GDA Corp.

Geospatial Data Analysis Corporation

"Monitoring The World, For A Better Tomorrow"

DMC Imagery: User Perspective

JACIE 2010

March 16-18, 2010

Content

- Intro
- Overview of DMC data
- Strengths and Constraints
- Recommendations
  - Surface Reflectance Calibration
  - Applications with DMC data

DMC Sample Dataset

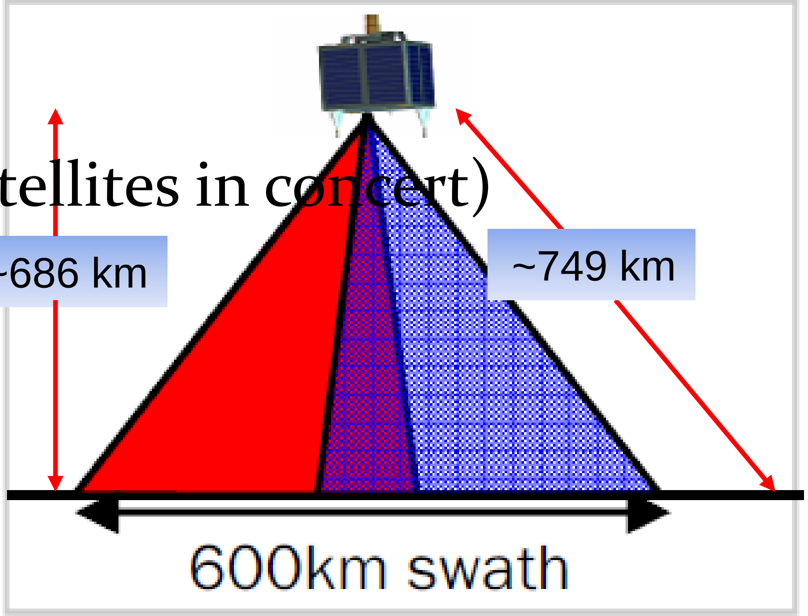
GDA Corp.

Mission	Location / Source	Acquisition Date	Acquisition Time	GSD (m)	Sun Elevation
NIGERIASAT	BE/NL	5/10/2009	8:02:18	32	36.4
NIGERIASAT	BE/NL	7/2/2009	8:08:32	32	39.5
NIGERIASAT	BE/NL	7/15/2009	8:00:43	32	37.9
NIGERIASAT	Bulgaria / Romania	5/8/2009	6:45:13	32	40.8
NIGERIASAT	Bulgaria / Romania	5/24/2009	6:50:43	32	43.3
NIGERIASAT	Bulgaria / Romania	6/20/2009	7:12:34	32	44.9
NIGERIASAT	Bulgaria / Romania	8/27/2009	6:46:55	32	33.4
UK-DMC	BE/NL	4/2/2009	8:10:32	32	25.7
UK-DMC	BE/NL	6/2/2009	8:19:43	32	41.1
UK-DMC	BE/NL	6/23/2009	8:14:59	32	40.9
UK-DMC	Sudan	11/14/2009	7:14:37	32	38.1
UK-DMC	Sudan	11/19/2009	7:04:26	32	35.8
UK DMC2	Sudan	12/18/2009	8:44:39	22	48.7
UK DMC2	Sudan	1/22/2010	8:49:25	22	50.9
UK DMC2	Argentina	12/6/2009	14:52:11	22	72.5
UK DMC2	Argentina	12/3/2009	14:48:59	22	72.5

GDA Corp.

Overview of DMC Data

- Six satellites in DMC Constellation
  - Two additional satellites are scheduled for launch for this year
- The same imager on each satellite
  - Linear pushbroom imager (SLIM-6)
  - Two cameras. 324.58km swath each. Some overlap
- Large footprint
  - Programmable image size: 160 x 160 km to 600 x 250 km
- Medium Resolution
  - GSD at nadir: 32m and 22m
- Up to daily revisit (by using DMC satellites in concert)
- Bands
  - Green, Red and NIR
  - Landsat 7 ETM+ equivalent.
  - NIR-R-G band order
- Quantization: 8 bit (from 11 bit)



GDA Corp.

Overview of DMC Data

DMC Constellation

	Mission	ECT	GSD (m)
1	AlSAT-1	8:53 am	32
2	Beijing-1	9:57 am	32
3	NigeriaSAT-1	8:45 am	32
4	UK-DMC-1	8:42 am	32
5	Deimos-1	10:45 am	22
6	UK-DMC-2	10:36 am	22
7*	NigeriaSAT-2	10:30 am	22
8*	NigeriaSAT-X	10:30 am	22

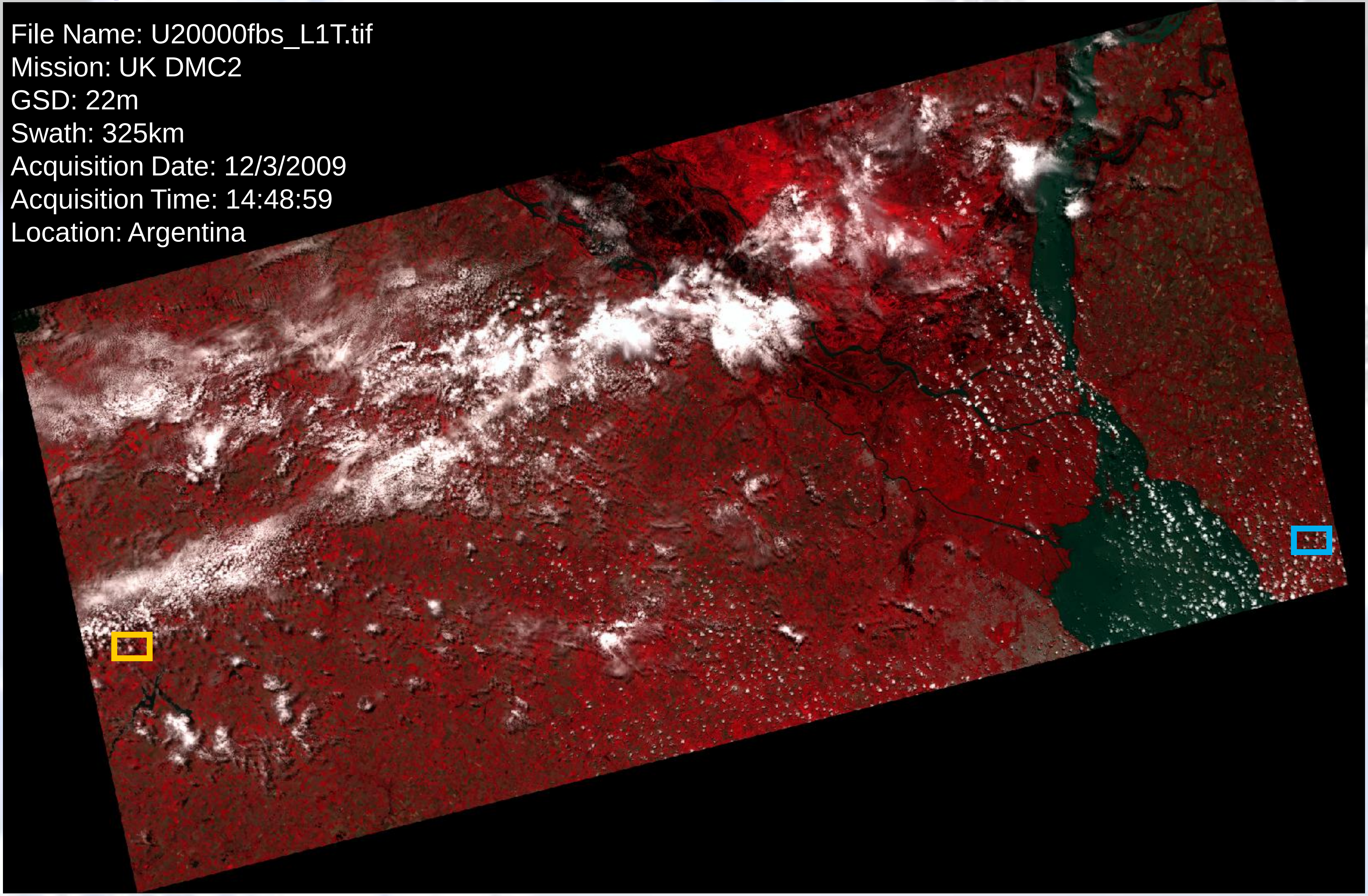
(*****) Predicted ECT's. The satellites (N2 and NX) scheduled for launch later this year

Landsat 7 ETM+ Equatorial Crossing Time (ECT) is 10:00 am

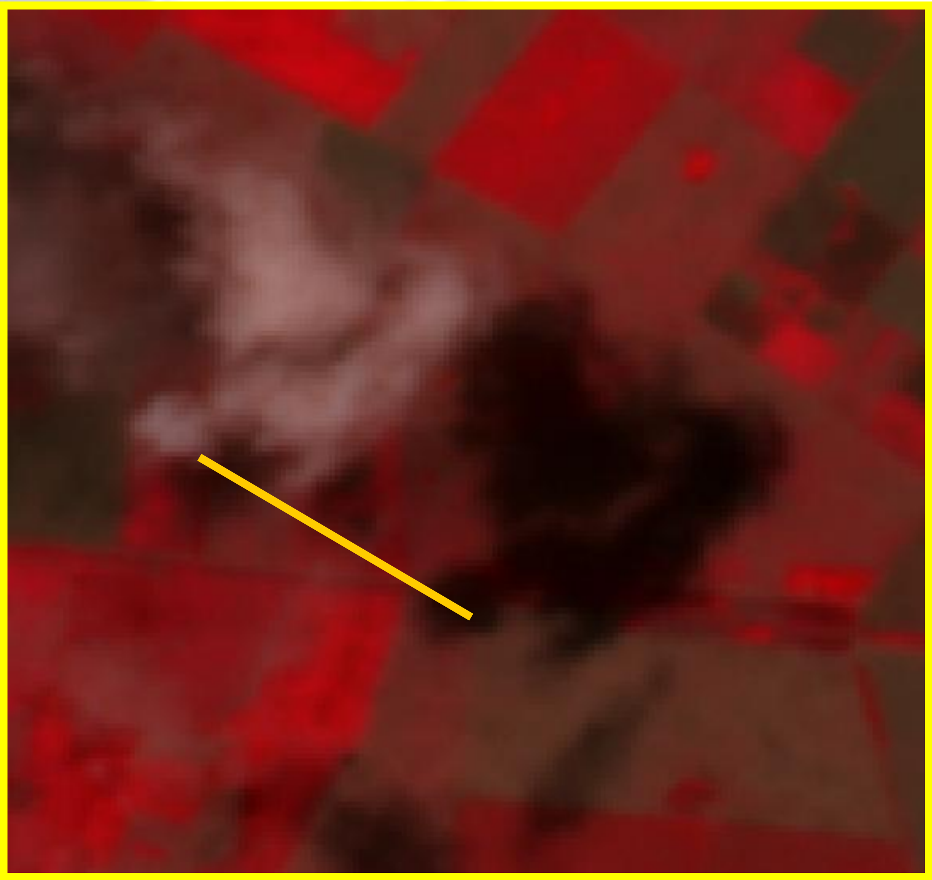
GDA Corp.

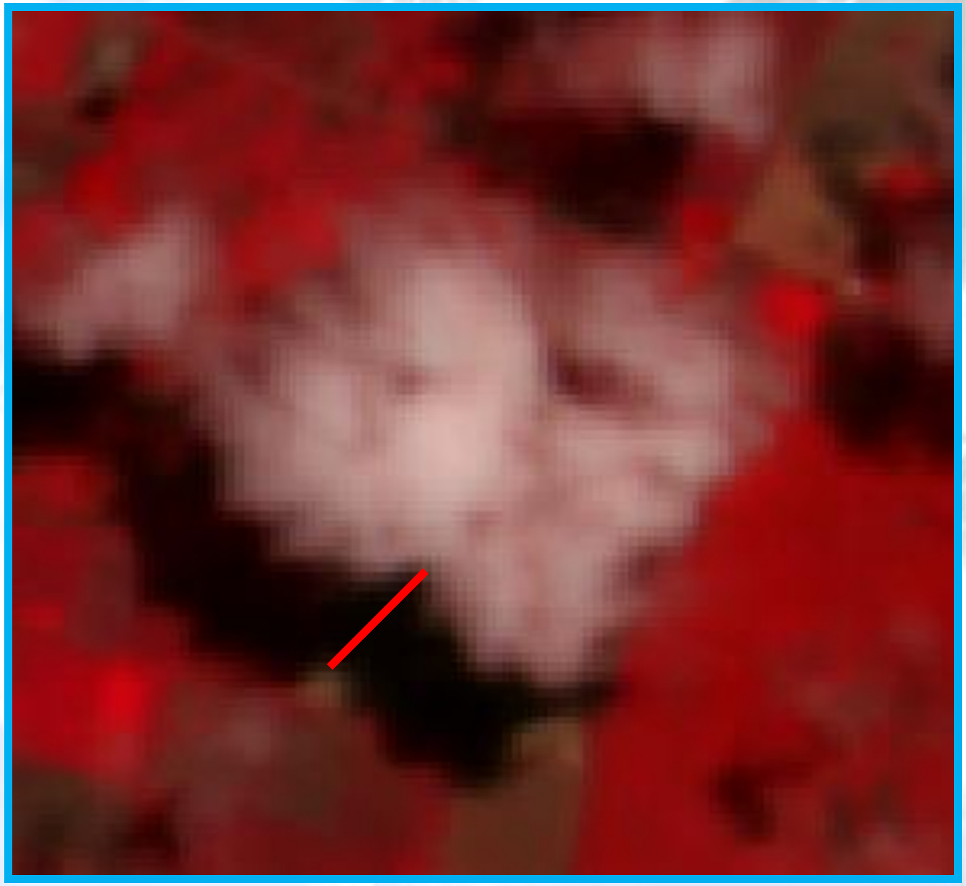
Overview of DMC Data

File Name: U20000fbs_L1T.tif
Mission: UK DMC2
GSD: 22m
Swath: 325km
Acquisition Date: 12/3/2009
Acquisition Time: 14:48:59
Location: Argentina



Overview of DMC Data





- Dramatic View Zenith changes across the imagery. (*As to be expected for any large footprint imagery.*)

GDA Corp.

Strengths / *Constraints*

- Constellation. Scheduled additions. Up to daily revisits. The same camera. Dedicated calibration and cross-calibration efforts. Well documented sensor characteristics.
  - *ECT differs among satellites. This increases spectral variability of the same LC class across time.*
  - *Early morning collection may result in (i) low solar elevation and (ii) high water / haze content in the atmosphere. Low sun elevations leads to (i) uneven illumination / shading in presence of topography, (ii) increase in the length of the solar path as well as change in composition and decline in the solar radiation reaching mapped surface.*
  - *Some radiometric calibration issues remain.*
  - *Some QA/QC is still manual.*
- Spatial Resolution
  - *32m as well as 22m imagery. Complicates simultaneous use of data from different DMC satellites.*
- Bands match specs of Landsat 7 ETM+
  - *Only G-R-NIR. No SWIR band(s).*

GDA Corp.

Strengths / *Constraints*

- Large Image Footprint
  - *Changes in view-sun geometry across the footprint*
  - *View elevation variation from 90 (nadir) to ~66 (scene edge)*
  - *Sensor to ground distance variation: ~10% increase from nadir to the edge of the scene*
  - *Variation across the scene in atmospheric transmittance along the solar and esp. view paths. These differences lead to the degradation in pixel values across the scene from nadir to scene edge. The amount of degradation also varies among bands, increasing from G to R to IR bands.*
  - *Changes in the relationship between view and solar geometries across the scene increase within the LC class spectral variability (BDRF).*
  - Note: These observations are NOT unique to DMC imagery! Any large footprint imagery has the same issues.

GDA Corp.

Recommendations

Surface Reflectance Calibration

- Corrects for per pixel / band variations in view & solar geometry, incidence angle, Earth curvature, surface elevation, & atmospheric transmittance
- Improves spectral properties across the scene at pixel level
- Improves relation among DMC imagery for different dates and from different satellites
- Allows for a mash up of DMC imagery with other image sources for multi-sensor analysis

A General Equation is below:

$$\rho = (\pi \bullet (L_\lambda - L_p) \bullet d^2) / (\cos(\Theta) \bullet E_0 \bullet T_z + E_d) \bullet T_v$$

ρ is surface reflectance,
L_λ is at-sensor spectral radiance,
L_p is path radiance,
d is earth-sun distance in astronomical units, varies according to the Julian day,
Θ is sun elevation,
E_o is mean per band solar spectral irradiance value,
E_d is diffuse sky irradiance,
T_z is atmospheric transmittance along the solar path,
T_v is atmospheric transmittance along the view path.

GDA Corp.

Recommendations

Applications with DMC imagery

- G-R-NIR band combination complicates the use of DMC imagery for mapping and monitoring. Lots of action happens in SWIR area.

Three general uses of DMC imagery can be suggested:

1) Mapping classes / features that are spectrally distinct (in absolute or in relative terms). Limited number of images may be sufficient.

   E.g., mapping poppy cultivation in Helmand / Afghanistan; spring grains (wheat, barley) in Northern Kazakhstan, floods, fire, general LC mapping

2) Monitoring spectral behavior of known classes in known locations over time. User requirements would dictate the data volume.

   E.g., precision agriculture – monitoring progress of a given crop on a given field

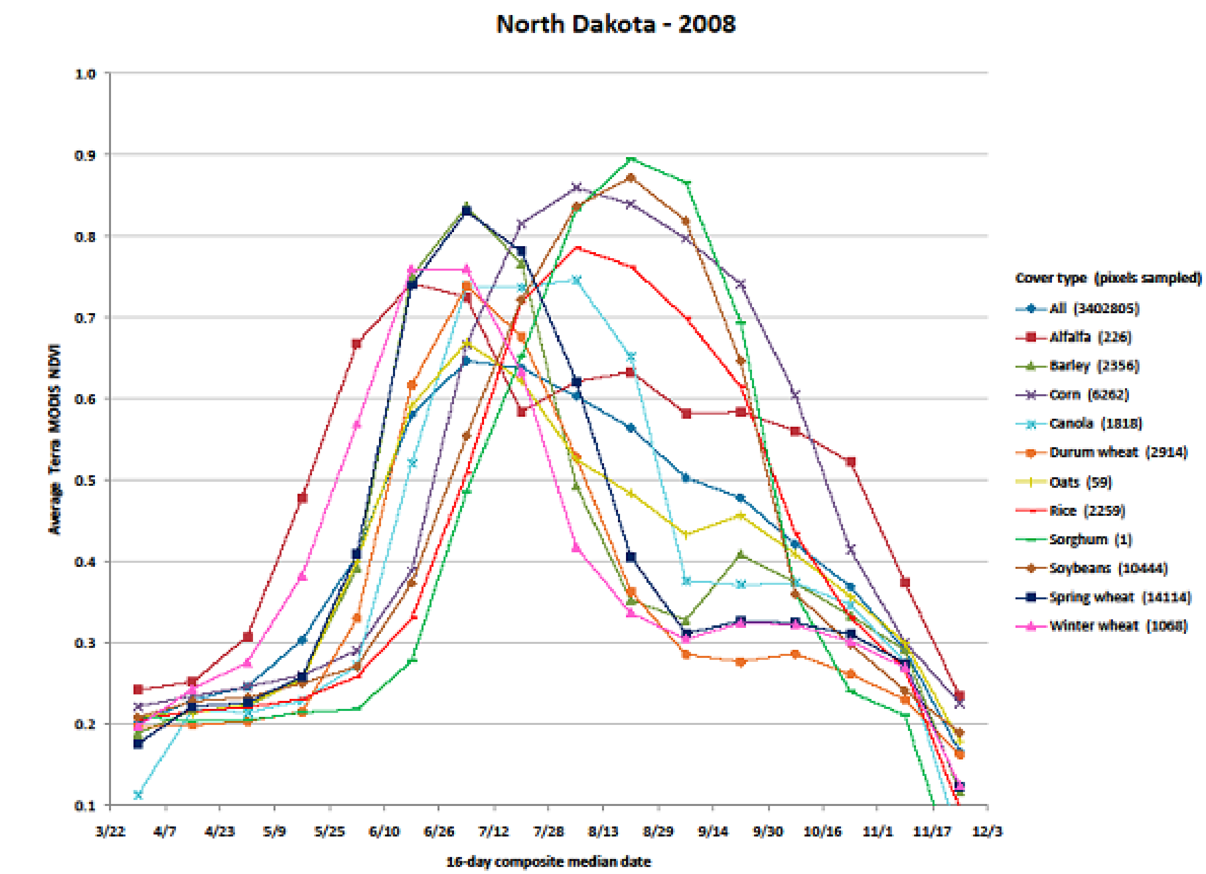
3) Mapping by relying on time series analysis of the imagery. Detail level mapping / analysis may be possible. Large data volume may be required. Image price may become a limiting factor.

GDA Corp.

Recommendations

Time Series Analysis of DMC imagery

- The most promising direction if detailed mapping is a goal. Use of NDVI time series may prove sufficient. Reliable radiometric calibration / cross-calibration required. Time-series smoothing may still be needed.



Source: Phenological Atlas by Dave Johnson (USDA NASS)

GDA Corp.

Contact Information

GDA Corp.

200 Innovation Blvd.
Suite 234
State College, PA 16803
T: 814-237-4060
F: 814-689-3375
E: dmitry@gdacorp.com
W: www.gdacorp.com