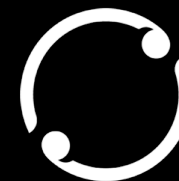# Remote Sensing 101

**A basic introduction to remote sensing**

David Pairman

Manaaki Whenua
Landcare Research

# Remote sensing – a mature technology

- Definition

- Resolution

- Primary technologies and instrumentation
  - Key characteristics
  - Uses

- Platforms
  - Advantages / disadvantages
  - Limitations

- Analysis ready data preparation

- Analysis techniques
  - Manual
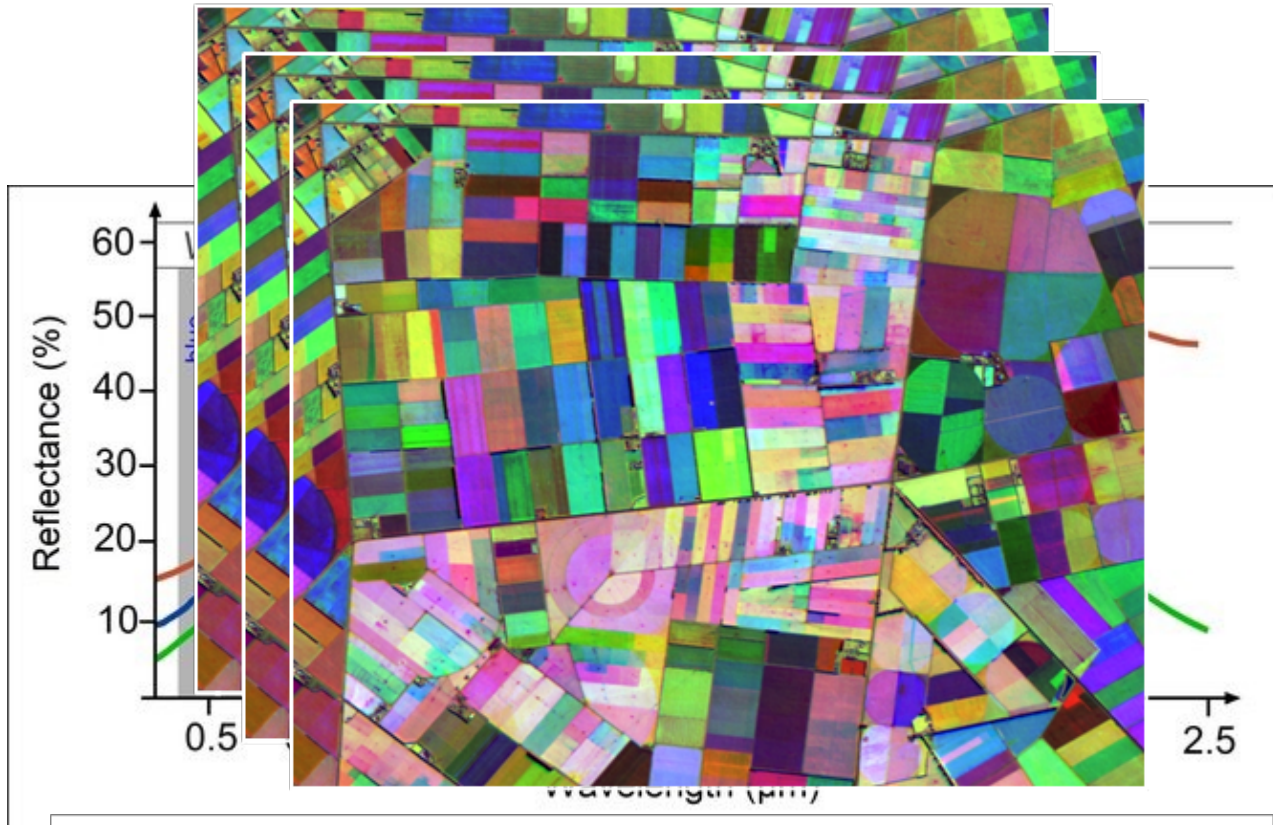 - Physics / modelling
  - Data driven
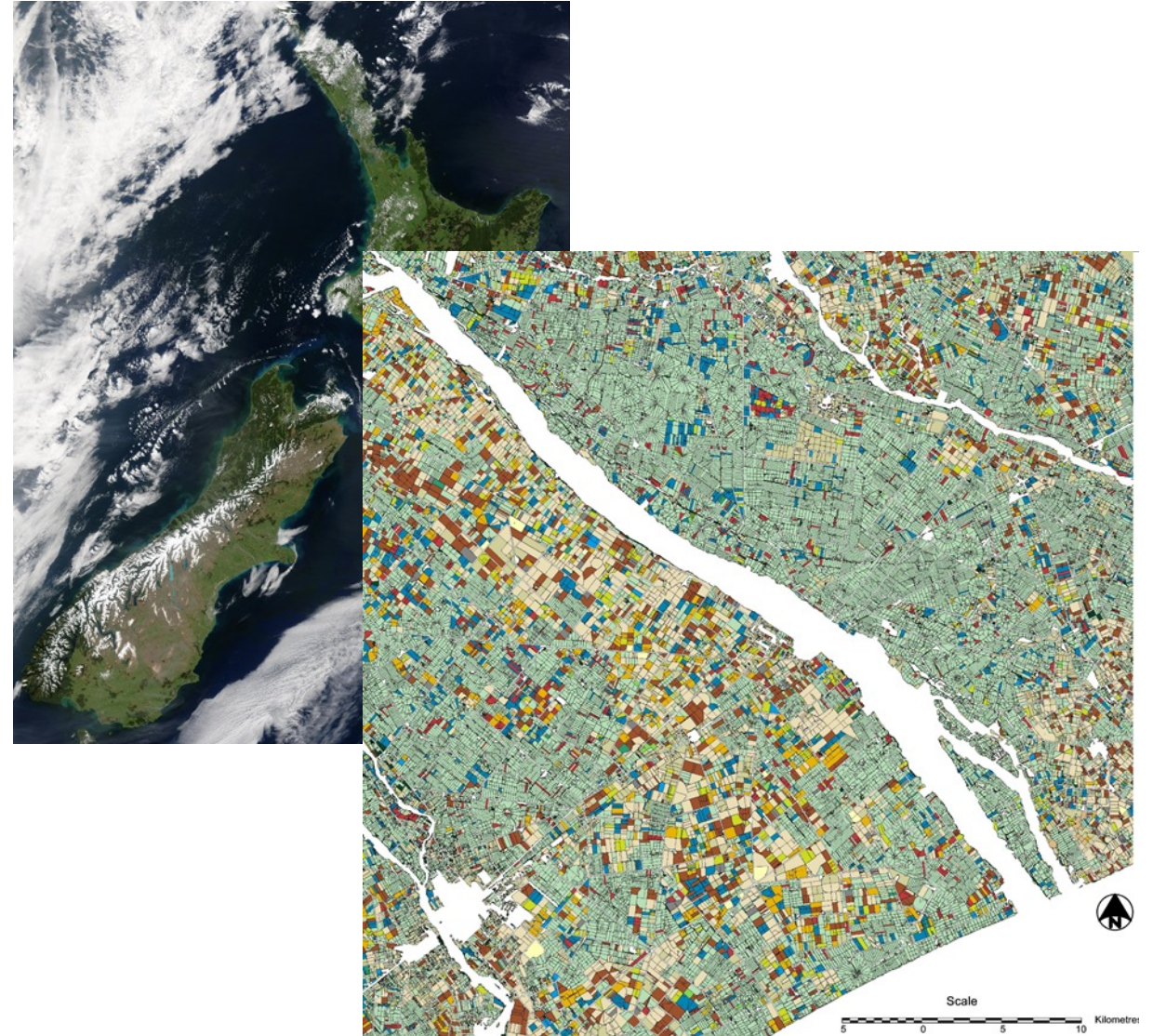
Remote sensing - acquiring information about an object or surface without physical contact
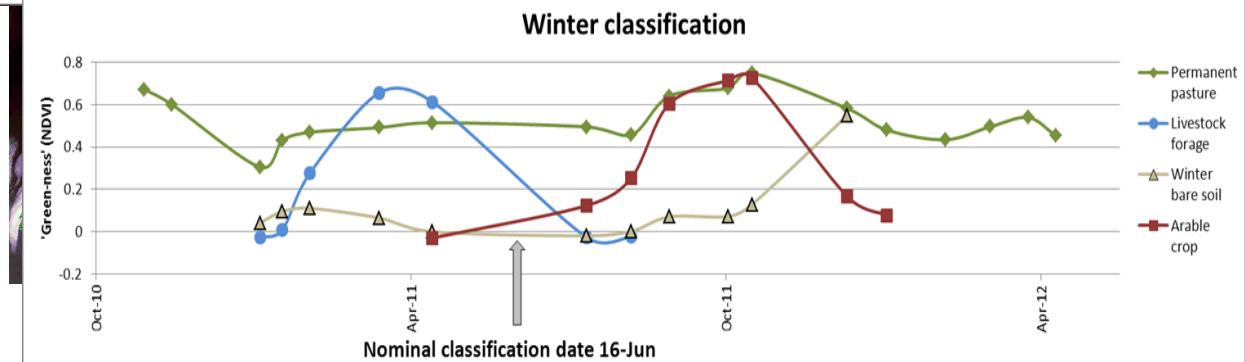
The art, science and technology for detecting and interpreting emitted, or reflected energy.
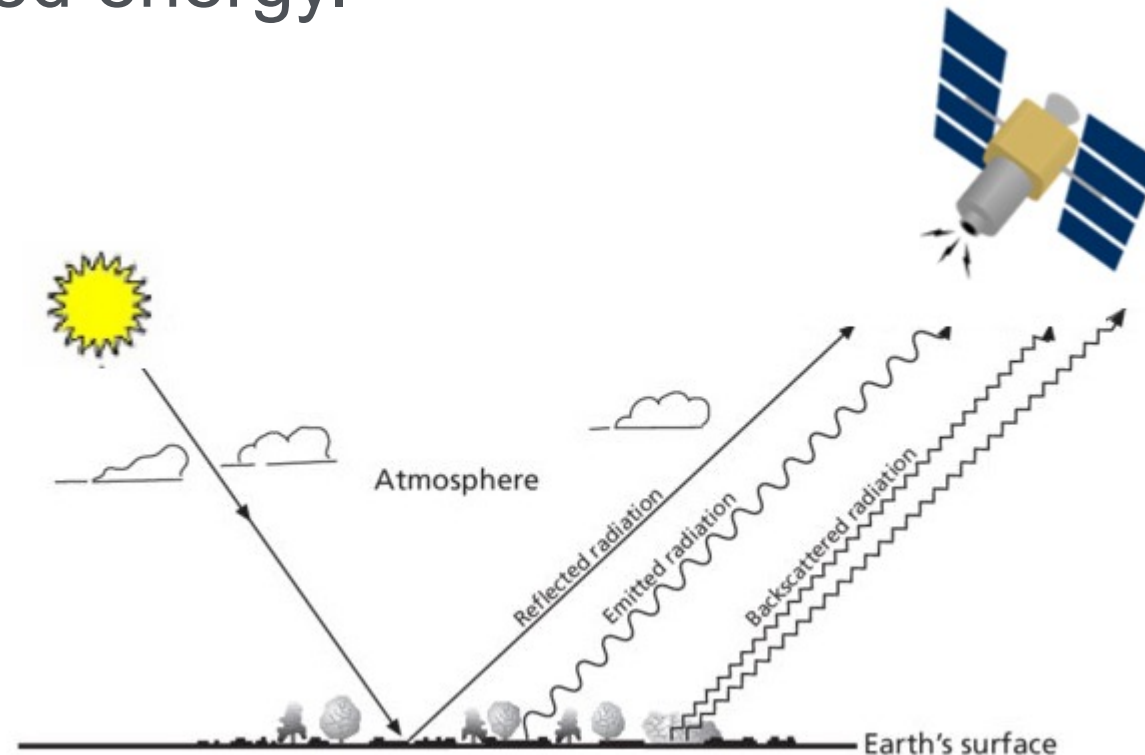
Resolution – three key types

- Spatial resolution
  - How small an object is resolved
  - Match to applications objectives

- Spectral resolution
  - Number & placement of bands
  - Detail in spectral responses

- Temporal resolution
  - Avoid cloud
  - Capture short-lived phenomena
  - Phenology

Technologies - optical

False colour – Richmond – 23 Feb 2017

Comparison of Landsat 7 and 8 bands with Sentinel-2
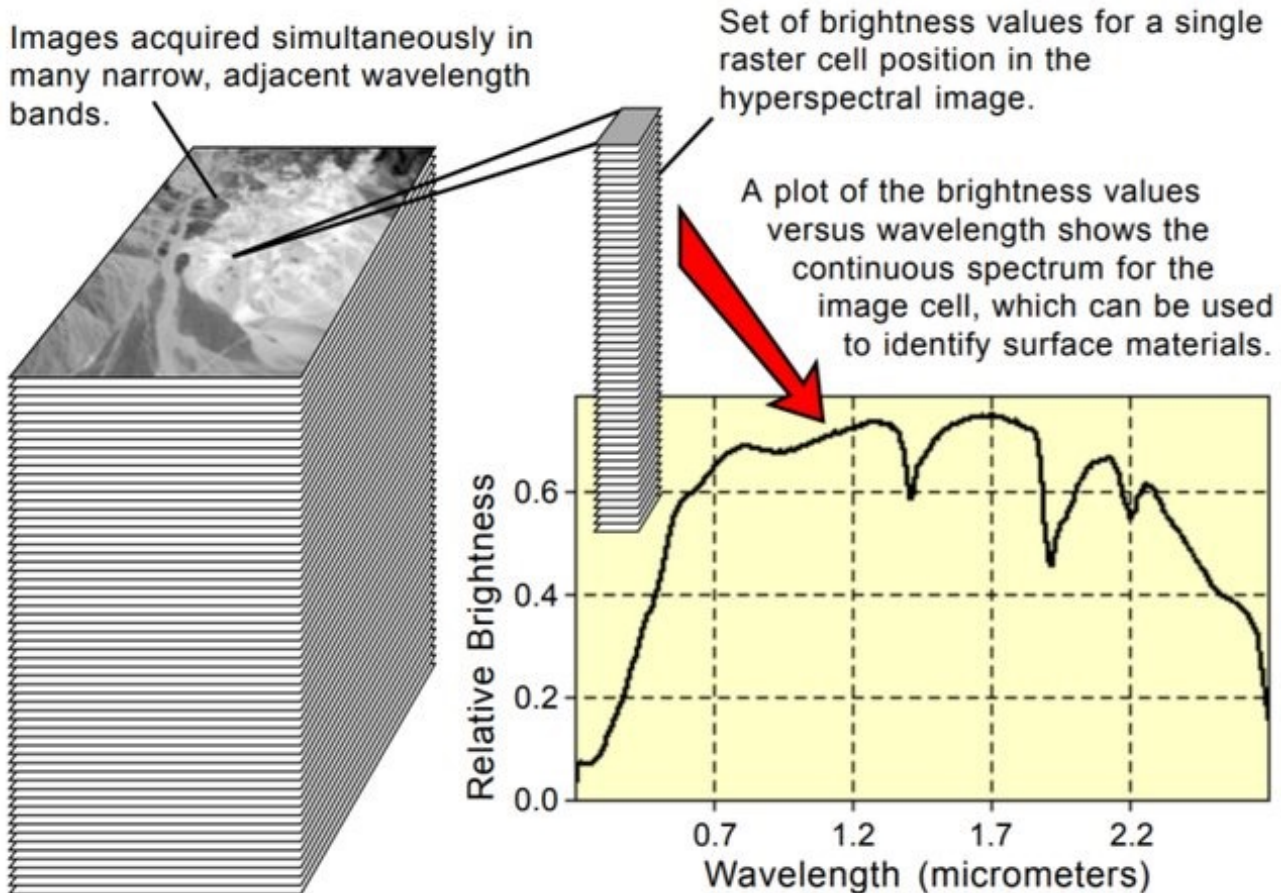
- Familiar "photographs"
- Multispectral
  - Surface colour
  - Vegetation leaf pigments
- High resolutions
- Used in majority of remote sensing applications
- Vegetation classification, change, health
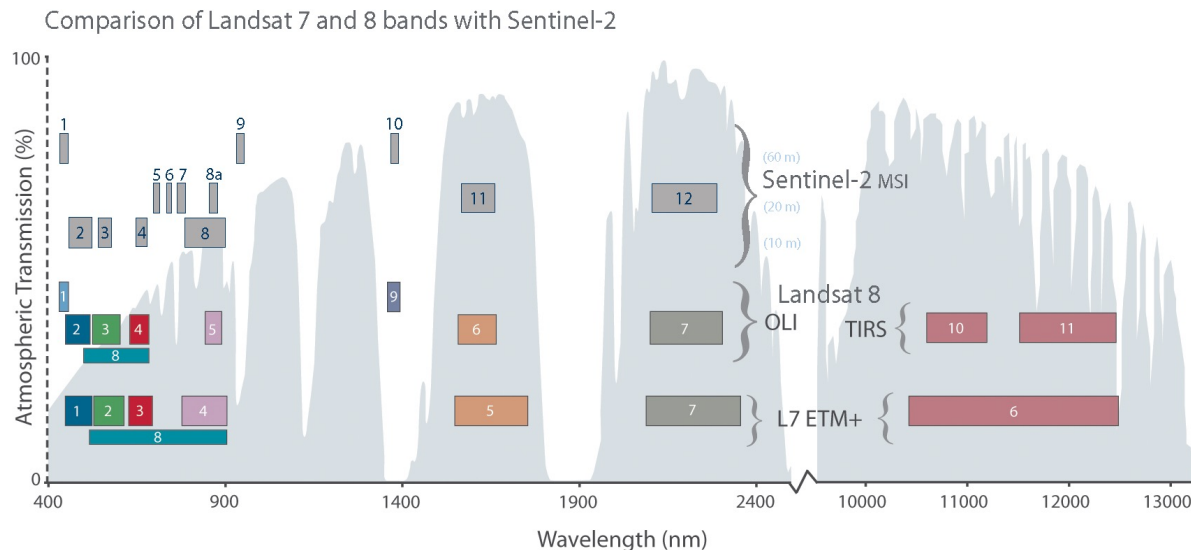
Technologies - hyperspectral

Images acquired simultaneously in many narrow, adjacent wavelength bands.

Set of brightness values for a single raster cell position in the hyperspectral image.

A plot of the brightness values versus wavelength shows the continuous spectrum for the image cell, which can be used to identify surface materials.

Relative Brightness

0.6
0.4
0.2
0.0

0.7   1.2   1.7   2.2
Wavelength (micrometers)

- Hundreds of very narrow spectral bands

- Full detail of spectrum

- Process as a spectral cube

- Spectral unmixing of pixels

- Spectral/spatial trade-off

- Uses in
  – Geology
  – Ecology / species differentiation
  – Plant health
  – Coastal waters

Technologies - radar (SAR)

Sentinel-1
2017

- **C-band SAR** (~5.5 cm wavelength)
- 1 dB radiometric accuracy
- Level-1 Ground Range Detected (GRD) product
- **high sensitivity to the top-most canopy layer**

ALOS-PALSAR
2007

- **L-Band SAR** (~24 cm wavelength)
- dual-polarization mode (HH and HV)
- slope-corrected, ortho-rectified, resampled to the NZTM 10 m
- **captures structural information within canopy**

- Active sensor

- Usually single frequency

- Polarised radiation - transmit and receive

- Backscatter and it's polarisation influenced by;
  - Scatterer size (branch/leaf), shape, orientation
  - Target moisture
  - Surface roughness

- See through cloud (regular coverage)

- Uses in
  - Biomass measurement
  - Vegetation structure
  - Change
  - Geological processes (interferometry)
  - Sea ice
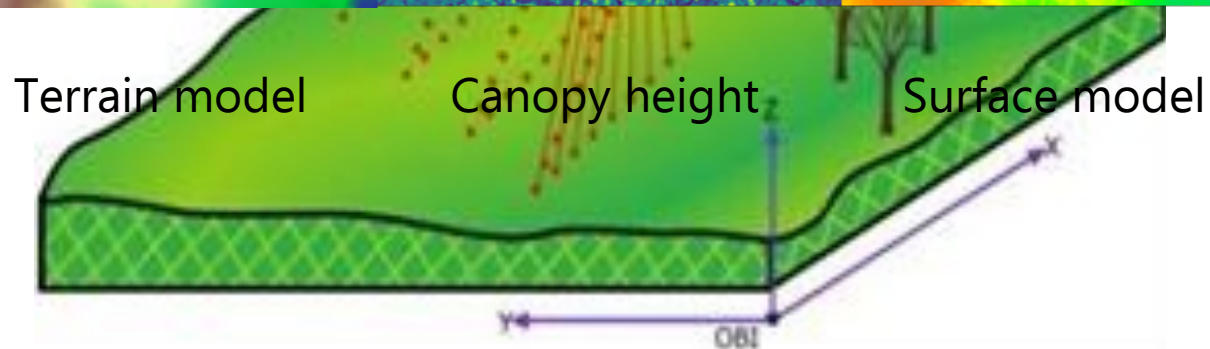 - Ship detection
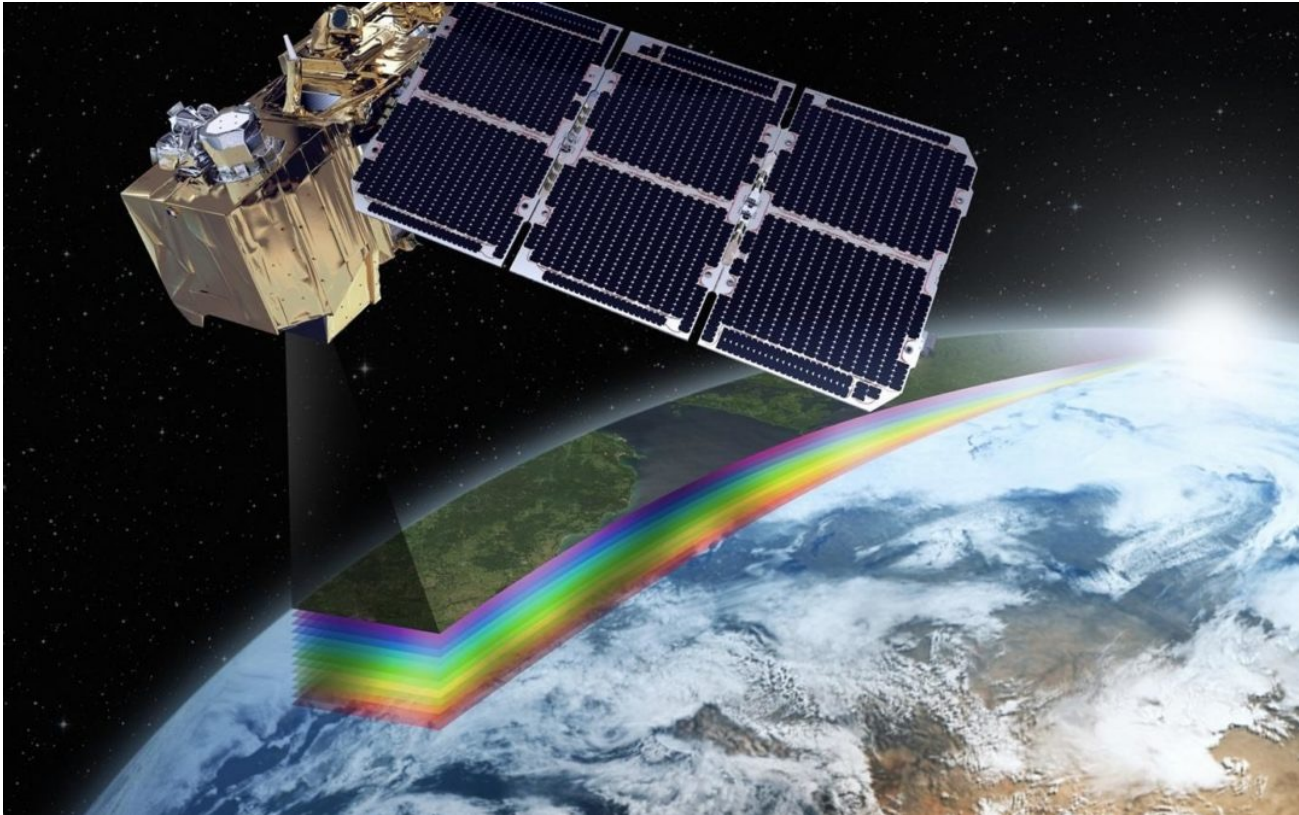 - Oil spill

Technologies - LiDAR

LASER SCANNING

DTM — Terrain model

CHM — Canopy height

DSM — Surface model

- Active sensor (optical)
- Aircraft or drone
- Uses in
  - Terrain model generation
  - Surveying & construction
  - Hydrology (flood prediction)
  - Building footprints
  - Vegetation height/structure
  - Forestry
  - Archaeology
  - Image correction (DTM)

Platforms - Satellites

- Instruments
  - Optical multispectral
  - Radar (SAR)
  - Hyperspectral (limited/experimental)
  - Other passive (thermal & microwave)

- Advantages
  - Large regular coverage
  - Continuously deployed
  - Cheap(ish)
  - Well calibrated
  - Easier to standardise

- Disadvantages
  - Limited temporal (note constellations)
  - Limited spatial
  - Cloud (optical)

Platforms - Aircraft

- Instruments
  - Optical multispectral
  - Radar (SAR)
  - Hyperspectral
  - LiDAR
  - Other passive (Thermal, Aeromagnetic, Gamma)

- Advantages
  - High resolution
  - Tailored deployments
  - Experimental instrumentation

- Disadvantages
  - Flight planning
  - Weather – expense of standby
  - Smaller coverage extent
  - Difficult to calibrate
  - Relatively expensive to process/standardise

Platforms – UAV (drone)

- Instruments
  - Optical multispectral
  - Hyperspectral
  - LiDAR
  - SAR
  - Other passive (Thermal, Aeromagnetic, Gamma)

- Advantages
  - Very high resolution
  - Tailored flexible deployments
  - Tailored instrumentation
  - Programmable flightpaths
  - Ground truth for lower resolution, wider study

- Disadvantages
  - Small coverage extent
  - Visual line of sight (so far)

Analysis ready data preparation
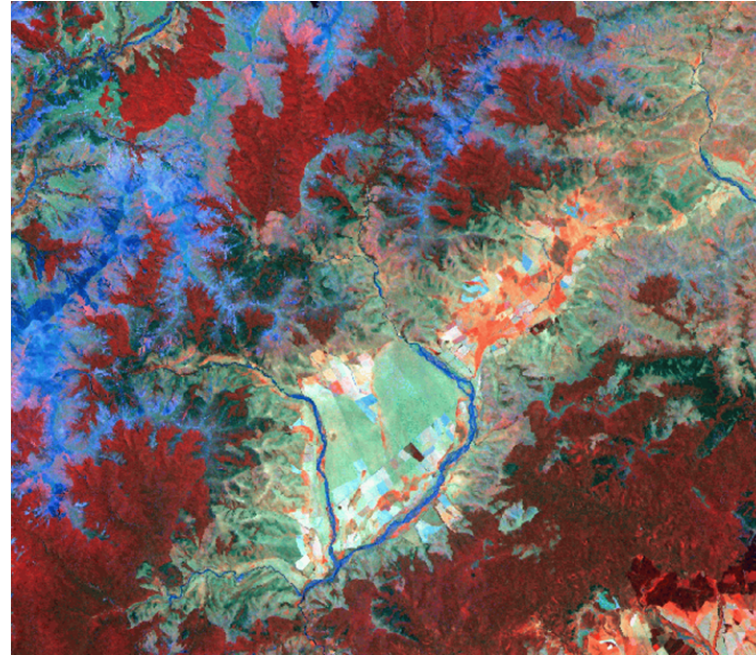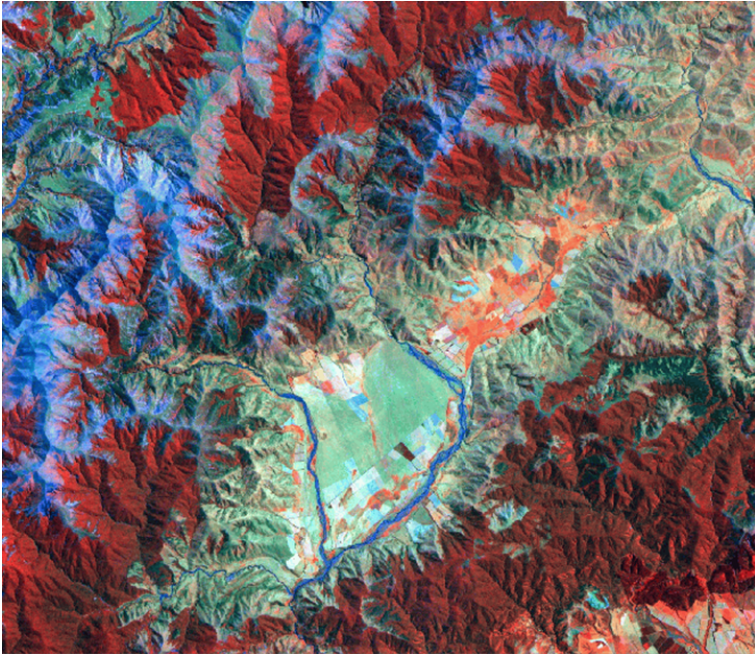
- Calibration
  - Instrument
  - Atmospheric

- Rectification
  - Terrain distortions
  - Projection to map grid

- Standardisation
  - Radiometric terrain effects

- Cleaning
  - Cloud identification
  - Other bad/corrupted data
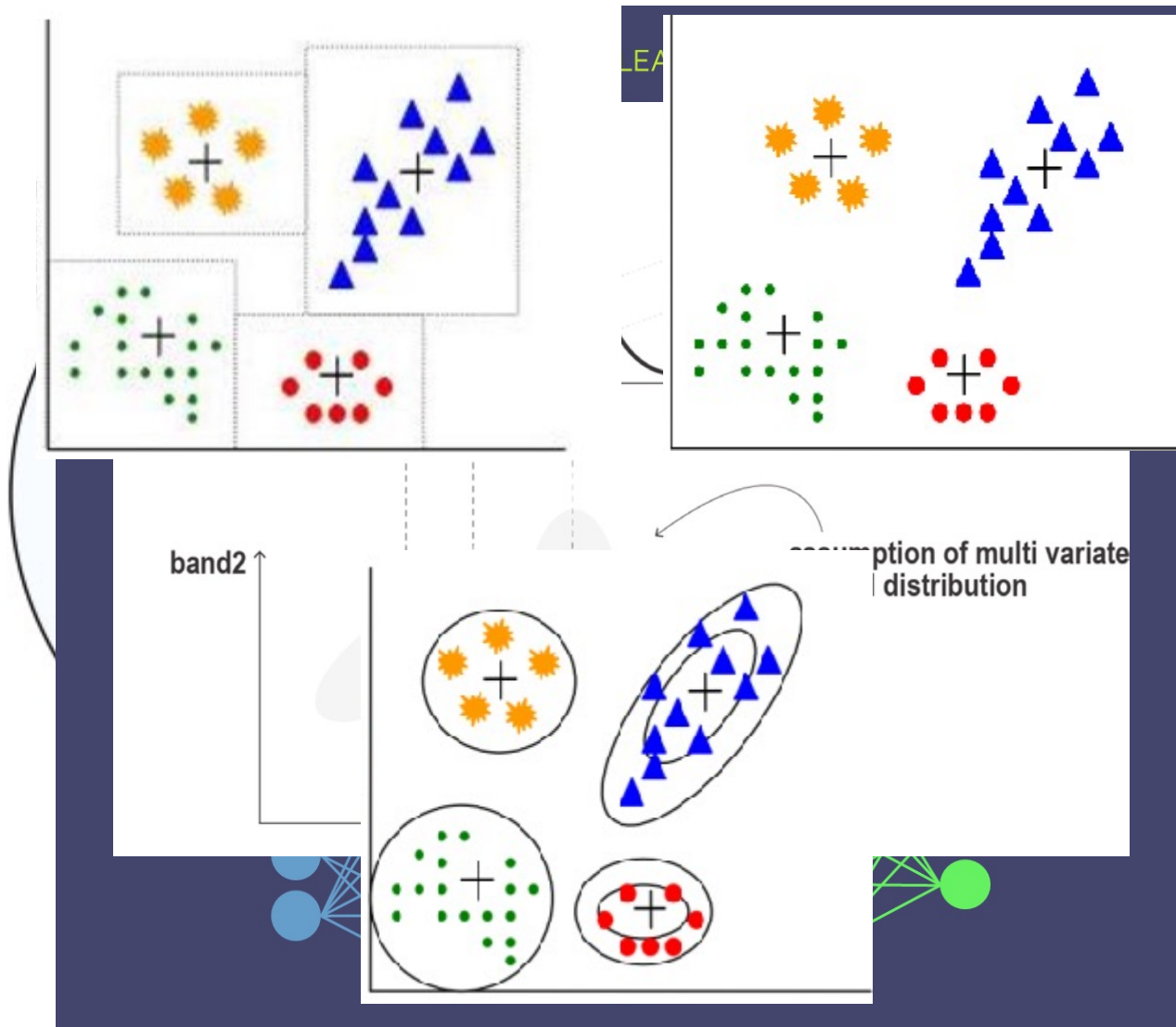
Analysis techniques

- Manual interpretation
  - Uses context, experience
  - Labour intensive
  - Overwhelmed by data
  - Difficult to visualise many bands or temporal steps

Analysis techniques
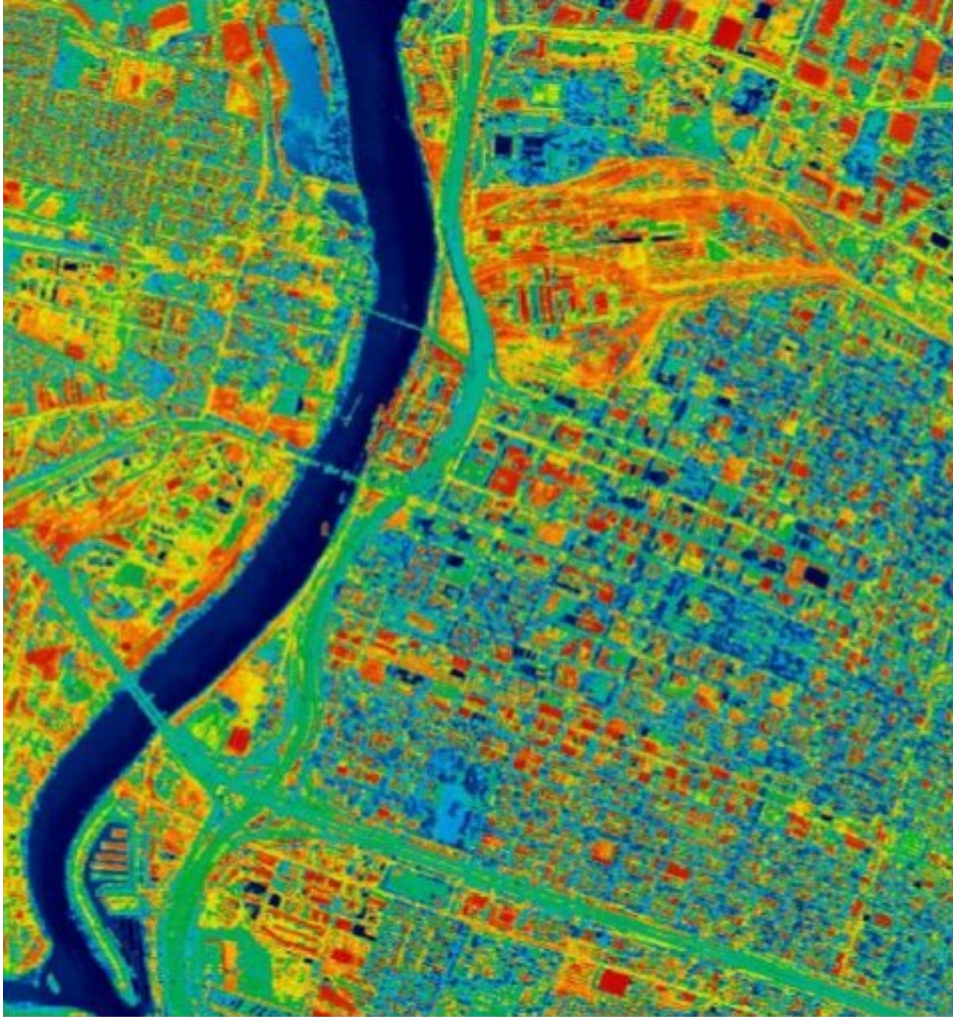
- Manual interpretation
- Physics based modelling
  - Surface temperature
  - Terrain/vegetation height (LiDAR)
  - Albedo
  - Wind speed

Analysis techniques

- Manual interpretation
- Physics based modelling
- Data driven techniques
  - Simplest to represent classes using limits, means, SD
  - Constrained models need less training data
  - Many more modern and sophisticated methods
  - Still have underlying limitations and reliance on ==adequate training data==

Questions?