LA-UR- 91 4034

LA-UR--91-4034

DE92 005061

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SUBMITTED TO: Proceedings of the Gamma-Ray Burst Workshop, Huntsville, AL
October 15-18, 1991

12/6/91

Gamma-Ray Burst Data from DMSP Satellites

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ABSTRACT

A number of gamma-ray bursts have been detected by means of gamma-ray detectors aboard three Air Force Defense Meteorological Satellite Program (DMSP) satellites, in polar orbits at 800 km altitude. The gamma-ray data have a 2-second resolving time, and are usually telemetered in 5 energy bins in the range 50-1000 keV. Although it is not possible to detect gamma-ray bursts when the DMSP satellites are passing through the radiation belt or the South Atlantic Anomaly, or when the source is obscured by the Earth, a number of gamma-ray bursts have been detected by two or even three of the satellites. The DMSP data may be of considerable assistance in evaluating time histories, locations, and spectra of gamma-ray bursts.

INTRODUCTION

Several years ago the U.S. Air Force began a program of launching Defense Meteorological Satellites, to investigate the environment of Earth from an orbital altitude of 800 km. The three DMSP satellites currently in use (Flights 8, 9, and 10) were launched in June 1987, February 1988, and November 1990. They are in sun-synchronous near-polar (99°) orbits, reaching 81° latitude, nominally in noon-midnight or dawn-dusk orbits. On board each spacecraft (Figure 1) are two gamma-ray detectors, each with 100 cm^2 detection area of NaI, as well as charged-particle detectors. With three flights in orbit there is a good chance of seeing gamma-ray bursts, and a considerable number have already been detected. Data from some recent (1991) bursts will be presented.

RESULTS

The DMSP satellites pass through the horns of the outer Van Allen radiation belts four times in each polar orbit. As the Earth turns under them, they also pass through the South Atlantic Anomaly on many orbits, experiencing very high counting rates. Thus the gamma-ray count rate during one 100-minute orbit looks, typically, like the upper curves in Figure 2. The data here have been smoothed over 20-sec intervals; the South Atlantic Anomaly is the peak furthest to the right. The lower curves represent charged-particle count rates. There are long periods during which gamma-ray bursts can be readily detected, as happened here on 8 February 1991. This gamma-ray burst was detected by two DMSP flights, and also, 40 sec earlier, by Pioneer Venus Orbiter (PVO), at 32376 sec UT.

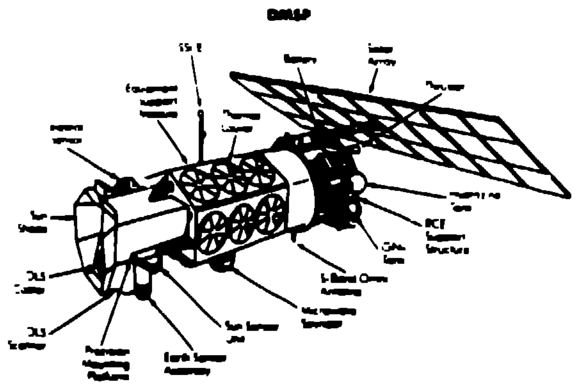

Fig. 1: DMSP spacecraft.

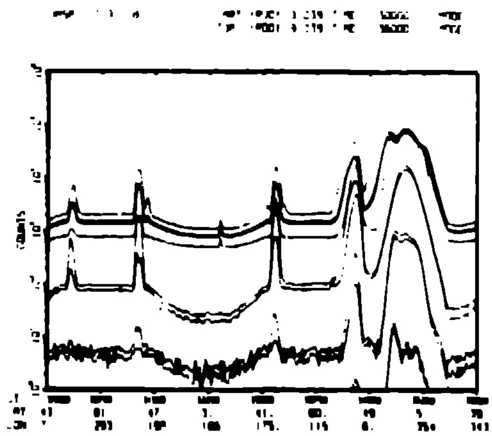

Fig. 2: Data for 2/8/91 (100 min).

Figure 3 gives a more detailed look at the data from DMSP Flight 9 on 8 February, with 2-sec resolution and with several channels of gamma-ray data displayed (for DMSP 9 the channels shown are 50-1000 and 100-1000 keV, for each of the two counters). This burst, which lasted about 6 sec, was also detected by DMSP 8. The peak counting rate occurred at 32415.5 sec UT, as detected by DMSP 9, or at 32415.7 sec UT according to DMSP 8. Both times have been corrected for delays in transmission, and are uncertain by ±1.0 sec because of the 2-sec time bins. This uncertainty in time applies all to the DMSP events discussed here. Additional time uncertainty is introduced by counting statistics, and by the fact that a very narrow peak might not be resolved.

Another gamma-ray burst (Figure 4) was detected on 10 March, and was seen by all three DMSP flights, as well as by PVO (at 47565 sec UT) and other satellites. The data from DMSP 9 in this figure

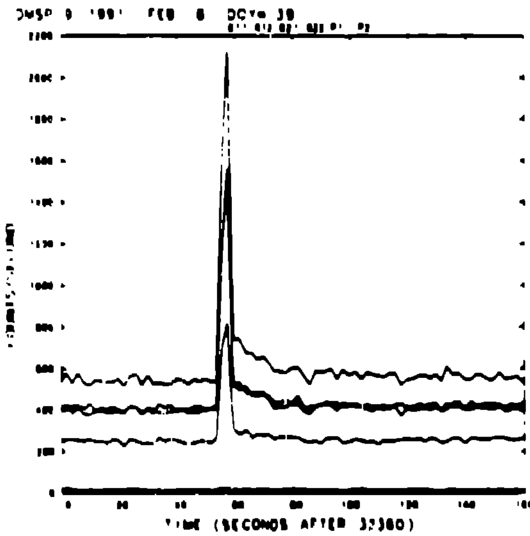

Fig. 3: DMSP 9 data for 2/8/91.

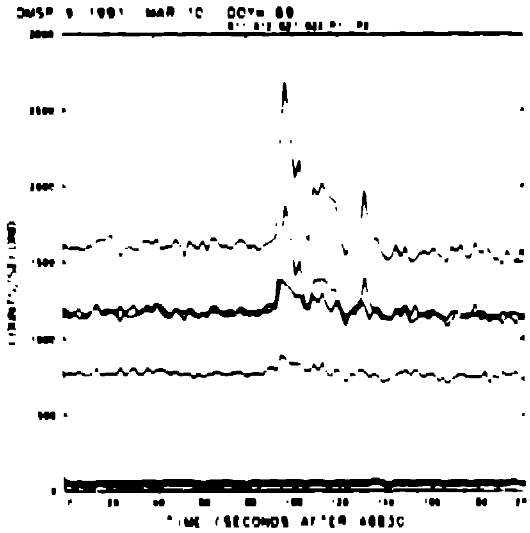

Fig. 4: DMSP 9 data for 3/10/91.

show three peaks extending over 40 seconds. The first peak occurred at 46923.2, 46924.9, or 46925.7 sec UT, according to Flights 8, 9, and 10, respectively. Two of the spacecraft were at positions within 90° of the source direction (Granat GRS1217+066, IAU Circular 5207, 3/13/91), and had the burst in full view. The third satellite was 109° away on the other side of the earth, but was high enough (800 km) to see the burst over the limb of the earth; these DMSP flights can view sources up to 115° from the zenith.

On 12 March another gamma-ray burst was seen by two DMSP flights. The data from DMSP 10 displayed in Figure 5 are for energy ranges 20-1000, 200-1000, and 550-1000 keV. This burst also had three main peaks in its counting rate, and lasted for 80 sec. The first peak occurred at 45793.8 sec UT, from DMSP 10 data, or at 45791.3 sec UT according to DMSP 8. This burst was also detected by PVO at 45652 sec UT, 140 sec earlier, and may have been of solar origin.

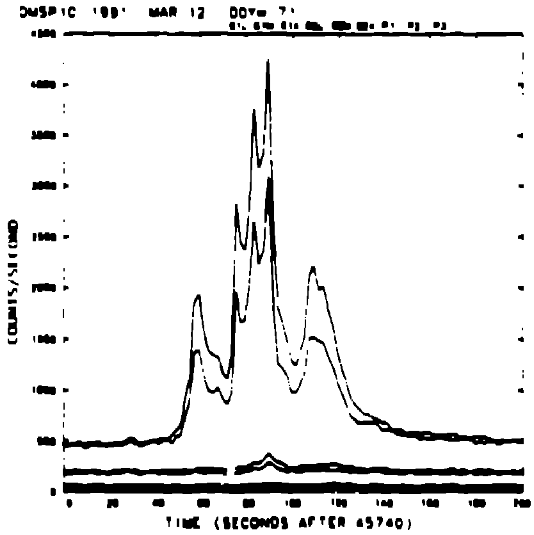

Fig. 5: DMSP 10 data for 3/12/91.

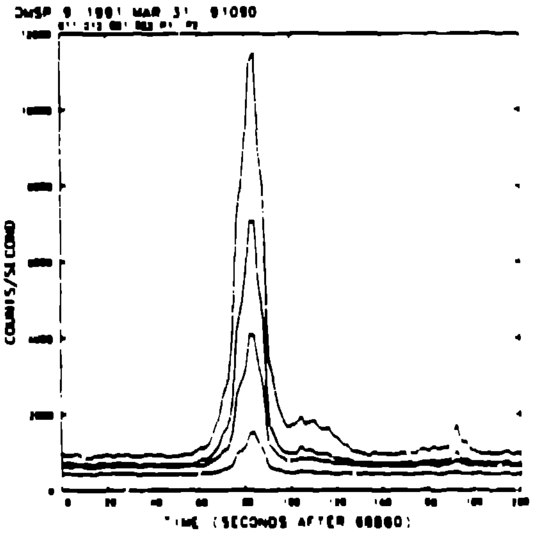

Fig. 6: DMSP 9 data for 3/31/91.

On 31 March a strong gamma-ray burst was seen by two DMSP satellites, as seen in Figure 6. The data from DMSP 9 show the peak rate at 68942.4 sec UT, followed by a long softer tail, with a final soft burst at 69030.4 sec UT. DMSP 8 data gave an essentially identical initial peak time of 68942.5 sec UT.

Another gamma-ray burst was detected on 3 May 1991 by two DMSP satellites, as well as by Ulysses and by Comptel on GRO, in orbit by this time. The data from DMSP 8 (Figure 7) cover the energy ranges from 50, 100, 200, and 420 keV to 1000 keV. The peak time was 25454.2 (DMSP 8) or 25453.7 sec UT (DMSP 9), in agreement with the GRO trigger time of 25455 sec UT (IAU Circular 5369, 10/16/91; l=171°, b=7°). This strong burst was followed by a delayed weaker burst 46 sec later, at 25500.2 (DMSP 8) or 25499.7 sec UT (DMSP 9).

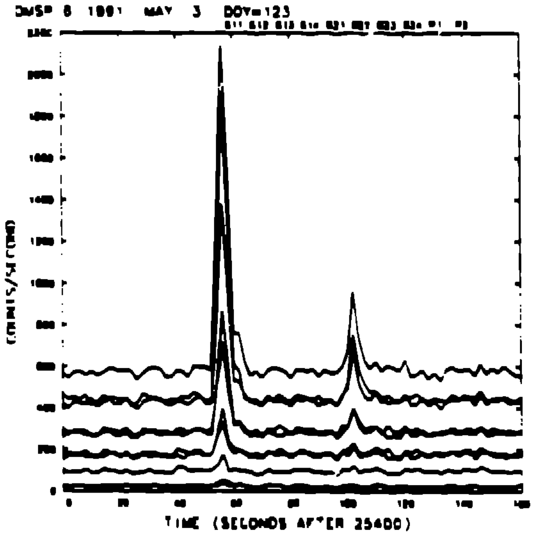

Fig. 7: DMSP 8 data for 5/3/91.

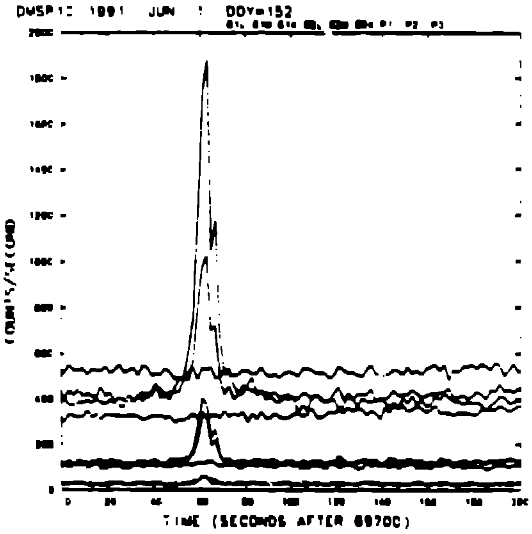

Fig. 8: DMSP 10 data for 6/1/91.

On 1 June another gamma-ray burst was detected by two DMSP flights (Figure 8), as well as by GRO (IAU Circular 5369, 10/16/91; ℓ=72.5°, b=-5°). The burst peaked at 69756.1 or 69757.6 sec UT, from data of DMSP 9 and DMSP 10 (the GRO trigger time was 69736 sec UT, perhaps due to a weak precursor).

A gamma-ray burst with a complex time history was detected on 3 August by all three DMSP satellites. The data from DMSP 9 are shown (Figure 9). The initial peak in counting rate occurred at 4918.9, 4919.9, or 4920.6 sec UT, based on the data from DMSP Flights 8, 9, and 10.

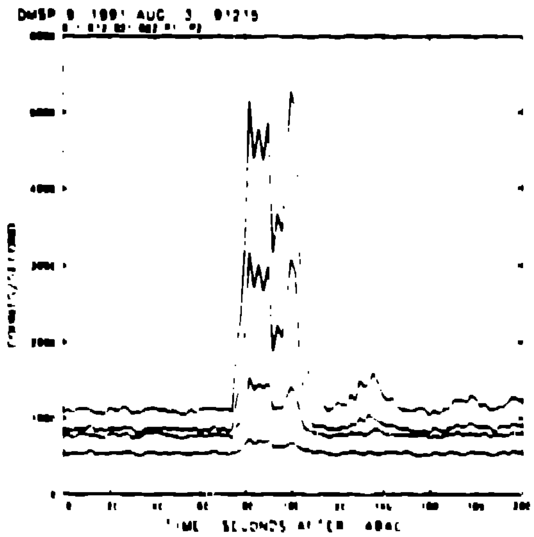

Fig. 9: DMSP 9 data for 8/3/91.

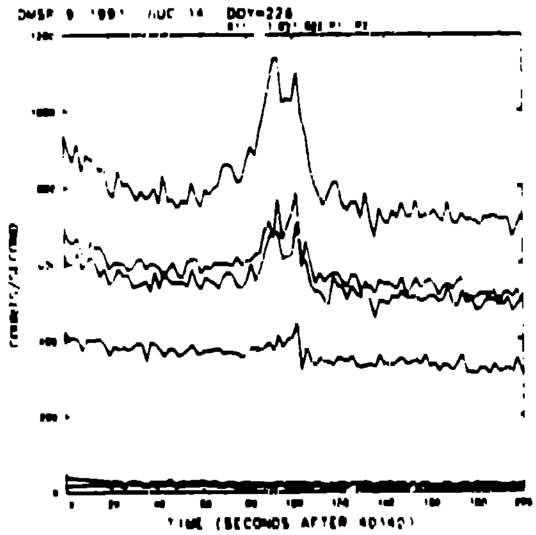

Fig. 10: DMSP 9 data for 8/14/91.

Finally, two DMSP satellites detected a double-peaked burst on 14 August 1991 (Figure 10). The peaks occurred at 40231.5 and 40239.5 sec UT, based on DMSP 9 data, or at 40232.1 and 40240.1 sec UT, from DMSP 10. In this case, as in many cases, the third satellite was passing through the radiation belt and gave no useful data at the burst time.

DISCUSSION

These examples do not, of course, comprise the entire list of gamma-ray bursts detected by the DMSP spacecraft. Only strong bursts detected by two or three flights in 1991 have been shown. Comparison with data from other satellites will doubtless lead to confirmation of other apparent bursts detected by one DMSP satellite. The data now coming in from three DMSP birds will be of value in determining time histories and spectra of numerous gamma-ray bursts.

Although these data have only 2-sec time resolution, they will also be of value in determining source locations. When two or three of these satellites detect the same burst, the peak times may be determined with better precision. Furthermore, we hope that better time resolution based on event triggers will become available in the future. DMSP satellites now in orbit have given us important additions to the current long-baseline space network. Their data will improve detection efficiency (since the near-earth satellites are all subject to obscuration and radiation problems), and should allow better understanding of the locations and nature of the still-mysterious gamma-ray bursts.

Added Note: The next satellite in this series, DMSP 11, was launched on 28 November 1991.

This work was supported by the U.S. Department of Energy and by the U.S. Department of Defense.