

Fig. 1: (top left): Yohkoh/SXT irradiance for 1991-2001 in 3-45Å.

Fig. 2: (middle left): Filter-ratio temperatures derived from the thin-Al and Al/Mg/Mn filter pairs.

Fig. 3: (bottom left): Filter-ratio emission measures associated with the temperatures in Fig. 2.

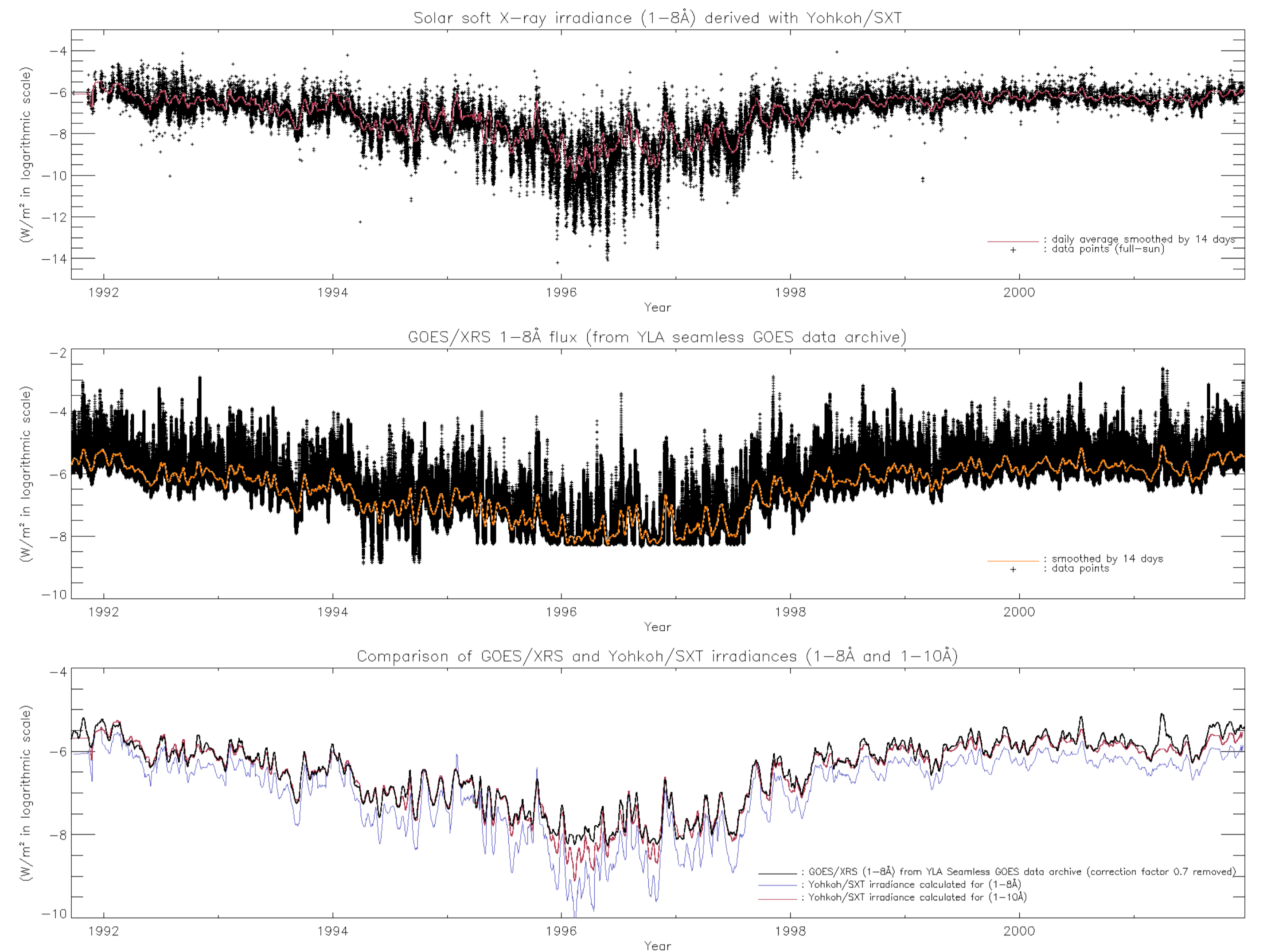


Fig. 4: (top right): Yohkoh/SXT irradiance calculated in 1-8Å.

Fig. 5: (middle right): GOES/XRS 1-8Å flux for 1991-2001 from YLA seamless GOES data archive.

Fig. 6: (bottom right): Comparison of SXT irradiance with GOES/XRS.

Summary

Solar soft X-ray irradiance (3-45Å) was calculated using the mission-long Yohkoh/SXT full-Sun images (1991-2001) obtained with two analysis filters (thin-Al and Al/Mg/Mn). We applied the most recent results of the re-calibrated SXT effective area functions (see §3.1) to this calculation. We assumed so-called, 'hybrid' elemental abundances by Schmelz (2012). It turned out that the 'coronal' and 'photospheric' abundances provide 10% lower and 25% higher values, respectively, than the hybrid abundance. SXT irradiance calculated in 1-10Å shows best correlation with GOES/XRS, especially when the flux level is around $10^7 W/m^2$ (see Fig. 6). This indicates that SXT's 1-10Å irradiance is useful as the correction of GOES/XRS irradiance around the solar minimum (1995-1998).

1. Introduction

1.1 Yohkoh/SXT and the YLA

- Yohkoh (Japanese word for 'sunshine') is a Japan/US/UK mission for high-energy solar physics (1991-2001). See Fig. 7.
- SXT (Soft X-ray Telescope) is a grazing incidence telescope on-board the Yohkoh satellite to form X-ray images in the 3 to 45Å range on a 1024x1024 CCD. The predecessor of Hinode/XRT.
- All usable dataset from the Yohkoh mission (from raw level to highly calibrated) are accessible from the Yohkoh Legacy data Archive (YLA) at <http://www.solar.physics.montana.edu/yohkoh/>.

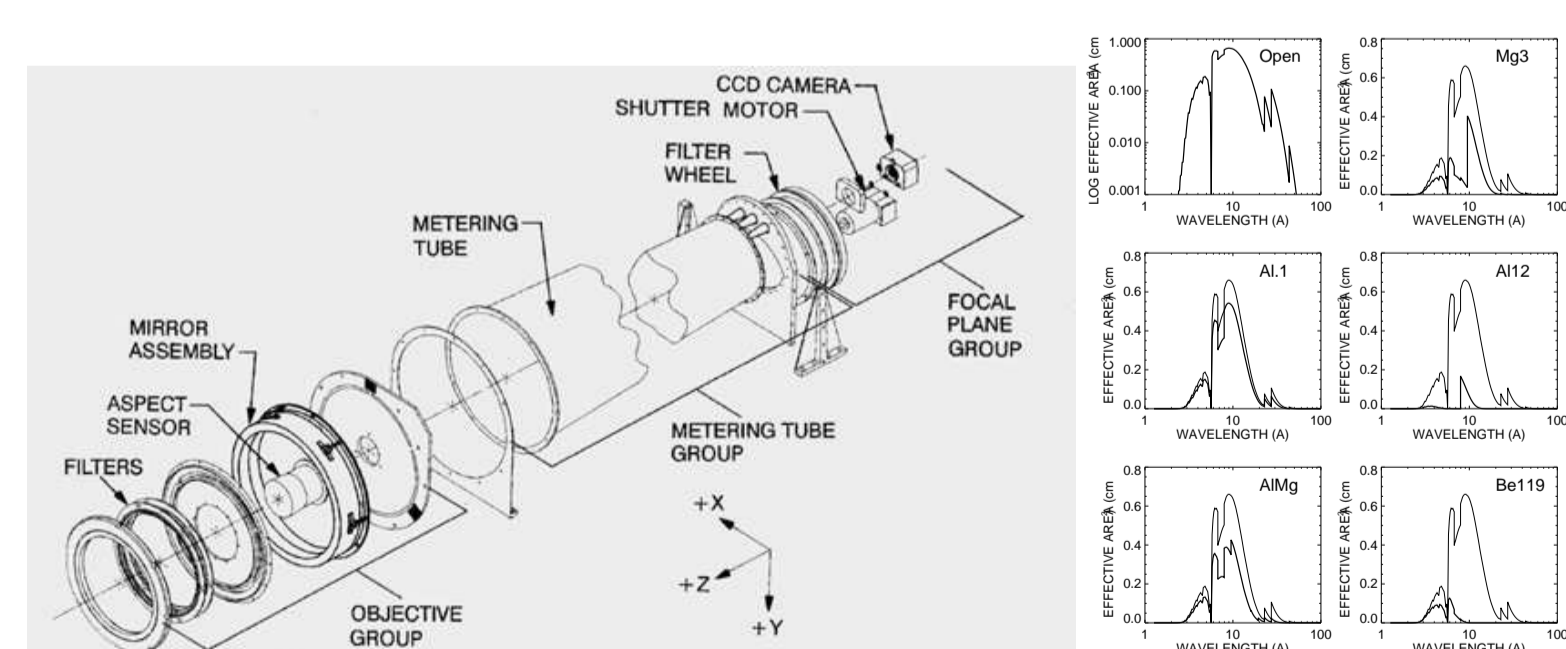


Fig. 7: Yohkoh/SXT assembly and spectral response of X-ray analysis filters (from YLA web site).

1.2 YLA seamless GOES/XRS archive

- Seamless GOES/XRS data (1991-2001) are prepared by the YLA team. They are essentially composite data from the primary GOES satellite of the time. Time resolution is 1 min.
- The missing-data periods (eclipses, etc.) of the primary satellite were replaced as much as possible with those of the secondary satellite.
- The scaling factors applied by SWPC to the archived flux were corrected (removed) to get true fluxes for 1991-2001. (cf. https://ngdc.noaa.gov/stp/satellite/goes/doc/GOES_XRS_readme.pdf)

2. Data processing

The Yohkoh Legacy data Archive (YLA) provides the mission-long SXT full-sun composite images as SXT level 2 data. Data were processed with the following steps.

1. Find pairs of thin-Al and Al/Mg/Mn filter images taken close in time (< 5 min. apart) and review for quality check.
2. Collect coronal intensities within 1.2Rs to obtain full-sun integrated signal pairs from each pair of images.
3. Derive filter-ratio temperature and emission measure from each signal pairs
4. Isothermal coronal spectra is calculated from the derived temperatures and emission measures, using CHIANTI atomic DB and software (ver. 8.0.7).
5. Integrate obtained spectrum over SXT's effective spectral range (3-45Å) or other desired range (e.g. 1-8Å) to derive coronal irradiance in the unit of W/m^2 .

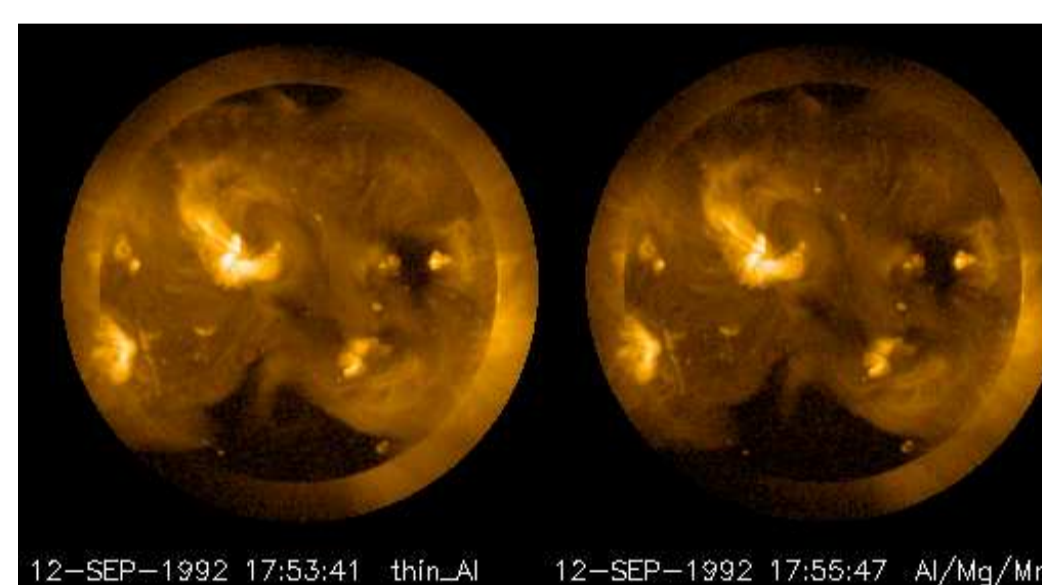


Fig. 8: Example of thin-Al and Al/Mg/Mn filter image pair. The areas outside 1.2Rs are masked.

3 Results

3.1 New SXT effective area function

A significant decrease of the signal level of SXT's aspect sensor (visible telescope) was observed for the first 14 months after the launch of the satellite (see Fig. 8, left plot). It was long considered only affect visible light signals, and not affect the X-ray signals. However, the variation of the total coronal emission measures shows artificial dip that is not related to the solar activity.

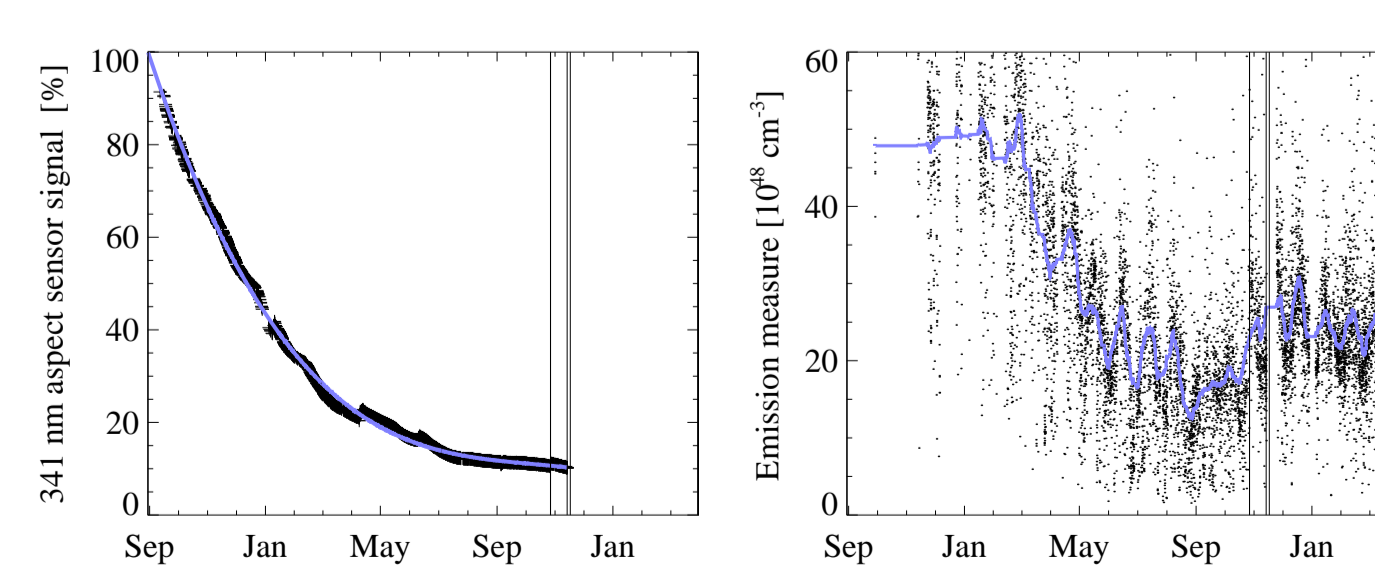


Fig. 9: Left: Decay of aspect sensor signal, overlaid (blue line) with a third-order polynomial fit to the data. Right: Full-sun emission measure derived from 9510 filter-ratio pairs acquired prior to 1993 April 1. (from Acton 2018)

To correct this, Acton (2018) introduced the accumulation of some material (evaporated from the telescope body) on the outer surface of SXT (and affects aspect sensor and pre-filter). Acton (2018) assumed the material contains Carbon, and estimated the growth rate of the carbon layer that explains the decrease of the visible light signals. The transmission of the pre-filter was modified using the same accumulation rate, and propagated to the SXT effective area function. Fig. 10 shows the SXT irradiance for 1992 derived with old and new SXT effective area functions. The difference is the largest for the period until the first pre-filter failure on 27-Oct-1992.

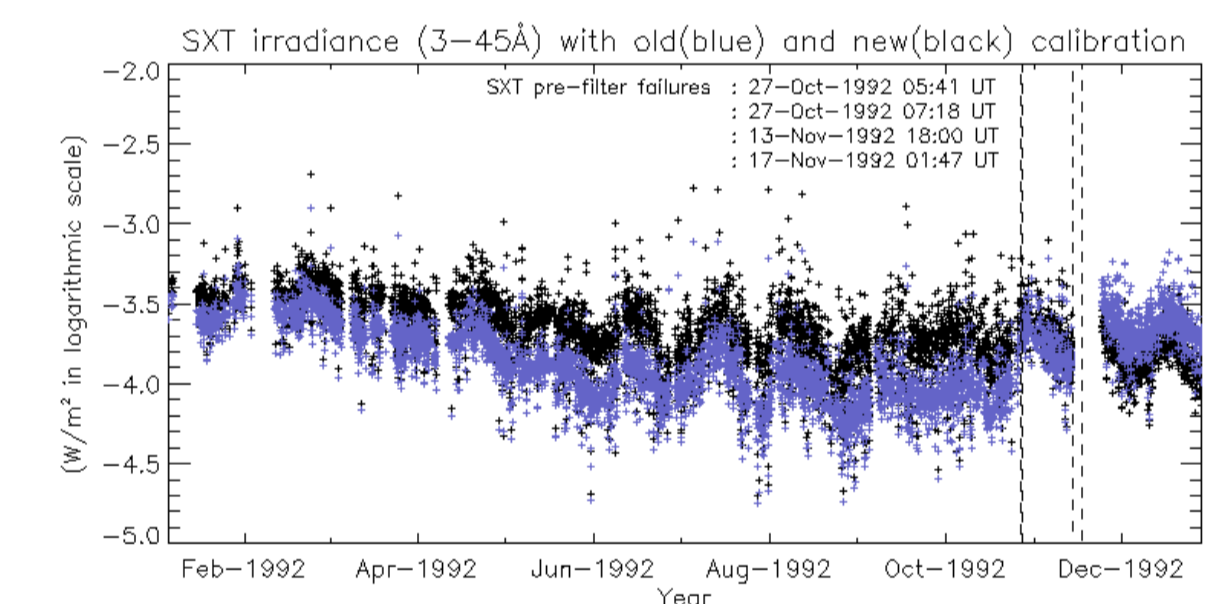


Fig. 10: 1992 SXT irradiance with old and new calibration.

3.2 Choice of elemental abundances

Our calculation assumes the elemental abundances by Schmelz et al. (2012), which is so-called 'hybrid' abundance set. We also tried other sets: so-called 'coronal' abundance by Feldman et al. (1992) and 'photospheric' by Caffau et al. (2011).

It turned out that the coronal and photospheric abundance sets provide 10% lower and 25% higher values, respectively, than the hybrid abundance set.

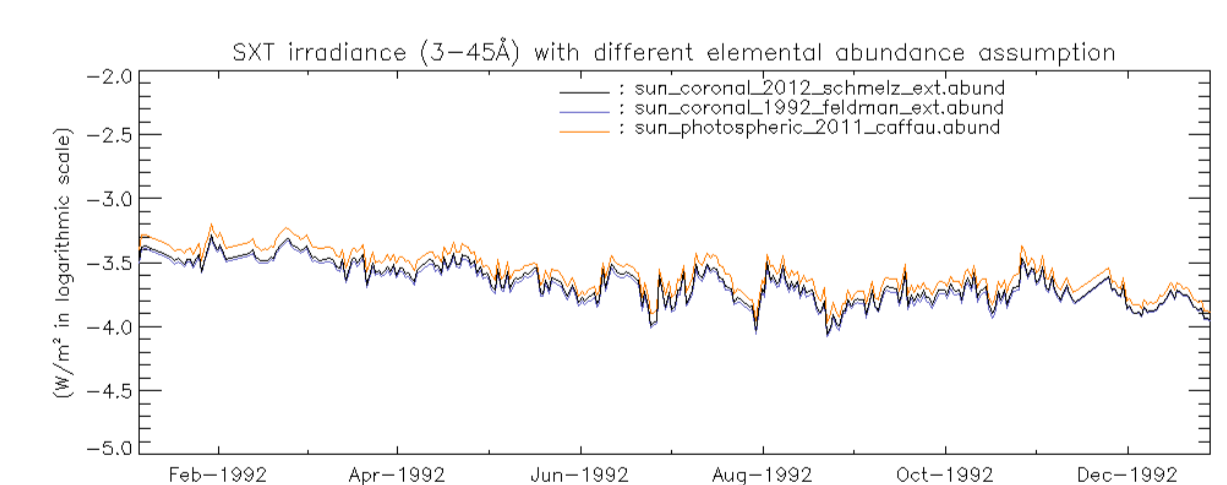


Fig. 11: 1992 SXT irradiance with different elemental abundance assumptions.

3.3 Comparison with GOES/XRS 1-8Å flux

See summary and Fig. 4 to Fig. 6.

References

- Acton, L. W. (2018) submitted to Solar Physics.
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