

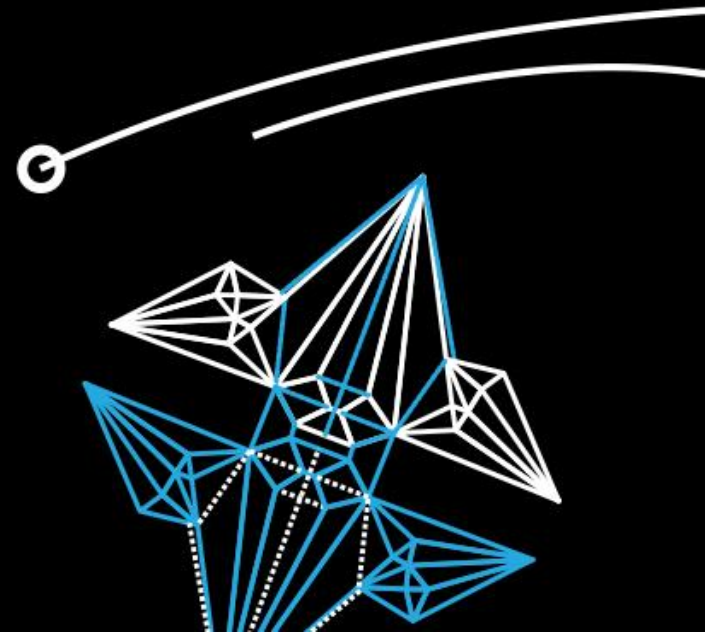
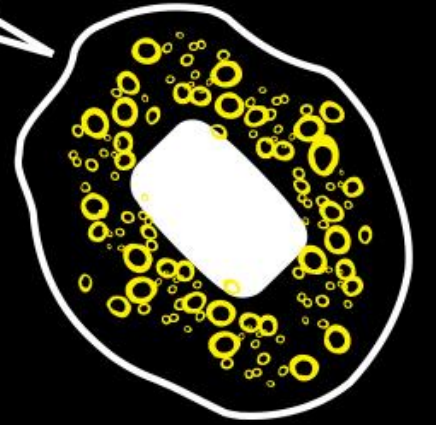
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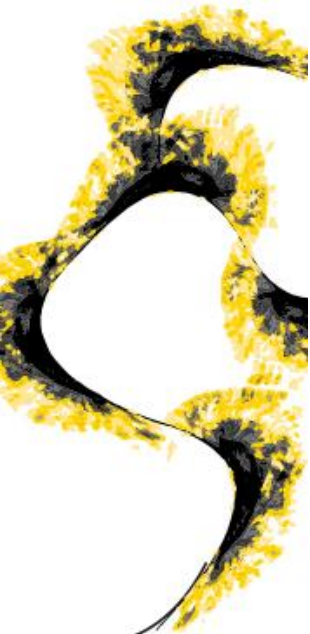
THERMAL REMOTE SENSING

A (VERY) SHORT INTRO

T.A. GROEN

M.T. MARSHALL





THERMAL INFRARED REMOTE SENSING

FROM THEORY TO APPLICATIONS

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



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STUDY PROGRAM

MASTER OF SCIENCE DEGREE AND EARTH OBSERVATION

The structure below allows you to compare different specializations and generate a personalised study guide with the help of our study guide tool.

SELECT YOUR SPECIALIZATION

- ☐ Applied Remote Sensing for Earth Science
- ☐ Land Administration (LA)
- ☐ Natural Resources Management (NR)
- ☐ Urban Planning and Management (U)

< BACK

THERMAL INFRARED REMOTE SENSING: FROM THEORY TO APPLICATIONS

Date 02 September 2019 - 04 October 2019

Course type Electives

Credits (EC) 5

Coordinator Hecker, C.A. (Christopher, dr.)

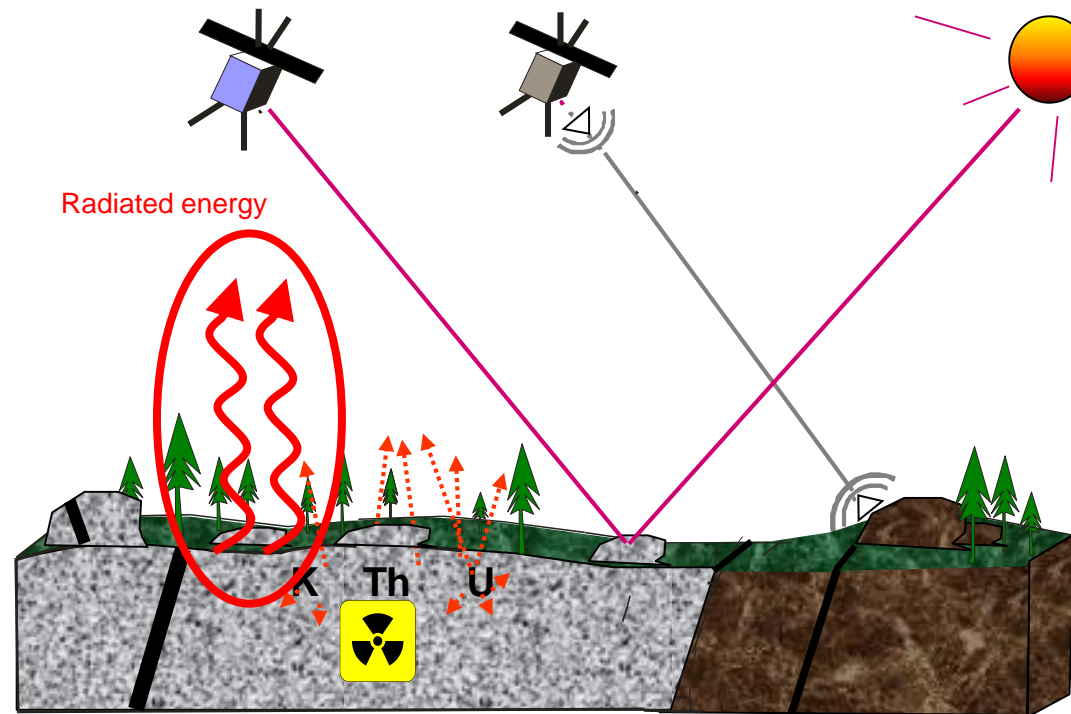
Learning outcomes Upon completion of this course, the student is able to:

- LO 1** Explain the theory of TIR, emissivity and the concepts of radiant vs. kinetic temperature.
- LO 2** Summarize the usage of TIR data and its limitations in various application fields.
- LO 3** Independently operate state-of-the-art instruments under laboratory and field conditions, and collect good quality data.
- LO 4** Retrieve and interpret qualitative and quantitative information from broadband or (hyper-) spectral instrumentation.
- LO 5** Define experiments and methods with TIR instrumentation / data to answer relevant research questions.

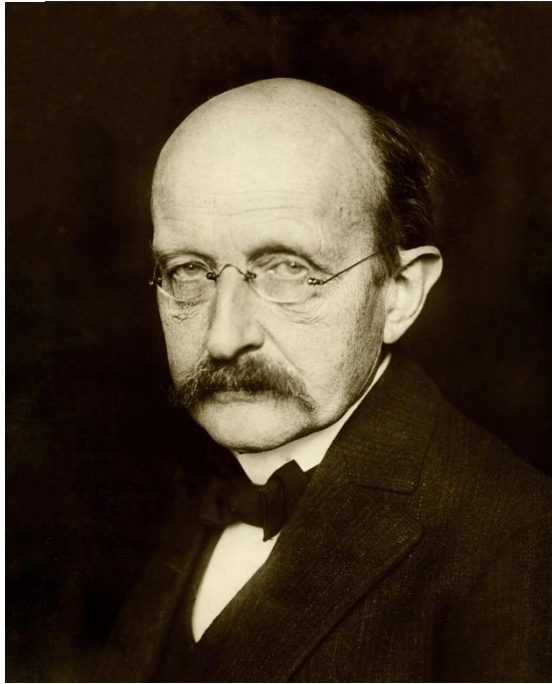
Teaching and The course contains lectures to introduce new theory, reading assignments followed by feedback sessions to discuss

<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?



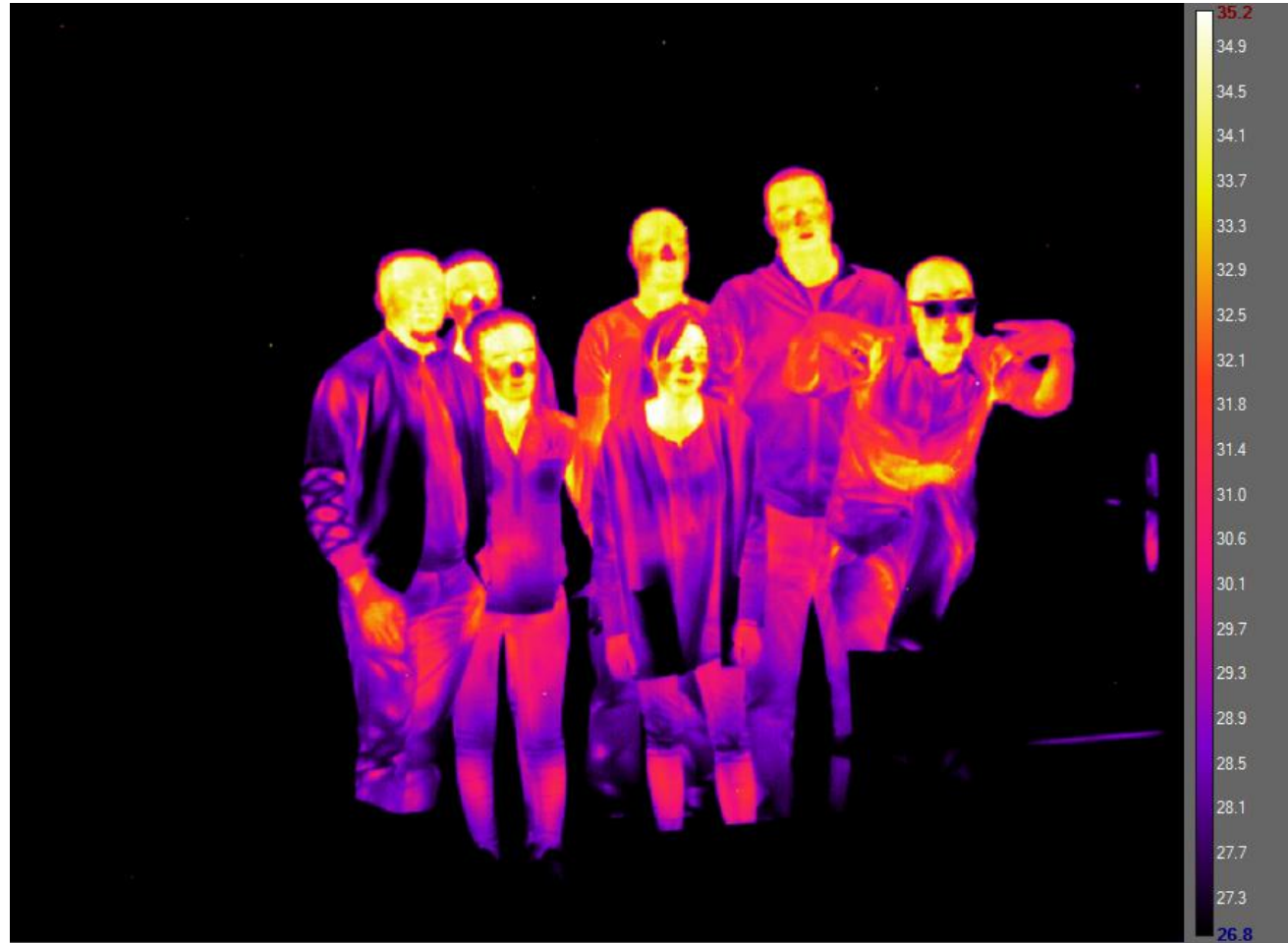
All objects with a temperature $> 0\text{K}$ radiate energy

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

Max Planck; 1858-1947

$M_{\lambda,T}$ = spec. rad. emittance
 λ = wavelength
 T = radiant temperature
 C_1 = 1st rad. constant
 C_2 = 2nd rad. constant

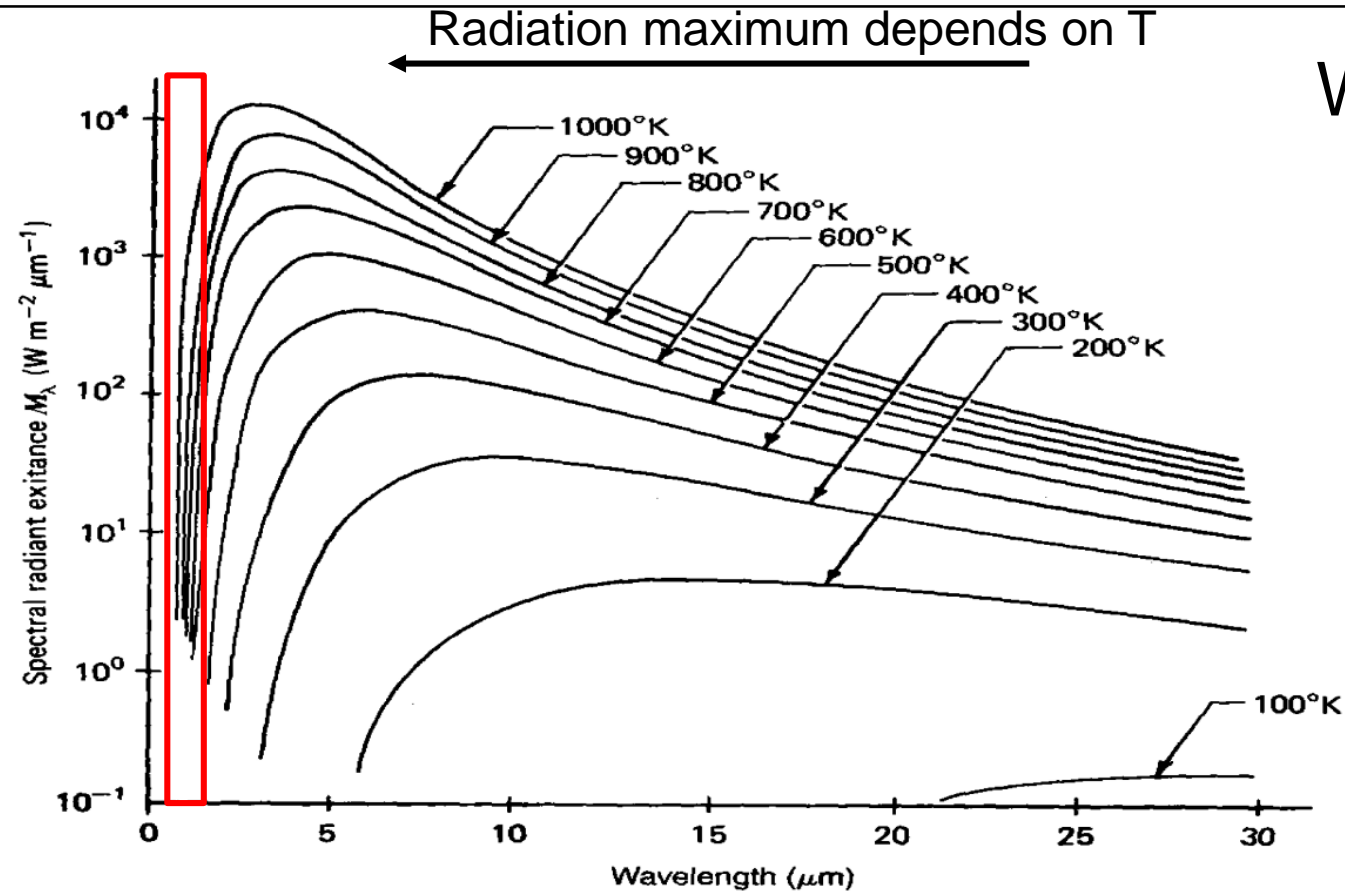
WHY DON'T WE SEE THERMAL RADIATION THEN?



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WE CAN SEE (PART OF) IT!

BLACK BODY CURVES



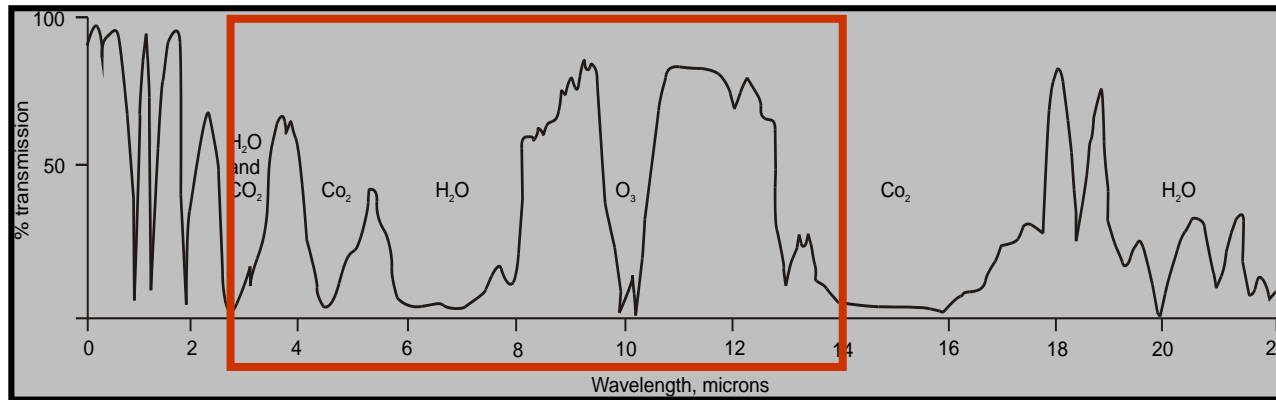
Wiens Shift

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?



- 3-5 μ m (MWIR) and 8-14 μ m (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 - 5μm)			MIR (5 - 25/40μm)		FIR (25/40 - 200/300μm)
Remote Sensing	VIS	NIR (0.7 - 1.0)	SWIR (1.0 - 2.5μm)	TIR (3 - 5 μm MWIR) (8 - 14μm LWIR)			
		0.7μm 1.0μm	2.5μm	14μm			

BUT PLANCKS LAW ONLY WORKS FOR BLACK BODIES

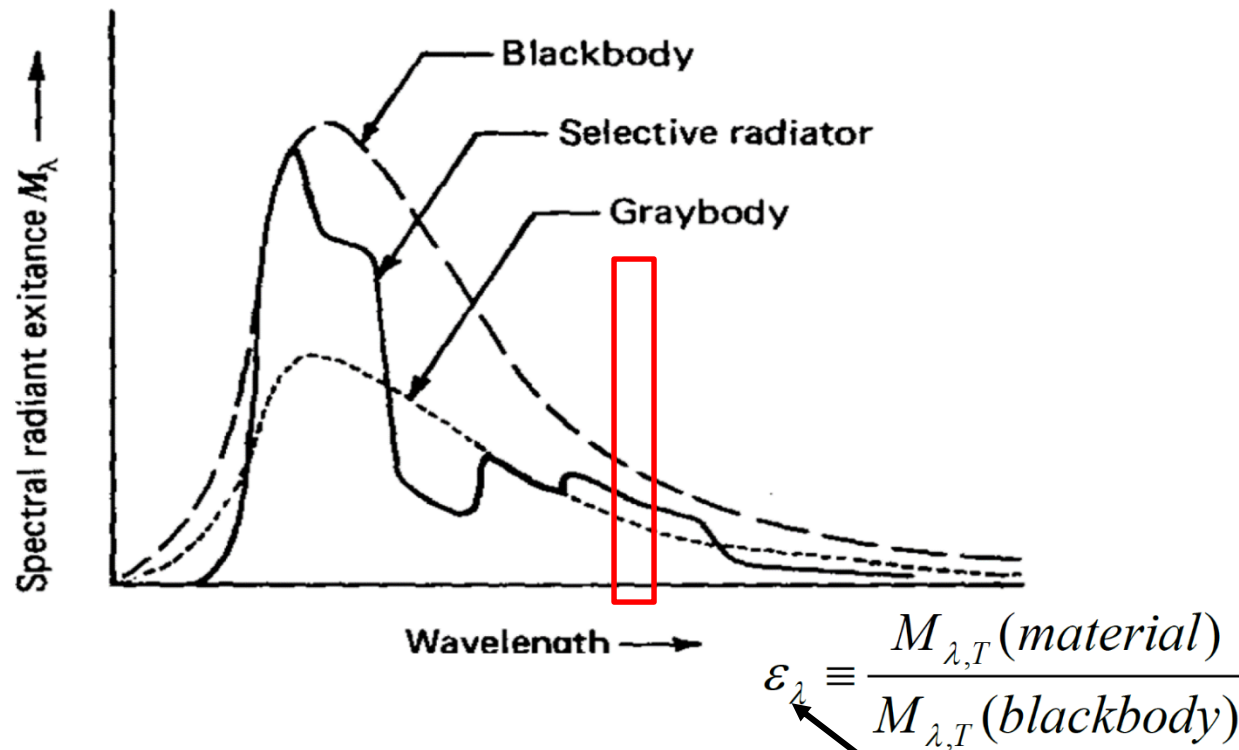


TABLE 5.2 Typical Emissivities of Various Common Materials Over the Range of 8 to 14 μm

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

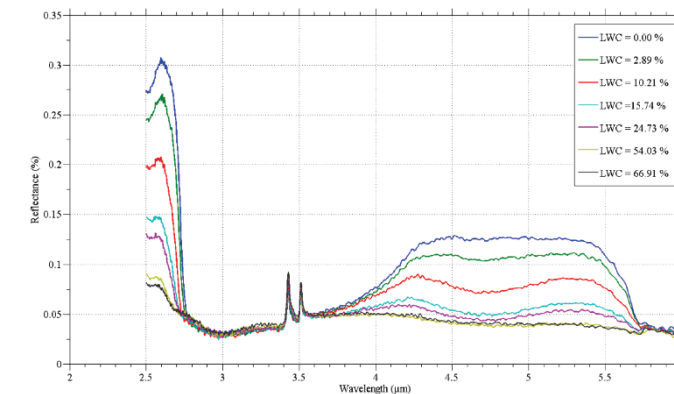
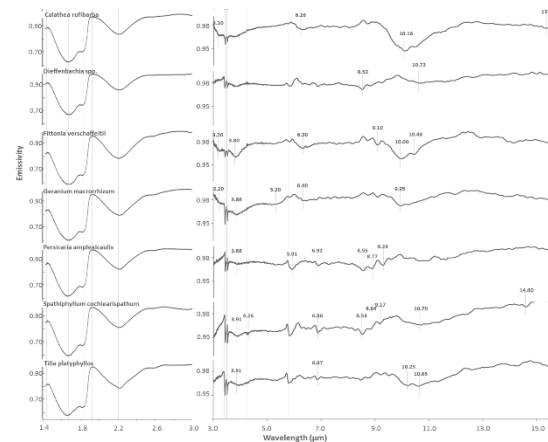
Source: Lillesand and Kiefer 2000

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Emissivity

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
 - ???



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=fpx7hsoYE4>
or vice versa