

Emerging remote environmental monitoring techniques

Remote Sensing

Satellite and airborne Remote Sensing techniques

Emerging trends in remote sensing are occurring largely in four broad areas:

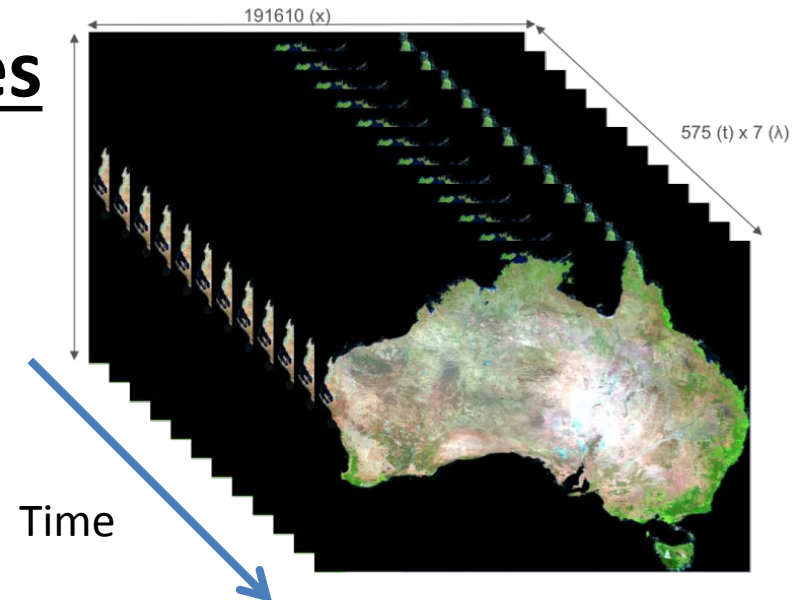
1. advances in cloud based image analysis and processing techniques
2. advances in computer vision, object based feature extraction, and computer learning algorithms
3. increase in spatial resolution (the size of the pixel)
4. increase in spectral resolution (the number of spectral bands)

Current remote sensing technologies

Most widely used satellite sensor technologies:

- Landsat 4,5,7 and 8, MODIS, SPOT, Aster, others
- Main issue is scale:
 - Landsat - 30m pixel, 16 day return, approx 30yrs
 - MODIS – 250m to 500m, daily, 15 yrs

- **However significant archives**

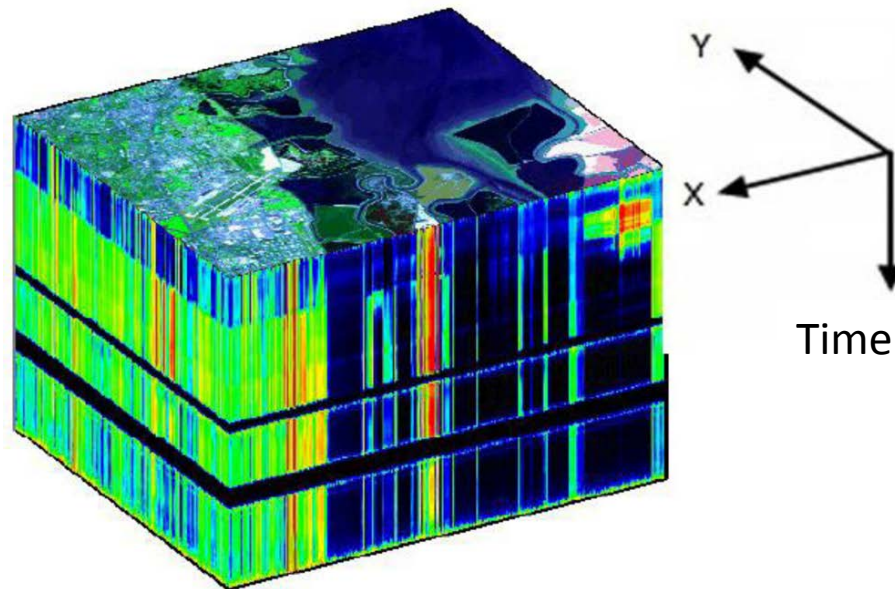


Emerging image processing and analysis methods

Emerging technologies - cloud based computing platforms can handle massive image archives

- **Google Earth Engine**
- **Earth Observation Data Centre**

Data cube



Emerging image processing and analysis methods

Benefits:

- Access to extensive archives of imagery and other earth observation data with
- Access advanced image processing techniques such as object based feature extraction, and computer learning algorithms.

Constraints:

- Requires a degree of technical skill (e.g. GEE requires scripting in Java or Python)

Application is Northern Australia

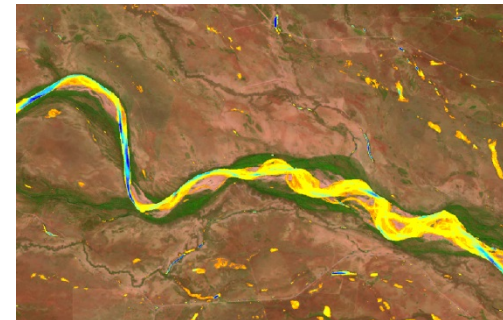
- Most common application is feature change over time
- vegetation and land cover change, water quality monitoring, flood mapping, and fire monitoring

Application of archival satellite imagery

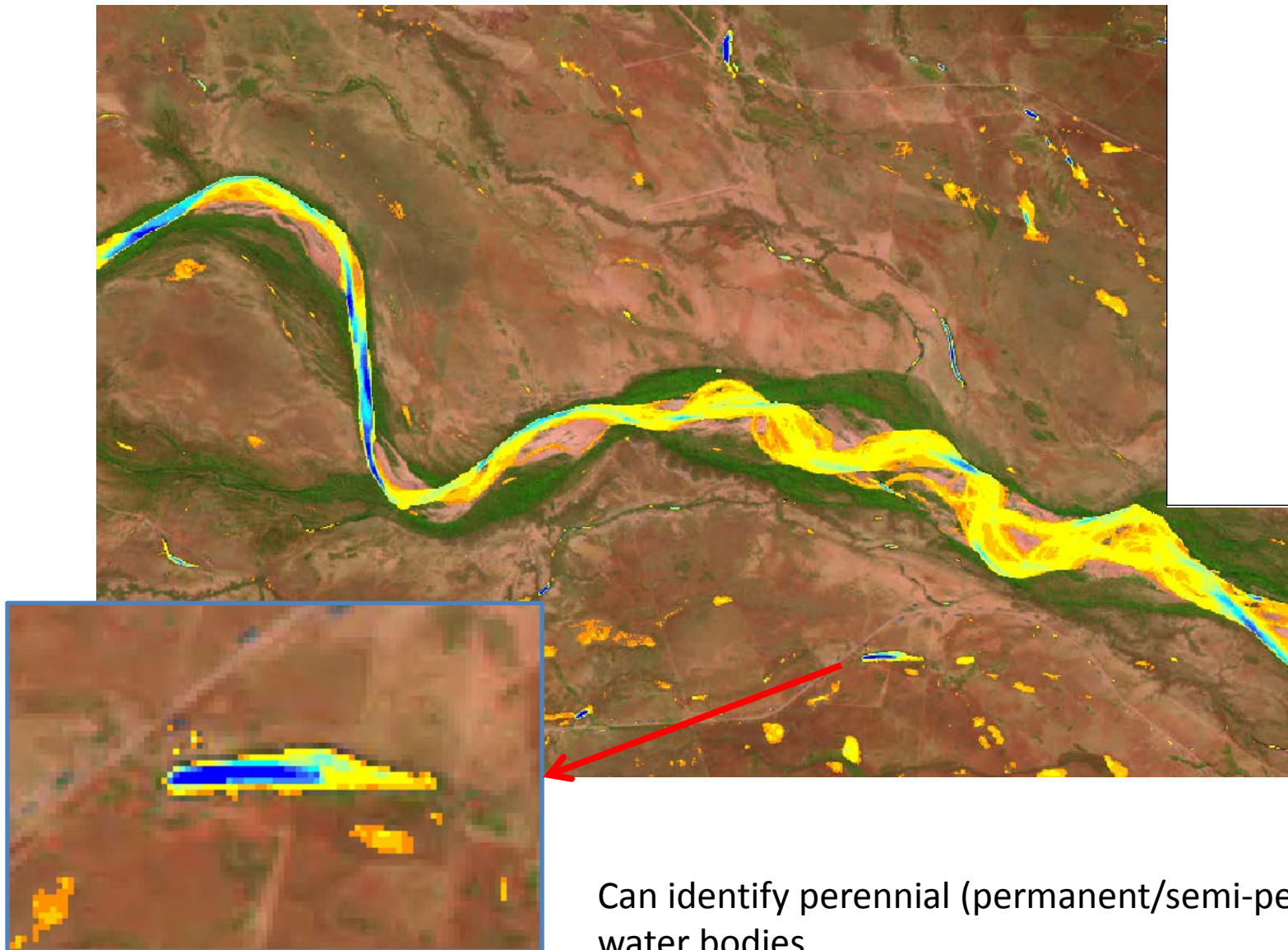
Water Observations from Space (WOfS)
developed by GeoScience Australia

- Australia-wide Landsat 5 and Landsat 7 satellite imagery archive to display detected surface water
- 1987 to present WOfS is a web service displaying historical surface water observations

<http://www.ga.gov.au/flood-study-web/#/water-observations>



1987-present water observations



Water observations from space (WOfS)

Benefits:

- Long-term record of water in the landscape in northern Australia

Constraints:

- WOfS, view the same area of Australia only once every 16 days. A limitation of WOfS is that not all historical surface water inundation will have been observed by satellite.

Application in northern Australia

- to identify and map perennial waterbodies that act as aquatic refuges at the end of the dry season

Emerging satellite systems

- Sentinel system of satellites



- Sentinel 1

- all weather C-Band Synthetic Aperture Radar (SAR) sensor
 - spatial resolutions ranging from 5m to 100m with a return interval of 12 days and multi-polarisation

- Sentinel 2

- Multispectral sensor - 13 spectral bands, visible, near-infrared to the shortwave infrared, return interval 5 days
 - 13 spectral bands, 4 spectral bands at 10m resolution

- **ESA open access to data**

Current remote sensing technologies

Most widely used satellite sensor technologies:

- Landsat 4,5,7 and 8, MODIS, SPOT, Aster, others
- Main issue is scale:

Google Earth (Moonie River)



Waterhole (15m wide)

Landsat 7



- **Sentinel system will provide much better resolution**

Red Lilly– Predicted cover and turbidity

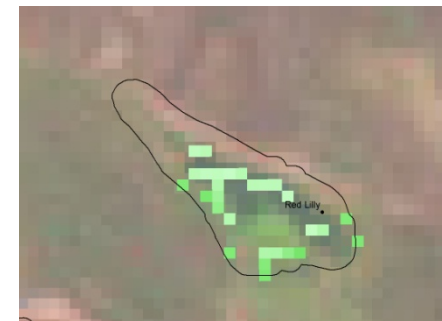
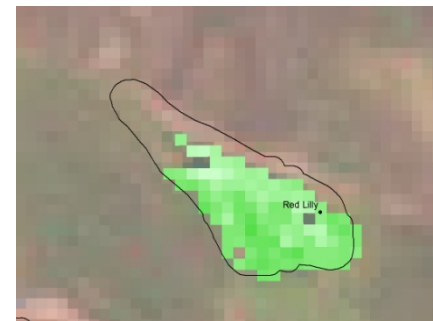
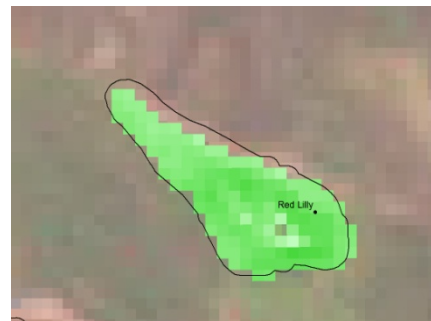
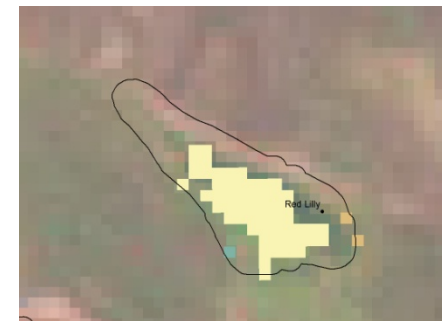
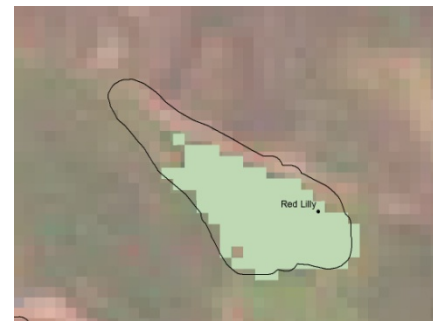


**Turbidity (NTU)
Value**



High : > 500

Low : 0



June 2010

August 2009

October 2009

Emerging landscape scale satellite systems

Benefits:

- High spatial resolution (10-60m), short return interval (5 days)

- **ESA open access to data**

- Constraints

- Recent system so **limited archive**

- Application in northern Australia

- range of environmental monitoring including vegetation health and structure, landcover monitoring, fire monitoring, waterbody and flood extent mapping, water turbidity and weed cover monitoring.

Emerging high spatial resolution satellite sensors

- Range of sensors with pixels < 1m in last few years

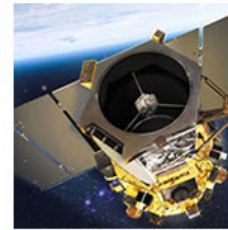
Worldview-3 (0.31m)



GeoEye-2 / WorldView-4 (2016)



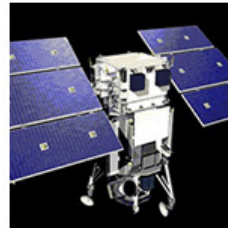
GeoEye-1 (0.41m)



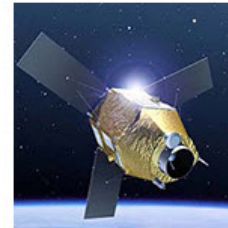
WorldView-2 (0.46m)



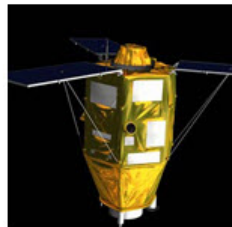
WorldView-1 (0.46m)



Pleiades-1A (0.5m)



Pleiades-1B (0.5m)



QuickBird (0.61m)

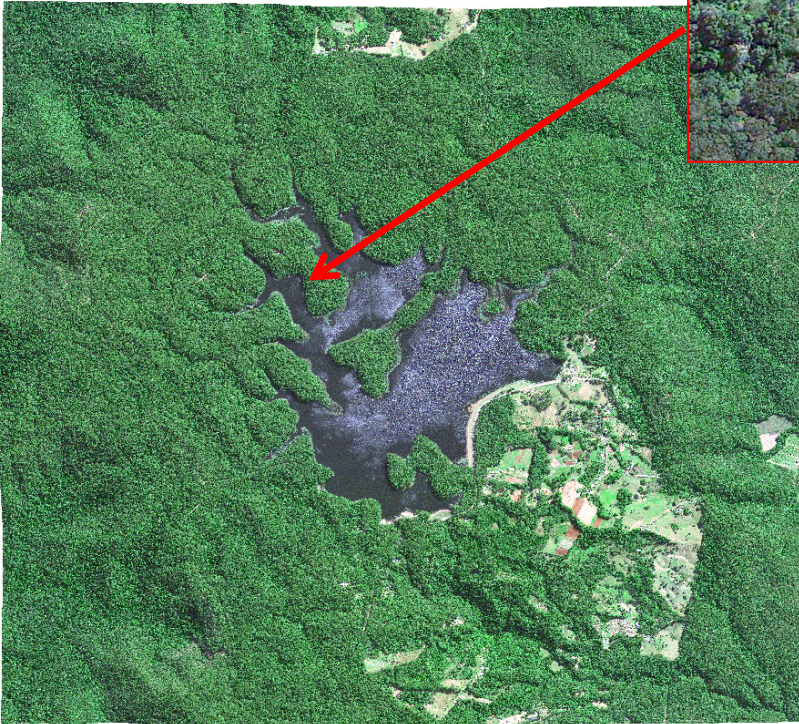


IKONOS (0.82m)



Emerging high spatial resolution satellite sensors

- Geoeye-1
- Requires 'tasking'
 - Specify capture area



0.41m resolution
225 sq km scene
approx \$1000/scene
8 scenes for Lake Argyle

Emerging high spatial resolution satellite sensors

Benefits:

- enhances the capacity of satellite imagery to delineate features on the surface of the earth that courser resolution satellites cannot achieve

Constraints:

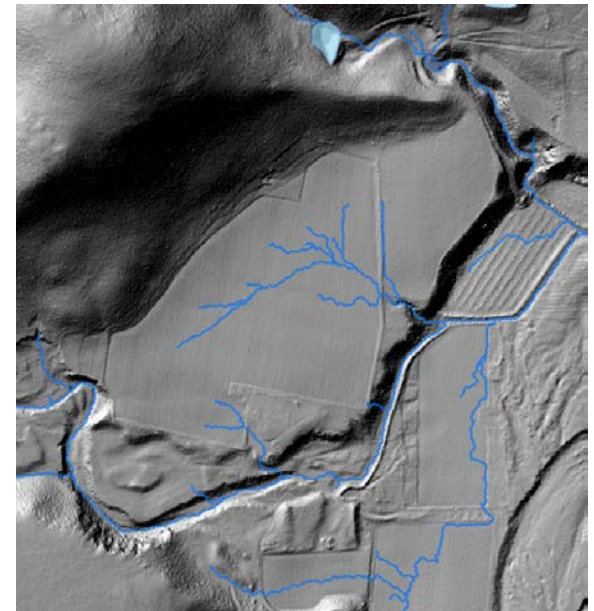
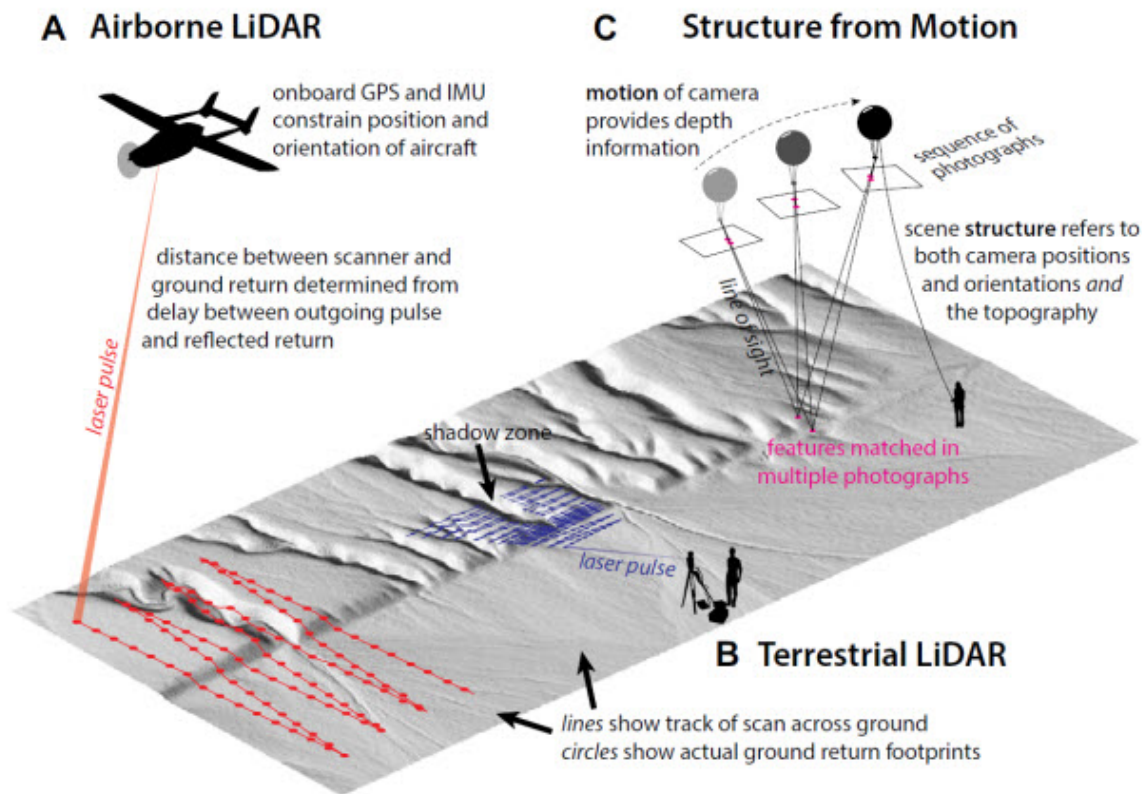
- require specific tasking of the satellite to capture a temporal series
- Tends to be expensive to cover large areas

Application in northern Australia

- Applications that require high spatial resolution e.g. weed mapping, wetland and riparian veg mapping

Emerging airborne technologies

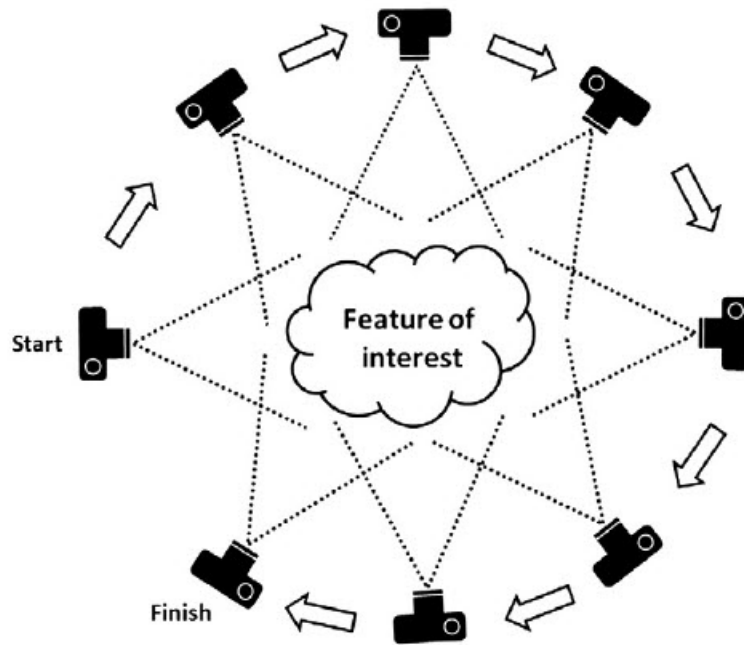
- Historically aerial photography
- LiDAR (Light detection and ranging)
- Structure from motion (emerging technology)



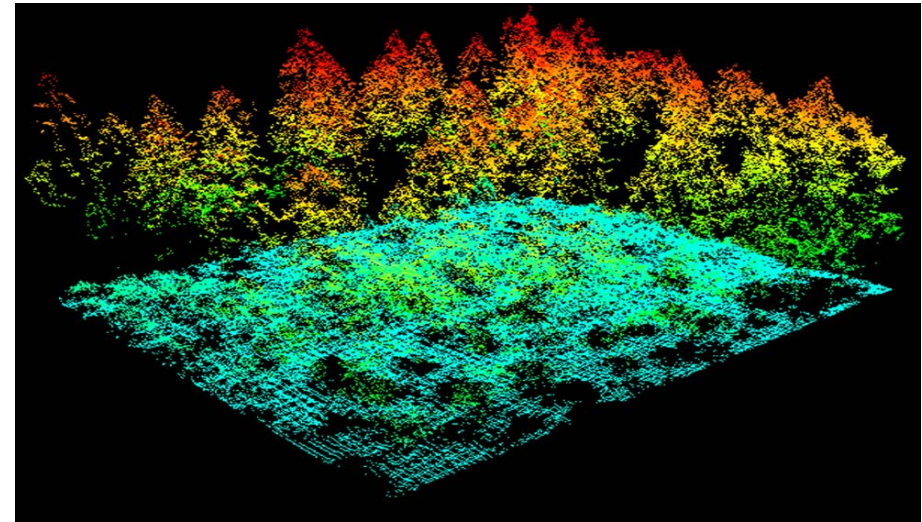
LiDAR 'bare earth'
Elevation model

Emerging airborne technologies

Structure from motion



Multiple views of feature

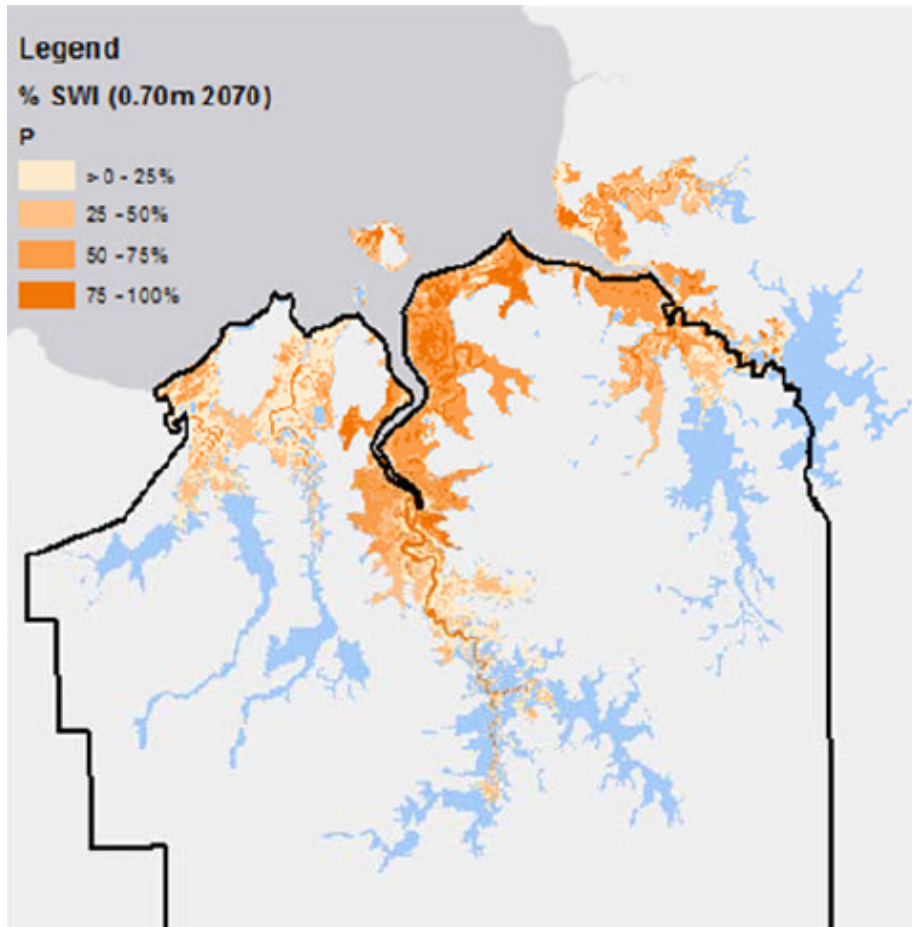


Point cloud

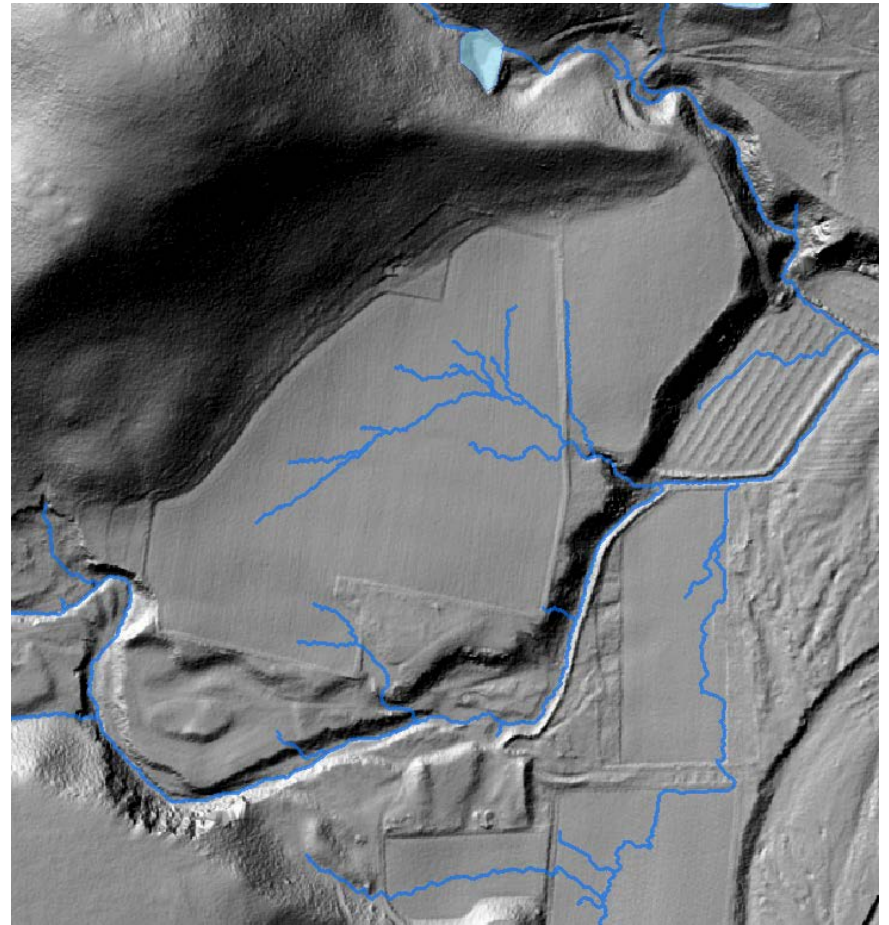
- Most relevant for UAV systems
- Could have applications with aircraft

Emerging airborne technologies

Applications



Salt water intrusion in Kakadu
(Bayliss et al)



Gully erosion

Emerging airborne technologies

Benefits:

- hydrological modelling
- Canopy heights, biomass measurements, and leaf area

Constraints:

- detail data captured in a point cloud, data processing overheads are high
- Capture costs are relatively high

Application in northern Australia:

- hydrologic modelling of sea level rise and salt water intrusion due to climate change (e.g. Kakadu floodplains)
- Using time series of LiDAR data estimates of the volume of soil lost from gully erosion can be estimated in northern Australia (Brooks et al.).

Summary

- The **Sentinel system of satellites** will emerge as a very useful free source of earth observation data
- Cloud based image analysis and processing techniques will become more widely used – **GEE and EODC**
- Emerging advances in computer vision and image analysis will continue – **LiDAR, Structure from motion**
- Increase in the uptake of high spatial resolution (< 1m) satellite sensors - **world view 3, Geoeye-2**