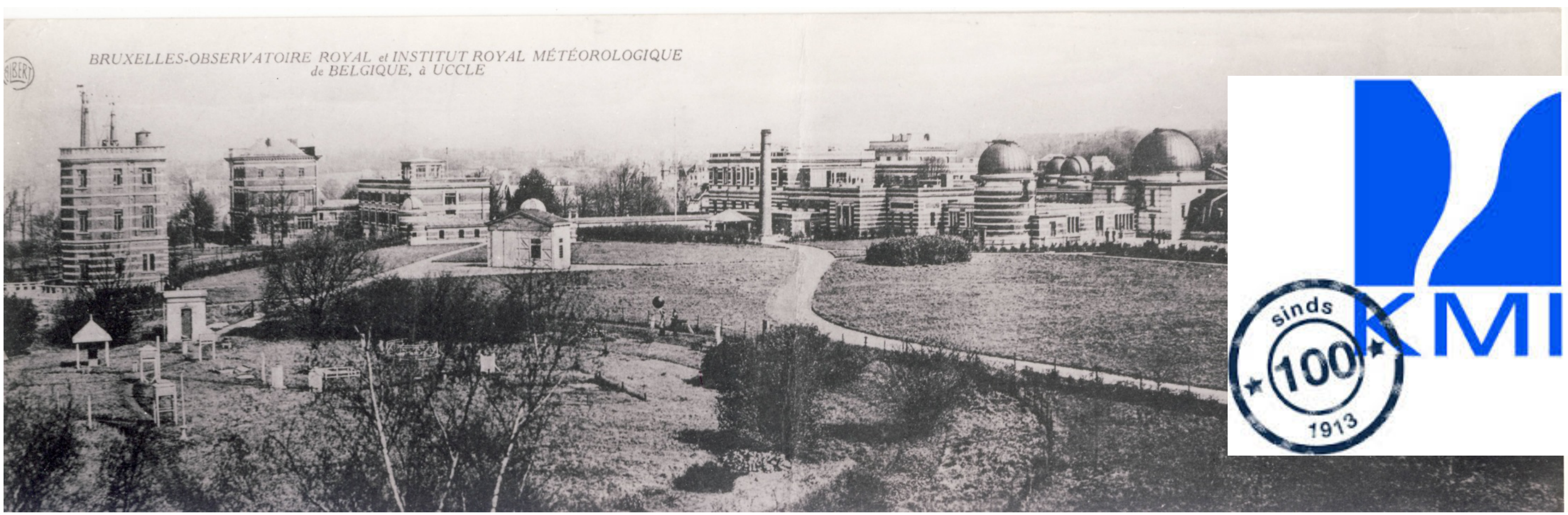
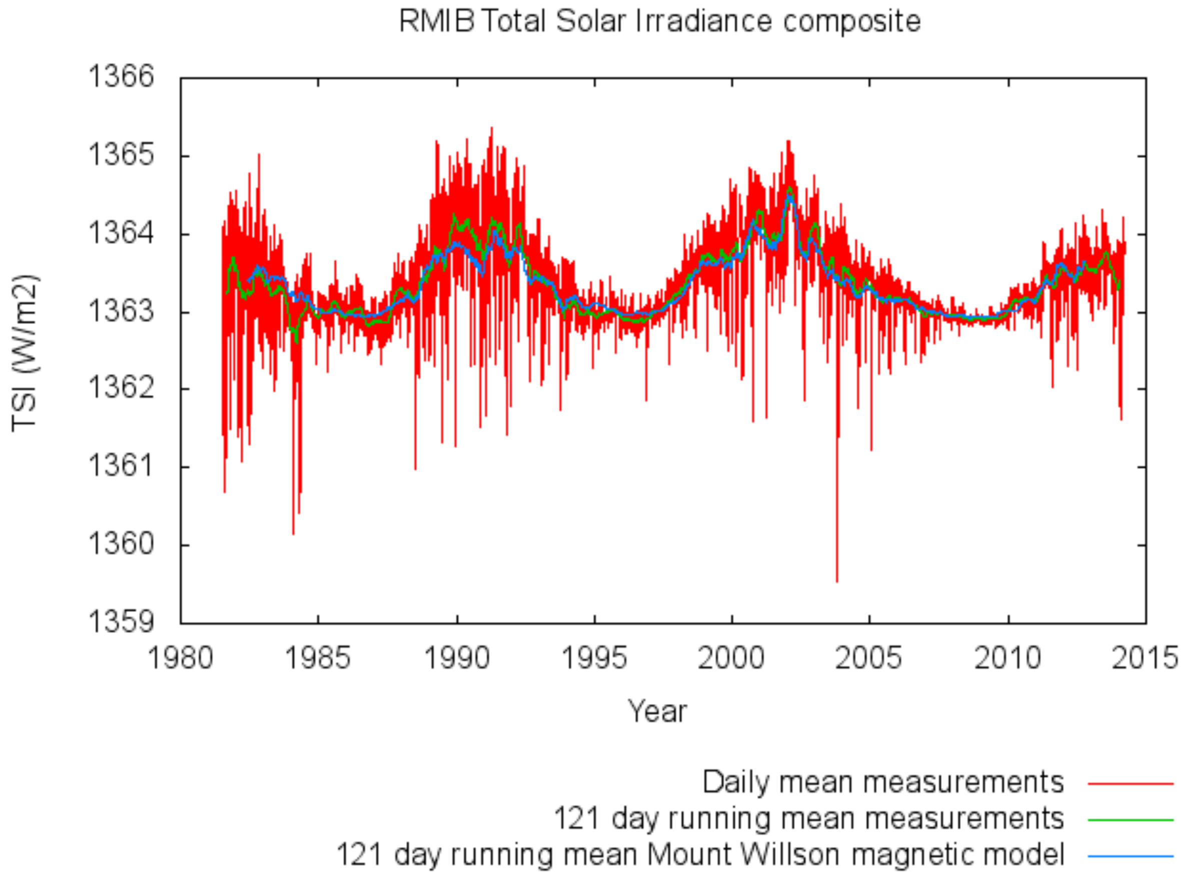
The value of the Solar Constant

STEVEN DEWITTE – RMIB

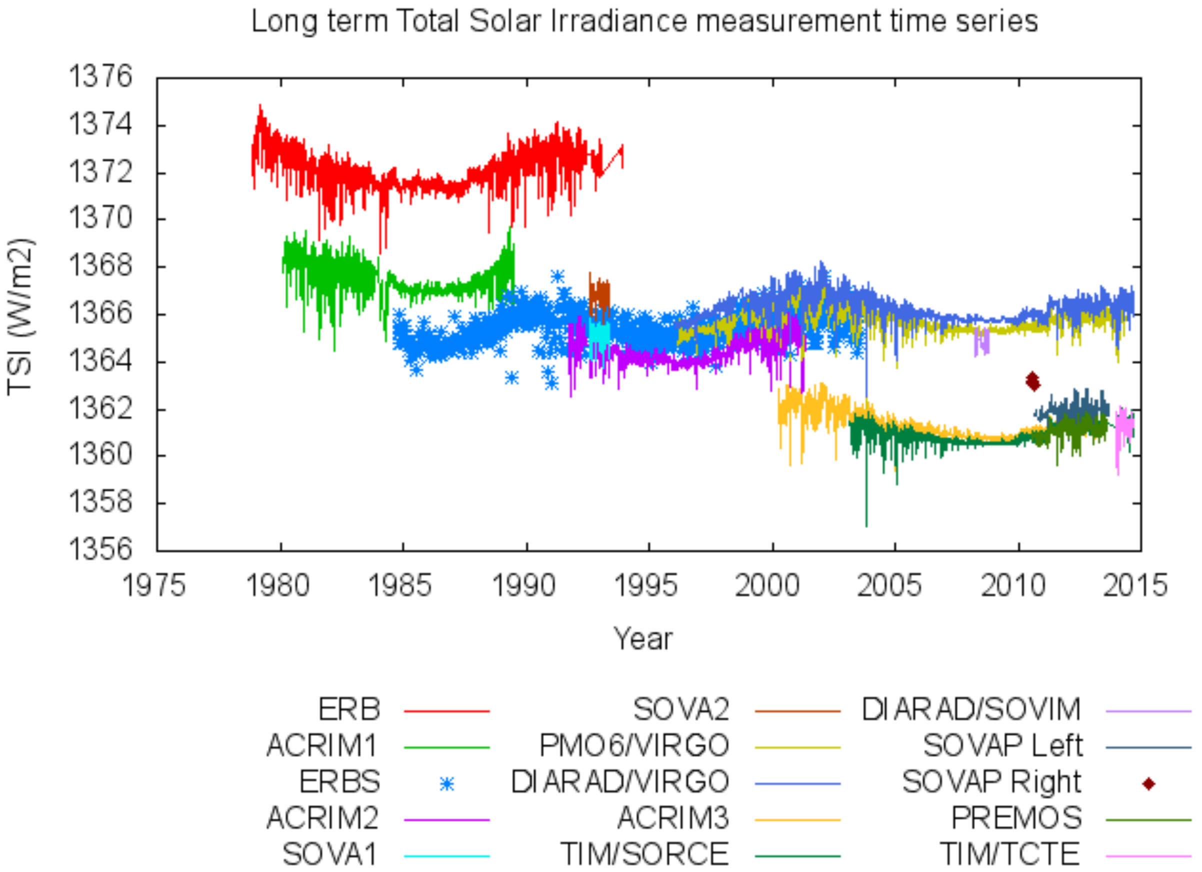
Sun-Climate Symposium, 10/11/2015



The 'simplest' problem: TSI variability



The oldest and most difficult problem: absolute level



RMIB SPACE RECORD: 11!

PAST IN SPACE:

1983	SPACELAB 1 NASA ESA
1992	ATLAS-I NASA STS-45
1992	**EURECA ESA STS-46: returned to ground**
1993	ATLAS-II NASA STS-56
1994	ATLAS-III NASA STS-66
1997	HITCHHIKER NASA STS-85
1998	HITCHHIKER NASA STS-95
2003	FREESTAR NASA STS-107

NOW IN SPACE:

SOHO/VIRGO/DIARAD ESA	December 1995	> **ongoing (> 19 y)**
ISS/SOVIM/DIARAD ESA	February 2008	> 1 year
PICARD/SOVAP CNES	June 2010	> terminated

PLANNED:

FY3E/JOIM/DIARAD CMA	2018

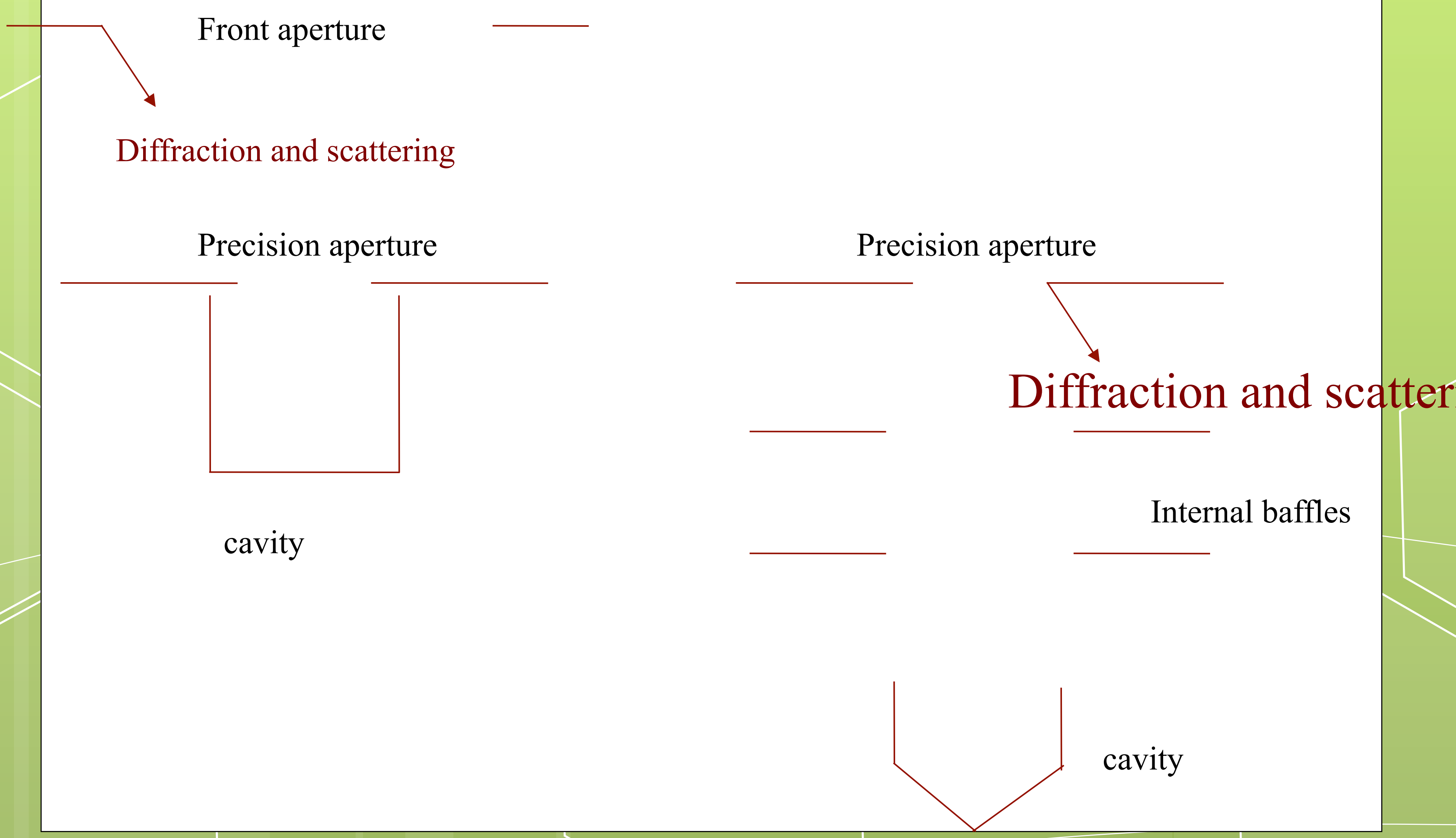
DIARAD absolute level revision

- Use as independent absolute radiometer -> no calibration
- New method of non-equivalence characterisation -> lower irradiance
- Best radiometers: DIARAD/SOVIM, SOLCON, SOVAR
  - Thick sidewalls + metallic bottom -> good spatial uniformity -> low uncertainty non equivalence
  - DIARAD/SOVIM: improved shutter design + most recent characterisation
- Revised Solar Constant: 1362.9 +/- 0.9 W/m^2 (2 sigma uncertainty) at solar minimum
- DIARAD/VIRGO, Sova-Picard: thin sidewalls -> high uncertainty non equivalence

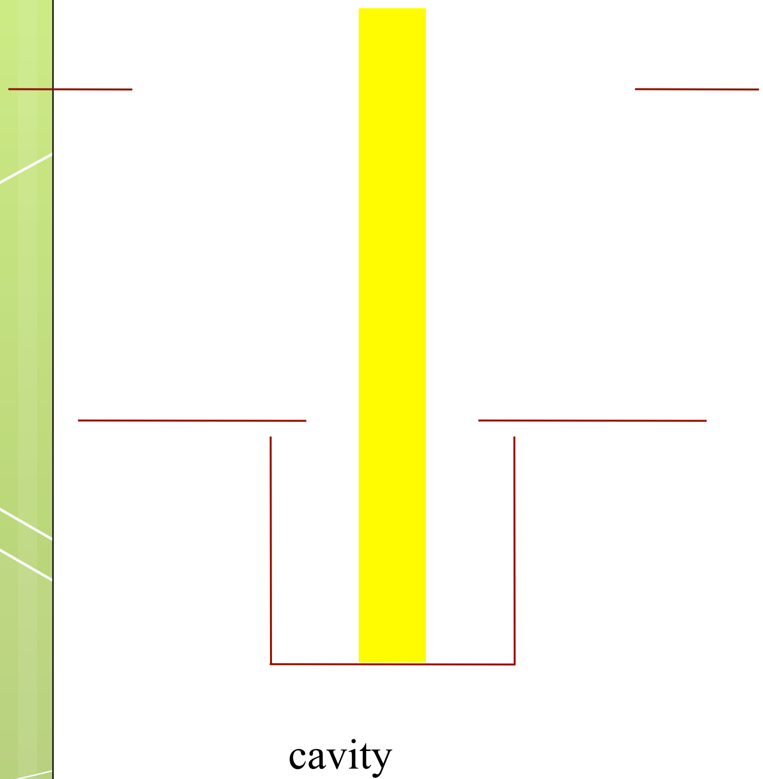
Comparison campaign at LASP TRF with Sovar radiometer: Validation, not calibration

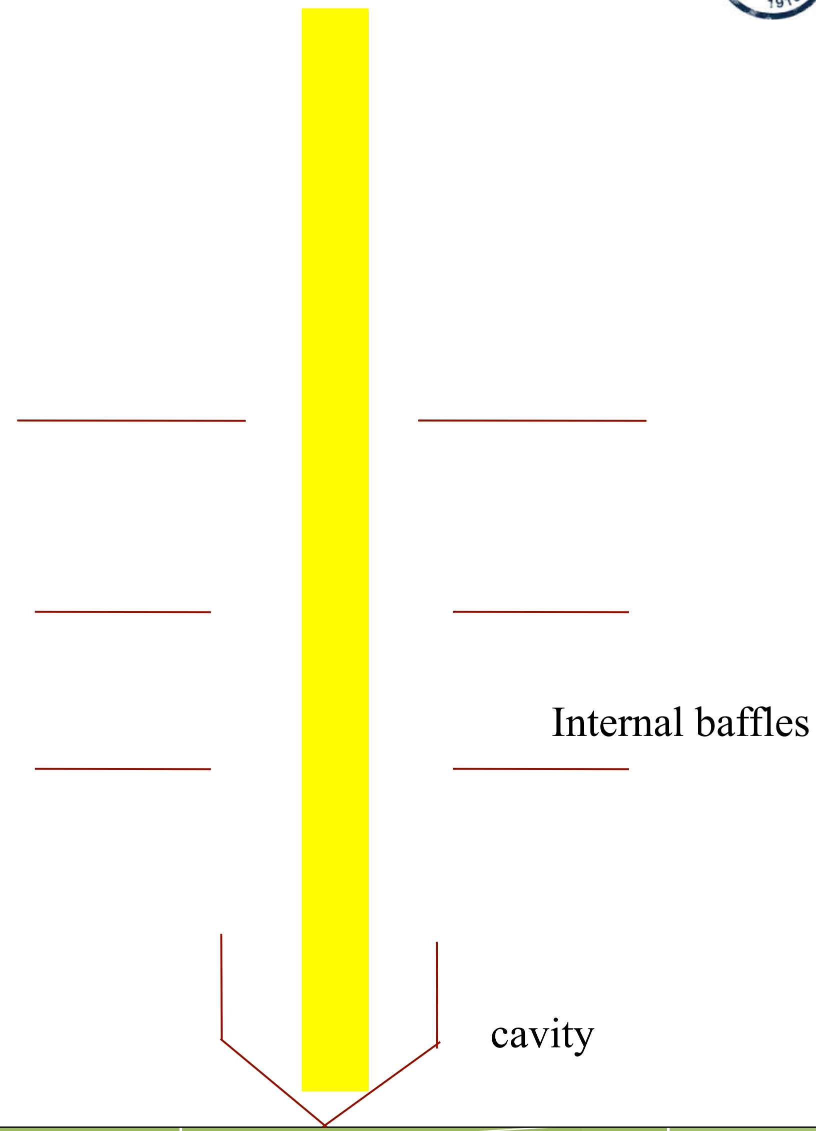
- Sovar: DIARAD type radiometer that flew on Eureca in 1992, brought back to ground by space shuttle.
- Comparison campaign with LASP TRF Crogenic radiometer in May-June 2013.

DIARAD & TIM type geometry



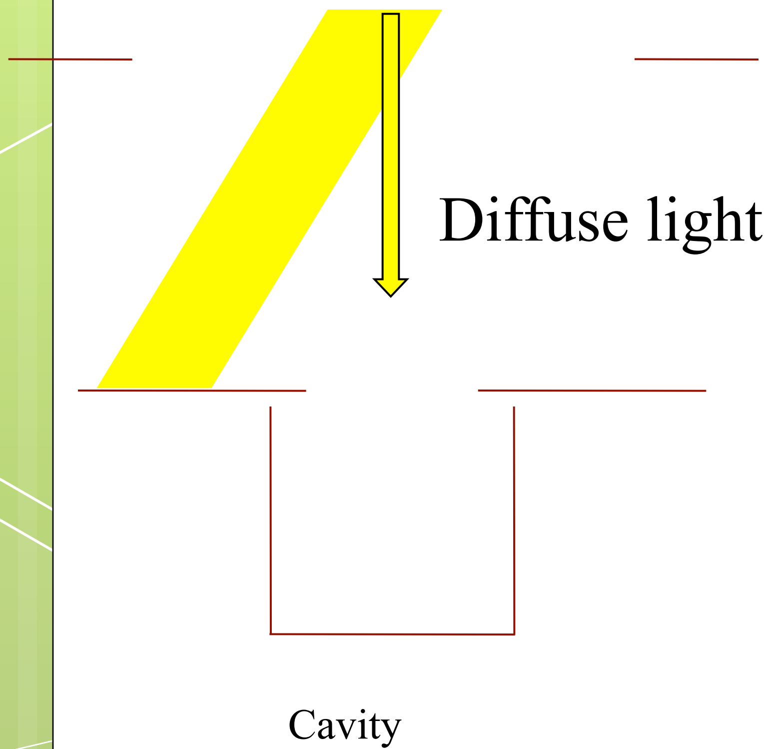
Power comparison

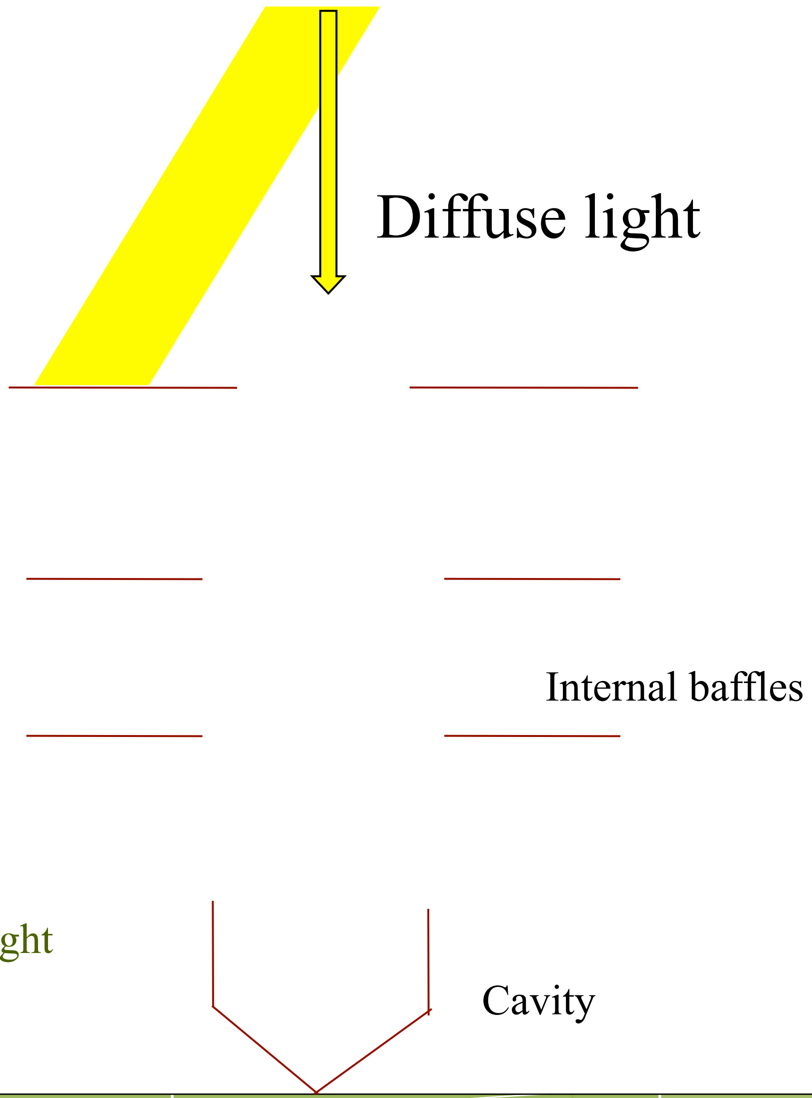




RESULT:
Sovar and Cryo power agree within 3 ppm !

Diffuse light characterisation

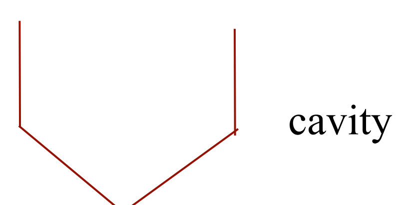




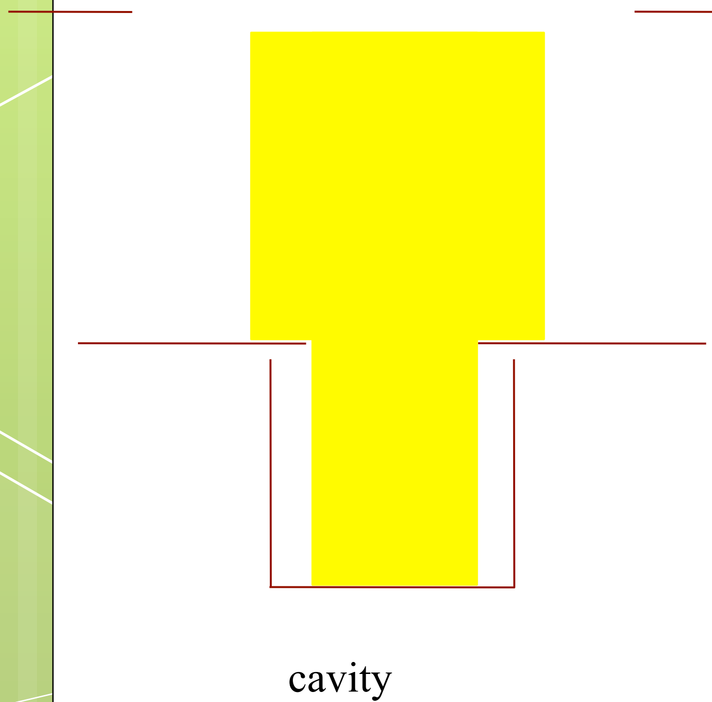
RESULT:
Sovar and Cryo measure same amount of diffuse light
-> diffuse light is coming from TRF

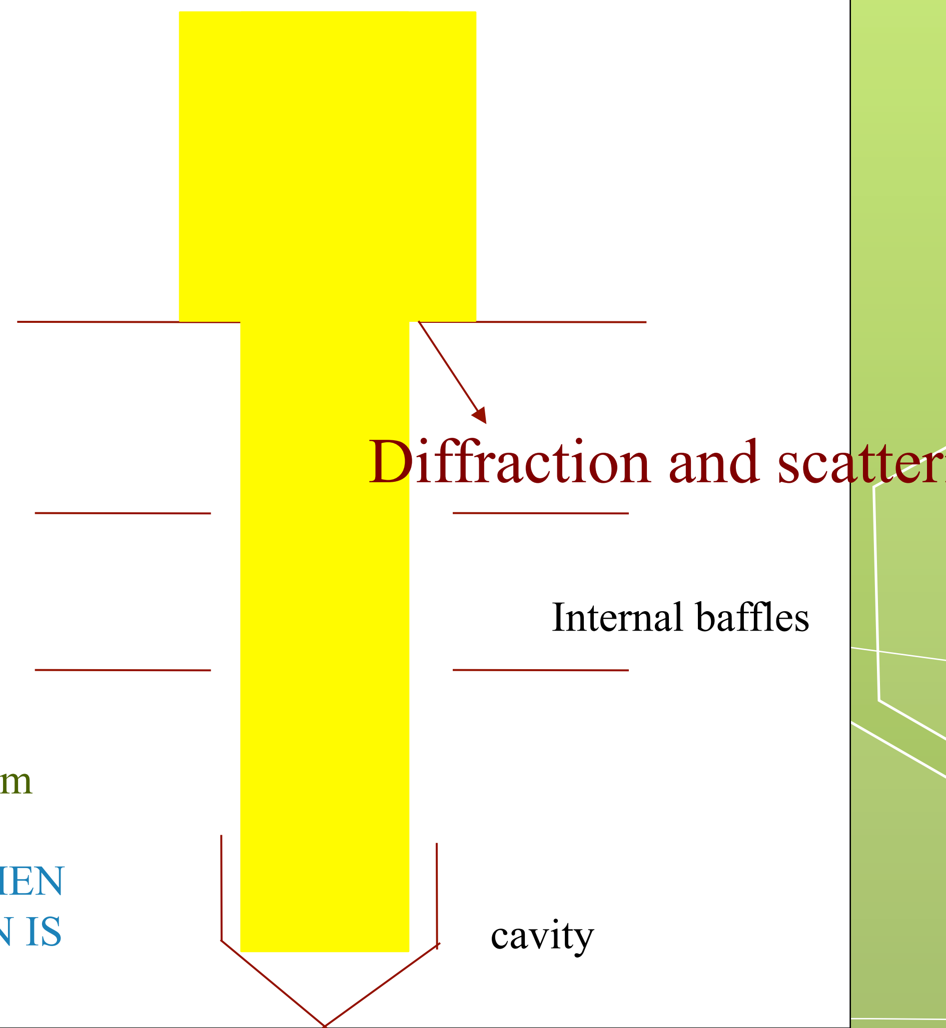
Sovar diffraction characterisation

RESULT:
Sovar experimental diffraction correction: 558 ppm
to be compared with theoretical value of 717 ppm



Irradiance comparison = TRF diffraction characterisation





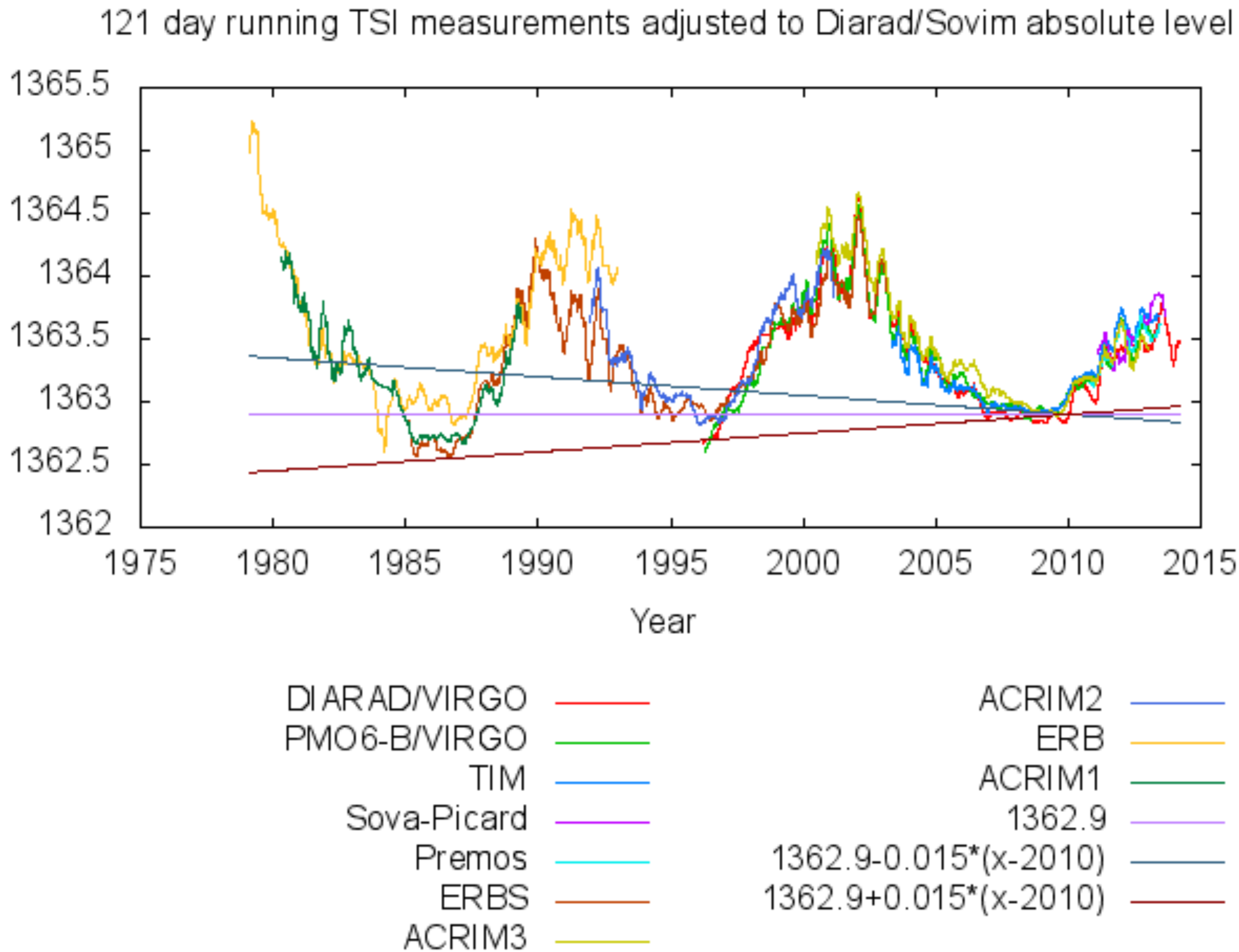
RESULT:
Cryo experimental diffraction correction: 2549 ppm
= Much higher than theoretical value
-> TOO LOW IRRADIANE IS MEASURED WHEN THEORETICAL DIFFRACTION CORRECTION IS USED.

Conclusion Sovar-TRF cryogenic comparison campaign

After elimination of all other possible causes of difference – power difference, diffuse light, Sovar scattering and diffraction – the difference in irradiance comparison can only be: **the TRF cryogenic radiometer irradiance is too low because its diffraction and scattering correction is too low.**

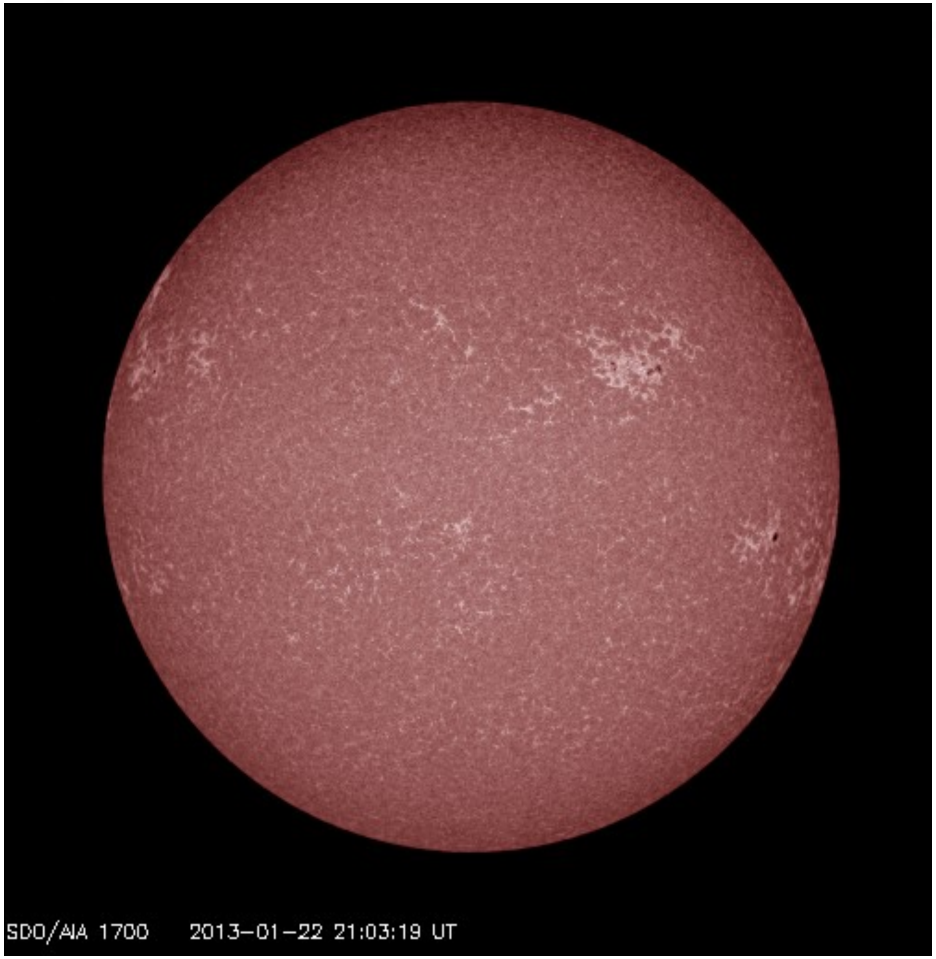
It is **likely that the TIM in-flight irradiance is too low** for the same reason.

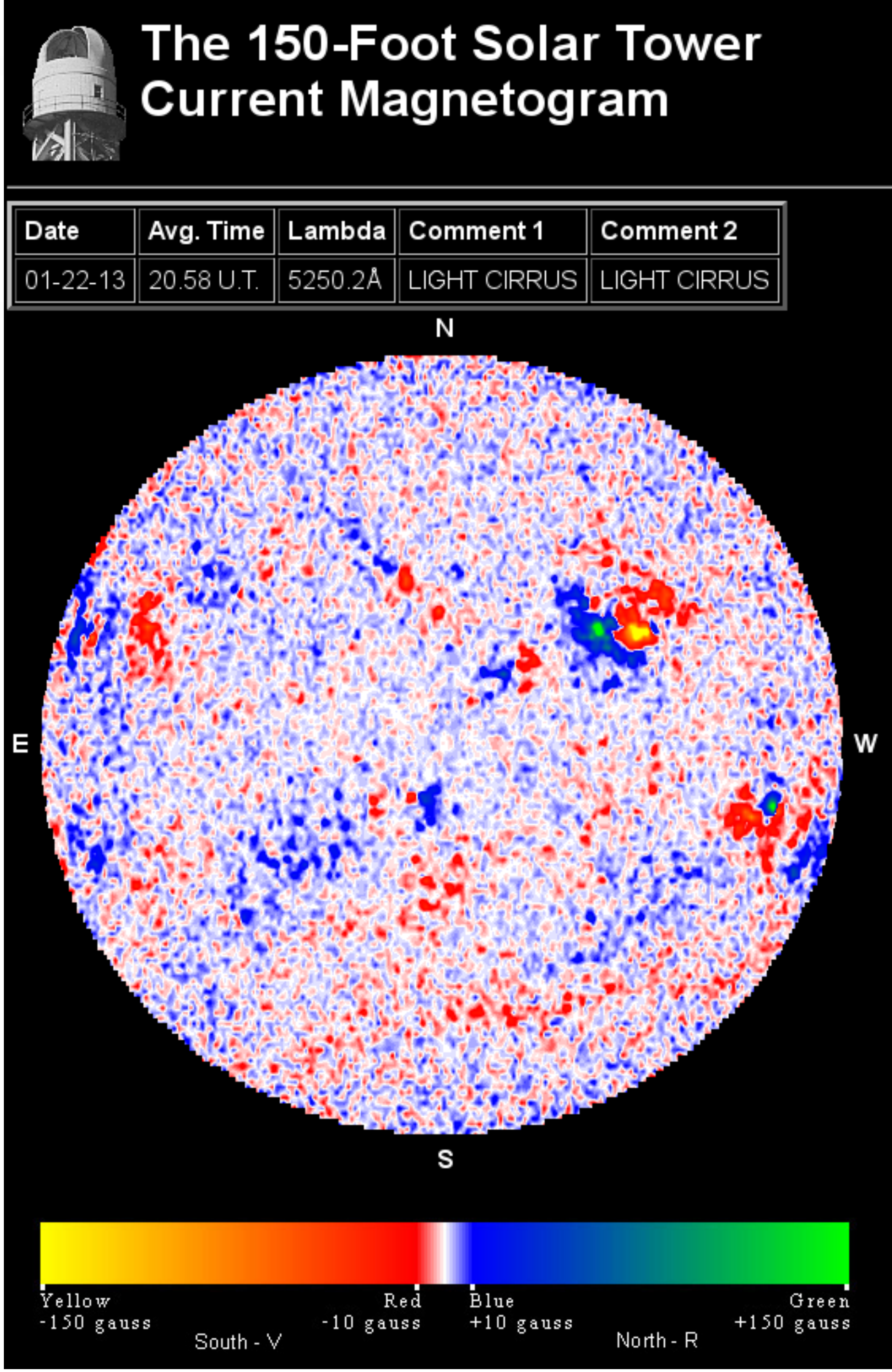
We have no indication to question the revised Sovar or DIARAD/SOVIM



121 day running TSI measurements adjusted to Diarad/Sovim absolute level
1365.5
1365
1364.5
1364
1363.5
1363
1362.5
1362
1975
1980
1985
1990
1995
2000
2005
2010
2015
Year
DIARAD/VIRGO
PMO6-B/VIRGO
TIM
Sova-Picard
Premos
ERBS
ACRIM3
ACRIM2
ERB
ACRIM1
1362.9
1362.9-0.015*(x-2010)
1362.9+0.015*(x-2010)

UV image

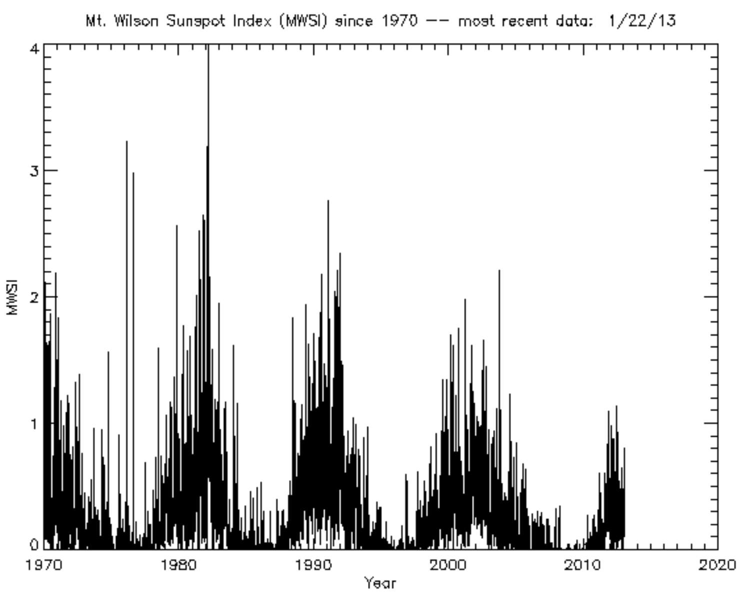

SDO/AIA 1700 2013-01-22 21:03:19 UT

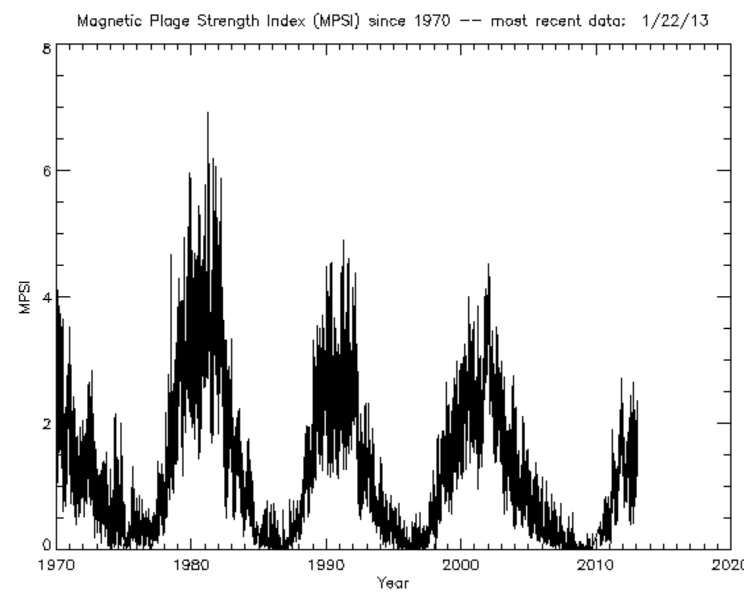

The 150-Foot Solar Tower
Current Magnetogram
Date
01-22-13
Avg. Time
20.58 U.T.
Lambda
5250.2Å
Comment 1
LIGHT CIRRUS
Comment 2
LIGHT CIRRUS
N
E
W
S
Yellow
-150 gauss
Red
-10 gauss
Blue
+10 gauss
Green
+150 gauss
South - V
North - R

Mount Willson indices

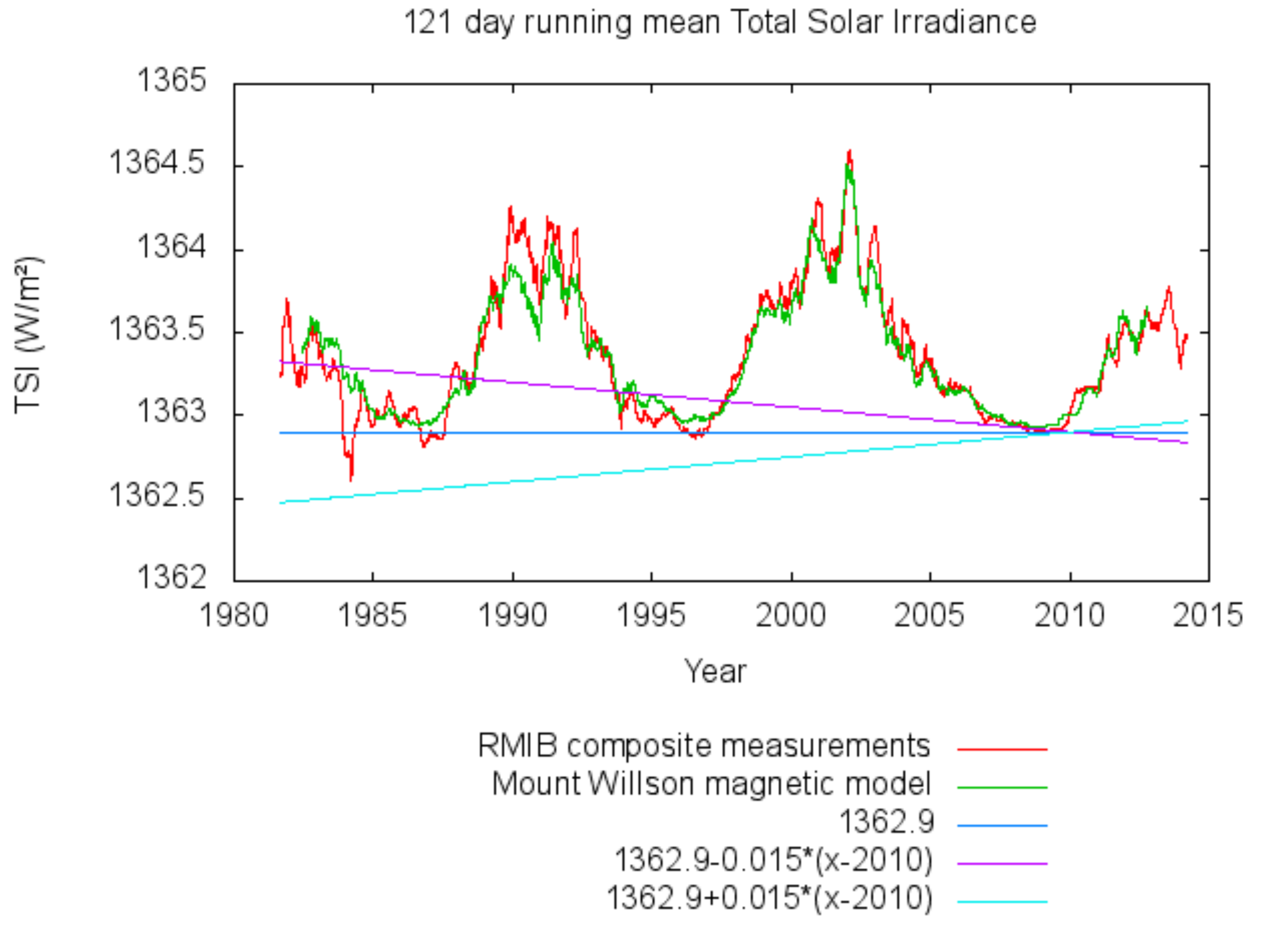
MWSI
Strong magnetic fields
Sunspots

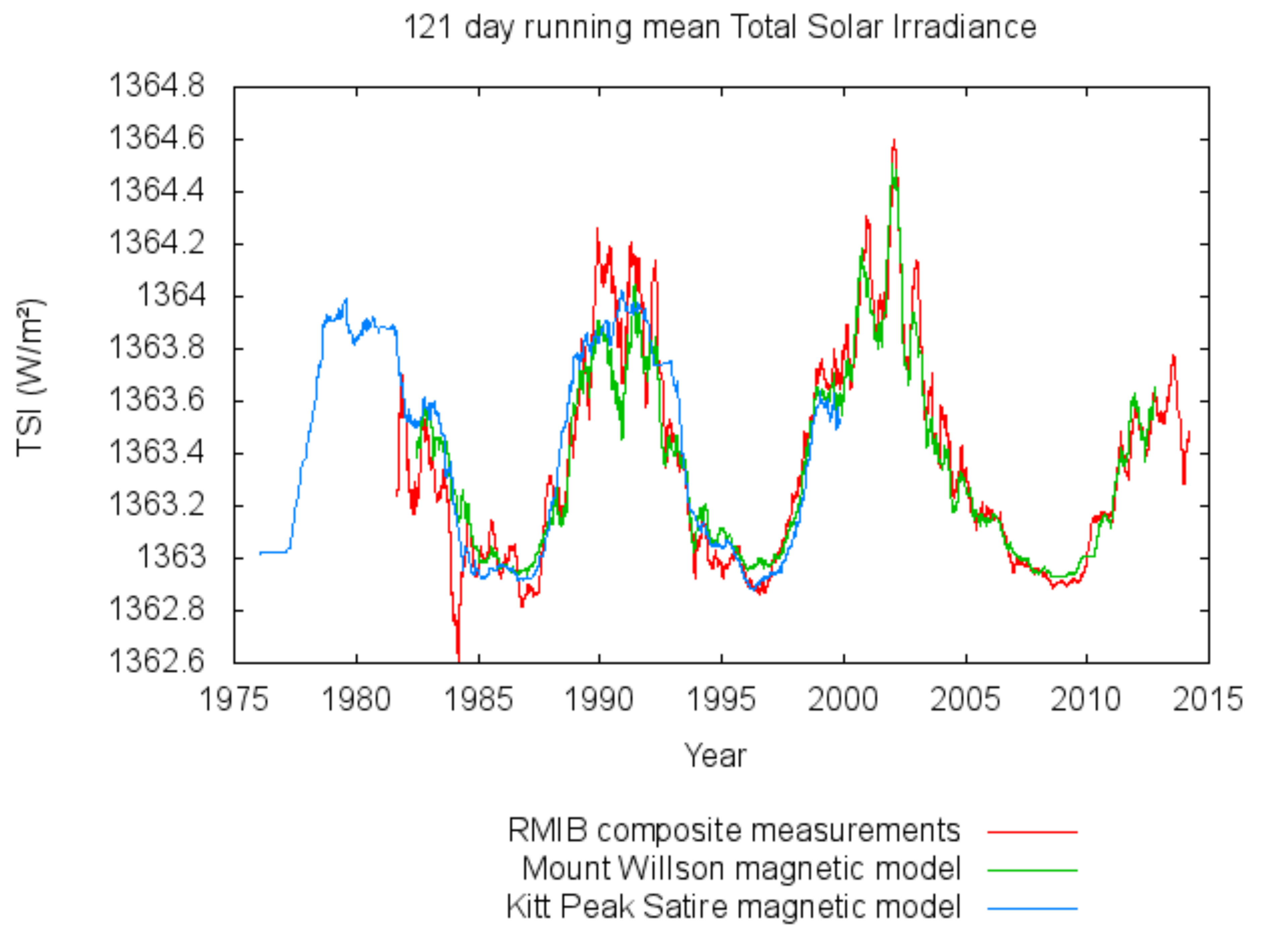
MPSI
Intermediate magnetic fields
Facula

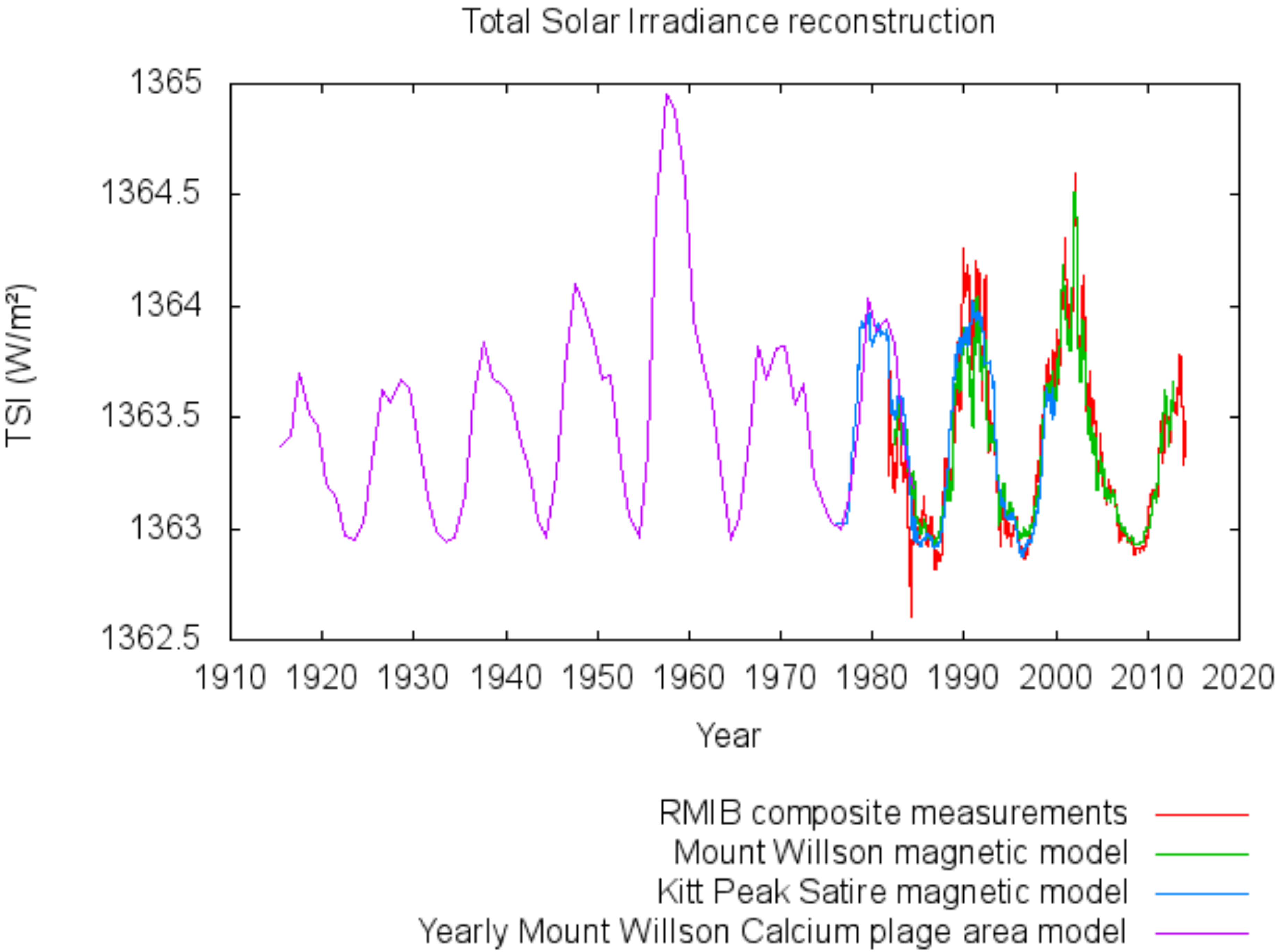


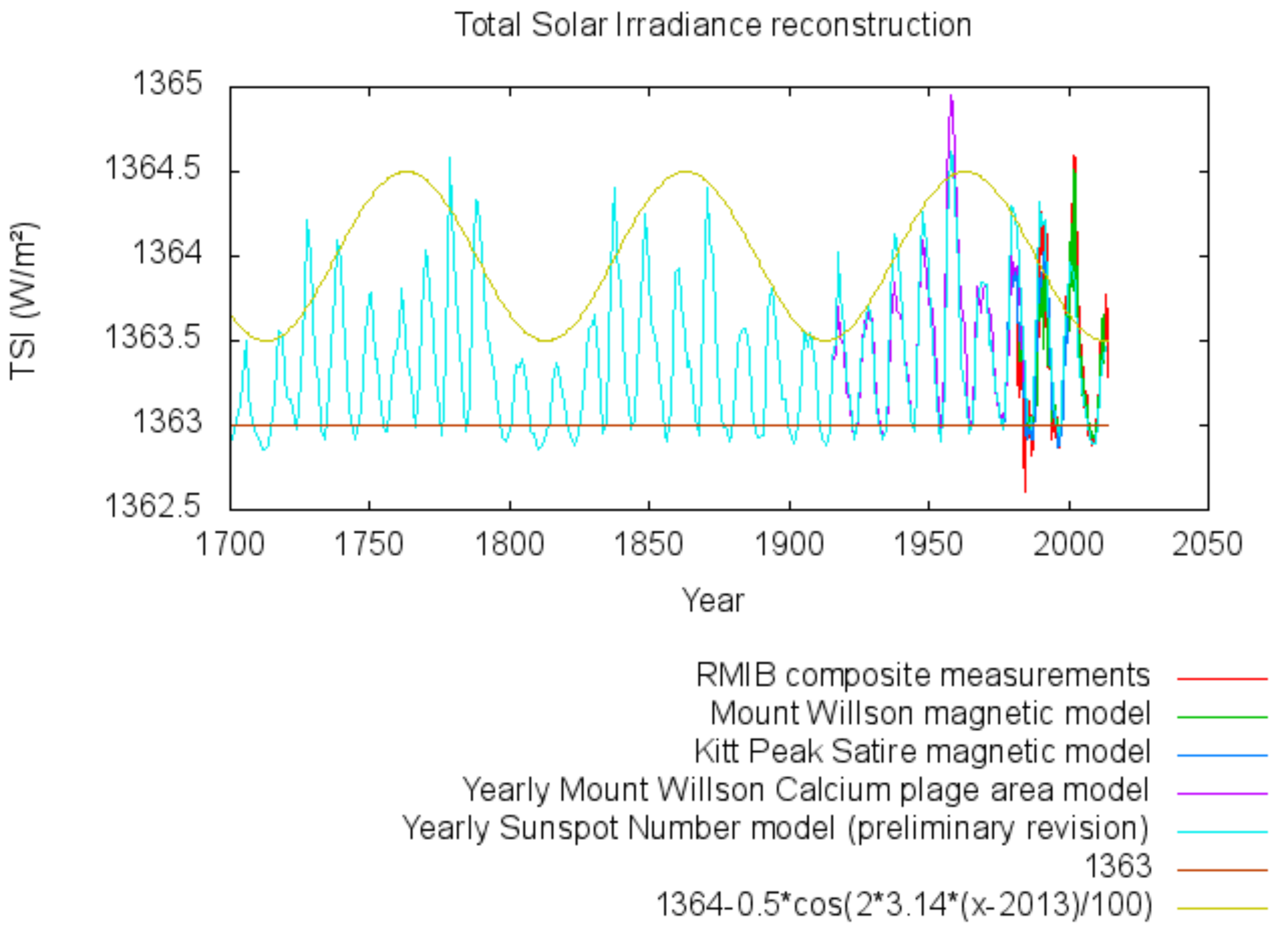


TSI model = A + B * MWSI + C * MPSI


121 day running mean Total Solar Irradiance
TSI (W/m²)
1365
1364.5
1364
1363.5
1363
1362.5
1362
1980
1985
1990
1995
2000
2005
2010
2015
Year
RMIB composite measurements
Mount Willson magnetic model
1362.9
1362.9-0.015*(x-2010)
1362.9+0.015*(x-2010)


121 day running mean Total Solar Irradiance
TSI (W/m²)
1364.8
1364.6
1364.4
1364.2
1364
1363.8
1363.6
1363.4
1363.2
1363
1362.8
1362.6
1975
1980
1985
1990
1995
2000
2005
2010
2015
Year
RMIB composite measurements
Mount Willson magnetic model
Kitt Peak Satire magnetic model


Total Solar Irradiance reconstruction
1365
1364.5
1364
1363.5
1363
1362.5
TSI (W/m²)
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
2020
Year
RMIB composite measurements
Mount Willson magnetic model
Kitt Peak Satire magnetic model
Yearly Mount Willson Calcium plage area model


Total Solar Irradiance reconstruction
1365
1364.5
1364
1363.5
1363
1362.5
TSI (W/m²)
1700
1750
1800
1850
1900
1950
2000
2050
Year
RMIB composite measurements
Mount Willson magnetic model
Kitt Peak Satire magnetic model
Yearly Mount Willson Calcium plage area model
Yearly Sunspot Number model (preliminary revision)
1363
1364-0.5*cos(2*3.14*(x-2013)/100)

Conclusions

Our best estimate of the revised Solar Constant is 1363 W/m^2 at solar minimum.

Within the measurement uncertainty of +/- 0.15 W/m^2/dec there is no variation of the TSI quiet sun level during the last 30 years

Over the last 300 years there is a 100 year modulation rather than a long term increase of the solar activity

The average 11 year solar radiative forcing is of the order of 0.25 W/m^2 with a 100 year modulation of the order of +/- 0.125 W/m^2

So TSI variations can not explain the Little Ice Age nor the recent T plateau

Open question: what causes the 100 year modulation of solar activity ?