

# Effect of Sun Incidence Angle on Classifying Water Bodies in Landsat Images

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# Remote Sensing

- Remote sensing is the science and art of collecting information without physical/ direct contact
- Basis
  - Measures the emittance, reflection, and interaction of different light wavelengths, Electromagnetic Radiation, with distant objects
  - These interactions are then identified and categorized either by class, type, substance, and spatial quantities
  - The use of light spectral analysis to assess environmental aspects, such as overall terrain, invasive species, water bodies, agricultural maintenance

# Remotely sensed data -> Map



Credit: [earthobservatory.nasa.gov](http://earthobservatory.nasa.gov) & [Landcover.usgs.gov](http://Landcover.usgs.gov)

# Types of Classification

- Extracting information from remotely sensed data
  - **Supervised classification:** analyst identifies few known locations of features, algorithm determines the statistics and assigns pixels to thematic classes (water, bare ground etc)
  - **Unsupervised classification:** Algorithm groups the pixels based on statistics and then the analyst labels those groups based on interpretation techniques

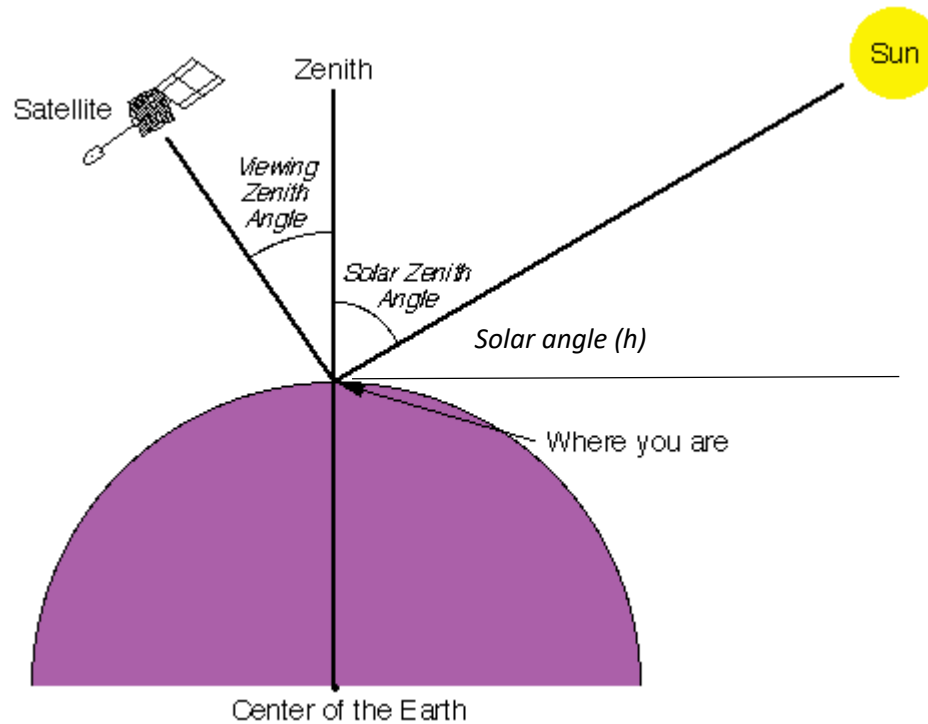
# Unsupervised Classification

- Reflectance properties of pixels are grouped into a set number of clusters, which are then analyzed and placed in specific labelled classes
- **Flexibility** to the **analyst** for assigning groups to thematic classes
- **Bias** is an issue
  - Clusters sometimes become difficult to decipher
  - Water or non-water? Shore or turbid, shoreline water?

# Factors Affecting Water Body Classification

- Water Clarity (turbidity)
- Presence of Biological Materials (algae, bacteria)
- Shape of Water Body (narrow, linear)
- Surrounding Water Body Terrain (mountainous/elevated, flat)
- Sun Incidence Angle

# Analysis of Sun Incidence Angle (h)



# Hypothesis

- As the sun incidence **angle increases** in relation to the geography of the water body, the **difficulty** of assessing unsupervised clusters into classes **will decrease**.
  - Qualitative assessment will become less difficult.
- The sun incidence angle will **not influence** qualitative analysis of water bodies with **flat surrounding** terrains.
- The sun incidence angle will **influence** qualitative analysis of water bodies with **mountainous/elevated surrounding** terrains.



# Objectives

- Acquire images with different sun angles and assess its impact on interpreting water bodies
  - Assess the difficulty during unsupervised classification contributed to specific sun incidence angles
- Select water bodies with different surrounding terrain
  - Pilot Butte (flat)
  - Fontenelle (relatively flat)
  - Keyhole (relatively mountainous/ elevated)
  - Bull Lake (very mountainous/ elevated)

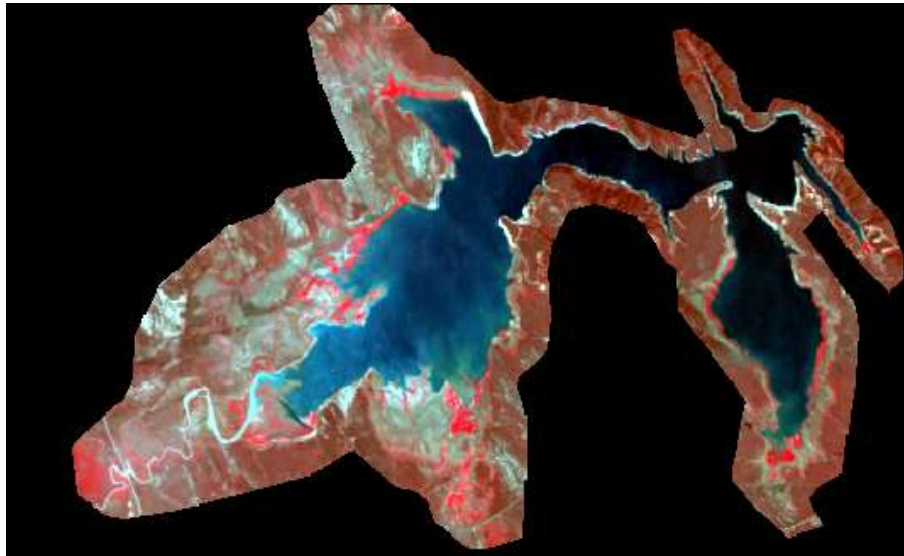
# Methods

- Landsat images obtained at different months (i.e., different sun incidence angles)
- Sun angle values were withheld by the mentor to eliminate any bias
- Each image analyzed using program ERDAS Imagine 2013

# Methods

- Pixels in each image were grouped using unsupervised classification algorithm
  - 50 clusters (classes)
  - Convergence 0.9995
  - 500 iterations
- Assign each cluster (50 total) to “Water- 1” or “Non-Water-0” and calculated the area of the water bodies
- Record amount of difficulty in assigning each cluster (scale: 1= simple to label – 10 = difficult to label)
- Each classified image was compared to its sun incidence angle value

# Example of Classified Image



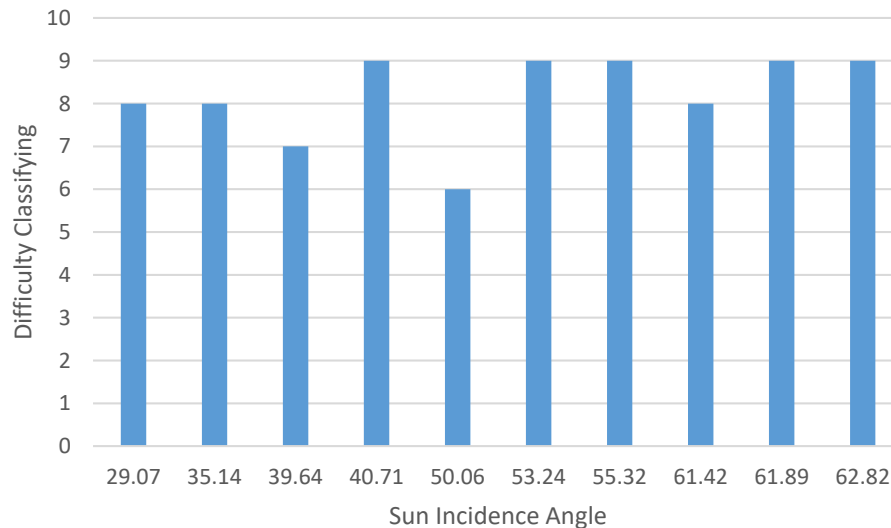
Key Hole: 05/26/2006

Row	Histogram	Color	Red	Green	Blue	Opacity	Class_Names	Area
0	66911		0	0	0	0	Unclassified	6021.99
1	6142		0	0	1	1	Water	552.78
2	1214		0	0	1	1	Water	109.26
3	4850		0	0	1	1	Water	436.5
4	784		0	0.39	0	1	Non	70.56
5	505		0	0	1	1	Water	45.45
6	1344		0	0.39	0	1	Non	120.96
7	3376		0	0	1	1	Water	303.84
8	2442		0	0.39	0	1	Non	219.78
9	407		0	0	1	1	Water	36.63
10	3450		0	0.39	0	1	Non	310.5
11	1124		0	0.39	0	1	Non	101.16
12	3806		0	0.39	0	1	Non	342.54
13	3346		0	0.39	0	1	Non	301.14
14	375		0	0.39	0	1	Non	33.75
15	830		0	0.39	0	1	Non	74.7
16	375		0	0.39	0	1	Non	33.75
17	2643		0	0	1	1	Water	237.87
18	349		0	0.39	0	1	Non	31.41
19	3255		0	0.39	0	1	Non	292.95
20	2110		0	0.39	0	1	Non	189.9
21	250		0	0.39	0	1	Non	22.5
22	486		0	0.39	0	1	Non	43.74
23	306		0	0.39	0	1	Non	27.54
24	1344		0	0.39	0	1	Non	120.96
25	249		0	0	1	1	Water	22.41
26	910		0	0.39	0	1	Non	81.9
27	1454		0	0.39	0	1	Non	130.86
28	1171		0	0.39	0	1	Non	105.39
29	1313		0	0.39	0	1	Non	118.17
30	1793		0	0.39	0	1	Non	161.37
31	2857		0	0.39	0	1	Non	257.13
32	389		0	0.39	0	1	Non	35.01
33	1081		0	0.39	0	1	Non	97.29
34	231		0	0	1	1	Water	20.79
35	1518		0	0.39	0	1	Non	136.62
36	284		0	0	1	1	Water	25.56
37	1785		0	0.39	0	1	Non	160.65
38	736		0	0.39	0	1	Non	66.24
39	775		0	0.39	0	1	Non	69.75
40	1661		0	0.39	0	1	Non	149.49
41	838		0	0.39	0	1	Non	75.42
42	306		0	0.39	0	1	Non	27.54
43	1574		0	0.39	0	1	Non	141.66
44	594		0	0.39	0	1	Non	53.46
45	204		0	0	1	1	Water	18.36
46	927		0	0.39	0	1	Non	83.43
47	227		0	0	1	1	Water	20.43
48	443		0	0.39	0	1	Non	39.87
49	503		0	0.39	0	1	Non	45.27
50	105		0	0.39	0	1	Non	9.45

# Results and Discussion

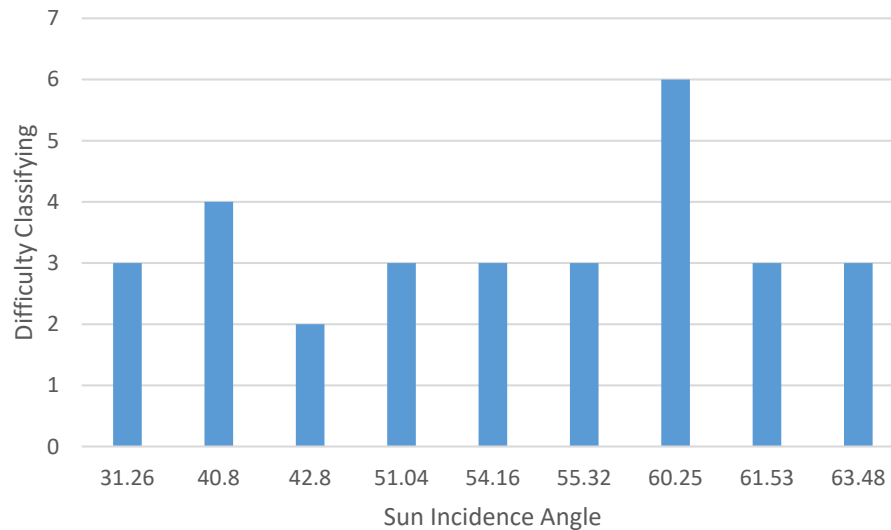
# Pilot Butte

- Flat, small reservoir
- All 10 images were difficult to label
  - Difficulty range: 6 – 9
  - Small size – image was pixelated
  - Sun incidence angle did NOT pose any difficulty in assigning the clusters to water or non-water classes



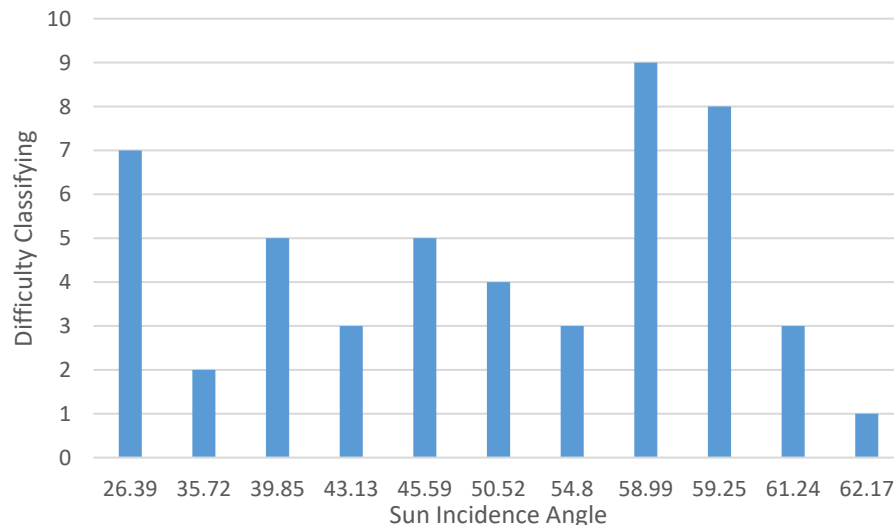
# Fontenelle

- Relatively flat
- 8 of 9 Images were easy to label
  - Difficulty range 2-6
  - Sun incidence angle did NOT pose any difficulty in assigning the clusters to water or non-water classes



# Keyhole

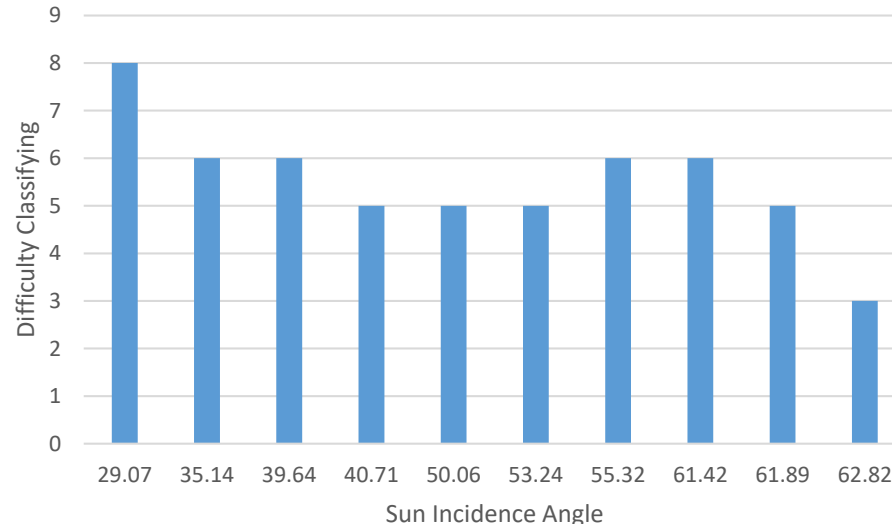
- Relatively mountainous/ elevated
- 7 of 11 images were of average difficulty to label
  - Difficulty range 1-9
  - 7 of 11 images were in agreement with hypothesis (lower sun incidence angle= more difficulty in assignment)
  - 4 of 11 images were in disagreement with hypothesis- other factors could have influenced such outcome
  - Sun incidence angle did pose difficulty in assigning the clusters to water or non-water classes





# Bull Lake

- Very mountainous and elevated
- 8 of 10 images were of average difficulty/ difficult to label
  - Difficulty range 3-8
  - 8 of 10 images were in agreement with hypothesis(lower sun incidence angle= more difficulty in assignment)
  - 2 of 10 images were in disagreement with hypothesis- other factors could have influenced such outcome
  - Sun incidence angle did pose difficulty in assigning the clusters to water or non-water classes



# Conclusion

- In general, **low sun incidence angles** resulted in **more classification difficulty** in water bodies with mountainous/ elevated surrounding terrain (Bull Lake and Keyhole)
  - When the terrain is flat – incidence angle does not seem to affect (Fontenelle)
  - When the terrain is rugged – incidence angle does seem to affect (Bull Lake)
- **Other factors** such as (size, clarity, image quality) could have contributed to the analyst's ability to distinguish water
  - When the water body is too small, contrast between water and non-water is poor due to image quality (Pilot Butte)

# Future Research

- Quantitative approach
  - Quantity of water body values using unsupervised method vs. on ground influx of water body values
  - Level of discrepancy
  - Does sun incidence angle affect quantitative analysis?
- Include more water bodies with rugged terrain to confirm these findings

# Acknowledgements

- Wyoming View
- Mentor Dr. Ramesh Sivanpillai



# Sources

- [cfa.harvard.edu](http://cfa.harvard.edu)
- <http://nasasearch.nasa.gov/search?utf8=%E2%9C%93&affiliate=nasa&query=methods+remote+sensing> (NASA)
- <http://science-edu.larc.nasa.gov/SCOOOL/Spanish/definitions-sp.html> (NASA)
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- [landsat.usgs.gov](http://landsat.usgs.gov) – Information about Landsat