# Tutorial 10

# Information extraction from high resolution optical satellite sensors

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Section 7

# Land use and land cover mapping

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## Historical context

- Satellite imagery used in land cover mapping for decades
- AVHRR: 1978-present 1 km resolution
- LANDSAT: 1972-present MSS: 80 m, TM: 30 m resolution
- SPOT: 1986-present SPOT 1-4: 20m resolution, SPOT 5: 10m resolution
- All have different spectral responses, so generate different land cover classifications

## Historical context

- “Traditionally” land-cover projects have been over large areas
- Each pixel in the image gives a generalised concept of land-cover class
- Applications include:
- Forestry
- Hydrology
- Ocean monitoring
- Agricultural monitoring
- Geology and geomorphology
- Topographic mapping…?

## Commercial high resolution satellites with multispectral sensors

| | GSD (m) | Blue (nm) | Green (nm) | Red (nm) | IR (nm) |
|---|---|---|---|---|---|
| Ikonos | 4m | 450-520 | 520-600 | 630-700 | 760-850 |
| Quickbird | 2.8m | 450-520 | 520-600 | 630-690 | 760-900 |
| Orbview 3 | 4m | 450-520 | 520-600 | 625-695 | 760-900 |
| GeoEye 1 | 1.64m | 450-520 | 520-600 | 625-695 | 760-900 |

- Corresponding almost exactly to bands 1-4 of Landsat
- Note that, unlike Landsat, there are no thermal or mid-infrared channels

## Spatial resolution

- When compared with Landsat:
- New hi-res satellite images show far more detail…
- …and far more “noise”

500 m pixels

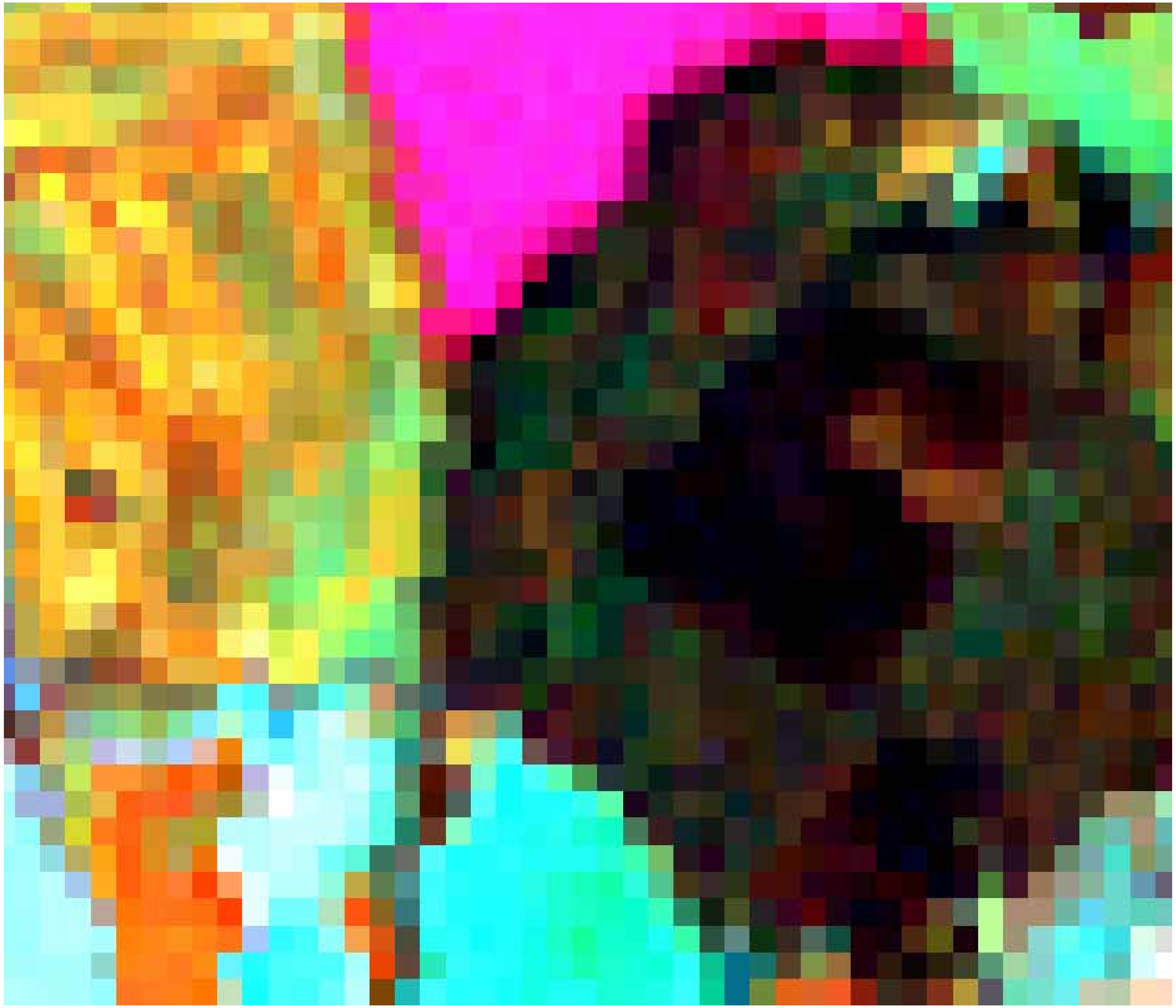
from proposed

GMES sentinel

satellite

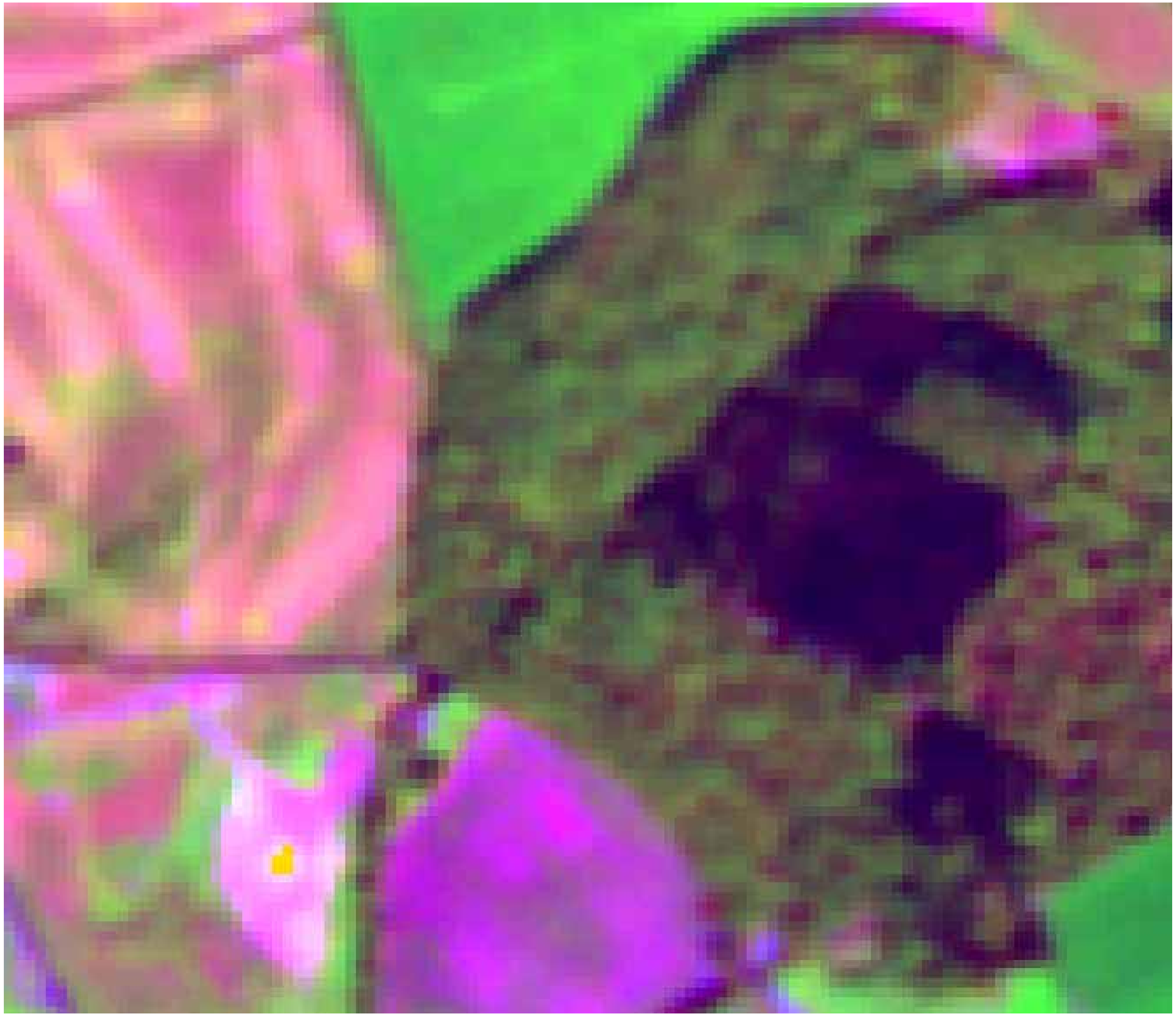
30 m pixels

from LANDSAT

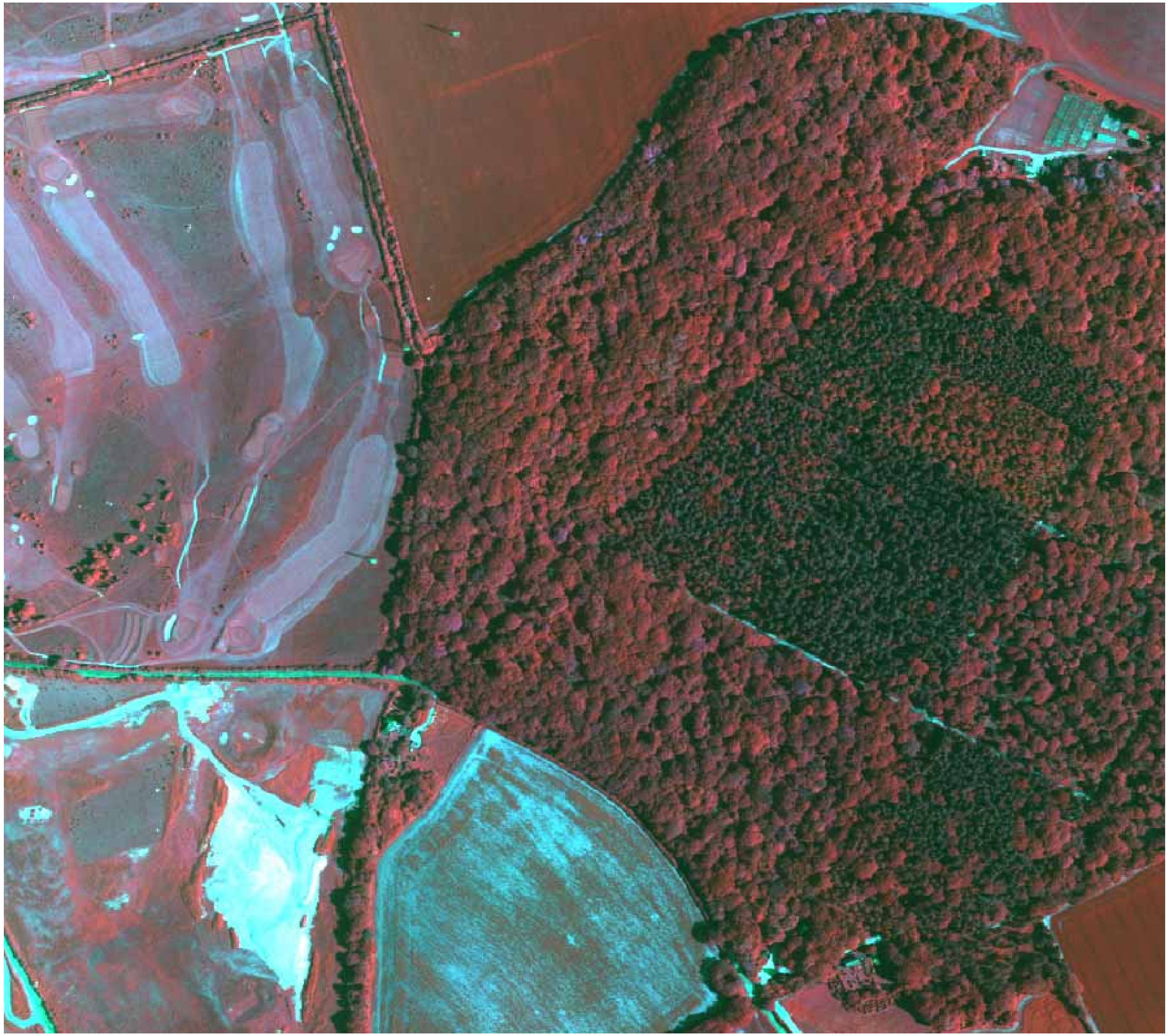


10m pixels,

from SPOT



0.6m pixels, from Intergraph DMC aerial camera



## Uses of High-resolution multispectral satellite data

- Multispectral in this case means 4-bands
- Can be used to derive the “traditional” indices such as NDVI (normalized difference vegetation index) using the red (R) and near infrared (IR) bands

$$NDVI = \frac{IR - R}{IR + R}$$

## Characteristics of high resolution imagery

- Pixel resolution increases complexity of classification
- Most pixels show „mixed pixel“ characteristics
- Areas covered by one image are much smaller than remote sensing practioners are used to

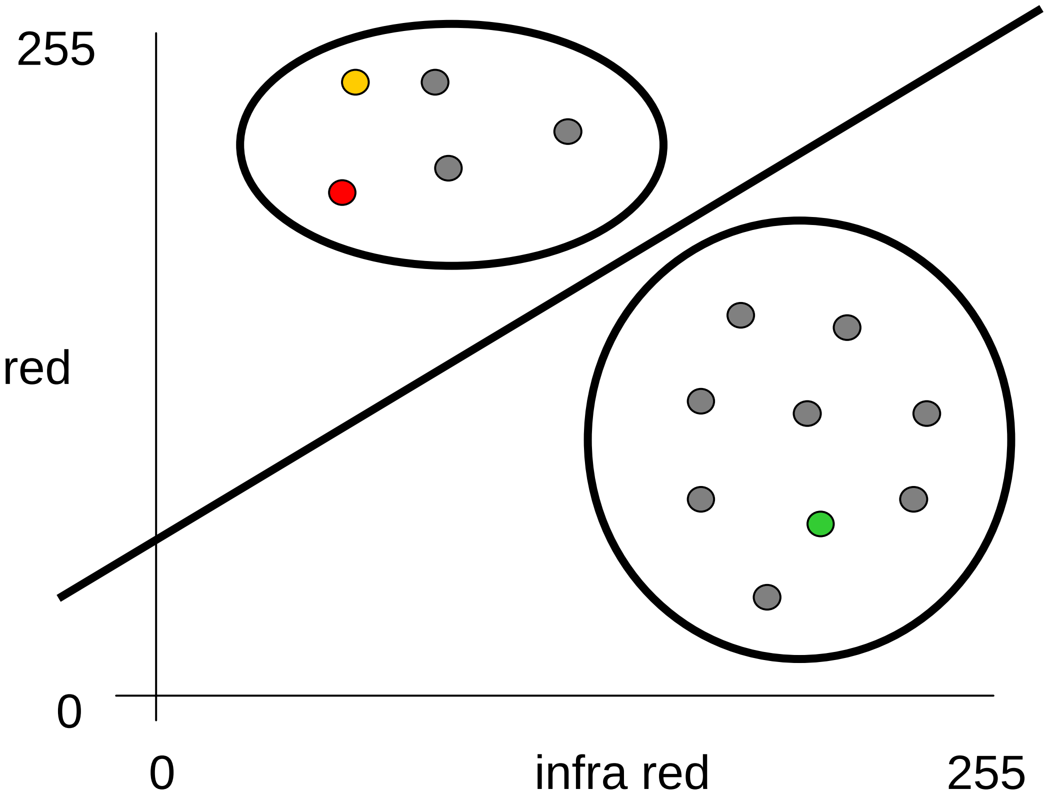
## Methods of classification

- Based only on spectral data (3, 4, 7, or many bands)
- + height (e.g. Using stereo images)
- + texture
- + context (e.g. a high object with straight edges surrounded by lower objects)
- ...or different combinations of these

# Methods of classification

- Many different ways of classifying
- Maximum likelihood (e.g. ERDAS Imagine)
- Object-based segmentation (e.g. Definiens)
- Support Vector Machines
- Decision Trees
- Neural networks

| | Infra red | Red |
|---|---|---|
| Pixel 1: | 30 | 200 |
| Pixel 2: | 32 | 236 |
| Pixel 3: | 200 | 43 |



## Methods of classification – which one to choose

- Depends on what you want to achieve
- Some methods are simple and fast
- Some are reliable, but slow
- Some need a lot of preparatory work (training, formulating rules)
- Find out who has a similar problem and see what they have used!

## Classifications

- Again there are many to choose from
- Depends to a large extent on the nature of the data and the classifier
- Standard classifications in different regions:
- E.g. CORINE in Europe
- These may be too general for many applications
- Most users requirements are slightly different
- So there is a tendency to make up your own classification
- This is fine for internal use, but what about collaborative work and comparison to a common standard?

# A hierarchical classification scheme - Corine

- 1. Artificial surfaces
- 2. Agricultural areas
- 3. Forest and seminatural areas
- 
- 4. Wetlands
- 5. Water bodies

1.1 Urban fabric
- 1.1.1 Continuous urban fabric
- 1.1.2 Discontinuous urban fabric

1.2 Industrial, commercial and transport units
- 1.2.1 Industrial or commercial units
- 1.2.2 Road and rail networks and associated land
- 1.2.3 Port areas
- 1.2.4 Airports

1.3 Mine, dump and construction sites
- 1.3.1 Mineral extraction sites
- 1.3.2 Dump sites
- 1.3.3 Construction sites

1.4 Artificial, non-agricultural vegetated areas
- 1.4.1 Green urban areas
- 1.4.2 Sport and leisure facilities

4.1 Inland wetlands
- 4.1.1 Inland marshes
- 4.1.2 Peat bogs

4.2 Maritime wetlands
- 4.2.1 Salt marshes
- 4.2.2 Salines
- 4.2.3 Intertidal flats

## Future Satellite capability

- GeoEye 1 will have sensors capable of 1.64m multispectral imaging, launch planned in August 2008
- WorldView 2 will provide 1.8m multispectral images, launch planned late 2008
- With pan-sharpening, high-resolution (40cm) 4-band images may be derived from these (although these will not be the same as original 40cm images).
- Some organizations are concentrating on low-resolution rapid-repeat global-coverage satellite constellations (GMES, DMC, RapidEye)

# OEEPE (EuroSDR) study

- To investigate the use of high-resolution satellite imagery for national mapping
- Started in 2001, involving mapping agencies and academic institutions from several European countries
- One aspect was to investigate land cover
- IKONOS 4m multispectral image of Chandler‘s Ford (Hampshire, UK)
- A mixture of urban, agricultural and wooded land cover

# Land cover from 4m Ikonos data – OEEPE results

- **Sweden**: Ikonos suitable for identification and capture of land cover types found in Swedish 1:10 000 scale mapping
- **UK**: Ikonos, when combined with national mapping vector data (OS MasterMap) suitable for identifying most of the CORINE land cover/land use classes
- **Germany**: Identified several problems when trying to classify the imagery on its own.

## OEEPE results - Some comments

- High-resolution imagery introduces shadows, which are generalised out of lower resoluton imagery.  These shadows:
  - Could be used to identify shadow-casting objects
  - Or could be seen as a barrier to accurate classification

## OEEPE results - Some comments

- High-resolution imagery is very heterogeneous – a single residential property may have building, road, low vegetation, high vegetation, and water pixels within its boundary. These are usually averaged out in lower resolution imagery.
- This leads to **lower** accuracy when assessing pixel classification techniques
- ...sounds counter-intuitive.

## Successful applications of high-resolution imagery to land cover mapping

- Olive-tree identification (K. G. Karantzalos, D. P. Argialas, Greece)
- Crop monitoring (Josiane Masson, JRC, Italy)
- Forest mapping in the US and elsewhere
- Mapping urban sprawl in developing countries

## Why not more application examples?

- Cost of the imagery?
- Limited extent of available data?
- Difficulty in obtaining suitable data (e.g. Too much cloud cover in Northern Europe)?
- No guarantee of continuity (no constellations of satellites – maybe soon)?
- Many remote sensing practitioners used to working with lower resolution imagery, and reluctant to abandon previous research?
- Many photogrammetrists used to working with higher resolution imagery, and reluctant to abandon previous research?
- A combination of the above?

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# Advantages of satellite imagery over aerial photography

- The satellite is operational 365 days of the year,
- Frequent re-visit times (e.g. every 4 days),
- Imagery is post-processed relatively quickly,
- No Air Traffic Control restrictions apply,
- Large area footprint (e.g. 16.5 x 16.5 km2) cuts down the need for block adjustment and creation of image mosaics,
- The satellite can easily access remote or restricted areas,
- No aircraft, cameras or expensive equipment are required (by the end user).

# And the disadvantages …

- The typical off-nadir viewing angle of up to 25° is not acceptable
- The production processes required for high resolution satellite imagery may be different to those of traditional photogrammetric data capture
- The reliability of capture and delivery of imagery is unknown,
- Image resolution is low compared to most aerial photography.
- There is a strong possibility of cloud cover