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The Night Eye in the Sky

The Defense Meteorological Satellite Program's low-light sensor images city lights, auroral displays, volcanoes, oil and gas fields, and forest fires.

A DATA SYSTEM employed by the Department of Defense and the United States Air Force's Air Weather Service was made public in 1973. This system became widely known as the Data Acquisition and Processing Program (DAPP) but its name was changed to Defense Meteorological Satellite Program (DMSP) effective 13 December 1973 (Meyer, 1972). Images captured by the low-light sensor in this system are discussed in this article. These nighttime images in the visible and near-infrared not only have enhanced operational meteorological support but also provide a promising new research tool with potential civilian (as well as military) applications.

NIGHTTIME IMAGERY

The accompanying illustrations provide graphic examples of nighttime images taken near local midnight in different areas of the world (Brandli, 1974). City lights, auroral displays, volcanoes, oil and gas fields, and forest fires are some of the phenomena detected by one of the radiometric sensors of the DMSP. This 4.0 km resolution radiometer of the DMSP system "sees" in the spectral interval from 0.4 to 1.1 micrometers. The newest satellites—since 1976—have a resolution of 3.0 km or better. Therefore, the information displayed in the images provides an added bonus in that important subvisual and supervisual events occurring below the satellite are detected in addition to those detected in the visual range (0.5 to 0.7 micrometers). With this sun-synchronous satellite system, nighttime coverage of the same location usually can be achieved twice each night. These DMSP satellites record imagery at a map scale of 1:7,500,000 or 1:15,000,000 from a viewing platform 900 km high.

AURORA BOREALIS

One such "bird's-eye view" shows the lights of many North American cities and the aurora borealis or northern lights (Figure 1). The mapping and study of this important space phenomenon have been a challenge since first observed from the ground. Now this mapping and research can be done routinely by a system already in being (Brandli, 1974). Such broad-scale depictions of the aurora are a first by DMSP. As mentioned earlier, the human eye senses only energy in the spectral interval from 0.5 to 0.7 micrometers whereas the low-light sensor of the DMSP records energy emissions out to 1.1 micrometers. Since important emission lines of the aurora extend out to 1.08 micrometers, the broader spectral interval cap-

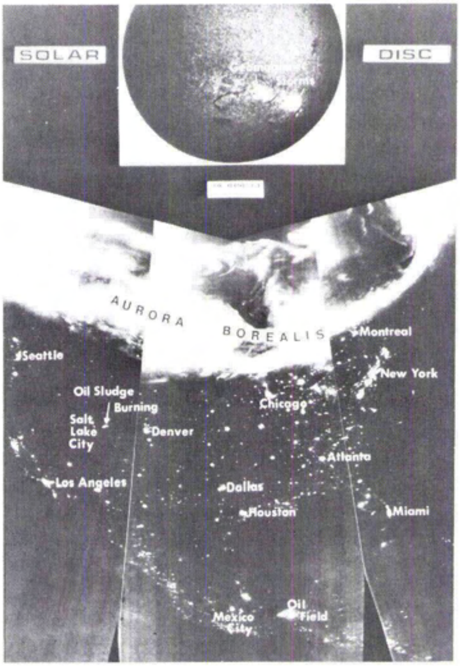

FIG. 1 DMSP nighttime imagery (18 April 1974). Above the 4-km resolution imagery is a photo of the sun taken by the Air Force Solar Observatory in Puerto Rico on 14 April 1974. The storm on the sun intensified the Aurora activity.

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tured by the DMSP results in the very bright scene displayed on the imagery. That is, the sensor has processed the emissions from a wider viewing band and presented it to our eyes as a very intense auroral display.

The Energy Crisis

The world energy crisis suggests yet another use for DMSP data. Further examination of Figure 1 shows the brightness (i.e., intensity) of the illumination from all major and minor cities in North America. The large cities forming the megalopolis of the northeast, Chicago along the shore of Lake Michigan, and the far western population centers of Los Angeles and San Francisco all are shown under no-moonlight conditions. Miami and the "Gold Coast" of southern Florida are equally bright. During our present energy crisis, the DMSP nighttime low-light sensor could monitor city light intensities. According to 1970 General Electric surveys, direct energy consumption from lighting accounts for about 20 percent of the country's electric power consumption or between three and five percent of the total energy consumption (Today, 1974). In some of the larger cities, consumption is even higher. New York City's Consolidated Edison reports that 40 percent of its power goes for lighting.

City Lights Location

Geographical location and gridding of real-time meteorological satellite systems of the Department of Defense, the National Oceanic and Atmospheric Administration, and the National Aeronautics and Space Administration comprise a difficult task. The importance of putting latitude and longitude lines on satellite imagery cannot be stressed enough, yet difficulties do exist in computer mapping. At this stage of development, without sufficient human quality control, great errors in computer gridding can occur. If a photo is not gridded properly, the location of all information derived from it is unreliable. (Brandli and Munson, 1974). Figure 1 presents no problems in geographical interpretation to a human observer. However, another tactic for solving the difficult gridding problem presents itself here with the storage in a computer of this city light location and intensity much like a stellar background used for space navigation. In this manner, the simultaneous, three-dimensional, nighttime infrared imagery could be accurately gridded; also, spurious lighting could be studied for other physical events such as forest fires.

Fires

The United States and Canada spend untold numbers of dollars for forest fire detection in remote areas of North America. The low-moonlight DMSP sensor, as well as other sensors of the DMSP system such as the 0.62 km resolution infrared 8-13 micrometers radiometer, could be of great assistance in locating forest fires (Brandli and Reinke, 1977). The normal DMSP configuration, in which two operational satellites produce imagery over a particular area every six hours, is certainly capable of performing such a task. A computer-stored city illumination map, as mentioned earlier, could aid in the location of new forest fires by sounding an alarm when a "light" cannot be identified. It must be noted, however, that not all spurious light sources are forest fires.

Oil Fields or Energy Source

Figure 2 is a nighttime image without moonlight over Southern Europe and Northern Africa. The well-lighted African oil fields can be readily detected near the bottom of the photograph. Short, black lines parallel to the satellite radiometer scan lines are seen adjacent to these oil field fires (Dickinson *et al.*, 1974). The black lines appear to originate at the brightest source of light. This sensor or atmospheric phenomenon will be discussed in the next section.

Volcanoes

Figure 3 imagery was taken over the Hawaiian Islands in the central Pacific before a new-moon phase. The bright "light" with the haloed rings around it is the erupt-

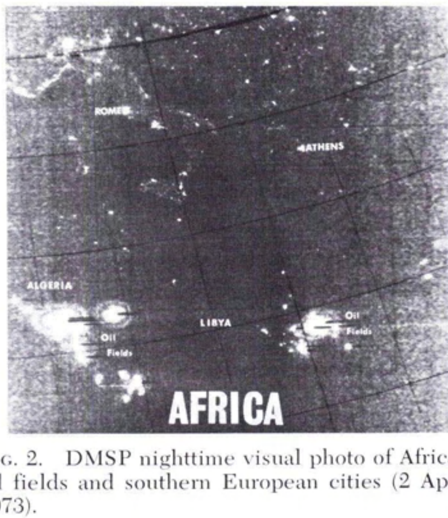

Fig. 2. DMSP nighttime visual photo of African oil fields and southern European cities (2 April 1973).

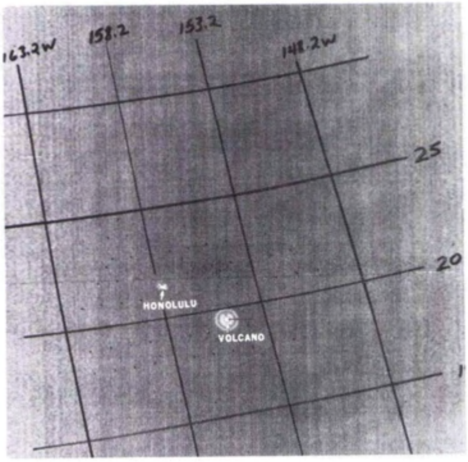

FIG. 3. No moonlight view of the lights of Oahu and of Kilauea Volcano (28 December 1970).

ing volcano of Kilauea. This ringed pattern could be a halo formed by ice crystal clouds, volcanic smoke particles, or even an out-of-focus mirror in the radiometric sensor. The geometry of this halo is similar to the rings occasionally seen from earth around the sun or moon caused by ice-crystal cirrus clouds. These ringed patterns are also seen around oil and gas fields, except over the United States and other industrial nations where the oil and gas fields are generally capped. The black line is a sensor oversaturation line. The line is to the right because as the spacecraft moves southward during this picture, the sensor is scanning from the spacecraft's right to left side. Volcanic eruptions, both explosive and effusive, can easily be seen in remote areas with this nighttime visual and near-infrared sensor. On the island of Oahu, Honolulu and Waikiki Beach stand out as the large elongated bright spot on the photo. A careful check of current events is important for the DMSP analyst, lest bright apparitions such as nuclear explosions escape his examination of the images.

LIGHTNING AND NUCLEAR TESTS

Any other birght spot on the nighttime images not accounted for could be caused by nuclear tests, missile launches, nose cone re-entry, electrical storms, etc. Lightning activity in intense storm areas is clearly captured on these brief views of the earth by the DMSP sensors.

The aurora, city light intensity, nighttime gridding, forest fire, lightning, volcanoes, and oil and gas fields are only a few of the many spectacular intelligence yields available from the low-light visible sensor of the Defense Meteorological Satellite Program. Other sensor applications, particularly in the field of meteorology, will no doubt be presented in many scientific journals and symposiums in the near future. Perhaps the knowledge of this unique system and some of the applications presented here will stimulate the reader to think of other uses for the DMSP.

DMSP DATA AVAILABILITY

DMSP data can be purchased from the Space Science and Engineering Center, University of Wisconsin, 1225 West Dayton Street, Madison, Wisconsin 57306. (Telephone: 608-262-5335.) Prints, slides, or negatives can be purchased from $2.00 to $6.00 per item.

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