UNIVERSITY OF TWENTE.

THERMAL REMOTE SENSING

A (VERY) SHORT INTRO

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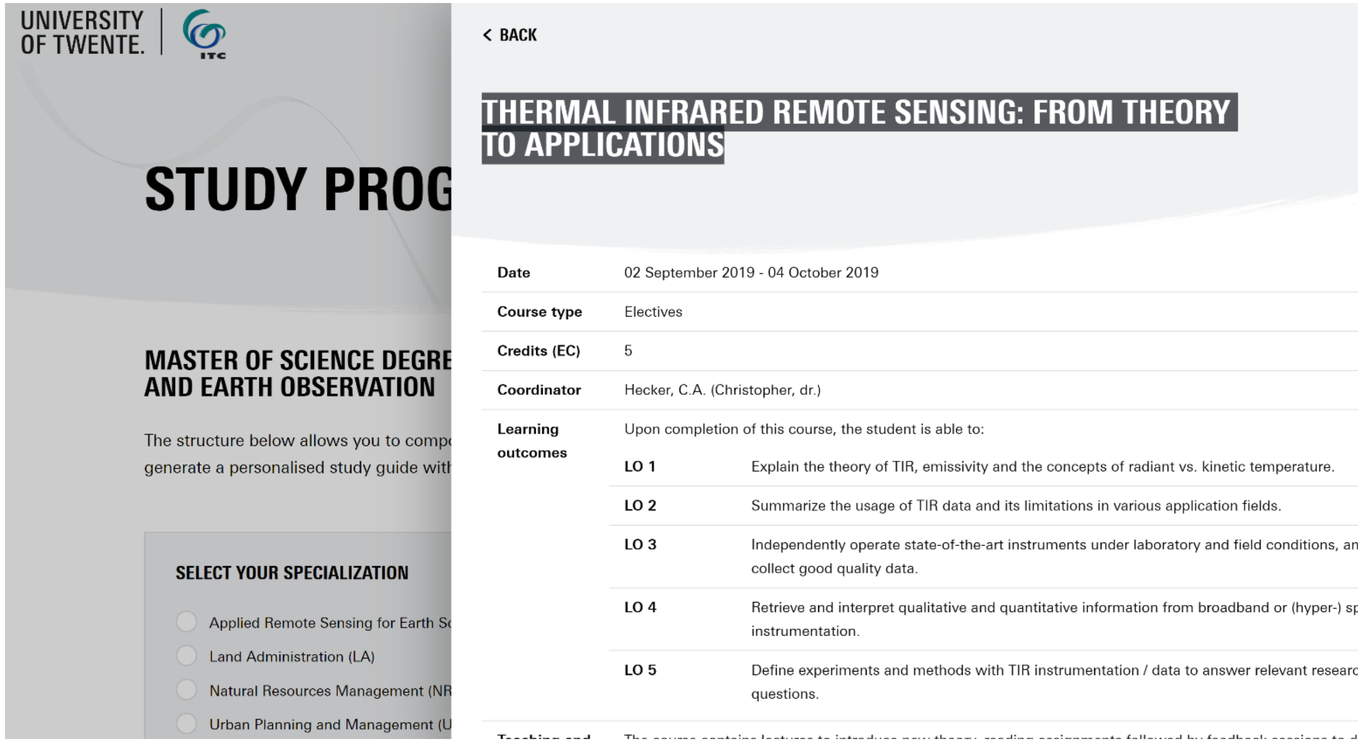
THERMAL INFRARED REMOTE SENSING

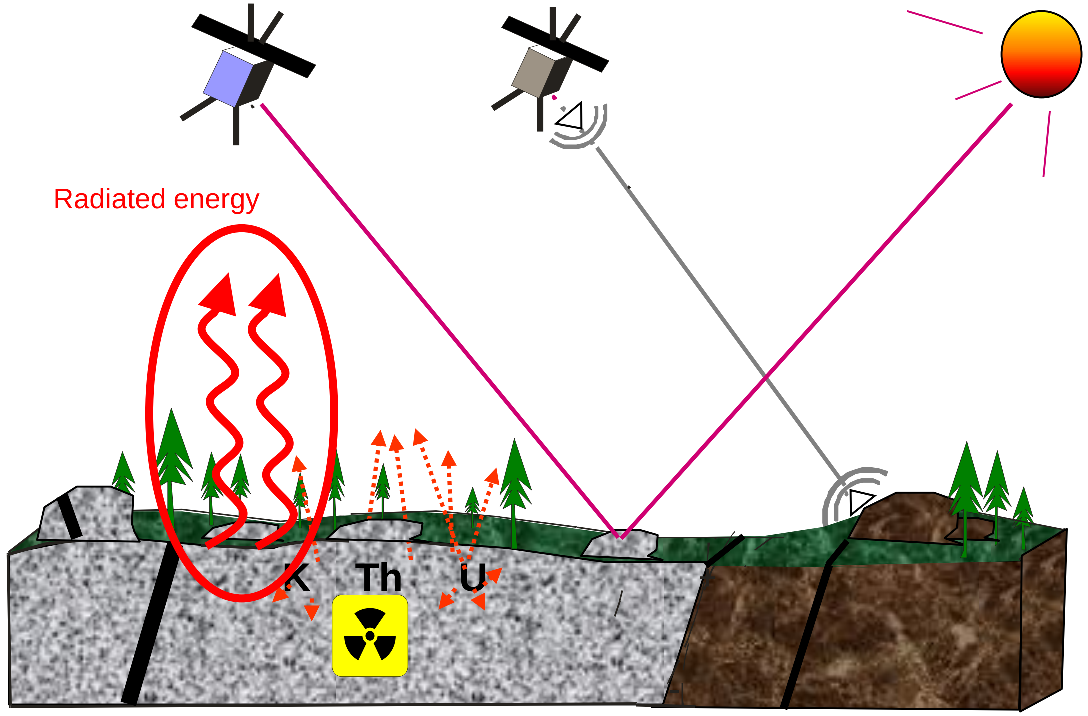
FROM THEORY TO APPLICATIONS

- 5 EC Elective
- Q5 (start of year 2)

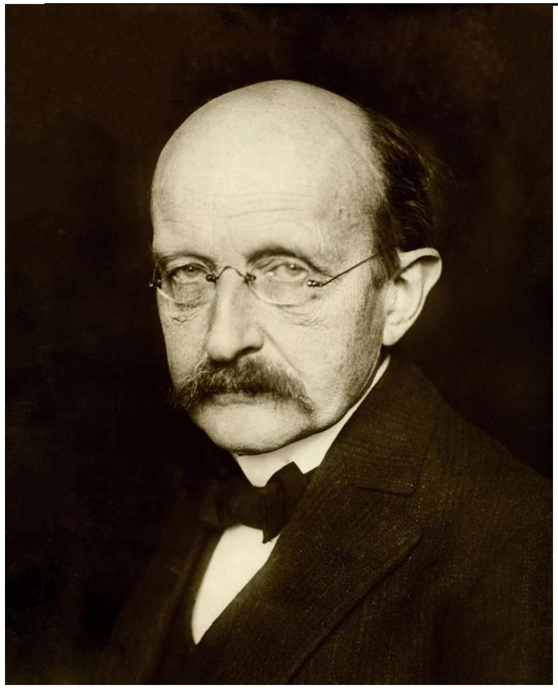


https://studyguide.itc.nl/m-geo/201900043/thermal-infrared-remote-sensing:-from-theory-to-applications

WHAT IS REMOTE SENSING?



WHERE DOES THERMAL RADIATION COME FROM?



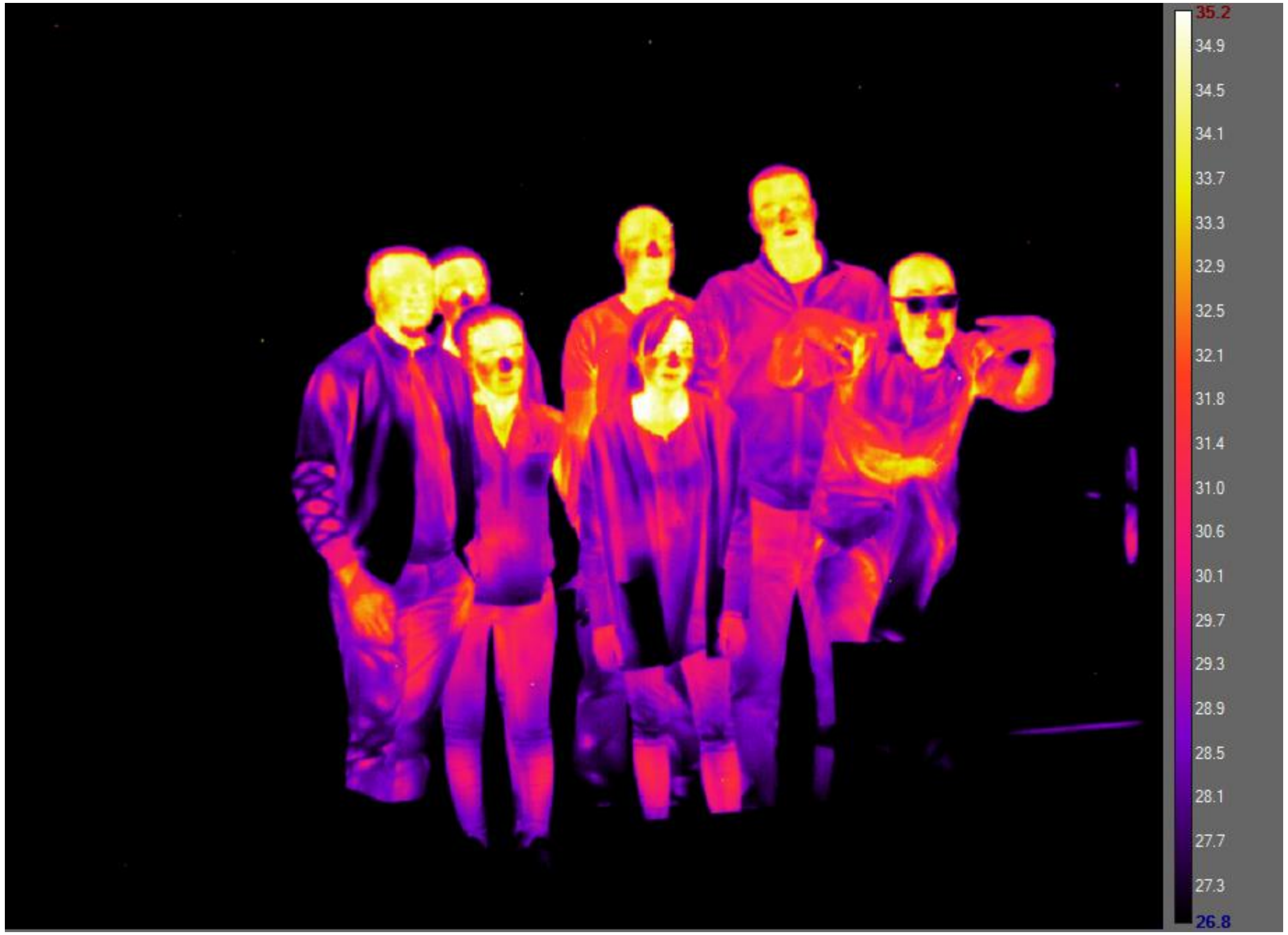
All objects with a temperature > 0K radiate energy

$$M_{\lambda,T} \equiv \frac{C_1}{\lambda^5\left(e^{\frac{C_2}{\lambda T}}-1\right)}$$

Max Planck;1858-1947

$M_{\lambda,T}$ = spec. rad. emittance
λ = wavelength
T = radiant temperature
C1 = 1st rad. constant
C2 = 2nd rad. constant

WHY DON'T WE SEE THERMAL RADIATION THEN?

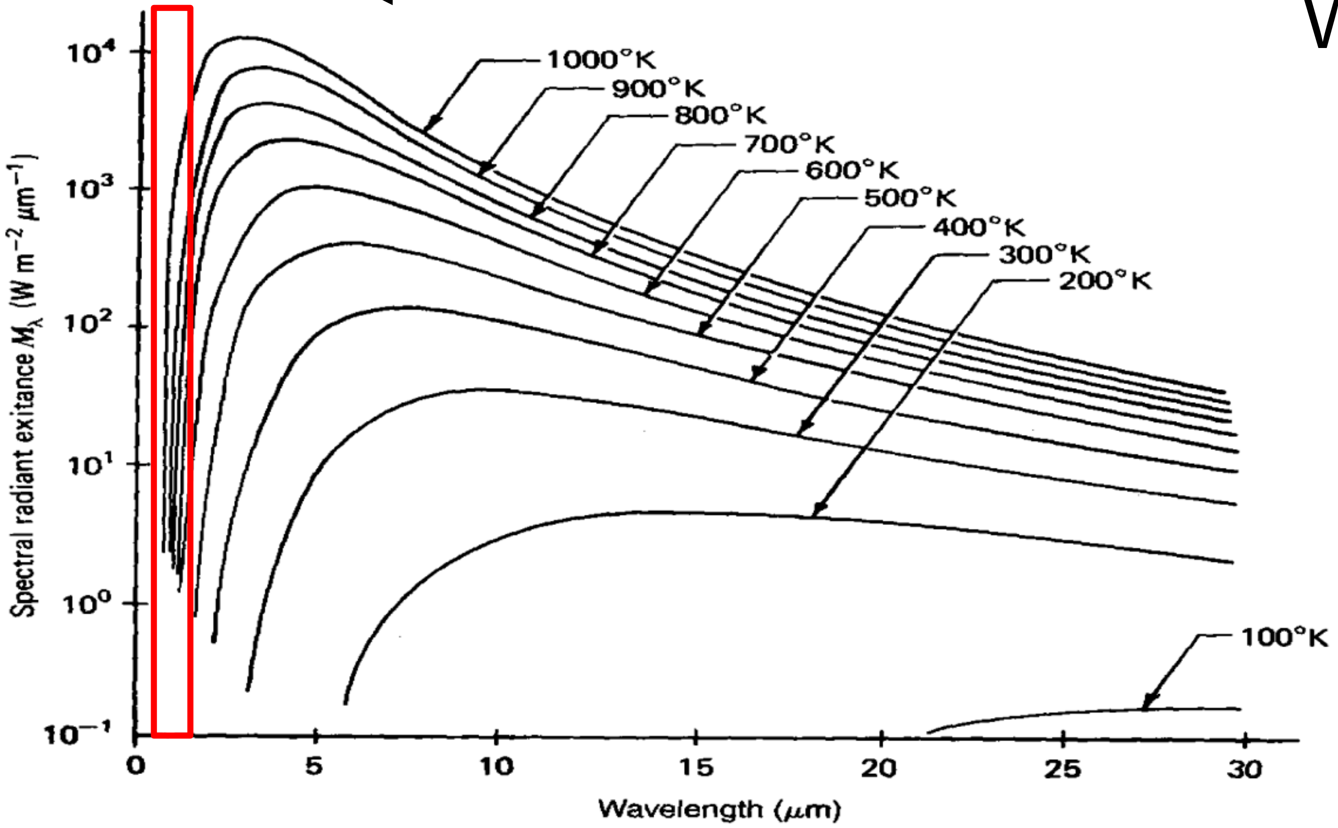


WE CAN SEE (PART OF) IT!

BLACK BODY CURVES

Radiation maximum depends on T

Wiens Shift

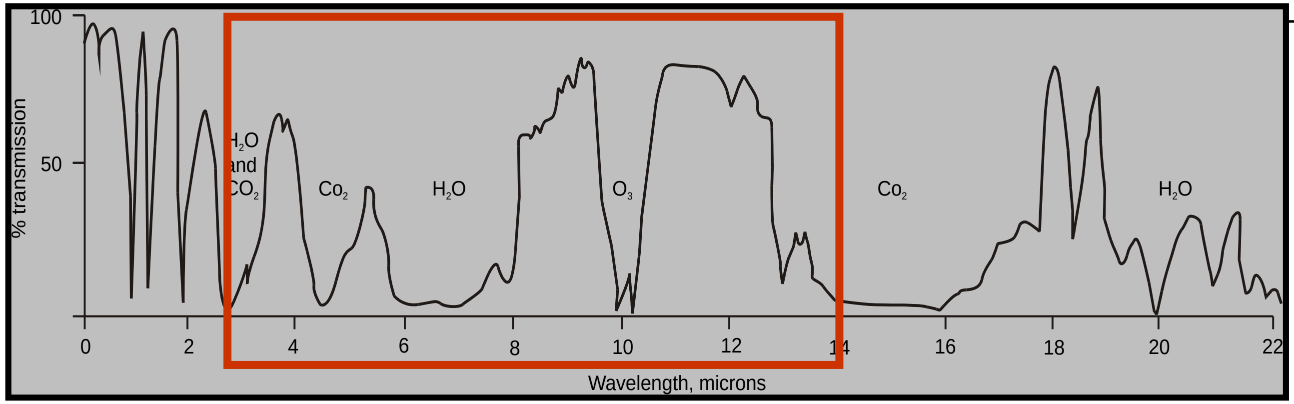


Graphical display of Planck's Radiation Law

$$M_{\lambda,T} \equiv \frac{C_1}{\lambda^5\left(e^{\frac{C_2}{\lambda T}}-1\right)}$$

- Source: Lillesand and Kiefer (2000)

SO WHAT IS TIR REMOTE SENSING?



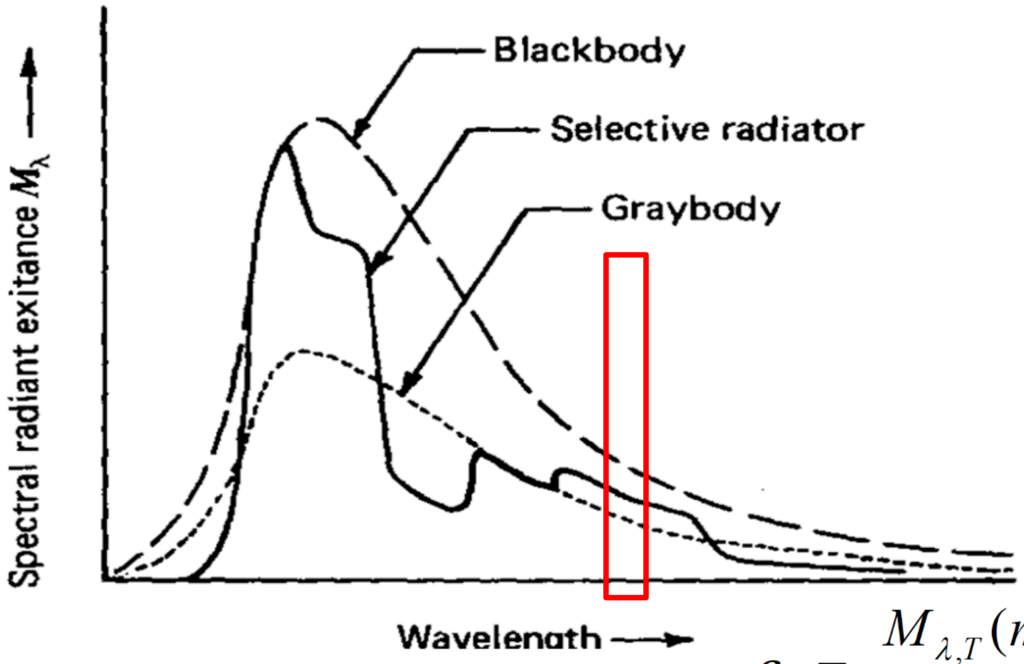
- 3-5µm (MWIR) and 8-14µm (LWIR) together form TIR
- MWIR complex due to overlaps with reflected sunlight
- MWIR for gases, LWIR for ground applications

IR RANGES IN DIFFERENT DISCIPLINES

Application Field	$13000\ cm^{-1}$	$4000\ cm^{-1}$	$400\ cm^{-1}$	$100\ cm^{-1}$	
Spectroscopy	VIS	NIR ($13000 - 4000\ cm^{-1}$)	MIR ($11000 - 400\ cm^{-1}$)	FIR ($400 - 100\ cm^{-1}$)	
Astronomy	VIS	NIR ($0.7/1.0 - 5\mu m$)	MIR ($5 - 25/40\mu m$)	FIR ($25/40 - 200/300\mu m$)	
Remote Sensing	VIS	NIR ($0.7 - 1.0$)	SWIR ($1.0 - 2.5\mu m$)	TIR ($3 - 5\ \mu m$ MWIR) ($8 - 14\mu m$ LWIR)	
	$0.7\mu m$	$1.0\mu m$	$2.5\mu m$	$14\mu m$	

Source: Hecker, et al. (2010) *Earth-Science Reviews*

BUT PLANCKS LAW ONLY WORKS FOR BLACK BODIES



$$\varepsilon_\lambda \equiv \frac{M_{\lambda,T}(material)}{M_{\lambda,T}(blackbody)}$$

Emissivity

TABLE 5.2 Typical Emissivities of Various Common Materials Over the Range of 8 to 14 μm

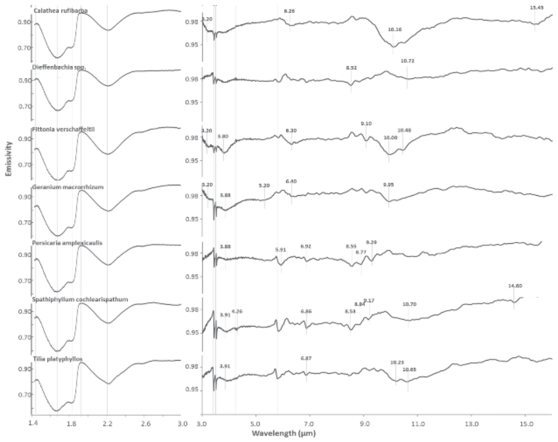
Material	Typical Average Emissivity ε over 8–14 μm[a]
Clear water	0.98–0.99
Wet snow	0.98–0.99
Human skin	0.97–0.99
Rough ice	0.97–0.98
Healthy green vegetation	0.96–0.99
Wet soil	0.95–0.98
Asphaltic concrete	0.94–0.97
Brick	0.93–0.94
Wood	0.93–0.94
Basaltic rock	0.92–0.96
Dry mineral soil	0.92–0.94
Portland cement concrete	0.92–0.94
Paint	0.90–0.96
Dry vegetation	0.88–0.94
Dry snow	0.85–0.90
Granitic rock	0.83–0.87
Glass	0.77–0.81
Sheet iron (rusted)	0.63–0.70
Polished metals	0.16–0.21
Aluminum foil	0.03–0.07
Highly polished gold	0.02–0.03

Source: Lillesand and Kiefer 2000

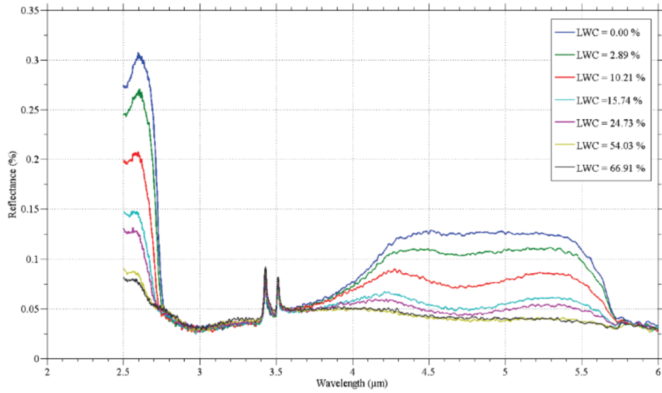
APPLICATION OF THERMAL REMOTE SENSING

- Estimate temperature of surfaces
  - Related to Evapotranspiration
  - Water content
  - Assess variability in temperature fluctuations (Thermal Inertia)
- Extract (hyper) spectral features that indicate surface properties
  - Water content
  - Cellulose content in leaves
  - Plant species
  - ???

pixabay.com/nl/illustrations/thermometer-temperatuur-koud-4467023/



Buitrago et al. 2018



Ullah et al. 2013

SOME QUESTIONS

- How can you estimate temperature when you measure emitted radiance at a given wavelength?
  - Use Plancks law!
- What factors influence the relation between measured radiance and temperature?
  - Composition of the atmosphere
  - Emissivity

VIDEO'S TO WATCH TO UNDERSTAND & DEMONSTRATE TIR USING THERMAL CAMERA'S

- https://www.youtube.com/watch?v=HgRjXZV-kew
  Very clear explanation on emissivity and how it affects thermal radiation
- https://www.youtube.com/watch?v=MBm_DtxXWns
  Shows how emissivity affects the Thermal signal
  → question, which of the three surface types has the highest emissivity?
- https://www.youtube.com/watch?v=hawUYtMIxfE
  Things that are opaque in the visible light, can be transparent in the thermal part
- https://www.youtube.com/watch?v=fpx7hsoYEt4
  or vice versa