NASA Technical Memorandum 100688

Suggested Severe Local Storm Operational Scenario for GOES I-M

William E. Shenk and Fredrick Mosher

NOVEMBER 1987

NASA

NASA Technical Memorandum 100688

Suggested Severe Local Storm Operational Scenario for GOES I-M

William E. Shenk
Laboratory for Atmospheres
Goddard Space Flight Center
Greenbelt, Maryland

Fredrick Mosher
National Severe Storms Forecast Center
National Oceanic and Atmospheric Administration
Washington, D.C.

NASA
National Aeronautics
and Space Administration

Scientific and Technical
Information Branch

1987

Suggested Severe Local Storm Operational Scenario for GOES I-M

by
William E. Shenk
Laboratory for Atmospheres, Goddard Space Flight Center
and
Fredrick Mosher
NOAA/National Severe Storms Forecast Center

1. Introduction

The GOES I-M observations that are taken during a day of intense convection in the midwestern U.S. will be expected to place the greatest demands on the satellite and ground facilities. This is due to the space and time scale of the meteorological features and the rapid perishability of the products. All other mesoscale phenomena observing scenarios could be variations on the one for severe local storms, and no increase in overall capability will be needed.

2. Severe Local Storm Phases

There are three basic phases in the evolution of a severe local storm day. The first is to define the atmospheric conditions which are favorable for storm development. This will involve the use of regional scale and possibly mesoscale models which will need satellite data as part of the total data base. Also, the progress of key atmospheric circulation features (e.g., jet streams, areas of low level convergence) and indices (e.g., stability) will have to be monitored during the day, especially in the morning through early afternoon before any strong convection has started to develop. This is also when the modelling results are the most useful.

The second phase is when the convection begins to grow beyond the cumulus phase. Two important new things happen. One is the monitoring of the convection growth rates, and the other is the localizing of some of the quantities that were measured in phase one. Whereas phase one is the current outlook and watch process, phase two is the updating of watches and the beginning of the warnings.

Phase three is when there are areas of mature strong convection in progress. The same monitoring of favorable atmospheric conditions continues but its importance is lessened since convection has already appeared in most of the places that can support it. The emphasis has now shifted primarily to the monitoring of the rapid fluctuations of the convective cores to ascertain their present and anticipated (within an hour) severity. Very high imaging rates are now required because updraft speeds are near their maximum, and the air can rise, often nearly undiluted, to at or above tropopause levels. Another important area of observation in phase three is the interactions between the storms and their immediate environment. This exchange of heat and momentum often results in circulations which can act to modulate convection intensity and strongly influence the environmental structure both upstream and downstream from the storms. The measurements associated with phase three can primarily concentrate on the most active areas.

The required measurements associated with the phases have considerable overlap in time and space. There are gradual transitions between phases. One portion of the total surveyed area could be in phase one while another portion is in phase three.

3. GOES I-M Capabilities

The GOES I-M spacecraft will be a three-axis, body-stabilized platform with separate imaging and sounding instruments. Unlike the present GOES where the VAS (VISSR Atmospheric Sounder) is time-shared to perform the imaging and sounding functions, the GOES I-M imager and sounder operate completely independent of each other. The GOES I-M radiometers offer improved sensitivity, scan flexibility, pointing accuracy, signal quantization, and spatial resolution when compared to the current VAS. These characteristics are briefly summarized (see Juarez and Koenig, 1986 for additional details).

The imager on GOES I-M is capable of multispectral observations at intervals less than 30 sec over areas of about 1000x1000 km and can scan the full disk in under 30 minutes. The resolution will range from 1 km to 8 km depending on spectral interval. The sensitivity in the thermal bands will be better than 0.25 K at nominal scene temperatures. The absolute considerable improvement over the current 10 to 20 km (Juarez and Koenig, 1986). These capabilities offer the opportunity for better atmospheric monitoring and wind field depiction through tracking clouds and moisture features in image sequences.

The GOES I-M sounder is a 19 channel filter radiometer that has a small instantaneous geometric field of view (8 km), a high sampling rate providing rapid areal coverage (soundings over the contiguous United States require roughly 40 minutes and soundings over a 1000x1000 km area require about 10 minutes), and an increased thermal sensitivity for each field of view (e.g. better than the sounding requirement). While the vertical resolution of the soundings has not been significantly changed from the VAS, the improved calibration of these radiances with an external blackbody is expected to yield high quality soundings of temperature and moisture.

4. GOES I-M Observations

In designing the severe local storm scenario, there were three different types of requirements that were considered. In addition to the special observations for severe local storms there are simultaneous requirements for full disk imaging and higher frequency regional scale imagery to satisfy local needs over the U.S. and nearby areas away from the severe storm regions.

Another important item was discovered when the coverages from the current satellite locations were examined. It was found that it would be difficult to make quantitative calculations east of the Mississippi river from GOES-West at its current location (135°W). This, plus other considerations, has led to the suggestion that the GOES I-M satellites be positioned at 70°W and 120°W. The coverages shown in this severe local storm scenario are based on the 70° and 120°W locations. The scenarios would still work with the satellites at their current locations but there would be a greater dependence on GOES-East. Thus, the substantial operational flexibility that has been built into the GOES I-M system with a separate imager and sounder on each satellite can be most effectively utilized with the 70°W and 120°W locations.

The scenarios will be shown in two steps. First, the imager and sounder coverage maps will be shown for the three severe storm phases mentioned earlier and then the coverages that match the storm phase will be presented as a function of time for a typical severe storm day.

a. Sounder Coverage Scenarios

There are two types of suggested sounder coverage. Fig. 1 shows the sounder coverages for GOES-East and GOES-West during the first two phases of severe local storm development. This coverage could also be used for any regional scale requirements that were centered over the U.S. The overlap area between the satellites can be used for profile comparisons. The practical profiling limit for each sounder is shown which will reduce the effective area for profiling slightly below the scanned areas. There is a slight bias in the combined coverage towards the west to detect systems moving from the west that could influence severe weather conditions in 24-48 hours in the central U.S. Areas of this size can be covered by each sounder in less than an hour. The size of each area is about the same, thus the sounder scans can be synchronized.

Once the storms have reached the mature state (phase three) then a scenario change is suggested. Fig. 2 shows a typical case where GOES-West still covers the same sized regional area as before (shifted 10^{o} of longitude further east than in Fig. 1) while GOES-East is focussed on a local area. This local area is where strong storm-environment interactions should be occuring and/or is an important area for future storm development where clouds are more numerous and the higher observation frequency will yield enough profiles for adequate coverage. The small area is scanned in less than 10 minutes. The practical profiling limits are shown again. Fig. 2 also illustrates the value of placing GOES-West at 120^{o}W. The practical profiling limit shifts 15^{o} longitude further west with GOES-West at 135^{o}W. This would significantly reduce the effective profiling coverage over the U.S. with GOES-West thus forcing GOES-East to be the sounder mainly providing regional coverage.

b. Imaging Coverage Scenarios

The imaging scenarios are a little more complicated than the ones for the sounders because there is a need for full-time imagery to support U.S. and international users, and to produce winds from cloud motions every 6 hours. Fig. 3 shows the suggested imagery coverage from both satellites to support phases one and two of the severe local storm development cycle. Each satellite covers most of the U.S. and nearby adjacent states covering about the same area as Fig. 1. There is larger overlap in the center of the U.S. for stereo coverage which will be important for cloud height measurements that will be used to support winds from cloud motions and convective growth calculations. The practical limits for winds from cloud motions, stereo, and imagery from a general user's perspective (75^{o} of great circle arc from the subsatellite point) are all shown in Fig. 3. It will take about 3 minutes to take each image. They are the same size. The 3-minute interval will be needed for mesoscale low level winds from cloud motions and convective growth in the early stages. Time compositing can be used to obtain surface temperature and low level moisture information at longer intervals with reduced cloud effects due to the high image frequency. Mesoscale wind fields could be calculated at approximately 10-minute intervals. The areal coverage of each image could be expanded significantly in the east-west direction without a large increase in the image time. Increasing the image size by another 50% in the east-west direction would only add about 0.5 minutes to the image time (i.e. to 3.5 minutes). This level of increase would enlarge the stereo area to cover most of the U.S.

Once the storms have reached the mature stage when significant tropopause penetration is occurring, a second type of image scenario is suggested. Fig. 4 shows the coverage for two types of image scanning. The larger area is done from either satellite and provides the routine coverage of the U.S. and adjacent waters every 3.5 minutes. These images would be used for the same purpose as the ones shown in Fig. 3. The much smaller area, which could be done by either satellite, is designed for intensive convection monitoring, and covers the approximately 1000x1000 km area in about 25 secs. This high frequency allows the proper determination of convective vertical rise rates for even the most intense cells. While slower image rates would still capture most of rise rates correctly, the most intense convection would not be properly measured. Since it is the extremes that are the most important, the system should be designed to measure them. The small images can be combined with the larger ones to generate useful stereo in the small image areas at the frequency of the larger images since the greatest time separation between two would be 12 sec. The high frequency in the small areas would provide the best low level cloud motion winds since cumulus continuity would be outstanding. Experiments should be performed with both satellites scanning the same small area to see if the high frequency stereo (which would also be more precise than the stereo done between the small and large images) would substantially benefit the intense convection analysis.

The final imaging scenario is when full disk imaging is required. During the winds determination period both satellites will probably be simultaneously operated in the full disk mode (every 6 hours). In between, it is suggested that any full disk imaging be staggered in time. Thus, one satellite would take one of the large areas in Fig. 4 while the other would cover the full disk (Imaging Scenario 3). Again, if GOES-West were at its current location the view of the U.S. would be considerably poorer than the diagram for GOES-West shown in Fig. 4. For example, the 75^{o} of great circle arc practical viewing limit would be just east of Maine with GOES-West at 135^{o}W.

c. Scenario Timetables

Since these sounding and imaging coverage scenarios change during the day as the meteorological situation evolves, a timetable for their use was developed. Fig. 5 shows the timetable for a typical midwestern U.S. severe local storm day. The general operational requirements are interleaved with the special requirements for the storm event. It is assumed that the significant convective onset (i.e. storms reaching the mature stage) begin at 1400 CST.

The timetable is subdivided for the imagers and sounders and the GOES-West and GOES-East imager timetables are individually depicted. The numbers above each of the horizontal bars refer to a particular sounder or imager coverage scenario and temporal resolution and correlate with the scenario numbers shown in Figs. 1-4. The total special observation period extends from 0500 CST (1100) GMT on one day to 0100 CST (0700 GMT) on the next.

The first sounder coverage scenario is used up to 1400 CST to determine the atmospheric state prior to and during the early stages of the convection. Later this scenario is employed again for an hour each to support dynamic model initialization at the times when the full disk images are being used for cloud motion winds. All of the other times the second sounding scenario is used during the intense convection periods. During a severe storm event no "global" sounding coverage is suggested from the GOES satellites.

The imagery timetable is similar to the sounding timetable in that the switch is made at 1400 CST to the more intensive local coverage from one of the satellites. The severe local storm coverage is interleaved with the full disk requirements throughout the period. The image boundaries can be flexible to cover the incipient storm development with stereo. The full disk requirements not associated with cloud motion winds are staggered such that regional imaging scenario 3 can continue the regional coverage uninterrupted during the time in between the cloud motion wind periods.

The last note in Fig. 5 gives four suggested priorities for increasing the regional and local coverage during a severe local storm event by reducing the full disk requirements. The first suggested priority is to eliminate the full disk images for winds from 1130-1300 CST. This is usually a critical period during the convection cycle when rapid development can occur. Also, this is not a major synoptic time when the cloud motion winds are combined with the radiosonde measurements. The second priority would be to continue image scenario 2 from 1500-1600 CST. This is often the peak of convective severity and the 25 sec interval imagery would have its greatest value. The third priority is the continuation of imagery scenario 2 between 1730-1900 CST. This would eliminate large-scale winds from cloud motions from the full disk imaging. This decision could be made based on the severity of the event. For events that persist into the evening, the choice could also be made to eliminate the full disk requirement from 2100-2200 CST and continue image scenario 2.

Table 1 shows a list of severe local storm products that could be produced from GOES I-M data. Suggested coverages and temporal frequencies are also given. All of these should be ready for use when the first two satellites are in orbit. There has been considerable research done on the methods of obtaining these products and their value during the past decade. Perhaps the most demanding item on the table is the product frequency. Implementation will require considerable automation and the extensive use of interactive facilities. Hopefully, in the 1990's, some of the local area calculations can be done by the local NWS offices as the new data system is installed.

4. Conclusions

The combination of a more flexible and quantitative GOES satellite system with more powerful and interactive ground facilities should lead to large advances in the utilization of GOES data in severe local storm analysis and forecasting. How the GOES satellites are operated, where they are located, and what products are derived is critical for success. Hopefully, by considering these issues now, we can properly prepare ourselves to realize the full value of these valuable data.

Reference

Juarez, D. J. and E. W. Koenig, 1986: "Infrared imaging and sounding from a geostationary body stabilized spacecraft," Second Conference on Satellite Meteorology/Remote Sensing and Applications, May 13-16, 1986, AMS Preprints, 503.

Table 1

Severe Local Storm Products from GOES I-M

Product	Coverage⁺	Frequency (Min)
o Surface Temperature	Regional	60
	Local	10
o Profiles		
o Temperature	Regional	60
	Local	10
o Moisture	Regional	60
	Local	10
o Lower Tropospheric Moisture	Regional	60
	Local	10
o Winds from Cloud Motions	Regional	60-360*
	Local	30-60
o Convective Intensity	Local	0.5-30
o Precipitation	Regional	60
	Local	5-60
o Cloud Top Hts.	Regional	60
	Local	0.5-10

*For insertion into models
⁺Coverages
Regional - 3000x3000 km
Local - 1000x1000 km

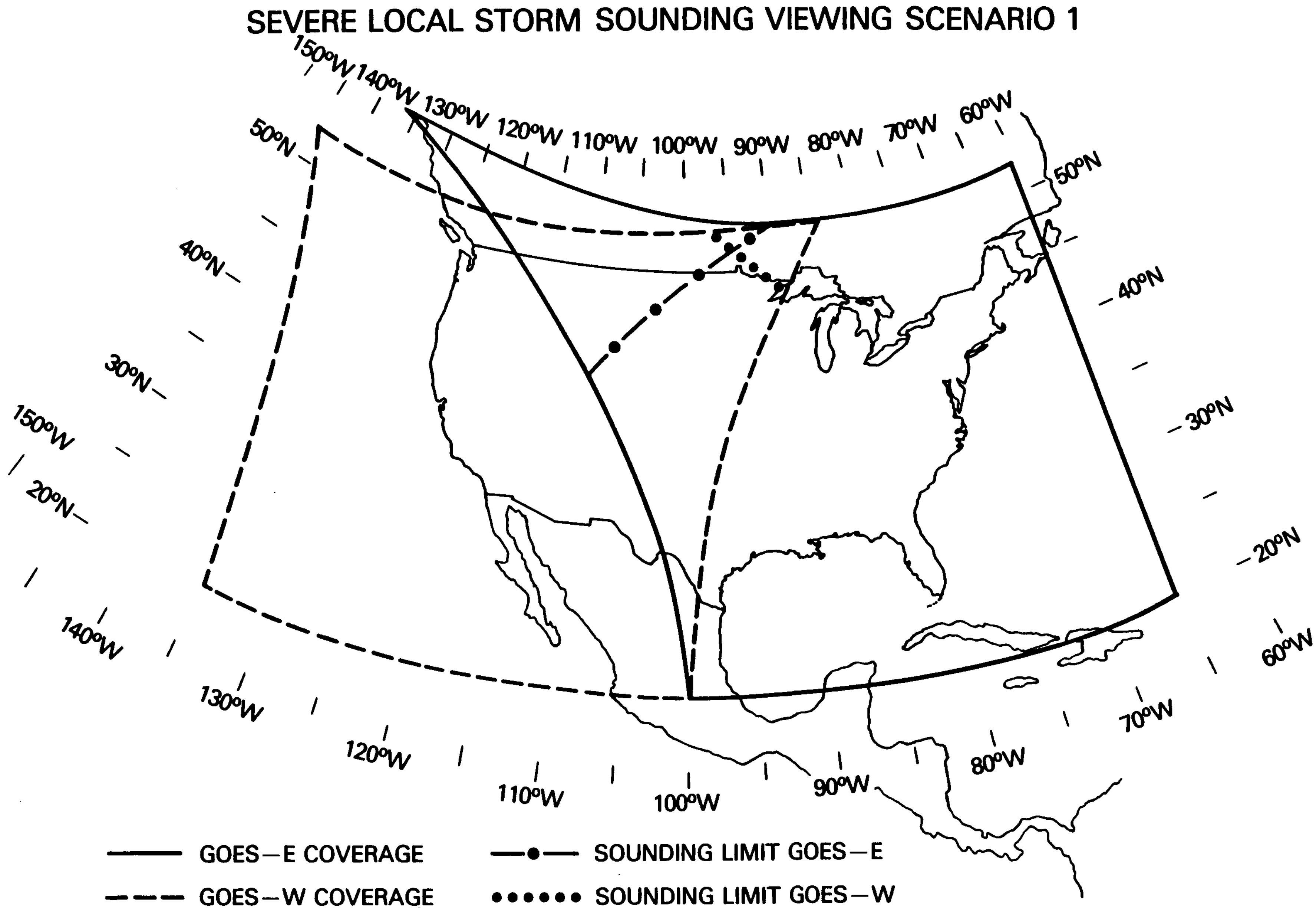

Figure 1. First GOES I-M severe local storm sounding viewing scenario coverage with the GOES-East subsatellite point at 70°W and the GOES-West subsatellite point at 120°W.

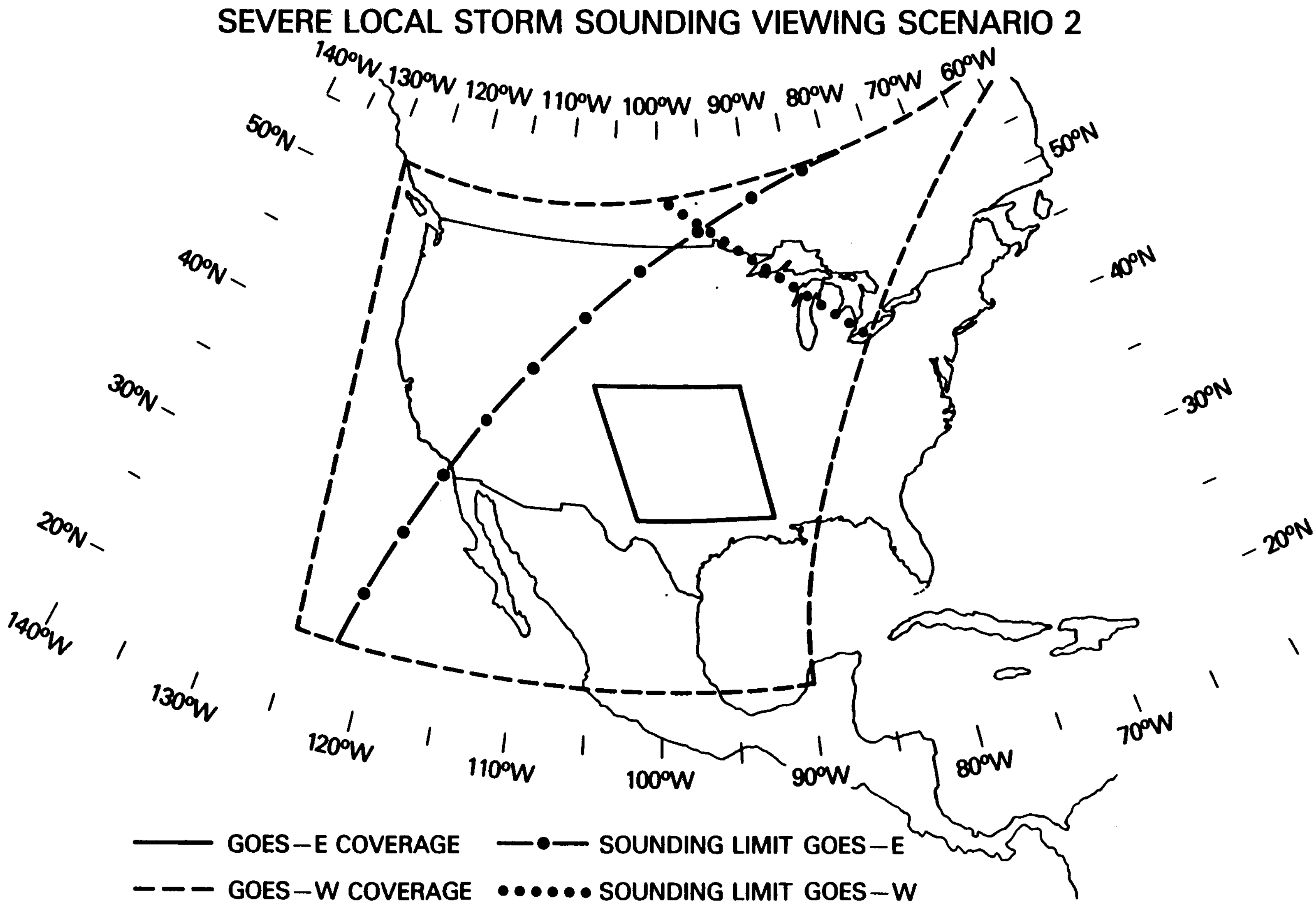

Figure 2. Second GOES I-M severe local storm sounding viewing scenario coverage. The GOES-East and GOES-West subsatellite locations are the same as Figure 1.

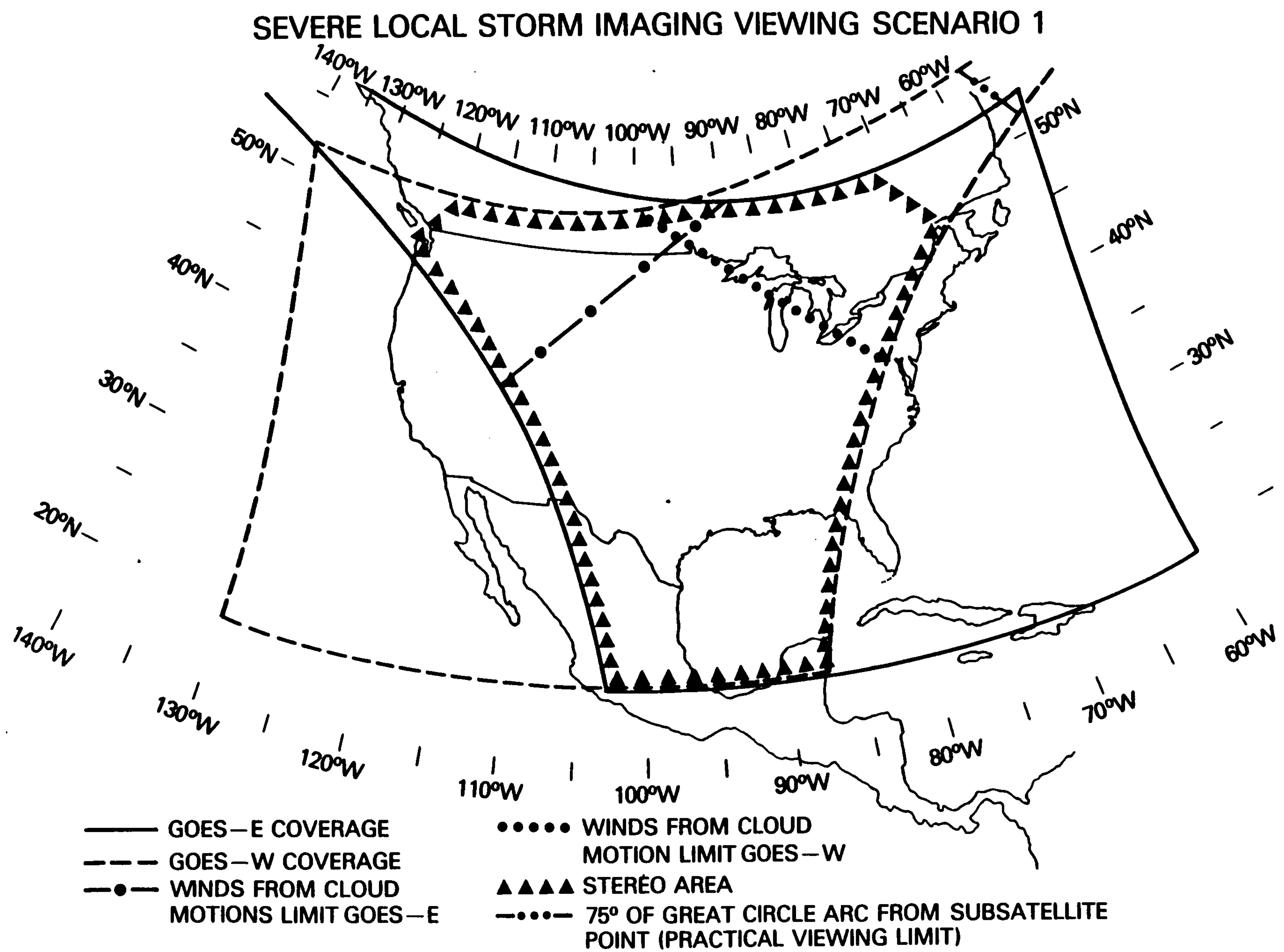

Figure 3. First GOES I-M severe local storm imaging viewing scenario coverage. Same subsatellite points as in Figure 1.

SEVERE LOCAL STORM IMAGING VIEWING SCENARIO 2

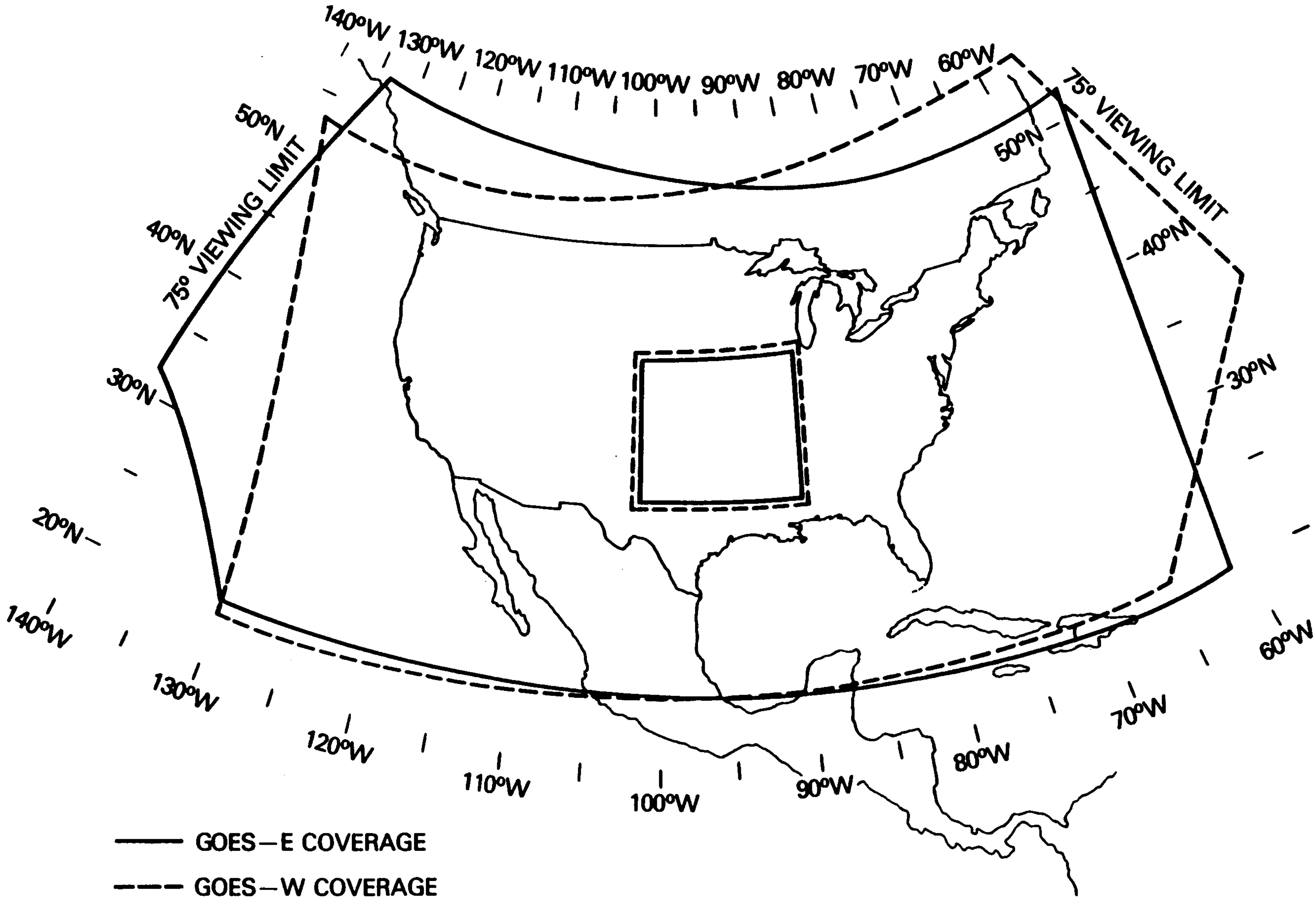

Figure 4. Second GOES I-M severe local storm imaging viewing scenario viewing coverage. Same subsatellite points as in Figure 1.

SOUNDING AND IMAGING SCENARIO TIMETABLES FOR GOES I—M

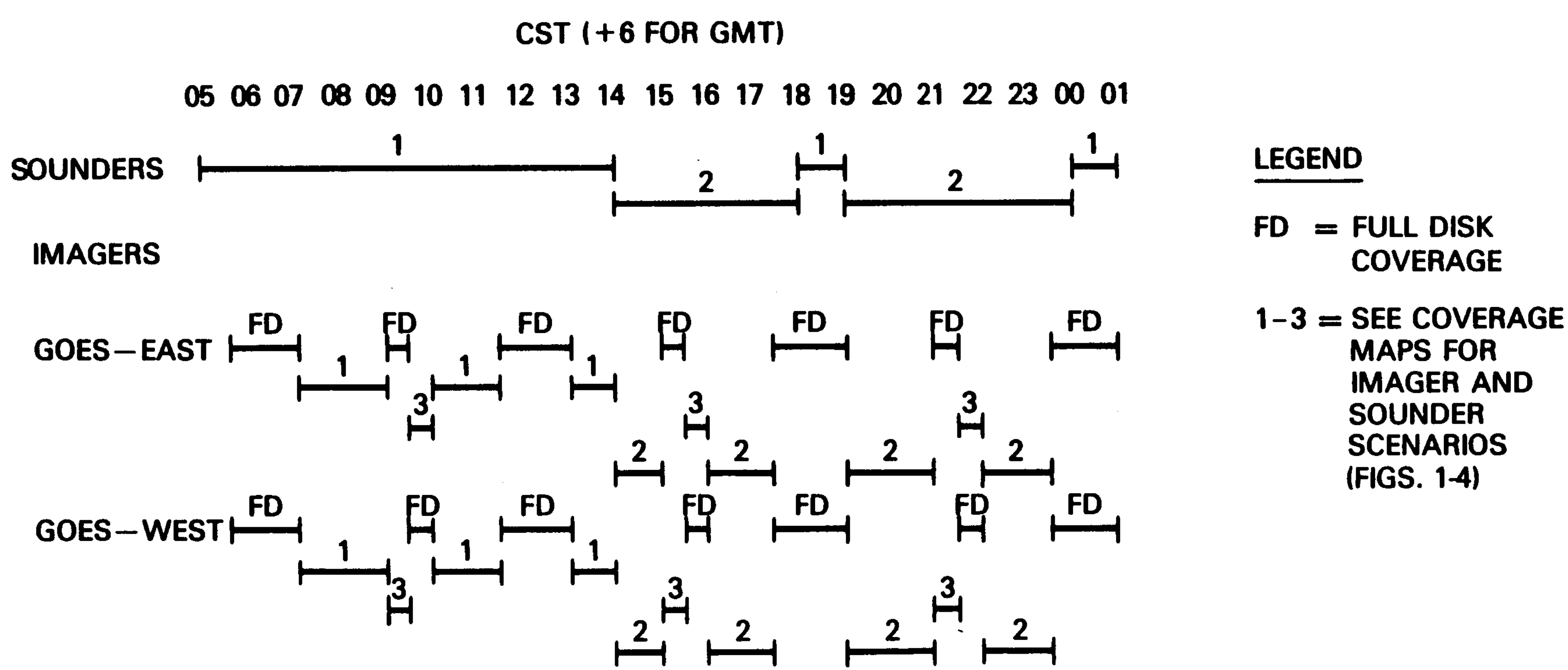

Figure 5. GOES I-M sounding and imaging timetables for a typical severe local storm event. Assume the onset of severe convection at 1400 CST.

NASA
National Aeronautics and Space Administration

Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
NASA TM-100688		

4. Title and Subtitle	5. Report Date
Suggested Severe Local Storm Operational Scenario for GOES I-M	November 1987
	6. Performing Organization Code: 610.0
7. Author(s)	8. Performing Organization Report No.
William E. Shenk and Fredrick Mosher	88B0041
	10. Work Unit No.
9. Performing Organization Name and Address	11. Contract or Grant No.
Laboratory for Atmospheres Goddard Space Flight Center Greenbelt, Maryland 20771	
	13. Type of Report and Period Covered: Technical Memorandum
12. Sponsoring Agency Name and Address	14. Sponsoring Agency Code
National Aeronautics and Space Administration Washington, D.C. 20546-0001	

15. Supplementary Notes

Fredrick Mosher is affiliated with NOAA/National Severe Storms Forecast Center, Washington, D.C.

16. Abstract

The GOES I-M satellite system is expected to provide continuous high resolution estimates of temperature and moisture profiles, winds from cloud motions, surface temperature, cloud properties, and precipitation for severe local storm and tropical cyclone events. The suggested operational schedule for the GOES I-M satellite emphasizes the observation frequencies, spatial coverage, spectral bands, etc. for the GOES I-M imager and sounder instruments that are expected to optimize the determination of the relevant meteorological parameters. During severe local storm events, the imager would be programmed to perform high frequency imaging ($\leq$3.5 minutes) for determining winds from cloud motions and for monitoring severe convection. In addition, the sounder would provide temperature and moisture profiles every hour over a 3000x3000 km domain during the antecedent stage or over a 1000x1000 km area every 10 minutes during the mature storm stage.

17. Key Words (Suggested by Author(s))	18. Distribution Statement
GOES I-M Satellites, severe local storms, operational scenarios	Unclassified - Unlimited Subject Category 47

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of pages	22. Price
Unclassified	Unclassified		

NASA FORM 1626 OCT 86