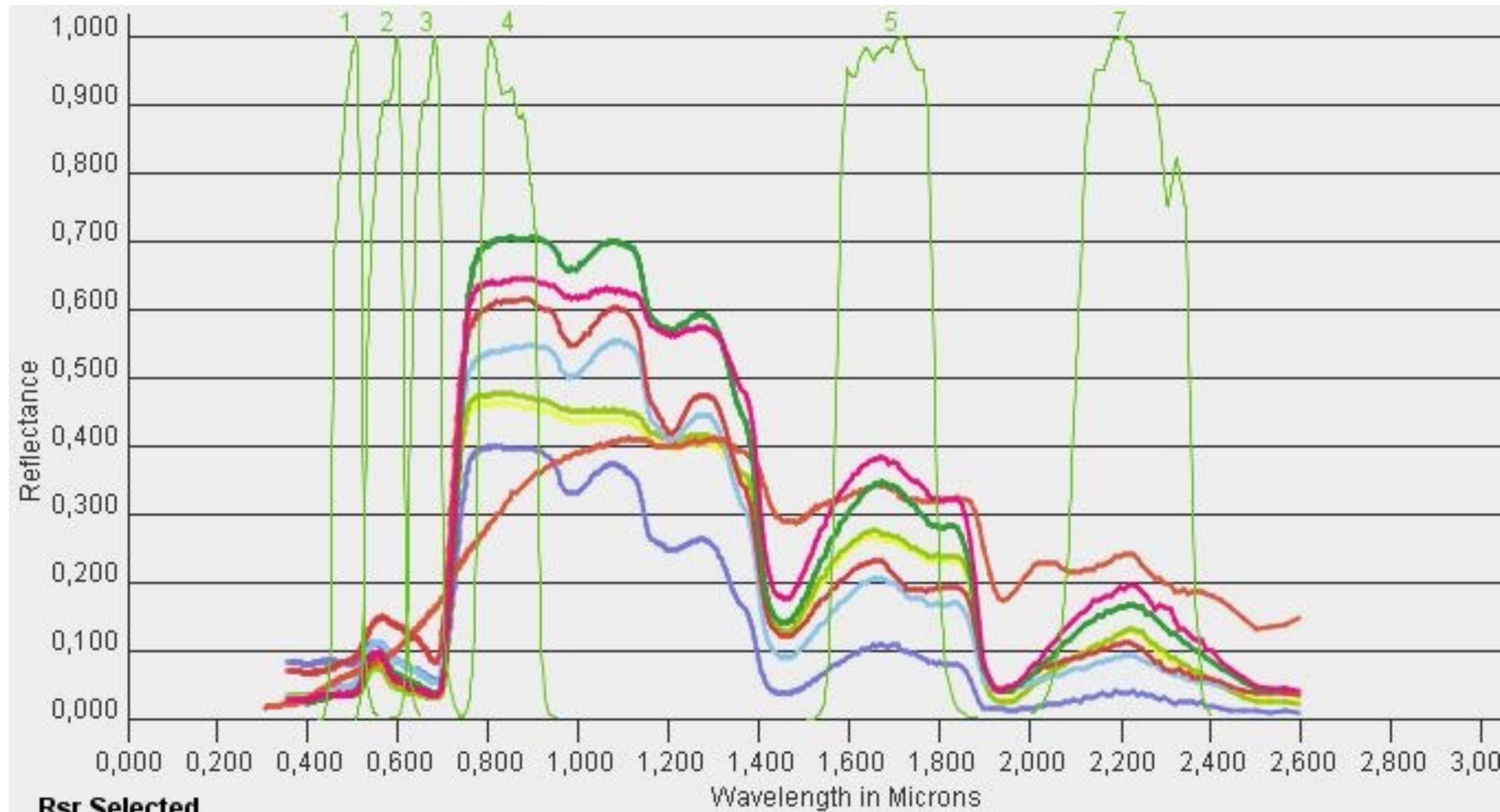


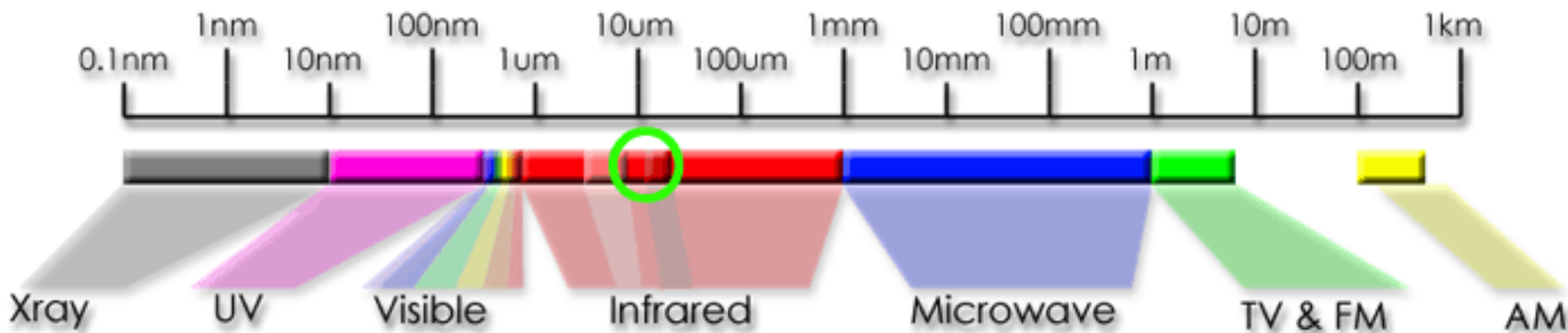
Thermal Remote Sensing



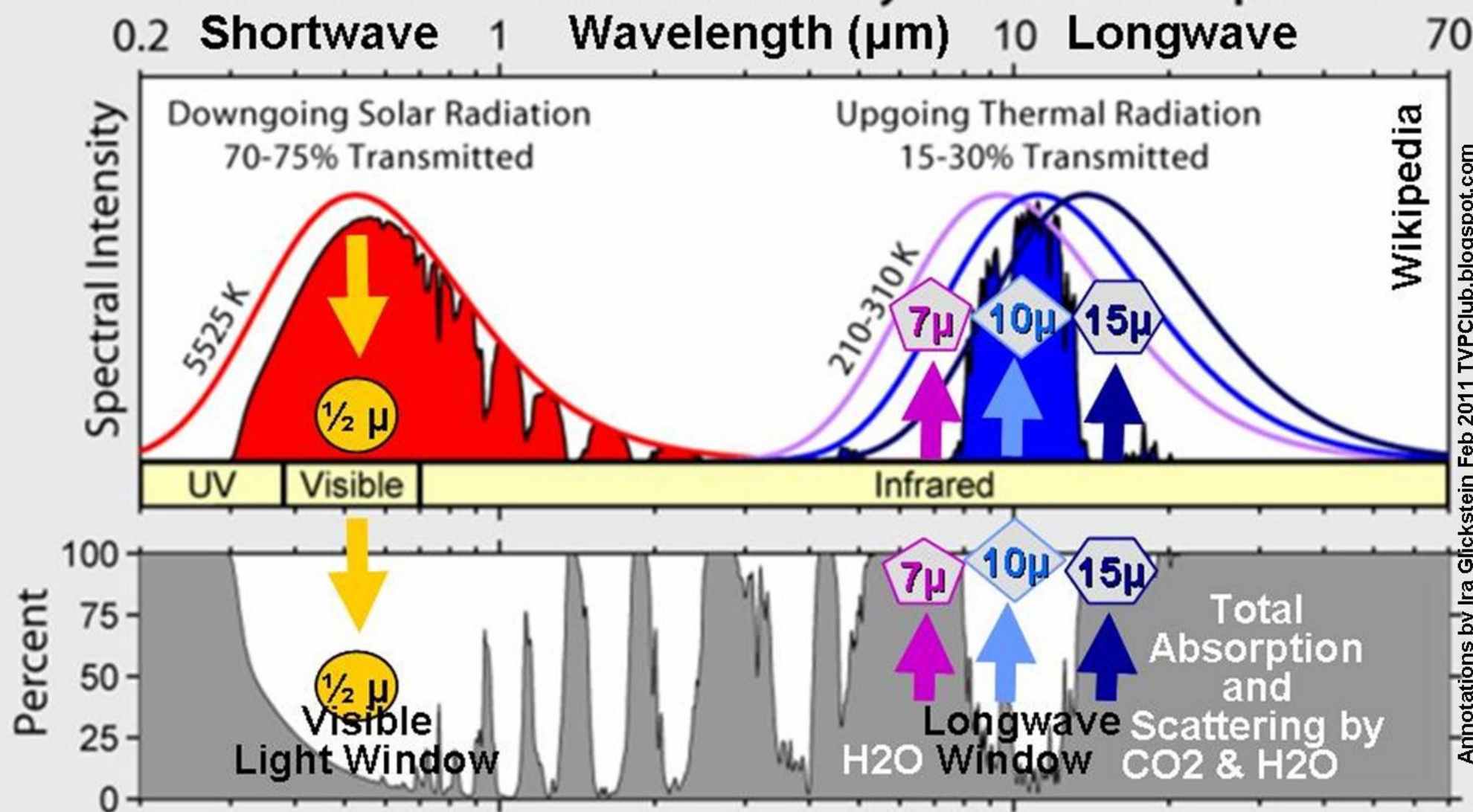
Ruedi Boesch



Electromagnetic Spectrum

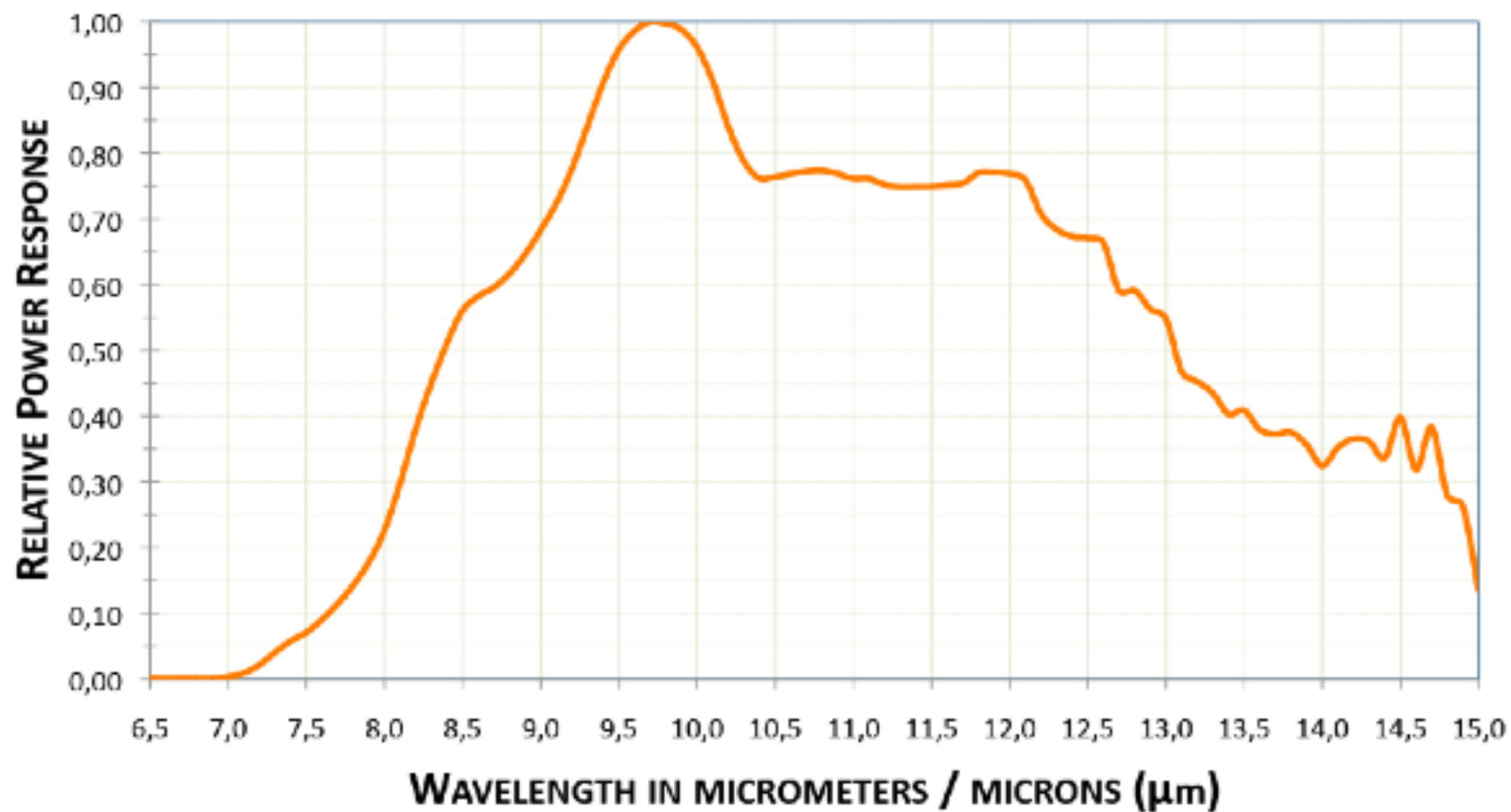


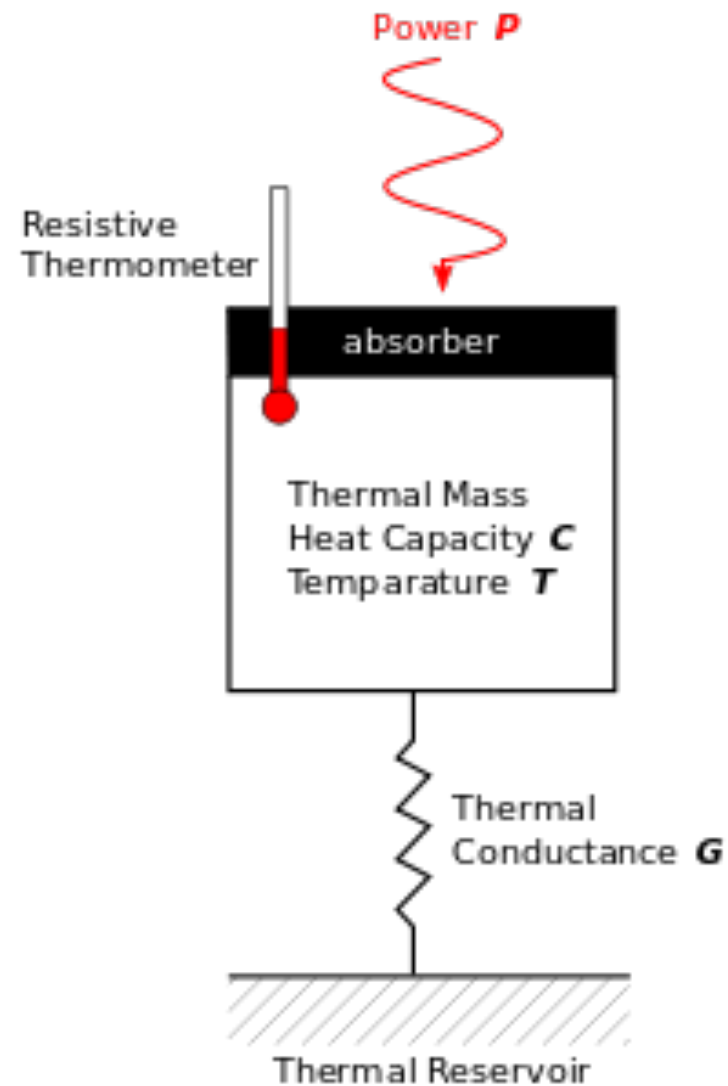
Radiation Transmitted by the Atmosphere





**Typical Spectral Response Curve -
FLIR's Tau2, Quark2, Muon Cameras**





Conceptual schematic of a **bolometer** (Samuel Pierpont Langley 1878)

...

The change in temperature is read out with a resistive thermometer. The intrinsic thermal time constant is $\tau = C/G$.

...

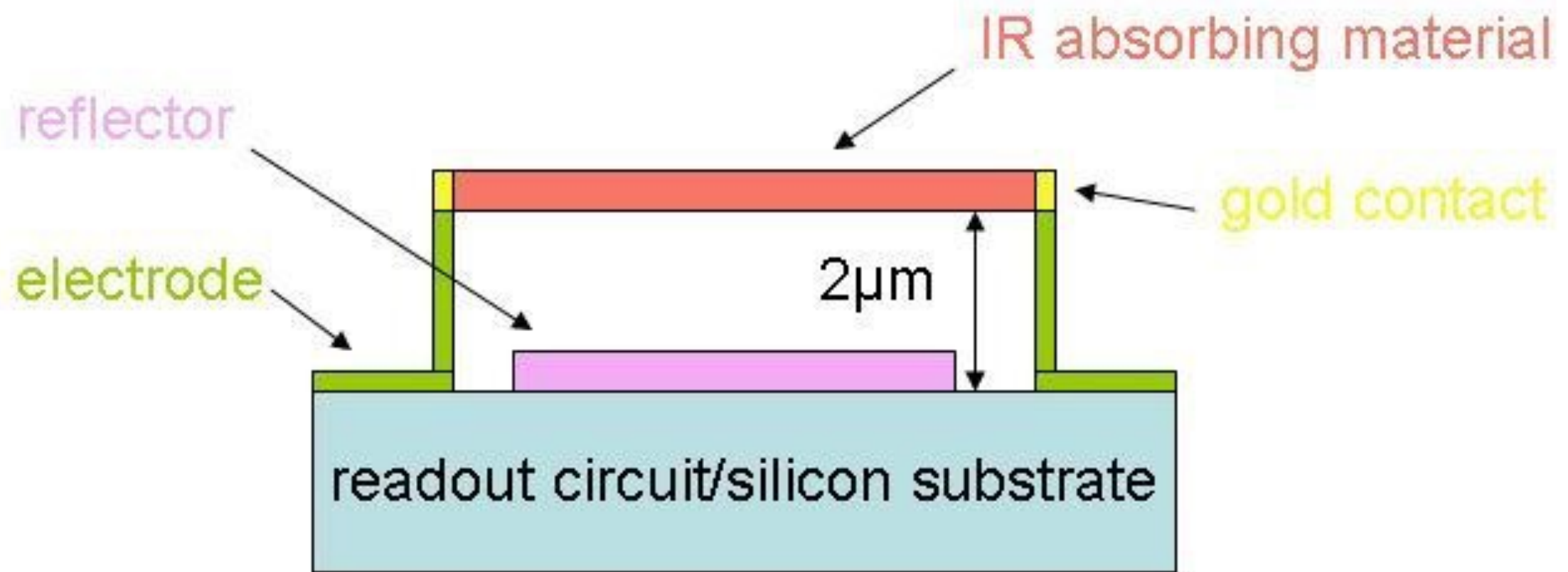


Image	640 x 512
Pixel size	17 microns
Spectral	7.5-13.5 microns
Time to Image	<5 secs
Weight	70g

non-irrigated / irrigated

$\partial T \geq 4 \text{ K}$

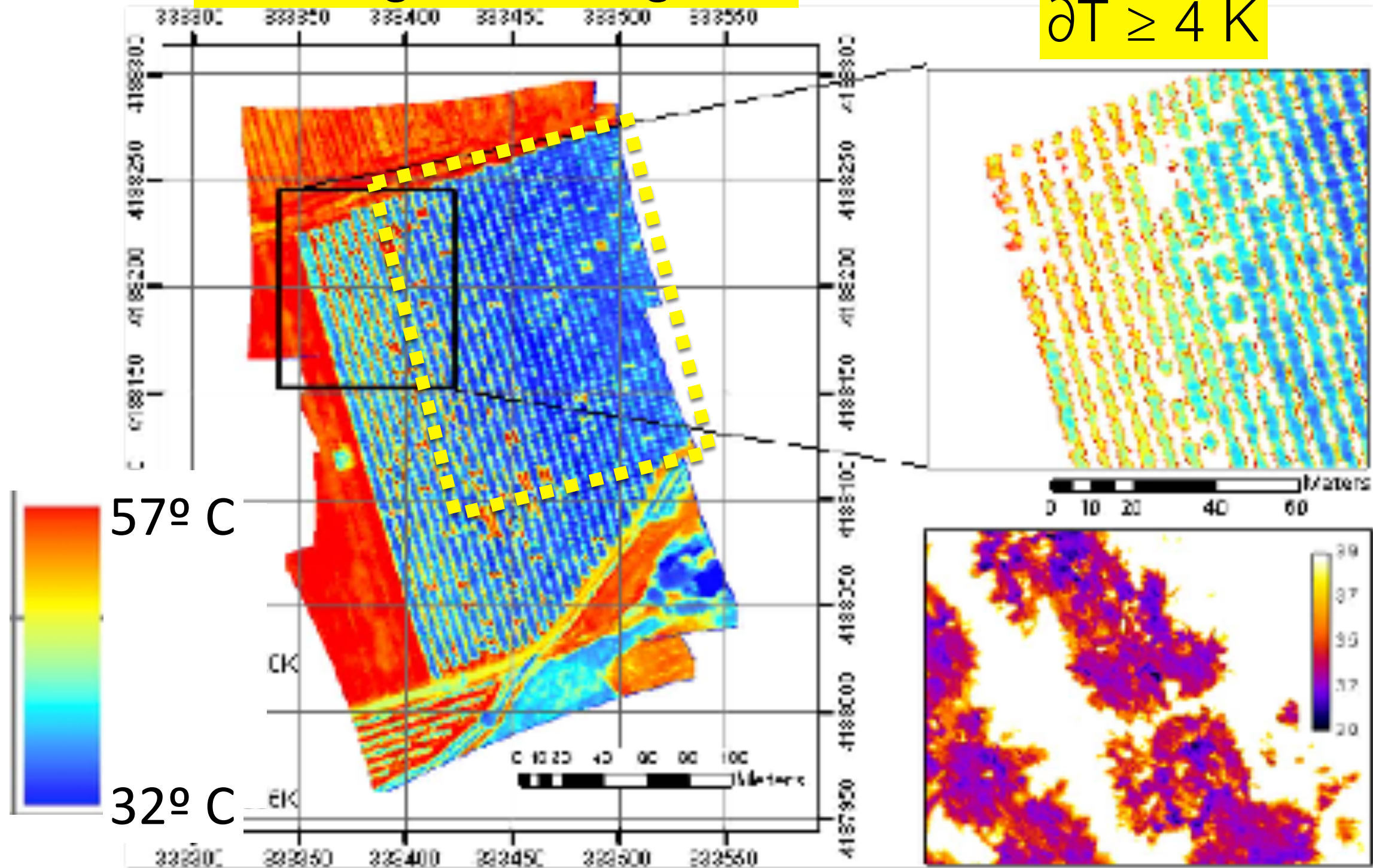
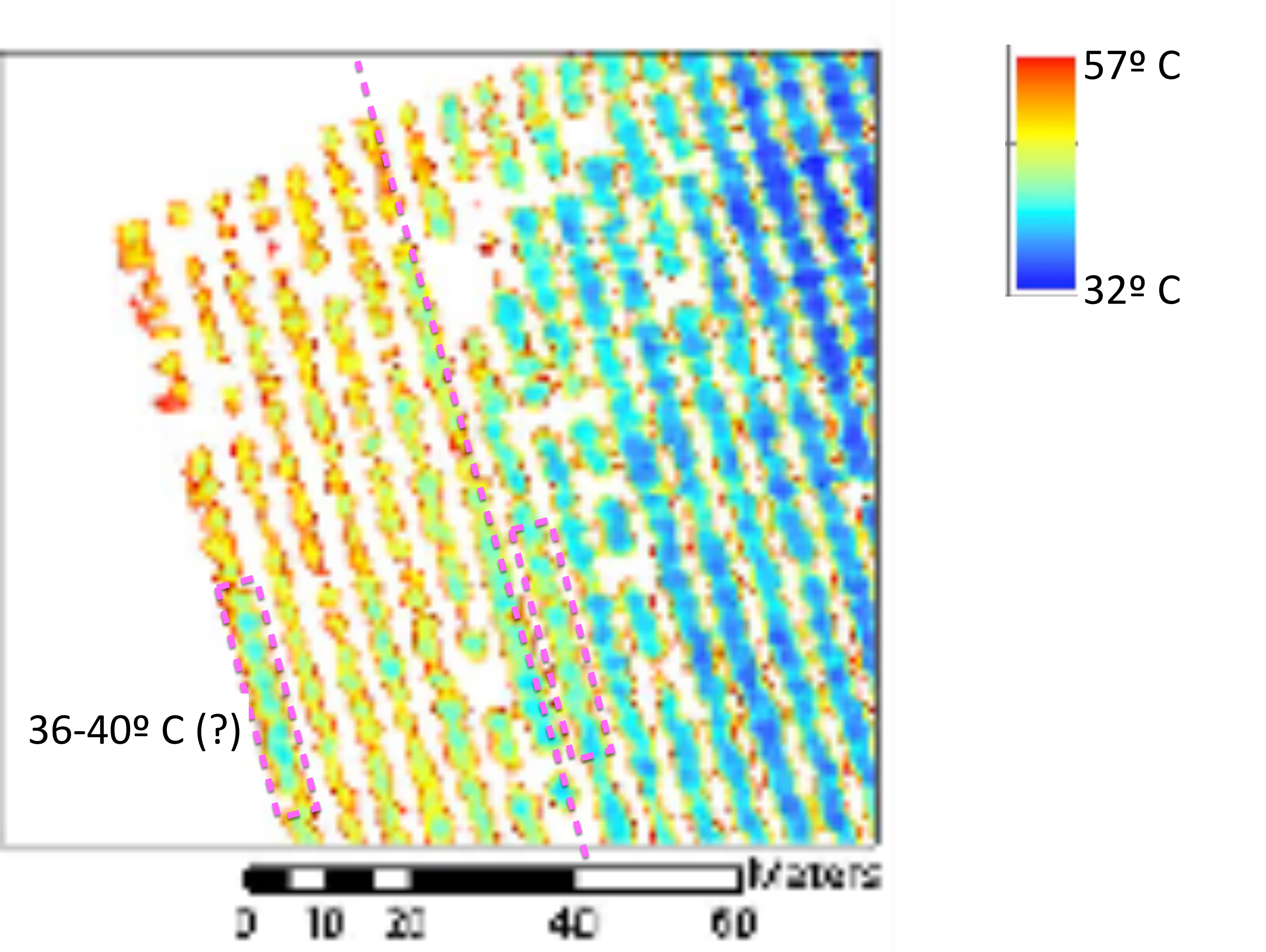


Fig. 11. Thermal orthomosaic obtained from the UAV over the peach orchard at 40-cm resolution. The zoomed image on the top shows the water stressed tree (warmer, in red and yellow) as compared with the fully irrigated trees (blue). The bottom right image shows a low-altitude image where within-crown thermal variability is observed.

where M is the rotation matrix obtained from the attitude angles, c is the focal distance, and λ_p is the associated scale factor.

D. Automatic Mosaicking With Aerotriangulation Methods

GPS and INS systems used along with photogrammetry



Surface temperature =

Emissivity (λ) +

Thermal radiation $^{\downarrow}$ · Atmospheric transmittance +

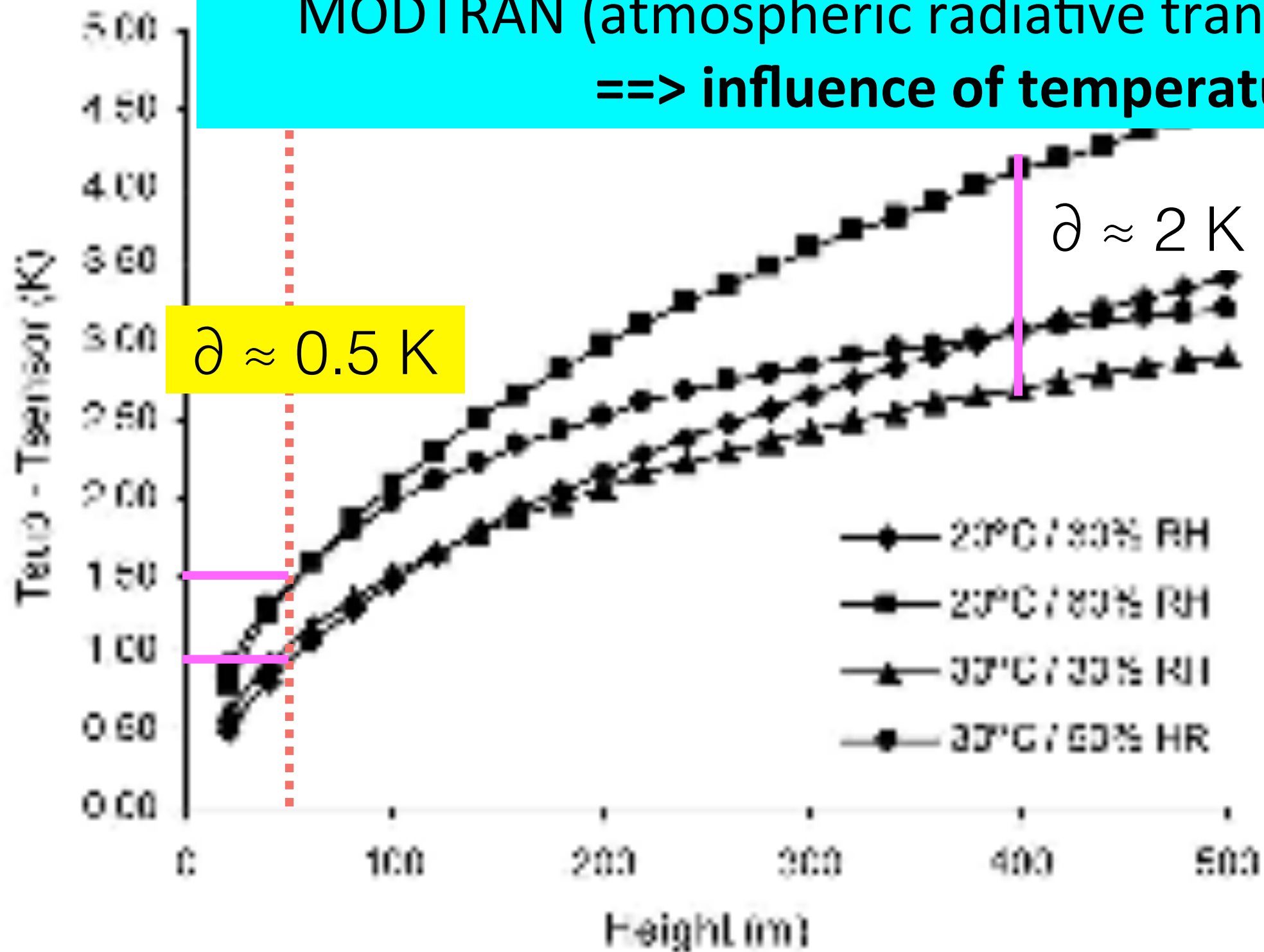
Thermal radiation $^{\uparrow}$

1. Emissivity:

surface emissivity of 0.98 is an accepted value for natural vegetation
(Salisbury 1992)

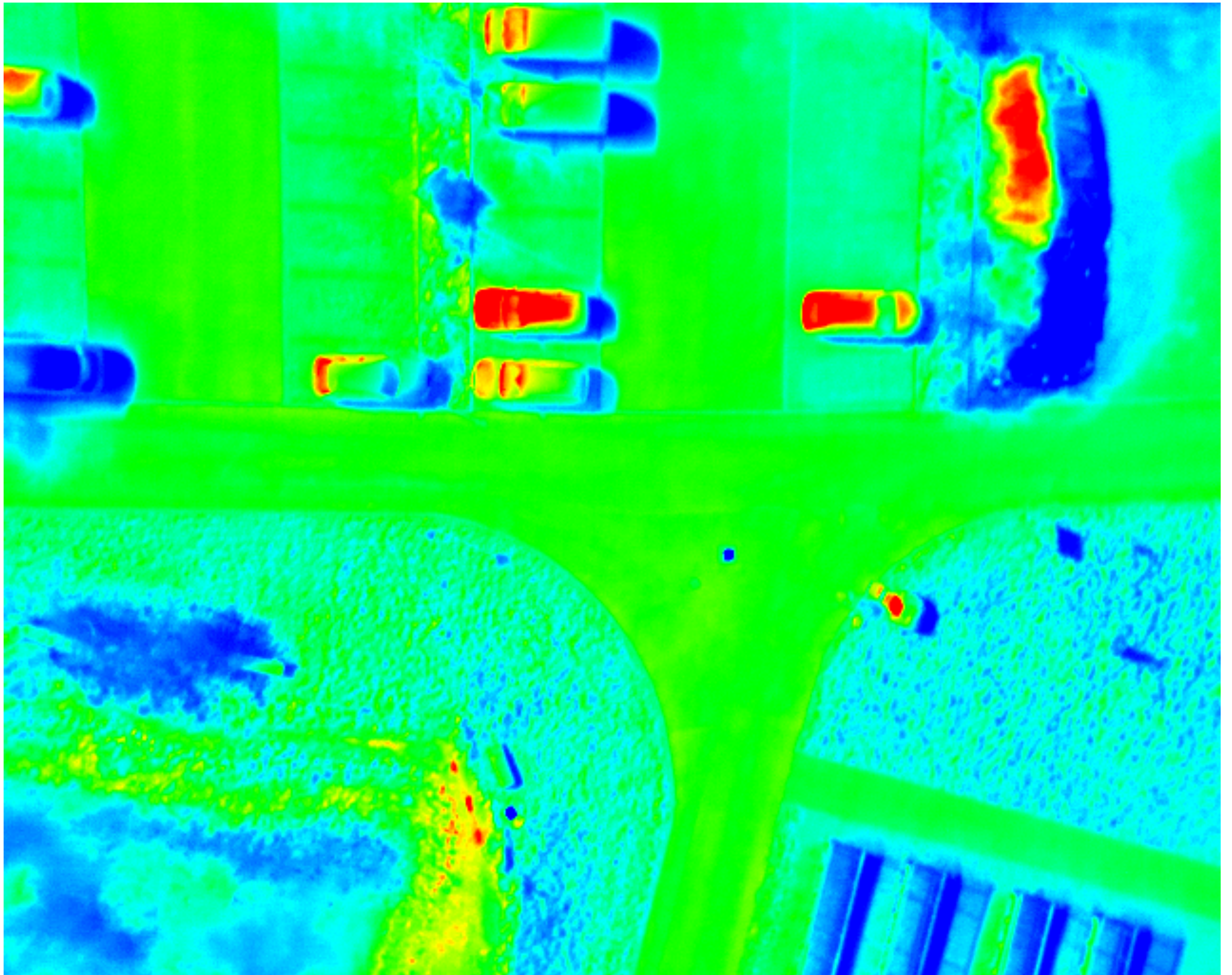
2. Atmospheric transmittance: modeled with MODTRAN

MODTRAN (atmospheric radiative transfer model)
==> influence of temperature/humidity ?



(b)





90m GSD: 8cm

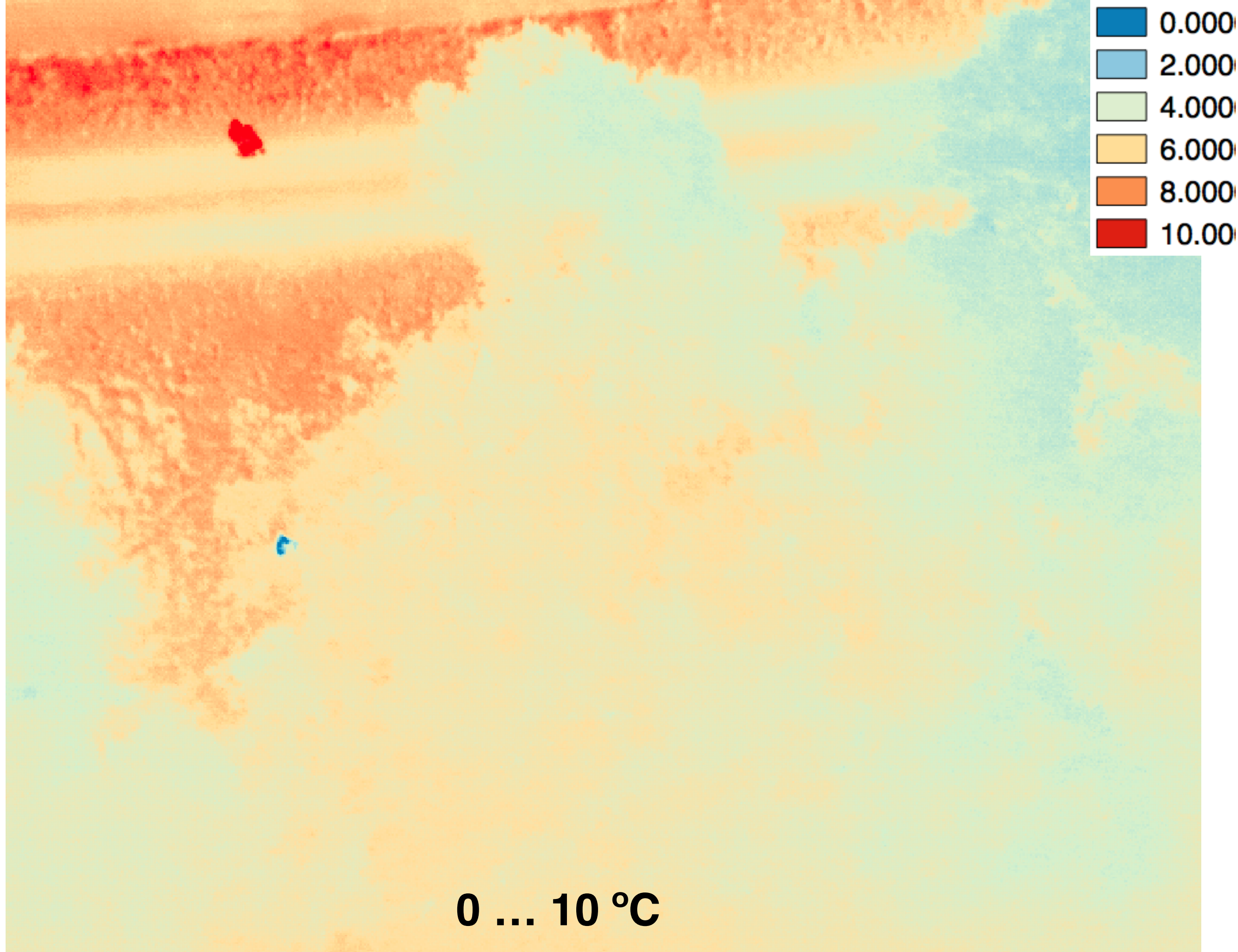


50m GSD: 4cm

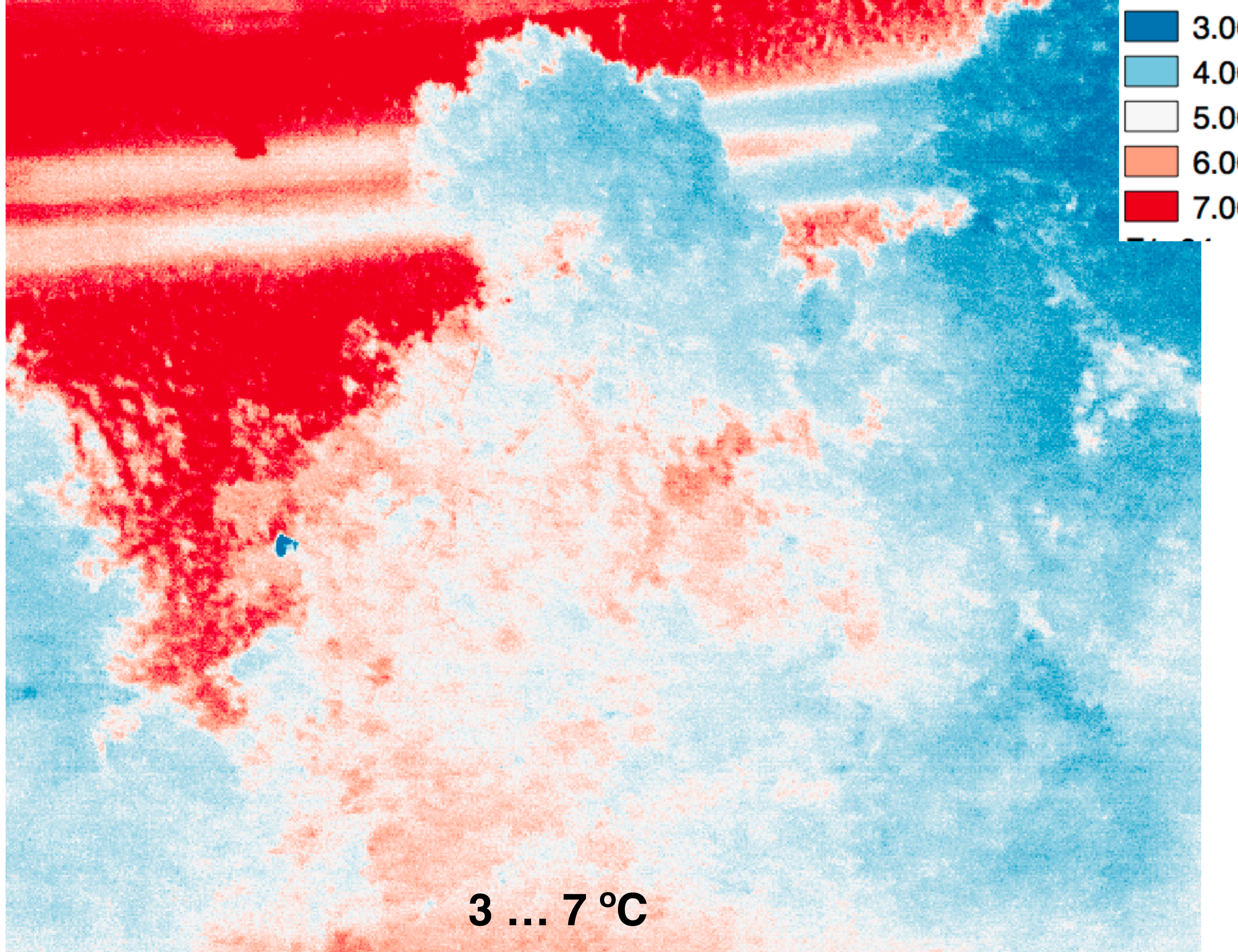


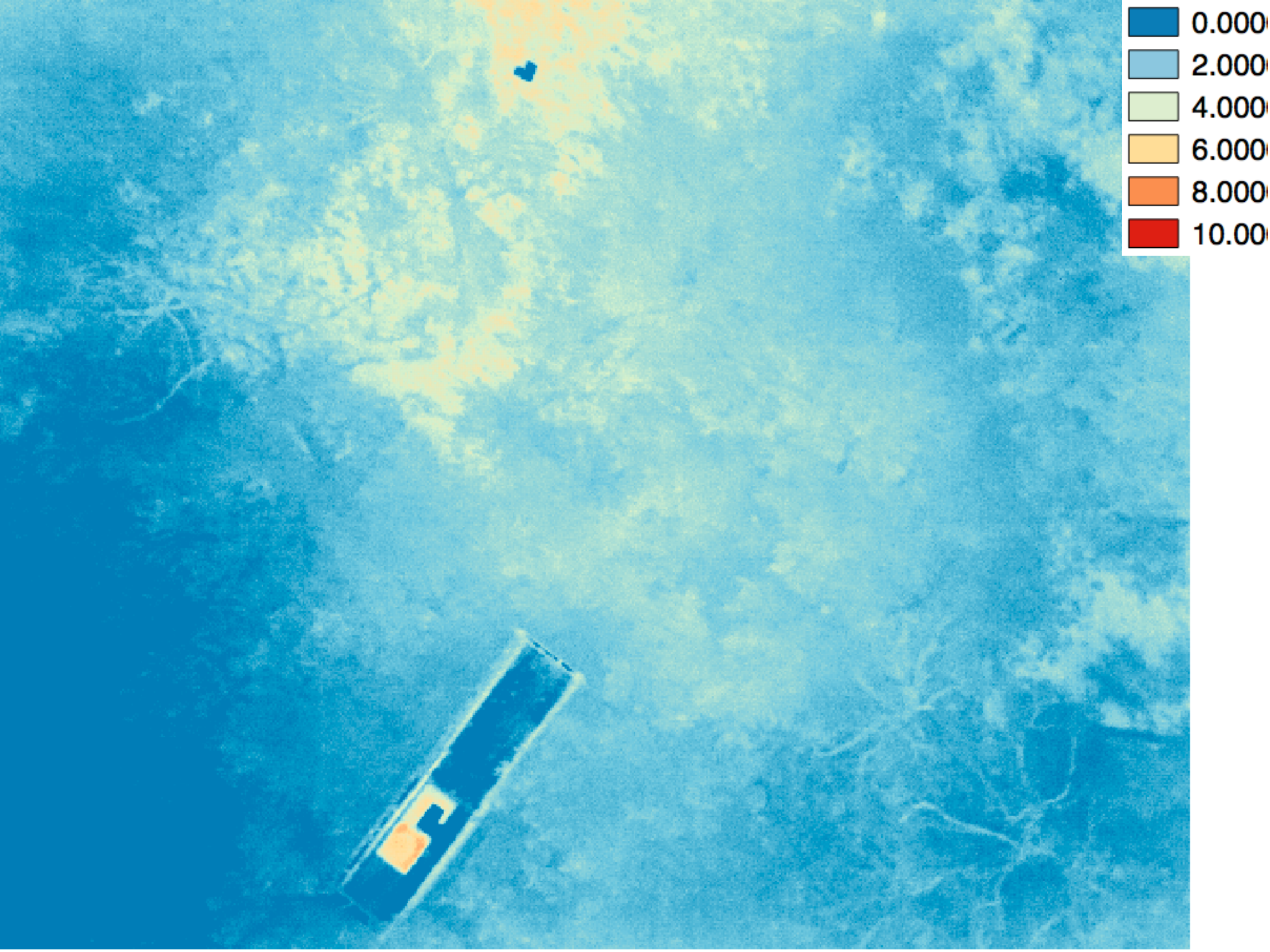


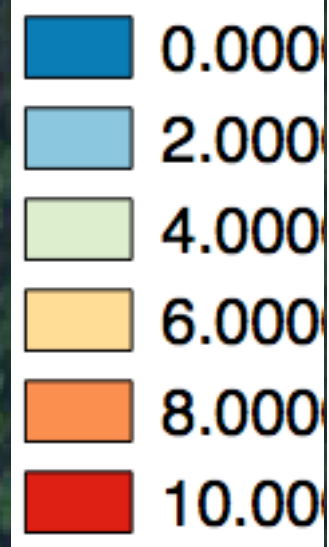
-4.6 ... 20.7 °C

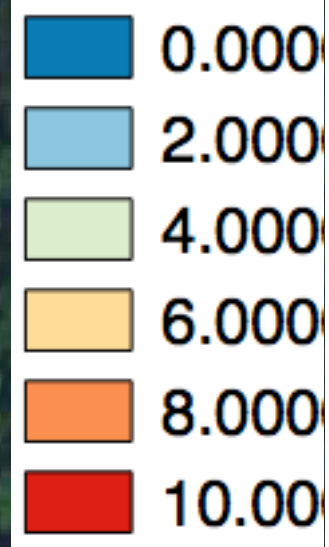
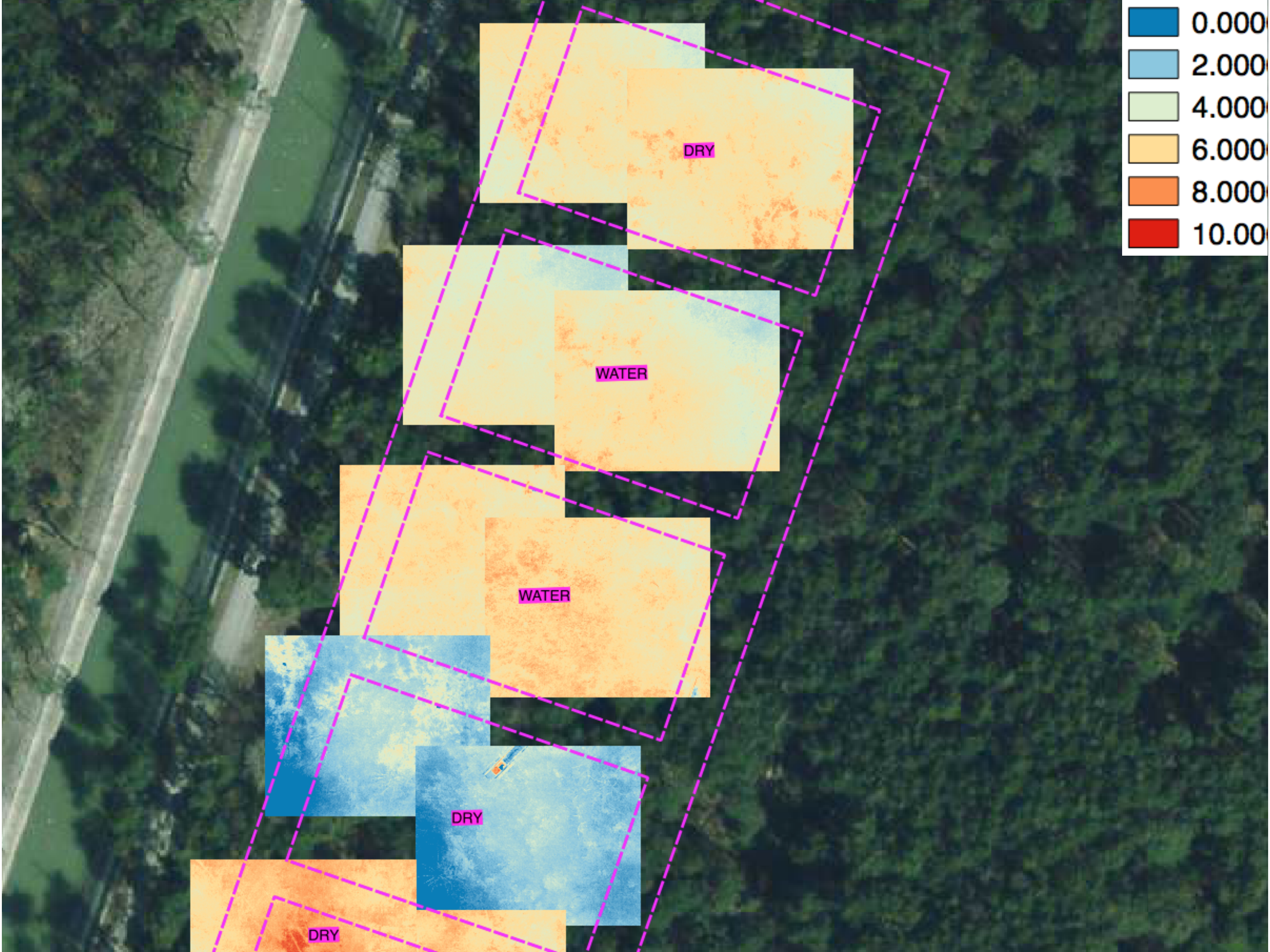


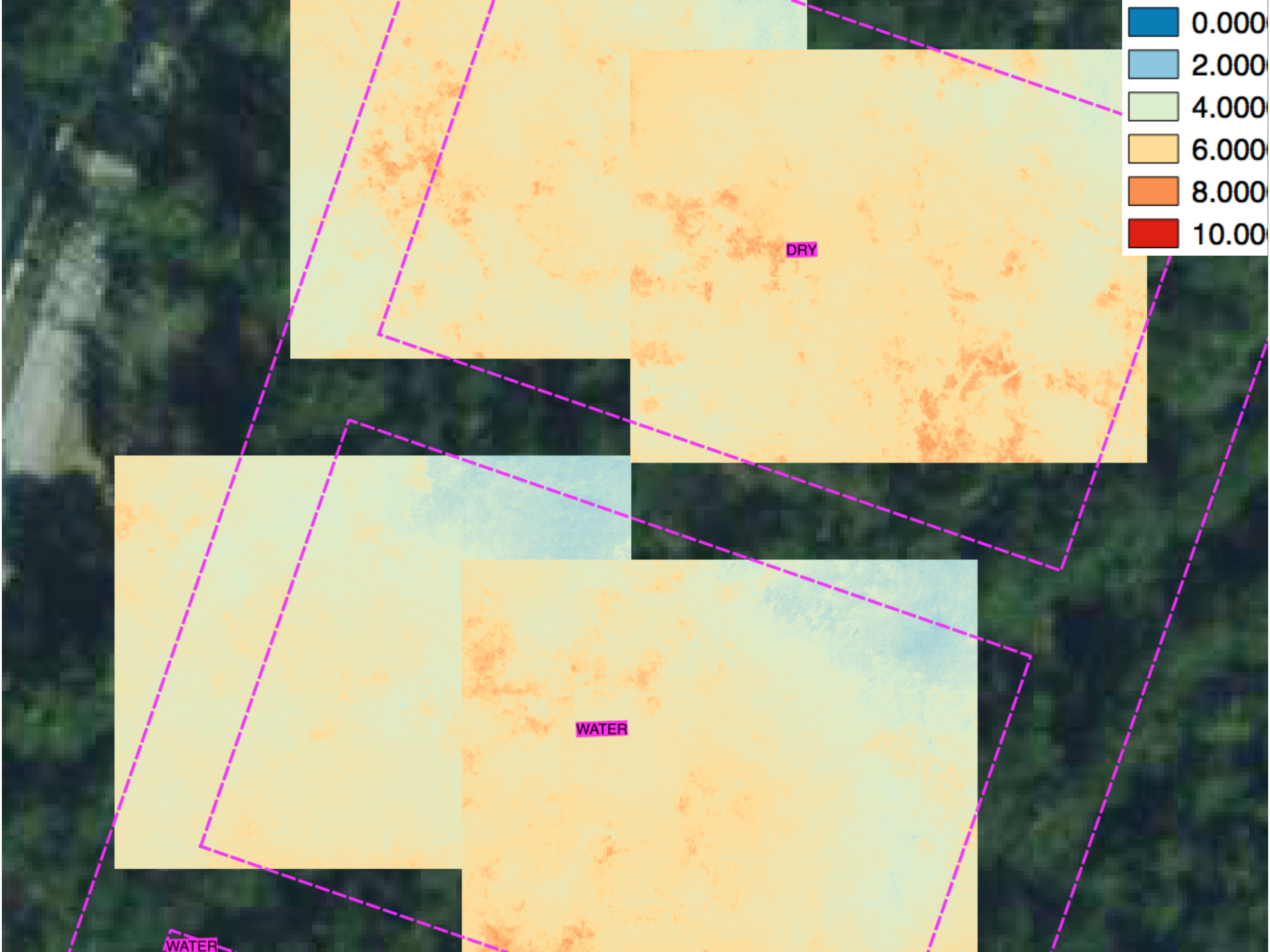
0 ... 10 °C





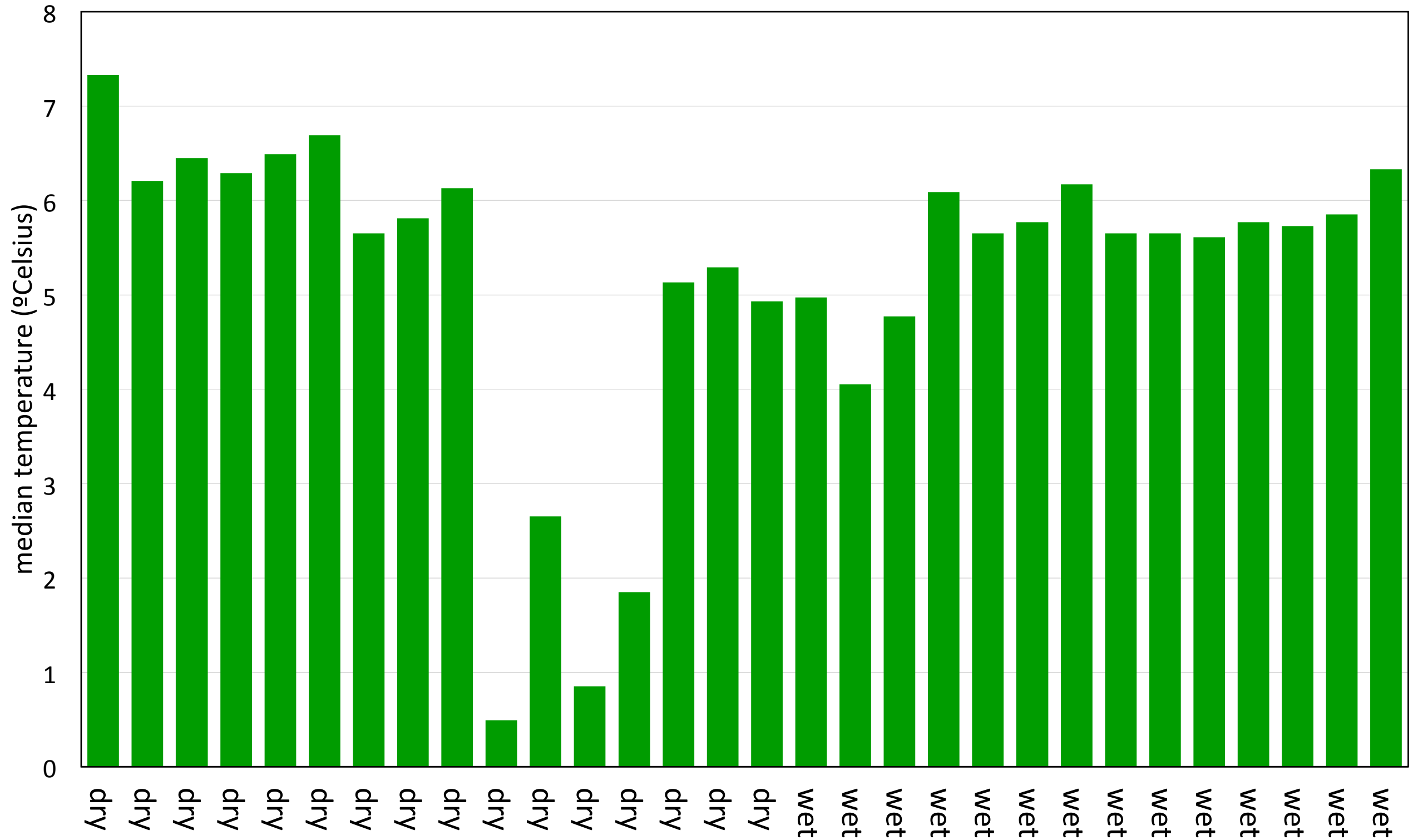








**30 manually selected tree top samples
(1000-4000 pixels)**



Conclusions

- multispectral sensor (0.7 - 1?
- significant discrimination in spring, summer ?
- coniferous trees ?