Shrinking of the Aral Sea:
Water Loss Analysis of a Disappearing Lake

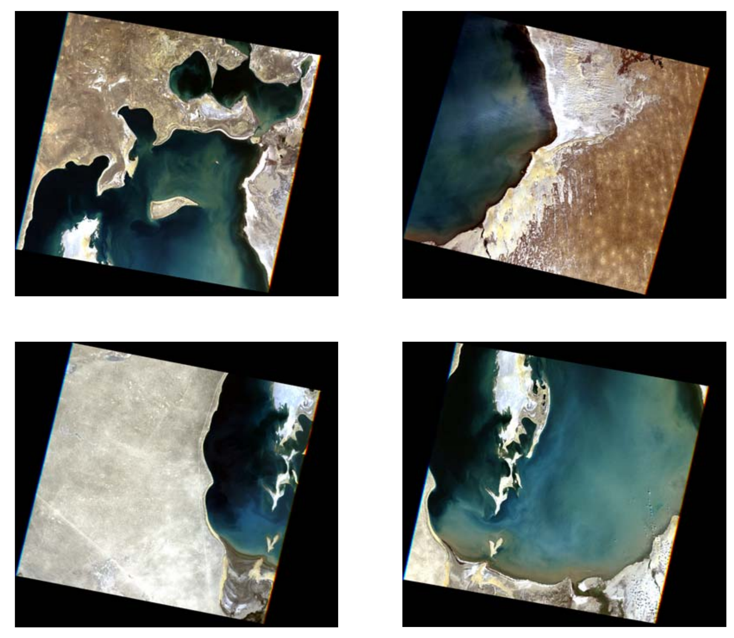
Introduction

The Aral Sea is located on the border of Kazakhstan and Uzbekistan in central Asia. The Aral is fed by two rivers: the Syr Darya in the north and the Amu Darya in the south. Once home to a thriving fishing industry, the Aral has diminished greatly in size due to water diversions.

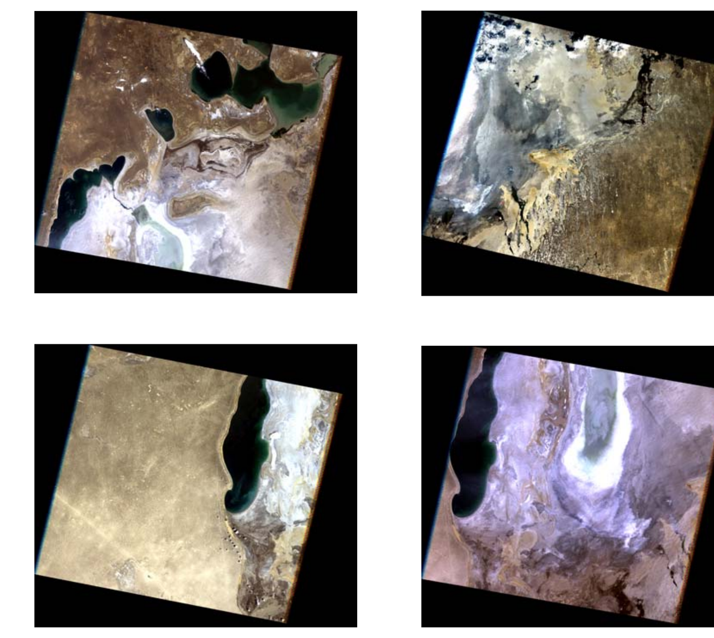
Since the 1960s, water has been withdrawn from Syr Darya and Amu Darya in order to irrigate crops, such as cotton. The size of the Aral has steadily declined since water withdrawals began, leading to the formation of two distinct water bodies (North and South Aral) instead of one continuous sea. Salinity has increased from 10 to 100 grams per liter, making the water uninhabitable for fish.

This remote sensing analysis will focus on volume and surface area changes to the South Aral Sea (also called the Large Aral) between 1988 and 2009. ENVI remote sensing software and ArcGIS were used to analyze satellite images.

1988

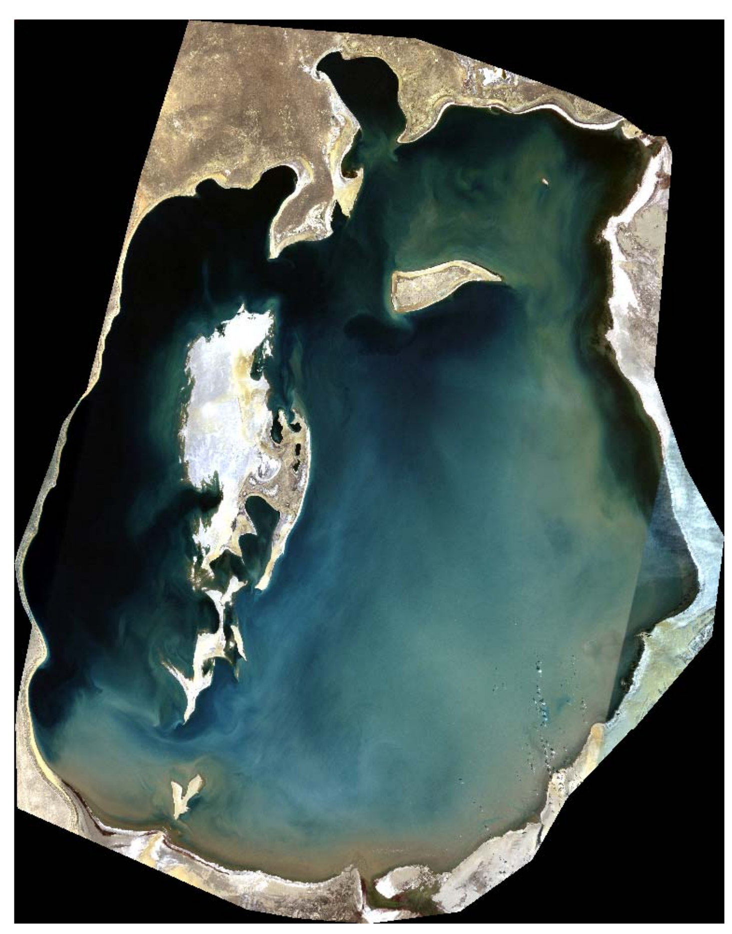


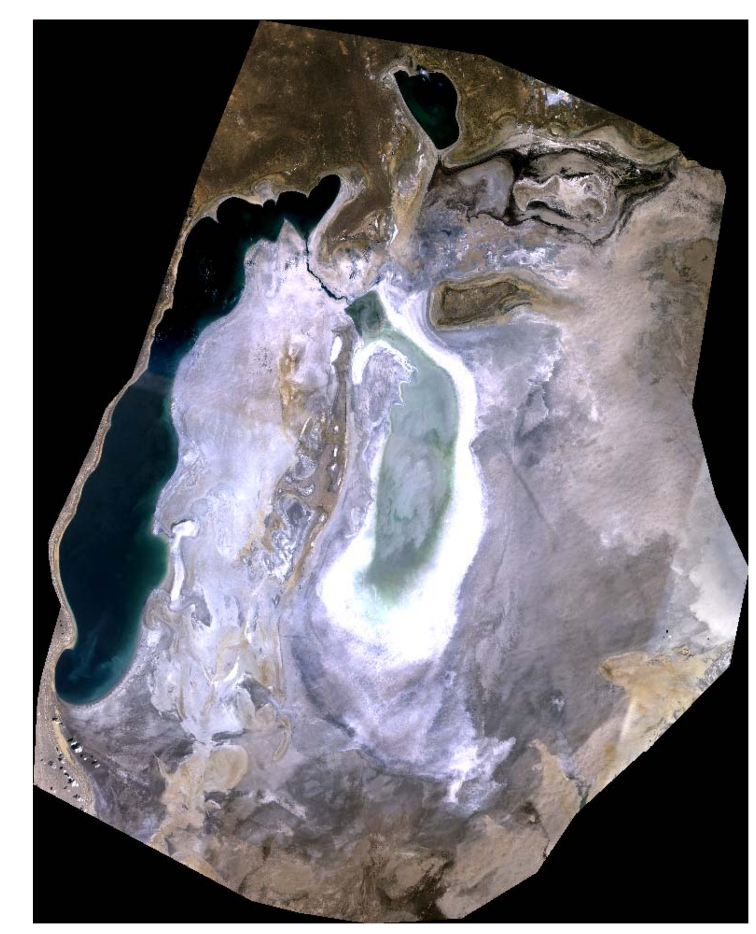
2009



Raw Images

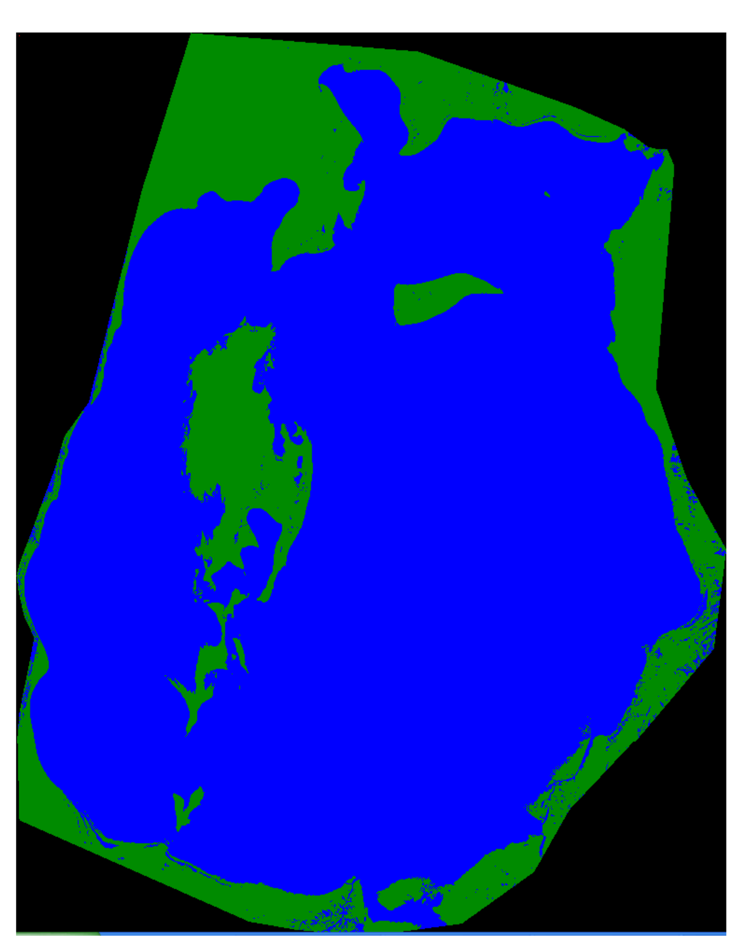
Four Landsat 4-5 Thematic Mapper (TM) images for each classification year were downloaded from GLOVIS[1]. The images are from the same season (summer) and were selected to minimize cloud cover. Each image was generated by combining six spectral bands to form one image. Bands 3-2-1 are displayed here for a true color image.

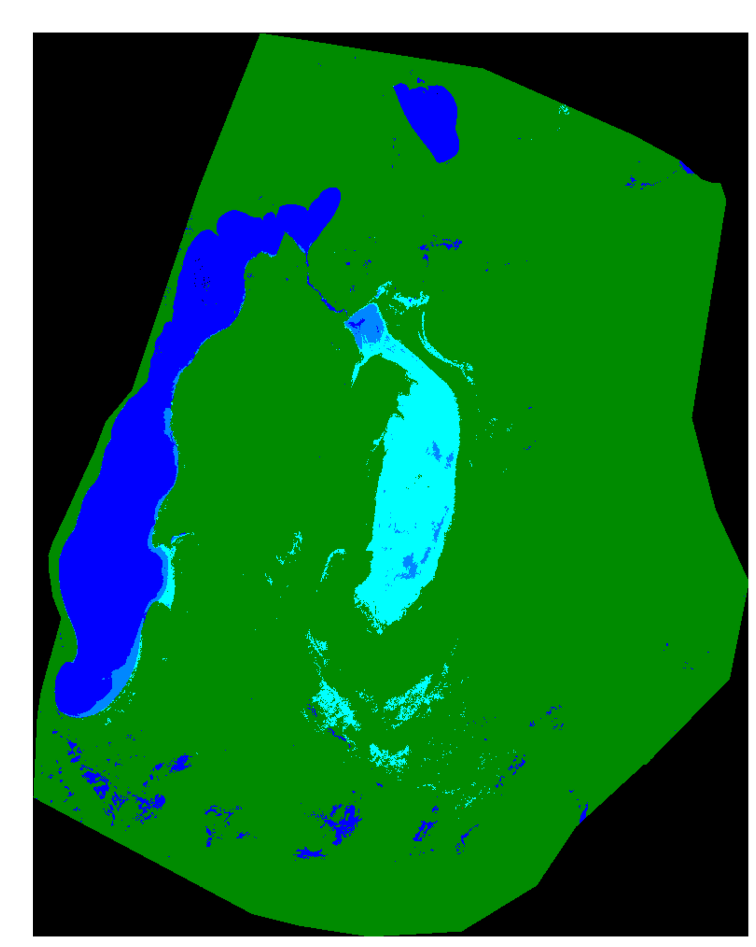




Mosaicking

Composites of the four images were generated in ENVI using georeferenced mosaicking. Images were then clipped to only include the area of analysis (South Aral Sea). A mask was used such that the same clipped area was taken for each image year. Clouds and other atmospheric interferences were obscured using clips from images with clear skies in order to ensure correct classification occurred.





Classification

Unsupervised classification using the K-Means algorithm was conducted for both analysis years. Majority analysis was used to remove spurious pixels from areas dominated by another classification. Classification errors are present due to similarities in land cover pixel properties, but these errors do not appear significant in the analysis.

Water	Shallow Water
Non-water	Very Shallow Water

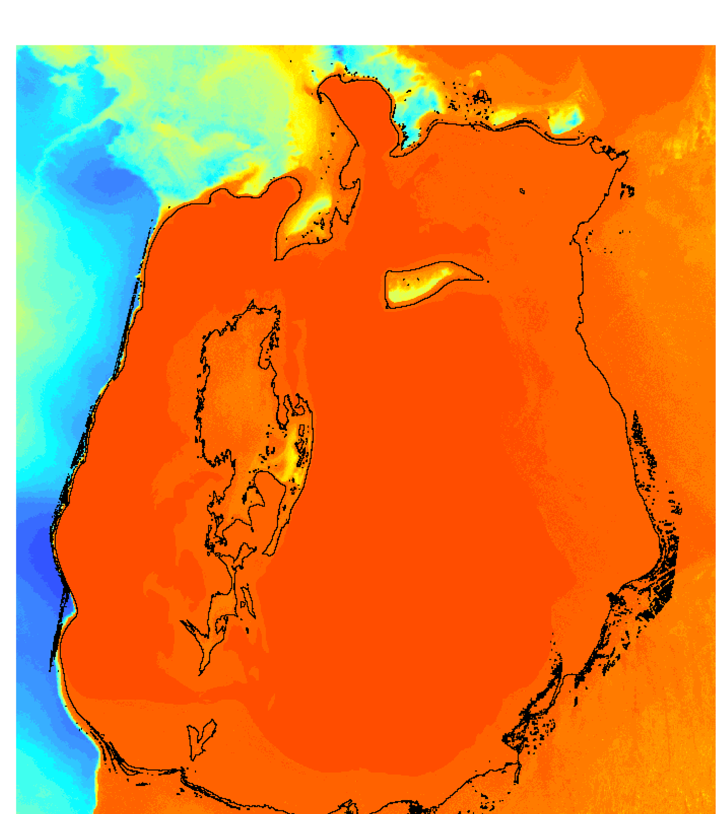
Change Detection - Area Loss

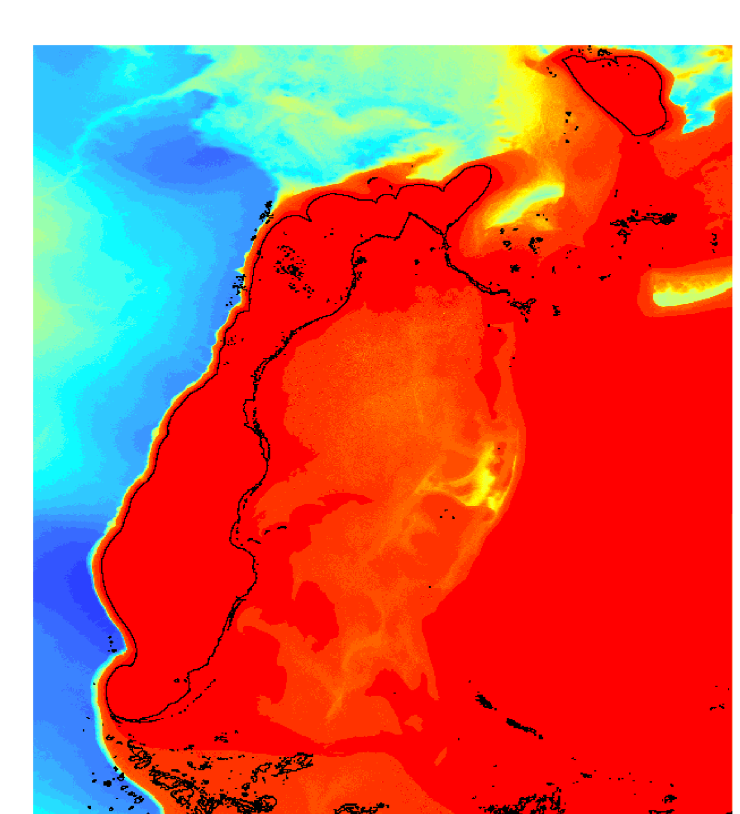
Change detection (CD) statistics were calculated based on the classified images (right) to determine the water area loss in the South Aral region. Literature values for years closest to those analyzed are shown for comparison.

Water area was reduced by 89 percent from 1988 to 2009 with most (82%) of the former water area converted to non-water (i.e. land).

CD Analysis Values	Area (sq. km)	% Change from 1988
1988 Water	39,204	-
1988 Non-Water	12,254	-
2009 Water	4,517	-89%
2009 Non-water	44,187	+261%

Literature Values[3]	Area (sq. km)	% Change from 1989
1989 Water	36,930	-
2006 Water	14,325	-61%





Volume Loss

Images from the Shuttle Radar Topography Mission[2] (SRTM) were used along with the ENVI classification (above) and 3D Analyst in ArcGIS. Analysis results revealed a **loss of 947 km^3** of water from the South Aral between 1988 and 2009.

	SRTM Analysis
Year	Volume (km^3)
1988	1005
2009	58

	Literature[3]
Year	Volume (km^3)
1989	341
2006	81

Acknowledgements:
Thank you to Dr. Eman Ghoneim and Simcha Levental for all of their help.

References:
[1] USGS Global Visualization Viewer (http://glovis.usgs.gov/)
[2] Shuttle Radar Topography Mission (http://srtm.csi.cgiar.org/)
[3] Micklin, Philip. "The Aral Sea Disaster." Annu. Rev. Earth Planet. Sci. 2007. 35:47–72.
[4] Waltham, T. and Sholji, I. "The demise of the Aral Sea – an environmental disaster." Geology Today, Vol. 17, No. 6, Nov.–Dec. 2001

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May 6, 2010