Applied Meteorology Unit (AMU)

Quarterly Report

First Quarter FY-99

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ENSCO, Inc.
1980 N. Atlantic Ave., Suite 230
Cocoa Beach, FL 32931
(407) 853-8105 (AMU)
(407) 783-9735

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Executive Summary

This report summarizes AMU activities for the first quarter of FY 99 (October - December 1998). A detailed project schedule is included in the Appendix.

Ms. Lambert collected all data sets needed for the development of statistical forecast tools. These sets include data from buoy and Coastal-Marine Automated Network stations off the Florida east coast, hourly surface observations from stations in central Florida, rawinsonde observations for central Florida, and the 5-minute observations from the KSC/CCAS wind tower network. The surface stations and data types used for the task are given in this report.

Mr. Wheeler provided technical support for the migration of the current functionality to the MIDDS-X weather display system. This was completed at the end of November.

Mr. Evans has completed the Delta explosion analysis. The compilation of the draft final report is completed and is currently under review. The model output used to analyze the plume from the explosion is shown in this report. The conclusions from the RAMS model runs are:

- The wind flow predictions in *this* case were fairly accurate based on qualitative comparisons with observations.
- RAMS under-predicted onshore flow at the level of the Delta II cloud.
- RAMS accurately predicted the strength and height of inversion for *this* case.

During the past quarter, Dr. Manobianco and Mr. Case completed the Local Data Integration System (LDIS) final report. A portion of the LDIS final report is presented in this report and primarily focuses on data non-incorporation experiments that were conducted to assess the influence of specific data sets on the subsequent analyses. The following bullets summarize the most notable points that can be inferred from the data non-incorporation experiments:

- WSR-88D data have the greatest impact on the analysis of wind and moisture. Aircraft/cloud drift and water vapor winds and profiler observations have a similar effect on the wind analyses but to a much smaller extent than radar data.
- Satellite and WSR-88D data have a more significant impact on the moisture analyses during the warm rather than cool season case.
- Surface data have a much greater impact on the analysis of zonal wind during the warm rather than cool season.
- Rawinsonde and GOES-8 sounding data have the most significant influence on the analysis of potential temperature and pressure.
- There are no clear trends to indicate that specific data have more or less impact on 10-km versus 2-km analyses.

In December, Dr. Manobianco circulated a memorandum outlining options for the meso-model task. All customers expressed an interest in the option that includes an evaluation of the DOF MM5 model for the 1998 warm season and a 12-month evaluation of the ERDAS RAMS model. The options and issues relating to the meso-model task were discussed during the AMU mid-course tasking review on 8 January 1999. Descriptions of the evaluations to be performed are included in this report.

During this quarter, Dr. Manobianco presented results from the AMU's twin season evaluation of the meso-eta model to the Melbourne National Weather Service. Mr. Wheeler attended the Annual McIDAS Users Group Meeting at the Space Science and Engineering Center in Madison, WI. He also attended the National Weather Association 23rd Annual Meeting in Oklahoma City, OK where he presented a poster describing the results of the WSR-88D cell trends task. From 3-6 December, Mr. Wheeler visited the Spaceflight Meteorology Group at Johnson Space Flight Center to observe weather operations during the launch of STS-88.

Dr. Merceret's technical activities centered on the Shuttle Launch Commit Criteria (LCC). Shuttle evaluated the effects of response characteristics and sampling processes of the Launch Complex-39 wind sensors and the effect of the spacing of the wind sensor from the pad on the ground wind LCC. Shuttle is also considering a LCC to protect launch guests from possible toxic hazards in the event of a launch failure in the vicinity of the pad. Dr. Merceret assisted in the evaluation of the various proposals and analyses presented by Eastern Range and NASA personnel. Dr. Merceret continued his investigation of the lifetime of upper-air wind features as a function of their size.

SPECIAL NOTICE TO READERS

AMU Quarterly Reports are now published on the Wide World Web (WWW). The Universal Resource Locator for the AMU Home Page is:

http://technology.ksc.nasa.gov/WWWaccess/AMU/home.html

The AMU Home Page can also be accessed via links from the NASA KSC Internal Home Page alphabetical index. The AMU link is "CCAS Applied Meteorology Unit".

If anyone on the current distribution would like to be removed and instead rely on the WWW for information regarding the AMU's progress and accomplishments, please respond to Frank Merceret (407-867-2666, francis.merceret-1@ksc.nasa.gov) or Ann Yersavich (407-853-8203, anny@fl.ensco.com).

1. BACKGROUND

The AMU has been in operation since September 1991. The progress being made in each task is discussed in Section 2 with the primary AMU point of contact reflected on each task and/or subtask.

2. AMU ACCOMPLISHMENTS DURING THE PAST QUARTER

2.1 TASK 001 AMU OPERATIONS

At the request of Mr. David Sharp (NWS MLB), Dr. Manobianco briefed results from the AMU's twin season evaluation of the meso-eta model to personnel at NWS MLB during October. The presentation was designed to provide new forecasters with a brief overview of the AMU and to highlight key aspects of the meso-eta model evaluation.

During October, Mr. Wheeler attended the Annual McIDAS Users Group Meeting at the Space Science and Engineering Center (SSEC) in Madison, WI. The main emphasis of the meeting was SSEC's plans to make McIDAS year 2000 compliant. This capability will be incorporated in the November 1998 and May 1999 releases. Most of the programs and data filing schemes are already compliant. Also presented was SSEC's future plans and migration of McIDAS to Microsoft Windows NT.

During this past quarter, Mr. Wheeler also traveled to Oklahoma City, OK to attend the National Weather Association 23rd Annual Meeting where he presented his poster "WSR-88D Cell Trends Final Report". From 3-6 December, he traveled to Johnson Space Flight Center to visit SMG and observe their support for the launch of STS-88.

AMU HARDWARE AND SOFTWARE MAINTENANCE

In late December, the MIDDS-OS/2 workstation hard drive failed. The AMU called the Outsourcing Desktop Initiative for NASA (ODIN) contractor for repair. ODIN responded and installed a larger hard drive (4.3 GB). After the repair, the system was converted to the Windows NT operating system and will be used as a personal workstation. As of 1 January 1999, the AMU did not renew its McIDAS-OS/2 license, however, we did renew the annual McIDAS-X license.

As was noted in the last quarterly report, IBM will no longer be supporting the UNIX to UNIX copy (UUCP) protocol for electronic mail (e-mail) transfer in the next release of the AIX operating system. As a result, the AMU has changed over to a Windows NT server-based e-mail program.

AMU MIDDS-X CONVERSION

Mr. Wheeler continued to update and migrate the current AMU's MIDDS-OS/2 functionality over to the new AMU MIDDS-X workstations during October and November. The work on this task was completed in December.

2.2 TASK 002 TRAINING

CSR provided startup and functionality training to the AMU personnel on the new MIDDS-X weather display system. The Graphical User Interface (GUI) was reviewed in detail. Also, all AMU personnel attended a training session on the new capabilities of McIDAS-X provided by SSEC.

2.2 TASK 003 SHORT-TERM FORECAST IMPROVEMENT

SUBTASK 3 STATISTICAL SHORT-RANGE FORECAST TOOLS (MS. LAMBERT)

During this quarter, all data sets needed for the task were collected. These sets include data from buoy and Coastal-Marine Automated Network (C-MAN) stations off the Florida east coast, hourly surface observations from stations in central Florida, rawinsonde observations for central Florida, and the 5-minute observations from the KSC/CCAS wind tower network. The periods of record for each of the data types differ by several years. The buoy data are from 1988 to the present and the C-MAN data are from 1986 to the present. The surface observation data are from 1973 through early 1997 with most stations missing data from 1996. The wind tower network data are from 1986 to 1996. The period of record for the rawinsonde observations is not yet known.

The data from two buoy and three C-MAN stations have been processed and formatted in files that can be easily imported into a database or spreadsheet. The station identifications and their latitude/longitude locations used for this task are given in Table 1.

Table 1. List of buoy and C-MAN stations used in this task.

Buoy (*) and C-MAN (#) Station ID	*Latitude(N) / Longitude(W)*
41009 * (East of KSC/CCAS)	28° 30' / 80° 10'
41010 * (East of 41009)	28° 54' / 78° 33'
SAUF # (St Augustine, FL)	29° 52' / 81° 16'
SPGF # (Settlement Pt, GBI)	26° 37' / 80° 02'
LKWF # (Lake Worth, FL)	26° 42' / 79° 00'

The temporal resolution of the buoy and C-MAN station data are 30 minutes and 1 hour, respectively. All the files contain 12 variables, 8 of which are extracted. The variables extracted are

- Air temperature,
- Sea surface temperature,
- Dew point temperature,
- Sea level pressure,
- Wind speed,
- Wind direction,
- Wind gust (speed), and
- Visibility.

The 4 that are not extracted, and therefore not used in the task, are

- Wave height,
- Average wave period,

- Dominant wave period, and
- Mean wave direction.

The surface data file from the Air Force Combat Climatology Center (AFCCC) has also been decoded and is in the process of being imported into a database program. The file contains data from 28 stations in Florida. Table 2 lists all surface stations that can potentially be used for the task.

Table 2. List of surface stations used in this task.

Station ID	*Latitude(N) / Longitude(W)*	*Station ID*	*Latitude(N) / Longitude(W)*
AGR (Avon Park G. Rng.)	27º 39' / 81º 20'	NRB (Mayport NS)	30º 24' / 81º 25'
BOW (Bartow Mun.)	27º 57' / 81º 47'	NZC (Cecil Field NAS)	30º 13' / 81º 53'
COF (Patrick AFB)	28º 14' / 80º 36'	OCF (Ocala Municipal)	29º 10' / 82º 13'
CRG (Jacksonville/Craig)	30º 20' / 81º 31'	ORL (Orlando/Herndon)	28º 33' / 81º 20'
DAB (Daytona Beach)	29º 11' / 81º 03'	PBI (West Palm Beach)	26º 41' / 80º 07'
FMY (Ft. Myers/Page Fld.)	26º 35' / 81º 52'	PIE (St. Petersburg)	27º 55' / 82º 41'
FPR (Ft. Pierce)	27º 30' / 80º 22'	RSW (Ft. Myers/SW FL)	26º 32' / 81º 45'
GNV (Gainesville)	29º 41' / 82º 16'	SFB (Sanford)	28º 47' / 81º 14'
JAX (Jacksonville Intl.)	30º 30' / 81º 42'	SPG (St. Petersburg)	27º 46' / 82º 38'
LAL (Lakeland Reg.)	27º 59' / 82º 01'	SRQ (Sarasota/Bradenton)	27º 24' / 82º 33'
MCF (MacDill AFB)	27º 51' / 82º 31'	TIX (Titusville)	28º 31' / 80º 48'
MCO (Orlando Jetport)	28º 26' / 81º 19'	TPA (Tampa Intl.)	27º 58' / 82º 32'
MLB (Melbourne Reg.)	28º 06' / 80º 39'	TTS (Shuttle Landing Fac.)	28º 37' / 80º 43'
NIP (Jacksonville NAS)	30º 14' / 81º 41'	VRB (Vero Beach Reg.)	27º 39' / 80º 25'

All observations in the file contain 19 mandatory variables and some combination of 146 additional variables. The variables include meteorological observations and flags denoting the quality or occurrence of an observation. Of the 165 variables, the following were extracted for use in developing the statistical forecast equations. The complete list of variables is available from Ms. Lambert (winnie@fl.ensco.com, 407-853-8130).

- Wind Direction
- Wind Speed
- Wind Gust
- Ceiling
- Visibility
- Temperature
- 3-Hour Pressure Change
- 24-Hour Pressure Change
- Manual and Automated Weather Observations
- Cloud Coverage (oktas) for up to 4 cloud decks
- Cloud Deck Height
- Cloud Deck Characteristics

- Dew Point Temperature
- Mean Sea Level Pressure
- Altimeter Setting
- Total Cloud Coverage (oktas)
- Total Lowest Cloud Cover
- Lowest Cloud Base Height

The decoders for the wind tower data and the upper air data files are still being developed.

2.3 TASK 004 INSTRUMENTATION AND MEASUREMENT

SUBTASK 5 I&M AND RSA SUPPORT (DR. MANOBIANCO/MR. WHEELER)

There was no work performed on this task during this quarter.

SUBTASK 9 MIDDS-X TRANSITION (MR. WHEELER)

Mr. Wheeler worked with Mr. Weems (RWO) and CSR on the MIDDS/MIDDS-X transition by providing technical support in migrating the current functionality to the MIDDS-X weather display system. Approximately 12 different commands and/or output displays were tested or evaluated. Mr. Wheeler also attended a meeting on MIDDS-X testing and approval for it's operational use. System test and training was completed in November. This task was completed at the end of November.

2.4 TASK 005 MESOSCALE MODELING

SUBTASK 4 DELTA EXPLOSION ANALYSIS (MR. EVANS)

The Delta Explosion Analysis project is being funded by KSC under AMU option hours. The primary goal of this task is to conduct a case study of the explosion plume using the RAMS, REEDM, and HYPACT models and compare the model results with available meteorological and plume observations. The analysis has been completed and the results are being included into the final report. The compilation of the draft final report is completed and is currently under review. In this quarterly report we present the results of the RAMS model runs.

RAMS-ERDAS

We conducted the Delta modeling analysis by running RAMS for 17 January 1997 and using the forecast meteorological data to drive the diffusion model HYPACT. The RAMS-ERDAS configuration was the same as the configuration used for the daily operation of RAMS in the prototype ERDAS. This configuration has been set since the prototype ERDAS was installed in the ROCC in 1994. This key points of this configuration are:

- RAMS version 3a
- Microphysics inactive (NLEVEL=1)
- 3 nested grids
  - Coarse grid: 60 km spacing, 2220 x 2100 km domain
  - Medium grid: 15 km spacing, 495 x 555 km domain
  - Fine grid: 3 km spacing, 108 x 108 km domain
- Vertical grid with 10-m lowest grid point on fine grid and expanding in depth upward
- Twice daily RAMS runs initialized at 0000 and 1200 UTC with hourly forecast output
- Input data used to initialize the model are obtained from MIDDS and include:
  - NCEP ETA data
  - rawinsondes
  - surface and buoy data
  - local CCAS/KSC WINDS tower data

RAMS-PROWESS

The RAMS-PROWESS runs were made using the version of RAMS on the PROWESS workstations. The PROWESS workstations consist of one IBM RS/6000-370 and seven IBM RS/6000-250 workstations which run the parallel version of RAMS. The key points of this configuration are:

- RAMS version 4a
- Microphysics active (NLEVEL=3)
- 4 nested grids
  - Coarse grid: 72 km spacing, 2376 x 2088 km domain
  - Medium grid: 18 km spacing, 594 x 666 km domain
  - Fine grid: 6 km spacing, 222 x 222 km domain
  - Finest grid: 1.5 km spacing, 61.5 x 85.5 km domain
- Vertical grid with 38-m lowest grid point
- Twice daily RAMS runs initialized at 0000 and 1200 UTC with hourly forecast output
- Hourly output beginning at initialization time of 1200 UTC
- Input data used to initialize the model is obtained from MIDDS and includes
  - NCEP ETA data
  - Rawinsondes
  - Surface and buoy data
  - Local CCAS/KSC WINDS tower data

RAMS Results from ERDAS and PROWESS

The RAMS runs were initialized at 1200 UTC, approximately 4.5 hours before the Delta explosion. The meteorology during this day did not change significantly because of the presence of the post-frontal regime with the continued cold air advection. There were no sea breezes, river breezes, thunderstorms, or other significant local-scale phenomena for RAMS to forecast for the Cape Canaveral area.

Graphs comparing ERDAS RAMS wind data with observed data are presented in Figures 1 and 2. These figures show the observed vertical wind profiles at 1613 UTC and the predicted vertical wind profiles at 1600 UTC. RAMS predicted the wind speed profile accurately through the mixing layer to the inversion at 900 meters and then accurately predicted the gradual increase to 25 m s^{-1} at 4500 meters. RAMS predicted the wind direction more westerly than northwesterly in the layer from the surface to approximately 500 meters but then accurately predicted the wind shift at the 900-meter inversion and the westerly winds aloft.

The potential temperature profile predicted by RAMS at 1600 UTC closely matched the observed profile at 1613 UTC (Fig.3). The base of the predicted inversion was only slightly lower than the base of the observed inversion.

Maps showing RAMS forecast data from ERDAS and PROWESS for the period 1500 UTC to 2000 UTC are shown in Figures 4 to 10. Data are presented that represent wind flow in the different layers important in the plume analysis. The wind flow as shown by streamline analysis for different times and different levels are presented in Figures 4 to 7. The streamlines indicate the wind direction at a point in time and space.

The streamlines for the lowest RAMS level in both configurations indicate persistent northwesterly flow for the duration of the Delta plume analysis over the Cape Canaveral region (Figs. 4, 5a and b). The models predicted a slight shift in flow from northwesterly to north-northwesterly from 1500 to 1900 UTC but the shift was not significant with respect to the plume transport in HYPACT.

The streamlines for the layers centered at 782 meters in ERDAS and 724 meters in PROWESS are shown in Figures 5c, 5d, and 6 for the Delta analysis period. The 700-800 meter layer is important because this is the level just below the strong inversion that existed on 17 January. The winds in this level strongly influenced the transport of the lower plume. The analyses show that RAMS predicted northerly flow over Cape Canaveral at 1500 UTC. By 1700

UTC, RAMS predicted northeasterly wind flow in the region south of Cape Canaveral, over the ocean. The northeast flow became more pronounced at 1900 UTC. The ERDAS and PROWESS configurations generally agreed in predicting northeast winds south of Cape Canaveral but for the area north and west of Cape Canaveral, PROWESS RAMS predicted northerly flow while ERDAS RAMS predicted northeasterly flow across the entire Cape Canaveral region.

For the layers well above the inversion at 1580 meters for ERDAS RAMS and 1699 meters for PROWESS RAMS, the streamline analysis from both models showed persistent west-northwesterly flow through the Delta analysis period (Fig. 7). Both models showed similar wind flow at 1500 and 2000 UTC. The winds at this level influenced the transport of the upper cloud.

The RAMS temperature predictions for the lowest levels in the ERDAS and PROWESS configurations are shown in Figure 8. The analyses are shown to compare the configuration differences and also to show the change over time of the predicted low-level temperature structure. At 1500 UTC, both configurations show an east-west temperature gradient with colder temperatures over the land and warmer temperatures to the east over the ocean. It is difficult to compare the actual temperatures since the lowest level in ERDAS is centered at 10 meters and the lowest level in PROWESS is centered at 35 meters. By 2000 UTC, the temperature gradient had shifted to north-south in both models and ERDAS RAMS, with its lowest level at 10 m, shows more influence of the land-water interfaces associated with rivers and islands.

The vertical potential temperature structure of the atmosphere as predicted by RAMS is shown in Figure 9. These figures show an east-west cross section of the potential temperature as predicted by the two configurations of RAMS at different times. The figures show that ERDAS RAMS predicted an elevated inversion at approximately 750 meters at 1500 UTC while PROWESS RAMS predicted the inversion at approximately 500 meters at 1500 UTC. By 2000 UTC the models lifted the inversion to approximately 1000 meters for ERDAS RAMS and 750 meters for PROWESS RAMS. Rawinsonde data from 1613 UTC indicated the base of the inversion was at approximately 900 meters (Figure 3).

Conclusions from RAMS Model Runs

- The wind flow predictions in *this* case were fairly accurate based on qualitative comparisons with observations. Both ERDAS and PROWESS configurations of RAMS produced wind flow measurements that matched closely with rawinsonde and profiler measurements and seemed to provide good input to HYPACT. The meteorological conditions on this day were strongly influenced by synoptic rather than local forcing.
- RAMS under-predicted onshore flow at the level of the Delta II cloud. RAMS predicted onshore flow in the 600- to 900-meter layer in the area south of Cape Canaveral. However, the northeast onshore flow was probably a little stronger than modeled as evidenced by the track of the actual cloud.
- RAMS accurately predicted the strength and height of inversion for *this* case. The well-defined inversion that was measured by rawinsonde and had a significant influence on the explosion cloud was accurately predicted by RAMS in its strength and height. The inversion was determined by the vertical temperature profile.

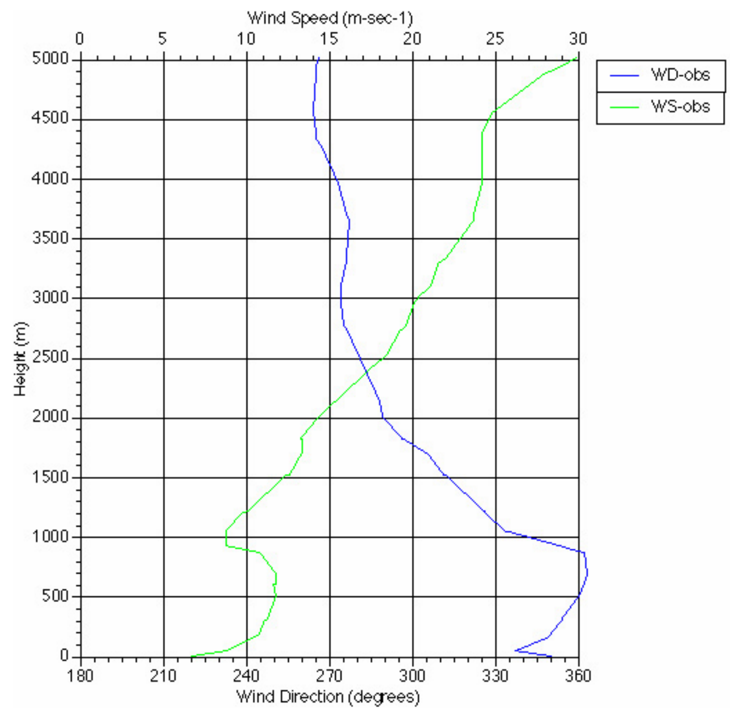


Figure 1. Observed wind speed and direction from rawinsonde at 1613 UTC. Note that the observed wind directions from 0 - 15 are shown on the graph as greater than 360°.

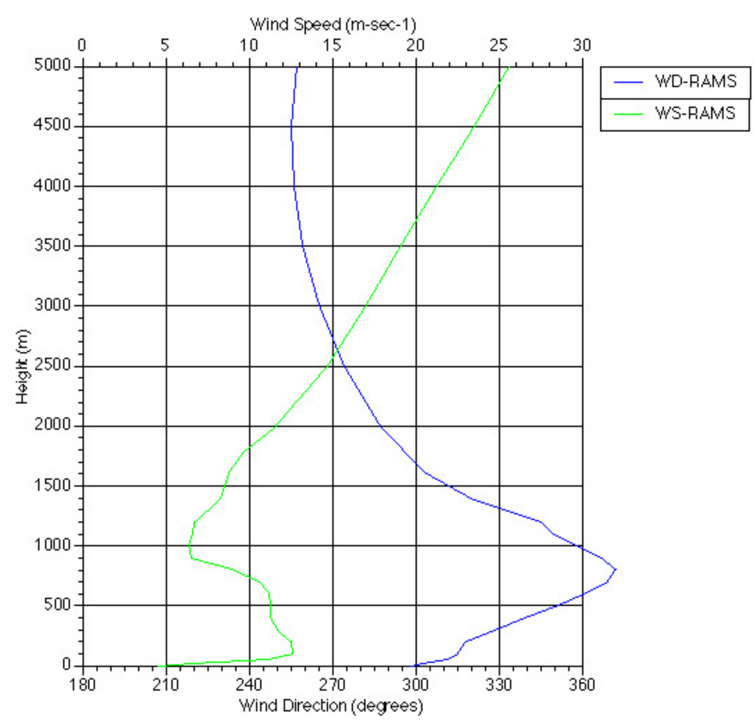


Figure 2. Predicted wind speed and direction from ERDAS RAMS at 1600 UTC. Note that the observed wind directions from 0 - 15° are shown on the graph as greater than 360°.

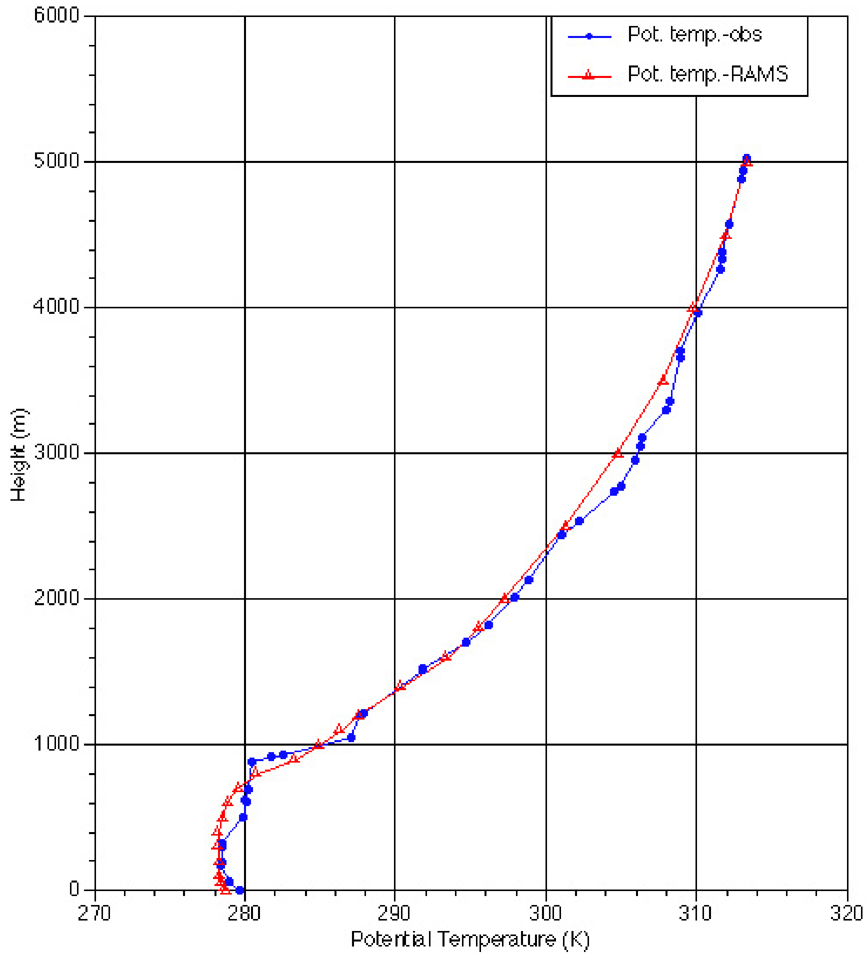
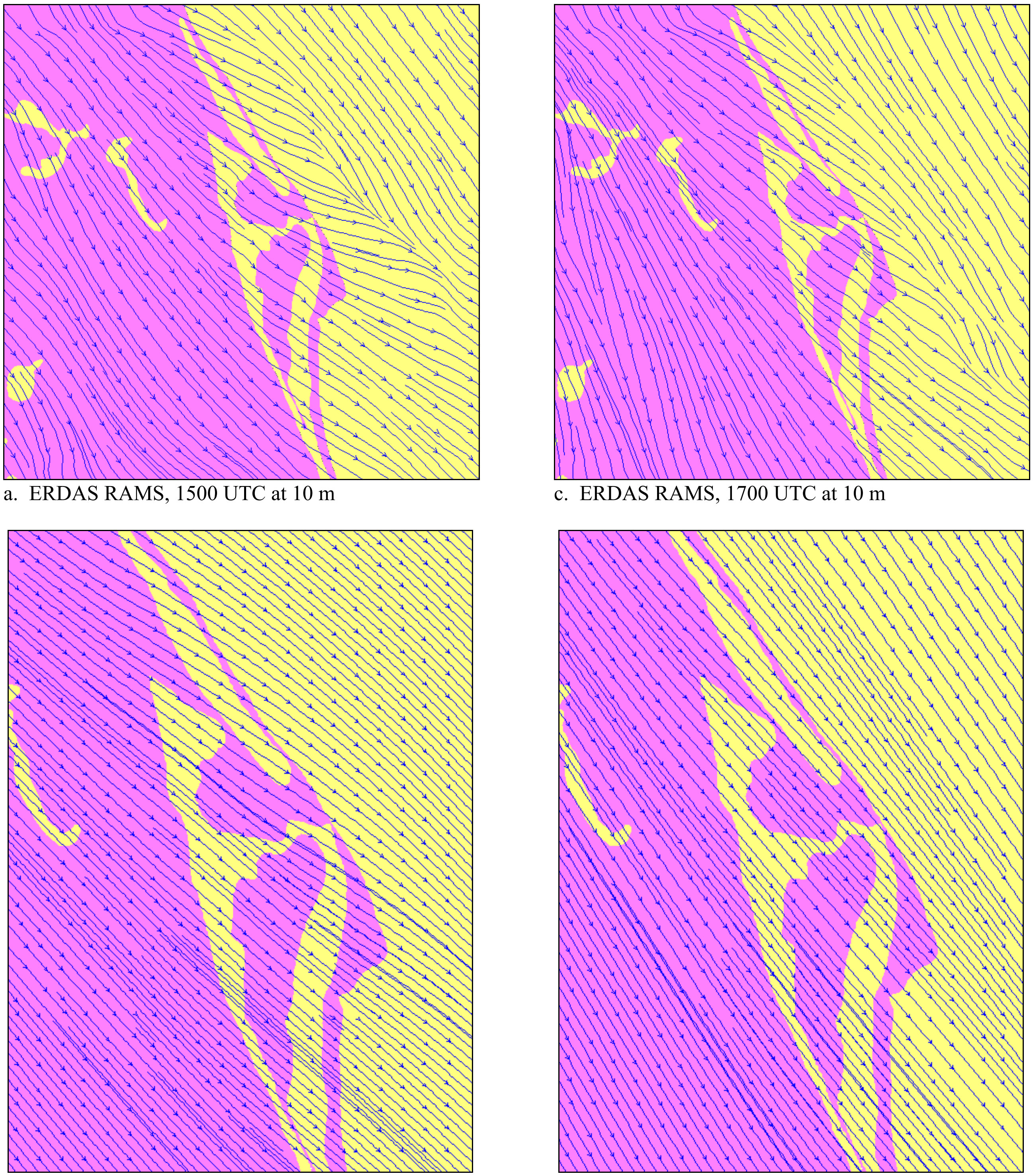


Figure 3. Rawinsonde-observed potential temperature at 1613 UTC compared to model-predicted potential temperature at 1600 UTC. The model predictions were from ERDAS RAMS.



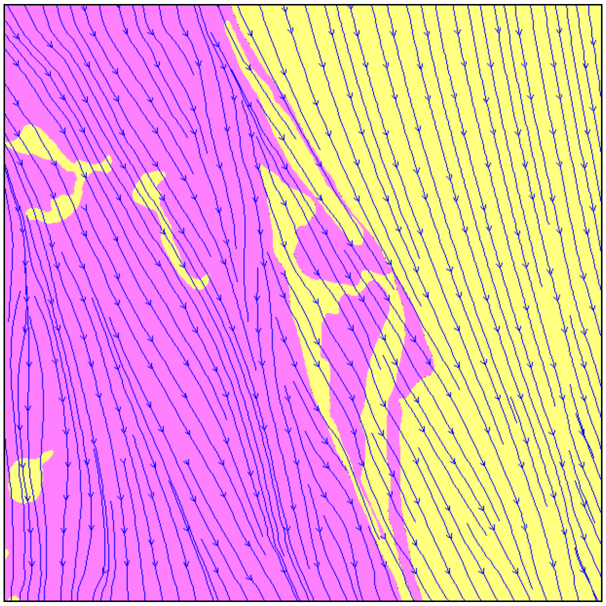
a. ERDAS RAMS, 1500 UTC at 10 m

c. ERDAS RAMS, 1700 UTC at 10 m

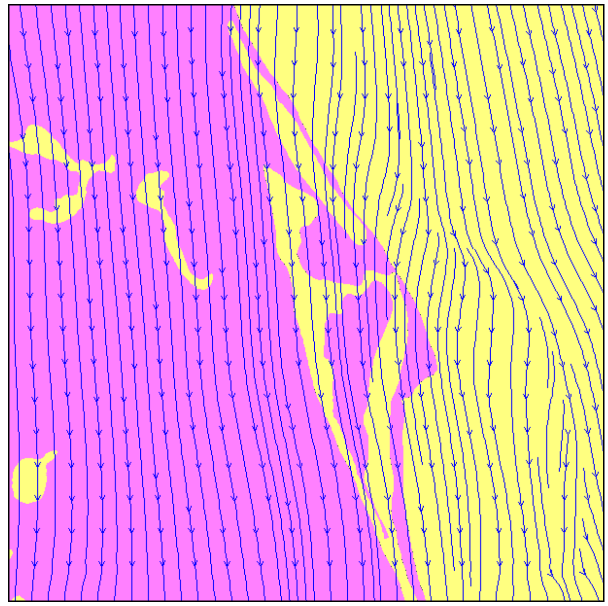
b. PROWESS RAMS, 1500 UTC at 35 m

d. PROWESS RAMS, 1700 UTC at 35 m

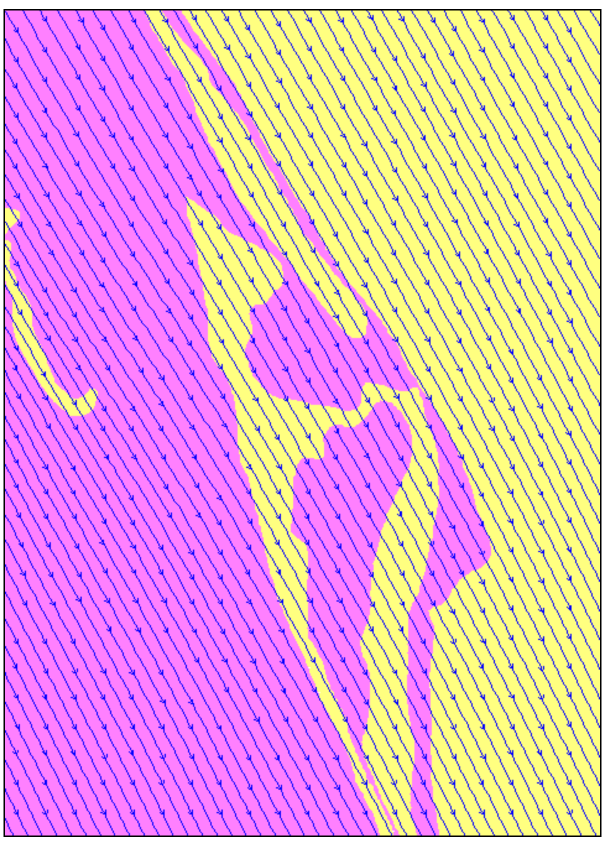
Figure 4. Streamline forecasts comparing output from ERDAS and PROWESS on 17 January 1997. Each figure is marked with its model configuration, time, and height.



a. ERDAS RAMS, 1900 UTC at 10 m



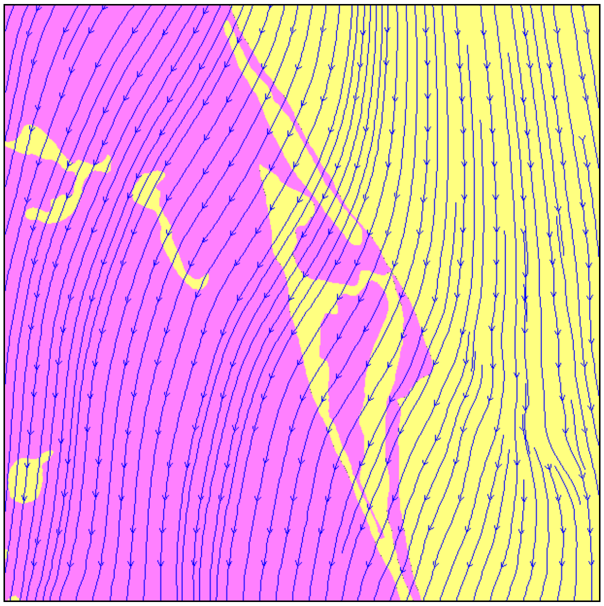
c. ERDAS RAMS, 1500 UTC at 782 m

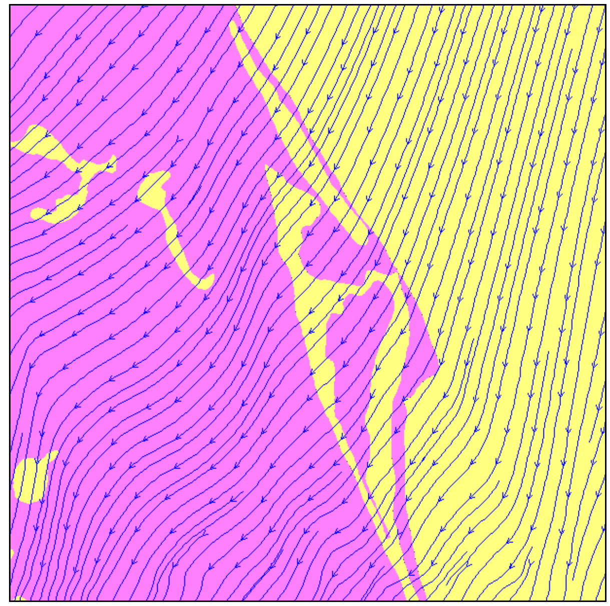


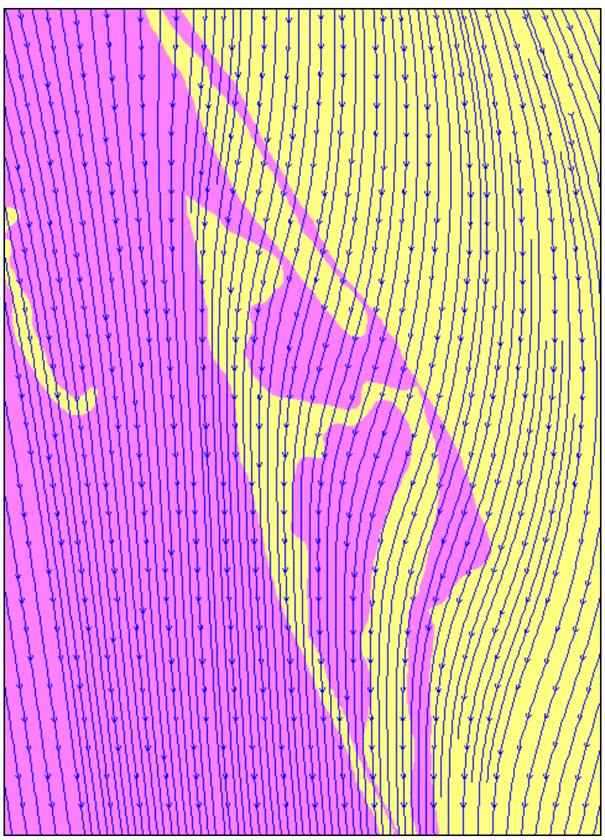
b. PROWESS RAMS, 1900 UTC at 35 m

d. PROWESS RAMS, 1500 UTC at 724 m

Figure 5. Streamline forecasts comparing output from ERDAS and PROWESS on 17 January 1997. Each figure is marked with its model configuration, time, and height.


a. ERDAS RAMS, 1700 UTC at 782 m


c. ERDAS RAMS, 1900 UTC at 782 m


b. PROWESS RAMS, 1700 UTC at 724 m

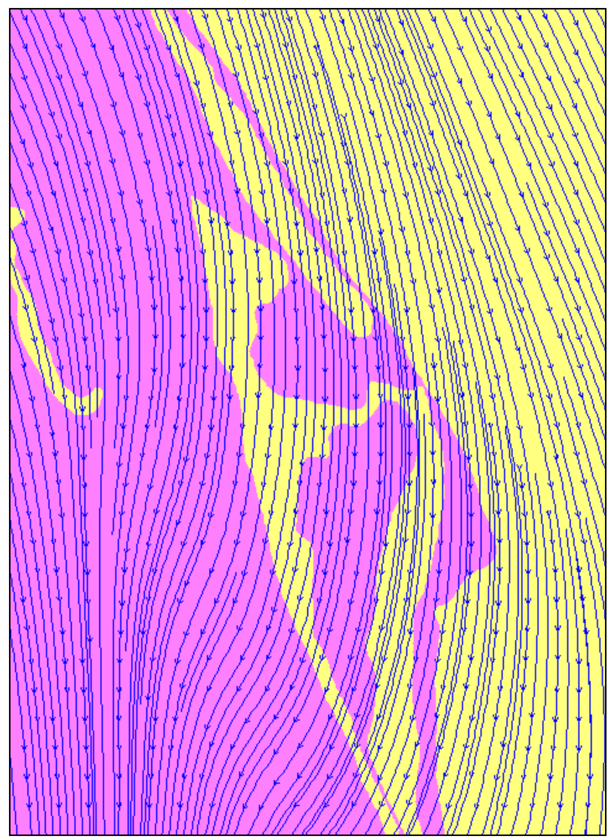
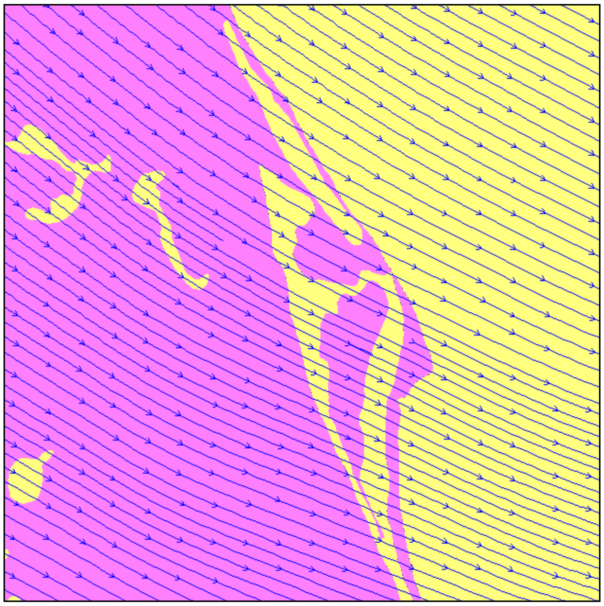
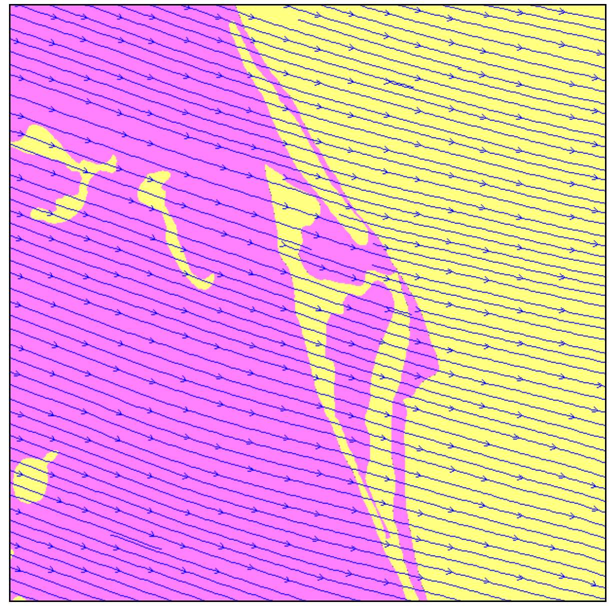

d. PROWESS RAMS, 1900 UTC at 724 m

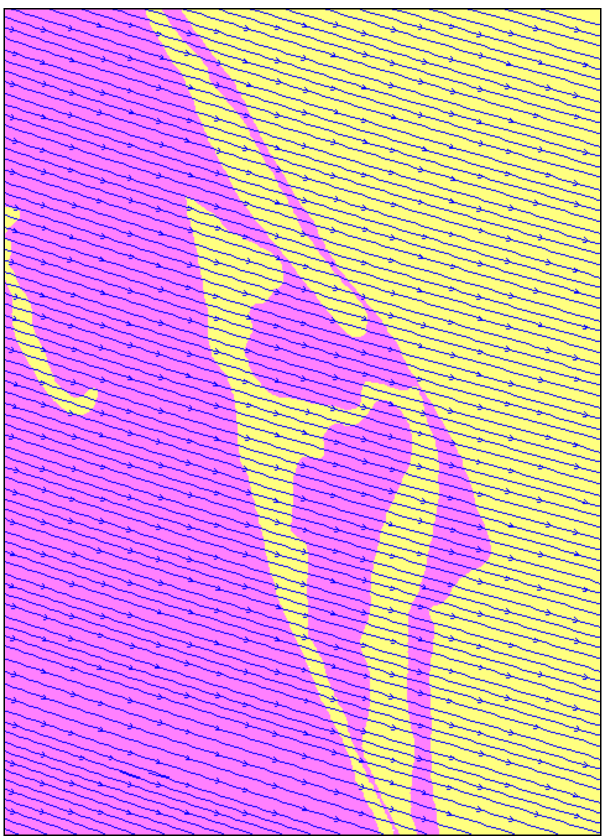
Figure 6. Streamline forecasts comparing output from ERDAS and PROWESS on 17 January 1997. Each figure is marked with its model configuration, time, and height.



a. ERDAS RAMS, 1500 UTC at 1580 m



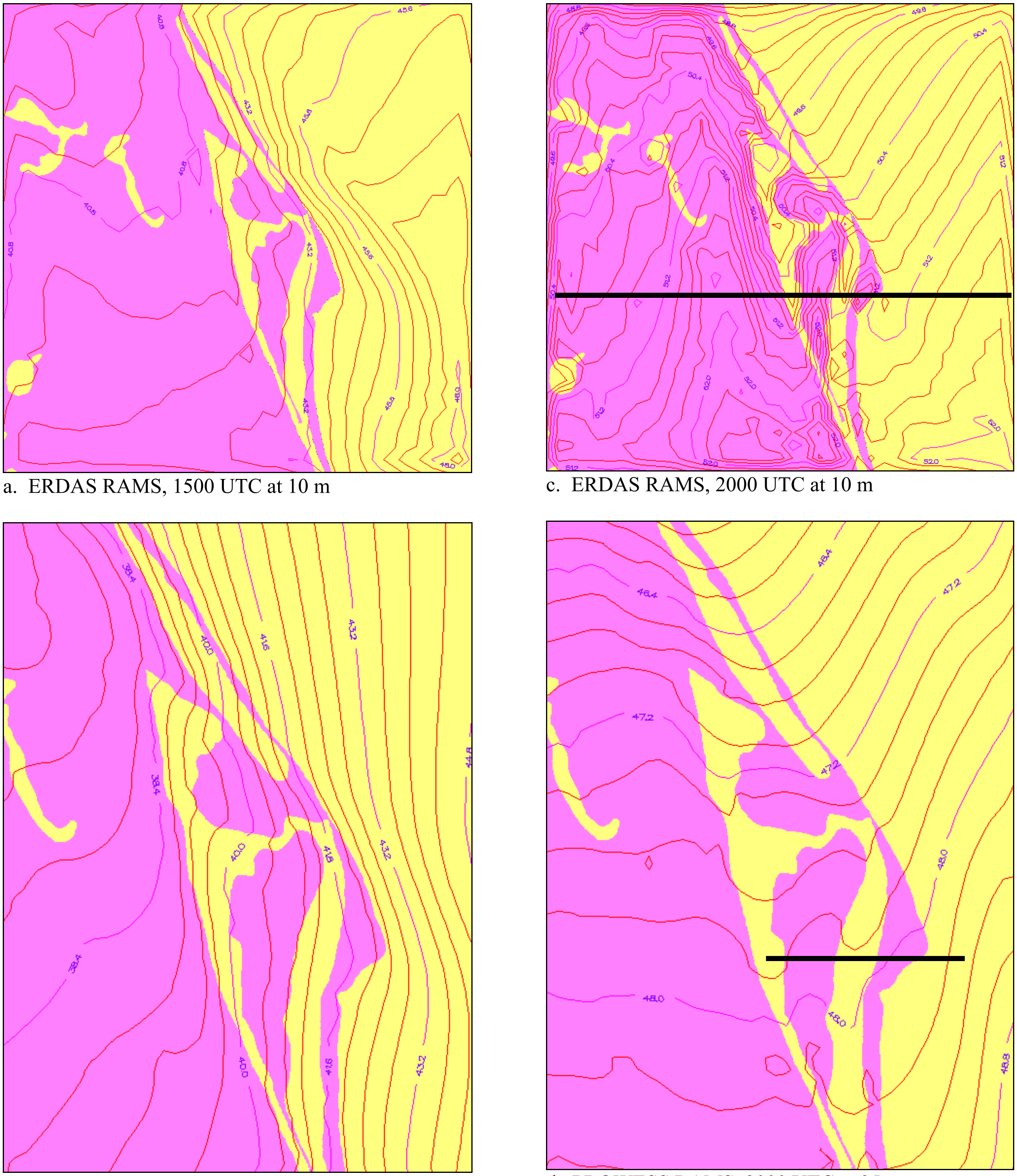
c. ERDAS RAMS, 2000 UTC at 1580 m



b. PROWESS RAMS, 1500 UTC at 1699 m

d. PROWESS RAMS, 2000 UTC at 1699 m

Figure 7. Streamline forecasts comparing output from ERDAS and PROWESS on 17 January 1997. Each figure is marked with its model configuration, time, and height.



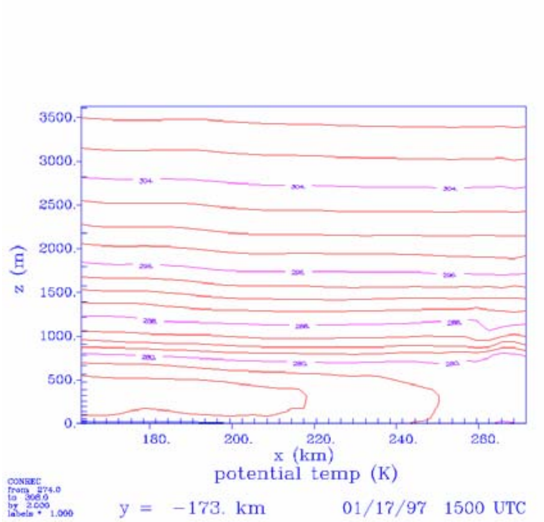
a. ERDAS RAMS, 1500 UTC at 10 m

c. ERDAS RAMS, 2000 UTC at 10 m

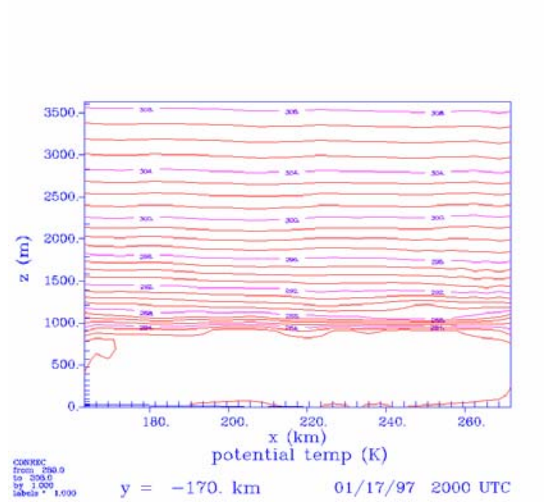
b. PROWESS RAMS, 1500 UTC at 35 m

d. PROWESS RAMS, 2000 UTC at 35 m

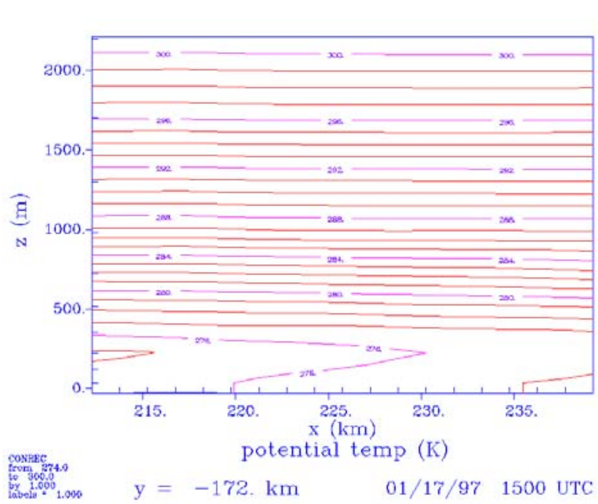
Figure 8. Surface temperature (F) forecasts comparing output from ERDAS and PROWESS on 17 January 1997. Each figure is marked with its model configuration, time, and height. The dark bold line in panels c and d shows the approximate location of the potential temperature cross sections shown in Figure 9.



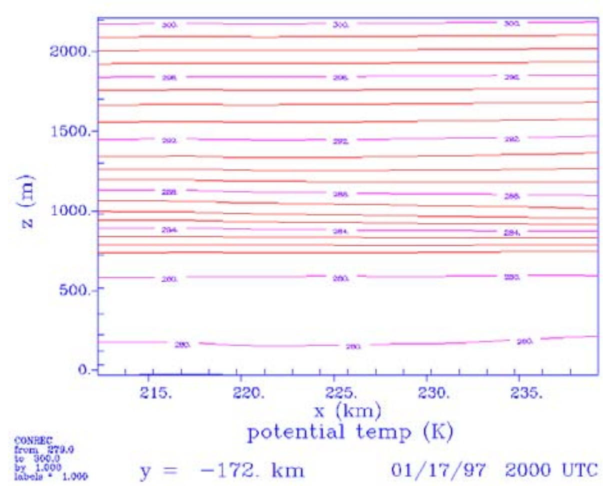
a. ERDAS RAMS, 1500 UTC



b ERDAS RAMS, 2000 UTC



c. PROWESS RAMS, 1500 UTC



d. PROWESS RAMS, 2000 UTC

Figure 9. Potential temperature (K) cross section forecasts comparing output from ERDAS and PROWESS on 17 January 1997. Each figure is marked with its model configuration and time. The cross-sections intersect the Cape Canaveral Air Station along an east-west line as shown in Figure 8. The ERDAS cross-section is approximately 110 km wide and the PROWESS cross section is approximately 25 km wide.

SUBTASK 5 MODEL VALIDATION PROGRAM (MR. EVANS)

The primary purpose of the U.S. Air Force's Model Validation Program (MVP) Data Analysis project, which is being funded by option hours from the U.S. Air Force, is to produce RAMS and HYPACT data for the three MVP sessions conducted at Cape Canaveral in 1995-1996. This program involves evaluation of Range Safety's modeling capability using controlled releases of tracers from both ground and aerial sources.

The status of the MVP data analysis tasks is presented in Table 3.

Table 3. Status of MVP data analysis tasks.			
MVP Data Analysis Task	**Session I**	**Session II**	**Session III**
Prepare Data	Completed	Completed	Completed
Run ERDAS-RAMS	Completed	Completed	Completed
Run ERDAS-HYPACT	Completed	Partially completed	Completed
Run PROWESS-RAMS	Completed	Completed	Completed
Run PROWESS-HYPACT	Completed	Completed	Completed
Submit Data to NOAA-ATDD	Completed	To be done	Completed (ERDAS-HYPACT reruns must still be submitted)

Activity over the last quarter has been limited. The remaining analysis to be completed is the ERDAS-HYPACT runs for Session II. The data from the Session II runs along with the ERDAS-HYPACT data Session III rerun will be submitted when all analysis is completed.

SUBTASK 7 LOCAL DATA INTEGRATION SYSTEM / CENTRAL FLORIDA DATA DEFICIENCY (DR. MANOBIANCO)

During the past quarter, Dr. Manobianco and Mr. Case completed the Local Data Integration System (LDIS) final report. Internal reviews were conducted within the AMU followed by external reviews at the Spaceflight Meteorology Group (SMG), 45th Weather Squadron (45 WS), and the National Weather Service at Melbourne (NWS MLB). Recommendations by each customer were incorporated into the final report that will be distributed in January 1999.

A portion of the LDIS final report is presented in this quarterly report and primarily focuses on data non-incorporation (DNI) experiments that were conducted to assess the influence of specific data sets on the subsequent analyses. First, a brief description of the two case studies used in the LDIS report is provided. A discussion of the characteristics of data used by LDIS is also presented followed by a brief description of the analysis and grid setup. Finally, the methodology and results of the DNI experiments are given.

Case Study Descriptions

The DNI experiments were conducted for both a warm (26-27 July 1997) and a cool season (12 December 1997) event in order to examine the influence of particular data sets on LDIS. The warm season event featured a strong thunderstorm outflow boundary which propagated across the Kennedy Space Center/Cape Canaveral Air Station (KSC/CCAS) and forced Atlas launch operation A1393 to be scrubbed for the day. The cool season case consisted of a slow-moving cold front accompanied by extensive post-frontal precipitation with embedded convection.

Data Coverage in Central Florida

Data density and coverage in east central Florida varies considerably depending on the level in the atmosphere and distance from KSC/CCAS. All observational data within 250 km of KSC/CCAS that can be incorporated by LDIS are shown in Table 4. This table also includes an estimate of the horizontal resolution, vertical extent, frequency of observation, and variables that are measured for each data source. The horizontal resolution of the various data types is estimated from the observations collected for the two case studies. The impact of the data listed in Table 4 is assessed within the DNI experiments described below.

LDIS Analysis and Grid Configuration

The Advanced Regional Prediction System (ARPS) Data Analysis System (ADAS) was used to create analyses on a 10-km and 2-km grid. The 10-km grid covers much of the Florida peninsula and adjacent waters of the Atlantic Ocean and Gulf of Mexico whereas the 2-km domain is centered over KSC/CCAS and includes adjacent portions of east-central Florida and the Atlantic Ocean. ADAS analyses were generated for both analysis grids every 15 minutes at 0, 15, 30, and 45 minutes past the hour. A more complete description of the LDIS configuration is found in the final report.

Data Non-Incorporation Experiments

This section discusses the methodology for the DNI experiments and presents results from the DNI runs for the warm and cool season cases. The DNI experiments are designed to assess the impact that specific data sources from Table 4 have on the subsequent analyses for the warm and cool season cases. Although DNI is applied for only two cases here, the results should help users to understand the impact of missing data on LDIS analyses. This point is especially important for LDIS running in real-time since there will be instances when data are unavailable due to equipment malfunction, transmission errors, or communication problems.

Table 4. Data availability within 250 km of KSC/CCAS including data type, horizontal resolution, vertical extent, variable(s) observed, and frequency.

Data Type	*Horizontal Resolution*	*Vertical Extent*	*Variables*	*Frequency (min)*
GOES-8 VIS imagery	1 km	---	brightness T	15
GOES-8 IR imagery	4 km	---	brightness T	15
Cloud/WV drift winds	24 km	Variable	u, v	360
METAR	34 km*	Sfc	u, v, T, T_d, p	60
Buoy/ship	34 km*	Sfc	u, v, T, T_d, p, SST	60
Central Florida mesonet	34 km*	Sfc	u, v, T, T_d, p	60
KSC/CCAS towers	4 km	1.8–150 m	u, v, T, RH	5
Rawinsonde	200 km	Sfc to Stratosphere	u, v, T, RH	720
GOES-8 Soundings	30 km	Sfc to Stratosphere	T, q	60
WSR-88D	0.2–1.0 km	Variable+	radial wind, ref, SW	6
Aircraft/pilot reports	Variable	Variable	u, v, T, ICE, TURB, cloud	Variable
ACARS	25 km	Variable	u, v, T	7.5
915 MHz Profiler	11 km**	0.117–3.1 km	u, v, T_v	15
50 MHz Profiler	11 km**	2.0–18.6 km	u, v	5

*Represents the combined horizontal resolution of METAR, buoy/ship, and the central Florida mesonet.
+Depends on radar echoes.
**The combined horizontal resolution of five 915 MHz profilers and one 50 MHz profiler over KSC/CCAS.

u = west-east wind	v = north-south wind		
T = temperature	T_d = dew point	T_v = virtual temperature	SST= sea-surface temp.
RH = relative humidity	q = specific humidity	p = pressure	ref = reflectivity
ICE = icing	TURB = turbulence	WV = water vapor	SW = spectral width
VIS = visible	IR = infrared	GOES = Geostationary Orbiting Environmental Satellite	

ACARS = Aeronautical Radio, Inc. (ARINC) Communications, Addressing and Reporting System

Experiment Design

The DNI experiments are designed to run ADAS in the same configuration as in the full data analysis but withhold selected data. Given thirteen separate data sources listed in Table 4, there are many possible combinations for withholding certain data types. In addition, data can be excluded at select times or during the entire analysis periods. It is not practical to run all such combinations or even anticipate when certain data types or groups of data may be missing. Therefore, the DNI experiments (Table 5) consider a very limited subset based on primarily data type and vertical extent. For example, METAR, buoy/ship, central Florida mesonet and KSC/CCAS tower data are withheld for DNI run #5 (NOSFC) while rawinsonde and GOES-8 soundings data are withheld for DNI run #7 (NOSND). In the event that only background fields from the RUC or another regional-scale model are available, the DNI experiment #1 (NODAT) excludes all data and provides a benchmark to compare with the full analysis of all available data. Except for NOSND, data listed in Table 5 are excluded by ADAS on both the 10-km and 2-km domains for each 15-minute cycle during the entire warm and cool season analysis periods. Since rawinsonde and GOES-8 soundings are not analyzed on the 2-km domain, NOSND is run only on the 10-km domain.

Table 5. Listing of data non-incorporation (DNI) experiments.

DNI Exp. #	***DNI Exp. Name***	***Data Excluded***
1	NODAT	All
2	NOAIR	ACARS, aircraft/pilot reports, cloud/WV drift winds
3	NORAD	WSR-88D
4	NOPRO	915 MHz and 50 MHz profiler
5	NOSFC	METAR, buoy/ship, central Florida mesonet, KSC/CCAS towers
6	NOSAT	GOES-8 VIS/IR imagery
7	NOSND	Rawinsondes, GOES-8 soundings

Analysis Methodology

Each 15-minute ADAS cycle on the 10-km and 2-km domain generates ~18 megabytes (MB) of output. The large volume of output results from the horizontal and vertical distribution of many variables such as pressure, temperature, wind, moisture, etc. Since ADAS is run for 33 analysis times in the warm and cool season cases, the total amount of output per case is on the order of 594 MB (18 MB x 33 cycles). Finally, the full analysis cycle is repeated seven times for the DNI experiments. Therefore, the total amount of ADAS output available for analysis of the DNI experiments is on the order 4752 MB per case (594 MB x 7 DNI runs + 594 MB x 1 run including all data).

As with the design of the DNI experiments, there are several ways to analyze and present the results given the large amount of data generated by these runs. The methodology of choice highlights how DNI impacts the analysis of features such as the outflow boundary and cold front for the warm and cool season cases, respectively. To accomplish this, spatial correlation coefficients (CCs) are computed between the full (or control) analysis and each DNI run. Spatial CCs measure the degree to which patterns are similar between two fields (Anthes 1983). Values of CCs range from –1 to 1 where 1 indicates exact agreement while 0 indicates no correspondence. (Note for CCs of –1, the patterns have the same shape and intensity but opposite sign.)

The CCs are computed for u- and v-wind components, moisture (RH*), potential temperature (θ), and pressure (p). Separate CCs for these variables are calculated at each vertical level and time for the 10-km and 2-km analyses only over the area of the 2-km domain. As a result, this technique does not measure the impact of DNI on the 10-km analyses outside of the 2-km domain. The CCs display considerable variability as a function of variable, vertical level and time for the following reasons:

- Each data type listed in Table 4 does not affect every analysis variable. For example, wind profiler observations do not directly impact moisture and temperature analyses.
- Each data type listed in Table 4 affects analyses only at a limited number of vertical levels depending on where observations are available and the vertical correlation range. For example, surface wind observations do not impact wind analyses in the middle troposphere.
- Each data type affects analyses only at times when observations are available.

Interpretation of Correlation Coefficients

The CCs are useful to quantify the effect of withholding certain data types on analyses from the warm and cool season cases. In general, CCs near 0 (1) indicate that the observations have relatively more (less) impact on the resulting analyses. Figure 10 illustrates the physical significance of a small CC that occurs between the control analysis and the analysis from DNI experiment #3 (NORAD). The magnitude of the 480-m u-wind component at 2300 UTC 26 July on the 2-km domain from the control and NORAD runs is depicted in Figures 10a and b, respectively. Strong positive (westerly) u-wind components present in the control run south of KSC/CCAS are nonexistent in the NORAD experiment. The difference field (NORAD – control) clearly illustrates a significant discrepancy in the u-wind component as denoted by differences as large as 12 m s^{-1} (Fig. 10c). The CC for the 480-m u-wind fields in Figures 10a and 10b is 0.19. This result demonstrates that WSR-88D data have a large impact in defining the structure of the outflow boundary in the wind field at this particular time and level.

A similar comparison of the surface u-wind component at 2000 UTC 26 July is shown in Figures 10d-f. The control analysis displays negative (easterly) u-wind components extending ~60 km inland south of KSC/CCAS in association with the east coast sea breeze (Fig. 10d). Although METAR, buoy/ship, central Florida mesonet and KSC/CCAS tower data are withheld in DNI experiment #5 (NOSFC), the surface u-wind field still shows easterly u-wind components south of KSC/CCAS (Fig. 10e). The magnitude of the u-wind is 0.5−1 m s^{-1} less than in the control run as illustrated by the difference field (Fig. 10f). The CC for the surface u-wind fields in Figures 10d and 10e is 0.98. A CC of 0.98 indicates that the surface wind field patterns at 2000 UTC are quite similar and that data withheld in NOSFC have a relatively small impact on the analysis of the u-wind component.

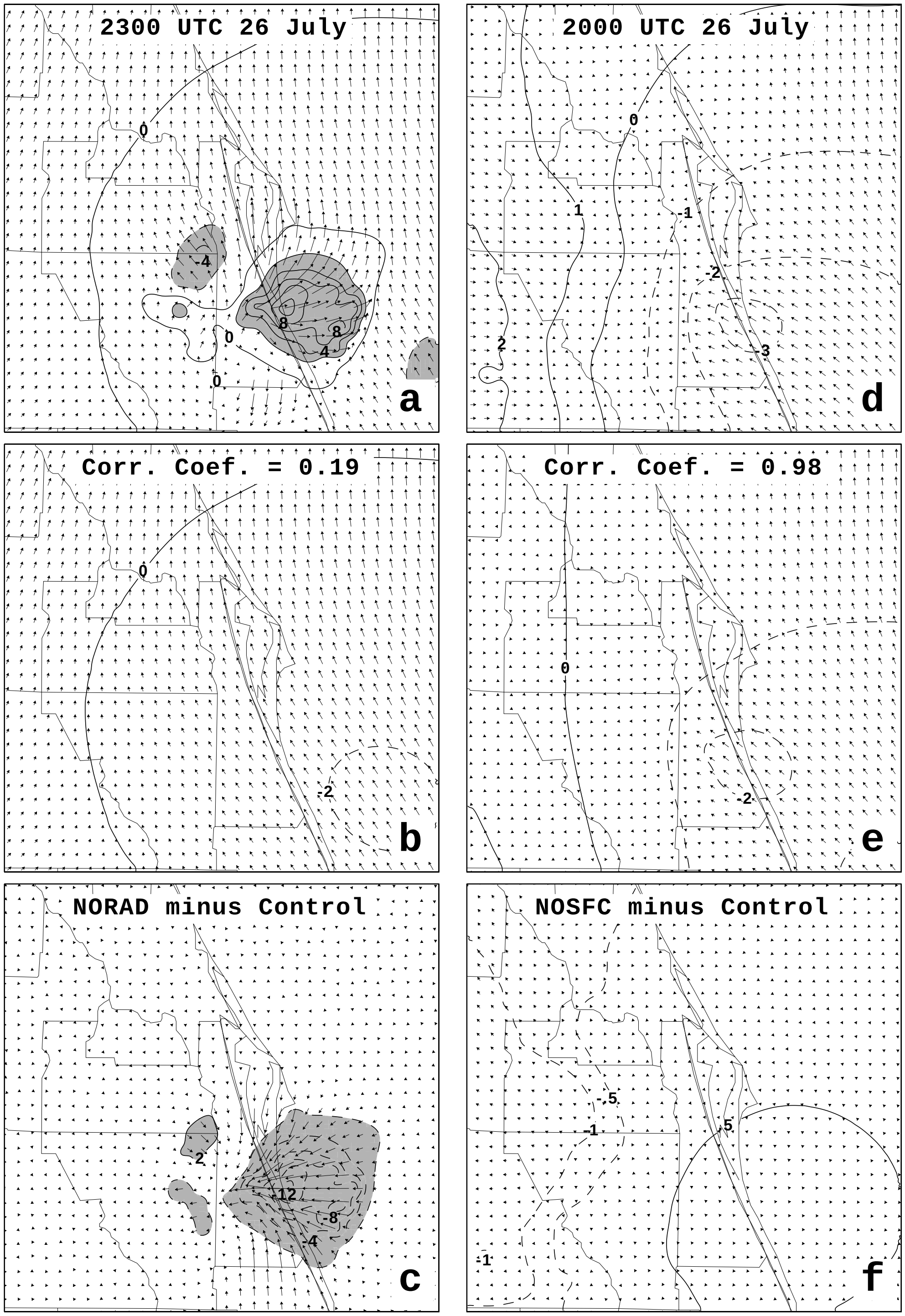


Figure 10. The 480-m wind vectors and u-wind component (m s^{-1}) at 2300 UTC 26 July are shown for the a) control analysis, b) data non-incorporation (DNI) experiment #3 (NORAD), and c) difference field (NORAD minus control). A similar plot of the surface wind field and u-wind component at 2000 UTC 26 July is depicted for the d) control analysis, e) DNI experiment #5 (NOSFC), and f) difference field. U-wind components > 2 m s^{-1} are shaded and negative isotachs are given by dashed lines. The spatial correlation coefficient computed between the wind fields in panels a) and b) [d) and e)] is listed in panel b) [e)].

Results of Data Non-Incorporation

Given the large volume of output generated by the control and DNI runs, it is not practical to present results in the format shown in Figure 10. Instead, results from the DNI experiments are summarized as follows. For each warm and cool season DNI experiment, the minimum CC at any vertical level from both the 10-km and 2-km analyses is determined for a given variable and time. Each data type affects the analysis at a limited number of vertical levels. In fact, some observations such as cloud drift and water vapor winds can impact analyses at different levels each cycle. Therefore, the minimum CCs at any vertical level highlight the maximum impact of each DNI experiment for a specific variable and time.

The minimum CCs are then averaged over all warm and cool season analysis times when data for the DNI experiment are available in the 2-km domain. The procedure summarizes the temporal variation in minimum CC for each variable and experiment in terms of a single number. However, time-averaging masks changes in CCs resulting from the impact that data have on the analysis at different times.

The time-averaged CCs for each variable and DNI experiment are displayed as bar charts in Figure 11. The following points are important for interpreting the CCs plotted in Figure 11:

- The absence of a DNI experiment name on any graph indicates that data from that run do not directly impact the variables listed. For example, 915-MHz and 50-MHz profiler data excluded in DNI experiment #5 (NOPRO) do not affect the analysis of moisture (RH*), potential temperature (θ), or pressure (p). Therefore, RH*, θ, and p fields from the control and NOPRO are identical and produce a CC of 1. In fact, CCs for analysis variables not affected by a given data type will be 1 at all levels and times regardless of when and where such data are available. Since these results are not useful when comparing with other CCs, the DNI experiment name is omitted from the appropriate graph.

- The absence of a bar for specific DNI experiments denotes that CCs are not computed because observations are not available for that run at any time within the 2-km domain. There are a number of time-averaged CCs equal to 1 for different variables and experiments. This result occurs when observations within the 2-km domain do not impact the analysis.

The CCs shown in Figure 11 provide a means for ranking the impact that data from each DNI run have on the analysis for each case. The larger (smaller) values of CC indicate that specific data have less (more) effect on the resulting analysis for a specific variable, DNI experiment, and grid. The following bullets summarize the most notable points that can be inferred from the CCs:

- WSR-88D data (NORAD) have the greatest impact on the analysis of wind (u, v) and moisture (RH*). Aircraft/cloud drift and water vapor winds (NOAIR) and profiler (NOPRO) observations have a similar effect on the wind analyses but to a much smaller extent than radar data.

- Satellite (NOSAT) and WSR-88D data (NORAD) have a more significant impact on the moisture analyses during the warm rather than cool season case. The possible reasons for this result are twofold. First, the warm season case features more fine-scale structures of localized convection that are well represented by the radar data set. Second, the cool season analyses use higher resolution 40-km RUC background grids whereas the 60-km RUC grids are used for the warm season case. In addition, the RUC background field can more appropriately resolve the large-scale features associated with a frontal zone compared to the small-scale features associated with convection.

- Surface data (NOSFC) have a much greater impact on the analysis of zonal wind (u) during the warm rather than cool season. This is likely due to the characteristics of the warm season case selected in which a strong zonal outflow boundary deviated significantly from the RUC background winds. In general, the surface data should have a more significant impact on the complete wind field in the warm rather than cool season.

- Rawinsonde and GOES-8 (NOSND) sounding data have the most significant influence on the analysis of potential temperature (θ) and pressure (p).

- There are no clear trends to indicate that specific data have more or less impact on 10-km versus 2-km analyses.

The DNI experiments suggest that WSR-88D data have the most significant impact on the wind and moisture analyses for both the warm and cool season cases. However, this result can be misleading because each case is characterized by substantial precipitation and hence the presence of targets needed to produce reflectivity and radial wind data. Although the WSR-88D has the highest spatial resolution compared with other sensors used in LDIS, these data would have much less of an impact on the analyses in cases with limited or no radar targets. In order to address the limitations of using only two cases for DNI experiments, CCs could be computed from analyses over a period of several weeks. Such an effort would require substantial computing and data processing resources, but would provide a more representative sample of diverse weather scenarios to assess the relative impact of each data set on the subsequent analyses.

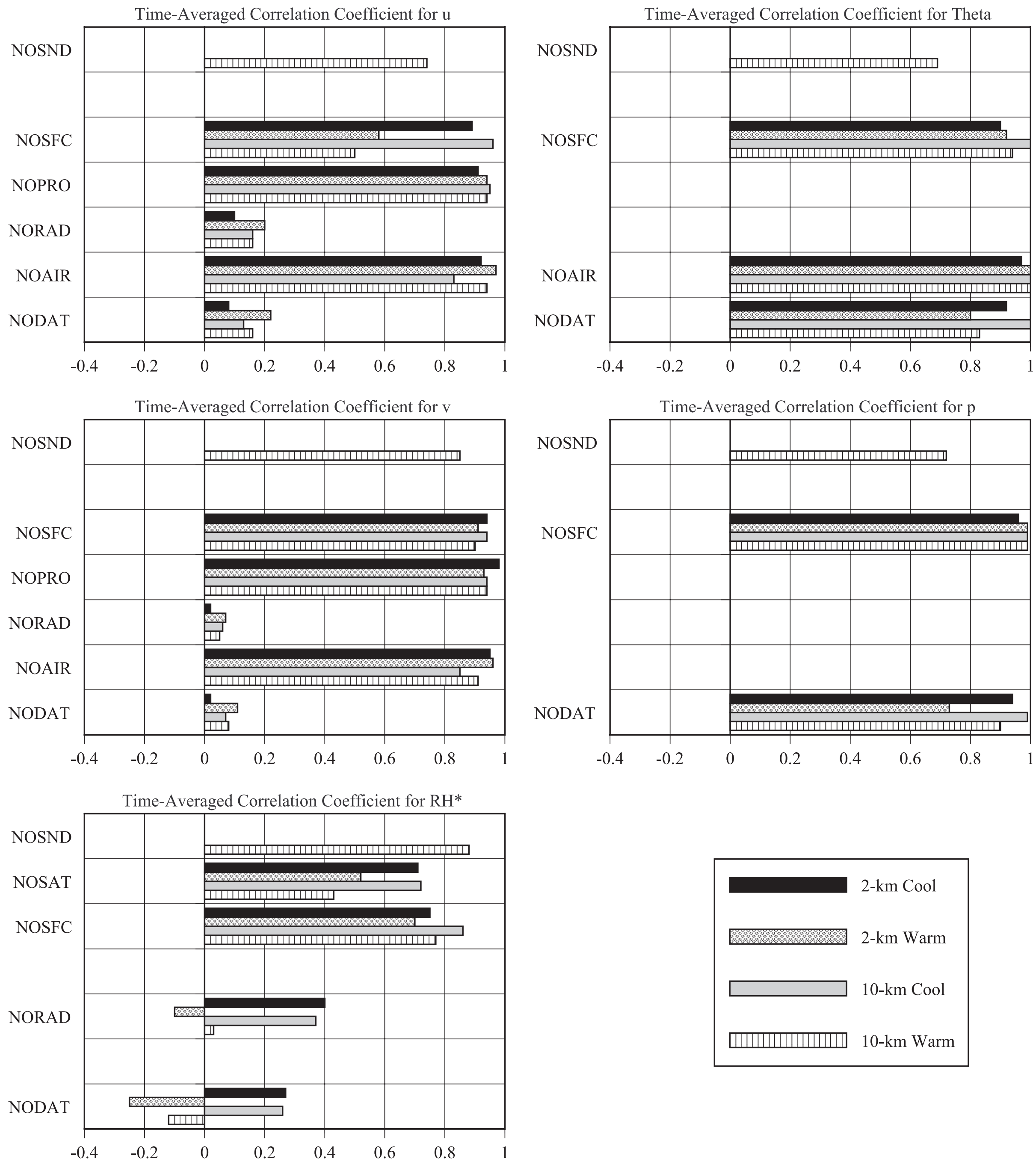


Figure 11. Time-averaged correlation coefficients (CCs) for data non-incorporation (DNI) experiments as a function of variable, case, and grid domain. The absence of a DNI experiment name on any graph indicates that data from that run do not directly impact the variables in question. The absence of a bar for specific DNI experiments denotes that CCs are not computed. See text for details.

Reference

Anthes, R. A., 1983: Regional models of the atmosphere in middle latitudes. *Mon. Wea. Rev.*, **111**, 1306-1335.

SUBTASK 8 MESO-MODEL EVALUATION (DR. MANOBIANCO)

The meso-models available for this task include MM5 run at the Air Force Weather Agency (AFWA) and Florida Department of Forestry (DOF) and RAMS run at NWS Tampa (TPA). In addition, the Meteorological and Range Safety System (MARSS)/Eastern Range Dispersion Assessment System (ERDAS) replacement running RAMS on the Eastern Range (ER) will be installed and certified for operational use by the 45th Range Safety (45 SE) around the beginning of 1999. Representatives from 45 SE and the 45 WS expressed a strong desire to have this local version of RAMS included in the AMU meso-model evaluation.

The 1998 warm season archive of MM5 runs from AFWA and RAMS runs from NWS TPA is not sufficient to perform the evaluation. Given the current status of the MARSS/ERDAS replacement at CCAS, there are also no local RAMS runs available from the 1998 warm season for the evaluation. On the other hand, Dr. Chris Herbster (DOF representative) can provide archived data for 119 DOF MM5 runs from 1 May 1998 through 30 September 1998. This archive is sufficient to evaluate model forecasts of the sea breeze and convective precipitation during the 1998 warm season.

In December 1998, Dr. Manobianco circulated a memorandum outlining five options for the meso-model task. All customers expressed an interest in option #5 that includes an evaluation of the DOF MM5 model for the 1998 warm season and a 12-month evaluation of the ERDAS RAMS model. The options and issues relating to the meso-model task were discussed during the AMU mid-course tasking review on 8 January 1999. Option #5 was approved by consensus during the mid-course review.

AMU personnel will perform the DOF MM5 evaluation that will compare and benchmark forecasts of the sea breeze and convective precipitation from MM5 with those from NCEP's 32-km Eta model. The sea breeze and convective precipitation forecasts will be verified for all available warm season cases using the subjective methodology designed for the 29-km (meso-) Eta model evaluation (Manobianco and Nutter 1999).

The sea-breeze verification will determine model skill in forecasting the occurrence of an east or west coast sea breeze along areas of the Florida peninsula that are contained within all model domains. The occurrence of observed sea breezes will be determined subjectively using GOES visible imagery and standard surface observations. Animating horizontal and vertical cross sections of model output will determine the occurrence of forecast sea breezes.

The methodology that will be used for the entire warm season verification of precipitation is also the same as that used during the meso-Eta model evaluation. The occurrence of observed precipitation will be determined from hourly composites derived by NCEP using Office of Hydrology rain gauge and WSR-88D-derived precipitation. The occurrence of forecast precipitation will be determined using gridded fields of total precipitation.

The technical portion of the ERDAS RAMS evaluation will be performed by ENSCO personnel on the Performance Evaluation, Test and Simulation (PET&S) contract managed by the 45th Maintenance Squadron (45 MXS). AMU personnel will direct the evaluation and help to establish the evaluation protocol and analyze results.

Reference

Manobianco, J., and P. A. Nutter, 1999: Evaluation of the 29-km Eta Model. Part II: Subjective Verification over Florida. *Wea. Forecasting*, **14**, 18-37.

2.5 AMU CHIEF'S TECHNICAL ACTIVITIES (DR. MERCERET)

During October, Dr. Merceret's technical activities centered on the Shuttle Launch Commit Criteria (LCC). Shuttle evaluated the effects of the response characteristics and sampling processes of the Launch Complex-39 wind sensors, and the effect of the spacing of the wind sensor from the pad on the wind limits specified in the LCC. Dr. Merceret and Dr. Stanley Adelfang of MSFC collaborated on several analyses of data relating to sensor response, averaging and sampling interval, and effects of sensor placement on the representativeness of peak wind measurements at the pads. Presentations were made to several Shuttle panels and boards before STS-95 and STS-88.

Shuttle is also considering a LCC to protect launch guests from possible toxic hazards in the event of a launch failure in the vicinity of the pad. In the unlikely event of a catastrophic failure of the vehicle, and under certain combinations of wind and temperature profiles, the potential exists for hydrogen chloride (HCL) concentrations at the causeway-viewing site to exceed recommended levels. Dr. Merceret assisted in the evaluation of the various proposals and analyses presented by Eastern Range and NASA safety personnel.

Dr. Merceret continued work on the investigation of the lifetime of upper-air wind features as a function of their size. He is also revising the manuscript on resolution of the KSC 50 MHz Doppler Radar Wind Profiler.

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Acronym List

30 SW	30th Space Wing
30 WS	30th Weather Squadron
45 LG	45th Logistics Group
45 MXS	45th Maintenance Squadron
45 OG	45th Operations Group
45 SW	45th Space Wing
45 WS	45th Weather Squadron
ACARS	Aeronautical Radio, Inc. (ARINC) Communications, Addressing and Reporting System
ADAS	ARPS Data Assimilation System
AFB	Air Force Base
AFCCC	Air Force Combat Climatology Center
AFMC	Air Force Materiel Command
AFRL	Air Force Research Laboratory
AFSPC	Air Force Space Command
AFWA	Air Force Weather Agency
AMU	Applied Meteorology Unit
ARPS	Advanced Regional Prediction System
ATDD	Atmospheric Turbulence and Diffusion Division
CC	Correlation Coefficient
CCAS	Cape Canaveral Air Station
C-MAN	Coastal-Marine Automated Network
CSR	Computer Science Raytheon
DAB	Daytona Beach Rawinsonde Station Identification
DNI	Data Non-Incorporation
DOF	Department of Forestry
DRWP	Doppler Radar Wind Profiler
ER	Eastern Range
ERDAS	Eastern Range Dispersion Assessment System
FSL	Forecast Systems Laboratory
FSU	Florida State University
FY	Fiscal Year
GOES	Geostationary Orbiting Environmental Satellite
GUI	Graphical User Interface
HYPACT	Hybrid Particle And Concentration Transport
I&M	Improvement and Modernization
IR	Infrared
JSC	Johnson Space Center
KSC	Kennedy Space Center

Acronym List

LC	Launch Complex
LCC	Launch Commit Criteria
LDIS	Local Data Integration System
MARSS	Meteorological and Range Safety System
McIDAS	Man computer Interactive Data Access System
MCO	Orlando Rawinsonde Station Identification
METAR	Aviation Routine Weather Report
MIDDS	Meteorological Interactive Data Display System
MSFC	Marshall Space Flight Center
MVP	Model Validation Program
NASA	National Aeronautics and Space Administration
NCAR	National Center for Atmospheric Research
NCEP	National Center for Environment Prediction
NOAA	National Oceanic and Atmospheric Administration
NSSL	National Severe Storms Laboratory
NWS MLB	National Weather Service Melbourne
NWS TPA	National Weather Service Tampa
ODIN	Outsourcing Desktop Initiative for NASA
PET&S	Performance Evaluation, Test & Simulation
PROWESS	Parallelized RAMS Operational Weather Simulation System
PSU	Penn State University
RAMS	Regional Atmospheric Modeling System
REEDM	Rocket Exhaust Effluent Diffusion Model
RSA	Range Standardization and Automation
RUC	Rapid Update Cycle
RWO	Range Weather Operations
SMC	Space and Missile Center
SMG	Spaceflight Meteorology Group
SSEC	Space Science and Engineering Center
STS	Space Transportation System
USAF	United States Air Force
UUCP	UNIX to UNIX Copy Protocol
VRB	Vero Beach Rawinsonde Station Identification
WSR-88D	Weather Surveillance Radar - 88 Doppler
WWW	World Wide Web

Appendix A

AMU Project Schedule 31 January 1999				
AMU Projects	Milestones	Actual / Projected Begin Date	Actual / Projected End Date	Notes/Status
Statistical Short-range Forecast Tools	Determine Predictand(s)	Aug 98	Sep 98	Completed
	Data Collection, Formulation and Method Selection	Sep 98	Feb 99	On Schedule
	Equation Development	Feb 99	Apr 99	On Schedule
	Tests with Independent Data	Apr 99	May 99	On Schedule
	Tests with Individual Cases	May 99	Jun 99	On Schedule
	Prepare Products, Final Report for Distribution	May 99	Jul 99	On Schedule
AMU MIDDS-X Conversion	Migrate Current Data Display/Archive Procedures to New Platform	Jul 98	Dec 98	Completed
MIDDS-X Transition	Technical Expertise/Assistance	Jul 98	Nov 98	Completed
LDIS / Central FL Data Deficiency	Identify Mesoscale Data Sources in central Florida	May 97	May 98	Completed
	Identify / Install Prototype Analysis System	Aug 97	Nov 97	Completed
	Case Studies Including Data Non-incorporation	Nov 97	Nov 98	Completed
	Final Report	Jul 98	Dec 98	Completed
LDIS Extension	Optimize Temporal Continuity of Analyses	Oct 98	Dec 98	Completed
	Determine Configuration Changes Required for Simulated Real-time Runs	Nov 98	Feb 99	On Schedule
	Simulate Real-Time Runs	Feb 99	Apr 99	On Schedule
	Determine Deficiencies /Sensitivities of Simulated Real-time Runs	Apr 99	May 99	On Schedule
	Final Report	May 99	Jun 99	On Schedule
Meso-Model Evaluation	Recommend Models for Evaluation	Jul 98	Dec 98	Completed
	Perform Evaluation	Jan 99	Apr 99	On Schedule
	Final Report	May 99	Jun 99	On Schedule
Delta Explosion Analysis	Analyze Radar Imagery	Jun 97	Nov 97	Completed
	Run Models/Analyze Results	Jun 97	Jun 98	Completed
	Final Report	Feb 98	Jan 99	In process of writing final draft
	Launch site climatology plan	Apr 98	May 98	Completed

AMU Project Schedule 31 January 1999				
AMU Projects	Milestones	Actual / Projected Begin Date	Actual / Projected End Date	Notes/Status
Model Validation Program	Inventory and Conduct RAMS runs for Sessions I, II, and III	Jul 97	Jul 98	Session I and III completed
	Run HYPACT for all MVP Releases	Aug 97	Jan 99	Session I and III completed; Session II PROWESS completed
	Deliver Data to NOAA/ATDD	Oct 97	Jan 99	All data will be submitted in Jan
	Acquire Meteorological Data for Titan Launches	Jul 97	Jan 99	
Local Radar Atlas	Develop Atlas on Significant Local Radar Signatures	Jan 99	Jul 99	On Schedule
Weather Event Studies	As Tasked, Analyze Significant Weather Events	Jan 99	Jul 99	On Schedule