Mesquite Sand Dunes Dune Crests & Wind Direction

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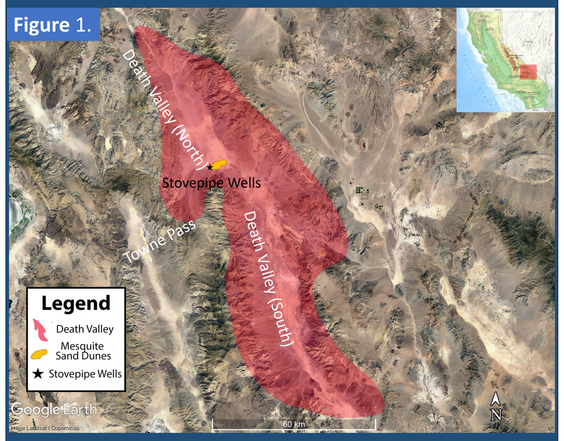
Introduction: The Mesquite Dune field is located in the north-central portion of Death Valley, CA, (Fig. 1) near Stovepipe Wells. This region of interest contains a variety of different types of dunes. This is attributed to varying sand supply from alluvial fans throughout Death Valley, as well as varying wind direction and speeds. Objectives of this study were to determine the orientation and types of dunes present, determine their relative stability and mobility, evaluate sand supply and possible wind directions based on dune type/orientation, correlate wind data to determine seasonal activity as it relates to dune geometry, and determine the possibility of dune crest reversals (as observed in the field in January 2024).

Figure 1.



Methods:

- Downloaded aerial images and satellite photos on Earth Explorer. (https://earthexplorer.usgs.gov/)
- Traced dune crests in ArcGIS Pro.
- Downloaded wind data from the Stovepipe Well's weather station through "Visual Crossing" website. (https://www.visualcrossing.com/weather/weather-data-services#)
- Crest azimuth and wind direction data plotted as rose diagrams using GeoRose®. (https://www.yongtechnology.com/georose/)

Results Wind Direction and Speed: Mesquite Dune field is impacted by two dominate wind directions, the southeast and the northwest (fig. 2). Of these, the wind speed has a higher average for the southeast direction at around 20 mph (fig. 3). The Spring and Summer average wind speed was about 15 mph while Fall and Winter was 9.5 mph (fig 3). The maximum and minimum wind speeds were 55.8 mph to 2.9 mph (fig. 3). Spring and Summer seasons have longer durations of higher wind speeds compared to Fall and Winter (fig. 3).

Figure 2.

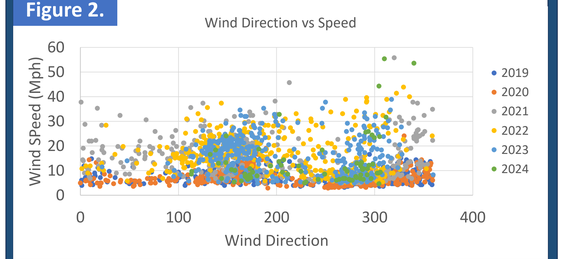
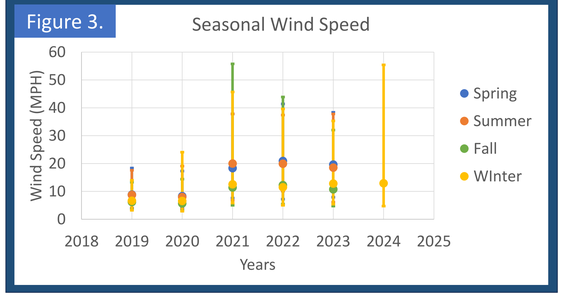
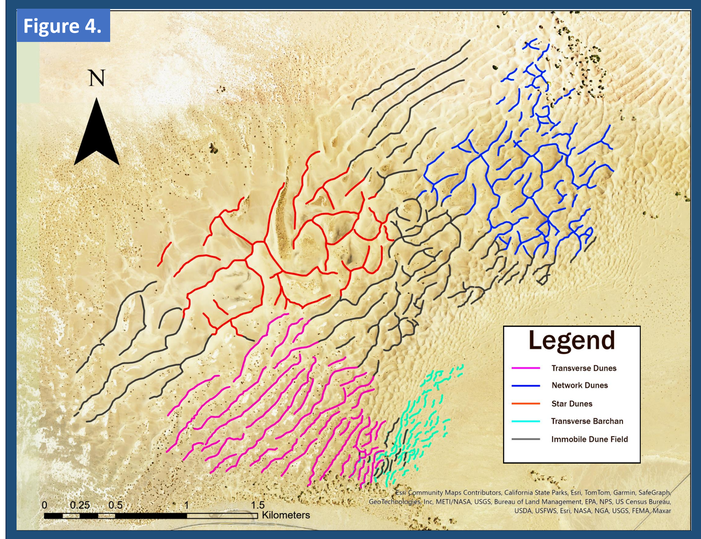


Figure 3.



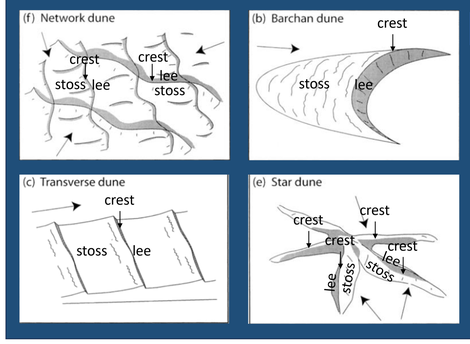
Crest Orientation Results

Figure 4.



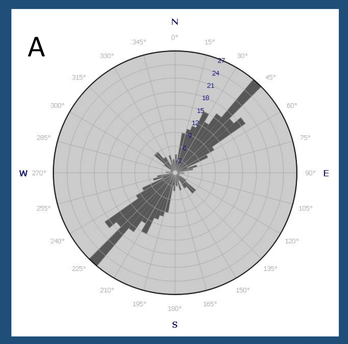
Mapping Crest Results: This map shows crest orientations for dunes in the Mesquite Dune field. Different color dune crest orientation represent different types of dunes. The continuous, and mostly immobile part of the dune field is made of transverse, network, and star dunes. The mobile part of the dune on the fringes of the field are made of transverse barchan and barchan dunes (see fig. 5 for dune type descriptions).

Figure 5.

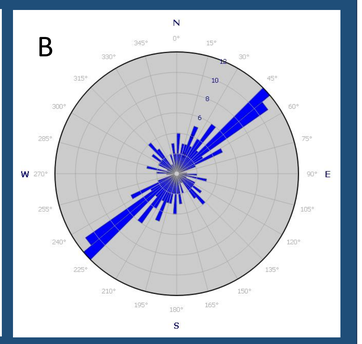


Dune Types: Representation of the dune types present in the dune field. The graphics show the wind directions under which the dunes form and the location of the crest, lee, and stoss sides of the dunes.

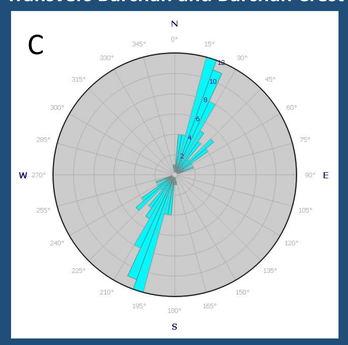
Immobile dune crests



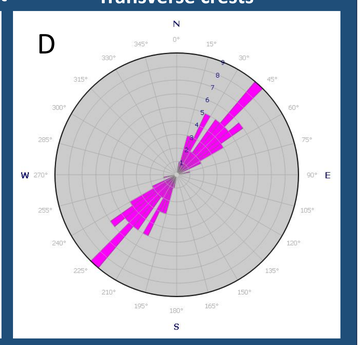
Network crests



Transvers Barchan and Barchan Crest



Transverse crests



Star crests

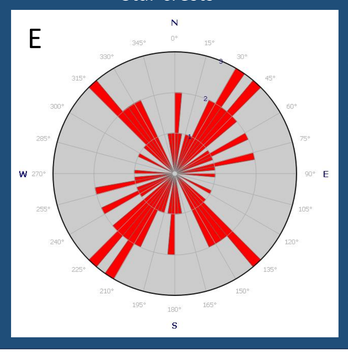
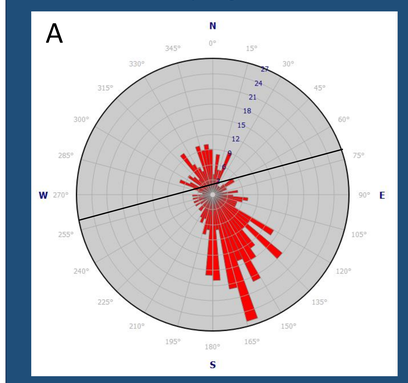


Figure 6.

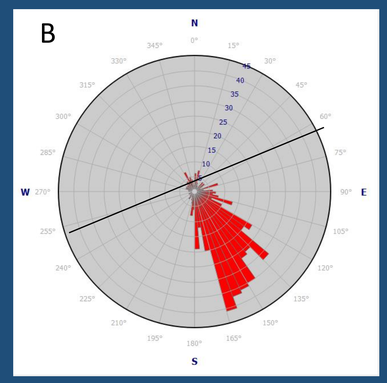
Azimuths of dune crests in the Mesquite Dune field. A through D show crest azimuths from northeast to southwest, with the transverse barchan/barchan dunes (C) showing a minor variance from this trend (north-northeast to south-southwest). Star dunes (E) show two dominant azimuths (northeast to southwest, southeast to northwest) but with significant variability.

Results Wind Direction

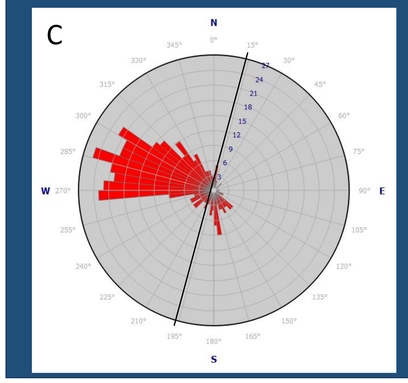
Spring



Summer



Fall



Winter

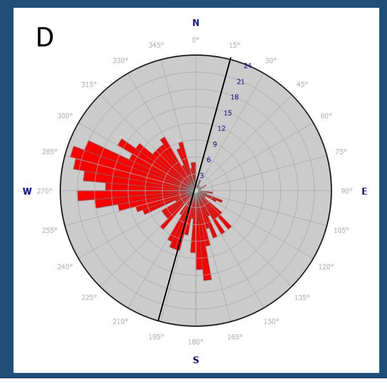


Figure 7.

The wind direction varies during the different seasons. In the Sprint, the wind comes mainly from the southeast with some reversal to the northwest. Summer wind derives mainly from the southeast. Fall wind comes mainly from west-northwest. Winter wind is from the west-northwest with some reversal to the southeast. The black lines in the rose diagram present the predicted dune azimuth of a transverse dune assuming the dominant wind direction.

Results Dune Reversals – Similar Location

Figure 8. Wind direction from northwest 2020

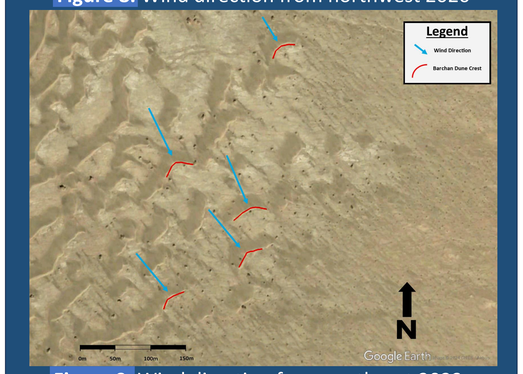
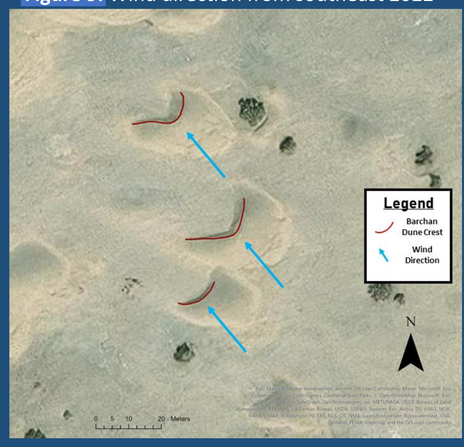


Figure 9. Wind direction from southeast 2022



Figures 8 and 9: Dune crest orientation reversal in mobile barchan dunes near the southeast fringe of the field. Wind from the west-northwest creates barchans with horns pointing to the southeast. This likely occurs as a result of fall-winter winds that are funneled though northern Death Valley (fig. 1 & 8). North winds were observed during the GCSI trip in January 2024. Winds from the southeast from spring-summer winds create barchans with horns pointing to northeast (fig. 1 & 9).

Conclusions:

- Sand supply and presence of converging seasonal (climate)/topographically-controlled winds have a large influence on dune size, type, and mobility in the Mesquite Dune field.
- The continuous dune field, with a higher sand supply and location near the convergence of seasonal and topographically-controlled winds, remains relatively stable and immobile. The fringes of the dune field have lower sand supply. Dunes are relatively mobile and unstable at the fringes in response to shifts in these winds.
- There are 3 transverse dune types in the dune field: transverse, transverse barchan, and barchan whose crests primarily align in a northeast to southwest direction, suggesting a single dominant wind orientation (Fig. 6). The strike of Death Valley appears to confine winds to a general northwest-southeast direction, which influences the orientation of these transverse dune crests.
- Stars and networks indicate multiple competing wind directions, but only near the center of the main dune field on the flats, possibly due to wind convergences owing to the geometry of Death Valley and the addition of fall and winter Pacific winds. These winds travel over Towne Pass, which is located in the highlands just west of Stovepipe Wells.
- Reversals of barchan and transverse dune orientation occur in the Mesquite Dune field between summer and winter seasons. Throughout the year, the average wind direction shifts from the southeast during spring and summer to west-northwest during fall and winter. West-northwest winds from the Pacific travel over Towne Pass to influence the main star and network dunes in the winter, but reversals in the transverse and barchan dunes indicate a strong component of wind funneled from the north, likely controlled by the alignment of northern Death Valley. During the spring/summer months, wind speed is on average higher (Fig. 7) and is the dominant wind.

References:
-Aerial and Satellite Images and photos. EarthExploer (https://earthexplorer.usgs.gov/)
Pixel size in pixel per meter. 1982 24,000 mpp, 1993, 2005, and 2014 1 mpp, 2022 0.6 mpp)
-Wind data: USCRN weather station Stovepipe Well's / visualcrossing (https://www.visualcrossing.com/weather/weather-data-services#)
-Bishop, S.R., Carretero-González, R., Momiji, H., Warren, A., 2001, Modelling desert dune fields base on discrete dynamics: Discrete Dynamics in Nature and Society, v. 7. https://doi.org/10.1080/10260220290013462
-Google Earth Pro v. 7.3.6. (February 2, 2020) Mesquite Sand Dunes, Death Valley. 36°36'40''N, 117°06'03''W eye elevation 522 Meters. CNES and Airbus 2024. (April 2, 2024)
-Google Earth Pro v. 7.3.6. (March 9, 2013), Death Valley. 36°10'53''N, 116°41'11''W eye elevation 522 Meters. Landsat/Copernicus. (April 2, 2024)