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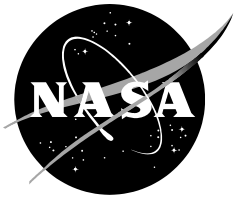

Vandenberg Air Force Base Climatology Database

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November 2013

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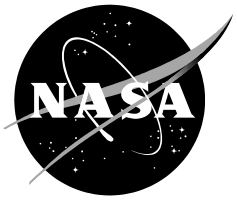

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Executive Summary

Customer: Launch Services Program (LSP)

NASA's LSP and other programs operating at Vandenberg Air Force Base (VAFB) use extended range forecasts issued by the 30th Operational Support Squadron Weather Flight (30 OSSWF) to determine if they need to protect personnel by limiting daily activities or protect property such as a launch vehicle. The 30 OSSWF forecasters and launch weather officers currently rely on the Automated Surface Observing System at the VAFB runway to help with their extended forecasts. Given this one station is not as representative of the weather across all of VAFB as their meteorology tower network, the 30 OSSWF requested the Applied Meteorology Unit (AMU) develop a climatology database using data from the tower network.

The 30 OSSWF delivered all available data from their 26 VAFB wind towers for the October 2007–November 2012 time period as part of the AMU's VAFB Pressure Gradient Wind Study task (Shafer 2013). As discussed in the November 2012 AMU Tasking Meeting, if time permitted, the AMU agreed to use the VAFB tower data to build a master climatology database for each of the 26 towers. Although not part of the original task, the AMU and 30 OSSWF also discussed developing a graphical user interface (GUI) that would calculate and display climatology statistics. The Kennedy Space Center weather office agreed this would be a valuable capability for the 30 OSSWF to support their customers and approved the additional work. The AMU decoded the VAFB tower data and identified all observations that fell within valid meteorological ranges. Once erroneous data were removed, this information was consolidated into one database text file to be used in the tool.

Initially, the 30 OSSWF requested this tool be a Microsoft Excel GUI but the AMU discovered Excel is not capable of containing the entire VAFB tower database. Given this limitation, the AMU and 30 OSSWF decided to use Microsoft Access 2010 which can contain a much larger amount of data. The GUI includes user input forms, a query table and a report option. This provides the 30 OSSWF with a quick, user-friendly capability to access daily and hourly averages and extremes to easily communicate climatology information to their customers.

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1 Introduction

The 30th Operational Support Squadron Weather Flight (30 OSSWF) provides comprehensive weather services to the space program at Vandenberg Air Force Base (VAFB) in California. One of their responsibilities is to deliver extended range forecasts to launch customers and range safety for their day-to-day and day of launch operations. NASA's LSP and other programs at VAFB use these forecasts to determine if they need to limit activities or protect property such as a launch vehicle.

The 30 OSSWF forecasters and launch weather officers currently rely on the meteorological observations from the Automated Surface Observing System (ASOS) at the VAFB runway to help with their extended forecasts. This single ASOS is unrepresentative of the weather across all of VAFB and is located up to 10 NM from some of the launch pads. The geographical diversity of VAFB and its impact on weather phenomena requires additional sources of weather information around the area to properly capture the local meteorology. Furthermore, there are vertical variations of weather phenomena that are important to space launch that are not available in ASOS climatology. Fortunately, VAFB has an existing meteorology tower network consisting of 26 towers (Figure 1) that report observations of temperature, dewpoint, relative humidity, average one-minute wind speed and direction, and peak wind speed and direction.

The 30 OSSWF receives numerous requests for VAFB tower network climatology data from their launch customers for planning purposes but they do not have a database or capability to easily access or display this information. Therefore, the 30 OSSWF requested the Applied Meteorology Unit (AMU) develop a climatology database based on their tower network, if time permitted, at the completion of the AMU's VAFB Pressure Gradient Wind Study task (Shafer 2013). They also discussed creating a graphical user interface (GUI) that would calculate and display climatology statistics based on the VAFB tower database. Having a quick and user friendly tool with access to daily and hourly averages and extremes would allow the forecasters to easily communicate climatology information to their customers. It will also help the forecasters to better understand the uniqueness of each tower location and recognize which towers are more prone to the issuance of weather watches and warnings.

Figure 1. Locations of the 26 towers in the VAFB network. The red box highlights the runway and location of ASOS.

2 VAFB Tower Data

The 30 OSSWF delivered all available data from their 26 VAFB wind towers (Figure 1) for the October 2007–November 2012 time period to the AMU as part of the AMU's VAFB Pressure Gradient Wind Study task. Each tower reports observations at 6, 12, and 54 ft (2, 4, and 16 m) with the exception of tower 0087, which only had observations at 54 ft. Observations include temperature (F), dewpoint (F), relative humidity (%), average one-minute wind speed (kt) and direction (deg), and peak wind speed (kt) and direction (deg).

The AMU decoded the VAFB tower data and identified all observations that fell within valid meteorological ranges. The valid ranges used are listed in Table 1. Observations not within the ranges were considered erroneous and removed from the database. Once erroneous data were removed, the hourly averages for each variable at each sensor height and tower were calculated using Perl scripts written by the AMU. This information was consolidated into one database text file that contains the tower number, sensor height, year, month, day, hour, and variable names for each observation.

Table 1. Summary of the ranges used to identify valid observation values.

Variable	Quality Control
Temperature	T > -100
Dewpoint	Td > -100
Relative Humidity	0 ≤ RH ≤ 100
Wind Speeds	Wspd ≥ 0
Wind Directions	0 ≤ Wdir ≤ 360

3 GUI Development

Although not part of the original task, the AMU and 30 OSSWF discussed developing a GUI that would calculate and display climatology statistics based on the VAFB tower database. This would allow the 30 OSSWF a way to easily communicate this information to their operational customers in real-time when requested. The Kennedy Space Center (KSC) weather office agreed this would be a valuable capability for the 30 OSSWF and approved the additional work.

Initially, the 30 OSSWF requested this tool be a Microsoft Excel GUI but the AMU discovered Excel is not capable of containing the entire VAFB tower database. Given this limitation, the AMU and 30 OSSWF decided to use Microsoft Access 2010 which can contain a much larger amount of data. Because of the complexities of using Access to manipulate the large database, the AMU requested assistance from Mr. Christopher Jessen, a staff engineer and Access expert in ENSCO's Aerospace Sciences and Engineering division. The AMU worked with Mr. Jessen to streamline the functionality of the database so Access would efficiently process the large amount of tower data. Figure 2 shows an example of the main page of the Access GUI, which includes user input forms, a query table and a report option.

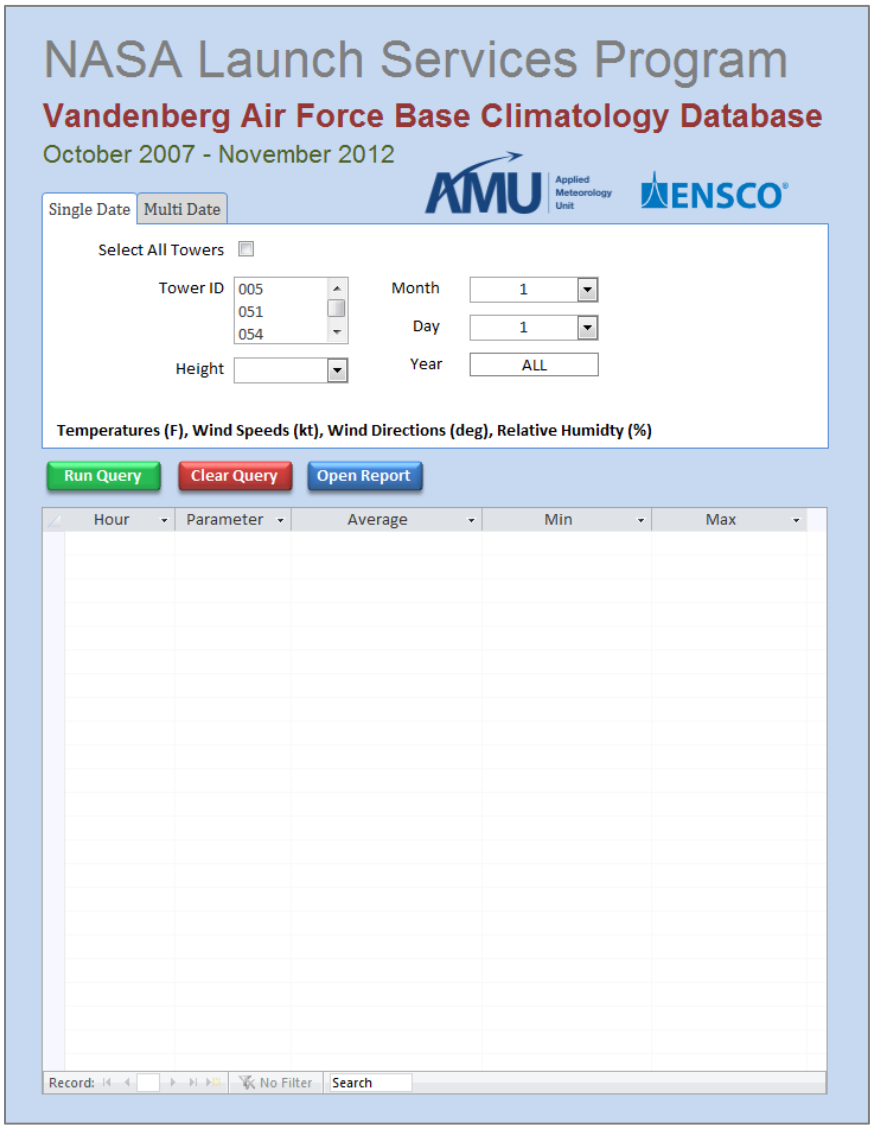


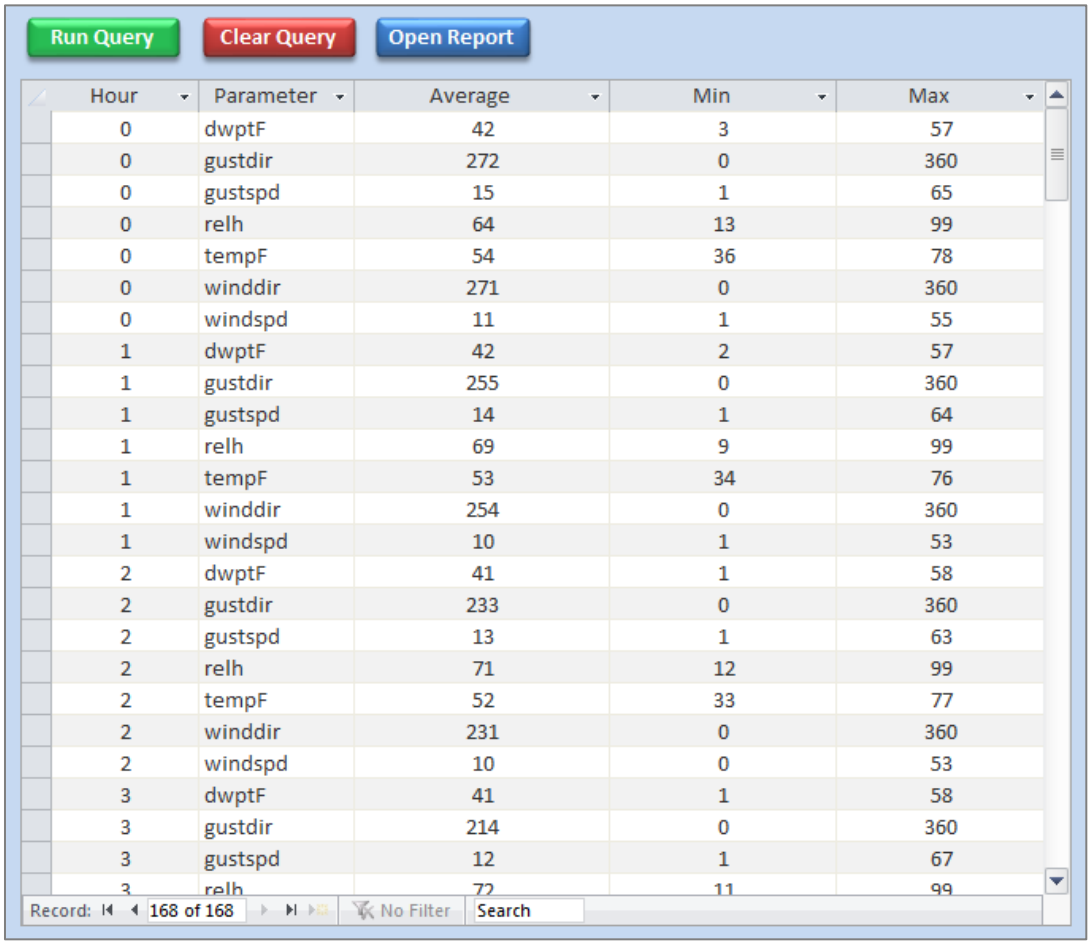
Figure 2. Main page of 30 OSSWF tower climatology GUI.

At the top of the GUI there are two tabs; “Single Date” and “Multi Date”. These are forms for the user to choose and select specific query information depending on the date(s) of interest. If the user would like climatology statistics for one particular day, they would choose the “Single Date” tab (Figure 3). The user would select up to 26 towers in the Tower ID list, one sensor Height, the Month and the Day before running the query. Data in all years from 2007 to 2012 are automatically included in the query. For a period that is more than a single day, the user would select the “Multi Date” tab (Figure 4). Similar to the “Single Date” tab, the user would select up to 26 towers and one sensor height. They would also select the start and end dates of their period of interest and one or more years to include in the query.

Figure 3. The top portion of the 30 OSSWF GUI "Single Date" tab (see Figure 2). Users input specific query information in this form to generate desired climatology statistics.

Figure 4. Same as Figure 3 but for the "Multi Date" tab.

Below the form tabs are three buttons and the query display table (Figure 5). Once the user has completed the form they would then click the green “Run Query” button to populate the query table below. The query table lists the hourly average, minimum and maximum value of each available variable within the database that meets the criteria selected in the top portion of the GUI. These values are calculated using the Access built-in functions shown in Table 2 with the exception of the average wind directions.



Hour	Parameter	Average	Min	Max
0	dwptF	42	3	57
0	gustdir	272	0	360
0	gustspd	15	1	65
0	relh	64	13	99
0	tempF	54	36	78
0	winddir	271	0	360
0	windspd	11	1	55
1	dwptF	42	2	57
1	gustdir	255	0	360
1	gustspd	14	1	64
1	relh	69	9	99
1	tempF	53	34	76
1	winddir	254	0	360
1	windspd	10	1	53
2	dwptF	41	1	58
2	gustdir	233	0	360
2	gustspd	13	1	63
2	relh	71	12	99
2	tempF	52	33	77
2	winddir	231	0	360
2	windspd	10	0	53
3	dwptF	41	1	58
3	gustdir	214	0	360
3	gustspd	12	1	67
3	relh	72	11	99

Figure 5. The lower, or query, portion of the GUI including the functional buttons and table of climatology statistics (see Figure 2).

Table 2. List of Access built-in functions used to calculate the climatology statistics.

Access Function	Description
Avg Function	Returns the arithmetic mean of a set of numeric values in a select query.
Max Function	Returns the maximum value in a set of numeric values in a select query.
Min Function	Returns the minimum value in a set of numeric values in a select query.

The arithmetic mean is not an accurate representation of average wind direction. This is especially true for wind direction when averaging winds that vary between the northwest and northeast sectors crossing through north at 0 degrees. In order to properly determine this value,

the u- and v-components of each individual wind vector must first be calculated using the wind speed and direction values. The u- and v-components would then be averaged and used to calculate the average wind speed and direction with standard trigonometric functions. Due to how data are structured in Access, it was difficult to pair the wind directions with their corresponding wind speeds to calculate the standard u- and v-components. Given this Access issue, the time constraints for this project, and the elements of the task originally agreed upon at the November 2012 tasking meeting, the AMU calculated the u- and v-components using direction only for this version of the GUI.

The resulting average wind direction values are not the same but similar to those calculated using the standard u- and v-components. A cursory statistical test showed the average difference between the average wind directions calculated from this method and the speed-weighted method to be 3 deg with a standard deviation of 1 deg. Once the individual direction-based components are determined, Access uses them to calculate the average u- and v-components of all the directions in the query and then converts them back to average direction in degrees. The formulas used to calculate the direction-based u- and v-components and average wind directions are given in Table 3.

Table 3. Summary of calculations used to create the average direction in degrees.

Calculations to determine the direction-based u- and v-components	
Variable	**Formula**
u-direction	u = cos((270-Wdir)*(pi/180))
v-direction	v = sin((270-Wdir)*(pi/180))
Calculations to convert the u- and v-components to average direction in degrees	
Condition	**Formula**
v-direction > 0	avgdir = ((180/pi)*atan(avgu/avgv)) + 180
u-direction and v-direction < 0	avgdir = ((180/pi)*atan(avgu/avgv))
u-direction > 0 and v-direction < 0	avgdir = ((180/pi)*atan(avgu/avgv)) + 360

Where: Wdir = Wind direction (degrees)
avgu = Average u-direction from a set of values in a select query
avgv = Average v-direction from a set of values in a select query
avgdir = Average wind direction in degrees
pi = 3.14159265358979

Once the user is finished with their query they may clear it by clicking the red “Clear Query” button, or they may view and print a query report. Clicking the blue “Open Report” button will re-run the current query and open a report display. The user may then right click in the window of the report and select the print preview option to print the report. The report displays the query criteria from the form at the top of the first page and the results are shown in the query table. Figure 6 and Figure 7 are examples of the first two pages of the report.

NASA Launch Services Program

Vandenberg Air Force Base Climatology Database

October 2007 - November 2012

Tower(s): 005, 051, 054, 057, 058, 059, 060, 061, 064, 065, 066, 070, 071, 072, 073, 074, 075, 076, 077, 078, 079, 080, 081, 102, 300, 301

Height: 16m Dates: 1/1 to 3/31 Year(s): 2007, 2008, 2009, 2010, 2011, 2012

Temperatures (F), Wind Speed (kt), Wind Direction (deg), Relative Humidty (%)

Hour	Parameter	Average	Min	Max
0	dwptF	42	3	57
0	gustdir	272	0	360
0	gustspd	15	1	65
0	relh	64	13	99
0	tempF	54	36	78
0	winddir	271	0	360
0	windspd	11	1	55
1	dwptF	42	2	57
1	gustdir	255	0	360
1	gustspd	14	1	64
1	relh	69	9	99
1	tempF	53	34	76
1	winddir	254	0	360
1	windspd	10	1	53

Figure 6. The first page of an example report with the selected query criteria information at the top.

Hour	Parameter	Average	Min	Max
2	dwptF	41	1	58
2	gustdir	233	0	360
2	gustspd	13	1	63
2	relh	71	12	99
2	tempF	52	33	77
2	winddir	231	0	360
2	windspd	10	0	53
3	dwptF	41	1	58
3	gustdir	214	0	360
3	gustspd	12	1	67
3	relh	72	11	99
3	tempF	51	32	76
3	winddir	213	0	360
3	windspd	9	0	49
4	dwptF	41	1	56
4	gustdir	200	0	360
4	gustspd	12	1	70
4	relh	73	12	99
4	tempF	51	32	75

Figure 7. Second page of the example report from Figure 6. The page number information is shown in the bottom right corner.

4 Summary and Future Work

The 30 OSSWF provides comprehensive weather services to the space program at VAFB. One of their responsibilities is to issue extended range forecasts to launch customers and range safety for their day-to-day and day-of-launch operations at VAFB. NASA's LSP and other programs use these forecasts to determine if they need to limit activities or protect property such as a launch vehicle. The 30 OSSWF forecasters and launch weather officers currently rely on the ASOS at the VAFB runway to help with their extended forecasts. Given this is unrepresentative of the weather at the launch pads and across VAFB and there is an existing meteorology tower network across VAFB, the 30 OSSWF requested the AMU develop a tower climatology database and tool that would easily display climatology statistics.

The 30 OSSWF delivered all available data from their 26 VAFB wind towers for the October 2007–November 2012 time period as part of the AMU's VAFB Pressure Gradient Wind Study task. As discussed in the November 2012 AMU Tasking Meeting, if time permitted, the AMU agreed to use the VAFB tower data to build a master climatology database for each of the 26 towers. Although not part of the original task, the AMU and 30 OSSWF also discussed developing a GUI that would calculate and display climatology statistics. The KSC weather office agreed this would be a valuable capability for the 30 OSSWF and approved the additional work. The AMU decoded the VAFB tower data and identified all observations that fell within valid meteorological ranges. Once erroneous data were removed, this information was consolidated into one database text file to be used when developing the 30 OSSWF tool.

Initially, the 30 OSSWF requested this tool be an Excel GUI but the AMU discovered Excel is not capable of containing the entire VAFB tower database. Given this limitation, the AMU and 30 OSSWF decided to use Access, which can contain a much larger amount of data. This GUI includes user input forms, a query table, and a report option. This provides the 30 OSSWF with a quick, user-friendly capability to access daily and hourly averages and extremes to easily communicate climatology information to their customers.

The AMU suggests the 30 OSSWF submit a formal task proposal to update the GUI. Should this become a formal task, the AMU would process additional year(s) to add to the database, the average wind direction calculations would be modified, and the functionality of the tool would be adjusted based on feedback from 30 OSSWF.

References

Shafer, J., 2013: Vandenberg Air Force Base Pressure Gradient Wind Study. NASA Contractor Report CR-2013-217922, Kennedy Space Center, FL, 27 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/30oss-pgrad.pdf]

List of Acronyms

30 OSSWF	30th Operational Support Squadron Weather Flight
AMU	Applied Meteorology Unit
ASOS	Automated Surface Observing System
GUI	Graphical User Interface
KSC	Kennedy Space Center
LSP	Launch Services Program
VAFB	Vandenberg Air Force Base

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