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UV/VIS/NIR SPECTROPHOTOMETRIC NEAR-NORMAL SPECULAR TRANSMITTANCE AND REFLECTANCE MEASUREMENT INTERCOMPARISON

I N I T I A L S A M P L E C H A R A C T E R I S A T I O N

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1 INTRODUCTION

WinDat is a European RTD Thematic Network (2001-2004) which aims to make available and freely distribute a European software tool for the calculation of the thermal and solar properties of commercial and innovative window systems on the basis of known component properties and thermal and solar/optical interactions between the components. It is intended that this tool will be collectively supported and used in research, industry, standardisation, education and design throughout Europe. It will be used to compare, select and promote innovative windows and window components for the optimum use of renewable energy and maximised energy savings and indoor comfort. One of the unique elements in the software tool is the combination of glazings and shading devices. This makes the tool particularly suited to calculate the thermal and solar performance of complex windows and active facades. One of the early achievements (Spring 2002) was the agreement on a draft European procedure and format for the collation of optical properties of non-scattering glazings. It will be ensured that the European database is compatible with the existing database in USA (Optics5) with the long-term aim of creating a single international glazing library for worldwide application.

This WinDat inter-laboratory comparison forms part of the procedure to assure the quality of spectral transmittance and reflectance data in the range 2500 –300 nm held in the WIS database [4,5]. Participants include European manufacturers who submit data for inclusion in the WIS database and other European laboratories with the capability for accurate measurement of spectral optical properties of glass and glazing products. This is the first such exercise undertaken within WinDat. It is intended this activity be repeated regularly with a frequency of no less than once in every 5 years.

Oxford Brookes University has responsibility for coordination of the WinDat inter-laboratory comparison. This report describes the calibration and characterisation of the samples selected for measurement prior to despatch of the samples to the participating laboratories.

2 TEST SAMPLES

15 sets of test samples have been prepared for the WinDat UV/Vis/NIR spectrophotometric near-normal specular transmittance and reflectance measurement intercomparison..

Each set contains 4 commercially available glass samples:

- Planitherm Std (Single Ag based, low emissivity)
- SS-108 (Stainless steel/Silicon nitride based, medium emissivity)
- Ecologique (SnO_2:F, low emissivity)
- SKN-165B (Double Ag based low emissivity)

Each sample is of dimension 100mm x 100 mm. All samples were procured from St Gobain Recherche, Aubervilliers, France.

2.1 SAMPLE CODING

The samples are coded as follows (XX = Box number 01 –15 inclusive):

WD04_BOX XX_ S01: Planitherm Std (Single Ag based, low emissivity)

WD04_BOX XX_ S02: SS-108 (Stainless steel/Silicon nitride based, medium emissivity)

WD04_BOX XX_ S04: Ecologique (SnO_2:F, low emissivity)

WD04_BOX XX_ S05: SKN-165B (Double Ag based low emissivity)

Thus Sample "WD04_BOX 06_ S05" is the SKN-165B sample contained in Box No. 06.

Each sample is labelled according to this coding. The labelled side of the samples is identified as the "Front" (Uncoated) side.

N.B. There is no sample numbered S03. This derives and is consistent with earlier labelling from an infrared interlaboratory comparison undertaken within the Thermes FP5 project where the same sample types were measured.

3 EXPERIMENTAL

3.1 MEASUREMENT SETUP

All samples were measured to ensure acceptable homogeneity across the sets of samples distributed to the participants. In addition the initial characterisation measurements were used to provide "reference" values against which the measurements performed by the participants are compared. Thus the results can be presented in terms of differences between the values obtained by the participants and the initial characterisation value determined by the coordinating laboratory (Brookes). This approach enables differences arising from variations between individual samples of a given sample type to be removed from the analysis.

The measurements were performed using a Perkin Elmer Lambda 900 spectrophotometer equipped with a PELA 150 integrating sphere reflectance/transmittance accessory.

For reflectance measurements the instrument was calibrated using a traceable standard second surface aluminium mirror [1]. Samples were mounted at the rear sample port of the integrating sphere.

For transmittance measurements the instrument was calibrated using a traceable Spectralon diffuse reflectance standard [2]. Samples were mounted to cover the sample beam entry port of the integrating sphere.

3.2 MEASUREMENTS

For all samples the following measurements were performed:

Spectral transmittance 300 – 2500 nm

Spectral reflectance 300 – 2500 nm

The wavelength interval was 5 nm throughout the whole measured wavelength range.
The measurements were made for near-normal incidence only.

For the purposes of this intercomparison where the samples are coated, the coated side is identified as the "Back" side. The labelled side of the samples is the "Front" (Uncoated) side.

The reflectance was measured for both presentations of the "Back " (Coated) side and "Front"(Uncoated) sides of the samples to the incident beam.

3.3 CALCULATION OF THE INTEGRATED OPTICAL PROPERTIES

The integrated photopic and solar integrated properties of the samples have been calculated according to the recommended procedures of the European standard EN410 [1].

The photopic (visible) transmittance and reflectance values were calculated using Table 1 of EN 410.

The solar transmittance and reflectance values were calculated using Table 2 of EN 410.

4 MEASUREMENT RESULTS

4.1 SPECTRAL MEASUREMENTS

For Sample 01, the average spectral reflectance and transmittance of all 15 samples are shown in Figure 1. The Standard Deviation of the measured spectral reflectance and transmittance of the 15 samples is shown in Figure 2.

The measured values of the reflectance, Rb, at 500 nm and 1500 nm of the 15 samples of Sample 1 arranged by box number. are shown in Figure 3 and Figure 4 respectively. The measured values of the reflectance, Rf, at 500 nm and 1500 nm of the 15 samples of Sample 1 arranged by box number. are shown in Figure 5 and Figure 6 respectively. The measured values of the transmittance, T, at 500 nm and 1500 nm of the 15 samples of Sample 1 arranged by box number. are shown in Figure 7 and Figure 8 respectively.

The corresponding data for Sample 02 are presented in Figure 9 - Figure 16 inclusive.

The corresponding data for Sample 03 are presented in Figure 17-

Figure 24 inclusive.

The corresponding data for Sample 04 are presented in Figure 25- Figure 32 inclusive.

4.2 CALCULATED INTEGRATED OPTICAL PROPERTIES

The calculated integrated photopic and solar optical properties of each sample are shown on Table 1. The following nomenclature is used:

T_s Solar transmittance

Rb_s Solar reflectance (Back side)

Rf_s Solar reflectance (Front side)

T_v Visible transmittance

Rb_v Visible reflectance (Back side)

Rf_v Visible reflectance (Front side)

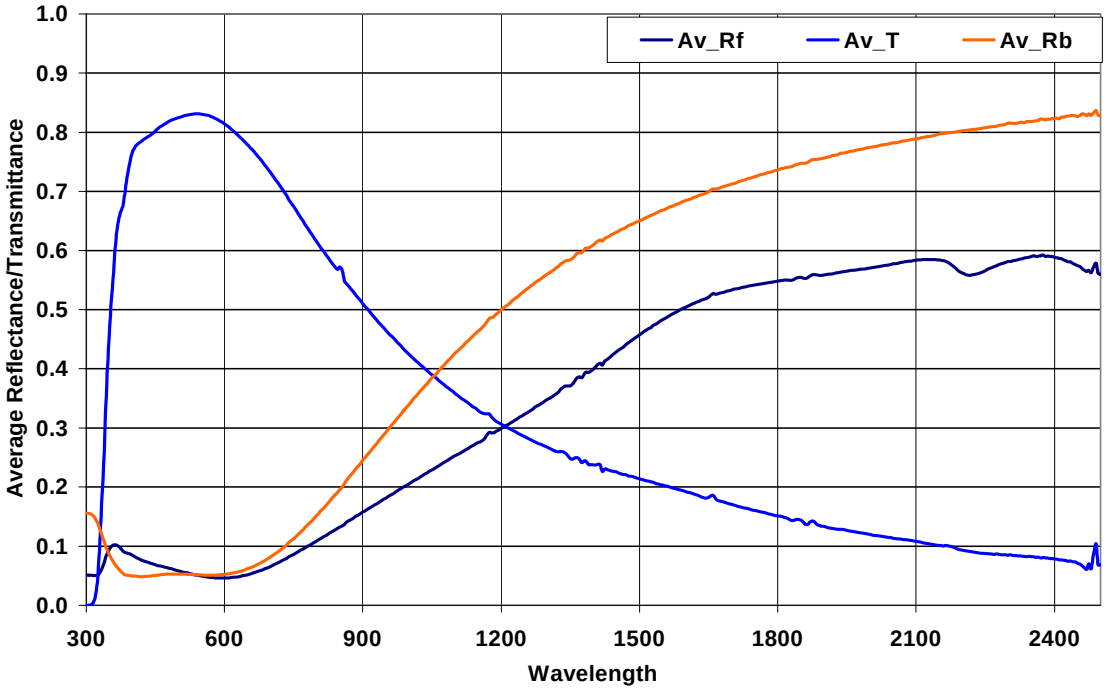


Figure 1 Average reflectance and transmittance of the 15 samples: Sample S01.

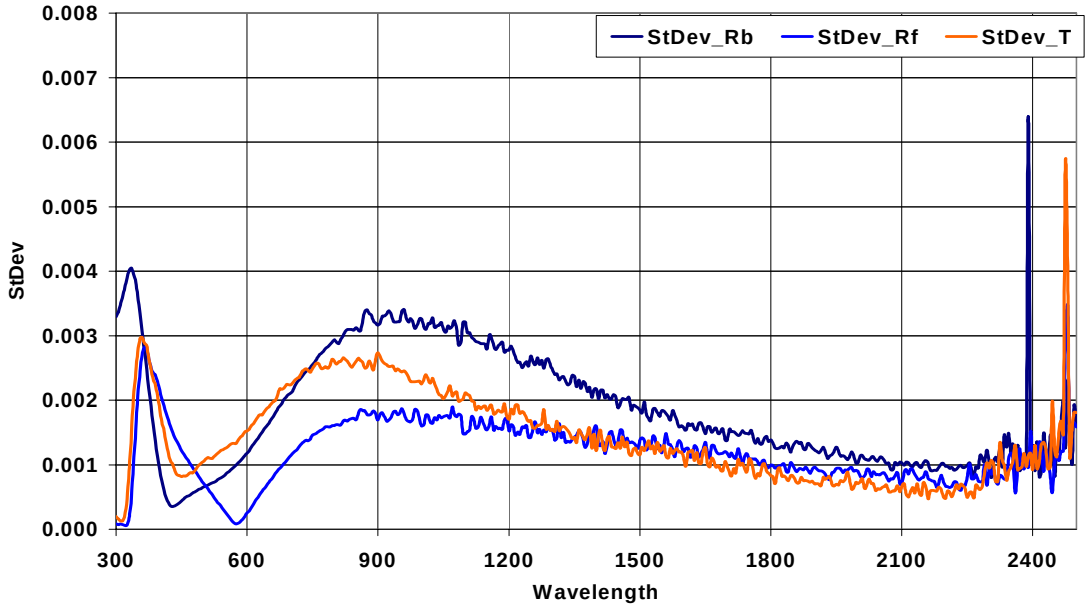


Figure 2 Standard Deviation of the reflectance and transmittance of the 15 samples: Sample S01.

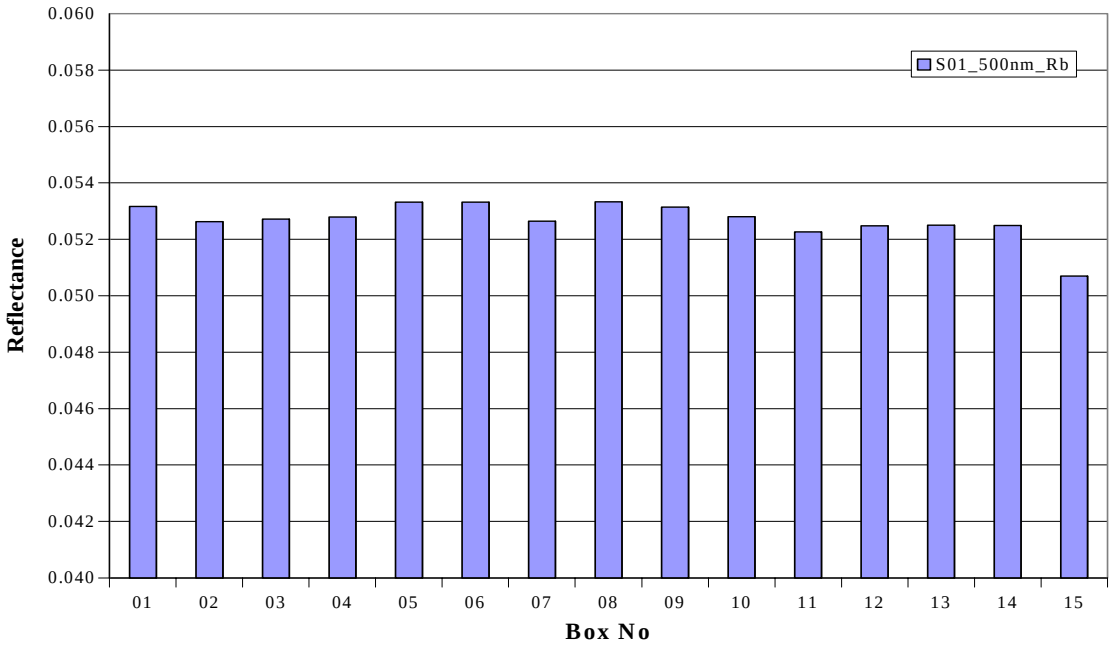


Figure 3. Variation of the reflectance Rb of the 15 samples by box number. Sample S01, Reflectance Rb, Wavelength 500 nm.

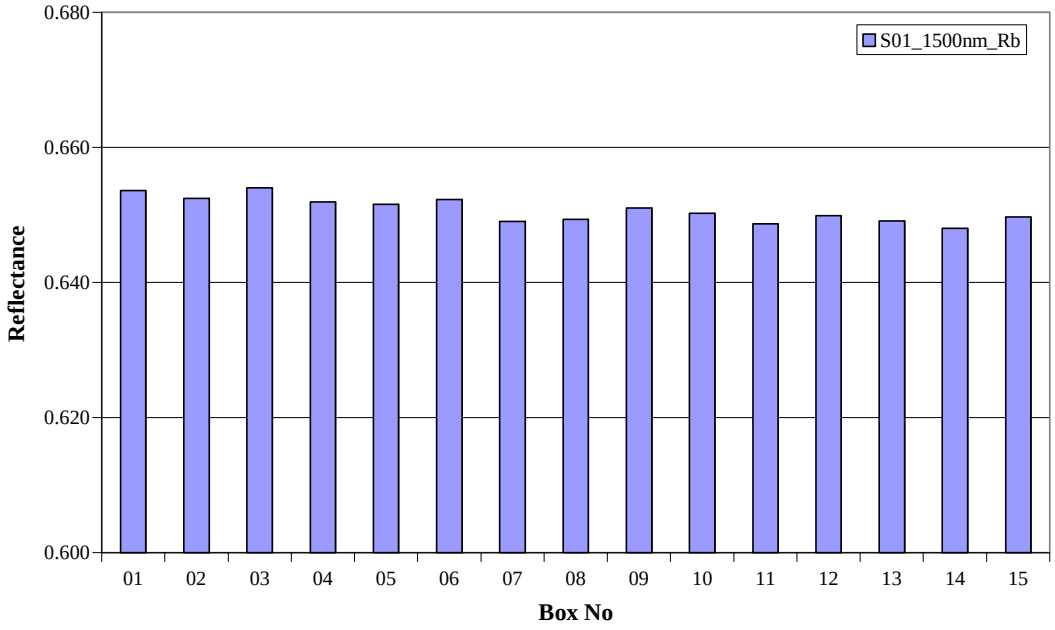


Figure 4. Variation of the reflectance Rb of the 15 sets of samples by box number: Sample S01, Reflectance Rb, Wavelength 1500 nm.

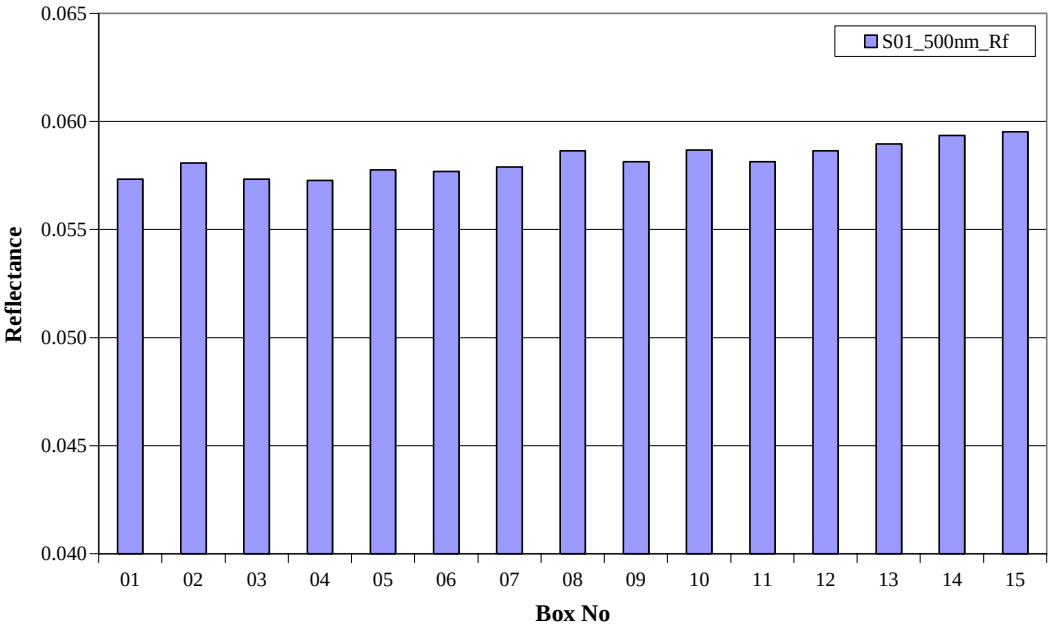


Figure 5. Variation of the reflectance Rf of the 15 samples by box number. Sample S01, Reflectance Rf, Wavelength 500 nm.

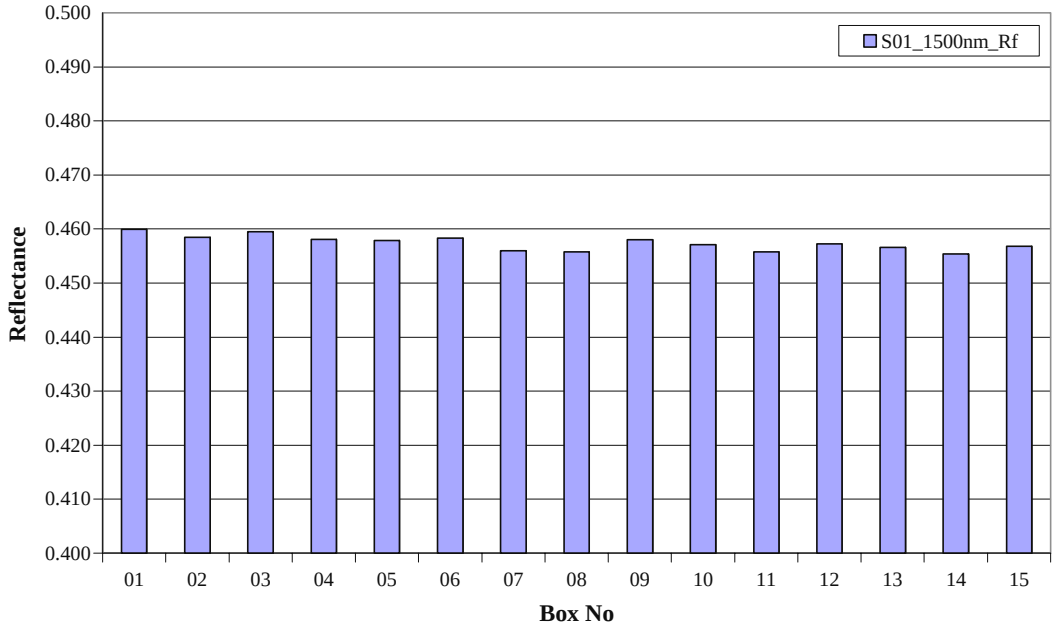


Figure 6. Variation of the reflectance Rf of the 15 samples by box number. Sample S01, Reflectance Rf, Wavelength 1500 nm.

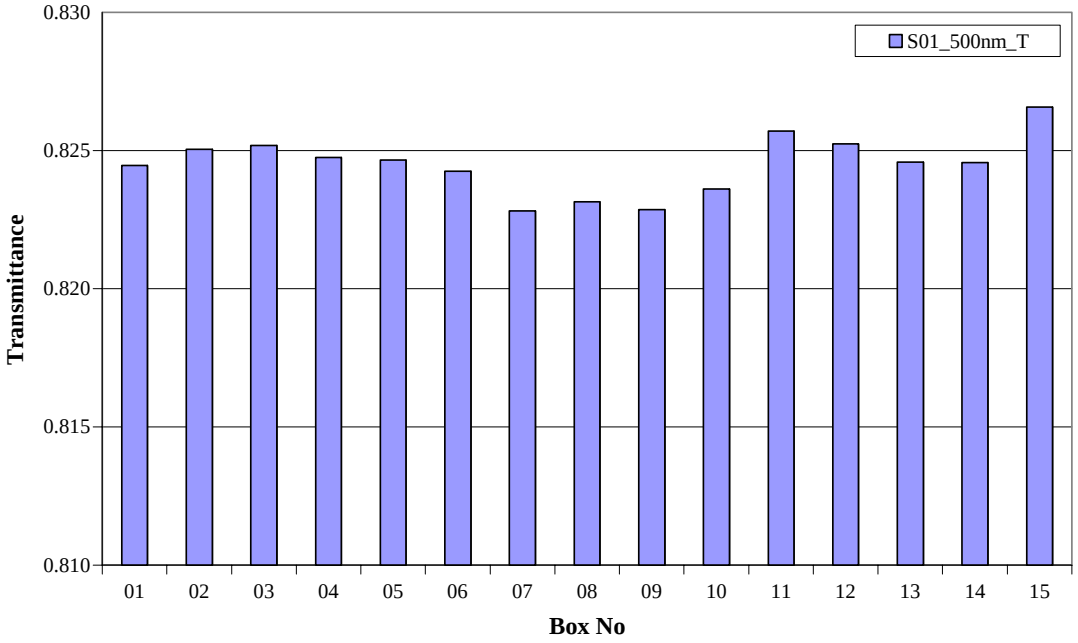


Figure 7. Variation of transmittance T of the 15 samples by box number. Sample S01, Transmittance T, Wavelength 500 nm.

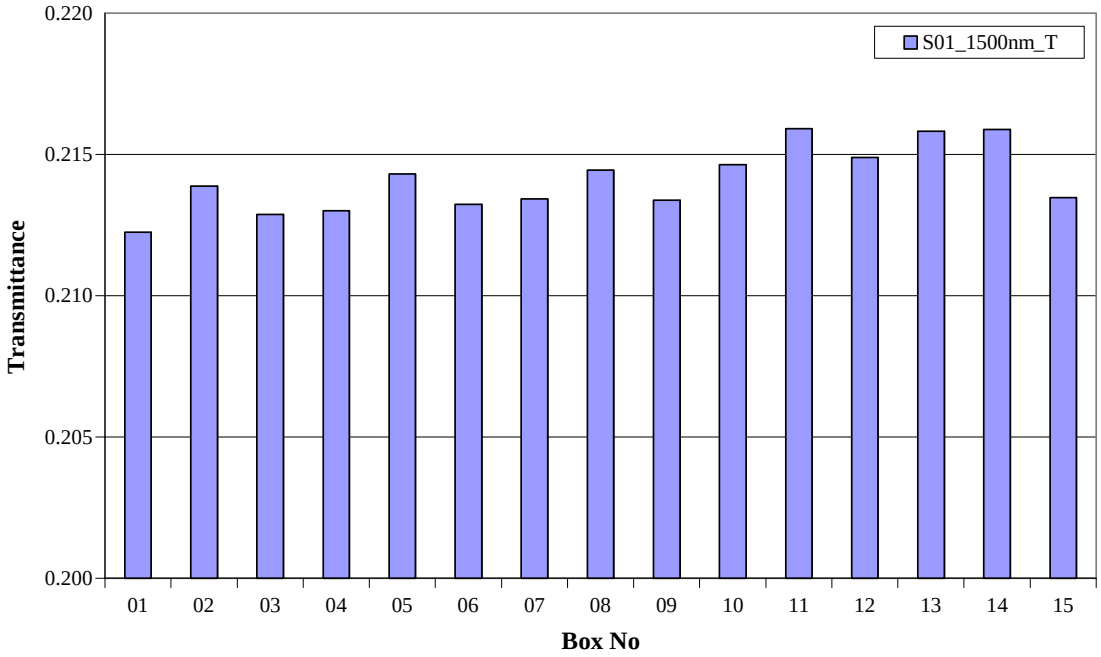


Figure 8. Variation of the transmittance of the 15 samples by box number. Sample S01, Transmittance T, Wavelength 1500 nm.

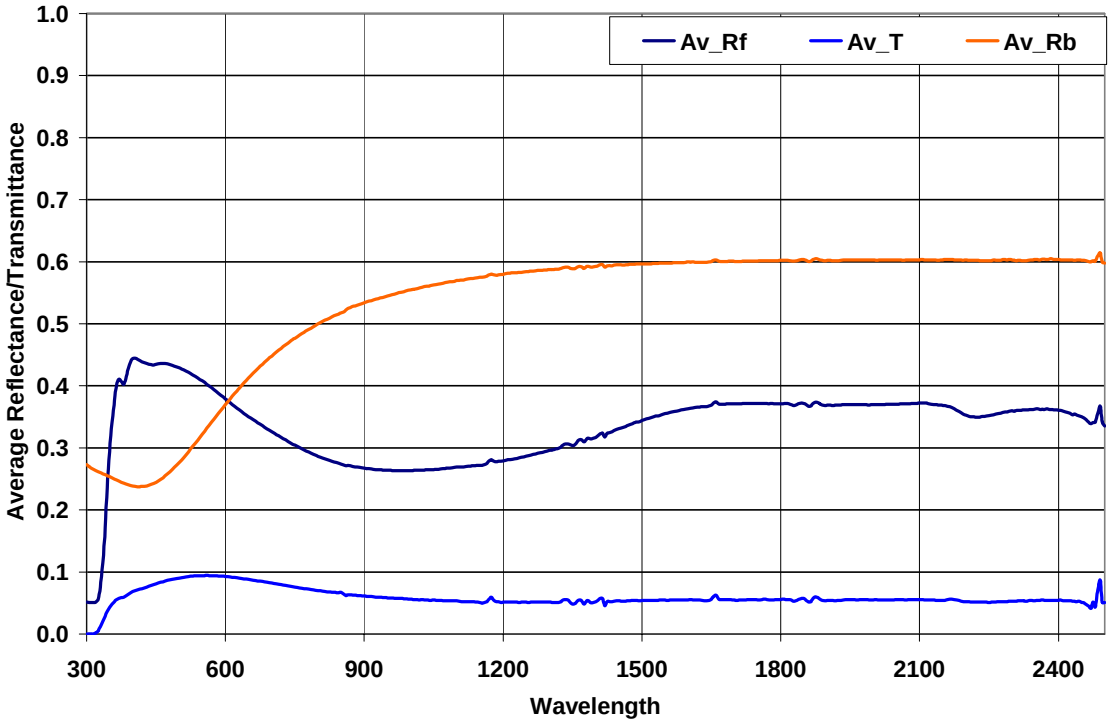
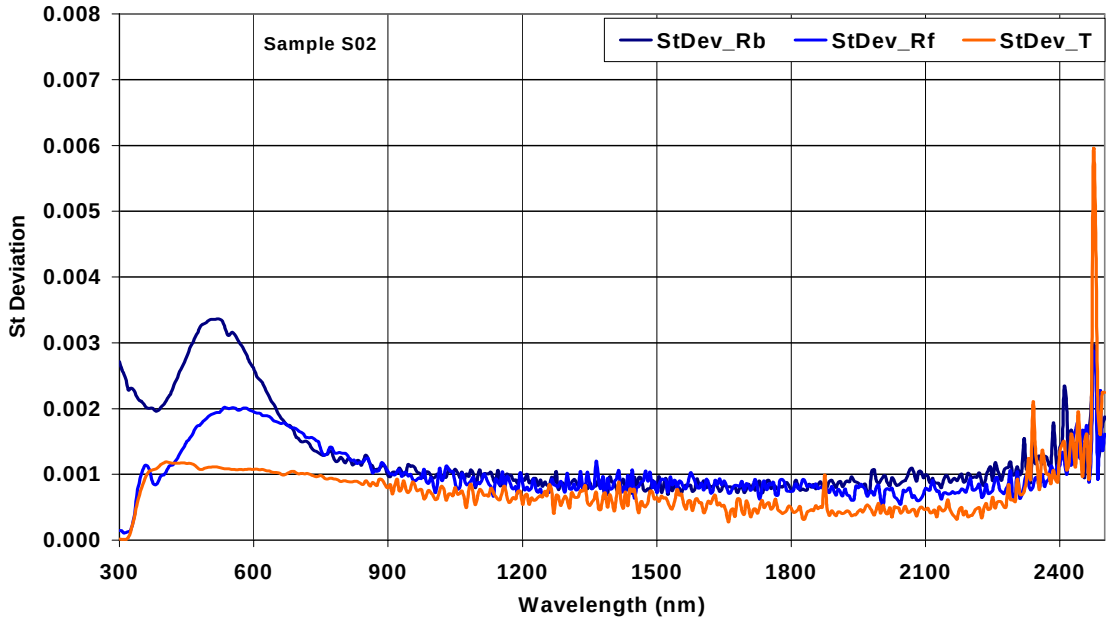


Figure 9 The average measured spectral reflectance and transmittance of the 15 samples:



Sample S02.

Figure 10 The Standard Deviation of the spectral reflectance and transmittance of the 15 samples: Sample S02.

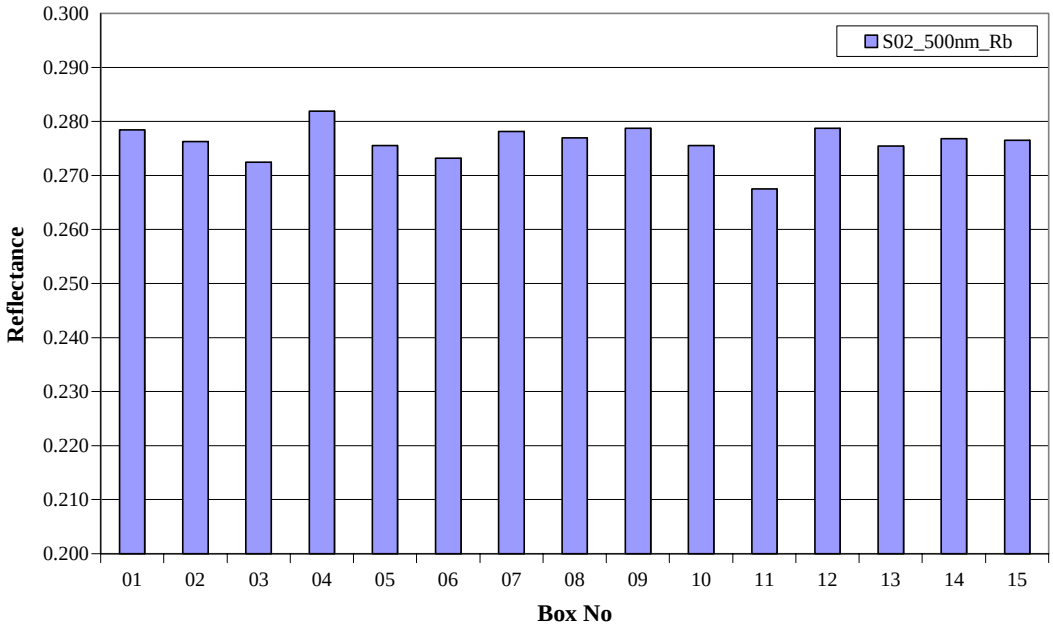


Figure 11. Variation of the measured reflectance Rb of the 15 samples by box number. Sample S02, Reflectance Rb, Wavelength 500 nm.

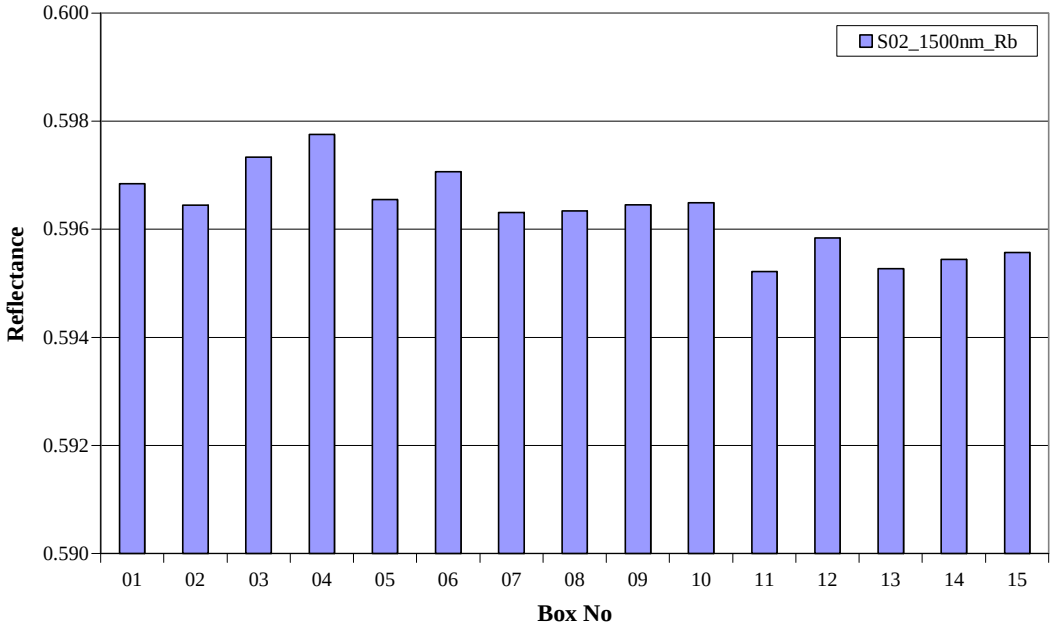


Figure 12. Variation of the measured reflectance Rb of the 15 samples by box number. Sample S02, Reflectance Rb, Wavelength 1500 nm.

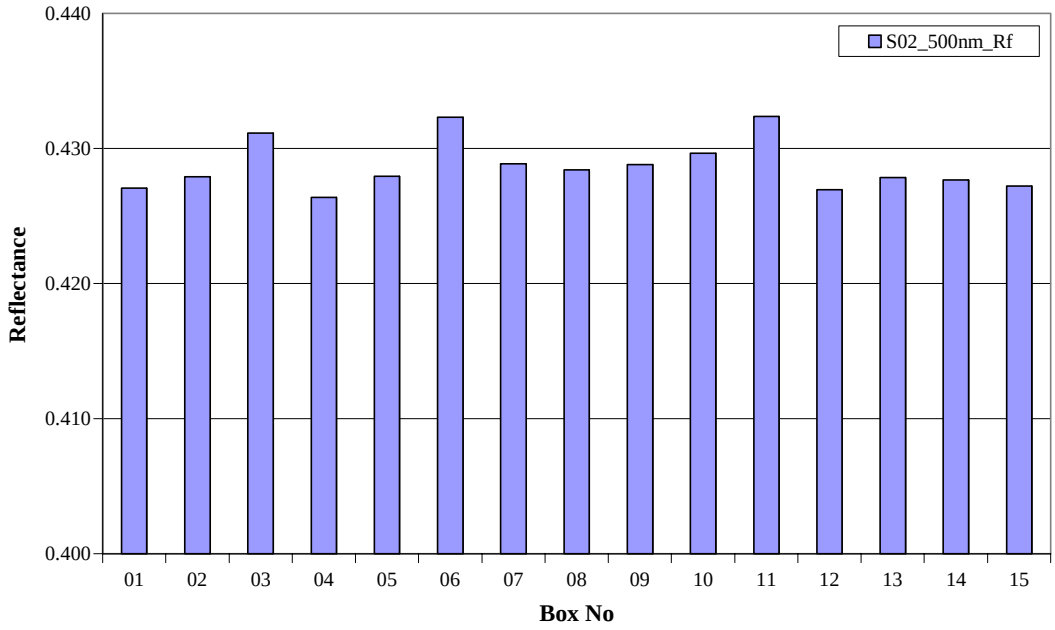


Figure 13. Variation of the measured reflectance Rf of the 15 samples by box number. Sample S02, Reflectance Rf, Wavelength 500 nm.

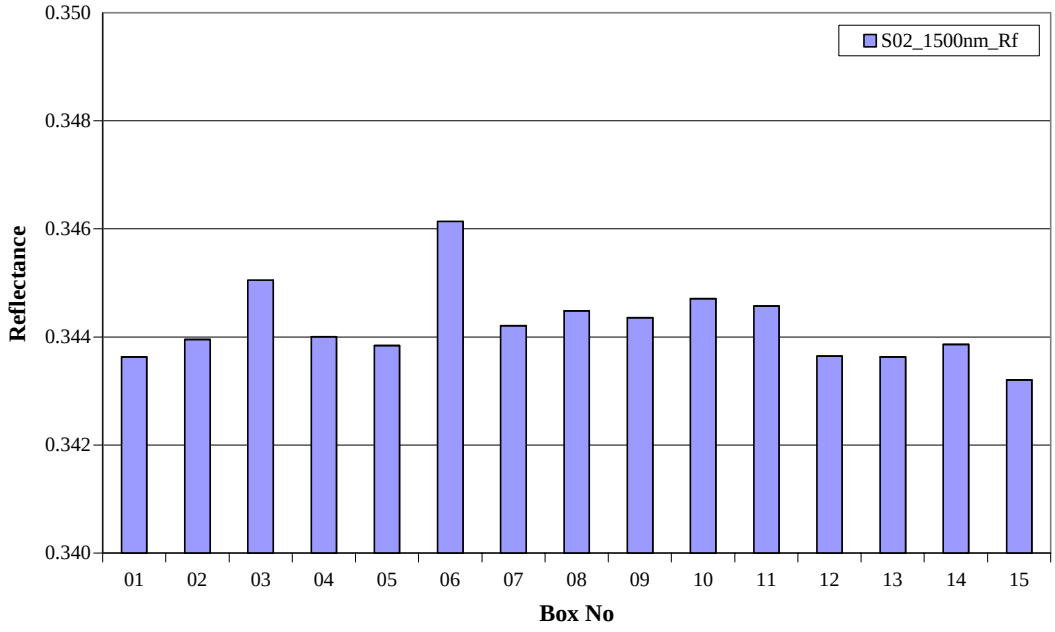


Figure 14. Variation of the reflectance Rf of the 15 samples by box number. Sample S02, Reflectance Rf, Wavelength 1500 nm.

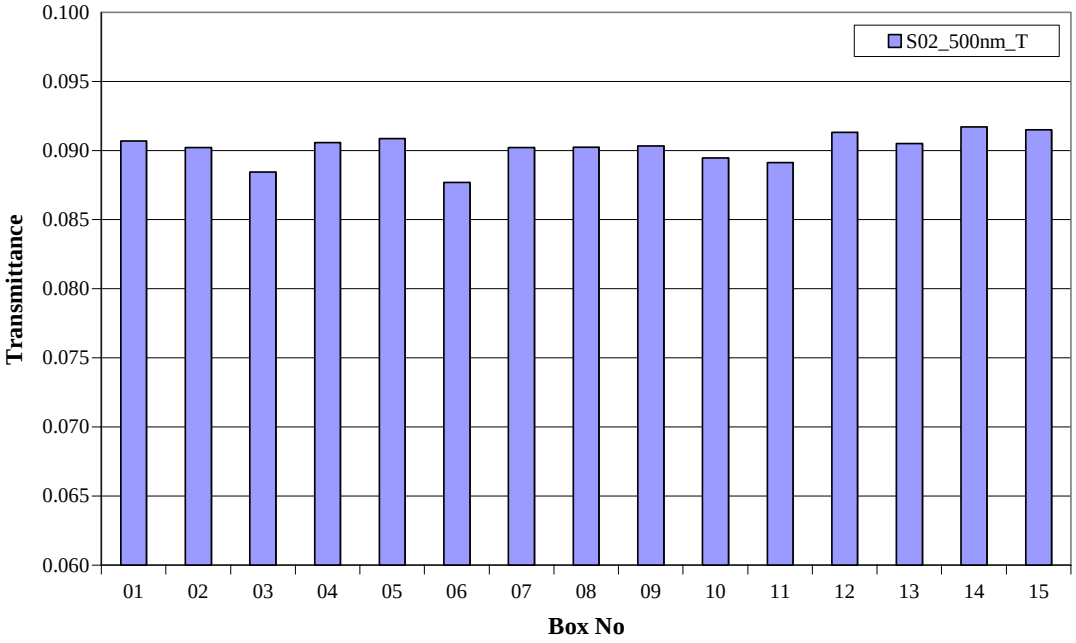


Figure 15. Variation of the measured transmittance of the 15 samples by box number. Sample S02, Transmittance T, Wavelength 500 nm.

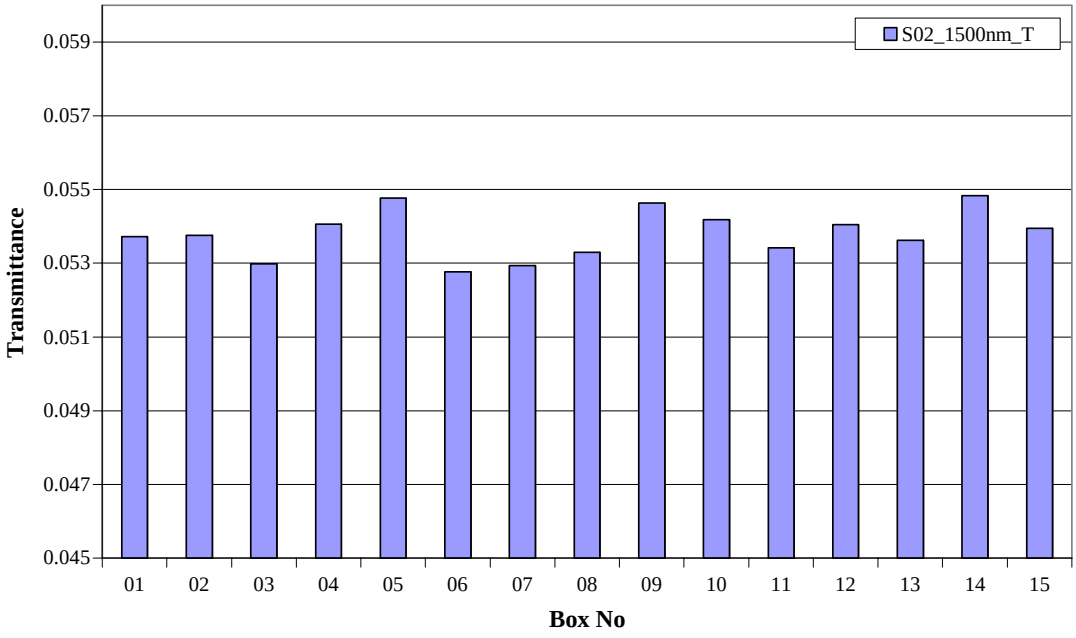


Figure 16. Variation of the measured transmittance of the 15 samples by box number. Sample S02, Transmittance T, Wavelength 1500 nm.

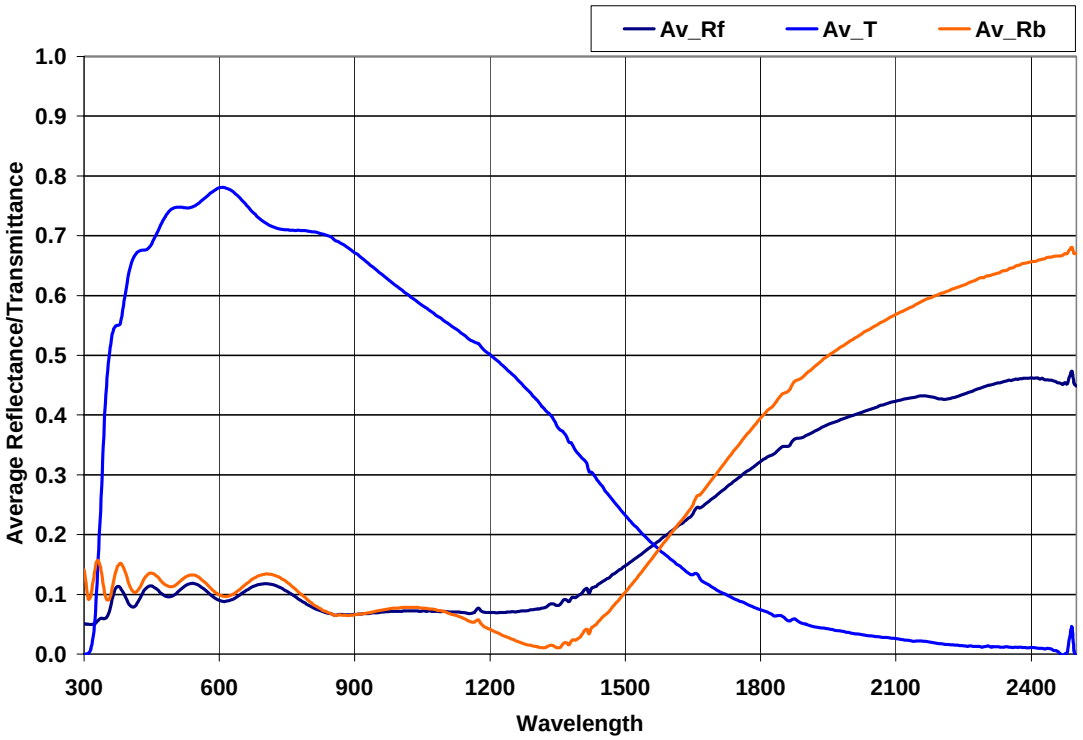


Figure 17 The average measured spectral reflectance and transmittance of the 15 samples: Sample S04.

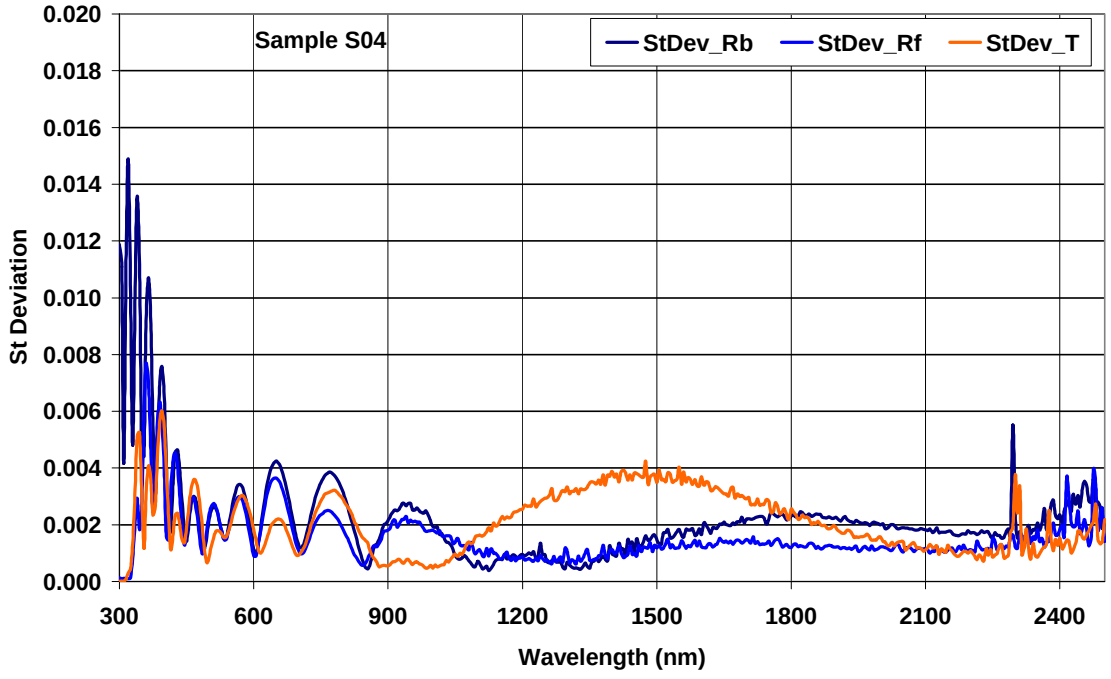


Figure 18 The Standard Deviation of the spectral reflectance and transmittance of the 15 samples: Sample S04.

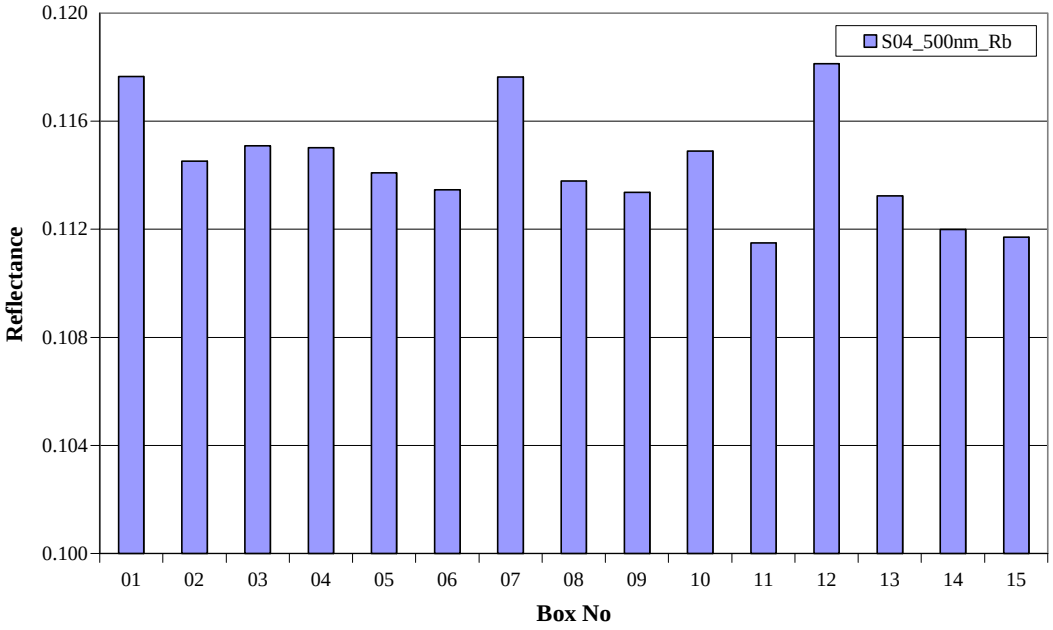


Figure 19. Variation of the reflectance Rb of the 15 samples by box number. Sample S04, Reflectance Rb, Wavelength 500 nm.

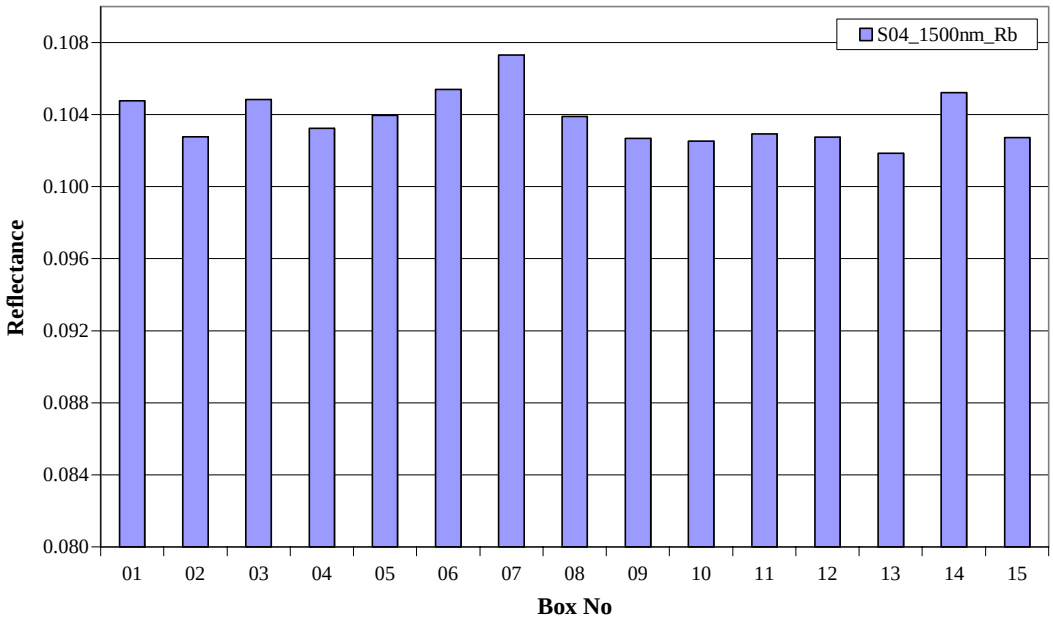


Figure 20. Variation of the reflectance Rf of the 15 samples by box number. Sample S04, Reflectance Rb, Wavelength 1500 nm.

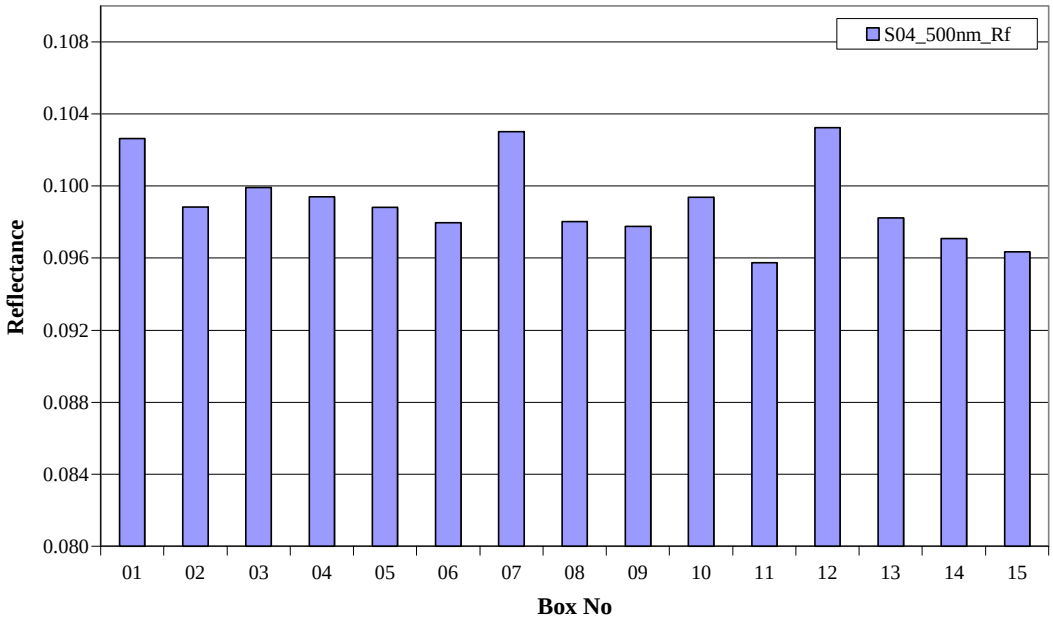


Figure 21. Variation of the reflectance Rf of the 15 samples by box number. Sample S04, Reflectance Rf, Wavelength 500 nm.

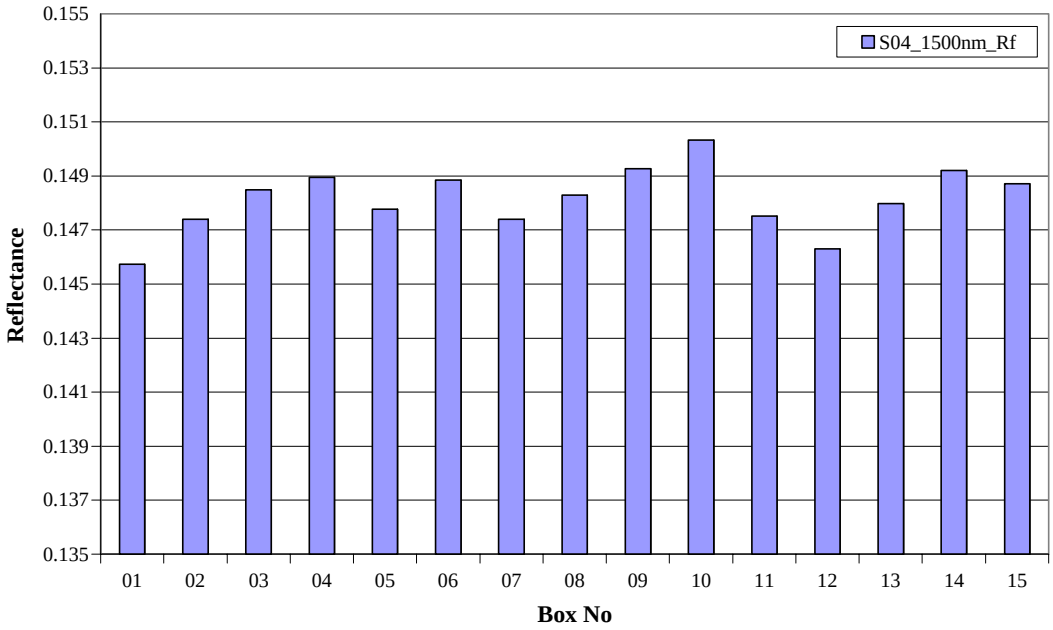


Figure 22. Variation of the reflectance Rf of the 15 samples by box number. Sample S04, Reflectance Rf, Wavelength 1500 nm.

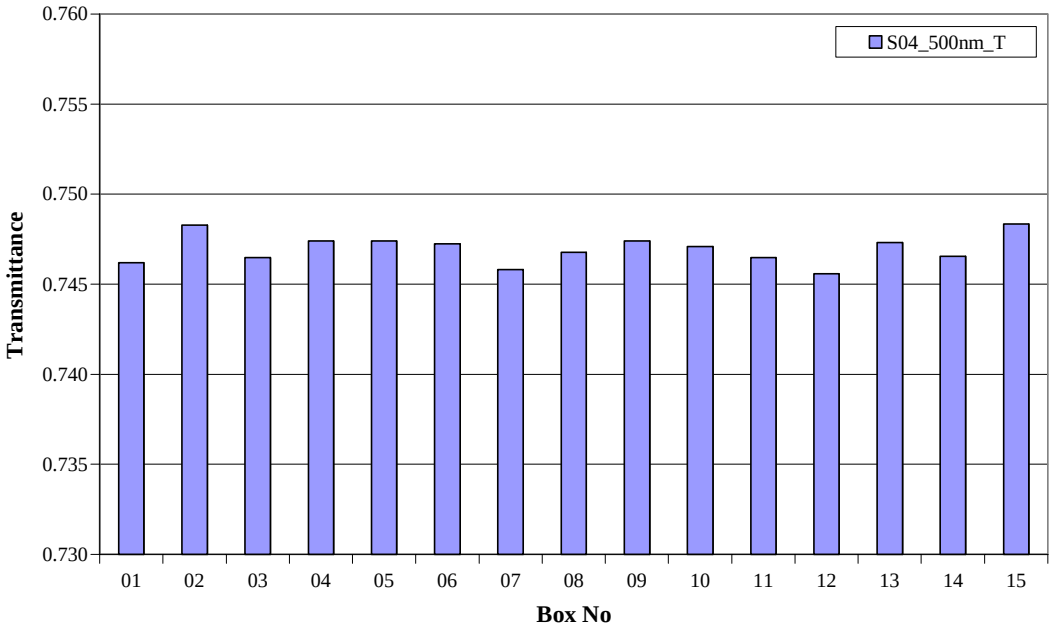


Figure 23. Variation of the transmittance T of the 15 samples by box number. Sample S04, Transmittance T, Wavelength 500 nm.

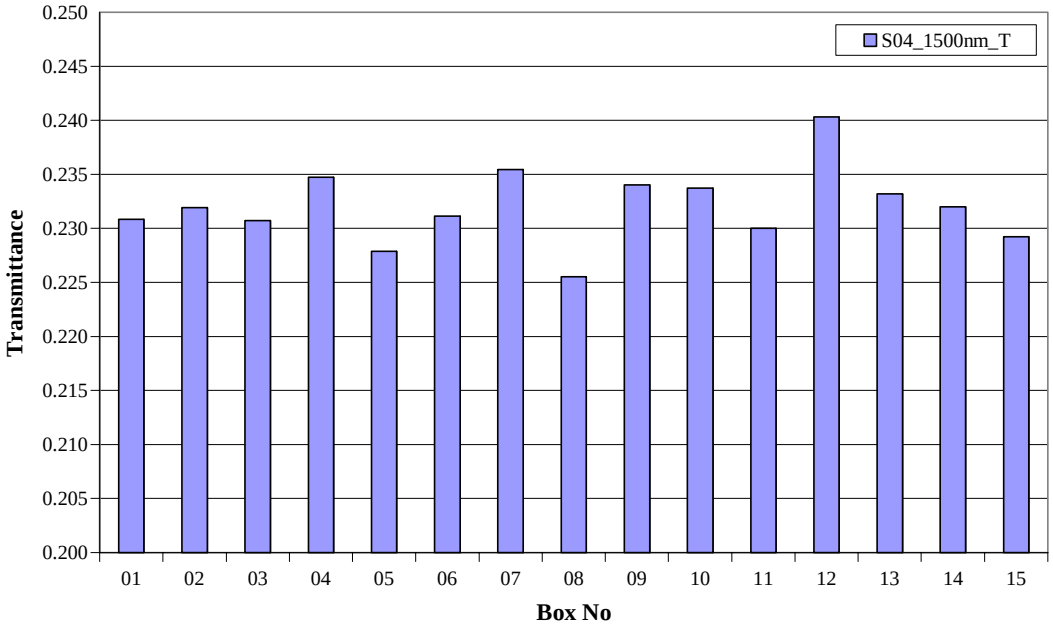


Figure 24. Variation of transmittance T of the 15 samples by box number. Sample S04, Transmittance T, Wavelength 1500 nm.

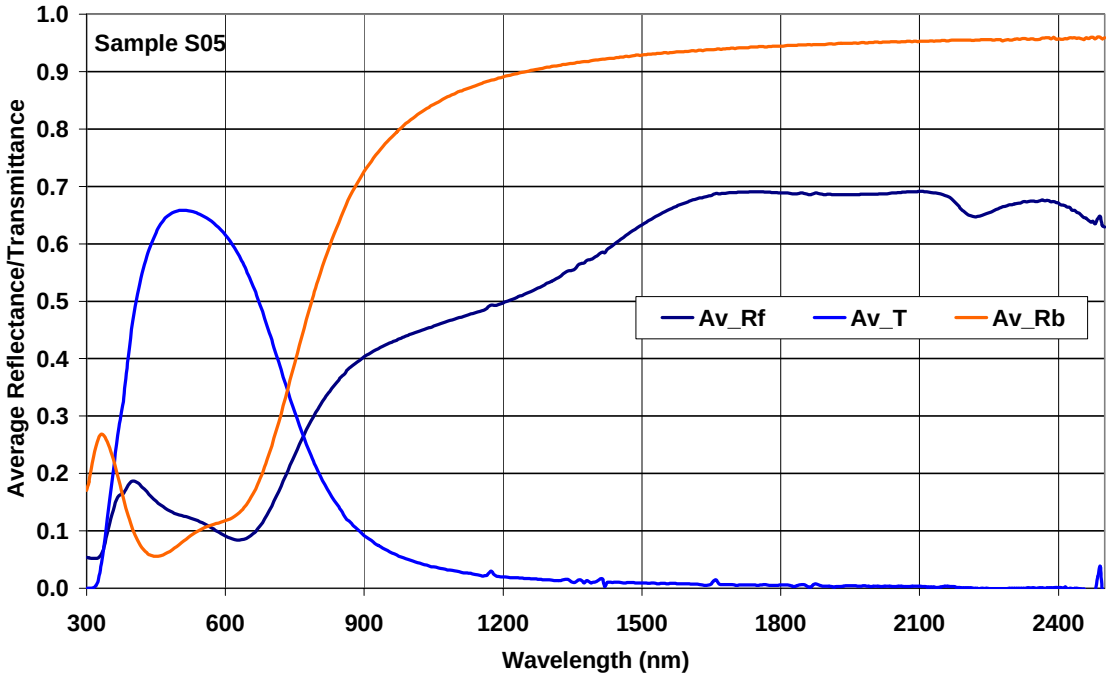


Figure 25. The average measured spectral reflectance and transmittance of the 15 samples: Sample S05.

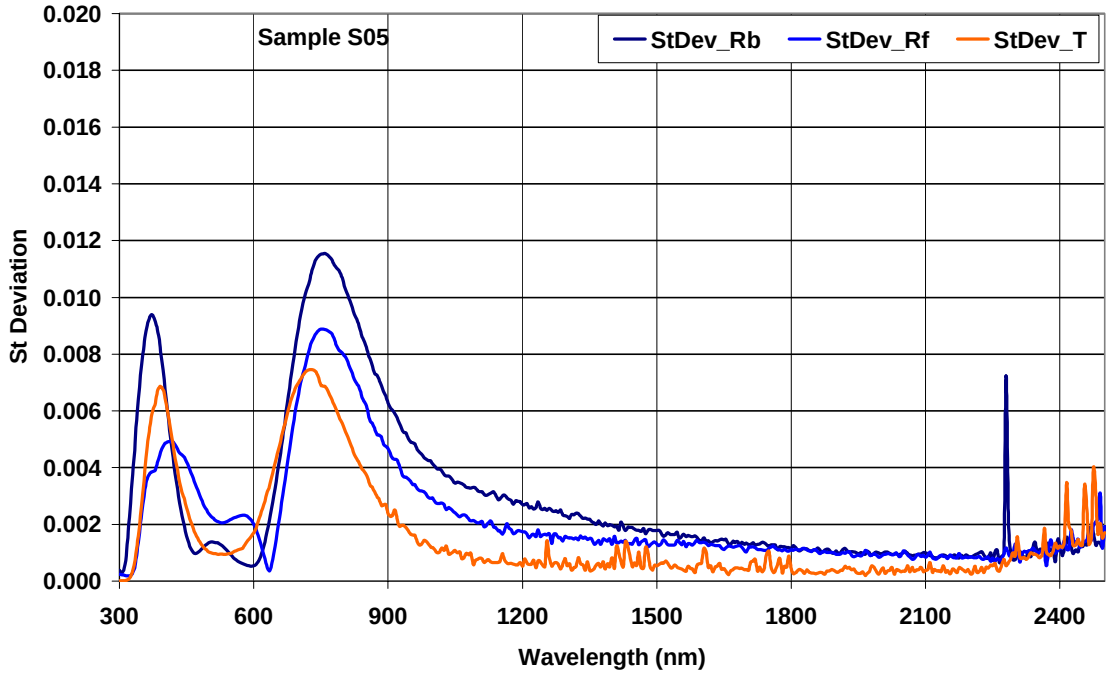


Figure 26. The Standard Deviation of the spectral reflectance and transmittance of the 15 samples: Sample S05.

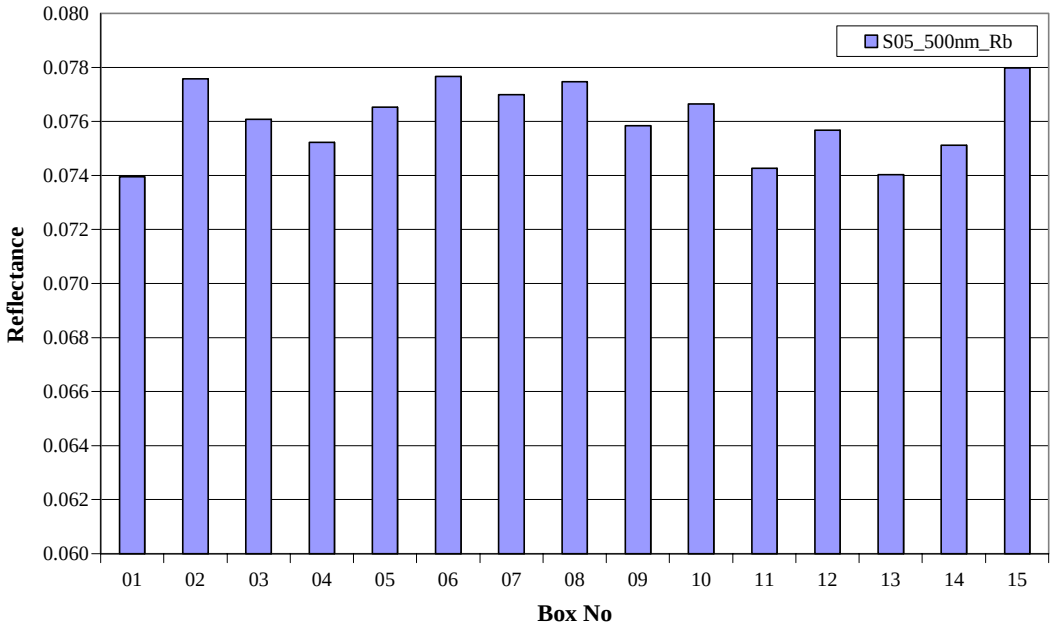


Figure 27. Variation of the reflectance Rb of the 15 samples by box number. Sample S05, Reflectance Rb, Wavelength 500 nm.

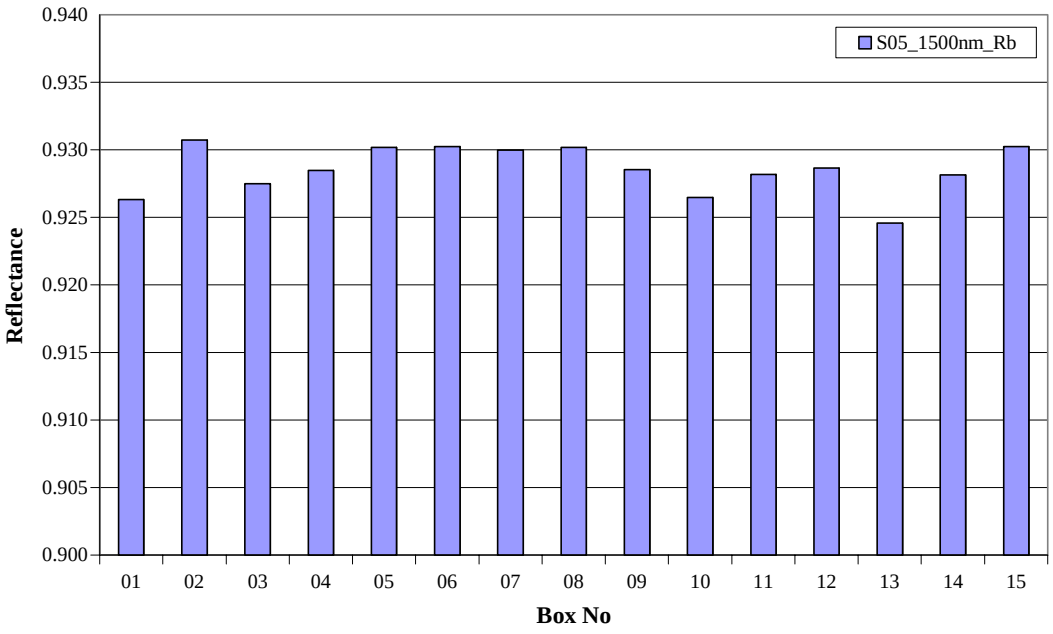


Figure 28. Variation of the reflectance Rb of the 15 samples by box number: Sample S05, Reflectance Rb, Wavelength 1500 nm.

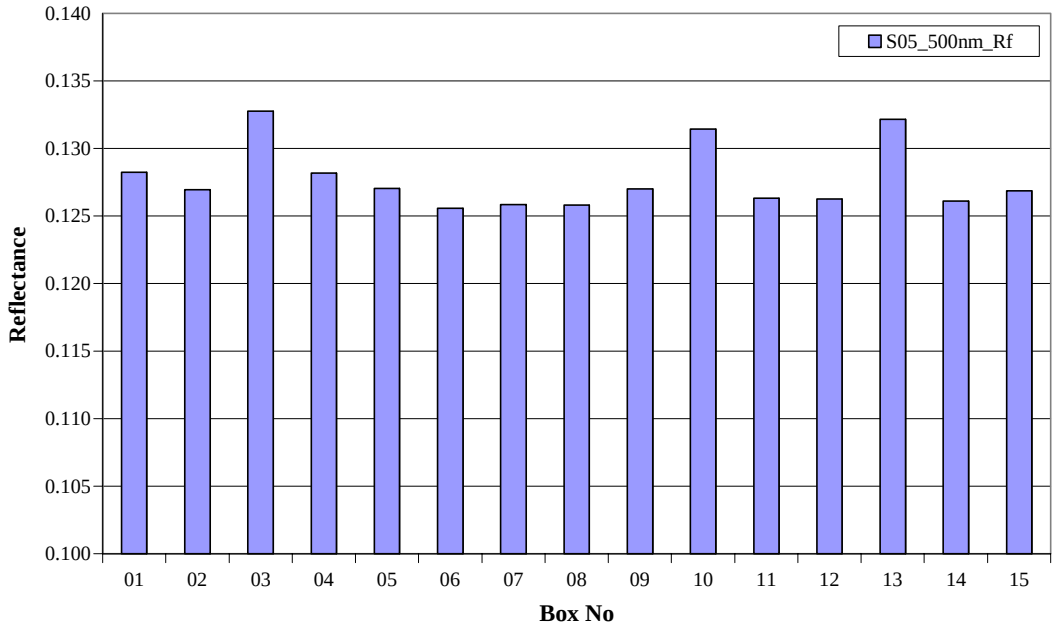


Figure 29. Variation of the reflectance Rf of the 15 samples by box number: Sample S05, Reflectance Rf, Wavelength 500 nm.

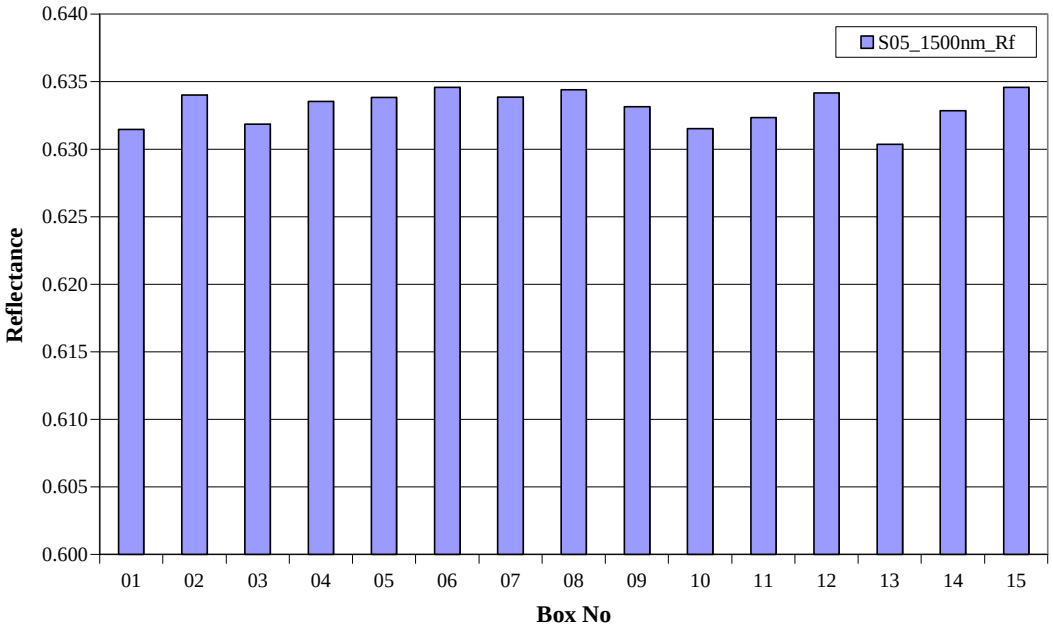


Figure 30. Variation of the reflectance Rf of the 15 samples by box number: Sample S05, Reflectance Rf, Wavelength 1500 nm.

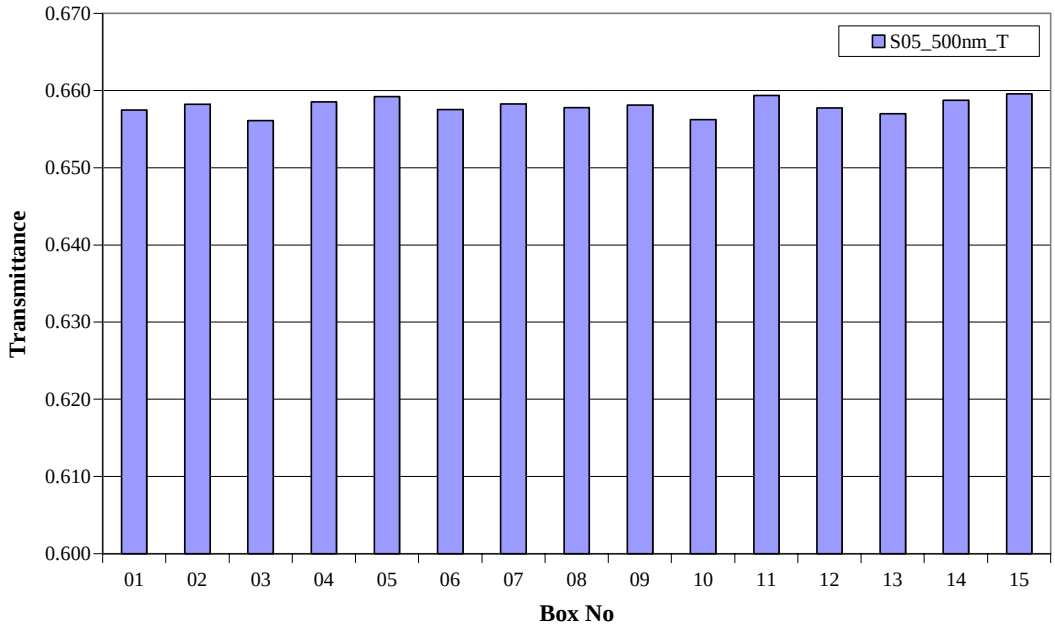


Figure 31. Variation of the transmittance T of the 15 samples by box number: Sample S05, Transmittance T, Wavelength 500 nm.

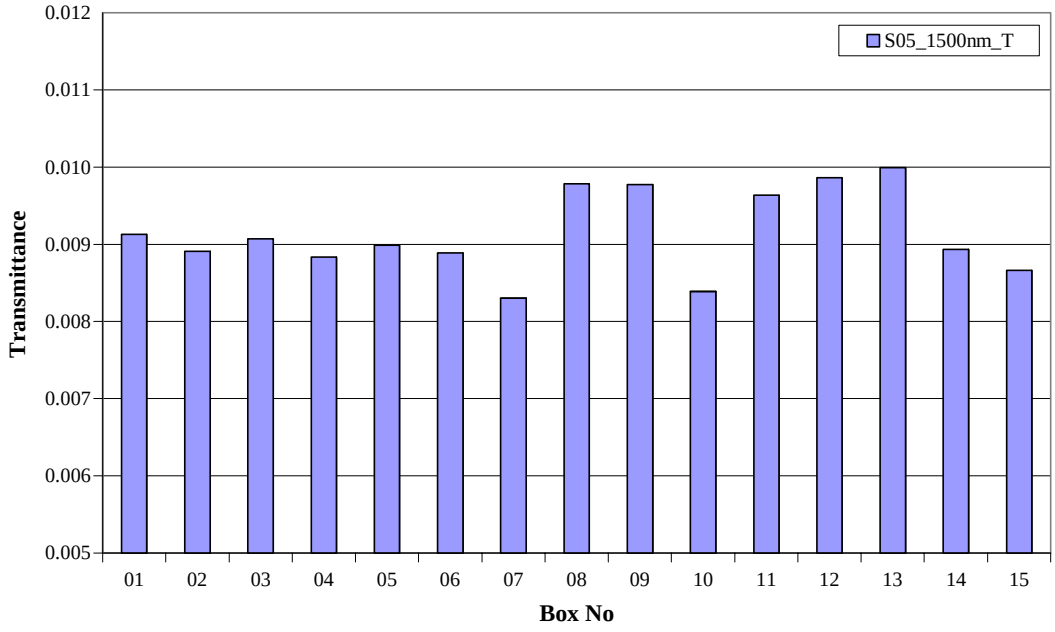


Figure 32 Variation of the transmittance T of the 15 samples by box number: Sample S05, Transmittance T, Wavelength 1500nm.

Table 1 The calculated integrated photopic (visible) and solar properties of the 15 sample sets (Boxes)

BoxNum	Sample	SampleName	T_s	Rf_s	Rb_s	T_v	Rf_v	Rb_v
01	S01	S01_01	0.601	0.154	0.214	0.822	0.050	0.053
01	S02	S02_01	0.072	0.344	0.429	0.093	0.400	0.331
01	S04	S04_01	0.615	0.110	0.124	0.757	0.105	0.118
01	S05	S05_01	0.338	0.276	0.414	0.637	0.111	0.102
02	S01	S01_02	0.602	0.154	0.212	0.823	0.051	0.052
02	S02	S02_02	0.072	0.344	0.428	0.093	0.401	0.329
02	S04	S04_02	0.616	0.110	0.123	0.758	0.105	0.118
02	S05	S05_02	0.336	0.279	0.420	0.636	0.109	0.105
03	S01	S01_03	0.602	0.154	0.214	0.822	0.050	0.053
03	S02	S02_03	0.071	0.346	0.427	0.091	0.404	0.326
03	S04	S04_03	0.615	0.110	0.123	0.757	0.105	0.118
03	S05	S05_03	0.337	0.277	0.416	0.636	0.114	0.104
04	S01	S01_04	0.601	0.153	0.213	0.822	0.050	0.053
04	S02	S02_04	0.072	0.343	0.431	0.093	0.400	0.334
04	S04	S04_04	0.617	0.110	0.123	0.758	0.106	0.119
04	S05	S05_04	0.337	0.278	0.417	0.638	0.110	0.103
05	S01	S01_05	0.602	0.153	0.213	0.822	0.051	0.053
05	S02	S02_05	0.072	0.344	0.427	0.093	0.401	0.328
05	S04	S04_05	0.615	0.110	0.124	0.757	0.105	0.117
05	S05	S05_05	0.336	0.278	0.419	0.638	0.109	0.104
06	S01	S01_06	0.601	0.153	0.213	0.822	0.051	0.053
06	S02	S02_06	0.070	0.347	0.428	0.090	0.406	0.327
06	S04	S04_06	0.616	0.110	0.124	0.758	0.106	0.119
06	S05	S05_06	0.334	0.280	0.422	0.635	0.108	0.105
07	S01	S01_07	0.601	0.152	0.211	0.820	0.051	0.053
07	S02	S02_07	0.072	0.345	0.428	0.093	0.402	0.331
07	S04	S04_07	0.617	0.111	0.123	0.759	0.105	0.117
07	S05	S05_07	0.334	0.279	0.421	0.635	0.108	0.104
08	S01	S01_08	0.602	0.153	0.211	0.821	0.051	0.053
08	S02	S02_08	0.072	0.345	0.428	0.092	0.402	0.330
08	S04	S04_08	0.614	0.110	0.124	0.756	0.106	0.119
08	S05	S05_08	0.334	0.280	0.422	0.635	0.108	0.104
09	S01	S01_09	0.601	0.153	0.212	0.820	0.051	0.053
09	S02	S02_09	0.072	0.345	0.429	0.093	0.402	0.331
09	S04	S04_09	0.617	0.110	0.124	0.759	0.106	0.119

BoxNum	Sample	SampleName	T_s	Rf_s	Rb_s	T_v	Rf_v	Rb_v
09	S05	S05_09	0.335	0.278	0.419	0.636	0.109	0.103
10	S01	S01_10	0.602	0.153	0.211	0.822	0.051	0.052
10	S02	S02_10	0.071	0.345	0.428	0.092	0.403	0.329
10	S04	S04_10	0.617	0.111	0.124	0.758	0.107	0.120
10	S05	S05_10	0.335	0.278	0.418	0.635	0.112	0.104
11	S01	S01_11	0.605	0.152	0.210	0.824	0.051	0.052
11	S02	S02_11	0.071	0.347	0.423	0.091	0.406	0.321
11	S04	S04_11	0.615	0.110	0.123	0.756	0.107	0.120
11	S05	S05_11	0.338	0.276	0.416	0.638	0.110	0.102
12	S01	S01_12	0.603	0.153	0.211	0.824	0.051	0.052
12	S02	S02_12	0.073	0.343	0.428	0.094	0.400	0.331
12	S04	S04_12	0.619	0.110	0.123	0.760	0.106	0.118
12	S05	S05_12	0.337	0.277	0.417	0.637	0.110	0.104
13	S01	S01_13	0.603	0.153	0.210	0.823	0.051	0.052
13	S02	S02_13	0.072	0.344	0.427	0.093	0.401	0.328
13	S04	S04_13	0.616	0.110	0.124	0.758	0.106	0.119
13	S05	S05_13	0.338	0.275	0.413	0.637	0.114	0.102
14	S01	S01_14	0.604	0.152	0.209	0.823	0.051	0.052
14	S02	S02_14	0.073	0.344	0.427	0.094	0.401	0.329
14	S04	S04_14	0.616	0.110	0.123	0.757	0.107	0.120
14	S05	S05_14	0.337	0.277	0.417	0.637	0.109	0.103
15	S01	S01_15	0.604	0.153	0.209	0.825	0.051	0.050
15	S02	S02_15	0.073	0.343	0.427	0.094	0.400	0.329
15	S04	S04_15	0.615	0.110	0.123	0.757	0.105	0.118
15	S05	S05_15	0.336	0.279	0.420	0.638	0.109	0.105

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