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TITLE: Observation Simulation Experiments with Regional Prediction Models

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SIGNIFICANT ACCOMPLISHMENTS IN THE PAST YEAR:

Research efforts in FY 1990 included studies employing regional scale numerical models as aids in evaluating potential contributions of specific satellite observing systems (current and future) to numerical prediction. One study involves Observing System Simulation Experiments (OSSEs) which mimic operational initialization/forecast cycles but incorporate simulated AMSU radiances as input data. The objective of this and related studies is to anticpate the potential value of data from these satellite systems, and develop applications of remotely sensed data for the benefit of short range forecasts. Techniques are also being used that rely on numerical model-based synthetic satellite radiances to interpret the information content of various types of remotely sensed image and sounding products. With this approach, evolution of simulated channel radiance image features can be directly interpreted in terms of the atmospheric dynamical processes depicted by a model.

Progress is being made in a study using the internal consistency of a regional prediction model to simplify the assessment of forced diabatic heating and moisture intialization in reducing model spinup times. Techniques for model initialization are being examined, with focus on implications for potential applications of remote microwave observations (AMSU and SSM/I) in shortening model spinup time for regional prediction.

1. Satellite OSSE Experiments

A collaborative effort is in progress between MSFC, Drexel University and the University of Wisconsin to simulate and assimilate satellite channel radiances from HIRS, MSU and AMSU. These studies involve radiative transfer calculations on model thermodynamic fields to generate specific channel radiance "measurements" and synthetic radiance imagery with characteristics of future space sensors, and whose patterns can be diagnostically linked with model dynamical processes. These same radiances are also used to study the impact of satellite products retrieved

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from these radiances on numerical forecast accuracy. An OSSE approach for studying the impact of HIRS and AMSU radiances and soundings in a numerical prediction cycle has been tested. In these experiments the MSFC-LAMPS regional model served as the nature run and source of simulated HIRS and AMSU radiances for assimilation into Wisconsin's CIMSS regional model. A retrieval algorithm developed by Eyre (1989) for the CIMSS model is used to retrieve thermodynamic profiles from radiances generated from the LAMPS model atmospheric states.

In the evaluation of satellite retrievals it is important to consider not just RMS error statistics of the retrievals, but how much the retrievals contribute to a reduction of error in a model forecast. The OSSE strategy permits a controlled examination of the impact (in this study) of HIRS and AMSU satellite retrievals, and of the assimilation techniques on a model forecast. The quality and potential impact of physically retrieved satellite soundings in an operational forecast setting is largely determined by the quality the first guesses. Both first guess profiles for soundings, and horizontal first guess analysis fields are provided by model output from an earlier forecast cycle. The value of satellite soundings in an assimilation/forecast framework are considered in this study as a function of errors inherent in the retrieval process versus errors implicit in the first guess initial fields and profiles.

A complete OSSE was performed for the Genesis of Atlantic Lows Experiment (GALE) Intensive Observation Period 2 (IOP2) using the LAMPS model as a nature run. A LAMPS forecast state was interpolated to the CIMSS model coordinates to serve as an "perfect" initial state for a control CIMSS run "I". A second CIMSS simulation "II" was performed with the same initial state but including realistic spatial errors corresponding to those that typically derive from the forecast errors in operational prediction models. A third CIMSS simulation "III" additionally included satellite retrievals generated from the nature run in order to observe the degree to which the soundings would correct for initial and forecast errors resulting from the perturbed first guess fields in experiment II.

This methodology will be applied to another case from COHMEX during the next year. Results for the HIRS-AMSU combination are encouraging for one case study, although additional realism needs to be added to the assimilation approach for AMSU radiances and profiles. During the next year, Wisconsin plans to explicity incorporate the effects of cloudwater, rainwater and ice from the LAMPS model in the forward calculation of the AMSU microwave radiances, and also potentially in the retrieval algorithm.

Two companion papers describing this and related simulation work at both MSFC and Wisconsin are being readied for submission to The Bulletin of the American Meteorological Society. Two conference papers have been prepared for presentation at the AMS Fifth Satellite Meteorology and Oceanography Conference this Fall regarding the efforts.

A study is in progress at Wisconsin under this RTOP to simulate the retrieval of cloud properties from AMSU. A paper is being prepared describing a microwave analog to the CO_2 slicing method for determining cloud height using AMSU radiances. Results to date indicate that AMSU channel 19 and 20 can provide accurate cloud heights with RMS errors of 40 to 80 mb over both land and water. As with CO_2 slicing, best results are for high and middle level clouds.

2. Diabatic Initialization Experiments

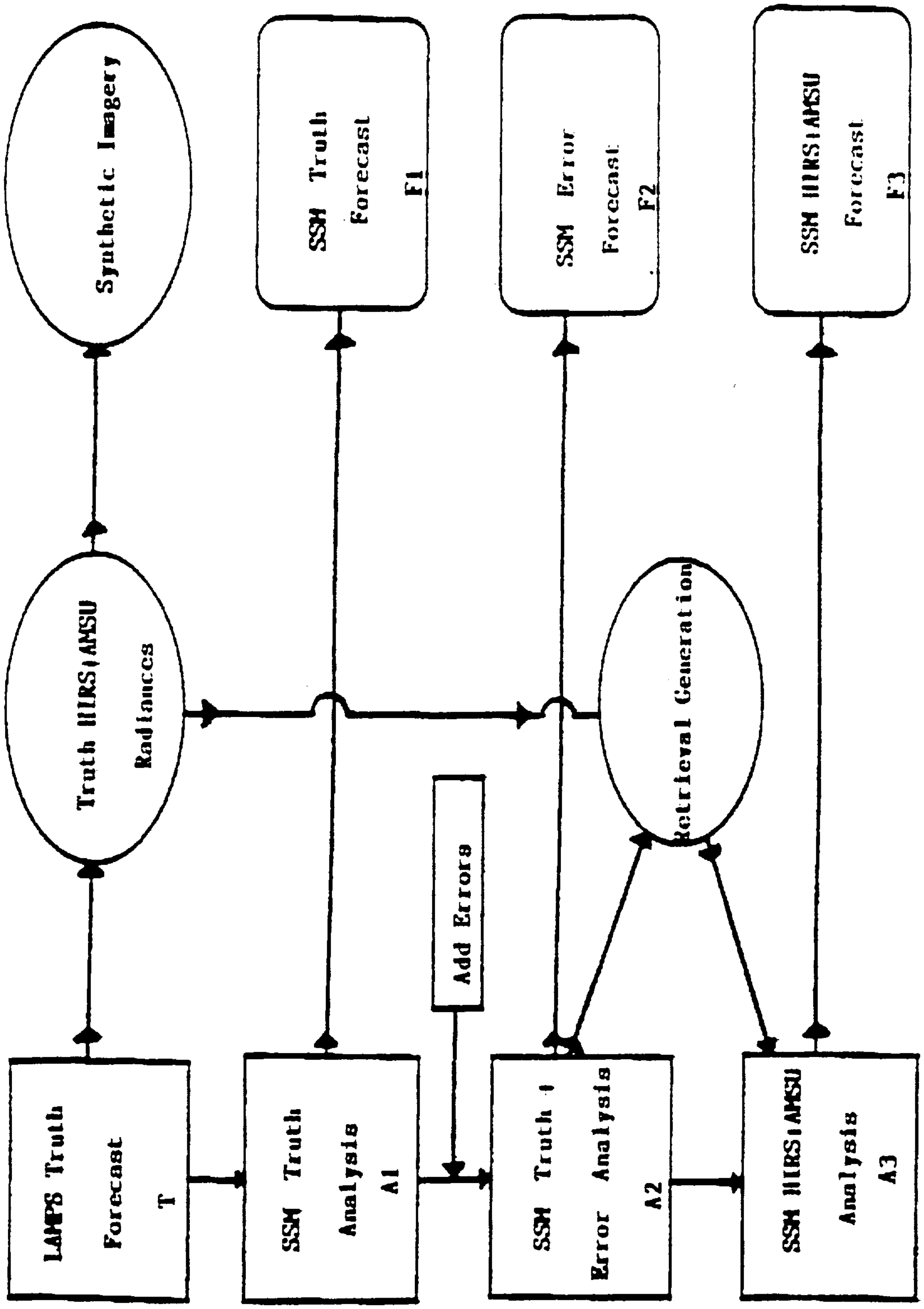
Simulation experiments have been performed with the LAMPS model to elucidate the importance of diabatic heating and meso-scale moisture information in the spinup of precipitation in regional models. A persistent problem in numerical forecasting is an unrealistic delay in the generation of internally consistent, mesoscale divergent wind fields (vertical motion), diabatic heating and precipitation.

This study investigates techniques for reducing model spinup in the LAMPS model through the use mesoscale cloud and precipitation available through space-based microwave senors such as SSM/I to locally modify an otherwise synoptic scale moisture analysis. This study uses a 24 hour LAMPS model simulation for March 6, 1982 as a surrogate (or "true") atmosphere from which is drawn internally consistent meso-beta scale information on clouds, humidity, rainfall and diabatic heating rates. The surrogate atmosphere is sampled to obtain data with an average spacing of 500 km that are then objectively analyzed to provide a synoptic scale atmospheric base state for the remaining model simulations. Experiments based on these synoptic-scale states employ various combinations of forced insertion of true diabatic heating rate fields, replacement of synoptic scale moisture distributions with the true distributions, or enhancement of the synoptic scale moisture distributions based on precipitation and clouds from the "true" atmosphere. The objective of these experiments is to determine which if any of the experimental modifications best reproduces the evolution of true atmosphere, and reduces the spinup time for precipitation compared with a simple dry synoptic scale initialization.

The spinup delay common with a synoptic scale initial state is easily reproduced. Results of all experiments suggest that diabatic forcing by itself only has a weakly positive effect on the spinup, but can have a substantial positive impact on longer term precipitation accumulation with respect to the synoptic control case. The total impact of the forced heating alone is sensitive to the length of the forcing.

The most important factor for spinup is the moisture field. An interesting result was that in terms of spinup time, 12 hour precipitation accumulations, and Mean Sea Level Pressure forecasts, experiments initialized with a synoptic scale humidity analysis enhanced only locally (and very simply) in accordance with clouds and precipitation from the surrogate run performed nearly as well as a simulation with the entire moisture analysis perfectly specified from the surrogate run. The implications are that improvements in short term precipitation forecasts are possible with information only on the horizontal distribution and height of precipitating columns as could be provided from space based microwave sensors.

A paper on the methodologies and results is being prepared. Another case (from ERICA) is being readied to further examine the extent to which the above results study are case dependent.


LAMPS Truth Forecast T
SSM Truth Analysis A1
SSM Truth + Error Analysis A2
SSM HIRS+AMSU Analysis A3
Add Errors
Truth HIRS+AMSU Radiances
Retrieval Generation
Synthetic Imagery
SSM Truth Forecast F1
SSM Error Forecast F2
SSM HIRS+AMSU Forecast F3