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PROBLEM OF MISTAKES IN DATABASES, PROCESSING AND INTERPRETATION OF OBSERVATIONS OF THE SUN.

II. SOLAR FLARES

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ABSTRACT. The contribution of space-based observations of solar flares in the database for the past 50 years has increased significantly, almost completely replacing the ground observations. The statistical parameters of the temporal distribution of solar flares, obtained using ground-based and space-based observations, differ significantly. We investigated the reasons for these differences to be taken into account in the study of flare activity of the Sun in the solar activity cycles 21-24.

Keywords: Sun: – Solar Activity, Observations, Solar Flares, Solar Proton Events, correction the datasets.

1. Introduction

Database users often don't question themselves about representativity of material there, about the sunflares in particular, even though one can almost always find an answer from technical documentation or primary arrays of observations. Fairly often the gaps in observation days influence the research conclusions essentially. Statistical processing of non-uniform series sometimes has been causing incorrect results about influence of direction towards the galaxy center or position of Earth, Jupiter and Saturn on flare production in active areas.

2. Data of Solar flares

Series of ground-based patrol optical observations of solar flares is longer than space one. Data about flares in H α line from 1965 to 2008 there was composed (grouped together) earlier from reports of ten observatories in Database NGDC NOAA and recently in this database there were published results of observations of 24th cycle of solar activity for appending to this series. Based on it, we have built continuous row of annual number 176357 flares in H α line (1965–2016) which contains 117910 flares in period 1976–2016. Continuous uniform series of X-ray flares was possible to build only from 1976 [1]. It contains 54682 solar flares of C, M, X classes, from which 4845 flares are of classes M and X. Fraction of all optical flares are associated with X-ray flares of weaker energy class B, however amount of these flares we haven't been considering because until 1983 they were not being recorded.

3. The time variations of flares number

The comparison of amount of observed optical and X-ray solar flare events (SFE) is shown on Fig. 1, from which we can see, that until 2000 year number of terrestrial observations of flares (by patrolling in spectral line H α) was twice as much as total number of observations of X, M and C flares by spacecraft, and even more than that in first half on 21st cycle of solar activity. During the last years number of terrestrial observatories which conduct the patrolling of flares has been decreased to four and amount of space data has become equal to that of terrestrial. Partially because of this, and not only due to century changes in solar activity, we see the larger decrease of amount of observed optical flares (by 4 times) than X-ray ones (by 2 times) during 21–24 cycles of solar activity.

To evaluate influence of astroclimate season changes on number of terrestrial registered solar flares a comparative analysis of variations of monthly average number of flares during numerous years for terrestrial and space observations (figure 2) was conducted.

From figure 2 we can see season change of frequency of optical flares by terrestrial observations (in July–August there are 20% more observed flares, than in February, the accuracy of difference existence is over 95%) compared to equal by error margin frequency of X-ray flares by satellite observations. Most observatories are situated in north hemisphere, hence in summer optical observatories register more flares.

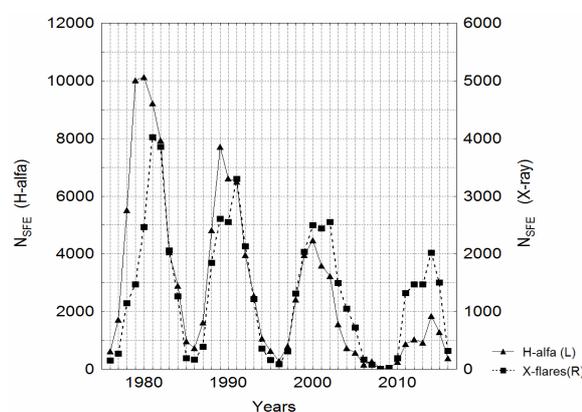


Figure 1: Annual amount of registered solar flare events

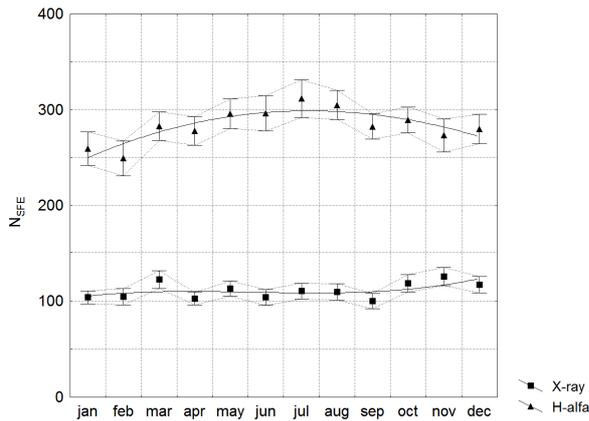


Figure 2: Distribution of number of observed optical solar flares from 1965 to 2015 and X-ray flares – from 1976 to 2016.

Analogically inter-year fluctuations of astroclimate may compromise the uniformity of optical observations series.

4. Data of SPE number

Processing of series of solar proton events data and solar flares showed, that almost every 10th visible solar flare on the solar disk of class M or X (which has electromagnetic energy flux exceeding 10^{-5} W/m² in maximum), is source of solar proton events. Solar proton events (solar particle events–SPE) are proton fluxes, more than 1 pfu (1 proton per cm² sr) with energies > 10 MeV at distance of 1 a.u., which are registered by orbital spacecraft after emission of high-energy neutrons and protons by powerful solar flares or particle acceleration on front of shockwave after coronal mass ejections (CME). Significant part of SPE from powerful flares are not registered by orbital spacecraft because it travels in interplanetary space at large distances from Earth.

We have built series of annual amount of SPE, based on catalogues of electronic library WDC from 1970 to 2009 and using Database SPDF NASA for 2010–2016. The list of reliably confirmed SPE in electronic library WDC contains 419 events from 1976 to 2006 yy, it is almost twice as large as list of events in NGDC NOAA base (225 SPE for the same time frame). There is no data for 24th cycle of solar activity in WDC catalogues yet, so we used the results of satellite measurements from NASA SPDF database, which contains 357 events from 1970 to 2016, and 44 events from 2010 to 2016.

Statistical analysis showed that correlation relation index of annual SPE amount with optical flares in H α line ($r = 0.75$) is less, then with total amount of X-ray flares of C, M and X classes ($r = 0.84$). Relation of number of SPE with sum of X-ray flares of classes M and X is the strongest ($r = 0.88$).

5. Reconstruction of true number of flares

Though this is strong statistical connection, it should be noted that series of number of X-ray solar flares received from various spacecraft of GOES series, so it is necessary

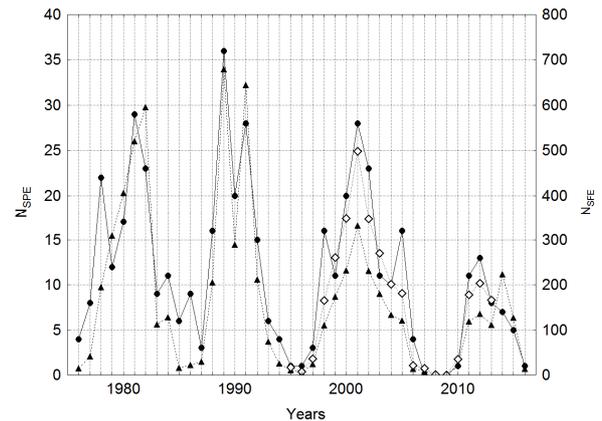


Figure 3: 11-year cycles of solar activity from 21st to 24th in number of SPE and solar flares of classes M and X. On left Y axis—annual amount of SPE (circles), on right—annual amount of M and X-flares (triangles) and the corrected curve of flare number during 1996–2013 is shown (rhombs).

to confirm its uniformity. To do this we compare it with annual amount of SPE caused by powerful flares.

From figure 3 we see, that during last two cycles of solar activity the plot of amount of SPE goes 1.5 times higher than plot of amount of solar flares. Since SPE are caused by these same flares, there cannot be such significant difference between 23–24 cycles of solar activity and 21–22. Most likely, the lowered since 1995 evaluation of amount of powerful solar flares appears due to inaccuracies in calibration of receiver of X-ray radiation, which should be considered in further work. The conducted recalculation of annual amount of M and X flares after correction of boundary energy for their classification according to correction indices, set for satellites GOES 8–GOES 15 (Database NGDC NOAA). Results of recalculation are shown on figure 3 by rhombs.

Further work on analysis and correction of data concerning flare activity of the Sun is necessary in catalogues and electronic sources, also reevaluation of research published earlier on number of flares at various time intervals. In particular, the conclusions of series of publications concerning low solar activity in 23rd cycle were incorrect.

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References

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- Electronic library WDC (World Data Centers) http://www.wdcb.ru/stp/online_data.ru.html#ref113_r/ (Catalog of Solar Proton Events 1970–1979, 1982, 184 c.; Solar Proton Events. Catalogue 1980–1986, 1989, 159c.; Catalogue of Solar Proton Events 1987–1996, 1998, 246c.; Catalogue of Solar Proton Events in the 23rd Cycle of Solar Activity (1996 – 2008), 2016, 740 c.)