The Greatest Lakes: Using Data Mining Techniques to Analyze Physical Properties of the Great Lakes

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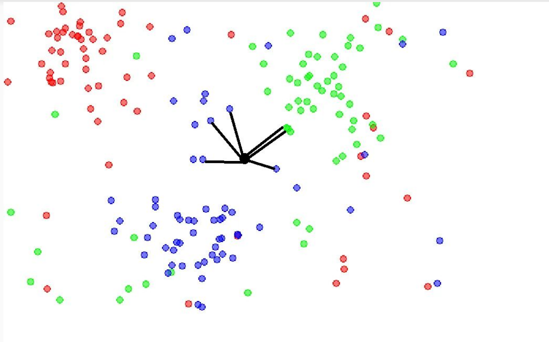
https://northernmichiganlandbrokers.com/page/the-great-lakes/

Overview: Key Questions

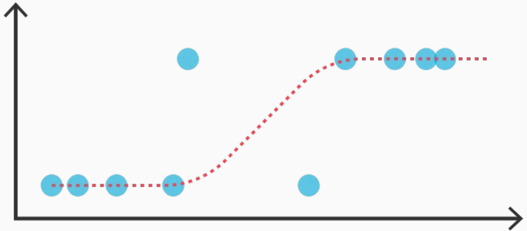
- Based on surface temperature and physical properties, can you predict the percentage ice concentration and whether that percentage will exceed a a given threshold across the Great Lakes?
- Can you predict which lake a set of characteristics (surface temperature, ice concentration, and physical properties) most likely belongs to?

Algorithms used

- K-Nearest Neighbors for classification
- Logistic Regression for surface temperature and ice concentration



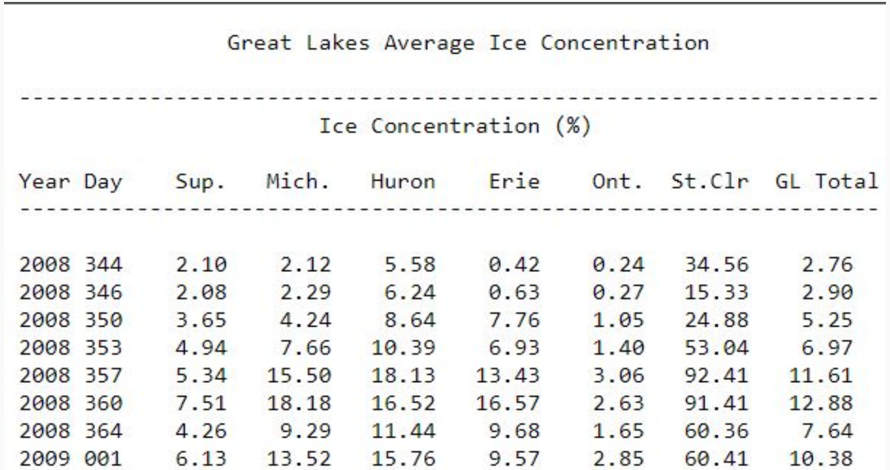
https://www.unite.ai/what-is-k-nearest-neighbors/



https://www.tibco.com/reference-center/what-is-logistic-regression

Description of data set

- Public datasets collected and published by NOAA's CoastWatch program and The Great Lakes Environmental Research Laboratory.
- We queried and cleaned 26 .dat files containing observed surface temp and ice concentration with Requests and Pandas.
- We also merged a table with the physical characteristics of each of the Great Lakes.



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                   Great Lakes Average Ice Concentration

---------------------------------------------------------------------
                           Ice Concentration (%)

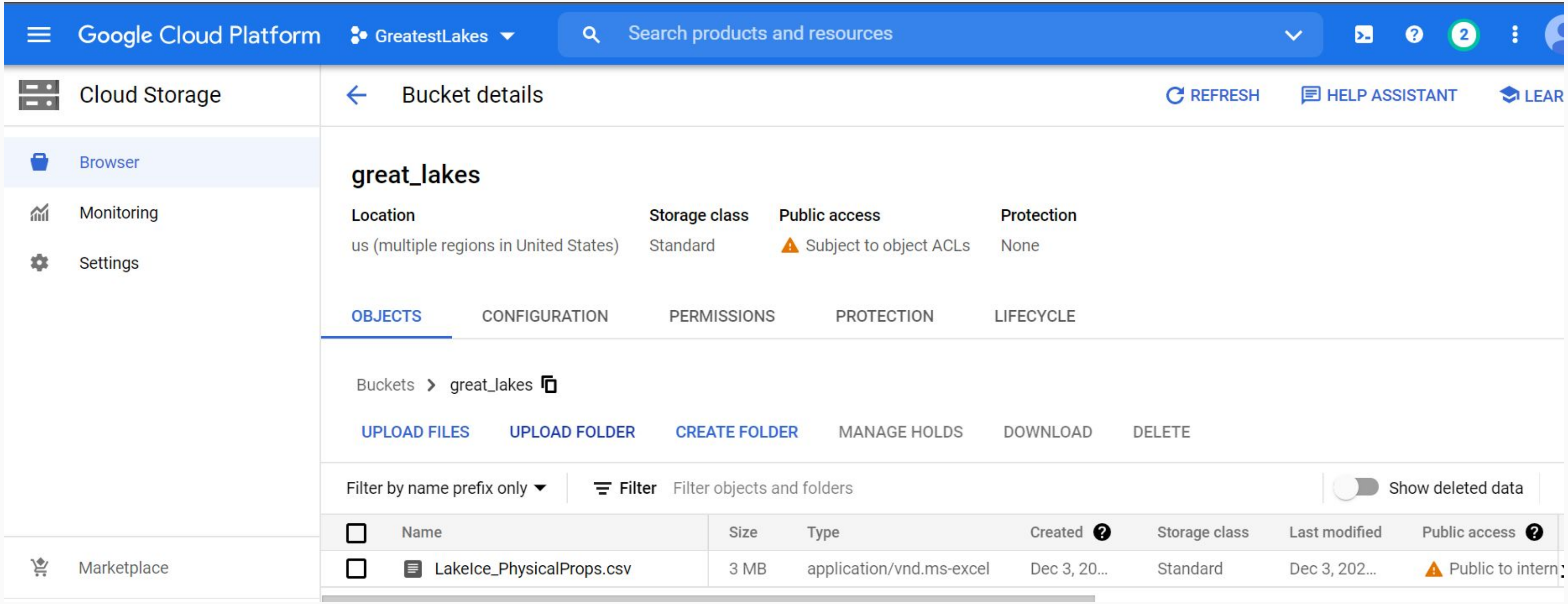
Year Day     Sup.    Mich.    Huron     Erie     Ont.   St.Clr  GL Total
---------------------------------------------------------------------


2008 344     2.10     2.12     5.58     0.42     0.24    34.56     2.76
2008 346     2.08     2.29     6.24     0.63     0.27    15.33     2.90
2008 350     3.65     4.24     8.64     7.76     1.05    24.88     5.25
2008 353     4.94     7.66    10.39     6.93     1.40    53.04     6.97
2008 357     5.34    15.50    18.13    13.43     3.06    92.41    11.61
2008 360     7.51    18.18    16.52    16.57     2.63    91.41    12.88
2008 364     4.26     9.29    11.44     9.68     1.65    60.36     7.64
2009 001     6.13    13.52    15.76     9.57     2.85    60.41    10.38
```

Data cleaning and preprocessing

- Resulting dataset contained a total of 31,126 rows and 16 variables.
- Most important features were surface temperature and ice concentration.
    - Only 8, 855 rows contained ice data.
- To circumvent connection errors across machines, we hosted a copy of our full dataset on GCP

Data Warehousing



great_lakes

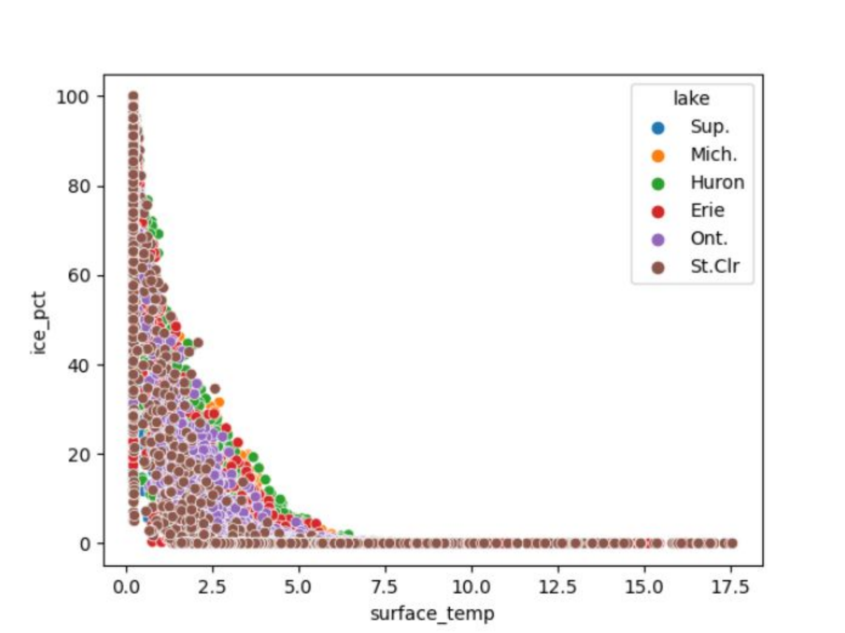
Location	Storage class	Public access	Protection
us (multiple regions in United States)	Standard	⚠ Subject to object ACLs	None

Buckets > great_lakes

□	Name	Size	Type	Created	Storage class	Last modified	Public access
□	LakeIce_PhysicalProps.csv	3 MB	application/vnd.ms-excel	Dec 3, 20...	Standard	Dec 3, 202...	⚠ Public to intern

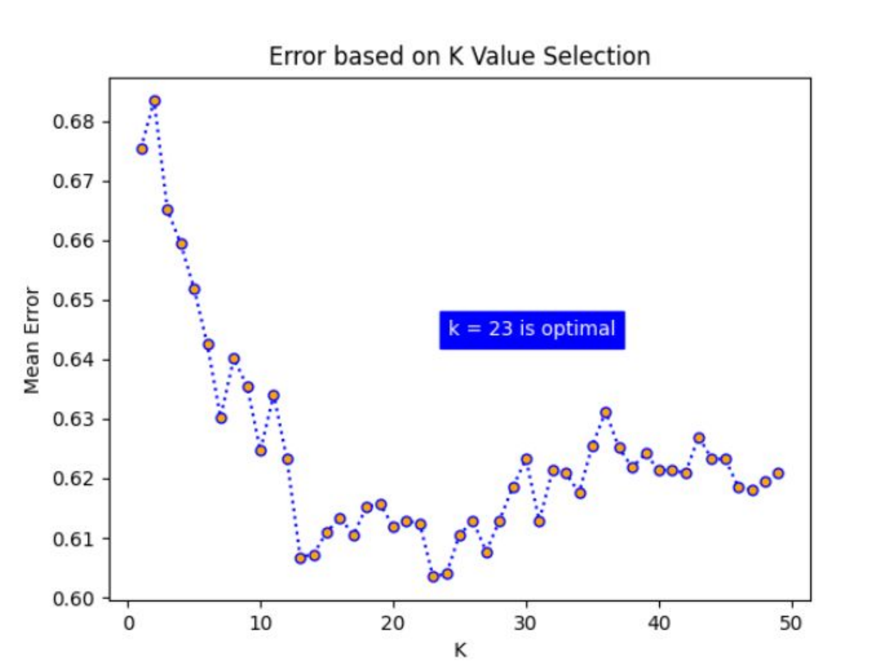
Implementation of K-Nearest Neighbors

- Classifying data points by lake
- Use surface temperature and ice concentration %
- Naive baseline model: 16.7% chance of correctly guessing lake



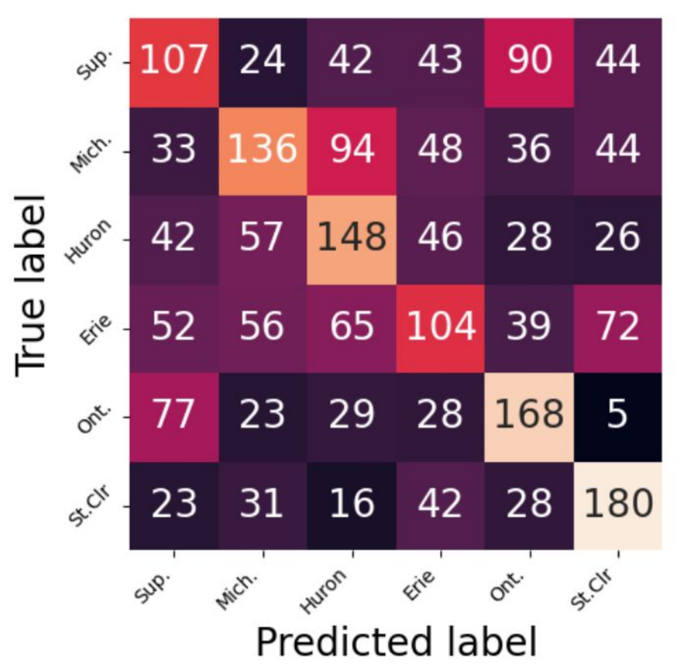
Implementation of K-Nearest Neighbors

- Tuning k-value to maximize accuracy of classification
- Loop through k-vals from 1-50
- Optimal k = 23
- Final model accuracy score: 39.7%



Results

- Final KNN model (k = 23) classified observations with 39% accuracy
- Best accuracy: Lake St. Clair
- Distinguishing between Lake Superior vs. Lake Ontario

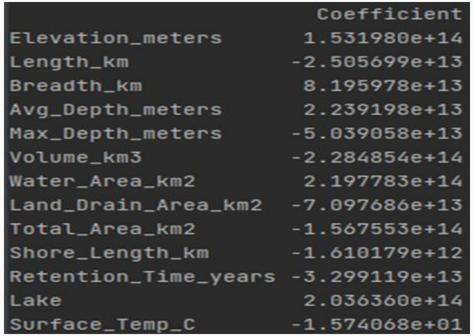


	Sup.	Mich.	Huron	Erie	Ont.	St.Clr
Sup.	107	24	42	43	90	44
Mich.	33	136	94	48	36	44
Huron	42	57	148	46	28	26
Erie	52	56	65	104	39	72
Ont.	77	23	29	28	168	5
St.Clr	23	31	16	42	28	180

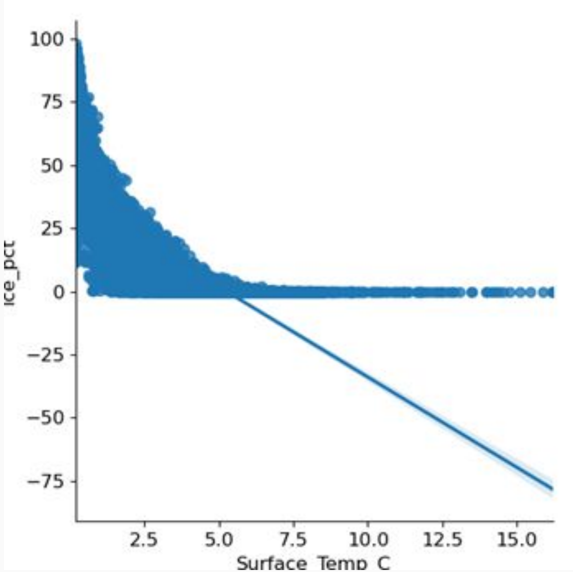
Implementation of Linear regression

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_p X_p + \epsilon$$

- Lake Erie:0, Lake Huron:1, Lake Michigan:2, Lake Ontario:3, Lake Superior:4.
- Test set MSE: 324.3781 Train set MSE:323.9782

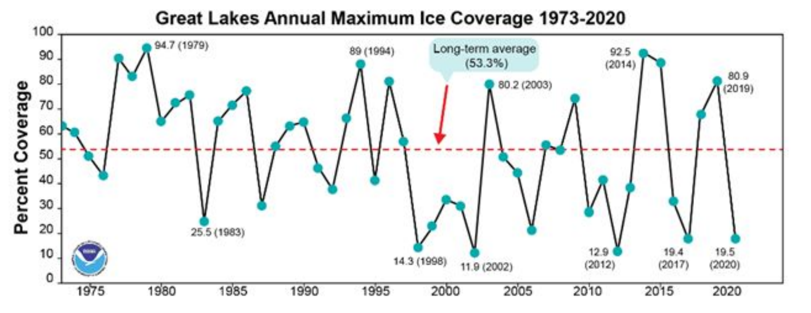


```
                          Coefficient
Elevation_meters         1.531980e+14
Length_km               -2.505699e+13
Breadth_km               8.195978e+13
Avg_Depth_meters         2.239198e+13
Max_Depth_meters        -5.039058e+13
Volume_km3              -2.284854e+14
Water_Area_km2           2.197783e+14
Land_Drain_Area_km2     -7.097686e+13
Total_Area_km2          -1.567553e+14
Shore_Length_km         -1.610179e+12
Retention_Time_years    -3.299119e+13
Lake                     2.036360e+14
Surface_Temp_C          -1.574068e+01
```



Implementation of Logistic regression

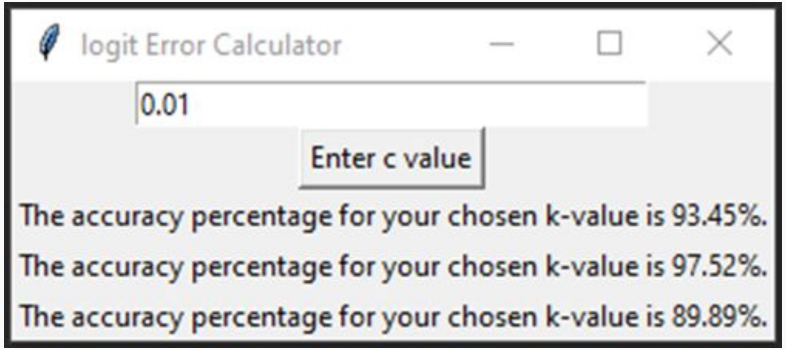
- Threshold: 0.533
- Model accuracy score: 0.9345
- Training-set accuracy: 0.9365
- Test-set accuracy: 0.9345
- No overfitting



Great Lakes Annual Maximum Ice Coverage 1973-2020

Implementation of Logistic regression

- Increase C to 100
  - Training-set accuracy: 0.9771; Test-set accuracy is 0.9752
- Setting C to 0.01
  - Training-set accuracy: 0.8964; Test-set accuracy: 0.8989
- More complex model should perform better



0.01

The accuracy percentage for your chosen k-value is 93.45%.

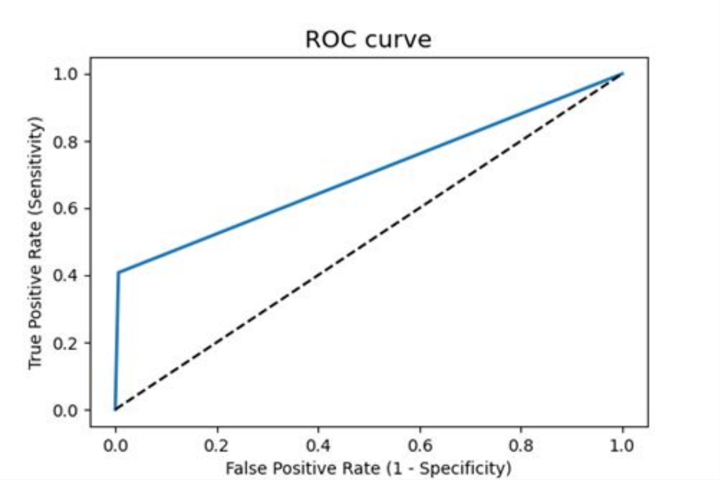
The accuracy percentage for your chosen k-value is 97.52%.

The accuracy percentage for your chosen k-value is 89.89%.

Implementation of Logistic regression

	Actual Positive:1	Actual Negative:0
Predict Positive:1	1582	10
Predict Negative:0	106	73

- Precision: 0.9937
- Sensitivity: 0.9372
- Specificity: 0.8795

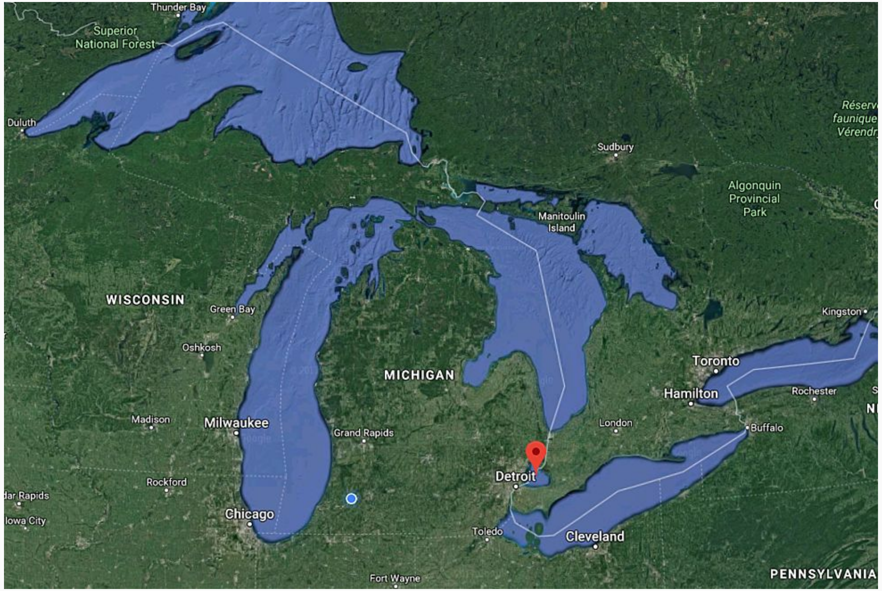


Model Summary

- Majority of observations predict that there will be no maximum ice coverage
- Logistic regression is safe and robust
- Use different threshold
- Lasso regression and elastic net

Conclusion

- Classification: Lake Ontario and Lake Superior similarities
- Lake St. Clair observations easiest to classify
-



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