Postprint: Characteristics of Surface Layer Wind Speed Fluctuations Under Different Weather Conditions

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Abstract

Using wind speed and direction observation data from the hinterland of the Taklamakan Desert (Tazhong area), this study analyzes the characteristics of mean wind speed, wind speed fluctuations, and wind direction fluctuations at different heights under clear, sandstorm, and blowing sand weather conditions, and explores the influence of sand-dust weather on wind speed and direction fluctuations in the near-surface layer. The results show that: (1) Under the three weather conditions, fluctuating wind speeds at various heights above 0.5 m from the surface exhibit good correlation, with even more significant correlation between adjacent heights, where all correlation coefficients exceed 0.68; the range of wind speed fluctuations is positively proportional to height. (2) With increasing height, wind speed fluctuation intensity shows an increasing trend under sandstorm and blowing sand conditions, while under clear weather it first increases then decreases; wind speed fluctuation intensity is highest during sandstorms, followed by blowing sand conditions, and lowest during clear weather; under different weather conditions, the growth rate of wind speed fluctuation intensity within the 2 m height range is greater than that in the 2–10 m height range. (3) Under different weather conditions, wind direction fluctuation amplitudes are all relatively small and basically do not change with height.

Full Text

Preamble

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2. Materials and Methods

2.1 Data Collection

The observational data were collected at the Tazhong station in the hinterland of the Taklimakan Desert. Wind speed measurements were recorded at heights of 0.5 m, 1 m, 2 m, 4 m, and 10 m above the ground surface, with a measurement range of -3.00 to 4.08 $m \cdot s^{-1}$ and a resolution of 0.5 $m \cdot s^{-1}$. The dataset captured wind speed fluctuations under three distinct weather conditions: sandstorm events, sunny days, and blowing sand weather.

[FIGURE 2] shows the wind speed fluctuation during a sandstorm event, [FIGURE 3] illustrates the wind speed fluctuation on a sunny day, and [FIGURE 4] depicts the wind speed fluctuation during blowing sand weather. The wind speed fluctuation range was -2.16 to 3.72 $m \cdot s^{-1}$ for blowing sand conditions, with a 0.5 m resolution. For sandstorm conditions, the range was -1.20 to 2.11 $m \cdot s^{-1}$ at 10 m height, demonstrating significant variation across measurement heights.

2.2 Statistical Analysis

The analysis examined 18 sandstorm events, with wind speed data aggregated at 1-minute and 2-minute intervals for heights of 2–10 m, and at 0.5–2 m intervals for near-surface measurements. The correlation coefficients between wind speeds at adjacent heights exceeded 0.68, indicating strong vertical correlation in wind speed fluctuations.

[FIGURE 6] presents the statistical relationships between wind speeds at different heights. The data show that wind speed fluctuation intensity increases with height during sandstorm and blowing sand conditions, while on sunny days it first increases and then decreases. The rate of increase in fluctuation intensity within the 0–2 m layer was higher than that in the 2–10 m layer across all weather conditions.

2.3 Calculation of Fluctuation Intensity

The intensity of wind speed fluctuation was calculated using standard statistical methods. The fluctuation intensity values ranged from 0.07 to 0.20 for blowing sand conditions, and from 0.12 to 0.37 for sandstorm conditions, demonstrating the influence of weather processes on atmospheric stability near the surface.

3. Results and Discussion

3.1 Wind Speed Variation Characteristics

The wind speed variation characteristics were analyzed based on field observations and meteorological data. The threshold wind velocity for sand particle movement was found to be 2.0–3.5 $m \cdot s^{-1}$, consistent with previous studies in

the region. The wind speed fluctuation intensity showed a proportional relationship with height above the ground surface, particularly within the 2–10 m layer.

The analysis revealed that wind speed fluctuations at heights above 0.5 m were well-correlated, with correlation coefficients between adjacent measurement levels exceeding 0.68. The fluctuation range increased with height, and the intensity of wind speed fluctuations showed distinct patterns under different weather conditions.

3.2 Wind Direction Fluctuations

Wind direction fluctuations remained relatively low under all weather conditions and did not exhibit significant variation with height. This stability in wind direction suggests that the primary variability in near-surface airflow is captured by wind speed rather than directional changes.

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Wind Speed Fluctuation near the Ground Surface over the Hinterland of the Taklimakan Desert under Different Weathers

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Abstract: This study was based on the field observation and meteorological data at Tazhong in the Taklimakan Desert. The purposes of the study were to investigate the characteristics of wind velocity fluctuation over the quick-sand surface in the desert hinterland, analyze the average wind speed and wind direction fluctuation on sunny day, in sandstorm and under blowing sand weather, and lucubrate the effects of sandstorm on the wind speed and wind direction fluctuation near the ground surface. The results are as follows: (1) There was a good correlation of wind speed fluctuation at different heights higher than 0.5 m from the ground surface, especially there was a significant correlation of wind speed between the adjacent heights, and the correlation coefficient was higher than 0.68. The wind speed fluctuation range was proportional to the height; (2) With the increase of height from the ground surface, the intensity of wind speed fluctuation was in an increase trend in sandstorm and under blowing sand weather, but it was increased at first and then decreased on sunny day. The increase of wind speed fluctuation intensity within 2-m height was higher than that at the height range of 2-10 m under different weather conditions; (3) The wind direction fluctuation under different weather conditions was low and did not basically change with the height.

Keywords: quick-sand surface; air layer near ground surface; wind speed fluctuation; fluctuation intensity; wind direction fluctuation; Taklimakan Desert

Note: Figure translations are in progress. See original paper for figures.