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The role of maximum wind speed in sand-transporting events

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ABSTRACT

A sand-transporting event is the minimum unit of aeolian sand transport process. To understand the role of maximum wind speed in such sand-transporting events, wind speeds were measured at a height of 2 m above the ground in the arid (Menggen) and semi-arid (Taibus Banner) regions in north China during 2009 and 2011. The sand transport flux of each sand-transporting event was calculated based on theoretical equations. Then, the relationships between the maximum wind speed and the average wind speed, the duration and sand transport flux of sand-transporting events were analyzed. It was found that the maximum wind speed was proportional to the average wind speed of sand-transporting events, with a linear model fit, and was also significantly correlated with the duration of sand-transporting events with a power model fit. The maximum wind speed was also positively correlated with sand transport flux of sand-transporting events according to a power model. The maximum wind speed could therefore represent both wind speed and the duration of sand-transporting events, and play a decisive role in the sand transport process of these events. The sand transport flux of sand-transporting events can be predicted rapidly and conveniently by monitoring maximum wind speed.

1. Introduction

Aeolian sand transport is an important process in many research fields, such as physics, geosciences, agriculture, and engineering and is influenced by the strength and duration of the wind, the properties of the surface, and sand flux (fetch) (Owen, 1964; Buckley, 1987; Anderson and Haff, 1988; Iversen and Rasmussen, 1994; Gillette et al., 2001; Zou et al., 2001; Cornelis and Gabriels, 2003; McKenna, 2003; Dong et al., 2004; Liu et al., 2005; Barchyn and Hugenholtz, 2012). A sand-transporting event is the basic and minimum unit of sand transport process (Gillies et al., 2006; Udo et al., 2008; Lancaster et al., 2010; Delgado-Fernandez and Davidson-Arnott, 2011; Gillies and Lancaster, 2013; Yurk et al., 2013). Studying sand-transporting events is considered as the first and critical step in understanding the complicated sand transport processes.

By definition, once wind speed is greater than the threshold leading to the movement of sand particles, a sand-transporting event occurs. However, due to inertia of sand transport processes (Jackson, 1996), the limitation of the effectiveness of sand traps (such as Safires, Baas, 2004; Barchyn and Hugenholtz, 2011), and complications of wind near the earth's surface (Bao and Li, 2004; Zhang et al., 2006), identifying a sand-transporting event from the preceding and following events is very difficult. Measurement of sand transport at fixed intervals is still the most effective method for identifying a sand-transporting event and to obtain sand transport flux (Speirs et al., 2008; Gillies et al., 2013).

Sand transport rate and 10-min average wind speeds at a height of 2 m above the ground conform very well from field observations (Wu and Ci, 2002; Liu et al., 2005; Wu, 2010; Gillies et al., 2013). Therefore, measuring sand-transporting events using such wind speed observations is a reasonable and effective method. In addition, a sand-transporting event is unique in terms of average wind speed, duration and sand transport flux (Maurer et al., 2010). The average wind speed is the mean value of wind speed during sand-transporting events. The duration is the length of time of the sand-transporting events lasting for, and sand transport flux is the amount of sand driven by wind during such events, representing their magnitude. In most of previous studies, average wind speed, duration and sand transport flux of sand-transporting events have always been seen as characteristic values to describe these events (Lancaster and Baas, 1998; Farrell et al., 2012; Gillies et al., 2013; Yurk et al., 2013). Little attention has been paid to the relationships among these three characteristic values of sand-transporting events. Moreover, the maximum wind speed is also an important element of sand-transporting events, which is the maximum value of wind speeds during a sand-transporting event, yet this has been largely neglected when analyzing these events. Only Liu (1999) and Liu et al. (2005) note that the maximum wind speed of sand-transporting events is important for assessing their aeolian sand transport. However, no further studies have focused on the role of maximum wind speed in sand-transporting events. Whether there are relationships between

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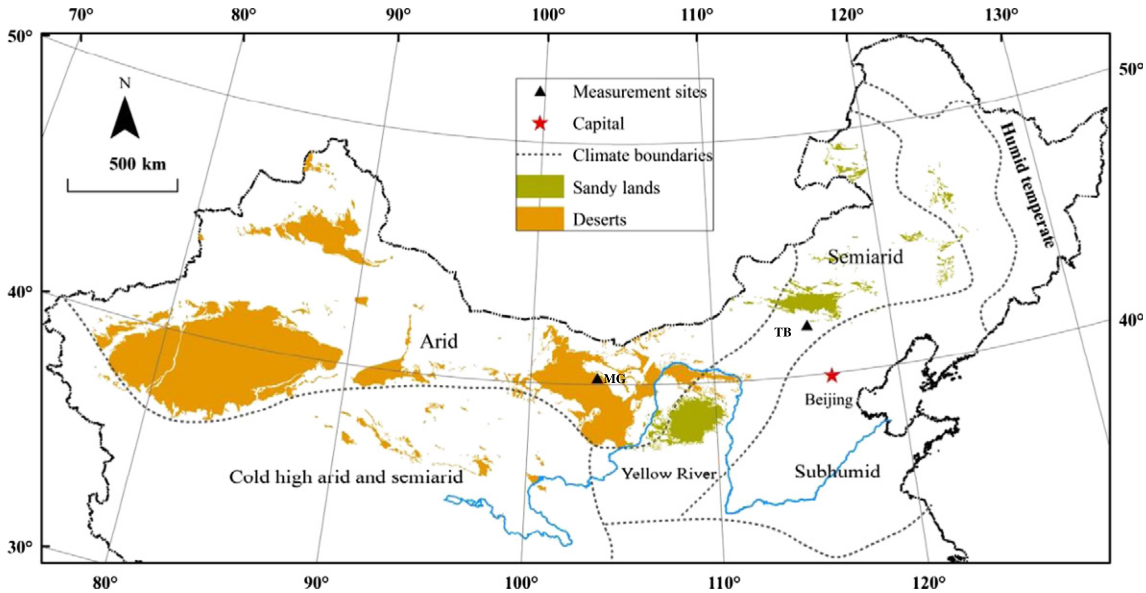

Fig. 1. The locations and climate information of the measurement sites. MG and TB are the abbreviation of Menggen town and Taibus Banner, respectively.

the maximum wind speed and other parameters of sand-transporting events, unifying those elements together is critical links in understanding sand transport processes, especially during sand and dust storms. Therefore, the objectives of this study are to reveal the role of maximum wind speed in sand-transporting events by analyzing the relationships between the maximum wind speed and the average wind speed, the duration, and sand transport flux of sand-transporting events.

2. Regional setting

Menggen town (abbreviated to MG) (40°01′ N, 103°52′ E, 1405 m a.s.l.) is located at the conjunction area of the Badain Jaran and Tengger deserts, belonging to the arid region (Fig. 1). The average day–night and summer–winter temperature differences are approximately 30 °C and 35 °C, respectively. The average annual precipitation is less than 100 mm, and most of the rain events are concentrated in the months of July, August, and September. The average annual potential evaporation is 1450 mm. The average monthly wind speed ranges from 3.1 to 4.4 m s^{-1}. Strong winds (>17.2 m s^{-1}) occur for approximately 30 days $year^{-1}$. This region is the main source of sandstorms in China (Lee and Sohn, 2011). *Chenopodiaceae*, *Asteraceae*, *Zygophyllaceae*, *Rosaceae*, and *Leguminosae* are the dominant plant species, with vegetation cover ratios of less than 5% in the interdune areas of this region (He et al., 2010). The local landforms are barchan and transverse dunes in different sizes, sand sheets, and nebkhas. Most of the surfaces in this area belong to shifting sand dune fields, being covered with dry quartz sand with a mean grain diameter of 270 μm.

Taibus Banner (TB), Inner Mongolia, China, lies in a farming-pastoral ecotone between the traditional humid cultivation area and semiarid pastoral grasslands, the south most part of Otindag Sandy Land (41°35′–41°10′ N, 114°51′–115°49′ E) (Fig. 1). TB covers an area of 3414.74 km^2, with elevations varying between 1000 and 1500 m. This region is one of the most ecologically fragile zones in China with the most severe wind erosion, land desertification and aeolian sand hazards

Fig. 2. Instruments used to measure meteorological data. 1. Wind vane. 2. Propeller anemometer. 3. Solar panels. 4. Battery. 5. Datalogger. 6. Temperature and humidity sensor. 7. Sediment collector. 8. Fence. 9. Shifting dune.
The picture was from Yang et al. (2014).