Defense Meteorological Satellite Program (DMSP)

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DMSP

The Defense Meteorological Satellite Program(DMSP) is a Department of Defense(DoD) program run by the Air Force Space and Missle Systems Center(SMC). The DMSP program designs, builds, launches, and maintains several near polar orbiting, sun synchronous satellites monitoring the meteorological, oceanographic, and solar-terrestrial physics environments.

DMSP satellites are in a near polar orbiting, sun synchronous orbit at an altitude of approximately 830 Km above the earth. Each satellite crosses any point on the earth twice a day and has an orbital period of about 101 minutes thus providing complete global coverage of clouds every six hours.

Each DMSP satellite monitors the atmospheric, oceanographic and solar-geophysical environment of the Earth. The visible and infrared sensors collect images of global cloud distribution across a 3,000 km swath during both daytime and nighttime conditions. The coverage of the microwave imager and sounders are one-half the visible and infrared sensors coverage, thus they cover the polar regions above 60 on a twice daily basis but the equatorial region on a daily basis. The space environmental sensors record along track plasma densities, velocities, composition and drifts.

The data from the DMSP satellites are recieved and used at operational centers on a continual basis. The data are sent daily to the National Geophysical Data Center(NGDC), Solar Terrestrial Physics Division(STPD) for creation of an archive.

1.1 SSM/I DESCRIPTION

The SSM/I is a seven-channel, four frequency, linearly-polarized, passive microwave radiometric system which measures atmospheric, ocean and terrain microwave brightness temperatures at 19.35, 22.235, 37.0 and 85.5 GHz. The data are used to obtain synoptic maps of critical atmospheric, oceanographic and selected land parameters on a global scale. The SSM/I archive data set consists of antenna temperatures recorded across a 1,400 km conical scan, satellite ephemeris, earth surface positions for each pixel and instrument calibration. Electromagnetic radiation is polarized by the ambient electric field, scattered by the atmosphere and the Earth's surface and scattered and absorbed by atmospheric water vapor, oxygen, liquid water and ice.

INSTRUMENT DESCRIPTION:

The SSM/I instrument consists of an offset parabolic reflector that is 24 x 26 inches fed by a seven- port horn antenna. The reflector and feed are mounted on a drum which contains the radiometers, digital data subsystem, mechanical scanning subsystem and power subsystem. The drum assembly rotates about the axis of the drum. A small mirror and a hot reference absorber are mounted on the assembly.

The instrument sweeps a 450 cone around the satellite velocity vector so that the Earth incidence angle is always 540. Data are recorded during the 102.40 of the cone when the antenna beam intercepts the Earth's surface. The channel footprint varies with channel energy, position in the scan, along scan or along track direction and altitude of the satellite. The 85 GHz footprint is the smallest with a 13 x 15 km and the 19 GHz footprint is the largest at 43 x 69 km. Because the 85 GHz footprint is so small, it is sampled twice as often, i.e., 128 times a scan. One data cycle consists of 4 85 GHz scans and 2 scans of the 19, 22 and 37 GHz channels. The complete cycle takes 28 seconds and it must be complete to process the data.

DMSP satellites are in a sun-synchronous, low altitude polar orbit. The orbital period is 101 minutes and the nominal altitude is 830 km.

PROCESSING:

The SSM/I processor is queried once a second by onboard computer and the data are placed into the "TS SSP" data field. Data stored on recorders are down linked to Thule AFB once an orbit, sent to Air Force Global Weather Central (AFGWC) via communications satellite, written to 8 mm tapes by the ARchive Processing System (ARPS) and sent to the National Geophysical Data Center (NGDC) on a daily basis. At NGDC, the "TS SSP" data are decommutated, deinterleaved, bit flipped, reordered and restructured into orbits beginning with the equatorial crossing as the satellite travels from south to north. Satellite ephemeris are computed using a physically-based, orbital mechanics model. SSM/I pixels are geolocated using the satellite ephemeris and satellite attitude corrections. Antenna temperatures are computed from instrumental counts by a linear equation, i.e., the conversion is reversible.

In the decommutation step, we encountered bit reversals that occurred 1.8 - 3.4% of the time and are probably caused by ionospheric scintillation. These are identified through careful checking procedures and corrected. Archive tapes contain an automated format statement, an orbital inventory, metadata by orbit and geolocated antenna temperatures. A typical tape contains 8 days of data from two satellites.

APPLICATIONS:

SSM/I data are used to derive geophysical parameters; notably, ocean surface wind speed, area covered by ice, age of ice, ice edge, precipitation over land, cloud liquid water, integrated water vapor, precipitation over water, soil moisture, land surface temperature, snow cover and sea surface temperature. Most current methods use statistical algorithms which mean or difference channel brightness temperatures [Hollinger et al., 1989]. Brightness temperatures are computed from antenna temperatures using the published antenna pattern correction which includes dynamic adjustments for antenna side lobe, antenna efficiencies and neighboring pixel contributions. Future methods will be physically based using data from all atmospheric sensors on DMSP satellites, i.e., SSM/I, OLS, SSM/T and SSM/T-2.

1.2 SSM/T2 DESCRIPTION

The SSM/T-2 sensor is a five channel, total power microwave radiometer with three channels situated symmetrically about the 183.31 GHz water vapor resonance line and two window channels. This instrument was flown on all DMSP Block 5D-2 satellites starting with F11 launched in 1991. SSM/T-2 is designed to provide global monitoring of the concentration of water vapor in the atmosphere under all sky conditions by taking advantage of the reduced sensitivity of the microwave region to cloud attenuation.

INSTRUMENT DESCRIPTION:

The SSM/T-2 is a cross-track scanning, five channel, passive total power microwave radiometer system which consists of a single, self-contained module with a step-scan motion in the cross-track direction of +/- 40.5 degrees. The SSM/T-2 scan mechanism is synchronized with the SSM/T-1 so that the beam cell patterns of the two sensor coincide. The SSM/T-2 observation rate is 7.5 scans per minute. There are 28 observations (beam positions) per scan for each of the five channels, with each observation having a spatial resolution of approximately 48 km. All five channels have coincident centers. The total swath width for the SSM/T-2 is approximately 1500 km.

The SSM/T-2 employs a single offset parabolic reflector with a 2.6 inch diameter projected aperature. The reflector is shrouded to eliminate the possiblity of rays from the sun striking either of the calibration paths and causing unwanted thermal gradients. The feedhorn is a corrugated pyramidal horn with a flare designed to minimize phase center seperation over the bandwith (91 to 183.3 GHz), while providing a spherical wave illumination of the reflector. To achieve the cross-track scanning, the reflector alone rotates. The rotation of the reflector produces a rotation of the plane of polarization of the upwelling scene TBs which is permitted provided that the polarization remains identical for the two window channels and 183.3 +/- 7 GHz. These channels must have the same polarization characteristics because they measure contributions from both the atmosphere and the surface. Note that all SSM/T-2 channels possess the same polarization.

During each scan period, and for all five channels at twenty-eight discrete earth viewing positions, four discrete calibration measurements of a hot-load target (~300K), and cosmic background radiation (~3K) are monitored.

The SSM/T-2 inflight warm-load calibration target is a derivative of the SSM/T-2 warm load calibration target. The warm load (~300 K) is shrouded to improve radio frequency (RF) coupling of energy to the reflector/feedhorn antenna. This minimizes potential calibration errors arising from the reception of extraneous energy due to scattering of earth or solar radiation off of the spacecraft. The cold path is a cylindrical oversized waveguide tube which permits a direct view of the cosmic background (~3 K) by the antenna reflector during calibration.

The periodic calibration data are modeled by a linear transfer function to characterize the state of the total power radiometer and remove time variations of the receiver gain and offset for frequencies less than half the reciprocal of the calibration period. As a consequence relatively large temperature related receiver gain drifts are taken into account in the periodic construction of the transfer function. The minimal detectable temperature difference is 0.45 K. The SSM/T-2 employs a calibration period of 8 seconds in which four samples are taken of a warm-load calibration target along with four samples of the cosmic background.

PROCESSING:

Processing of imagery in support of DOD operations and scientific research occurs onboard the satellite, at Air Force Global Weather Central (AFGWC) and at the National Geophysical Data Center (NGDC). Satellite telemetry are down linked to Thule AFB and transmitted to AFGWC via communications satellite.

APPLICATIONS:

The imaging of SSM/T-2 data offers a new perspective on the atmosphere that complements other remotely sensed datasets. Conlee (1995, Texas A&M Dissertation) shows that major mid-latitude weather phenomena such as fronts and extratropical cyclones have excellent signatures in SSM/T-2 data, including three-dimensional structure. Other phenomena such as as tropical cyclones, tropical plumes, subtropical anticyclones and surface states such as sea ice and snow cover may be identified.

Applications other than profiling are possible with the SSM/T-2. The retrieval of vertically integrated water vapor is also possible due to the strong sensitivity of the 183.31 Ghz water vapor absorption line.
