Analyzing phenology of grassland along a transect through altitudinal zones using remote sensing

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Outline

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1. Motivation

- 2 °C temperature increase in the Alps in 20th century (European Environment Agency, 2009)
- Phenology as a good way to observe impact of climate change in ecology (Rosenzweig et al., 2007)
- Grasslands, especially those in the mountain areas, are sensitive to climatic impacts (Hülber et al., 2010).
- A need for a better understanding of climatic impacts on grassland phenology for future agricultural management under climate change

- **Aims**

1) To investigate grassland green up dates in mountain areas at different site conditions (e.g. altitude and aspect)

2) To provide a better understanding of how climatic factors affect grassland green up dates

3.1. Estimation of Green-up Dates

- Remote sensing data:
  - Landsat 8 (2014 - 2017)
  - Sentinel 2 (2016 and 2017)

- Approaches
  - Curve fitting to obtain smooth time series
  - A threshold method to estimate green up date

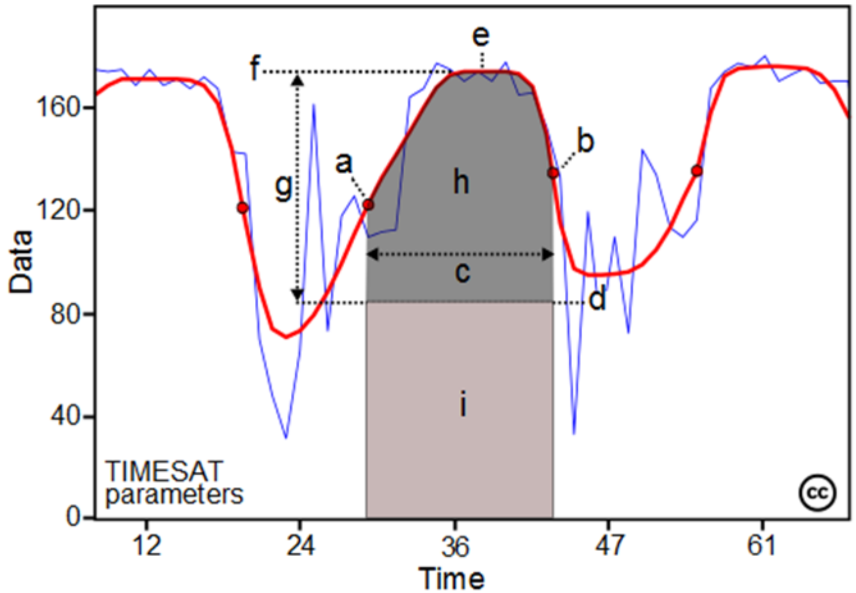


Fig. 1: Phenology extraction by TIMESAT, image taken from Eklundh, L. & Jönsson, P. (2012)

(a) beginning of season, (b) end of season, (c) length of season, (d) base value, (e) time of middle of season, (f) maximum value, (g) amplitude, (h) small integrated value, (h+i) large integrated value

3.2. Validation of Results Using WebCams

- Webcam images are used for deriving in situ phenology estimates
  → Result validation

Fig. 2: Region selection in Phenopix (Filippa et al, 2016) for an image from WebCam near Ammer Catchment (Source: Gemeinde Ettal)

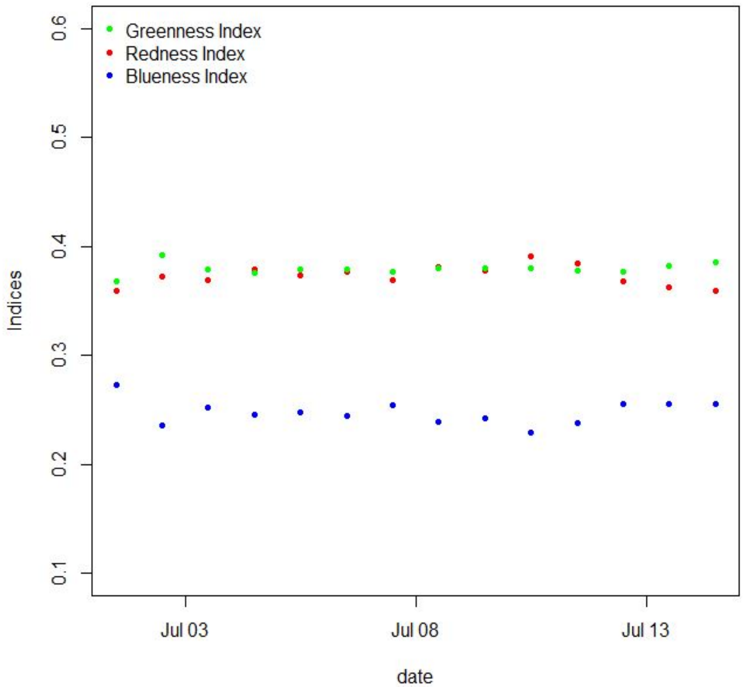
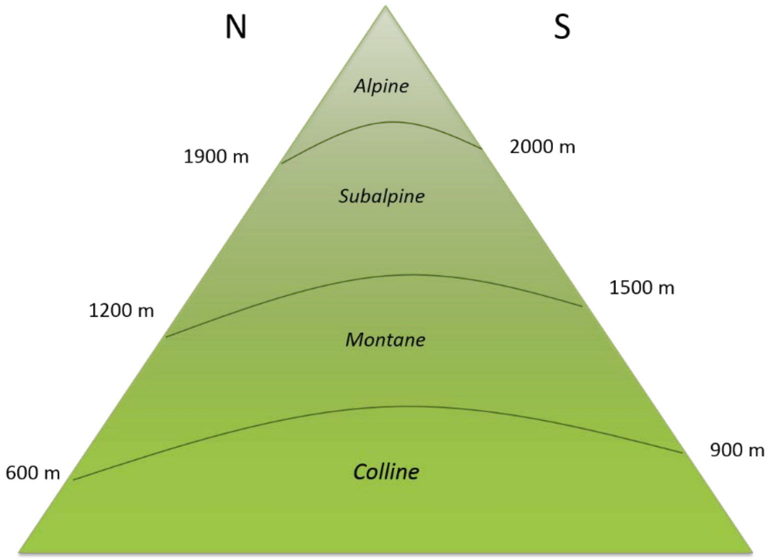


Fig. 3: Relative indices in Phenopix (Jul 01 – Jul 14 2016)

4. Study Area - The European Alps -

- Climate driven by altitude leads to different vegetation belts.
- Each belt reaches over 500 – 700m vertically and the altitude of each belt is higher in the central Alps.
- Grasslands can be found overall in the Alps.



Vegetation belt heights taken from Eggenberg, S. & Adrian, M. (2009)

Fig. 4: Vegetation belts in the Alps

5. Data and Methods

- Consideration of topographic effects on NDVI
  - Data: 2 Landsat-8 tiles (19327 and 19328) taken in May, June and July, in total 4 scenes

  - Methods:
    1. C correction (Teillet et al., 1982) and modified cosine correction (Civco,1989) on NIR and R bands
    2. NDVI calculation by corrected bands and comparison with NDVI product

- Estimation of green up dates
  - Data : Landsat-8 tiles (19327) for the whole year 2014
  - Methods: TIMESAT software
    1. Adjustment of time steps
    2. Down weighting at cloudy and snowy pixels
    3. Curve fitting (logistic filtering)
    4. Amplitude threshold method (25 %) to extract green up dates

- NDVI is known to be less sensitive to topographic effects (Matsushita et al., 2007 and Moreira et al., 2016)

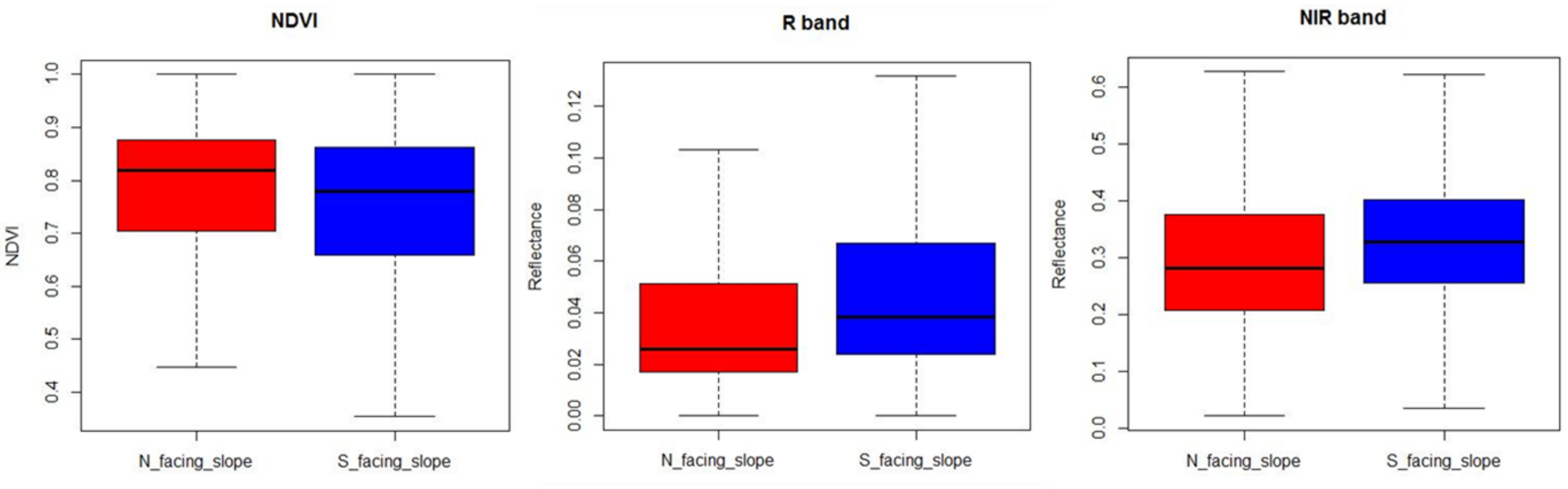


Fig. 6: Box plot of NDVI, R and NIR band at N (North) and S (South) facing slopes before topographic correction (Image tile: 19327, date: 10 Jun 2014)

- Reduction of differences in mean NDVI values between north facing and south facing slopes
- C correction reduced differences more than modified cosine correction.
- However in general the reduction rate was very small (maximum 0.59 % with C correction).

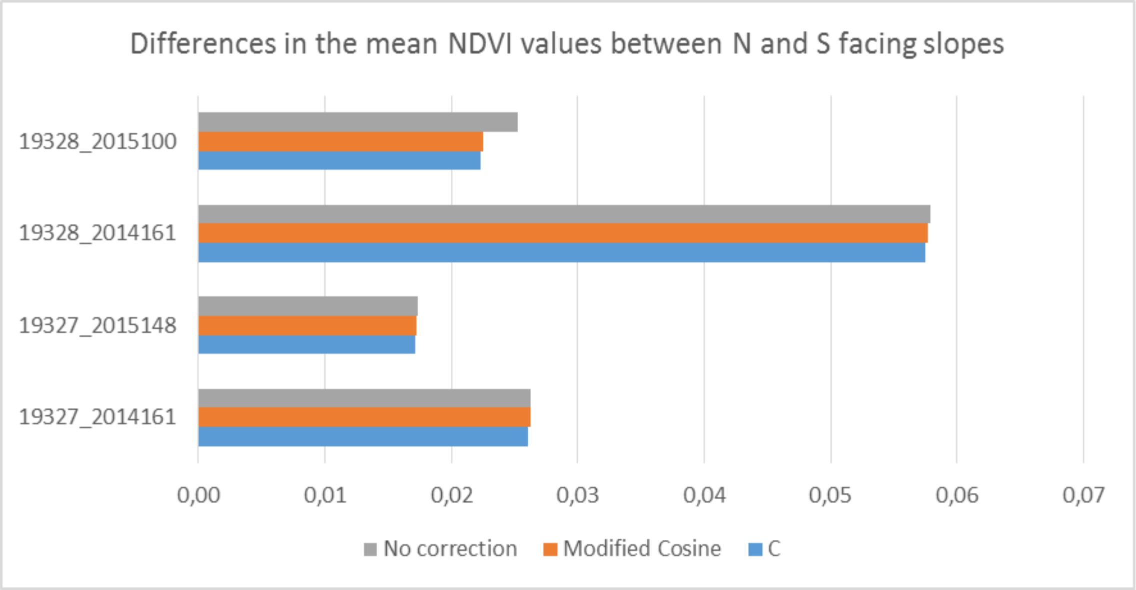
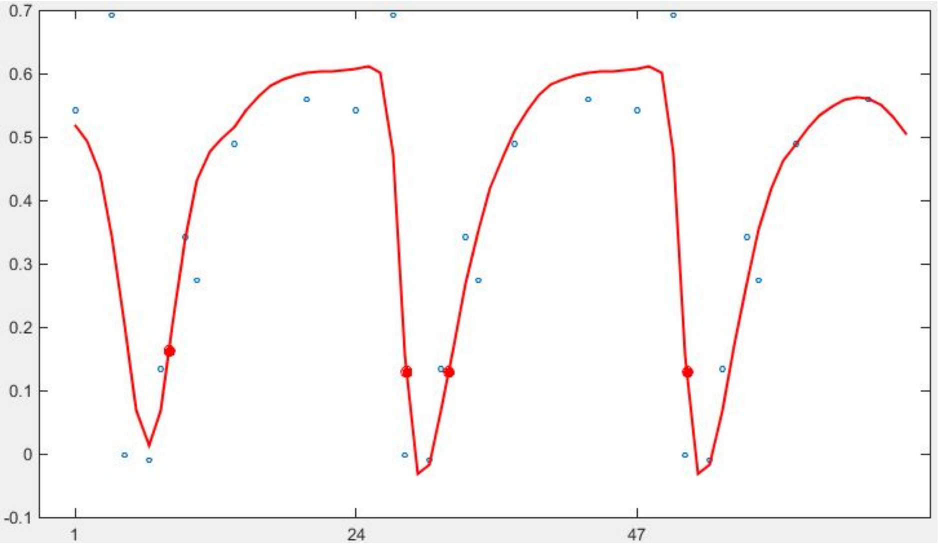


Fig. 7: Differences in mean NDVI values between N and S facing slopes

NDVI



Order of remote sensing time series

Fig. 8: Example of curve fitting at a pixel in TIMESAT for the year 2014 (The year of 2014 is multiplicated in the graph)

- Setting:
  - Curve Fitting: logistic filtering
  - Threshold: 25% increase of amplitude
  - Number of envelope iteration: 1 (with lowest adaptation strength)

- The fitness of a curve depends on:
  - The number of valid observations and when they were observed
  - Settings in TIMESAT software

6.2. Estimation of Green-up Dates

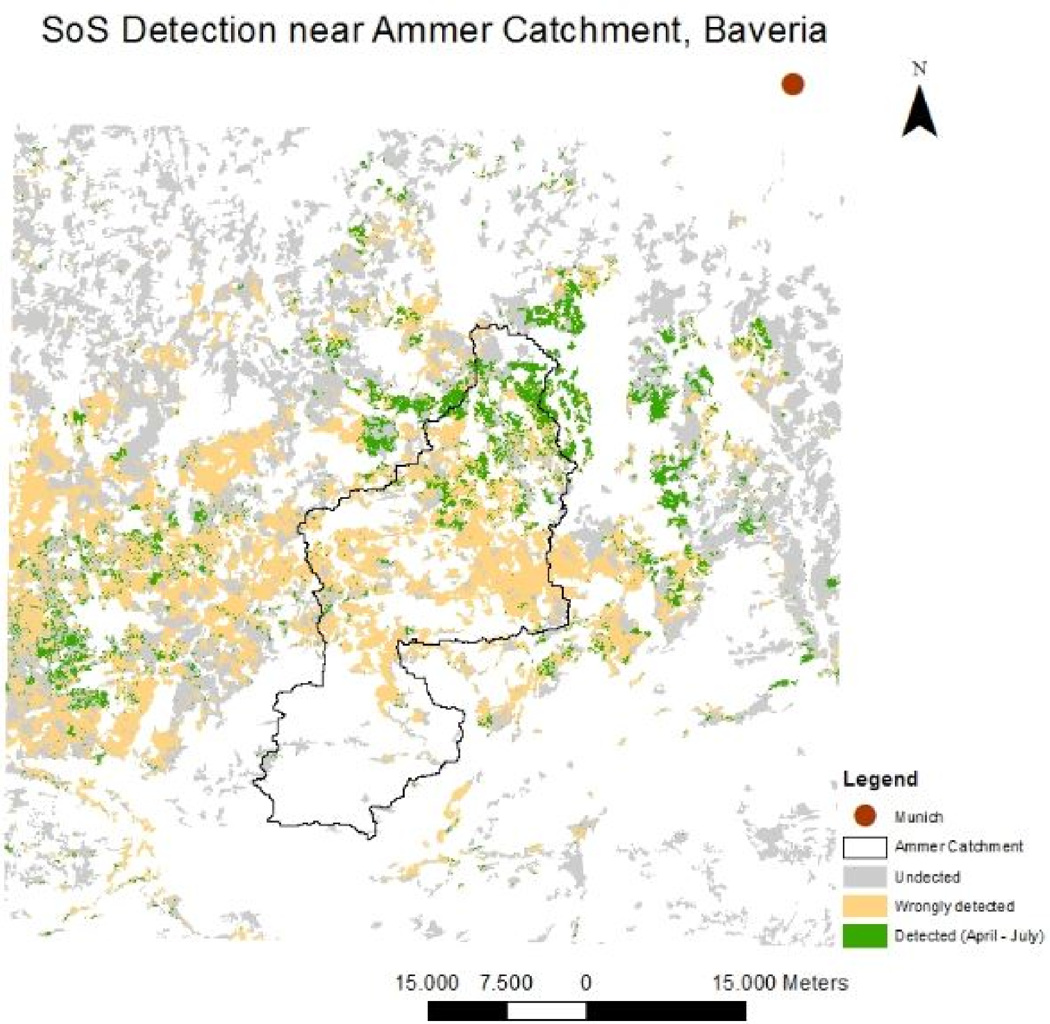


Fig. 9: Detection of SoS in TIMESAT for the year 2014

- TIMESAT is applicable to Landsat-8 data
- However, due to cloud occurrence SoS (Start of Season) can be detected at limited sites
- Undetected noises can lead to wrong detection of phenology
- The fitness of a curve can be improved by parameters setting (e.g. number of envelope iterations and adaptation strength)

7. Findings

- Topographic correction did not produce significant differences on NDVI (Landsat-8) in the study area
- Frequent cloud occurrences limit the ability to derive spatially consistent phenology from Landsat-8
- However, Landsat-8 can be used to estimate SoS through TIMESAT
- As a next step, the number of valid remote sensing observations will be increased by integrating other remote sensing data

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Thank you for your attention!