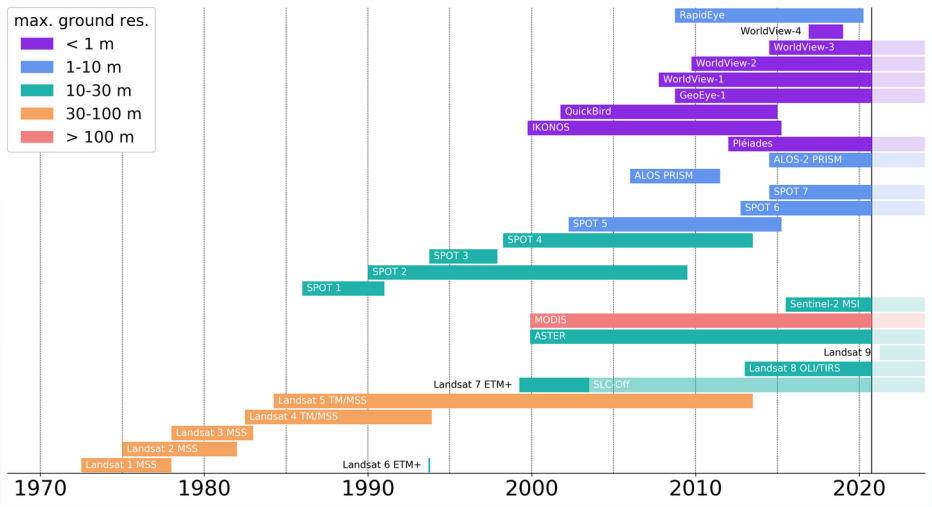
EGM702 – Photogrammetry and Advanced Image Analysis

Week 4, Part 5: Time Series Analysis

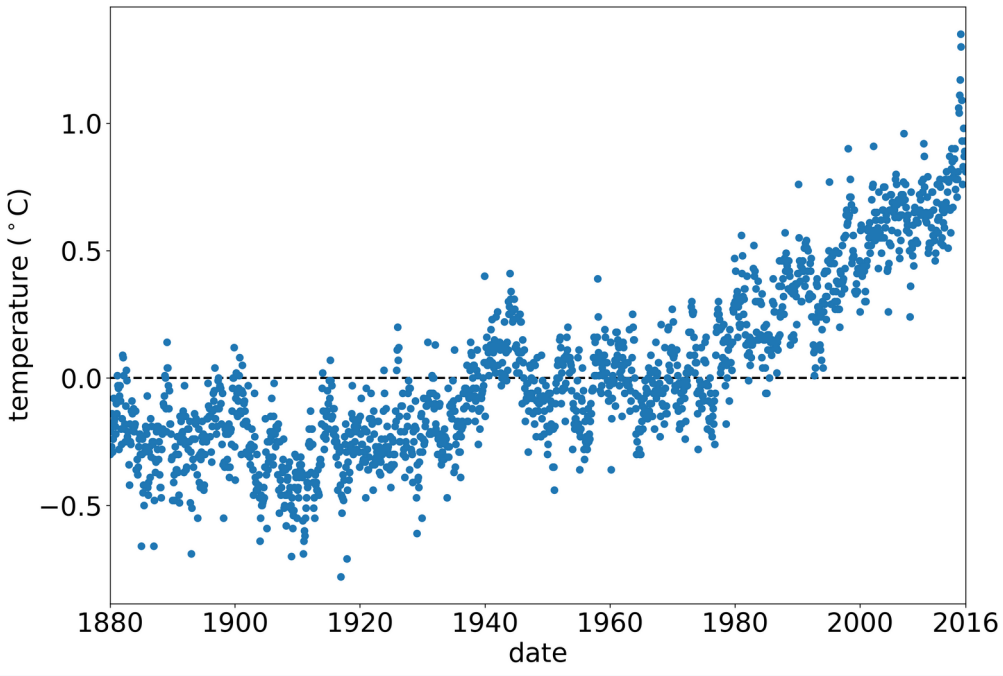
Satellite image repeat times

- Continuous acquisition:
  - MODIS: 1-2 days
  - Sentinel-2: 5 days*
  - Landsat: 16 days*
  - AVHRR, VIIRS: < 1 day
- Other satellites: tasked/sporadic acquisition



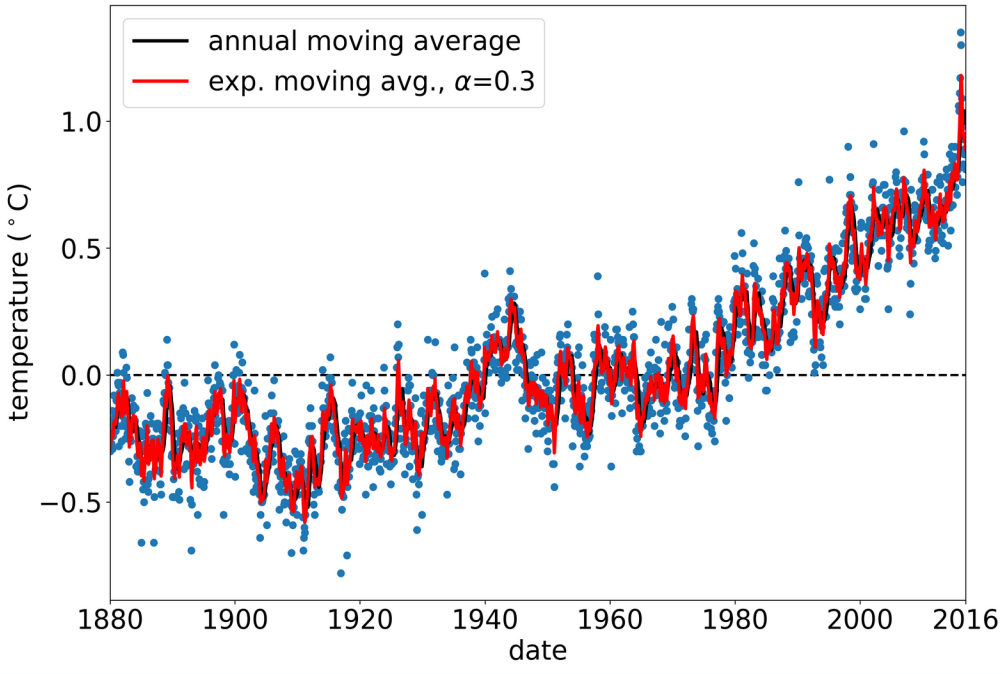
Time series

- Ordinarily, a series of values at equally-spaced time intervals
- Stationary: mean, variance are constant in time
  - i.e., no trend present
- Seasonality: periodic fluctuations
  - Can examine/derive with temporal autocorrelation



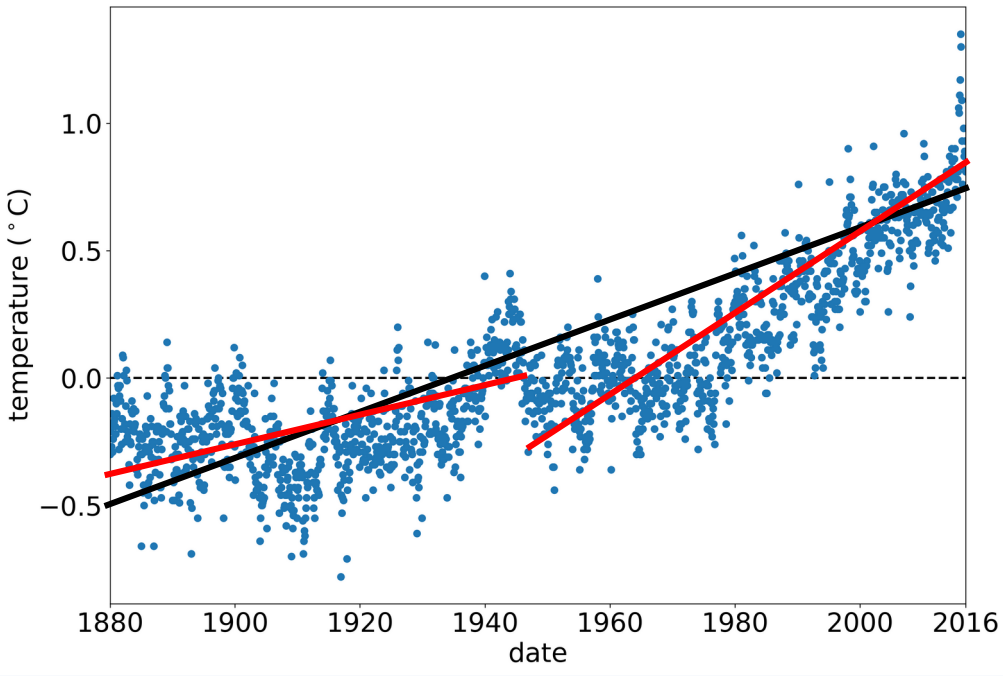
Moving averages

- Moving (rolling) averages:
  - Idea: recent observations affect current observation
  - Smooths time series
  - Can help to identify/highlight trends
- Exponential smoothing:
  - Weighted average of previous time steps
  - Formula: $\mathrm{EMA}_t = \alpha x_t + (1-\alpha)\,\mathrm{EMA}_{t-1}$
  - Recent data: more weight



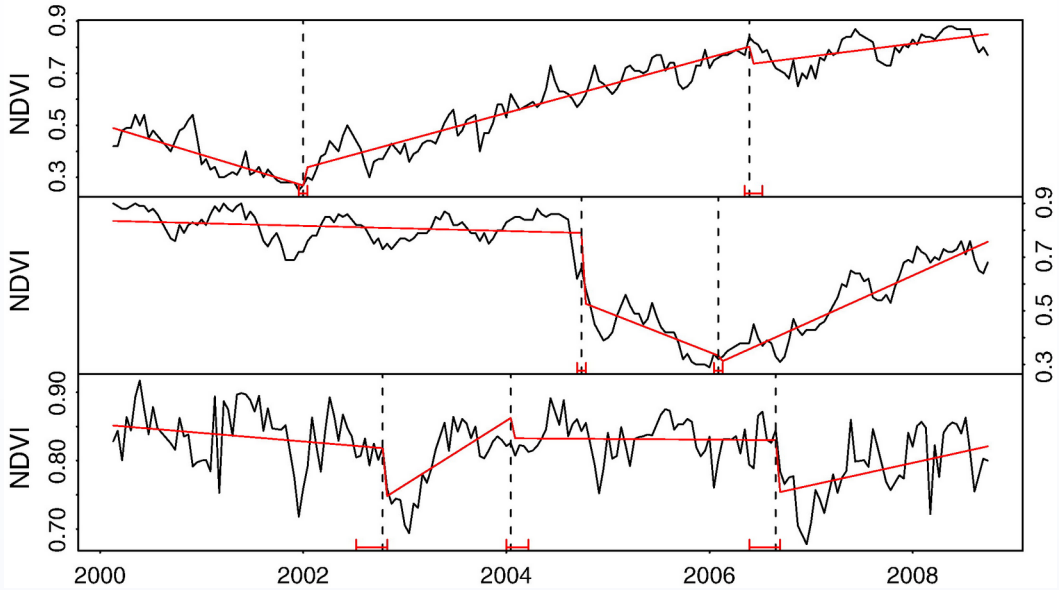
Trend estimation

- To estimate trend, often use linear regression
  - e.g., ordinary least-squares
- Problems:
  - Trends not always linear
  - Trends can change in time
- One solution: piecewise linear regression
  - Where to choose segments?



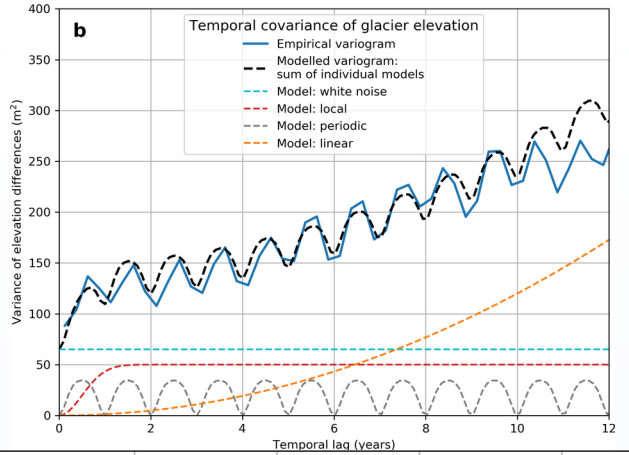
Breakpoints

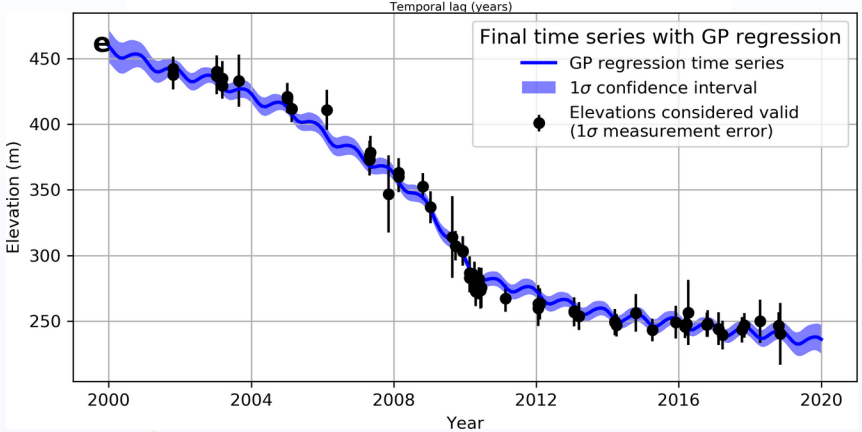
- Changes in trends (breakpoints)
  - i.e., fire, deforestation, planting, landslides, ...
- Example: Breaks For Additive Seasonal and Trend (BFAST; Verbesselt et al., 2010)



Temporal kriging

- Many time series applications assume equally-spaced intervals
  - Not always feasible with remote sensing
- Recall W2, P3: using variance to interpolate (predict) values at unsampled points (Kriging)
  - Can use Kriging to interpolate time
- Example: glacier surface elevation
  - Model variance components
  - Use elevation measurements, associated uncertainty to derive time series





Summary

- Remote sensing can give dense repeat observations; time series analysis helps understand changes
- Often interested in estimating trends, changes in trends (breakpoints)
- Analysis can be simple (e.g., moving average/linear trends) or more complex (e.g., temporal kriging)

Additional resources

- Lillesand, Kiefer & Chipman – Chapter 7
- Introduction to Time Series Analysis [NIST]
- Eastman et al., 2009 [Int J Rem Sens]
- Verbesselt et al., 2010 [Rem Sens of Env]
- Kennedy et al., 2020 [Rem Sens]