# LEDAPS Update

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November 1 2010

# Outline

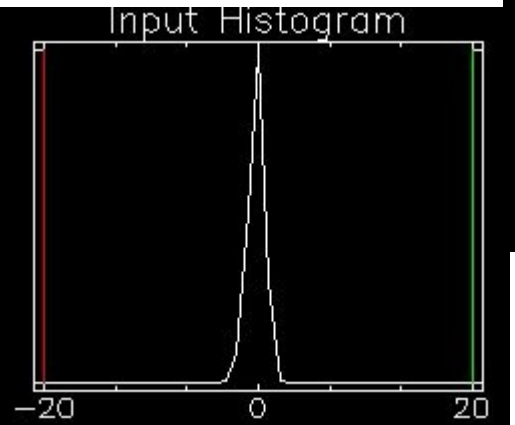
- Bug Fix to LEDAPS SR Code
- Topographic Illumination Correction
- Angular Effects in Landsat Timeseries

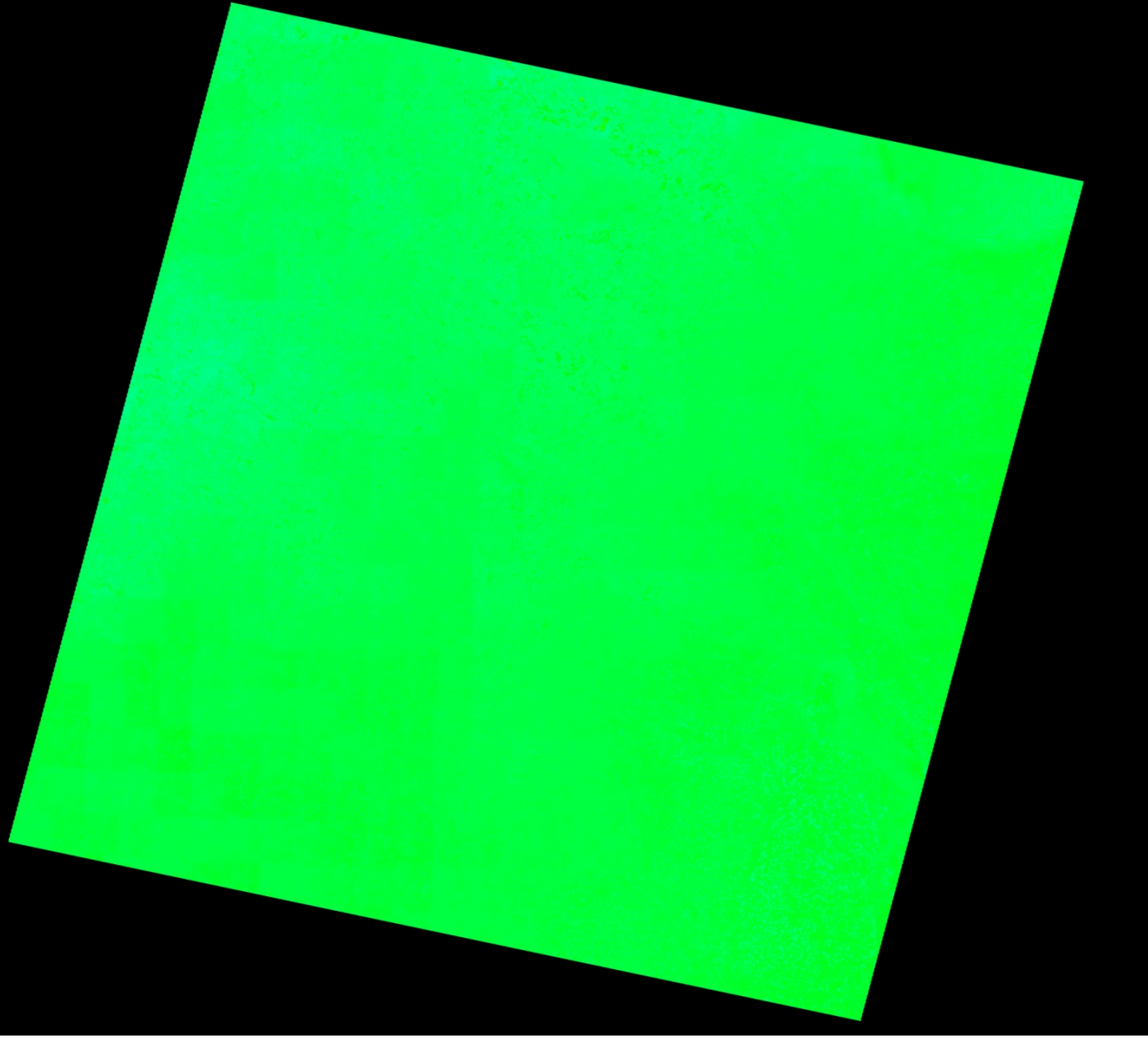
# Surface pressure bug fix

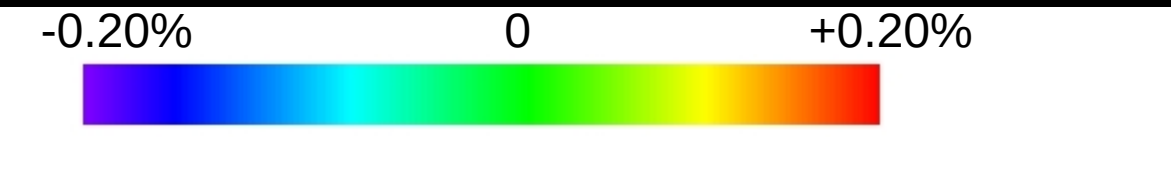
- LEDAPS/6S uses both NCEP surface pressure (2.5deg) and DEM (1km) to calculate Rayleigh scattering
- September 2010 – team discovered that DEM was not being referenced correctly – no topographic adjustment
- Problem fixed (mostly)… next slides indicate magnitude of effect

P15r34 (VA)
Diff _red
(without dem – with dem

(-0.20% to +0.20%)
All in absolute SR value

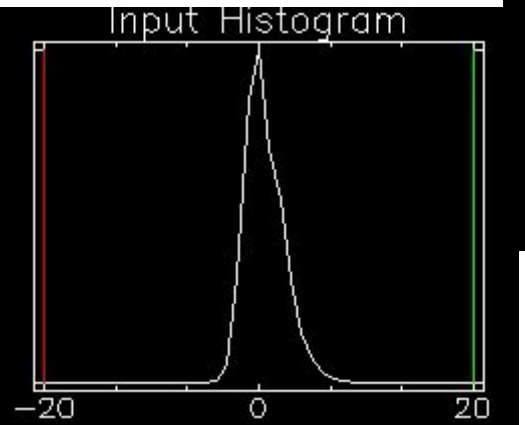


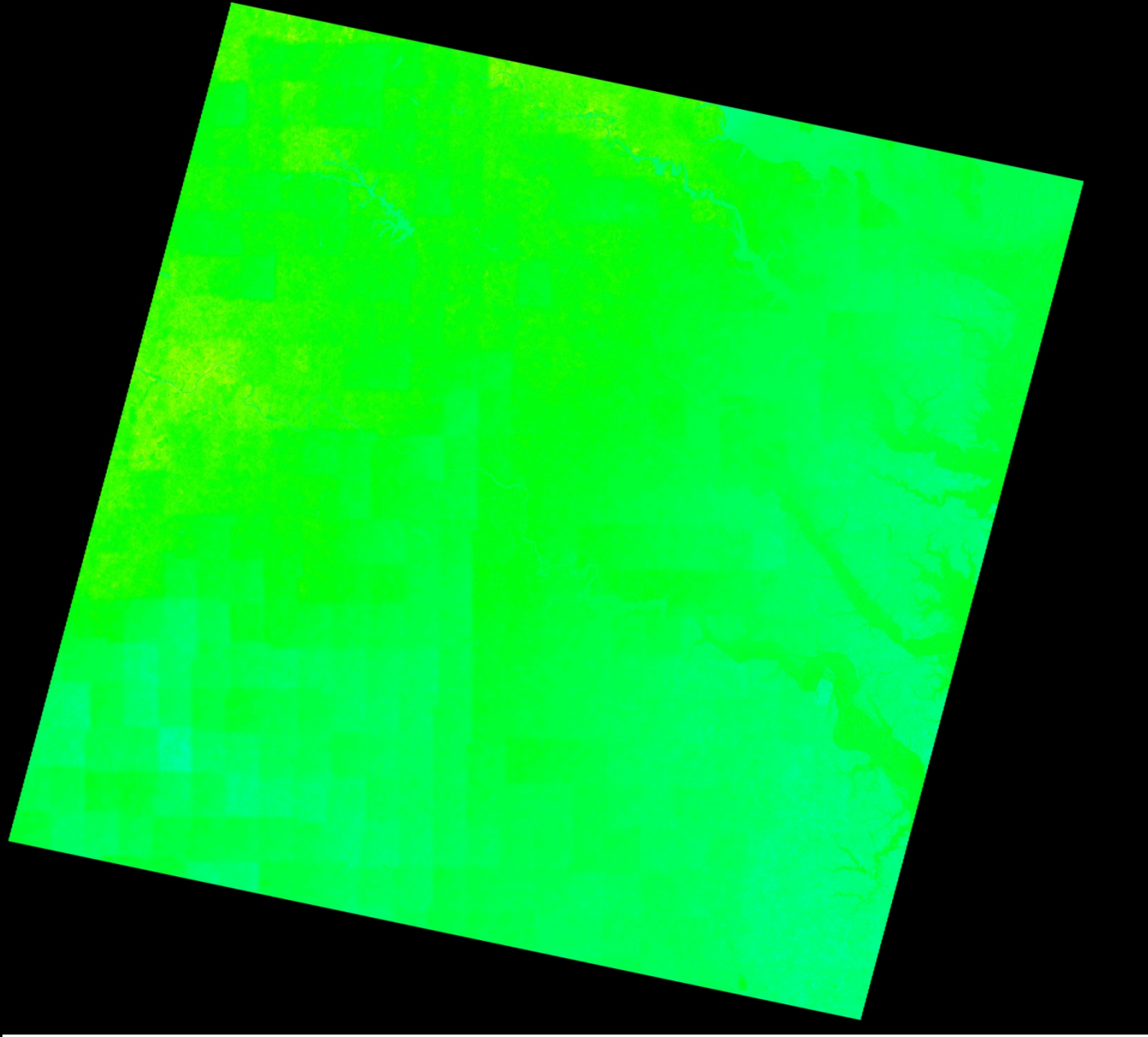





P15r34 (VA)
Diff _NIR
(without dem – with dem

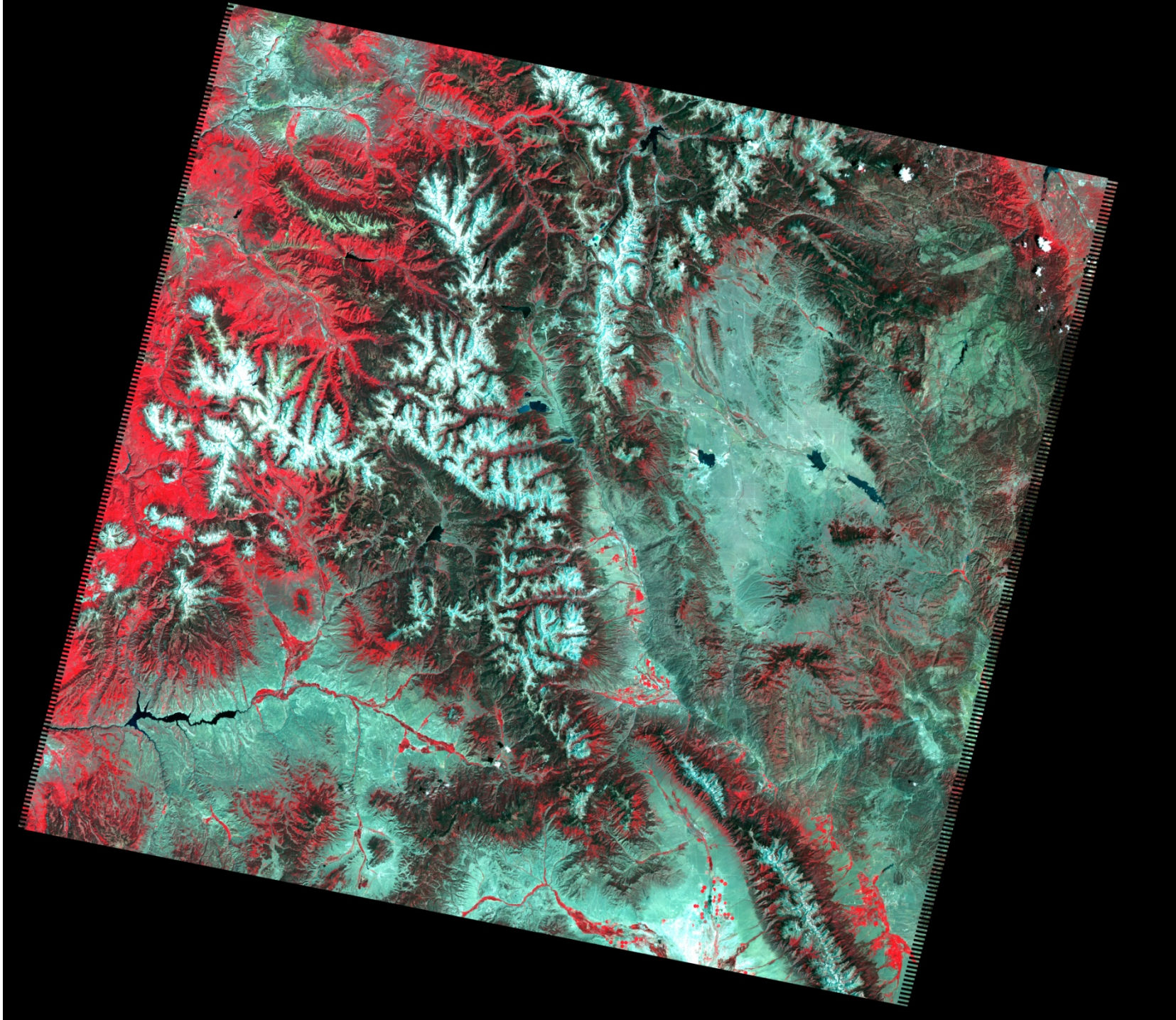
(-0.20% to +0.20%)
All in absolute SR value



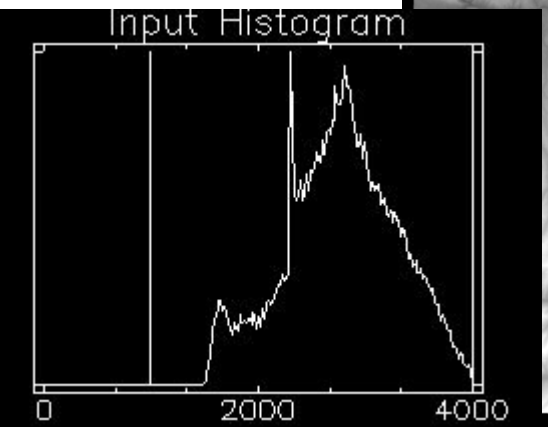



P34r33
(CO)
6/21/2010

Indsr (432)
with DEM
data

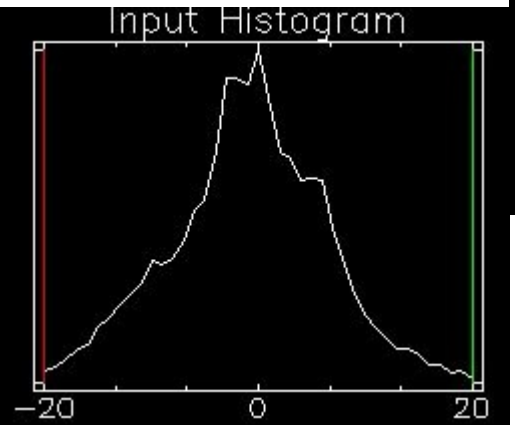


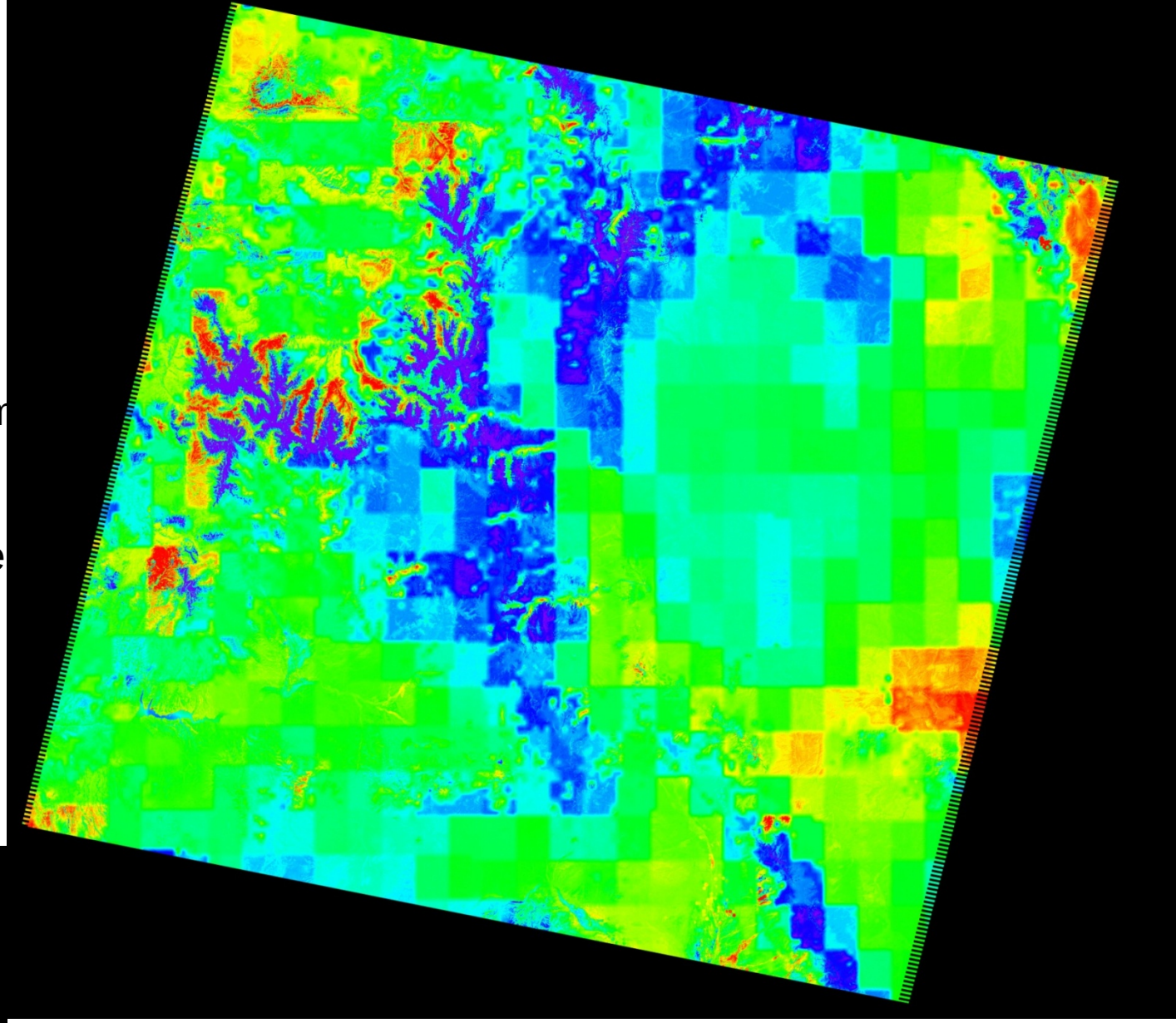
SRTM DEM
p34r33
(stretch range:
1000-4000m)

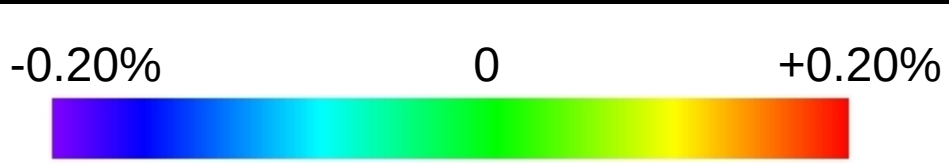


Diff _red
(without dem – with dem

(-0.20% to +0.20%)
All in absolute SR value

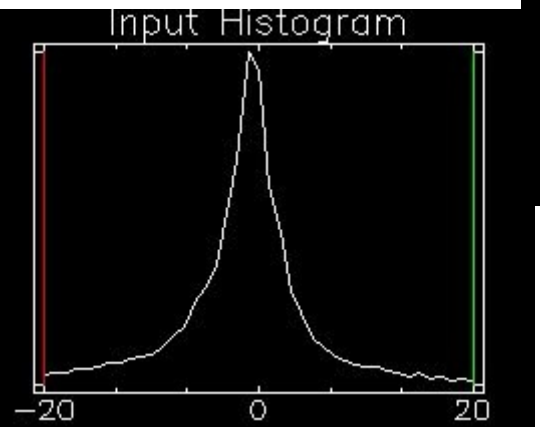


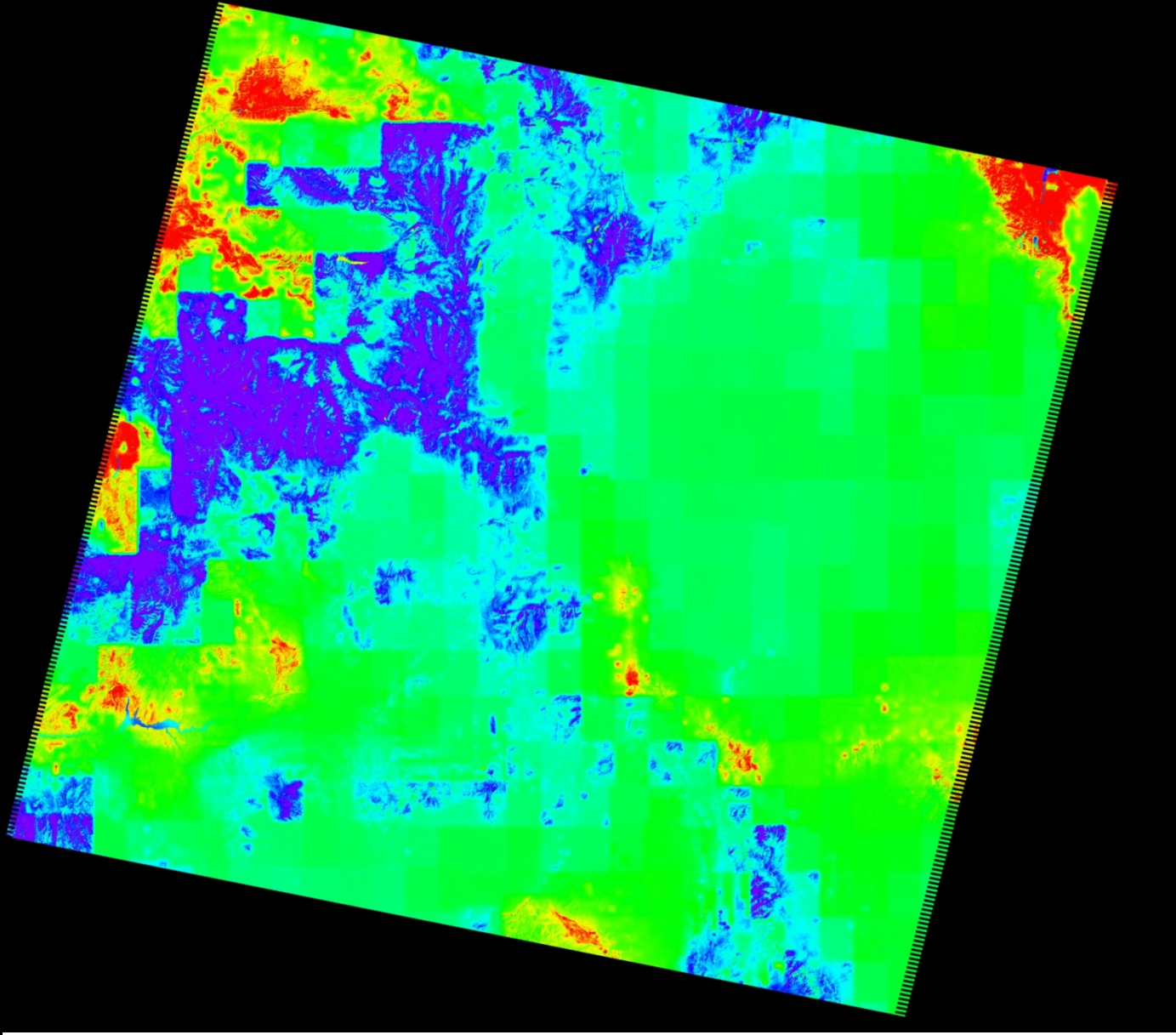



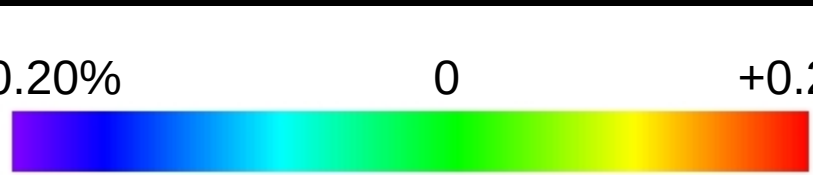


Diff _NIR
(without dem –
With dem)

(-0.20% to +0.20%)

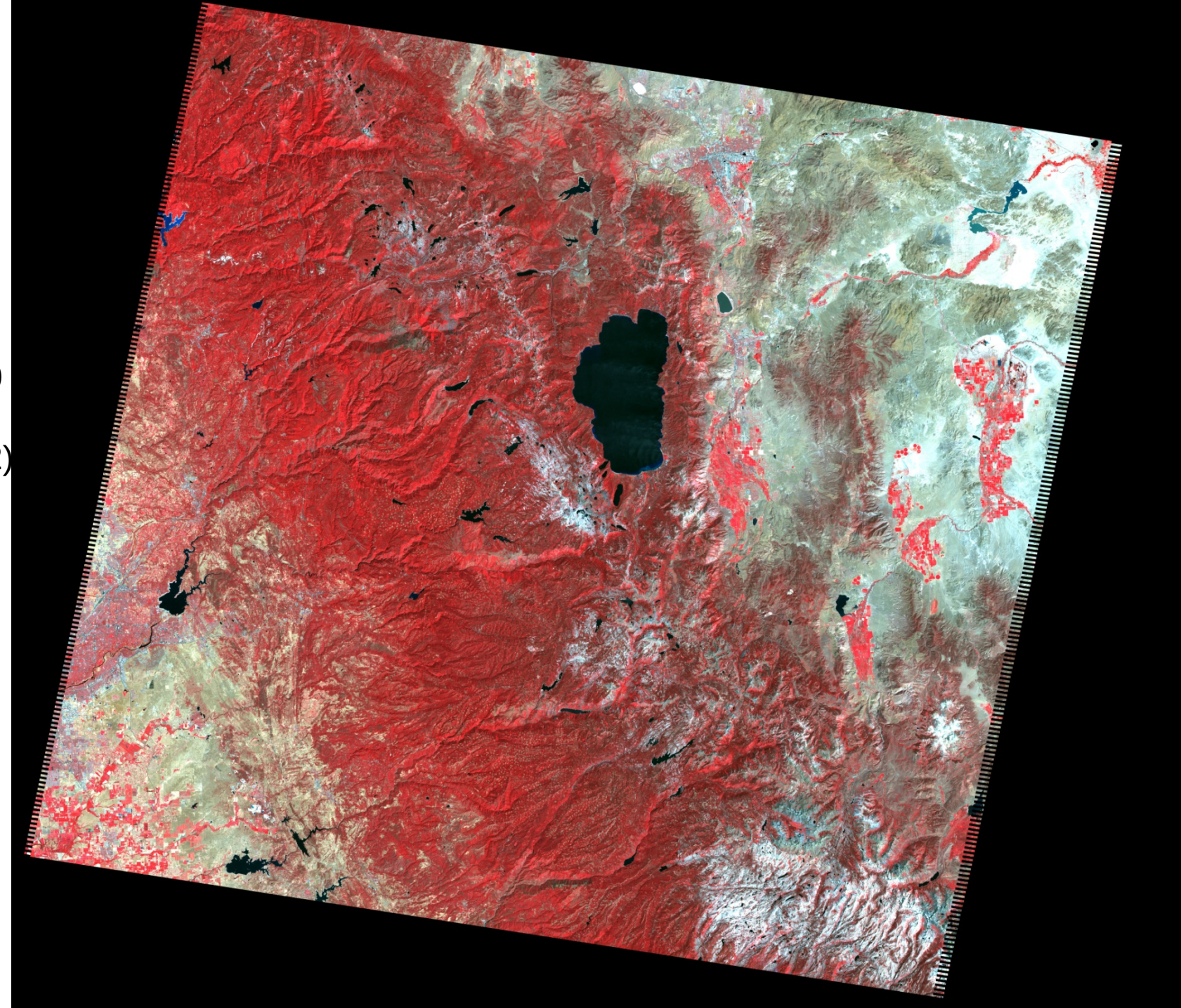


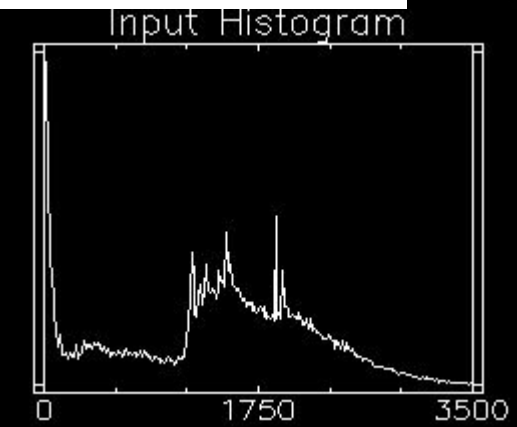


P43r33
(CA)
8/23/2010

Indsr (432)
with DEM

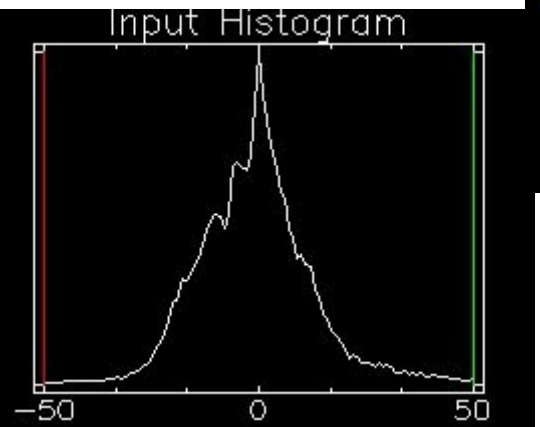


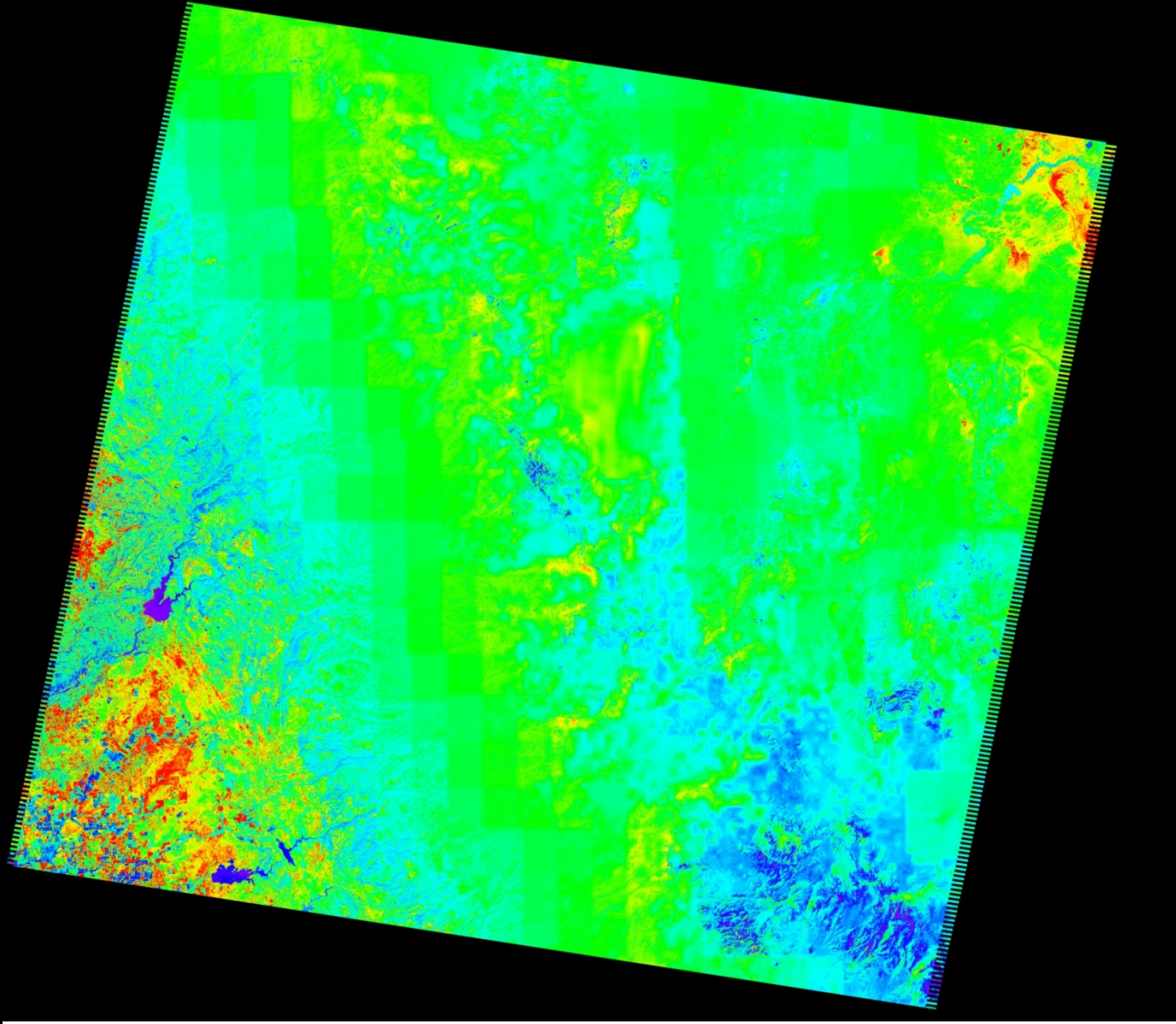
SRTM DEM
p43r33
(stretch range:
0-3500m)

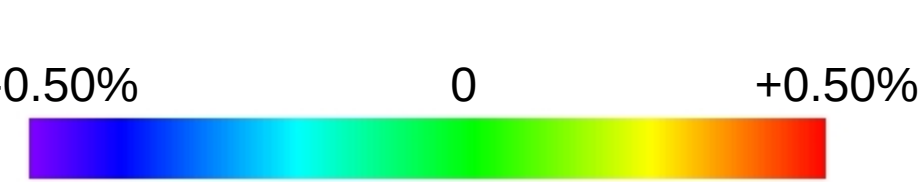


Diff _red
(without dem – with dem)

(-0.50% to +0.50%)

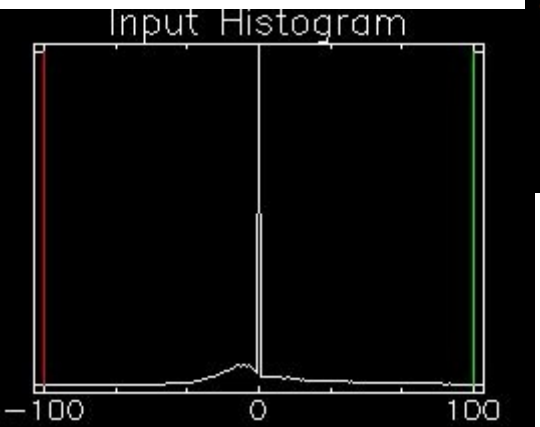


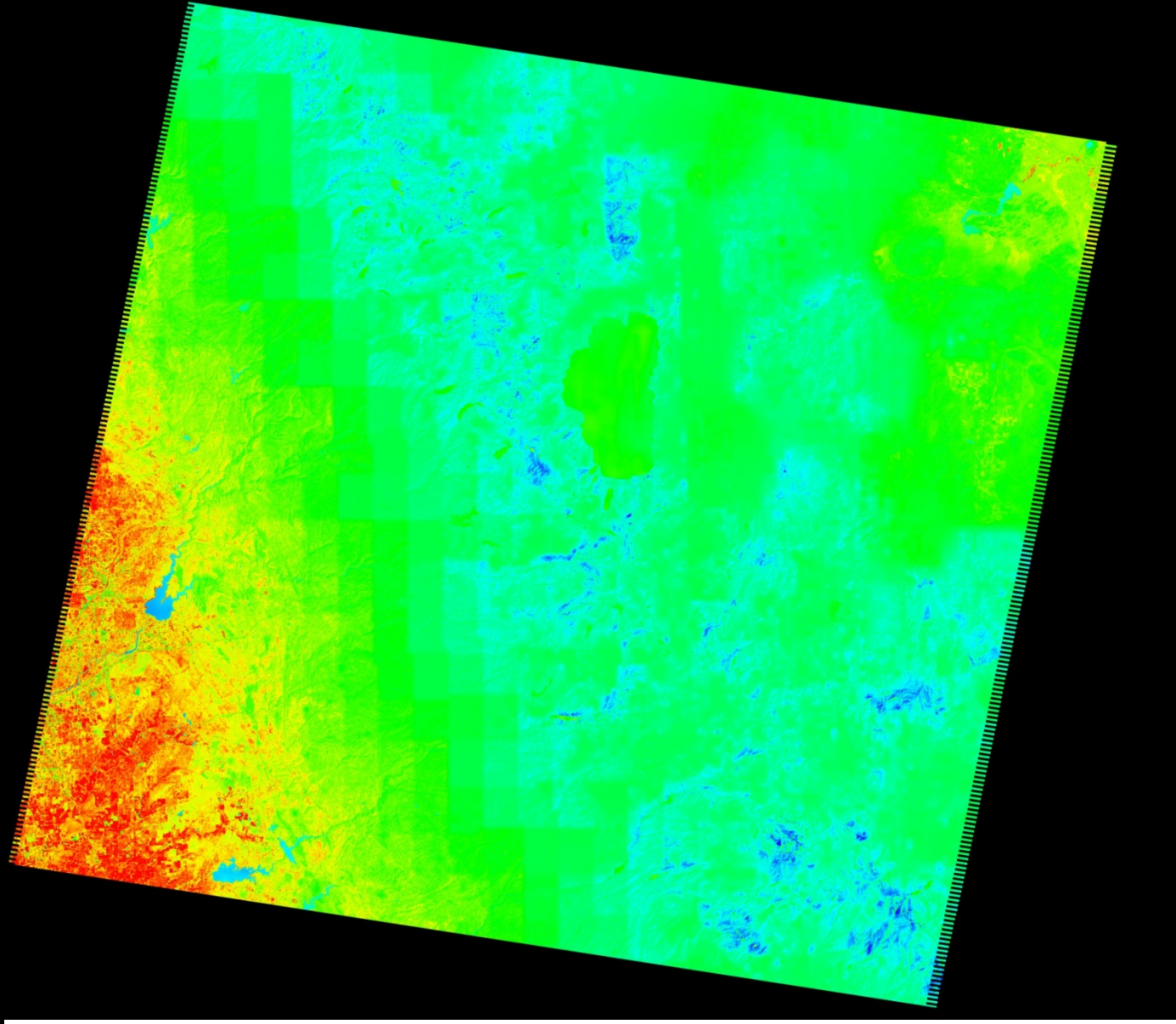



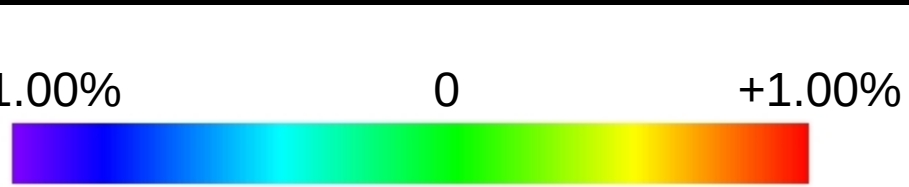


Diff _NIR
(without dem – withdem)

(-1.00% to +1.00%)



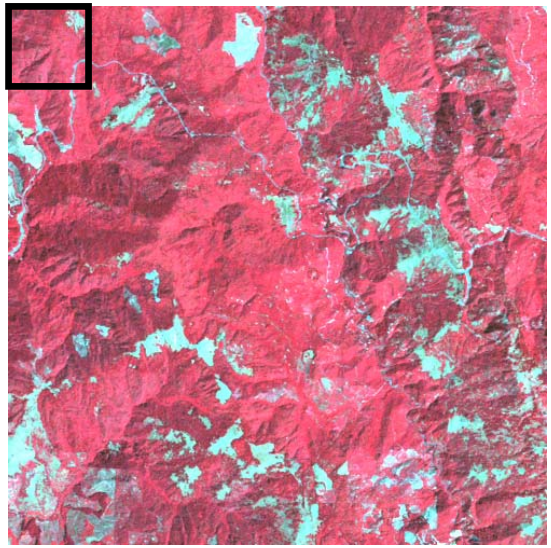





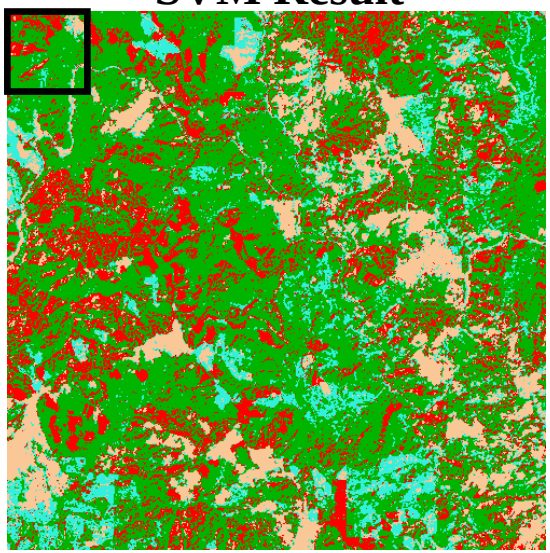
# Mapping Forest Changes in Mountain Area

**Path 46, Row 32**

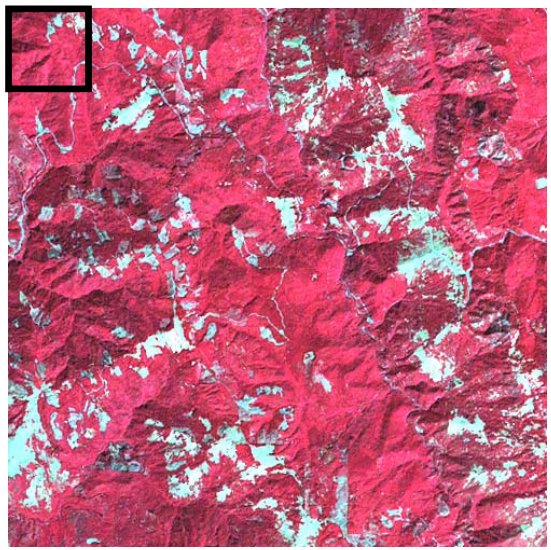

**1989-09-03**



**SVM Result**




**2002-10-01**

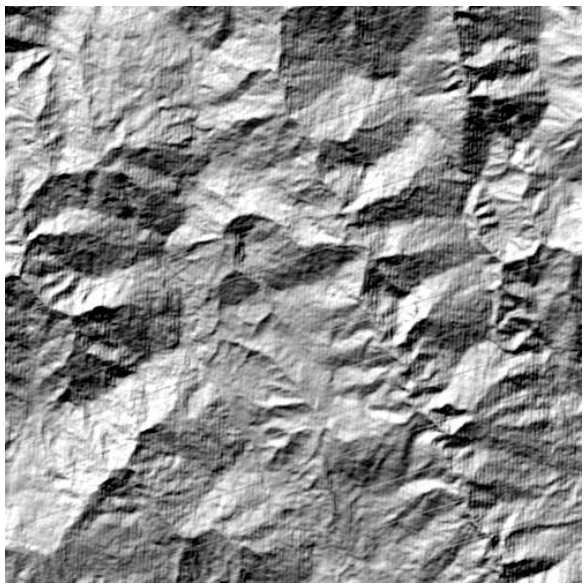


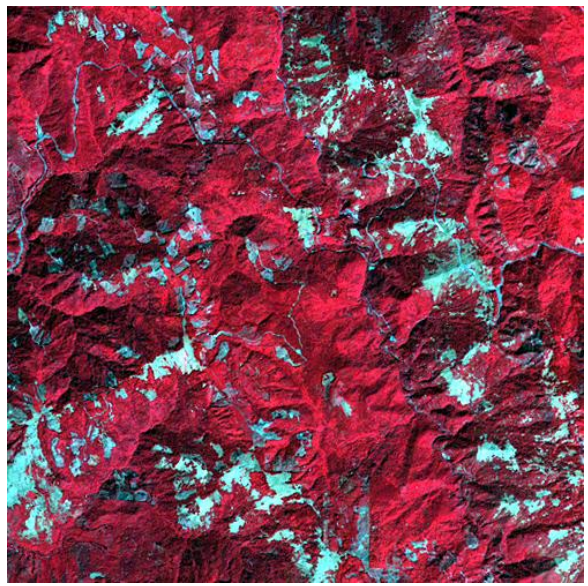
# Illumination Condition (IL)

$$IL = \cos Z \bullet \cos S + \sin Z \bullet \sin S \bullet \cos(\phi_z - \phi_S)$$

Z: the solar zenith angle,
$\Phi_z$: the solar azimuth angle,

S: the slope angle,
$\Phi_s$: is the aspect angle of the incline surface.





Special Case:

Flat area: $IL = \cos Z$

Slope face to Sun: $IL = 1$

# Traditional Illumination Correction Models

- **Cosine model**

$$L_H = L_i(\frac{\cos Z}{IL})$$

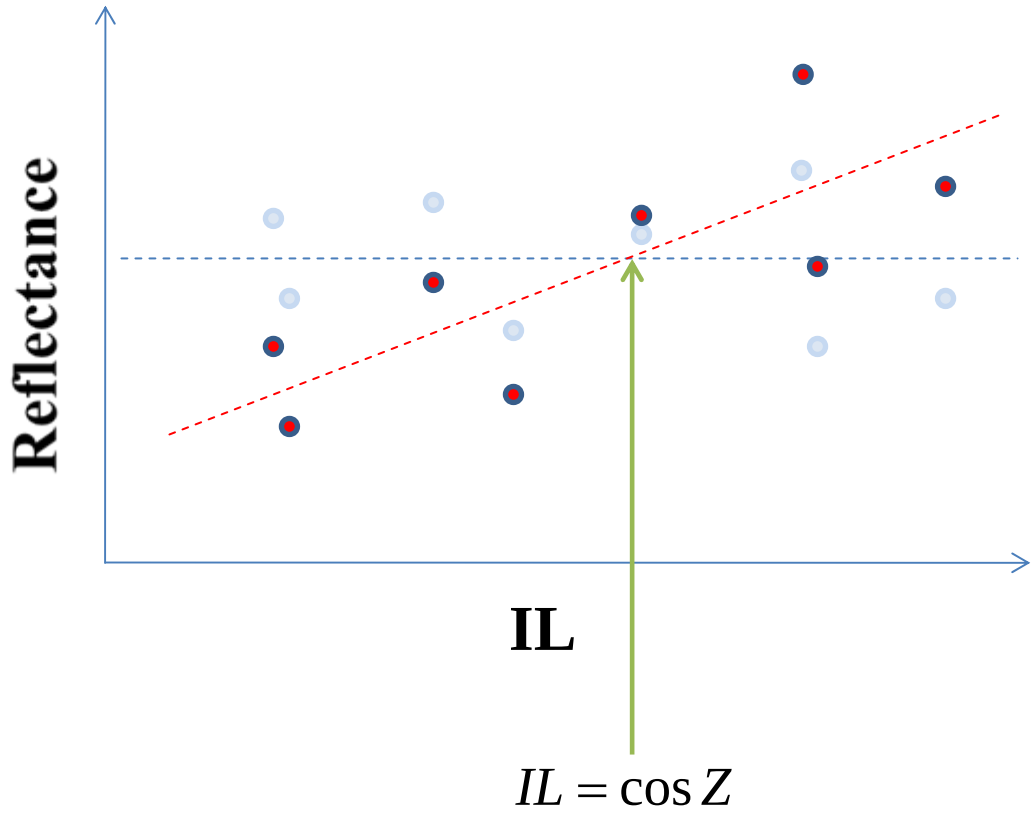
- **C model**

$$L_H(\lambda) = L_i(\lambda)\frac{\cos Z + c}{IL + c}$$

Where $c=a/b$ , $a$ and $b$ is from regression $L_i(\lambda) = a \bullet IL + b$

Teillet, P. M., Guindon, B., And Goodenough, D. G., "On the slope-aspect correction of multispectral scanner data." *Can. J. Remote Sens.,* 8, 84-106, 1982.

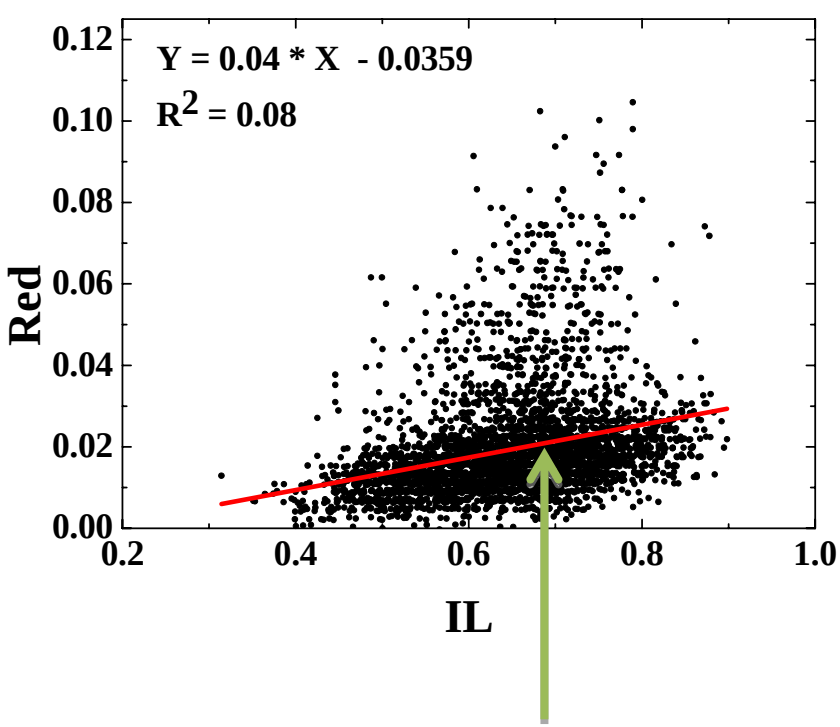
# Rotation Model



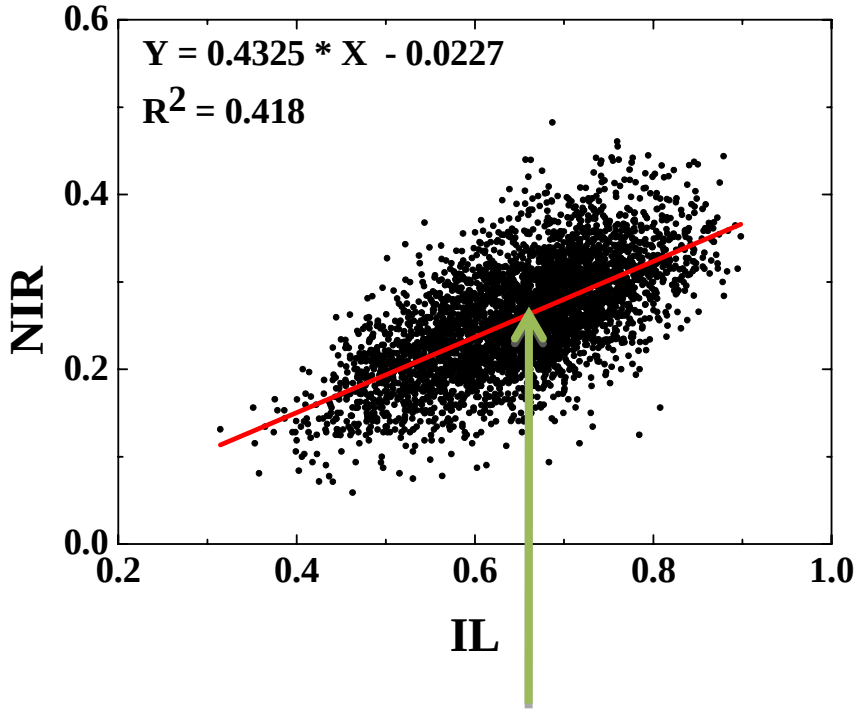

**Rotation Model :** $$L_H(\lambda) = L_i(\lambda) - (a * IL + b)$$

Where $a$ and $b$ is from regression $L_i(\lambda) = a \bullet IL + b$

# IL vs. TOC Reflectance



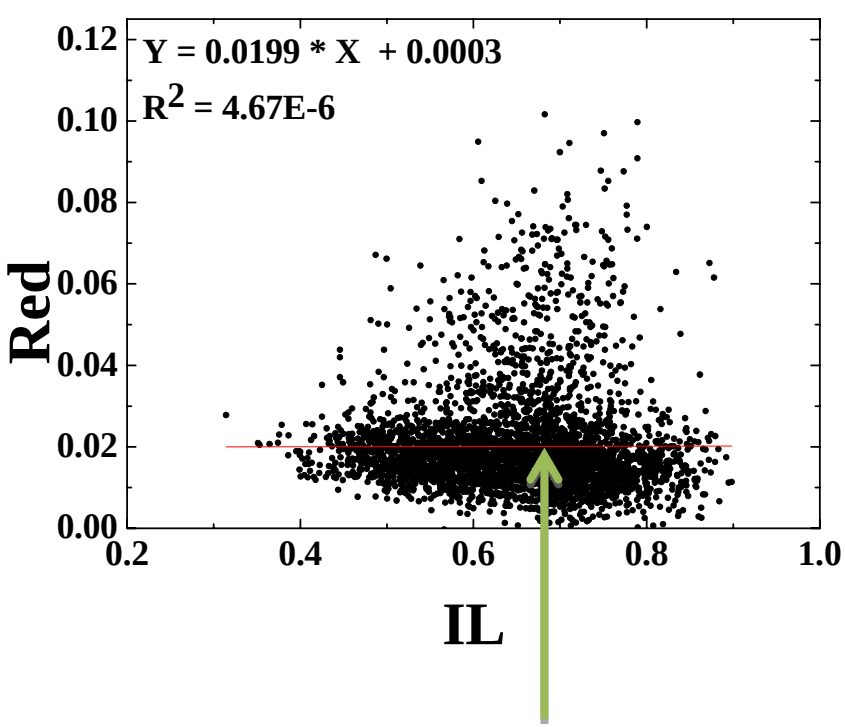

$IL = \cos Z = 0.675$



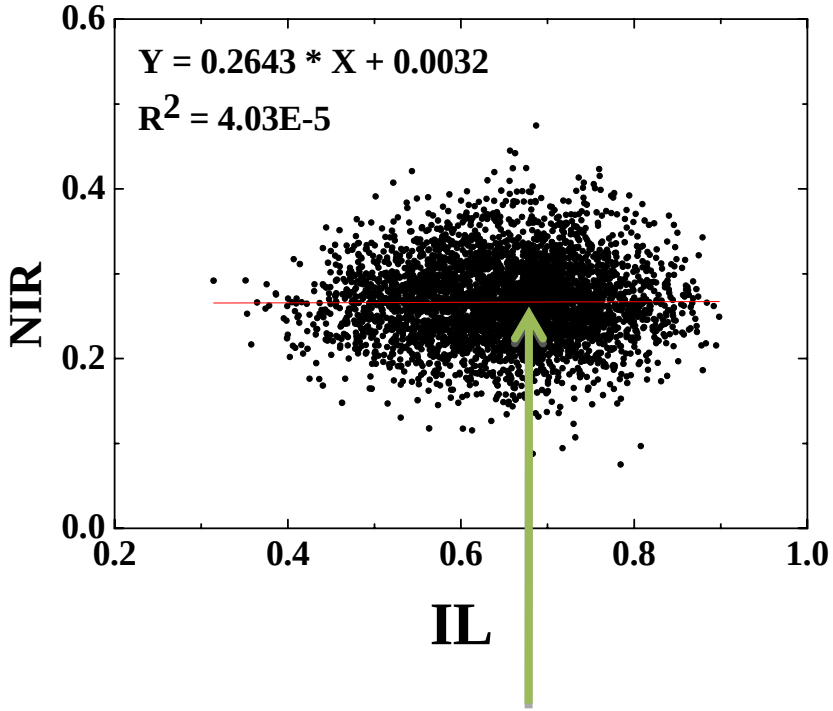

$IL = \cos Z = 0.675$

**Note: Only non-shadow forest pixels are used in this study.**

# IL vs. TOC Reflectance




$IL = \cos Z = 0.675$




$IL = \cos Z = 0.675$

**Note: Only non-shadow forest pixels are used in this study.**

# Homogeneity After Correction

**Relative Standard Deviation of TOA**

| Band | Original | Cosine Model | C Model | Rotation Model |
|---|---|---|---|---|
| 1 | 5.4% | 19.5% | 4.8% | **4.8%** |
| 2 | 13.1% | 15.7% | 9.6% | **9.5%** |
| 3 | 22.9% | 21.7% | **19.6%** | 19.7% |
| 4 | 29.3% | 16.7% | 16.3% | **14.5%** |
| 5 | 40.9% | 30.5% | 29.2% | **27.0%** |
| 7 | 10.5% | 15.4% | 7.0% | **6.9%** |

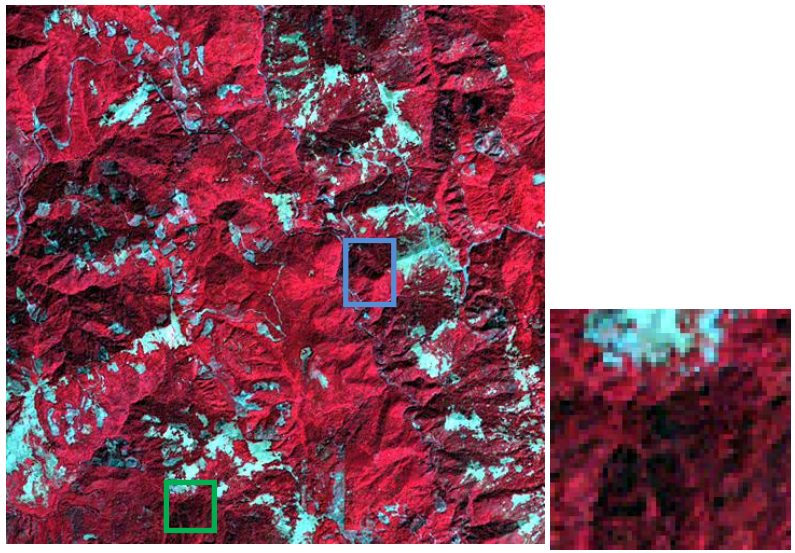
**Relative Standard Deviation of TOC**

| Band | Original | Cosine Model | C Model | Rotation Model |
|---|---|---|---|---|
| 1 | 42.7% | 39.3% | 39.1% | **37.6%** |
| 2 | 36.2% | 28.6% | 28.5% | **26.5%** |
| 3 | 57.7% | 52.4% | 52.1% | **49.6%** |
| 4 | 30.2% | 17.5% | 17.0% | **15.0%** |
| 5 | 42.1% | 32.1% | 31.0% | **28.5%** |
| 7 | 10.6% | 15.9% | 7.0% | **7.0%** |

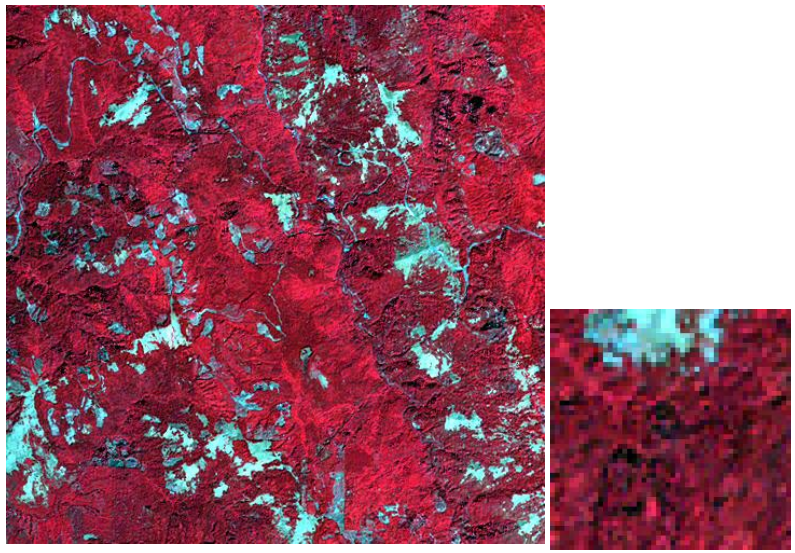
Relative Standard Deviation = Standard Deviation / Mean

# Corrected TOC Reflectance

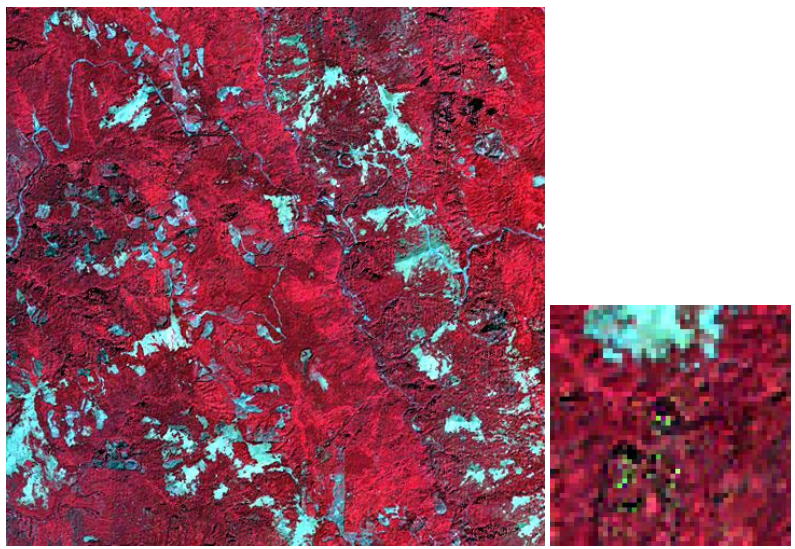
## Original Landsat



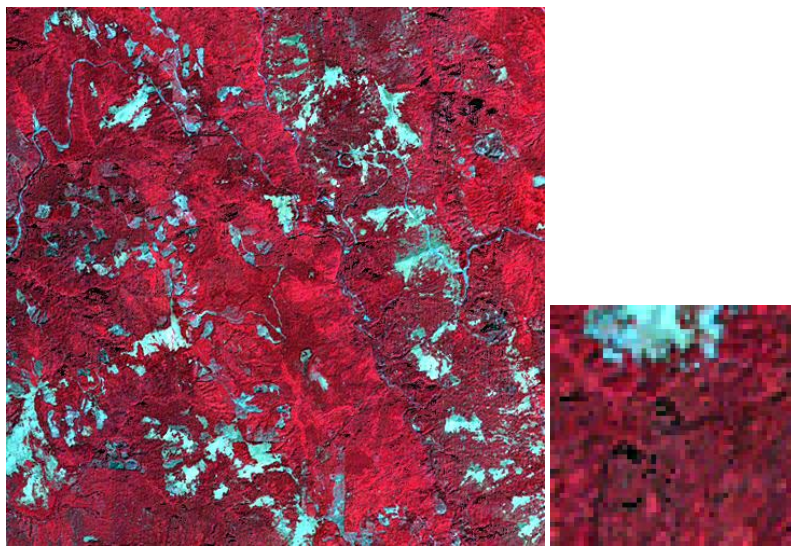
## Cosine Model



## C Model

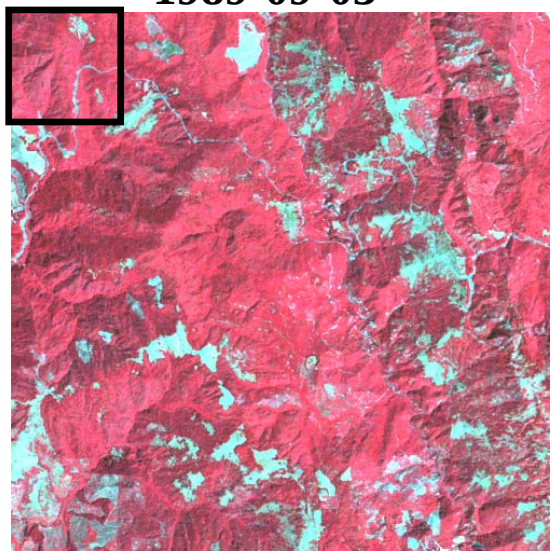


## Rotation Model

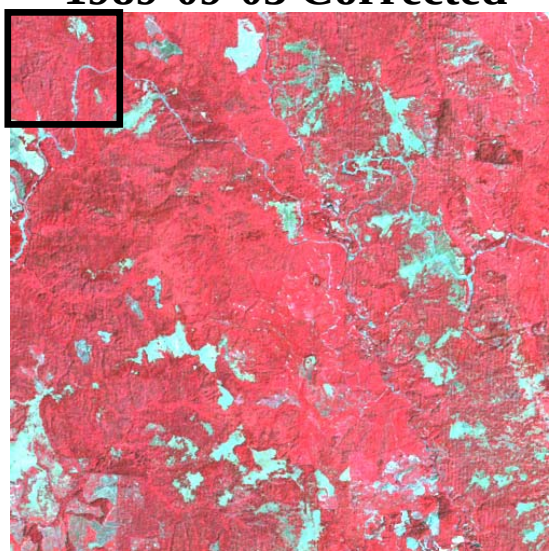


# SVM Result

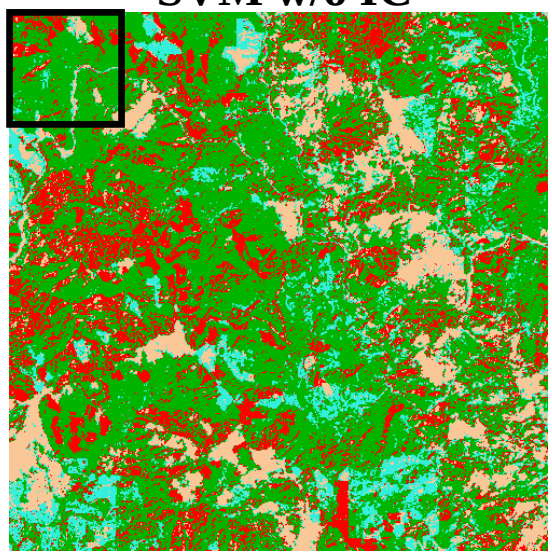
1989-09-03



1989-09-03 Corrected



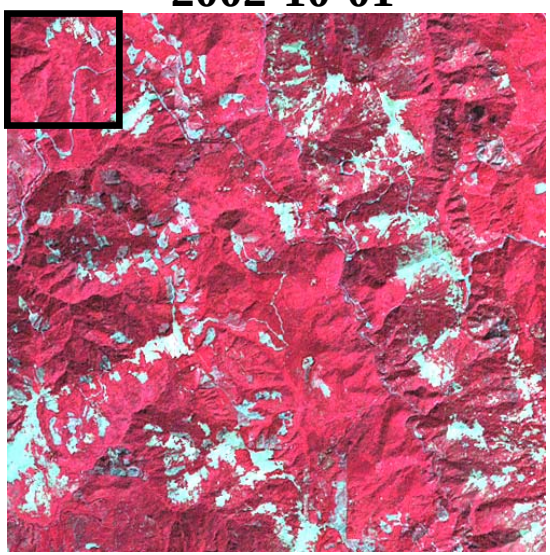
SVM w/o IC



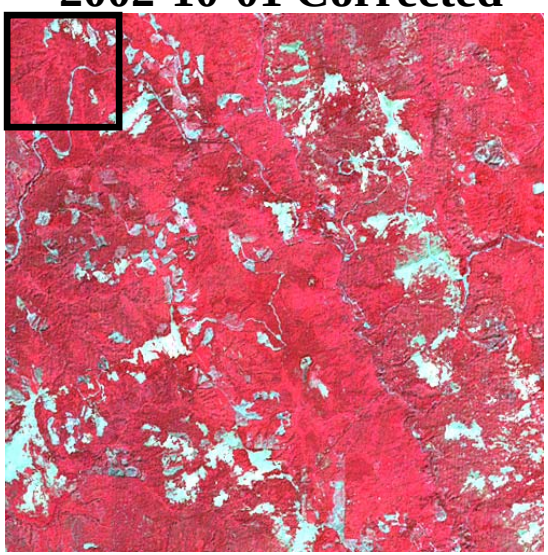
Deforest

Regrowth

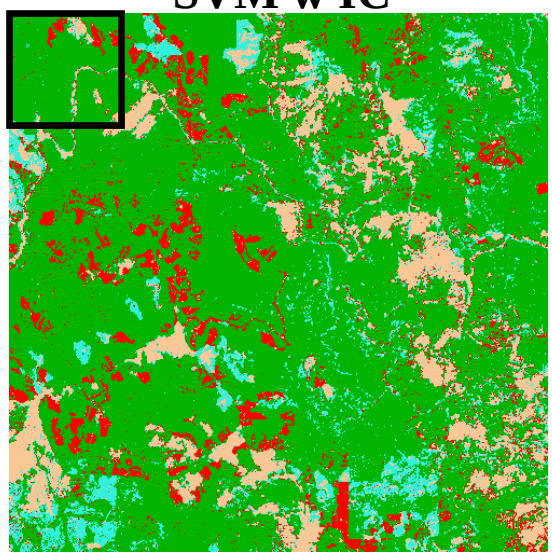
2002-10-01



2002-10-01 Corrected



SVM w IC



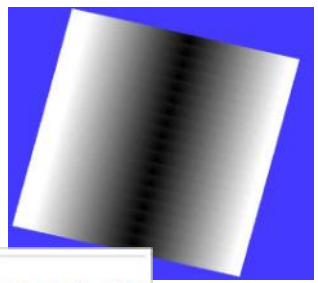
Forest

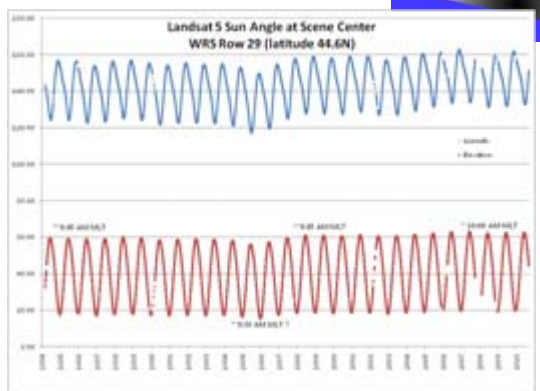
Non Forest

# 3. Influence of Angular Effects on Landsat Surface Reflectance Time Series

**Issues associated with assembling per-pixel timeseries of Landsat SR:**

- Within-scene (view angle) BRDF effect caused by the changes of viewing geometries (~+-7.5 degrees)
- Seasonal (solar angle) effects
- MLT Drift (solar angle) effects



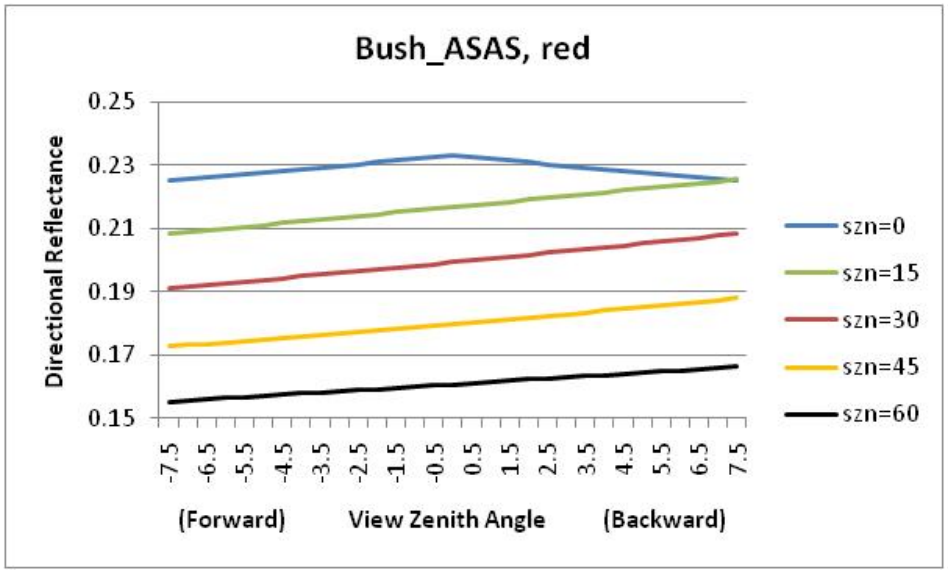


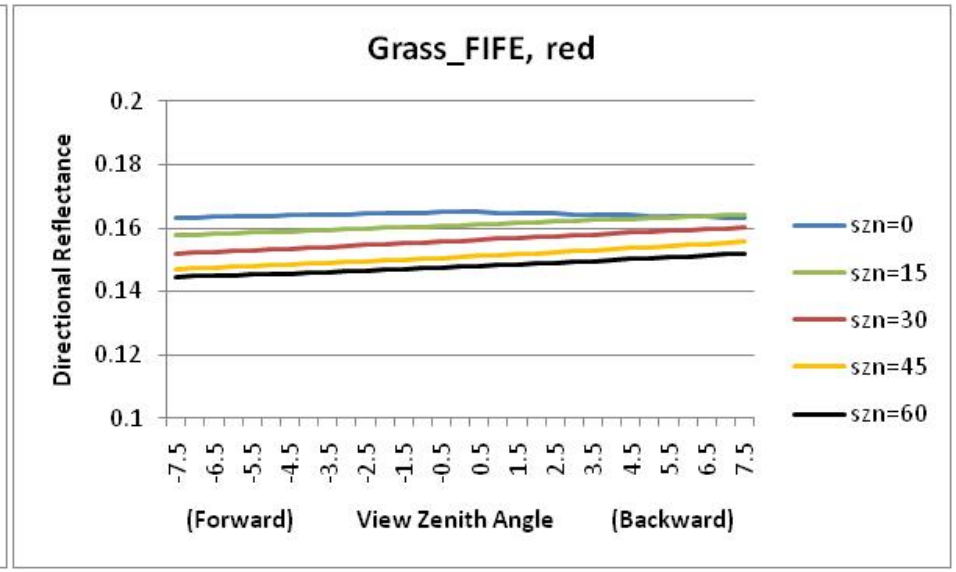

**How much variability can we expect from each of these?**

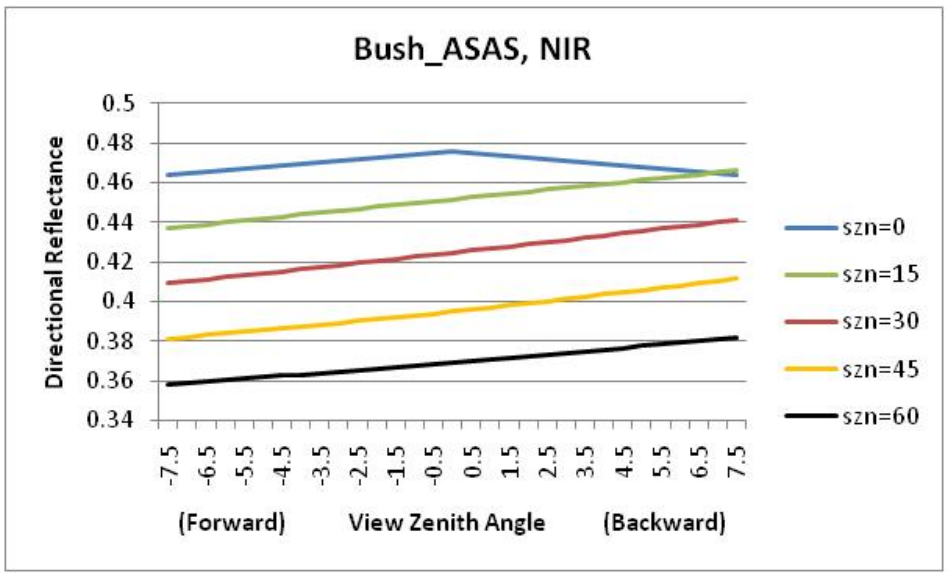
# Approach

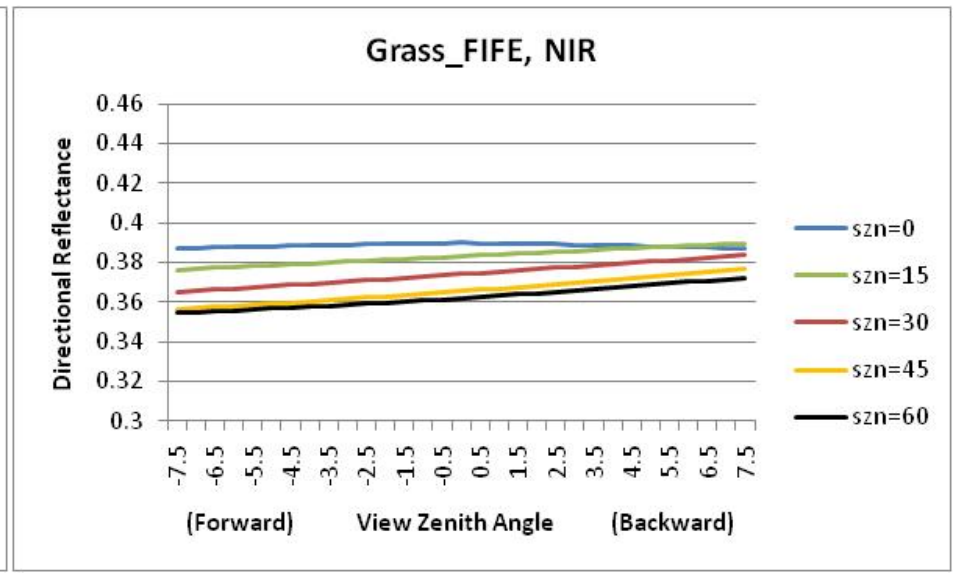
- Use empirical data (ASAS, Parabola) to derive BRDF kernel for land cover types
- Simulate effect of view, solar angle variations associated with each effect

# **View Angle Effects** Within Landsat Scene: Up to 2% abs SR variation



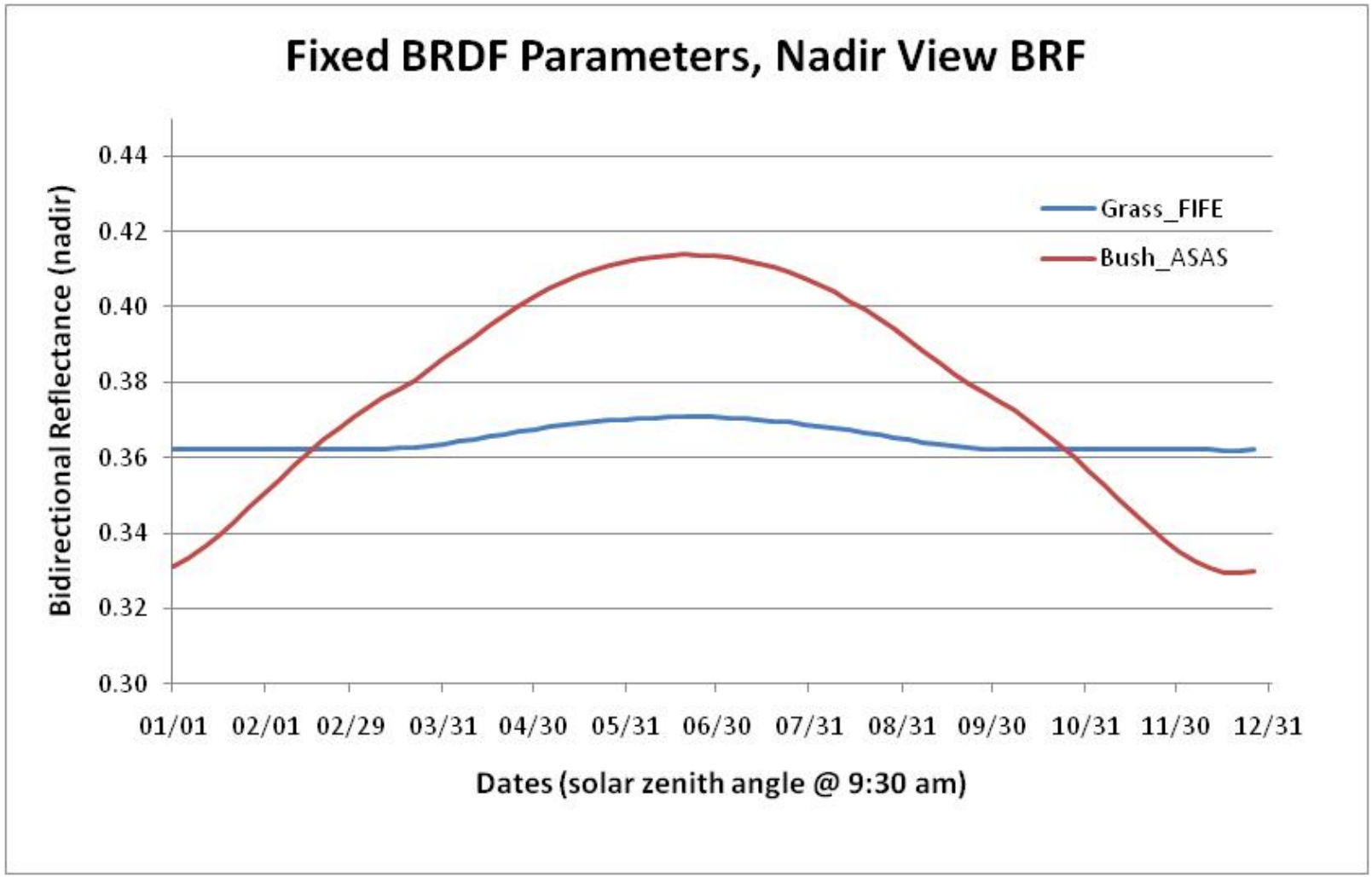




Bidirectional Reflectance for Landsat View Angles (+-7.5) at Principal Plane using in-situ measurement

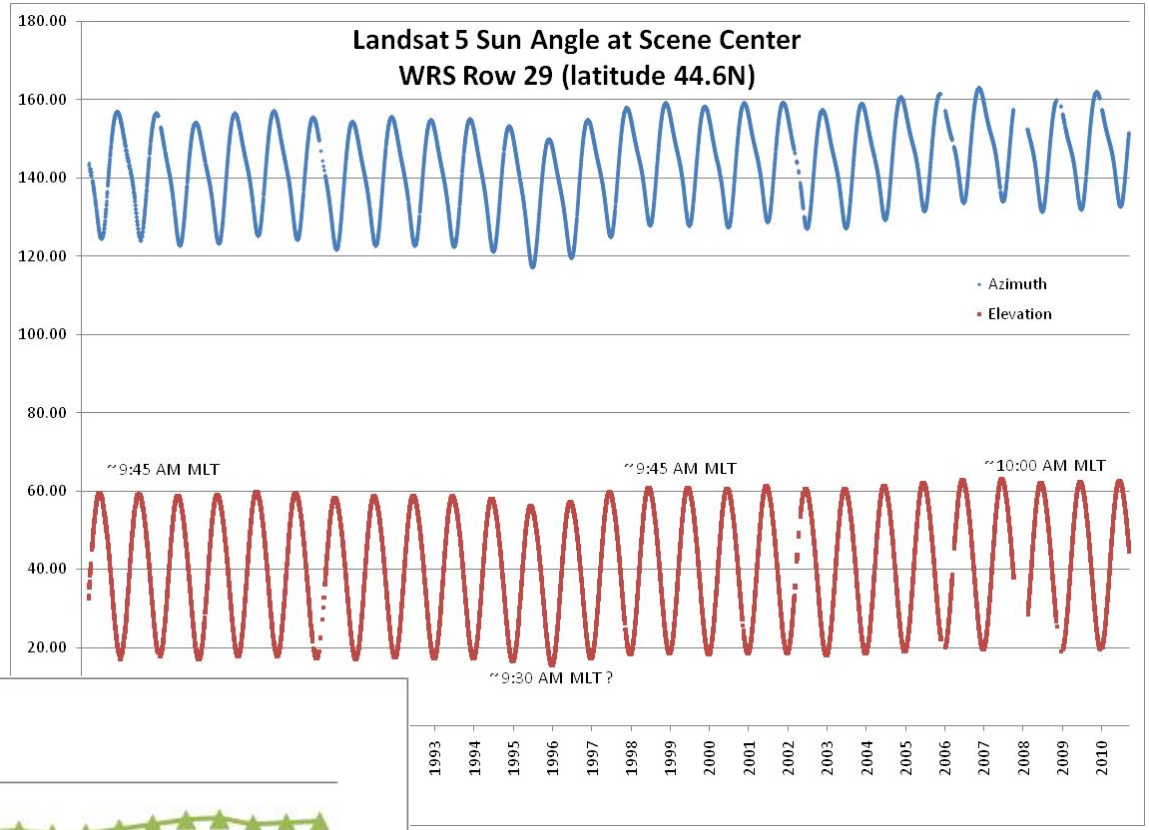
**Seasonal Solar Angle Effect**: Up to ~8% abs SR variation (but more like <3% when within single season)

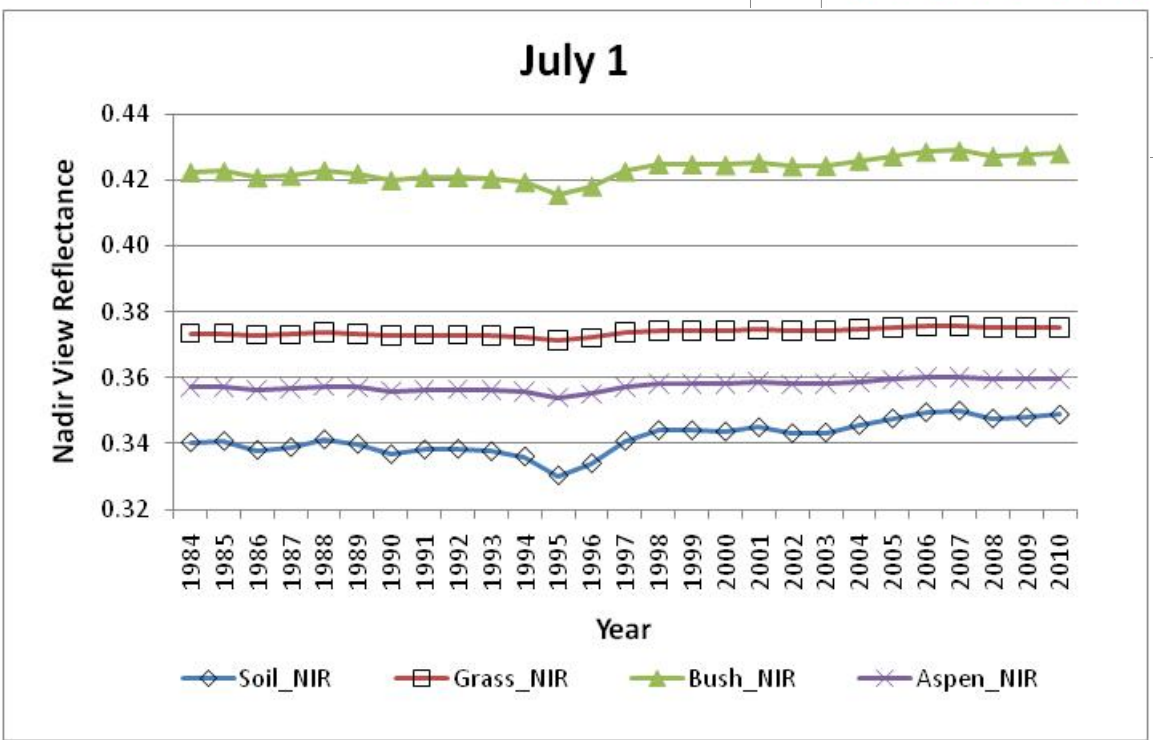



Reflectance varying from different acquisition dates
(fixed BRDF parameters were used across whole year)

# Effects by Orbit Drift
(L5 example)

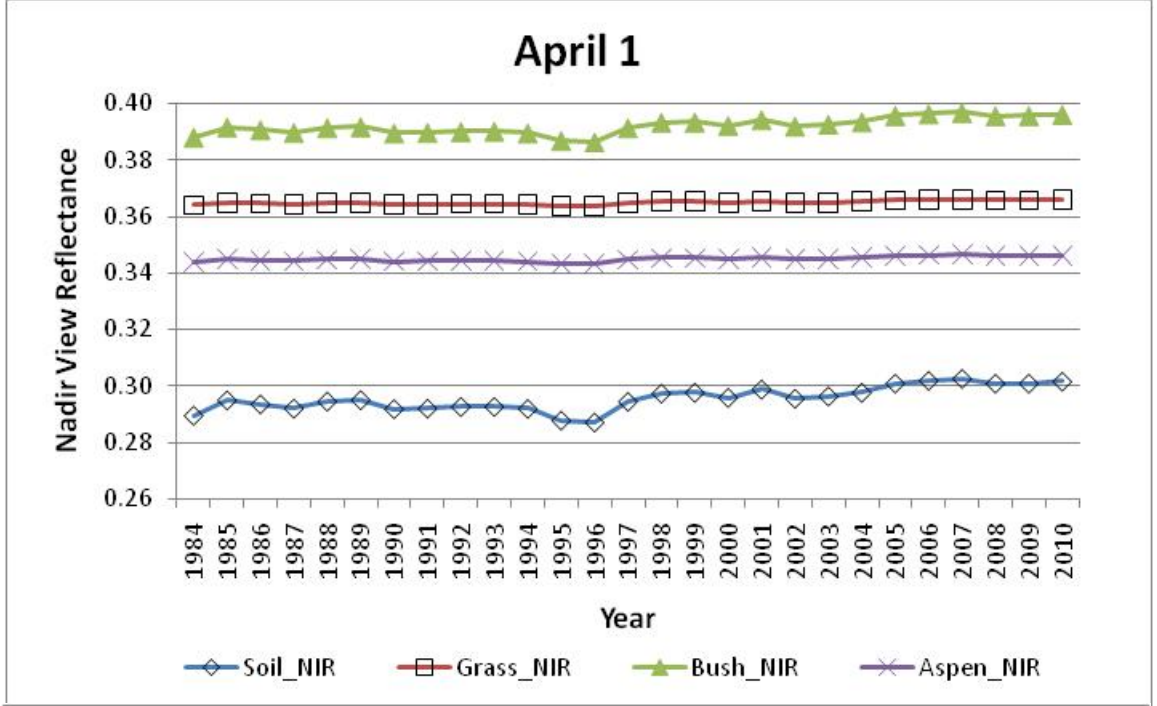
Up to 1% abs SR



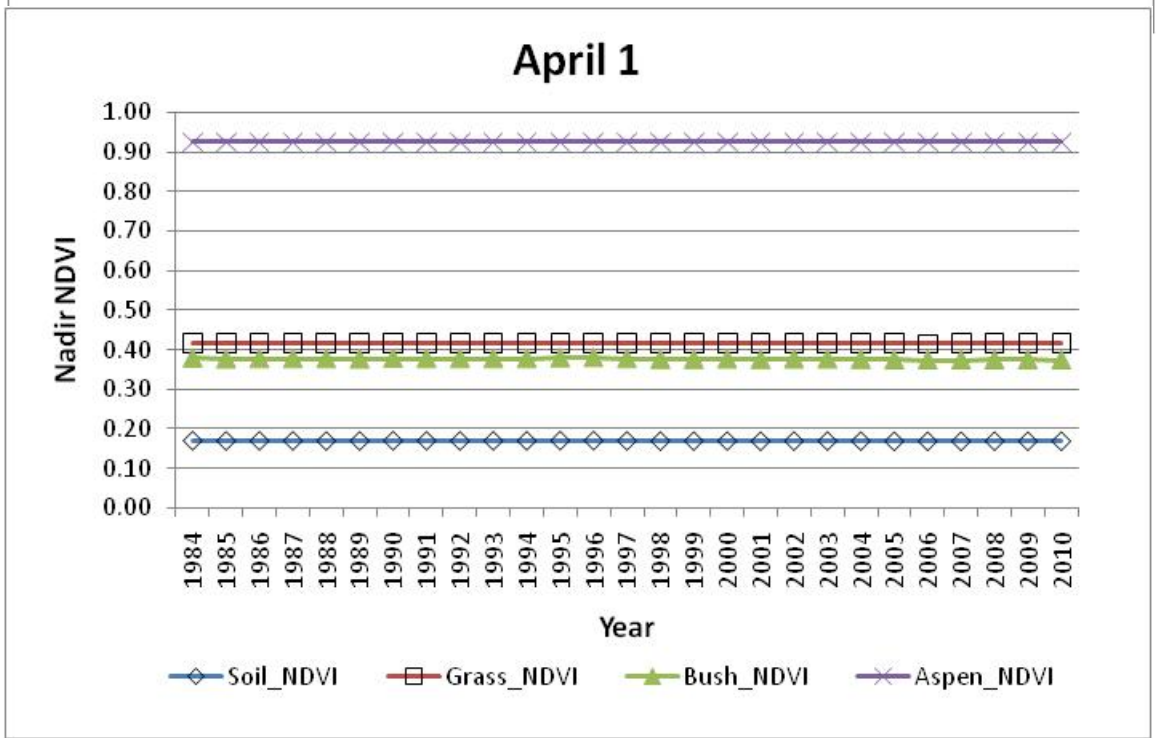




Landsat 5
WRS-2 row 29 (44.6 degree North)
(1984 to current)

NIR


April 1
Nadir View Reflectance
0.40
0.38
0.36
0.34
0.32
0.30
0.28
0.26
1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010
Year
Soil_NIR
Grass_NIR
Bush_NIR
Aspen_NIR

NDVI


April 1
Nadir NDVI
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010
Year
Soil_NDVI
Grass_NDVI
Bush_NDVI
Aspen_NDVI