Western Region Technical Attachment
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UPDATE: STORM PROJECT (STormscale Operational and Research Meteorology)

[Editor's Note: The STORM Project is a long-range effort to bring together operational and research meteorologists to better understand mesoscale interactions and improve the 0-48 hour forecasts. Participants in the STORM Project include private sector, university, and government meteorologists. STORM will be implemented as a series of experiments, starting with STORM I in 1992-93, focussing on the central U.S. STORM II and III will focus on the eastern two-thirds and western U.S., respectively, in the mid to late 1990s. One of the main objectives of the STORM Project is to learn how to make maximum use of the new operational data sets (ASOS, NEXRAD, Profiler, GOES-NEXT). The following are excerpts from STORM Watch, an occasional bulletin of the STORM Project.]

STORM PLANNING WORKSHOP

In July about 120 members of the meteorological community met in in Longmont, Colorado, to work on the draft of the STORM implementa- tion plan, which had been circulated earlier in the spring by the STORM Project Office. The tasks for the group included laying out a 10-year direction for STORM and a more detailed direction for the first scale-interaction experiment. For three days, the meetings alternated between plenary sessions and smaller working groups; that format allowed both full discussion and specific accomplishments.

Early in the meeting, two STORM goals were defined:

- o To improve the 0-48-hour prediction of precipitation and severe weather.
- o To advance fundamental understanding of precipitation and other mesoscale processes and their role in the hydrological cycle.

With those in mind, the workshop addressed four aspects of STORM: the core scientific program, four-dimensional data assimilation and modeling, applied research and training, and data management.

<u>Core Scientific Program</u>

Four research and forecast problems were suggested as the basis for the core scientific program:

- o What is the interaction of jet streaks, attendant mesoscale precipitation, and severe weather?
- o How does large-scale "development" act to generate organized mesoscale precipitation events and severe weather, and influence their evolution?
- o How do organized mesoscale convective events act to feed back and influence the evolution of the larger-scale circulation?
- o What are the relative roles of large-scale forcing (cyclogenesis, frontogenesis) and small-scale events (gravity waves) in subsequent developments?

Systematic Expansion of the Operational Networks

By the early 1990s, there will be a tremendous increase in operational mesoscale data in the central United States from many NEXRAD Doppler radars, the demonstration network of 30 wind profilers, many ASOS (automatic surface) stations, and advanced sounders on the next generation GOES (geostationary) satellites. With little supplementation, this year-round data stream will be useful to many research and operational objectives of STORM, and will provide the basis for the central U.S. scale interaction experiments.

By the middle 1990s, new satellite capabilities, a greatly expanded network of NEXRAD radars, and automated surface systems will be in place over most of the country. Only the absence of mesoscale capability for wind, temperature, and moisture profiles prevents this data base from being truly useful for STORM over the contiguous United States. Therefore, STORM requirements include mesoscale sounding capability to expand systematically from the central United States in the early 1990s, to the east and gulf coasts by the middle 1990s, and finally to the west coast by the late 1990s (Fig. 1).

This planned stepwise implementation of the operational data base suggests a common sense strategy for a stepwise expansion of the domain where STORM field experiments are carried out, and indirectly for their observational requirements. In 1992-1993, by concentrating on the subset of STORM objectives which can be carried out within the domain of the wind profiler network in the central United States, the requirements for both supplemental soundings and Doppler radars are minimized although still substantial. Assuming the expansion of an operational sounding and radar capability to the eastern two-thirds of the country by the mid 1990s, and an improved understanding of the extent to which remote sensing alone can provide some of the information, the experiments of the mid 1990s can be planned to include those objectives requiring a larger domain and offshore data. Similarly, further expansion of the domain (to include the western states) and the objectives to a national scale can take place during the 1990s.

STORM I, 1992-1993: Focus on the Central United States

The combined operational data set available during 1992-1993, including satellite, radar, profiler, and surface data, represents an enormous head start toward the data base for scale interaction studies. The additional requirements are substantial, but small in proportion to the investment made in the operational data. The payoff in basic and applied research opportunities will be large and varied.

Numerical models from mesoscale to global scale require verification data for their evaluation and improvement. Regardless of the domain of the model, many of the important processes whose physics must be verified operate on the mesoscale. A prime example is cumulus parameterization. By addition of thermodynamic profiles and boundary layer data to the operational data base, a verification data set for boundary layer and convective parameterization can be created, which will be better than any previous set, and the first such set ever over land.

STORM I will include acitivities which will operate routinely all year round. Without doubt these include both real-time and retrospective numerical modeling and data assimilation, which can make good use of the operational data base. But also there will be intensive observing campaigns during both the cool and warm seasons.

Cool season objectives which are appropriate and tractable during 1992-1993 in the central United States include the following:

o Conditions for existence of baroclinic, symmetric, and conditional instability, and the interactions among them. o The baroclinic planetary boundary layer, its differences from the barotropic boundary layer, and the effects of the boundary layer on evolving cyclones, fronts, and low-level jets. o The mesoscale structure of precipitation systems associated with Midwest cyclones and fronts, and how these may differ from those reported near the east and west coasts. o The conditions for generation of large-amplitude gravity waves, and the role of such waves in organizing mesoscale precipitation features. o The effects of cold air damming along the east slopes of the Rockies, high plains blizzards, and the possible role of cold conveyor belts in upslope snowstorms. o The effects of melting precipitation on thermal and kinematic fields associated with cyclones and fronts. o Improved short-range forecasts of significant weather associated with winter cyclones, including winds, temperature changes, clouds and fog, and particularly precipitation type (rain vs ice storm vs snowstorm) and amount.

The warm season component of STORM I will focus on Mesoscale Convective Systems (MCSs). Fundamental questions about MCSs remain which cannot be addressed effectively without a scale interaction data base.

STORM II and III: Middle and Late 1990s

For field programs beyond STORM I, it becomes more difficult and perhaps premature to state details. Nevertheless, the general shape of the opportunities in the middle and late 1990s can be described.

The broader geographic coverage and larger domain of mesoscale data create major opportunities for studying a broader range of scale interaction problems. In particular, it will be possible to define a large fraction of many jet streak and upper trough systems, such that the upstream conditions preceding incipient cyclogenesis or MCS development can be defined and initialized in numerical prediction models. Conversely, the downstream influence of an MCS over the midwest, for example, the creation of a jet streak aloft or a mesoscale subsidence region at the top of the boundary layer, can be defined and used as verification for model predictions.

During the warm season, it will finally become possible to investigate problems which are beyond the scope of the more limited domain of STORM I. What are the differences between MCSs in the central United States and those in the east and southeast? There is no doubt that MCSs account for a large fraction of the significant and severe weather and flash flooding in those regions, but we know that they tend to be smaller and shallower than midwestern MCSs. When a midwestern MCS dies, there is often a middle tropospheric vortex left behind which can generate a new episode of organized convection the next day. This process can be responsible for MCSs which cause major weather events and eventually an upscale cyclogenesis. The enlarged domain of the mid 1990s is necessary for study of this chain of events because of the need to cover the entire life cycle of MCSs and their induced circulations.

The complex topography in the western United States covers the spectrum of the mesoscale. Basic and applied research topics abound, and range from such comparatively simple subjects as mountain waves and associated windstorms, turbulence, and icing, to the full range of scale interactions taking place when cyclonic storms and fronts move onshore, or those processes which govern warm season convective rainfall, involving scales up to those of the summer monsoon circulation. Most of these issues demand scale interaction data sets for their resolution, but in addition, limited objective experiments may well be required to sharpen the questions to be asked, and for each question, to learn how to deploy observing systems in complex terrain for maximum effectivenes.

How can we understand the mesoscale structure of the precipitation associated with Pacific cyclonic storms, and how the storm structure, frontal structure, and precipitation will be influenced by the complex orography in the west? Better quantitative precipitation prediction, flood prediction, and water resources management are three examples of the benefits which can be expected from improved ability to model and predict such storms. Obviously, there are significant additional observing resources needed to define both the initial storm structure over the ocean and its evolution onshore.

The major payoff to the nation from the STORM program may well come from the truly national data base which we anticipated by the late 1990s. Only with a national network together with numerical models capable of mesoscale resolutions over a very large (perhaps global) domain, will we be able to consider the evolution of fronts, cyclones, jet streaks, and their associated weather over their life history. With such a national network, we can at last study in depth the issue of cyclogenesis in the lee of the Rockies and subsequent downstream events which are responsible for much of the significant and severe weather that evolves between the Rockies and the east coast. Basic researchers will be able to diagnose the processes in development and evolution of jet streaks, which take place over a huge domain despite their short time scale. Forecast–experiments and verification will become more meaningful over the full 0-48-hour time scale than previously possible, when only a fraction of the area had a mesoscale data base.

Summary

Events of the past five years have not changed the basic goals of the STORM program for advancing mesoscale meteorological science and improving forecasts, but they have altered the strategy for field experiments. In 1983, it seemed as though operational mesoscale data sets were far in the future; now they are a year or two away. This data base will expand systematically, providing the opportunity for selective supplementation for research programs, first in the central United States, then over the eastern two-thirds of the country, and within a decade will be national in scope. During the coming year, specific experiment design documents will be written for STORM I programs scheduled for early 1992 and spring-summer 1993. Opportunities for participation in the planning process will come from the STORM Project Office.

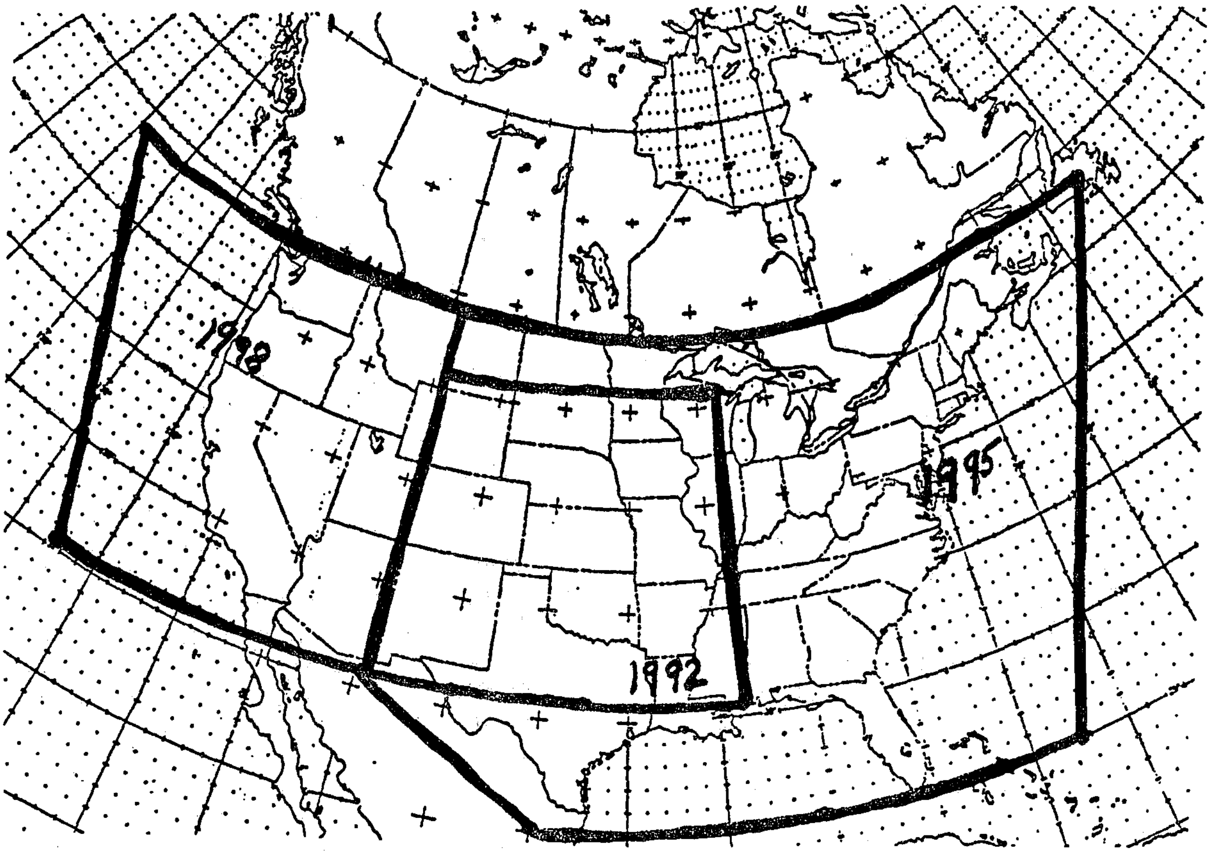

Fig. 1. The expanding mesoscale data base makes supplemental data sets feasible in the above areas after the year indicated.