

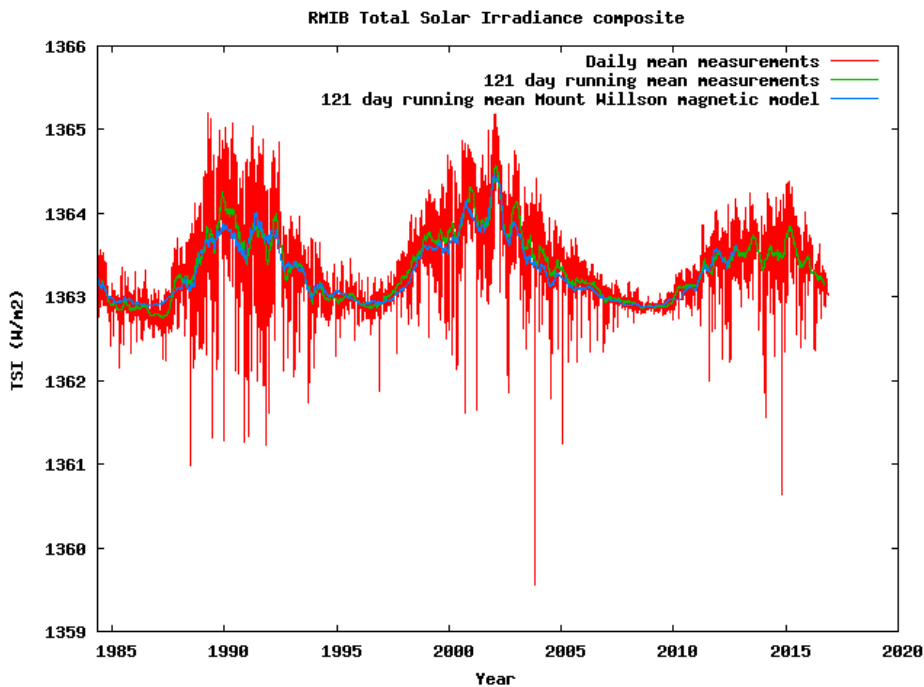
# A solar reference spectrum for the (inter)calibration of earth observing satellites

S. Dewitte – RMIB

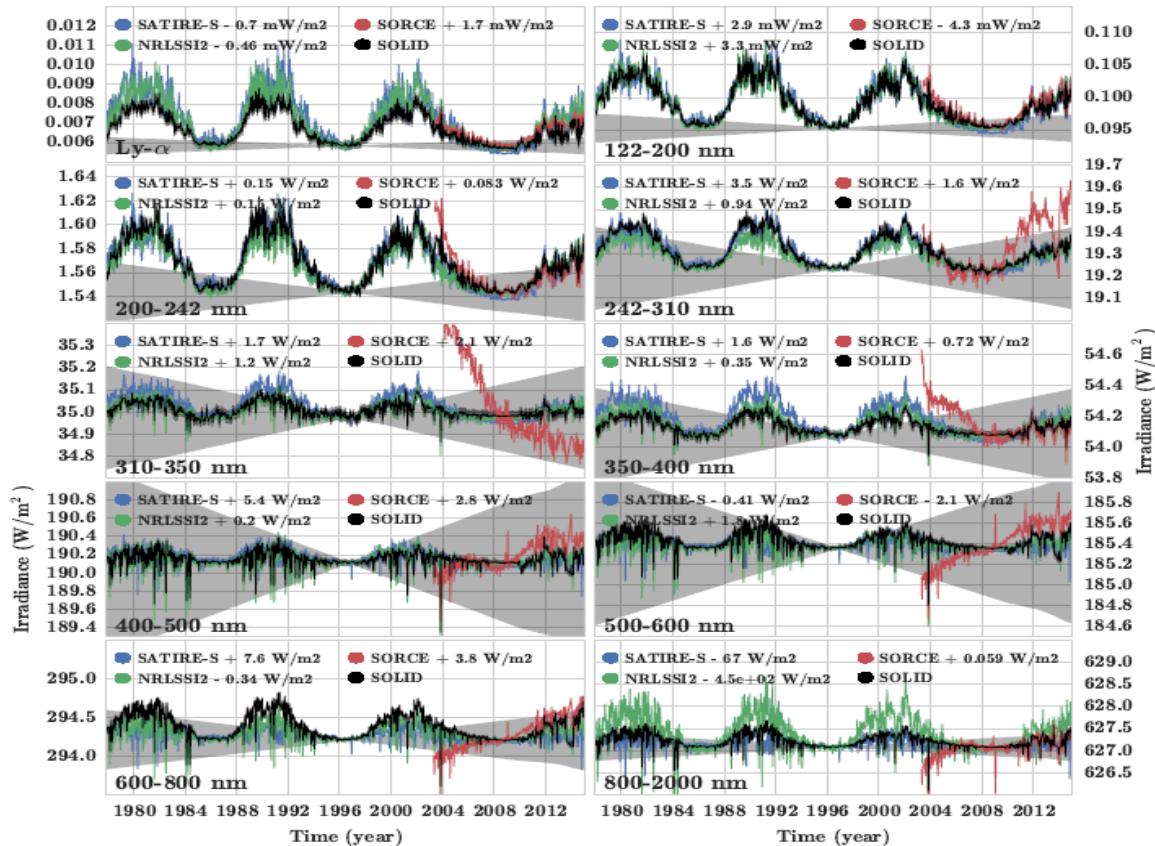
Solspec measurements: G. Thuillier – LATMOS

# Total Solar Irradiance

- [Dewitte & Nevens, 2016]
- Variability with 11 y solar cycle  $\sim 0.1\%$
- Good reproduction with regression model based on sunspots and facula
- Absolute level near solar minimum:  $1363 \text{ W/m}^2$



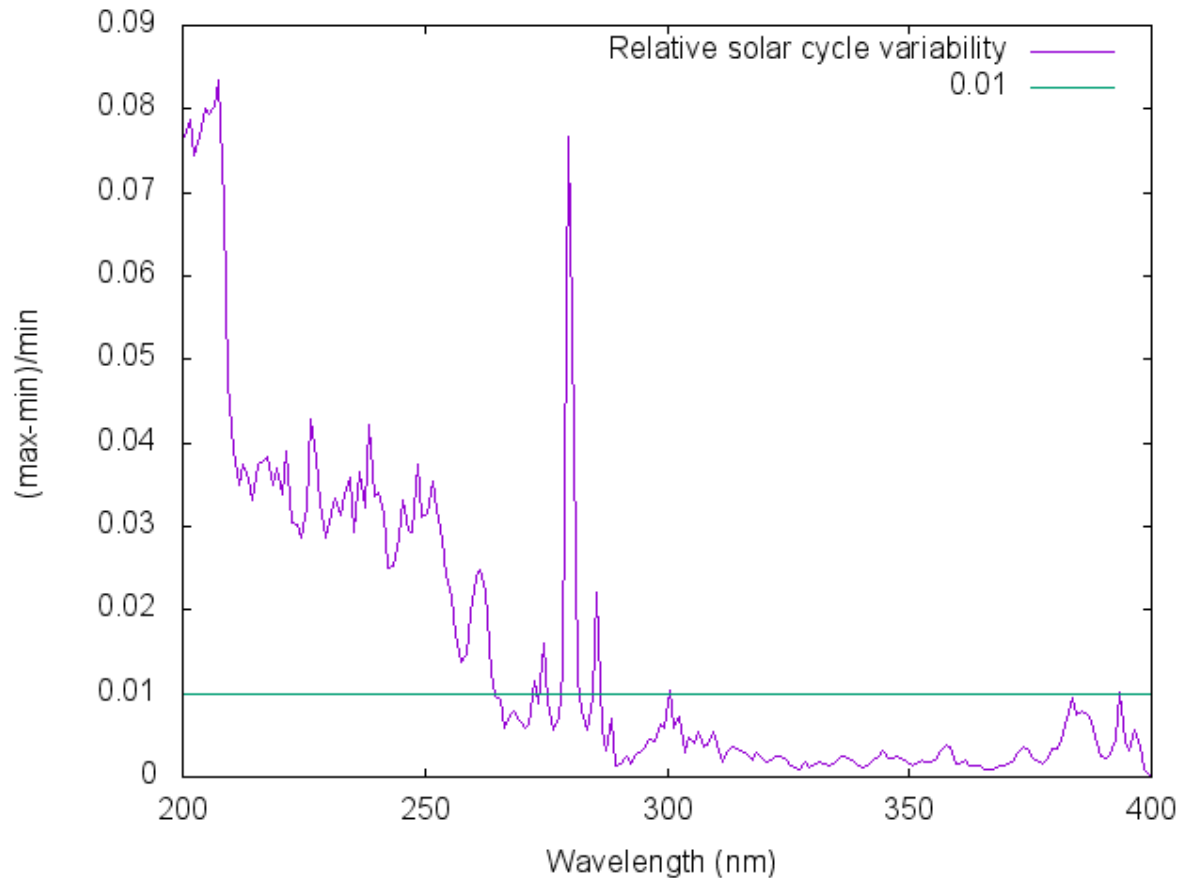
# Spectral Solar Irradiance variability



- UV: facular brightening
- VIS/IR: facular brightening + sunspot darkening

[Solid composite, Habereiter et al, 2017]

# Spectral Solar Irradiance variability



- Solar cycle variability < 1% for wavelengths > 285 nm

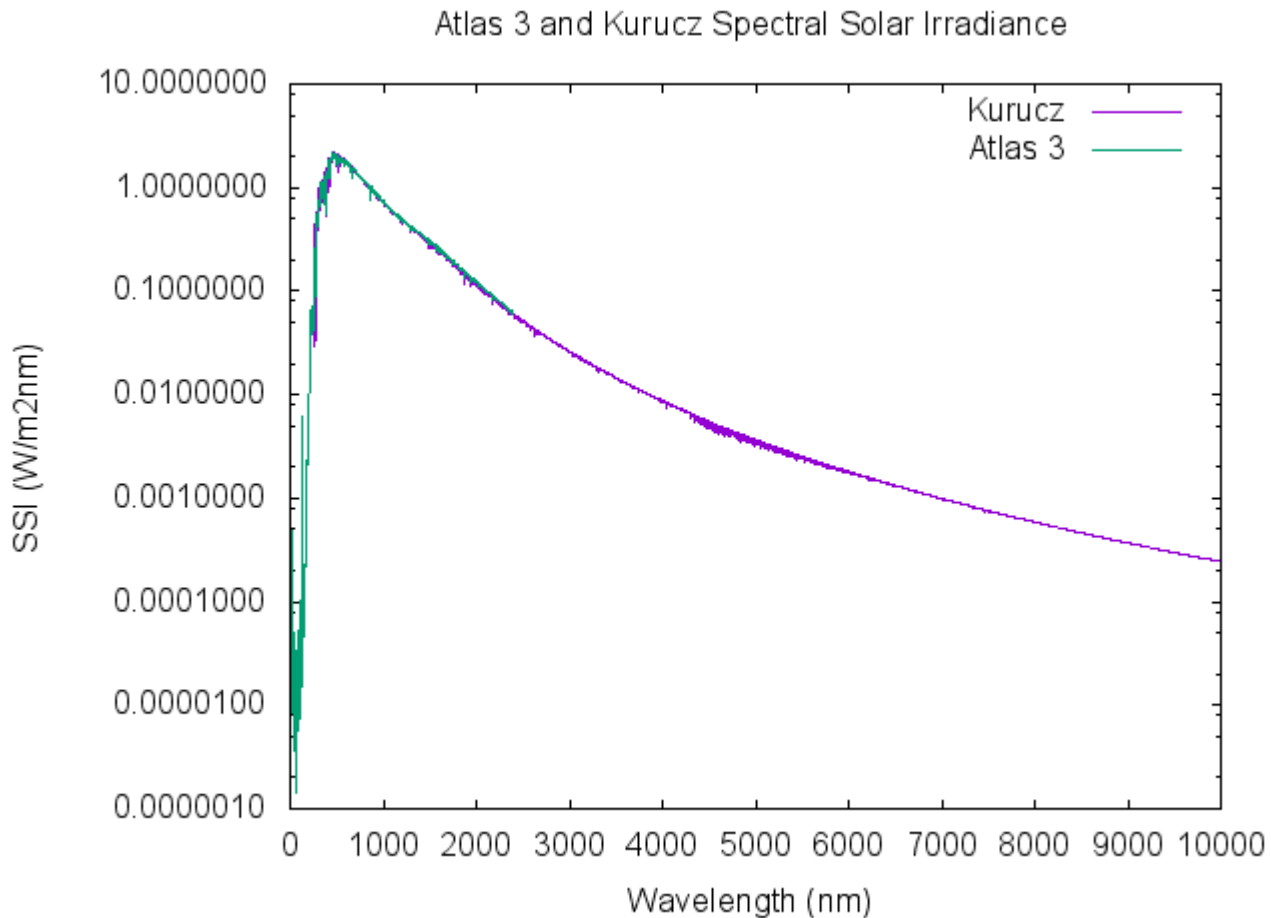
[NRLSSI2]

# Solspec instruments

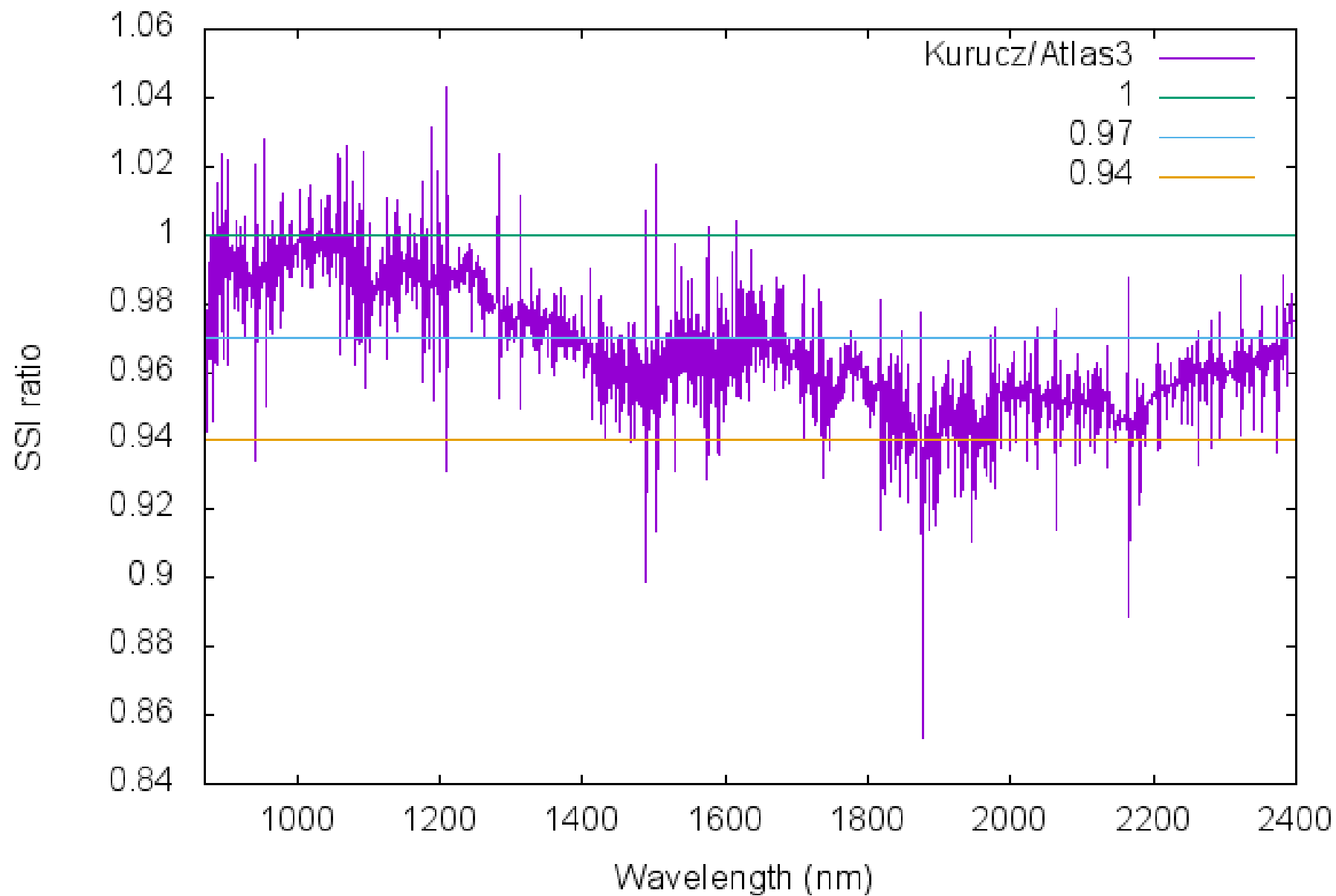
- Double monochromator for 3 spectral regions: UV + VIS + IR
- On-ground absolute calibration, accuracy: 3%
- In-flight ageing monitoring with lamps
- Published reference spectra 0.1-2400 nm [Thuillier et al, 2004]
  - Actual Solspec: 200-2400 nm
  - Other instruments: 0.1-400 nm
  - Atlas 1 period: March 1992: high solar activity
  - **Atlas 3 period: Nov 1994: low solar activity -> widely used as reference spectrum.**

# Extension beyond 2400 nm

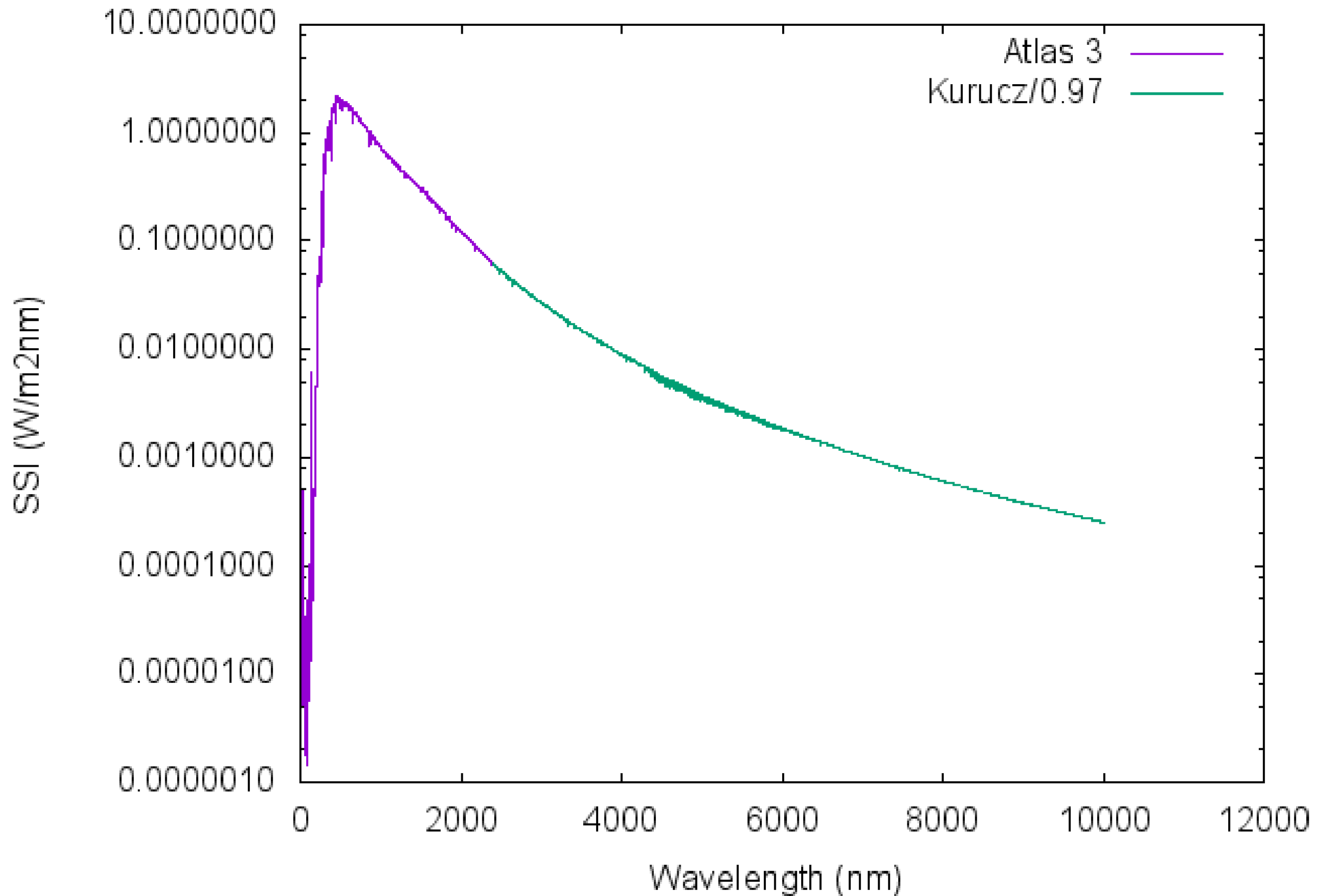
- Theoretical spectrum from [Kurucz, 1992]
- Range: 250-10000 nm



IR (870-2400 nm) ratio Kurucz / Atlas 3



Combined SSI Atlas 3 (<2397nm) plus rescaled(/0.97) Kurucz (>2397nm)

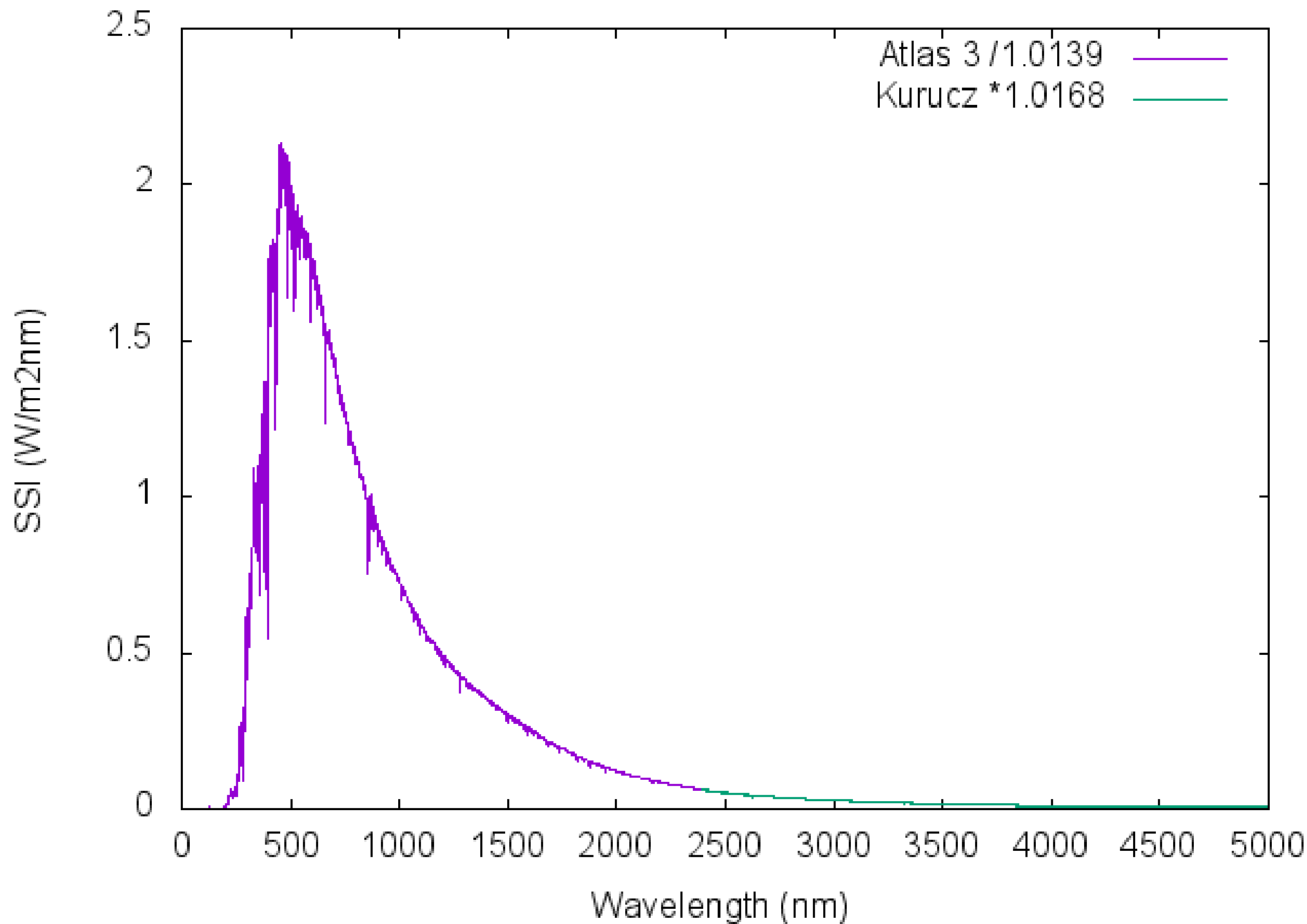




# TSI scaling

- TSI 11 Nov 1994: 1363.3 W/m<sup>2</sup>
- Integrated spectrum: 1382.3 W/m<sup>2</sup>
- Ratio: 1.0139 compatible with 3% absolute accuracy
- For TSI compatibility:
- Divide Atlas 3 by 1.0139
- Multiply Kurucz by  $1/(0.97*1.0139)=1.0168$

SSI rescaled for TSI=1363.3 W/m<sup>2</sup>



# Conclusions

- The solar spectrum can be considered constant for wavelengths above 280 nm within a 1% uncertainty.
- The Solspec instruments are designed for a measurement of the solar spectrum with an absolute accuracy of 3%.
- A widely used Solspec based reference spectrum is the Atlas 3 spectrum going up to 2397 nm.
- For longer wavelengths it can be extended by the Kurucz theoretical spectrum.

# References

- "Solar Irradiance Spectra for Two Solar Activity Levels", Gerard Thuillier, Linton Floyd, Thomas N. Woods, Richard Cebula, Ernest Hilsenrath, Michel Herse, and D. Labs, Solar Physics, 34, 256-261, 2004.
- Kurucz, R.L., "Synthetic infrared spectra", in Infrared Solar Physics, IAU Symp. 154, edited by D.M. Rabin and J.T. Jefferies, Kluwer, Acad., Norwell, MA, 1992.
- "The Total Solar Irradiance Climate Data Record", Steven Dewitte and Stijn Nevens 2016 ApJ 830 25