Forest microclimate and its modelling with remote sensing

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Questions1: How does the real microclimate conditions differ from that one usually used for bioclimatic modeling?

Introduction

Bioclimatic models forecast redistribution, assemblage change and extinction risk for many species as a result of the anthropogenic climate change. However, these predictions mostly stand on coarse interpolated climate measurements and neglect microclimate heterogeneity relevant for species living near the ground. To not take into account that aspect may lead to overestimation of potential impacts of climate change.
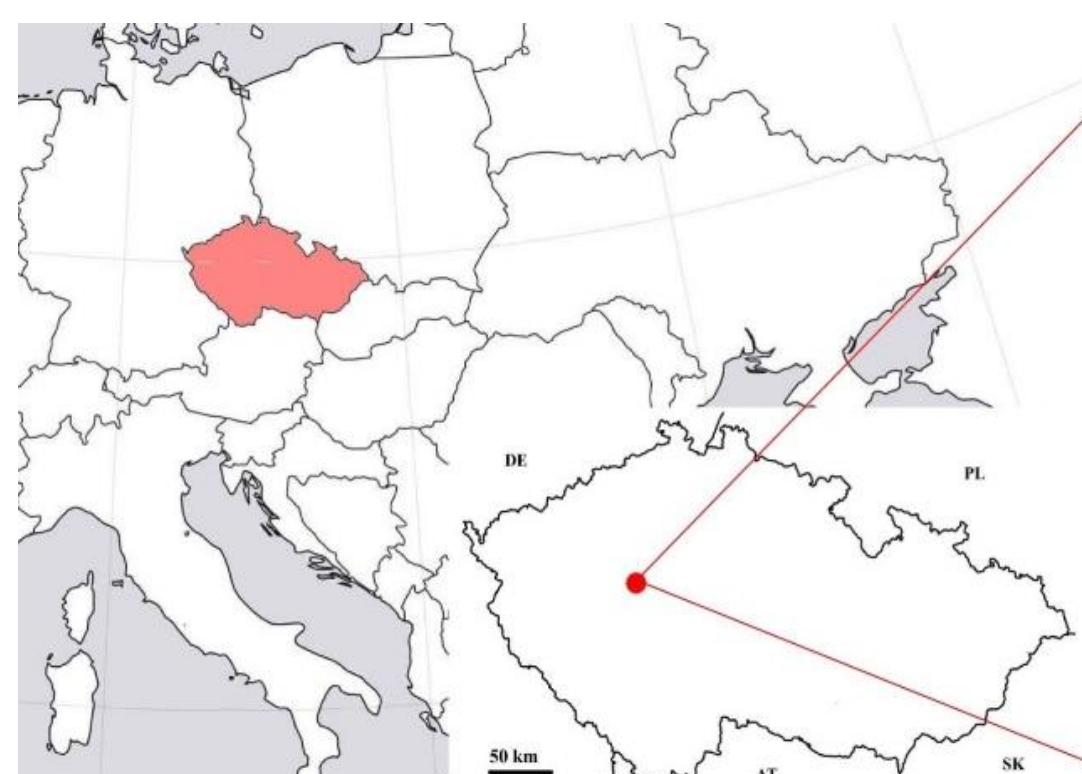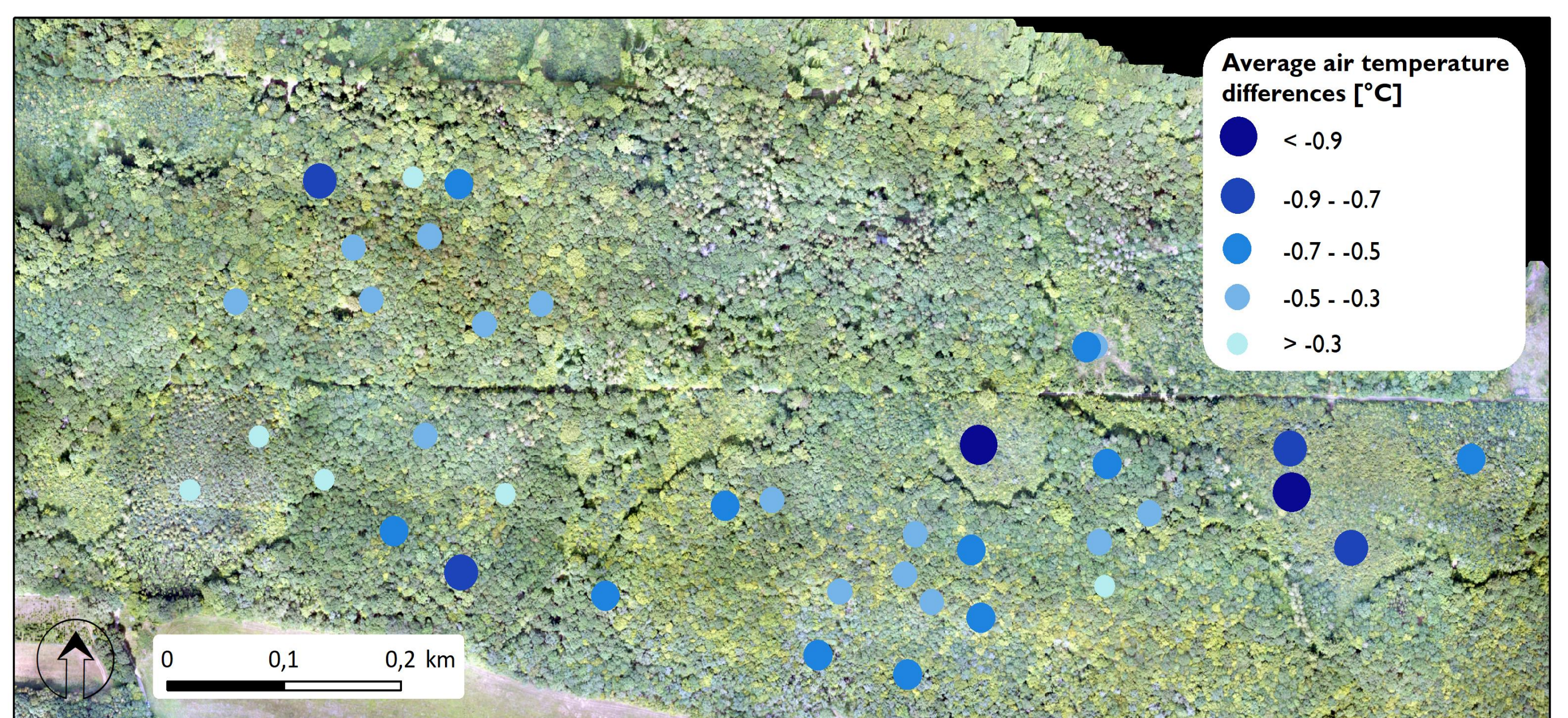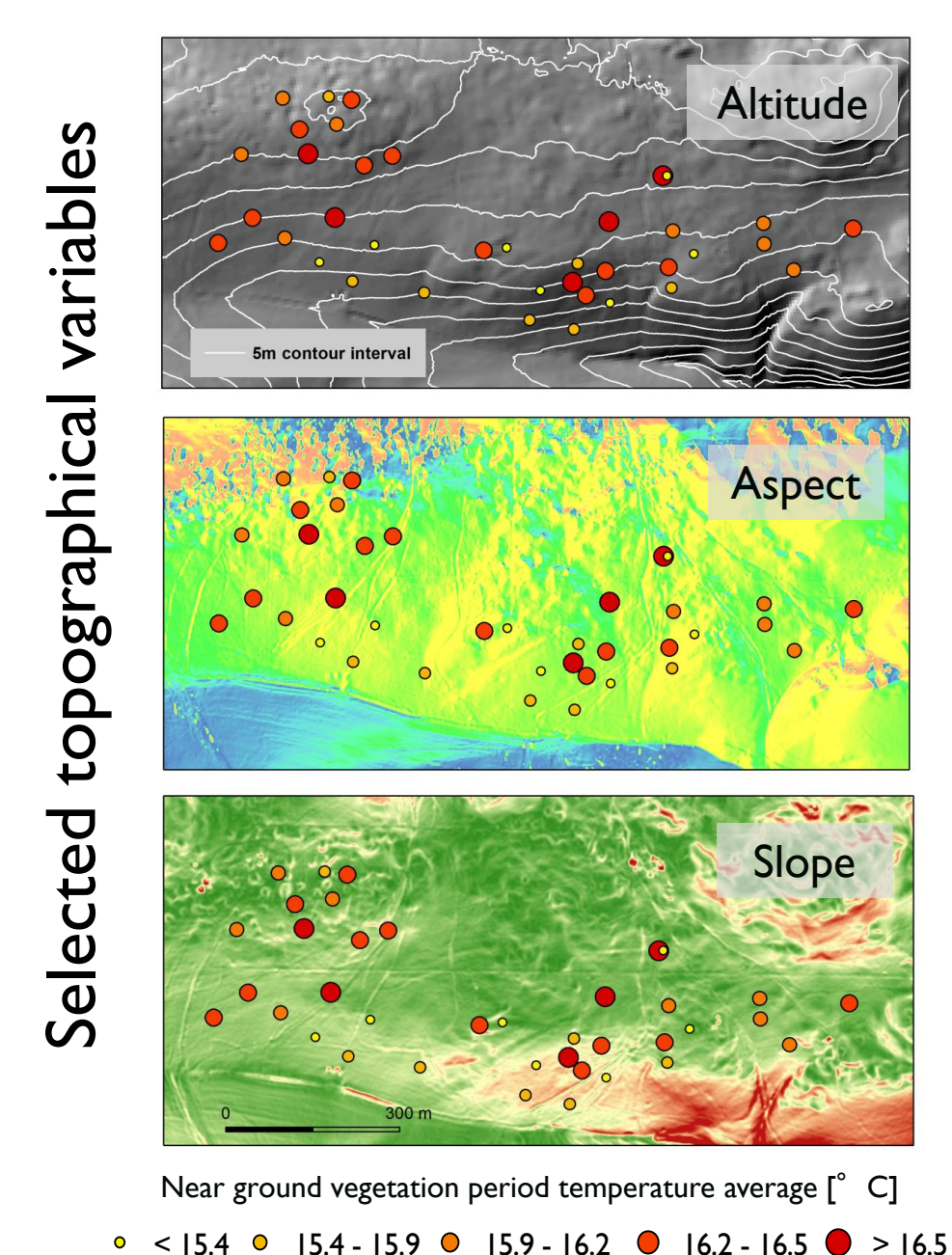

Fig. 1. Comparison of air average temperature during vegetation season (may – september) between 37 microclimatic stations and adjacent standart meteorological station (Praha – Ruzyně), from where is the data used in database WorldClim.

Average air temperature differences [°C]
- < -0.9
- -0.9 - -0.7
- -0.7 - -0.5
- -0.5 - -0.3
- > -0.3

0   0,1   0,2 km

Questions 2: What is the spatial pattern and seasonal variation of microclimate within a topographically homogeneous site?

Selected topographical variables

 Altitude

 Aspect

 Slope

Near ground vegetation period temperature average [°C]
- < 15.4
- 15.4 - 15.9
- 15.9 - 16.2
- 16.2 - 16.5
- > 16.5

In our study, based on very detailed 37 microclimatic measurements of soil, near the ground and air temperature, we point out that even within a topographically homogeneous 20-ha temperate forest microclimate highly varied.

- 0.9 – 2.2° C differences for a vegetation period average
- higher differences for temperature extremes (min 4.8° C, max 6.2° C for the above ground sensor)
- temperature deviations refer to open canopy gaps and dense forest canopy
- spatial pattern is not caused by geomorphometric characteristics

Fig. 2. Microclimate heterogenity during vegetation season within a 20-ha temperate forest measured by TMS 4 datalloger (Wild et al. 2019) in three vertical levels relevant for plant understorey.

3 — 15 cm above ground sensor
2 — ground sensor
1 — 8 cm below ground sensor
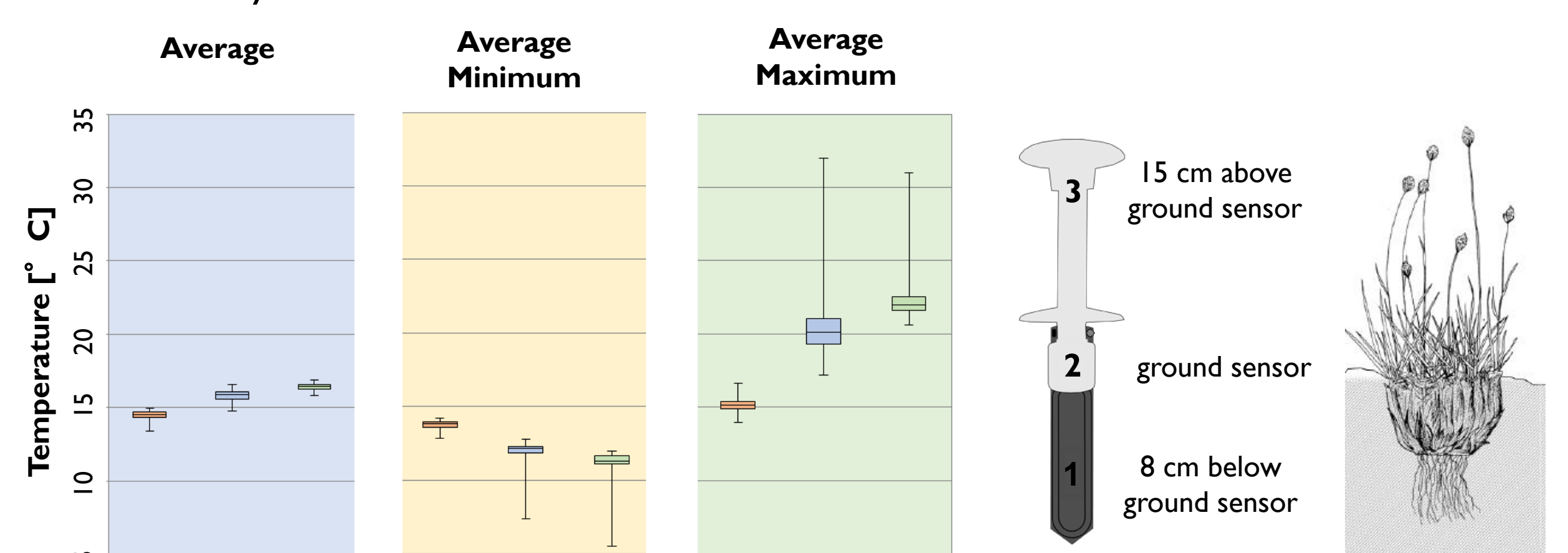
Questions 3: How is microclimate dermined by forest canopy and how to extrapolate predicted variables?

Analysis of the hemispherical photographs revealed an influence of forest canopy cover in modifying microclimate. Higher predictability was found for below ground temperature average, whereas air and the near temperature was difficult to quantify. A similar trend with lower dependencies showed canopy variables derived from UAV (Unmanned aerial vehicle) laser scanning and optical-based methods.
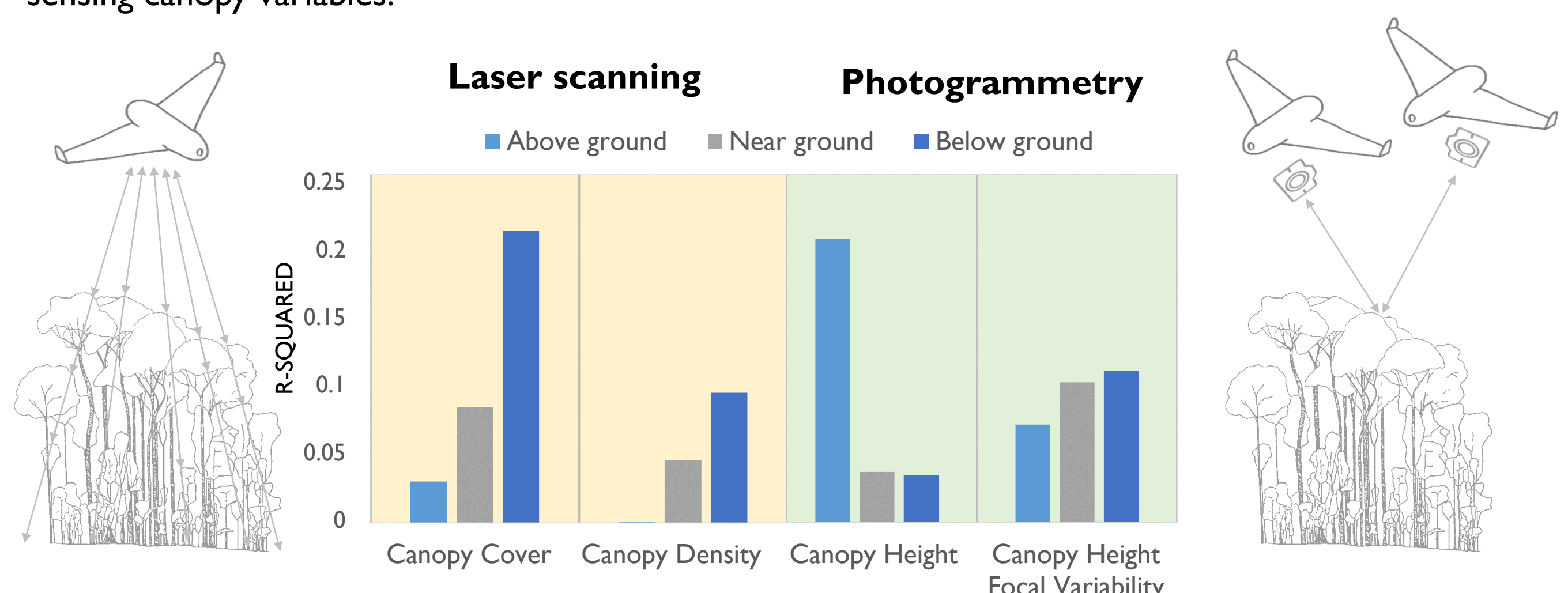
Fig. 3. Variability in mean annual temperature explained by canopy openness in differerent zenith angles.

Zenith Z=0°
Z=30°
Z=60°
Z=90°

R-SQUARED vs ZENITH ANGLE
- below ground
- near ground
- above ground
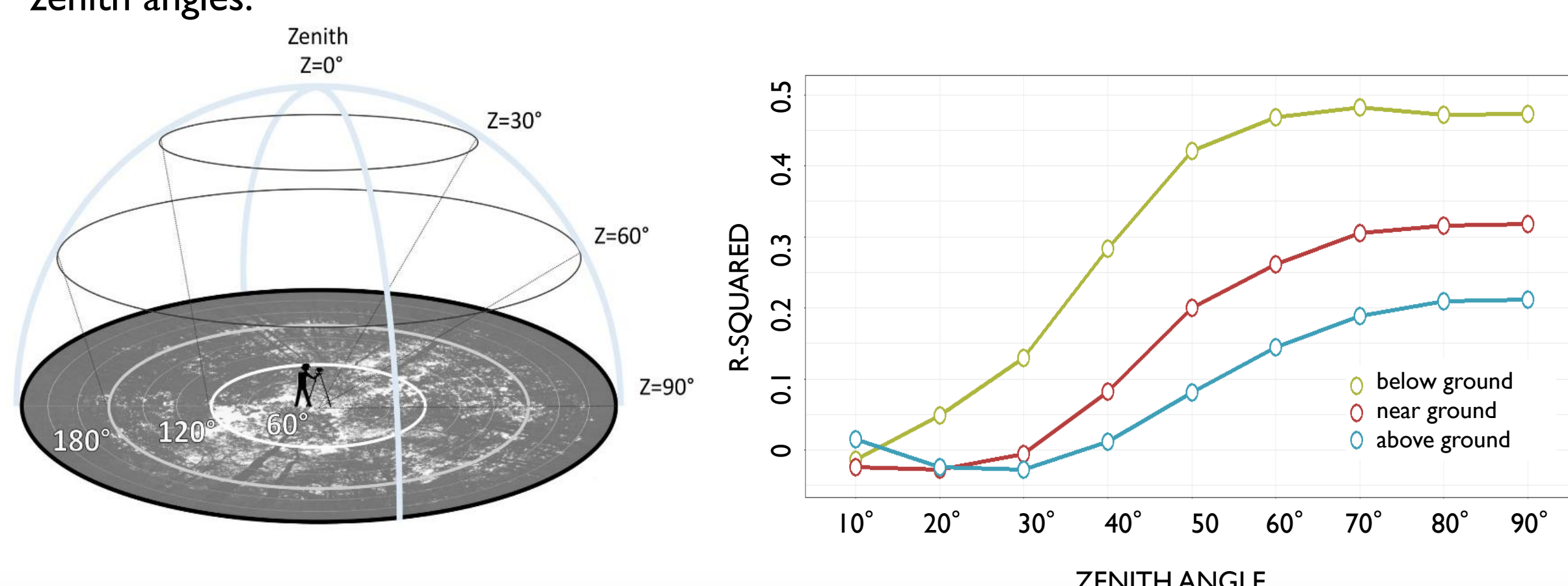
Highlights:

- At small scale, forest microclimate varied greatly depending on canopy openness; especially true for temperature extremes crucial for plants.

- UAV-derived microclimate proxy variables are capable to improve the bioclimatic predictions at a landscape scale.

Fig. 4. Proportion of the variance in average vegetation season temperatures predicted by remote sensing canopy variables.

Laser scanning   **Photogrammetry**
- Above ground
- Near ground
- Below ground

R-SQUARED: Canopy Cover, Canopy Density, Canopy Height, Canopy Height Focal Variability

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Reference

Wild J., Kopecký M., Macek M., Šanda M., Jankovec J., Haase T. (2019): Climate at ecologically relevant scales: a new temperature and soil moisture logger for long-term microclimate measurement. Agricultural and Forest Meteorology.

Acknowledgments