Report Outline: Interpolation

Course Name: Spatial Data Analysis
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Analysis Question

- **Question 1:** How can we predict a continuous snow depth surface over the area using spatial interpolation techniques?
- **Question 2:** Which interpolation method provides a more accurate snow depth prediction surface?
- **Question 3:** Where is the best location for a ski resort, considering criteria such as slope, shading, and orientation away from the sun?

Criteria

Criteria for Each Task:

Task 1 - Snow Depth Prediction:

Use spatial interpolation to create a continuous surface representing snow depth based on snow station data.
Compare the accuracy of different interpolation methods (Inverse Distance Weighting | IDW and Kriging) to find the method that best fits the observed data.

Task 2 - Ski Resort Location:

Slope: Suitable slope for skiing.
Shading: Areas with sufficient shading to preserve snow cover.
Orientation: Prefer north-facing slopes to reduce direct sunlight exposure.

Data

Dataset	Desc	Source	Data model	Type of feature	Attributes
DEM	Digital Elevation Model (DEM) providing elevation values for the	Provided (areleva1)	Raster	Continues	nodata, width, height, count, crs, transform
Snow Points	Locations of snow stations with snow depth	Provided	Vector	Point	STATION, SNOWDEPTH, geometry POINT(x,y)
DAM Line	Proposed location for dam	Provided	Vector	Line	Id, geometry LINESTRING
Ridges	Lines where two sloping surfaces meet, marking ridge locations	Provided	Vector	Line	FNODE, TNODE, LPOLY, RPOLY, LENGTH, RIDGES, RIDGES_ID, RCOV2, RCOV2_ID, geometry

Methodology

This section describes the methods and functions applied in the analysis, organized by task and criteria.

Task 1: Snow Depth Prediction

- Interpolation Methods:
    - IDW (Inverse Distance Weighting):
        - Used IDW interpolation method to predict snow depth across the study area.
        - IDW weights snow depth values based on distance, giving higher weight to closer points.
    - Kriging:
        - Applied Kriging interpolation to predict snow depth.
        - Kriging considers both distance and spatial autocorrelation, creating a more nuanced prediction surface than IDW.

- Validation:
    - Used Cross-Validation to evaluate the accuracy of each interpolation method.
    - Calculated Root Mean Square Error (RMSE) and R-squared for IDW and Kriging to assess their predictive accuracy.
    - Compared the results to determine the more accurate interpolation method (Kriging was more accurate based on lower RMSE and higher R-squared).

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Interpolation Methods Comparison:
IDW Cross-validated RMSE: 4.823
IDW Cross-validated R-squared: 0.629
Kriging Cross-validated RMSE: 4.460
Kriging Cross-validated R-squared: 0.695
```

Task 2: Ski Resort Location Selection

- Criteria Analysis:
    - Slope Calculation: Derived slope from the DEM to find areas with suitable inclines for skiing.
    - Aspect Calculation: Computed aspect from the DEM to identify slope orientation, focusing on slopes not directly facing the sun.
    - Shading Analysis (Hillshade): Created a hillshade map to assess areas with natural shading, which helps preserve snow cover.

- Ski Resort Suitability Map:
    - Combined slope, aspect, and hillshade layers to produce a suitability map.
    - Highlighted areas with suitable slope, orientation away from the sun, and adequate shading for ski resort planning.

Results

Snow Depth Prediction Results:

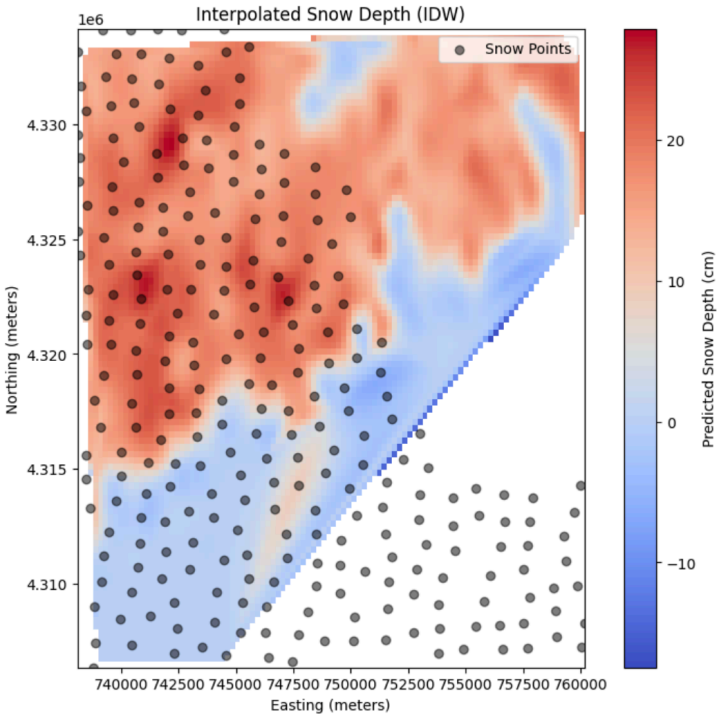
- Generated two continuous snow depth surfaces using **IDW** and **Kriging**.
- **IDW Results:**
    - RMSE: 4.823, R-squared: 0.629
- **Kriging Results:**
    - RMSE: 4.460, R-squared: 0.695
- **Conclusion:** Kriging provided a more accurate prediction of snow depth with lower RMSE and higher R-squared, suggesting it is better suited for this spatial interpolation task.

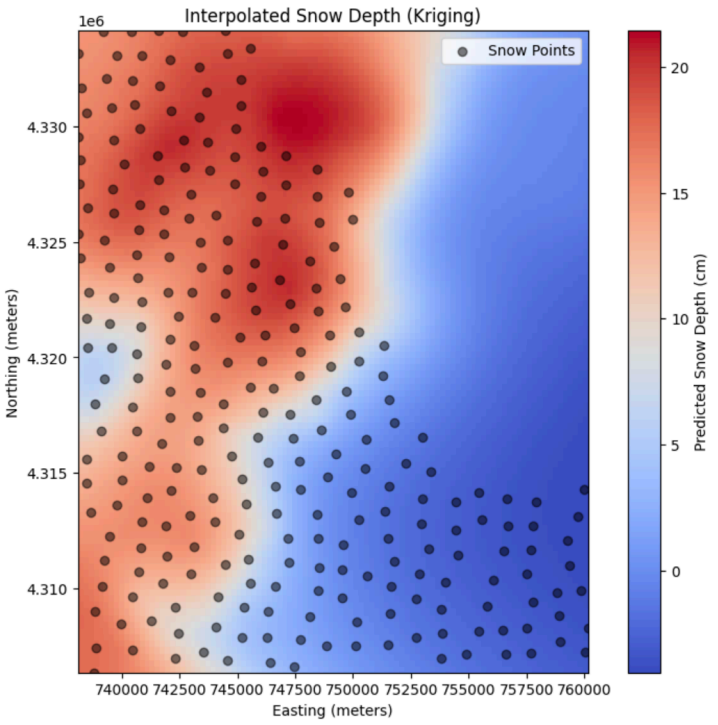
Ski Resort Suitability Results:

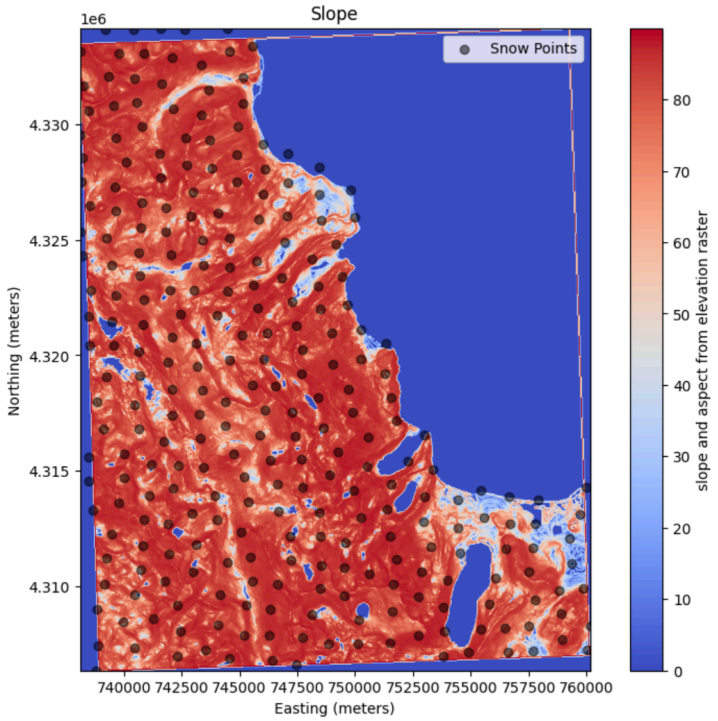
- Derived maps of slope, aspect, and hillshade from the DEM.

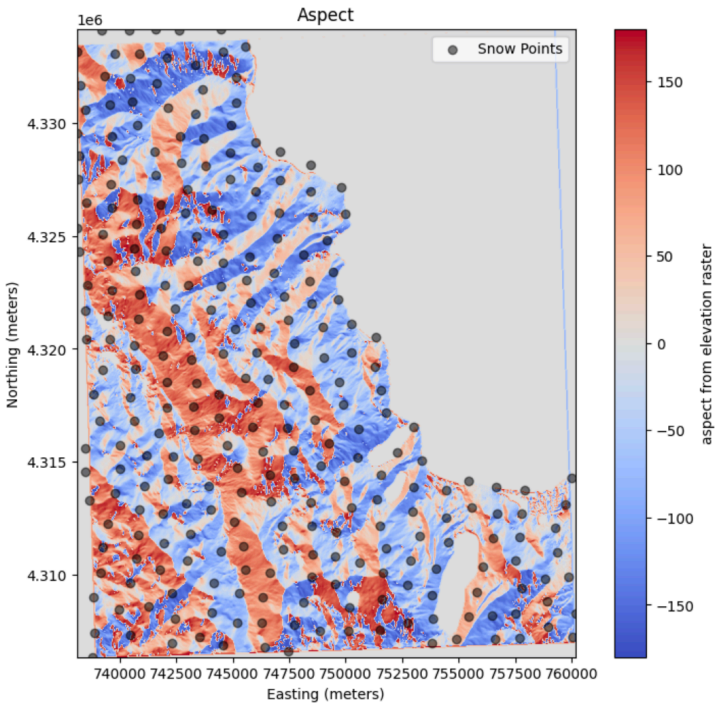
- Created a suitability map by combining the criteria of:
    - **Slope:** Moderate slopes optimal for skiing.
    - **Aspect:** North-facing slopes to minimize sun exposure.
    - **Hillshade:** Areas with high natural shading.
- The suitability map identifies optimal areas for ski resort location based on physical terrain properties.

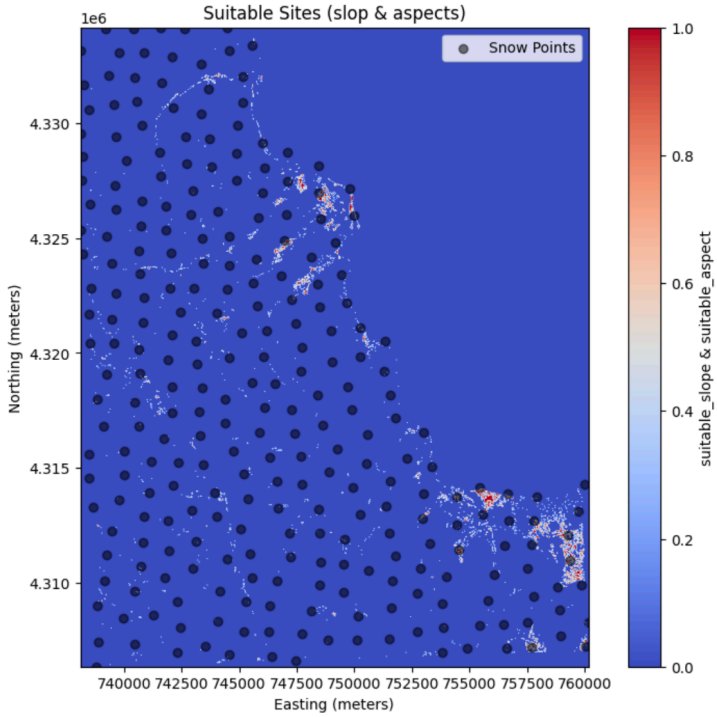
Visualization

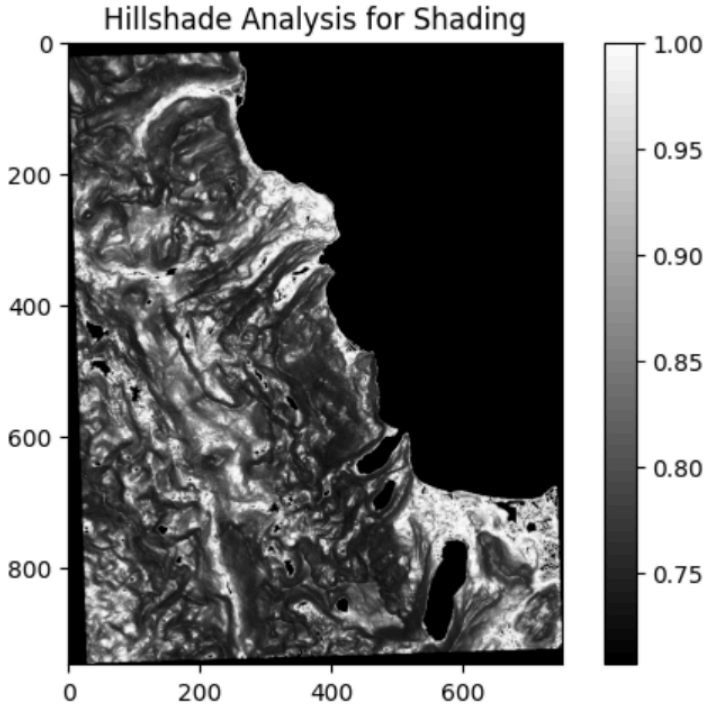


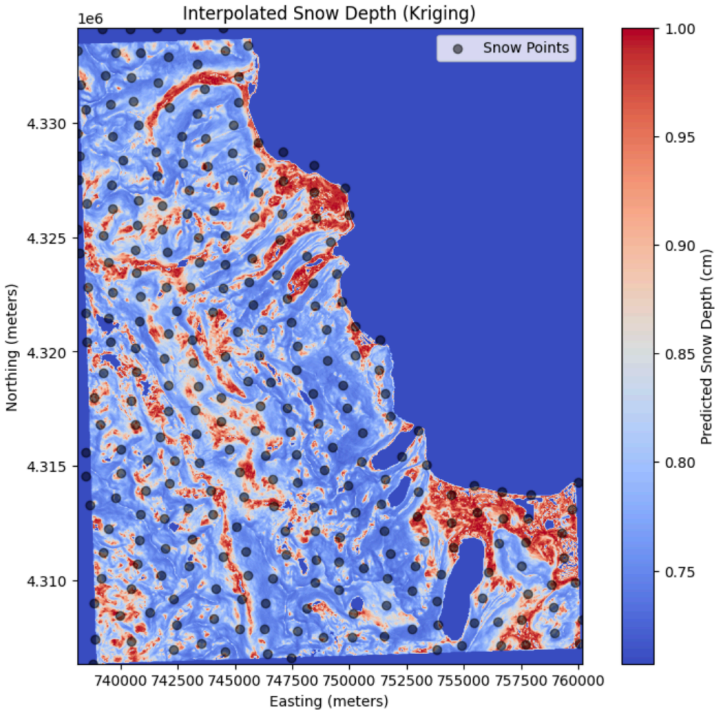


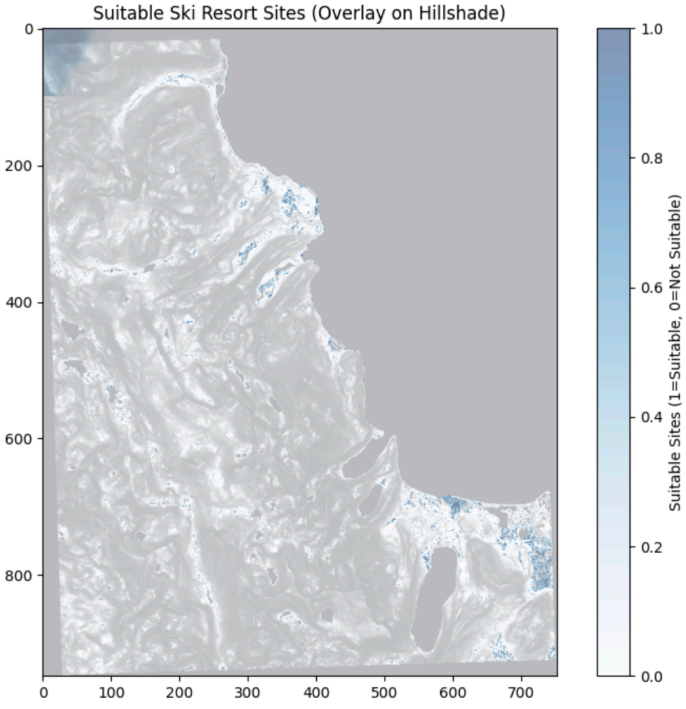





Suitable Sites (slop & aspects)
1e6
Snow Points
4.330
4.325
4.320
4.315
4.310
Northing (meters)
740000 742500 745000 747500 750000 752500 755000 757500 760000
Easting (meters)
1.0
0.8
0.6
0.4
0.2
0.0
suitable_slope & suitable_aspect


Hillshade Analysis for Shading
0
200
400
600
800
0
200
400
600
1.00
0.95
0.90
0.85
0.80
0.75


Interpolated Snow Depth (Kriging)
1e6
Snow Points
4.330
4.325
4.320
4.315
4.310
Northing (meters)
740000 742500 745000 747500 750000 752500 755000 757500 760000
Easting (meters)
1.00
0.95
0.90
0.85
0.80
0.75
Predicted Snow Depth (cm)


Suitable Ski Resort Sites (Overlay on Hillshade)
0
200
400
600
800
0
100
200
300
400
500
600
700
1.0
0.8
0.6
0.4
0.2
0.0
Suitable Sites (1=Suitable, 0=Not Suitable)

Conclusion

- **Interpolation Method Evaluation:** Kriging outperformed IDW in predicting snow depth, as evidenced by cross-validation metrics (lower RMSE and higher R-squared). Kriging's spatial autocorrelation adjustment makes it a more effective method for this application.
- **Ski Resort Location:** By analyzing slope, aspect, and shading, areas with favorable conditions for skiing were identified. North-facing slopes with moderate incline and natural shading are recommended as they will likely retain snow cover longer, meeting the needs of a ski resort.
- **Recommendation:** For future analysis, consider exploring more advanced Kriging models (e.g., Ordinary or Universal Kriging) to further enhance accuracy, and validate predictions with additional snow depth measurements if available.

Check out the code on google colab Notebook