

# Thermal Band Gymnastics for Evapotranspiration Retrievals

Rick Allen

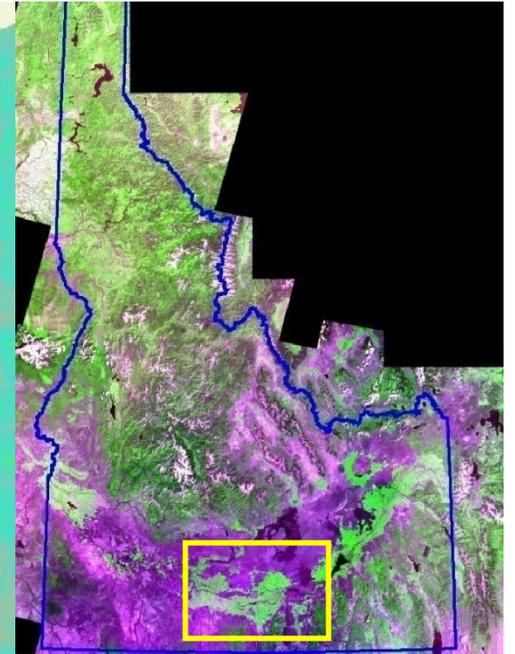
University of Idaho

## Partners:

Dr. Jeppe Kjaersgaard, Dr. Ricardo Trezza, Mr. Clarence Robison, Dr. Aureo deOliveira, Univ. Idaho  
Mr. Tony Morse, Mr. William Kramber, Idaho Dept. Water Resources  
Dr. Jan Hendrickx, New Mexico Tech, Dr. Ayse Irmak, UNL, Dr. Graeme Aggett, AMEC Corp  
Dr. Magali Garcia, Univ. La Paz, Bolivia

Wood River

# Magic Valley, Idaho – Total Seasonal Water Use -- 2006

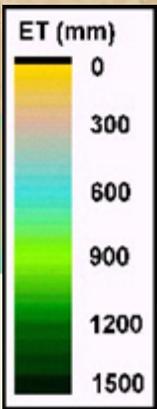


NSCC

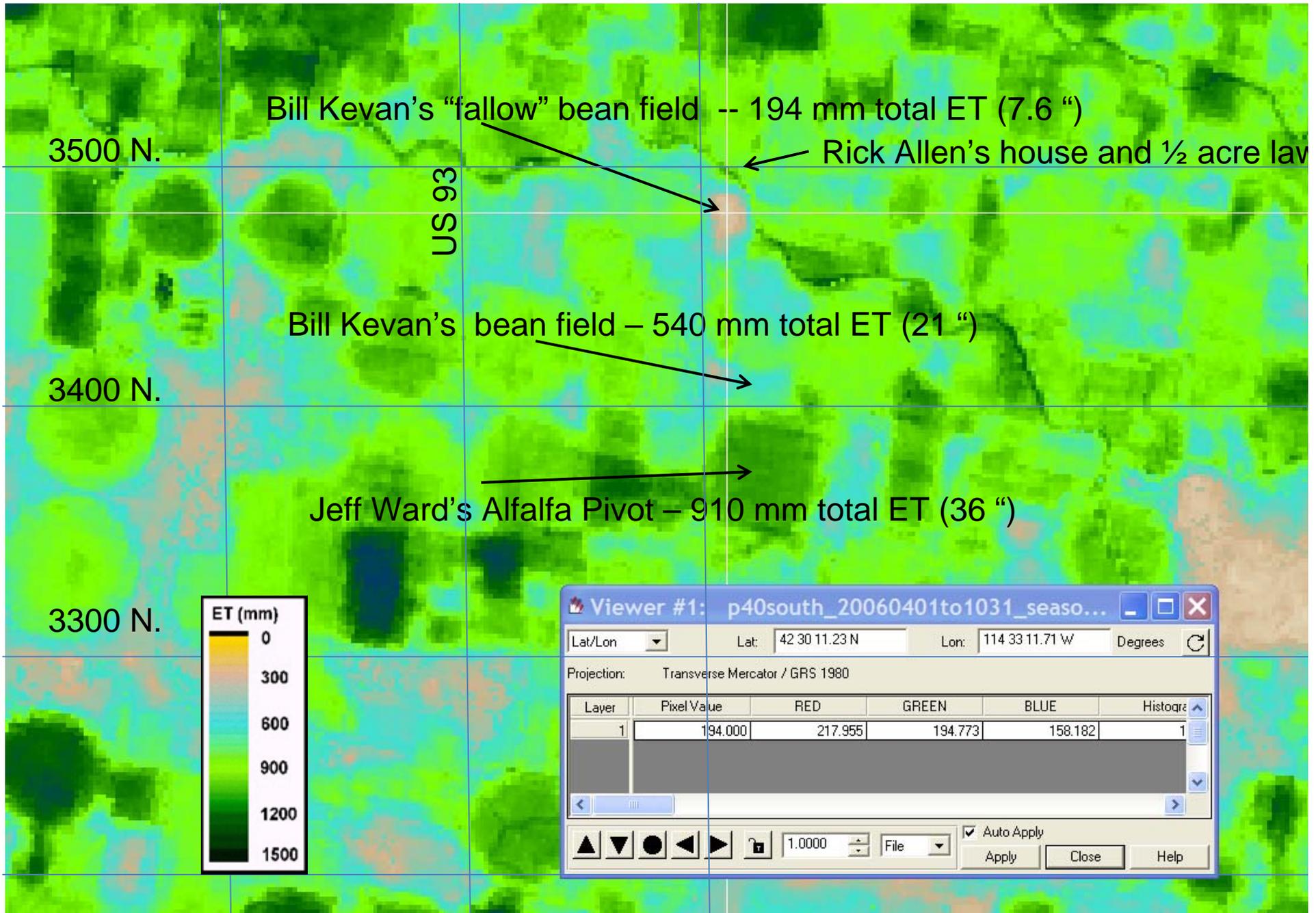
Minidoka

TFCC

SRCC

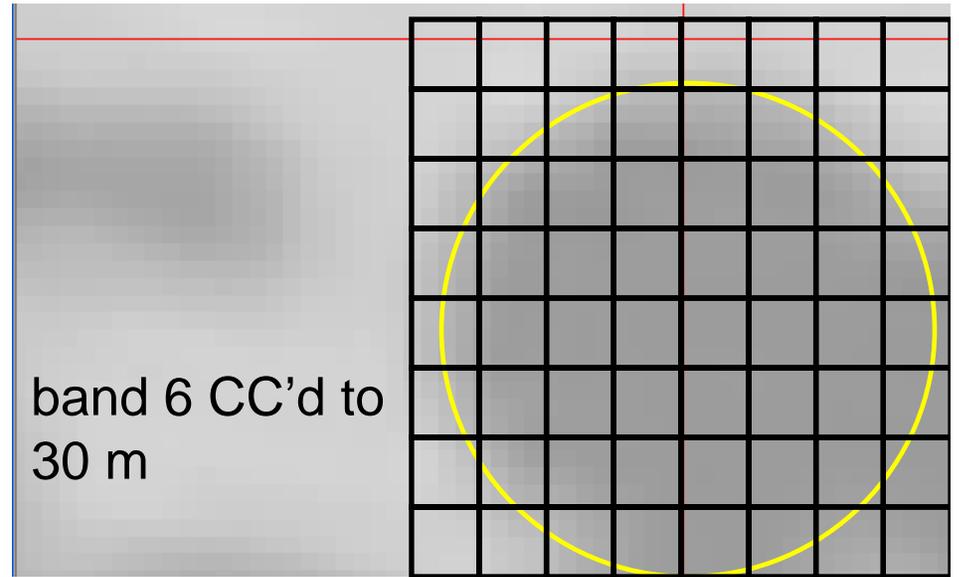
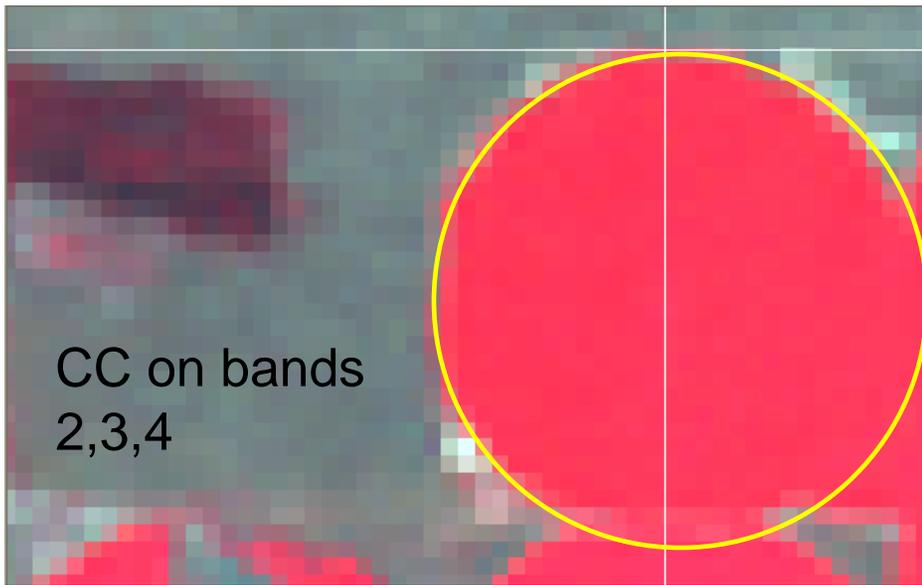


# Growing Season ET, south of Twin Falls, Idaho, 2006

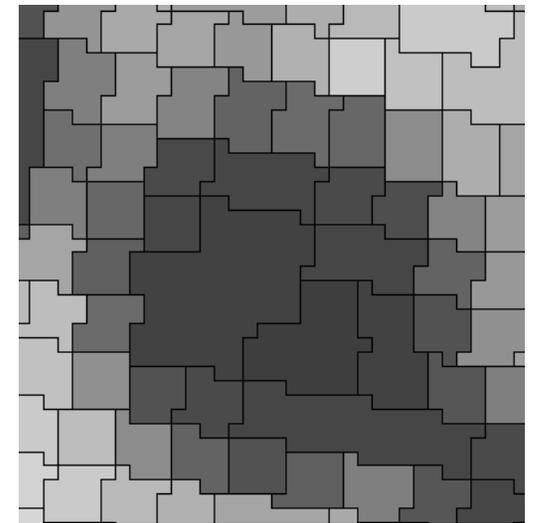
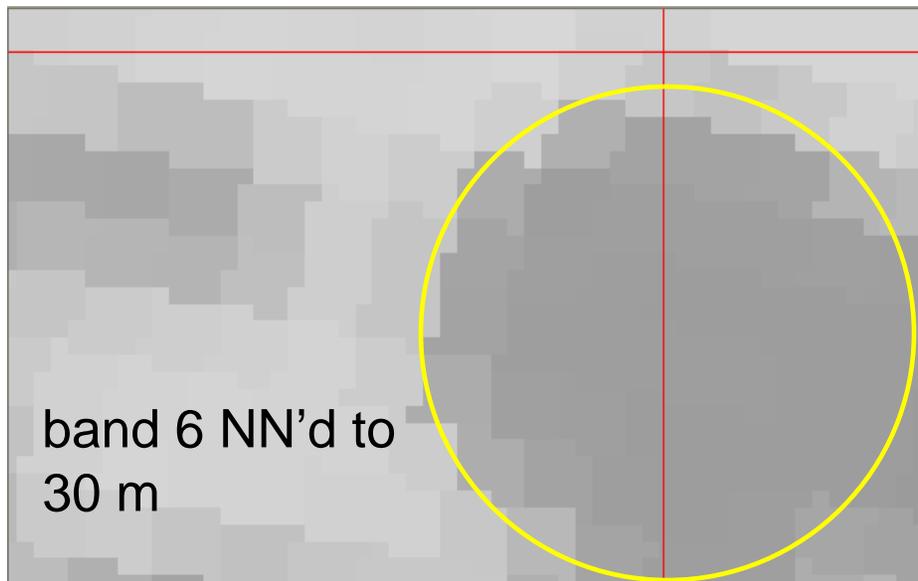


# Sharpening the Thermal Band

- In 2008-2009 we tested the impact of sharpening NN resampled band 6 (NLAPS/L1T) vs. CC resampled band 6 (new LPGS/L1T system)
- We use NDVI and LST vs. NDVI relationships developed during the METRIC surface energy balance processing to sharpen, with conservation of LST per original pixel
- With LPGS/CC thermal sharpening, we must first recreate 'pseudo' 120 m thermal pixels

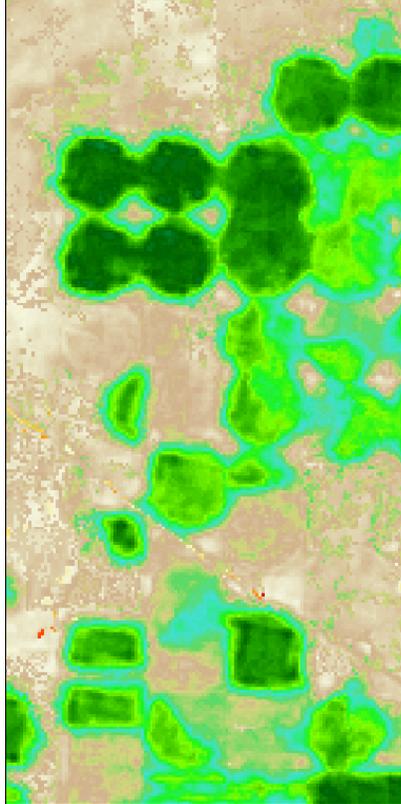


**Landsat 5 06/20/06 – S. Idaho – LST**

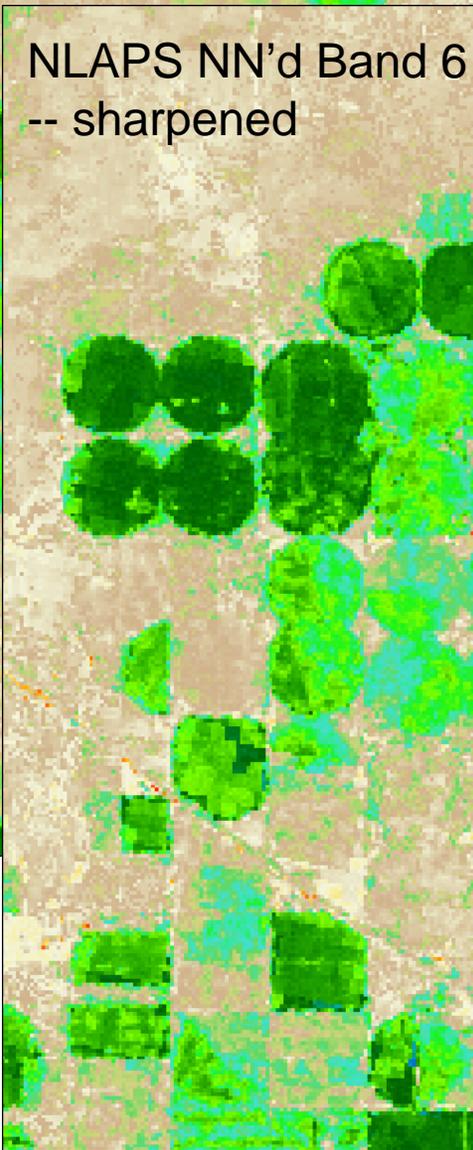


ETrF = fraction of potential (reference ET)

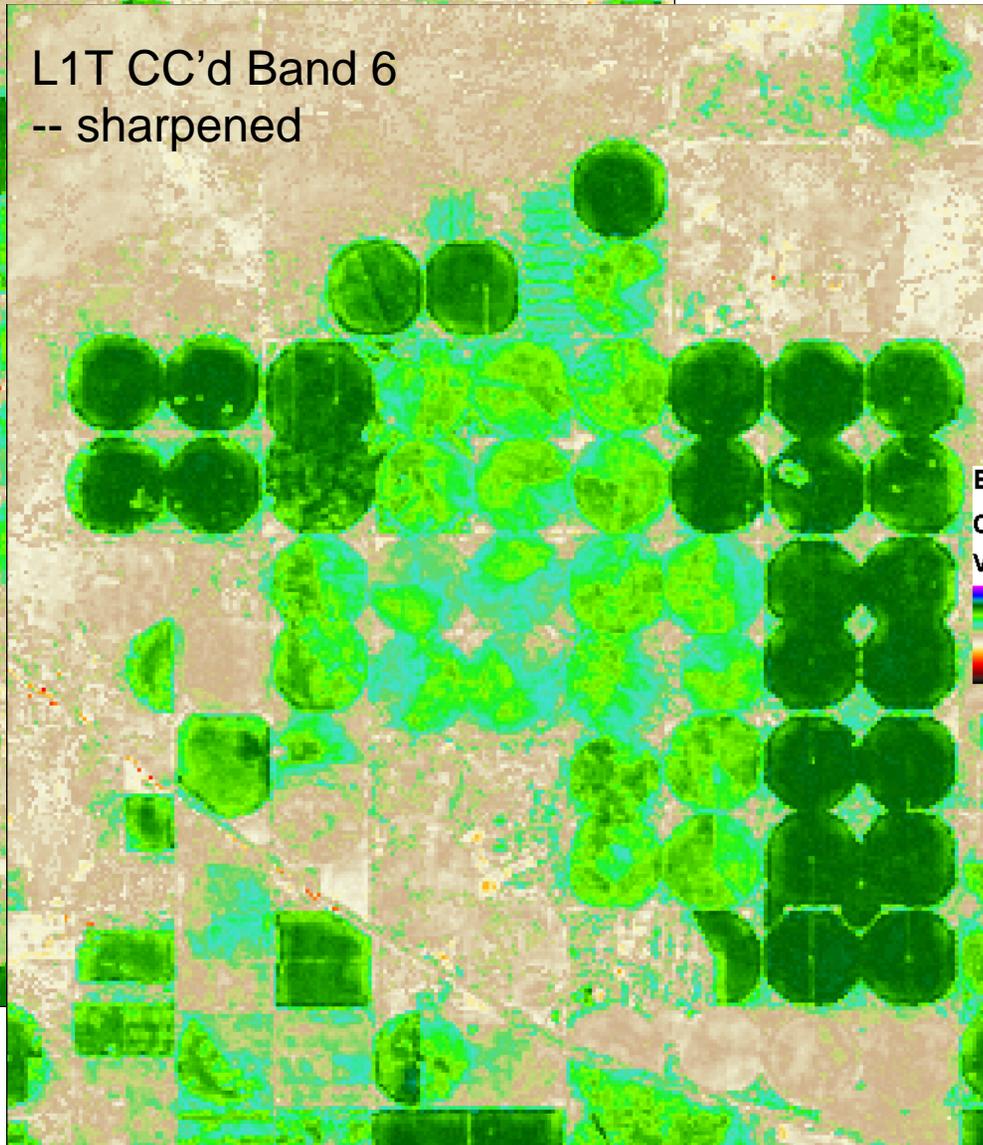
L1T CC'd Band 6  
- no sharpening



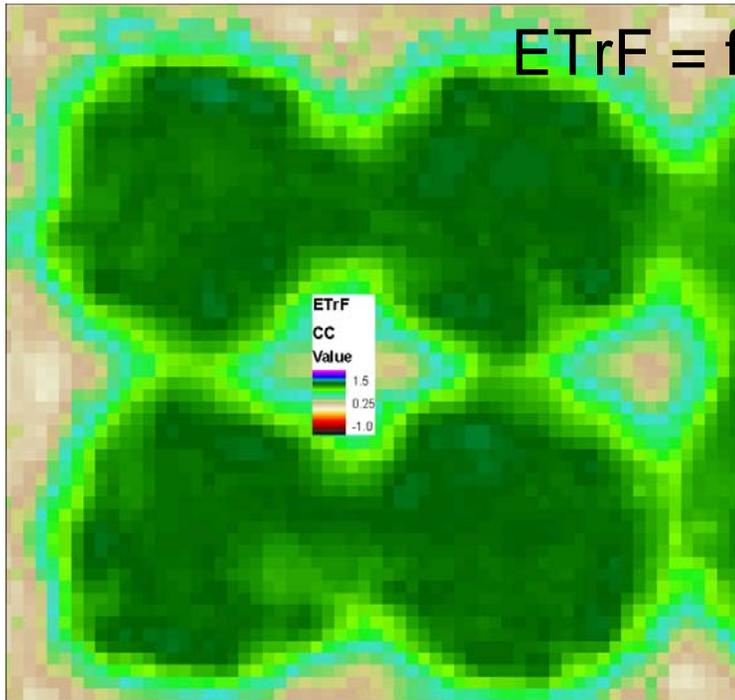
NLAPS NN'd Band 6  
-- sharpened



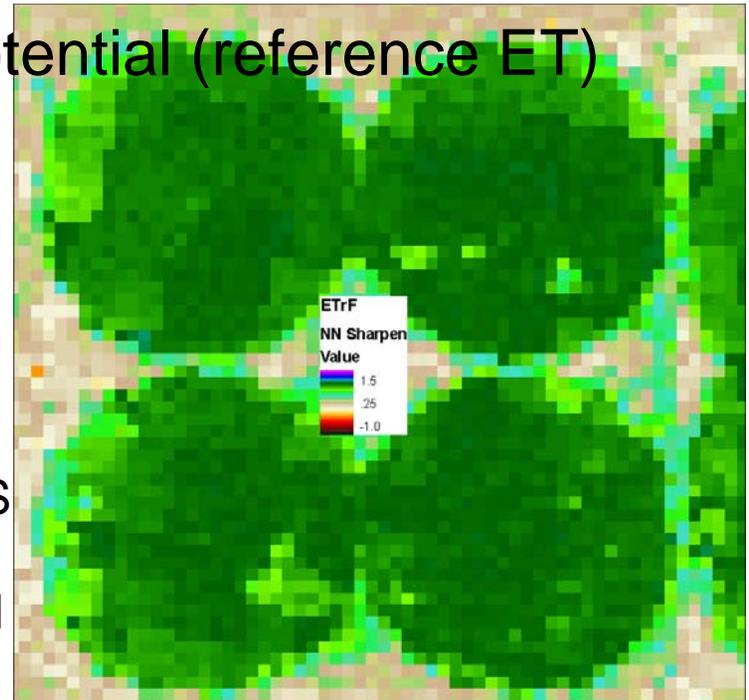
L1T CC'd Band 6  
-- sharpened



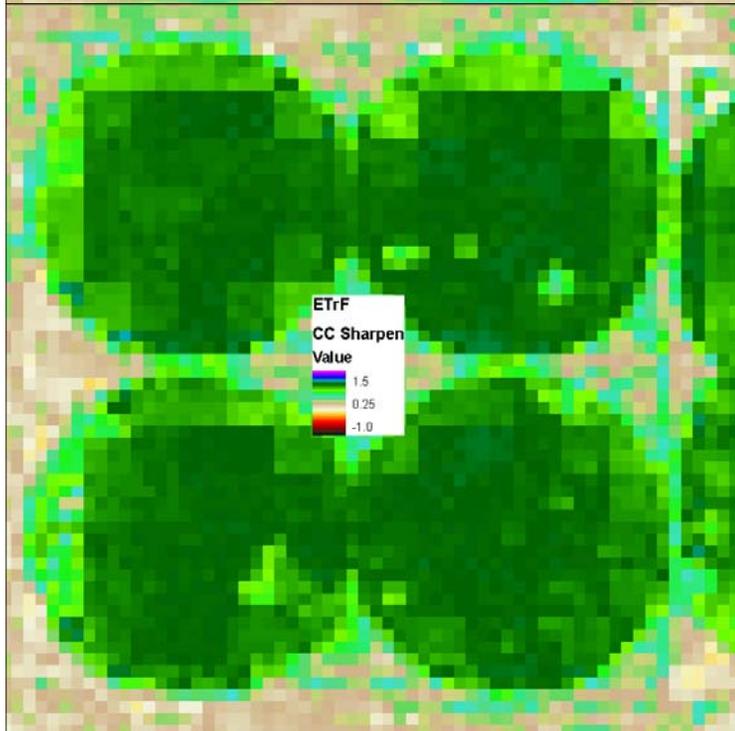
ETrF = fraction of potential (reference ET)



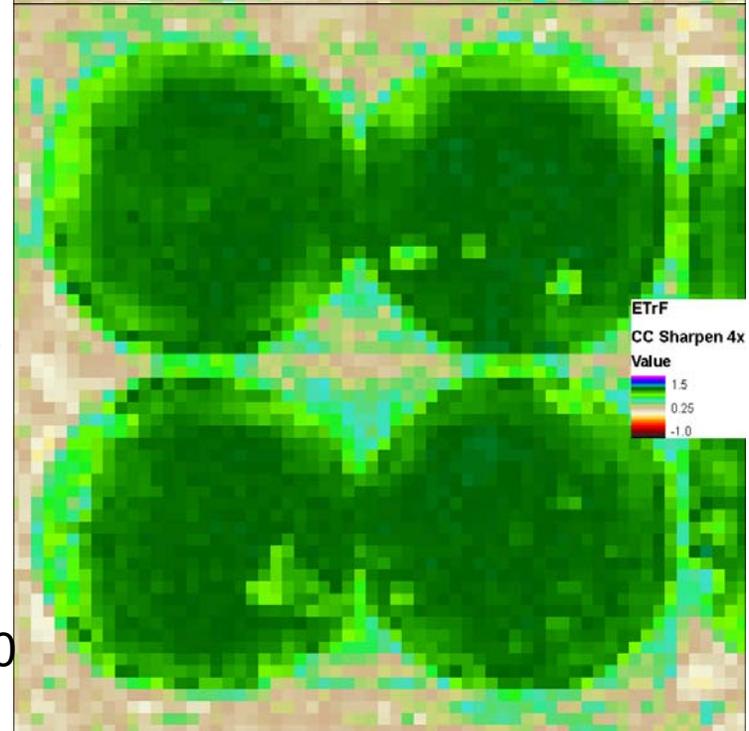
original LST  
from L1T,cc



old NLAPS  
LST, NN -  
sharpened



original LST  
from L1T,cc  
- sharpened  
with 1 4x4  
pass



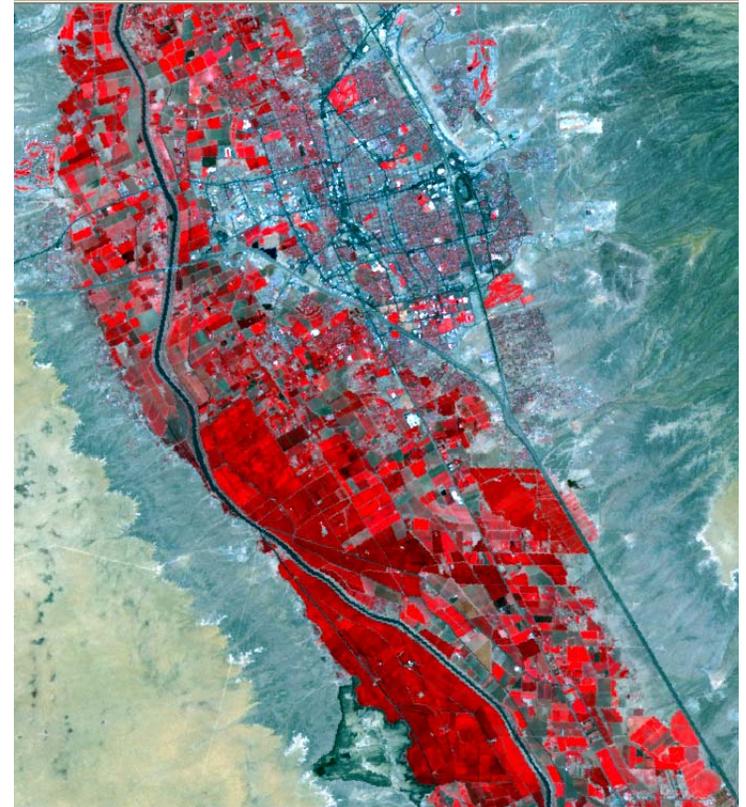
original LST  
from L1T,cc  
- ave of 4  
4x4 passes  
each with  
additional 30  
m shift

# Impact of Coregistration Error between TIRS and OLI

- How might systematic georegistration error between TIS and OLI impact accuracy of ET retrievals?

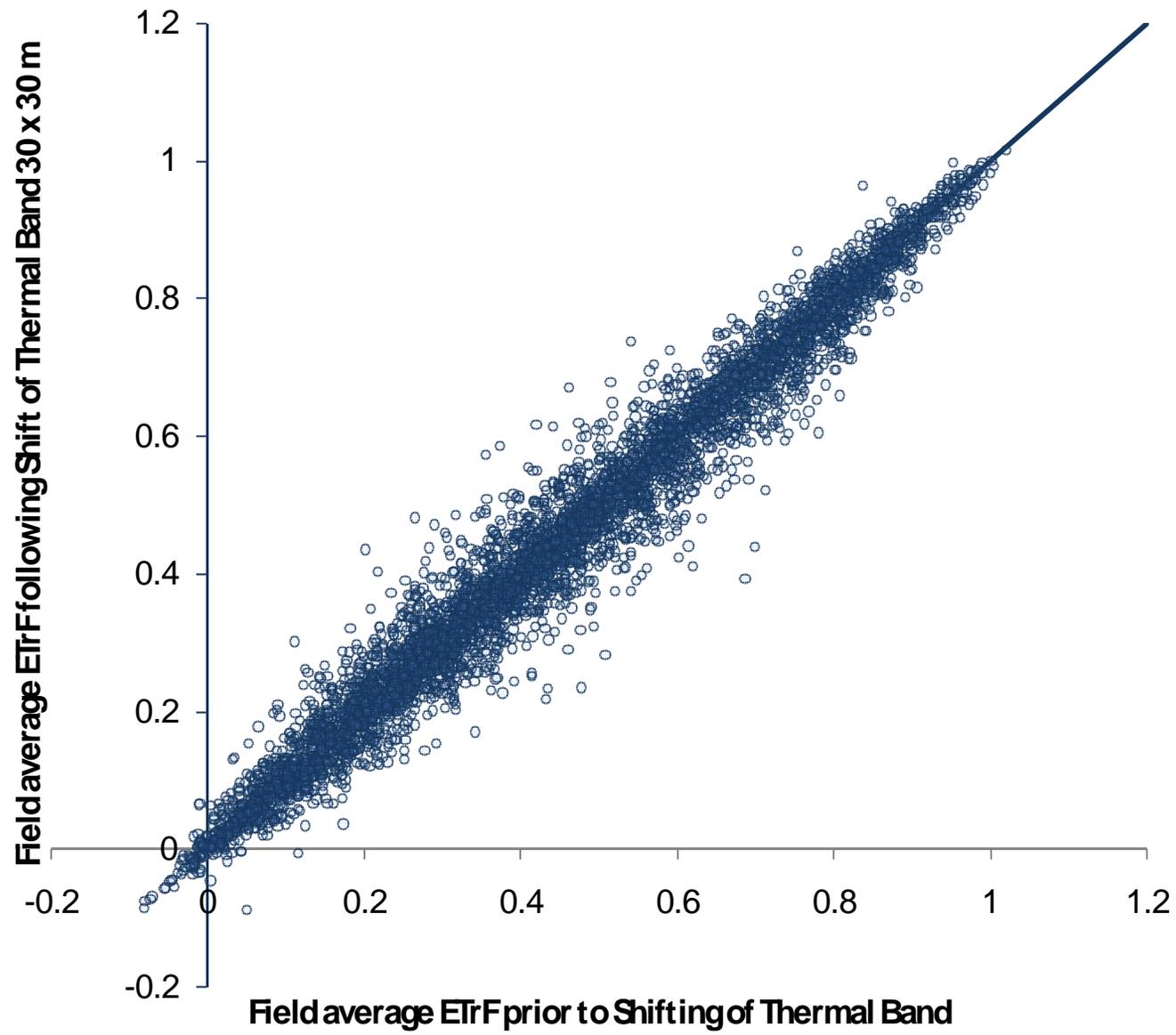
# Analysis in the Lower Rio Grande, NM

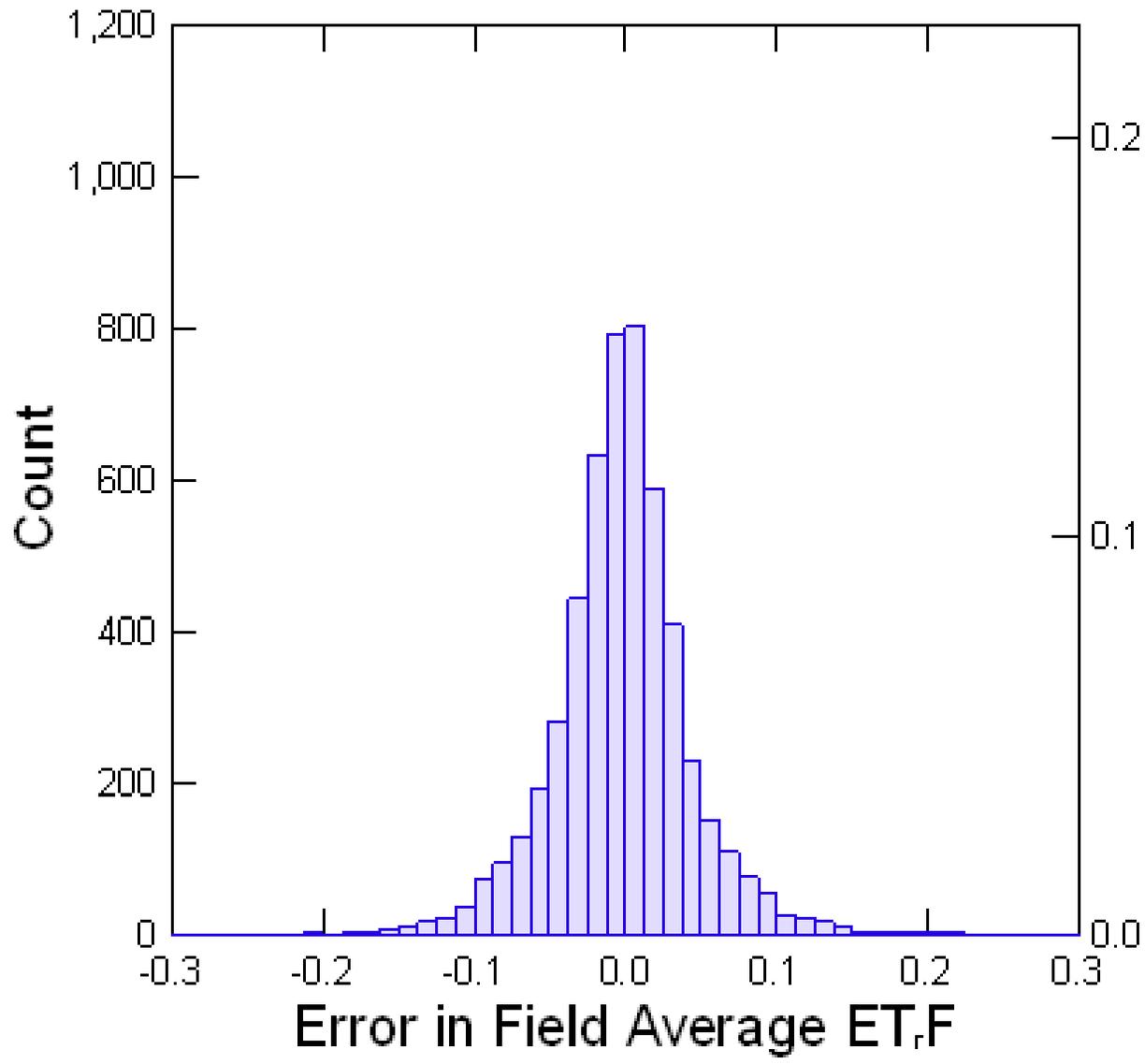
- The Lower Rio Grande region grows a substantial proportion of pecans marketed in the U.S. along with hot chile peppers, onions, alfalfa, corn and cotton
- the thermal band of the Landsat 5 image was shifted 30 m to the east and 30 m to the south



# Impact of TIRS vs. OLI Reg. Error

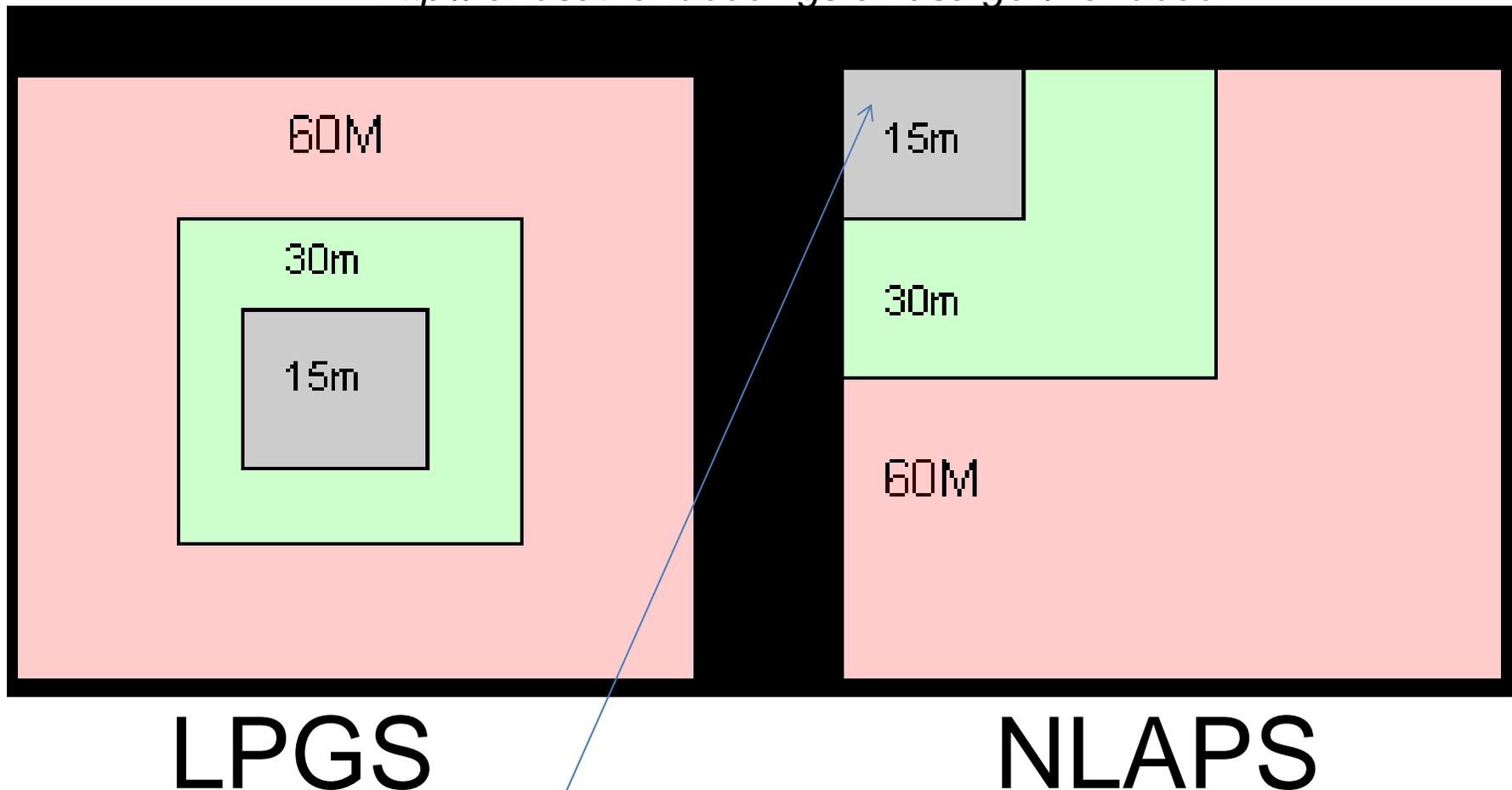
- Pixel to pixel error (30 m):
  - Along transects across fields, 59% of 30 m pixels experienced no change in ET (they resided within the original 120 m thermal pixel). 41% of pixels realized a change. The coefficient of variation of the change in ET averaged 19% over all pixels  
--Result = 0.5% error in ET / 1 m error in registration for Landsat retrievals
- Field-average error:
  - Over 5200 fields sampled, field-averaged  $ET_{r,F}$  changed by 10% (Coef. Variation)—  
Result = 0.25% error in ET / 1 m registration for Landsat retrievals



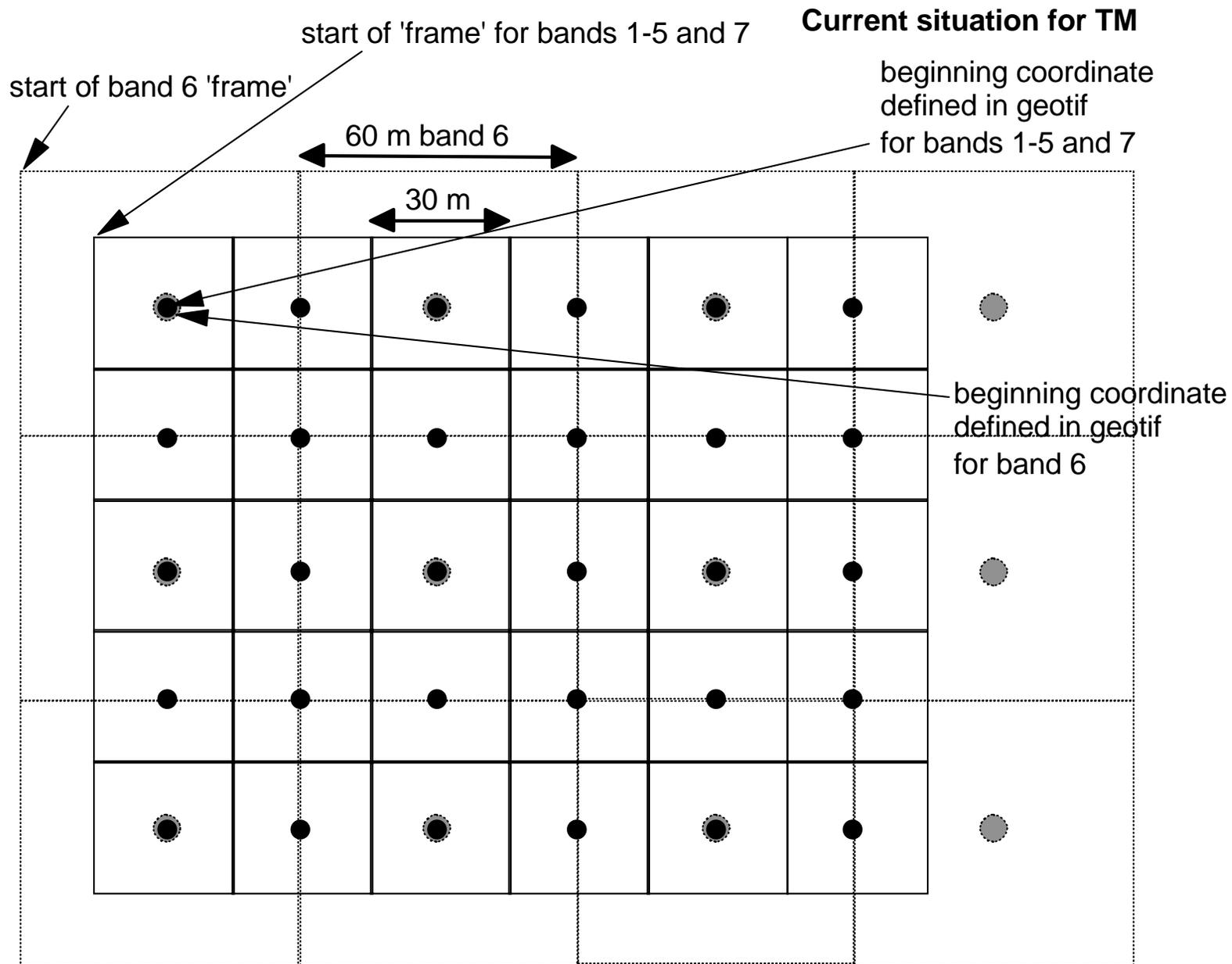


# Issues with Center-Point defined LPGS Images

<http://landsathandbook.gsfc.nasa.gov/handbook>

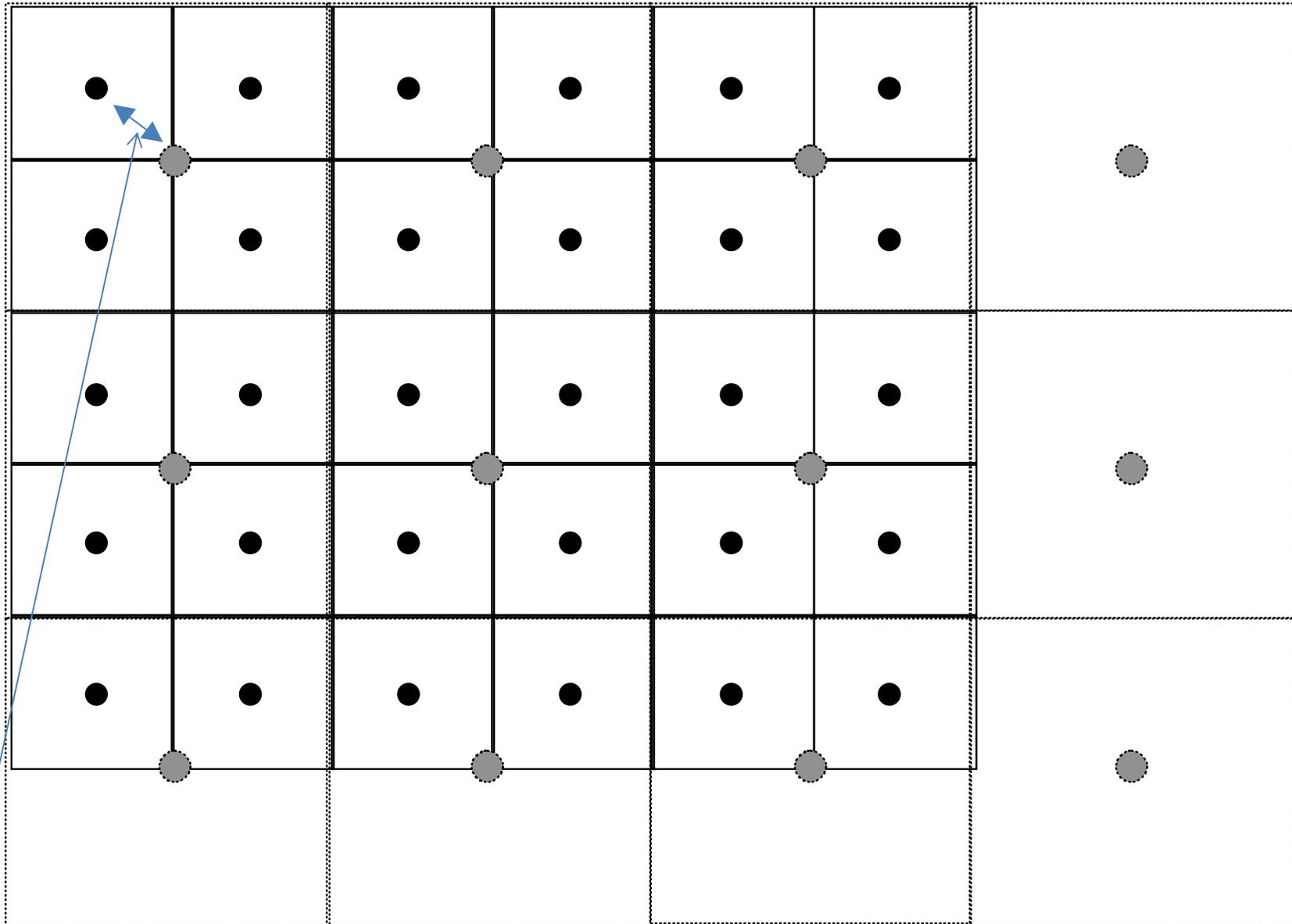


Translation of GeoTiff files by 1) ERDAS, 2) ENVI, 3) ARC-GIS



top and left edges of 'frames' of all loaded layers are aligned based on starting coordinates of band 1. Result is the 60 m band 6 pixel shifted to the right 15 m and downward 15 m.

## Current outcome when stacking all 7 bands into ERDAS, ENVI and ArcView

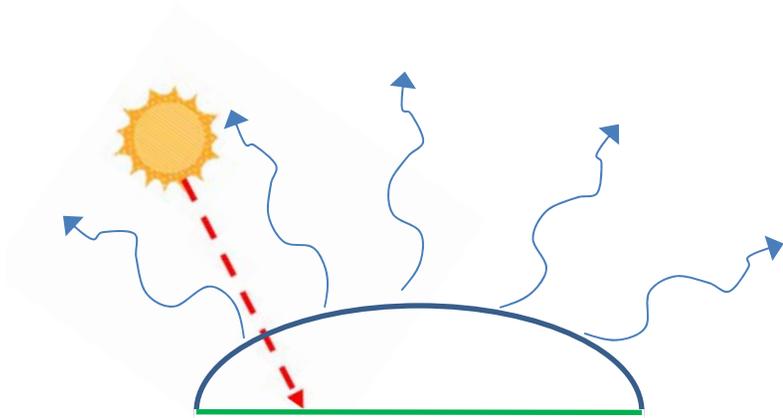


these two center points should have the same coordinate in the image processor

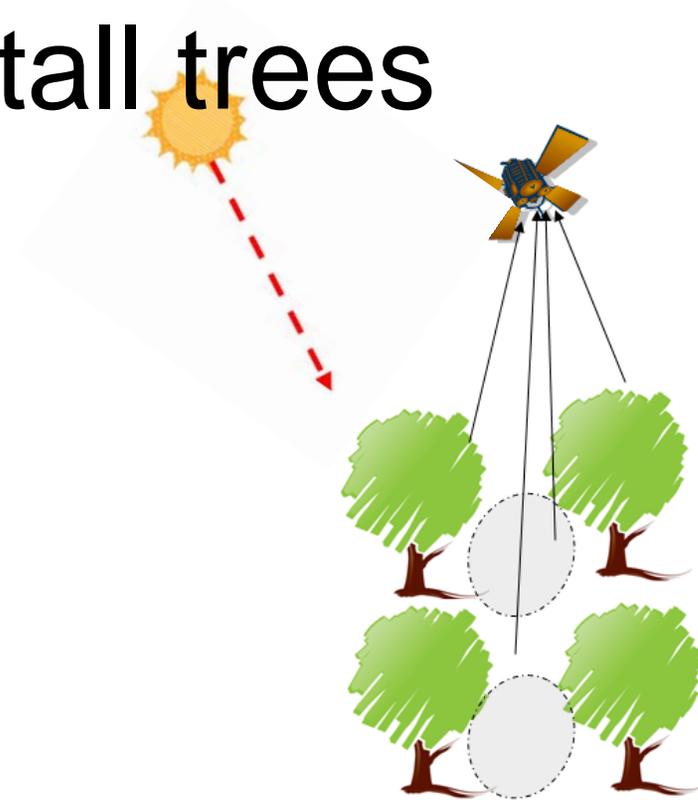
# (Our) Solution

1. Load 60 m band 6 separately
2. resample to 30 m using CC
3. Shift reference coordinate for upper left corner east and south by 15 m
4. Save and then stack with other six bands
5. Note: All 7 bands are then spatially congruent, but then all should be additionally shifted E and S by 15 m.

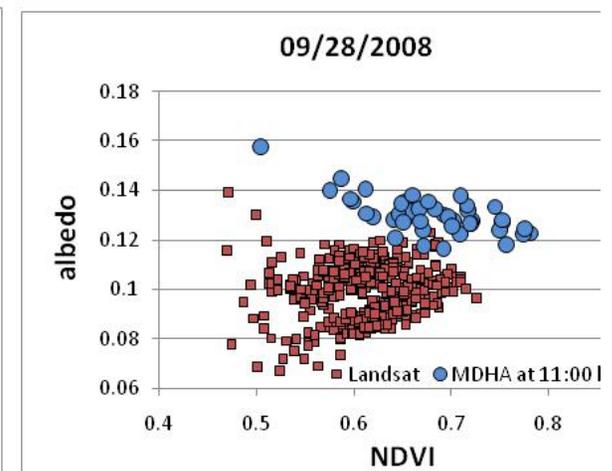
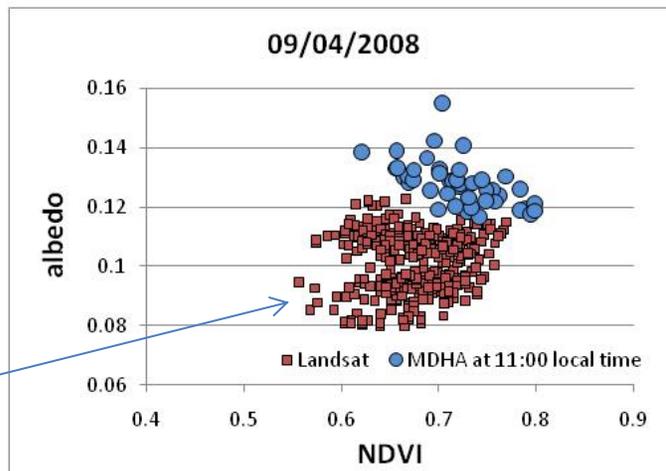
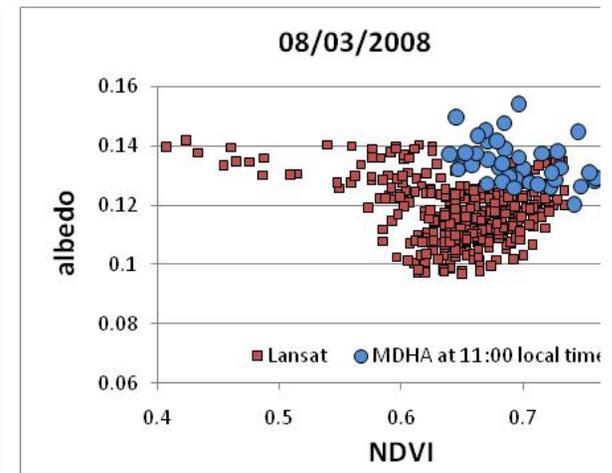
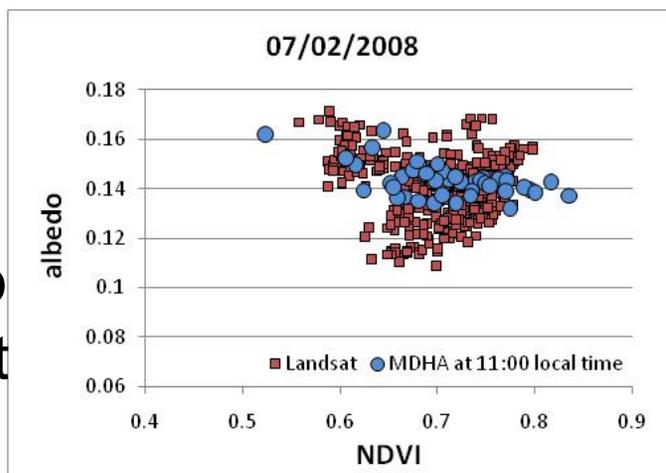
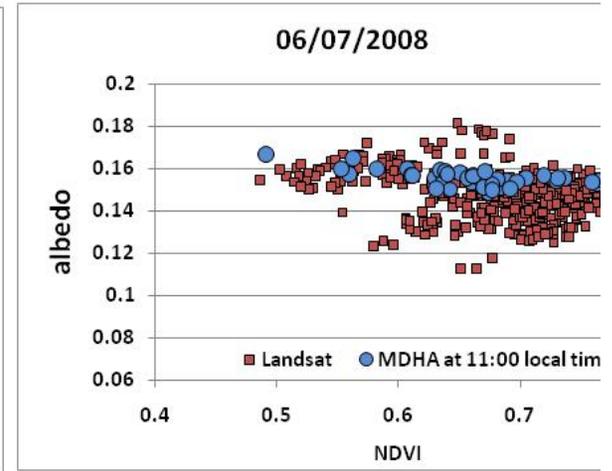
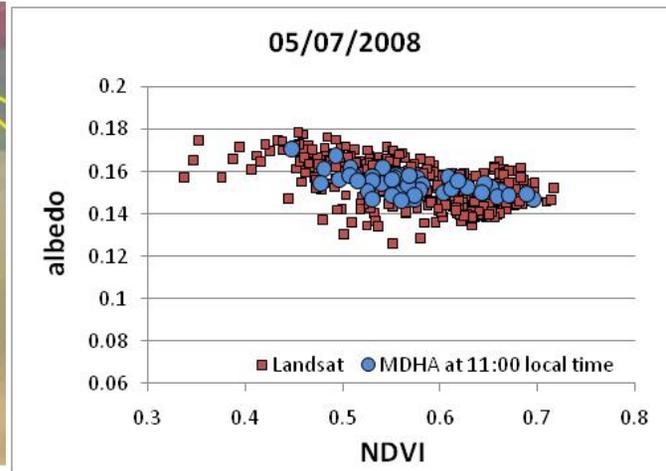
# Developing a (sort of) directional-hemispherical function for Landsat reflectance for tall trees



directional hemispherical



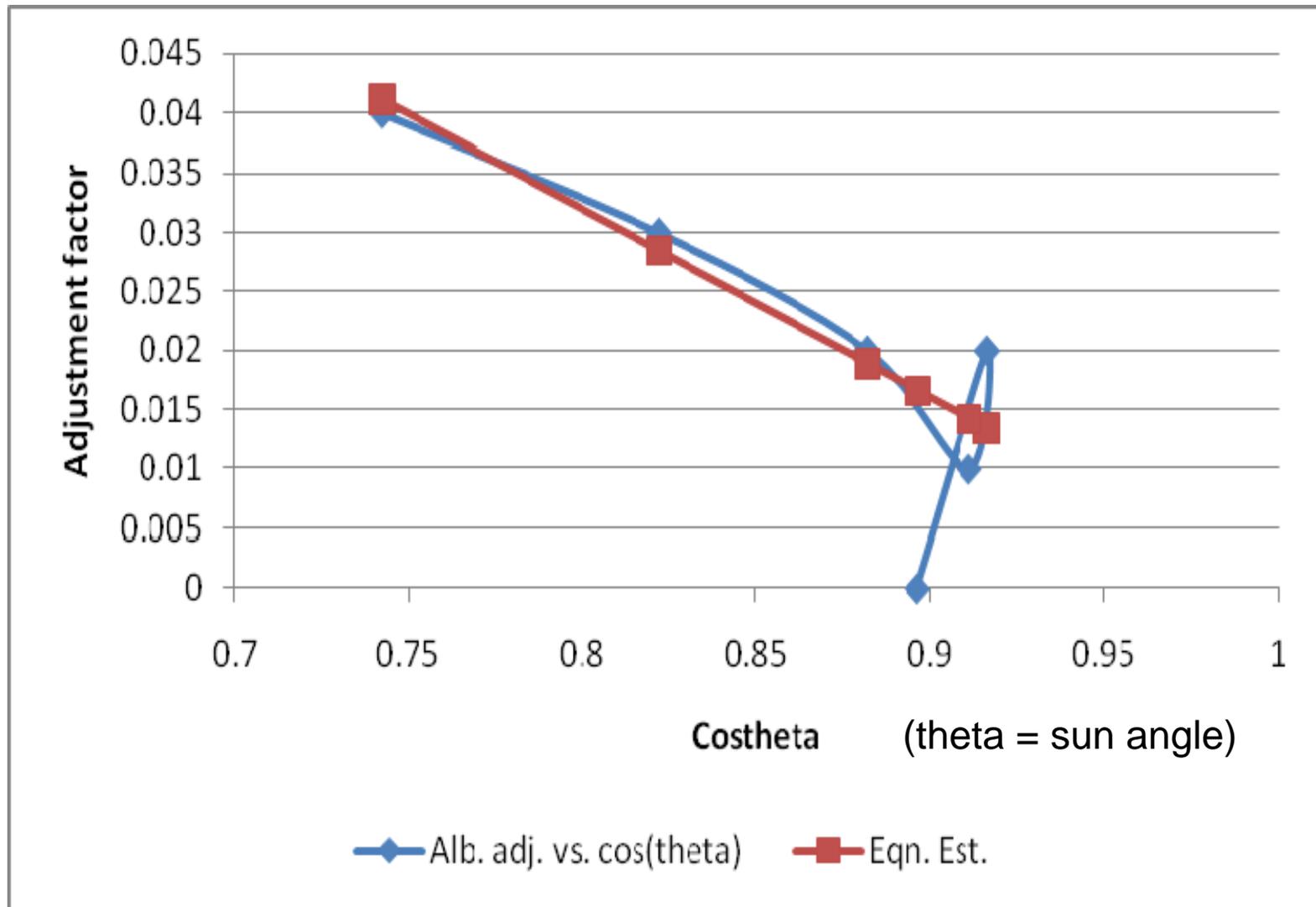
bi-directional  
(i.e., directional – nadir directional)



Comparing MODIS directional hemispherical albedo (MDHA) with Landsat Nadir derived albedo with varying sun angle (times of the year) – Pecan Orchards

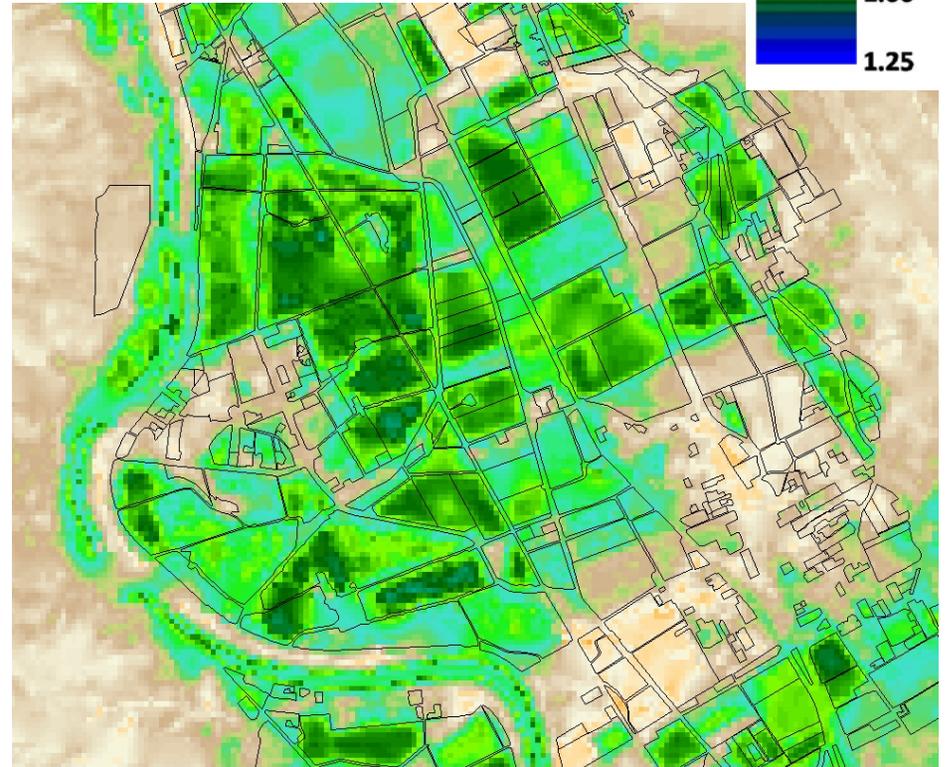
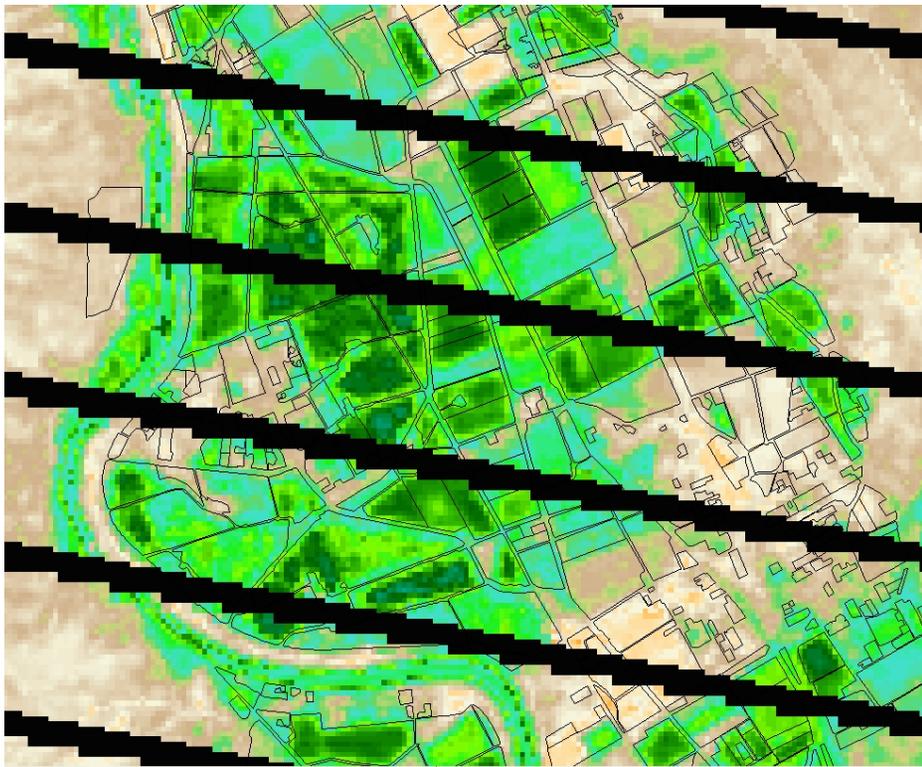
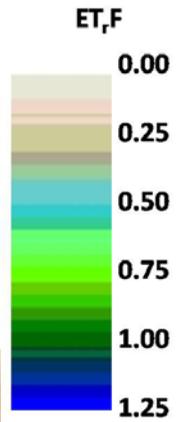
*Larger shadow effect at lower solar angles*

# Additive Adjustment to estimate directional-hemispherical albedo from Landsat-derived bi-directional albedo



# Gap-filling of ETM+ ---- Done to the ET product after the Surface Energy Balance Process

ETrF for an area NW of Las Cruces, NM



Before

After

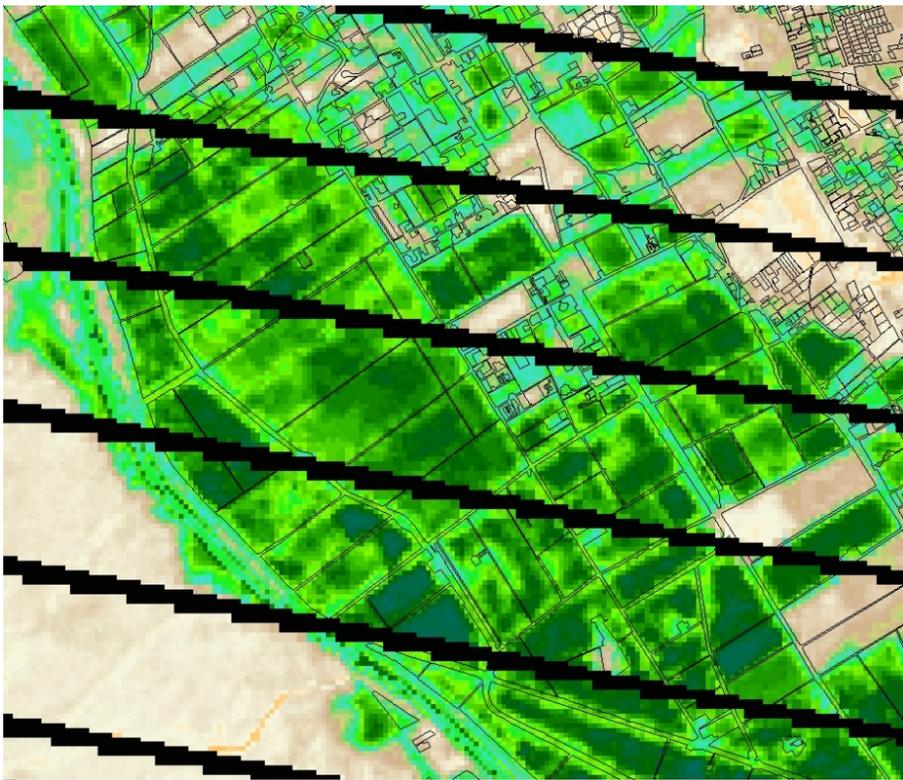
Using “natural neighbor” filling algorithm in Arc-GIS

July 2, 2008, path 33 row 37

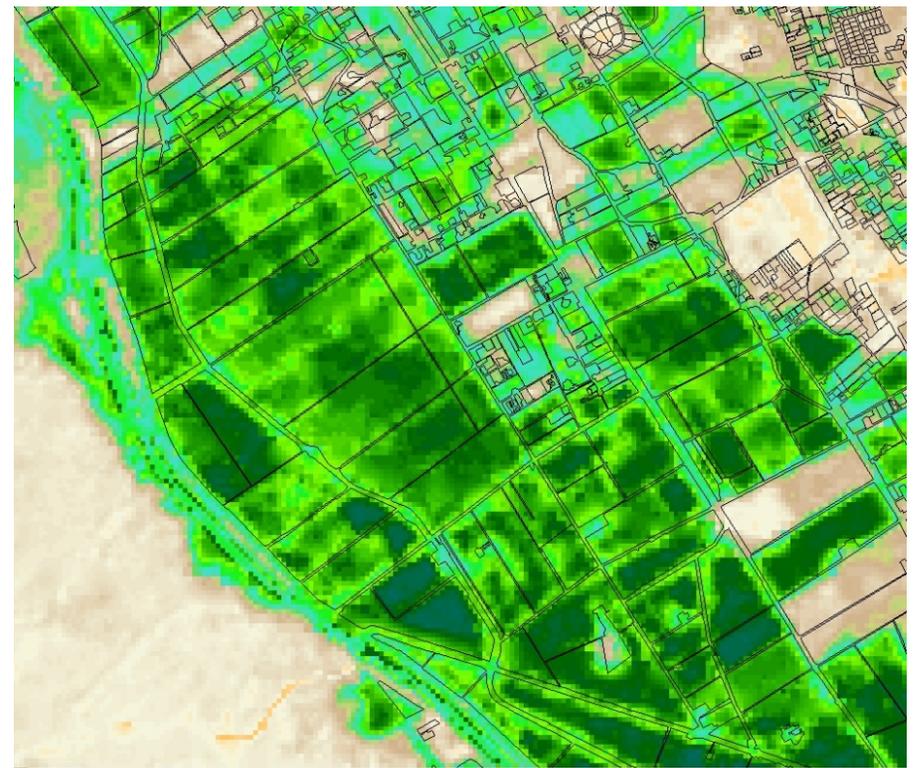
ETrF = fraction of reference ET

# Gap-filling of ETM+ ---- Done to the ET product after the Surface Energy Balance Process

ETrF for area south of Las Cruces, NM (large fields are pecan orchards)



Before

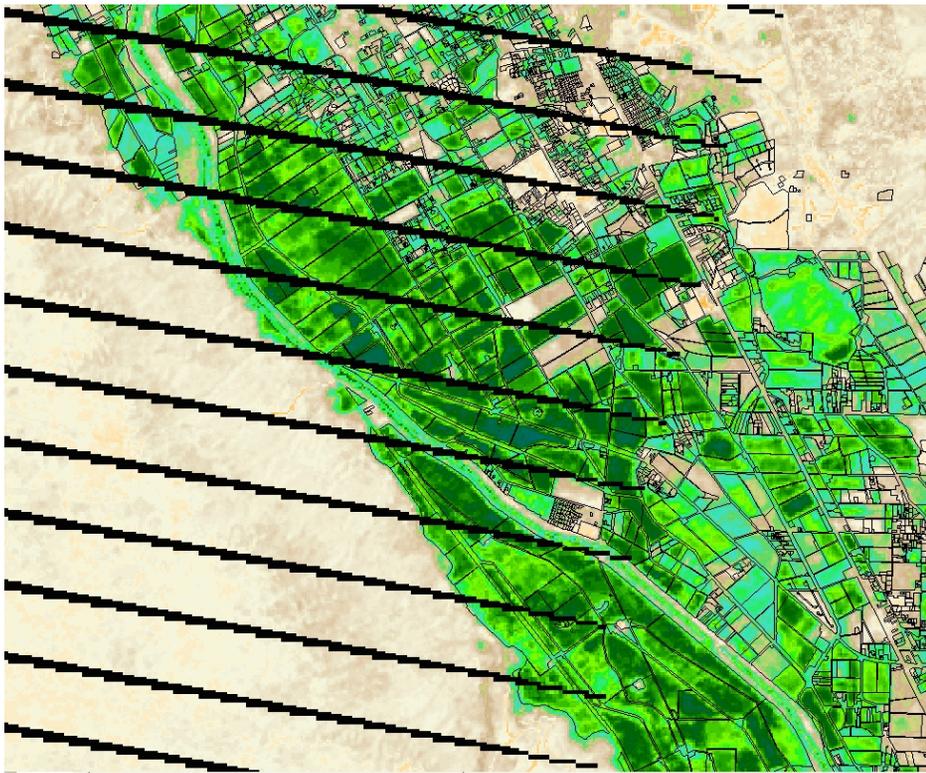


After

July 2, 2008, path 33 row 37

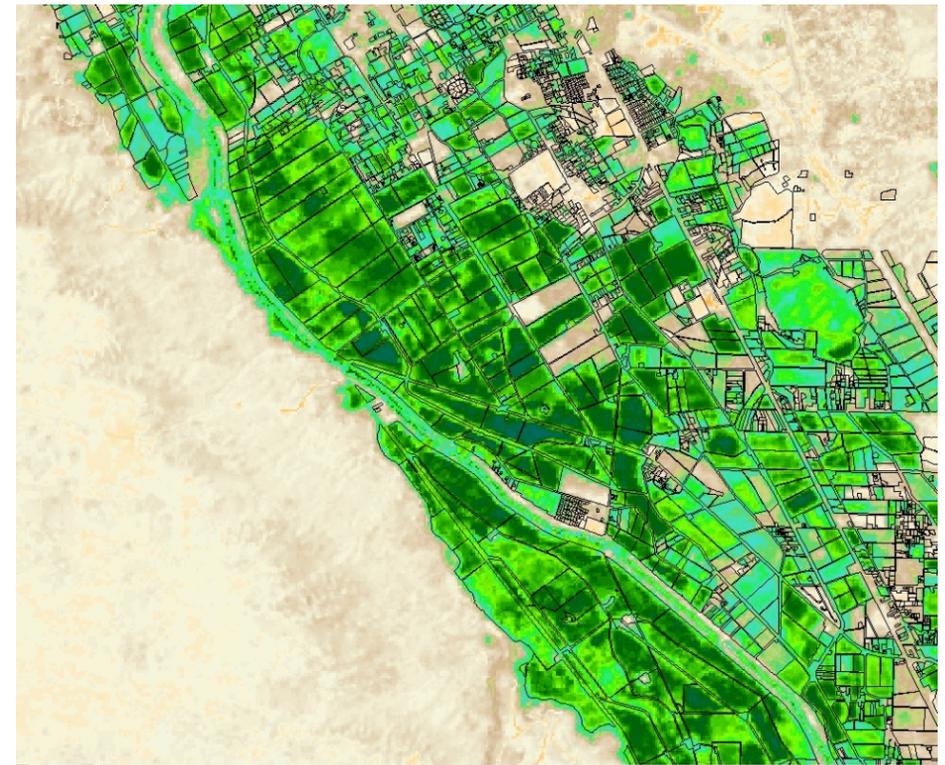
# Gap-filling of ETM+ ---- Done to the ET product after the Surface Energy Balance Process

ETrF for area south of Las Cruces, NM (large fields are pecan orchards)

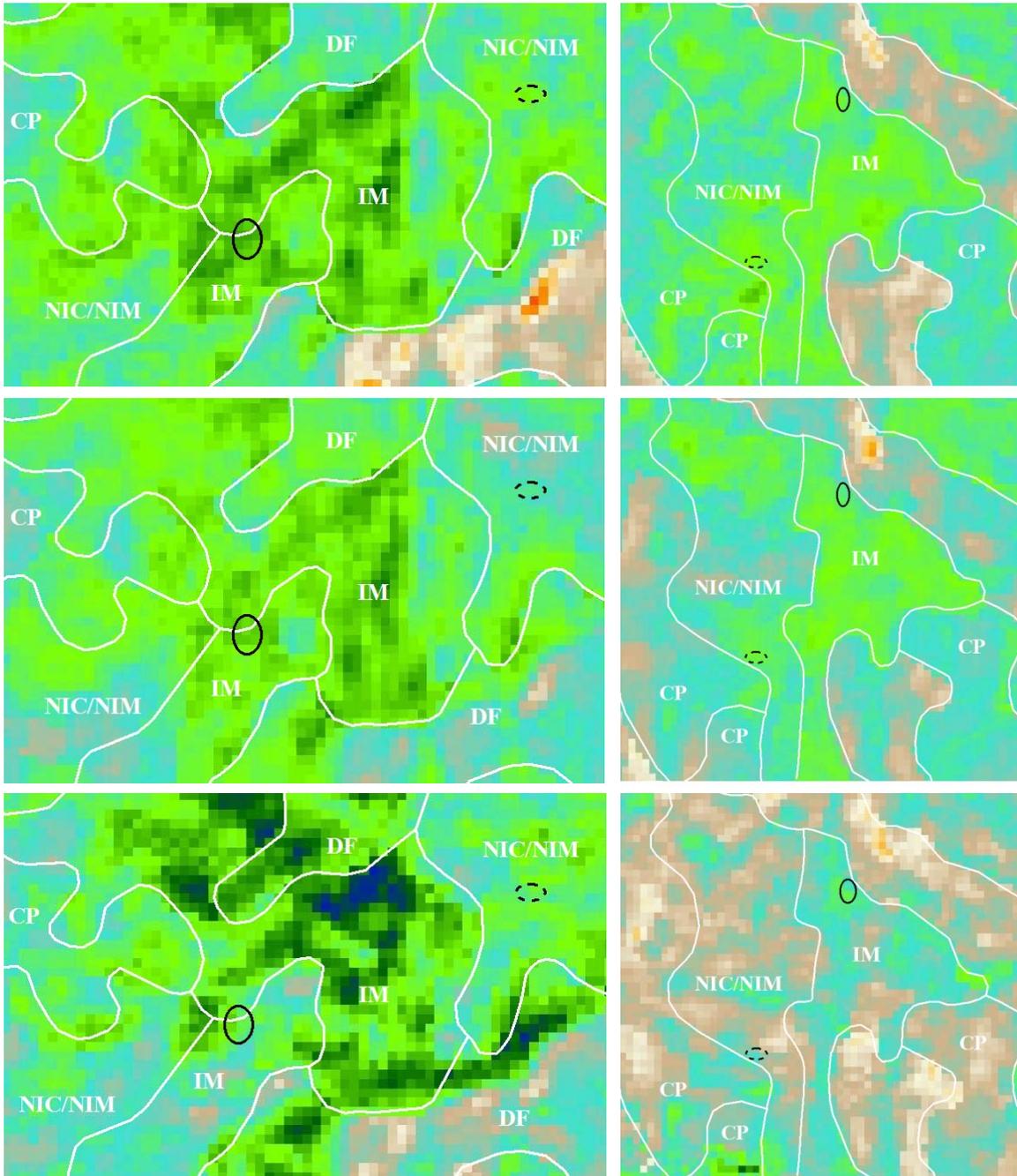


Before

July 2, 2008, path 33 row 37



After



## Using thermal images and retrieved evapotranspiration to assist in classifying vegetation of mountain landscapes of Northeast Portugal

Pôças, et al., 2009.

Classification accuracy increased by 27% (to 93%) when ET was used in addition to VI's

# Some Very Nice News...

“Mapping Evapotranspiration from Satellites”

*Idaho Department of Water Resources  
and University of Idaho*



competed in 2009 for Harvard's Ash Institute's  
Innovations in American Government Award



HARVARD Kennedy School

**ASH INSTITUTE**

for Democratic Governance and Innovation

# Some Very Nice News...

2007 - ET mapping made the **Top 50**

2009 - **Award Finalist (top 16)** *out of 600*

Winners have been  
privately notified  
Public announcement  
embargoed until July  
***Winners' banquet in  
September in  
Washington, DC***



# Quotes from Harvard's Site Visit Report

- “Remarkably, METRIC enables Idaho DWR analysts and administrators to measure ET across large expanses of both **space and time.**”
- “METRIC....is **measurably more accurate, fast, and cost-effective** than the traditional, cumbersome, slow and expensive methods that were commonly used in the last century.”
- “...it would be **practically *impossible* to adjudicate water rights disputes in the future without [TIRS].**”
- “It is measurably effective in that it has distinctive capacities to monitor evapotranspiration and **consumptive water use across both space...and time (..with the help of historic Landsat thermal band images)** ”