590710   0.211330 -7.5271 1.618e-13 ***
## log(Sunshine_Hours_lag8 + 0.1)_12  0.346296   0.099599  3.4769 0.0005389 ***
## log(Humidity_lag8)_12              0.412037   0.215851  1.9089 0.0566885 .
## rho_12                            -0.104448   0.070929 -1.4726 0.1413219
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## R-squared: 0.4386
##   Equation  13
##                                    Estimate Std. Error t value  Pr(>|t|)
## (Intercept)_13                    11.138884  13.452282  0.8280  0.407939
## log(Male2Female)_13               -1.126404   2.324547 -0.4846  0.628135
## log(Median_Age)_13                 0.281947   1.360124  0.2073  0.835840
## log(Mean_Temp_lag8)_13            -1.637440   0.192898 -8.4886 < 2.2e-16 ***
## log(Sunshine_Hours_lag8 + 0.1)_13  0.268683   0.078668  3.4154  0.000674 ***
## log(Humidity_lag8)_13              0.338827   0.199626  1.6973  0.090086 .
## rho_13                            -0.074246   0.065763 -1.1290  0.259293
```

```
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## R-squared: 0.4988
##   Equation  14
##                                    Estimate Std. Error t value  Pr(>|t|)
## (Intercept)_14                    14.105360  13.858007  1.0178   0.30910
## log(Male2Female)_14               -1.967121   2.401674 -0.8191   0.41303
## log(Median_Age)_14                 0.431891   1.382130  0.3125   0.75477
## log(Mean_Temp_lag8)_14            -1.639816   0.197590 -8.2991 5.479e-16 ***
## log(Sunshine_Hours_lag8 + 0.1)_14  0.287538   0.063693  4.5145 7.458e-06 ***
## log(Humidity_lag8)_14              0.427114   0.219815  1.9431   0.05241 .
## rho_14                            -0.061443   0.069297 -0.8867   0.37557
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## R-squared: 0.4804
##   Equation  15
##                                    Estimate Std. Error t value  Pr(>|t|)
## (Intercept)_15                     6.148692  13.335339  0.4611   0.64488
## log(Male2Female)_15               -1.428515   2.318592 -0.6161   0.53802
## log(Median_Age)_15                 2.069942   1.319331  1.5689   0.11712
## log(Mean_Temp_lag8)_15            -1.493138   0.184238 -8.1044 2.398e-15 ***
## log(Sunshine_Hours_lag8 + 0.1)_15  0.163444   0.052741  3.0990   0.00202 **
## log(Humidity_lag8)_15              0.207659   0.211255  0.9830   0.32596
## rho_15                            -0.025761   0.073195 -0.3520   0.72498
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## R-squared:  0.51
##   Equation  16
##                                     Estimate Std. Error t value  Pr(>|t|)
## (Intercept)_16                     2.1794037 13.0354064  0.1672  0.867268
## log(Male2Female)_16               -0.9317497  2.2679889 -0.4108  0.681327
## log(Median_Age)_16                 2.5930882  1.2846786  2.0185  0.043927 *
## log(Mean_Temp_lag8)_16            -1.5096094  0.1954797 -7.7226 3.998e-14 ***
## log(Sunshine_Hours_lag8 + 0.1)_16  0.1422681  0.0510053  2.7893  0.005428 **
## log(Humidity_lag8)_16              0.1510630  0.1876508  0.8050  0.421083
## rho_16                             0.0087468  0.0723014  0.1210  0.903744
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## R-squared: 0.5064
##   Equation  17
##                                    Estimate Std. Error t value  Pr(>|t|)
## (Intercept)_17                     5.523397  12.426436  0.4445    0.6568
## log(Male2Female)_17               -1.200782   2.163160 -0.5551    0.5790
## log(Median_Age)_17                 2.076583   1.221978  1.6994    0.0897 .
## log(Mean_Temp_lag8)_17            -1.537280   0.181018 -8.4924 < 2.2e-16 ***
## log(Sunshine_Hours_lag8 + 0.1)_17  0.215539   0.052761  4.0852 4.919e-05 ***
## log(Humidity_lag8)_17              0.148054   0.161515  0.9167    0.3596
## rho_17                            -0.013813   0.065373 -0.2113    0.8327
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## R-squared: 0.5276
##   Equation  18
##                                    Estimate Std. Error t value  Pr(>|t|)
## (Intercept)_18                     5.290393  12.656187  0.4180 0.6760704
```

```
## log(Male2Female)_18               -1.556755   2.197782 -0.7083 0.4789786
## log(Median_Age)_18                 2.560824   1.244012  2.0585 0.0399135 *
## log(Mean_Temp_lag8)_18            -1.291377   0.172456 -7.4882  2.13e-13 ***
## log(Sunshine_Hours_lag8 + 0.1)_18  0.205285   0.061506  3.3376 0.0008901 ***
## log(Humidity_lag8)_18              0.088840   0.169940  0.5228 0.6012985
## rho_18                            -0.074457   0.072643 -1.0250 0.3057382
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## R-squared:  0.51
##   Equation  19
##                                    Estimate Std. Error t value  Pr(>|t|)
## (Intercept)_19                     0.871139  12.942322  0.0673    0.9464
## log(Male2Female)_19               -0.213160   2.217477 -0.0961    0.9234
## log(Median_Age)_19                 2.081718   1.281445  1.6245    0.1047
## log(Mean_Temp_lag8)_19            -1.284355   0.198247 -6.4785 1.756e-10 ***
## log(Sunshine_Hours_lag8 + 0.1)_19  0.128331   0.078135  1.6424    0.1010
## log(Humidity_lag8)_19              0.070632   0.228839  0.3087    0.7577
## rho_19                            -0.019762   0.096924 -0.2039    0.8385
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## R-squared: 0.5233
##   Equation  20
##                                    Estimate Std. Error t value  Pr(>|t|)
## (Intercept)_20                     1.280947  12.799995  0.1001   0.92031
## log(Male2Female)_20               -0.907790   2.228217 -0.4074   0.68384
## log(Median_Age)_20                 2.946753   1.273953  2.3131   0.02101 *
## log(Mean_Temp_lag8)_20            -1.025793   0.148198 -6.9218 1.018e-11 ***
## log(Sunshine_Hours_lag8 + 0.1)_20  0.109231   0.050411  2.1668   0.03059 *
## log(Humidity_lag8)_20             -0.025138   0.141411 -0.1778   0.85896
## rho_20                            -0.143481   0.074322 -1.9305   0.05395 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## R-squared: 0.4934
##   Equation  21
##                                    Estimate Std. Error t value  Pr(>|t|)
## (Intercept)_21                     2.079365  12.632748  0.1646   0.86931
## log(Male2Female)_21               -0.769726   2.188687 -0.3517   0.72518
## log(Median_Age)_21                 2.727955   1.268717  2.1502   0.03189 *
## log(Mean_Temp_lag8)_21            -1.041427   0.149615 -6.9607 7.865e-12 ***
## log(Sunshine_Hours_lag8 + 0.1)_21  0.070565   0.067475  1.0458   0.29602
## log(Humidity_lag8)_21             -0.083360   0.139886 -0.5959   0.55142
## rho_21                            -0.178023   0.078059 -2.2806   0.02287 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## R-squared: 0.5048
##   Equation  22
##                                    Estimate Std. Error t value  Pr(>|t|)
## (Intercept)_22                    -0.837759  13.119953 -0.0639   0.94911
## log(Male2Female)_22               -0.434774   2.261166 -0.1923   0.84758
## log(Median_Age)_22                 3.072665   1.332482  2.3060   0.02141 *
## log(Mean_Temp_lag8)_22            -0.929009   0.142481 -6.5202 1.353e-10 ***
## log(Sunshine_Hours_lag8 + 0.1)_22 -0.017026   0.071616 -0.2377   0.81215
## log(Humidity_lag8)_22             -0.051339   0.159781 -0.3213   0.74807
## rho_22                            -0.202667   0.083688 -2.4217   0.01570 *
```

```
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## R-squared: 0.4904
##
## Variance-Covariance Matrix of inter-equation residuals:
##  0.7204966 0.6338744 0.5248385 0.5034573 0.4965724 0.4427671 0.3831851
##  0.6338744 0.6298058 0.5309442 0.5189484 0.5005380 0.4385852 0.3878907
##  0.5248385 0.5309442 0.5126003 0.5023227 0.4938828 0.4259262 0.3840332
##  0.5034573 0.5189484 0.5023227 0.5207078 0.5271069 0.4622847 0.4190731
##  0.4965724 0.5005380 0.4938828 0.5271069 0.5892863 0.5117040 0.4657377
##  0.4427671 0.4385852 0.4259262 0.4622847 0.5117040 0.5051340 0.4600011
##  0.3831851 0.3878907 0.3840332 0.4190731 0.4657377 0.4600011 0.4441410
##  0.3758362 0.3747196 0.3759859 0.4141676 0.4589614 0.4589156 0.4426326
##  0.3465666 0.3398036 0.3413130 0.3825363 0.4270146 0.4320255 0.4159743
##  0.3040524 0.3009956 0.2887747 0.3293635 0.3684856 0.3747414 0.3620352
##  0.2592032 0.2556305 0.2589953 0.3009569 0.3311459 0.3414950 0.3284456
##  0.2435988 0.2377375 0.2367796 0.2766476 0.2875362 0.3071727 0.2939594
##  0.2054385 0.1979124 0.1903441 0.2232803 0.2269505 0.2548870 0.2468752
##  0.1913551 0.1854059 0.1739522 0.2057288 0.2041980 0.2355340 0.2307224
##  0.1797603 0.1685549 0.1539840 0.1844245 0.1861417 0.2178577 0.2114469
##  0.1867252 0.1784313 0.1642707 0.1933115 0.1980927 0.2213245 0.2147772
##  0.2072797 0.1968467 0.1799338 0.2036649 0.2067721 0.2267522 0.2190055
##  0.2147320 0.2097544 0.2012665 0.2227491 0.2249899 0.2387266 0.2312747
##  0.1858132 0.1802004 0.1871397 0.2074304 0.2138924 0.2246355 0.2113395
##  0.1934434 0.1925595 0.1947170 0.2201190 0.2268172 0.2435416 0.2344280
##  0.1808506 0.1829938 0.1910915 0.2163209 0.2246524 0.2398431 0.2337634
##  0.1898604 0.1942008 0.2068172 0.2317878 0.2409563 0.2519133 0.2473689
##
##  0.3758362 0.3465666 0.3040524 0.2592032 0.2435988 0.2054385 0.1913551
##  0.3747196 0.3398036 0.3009956 0.2556305 0.2377375 0.1979124 0.1854059
##  0.3759859 0.3413130 0.2887747 0.2589953 0.2367796 0.1903441 0.1739522
##  0.4141676 0.3825363 0.3293635 0.3009569 0.2766476 0.2232803 0.2057288
##  0.4589614 0.4270146 0.3684856 0.3311459 0.2875362 0.2269505 0.2041980
##  0.4589156 0.4320255 0.3747414 0.3414950 0.3071727 0.2548870 0.2355340
##  0.4426326 0.4159743 0.3620352 0.3284456 0.2939594 0.2468752 0.2307224
##  0.4559346 0.4289766 0.3747412 0.3426445 0.3088026 0.2572942 0.2369501
##  0.4289766 0.4173214 0.3657602 0.3352962 0.3064949 0.2573535 0.2409552
##  0.3747412 0.3657602 0.3448464 0.3084914 0.2853803 0.2443765 0.2285279
##  0.3426445 0.3352962 0.3084914 0.2951812 0.2781640 0.2415946 0.2301893
##  0.3088026 0.3064949 0.2853803 0.2781640 0.2804359 0.2504533 0.2414661
##  0.2572942 0.2573535 0.2443765 0.2415946 0.2504533 0.2451296 0.2444020
##  0.2369501 0.2409552 0.2285279 0.2301893 0.2414661 0.2444020 0.2593096
##  0.2166498 0.2209653 0.2103085 0.2096288 0.2216165 0.2281916 0.2446799
##  0.2181580 0.2186134 0.2078068 0.2042845 0.2140455 0.2199090 0.2336014
##  0.2235455 0.2195802 0.2073256 0.2001169 0.2075717 0.2105525 0.2163261
##  0.2366994 0.2298630 0.2117848 0.2027512 0.2062947 0.2065077 0.2096814
##  0.2187901 0.2124077 0.1917928 0.1888356 0.1867801 0.1874331 0.1895215
##  0.2442258 0.2426262 0.2213352 0.2123494 0.2134278 0.2086216 0.2124750
##  0.2469517 0.2441019 0.2220891 0.2115318 0.2089502 0.1989333 0.1988693
##  0.2620160 0.2568315 0.2331108 0.2204748 0.2140491 0.1991887 0.1949911
##
##  0.1797603 0.1867252 0.2072797 0.2147320 0.1858132 0.1934434 0.1808506
##  0.1685549 0.1784313 0.1968467 0.2097544 0.1802004 0.1925595 0.1829938
##  0.1539840 0.1642707 0.1799338 0.2012665 0.1871397 0.1947170 0.1910915
```

```
##  0.1844245 0.1933115 0.2036649 0.2227491 0.2074304 0.2201190 0.2163209
##  0.1861417 0.1980927 0.2067721 0.2249899 0.2138924 0.2268172 0.2246524
##  0.2178577 0.2213245 0.2267522 0.2387266 0.2246355 0.2435416 0.2398431
##  0.2114469 0.2147772 0.2190055 0.2312747 0.2113395 0.2344280 0.2337634
##  0.2166498 0.2181580 0.2235455 0.2366994 0.2187901 0.2442258 0.2469517
##  0.2209653 0.2186134 0.2195802 0.2298630 0.2124077 0.2426262 0.2441019
##  0.2103085 0.2078068 0.2073256 0.2117848 0.1917928 0.2213352 0.2220891
##  0.2096288 0.2042845 0.2001169 0.2027512 0.1888356 0.2123494 0.2115318
##  0.2216165 0.2140455 0.2075717 0.2062947 0.1867801 0.2134278 0.2089502
##  0.2281916 0.2199090 0.2105525 0.2065077 0.1874331 0.2086216 0.1989333
##  0.2446799 0.2336014 0.2163261 0.2096814 0.1895215 0.2124750 0.1988693
##  0.2397552 0.2295874 0.2096668 0.2030287 0.1855671 0.2064033 0.1922656
##  0.2295874 0.2286284 0.2127675 0.2077443 0.1860718 0.2041977 0.1903563
##  0.2096668 0.2127675 0.2076949 0.2050807 0.1817340 0.1980023 0.1869805
##  0.2030287 0.2077443 0.2050807 0.2120664 0.1927143 0.2058265 0.1958122
##  0.1855671 0.1860718 0.1817340 0.1927143 0.2093427 0.1990144 0.1909999
##  0.2064033 0.2041977 0.1980023 0.2058265 0.1990144 0.2204402 0.2142988
##  0.1922656 0.1903563 0.1869805 0.1958122 0.1909999 0.2142988 0.2137079
##  0.1880288 0.1863707 0.1852072 0.1971267 0.1944000 0.2167237 0.2186024
##
##  0.1898604
##  0.1942008
##  0.2068172
##  0.2317878
##  0.2409563
##  0.2519133
##  0.2473689
##  0.2620160
##  0.2568315
##  0.2331108
##  0.2204748
##  0.2140491
##  0.1991887
##  0.1949911
##  0.1880288
##  0.1863707
##  0.1852072
##  0.1971267
##  0.1944000
##  0.2167237
##  0.2186024
##  0.2285957
## Correlation Matrix of inter-equation residuals:
##  1.0000000 0.9445816 0.8938163 0.8661542 0.8373391 0.8101958 0.7708630
##  0.9445816 1.0000000 0.9451757 0.9304032 0.8773063 0.8322519 0.8120188
##  0.8938163 0.9451757 1.0000000 0.9792927 0.9294495 0.8769215 0.8662072
##  0.8661542 0.9304032 0.9792927 1.0000000 0.9639141 0.9168930 0.9050991
##  0.8373391 0.8773063 0.9294495 0.9639141 1.0000000 0.9339933 0.9197071
##  0.8101958 0.8322519 0.8769215 0.9168930 0.9339933 1.0000000 0.9786770
##  0.7708630 0.8120188 0.8662072 0.9050991 0.9197071 0.9786770 1.0000000
##  0.7566578 0.7812539 0.8408729 0.8831944 0.8988455 0.9685694 0.9892148
##  0.7423731 0.7619515 0.8146018 0.8633070 0.8851652 0.9583502 0.9769525
##  0.7207786 0.7492124 0.7745457 0.8290247 0.8617076 0.9339558 0.9549950
##  0.6967877 0.7253362 0.7756754 0.8381620 0.8561085 0.9389615 0.9577203
```

```
##  0.6676240 0.7019273 0.7484964 0.8147587 0.8180856 0.9166077 0.9328076
##  0.6219317 0.6605636 0.7024378 0.7651165 0.7633608 0.8745780 0.8999962
##  0.5990744 0.6479528 0.6872911 0.7473215 0.7278307 0.8366859 0.8675195
##  0.6027280 0.6378640 0.6740610 0.7359286 0.7245940 0.8347616 0.8607348
##  0.6157629 0.6562523 0.6937587 0.7529302 0.7475903 0.8459257 0.8757802
##  0.6434247 0.6771577 0.7104274 0.7631799 0.7589742 0.8609755 0.8927743
##  0.6313686 0.6741060 0.7232996 0.7708472 0.7652871 0.8568941 0.8936217
##  0.5705892 0.5985786 0.6790025 0.7254579 0.7182127 0.8128706 0.8352580
##  0.5926739 0.6349243 0.7014461 0.7533305 0.7503567 0.8454823 0.8789065
##  0.5823713 0.6239287 0.6970513 0.7474359 0.7451136 0.8389184 0.8782199
##  0.5817169 0.6274675 0.7027771 0.7516652 0.7480255 0.8399266 0.8811851
##
##  0.7566578 0.7423731 0.7207786 0.6967877 0.6676240 0.6219317 0.5990744
##  0.7812539 0.7619515 0.7492124 0.7253362 0.7019273 0.6605636 0.6479528
##  0.8408729 0.8146018 0.7745457 0.7756754 0.7484964 0.7024378 0.6872911
##  0.8831944 0.8633070 0.8290247 0.8381620 0.8147587 0.7651165 0.7473215
##  0.8988455 0.8851652 0.8617076 0.8561085 0.8180856 0.7633608 0.7278307
##  0.9685694 0.9583502 0.9339558 0.9389615 0.9166077 0.8745780 0.8366859
##  0.9892148 0.9769525 0.9549950 0.9577203 0.9328076 0.8999962 0.8675195
##  1.0000000 0.9890681 0.9651935 0.9725644 0.9501531 0.9147858 0.8778029
##  0.9890681 1.0000000 0.9747125 0.9778546 0.9608101 0.9226943 0.8890251
##  0.9651935 0.9747125 1.0000000 0.9787840 0.9650226 0.9340517 0.8983736
##  0.9725644 0.9778546 0.9787840 1.0000000 0.9867736 0.9614474 0.9338393
##  0.9501531 0.9608101 0.9650226 0.9867736 1.0000000 0.9808549 0.9570179
##  0.9147858 0.9226943 0.9340517 0.9614474 0.9808549 1.0000000 0.9864019
##  0.8778029 0.8890251 0.8983736 0.9338393 0.9570179 0.9864019 1.0000000
##  0.8730873 0.8839318 0.8962729 0.9256021 0.9506892 0.9808442 0.9890561
##  0.8848736 0.8897946 0.8998215 0.9225337 0.9433285 0.9724035 0.9768180
##  0.9048329 0.9037153 0.9098429 0.9289280 0.9473356 0.9721968 0.9675762
##  0.9056357 0.9023920 0.8985835 0.9196890 0.9328886 0.9554446 0.9509259
##  0.8523283 0.8421470 0.8264951 0.8669846 0.8689958 0.8938894 0.8865751
##  0.8945268 0.8981785 0.8890995 0.9170156 0.9350876 0.9505018 0.9462658
##  0.8979029 0.9005224 0.8872284 0.9150499 0.9305573 0.9396425 0.9306487
##  0.9009673 0.9028524 0.8878954 0.9144090 0.9254097 0.9276195 0.9150496
##
##  0.6027280 0.6157629 0.6434247 0.6313686 0.5705892 0.5926739 0.5823713
##  0.6378640 0.6562523 0.6771577 0.6741060 0.5985786 0.6349243 0.6239287
##  0.6740610 0.6937587 0.7104274 0.7232996 0.6790025 0.7014461 0.6970513
##  0.7359286 0.7529302 0.7631799 0.7708472 0.7254579 0.7533305 0.7474359
##  0.7245940 0.7475903 0.7589742 0.7652871 0.7182127 0.7503567 0.7451136
##  0.8347616 0.8459257 0.8609755 0.8568941 0.8128706 0.8454823 0.8389184
##  0.8607348 0.8757802 0.8927743 0.8936217 0.8352580 0.8789065 0.8782199
##  0.8730873 0.8848736 0.9048329 0.9056357 0.8523283 0.8945268 0.8979029
##  0.8839318 0.8897946 0.9037153 0.9023920 0.8421470 0.8981785 0.9005224
##  0.8962729 0.8998215 0.9098429 0.8985835 0.8264951 0.8890995 0.8872284
##  0.9256021 0.9225337 0.9289280 0.9196890 0.8669846 0.9170156 0.9150499
##  0.9506892 0.9433285 0.9473356 0.9328886 0.8689958 0.9350876 0.9305573
##  0.9808442 0.9724035 0.9721968 0.9554446 0.8938894 0.9505018 0.9396425
##  0.9890561 0.9768180 0.9675762 0.9509259 0.8865751 0.9462658 0.9306487
##  1.0000000 0.9932931 0.9840188 0.9695566 0.9116768 0.9641555 0.9473015
##  0.9932931 1.0000000 0.9934411 0.9848425 0.9233301 0.9730374 0.9577685
##  0.9840188 0.9934411 1.0000000 0.9903833 0.9233172 0.9755836 0.9652907
##  0.9695566 0.9848425 0.9903833 1.0000000 0.9424860 0.9886098 0.9809881
##  0.9116768 0.9233301 0.9233172 0.9424860 1.0000000 0.9461421 0.9380402
```

```
##  0.9641555 0.9730374 0.9755836 0.9886098 0.9461421 1.0000000 0.9959666
##  0.9473015 0.9577685 0.9652907 0.9809881 0.9380402 0.9959666 1.0000000
##  0.9312500 0.9429089 0.9523723 0.9736483 0.9324938 0.9890101 0.9964102
##
##  0.5817169
##  0.6274675
##  0.7027771
##  0.7516652
##  0.7480255
##  0.8399266
##  0.8811851
##  0.9009673
##  0.9028524
##  0.8878954
##  0.9144090
##  0.9254097
##  0.9276195
##  0.9150496
##  0.9312500
##  0.9429089
##  0.9523723
##  0.9736483
##  0.9324938
##  0.9890101
##  0.9964102
##  1.0000000
##
##  R-sq. pooled: 0.7738
##  Breusch-Pagan:  6954  p-value: (   0)
```

Model with 11-day moving average of climatic variables:

```
sur.slm_lag11 <- spsur::spsurtime(formula = formula_lag11,
                                  data=GPanel,
                                  time = GPanel$Date,
                                  type = "slm",
                                  fit_method = "3sls",
                                  listw=  listw)
```

```
## Time to fit the model:  0.58  seconds
```

```
summary(sur.slm_lag11)
```

```
## Call:
## spsur::spsurtime(formula = formula_lag11, data = GPanel, time = GPanel$Date,
##     listw = listw, type = "slm", fit_method = "3sls")
##
##
## Spatial SUR model type:  slm
##
## Equation  1
##                                  Estimate Std. Error t value Pr(>|t|)
## (Intercept)_1                   48.413622  26.379511  1.8353 0.066894 .
## log(Male2Female)_1              -5.544849   4.443317 -1.2479 0.212486
## log(Median_Age)_1               -5.107345   2.746269 -1.8597 0.063346 .
## log(Mean_Temp_lag11)_1          -1.639449   0.582809 -2.8130 0.005047 **
```

```
## log(Sunshine_Hours_lag11 + 0.1)_1  0.042746   0.273852  0.1561 0.876006
## log(Humidity_lag11)_1              0.407414   0.550804  0.7397 0.459750
## rho_1                              0.294248   0.134863  2.1818 0.029457 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## R-squared: 0.2647
##   Equation  2
##                                  Estimate Std. Error t value Pr(>|t|)
## (Intercept)_2                    38.36960   23.45387  1.6360 0.102302
## log(Male2Female)_2               -5.10121    4.02552 -1.2672 0.205503
## log(Median_Age)_2                -2.81390    2.42078 -1.1624 0.245476
## log(Mean_Temp_lag11)_2           -1.46000    0.50986 -2.8635 0.004316 **
## log(Sunshine_Hours_lag11 + 0.1)_2  0.04241    0.24973  0.1698 0.865196
## log(Humidity_lag11)_2             0.29722    0.45469  0.6537 0.513537
## rho_2                             0.10572    0.11578  0.9131 0.361518
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## R-squared: 0.2288
##   Equation  3
##                                  Estimate Std. Error t value  Pr(>|t|)
## (Intercept)_3                    30.18608   20.82864  1.4493 0.1477178
## log(Male2Female)_3               -3.55522    3.59894 -0.9879 0.3235708
## log(Median_Age)_3                -2.56329    2.14679 -1.1940 0.2328829
## log(Mean_Temp_lag11)_3           -1.41480    0.41213 -3.4329 0.0006327 ***
## log(Sunshine_Hours_lag11 + 0.1)_3  0.16021    0.24604  0.6512 0.5151574
## log(Humidity_lag11)_3             0.20479    0.36642  0.5589 0.5764135
## rho_3                             0.28634    0.10043  2.8511 0.0044862 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## R-squared: 0.2756
##   Equation  4
##                                   Estimate Std. Error t value Pr(>|t|)
## (Intercept)_4                    24.966198  20.480895  1.2190 0.223259
## log(Male2Female)_4               -2.930008   3.551056 -0.8251 0.409594
## log(Median_Age)_4                -1.918448   2.123095 -0.9036 0.366517
## log(Mean_Temp_lag11)_4           -1.486651   0.373174 -3.9838  7.5e-05 ***
## log(Sunshine_Hours_lag11 + 0.1)_4  0.350411   0.244212  1.4349 0.151776
## log(Humidity_lag11)_4             0.171467   0.333066  0.5148 0.606847
## rho_4                             0.259670   0.088354  2.9390 0.003402 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## R-squared: 0.2712
##   Equation  5
##                                   Estimate Std. Error t value  Pr(>|t|)
## (Intercept)_5                    11.519228  20.928471  0.5504 0.5822159
## log(Male2Female)_5               -0.801973   3.600187 -0.2228 0.8237889
## log(Median_Age)_5                -1.125536   2.185911 -0.5149 0.6067836
## log(Mean_Temp_lag11)_5           -1.456676   0.389410 -3.7407 0.0001987 ***
## log(Sunshine_Hours_lag11 + 0.1)_5  0.371161   0.277678  1.3367 0.1817727
## log(Humidity_lag11)_5             0.337052   0.360012  0.9362 0.3494835
## rho_5                             0.293129   0.086841  3.3755 0.0007780 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## R-squared: 0.2577
```

```
##   Equation  6
##                                  Estimate Std. Error t value  Pr(>|t|)
## (Intercept)_6                     7.38863   18.62453  0.3967    0.6917
## log(Male2Female)_6                1.12891    3.21418  0.3512    0.7255
## log(Median_Age)_6                -1.47949    1.93751 -0.7636    0.4454
## log(Mean_Temp_lag11)_6           -1.45681    0.34046 -4.2789 2.142e-05 ***
## log(Sunshine_Hours_lag11 + 0.1)_6 -0.12078    0.20592 -0.5865    0.5577
## log(Humidity_lag11)_6             0.12246    0.26976  0.4540    0.6500
## rho_6                            -0.12415    0.08074 -1.5377    0.1246
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## R-squared: 0.2884
##   Equation  7
##                                   Estimate Std. Error t value  Pr(>|t|)
## (Intercept)_7                     6.429536  16.606563  0.3872    0.6988
## log(Male2Female)_7                1.013027   2.873661  0.3525    0.7246
## log(Median_Age)_7                -0.971000   1.726086 -0.5625    0.5739
## log(Mean_Temp_lag11)_7           -1.712589   0.292389 -5.8572 7.271e-09 ***
## log(Sunshine_Hours_lag11 + 0.1)_7  0.121880   0.157646  0.7731    0.4397
## log(Humidity_lag11)_7             0.048670   0.223012  0.2182    0.8273
## rho_7                            -0.029941   0.070892 -0.4223    0.6729
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## R-squared: 0.3593
##   Equation  8
##                                   Estimate Std. Error t value  Pr(>|t|)
## (Intercept)_8                     7.908506  16.617523  0.4759 0.6342859
## log(Male2Female)_8                0.616991   2.862049  0.2156 0.8293812
## log(Median_Age)_8                -0.994125   1.724127 -0.5766 0.5643995
## log(Mean_Temp_lag11)_8           -2.241336   0.291807 -7.6809   5.4e-14 ***
## log(Sunshine_Hours_lag11 + 0.1)_8  0.550106   0.148066  3.7153 0.0002193 ***
## log(Humidity_lag11)_8             0.262748   0.218896  1.2003 0.2304189
## rho_8                             0.065160   0.071398  0.9126 0.3617563
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## R-squared: 0.4062
##   Equation  9
##                                   Estimate Std. Error t value  Pr(>|t|)
## (Intercept)_9                    17.428126  16.120001  1.0811    0.2800
## log(Male2Female)_9               -1.190685   2.765525 -0.4305    0.6669
## log(Median_Age)_9                -1.361279   1.655441 -0.8223    0.4112
## log(Mean_Temp_lag11)_9           -2.330495   0.291374 -7.9983 5.299e-15 ***
## log(Sunshine_Hours_lag11 + 0.1)_9  0.729471   0.164352  4.4385 1.054e-05 ***
## log(Humidity_lag11)_9             0.354499   0.242343  1.4628    0.1440
## rho_9                             0.016548   0.086572  0.1911    0.8485
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## R-squared: 0.4138
##   Equation  10
##                                    Estimate Std. Error t value  Pr(>|t|)
## (Intercept)_10                    14.091397  14.900255  0.9457 0.3446235
## log(Male2Female)_10               -1.543865   2.548351 -0.6058 0.5448266
## log(Median_Age)_10                -0.129264   1.525694 -0.0847 0.9325048
## log(Mean_Temp_lag11)_10           -2.118055   0.277509 -7.6324 7.649e-14 ***
```

```
## log(Sunshine_Hours_lag11 + 0.1)_10  0.551808   0.155905  3.5394 0.0004279 ***
## log(Humidity_lag11)_10              0.479776   0.255458  1.8781 0.0607869 .
## rho_10                             -0.041520   0.087722 -0.4733 0.6361418
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## R-squared: 0.4493
##   Equation  11
##                                     Estimate Std. Error t value Pr(>|t|)
## (Intercept)_11                     10.765483  13.868288  0.7763  0.43786
## log(Male2Female)_11                -0.545143   2.391240 -0.2280  0.81973
## log(Median_Age)_11                 -0.293207   1.405823 -0.2086  0.83485
## log(Mean_Temp_lag11)_11            -1.956502   0.225714 -8.6681  < 2e-16 ***
## log(Sunshine_Hours_lag11 + 0.1)_11  0.218053   0.099786  2.1852  0.02921 *
## log(Humidity_lag11)_11              0.338180   0.229144  1.4758  0.14044
## rho_11                              0.033167   0.071482  0.4640  0.64280
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## R-squared: 0.4832
##   Equation  12
##                                      Estimate Std. Error t value  Pr(>|t|)
## (Intercept)_12                     11.9847344 14.3838645  0.8332  0.405015
## log(Male2Female)_12                -0.9338541  2.4812392 -0.3764  0.706760
## log(Median_Age)_12                 -0.4292512  1.4545800 -0.2951  0.768003
## log(Mean_Temp_lag11)_12            -1.8426582  0.2231855 -8.2562 7.603e-16 ***
## log(Sunshine_Hours_lag11 + 0.1)_12  0.2337495  0.0909874  2.5690  0.010407 *
## log(Humidity_lag11)_12              0.5955628  0.2259649  2.6356  0.008586 **
## rho_12                              0.0030812  0.0720207  0.0428  0.965888
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## R-squared: 0.4578
##   Equation  13
##                                     Estimate Std. Error t value  Pr(>|t|)
## (Intercept)_13                     16.230181  13.829928  1.1736  0.240976
## log(Male2Female)_13                -1.981472   2.381088 -0.8322  0.405599
## log(Median_Age)_13                 -0.176307   1.391695 -0.1267  0.899227
## log(Mean_Temp_lag11)_13            -1.921547   0.223764 -8.5874 < 2.2e-16 ***
## log(Sunshine_Hours_lag11 + 0.1)_13  0.202477   0.074956  2.7013  0.007077 **
## log(Humidity_lag11)_13              0.523438   0.214080  2.4451  0.014731 *
## rho_13                              0.065175   0.072450  0.8996  0.368654
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## R-squared: 0.4946
##   Equation  14
##                                     Estimate Std. Error t value  Pr(>|t|)
## (Intercept)_14                     18.983310  14.048181  1.3513  0.177040
## log(Male2Female)_14                -2.721227   2.415976 -1.1263  0.260409
## log(Median_Age)_14                 -0.037472   1.401664 -0.0267  0.978680
## log(Mean_Temp_lag11)_14            -1.842188   0.231235 -7.9667 6.697e-15 ***
## log(Sunshine_Hours_lag11 + 0.1)_14  0.222262   0.068386  3.2501  0.001209 **
## log(Humidity_lag11)_14              0.519279   0.230076  2.2570  0.024319 *
## rho_14                              0.061747   0.075718  0.8155  0.415075
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## R-squared: 0.4881
```

```
##   Equation  15
##                                    Estimate Std. Error t value  Pr(>|t|)
## (Intercept)_15                    10.401954  13.092655  0.7945 0.4271835
## log(Male2Female)_15               -1.918158   2.266571 -0.8463 0.3976875
## log(Median_Age)_15                 1.333592   1.299989  1.0258 0.3053207
## log(Mean_Temp_lag11)_15           -1.627684   0.186534 -8.7259 < 2.2e-16 ***
## log(Sunshine_Hours_lag11 + 0.1)_15  0.208723   0.055021  3.7935 0.0001615 ***
## log(Humidity_lag11)_15             0.296260   0.188424  1.5723 0.1163361
## rho_15                             0.105820   0.069823  1.5155 0.1300925
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## R-squared: 0.5257
##   Equation  16
##                                    Estimate Std. Error t value  Pr(>|t|)
## (Intercept)_16                     6.073675  12.689649  0.4786 0.6323513
## log(Male2Female)_16               -1.334684   2.203851 -0.6056 0.5449691
## log(Median_Age)_16                 1.807088   1.261448  1.4326 0.1524373
## log(Mean_Temp_lag11)_16           -1.535966   0.179548 -8.5546 < 2.2e-16 ***
## log(Sunshine_Hours_lag11 + 0.1)_16  0.206566   0.056196  3.6758 0.0002554 ***
## log(Humidity_lag11)_16             0.225458   0.167136  1.3489 0.1777945
## rho_16                             0.107643   0.068954  1.5611 0.1189629
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## R-squared: 0.5305
##   Equation  17
##                                    Estimate Std. Error t value  Pr(>|t|)
## (Intercept)_17                     7.887738  12.620938  0.6250    0.5322
## log(Male2Female)_17               -1.360410   2.194412 -0.6199    0.5355
## log(Median_Age)_17                 1.363442   1.255713  1.0858    0.2779
## log(Mean_Temp_lag11)_17           -1.482038   0.169828 -8.7267 < 2.2e-16 ***
## log(Sunshine_Hours_lag11 + 0.1)_17  0.269325   0.057108  4.7160 2.909e-06 ***
## log(Humidity_lag11)_17             0.220004   0.138939  1.5835    0.1138
## rho_17                             0.071966   0.065874  1.0925    0.2750
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## R-squared: 0.5222
##   Equation  18
##                                    Estimate Std. Error t value  Pr(>|t|)
## (Intercept)_18                     8.400154  12.479203  0.6731    0.5011
## log(Male2Female)_18               -1.733994   2.169552 -0.7992    0.4244
## log(Median_Age)_18                 1.771988   1.241646  1.4271    0.1540
## log(Mean_Temp_lag11)_18           -1.376277   0.167192 -8.2317 9.160e-16 ***
## log(Sunshine_Hours_lag11 + 0.1)_18  0.295847   0.067239  4.3999 1.253e-05 ***
## log(Humidity_lag11)_18             0.140308   0.143978  0.9745    0.3301
## rho_18                             0.013477   0.071123  0.1895    0.8498
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## R-squared: 0.5307
##   Equation  19
##                                    Estimate Std. Error t value  Pr(>|t|)
## (Intercept)_19                     3.854042  13.083411  0.2946   0.76841
## log(Male2Female)_19               -0.240650   2.233310 -0.1078   0.91422
## log(Median_Age)_19                 1.145395   1.319022  0.8684   0.38549
## log(Mean_Temp_lag11)_19           -1.363888   0.191515 -7.1216 2.677e-12 ***
```

```
## log(Sunshine_Hours_lag11 + 0.1)_19  0.245130   0.099958  2.4523   0.01444 *
## log(Humidity_lag11)_19              0.140775   0.230444  0.6109   0.54147
## rho_19                              0.046550   0.096619  0.4818   0.63011
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## R-squared: 0.5266
##   Equation  20
##                                     Estimate Std. Error t value  Pr(>|t|)
## (Intercept)_20                      5.653701  12.833702  0.4405   0.65969
## log(Male2Female)_20                -1.077455   2.222385 -0.4848   0.62796
## log(Median_Age)_20                  1.899559   1.298504  1.4629   0.14395
## log(Mean_Temp_lag11)_20            -1.104157   0.151473 -7.2894 8.511e-13 ***
## log(Sunshine_Hours_lag11 + 0.1)_20  0.110393   0.059813  1.8456   0.06537 .
## log(Humidity_lag11)_20             -0.046420   0.170463 -0.2723   0.78546
## rho_20                             -0.030479   0.077843 -0.3916   0.69551
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## R-squared: 0.5071
##   Equation  21
##                                     Estimate Std. Error t value  Pr(>|t|)
## (Intercept)_21                      7.271966  12.558728  0.5790    0.5628
## log(Male2Female)_21                -1.045307   2.168125 -0.4821    0.6299
## log(Median_Age)_21                  1.664692   1.277865  1.3027    0.1931
## log(Mean_Temp_lag11)_21            -1.111652   0.149024 -7.4595 2.605e-13 ***
## log(Sunshine_Hours_lag11 + 0.1)_21  0.029470   0.061270  0.4810    0.6307
## log(Humidity_lag11)_21             -0.167351   0.171868 -0.9737    0.3305
## rho_21                             -0.059654   0.078880 -0.7563    0.4498
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## R-squared: 0.5259
##   Equation  22
##                                       Estimate  Std. Error t value  Pr(>|t|)
## (Intercept)_22                      4.5641e+00  1.3007e+01  0.3509    0.7258
## log(Male2Female)_22                -7.2524e-01  2.2417e+00 -0.3235    0.7464
## log(Median_Age)_22                  2.0171e+00  1.3295e+00  1.5172    0.1297
## log(Mean_Temp_lag11)_22            -1.0410e+00  1.4984e-01 -6.9475 8.584e-12
## log(Sunshine_Hours_lag11 + 0.1)_22 -1.1705e-05  6.3680e-02 -0.0002    0.9999
## log(Humidity_lag11)_22             -1.9965e-01  1.8065e-01 -1.1052    0.2695
## rho_22                             -6.6000e-02  8.1673e-02 -0.8081    0.4193
##
## (Intercept)_22
## log(Male2Female)_22
## log(Median_Age)_22
## log(Mean_Temp_lag11)_22            ***
## log(Sunshine_Hours_lag11 + 0.1)_22
## log(Humidity_lag11)_22
## rho_22
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## R-squared: 0.5155
##
## Variance-Covariance Matrix of inter-equation residuals:
##  0.8120411 0.7056270 0.5977397 0.5702723 0.5660145 0.4847193 0.4167961
##  0.7056270 0.6937768 0.5918479 0.5791645 0.5609433 0.4728287 0.4147636
```

```
##  0.5977397 0.5918479 0.5663387 0.5525895 0.5380267 0.4503976 0.4004265
##  0.5702723 0.5791645 0.5525895 0.5590887 0.5493546 0.4673474 0.4131887
##  0.5660145 0.5609433 0.5380267 0.5493546 0.5757850 0.4840060 0.4267388
##  0.4847193 0.4728287 0.4503976 0.4673474 0.4840060 0.4662178 0.4086676
##  0.4167961 0.4147636 0.4004265 0.4131887 0.4267388 0.4086676 0.3779338
##  0.3993952 0.3838801 0.3786634 0.3927655 0.4066919 0.3970265 0.3679210
##  0.3753265 0.3559380 0.3485577 0.3633619 0.3780162 0.3681318 0.3431070
##  0.3338609 0.3218883 0.2959867 0.3126347 0.3304431 0.3252263 0.3056945
##  0.2831147 0.2799092 0.2712641 0.2932040 0.3022511 0.3078853 0.2870375
##  0.2627641 0.2630604 0.2548522 0.2790136 0.2804282 0.3018132 0.2797317
##  0.2159196 0.2186631 0.2115736 0.2313112 0.2283665 0.2578441 0.2420319
##  0.2111760 0.2150964 0.2068294 0.2249457 0.2182853 0.2463041 0.2327205
##  0.2017883 0.2001996 0.1922614 0.2087625 0.2061565 0.2328113 0.2197039
##  0.2176515 0.2147667 0.2042642 0.2180205 0.2177597 0.2345462 0.2229551
##  0.2286920 0.2212602 0.2091919 0.2212841 0.2202133 0.2386806 0.2272998
##  0.2229936 0.2217544 0.2146321 0.2260577 0.2238648 0.2367117 0.2257802
##  0.1900137 0.1954066 0.2061940 0.2200444 0.2161950 0.2276962 0.2133018
##  0.2108540 0.2144210 0.2174838 0.2309651 0.2310089 0.2446008 0.2326560
##  0.2082455 0.2117045 0.2164109 0.2284173 0.2282304 0.2377999 0.2291498
##  0.2177786 0.2244016 0.2306529 0.2434490 0.2420955 0.2501162 0.2414299
##
##  0.3993952 0.3753265 0.3338609 0.2831147 0.2627641 0.2159196 0.2111760
##  0.3838801 0.3559380 0.3218883 0.2799092 0.2630604 0.2186631 0.2150964
##  0.3786634 0.3485577 0.2959867 0.2712641 0.2548522 0.2115736 0.2068294
##  0.3927655 0.3633619 0.3126347 0.2932040 0.2790136 0.2313112 0.2249457
##  0.4066919 0.3780162 0.3304431 0.3022511 0.2804282 0.2283665 0.2182853
##  0.3970265 0.3681318 0.3252263 0.3078853 0.3018132 0.2578441 0.2463041
##  0.3679210 0.3431070 0.3056945 0.2870375 0.2797317 0.2420319 0.2327205
##  0.3749958 0.3541071 0.3115622 0.2931748 0.2848373 0.2456083 0.2364708
##  0.3541071 0.3472546 0.3046557 0.2820039 0.2733500 0.2344957 0.2265209
##  0.3115622 0.3046557 0.2932029 0.2635006 0.2580610 0.2258557 0.2171090
##  0.2931748 0.2820039 0.2635006 0.2595524 0.2608781 0.2343400 0.2270012
##  0.2848373 0.2733500 0.2580610 0.2608781 0.2786683 0.2574149 0.2516742
##  0.2456083 0.2344957 0.2258557 0.2343400 0.2574149 0.2536483 0.2520978
##  0.2364708 0.2265209 0.2171090 0.2270012 0.2516742 0.2520978 0.2582067
##  0.2227937 0.2116195 0.2042314 0.2116084 0.2345705 0.2342851 0.2385148
##  0.2262713 0.2148706 0.2061268 0.2072423 0.2252164 0.2226776 0.2259486
##  0.2315683 0.2190383 0.2067165 0.2072975 0.2246326 0.2208924 0.2227347
##  0.2288748 0.2160566 0.2029150 0.2036670 0.2187182 0.2137457 0.2149273
##  0.2106241 0.1901949 0.1766695 0.1895122 0.2025737 0.1963199 0.1951276
##  0.2335005 0.2182119 0.2016051 0.2050060 0.2198689 0.2111505 0.2097947
##  0.2310784 0.2163424 0.1976645 0.1985528 0.2105332 0.1999238 0.1976595
##  0.2429233 0.2266225 0.2049223 0.2061361 0.2168079 0.2035519 0.2015255
##
##  0.2017883 0.2176515 0.2286920 0.2229936 0.1900137 0.2108540 0.2082455
##  0.2001996 0.2147667 0.2212602 0.2217544 0.1954066 0.2144210 0.2117045
##  0.1922614 0.2042642 0.2091919 0.2146321 0.2061940 0.2174838 0.2164109
##  0.2087625 0.2180205 0.2212841 0.2260577 0.2200444 0.2309651 0.2284173
##  0.2061565 0.2177597 0.2202133 0.2238648 0.2161950 0.2310089 0.2282304
##  0.2328113 0.2345462 0.2386806 0.2367117 0.2276962 0.2446008 0.2377999
##  0.2197039 0.2229551 0.2272998 0.2257802 0.2133018 0.2326560 0.2291498
##  0.2227937 0.2262713 0.2315683 0.2288748 0.2106241 0.2335005 0.2310784
##  0.2116195 0.2148706 0.2190383 0.2160566 0.1901949 0.2182119 0.2163424
##  0.2042314 0.2061268 0.2067165 0.2029150 0.1766695 0.2016051 0.1976645
```

```
##  0.2116084 0.2072423 0.2072975 0.2036670 0.1895122 0.2050060 0.1985528
##  0.2345705 0.2252164 0.2246326 0.2187182 0.2025737 0.2198689 0.2105332
##  0.2342851 0.2226776 0.2208924 0.2137457 0.1963199 0.2111505 0.1999238
##  0.2385148 0.2259486 0.2227347 0.2149273 0.1951276 0.2097947 0.1976595
##  0.2270670 0.2175742 0.2146954 0.2082726 0.1912063 0.2055211 0.1949726
##  0.2175742 0.2150386 0.2124267 0.2076010 0.1873559 0.2020256 0.1935406
##  0.2146954 0.2124267 0.2137000 0.2082847 0.1879573 0.2044474 0.1970802
##  0.2082726 0.2076010 0.2082847 0.2079457 0.1917091 0.2060348 0.1991069
##  0.1912063 0.1873559 0.1879573 0.1917091 0.2155187 0.2035494 0.1971637
##  0.2055211 0.2020256 0.2044474 0.2060348 0.2035494 0.2203075 0.2136188
##  0.1949726 0.1935406 0.1970802 0.1991069 0.1971637 0.2136188 0.2102634
##  0.1985999 0.1972417 0.2007025 0.2036024 0.2024764 0.2190456 0.2163732
##
##  0.2177786
##  0.2244016
##  0.2306529
##  0.2434490
##  0.2420955
##  0.2501162
##  0.2414299
##  0.2429233
##  0.2266225
##  0.2049223
##  0.2061361
##  0.2168079
##  0.2035519
##  0.2015255
##  0.1985999
##  0.1972417
##  0.2007025
##  0.2036024
##  0.2024764
##  0.2190456
##  0.2163732
##  0.2250850
## Correlation Matrix of inter-equation residuals:
##  1.0000000 0.9418727 0.8979235 0.8713492 0.8580815 0.8232855 0.7911893
##  0.9418727 1.0000000 0.9484051 0.9400377 0.9062664 0.8560149 0.8408058
##  0.8979235 0.9484051 1.0000000 0.9836517 0.9488438 0.8902893 0.8836218
##  0.8713492 0.9400377 0.9836517 1.0000000 0.9693633 0.9189988 0.9076899
##  0.8580815 0.9062664 0.9488438 0.9693633 1.0000000 0.9336573 0.9201693
##  0.8232855 0.8560149 0.8902893 0.9189988 0.9336573 1.0000000 0.9779079
##  0.7911893 0.8408058 0.8836218 0.9076899 0.9201693 0.9779079 1.0000000
##  0.7730138 0.8001018 0.8534203 0.8783596 0.8931134 0.9625350 0.9858411
##  0.7594705 0.7845102 0.8290109 0.8576277 0.8777197 0.9421682 0.9674957
##  0.7407585 0.7730717 0.7852224 0.8181488 0.8538723 0.9182368 0.9478609
##  0.7122458 0.7468917 0.7879184 0.8310226 0.8466348 0.9297517 0.9560427
##  0.6665176 0.7041866 0.7464551 0.7940148 0.7995132 0.9050094 0.9295493
##  0.6117013 0.6510842 0.6949088 0.7354493 0.7348136 0.8548673 0.8886742
##  0.6032309 0.6496938 0.6935039 0.7310573 0.7189969 0.8308634 0.8697996
##  0.6168515 0.6496255 0.6925008 0.7271069 0.7232367 0.8378556 0.8757448
##  0.6342347 0.6731127 0.7138005 0.7457960 0.7461956 0.8475060 0.8890463
##  0.6426778 0.6743545 0.7128299 0.7423104 0.7424894 0.8509771 0.8935877
##  0.6318924 0.6733929 0.7226432 0.7494996 0.7464736 0.8455958 0.8897114
```

```
##  0.5634466 0.5975547 0.6776267 0.7070040 0.6945162 0.8008515 0.8302588
##  0.5920144 0.6366489 0.7035742 0.7334897 0.7354153 0.8376292 0.8795892
##  0.5888237 0.6333894 0.7031391 0.7316893 0.7329875 0.8318697 0.8794526
##  0.5900192 0.6410802 0.7106373 0.7400674 0.7380289 0.8371331 0.8853015
##
##  0.7730138 0.7594705 0.7407585 0.7122458 0.6665176 0.6117013 0.6032309
##  0.8001018 0.7845102 0.7730717 0.7468917 0.7041866 0.6510842 0.6496938
##  0.8534203 0.8290109 0.7852224 0.7879184 0.7464551 0.6949088 0.6935039
##  0.8783596 0.8576277 0.8181488 0.8310226 0.7940148 0.7354493 0.7310573
##  0.8931134 0.8777197 0.8538723 0.8466348 0.7995132 0.7348136 0.7189969
##  0.9625350 0.9421682 0.9182368 0.9297517 0.9050094 0.8548673 0.8308634
##  0.9858411 0.9674957 0.9478609 0.9560427 0.9295493 0.8886742 0.8697996
##  1.0000000 0.9867944 0.9600631 0.9689279 0.9420993 0.8987102 0.8787952
##  0.9867944 1.0000000 0.9672660 0.9656657 0.9384925 0.8905986 0.8737365
##  0.9600631 0.9672660 1.0000000 0.9700037 0.9464422 0.9069241 0.8838030
##  0.9689279 0.9656657 0.9700037 1.0000000 0.9837024 0.9552088 0.9367945
##  0.9420993 0.9384925 0.9464422 0.9837024 1.0000000 0.9810254 0.9640752
##  0.8987102 0.8905986 0.9069241 0.9552088 0.9810254 1.0000000 0.9897187
##  0.8787952 0.8737365 0.8838030 0.9367945 0.9640752 0.9897187 1.0000000
##  0.8877012 0.8775358 0.8901713 0.9376514 0.9644955 0.9861479 0.9889524
##  0.8998033 0.8874782 0.8986870 0.9357103 0.9574771 0.9755806 0.9760082
##  0.9075057 0.8910418 0.8957359 0.9338541 0.9571775 0.9733272 0.9712325
##  0.9018305 0.8853935 0.8843158 0.9259553 0.9446338 0.9597278 0.9587520
##  0.8349366 0.8010245 0.7940077 0.8666854 0.8789335 0.8952348 0.8926833
##  0.8917158 0.8744508 0.8671223 0.9181560 0.9404809 0.9481809 0.9458024
##  0.8951088 0.8786383 0.8636080 0.9118930 0.9315965 0.9347489 0.9315157
##  0.8989439 0.8822184 0.8636458 0.9123114 0.9286538 0.9270146 0.9246910
##
##  0.6168515 0.6342347 0.6426778 0.6318924 0.5634466 0.5920144 0.5888237
##  0.6496255 0.6731127 0.6743545 0.6733929 0.5975547 0.6366489 0.6333894
##  0.6925008 0.7138005 0.7128299 0.7226432 0.6776267 0.7035742 0.7031391
##  0.7271069 0.7457960 0.7423104 0.7494996 0.7070040 0.7334897 0.7316893
##  0.7232367 0.7461956 0.7424894 0.7464736 0.6945162 0.7354153 0.7329875
##  0.8378556 0.8475060 0.8509771 0.8455958 0.8008515 0.8376292 0.8318697
##  0.8757448 0.8890463 0.8935877 0.8897114 0.8302588 0.8795892 0.8794526
##  0.8877012 0.8998033 0.9075057 0.9018305 0.8349366 0.8917158 0.8951088
##  0.8775358 0.8874782 0.8910418 0.8853935 0.8010245 0.8744508 0.8786383
##  0.8901713 0.8986870 0.8957359 0.8843158 0.7940077 0.8671223 0.8636080
##  0.9376514 0.9357103 0.9338541 0.9259553 0.8666854 0.9181560 0.9118930
##  0.9644955 0.9574771 0.9571775 0.9446338 0.8789335 0.9404809 0.9315965
##  0.9861479 0.9755806 0.9733272 0.9597278 0.8952348 0.9481809 0.9347489
##  0.9889524 0.9760082 0.9712325 0.9587520 0.8926833 0.9458024 0.9315157
##  1.0000000 0.9940076 0.9906452 0.9815198 0.9181101 0.9678634 0.9560617
##  0.9940076 1.0000000 0.9955750 0.9912790 0.9217867 0.9732159 0.9642415
##  0.9906452 0.9955750 1.0000000 0.9923036 0.9200950 0.9774277 0.9717221
##  0.9815198 0.9912790 0.9923036 1.0000000 0.9369400 0.9896569 0.9849052
##  0.9181101 0.9217867 0.9200950 0.9369400 1.0000000 0.9476018 0.9418986
##  0.9678634 0.9732159 0.9774277 0.9896569 0.9476018 1.0000000 0.9968051
##  0.9560617 0.9642415 0.9717221 0.9849052 0.9418986 0.9968051 1.0000000
##  0.9486809 0.9571571 0.9644521 0.9800781 0.9371319 0.9927857 0.9974767
##
##  0.5900192
##  0.6410802
##  0.7106373
```

```
##  0.7400674
##  0.7380289
##  0.8371331
##  0.8853015
##  0.8989439
##  0.8822184
##  0.8636458
##  0.9123114
##  0.9286538
##  0.9270146
##  0.9246910
##  0.9486809
##  0.9571571
##  0.9644521
##  0.9800781
##  0.9371319
##  0.9927857
##  0.9974767
##  1.0000000
##
##  R-sq. pooled: 0.7835
##  Breusch-Pagan:  7461  p-value: (   0)
```

Model with 11-day weighted moving average of climatic variables:

```
sur.slm_lag11w <- spsur::spsurtime(formula = formula_lag11w,
                                   data=GPanel,
                                   time = GPanel$Date,
                                   type = "slm",
                                   fit_method = "3sls",
                                   listw=  listw)
```

```
## Time to fit the model:  0.36  seconds
```

```
summary(sur.slm_lag11w)
```

```
## Call:
## spsur::spsurtime(formula = formula_lag11w, data = GPanel, time = GPanel$Date,
##     listw = listw, type = "slm", fit_method = "3sls")
##
##
## Spatial SUR model type:  slm
##
## Equation  1
##                                      Estimate Std. Error t value  Pr(>|t|)
## (Intercept)_1                       31.218726  26.156528  1.1935 0.2330684
## log(Male2Female)_1                  -3.768725   4.483467 -0.8406 0.4008716
## log(Median_Age)_1                   -3.150522   2.679908 -1.1756 0.2401551
## log(Mean_Temp_lag11w)_1             -1.070296   0.504505 -2.1215 0.0342359 *
## log(Sunshine_Hours_lag11w + 0.1)_1   0.025972   0.284809  0.0912 0.9273686
## log(Humidity_lag11w)_1               0.427115   0.428354  0.9971 0.3190598
## rho_1                                0.403794   0.117744  3.4294 0.0006407 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## R-squared: 0.2052
##   Equation  2
```

```
##                                    Estimate Std. Error t value Pr(>|t|)
## (Intercept)_2                     24.217204  23.487513  1.0311 0.302869
## log(Male2Female)_2                -3.637960   4.099355 -0.8874 0.375146
## log(Median_Age)_2                 -1.264736   2.391334 -0.5289 0.597056
## log(Mean_Temp_lag11w)_2           -1.066531   0.442894 -2.4081 0.016296 *
## log(Sunshine_Hours_lag11w + 0.1)_2  0.140962   0.234510  0.6011 0.547976
## log(Humidity_lag11w)_2              0.308834   0.351107  0.8796 0.379381
## rho_2                               0.289792   0.096292  3.0095 0.002712 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## R-squared:  0.17
##   Equation  3
##                                    Estimate Std. Error t value  Pr(>|t|)
## (Intercept)_3                     12.597745  21.024574  0.5992   0.54924
## log(Male2Female)_3                -1.184885   3.693921 -0.3208   0.74848
## log(Median_Age)_3                 -0.975471   2.134354 -0.4570   0.64779
## log(Mean_Temp_lag11w)_3           -0.798061   0.371871 -2.1461   0.03221 *
## log(Sunshine_Hours_lag11w + 0.1)_3 -0.121472   0.216008 -0.5623   0.57406
## log(Humidity_lag11w)_3             0.058640   0.308607  0.1900   0.84935
## rho_3                              0.421874   0.080904  5.2145 2.436e-07 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## R-squared: 0.2038
##   Equation  4
##                                    Estimate Std. Error t value  Pr(>|t|)
## (Intercept)_4                     11.700176  20.801550  0.5625  0.573980
## log(Male2Female)_4                -1.216784   3.652960 -0.3331  0.739163
## log(Median_Age)_4                 -0.452433   2.110770 -0.2143  0.830341
## log(Mean_Temp_lag11w)_4           -0.891664   0.327500 -2.7226  0.006639 **
## log(Sunshine_Hours_lag11w + 0.1)_4  0.012906   0.215104  0.0600  0.952175
## log(Humidity_lag11w)_4            -0.123853   0.300243 -0.4125  0.680094
## rho_4                              0.348264   0.072949  4.7741 2.204e-06 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## R-squared: 0.2099
##   Equation  5
##                                    Estimate Std. Error t value  Pr(>|t|)
## (Intercept)_5                     -2.300799  21.587759 -0.1066   0.91515
## log(Male2Female)_5                 0.701062   3.764219  0.1862   0.85231
## log(Median_Age)_5                  0.680827   2.230929  0.3052   0.76032
## log(Mean_Temp_lag11w)_5           -0.745558   0.370682 -2.0113   0.04468 *
## log(Sunshine_Hours_lag11w + 0.1)_5  0.083063   0.308166  0.2695   0.78759
## log(Humidity_lag11w)_5             0.010621   0.357927  0.0297   0.97634
## rho_5                              0.358940   0.081402  4.4095 1.201e-05 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## R-squared: 0.1765
##   Equation  6
##                                    Estimate Std. Error t value  Pr(>|t|)
## (Intercept)_6                      1.678543  19.366707  0.0867 0.9309576
## log(Male2Female)_6                 1.624680   3.367858  0.4824 0.6296688
## log(Median_Age)_6                 -0.607193   2.016196 -0.3012 0.7633847
## log(Mean_Temp_lag11w)_6           -0.970983   0.290733 -3.3398 0.0008834 ***
## log(Sunshine_Hours_lag11w + 0.1)_6 -0.248948   0.233610 -1.0657 0.2869484
```

```
## log(Humidity_lag11w)_6             -0.125553   0.312607 -0.4016 0.6880792
## rho_6                              -0.085298   0.085745 -0.9948 0.3201906
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## R-squared: 0.2123
##   Equation  7
##                                      Estimate  Std. Error t value  Pr(>|t|)
## (Intercept)_7                      1.75501183 16.58422845  0.1058    0.9158
## log(Male2Female)_7                 1.30665744  2.88687936  0.4526    0.6510
## log(Median_Age)_7                 -0.32194853  1.71348958 -0.1879    0.8510
## log(Mean_Temp_lag11w)_7           -1.19473405  0.21745834 -5.4941 5.521e-08
## log(Sunshine_Hours_lag11w + 0.1)_7  0.00338311  0.13008099  0.0260    0.9793
## log(Humidity_lag11w)_7            -0.04982730  0.24890764 -0.2002    0.8414
## rho_7                              0.00046549  0.07513578  0.0062    0.9951
##
## (Intercept)_7
## log(Male2Female)_7
## log(Median_Age)_7
## log(Mean_Temp_lag11w)_7            ***
## log(Sunshine_Hours_lag11w + 0.1)_7
## log(Humidity_lag11w)_7
## rho_7
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## R-squared: 0.3294
##   Equation  8
##                                     Estimate Std. Error t value  Pr(>|t|)
## (Intercept)_8                       2.969292  15.573542  0.1907   0.84885
## log(Male2Female)_8                  1.041146   2.709672  0.3842   0.70092
## log(Median_Age)_8                  -0.333013   1.597970 -0.2084   0.83498
## log(Mean_Temp_lag11w)_8            -1.613850   0.205635 -7.8481 1.604e-14 ***
## log(Sunshine_Hours_lag11w + 0.1)_8  0.160783   0.090990  1.7670   0.07766 .
## log(Humidity_lag11w)_8              0.144623   0.219721  0.6582   0.51062
## rho_8                               0.065441   0.072342  0.9046   0.36599
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## R-squared: 0.4331
##   Equation  9
##                                     Estimate Std. Error t value  Pr(>|t|)
## (Intercept)_9                      19.827074  14.625032  1.3557 0.1756380
## log(Male2Female)_9                 -1.583752   2.517029 -0.6292 0.5294157
## log(Median_Age)_9                  -1.452606   1.496548 -0.9706 0.3320672
## log(Mean_Temp_lag11w)_9            -1.938786   0.226833 -8.5472 < 2.2e-16 ***
## log(Sunshine_Hours_lag11w + 0.1)_9  0.320749   0.091384  3.5099 0.0004773 ***
## log(Humidity_lag11w)_9              0.156560   0.223584  0.7002 0.4840180
## rho_9                               0.076316   0.081351  0.9381 0.3485155
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## R-squared: 0.494
##   Equation  10
##                                      Estimate Std. Error t value  Pr(>|t|)
## (Intercept)_10                      25.031510  13.469546  1.8584   0.06354 .
## log(Male2Female)_10                 -3.449000   2.297409 -1.5013   0.13374
## log(Median_Age)_10                  -0.536838   1.359936 -0.3948   0.69315
```

```
## log(Mean_Temp_lag11w)_10            -2.125158   0.233852 -9.0876 < 2.2e-16 ***
## log(Sunshine_Hours_lag11w + 0.1)_10  0.459190   0.092466  4.9660 8.614e-07 ***
## log(Humidity_lag11w)_10              0.338656   0.233909  1.4478   0.14812
## rho_10                              -0.023886   0.084005 -0.2843   0.77623
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## R-squared: 0.5534
##   Equation  11
##                                      Estimate Std. Error t value  Pr(>|t|)
## (Intercept)_11                      23.061968  12.654366  1.8225 0.0688173 .
## log(Male2Female)_11                 -2.982100   2.173335 -1.3721 0.1704666
## log(Median_Age)_11                  -0.239749   1.250895 -0.1917 0.8480634
## log(Mean_Temp_lag11w)_11            -2.066155   0.209437 -9.8653 < 2.2e-16 ***
## log(Sunshine_Hours_lag11w + 0.1)_11  0.271070   0.073369  3.6946 0.0002376 ***
## log(Humidity_lag11w)_11              0.116594   0.222030  0.5251 0.5996613
## rho_11                              -0.027141   0.072928 -0.3722 0.7098834
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## R-squared: 0.5851
##   Equation  12
##                                      Estimate Std. Error t value  Pr(>|t|)
## (Intercept)_12                      20.922015  13.552468  1.5438    0.1231
## log(Male2Female)_12                 -2.904554   2.344699 -1.2388    0.2158
## log(Median_Age)_12                   0.101964   1.323422  0.0770    0.9386
## log(Mean_Temp_lag11w)_12            -1.931028   0.213062 -9.0632 < 2.2e-16 ***
## log(Sunshine_Hours_lag11w + 0.1)_12  0.312998   0.070812  4.4202 1.145e-05 ***
## log(Humidity_lag11w)_12              0.266170   0.237909  1.1188    0.2636
## rho_12                              -0.105780   0.069695 -1.5178    0.1295
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## R-squared: 0.5328
##   Equation  13
##                                      Estimate Std. Error t value  Pr(>|t|)
## (Intercept)_13                      19.678045  13.982628  1.4073  0.159781
## log(Male2Female)_13                 -3.010935   2.416270 -1.2461  0.213146
## log(Median_Age)_13                   0.730053   1.359940  0.5368  0.591559
## log(Mean_Temp_lag11w)_13            -1.826385   0.228397 -7.9966 5.368e-15 ***
## log(Sunshine_Hours_lag11w + 0.1)_13  0.225996   0.072953  3.0978  0.002028 **
## log(Humidity_lag11w)_13              0.126002   0.263894  0.4775  0.633177
## rho_13                              -0.114892   0.070194 -1.6368  0.102131
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## R-squared: 0.5008
##   Equation  14
##                                      Estimate Std. Error t value  Pr(>|t|)
## (Intercept)_14                      21.114069  14.604822  1.4457 0.1487158
## log(Male2Female)_14                 -3.170082   2.524453 -1.2557 0.2096298
## log(Median_Age)_14                   0.494117   1.425526  0.3466 0.7289811
## log(Mean_Temp_lag11w)_14            -1.760930   0.231257 -7.6146 8.686e-14 ***
## log(Sunshine_Hours_lag11w + 0.1)_14  0.219154   0.063763  3.4370 0.0006233 ***
## log(Humidity_lag11w)_14              0.171270   0.255176  0.6712 0.5023270
## rho_14                              -0.121903   0.068550 -1.7783 0.0757915 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
## R-squared: 0.459
##   Equation  15
##                                    Estimate Std. Error t value  Pr(>|t|)
## (Intercept)_15                    10.554179  13.387372  0.7884    0.4308
## log(Male2Female)_15               -1.942054   2.324219 -0.8356    0.4037
## log(Median_Age)_15                 1.839151   1.320345  1.3929    0.1641
## log(Mean_Temp_lag11w)_15          -1.552663   0.191953 -8.0888 2.697e-15 ***
## log(Sunshine_Hours_lag11w + 0.1)_15  0.198283   0.049740  3.9864 7.420e-05 ***
## log(Humidity_lag11w)_15           -0.019207   0.194181 -0.0989    0.9212
## rho_15                            -0.063899   0.058267 -1.0967    0.2732
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## R-squared: 0.5107
##   Equation  16
##                                    Estimate Std. Error t value  Pr(>|t|)
## (Intercept)_16                     2.822534  13.241142  0.2132  0.831262
## log(Male2Female)_16               -0.817138   2.303213 -0.3548  0.722861
## log(Median_Age)_16                 2.312276   1.322258  1.7487  0.080780 .
## log(Mean_Temp_lag11w)_16          -1.225014   0.167326 -7.3211 6.838e-13 ***
## log(Sunshine_Hours_lag11w + 0.1)_16  0.173655   0.053748  3.2309  0.001292 **
## log(Humidity_lag11w)_16           -0.050299   0.167882 -0.2996  0.764567
## rho_16                            -0.024994   0.059765 -0.4182  0.675920
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## R-squared: 0.4872
##   Equation  17
##                                    Estimate Std. Error t value  Pr(>|t|)
## (Intercept)_17                     2.180781  13.355523  0.1633  0.870340
## log(Male2Female)_17               -0.473969   2.321950 -0.2041  0.838315
## log(Median_Age)_17                 1.928080   1.346416  1.4320  0.152592
## log(Mean_Temp_lag11w)_17          -1.012898   0.148957 -6.7999 2.262e-11 ***
## log(Sunshine_Hours_lag11w + 0.1)_17  0.170926   0.056783  3.0102  0.002706 **
## log(Humidity_lag11w)_17           -0.041051   0.153051 -0.2682  0.788611
## rho_17                            -0.025699   0.064427 -0.3989  0.690096
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## R-squared: 0.4612
##   Equation  18
##                                    Estimate Std. Error t value  Pr(>|t|)
## (Intercept)_18                     2.051648  12.991344  0.1579  0.874562
## log(Male2Female)_18               -0.704834   2.258592 -0.3121  0.755083
## log(Median_Age)_18                 2.291176   1.315580  1.7416  0.082027 .
## log(Mean_Temp_lag11w)_18          -0.913034   0.135451 -6.7407 3.321e-11 ***
## log(Sunshine_Hours_lag11w + 0.1)_18  0.189830   0.060415  3.1421  0.001749 **
## log(Humidity_lag11w)_18           -0.050402   0.138358 -0.3643  0.715756
## rho_18                            -0.103021   0.071257 -1.4458  0.148692
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## R-squared: 0.4789
##   Equation  19
##                                    Estimate Std. Error t value  Pr(>|t|)
## (Intercept)_19                    -2.747362  13.364466 -0.2056    0.8372
## log(Male2Female)_19                0.757211   2.284530  0.3315    0.7404
## log(Median_Age)_19                 1.835603   1.375436  1.3346    0.1825
```

```
## log(Mean_Temp_lag11w)_19            -0.951805   0.165868 -5.7383 1.429e-08 ***
## log(Sunshine_Hours_lag11w + 0.1)_19  0.176831   0.112369  1.5737    0.1160
## log(Humidity_lag11w)_19             -0.081627   0.195896 -0.4167    0.6770
## rho_19                              -0.078424   0.100091 -0.7835    0.4336
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## R-squared: 0.4863
##   Equation  20
##                                      Estimate Std. Error t value  Pr(>|t|)
## (Intercept)_20                       0.235636  12.988773  0.0181   0.98553
## log(Male2Female)_20                 -0.338211   2.244000 -0.1507   0.88024
## log(Median_Age)_20                   2.517564   1.326650  1.8977   0.05815 .
## log(Mean_Temp_lag11w)_20            -0.798235   0.130110 -6.1351 1.431e-09 ***
## log(Sunshine_Hours_lag11w + 0.1)_20  0.077695   0.085778  0.9058   0.36537
## log(Humidity_lag11w)_20             -0.149784   0.161505 -0.9274   0.35403
## rho_20                              -0.147578   0.082420 -1.7906   0.07380 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## R-squared: 0.4822
##   Equation  21
##                                      Estimate Std. Error t value  Pr(>|t|)
## (Intercept)_21                      -0.342190  12.760412 -0.0268   0.97861
## log(Male2Female)_21                 -0.020484   2.195904 -0.0093   0.99256
## log(Median_Age)_21                   2.467104   1.312883  1.8791   0.06064 .
## log(Mean_Temp_lag11w)_21            -0.699969   0.121847 -5.7446 1.379e-08 ***
## log(Sunshine_Hours_lag11w + 0.1)_21 -0.069046   0.082047 -0.8415   0.40034
## log(Humidity_lag11w)_21             -0.267353   0.182586 -1.4643   0.14358
## rho_21                              -0.167206   0.086094 -1.9421   0.05253 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## R-squared: 0.4907
##   Equation  22
##                                      Estimate Std. Error t value  Pr(>|t|)
## (Intercept)_22                      -2.538146  13.104478 -0.1937   0.84648
## log(Male2Female)_22                  0.310560   2.250044  0.1380   0.89026
## log(Median_Age)_22                   2.766201   1.353127  2.0443   0.04130 *
## log(Mean_Temp_lag11w)_22            -0.648306   0.127440 -5.0872 4.685e-07 ***
## log(Sunshine_Hours_lag11w + 0.1)_22 -0.100589   0.079447 -1.2661   0.20590
## log(Humidity_lag11w)_22             -0.404297   0.220082 -1.8370   0.06663 .
## rho_22                              -0.151682   0.088374 -1.7164   0.08654 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## R-squared: 0.4871
##
## Variance-Covariance Matrix of inter-equation residuals:
##  0.8563332 0.7497242 0.6322792 0.6007832 0.6029492 0.5187877 0.4177832
##  0.7497242 0.7347252 0.6292667 0.6138023 0.6099079 0.5113207 0.4214504
##  0.6322792 0.6292667 0.6008984 0.5867378 0.5806025 0.4860563 0.4052907
##  0.6007832 0.6138023 0.5867378 0.5918263 0.5900993 0.5007987 0.4161214
##  0.6029492 0.6099079 0.5806025 0.5900993 0.6239275 0.5257925 0.4305935
##  0.5187877 0.5113207 0.4860563 0.5007987 0.5257925 0.5161139 0.4311239
##  0.4177832 0.4214504 0.4052907 0.4161214 0.4305935 0.4311239 0.3844768
##  0.3625120 0.3526641 0.3474777 0.3586845 0.3676760 0.3829246 0.3491968
##  0.3041263 0.2886560 0.2819368 0.2931898 0.3042254 0.3219244 0.2958000
```

```
##  0.2550321 0.2408281 0.2136559 0.2219894 0.2376497 0.2570044 0.2395906
##  0.2370496 0.2266858 0.2093509 0.2201508 0.2303050 0.2456785 0.2283934
##  0.2340774 0.2326916 0.2171659 0.2341084 0.2414538 0.2647688 0.2432877
##  0.2080061 0.2193082 0.2086251 0.2278481 0.2301010 0.2577245 0.2380308
##  0.2216757 0.2362124 0.2250390 0.2439842 0.2407950 0.2672806 0.2482261
##  0.2311607 0.2320090 0.2180712 0.2304447 0.2287546 0.2561513 0.2384601
##  0.2545636 0.2525107 0.2363416 0.2449688 0.2452561 0.2676841 0.2514216
##  0.2678014 0.2607718 0.2442968 0.2499241 0.2504577 0.2754850 0.2592658
##  0.2519683 0.2500895 0.2415900 0.2474108 0.2452706 0.2623356 0.2489268
##  0.2077219 0.2100918 0.2247922 0.2327921 0.2279200 0.2444980 0.2326043
##  0.2230292 0.2275485 0.2311797 0.2376763 0.2380552 0.2558500 0.2440500
##  0.2222662 0.2266294 0.2302258 0.2353565 0.2374153 0.2486204 0.2393266
##  0.2265676 0.2351800 0.2385733 0.2460933 0.2480463 0.2586339 0.2482126
##
##  0.3625120 0.3041263 0.2550321 0.2370496 0.2340774 0.2080061 0.2216757
##  0.3526641 0.2886560 0.2408281 0.2266858 0.2326916 0.2193082 0.2362124
##  0.3474777 0.2819368 0.2136559 0.2093509 0.2171659 0.2086251 0.2250390
##  0.3586845 0.2931898 0.2219894 0.2201508 0.2341084 0.2278481 0.2439842
##  0.3676760 0.3042254 0.2376497 0.2303050 0.2414538 0.2301010 0.2407950
##  0.3829246 0.3219244 0.2570044 0.2456785 0.2647688 0.2577245 0.2672806
##  0.3491968 0.2958000 0.2395906 0.2283934 0.2432877 0.2380308 0.2482261
##  0.3391591 0.2985692 0.2421360 0.2305512 0.2444102 0.2363193 0.2446453
##  0.2985692 0.2899408 0.2427850 0.2297525 0.2425349 0.2309601 0.2372488
##  0.2421360 0.2427850 0.2360346 0.2150874 0.2259770 0.2146201 0.2140925
##  0.2305512 0.2297525 0.2150874 0.2083799 0.2177413 0.2093984 0.2088829
##  0.2444102 0.2425349 0.2259770 0.2177413 0.2409546 0.2385367 0.2380995
##  0.2363193 0.2309601 0.2146201 0.2093984 0.2385367 0.2536318 0.2595611
##  0.2446453 0.2372488 0.2140925 0.2088829 0.2380995 0.2595611 0.2779699
##  0.2365750 0.2249668 0.2027239 0.1952304 0.2196417 0.2344326 0.2506091
##  0.2468782 0.2268166 0.1993080 0.1894889 0.2105407 0.2212101 0.2380263
##  0.2547158 0.2286772 0.1944286 0.1827063 0.2023358 0.2106907 0.2275878
##  0.2445054 0.2178066 0.1798397 0.1708389 0.1899406 0.1994579 0.2169882
##  0.2274722 0.1896538 0.1442249 0.1437451 0.1607225 0.1727776 0.1896094
##  0.2374458 0.2049969 0.1633138 0.1556990 0.1747443 0.1838365 0.2003958
##  0.2310646 0.1958998 0.1544069 0.1479350 0.1635375 0.1690506 0.1824259
##  0.2384070 0.2022447 0.1587804 0.1537163 0.1697704 0.1741402 0.1867310
##
##  0.2311607 0.2545636 0.2678014 0.2519683 0.2077219 0.2230292 0.2222662
##  0.2320090 0.2525107 0.2607718 0.2500895 0.2100918 0.2275485 0.2266294
##  0.2180712 0.2363416 0.2442968 0.2415900 0.2247922 0.2311797 0.2302258
##  0.2304447 0.2449688 0.2499241 0.2474108 0.2327921 0.2376763 0.2353565
##  0.2287546 0.2452561 0.2504577 0.2452706 0.2279200 0.2380552 0.2374153
##  0.2561513 0.2676841 0.2754850 0.2623356 0.2444980 0.2558500 0.2486204
##  0.2384601 0.2514216 0.2592658 0.2489268 0.2326043 0.2440500 0.2393266
##  0.2365750 0.2468782 0.2547158 0.2445054 0.2274722 0.2374458 0.2310646
##  0.2249668 0.2268166 0.2286772 0.2178066 0.1896538 0.2049969 0.1958998
##  0.2027239 0.1993080 0.1944286 0.1798397 0.1442249 0.1633138 0.1544069
##  0.1952304 0.1894889 0.1827063 0.1708389 0.1437451 0.1556990 0.1479350
##  0.2196417 0.2105407 0.2023358 0.1899406 0.1607225 0.1747443 0.1635375
##  0.2344326 0.2212101 0.2106907 0.1994579 0.1727776 0.1838365 0.1690506
##  0.2506091 0.2380263 0.2275878 0.2169882 0.1896094 0.2003958 0.1824259
##  0.2384326 0.2326068 0.2263204 0.2158617 0.1906997 0.1999071 0.1855681
##  0.2326068 0.2363078 0.2350985 0.2253884 0.2001729 0.2103706 0.1992798
##  0.2263204 0.2350985 0.2414262 0.2320593 0.2078580 0.2197747 0.2096844
```

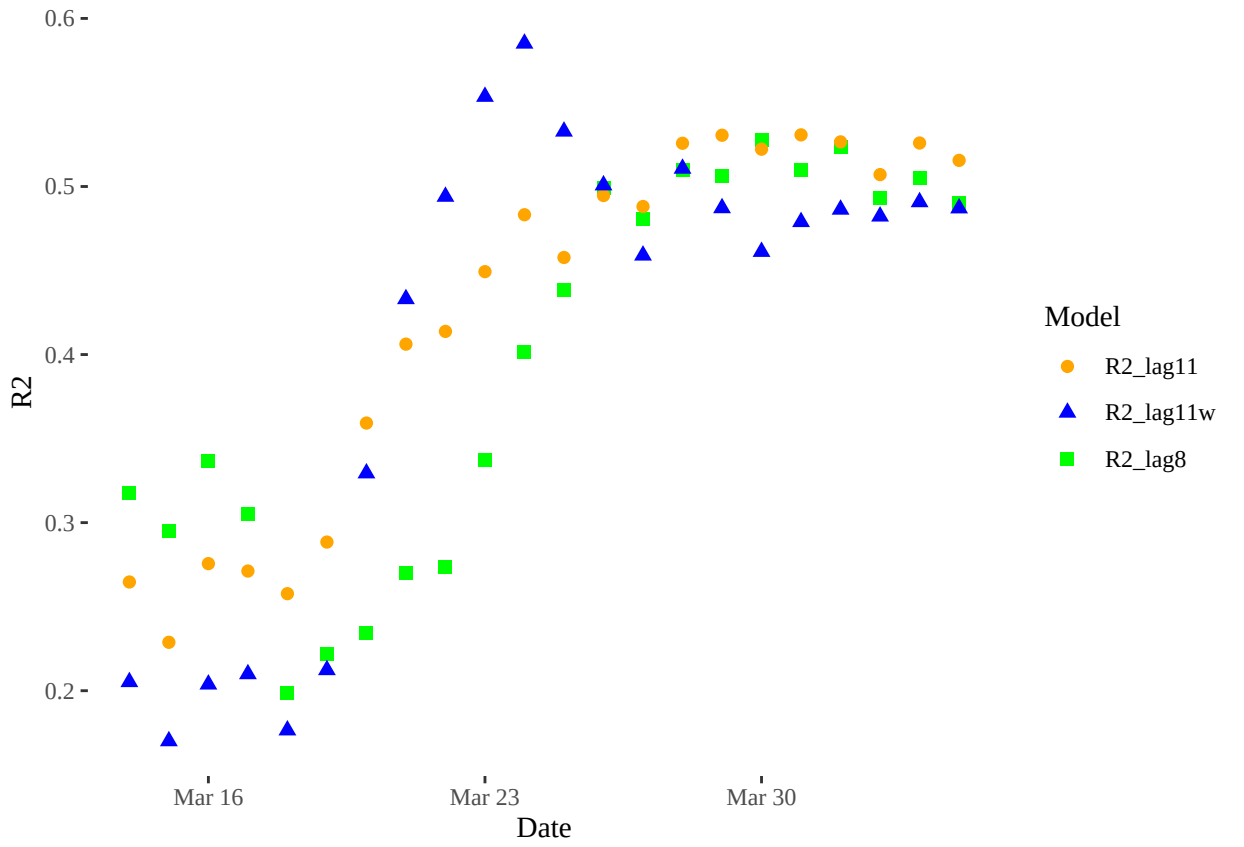
```
##  0.2158617 0.2253884 0.2320593 0.2286708 0.2099120 0.2206044 0.2111419
##  0.1906997 0.2001729 0.2078580 0.2099120 0.2301533 0.2149733 0.2081532
##  0.1999071 0.2103706 0.2197747 0.2206044 0.2149733 0.2265371 0.2185486
##  0.1855681 0.1992798 0.2096844 0.2111419 0.2081532 0.2185486 0.2176507
##  0.1894883 0.2027301 0.2120364 0.2128743 0.2094530 0.2184003 0.2205664
##
##  0.2265676
##  0.2351800
##  0.2385733
##  0.2460933
##  0.2480463
##  0.2586339
##  0.2482126
##  0.2384070
##  0.2022447
##  0.1587804
##  0.1537163
##  0.1697704
##  0.1741402
##  0.1867310
##  0.1894883
##  0.2027301
##  0.2120364
##  0.2128743
##  0.2094530
##  0.2184003
##  0.2205664
##  0.2287325
## Correlation Matrix of inter-equation residuals:
##  1.0000000 0.9480206 0.9041731 0.8780157 0.8670069 0.8226090 0.7875695
##  0.9480206 1.0000000 0.9523757 0.9446388 0.9209563 0.8601493 0.8426436
##  0.9041731 0.9523757 1.0000000 0.9848051 0.9542590 0.8904519 0.8831998
##  0.8780157 0.9446388 0.9848051 1.0000000 0.9724348 0.9181212 0.9071031
##  0.8670069 0.9209563 0.9542590 0.9724348 1.0000000 0.9344318 0.9160073
##  0.8226090 0.8601493 0.8904519 0.9181212 0.9344318 1.0000000 0.9796575
##  0.7875695 0.8426436 0.8831998 0.9071031 0.9160073 0.9796575 1.0000000
##  0.7677213 0.8005744 0.8521540 0.8763432 0.8824662 0.9614320 0.9850111
##  0.7392845 0.7663128 0.8056897 0.8334128 0.8476520 0.9308319 0.9563911
##  0.7148796 0.7484447 0.7500434 0.7763393 0.8087051 0.8875587 0.9173747
##  0.7149075 0.7543286 0.7775873 0.8127472 0.8301017 0.9108145 0.9396659
##  0.6681767 0.7173894 0.7431131 0.7874154 0.8000044 0.8984977 0.9255316
##  0.6092464 0.6708908 0.6992569 0.7425747 0.7480056 0.8596438 0.8939176
##  0.5983852 0.6702386 0.6989755 0.7406074 0.7338035 0.8424386 0.8807517
##  0.6422804 0.6990348 0.7276699 0.7632134 0.7614689 0.8711820 0.9051662
##  0.6592964 0.7185728 0.7500242 0.7809307 0.7841886 0.8841586 0.9208291
##  0.6674957 0.7159249 0.7490134 0.7750818 0.7802444 0.8843367 0.9224677
##  0.6544941 0.7094061 0.7533633 0.7791204 0.7788037 0.8712502 0.9121976
##  0.5938477 0.6364650 0.7171035 0.7455681 0.7337886 0.8226166 0.8563631
##  0.6117376 0.6676592 0.7285899 0.7560904 0.7600177 0.8513286 0.8942976
##  0.6144783 0.6683163 0.7300645 0.7548962 0.7601615 0.8461744 0.8929741
##  0.6123803 0.6722243 0.7314936 0.7588995 0.7613426 0.8505173 0.8979832
##
##  0.7677213 0.7392845 0.7148796 0.7149075 0.6681767 0.6092464 0.5983852
##  0.8005744 0.7663128 0.7484447 0.7543286 0.7173894 0.6708908 0.6702386
```

```
##  0.8521540 0.8056897 0.7500434 0.7775873 0.7431131 0.6992569 0.6989755
##  0.8763432 0.8334128 0.7763393 0.8127472 0.7874154 0.7425747 0.7406074
##  0.8824662 0.8476520 0.8087051 0.8301017 0.8000044 0.7480056 0.7338035
##  0.9614320 0.9308319 0.8875587 0.9108145 0.8984977 0.8596438 0.8424386
##  0.9850111 0.9563911 0.9173747 0.9396659 0.9255316 0.8939176 0.8807517
##  1.0000000 0.9795184 0.9345845 0.9587410 0.9467290 0.9123612 0.8955044
##  0.9795184 1.0000000 0.9568190 0.9729609 0.9630639 0.9238232 0.9067281
##  0.9345845 0.9568190 1.0000000 0.9765729 0.9654988 0.9275270 0.8965200
##  0.9587410 0.9729609 0.9765729 1.0000000 0.9836429 0.9549084 0.9303749
##  0.9467290 0.9630639 0.9654988 0.9836429 1.0000000 0.9797549 0.9540387
##  0.9123612 0.9238232 0.9275270 0.9549084 0.9797549 1.0000000 0.9854090
##  0.8955044 0.9067281 0.8965200 0.9303749 0.9540387 0.9854090 1.0000000
##  0.9223675 0.9205971 0.9124620 0.9396445 0.9607125 0.9807600 0.9859489
##  0.9342251 0.9218003 0.9067353 0.9309860 0.9490218 0.9629303 0.9679850
##  0.9392395 0.9198896 0.8942021 0.9167160 0.9344017 0.9438136 0.9472053
##  0.9283500 0.9069099 0.8685756 0.9002751 0.9173773 0.9295720 0.9384114
##  0.8736185 0.8293017 0.7673602 0.8233512 0.8366235 0.8558438 0.8656963
##  0.9108552 0.8877651 0.8374839 0.8753436 0.8971082 0.9061633 0.9174618
##  0.9092543 0.8817710 0.8272351 0.8641872 0.8819650 0.8865207 0.8956988
##  0.9124530 0.8844654 0.8284442 0.8660872 0.8835756 0.8862380 0.8946651
##
##  0.6422804 0.6592964 0.6674957 0.6544941 0.5938477 0.6117376 0.6144783
##  0.6990348 0.7185728 0.7159249 0.7094061 0.6364650 0.6676592 0.6683163
##  0.7276699 0.7500242 0.7490134 0.7533633 0.7171035 0.7285899 0.7300645
##  0.7632134 0.7809307 0.7750818 0.7791204 0.7455681 0.7560904 0.7548962
##  0.7614689 0.7841886 0.7802444 0.7788037 0.7337886 0.7600177 0.7601615
##  0.8711820 0.8841586 0.8843367 0.8712502 0.8226166 0.8513286 0.8461744
##  0.9051662 0.9208291 0.9224677 0.9121976 0.8563631 0.8942976 0.8929741
##  0.9223675 0.9342251 0.9392395 0.9283500 0.8736185 0.9108552 0.9092543
##  0.9205971 0.9218003 0.9198896 0.9069099 0.8293017 0.8877651 0.8817710
##  0.9124620 0.9067353 0.8942021 0.8685756 0.7673602 0.8374839 0.8272351
##  0.9396445 0.9309860 0.9167160 0.9002751 0.8233512 0.8753436 0.8641872
##  0.9607125 0.9490218 0.9344017 0.9173773 0.8366235 0.8971082 0.8819650
##  0.9807600 0.9629303 0.9438136 0.9295720 0.8558438 0.9061633 0.8865207
##  0.9859489 0.9679850 0.9472053 0.9384114 0.8656963 0.9174618 0.8956988
##  1.0000000 0.9929275 0.9806243 0.9723941 0.9046571 0.9520578 0.9366526
##  0.9929275 1.0000000 0.9931146 0.9879382 0.9209537 0.9679472 0.9586545
##  0.9806243 0.9931146 1.0000000 0.9919387 0.9260344 0.9766508 0.9708744
##  0.9723941 0.9879382 0.9919387 1.0000000 0.9434969 0.9902153 0.9860941
##  0.9046571 0.9209537 0.9260344 0.9434969 1.0000000 0.9514692 0.9488604
##  0.9520578 0.9679472 0.9766508 0.9902153 0.9514692 1.0000000 0.9962962
##  0.9366526 0.9586545 0.9708744 0.9860941 0.9488604 0.9962962 1.0000000
##  0.9357275 0.9573880 0.9677195 0.9836810 0.9458043 0.9915411 0.9971475
##
##  0.6123803
##  0.6722243
##  0.7314936
##  0.7588995
##  0.7613426
##  0.8505173
##  0.8979832
##  0.9124530
##  0.8844654
##  0.8284442
```

```
##  0.8660872
##  0.8835756
##  0.8862380
##  0.8946651
##  0.9357275
##  0.9573880
##  0.9677195
##  0.9836810
##  0.9458043
##  0.9915411
##  0.9971475
##  1.0000000
##
##  R-sq. pooled: 0.7764
##  Breusch-Pagan:  7014  p-value: (   0)
```

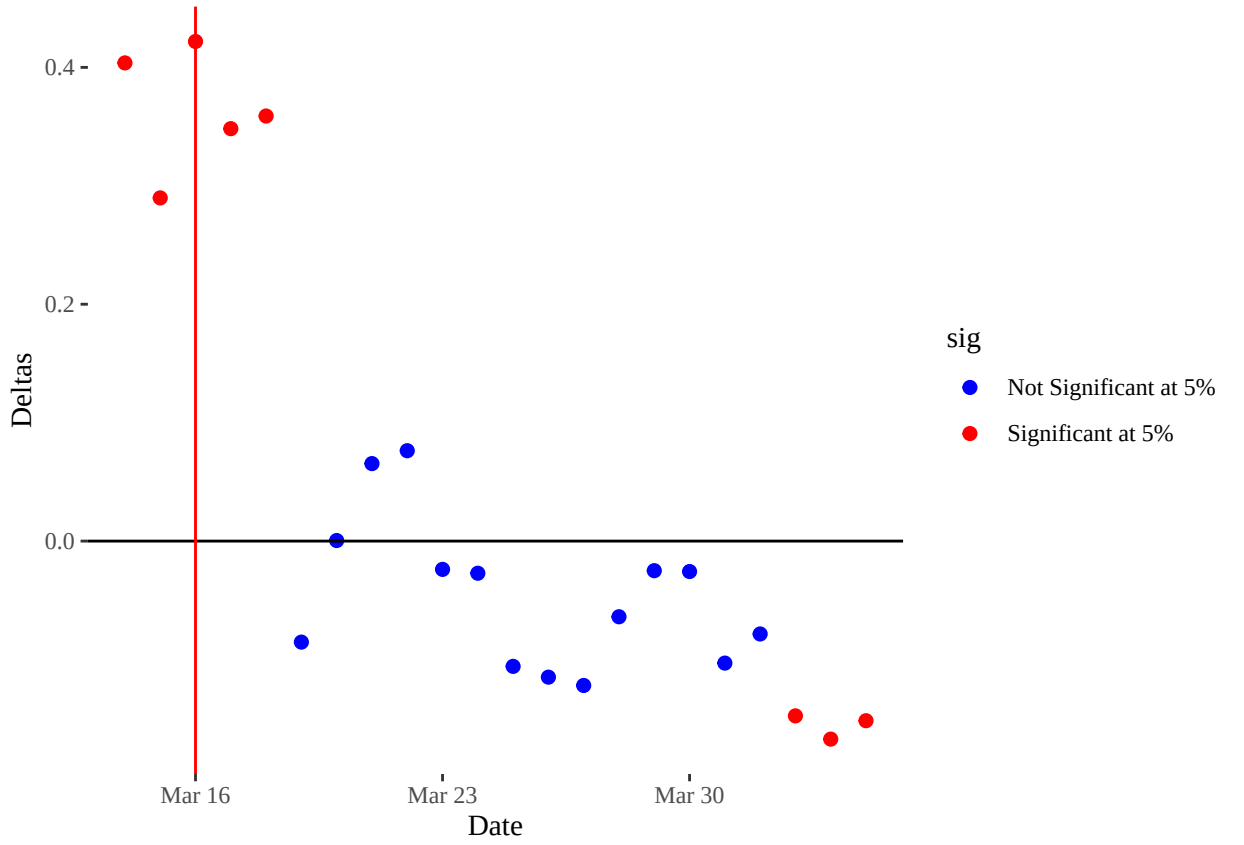
Compare goodness of fit:

```
data.frame(R2_lag8 = sur.slm_lag8$R2,
           R2_lag11 = sur.slm_lag11$R2,
           R2_lag11w = sur.slm_lag11w$R2) %>%
  slice(2:n()) %>%
  rownames_to_column(var = "Equation") %>%
  mutate(Date = seq(ymd("2020-03-14"),
                        ymd("2020-04-04"),
                            by = "days")) %>%
  pivot_longer(cols = starts_with("R"), names_to = "Model", values_to = "R2") %>%
  ggplot(aes(x = Date, y = R2, color = Model, shape = Model)) +
  geom_point(size = 2) +
  scale_color_manual(values = c("R2_lag11w" = "blue", "R2_lag11" = "orange", "R2_lag8" = "green") ) +
  theme_tufte()
```




**Dinámica temporal de la dependencia espacial (Coef lambda estimado en las T=22 ecuaciones)**

```
data.frame(Date = seq(ymd("2020-03-14"),
                      ymd("2020-04-04"),
                          by = "days"),
           Deltas = sur.slm_lag11w$deltas,
           tvalue = sur.slm_lag11w$deltas/sur.slm_lag11$deltas.se) %>%
  mutate(sig = ifelse(abs(tvalue) > 1.64, "Significant at 5%", "Not Significant at 5%")) %>%
  ggplot(aes(x = Date, y = Deltas, color = sig)) +
  geom_point(size = 2) +
  scale_color_manual(values = c("Significant at 5%" = "red", "Not Significant at 5%" = "blue")) +
  geom_hline(yintercept = 0) +
  geom_vline(xintercept = as_date("2020-03-16"), color = "red") +
  theme_tufte()
```




- La estructura de dependencia espacial, pasa de positiva (significativa) a no significativa para finalmente ser negativa (significativa)
- Esto puede explicarse:
- en una PRIMERA ETAPA al inicio del brote epidémico había contagio entre provincias colindantes.
- en una SEGUNDA ETAPA Al introducir medidas de confinamiento las provincias quedaron 'aisladas' y cada una creció a un ritmo diferente. La estructura de dependencia espacial se 'disolvió'
- en una TERCERA ETAPA, en muchas provincias se controló parcialmente la epidemia. Salvo en X-provincias que siguieron creciendo fuertemente. Eso dio lugar a patrones de dependencia espacial negativa.

## Analisis of autocorrelated residuals

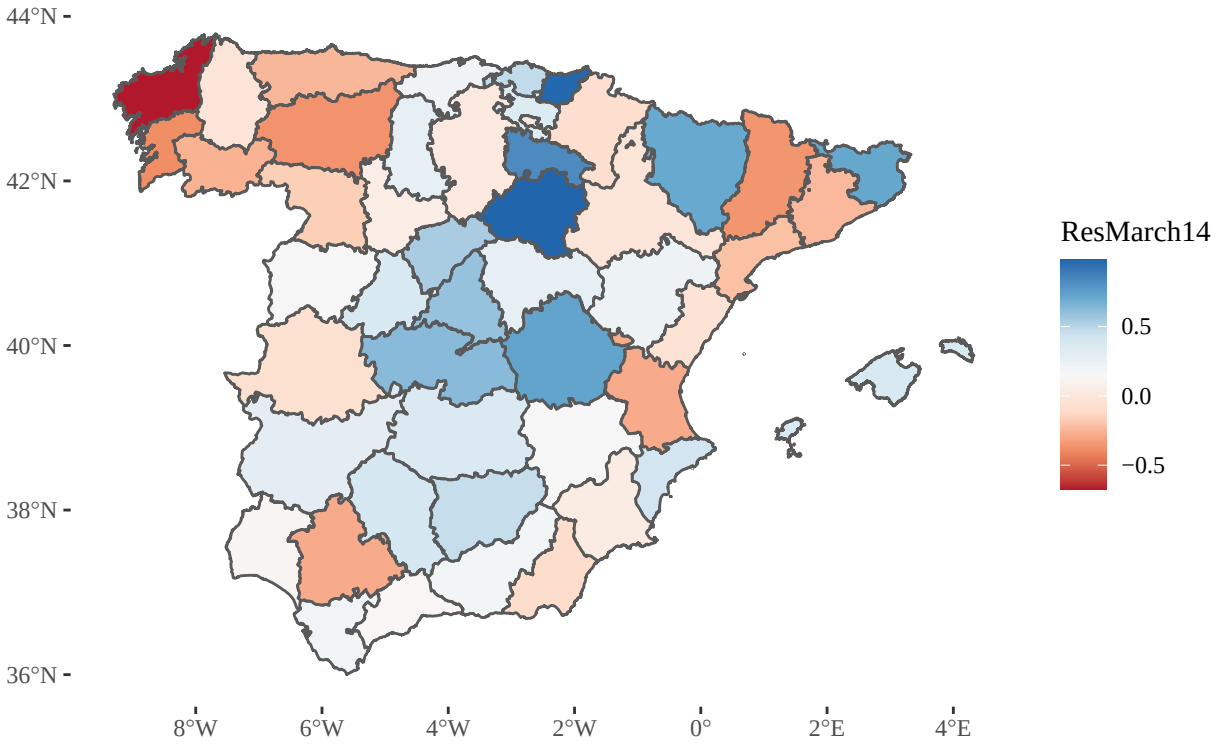
Extract residuals for March 14 and April 2, and compute autocorrelated residuals:

```
residuals_Mar14 <- as.matrix(residuals(sur.slm_lag11w))[[1]]
residuals_Mar14 <- lag.listw(listw, residuals_Mar14)

residuals_Apr04 <- as.matrix(residuals(sur.slm_lag11w))[[22]]
residuals_Apr04 <- lag.listw(listw, residuals_Apr04)
```

Plot residuals on March 14 (positive autocorrelation):

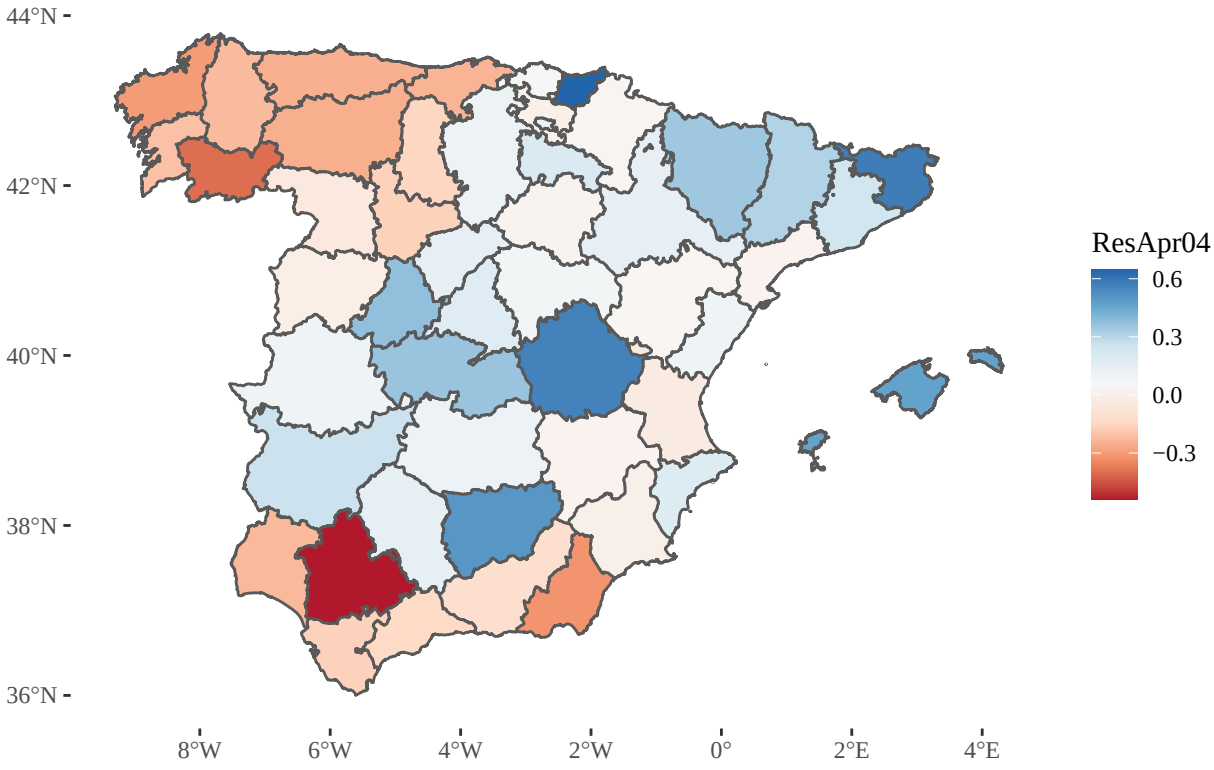
```
covid19_spain %>% filter(Date == "2020-03-14") %>%
  mutate(ResMarch14 = residuals_Mar14) %>%
  filter(CCAA != "Canarias") %>%
  ggplot() +
  geom_sf(aes(fill = ResMarch14)) +
```

```
  scale_fill_distiller(palette = "RdBu", direction = 1) +
  theme_tufte()
```




Plot residuals on April 4:

```
covid19_spain %>% filter(Date == "2020-03-14") %>%
  mutate(ResApr04 = residuals_Apr04) %>%
  filter(CCAA != "Canarias") %>%
  ggplot() +
  geom_sf(aes(fill = ResApr04)) +
  scale_fill_distiller(palette = "RdBu", direction = 1) +
  theme_tufte()
```

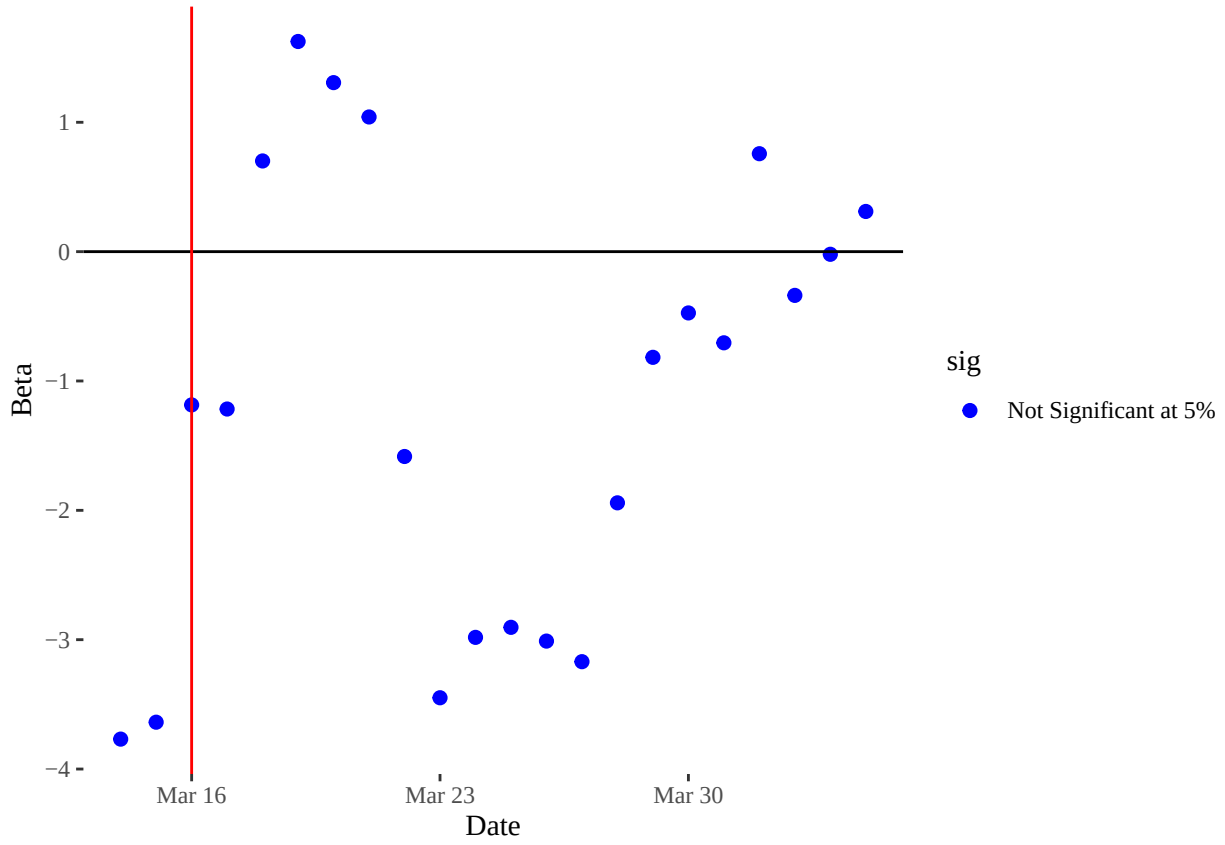



## Temporal variation of coefficients of control variables

### Male to Female Ratio

- No es significativa

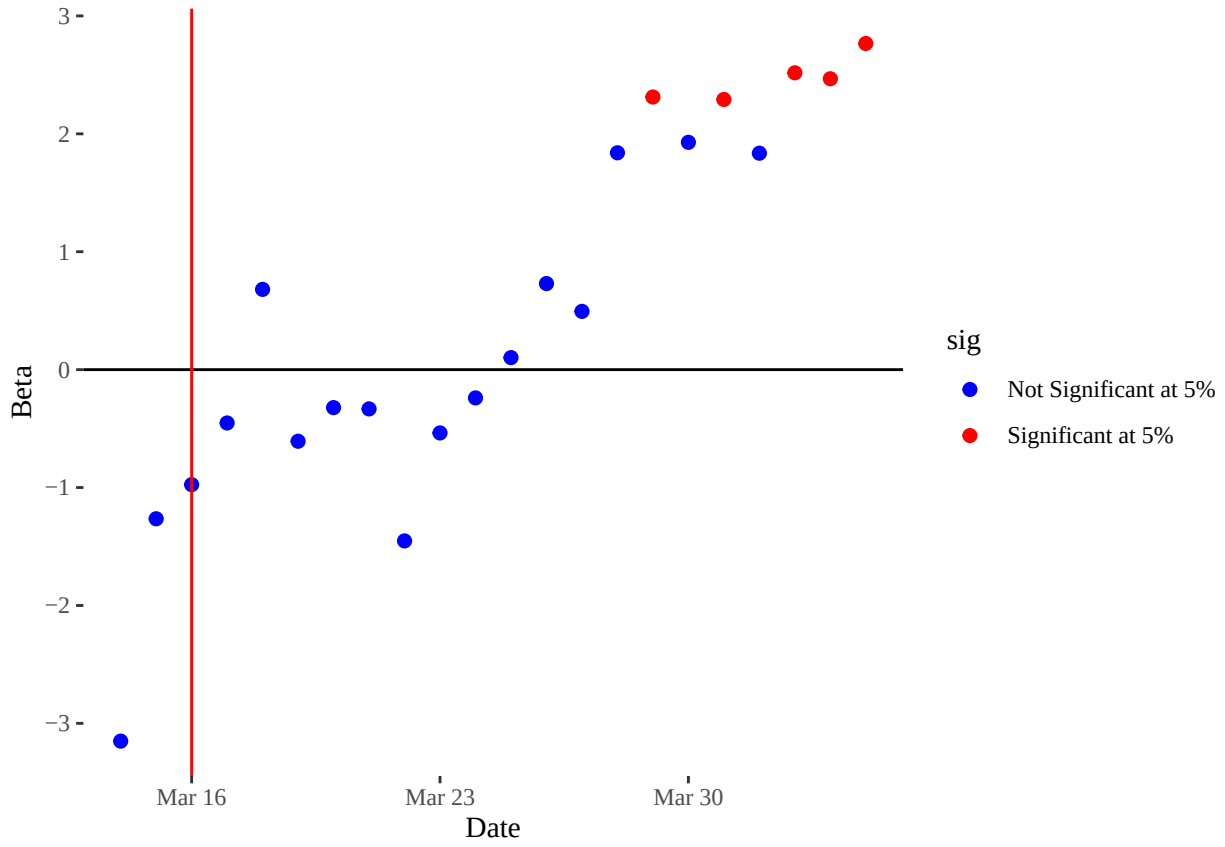
```
n = 2
data.frame(Date = seq(ymd("2020-03-14"),
                      ymd("2020-04-04"),
                          by = "days"),
           Beta = matrix(sur.slm_lag11w$coefficients,ncol = 22)[n,],
           tvalue = matrix(sur.slm_lag11w$coefficients/sur.slm_lag11w$rest.se,ncol = 22)[n,]) %>%
  mutate(sig = ifelse(abs(tvalue) > 1.64, "Significant at 5%", "Not Significant at 5%")) %>%
  ggplot(aes(x = Date, y = Beta, color = sig)) +
  geom_point(size = 2) +
  scale_color_manual(values = c("Significant at 5%" = "red", "Not Significant at 5%" = "blue")) +
  geom_hline(yintercept = 0) +
  geom_vline(xintercept = as_date("2020-03-16"), color = "red") +
  theme_tufte()
```




### Median Age

- Los coeficientes de las variables de control (EM y HM) tienen el signo esperado
- Los primeros días tienen valores elevados cuando la pandemía no estaba controlada (aún no había confinamiento)

```
n = 3
data.frame(Date = seq(ymd("2020-03-14"),
                      ymd("2020-04-04"),
                          by = "days"),
           Beta = matrix(sur.slm_lag11w$coefficients,ncol = 22)[n,],
           tvalue = matrix(sur.slm_lag11w$coefficients/sur.slm_lag11w$rest.se,ncol = 22)[n,]) %>%
  mutate(sig = ifelse(abs(tvalue) > 1.64, "Significant at 5%", "Not Significant at 5%")) %>%
  ggplot(aes(x = Date, y = Beta, color = sig)) +
  geom_point(size = 2) +
  scale_color_manual(values = c("Significant at 5%" = "red", "Not Significant at 5%" = "blue")) +
  geom_hline(yintercept = 0) +
  geom_vline(xintercept = as_date("2020-03-16"), color = "red") +
  theme_tufte()
```

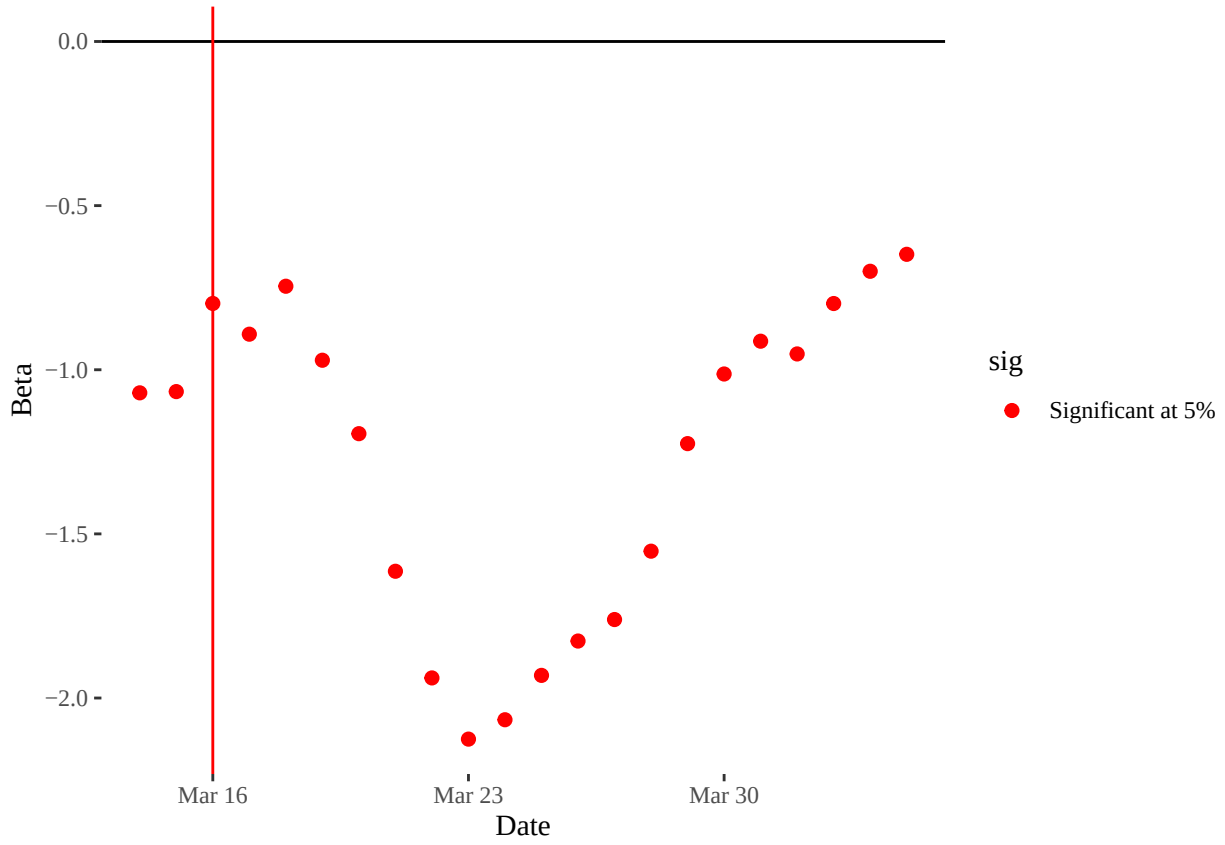



## Dinámica temporal de Variables Climáticas

### TEMPERATURA

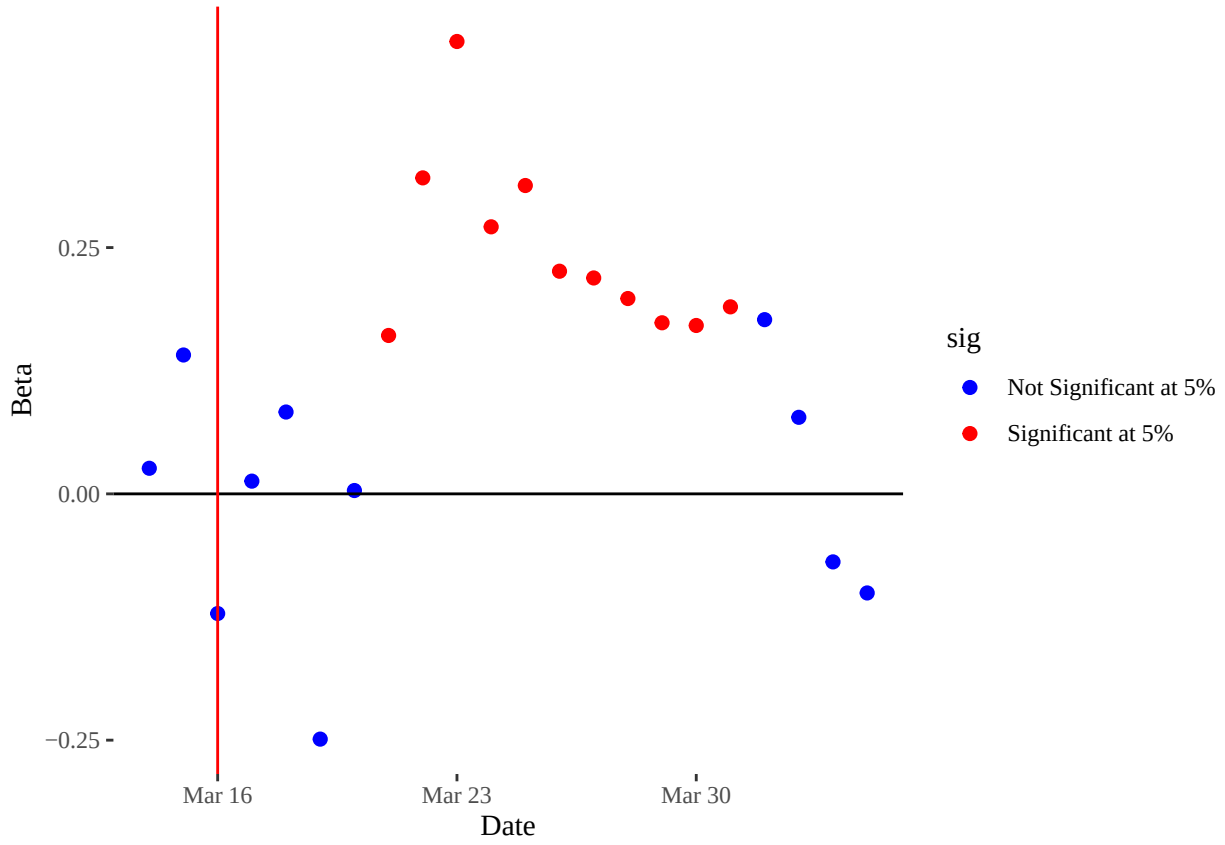
- Los coeficientes de las variables de control (EM y HM) tienen el signo esperado
- Los primeros días tienen valores elevados cuando la pandemía no estaba controlada (aún no había confinamiento)

```
n = 4
data.frame(Date = seq(ymd("2020-03-14"),
                      ymd("2020-04-04"),
                          by = "days"),
           Beta = matrix(sur.slm_lag11w$coefficients,ncol = 22)[n,],
           tvalue = matrix(sur.slm_lag11w$coefficients/sur.slm_lag11$rest.se,ncol = 22)[n,]) %>%
  mutate(sig = ifelse(abs(tvalue) > 1.64, "Significant at 5%", "Not Significant at 5%")) %>%
  ggplot(aes(x = Date, y = Beta, color = sig)) +
  geom_point(size = 2) +
  scale_color_manual(values = c("Significant at 5%" = "red", "Not Significant at 5%" = "blue")) +
  geom_hline(yintercept = 0) +
  geom_vline(xintercept = as_date("2020-03-16"), color = "red") +
  theme_tufte()
```



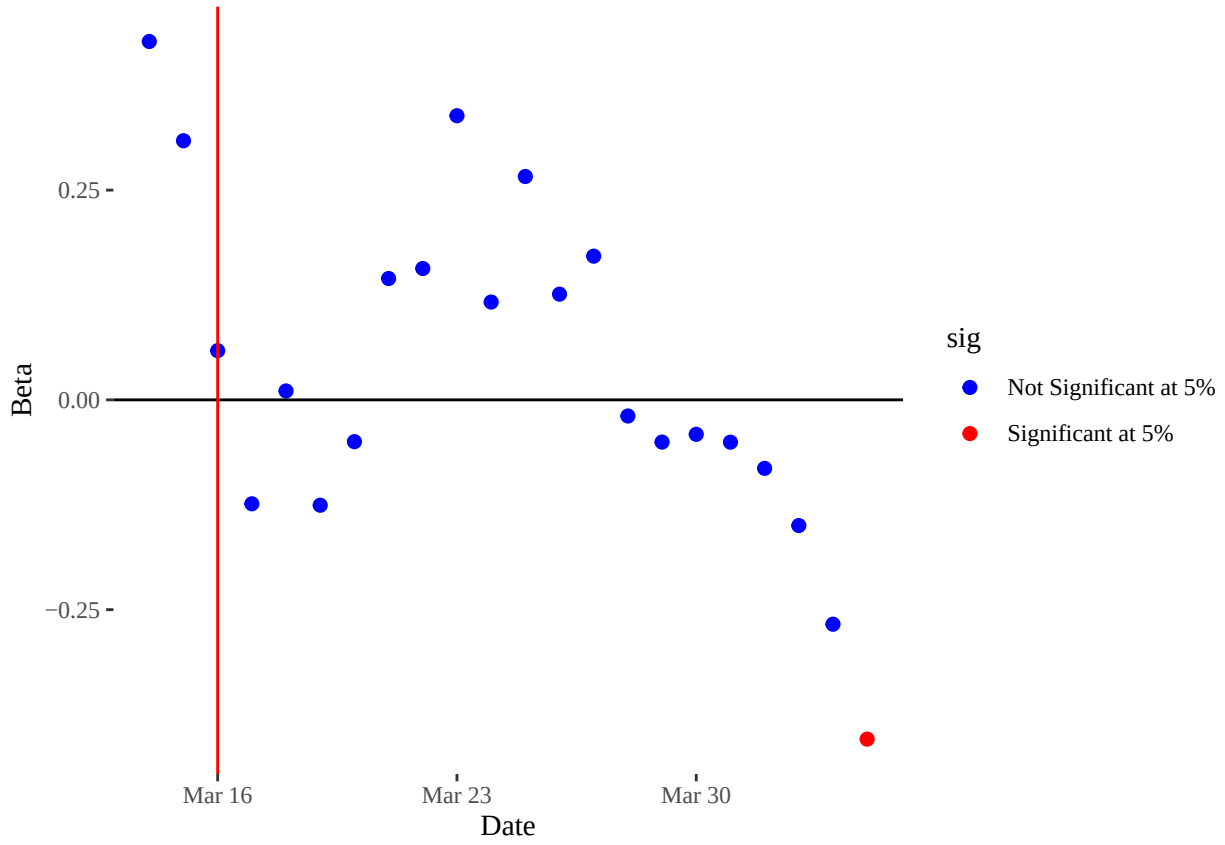

**Hours of sunshine**

```
n = 5
data.frame(Date = seq(ymd("2020-03-14"),
                      ymd("2020-04-04"),
                          by = "days"),
           Beta = matrix(sur.slm_lag11w$coefficients,ncol = 22)[n,],
           tvalue = matrix(sur.slm_lag11w$coefficients/sur.slm_lag11w$rest.se,ncol = 22)[n,]) %>%
  mutate(sig = ifelse(abs(tvalue) > 1.64, "Significant at 5%", "Not Significant at 5%")) %>%
  ggplot(aes(x = Date, y = Beta, color = sig)) +
  geom_point(size = 2) +
  scale_color_manual(values = c("Significant at 5%" = "red", "Not Significant at 5%" = "blue")) +
  geom_hline(yintercept = 0) +
  geom_vline(xintercept = as_date("2020-03-16"), color = "red") +
  theme_tufte()
```



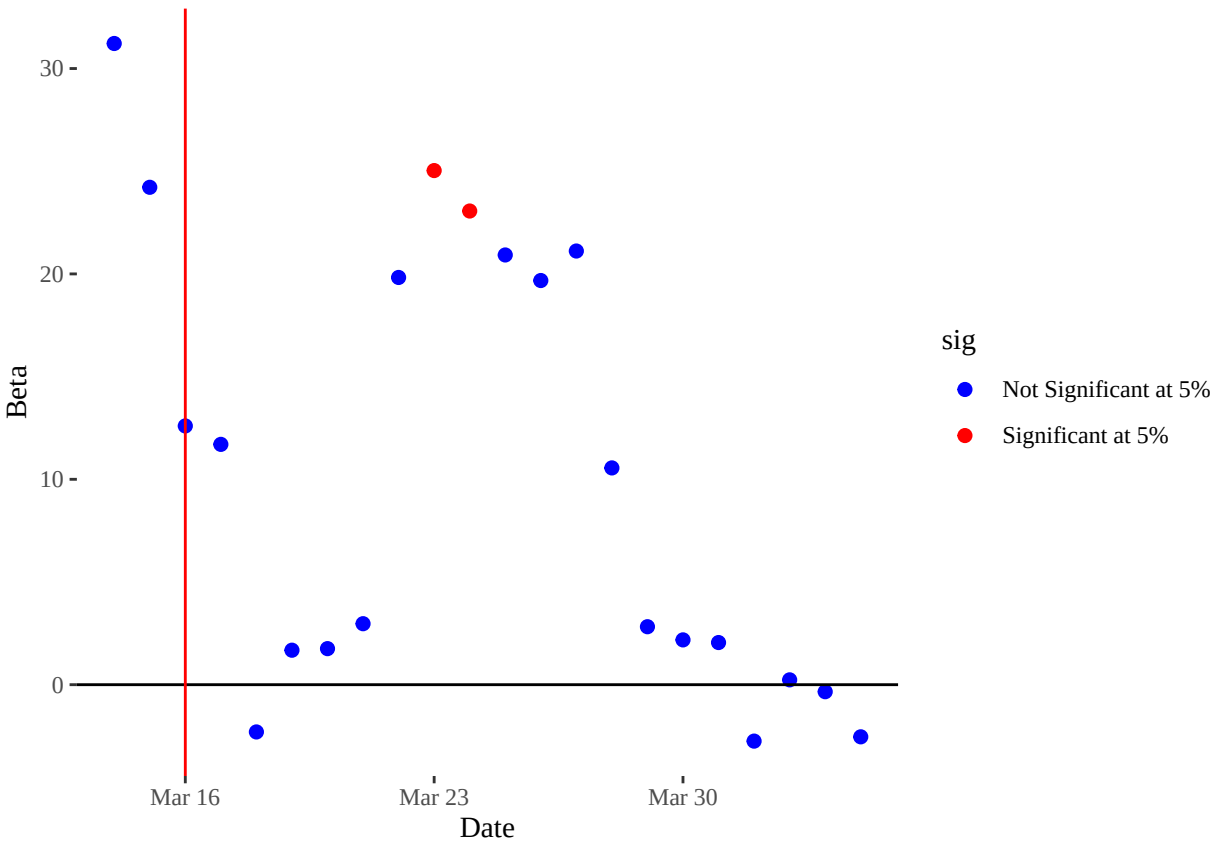

**Humidity**

```
n = 6
data.frame(Date = seq(ymd("2020-03-14"),
                      ymd("2020-04-04"),
                          by = "days"),
           Beta = matrix(sur.slm_lag11w$coefficients,ncol = 22)[n,],
           tvalue = matrix(sur.slm_lag11w$coefficients/sur.slm_lag11w$rest.se,ncol = 22)[n,]) %>%
  mutate(sig = ifelse(abs(tvalue) > 1.64, "Significant at 5%", "Not Significant at 5%")) %>%
  ggplot(aes(x = Date, y = Beta, color = sig)) +
  geom_point(size = 2) +
  scale_color_manual(values = c("Significant at 5%" = "red", "Not Significant at 5%" = "blue")) +
  geom_hline(yintercept = 0) +
  geom_vline(xintercept = as_date("2020-03-16"), color = "red") +
  theme_tufte()
```




**Intercept**

```
n = 1
data.frame(Date = seq(ymd("2020-03-14"),
                      ymd("2020-04-04"),
                          by = "days"),
           Beta = matrix(sur.slm_lag11w$coefficients,ncol = 22)[n,],
           tvalue = matrix(sur.slm_lag11w$coefficients/sur.slm_lag11w$rest.se,ncol = 22)[n,]) %>%
  mutate(sig = ifelse(abs(tvalue) > 1.64, "Significant at 5%", "Not Significant at 5%")) %>%
  ggplot(aes(x = Date, y = Beta, color = sig)) +
  geom_point(size = 2) +
  scale_color_manual(values = c("Significant at 5%" = "red", "Not Significant at 5%" = "blue")) +
  geom_hline(yintercept = 0) +
  geom_vline(xintercept = as_date("2020-03-16"), color = "red") +
  theme_tufte()
```


30
20
10
0
Beta
Mar 16
Mar 23
Mar 30
Date
sig
Not Significant at 5%
Significant at 5%