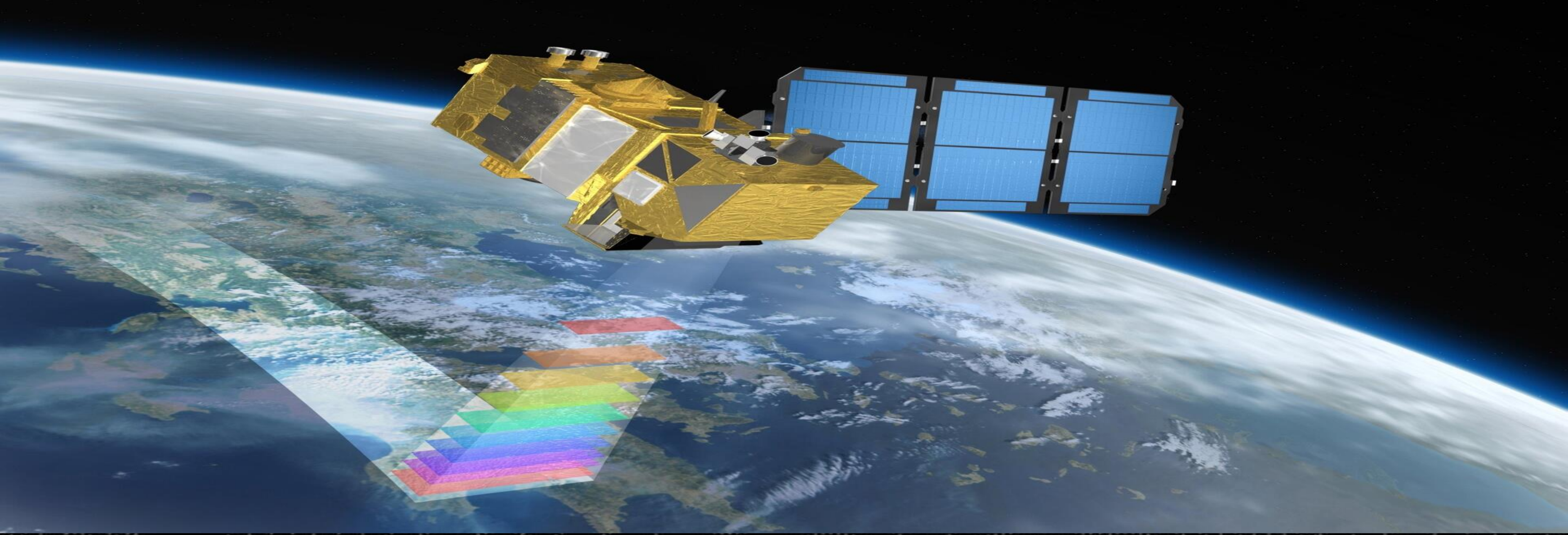


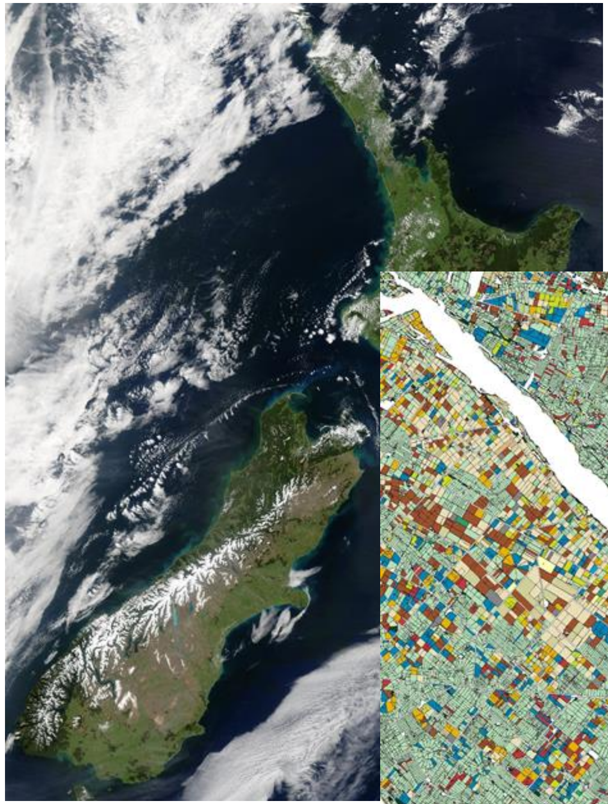
Introductory concepts of remote sensing and classification

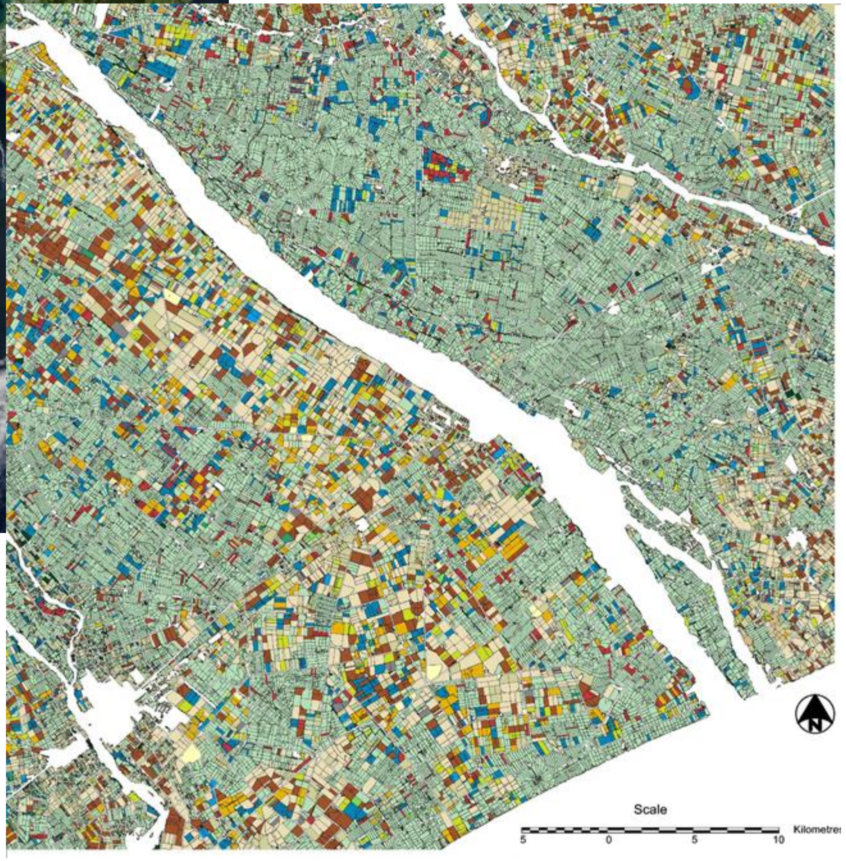
David Pairman

Manaaki Whenua
Landcare Research

Remote sensing – a mature technology

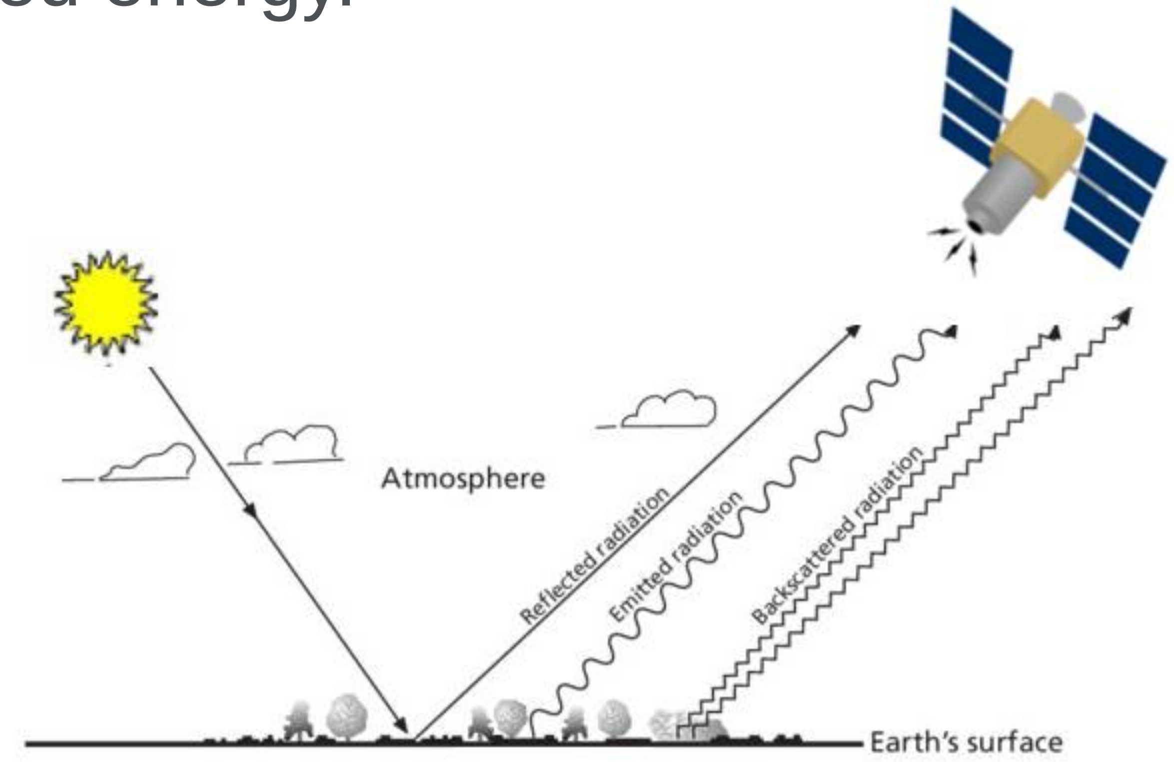
- Definition
- Resolution
- Primary technologies and instrumentation
  - Key characteristics
  - Uses
- Platforms
  - Advantages / disadvantages
  - Limitations
- Analysis ready data preparation
- Classification
  - Aim
  - Input data
  - Pitfalls





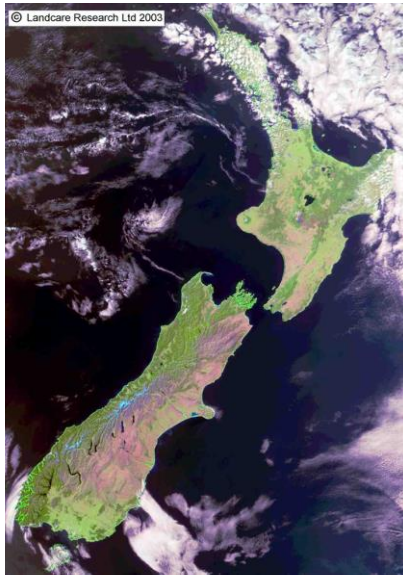
Remote sensing - acquiring information about an object or surface without physical contact

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

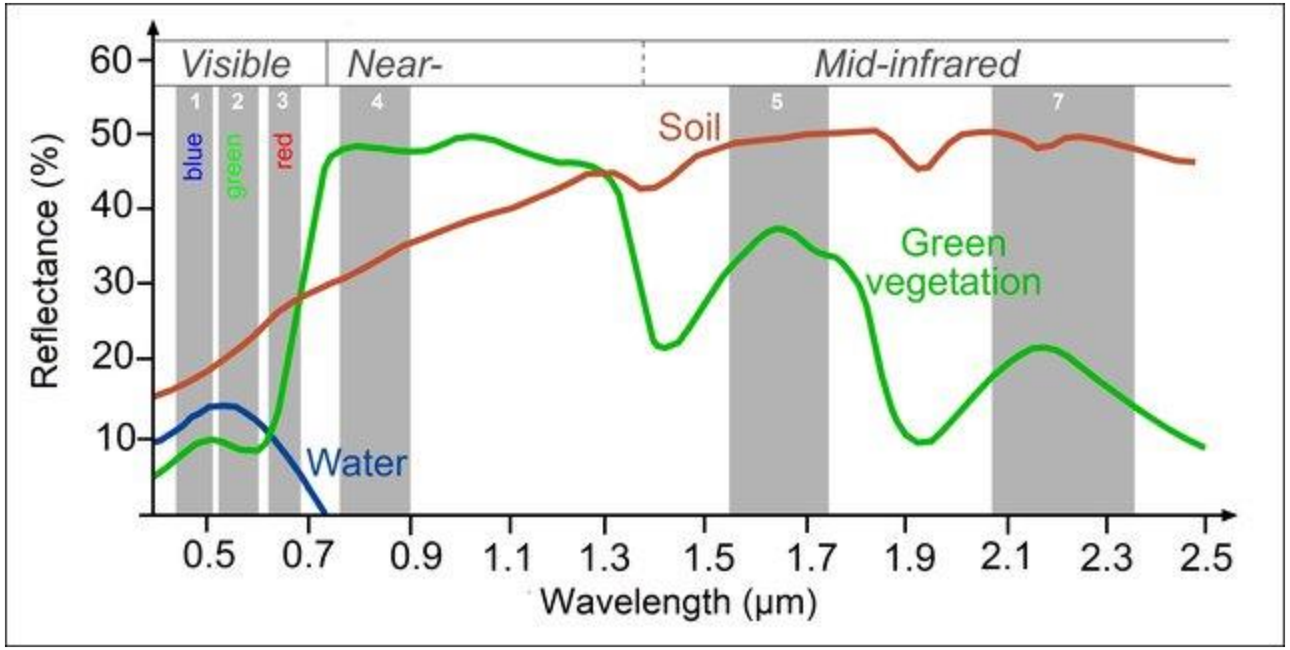


NOAA-16 19 March 2003

SPOT 22 Aug 2011

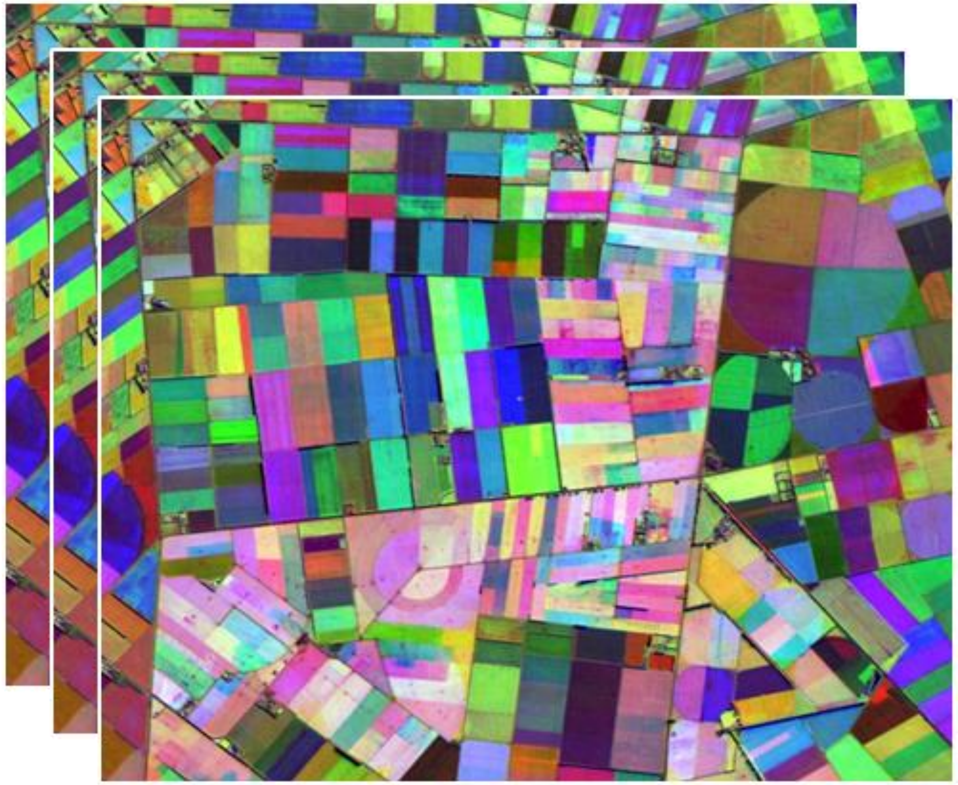
Quickbird 31 May 2005

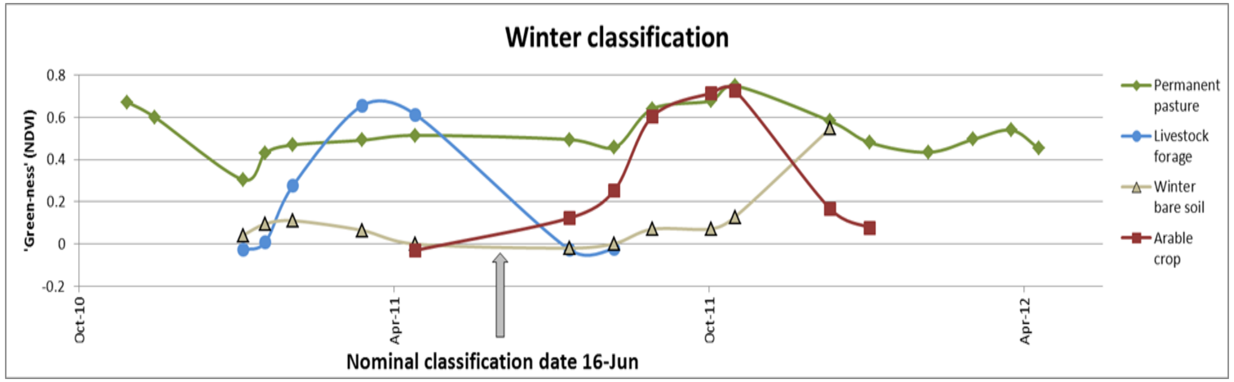
Resolution – three key types



- Spatial resolution
  - How small an object is resolved
  - Match to applications objectives
- Spectral resolution
  - Number & placement of bands
  - Detail in spectral responses

Resolution – three key types



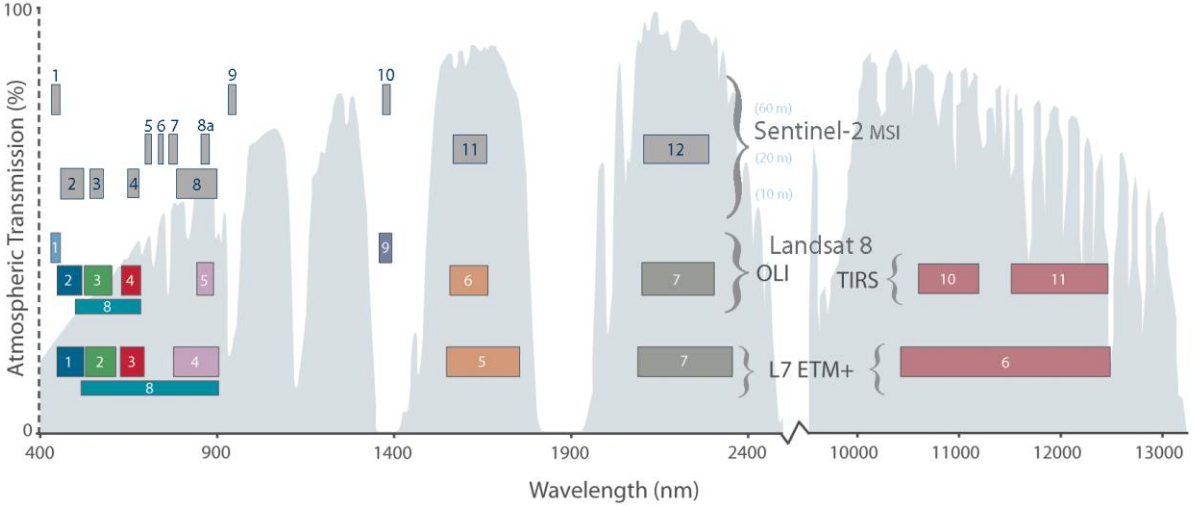


- Spatial resolution
  - How small an object is resolved
  - Match to applications objectives
- Spectral resolution
  - Number & placement of bands
  - Detail in spectral responses
- Temporal resolution
  - Avoid cloud
  - Capture short-lived phenomena
  - Phenology

Technologies - optical

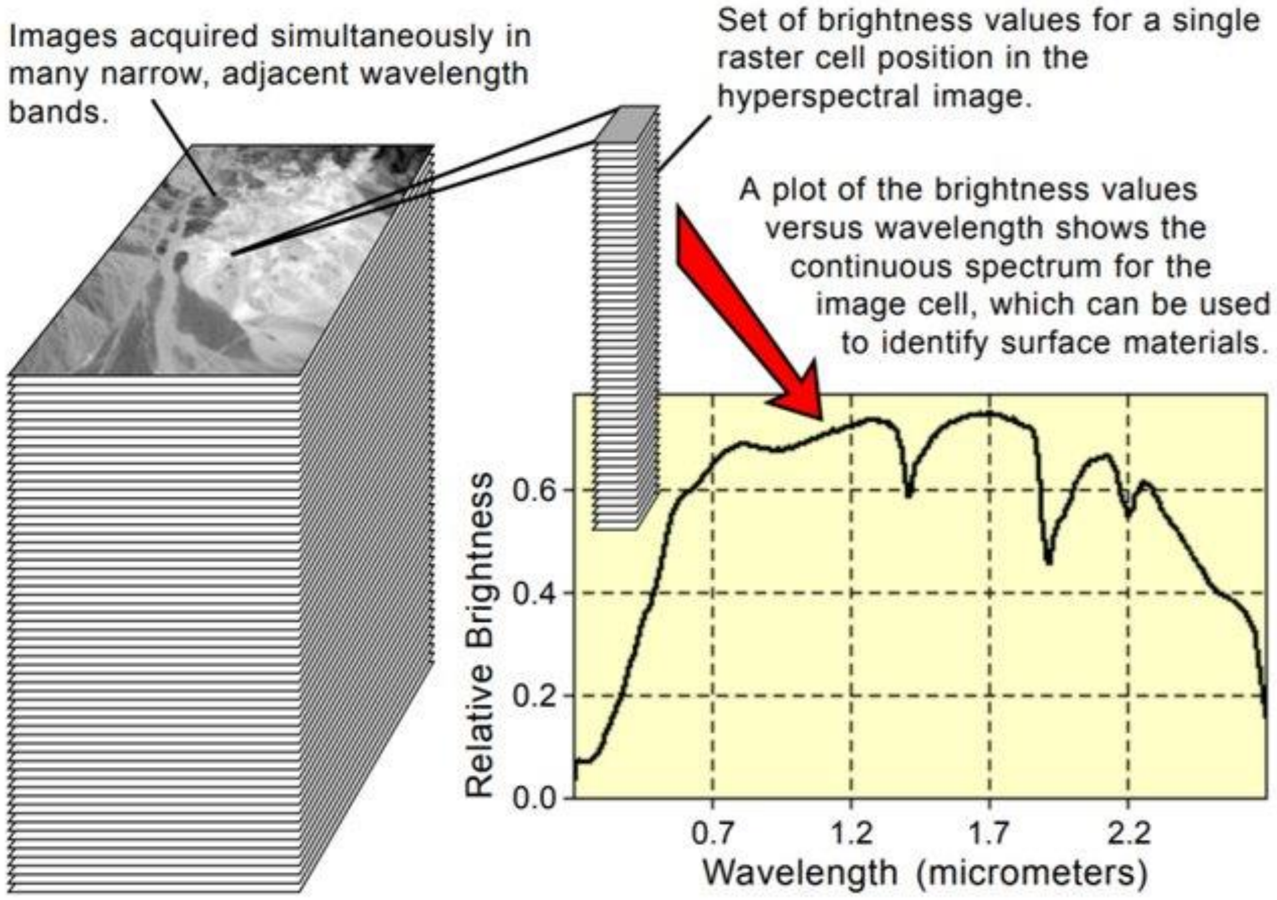
False colour – Richmond – 23 Feb 2017

Comparison of Landsat 7 and 8 bands with Sentinel-2



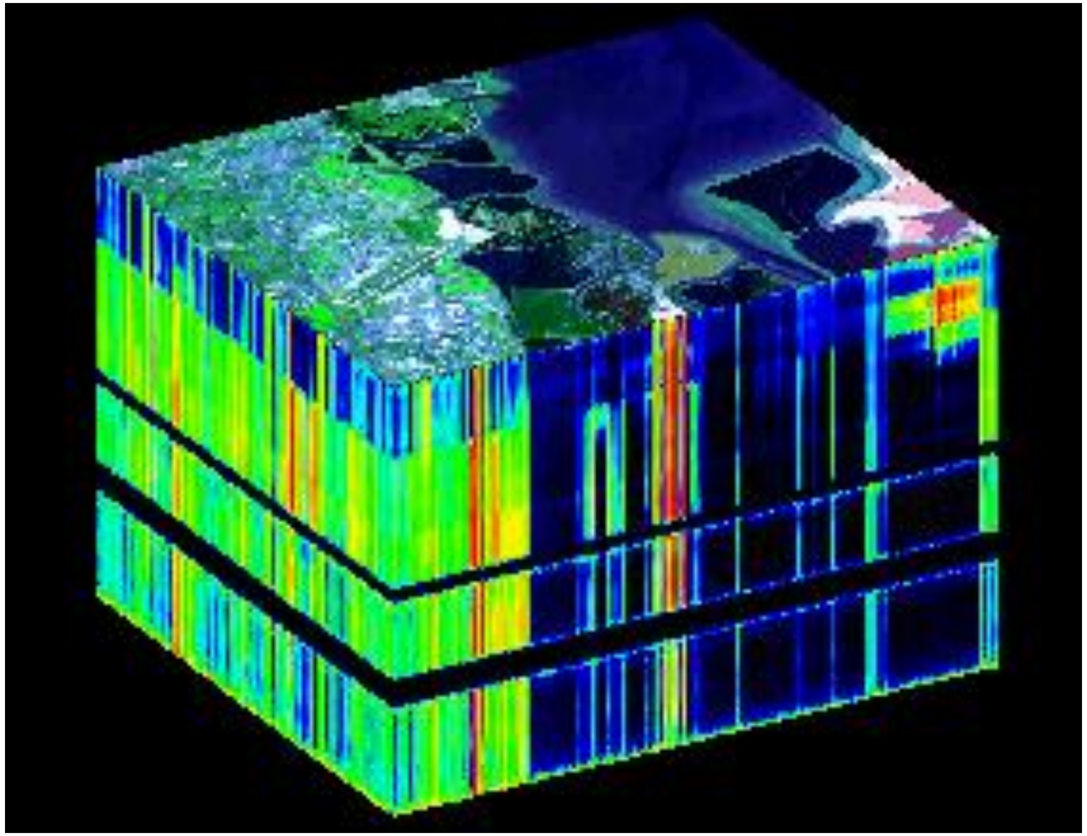
- Familiar "photographs"
- Multispectral
  - Surface colour
  - Vegetation leaf pigments
- High resolutions
- Used in majority of remote sensing applications
- Vegetation classification, change, health

Technologies - hyperspectral



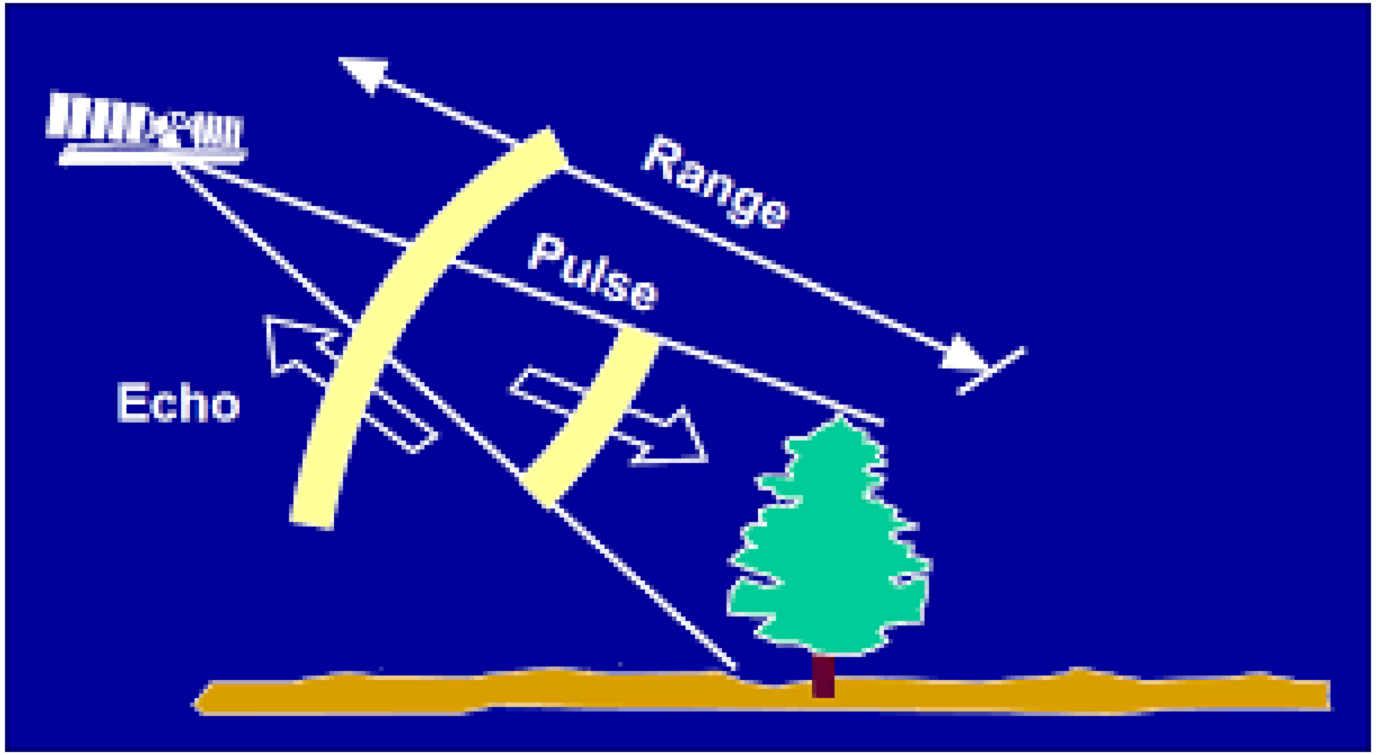
- Hundreds of very narrow spectral bands
- Full detail of spectrum
- Process as a spectral cube
- Spectral unmixing of pixels
- Spectral/spatial trade-off
- Uses in
  - Geology
  - Ecology / species differentiation
  - Plant health
  - Coastal waters

Technologies - hyperspectral



- 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)

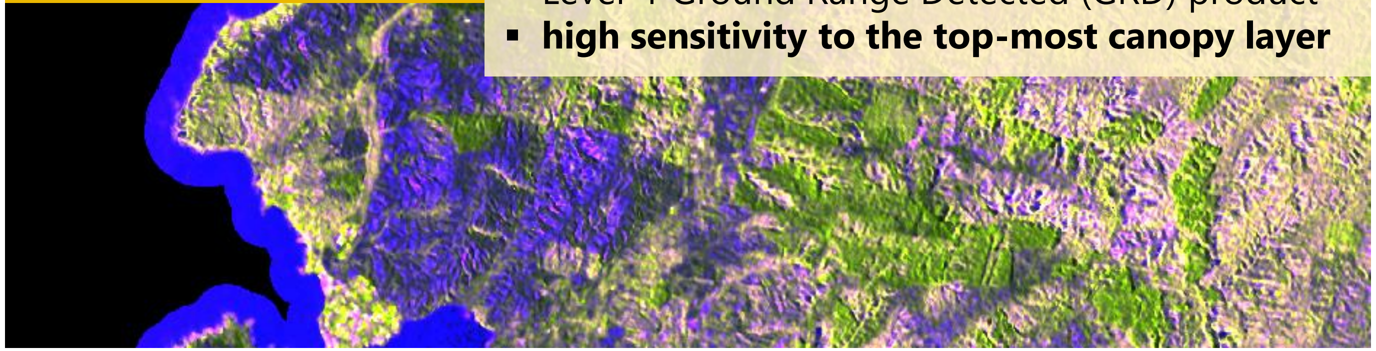


- Active sensor
- Usually single frequency
- Polarised radiation - transmit and receive
- Backscatter and it's polarisation influenced by;
  - Scatterer size (branch/leaf), shape, orientation
  - Target moisture
  - Surface roughness
- See through cloud (regular coverage)
- Uses in
  - Biomass measurement
  - Vegetation structure
  - Change
  - Geological processes (interferometry)
  - Sea ice
  - Ship detection
  - Oil spill

Technologies - radar (SAR)

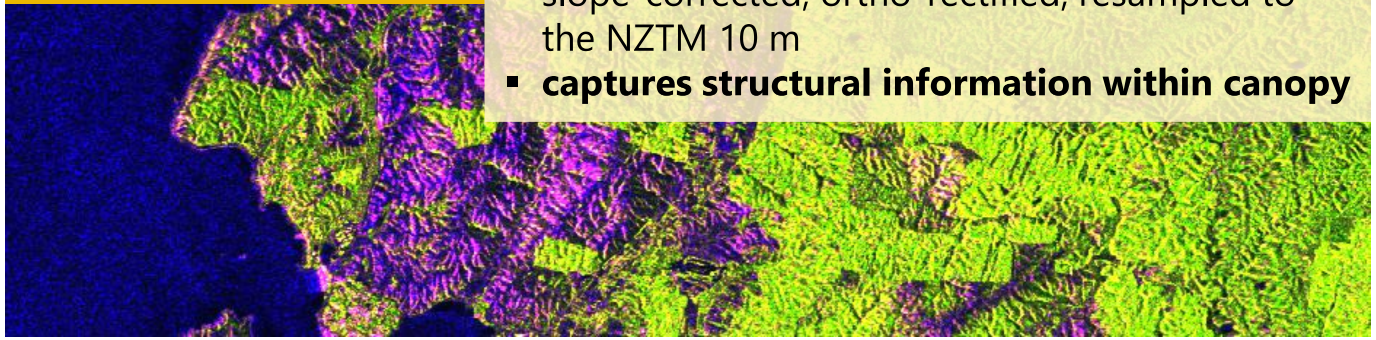
Sentinel-1
2017

- **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**



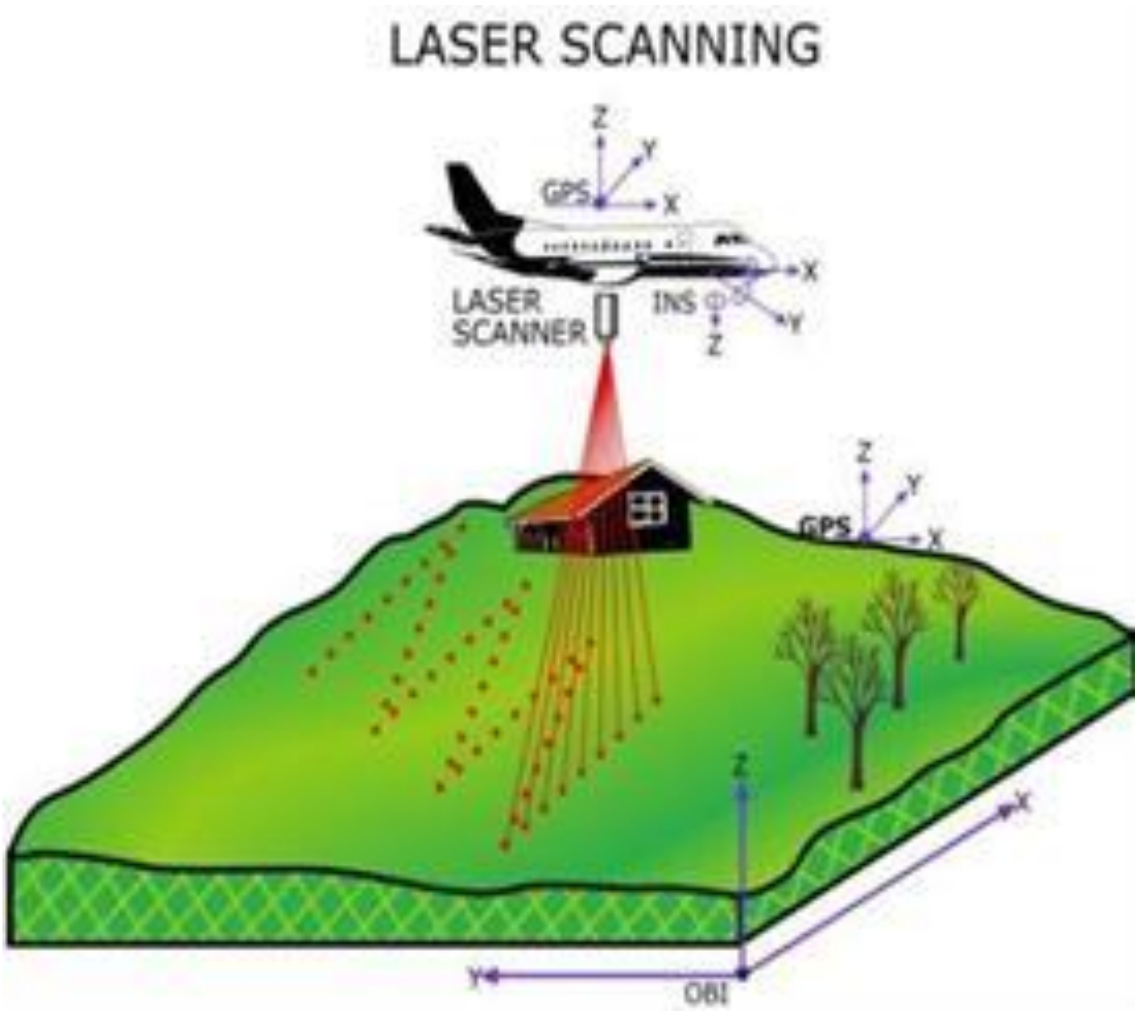
ALOS-PALSAR
2007

- **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**



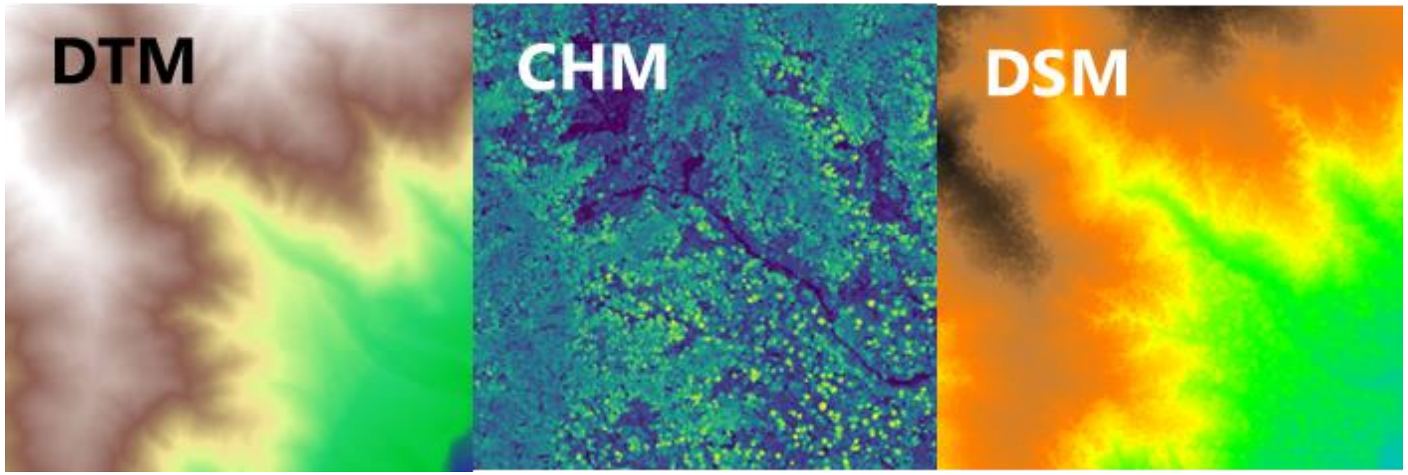
- Active sensor
- Usually single frequency
- Polarised radiation - transmit and receive
- Backscatter and it's polarisation influenced by;
  - Scatterer size (branch/leaf), shape, orientation
  - Target moisture
  - Surface roughness
- See through cloud (regular coverage)
- Uses in
  - Biomass measurement
  - Vegetation structure
  - Change
  - Geological processes (interferometry)
  - Sea ice
  - Ship detection
  - Oil spill

Technologies - LiDAR



- 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)

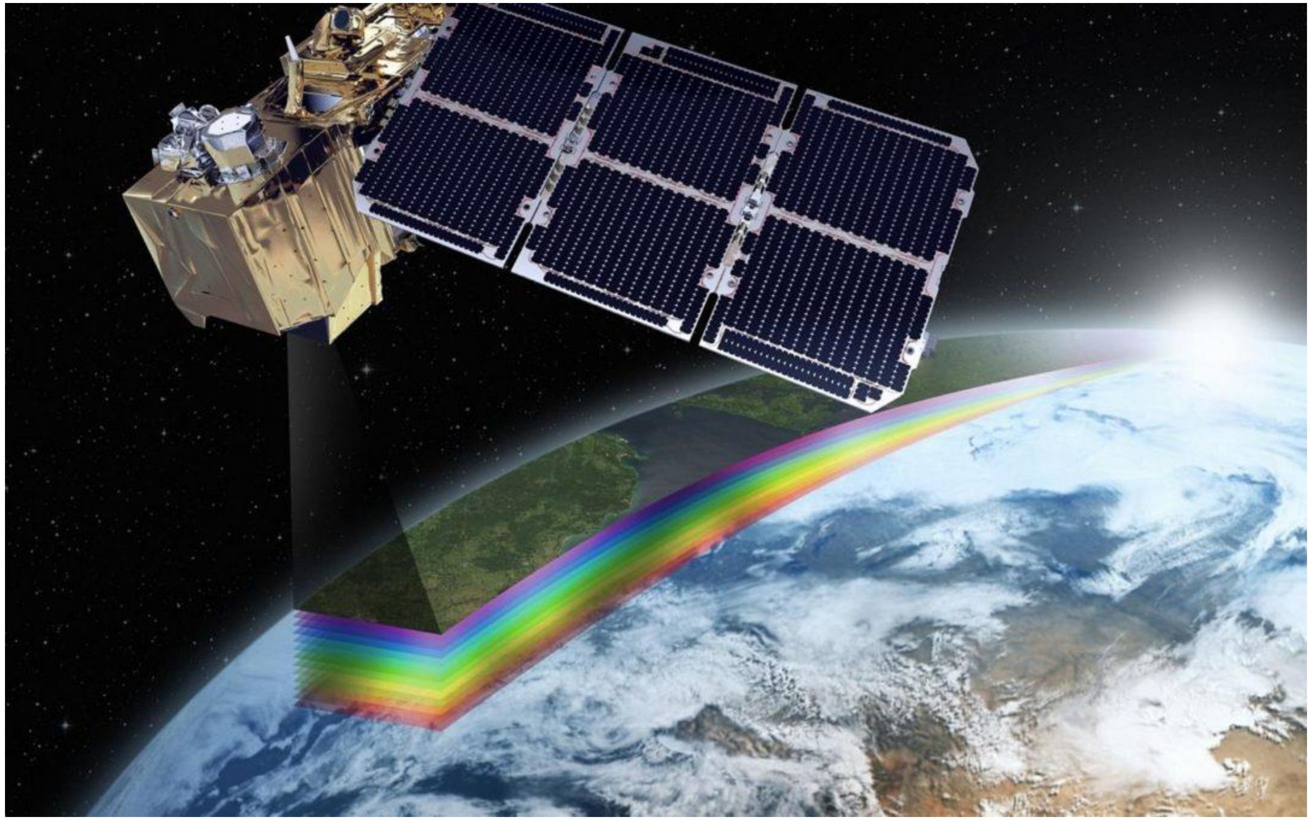
Technologies - LiDAR



Terrain model Canopy height 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)

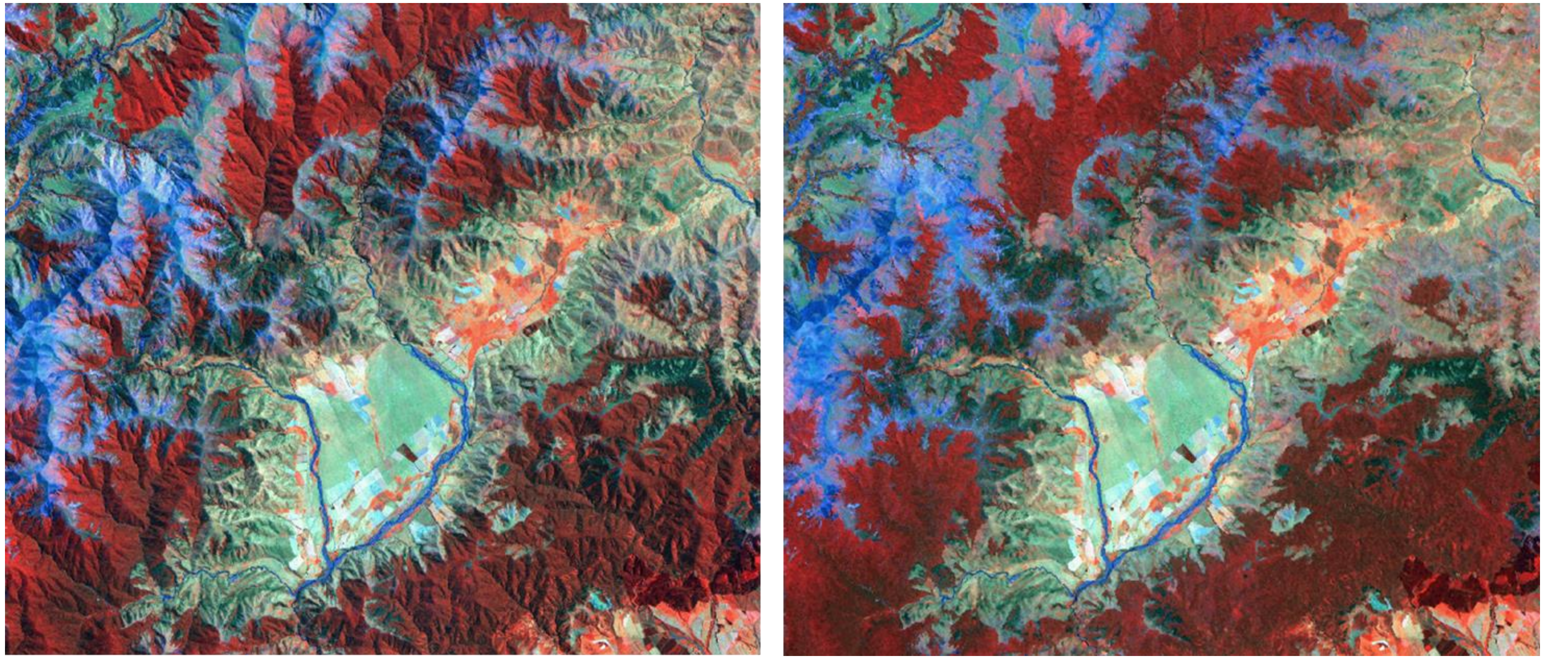
Platforms - Aircraft

- 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)

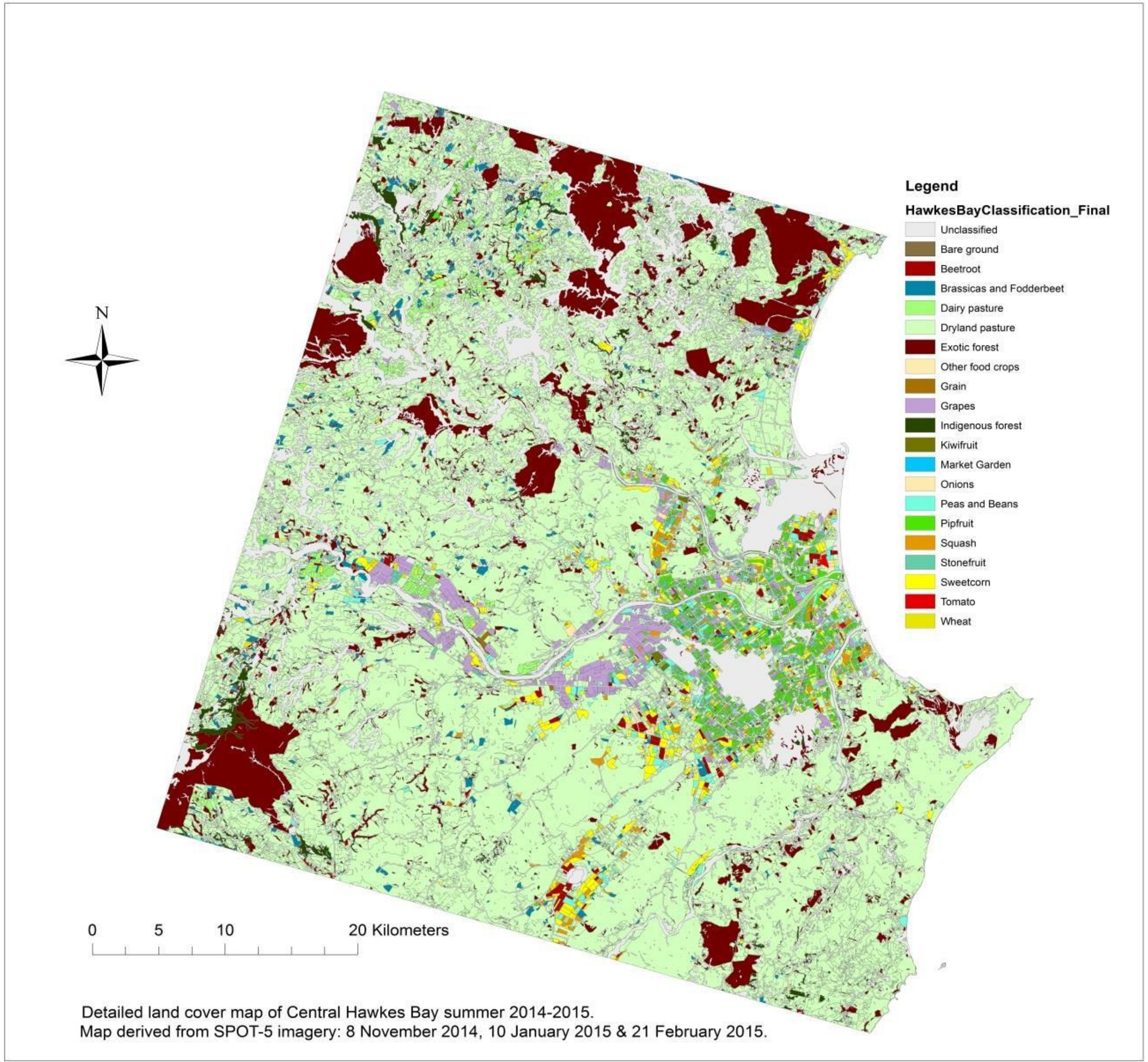
- Instruments
  - Optical multispectral
  - Hyperspectral
  - LiDAR
  - SAR
  - Other passive (Thermal, Aeromagnetic, Gamma)
- Advantages
  - Very high resolution
  - Tailored flexible deployments
  - Tailored instrumentation
  - Programmable flightpaths
  - Ground truth for lower resolution, wider study
- 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

Classification analysis



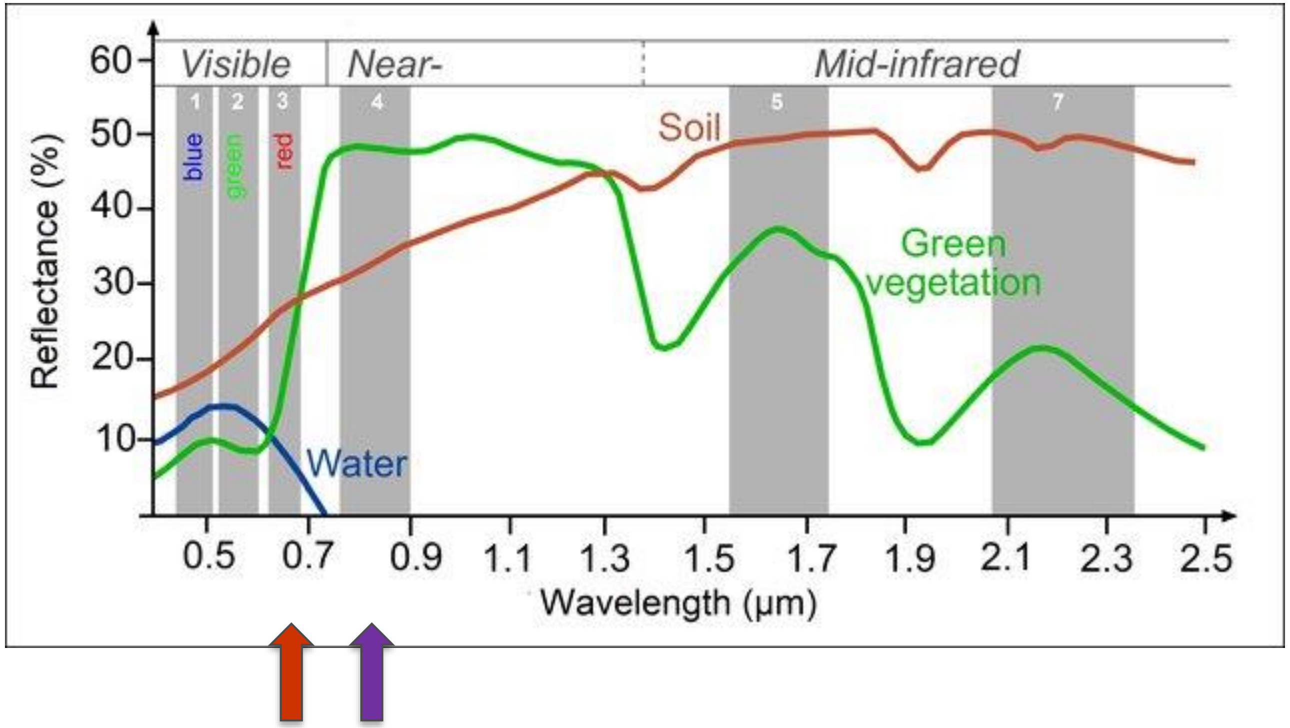
Aim: To identify membership of pixels or objects into a set of classes

- Inputs a set of features
- Usually a data-driven approach to define underlying models
  - Statistical models
  - Machine learning
- Training data required

Classification - inputs

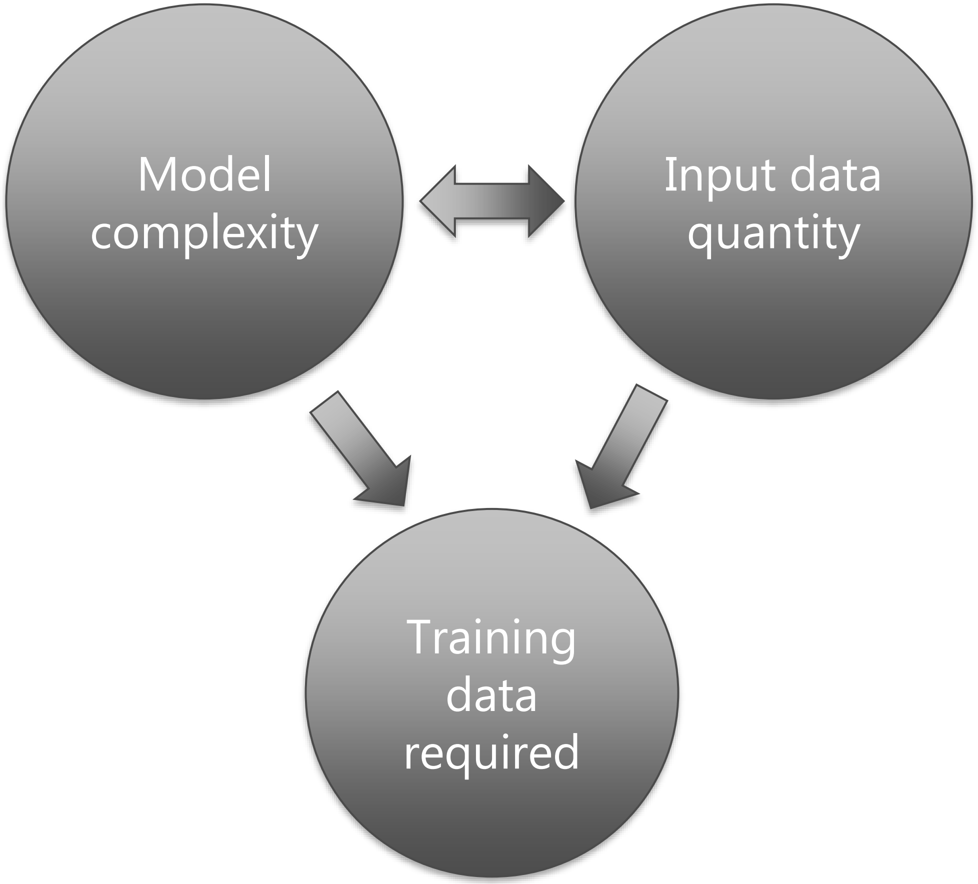
A set of "features" from which a decision can be made

- Different spectral bands
- Derived band combinations
- Temporal sequences
- Derived temporal indices



NDVI = (NIR-RED)/(NIR+RED)

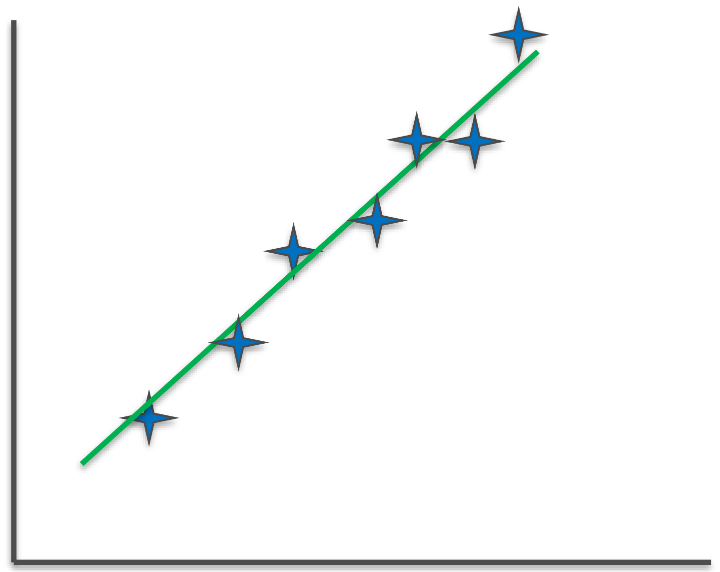
Classification - trade-off



- Complex models
  - More capable
  - Require more training data
- More input data
  - Potentially more information
  - Require more training data

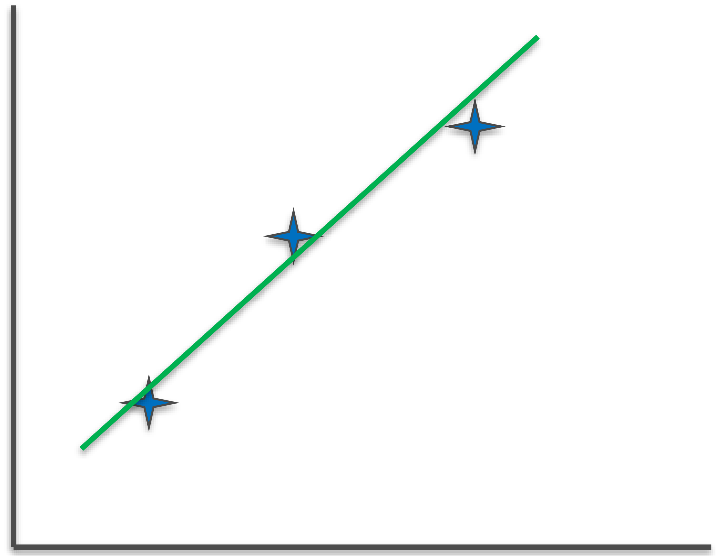
Training data is critical

- Overfitting – mitigated by:
  - Simpler model
  - Less input data
  - More training data



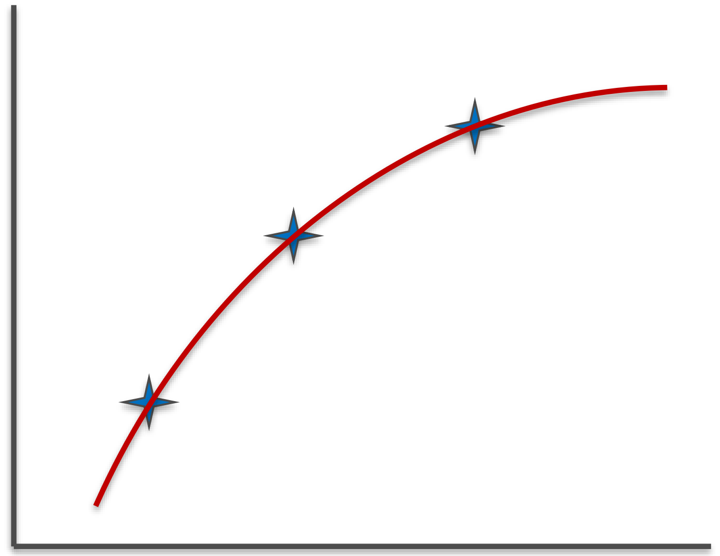
Training data is critical

- Overfitting – mitigated by:
  - Simpler model
  - Less input data
  - More training data



Training data is critical

- Overfitting – mitigated by:
  - Simpler model
  - Less input data
  - More training data

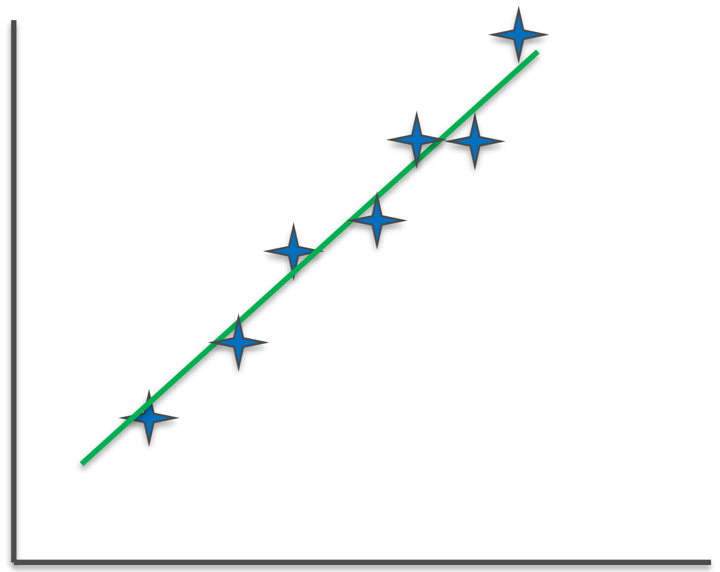


Training data is critical

- Overfitting – mitigated by:
  - Simpler model
  - Less input data
  - More training data

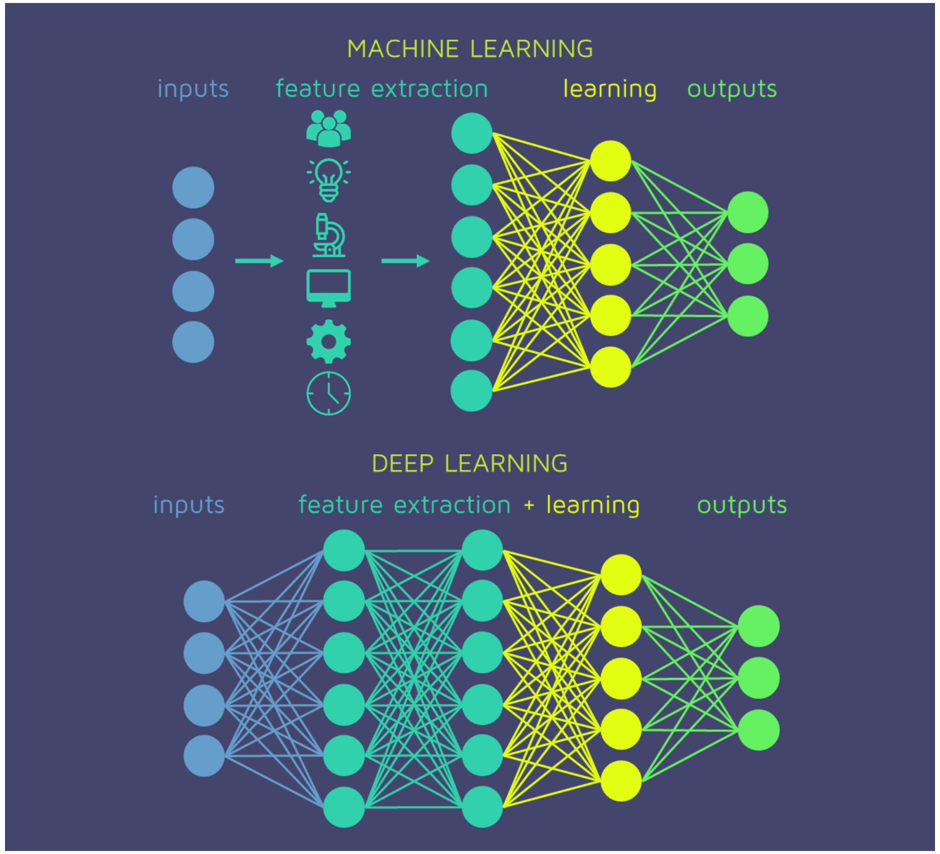
- Unrepresentative training
  - Should cover full extent of relevant input feature space
  - Don't just choose the most pure pixels/features

- More training data is nearly always beneficial

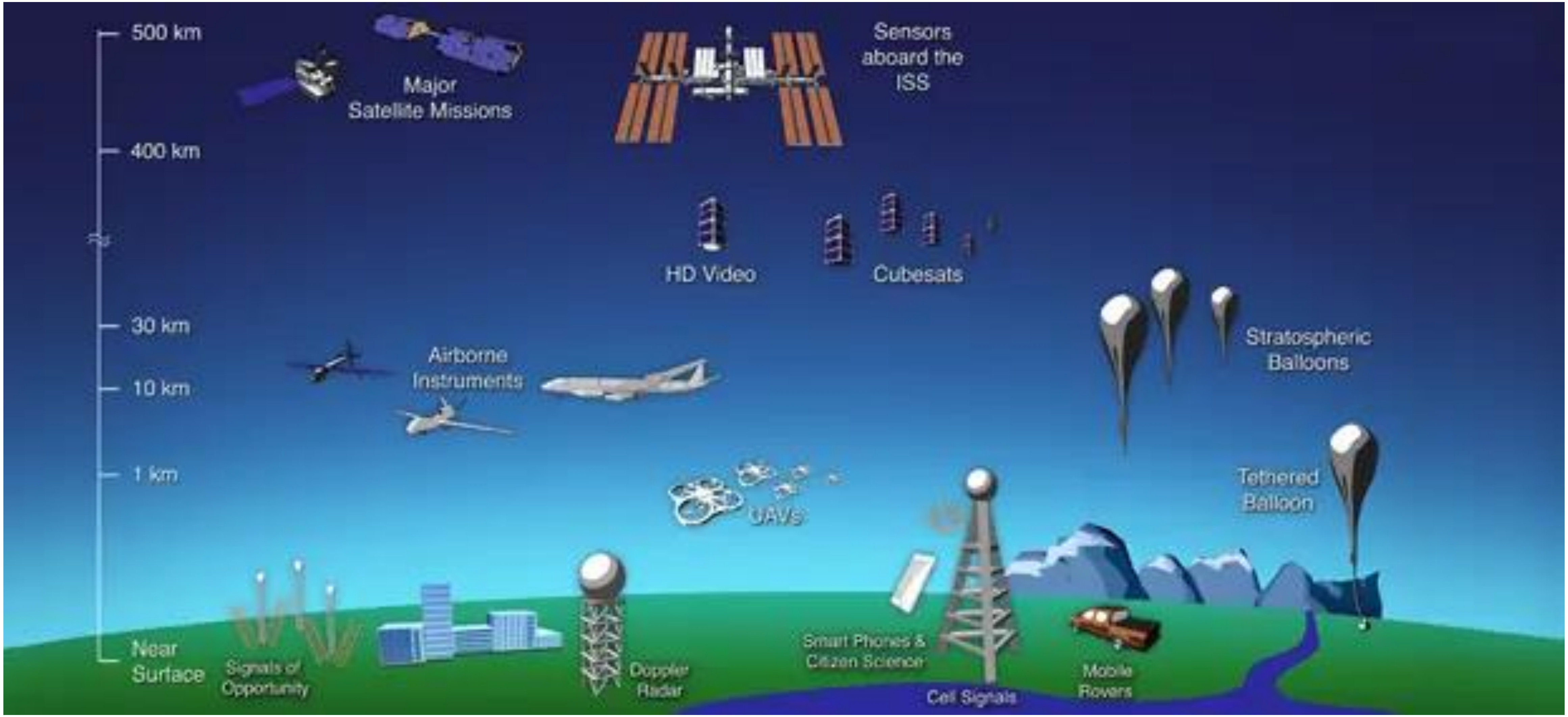


Testing / accuracy assessment

- Understand model performance
  - Particularly for complex models – e.g. deep learning
- Testing data must be independent
  - Strategies can randomly partition training/testing data
  - Multiple runs on split data can maximise the resource
- Identify where more training required
- Experiment with input data requirements



Questions?


500 km
400 km
30 km
10 km
1 km
Near Surface
Major Satellite Missions
Sensors aboard the ISS
HD Video
Cubesats
Airborne Instruments
Stratospheric Balloons
Tethered Balloon
UAVs
Signals of Opportunity
Doppler Radar
Smart Phones & Citizen Science
Cell Signals
Mobile Rovers