SPECTRAL CHARACTERIZATION OF SURFACE EMISSIVITIES IN THE THERMAL INFRARED

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CONTENT

INTRODUCTION

- Thermal infrared (TIR) remote sensing trends to hyperspectral sensors on board satellites (e.g. HyspIRI and ECOSTRESS missions).

- It is needed to characterize spectrally the emissivity of surface components for an accurate application of the TIR data.

- This work have analyzed five different samples with singular spectral features (gypsum, quartz, calcite, salt and rose plants), using a hand-portable Fourier transform infrared (FT-IR) spectrometer, Desings & Prototypes (D&P) Instruments model 102.

FT-IR D&P 102 SPECTROMETER
TECHNICAL FEATURES

Wavelength range	**2 – 16 µm**
Spectral resolution	4, 8 and 16 cm^{-1} (optional 2 cm^{-1})
Operating temperature range	15 to 35 ˚C (instrument temp.)
Field of View (FOV)	4.8˚

Michelson interferometer
(infrared optics, beam splitter and a scanning mirror assembly)

Dimensions	36 × 20 × 23 cm^3
Weight	6.8 kg
Operating software	*Designs & Prototypes FTIR*

Warm/cold backbody

Temperature range	3 to 95 ˚C
Accuracy	±0.2 ˚C

FT-IR D&P 102 SPECTROMETER
PROTOCOL OF MEASUREMENTS

- **Retrieval of thermal infrared emissivities under field conditions**

- Fill the liquid nitrogen tank and wait for stabilization.

- Sequence of measurements:

- Radiances from a **black body** at reference cold and warm calibration temperatures

  (to calibrate the target and downwelling radiances)

- Hemispherical downwelling radiance ($L_{p\lambda}$) reflected by a diffuse reflectance **panel** (gold plate)

- **Target** leaving radiance ($L_{t\lambda}$)

$$L_{t\lambda} = \varepsilon_\lambda B_\lambda(T_t) + (1 - \varepsilon_\lambda) L_{p\lambda}$$

Where:
B: Planck function for a black body spectral radiance
T_t: Target surface temperature
ε_λ: Target spectral emissivity

FT-IR D&P 102 SPECTROMETER

DATA PROCESSING

$$\varepsilon_\lambda = [L_{t\lambda} - L_{p\lambda}] / [B_\lambda(T_t) - L_{p\lambda}]$$

Where:

B: Planck function for a black body spectral radiance

T_t: Target surface temperature

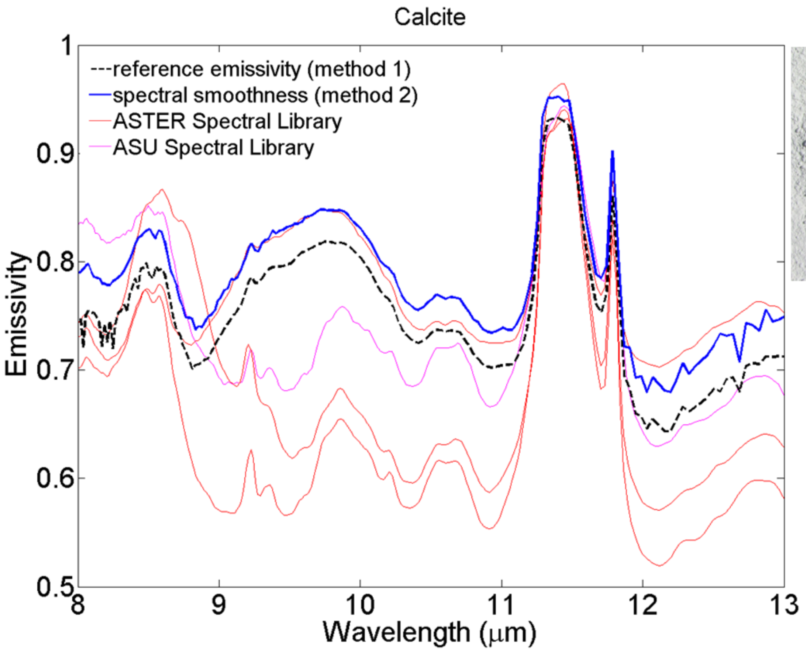
ε_λ: Target spectral emissivity

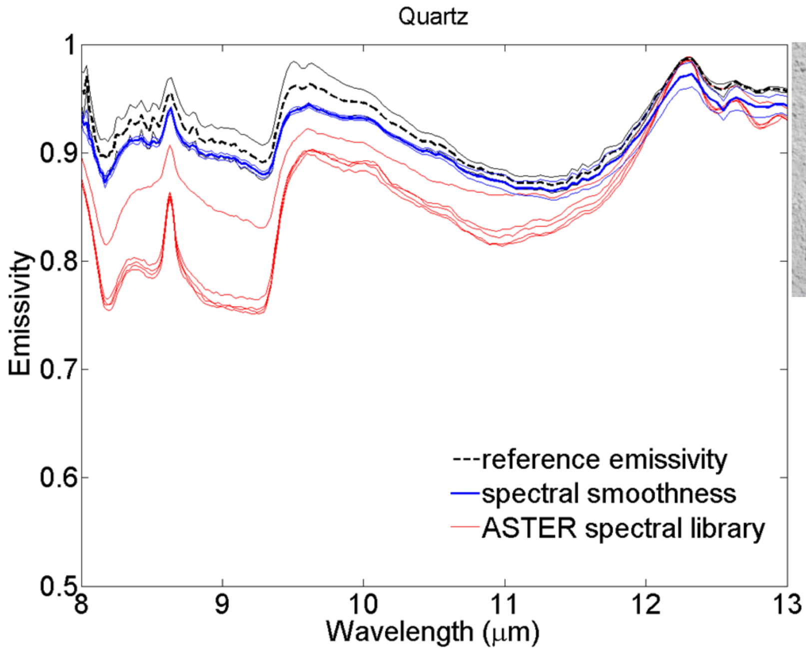
$L_{p\lambda}$: Hemispherical downwelling radiance

$L_{t\lambda}$: Target leaving radiance

- Two methods have been used to obtain the target Surface temperatura (T_t):
  - Method 1: A reference emissivity value was assumed within a portion of the measured spectrum, which was obtained from reference spectral data.
  - Method 2: Spectral smoothness method. T_t was obtained by minimization of the reflected atmospheric emission lines within a portion of the measured spectrum (8.12 – 8.60 µm).

RESULTS

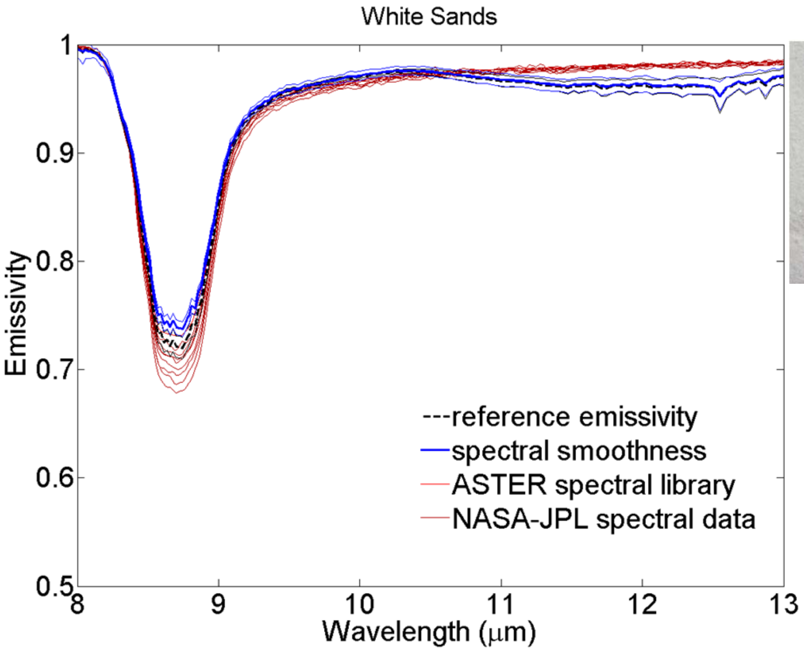


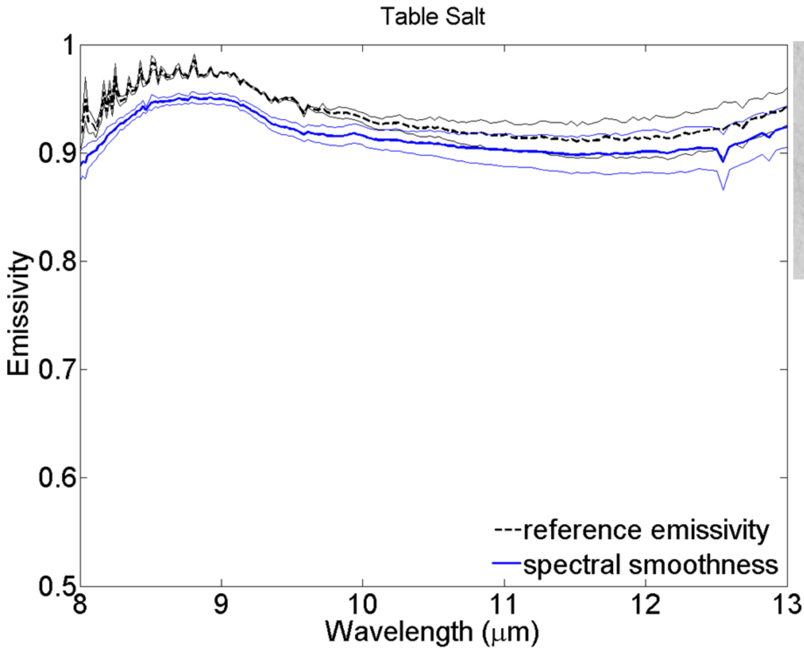


Reference emissivity method			
Sample	Spectral interval (μm)	Emissivity (mean ± SD)	Source
Calcite	11.35 - 11.55	0.925 ± 0.028	ASTER Spectral Library 3 samples (particle size < 45 μm)

Reference emissivity method			
Sample	Spectral interval (μm)	Emissivity (mean ± SD)	Source
Quartz	12.19 - 12.39	0.980 ± 0.006	ASTER Spectral Library 5 samples (particle size < 45 μm)

RESULTS

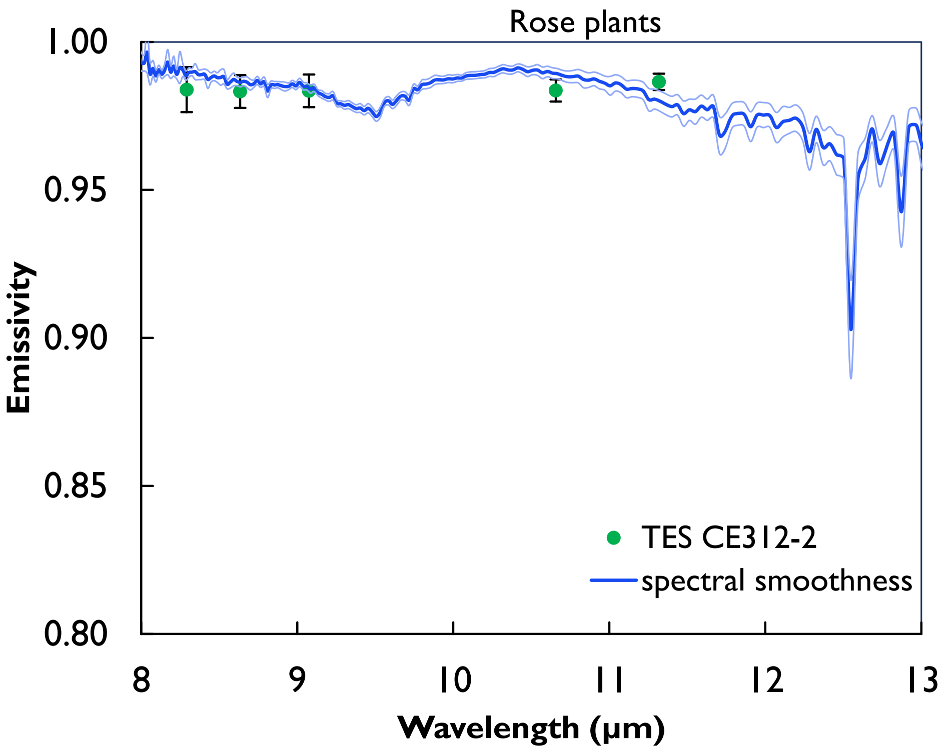




Reference emissivity method			
Sample	Spectral interval (μm)	Emissivity (mean ± SD)	Source
White Sands	8.00 - 8.10	0.9954 ± 0.0008	ASTER Spectral Library 1 sample (particle size 125-500 μm)

Reference emissivity method			
Sample	Spectral interval (μm)	Emissivity (mean ± SD)	Source
Table Salt	8.90- 9.40	0.965 ± 0.005	measured with CE312 radiometers following the TES method

RESULTS


Rose plants
Emissivity
1.00
0.95
0.90
0.85
0.80
8
9
10
11
12
13
Wavelength (μm)
TES CE312-2
spectral smoothness

CONCLUSIONS

- A good agreement is observed between our measurements and laboratory-measured spectra of identical samples (e.g. White Sands).
- It is showed the consistency achieved by the FT-IR spectrometer measurements in field conditions.
- Several spectral features are observed for the studied samples:
  - The high spectral constrast of gypsum in the 8 – 13 μm.
  - The high emissivity values for salt samples from 8 – 13 μm.
  - The weak absorption feature of the quartz Reststrahlen bands.
  - The absorption features at 11.4 μm and 11.8 μm characteristics of calcite.

Seminario: Protocolos y librerías espectrales en espectroscopía de campo

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