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Assessing Upper-level Winds on Day-of-Launch at Vandenberg Air Force Base and Wallops Flight Facility

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November 2013

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Executive Summary

Customer: NASA's Launch Services Program (LSP)

The Applied Meteorology Unit (AMU) initially developed a day-of-launch capability for the 45th Weather Squadron (45 WS) Launch Weather Officers (LWOs) to monitor the upper-level winds for their launch customers at Kennedy Space Center (KSC) and Cape Canaveral Air Force Station (CCAFS) (Bauman and Wheeler, 2012). This capability was primarily developed for NASA's LSP. Because LSP conducts space launch operations at Vandenberg Air Force Base (VAFB) in California and Wallops Flight Facility (WFF) in Virginia, the AMU modified the upper-level winds tool for use at both locations.

The upper-level winds tool consists of a graphical user interface (GUI) that allows the LWOs at VAFB and WFF to plot charts of upper-level wind speed and direction observations and then overlay point forecast profiles from available numerical weather prediction models on the charts. This tool provides the LWOs with the capability to quickly retrieve and display the upper-level observations, compare them to the numerical weather prediction model point forecasts and provide upper-level wind information to the payload/launch team during the countdown. The observations are taken from the VAFB Real Time Automated Meteorological Profiling System (RTAMPS) rawinsondes and WFF rawinsondes. The model data includes the National Centers for Environmental Prediction North American Mesoscale, Rapid Refresh and Global Forecast System models. Comparing the model output to the observations would allow the LWOs to objectively assess the performance of these models and communicate that information to the launch team.

The AMU developed the upper-level winds tool as an Excel-based GUI for the LWOs to assess the model forecast upper-level winds compared to the observations. This GUI allows the LWOs to first initialize the models by comparing the 0-hour model forecasts to the observations and then to display model forecasts in 3-hour intervals from the current time through 12 hours. The AMU wrote Excel Visual Basic for Applications scripts that drive the GUI by automatically acquiring, downloading and processing the observations and model forecast data, and then displaying the resulting output in text format in Excel spreadsheets and in graphic format as Excel charts. The output of the observational data provides the LWO with the observation type and location, date and time, height, and wind direction and speed. The output of the model data provides the LWO with the model type and forecast point location, date and time of the model start and forecast intervals, height and wind direction and speed.

In the future, the AMU recommends adding output from a local high resolution version of the Weather Research and Forecasting (WRF) model. The AMU and National Oceanic and Atmospheric Administration Environmental Systems Research Laboratory are working on implementing local versions of WRF at WFF and VAFB, respectively. Once WRF is running routinely at each location, the AMU could add the WRF forecasts to this tool for use in the same manner as the NCEP NAM, RAP and GFS model forecasts.

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1. Introduction

The Applied Meteorology Unit (AMU) developed a day-of-launch capability to monitor upper-level wind observations and forecasts for NASA's Launch Services Program (LSP) at Kennedy Space Center (KSC) and Cape Canaveral Air Force Station (CCAFS) and for future use by NASA's Space Launch System when it begins operating at KSC. The 45th Weather Squadron (45 WS) Launch Weather Officers (LWOs) use this tool to monitor the upper-level winds and to keep their launch customers at KSC/CCAFS informed about observed and forecast changes in upper-level winds (Bauman and Wheeler 2012). Because LSP conducts space launch operations at Vandenberg Air Force Base (VAFB) in California and Wallops Flight Facility (WFF) in Virginia, the AMU modified the upper-level winds tool for use at both locations. The tool consists of a Microsoft Excel-based graphical user interface (GUI) that allows the LWOs at VAFB and WFF to create charts of upper-level wind speed and direction observations and then overlay point forecast[1] profiles from the National Centers for Environmental Prediction (NCEP) North American Mesoscale (NAM), Rapid Refresh (RAP) and Global Forecast System (GFS) models to assess the performance of these models. This tool provides the LWOs with the capability to quickly retrieve and display the upper-level observations, compare them to the numerical weather prediction model point forecasts and provide upper-level wind information to the payload/launch team during the countdown. Figure 1 shows VAFB map with the locations of

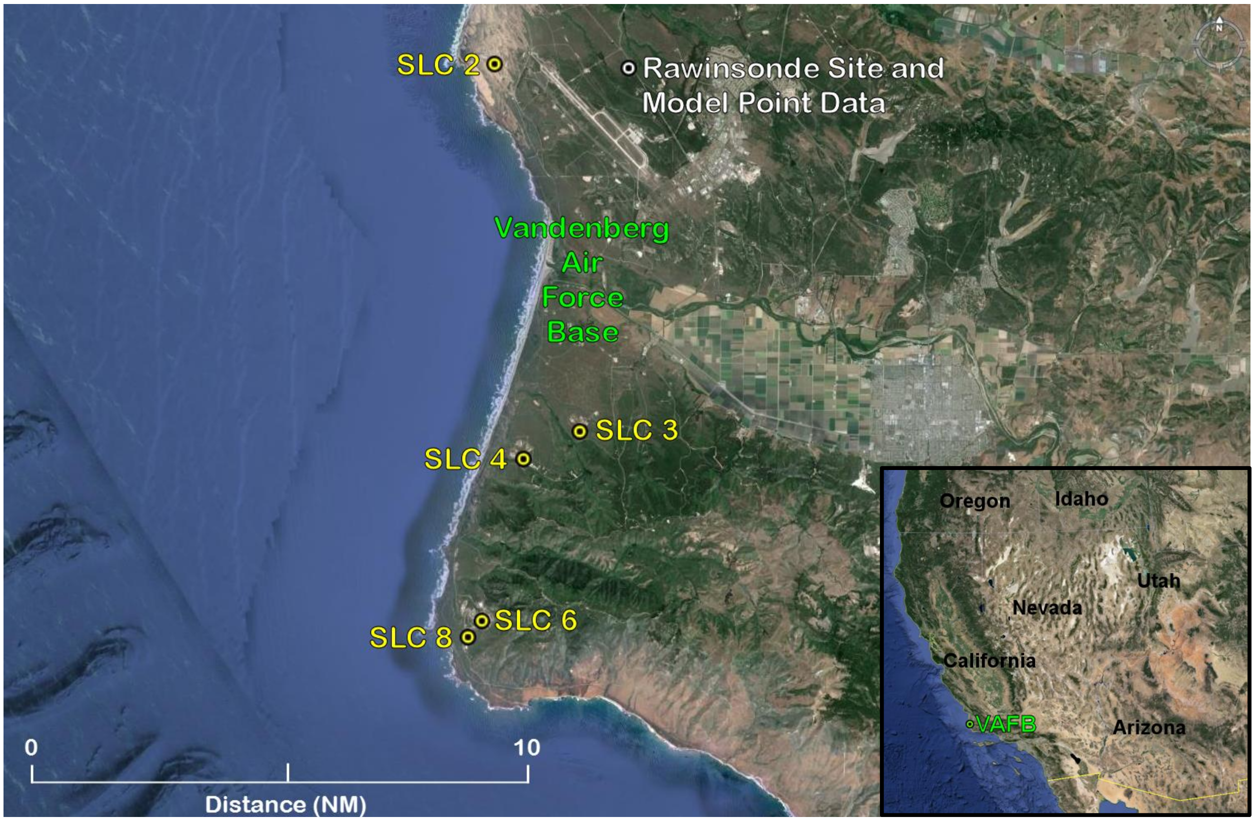

Figure 1. Map of VAFB showing locations of the rawinsonde site, the point forecast from the model data and SLCs. LSP launches Delta II from SLC 2, Atlas V from SLC 3, and Falcon 9 from SLC 4. The inset map in the lower right corner shows the location of VAFB on the southern California coast.

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[1] A point forecast is generated from a gridded data set such as a numerical weather prediction model for a single point within the grid. The forecast point is usually not co-located with a grid point and, therefore, the forecast point consists of data interpolated from the nearest grid points in the data set.

the rawinsonde observation site, the point forecast from the model data, and the space launch complexes (SLCs). Figure 2 shows a map of WFF with the locations of the rawinsonde observation site, the point forecast from the model data and the launch sites.

Figure 2. Map of WFF showing locations of the rawinsonde site, the point forecast from the model data and launch sites. The inset map in the upper left corner shows the location of WFF along the mid-Atlantic coast. WFF provides orbital launch services for small-to-medium class launch vehicles including NASA launches managed by LSP.

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2. Data

The goal of this task is to build a GUI that allows the LWOs to compare model wind profile forecasts to observed wind profiles closest in time to the 0-hour model wind profile forecast. This will allow them to determine which model has the best performance, i.e. to initialize the models. Their requirement is to display model forecasts in 3-hour intervals from the current time through 12 hours and display the data to the launch team.

The AMU developed the KSC/CCAFS tool using Microsoft Excel to download, ingest, format and display the data. The AMU verified the real time rawinsonde observations were available on local computers at VAFB and WFF and the model forecast point data for VAFB and WFF were available from the Iowa State University Archive Data Server (mtarchive.geol.iastate.edu) in a format that can be ingested by Excel. Therefore, the AMU would modify the KSC/CCAFS Excel tool to ingest rawinsonde observations from VAFB and WFF and model data from the Iowa State server with scripts developed using Visual Basic for Applications (VBA) in Excel.

2.1 Data Acquisition

One challenge with using near real-time data in Excel was to ensure the latest available model data were being acquired and that they were time-matched to the rawinsonde observations. NCEP runs the RAP model every hour and the NAM and GFS models every six hours at 0000, 0600, 1200, and 1800 UTC. Each model produces forecasts at least 12 hours beyond the initial time. The RAP and NAM models output forecasts at 1-hour intervals while the GFS model outputs forecasts at 3-hour intervals. Since each model has a different run time to complete the entire forecast cycle, the AMU conducted tests of the availability of the files on the Iowa State server to determine how long after model initialization time the files were ready for download. The AMU concluded that the RAP model forecasts are available from the Iowa State data server about 1 hour 45 minutes after each hour, the NAM model forecasts are available about 3.5 hours after each initialization time, and the GFS model forecasts are available about 4.5 hours after each initialization time.

At VAFB and WFF, the LWOs manually retrieve the rawinsonde data files from their respective balloon processing facilities and save them on a local computer. Working with meteorologists at VAFB and WFF, the AMU modified the VBA code in the KSC/CCAFS Excel tool to ask the user to choose a rawinsonde file to process from a pre-selected directory path on their computer. Once the user chooses the file, the rawinsonde data are imported, processed, and displayed in Excel. The formats of the rawinsonde files at VAFB and WFF are different from each other as well as from KSC/CCAFS, which required the AMU to modify the VBA code to properly import the files into Excel.

2.2 Data Processing

The LWO's requested using the rawinsonde observations for two applications. First, they want to use them to initialize each model's 0-hour forecast by comparing the rawinsonde observations to each model to determine which model is performing the best. Second, they want to use them to show the launch team how the upper-level winds are forecast to change by displaying the model forecasts valid at or near the same time of the most recent rawinsonde observation plus the model forecasts for the next 0-12 hours.

Before any of the data files are retrieved, several scripts are run to determine the current UTC time to ensure the latest model data are downloaded for processing. All time conversions used in the VBA scripts in this task are based on the local time of the user's computer. However, before converting local time to UTC, the AMU needed to include a check to determine if the current date was within Standard Time (ST) or Daylight Saving Time (DST). To do so, the

AMU downloaded an Excel DST module from Pearson Software Consulting, LLC that does this calculation (http://www.cpearson.com/EXCEL/DaylightSavings.htm). To make use of this module, the AMU first used the Excel built-in function "`=NOW()`" to obtain the local time from the user's computer. Next, the DST module is called to determine whether local time is in ST or DST using the function "`=IsDateWithinDST()`". Finally, to determine the correct UTC, the AMU VBA code adds five hours to local time during ST or four hours during DST for WFF, and eight hours to local time during ST or seven hours during DST for VAFB. The UTC time is saved in the Excel GUI and accessed by each script that needs to determine which model data and observations to use. The AMU then wrote a VBA script to automatically run the time calculation every time the GUI is started. In Excel VBA, naming a macro "Auto_Open" will automatically run all of the code within that macro each time the macro-enabled Excel file is opened.

2.2.1 Model Initialization

Based on the current UTC time and the times the model files are available on the Iowa State server, the first Excel script used to assess each model's initialization displays a pop-up window to instruct the user to choose a rawinsonde file closest to the model 0-hour forecast time so the observation can be compared to the model's initial conditions. Figure 3 shows a sample pop-up window generated when initializing the GFS model. It shows the user the current UTC time and instructs them to open a rawinsonde (sounding) file closest in time to the latest GFS model initialization. When the user clicks the 'OK' button, the Excel 'Open file' window is presented to the user as shown in Figure 4. The script opens the folder C:\Upper Level Winds, which contains the user's rawinsonde files allowing them to choose the file closest in time to the model initialization time. The user can single-click a filename and then select the 'Open' button or double-click a filename to open the file.

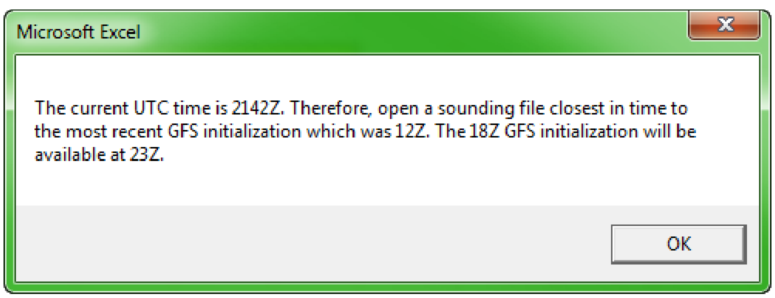


Figure 3. An Excel pop-up window used to instruct the user about what rawinsonde file to open based on the most recent model initialization time.

The VAFB and WFF rawinsonde files are in American Standard Code for Information Interchange (ASCII) format and are ingested into Excel as text files. Raw VAFB and WFF rawinsonde files ingested into Excel before processing are shown in Figure 5 and Figure 6, respectively. After accessing and ingesting the data files, the VBA code removes all unneeded parameters and reformats the data to prepare it for creating Excel charts. The reformatted rawinsonde data from VAFB and WFF are shown in Figure 7a and b, respectively.

Another VBA script written by the AMU extracts the rawinsonde observation's height, wind speed, wind direction, data type, location, date, and time from the reformatted data and creates charts containing the vertical profiles of wind speed and wind direction. Figure 8 shows the wind speed and wind direction plots for a VAFB rawinsonde from 1125 UTC on 12 September 2013. The data type, date, and time of the observation are displayed in the upper left of the chart.

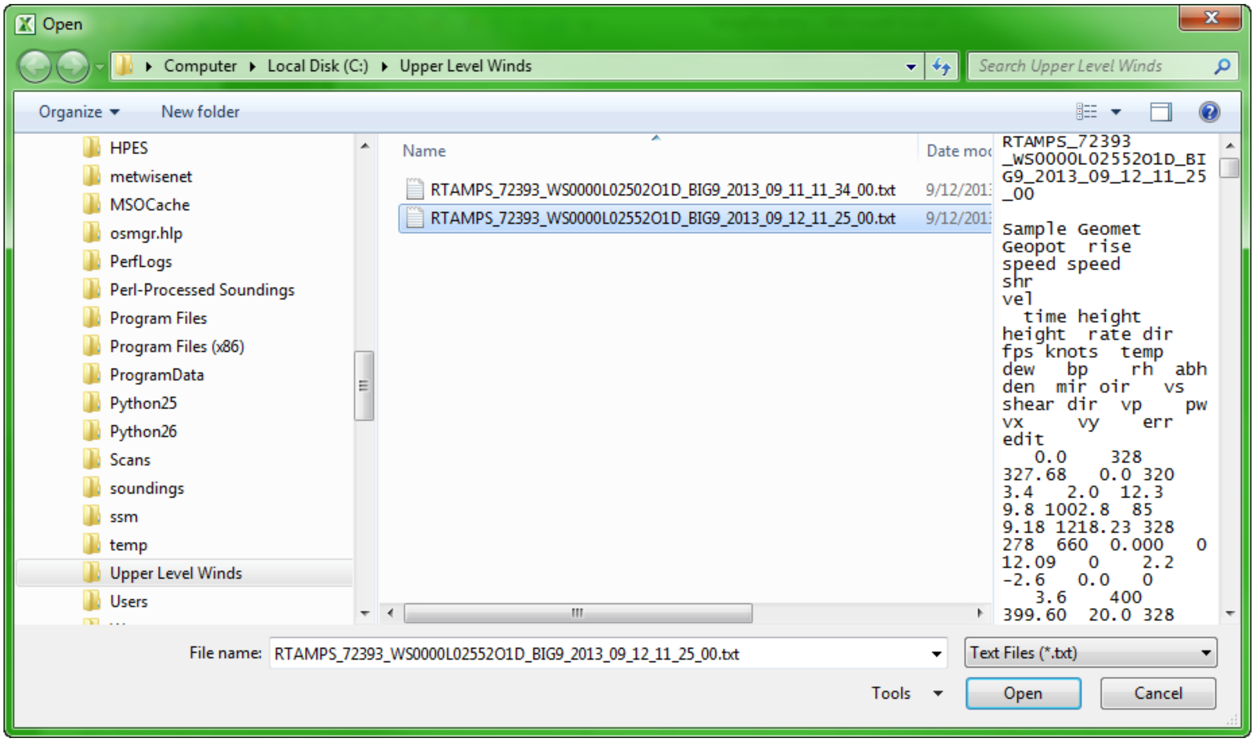
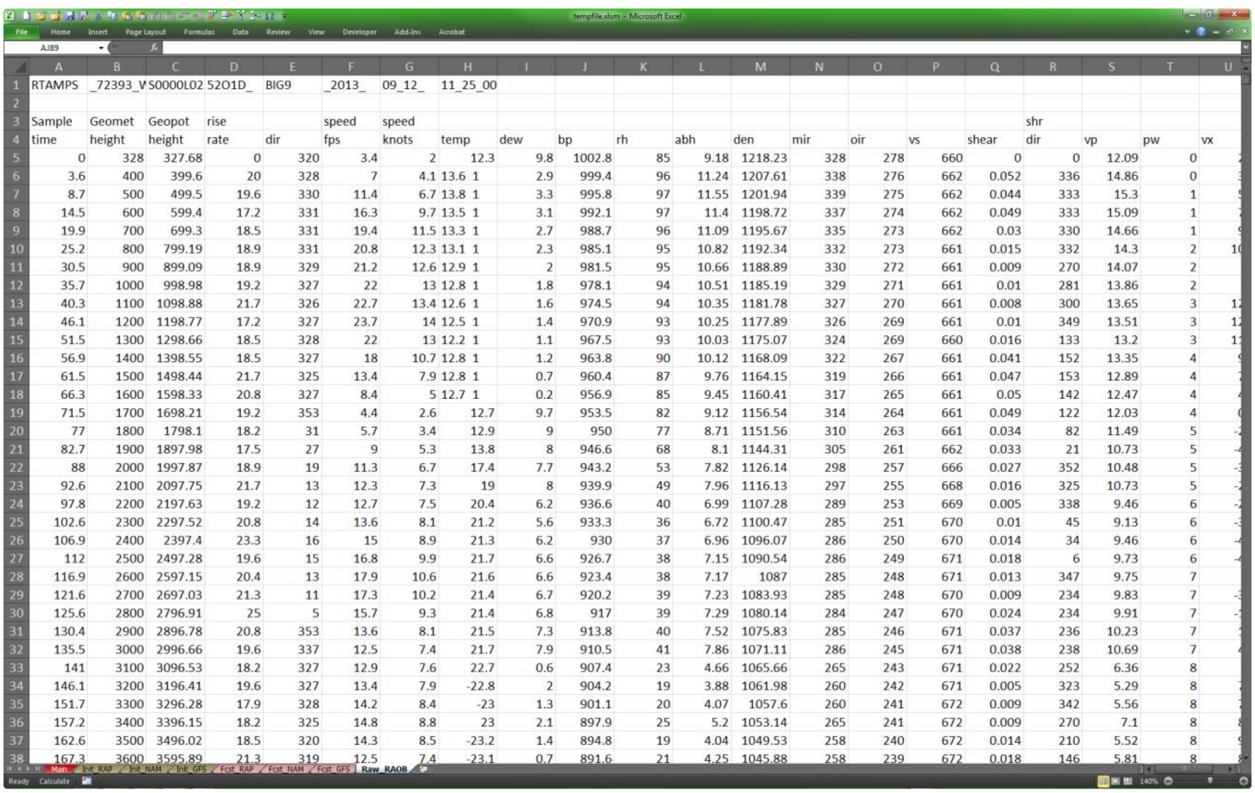


Figure 4. The Excel ‘Open file’ window shows the user what rawinsonde files are available.



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3	Sample	Geomet	Geopot	rise		speed	speed											shr			
4	time	height	height	rate	dir	fps	knots	temp	dew	bp	rh	abh	den	mir	oir	vs	shear	dir	vp	pw	vx
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12	35.7	1000	998.98	19.2	327	22	13	12.8 1	1.8	978.1	94	10.51	1185.19	329	271	661	0.01	281	13.86	2	
13	40.3	1100	1098.88	21.7	326	22.7	13.4	12.6 1	1.6	974.5	94	10.35	1181.78	327	270	661	0.008	300	13.65	3	
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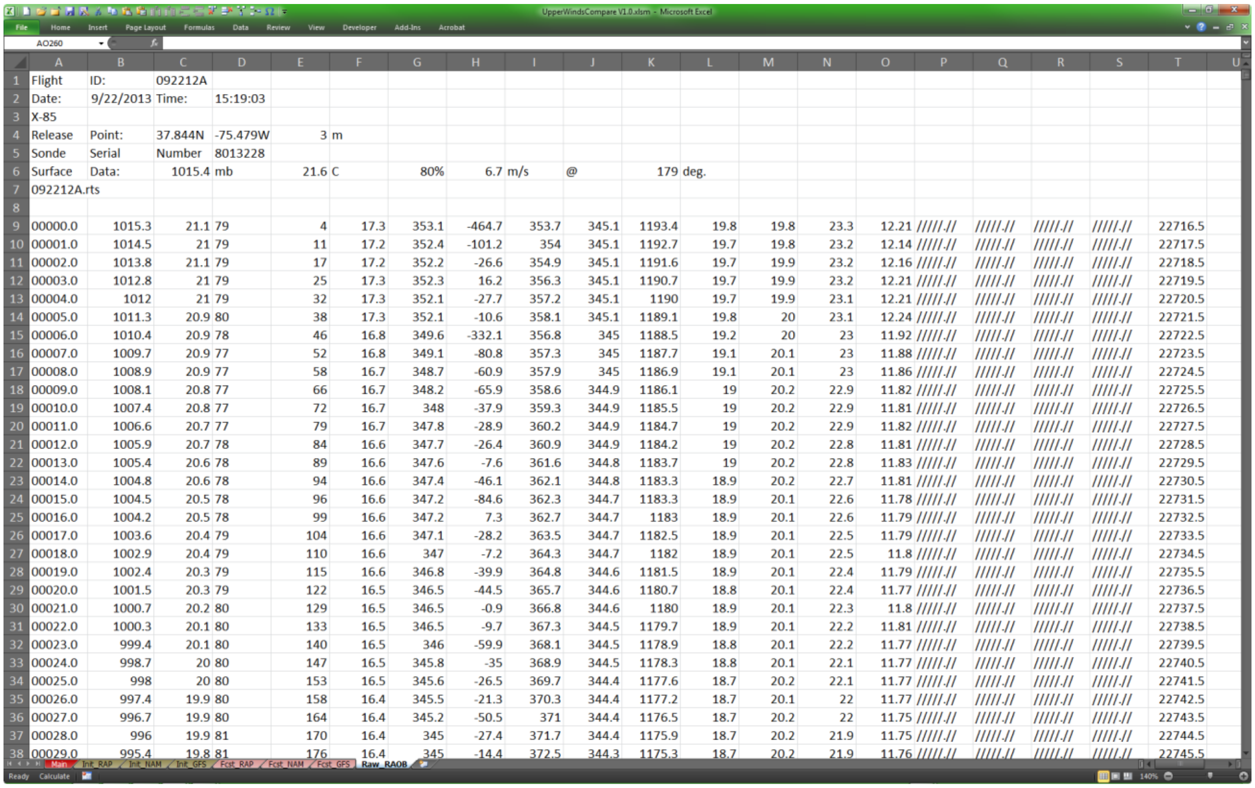
26	106.9	2400	2397.4	23.3	16	15	8.9	21.3	6.2	930	37	6.96	1096.07	286	250	670	0.014	34	9.46	6	
27	112	2500	2497.28	19.6	15	16.8	9.9	21.7	6.6	926.7	38	7.15	1090.54	286	249	671	0.018	6	9.73	6	
28	116.9	2600	2597.15	20.4	13	17.9	10.6	21.6	6.6	923.4	38	7.17	1087	285	248	671	0.013	347	9.75	7	
29	121.6	2700	2697.03	21.3	11	17.3	10.2	21.4	6.7	920.2	39	7.23	1083.93	285	248	670	0.009	234	9.83	7	
30	125.6	2800	2796.91	25	5	15.7	9.3	21.4	6.8	917	39	7.29	1080.14	284	247	670	0.024	234	9.91	7	
31	130.4	2900	2896.78	20.8	353	13.6	8.1	21.5	7.3	913.8	40	7.52	1075.83	285	246	671	0.037	236	10.23	7	
32	135.5	3000	2996.66	19.6	337	12.5	7.4	21.7	7.9	910.5	41	7.86	1071.11	286	245	671	0.038	238	10.69	7	
33	141	3100	3096.53	18.2	327	12.9	7.6	22.7	0.6	907.4	23	4.66	1065.66	265	243	671	0.022	252	6.36	8	
34	146.1	3200	3196.41	19.6	327	13.4	7.9	-22.8	2	904.2	19	3.88	1061.98	260	242	671	0.005	323	5.29	8	
35	151.7	3300	3296.28	17.9	328	14.2	8.4	-23	1.3	901.1	20	4.07	1057.6	260	241	672	0.009	342	5.56	8	
36	157.2	3400	3396.15	18.2	325	14.8	8.8	23	2.1	897.9	25	5.2	1053.14	265	241	672	0.009	270	7.1	8	
37	162.6	3500	3496.02	18.5	320	14.3	8.5	-23.2	1.4	894.8	19	4.04	1049.53	258	240	672	0.014	210	5.52	8	
38	167.3	3600	3595.89	21.3	319	12.5	7.4	-23.1	0.7	891.6	21	4.25	1045.88	258	239	672	0.018	146	5.81	8	

Figure 5. Raw data from a VAFB rawinsonde after being ingested into Excel.



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3	X-85																			
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5	Sonde	Serial	Number	8013228																
6	Surface	Data:	1015.4	mb	21.6	C	80%	6.7	m/s	@	179	deg.								
7	092212A.rts																			
8																				
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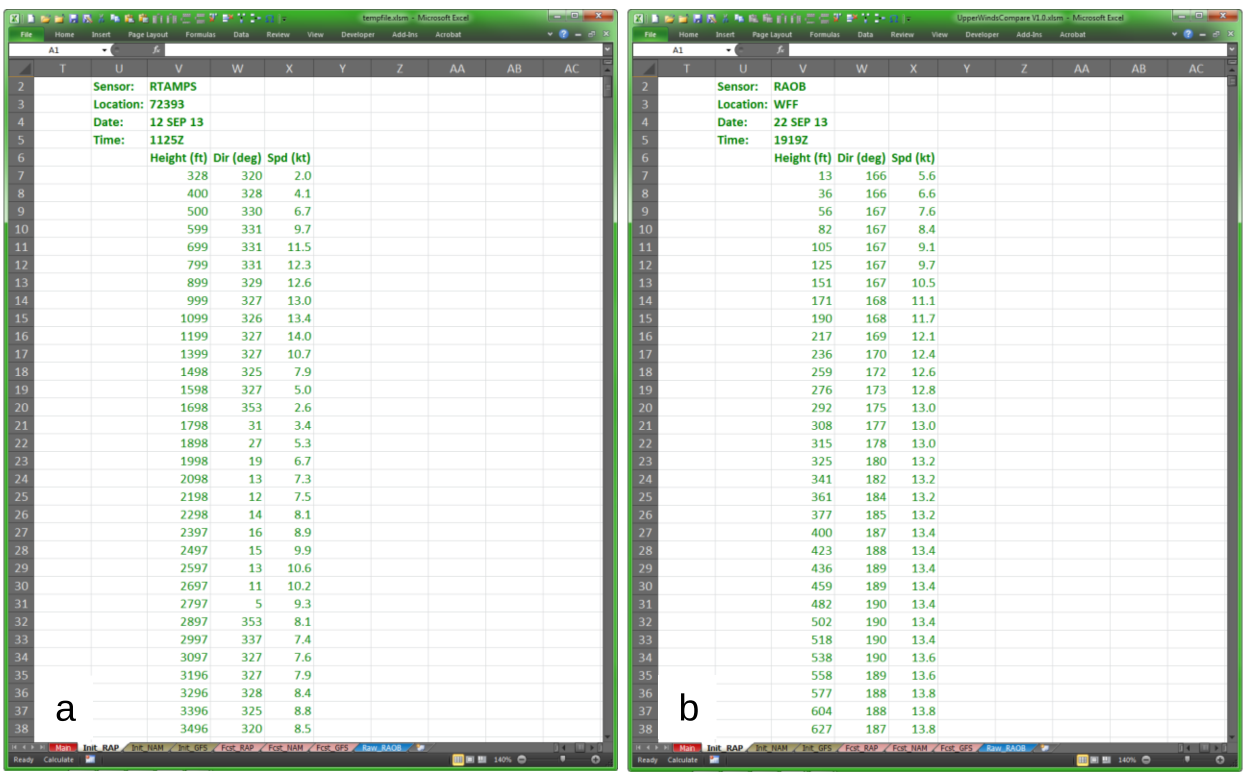
19	00010.0	1007.4	20.8	77	72	16.7	348	-37.9	359.3	344.9	1185.5	19	20.2	22.9	11.81	/////.//	/////.//	/////.//	/////.//	22726.5
20	00011.0	1006.6	20.7	77	79	16.7	347.8	-28.9	360.2	344.9	1184.7	19	20.2	22.9	11.82	/////.//	/////.//	/////.//	/////.//	22727.5
21	00012.0	1005.9	20.7	78	84	16.6	347.7	-26.4	360.9	344.9	1184.2	19	20.2	22.8	11.81	/////.//	/////.//	/////.//	/////.//	22728.5
22	00013.0	1005.4	20.6	78	89	16.6	347.6	-7.6	361.6	344.8	1183.7	19	20.2	22.8	11.83	/////.//	/////.//	/////.//	/////.//	22729.5
23	00014.0	1004.8	20.6	78	94	16.6	347.4	-46.1	362.1	344.8	1183.3	18.9	20.2	22.7	11.81	/////.//	/////.//	/////.//	/////.//	22730.5
24	00015.0	1004.5	20.5	78	96	16.6	347.2	-84.6	362.3	344.7	1183.3	18.9	20.1	22.6	11.78	/////.//	/////.//	/////.//	/////.//	22731.5
25	00016.0	1004.2	20.5	78	99	16.6	347.2	7.3	362.7	344.7	1183	18.9	20.1	22.6	11.79	/////.//	/////.//	/////.//	/////.//	22732.5
26	00017.0	1003.6	20.4	79	104	16.6	347.1	-28.2	363.5	344.7	1182.5	18.9	20.1	22.5	11.79	/////.//	/////.//	/////.//	/////.//	22733.5
27	00018.0	1002.9	20.4	79	110	16.6	347	-7.2	364.3	344.7	1182	18.9	20.1	22.5	11.8	/////.//	/////.//	/////.//	/////.//	22734.5
28	00019.0	1002.4	20.3	79	115	16.6	346.8	-39.9	364.8	344.6	1181.5	18.9	20.1	22.4	11.79	/////.//	/////.//	/////.//	/////.//	22735.5
29	00020.0	1001.5	20.3	79	122	16.5	346.5	-44.5	365.7	344.6	1180.7	18.8	20.1	22.4	11.77	/////.//	/////.//	/////.//	/////.//	22736.5
30	00021.0	1000.7	20.2	80	129	16.5	346.5	-0.9	366.8	344.6	1180	18.9	20.1	22.3	11.8	/////.//	/////.//	/////.//	/////.//	22737.5
31	00022.0	1000.3	20.1	80	133	16.5	346.5	-9.7	367.3	344.5	1179.7	18.9	20.1	22.2	11.81	/////.//	/////.//	/////.//	/////.//	22738.5
32	00023.0	999.4	20.1	80	140	16.5	346	-59.9	368.1	344.5	1178.9	18.8	20.1	22.2	11.77	/////.//	/////.//	/////.//	/////.//	22739.5
33	00024.0	998.7	20	80	147	16.5	345.8	-35	368.9	344.5	1178.3	18.8	20.1	22.1	11.77	/////.//	/////.//	/////.//	/////.//	22740.5
34	00025.0	998	20	80	153	16.5	345.6	-26.5	369.7	344.4	1177.6	18.7	20.2	22.1	11.77	/////.//	/////.//	/////.//	/////.//	22741.5
35	00026.0	997.4	19.9	80	158	16.4	345.5	-21.3	370.3	344.4	1177.2	18.7	20.1	22	11.77	/////.//	/////.//	/////.//	/////.//	22742.5
36	00027.0	996.7	19.9	80	164	16.4	345.2	-50.5	371	344.4	1176.5	18.7	20.2	22	11.75	/////.//	/////.//	/////.//	/////.//	22743.5
37	00028.0	996	19.9	81	170	16.4	345	-27.4	371.7	344.4	1175.9	18.7	20.2	21.9	11.75	/////.//	/////.//	/////.//	/////.//	22744.5
38	00029.0	995.4	19.8	81	176	16.4	345	-14.4	372.5	344.3	1175.3	18.7	20.2	21.9	11.76	/////.//	/////.//	/////.//	/////.//	22745.5

Figure 6. Raw data from a WFF rawinsonde after being ingested into Excel.



a

	U	V	W	X
2	Sensor:	RTAMPS		
3	Location:	72393		
4	Date:	12 SEP 13		
5	Time:	1125Z		
6		Height (ft)	Dir (deg)	Spd (kt)
7		328	320	2.0
8		400	328	4.1
9		500	330	6.7
10		599	331	9.7
11		699	331	11.5
12		799	331	12.3
13		899	329	12.6
14		999	327	13.0
15		1099	326	13.4
16		1199	327	14.0
17		1399	327	10.7
18		1498	325	7.9
19		1598	327	5.0
20		1698	353	2.6
21		1798	31	3.4
22		1898	27	5.3
23		1998	19	6.7
24		2098	13	7.3
25		2198	12	7.5
26		2298	14	8.1
27		2397	16	8.9
28		2497	15	9.9
29		2597	13	10.6
30		2697	11	10.2
31		2797	5	9.3
32		2897	353	8.1
33		2997	337	7.4
34		3097	327	7.6
35		3196	327	7.9
36		3296	328	8.4
37		3396	325	8.8
38		3496	320	8.5

b

	U	V	W	X
2	Sensor:	RAOB		
3	Location:	WFF		
4	Date:	22 SEP 13		
5	Time:	1919Z		
6		Height (ft)	Dir (deg)	Spd (kt)
7		13	166	5.6
8		36	166	6.6
9		56	167	7.6
10		82	167	8.4
11		105	167	9.1
12		125	167	9.7
13		151	167	10.5
14		171	168	11.1
15		190	168	11.7
16		217	169	12.1
17		236	170	12.4
18		259	172	12.6
19		276	173	12.8
20		292	175	13.0
21		308	177	13.0
22		315	178	13.0
23		325	180	13.2
24		341	182	13.2
25		361	184	13.2
26		377	185	13.2
27		400	187	13.4
28		423	188	13.4
29		436	189	13.4
30		459	189	13.4
31		482	190	13.4
32		502	190	13.4
33		518	190	13.4
34		538	190	13.6
35		558	189	13.6
36		577	188	13.8
37		604	188	13.8
38		627	187	13.8

Figure 7. Rawinsonde data files from a) VAFB and b) WFF after unneeded parameters were removed, displaying the sensor type and location, date, time, height, wind direction, and wind speed.

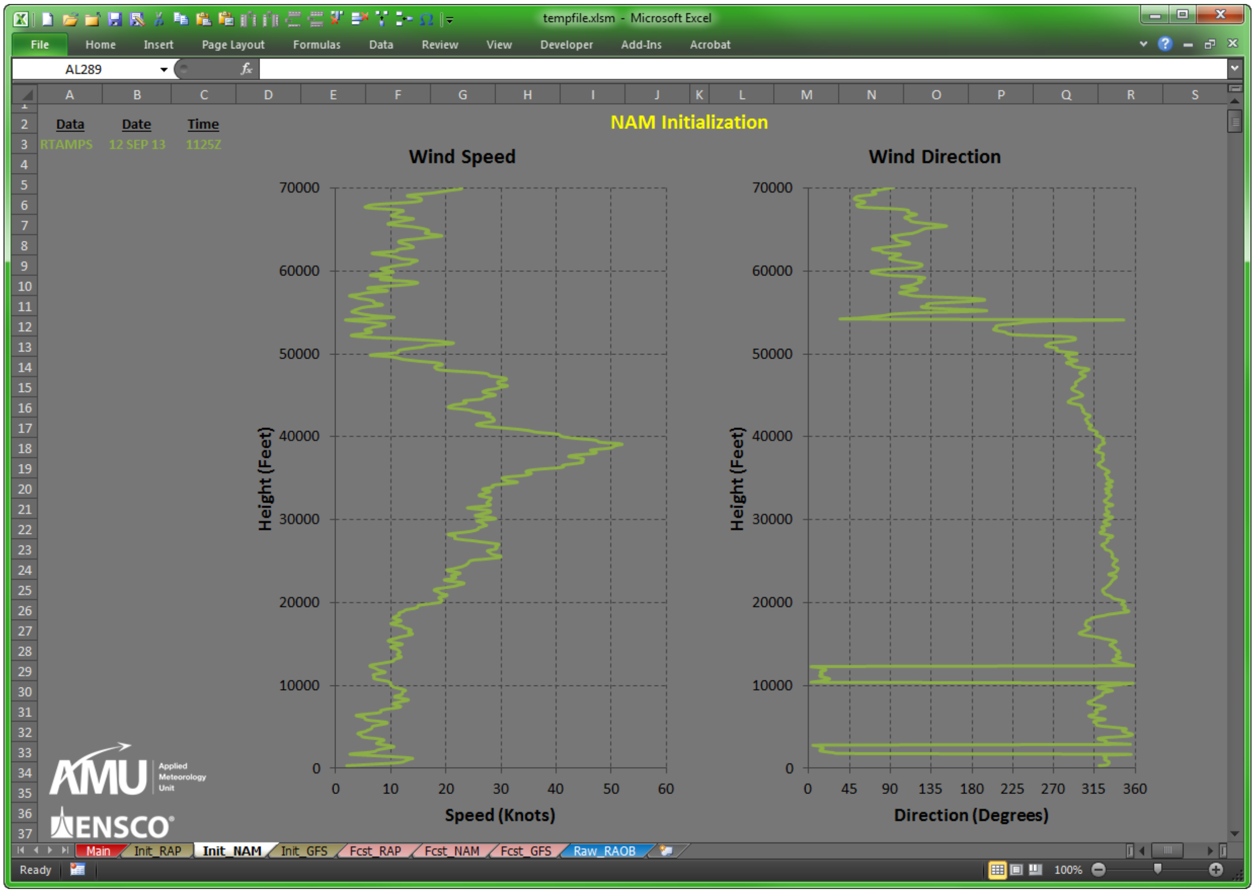


Figure 8. Wind speed (left) and wind direction (right) profiles from the 1125 UTC 12 September 2013 VAFB rawinsonde plotted in Excel. Data type, date, and time are shown in the upper left of the chart.

For the LWOs to initialize the models against the rawinsonde observations based on UTC, a VBA script retrieves the latest available model runs by issuing a File Transfer Protocol (FTP) command to download the model data from the Iowa State server. The AMU then wrote VBA scripts to download and process the model forecast point data from the Iowa State server. The data files are in ASCII format and ingested into Excel as text files. Each script reformats the files and displays the tabular data to the user (not shown). From the reformatted data, the next VBA script creates wind speed and direction profiles of the model forecast point data and overlays the data on the rawinsonde observation charts as shown in Figure 9.

The AMU tested the GUI VBA scripts at random times throughout the day to ensure the correct model data and observations were downloaded based on model initialization and availability times. There were occasions when the model data or observations were not available. Therefore, the AMU put error checks into the scripts so the software would not fail but instead return a message to the user that the model data or observation is not available, allowing them a choice to leave it out or check for it later.

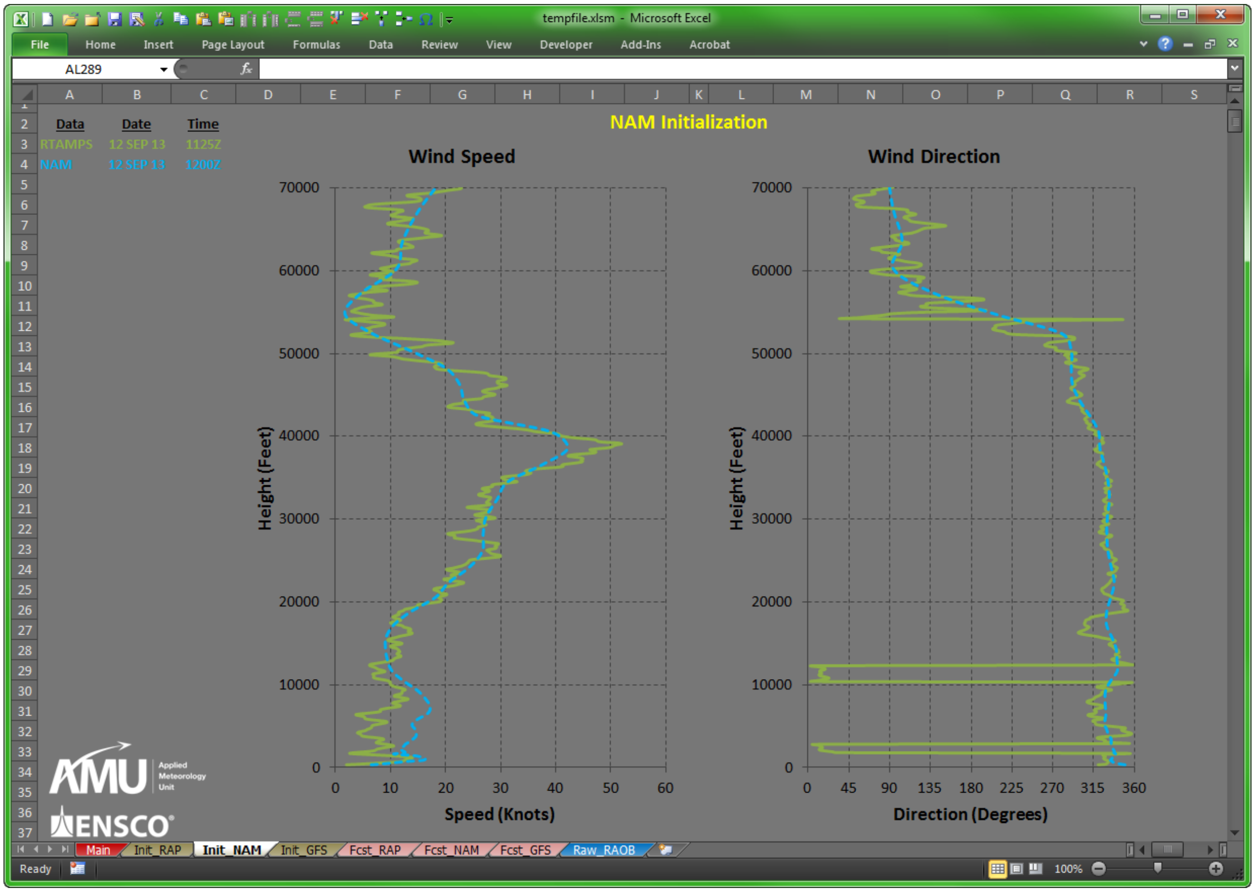


Figure 9. As in Figure 8 with the addition of the 1200 UTC 13 September 2013 NAM model 0-hour forecast (light blue dashed lines) plotted in Excel.

2.2.2 Model Forecasts

Since the requirement is to provide the LWOs with a GUI to overlay model forecasts in 3-hour intervals from the current time through 12 hours, the AMU developed VBA scripts to display the forecast wind profiles up to 12 hours after the current time to assess the upper-level wind changes on day-of-launch for the launch directors.

The VBA script that creates wind speed and direction profiles of the model forecast time intervals also overlays them on the rawinsonde observation profile charts as shown in Figure 10. The VAFB rawinsonde observation (solid green line) at 1125 UTC 12 September 2013 is plotted with the NAM model hourly forecasts (blue dashed lines) based on the 1800 UTC 12 September 2013 model run valid from the current time of 2000 UTC 12 September 2013 to 0500 UTC 13 September 2013 in 3-hour intervals. Even though the NAM forecasts are available hourly, forecast profiles valid every three hours are plotted on the chart to reduce clutter. The model forecast profiles are always plotted in four different shades of blue ranging from light (first model forecast valid time) to dark (last model forecast valid time) making it easier for the user to discern between the model forecast valid times. The forecast profile colors match the colors of the text showing data type, date and time displayed on the chart. To unclutter the model forecast profiles, the LWO can right-click on any line and delete it from the chart.

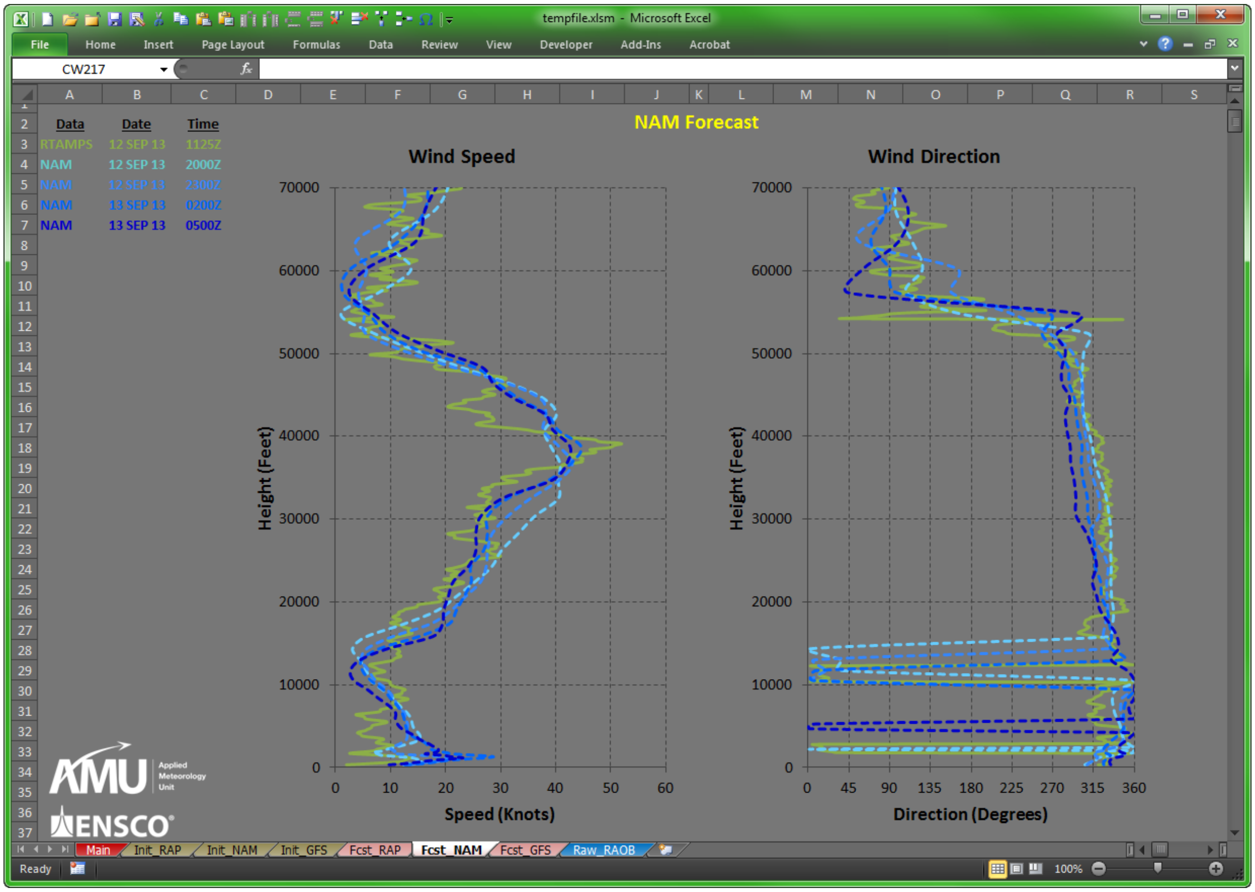


Figure 10. Wind speed (left) and wind direction (right) profiles from the 1125 UTC 12 September 2013 VAFB rawinsonde observation (green lines) and NAM model forecasts (dashed blue lines) valid every three hours from 2000 UTC 12 September 2013 through 0500 UTC 13 September 2013 plotted in Excel. Data type, date and time are shown in the upper left of the chart.

3. Graphical User Interface

A single Excel workbook file serves as the GUI consisting of eight tabs, or individual worksheets, that process and format the observations and model data as well as display tabular and graphic information. Within the Excel workbook there are nine modules containing the VBA scripts that control all aspects of the GUI operations based on user input. For brevity, only examples of the VAFB GUI will be shown. The WFF GUI is identical.

3.1 User Interface

The AMU developed a menu on the Main tab in the Excel GUI as shown in Figure 11. Upon opening the Excel workbook file, the Main tab is displayed and VBA scripts automatically run to determine and display the date, local time, UTC time and the results of the test for DST in the second row of the worksheet. The VAFB version tests for Pacific Daylight Time or Pacific Standard Time while the WFF version tests for Eastern Daylight Time or Eastern Standard Time. There are two menus containing user-selectable model data and observations. The first menu, "***Initialize models***", is designed to allow the LWOs to compare each model's 0-hour forecast to the rawinsonde observations to determine which model is most accurate. The second menu, "***Compare Forecasts to RTAMPS Obs***", allows the LWOs to compare each model's 3-12 hour forecasts to the rawinsonde observations.

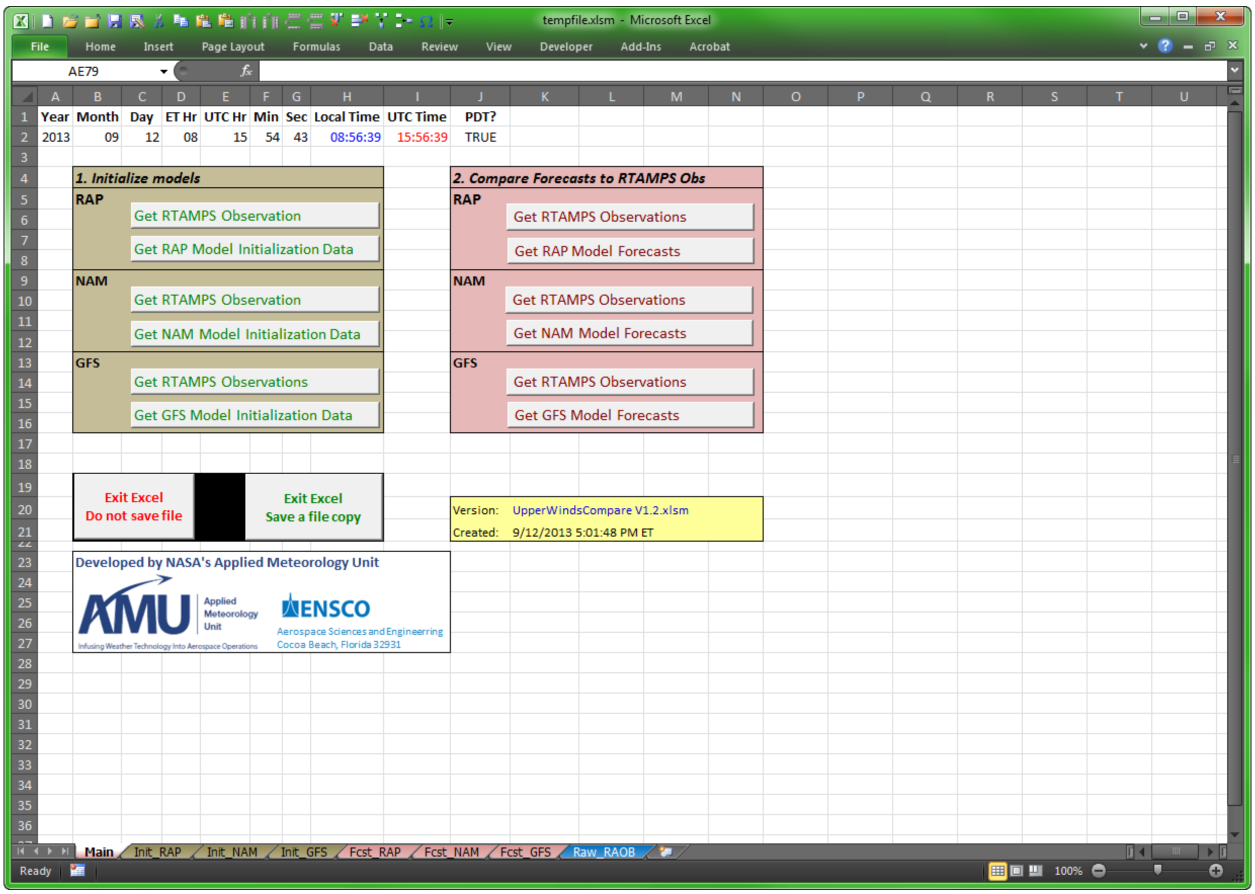


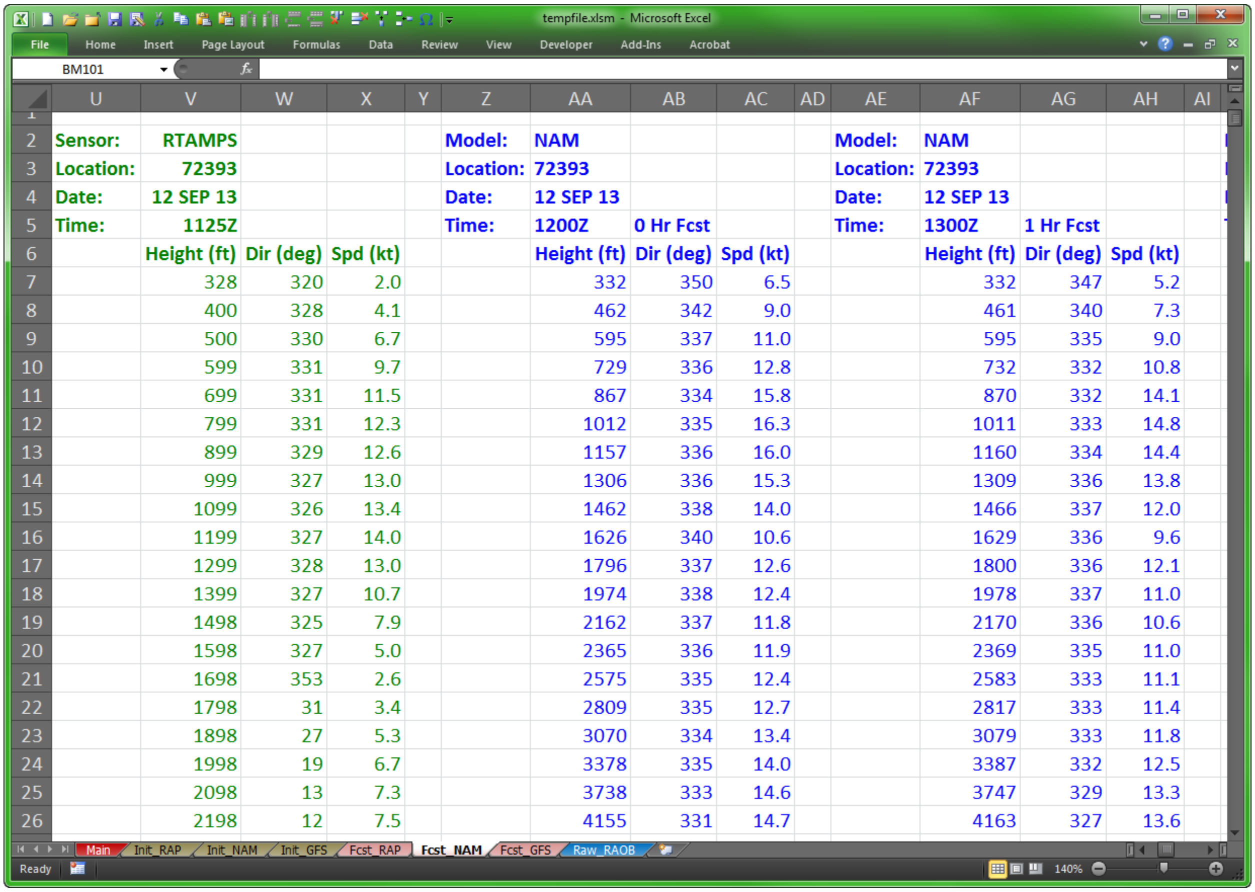
Figure 11. Main tab of the VAFB Excel GUI shows the primary user interface for selecting rawinsonde and model data to display.

In order to preserve the layout of the data and charts in each tab of the workbook, there are two buttons used to exit the GUI and Excel. The original file is never overwritten when the user chooses one of these buttons to exit. The button with green text will exit Excel and save a non-macro copy of the file in .xlsx format (Excel 2010) without any VBA code, but it will include all data and charts in the eight tabs created during the session. It also automatically creates a filename for the saved file using the current date-time. A message box is then displayed to the LWO showing the filename and directory path to the file. The button with red text will exit Excel and will not save any version of the file.

3.2 Data Display

The AMU used multiple tabs to organize and process the textual and graphics data and displays. As shown in Figure 11, the tabs along the bottom of the workbook are color-coded to help users identify common displays or actions. The first six tabs following the Main tab are color-coded to match the two menus on the Main tab. For example, the second gold tab after the Main tab called “Init_NAM” corresponds to the gold menu used to compare the NAM 0-hour forecast to the rawinsonde observation while the third pink tab after the Main tab called “Fcst_GFS” corresponds to the pink menu used to compare the GFS model forecasts to the rawinsonde observations. After the LWO makes a choice from a menu, the resulting charts are displayed in the tab corresponding to the menu color, model and observation type.

Textual observation and model data are stored in the same tabs as the wind profile charts. When an LWO chooses a model/observation pair from the menu, a VBA script automatically retrieves the observation and model data files from their respective servers, saves the raw data in the appropriate tabs, and then reformats the data to create charts and make the textual data easy for the LWO to read. An example of reformatted textual data from the rawinsonde at 1125 UTC on 13 September 2013 and NAM model from 1200 UTC on 13 September 2013 is shown in Figure 12. Besides looking at the example charts shown in Figures 8-10 that are created from the reformatted text data, the LWO can inspect the observations and model data displayed in neatly organized Excel spreadsheets in formats they are familiar with.



U	V	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG	AH
Sensor:	RTAMPS				Model:	NAM				Model:	NAM		
Location:	72393				Location:	72393				Location:	72393		
Date:	12 SEP 13				Date:	12 SEP 13				Date:	12 SEP 13		
Time:	1125Z				Time:	1200Z	0 Hr Fcst			Time:	1300Z	1 Hr Fcst	
	Height (ft)	Dir (deg)	Spd (kt)			Height (ft)	Dir (deg)	Spd (kt)			Height (ft)	Dir (deg)	Spd (kt)
	328	320	2.0			332	350	6.5			332	347	5.2
	400	328	4.1			462	342	9.0			461	340	7.3
	500	330	6.7			595	337	11.0			595	335	9.0
	599	331	9.7			729	336	12.8			732	332	10.8
	699	331	11.5			867	334	15.8			870	332	14.1
	799	331	12.3			1012	335	16.3			1011	333	14.8
	899	329	12.6			1157	336	16.0			1160	334	14.4
	999	327	13.0			1306	336	15.3			1309	336	13.8
	1099	326	13.4			1462	338	14.0			1466	337	12.0
	1199	327	14.0			1626	340	10.6			1629	336	9.6
	1299	328	13.0			1796	337	12.6			1800	336	12.1
	1399	327	10.7			1974	338	12.4			1978	337	11.0
	1498	325	7.9			2162	337	11.8			2170	336	10.6
	1598	327	5.0			2365	336	11.9			2369	335	11.0
	1698	353	2.6			2575	335	12.4			2583	333	11.1
	1798	31	3.4			2809	335	12.7			2817	333	11.4
	1898	27	5.3			3070	334	13.4			3079	333	11.8
	1998	19	6.7			3378	335	14.0			3387	332	12.5
	2098	13	7.3			3738	333	14.6			3747	329	13.3
	2198	12	7.5			4155	331	14.7			4163	327	13.6

Figure 12. VAFB rawinsonde data (green text) and NAM model hourly forecast data (blue text) after being ingested into Excel and reformatted displaying the sensor type and location, date, time, height, wind direction and speed.

4. Summary and Future Work

The AMU initially developed a day-of-launch capability for the 45 WS LWOs to monitor the upper-level winds for their launch customers at KSC and CCAFS. This capability was primarily developed for NASA's LSP. Because LSP conducts space launch operations at VAFB and WFF, the AMU modified the upper-level winds tool for use at both locations. The upper-level winds tool consists of a GUI that allows the LWOs at VAFB and WFF to plot charts of upper-level wind speed and direction observations and then overlay point forecast profiles from available numerical weather prediction models on the charts. This tool provides the LWOs with the capability to quickly retrieve and display the upper-level observations, compare them to the numerical weather prediction model point forecasts and provide upper-level wind information to the payload/launch team during the countdown. The observations are taken from the VAFB RTAMPS rawinsondes and WFF rawinsondes. The model data includes the NCEP NAM, RAP, and GFS models. Comparing the model output to the observations would allow the LWOs to objectively assess the performance of these models and communicate that information to the launch team.

The AMU developed the upper-level winds tool as an Excel-based GUI for the LWOs to assess the model forecast upper-level winds compared to the observations. This GUI allows the LWOs to first initialize the models by comparing the 0-hour model forecasts to the observations and then to display model forecasts in 3-hour intervals from the current time through 12 hours. The AMU wrote Excel VBA scripts that drive the GUI by automatically acquiring, downloading and processing the observations and model forecast data, and then displaying the resulting output in text format in Excel spreadsheets and in graphic format as Excel charts. The output of the observational data provides the LWO with the observation type and location, date and time, height, and wind direction and speed. The output of the model data provides the LWO with the model type and forecast point location, date and time of the model start and forecast intervals, height and wind direction and speed.

In the future, the AMU recommends adding a local high resolution version of the Weather Research and Forecasting (WRF) model. The AMU is working on a task to assess and implement a high temporal and horizontal resolution WRF to be run locally at WFF (Watson 2012). The intent of this task is to determine the optimum physics schemes and data assimilation methods to run WRF over the WFF region on a routine basis. The National Oceanic and Atmospheric Administration Environmental Systems Research Laboratory will be implementing a local version of WRF at VAFB. Once WRF is running routinely at each location, the AMU could add the WRF forecasts to this tool for use in the same manner as the NCEP NAM, RAP and GFS model forecasts.

References

Bauman, W. and M. Wheeler, 2012: Assessing Upper-level Winds on Day-of-Launch. NASA Contractor Report CR-2012-216313, Kennedy Space Center, FL, 20 pp. [Available from ENSCO, Inc., 1980 N. Atlantic Ave., Suite 830, Cocoa Beach, FL, 32931 and online at http://science.ksc.nasa.gov/amu/final-reports/lsp-upper-wind-changes.pdf.]

Watson, L. R. 2013: Range-specific High-resolution Mesoscale Model Setup. NASA Contractor Report CR-2013-217911, Kennedy Space Center, FL, 41 pp. [Available from ENSCO, Inc., 1980 N. Atlantic Ave., Suite 830, Cocoa Beach, FL, 32931 and online at http://science.ksc.nasa.gov/amu/final-reports/range-specific-hi-res-model-setup.pdf.]

List of Acronyms

45 WS	45th Weather Squadron
AMU	Applied Meteorology Unit
ASCII	American Standard Code for Information Interchange
CCAFS	Cape Canaveral Air Force Station
DST	Daylight Saving Time
FTP	File Transfer Protocol
GFS	Global Forecast System
GUI	Graphical User Interface
HTTP	Hypertext Transfer Protocol
KSC	Kennedy Space Center
LSP	Launch Services Program
LWO	Launch Weather Officer
NAM	North American Mesoscale
NCEP	National Centers for Environmental Prediction
RAP	Rapid Refresh
RTAMPS	Real Time Automated Meteorological Profiling System
SLC	Space Launch Complex
ST	Standard Time
UTC	Coordinated Universal Time
VAFB	Vandenberg Air Force Base
VBA	Visual Basic for Applications
WFF	Wallops Flight Facility
WRF	Weather Research and Forecasting
XMR	CCAFS rawinsonde 3-letter identifier

NOTICE