Advances in the Development of an Integrated Data Assimilation and Sounding System

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Overview

The Integrated Data Assimilation and Sounding System (IDASS) provides continuous high-resolution tropospheric profiles. The **measurement system** (Integrated Sounding System, or ISS) is developed around a suite of in situ and active and passive remote sensors. Individually these sensors satisfy certain needs; together, they function in a synergistic and complementary mode. ISS subsystems may include multiple-frequency UHF wind profiler(s) with radio acoustic sounding (RASS), a NAVAID-based sounding system, a surface meteorological station, a microwave profiler, a high-resolution infrared sounder, and a laser ceilometer. The ISS operates as an integrated system. Important aspects of the system are the synergistic interaction of data streams from the individual instruments and the application of real-time and *post facto* data assimilation, as well as the mechanical integration that provides a transportable central data acquisition, processing, display and communications capability in the field for research studies.

Observations from ISS networks provide a high-resolution description of atmospheric structure on the meso-ß scale. Measurements from the in situ and remote sensing instruments are coupled with a state-of-the-art mesoscale modeling system. In the mesoscale **data assimilation** process, the model solution is relaxed toward the available observations so that it is consistent with the measurements. Over regions where there are no observations, the evolution of the model fields is constrained by the model's dynamic and physical processes. The end product is a highly resolved four-dimensional meteorological data set (including three components of wind, temperature, humidity, cloud water, and integrated moisture). The mesoscale data assimilation scheme is the Newtonian nudging technique. During the data assimilation period, observations of wind, temperature, and humidity are used to nudge (or relax) the time-dependent model variables to the observed values.

We are using an enhanced nonhydrostatic version of the Penn State/NCAR mesoscale model which includes parameterizations of surface and planetary boundary-layer processes, convective and nonconvective clouds, and radiation. A comprehensive data analysis system is coupled with the model, allowing real-data experimentation.

Initial evaluations of the measurement and modeling components of the IDASS system were conducted in conjunction with the 1990 and 1991 Winter Icing and Storms Programs (WISP) conducted on the Front Range of northeastern Colorado; the spring 1979 Severe Environmental Storms and Mesoscale Experiment (SESAME) study undertaken in the south-central states of Texas, Oklahoma and Kansas; and a November 1992 ISS instrumentation test near the Cloud and Radiation Testbed (CART) central facility.

Integrated Sounding System

ISS measurement facilities that have been evaluated to date include multiple frequency UHF/VHF Doppler wind profilers and RASS; microwave radiometers; a high-resolution interferometer spectrometer (HIS); a NAVAID atmospheric sounding system; and a surface meteorological station measuring state variables, winds, trace gases, and all components of the surface energy

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balance. Additionally, we have been developing a 915-MHz boundary-layer radio interferometric wind profiler which offers the potential to measure mean and flux profiles from a single sampling volume (avoiding the limitations of beam swinging techniques).

Using assimilation of ISS (and other) data in a mesoscale model, we seek to provide physically consistent vertical profiles of winds, temperature and humidity at each ISS measurement site. Perhaps of even greater value, application of data assimilation to a network of ISS sites can yield highly resolved four-dimensional fields.

Mesoscale Data Assimilation

The mesoscale data assimilation scheme we are using is the Newtonian nudging technique originally developed by Anthes (1974) and Hoke and Anthes (1976). During the data assimilation period, observations of wind, temperature, and humidity are used to nudge (or relax) time-dependent model variables to the observed values. The dynamical and thermodynamical processes of the model then spread the influence of the observations to nearby points, so that a balanced set of four-dimensional meteorological fields, consistent with the model equations, can be obtained. Specifically, a forcing (or relaxing) term is added to the prognostic equations of the model. The magnitude of the additional forcing term is a function of the difference between the measurement and the model solution and the distance in both time and space between the observations and the specific model grid-point under consideration. Details of the mesoscale data assimilation procedure can be found in Kuo and Guo (1989) and Stauffer and Seaman (1990).

The mesoscale model is a very important component of the data assimilation system. We have been using the Penn State/NCAR mesoscale model MM4 (described by Anthes et al. 1987). The model includes parameterizations of surface and planetary boundary-layer processes, convective and nonconvective clouds, and radiation. Because the ISS measurements are "point" measurements, it is desirable to have the highest possible resolution for the assimilation model. Consequently, we have been involved in the development of a nonhydrostatic version of the Penn State/NCAR mesoscale model. The new model (MM5) is capable of real data assimilation with a grid size ranging from 1 km to 100 km. Preliminary tests on the Valentine's Day storm during WISP-1990 have shown that the nonhydrostatic mesoscale model is comparable with the hydrostatic model for a grid size of 20-km (which is in the hydrostatic regime).

Recent IDASS Advances

Recent IDASS developments and advances have occurred over a broad range of technological and modeling/data assimilation areas. Each of these is described in detail in the following papers included elsewhere in these proceedings. The subjects and associated authors include:

- System Design and Implementation of the Integrated Sounding System (Martin and Barrett)
- An Ultra-High Frequency Boundary-Layer Doppler/Interferometric Profiler (Van Baelen)
- Boundary-Layer Observations Over the Southern Great Plains Cloud and Radiation Testbed Site During the November 1992 Flux-Profiler Test (Oncley and Van Baelen)
- Meso-Beta-Scale Data Assimilation of the Winter Icing and Storms Program/Atmospheric Radiation Measurement 91 Intensive Observing Period Case on 6 March 1991 (Kuo and Guo)
- The Effect of Network Resolution on Data Assimilation in a Mescoscale Model (Dudhia)
- Comparison of Mescoscale Model and Tower Measurements of Surface Fluxes During Winter Icing and Storms Program/Atmospheric Radiation Measurement 91 (Oncley and Dudhia)
- Radiation Studies with a High-Resolution Mesoscale Model (Dudhia).

References

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