The Nebraska Airborne Remote Sensing Facility

CALMIT

CENTER FOR ADVANCED LAND MANAGEMENT INFORMATION TECHNOLOGIES

Why Airborne Remote Sensing?

- Configuration of multiple sensor types, as needed
- Facilitates research on spatial scaling
- Contributes to educational / classroom efforts
- Opportunities for aviation-related research (e.g., GPS, flight-mission execution)

Why Airborne Remote Sensing?

- Complement to CALMIT field program
- Complement to CALMIT satellite-based programs

Aircraft Purchase: February, 2001

Piper Saratoga

Project Partners

- Department of Electrical Engineering, UN-Lincoln
- CALMIT, UN-Lincoln
- Aviation Institute, UN-Omaha

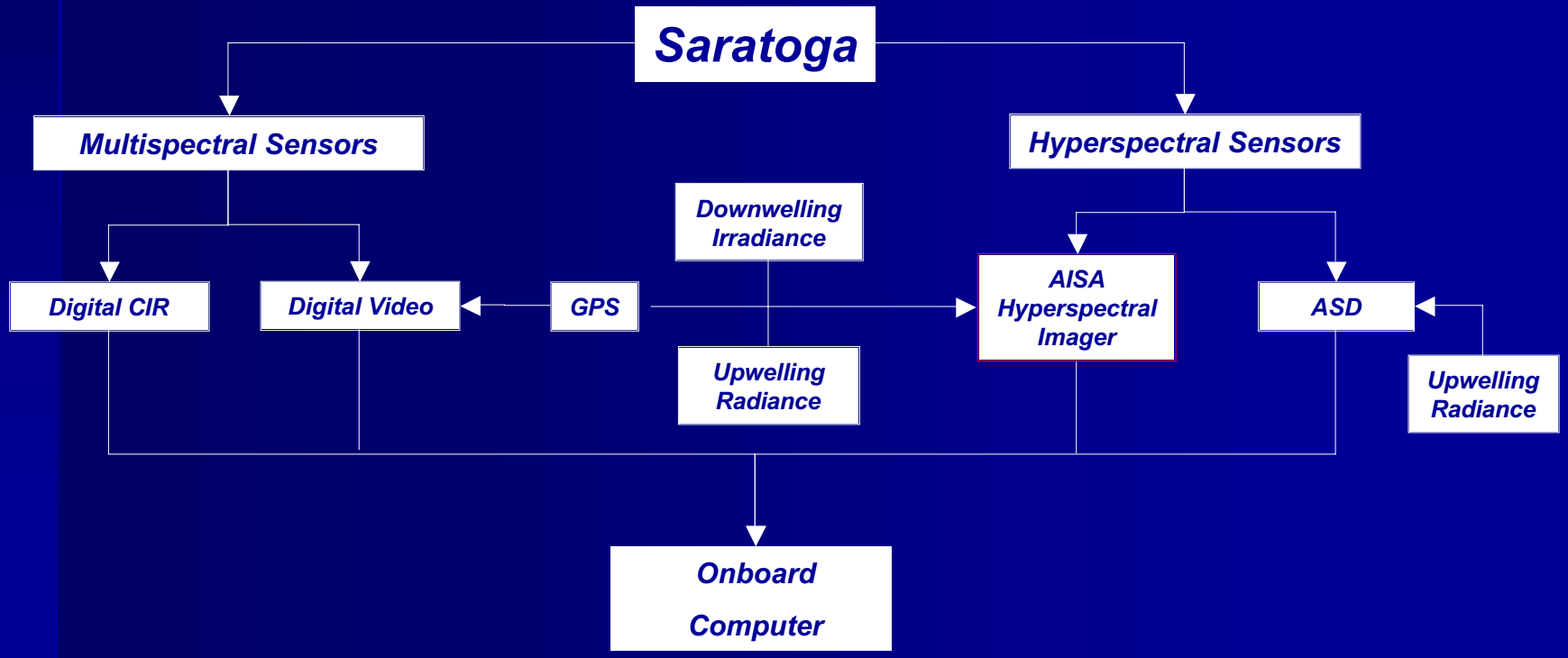
Saratoga Characteristics

- Cruising speed = 135 mph
- Maximum range = 800 miles
- Six passengers (two seats removed for remote sensing)

Modifications to Saratoga

CALMIT

Aerial Data Collection



Equipment Array

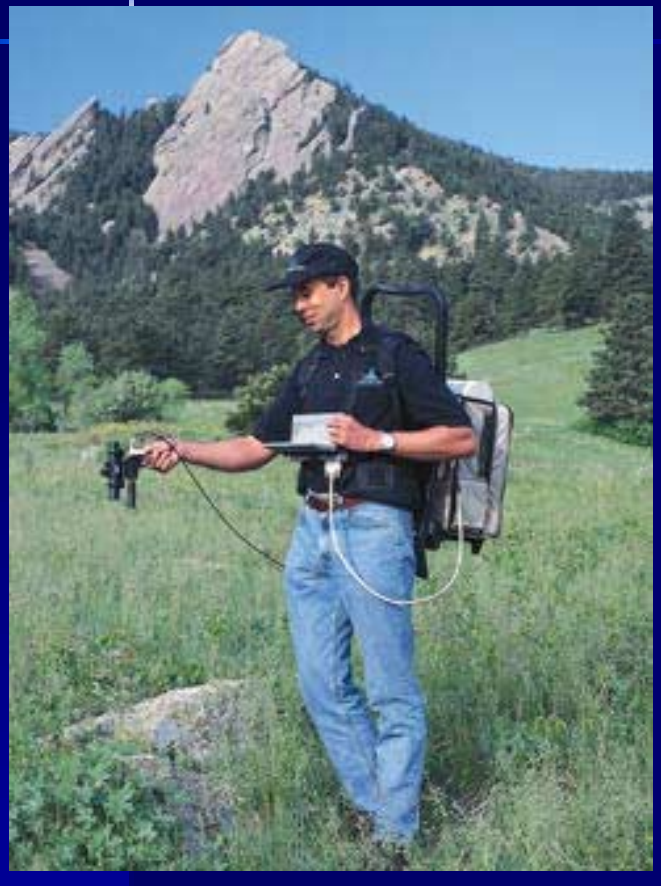
- AgGPS 170 field computer and light-bar GPS
- Sony video camera
- Nadir video for both pilot and technicians
- Red Hen system
- Analytical Spectral Devices (ASD-FR)
- Digital Kodak color-infrared camera
- Hyperspectral imager (AISA)

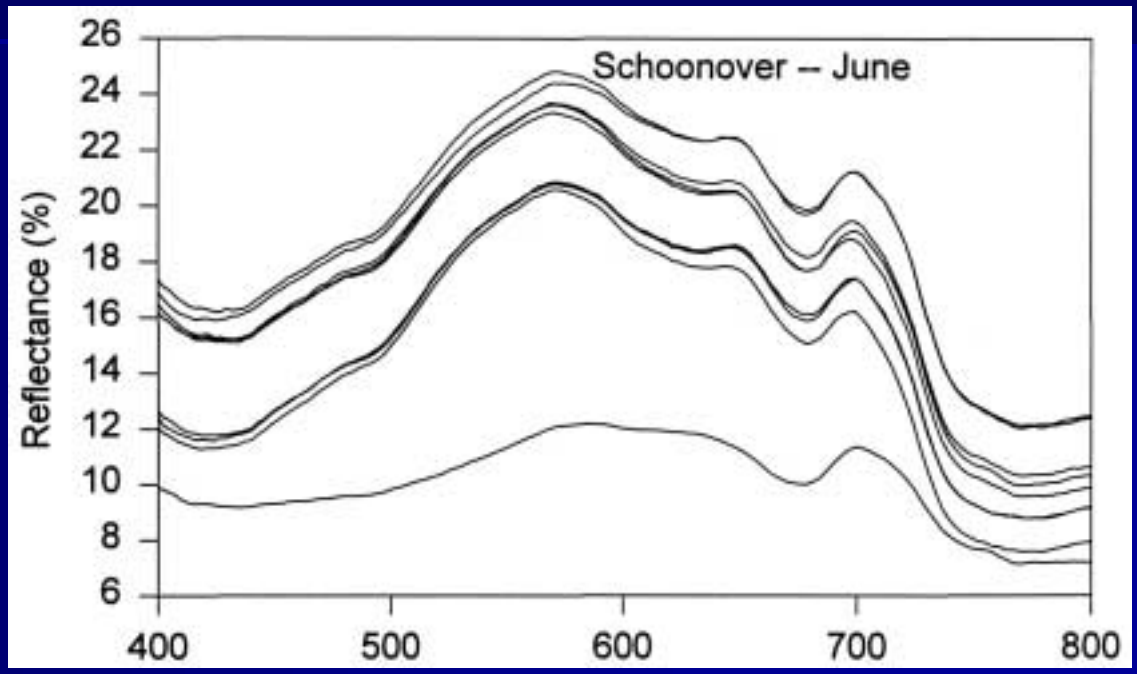
Equipment Configuration

Kodak Digital Camera: Fremont Lakes, Nebraska

Kodak Digital Camera:
CALMIT Field Facility at ARDC

ASD-FR with Boresighted Video and GPS





AISA Hyperspectral Imager

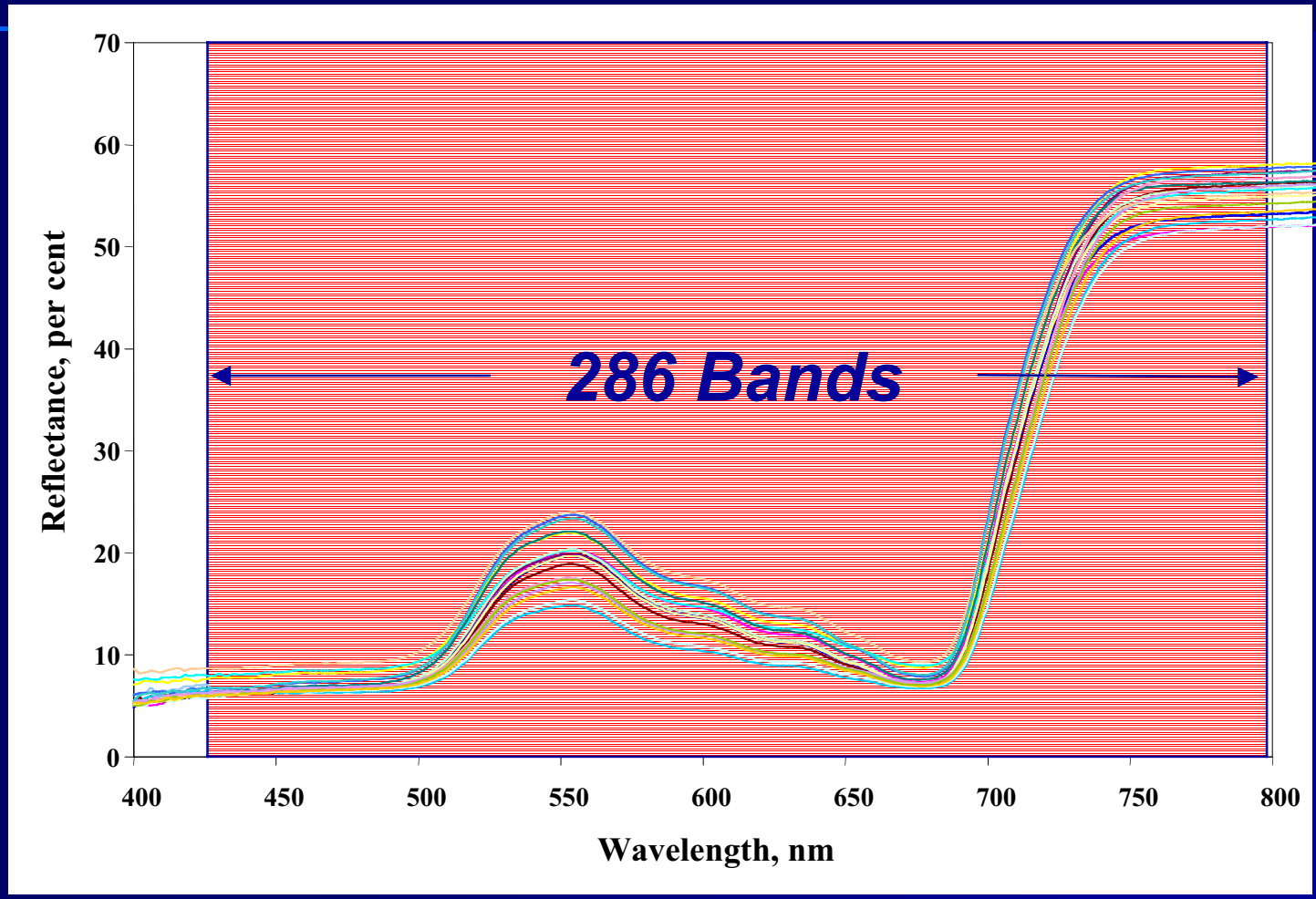
Selected AISA Specifications

- Pushbroom imaging spectrometer built by Specim Ltd., Oulu, Finland
- Spectral range: 430-900 nm
- FOV: 21 degrees (across track)

Selected AISA Specifications

- Programmable from 1-286 channels
- Spectral bandwidths:
  - 1.63 to 9.80 nm
- Pixels per swath: 360

VNIR AISA Bands (Hyperspectral)



Why AISA?

- Narrow spectral features (spectroscopy)
- Good radiometric accuracy and large dynamic range
- Spatial coverage (image)

AISA Features

- Easy configuration based on ASCII files
- Integrated DGPS/INS for image navigation
- Portable and designed to fit standard mounts

Upward-Looking Fiber Optic

To capture downwelling irradiance

AISA Hyperspectral Scanner

- 3 Operating modes:
  - Full spectral (A mode)
  - Full spatial (B mode)
  - Full spectral / Partial spatial (C mode)

A mode

- Full spectral
- All spectral information on the CCD is stored.
- The minimum integration time is 150 ms
- Usually used in laboratory experiments and on slowly moving platforms.

B Mode

- At full spatial configuration the number of spectral channels must be reduced
- User can choose:
  - integration time
  - number of spectral channels
  - wavelengths of the spectral channels
- This is the usual configuration

C Mode

- Full spectral / partial spatial
- All 286 channels at coarse spatial resolution
- The minimum integration time is 55 ms.

Spatial Considerations

- Resolution
- Field of View (FOV)
- Instantaneous Field of View (IFOV)
- Ground Sampling Distance (GSD)

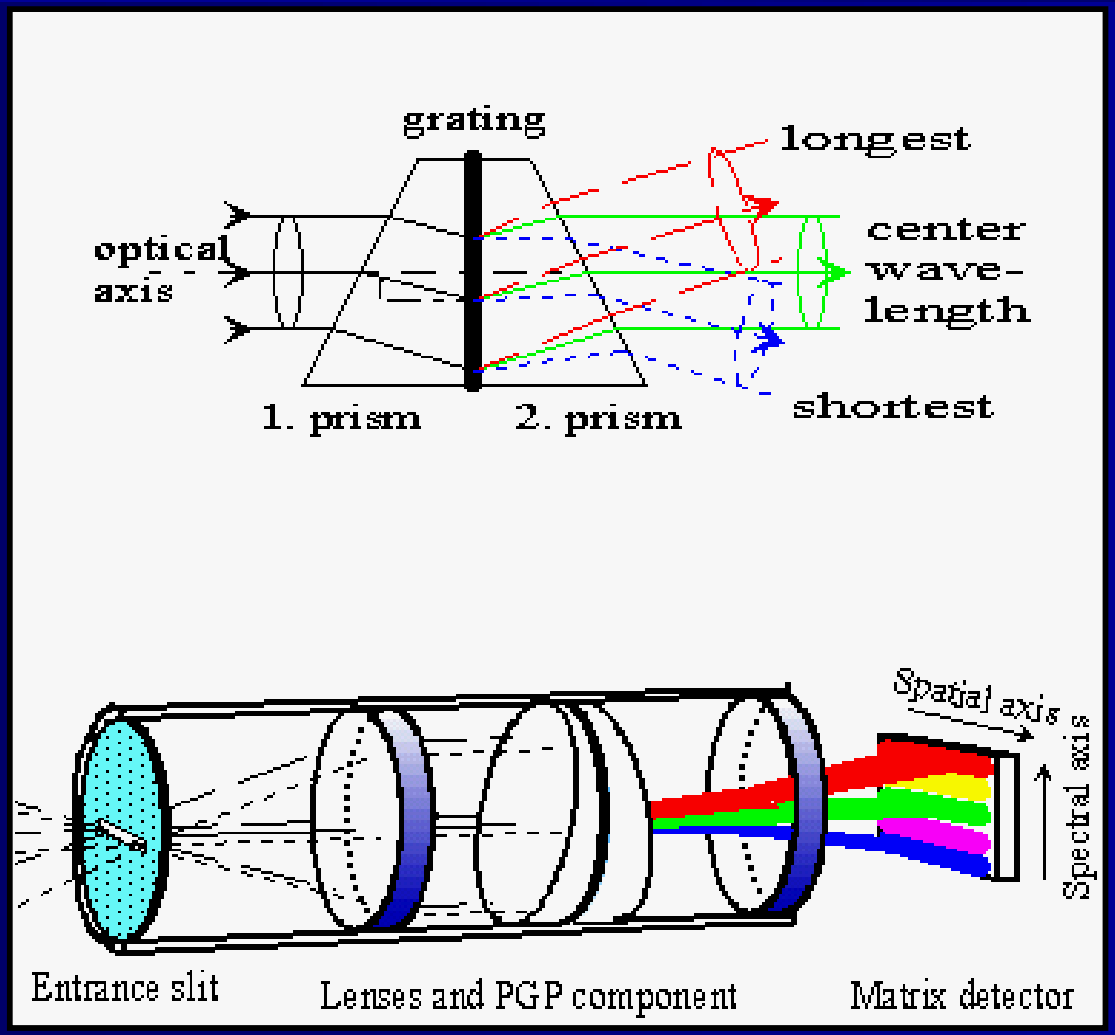
Spectral Considerations

- Resolution
- Range
- Bandwidth or Sampling Interval

Spatial Resolution	# Spectral Bands
1/1.5 meter	25
2/2.5 meter	35
3 meter	45
4 meter	70

Proposed configuration on a Saratoga with fixed flight speed of 120 knots.

AISA Optical Design



AISA Calibration

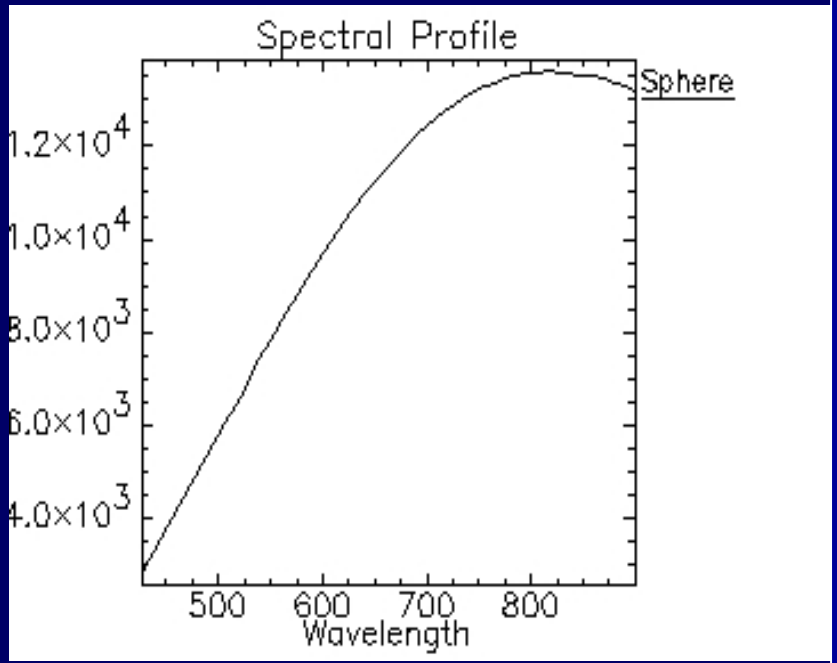
- Calibrated at the NASA – John C. Stennis Space Center, Mississippi (Winter, 2001)
- Checked at 3DI offices in Easton, MD (Summer, 2002)

Calibration Targets
CALMIT Field Facility at ARDC

Lab Calibration: Spectral

- Integrating sphere and monochromatic laser
- Cutoff filters
- Full Width at Half Maximum (FWHM)

Lab Calibration: Radiometric

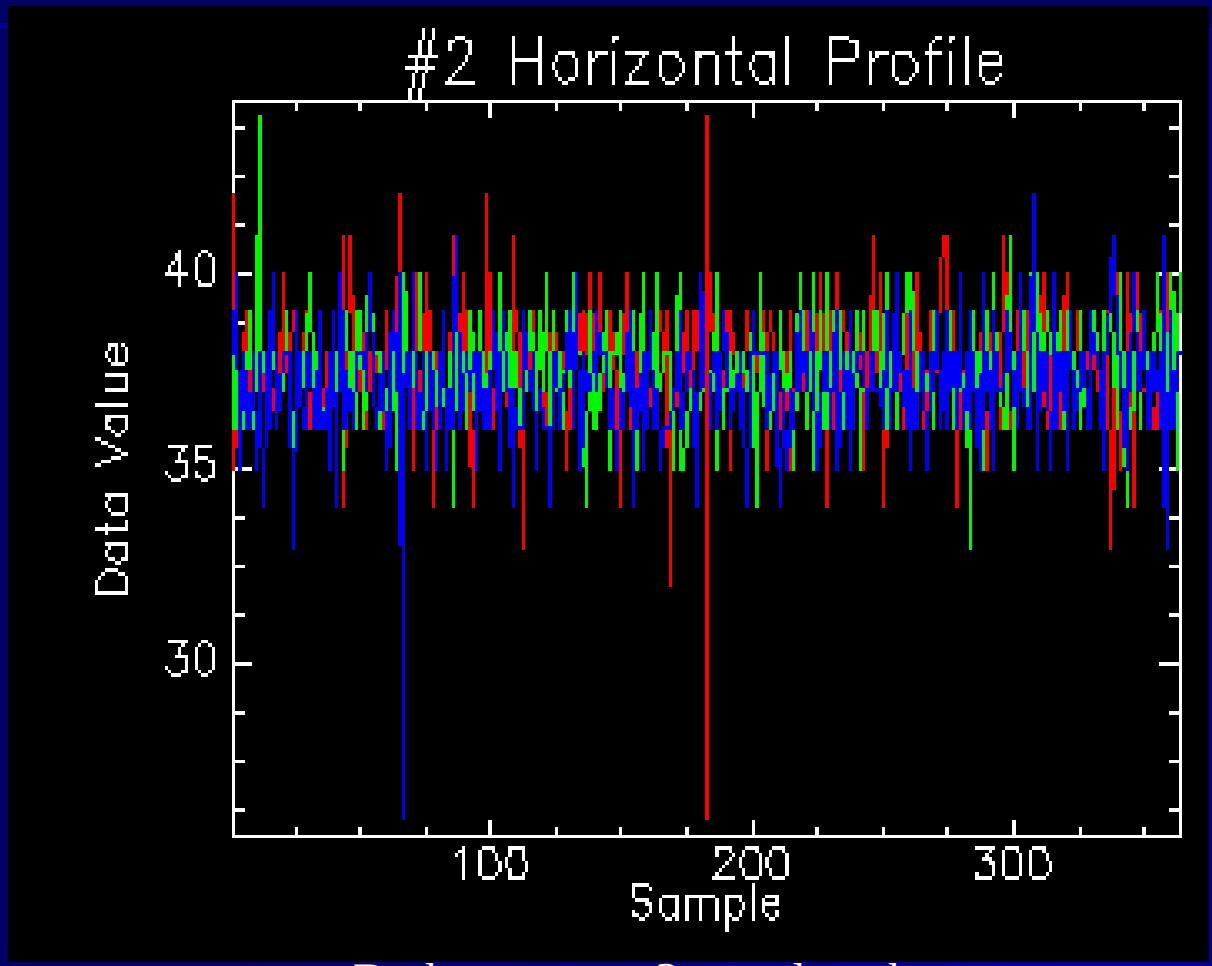


Regarding Calibration:

- Abundance of uncalibrated hyperspectral data
- Uncalibrated data are basically worthless and misleading

!CALIBRATION! !CALIBRATION! !CALIBRATION!

Dark Current / Signal



Dark current at 3 wavelengths,
across the field-of-view

Geolocation Accuracy

- Mapping
- Accuracy is application dependent
- Ground-control points / system geo-location

Geometric Corrections and Georeferencing

- Inertial Navigation System (INS) and Differential GPS (DGPS)
- Frame-by-frame georeferencing
- Pitch, roll, and yaw are encoded

Unrectified versus Rectified

Data Pre-processing

- **AISA pre-processing software (CaliGeo) provides:**
  - **Automatic geometric correction**
  - **Rectification**
  - **Mosaicing**
  - **Calculation of radiance or apparent at-platform reflectance (FODIS ratio)**
  - **Automated batch processing provides for rapid turnaround times for data delivery.**

Mission Planning

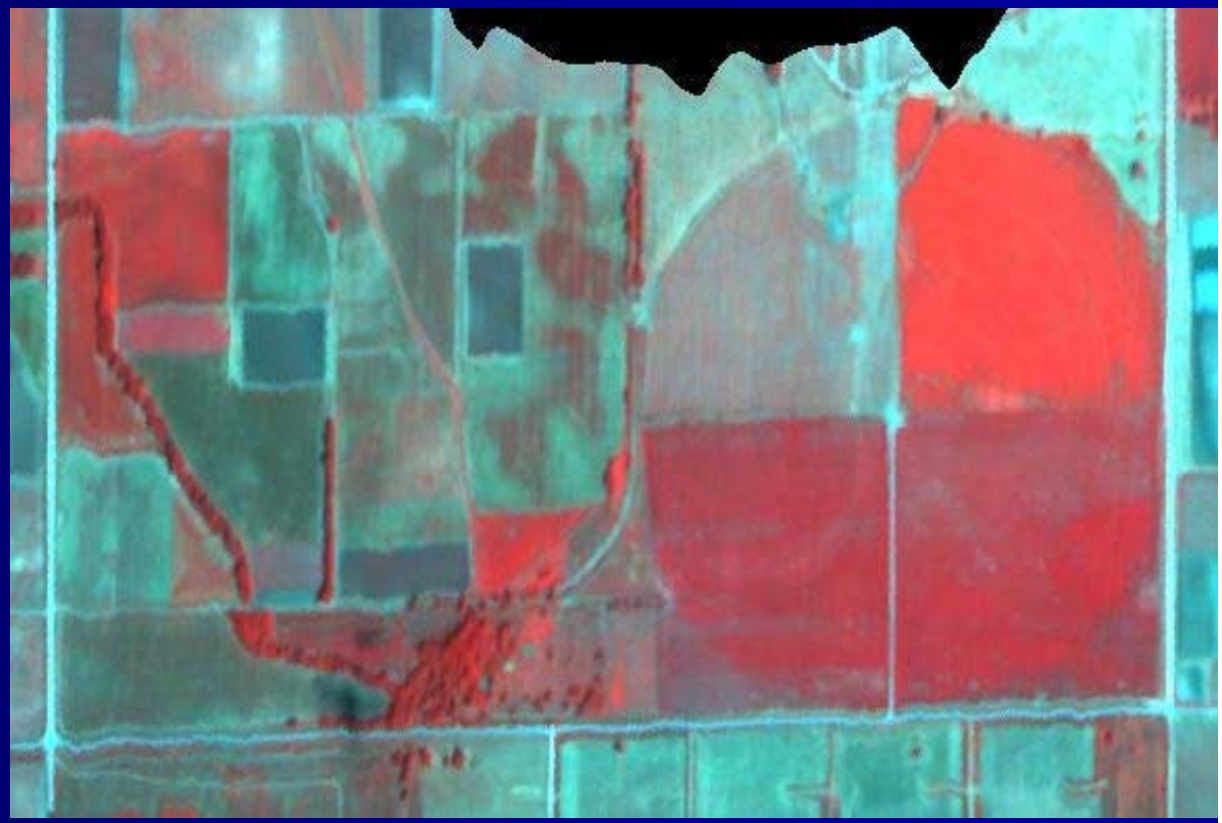
- Data are extremely sensitive to solar angle
- BRDF
- 2 hours +/- local solar zenith
- Time of year for extreme latitudes

Mission Planning Issues

- Cloud cover
- Shadows
- Flight turbulence

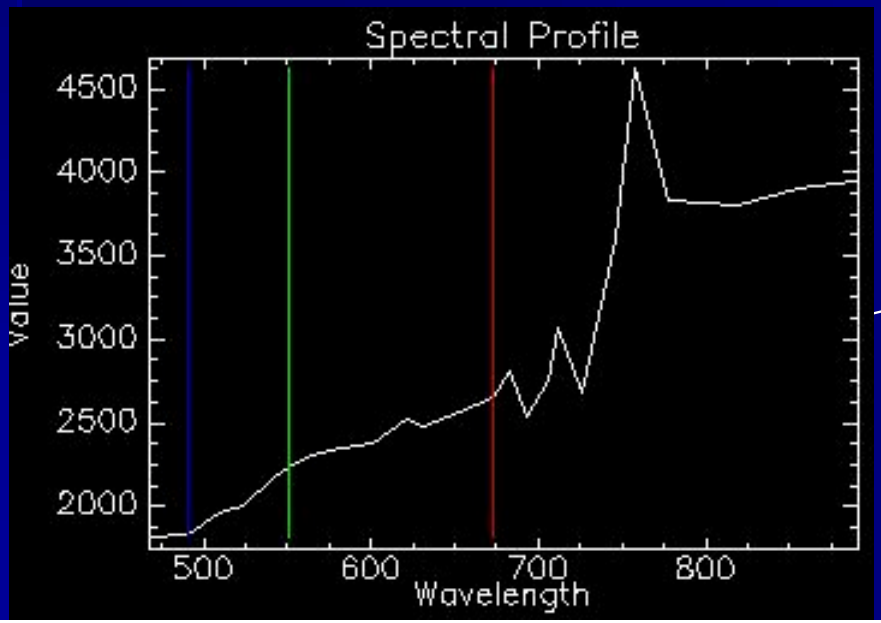
Agriculture: Mead, NE
June 21, 2002

- Color Infrared
  - Red: 819 nm
  - Green: 699 nm
  - Blue: 598 nm



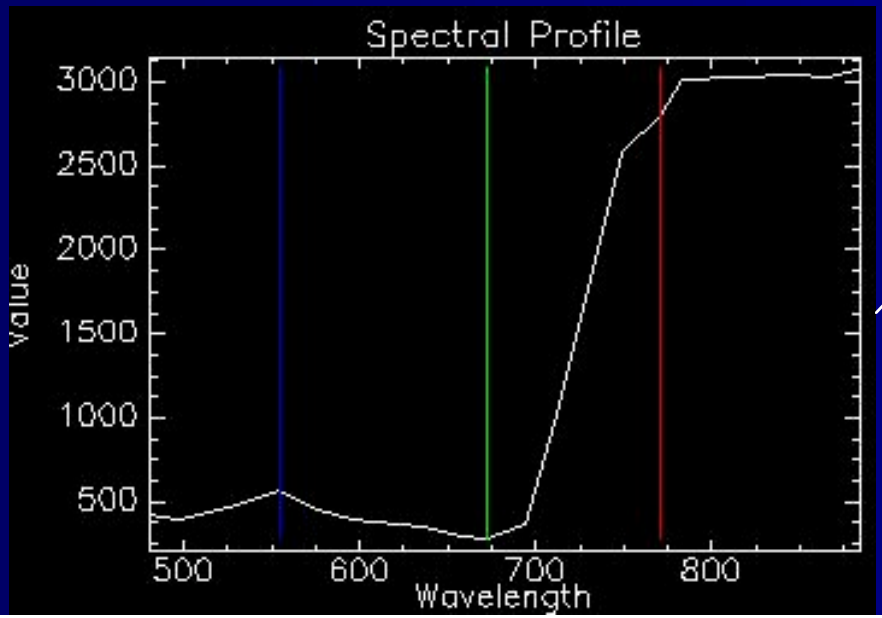
Agriculture: Ames, Iowa
August 9, 2002

- True Color-Bare Soil
  - Red: 673 nm
  - Green: 550 nm
  - Blue: 490 nm



Agriculture: Ames, Iowa
August 9, 2002

- Color Infrared-Vegetation
  - Red: 771 nm
  - Green: 673 nm
  - Blue: 550 nm

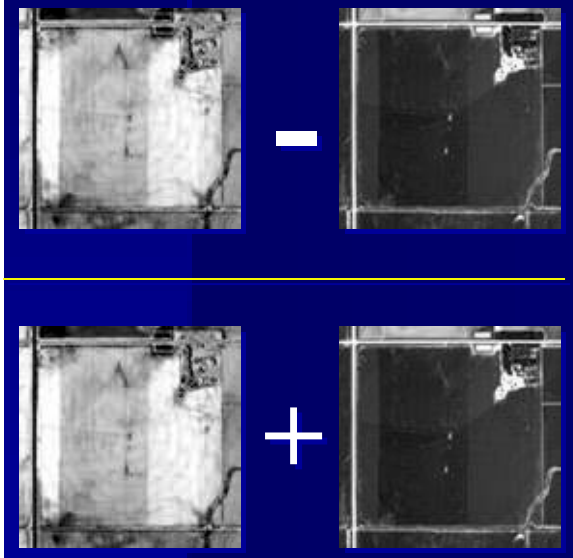


Sample Product: NDVI

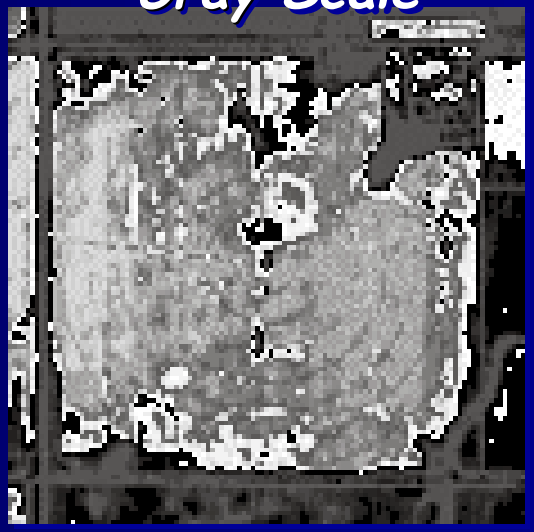
$$NDVI = \frac{(NIR-Red)}{(NIR+Red)}$$

$$NDVI = \frac{(777-673)}{(777+673)}$$

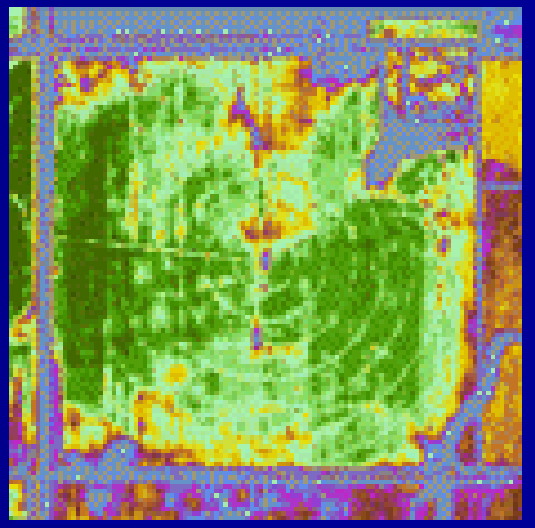
Sample Product: NDVI Image



NDVI Gray Scale



Colorized Vegetation Map



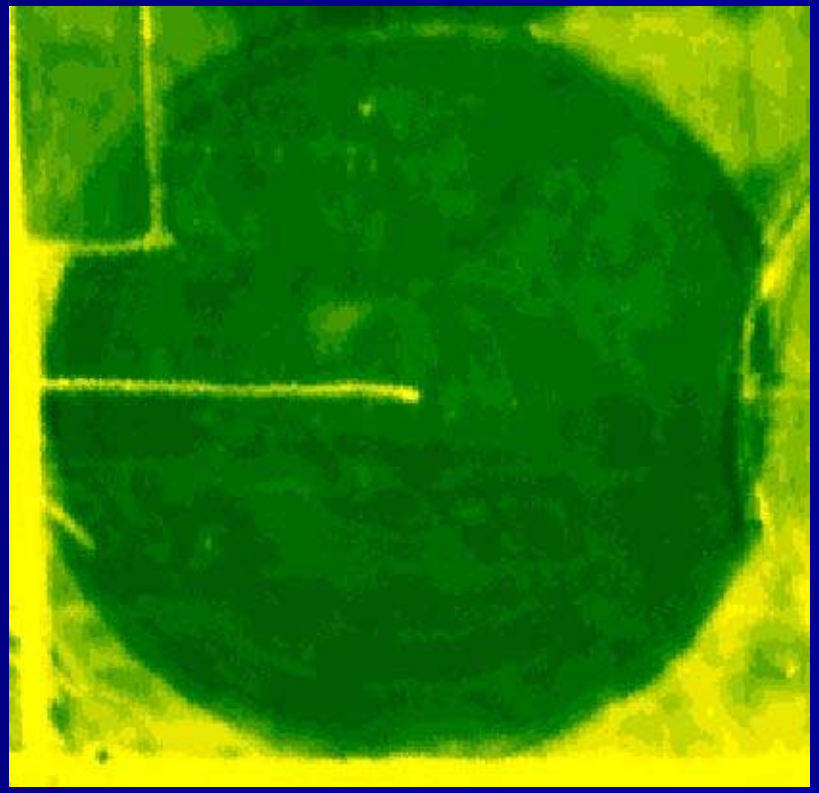
Vegetation Indices

NDVI

(NIR-Red)/(NIR+Red)

VARI

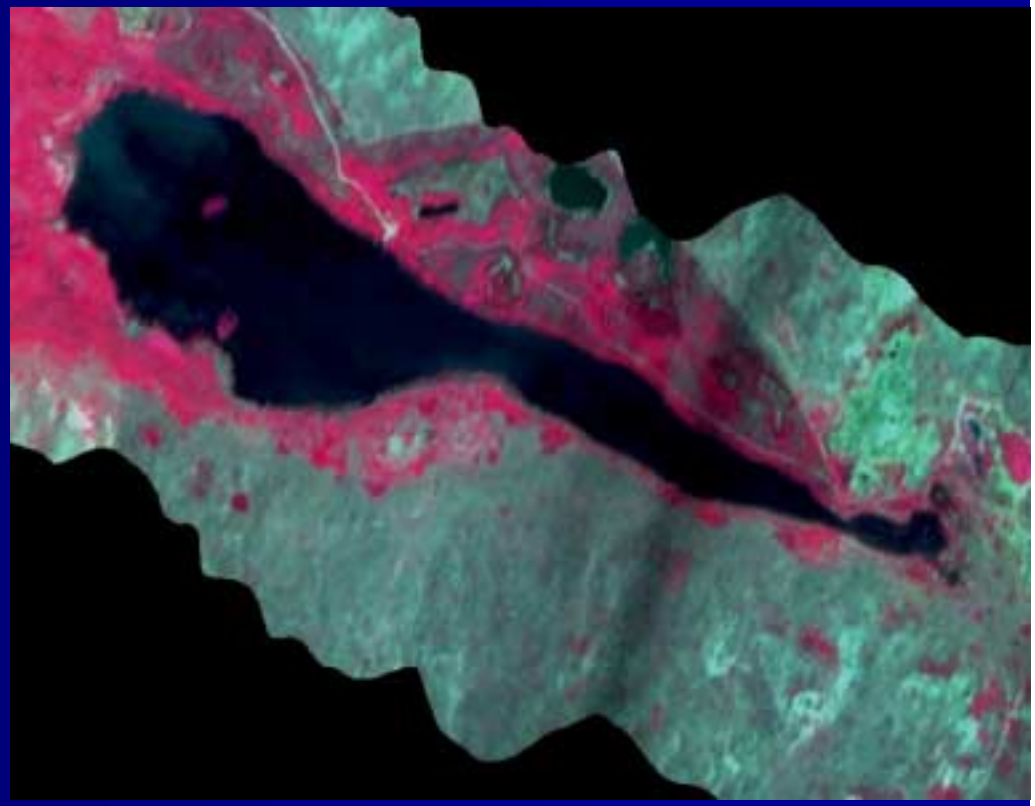
[(Green – Red)/(Green + Red– Blue)]



Long Lake, Nebraska Sandhills

June 2002

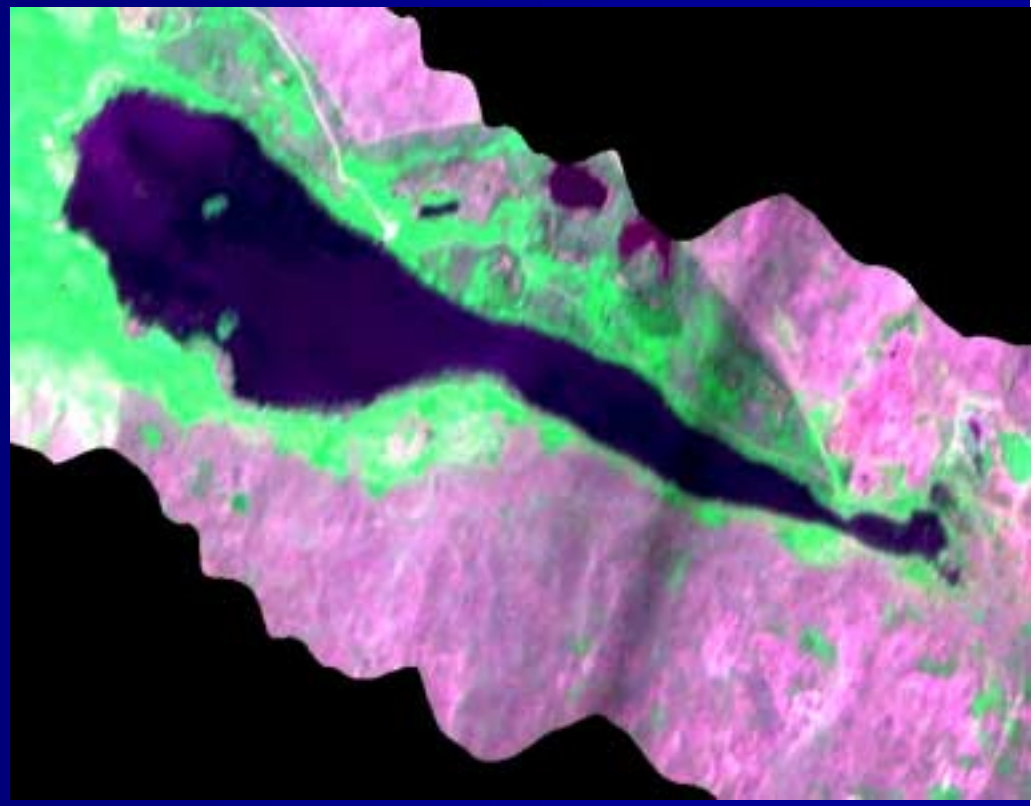
- Color Infrared
  - Red: 752 nm
  - Green: 648 nm
  - Blue: 550 nm



Long Lake, Nebraska Sandhills

June 2002

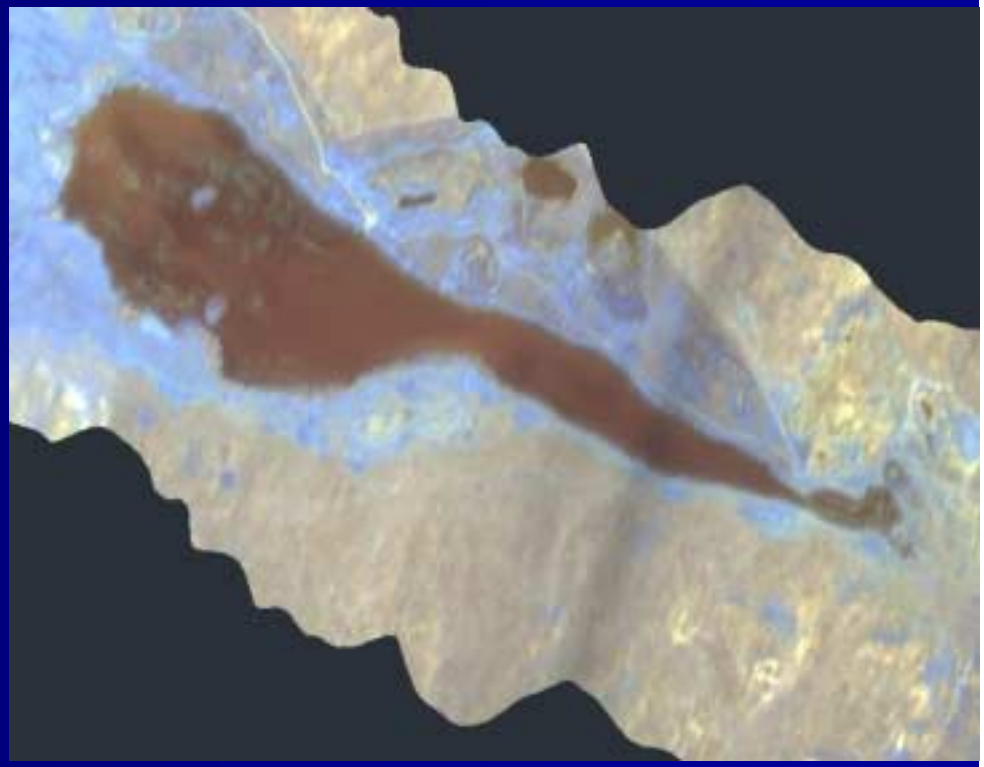
- RGB Composite
  - Red: 648 nm
  - Green: 848 nm
  - Blue: 522 nm



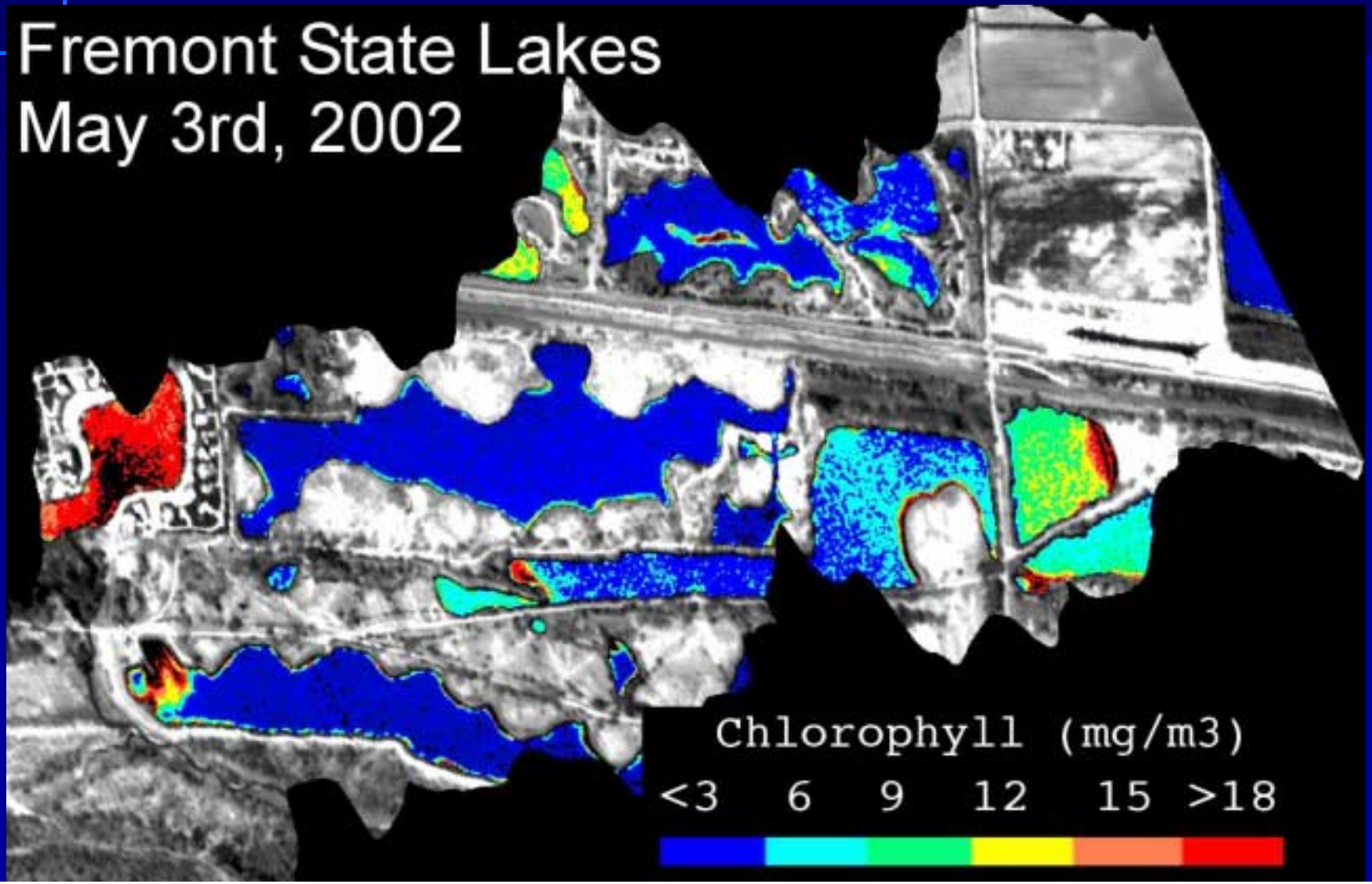
Long Lake, Nebraska Sandhills

June 2002

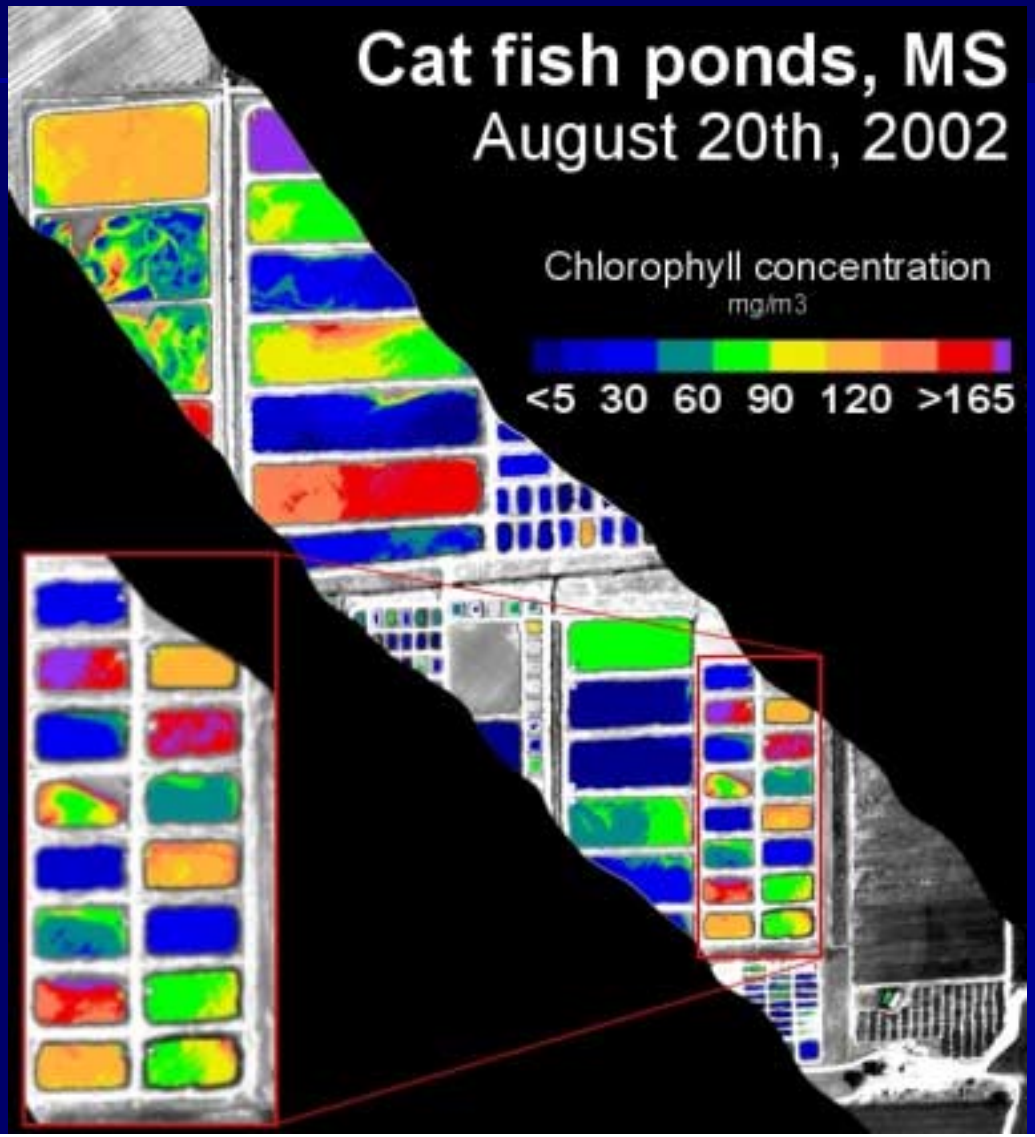
- RGB Composite
  - Red: 522 nm
  - Green: 711 nm
  - Blue: 807 nm



Water Quality: Fremont, NE

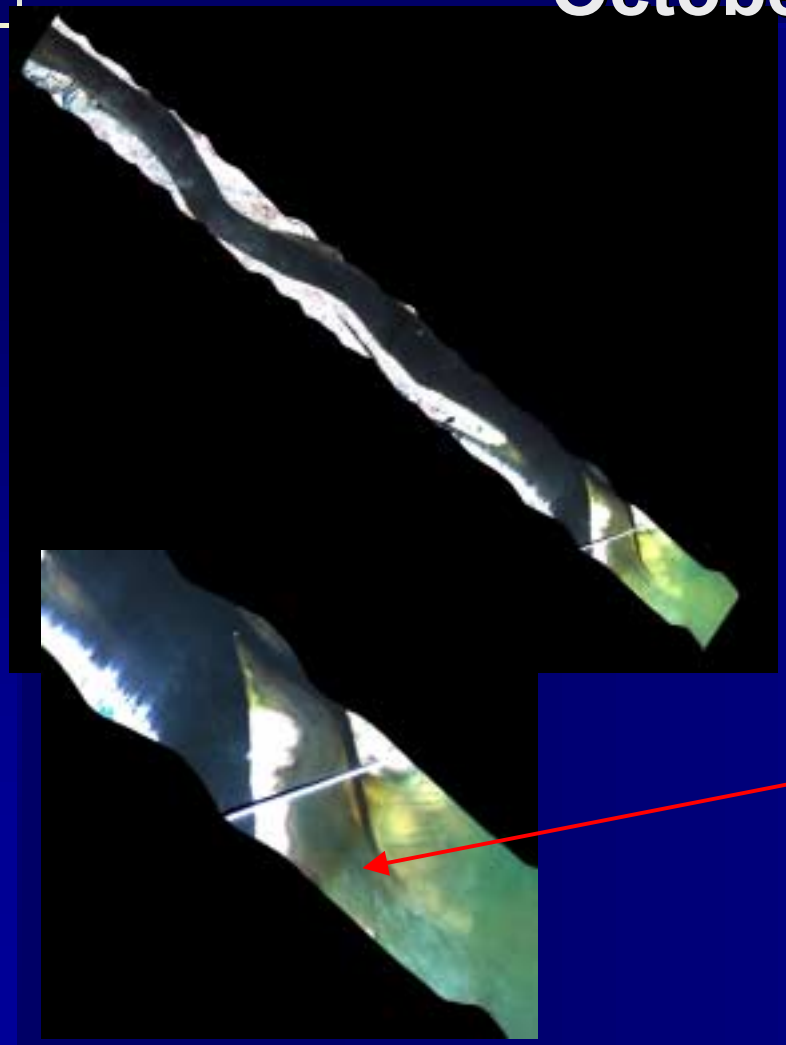


Water Quality: Greenville, MS

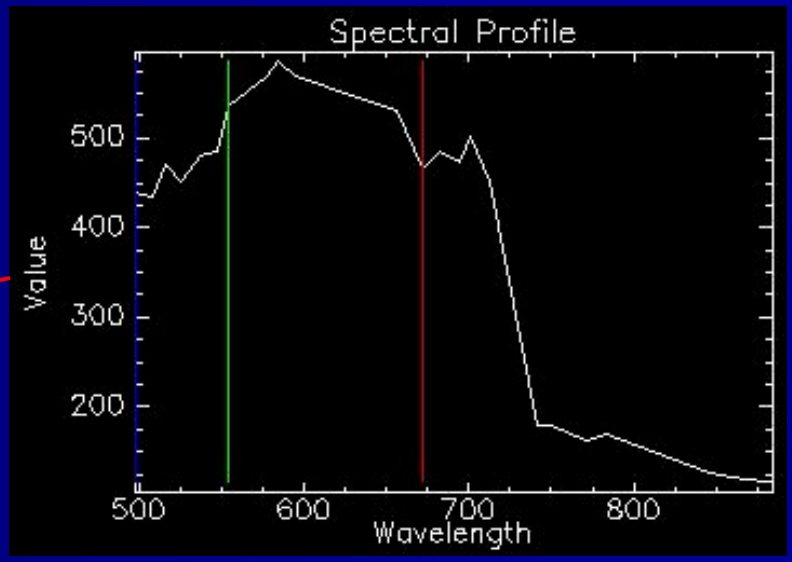


Water Quality: Apalachicola Bay, Florida

October 17, 2002



- RGB Composite
  - –Red: 672 nm
  - –Green: 584 nm
  - –Blue: 525 nm



AISA Missions: 2002 Agricultural

- Iowa
- Illinois
- Missouri
- Kansas - Konza prairie
- Mississippi
- Nebraska

AISA Missions: 2002 Water Quality

- Nebraska-Sandhills Lakes
- Nebraska-Fremont Lakes
- Florida- Apalachicola Bay

Future Sensors: Electrical Engineering

- Airborne Laser Polarimeter System (ALPS) operating at 532 and 1064 nm wavelengths

Future Sensors: Electrical Engineering

- UNL-developed noise radar scatterometer operating at 1.275 GHz (L-band) and 10 GHz (X-band) frequencies