Examining Surface Reflectance, NDVI and LAI from TM, ETM+ and OLI for Data Fusion and ET Mapping

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and also contributed by David Roy and his group

*USDA is an equal opportunity provider and employer*
Motivations

- Data fusion requires consistent Landsat and MODIS data
  - consistent Landsat data (TM, ETM+, OLI)
  - consistent relations between Landsat and MODIS
- ET mapping needs LAI, NDVI and surface temperature from Landsat
  - consistent LAI retrieved among Landsat sensors
- Temporally consistent is more important for us
- Previous publications have revealed the differences between ETM+ and OLI (Flood, 2014; Li et al., 2014; Roy et al., 2015)
Landsat minus MODIS
(mean biases, mean absolute differences and $R^2$)

Central Iowa
2001 to 2014

Landsat: p26r31
MODIS: h10v04, h11v04

MODIS daily SR were corrected to NBAR and reprojected to Landsat UTM projection

Each bar represents result generated using all clear Landsat and MODIS pixels from the entire year (960m).
Lodi, CA
2014

29 Landsat 7 ETM+
33 Landsat 8 OLI

GRAPEX- Grape Remote sensing Atmospheric Profiling & Evapotranspiration eXperiment
NDVI comparisons
NDVI comparisons
Nebraska Mead Sites

NDVI MEAD site (red box ~ 30 km average) 2013

LAI MEAD site (red box ~30 km average) 2013
Relative Correction using Linear Regression

<table>
<thead>
<tr>
<th>L7day</th>
<th>L8day</th>
<th>bname</th>
<th>a</th>
<th>b</th>
<th>R</th>
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</table>

\[ L8 = a + b \times L7 \]

- overlapped L7 and L8 (+-1 day)
- date
- location
- band

For Gallo CA
- From Flood et al., Remote Sens., 2014. using Landsat scenes in Australia

\[ \rho_{ETM+} = c_0 + c_1 I_{OLI} \]

<table>
<thead>
<tr>
<th>Band</th>
<th>(c_0)</th>
<th>(c_1)</th>
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<tbody>
<tr>
<td>ETM 1 (OLI 2)</td>
<td>0.00501</td>
<td>0.95852</td>
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<td>ETM 2 (OLI 3)</td>
<td>0.00307</td>
<td>0.98911</td>
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<tr>
<td>ETM 3 (OLI 4)</td>
<td>0.00198</td>
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<td>ETM 4 (OLI 5)</td>
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<tr>
<td>ETM 5 (OLI 6)</td>
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<td>0.98824</td>
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<tr>
<td>ETM 7 (OLI 7)</td>
<td>−0.00147</td>
<td>0.97591</td>
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- From Li et al., Remote Sens., 2014. using Landsat scenes in Southeast Asia

\[
\text{Intercalibrated } \text{LSWI}_{\text{Landsat-8 OLI}} = 1.00324 \times \text{LSWI}_{\text{Landsat-7 ETM+}} + 0.01466
\]

\[
\text{Intercalibrated } \text{NBR}_{\text{Landsat-8 OLI}} = 0.95342 \times \text{NBR}_{\text{Landsat-7 ETM+}} + 0.05844
\]

\[
\text{Intercalibrated } \text{NDVI}_{\text{Landsat-8 OLI}} = 0.97998 \times \text{NDVI}_{\text{Landsat-7 ETM+}} + 0.07592
\]

\[
\text{Intercalibrated } \text{MNDWI}_{\text{Landsat-8 OLI}} = 0.88513 \times \text{MNDWI}_{\text{Landsat-7 ETM+}} - 0.04079
\]


<table>
<thead>
<tr>
<th>TOA NDVI</th>
<th>RMA</th>
<th>(\text{OLI} = 0.0306 + 0.9824 \text{ETM} )</th>
</tr>
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<tbody>
<tr>
<td>OLS</td>
<td>(\text{OLI} = 0.0490 + 0.9352 \text{ETM} + )</td>
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<tr>
<td>OLS</td>
<td>(\text{ETM} = -0.0110 + 0.9690 \text{OLI} )</td>
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<table>
<thead>
<tr>
<th>Surface NDVI</th>
<th>RMA</th>
<th>(\text{OLI} = 0.0149 + 1.0035 \text{ETM} )</th>
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<tbody>
<tr>
<td>OLS</td>
<td>(\text{OLI} = 0.0235 + 0.9723 \text{ETM} + )</td>
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<tr>
<td>OLS</td>
<td>(\text{ETM} = 0.0029 + 0.9589 \text{OLI} )</td>
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<tr>
<td>SR: ETM+ = a * OLI + b</td>
<td>Roy_OLS</td>
<td>Flood</td>
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<tr>
<td>------------------------</td>
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<tr>
<td></td>
<td>slope</td>
<td>intercept</td>
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<td>ETM 1 (OLI 2)</td>
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<td>NDVI: OLI = a* ETM + b</td>
<td>0.9723</td>
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SR: OLI = a*ETM + b

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<tr>
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<td>intercept</td>
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<td>ETM 7 (OLI 7)</td>
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<td>0.0029</td>
<td>0.9071</td>
<td>0.0172</td>
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</table>

(RMA: reduced major axis; OLS: ordinary least square)

![Graph showing the relationship between ETM and OLI for different algorithms](image)
Discussion

• Regression model depends on the samples used (empirical)
  – time and location
  – land cover types
  – vegetation density and condition

• Apply before or after atmosphere correction?

• Use OLI or ETM+ as the standard?
  – ETM+ is consistent with TM and so history data can be used
  – OLI is more consistent with MODIS and has better quality

• Physical-based model/approach?
  Regression approach is hard for scene based correction (one regression per scene/date) since samples need to be extracted from the overlapped area between L7 and L8
NC2 is 20 year old forest; NC3 is a clear cut site, with seedling replanting