Methodology toward a long-term realistic Wind Resource Assessment applied in Colima valley, México.

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ABSTRACT

In the present work SODAR technology combined with a specific meteorological tower network are used to investigate characteristics and evolution of the planetary boundary layer in the valley of Colima, central western Mexico, and its wind power generation potential. Relevant mesoscale phenomena such as Supergeostrophic Low Level Jets (LLJ) are for the first time reported in this part of the tropics. These meso β phenomena, which are very relevant for wind power generation, are characterized in Colima valley for the years 2010 and 2011. The ability to detect, monitor and include in wind power assessment such phenomena ignored by the classical approach in tropical regions with complex topography shows the importance of methodology used for a long term and reliable development of this new energy.

INTRODUCTION

Colima Valley is typically considered to have a low wind power generation potential as many other parts of the Mexican transverse volcanic axis and other regions with complex topography. Wind resource assessment is typically conducted analyzing WMO weather station network data, and in some cases rawinsonde data, to develop 40 km grided wind maps as a first approach, in general at 50 m Above Ground Level, using a logarithmic extrapolation from data at low height. In regions catalogued with good wind potential, up to 80-m instrumented towers are typically installed by companies involved in wind farm development to further investigate the potential of selected sites. Previous work has shown the importance to wind power generation of LLJs, and other work has tried to pin point globally region favorable for LLJ formation without success for the region under study, therefore the specific method developed here.

METHODOLOGY FRAMEWORK AND SITING

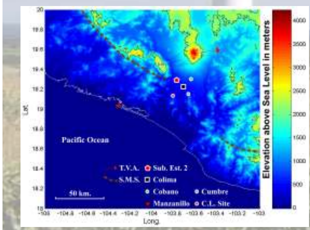
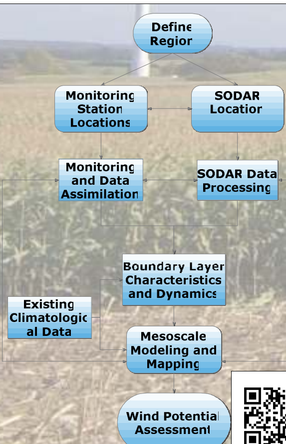
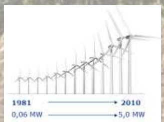


Figure 2. Monitoring site locations.



SODAR MFAS, Scintec.



Evolution of wind turbines in last 3 decades.

RESULTS

Figure 1. Region of Study (Colima, in Green) and SLP field for March-April 2010.

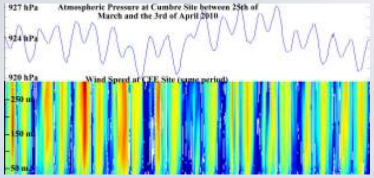


Figure 3. Atmospheric pressure and wind speed time series.

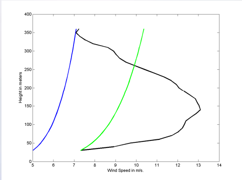


Figure 4. Measured LLJ vertical profile (black) compared with log. approximation from 10 m. (blue) and 30 m. (green) measurements.

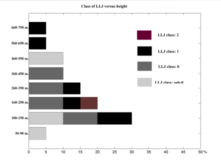


Figure 5. Histogram of Low Level Jets for March April 2010.

Hub height for modern wind turbines is typically around or greater than 100 m AGL, and the data set presented here for specific time periods of 2010 and 2011 shows a non-logarithmic wind profile of the lower 500 m of the Atmospheric Boundary Layer, especially at night and early morning, due to the systematic presence of northerly supergeostrophic low level jets. The afternoon is typically characterized by south westerly sea breeze.

To evaluate more specifically this potential, the supergeostrophic low level jets are characterized considering criteria defined in previous studies of the Low Level Jets of the North American Great Plains and refined by others using similar monitoring tools as the ones used in the present study, such as in CASES-99, Lamar Project and ABLE studies. Almost every night shows the development of at least one Jet with nose height between 100 m and 700 m above the valley floor with categories ranging from sub-zero up to category 2 jets (rarely 3), with lower height zero-category jets dominating with a consistent northerly direction. The region of study being in the tropics, most of the year the horizontal pressure gradient is typically small implying a relatively weak geostrophic background state in the wind field making the observed jets strongly supergeostrophic. The onset of the jets is typically later than in other regions since the region of study is only at 19.23° north. Wind profiles and time evolution of wind direction at nose level are investigated to determine if inertial oscillation mechanism is dominating over baroclinicity over sloping terrain. So far results show that shallow baroclinicity is the dominating mechanism, it is clear the ocean-land interaction and topography play an important role.

The typical use of logarithmic extrapolation from 10-meter WMO stations is compared to some specific vertical profile, time series and time averages. The discrepancies between the classical method and the SODAR measurement invalidate this traditional method as used normally for wind resource assessment; and the presence of such phenomena increases drastically the potential for wind power generation in such region.

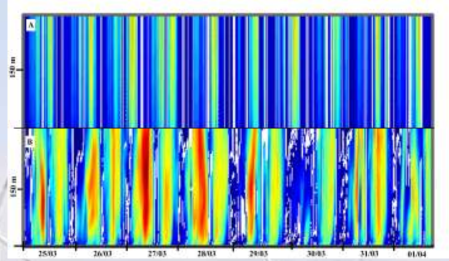


Figure 6. (A) Log. Extrapolated wind speed and (B) Measured wind speed.

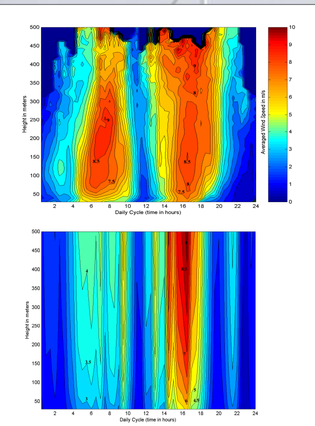


Figure 7. Measured wind speed average above) versus log. estimated wind speed average (below).

CONCLUSIONS

The presence of LLJ in the region of interest invalidates typical logarithmic extrapolation from lower heights as used normally for wind resource assessment; and the presence of such phenomena increases drastically the potential for wind power generation in such region. So far it is not clear which is the leading mechanism and more work is needed to determine that aspect and analyze the key forcing affecting the region of interest . Also the spatial scale of such meso β scale phenomena reaches farther than our monitoring network and this makes mesoscale modeling a fundamental complementary tool to realize a complete study. Therefore another approach than the traditional one for wind resource assessment is needed to be able to determine realistically the availability of such renewable energy in other regions than the typically known high potential regions. As the present study shows, it can be done integrating classical instrumented towers, wind profiler technology such as SODAR or LIDAR. Mesoscale modeling must be included as a next step. This kind of methodology can also be useful at existing wind farm for managing purposes doing short range mesoscale forecast.

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