be analyzed for NH_4^+, SO_4^{--} and other species. Shorter-time interval sampling should also be conducted and the samples analyzed for critical species. Cloud condensation nuclei (CCN) should be sampled both by aircraft and at the surface. The gases SO_2 and NH_3 should also be sampled from the aircraft and at the surface. These data will aid in understanding the behavior of sulfates and their relationship to CCN.

4.6 Joint sessions on validation of coupled models and techniques/resources for storm-scale numerical weather prediction

Bill Kuo and Kelvin Droegemeier

This joint session considered the recent modeling successes made with high resolution models which may be either nested within coarser mesh models or which may employ adaptive grid stategies. Suggestions for future multiscale model verification needs considered the special quality of these kinds of models. In addition, the requirements of coupled chemistry, land surface, hydrological, etc. models were considered by this group in making its recommendations.

4.6.1 Session on validation of coupled models

Bill Kuo

N94-24399

a. Current status

The use of a mesoscale model with a grid size of 20-km during STORM-FEST in 1992 has proven to be extremely valuable. The availability of forecast products at a much higher temporal and spatial resolution was very helpful for mesoscale forecasting, mission planning, and the guidance of research aircraft. Recent numerical simulation of ocean cyclones and mesoscale convective systems using nonhydrostatic cloud/mesoscale models with a grid size as small as 2-km have demonstrated the potential of these models for predicting mesoscale convective systems, squall lines, hurricane rainbands, mesoscale gravity waves, and mesoscale frontal structures embedded within an extratropical cyclone. Although mesoscale/cloud scale models have demonstrated strong potential for use in operational forecasting, very limited quantitative evaluation (and verification) of these models have been performed. As a result, the accuracy, the systematic biases, and the useful forecast limits have not been properly defined for these models. Also, no serious attempts were made to use these models for operational prediction of mesoscale convective systems.

b. Most critical unknowns

The problems of mesoscale model verifications can be summarized as follows:

- Conventional rawinsonde and surface observations have insufficient temporal and spatial coverage. These data are useful for synoptic scale model verification, but are of limited value for mesoscale model verification.

- Observations from upcoming mesoscale observing platforms have significant variations in measurement characteristics, data quality, and temporal and spatial resolution. Each of these observation platforms (such as the profilers, the ACARS observations, RASS, ground-based microwave radiometers, NEXRAD, and the GOES-Next satellites) by itself does not provide a complete decription of mesoscale weather systems.

- *The hydrological cycle appears to be the weakest component of operational and research models.* Unfortunately, moisture variables, which are crucial for validation of model precipitation parameterizations, are poorly observed.

c. Specific recommendations

- *Perform a comprehensive verification of mesoscale prediction, high quality "assimilated fields".* Therefore, it is essential to develop a "state-of-the-art" mesoscale data assimilation system to produce IIIb analysis for CME, with a horizontal resolution of ~10 km.

- The quality of the IIIb analysis must be evaluated carefully. This can be done either using some independent observations or by looking at the quality of very short-range forecasts.

- Meso-gamma scale data assimilation based on Doppler radar data should be encouraged. This will provide a detailed description of mesoscale convective systems at a horizontal resolution of 1 km. However, because of the large volume of data and the computing resources required, this type of data assimilation probably can only be done on selected cases at selected times.

- The meso-beta-scale and gamma-scale assimilated fields can then be used to initialize and verify cloud/mesoscale models

d. Observational needs:

- *For CME we need broad rawinsonde coverage at a variety of scales if we are to capture the genesis, development and dissipation stages of the MCS.* This is essential if we are going to advance cloud/mesoscale models for predicting the initiation and organization of mesoscale convective systems.

- *We need high resolution, high quality moisture measurements.* Such data are required to validate model hydrological processes. For example, can we accurately compute the water budgets on the scale of an MCS at a temporal resolution of about 1 h?

- We need high resolution (both in time and space) precipitation data for model verification.

- We need comprehensive dual Doppler radar coverage. Both airborne and ground-based radars are needed to provide detailed flow fields for the entire life cycle of a MCS.

N94-24400

4.6.2 Session on techniques and resources for storm-scale numerical weather prediction

Kelvin Droegemeier

The recommendations of this group are broken down into three areas: modeling and prediction, data requirements in support of modeling and prediction, and data management. The format in this section differs somewhat from that used in the previous workshop session descriptions, due to the more technical nature of the material.

I. Modeling and Prediction

a. Current Status

This group worked under the assumption that the CME would run a realtime forecast model in support of field operations and to evaluate the model's predictive capabilities as applied to MCS's and related phenomena. Additionally, the model would provide assimilated datasets for post-analysis. It is unlikely that massively parallel processing (MPP) systems will be utilized effectively enough by mid 1995 to play a role in this program, and thus the group recommended that the model be used on a more conventional (e.g., Cray-type) platform. However, if significant strides are made in MPP utilization during the next two years, an MPP option should be left open, particularly in light of the extremely large memories available on such machines. The NOAA Forecast Systems Laboratory recently completed an evaluation of current mesoscale models, and an even more detailed study of this type is being performed by the Air Force. The choice of a model or models for CME should be carefully orchestrated, with consideration given to model capabilities, efficiency, flexibility, and appropriateness for the CME mission.

b. Modeling and Technological Recommendations

The principal unknowns at this point, apart from the model itself, concern data, initialization methods, validation techniques, computing facilities, and data storage and display strategies. It is likely that *special computing facilities will be required* to support model execution and output archival, as well as collection of raw input data. The CME should determine which group or groups will bear this responsibility, and assess the need