CHAPTER 3

OTHER OBSERVATIONS

3.1 General. In addition to aerial reconnaissance data, the observational systems used in support of the *National Winter Storms Operations Plan* include land surface, ship, radar, buoy, upper air, and satellite data. The routine operations of these various data sources are detailed in the following Federal Meteorological Handbooks and plans:

- Federal Meteorological Handbook No. 1, *Surface Weather Observations and Reports*
- Federal Meteorological Handbook No. 2, *Surface Synoptic Codes*
- Federal Meteorological Handbook No. 3, *Rawinsonde and Pibal Observations*
- Federal Meteorological Handbook No. 11, *Doppler Radar (Parts A, B, C, and D)*
- *Operations of the National Weather Service*
- *Federal Plan for Environmental Data Buoys*
- The *GOES User's Guide* and operational amendments
- *The NOAA Polar Orbiter Data Users Guide*
- *National Operations Plan for Drifting Data Buoys*
- *The Coastal Marine Automated Network (C-MAN) NWS Users Guide*
- *Tide/Water Level Information Data and Evaluation System (TIDES) NWS Users Guide*

Procedures for obtaining special or non-routine observations required in support of winter storm detection and forecasting, while covered to some extent in these documents, are described in detail in *National Weather Service Operations Manual*, Chapter B-90, "Special Warning Program Observations." The chapter covers observational programs of several agencies involved. The only two observational programs that will be covered in any detail here are the two data sources that provide unique capabilities to support winter storm analysis and forecasting.

3.2 Satellite Observations.

3.2.1 Department of Commerce (DOC), National Oceanic and Atmospheric Administration (NOAA), National Environmental Satellite, Data, and Information Service (NESDIS).

3.2.1.1 Geostationary Operational Environmental Satellite (GOES). Using modern 3-axis stabilization for orbit control, GOES-12 at 75°W and GOES-10 at 135°W support the operational two-GOES constellation. Independent imager and sounder instruments eliminate the need to time share, yielding an increase in spatial coverage of image and sounder data at more frequent scanning intervals. The GOES also provides higher resolution and additional spectral channels than its predecessor, affording the hydrometeorological community improvements in detection, monitoring, and analysis of winter storms. From 135° W and 75° W, routine GOES satellite data coverage is extensive, stretching from the central Pacific through the Americas to the eastern Atlantic.

Routinely, each GOES schedule provides two views of the CONUS (GOES-10 view is termed PACUS) every 30 minutes. More frequent interval scans can be employed to support NOAA's warning programs, including the tracking of winter storms. Government agencies and the private sector have access to digital data transmissions directly from NOAAPORT or directly from GOES.

The current series of GOES satellites provide satellite data generated from full resolution, and imager and sounder data. Imagery at 1, 4, and 8 km resolution is available for daytime and nighttime applications. The increased resolution of the satellite imagery is a vast improvement from previous satellites. Visible data are available at 1 km resolution, "near infrared" (channel 2 data) as well as the infrared channels 4 and 5 on GOES-10 are available at 4 km resolution, and water vapor (channel 3) is available at 8 km resolution on GOES-10 and 4 km on GOES-12. Channel 2 data are valuable for the detection of low clouds, fog, stratus, and surface hot spots; channel 5 data available on GOES-10, in combination with data from channels 2 and/or 4, are useful for detecting volcanic ash in the atmosphere. On GOES-12, channel 5 is replaced by a new 13.3F channel 6 that detects the presence of CO_2. Channel 6 improves the measurement of the height of clouds and volcanic ash, thus improving computer model forecasts and ash warnings to the aviation community. The digital data may be enhanced to emphasize different features as desired. A suite of digital data and products is available to users in the National Weather Service (NWS), the National Environmental Satellite, Data, and Information Service (NESDIS), other Federal agencies, the academic community, and many private agencies, both national and international. These data are made available through NOAAPORT, McIDAS, the Internet, and other means such as local networks.

3.2.1.1.1 GOES-12. GOES-12, launched July 23, 2001, supports the GOES-East station at 75°W, serves NOAA operations including the HPC, WFOs, other Federal agencies, and the private sector. Various imager channels at higher resolutions are being utilized to monitor the intensification and movement winter storms. Retrievals from the GOES sounder are incorporated into NCEP's numerical models to improve model output. In addition, sounder data are being exploited to generate derived- product imagery; such as, total precipitable water, atmospheric stability indices, and surface and cloud temperatures.

3.2.1.1.2 GOES-9. GOES-9, launched May 2, 1995, was replaced by GOES-10 as the operational satellite located at 135EW due to an imminent failure of GOES-9. While some momentum wheel problems exist on GOES-9, it remains capable of performing operations. GOES-9 replaced the Japanese Meteorological Agency's (JMA) GMS-5 over the west Pacific in mid-2003. The GMS-5 satellite has outlived its designed lifetime and has no fuel on board to maintain its inclination. JMA and NESDIS agreed to replace GMS-5 with GOES-9 to continue imagery over the Pacific Ocean as well as eastern Asia, Japan, and Australia. This will be the first time sounder data from GOES is captured over much of the Pacific Ocean.

3.2.1.1.3 GOES-10. GOES-10, a clone of GOES-8, was launched on April 24, 1997, and supports the GOES-West station at 135EW. The spacecraft carries the same specified imager and sounder instruments as GOES-8 and GOES-9. GOES-10 was declared operational in July 1998 and was moved to 135EW. The routine scanning mode of GOES-10 provides coverage of the Northern and Southern Hemisphere eastern Pacific Ocean as well as the western United States. The GOES-West satellite also supports the missions of the HPC and WFOs, providing coverage of developing winter storms in the from the developing from the Pacific. The DOD and other Federal agencies are also supported.

3.2.1.1.4 GOES-11. GOES-11 was launched on May 3, 2000. GOES-11 is also a clone of GOES-8 and carries the same imager and instrumentation capabilities as GOES-8 and GOES-10. GOES-11 is stored on orbit until required to replace either of the operational satellites.

3.2.1.1.5 GOES-8. GOES-8 was launched on April 13, 1994. GOES-8 is similar to GOES-9 through GOES-11 and is stored on orbit close to GOES-9 to support the west Pacific Ocean coverage should GOES-9 fail.

3.2.1.1.6 GOES Scan Operations. The spacecraft routinely scans the United States every 15 minutes. A full disk image is scanned every 3 hours and takes nearly 30 minutes to complete. Forecasters view digital GOES data more frequently and with greater spatial resolution. The digital data provide the user with the flexibility to customize gridding and enhancement curves for the data. The GOES spacecraft were also designed for flexible scanning of the earth. Any variation of scan or sector coverage at regular time intervals can be scheduled in a 30-minute time frame. Rapid Scan Operations (RSO) and Super-Rapid Scan Operations (SRSO) are available on the current generation of satellites. RSO and SRSO allow for small sections of the earth to be scanned more frequently, at up to 1-minute intervals; however, by doing so, other portions of the earth are scanned with less regularity. Definitions of the GOES RSO and SRSO scanning coverage and scanning times can be found at *www.ssd.noaa.gov*, then "click on" GOES Satellite Operations, or go directly to *www.ssd.noaa.gov/PS/SATS/index.html*.

3.2.1.1.7 Requests for Special Satellite Sectors. Special RSO and SRSO GOES data on critical severe storm days may be requested via the NCEP Senior Duty Meteorologist (SDM). The SDM will coordinate operational requests through the NESDIS Satellite Services Division (SSD), Satellite Analysis Branch (SAB). The details of these procedures are described in the NESDIS/NWS Satellite Schedule Coordination and Dissemination Procedures Plan, which is available on the SSD web site (*www.ssd.noaa.gov/PS/SATS/satops/*) for National Weather Services users and selected other users such as CIRA.

3.2.1.1.8 GOES Imager and Sounder. GOES-10 and GOES-12 host an imager capable of detecting atmospheric temperature and moisture measurements in five spectral bands at high resolutions, including the new 3.9Fand 12.0F (GOES-10) and 13.3F (GOES-12) wavelengths. GOES-10 and GOES-12 also have the feature of transmitting these five spectral bands simultaneously, affording the user community continuous views of atmospheric measurements in various wavelengths, each with its own meteorological and hydrological applications. The five channels and respective resolutions are as follows:

- Channel 1 (Visible, 0.55 to 0.75 microns) - 1 kilometer resolution
- Channel 2 (Infrared, 3.8 to 4.0 microns) - 4 kilometer resolution
- Channel 3 (Water vapor, 6.5 to 7.0 microns) - 8 kilometer (GOES-10), 4 kilometer (GOES-12)
- Channel 4 (Infrared, 10.2 to 11.2 microns) - 4 kilometer resolution
- Channel 5 (Infrared, 11.5 to 12.5 microns) - 4 kilometer (GOES-10 only)
- Channel 6 (Infrared, 13.0 to 13.7 microns) - 4 kilometer (GOES-12 only)

The sounder on GOES-10 and GOES-12, consisting of 19 spectral channels, is used for measurements of atmospheric temperature and moisture profiles, surface and cloud-top temperature, and ozone distribution. Products derived from the sounder include precipitable water and the lifted index--a measure of atmospheric instability. Comparable to the imager, the sounder is capable of providing various scan coverages, such as full earth imagery, sectorized imagery, and local imagery. An independent sounder platform, governed under its own schedule, provides an expansion of sounder data coverage and an increase in the frequency of transmissions. GOES-10 and GOES-12 also carry vital subsystems; such as, the SEM, DCS, WEFAX, and SAR operations.

3.2.1.1.9 GOES Products. Under the NESDIS support concept, satellite imagery, in support of the National Winter Storms Operations Plan, is distributed by the Environmental Satellite Distribution/Interactive Processing Center in Camp Springs, Maryland, to the national centers (NCEP), NWS Weather Forecast Field Offices (WFO), and to the Satellite Analysis Branch (SAB) and other NESDIS units. Data from the polar-orbiting satellites is available to SAB and the NCEP national centers, but not to NWS field sites.

NESDIS operates 24 hours a day to provide a myriad of satellite services and products to NCEP and NWS field sites. Internally at the NOAA Science Center, SAB meteorologists provide satellite interpretation and analyses to NCEP meteorologists, relating valuable information on present locations and intensities of winter storms, as well as the projected movement and development of these storms. In addition, snowfall estimates are derived from satellite signatures and reported to NCEP and the WFOs to assist forecasters in determining fall rates and projected accumulations. As conditions warrant, winter storm precipitation analyses and estimates are disseminated to the appropriate WFOs and River Forecast Centers (RFC) across the United States.

All WFOs have access to the digital GOES data stream through AWIPS workstations. The satellite data feed to AWIPS/NOAAPORT is performed at the Satellite Central Data Distribution Facility in Camp Springs, MD. A large amount of satellite data are also available on a number of web site servers, both government operated and in the private sector.

The principal GOES-10 and GOES-12 products (see Table 3-1) are half-hourly pictures with navigation and calibration files included. During daylight hours, 1, 2, 4, and 8 kilometer resolution visible fixed standard sectors are produced for AWIPS/NOAAPORT distribution. Equivalent infrared sectors (4 kilometer), including water vapor (4 or 8 kilometer), for all available channels are available 24 hours a day. Satellite raw and remapped imagery, with navigation and calibration, is available to McIDAS users within the NWS and NESDIS community. Using the 3.9F and 10.7F channels together, a low-level cloud/fog product is produced, which the WFOs now use routinely.

3.2.1.2 24-Hour Points of Contact.

- NCEP/NCO Senior Duty Forecaster (SDM)--301-763-8298
- NCEP/HPC Senior Branch Forecaster--301-763-8201
- NESDIS/SAB--301-763-8444

3.2.1.3 NOAA Polar-Orbiting Satellites. Two primary operational NOAA polar-orbiting satellites, NOAA-16 and NOAA-17, provide image coverage four times a day over a respective area in 6 spectral channels (only supports 5 channels at one time, with channel switching to support the 6th channel on NOAA-17). These satellites cross the U.S. twice per day at 12-hour intervals for each geographical area near the Equatorial crossing times listed in Table 3-1. NOAA-16 and NOAA-17 provide the same capabilities as previous NOAA satellites, except for the addition of an Advanced Microwave Sounder Unit (AMSU). Data are available via direct readout--high resolution picture transmission (HRPT) or automatic picture transmission (APT)--or central processing. The Air Force Weather Agency (AFWA), Offutt AFB, NE, receives global NOAA imagery data direct from central readout sites on a pass-by-pass basis. The Command and Data Acquisition (CDA) stations at Fairbanks, AL, and Wallops, VA, acquire recorded global area coverage data, and then route the data to NESDIS computer facilities in Suitland, MD, where the data are processed and distributed to the NOAA, the DOD, and private communities.

3.2.1.3.1 NOAA-15. NOAA-15 is used as a backup satellite. While NOAA-15 continues to provide continuous imagery and products, their use is secondary to the operational uses of NOAA-16 and NOAA-17 imagery and products. Also, some users continued to need NOAA-15 data after NOAA-17 became operational. These data include sounder-based derived products like rain rate and total precipitable water.

3.2.1.3.2 NOAA-16. NOAA-16 was launched on September 21, 2000, and is in full operational use with the same capabilities as NOAA-15.

3.2.1.3.3 NOAA-17. NOAA-17, launched June 24, 2002, is in full operational use with the same capabilities as NOAA-15 and NOAA-16.

3.2.2 Department of Defense (DOD) Defense Meteorological Satellite Program (DMSP). The DMSP constellation consists of at least two spacecraft placed in sun-synchronous orbits best suited to support military operations. In addition to the very high resolution visible and infrared imagery, DMSP provides a variety of remotely sensed terrestrial and space environmental data. A suite of microwave radiometers provides microwave imagery as well as surface characteristics and upper air temperature and moisture soundings. The DMSP data capabilities in the area of concern are provided in Table 3-1. Special requests for DMSP support will be addressed to CARCAH.

Table 3-1. Satellites and Satellite Data Availability for the National Winter Storms Operations Plan.

Geosynchronous Orbit

SATELLITE	TYPE OF DATA	LOCAL TIME	REMARKS
GOES-12 at 75EW GOES-10 at 135EW GOES-11 at 108EW (on orbit storage for GOES-10 or GOES-12) GOES-9 at 165EE (supporting JMA) GOES-8 at 155EE (on orbit storage for GOES-9)	Multispectral Imager and Sounder 5 channels for the Imager 19 channels for the Sounder	Every 30 minutes, in Routine Scan Mode, provides 3 sectors with prescribed coverages: Northern Hemisphere (NH) or Extended NH, CONUS or PACUS, and Southern Hemisphere (SH). Exception is transmission of a full disk every 3 hours. Available Rapid Scan Operations (RSO) yield increased transmissions to 7.5 minute intervals to capture rapidly changing, dynamic weather events.	1. 1, 2, 4, and 8 km visible standard sectors. 2. 4 km equivalent resolution IR sectors. 3. Equivalent and full resolution IR enhanced imagery. 4. Full disk IR imagery every 3 hours. 5. 8 km resolution water vapor sectors. 6. Quantitative precipitation estimates, high density cloud and water vapor motion wind vectors, and experimental visible and sounder winds. 7. Operational moisture sounder data (precipitable water) in four levels for inclusion in NCEP numerical models. Other sounder products include: gradient winds, vertical temperature and moisture profiles, mid-level winds, and derived product imagery (precipitable water, lifted index, and surface skin temperature. 8. Tropical storm monitoring and derivation of intensity analysis. 9. Volcanic ash monitoring and dissemination of volcanic ash advisory statements. 10. Daily Northern Hemisphere snow cover analysis. 11. Twice daily fire and smoke analysis over specific areas within CONUS.

Polar Orbiting

SATELLITE	TYPE OF DATA	LOCAL TIME*	REMARKS
NOAA-17	AVHRR: GAC and LAC (recorded), HRPT and APT (direct readout) AMSU and HIRS	1010D/2110A	1. 1 k m resolution HRPT/ Local Area Coverage (LAC) data. 2. 4 km resolution APT/ Global Area Coverage (GAC) data. 3. Mapped imagery. 4. Unmapped imagery (all data types) at DMSP sites. 5. Sea-surface analysis. 6. Soundings. 7. Moisture profiles. 8. Remapped GAC sectors. 9. Sounding-derived products: total precipitable water, rain rate, and surface winds under sounding (NOAA-15). 10. Daily northern hemisphere snow cover analysis 11. Twice daily fire and smoke analysis over specific areas within CONUS.
NOAA-16		0159D/1359A	
NOAA-15		0655D/1855A	
DMSP F-15	OLS Imagery (recorded and direct) SSM/I, SSM/T-1, SSM/T-2	0925D/2125A	1. 0.3 nm (regional) and 1.5 nm (global) resolution (visual and infrared) imagery available via stored data recovery through AFWA. 2. Regional coverage at 0.3 nm and 1.5 nm (visual and infrared) imagery available from numerous DOD tactical terminals. 3. SSM/T-1, SSM/T-2, and SSM/I data transmitted to NESDIS and FNMOC from AFWA.
DMSP F-14	Same as F-15, except SSM/T-1 non-functional	0845D/2045A	
DMSP F-13	Same as F-15, except no SSM/T-2	0600D/1800A	
DMSP F-12	Same as F-15, except SSM/I and SSM/T-1 non-functional	0820D/2020A	

* Local time/equatorial crossing time/D = Daylight descending/A = Daylight ascending

3.3 Automated Coastal Marine and Ocean Observations.

3.3.1 Moored Data Buoys and Coastal Marine Automated Network.

3.3.1.1 Procedures. Moored buoy and Coastal Marine Automated Network (C-MAN) stations routinely acquire and transmit data every hour. Buoy observations include wind direction, speed, and peak 5-second wind; sea level pressure; air temperature; dew point temperature; sea surface temperature; significant wave height and dominant wave period; and wave energy spectra. Descriptions of the measurements from a typical moored buoy and C-MAN station are provided in Tables 3-2 and 3-3, respectively. Consult NDBC's web page at *www.ndbc.noaa.gov* to view the station locations, latest station operating status, and for site-specific information.

3.3.1.2 Communications. Data are transmitted by ultra-high frequency (UHF) communications via NOAA's GOES system to NESDIS, then relayed to the National Weather Service Telecommunications Gateway (NWSTG) for processing, including real-time quality control, and dissemination. Data from moored buoys are distributed in World Meteorological Organization (WMO) FM13-IX SHIP code. C-MAN observations are distributed in CMAN code which is a modified form of FM12-IX SYNOP code.

3.3.1.3 Point of Contact (Daytime). The NDBC Data Analyst can be reached at 228-688-3134.

3.3.2 Drifting Data Buoys.

3.3.2.1 Procedures. These buoys are deployed by ship or aircraft in data sparse areas. Their movement depends upon ocean currents and winds. Data available include position; sea level pressure; wind speed and direction; air temperature; and sea surface temperature. Although NWS does not routinely deploy drifting buoys, several are deployed each year in the North Pacific by Meteorological Service of Canada and their observations are available in real time.

3.3.2.2 Communications. Data are transmitted by UHF communications via NOAA polar-orbiting satellites to NESDIS ground receiving stations and then relayed to the U.S. Argos Global Processing Center in Largo, Maryland. Following processing and limited quality control at Service Argos, the observations are sent on to the NWSTG for dissemination. Drifting buoy observations are in FM18-IX BUOY code format.

Table 3-2. Moored buoy payload data.

PARAMETER	REPORTING RANGE	REPORTING RESOLUTION	SAMPLE INTERVAL	SAMPLE PERIOD	TOTAL SYSTEM ACCURACY
WIND SPEED	0 TO 60 m/s	0.1 m/s	1 s	8 min	±1 m/s or 10%
WIND DIRECTION	0 TO 360E	1E	1 s	8 min	±10E
PEAK WIND	0 TO 82 m/s	1 m/s	1 s	5 s	±1 m/s or 10%
AIR TEMPERATURE	-30 TO 70 EC	0.1 EC	90 s	8 min	±1 EC
ATMOSPHERIC PRESSURE	800 TO 1100 hPa	0.1 hPa	4 s	8 min	±1 hPa
SEA SURFACE TEMPERATURE	-7 TO 41 EC	0.1 EC	1 s	8 min	±1 EC
SIGNIFICANT WAVE HEIGHT	0 TO 35 m	0.1 m	0.39 s	20 min	±0.2 m or 5%
WAVE PERIOD	3 TO 30 s	0.1 s	0.39 s	20 min	±1 s
NONDIRECTIONAL WAVE SPECTRA	0.03 TO 0.40 Hz	0.01 Hz	0.39 s	20 min	—
DEW POINT TEMPERATURE*	-35 TO 30 EC	0.1 EC	1 s	8 min	±1 EC
SOLAR RADIATION*	0 TO 2150 W/m^2	0.5 W/m^2	1 s	8 min	±5%
PRECIPITATION RATE*	1 TO 1600 mm/hr	1 mm	1 s	15 min	±5%
DIRECTIONAL WAVES*	0 TO 360E	1.0E	0.5 s	20 min	±5E
OCEAN CURRENTS (ADCP)*	0 TO 1000 cm/s	0.5 cm/s	1.5 s	20 min	±2 cm/s

*PARAMETER REPORTED ON SELECTED BUOYS

Table 3-3. Data from a typical fixed C-MAN station.

MEASURANDS	REPORTED DATA	REPORTING RANGE	REPORTING RESOLUTION	MINIMUM AVERAGING PERIOD (SELECTABLE)	TOTAL SYSTEM ACCURACY
WIND DIRECTION	TRUE WIND DIRECTION	0E – 360E	1.0E	2 min	±15E TRUE (±10E DESIRED)
WIND SPEED	AVG. WIND SPEED	0 – 120 kn	1.0 kn	2 min	±2.0 kn or 5%
	PEAK WIND GUST	0 – 160 kn	1.0 kn	(SELECTABLE)	±2.0 kn or 5%
WAVES	SIGNIFICANT WAVE HEIGHT ($H_{1/3}$)	0 – 49 m	0.5 m	(SELECTABLE)	0.5 m
	WAVE PERIOD (T)	2.5 – 5 s	1 s	(SELECTABLE)	±1 s
	PROBABLE MAXIMUM WAVE HEIGHT	0 – 49 m	0.5 m	(SELECTABLE)	0.5 m
BAROMETRIC PRESSURE	SEA LEVEL PRESSURE	900 – 1100 hPa	0.2 hPa	2 min	±1.0 hPa ABSOLUTE
AIR TEMPERATURE	AIR TEMPERATURE	-30 to +70 EC	0.1 EC	1 min	±1.0 EC
SEA SURFACE TEMPERATURE*	SEA SURFACE TEMPERATURE	-6 to +40 EC	0.5 EC	1 min	±1.0 EC
DEW POINT*	DEW POINT TEMPERATURE	-35 to +30 EC	0.5 EC	1 min	-35 to -24EC: ±2 EC -23.5 to -1.5EC: ±1.5 EC -1.5 to +30 EC: ±1.0 EC
SECTOR VISIBILITY*	VISIBILITY RANGE	0 – 8 statute mi		2 min	0 to 3 mi: ±10% 3 to 8 mi: ±1 mi
WATER LEVEL*	WATER LEVEL	0 – 99.99 ft	0.01 ft	(PERIODICALLY RESET TO ZERO)	TBD

* PARAMETER REPORTED ON SELECTED STATIONS