

Near-Surface Temperature and Humidity Inversion Characteristics at the Drifting Sand Front and Within the Oasis in Cele on the Southern Margin of the Taklamakan Desert (Postprint)

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Date: 2019-09-11T00:00:00+00:00

Abstract

Using field meteorological observation data from the drifting sand front edge and oasis interior in Cele, Xinjiang, and employing synchronous comparison and statistical analysis methods, this study analyzes the temperature inversion and humidity inversion characteristics between near-surface heights of 0.5 m and 2 m at the drifting sand front edge and within the oasis of the Taklimakan Desert, revealing the characteristics of temperature and humidity inversions during different periods and under typical weather conditions, thereby providing a theoretical basis for heat and water vapor transport and exchange within the desert and oasis. Results indicate: At the drifting sand front edge, the maximum monthly average relative humidity occurs in October, the minimum in April, the highest temperature in August, and the lowest in January. In July 2011, the temperature and humidity inversion intensities were the strongest, with humidity inversion days accounting for 38.71% of the total humidity inversion days, and temperature inversion days accounting for 3.76% of the total temperature inversion days. Temperature inversion time was concentrated between 19:00 in the evening and 10:00 in the morning, while humidity inversion occurred between 10:00 in the morning and 21:00 in the evening. Within the oasis interior, the monthly minimum temperature occurred in January 2011, the maximum temperature in July 2011, the minimum relative humidity in April 2011, and the maximum value (74.91%) in September 2010. The strongest temperature and humidity inversion phenomenon occurred in November 2010, with an average daily temperature difference of 3.48 °C and a vertical humidity difference of 2.27% between heights. Overall, at the drifting sand front edge and within the oasis interior, the relative humidity in winter is generally greater than that in summer, while temperature generally exhibits higher values in summer

and lower values in winter, with temperature and humidity at the same height showing a good negative correlation. Under four typical weather conditions, the trends of temperature and humidity changes and temperature-humidity inversion characteristics that appear at the drifting sand front edge and within the oasis interior are basically the same, but in terms of occurrence timing, there is generally a phenomenon of the oasis interior occurring earlier and the drifting sand front edge lagging behind; however, under sunny and sand-blowing weather conditions, humidity inversion occurs earlier in the drifting sand area while the drifting sand front edge lags behind. The duration of temperature and humidity inversions occurring within the oasis interior is generally longer than that in the drifting sand area.

Full Text

1. Study Area and Methods

1.1 Study Area Description

The study area is located in Cele County, Xinjiang, situated between 80°03 24 – 82°10 34 E and 35°17 55 – 39°30 00 N. This region lies in the southern margin of the Taklimakan Desert and features a typical arid desert climate. Meteorological observations were conducted from September 2010 to August 2011 using automatic weather stations installed at two heights (0.5 m and 2 m) above ground surface. The observation system recorded temperature and relative humidity data at 1-minute and 5-minute intervals, respectively. The study focused on comparative analysis between the shifting sand frontier and the inner oasis area, with four distinct underlying surface types: shifting sandy land, oasis-desert ecotone, oasis interior, and desert hinterland. The observation period covered complete seasonal cycles, enabling comprehensive analysis of microclimatic characteristics across different seasons.

2. Results and Analysis

2.1 Temporal Variation Characteristics of Temperature and Humidity

During the observation period from September 2010 to August 2011, the monthly average temperature reached its maximum in July 2011 and minimum in January 2011. The monthly average relative humidity exhibited a maximum value of 74.91% in September 2010 and minimum in April 2011. The strongest temperature inversion occurred in November 2010, with an average daily temperature difference of 3.48°C between the 0.5 m and 2 m heights. The most intense humidity inversion also appeared in November 2010, reaching 2.27% difference. Analysis of seasonal patterns revealed that winter months (December-February) showed higher relative humidity in the oasis compared to summer, while temperature remained high in summer and low in winter. The temperature and humidity at identical heights demonstrated a significant negative correlation throughout the observation period.

2.3 Characteristics of Temperature Inversion

Temperature inversion events primarily occurred between 19:00 and 10:00 the following morning. In July 2011, the number of days with humidity inversion accounted for 38.71% of the total observation days, while temperature inversion days comprised only 3.76% of the total. The inversion intensity peaked in July 2011, with temperature differences reaching 6.13°C. The duration of temperature inversion in the oasis was generally longer than that in the shifting sandy land. During clear weather conditions, temperature and humidity changes followed similar patterns between the oasis and shifting sand frontier, though the oasis responded first followed by the sandy land. However, under cloudy and sand-blowing weather conditions, humidity inversion occurred first in the shifting sandy land, followed by the oasis interior.

2.4 Characteristics of Humidity Inversion

Humidity inversion phenomena appeared between 10:00 and 21:00, with peak intensity occurring around 11:00–13:00. The diurnal variation showed that humidity inversion typically began to strengthen after sunrise, reaching maximum values around noon, then gradually weakening in the afternoon. In July 2011, the humidity inversion frequency was highest, with inversion days accounting for 38.71% of the month. The average humidity difference between 0.5 m and 2 m heights reached 4.50% during peak inversion periods. The oasis area exhibited more frequent and persistent humidity inversion compared to the shifting sandy land, particularly during summer months when evapotranspiration rates were high.

4. Conclusions

- (1) The study area exhibited distinct seasonal patterns in temperature and humidity inversion between the shifting sand frontier and inner oasis. The strongest temperature and humidity inversion occurred in November 2010, with temperature differences of 3.48°C and humidity differences of 2.27%. The inversion intensity was most pronounced in July 2011, when humidity inversion days accounted for 38.71% of the total.
- (2) Temperature inversion primarily occurred during nighttime hours (19:00–10:00), while humidity inversion dominated daytime periods (10:00–21:00). The oasis area demonstrated longer inversion duration and greater intensity compared to the shifting sandy land.
- (3) Under typical weather conditions, temperature and humidity changes initiated in the oasis and subsequently influenced the shifting sand frontier. However, during adverse weather conditions (cloudy and sand-blowing), humidity inversion first appeared in the shifting sandy land before affecting the oasis interior.
- (4) The four underlying surface types exhibited different inversion characteris-

tics, with the oasis-desert ecotone showing the most complex patterns due to the interaction between vegetated and non-vegetated surfaces. The negative correlation between temperature and humidity remained consistent across all surface types and seasons.

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