Total Solar Irradiance measurements over the last 30 years and reconstruction over the last 300 years

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Absolute Radiometry

Royal Meteorological Insititute of Belgium

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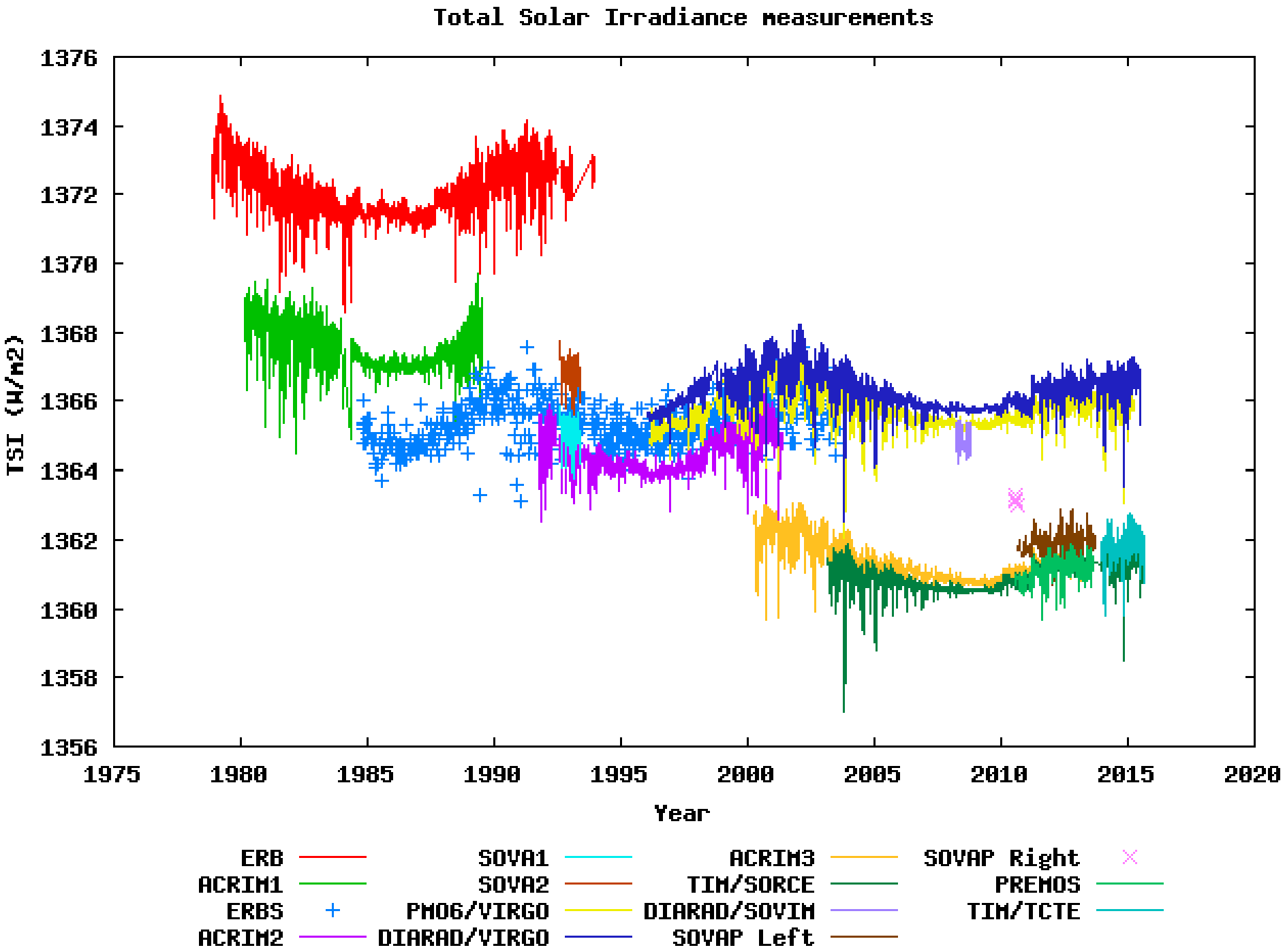
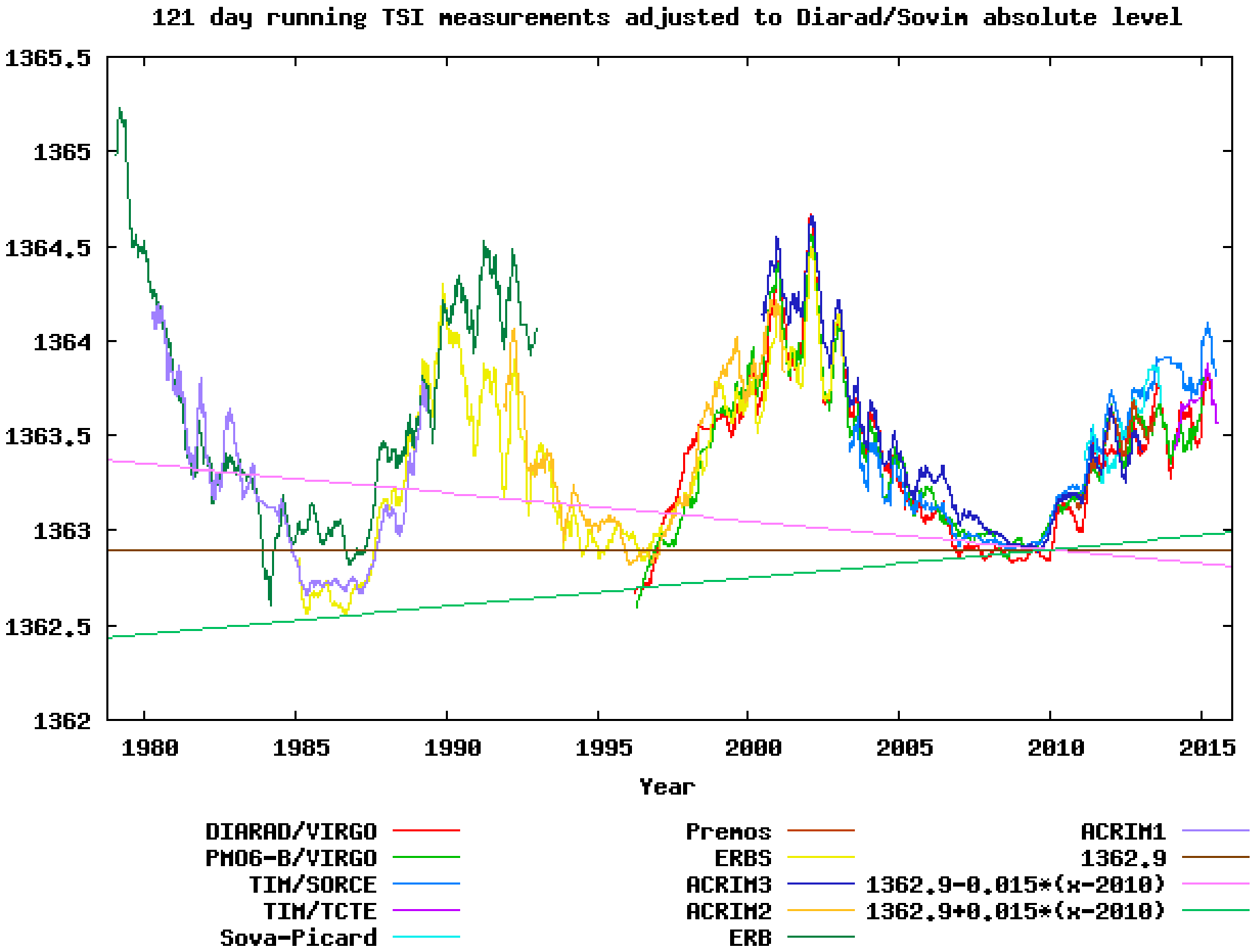
30+ years of TSI measurements

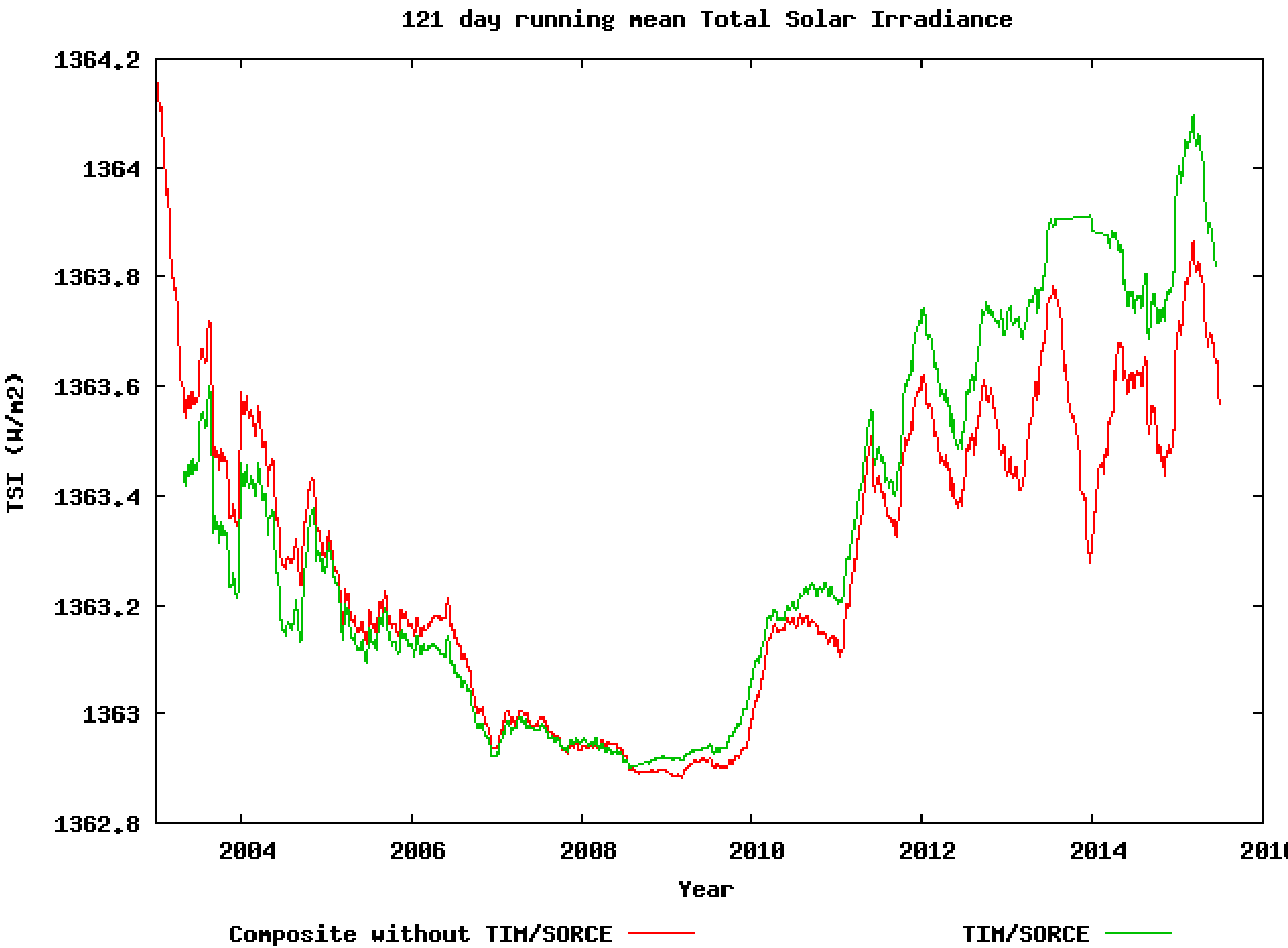
From various institues and agencies.

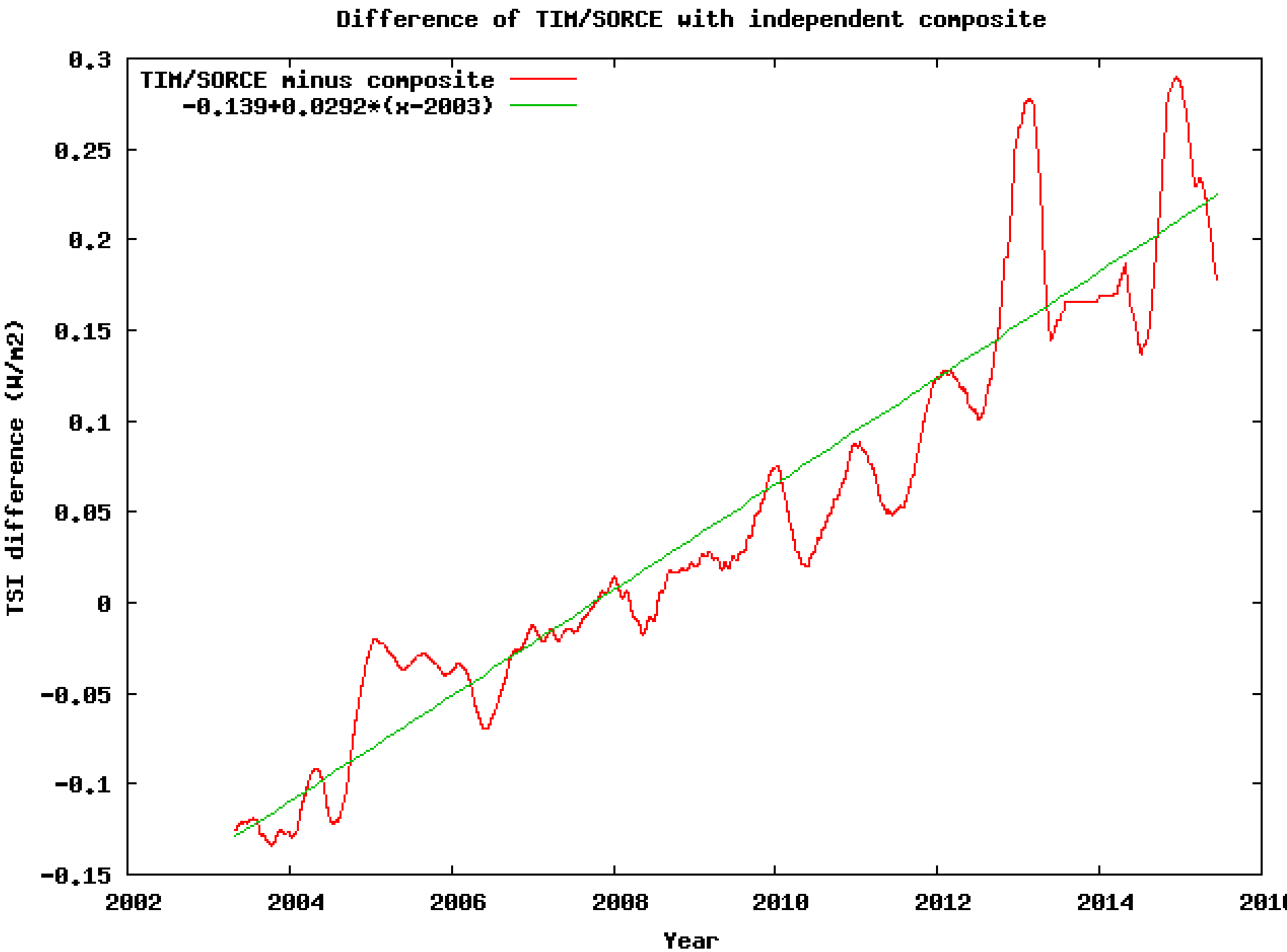
RMIB TSI space record:

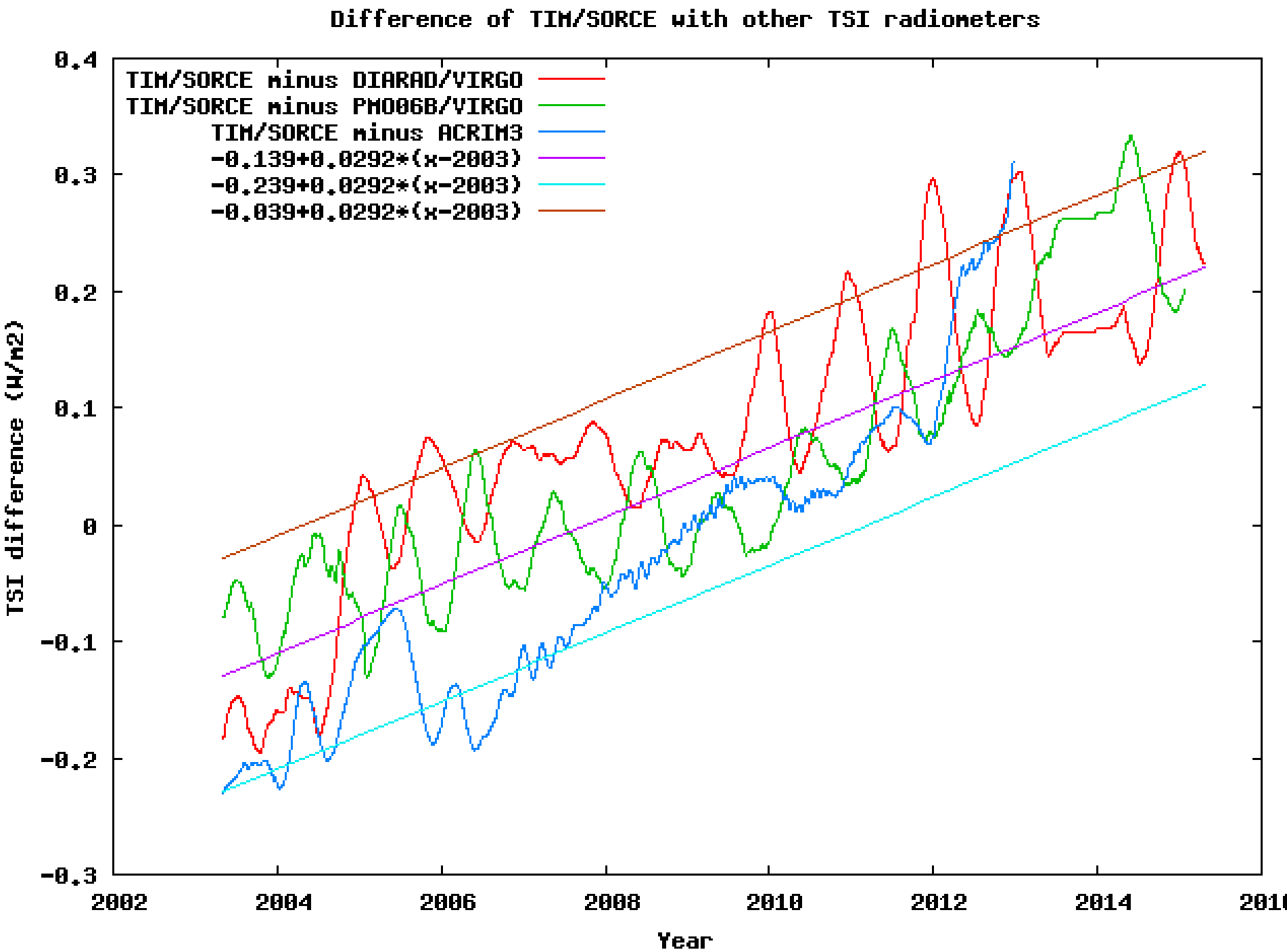
- 1983 SPACELAB 1 NASA ESA
- 1992 ATLAS-I NASA STS-45
- 1992 **EURECA/SOVA ESA STS-46 (returned to ground)**
- 1993 ATLAS-II NASA STS-56
- 1994 ATLAS-III NASA STS-66
- 1995 **SOHO/VIRGO/DIARAD (ongoing >19 year)**
- 1997 HITCHHIKER NASA STS-85
- 1998 HITCHHIKER NASA STS-95
- 2003 FREESTAR NASA STS-107
- 2008 **ISS/SOVIM/DIARAD (>1year)**
- 2010 PICARD/SOVA CNES (terminated)
- 2018 **FY3E/JOIM/DIARAD CMA (planned)**

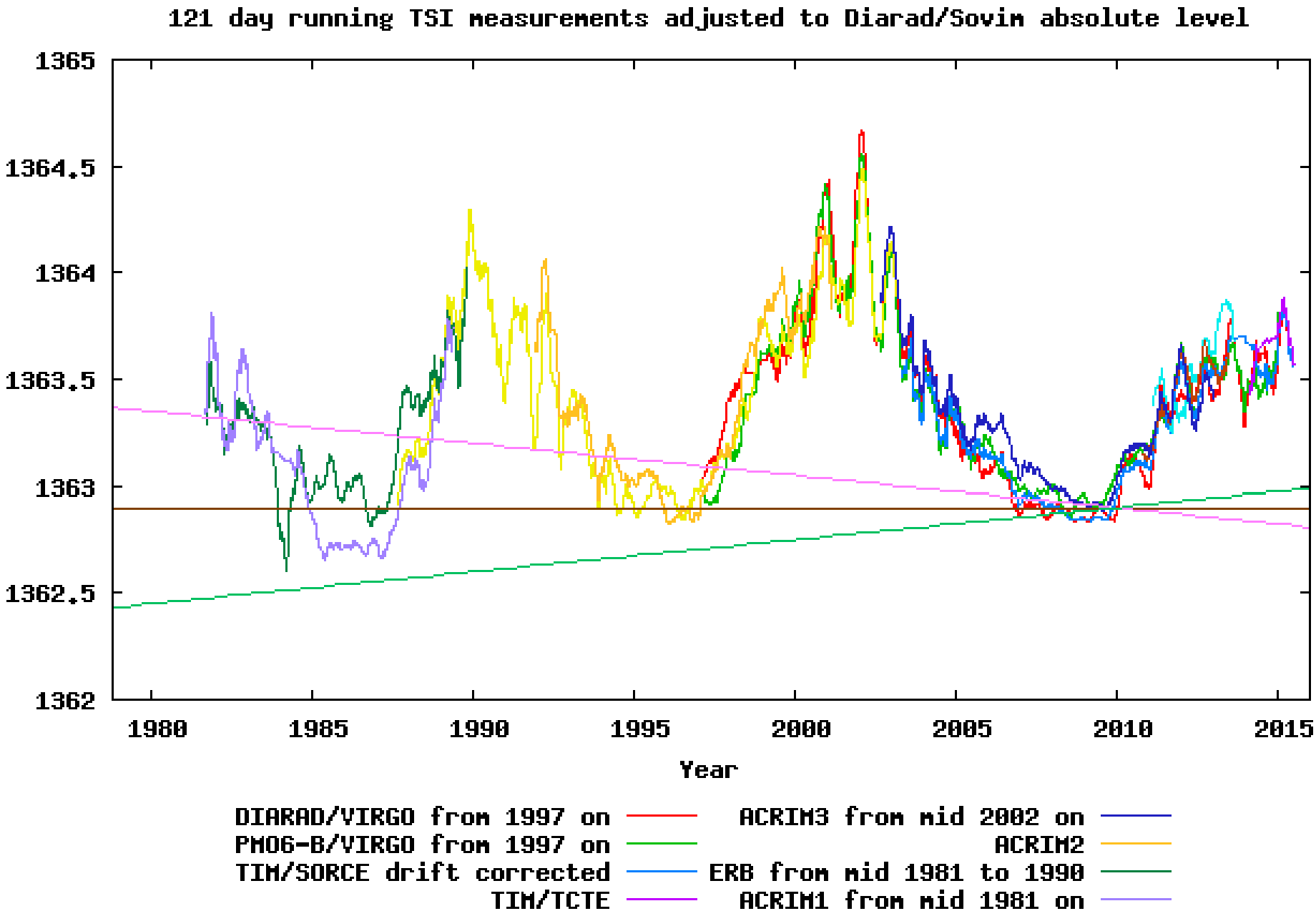

Total Solar Irradiance measurements
TSI (W/m2)
1376
1374
1372
1370
1368
1366
1364
1362
1360
1358
1356
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020
Year
ERB
ACRIM1
ERBS
ACRIM2
SOVA1
SOVA2
PMO6/VIRGO
DIARAD/VIRGO
ACRIM3
TIM/SORCE
DIARAD/SOVIM
SOVAP Left
SOVAP Right
PREMOS
TIM/TCTE

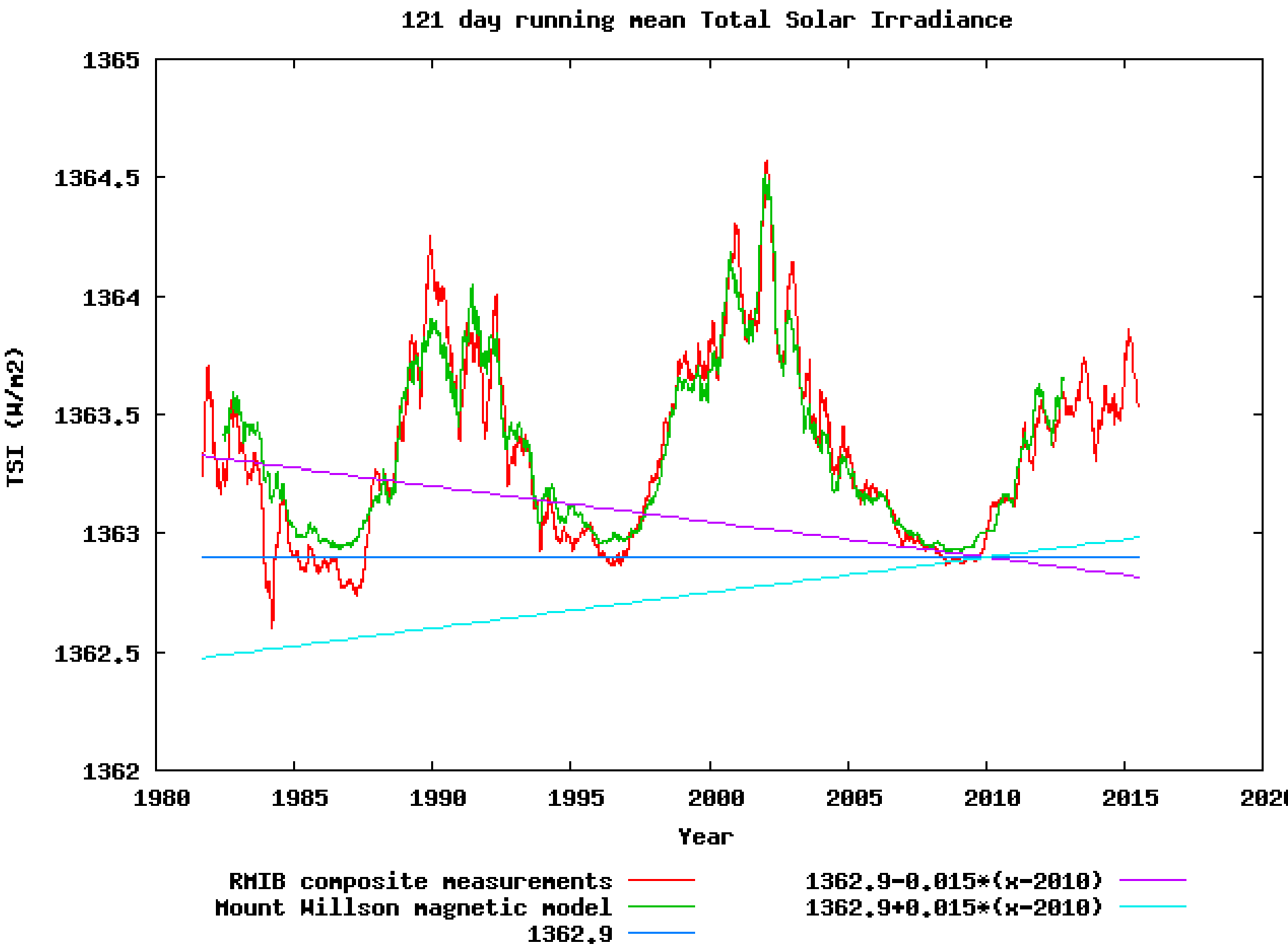

121 day running TSI measurements adjusted to Diarad/Sovim absolute level
1365.5
1365
1364.5
1364
1363.5
1363
1362.5
1362
1980
1985
1990
1995
2000
2005
2010
2015
Year
DIARAD/VIRGO
PMO6-B/VIRGO
TIM/SORCE
TIM/TCTE
Sova-Picard
Premos
ERBS
ACRIM3
ACRIM2
ERB
ACRIM1
1362.9
1362.9-0.015*(x-2010)
1362.9+0.015*(x-2010)


121 day running mean Total Solar Irradiance
1364.2
1364
1363.8
1363.6
1363.4
1363.2
1363
1362.8
TSI (W/m2)
2004
2006
2008
2010
2012
2014
2016
Year
Composite without TIM/SORCE
TIM/SORCE


Difference of TIM/SORCE with independent composite
TIM/SORCE minus composite
-0.139+0.0292*(x-2003)
TSI difference (W/m2)
Year
0.3
0.25
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
2002
2004
2006
2008
2010
2012
2014


Difference of TIM/SORCE with other TSI radiometers
TIM/SORCE minus DIARAD/VIRGO
TIM/SORCE minus PMO06B/VIRGO
TIM/SORCE minus ACRIM3
-0.139+0.0292*(x-2003)
-0.239+0.0292*(x-2003)
-0.039+0.0292*(x-2003)
TSI difference (W/m2)
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
2002
2004
2006
2008
2010
2012
2014
Year

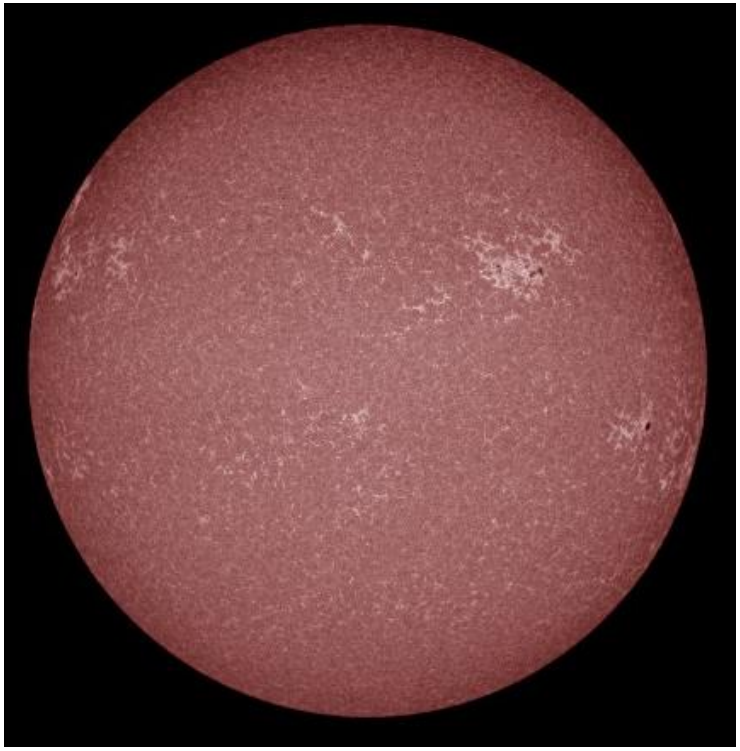

121 day running TSI measurements adjusted to Diarad/Sovim absolute level
1365
1364.5
1364
1363.5
1363
1362.5
1362
1980
1985
1990
1995
2000
2005
2010
2015
Year
DIARAD/VIRGO from 1997 on
PMO6-B/VIRGO from 1997 on
TIM/SORCE drift corrected
TIM/TCTE
Sova-Picard
Premos
ERBS from mid 1987 on
ACRIM3 from mid 2002 on
ACRIM2
ERB from mid 1981 to 1990
ACRIM1 from mid 1981 on
1362.9
1362.9-0.015*(x-2010)
1362.9+0.015*(x-2010)

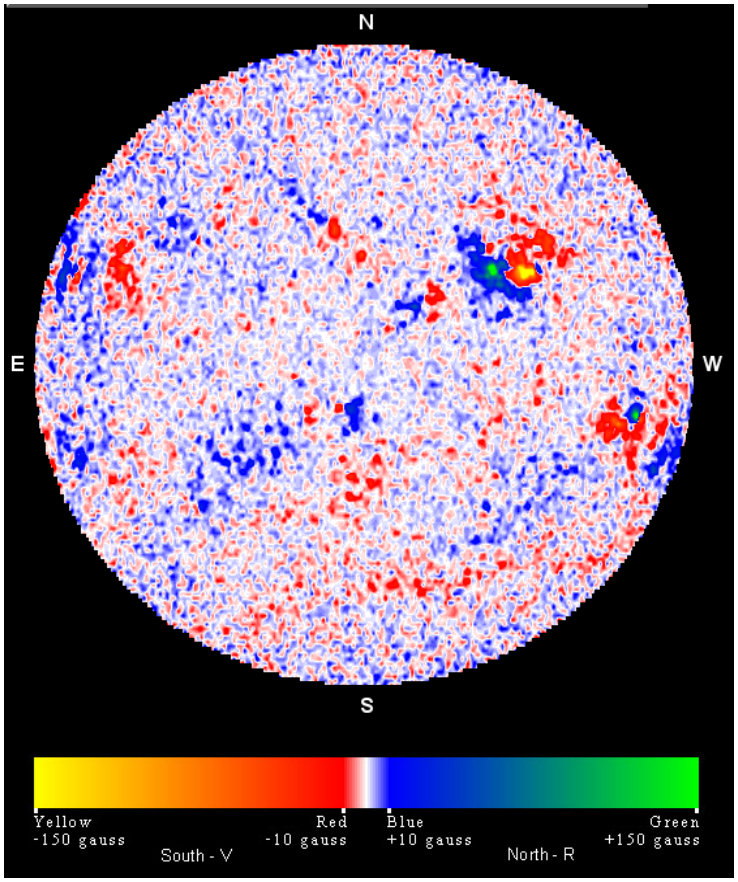

121 day running mean Total Solar Irradiance
TSI (W/m2)
1365
1364.5
1364
1363.5
1363
1362.5
1362
1980
1985
1990
1995
2000
2005
2010
2015
2020
Year
RMIB composite measurements
Mount Willson magnetic model
1362.9
1362.9-0.015*(x-2010)
1362.9+0.015*(x-2010)

Further back: sunspots and facula

Sunspots: dark, strong magnetic field, relative short lifetime

Facula: bright, intermediate magnetic field, relative long lifetime





L: UV image. R: Magnetogram

Further back: mount Wilson indices

MWSI

Mt. Wilson Sunspot Index

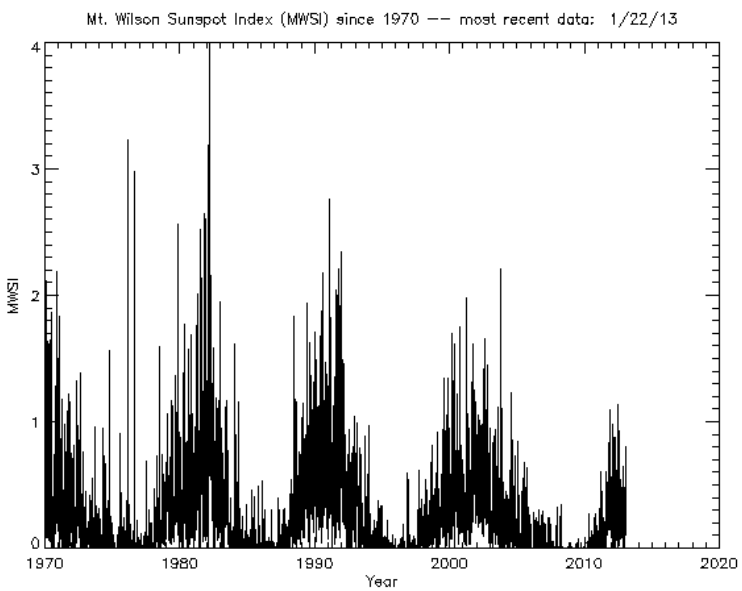
Strong magnetic fields

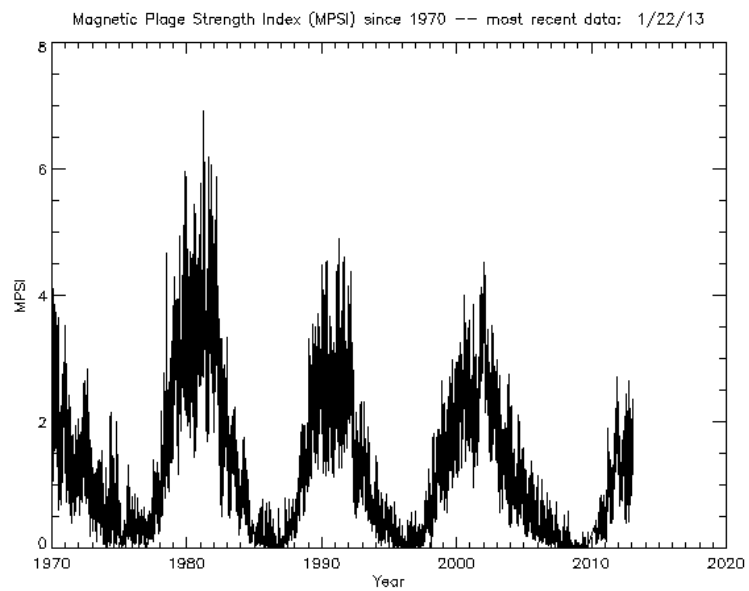
MPSI

Magnetic Plage Strength Index

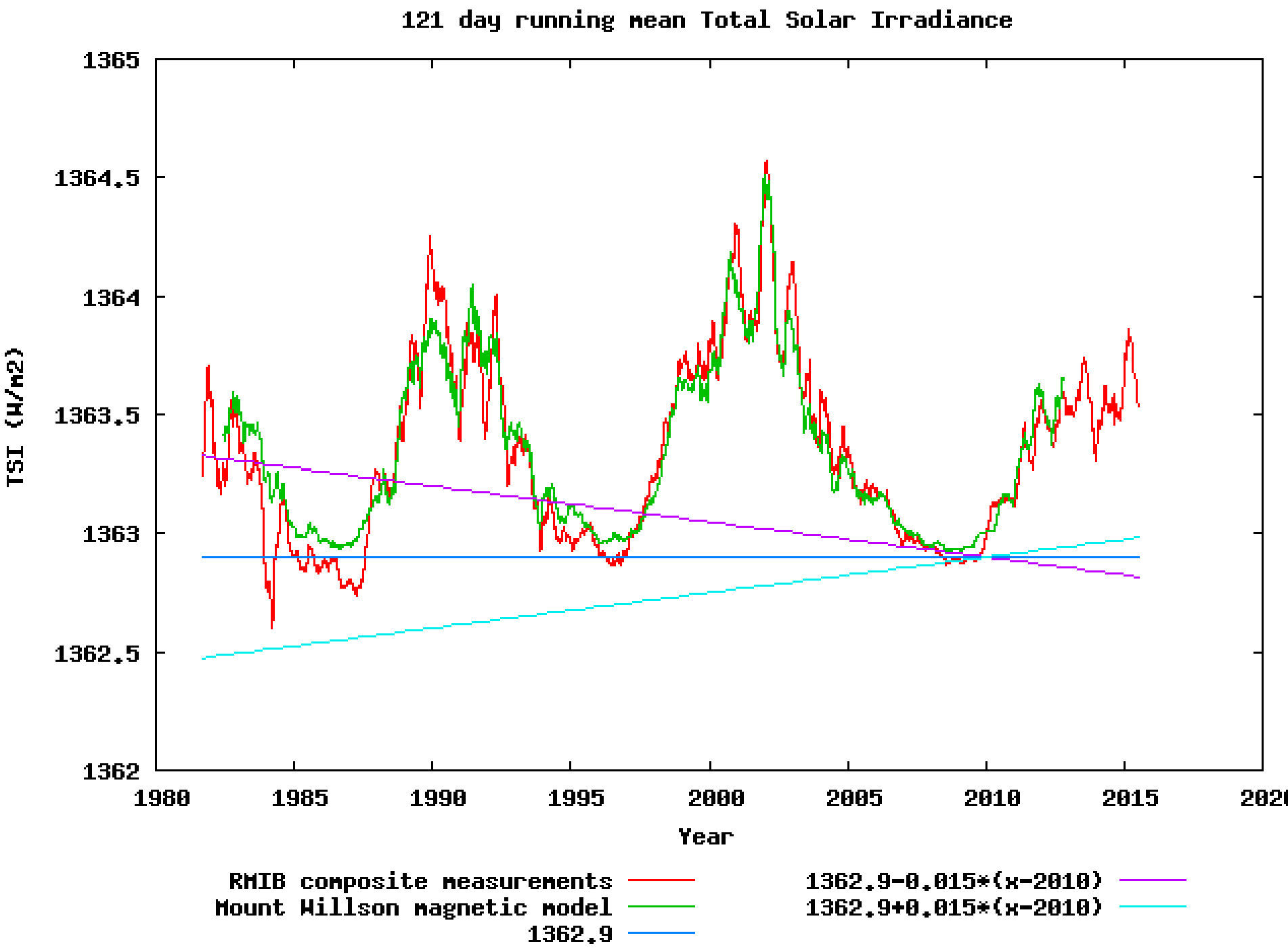
Intermediate magnetic fields

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
2020
Year
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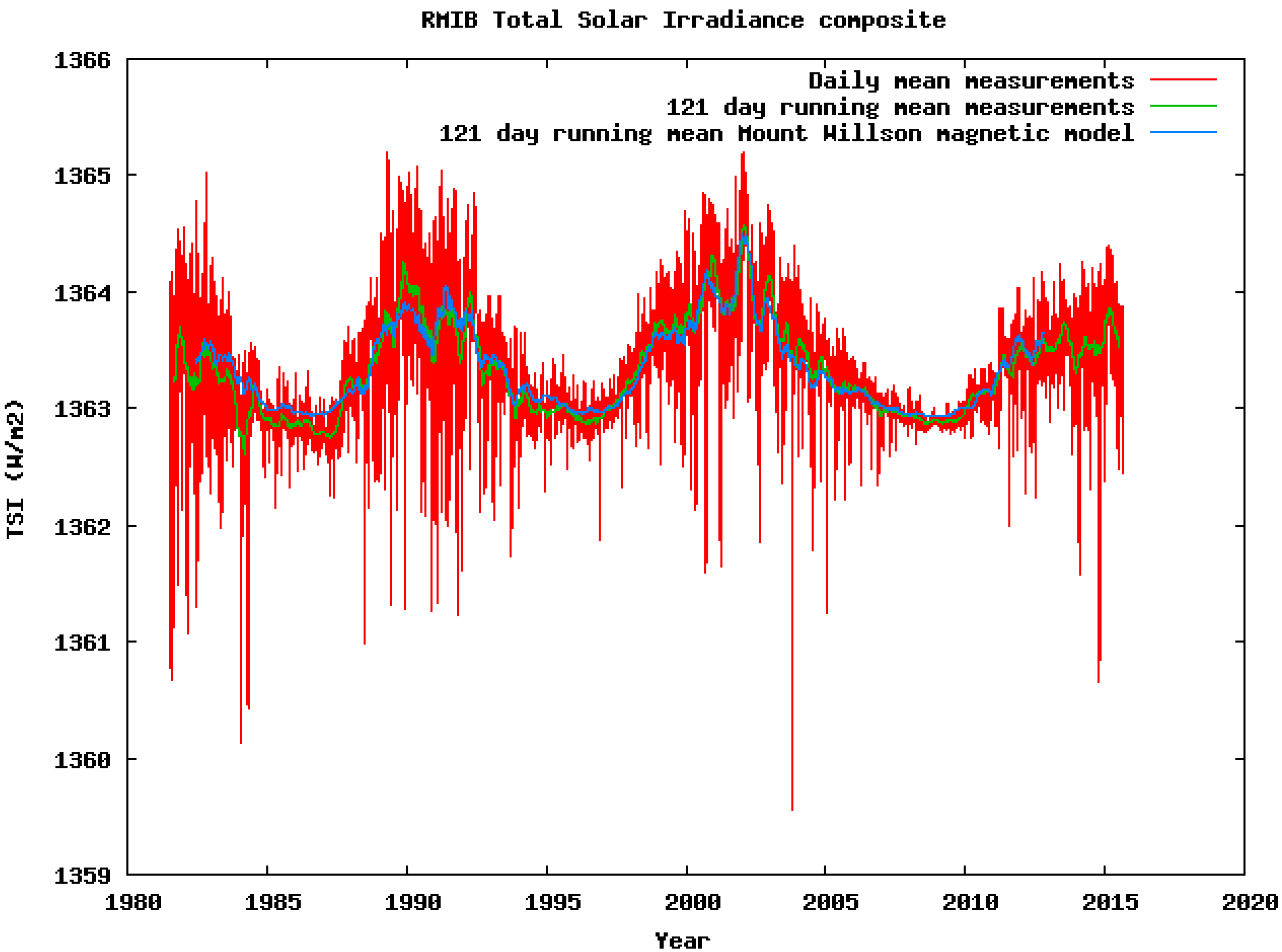
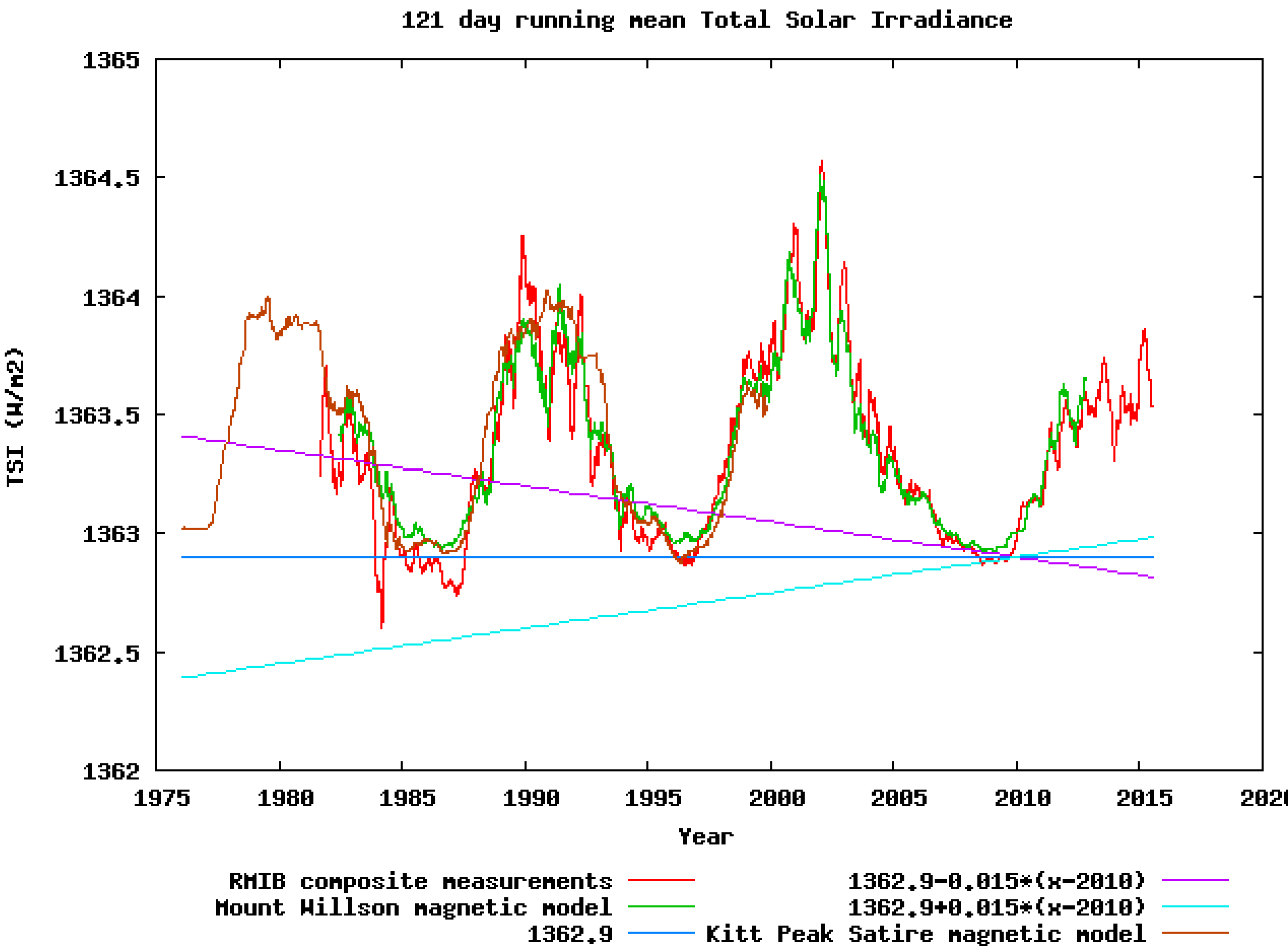
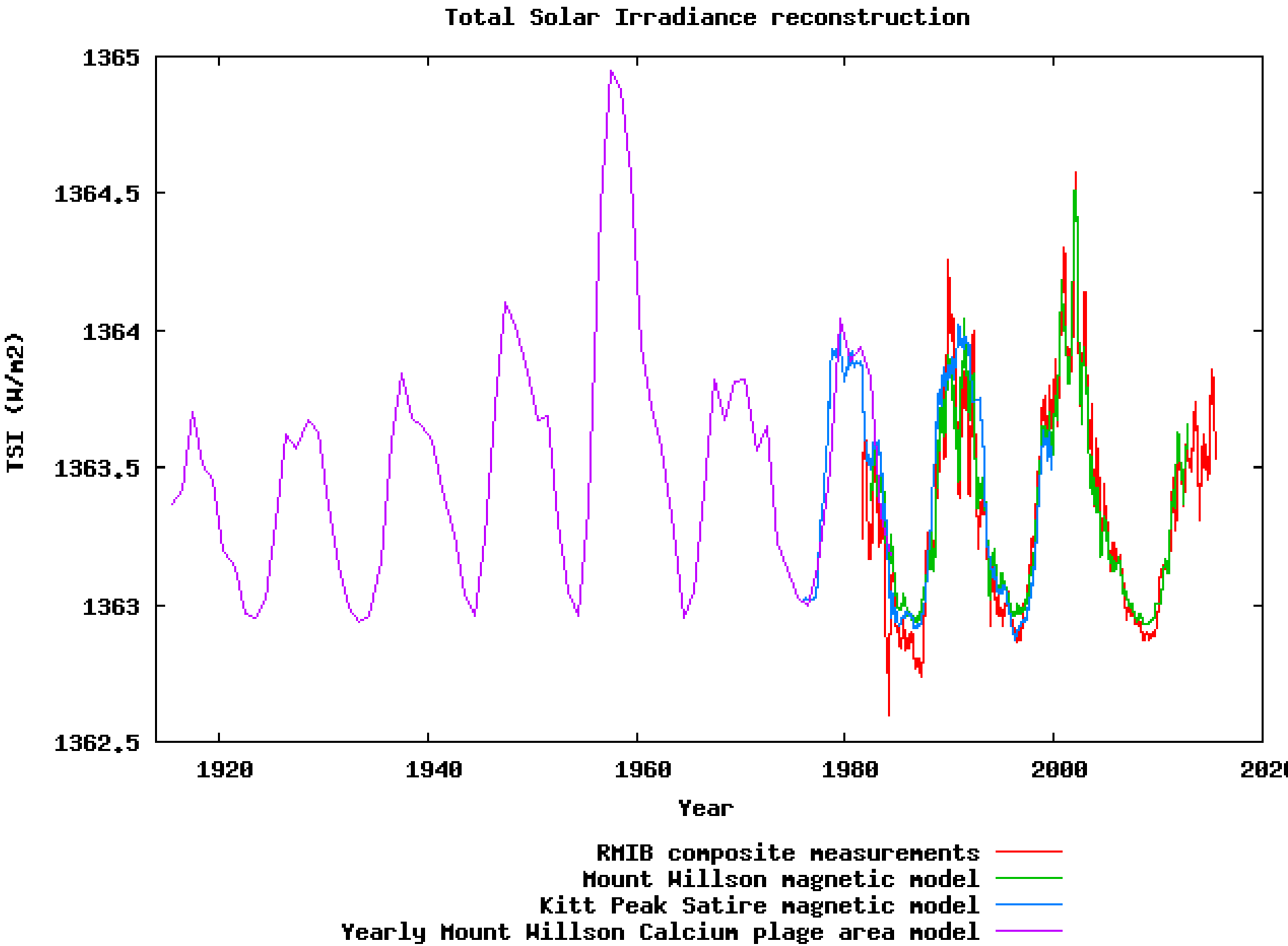
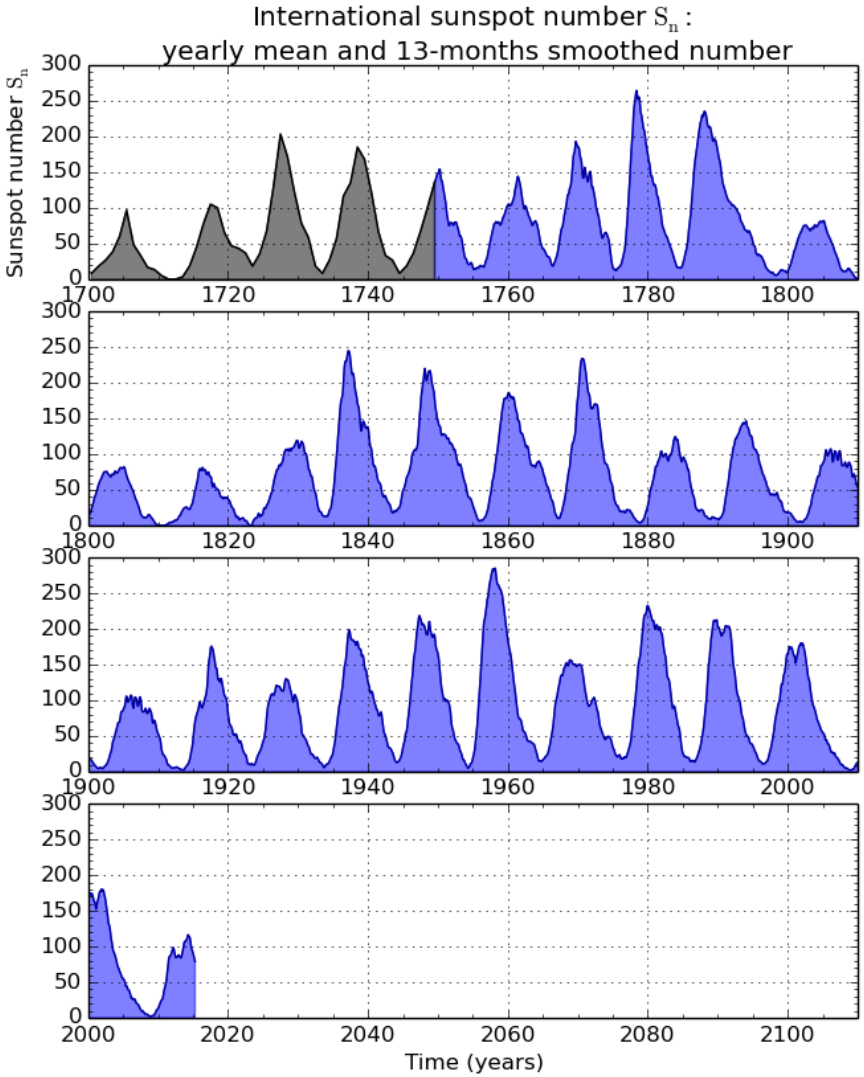
1362.9
1362.9-0.015*(x-2010)
1362.9+0.015*(x-2010)


RMIB Total Solar Irradiance composite
Daily mean measurements
121 day running mean measurements
121 day running mean Mount Willson magnetic model
TSI (W/m2)
1366
1365
1364
1363
1362
1361
1360
1359
1980
1985
1990
1995
2000
2005
2010
2015
2020
Year

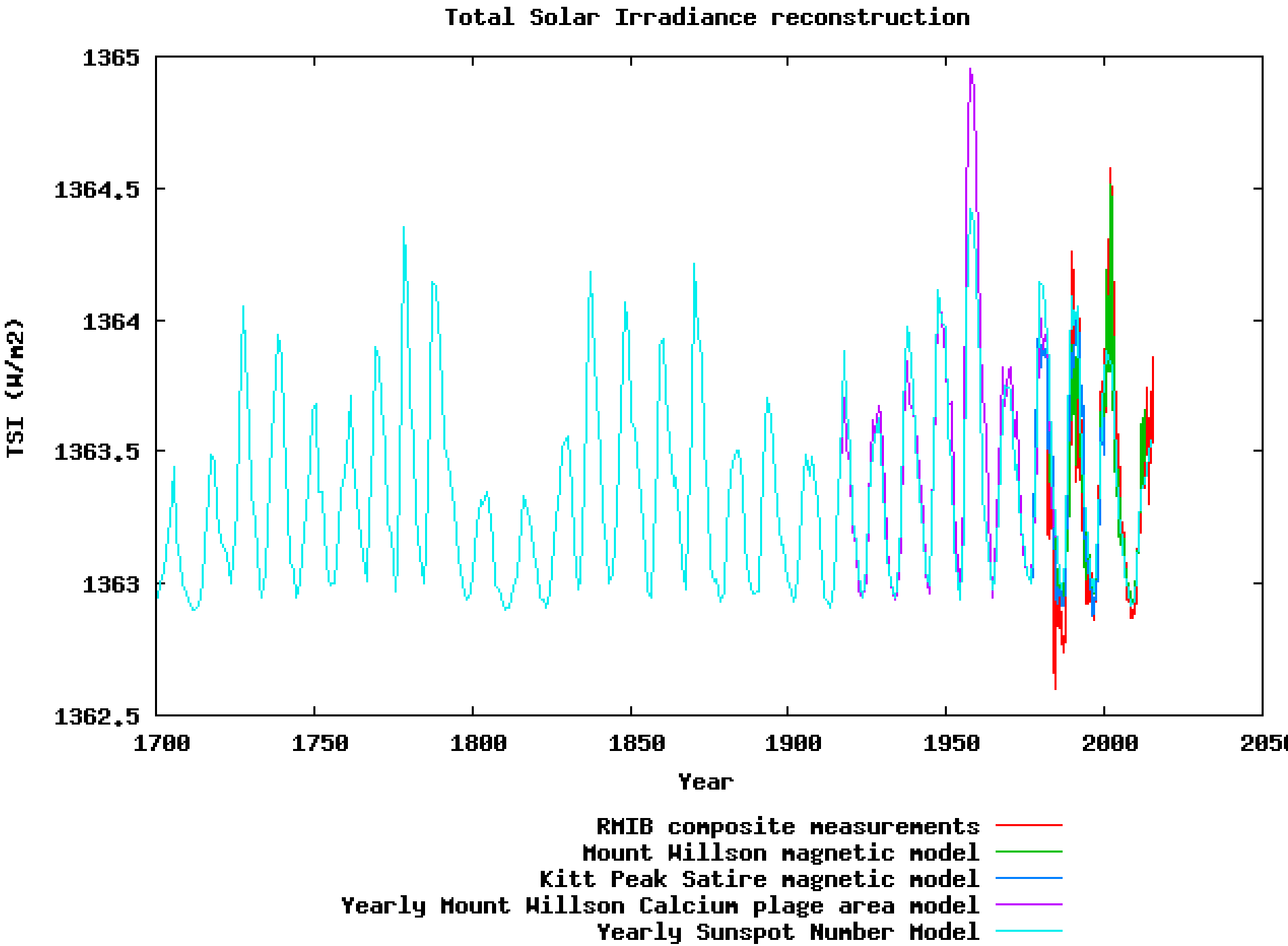

121 day running mean Total Solar Irradiance
TSI (W/m2)
1365
1364.5
1364
1363.5
1363
1362.5
1362
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020
Year
RMIB composite measurements
Mount Willson magnetic model
1362.9
1362.9-0.015*(x-2010)
1362.9+0.015*(x-2010)
Kitt Peak Satire magnetic model


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

Even further back: sunspot number



SILSO graphics (http://sidc.be/silso) Royal Observatory of Belgium 2015 November 1


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

Conclusions

- Regression models on sunspot data combined with 30 year of TSI measurements are used to reconstruct the TSI over a 300 year period.

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

- Within the measurement uncertainty there is no variation of the TSI at the minimum of a 11 year cycle during the last 30 years (3 minima)