Alternative basic wind speed maps for the Brazilian wind code based on a climatological approach

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SUMMARY: (10 pt)
Basic wind speed maps are traditionally developed on the basis of extreme value wind speed data collected at meteorological stations, use of statistical methods for data characterization and application of mathematical regression. However, in this approach, the spatial distribution and characteristics of the atmospheric phenomena that induce strong winds are disregarded. This work presents alternative proposals for a new basic wind speed map for the Brazilian Wind Code NBR-6123 based on a climatological approach as well as in recent research including new data from hundreds of meteorological stations.

Keywords: basic wind speed, wind climate, Brazilian wind code

1. INTRODUCTION

In the Brazilian Wind Code NBR-6123 the basic wind speed V_0 is defined as the maximum wind speed averaged over three seconds (gust wind speed), which may be exceeded on average once every 50 years, measured at 10-meters height in flat open country. From the annual maximum gust wind speeds of 49 meteorological stations located at the main Brazilian airports the isopleths map (Padaratz, 1977) of Fig. 1 was drawn.

Recent research includes the works of Beck and Correa (2013) and Vallis (2019), which have proposed isopleths maps developed from mathematical regression methods for data interpolation. Additionally, Vallis (2019) proposed a V_0 map for Brazil in zones format and developed algorithms for the classification and identification of synoptic and non-synoptic extreme wind events, concluding that the non-synoptic winds determine the extreme winds in the majority of the Brazilian territory. Further expansion of the analysis from surface observations in South America is presented in Vallis et al. (2019). Pioneer work of classification and identification of synoptic and non-synoptic extreme wind events in Brazil are presented by Riera and Nanni (1989) and Riera and Rocha (1998). Worldwide, the separation of recorded data by storm type was presented by Gomes and Vickery (1977).

The meteorological phenomena that produce the non-synoptic winds have different characteristics in the several regions of the country. The recognition of this fact leads to the proposal of a V_0 map with a climatological approach in contraposition to the traditional approach based in mathematical interpolation of the individual values obtained in selected meteorological stations.

The aim of this work is to present and justify alternative proposals for a new basic wind speed map for NBR-6123 based on a climatological approach. For this purpose, a map was elaborated identifying the climatological zones in Brazil associated with strong winds, from the point of view of the dominant atmospheric events. Subsequently, a literature review was carried out considering the publications in Brazil containing wind speed data and V_0 map propositions. This work presents the adopted methodology and development of this new proposed map, including alternatives.

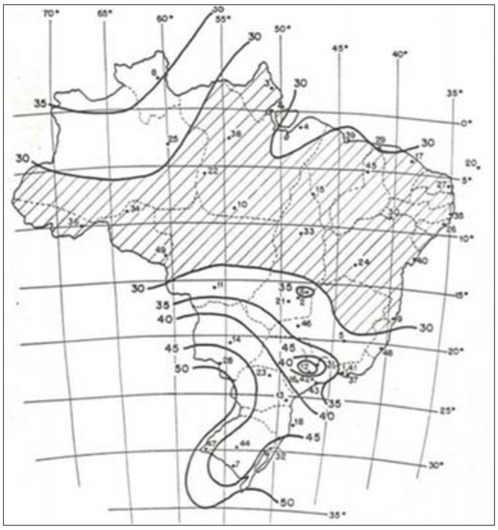

Figure 1. Isopleth map of the current Brazilian Wind Code NBR-6123 (ABNT, 1988).

2. BRAZILIAN CLIMATOLOGY

Due to the large extension of its territory, Brazil is affected by atmospheric conditions with distinct characteristics among different regions of the country (Loredo-Souza, 2012). These conditions can, occasionally, lead to the generation of meteorological phenomena that induce strong winds, with potential to cause damages in buildings and other constructions (Loredo-Souza et al., 2016). Some of these phenomena, such as the extratropical cyclones for example, belong to the synoptic scale, with horizontal dimensions of the order of hundreds of kilometers and duration of up to a few days. Other extreme winds are associated to local convective storms (for example thunderstorms - TS), which belong to the so-called mesoscale (or convective scale) and have a horizontal scale of the order of 10km and duration of the order of one hour. Among the most intense TS winds are those associated to strong downbursts and tornadoes. The Brazilian regions which share common atmospheric conditions, leading to meteorological phenomena capable of producing wind gusts of destructive potential, are illustrated in Fig. 2-Left. This map is proposed by the authors to guide wind engineers. This climatological map, to be used in addition to the measured wind data (to be described in the full paper), is the basis for the technical sketch of the of the basic wind speed maps proposed for NBR-6123.

3. BASIC WIND SPEEDS FOR BRAZIL

Among the pioneer works which dedicated attention to the identification and classification of synoptic and non-synoptic winds, we mention Riera and Nanni (1989) who analysed maximum annual speeds for four cities in Rio Grande do Sul state. The authors showed that, for each type of storm taken independently, distribution Type I (Gumbel) better adjusts to the wind speeds than those from Type II and lognormal, although with distinct parameters. Consequently, a mixed series (with maximum speed values from synoptic and non-synoptic winds taken together) cannot be adequately represented by a single Type I distribution, being better adjusted by a distribution Type II, as observed in the initial studies for NBR-6123 (Riera, 2016).

Recent studies were cited in the introduction. The work of Vallis (2019) considered a huge amount (692) of meteorological stations in the analysis, as well as a careful analysis of the quality and homogeneity of the meteorological data used (Vallis et al., 2017).

4. PROPOSITION OF NEW BASIC WIND SPEED MAPS

After realizing that extreme winds are caused by non-synoptic phenomena in the majority of the Brazilian territory and considering that design criteria and aerodynamic coefficients present in wind codes were developed for synoptic winds, the possibility of establishing basic speed maps and procedures for each type of wind was brought up. The updated literature, however, points towards the impossibility of this separation at the moment (Letchford and Lombardo, 2015; Solari, 2020), due to the lack of analytical models of worldwide acceptance to adequately represent the characteristics of the non-synoptic wind flow and its interaction with the constructions. Moreover, it is worth noting that in a same meteorological event both types of winds may occur simultaneously; this fact adds more difficulties to the idea of treating them separately. Another issue to highlight is the need to improve the reliability of the country´s collected data before two maps could be considered. In this perspective, the proposition to the new edition of the NBR-6123 is a basic wind speed map without separation of the wind type.

Alternative maps were elaborated on the basis of the climate regions shown in Figure 2 and on the basic speed (V_0) values obtained from the work of Vallis (2019) associated to selected stations, particularly those with higher values of V_0. This procedure is justified by the narrow spatial scale of the non-synoptic winds leading to significant sub-sampling of the events. Records of a non-synoptic wind may be captured by one station and not by the adjacent ones, or may not be captured at all. One of the proposals is shown in Fig. 2 - Right.

5. CONCLUSIONS

From a map showing the climatic regions associated to the meteorological phenomena which produce strong winds in Brazil, as well as basic wind speed values, V_0, obtained from selected meteorological stations, distinct maps of basic wind speeds were proposed to as a choice to integrate the new edition of the Brazilian Wind Code NBR-6123. The adopted climatological approach took into account the physical characteristics of the meteorological phenomena, contrary to the usual procedure of local V_0 interpolations associated to selected stations.

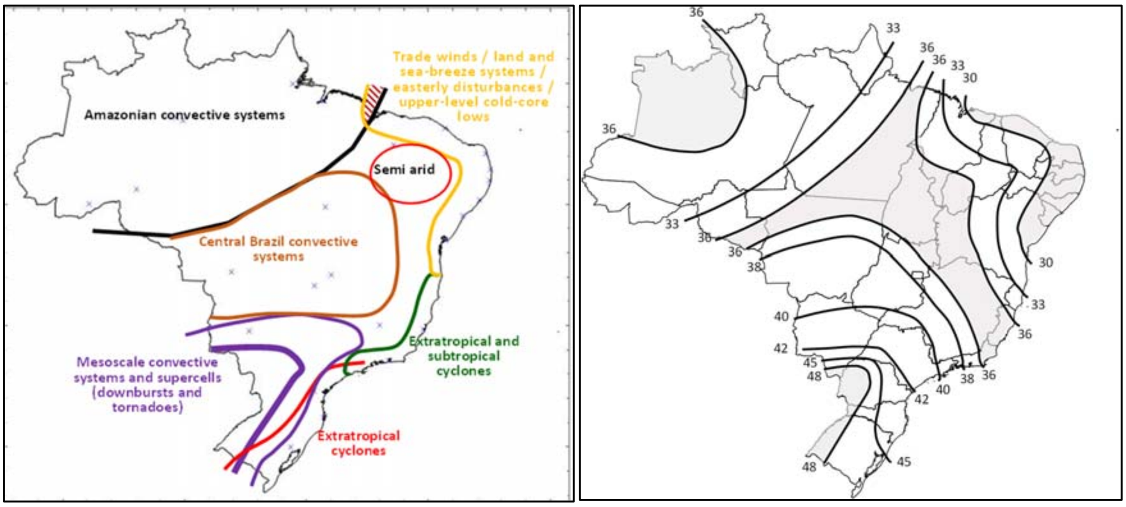

Figure 2. Left: Climatic regions associated to the meteorological phenomena which produce strong winds in Brazil. Right: Example of basic wind speeds map, Vo (m/s), proposed for the new Brazilian Wind Code NBR-6123.

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