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Study of solar flares' latitudinal distribution during the solar period 2002–2017: GOES and RHESSI data comparison

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Abstract

The purpose of the present research is to study the latitudinal distribution and its asymmetry of solar flares during the period 2002–2017 and make a comparison between the studied data from two different satellites (GOES and RHESSI). We tried to benefit from available advantages of GOES and RHESSI satellites, where GOES satellite is providing classes associated to each flare, while RHESSI is providing the location of the recorded solar flare events. The distribution of the solar flares' location during the period 2002–2017 shows that most of the flares are located in the southern hemisphere (57% of C – class, 61% of B – class, 56% of M – class and 61% of X – class). The study of the solar flare events from RHESSI flare catalog during each phase of the solar cycles 23 and 24 (during the period 2002–2017) showed that the most of flare events are happening during the declining phase of the solar cycle and keeping the tendency to have more southern events (61%) than the northern ones, while there are more flares found in the northern hemisphere (64%) than the southern hemisphere during the rising phase of the solar cycle 24. We calculated the mean latitude value in the northern hemisphere and found it to be about +13° (about 7.5% of all solar flare records are located on this latitude) using flare events recorded by GOES and RHESSI, but there is a slight difference between the mean latitude values calculated using GOES (about −13°) and RHESSI (about −15°), about 6% of all solar flares recorded by RHESSI in the southern hemisphere are located on this latitude.

Keywords: Sun; Solar flare; Solar cycle; Solar physics; Space weather

1. Introduction

Among different interesting solar phenomena solar flares events are very important because they can cause many problems for the terrestrial environment and communications, such as disturbing the magnetosphere, breaking power grids at high latitudes and damaging satellites equipment.

Solar flare related with some solar phenomena such as filaments and prominences (Liu et al., 2015; Holman and Foord, 2015), filament disappearances (Mawad et al., 2015), coronal mass ejections (Youssef et al., 2013; Shaltout and Mawad, 2011; Mahrous et al., 2009; Shaltout et al., 2006), solar wind (Korreck et al., 2008), and coronal holes (Cliver, 1995). A solar flare is an important source of the space weather (Farid et al., 2015; Yermolaev and Yermolaev, 2009).

The first observations of solar X-ray radiation were performed more than 60 years ago (Friedman et al., 1951). Solar flares are explosive phenomena that emit electromagnetic radiation extending from radio to γ -rays. Solar flares

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are observed at all wavelengths from decameter radio waves to gamma-rays beyond 1 GeV. (Benz, 2017).

The GOES (Geostationary Operational Environmental Satellite) X-ray instruments have observed the solar activity for several decades and created the largest database of solar flares (GOES, Bornmann et al., 1996). On each GOES satellite there are two X-ray Sensors (XRS) which provide solar X-ray fluxes for the wavelength bands of 0.5–4 Å (short wavelength channel) and 1–8 Å (long wavelength channel). Measurements in these bands have been made by NOAA satellites since 1974 and the design has changed little during that period (Garcia, 1994). The GOES classes represent the peak fluxes in the 1–8 Å channel during the flare. Another example of flare-observing instruments is the Reuven Ramaty High Energy Solar Spectroscopic Imager (RHESSI, Lin et al., 2002), launched in February 2002. RHESSI observes the X-ray radiation of flares in a wide range of energies, from 3 keV to >300 keV. The satellite detects the events and has its own flare list separate from the GOES flare list.

Measurements of hard X-rays (HXRs) up to ~300 keV indicates the presence of electrons with energies up to a few MeV producing bremsstrahlung in the high-density regions of the solar corona and chromosphere. Some of electron bremsstrahlung emission of the solar flares obtained by GOES X-class is detected up to tens of MeV (e.g., Trottet et al., 1998).

The data comes from the NOAA Space Weather Prediction Center (SWPC) and is archived at the NOAA National Center for Environmental Information (NCEI) which was formerly the National Geophysical Data Center (NGDC).

Pandey et al. (2015) tried to statistically study the solar flares latitudinal occurrence and solar flare classes in the period 1976–2008 using 63,000 solar flares recorded by GOES; they found that the solar flares are accumulating in latitude belts or populations in the northern and southern hemispheres.

Papagiannis et al. (1972) studied 350 solar flares accompanied by type IV radio bursts covering a period of 14 years (1956–1969). They concluded that the two peaks in cycle 20 are independent, and their relative strength varies strongly with latitude. However, in cycle 19 this effect is not evident, possibly because of the extremely high level of activity during this cycle. In both cycles, the second maximum shows the highest concentration of the most energetic events.

Rao (1974) studied the behavior of solar flare events and mentioned the continuous generation of new events at higher latitudes and their migration toward the equator within about 5 years.

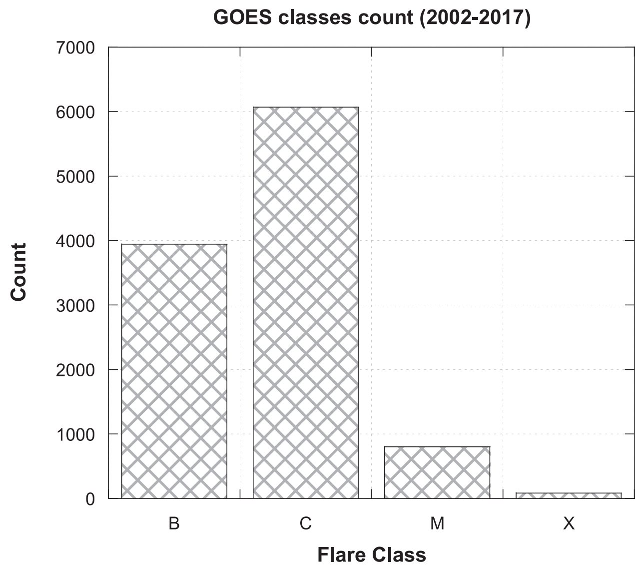

Fig. 1. Histogram of flares of different GOES class.

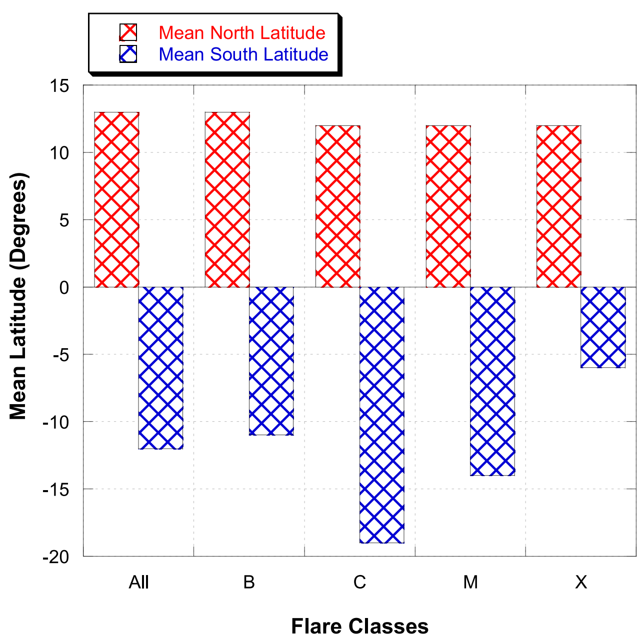

Fig. 2. Latitudinal distribution for flares of different GOES class.

Table 1
Statistics of X-ray solar flare latitudes distribution with solar classes (Obtained from GOES flare catalog).

Class	Northern Hemisphere Latitude				Southern Hemisphere Latitude			
	Count	Min	Max	Mean	Count	Min	Max	Mean
All	4549	0	86	13 ± 0.1	6352	−1	−81	-12.96 ± 0.08
B	1540	0	86	$13 \pm 0.\ 23$	2406	−1	−81	-11.30 ± 0.15
C	2622	0	41	12.67 ± 0.10	3446	−1	−34	-19.93 ± 0.09
M	353	0	56	12.48 ± 0.34	447	−1	−37	-14.38 ± 0.27
X	34	2	27	12.85 ± 0.86	53	−6	−21	-6.69 ± 0.55

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