Climatic Drivers of Greening Trends in the Alps

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Motivation

- widespread greening at global level (e.g. Zhu et al 2018, Nat. Clim. Chang.); cold environments (arctic and sub-arctic) are greening faster than temperate areas in response to accelerated warming (e.g. Keenan et al. 2018 Nat. Clim. Chang.)
- less work has been devoted to quantifying and understanding patterns of greening in temperate mountain regions, such as the European Alps (Carlson et al. 2017, ERL)
- the Alps are a hot spot of climate and land-use changes → influencing ecosystem processes and services in densely populated alpine valleys

Questions

1) Are the Alps getting greener? What is the magnitude of greening trends in alpine ecosystems?

2) Which are the drivers of NDVI trends?

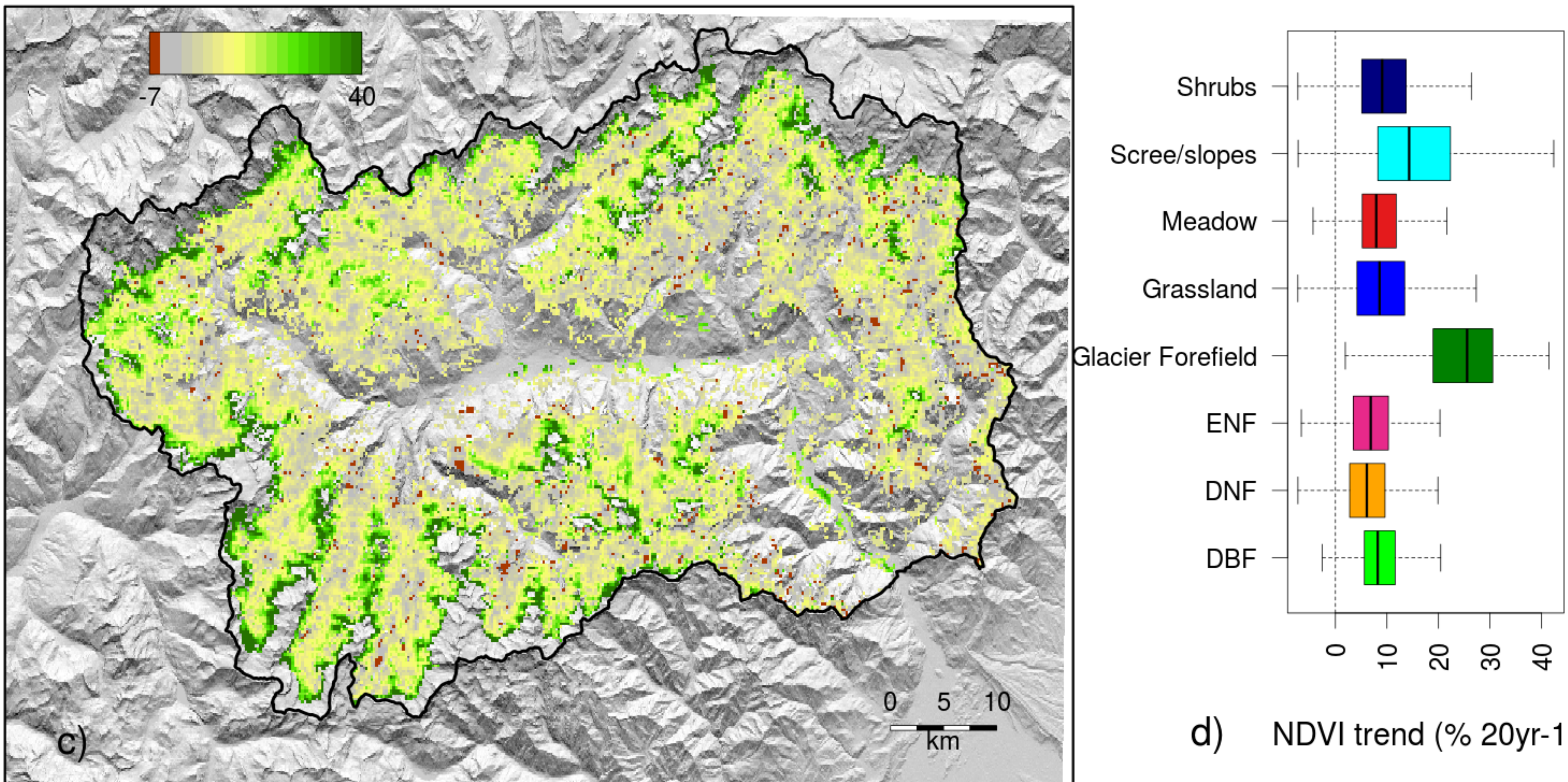
3) Can we detect alpine greening using MODIS data (spatial resolution, ndvi saturation)?

Study area: Aosta Valley, NW European Alps, 300-4810 m asl

Data: MODIS NDVI archive (2000-2018)

Method: Trend NDVI, BFAST i.e. **peak ndvi** and **ndvi seasonal curve** (disturbances removed)

Relative NDVI trend$_{BFAST}$ (200-2018) in alpine ecosystems

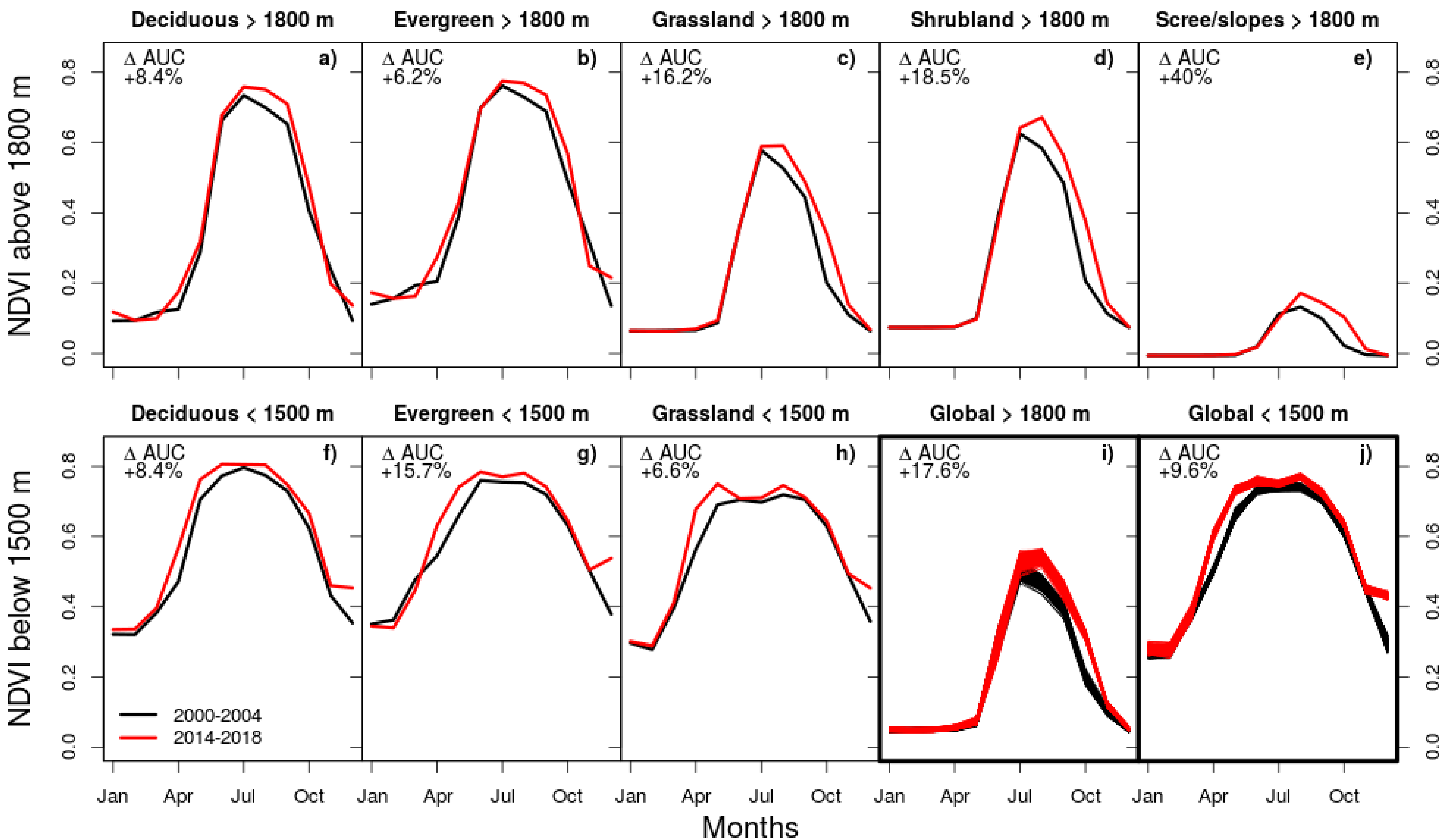


Filippa et al. 2019, Remote Sensing, https://www.mdpi.com/2072-4292/11/21/2527/htm

Drivers of change: the role of elevation

> 1800 m asl (top row) → later fall

< 1500 m asl (bottom row) → earlier spring



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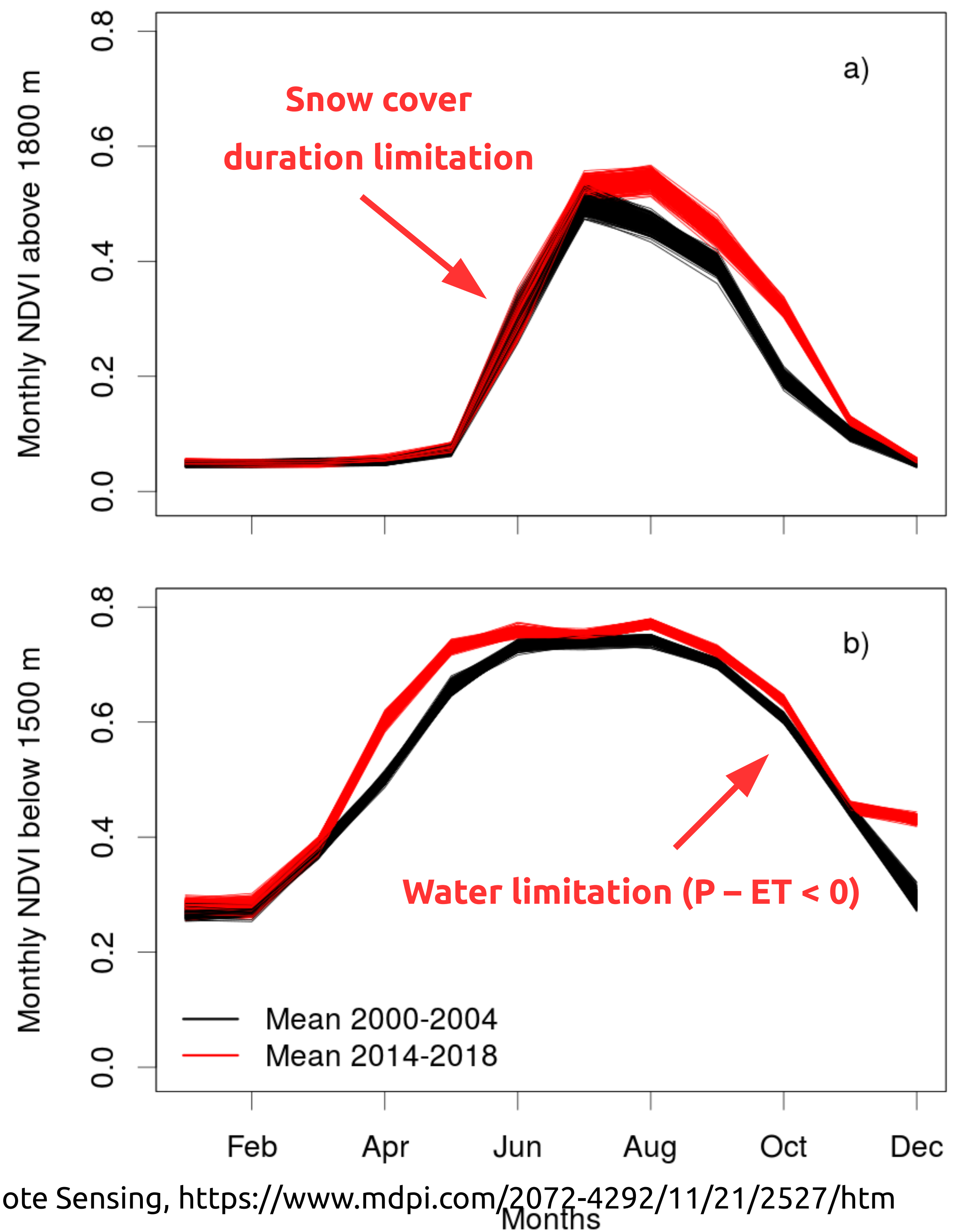

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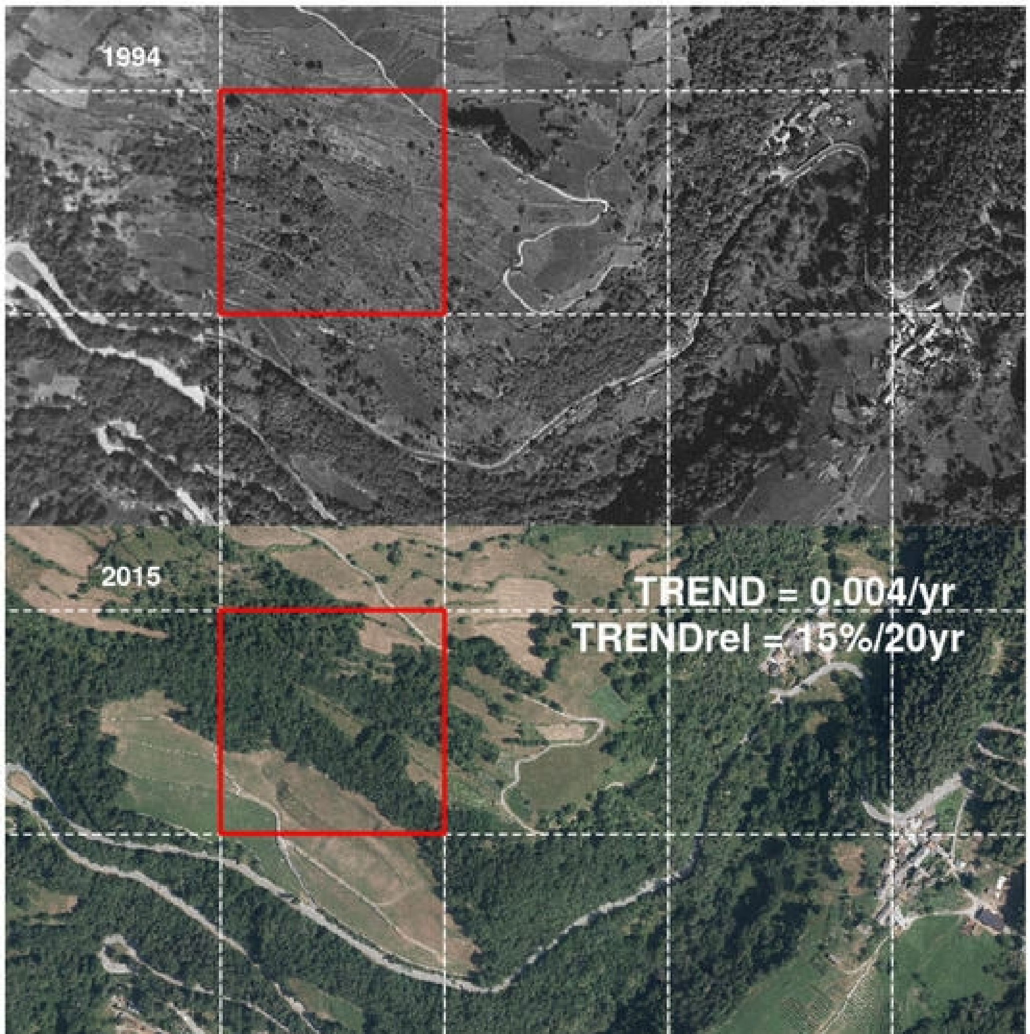
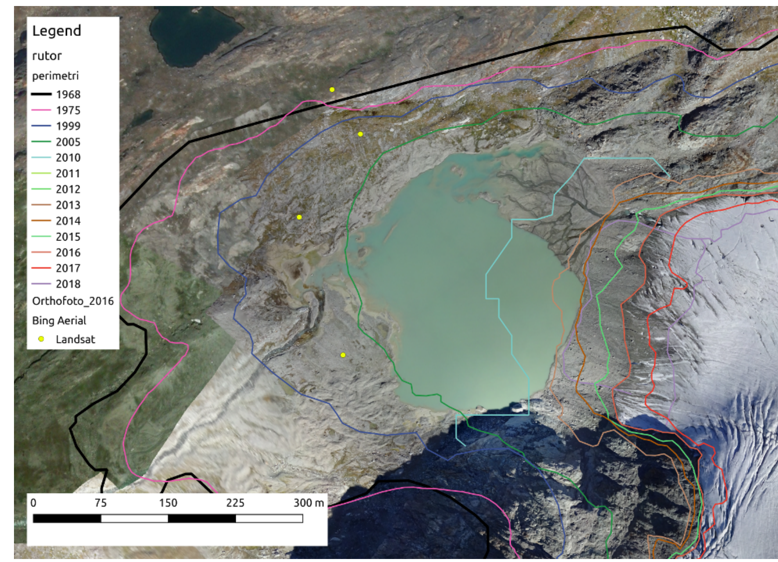
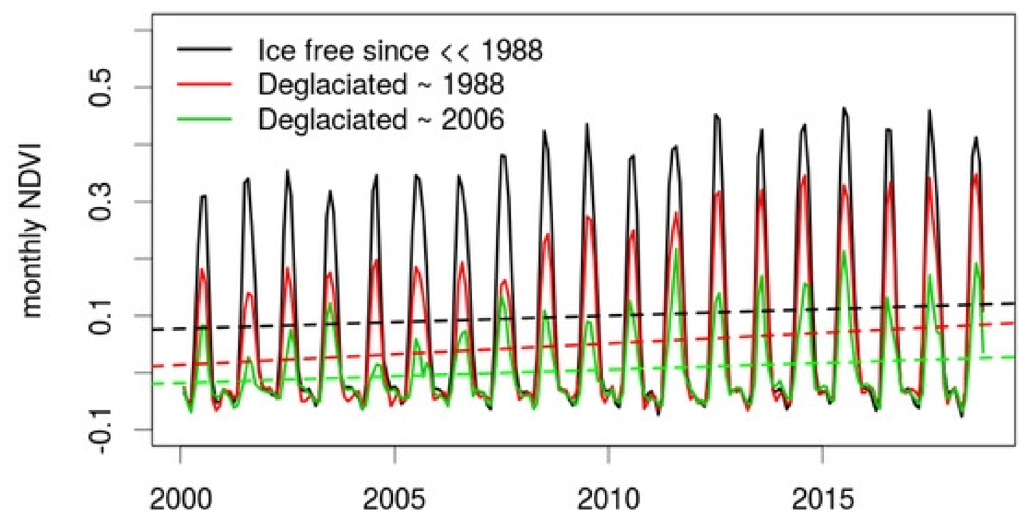
Specific alpine processes related to land cover/use change

Shrubs/forest encroachment agriculture and pasture abandonment



vegetation colonization of pro-glacial margins and upward shift of herbaceous plant species





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Conclusions

- evidences for widespread greening of alpine ecosystems
- MODIS archive can be used to detect greening trends (no limitations caused by spatial resolution or ndvi saturation)
- BFAST method allows to remove disturbances and analyze trends driven either by NDVI peak and by NDVI seasonal trajectories
- temperature and snow cover duration are the main drivers of greening trends
- seasonal timing of greening is regulated by elevation- and ecosystem-dependent factors: snow prevents spring plant development above 1800 m, whereas at low elevation water and photoperiod both interact as limiting factors in autumn

Perspectives

- expand the scale to an alpine-wide domain in order to (i) confirm or discard patterns observed here and (ii) take into account processes operating at a larger scale
- combine differnt eo archives (MODIS and Landsat)
- glacier forefields colonization dynamics

Methods

Remote sensing data

All satellite data cover the period from February 2000 to December 2018.

MODIS Terra surface reflectance images (MOD09Q1) collection 6 at 250 spatial and 8 days temporal resolution was used to compute NDVI maps, which were then masked according to the MOD09Q1 quality flags.

MOD10A2 collection 6 snow covered area (SCA) standard product was used to compute a winter baseline for NDVI: first, the SCA dataset was used to mask snow-free pixels. For each pixel, the 5th percentile of NDVI was computed on the whole time series to determine a per-pixel climatological minimum snow-free NDVI. This minimum snow-free map was used to mask each 8-day NDVI map, with values lower than the climatological minumum substituted with it on a pixel basis.Corrected 8-day maps were averaged to a monthly product which was used in all subsequent analyses.

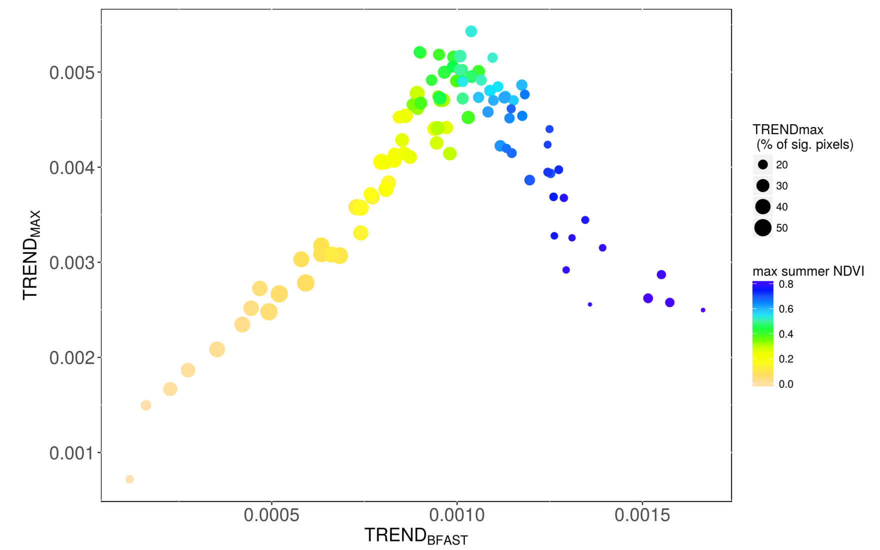
Data analysis

The BFAST (Breaks For Additive Seasonal and Trend) method implemented in the bfast R package was used to calculate NDVI trends over the 2000–2018 period. This method is particularly suitable for the detection of disturbed time series and concomitant trend detection. Pixels showing clear breaks in either long-term trend or seasonal components were removed from the analysis of trends.

TRENDBFAST values were also expressed as percentage of the long term pixel-based mean and further multiplied by 20 to represent the cumulated NDVI increase in the two decades (2000–2018)

The BFAST method allowed us to remove disturbed and non-linear signals from ~37% of the vegetated land and to focus our analysis on widespread greening trends representing more than half of the vegetated areas

This method marks an improvement over the traditional TRENDMAX; it allow the detection of a greater number of pixels with significant trends but it is also more robust against the saturation of NDVI signal



For more details: Filippa et al. 2019, Remote Sensing,

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