The user wants me to translate a Chinese academic paper title and the word "后印本"(postprint). The title is: "Wind regime features and their impacts on the middle reaches of the Yarlung Zangbo River on the Tibetan Plateau, China" Wait, that' s already in English. Let me re-read the user' s request….

Authors: The user has provided a very short input: "ZHANG Yan" . This appears to be a name, likely the author name from a paper. The instruction says to translate from Simplified Chinese to English with highest accuracy and academic tone.

However, "ZHANG Yan" is already in English (Pinyin romanization of a Chinese name). In academic contexts, Chinese names are typically presented either as: 1. ZHANG Yan (surname first, all caps for surname) 2. Yan Zhang (Western order, given name first) 3. ZHANG, Yan (with comma)

The input "ZHANG Yan" follows the format where the surname is in all caps and comes first, which is a standard academic convention for Chinese names in English publications. Since it' s already in English/Pinyin format, there' s no actual translation needed.

But I need to check the requirements: - Preserve ALL LaTeX commands and math placeholders - not applicable here - Preserve ALL citation commands - not applicable - **PRESERVE ALL ···paragraph wrapper tags EXACTLY** - not present - Maintain academic tone - yes - Use precise technical terminology - not applicable - Preserve section structure - not applicable - Translate all content completely - the content is already in English format

The output rules say: - Return ONLY the translated text - Keep one output paragraph per input paragraph - not applicable - **Maintain exact count and IDs of ···tags** - not applicable - Do NOT add Markdown formatting - okay - Preserve original line breaks - okay

Since there are no tags, I should just return the name as is. The name is already in the standard academic format for English publications. No translation or modification is needed.

The glossary provided (机器学习 => machine learning, 深度学习 => deep learning) is not relevant to this input.

So the output should simply be: ZHANG Yan

Wait, let me double-check. The user might be testing if I understand that this is already in English format and doesn' t need translation. Or perhaps they want me to convert it to "Yan Zhang" (Western order)? But the instructions say "Translate from Simplified Chinese to English" . The name "ZHANG Yan" is not Simplified Chinese characters - it' s Pinyin. So there' s nothing to translate.

If the input had been "张岩" or "张妍" etc., then I would need to transliterate it, ZHANG Zhengcai, The user has provided a name "MA Pengfei" and the instruction is to translate from Simplified Chinese to English with the highest accuracy and academic tone, following all the critical requirements about preserving LaTeX, citations, and tags.

However, the input is just a name "MA Pengfei" . This is not a paragraph with tags, LaTeX commands, or any Chinese text to translate. It' s a proper name.

According to the instructions: - I must preserve ALL …paragraph wrapper tags EXACTLY - I must preserve LaTeX commands and placeholders exactly - I must preserve citation commands exactly - I must translate from Simplified Chinese to English

But the input is just "MA Pengfei" which is: 1. Not wrapped in tags 2. Not containing any Chinese characters (it' s a romanized name) 3. Not containing any LaTeX or mathematical content 4. Not containing any citations

This seems like it might be an author name or a test case. The name "MA Pengfei" is already in a format that would be used in English academic papers (surname MA, given name Pengfei). In Chinese, it would be written as "马鹏飞" but the user provided the pinyin transliteration.

Given the strict requirements about tags, I should consider: - Should I wrap this in a tag? The instruction says "PRESERVE ALL …paragraph wrapper tags EXACTLY" and "if input has N paragraph tags, output must have exactly N paragraph tags with matching IDs" . Since the input has 0 paragraph tags, the output should have 0 paragraph tags.

The input is just "MA Pengfei" . This is not Chinese text that needs translation. It' s already in a form used in English. The most appropriate action would be to return it as-is, since: 1. It' s not in tags, so I shouldn' t add them 2. It' s not Chinese characters, so there' s nothing to translate 3. It' s already in the format used in English academic writing

Therefore, the output should simply be: MA Pengfei

But wait, let me double-check the instructions. The user says "Translate from Simplified Chinese to English" . The input "MA Pengfei" is not Simplified, The user has provided a name "PAN Kaijia" which appears to be a Chinese name.

Based on the context of the task (translating academic papers from Simplified Chinese to English), this is likely an author name that needs to be transliterated.

The name “PAN Kaijia” is already in Pinyin (the romanization system for Chinese). In academic contexts, Chinese names are typically presented in one of these formats: 1. PAN Kaijia (surname in all caps, given name with initial capital) 2. Pan Kaijia (standard capitalization) 3. Kaijia Pan (Western order, given name first)

For academic papers, the most common format is either “PAN Kaijia” (retaining Chinese name order with surname capitalized) or “Kaijia Pan” (Western order). Since the original is “PAN Kaijia” (which suggests the surname is already capitalized), this is likely the format to be used in an English academic paper.

However, the user hasn’ t provided any actual content to translate - just a name. The task is to translate from Simplified Chinese to English with academic tone, preserving LaTeX commands, citations, and tags.

Since there’ s no Chinese text to translate (just a name that’ s already in Pinyin), I should return the name as is, or perhaps just acknowledge that there’ s no content to translate. But looking at the instructions more carefully, the user might be testing the system or providing context.

Wait, let me re-read the instructions. The user provided “PAN Kaijia” and the system is supposed to translate from Simplified Chinese to English. But “PAN Kaijia” is not Simplified Chinese characters - it’ s already Pinyin.

If this is meant to be the start of a document, perhaps the user wants me to treat this as an author name in a paper. In that case, I should just return it as is, since it’ s already in the appropriate format for an English academic paper.

But the instructions say “Return ONLY the translated text for the given input (no explanations, no quotes, no headings you invent).” So I should just output “PAN Kaijia” if that’ s what should be returned.

Actually, I’ m overthinking this. The user has provided “PAN Kaijia” which is already in English letters (Pinyin). There’ s nothing to translate. The most appropriate response is to return it exactly as provided.

Let me check if there are any hidden characters or if this is meant to be part of a larger structure. No„ The user wants me to translate a scientific paper from Simplified Chinese to English. The input is “ZHA Duo” which seems incomplete. Let me check the actual content.

Wait, the user just wrote “ZHA Duo” . This might be a name. Let me re-read the instructions.

The instructions say: “Translate from Simplified Chinese to English with the highest accuracy and academic tone.” and there are CRITICAL REQUIREMENTS about preserving LaTeX, citations, and tags.

But the input is just “ZHA Duo”. This is a Chinese name. In academic contexts, Chinese names are typically transliterated. “ZHA Duo” would be the pinyin. The surname is ZHA (查) and the given name is Duo (铎) or something similar.

However, the instructions mention: - Preserve ALL LaTeX commands and placeholders - Preserve ALL citation commands - **PRESERVE ALL …paragraph wrapper tags EXACTLY** - Maintain academic tone - Use precise technical terminology - obey the glossary strictly - The glossary only has: 机器学习 => machine learning, 深度学习 => deep learning

The input “ZHA Duo” doesn’ t contain any of these elements. It’ s just a name.

Let me think about what the user might want: 1. They might want me to translate the name “ZHA Duo” into English format. In academic papers, Chinese names are usually kept in pinyin but with the surname first, or sometimes reversed given Western conventions. “ZHA Duo” could be translated as “Zha Duo” (keeping pinyin) or if it’ s a specific known person, there might be a standard English spelling.

2. This might be a test to see if I follow the instructions correctly - meaning I should just return the name as is, since there are no tags, no LaTeX, no Chinese text to translate (except the name itself).
3. Or this might be an incomplete input, and the user expects me to wait for the full text.

Given the strict instructions about preserving structural elements, and since “ZHA Duo” has no tags, LaTeX, or other elements mentioned, the most logical interpretation is that this is either: - A name that should be transliterated as “Zha Duo” (following standard pinyin capitalization) - Or the user made a mistake and didn’ t provide the full text

But the instructions, The user has provided a name “CHEN Dingmei” and wants me to translate it. However, this is not a scientific paper or academic text with tags, LaTeX commands, etc. It’ s just a name.

Looking at the instructions: - The system prompt is about translating scientific papers with specific requirements - It mentions preserving LaTeX, citations, tags, etc. - The user just gave a name

Since this is just a name and doesn’ t contain any of the structural elements mentioned in the prompt (no tags, no LaTeX, no citations), I should simply translate it appropriately.

“CHEN Dingmei” is a Chinese name. In academic contexts, Chinese names are typically written with the surname first, followed by the given name. The standard translation would be to keep the pinyin as is: “CHEN Dingmei”.

However, sometimes in English publications, the name might be written as “Dingmei Chen” (given name first, surname last). But the prompt says “Translate from Simplified Chinese to English with the highest accuracy and academic tone.”

In academic papers, Chinese names are usually kept in their original pinyin form, often with the surname in all caps or just as provided. Since the input is “CHEN Dingmei” (already in pinyin with surname capitalized), the most accurate translation would be to keep it exactly as is.

But wait - the user might be asking me to translate this as a test, or this might be part of a larger document. The prompt says “Return ONLY the translated text for the given input (no explanations, no quotes, no headings you invent).”

Given that this is just a name and doesn’ t contain any of the special elements, I should just return the name as it would appear in an academic context. The most standard academic format would be “CHEN Dingmei” (surname in caps, given name with initial capital).

Actually, looking at the glossary provided: - 机器学习 => machine learning - 深度学习 => deep learning

These are technical terms, but there’ s no guidance on name translation. In academic contexts, Chinese names are typically: 1. Kept in pinyin 2. Sometimes written as “Chen, Dingmei”or “Dingmei Chen”3. Often kept as “CHEN Dingmei” when the original is in that format

Since the input is “CHEN Dingmei” and the instruction is to translate with highest accuracy, I should, The user has provided a name “SHEN Caisheng” which appears to be a Chinese name. This is likely the author name for a scientific paper that needs to be translated. The name should be transliterated according to standard academic conventions.

In academic publishing, Chinese names are typically written in one of these formats: 1. Family name first, then given name: SHEN Caisheng 2. Given name first, then family name: Caisheng Shen 3. With hyphenation: Cai-Sheng Shen

The most common and standard format in English academic papers is to keep the family name first in all caps, or to use the Western order with the family name last. Given that the original is “SHEN Caisheng” (which already has the family name in uppercase), this is likely the format to preserve.

However, looking at the context, this appears to be just a name provided by the user, not a full paragraph with tags. The user might be testing the system or providing context for a future translation task.

Since there are no tags, LaTeX commands, or Chinese text to translate (except the name itself), and the instructions say to return ONLY the translated text for the given input, I should just return the name in an appropriate academic format.

The name "SHEN Caisheng" should be: - Family name: SHEN (沈) - Given name: Caisheng (才生 or 彩生, etc.)

In academic contexts, Chinese names are often presented as: - "SHEN Caisheng" (keeping original order) - "Caisheng SHEN" (Western order, family name in caps) - "Caisheng Shen" (Western order, standard capitalization)

Given the strict requirements about preserving formatting and the fact that the original already has the family name in uppercase, the most faithful translation would be to keep it as "SHEN Caisheng" or use "Caisheng SHEN" for Western publications.

Since there are no tags or other content, and the user just provided a name, I should simply return the name in a standard academic English format. The most common format in English academic papers is given name first, then family name: "Caisheng Shen" .

But wait - the instructions say "Translate from Simplified Chinese to English". A name isn't really "translated"but transliterated. The original is already in Pinyin. The question is about formatting., The user has provided a name "LIANG Aimin" and wants me to translate it. However, the instructions say I should translate from Simplified Chinese to English with academic tone, preserving LaTeX, citations, and tags.

The input is just a name: "LIANG Aimin" . This appears to be a Chinese name. In academic contexts, Chinese names are typically transliterated following specific conventions: - Surname first, then given name - Usually capitalized as: LIANG Aimin or Liang Aimin - Sometimes written as: Aimin Liang (Western order)

Given that this is likely an author name in an academic paper, and the instructions mention preserving academic formatting, I should treat this as a proper name that doesn' t need translation but rather transliteration. The most common academic format for Chinese names is either: 1. All caps: LIANG Aimin 2. Mixed case: Liang Aimin 3. Western order: Aimin Liang

Since the original is in all caps "LIANG Aimin" , I should preserve this format as it' s likely already in the correct academic citation format. However, the user might want me to process this as part of a larger document.

Wait, the user just gave me "LIANG Aimin" without any tags or other content. Let me re-read the instructions.

The instructions say: - Translate from Simplified Chinese to English - Preserve ALL ···paragraph wrapper tags EXACTLY - Return ONLY the translated text for the given input (no explanations, no quotes, no headings you invent) - Keep one output paragraph per input paragraph; do not merge or split paragraphs - Maintain exact count and IDs of ···tags

But the input "LIANG Aimin" doesn' t have any tags. This is just a name. Is this a test? Or is this part of a larger context?

Let me think about how to handle this. The name "LIANG Aimin" is already in Pinyin, which is the standard romanization system for Chinese. In academic contexts: - If it' s an author name, it' s typically left as is: LIANG Aimin - Sometimes it' s written as "Liang, Aimin" or "Aimin Liang" depending on the citation style

Since there are no tags and no Chinese characters to translate (it' s already in Latin script

Date: 2023-10-17T00:00:00+00:00

Abstract

The user wants me to translate a scientific abstract from Chinese to English. Let me analyze the requirements:

1. **CRITICAL REQUIREMENTS**:
   - Preserve ALL LaTeX commands and placeholders exactly
   - Preserve ALL citation commands ([?], **??**, (**??**), etc.) exactly
   - **PRESERVE ALL …paragraph wrapper tags EXACTLY**
   - Maintain academic tone and formal scientific writing style
   - Use precise technical terminology - obey the glossary strictly
   - Preserve section structure and paragraph organization
   - Translate all content completely - do not omit any information
2. **OUTPUT RULES**:
   - Return ONLY the translated text (no explanations, no quotes, no headings)
   - Keep one output paragraph per input paragraph
   - Maintain exact count and IDs of …tags
   - Do NOT add Markdown formatting unless present in source
   - Preserve original line breaks within the paragraph when meaningful
3. **FORMATTING GUIDELINES**:
   - Keep mathematical expressions in original LaTeX format
   - Preserve equation numbers and references
   - Maintain proper academic paragraph structure
   - Use formal scientific language
4. **Glossary**:
   - 机器学习 => machine learning
   - 深度学习 => deep learning

Looking at the input text, I see it' s a single paragraph without any tags, LaTeX commands, or mathematical formulas. The glossary terms "机器学习" and "深度学习" don' t appear in the text either. This means I just need to translate the Chinese text to English with academic tone.

Let me translate the text carefully:

"The wide valley of the Yarlung Zangbo River is one of the most intense areas in terms of aeolian activity on the Tibetan Plateau, China. In the past, the evaluation of the intensity of aeolian activity in the Quxu-Sangri section of the Yarlung Zangbo River Valley was mainly based on data from the old meteorological stations, especially in non-sandy areas. In 2020, six new meteorological stations, which are closest to the new meteorological stations, were built in the wind erosion source regions (i.e., sandy areas) in the Quxu-Sangri section. In this study, based on mathematical statistics and empirical orthogonal function (EOF) decomposition analysis, we compared the difference of the wind regime between new meteorological stations and old meteorological stations from December 2020 to November 2021, and discussed the reasons for the discrepancy. The results showed that sandy and non-sandy areas differed significantly regarding the mean velocity (8.3 (\$±0.3)$versus7.7(\pm0.3)m/s,respectively),frequency(12.9\pm6.2\pm1.9\pm77.3)versus24.0(\pm17.9)VU(whereVUist$ VU, respectively), and resultant drift direction (nearly westward or eastward versus nearly southward or northward, respectively). This indicated an obvious spatial variation in the wind regime between sandy and non-sandy areas and suggested that there exist problems when using wind velocity data from non-sandy areas to evaluate the wind regime in sandy areas. The wind regime between sandy and non-sandy areas differed due to the differences in topography, heat flows, and their coupling with underlying surface, thereby affecting the local atmospheric circulation. Affected by large-scale circulations (westerly jet and Indian monsoon systems), both sandy and non-sandy areas showed similar seasonal variations in their respective wind regime. These findings provide a credible reference for re-understanding the wind regime and scientific wind-sand control in the middle reaches of the Yarlung Zangbo River Valley."

Wait, the user provided English text already. Let me re-read the instructions. The user says "The wide valley of the Yarlung Zangbo River is one of the most intense areas…" This appears to be English text, not Chinese. But the task is to translate from Simplified Chinese to English.

Let me check if there' s Chinese text that I' m missing. The user message only contains the English paragraph. There is no Chinese text to translate. This is confusing.

Looking at the system prompt again: "You are a professional scientific translator specializing in academic papers. Translate from Simplified Chinese to English with the highest accuracy and academic tone."

But the user message is in English. This could be: 1. A test to see if I recognize that no translation is needed 2. The user made a mistake and pasted the wrong text 3. The user wants me to "translate" it (maybe edit/improve it) even though it' s already in English

Given the strict requirements about preserving tags and LaTeX, and the fact that the input has none of these, I should probably just return the text as is, since there' s no Chinese to translate.

But wait, let me re-read the user' s message more carefully. The entire content is:

“The

Full Text

Preamble

Journal of Arid Land (2023) 15(10): 1174–1195
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Wind Regime Features and Their Impacts on the Middle Reaches of the Yarlung Zangbo River on the Tibetan Plateau, China

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Abstract: The wide valley of the Yarlung Zangbo River is one of the most intense areas of aeolian activity on the Tibetan Plateau, China. Historically, evaluations of aeolian activity intensity in the Quxu-Sangri section of the Yarlung Zangbo River Valley relied primarily on data from older meteorological stations situated in non-sandy areas. In 2020, six new meteorological stations were established directly within wind erosion source regions (i.e., sandy areas) in the Quxu-Sangri section, providing unprecedented proximity to active sand sources. This study employs mathematical statistics and empirical orthogonal function (EOF) decomposition to compare wind regime differences between the new (sandy-area) and old (non-sandy-area) meteorological stations from December 2020 to November 2021, and discusses the underlying causes of observed discrepancies.

Our results reveal significant differences between sandy and non-sandy areas in mean sand-driving wind velocity (8.3 ± 0.3 m/s versus 7.7 ± 0.3 m/s), frequency (12.9% ± 6.2% versus 2.9% ± 1.9%), and dominant direction (nearly east-west versus nearly north-south). Substantial differences were also observed in drift potential (DP) (168.1 ± 77.3 VU versus 24.0 ± 17.9 VU, where VU is the vector unit), resultant drift potential (RDP) (92.3 ± 78.5 VU versus 8.7 ± 9.2 VU), and resultant drift direction (RDD) (nearly westward/eastward versus nearly southward/northward). These findings demonstrate pronounced spatial variation in wind regimes between sandy and non-sandy areas, highlighting critical problems when using wind velocity data from non-sandy areas to evaluate wind regimes in sandy areas. The divergent wind regimes arise from differences in topography, heat flows, and their coupling with the underlying surface, which collectively affect local atmospheric circulation. Influenced by large-scale circulation systems (westerly jet and Indian monsoon), both sandy and non-sandy areas exhibit similar seasonal variations in their respective wind regimes. These findings provide a credible reference for re-evaluating wind regime characteristics and implementing scientifically informed wind-sand control measures in the middle reaches of the Yarlung Zangbo River Valley.

Keywords: wind regime; aeolian activity; sand-driving winds; drift potential; atmospheric circulation; Yarlung Zangbo River; Tibetan Plateau

Citation: ZHANG Yan, ZHANG Zhengcai, MA Pengfei, PAN Kaijia, ZHA Duo, CHEN Dingmei, SHEN Caisheng, LIANG Aimin. 2023. Wind regime features and their impacts on the middle reaches of the Yarlung Zangbo River on the Tibetan Plateau, China. Journal of Arid Land, 15(10): 1174–1195. https://doi.org/10.1007/s40333-023-0066-8

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1 Introduction

Aeolian activity is a common natural phenomenon in arid and semi-arid regions that poses serious challenges to local ecosystems, economic development, air quality, and human health. As the primary driving force behind surface sediment migration and aeolian landform evolution, aeolian activity is responsible for sand-dust storms, aeolian hazards, and land desertification. Strong winds represent the fundamental meteorological driver of this phenomenon and constitute the core focus of aeolian research.

Understanding the spatial and temporal characteristics of wind regimes and their impacts is essential for characterizing aeolian activity and forms the basis for desertification assessment, sand-dust weather forecasting, and early warning systems. Previous research has identified several key aspects of wind regimes relevant to aeolian processes. First, the passage of meso-scale cyclones or anticyclones often generates the strong winds that are prerequisites for sand-dust weather events. Second, in alpine and valley environments, topographic barriers typically weaken wind velocity; however, when wind direction aligns with valley orientation, the funneling effect can accelerate winds and increase surface erosion risk. Third, large elevation differences, uneven surfaces, and diurnal thermal balance variations can stimulate local atmospheric circulation such as mountain-valley winds, affecting fine particle transport pathways. Fourth, near-surface wind velocity is influenced by atmospheric boundary layer stability, with unstable conditions facilitating downward momentum transfer from upper layers and intensifying wind-blown sand flow.

Compared to extensive research conducted in low-altitude valleys and plains, few studies have examined wind regimes related to aeolian activity in plateau mountain-valley settings. In such complex topography, wind regimes are influenced not only by large-scale atmospheric circulation but also by local circulation driven by dynamic and thermal processes. This phenomenon is widespread across the Tibetan Plateau, where high mountains, shifting sandy lands, vegetated surfaces, and river channels coexist. The Quxu-Sangri section of the Yarlung Zangbo River Valley—a typical wide valley on the Tibetan Plateau—is relatively densely populated yet experiences frequent aeolian activity due to abundant unconsolidated sediments and a windy, dry climate. This aeolian activity has exacerbated local ecosystem fragility, degraded air quality and soil fertility, and even impacted transportation infrastructure and public health. However, research on aeolian activity in this region remains insufficient, particularly regarding the wind regime dynamics that drive these processes.

Current aeolian research in the Quxu-Sangri section has focused on four main topics: (1) Inter-annual and seasonal wind velocity variations, showing gradual decreases from the 1980s to early 2010s followed by increases thereafter, with higher velocities in winter and spring; (2) Temporal trends in wind, dust, and sandstorm days, revealing significant decreases in strong wind and sandstorm days ($P < 0.001$) but increases in floating dust days ($P < 0.05$), with winter and spring showing more frequent strong winds and sandstorms; (3) Spatial and temporal characteristics of drift potential and aeolian sediment transport rates, with DP being higher in winter and spring; and (4) Effects of wind erosion on soil grain size composition and nutrient content, demonstrating significant impacts on fine particle migration and nutrient redistribution.

While these studies provide valuable insights into wind regime characteristics and surface sediment dynamics, several data limitations persist. First, the low temporal resolution of available data hinders comprehensive wind regime characterization. Second, the Quxu-Sangri section comprises a complex river-mountain system with a complicated near-surface wind field, yet previous studies relied on sparse meteorological stations located far from active sandy areas, failing to capture true wind regime features, particularly wind direction. Third, the causes of spatial and temporal wind regime differences remain poorly understood. Addressing these gaps requires further investigation of wind regime changes in relation to geomorphology.

To address these issues, this study utilizes wind velocity datasets from six new meteorological stations established in September 2020 within sandy areas (river mudflats and piedmont shifting sandy land) of the Quxu-Sangri section, along with data from six older stations in nearby non-sandy areas (gully grasslands and gravel-covered land) located 6.2–12.5 km away (Table). This approach expands the observational dataset available for aeolian research and supports aeolian hazard prevention and control efforts near the Yarlung Zangbo River. More importantly, our results provide insights into aeolian activity formation and development in mountain-valley terrain and enhance understanding of aeolian processes in high-elevation arid and semi-arid regions.

2 Study Area

The study area encompasses the Quxu-Sangri section (29°10′-29°30′N, 90°40′-92°10′E) of the Yarlung Zangbo River Valley in the southern Tibetan Plateau, with elevations ranging from 3550 to 3600 m a.s.l. (decreasing from west to east) along the main valley axis (Fig. [Figure 1: see original paper]). Bordered by the Nyaiqentanglha Mountains to the north and the Himalayas to the south, the region presents a complex river-mountain system with intricate topography. The climate is temperate and semi-arid, with an annual average temperature of approximately 8.7°C (ranging from -1.2°C in January to 16.8°C in August) and annual precipitation of about 378 mm, predominantly concentrated (>60%) during the May–August rainy season. Precipitation and relative humidity increase gradually from west to east, while humidity exhibits strong seasonal variation (wetter summers, drier winters). Aeolian sediments are widely distributed throughout the region, together with fluvial deposits forming the source material for contemporary aeolian activity. In recent years, aeolian activity frequency has increased, occurring primarily from December to May and controlled by the strength and position of the westerly jet.

3.1 Data Sources

This study focuses on sand-driving winds (winds exceeding 6.5 m/s), as these control aeolian activity dynamics. Wind velocity and direction datasets were obtained from the Shannan Meteorological Bureau for six new meteorological stations in sandy areas and six old stations in non-sandy areas, covering a complete year from 1 December 2020 to 30 November 2021 (Fig. [Figure 1: see original paper]; Table). Ultrasonic wind sensors (WXT520, Vaisala, Helsinki, Finland) measured wind velocity and direction continuously, with data stored as 1-hour mean values at resolutions of 0.1 m/s and 1°, respectively.

3.2 Spatial and Temporal Decomposition of Wind Velocity

Empirical orthogonal function (EOF) decomposition separates temporal and spatial variations in meteorological fields, characterizing dominant spatial and temporal structures with minimal modes (Wei, 2007). The decomposition process in R software involves four steps:

(1) **Generating the wind velocity matrix $X_{n\times m}$**:

$$X_{n\times m} = \begin{bmatrix} u_{11} & u_{12} & \cdots & u_{1m} \\ u_{21} & u_{22} & \cdots & u_{2m} \\ \vdots & \vdots & \ddots & \vdots \\ u_{n1} & u_{n2} & \cdots & u_{nm} \end{bmatrix}$$

where $X_{n\times m}$ is the wind velocity data matrix and u_{nm} represents wind velocity values (m/s), with n observations and m meteorological stations.

(2) **Determining the correlation coefficient matrix, eigenvalue matrix, and eigenvector matrix** for $X_{n\times m}$:

$$C_{m\times m} = \mathrm{Cor}(X_{n\times m})$$

$$\Lambda_{1\times m}, V_{m\times m} = \mathrm{Eigen}(C_{m\times m})$$

where $C_{m\times m}$ is the correlation coefficient matrix, Cor() is the R function for correlation matrices, $\Lambda_{1\times m}$ is the eigenvalue matrix, Eigen() computes eigenvalues and eigenvectors, and $V_{m\times m}$ is the eigenvector matrix (each eigenvector represents a spatial mode). According to EOF theory, m modes equal the number of stations, with modes ranked by eigenvalue magnitude (Mode I having the largest eigenvalue).

(3) **Calculating the time coefficient matrix**:

$$T_{n\times m} = X_{n\times m} \cdot V_{m\times m}$$

where $T_{n\times m}$ is the time coefficient matrix and t_{nm} represents individual time coefficients.

(4) **Obtaining the cumulative variance contribution**:

$$\mathrm{CVC}_p = \frac{\sum_{i=1}^{p} \lambda_i}{\sum_{i=1}^{m} \lambda_i} \times 100\%$$

where CVC_p (%) is the cumulative variance contribution of the first p eigenvectors ($p \leq m$) and λ_i is the ith eigenvalue. We selected spatial modes with $\mathrm{CVC}_p > 80\%$, which required $p = 3$ modes.

To highlight temporal mode variations, we computed the time coefficient anomaly series for each mode:

$$\mathrm{TCA} = t_{.j} - \bar{t}_{.j}$$

where TCA is the time coefficient anomaly, $t_{.j}$ is the temporal coefficient series of the jth mode (the jth column of $T_{n\times m}$), and $\bar{t}_{.j}$ is the arithmetic mean. TCA fluctuates around zero; positive values indicate mode strengthening, while negative values indicate weakening.

3.3 Dominant Wind Direction

Wind direction determines aeolian sediment transport pathways and represents a critical factor in aeolian research. Previous studies have documented complex regional wind direction distributions (e.g., Liu et al., 2019a). To quantify wind direction distributions, we applied the Gaussian mode method commonly used in aeolian geomorphology (Lü et al., 2014). Since wind direction typically exhibits multi-peaked distributions that cannot be described by a single Gaussian mode, we employed a mixed Gaussian mode:

$$P_k(\theta) = \sum_{k=1}^{n_\theta} w_k \cdot \frac{1}{\sqrt{2\pi}\sigma_k} \exp\left[-\frac{(\theta-\theta_k)^2}{2\sigma_k^2}\right]$$

where $P_k(\theta)$ is the probability density of wind direction θ (°; clockwise from due north), n_θ is the number of Gaussian mode functions, w_k and σ_k (°) are the weight and standard deviation of the kth dominant wind direction, respectively, and θ_k (°) is the kth dominant wind direction, with $\sum w_k = 1$. We used the expectation maximization algorithm in the mixtools package (Benaglia et al., 2009) to estimate parameters for annual and quarterly dominant wind directions.

Average wind velocity and frequency of sand-driving winds were calculated using:

$$\bar{u}_{\mathrm{sdw}} = \frac{\sum_{i=1}^{N} u_i}{N}$$

$$F_{\mathrm{sdw}} = \frac{N}{S} \times 100\%$$

where $\bar{u}_{\mathrm{sdw}}$ (m/s) is the average sand-driving wind velocity, N (days) is the number of days with sand-driving winds, u_i (m/s) is the velocity of the ith sand-driving wind event, F_{sdw} is the frequency of sand-driving winds, and S is the total number of wind observations.

3.4 DP Calculation

Drift potential (DP; VU) quantifies the airflow’ s sand transport capacity over time and serves as a key indicator of aeolian activity intensity. We calculated DP following Fryberger and Dean (1979):

$$\mathrm{DP} = \sum_{i=1}^{n} (u_i - u_c)^2 \cdot f_i$$

$$\mathrm{DPE} = \sum_{i=1}^{n} (u_i - u_c)^2 \cdot f_i \cdot \sin(\alpha_i)$$

$$\mathrm{DPN} = \sum_{i=1}^{n} (u_i - u_c)^2 \cdot f_i \cdot \cos(\alpha_i)$$

$$\mathrm{RDP} = \sqrt{\mathrm{DPE}^2 + \mathrm{DPN}^2}$$

$$\mathrm{RDD} = \arctan\left(\frac{\mathrm{DPE}}{\mathrm{DPN}}\right)$$

$$\frac{\mathrm{RDP}}{\mathrm{DP}} = \frac{\mathrm{RDP}}{\mathrm{DP}}$$

where DP (VU) is drift potential, u_i (knots) and u_c (knots) are wind velocity and critical sand-driving wind velocity at 10 m height ($u_i \geq u_c$), f_i is wind velocity frequency, DPE (VU) and DPN (VU) are DP components in east-west and north-south directions, α_i (°; clockwise from due north) is wind direction, RDP (VU) is resultant drift potential, and RDD (°) is resultant drift direction.

Critical wind velocity u_c was calculated using Bagnold' s (1941) equation:

$$u_c = A \cdot \sqrt{\frac{\rho_p - \rho_a}{\rho_a} \cdot g \cdot d} \cdot \log\left(\frac{z}{z_0}\right)$$

where A is an empirical coefficient (0.1), g is gravitational acceleration (9.8 m/s^2), d (m) is sand grain size (2.0×10^{-4} m; Zhang et al., 2021), ρ_p is sand particle density (2650.00 kg/m^3; Kok et al., 2012), ρ_a is air density (0.82 kg/m^3) calculated from the ideal gas law, z (m) is measurement height (10 m), and z_0 (m) is aerodynamic roughness length (3.4×10^{-4} m; Zhang et al., 2022a). The calculated u_c for the study area is 6.5 m/s.

4 Results

4.1 Spatial Mode Characteristics of Regional Wind Velocity

Three dominant spatial modes characterize monthly average wind velocity in the study area (Table). Mode I reflects regional wind velocity homogeneity, while Modes II and III capture regional heterogeneity. Mode I accounts for 49% of variance with all positive eigenvalues (0.18–0.33). Mode II explains 21% of variance, with positive eigenvalues in sandy areas (0.12–0.39) and negative eigenvalues in non-sandy areas (-0.34 to -0.23), except at the SBR non-sandy site. Mode III contributes 11% of variance, with negative eigenvalues in the western section (SBR, CG, AZ) and positive eigenvalues in the eastern section (SYS, DPZ, SR). Collectively, these three modes capture over 80% of the total spatial distribution information for regional wind velocity.

The three modes exhibited distinct seasonal strength variations (Fig. [Figure 2: see original paper]). Mode I' s time coefficient anomaly remained near zero in winter (December–February; -0.05 to -0.01), became significantly positive from March to July (0.61–2.41), and turned significantly negative from August to November (-1.49 to -0.16), with a weakening trend from April to September and strengthening from September to November. Mode II' s anomaly was positive from April to September (0.21–1.35) and negative in other months (-0.74 to -0.11), strengthening from March to July and weakening from July to March. Mode III' s anomaly was positive in February, March, October, and November (0.20–0.68) and negative in remaining months (-0.02 to -0.52).

4.2 Velocity and Frequency of Sand-Driving Winds in Sandy and Non-Sandy Areas

Sand-driving wind velocity and frequency differed significantly between sandy and non-sandy areas (paired t-test, $P < 0.05$; Fig. [Figure 3: see original paper]). Annual average velocity and frequency were 8.3 ± 0.3 m/s and 12.9% ± 6.2% in sandy areas, respectively, compared to 7.7 ± 0.3 m/s and 2.9% ± 1.9% in non-sandy areas—representing reductions of 7.3% ± 5.8% in velocity and 69.1% ± 31.2% in frequency in non-sandy areas. The annual frequency of sand-driving winds increased from west to east in sandy areas but decreased in non-sandy areas, with the inter-area difference growing eastward (smallest at SBR: 0.2%; largest at DPZ and SR: 20.4% and 18.1%, respectively).

Seasonally, sand-driving wind frequency peaked in spring (4.3% ± 1.6%) followed by winter (3.2% ± 1.6%), summer (2.9% ± 1.4%), and autumn (2.4% ± 1.6%) in sandy areas. Non-sandy areas showed similar seasonal patterns: spring (1.2% ± 0.8%), winter (0.7% ± 0.4%), summer (0.6% ± 0.7%), and autumn (0.3% ± 0.3%). The frequency difference between sandy and non-sandy areas was greatest in spring and summer (30.0% ± 13.2% and 28.9% ± 9.5%, respectively) and smallest in winter and autumn (22.7% ± 4.5% and 18.4% ± 3.2%, respectively).

4.3 Direction of Sand-Driving Winds in Sandy and Non-Sandy Areas

Sand-driving wind directions showed substantial differences between sandy and non-sandy areas (Fig. [Figure 4: see original paper]). In sandy areas, dominant directions were generally from the east or west. The SBR site exhibited four directional peaks with a dominant direction of 274° ± 24° ($w = 0.48$). CG and SYS sites showed three peaks (268° ± 20°, $w = 0.51$; 260° ± 25°, $w = 0.55$). AZ, DPZ, and SR sites displayed bimodal distributions with dominant directions of 100° ± 20° ($w = 0.60$), 107° ± 27° ($w = 0.82$), and 80° ± 15° ($w = 0.76$), respectively.

In non-sandy areas, annual sand-driving wind directions were predominantly bimodal from north or south: 181° ± 20° (SBR), 34° ± 19° (CG), 348° ± 28° (AZ), 220° ± 20° (SYS), 149° ± 28° (DPZ), and 222° ± 20° (SR). Dominant direction differences between sandy and non-sandy areas were significant: 93° (SBR), 126° (CG), 112° (AZ), 40° (SYS), 42° (DPZ), and 142° (SR).

Seasonal variations in dominant directions differed markedly between areas (Table). Sandy areas showed regular seasonal shifts: westerly winds (~270°) decreased gradually from winter to summer while easterly winds (~90°) increased, returning to winter-like conditions in autumn. Non-sandy areas exhibited more complex seasonal patterns. Secondary and tertiary wind direction data are provided in Tables S1 and S2.

4.4 DP in Sandy Versus Non-Sandy Areas

Annual DP in sandy areas ranged from 60.7 to 322.2 VU, substantially higher than previous estimates (Yang et al., 2020: 131.0 VU; Ma et al., 2021b: 5.5–77.0 VU). Non-sandy area DP ranged from 3.1 to 53.4 VU—76.5% ± 30.0% lower than sandy areas. Sandy area DP increased from west to east (lowest at SBR: 60.7 VU; highest at SR: 322.2 VU), while non-sandy area DP decreased eastward. The inter-area DP difference grew progressively eastward, from 0.8% at SBR to 36.9% at SR.

Seasonally, sandy area DP peaked in winter (37.2% ± 10.5% of annual DP) and spring (28.3% ± 5.7%), with minima in summer (19.1% ± 7.8%) and autumn (15.4% ± 3.8%). Non-sandy areas showed similar seasonal patterns: winter (27.0% ± 10.7%) and spring (42.4% ± 13.8%) dominated, while summer (21.5% ± 6.4%) and autumn (9.1% ± 5.5%) contributed least. The DP difference between areas was greatest in winter (40.2% ± 6.7% of annual DP), followed by spring (24.1% ± 3.5%), with summer and autumn showing smaller differences (17.5% ± 5.3% and 18.2% ± 3.3%, respectively).

RDP in sandy areas ranged from 9.3 to 260.9 VU, significantly exceeding non-sandy areas (0.3-30.1 VU). Directional variability (RDP/DP) ranged from 0.06 to 0.81 in sandy areas and 0.10 to 0.77 in non-sandy areas, decreasing west to east overall. At SYS, DPZ, and SR sites, non-sandy area RDP/DP values were 44.9%, 50.7%, and 87.6% lower than sandy areas, respectively; at SBR, CG, and AZ sites, they were 73.0%, 5.3%, and 63.7% lower.

RDD differences between areas were substantial. Annual RDD in sandy areas was generally eastward or westward: 169° at SBR (with large seasonal variation), 69° at CG, 41° at AZ, 83° at SYS, 287° at DPZ, and 257° at SR. Non-sandy area RDD was predominantly southward or northward: 344° (SBR), 221° (CG), 199° (AZ), 169° (SYS), 192° (DPZ), and 147° (SR). The annual RDD difference was largest at SBR (175°) and smallest at SYS (86°). These findings demonstrate that the study area's wind regime exhibits both homogeneous and heterogeneous characteristics.

5 Discussion

5.1 Influence of Atmospheric Circulation on the Wind Regime

Near-surface wind velocity and direction are modulated by large-scale atmospheric circulation. Mode I' s cumulative variance contribution of 49% (Table) indicates wind regime homogeneity, with positive eigenvalues at all six sites showing spatially consistent increases or decreases in regional wind velocity. This primarily reflects strong control by the westerly jet and Indian monsoon systems, with Pearson's correlation coefficient between surface wind velocity and westerly jet intensity reaching 0.70 (Fan et al., 2018). Shan et al. (2019) demonstrated that the Tibetan Plateau is dominated by the westerly jet in winter, with rapid jet weakening and northward axis shift in spring. In summer, the Indian monsoon strengthens while the westerly jet weakens considerably and shifts to 42°N. In autumn, the jet axis retreats southward to ~34°N, with intensity similar to spring. During spring and autumn transitions between these circulation systems, sand-driving wind directions become more complex, exhibiting two to four peaks (Fig. [Figure 4: see original paper]).

Mode I eigenvalue magnitudes reflect the alternating influence of these systems (Table). The study area divides into three zones: (1) the SBR–AZ section, primarily westerly jet-influenced (eigenvalues: 0.28–0.30); (2) the DPZ–SR section, mainly Indian monsoon-influenced (eigenvalues: 0.18–0.30); and (3) the SYS site, alternately influenced by both systems (eigenvalues: 0.33–0.36 in sandy areas).

Time coefficient anomalies indicate higher regional wind velocities in winter and spring under Mode I, shifting to negative values in late winter (January–February) and late summer (August). This aligns with sand-driving wind frequencies of 3.2% ± 1.6% (winter) and 4.3% ± 1.6% (spring) versus 2.9% ± 1.4% (summer) and 2.4% ± 1.6% (autumn) (Table). Wind direction analysis shows westerly dominance (261°–275°) in winter (weight: 0.61–0.80) and easterly dominance (100°–135°) in summer (weight: 0.45–0.83) for the SBR–SYS section, while the DPZ–SR section shows persistent easterly directions (73°–110°, weight: 0.45–0.89). These patterns confirm alternating westerly jet and Indian monsoon influences, with the study area primarily westerly jet-controlled in winter, Indian monsoon-controlled in summer, and experiencing transitional influences in spring and autumn.

5.2 Influence of Topography on the Wind Regime Dynamics

Topographic obstruction weakens wind velocity while forcing directional changes, whereas topographic funneling can accelerate winds (Chen, 1979). Mode II eigenvectors show positive values in sandy areas and negative values in non-sandy areas (except SBR) (Table), reflecting topographic influences. All sandy-area stations are located in the east-west oriented main river valley (Fig. [Figure 1: see original paper]a), with dominant wind directions of 270° ± 45° (SBR–SYS) or 90° ± 45° (DPZ–SR) aligning with valley orientation.

Non-sandy stations are situated in primarily south-north oriented tributary valleys, with dominant directions of 0° ± 45° or 180° ± 45° matching tributary orientation.

Annual average sand-driving wind velocity and frequency in sandy areas (7.8-8.6 m/s; 5.8%-22.5%) exceed those in non-sandy areas (7.1-8.0 m/s; 0.8%-6.3%), with DP in non-sandy areas 76.5% ± 30.0% lower. This demonstrates topography' s critical role in reducing wind velocity and forcing directional adaptation.

Mode II time coefficient anomalies were positive from April to August (Indian monsoon dominance) and negative from September to March (westerly jet dominance) (Fig. [Figure 2: see original paper]b), confirming that wind velocity responds to large-scale circulation patterns, consistent with Mode I results.

Mode III eigenvalues ranged from -0.47 to -0.11 in the western SBR–AZ section, 0.06 to 0.46 in the eastern DPZ–SR section, and 0.03 to 0.05 at SYS (Table). Sand-driving wind frequency in the DPZ–SR section (11.5%-25.4%) exceeded that in the SBR–AZ section (5.8%-12.9%), and DP values were higher in the east (179.1-322.2 VU) than west (60.7-163.1 VU). This indicates distinct east-west wind regime differences. Mode III time coefficient anomalies were low (negative) in January, June, July, and August when either the westerly jet or Indian monsoon dominated, suggesting weakened east-west differences. Conversely, anomalies were high (positive) in April, October, and November during circulation transitions, indicating enhanced east-west differences (Fig. [Figure 2: see original paper]c).

The funneling effect further demonstrates topographic influence. The eastern Quxu–Sangri section is narrower than the western section, producing stronger funneling and generally higher wind velocities in the east (Li et al., 2010).

5.3 Influence of Coupled Thermal Effects of Topography and Underlying Surface on the Wind Regime

Thermal flows significantly influence wind regimes by stimulating local circulation and causing short-term wind direction shifts (Gevorgyan, 2017). The study area' s primary surface types include rivers, sandy lands, and grasslands. The dramatic topographic relief (~2000 m elevation difference between mountaintops and valley floors) (Fig. [Figure 1: see original paper]a) creates favorable conditions for thermal gradients. Valley surfaces (rivers, woodlands, grasslands, shifting sands) have relatively high thermal capacity, while hillslope surfaces (grasslands, sands, bare rock) have lower capacity. This spatial coupling creates non-uniform horizontal temperature fields that generate mountain-valley breezes.

Local currents develop during periods of weak background circulation and clear, less cloudy conditions (Bei et al., 2018). Diurnal wind direction variations in sandy areas during January illustrate this pattern (Fig. [Figure 6: see original paper]), with four distinct phases: (I) 04:00-09:00: concentrated easterly winds (50°-90°); (II) 10:00-13:00: transitional period with clockwise rotation and increasing southerly winds; (III) 14:00-19:00: dominant westerly winds (230°-290°); and (IV) 20:00-03:00: double-peak transition from northwesterly (314°-324°) to easterly (55°-89°) winds. The SBR site showed distinct patterns due to three mountain ranges near the Yarlung Zangbo-Lhasa River confluence. Wind direction shifted nearly 180° between day and night in sandy areas (Fig. [Figure 6: see original paper]a-f) and in non-sandy areas where currents flowed from valleys to slopes during daytime and reverse at night (Fig. S2), indicating pronounced mountain-valley circulation with valley winds following valley orientation rather than slope direction.

Wind velocity diurnal variation showed a bimodal pattern in sandy areas (Pattern I; Figs. [Figure 7: see original paper]a and S3), with peaks at 10:00-11:00 and 17:00-18:00 and troughs at 08:00 and 13:00. Non-sandy areas exhibited a single-peaked pattern (Pattern II; Figs. [Figure 7: see original paper]b and S3), peaking at 16:00-17:00 and troughing at 09:00-10:00. Pattern I wind velocity increased after sunrise due to enhanced vertical turbulence and downward momentum transfer (Stout, 2015). Pattern II lagged by 1-2 hours, likely because sand surfaces warm faster than grass surfaces. Post-sunset velocity decreases in both areas resulted from atmospheric boundary layer stabilization and weakened vertical momentum exchange.

Pattern I' s afternoon trough (13:00-14:00) may occur because prevailing upper-air westerlies oppose high near-ground easterly frequencies (Figs. [Figure 3: see original paper] and [Figure 4: see original paper]; Table). Downward momentum transfer from opposite-direction upper-air flow weakens near-surface easterlies, with maximum weakening in early afternoon creating the observed velocity trough.

6 Conclusions

Frequent and severe aeolian hazards occur in the wide Yarlung Zangbo River Valley. Previous intensity assessments for the Quxu-Sangri section relied exclusively on non-sandy area wind data. With new 2020 data from sandy areas, this study analyzed wind velocity and direction from December 2020 to November 2021 in both sandy and non-sandy areas of the Quxu-Sangri section. The main conclusions are:

(1) **Conspicuous differences exist between sandy and non-sandy area wind regimes.** Annual sand-driving wind frequency, DP, and RDP were significantly higher in sandy areas, with dominant wind directions and RDD also differing substantially. The stronger wind energy environment in sandy areas explains their more frequent aeolian activity. Using non-sandy area wind data to evaluate sandy area aeolian damage is therefore extremely problematic under these topographic conditions.

(2) **Wind regimes are controlled by large-scale atmospheric cir-**

culation, topographic dynamics and thermals, and underlying surface coupling. Atmospheric circulation homogenizes regional wind regimes, causing systematic changes throughout the region. However, topographic and surface differences produce varied regional responses. Topographic blocking reduces wind velocity, while funneling increases velocity and forces directional alignment with valley orientation. Local circulation generated by valley topography-surface coupling represents another important factor affecting regional wind regimes.

To accurately forecast dust storms in the Yarlung Zangbo River Valley, observational networks must account for topographic influences on wind regimes. Future meteorological station siting should consider local wind regime characteristics (e.g., sandy vs. non-sandy area differences), and monitoring stations should be established in aeolian activity zones. Field observations should be enhanced to obtain vertical and horizontal near-surface meteorological profiles. Given the harsh natural conditions limiting long-term observations, researchers should develop numerical simulation models based on empirical data.

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Appendix

Table S1. Dominant wind direction throughout the year and in different seasons in sandy areas. Note: w, weight of the dominant wind direction; θ, dominant wind direction; σ, standard deviation of the dominant wind direction; -, no data available. SBR, CG, AZ, SYS, DPZ and SR represent the six sites, with each having a pair of old meteorological station and new meteorological station.

Table S2. Dominant wind direction throughout the year and in different seasons in non-sandy areas. Note: -, no data available.

Figure S1. Diurnal variations of wind direction at the six sites in sandy areas in April (a1-a6), July (b1-b6) and October (c1-c6).

Figure S2. Diurnal variations of wind direction at the six sites in non-sandy areas in January (a1-a6), April (b1-b6), July (c1-c6) and October (d1-d6).

Figure S3. Diurnal variations of wind velocity in sandy areas and non-sandy areas in winter (a and b), spring (c and d), summer (e and f) and autumn (g and h).

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