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Spatiotemporal Analysis of Wind Extremes in Santa Barbara County, CA

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Abstract

Downslope and gusty winds in the lee of the Santa Ynez Mountains (SYM) greatly influence the Santa Barbara (SB) coast in California. These winds, known as 'Sundowners' due to their typical peak after sunset, are characterized by northerly cross-mountain flow and strong stability at mountaintop level. The National Weather Service (NWS) defines a Sundowner when sustained cross-mountain winds greater or equal to 30 mph or gusts greater or equal to 35 mph are observed at surface stations located downwind of the SYM. In addition to gale-force winds, temperatures above 100°F and relative humidity below 15% are not uncommon during sundowners, and the marine layer influences the spatial extent to which these strong winds may reach. These conditions have led to turbulence which effects aviation at the local airport and the rapid spread of multiple destructive wildfires in the region, including the Jesusita Fire (2009), Sherpa Fire (2016), and Thomas Fire (2017).

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INTRODUCTION

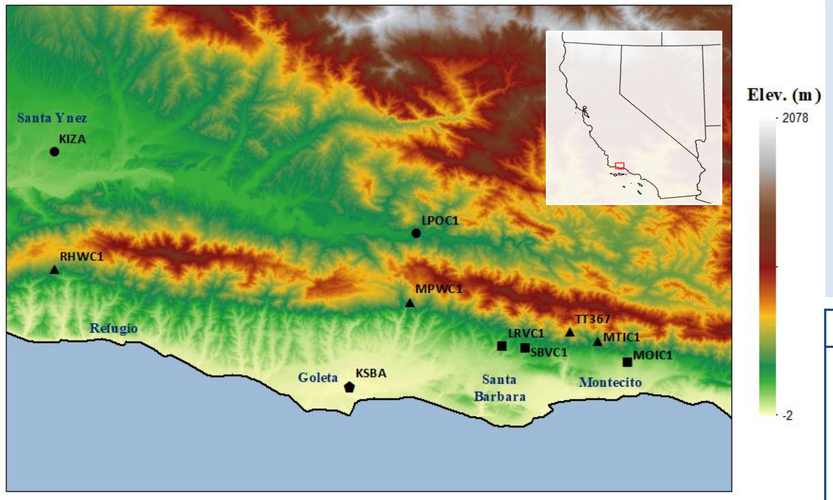
Downslope and gusty winds in the lee of the Santa Ynez Mountains (SYM) greatly influence the Santa Barbara (SB) coast in California. These winds, known as 'Sundowners' due to their typical peak after sunset, are characterized by northerly cross-mountain flow and strong stability at mountaintop level. The National Weather Service (NWS) defines a Sundowner when sustained cross-mountain winds greater or equal to 30 mph or gusts greater or equal to 35 mph are observed at surface stations located downwind of the SYM. In addition to gale-force winds, temperatures above 100°F and relative humidity below 15% are not uncommon during sundowners, and the marine layer influences the spatial extent to which these strong winds may reach. These conditions have led to turbulence which effects aviation at the local airport and the rapid spread of multiple destructive wildfires in the region, including the Jesusita Fire (2009), Sherpa Fire (2016), and Thomas Fire (2017).

OBJECTIVES

The east-west oriented SYM and the Santa Ynez valley create complex local circulations and interacting diurnal flows, however little is known regarding the spatiotemporal variability of winds in this region. Furthermore, 'extreme' winds significantly vary temporally and geographically. The objectives of this study are:

- To characterize regional diurnal wind circulations and seasonal differences
- To analyze the effects of strong, downslope winds on temperature and relative humidity
- To examine diurnal patterns of Sundowners using the NWS criteria at individual stations

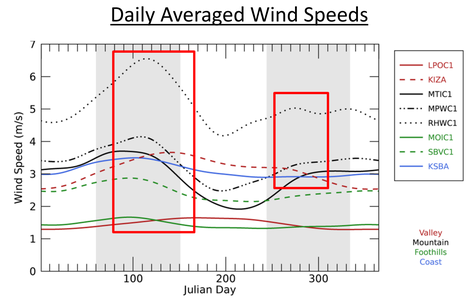
METHODOLOGY



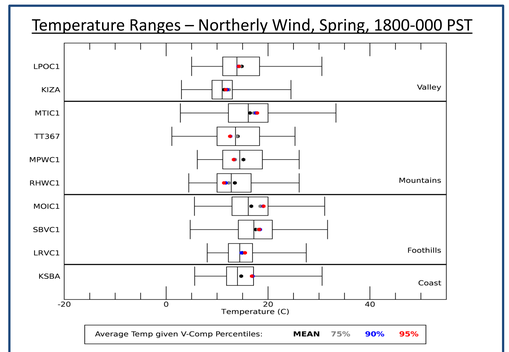
Valley ● Mountain ■ Foothill ▲ Coast ⬟

- Used hourly data from National Weather Service Automatic Surface Observing Systems and National Forest Service Remote Automatic Weather Service stations
- Applied a lower wind threshold of 0.5 m/s

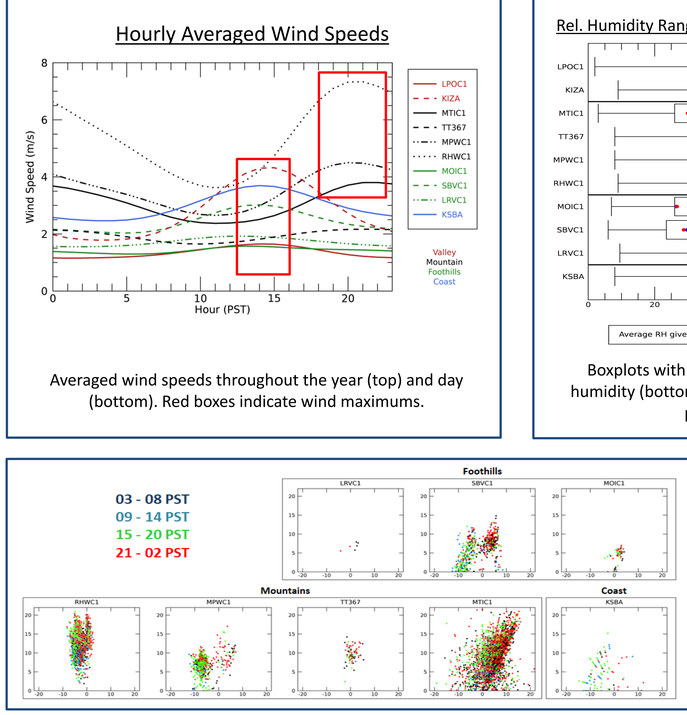
RESULTS



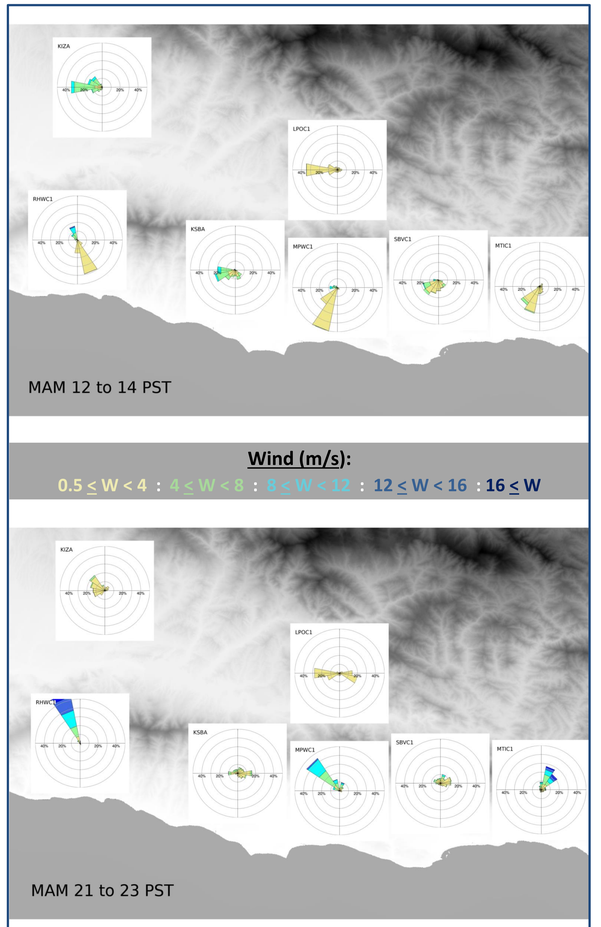
Averaged wind speeds throughout the year (top) and day (bottom). Red boxes indicate wind maximums.



Boxplots with average temperature (top) and relative humidity (bottom) values during given v-component wind percentiles (colored dots).



U and V wind components during Sundowners using NWS criteria (northerly wind and sustained wind ≥ 30 mph or gusts ≥ 35 mph). Colors indicate time of day, broken into 6 hour increments.



Wind roses for spring (MAM) from 1200 to 1400 PST (top) and 2100 to 2300 PST (bottom). The length of each spoke indicates the wind direction frequency and colors indicate wind speed frequency for each direction.

STATION	LATITUDE	LONGITUDE	ELEVATION (m)	TYPE	DATA START	DATA END
KIZA	34.606	-120.075	205	NWS	April 2005	June 2018
KSBA	34.426	-119.843	3	NWS	Nov. 1998	June 2018
LPOC1	34.544	-119.791	299	RAWS	Dec. 1999	June 2018
LRVC1	34.457	-119.723	204	RAWS	Dec. 2015	June 2018
MOIC1	34.445	-119.625	87	RAWS	April 2011	June 2018
MPWC1	34.491	-119.796	454	RAWS	July 2015	June 2018
MTIC1	34.461	-119.649	493	RAWS	Jan. 2000	Dec. 2017
RHWC1	34.516	-120.075	447	RAWS	July 2015	June 2018
SBVC1	34.455	-119.705	230	RAWS	June 2011	June 2018
TT367	34.468	-119.671	656	RAWS	Nov. 2015	June 2018

CONCLUSIONS

- Strongest winds at mountain stations:
  - Spring, secondary max. in fall
  - Evening, between 1900 and 2100 PST
- Strongest winds at non-mountain stations:
  - Spring, no secondary max.
  - Afternoon, between 1300 to 1500 PST
- Thermally-driven circulations shown: Mountain, Valley, and Land-Sea
- No evident temporal trends (not shown)
- Spatiotemporal patterns of Sundowners
  - Eastward temporal propagation

FUTURE WORK

- Climatology analysis using 30-year WRF output
- Thresholds for 'extreme' downslope winds
- Spatiotemporal variability of Sundowners
  - East and west regimes
  - Variability of mechanisms

ACKNOWLEDGEMENTS

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