Total Solar Irradiance measurements: Quantification of the solar radiative forcing of the earth's climate from 30 years of observations from space

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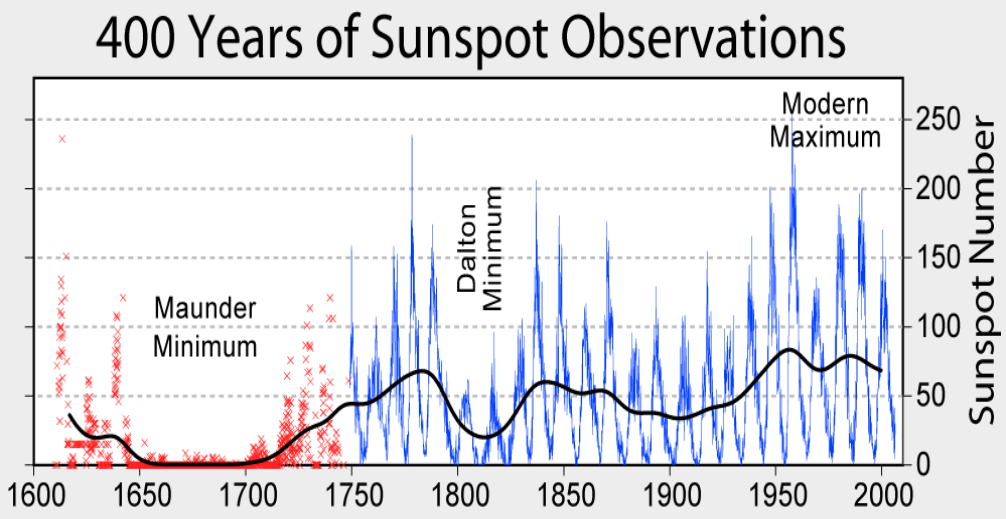
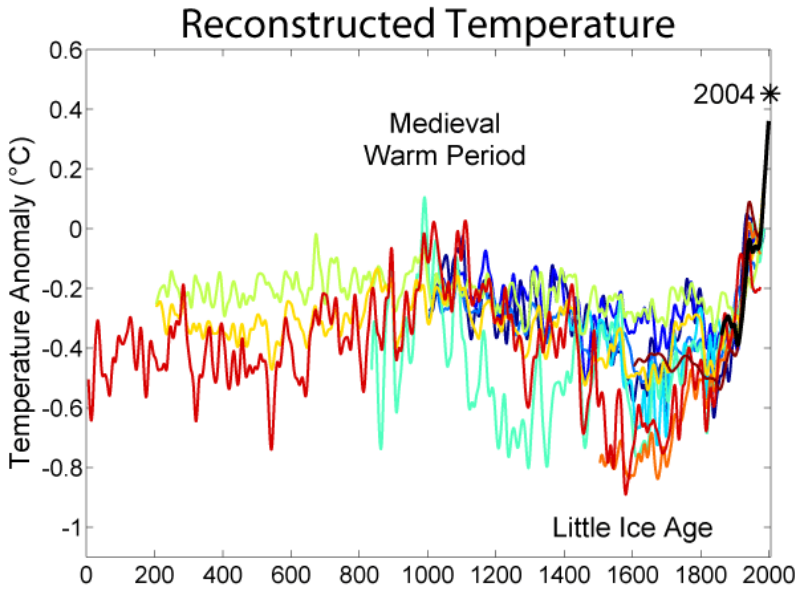
ftp://gerb.oma.be/steven/RMIB_TSI_composite/

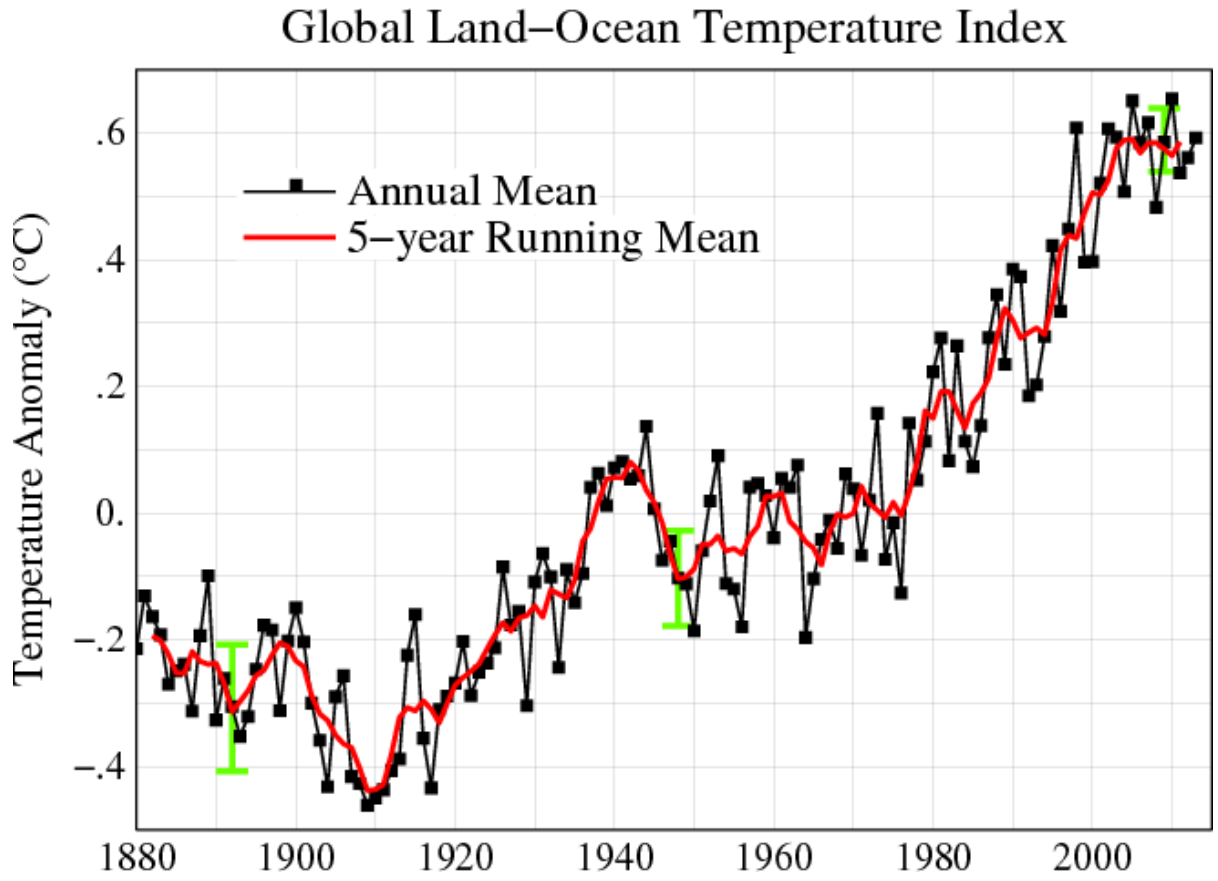
Solar Metrology Symposium, 8/10/2014

Little Ice Age caused by Maunder Minimum ?





T plateau since 2000 partly caused by sun ?



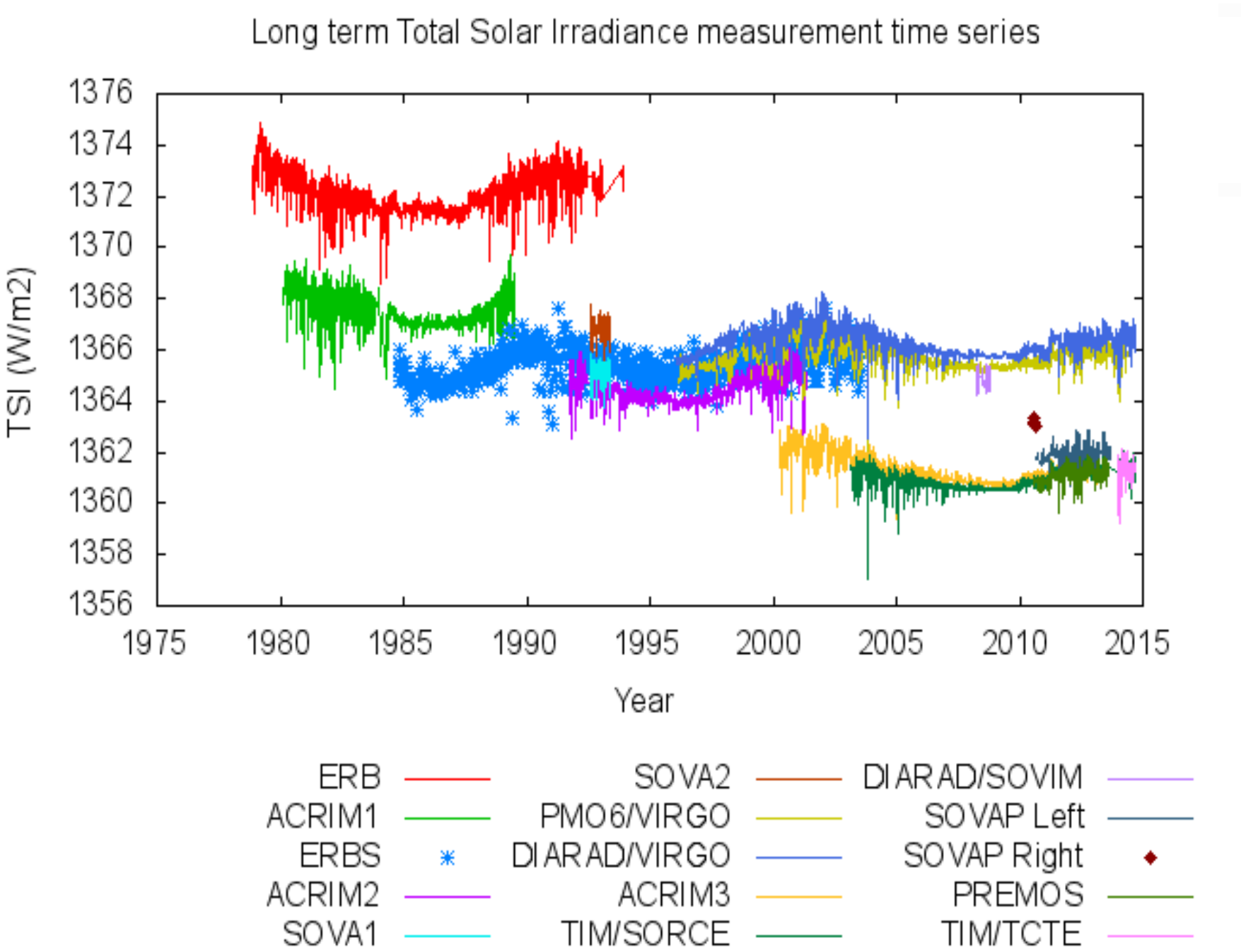
RMIB SPACE RECORD: 11!

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 (> 18 y)**
- ISS/SOVIM/DIARAD ESA February 2008 > 1 year
- PICARD/SOVAP CNES June 2010 > terminated


Long term Total Solar Irradiance measurement time series
TSI (W/m2)
1376
1374
1372
1370
1368
1366
1364
1362
1360
1358
1356
1975
1980
1985
1990
1995
2000
2005
2010
2015
Year
ERB
ACRIM1
ERBS
ACRIM2
SOVA1
SOVA2
PMO6/VIRGO
DIARAD/VIRGO
ACRIM3
TIM/SORCE
DIARAD/SOVIM
SOVAP Left
SOVAP Right
PREMOS
TIM/TCTE

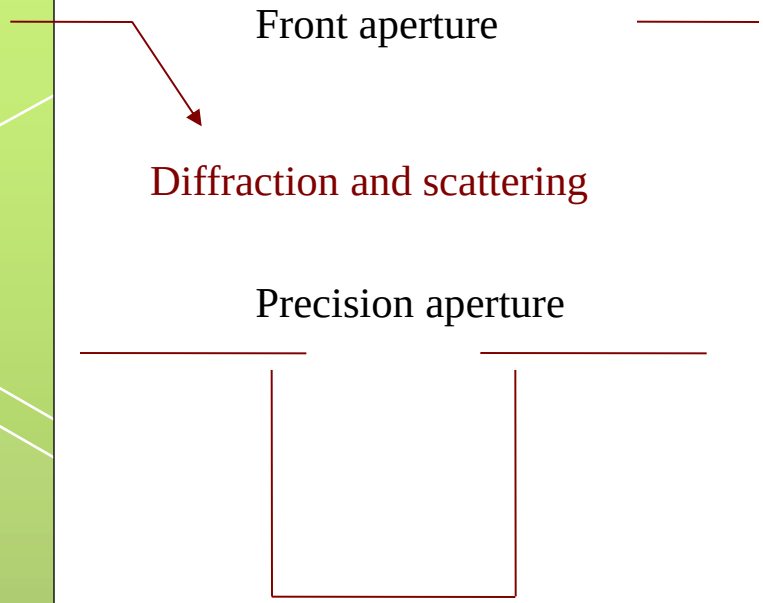
DIARAD absolute level revision

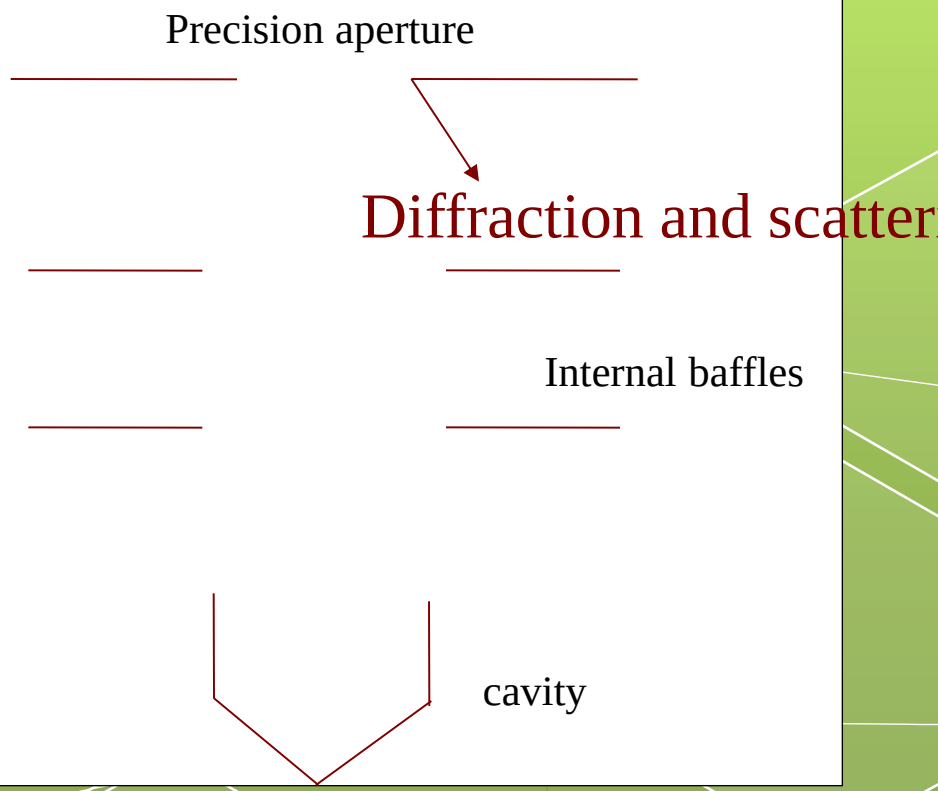
- Use as independent absolute radiometer -> no calibration
- New method of non-equivalence characterisation (see presentation A.Chevalier) -> lower irradiance
- Best radiometers: DIARAD/SOVIM, SOLCON, SOVAR
  - Thick sidewalls -> good spatial uniformity -> low uncertainty non equivalence
  - DIARAD/SOVIM: improved shutter design + most recent characterisation
- Revised Solar Constant: 1362.9 +/- 0.9 W/m² (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

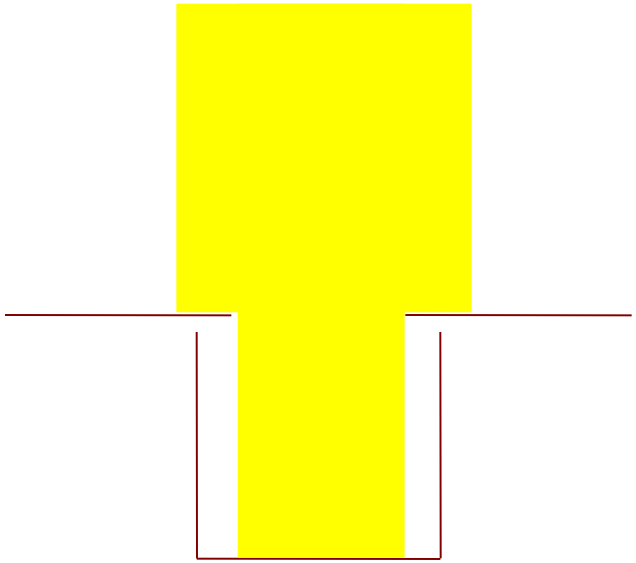
- Sovar: DIARAD type radiometer that flew on Eureca in 1992, brought back to ground by space shuttle.
- Comparison campaign with LASP TRF Crogenic radiometer in May-June 2013.

DIARAD & TIM type geometry

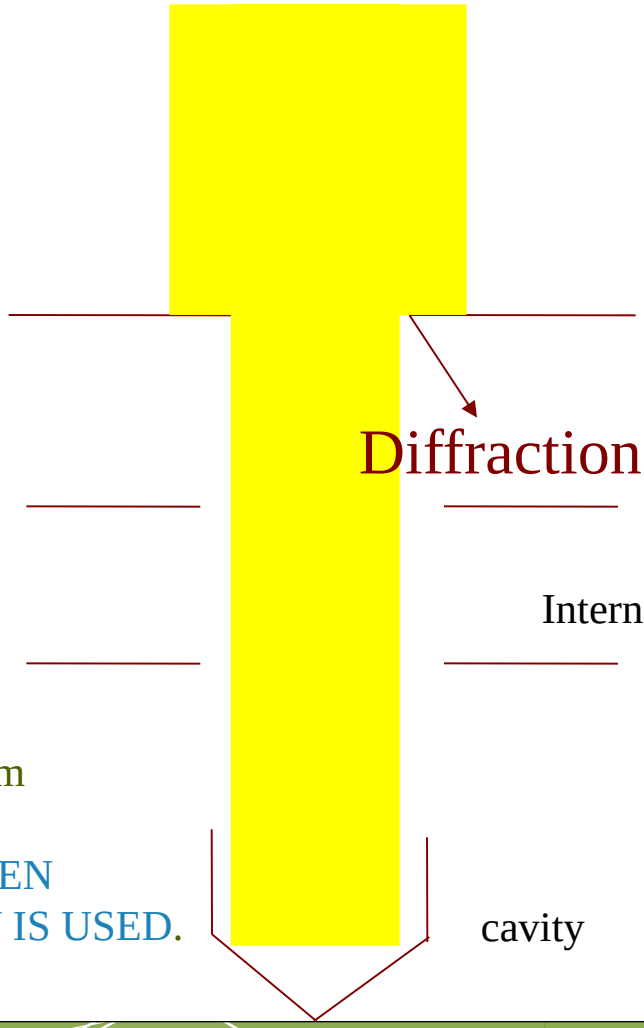




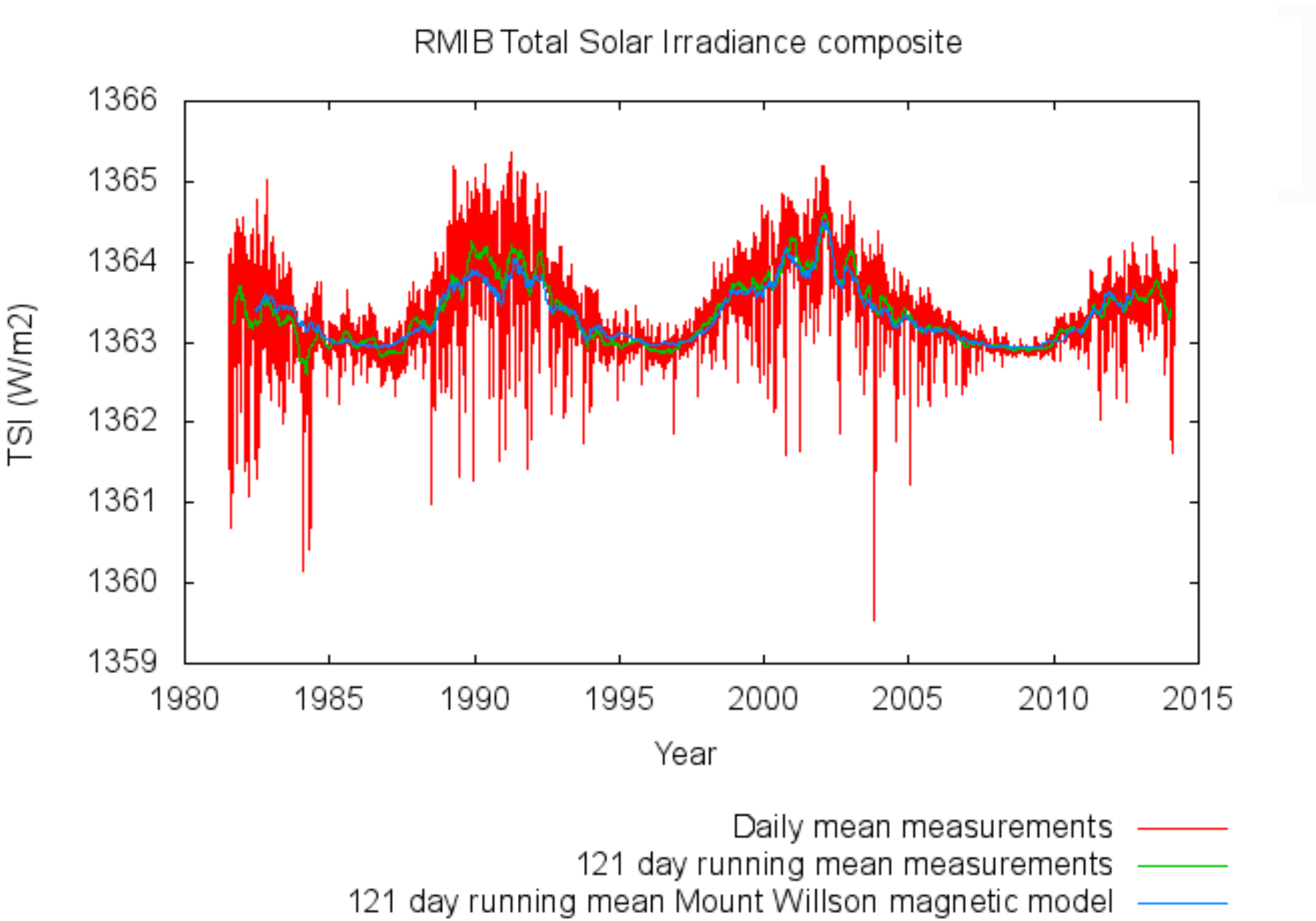
Irradiance comparison = TRF diffraction characterisation

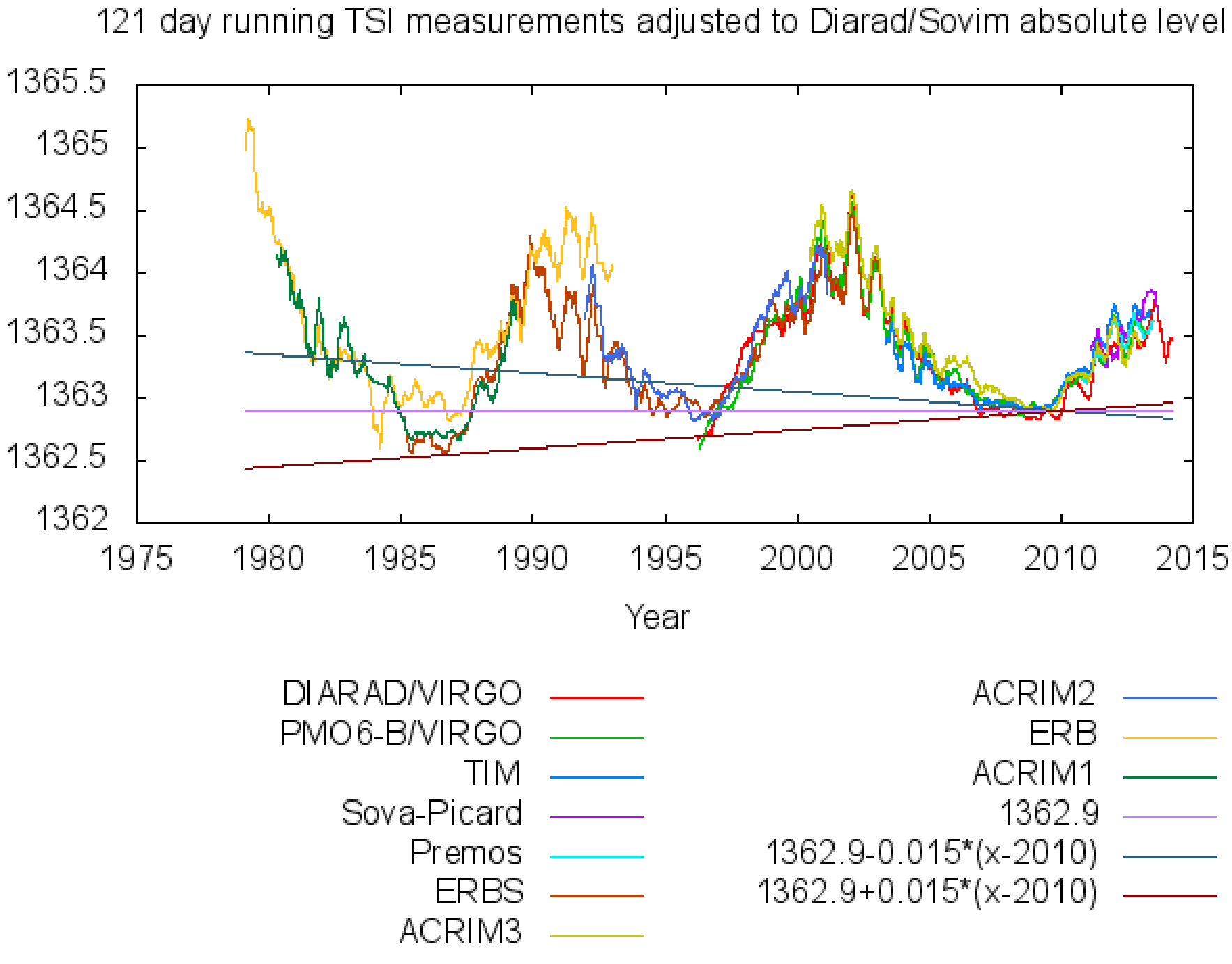


cavity

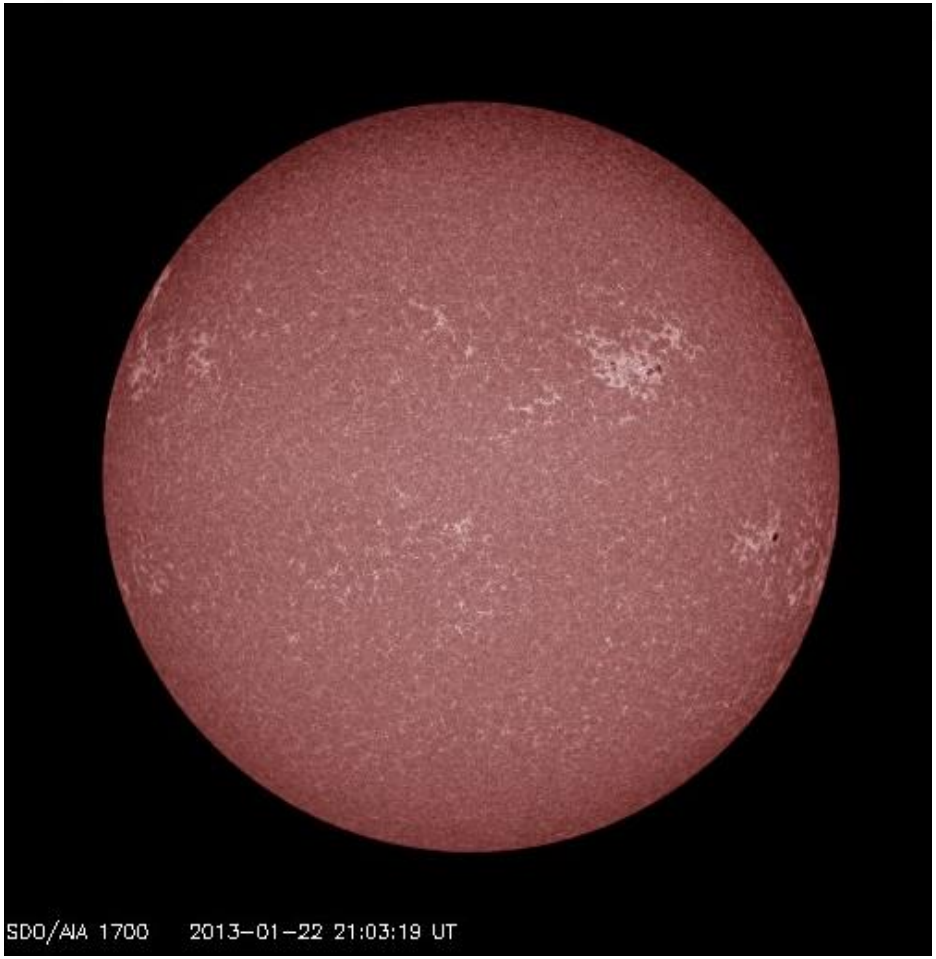


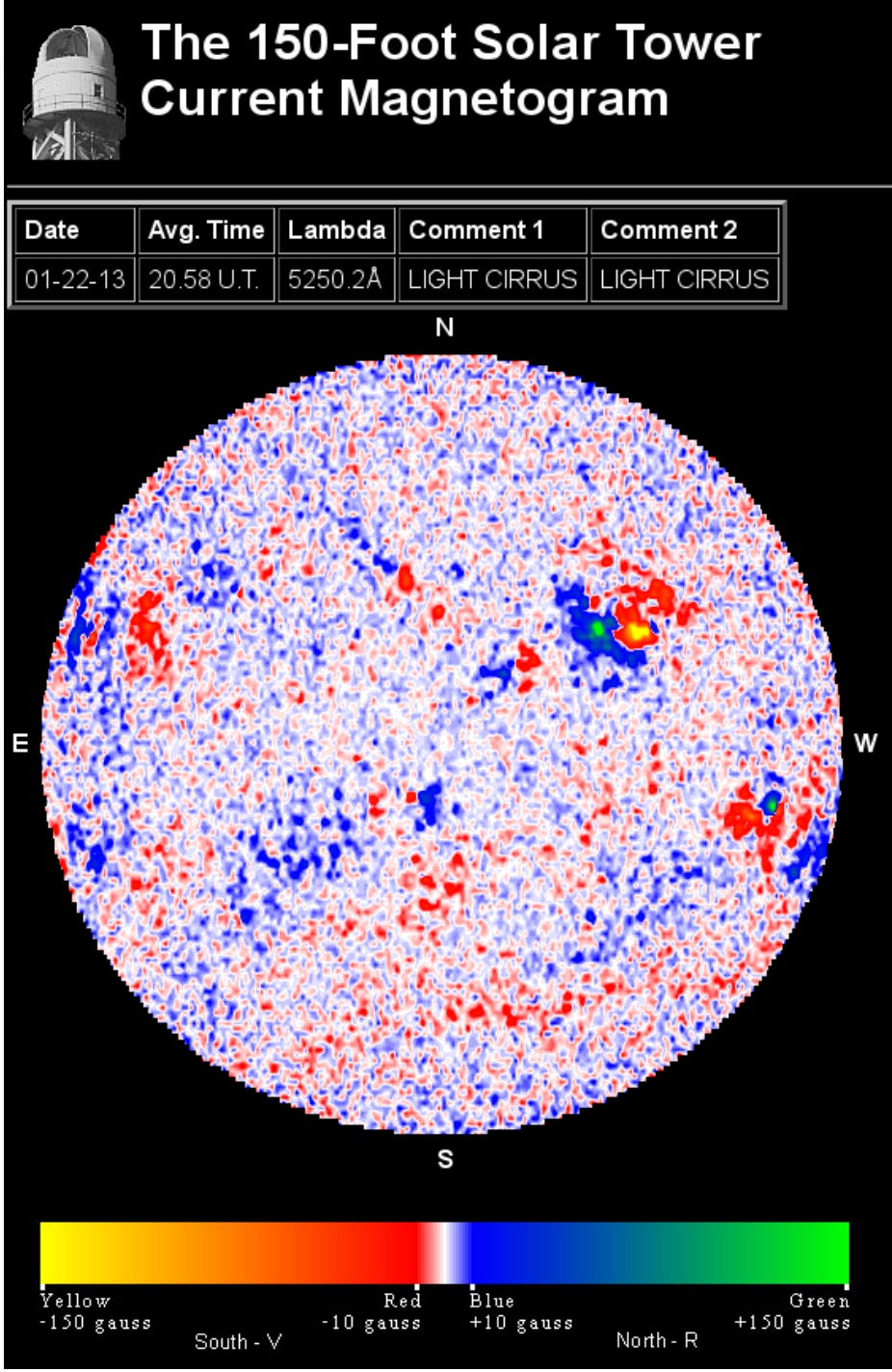
RESULT:
Cryo experimental diffraction correction: 2549 ppm
= Much higher than theoretical value
-> TOO LOW IRRADIANE IS MEASURED WHEN THEORETICAL DIFFRACTION CORRECTION IS USED.


RMIB Total Solar Irradiance composite
TSI (W/m2)
1366
1365
1364
1363
1362
1361
1360
1359
1980
1985
1990
1995
2000
2005
2010
2015
Year
Daily mean measurements
121 day running mean measurements
121 day running mean Mount Willson magnetic model


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

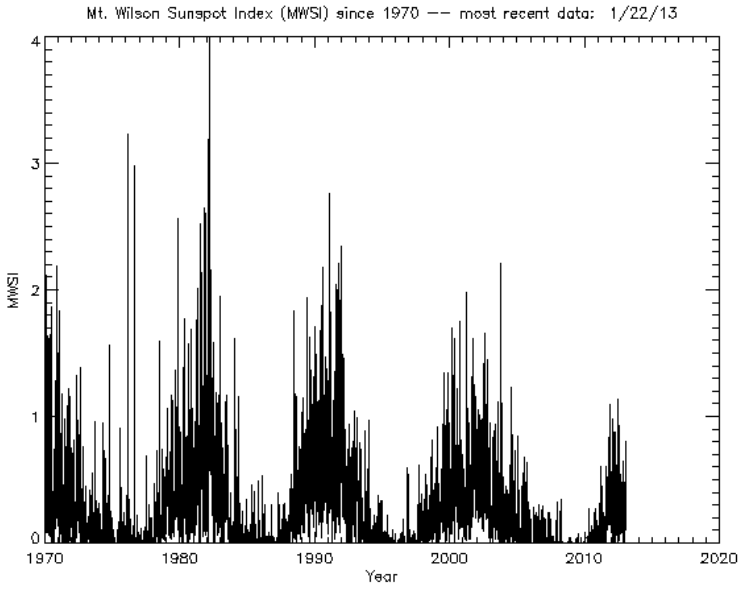

The 150-Foot Solar Tower
Current Magnetogram
Date
Avg. Time
Lambda
Comment 1
Comment 2
01-22-13
20.58 U.T.
5250.2Å
LIGHT CIRRUS
LIGHT CIRRUS
N
E
W
S
Yellow
-150 gauss
Red
-10 gauss
Blue
+10 gauss
Green
+150 gauss
South - V
North - R

Mount Willson indices

MWSI

Strong magnetic fields

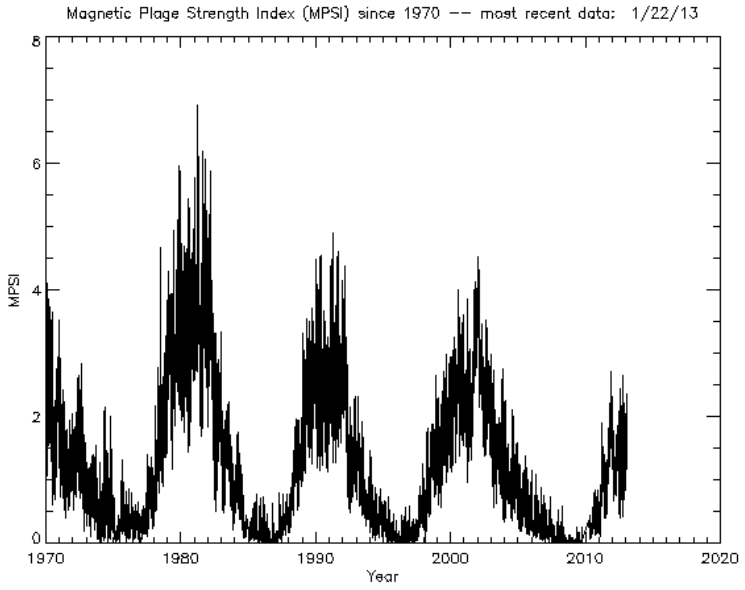
Sunspots



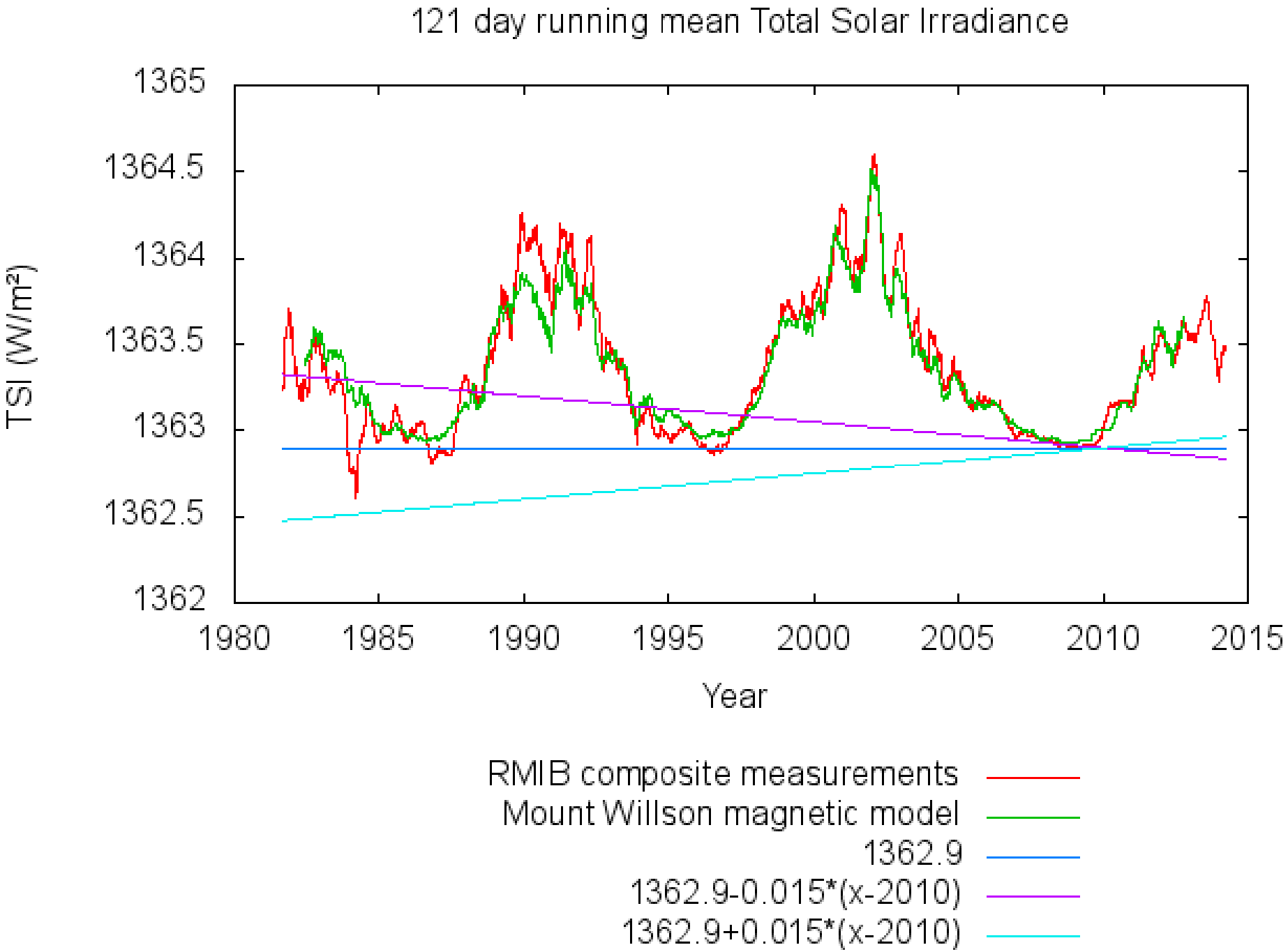
MPSI

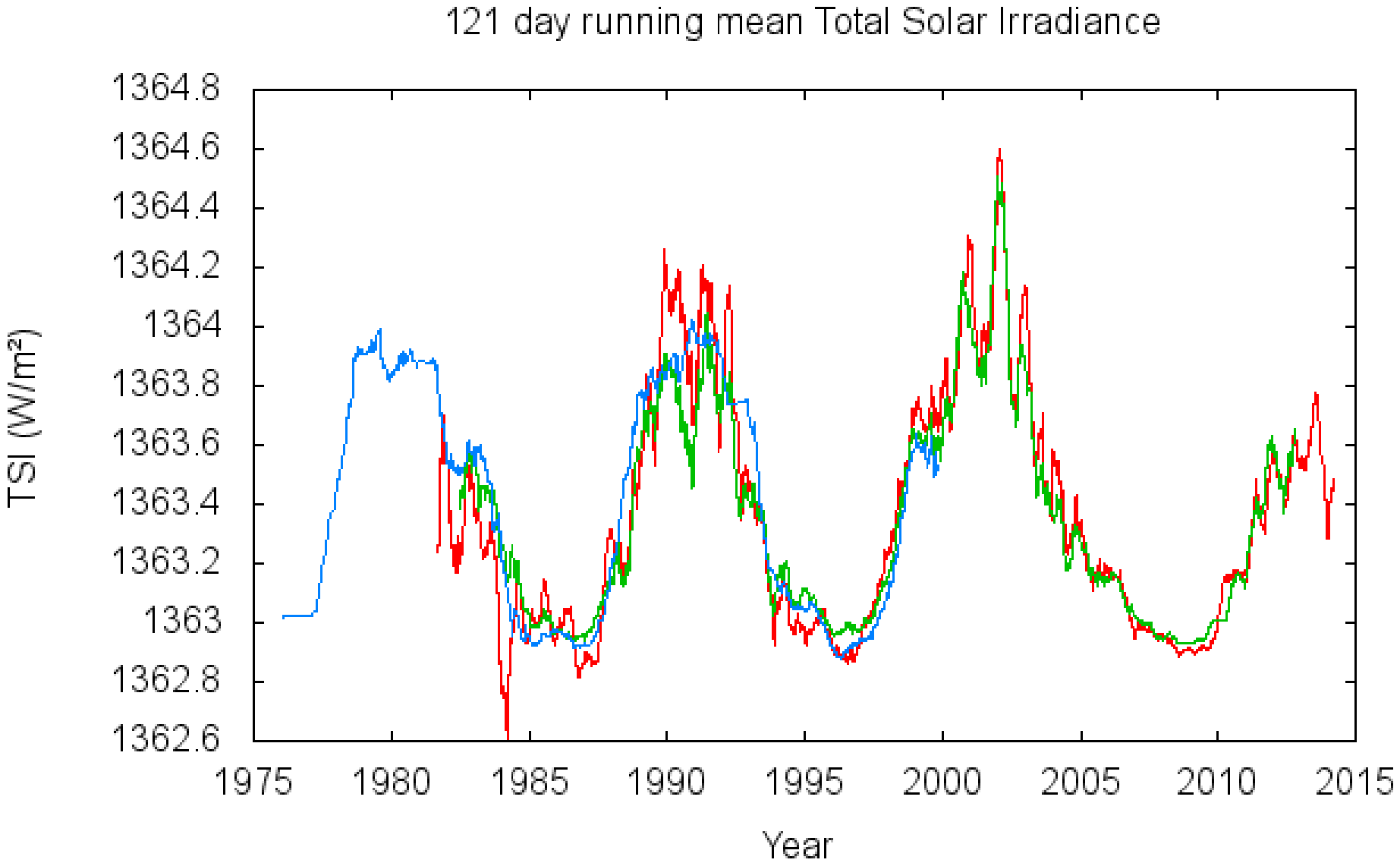
Intermediate magnetic fields

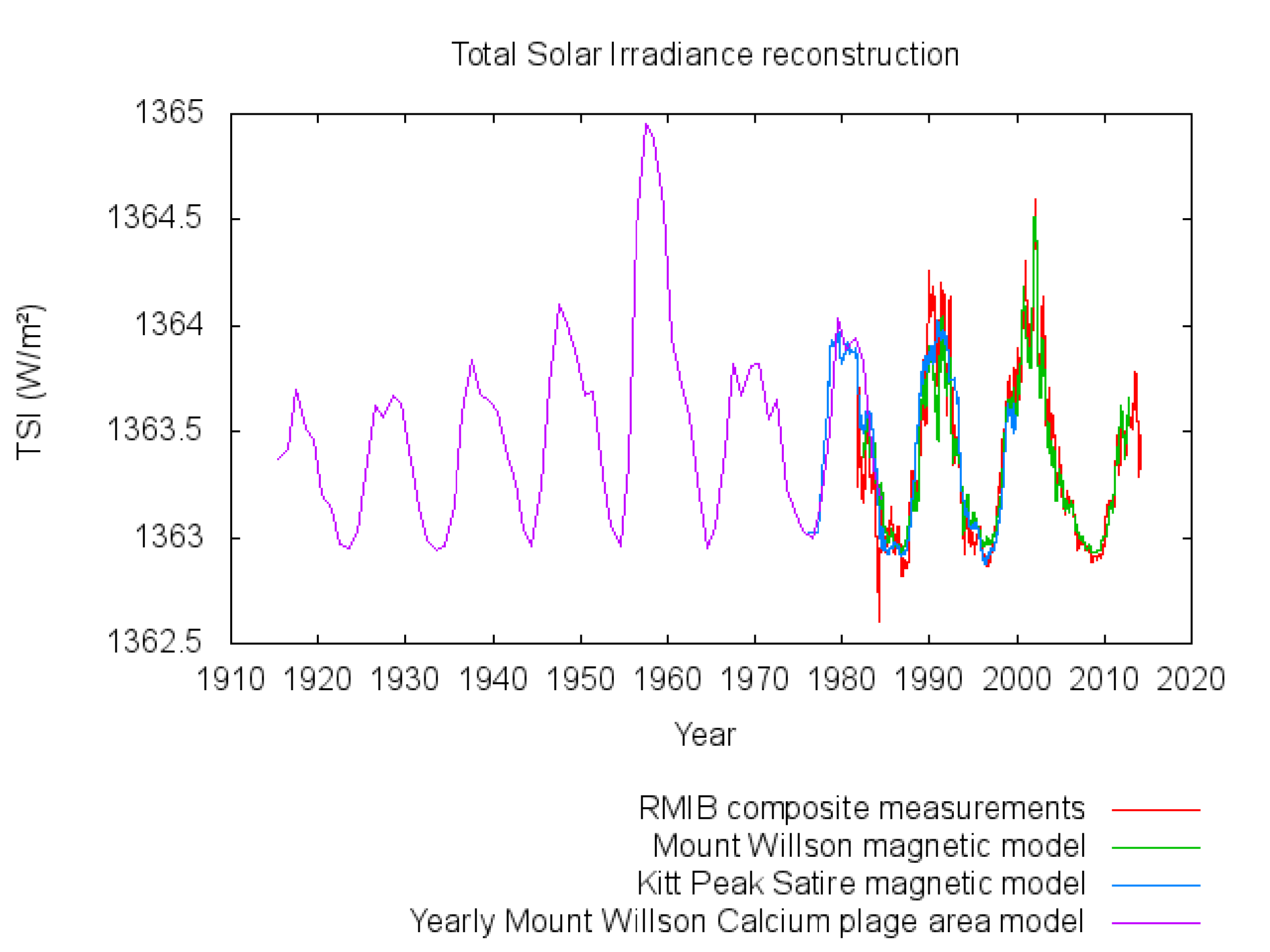
Facula

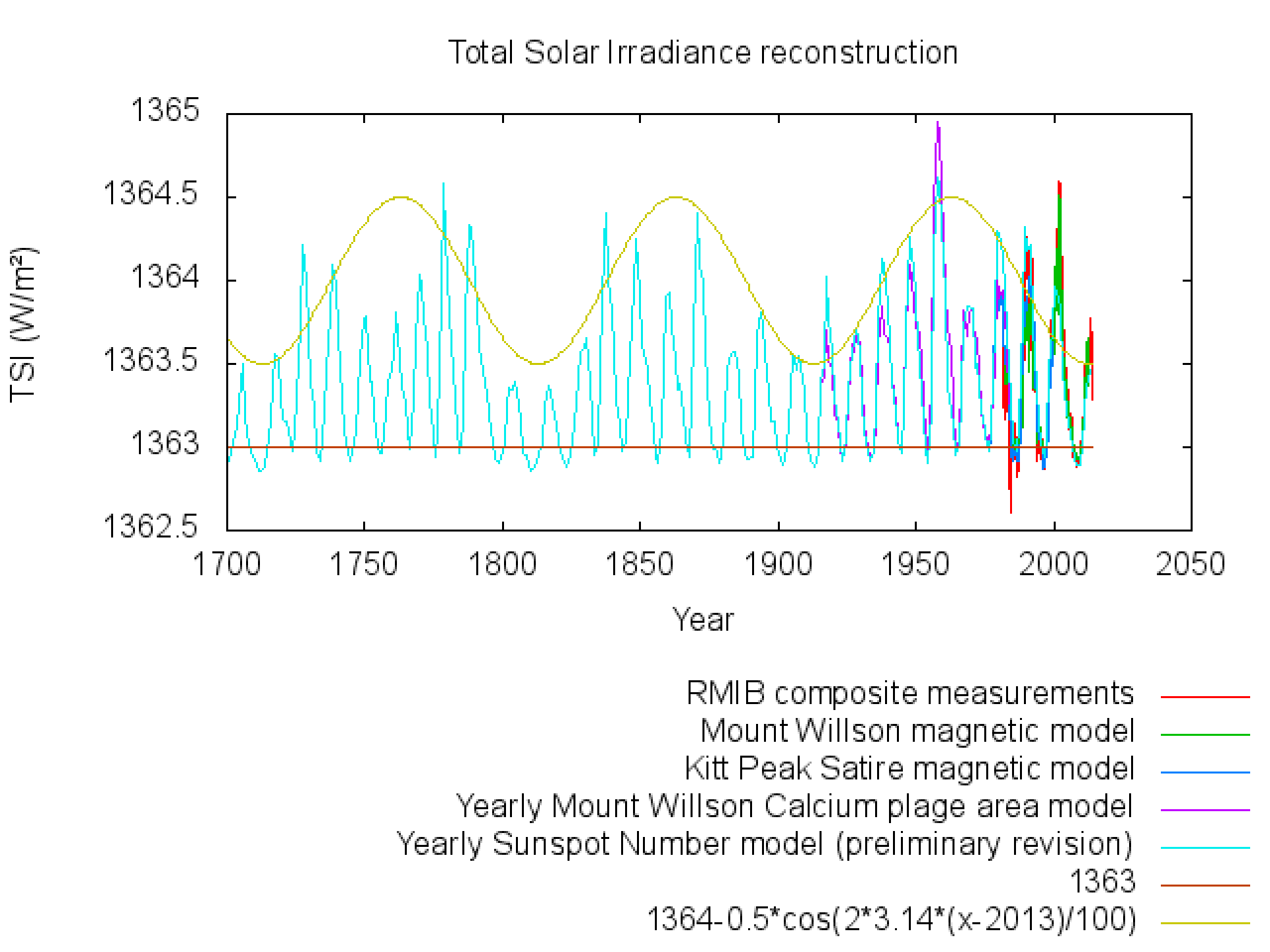


TSI model = A + B * MWSI + C * MPSI


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

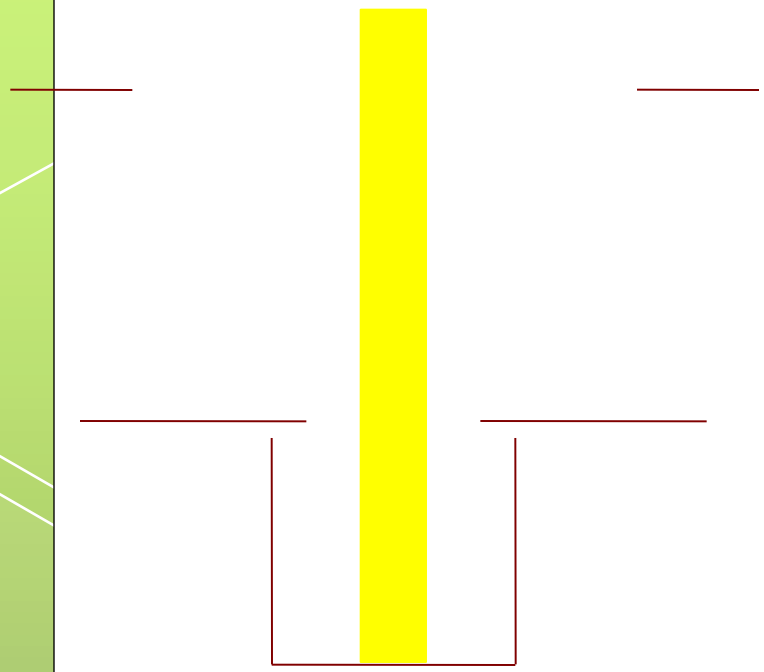

Total Solar Irradiance reconstruction
TSI (W/m²)
1365
1364.5
1364
1363.5
1363
1362.5
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
2020
Year
RMIB composite measurements
Mount Willson magnetic model
Kitt Peak Satire magnetic model
Yearly Mount Willson Calcium plage area model


Total Solar Irradiance reconstruction
TSI (W/m²)
1365
1364.5
1364
1363.5
1363
1362.5
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)

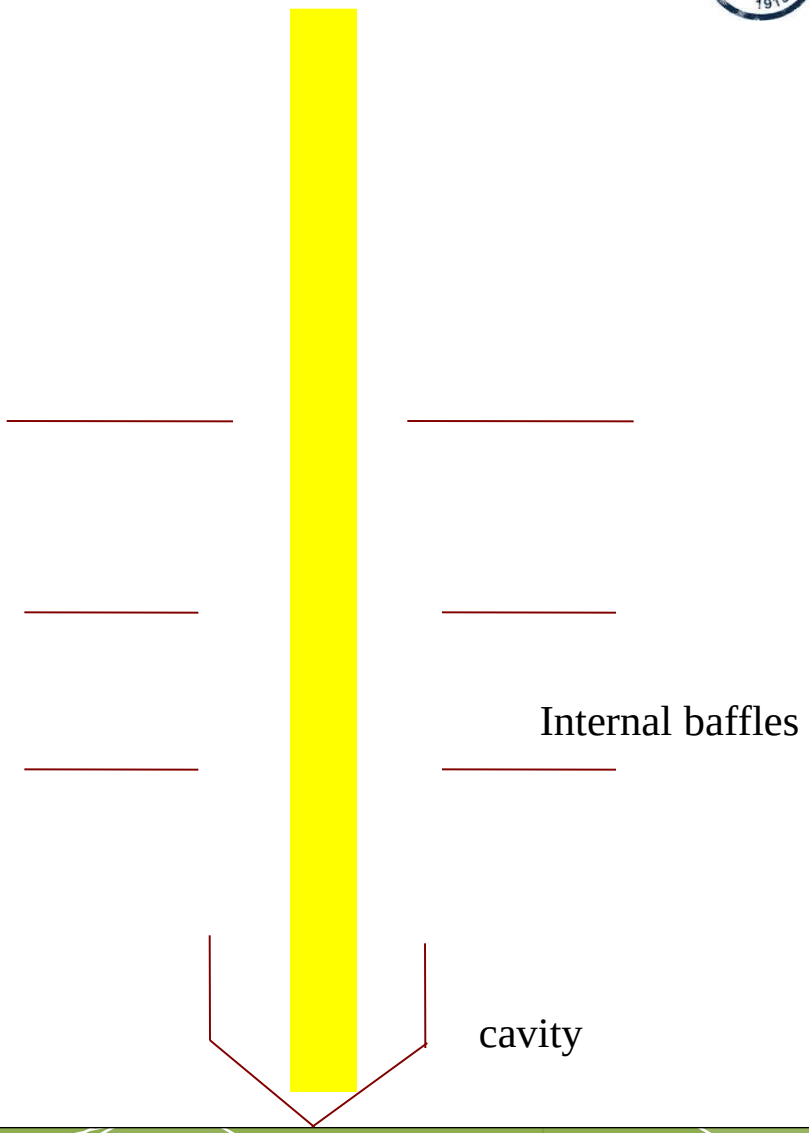
Conclusions

- Our best estimate of the revised Solar Constant is 1363 W/m² at solar minimum.
- Within the measurement uncertainty of +/- 0.15 W/m²/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/m² with a 100 year modulation of the order of +/- 0.125 W/m²
- 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 ?
- ftp://gerb.oma.be/steven/RMIB_TSI_composite/

Power comparison



cavity

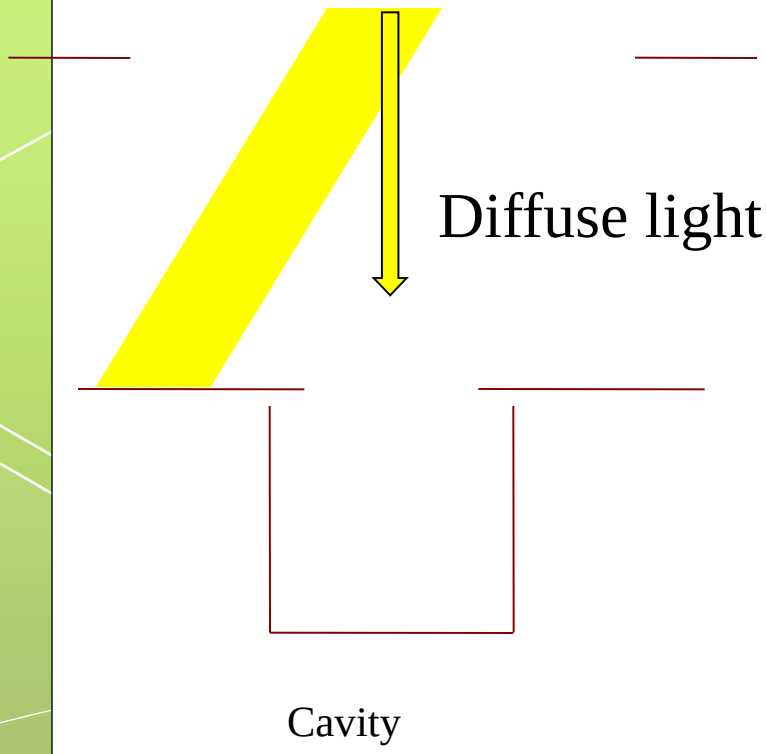


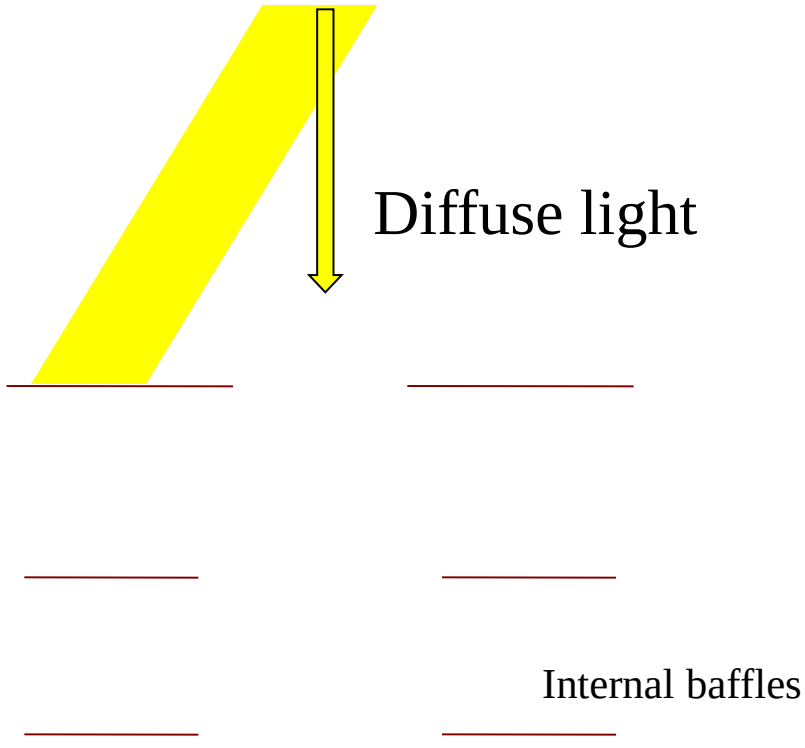
Internal baffles

cavity

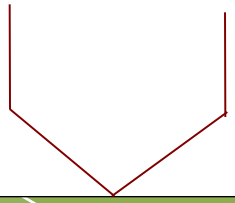
RESULT:
Sovar and Cryo power agree within 3 ppm !

Diffuse light characterisation



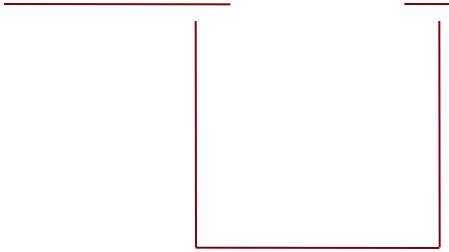


RESULT:
Sovar and Cryo measure same amount of diffuse light
-> diffuse light is coming from TRF

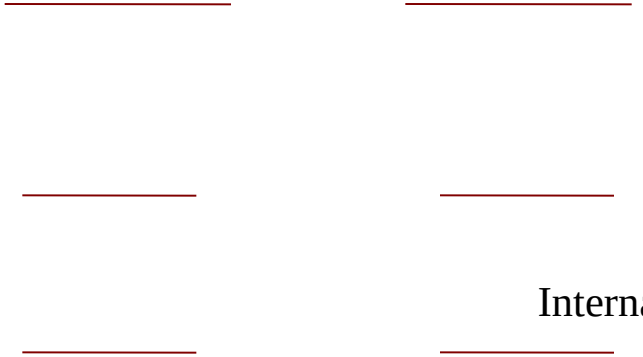


Sovar diffraction characterisation

Diffraction and scattering

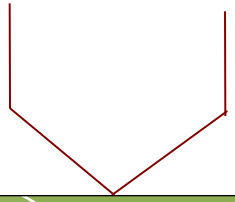


cavity



Internal baffles

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



cavity