How Many Bits?

Radiometric Resolution as a Factor in Obtaining Forest Information with Remotely Sensed Measurements

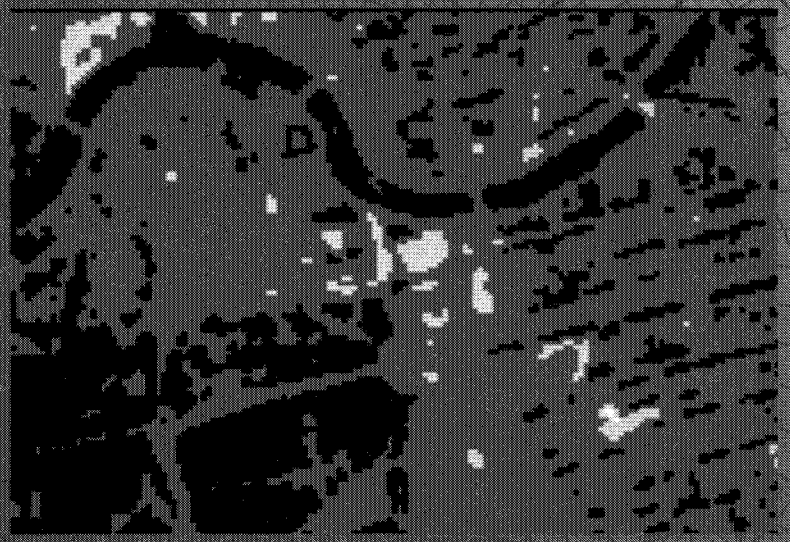
-Shannon Franks-
Geography Department
University of Maryland

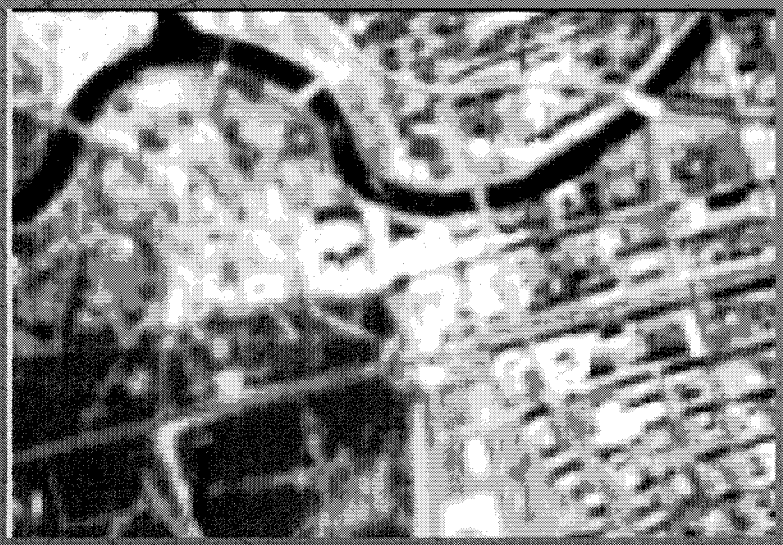
-Dr. Jeffrey Masek-
NASA-Goddard Space Flight Center
Greenbelt, Maryland USA

May 3rd, 2007

Radiometric Resolution

- Definition- the amount of energy required to increase a pixel value by one quantization level or 'count'.
- In summary, radiometric resolution determines how finely the sensor can distinguish between objects of similar reflection. The higher the radiometric resolution, the better we can distinguish even subtle differences in reflection





Why is this important

- Currently, we do not know what observational measurements are needed in all remote sensing applications.
- Studies such as this will better inform scientist, engineers, and managers when planning future satellite missions.
- Although this study will not provide all the answers, it is a step in the right direction

Background and Introduction

- Applications of terrestrial remote sensing have moved from qualitative, visual analyses to more quantitative interpretations
- Previous studies often have found radiometric resolution not to be an important factor in the capability of a remote sensing system to discriminate land features.
  - But for forest canopies the case may differ
- Does higher radiometric resolution benefit, and if so, how much and in what way?
- Is 8 bits enough?

Quantization

- Definition- The number of individual levels used to digitize a range of radiometric values

- Examples: Landsat 7: 8 bits = 256 values
  IKONOS: 11 bits = 2048 values
  MODIS: 12 bits = 4096 values
  EO1 ALI: 12 bits = 4096 values

Data and Methods

EO1 ALI

- August 9th, 2001
- 3.1-degree off-nadir
- Cloud Free
- Lies within P16/R33

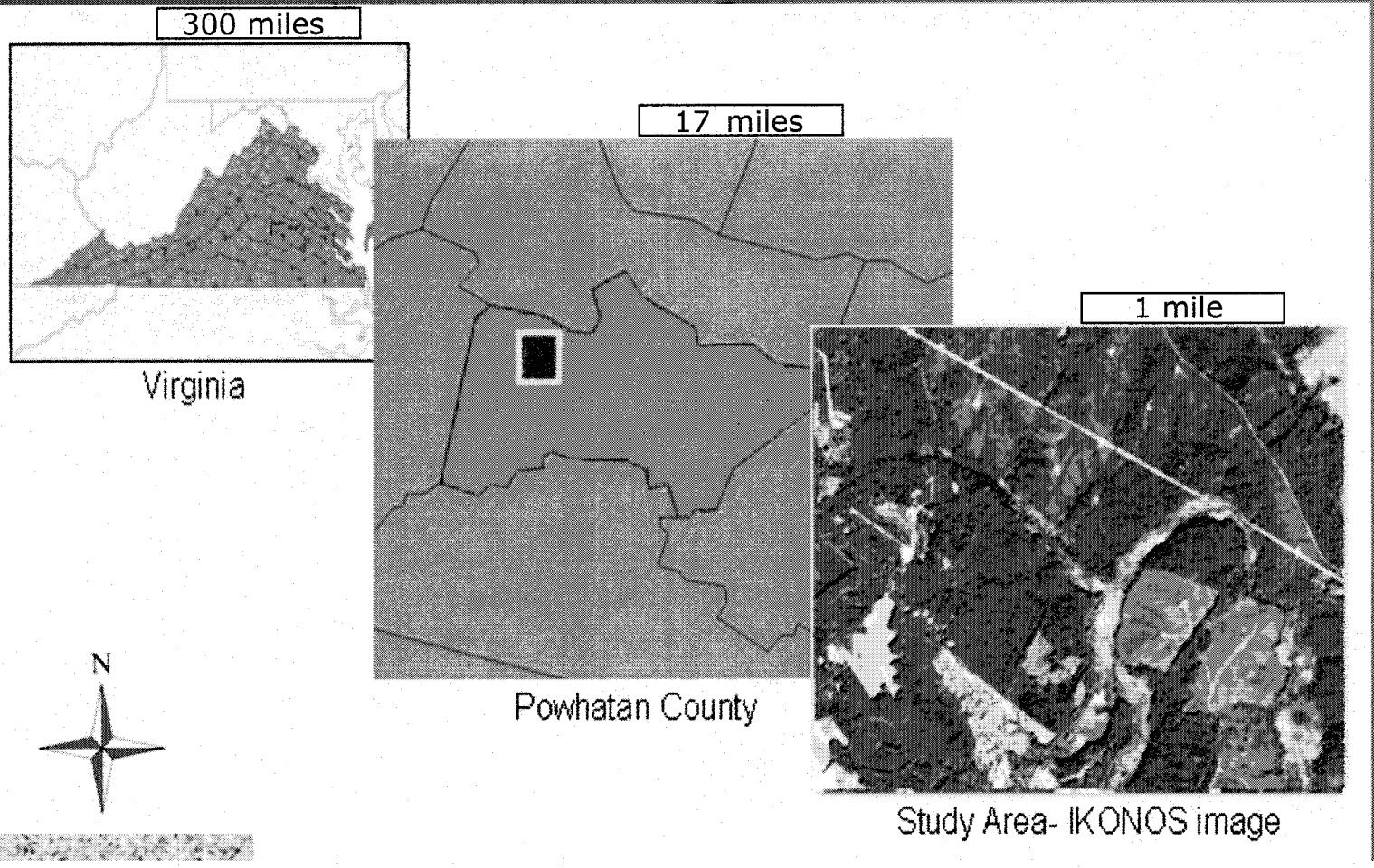
IKONOS

- October 10, 2000
- 6.7-degree off-nadir
- Cloud Free
- Lies within P15/R34

- Aggregated IKONOS to 32 meters (17 bits)
- Truncated IKONOS to 8 and 11 bits
- Truncated ALI to 8, 11, 12
- Radiometric Calibration to TOA Reflectance

The Study Site

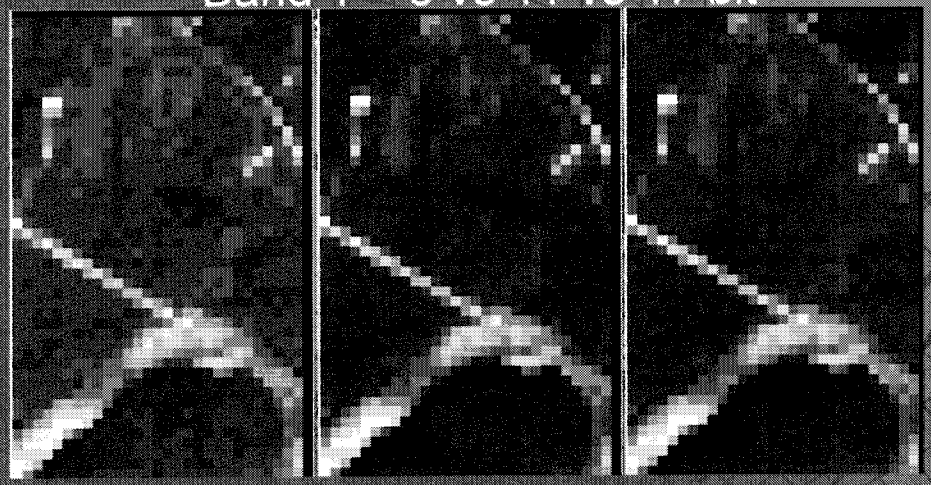
- Industrial forestry site in central Virginia was chosen because of its large variability in standing biomass



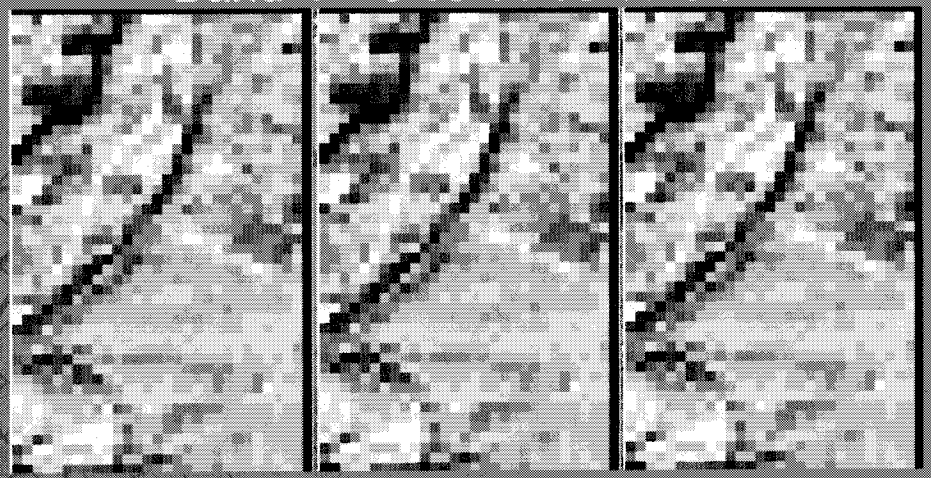


Results – Visual Inspection

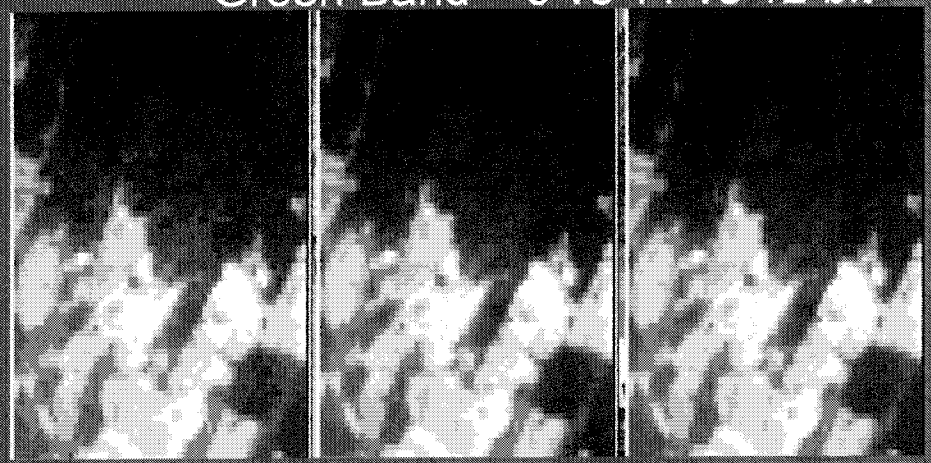
Band 1 – 8 vs 11 vs 17 bit



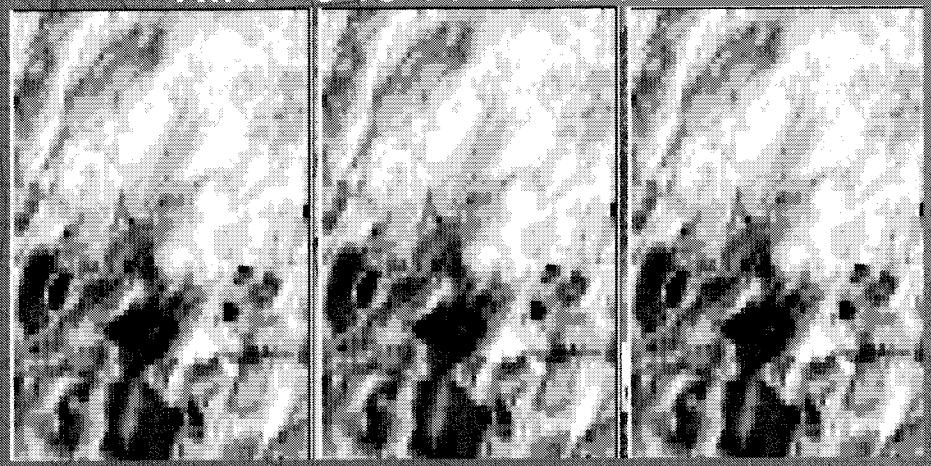
Band 4 – 8 vs 11 vs 17 bit



Green Band – 8 vs 11 vs 12 bit



NIR – 8 vs 11 vs 12 bit



Scatterplots- IKONOS



Scatterplots- ALI

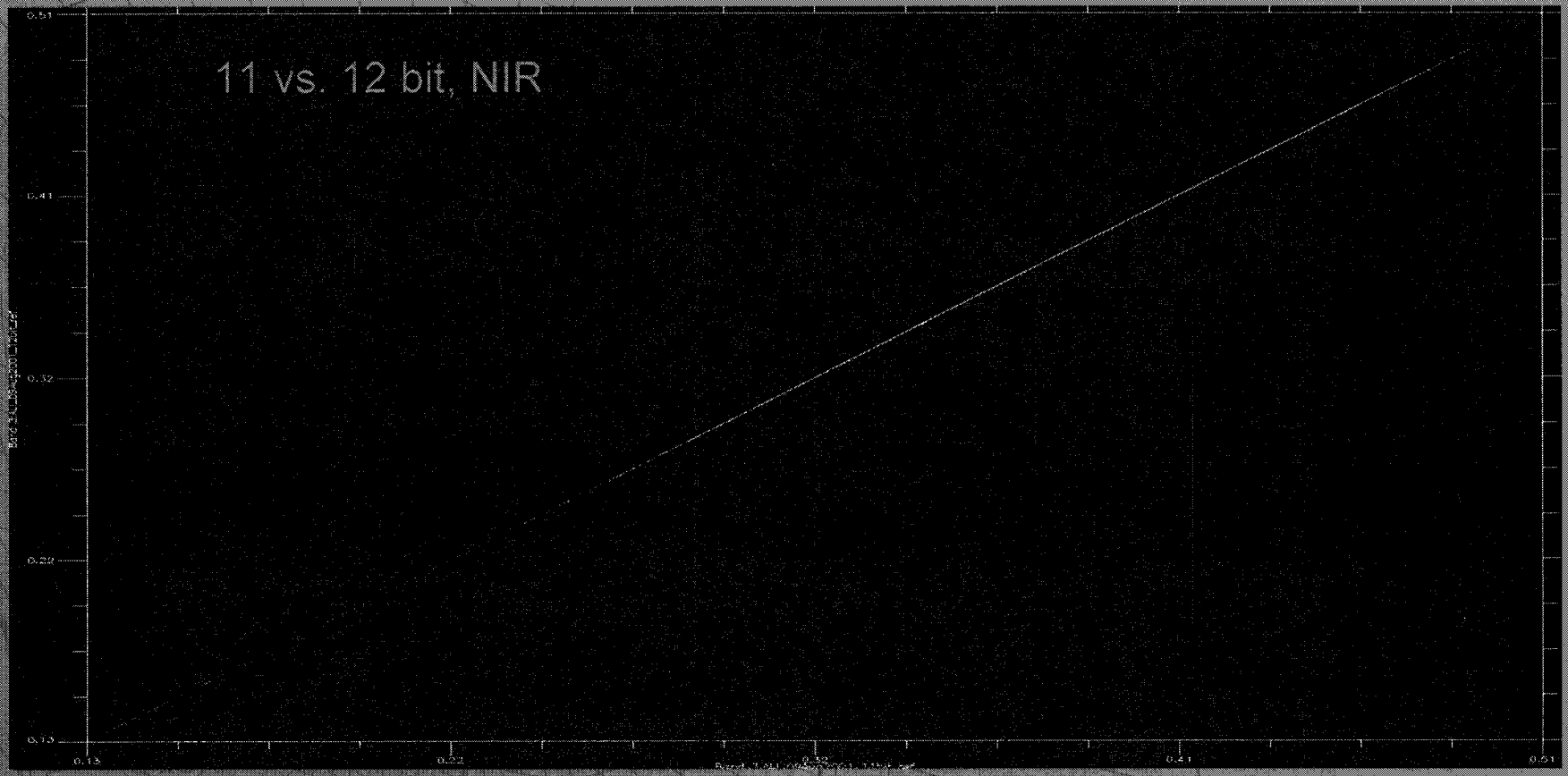


Image Differencing Results

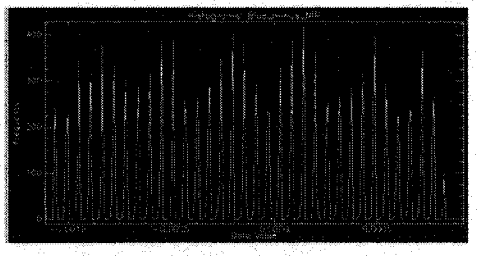
ALI

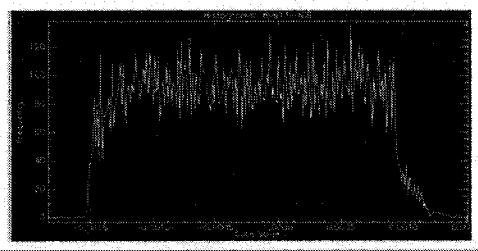
8 bit vs. 11 bit: Green- 0.20%, NIR- 0.33%
8 bit vs. 12 bit: Green- 0.21%, NIR- 0.35%
11 bit vs. 12 bit: Green- 0.09%, NIR- 0.08%

IKONOS

8 bit vs. 11 bit: b1- 0.22%, b4- 0.37%
8 bit vs. 17 bit: b1- 0.22%, b4- 0.39%
11 bit vs. 17 bit: b1- 0.02%, b4- 0.03%

Example





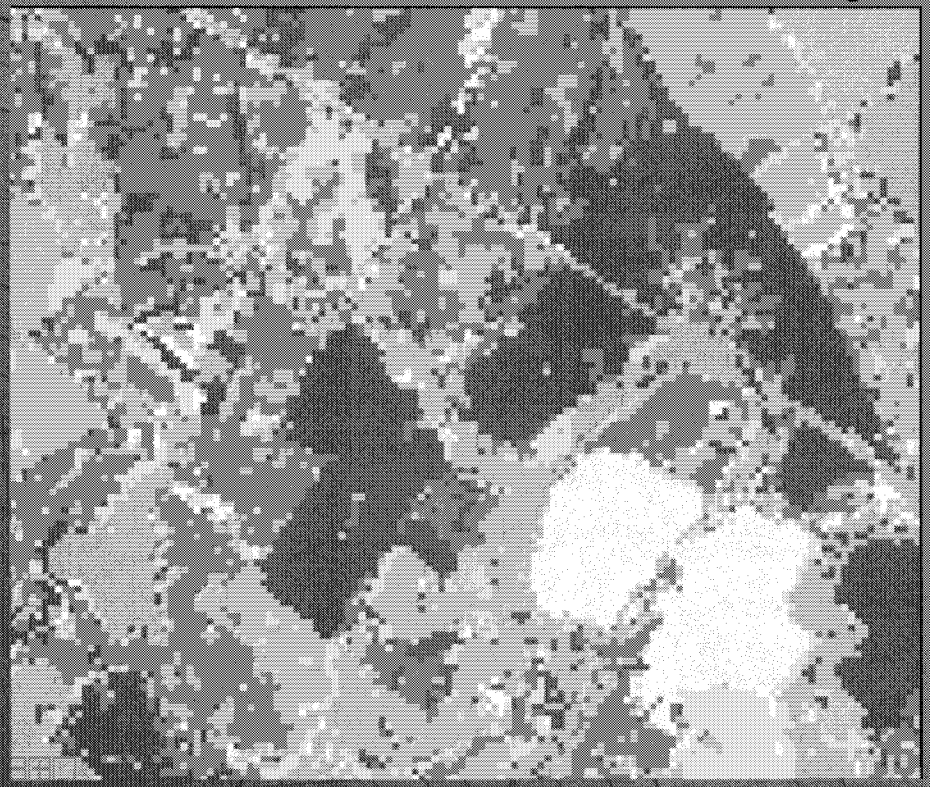
- Blue Band:
  - Min: -0.001114
  - Max: 0.000927
  - Diff: 0.002041
- NIR:
  - Min: -0.001832
  - Max: 0.001508
  - Diff: 0.00334

Conclusions from the image differencing:

a). Usually larger difference between NIR over Blue or Green band

b). The largest difference is always between 8 vs. 12 bit (ALI) and 8 vs. 17 (IKONOS), like expected. The difference is very marginal.

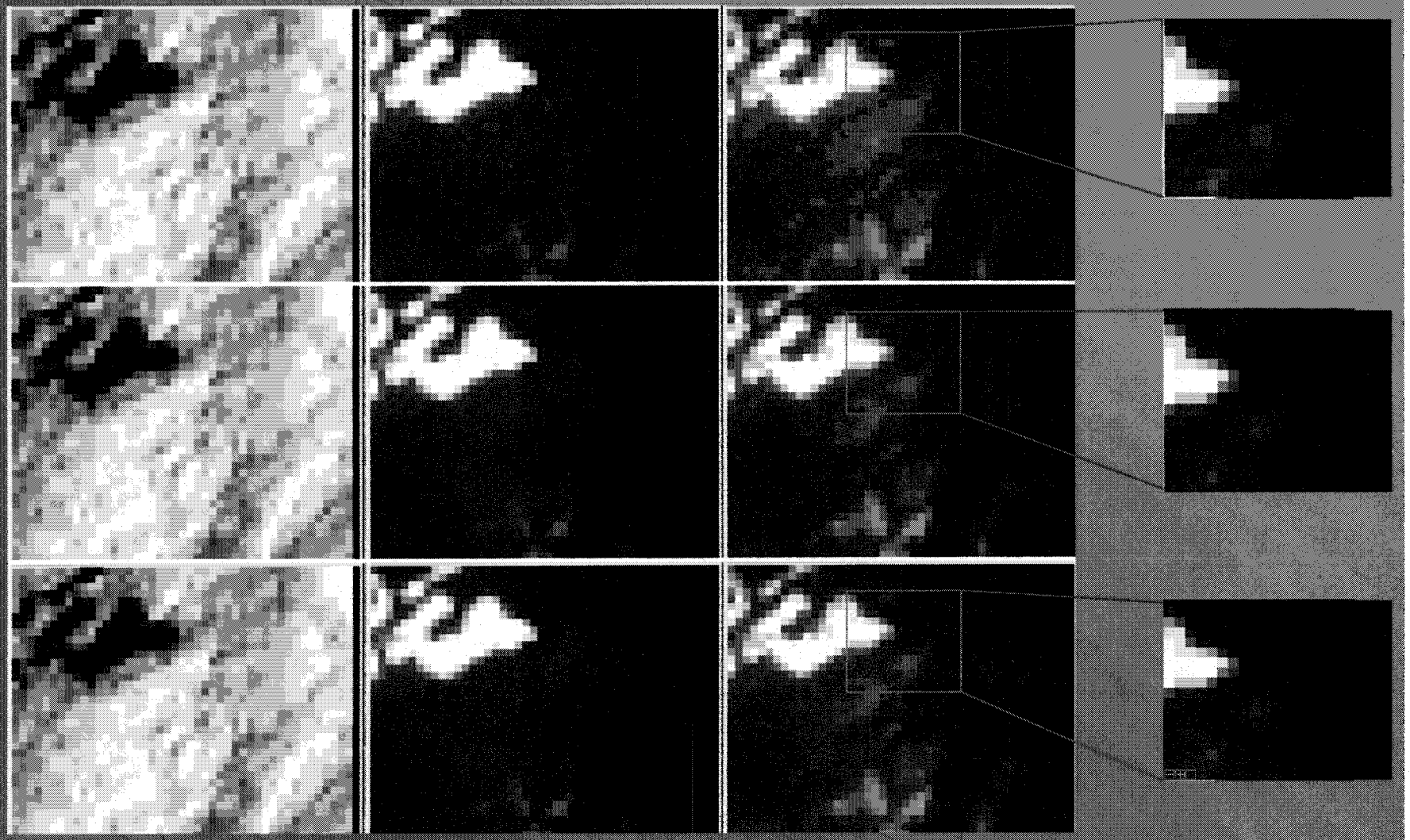
Disturbance Map



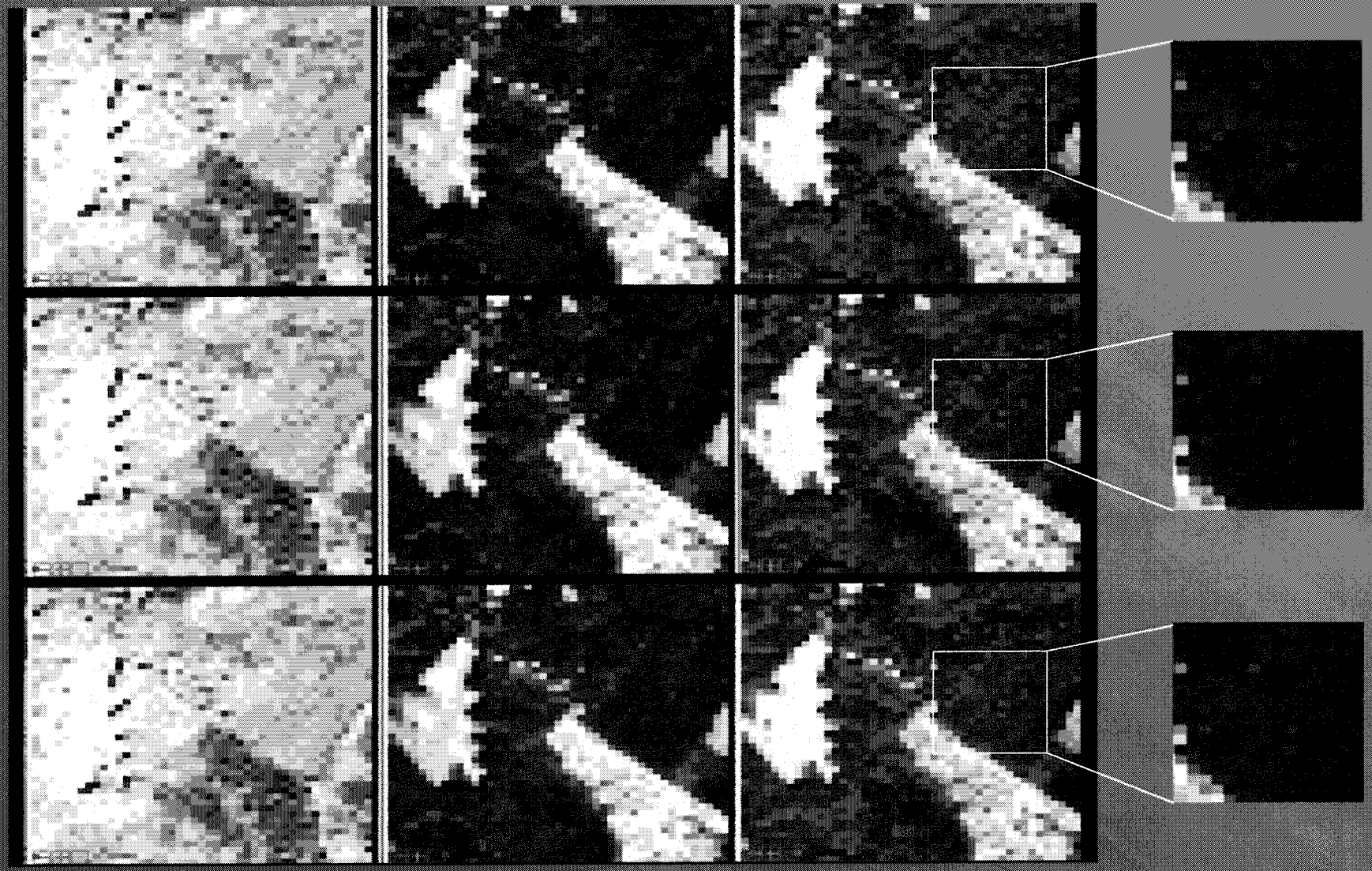
Year Disturbed

Non-Forest	1988	1993	1998
Forest	1989	1994	1999
1985	1990	1995	2000
1986	1991	1996	2001
1987	1992	1997	

ALI Disturbance Assessment

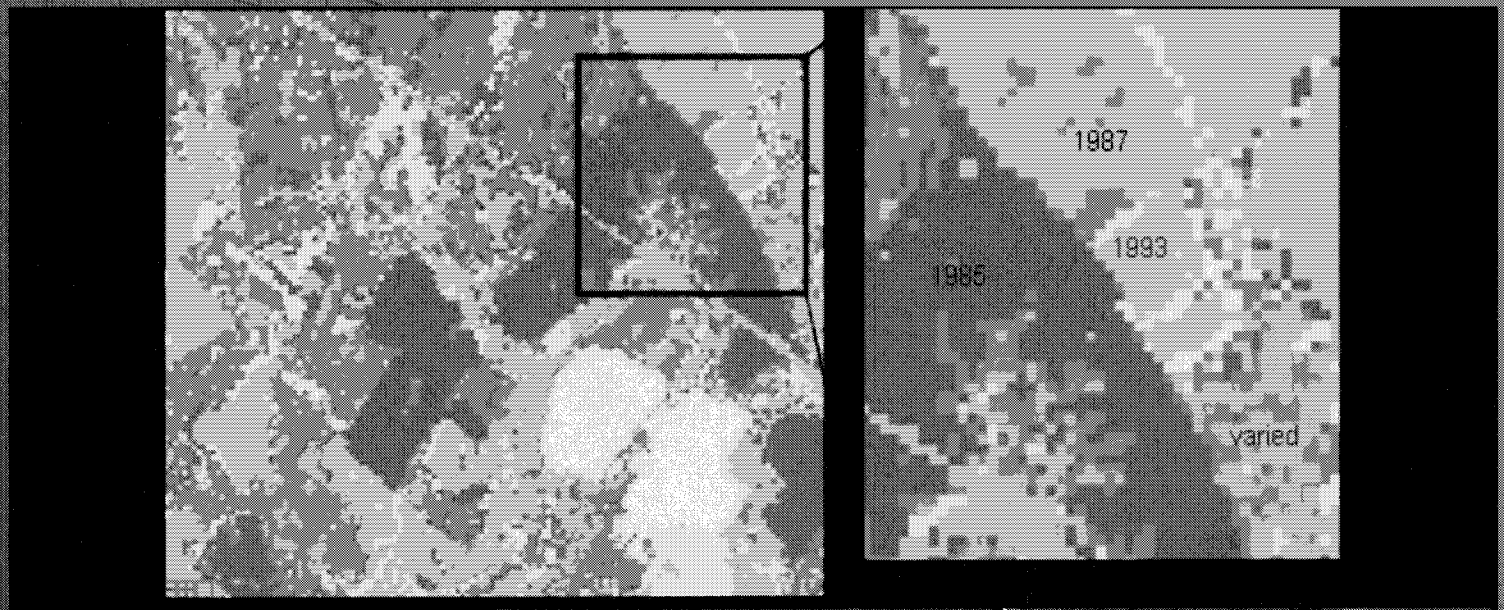


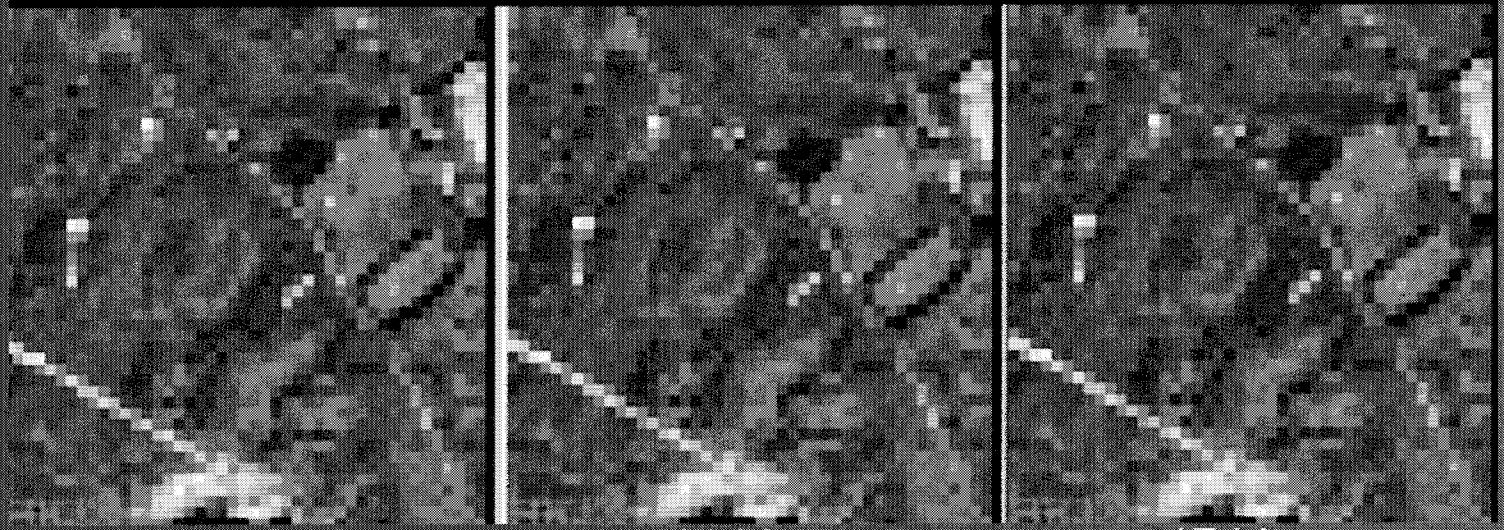
IKONOS Disturbance Assessment



IK Disturbance Assessment

Ex. 1
4,3,2

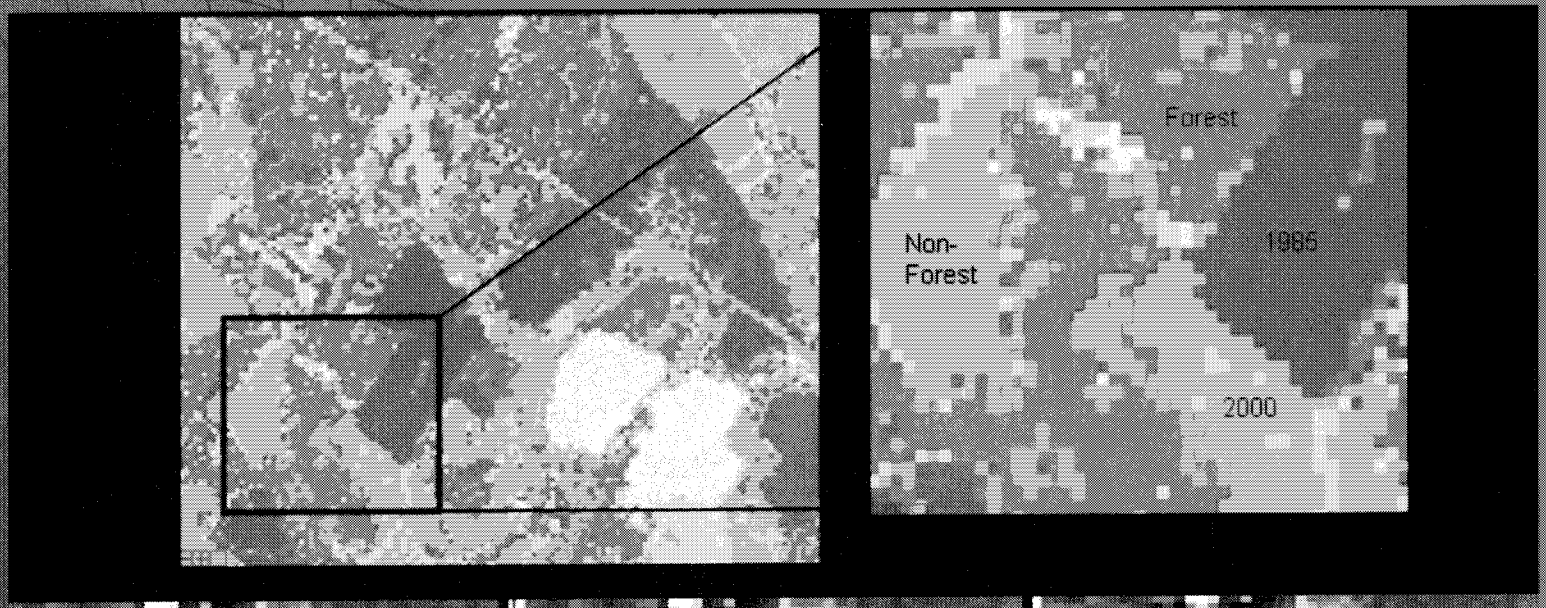


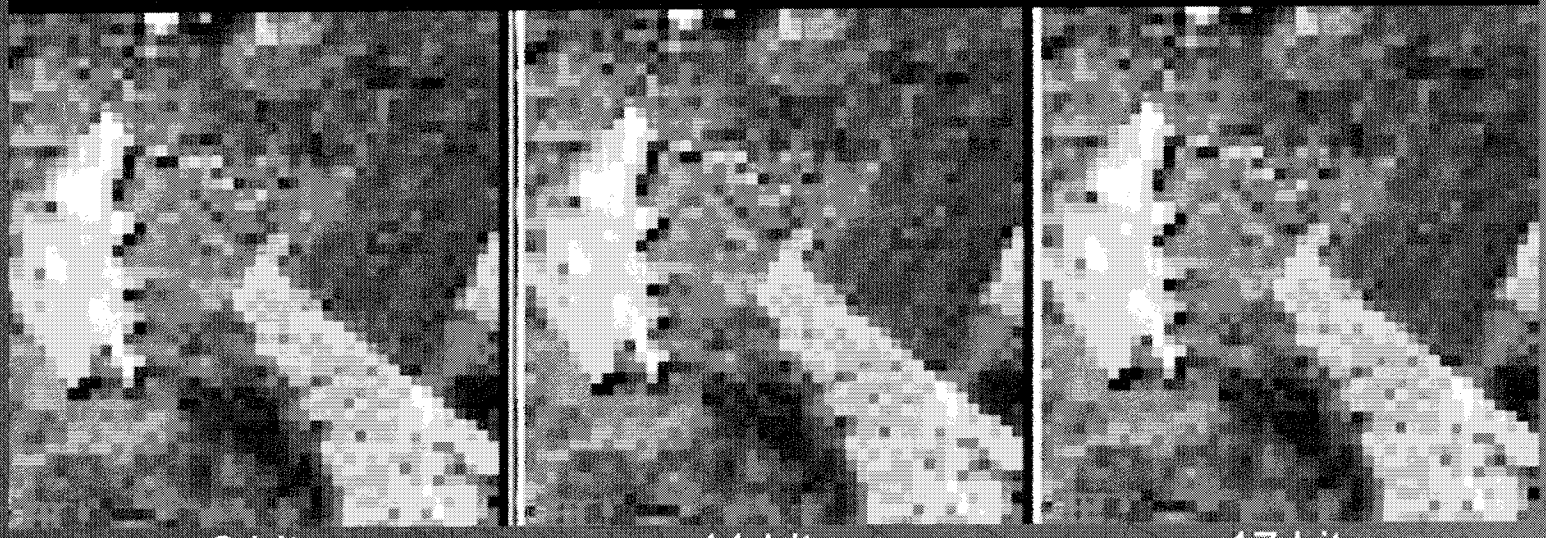


8 bit 11 bit 17 bit

IK Disturbance Assessment

Ex. 2
4,3,2





8 bit 11 bit 17 bit

Summary

- Results show that there is approximately a 0.2% increase (Bands 1 & 2) and 0.35% increase (NIR) in the amount of information content when using higher resolution (11, 12, or 17) over using 8 bit data.
- A difference of radiometric resolution can be seen between the green bands (particularly when comparing 8 bits to 11 bits), but when concerning only boundary discrimination or biomass, having bit depth greater than 8 bits shows no improvement.
- For the NIR band, the extra radiometry does not show any improvements for detecting forest variations or boundary discrimination.

Conclusions

- While it has been shown that there are differences in the varying radiometric resolution datasets, this study shows no clear evidence that increasing the quantization above 8 bits is beneficial for forestry monitoring.
- It is important to recognize that this study did not attempt statistical correlation with ground based data, although it is likely that variability within and between images will overwhelm the slight increases reamed from increasing the radiometric resolution.
- The results of this study are important for future satellite missions that could employ very high radiometric resolutions.