I. Irrelevant

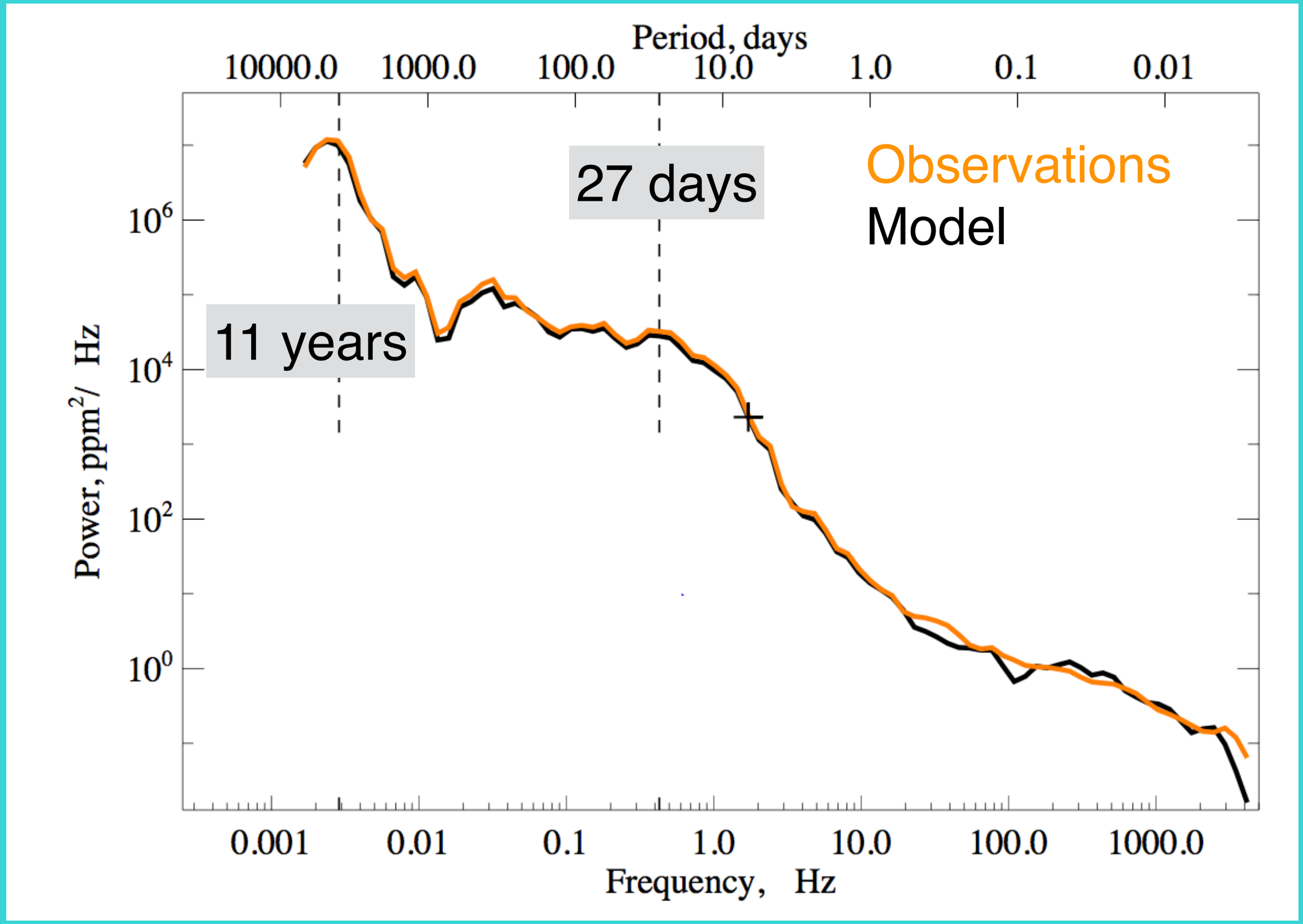
I. Irrelevant

II. Harshly done

I. Irrelevant

II. Harshly done

1996-2015


Period, days
10000.0
1000.0
100.0
10.0
1.0
0.1
0.01
27 days
11 years
Observations
Model
10^6
10^4
10^2
10^0
Power, ppm^2/ Hz
0.001
0.01
0.1
1.0
10.0
100.0
1000.0
Frequency, Hz

I. disc area coverages + semi-empirical atmospheric structures + LTE code

II. disc area coverages + MHD cubes + LTE code

III. disc area coverages + semi-empirical atmospheric structures + NLTE code

I. disc area coverages + semi-empirical atmospheric structures + LTE code

II. disc area coverages + MHD cubes + LTE code

III. disc area coverages + semi-empirical atmospheric structures + NLTE code

...

disc area coverages + MHD cubes + NLTE code

The NESSY code

Statistical Equilibrium Block

~10^2 levels

Spectrum Synthesis Program

~10^7 lines

The NESSY code

Populations of the NLTE Levels

Statistical Equilibrium Block

~10^2 levels

Spectrum Synthesis Program

~10^7 lines

The NESSY code

Populations of the NLTE Levels

Statistical Equilibrium Block

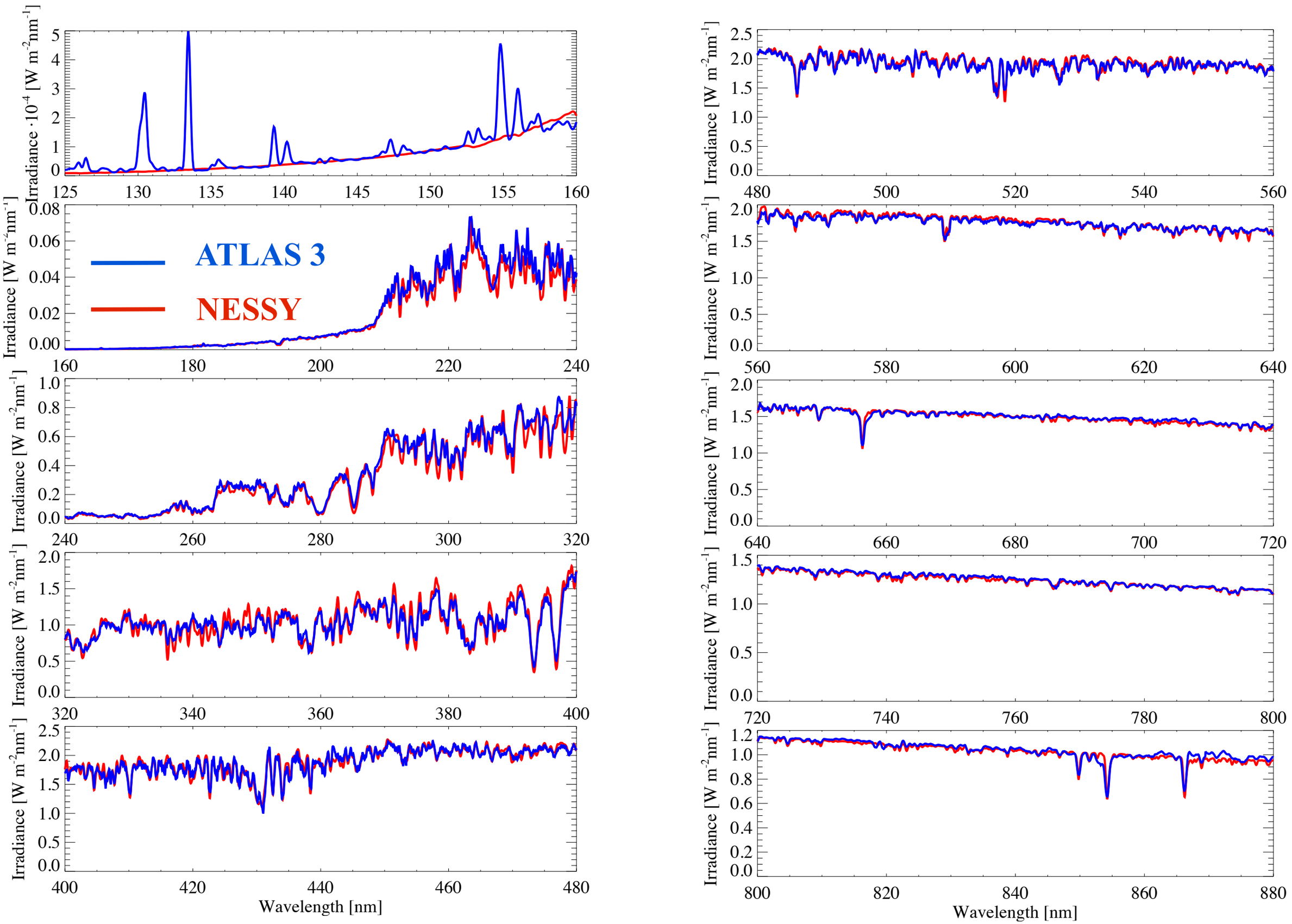
Spectrum Synthesis Program

~10^2 levels

~10^7 lines

Opacity Distribution Function

Solar spectrum



NESSY

NLTE Spectral SYnthesis Code
Tagirov et al. 2016

BEFORE

NESSY

NLTE Spectral SYnthesis Code
Tagirov et al. 2016

NESSY

NLTE Spectral SYnthesis Code
Tagirov et al. 2016

BEFORE

DURING

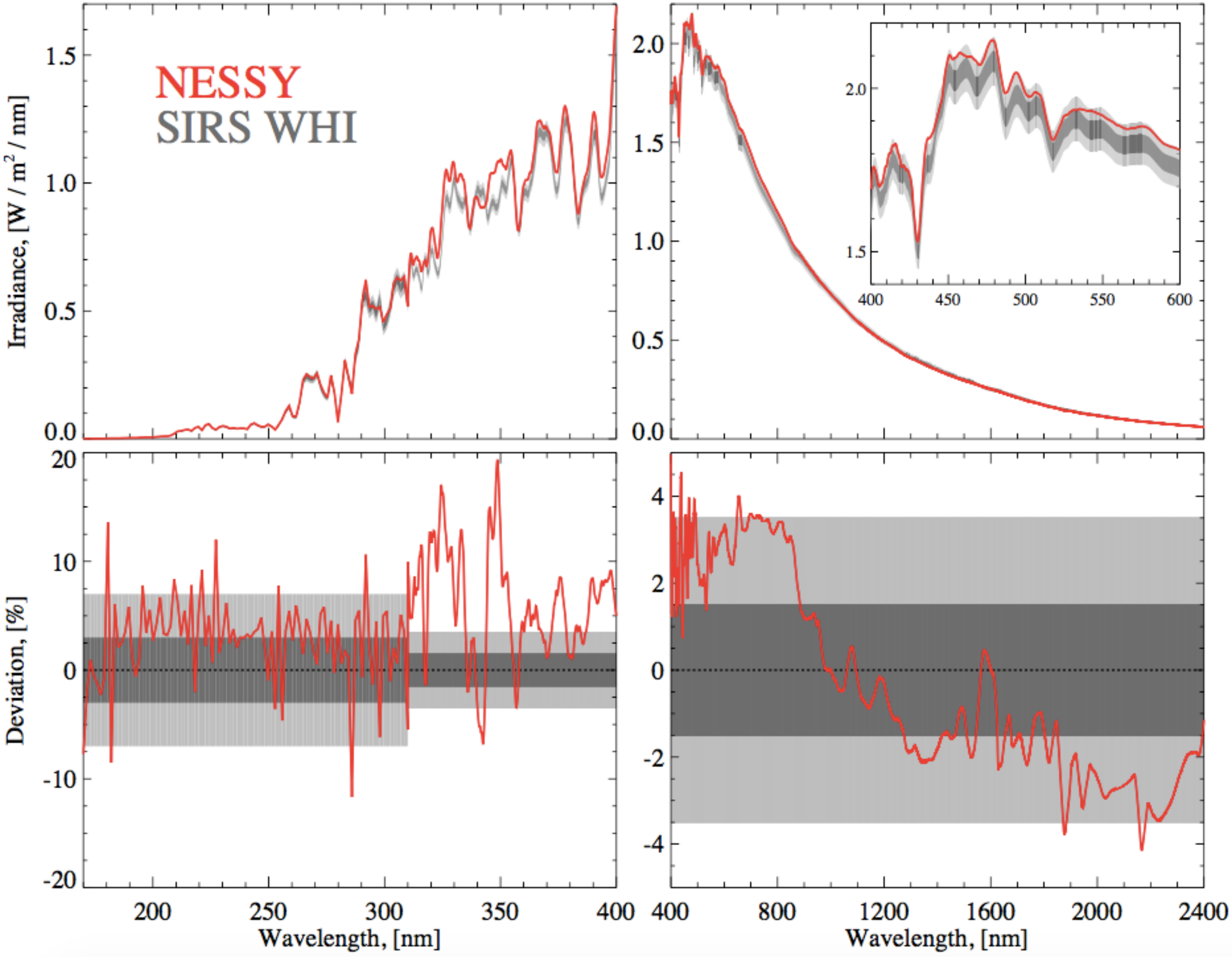
NESSY

NLTE Spectral SYnthesis Code
Tagirov et al. 2016

BEFORE

DURING

AFTER


NESSY
SIRS WHI
Irradiance, [W / m² / nm]
Deviation, [%]
Wavelength, [nm]
Wavelength, [nm]

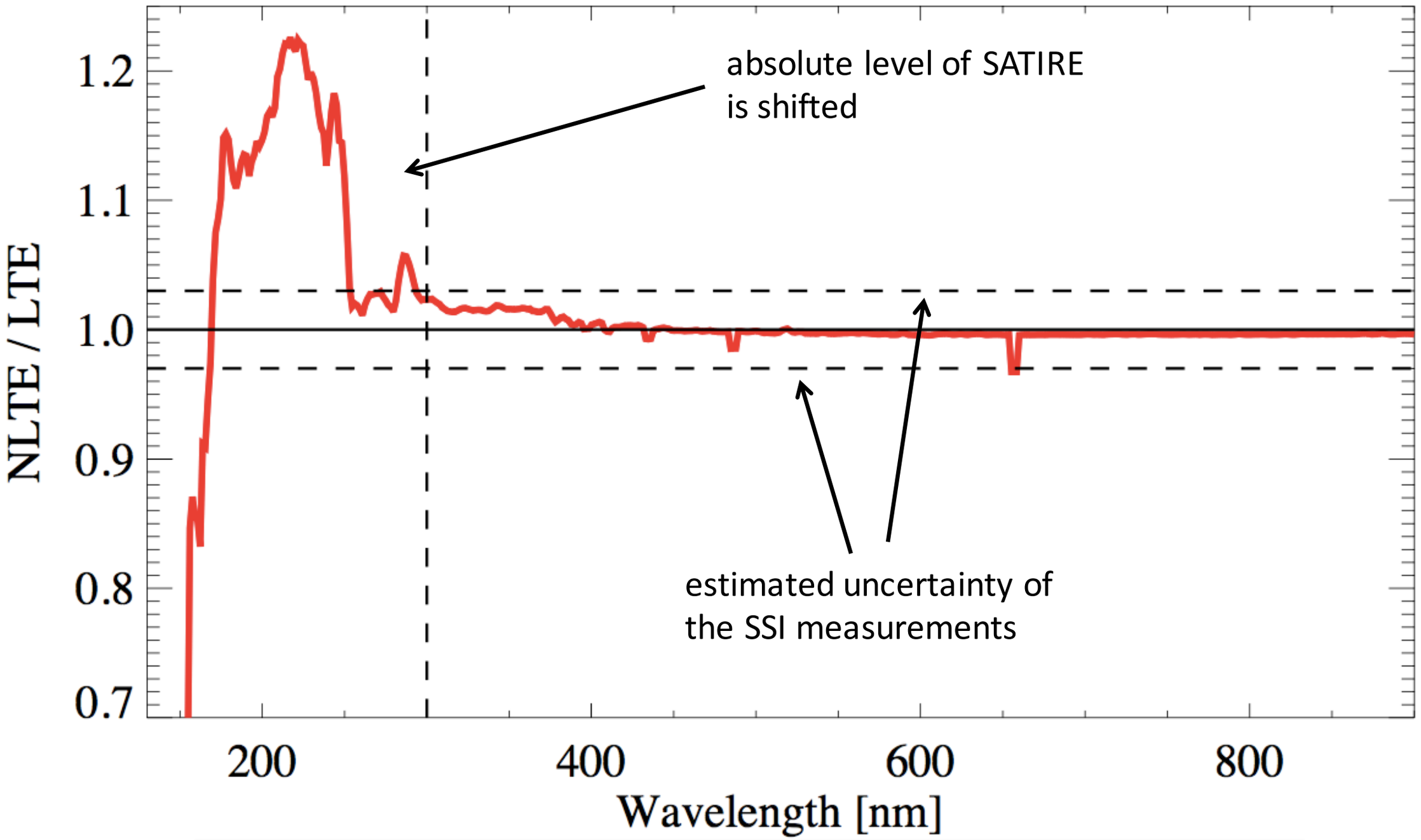
SATIRE-S (Yeo et al. 2014)

180-300 nm: absolute level offset to WHI

115 - 180 nm: rescaled based on SORCE/SOLSTICE

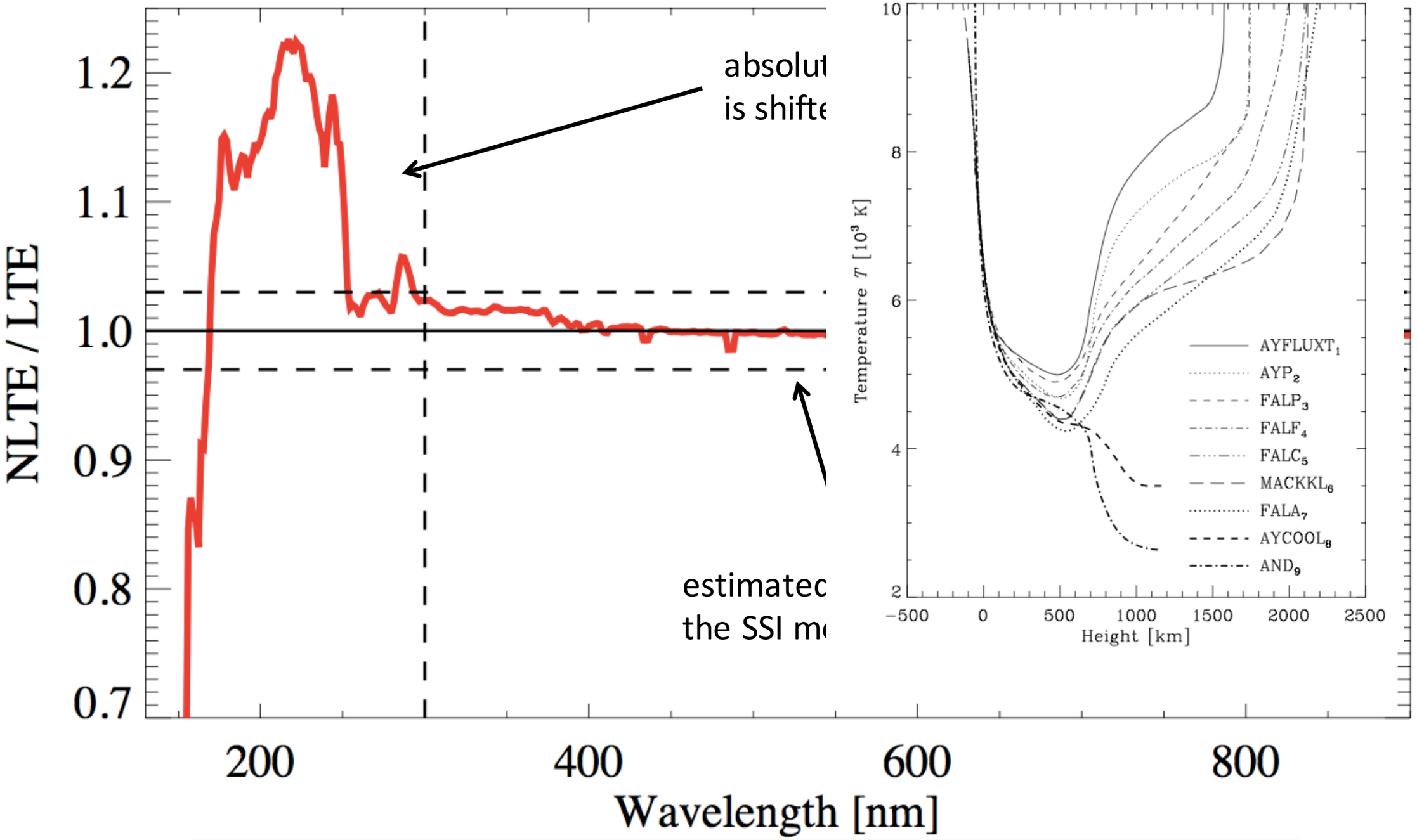
Effect of the NLTE on the absolute SSI level

Calculations with NLTE code for Spectrum SYnthesis (NESSY)



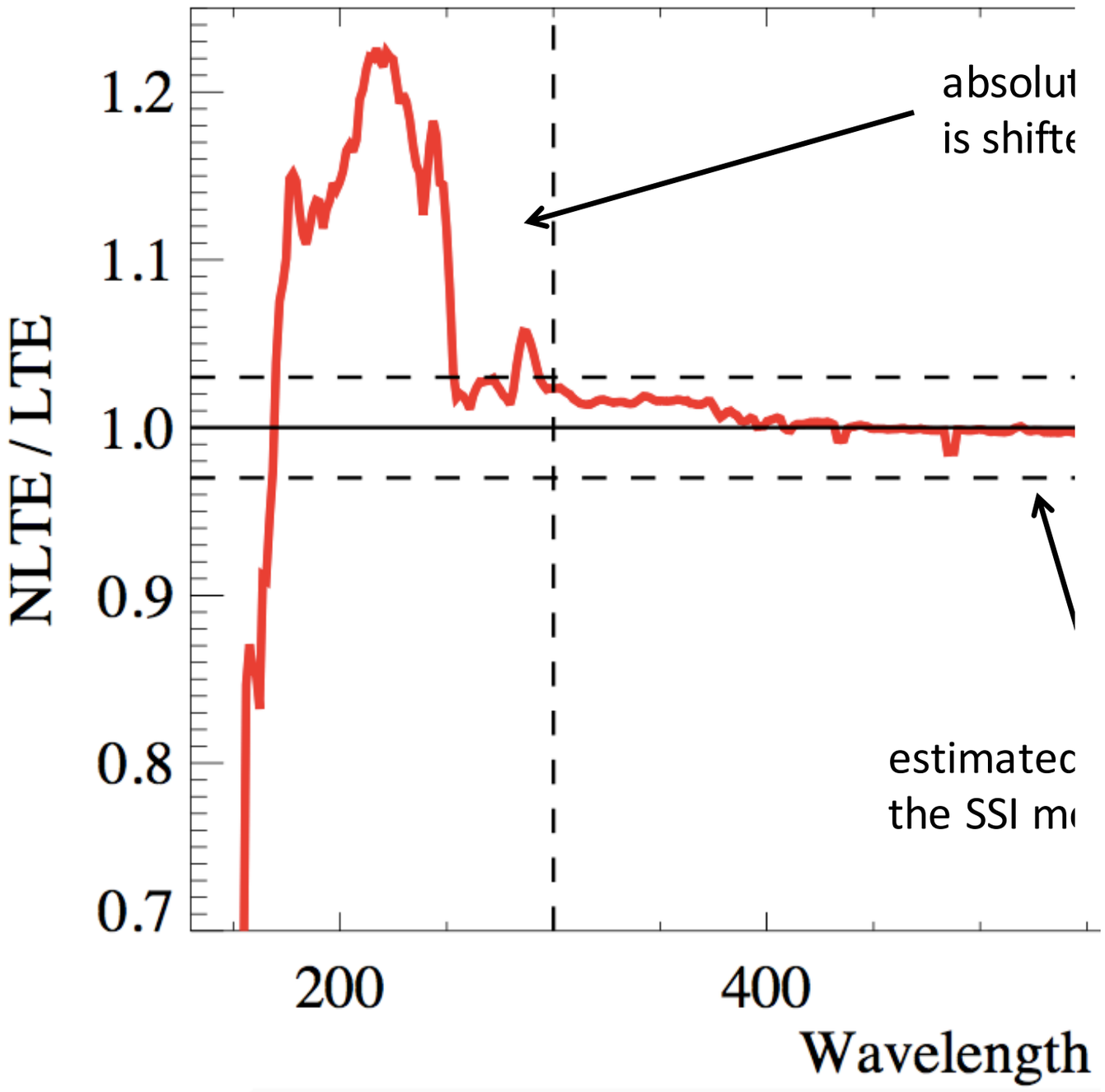
Effect of the NLTE on the absolute SSI level

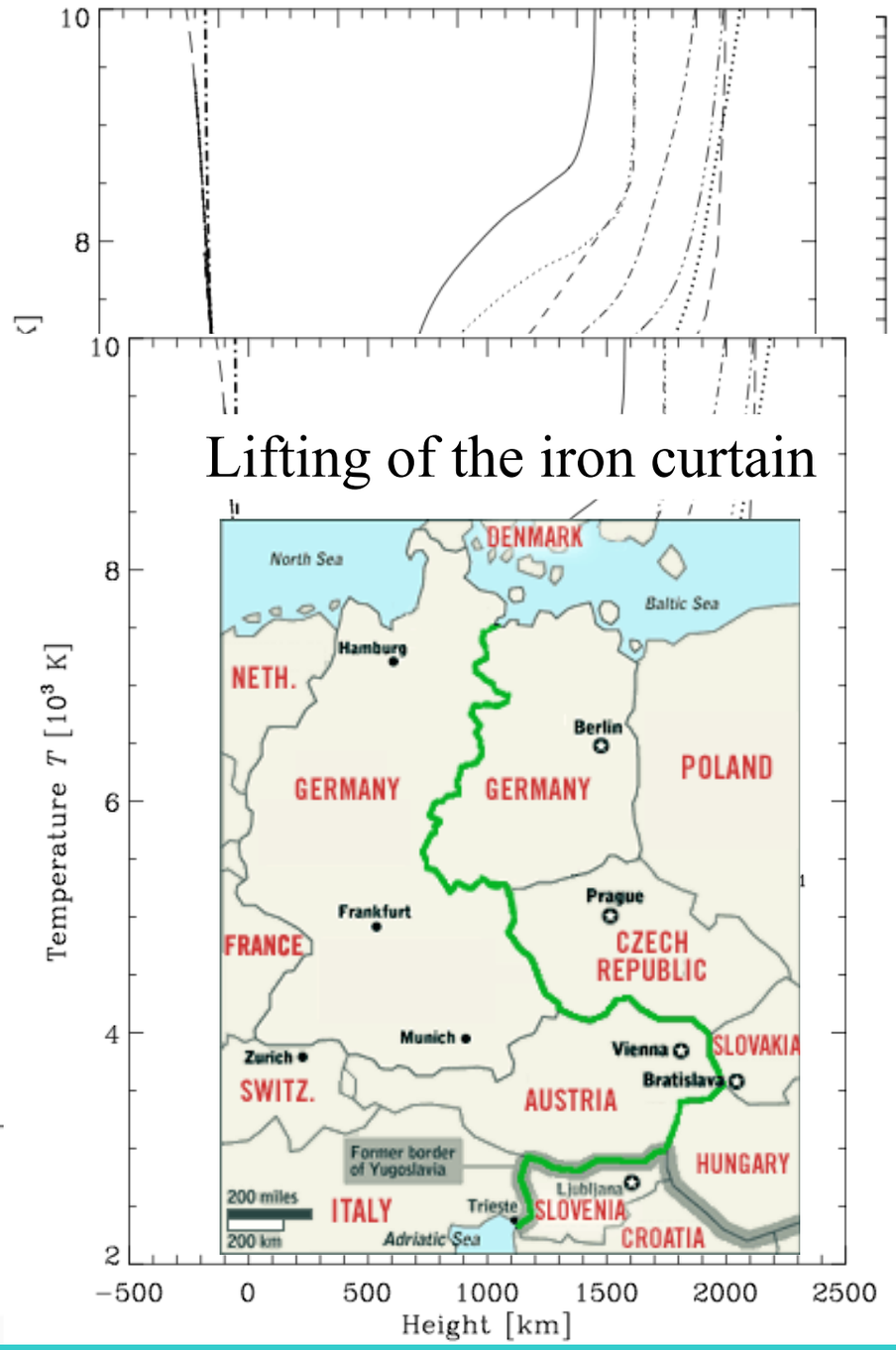
Calculations with NLTE code for Spectrum SYnthesis (NESSY)



Effect of the NLTE on the absolute SSI level

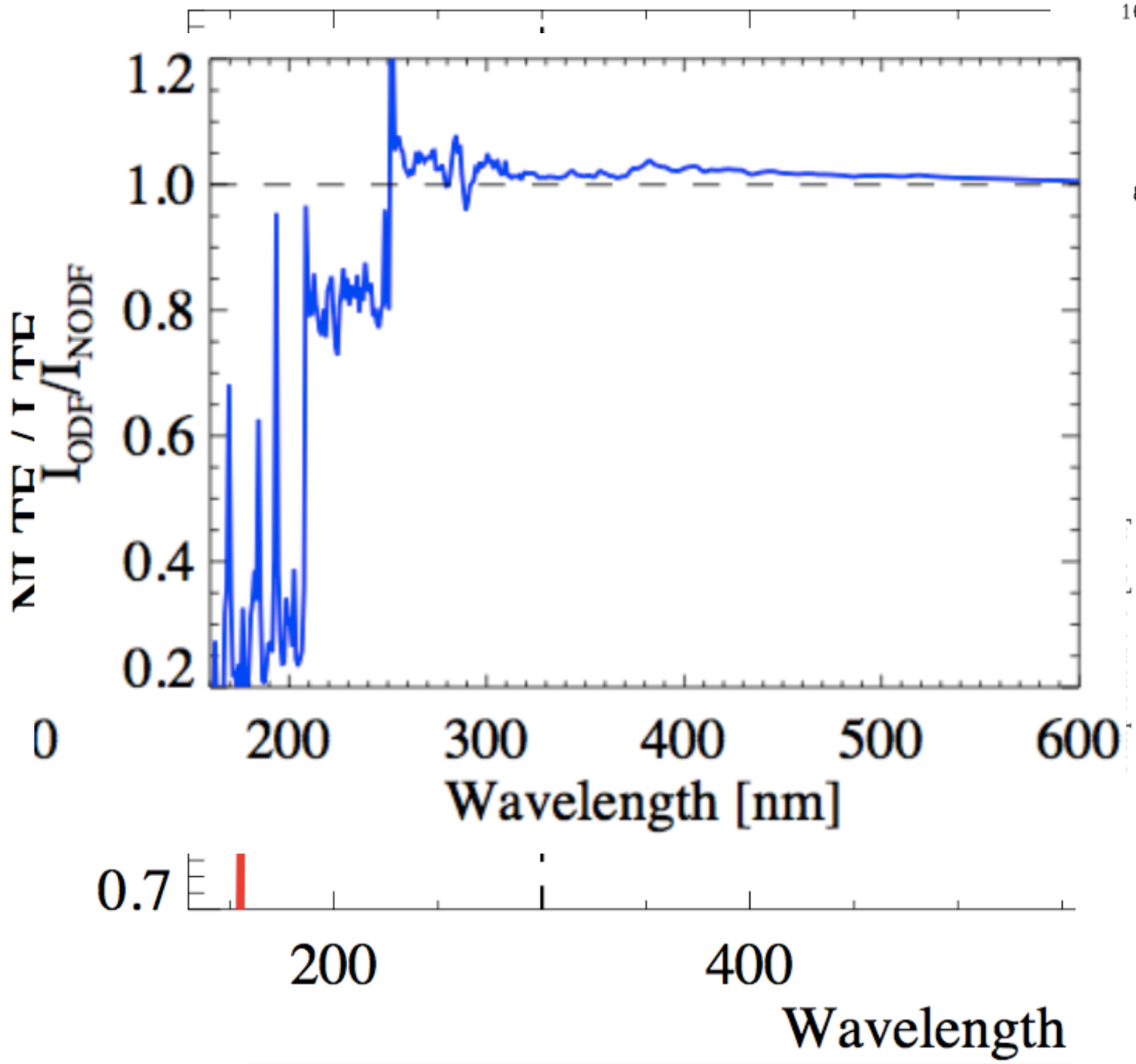
Calculations with NLTE code for Spectrum SYnthesis (NESSY)

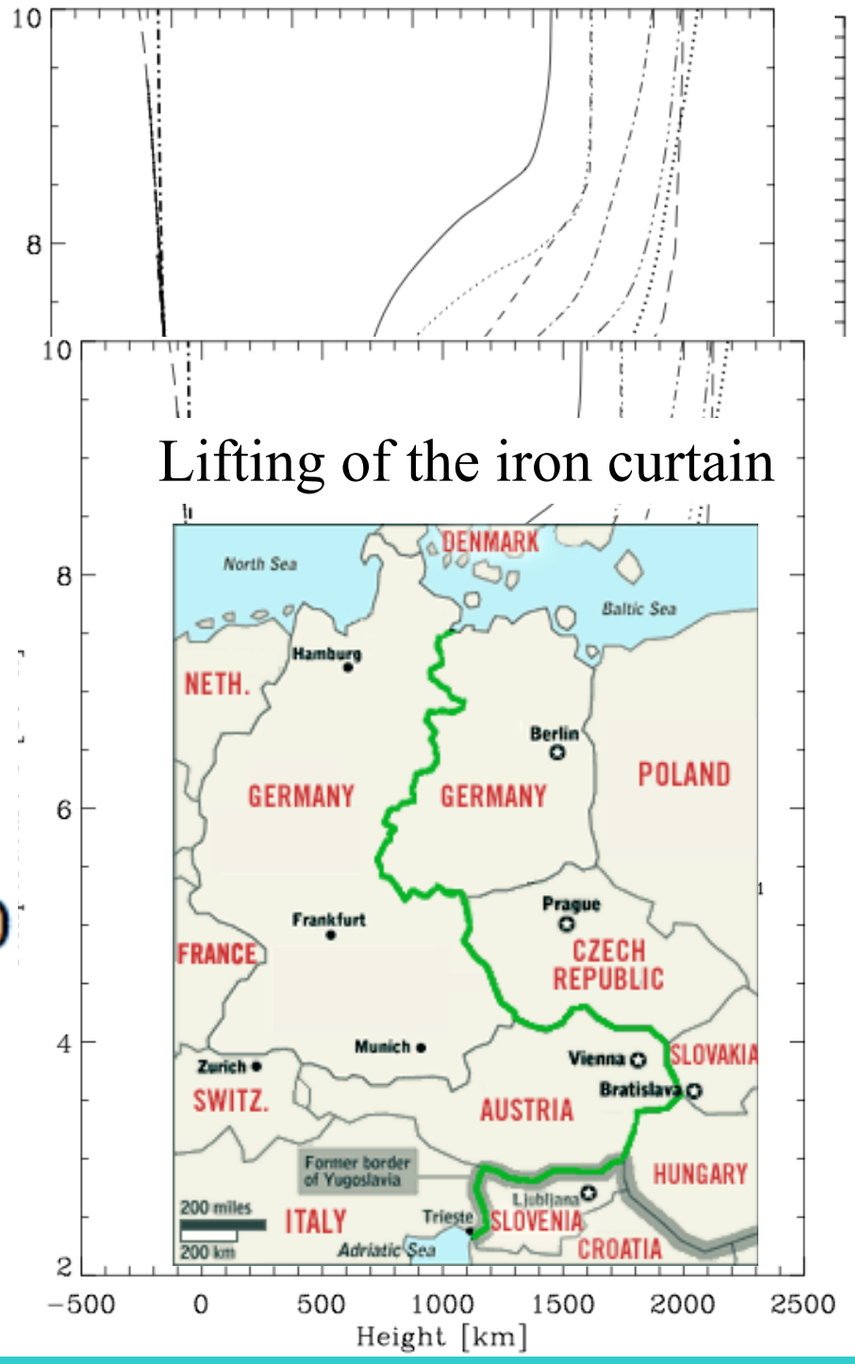




Effect of the NLTE on the absolute SSI level

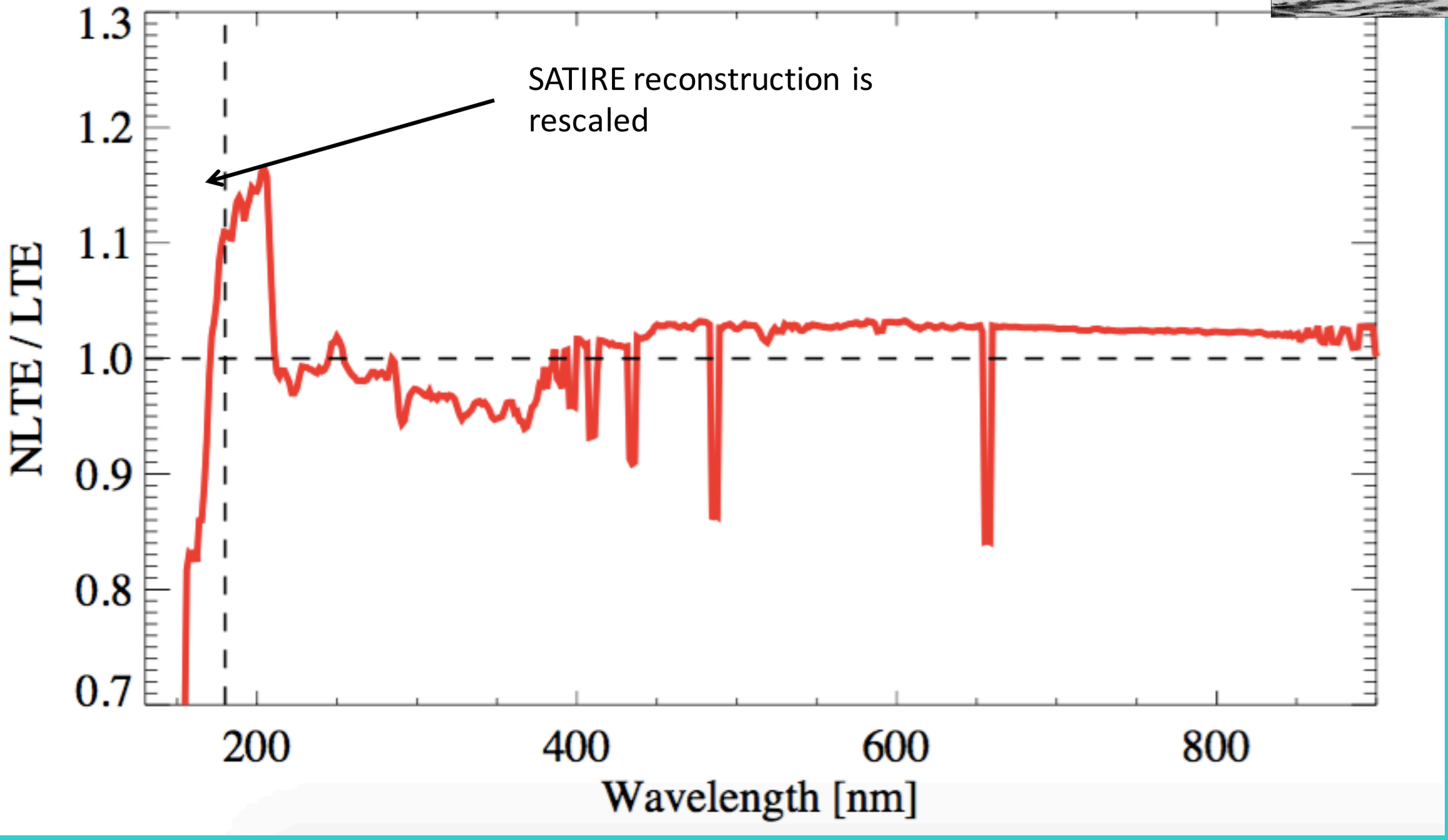
Calculations with NLTE code for Spectrum SYnthesis (NESSY)





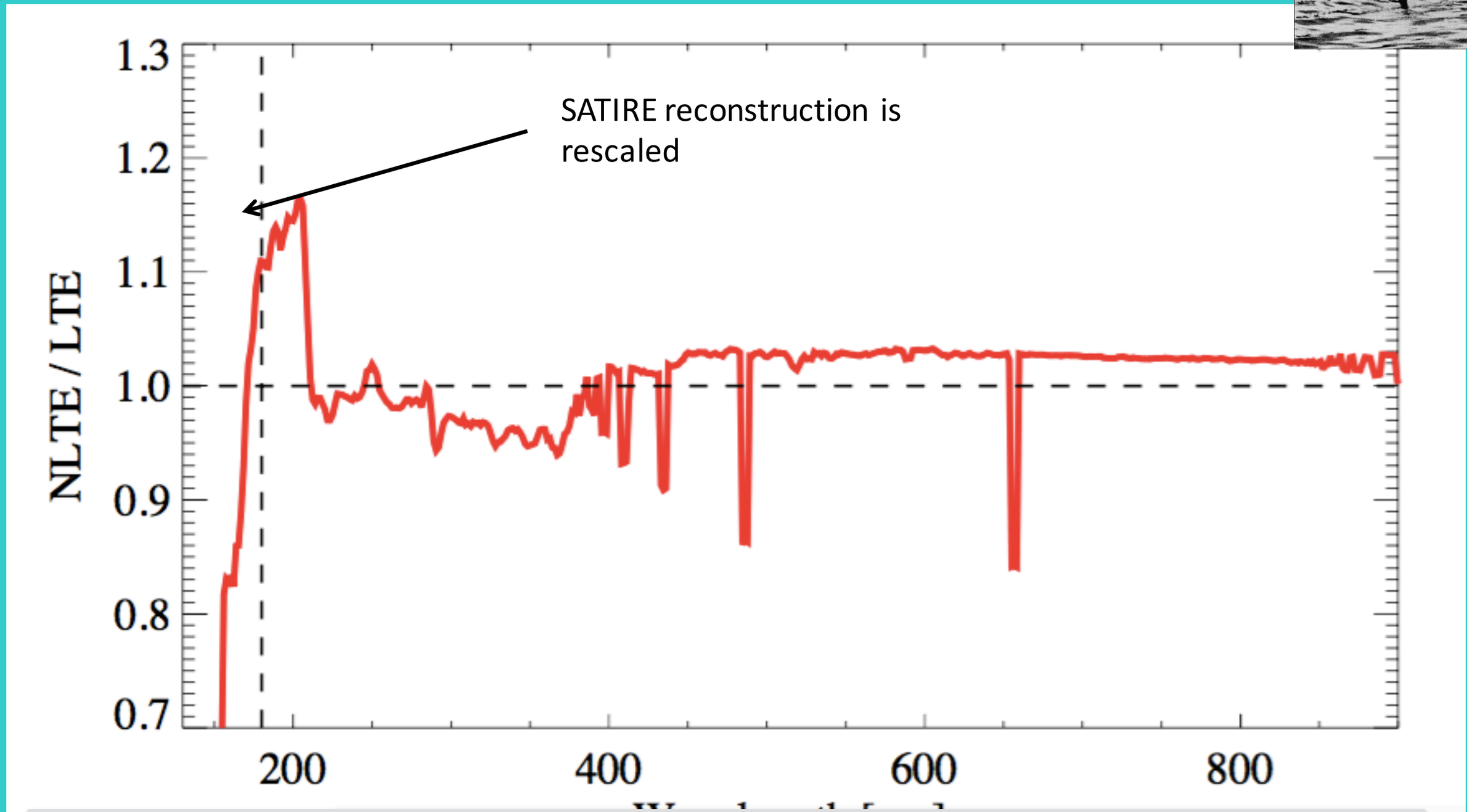
Effect of the NLTE on the facular contrast and SSI variability

Calculations with NLTE code for Spectrum SYnthesis (NESSY)



Effect of the NLTE on the facular contrast and SSI variability

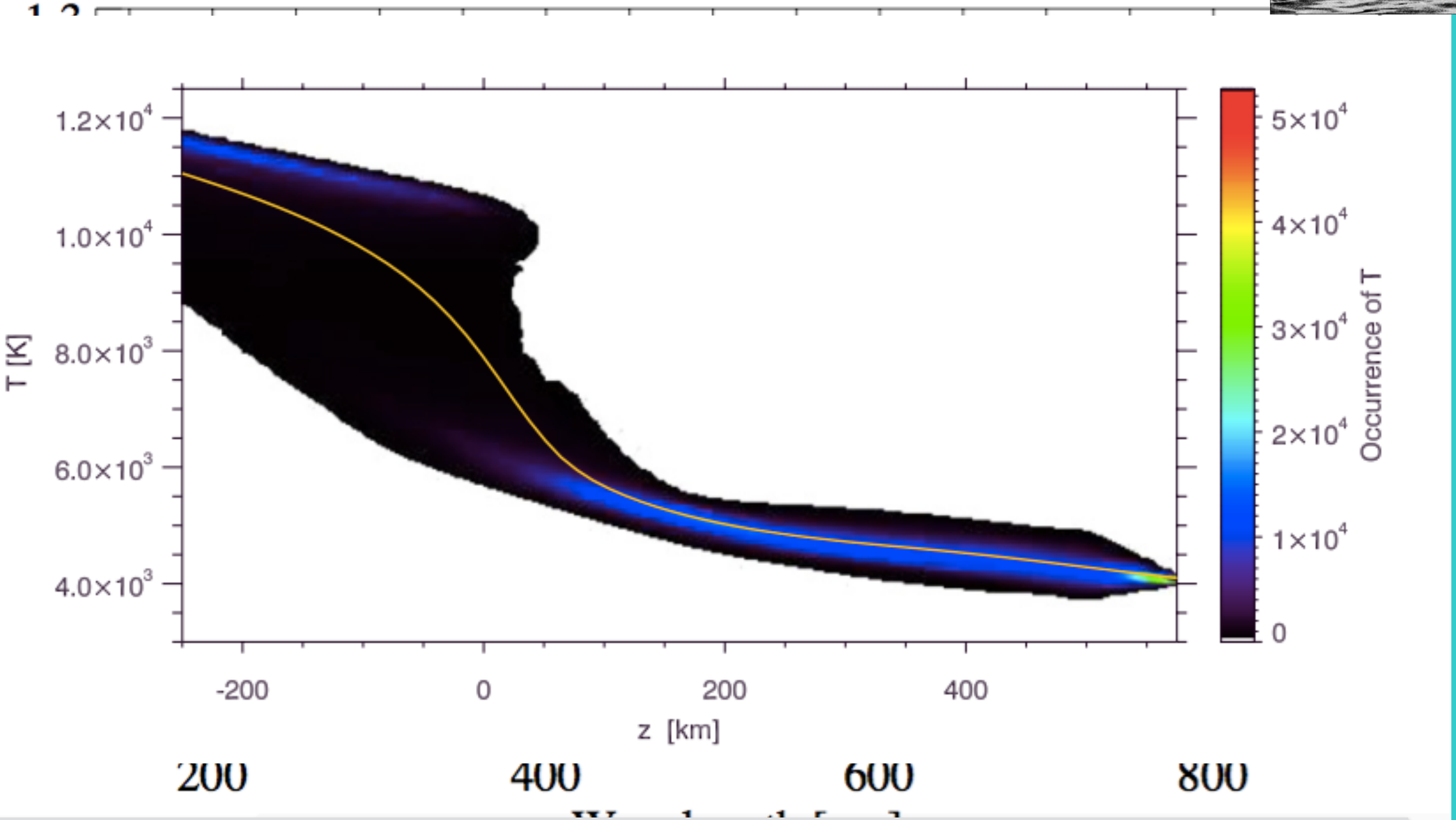
Calculations with NLTE code for Spectrum SYnthesis (NESSY)



Static 1D modeling of the continua from the solar atmosphere has reached such sophistication that even the modelers themselves may misinterpret their results (Rutten & Uitenbroek 2012)

Effect of the NLTE on the facular contrast and SSI variability

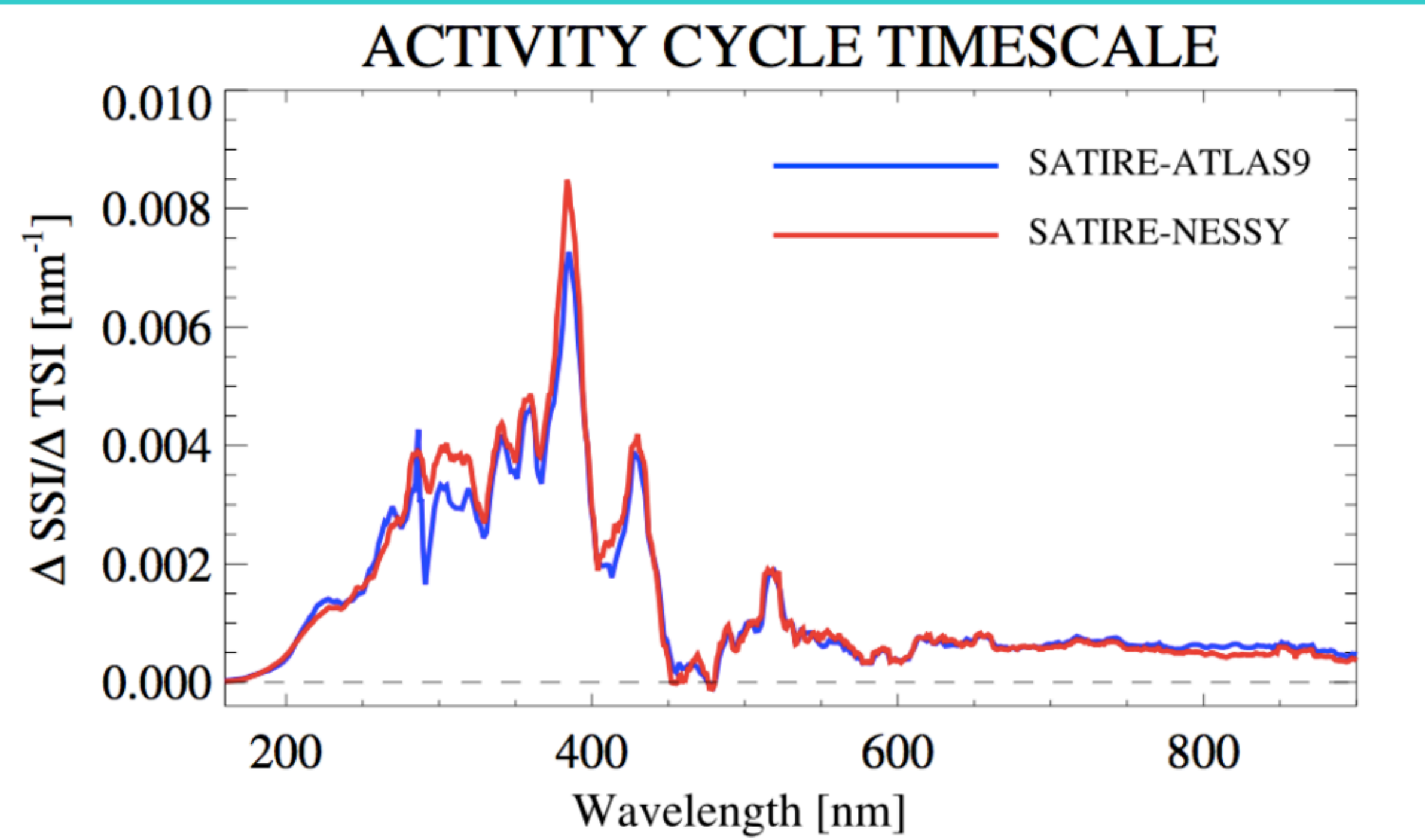
Calculations with NLTE code for Spectrum SYnthesis (NESSY)



200 400 600 800

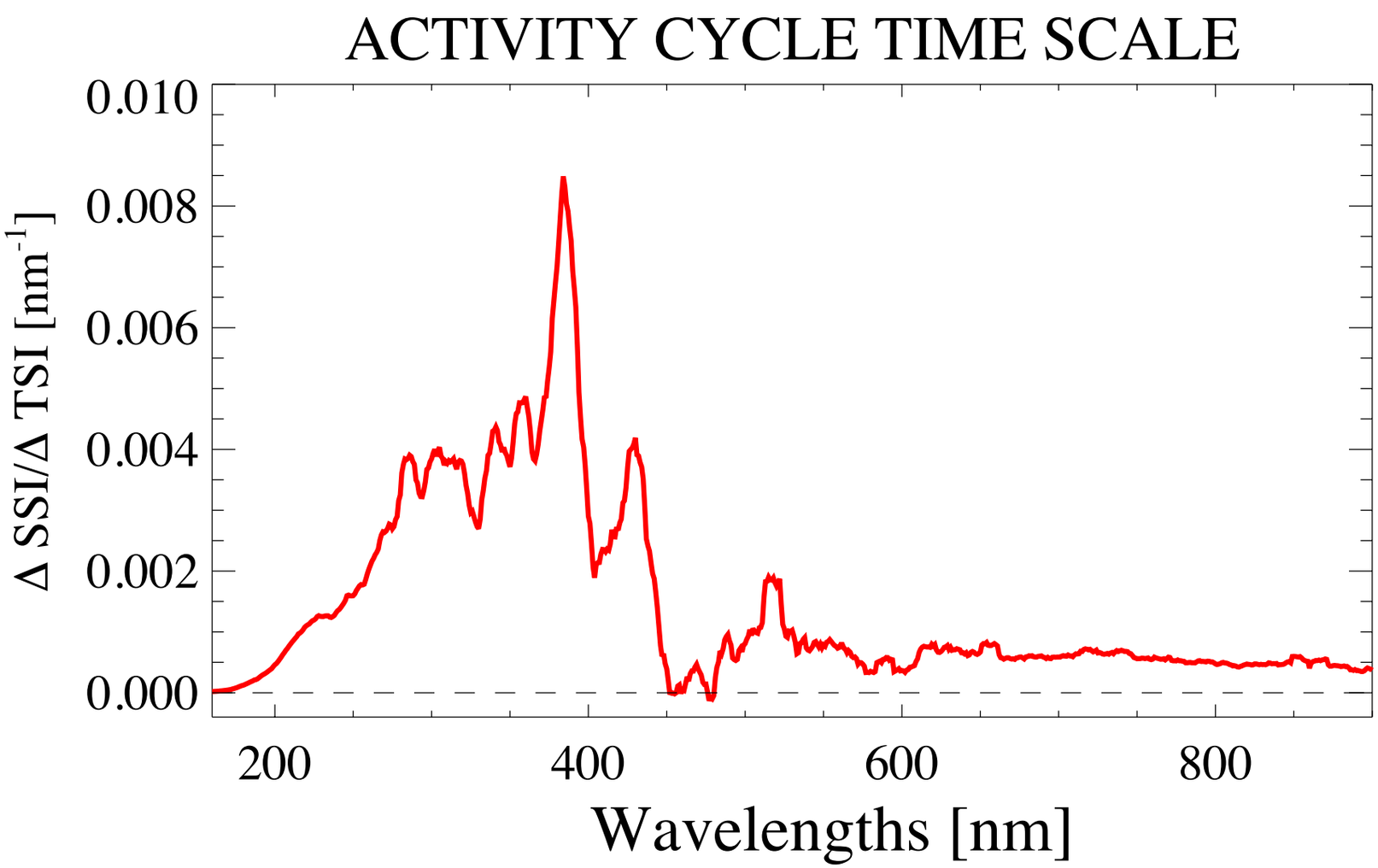
Static 1D modeling of the continua from the solar atmosphere has reached such sophistication that even the modelers themselves may misinterpret their results (Rutten & Uitenbroek 2012)

SATIRE-ATLAS9 vs SATIRE-NESSY

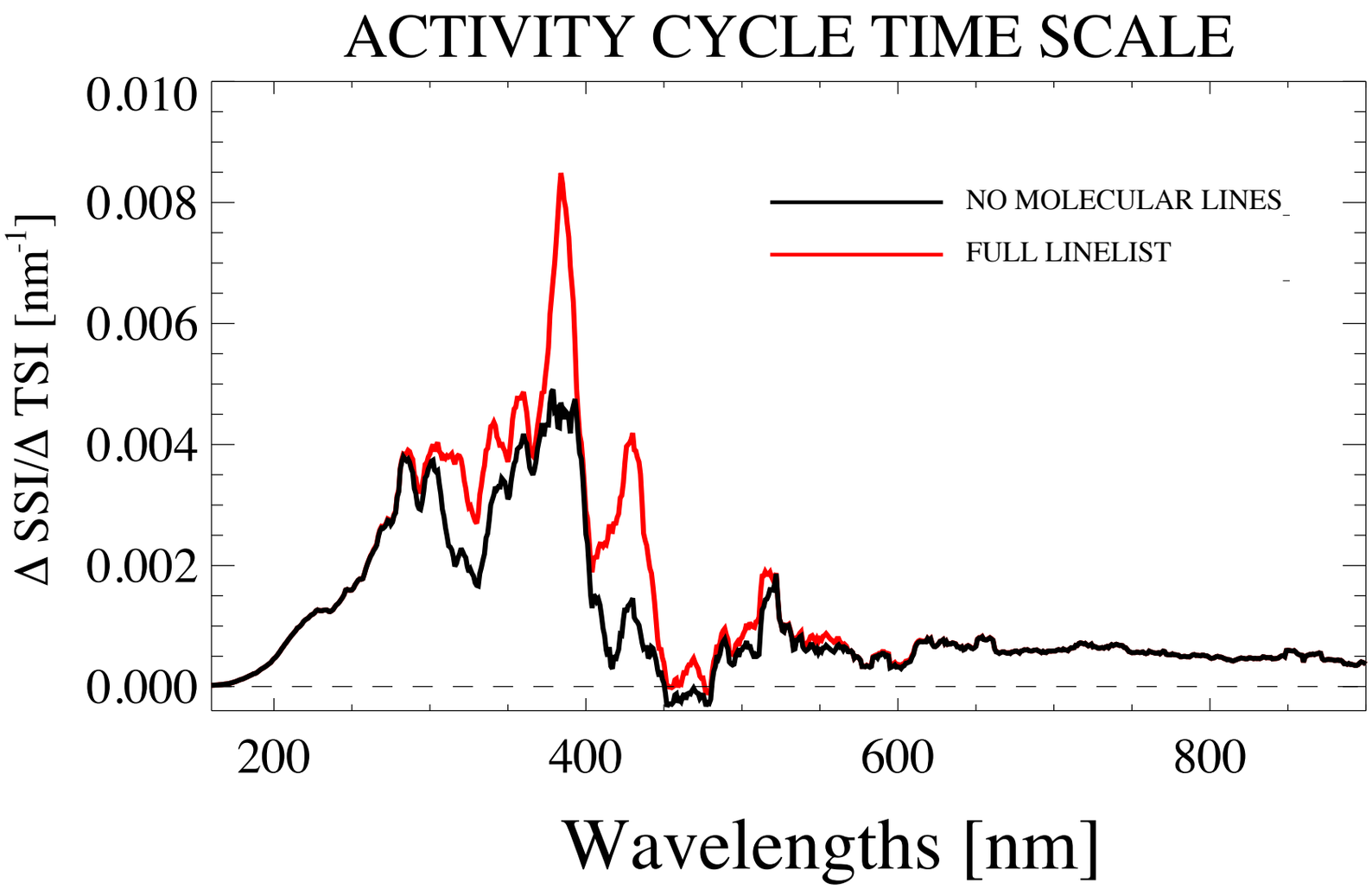


$$\frac{\Delta SSI}{\Delta TSI}(\lambda) = \frac{< SSI(\lambda, t) >_{2002} - < SSI(\lambda, t) >_{2008}}{< TSI(t) >_{2002} - < TSI(t) >_{2008}}$$

$$\frac{\Delta \mathrm{SSI}}{\Delta \mathrm{TSI}}(\lambda) = \frac{< \mathrm{SSI}(\lambda, t) >_{2002} - < \mathrm{SSI}(\lambda, t) >_{2008}}{< \mathrm{TSI}(t) >_{2002} - < \mathrm{TSI}(t) >_{2008}}$$



$$\frac{\Delta \mathrm{SSI}}{\Delta \mathrm{TSI}}(\lambda) = \frac{< \mathrm{SSI}(\lambda, t) >_{2002} - < \mathrm{SSI}(\lambda, t) >_{2008}}{< \mathrm{TSI}(t) >_{2002} - < \mathrm{TSI}(t) >_{2008}}$$



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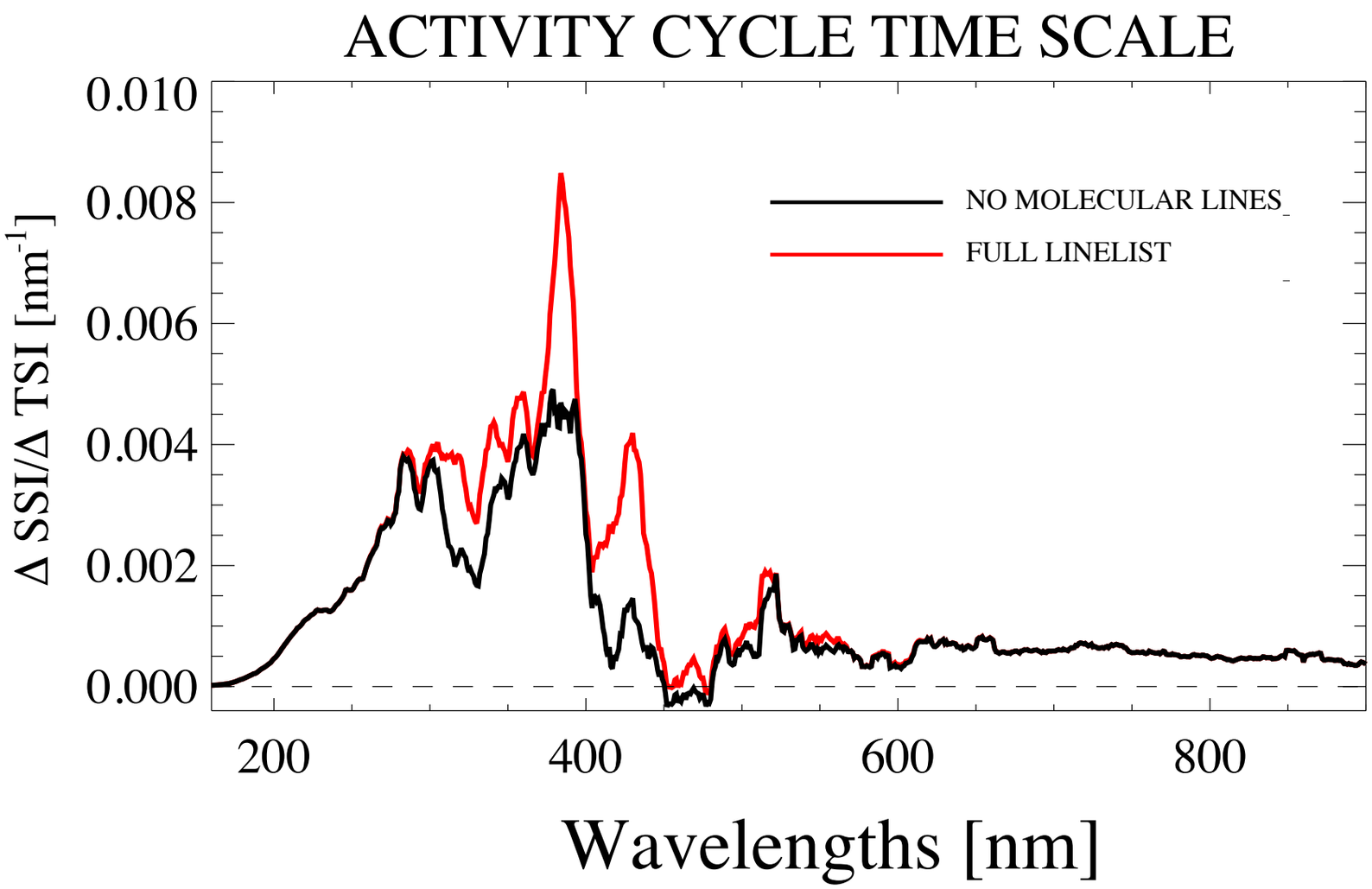
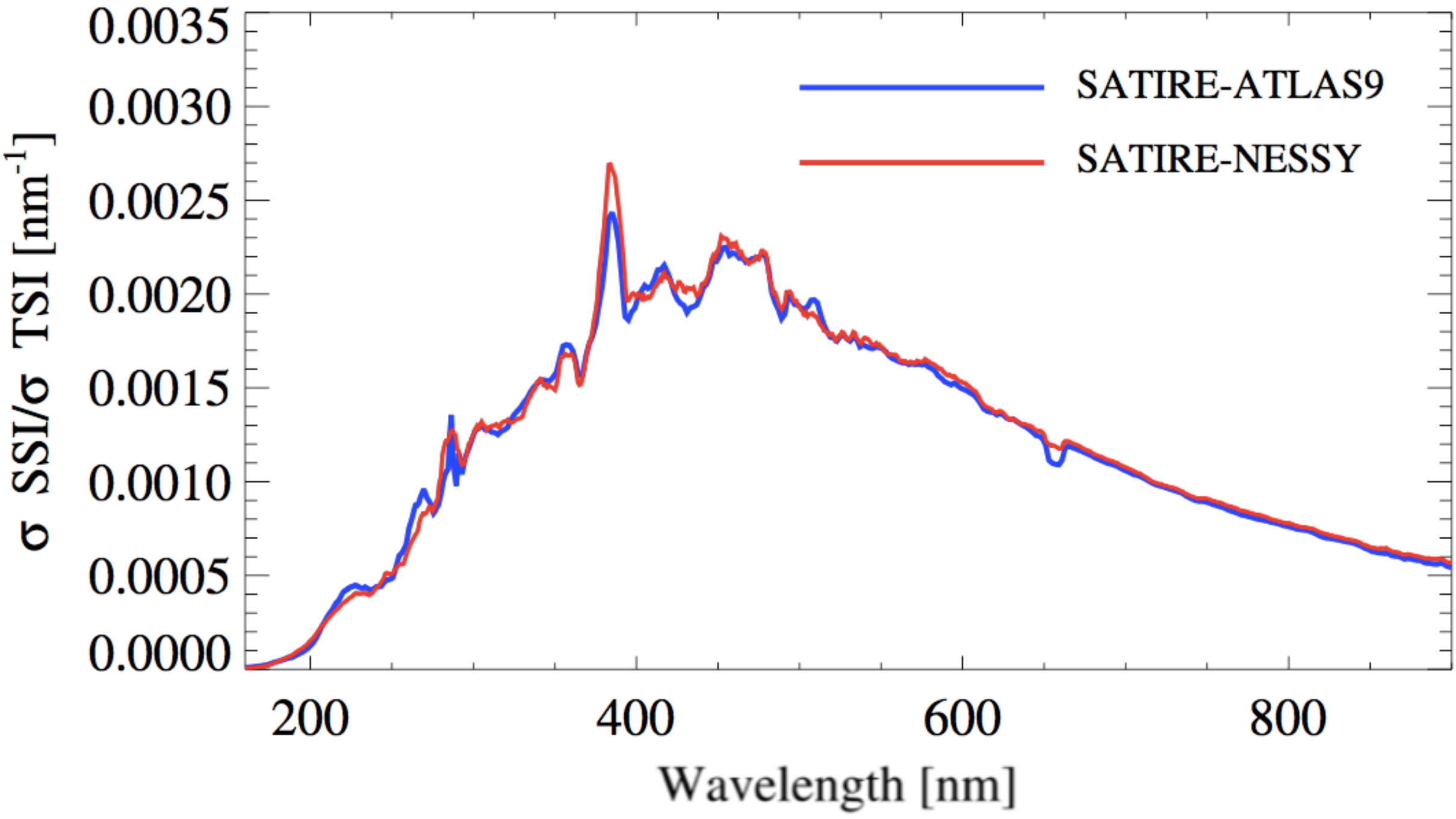


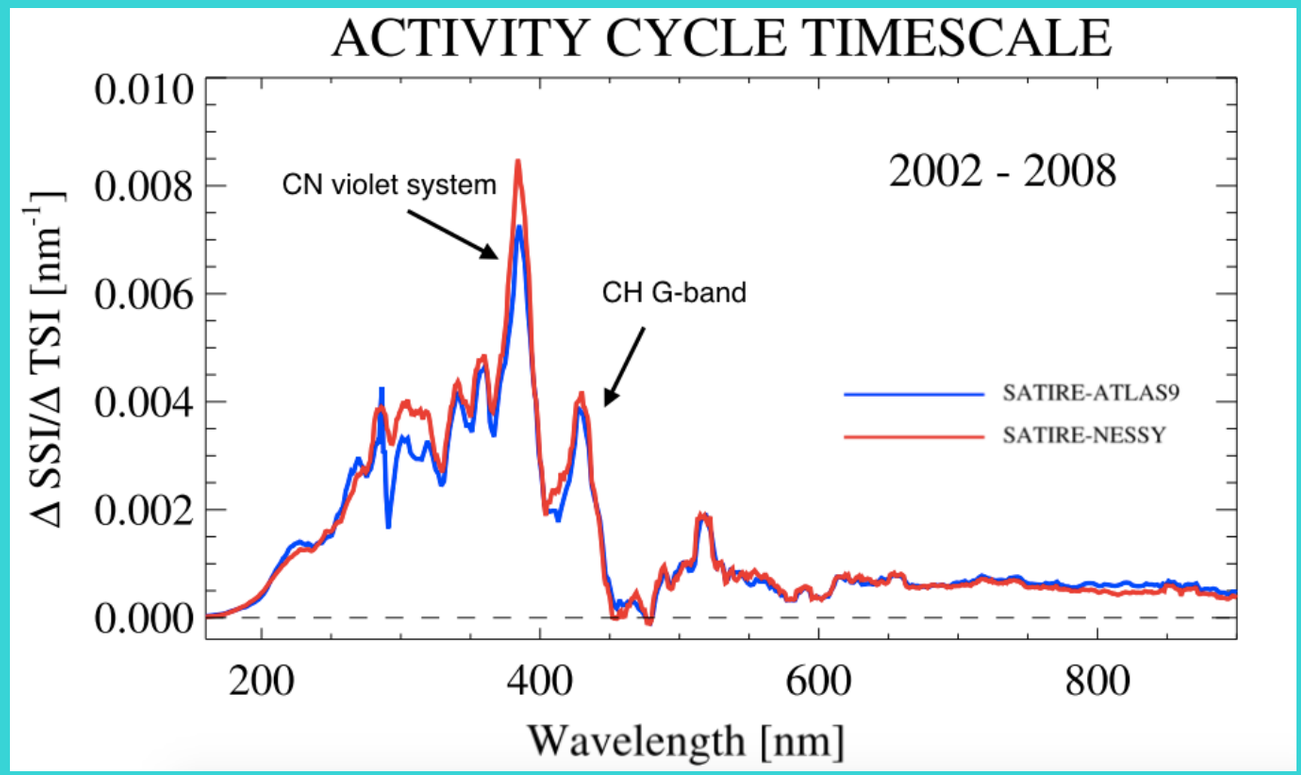
quarter of the TSI variability comes from the molecular lines

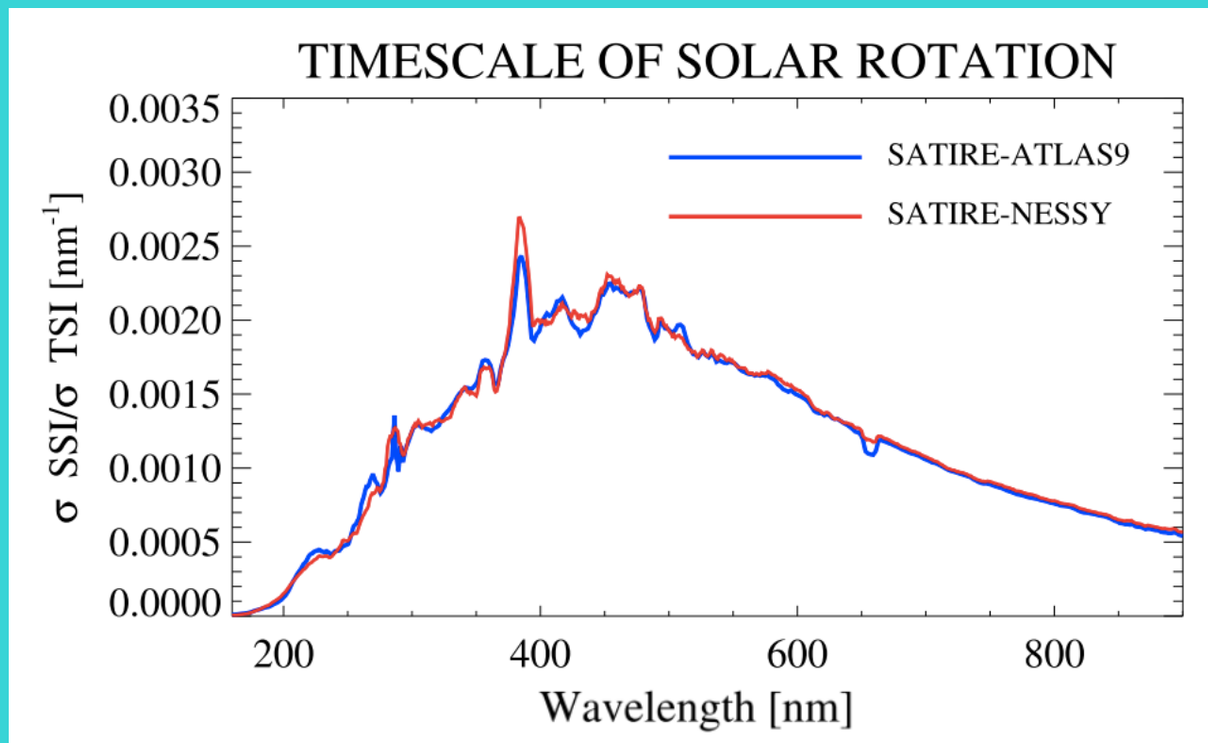
TIMESCALE OF SOLAR ROTATION

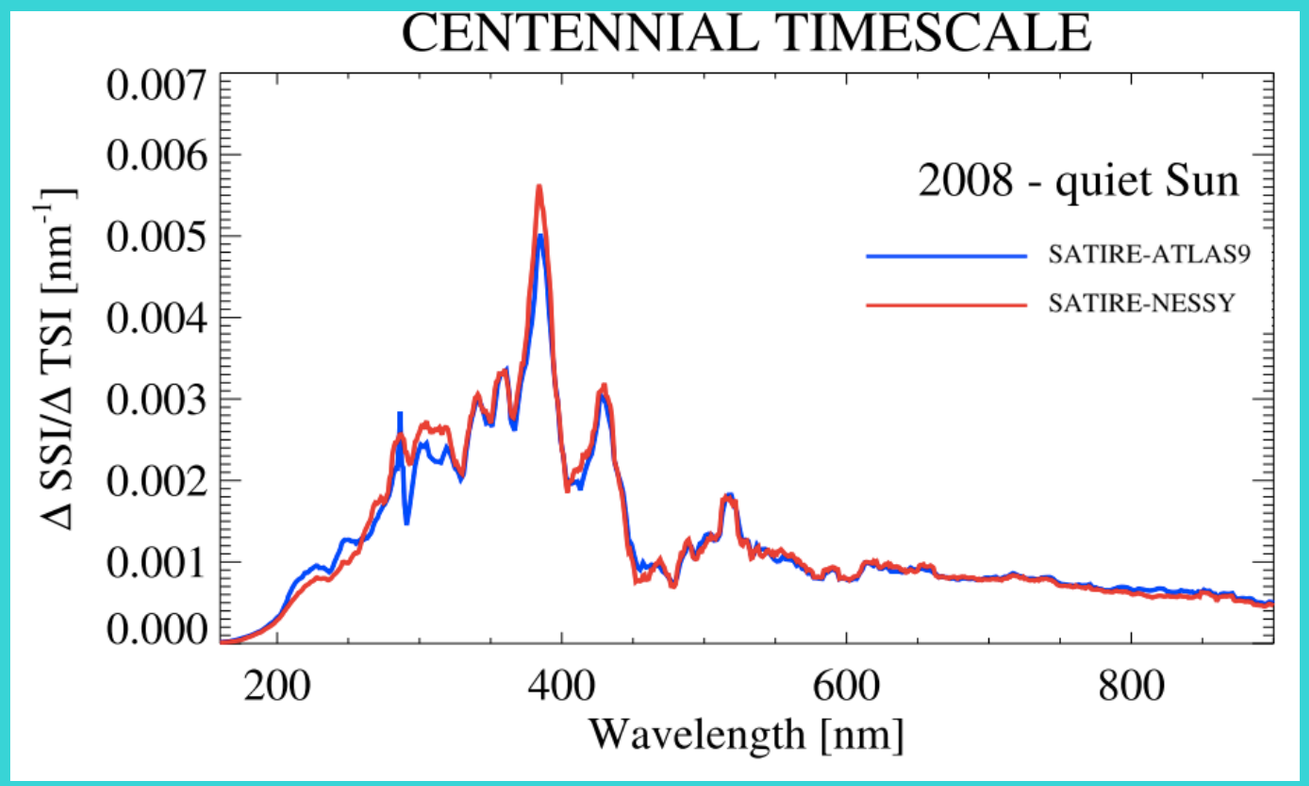


$$\frac{\sigma\mathrm{SSI}}{\sigma\mathrm{TSI}}(\lambda) = \frac{\mathrm{rms}\left(\mathrm{SSI}(\lambda,t) - \langle \mathrm{SSI}(\lambda,t)\rangle_{81}\right)}{\mathrm{rms}\left(\mathrm{TSI}(t) - \langle \mathrm{TSI}(t)\rangle_{81}\right)},$$

Various timescales of the irradiance variability







Model CHRONOS

CHRONOS (Code for the High ResolutiOn recoNstructiOn of Solar spectral irradiance):

CHRONOS = NESSY + filling factors

- Radiation code for the SSI calculations

SSR11: COSI using homogeneous distribution (full disk approach)

CHRONOS: NESSY (Tagirov et al., 2016), using activity belts for spots and plages.

- Calculation of the filling factors

SSR11: Linear relation to SSN for spots and plages.

CHRONOS: Linear/nonlinear relation to SSN for umbra/penumbra and plages.

- Calculation of the quiet Sun irradiance

SSR11: Model A from Fontenla et al. (1999); SMP from (McCracken et al., 2004)

CHRONOS: Model B; SMP from (Steinhilber et al., 2009)

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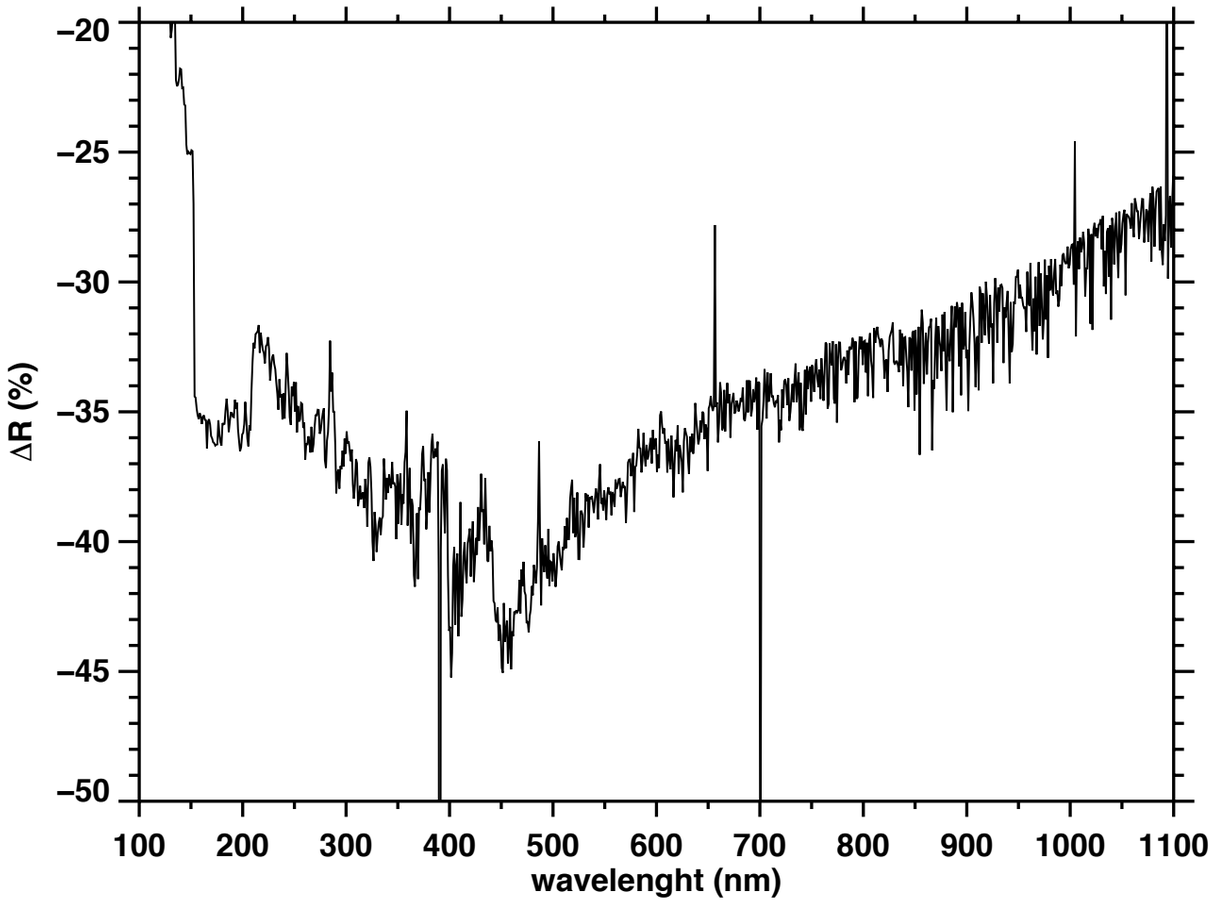
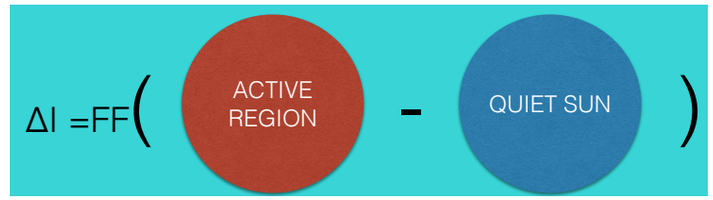
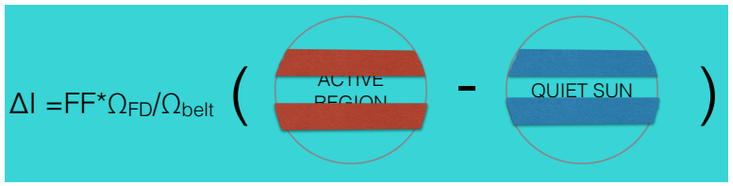
Activity belts for the irradiance calculations

SSR11: homogeneous distribution (full disk approach)





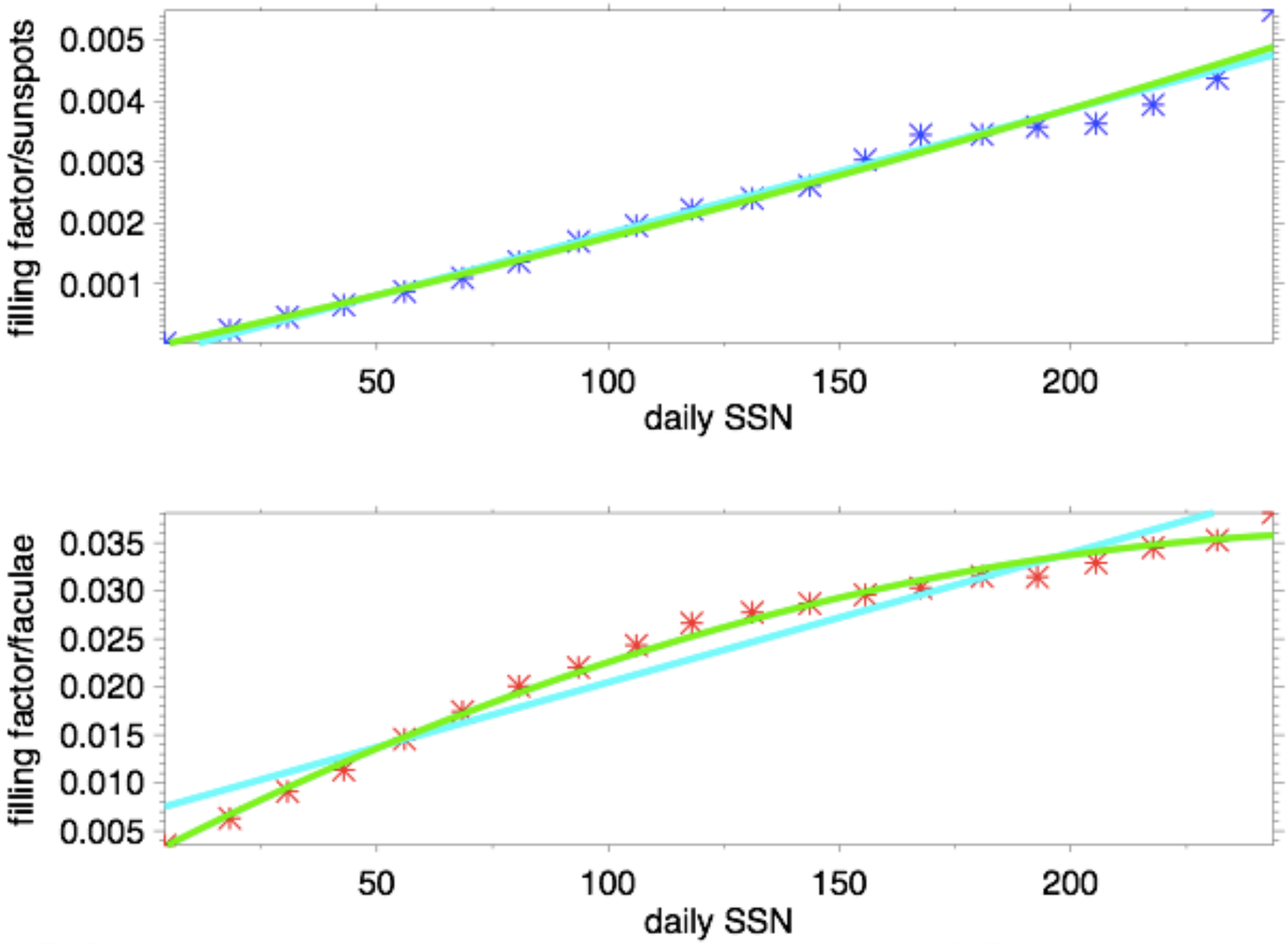


Relative deviation of the facular contribution to the brightening of the Sun (I_{FAC}-I_{QS}) calculated using activity belt approach from full disk model.

CHRONOS: activity belts for spots and plages.

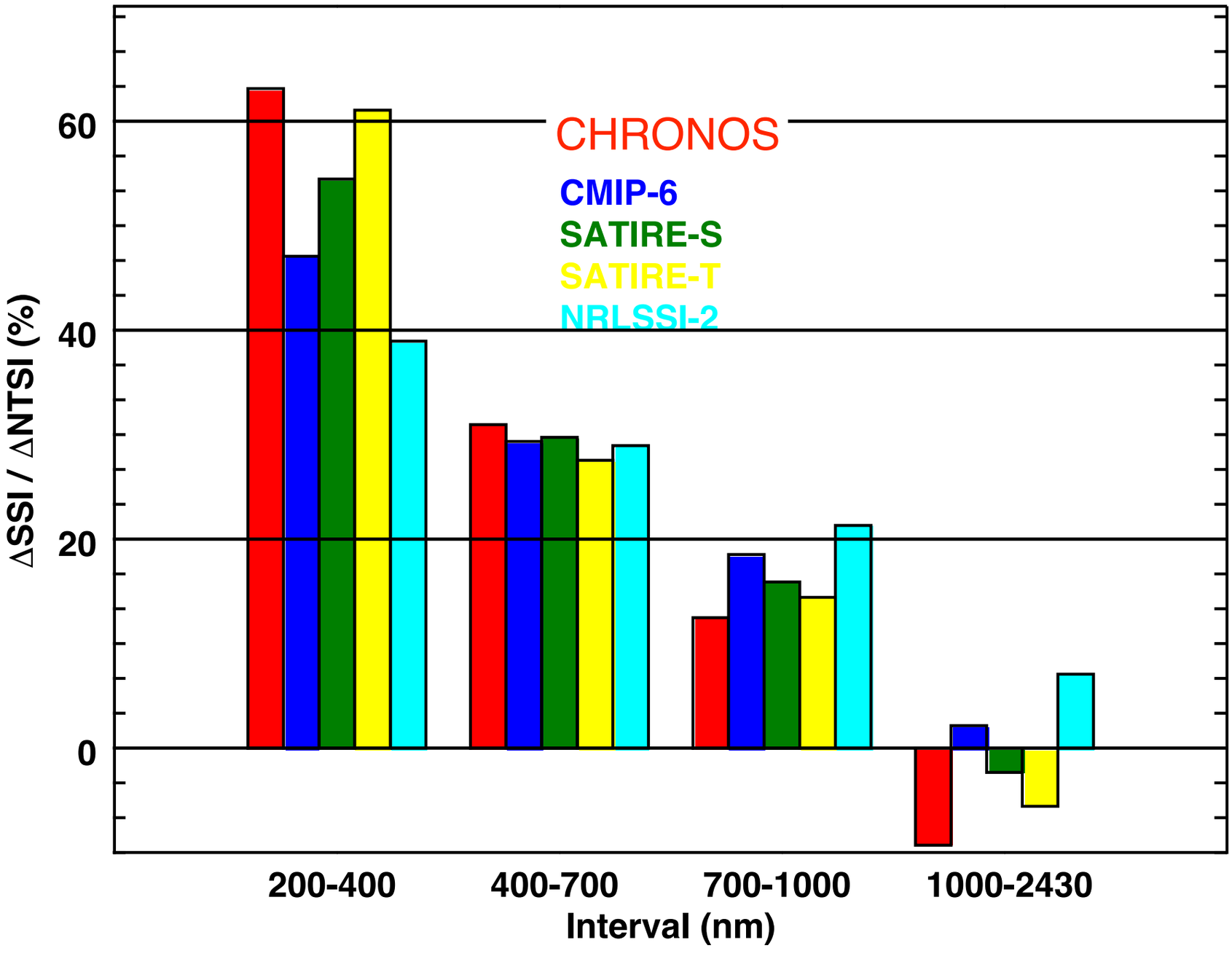
Calculations of the filling factors

SSR11: Linear relation to SSN for spots and plages.



CHRONOS: Linear/nonlinear relation to SSN for umbra/penumbra and plages.

Relative contribution of the UV (200–400 nm), visible (400–700 nm), near-IR (700–1000 nm) and IR (1000–2430 nm) ranges to the TSI change over the solar cycle



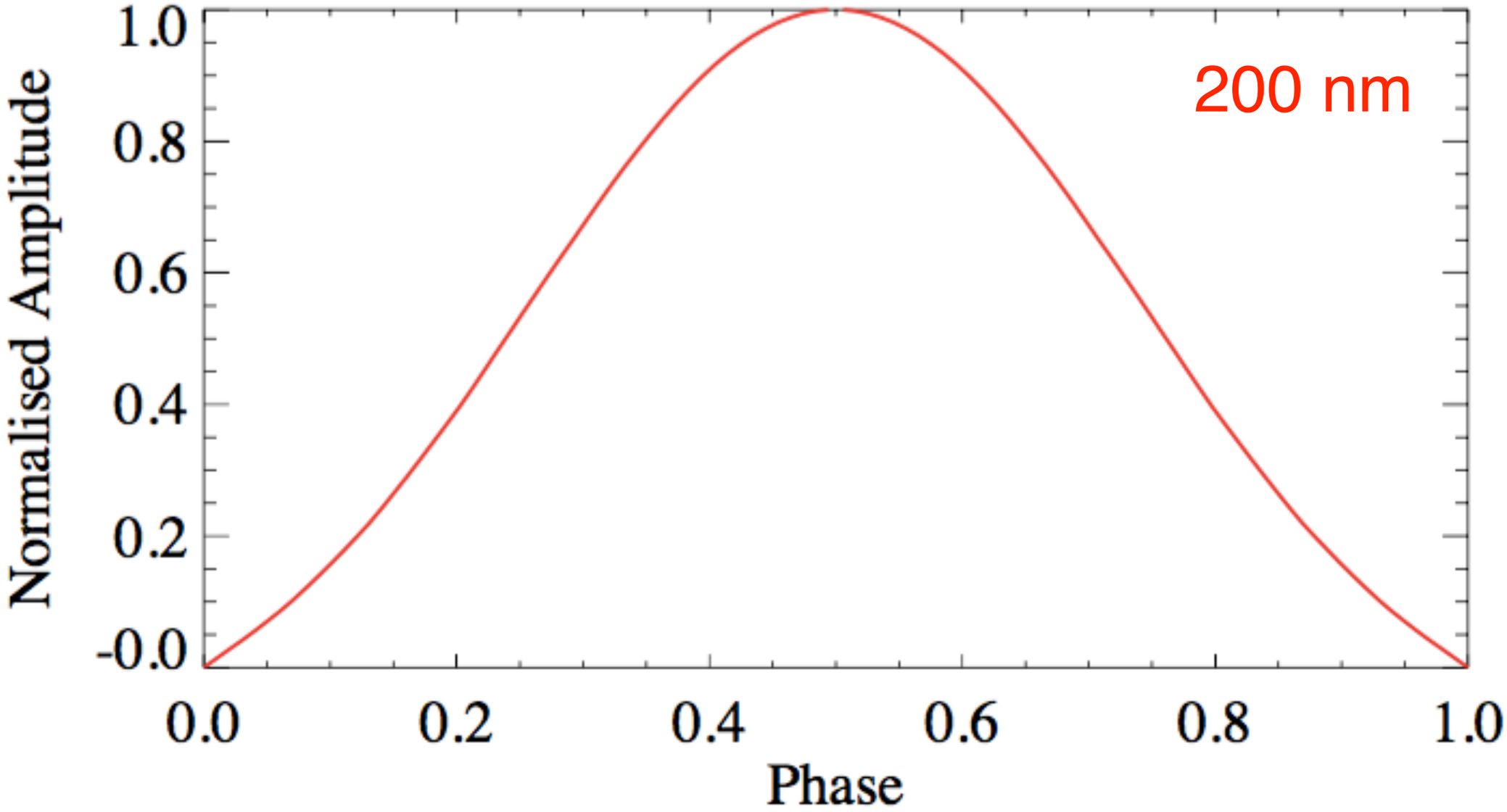
1999-2014

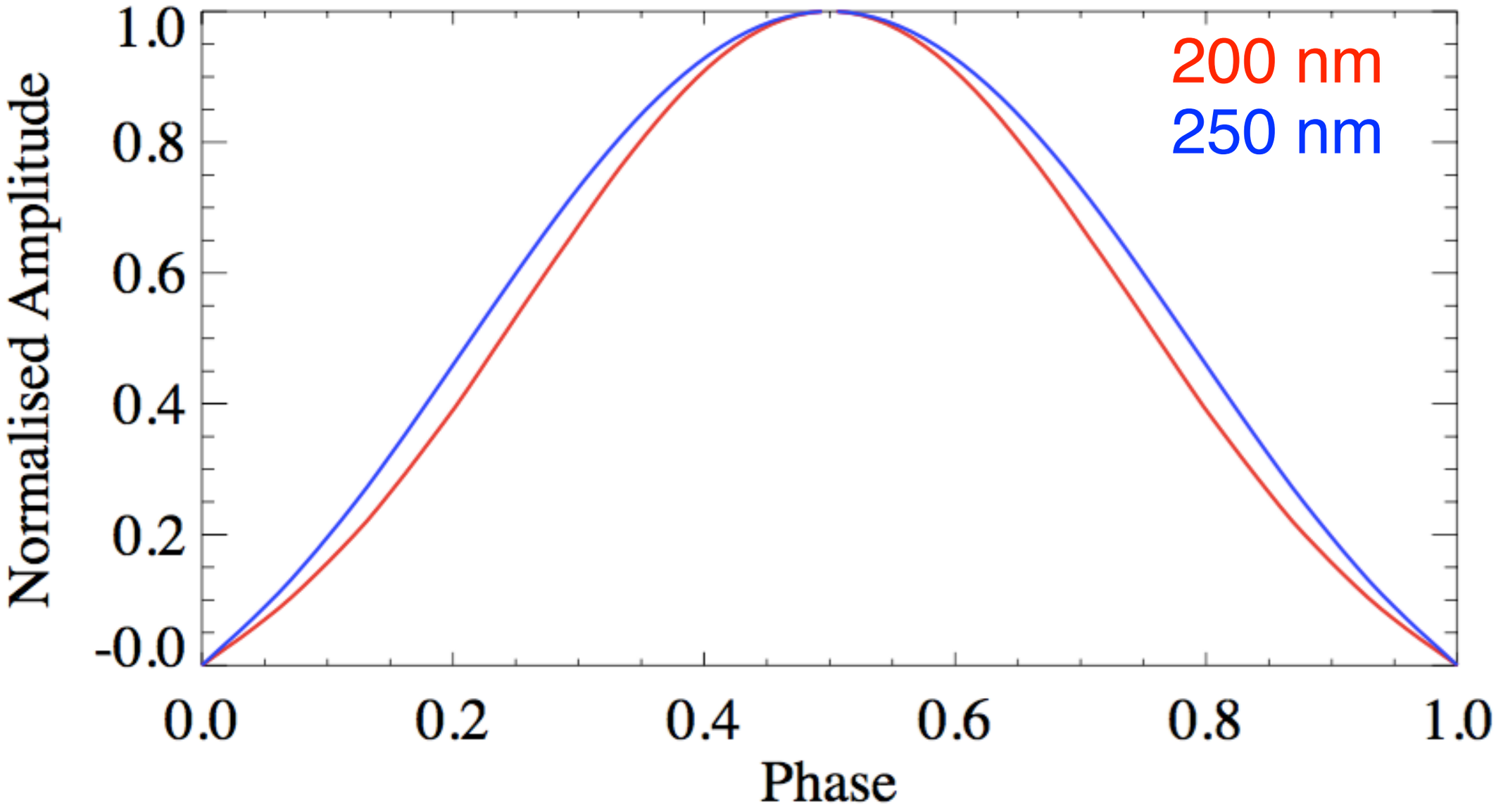
a)

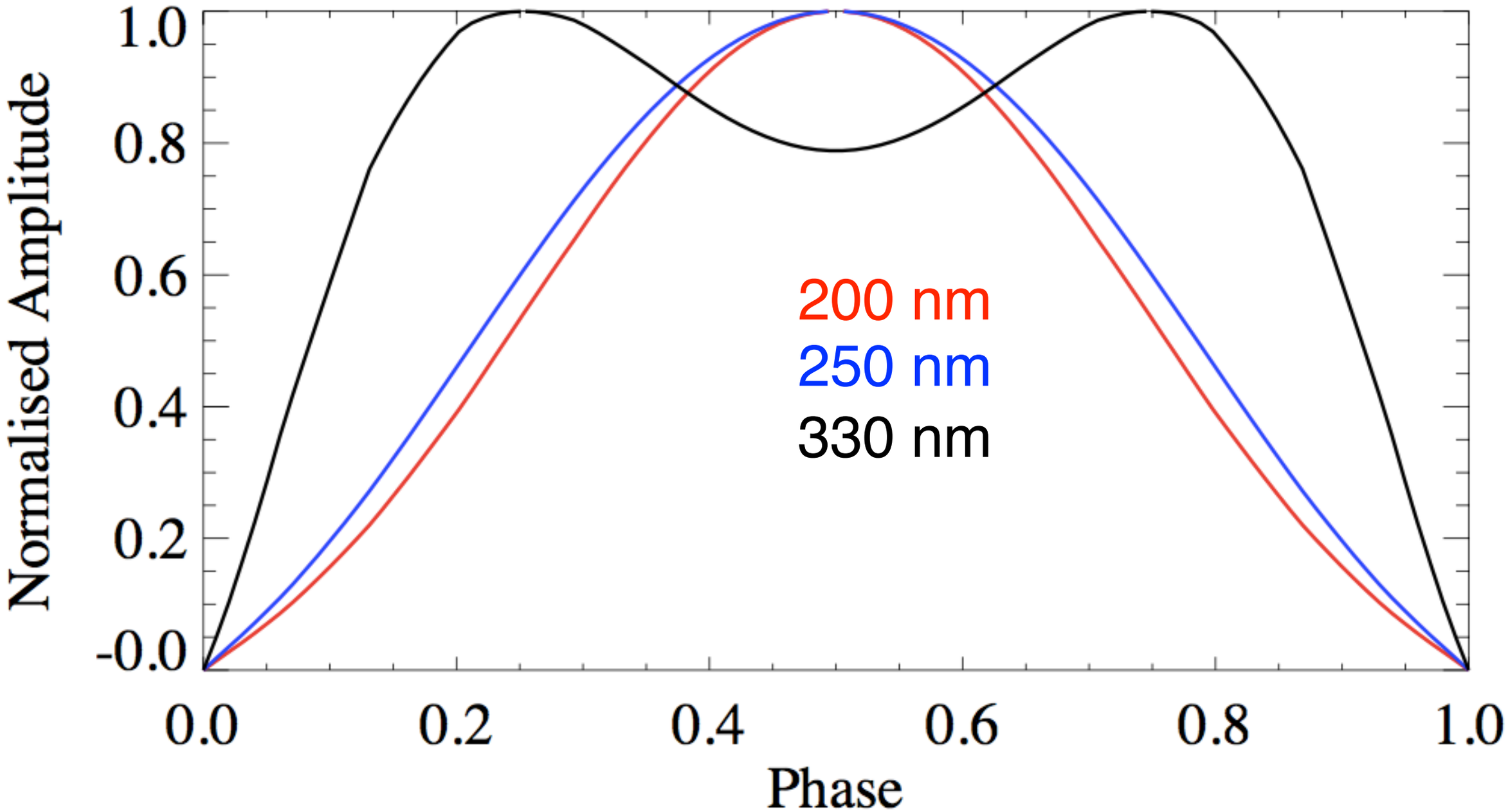
10.0
1.0
0.1
σ SSI [mmag]

100
10
1
Efficiency [%]

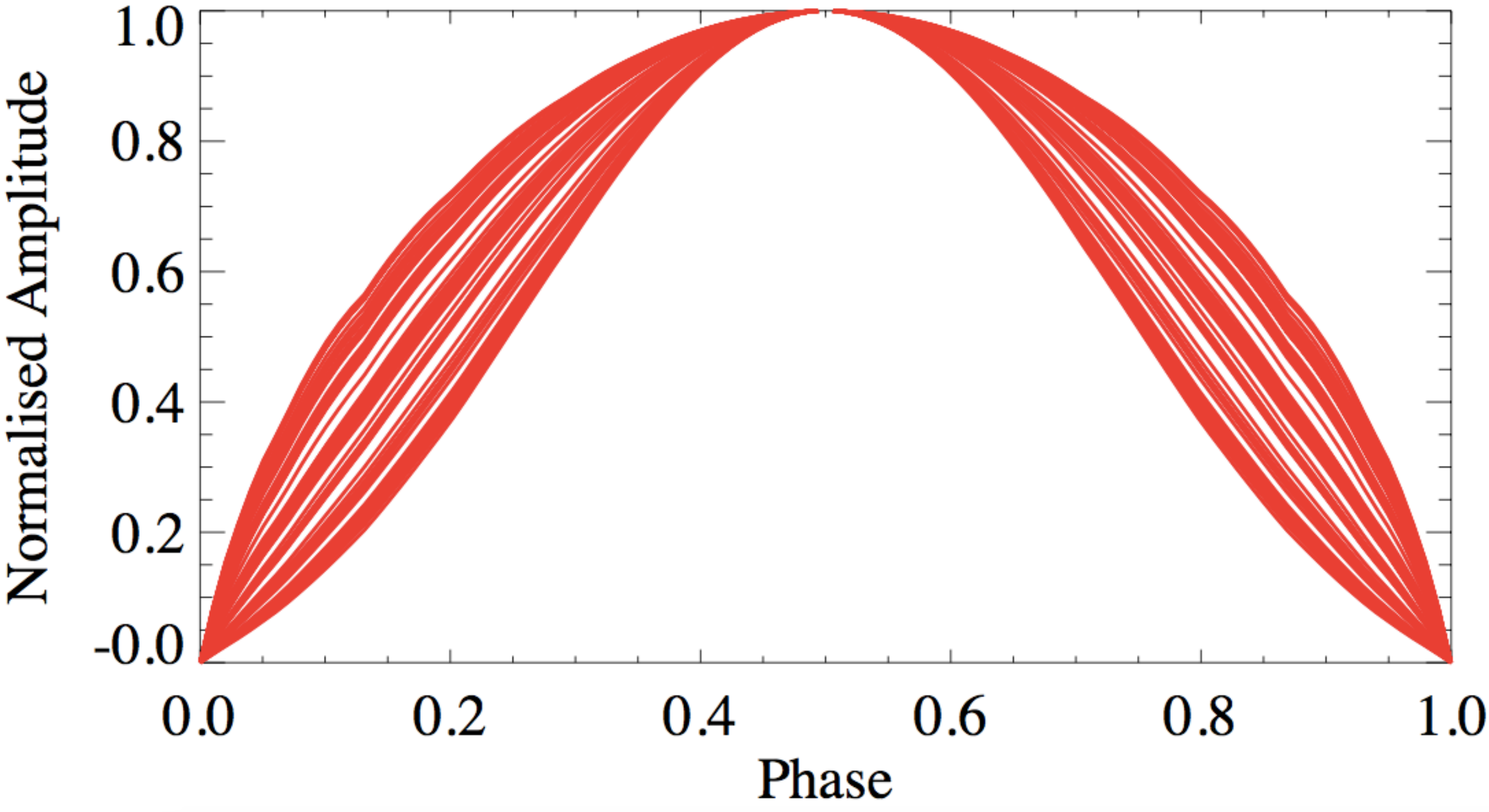
200
300
400
600
800
1000
1200
1400
Wavelength [nm]


200 nm
Normalised Amplitude
1.0
0.8
0.6
0.4
0.2
-0.0
0.0
0.2
0.4
0.6
0.8
1.0
Phase

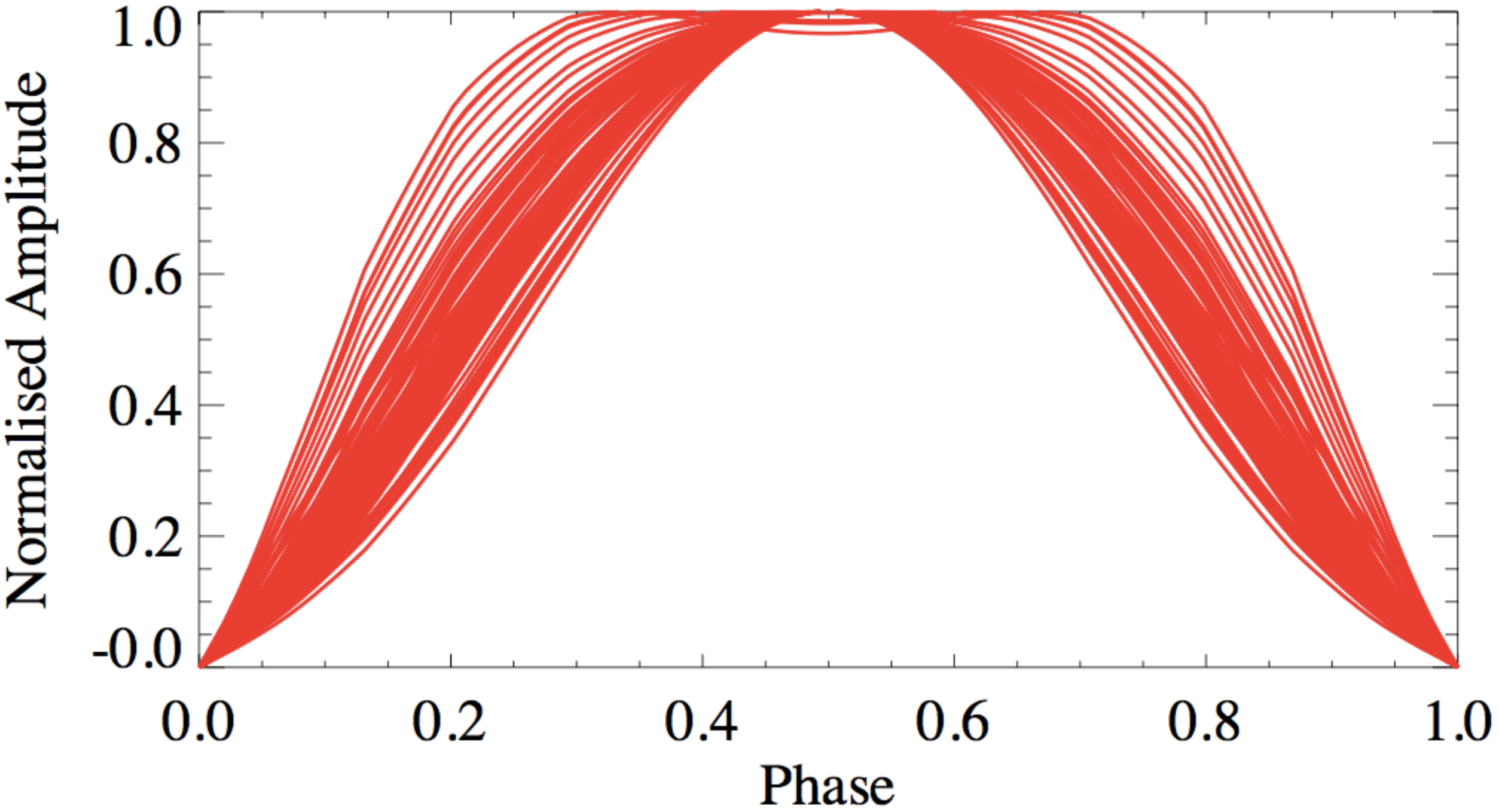

200 nm
250 nm
Normalised Amplitude
1.0
0.8
0.6
0.4
0.2
-0.0
0.0
0.2
0.4
0.6
0.8
1.0
Phase


Normalised Amplitude
1.0
0.8
0.6
0.4
0.2
-0.0
0.0
0.2
0.4
0.6
0.8
1.0
Phase
200 nm
250 nm
330 nm

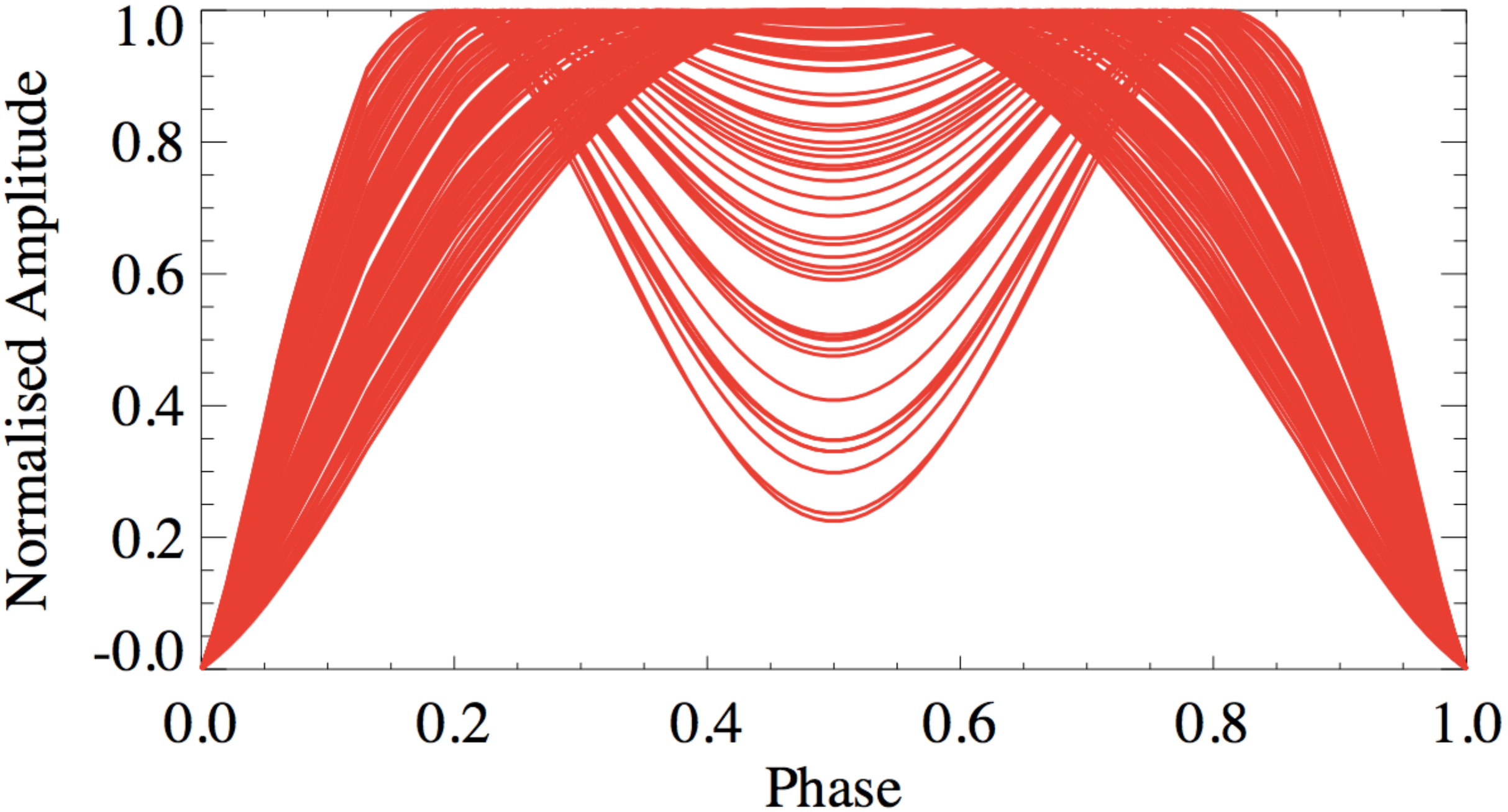
130-200 nm



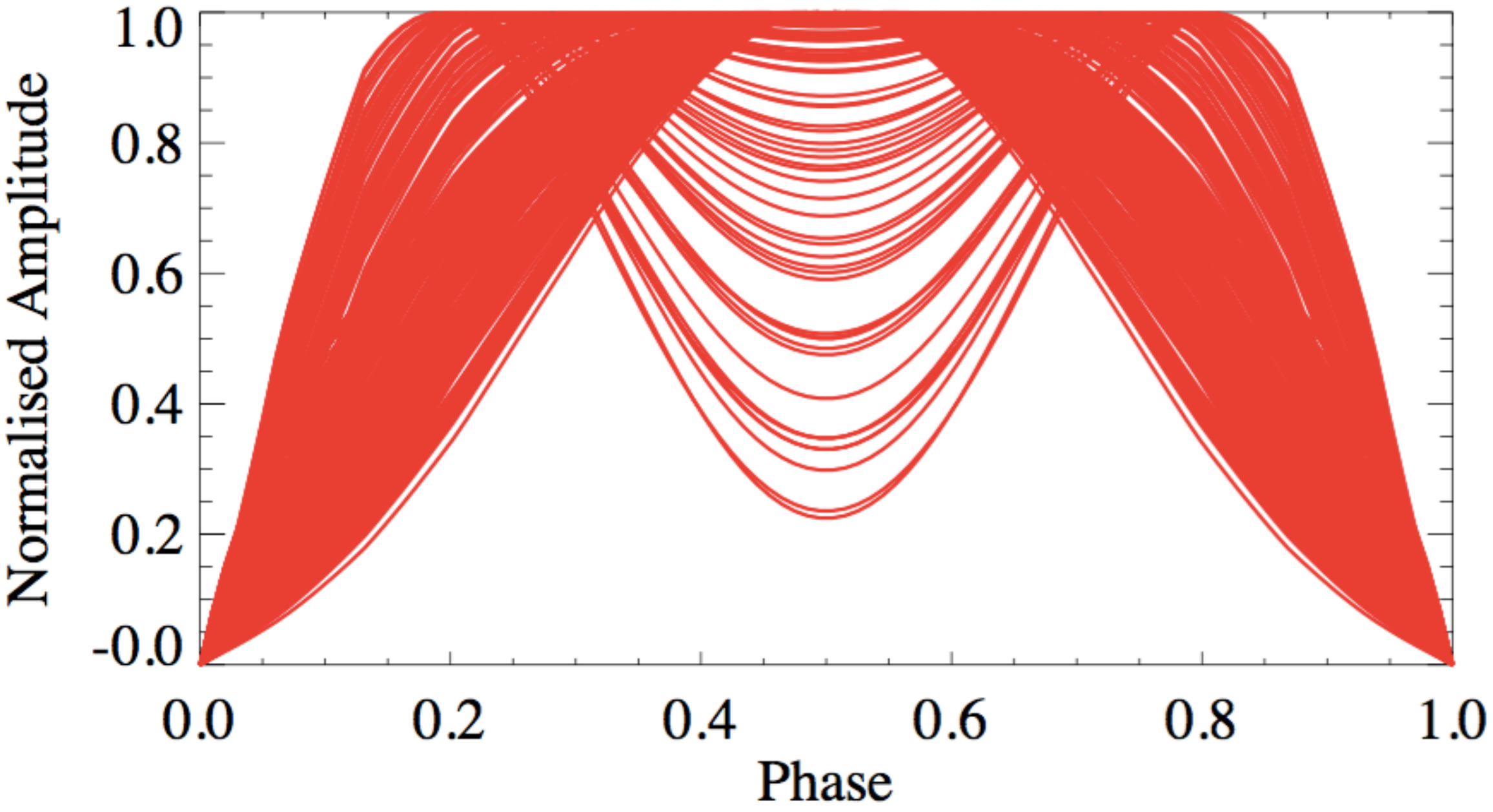
200-300 nm

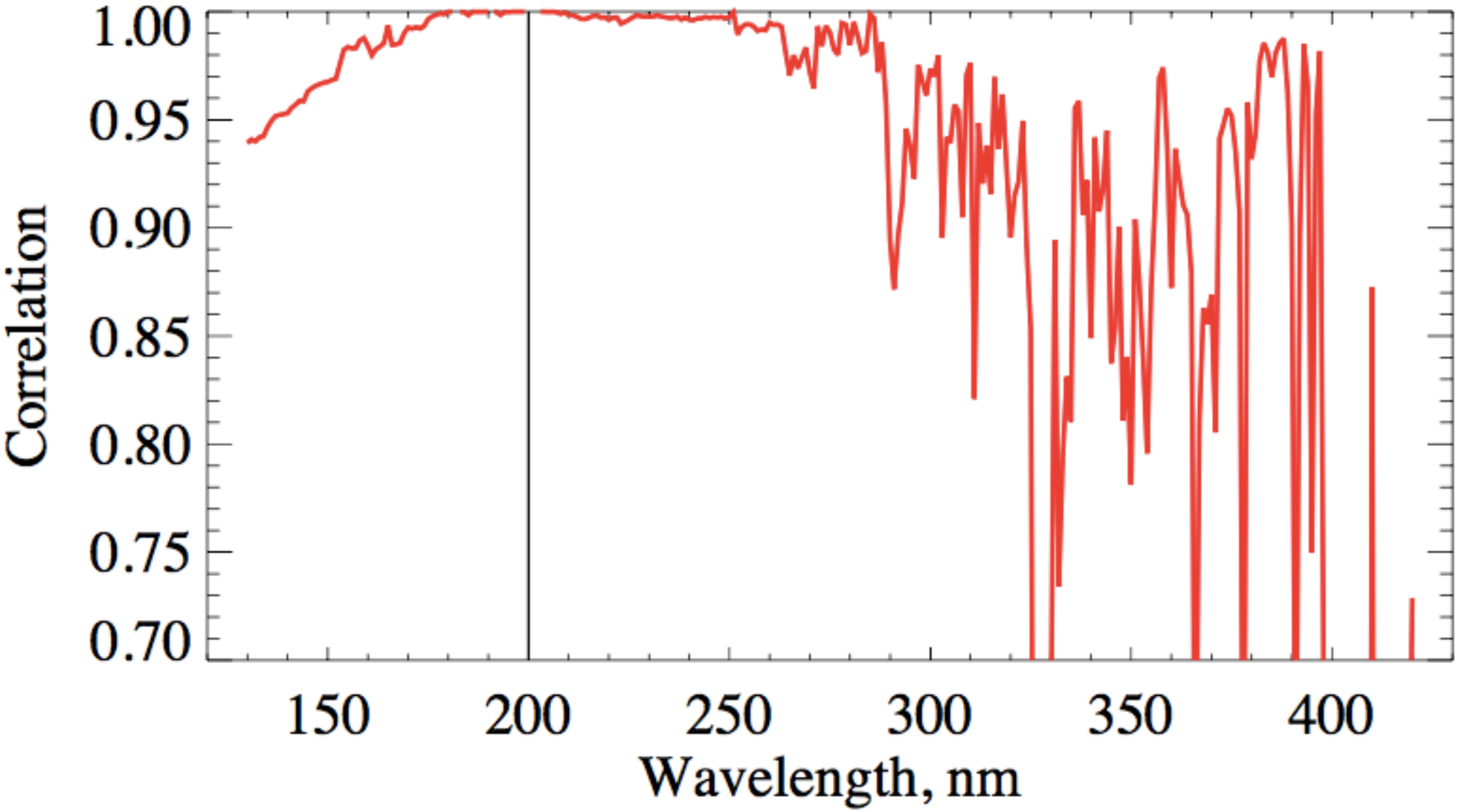


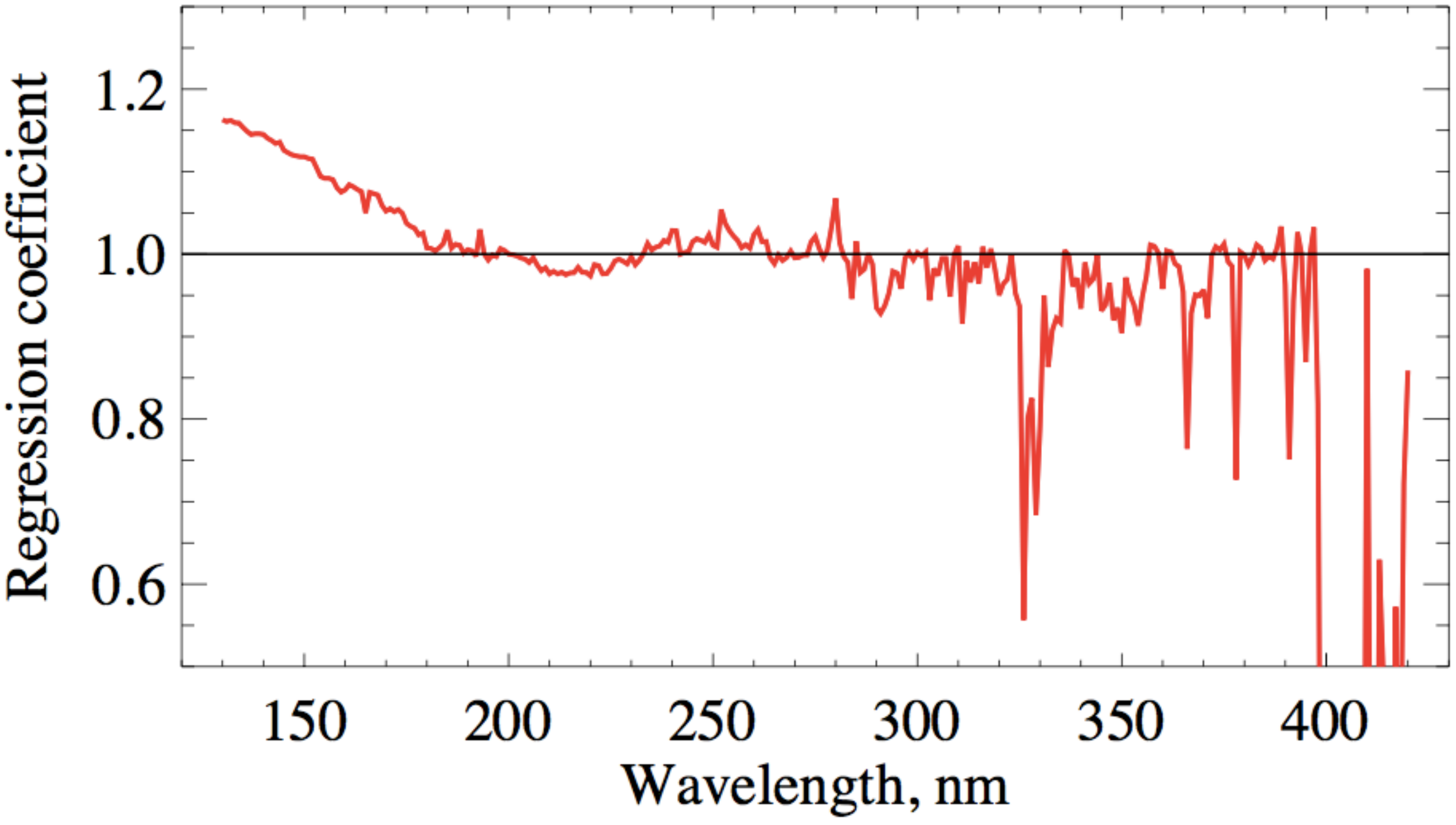
300-420 nm

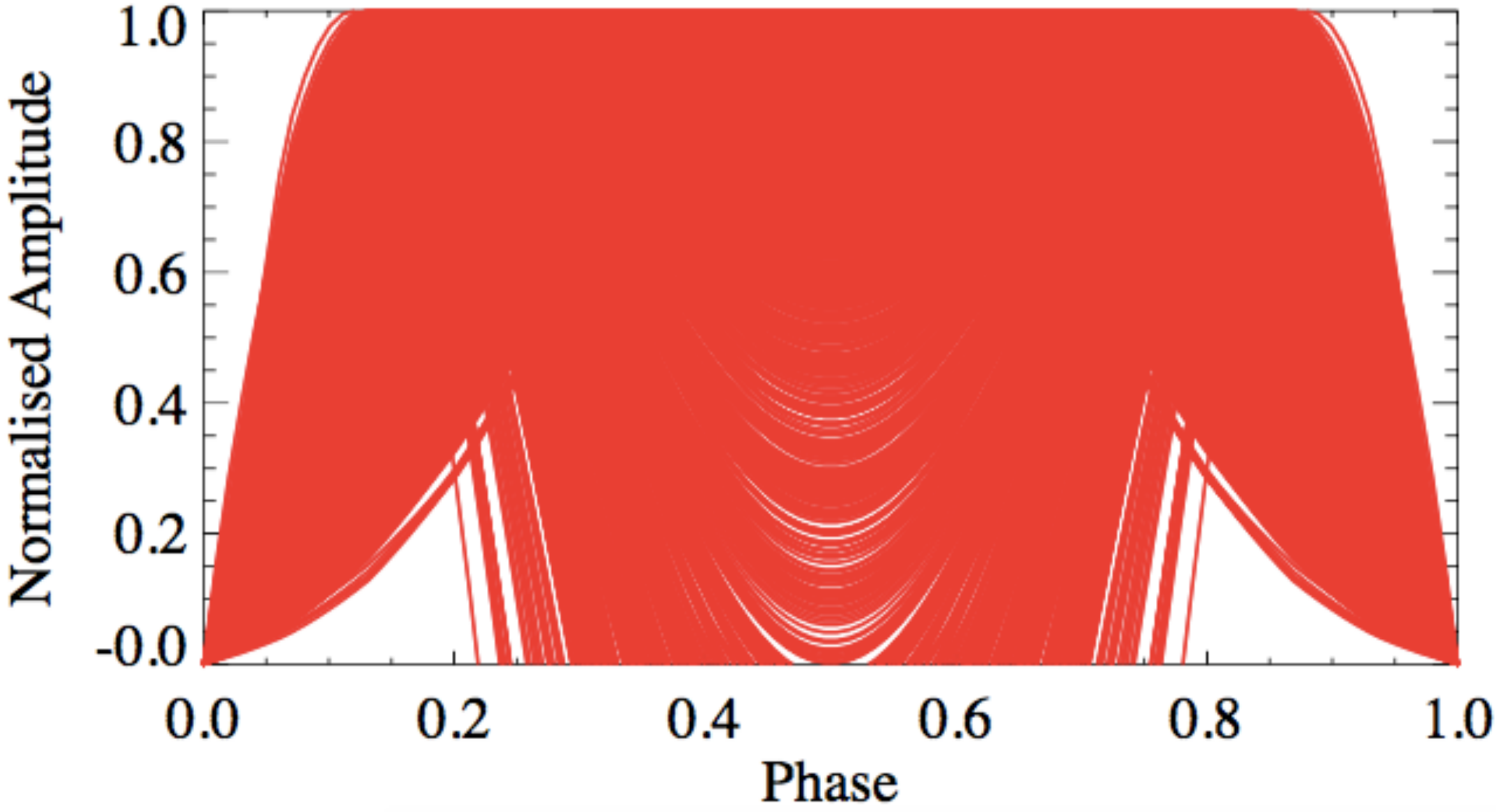


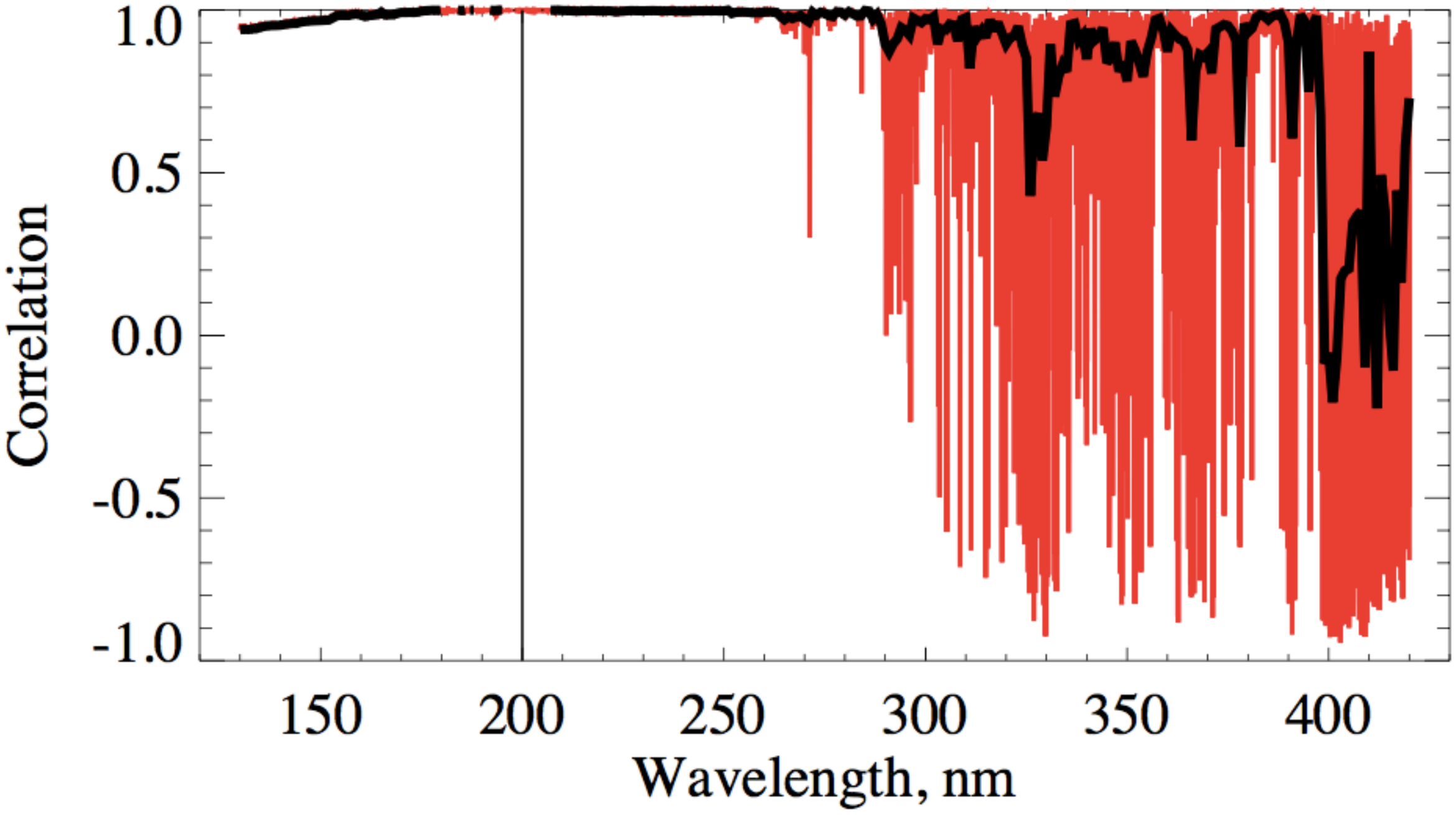
130-420 nm

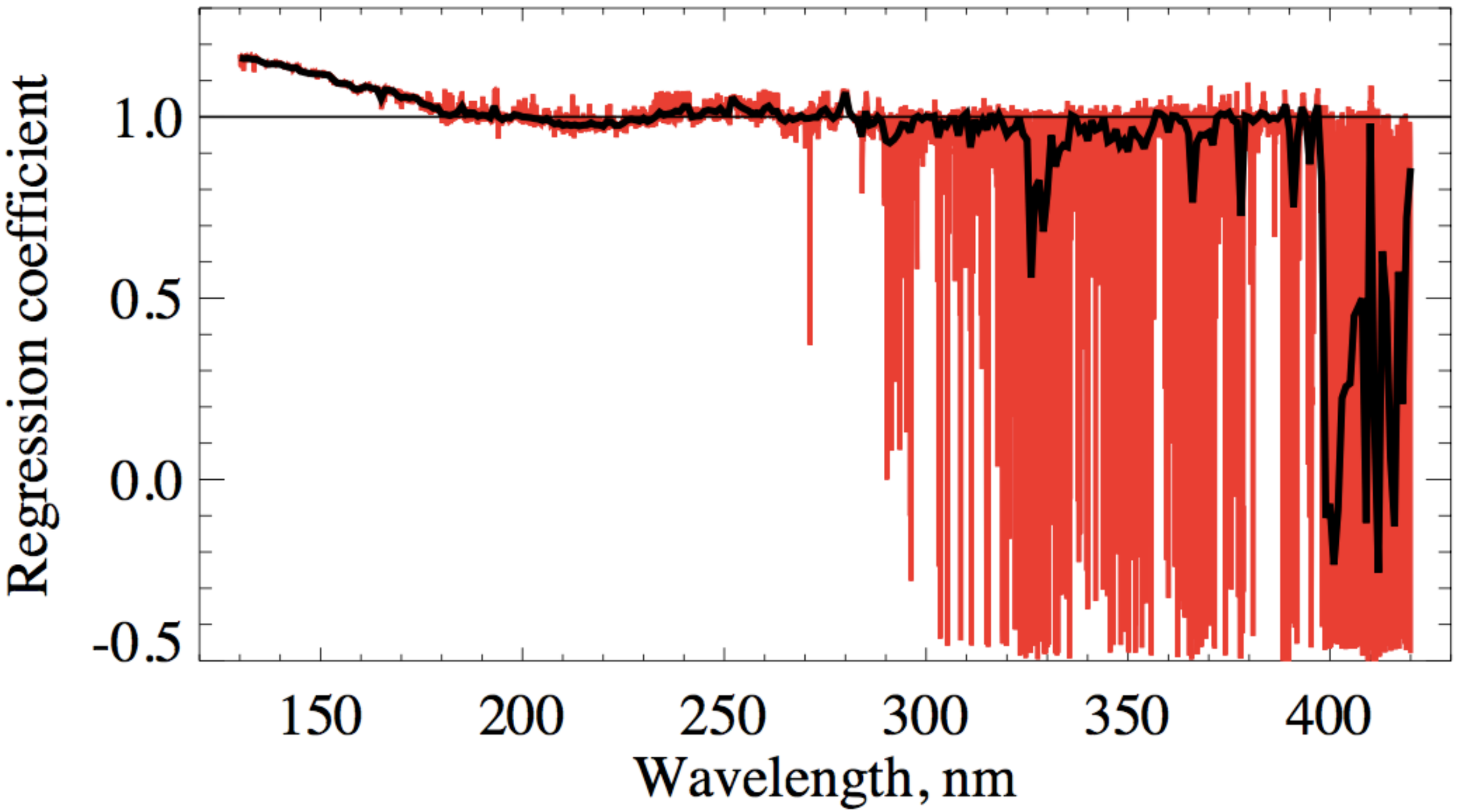



1.00
0.95
0.90
0.85
0.80
0.75
0.70
Correlation
150
200
250
300
350
400
Wavelength, nm


Regression coefficient
1.2
1.0
0.8
0.6
150
200
250
300
350
400
Wavelength, nm


Normalised Amplitude
1.0
0.8
0.6
0.4
0.2
-0.0
0.0
0.2
0.4
0.6
0.8
1.0
Phase


1.0
0.5
0.0
-0.5
-1.0
Correlation
150
200
250
300
350
400
Wavelength, nm


Regression coefficient
1.0
0.5
0.0
-0.5
150
200
250
300
350
400
Wavelength, nm