A Study of Land Cover Change Detection with Tanimoto Distance

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OUTLINE

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- Tanimoto Similarity Metric
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Background

- Land cover change detection
  - Critical to production inventory monitoring and policy making;
- What is our focus among many land cover types:
  - Citrus grove
- What are challenges?
  - Data from different sensors (digital/film)
    - Radiometric, spatial resolution, spectral coverage differences (make the change detection very difficult)
- What is the method suitable for citrus grove change detection?

Change Detection Methods: Pre-classification

- Many methods:
  - Image differencing (normalized/non-normalized)
  - Change vector analysis;
  - Inner product analysis;
  - Image ratioing;
  - Vegetation Index differencing;
  - Spectral correlation analysis;
  - Principal Component Analysis (PCA);
- Straightforward – no classification (direct comparison);
- Many of them are sensitive to radiometric difference;
- Good sensor calibration and radiometric normalization may be needed;
- Difficult in handle images acquired with different sensors.

Change Detection Methods: Post-classification

- Two steps: 1) Classification; 2) Post classification analysis
- Post classification interpretation may introduce extra errors;
- Accuracy Depends on the Accuracy of the Classification
  - Best Accuracy: Bigger one of two classification errors;
  - Worst Accuracy: Sum of Two Classification errors;
- Complicated - require experienced & well trained analyst;
- Intra-class change is not defined
  - Difficult in detecting citrus growth
- Suitable for large scale land cover change detection (many cover types involved);
- Not best for single cover type change detection such Citrus

What Is An Ideal Method?

- Minimum human-machine interaction;
- User-friendly--require minimum experience and training for operation;
- Easy to understand and easy to implementation;
- Robust to various kinds of image data conditions;
- Robust to Radiometric difference;
- Invariant to image dynamic range.

Direct Comparison Methods

- Direct comparison methods
  - Sensitive to spatial resolution, dynamic range, radiometric, and spectral differences;
  - Solution:
    - Resample and rescale;
    - May perform radiometric normalization using histogram matching;
- Image difference – the most straightforward method
  - but not effective enough with radiometric differences!
- Explore new method - Tanimoto distance;
  - It's a normalized metric and may reduce some effect of radiometric differences;
  - To see if it's more effective than image difference/EU.

What Is Tanimoto Distance?

$$T(x,y) = \frac{x \cdot y}{\|x\|^2 + \|y\|^2 - x \cdot y}$$

- A similarity metric for two vector attributes x and y;
- Originally, it’s for discrete variables, widely used in biological, botanical analysis;
- Normalized metric [0, 1], with 1 for maximum similarity and 0 for minimum similarity;
- Not radiometric invariant;
- Purpose: To see if it gives us a better performance.

Experiments & Results

Data Processing & Experiments

- Data processing
  - Raw images (only rescaling & re-sampling);
  - Higher bits clipped (information compacted in lower bits);
  - Radiometric normalized with histogram transformation.
- Experimental scenarios
  - Euclidean distance metric;
  - Tanimoto distance metric.

Raw Images without Clipping Nor Normalizing

2004 raw image

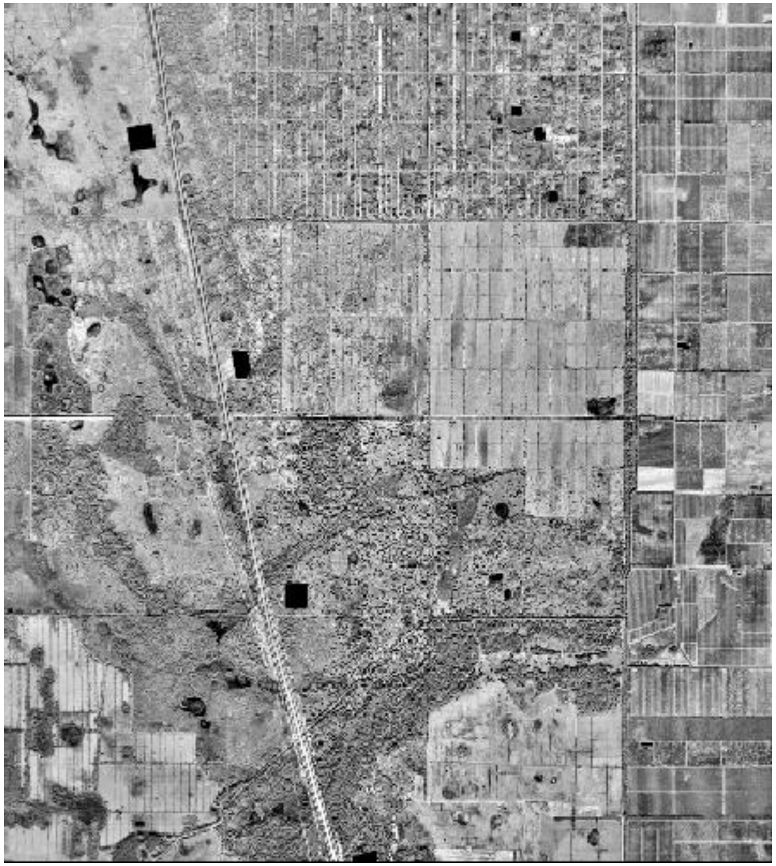
1999 raw image (Reference)

Clipped and Normalized 2004 Image

2004 clipped image

2004 image normalized to 1999

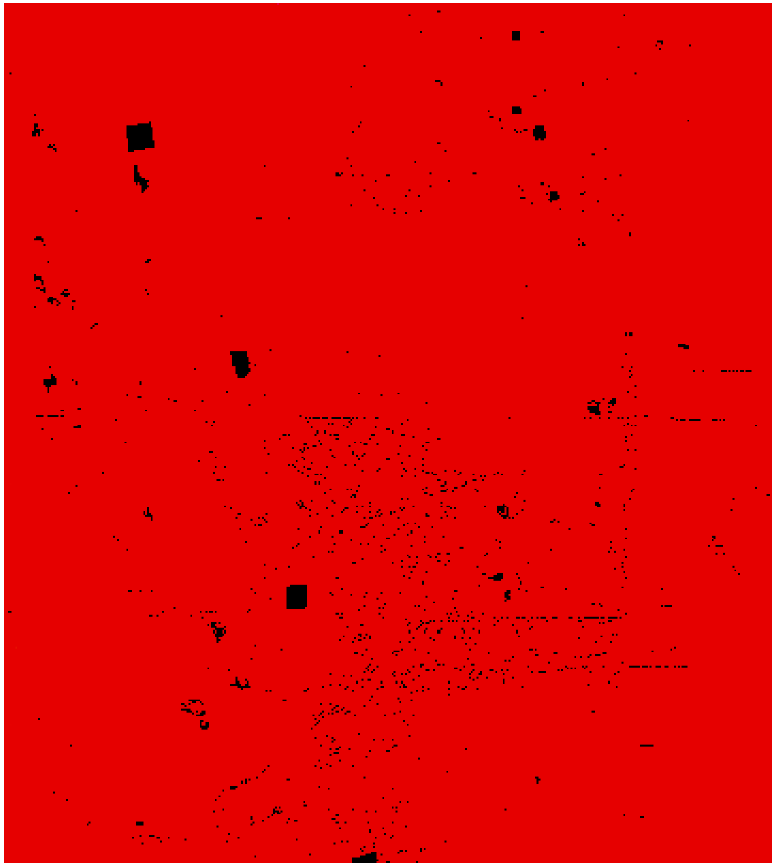
Distance Maps for Raw Image with no Clipping & Normalizing



Euclidean Dist Map

Tanimoto Dist Map

Change Maps for Raw Image with no Clipping & Normalizing (30%)

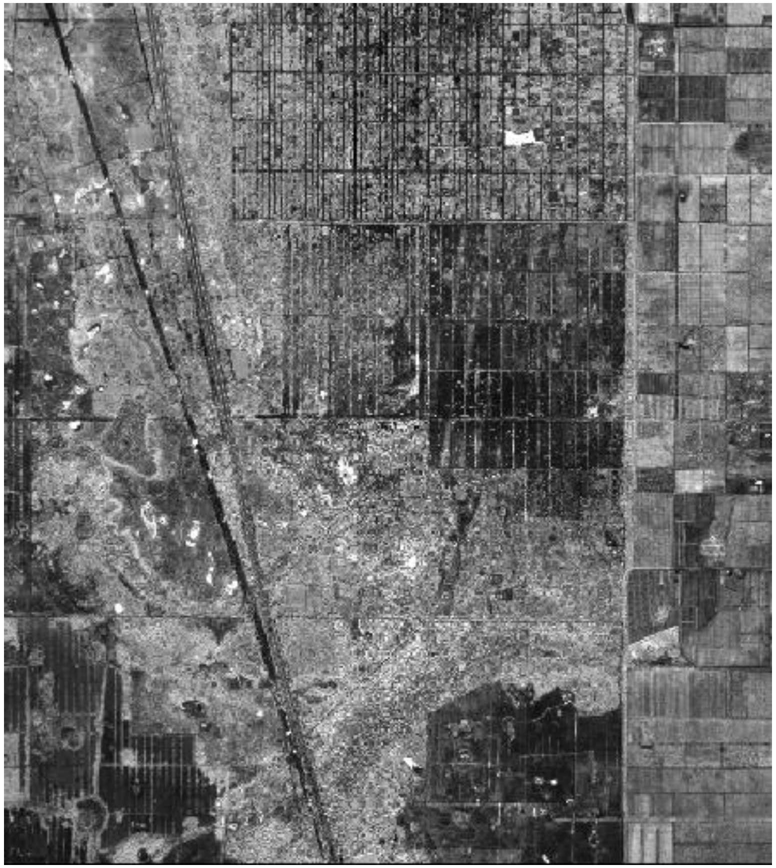


Euclidean

Tanimoto

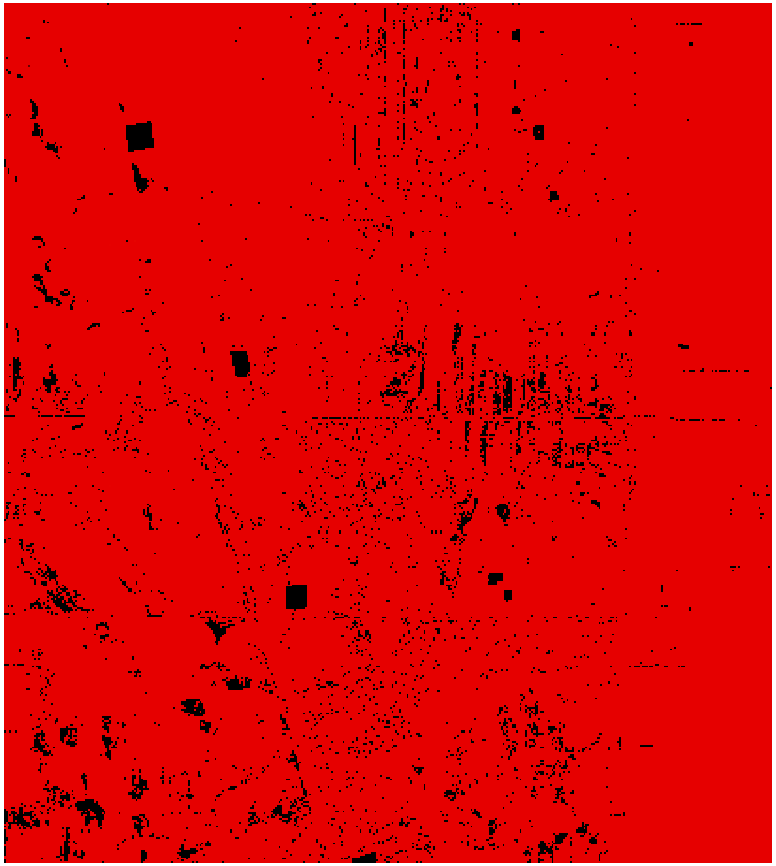
Distance Maps for Clipped Raw Images

Euclidean Dist Map

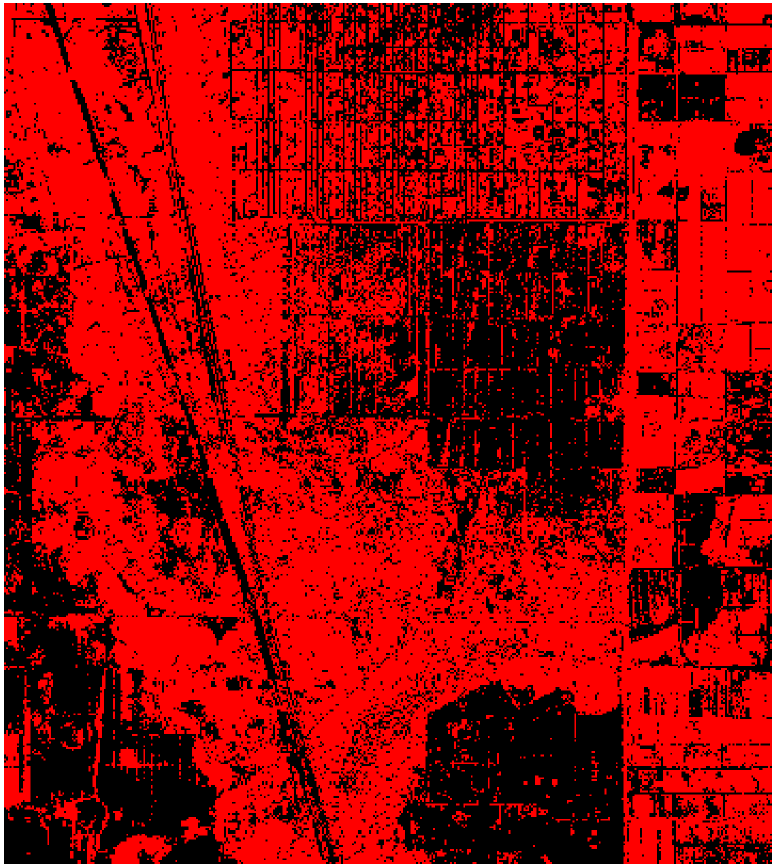


Tanimoto Dist Map

Change Maps for Clipped Raw image (20% Threshold)

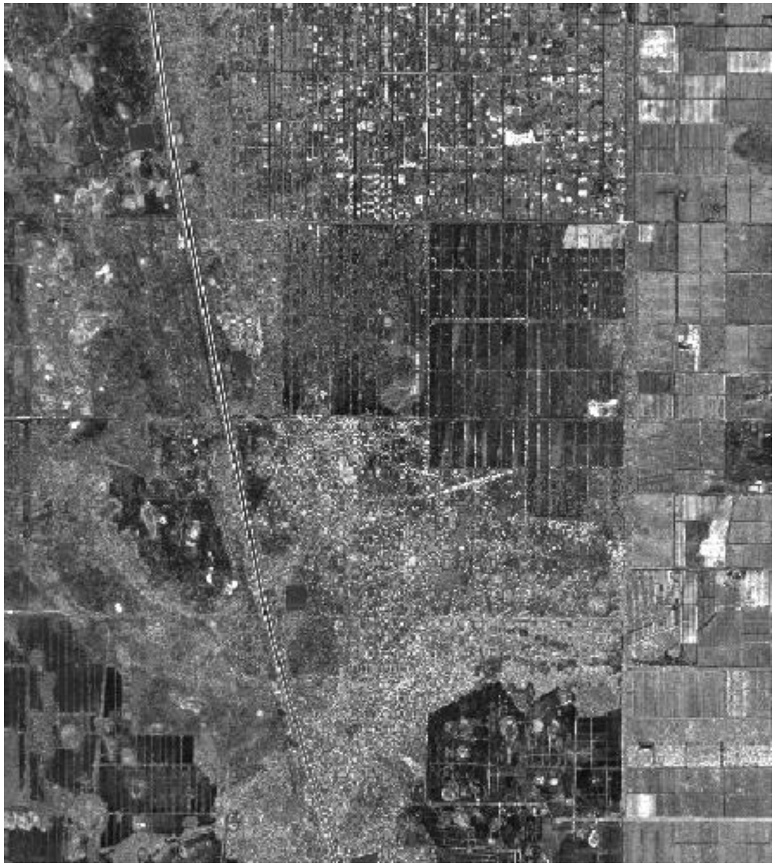


Euclidean Change Map

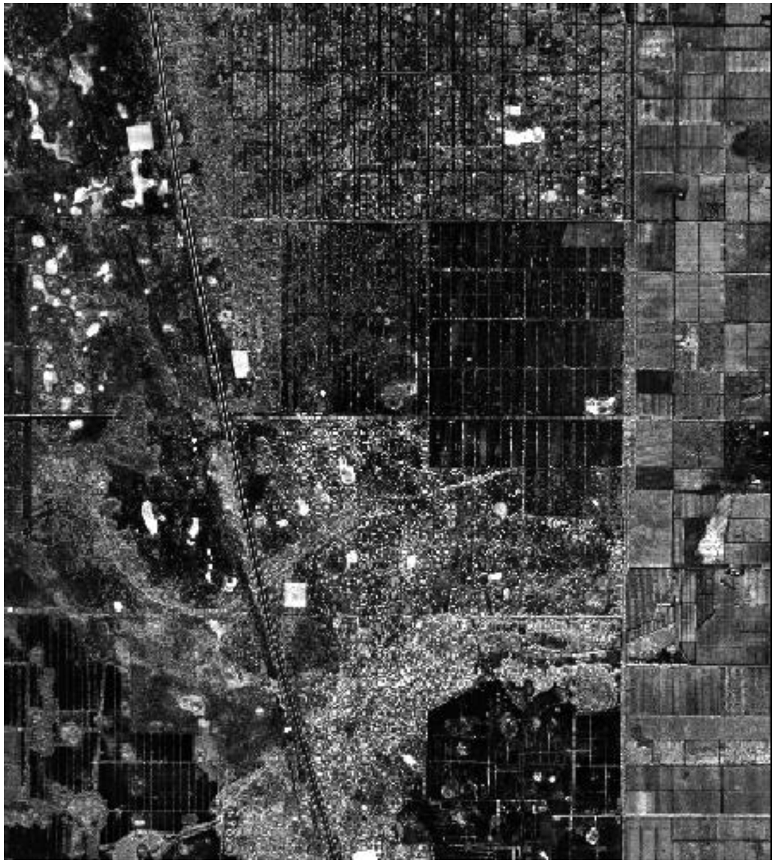


Tanimoto Change Map

Distance Maps for Normalized Images

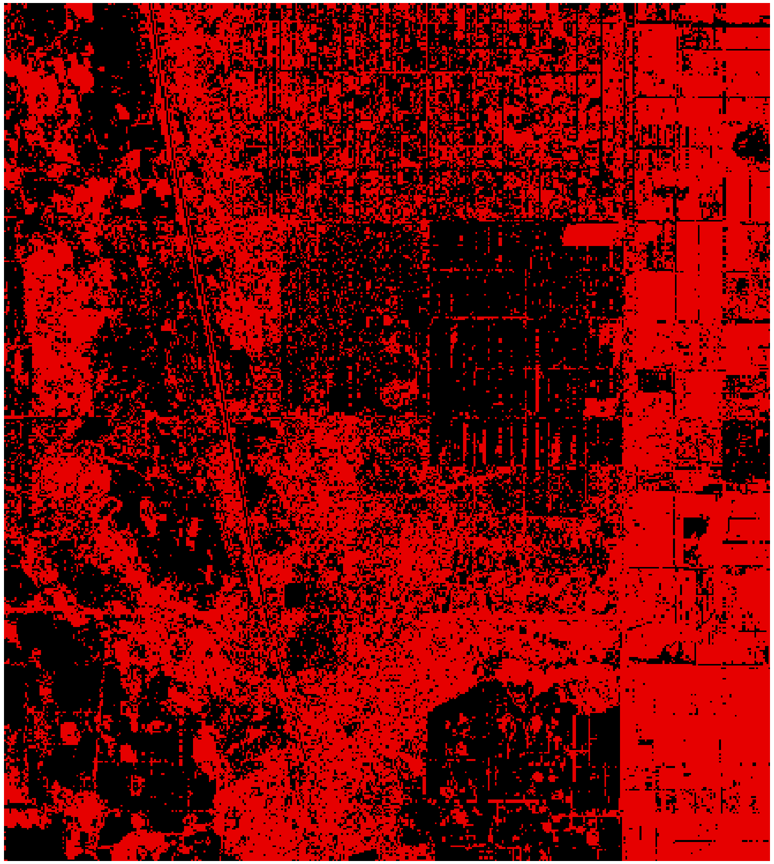


Euclidean Dist Map



Tanimoto Dist Map

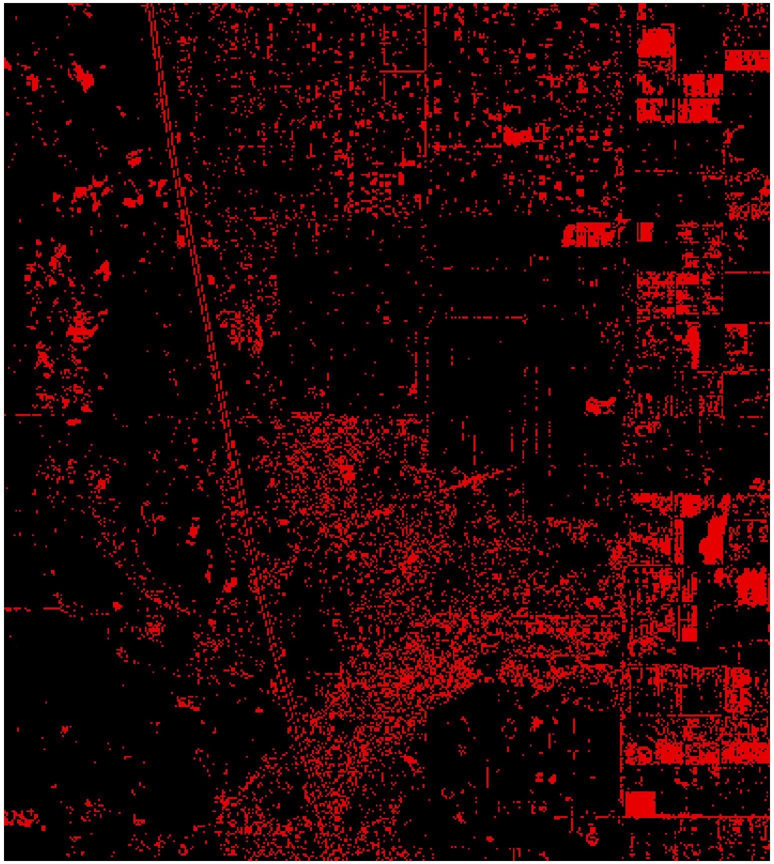
Change Maps for Normalized Images(20%)



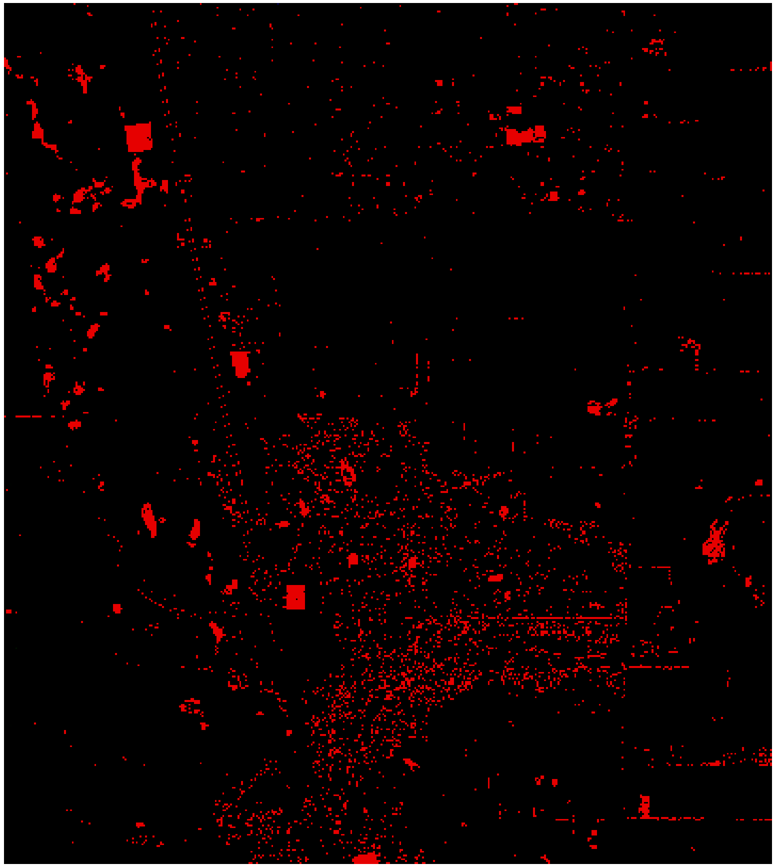
Euclidean Change Map

Tanimoto Change Map

Change Maps for Normalized Images (30%)



Euclidean Change Map



Tanimoto Change Map

Conclusions

- Tanimoto similarity metric is significantly more sensitive to changes than Euclidean distance (This is evidenced by change maps with 20% threshold);
- Experimental results confirm that Tanimoto similarity metric is not radiometric invariant, but it is more robust to radiometric difference than Euclidean distance because it is a normalized metric;
- Radiometric normalization is still critical to effectiveness of using Tanimoto similarity metric for change detection;
- Change detection results indicate that the proposed Tanimoto similarity metric has comparable effectiveness to the Euclidean distance metric;
- The change detection threshold is critical to identify changes.

THANK YOU!

QUESTIONS & COMMENTS?