

Forecasting flood inundation

A model study about how to predict the probability of an area being inundated by a flood

Spring 2022

CPLN 675 Land Use and Environmental Modeling

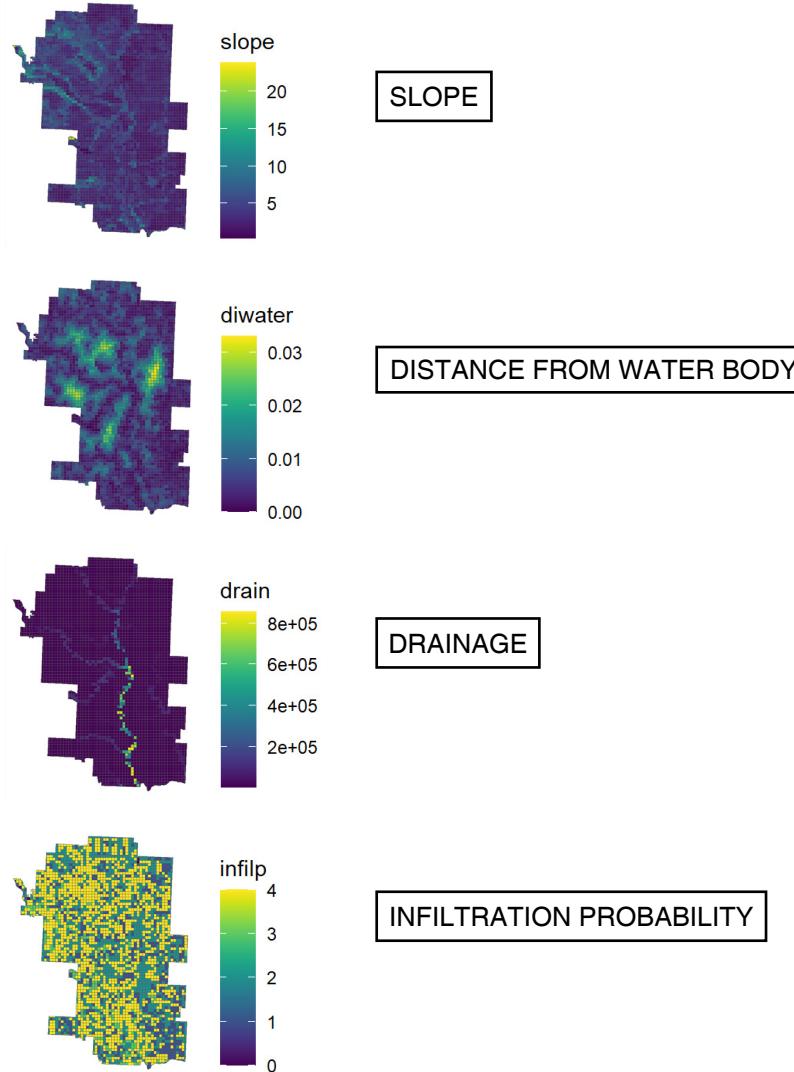
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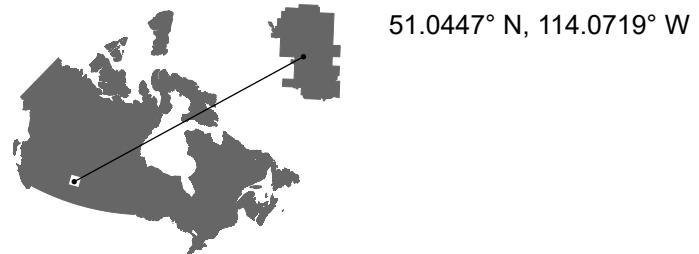
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Calgary / Canada



CALGARY'S MOST DAMAGING FLOOD JUNE 20, 2013

The costliest natural disaster in Canadian history, the flood of 2013 damaged or destroyed many homes and businesses as well as vital portions of the city's infrastructure. In the absence of electricity, social media became a powerful tool to disperse information and bring Calgarians together.

CLIMATE IN CALGARY

Calgary experiences a semi-monsoonal humid continental climate within eastern parts of the city and a subarctic climate within western parts of the city due to an increase in elevation. The city has warm summers and freezing, dry winters.

Data source:

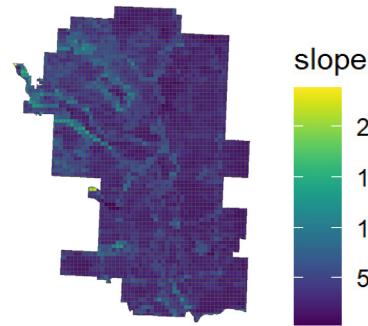
<https://floodstory.com/>

<https://mhfd.org/services/floodplain-management/>

<https://data.calgary.ca/Base-Maps/Digital-Elevation-Model-DEM-ASCII-2M/eink-tu9p>

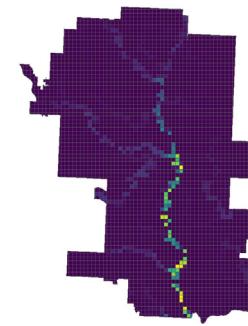
<http://www.cec.org/north-american-environmental-atlas/land-cover-30m-2015-landsat-and-rapideye/>

Calgary / Flood Map



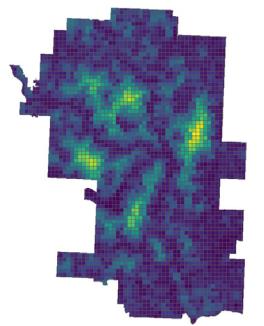
slope

20
15
10
5



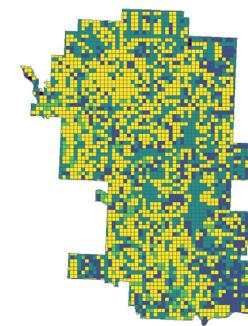
drain

8e+05
6e+05
4e+05
2e+05



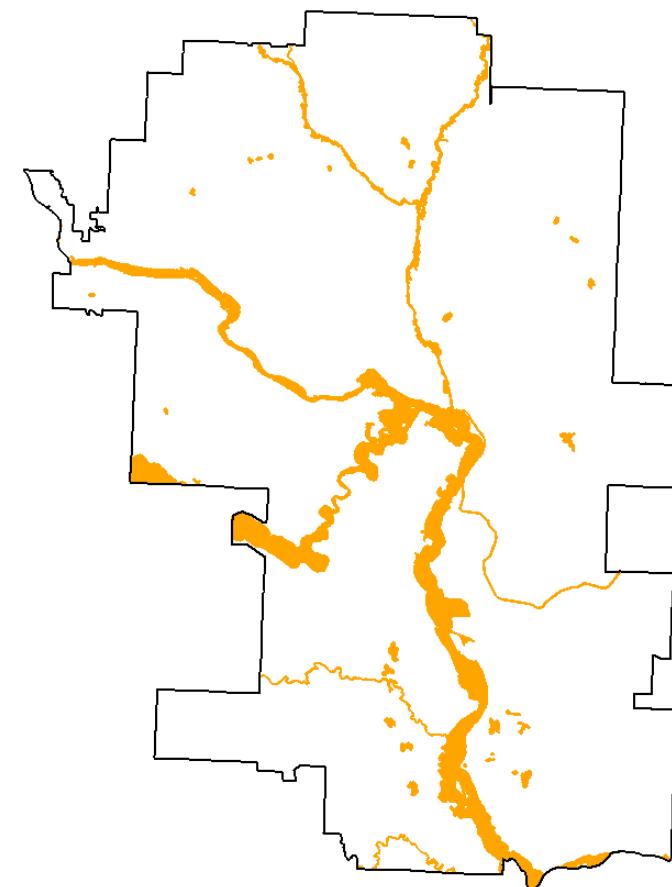
diwater

0.03
0.02
0.01
0.00



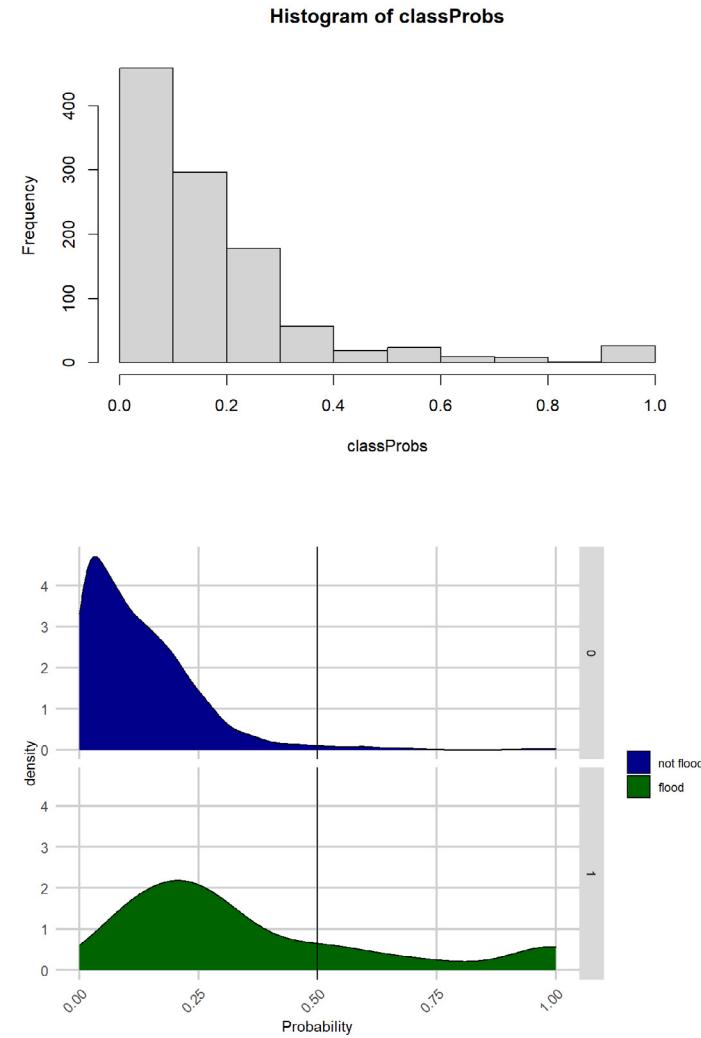
infilp

4
3
2
1
0



Model & Validation

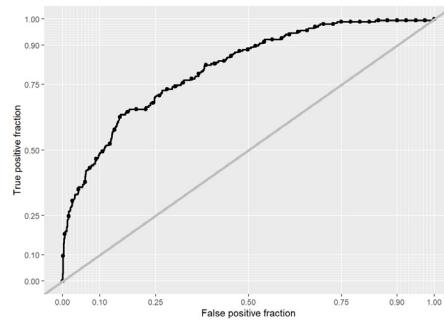
```
##  
## Call:  
## glm(formula = is_flood ~ ., family = binomial(link = "logit"),  
##   data = floodTrain %>% as.data.frame() %>% select(-geometry))  
##  
## Deviance Residuals:  
##   Min     1Q Median     3Q    Max  
## -4.1357 -0.6044 -0.4056 -0.1546  2.7406  
##  
## Coefficients:  
##             Estimate Std. Error z value Pr(>|z|)  
## (Intercept) -1.451e+01  3.394e+02 -0.043   0.966  
## diwater    -2.323e+02  2.253e+01-10.311 < 2e-16 ***  
## slope      9.710e-02  2.494e-02  3.893 9.89e-05 ***  
## drain      1.591e-05  1.923e-06  8.277 < 2e-16 ***  
## infilp1    1.367e+01  3.394e+02  0.040   0.968  
## infilp2    1.304e+01  3.394e+02  0.038   0.969  
## infilp3    1.440e+01  3.394e+02  0.042   0.966  
## infilp4    1.335e+01  3.394e+02  0.039   0.969  
##---  
## Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1  
##  
## (Dispersion parameter for binomial family taken to be 1)  
##  
## Null deviance: 2290.6 on 2512 degrees of freedom  
## Residual deviance: 1771.9 on 2505 degrees of freedom  
## AIC: 1787.9  
##  
## Number of Fisher Scoring iterations: 12
```



Confusion Metrics

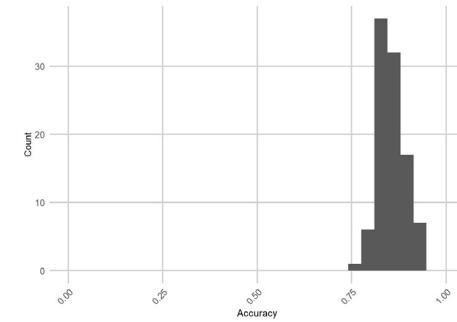
```
## Confusion Matrix and Statistics
##
## Reference
## Prediction 0 1
##    0 855 152
##    1 14 54
##
## Accuracy : 0.8456
##             95% CI : (0.8226, 0.8667)
## No Information Rate : 0.8084
## P-Value [Acc > NIR] : 0.0008601
##
## Kappa : 0.3305
##
## McNemar's Test P-Value : < 2.2e-16
##
## Sensitivity : 0.26214
## Specificity : 0.98389
## Pos Pred Value : 0.79412
## Neg Pred Value : 0.84906
## Prevalence : 0.19163
## Detection Rate : 0.05023
## Detection Prevalence : 0.06326
## Balanced Accuracy : 0.62301
##
## 'Positive' Class : 1
```

ROC Curve



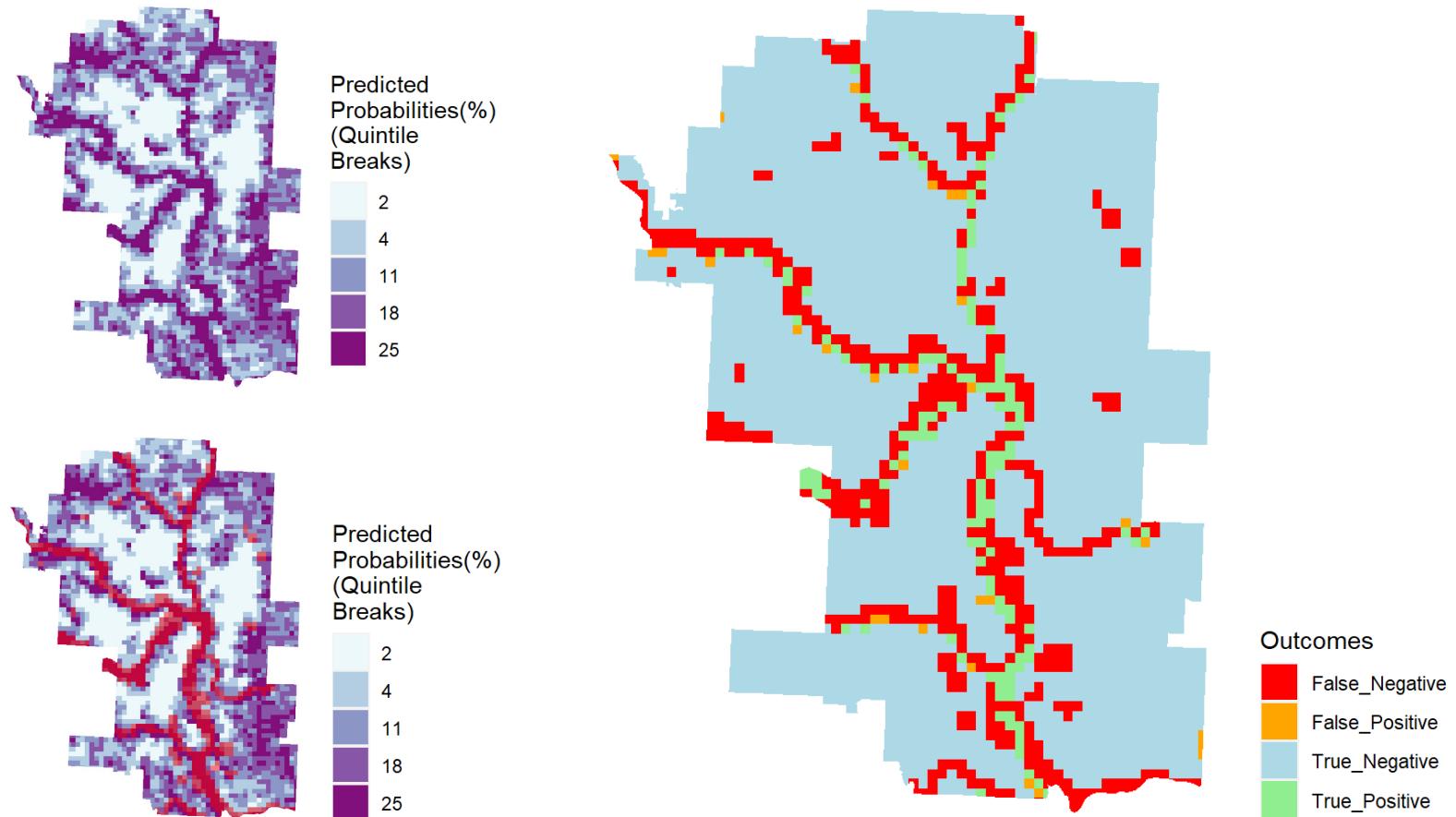
```
## Setting levels: control = 0, case = 1
## Setting direction: controls < cases
## Area under the curve: 0.8124
```

Cross validation

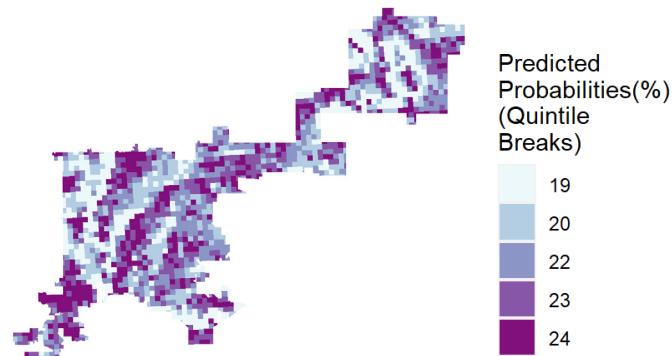


```
## Generalized Linear Model
##
## 3588 samples
## 4 predictor
## 2 classes: '0', '1'
##
## No pre-processing
## Resampling: Cross-Validated (100 fold)
## Summary of sample sizes:
## 3553, 3552, 3552, 3552, 3552, 3551, ...
## Resampling results:
##
##   Accuracy   Kappa
## 0.8526246 0.2710506
```

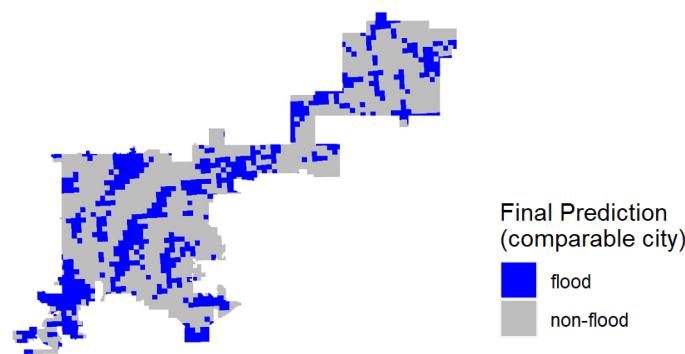
Map Predictions



Denver / USA



39.7392° N, 104.9903° W



CLIMATE IN DENVER

Denver lies within the humid continental climate zone , bordering on the cold semi-arid climate , although the subtropical microclimates can be found. It has four distinct seasons and receives most of its precipitation from April through August. Due to its inland location on the High Plains, at the foot of the Rocky Mountains, the region can be subject to sudden changes in weather.