

R: Spatial autocorrelation

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```
library(sf)
```

```
## Linking to GEOS 3.7.2, GDAL 3.0.1, PROJ 6.2.0
```

```
lux <- st_read("../data/lux_tmerc.gpkg")
```

```
## Reading layer `lux_tmerc' from data source `/home/rsb/presentations/ectqg19-workshop/data/lux_tmerc'.
## Simple feature collection with 102 features and 16 fields
## geometry type:  MULTIPOLYGON
## dimension:      XY
## bbox:           xmin: 48930.89 ymin: 57015.29 xmax: 106113.8 ymax: 138759.2
## epsg (SRID):    NA
## proj4string:     +proj=tmerc +lat_0=49.8333333333333 +lon_0=6.16666666666667 +k=1 +x_0=80000 +y_0=100000
```

```
library(spdep)
```

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

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

```
nb_cont <- poly2nb(lux, row.names=as.character(lux$LAU2))
```

```
lw_B <- nb2listw(nb_cont, style="B")
```

```
lw_W <- nb2listw(nb_cont) # default style="W"
```

```
moran.test(lux$light_level, listw=lw_B, randomisation=TRUE, alternative="two.sided")
```

```
##
```

```
## Moran I test under randomisation
```

```
##
```

```
## data: lux$light_level
```

```
## weights: lw_B
```

```
##
```

```
## Moran I statistic standard deviate = 4.7986, p-value = 1.598e-06
```

```
## alternative hypothesis: two.sided
```

```
## sample estimates:
```

| ## Moran I statistic | Expectation | Variance |
|----------------------|-------------|----------|
|----------------------|-------------|----------|

| | | |
|---------------|-------------|------------|
| ## 0.25764008 | -0.00990099 | 0.00310848 |
|---------------|-------------|------------|

```
moran.test(lux$light_level, listw=lw_W, randomisation=TRUE, alternative="two.sided")
```

```
##
```

```
## Moran I test under randomisation
```

```
##
```

```
## data: lux$light_level
```

```
## weights: lw_W
```

```
##
```

```
## Moran I statistic standard deviate = 3.9672, p-value = 7.273e-05
```

```
## alternative hypothesis: two.sided
```

```
## sample estimates:
```

| ## Moran I statistic | Expectation | Variance |
|----------------------|-------------|----------|
|----------------------|-------------|----------|

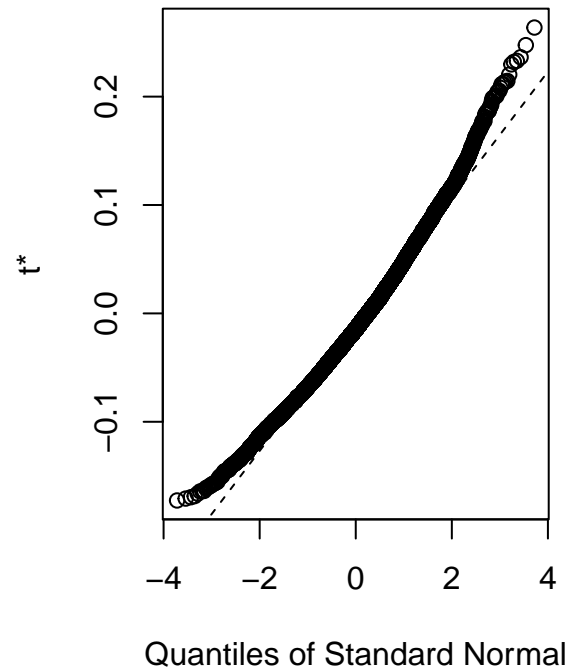
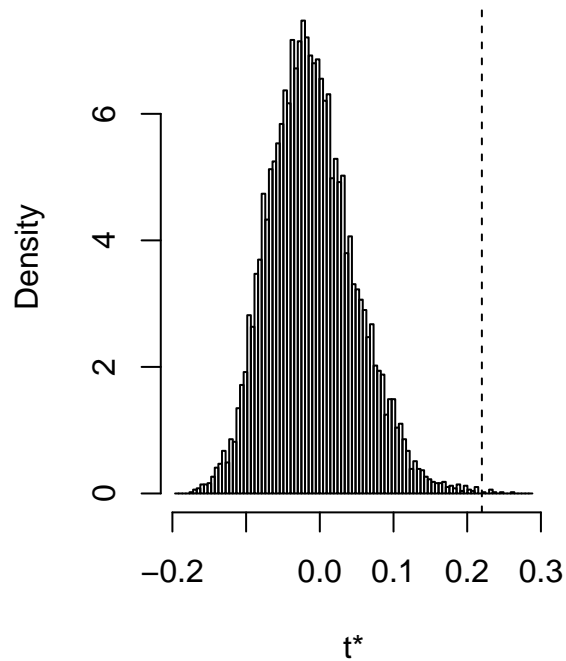
| | | |
|----------------|--------------|-------------|
| ## 0.219888588 | -0.009900990 | 0.003355057 |
|----------------|--------------|-------------|

```
set.seed(1)
perm_boot <- moran.mc(lux$light_level, listw=lw_W, nsim=9999, return_boot=TRUE)
c(mean=mean(perm_boot$t), var=var(perm_boot$t))
```

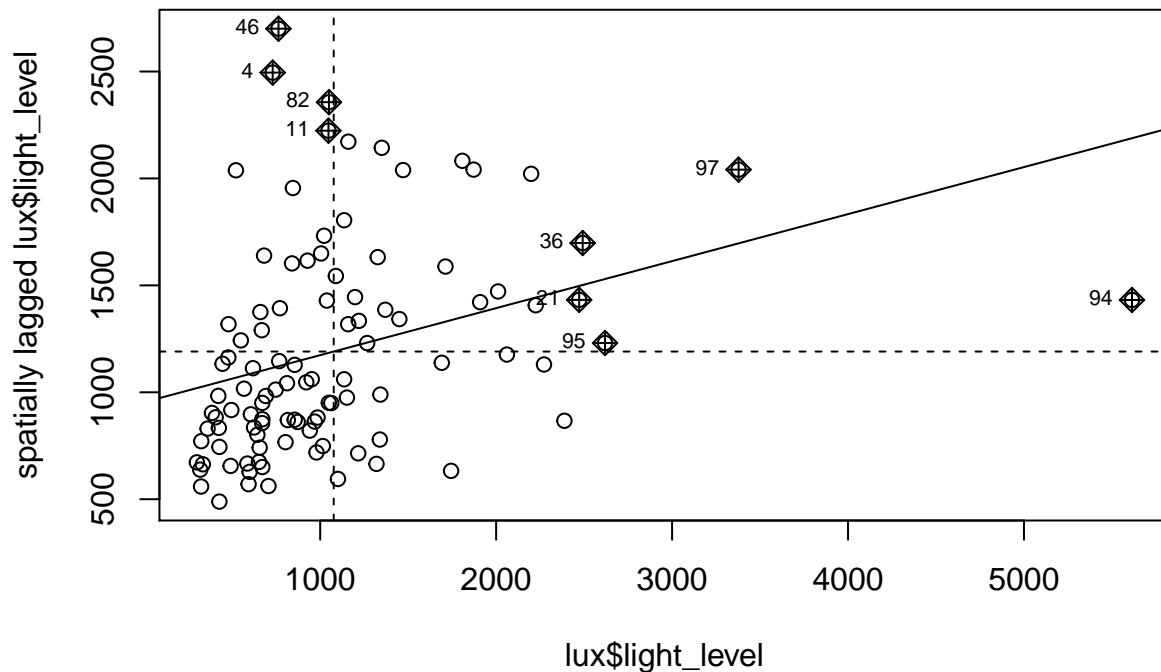
```
##          mean          var
## -0.01020404  0.00340162
```

```
plot(perm_boot)
```

Histogram of t



```
moran.plot(lux$light_level, listw=lw_W)
```



```
OLS <- lm(light_level ~ pop_den, lux)
summary(OLS)
```

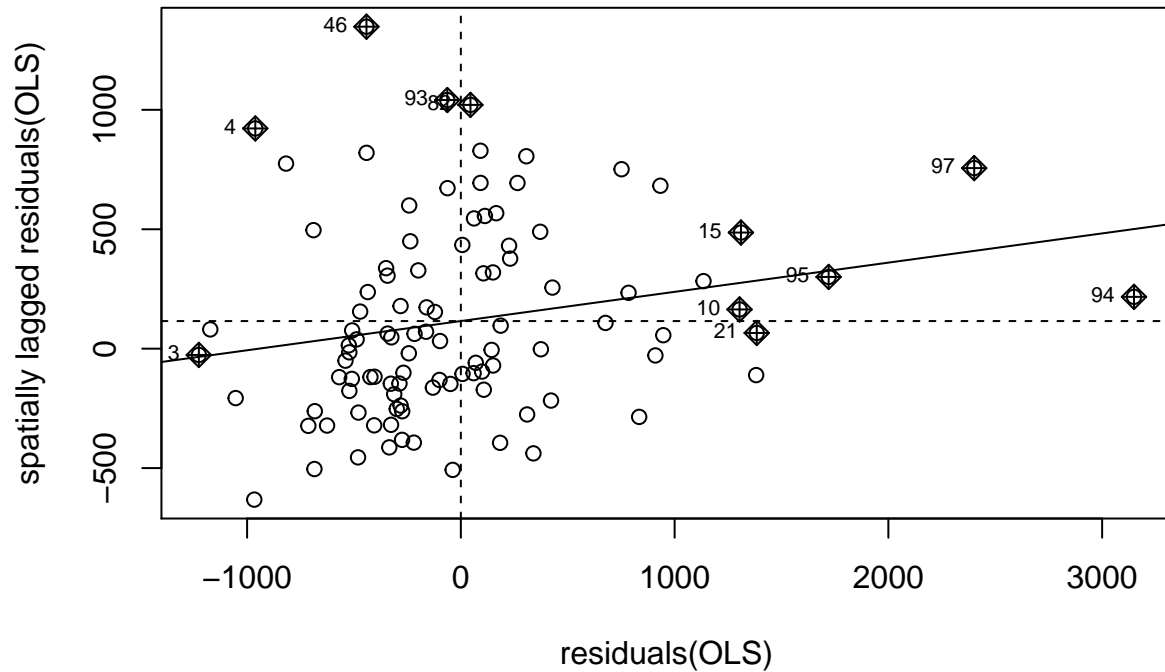
```
##
## Call:
## lm(formula = light_level ~ pop_den, data = lux)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -1225.7  -418.8  -145.5   185.5   3149.2
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)  871.3159    84.0395  10.368 < 2e-16 ***
## pop_den       0.7087     0.1669   4.246 4.89e-05 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 693.7 on 100 degrees of freedom
## Multiple R-squared:  0.1527, Adjusted R-squared:  0.1443
## F-statistic: 18.03 on 1 and 100 DF,  p-value: 4.887e-05
```

```
lm.morantest(OLS, listw=lw_W, alternative="two.sided")
```

```
##
## Global Moran I for regression residuals
##
## data:
## model: lm(formula = light_level ~ pop_den, data = lux)
## weights: lw_W
##
## Moran I statistic standard deviate = 2.2291, p-value = 0.02581
## alternative hypothesis: two.sided
```

```
## sample estimates:
## Observed Moran I      Expectation      Variance
##      0.122316539      -0.014379855      0.003760716
```

```
moran.plot(residuals(OLS), listw=lw_W)
```



```
locm <- localmoran(lux$light_level, listw=lw_W, alternative="two.sided")
lux$locIz <- locm[,4]
plot(lux[, "locIz"])
```

