

Variability of solar irradiance: what we do and do not know

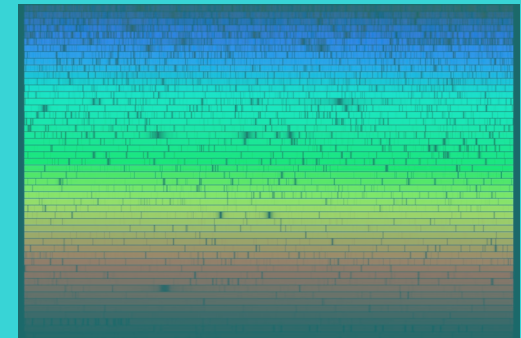


Outline

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4	Results	4
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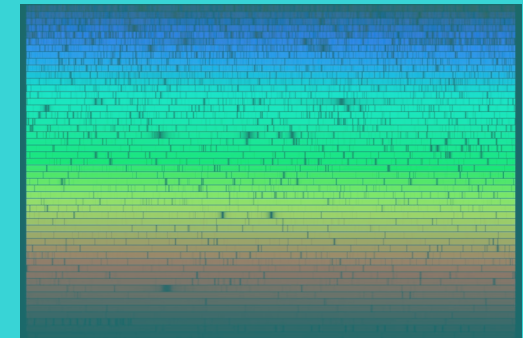
Outline

1. Quiet Sun Spectrum

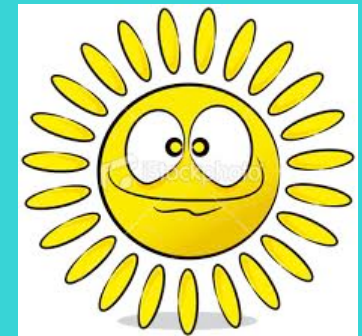


Outline

1. Quiet Sun Spectrum

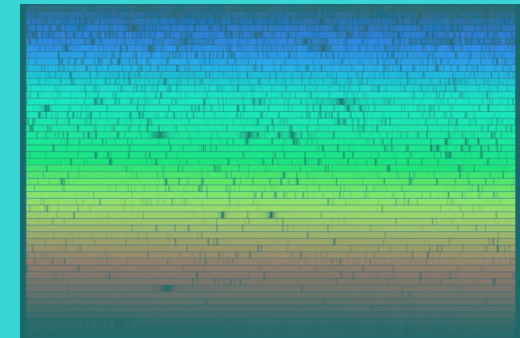


2. Current problems in SSI modeling

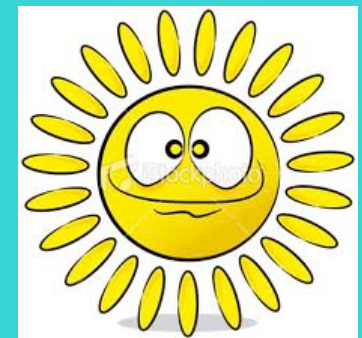


Outline

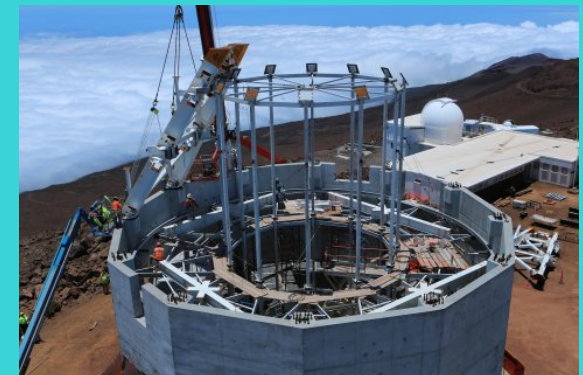
1. Quiet Sun Spectrum



2. Current problems in SSI modeling

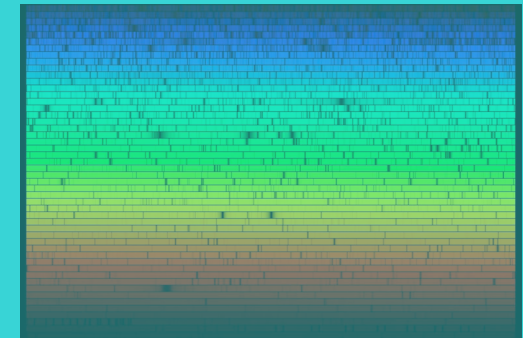


3. Solar measurements



Outline

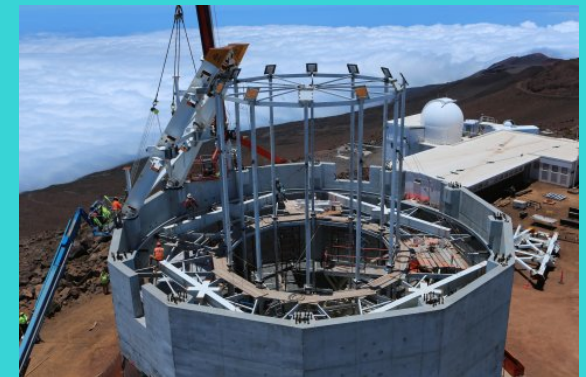
1. Quiet Sun Spectrum



2. Current problems in SSI modeling



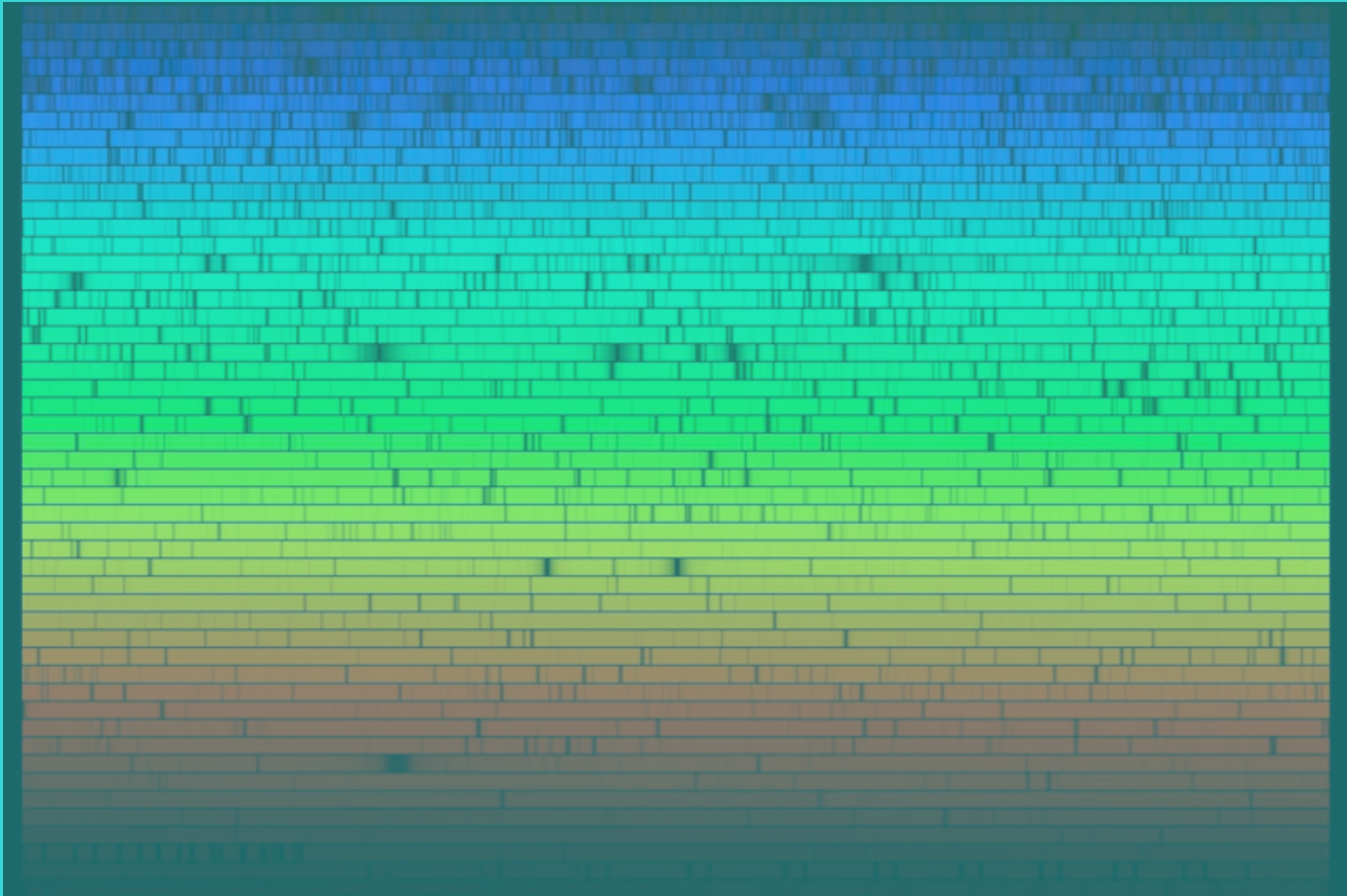
3. Solar measurements



4. Stellar measurements

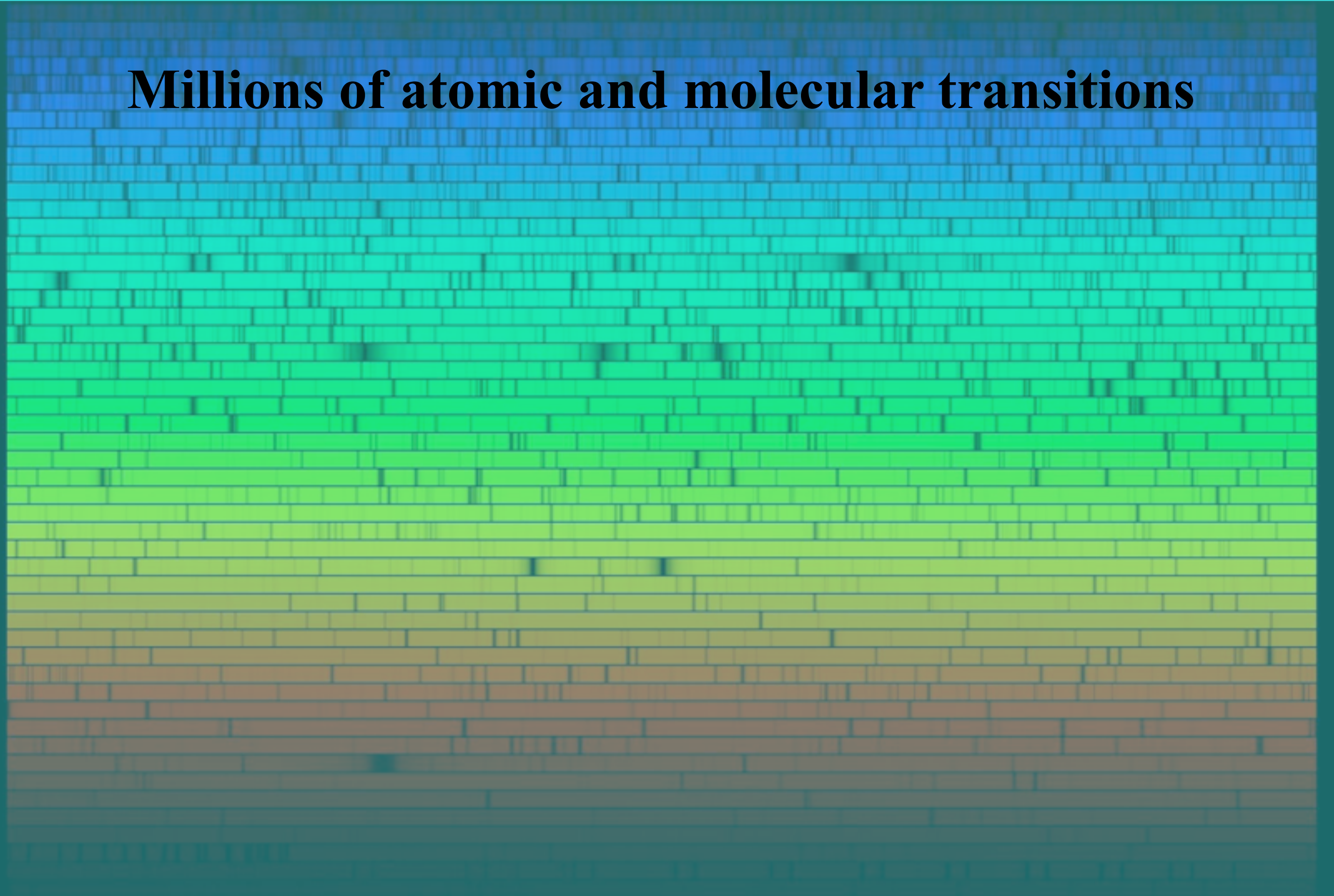


Calculations of the solar spectrum



Calculations of the solar spectrum

Millions of atomic and molecular transitions



Calculations of the solar spectrum

Millions of atomic and molecular transitions

Non-local thermodynamic equilibrium

Calculations of the solar spectrum

Millions of atomic and molecular transitions

Non-local thermodynamic equilibrium

COde for the Solar Irradiance (COSI)

Calculations of the solar spectrum

Millions of atomic and molecular transitions

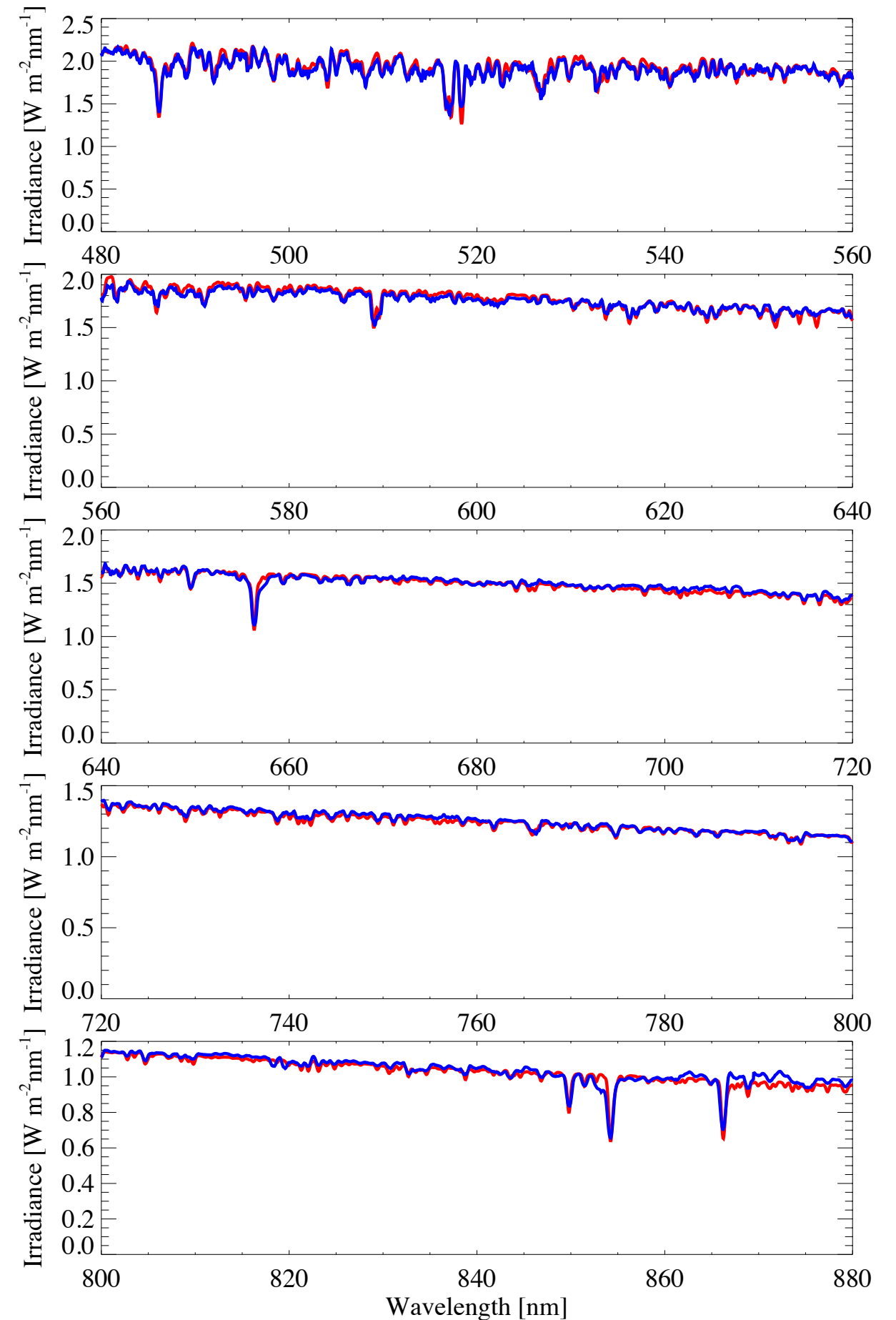
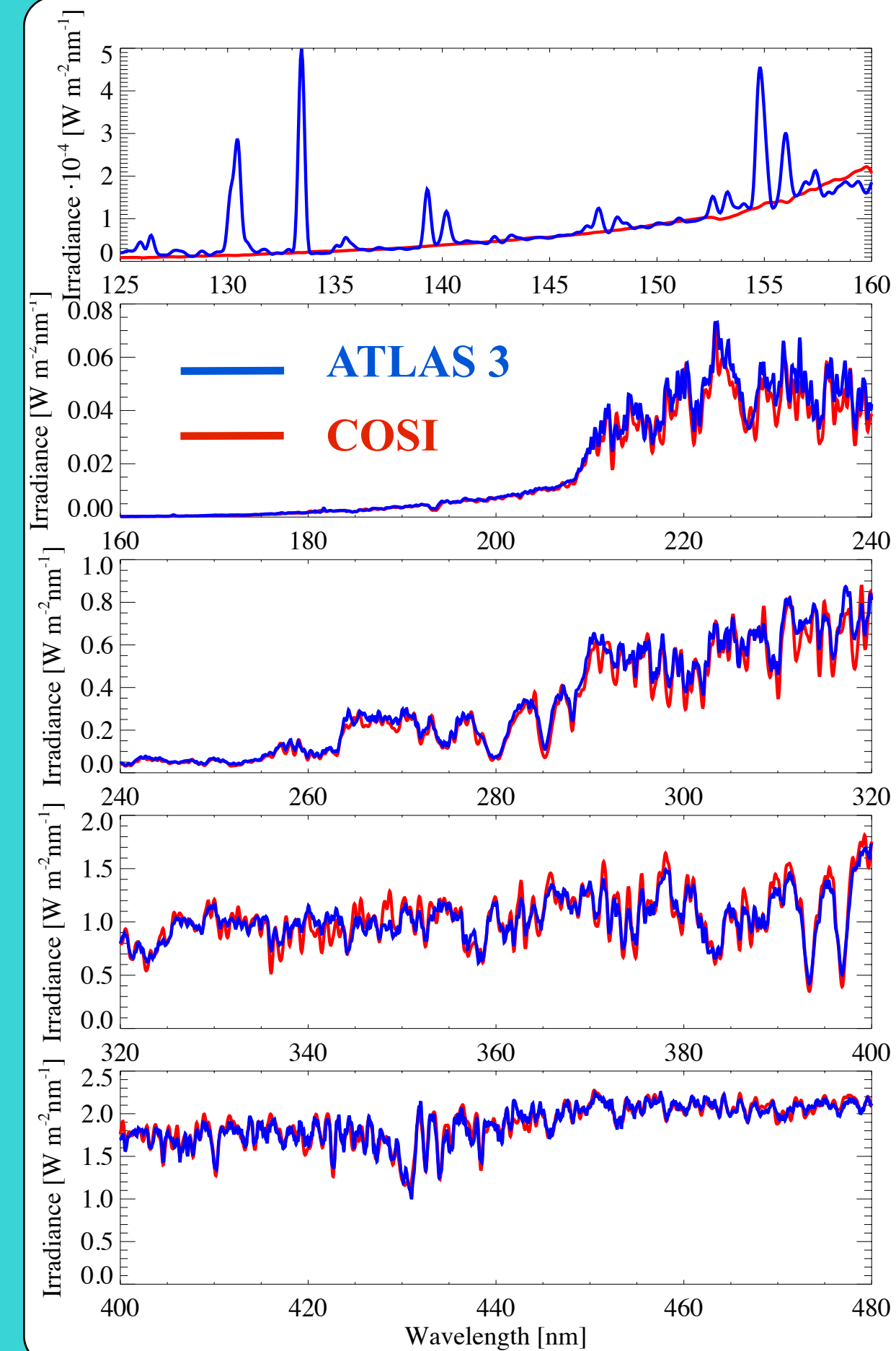
Non-local thermodynamic equilibrium

COde for the Solar Irradiance (COSI)

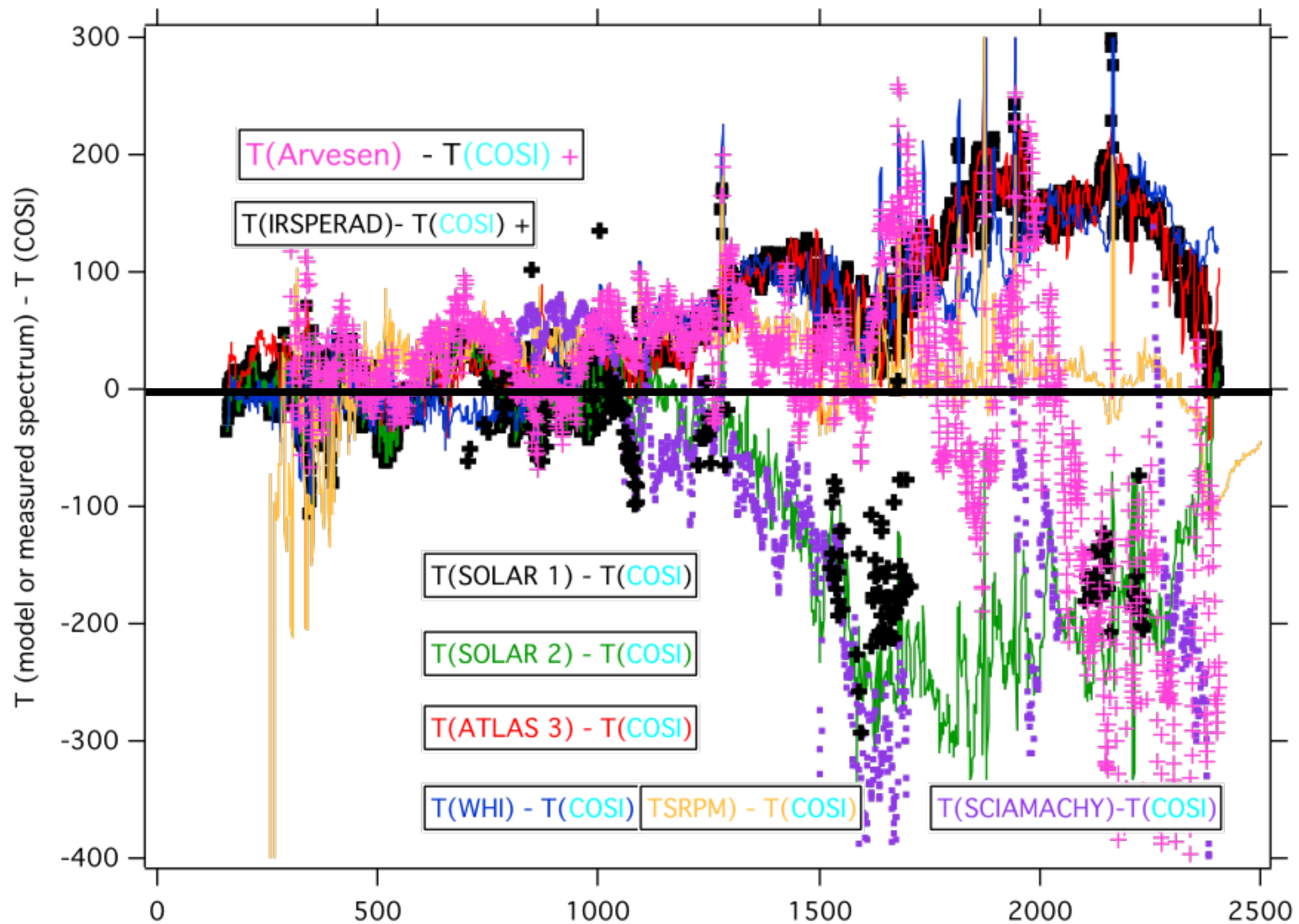
see poster by Rinat Tagirov



COSI vs. ATLAS 3

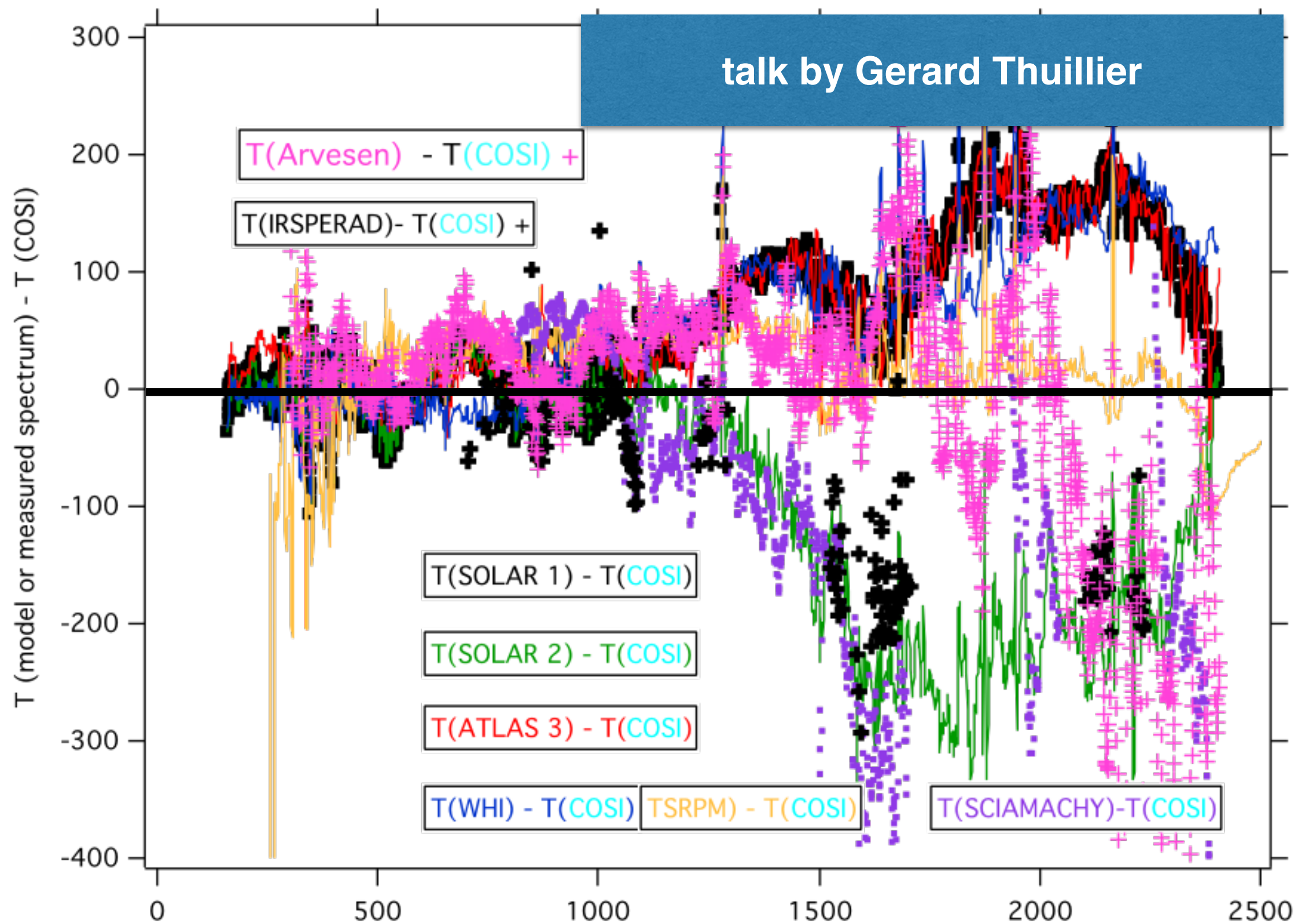


IR problem



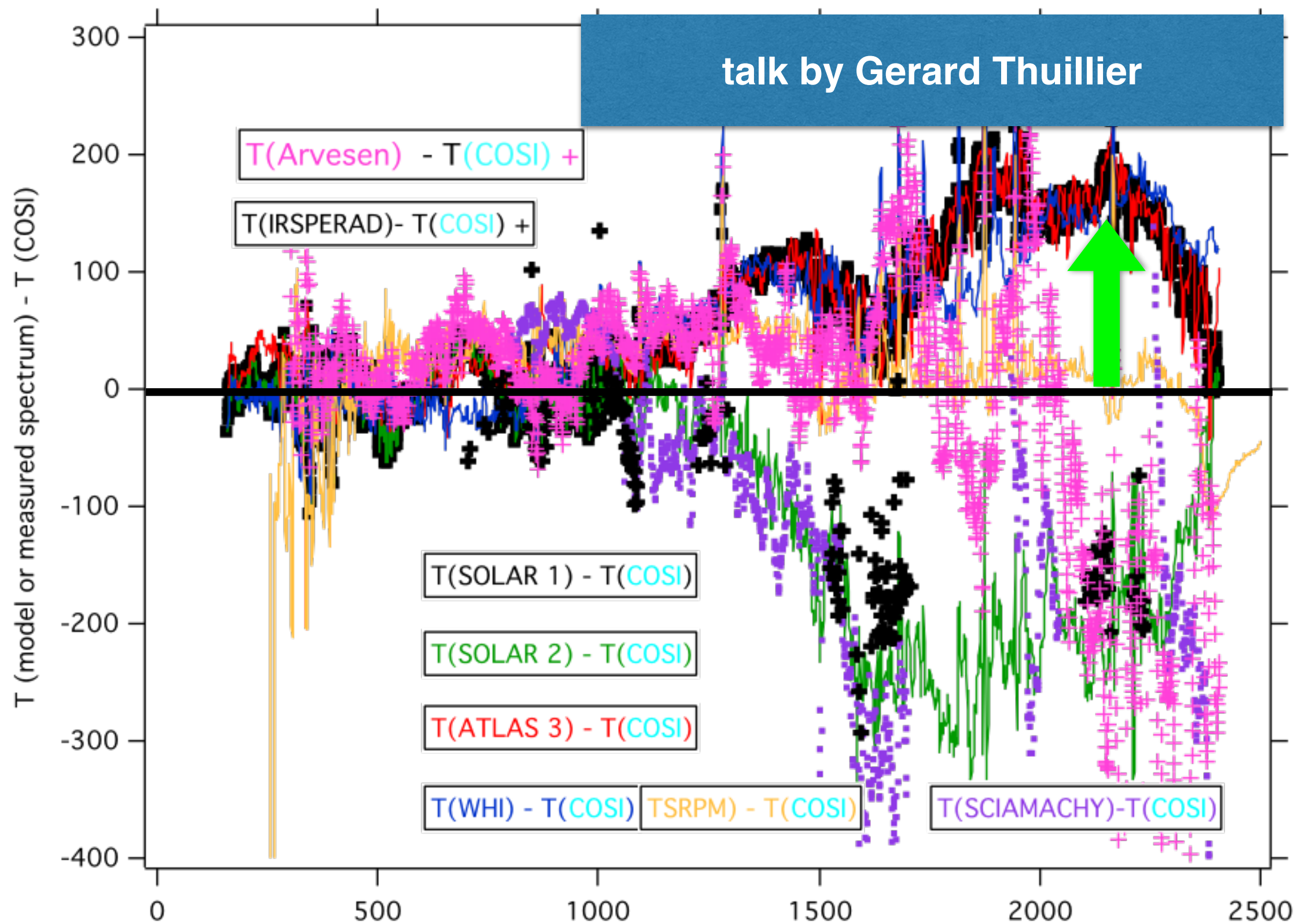
from Thuillier et al. 2014

IR problem



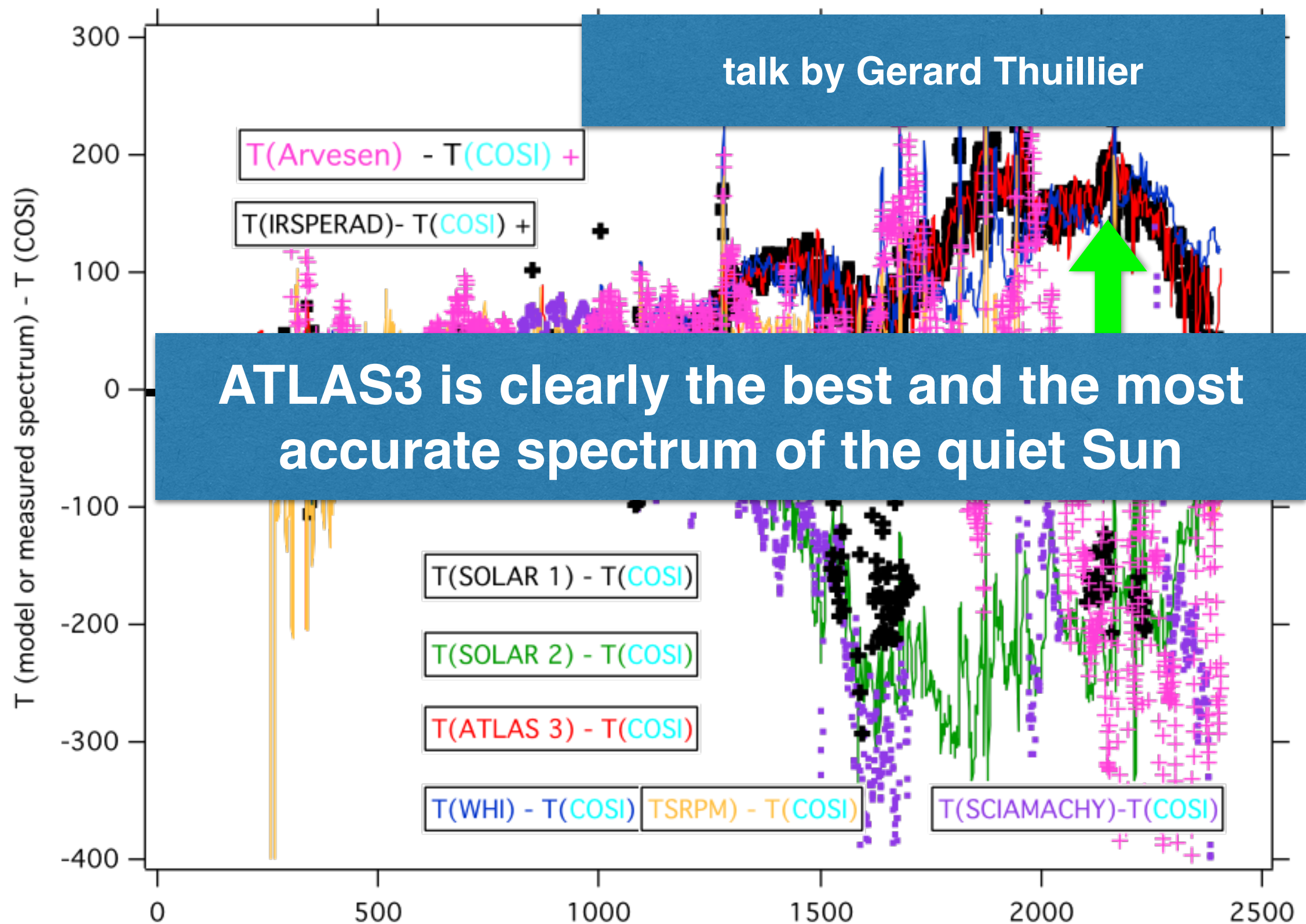
from Thuillier et al. 2014

IR problem



from Thuillier et al. 2014

IR problem

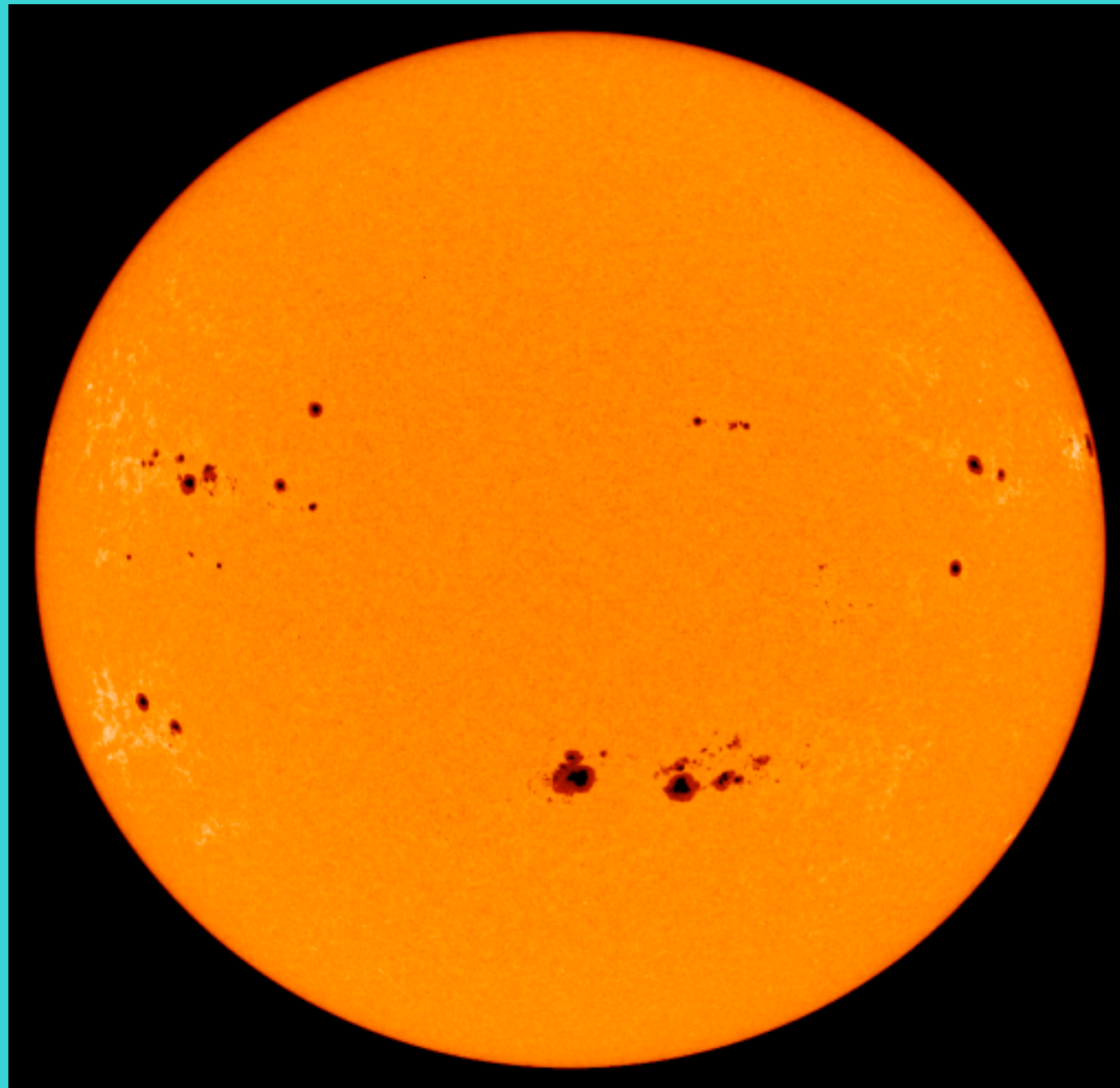


from Thuillier et al. 2014

Modeling of the SSI variability

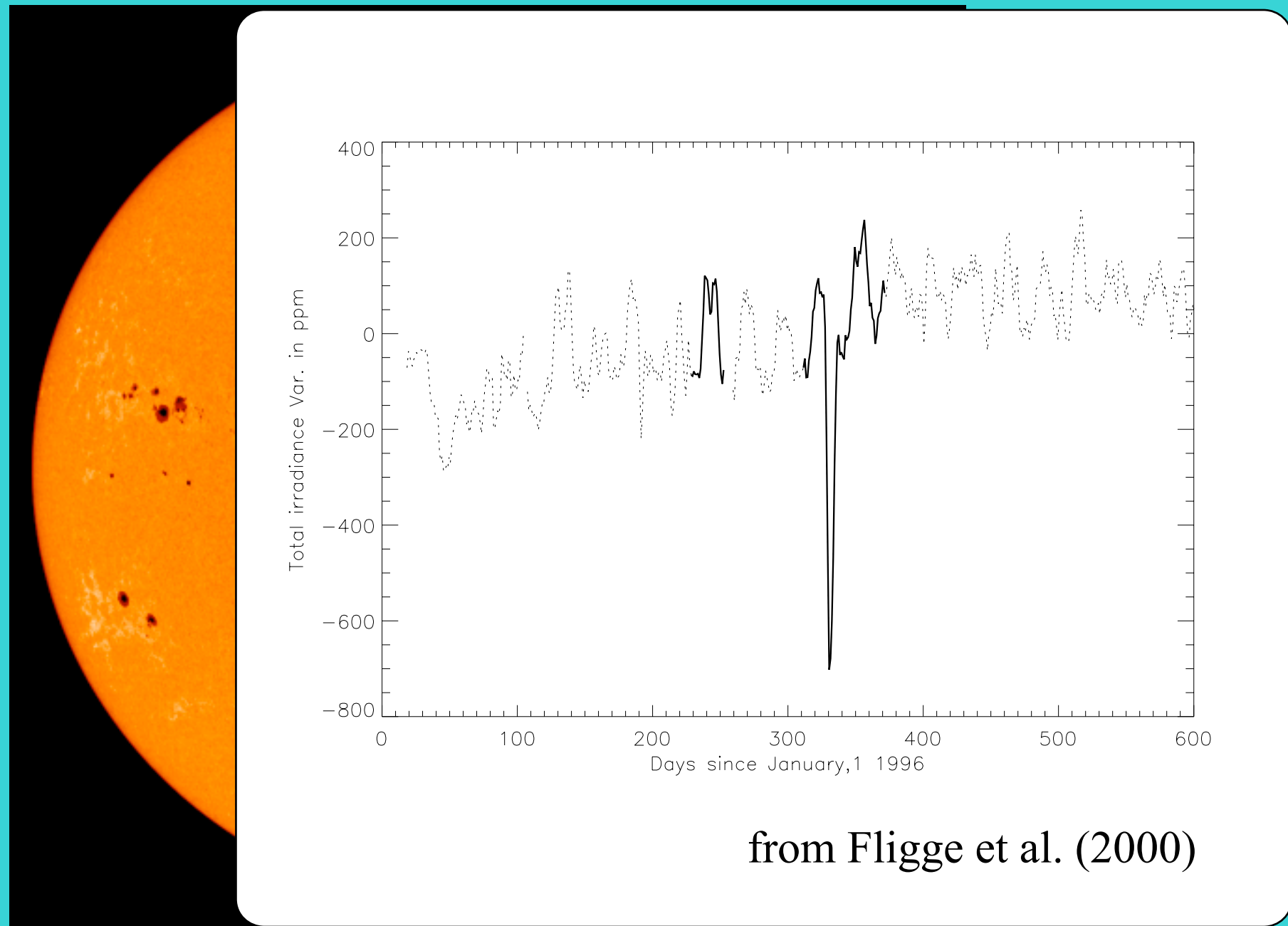
Modeling of the solar irradiance variability

Main assumption. Variations in solar irradiance are directly related to the evolution of surface magnetic flux



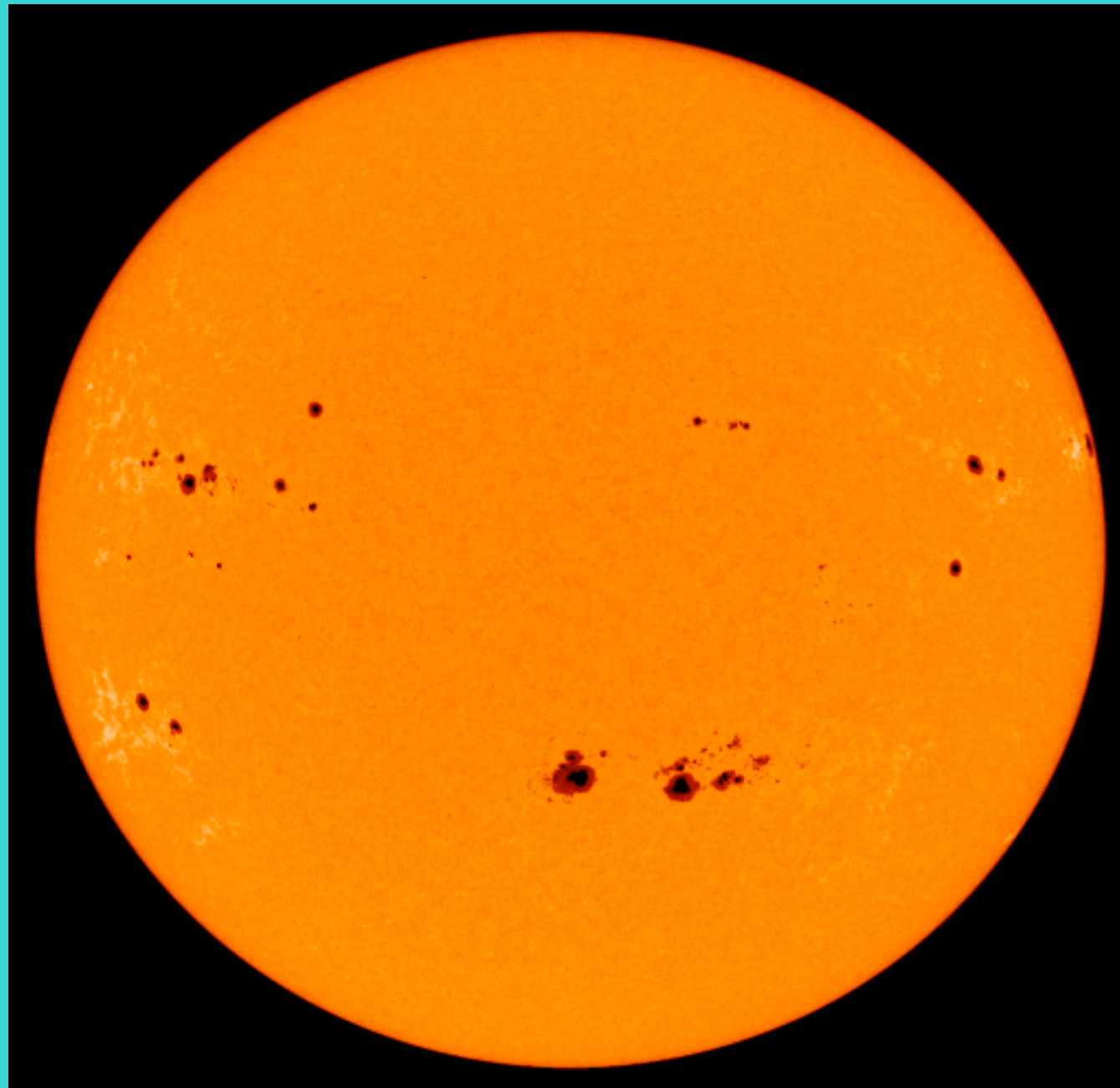
Modeling of the solar irradiance variability

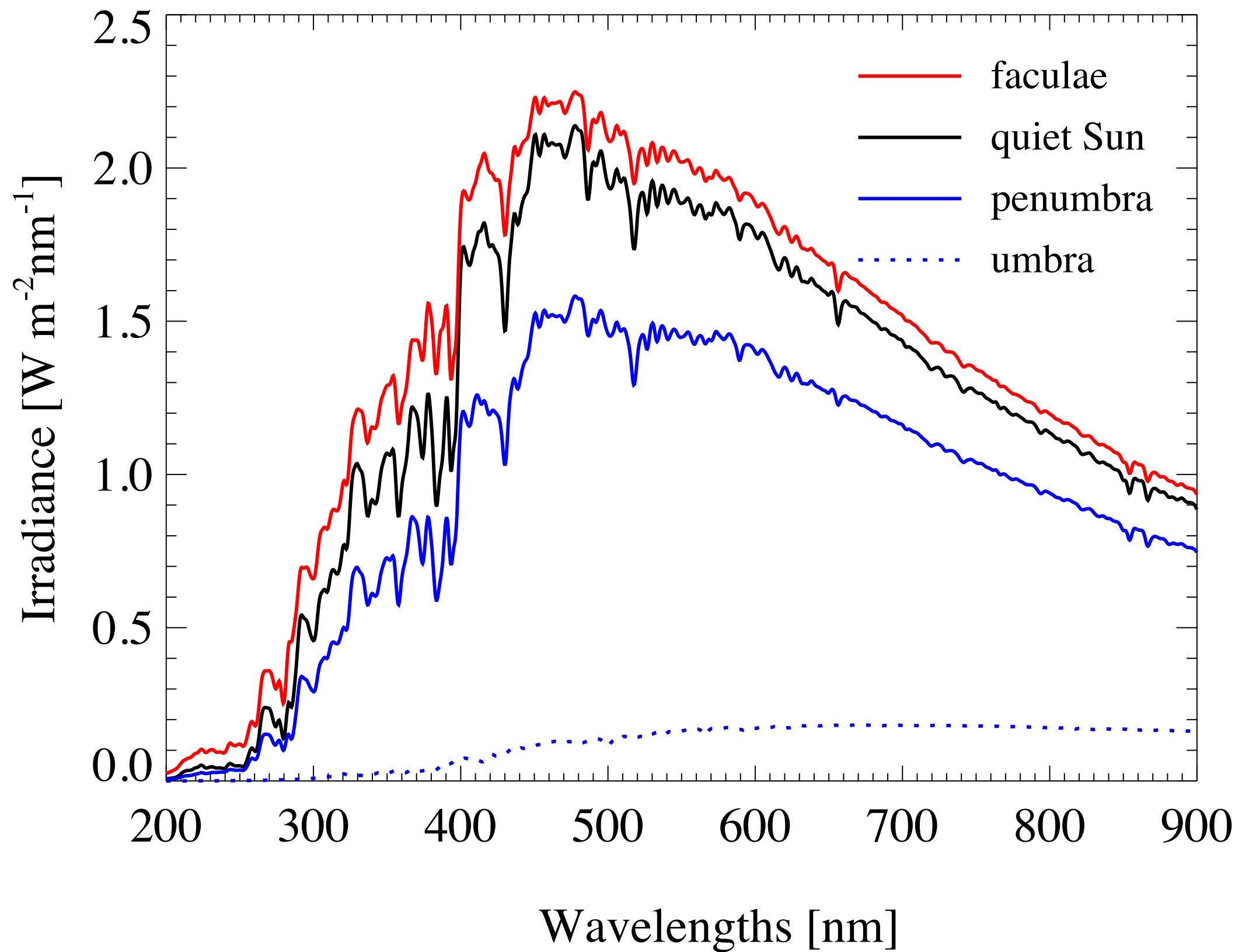
Main assumption. Variations in solar irradiance are directly related to the evolution of surface magnetic flux



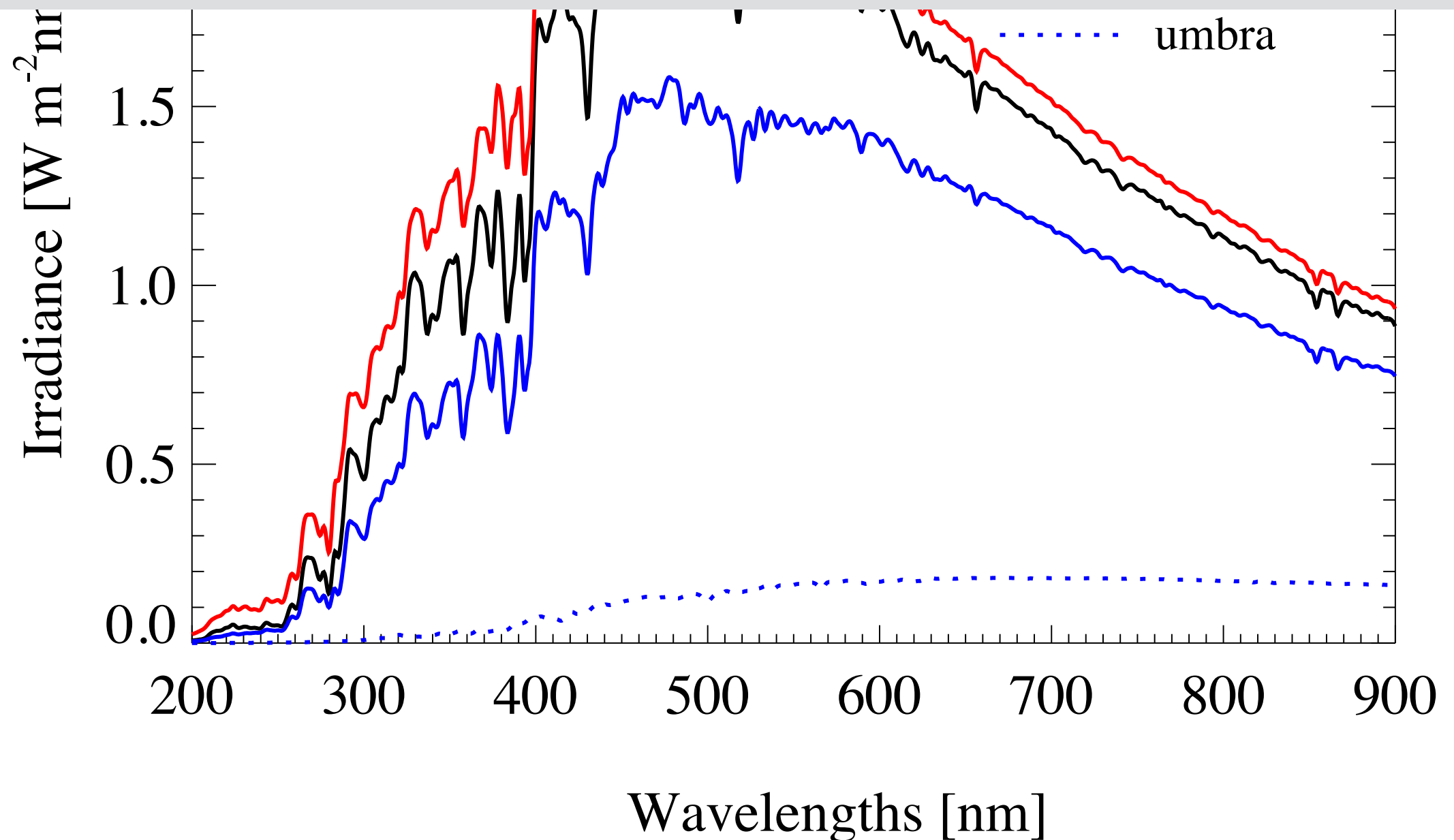
Modeling of the solar irradiance variability

Main assumption. Variations in solar irradiance are directly related to the evolution of surface magnetic flux

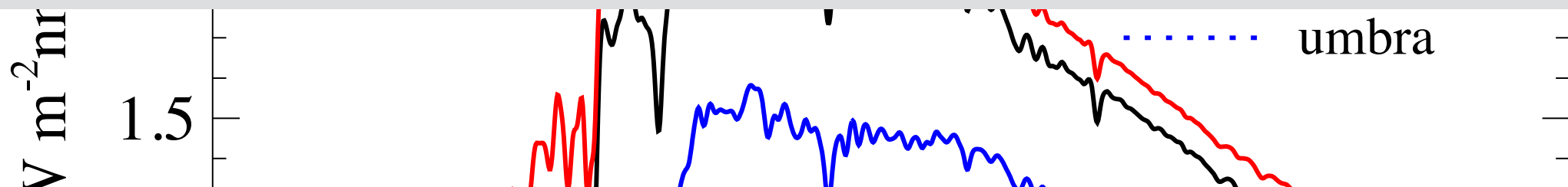




**Irradiance reconstruction = surface coverages +
spectra of the individual components**

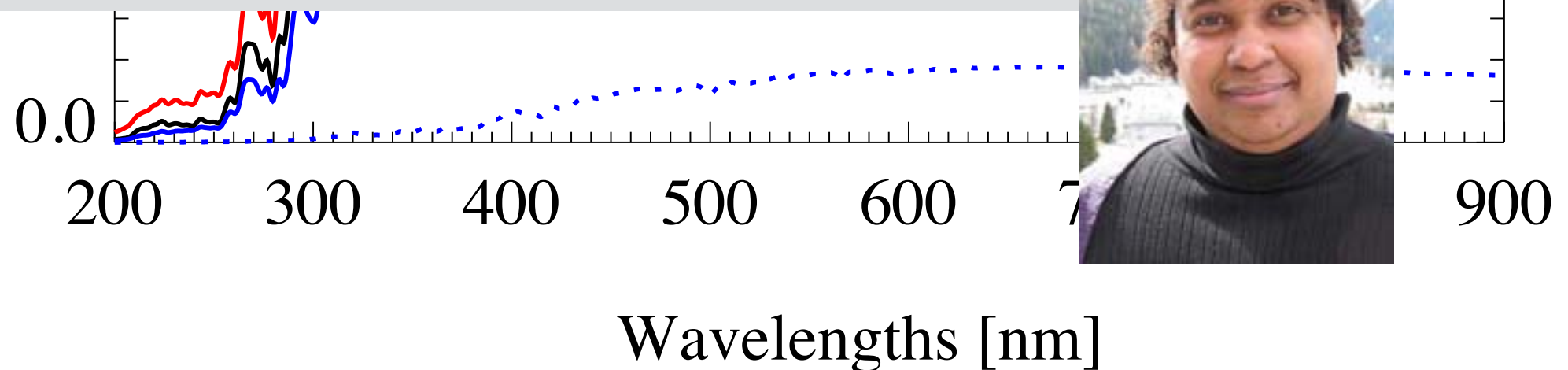


**Irradiance reconstruction = surface coverages +
spectra of the individual components**



Code for Solar Irradiance Reconstruction (COSIR)

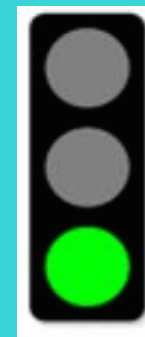
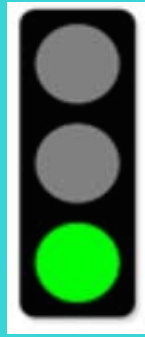
talk by Wilnelia Adams



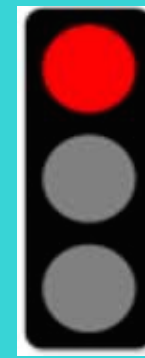
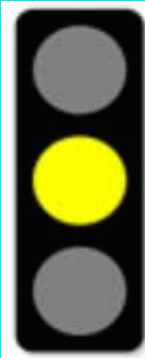
TSI

SSI

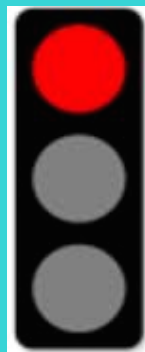
27-day



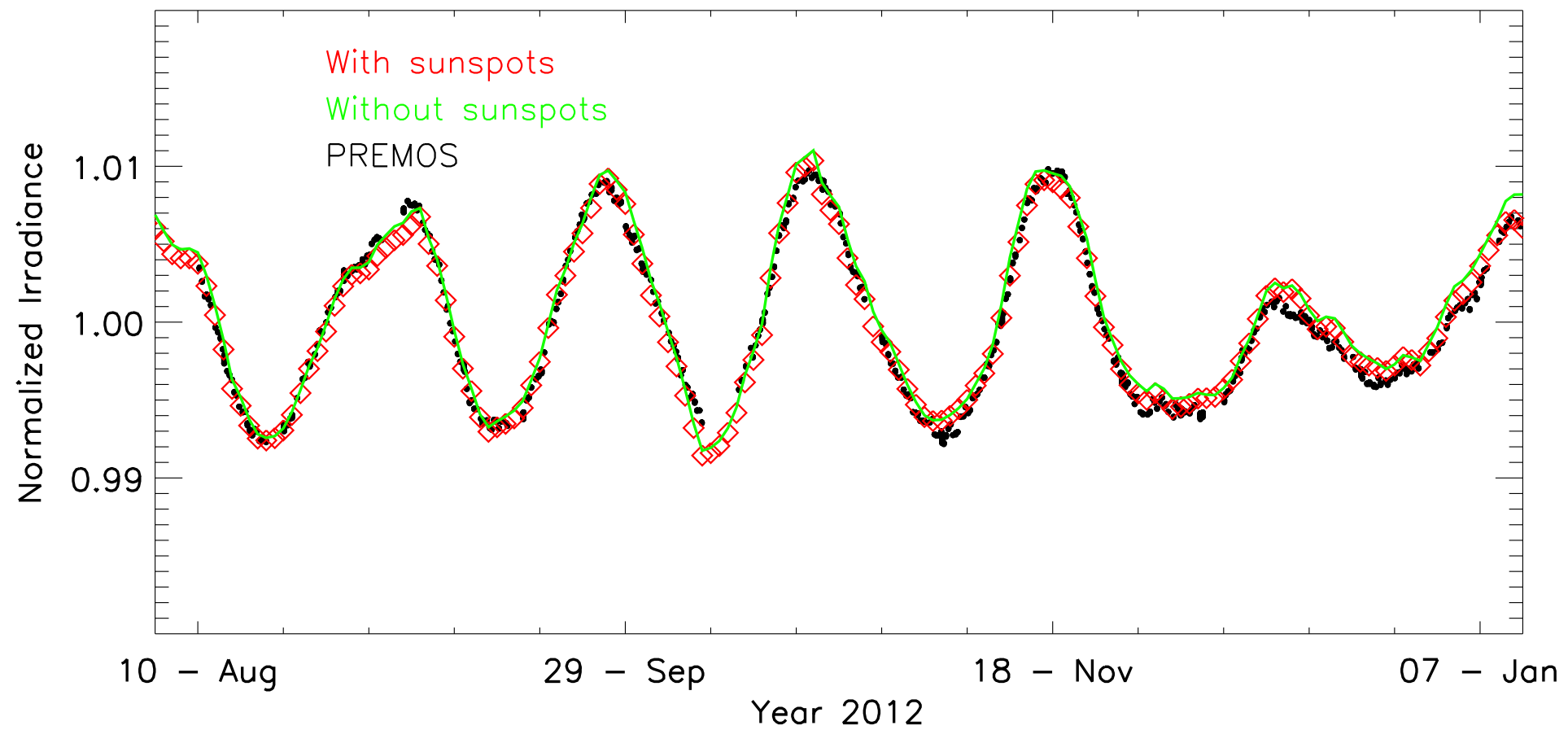
11-year



long-term

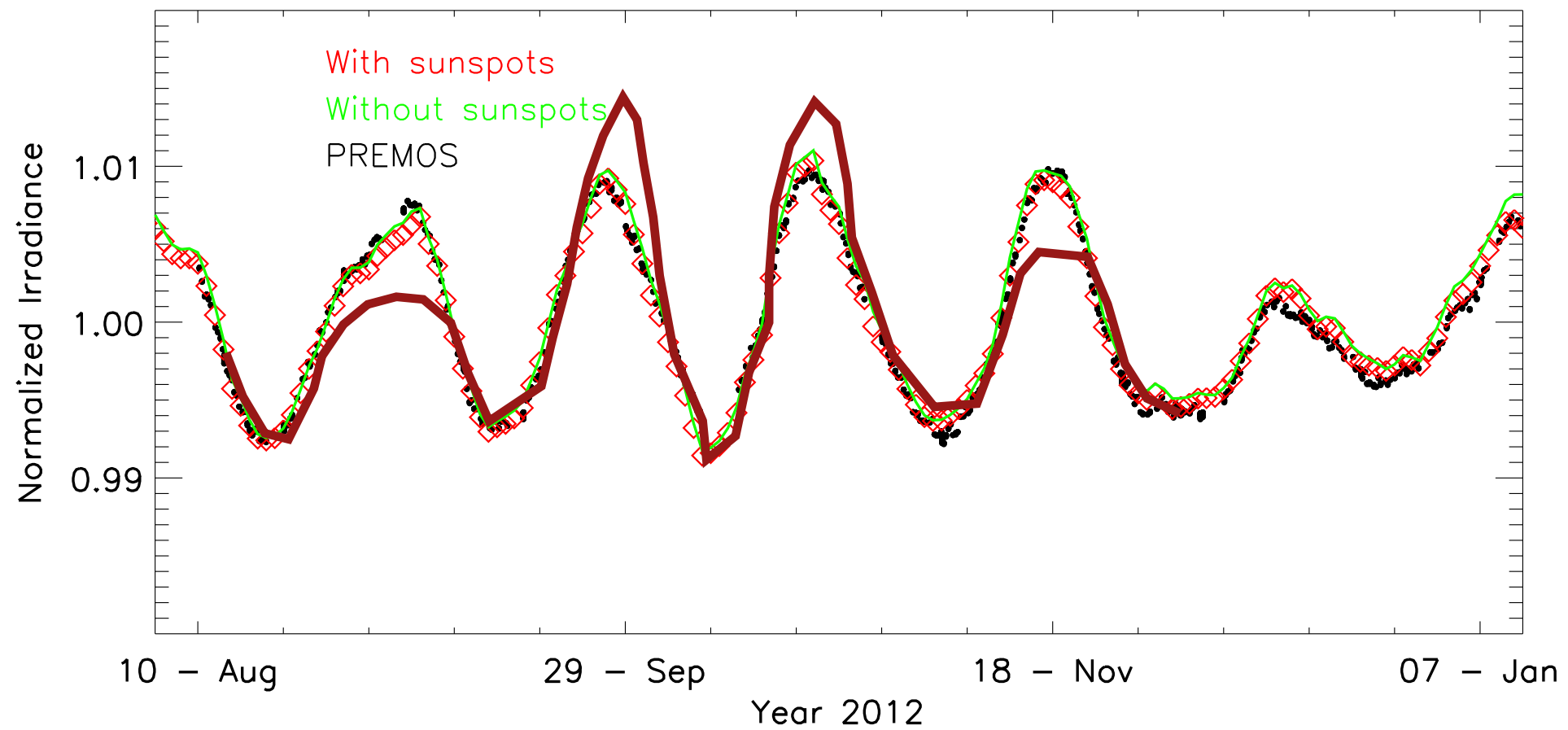


220 nm channel



from Cessateur et al. 2014

220 nm channel

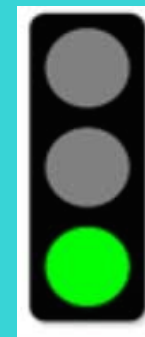
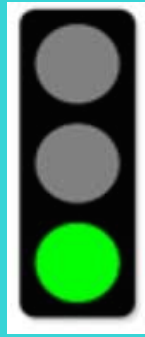


from Cessateur et al. 2014

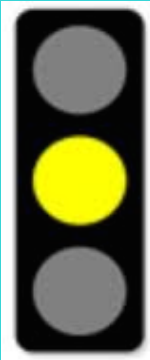
TSI

SSI

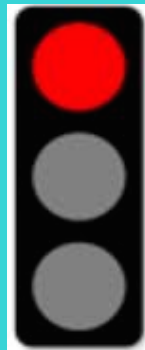
27-day



11-year



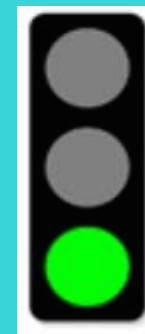
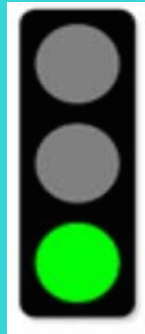
long-term



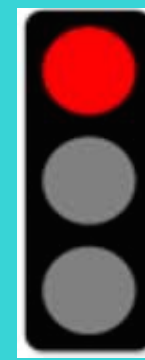
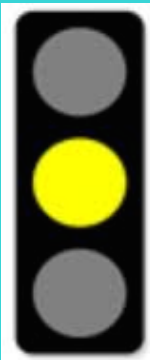
TSI

SSI

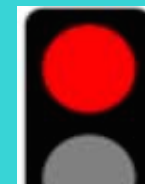
27-day



11-year



long-term

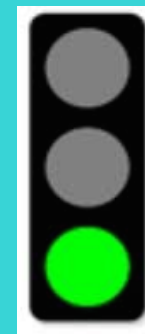
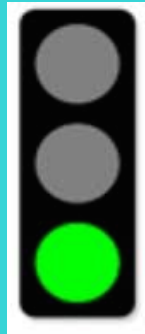


What to do?

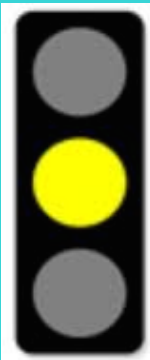
TSI

SSI

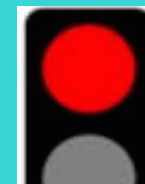
27-day



11-year



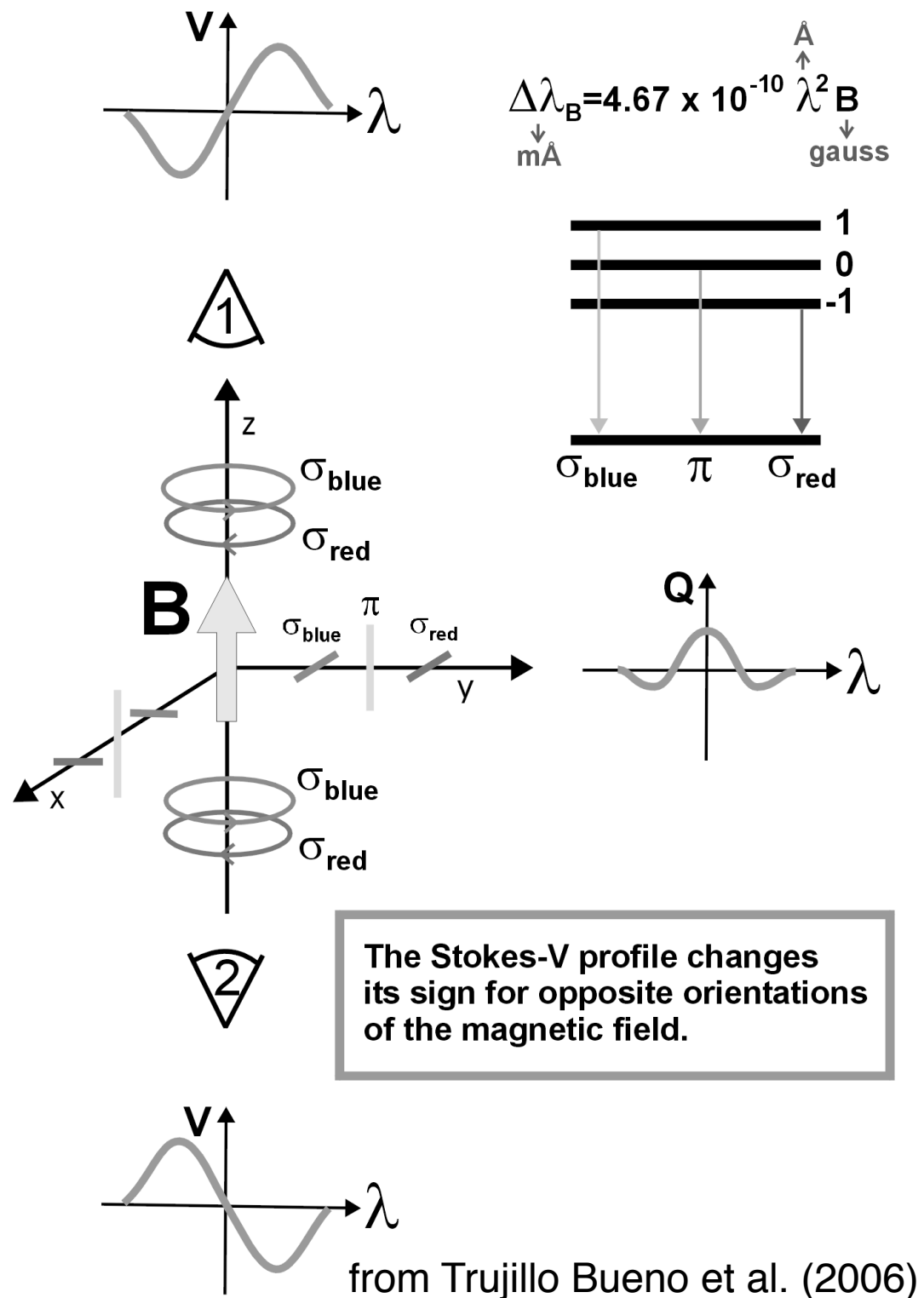
long-term



What to do?

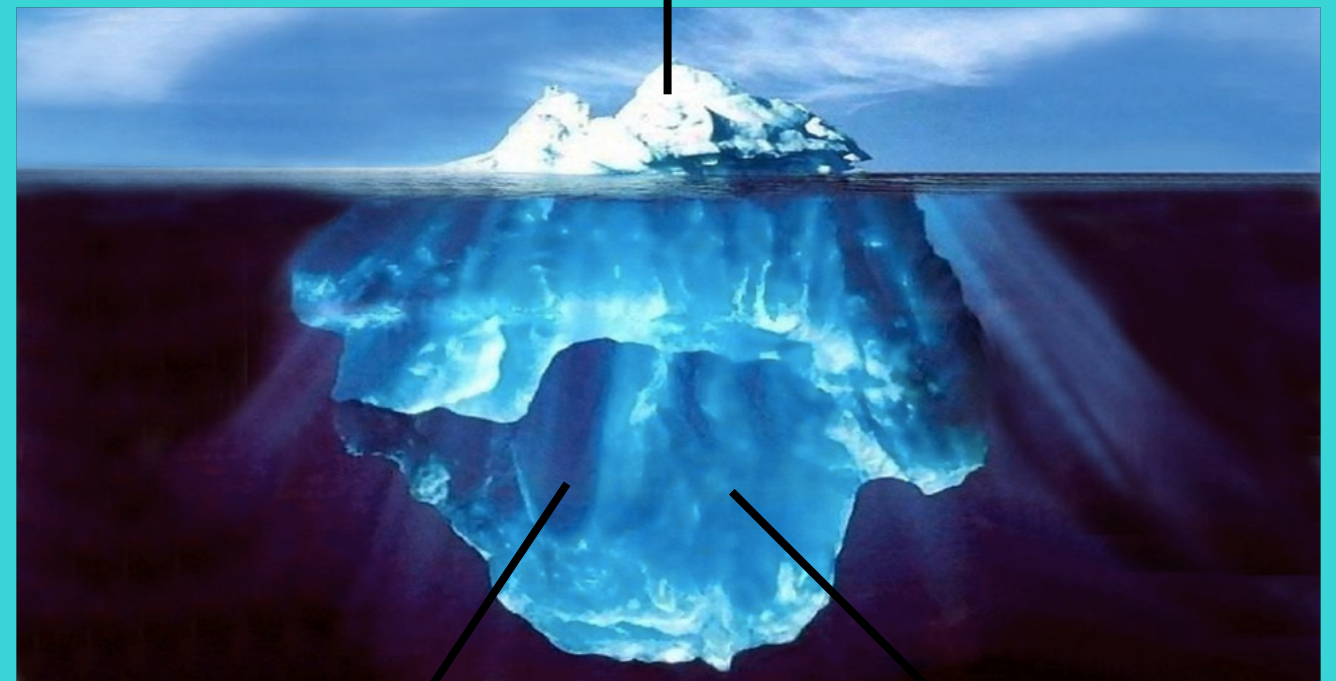
Who's to blame?

The Zeeman Effect



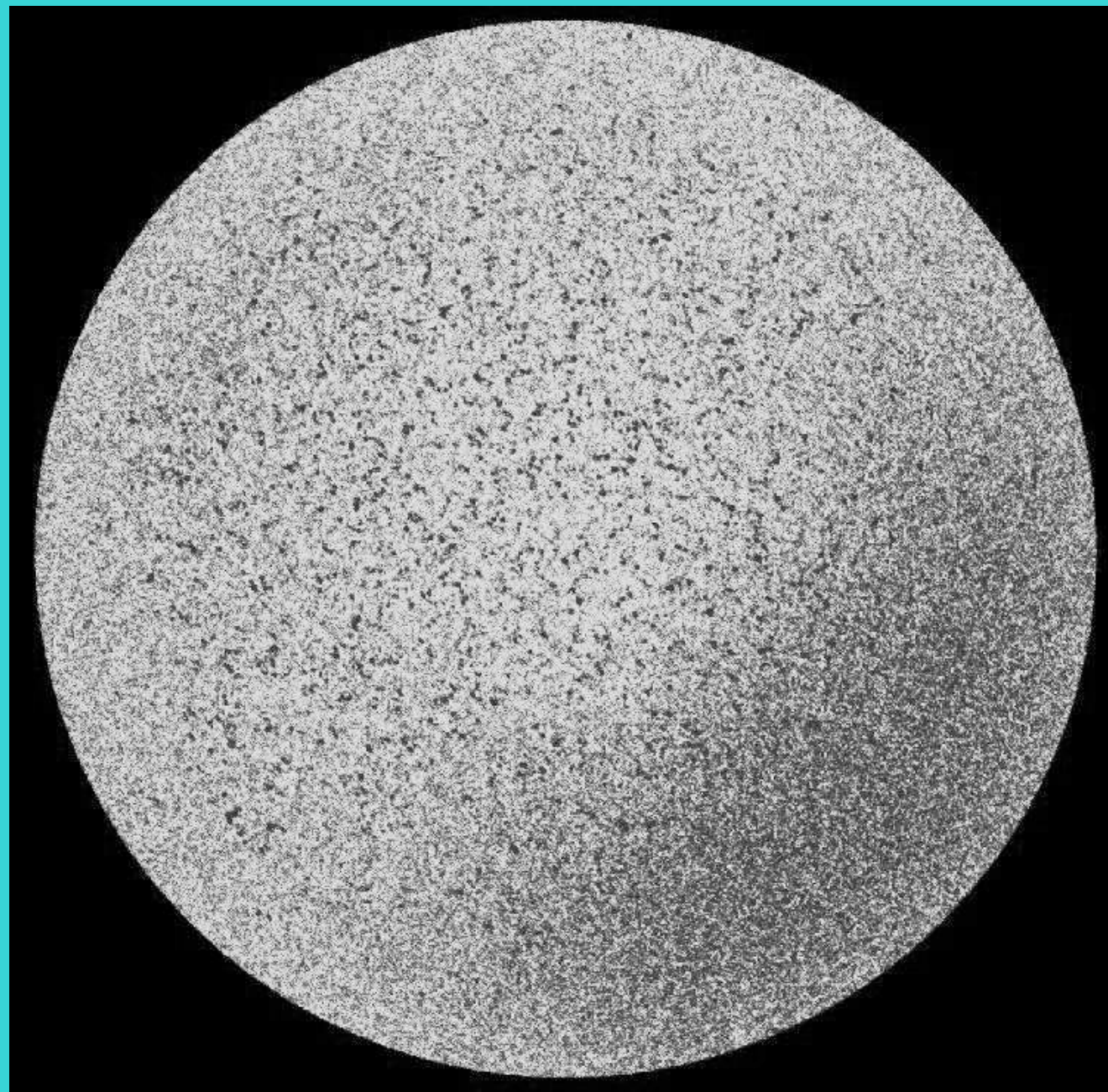
The resolved magnetic field is just “tip of the iceberg”

27-day variability



11-year variability

long-term variability



from Ball et al. (2012)

NO contribution to the rotational variability

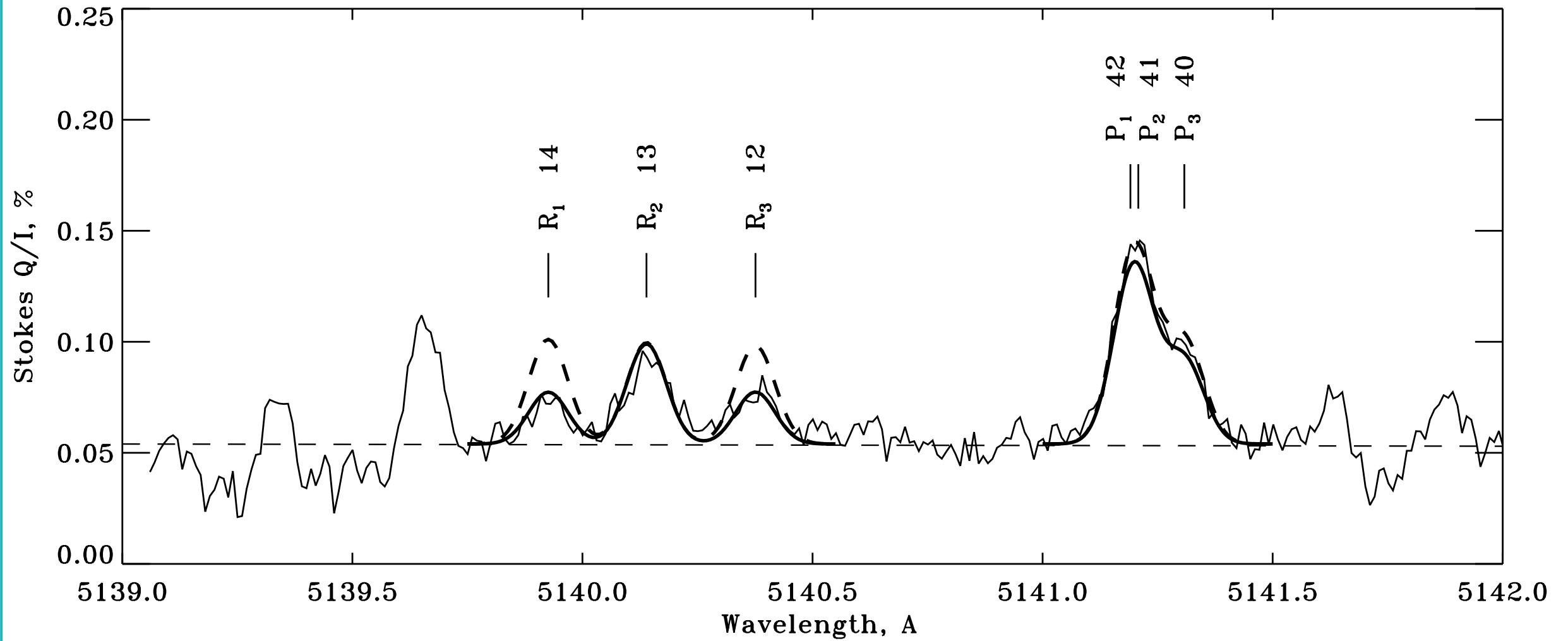
Strong contribution to the 11-year and possibly long-term variability



**look closer
into the Sun**

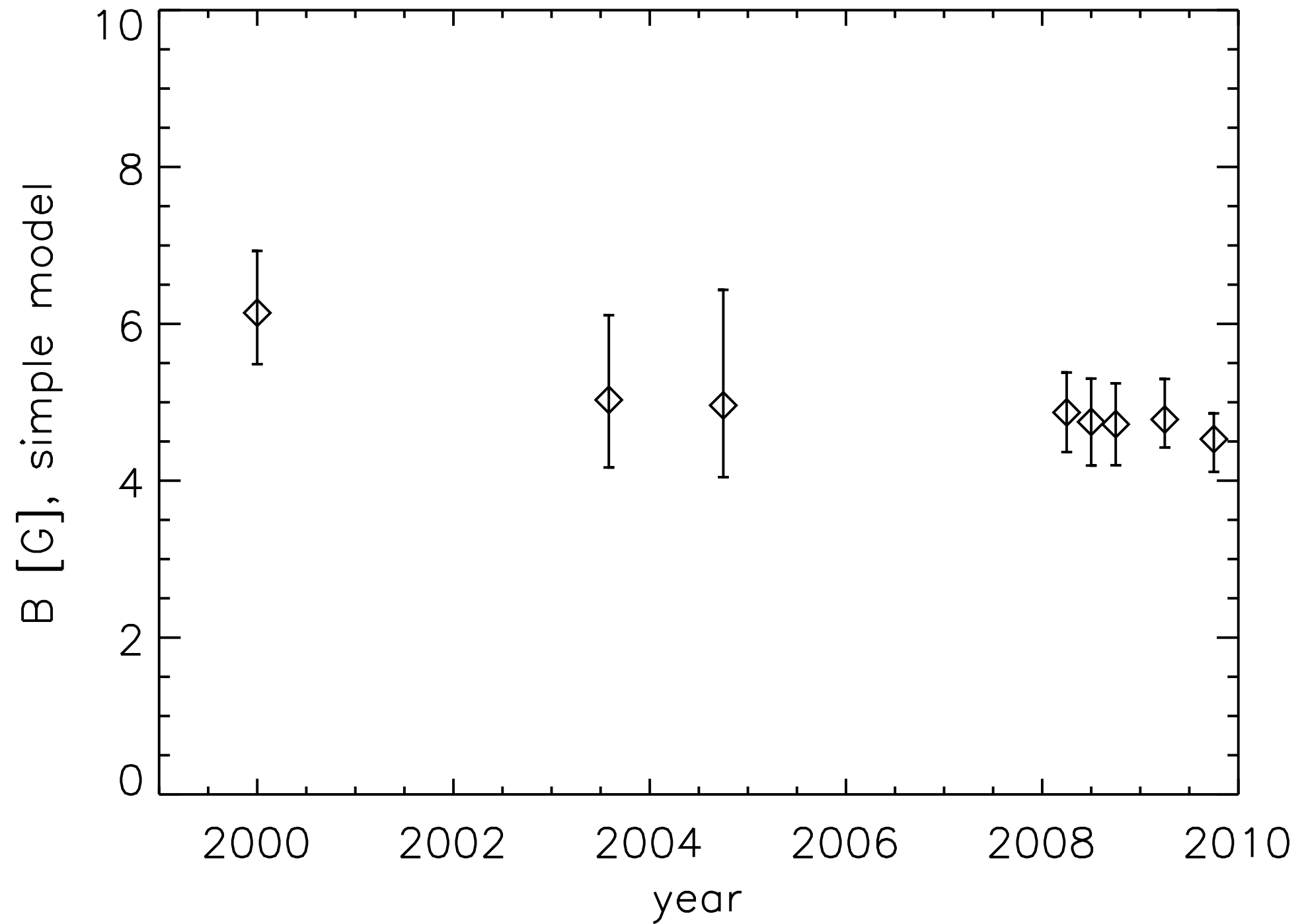
**look farther away
into the stars**

Second Solar Spectrum



from Berdyugina & Fluri 2004

Behavior of the Quiet Sun



Kleint et al. (2010, 2011)

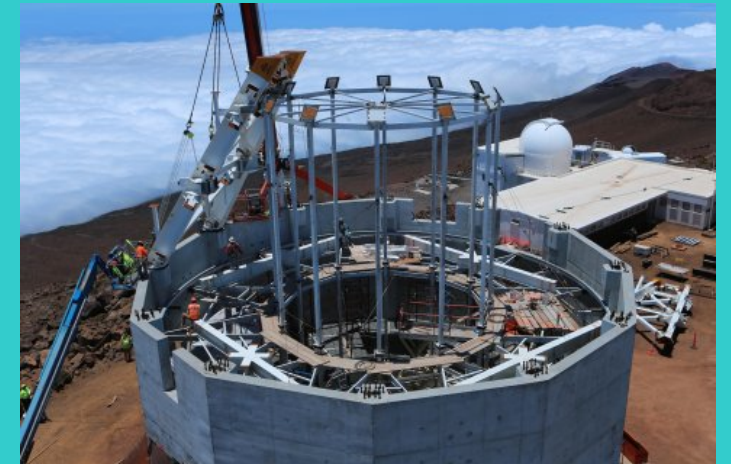
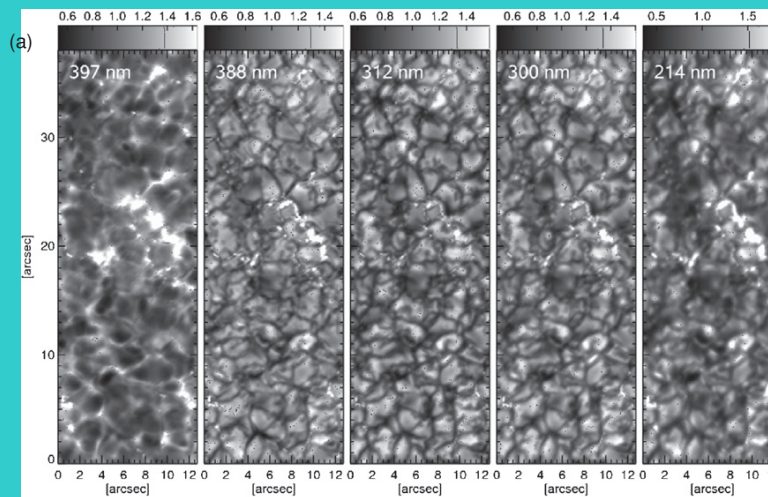
What to do?

realistic MHD

Synoptic Hanle effect
programs

SUNRISE balloon
(100 km)

ATST
(30 km)



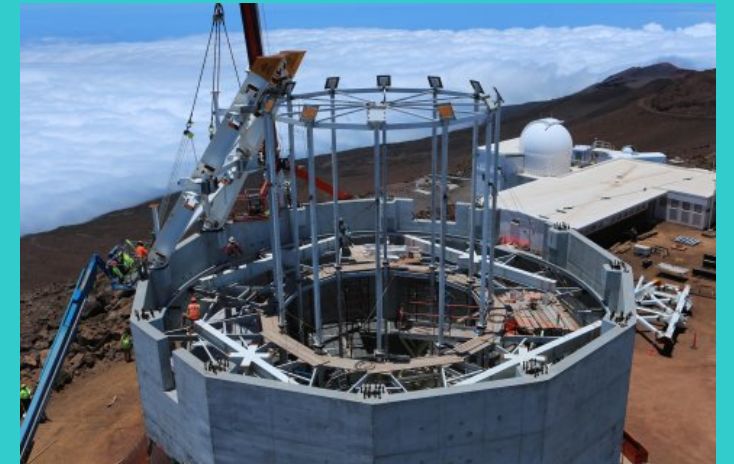
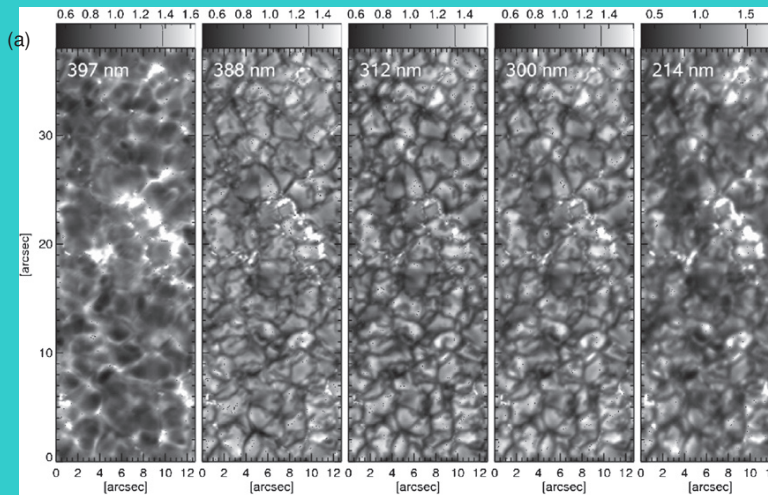
What to do?

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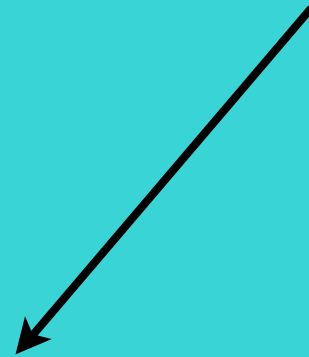


validation against as much observed data as possible

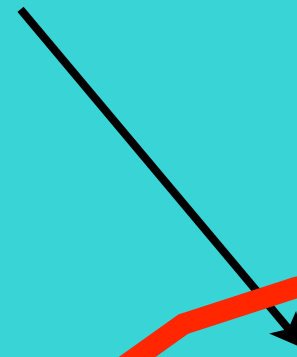


**look closer
into the Sun**

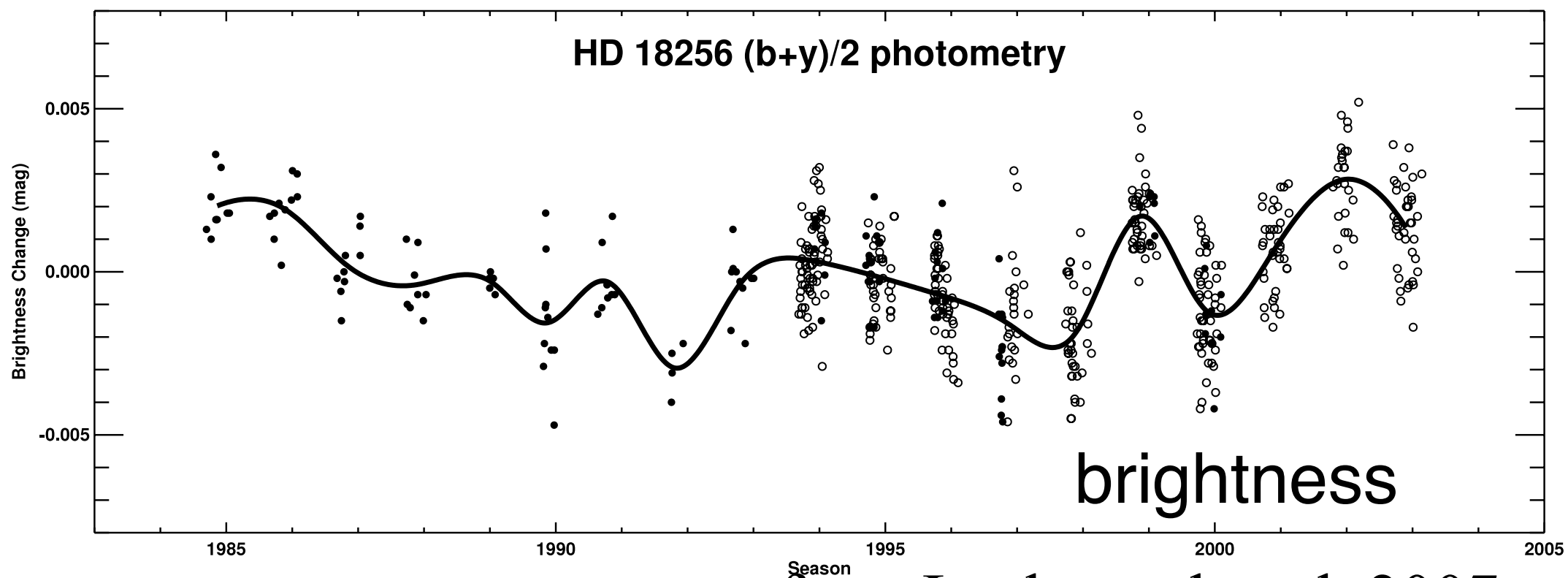
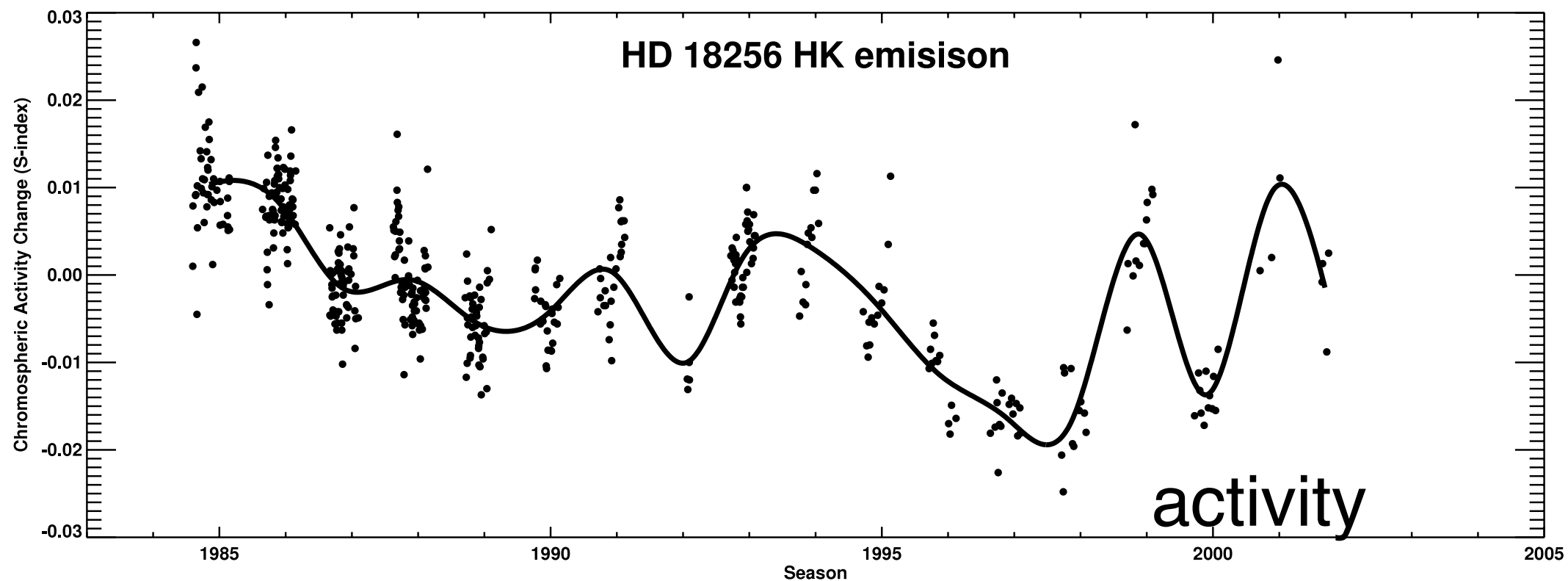
**look farther away
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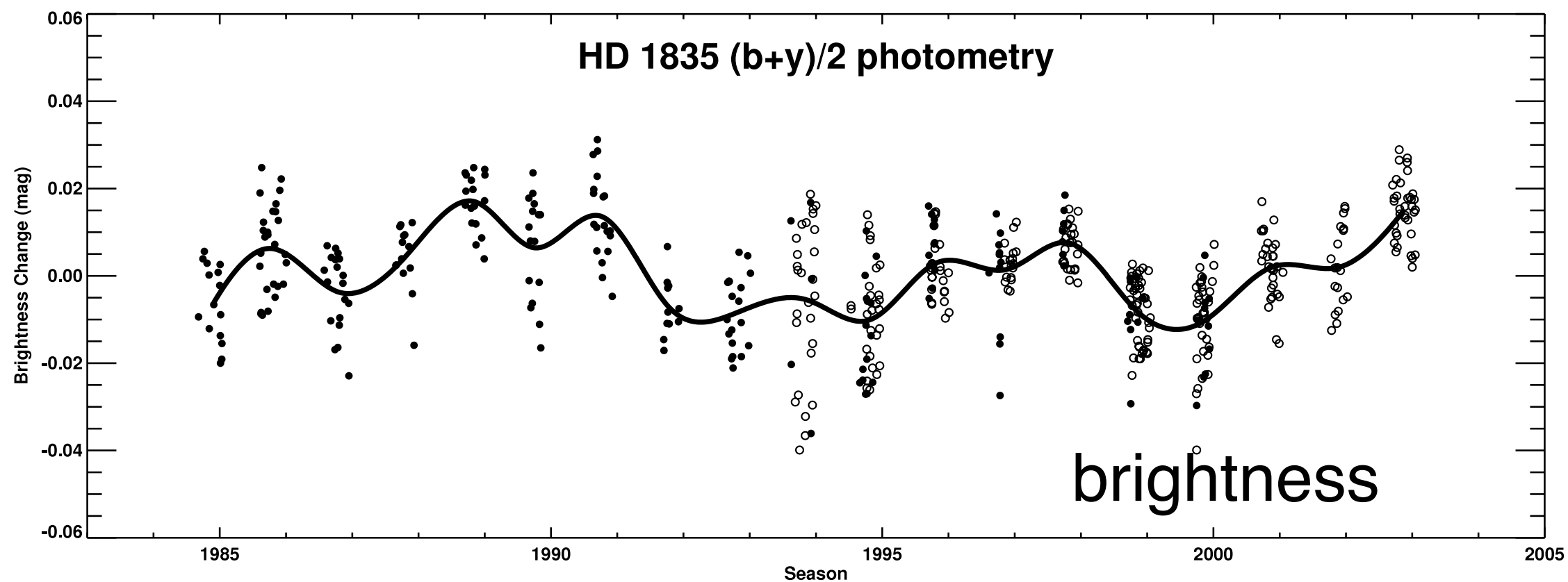
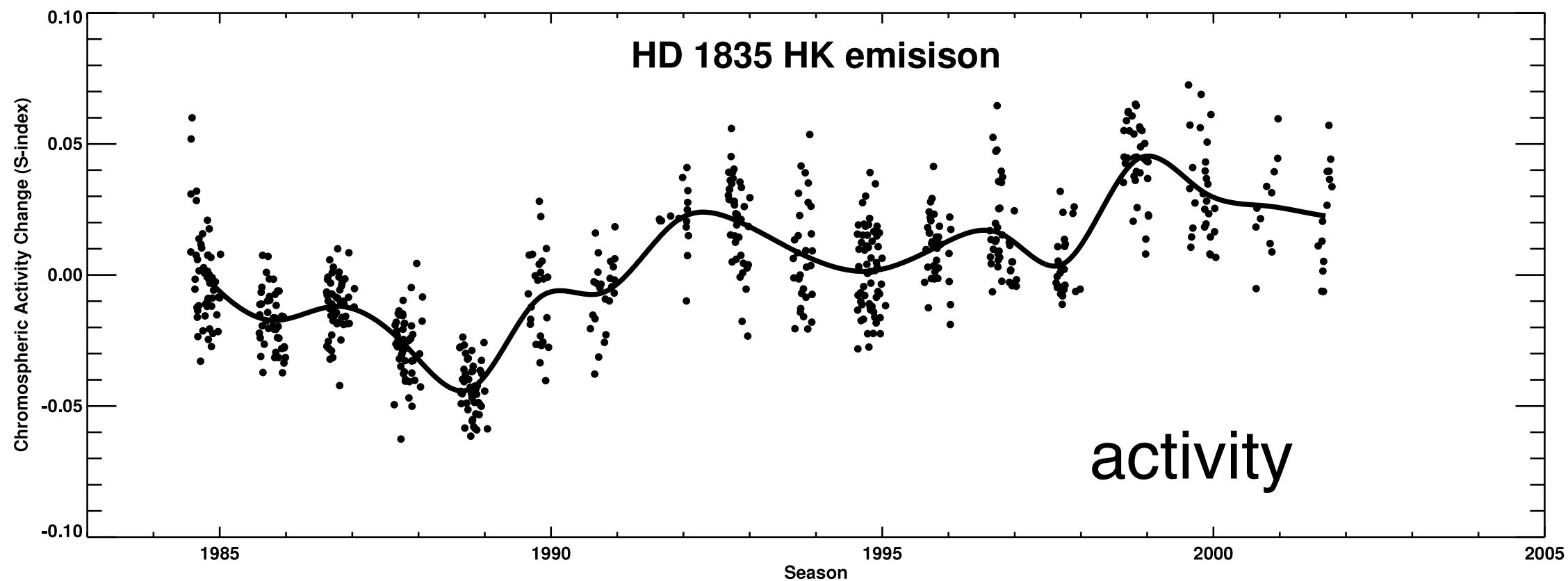
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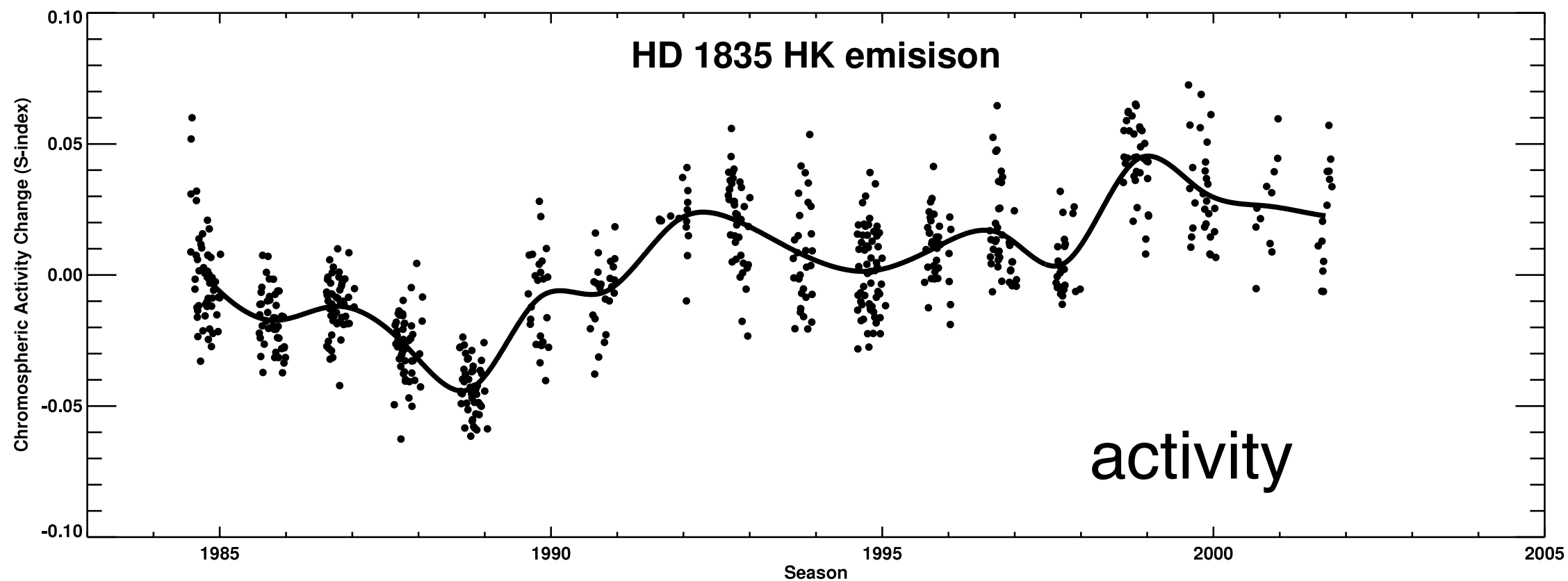


**look farther away
into the stars**

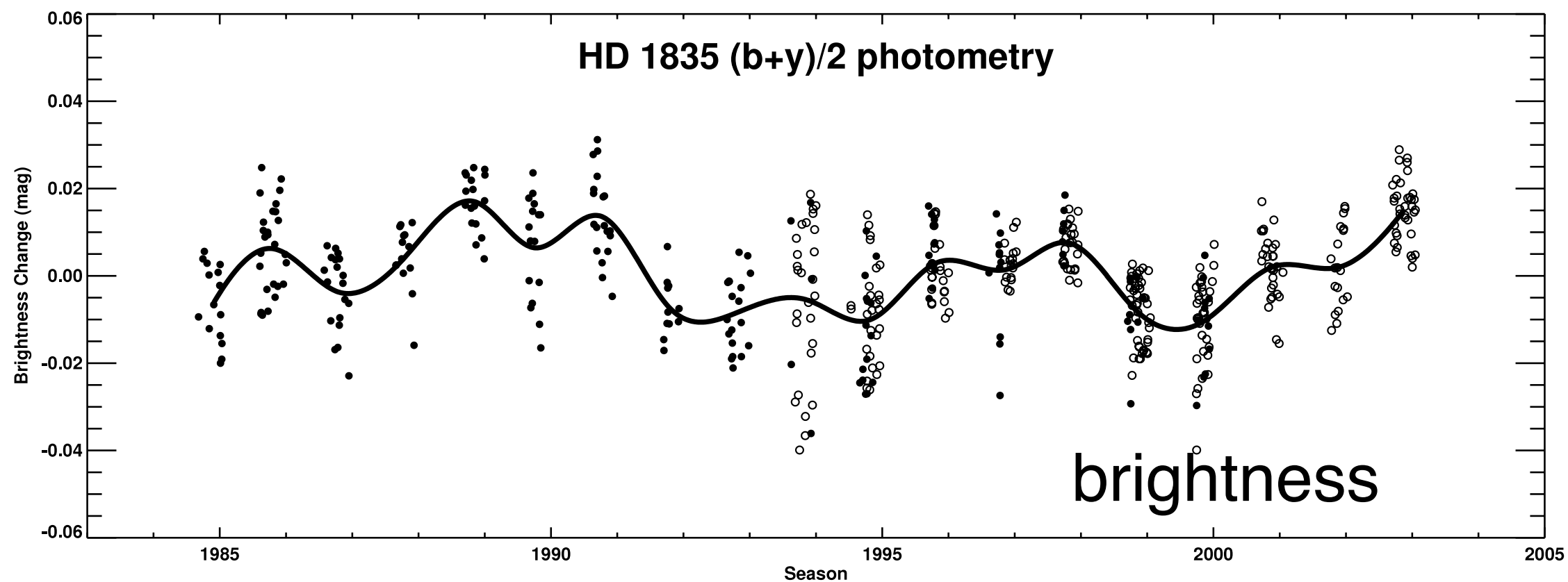


from Lockwood et al. 2007

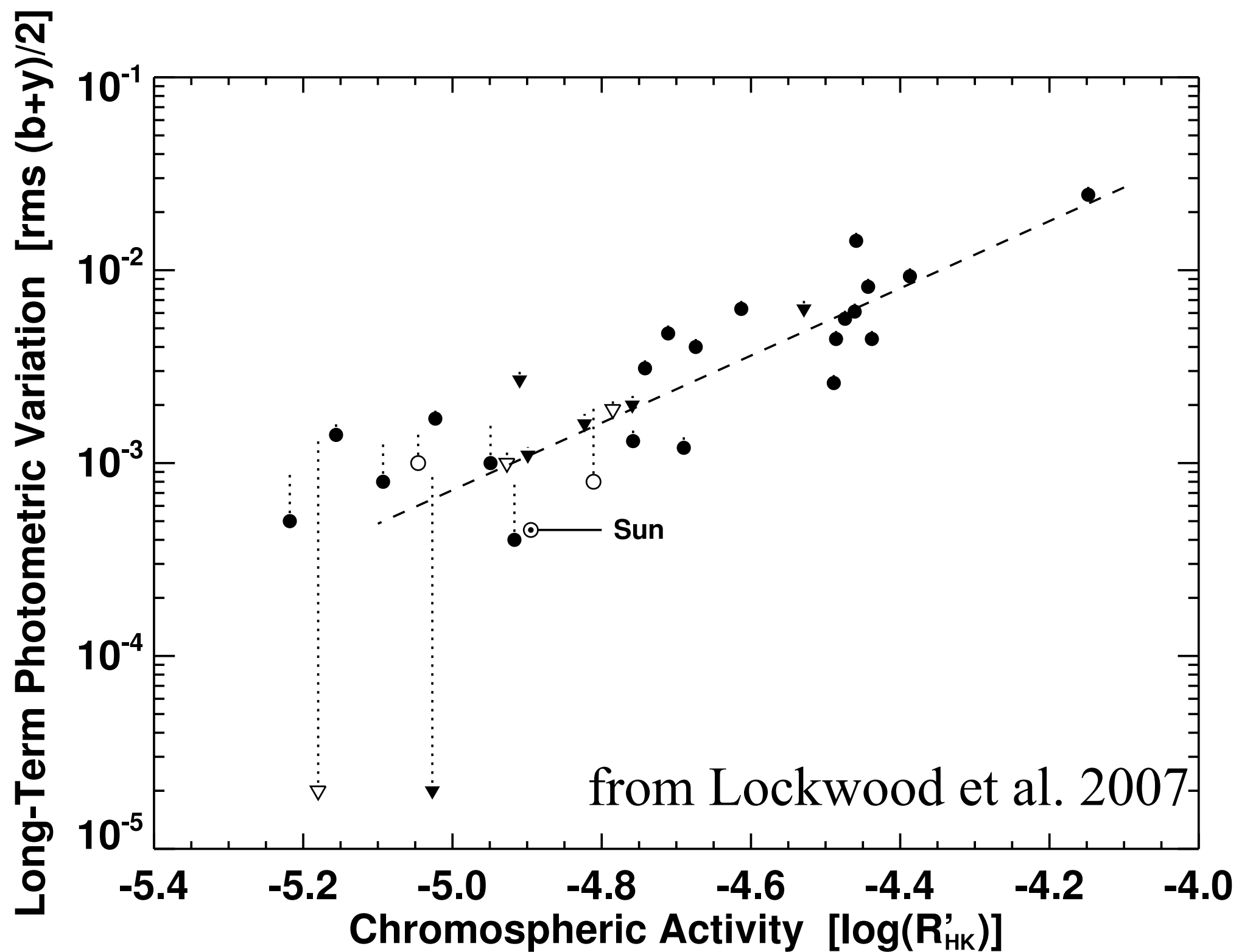




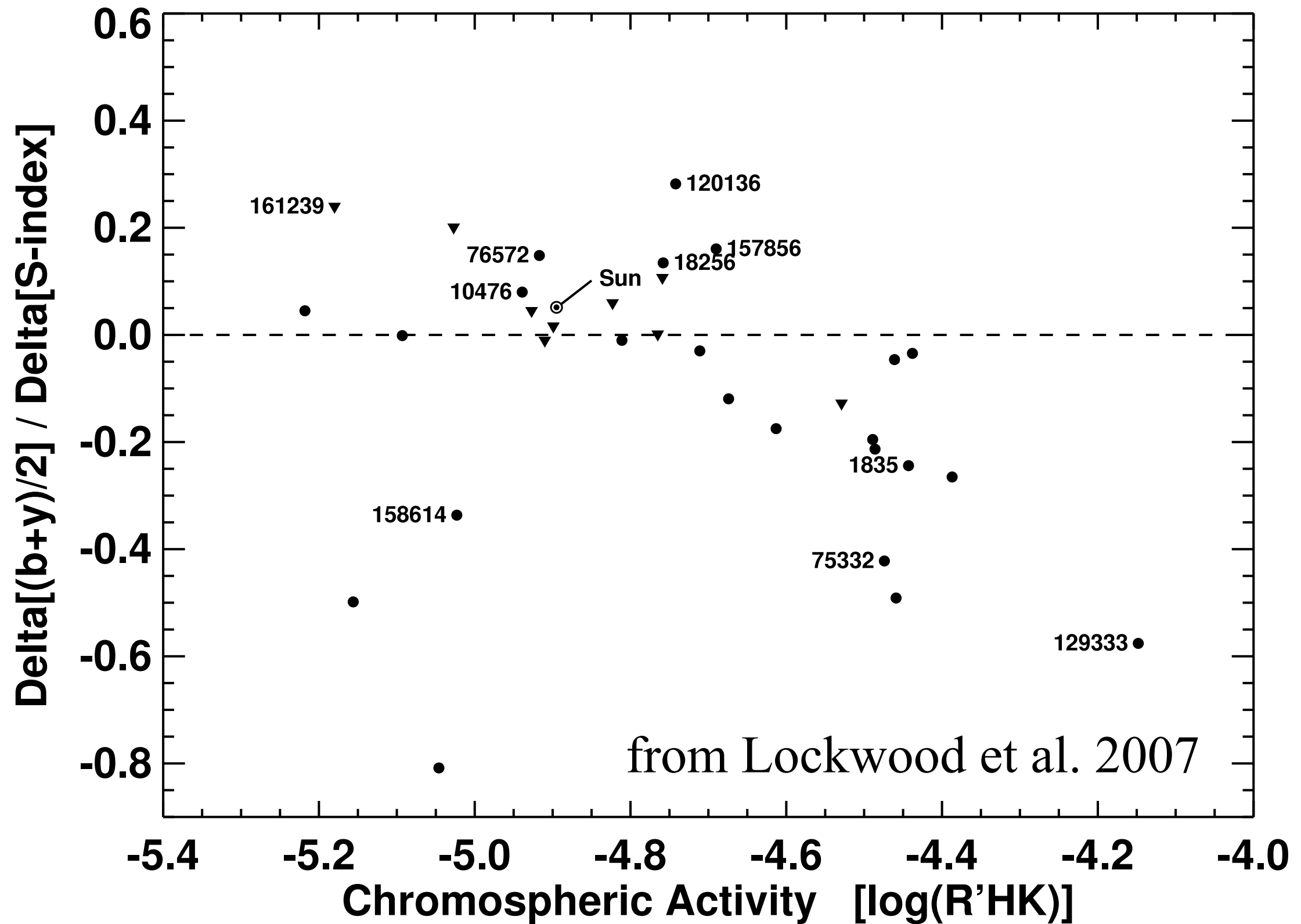
solar variability 0.0002 mag



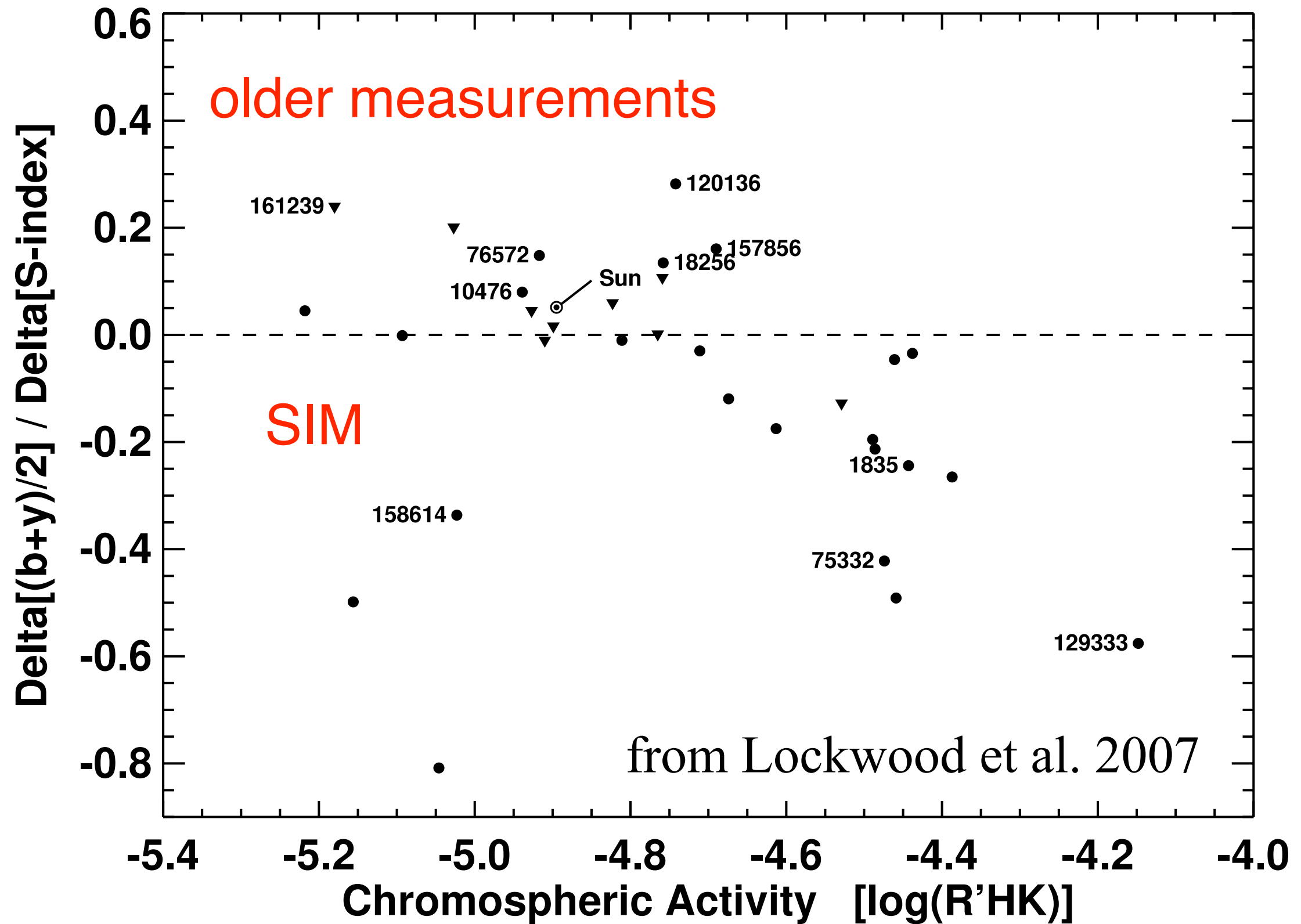
Variability as a function of activity



Spot and faculae dominated variability



Spot and faculae dominated variability



Spectral And Total Irradiance Reconstruction (SATIRE)

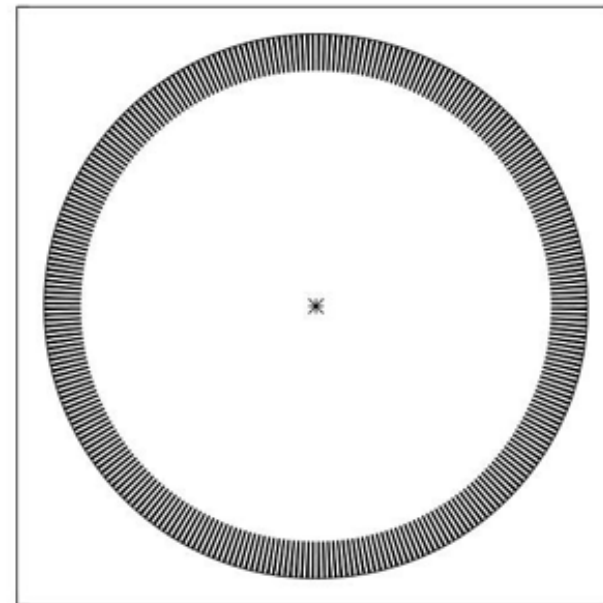
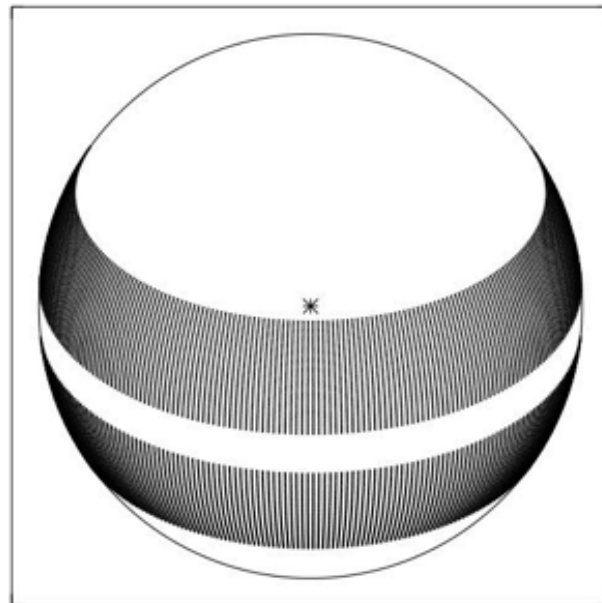
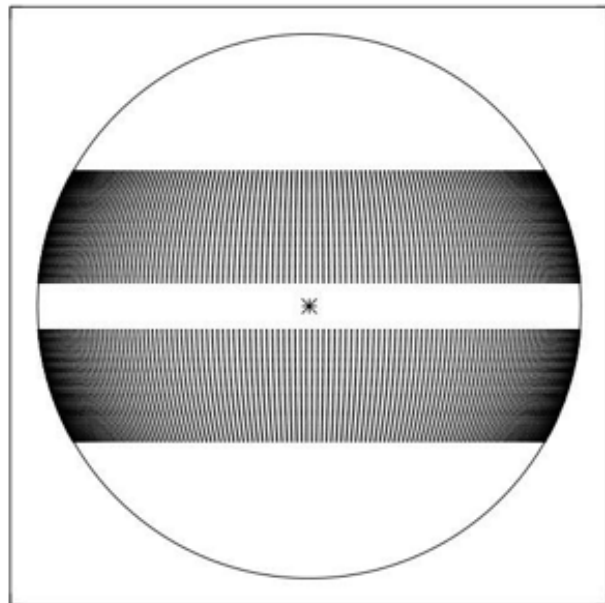
Spectral And Total Irradiance Reconstruction (SATIRE)

extrapolated to stars by treating them as
hypothetical Suns with coverage by magnetic
features different from that of the Sun

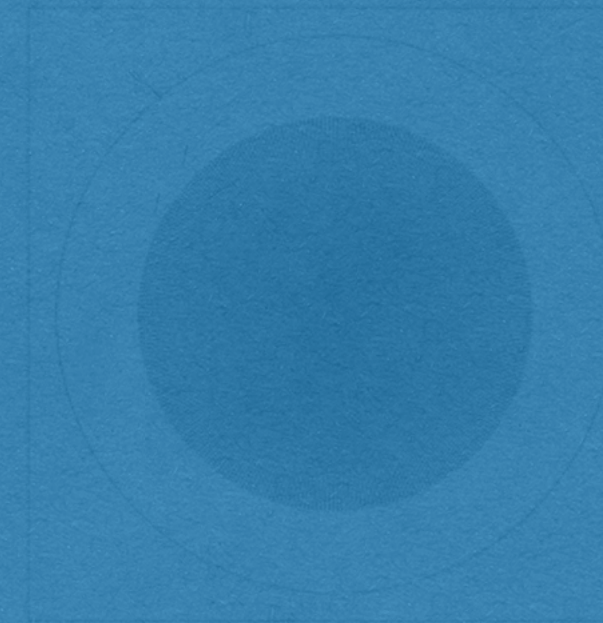
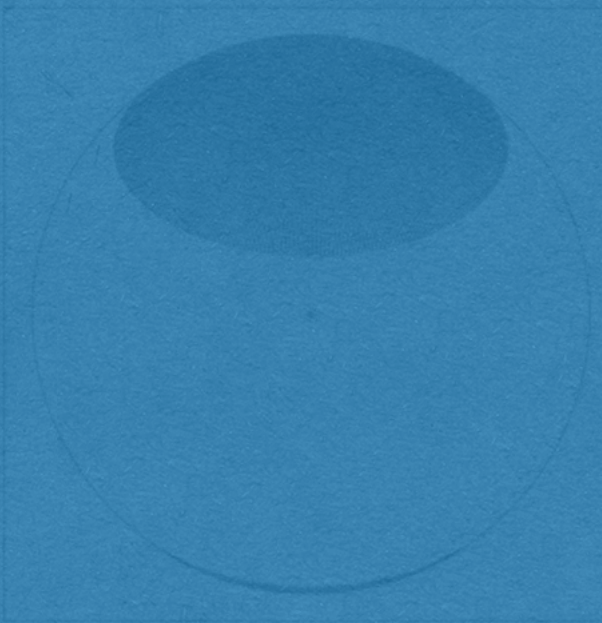
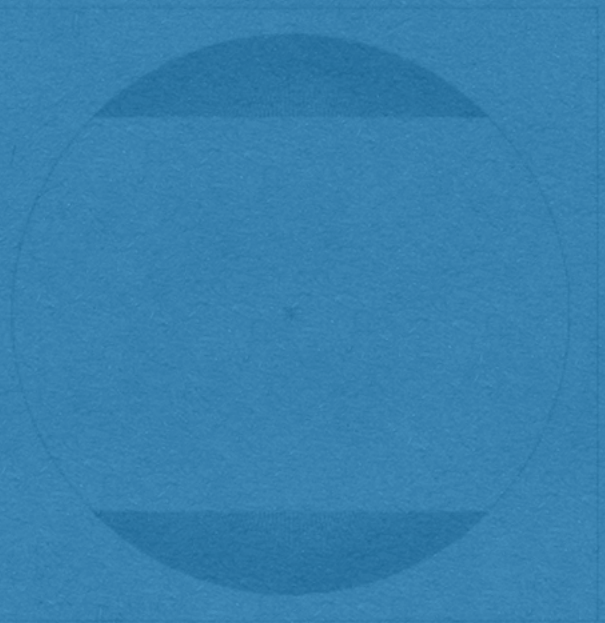
equator

intermediate

polar



slow-rotator

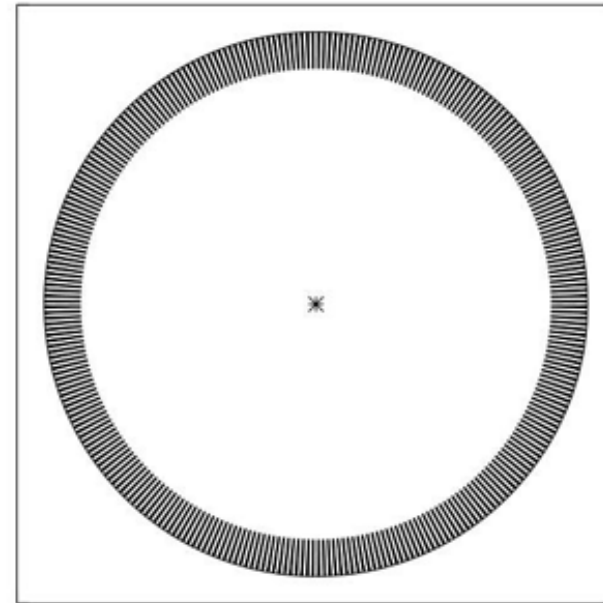
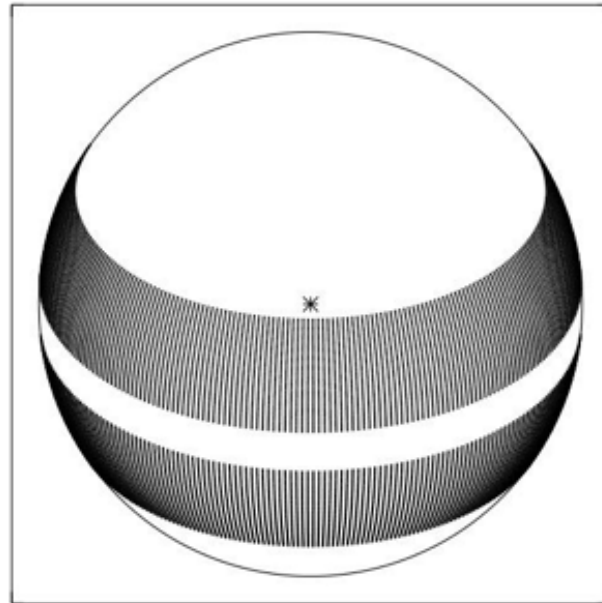
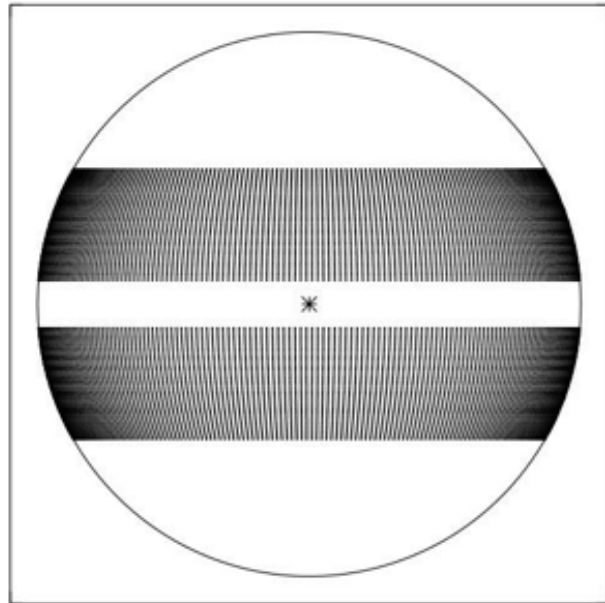


fast-rotator

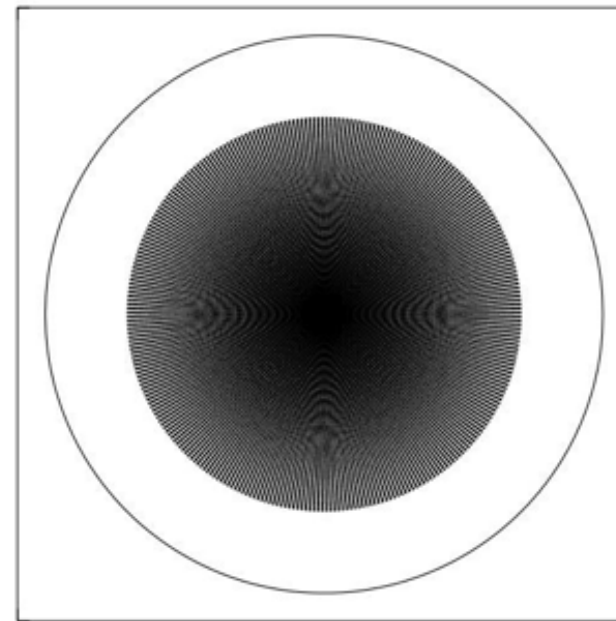
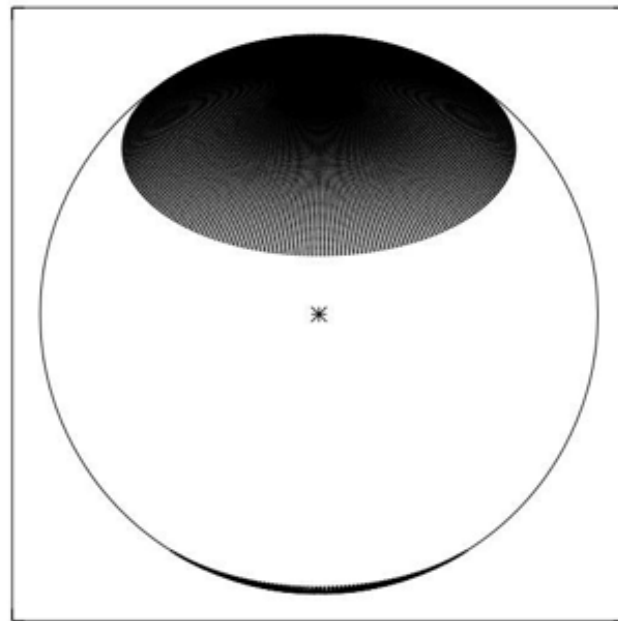
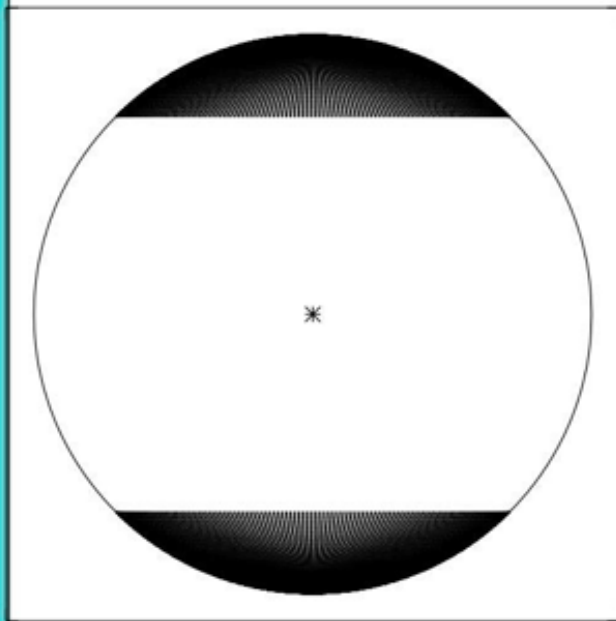
equator

intermediate

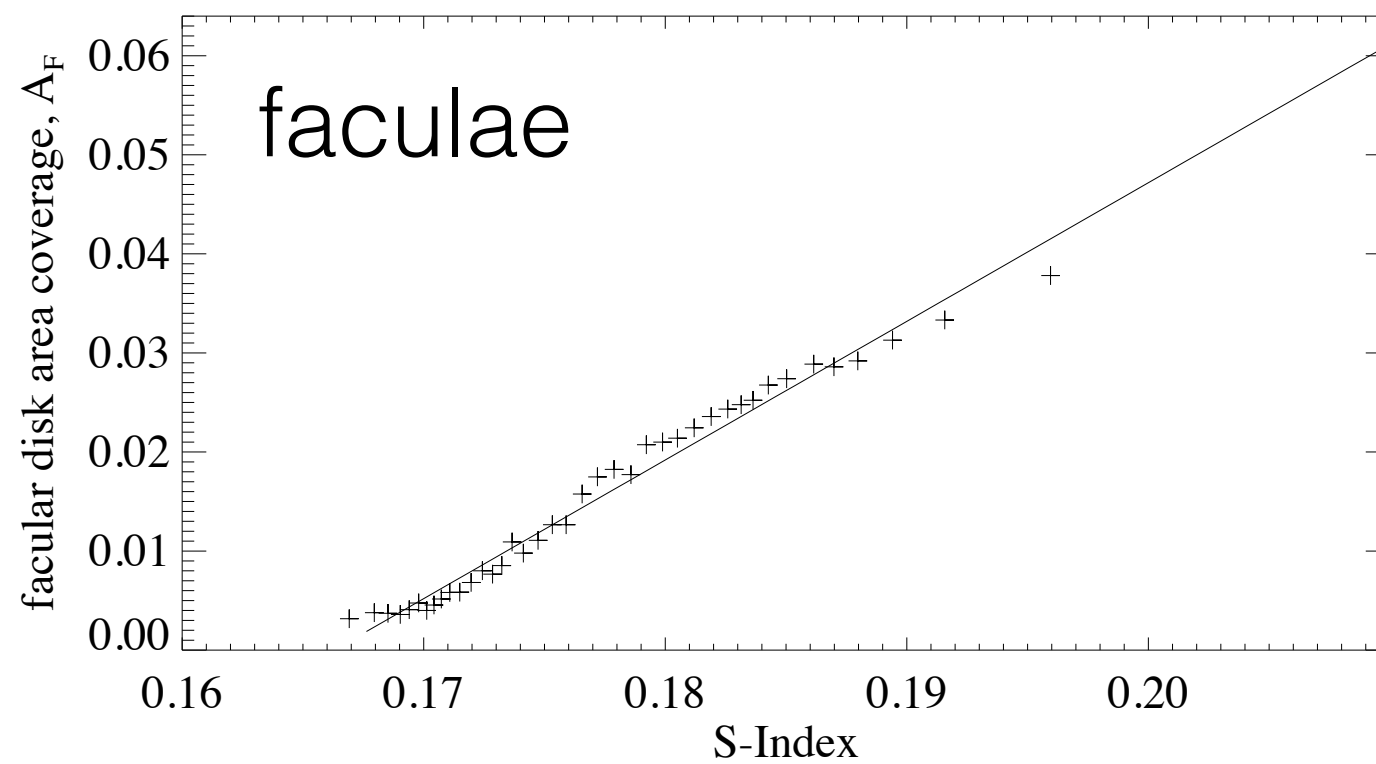
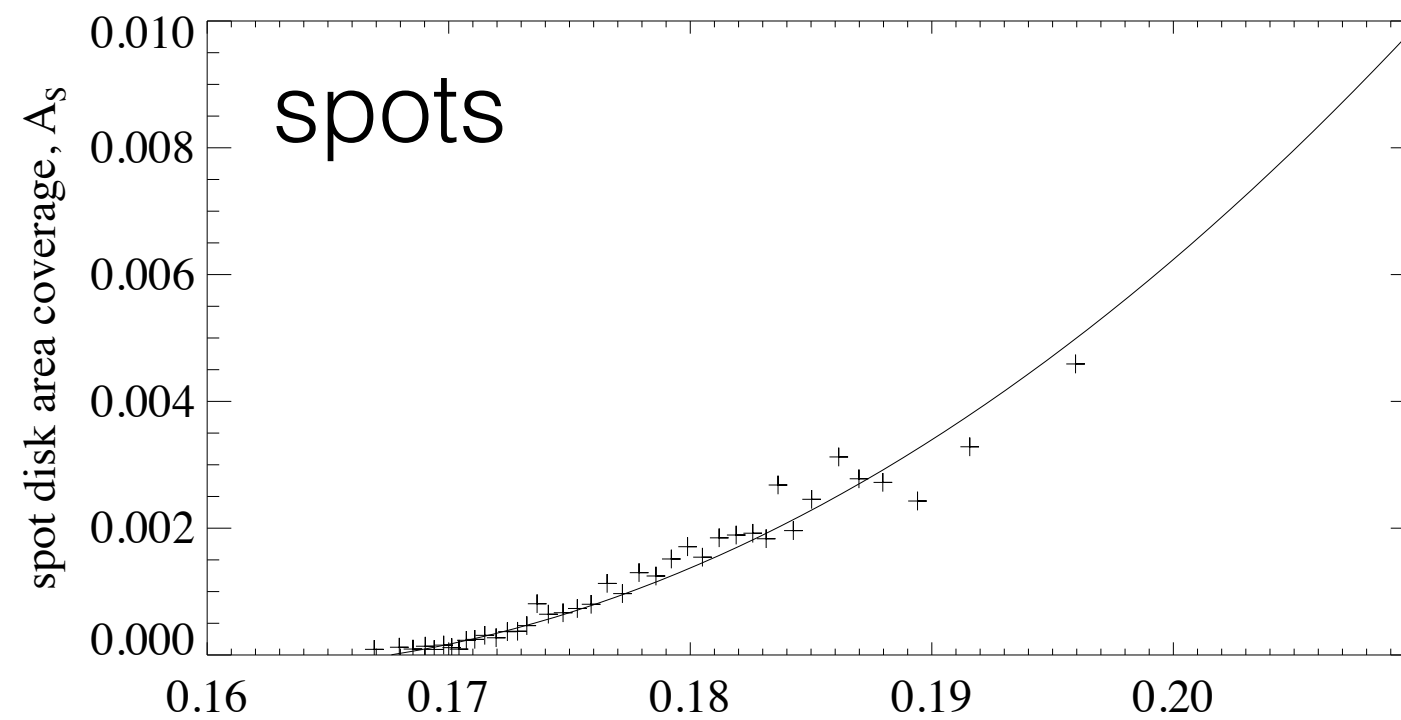
polar

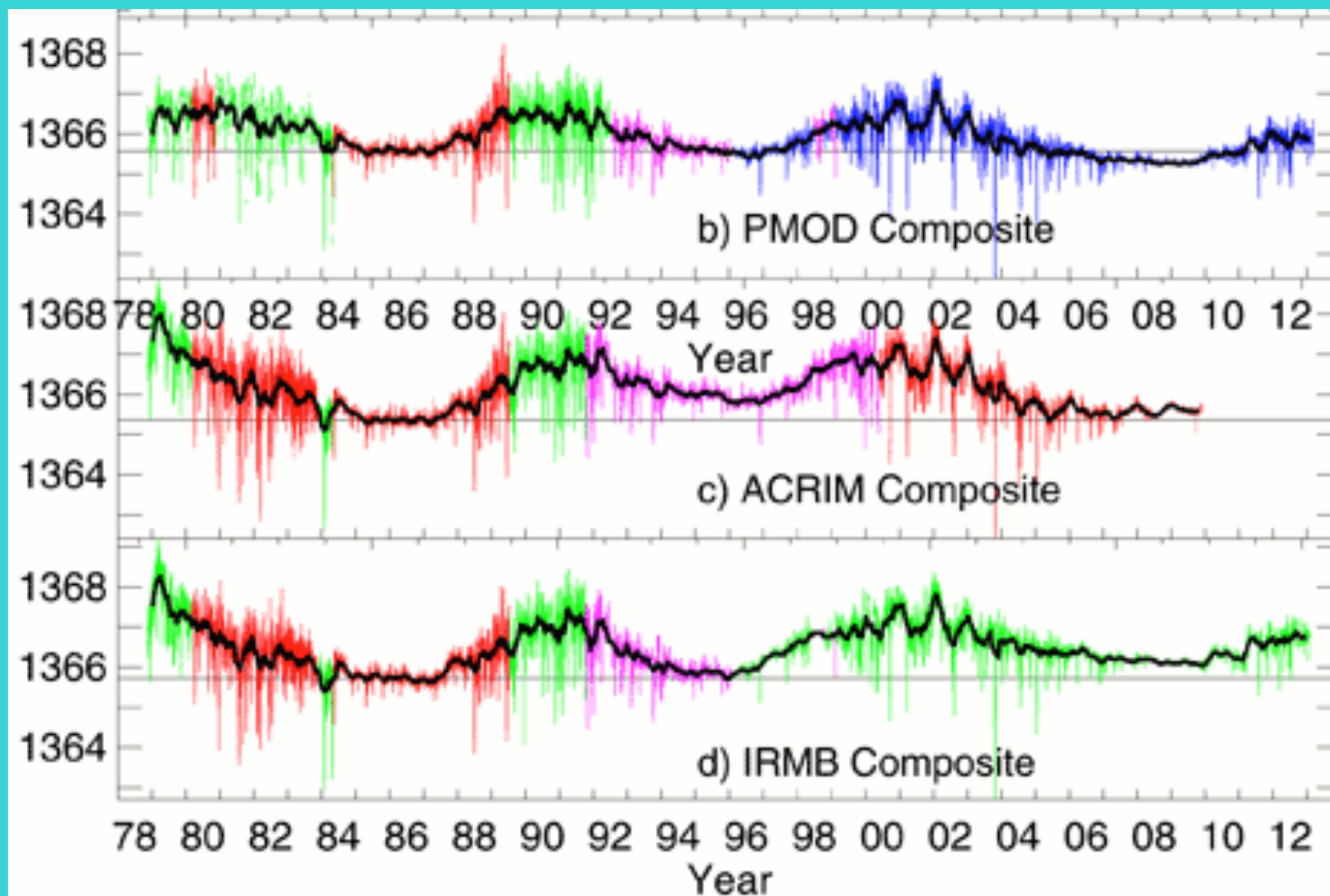


slow-rotator



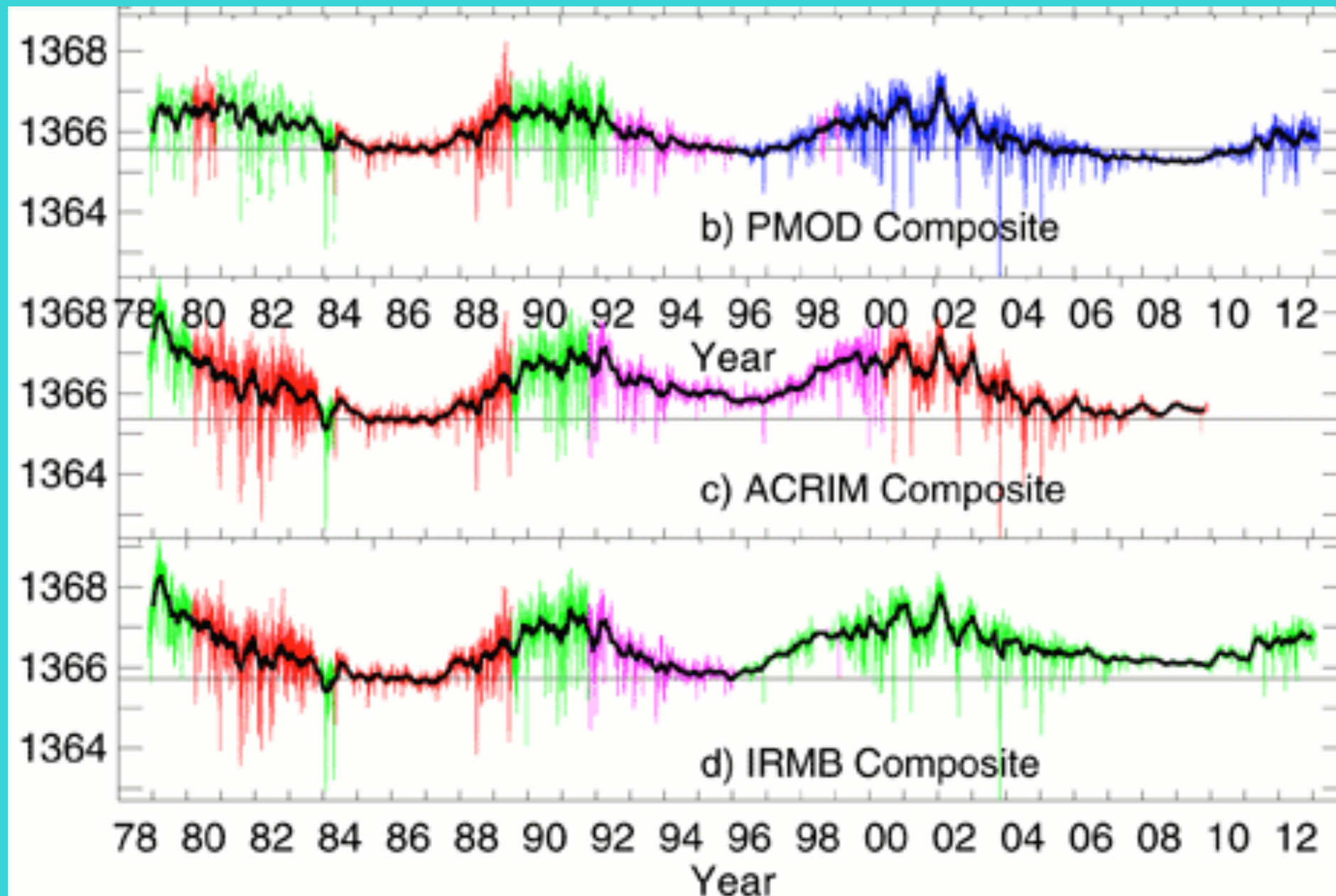
fast-rotator





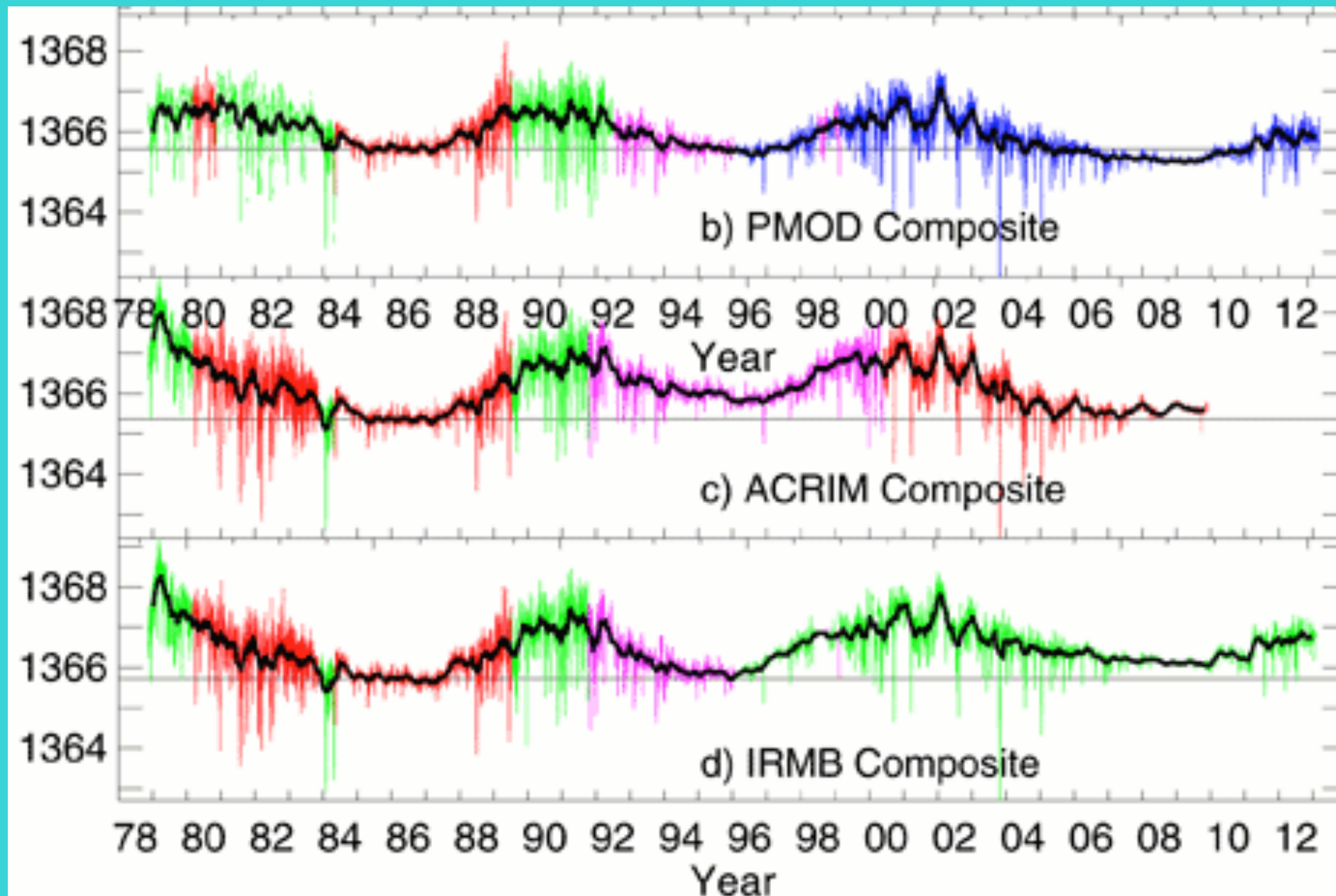
SSN 160 160 120

TSL



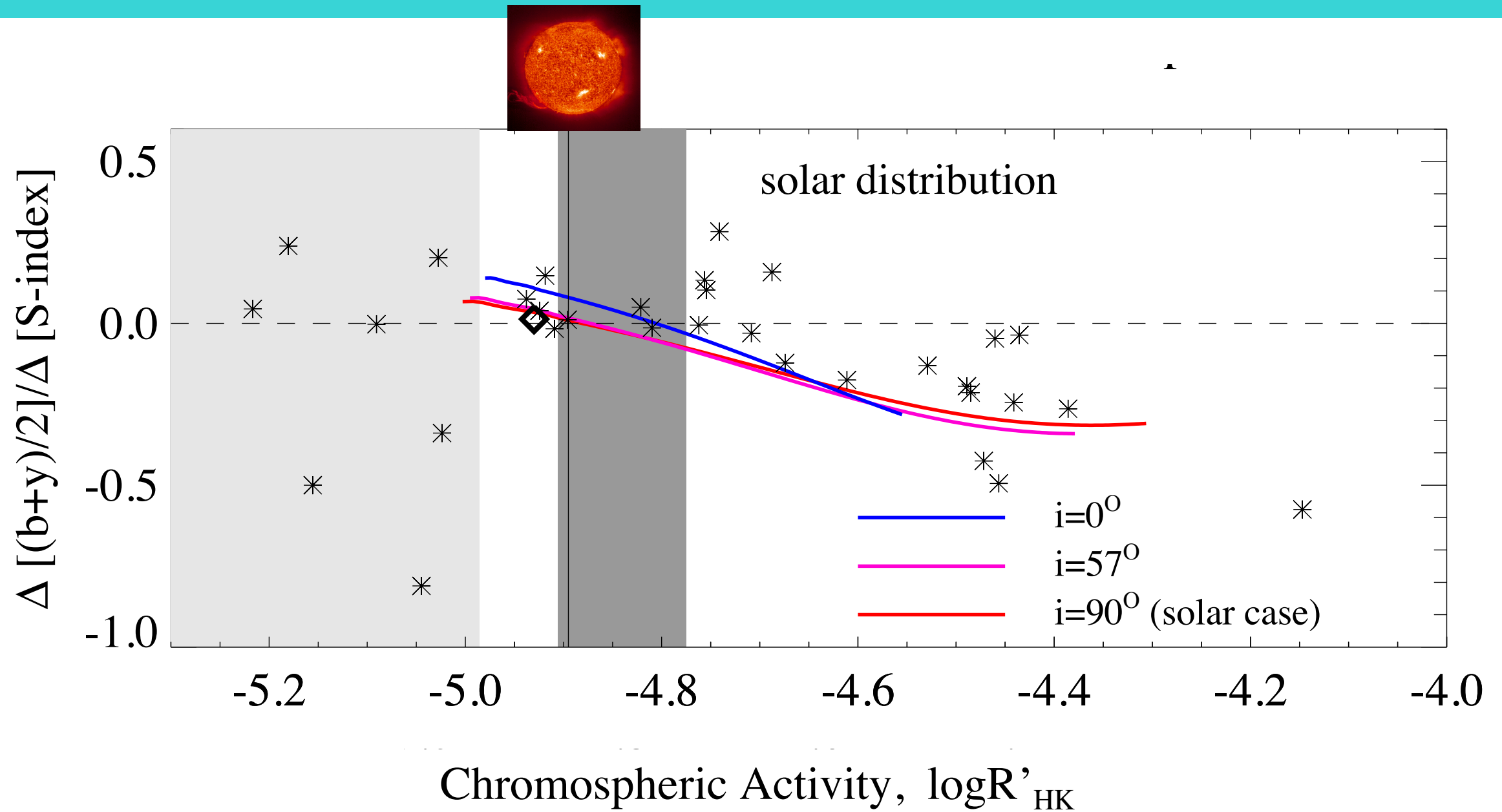
SSN 160 160 120

TSI

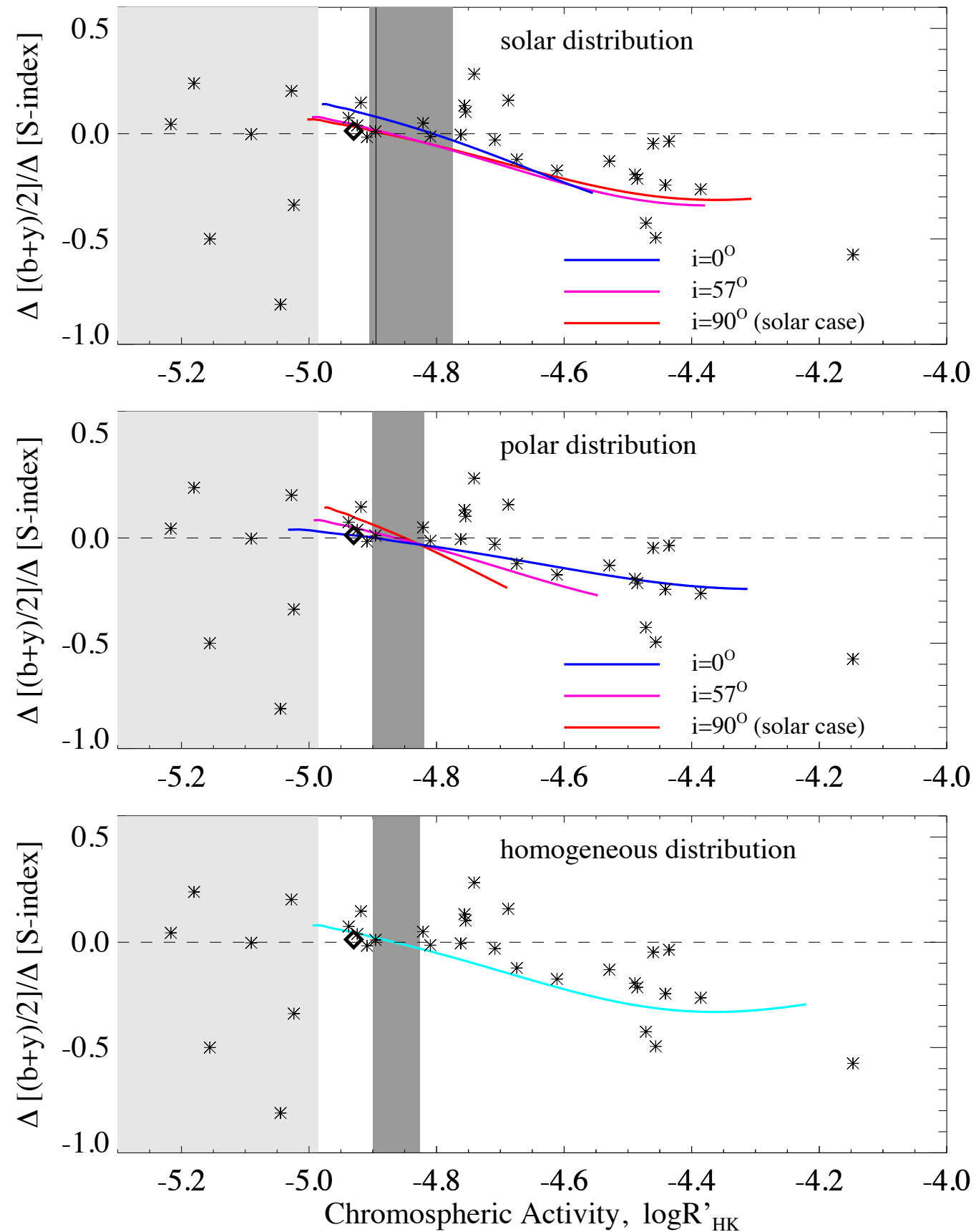


similar to HD 140538...

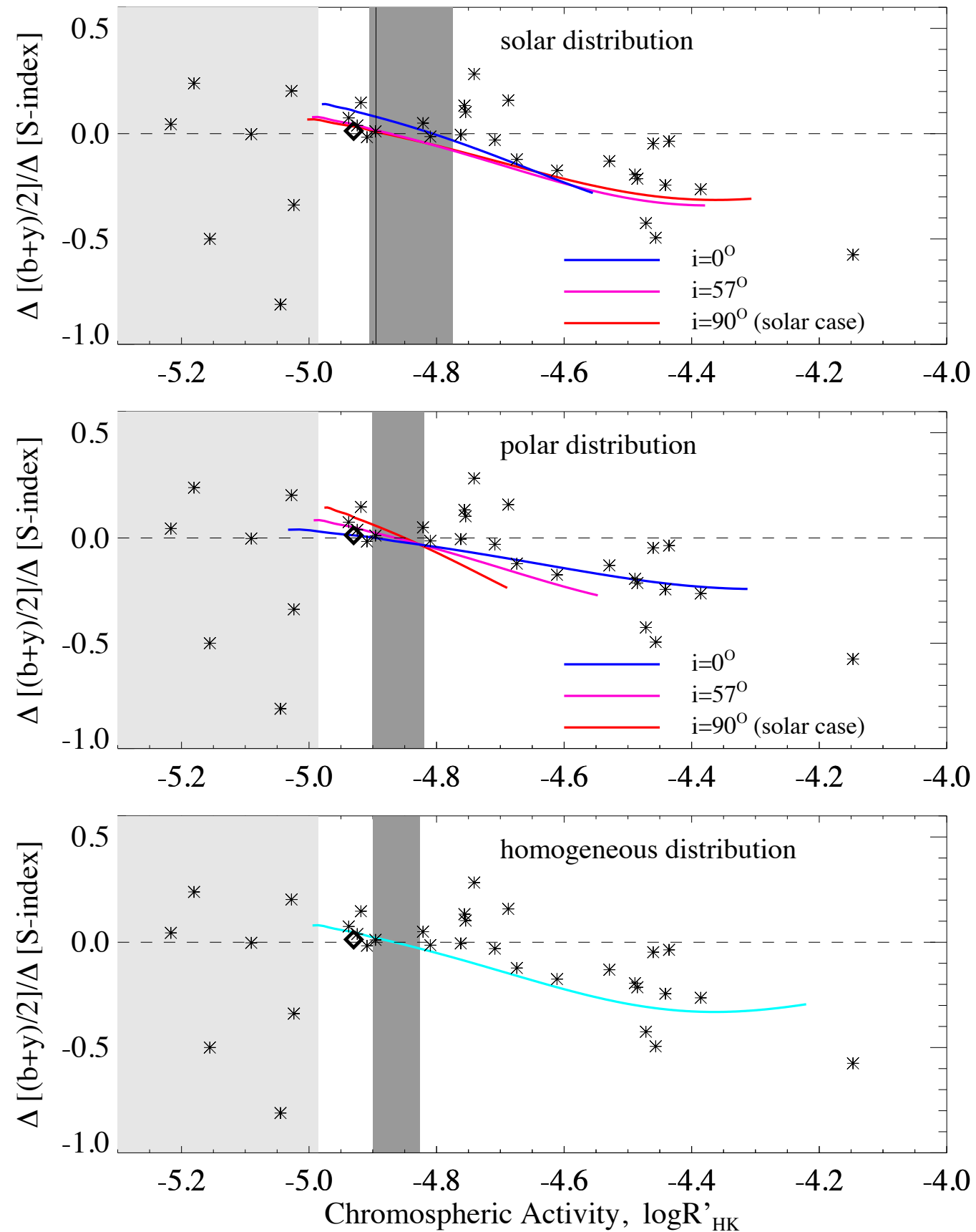
Spot- vs faculae- dominated regimes



Spot- vs faculae- dominated regimes

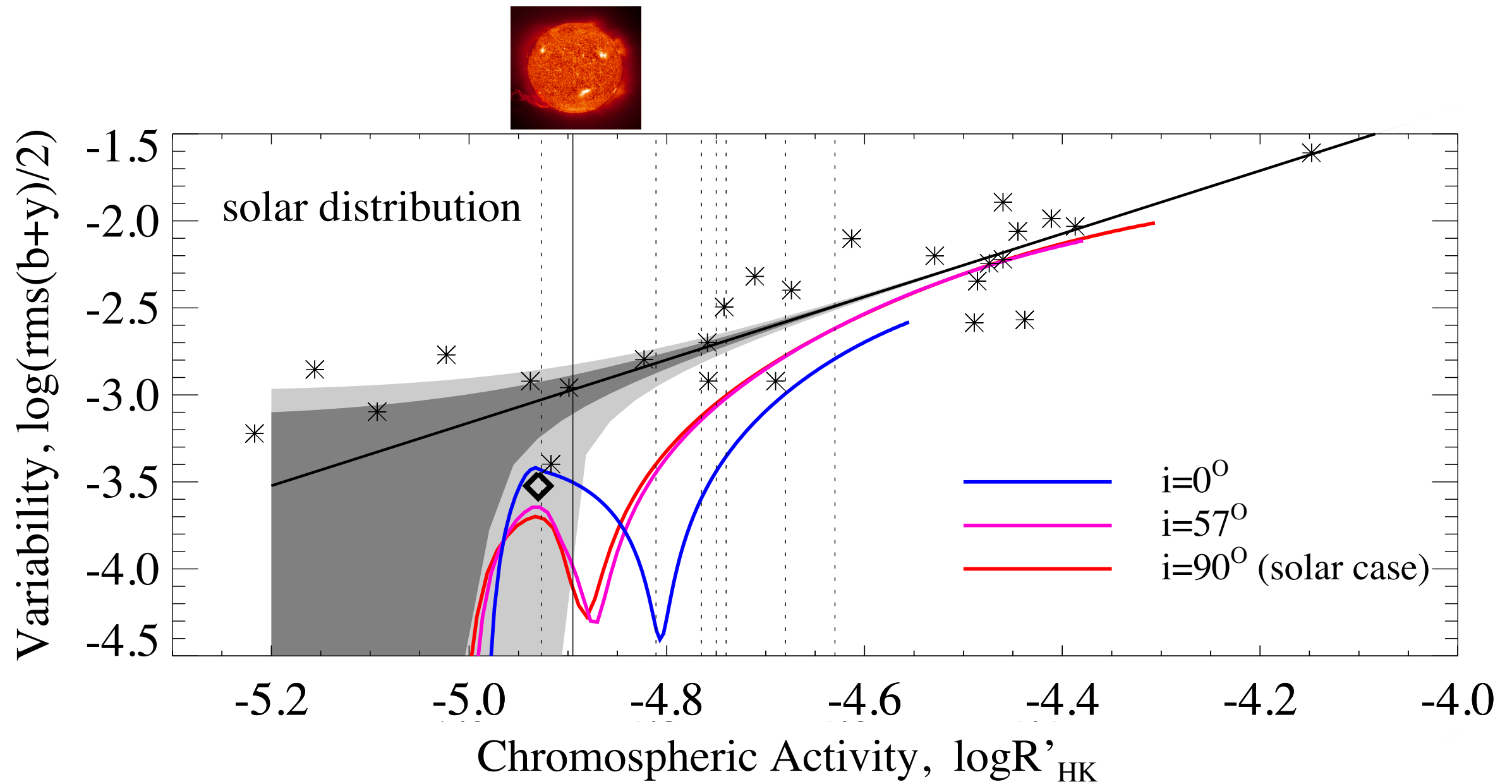


Spot- vs faculae- dominated regimes

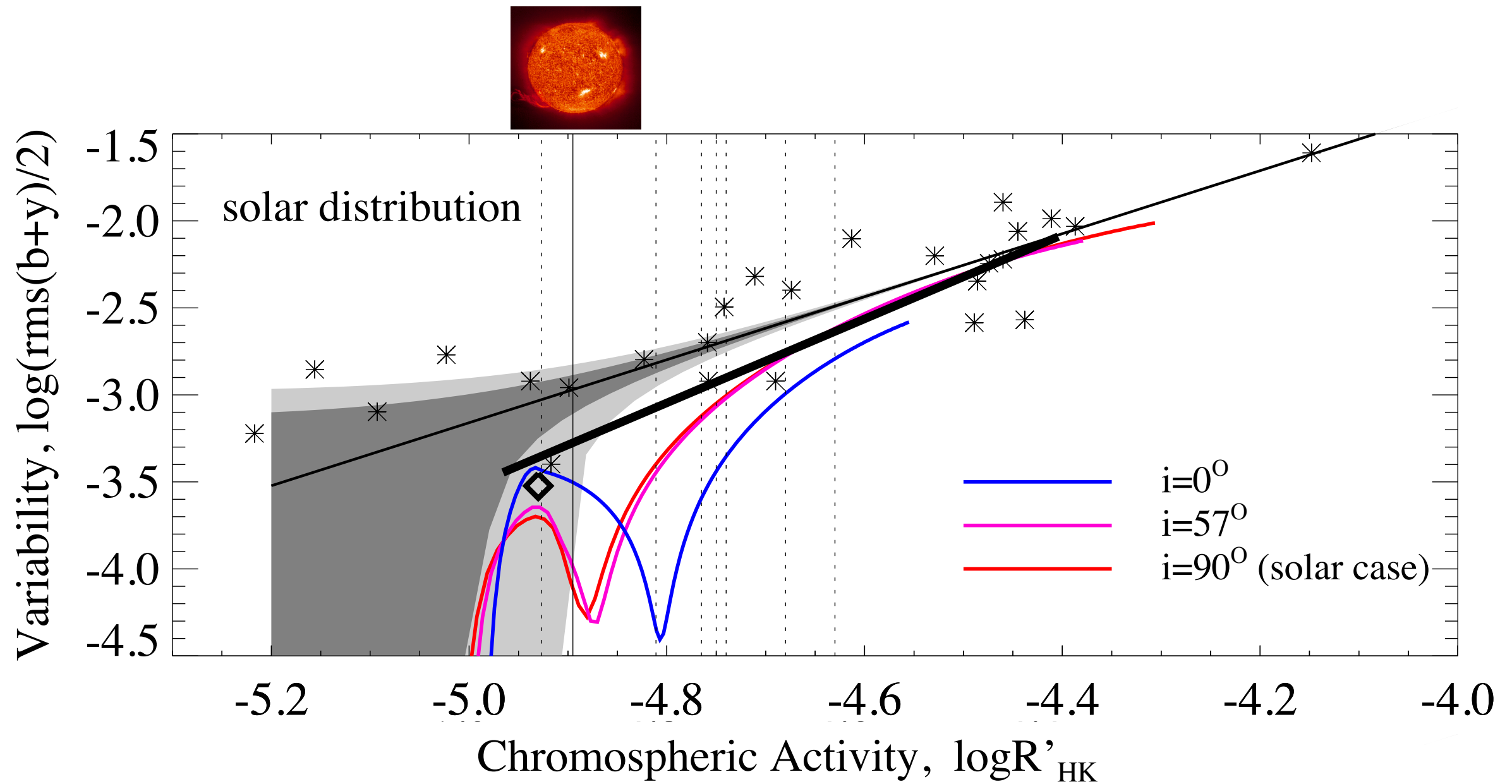


“Such an inadequate sample cannot fully constrain the activity at which a star might flip from spot-dominated to faculae-dominated brightness variations, but even this small sample demonstrates that these regimes are far from sharply defined.” from Hall et al. (2009)

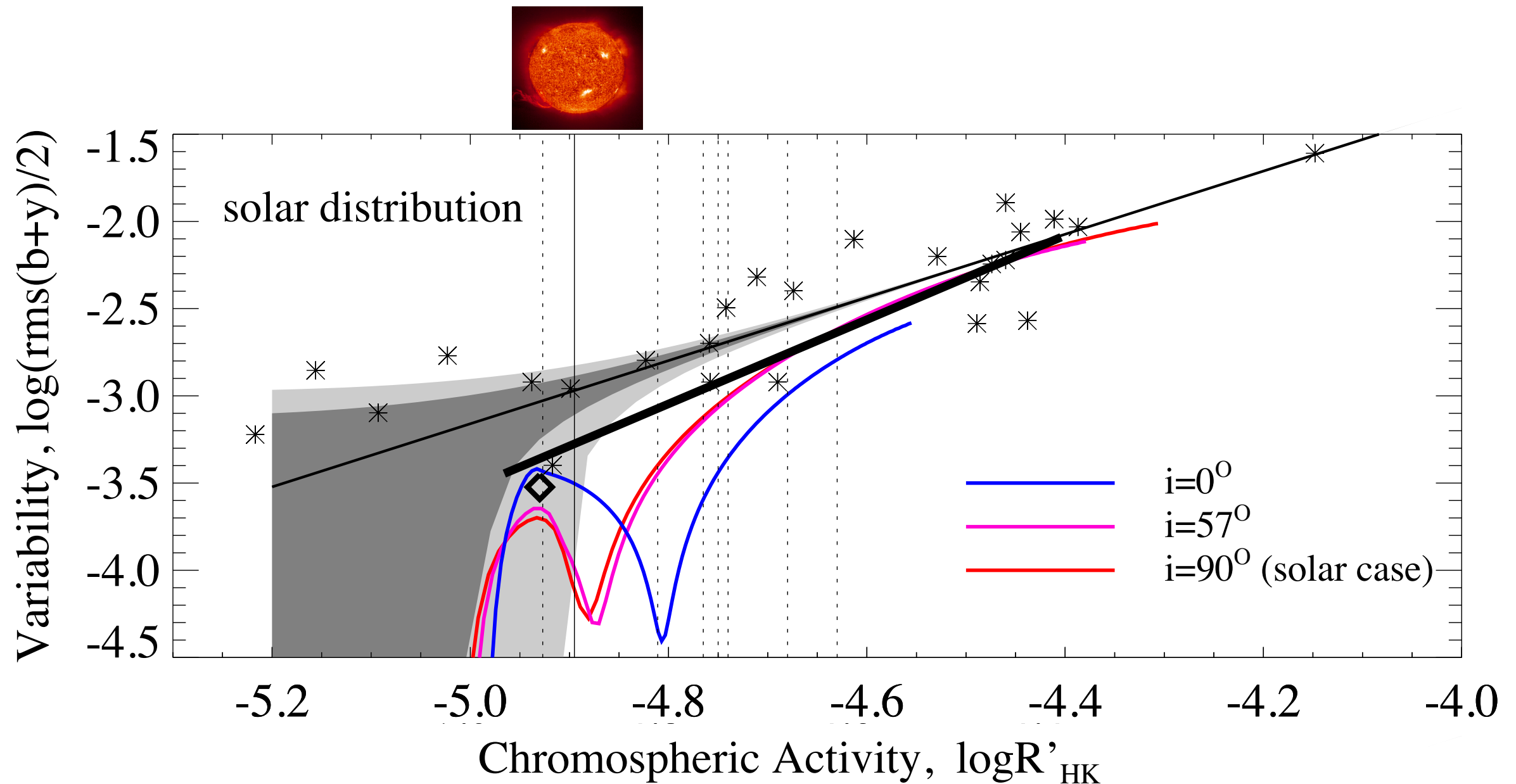
Variability vs. magnetic activity



Variability vs. magnetic activity



Variability vs. magnetic activity



no variability gap in stellar data

FM 13: Brightness variations of the Sun and Sun-like stars







THANK YOU!