UNIVERSIDADE FEDERAL
DE SANTA CATARINA

LEPTEN
Laboratórios de Engenharia de Processos
de Conversão e Tecnologia de Energia

Wind lidar profiler performance in the northeast coast of Brazil

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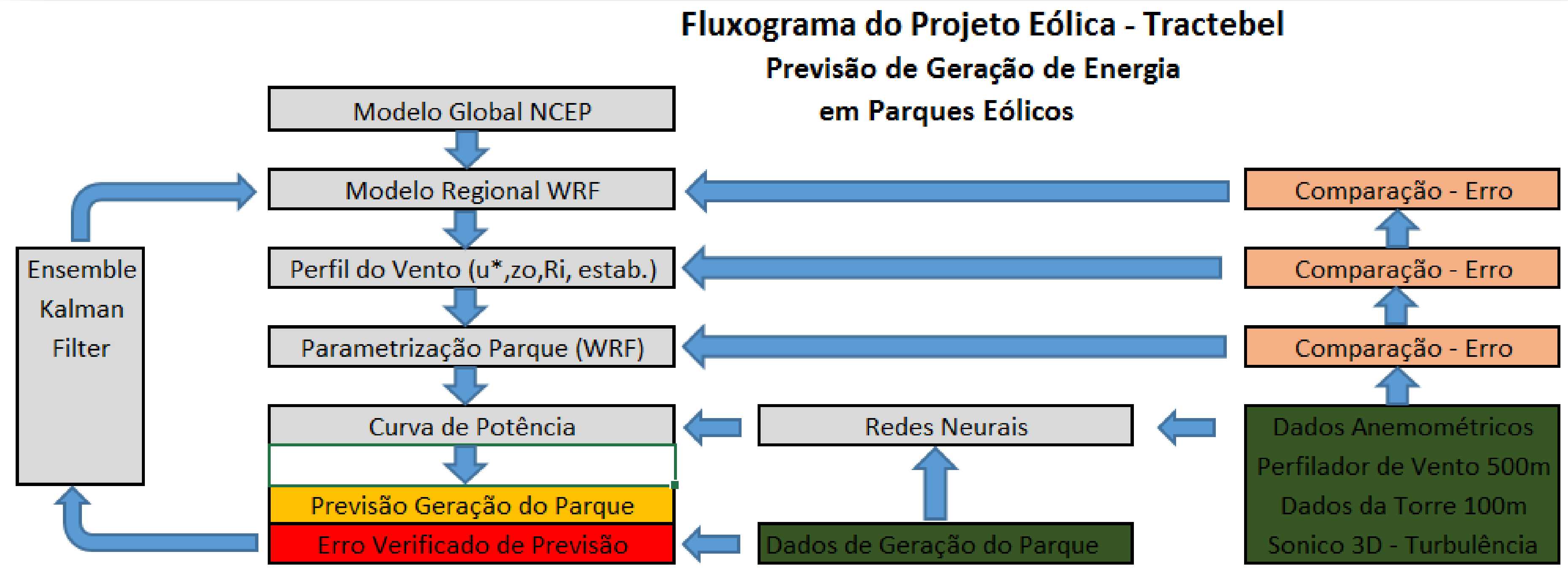
VIII WORKSHOP LIDAR MEASUREMENTS IN LATIN AMERICA

April 9th, 2014
Lidar applications for environmental sciences
VIII Workshop on Lidar Measurement in Latin America
Cayo Coco, Cuba

- **3-years R&D Project UFSC-IFSC-Tractebel Energia S.A. (GDF Suez);**
- **EUR 800,000.00 (Hardware + Software + HR) from 2011 to 2014;**
- **Short-term (72h) wind power forecasting software;**

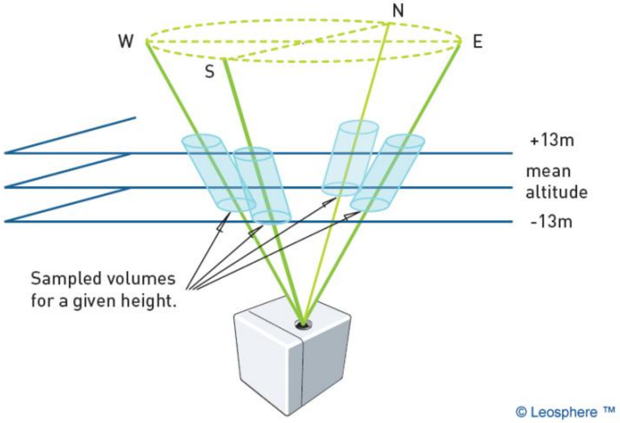


Haas, R. et al. Desenvolvimento de tecnologias de previsão de geração de energia elétrica para parques eólicos em operação. In: **VIII CITENEL – Congresso de Inovação Tecnológica em Energia Elétrica 2015**, Costa do Sauípe. VIII CITENEL – Anais, 2015 (*accepted*).

Motivation for the study:

- **Study possible source of deviations in wind lidar performance;**
- **Evaluate the influence of atmospheric conditions (RH, TI, precipitation) on wind lidar performance over the 1-year measurement campaign;**
- **What's the performance of wind lidars for wind energy applications [1,2]?**

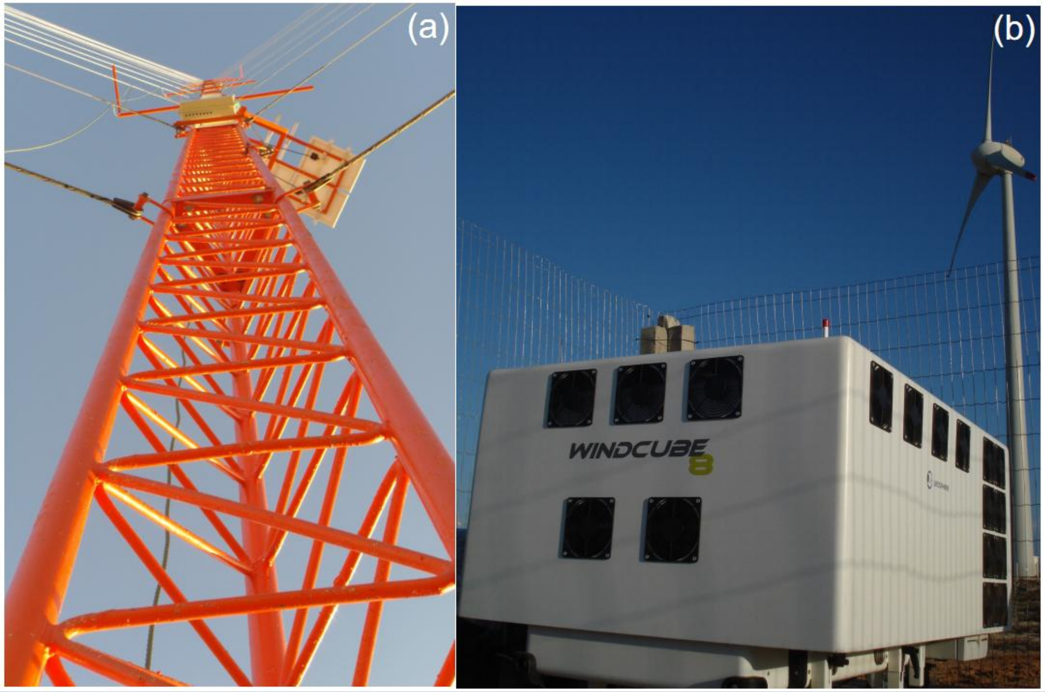
[1] IEC. **Wind turbines, 61400 part 12-1**: power performance measurements of electricity producing wind turbines, Switzerland, International Electrotechnical Commission, 2005.
[2] MEASNET. **Evaluation of site-specific wind conditions, version 1**. Measuring Network of Wind Energy Institutes, 2009.



- **Pedra do Sal Experiment is analyzed;**

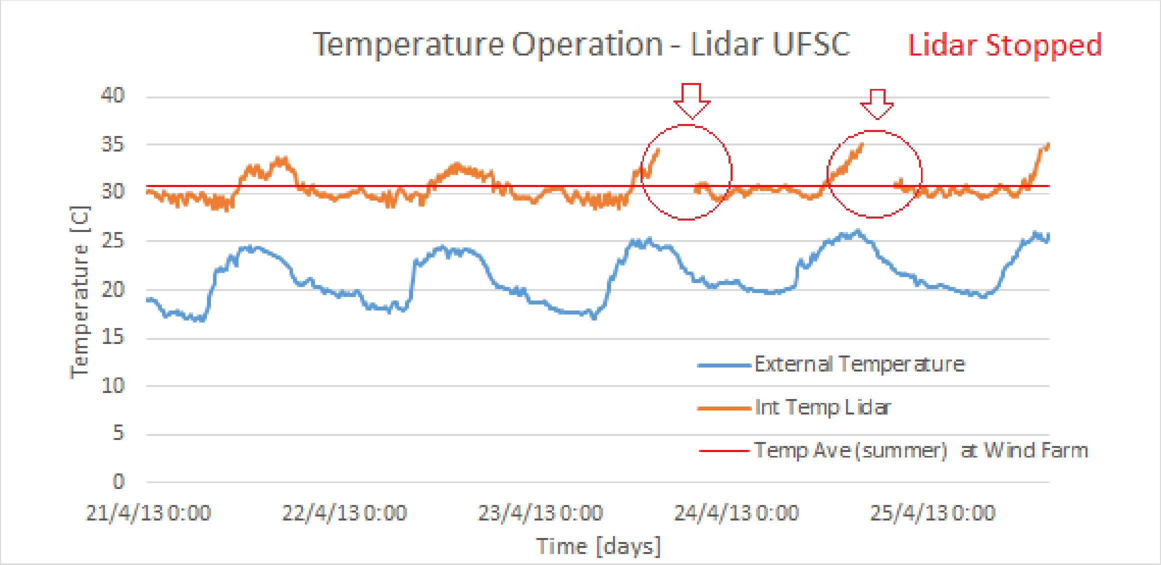
- **Site is strongly influenced by trade winds and local sea breeze (92.7% blows from the ocean);**

- **Data from meteorological mast is taken for evaluation (565m away from Lidar);**

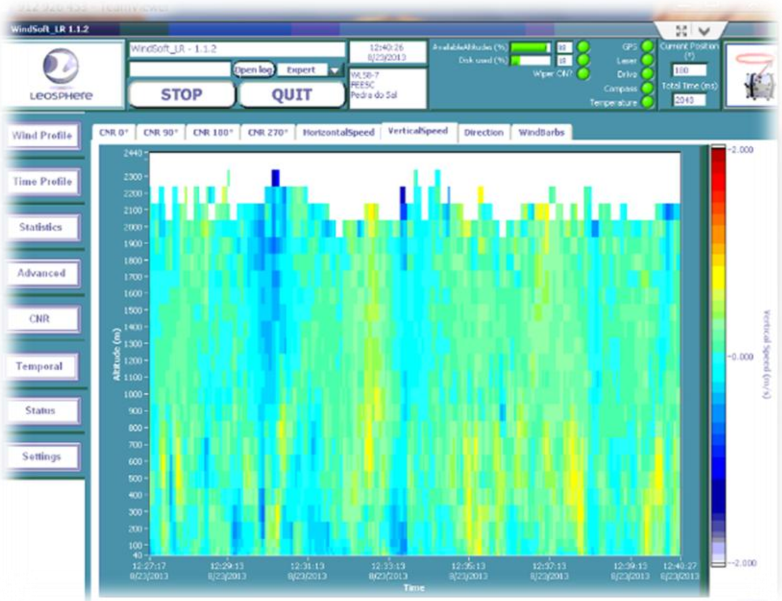


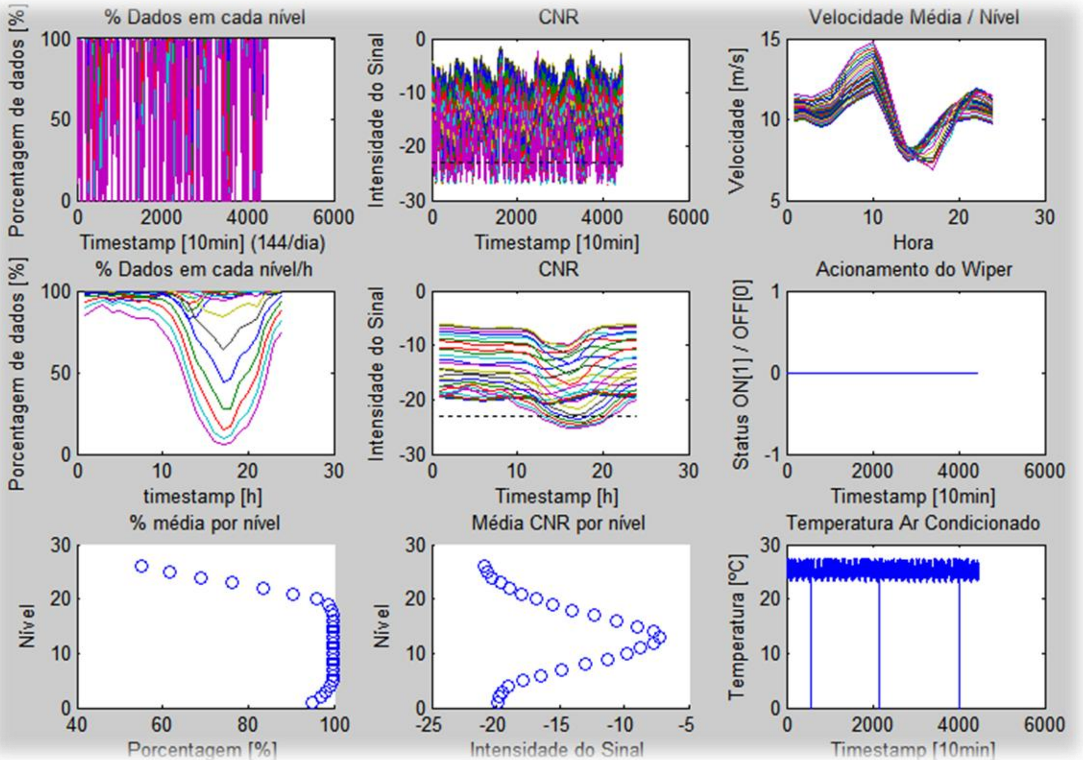
- **Wind lidar focal point is set at 220m**
- **90.000 pulses per line of sight gives a CNR Threshold = -28dB;**
- **Selected Wind lidar data only with 100% availability;**
- **Team Viwer shows real time data and configuration (show);**

- **Internal temperature problems with original Peltier cooling;**
- **Two A/C systems, with 800W and 100kg total, had to be attached into the Lidar;**
- **Losses in portability and energy consumption;**



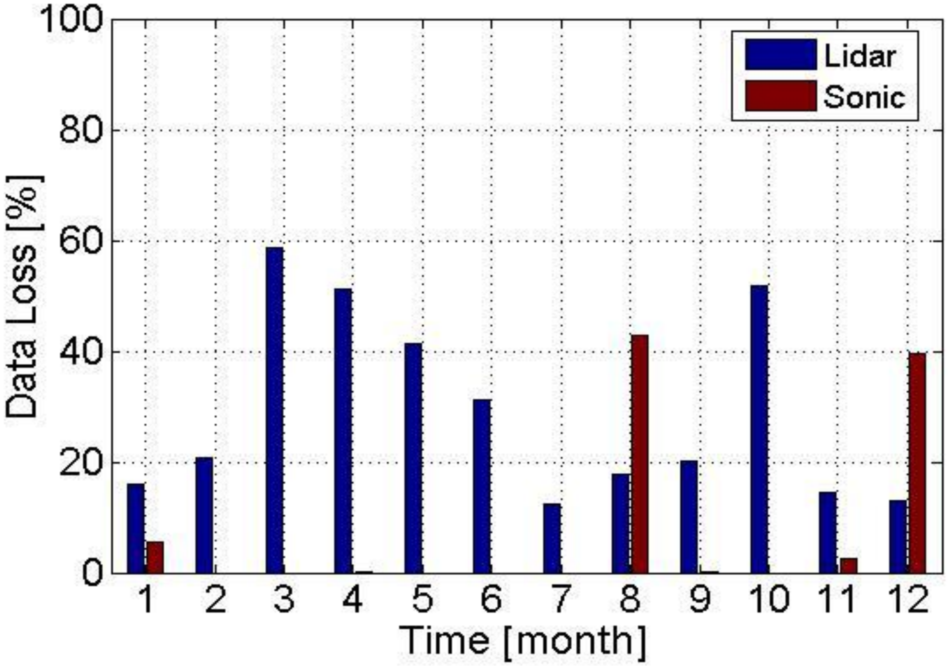
- Continuous 1-year 10min average data (September 2013 to August 2014);
- Met tower data used for relative humidity and wind speed reference;
- Precipitation data from INMET station (20km away from test site);
- Lidar Data monitoring and filtering procedure with Matlab rotine;

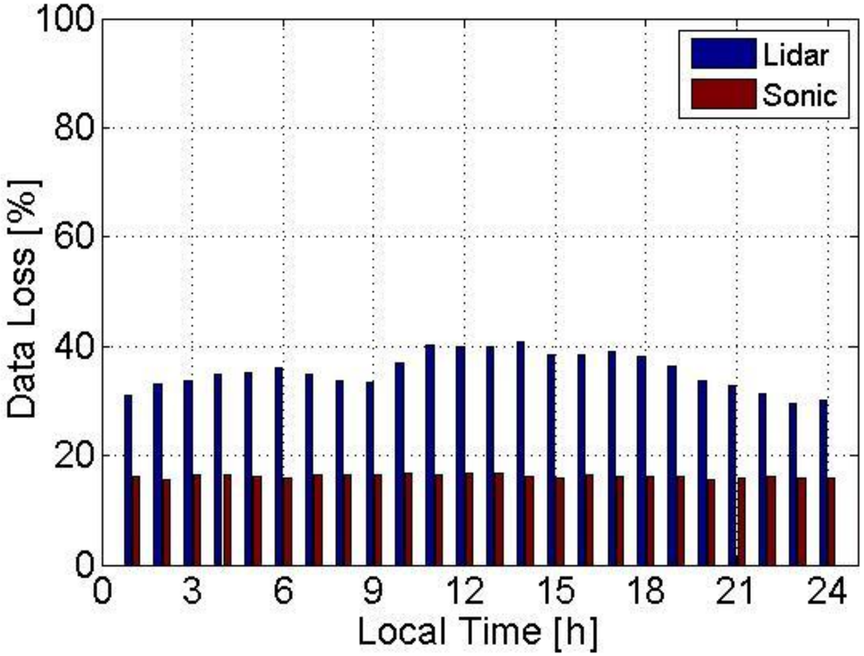




- **Seasonal and daily wind regime impact on data loss (fig);**

- **Lidar presented durty and scratched lenses in October, therefore the 48.2% in data loss can be considered operational;**





Sakagami, Y. et al. A simple method to estimate atmospheric stability using lidar wind profiler. In: **EWEA Offshore Conference 2015,** Copenhagen, 2015.

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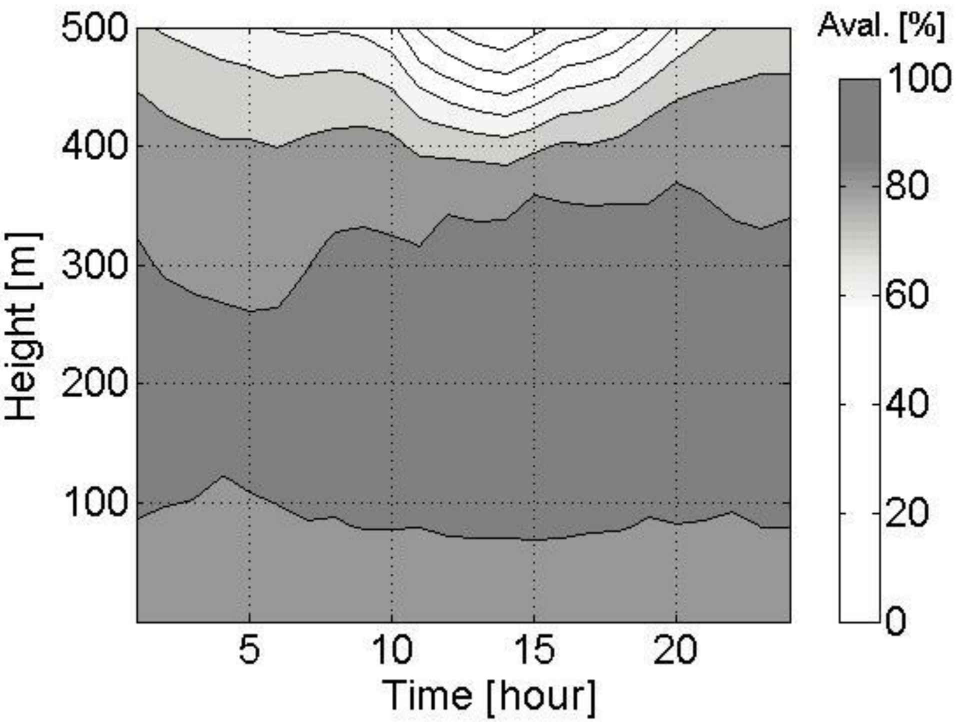
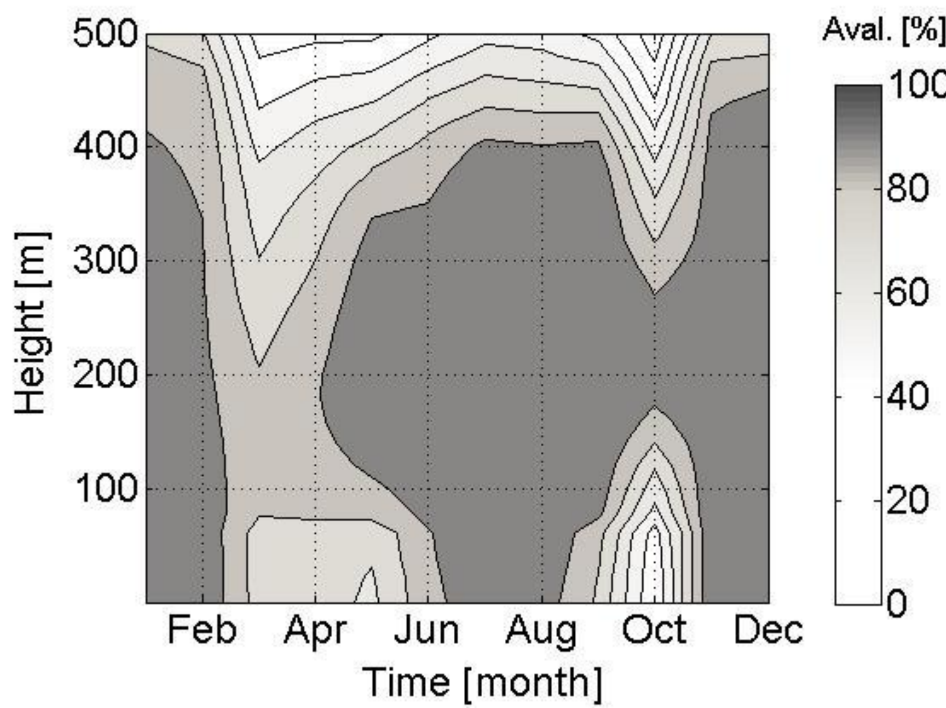
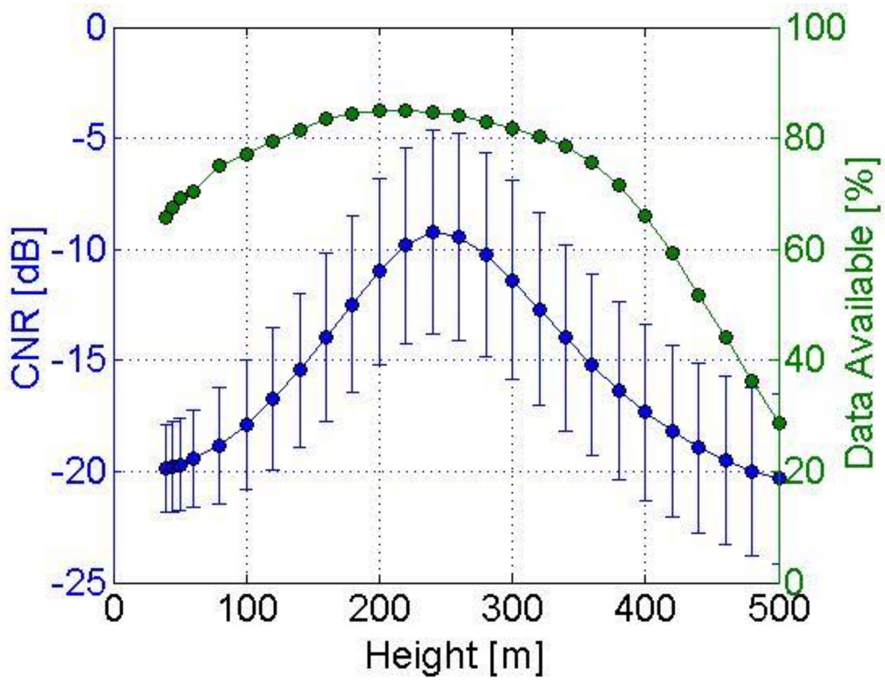
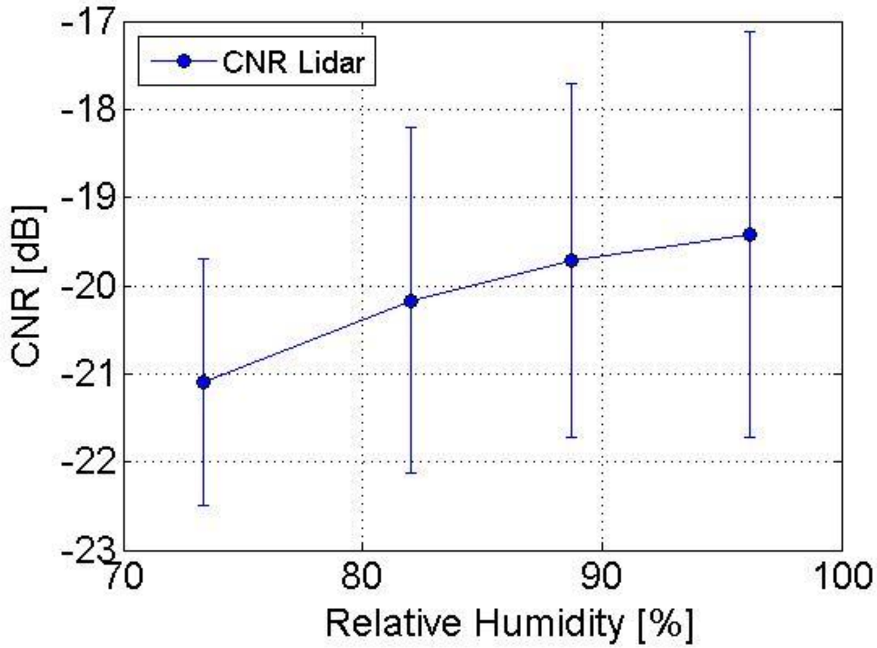




Carrier-to-Noise Ratio (CNR) behav ior

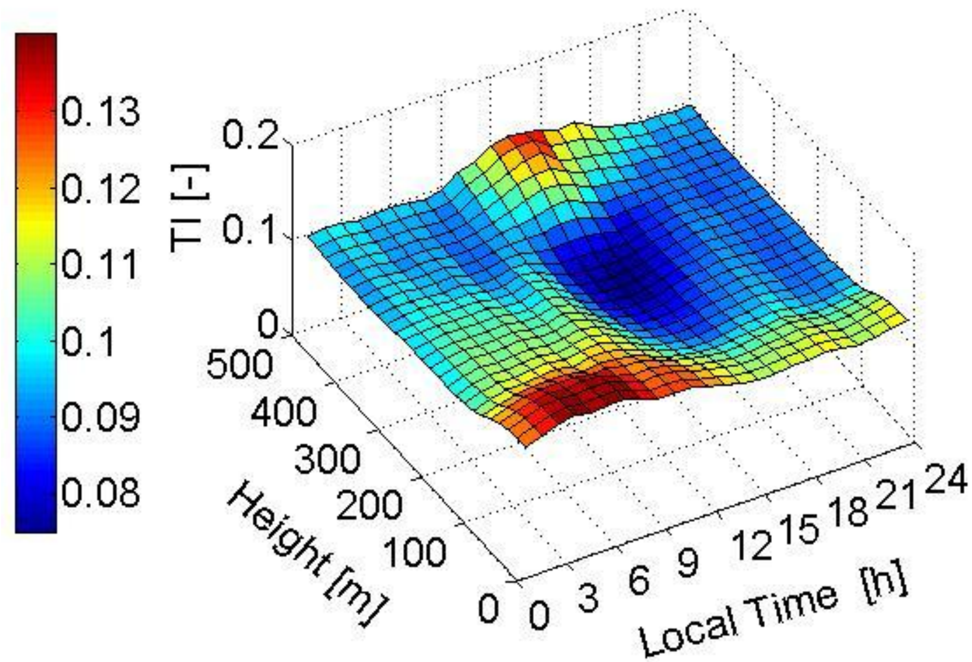
- **Highest CNR of -9.22dB at the focal point (220m) and lowest at 40m (-19.9dB) and 500m (-20.3dB);**
- **Availability drops after 400m, with Recovery=66% up to 400m and 28.7% for all available heights;**
- **Oceanic conditions prevail, with CNR not sensible to relative humidity;**

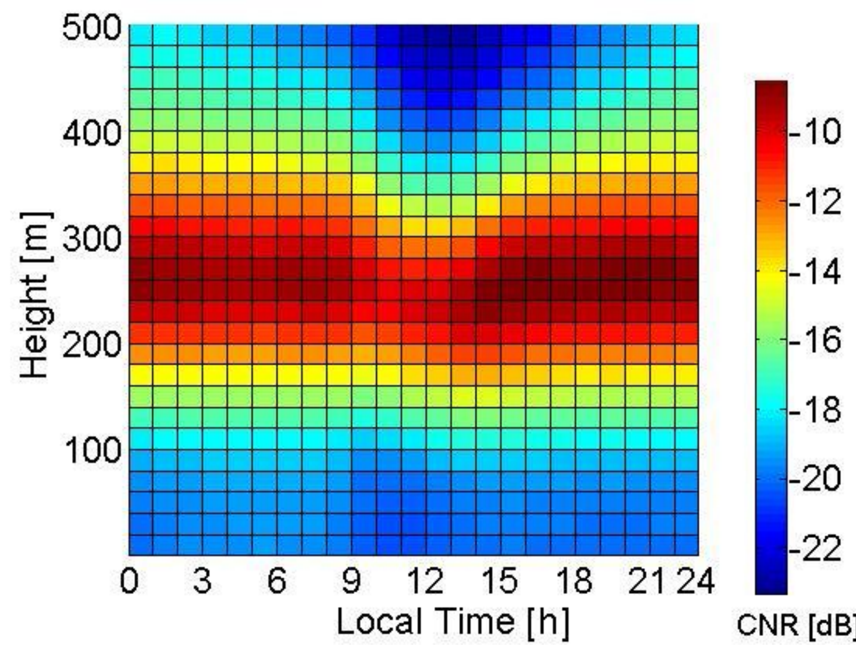




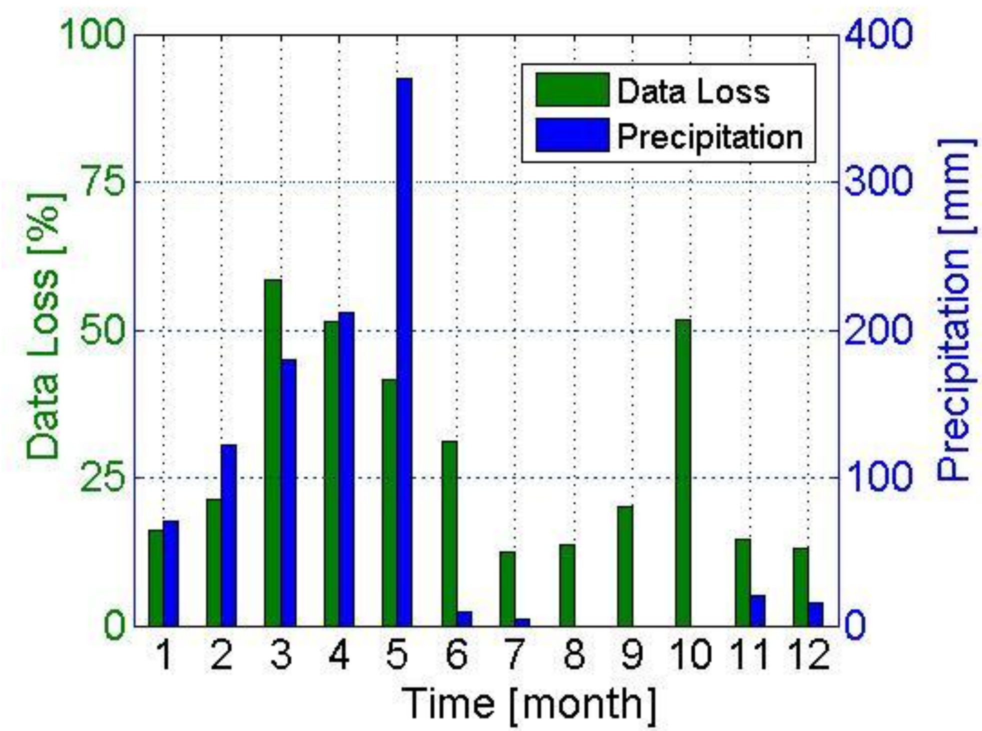
Turbulence Intensy (TI) = σ/V impact on CNR:

- **Hight TI values at low altitude in the beginning of the day and at high altitudes in the afternoon;**
- **Low CNR levels can be associated with high TI at high altitudes;**
- **Sea breeze and local recirculation may decrease aerosol content above 300m;**





- **Intertropical Convergence Zone (ITCZ) influence the precipitation regime in Brazilian northeast region;**
- **Up to 58.6% of data loss in the rain season, from March to May;**
- **October is considered an operational outlier (lens cleaning issue);**



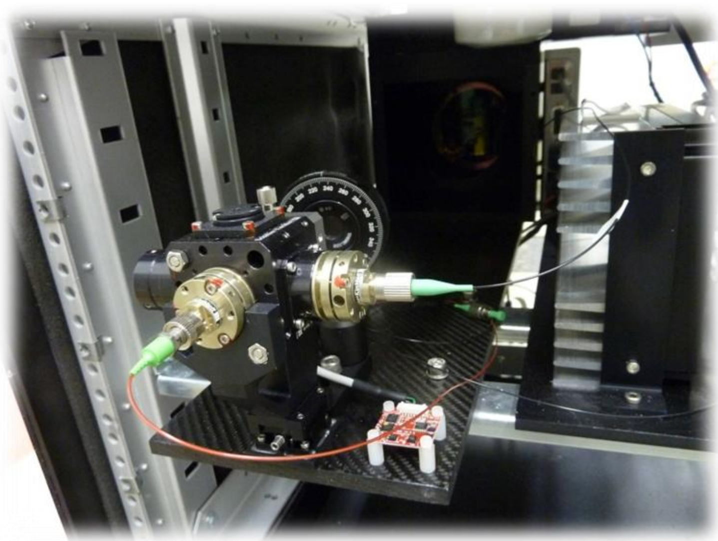
Haas, R. et al. Influência de Fenômenos Climáticos no Desempenho de dois Parques Eólicos. In: **VII CITENEL – Congresso de Inovação Tecnológica em Energia Elétrica 2013**, Rio de Janeiro. VII CITENEL - Anais, 2013.

- System **moving parts (wipper)** can always be a problem;
- Low CNR levels due to **durty and scrachted lenses**;
- October 2013 with **no wipper activation** even with low CNR (**data quality alert**);

Before maintenance

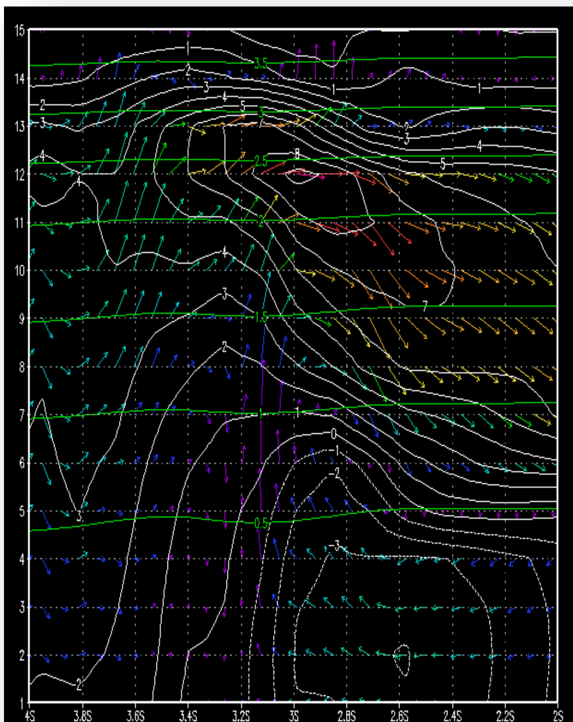
After maintenance

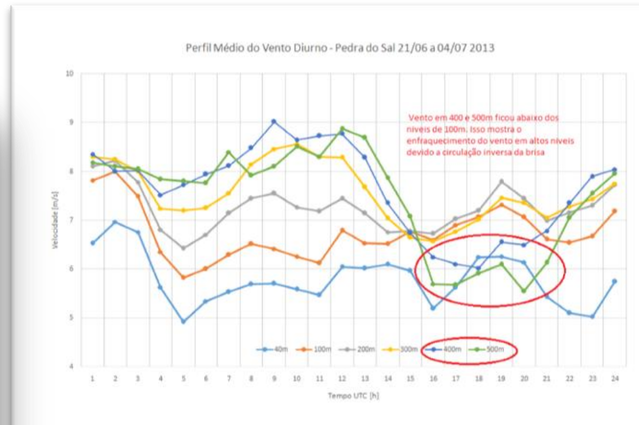
- **Many challenges** faced during the **continuous 1-year** lidar campaign;
- **Internal temperature, lens cleaning and marine corrosion** were the biggest operational issues;
- **Fair recovery rate (66%)** with the aquisition of a **multi-purpouse dataset**;
- **Aerosol measurements needed** to better understand performance above 350m;

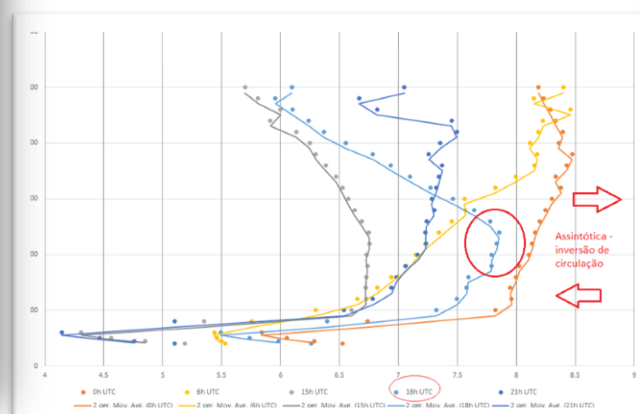


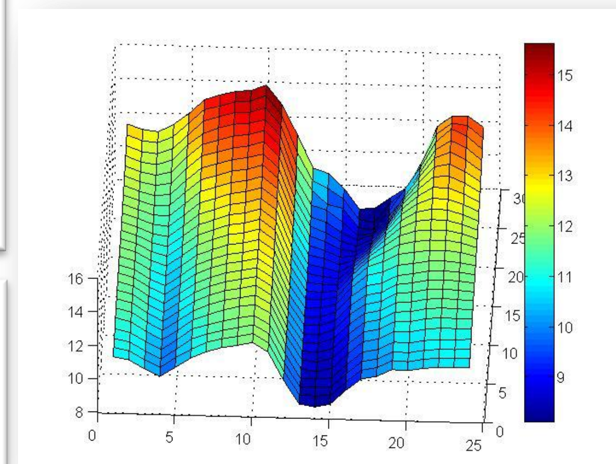
Appendix A

- **WRF (15x15km, 10min) with Lidar: sea breeze recirculation:**



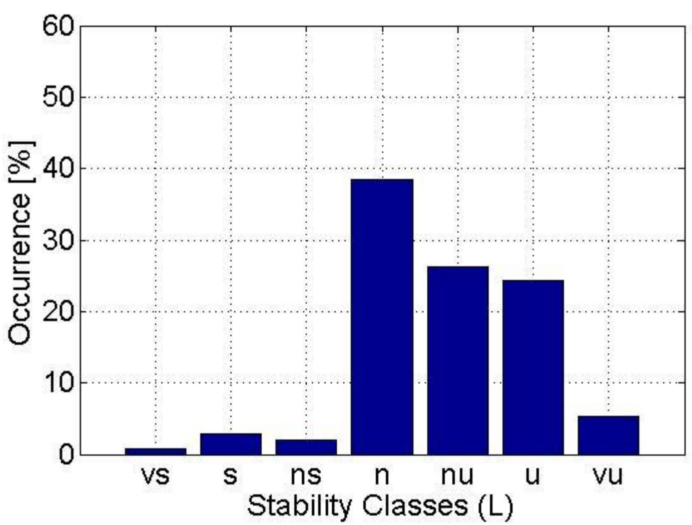


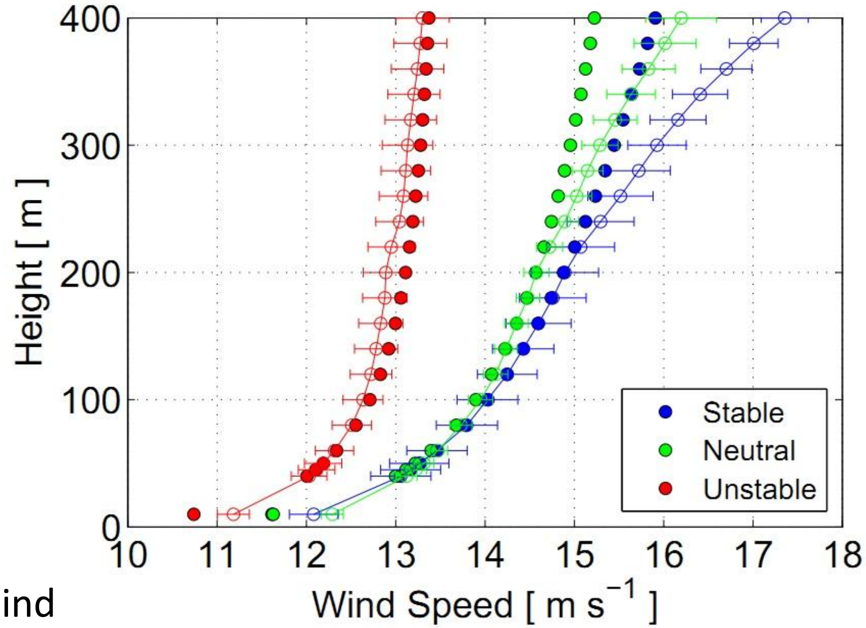




Appendix B

- **100m met mast with seven instrumented first-class wind levels;**
- **20Hz wind data from two 3-D sonic anemometers used for micrometeorological studies;**
- **Atmospheric stability impact on wind turbine performance and validation of Monin-Obukhov Similarity Theory (MOST) for the studied site;**





a. Wind Profile at $u_* = 0.40\ m\ s^{-1}$

Sakagami, Y et al. Logarithmic Wind Profile: A Stability Wind Shear Term. **arXiv:1405.5158, physics.ao-ph**, 2014.

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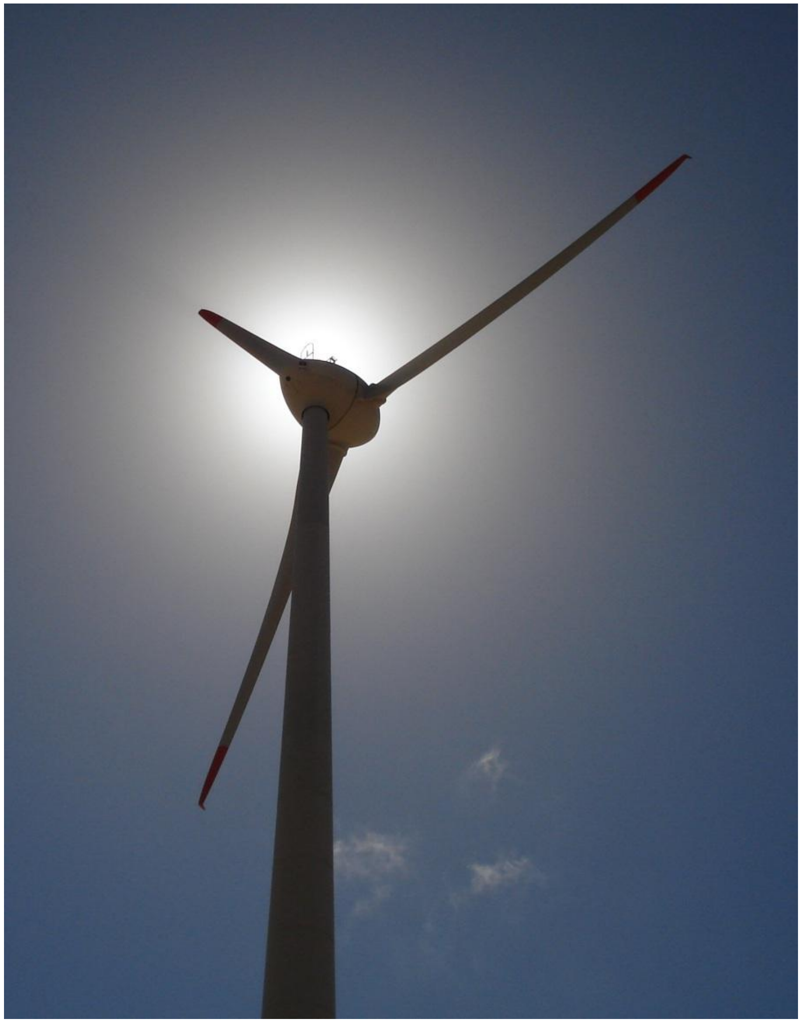

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Acknowledgments:

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