Can thermal imaging supports the determination of the age of bamboo culms? A case study from Pereira, Colombia

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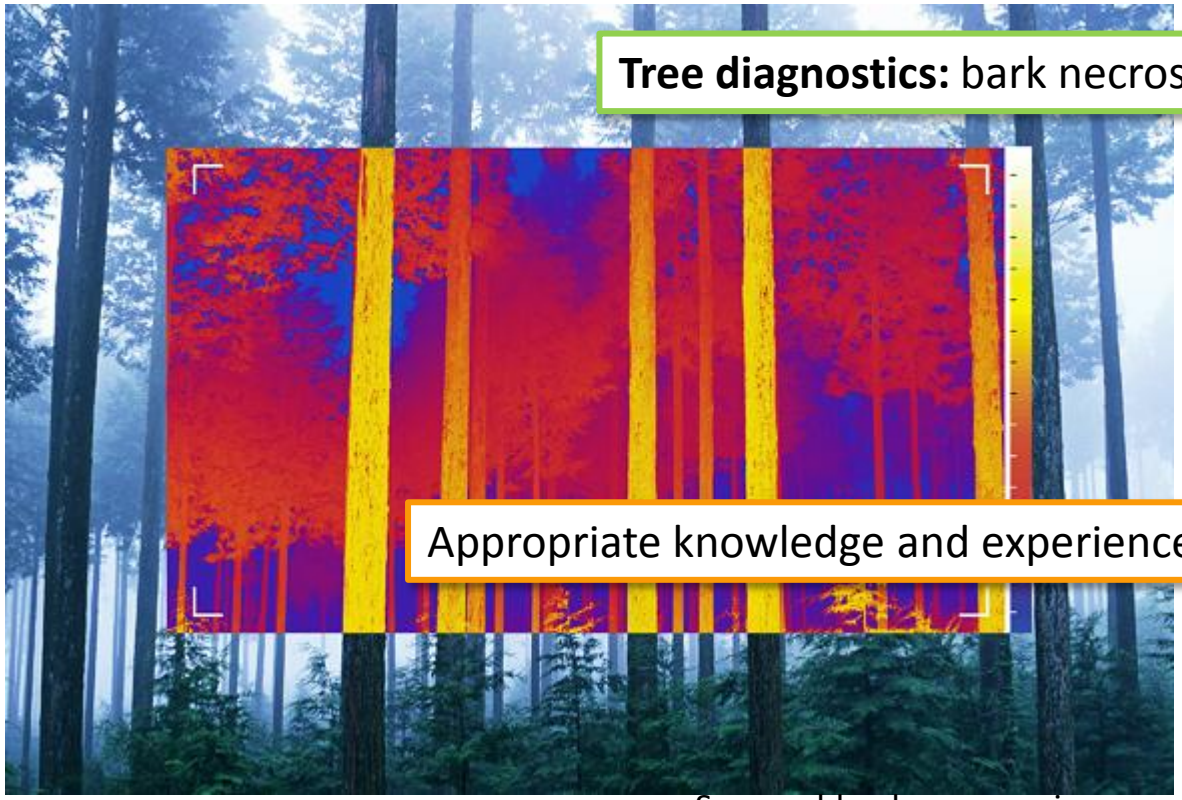
Thermal Imaging for Tree Assessment



Tree diagnostics: bark necrosis, decay, non-visible damages

Appropriate knowledge and experience for a correctly interpretation

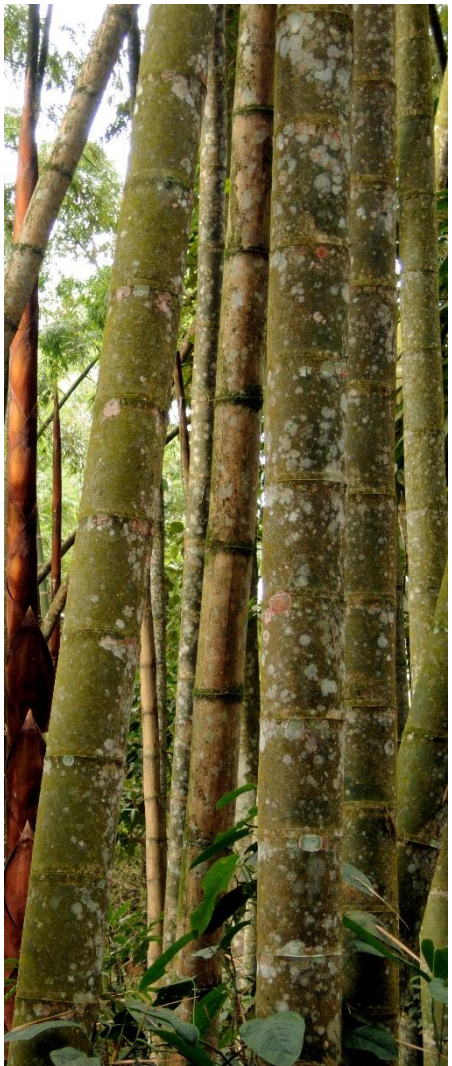
Source: blog.lumasenseinc.com

Motivation

Culm maturity of the bamboo species *Guadua angustifolia* K. is important, because …

- physical and chemical properties are optimal
- it can be used for construction purposes
- best resistance against fungi and insects

Assessment of maturity based mainly on the experience of the guadua manager



Hypothesis

Physiological processes occurring as culms mature and this may lead to differences in properties of the culm surface

Culm surface temperature differs with culm age

Study Area

- Botanical garden of the *Universidad Tecnologica de Pereira*, Colombia

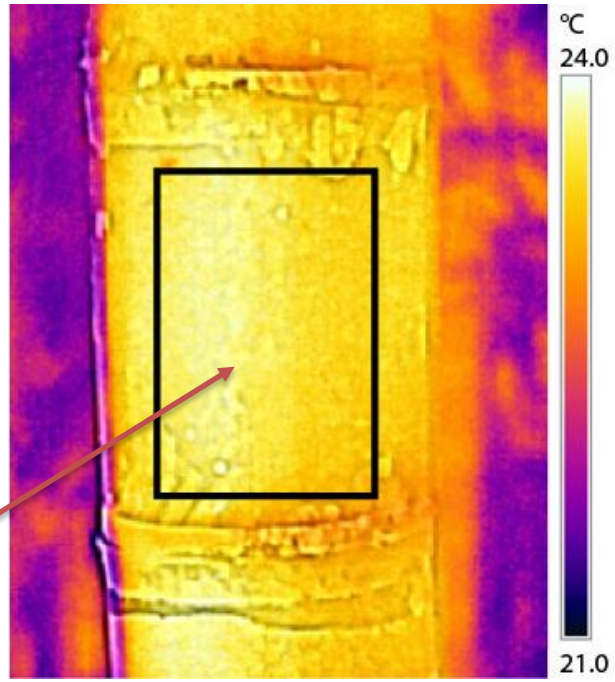
- Altitude: 1450 m
- Rainfall: 2600 mm
- Temperature: 23°C

- Natural guadua bamboo forest

- Permanent observation plots with labeld culms

Determining Surface Temperature

- Device: Thermal camera FLIR 60Ebx
- Emitted longwave radiation is measured at internode 4, 6 and 8
- Total of 360 images
- Time of mesaurements: 5 pm to 7 pm
- 4 culms per age class (1, 2 and 3 years)



Mean surface temperature per internode

A Short Introduction into Thermal Infrared Radiation

Electromagnetic Spectrum

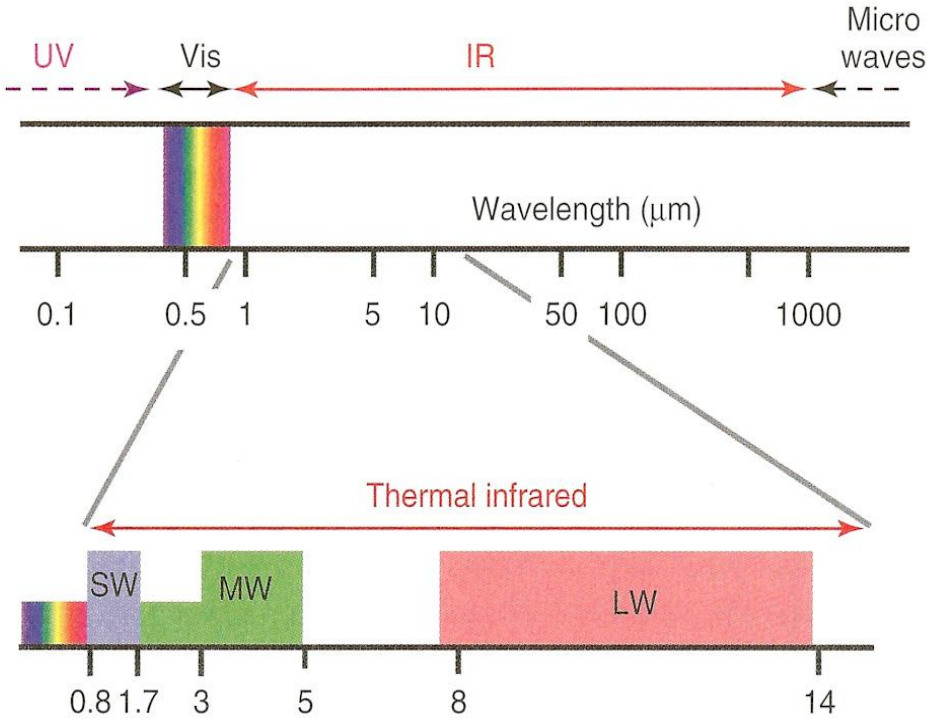
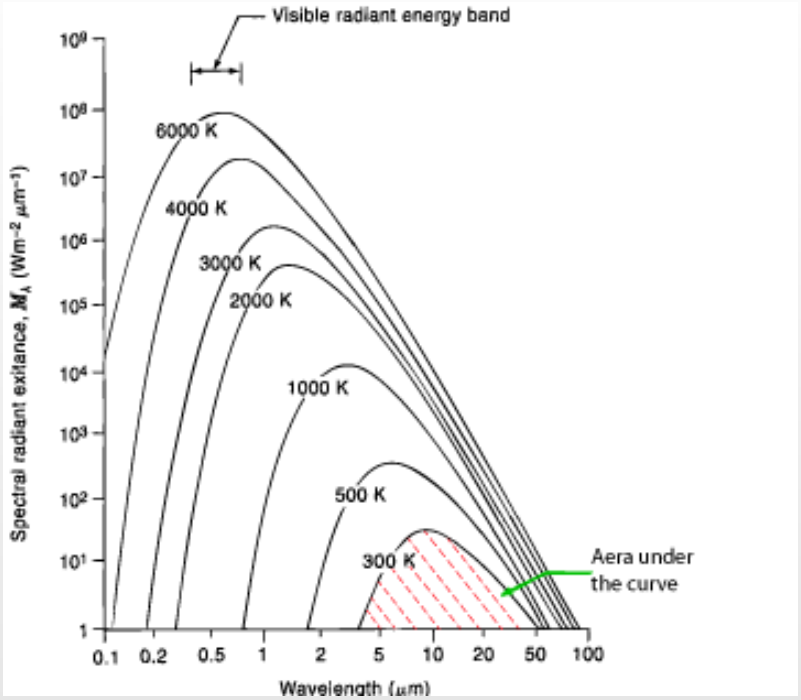


Figure 1.8 Infrared (IR) and adjacent spectral regions and expanded view of the so-called thermal infrared. This is the region where IR imaging systems for shortwave (SW), mid-wave (MW), or long-wave (LW) cameras exist. Special systems have extended MW or SW ranges.

- Thermal infrared lies between visible and microwave spectra
- Primary source of infrared radiation is heat or thermal radiation
- Objects above absolute zero (- 273°C or 0 K) emit radiation
- Thermal cameras work mainly in 8 to 14 µm range (atmospheric window)

Josef Stefan Boltzmann
(1835 – 1893)

Stefan-Boltzmann Law

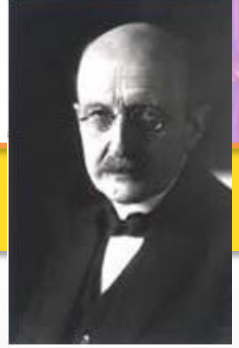


- Applies only to the blackbody (theoretical surfaces that absorb all incident heat radiation)
- Gives the total energy being emitted at all wavelengths by the blackbody (which is the area under the Planck Law curve)

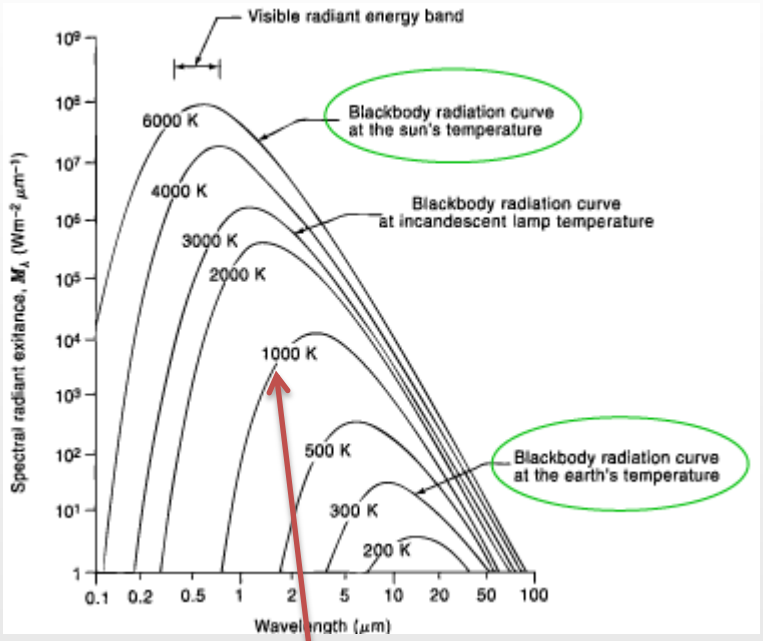
$$E = \sigma T^4$$

E is the radiant heat energy
T is the absolute temperature (Kelvin)
$\sigma = 5.6704 \times 10^{-8}$ W m^{-2} K^{-4} (Stefan-Boltzmann constant)

Planck's Blackbody Radiation Law



Max Planck
(1858 – 1947)



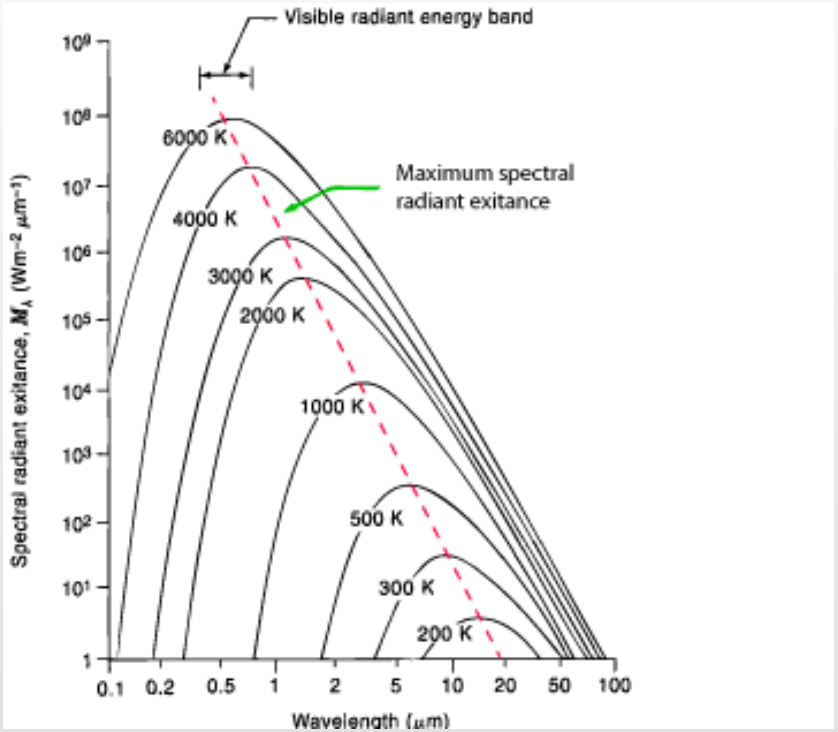
~ 900K → Iron glow dark red

- Describes the electromagnetic radiation emitted from a blackbody at a certain wavelength as a function of its absolute temperature

- Sun = 5777K
  Human = 300K

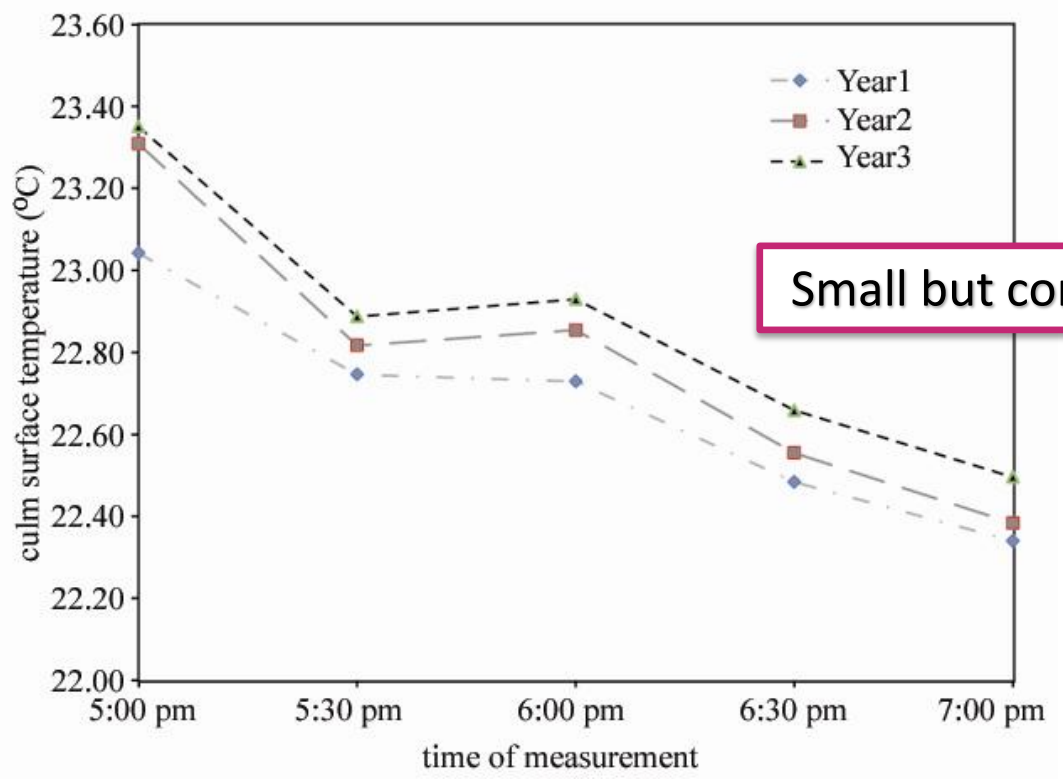
Wien‘s Displacement Law

Wilhelm Wien
(1864 – 1928)



- Describes the wavelength at which the **maximum spectral radiant exitance** occurs
- With increasing temperature λmax shifts to shorter wavelengths

Main Result



Small but constant temperature difference

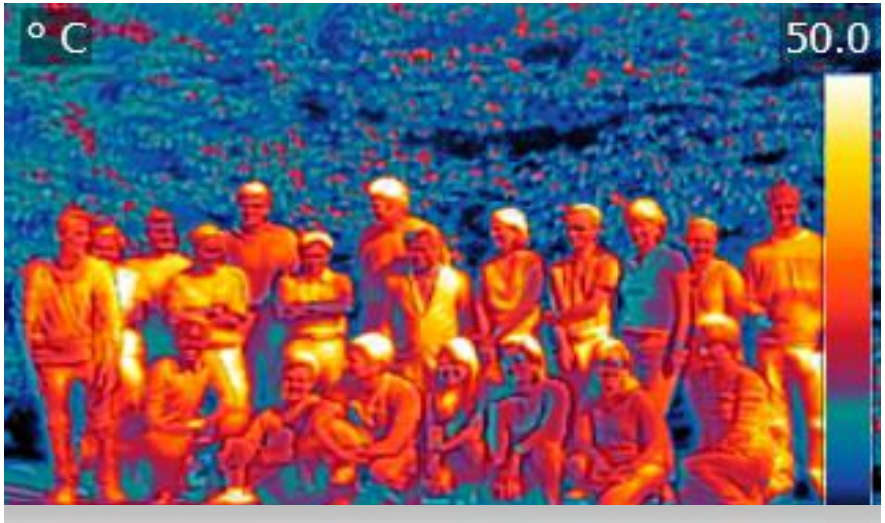
Conclusion

- Differences in culm surface temperature as a function of maturity may exist for guadua bamboo and can may support determining the age

Further research is necessary

- Bamboo culm characteristics may influence the final surface temperature
  (internode wall thickness, cell wall structure, density)

- Influence of physiological aspects
  (sap flow, moisture content)



Thanks for your attention

Acknowledgements

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