Landsat Science Team Meeting, Virginia Tech, January 12-14, 2016

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

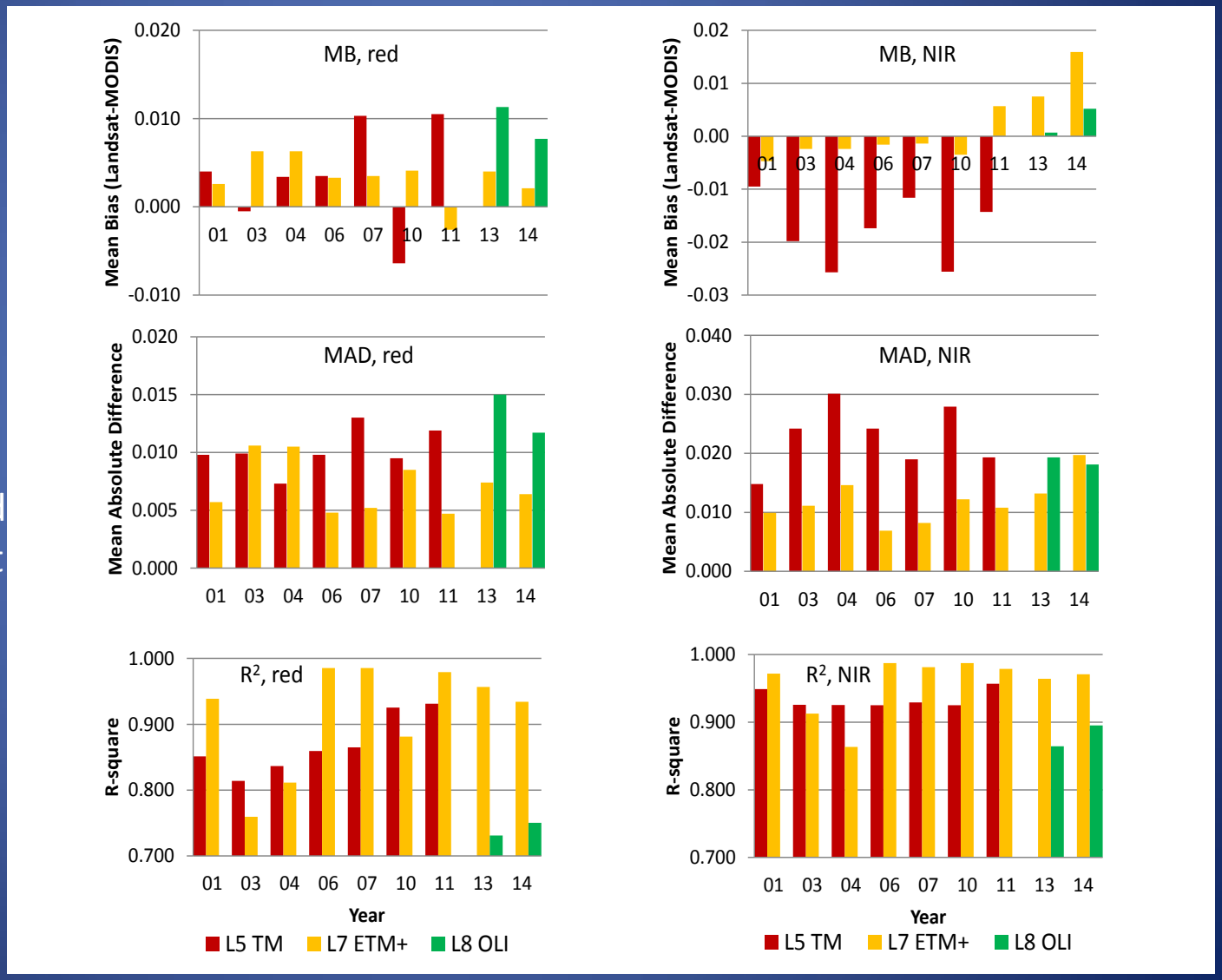
(mean biases, mean absolute differences and R^2)

Central Iowa
2001 to 2014

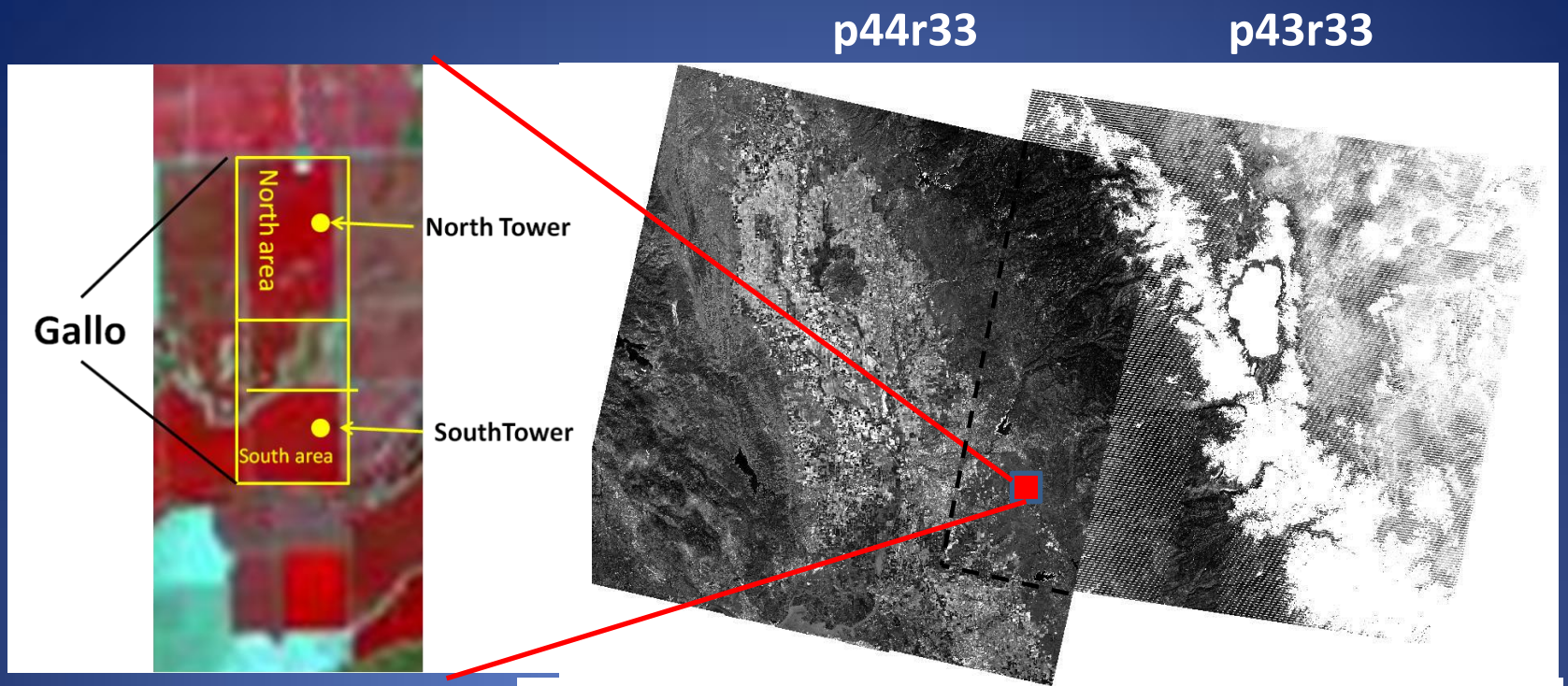
Landsat: p26r31
MODIS: h10v04, h11v04

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).

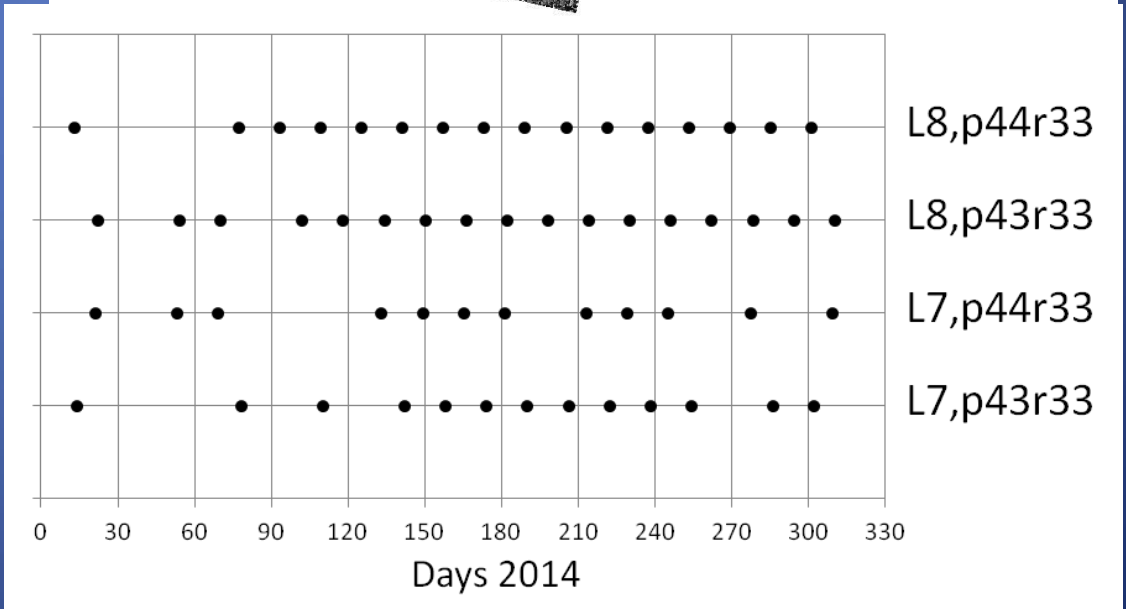


Red NIR

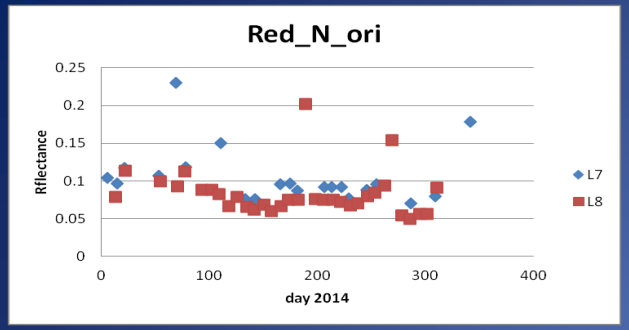


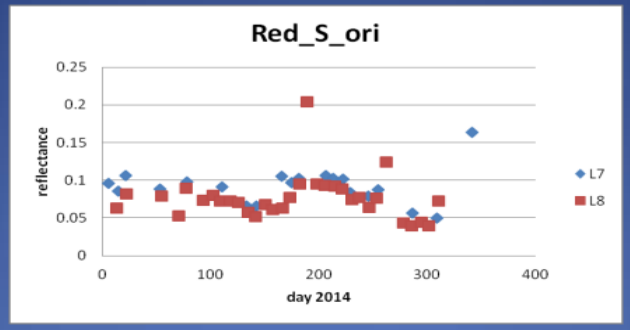
Lodi, CA
2014

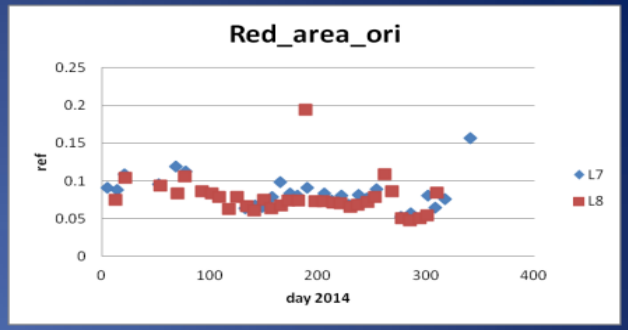
29 Landsat 7 ETM+
33 Landsat 8 OLI

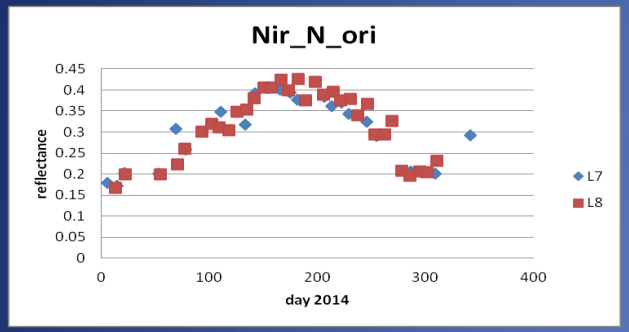


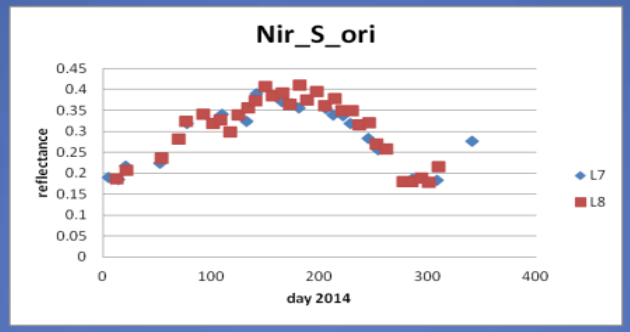
GRAPEX- Grape Remote sensing Atmospheric Profiling & Evapotranspiration eXperiment

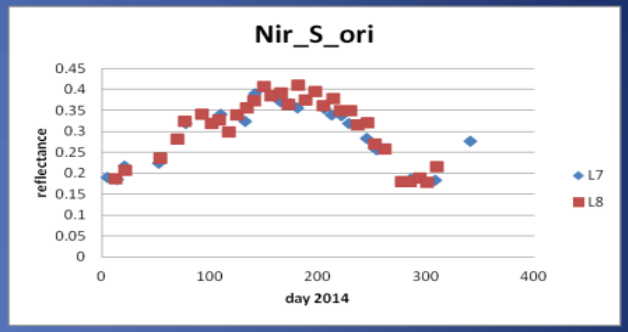

Red_N_ori
Rflectance
day 2014
L7
L8

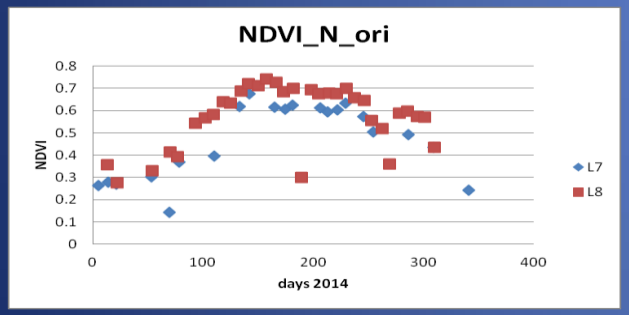

Red_S_ori
reflectance
day 2014
L7
L8

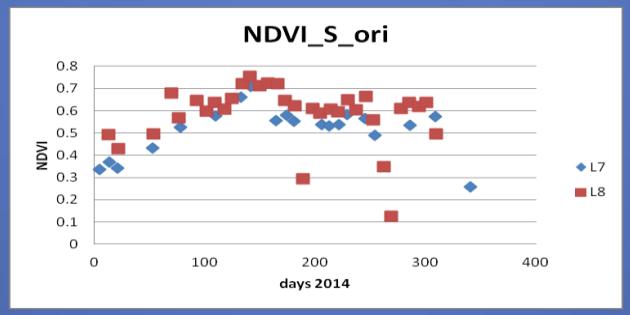

Red_area_ori
ref
day 2014
L7
L8

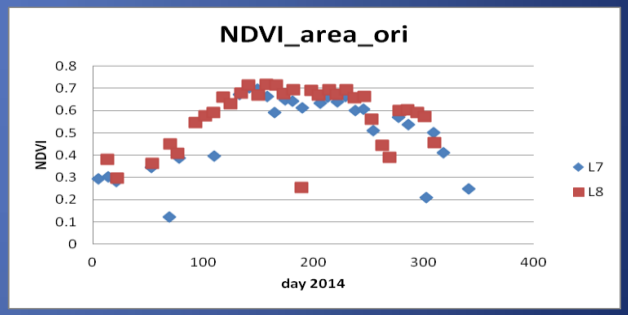

Nir_N_ori
reflectance
day 2014
L7
L8

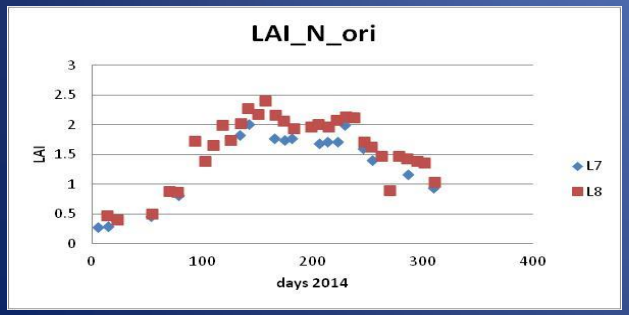

Nir_S_ori
reflectance
day 2014
L7
L8

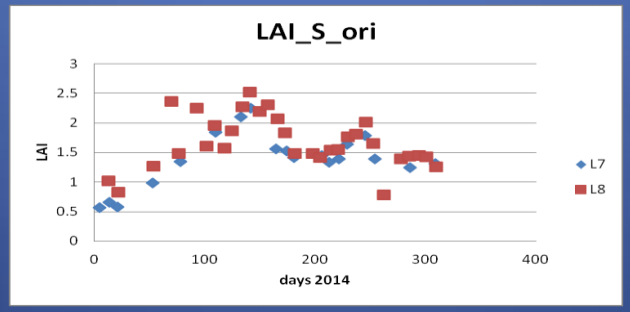

Nir_S_ori
reflectance
day 2014
L7
L8

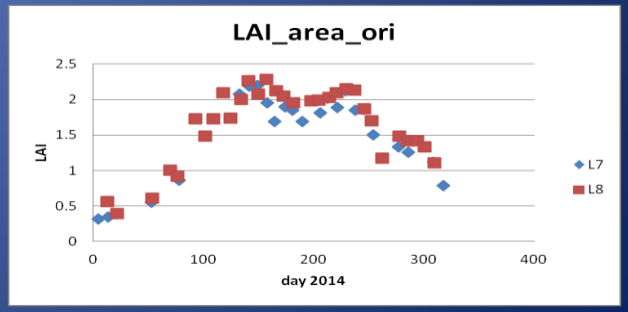

NDVI_N_ori
NDVI
days 2014
L7
L8


NDVI_S_ori
NDVI
days 2014
L7
L8

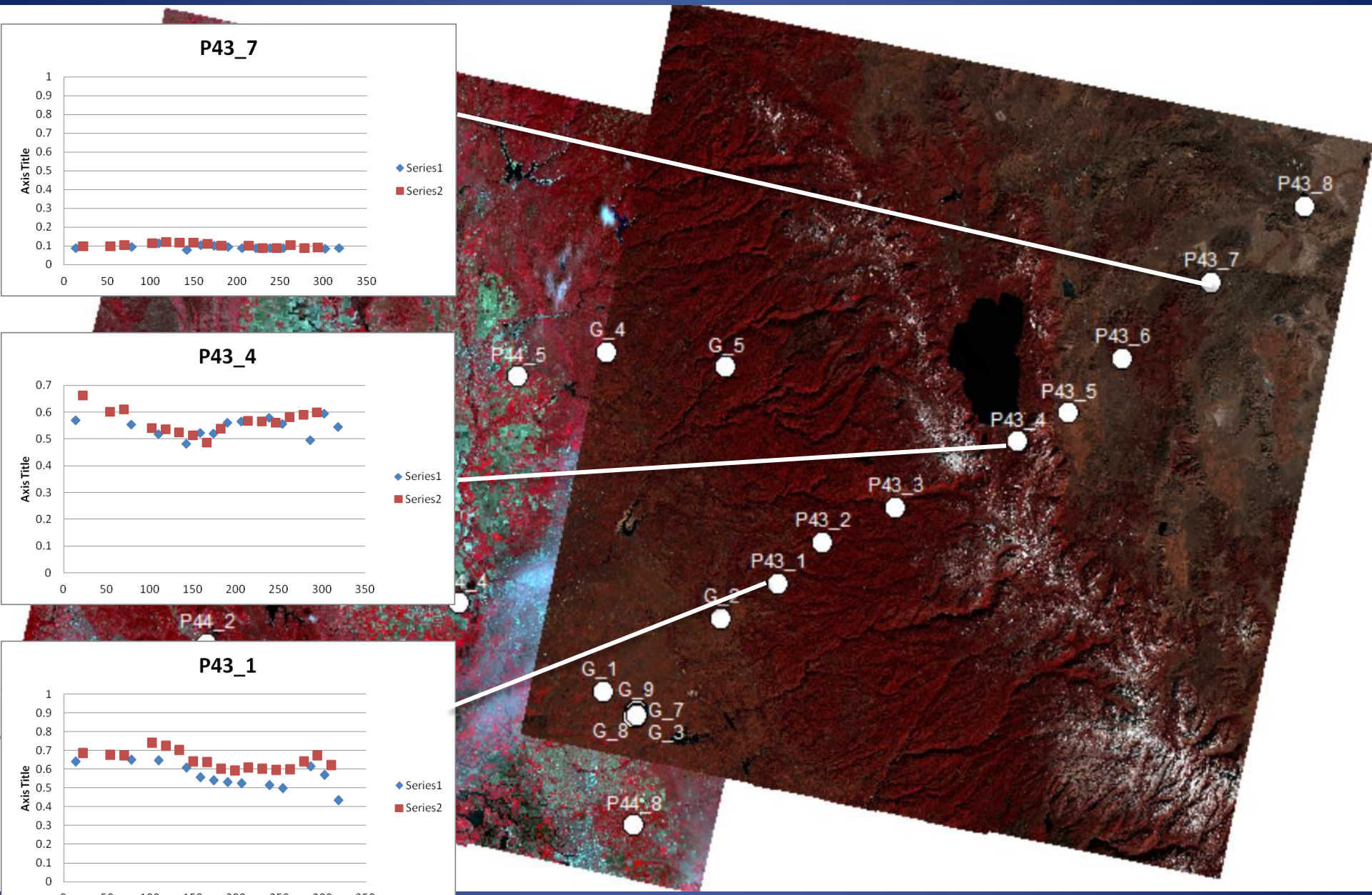

NDVI_area_ori
NDVI
day 2014
L7
L8


LAI_N_ori
LAI
days 2014
L7
L8

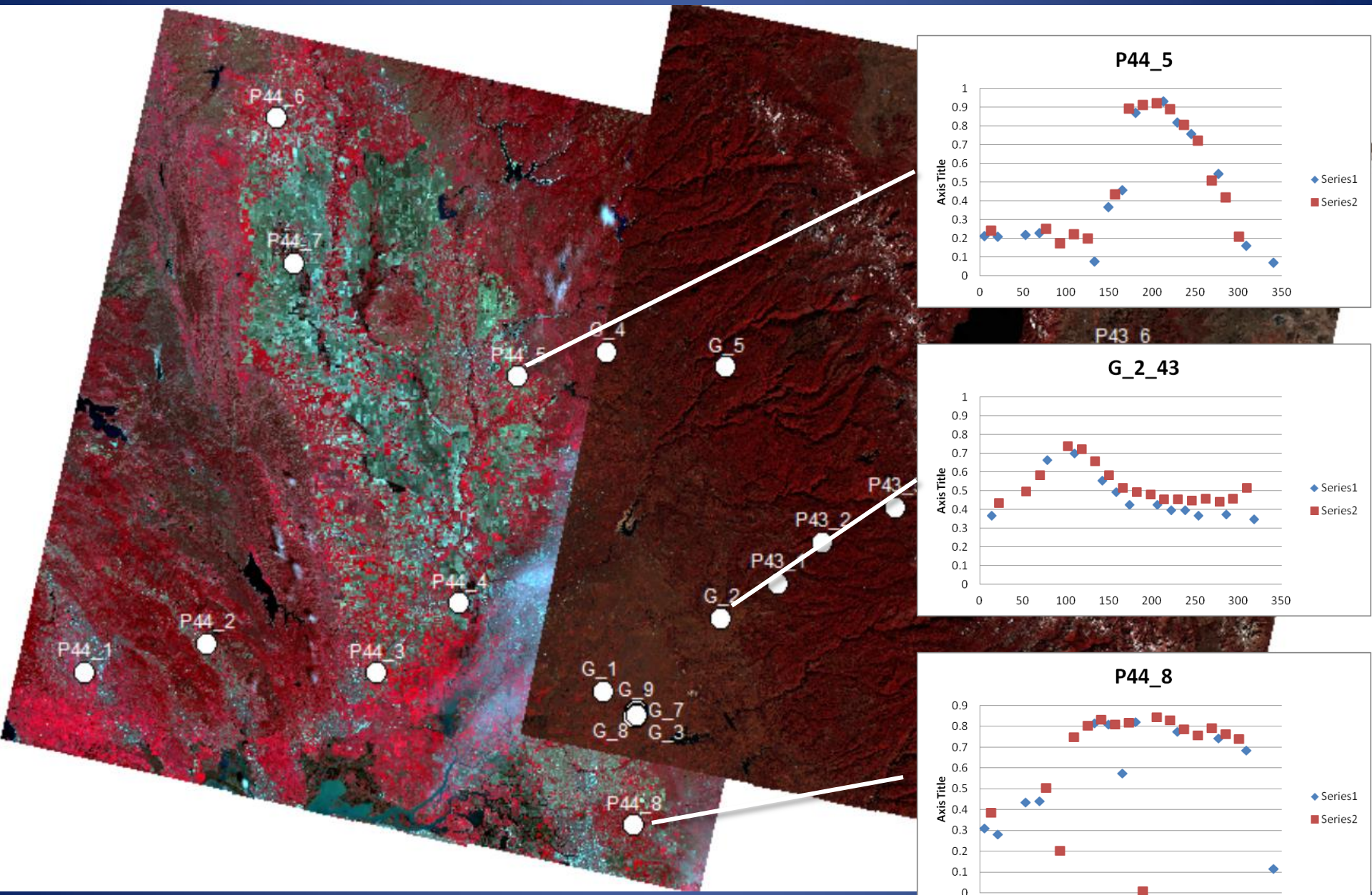

LAI_S_ori
LAI
days 2014
L7
L8


LAI_area_ori
LAI
day 2014
L7
L8

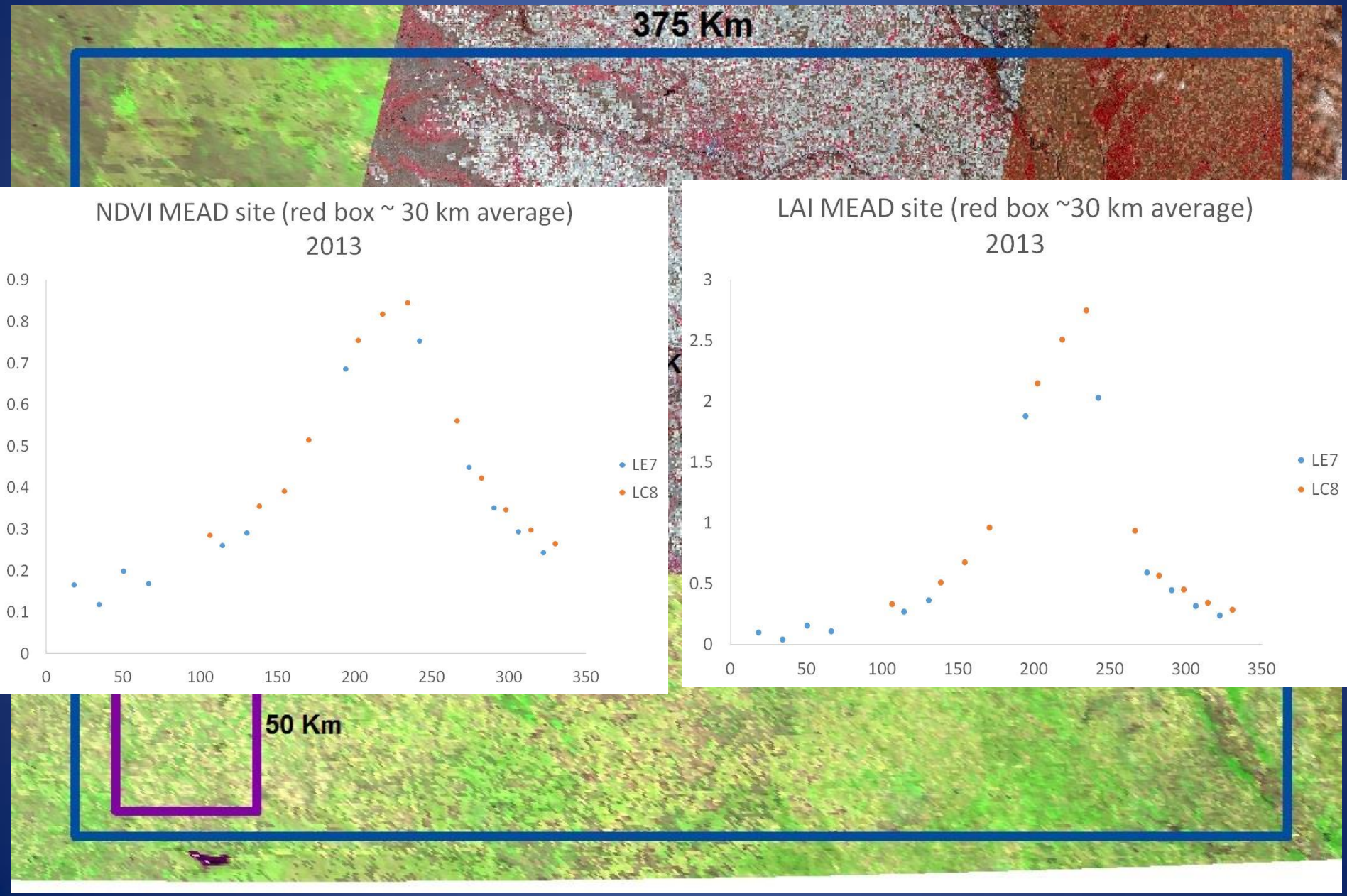
NDVI comparisons



NDVI comparisons



Nebraska Mead Sites



Relative Correction using Linear Regression

L7day	L8day	bname	a	b	R
254	253	green	-0.00646	0.9277	0.963
254	253	red	-0.00823	0.9697	0.982
254	253	nir	-0.03256	1.083	0.926
254	253	swir1	-0.02113	1.062	0.987
254	253	swir2	-0.01278	1.060	0.985
286	285	blue	-0.01056	0.8645	0.893
286	285	green	-0.00987	0.9590	0.945
286	285	red	-0.0099	0.995	0.974
286	285	nir	-0.00809	1.001	0.891
286	285	swir1	-0.01414	1.048	0.98
286	285	swir2	-0.00873	1.068	0.984
302	301	blue	0.006262	0.4667	0.622
302	301	green	0.010546	0.611	0.694
302	301	red	0.004692	0.7853	0.789
302	301	nir	0.111709	0.4354	0.520
302	301	swir1	0.034379	0.8643	0.766
302	301	swir2	0.015389	0.9344	0.793

L8=a+b*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 $\rho_{ETM+} = c_0 + c_1 \rho_{OLI}$

TOA

Band	c_0	c_1
ETM 1 (OLI 2)	0.00501	0.95852
ETM 2 (OLI 3)	0.00307	0.98911
ETM 3 (OLI 4)	0.00198	0.99291
ETM 4 (OLI 5)	0.00087	0.93819
ETM 5 (OLI 6)	0.00141	0.98824
ETM 7 (OLI 7)	–0.00147	0.97591

SR

Band	c_0	c_1
ETM 1 (OLI 2)	0.00041	0.97470
ETM 2 (OLI 3)	0.00289	0.99779
ETM 3 (OLI 4)	0.00274	1.00446
ETM 4 (OLI 5)	0.00004	0.98906
ETM 5 (OLI 6)	0.00256	0.99467
ETM 7 (OLI 7)	–0.00327	1.02551

- From Li et al., Remote Sens., 2014. using Landsat scenes in Southeast Asia

$$\text{Intercalibrated LSWI}_{\text{Landsat-8 OLI}} = 1.00324 * \text{LSWI}_{\text{Landsat-7 ETM+}} + 0.01466 \quad (5)$$

$$\text{Intercalibrated NBR}_{\text{Landsat-8 OLI}} = 0.95342 * \text{NBR}_{\text{Landsat-7 ETM+}} + 0.05844 \quad (6)$$

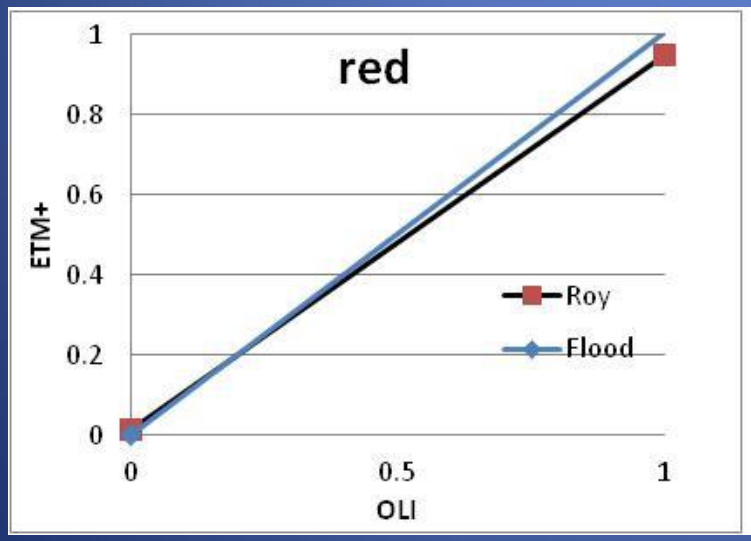
$$\text{Intercalibrated NDVI}_{\text{Landsat-8 OLI}} = 0.97998 * \text{NDVI}_{\text{Landsat-7 ETM+}} + 0.07592 \quad (7)$$

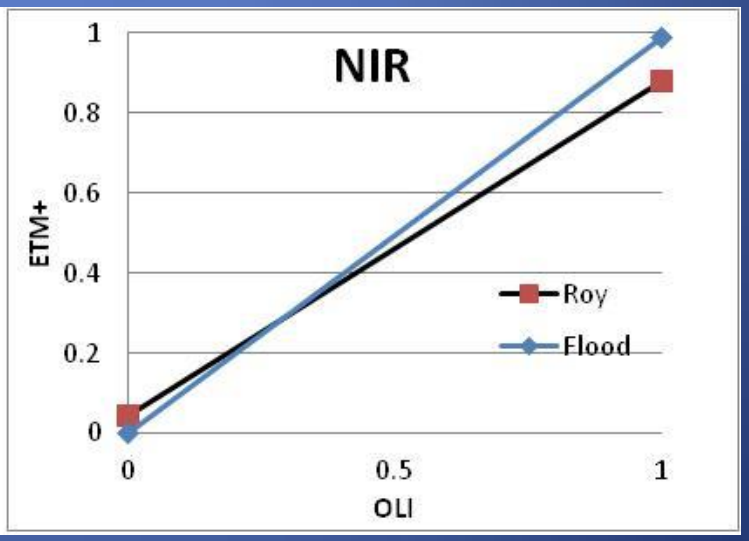
$$\text{Intercalibrated MNDWI}_{\text{Landsat-8 OLI}} = 0.88513 * \text{MNDWI}_{\text{Landsat-7 ETM+}} - 0.04079 \quad (8)$$

- From Roy et al., Remote Sens. Environ., 2016. using Landsat scenes in conterminous U.S.

TOA NDVI	RMA	OLI = 0.0306 + 0.9824 ETM
	OLS	OLI = 0.0490 + 0.9352 ETM +
	OLS	ETM+ = − 0.0110 + 0.9690 OLI
Surface NDVI	RMA	OLI = 0.0149 + 1.0035 ETM
	OLS	OLI = 0.0235 + 0.9723 ETM +
	OLS	ETM+ = 0.0029 + 0.9589 OLI

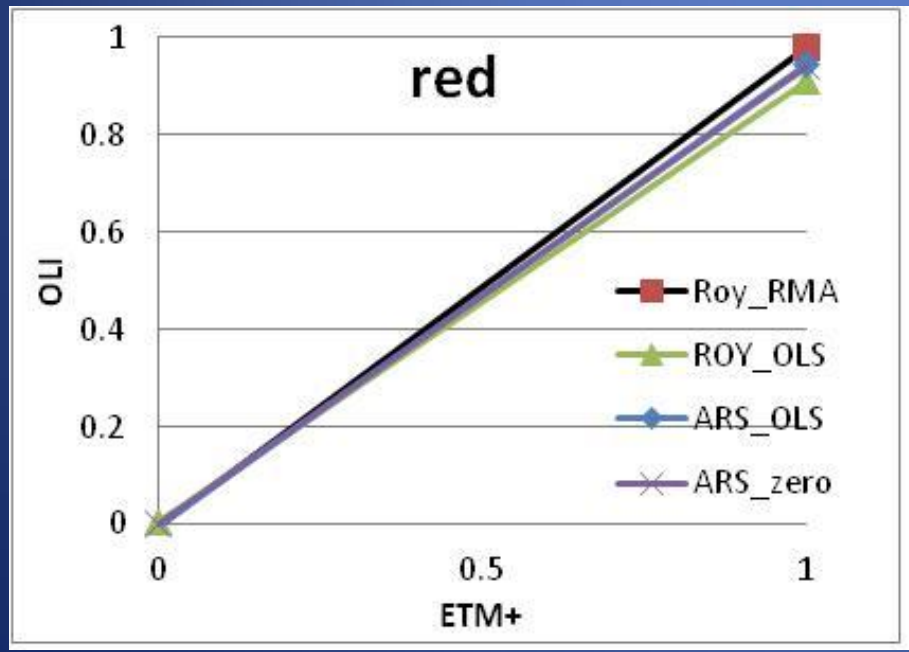
SR: ETM+ = a *OLI + b	Roy_OLS		Flood		Li	
	slope	intercept	slope	intercept	slope	intercept
ETM 1 (OLI 2)	0.885	0.0183	0.9747	0.00041		
ETM 2 (OLI 3)	0.9317	0.0123	0.99779	0.00289		
ETM 3 (OLI 4)	0.9372	0.0123	1.00446	0.00274		
ETM 4 (OLI 5)	0.8339	0.0448	0.98906	0.00004		
ETM 5 (OLI 6)	0.8639	0.0306	0.99467	0.00256		
ETM 7 (OLI 7)	0.9165	0.0116	1.02551	-0.00327		
NDVI: OLI = a* ETM + b	0.9723	0.0235			0.97998	0.07592

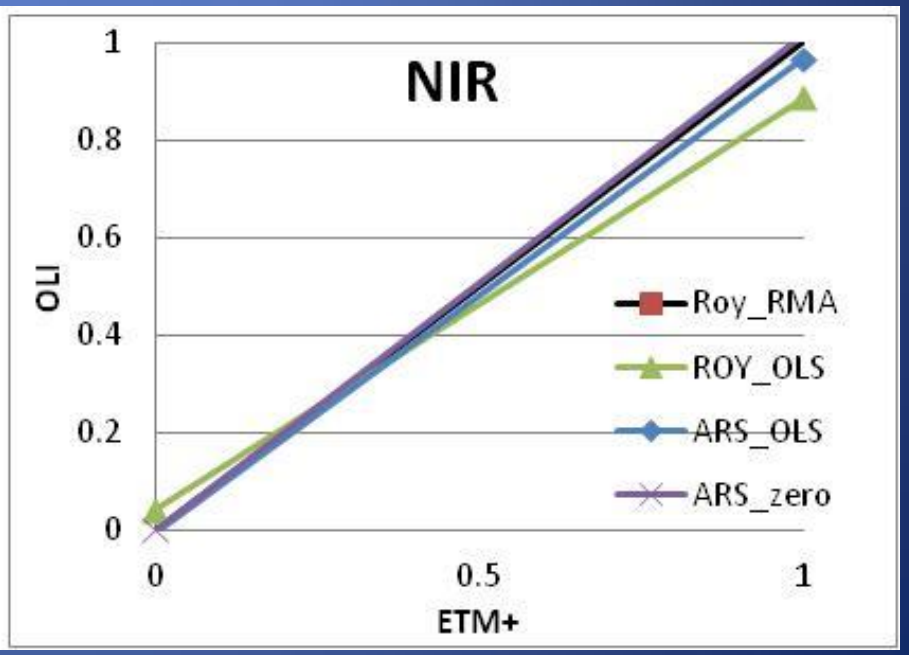




SR: OLI = a*ETM + b	Roy_RMA		Roy_OLS		ARS_OLS		ARS_zero
	slope	intercept	slope	intercept	slope	intercept	slope
ETM 1 (OLI 2)	0.9785	-0.0095	0.8474	0.0003	0.80491	-0.00217	0.7536
ETM 2 (OLI 3)	0.9542	-0.0016	0.8483	0.0088	0.897956	-0.00193	0.8968
ETM 3 (OLI 4)	0.9825	-0.0022	0.9047	0.0061	0.946949	-0.0036	0.9405
ETM 4 (OLI 5)	1.0073	-0.0021	0.8462	0.0412	0.973335	-0.00547	1.0160
ETM 5 (OLI 6)	1.0171	-0.003	0.8937	0.0254	1.02328	-0.01368	1.0147
ETM 7 (OLI 7)	0.9949	0.0029	0.9071	0.0172	1.02863	-0.00744	1.0283

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



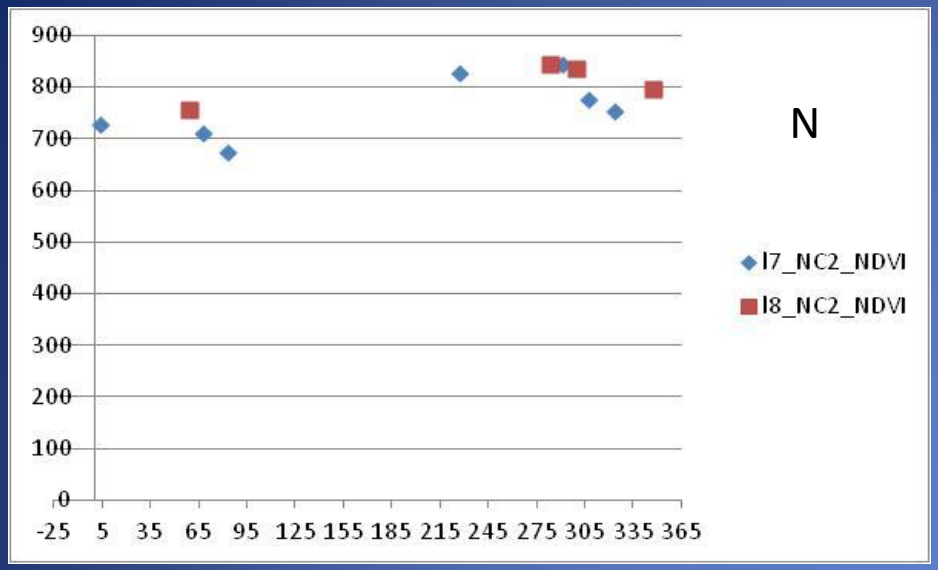


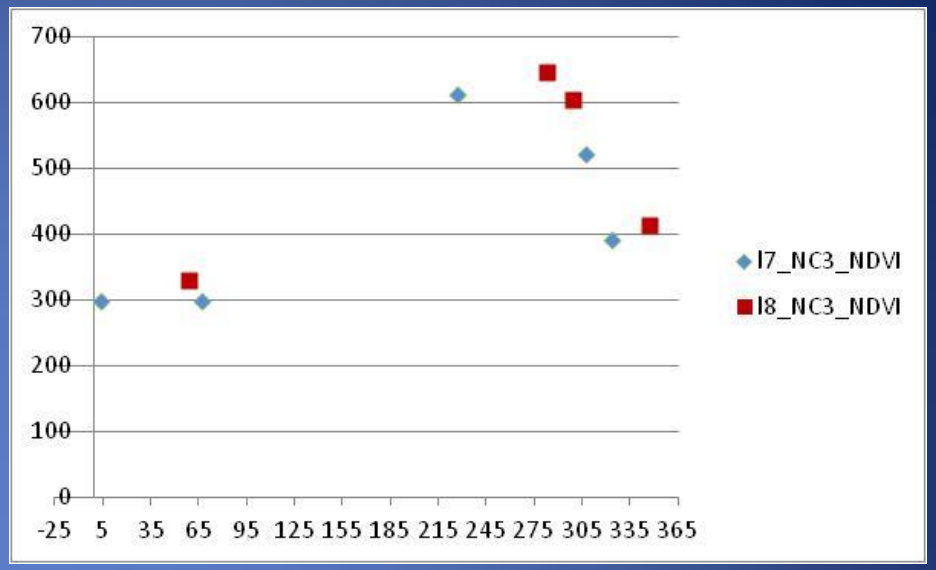
Discussion

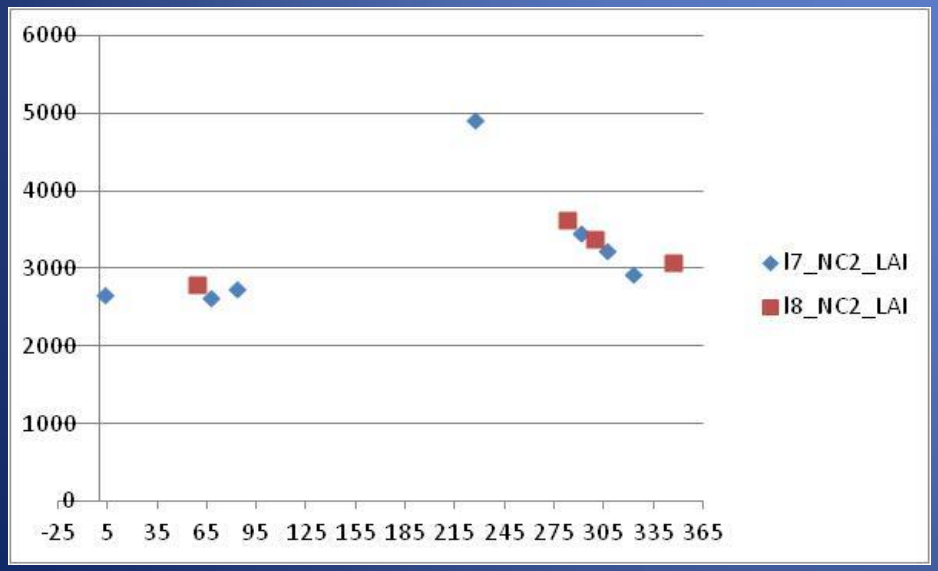
- Regression model depends on the samples used (empirical)
  - time and location
  - land cover types
  - vegetation density and condition
- Apply before or after atmosphere correction?
- Use OLI or ETM+ as the standard?
  - ETM+ is consistent with TM and so history data can be used
  - OLI is more consistent with MODIS and has better quality
- Physical-based model/approach?

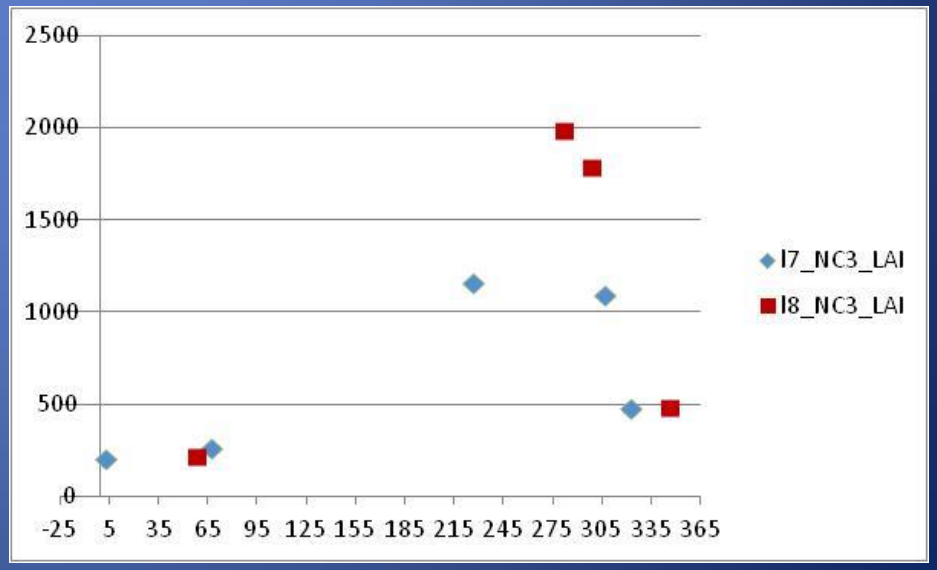
  Regression approach is hard for scene based correction (one regression per scene/date) since samples need to be extracted from the overlapped area between L7 and L8

North Carolina Sites









NC2 is 20 year old forest; NC3 is a clear cut site, with seedling replanting