Fair-Weather Diurnal Wind Field in a Complex Mountainous Region

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Introduction

Thermally driven or diurnal wind systems are known to form regularly in the mountain areas of the arid Intermountain West (Stewart et al. 2002). The U. S. Army's Dugway Proving Ground (DPG) has collected a large archive of wind data from their Surface Automated Measurement System (SAMS) network of 26 10-m towers in the Great Salt Lake Desert of west-central Utah. The goal of this research is to determine the diurnal wind patterns on summer fair weather days over this area of complicated topography in the Intermountain Basin.

Goal

The specific goal of this project is to produce a QuickTime animation to illustrate the diurnal evolution of the wind field over the entire DPG region at hourly time steps. The animation will improve understanding of the typical flows at DPG under fair weather conditions when synoptic flows are weak and skies are clear.

Topography and Site Locations

Dugway Proving Ground (Figure 1) is surrounded by mountain ranges on all sides. The Stansbury and Onaqui Mountains are to the east. To the southwest is the Deep Creek Range. To the north is the Cedar Mountains, which run north-south at their north end, and east-west at their south end. The Dugway Valley and Proving Ground are confined between the south end of the Cedar Mountains and the Dugway Range farther to the west. A gap in the middle of the Dugway Range separates the main range from Granite Peak (4767 ft), an important feature for the dynamics of this valley.

Figure 1. Topography. Study area in red box, lakes in blue, Great Salt Lake Desert in white.

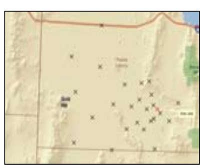


Figure 2. Locations of SAMS sites within and surrounding DPG. The Ditto site is indicated in red.

Data Processing

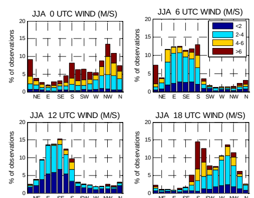
Data were available from a network of twenty-six 10-m towers located in and surrounding DPG for the period from January 1998 through August 2008. We wished to investigate diurnal wind systems on summer (June, July and August) fair weather days. There were about 11 x 3 x 30 = 990 possible days in the period of record.

Fair weather days were defined as days with clear or partly cloudy skies and weak background synoptic-scale flows. The radiation and wind speed thresholds were defined using data from the Ditto site.

Wind Speed Threshold

A day was considered to have low background winds if the daily maximum wind speed at Ditto was below the average monthly maximum wind speed over the period of record. About 50% of the summer days met this wind speed threshold.

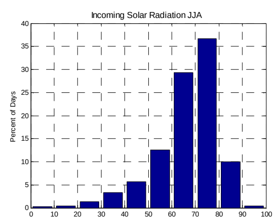
Figure 3. Clockwise from top left is the mean wind speed for the Ditto site for June, July and August at 00, 06, 12, and 18 UTC. Data are binned in direction and partitioned for speed intervals of 2 m/s.



Clear Skies (Solar Radiation) Threshold

A day was considered to be clear or partly cloudy if the measured daily total solar radiation was greater than 70% of the theoretical daily total extraterrestrial solar radiation, as determined from Whiteman and Allwine's (1986) solar model. 47% of the days in June/July/August met this radiation criteria.

Figure 4. Percentage of days receiving different percentages of the theoretical daily total extraterrestrial radiation. 47% of the days receive more than 70% of the theoretical value.



31% of the days in the summertime data set met both the radiation and wind speed criteria, for a total of 331 days. Some of the sites were established later than others; these sites have smaller periods of record and thus fewer fair weather days.

Approach

An average wind vector was determined for each site for each hour of the 24-hour day. A vector average was obtained from wind observations for that hour from the string of ~331 fair weather days. The results for 00, 06, 12, and 18 MST are shown in Fig. 5 a-d. Maps drawn for each of the 24 hours of the day were animated using QuickTime to reveal the temporal evolution of the wind field. The animation can be seen on the computer near this poster.

Results

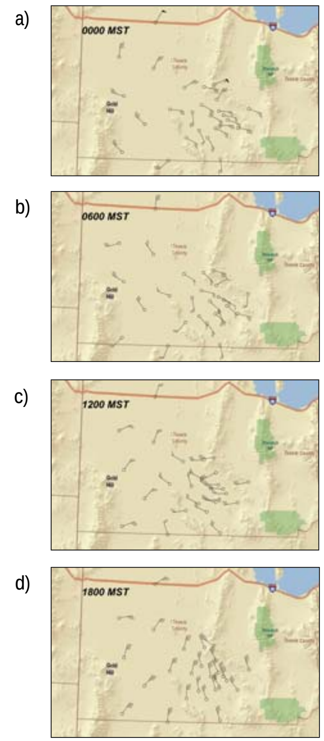


Figure 5. Wind fields at a) 00, b) 06, c) 12, and d) 18 MST. A wind flag indicates a speed of 5 m/s, a full barb is 1 m/s and a half-barb is 0.5 m/s.

Regular diurnal oscillations of the wind field are seen at DPG, with flow speeds typically 1 - 4 m/s.

•At 0000 MST, down-valley winds blow from the southeast through the main part of DPG. Winds from the north at the north end of DPG converge with these winds west of Granite mountain in a low part of the basin.

•At 0600 MST, winds converge into the Dugway basin from all directions, with an area of confluence to the north of Granite Mountain.

• At 1200 MST, northerly winds come into the north end of the basin and then diverge from the basin to the east, south and southwest

• At 1800 MST, winds are northerly or northeasterly throughout the domain.

Future Work

We plan to continue exploring this data set, refining the wind and radiation threshold criteria, creating hodographs and wind roses for all of the sites, and producing animations for the other seasons.

Figure 6. Dugway Proving Ground: Looking northeast, with Granite Peak in the distance.

Acknowledgments & References

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