P1.7 THE IMPACT OF ASSIMILATING ACARS DATA ON THE PERFORMACE OF A REAL-TIME FDDA WEATHER ANALYSIS AND FORECASTING SYSTEM

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1. INTRODUCTION

Conventional mesoscale real-time forecasts generally rely on static initialization to provide a set of initial conditions for the forecast models at the initial time only. The problems with these “cold-start” forecasts are generally associated with the “spin-up” processes in the models. At the National Center for Atmospheric Research, a group of scientists and engineers have developed a mesoscale Real-Time Four-Dimensional Data Assimilation (RT-FDDA) weather analysis and forecasting system to address this specific deficiency in cold-start forecasts (Cram *et al*., 2001). This system is built upon the 5th generation of the Pennsylvania State University/National Center for Atmospheric Research Mesoscale Model (PSU/NCAR MM5). The system was originally developed for the Army’s Dugway Proving Ground in Utah, and was subsequently ported to other test ranges.

This system uses a cycling methodology to continuously provide most updated analysis every three hours, before a forecast stage begins. The analysis stage in each cycle uses flexible observation nudging, which is capable of assimilating observations that have taken place anytime within the valid time period of analysis. The assimilation process continuously nudges model solutions to observations (Newtonian relaxation). Currently, surface observations from a wide variety of platforms are ingested into the assimilation scheme. Upper-air observations, however, are limited to the NWS soundings, satellite wind, and profilers and soundings at specific Army test ranges. A new addition to the existing upper-air observation platforms used in the current system is underway. We are experimenting to incorporate observations from the Aircraft Communications Addressing and Reporting System (ACARS). In this paper, we will present preliminary results from qualitative comparison of cloud patterns between simulations with and without ACARS data. We will also present quantitative evaluation against independent rawinsonde measurements.

2. MM5 CONFIGURATION

The triplely nested, two-way interactive domains, centered at the Army’s White Sand Missile Range in New Mexico, cover most of the region west of the Mississippi River in the United States and northern Mexico. The coarse domain has 30-km grid, while the two finer grids have10 and 3.3 km resolution. The location and grid configuration are shown in Fig. 1. There are 31 levels in the vertical on a terrain-following coordinate (σ levels), about 15 of which are within the boundary layer. At the top of the model (50 hPa), a radiative boundary condition is imposed to absorb the energy from spurious gravity waves.

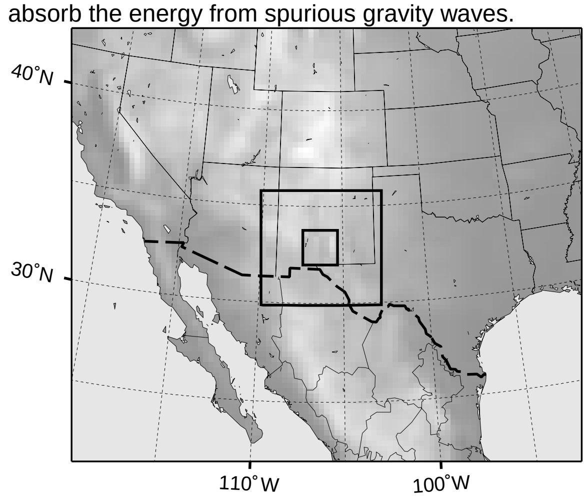

Fig. 1, Domain configuration of the RT-FDDA system with terrain image on the background.

The non-hydrostatic mode of MM5 is used. The physical options used mostly come in a standard MM5 package, with the exception of a simple soil moisture variability scheme, and a snow scheme that accounts for accumulation and melting. Grell cumulus parameterization is used on 30 and 10 km grids. A simple ice cloud physics scheme determines ice/no ice based on temperature below/above freezing. MRF PBL scheme, multilevel soil temperature scheme, and cloud radiation scheme are also employed in the system.

3. ACARS DATA

Reports of meteorological conditions from commercial aircraft have gone through major quality upgrade in the last couple of decades by using more advanced sensors and by adopting automated digital report system such as ACARS. The quality of wind and temperature measurements obtained via ACARS has been the subject of several studies, e.g., Lord *et al*. (1984), Schwartz and Benjamin (1995), and Benjamin *et al*. (1999). In general, the quality of ACARS reports is considered good when rawinsonde observations are used to gauge data quality and when statistical analysis of neighboring (spatially and temporally) ACARS reports is conducted.

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Observations coming through the data ingest system are normally subject to quality check against fellow observations nearby and the background fields. However, as shown in an ACARS distribution diagram in Fig. 2, ACARS data are normally concentrated near the airport only, and they are unlikely to represent data at an analysis level. Due to these facts, quality check in the objective analysis is not conducted for ACARS data currently. We are developing a more sophisticated QC scheme to be implemented in the future. In the meantime, to mitigate the errors going into the analysis, a preliminary quality control procedure has been implemented to filter out questionable data.

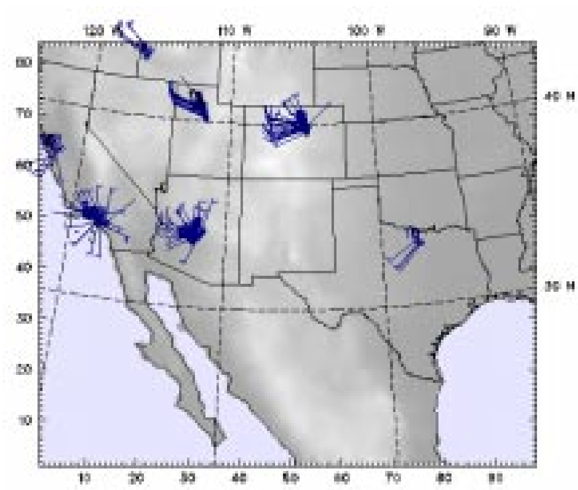

Fig. 2, A snapshot of ACARS observation distribution between the surface and 600 hPa level at 1500 UTC, October 4, 2000.

4. CASE EXAMPLE

We examined snapshots of cloud analysis of both runs with and without ACARS data, and compared them to GOES 8 IR images. The case presented here is for valid analysis time at 1900 UTC, October 3.

Fig. 3a shows GOES IR brightness temperature that roughly covers the same area as the model coarse domain. The valid scan time is 1845 UTC, October 3. Notable cloud systems include (A) midlevel to high clouds in central Nebraska, extending to southeastern Wyoming, just north of Colorado; (B) large convective cloud cluster hovering northwestern Mexico; (C) extensive high cloud in the ITCZ close to 10 deg north; (D) scattering midlevel to high clouds around the state borders of New Mexico; and (E) multilevel cloud system in south-central Texas.

Fig. 3b shows MM5's cloud top temperature diagnosis without ACARS data in the assimilation scheme (referred to as non-ACARS run hereafter); whereas Fig. 3c shows the same, except for the synchronized, parallel MM5 analysis with ACARS data. Both the non-ACARS and ACARS runs appear to under-diagnose the size of the northwestern Mexico convective cluster. In the non-ACARS run, in particular, very small area can be identified as high, cold cloud top; whereas the ACARS run shows more extensive high cloud coverage, as well as overall coverage. The cloud system appearing in Nebraska, as shown in Fig. 3b, is also notably smaller compared to the IR brightness temperature image; whereas the ACARS run shown in Fig. 3c generated much closer cloud area. The same can be said of cloud system (D). Also missing from the non-ACARS run is cloud system (E) in south-central Texas.

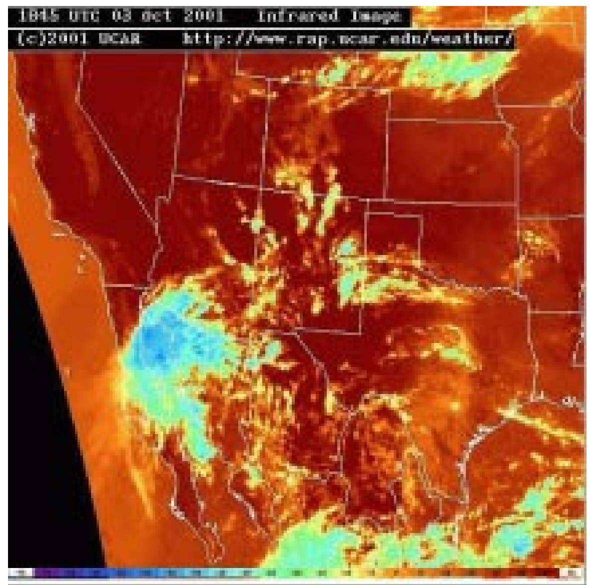

Fig. 3a, GOES 8 IR brightness temperature at 1845 UTC, October 3.

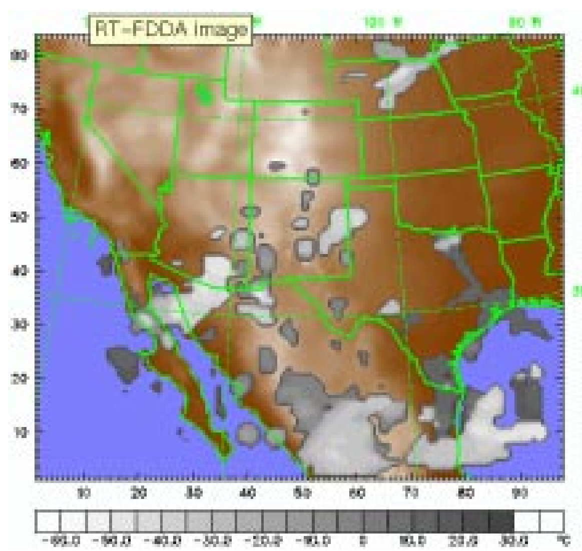

Fig. 3b, Cloud top temperature diagnosis for the RT-FDDA final analysis without ACARS data, valid at 1900 UTC, October 3.

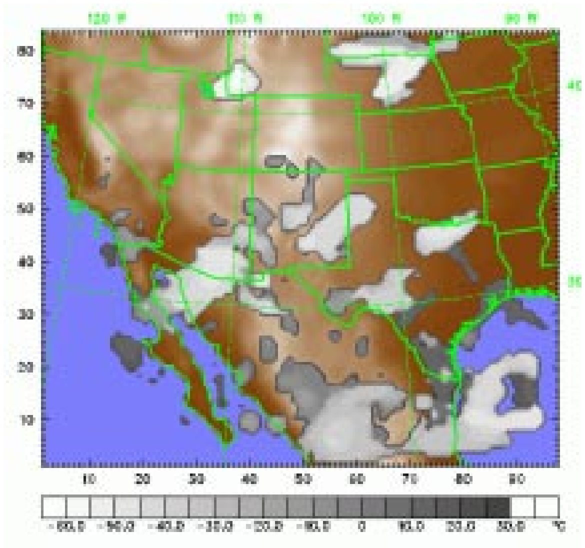

Fig. 3c, Same as Fig. 3b, except for ACARS run.

For upper-air verification statistics, there is no rawinsonde applicable to this time, since the valid analysis time is neither 0000 nor 1200 UTC. An indirect verification is conducted by using the 5h forecast (following the analysis), valid at 0000 UTC, October 4, against the independent rawinsonde measurements at the same time.

Table 1a lists the verification statistics at mandatory levels for forecast following the non-ACARS analysis; whereas Table 1b shows those for the forecast following the analysis with ACARS data. It appears that, while the forecast from the analysis with ACARS slightly improve the statistics over the forecast from the non-ACARS analysis at some levels/variables, it also slightly degrades the verification statistics at other levels/variables. Overall, the verification statistics actually show slightly negative impact when ACARS data are assimilated in the analysis.

Table 1a, Verification statistics for 5h forecast after the 1900 UTC, October 3 analysis without ACARS data.

P (hPa)	T (K)		RH (%)		SPD (ms^{-1})		DIR (°)		N
	Bias	RMSE	Bias	RMSE	Bias	RMSE	Bias	RMSE	
1000	-1.7	2.1	0.9	1.4	1.1	1.4	-11.5	15.0	4
850	-0.3	0.9	0.1	1.1	-0.5	2.2	-2.0	41.1	26
700	-0.3	0.9	0.2	1.1	0.5	2.2	2.7	46.2	33
500	0.5	1.1	-0.0	0.6	0.1	2.3	-5.2	16.9	33
400	0.4	0.8	0.0	0.3	-0.2	3.2	-0.5	13.7	33
300	0.9	1.1	0.0	0.1	0.5	4.4	0.5	15.7	33
250	1.6	1.9	0.0	0.0	-0.1	3.8	3.7	12.4	31
200	1.2	1.9	0.0	0.0	-1.7	3.8	0.2	19.4	30
150	0.0	1.1	0.0	0.0	-0.9	2.5	-5.0	10.7	30
100	0.9	1.7	0.0	0.0	1.1	2.0	-4.0	9.7	30

Table 1b, Verification statistics for 5h forecast after the 1900 UTC, October 3 analysis with ACARS data.

P (hPa)	T (K)		RH (%)		SPD (ms^{-1})		DIR (°)		N
	Bias	RMSE	Bias	RMSE	Bias	RMSE	Bias	RMSE	
1000	-1.8	2.2	11.8	16.1	0.9	1.5	-13.0	16.1	4
850	-0.3	1.1	1.7	9.7	-0.5	1.7	4.8	34.3	26
700	-0.2	1.0	3.0	13.5	0.7	2.0	8.6	40.0	33
500	0.3	1.1	-5.1	20.4	0.5	1.7	-3.6	19.6	33
400	0.2	0.9	-3.7	20.9	-0.4	2.7	-0.9	14.7	33
300	0.5	0.9	-1.7	16.0	0.4	3.6	-1.2	19.0	33
250	1.3	1.7	-0.9	11.7	0.6	3.2	3.0	14.3	31
200	1.4	2.0	2.4	14.0	-0.8	2.8	4.4	21.4	30
150	0.4	1.2	5.0	10.1	-0.4	2.0	-3.4	11.0	30
100	1.0	1.9	3.7	8.4	1.3	1.8	-3.8	11.4	30

5. SUMMARY AND FUTURE WORK

This study focuses on utilizing the abundant meteorological condition reports from ACARS to improve analysis in a mesoscale real-time FDDA weather analysis/forecasting system. Preliminary results suggest that, by incorporating ACARS data in the assimilation scheme, cloud distribution patterns can be improved, even though verification statistics against rawinsonde measurements show zero or even slightly negative impact. Although studies suggest good data quality for ACARS reports, it is not uncommon to find erroneous data. We are currently working on a more sophisticated QC algorithm in an attempt to reduce the errors going into analysis process.

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