

**Thermography test
MEDNET Zagreb, Croatia**

Zagreb, July 2013

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1. Introduction

1.1. What is Thermography

Infrared thermography (IRT), thermal imaging, and thermal video are examples of infrared imaging science. Thermographic cameras detect radiation in the infrared range of the electromagnetic spectrum (roughly 9,000–14,000 nanometers or 9–14 μm) and produce images of that radiation, called thermograms. Since infrared radiation is emitted by all objects above absolute zero according to the black body radiation law, thermography makes it possible to see one's environment with or without visible illumination. The amount of radiation emitted by an object increases with temperature; therefore, thermography allows one to see variations in temperature. When viewed through a thermal imaging camera, warm objects stand out well against cooler backgrounds; humans and other warm-blooded animals become easily visible against the environment, day or night. As a result, thermography is particularly useful to military and other users of surveillance cameras.

Thermography has a long history, although its use has increased dramatically with the commercial and industrial applications of the past fifty years. Government and airport personnel used thermography to detect suspected swine flu cases during the 2009 pandemic. Firefighters use thermography to see through smoke, to find persons, and to localize the base of a fire. Maintenance technicians use thermography to locate overheating joints and sections of power lines, which are a sign of impending failure. Building construction technicians can see thermal signatures that indicate heat leaks in faulty thermal insulation and can use the results to improve the efficiency of heating and air-conditioning units. Some physiological changes in human beings and other warm-blooded animals can also be monitored with thermal imaging during clinical diagnostics. ^[1]

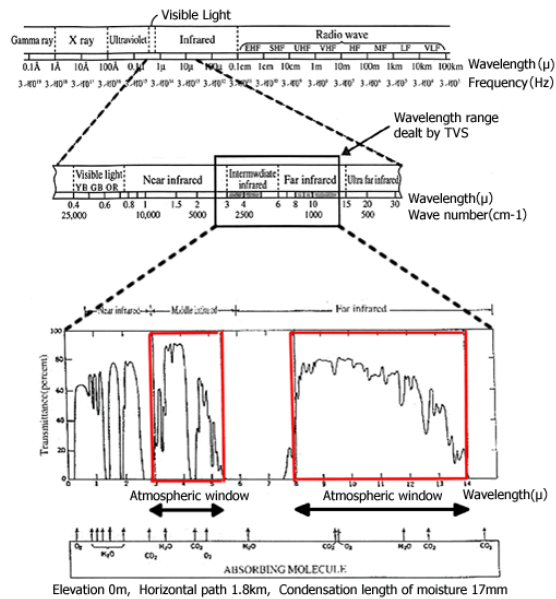
Thermography was discovered by a British astronomer, Herschel, in 1800. When dispersing sunlight using a prism, Herschel accidentally found that there was an invisible light on the outside of red light when increases the temperature of an object.

Infrared is invisible since its wavelength is longer than visible light. It has nothing to do with brightness or darkness of visible light. It is emitted naturally from any object of which temperature is absolute zero (0K) or higher. Therefore, it can be applied to any field. It has a characteristic of heating an object. Therefore, it is sometimes called "heat wave". It is a kind of light (electromagnetic wave). It can be transmitted through vacuum. There is a correlation between infrared energy and temperature of an object. Therefore, it can be used to measure the temperature of an object.

Wavelength is 0.7 μm or longer Wavelength is 1 mm or less = Frequency is 300 GHz or more. ^[2]

^[1] Source: <https://en.wikipedia.org/wiki/Thermography>

^[2] Source: <http://www.infrared.avio.co.jp/en/products/ir-thermo/what-thermo.html>



The source : R.D.Hudson, Jr. "INFRARED SYSTEM ENGINEERING" (John Wiley & Son, 1969)

2. Task

The purpose of the thermal measurement was influence of the cell phone on the human head temperature during the cell phone conversation:

- a) without NESU
- b) with NESU

3. Conditions of measurement

Measurements were performed on:

- the male gender, age 43;
- cell phone NOKIA 5320;
- cell phone distance during both testing: 5 cm from the head → reason: to avoid direct influence of the cell phone temperature on the head since the purpose of the testing was to see whether the head will be heated by electromagnetic radiation from the cell phone and its influence on the person who use the cell phone;
- room temperature was 23°C during both measurements ;
- room humidity was 38% during both measurements.

4. Measurement

Measurements were divided in three parts: the state of the person before cell phone conversation, the state of the person after cell phone conversation without NESU and the state of the person after cell phone conversation with NESU.

Before first (without NESU) and second (with NESU) recording was the time difference in order to enable person to become in the state before cell phone recording (initial state).

4.1. The state of the person before cell phone conversation

The human head was recorded in three positions:

- lateral left
- lateral right
- nape

Photos below show how the cell phone was kept during recording.



Figure 1: Position how the cell phone was hold (5 cm from the head)

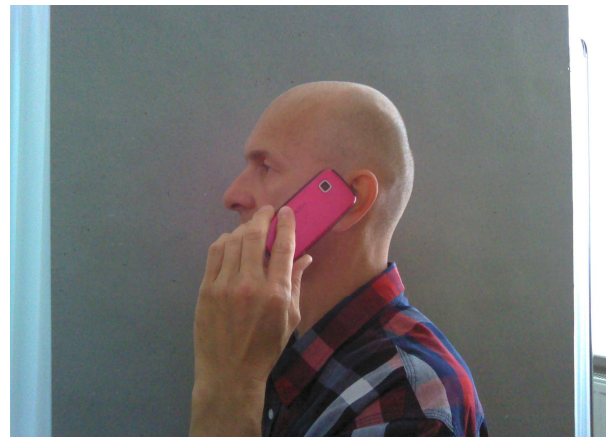


Figure 2: Position how the cell phone was hold (5 cm from the head)

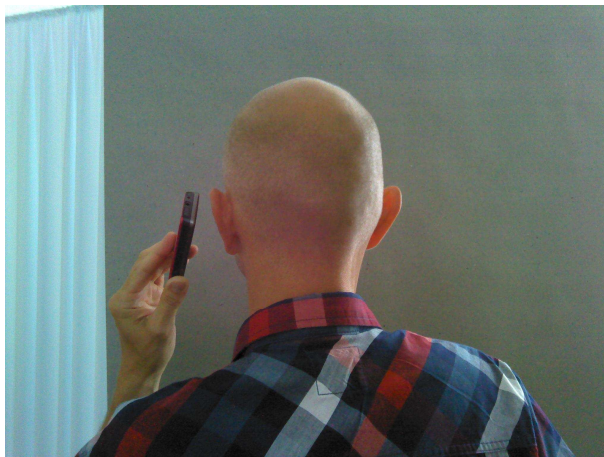


Figure 3: Position how the cell phone was hold (5 cm from the head)



Figure 4: Example how the same photo looks recorded by Thermographic camera

4.2. The state of the person after cell phone conversation without NESU

- Human head was recorded during cell phone conversation without NESU card for 10 min.
- The head was recorded in three positions before conversation (lateral left, lateral right and nape).
- The cell phone was kept 5 cm from the head.
- The head was recorded laterally every 5 sec in order to see influence of the cell phone on the human head.
- At the end of conversation, after 10 min, the human head was again recorded in three positions (lateral left, lateral right and nape).
- 6 referent points were defined in order to precisely define temperature increase on the human head.
- Results are shown below

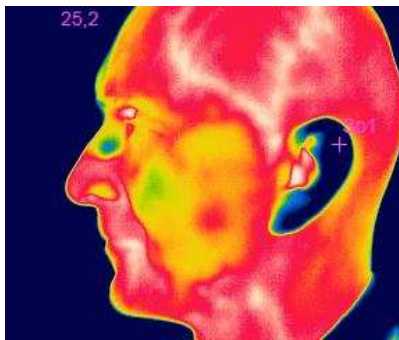


Figure 5: Left lateral head before using cell phone without NESU

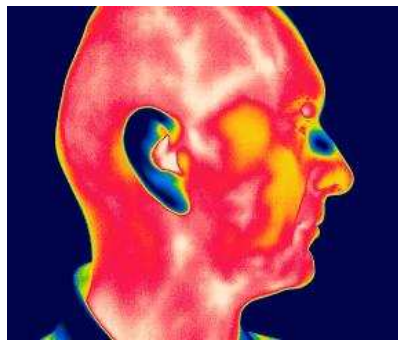


Figure 6: Right lateral head before using cell phone without NESU

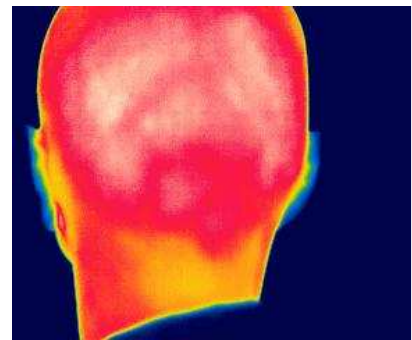


Figure 7: Nape before using cell phone without NESU

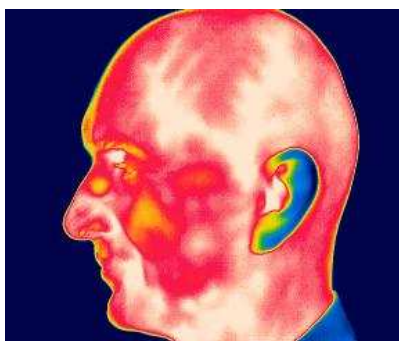


Figure 8: Left lateral head after using cell phone 10 min without NESU

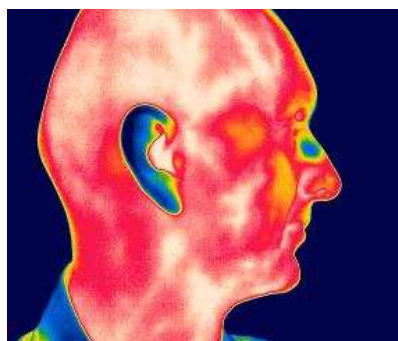


Figure 9: Right lateral head after using cell phone 10 min without NESU

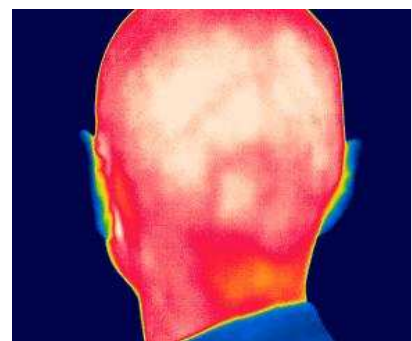


Figure 10: Nape after using cell phone 10 min without NESU

4.3. The state of the person after cell phone conversation with NESU

- Human head was recorded during cell phone conversation with NESU card for 10 min.
- The head was recorded in three positions before conversation (lateral left, lateral right and nape).
- The cell phone was kept 5 cm from the head.
- The head was recorded laterally every 5 sec in order to see influence of the cell phone on the human head.
- At the end of conversation, after 10 min, the human head was again recorded in three positions (lateral left, lateral right and nape).
- 6 referent points were defined in order to precisely define temperature increase on the human head.
- Results are shown below

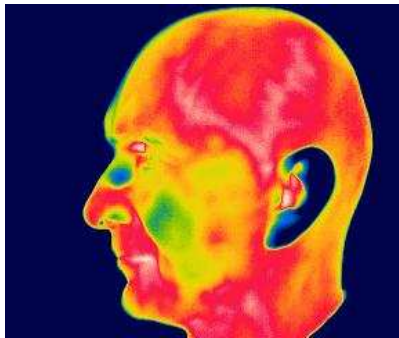


Figure 11: Left lateral head before using cell phone with NESU

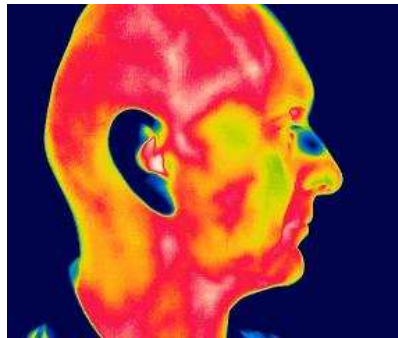


Figure 12: Right lateral head before using cell phone with NESU

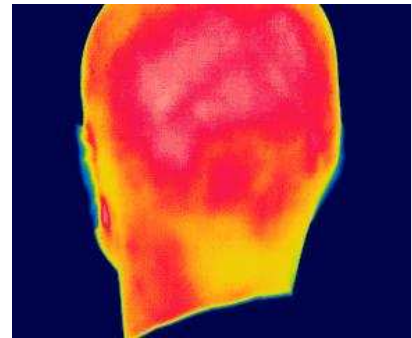


Figure 13: Nape before using cell phone with NESU

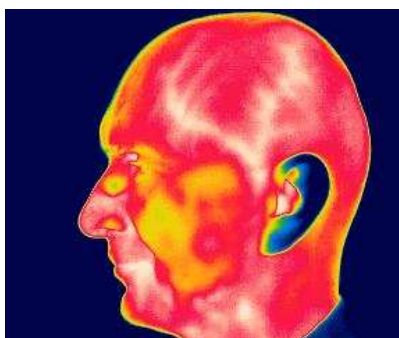


Figure 14: Left lateral head after using cell phone 10 min with NESU

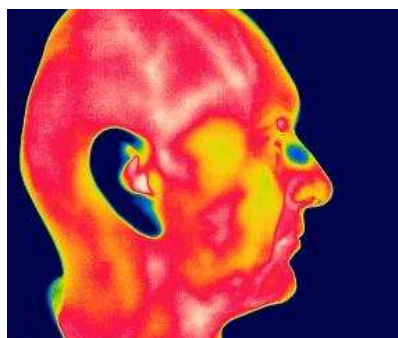


Figure 15: Right lateral head after using cell phone 10 min with NESU

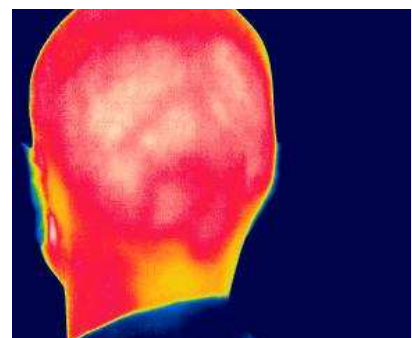


Figure 16: Nape after using cell phone 10 min with NESU

4.4. Comparison - the state of the person after cell phone conversation without and with NESU

On photos below can be seen difference how the head of a person was heated during the cell phone conversation without NESU and with NESU. The head of person was heated much less while using cell phone with NESU.

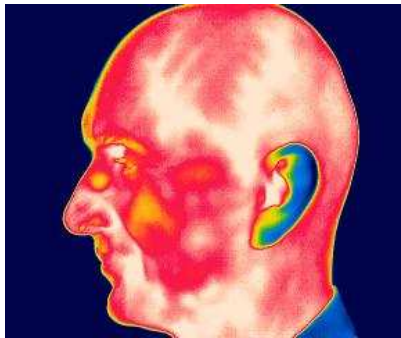


Figure 17: Left lateral head after using cell phone 10 min without NESU

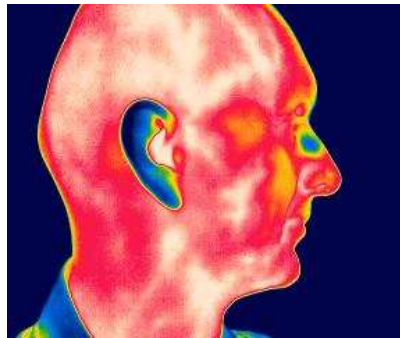


Figure 18: Right lateral head after using cell phone 10 min without NESU

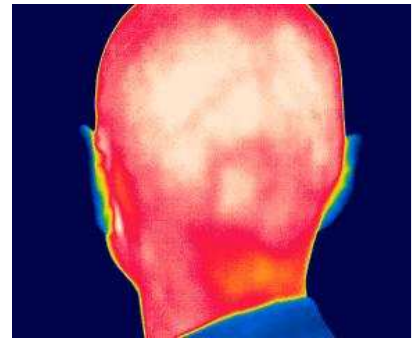


Figure 19: Nape after using cell phone 10 min without NESU

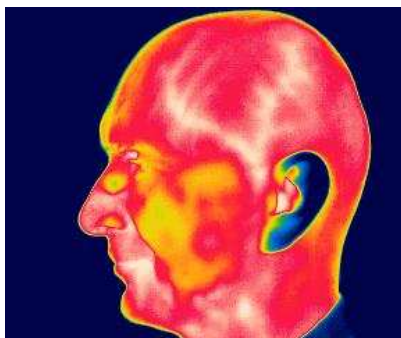


Figure 20: Left lateral head after using cell phone 10 min with NESU

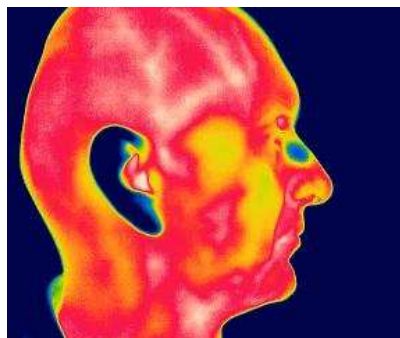


Figure 21: Right lateral head after using cell phone 10 min with NESU

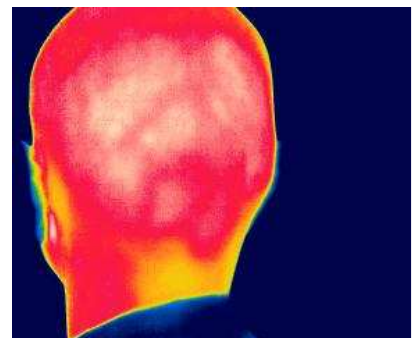


Figure 22: Nape after using cell phone 10 min with NESU

On the figures below can be seen six referent points on the head which were measured on the person before using cell phone and after using cell phone without and with NESU. The main differences are shown in the table below.

Points	The state of a person prior cell phone conversation without NESU [°C]	The state of a person after cell phone conversation without NESU [°C]	Difference [°C]	The state of a person prior cell phone conversation with NESU [°C]	The state of a person after cell phone conversation with NESU [°C]	Difference [°C]	Increase without / with NESU [%]
Sp1	35,9	36,6	0,7	35,5	36,0	0,5	40
Sp2	35,9	36,4	0,5	35,3	35,7	0,4	25
Sp3	36,1	36,5	0,4	35,6	35,6	0,0	400
Sp4	36,0	36,9	0,9	36,0	36,2	0,2	350
Sp5	29,2	31,2	2,0	28,7	29,3	0,6	233
Sp6	34,7	35,8	1,1	34,4	34,9	0,5	120
Average			0,93			0,37	155

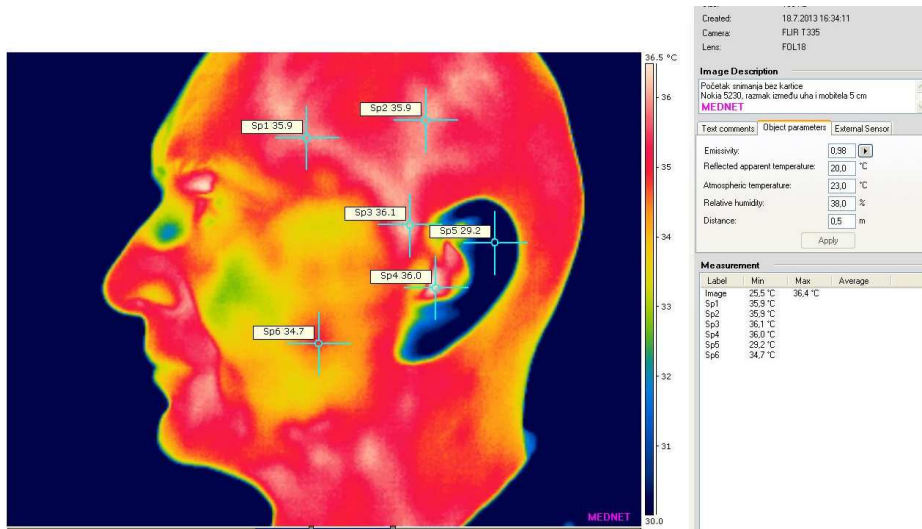


Figure 23: The state of a person prior cell phone conversation without NESU

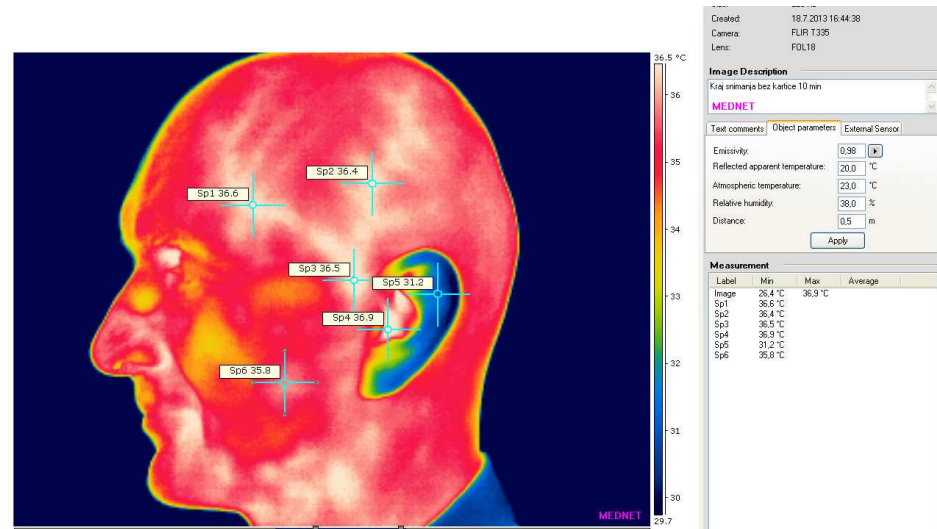


Figure 24: The state of a person after cell phone conversation without NESU

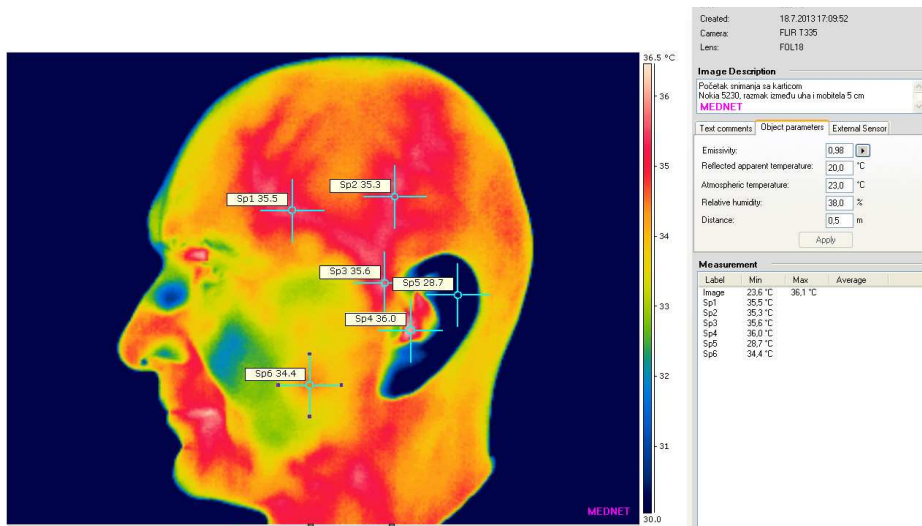


Figure 25: The state of a person prior cell phone conversation with NESU

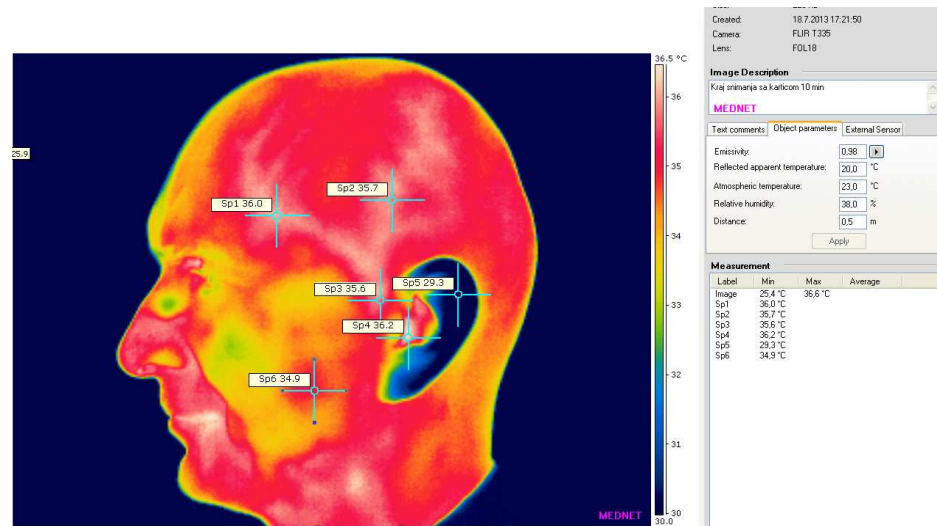


Figure 26: The state of a person after cell phone conversation with NESU

5. Conclusion

Measurements were done on July 18th 2013.

The main conditions were the same during all measurements: same outside temperature, same humidity, same durations of recording (10 min), same person, same cell phone.

Results show:

- the average increase of the temperature on 6 points at the human head was 0,93°C after using the cell phone without NESU;
- after using the cell phone without NESU at all 6 points temperature was increased; the increase was from 0,4°C (point 3) up to 2°C (point 5);
- the average increase of the temperature on 6 points at the human head was 0,37°C after using the cell phone with NESU;
- after using the cell phone with NESU at 5 points temperature was increased up to 0,6°C (point 5) and at one point there was no temperature increase (0,0°C at the point 3).