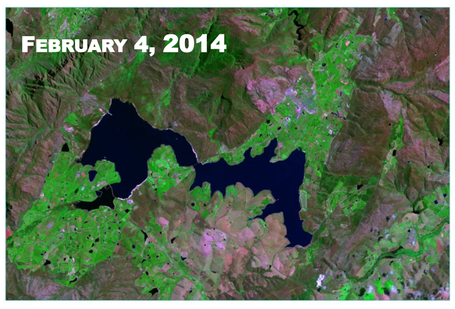
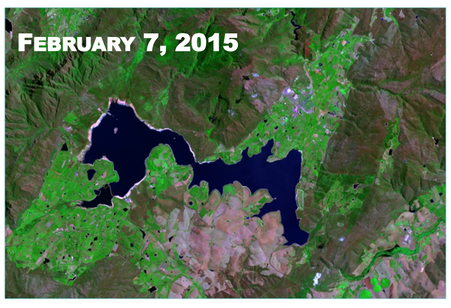
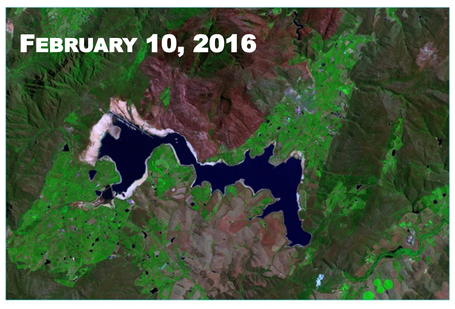
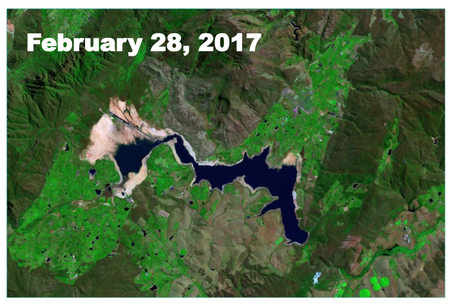
Day Zero

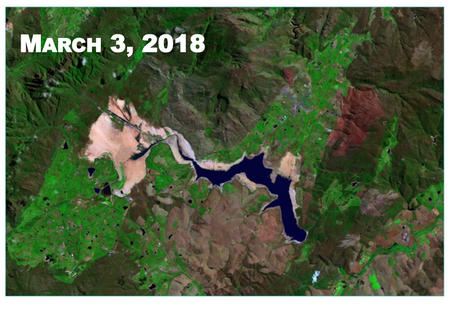
Investigating the loss in Cape Town's Largest Dam





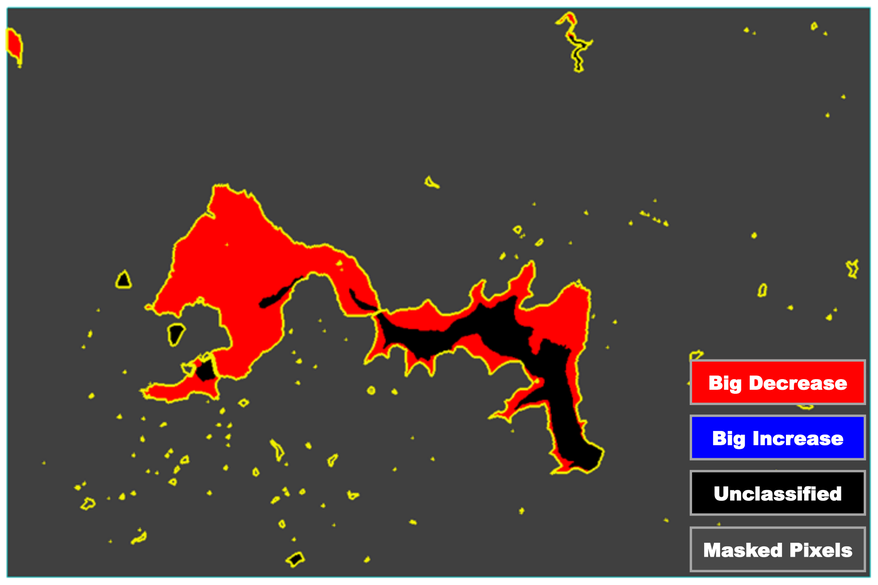






Background

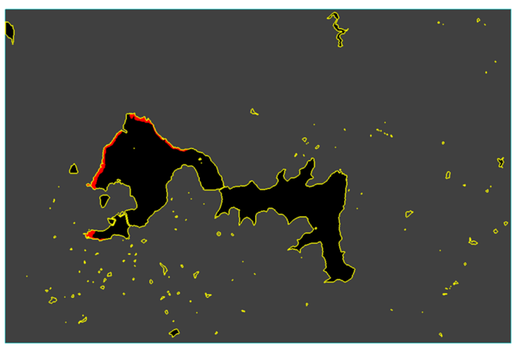
Cape Town, South Africa is running out of water in large part due to several years of drought. The current water system is almost entirely dependent on rainfall, leaving the city vulnerable to extreme weather events.[1] A drought of the current magnitude is expected once in 311 years.[1] Such an extreme event seems like an anomaly, but climate change may lead to more frequent and intense droughts such as this.[2] In addition to the severe drought, rapid population growth,[3] increased consumption,[3] unreported agricultural use,[4] and poor water management [4] have also been cited as contributors to the problem. The dam reservoirs have been dwindling and are currently at 20% capacity (4/26/18).[5] If the reservoirs hit 13.5%, the city plans to shut off the taps to Cape Town's 4 million residents.[2] This project will investigate the change to the Theewaterskloof Dam, the largest of the six dams.[1] It is currently at 10.3% (4/26/18).[5] In 2014, the six dams were full. Understanding how Cape Town ended up in this situation is critical to anticipating and preventing future water crises.



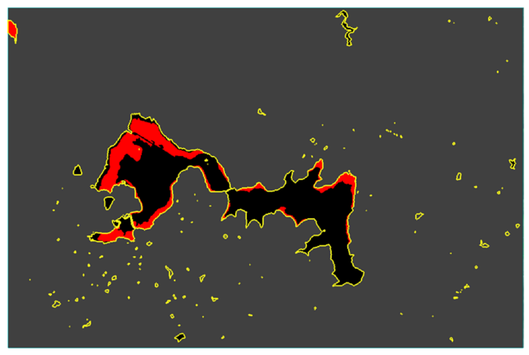
Overall Water Reservoir Change, 2014-2018

Methods

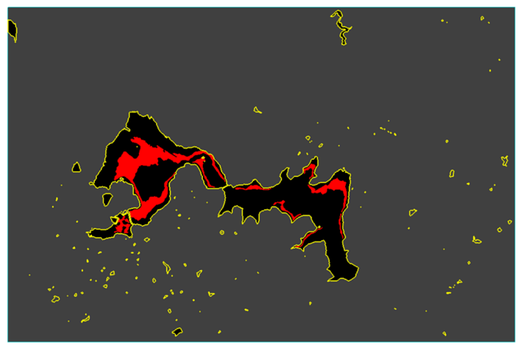
- Re-sizing: Resize images to encompass only the study area.
- Build mask: Use a histogram to build a mask such that only water features are included.
- Create outline of water features using mask.
- Apply mask to eliminate non-water areas from reservoir analysis, and water areas from vegetation analysis.
- Create index images using the Normalized Difference Water Index (NDWI) to better delineate the boundary between water and land.
- Create index images using the Normalized Vegetation Index (NDVI) to characterize the density and health of vegetation.
- Perform Change Detection Analyses for overall and annual changes to the reservoir and vegetation
- Perform thresholding using Otsu's auto-thresholding method. Clean up images by performing smoothing and aggregation.



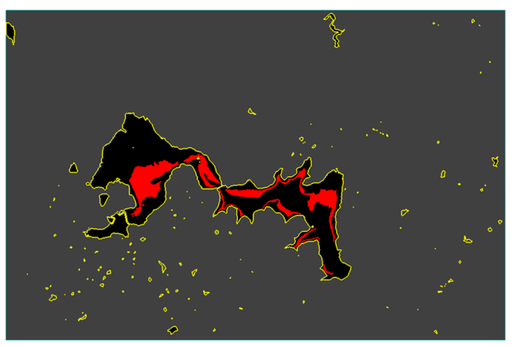
Water Reservoir Change, 2014-2015



Water Reservoir Change, 2015-2016



Water Reservoir Change, 2016-2017



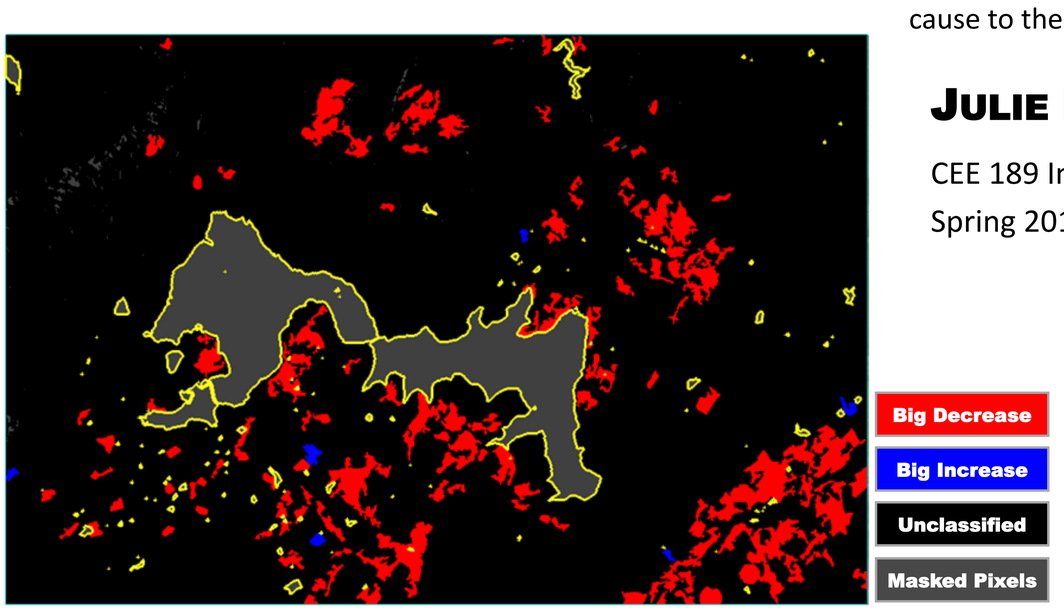
Water Reservoir Change, 2017-2018

Results

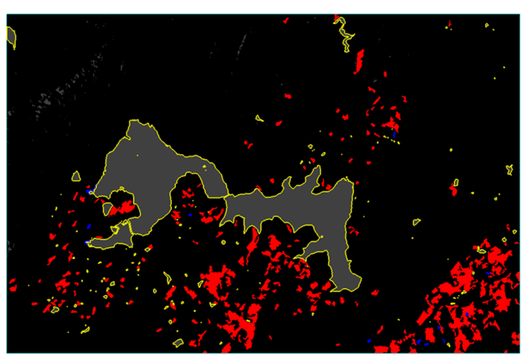
- **2014-2015:** Widespread loss of agriculture and grasslands. Most significant agricultural loss happened this year, although loss to the water reservoir was the smallest this year.
- **2015-2016:** Largest area of loss was natural vegetation in mountains, scattered agriculture loss. High loss to the water reservoir. The large areas of loss in natural vegetation this year indicate severe drought, as natural vegetation relies solely on rainfall, not irrigation. However, agriculture loss was much less severe than the previous year, and does not match the losses in natural vegetation. This could indicate some change to water management, such as more water going toward agriculture irrigation to prevent further loss after severe agriculture losses in 2014-2015. This would lead to increased drawdown in the reservoir.
- **2016-2017:** Recovery in natural vegetation in mountainous region, scattered agricultural loss and recovery. The recovery of natural vegetation this year indicate that the drought may have been less severe. However, the reservoir continued to dwindle at about the same rate (high loss).
- **2017-2018**: Recovery in natural vegetation in mountainous region, scattered agricultural loss and recovery. The recovery of natural vegetation this year indicate that the drought may have been less severe. However, the reservoir continued to dwindle at about the same rate (high loss).

Research questions

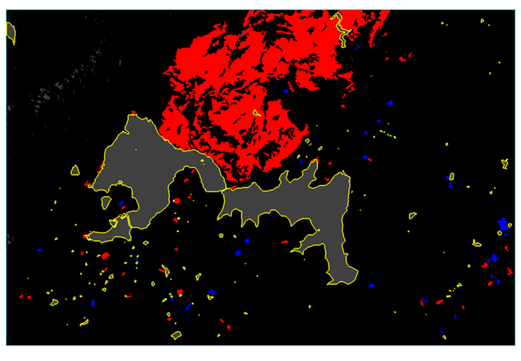
- How has the surface area of the Theewaterskloof Dam Reservoir changed from 2014 to 2018? Has the change been consistent each year or has it varied?
- How has vegetation in the area surrounding the Theewaterskloof Dam changed from 2014 to 2018? Has the change been consistent each year or has it varied?
- How does the timeline of vegetation change correspond to the change in the Theewaterskloof Dam water supply? How are they related?



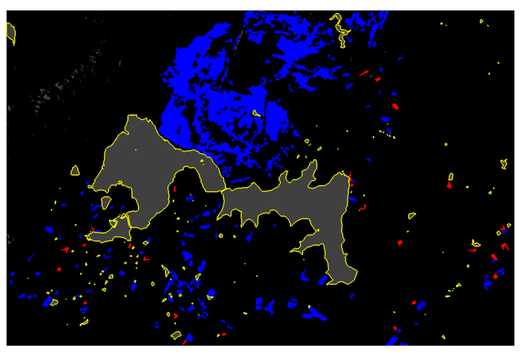
Overall Vegetation Change, 2014-2018



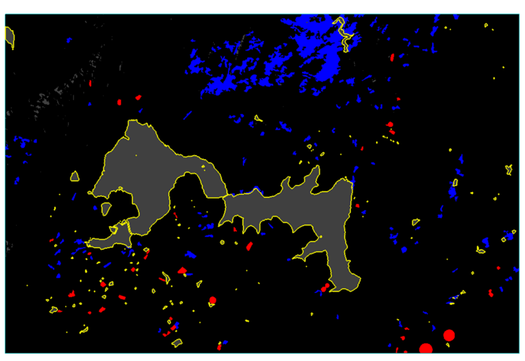
Vegetation Change, 2014-2015



Vegetation Change, 2015-2016



Vegetation Change, 2016-2017



Vegetation Change, 2017-2018

Conclusions

The mismatch between vegetation and water change points to lack of rainfall not being the only cause of the water crisis. A potential explanation is some change in water demand or water allocation/management. The theory of water going to agriculture is supported by the change detection analyses, which show relatively few agriculture losses 2015-2018 compared to 2014-2015, and huge losses to the water supply. There may be other explanations for this pattern. However, the mismatch between vegetation and water change does indicate that lack of rainfall is likely not the only contributing cause to the water crisis.

Julie Powers

CEE 189 Intro to Remote Sensing

Spring 2018

Data Sources:

Tier 1 Landsat-8 images courtesy of the U.S. Geological Survey.

References:

1. City of Cape Town Department of Water and Sanitation. Water Oulook 2018 Report. (2018).
2. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. Climate Change 2014 Synthesis Report, Summary for Policymakers. (IPCC).
3. Bohatch, T. What's causing Cape Town's water crisis? GroundUp (2017).
4. Wolski, P. How severe is the drought? An analysis of the latest data. (2018).
5. City of Cape Town. Current Dam Water Levels. (2018).