Definition of Data Collection Task

Paul Menzel

Space Science and Engineering Center

9 November 1976

It is the intent of this paper to describe the Data Collection Task being undertaken here at SSEC. I will try to indicate what data sources we will attempt to acquire, how they will be useful, and what the status of the data collection definition is.

First, it is useful to focus back on the primary goal of the VAS mission: to better "see" all aspects of the mesoscale phenomena. This will be accomplished by acquiring as complete a four dimensional data set as possible. Four dimensional here implies coordinated horizontal, vertical, and temporal descriptions of the physical state of the atmosphere. The notion of appropriate scale will be very important. More will be said about this later.

The anticipated primary sources of meteorological observations include VAS, VISSR images from the SMS series, polar orbiting satellite images and soundings from TIROS-N and the satellites of the DMSP (Defense Meteorological Satellite Program), Conventional Weather Data (NMC, AFOS, or Kansas City Satellite Field Service Station Information), and digital radar information. If other sources of information prove meteorologically valuable then we will try to incorporate them also. The data set should be as complete as possible a description of mesoscale phenomena that will be useful to meteorologists. If a crystal ball will help, we'll use it!

It should be noted that such a variety of sources of meteorological observations is needed because different sources satisfy different meteorological knowledge requirements necessary to monitor and predict mesoscale phenomena. In a 1971 SEOS feasibility study conducted here at SSEC, different knowledge requirements for mesoscale study were listed in order of importance. Table 1 shows them and indicates the sources of information.

The most important knowledge requirement is the boundary layer motion field. The boundary layer is considered to be the lower 10% of the atmosphere where the vertical viscous force is comparable in magnitude to the pressure gradient and Coriolis forces. The turbulent stresses of the boundary layer are both mechanical (such as friction) and thermal (such as solar heating) and are strongly dependent on topography, ground cover, and moisture content of the air. The evaporation of water is a major source of energy for barodinic disturbances. From VAS we expect information on the low level moisture fields and conventional weather data should relate ground cover and winds. The wind magnitude and direction is a key indicator of developing activity because it shows where convergent and divergent regions are.

Vertical Stability is an important indicator of mesoscale weather. Relieving stresses caused by unstable layering in the vertical direction in the atmosphere implies large vertical motions and energy releases. Information on the time rate of change of the temperature field and moisture field in 3 directions are the keys to vertical instability. VAS and polar orbiting soundings and conventional weather radiosonde will provide this information.

Surface temperature is derived from blackbody temperatures of window channel radiances on VAS, VISSR, and polar orbiters and from ground observations at weather stations. Temperature lapse rates come from soundings and radiosondes. Regions of strong convective activity are found from time sequence imaging on VAS and VISSR, ground observations, and hydrometeor (i.e., rain) detection by radar. If convective activity is strong enough, it will be raining.

KNOWLEDGE REQUIREMENTS (listed in order of importance)	SOURCE: VAS	Polar Orbiter	VISSR	Conventional Weather	Radar
1. Boundary Layer Motion Field	X			X	
2. Vertical Stability	X	X		X	
3. Surface Temperature	X	X	X	X	
4. Temperature Lapse Rate	X	X		X	
5. Regions of Strong Convective Activity	X		X	X	X
6. Middle and Upper Tropospheric Motion	X		X	X	
7. Pressure Field in Boundary Layer				X	
8. Moisture Field	X	X		X	
9. Convergence and Divergence	X		X	X	
10. Wind Shear and Jet Stream	X		X	X	

TABLE 1

And so on down the list. The pressure field in the boundary layer comes from only conventional weather data.

It should be noted that these knowledge requirements were ranked for a large number of mesoscale phenomena. Priorities for severe storms (i.e. wind and moisture) would be different from those of frost watches (i.e. temperature field) or those of dust storms. This table should be viewed with that in mind.

Not only is it inadequate in presenting specific priorities; it also fails to indicate what VAS offers that the other sources don't. Without VAS it seems that complete information can still be obtained. What this table omits is the interaction of space and time scales. Much of conventional weather is obtained on the synoptic scale from weather stations separated by 300-400 km. Much of polar orbiter information under-samples some areas, over-samples others and does so every 4 to 6 hours. These time and space scales are adequate for describing larger scale weather phenomena but they are inadequate by themselves to describe mesoscale phenomena. To see this more clearly consider Table 2. Clearly mesoscale space and time resolution desired varies with the atmospheric condition (stable, active, or severe) and it requires much more information than non-VAS data can provide.

VAS will fill the observation time and space gaps. As complete as possible a four dimensional data set will rely heavily on VAS to provide information where non-VAS coverage is weak and/or untimely.

Table 3 indicates roughly the timeliness of the non-VAS data. Surface data from weather stations is updated every 1 hour. The capability to incorporate special observations is very important--if a front crosses over

Mesoscale Phenomena

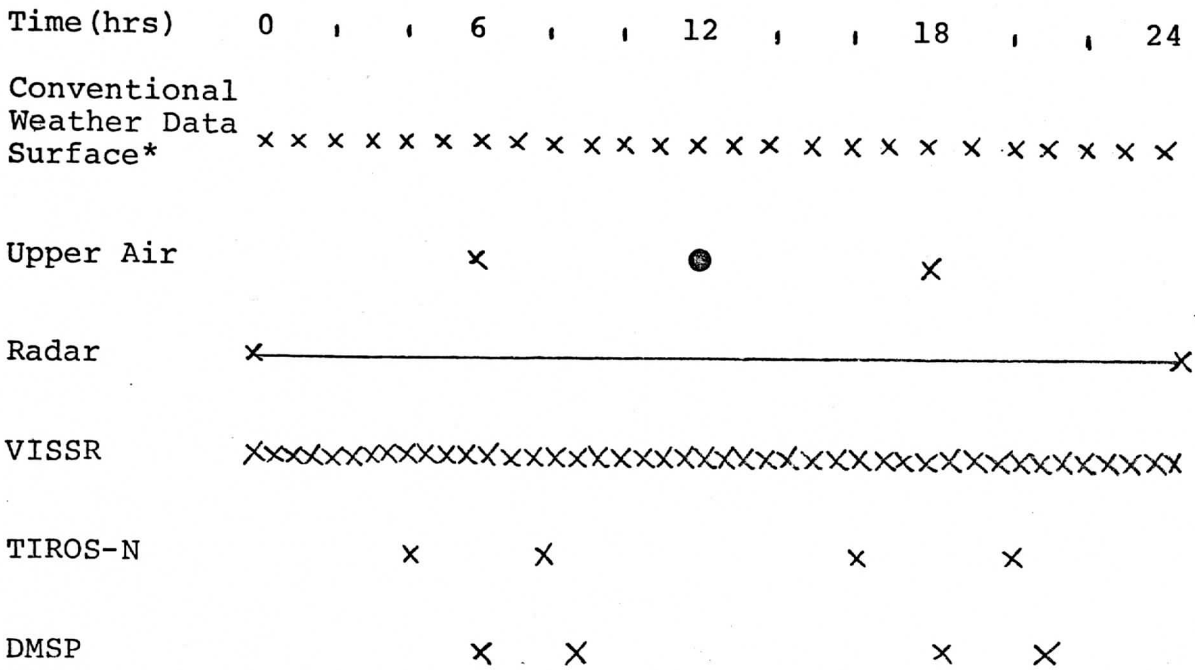
Space and Time Resolution

Atmospheric Condition	Resolution Desired	
	Space	Time
Stable	200-400 Km	1-2 Hr
Active	20-50 Km	1-2 Hr
Severe	20-50 Km	5-15 Min

note: Synoptic scale phenomena are adequately parameterized by observations separated by 300-400 Km at 4-6 hour intervals.

TABLE 2

Timeliness of Ancillary Data



* Capability to incorporate Special Observations

● Information here is derived from NMC Model (departures from balance then indicate possible areas of interest)

TABLE 3

a weather station and interesting weather occurs (i.e. rainfall) more frequent reports are to be received. Upper air data from radiosondes and aircraft is available every 12 hours. In between information is derived from the NMC model predictions. Departures from this prediction (evaluated assuming a balanced state of the atmosphere) indicate possible areas of interest for further VAS and VISSR observations. Examples of departures include winds being in opposite directions and fronts occurring where they shouldn't. Digital radar will be near continuous. VISSR updates occur every 20-30 minutes. TIROS-N morning and evening satellites have overpasses at 4, 8, 16, and 20 hours LST. DMSP provides 12 hour interval coverage. Since it has been observed that the maximum severe weather occurs at 3 or 4 in the afternoon, when non-VAS observations are sparse, it readily becomes evident that VAS filling of time and space gaps is crucial.

Now, to indicate more completely the importance of the non-VAS ancillary data, Table 4 indicates from the SEOS report the location of the mesoscale knowledge requirements as described by the observable physical fields (mass, motion, thermal, moisture, hydrometeor, ...). Almost half of the knowledge requirements are satisfied by observations at the earth surface and the boundary layer. Conventional weather data provides most of this information. Clearly VAS data by itself would be incomplete.

Ancillary data then provides the backdrop upon which VAS data will build. It will provide a description of the boundary layer, provide ground truth and reference data, and provide microwave sounding information which allows soundings where there are clouds. The polar orbiting satellites are equipped with microwave units, and are deemed essential to description of severe storms where clouds obscure much of the turbulence.

Location of Mesoscale Knowledge Requirements

Location \ Physical Field	Mass	Motion	Thermal	Moisture	Hydrometeor	Other
Earth Surface and Boundary Layer	X	XX	XX	X	X	XX
Middle Troposphere		XX	X	X		X
Upper Troposphere		X				
General Atmosphere						XX

TABLE 4

Table 5 reviews in more detail the sources of ancillary data. Surface data yields surface T, P, velocity, visibility, etc. Upper air yields profiles. Radar yields liquid water content. VISSR yields time sequence images allowing description of motion fields and identification of cloud types. Polar orbiters provide stratospheric soundings (the slowly varying stratosphere is adequately sampled by polar orbiters and helps pin down upper tropospheric determinations), soundings in cloudy regions (as mentioned before), and intercomparison soundings with VAS. In addition they also offer a different viewing angle than VISSR (or VAS) that helps with cloud height determinations. It should be pointed out that often observations from different sources are combined to produce inferred data. For example, if a weather station observes ground temperature of 20°C and the VISSR window channel blackbody temperature of the same area reads a lower temperature 10°C, then it can be inferred that the FOV is cloudy. This would be an example of auxilliary data for clear column retrieval.

This concludes the description of ancillary data that will be complemented by VAS data. We now turn our attention (see Figure 1) to how VAS will be programmed in a typical day of severe storm observation. Early in the day the NMC prediction indicates 10 to 20 possible danger areas deserving attention. Often a strong correlation exists between morning conditions and afternoon severe weather (such as tornadoes). Coordinating the NMC prediction with the latest mesoscale analysis and synthesis and with early morning VAS and VISSR images, the man in the loop can direct the VAS to an area of possible severe weather and program the instrument for sounding or imaging and use this new VAS data interactively to update his selection of VAS operating mode and target. This concept for VAS operation clearly

Ancillary Data

SOURCE	DATA TYPE	REMARKS
Conventional Weather Data		
- surface	T_s, P_s, v_s, cloud hts. visibility	Description of Boundary Layer, Ground Truth Information Auxilliary Data for Clear Column Retrieval
- upper air	T(P), Q(P), v(P)	Vertical Resolution of Temperature and Humidity Fields
- radar	radar	Liquid Water Content
VISSR	high resolution visible images, IR window images	Description of Motion Fields, Cloud Types
Polar Orbiting Satellites		
- TIROS-N		
BSU	14 channel IR sounding	Intercomparison Soundings with VAS
SSU	3 channel IR sounding	Stratospheric Soundings
MSU	4 channel Microwave sounding	Soundings in Cloudy Regions
AVHRR	high res. visible images	Different Viewing Angle than VISSR helps with Cloud Height Determination
- DMSP	high res. visible images IR channel soundings Microwave soundings	More Complete Data Base, Better Cloud Height Determinations

TABLE 5

Concept for Selection of VAS Operating Mode

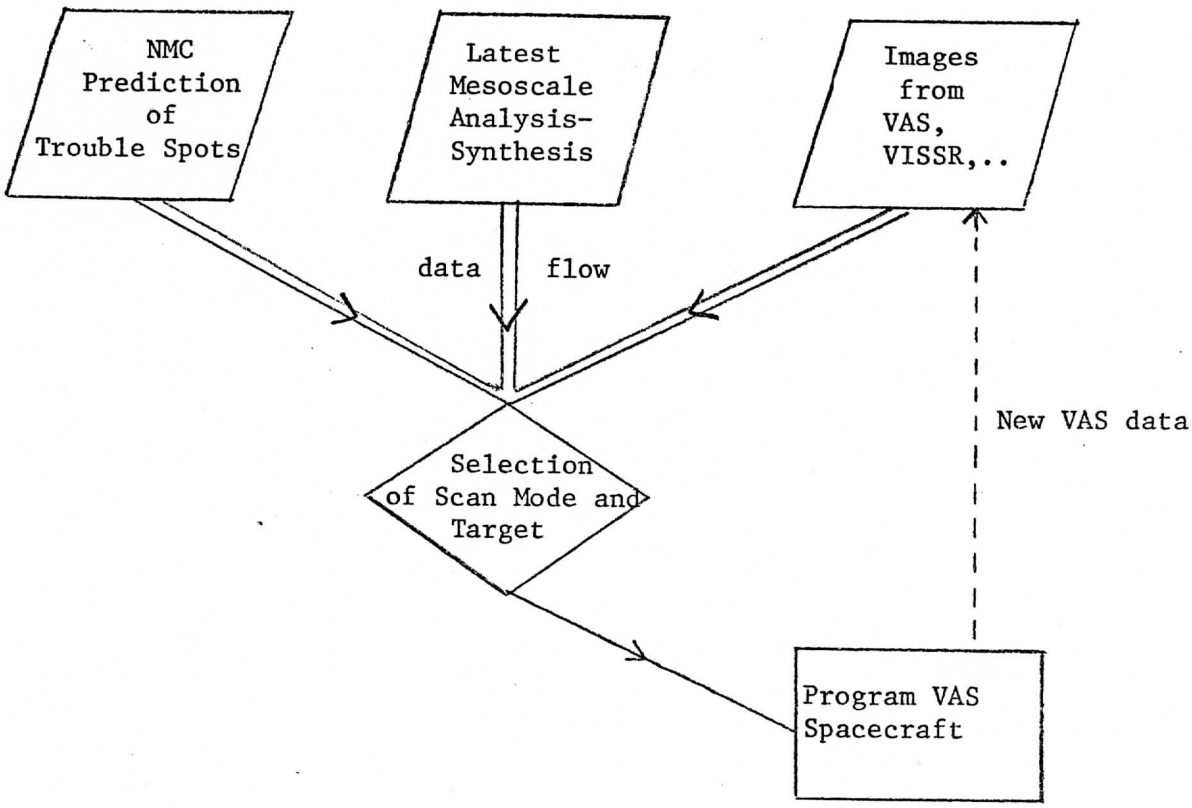


FIGURE 1

indicates the VAS advantage of watching for a storm and following it once it develops. It allows the operator to control the instrument so that VAS data contains information that cannot be gotten from other sources - the hard to get soundings around active weather and the strong gradients which are real and not noise.

The next two tables (Tables 6 and 7) will indicate the status of the data collection definition. Data collection is subdivided into six activities: Reception, Signal Decoding, Reformatting and Averaging, Calibration, Navigation, and Archiving. Conventional Weather and VISSR are well defined from previous SSEC experience in all activities but archiving. Selection of manageable amounts of data for archiving will need more definition. There will be a lot of data to handle (raw data with many redundancies, processed data, synthesized data) and only some of it will be archived. For conventional weather data we plan to implement an NMC phone line in 1977. For TIROS-N data collection the situation is still somewhat up in the air, since the data reception is not yet defined. Three alternatives are still under consideration and will be discussed shortly. Calibration and Navigation for TIROS-N are being defined at NOAA. For VAS, data reception is well defined and signal decoding and reformatting and averaging are mostly defined. Harold Ausfressor of Westinghouse is working on the latter two activities. VAS data calibration is partially defined: some difficulties in the last thermal vacuum test still need to be cleared up. Navigation of VAS will be VISSR like and is being defined at GSFC.

Some data collection capability is available on the McIDAS right now. A Kansas City phone line makes conventional weather data available and VISSR images are received directly at the Center and processed on the McIDAS.

Status of Data Collection Definition

	Conventional Weather[x]	VISSR	TIROS-N	VAS
Reception	defined	defined	not defined[y]	defined
Decoding Signal	defined	defined	not defined	partially defined
Reformatting and Averaging	defined	defined	not defined	partially defined
Calibration	N/A	defined	being defined at NOAA	partially defined
Navigation	N/A	defined	being defined at NOAA	partially defined
Archiving	not defined	not defined	not defined	not defined

x plan to implement NMC phone line in 77

y three alternatives are under consideration

TABLE 6

TIROS-N DATA Acquisition Options

Acquisition Mode	Information Received*	Remarks
VHF Antenna	Basic Sounding Unit, Stratospheric Sounding Unit, Microwave Sounding Unit (this data is located in the TIP-TIROS Information Processor)	real time coverage
S-band Antenna	TIP and Advanced Very High Resolution Radiometer (AVHRR)	coverage at 1 Km resolution received real time
Suitland hook-up	S/C tape recorder (includes TIP, AVHRR, and global data)	global coverage at 4 Km resolution; limited area coverage at 1 Km resolution; tape recorder play back may not be timely for real time analysis

* HIRS data will also be available, but acquisition mode necessary is unclear at this time.

TABLE 7

SSEC also has some experience with polar orbiter data and such a capability can be implemented on the McIDAS.

The TIROS-N data acquisition options involve a VHF Antenna real time coverage during satellite overpass would include basic, stratospheric, and microwave soundings. S-band antenna would add 1 km resolution images. The Suitland hookup offers global coverage at 4 km resolution and limited area coverage at 1 km resolution in addition to soundings, but it may not be timely for real time analysis. An additional option not indicated in this chart may be a hookup to the Global Weather Central. This would access both TIROS-N and DMSP data. More information about this is still needed.

This then concludes the summary of the Data Collection task.