REQUEST FOR NRL P-3, ELDORA, MGLASS, ISFF, DROPSONDE AND SONDE SUPPORT
BAMEX (BOW ECHO AND MCV EXPERIMENT)
NCAR/ATD -OCTOBER 2002 OFAP MEETING

Submitted on 15 June 2002

PART I: GENERAL INFORMATION

Corresponding Principal Investigator

Name	Chris Davis
Institution	NCAR/MMM
Address	P.O. Box 3000, Boulder, Colorado 80307
Phone	303-497-8990
FAX	303-497-8181
Email	cdavis@ucar.edu

Project Description

Project Title	Bow Echo and MCV Experiment (BAMEX)
Co-Investigator(s) and Affiliation(s)	Facility PIs: Michael Biggerstaff, University of Oklahoma Roger Wakimoto, UCLA Christopher Davis, NCAR David Jorgensen, NSSL Kevin Knupp, University of Alabama, Huntsville Morris Weisman (NCAR) David Dowell (NCAR) Other Co-investigators (major contributors to science planning): George Bryan, Penn State University Robert Johns, Storm Prediction Center Brian Klimowski, NWSFO, Rapid City, S.D. Ron Przybylinski, NWSFO, St. Louis, Missouri Gary Schmocker, NWSFO, St. Louis, Missouri Jeffrey Trapp, NSSL Stanley Trier, NCAR Conrad Ziegler, NSSL A complete list of expected participants appears in Appendix A of the Science Overview Document (SOD).
Location of Project	St. Louis, Missouri
Start and End Dates of Project	20 May - 6 July 2003

ABSTRACT OF PROPOSED PROJECT

BAMEX is a study using highly mobile platforms to examine the life cycles of mesoscale convective systems. It represents a combination of two related programs to investigate (a) bow echoes, principally those which produce damaging surface winds and last at least 4 hours and (b) larger convective systems which produce long lived mesoscale convective vortices (MCVs). MCVs can serve as the focus of new convection and play a key role in multi-day convective events affecting a swath sometimes more than 1000 km in length with heavy to perhaps flooding rains. The main objectives regarding bow echoes are to understand and improve prediction of the mesoscale and cell-scale processes that produce severe winds. For MCV producing systems the objectives are to understand MCV formation within MCSs, the role of MCVs in initiating and modulating convection, the feedback of convection onto MCV intensity, and to improve the overall predictability of the vortex-convection coupled system.

We propose to use three aircraft, two equipped with dual Doppler radar capability (NRL P-3, NOAA P-3), the third equipped with dropsondes (Lear jet), to map the mesoscale evolution of long-lived MCSs including the development of mesoscale vortices and rear-inflow jets. Dropsondes will be used to document environmental structure, thermodynamic structure of the stratiform region (where rear-inflow jets and MCVs reside) and to capture the structure of mature MCVs in the absence of convection. In addition, a mobile array of ground-based instruments will be used to augment airborne radar coverage, document the thermodynamic structure of the PBL including any existing convergence boundaries and probe the surface cold pool and measure surface horizontal pressure and wind variations behind the leading convective line. The combination of aircraft and ground-based measurements is important for understanding the coupling between boundary-layer and free-tropospheric circulations within MCSs, and, in particular, how the rear-inflow penetrates to the surface in nocturnal severe wind cases.

Through the use of staggering of aircraft and because of the overall mobility of facilities, we anticipate sampling a significant fraction of the life cycle of MCSs and, in some cases we will be able to cover the entire life cycle (12 h). Because of the large domain of BAMEX, and consideration of both high shear and low shear environments, a large fraction of the long-lived convective systems that form in the central U.S. between late May and early July will be suitable for investigation, although BAMEX is specifically targeting the structural extremes of the MCS spectrum. We anticipate flying into at least 20 MCSs during the 6-week project and thereby obtaining a large sample of cases with high quality data for in depth analysis.

PROPOSAL SUMMARY

What are the scientific objectives of the proposed project?

Bow Echoes:

1) Relate bow echo behavior to synoptic scale or mesoscale environment.
2) Characterize bow echo morphology and evolution.
3) Document conditions leading to occurrence of severe weather.
4) Assess bow echo predictability.

MCVs:

5) Document the development of MCVs within organized mesoscale convective systems.
6) Document the redevelopment of convection or the lack thereof within MCV cases.

7) Determine the feedback of convective redevelopment on the lifecycle of MCVs.
8) Assess predictability of MCV formation, maintenance and attendant precipitation.

What are the hypotheses and ideas to be tested?

Bow Echoes:

There are systematic, observable precursors to severe weather in bow echoes based on

(a) environmental parameters, which give lead times of several hours but are applicable only if storms develop, and
(b) storm structure, which may give lead times of up to 1 hour.

MCVs:

(a) Mesoscale lifting induced by MCVs in shear focuses convection.
(b) Upscale growth of convection within the radius of maximum wind is crucial for vortex reintensification and thus promotion of multi-day MCV-convective cycles.

What previous experiments of similar type have been performed by you or other investigators?

PRE-STORM (1985)

Give references of results published and explain how the proposed experiment and the use of the requested facilities go beyond what has already been done:

Brandes, E. A., 1990: Evolution and structure of the 6-7 May 1985 mesoscale convective system and associated vortex. *Mon. Wea. Rev*., **118**, 109-127.

Carbone, R. E., J. W. Conway, N. A. Crook, M. W. Moncrieff, 1990: The generation and propagation of a nocturnal squall line. Part I: Observations and implications for mesoscale predictability. *Mon. Wea. Rev*., **118**, 26-49.

Cunning, J. B., 1986: The Oklahoma-Kansas preliminary regional experiment for STORM-Central. Bull. *Amer. Meteor. Soc*., **67**, 1478-1486.

Gallus Jr., William A., Richard H. Johnson, 1995: The Dynamics of Circulations within the Trailing Stratiform Regions of Squall Lines. Part I: The 10-11 June PRE-STORM System. *J. Atmos. Sci*., **52**, 2161-2187.

Houze, R. A., Jr. S. A. Rutledge, M. I. Biggerstaff, and B. F. Smull, 1989: Interpretation of Doppler weather radar displays of midlatitude mesoscale convective systems. *Bull Amer. Meteor. Soc*., **70**, 608-619.

Rutledge, S. A., R. A. Houze, M. I. Biggerstaff, and T. J. Matejka, 1988: The Oklahoma-Kansas Mesoscale Convective System of 10-11 June 1985: Precipitation Structure and Single-Doppler Radar Analysis. *Mon. Wea. Rev*., **116**, 1409-1430.

Loehrer, Scot M., Richard H. Johnson, 1995: Surface Pressure and Precipitation Life Cycle Characteristics of PRE-STORM Mesoscale Convective Systems. *Mon. Wea. Rev*., **123**, 600-621.

Smull, B. F. and J. A. Augustine, 1993: Multiscale analysis of a mature mesoscale convective complex. *Mon. Wea. Rev*., **121**, 103-132.

Trier, S. B., and D. B. Parsons, 1993: Evolution of environmental conditions preceding the development of a nocturnal mesoscale convective complex. *Mon. Wea. Rev*., **121**, 1078-1098.

Zhang, Da-Lin, Kun Gao, David B. Parsons, 1989: Numerical Simulation of an Intense Squall Line during 10-11 June 1985 PRE-STORM. Part I: Model Verification. *Mon. Wea. Rev*., **117**, 960-994.

BAMEX will extend PRE-STORM in the following ways:
1) Use of mobile platforms to allow mapping of large portion of MCS lifecycle.
2) Use of Airborne dual Doppler radars.
3) Dropsondes to investigate mesoscale thermodynamic structure.
4) Focus on predictability of attendant severe weather.
5) Extensive existing observational infrastructure (WSR-88D, wind profilers, mesonets) not present during PRE-STORM.

How will the instruments/platforms requested be used to test the hypotheses and address each of the objectives?
Objectives to be addressed by each type of observation are listed in parentheses and identified by their number given above (1-8).

ELDORA:
(a) sample inflow conditions (use in-situ data from aircraft) (1)
(b) document evolution of leading convective line (2),(7)
(c) map low-level winds near strong convective cells (3)
(d) determine mesoscale updraft intensity and structure (5)
(e) provide observations for predictability tests using variational data assimilation (4), (8)

Dropsondes:
(a) document mesoscale thermodynamic structure within stratiform region (2), (5), (7)
(b) document mesoscale structure of mature MCV including retrieval of mesoscale vertical motion (6)
(c) provide observations for predictability tests using conventional and variational data assimilation (4), (8)

Mobile Soundings:
(a) characterize kinematic and thermodynamic profiles of the environment ahead of an MCS. (1), (3)

What results do you expect and what are the limitations?
Given that there will also be the NOAA P-3 aircraft with dual Doppler radar and a ground-based mobile unit consisting of 2 C-band Doppler radars, a boundary layer wind and thermodynamic profiler, soundings and 4-station mesonet, in addition to the National Weather Service operational observational infrastructure, and given the system following strategy of BAMEX, we should be able to:
(1) Resolve the evolution and structure of mesoscale circulation features within MCSs, including mesoscale vortices and rear-inflow jets.
(2) Determine how damaging mesoscale winds reach the surface, especially in nocturnal bow echoes.
(3) Document structural aspects of mature MCVs that help trigger new convection.
(4) Determine critical processes in the re-intensification of MCVs.

BAMEX may be able to:
(1) Determine mechanisms responsible for tornado genesis within bow echoes.
(2) Determine mechanisms responsible for the decay of large MCSs following sunrise.

We expect to sample a large number of convective systems, probably between 20 and 30, given the large domain of BAMEX (600 km radius from St. Louis; see science overview document) and the climatological frequency with which significant, organized convection occurs in environments that are either characterized by strong shear (indicating bow echoes) or weak shear (indicating MCVs) and large CAPE during late May through early July. The desired structures will only emerge in a subset of these cases, but all apparently favorable situations will be investigated if possible.

Limitations will be:
(1) The ground-based systems and aircraft will not always be able to observe the same convective system. However, each component separately can address a number of BAMEX objectives. Furthermore, if airborne and ground-based facilities can be coordinated, unprecedented datasets will likely be obtained.

(2) Tornado formation in bow echoes is highly transient and may not be well-captured by available observations. However, since little is known about tornadogenesis in bow echoes, any observations could lead to a major advance. Thus, this portion of BAMEX has a higher risk than the rest of the experiment, but also a higher possible payoff.

(3) We would like sondes dropped from 40,000 feet or higher, and hence are interested in leasing a Lear jet like the one used for IHOP. If FAA restrictions prevent dropping from this altitude, we can drop from 26,000-30,000 feet or so without seriously compromising the objectives of BAMEX. Difficulties caused by electrification within the stratiform region are possible, again, a motivation to seek the highest flying aircraft available. We recognize that drops over heavily populated areas will not occur, but we believe that we can work around this limitation.

Provide details about the experiment design:
For observing a mature MCS, ELDORA will observe the leading line convection, the NOAA P-3 radar will map winds in the trailing stratiform region with its dual Doppler capability and the dropsonde aircraft will perform drops with a minimum of 60-90 km spacing (depending on altitude of aircraft) to cover the stratiform region and some of the area outside the precipitation shield. The NOAA P-3 will repeatedly traverse the along-line dimension of the stratiform region, requiring about 30 minutes to complete a 200 km segment (a typical scale of MCS). The aircraft bearing ELDORA will execute similar along-line passes immediately ahead of the convective system. The dropsonde aircraft will execute passes orthogonal to the NOAA P-3 passes, and offset subsequent passes so as to cover the length of the convective system. A total of about 30 sondes will be dropped during examination of bow echo systems. For MCVs that outlive their parent convection, as many as 45 dropsondes may be used on a given mission if the dropsonde jet can refuel and fly twice within the crew duty limit. In cases of mature MCVs, Doppler aircraft will likely not be used until convection re-organizes near the vortex.

The ground-based systems will be fixed during the passage of the MCS. Initially, they will sample the environment ahead of the system, with special attention to any thermal boundaries encountered in the boundary layer, especially those oriented normal to the approaching leading convective line. As a convective system approaches, radars will shift from clear-air scanning mode (emphasizing the PBL) to a storm-scanning mode to derive low-level winds. When the system is overhead, the mobile mesonet will probe the characteristics of the cold pool while the mobile profiling system documents the boundary-layer character, including stability and PBL depth. After the system passes, the radars will reverse their scanning direction to follow the retreating storm. Ground based systems will not attempt to chase retreating convective systems, but can be redeployed locally if there is another system approaching. In general, aircraft and ground-based systems will not be strongly coordinated, but the various ground-based systems will be highly coordinated among each other.

The base of operations will be St. Louis, Missouri, where we have NWSFO (with 2 BAMEX PIs) and a major airport. The range of BAMEX is about 600 km from St. Louis. Because BAMEX is not emphasizing convective initiation, we can afford to wait until convection appears to be organizing in order to deploy the aircraft. Ground based systems will be generally based away from St. Louis and will use one of several designated cities for a remote base where lodging and supplies are available. We anticipate that 4-6 hours of driving will be needed to position ground based systems. Thus, there will be more need to predict convective organization for deployment of ground-based systems than for the aircraft, and a greater risk that they will not intercept the desired MCS.

EDUCATIONAL BENEFITS OF THE PROJECT

List anticipated number of graduate and undergraduate students who will be involved directly and in a meaningful way in field work and/or data analysis related to this project:
Numerous graduate students and a few undergraduates will be involved in both the field phase and in data analysis. These will represent UCLA (2), University of Oklahoma and Texas A&M (7-8 total, supervised by M. Biggerstaff), University of Alabama, Huntsville (3-4), University at Albany, SUNY (1-2). Penn State, Colorado State University, the University of Illinois at Champaign and St. Louis University will each have 1-3 students participating. NCAR may use one undergraduate (through the SOARS program). The total of students, both graduate and undergraduate, expected to be involved is therefore between about 15 and 20.

Do you plan to enhance undergraduate and/or graduate classes with hands-on activities and observations related to this project?
Nearly all the universities listed above will do so.

Will you develop new curricula that will be related to the project?
The University at Albany SUNY, Penn State University and the University of Illinois tentatively plan to develop new curricula related to the project.

Do you plan any outreach activities to elementary and/or secondary school students and/or the public related to the project?
UAH and the University of Illinois may engage in this activity.

Do you plan to have any interactions with primary and secondary school educators to involve them in the project?
Not at this time.

Are you cooperating with an agency outreach program during this project?
No

Will information about the project's activities, results, data, and publications be made available via the internet?
Absolutely.

PREVIOUS RESEARCH PROJECT EXPERIENCE

Past ATD support:

Christopher A. Davis
Projects: WISPIT and WISP'94
Facilities: Soundings
Publications:

Davis, C. A., 1995: Observations and modeling of a mesoscale cold surge during WISPIT. *Mon. Wea. Rev.*, **123**, 1762-1780.

Davis, C. A., 1997: Mesoscale anticyclonic circulations in the lee of the central Rocky Mountains *Mon. Wea. Rev.*, **125**, 2838-2855.

Richard H. Johnson
Projects: PRE-STORM and TOGA COARE
Facilities: NCAR PAM mesonet stations and NCAR/NOAA Integrated Sounding systems:
Publications:

Knievel, J.C., and R.H. Johnson, 1998: Pressure transients within MCS mesohighs and wake lows, *Mon. Wea. Rev.*,**126**, 1907-1930.

Loehrer, S.M., and R.H. Johnson, 1995: Surface pressure and precipitation life cycle characteristics of PRE-STORM mesoscale convective systems. *Mon. Wea. Rev.*, **123**, 600-621.

Johnson, R.H., B.D. Miner, and P.E. Ciesielski, 1995: Circulations between mesoscale convective systems along a cold front.*Mon. Wea. Rev.*, **123**, 585-599.

Gallus, W.A., Jr., and R.H. Johnson, 1995: The dynamics of circulations within the trailing stratiform regions of squall lines: Part I: The 10-11 June PRE-STORM system. *J. Atmos. Sci.*, **52**, 2161-2187

Gallus, W.A., Jr., and R.H. Johnson, 1995: The dynamics of circulations within the trailing stratiform regions of squall lines: Part II: Influence of the convective line and ambient environment. *J. Atmos. Sci.*, **52**, 2188-2211.

Lin, X., and R.H. Johnson, 1994: Heat and moisture budgets and circulation characteristics of a frontal squall line. *J. Atmos. Sci.*, **51**, 1661-1681.

Bernstein, B.C., and R.H. Johnson, 1994: A dual-Doppler radar study of an OK PRE-STORM heat burst event. *Mon. Wea. Rev.*, **122**, 259-273.

Vescio, M.D., and R.H. Johnson, 1992: The wind response to transient mesoscale pressure fields associated with squall lines. *Mon. Wea. Rev*., **120**, 1837-1850.

Johnson, R.H., and D.L. Bartels, 1992: Circulations associated with a mature-to-decaying midlatitude mesoscale convective system. Part II: Upper-level features. *Mon. Wea. Rev*., **120**, 1301-1320.

Gallus, W.A., Jr., and R.H. Johnson, 1992: The momentum budget of an intense midlatitude squall line. *J. Atmos. Sci*., **49**, 422-450.

Stumpf, G.J., R.H. Johnson, and B.F. Smull, 1991: The wake low in a midlatitude mesoscale convective system having complex convective organization. *Mon. Wea. Rev*., **119**, 134-158.

Gallus, W.A., Jr., and R.H. Johnson, 1991: Heat and moisture budgets of an intense midlatitude squall line. *J. Atmos. Sci*., **48**, 122-146.

Johnson, R.H., W.A. Gallus Jr., and M.D. Vescio, 1990: Near-tropopausevertical motion within the trailing stratiform region of a midlatitude squall line. *J. Atmos. Sci*., **47**, 2200-2210.

Johnson, R.H., S. Chen, and J.J. Toth, 1989: Circulations associated with a mature-to-decaying midlatitude mesoscale convective system. Part I: Surface features - heat bursts and mesolow development. *Mon. Wea. Rev*., **117**, 942-959.

Johnson, R.H., and P.J. Hamilton, 1988: The relationship of surface pressure features to the precipitation and air flow structure of an intense midlatitude squall line. *Mon. Wea. Rev*., **116**, 1444-1472.

Johnson, R.H., and P.E. Ciesielski, 2000: Rainfall and radiative heating rate estimates from TOGA-COARE atmospheric budgets. *J. Atmos. Sci*., **57**, 1497-1514.

Johnson, R.H., 2000: Surface mesohighs and mesolows. *Bull. Amer. Meteor. Soc*. Special issue honoring Tetsuya Fujita, (in press).

Johnson, R.H., T.M. Rickenbach, S.A. Rutledge, P.E. Ciesielski, and W.H. Schubert,1999: Trimodal characteristics of tropical convection, *J. Climate***,** **12**, 2397-2418.

Haertel, P.T., and R.H. Johnson, 1998: Two-day disturbances in the equatorial western Pacific, *Q.J.R.M.S*., **124**, 615-636.

Ciesielski, P.E., L. Hartten and R.H. Johnson, 1997: Impacts of merging profiler and rawinsonde winds on TOGA COARE analyses, *J. of Atmos*. and *Oceanic Tech*., **14**, 1264-1279.

Johnson, R.H., and X. Lin, 1997: Episodic Trade-Wind Regimes over the western Pacific warm pool. *J. Atmos.Sci*., **54**, 2020-2034.

Godfrey, J.S., R.A. Houze, Jr., R.H. Johnson, R. Lukas, J.-L. Redelsperger, A. Sui and R. Weller, 1998: Coupled ocean-atmosphere response experiment: An interim report. *J. Geophys. Res.*, **103**, 14395-14450.

Lin, X., and R.H. Johnson, 1996: Kinematic and thermodynamic characteristics of the flow over the western pacific warm pool during TOGA/COARE. *J. Atmos.Sci*., **53**, 695-715.

Lin, X., and R.H. Johnson, 1996: Heating, moistening and rainfall over the western Pacific warm pool during TOGA COARE. *J. Atmos. Sci*., **53**, 3367-3383.

Johnson, R.H., P.E. Ciesielski and K.A. Hart, 1996: Tropical inversions near the 0°C level. *J. Atmos. Sci*., **53**, 1838-1855.

Wen-Chau Lee
Projects: TOGA COARE, VORTEX, FASTEX, IHOP
Facilities: ELDORA

Lee, W.-C., R. E. Carbone, and R. M. Wakimoto, 1992: The evolution and structure of the bow echo/microburst events. Part I: The microburst. *Mon. Wea. Rev*., **120**, 2188-2210.
Lee, W.-C., R. M. Wakimoto, and R. E. Carbone, 1992: The evolution and structure of the bow echo/microburst events. Part II: The bow echo. *Mon. Wea. Rev*., **120**, 2211-2225.
Lee, W.-C., F. D. Marks, and R. E. Carbone, 1994: Velocity Track Display (VTD) – A technique to extract primary vortex circulation of a tropical cyclone in real-time using single airborne Doppler radar data. *J. Atmos. Oceanic Technol*., **11**, 337-356.
Testud, J., P. H. Hildebrand, and W.-C. Lee, 1995: A procedure to correct airborne Doppler radar data for navigation errors, using the echo returned from the earth surface. *J. Atmos. Oceanic Technol.,* **12**, 800-820.
Carbone, R. E., W. A. Cooper, and W.-C. Lee, 1995: On the forcing of flow reversal along the windward slopes of Hawaii. *Mon. Wea. Rev*., **123**, 3466-3480.
Hildebrand, P. H., W.-C. Lee, C. A. Walther, C. Frush, M. Randall, E. Loew, R. Neitzel, R. Parsons, J. Testud, F. Baudin, and A. LeCornec, 1996: The ELDORA/ASTRAIA airborne Doppler weather radar design and observations from TOGA COARE. *Bull. Amer. Meteor. Soc.,* **77**, 213-232.
Hildebrand, P. H., and W.-C. Lee, 1996: Reply to Comments on "The ELDORA/ASTRAIA airborne weather radar: High-resolution observations from TOGA COARE." *Bull. Amer. Meteor. Soc.,* **77**, 2950-2952.
Wakimoto, R. M., W.-C. Lee, H. B. Bluestein, C.-H. Liu, and P. H. Hildebrand, 1996: ELDORA observations during VORTEX 1995. *Bull. Amer. Meteor. Soc.,* **77**, 1465-1481.
Li, J., D. Chen, and W.-C. Lee, 1997: Heavy rainfall event in Taiwan. *Mon. Wea. Rev*., **125,** 1060-1082.
Carbone, R. E., J. D. Tuttle, W. A. Cooper, V. Grubisic, and W.-C. Lee, 1998: Tradewind rainfall near the windward coast of Hawaii. *Mon. Wea. Rev*., **126,** 1060-1082.

Roger Wakimoto
Projects: JAWS, MIST, CINDE, CaPE, ERICA, VORTEX, FASTEX, IHOP
Facilities: ground based and air-borne Doppler (ELDORA) radars
Publications (last 5 years):

Wakimoto, R.M., W.-C. Lee, H.B. Bluestein, C.-H. Liu, and P.H. Hildebrand, 1996: ELDORA observations during VORTEX 95. *Bull Amer. Meteor. Soc*., **77**, 1465-1481.
Atkins, N.T., and R.M. Wakimoto, 1997: Influence of the synoptic-scale flow on sea-breezes observed during CaPE. *Mon. Wea. Rev*., **125**, 2112-2130.
Wakimoto, R.M., and C.-H. Liu, 1998: The Garden City, Kansas storm during VORTEX 95. Part II: The wall cloud and tornado. *Mon. Wea. Rev*., **126**, 393-408.
Wakimoto, R.M., C-H. Liu, and H. Cai, 1998: The Garden City, Kansas storm during VORTEX 95. Part I: Overview of the storm's life cycle and mesocyclogenesis. *Mon. Wea. Rev*., **126**, 372-392.
Neiman, P.J., and R.M. Wakimoto, 1999: The interaction of a Pacific cold front with shallow air masses east of the Rocky Mountains. *Mon. Wea. Rev*., **127**, 2102-2127.
Wakimoto, R.M., and B.L. Bosart, 2000: Airborne radar observations of a cold front during FASTEX. *Mon. Wea. Rev*., **128**, 2447-2470.
Wakimoto, R.M., and H. Cai, 2000: Analysis of a non-tornadic storm during VORTEX 95. *Mon. Wea. Rev*., **128**, 565-592.

Wakimoto, R.M., 2001: Convectively Driven High Wind Events. *Severe Convective Storms*, *Meteor. Monogr.*No. 50, Amer. Meteor. Soc., 255-298.

Morris Weisman
Projects: VORTEX and STEPS
Facilities: Mobile soundings and S-POL
Publications:
Atkins, N. T., M. L. Weisman, and L. J. Wicker, 1999: The influence of preexisting boundaries on supercell evolution. *Mon. Wea. Rev*., **127**, 2910-2927,

Conrad Ziegler
Projects: COPS-91, VORTEX, IHOP
Publications:
Hane, C., C. Ziegler, and H. B. Bluestein, 1993: Investigation of the dryline and convective storms initiated along the dryline: Field experiments during COPS-91. *Bull. Amer. Meteor. Soc*., **74**, 2133-2145.
Shaw, B., R. Pielke, and C. Ziegler, 1997: A three dimensional numerical simulation of a Great Plains dryline. *Mon. Wea. Rev*., **125**, 1489-1506.
Ziegler, C., T. Lee, and R. Pielke, 1997: Convective initiation at the dryline: A modeling study. *Mon. Wea. Rev*., **125**, 1001-1026.
Atkins, N., R. Wakimoto, and C. Ziegler, 1998: Observations of the fine-scale structure of a dryline during VORTEX 95, *Mon. Wea. Rev*., **126**, 525-550.
Ziegler, C., and E. Rasmussen, 1998: The initiation of moist convection at the dryline: Forecasting issues from a case study perspective. *Wea. Forecasting*, **13**, 1106-1131.

Expected publication date and journal:
Monthly Weather Review

FUNDING AGENCY INFORMATION

Funding Agency	National Science Foundation
Contract Officer	Steve Nelson
Contract Identification	
Proposal Status	
Approximate Amount budgeted	

PART II: FACILITY-SPECIFIC REQUESTS

AIRCRAFT: NRL P-3

Aircraft Operations

Preferred flight period	20 May 2003 - 6 July 2003
Number of flights required	20
Estimated duration of each flight	9 hours
Number of flights per day	1
Preferred base of operation	St. Louis
Alternate base	
Is Patuxent River Naval Air Station in Lexington Park, Maryland (base for the NRL P-3) acceptable as your operations base?	No
Average flight radius from base	800 km
Desired flight altitudes(s)	300 m up to 5 km
Particular part(s) of day for flights	Any time of the day
Statistically, how many days during specified period should be acceptable for flight operations?	25-35 (this includes all days on which organized convection develops somewhere in the BAMEX domain and conditions appear favorable for either bow echoes or MCVs)
Number of scientific observers on each flight *	6

Scientific rationale for the use of this aircraft in the proposed project:
The NRL P-3 with the NCAR ELDORA is essential for the success of BAMEX. The dual Doppler radar analysis using the high resolution ELDORA data is critical in determining the storm structure at the leading edge of the squall line. This, in conjunction with the dual-Doppler radar wind analysis from the NOAA P-3 behind the squall line and the thermodynamic structure obtained from the dropsonde aircraft, will describe the kinematic and thermodynamic structure of the Bow Echoes and MCV-producing MCSs.

Description of desired flight pattern(s), priorities, and estimate number of flights:
(Please include graphics and flight pattern images as needed)
1) The flight track for the mature MCS involving all three aircraft is shown in Figure 2.1. The strategy is to use the NRL-P3 with the NCAR ELDORA and the NOAA P-3 on either side of the leading convection of the bow-echo system in order to map the complete circulation near the leading line and rearward into the stratiform region. The NRL P-3 will focus on the inflow region in order to document the bowing process of a linear convective system. The NOAA P-3 will sample a larger scale stratiform region (up to 80 km) behind the convective line to document the rear inflow jet associated with the bow-echo system. The actual sampling area of these two aircraft depends on the size of the MCS. The dropsonde aircraft will probe the area behind the convective line, dropping sondes to help document the thermodynamic structure of the stratiform region. Sondes will be dropped in front of the convective line when the aircraft approaches and

departs the MCS in order to sample the environmental characteristics.

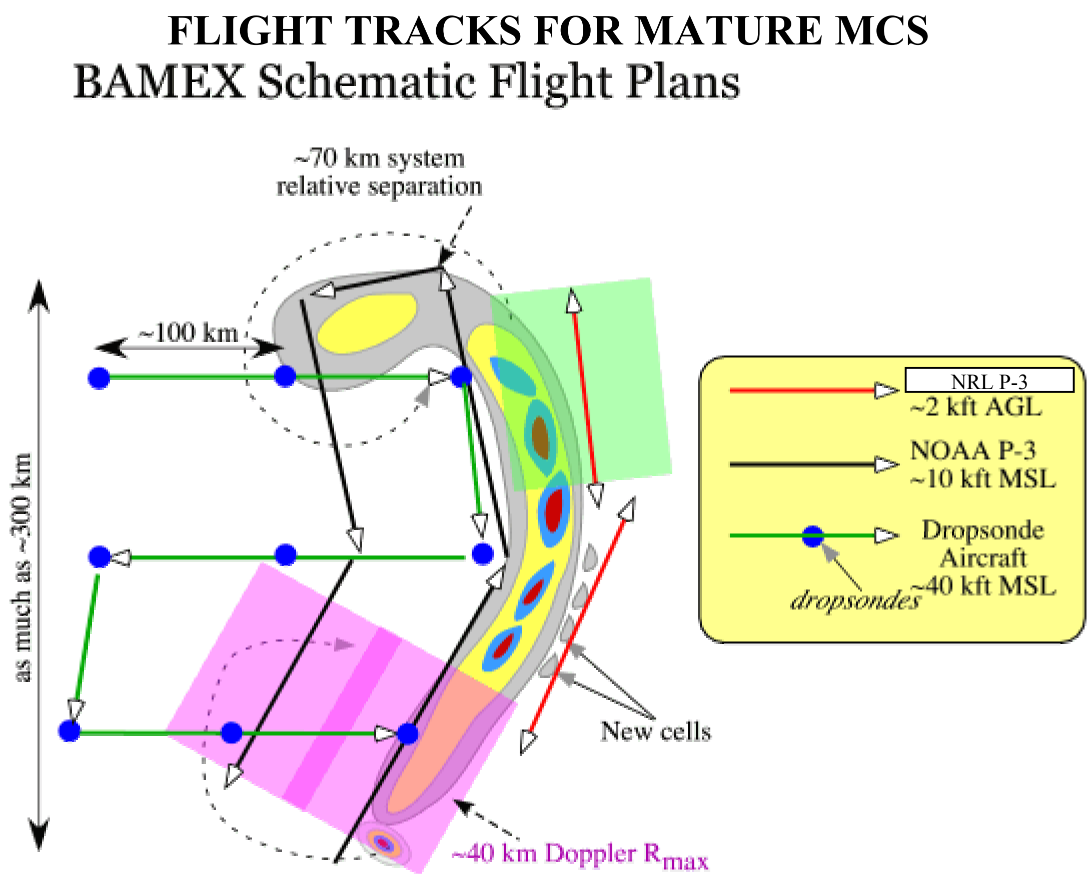


Fig. 2.1 *Schematic illustration of flight patterns in a mature long-lived MCS by the three BAMEX aircraft. The ~40 km nominal maximum range of the airborne Doppler radars are shown as the pink shading (for the NOAA P-3), and green shading (for the NRL P-3). Hypothesized mid-level circulation in the systems rear is shown schematically by the dashed arrows. It would take the NOAA P-3 about 90 minutes and the jet about 50 minutes to complete their patterns given the ~300 km size of the bow-echo shown in the schematic. Each flight pattern leg length would be scaled by the size of the precipitation region if it were smaller that the nominal ~300 km shown. Approximate dropsonde locations are shown as blue dots. Additional dropsondes (not shown) would be deployed by the jet, NOAA P-3, or NRL P-3 in front of the convective line prior to starting the patterns in the rear to document the environment ahead of the line.*

Because the development of the stratiform region typically lags the intensification of leading-line convection by a few hours, the take-off times of the NOAA P-3 will be staggered relative to the NRL P-3. Owing to the 9-hour flight duration of each aircraft, the overlap period will likely at least 6 h, and the staggering will allow a greater fraction of the total MCS lifetime to be sampled.

2) The second flight pattern will be flown only by the dropsonde aircraft in order to sample mature MCVs during the daytime that often will exist with a relative minimum of associated

convection (Figure 2.2). Once new convection forms near or within the MCV circulation and it is deemed likely that the convection will organize into an MCS, the NRL P-3 with ELDORA will be deployed and execute a flight pattern similar to that shown in Fig. 2.1. This aircraft will overlap temporally with the dropsonde aircraft. The NOAA P-3 will be delayed with respect to the NRL P-3. The Doppler aircraft will probe the organizing convection in an attempt to quantify its effect on the pre-existing MCV. If the dropsonde aircraft is double-crewed, it can be re-deployed into the maturing MCS and perform a flight pattern similar to that in Fig. 2.1. It may also be possible for the dropsonde aircraft to land, refuel and return to the MCS during a single crew duty cycle, albeit with a shorter time on-station.

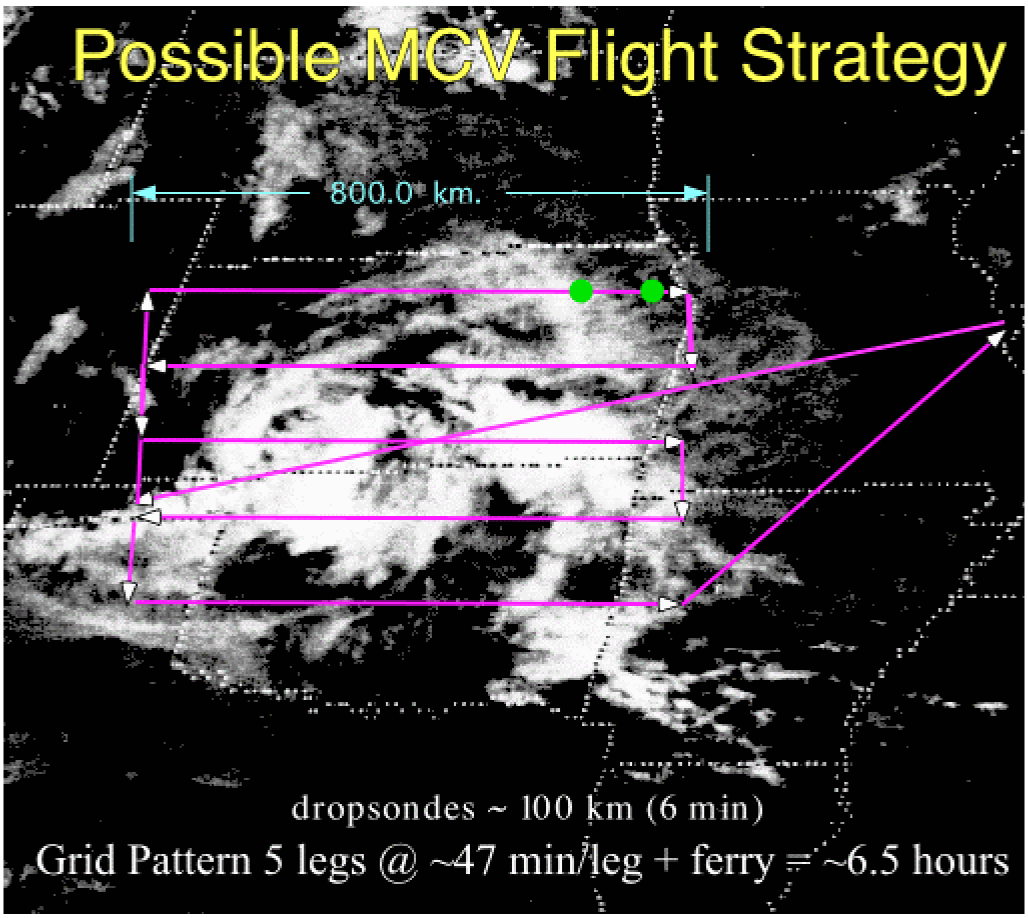


Fig. 2.2 *Schematic of jet (with dropsondes) flight pattern near a mature MCV with non-MCS attendant convection. Green dots illustrate the minimum spacing between dropsondes.*

ATD/RAF Airborne Scientific Instrumentation

It is probable that only a very limited set of RAF's standard measurements will be available. (See list above in Appendix 1.) At present, we expect to provide barometric (static) pressure, ambient temperature, dew point, 3-dimensional winds and aircraft position. For details about instrument type and performance, consult the RAF Bulletins on the RAF web site at http://raf.atd.ucar.edu/Bulletins.

This is sufficient for BAMEX needs.

User-supplied Scientific Payload

Please provide the following information for each user-supplied scientific instrument. (This form is virtually a copy from the C-130, and some topics either may have be omitted or may not pertain to the P-3. As of now, please give us as much information as possible.)

None provided.

Data Recording and Processing Requirements

What additional recording capability is needed? Please give us details on the number of signals, their characteristics, format, synchronous, fire-wire, ethernet, etc. (We may not be able to accommodate any and all signals.)

Standard in situ data and frequency are sufficient.

If nonstandard output formats and/or data rates are required, how often are the measurements needed? Note: The standard format for processed, RAF output data is netCDF. The standard output media are magnetic tape and ftp transfer. (Nonstandard rates and/or formats will be considered as special processing requests.)

N/A

Will you be using your own recording system?

No.

Supporting Services

Will you require air-ground communication? (If so, specify location of base station and operating frequencies.)

Yes, we require air-to-ground voice communication between the NRL P3 and the operations center in St. Louis, MO. The communication via satellite phone and modem is required to receive update WSR-88D and/or satellite imageries of the targeted system. Radio communications with NOAA P3 and the dropsonde aircraft are also required.

We also require real time overlays of aircraft positions on some combination of WSR-88D composite and visible and/or IR satellite imagery in the St. Louis operation center. A specific example would be P-3 flight tracks superposed on WSR-88D images produced by Zebra. This capability may be accomplished using the same satellite modem that will download the P-3 track to the operations center. We would require the imagery within 15 minutes of real-time and at 15 minute intervals.

Will NCAR support be required in preparing this instrument for use on the aircraft (other than inspection, installation and power hookup). ATD/RAF can provide design and fabrication support for hardware and electronic interfaces. (If so, specify type and lead time.)
Some development work will be necessary to provide the communication capabilities listed above.

Ground Support Needs for User-supplied Instrumentation

Preflight needs (prior to take-off) on flight days:

Access	1 hr
Power	1 hr

Postflight needs (after landing) on flight days:

Access	0.5 hrs
Power	0.5 hrs

Special support needs on flight days (and comments):
Not answered

Routine Maintenance on non-flight days:
None.

Access	Hrs
Power	Hrs

Special support needs on non-flight days (and comments):
Power will be needed when maintenance on the ELDORA system is needed.

On-site data access requirement:
The standard RAF data support is sufficient.

Summary of any special requirements, which pertain to NRL and RAF support:
None.

Has an ATD scientist/engineer/project manager been consulted to help complete this request?
Yes.

AIRBORNE INSTRUMENTATION:
ELECTRA DOPPLER RADAR (ELDORA)

Radar Operations

Scientific rationale for the use of ELDORA in the proposed project:
We desire to use ELDORA to help map out the 3-D flow field for the MCSs and MCVs studies. This, in conjunction with the Doppler observations from the NOAA P3 and dropsondes from the dropsonde aircraft, will document the kinematic and thermodynamic structures of the MCS and MCV systems.

Weather events during which collection is desired:
Late afternoon to mid-night for MCS missions and evening for MCV missions.

Typical operations schedule:
Late afternoon to midnight.

Estimated number of radar hours:
180

Typical radar parameters:
Number of PRFs: 2
Number of Frequencies: 2-4
Antenna Rotation Rate: 144 deg/sec
Gate Spacing along Beam (m): 37.5-150 m
Number of Gates: 500
Minimum Sensitivity Needs (dBZ at 50 km): 10 dBZe

Scientific rationale for desired radar parameters:
Maximize the spatial (along track) resolution in the precipitation region. Dual-PRF allows high Nyquist velocity to minimize velocity folding in the intense convective region.

Radar Display and Communications Needs

Summary of radar display and communication needs:
We require CAPPI display in real-time. We must have air to ground communications between the NRL P3 and the operation center in real time to aid in guiding the aircraft operations. We also require air-to-air communications between the NRL-P3, NOAA P3 and the dropsonde aircraft.

We also require real-time overlay of the aircraft positions on some combination of WSR-88D and satellite imagery in the St. Louis operations center.

Summary of on-site radar data access and analysis requirements:
The standard data content and format on exabyte tape are sufficient.

User-supplied Scientific Payload

Summary of auxiliary equipment located on airplane:

N/A

Supporting Services

Multiple radar coordination requirements:

We will attempt to coordinate with NOAA P3 whenever it is possible. In addition, we will need to use WSR-88D data to help guide the aircraft. Thus, air to ground communications are essential.

Summary of any special requirements that pertain to ATD or NRL support:

The real-time CAPPI is essential for the execution of BAMEX mission.

Is an ATD Scientific Project Manager needed for the project?

Yes.

Has an ATD scientist/engineer/project manager been consulted to help complete this request?

Yes.

AIRBORNE INSTRUMENTATION: GPS DROPSONDE SYSTEM

System Operations

Number of Systems requested:
1

Number of Sondes requested:
600 (15-20 missions dropping 30-35 sondes per mission)

Scientific rationale for the use of the system in the proposed project:
Dropsondes will be released from a high-altitude aircraft, likely the same type of jet used in IHOP, but flying between 40,000 and 45,000 feet ASL. FAA restrictions may prevent drops above about 30,000 feet. This is still acceptable for nearly all BAMEX objectives. The sondes will target the stratiform region of MCSs and capture mesoscale thermodynamic and kinematic structure, with emphasis on the formative stages and structure of mesoscale vortices. The sondes will also help document the environment around MCSs and structure of the atmosphere in the immediate vicinity of MCSs (outside the area of precipitation scatterers and hence radar coverage). Thermodynamic data within developing and mature MCSs is almost completely lacking, but important to document the structure of mesoscale convective vortices (MCVs). It is also important for augmenting the ground-based observing systems (GBOS) measurements of lower-tropospheric thermodynamic characteristics. This is important outside MCSs to document potential convective instability, but also inside systems to document cold pool characteristics and nocturnal inversions.

There will be two basic types of dropsonde missions, corresponding to the two schematic flight trackes (Figs 2.1 and 2.2). The first is flying over and near growing and mature MCSs. The second mission type includes flights over mature MCVs, generally in the afternoon before and during the time of convective regeneration near the vortices. Because of the possibility of flying both daytime and nighttime missions, it would be highly desirable to double-crew the Lear jet (a point to be negotiated separately from this facility request). Double-crewing is not needed for either P-3, because it is not anticipated that the P-3 will fly into mature MCVs without significant, organized convection accompanying them.

Approximately how many dropsondes will be released on each mission flight? A typical number will be 30-35, but could be as many as 45-50 for isolated missions when the aircraft refuels and flies two missions during the same crew duty cycle.
Using a Lear Jet, cruising at roughly 200 m s^{-1} and at 40,000 feet, sondes will require about 25 minutes to reach the ground. A few more minutes are needed to unpackage, load and postprocess the soundings. Assuming 4 frequency channels, the temporal spacing between sondes is about 8 minutes, corresponding to about 90 km horizontal spacing between sondes. If sondes are dropped from as low as 26,000 feet, the spatial separation decreases to 65-70 km (6 minute frequency). We anticipate 4-4.5 hours on station for the Lear jet, allowing approximately 30-35 sondes to be dropped per mission. Numerous passes across the MCS will occur during each mission (roughly two passes per hour for a large MCS of 350 km extent and four passes per hour for a small

MCS). Given that we are examining system-scale structures, time-to-space conversions will be possible and will probably halve the effective spacing between dropsondes.

At which frequency (i.e., time between drops) will the dropsondes be released?
We estimate that the drops will be 8 minutes apart if released from about 40,000 feet, but about 6 minutes apart if dropped from 26,000.

What is the general location in which the dropsondes will be dropped?
Drops can occur anywhere within the BAMEX domain (600 km radius from St. Louis, Missouri), away from heavily populated regions.

Supporting Services

Will you provide an operator for the dropsonde system?
We will require the same support that is needed for operating the dropsonde system for IHOP. As we understand it, Flight International, should they be the vendor leasing the Lear jet, will provide the dropsonde operator.

Is a ATD Scientific Project Manager needed for the project?
Yes.

Summary of any special requirements that pertain to ATD support:
In-flight communications with BAMEX operations center and P-3 aircraft are needed. It will be highly desirable to view the dropsonde data in near real-time. We anticipate that the same arrangements made for IHOP will be adequate for BAMEX.

Has an ATD scientist/engineer/project manager been consulted to help complete this request?
Yes.

GROUND-BASED SYSTEMS:

GPS/LORAN ATMOSPHERIC SOUNDING SYSTEM (GLASS) AND MOBILE GLASS

System Operations

Number of Systems requested:
2

Number of Sondes requested:
150

Scientific rationale for the use of the system in the proposed project:
The primary purpose of the MGLASS units is to document the evolution of the convective environment on finer time and space scales than can be provided by the dropsonde aircraft or standard NWS soundings, to support the similarly finer-scale observations being provided by the SMART-R radars, the mobile profiling system, and the mobile mesonets. Two MGLASS units are being requested to help document mesoscale variations in the environment, associated with pre-existing boundaries or broader baroclinic zones, which have especially been implicated in the production of severe weather with bow echoes. These soundings will be critical for both real time forecasting during the field phase, to help with deployment decisions, as well as for post analysis and numerical simulation studies. It is intended that the MGLASS units will be deployed of order 100-150 km ahead of an existing area of convection, as directed by the GBOS leader or Operations Director, and will take serial soundings at 2-3 h intervals as the convective system approaches. It is hoped that this sounding information can be relayed back to ATD in real time, for easy access from the Operations Center in St. Louis.

Supporting Services

Is a RTF Scientific Project Manager needed for the project?
No.

Summary of any special requirements that pertain to ATD support:
We require real-time transmission of the soundings to the BAMEX operations center (with not more than 60 minutes delay).

Has an ATD scientist/engineer/project manager been consulted to help complete this request?
Yes.

GROUND-BASED SYSTEMS:
SPECIAL REQUEST FOR ADDITIONAL GPS SONDES

Number of Systems requested:
0 (4 launch systems are being requested through a separate proposal to NSF by Dr. Robert Pasken of St. Louis University, in collaboration with NASA. All costs of operation of the NASA launchers, including personnel costs, equipment costs, operating costs and overhead are included as part of the Pasken proposal.)

Number of Sondes requested:
385

Scientific rationale for the use of the system in the proposed project:
The additional sondes are requested for the augmentation of the soundings from the NCAR MGLASS systems. With four additional launchers, different configurations of launch sites can be designed to either enhance the probability that soundings will intercept an MCS (distributing the launchers parallel to the system orientation), or increase the total sampling duration along the path of the MCS.

GROUND-BASED SYSTEMS:
INTEGRATED SURFACE FLUX SYSTEM (ISFF)

Rationale

Scientific objectives to be addressed using ISFF:
We will use both supplemental surface observations collected via the ISFF platforms deployed in BAMEX, an existing mesonetwork of surface stations organized at Iowa State University, the Iowa Environmental Mesonet (IEM), and other existing midwest networks to improve understanding of the low-level characteristics and evolution of bow echoes and the surface signals related to midlevel MCVs. The ISFF stations will be strategically placed to “fill in” some of the more obvious gaps in surface data coverage in the midwest. Specifically, the surface data will be used to:

(i) Document the surface pressure, wind and thermodynamic properties of bow echoes and MCVs over the entire life cycles of the parent MCSs,

(ii) Provide detailed information about the spatial and temporal variability of high winds in bow echoes, and

(iii) Identify surface processes associated with the spin-up of MCVs and subsequent associated regeneration of deep convection.

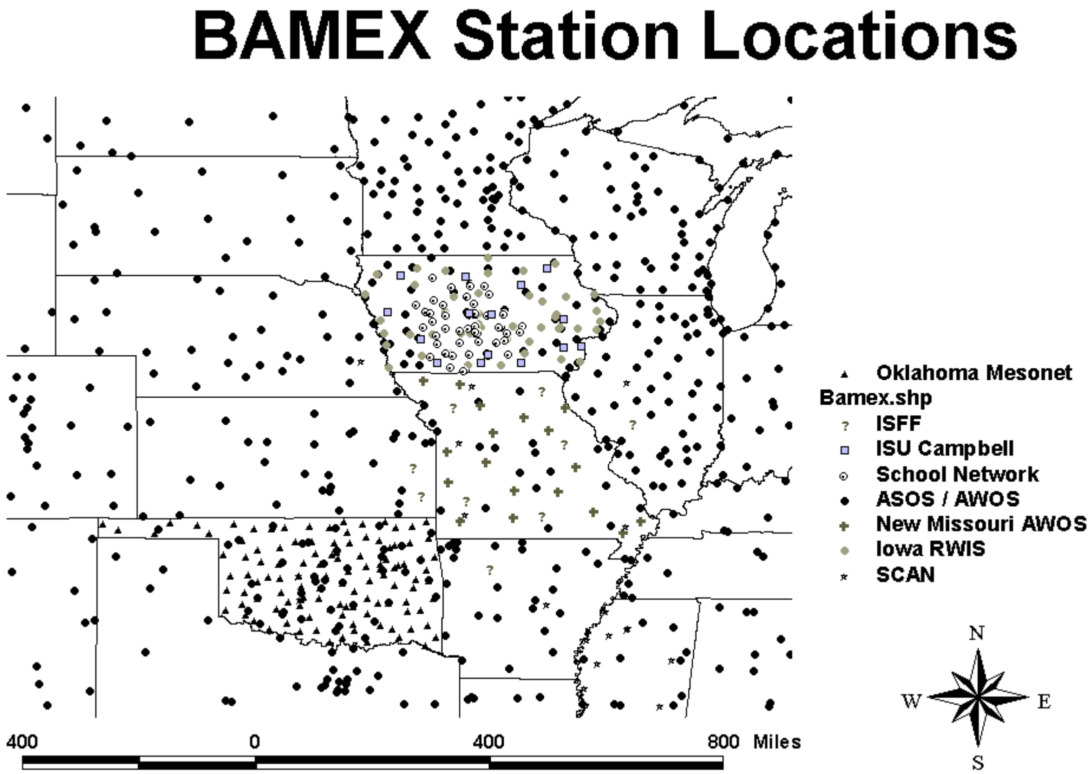
The research will also improve understanding of differences between nocturnal bow echo events where a pronounced cold pool is likely lacking and daytime events, determine the role of surface boundaries in bow echo formation and evolution, and reveal if surface boundaries are a necessary ingredient for redevelopment of convection in MCV events.

Data analysis methods to be used:
Data will be compiled and supplied to forecasters during the operational phase of the project. All data collected will archived at Iowa State University. After the operational phase, we will develop climatologies of surface features surrounding bow echoes and MCVs to determine surface characteristics around these mesoscale events. Both Barnes analysis techniques available within GEMPAK software, and bilinear and multiquadric interpolation codes available to the PIs will be used.

Measurements

Number of measurement sites:
9

Minimum/maximum separation of these sites:
50 km/250 km



Number and type of measurement at each site (e.g. 2 moisture flux, 5-level temperature profile):
The following variables must be measured at each site: wind (minimum 2-levels), temperature (minimum 2 levels), water vapor (minimum 2 levels), surface pressure, precipitation accumulation (5-minute intervals).

Number and description of NCAR-supplied nonstandard sensors (see www.atd.ucar.edu/sssf/facilities/isff/sensors/):
Rain gauge (Optical - ORG): 1Hz

Number and description of user-supplied sensors [give power requirements, data output (e.g. RS232 ASCII or 0-1V analog), and data handling (e.g. sampling rate, sorting by valve position)] ***Providing user-supplied sensors to ATD for pre-experiment testing is highly desirable.***
None.

Logistics for each location (power, phone, vehicle access, owner permission):
Unknown at this time.

Operations Base

Will an operations base be available or should ISFF supply?
St. Louis will be used (location of BAMEX base of operations).

Location of the base relative to measurement sites:
See map above ('?' Denotes anticipated ISFF locations)

Logistics at the base site (power, phone, network, vehicle access, owner permission) :
Exact location of base of operations is not known at this time.

Data Needs

Is archiving of high-rate (each sample) data needed or are time-averaged statistics sufficient?
1-minute averages are desired.

Averaging needed for statistics (ISFF default is 5 min.):
1-minute averages desired.

What data products are needed in real time? How should these be made available (e.g. WWW, display in base)?
We will work with the ops center to automate the creation and transmission of products necessary. All data will be archived at ISU.

Post-project: ATD typically distributes statistics via the WWW. What additional data products (plots, high-rate data, derived products) are desired? Is WWW distribution acceptable?
No additional products are needed. WWW distribution is acceptable.

Special data requirements:
none

Operations

Will there be intensive observation periods requiring 24-hour staffing. (ISFF data are collected continuously in any case.)
No.

Availability of investigator-supplied staff?
Staff will be available (graduate students from either Iowa State or CSU or both)

Other

Has ATD/RTF staff been consulted to help complete this request?
Yes.