USING THERMAL IR IMAGING FOR IDENTIFICATION OF COLD AIR INFLUXES AND TOPOCLIMATOLOGICAL INVESTIGATIONS – A CASE STUDY FROM ROZTOCZE NATIONAL PARK

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ABSTRACT

Meteorological research has been carried out in Roztocze Region for many years by numerous scientists. Nevertheless, information about its climate is limited to general climatic classifications of Poland. Knowledge about local climates of this specific area is rather limited. In this case study, the authors combined traditional methods of investigating this topic with ground-based thermal IR imaging not used in small-scale climatology so far.

Thermal IR images of places where cold air influxes are expected were taken as a first step of fieldworks. Then, measurements of temperature and relative humidity spatial differentiation were conducted at chosen sites. Simultaneously, continuous meteorological measurements were performed in different local ecosystems with the aim of e.g. verifying hypotheses about differences of thermal conditions at those sites. The results of fieldwork were processed and analysed using GIS and then related to local topographical conditions assumed from satellite imaging land cover.

As a conclusion of the investigation, it can be stated that the influence of forest on grassland phytoclimate during advection of cold air can be observed only in a limited range of distances. This interaction changes according to the type of weather, relief of the land and type of vegetation. It is also worth emphasizing that using a handheld thermal IR camera, GIS analysis and satellite imaging can be considerably helpful in research on local climate and extreme thermal phenomena.

INTRODUCTION

The Roztocze Region, located in the SE part of Poland, has been a site of environmental studies performed by Maria Curie-Sklodowska University for many years. Furthermore, various meteorological studies, especially in Roztocze National Park (RPN), were carried out. Nevertheless, knowledge about the climate of this area is generally limited only to a definition of main features in general Polish climate classifications. The most recent data on Roztocze climate are available in monographs of Roztocze region (1) and Roztocze National Park (2). However, there is lack of up-to-date research concerning topo- and microclimate spatial distribution in Roztocze National Park. Especially, there is no state-of-art knowledge about phytoclimates and local climates in this area. In the past, several studies on concrete ecosystems (3,4) and on the climatic conditions in the Zwierzyniec neighbourhood (5) were carried out, but all of them used manual instruments and longer measurement intervals. There was also an inquiry on topoclimatological research in protected areas in the Lublin region, but it touched the RPN area very generally (6).

Due to the fact that knowledge about microclimates in RPN is not well developed, we decided to find areas with specific hallmarks of microclimate, which is affected by its surroundings. We were especially looking for areas of cold air influxes which could be harmful to some plant species, particularly in certain stages of vegetation. A novelty provided by this research lies in handheld thermal IR camera application for locating cold air masses, which is not widely known in small-scale

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meteorological research so far. In previous research (7), it was proposed to apply remote sensing in topoclimatological mapping, but it has not been realised yet.

METHODS

Field research was performed in Roztocze National Park, in the neighbourhood of the forest settlement Florianka in September 2012. This investigation covered the most distinctive natural ecosystems of RPN (8) (common beech, fir forest, glade and woodless plateau). The distribution of measurement sites enabled the authors to find a microclimatic variety between places with different relief of the land and land cover. Measurements of air temperature and relative air humidity at all sites in the study area were conducted continuously with World Meteorological Organisation (WMO) standards of 10 min intervals and heights of 50 and 150 cm using automatic meteorological stations from ASTER consistent with WMO standards. Measurements were realised according to topoclimatological mapping assumptions using short observation periods (9).

With the aim of detecting locations of cold air influxes and forest influence on deforested areas, field measurements combined with ground-based thermal IR imaging were carried out. Firstly, ground-based thermal IR images of potential places were taken, where cold air influxes could be observed. Images were taken with a handheld thermographic camera MobileIR E4 from InfraTec with a thermal sensitivity of ≤100 mK (at 30°C) and a spectral range of 8-14 µm. Several pictures, out of about 50, taken during fieldwork confirmed locations with cold air influxes (valleys and hollow forms of land).

At one of those sites (with an area of about 5 hectares) further investigations on thermal and relative humidity characteristics were carried out. At 49 points distributed in a regular grid, values of temperature and relative humidity as well as coordinates were registered. For those measurements we used a thermohygrometer LAB-EL with a temperature accuracy of ±0,1°C and a relative humidity accuracy of ±2-4%. This field work was done early in the morning to avoid the influence of shortwave radiation emitted by the Sun and to get view of the potentially largest extent of cold air influx. Based on similar patrol measurements, phytoclimate features and interaction between local climate and vegetation have been specified for many years (10).

Analysis of spatial distribution of temperature and relative humidity was the last step of this case study. Values of those parameters were interpolated (radial basic function) using GIS software and then analysed in relation to topography and land cover (vegetation). A similar analysis of relief, land cover and ground humidity was previously performed for synthetic topoclimatic mapping in Poland (11).

RESULTS

Points of continuous meteorological measurements are shown in Figure 1. The topography of the research area is shown by contour lines with 2.5 m cutting. Land cover is presented with natural colour composition of bands 4-3-2 from WorldView2 satellite image.

In radiative types of weather, air cools down before sunrise and then colder (heavier) air flows down to lower areas depending on the relief of the land – sites N and S in Figure 1. Further fieldwork has confirmed locations with cold air influxes at those places (12,13)

In Figures 2 and 3, it can be observed that cold air influxes consist of several stages. In the beginning of the process, there is an increase in cold air extent (Figures 2 A,B and 3 A,B). Afterwards, there occurs further lowering of air temperature and its disparities rise, while the extent of this phenomenon is decreasing. It could be said that cold air is concentrating in small areas and has much lower temperatures than its surroundings. See Figures 2 C and 3 C as examples.

In addition, it can be observed that air over the tops of trees becomes warmer during sunrise, while the upper branches of trees become active layers and absorb solar radiation. Simultaneously, there is a strong decrease in air temperature on woodless plateaus (Florianka) and then a rapid increase in air temperature caused by solar radiation supply. Forest is characterised by the lowest changes of temperature because of the significant role of thermal inertia (Figure 4).

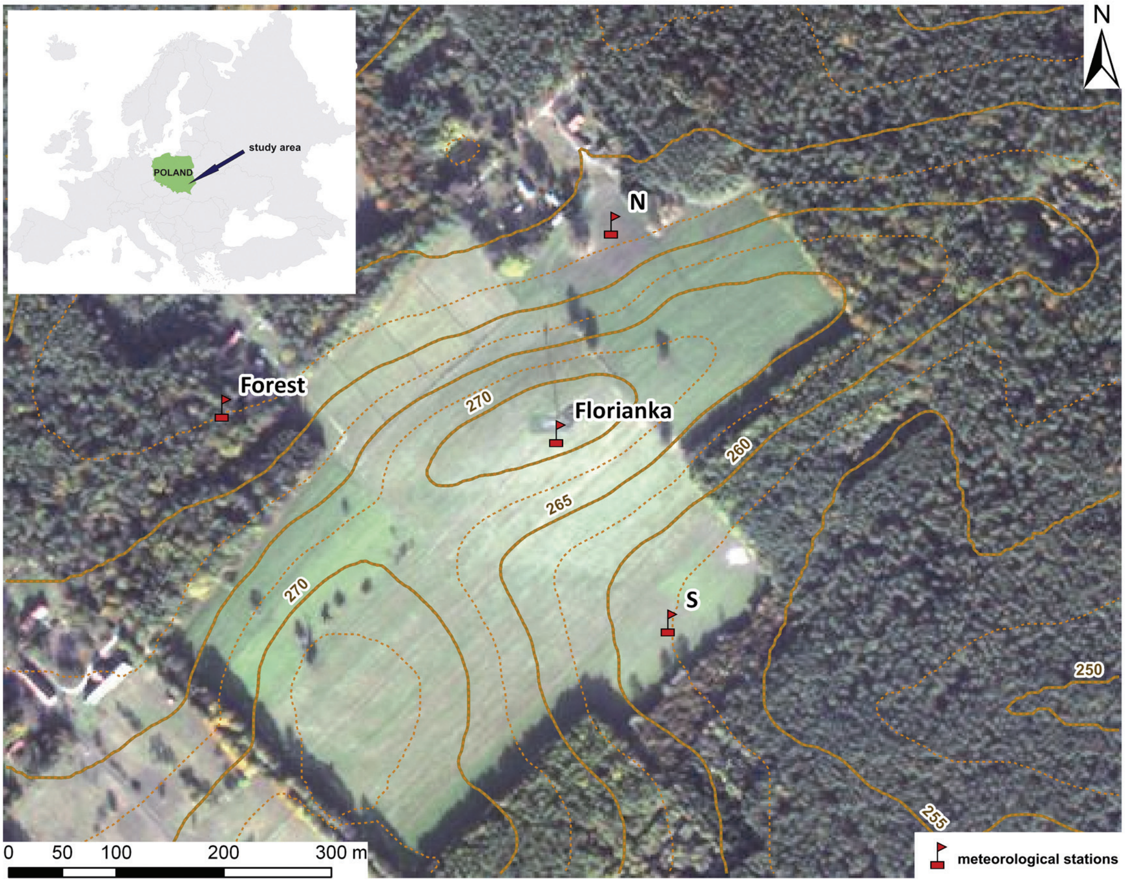

Figure 1: Location of study area and automatic meteorological stations, topography and land cover of the Florianka neighbourhood (WorldView2 satellite image, spectral composition 4-3-2, acquisition date 11 Oct 2011).

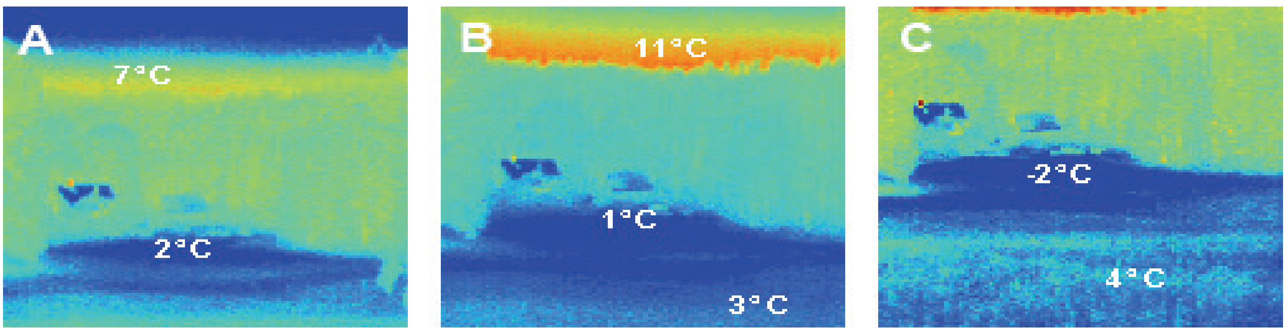

Figure 2: Ground-based thermal IR imaging series taken on 7th September 2012 just before (A), during (B) and just after (C) sunrise. Direction from station Florianka to point N.

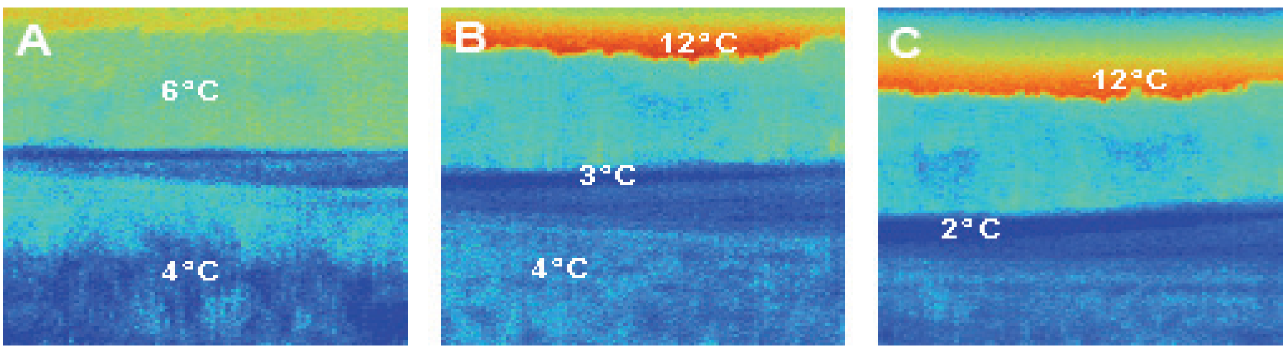

Figure 3: Ground-based thermal IR imaging series taken on 7th September 2012 just before (A), during (B) and just after (C) sunrise. Direction from station Florianka to point S.

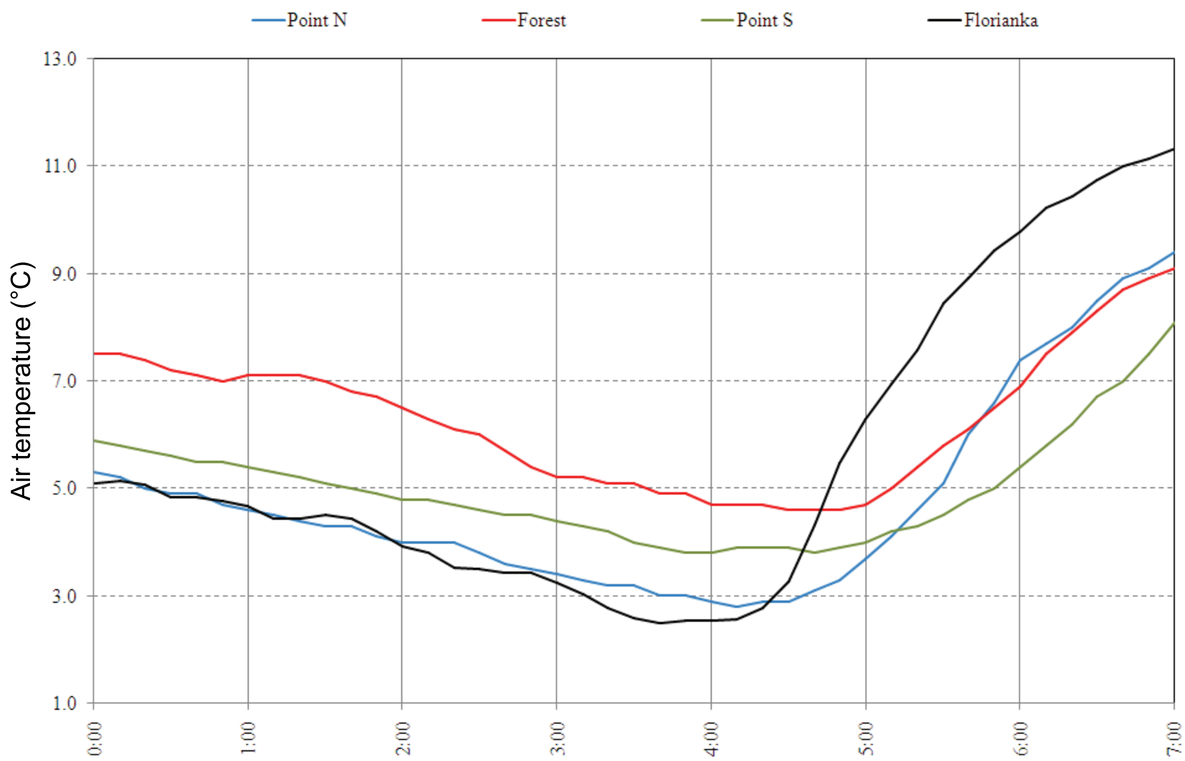

Figure 4: Course of air temperature 50 cm above the ground from midnight to 7 a.m. on 7 September 2012.

Values presented in Figures 2-3 differ slightly from those presented in Figure 4 due to different ways of measurement. Figure 4 shows the air temperature 50 cm above the ground, while thermal IR images are based on the surface temperature, which is connected with the temperature of air but is not equal.

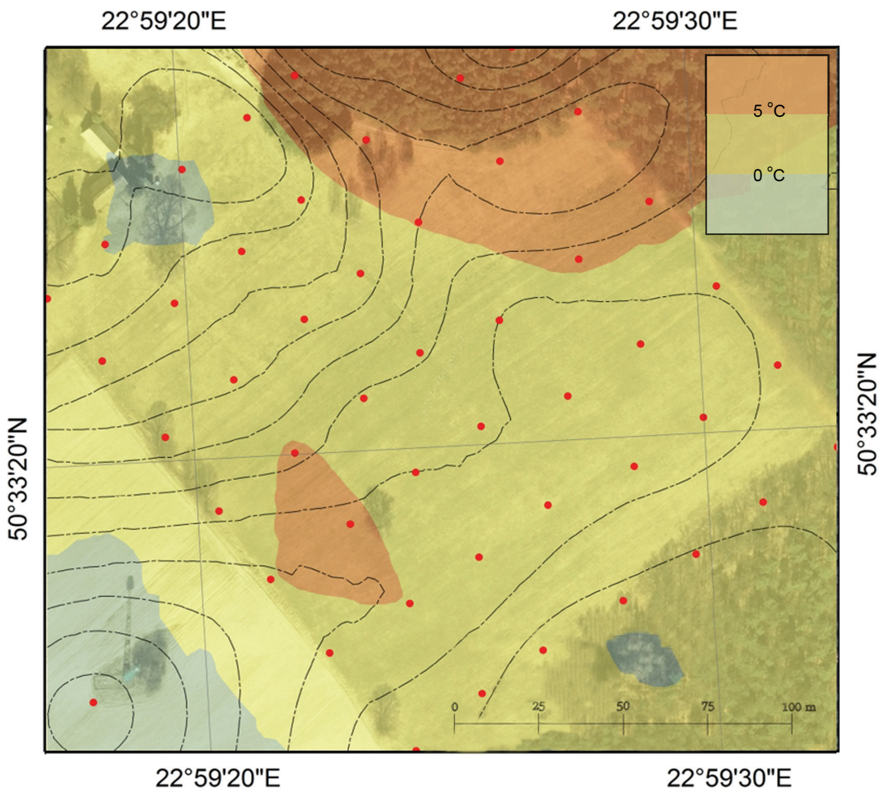

Figure 5: Values of air temperature 150 cm above the ground at 6 a.m. on 7 September 2012.

CONCLUSIONS

On the basis of conducted measurements, it can be stated that the grassland phytoclimate is most significantly influenced by the relief of the land and the thermal inertia of forest in concrete types of weather (radiative cooling down).

It is also worth emphasizing that the use of a handheld thermal IR camera, GIS analysis and patrol measurements can be considerably helpful in research on local climate and extreme thermal phenomena. Results of fieldwork revealed that considerable differences in daily air temperature changes and vertical air temperature distribution occur even in small areas.

For better understanding and recognition of phenomena of cold air influxes, the authors recommend further research on phytoclimates in different synoptic situations, seasons, types of weather and ecosystems of Roztocze National Park.

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