FUTURE U.S. SATELLITE PROGRAMS OF INTEREST TO SNOW SCIENTISTS

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ABSTRACT

The year 1978 could be a significant one for snow scientists because of new satellites, new sensors, and new programs. NASA is planning to launch the Heat Capacity Mapping Mission (HCMM) Satellite with a Heat Capacity Mapping Radiometer on board. This instrument will collect thermal infrared data every 12 hours, with 0.5 km resolution, the best resolution thus far obtained. It will also take digital image data in the visible band (0.5-1.1μm) at the same resolution. About the same time, early 1978, Landsat-C will be launched carrying a multispectral scanner (MSS) that contains a thermal band 250 meter resolution, in addition to the 4 bands previously flown. The Return Beam Vidicon (RBV) onboard Landsat-C will have improved, i.e., 40-meter, resolution. Nimbus-G will feature the 5-channel Scanning Multifrequency Microwave Radiometer (SMMR), a Temperature-Humidity Infrared Radiometer (THIR) in the 6.5-7.1μm and a 10.3-12.5μm band with a 22 and 8 km resolution, respectively, at nadir, and the Coastal Zone Color Scanner (CZCS), a 6-channel instrument with 800-m resolution. Next is Seasat-A, which will have limited coverage of land areas, but which has many new sensors: a 21.5 cm Synthetic Aperature Radar (25-meter resolution), a Visible Infrared Radiometer (VIRR) with 2 channels and 10-km resolution, the 5-channel Scanning Multifrequency Microwave Radiometer (SMMR), which will also be aboard Nimbus-G, with variable resolution (generally 10's of km's), the Seasat-A Satellite Scatterometer (SASS), and the Compressed Pulse Altimeter (CPA), a 13.9 GHz instrument.

As if this were not enough, NOAA is introducing the TIROS-N satellite with the AVHRR (Advanced Very High Resolution Radiometer). This 4-channel instrument will continue to have 1-km resolution locally. For global coverage the resolution of the IR will be improved to equal that of the visible, viz. 4 km. Channels include two thermal, one visible, and one near-IR. Implications for snow studies will be discussed.

Introduction

Snow scientists, hydrologists, engineers, and snow surveyors should be made aware of the increase in snow observations during the 1978-1979 snow season from various satellite-borne sensors of both NOAA and NASA. Not only the frequency (number) of observations but also the types of sensor have been increased. I believe that foreknowledge of the new remote sensing tools and their potential application to snow studies will be especially useful to the members of the Eastern Snow Conference. Four new research satellites, Landsat-C, Heat Capacity Mapping Mission (HCMM-A), Nimbus-G, and Seasat-A, will be launched by NASA during 1978. TIROS-N, a new-generation operational environmental satellite, will be launched by NASA for operation by NOAA/NESS.

Highlights of year will undoubtedly be the high thermal resolution of HCMM; the 6-channel Coastal Zone Color Scanner (CZCS) onboard Nimbus-G; the Synthetic Aperature Radar (25-m resolution); the 250-m spatial resolution of MSS-8, thermal-IR band on Landsat-C; and the 5-channel Scanning Multifrequency Microwave Radiometer (SMMR), both aboard Seasat-A; and also the Advanced Very High Resolution Radiometer (AVHRR) on TIROS-N, which will have a visible, a near-IR, and two thermal channels.

Landsat-C

Landsat-C is scheduled for launch in March 1978.* It will differ from previous Landsats by having MSS channel 8, a thermal-IR channel; and by having modified Return Beam Vidicon (RBV), which will provide 40-m spatial resolution. The RBV will produce panchromatic images only. It is a two-camera system with a broad band response 0.505 to 0.75μm. Each camera sensor will cover a 98-km^2 area per frame. Thus, side by side pictures, each 98 km (53 nm) on a side covering a swath width of approximately 183 km (99 nm). Four RBV frames will thus correspond to one MSS frame. The improved (40 m) ground resolution should be of interest to those snow scientists who are involved in small test basins. Table 1 shows the Landsat-C orbital parameters and the sensor characteristics. The Data Collection System (DCS) used in Landsat's 1 and 2 continues on Landsat-3. It obtains data from remote, automatic data collection platforms and relays the data to ground stations.

The Heat Capacity Mapping Mission Satellite (HCMM-A)

The HCMM-A satellite, one of the applications Explorer series, is scheduled for launch in April 1978.** It has a two-channel instrument called the Heat Capacity Mapping Radiometer (HCMR). The channels are in the visible (0.5-1.1μm) and in the thermal-IR (10.5-12.5μm) range. Spatial resolution is 500 m. The satellite is designed to pass overhead at 1330 local time in the afternoon and at 0300 local time in the predawn period. The objective is to calculate the thermal inertia of the surface as an aid to surface composition identification and other applications. The "eccentricity" of this orbit is such that day-night coverage occurs about every 5 or 6 days. However, individual single day or night passes should be available between 5-day day-night passovers. The orbit was designed to provide data chiefly in the northern temperate zone, south of 50°N.

The most attractive innovations of the HCMR are: (1) the 500-m spatial resolution for improved snow mapping; and (2) the high thermal sensitivity ($NE\Delta T$*** = 0.6° for the system). Table 2 lists the sensor characteristics.

Nimbus-G Satellite

Nimbus-G will be called Nimbus-6 when launched. It is currently scheduled for launch by NASA in September 1978. Nimbus-G will be in a sun-synchronous, near-polar orbit as an average altitude of 955 km. It will have a 6-day repeat cycle.

This satellite possesses a Scanning Multifrequency Microwave Radiometer (SMMR), which will measure radiation that penetrates cloud cover. The wavelengths (frequencies) of the SMMR are 4.55 cm (6.6 GHz), 2.81 cm (10.7 GHz), 1.67 cm (18 GHz), 1.36 cm (21 GHz), and 0.81 cm (37 GHz). The spatial resolution, however, is rather poor for snow surveys. It ranges from 22 x 19 km at best (at 0.81 cm) to 118 x 103 km at worst (at 4.55 cm). This instrument will also be flown on Seasat, which is described below.

* Landsat-C became Landsat-3 after a successful launch on 5 March 1978.
** HCMM-1 was successfully launched on 26 April 1978.
***Noise-equivalent temperature variability.

Of more interest to snow scientists will be the Coastal Zone Color Scanner (CZCS), which has a spatial resolution of 800 m and has 6 channels that are, as the name implies, most useful for coastal-zone studies of ocean color related to chlorophyll, sediments, etc. Nevertheless, these bands can also be used for spectral studies of snow reflectance. The wavelengths of the bands and other sensor characteristics are shown in Table 3.

Seasat-A*

This NASA-launched satellite is aimed at supplying the oceanographic community with a satellite dedicated to measuring ocean parameters. We in the snow-hydrology community may benefit from some of the onboard sensors when the satellite scans land areas adjacent to the sea.

The SMMR was described earlier under the section on the Nimbus-G satellite, and it will also be aboard Seasat-A. A Synthetic Aperature Radar (SAR) will also be flown. It will be turned on for limited periods (about 4% of the time) over selected target areas for wave spectra and sea-ice imagery. The SAR is a 21.5 cm (L-band) radar with a spatial resolution of 25 m and a 100-km swath width. Whether this sensor will detect snow or snow properties is conjectural. Some radar specialists feel that it will not. Of course, it was designed for ocean waves rather than snow, but the 25-m resolution is certainly appealing to those who maintain small test sites. Further details are listed in Table 4.

TIROS-N

TIROS-N is the third-generation polar-orbiting satellite launched by NASA for NOAA/NESS. Launch is currently scheduled for September 1978. Actually a two-satellite system, the TIROS-N carries a new sensor, the Advanced Very High Resolution Radiometer (AVHRR), which will provide twice-daily thermal IR and daily visible and near-IR data on an operational basis. Although the AVHRR has the same 1-km spatial resolution as its predecessors, new bands have been added. The sensor will have two thermal bands (later versions will have three), a visible band, and a near-IR band.

The near-IR channel is 0.72-1.1μm and should permit some detection of stage-of-metamorphosis or ripening of the snow pack. Of interest, too, is the improved thermal IR, which has an NEΔT or thermal accuracy of $<0.2^{\circ}$C compared with 0.5°C on the previous ITOS series (See Table 5.)

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*ed. note: Seasat-A failed completely on October 10, 1978.

TABLE 1. LANDSAT-C ORBITAL PARAMETERS AND SENSOR CHARACTERISTICS.

Orbital Parameters

Altitude.............................. 919 km

Period................................ 103 minutes

Equatorial Crossing................... 0909 local time

Cycle 18 days1/

Inclination........................... 99.09°

Orbit................................. Circular, near polar

Coverage.............................. 82°N to 82°S

Sensor	Spectral Band (μm)	Nominal Resolution at nadir	Swath Width (km)	Coverage	Remarks
Return Beam Vidicon (RBV)	0.505-705	40m	185	18-day	4 images, roughly equal to one MSS frame.
Multispectral Scanner (MSS)	0.5-0.6 0.6-0.7 0.7-0.8 0.8-1.1 10.5-12.5	80m 240m	185	18-day	10% forward lap; 14% side lap at equator; greater toward poles.

For more information see: Landsat-C Reference Manual
General Electric Space Div.
P.O. Box 8555
Philadelphia, Penna. 19101

1/ Follows Landsat-2 nine days later.

TABLE 2. HCMM ORBITAL PARAMETERS AND SENSOR CHARACTERISTICS.

Orbital Parameters

Altitude.............................. 620 km

Period................................ 96.7 minutes

Equatorial Crossing................... 0200 and 1400 local time

Cycle................................. 16 days (day/night coverage)

Inclination........................... 97.9°

Orbit................................. Circular, sun-synchronous 12-hr. coverage

Coverage.............................. 35°N to 35°S (day-night coverage)

Sensor	Spectral Band (μm)	Nominal Resolution at nadir	Swath Width (km)	Coverage	Remarks
HCMR	0.50-1.1				
	10.5-12.5	500m	700	16-day (day/night coverage)	Thermal-only coverage is more frequent over individual sites.

Standard products will be listed in catalogues by National Space Science Data Center, Code 601, NASA/GSFC, Greenbelt, Md., 20771.

For more information see: HCMM Data Users Bulletin
Code 902
NASA/GSFC
Greenbelt, Md. 20771

TABLE 3. NIMBUS-G ORBITAL PARAMETERS AND SENSOR CHARACTERISTICS.

Orbital Parameters

Altitude.............................. 955 km

Period................................ 104 minutes

Equatorial Crossing................... 1200 local time (ascending)

Cycle................................. 6-day

Inclination........................... 99.3°

Orbit................................. Sun-synchronous, near-polar

Coverage.............................. Global

Sensor	Spectral Band	Nominal Resolution at nadir	Swath Width (km)	Coverage	Remarks
SMMR 1/	4.55 cm 2.81 1.67 1.36 0.81	118x103 km 73x68 47x41 37x32 22x19	780	global 6-day	Same instrument on Seasat-A with limited coverage.
CZCS 2/	0.433-0.453μm 0.510-0.530 0.540-0.560 0.660-0.680 0.700-0.800 10.5-12.5	800m	1200	6-day	Mostly direct readout.
THIR 3/	10.3-12.5μm	8 km	3000	12-hr	

1/ Scanning multifrequency microwave radiometer.

2/ Coastal Zone Color Scanner.

3/ Temperature-Humidity Infrared Radiometer.

TABLE 4. SEASAT-A ORBITAL PARAMETERS AND SENSOR CHARACTERISTICS.

Orbital Parameters

Altitude.................................. 790 km

Period.................................... 100.75 minutes

Equatorial Crossing....................... Non sun-synchronous

Cycle..................................... 152 days (exact repeat) 14.3 orbits/day

Inclination............................... 108°

Orbit..................................... Nearly circular, non sun-synchronous

Coverage.................................. 72°N to 72°S

Sensor	Spectral Band	Nominal Resolution at nadir	Swath Width (km)	Coverage	Remarks
SMMR 1/	4.55 cm 2.81 1.67 1.36 0.81	118x103 km 73x68 47x41 37x32 22x19	650	36 hr	Polar coverage restricted to 72°N and 72°S.
SAR 2/	21.5 cm	25m	100	36 hr	Direct readout only; limited swath lengths.
VIR 3/	0.5-9µm 10.5-12.9	100 km	1500	36 hr	Polar coverage restricted. See SMMR.
SASS 4/	13.9 or 14.495 GHz	50 km	1900	36 hr	Very few observations; polar coverage restricted.
CPA 5/	13.9 GHz	1.6-12 km	10	6 mo	Polar coverage restricted.

1/ Scanning Multifrequency Microwave Radiometer.

2/ Synthetic Aperature Radar.

3/ Visible/Infrared Radiometer.

4/ Seasat-A Satellite Scatterometer.

5/ Compressed Pulse Altimeter.

TABLE 5. TIROS-N ORBITAL PARAMETERS AND SENSOR CHARACTERISTICS.

Orbital Parameters

Altitude.............................. 833 km

Period................................ 102 minutes

Equatorial Crossing................... 1500 local time (northbound)
0730 local time (southbound)

Cycle................................. 12 hr

Inclination........................... 99°

Orbit................................. Sun-synchronous, near-polar

Coverage.............................. Global with 2-satellite system at lower resolution

Sensor	Spectral Band	Nominal Resolution at nadir	Swath Width (km)	Coverage	Remarks
AVHRR[1/]	0.55-0.9µm 0.72-1.1 3.55-3.93 10.5-11.5	1-4 km	2800	12 hr	Global coverage at 4 mi resolution; mostly direct read-out at higher resolution

For further information see the TIROS-N/NOAA A-G Satellite Series, NOAA Tech. Memo. NESS 95 from NTIS, 5285 Port Royal Rd., Springfield, Va. 22161.

[1/] Advanced Very High Resolution Radiometer. In addition to the AVHRR, TIROS-N will have a TIROS operational Sounder (TOVS) system consisting of a High Resolution Infrared Radiation Sounder (HIRS), a Stratospheric Sounding Unit (SSU), and a Microwave Sounding Unit (MSU).