Regression_BH

2023-02-09

Run BH

```
library(tidyverse)
```

```
## -- Attaching packages --------------------------------------- tidyverse 1.3.2 --
## v ggplot2 3.4.0      v purrr   1.0.1
## v tibble  3.1.8      v dplyr   1.0.10
## v tidyr   1.3.0      v stringr 1.5.0
## v readr   2.1.3      v forcats 0.5.2
## -- Conflicts ------------------------------------------ tidyverse_conflicts() --
## x dplyr::filter() masks stats::filter()
## x dplyr::lag()    masks stats::lag()
```

```
results <- read.csv("p_values_weather_regression.csv")
```

```
#get p values
P <- results$p_values

#set alpha = 0.1
alpha = 0.1
BH_thres <- (1:length(results$p_values))*alpha/length(results$p_values)
sorted_idx <- order(P)
cutoff <- max(which(P[sorted_idx]<BH_thres))-1
idx_rej_BH <- sorted_idx[1:cutoff]
idx_rej_BH
```

```
##   [1]  477  452  480  276 1569 1302 1660  173 1280 1191 1107 1132 1244  648   58
##  [16] 1686 1203  851 1565  716 1477  370  552 1568  403 1446  904 1205   14 1347
##  [31] 1793 1615 1768  634  331  983 1117  780   57  991  927  352  471 1648  223
##  [46] 1175  353 1878  401   37 1122  508  318 1661  911  326  645  971  742 1610
##  [61]  356  453   48 1596 1594  872  177 1587 1472 1354  122  595  239 1269  284
##  [76]  633 1773  704  977 1671  768 1602 1505  873 1396 1801  110  186  583  998
##  [91]  103 1744 1414  512 1647   13  655  127 1308 1521  407  856 1216    2 1335
## [106]   46  577 1290  559 1592  485 1305  125  638   70 1510  273 1338  929 1032
## [121] 1436 1728 1023  404 1337 1022  630  464 1871  713  787 1856  931 1634 1523
## [136] 1314 1873 1516   22 1518 1427  659  511 1645 1738   65 1782  830 1558  663
## [151] 1085  627 1670   33 1405
```

```
selected_routes <- results[idx_rej_BH,]
selected_routes
```

```
##           routes count     p_values
## 477  31200-31222   717 4.481438e-11
## 452  31200-31105   750 1.496181e-08
## 480  31200-31225  1855 2.063515e-06
## 276  31105-31236   205 2.700694e-06
## 1569 31602-31106   608 3.270587e-06
```

```
## 1302 31232-31218   401 4.419167e-06
## 1660 31606-31607   285 5.701103e-06
## 173  31102-31221   314 1.205561e-05
## 1280 31231-31101   251 1.440717e-05
## 1191 31228-31217   482 1.647314e-05
## 1107 31225-31014   552 2.021604e-05
## 1132 31225-31235   314 2.058153e-05
## 1244 31229-31225   394 2.913200e-05
## 648  31204-31225   291 3.194106e-05
## 58   31011-31007  1468 3.281291e-05
## 1686 31608-31606   452 4.037432e-05
## 1203 31228-31235   291 4.340046e-05
## 851  31215-31205   489 5.933020e-05
## 1565 31602-31102   949 6.333201e-05
## 716  31207-31223   339 6.591878e-05
## 1477 31400-31201   274 7.625416e-05
## 370  31109-31600   280 7.721153e-05
## 552  31201-31604   505 8.524062e-05
## 1568 31602-31105   457 9.521942e-05
## 403  31110-31233   360 9.794176e-05
## 1446 31302-31305  1275 1.007469e-04
## 904  31217-31235  1170 1.266576e-04
## 1205 31228-31238   581 1.416149e-04
## 14   31003-31003   623 1.579899e-04
## 1347 31235-31218   563 1.602577e-04
## 1793 31618-31620   477 1.666264e-04
## 1615 31604-31205   260 1.698816e-04
## 1768 31616-31623  1002 2.155653e-04
## 634  31204-31200   971 2.576762e-04
## 331  31107-31400   305 2.611443e-04
## 983  31220-31221   254 2.621088e-04
## 1117 31225-31204   267 2.806419e-04
## 780  31213-31206   343 2.817897e-04
## 57   31011-31003   342 2.937821e-04
## 991  31220-31619   210 2.983683e-04
## 927  31218-31238   238 3.049376e-04
## 352  31108-31623   403 3.268216e-04
## 471  31200-31216   288 3.471354e-04
## 1648 31605-31613  1015 3.513279e-04
## 223  31104-31202   329 3.544408e-04
## 1175 31228-31103   220 3.549447e-04
## 353  31108-31624   367 4.061621e-04
## 1878 31623-31222   266 4.092722e-04
## 401  31110-31228   439 4.305333e-04
## 37   31007-31013   830 4.390265e-04
## 1122 31225-31215   604 4.400473e-04
## 508  31201-31101  2000 4.596204e-04
## 318  31107-31201   568 4.613183e-04
## 1661 31606-31608   504 4.792710e-04
## 911  31217-31618   450 5.141052e-04
## 326  31107-31217   231 5.151806e-04
## 645  31204-31221   314 5.160211e-04
## 971  31220-31110   259 5.281792e-04
## 742  31212-31109   284 5.469695e-04
```

```
## 1610 31603-31624   414 6.009577e-04
## 356  31109-31200   944 6.111609e-04
## 453  31200-31106   900 6.183295e-04
## 48   31009-31010   668 6.427509e-04
## 1596 31603-31203   355 6.784930e-04
## 1594 31603-31108   207 7.348403e-04
## 872  31216-31217   278 7.566245e-04
## 177  31102-31229   383 7.603454e-04
## 1587 31602-31230   211 7.785201e-04
## 1472 31400-31106   315 9.321263e-04
## 1354 31235-31235  2142 1.051520e-03
## 122  31101-31110   905 1.059694e-03
## 595  31203-31200  1998 1.151302e-03
## 239  31104-31227   249 1.251487e-03
## 1269 31230-31228   430 1.266044e-03
## 284  31106-31104  4817 1.325422e-03
## 633  31204-31110   277 1.418180e-03
## 1773 31617-31623   838 1.426548e-03
## 704  31206-31213   338 1.445223e-03
## 977  31220-31213   297 1.535012e-03
## 1671 31607-31601   245 1.555600e-03
## 768  31212-31600   255 1.575664e-03
## 1602 31603-31600   685 1.600778e-03
## 1505 31503-31202   559 1.612184e-03
## 873  31216-31219   274 1.643351e-03
## 1396 31237-31237  1360 1.703439e-03
## 1801 31619-31220   258 1.732439e-03
## 110  31100-31600   406 1.831581e-03
## 186  31103-31106  1155 1.841681e-03
## 583  31202-31600   204 1.870337e-03
## 998  31221-31110   683 1.897120e-03
## 103  31100-31228   465 1.929246e-03
## 1744 31613-31616   621 2.023654e-03
## 1414 31238-31228   559 2.184968e-03
## 512  31201-31105   534 2.313457e-03
## 1647 31605-31611   307 2.588989e-03
## 13   31003-31002   243 2.690980e-03
## 655  31205-31101   346 2.749896e-03
## 127  31101-31203  1436 2.846812e-03
## 1308 31232-31230   507 2.905378e-03
## 1521 31503-31620   410 2.982326e-03
## 407  31110-31305   221 3.042466e-03
## 856  31215-31217   410 3.080969e-03
## 1216 31228-31623   690 3.099624e-03
## 2    31001-31001   282 3.116730e-03
## 1335 31233-31624   257 3.237733e-03
## 46   31009-31007  2170 3.276752e-03
## 577  31202-31228   380 3.279258e-03
## 1290 31231-31623   234 3.421466e-03
## 559  31202-31105   353 3.425600e-03
## 1592 31602-31602   415 3.518394e-03
## 485  31200-31230   401 3.541542e-03
## 1305 31232-31223   280 3.551249e-03
## 125  31101-31201  2038 3.647478e-03
```

```
## 638  31204-31205  1118 3.794596e-03
## 70   31014-31215   265 3.863369e-03
## 1510 31503-31216   387 3.877829e-03
## 273  31105-31227   277 3.878712e-03
## 1338 31235-31201   203 3.885873e-03
## 929  31218-31609   625 3.905146e-03
## 1032 31222-31204   215 3.951263e-03
## 1436 31301-31303  1266 4.128418e-03
## 1728 31611-31623  2206 4.246186e-03
## 1023 31221-31602   265 4.490034e-03
## 404  31110-31235   203 4.509477e-03
## 1337 31235-31200   507 4.552036e-03
## 1022 31221-31600   284 4.647569e-03
## 630  31203-31624   392 4.695982e-03
## 464  31200-31205  2012 4.747540e-03
## 1871 31623-31205   301 4.860777e-03
## 713  31207-31110   224 4.903423e-03
## 787  31213-31223   399 5.080080e-03
## 1856 31622-31610   613 5.104332e-03
## 931  31218-31616   202 5.232764e-03
## 1634 31604-31624   816 5.240345e-03
## 1523 31503-31624   504 5.320830e-03
## 1314 31232-31604   311 5.369558e-03
## 1873 31623-31209   218 5.439490e-03
## 1516 31503-31503   326 5.775262e-03
## 22   31005-31005   290 5.839216e-03
## 1518 31503-31603   467 5.962431e-03
## 1427 31300-31200   415 6.069641e-03
## 659  31205-31106   236 6.171013e-03
## 511  31201-31104   718 6.227164e-03
## 1645 31605-31608   225 6.263739e-03
## 1738 31613-31606  1986 6.439330e-03
## 65   31013-31007   932 6.479887e-03
## 1782 31618-31601   345 6.581635e-03
## 830  31214-31228   572 6.607610e-03
## 1558 31600-31620  1306 6.611281e-03
## 663  31205-31111   212 6.795112e-03
## 1085 31224-31104   331 6.813383e-03
## 627  31203-31604   351 6.992589e-03
## 1670 31607-31208   208 7.267483e-03
## 33   31007-31009  2621 7.437546e-03
## 1405 31238-31204   200 7.501822e-03
```

Run Storey BH

```
Storey_BH <- function(P,alpha,gamma){
  pi_0_hat <- (sum(P>gamma))/(length(P)*(1-gamma))
  Storey_thres <- (1:length(P))*alpha/(length(P)*pi_0_hat)
  sorted_idx <- order(P)
  cutoff <- max(which(P[sorted_idx]<Storey_thres))
  idx_rej <- sorted_idx[1:cutoff]
  idx_rej
}
```

```
idx_rej_SBH <- Storey_BH(P, 0.1, 0.5)
```

Select the Routes by Storey BH

```
idx_rej_SBH
```

```
##   [1]  477  452  480  276 1569 1302 1660  173 1280 1191 1107 1132 1244  648   58
##  [16] 1686 1203  851 1565  716 1477  370  552 1568  403 1446  904 1205   14 1347
##  [31] 1793 1615 1768  634  331  983 1117  780   57  991  927  352  471 1648  223
##  [46] 1175  353 1878  401   37 1122  508  318 1661  911  326  645  971  742 1610
##  [61]  356  453   48 1596 1594  872  177 1587 1472 1354  122  595  239 1269  284
##  [76]  633 1773  704  977 1671  768 1602 1505  873 1396 1801  110  186  583  998
##  [91]  103 1744 1414  512 1647   13  655  127 1308 1521  407  856 1216    2 1335
## [106]   46  577 1290  559 1592  485 1305  125  638   70 1510  273 1338  929 1032
## [121] 1436 1728 1023  404 1337 1022  630  464 1871  713  787 1856  931 1634 1523
## [136] 1314 1873 1516   22 1518 1427  659  511 1645 1738   65 1782  830 1558  663
## [151] 1085  627 1670   33 1405  400  470 1805  149    4  896   86  396  550  604
## [166]  439  456  838  382 1896  620  985 1585  732 1682  816  941  554  221 1814
## [181]  623
```

```
selected_routes_SBH <- results[idx_rej_SBH,]
selected_routes_SBH
```

```
##           routes count     p_values
## 477  31200-31222   717 4.481438e-11
## 452  31200-31105   750 1.496181e-08
## 480  31200-31225  1855 2.063515e-06
## 276  31105-31236   205 2.700694e-06
## 1569 31602-31106   608 3.270587e-06
## 1302 31232-31218   401 4.419167e-06
## 1660 31606-31607   285 5.701103e-06
## 173  31102-31221   314 1.205561e-05
## 1280 31231-31101   251 1.440717e-05
## 1191 31228-31217   482 1.647314e-05
## 1107 31225-31014   552 2.021604e-05
## 1132 31225-31235   314 2.058153e-05
## 1244 31229-31225   394 2.913200e-05
## 648  31204-31225   291 3.194106e-05
## 58   31011-31007  1468 3.281291e-05
## 1686 31608-31606   452 4.037432e-05
## 1203 31228-31235   291 4.340046e-05
## 851  31215-31205   489 5.933020e-05
## 1565 31602-31102   949 6.333201e-05
## 716  31207-31223   339 6.591878e-05
## 1477 31400-31201   274 7.625416e-05
## 370  31109-31600   280 7.721153e-05
## 552  31201-31604   505 8.524062e-05
## 1568 31602-31105   457 9.521942e-05
## 403  31110-31233   360 9.794176e-05
## 1446 31302-31305  1275 1.007469e-04
## 904  31217-31235  1170 1.266576e-04
## 1205 31228-31238   581 1.416149e-04
## 14   31003-31003   623 1.579899e-04
```

```
## 1347 31235-31218   563 1.602577e-04
## 1793 31618-31620   477 1.666264e-04
## 1615 31604-31205   260 1.698816e-04
## 1768 31616-31623  1002 2.155653e-04
## 634  31204-31200   971 2.576762e-04
## 331  31107-31400   305 2.611443e-04
## 983  31220-31221   254 2.621088e-04
## 1117 31225-31204   267 2.806419e-04
## 780  31213-31206   343 2.817897e-04
## 57   31011-31003   342 2.937821e-04
## 991  31220-31619   210 2.983683e-04
## 927  31218-31238   238 3.049376e-04
## 352  31108-31623   403 3.268216e-04
## 471  31200-31216   288 3.471354e-04
## 1648 31605-31613  1015 3.513279e-04
## 223  31104-31202   329 3.544408e-04
## 1175 31228-31103   220 3.549447e-04
## 353  31108-31624   367 4.061621e-04
## 1878 31623-31222   266 4.092722e-04
## 401  31110-31228   439 4.305333e-04
## 37   31007-31013   830 4.390265e-04
## 1122 31225-31215   604 4.400473e-04
## 508  31201-31101  2000 4.596204e-04
## 318  31107-31201   568 4.613183e-04
## 1661 31606-31608   504 4.792710e-04
## 911  31217-31618   450 5.141052e-04
## 326  31107-31217   231 5.151806e-04
## 645  31204-31221   314 5.160211e-04
## 971  31220-31110   259 5.281792e-04
## 742  31212-31109   284 5.469695e-04
## 1610 31603-31624   414 6.009577e-04
## 356  31109-31200   944 6.111609e-04
## 453  31200-31106   900 6.183295e-04
## 48   31009-31010   668 6.427509e-04
## 1596 31603-31203   355 6.784930e-04
## 1594 31603-31108   207 7.348403e-04
## 872  31216-31217   278 7.566245e-04
## 177  31102-31229   383 7.603454e-04
## 1587 31602-31230   211 7.785201e-04
## 1472 31400-31106   315 9.321263e-04
## 1354 31235-31235  2142 1.051520e-03
## 122  31101-31110   905 1.059694e-03
## 595  31203-31200  1998 1.151302e-03
## 239  31104-31227   249 1.251487e-03
## 1269 31230-31228   430 1.266044e-03
## 284  31106-31104  4817 1.325422e-03
## 633  31204-31110   277 1.418180e-03
## 1773 31617-31623   838 1.426548e-03
## 704  31206-31213   338 1.445223e-03
## 977  31220-31213   297 1.535012e-03
## 1671 31607-31601   245 1.555600e-03
## 768  31212-31600   255 1.575664e-03
## 1602 31603-31600   685 1.600778e-03
## 1505 31503-31202   559 1.612184e-03
```

```
## 873  31216-31219   274 1.643351e-03
## 1396 31237-31237  1360 1.703439e-03
## 1801 31619-31220   258 1.732439e-03
## 110  31100-31600   406 1.831581e-03
## 186  31103-31106  1155 1.841681e-03
## 583  31202-31600   204 1.870337e-03
## 998  31221-31110   683 1.897120e-03
## 103  31100-31228   465 1.929246e-03
## 1744 31613-31616   621 2.023654e-03
## 1414 31238-31228   559 2.184968e-03
## 512  31201-31105   534 2.313457e-03
## 1647 31605-31611   307 2.588989e-03
## 13   31003-31002   243 2.690980e-03
## 655  31205-31101   346 2.749896e-03
## 127  31101-31203  1436 2.846812e-03
## 1308 31232-31230   507 2.905378e-03
## 1521 31503-31620   410 2.982326e-03
## 407  31110-31305   221 3.042466e-03
## 856  31215-31217   410 3.080969e-03
## 1216 31228-31623   690 3.099624e-03
## 2    31001-31001   282 3.116730e-03
## 1335 31233-31624   257 3.237733e-03
## 46   31009-31007  2170 3.276752e-03
## 577  31202-31228   380 3.279258e-03
## 1290 31231-31623   234 3.421466e-03
## 559  31202-31105   353 3.425600e-03
## 1592 31602-31602   415 3.518394e-03
## 485  31200-31230   401 3.541542e-03
## 1305 31232-31223   280 3.551249e-03
## 125  31101-31201  2038 3.647478e-03
## 638  31204-31205  1118 3.794596e-03
## 70   31014-31215   265 3.863369e-03
## 1510 31503-31216   387 3.877829e-03
## 273  31105-31227   277 3.878712e-03
## 1338 31235-31201   203 3.885873e-03
## 929  31218-31609   625 3.905146e-03
## 1032 31222-31204   215 3.951263e-03
## 1436 31301-31303  1266 4.128418e-03
## 1728 31611-31623  2206 4.246186e-03
## 1023 31221-31602   265 4.490034e-03
## 404  31110-31235   203 4.509477e-03
## 1337 31235-31200   507 4.552036e-03
## 1022 31221-31600   284 4.647569e-03
## 630  31203-31624   392 4.695982e-03
## 464  31200-31205  2012 4.747540e-03
## 1871 31623-31205   301 4.860777e-03
## 713  31207-31110   224 4.903423e-03
## 787  31213-31223   399 5.080080e-03
## 1856 31622-31610   613 5.104332e-03
## 931  31218-31616   202 5.232764e-03
## 1634 31604-31624   816 5.240345e-03
## 1523 31503-31624   504 5.320830e-03
## 1314 31232-31604   311 5.369558e-03
## 1873 31623-31209   218 5.439490e-03
```

```
## 1516 31503-31503   326 5.775262e-03
## 22   31005-31005   290 5.839216e-03
## 1518 31503-31603   467 5.962431e-03
## 1427 31300-31200   415 6.069641e-03
## 659  31205-31106   236 6.171013e-03
## 511  31201-31104   718 6.227164e-03
## 1645 31605-31608   225 6.263739e-03
## 1738 31613-31606  1986 6.439330e-03
## 65   31013-31007   932 6.479887e-03
## 1782 31618-31601   345 6.581635e-03
## 830  31214-31228   572 6.607610e-03
## 1558 31600-31620  1306 6.611281e-03
## 663  31205-31111   212 6.795112e-03
## 1085 31224-31104   331 6.813383e-03
## 627  31203-31604   351 6.992589e-03
## 1670 31607-31208   208 7.267483e-03
## 33   31007-31009  2621 7.437546e-03
## 1405 31238-31204   200 7.501822e-03
## 400  31110-31227   311 7.634105e-03
## 470  31200-31215  1382 8.247359e-03
## 1805 31619-31606   475 8.387267e-03
## 149  31101-31232   274 8.399807e-03
## 4    31001-31004   683 8.542894e-03
## 896  31217-31221   207 8.679981e-03
## 86   31100-31200   790 8.717483e-03
## 396  31110-31222   334 8.823092e-03
## 550  31201-31600   650 8.983165e-03
## 604  31203-31215   256 9.009726e-03
## 439  31111-31602   334 9.217459e-03
## 456  31200-31109   689 9.277249e-03
## 838  31214-31238   449 9.293213e-03
## 382  31110-31111   603 9.376022e-03
## 1896 31623-31608   399 9.472987e-03
## 620  31203-31235   283 9.532571e-03
## 985  31220-31224   422 9.869705e-03
## 1585 31602-31228   268 1.005763e-02
## 732  31208-31623  1124 1.025988e-02
## 1682 31607-31623   532 1.034244e-02
## 816  31214-31212  1067 1.049406e-02
## 941  31219-31205   296 1.100226e-02
## 554  31201-31623   297 1.134054e-02
## 221  31104-31200  2440 1.137887e-02
## 1814 31619-31620   447 1.197653e-02
## 623  31203-31503   476 1.231986e-02
```