Landsat and Sentinel-2 Data Synergy Potential for Agriculture

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NASA LCLUC-relevant Missions

**Systematic Missions** - Observation of Key Earth System Interactions

- **Landsat 7**
  - 4/15/99

- **Terra**
  - 12/18/99

- **Aqua**
  - 5/3/02

- **Suomi-NPP**
  - 10/28/11

- **Landsat 8**
  - 2/11/13

- **ESA Sentinel-2a**
  - end of 2014

- **ESA Sentinel-2b**
  - end of 2015

**Exploratory Missions** - Exploration of Specific Earth System Processes and Parameters and Demonstration of Technologies

- **SRTM**
  - 2/11/00

- **EO-1**
  - 11/21/00
History of the Landsat Program

Landsat 1: 1972–1978
Landsat 2: 1975–1982
Landsat 3: 1978–1983
Landsat 4: 1982–1993
Landsat 5: 1984–
Landsat 6
Landsat 7: 1999–
Landsat 8
Feb 2013

Gov’t Operations Commercial Operations Gov’t Operations
Landsat

- Infrequent observations
  - One-Landsat system: 16 day revisit time
  - Two-Landsat system: 8 days
  - Tests with 2-, 4-, 6-yr intervals for forest monitoring – optimal time depends on applications

- Cost
  - Until 2010 expensive, free now!
  - Preferable (and now possible) continuous monitoring

- Cloud occurrence
  - 16-day repeat cycle in the areas with frequent cloud may not provide enough time series for monitoring seasonal changes in vegetation
  - Need daily observations like from coarse-resolution sensors
More frequent imaging is needed to maximize opportunity for cloud free observations particularly for rapidly changing phenomena: Fire, Flooding, Agriculture
Advanced Use of Optical Mid-Resolution Data

- Fusing coarse- and mid-res data
- Using ALL cloud-free pixels in the imagery
- Fusing data from different mid-res sensors
Fusing Moderate and Coarse Resolutions

Landsat images over an area in Iraq 6 years apart (like in GLS)

MODIS time series of Green Index for an abandoned irrigated area

Iraq

Sep 2000

Sep 2006
AVHRR/ MODIS
• spatial resolution 15m, 30m, 90m
• 2048 km swath
• global coverage, 2 days

Landsat
• spatial resolution 15m, 30m
• 183 km
• 16 day orbital repeat
• seasonal global coverage

ASTER
• spatial resolution 15m, 30m, 90m
• 60 km
• 45-60 day orbital repeat
• global coverage, years

Commercial Systems
• spatial resolution ~ 1m
• ~ 10 km
• global coverage, decades, if ever

MISR
• spatial resolution 275m, 550m, 1100m
• 360 km
• global coverage, 9 days

VIIRS
• spatial resolution, 400/800m (nadir (Vis/IR))
• global coverage, 2x/day/satellite
• 3300 km swath

Synergistic Use of Optical Remote Sensing
Using ALL Cloud-Free Pixels in the Imagery

Web-enabled Landsat data (WELD) Project

The WELD project is systematically generating 30 m composited Landsat ETM+ mosaics at weekly, monthly, seasonal and annual time periods for the conterminous USA (CONUS) and Alaska. The composited mosaics are designed to provide consistent Landsat data that can be used to derive land cover and geo physical and bio physical products for regional assessment of surface dynamics and to study Earth system functioning.

Version 1.3 of the WELD monthly, seasonal and annual products generated from Landsat ETM+ terrain corrected (Level 1T) data with cloud cover <80% sensed December 2007 to November 2008 are available here.

WELD Browse Imagery

The thumbnail images below illustrate the currently available Version 1.3 WELD data products, please click on them to see a higher resolution version. These true color browse images show the Landsat ETM+ red, green and blue wavelength bands at approximately 500 m resolution.

CONUS Annual

Winter

December 2007

January 2008

February 2008

Spring

March 2008

April 2008

May 2008

Summer

June 2008

July 2008

August 2008

Autumn

September 2008

October 2008

November 2008
Web-Enabled Landsat Data (WELD). Year: 2009

Alaska ~ 1,700 L1T acquisitions / year
CONUS ~ 8,000 L1T acquisitions / year

New tools and methods to process large data volumes from Landsat

1.8km TOA true color browse, each pixel generated from 60 x 60 30m Landsat ETM+ pixels

Global WELD (NEX)
Agricultural monitoring has emerged as a key priority for GEO
• Global provisioning of food and water among most critical environmental issues in 21st century
• Maize (2008) and wheat (2010) supply constrictions caused global price spikes and food insecurity
• G20 Ag ministers requested creation of GEO-GLAM (Global Agricultural Monitoring initiative); ratified by CEOS (2011).

Crop assessments (type, condition) require ~weekly data @ <50m resolution

Currently no single remote sensing system satisfies this requirement
• MODIS & MERIS can provide weekly phenology but at regional scales
• Landsat can resolve individual fields, but only seasonally
Fusing Data From Landsat-like Sensors: Land-cover phenology at 30 m

- Red reflectance, near-infrared (NIR) reflectance, and NDVI values for individual fields from central Illinois during the first half of the 2006 growing season

- Data are combined from Landsat-5, -7, ASTER, and IRS
The goal is to provide enhanced continuity to Spot- and Landsat-like data

Optical payload with visible, near infrared and shortwave infrared sensors

13 spectral bands: 4 bands at 10 m, 6 bands at 20 m and 3 bands at 60 m spatial resolution

Altitude of ~ 800 km

Swath width of 290 km

For a planned pair of S-2 the revisit time will be 5 days at the equator (under cloud-free conditions)

More frequent (~3 days) at mid-latitudes

The first satellite is planned to launch in late 2014
Merging Sentinel-2 and Landsat data streams could provide < 5-day coverage required for Ag monitoring
• Both sensors have 10-30m coverage in VNIR-SWIR
• Satellite orbits complementary
  • Landsat-7 & -8 8 days out of phase
  • Sentinel-2a & 2b 5 days out of phase
  • Landsat and Sentinel sun synch orbits precess relative to each other
The picture shows the number of times the sensors for the Sentinel 2s, L-7, and LDCM (L-8) accessed areas on the ground over an 80 day period of time.

- 26 accesses indicates a maximum revisit interval of ~3 days 2 hours
- 56 accesses indicates a minimum revisit interval of ~1 day 10 hours

The large number of blue colored bands (>50 accesses) indicate that the revisit interval over the majority of the region is on the order of 1.5 days.
Thank you!