XXV FIG Congress
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"Engaging the Challenges, Enhancing the Relevance"
16 - 21 JUNE 2014, MALAYSIA

Incorporating Remote Sensing as a Tool to Assist Rehabilitation Monitoring in a Dolomite Mining Operation in South Australia

UNSW THE UNIVERSITY OF NEW SOUTH WALES

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N. KARIYAWASAM, S. RAVAL* and A. SHAMSODDINI

acsmp

LIME LABORATORY FOR IMAGING OF THE MINING ENVIRONMENT

Remote Sensing

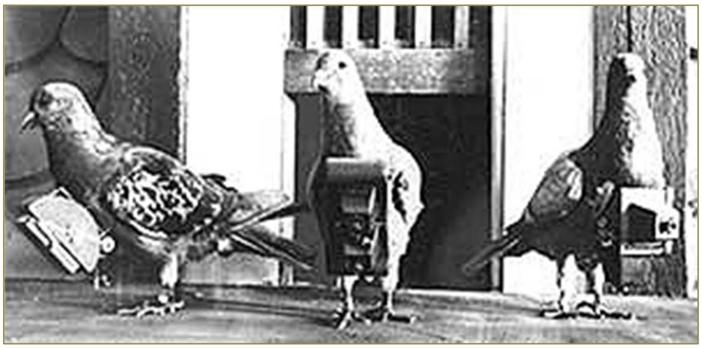
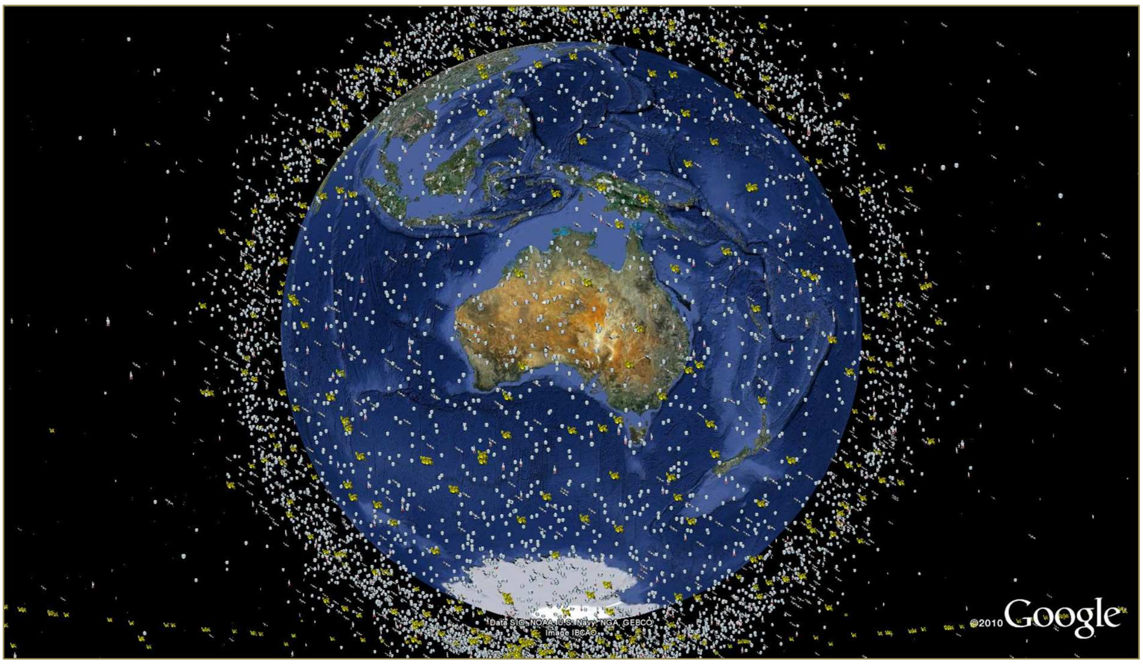


Image source: NASA

Current Space Objects

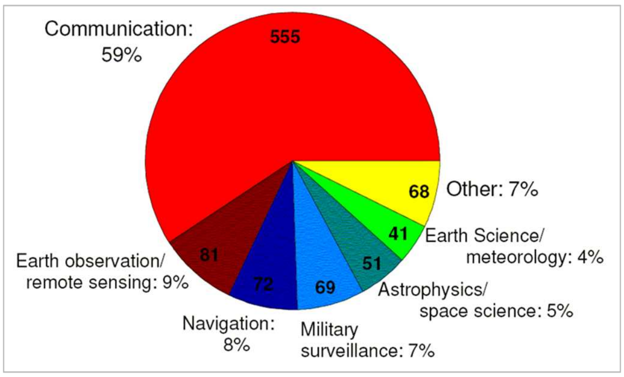


Based on the data collected from[U.S. Space Track]() and [UCS Satellite Database]()

Major Applications/Payers

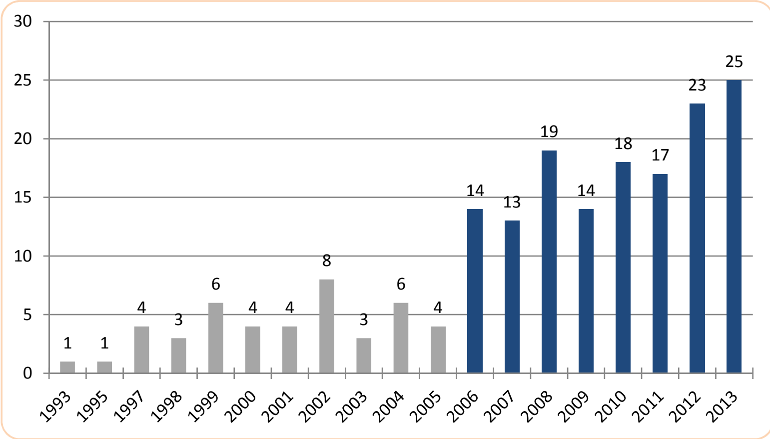
Satellite Quick Facts			
Total number of operating satellites: 1167			
LEO: 605	MEO: 77	Elliptical: 38	GEO: 447
United States: 502	Russia: 118	China: 116	
Total number of U.S. Satellites: 502			
Civil: 20	Commercial: 210	Government: 120	Military: 152

includes launches through 1/31/2014



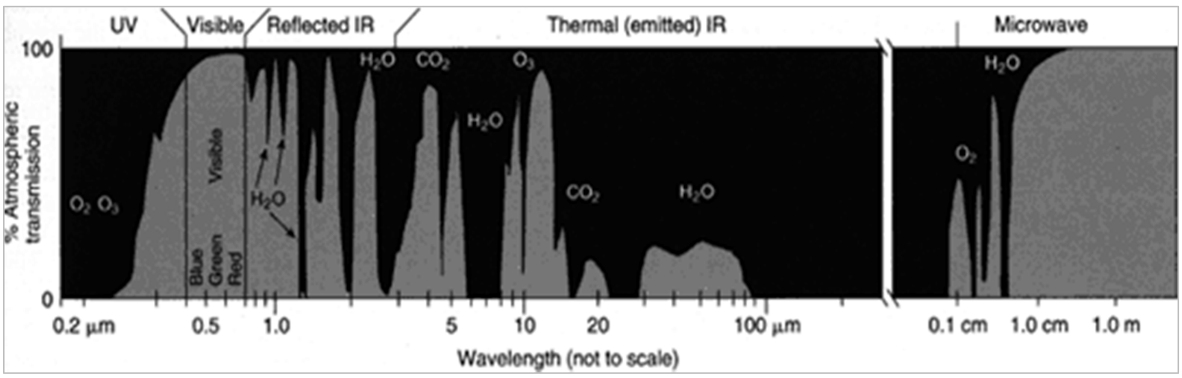
Source: UCS Satellite Database

Launch attempts for “Remote Sensing”

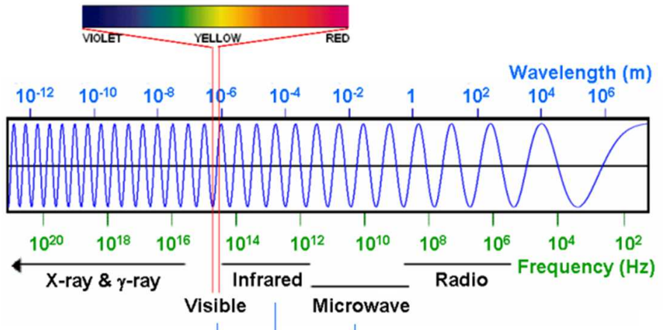


Source: UCS Satellite Database

Atmospheric interactions



Remote Sensing and Mining



Optical Remote Sensing

Satellite	Band	Wavelengths
Chris-Proba	Hyperspectral	415-1050 nm
IKONOS	Multispectral	Visible – NIR
SPOT5	Multispectral	Visible – NIR
Hyperion	Hyperspectral	400-2500 nm
World-View 2	Multispectral	Visible – NIR
more..		

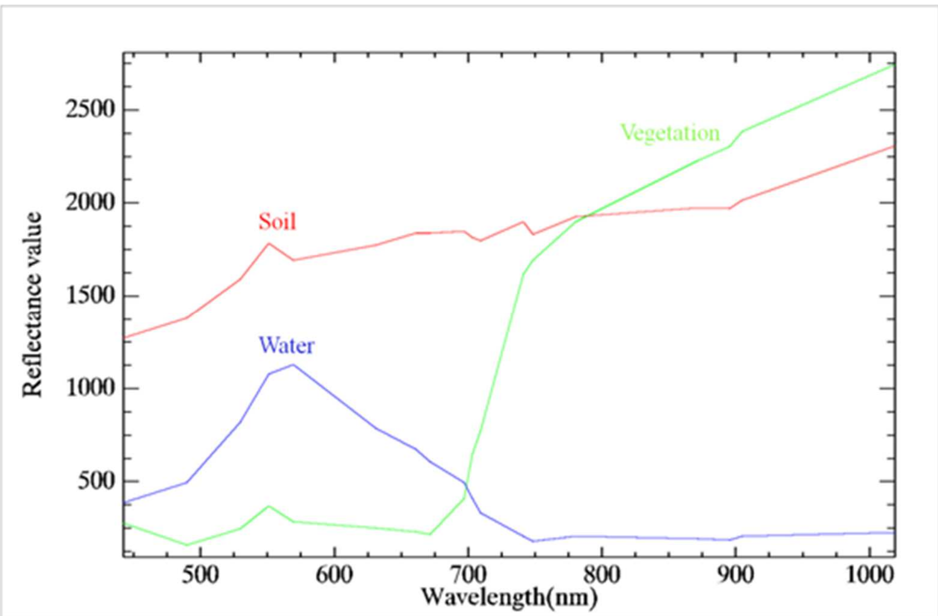
*Vegetation analysis * Mapping of acid mine drainage
*Contouring * Monitoring spontaneous combustion

Radar Remote Sensing

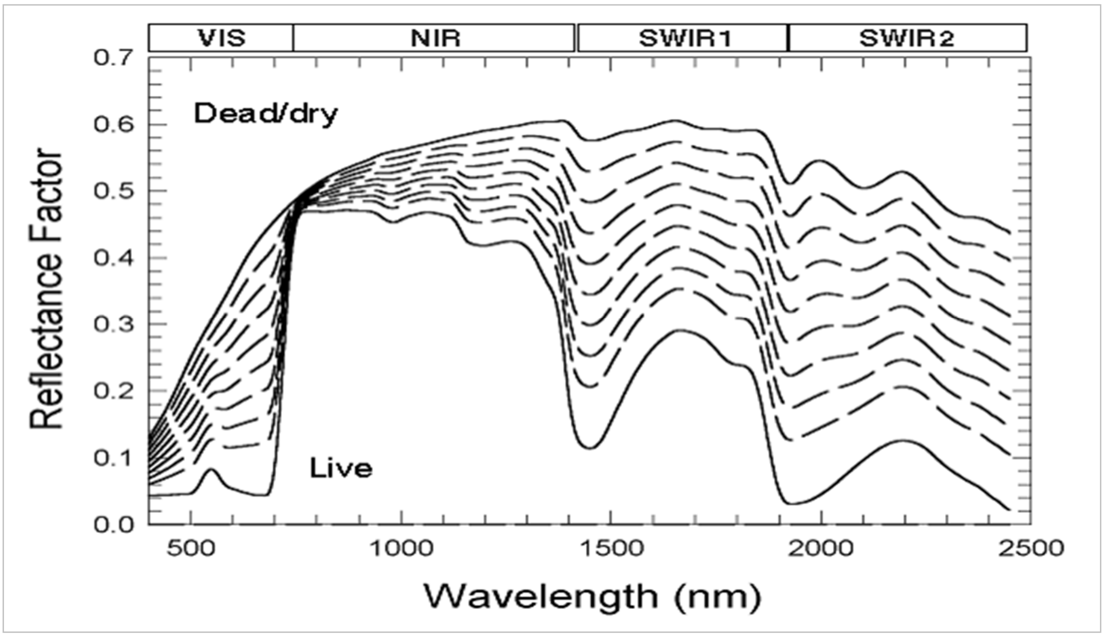
Satellite	Band	Wavelengths
ENVISAT ASAR	C	5.6 cm
ALOS PALSAR	L	23.5 cm
TerraSAR-X	X	3.1 cm
COSMOS-SKYMED	X	3.1 cm
Radarsat-2	C	5.6 cm

*Subsidence monitoring
* Pit/dump slopes stability monitoring

Spectral Characteristics

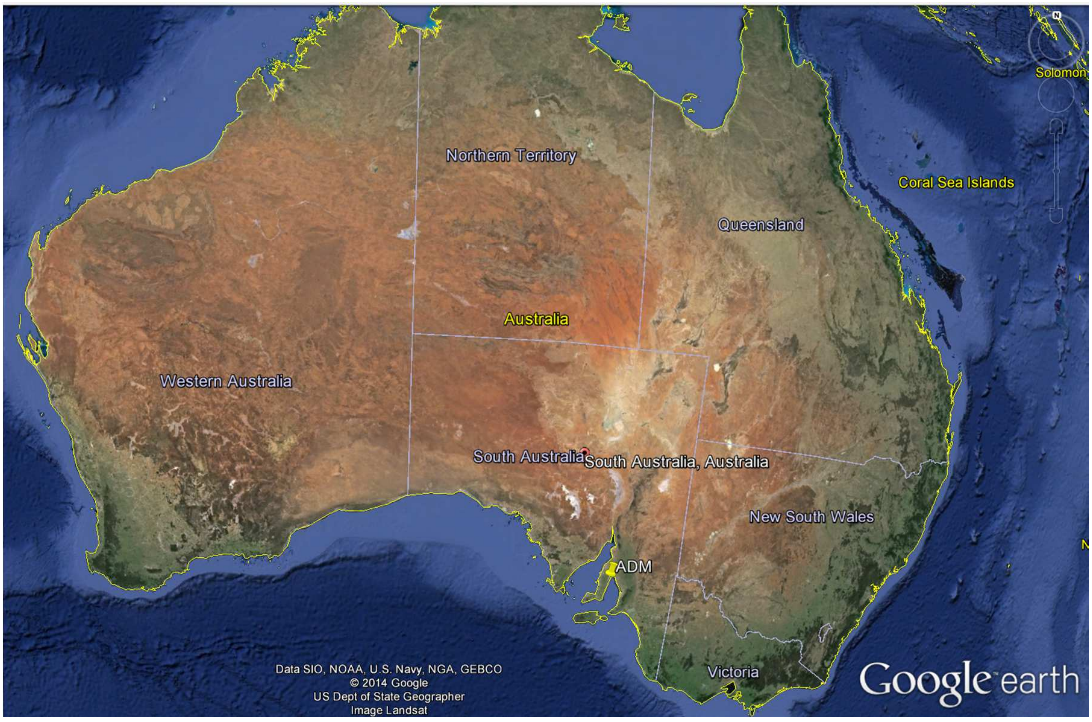


Spectral Characteristics



(modified after Asner, 1998)

Ardrossan Dolomite Operation (ADM) in SA



Ardrossan Dolomite Operation (ADM) in SA

Landsat Images

Image acquisition date	Sensor
01/10/2000	ETM+
01/28/2001	ETM+
02/16/2002	ETM+
01/08/2003	ETM+
03/17/2004	TM
09/25/2004*	TM
01/31/2005	TM
04/24/2006	TM
03/26/2007	TM
03/12/2008	TM
01/26/2009	TM
01/29/2010	TM
03/20/2011	TM
01/27/2012	ETM+

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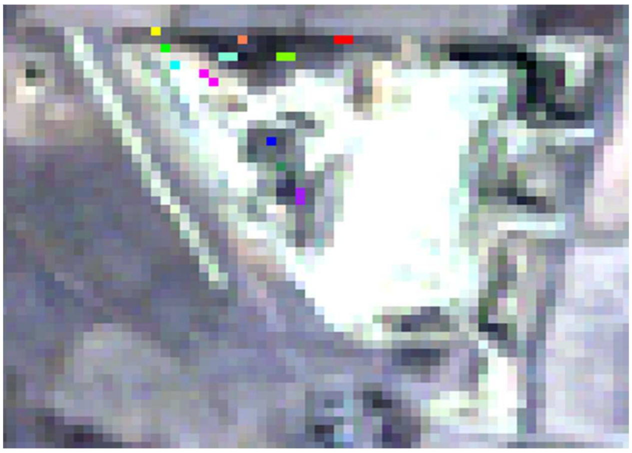
Region of Interest (ROI)



Region of Interest (ROI)

ROIs	Plantation Year (s)
r10	Late 1980s
r4 and r7	1997-1998
r1, r5 and r9	1998-1999
r2 and r11	1999-2000
r6, r8 and r12	2005-2006

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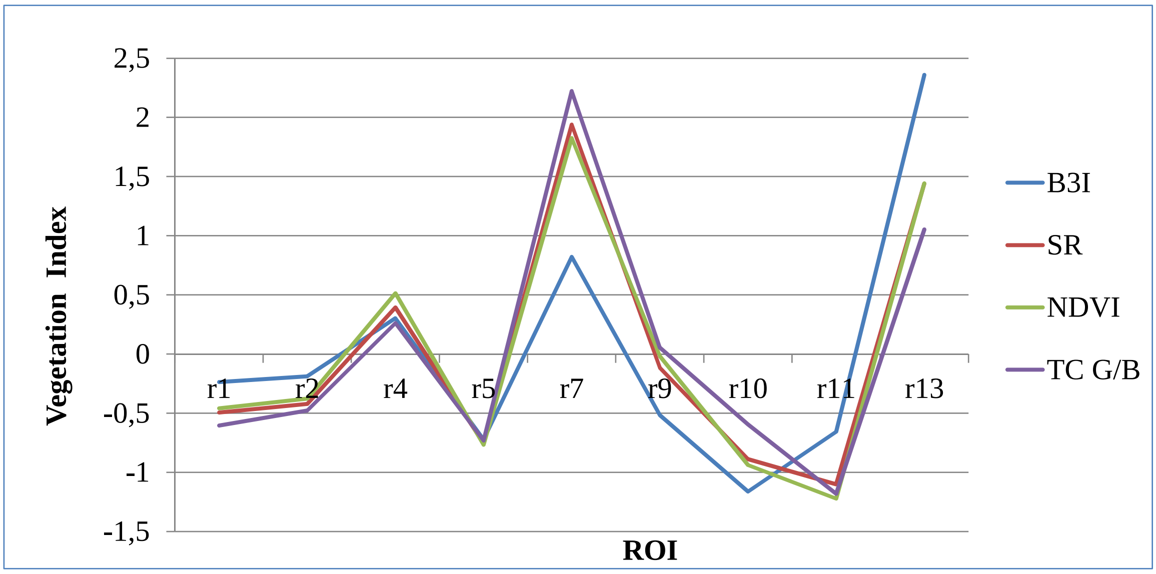
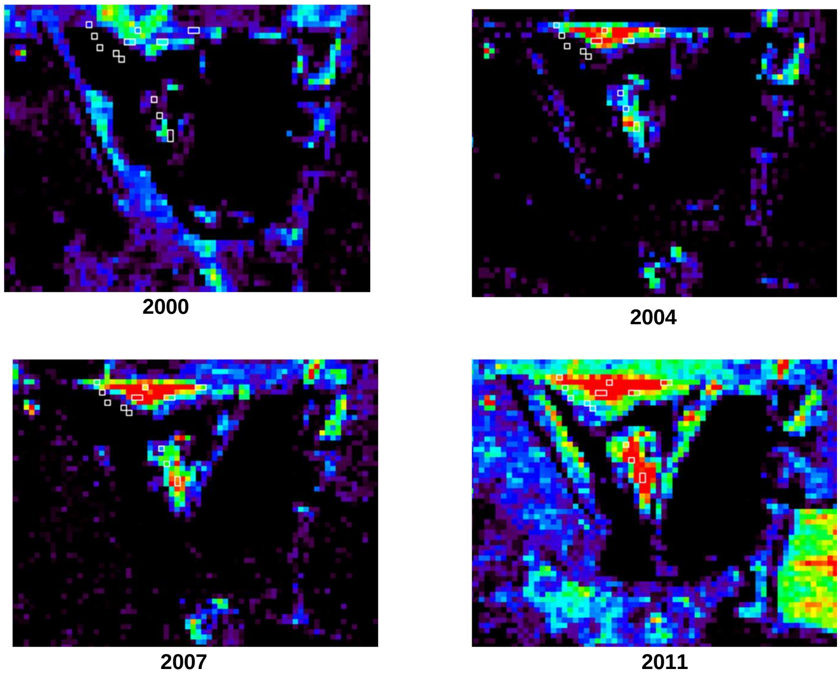
Spectral Derivatives

NDVI	• Robust over a wide range of conditions • Compensates for changing illumination conditions, surface slope, aspect, etc.
SR	• Used for discriminating between soil and vegetation in the study area
B3I	• Good indicator for forest disturbance, regrowth and biophysical parameters
TC G/B	• Brightness is responsive to the differences in soil brightness • Greenness is responsive to the green vegetation density • TC brightness - greenness defines the 'plane of vegetation'

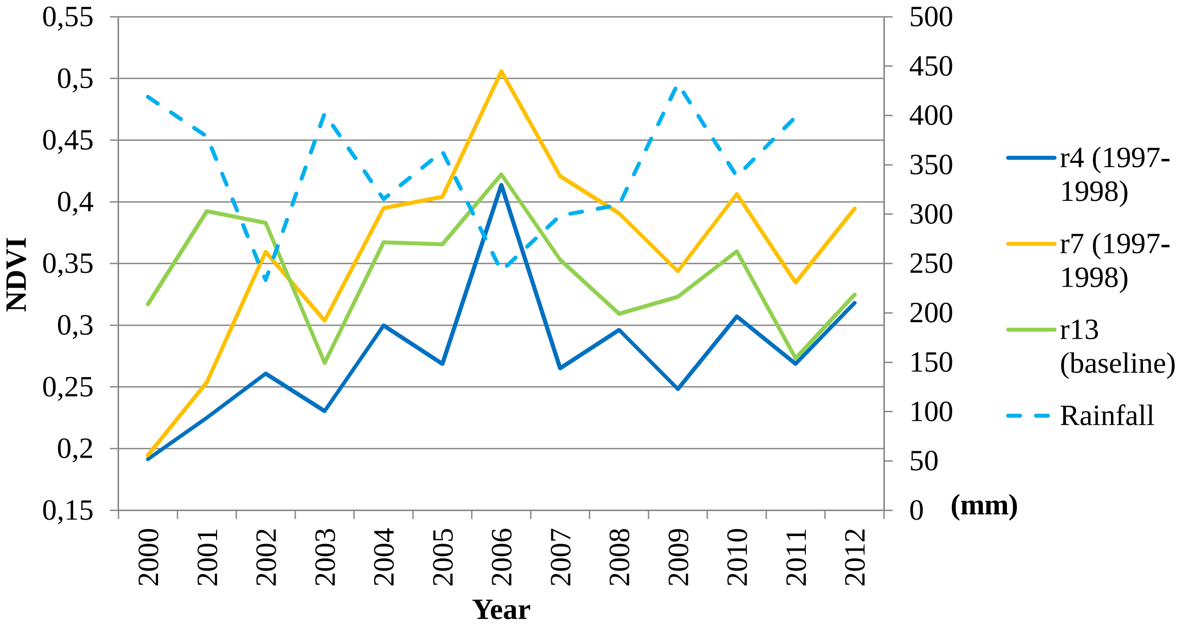
Spectral Derivatives – 2004 Comparison



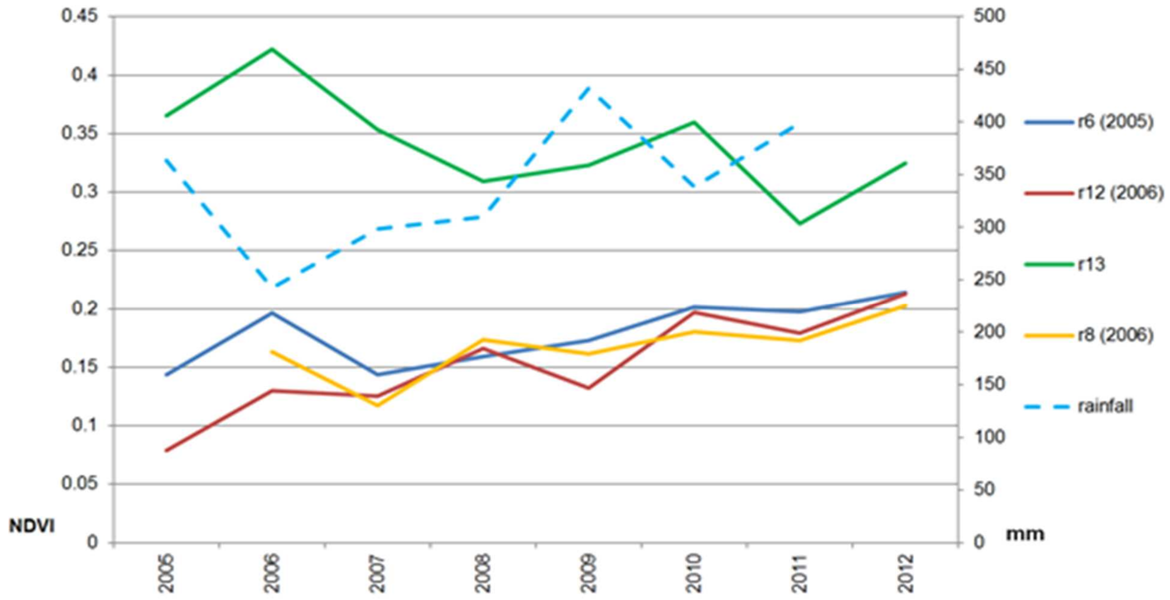
NDVI Results



NDVI v/s Rainfall



NDVI v/s Rainfall



Monitoring Biomass

Satellite remote sensing-based estimates of biomass production on reclaimed coal mines

by S. Raval, E. Sarver, A. Shamsoddini, C. Zipper, P. Donovan, D. Evans and H.T. Chu

Abstract ■ Remote-sensing methods have been used to evaluate vegetative growth patterns for many applications, though relatively little work has focused on tracking mine reclamation progress. For coal mines in Central Appalachia, reclamation approaches that include production of biofuel feedstocks are increasingly attractive, as these may yield significant post-mining land values and contribute to carbon-neutral energy supplies. To optimize biomass productivity, the influence of reclamation practices on biomass production must be well understood, which necessitates tracking biomass production over long time periods. Satellite-based estimations may offer low-cost alternatives to conventional biomass estimations and, also, the potential to provide critical input for carbon accounting at varied spatial scales. In this paper, experimental biomass production plots on reclaimed mine sites established in Wise County, VA, are used for a comparative study of satellite spectral derivatives, which are evaluated against ground-based biomass estimates. Metrics based on four spectral derivatives, band ratios and spectral transforms were regressed against biomass measured in situ for different species. The results demonstrate that greenness and principal component 2 (PC2) were more efficient than the other spectral derivatives for monitoring the biomass of this reclaimed area. Also, it is shown that Landsat-5 TM has provided promising results for monitoring of the biomass changes occurring from 2008 to 2010 over the study area.

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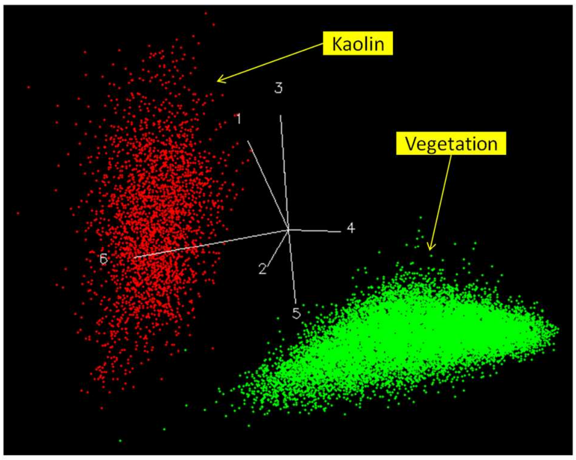
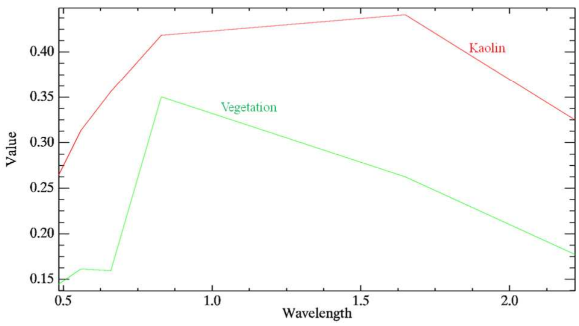
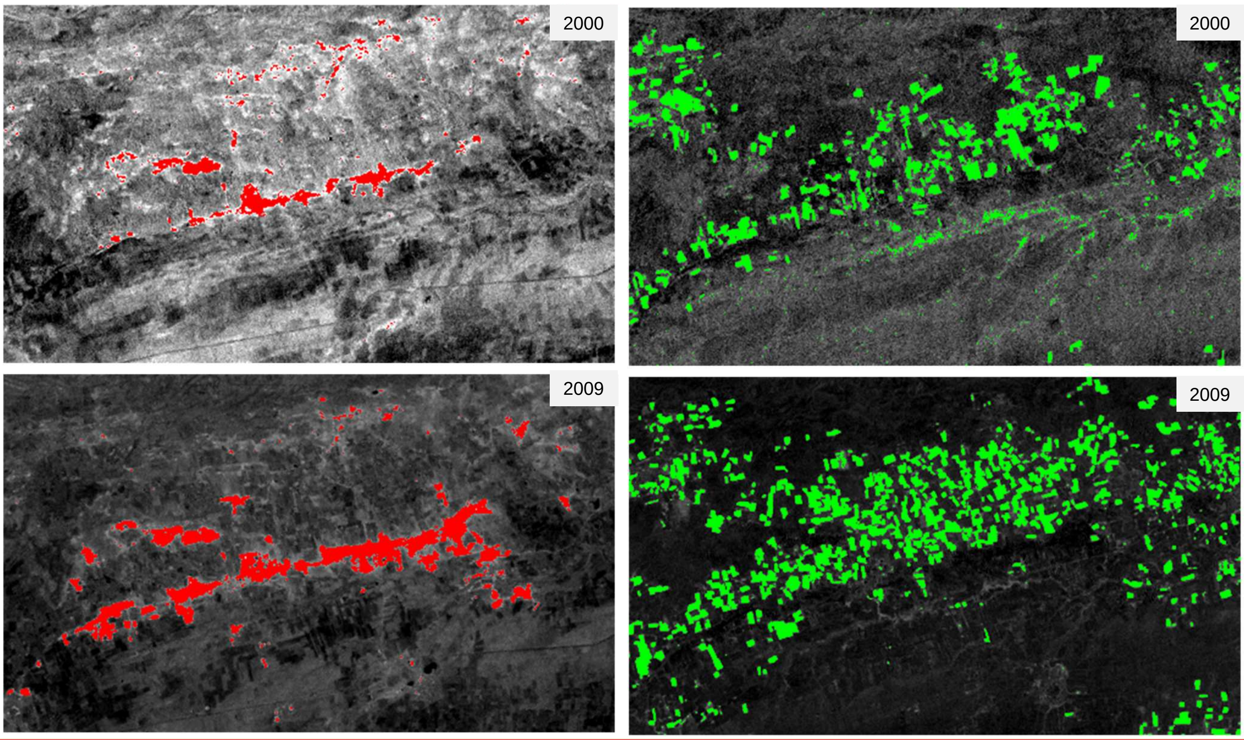
Land Cover and Land Use Mapping

Land Cover and Land Use Mapping

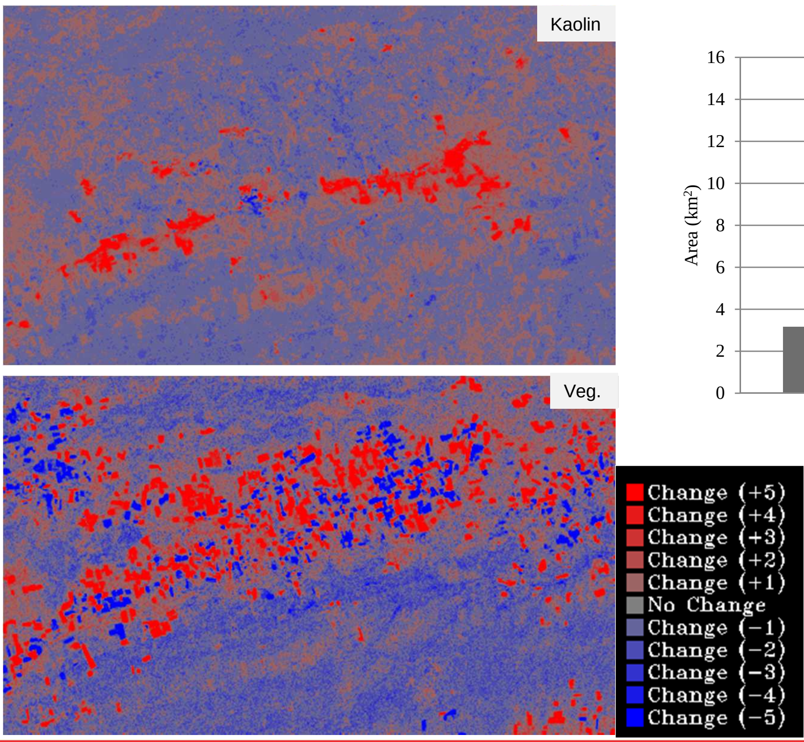


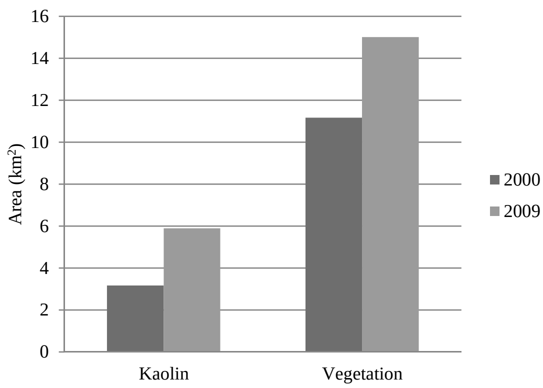


Land Cover and Land Use Mapping



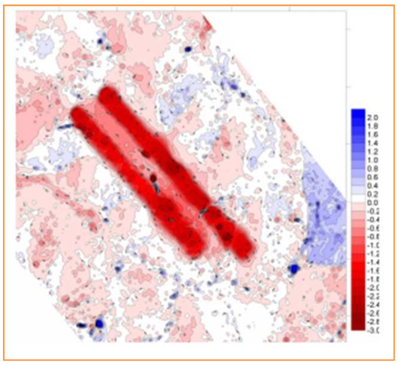
Land Cover and Land Use Mapping



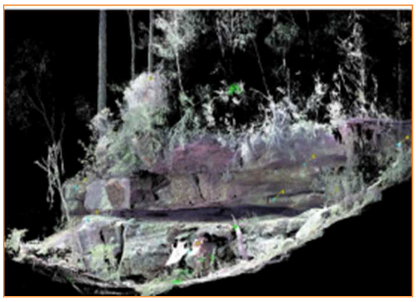


Monitoring Subsidence: Illawarra Coal *Anderson et al 2007*

Fixed Ruler at water pipe joint

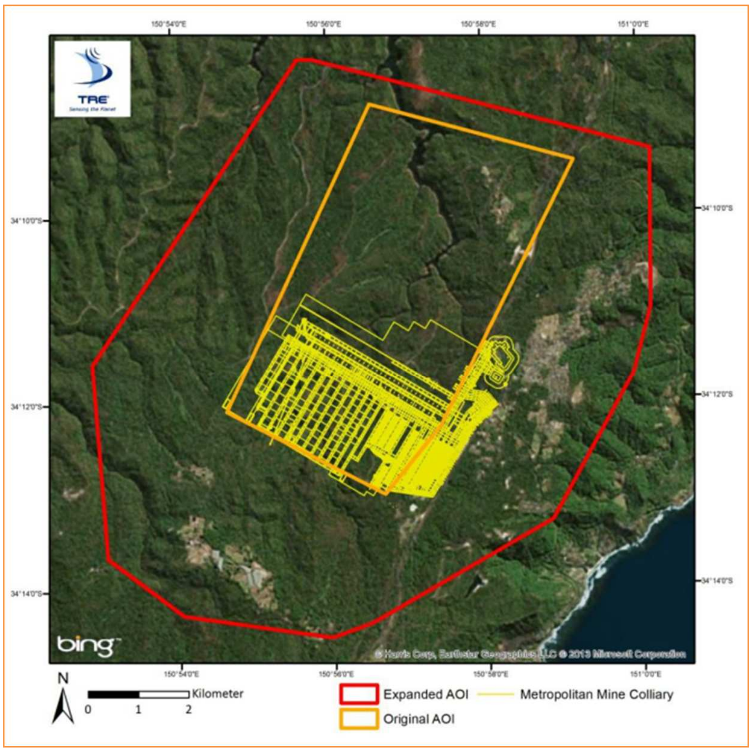


Subsidence Contours from ALS



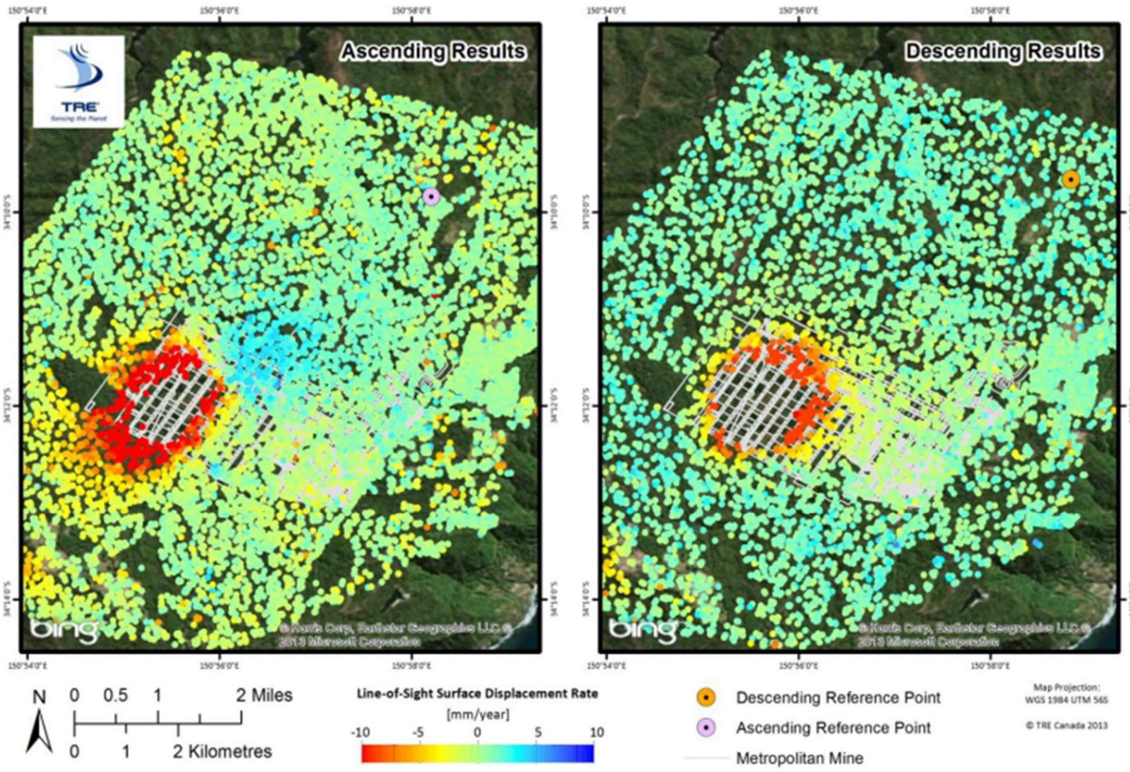
TLS 3D point cloud

Our Study@Metropolitan

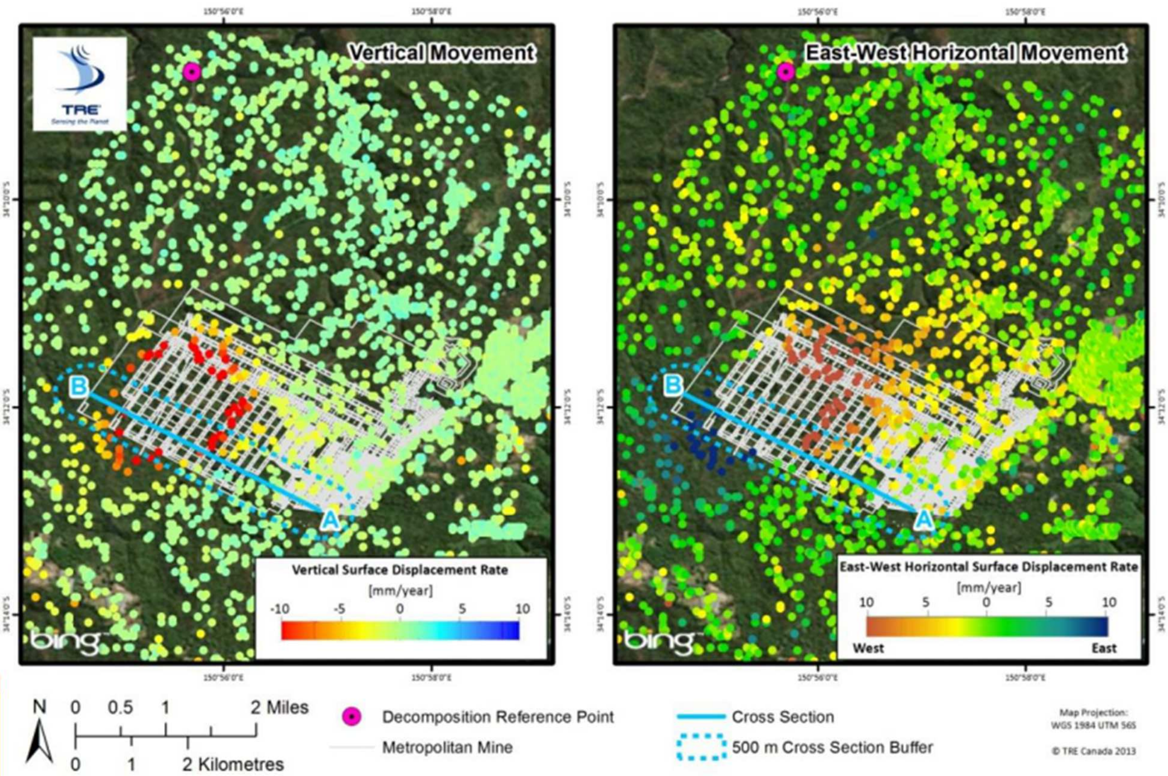


LOS Movement

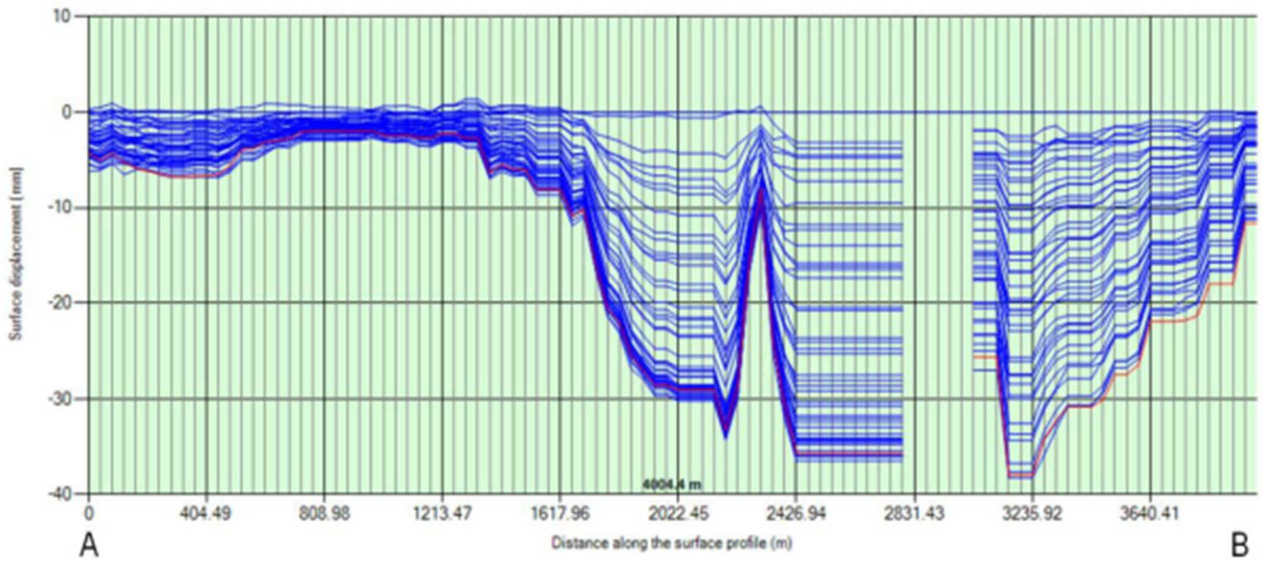
•191 pts/km2
•135 pts/km2



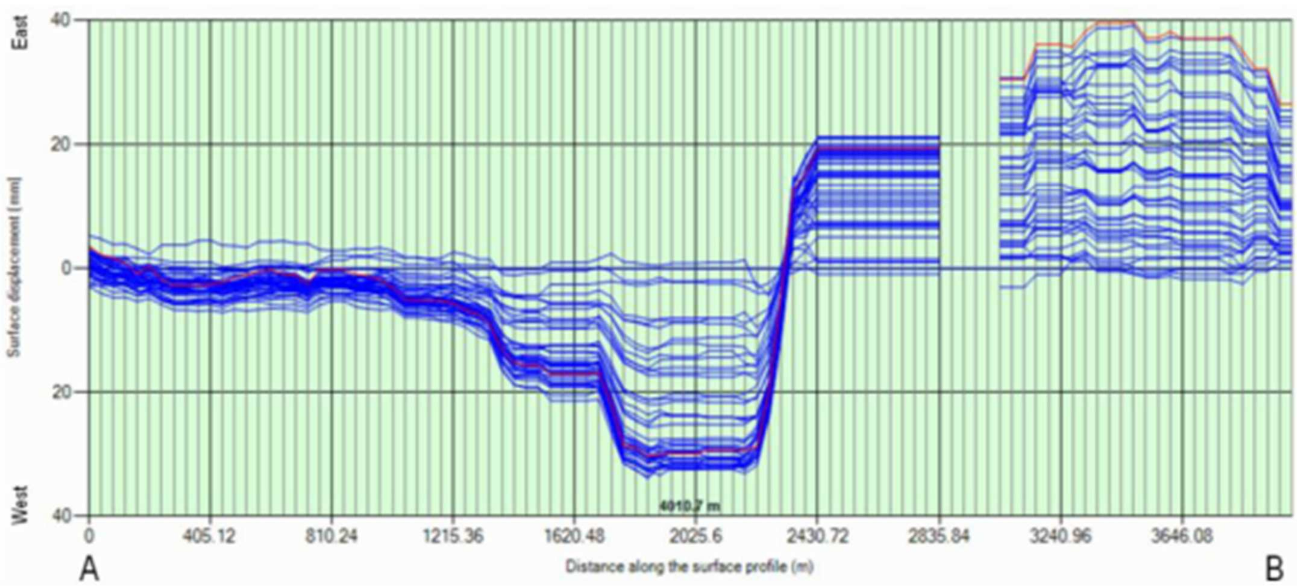
Vertical and Horizontal Movements



Changes in the Vertical Direction

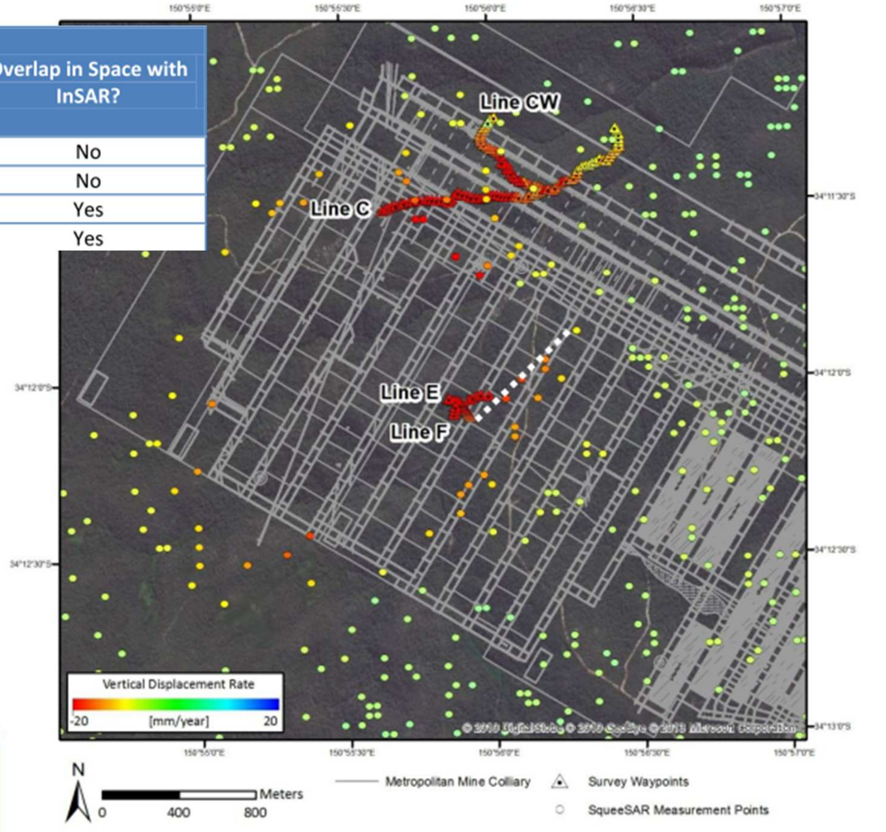


Changes in the East-West Horizontal Direction

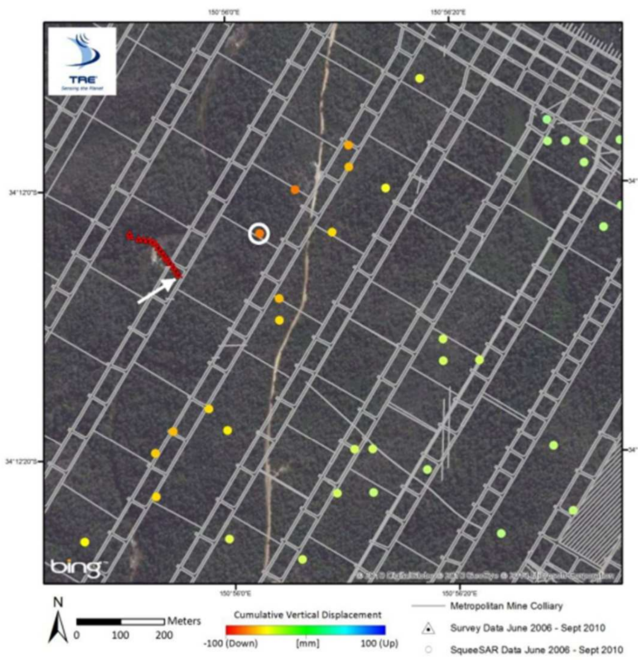


Integration with Ground Survey

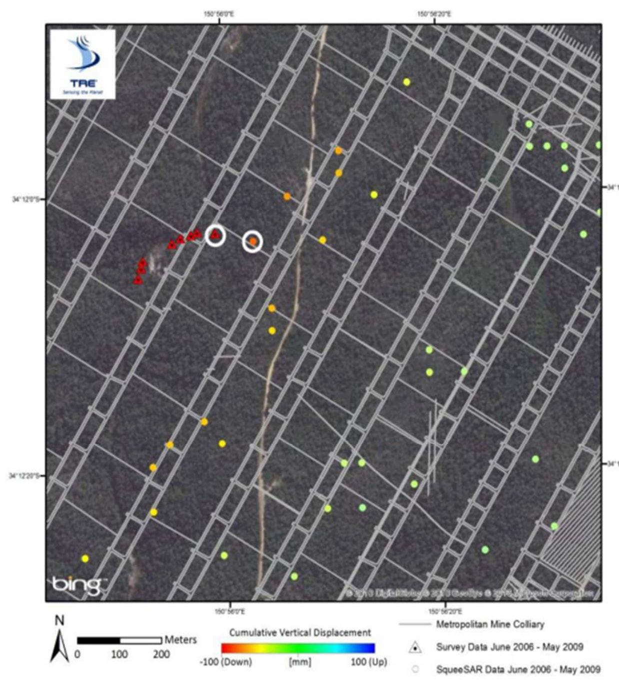
Survey Line	Overlap in Time with InSAR?	Overlap in Space with InSAR?
E Line	Yes	No
F Line	Yes	No
C Line	Limited	Yes
CW Line	Limited	Yes



Integration with Ground Survey

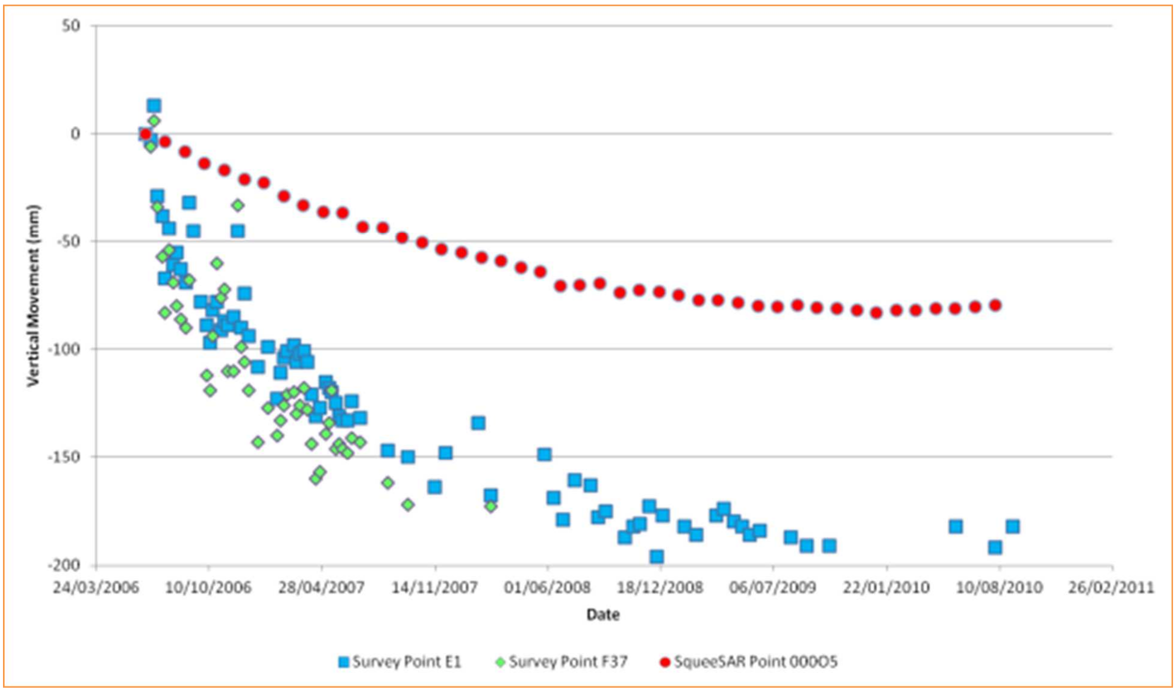


Survey Line E

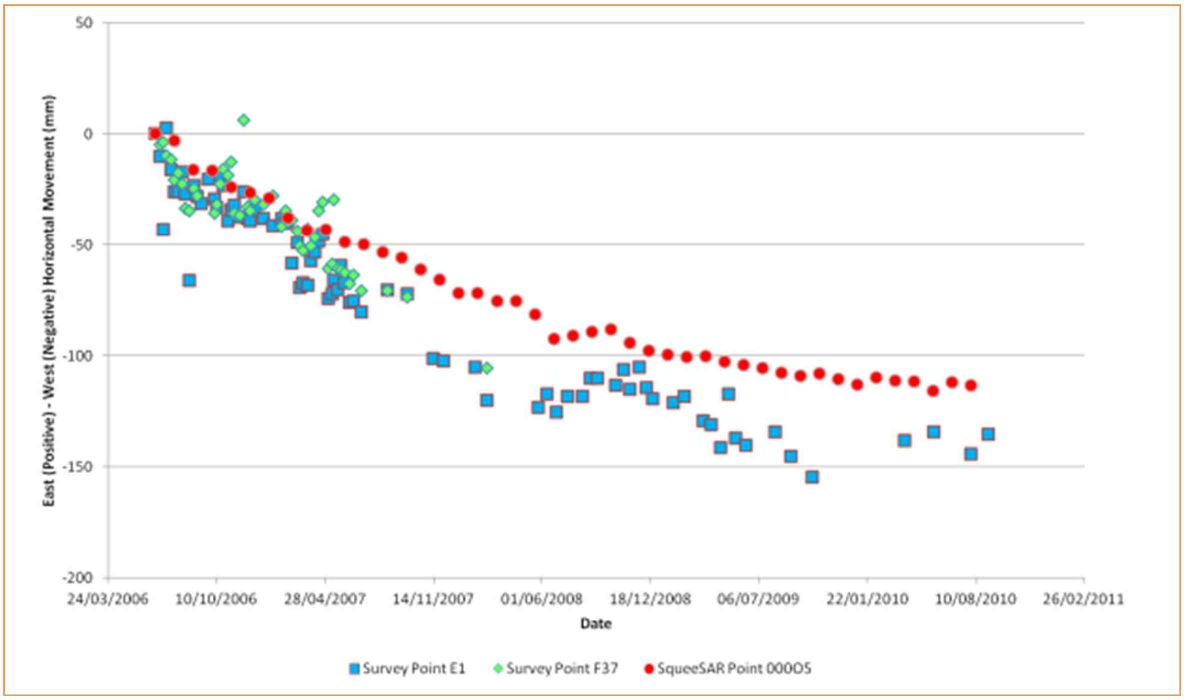


Survey Line F

Integration with Ground Survey: Vertical



Integration with Ground Survey: Horizontal



Slope Stability 2013 – P.M. Dight (ed)

Application of advanced InSAR techniques to detect vertical and horizontal displacements

J. Morgan *TRE Canada Inc., Canada*

S. Raval *The University of New South Wales, Australia*

B. Macdonald *TRE Canada Inc., Canada*

G. Falorni *TRE Canada Inc., Canada*

J. Iannacone *University of Modena and Reggio Emilia, Italy*

Abstract

The monitoring of surface subsidence is an important aspect in many underground mines. There are various ground-based methods that can be used for deformation monitoring, including optical levelling, GPS, and tiltmeters. This study proposes the use of satellite-based InSAR for the monitoring of surface movement over the Metropolitan Mine, an underground coal mine located in the Southern Coalfields of New South Wales, Australia where ground subsidence has been documented. An advanced multi-image InSAR approach, characterised by a high density of measurement points and millimetre precision, is applied to illustrate how results provide an overview of surface displacement dynamics before, during and after active mining. Two stacks of ENVISAT radar imagery (87 total images) acquired between June 2006 and August 2010 were analysed with the SqueeSAR™ algorithm to reconstruct ground movement patterns during this period. Movements were assessed on a 35-day interval (the revisitation frequency of the ENVISAT satellite), and a time series of deformation was generated for every measurement point. The use of two image stacks acquired from different viewing geometries allowed both the vertical and east–west components of ground movement over this site to be determined. Results illustrate the surface-level impact of underground mining by quantifying the spatial extent and timing of surface movement. The precision of the InSAR data were briefly assessed by comparing results with ground-based GPS survey measurements. While the timing and direction of movements were similar, the comparison was limited by the lack of both spatial and temporal overlap of the data sets. The use of a radar satellite with a higher temporal frequency is recommended for future monitoring of this site.

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Question Time

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