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Short communication

Have you never seen an infrared humus/human profile?☆

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ABSTRACT

One day, I was at work on my knees inspecting a soil profile when two young women arrived in the same forest cheerfully conversing amongst themselves. They began to take infrared photographs here and there. They did not see me at first as I was in a soil hole that I had dug for my research. They were studying how art and science could interact by "questioning" trees. They looked for their infrared "answers", mainly on the trunks and leaves.

A few weeks later, they sent me the IR soil photographs and without success, I tried to include them in a paper. Their initials are under the prepared figures and the original article evolved into a short communication. If you would like to see how humus profiles look like under infrared (IR) light, you may skim through the following pages; it will only take a few minutes.

It appeared that IR images can help in soil investigations, detecting the limits between organic and organic-mineral diagnostic horizons. Induced by the radiation emitted by surrounded bodies/matter, IR images correspond to bi-dimensional representations of the temperature of these bodies. Since temperature influences chemical and physical living processes, IR images arouse a multitude of questions related to living organisms and may reveal hidden "light truths." Some of these "light truths" are presented here. This paper is divided into scientific (1) and artistic (2) sections, both written in a nonacademic language.

1. IR soil profiles

IR photographs were taken with a FLIR T-Series camera, without a specific focal point, thus the images are the result of pure curiosity. The same soil under visible light (VL) was captured by a normal camera, using a macro objective. At home, both IR and VL images were put side by side and compared.

1.1. Are soil horizons more detectable with visible light (VL) than with infrared light (IR)?

The Eumoder humus form corresponds to a typical Moder system (please refer to Humusica 1, articles 4 and 5 for detailed presentation and description of this and other humus systems). In this humus form (Fig. 1: left VL; right IR), the organic OH horizon is continuous and shows a thickness of $<$ 1 cm. In all Moder humus forms, the transition between organic and organic-mineral horizons is gradual. This means that pedofauna feeding in organic horizons can descend easily downwards into subjacent mineral soil horizons. Moder systems occur in acid and relatively harsh habitats without anecic and endogeic earthworms (which, instead, generate organic-mineral biomacrostructured A horizons characterizing Mull systems in temperate climatic situations). Moder systems do not form in very harsh, cold, or/and acid environments (where Mor humus systems form without any significant pedofauna influence). We can say that the gradual transition from organic to mineral soil horizons in Moder systems is better represented in IR than in VL photographs. In fact, an IR blue-green area clearly defines the organic-mineral miA horizon present in our profile (Fig. 1 right), very different from purple (OH), red-orange (OF + OL) and yellow (OL) tints of overlaying organic horizons. In the field, as represented on the VL photograph, this biomicrostructured miA horizon is always very difficult to distinguish from the overlying OH horizon.

In order to better investigate these soil horizons, we took VL and IR photographs of them disposed on a shovel. Brown mineral and black "other horizons" appeared on VL images (Fig. 2a); yellow organic and red "other soil horizons" on IR ones (Fig. 2b). The organic-mineral miA horizon appeared among red "mineral" horizons on IR images and among black more "organic" horizon on VL photographs. The organic part of the humus profile irradiates more energy (yellow color, with shorter wave length) than the colder mineral part (red color). In relation to cold weather, one would assume that this would slow the degradation processes, leading to an accumulation of litter. However, it has also been noted elsewhere (Humusica 1, article 2: Essential bases − Functional considerations) that this is not a regular process as the organic horizons do not seem always affected by cold weather. This seems to imply that the organic layers (OL + OF + OH) act as an isolating

☆ Background light music while reading? Ann白安【是什麼讓我遇見這樣的你What brings me to you】 MV官方完整版: https://www.youtube.com/watch?v=aVmZpcrQBU4&list=PLJo0DrmM87TY6PPEDQyzCH0dPdOIYBpPx.

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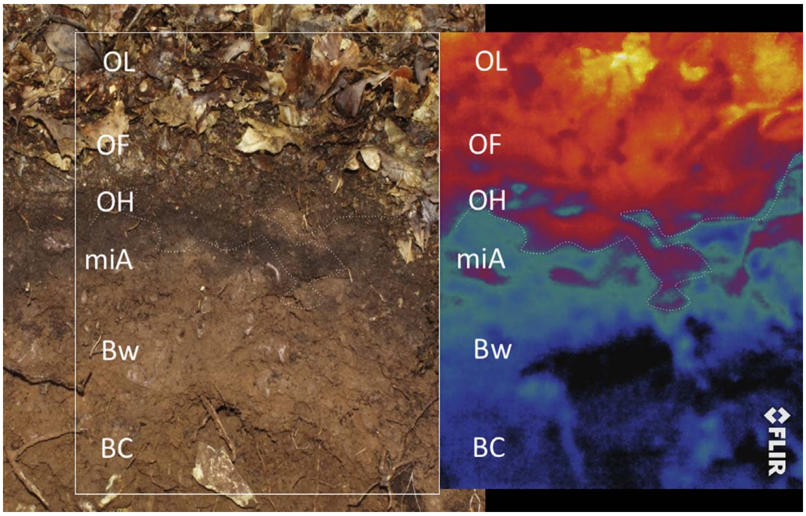

Fig. 1. Eumoder humus form in a temperate Atlantic oak hornbeam forest, visible light (VL) on the left, IR spectrum on the right. First traced on the IR photograph between red and blue-green colors, a very thin discontinuous white line is reported at the same place even on the VL photograph. This line shares organic and mineral parts of the soil profile. (IR photograph: C. D. and K. B.). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

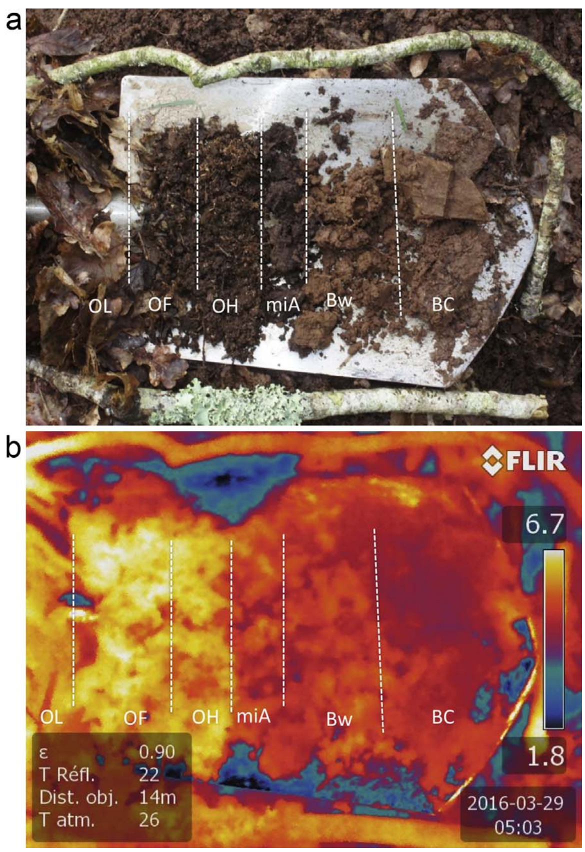

Fig. 2. Eumoder humus horizons disposed on a shovel. Samples of soil horizons were collected with the help of a knife-blade and organized from left to right on the shovel, as they were from top to bottom in the real profile. (IR photograph furnished by C. D. and K. B.).

cover for the microbial and faunal life below. This may protect the biodegradation processes of organic matter in lower organic horizons, gradually compensating the processes of production and accumulation of fresh litter occurring at the top. It would be interesting to film a real profile during an entire day in different seasons, and note the gradual variation of IR colors in all humus horizons.

In fact, thermography has been applied to synthetic soil profiles in comparison to artificial homogeneous sand columns, in order to evaluate the sensitivity of thermal images to detect a sequence of soil layers (Soliman et al., 2000). Soliman and his colleagues detected a sort of "time independent layers", i.e. subsoil thermal interfaces related to soil layering and moisture content, which should be equivalent to natural soil horizons. They used a thermal video camera and mapped a "thermal inertia", following the pioneer indications of Price (1977) and more recently of Karam (2000). Abrantes et al. (2017) and Lima de et al. (2014, 2015), following previous studies (Axelsson and Lunden, 1985; Kahle, 1977; Mira et al., 2007; Rosema et al., 1978; Schmugge et al., 1978), published interesting results about thermal-IR emissivity of soils, demonstrating its dependence on porosity, surface roughness and soil-moisture. In particular, they showed that daytime evaporation has a great influence on the thermal-IR signature, and that emissivity and evaporation capacity depend on soil-moisture and soil-type.

1.2. *Soil on fire*

In IR light, a soil looks like a fire, a pile of burning embers. This photographic feature reveals a physiologic reality: soil works like fire; the burning organic matter furnishes energy to the rest of the system, as if it were a purposely created secondary sun. The right part of 2b illustrate a physiologic soil reality which is not observed on corresponding VL photographs (Figs1left and 2a).

Following our curiosity, we went in the forest at night and took IR photographs of the same, uncovered soil profiles (Fig. 3). On this image, it is still possible to distinguish the more organic horizons (blue, warmer) from rather mineral ones (black, colder). As an "ecosystem fire", the soil "fire" was less bright at night, as if at night, the soil was "sleeping." Following the rhythmic changes of soil temperature, an IR video-camera should be able to give views of daily or seasonal dynamics. For instance, thermography was used by Rubio et al. (1997) and Kodikara et al. (2011) to estimate soil temperature and soil moisture throughout a complete growing season for a number of different crops and soils. On one picture, litter was photographed under direct sun radiation (Fig. 4). It is possible to see the cold blue shaded litter from more exposed to sun-lit litter. Can this observation be of any use in specific investigations? For example: in comparing areas damaged by fungi attacks or sites of particular bacterial colonies, with other areas receiving a different daily sun radiation? A IR video should be able to record the migration from red to blue-green areas of a forest floor, due to cover shadow dynamic, and be of interest in studies of processes of litter transformation. An IR camera could be used to identify parasites on living leaves.

1.3. *Soil in water*

Not far from the site reported in Fig. 1, there was a small pond fed by a fresh water source. We took some IR photographs of this Histic soil profile (Fig. 5). For detailed pedological information concerning Histic