Objective

• To optimize our automated change detection processes

• Existing literature:
  • Says crucial for direct comparison approaches
  • Not conclusive for statistical approaches
  • No work on specifically using our change detection approach

• Question: Can we make our automated change products more accurate by pre-processing our source imagery to a higher level?
  • Surface Reflectance (SR)
  • Terrain Normalization (TN)

• Not addressing geometric accuracy in this study
Imagery and AOI

3 Tiles of Sentinel-2 Imagery:
1 - Tile37-QED, 2018-09-10 & 2015-08-31, Jeddah, Saudi Arabia

2018-09-10

2015-08-31
Imagery and AOI

2 – Tile49-RGP, 2018-04-18 & 2016-07-29, Wuhan, China
Imagery and AOI

2 – Tile39-SWV, 2018-01-08 & 2015-08-12, Tehran, Iran

2018-01-08

2015-08-12
Imagery

- Orthorectified
- 4-band
  - VNIR (2,3,4,8)
  - 10m res
- 6-band
  - VNIR + SWIR1 and SWIR2 (2,3,4,8,11,12)
  - 10m res
- 10-band
  - All bands except for 3 60m atmospheric bands (1,9,10)
  - 20m res
Pre-processing methods

- Parameters tested:
  - Number of bands – 4, 6, 10
  - Atmospheric correction level – TOA, BOA (SR)
  - Terrain correction level – Corrected for terrain slope albedo, not corrected

- 12 (3x2x2) permutations of 3 footprints tested = 36 runs

- Run at 10m resolution
  - Except 10 band layers are 20m res

- Atmospheric correction performed using ATCOR to produce the SR

- Terrain normalization (TN) performed using C-Correction (Teillet, P.M, et al, 1982)

- DEM used: AW3D30 resampled to 10m and 20m from 30m (bilinear)
Change reference layer

• Define what is change?
  • NOAA C-CAP standards
  • Focus on new, destroyed, or moved features
  • No seasonal change: agriculture, vegetation phenology, snow/ice
  • Land use change vs. land cover change

• Reference change layer created for each of the 3 scene pairs
  • Created using automated change methods, post-classification, and lots of hand edits
  • < 3 pixels filtered out
Change detection method

• Cross Correlation Analysis (CCA)
• Statistical approach measuring variation of late-date DN values from strata means where strata are derived from the early-date imagery
• No direct comparison of imagery
• Output is a 16-bit Z-score layer correlated to probability of change
• Usually threshold layer to create binary change using an empirically derived universal coefficient
• For this test we won’t assume a single threshold
CCA Output

Early date scene, May 8 1990.

Z-score range of values

Late date scene, Oct 31 1996
Assessment approach

• Change reference layer (mask) compared to Z-scores (16-bit continuous)
• ROC Curve
  • Receiver Operating Characteristic
  • Graph Probability of Correct Change Detections vs Probability of False Positives
• AUC – Area Under Curve
Reference Change Mask T37QED

2018-09-10 S-2 image with reference change mask in yellow

2015-08-31 S-2 image with thresholded Z-score in yellow
Results 4-band T37QED

- SR increases accuracy slightly
- TN does not have much impact
- Desert scenes tend to be difficult to correct
- This scene pair has very little terrain variability
- TN, if not performed well or with poor DEM, often adds error in flat areas
- This reference change mask was probably the most precise, most time spent
- Also this scene pair is near anniversary
Results 6-band T37QED

- SR increases probability accuracy
- TN has almost no effect
- 6-band appears to be more accurate than 4-band change
Results 10-band T37QED

- SR processing increases accuracy
- TN decreases accuracy slightly
Reference Change Mask T49RGP

2018-04-18 S-2 image with reference change mask in yellow

2016-07-29 S-2 image with thresholded Z-score in yellow
Results 4-band T49RGP

- SR slightly reduced accuracy
- TN slightly reduced accuracy
- This scene has little terrain variability
- It is nearly totally vegetated and contains lots of water
Results 6-band T49RGP

- SR slightly reduced accuracy
- TN slightly reduced accuracy
Results 10-band T49RGP

- SR decreased accuracy
- TN did not consistently impact accuracy
- SR/TN run anomalous
Reference Change Mask T39SWV

2018-09-11 S-2 image with reference change mask in yellow

2015-08-12 S-2 image with thresholded Z-score in yellow
Results 4-band T39SWV

- SR improved results
- TN improved results
- This scene has varied terrain
- It has a good mix of land cover types
Results 6-band T39SWV

- SR slightly decreased accuracy
- TN increased accuracy
Results 10-band T39SWV

- SR slightly reduced accuracy
- TN increased accuracy
## Summary of AUC scores

<table>
<thead>
<tr>
<th>File\Tile</th>
<th>T37QED</th>
<th>T49RGP</th>
<th>T39SWV</th>
<th>MEANS</th>
<th>Statistics</th>
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</thead>
<tbody>
<tr>
<td>4-band TOA  TN</td>
<td>0.9605</td>
<td>0.912</td>
<td>0.7778</td>
<td>0.8834</td>
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<tr>
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<td>MEANS</td>
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<td>0.8080</td>
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</tbody>
</table>
Conclusions

• SR does not consistently increase accuracy in statistical change product
  • Maybe it makes more impact when imagery is spectrally or temporally more variable

• TN increases accuracy in scenes with variable terrain

• TN does not consistently decrease accuracy in flat scenes
  • Provided you use a good quality DEM

• More important what bands used than pre-processing used

• 4-band VNIR imagery consistently returns the lowest accuracies, SWIR bands are important

• General recommendation: 6-band TOA TN
Future study

• Assess on more Sentinel-2 tiles
• Increase sample to include:
  • Areas of more variable terrain
  • Varied biomes such as tropical and arctic
• Assess on varied sensors
• Cross-sensor change detection
• Assess using varied change detection techniques
Thank You