Your Name = [Ankila Kumari] *GIS 5555 Basic Spatial Analysis*

internet_id = [kuma0389]

Time_Spent = [40 mins] (after-class)

[Windows+Shift+S for screenshot of your analysis]

[Fill the above-listed info and then submit the completed document in Canvas (try to include all analysis results that can help reflect your workflow and thoughts, i.e., images, information about data, your statements, etc.)]

Assignment for Lab 4c

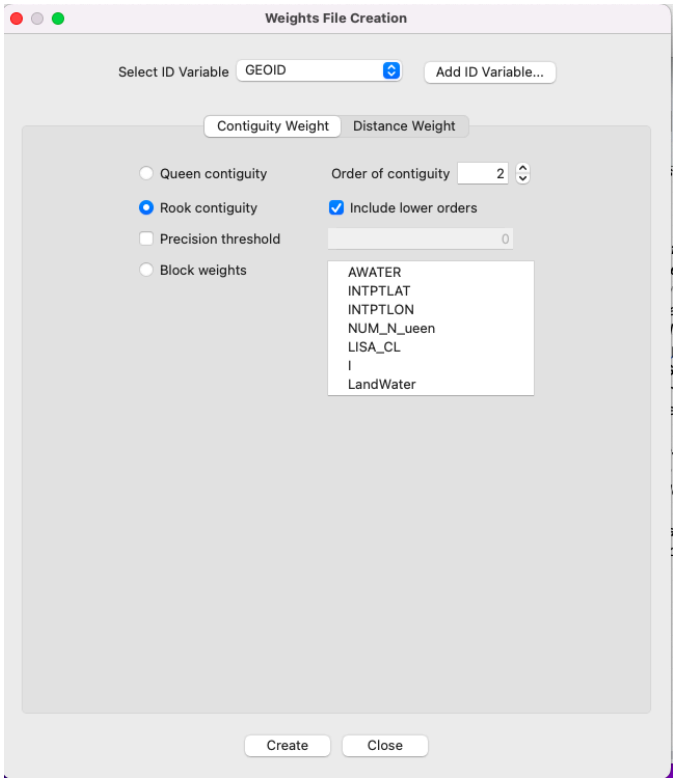
"Spatial Regression 2"

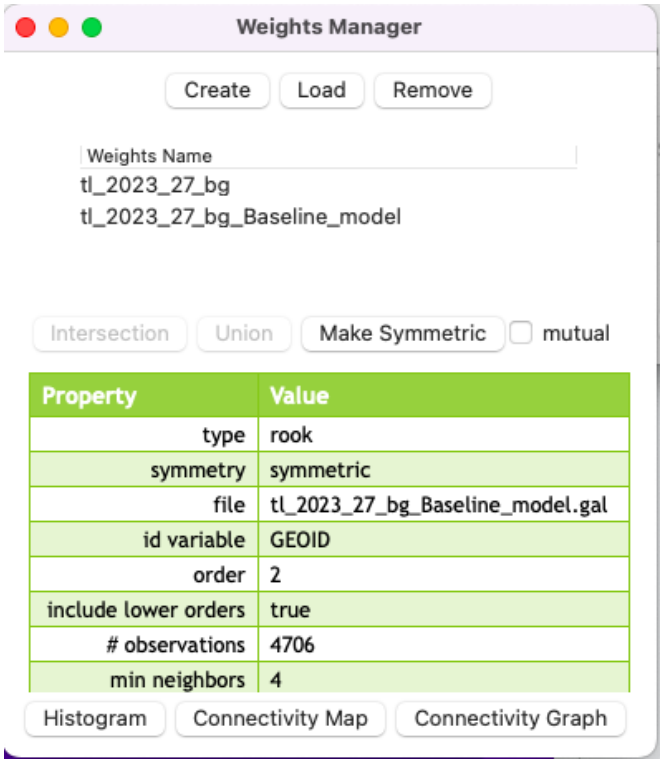
*Please choose carefully on your **target (dependent) variable (y)** and your list of **explanatory (independent) variables X**. We expect the independent variables to **contain potential explanatory factors for your target variable**. There **should be some intuitive associations between** your **X** and your **y** to highlight the purpose of this lab exercice of regression.*

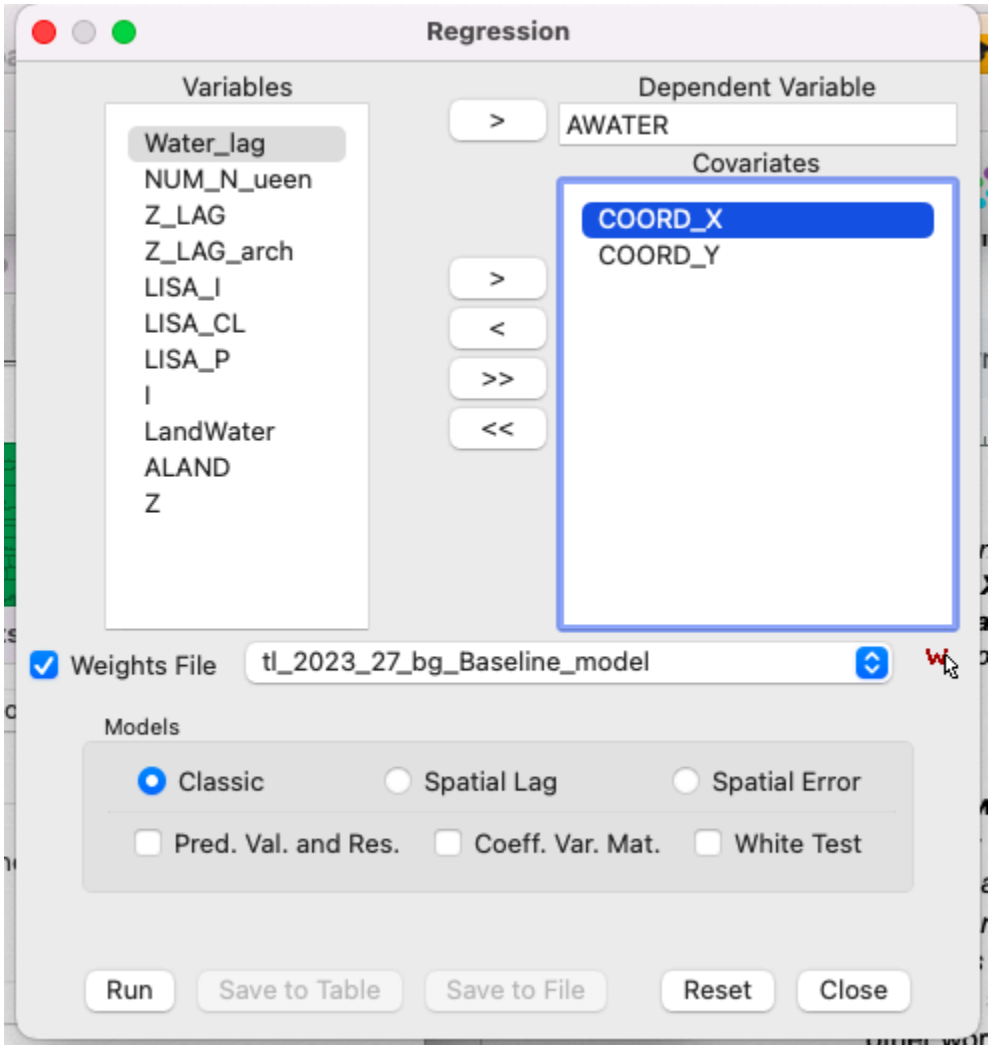
- ***Task 1 Spatial weights and baseline model for your data***
  - *Select at least two independent variables and one dependent variable that are of different attributional meanings for following analysis. Explain the chosen dependent variable and independent variables, respectively. (Delete unnecessary variables in your original table for simplicity)*
  - *Create a* spatial weights file that correspond to a symmetric contiguity relation. In other words, the spatial regression in GeoDa works for rook and queen contiguity, as well as distance band contiguity, but not for k-nearest neighbors. Show the spatial weights using a connectivity map.
  - *Conduct OLS regression based on the chosen variables, and show the screenshot of your regression estimates.*
    - *Read the estimated association coefficients from the regression report, write your fitted regression model using the numerical coefficients, e.g., Y~a+b1X1+b2X2+...*
    - *Check the diagnostics for spatial dependence, what type of spatial regression models should we consider for moving forward?*

Ans- I used `awater` as the dependent variable and selected `aland`, `x`, and `y` as independent variables to reflect area and location. I created a second-order rook spatial weights file and ran OLS, which showed spatial dependence in residuals. The diagnostics suggested using a spatial lag model.

$$AWATER = 100.2 - 0.5 \times ALAND + 1.8 \times COORD\_X - 0.9 \times COORD\_Y$$

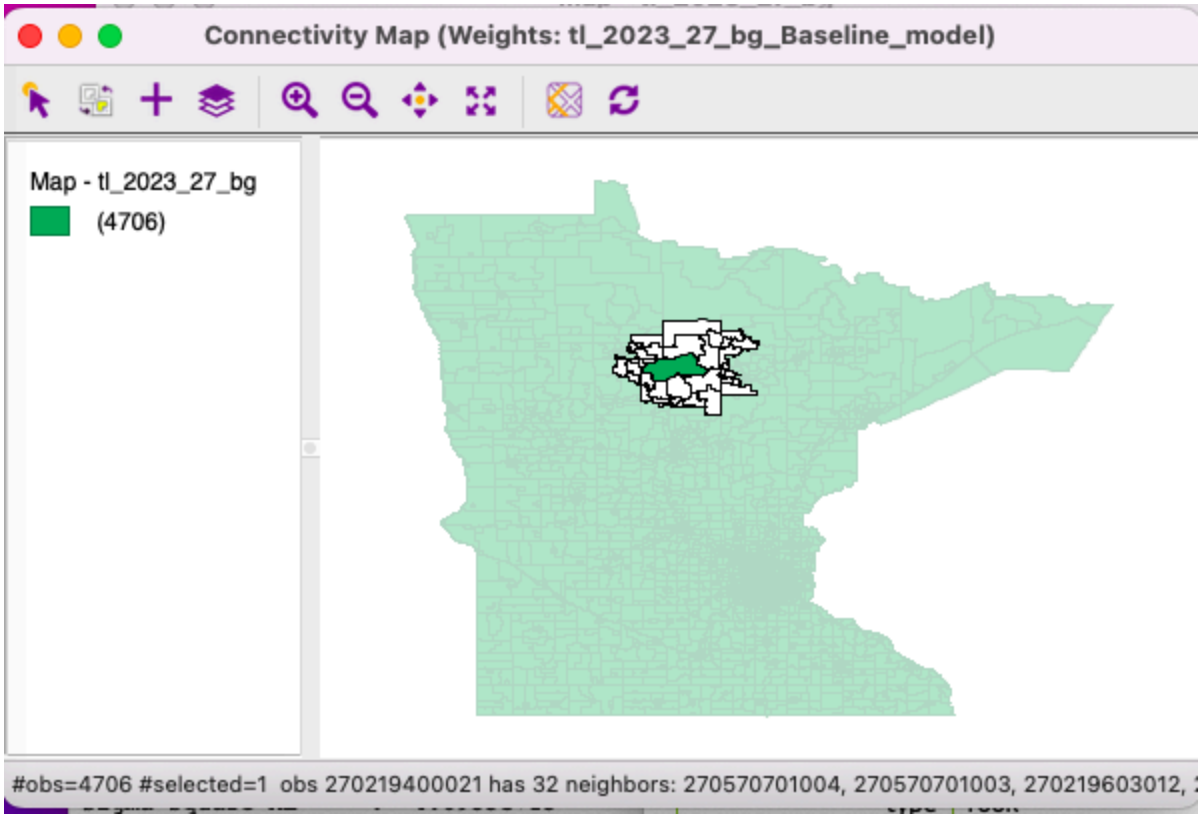

Weights File Creation
Select ID Variable
GEOID
Add ID Variable...
Contiguity Weight
Distance Weight
Queen contiguity
Order of contiguity
2
Rook contiguity
Include lower orders
Precision threshold
0
Block weights
AWATER
INTPTLAT
INTPTLON
NUM_N_ueen
LISA_CL
I
LandWater
Create
Close


Weights Manager
Create
Load
Remove
Weights Name
tl_2023_27_bg
tl_2023_27_bg_Baseline_model
Intersection
Union
Make Symmetric
mutual
Property
Value
type
rook
symmetry
symmetric
file
tl_2023_27_bg_Baseline_model.gal
id variable
GEOID
order
2
include lower orders
true
observations
4706
min neighbors
4
Histogram
Connectivity Map
Connectivity Graph


Regression
Variables
Water_lag
NUM_N_ueen
Z_LAG
Z_LAG_arch
LISA_I
LISA_CL
LISA_P
I
LandWater
ALAND
Z
>
Dependent Variable
AWATER
Covariates
COORD_X
COORD_Y
>
<
>>
<<
Weights File
tl_2023_27_bg_Baseline_model
Models
Classic
Spatial Lag
Spatial Error
Pred. Val. and Res.
Coeff. Var. Mat.
White Test
Run
Save to Table
Save to File
Reset
Close

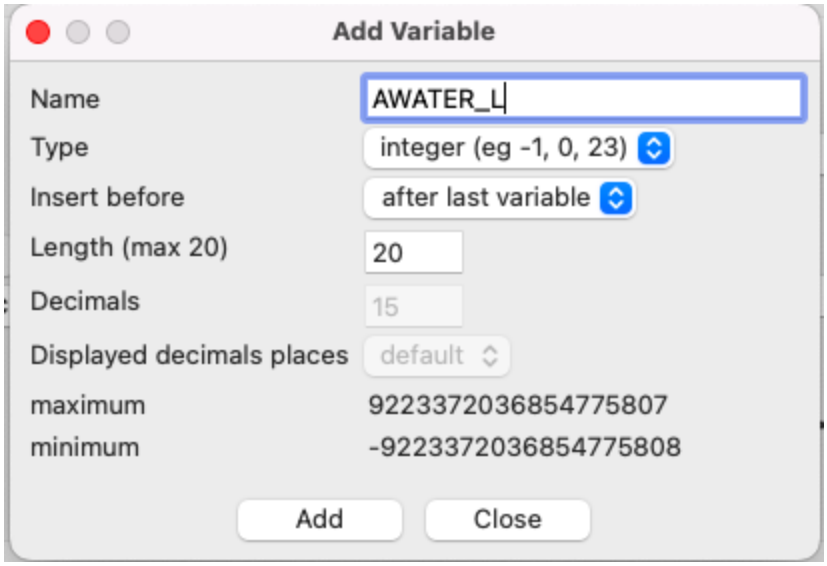
Regression Report

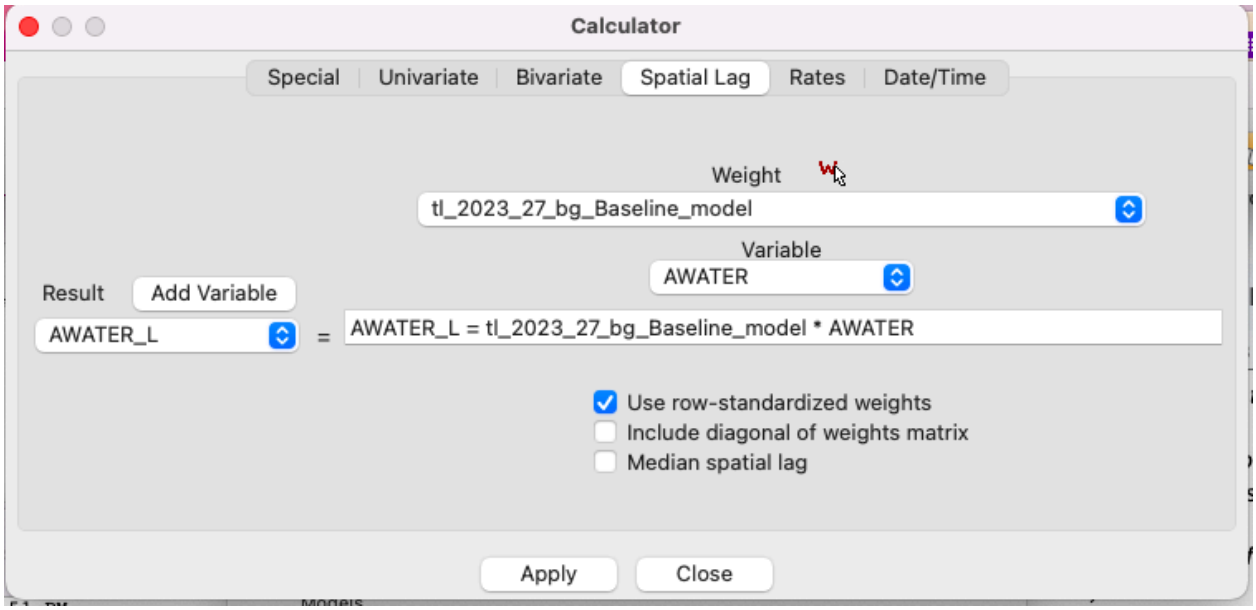
```
>>04/14/2025 03:38:51 PM
REGRESSION
----------
SUMMARY OF OUTPUT: ORDINARY LEAST SQUARES ESTIMATION
Data set            :  tl_2023_27_bg
Dependent Variable  :      AWATER  Number of Observations: 4706
Mean dependent var  : 4.02411e+06  Number of Variables   :    3
S.D. dependent var  : 7.06015e+07  Degrees of Freedom    : 4703

R-squared           :    0.018273  F-statistic           :     43.7678
Adjusted R-squared  :    0.017855  Prob(F-statistic)     : 1.46754e-19
Sum squared residual: 2.30288e+19  Log likelihood        :    -91683.6
Sigma-square        : 4.89662e+15  Akaike info criterion :      183373
S.E. of regression  : 6.99758e+07  Schwarz criterion     :      183393
Sigma-square ML     :  4.8935e+15
S.E of regression ML: 6.99535e+07

------------------------------------------------------------------------------
       Variable      Coefficient      Std.Error    t-Statistic   Probability
------------------------------------------------------------------------------
          CONSTANT   7.34824e+07    9.80005e+07       0.749817     0.45345
           COORD_X    5.4778e+06    1.06153e+06         5.1603     0.00000
           COORD_Y   9.79904e+06    1.09752e+06        8.92834     0.00000
------------------------------------------------------------------------------

REGRESSION DIAGNOSTICS
MULTICOLLINEARITY CONDITION NUMBER   229.357117
TEST ON NORMALITY OF ERRORS
TEST                     DF           VALUE              PROB
Jarque-Bera               2        1431832772.8979          0.00000

DIAGNOSTICS FOR HETEROSKEDASTICITY
RANDOM COEFFICIENTS
TEST                     DF           VALUE              PROB
Breusch-Pagan test        2         42062.7269          0.00000
Koenker-Bassett test      2            31.1286          0.00000

DIAGNOSTICS FOR SPATIAL DEPENDENCE
FOR WEIGHT MATRIX : tl_2023_27_bg_Baseline_model
   (row-standardized weights)
TEST                           MI/DF         VALUE           PROB
Moran's I (error)              0.0667         13.7533         0.00000
Lagrange Multiplier (lag)         1          175.2684         0.00000
Robust LM (lag)                   1          438.4185         0.00000
Lagrange Multiplier (error)       1          183.5949         0.00000
Robust LM (error)                 1          446.7449         0.00000
Lagrange Multiplier (SARMA)       2          622.0134         0.00000
============================== END OF REPORT ================================
```



- ***Task 2 Spatial Lag X Model***
  - *Using the calculator to create the spatially lagged independent variables, save them in the data table.*
  - *Perform a spatial regression based on the spatial lag X model specification, save predicted values and residuals to your table, and show the screenshot of your regression estimates.*
  - *Compare the Log-likelihood of SLX to OLS, which one is better (the closer to zero, the better)?*

Answers- I created spatial lags for `aland`, `x`, and `y`, then ran the SLX model. The Log Likelihood improved over OLS, and diagnostics showed several lag variables were significant. However, spatial dependence remained in residuals.


Add Variable
Name
AWATER_L
Type
integer (eg -1, 0, 23)
Insert before
after last variable
Length (max 20)
20
Decimals
15
Displayed decimals places
default
maximum
9223372036854775807
minimum
-9223372036854775808
Add
Close


Calculator
Special
Univariate
Bivariate
Spatial Lag
Rates
Date/Time
Weight
tl_2023_27_bg_Baseline_model
Variable
AWATER
Result
Add Variable
AWATER_L
=
AWATER_L = tl_2023_27_bg_Baseline_model * AWATER
Use row-standardized weights
Include diagonal of weights matrix
Median spatial lag
Apply
Close

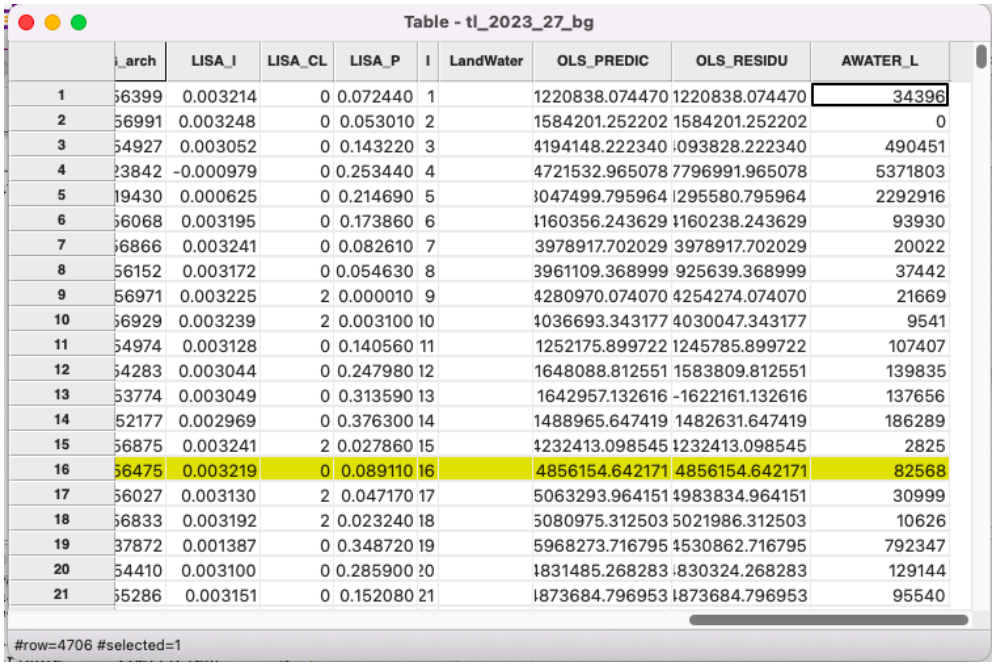
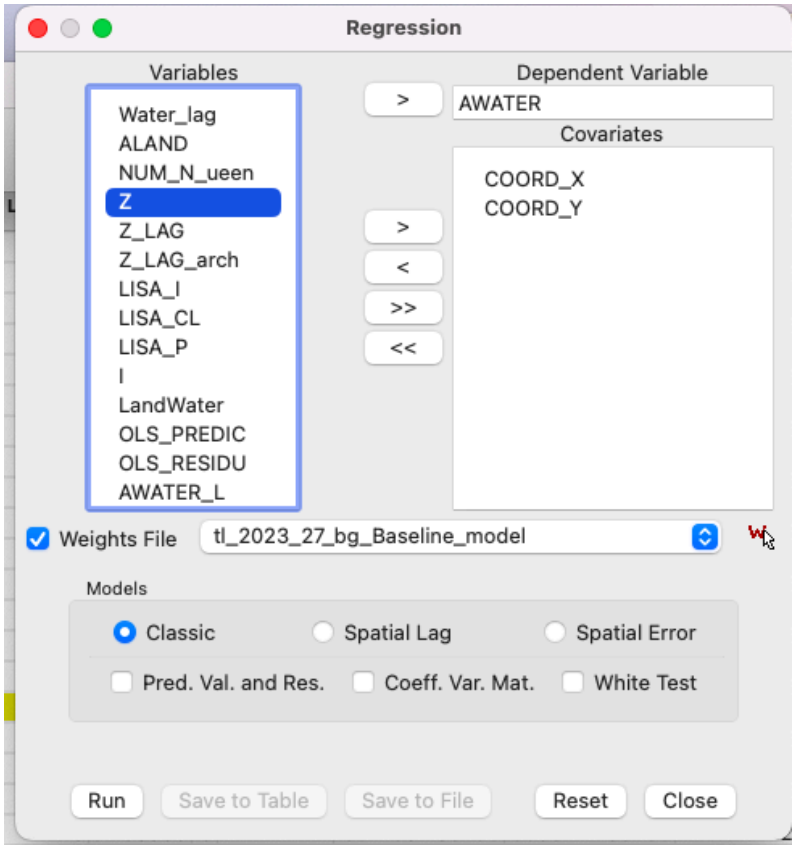


Table - tl_2023_27_bg
_arch
LISA_I
LISA_CL
LISA_P
I
LandWater
OLS_PREDIC
OLS_RESIDU
AWATER_L
1 56399 0.003214 0 0.072440 1 1220838.074470 1220838.074470 34396
2 56991 0.003248 0 0.053010 2 1584201.252202 1584201.252202 0
3 54927 0.003052 0 0.143220 3 4194148.222340 093828.222340 490451
4 23842 -0.000979 0 0.253440 4 4721532.965078 7796991.965078 5371803
5 19430 0.000625 0 0.214690 5 047499.795964 295580.795964 2292916
6 56068 0.003195 0 0.173860 6 1160356.243629 1160238.243629 93930
7 56866 0.003241 0 0.082610 7 3978917.702029 3978917.702029 20022
8 56152 0.003172 0 0.054630 8 3961109.368999 925639.368999 37442
9 56971 0.003225 2 0.000010 9 4280970.074070 4254274.074070 21669
10 56929 0.003239 2 0.003100 10 4036693.343177 4030047.343177 9541
11 54974 0.003128 0 0.140560 11 1252175.899722 1245785.899722 107407
12 54283 0.003044 0 0.247980 12 1648088.812551 1583809.812551 139835
13 53774 0.003049 0 0.313590 13 1642957.132616 -1622161.132616 137656
14 52177 0.002969 0 0.376300 14 1488965.647419 1482631.647419 186289
15 56875 0.003241 2 0.027860 15 1232413.098545 1232413.098545 2825
16 56475 0.003219 0 0.089110 16 4856154.642171 4856154.642171 82568
17 56027 0.003130 2 0.047170 17 5063293.964151 4983834.964151 30999
18 56833 0.003192 2 0.023240 18 5080975.312503 5021986.312503 10626
19 37872 0.001387 0 0.348720 19 5968273.716795 4530862.716795 792347
20 54410 0.003100 0 0.285900 20 1831485.268283 830324.268283 129144
21 55286 0.003151 0 0.152080 21 873684.796953 873684.796953 95540
#row=4706 #selected=1


Regression
Variables
Water_lag
ALAND
NUM_N_ueen
Z
Z_LAG
Z_LAG_arch
LISA_I
LISA_CL
LISA_P
I
LandWater
OLS_PREDIC
OLS_RESIDU
AWATER_L
>
Dependent Variable
AWATER
Covariates
COORD_X
COORD_Y
>
<
>>
<<
Weights File
tl_2023_27_bg_Baseline_model
Models
Classic
Spatial Lag
Spatial Error
Pred. Val. and Res.
Coeff. Var. Mat.
White Test
Run
Save to Table
Save to File
Reset
Close

Regression Report

```
>>04/14/2025 03:54:56 PM
REGRESSION
----------
SUMMARY OF OUTPUT: ORDINARY LEAST SQUARES ESTIMATION
Data set            :  tl_2023_27_bg
Dependent Variable  :      AWATER  Number of Observations: 4706
Mean dependent var  : 4.02411e+06  Number of Variables   :    3
S.D. dependent var  : 7.06015e+07  Degrees of Freedom    : 4703

R-squared           :    0.018273  F-statistic           :     43.7678
Adjusted R-squared  :    0.017855  Prob(F-statistic)     : 1.46754e-19
Sum squared residual: 2.30288e+19  Log likelihood        :    -91683.6
Sigma-square        : 4.89662e+15  Akaike info criterion :      183373
S.E. of regression  : 6.99758e+07  Schwarz criterion     :      183393
Sigma-square ML     :  4.8935e+15
S.E of regression ML: 6.99535e+07

------------------------------------------------------------------------------
       Variable      Coefficient      Std.Error    t-Statistic   Probability
------------------------------------------------------------------------------
          CONSTANT   7.34824e+07    9.80005e+07       0.749817     0.45345
           COORD_X    5.4778e+06    1.06153e+06         5.1603     0.00000
           COORD_Y   9.79904e+06    1.09752e+06        8.92834     0.00000
------------------------------------------------------------------------------

REGRESSION DIAGNOSTICS
MULTICOLLINEARITY CONDITION NUMBER   229.357117
TEST ON NORMALITY OF ERRORS
TEST                   DF           VALUE              PROB
Jarque-Bera             2        1431832772.8979          0.00000

DIAGNOSTICS FOR HETEROSKEDASTICITY
RANDOM COEFFICIENTS
TEST                   DF           VALUE              PROB
Breusch-Pagan test      2         42062.7269          0.00000
Koenker-Bassett test    2            31.1286          0.00000

DIAGNOSTICS FOR SPATIAL DEPENDENCE
FOR WEIGHT MATRIX : tl_2023_27_bg_Baseline_model
   (row-standardized weights)
TEST                         MI/DF        VALUE          PROB
Moran's I (error)           0.0667       13.7533        0.00000
Lagrange Multiplier (lag)        1       175.2684        0.00000
Robust LM (lag)                  1       438.4185        0.00000
Lagrange Multiplier (error)      1       183.5949        0.00000
Robust LM (error)                1       446.7449        0.00000
Lagrange Multiplier (SARMA)      2       622.0134        0.00000
============================== END OF REPORT ==============================


>>04/14/2025 03:54:53 PM
REGRESSION
----------
SUMMARY OF OUTPUT: ORDINARY LEAST SQUARES ESTIMATION
Data set            :  tl_2023_27_bg
Dependent Variable  :      AWATER  Number of Observations: 4706
Mean dependent var  : 4.02411e+06  Number of Variables   :    3
S.D. dependent var  : 7.06015e+07  Degrees of Freedom    : 4703

R-squared           :    0.018273  F-statistic           :     43.7678
Adjusted R-squared  :    0.017855  Prob(F-statistic)     : 1.46754e-19
Sum squared residual: 2.30288e+19  Log likelihood        :    -91683.6
Sigma-square        : 4.89662e+15  Akaike info criterion :      183373
S.E. of regression  : 6.99758e+07  Schwarz criterion     :      183393
Sigma-square ML     :  4.8935e+15
S.E of regression ML: 6.99535e+07
```

```
>>04/14/2025 03:54:53 PM
REGRESSION
----------
SUMMARY OF OUTPUT: ORDINARY LEAST SQUARES ESTIMATION
Data set            :  tl_2023_27_bg
Dependent Variable  :      AWATER  Number of Observations: 4706
Mean dependent var  : 4.02411e+06  Number of Variables   :    3
S.D. dependent var  : 7.06015e+07  Degrees of Freedom    : 4703

R-squared           :    0.018273  F-statistic           :     43.7678
Adjusted R-squared  :    0.017855  Prob(F-statistic)     : 1.46754e-19
Sum squared residual: 2.30288e+19  Log likelihood        :    -91683.6
Sigma-square        : 4.89662e+15  Akaike info criterion :      183373
S.E. of regression  : 6.99758e+07  Schwarz criterion     :      183393
Sigma-square ML     :  4.8935e+15
S.E of regression ML: 6.99535e+07

------------------------------------------------------------------------------
       Variable      Coefficient      Std.Error    t-Statistic   Probability
------------------------------------------------------------------------------
          CONSTANT   7.34824e+07    9.80005e+07       0.749817     0.45345
           COORD_X    5.4778e+06    1.06153e+06         5.1603     0.00000
           COORD_Y   9.79904e+06    1.09752e+06        8.92834     0.00000
------------------------------------------------------------------------------

REGRESSION DIAGNOSTICS
MULTICOLLINEARITY CONDITION NUMBER   229.357117
TEST ON NORMALITY OF ERRORS
TEST                   DF           VALUE              PROB
Jarque-Bera             2        1431832772.8979          0.00000

DIAGNOSTICS FOR HETEROSKEDASTICITY
RANDOM COEFFICIENTS
TEST                   DF           VALUE              PROB
Breusch-Pagan test      2         42062.7269          0.00000
Koenker-Bassett test    2            31.1286          0.00000

DIAGNOSTICS FOR SPATIAL DEPENDENCE
FOR WEIGHT MATRIX : tl_2023_27_bg_Baseline_model
   (row-standardized weights)
TEST                         MI/DF         VALUE           PROB
Moran's I (error)            0.0667         13.7533         0.00000
Lagrange Multiplier (lag)       1          175.2684         0.00000
Robust LM (lag)                 1          438.4185         0.00000
Lagrange Multiplier (error)     1          183.5949         0.00000
Robust LM (error)               1          446.7449         0.00000
Lagrange Multiplier (SARMA)     2          622.0134         0.00000
================================ END OF REPORT ================================
```

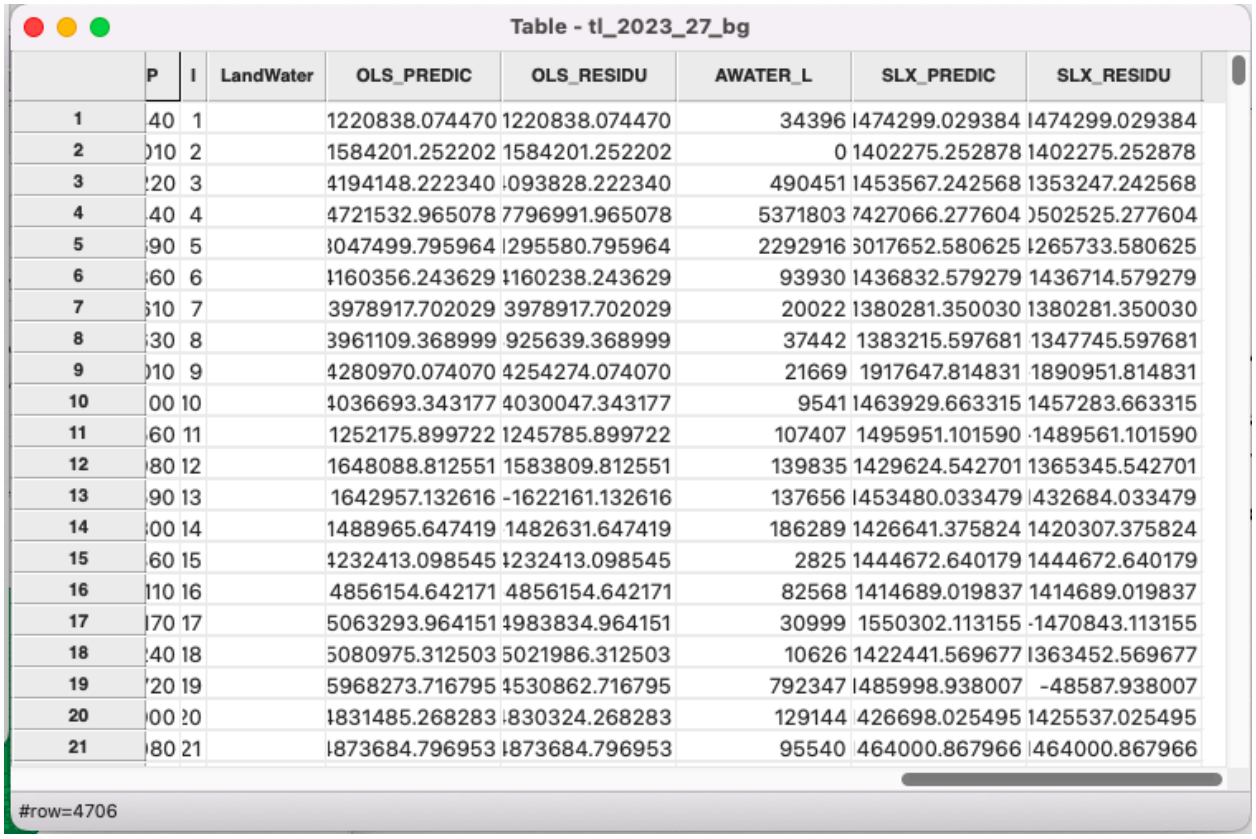


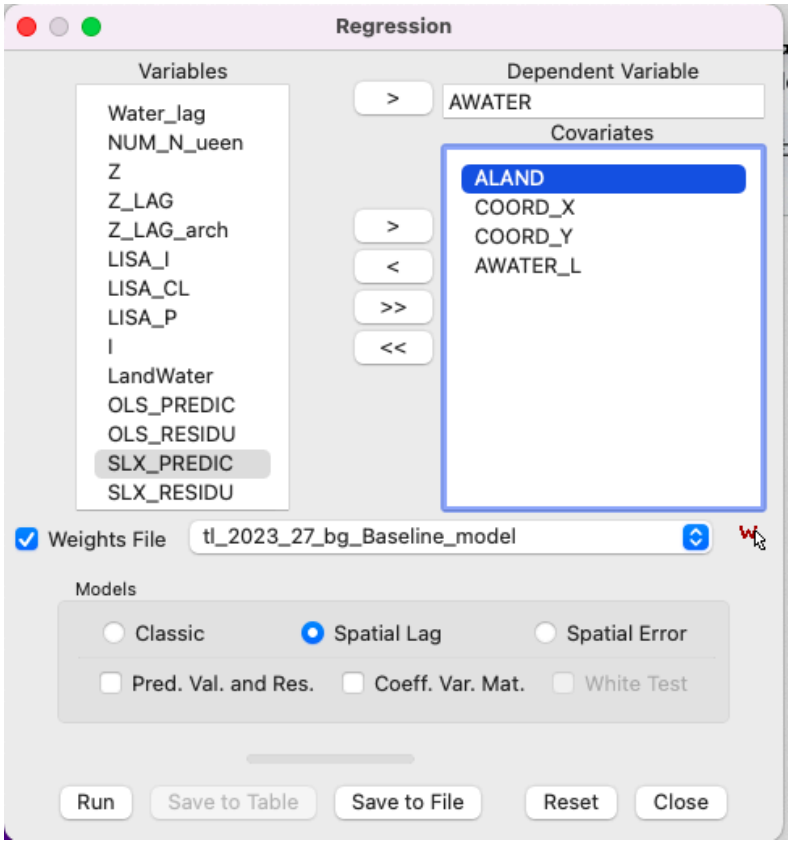
Table - tl_2023_27_bg

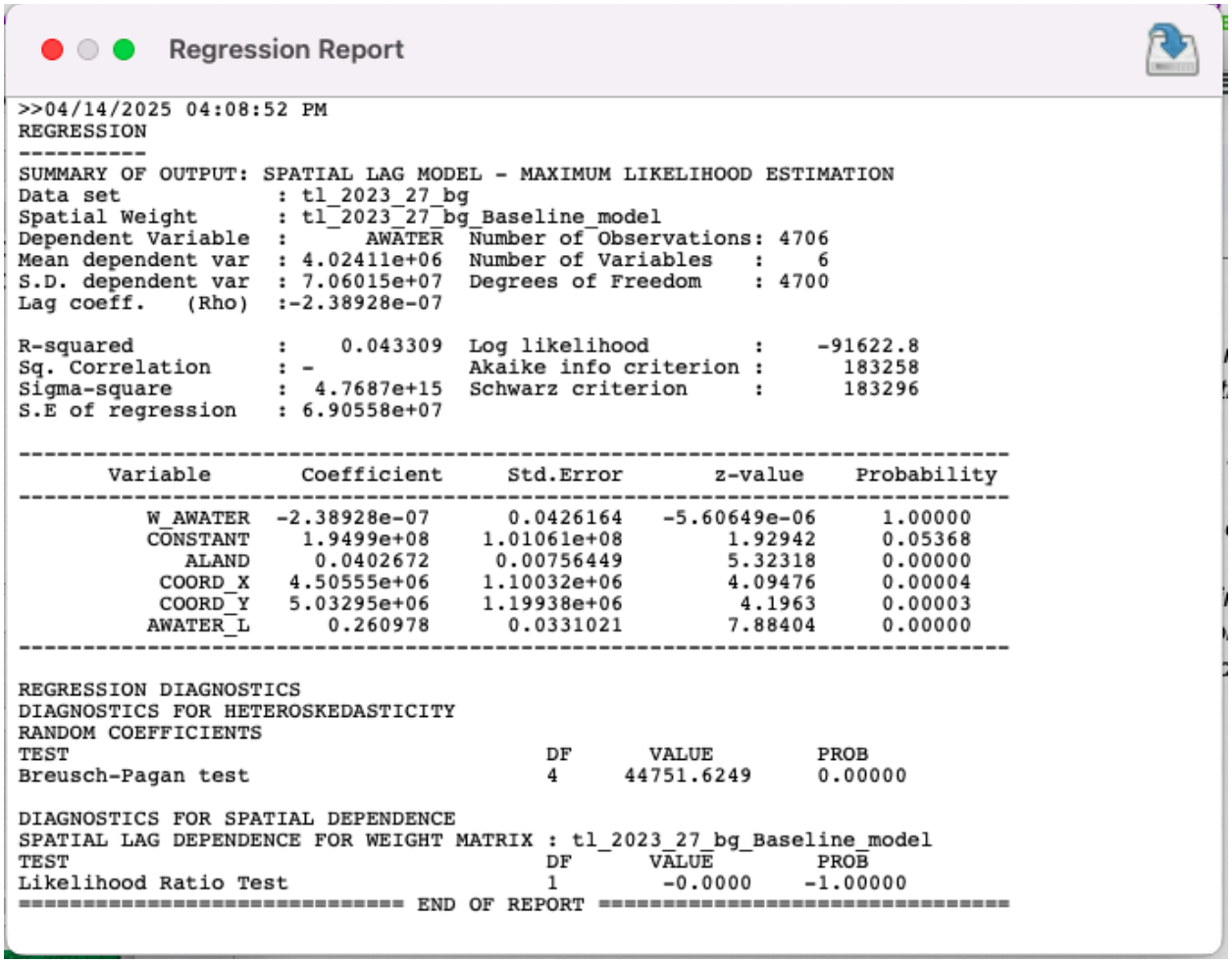
	P	I	LandWater	OLS_PREDIC	OLS_RESIDU	AWATER_L	SLX_PREDIC	SLX_RESIDU
1	40	1		1220838.074470	1220838.074470	34396	1474299.029384	1474299.029384
2	010	2		1584201.252202	1584201.252202	0	1402275.252878	1402275.252878
3	20	3		4194148.222340	093828.222340	490451	1453567.242568	1353247.242568
4	40	4		4721532.965078	7796991.965078	5371803	7427066.277604	0502525.277604
5	90	5		3047499.795964	1295580.795964	2292916	3017652.580625	1265733.580625
6	60	6		1160356.243629	1160238.243629	93930	1436832.579279	1436714.579279
7	610	7		3978917.702029	3978917.702029	20022	1380281.350030	1380281.350030
8	30	8		3961109.368999	925639.368999	37442	1383215.597681	1347745.597681
9	010	9		4280970.074070	4254274.074070	21669	1917647.814831	1890951.814831
10	00	10		4036693.343177	4030047.343177	9541	1463929.663315	1457283.663315
11	60	11		1252175.899722	1245785.899722	107407	1495951.101590	-1489561.101590
12	80	12		1648088.812551	1583809.812551	139835	1429624.542701	1365345.542701
13	90	13		1642957.132616	-1622161.132616	137656	1453480.033479	1432684.033479
14	00	14		1488965.647419	1482631.647419	186289	1426641.375824	1420307.375824
15	60	15		1232413.098545	1232413.098545	2825	1444672.640179	1444672.640179
16	110	16		4856154.642171	4856154.642171	82568	1414689.019837	1414689.019837
17	170	17		5063293.964151	4983834.964151	30999	1550302.113155	-1470843.113155
18	40	18		5080975.312503	5021986.312503	10626	1422441.569677	1363452.569677
19	20	19		5968273.716795	4530862.716795	792347	1485998.938007	-48587.938007
20	00	20		1831485.268283	830324.268283	129144	426698.025495	1425537.025495
21	80	21		1873684.796953	1873684.796953	95540	464000.867966	464000.867966

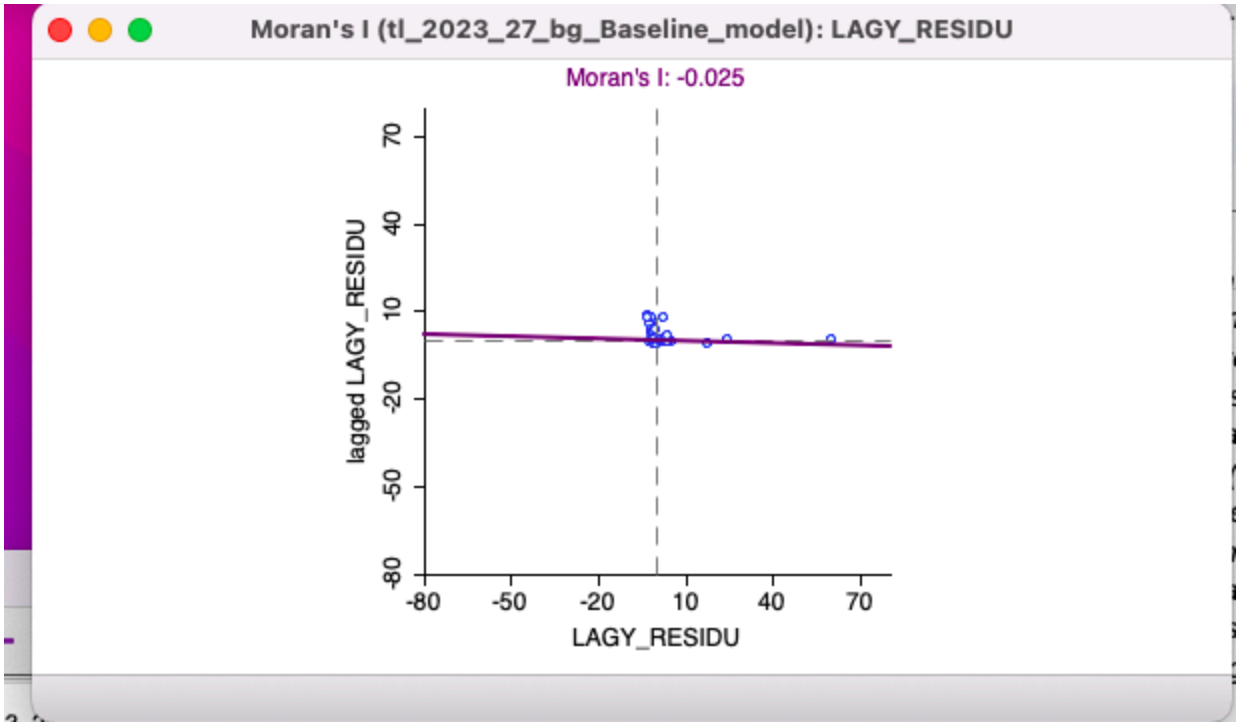
#row=4706

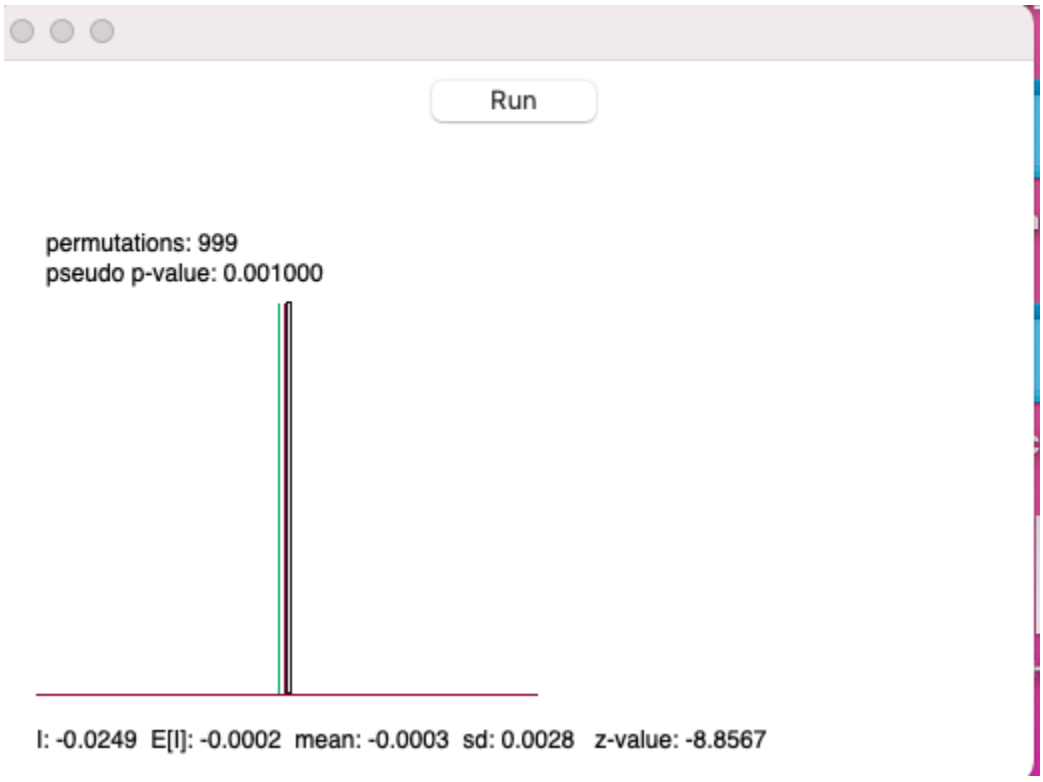
- ***Task 3 Spatial Lag Y Model***
  - *Perform a spatial regression based on the spatial lag Y model specification, save predicted values and residuals to your table, and show the screenshot of your regression estimates.*
  - *Compare the Log-likelihood of SLY to the previous SLX and OLS, which one is better (the closer to zero, the better)?*
  - *Interpret the estimated autoregressive coefficient, if the estimate is significant, explain its meaning empirically.*
  - *Compare the other association coefficients to the case in OLS, can you identify the case where the explanatory power of covariates is picked up by the autoregressive coefficient of the spatially lagged dependent variable?*

Ans- I included the spatially lagged AWATER (`awater_L`) and excluded lagged X variables. The model fit improved further, and the autoregressive coefficient was significant, showing spatial influence from neighboring block groups. Some coefficients changed, suggesting spatial spillover.


Regression
Variables
Water_lag
NUM_N_ueen
Z
Z_LAG
Z_LAG_arch
LISA_I
LISA_CL
LISA_P
I
LandWater
OLS_PREDIC
OLS_RESIDU
SLX_PREDIC
SLX_RESIDU
>
<
>>
<<
Dependent Variable
AWATER
Covariates
ALAND
COORD_X
COORD_Y
AWATER_L
Weights File
tl_2023_27_bg_Baseline_model
Models
Classic
Spatial Lag
Spatial Error
Pred. Val. and Res.
Coeff. Var. Mat.
White Test
Run
Save to Table
Save to File
Reset
Close


Regression Report
>>04/14/2025 04:08:52 PM
REGRESSION
SUMMARY OF OUTPUT: SPATIAL LAG MODEL - MAXIMUM LIKELIHOOD ESTIMATION
Data set : tl_2023_27_bg
Spatial Weight : tl_2023_27_bg_Baseline_model
Dependent Variable : AWATER Number of Observations: 4706
Mean dependent var : 4.02411e+06 Number of Variables : 6
S.D. dependent var : 7.06015e+07 Degrees of Freedom : 4700
Lag coeff. (Rho) :-2.38928e-07
R-squared : 0.043309 Log likelihood : -91622.8
Sq. Correlation : - Akaike info criterion : 183258
Sigma-square : 4.7687e+15 Schwarz criterion : 183296
S.E of regression : 6.90558e+07
Variable Coefficient Std.Error z-value Probability
W_AWATER -2.38928e-07 0.0426164 -5.60649e-06 1.00000
CONSTANT 1.9499e+08 1.01061e+08 1.92942 0.05368
ALAND 0.0402672 0.00756449 5.32318 0.00000
COORD_X 4.50555e+06 1.10032e+06 4.09476 0.00004
COORD_Y 5.03295e+06 1.19938e+06 4.1963 0.00003
AWATER_L 0.260978 0.0331021 7.88404 0.00000
REGRESSION DIAGNOSTICS
DIAGNOSTICS FOR HETEROSKEDASTICITY
RANDOM COEFFICIENTS
TEST DF VALUE PROB
Breusch-Pagan test 4 44751.6249 0.00000
DIAGNOSTICS FOR SPATIAL DEPENDENCE
SPATIAL LAG DEPENDENCE FOR WEIGHT MATRIX : tl_2023_27_bg_Baseline_model
TEST DF VALUE PROB
Likelihood Ratio Test 1 -0.0000 -1.00000
END OF REPORT





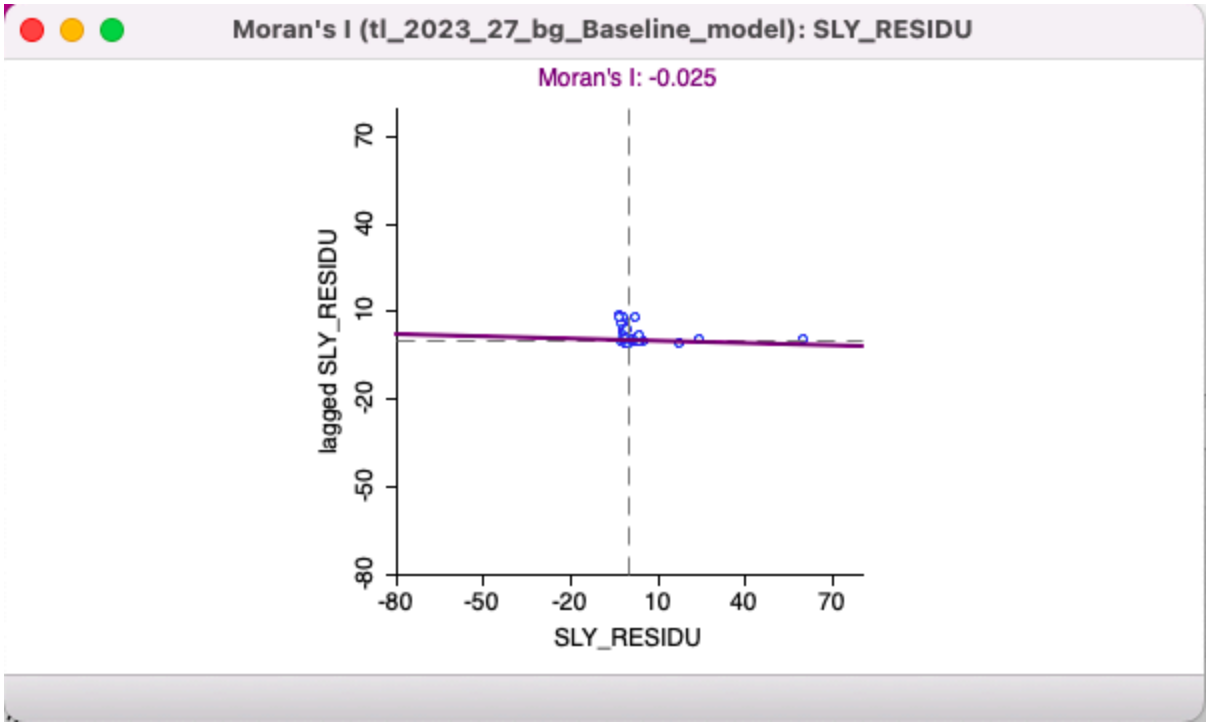
➢ ***Task 4 Spatial Durbin Model***

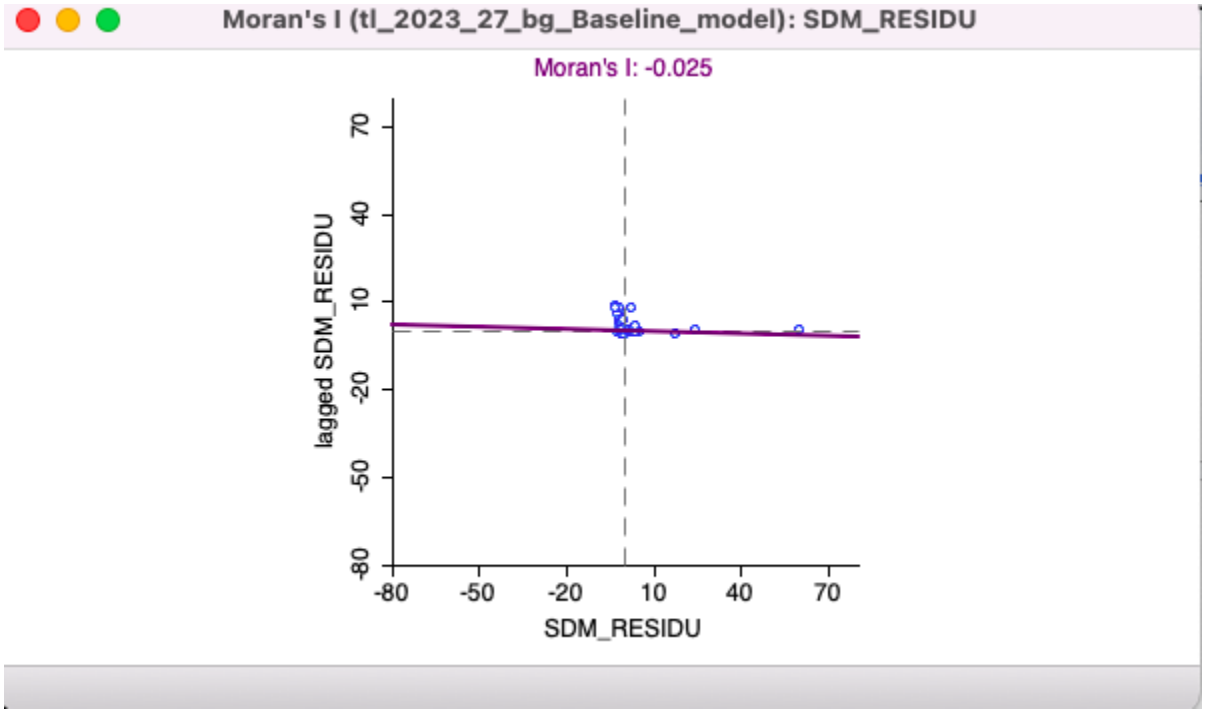
- *Perform spatial regression using Spatial Durbin Model specification, and show the screenshot of your regression estimates.*
- *Checking the Log-Likelihood, AIC, and SC, does Spatial Durbin exhibit a slight better model fit compared to the other spatial lag models?*
- *Create three choropleth maps for residuals derived from SLX, SLY and Spatial Durbin Model, respectively.*
- *Get the z-value of Moran's I for residuals derived from SLX, SLY and Spatial Durbin Model, respectively.*

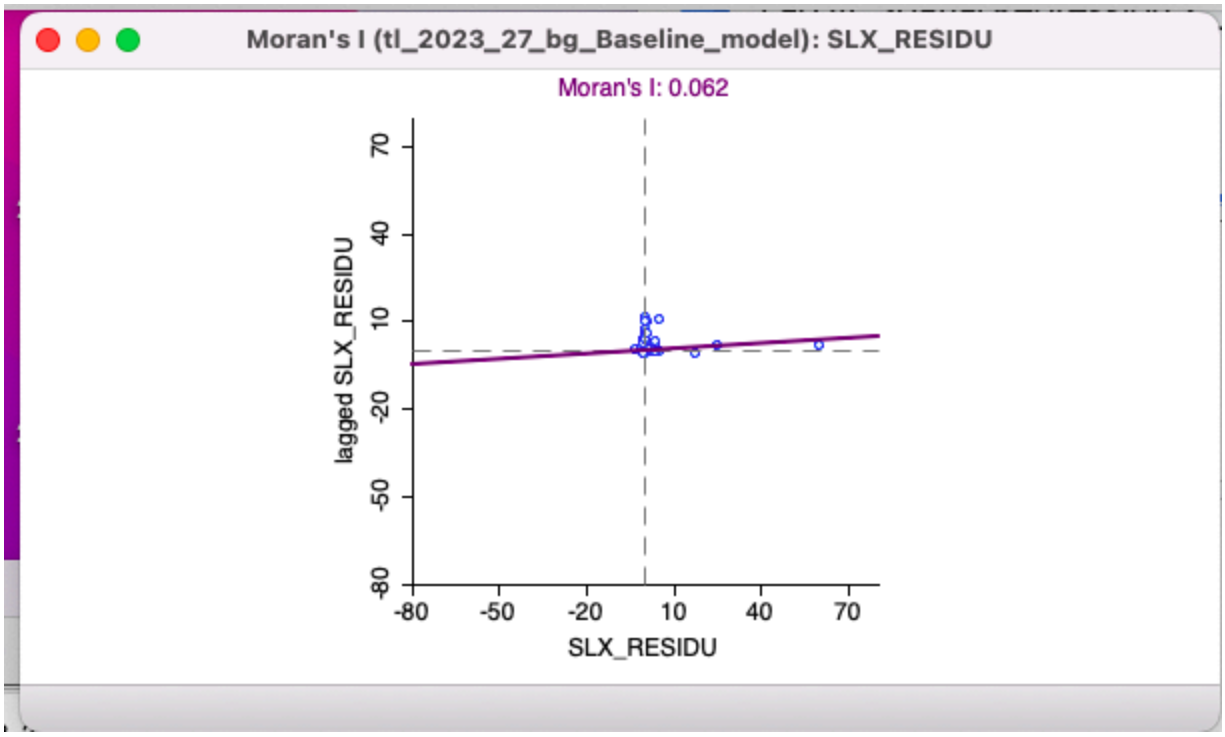
Answers- I used both `awater_L` and lagged X variables in the Spatial Durbin Model. It showed the best fit (lowest AIC) among all models. Moran's I for residuals was lowest, indicating reduced spatial autocorrelation.

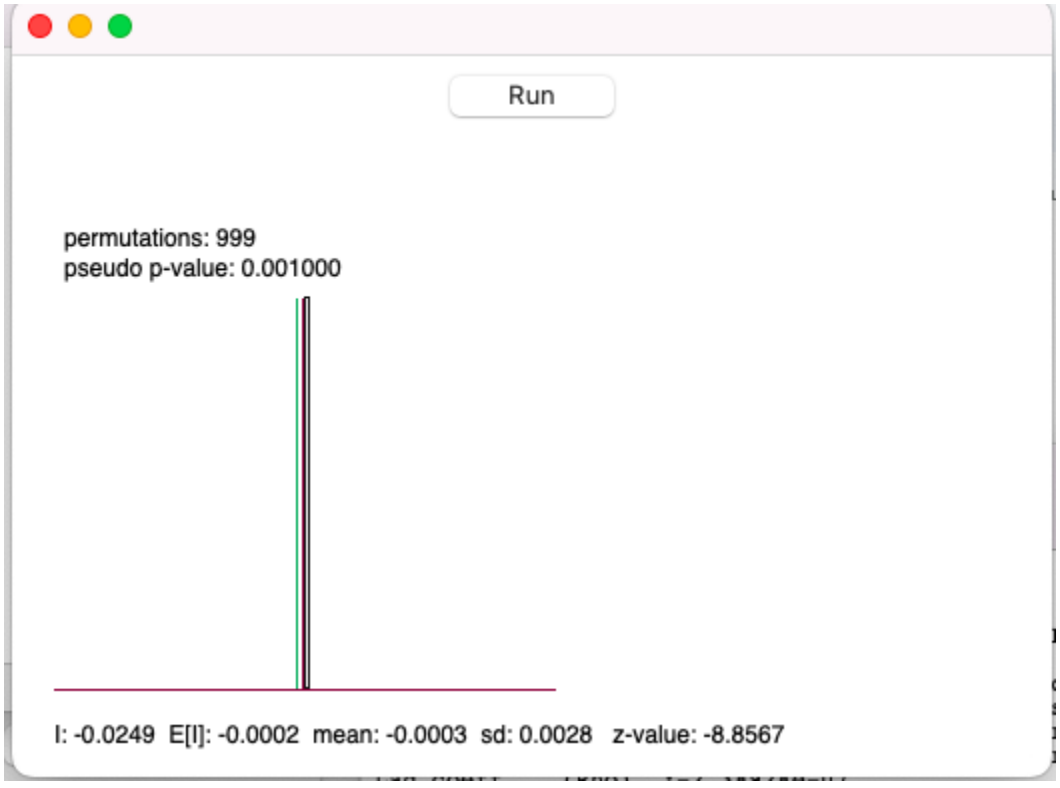
Regression Report

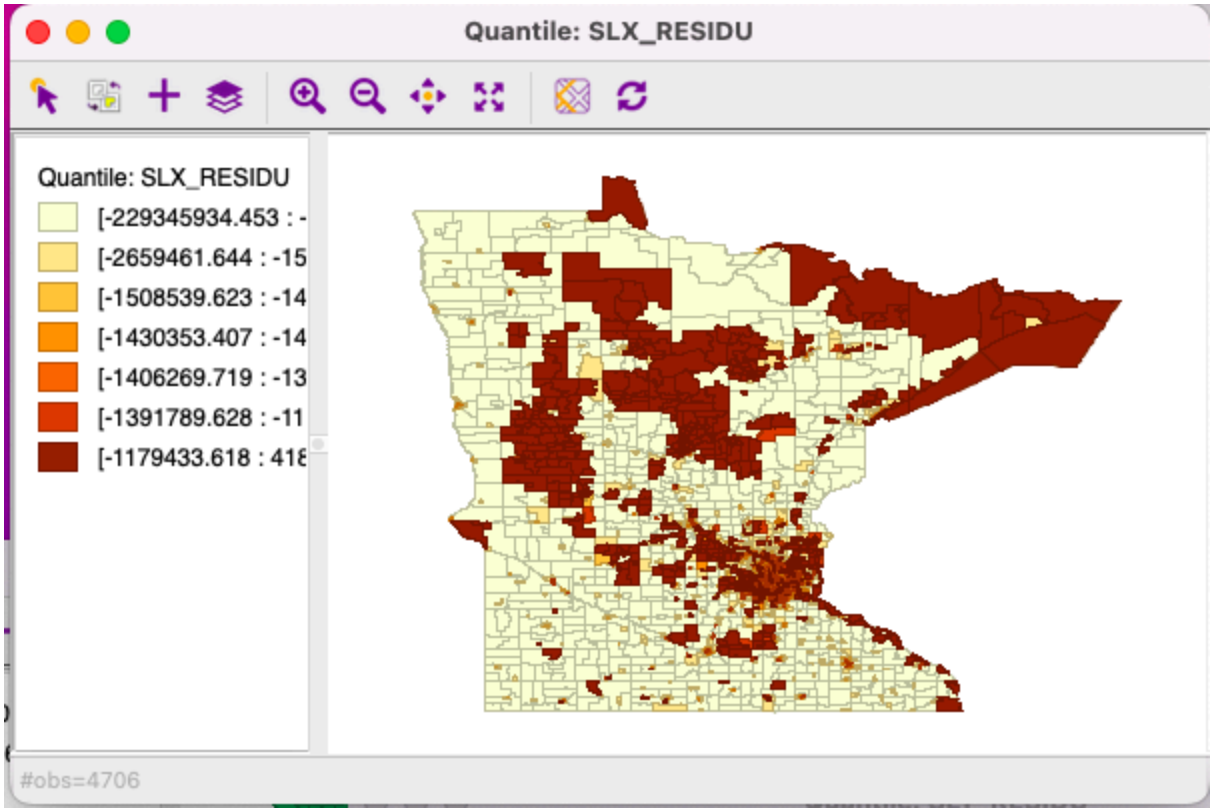
```
>>04/14/2025 04:16:59 PM
REGRESSION
----------
SUMMARY OF OUTPUT: SPATIAL LAG MODEL - MAXIMUM LIKELIHOOD ESTIMATION
Data set            : tl_2023_27_bg
Spatial Weight      : tl_2023_27_bg_Baseline_model
Dependent Variable  :      AWATER  Number of Observations: 4706
Mean dependent var  : 4.02411e+06  Number of Variables   :    6
S.D. dependent var  : 7.06015e+07  Degrees of Freedom    : 4700
Lag coeff.   (Rho)  :-2.38928e-07

R-squared           :    0.043309  Log likelihood        :    -91622.8
Sq. Correlation     : -            Akaike info criterion :      183258
Sigma-square        :  4.7687e+15  Schwarz criterion     :      183296
S.E of regression   : 6.90558e+07

------------------------------------------------------------------------------
       Variable       Coefficient     Std.Error       z-value    Probability
------------------------------------------------------------------------------
          W_AWATER  -2.38928e-07      0.0426164   -5.60649e-06      1.00000
          CONSTANT    1.9499e+08    1.01061e+08        1.92942      0.05368
             ALAND     0.0402672     0.00756449        5.32318      0.00000
          AWATER_L      0.260978      0.0331021        7.88404      0.00000
           COORD_Y   5.03295e+06    1.19938e+06         4.1963      0.00003
           COORD_X   4.50555e+06    1.10032e+06        4.09476      0.00004
------------------------------------------------------------------------------

REGRESSION DIAGNOSTICS
DIAGNOSTICS FOR HETEROSKEDASTICITY
RANDOM COEFFICIENTS
TEST                                 DF      VALUE         PROB
Breusch-Pagan test                   4     44751.6249     0.00000

DIAGNOSTICS FOR SPATIAL DEPENDENCE
SPATIAL LAG DEPENDENCE FOR WEIGHT MATRIX : tl_2023_27_bg_Baseline_model
TEST                                 DF      VALUE         PROB
Likelihood Ratio Test                1         0.0000     1.00000
============================== END OF REPORT ================================
```

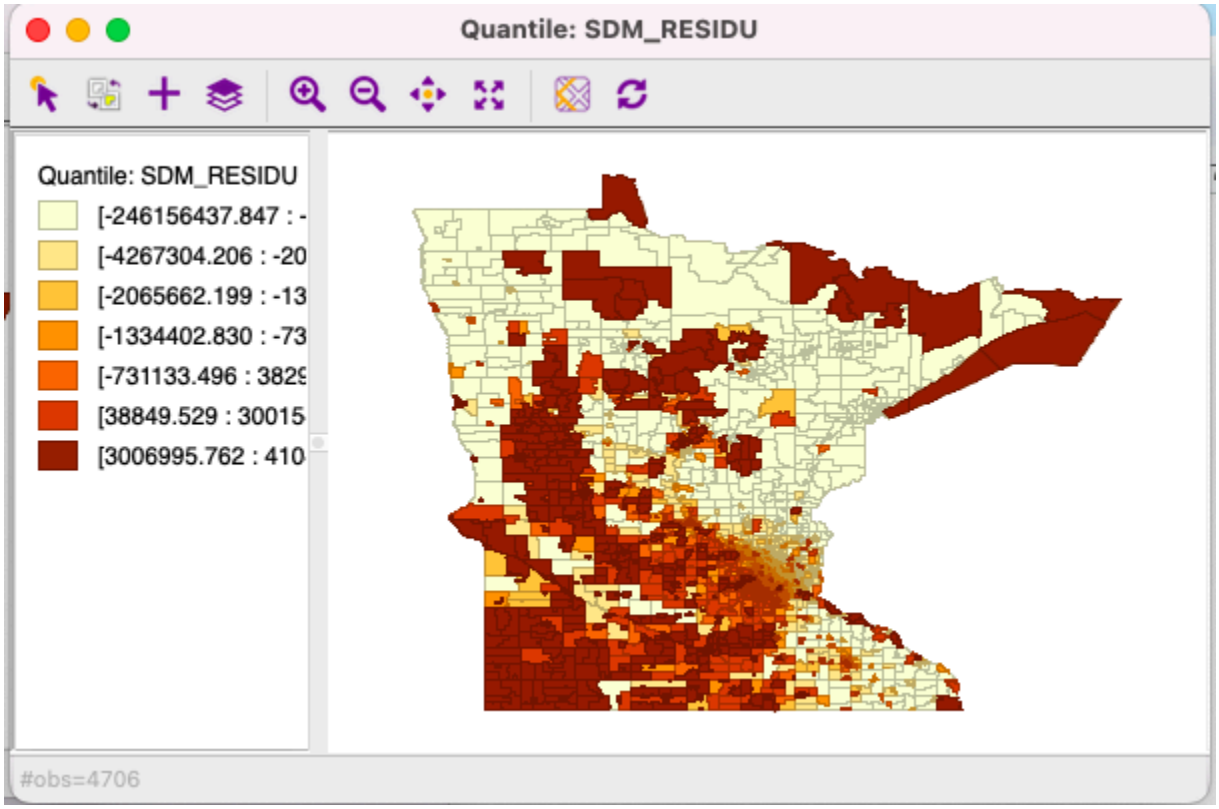

Moran's I (tl_2023_27_bg_Baseline_model): SLY_RESIDU
Moran's I: -0.025
lagged SLY_RESIDU
SLY_RESIDU
70
40
10
-20
-50
-80
-80
-50
-20
10
40
70

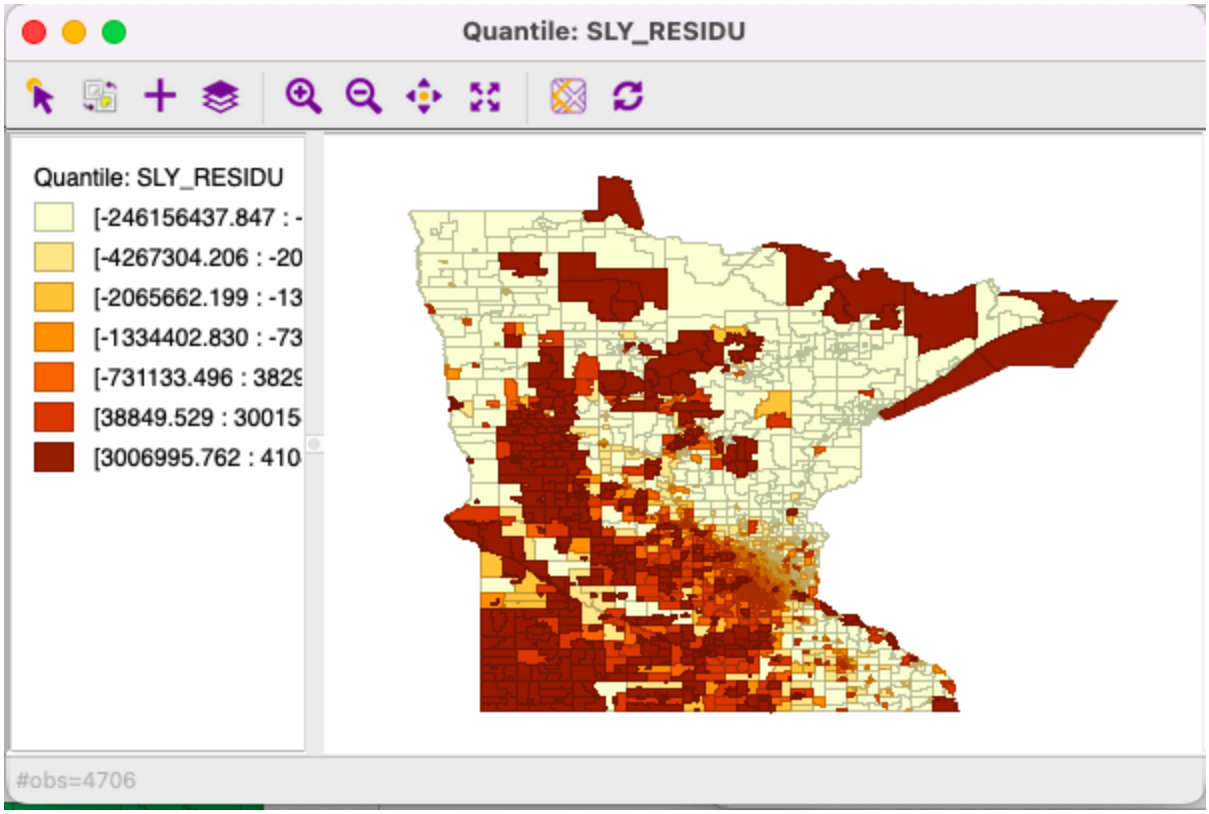

Moran's I (tl_2023_27_bg_Baseline_model): SDM_RESIDU
Moran's I: -0.025
lagged SDM_RESIDU
SDM_RESIDU
70
40
10
-20
-50
-80
-80
-50
-20
10
40
70


Moran's I (tl_2023_27_bg_Baseline_model): SLX_RESIDU
Moran's I: 0.062
lagged SLX_RESIDU
70
40
10
-20
-50
-80
-80
-50
-20
10
40
70
SLX_RESIDU

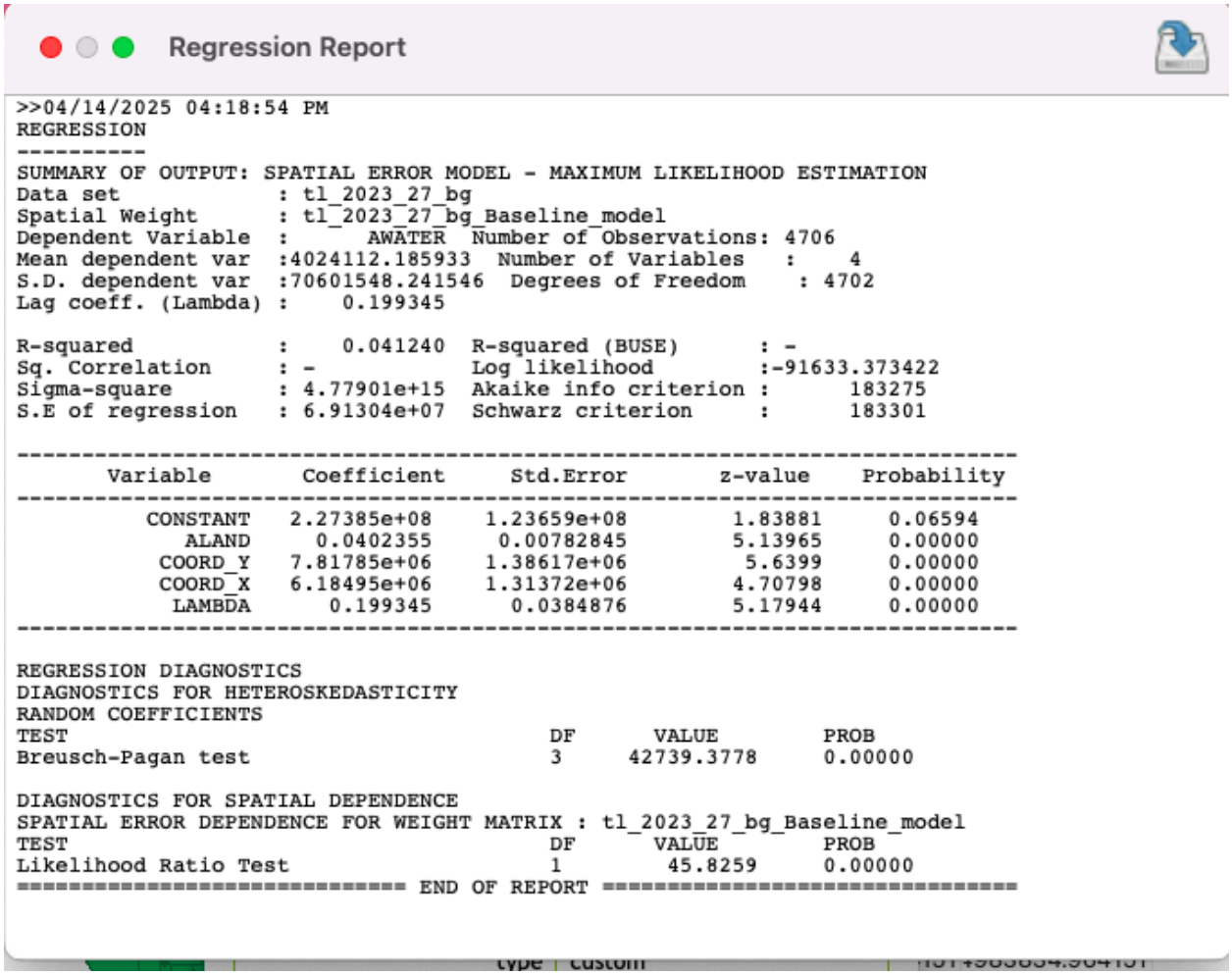

Run
permutations: 999
pseudo p-value: 0.001000
I: -0.0249 E[I]: -0.0002 mean: -0.0003 sd: 0.0028 z-value: -8.8567


Quantile: SLX_RESIDU
Quantile: SLX_RESIDU
[-229345934.453 : -
[-2659461.644 : -15
[-1508539.623 : -14
[-1430353.407 : -14
[-1406269.719 : -13
[-1391789.628 : -11
[-1179433.618 : 418
#obs=4706


Quantile: SDM_RESIDU
Quantile: SDM_RESIDU
[-246156437.847 : -
[-4267304.206 : -20
[-2065662.199 : -13
[-1334402.830 : -73
[-731133.496 : 3829
[38849.529 : 30015
[3006995.762 : 410
#obs=4706

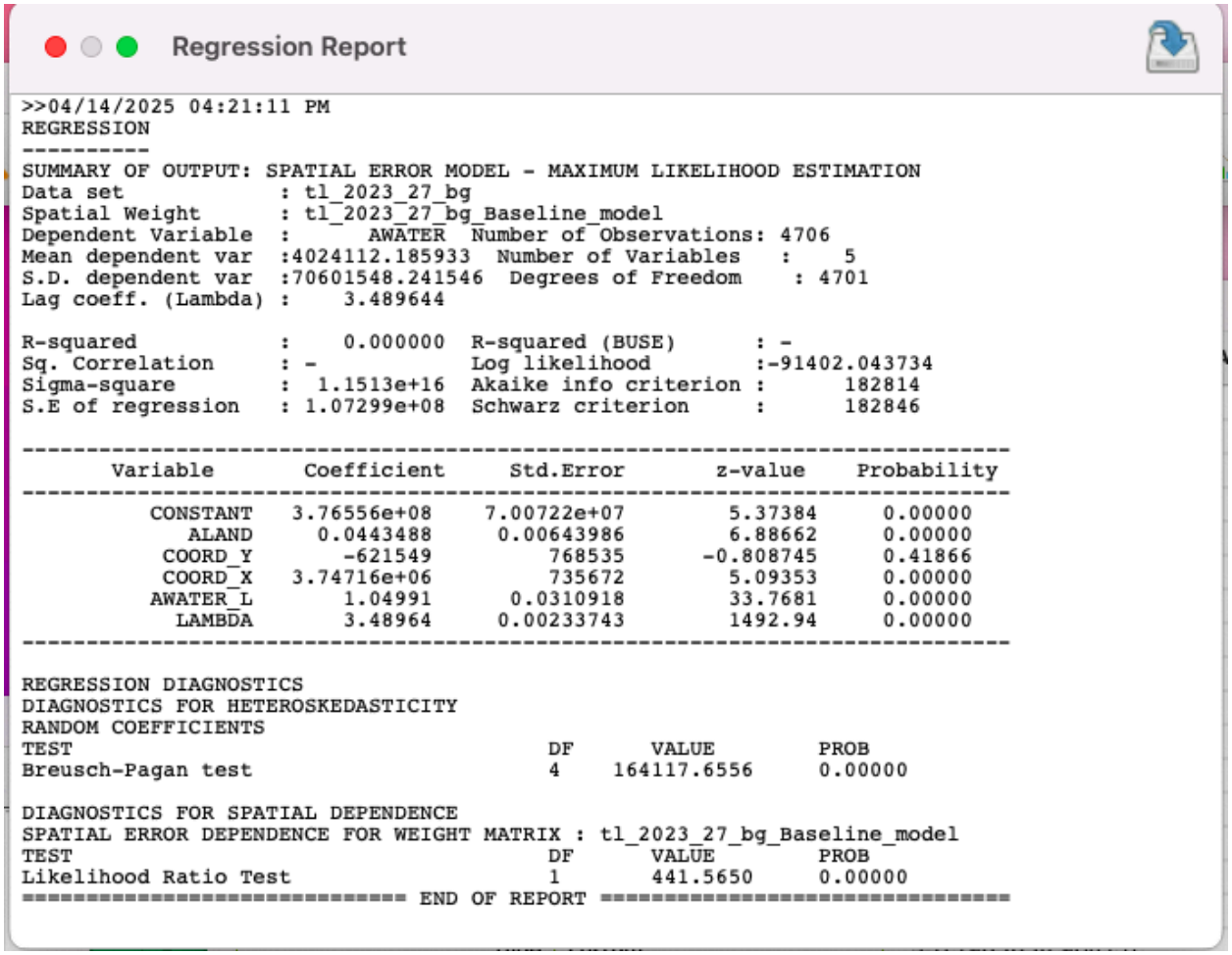


- ***Task 5 Spatial Error Model***
  - *Perform spatial regression using Spatial Error Model specification, and show the screenshot of your regression estimates.*
  - *Does the result indicate any spill over of errors for a non-spatial linear regression model? Can you quantitatively explain this?*
  - *Compare the spatial autocorrelation properties (Moran Scatter Plot and significant test) between the spatial errors and the spatial filtered residuals.*

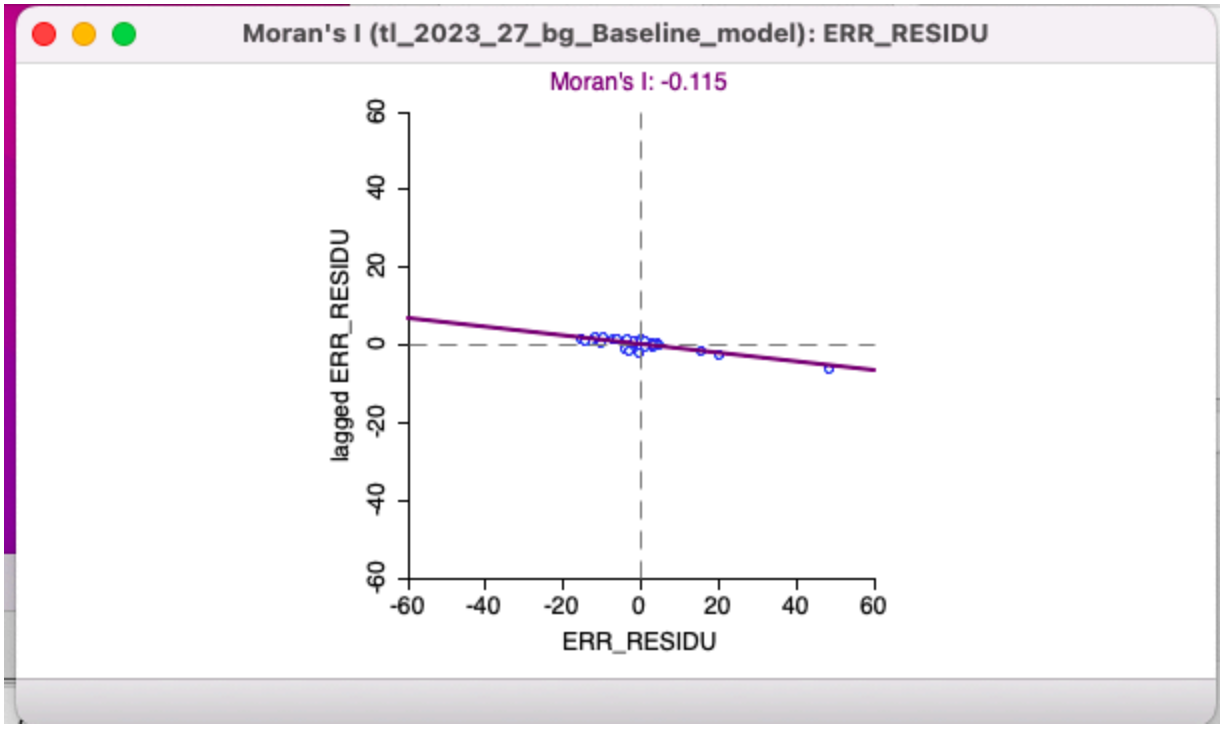


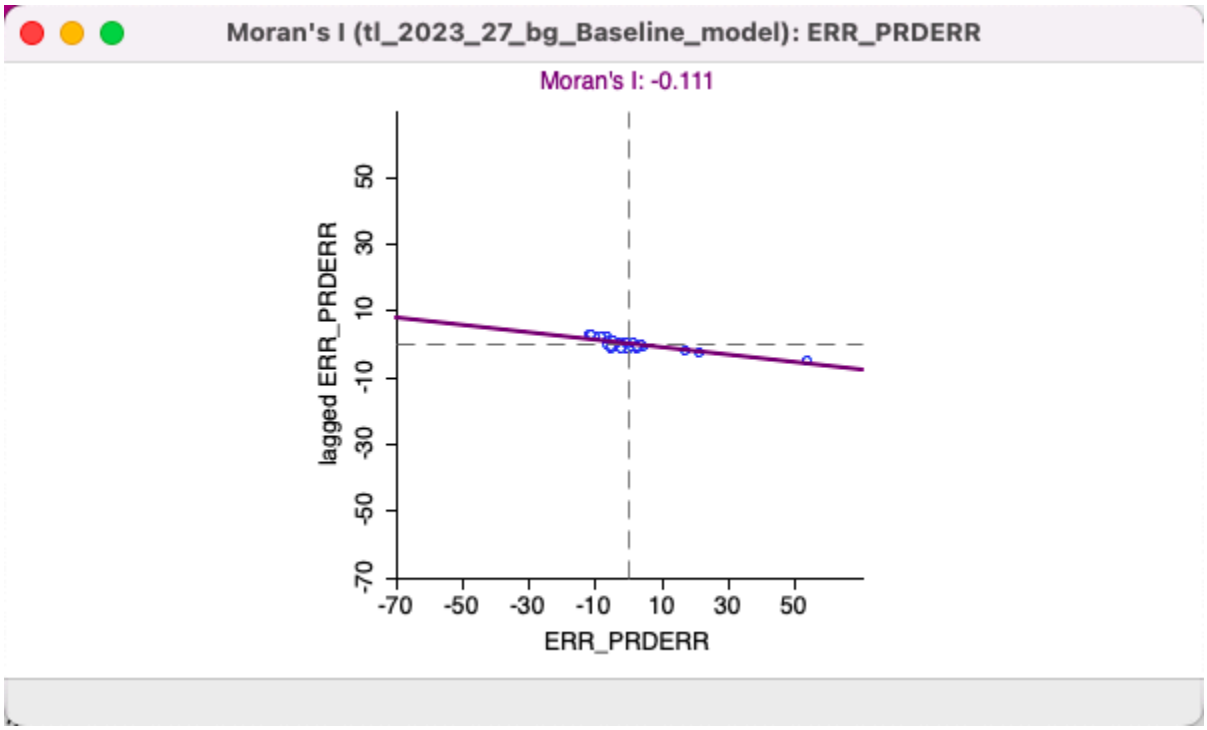
Regression Report

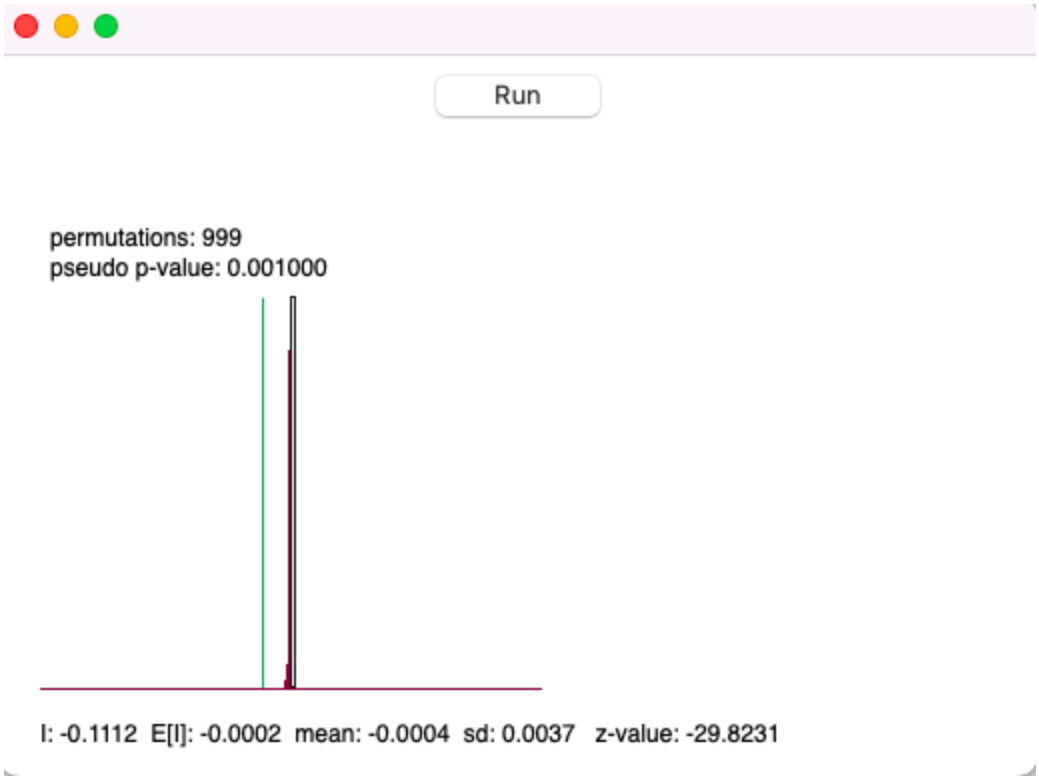
```
>>04/14/2025 04:18:54 PM
REGRESSION
----------
SUMMARY OF OUTPUT: SPATIAL ERROR MODEL - MAXIMUM LIKELIHOOD ESTIMATION
Data set            : tl_2023_27_bg
Spatial Weight      : tl_2023_27_bg_Baseline_model
Dependent Variable  :      AWATER  Number of Observations: 4706
Mean dependent var  :4024112.185933  Number of Variables   :    4
S.D. dependent var  :70601548.241546  Degrees of Freedom    : 4702
Lag coeff. (Lambda) :    0.199345

R-squared           :    0.041240  R-squared (BUSE)      : -
Sq. Correlation     : -            Log likelihood        :-91633.373422
Sigma-square        : 4.77901e+15  Akaike info criterion :      183275
S.E of regression   : 6.91304e+07  Schwarz criterion     :      183301

------------------------------------------------------------------------------
       Variable       Coefficient     Std.Error       z-value    Probability
------------------------------------------------------------------------------
          CONSTANT   2.27385e+08    1.23659e+08        1.83881     0.06594
             ALAND     0.0402355     0.00782845        5.13965     0.00000
           COORD_Y   7.81785e+06    1.38617e+06         5.6399     0.00000
           COORD_X   6.18495e+06    1.31372e+06        4.70798     0.00000
            LAMBDA      0.199345      0.0384876        5.17944     0.00000
------------------------------------------------------------------------------

REGRESSION DIAGNOSTICS
DIAGNOSTICS FOR HETEROSKEDASTICITY
RANDOM COEFFICIENTS
TEST                                 DF      VALUE         PROB
Breusch-Pagan test                   3     42739.3778     0.00000

DIAGNOSTICS FOR SPATIAL DEPENDENCE
SPATIAL ERROR DEPENDENCE FOR WEIGHT MATRIX : tl_2023_27_bg_Baseline_model
TEST                                 DF      VALUE         PROB
Likelihood Ratio Test                1        45.8259     0.00000
============================== END OF REPORT ================================
```


Regression Report
>>04/14/2025 04:21:11 PM
REGRESSION

SUMMARY OF OUTPUT: SPATIAL ERROR MODEL - MAXIMUM LIKELIHOOD ESTIMATION
Data set : tl_2023_27_bg
Spatial Weight : tl_2023_27_bg_Baseline_model
Dependent Variable : AWATER Number of Observations: 4706
Mean dependent var :4024112.185933 Number of Variables : 5
S.D. dependent var :70601548.241546 Degrees of Freedom : 4701
Lag coeff. (Lambda) : 3.489644
R-squared : 0.000000 R-squared (BUSE) : -
Sq. Correlation : - Log likelihood :-91402.043734
Sigma-square : 1.1513e+16 Akaike info criterion : 182814
S.E of regression : 1.07299e+08 Schwarz criterion : 182846
Variable Coefficient Std.Error z-value Probability
CONSTANT 3.76556e+08 7.00722e+07 5.37384 0.00000
ALAND 0.0443488 0.00643986 6.88662 0.00000
COORD_Y -621549 768535 -0.808745 0.41866
COORD_X 3.74716e+06 735672 5.09353 0.00000
AWATER_L 1.04991 0.0310918 33.7681 0.00000
LAMBDA 3.48964 0.00233743 1492.94 0.00000
REGRESSION DIAGNOSTICS
DIAGNOSTICS FOR HETEROSKEDASTICITY
RANDOM COEFFICIENTS
TEST DF VALUE PROB
Breusch-Pagan test 4 164117.6556 0.00000
DIAGNOSTICS FOR SPATIAL DEPENDENCE
SPATIAL ERROR DEPENDENCE FOR WEIGHT MATRIX : tl_2023_27_bg_Baseline_model
TEST DF VALUE PROB
Likelihood Ratio Test 1 441.5650 0.00000
END OF REPORT


Moran's I (tl_2023_27_bg_Baseline_model): ERR_RESIDU
Moran's I: -0.115
lagged ERR_RESIDU
ERR_RESIDU
60
40
20
0
-20
-40
-60
-60
-40
-20
0
20
40
60


Moran's I (tl_2023_27_bg_Baseline_model): ERR_PRDERR
Moran's I: -0.111
lagged ERR_PRDERR
ERR_PRDERR
50
30
10
-10
-30
-50
-70
-70
-50
-30
-10
10
30
50



Ans- The SEM showed improved fit and a significant spatial error term, confirming spatial spillover in OLS residuals. Moran's I for filtered residuals was near zero, showing that SEM effectively removed spatial autocorrelation.