SOLAR SPECTRUM AT TWO LEVELS OF SOLAR ACTIVITY

Gérard THUILLIER

Need for a spectrum extending from EUV to IR for atmosphere and solar physics, and preparations of platforms and instruments for use in space with the following characteristics:

Solar activity dependence

Absolute value

1 AU

Range: mainly from X-rays to IR

Accuracy and resolution as best as possible

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MERGING SPECTRA

No single instrument covers the X-rays to IR ⇒ use of data from several instruments

- Random errors may be decreased by averaging several spectra.

- Systematic errors (e. g. from calibration) from the same instrument are

not decreased by averaging data:

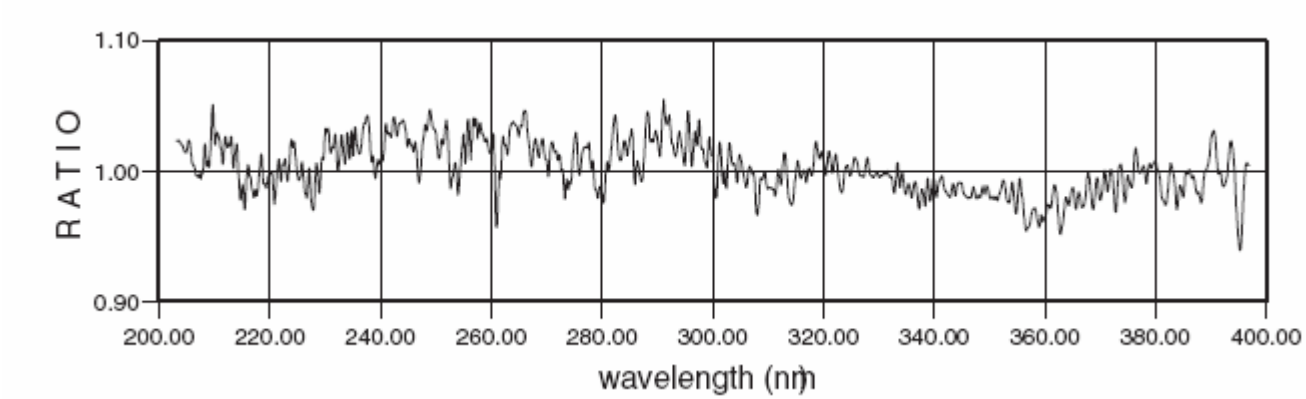
Woods et al. (1996) generated a mean spectrum using SUSIM/UARS

and SOLSTICE/UARS data for the ATLAS 1 and 2 periods.

Cebula et al. (1997) generated a mean spectrum using SUSIM, SSBUV,
and SOLSPEC data from ATLAS 1.

⇒ Comparison between these two mean spectra showed differences smaller

than differences between individual spectra.


1.10
1.00
0.90
RATIO
200.00
220.00
240.00
260.00
280.00
300.00
320.00
340.00
360.00
380.00
400.00
wavelength (nm)

SOURCE OF DATA

λ < Ly α : Rocket measurements by Woods et al., 1998

Ly α to 200 nm: SOLSTICE and SUSIM / UARS

200 < λ <400 nm: SOLSTICE/UARS
SUSIM/UARS
SSBUV/ATLAS
SUSIM/ATLAS
SOLSPEC/ATLAS

400<λ<870 nm SOLSPEC ATLAS 1-2-3

870<λ<2400 nm SOLSPEC/EURECA

Timing : ATLAS 1 : March 1992
ATLAS 3 : November 1994
EURECA : September 1992

Results: Two **composite** spectra

NORMALIZATION

Spectrometers in UV and visible have accuracy of the order of 2 to 3%. Radiometric measurements have accuracies of the order of 0.1 %.

The successive steps are:

1 Integration from 0.5 to 2400 nm

	E < 2400 nm	TSI (W/m2)	I (2400 nm)
Kurucz	1316.79	1368.11	59.97
ATLAS 1	1330.28	1367.7	60.44
ATLAS 3	1330.12	1366.7	60.44

2 Use of Kurucz (1995)' spectrum to calculate the energy above 2400 nm after matching the Kurucz' irradiance at 2400 nm to the measured irradiance at that wavelength.

	ATLAS1	ATLAS 3
Measured TSI	1367.7	1366.7
Cal. TSI	1382.91	1382.74
difference	1.11 %	1.17 %

Normalization coefficients are within the estimated spectrometric acuracy.

VARIABILITY BETWEEN ATLAS 1 AND ATLAS 3

Variability is given by the Mg II index:

	Composite	SUSIM	SBUV/2	F10.7
ATLAS 1	0.2748	0.2708	0.2756	192
ATLAS 3	0.2600	0.2596	0.2625	77.5

Variability ATLAS 1/ ATLAS 3

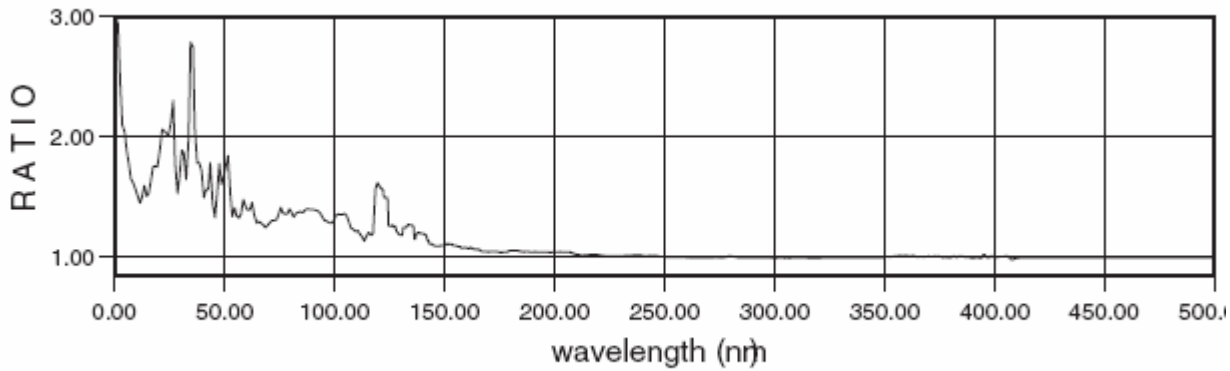
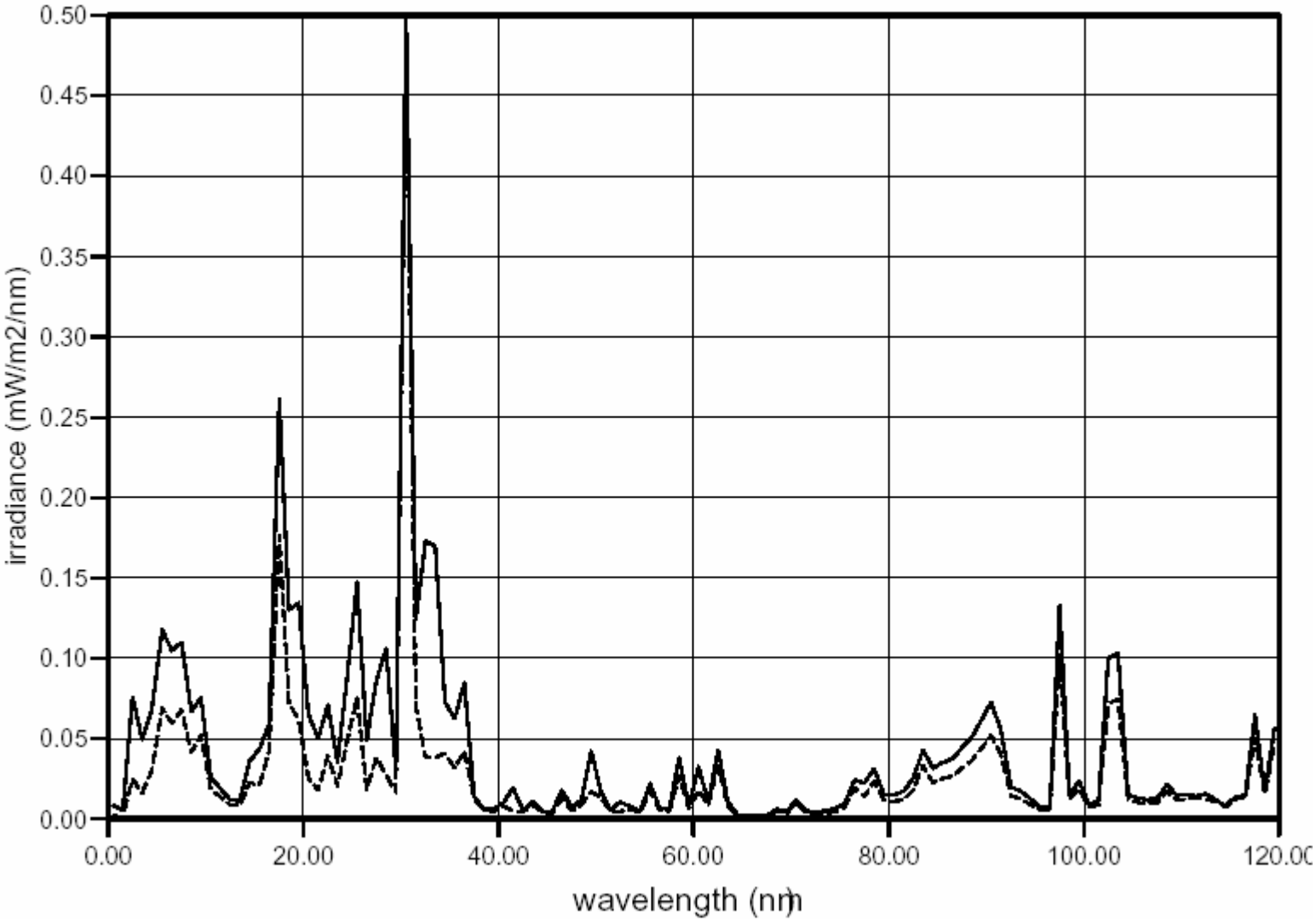


Figure 12. Ratio of the ATLAS 1 to ATLAS 3 spectra at 1 nanometer resolution.

When the solar variability is smaller than the accuracy of the measurements
The ratio of the two composite spectra has no meaning.


0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
irradiance (mW/m2/nm)
0.00
20.00
40.00
60.00
80.00
100.00
120.00
wavelength (nm)

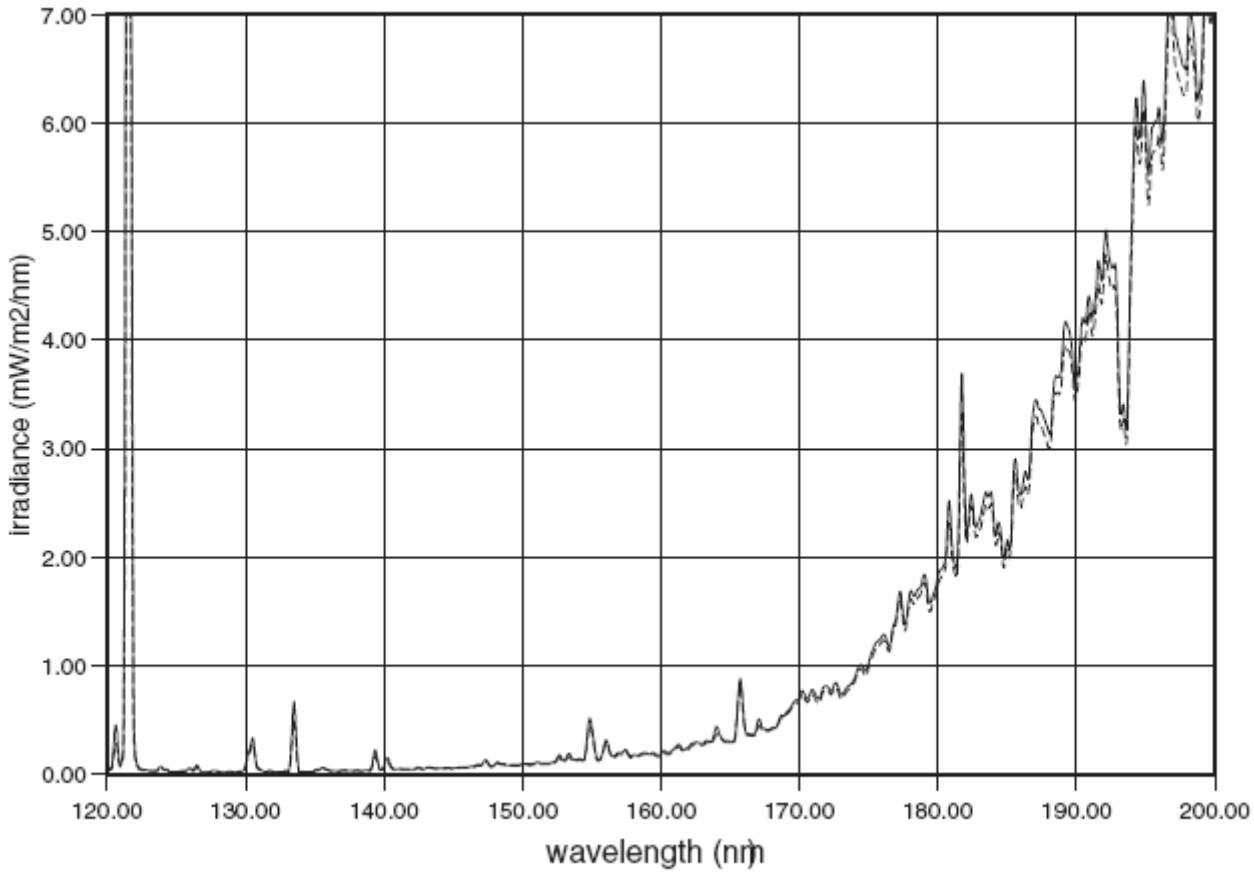


Figure 7. The UV spectrum up to 200 nm for ATLAS 1 (solid line) and ATLAS 3 (dashed line) periods.

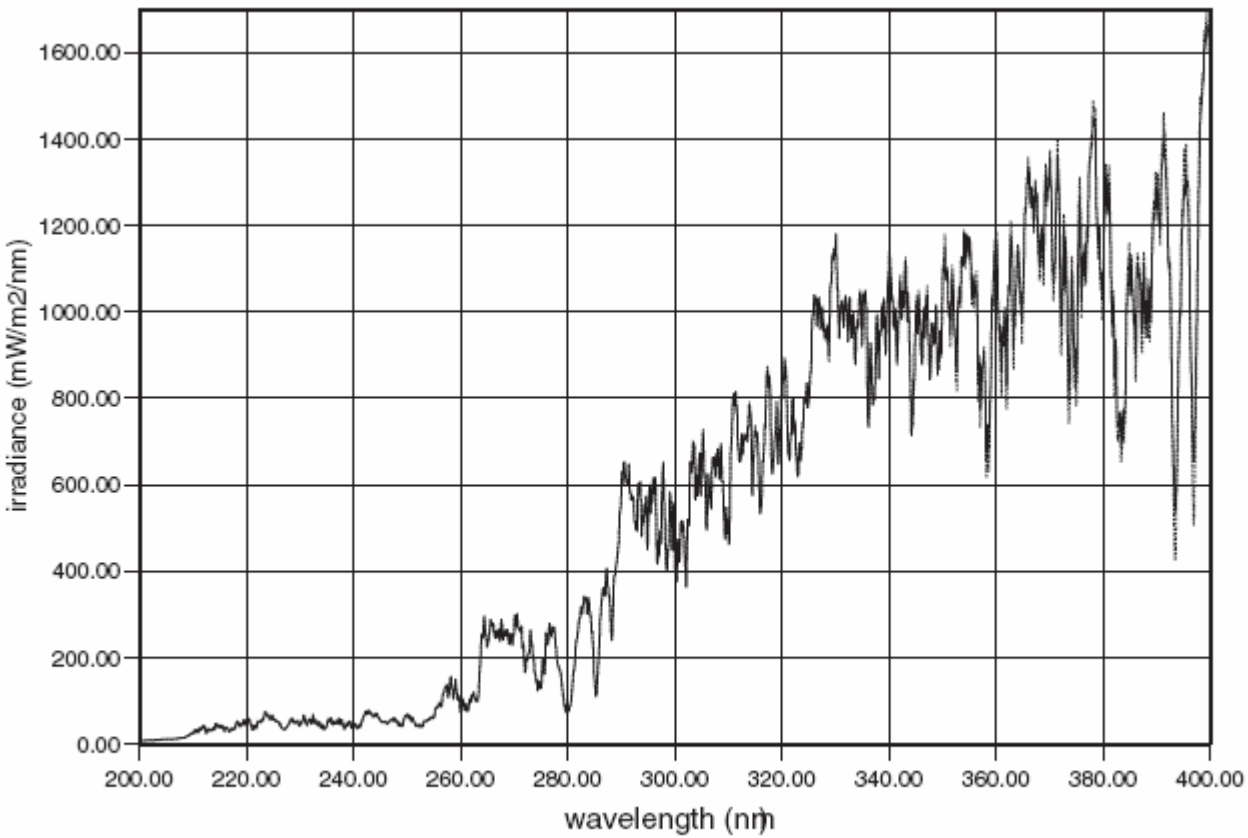
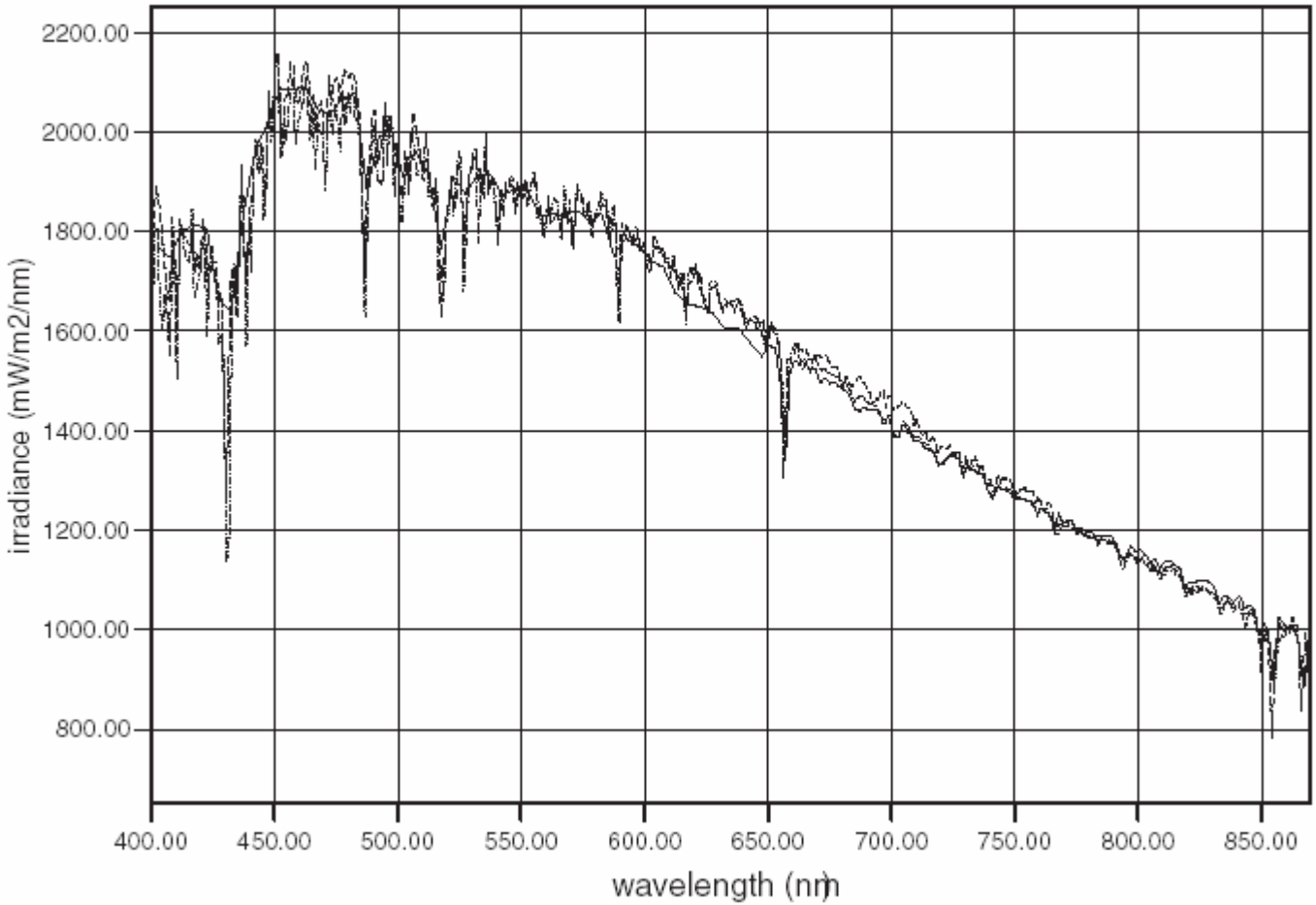


Figure 8. The 200-400 nm spectrum for ATLAS 1 (solid line) and ATLAS 3 (dashed line) periods.


2200.00
2000.00
1800.00
1600.00
1400.00
1200.00
1000.00
800.00
irradiance (mW/m2/nm)
400.00
450.00
500.00
550.00
600.00
650.00
700.00
750.00
800.00
850.00
wavelength (nm)

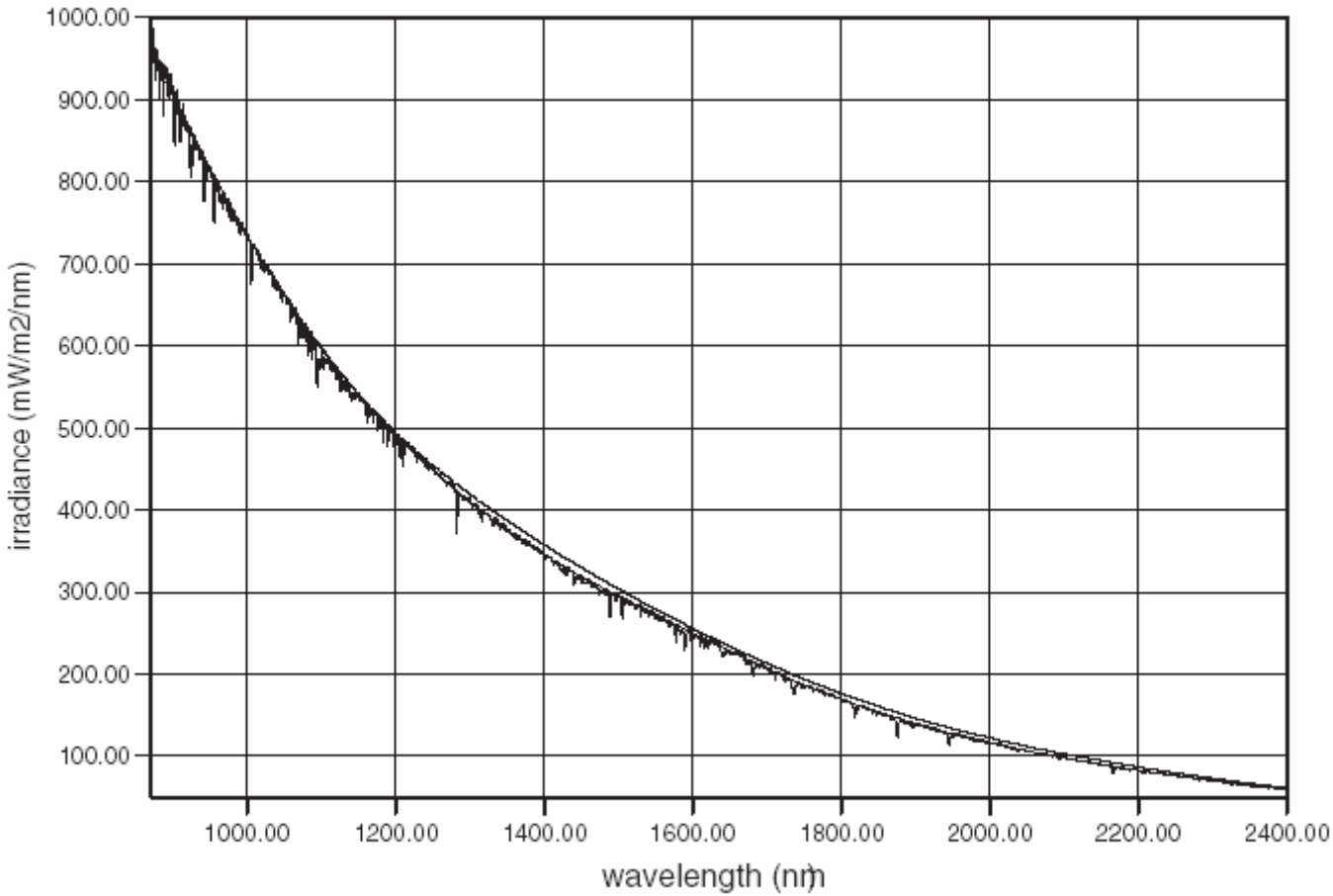
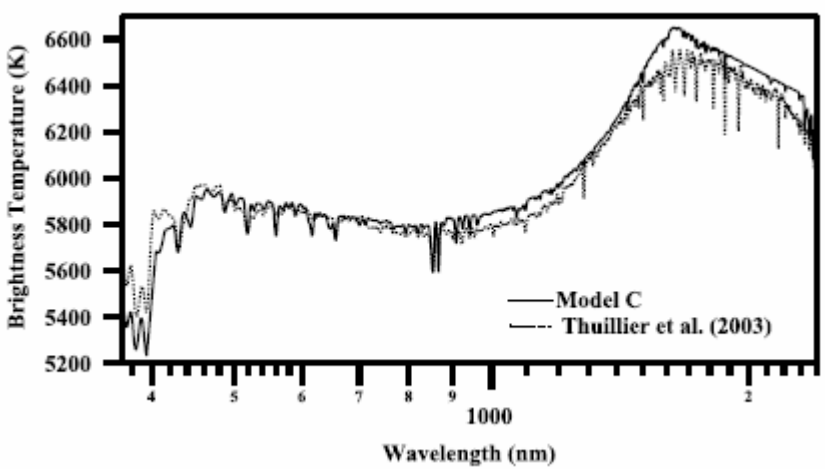
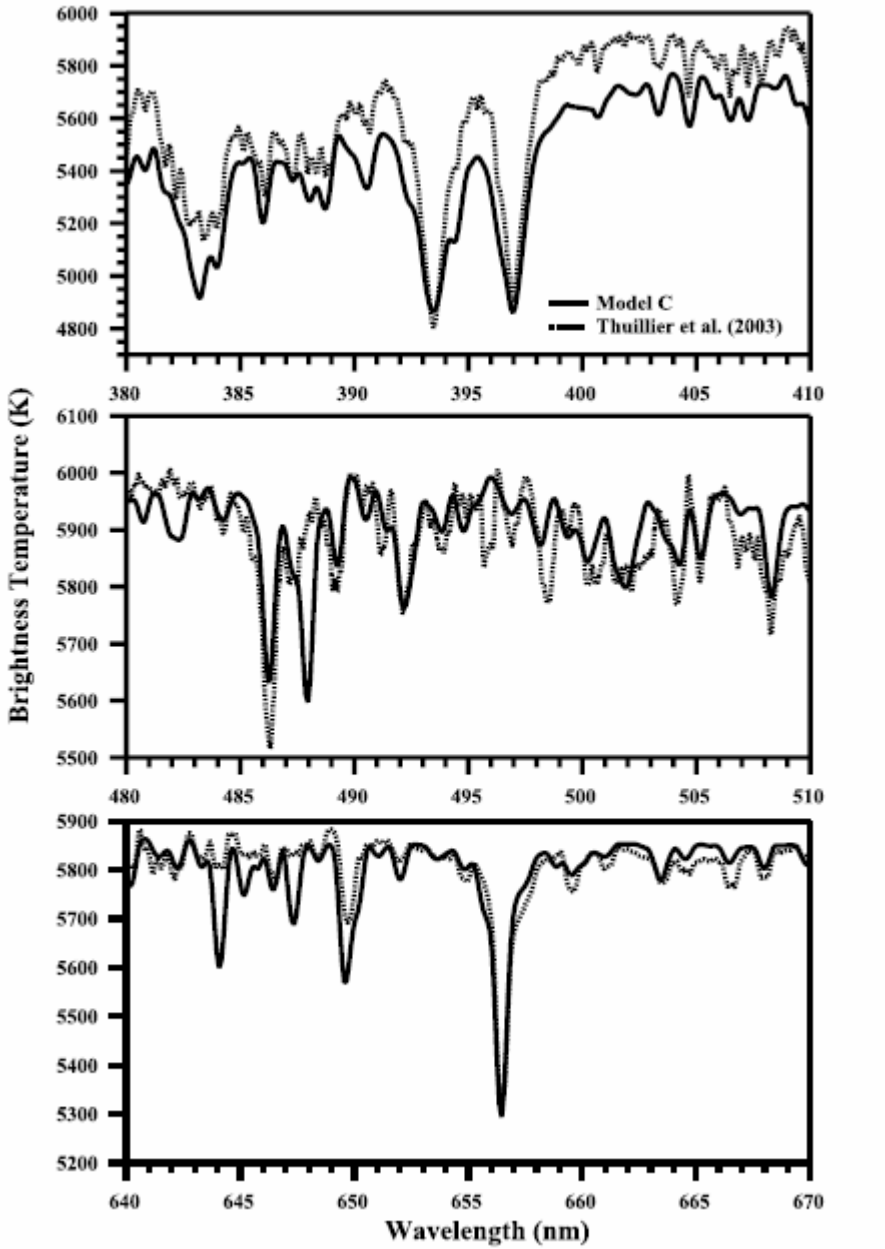
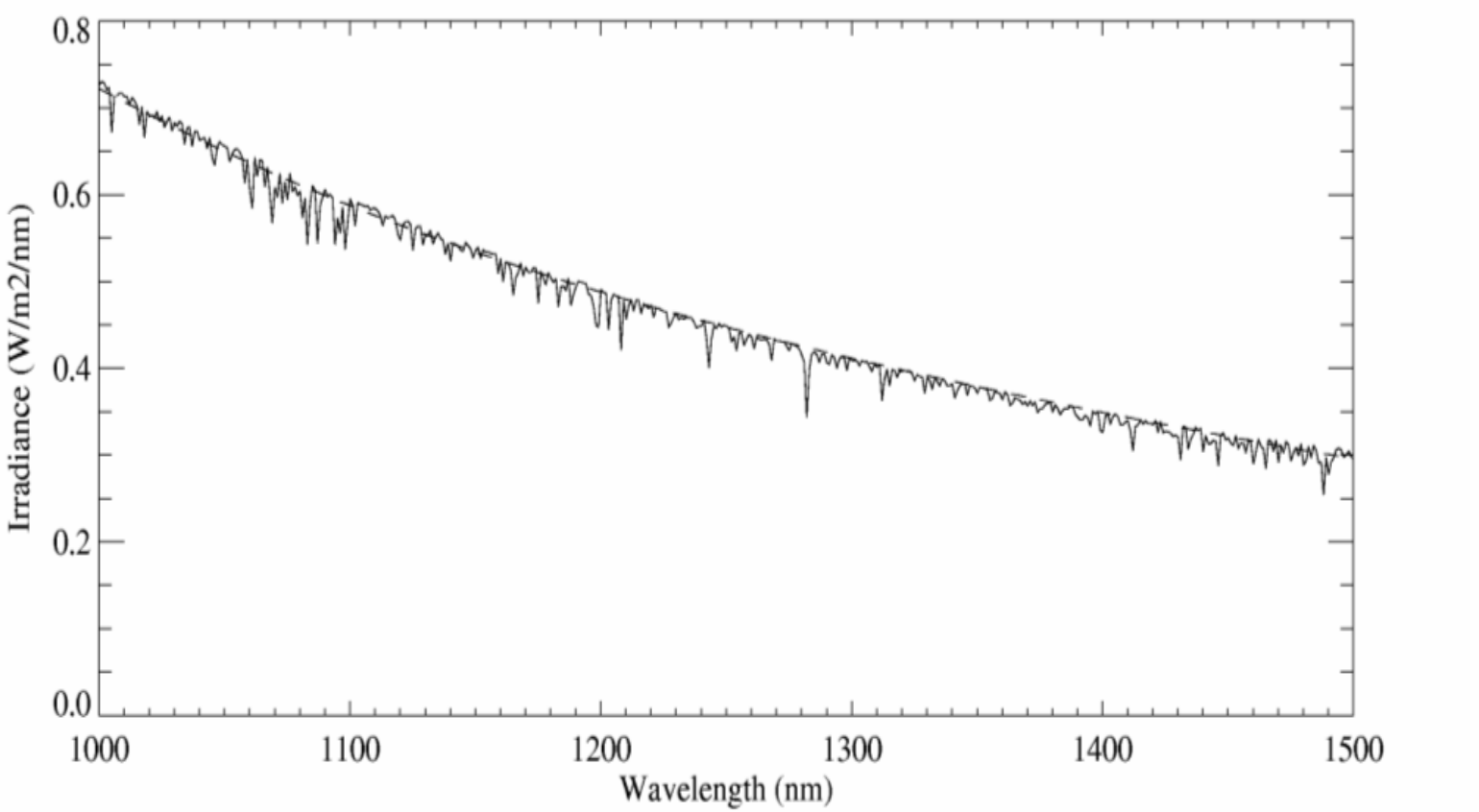


Figure 10. The IR range up to 2400 nm: comparison between spectra from *Kurucz* [1995] (dashed line) and SOSP without Fraunhofer lines (solid line).

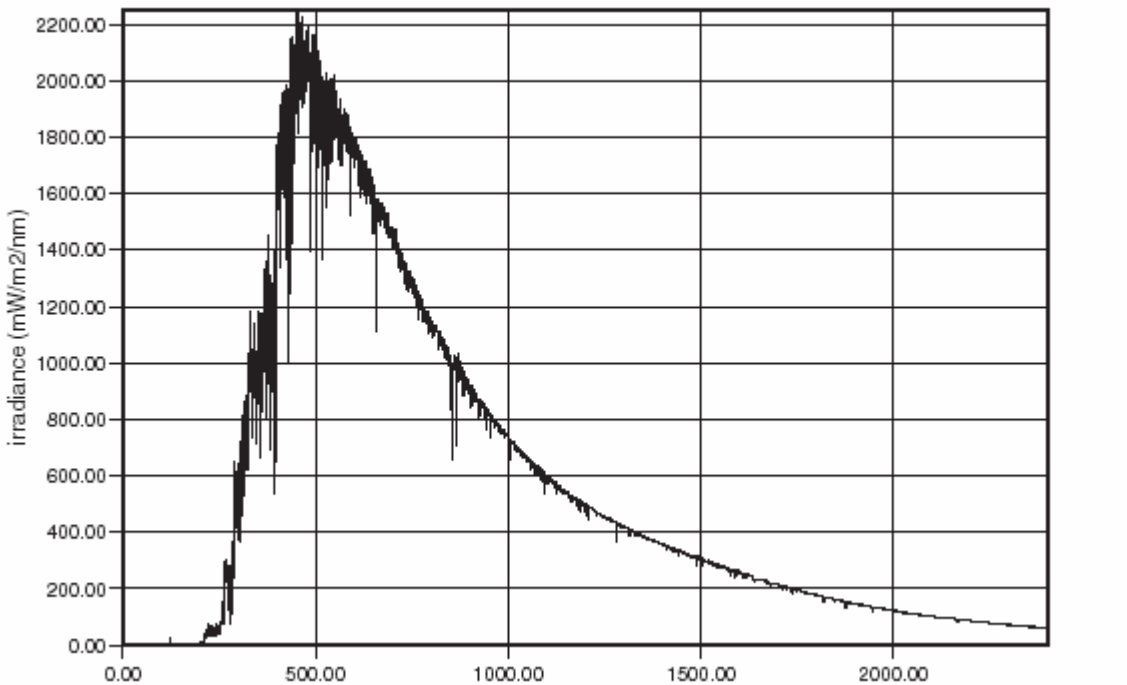


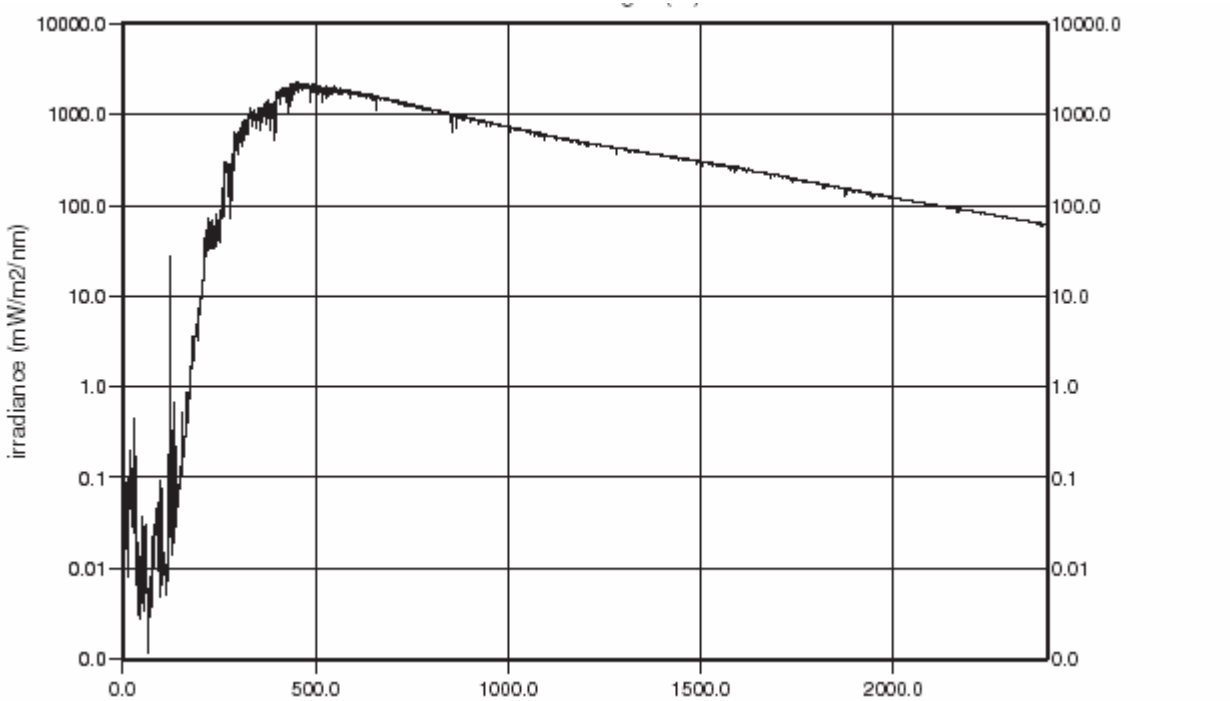
From Fontenla et al., 2006




0.8
0.6
0.4
0.2
0.0
Irradiance (W/m2/nm)
1000
1100
1200
1300
1400
1500
Wavelength (nm)

Fox, 2004


irradiance (mW/m2/nm)
2200.00
2000.00
1800.00
1600.00
1400.00
1200.00
1000.00
800.00
600.00
400.00
200.00
0.00
0.00
500.00
1000.00
1500.00
2000.00


irradiance (mW/m2/nm)
10000.0
1000.0
100.0
10.0
1.0
0.1
0.01
0.0
0.0
500.0
1000.0
1500.0
2000.0

SAMPLING AND RESOLUTION OF THE TWO COMPOSITE SPECTRA

Ranges	s (nm)	r (nm)
XUV-EUV	1	1
Ly α to 400 nm	0.05	0.25
400 to 2400 nm	0.2 to 0.6	0.5

REFERENCES

COMPOSITE SPECTRA ATLAS 1 and ATLAS 3:
Thuillier, G., Floyd, L., Woods, T. N., Cebula, R., Hilsenrath, E., Hersé, M., Labs, D., Solar irradiance reference spectra, AGU Monograph 141, Ed. J. Pap and P. Fox, 171-194, 2004

SOSLPEC spectrum:
Thuillier, G., Hersé, M., Labs, D., Foujols, T., Peetermans, W., Gillotay, D., Simon, P. C., Mandel, H. (2003) The solar spectral irradiance from 200 to 2400 nm as measured by the SOLSPEC spectrometer from the ATLAS and EURECA missions, Sol. Phys. , 224, 1-22, 2003

SOLAR on the Space Station:
Schmidtke, G., Fröhlich, C. and Thuillier, G., ISS-SOLAR: Total (TSI) and spectral (SSI) irradiance measurements**,** Adv. Sp. Res., 37, 2, 255-264, 2006

Comparison with theoretical models:
Fontenla, J., Avrett, G., Thuillier, G., and Harder, J., Semiempirical Models of the Solar Atmosphere. I. The Quiet- and Active Sun Photosphere at Moderate Resolution**,** .ApJ, 639, 1, 441-458, 2006

Fox, P., COSPAR Paris, 2004