3.4 PLANS FOR GROUND-BASED OBSERVATIONS DURING BAMEX

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1. INTRODUCTION

Despite recent advances in technology, numerical modeling, and fundamental knowledge of mesoscale convective systems (MCSs), we are often unable to accurately diagnose, much less predict, the onset and duration of severe weather. This is particularly true for severe straight-line winds and non-supercell tornadoes associated with bow echoes. Karl et al. (1999) found that the Damaging Downburst Prediction and Detection Algorithm (Eilts et al. 1996), which is based on Doppler radar data, had a high false alarm rate and a low probability of detection when applied to bow echo storms.

Another difficult forecasting problem is the redevelopment of convection associated with the remnants of a prior MCS. One of the best examples of this is the multi-day forcing of convection by a Mesoscale Convective Vortex (MCV; e.g. Bosart and Sanders 1981).

Both of these challenging forecast problems will be addressed in the Bow echo And Mesoscale convective vortex EXperiment (BAMEX). BAMEX will use a combination of airborne and mobile ground-based observing systems to document the broad-scale features of bow echoes and MCVs throughout their lifecycle as well as capture detailed interactions between the local environment and system-to-cell-scale circulations that produce severe weather and foster convective redevelopment.

The purpose of this paper is to describe how the ground-based observing system (GBOS) will be deployed to address BAMEX objectives.

2. BAMEX OBJECTIVES

The GBOS instruments will focus on the BAMEX objectives that require high temporal and spatial resolution and documentation of the mesoscale structure of the environment. For bow echoes, GBOS will initially target high-equivalent potential temperature, moisture convergent areas along pre-existing thermal boundaries. Klimowski et al. (2000) found that about half of the 110 bow echoes examined in their study formed in the vicinity of a surface boundary. Johns and Hirt (1987) noted that derechoes, representing the large end of the bow echo spectrum, tended to form along quasi-stationary fronts. The GBOS will help determine the effect of environmental variability, particularly variations in shear and instability, on storm structure. We will document the interaction of convection with environmental boundaries and try to explain the process of upscale growth from isolated cells to bow-shaped line segments.

In mature bow echoes, attention will shift to features that are sources of severe winds. One objective is to determine whether radar precursors such as the mid-altitude radial convergence (MARC; Schmocker et al. 1996) must be evaluated with regard to environmental parameters such as downdraft potential energy and low-level stability. Another fundamental objective is to determine the relative role of rear-inflow jets, pressure gradients across the cold pool, and convective-scale circulations in the production of severe surface winds. It is likely that each process contributes to the development of severe surface winds with the dominant process being case dependent. The goal is to determine what environmental and/or storm-induced factors favor one process over the others.

For MCVs, GBOS will assist in documenting the thermodynamic structure of the vortex and the forcing mechanisms associated with convective redevelopment. Two time scales are of interest. One is the diurnal scale associated with destabilization of the planetary boundary layer and the subsequent redevelopment of convective activity after the parent convective region had dissipated. The other is the 1-3 hour time scale associated the formation of successive lines of convection near the center of the vortex, as documented by Valdes-Manzanilla and Biggerstaff (1995) for the 5 May 1993 MCV over central Texas.

The primary objective is each situation is similar— to diagnose the large-scale ascent associated with the propagating MCV and the scale interactions that organize convection in the vicinity of the MCV.

3. GBOS INSTRUMENTATION

A list of ground-based platforms being proposed for BAMEX is shown in Table 1. The basic science plan requires a minimum of two sounding systems, four mobile mesonets, two mobile C-band Doppler radars, and the Mobile Integrated Profiling System (MIPS). Additional resources would increase the likelihood of success, extend the region of observational coverage, and increase the scale of forcing that could be diagnosed with the ground-based systems. Many of the science objectives of BAMEX require detailed observations over an extended period of time. It is hoped that more than the minimal configuration will be available during the project.

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Table 1. Ground-based observing platforms being proposed for BAMEX.

Instrument	Description	PI
NCAR MGLASS (2)	mobile GPS-based sounding system (profiles of T, T_d, and winds)	M. Weisman
MIPS	915 MHz profiler; Doppler sodar; RASS; lidar ceilometer, microwave radiometer, surface instrumentation	K. Knupp
SMART-radars (2)	mobile C-band Doppler radars	M. Biggerstaff
NSSL mobile mesonets (4)	automobile rack-mounted sensors for T, RH, P, and winds	D. Dowell
NSSL MGLASS (2)	mobile GPS-based sounding system (profiles of T, T_d, and winds)	
XPOW	mobile X-band polarimetric radar (Z,V, ZDR, KDP)	E. Anagnostou
DOW (1)	mobile X-band Doppler radar	Y. Richardson
surface stations	fixed site mesonet to fill gaps in operational network	R. Johnson

4. EXPERIMENT DESIGN

4.1 *Bow Echoes With Aircraft*

Due to the rapid propagation speed of bow echoes, the aircraft will focus on the evolution of the broad-scale circulations within the storm system. GBOS will compliment the aircraft mission by positioning itself to cover regions that the aircraft are unable to sample, especially during the developing to mature stages of the storm. For example, bow echoes occasionally develop serially along a frontal boundary or have a secondary, transverse, band of convection near the northern end of the system. These features make it difficult for aircraft to fly along the northern end of the convective line where cyclonic vorticity is often concentrated (e.g. Weisman 1993) and where detailed observations of the environment and airflow through the storm are needed. Hence, GBOS will concentrate on the region from the apex of the bow, northward, to the end of the convective line.

The mobile sounding systems will be positioned to augment the aircraft dropsondes, taking into account the areas that may be difficult for the aircraft to reach. This will permit analysis of the maximum scale of environmental forcing given the combined observational network. Moreover, it will ensure that we have adequate information on the inflow thermodynamics for model initiation and validation.

MIPS will be deployed slightly to the cool side of any pre-existing boundaries and in the area of high-resolution dual-Doppler coverage. This configuration will provide data to examine the interaction of the storm-induced mesoscale and convective-scale circulations with stable boundary layers and will aid in determining how to evaluate the potential for severe surface winds.

Mobile mesonets will be used to document the surface characteristics of the cold pool, especially the maximum wind gusts and the pressure gradients across the cold pool.

The ground-based Doppler radars will be deployed to provide high resolution (~1 km), rapid (~3 minute) sector scans over the northern portion of the bow echo. If three radars are available, we will use the third to extend the region of coverage unless the third radar is polarimetric. In that case, the polarimetric radar will be operated within the best dual-Doppler lobe (given local terrain and storm structure) and approximately 15-30 km from the MIPS. Data from the polarimteric radar will be combined with in situ microphysical data from the aircraft and vertical profiles of reflectivity from the MIPS to derive estimates of the raindrop size distribution. Evaporation of rain, and hence the strength of the cold pool, is assumed to be sensitive to the size spectrum of the rain.

4.2 *Bow Echoes Without Aircraft*

The experiment plan requires GBOS and the aircraft component to be able to address BAMEX objectives independently. This will maximize success of the overall program since the aircraft may be directed to an area outside GBOS' reach and GBOS may operate on days that the aircraft are unavailable. In these events, GBOS will initially deploy in the vicinity of pre-existing boundaries (Fig. 1), somewhat eastward of the area forecasted to be where storms will initiate. GBOS will document the vertical and horizontal structure of the boundary and will, hopefully, be in position to later address the interaction of convection with boundaries. Being slightly eastward of the forecast initiation zone will also give some opportunity for course correction once storms have triggered.

Prior to convective development, the mobile sounding systems will be deployed on each side of the boundary to document the vertical thermodynamic structure of the convergent thermal zone. Mobile mesonets will race across the boundary to document its movement as well as its strength. MIPS will again be deployed on the cool side of the boundary while the mobile Dopplers will provide volumes scans (including velocity-azimuth display scans) for wind retrievals across the boundary and through the lower levels of the atmosphere.

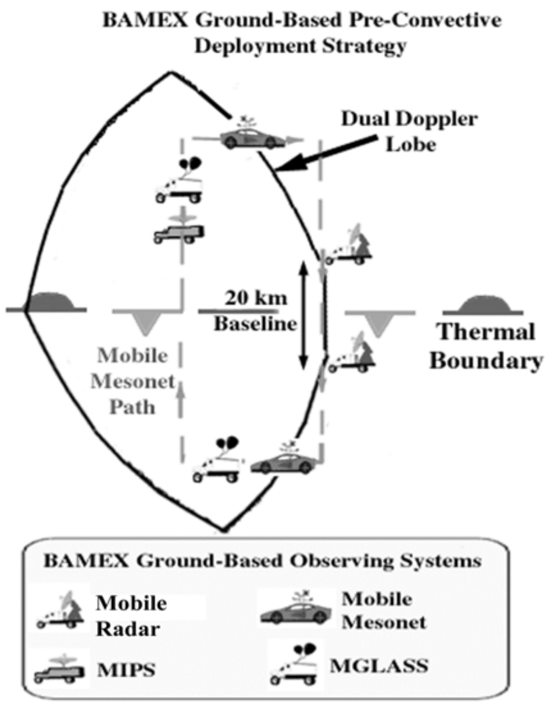

Figure 1. Pre-convective deployment strategy of GBOS during a bow echo mission.

Once convection has initiated, the mobile soundings and mesonets may be redeployed as necessary to document the inflow and low level outflow of the storms over a broader scale. The scanning Doppler radars will be repositioned to provide a larger area of coverage (Fig. 2). Volume scans will be obtained every ~3 minutes for wind retrievals. Operations will continue until no convection is within 200 km of the nearest scanning radar.

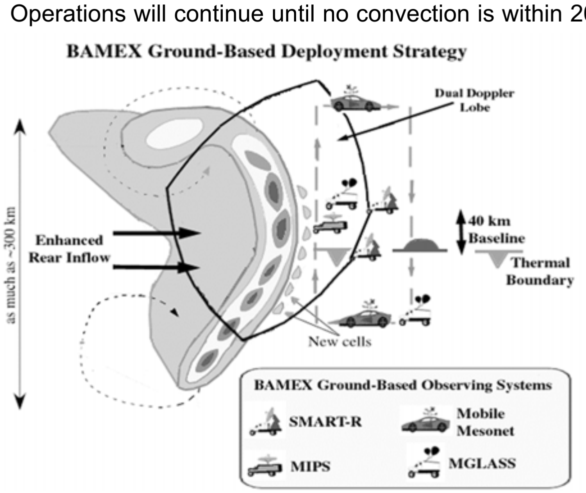

Figure 2. Deployment strategy of GBOS during mature bow echo mission.

4.3 *MCV Missions*

By necessity, the dropsonde aircraft will be a critical part of any MCV mission. How GBOS will compliment the aircraft operations depends on the location of GBOS relative to the MCV''s forward flank.

If the forward flank of the circulation has already passed the GBOS network, GBOS will focus on the center of the circulation, especially any secondary bands of convection that develop near the MCV center. The goal will be to measure the thermodynamic structure of the vortex and the strength of lifting associated with the propagating circulation.

The mobile soundings will be deployed to augment the dropsondes. MIPS will be positioned along the track of the vortex's center to provide detailed vertical structure of the vortex. The mobile mesonets will perform long transverses across the storm to document the strength of the cold pool and to map local convergent zones that may provide additional lifting for convective redevelopment. If convective activity is minimal, the scanning Dopplers will collect full volume scans for wind retrievals interspersed with Extended Velocity-Azimuth Display (EVAD; Srivastava et al. 1986) scans for improved retrieval of mean vertical motion in the storm system. Once convective activity begins, the scanning radars will focus on providing high temporal and spatial dual-Doppler coverage to evaluate the impact of the convection on the strength and structure of the mesoscale vortex.

If the forward flank of the circulation is upwind of the GBOS network, GBOS will be deployed ahead of the circulation and will focus on convective development along the periphery of the circulation. The observational strategy will be similar to that for mapping the vortex's center. However, the scale of the mobile mesonet deployment will be smaller to focus on the leading edge of any discernible cold pool.

5. LOGISTICS

BAMEX is the first major field campaign to have a completely mobile, continuously forward-deployed ground-based component. Previous campaigns have generally deployed from a fixed site base of operations for short periods of time. In BAMEX, the GBOS instruments will gather in St. Louis, MO at the beginning of the project and immediately deploy to the forecasted region of activity. At the beginning of each day (Fig. 3), the position of GBOS will be evaluated and decisions made to move as needed to maximize the potential for intercepting severe bow echoes or MCVs. The ability to redeploy on a daily basis is crucial given the climatology of the storms of interest.

A digital database of topography, aerial photos, roads, and airports has been generated to assist with deployment planning for GBOS. The database is used in a specifically created software package that can ingest images of radar, satellite, and storm track information from the web and display those using a common scale. Preliminary Doppler radar positions can be entered and the software will automatically overlay the dual-Doppler lobes relative to the ingested images (Fig. 4). Hence, we will be able to select the target location of each GBOS instrument before checking out of the hotel each morning. An advance scout vehicle will travel ahead of the GBOS caravan to finalize site selection based on local conditions.

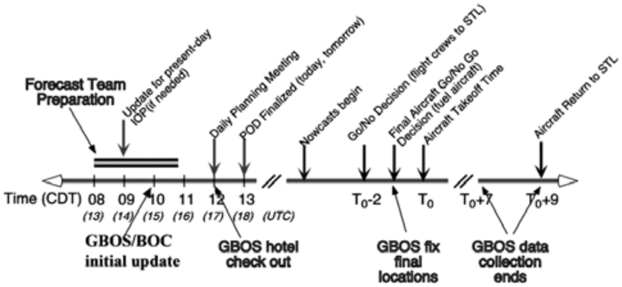

Figure 3. Daily schedule for operations planning.

Additionally, a quick county-by-county scale reference guide has been created for the entire BAMEX domain that shows regions that are best avoided. These include areas of significant topography and dense tall vegetation.

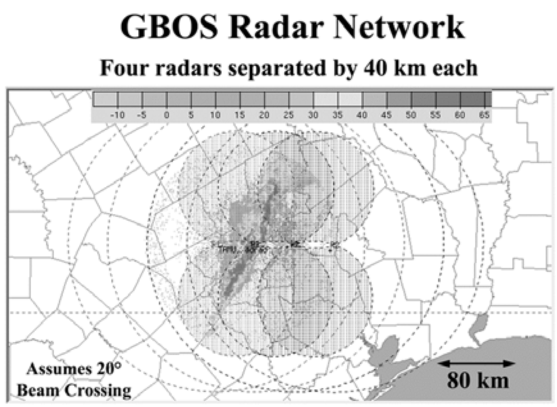

Figure 4. Example of GBOS deployment software showing the dual-Doppler coverage for four radars separated by 40 km each.

More than a man-year of effort has already been spent to prepare for the challenges of deploying GBOS during BAMEX. It is hoped that this effort will allow us to successfully pre-select the general location and configuration of the ground-based network at the beginning of each operational day. We expect that the most difficult instruments to field will be the scanning Dopplers. Once those sites have been established, the rest of the network can be more easily set up since the remaining instruments have fewer operational restrictions.

To facilitate the logistics of moving roughly twenty people on a daily basis, replenishing expendables (like helium for the soundings), and arranging travel for personnel and shipping of equipment, a dedicated project manager for GBOS will reside at the BAMEX Operations Center (BOC). That person will be responsible for all the day-to-day business needed to support the mobile GBOS. Scientists in the field will be able to concentrate on collecting the observations.

6. COORDINATION

Primary direction of the GBOS deployment will be provided by a GBOS Facilities Coordinator (GBOS-FC) residing at the BOC, in consultation with the GBOS Team Leader— the lead principal investigator in the field. The GBOS-FC will be responsible for working with the forecasters and the project scientist to develop the initial plan for GBOS. The Team Leader is responsible for communicating with and representing all the investigators in the field. Each day at 1500 UTC, the GBOS-FC and Team Leader will discuss the plan and reach mutual agreement on the general deployment strategy. The Team Leader has the responsibility of implementing the deployment plan.

The GBOS-FC will continue to provide weather updates to the Team Leader throughout the day. The Team Leader, working with each instrument lead investigator, will finalize site selection and begin operational coordination of the data collection. The GBOS-FC and Team Leader will continue to communicate so that information between the airborne and ground-based components of the network can be shared in real-time.

7. ACKNOWLEDGEMENTS

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