The Current and Future Status of Satellite Imagery and Their Use in Urban Applications

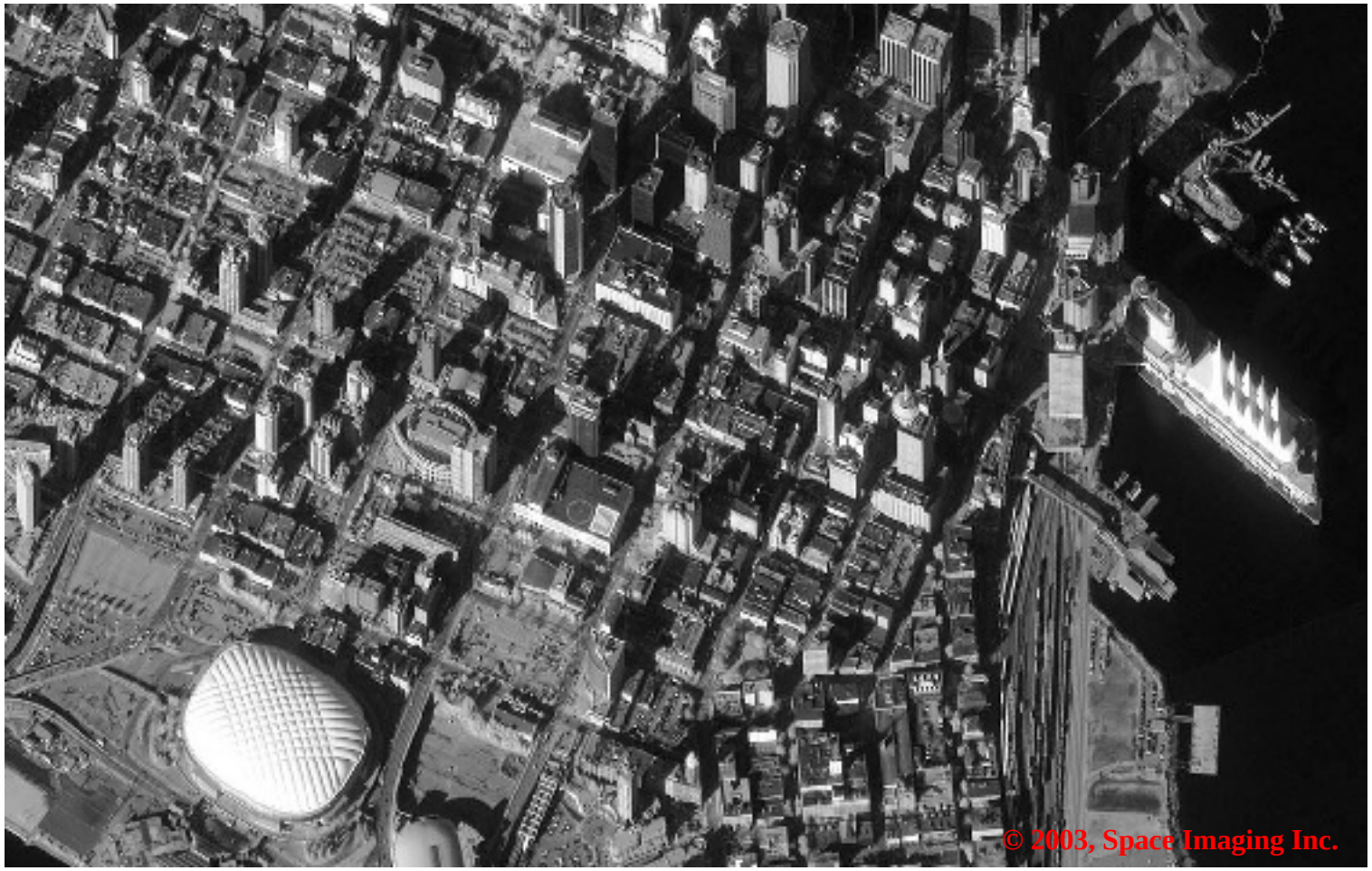
Mr. Karl Kliparchuk, M.Sc.

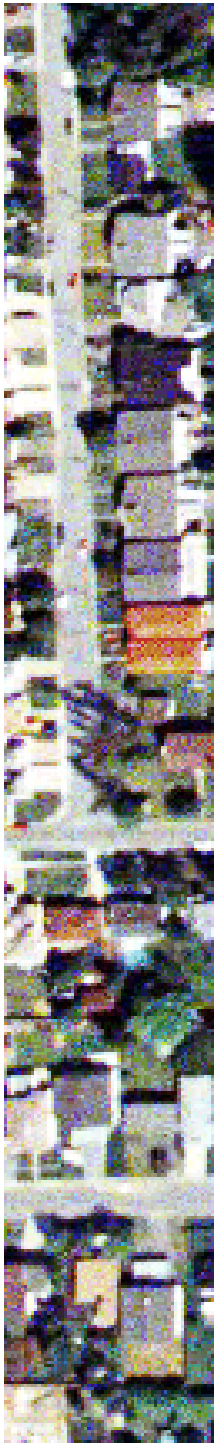
McElhanney Consulting Services Ltd.

Outline

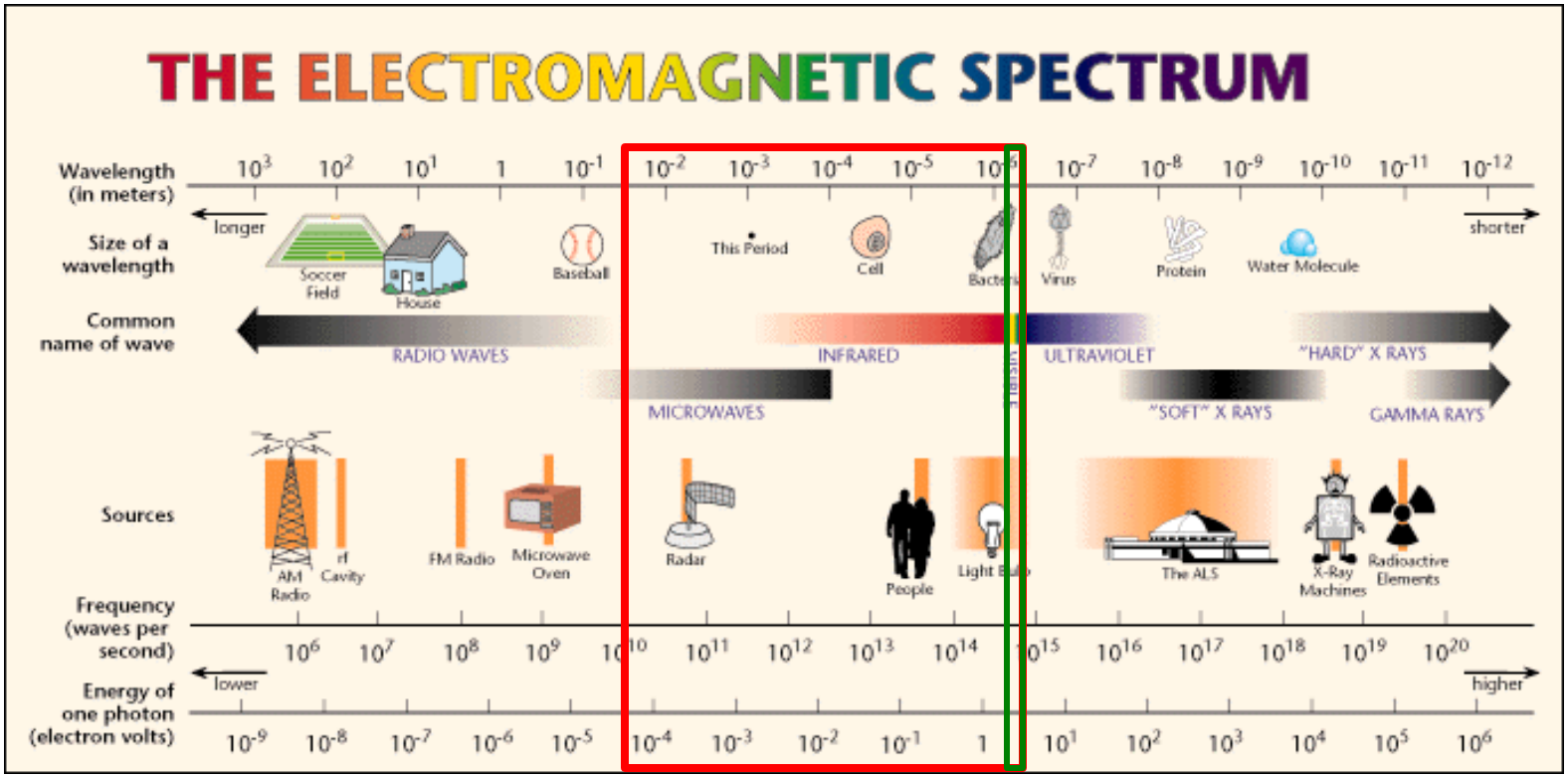
1. A Peek at the Spectrum
2. Brief History of Remote Sensing
3. Current Sensors
4. Integration of Remote Sensing with GIS for Urban Applications
5. Future Sensors

Remote Sensing





The Electromagnetic Spectrum



A Brief History of Remote Sensing

- 1850 Photography from balloons

A Brief History of Remote Sensing

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- 1909 Photography from airplanes
- 1940's Non-visible data acquisition (infrared)
- 1960's Remote sensing science comes of age (weather sat)
- 1972 Landsat-1 (ERTS-1) launched. MSS scanner.
- 1970's Image Processing software (DIPIX, ERDAS)
- 1984 Landsat-5 launched. Thematic Mapper scanner.
- 1986 SPOT-1 launched. Stereo imaging.
- 1995 RADARSAT-1 launched
- 1999 IKONOS launch and Landsat-7 launch

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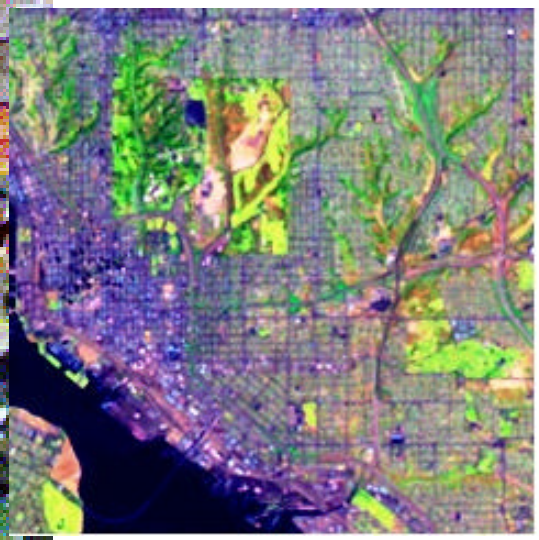
- 1995 RADARSAT-1 launched
- 1999 IKONOS launch and Landsat-7 launch
- 2000 EROS A1 launched
- 2001 Quickbird-2 launched
- 2002 SPOT-5 launched
- 2003 OrbView-3 launched

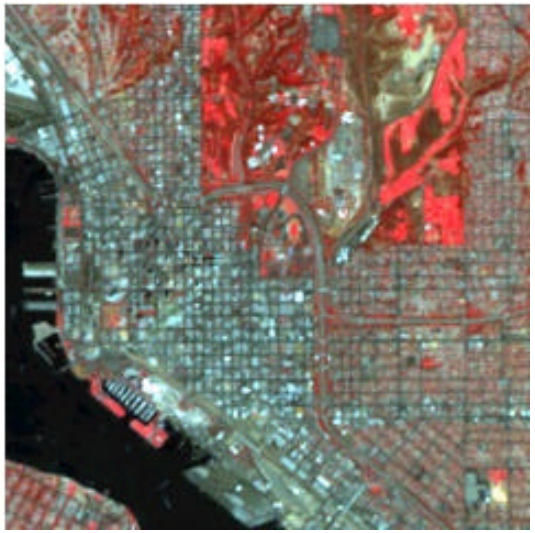
Example Types of Satellite Imagery

Low to Medium Spatial Resolution



Landsat Thematic Mapper

(30m)

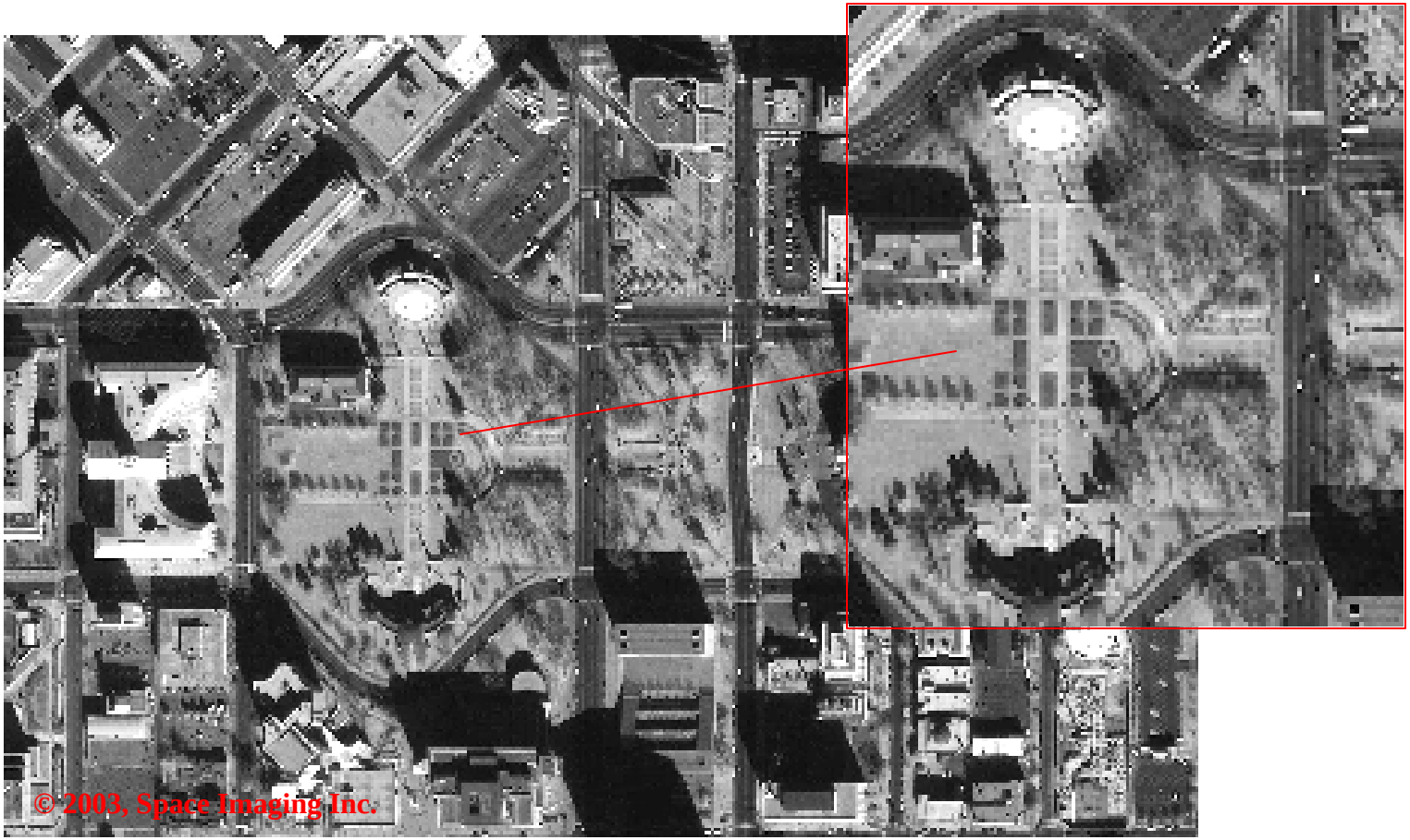


SPOT Multispectral

(20m)

IRS-1C (5m)

Example High Resolution Satellite Image



IKONOS (1m)

Resolutions

- *Spectral* resolution refers to the wavelength interval that a sensor records for a particular image band.
- *Spatial* resolution is a measure of the smallest object that can be resolved by the sensor.
- *Radiometric* resolution is a measure of the number of brightness levels recorded for each image band.

  (e.g. Landsat 5 TM: 8 bits. 2^8 = 256 brightness levels)
- *Temporal* resolution is a measure of the number of days needed for a sensor to revisit a site.

Resolutions for Some Satellite Sensors

Satellite	Temporal Resolution	Ground Swath	Spatial Resolution	Radiometric Resolution	Spectral Bands (micrometers)
Landsat 7 ETM	16 days	185 km	15 x 15 m (ETM 8), 30 x 30 m (TM 1-5,7), 60 x 60 m (TM 6HL)	8 bits (256 levels)	1) 0.45-0.52 2) 0.52-0.60 3) 0.63-0.69 4) 0.76-0.90 5) 1.55-1.75 7) 2.09-2.35 6) 10.4-12.5 p) 0.52-0.90
SPOT-5	26 days	117km	10 x 10m (MLA), 5 x 5m (PLA), 2.5 x 2.5 (PLA)	8 bits (256 levels)	1) 0.5-0.59 2) 0.61-0.68 3) 0.78-0.89 4) 1.58-1.75 p) 0.48-0.71
IKONOS	3 - 11 days	13 km	4 x 4m multi, 1 x 1m pan	11 bits, (2048 levels)	1) 0.45 - 0.52 2) 0.52 - 0.60 3) 0.63 - 0.69 4) 0.76 - 0.90 p) 0.45 - 0.90
Quickbird	1 - 3 days	16.5 km	2.44 x 2.44m multi, 0.61 x 0.61m pan	11 bits, (2048 levels)	1) 0.45 - 0.52 2) 0.52 - 0.60 3) 0.63 - 0.69 4) 0.76 - 0.90 p) 0.45 - 0.90

Satellite Imagery vs Aerial Photos

Satellite Imagery vs Aerial Photos

Optical Satellite Imagery	Aerial Photography (Film Based)
Price increases linearly with area increase.	Price increases at a lower rate with area increase.
Data captured digitally so no film to process.	Photos typically captured on film. Require scanning and corrections for flying direction.
Cloud cover a problem. Revisit of 3+ days.	Can fly below clouds, or fly another day.
61cm currently finest ground resolution.	Can produce images down to a few centimetres by varying flying height.
Imaging in both visible and near infrared parts of spectrum simultaneously.	Film-based cameras typically image using colour, b/w or near-infrared film separately.
A single scene for urban applications covers 10x10km or 16x16km (IK and QB).	@1:40,000 scale photo for 1m pixel, the useable area in 1 frame is 3.6 km x 6.4 km
Less mosaicking required.	More mosaicking required.
North-South imaging easier than East-West due to near polar satellite orbit.	Any direction for imaging is OK.
On average a suitable image available 7 days after ordering an image. Up to a month for very cloudy/rainy areas.	Depends upon availability of aircraft and weather.

Satellite Imagery vs Aerial Photo Prices

	Product	Accuracy	Resolution	Product Type	Price Rate
Aerial Photo (scanned, non-rectified)	9-inch	N/A	1-meter	Color	$4 - 5,000
Aerial Photo (orthorectified)	9-inch	custom	1-meter	Color	$10 - 15,000
IKONOS	Reference	25-meter	1-meter	Panchromatic & Multispectral	$5,300
	Precision **Orthorectified**	4-meter	1-meter	Panchromatic & Mulitispectral	$10,000
QuickBird	Standard	23-meter	.61-meter	Panchromatic & Mulitspectral	$3,600
	Orthorectified	10 - 12 meter Or custom	.61-meter	Panchromatic & Mulitspectral	$7,800

US$ prices (based on an area of 121 km^2)

Sarah R. Finley, "High-Resolution Satellite Imagery and Resource Management – Fact Sheet 3", University of Minnesota, Dept. of Forest Resources.

Locating Satellite Imagery

- Landsat (Geoconnections Discovery Portal)
  http://ceonet.ccrs.nrcan.gc.ca/
- SPOT
  http://sirius.spotimage.fr/anglais/welcome.asp
- IKONOS
  http://www.spaceimaging.com
- Quickbird
  http://www.digitalglobe.com
- OrbView-3
  http://www.orbimage.com

- Satellite imagery can be ordered through McElhanney

Satellite Image Pixel Size vs Mapping Scale

Sensor	Pixel Size	Potential Map Scale
Landsat 7 ETM	30m	1:100,000
SPOT 5	10m	1:50,000
SPOT 5	5m	1:25,000
IKONOS*	4m	1:20,000
IKONOS*	1m	1:5,000
Quickbird	2.44m	1:12,500
Quickbird	0.61m	1:1,500

(using one pixel = 0.3 mm on a map)

* OrbView-3 has the same spatial resolution

Some Urban Applications

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Some Urban Applications

- Identifying and categorizing landuse and landcover.
- Mapping impervious surfaces in order to estimate runoff amounts. (To plan for increasing pipe diameter in certain areas.)
- Flood hazard mapping (storm damage mapping)
- Assessing taxes based on evidence of structures.
- Identifying easement setback violations.
- Identifying and inventorying geographic data for site selection applications (such as siting roads, sanitary landfills, and transmission lines)
- Parks department mapping trails or locating diseased trees.
- Monitoring wetlands encroachment.

Urban Examples

Change Detection

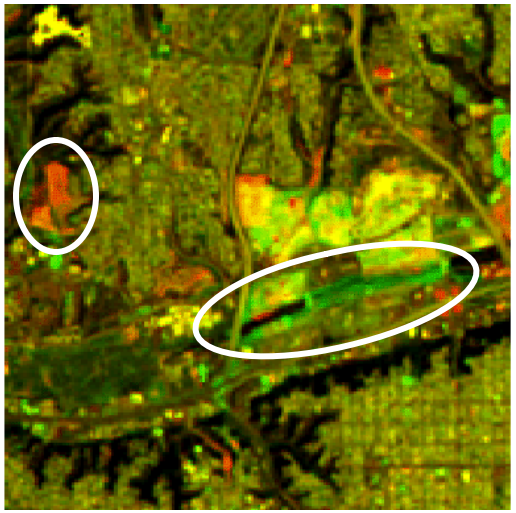
- Procedure of overlaying images from different dates together and identifying areas of change.
- Common changes are conversion of agricultural land into residential neighbourhoods, extending roads, constructing new commercial buildings.
- Also has been used to determine age and aging of different parts of a city. (Older parts have bigger trees.)

Urban Examples

Change Detection

Date 1

Date 2



Overlay of dates

Urban Examples

Changes to Structures

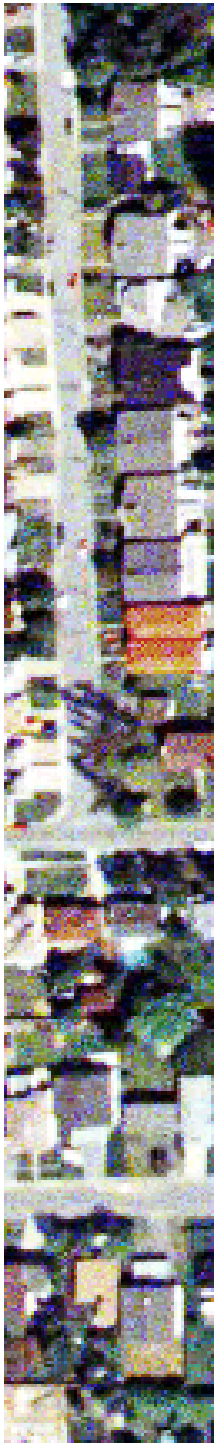
Near Infrared in the Quickbird image helps differentiate between vegetation and man-made structures.

Imagery from: "Quickbird Aerial Product Comparison", Aug 2002, prepared by Emap International for DigitalGlobe.

Urban Examples

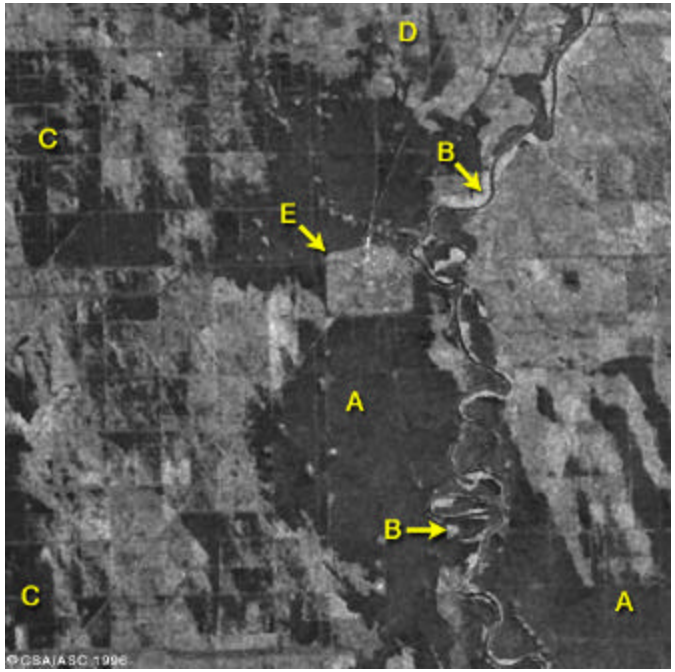
Monitoring New Development

Imagery from: "Quickbird Aerial Product Comparison", Aug 2002, prepared by Emap International for DigitalGlobe.

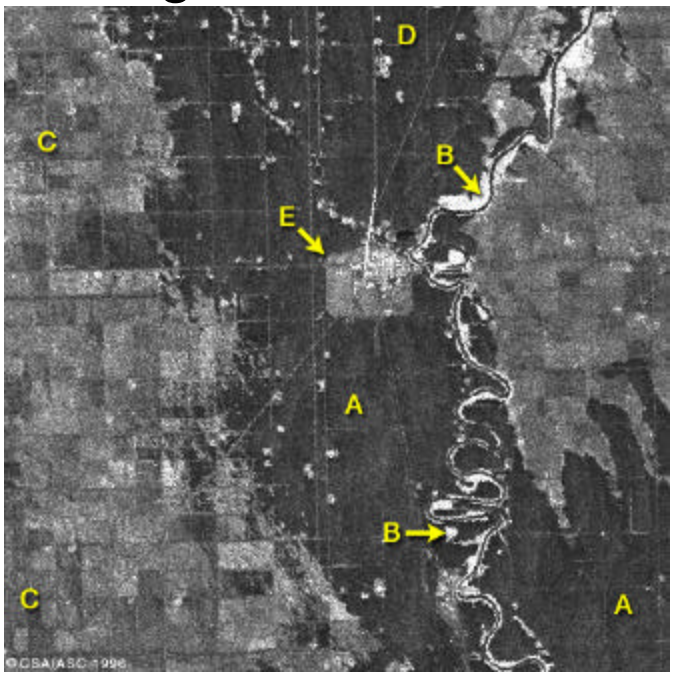


Urban Examples

Flood Monitoring



April 25, 1996



May 9, 1996

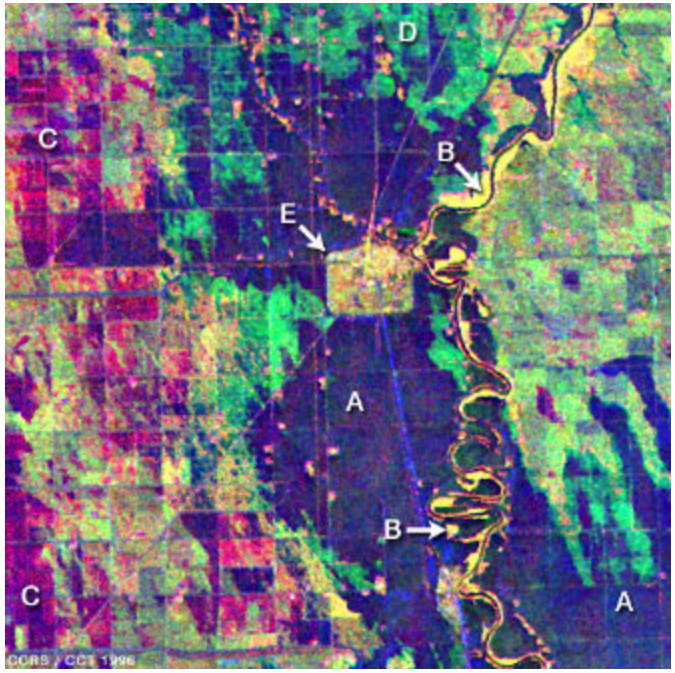
Flooded areas (**A**) Receded water (**C**)

Corner reflectors (**B**) New flooding (**D**)

Imagery from: "Flood Monitoring Using Multi-Temporal RADARSAT Imagery", Spring 1996 newsletter, Canadian Centre for Remote Sensing

Urban Examples

Flood Monitoring



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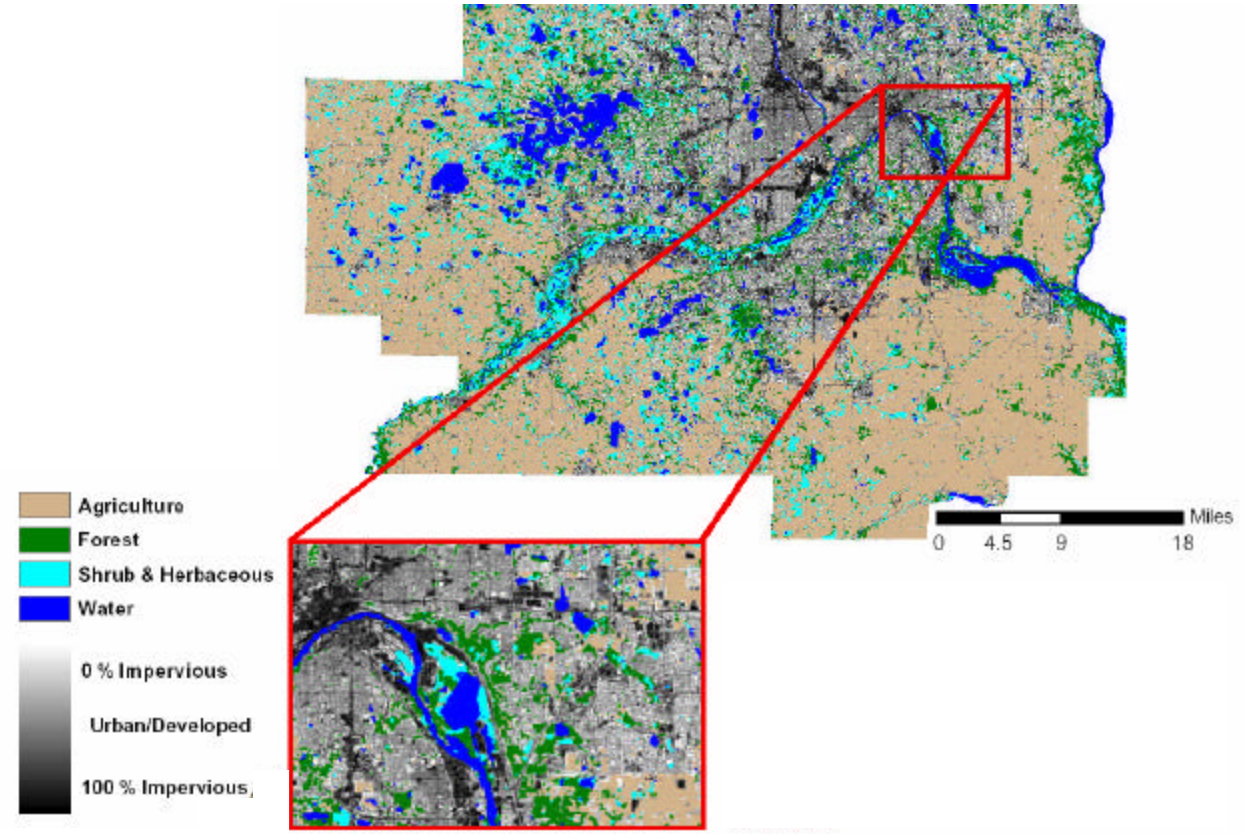
Imagery from: “Flood Monitoring Using Multi-Temporal RADARSAT Imagery”, Spring 1996 newsletter, Canadian Centre for Remote Sensing

Urban Examples

Impervious Surfaces



Sarah R. Finley, "Impervious Surface Mapping Using Satellite Remote Sensing – Fact Sheet 1", University of Minnesota, Dept. of Forest Resources.

Some Upcoming High Res Satellite Sensors

Country	New Sensor	Launch Year	Feature(s)
Canada	Radarsat-2	2005	3m RADAR, QuadPol
Israel	EROS B1	2003	0.5m pan
China/Brasil	CBERS-3		3m
Japan	ALOS	2004	PRISM (2.5m pan) stereo
Japan	ALOS	2004	AVNIR-2 (10m colour)
USA	WorldView		0.5m pan

There are many more satellites but they do not have fine spatial resolution so were omitted.

The Sky is Not the Limit!

Thank You.

Any Questions?