Soil emissivity spectra for ground and remote sensing thermal calibration

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Toulouse, June 2009
Experimental Setup
- FTIR spectra
- XRD diffraction analysis
- WDXRF analysis

Results and Comparisons

Conclusions
EXPERIMENTAL SET-UP

Soil Samples

Storaged in special devices

Fourier Transform Infrared Spectroscopy (FTIR)
To retrieve hemispherical integrated reflectance/emissivity

X-ray Diffraction Analysis (XRD)
To retrieve crystalline mineralogical phase (Calcite, Quartz, etc.)

Wavelength Dispersive X-Ray Fluorescence (WDXRF)
To retrieve chemical compositions of soil samples

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EXPERIMENTAL SET-UP (FTIR)

Soil Samples

Sample were Preprocessed follow Baldridge et al (2009)

FTIR+integrating sphere

Soil Emissivity spectra

Baldridge et al., 2009. The ASTER spectral library version 2.0, Remote Sensing of Environment 113 (4), 711–715
EXPERIMENTAL SET-UP (XRD)

Soil Samples

Oven drying (to eliminate humidity content)

Geologic mulling

XRD

Quartz Peak

Bruker D5000 diffractometer

Diffractogram

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EXPERIMENTAL SET-UP (WDXRF)

Soil Samples

Oven drying (to eliminate humidity content)

Press

Geologic mulling

Powder compounds

X-Ray Spectrometer (PW-2400) to determine chemical composition

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Experimental Setup
- FTIR spectra
- XRD diffraction analysis
- WDXRF analysis

Results and Comparisons

Conclusions
Soil emissivity Spectra

Marrakech, WATERMED 2002

Barrax, SPARC 2004
SEN2FLEX, 2005

Les Landes, CEFLES-2 2007

Madrid, DESIREX 2008

Noordwijk, EAGLE, 2006

Among others

test site...
Linear relationship between emissivity values calculated from ground measurements (applying TES method) and FTIR spectra for the whole set of soil samples.
# COMPARISONS with Ground measurements

Emissivity comparison retrieved by radiometric measurements (TES method) and the FTIR spectra

<table>
<thead>
<tr>
<th>Soil Code</th>
<th>8.1 - 8.5</th>
<th>8.5 - 8.9</th>
<th>8.9 - 9.3</th>
<th>10.3 - 11.0</th>
<th>11.3 - 11.7</th>
<th>Bias</th>
<th>σ</th>
<th>RMSE</th>
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<td>0.007</td>
<td>0.008</td>
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<td>0.007</td>
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<td>0.030</td>
<td>0.022</td>
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<td>0.018</td>
<td>0.020</td>
<td>0.006</td>
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<td>0.000</td>
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<td>0.000</td>
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<td>0.028</td>
<td>0.011</td>
<td>0.012</td>
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<tr>
<td>D2</td>
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<td>-0.007</td>
<td>-0.007</td>
<td>-0.002</td>
<td>-0.005</td>
<td>-0.006</td>
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<td>0.006</td>
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<td>0.020</td>
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<td>0.018</td>
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</table>

**TES method overall accuracy = 0.015**

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Comparison with others soil class available in the ASTER spectral library (ASL).

- Mollisol ASL = 9 soil samples
- Entisol ASL = 10 soil samples
- Inceptisol ASL = 7 soil samples
- Spodosol ASL = 1 soil samples with high content of amorphous material (87% glass)
**XRD**

Mineralogical Phases Of some soil Samples Analyzed With XRD. (X) Main Phases, (●) Rest of Identified Minerals.

<table>
<thead>
<tr>
<th>Soil code</th>
<th>Quartz</th>
<th>Calcite</th>
<th>Feldspar</th>
<th>Dolomite</th>
<th>Sheet-silicates</th>
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<tr>
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<td>X</td>
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<td></td>
<td>X</td>
<td></td>
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<td>X</td>
<td></td>
<td></td>
<td>●</td>
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</tbody>
</table>

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Chemical compounds in % for several soil samples analyzed using WDXRF. SiO and CaO are the predominant chemical compounds related with Quartz and Calcite.

Toulouse, June 2009
HYDRA 2008 – Doñana National Park (24-28 April)

**Ground instrument**

- Land black body calibration
- CIMEL CE 312-2 thermal radiometer (5 channels matching ASTER bands and 1 broad channel 8-13 µm)
- NEC TH9000 thermal camera (8-13 µm)
- Difusor Gold plate

Toulouse, June 2009
HYDRA 2008 – Doñana National Park (24-28 April)
HYDRA 2008 - AHS emissivity images

Sand Dunes measurements
HYDRA 2008 Field campaign

Comparison Emissivity values retrieved from AHS images, ground measurements and FTIR JPL spectra

**AHS – FTIR JPL total comparison**
- BIAS = -0.056
- Sigma = 0.057
- RMSE = 0.08

**AHS – FTIR JPL (for bands 73 to 78)**
- BIAS = -0.017
- Sigma = 0.002
- RMSE = 0.017
DESIREX 2008 - Madrid City (25 June – 4 July)

Ground instrument

- Land black body
- NEC TH9000 thermal camera
- CIMEL CE 312-2 thermal radiometer
- Raytek Thermal Radiometer
- Difusor Gold plate
- Väisälä RS-90 Radiosonde
- Apogee Thermal Radiometer

Car Transects

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DESIREX 2008 – Ground Measurements

Toulouse, June 2009
DESIREX 2008 - Remote Sensing data

- Landsat 5-TM
- TERRA - MODIS
- NOAA - AVHRR
- ENVISAT- AATSR
- MSG2 - SEVIRI
- TERRA - ASTER
- Airborne - AHS

Toulouse, June 2009
DESIEX 2008  Bare soil site

Emissivity values retrieved by AHS images for the average of different day times and FTIR JPL spectra

Toulouse, June 2009
DESIREX 2008  Bare soil site

Emissivity values retrieved by ASTER images for the average of different day times and FTIR JPL spectra
CONCLUSIONS

- In this study we have provided the emissivity spectra for a variety of samples which could be used to evaluate land surface temperature algorithms for a variety of airborne and satellite sensors.

- Results indicated a good agreement between ground and FTIR emissivity measurements, with a RMSE below 0.015 and a high correlation coefficient ($R^2 = 0.988$).

- Error typically 1% between FTIR and AHS-ASTER emissivity estimated using TES in the 10-12 $\mu$m