Remote Sensing 1: GEOG 4/585

Lecture 6.2.

Change detection

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Office hours: Monday 15:00-17:00
in 165 Condon Hall

Required reading:
Principles of Remote Sensing pp 185-188, pp 411-415, pp 424-436

Overview

- Examples of change detection from remote sensing
- Some concepts to think about
  - Type of change
  - Monitoring interval
- Pre-processing
- Preliminary classification
- Post-processing
  - Rule-based corrections
  - Posteriori class probabilities
- Trend analysis

Examples of change detection analysis

- Deforestation/reforestation
- Natural hazards (e.g. floods, landslides)
- Growth of urban or rural populations
- Species habitats
- Agriculture production
- Snow accumulation and melt


1984
2020


1984
2020

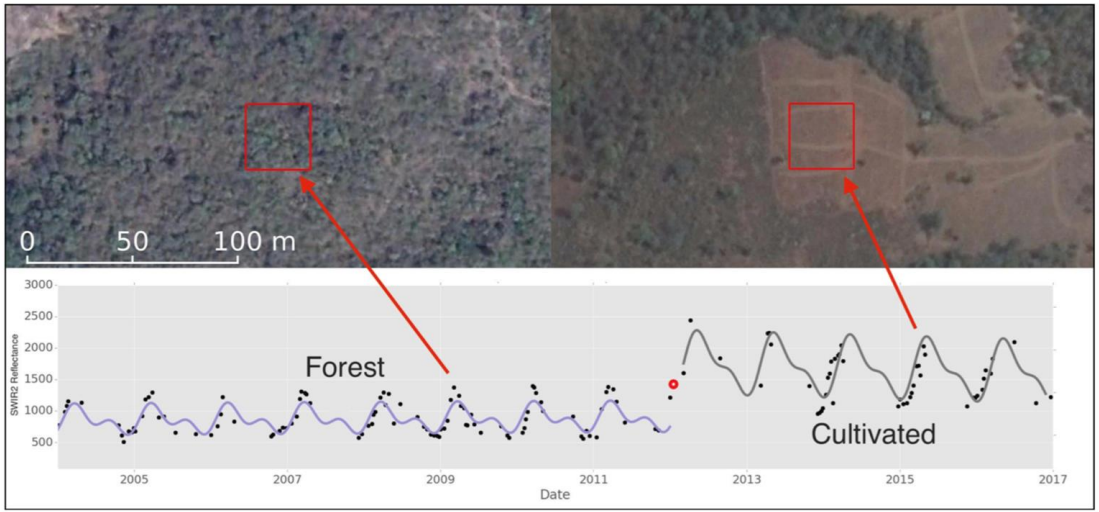

1984
2020

Two most common remote sensing tasks

1. Land cover classification
2. Land cover change detection
    a. Quantification of temporal phenomena from multidate imagery
        i. Detecting the changes that have occurred
        ii. Identifying the nature of the change
        iii. Measuring the areal extent of the change
        iv. Assessing the spatial pattern of the change

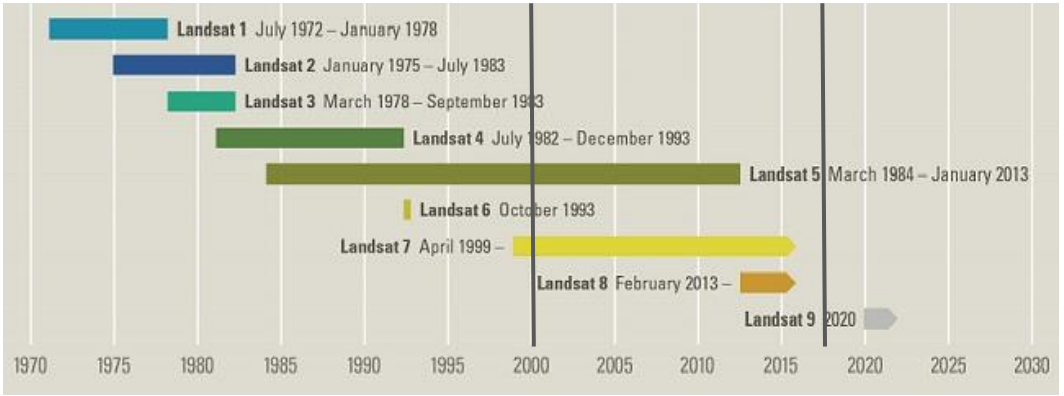
Types of change

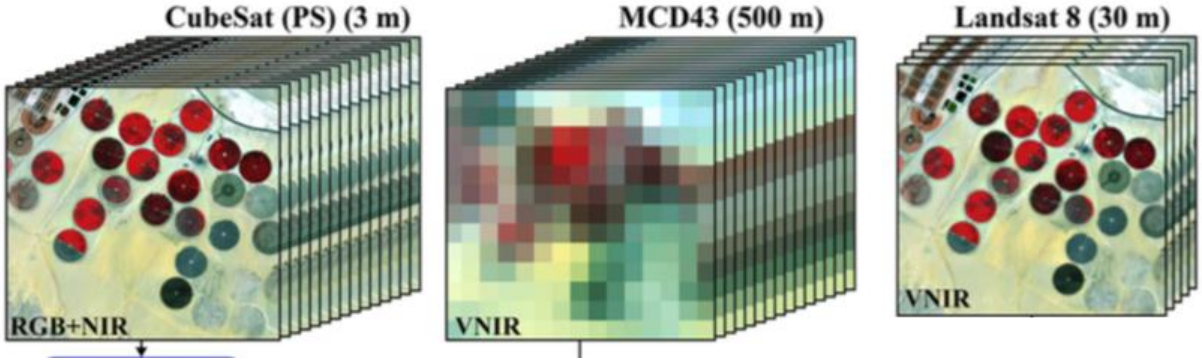
- Transitional changes
  - e.g. forest clearing, construction
- Conditional changes
  - e.g. agricultural water stress
- Abrupt changes
  - e.g. wildfire, landslide, hail storms
- Gradual changes
  - e.g. ecological succession, erosion



Monitoring interval/period

- Landsat program has a long record allowing monitoring of g*radual changes*
- MODIS and CubeSats have much more frequent revisit times allowing more precise timing of *abrupt changes*





Let’s play a game!

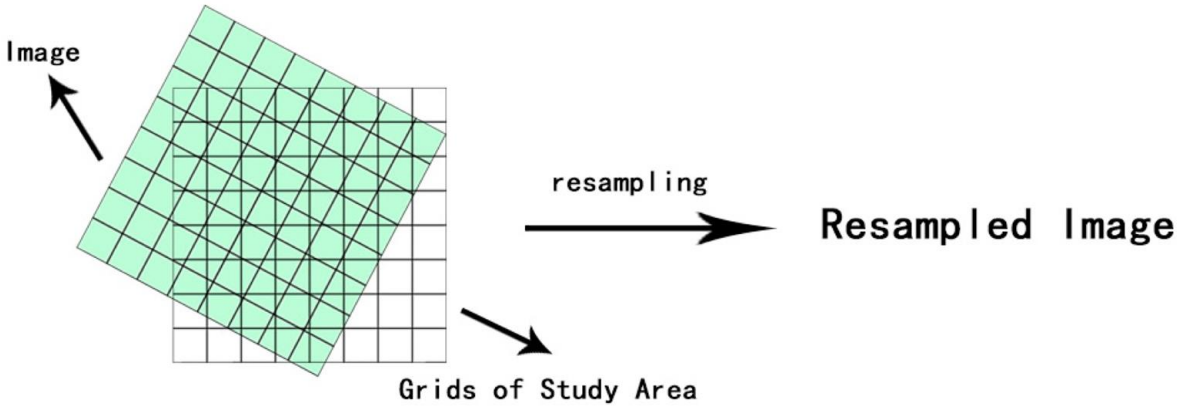
- Spot the change quiz:

Remote sensing classroom change pair game

Pre-processing

For classification and change detection of large areas or multi-temporal data we need our satellite imagery to be:

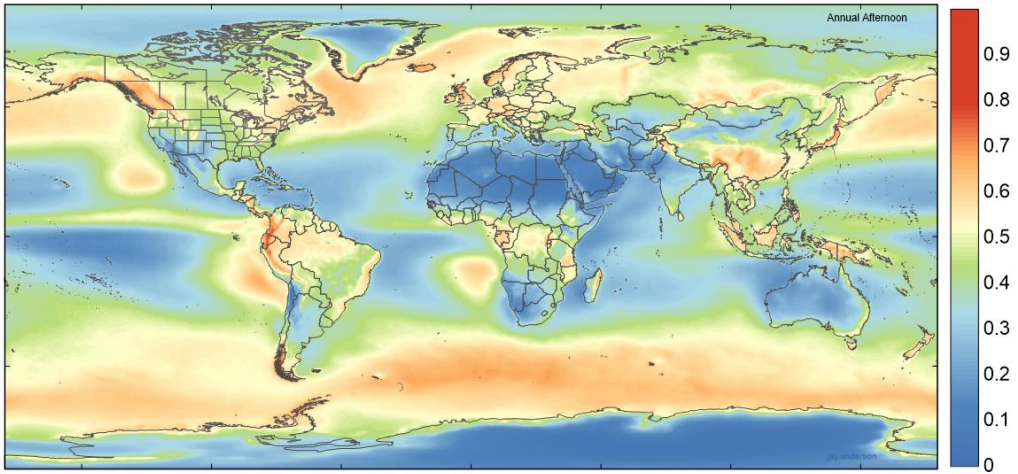
- Reprojected to common projection and extent
- Resampled to common spatial resolution
- Corrected for sun angle and atmospheric effects (e.g. invariant features, DOS, radiative transfer model)



Cloud masking

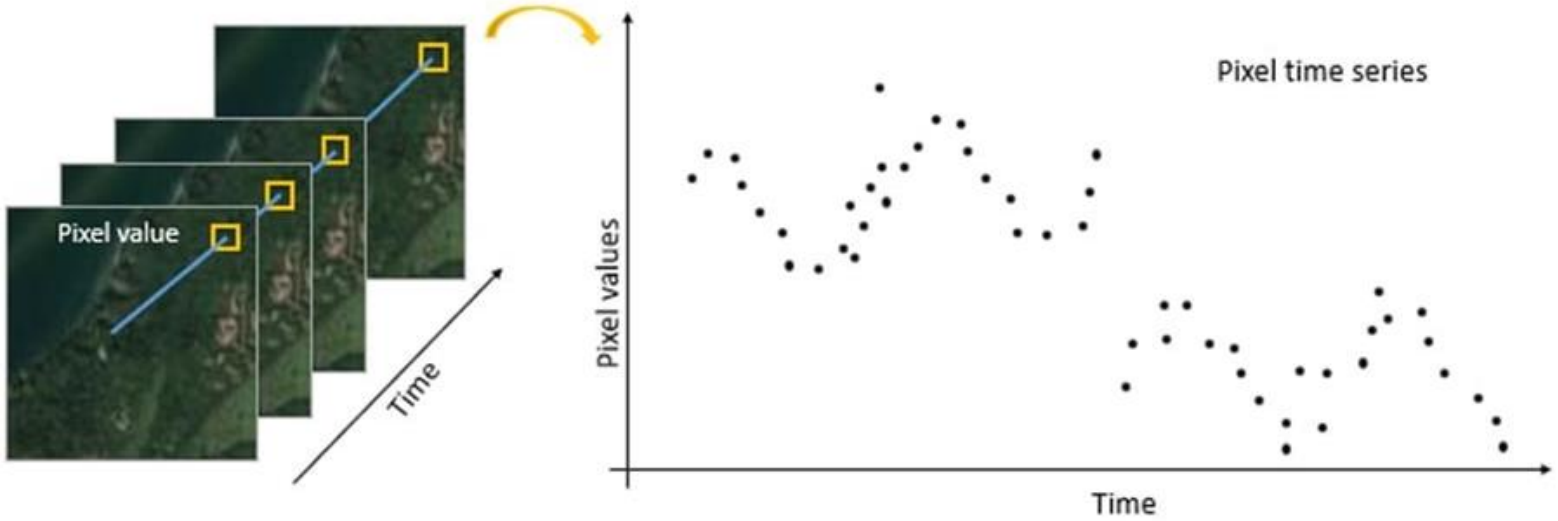
- Input data often includes substantial levels of missing data due to clouds (especially in the tropics) and low illumination and polar night in the northern high latitudes.

- Cloud masking algorithms (e.g. *Fmask*) can detect most pixels contaminated by clouds and cloud shadows and label them as “NoData”, but some clouds are challenging to detect



Image/pixel selection

- Some studies use every pixel over a given time period
- Useful for studying intra-annual dynamics and faster processes that might only be visible during a limited period of time.
    - e.g. seasonal crop dynamics

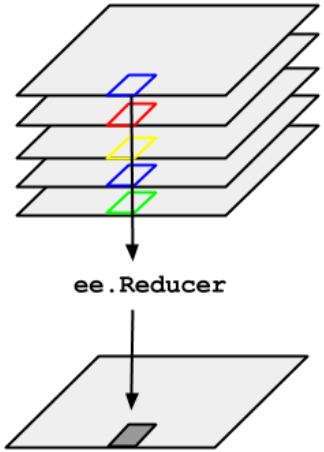


Best-available pixel

- Many studies now select the ‘best’ available pixel over a given time period

- These functions score each pixel based on:
  - Sensor
  - Sun angle
  - Distance to clouds and cloud shadows
  - Atmospheric opacity

- Reduces the influence of atmospheric effects and cloud contamination and better for “interannual” changes



Preliminary classification

Level I	Level II
Water	Water
Snow/Ice	Snow/Ice
Built	Low-density built
	High-density built
Bare	Soil
	Rock
	Sand
Trees	Deciduous Broadleaf
	Deciduous Needleleaf
	Evergreen Broadleaf
	Evergreen Needleleaf
	Mixed
Shrub	Shrub
Herbaceous	Grassland
	Agriculture
	Moss/lichen
Woodland	Woodland

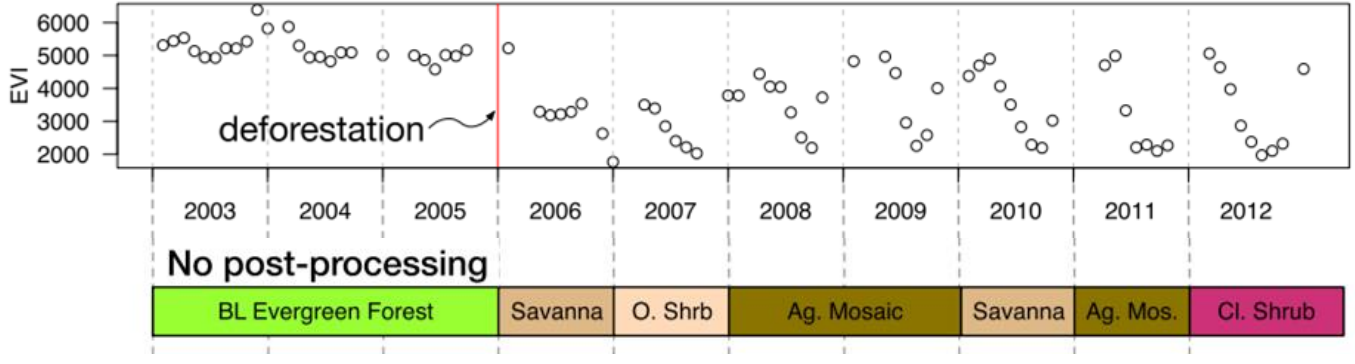
- Apply supervised image classification
- Classes dependent on task
- Mainly based on spectral characteristics

Post-classification errors

- It is unrealistic to assume that our preliminary classifications are 100% correct
  - Separability of classes is ambiguous, mixed-pixel effects
  - Biases in training data, biases due to phenology

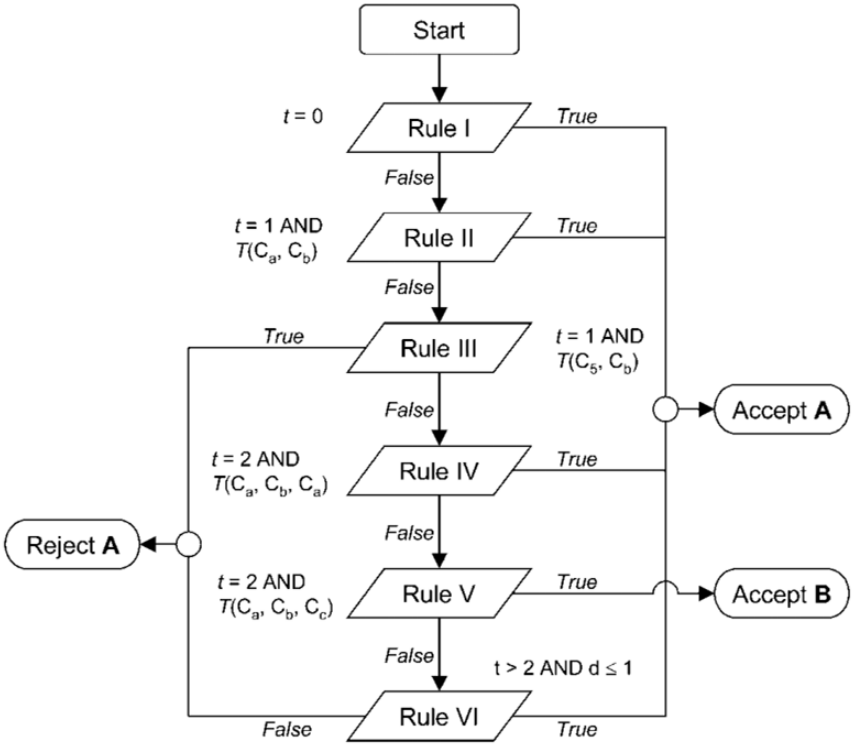
- Classification maps in heterogeneous areas tend to be unstable and may “toggle” year-to-year between similar classes

- Often land cover change maps significantly overestimate the amount of real land cover change



Rule-based corrections

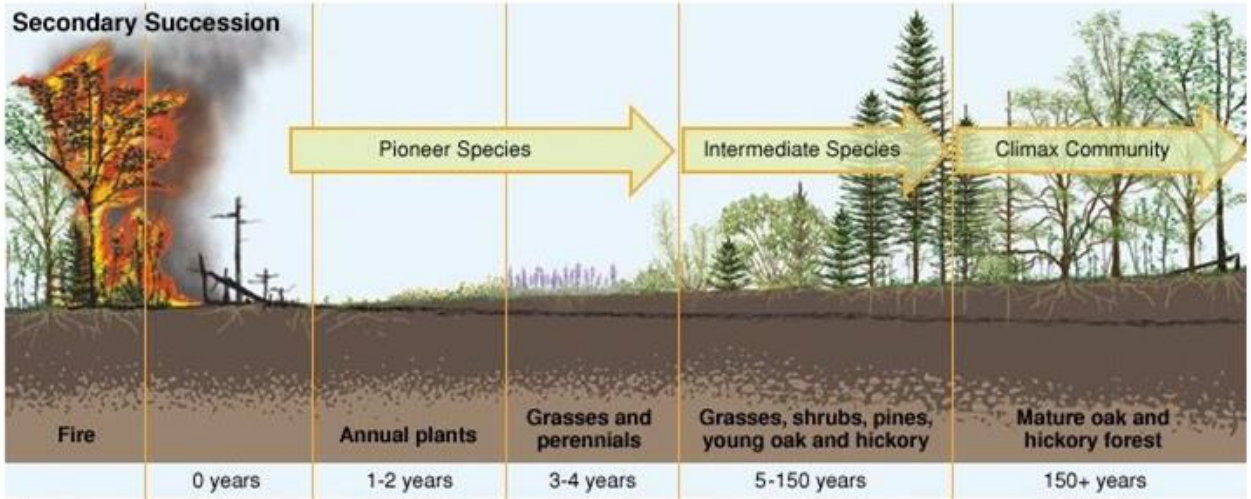
- We can apply rules restricting land cover transitions, for example:
  - If a pixel is initially classified as forest, it can't change to water
  - If a pixel has been classified as urban, it cannot be reversed
  - If a pixel changes once and then back again, it's likely an error
  - If a pixel changes multiple times during the study period, it's likely an error



Initial classification probabilities

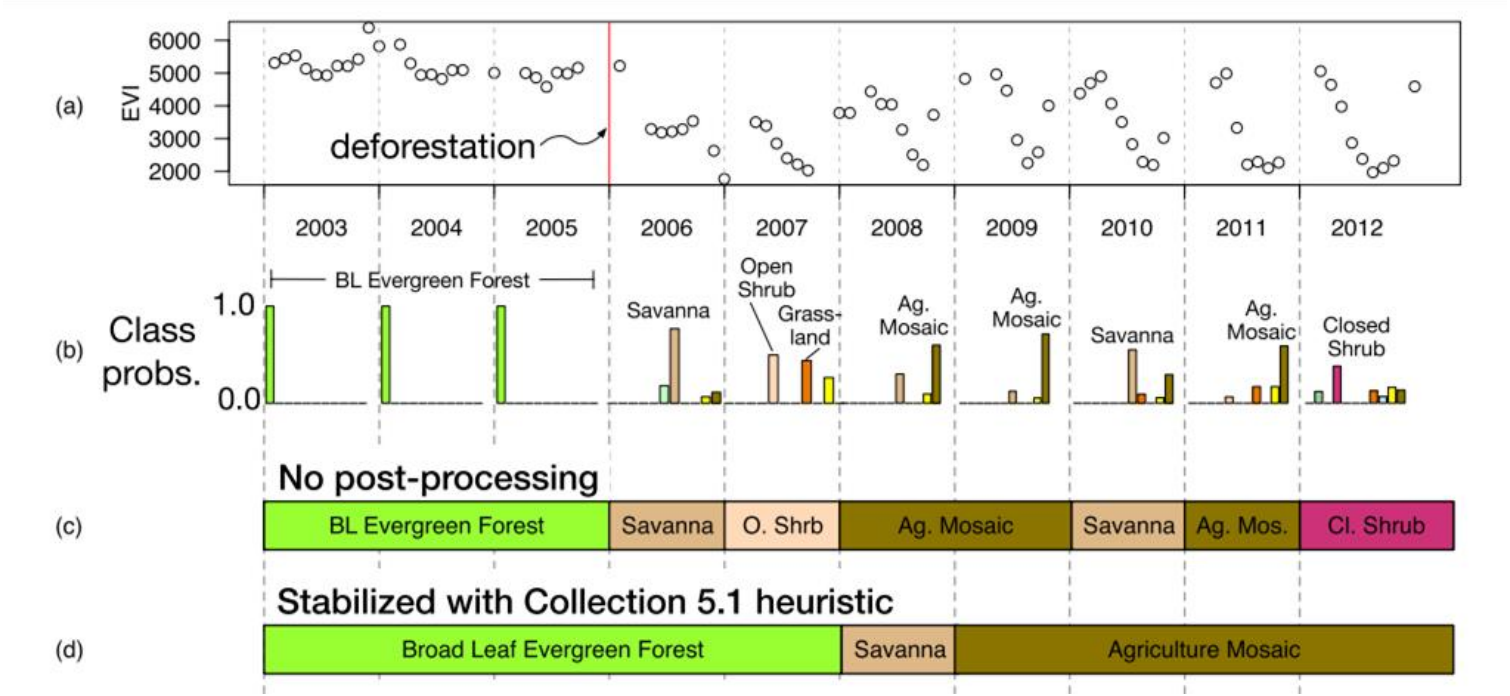
- The presence of change when combined with ecological knowledge or expectation of a given process post-change, can provide for a priori expectations of land cover

- For example, forests that are burned by wildfire typically transition initially to herbaceous vegetation cover, followed by a succession of other classes, ultimately returning to a forest class, provided no change in land use or condition has occurred



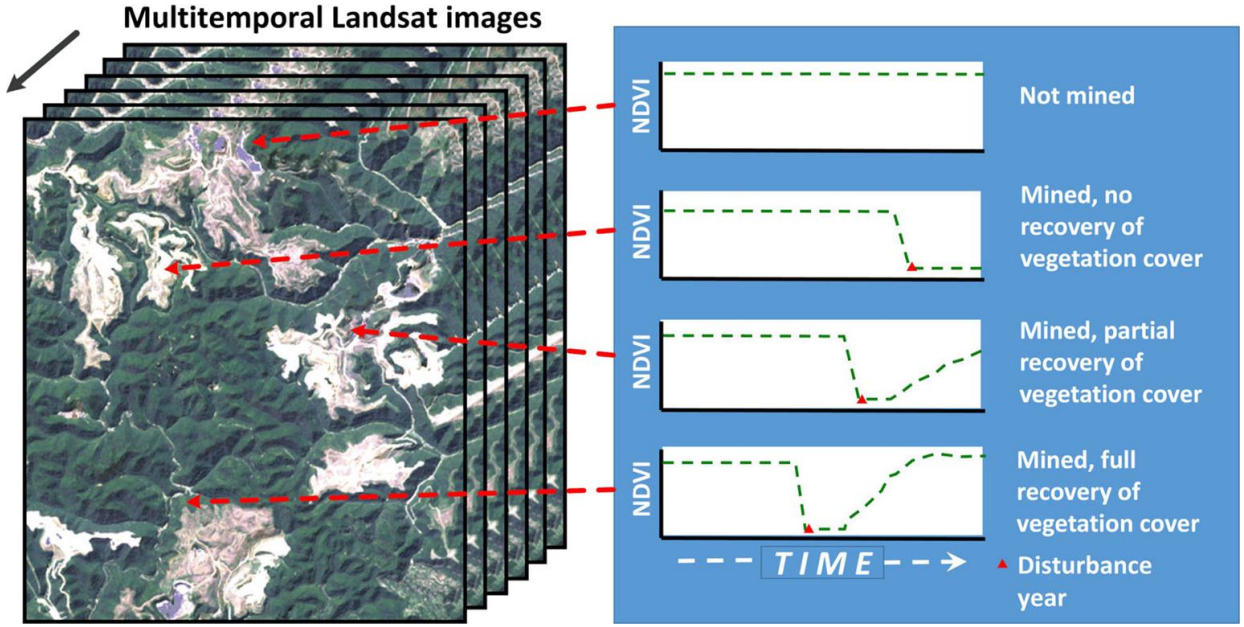
Posteriori class probabilities

- The examination of posteriori (knowledge from experience) class probabilities can be used to improve our image classification results (e.g. Markov Chains)



Trend analysis

- Track changes in spectral values (e.g. NDVI)



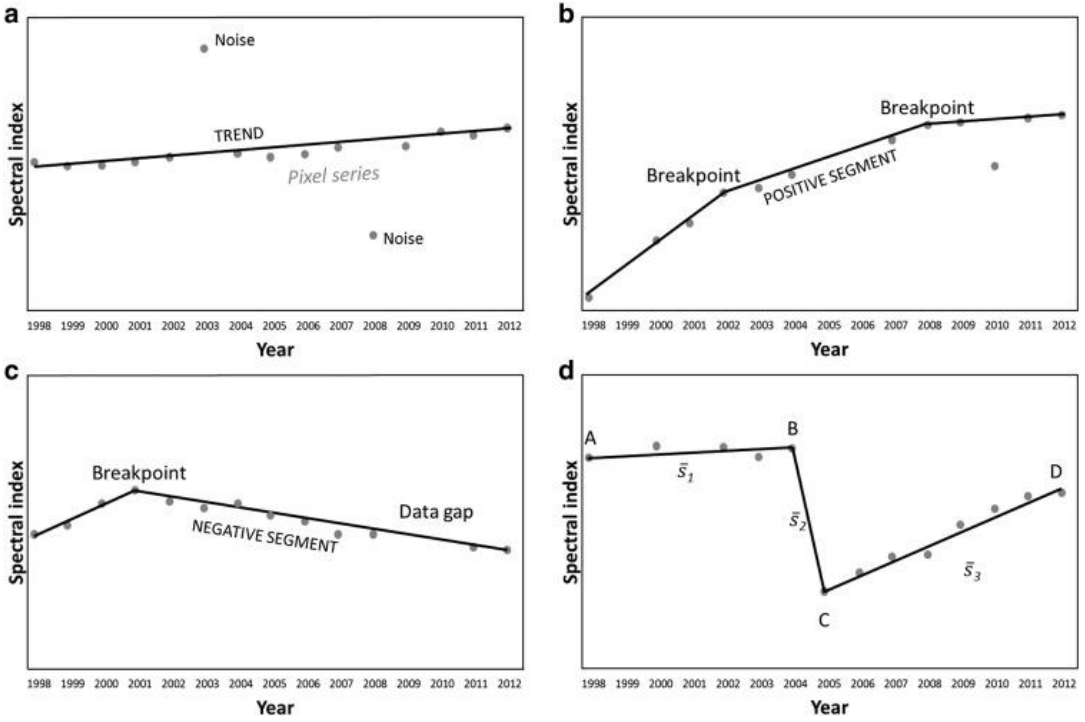
Trend analysis: breakpoints

A. Monotonic

B. multiple breakpoints all with positive slopes

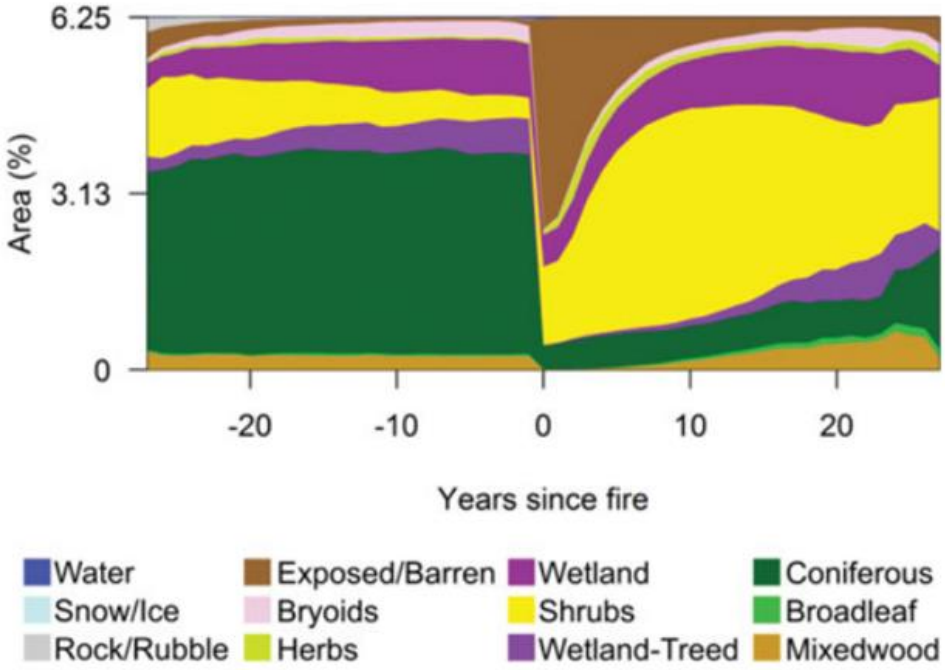
C. single-breakpoint

D. multiple-breakpoint

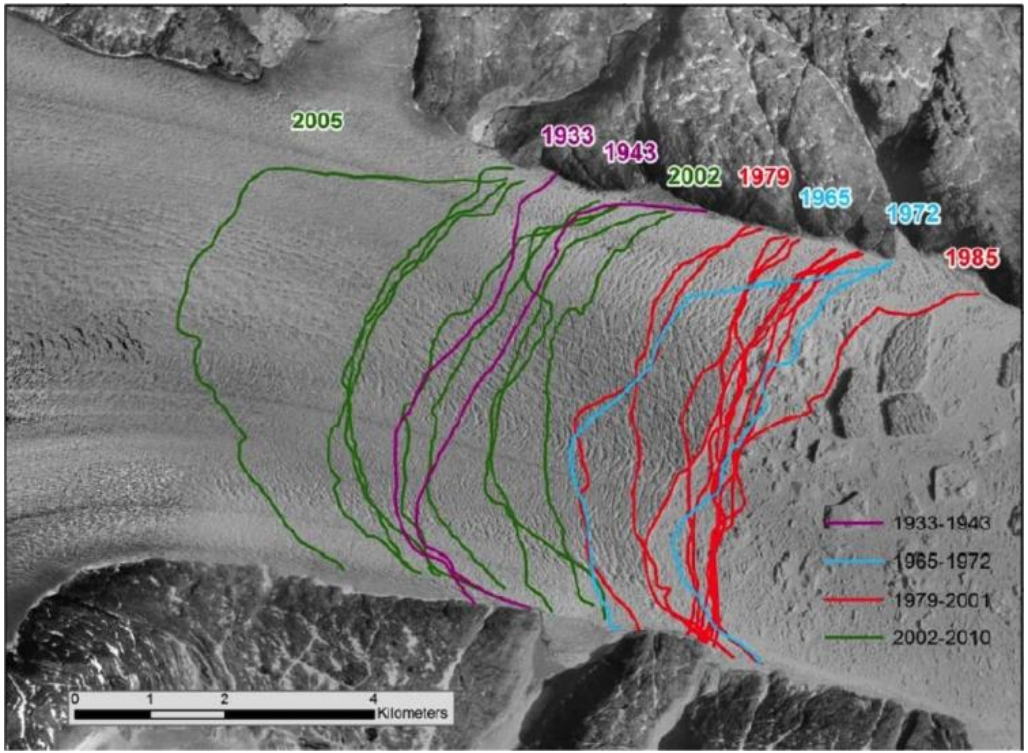


Trend analysis: class changes

- How have classes changed for a specific study region?



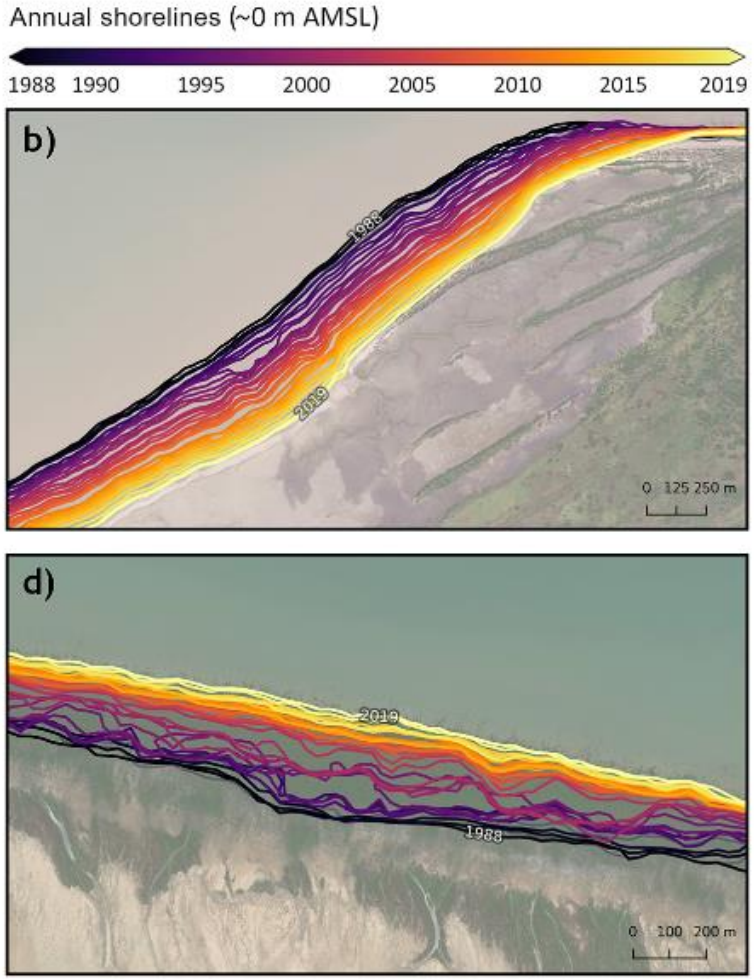
Glacier retreat

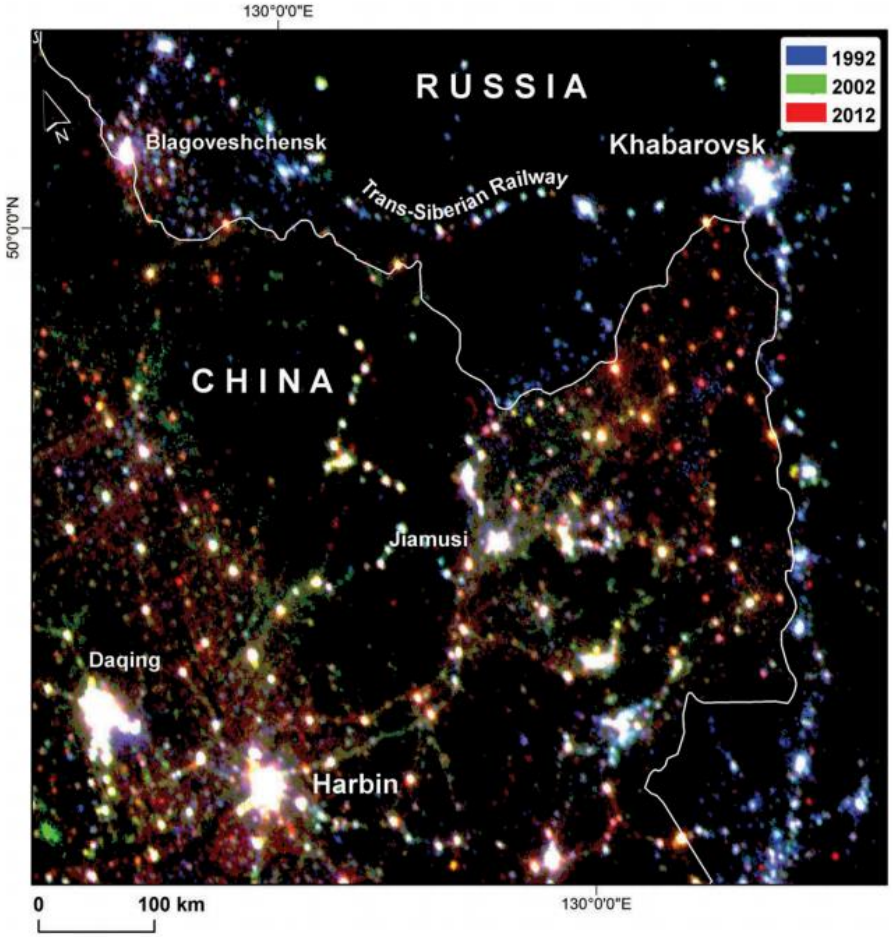


- Automated extraction of tidewater glacier terminus position using remote sensing.
- Helheim Glacier retreated several kilometers, almost doubled its flow rate, and thinned over 100 m from 2002 to 2005.

Coastline change

- Waterline extraction combined with tidal modelling method to map almost 2M km of shorelines along the entire Australian coast from 1988 to 2019.
- 22% of Australia's non-rocky coastline showed trends of significant coastal retreat or growth since 1988
- Continentally, coastal retreat was closely balanced by growth





Night-time lights

- Tritemporal composite showing the divergence Russia and China lights from 1992 to 2012
- Lights in China generally brightening and lights in Russia generally dimming
- Dimming lights indicate depopulation and economic decline in towns and villages along the Trans-Siberian Railway in Russia

Quiz

Quiz #2 based on Sections 4 and 5

Five questions

25 points

Deadline: November 2 Tuesday 11:59 pm

Today's lab

Lab Assignment #5: Change detection

Objectives:

- We will quantify changes in the Salton Sea between 1973 and 2020 in QGIS using the Landsat archive.

Deadline: November 2 Tuesday 11:59 pm