VORTEX

SERIES Report 8182

created for Your Company

March 21, 2012

Maizhokunggar, Lhasa, (Run 16086)
based on NCEP reanalysis data

Report Info

Customer	Your Company
User	iplus
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Run Started	
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Confidential	Client's discretion
Usage	Refer to VORTEX general terms at www.vortex.es

Outline

This report shows self-consistence, climate teleconnections and uncertainty analysis results for Vortex SERIES Run 16086. Time consistence testing has been applied to reject/confirm and locate potential inhomogeneities in the time-evolving structure of the series. Preliminary climate analysis of the SERIES is also presented in order to provide hints for understanding inter-annual variability features linked to potential teleconnections mechanisms. Teleconnections are described by selected climate indices that represent predominant referenced high-to-medium range climate signals. Control of inter annual variability on the overall long-term uncertainty is showed as reference for usage in site resource assessment analysis.

About SERIES

Vortex SERIES [1] are designed to minimize long-term resource uncertainty. SERIES provide a climatic reference to extend time representativeness of site measurements and to assess inter-annual climate control in the resource variability. SERIES can also be employed to infer resource uncertainty thresholds. SERIES are obtained from 3km resolution WRF model output runs that spans over 10 to 20 years. Vortex SERIES provide hourly time series of wind speed, direction, temperature and pressure.

WRF SERIES runs are driven by large scales conditions prescribed by Re-Analysis [2]. Re-Analysis consist on a large database that include many surface and 3D meteorological variables. Re-analysis output are produced from assimilation of observations coming from mixed sources. Assimilation system homogenizes the input data into coherent fields that are employed to initialize a global circulation model that add a new layer of derived variables.

VORTEX modeling system employs the third and latest re-analysis generation represented by NCEP and NASA projects. Re-Analysis can be affected by the own evolution on the observed technology, specially when significant advances have been added to the assimilation system at a particular period. Consequently, time inhomogeneities need to be checked for a consistent usability.

Along with potential artificial changes in the structure of the time series, natural climate signal control has to be assessed for a complete representation of site-specific resource variations. Although quantifications of variation in terms of remote signals are restricted by the own predictability of climate at seasonal scales, qualitative modulations of resource variability can be inferred. This can be done by composite analysis using relevant interannual climate indices.

A final by-product of Vortex SERIES is the long-term uncertainty quantification.Estimation of resource variations percentiles sensitivity with the number of years retained provides a reference value of the overall uncertainty of resource long-term assessment.

Tests of homogeneity in the mean and in the variance have been applied to the data. Specialized methods for finding single and multiple change points within the wind speed time series were employed, covering non-parametric frequentists and bayesian methods [see reference]. F-statistics based techniques(Chow test) and least squares regression are combined for an optimal model to detect and monitor structural changes.

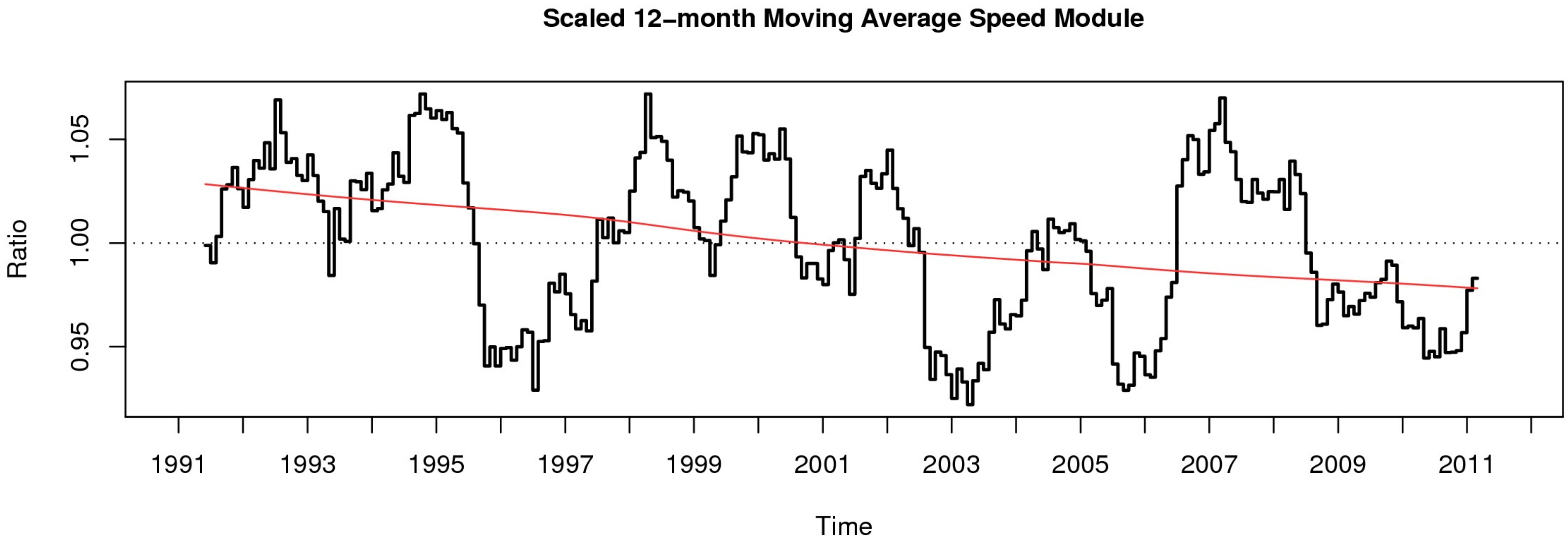
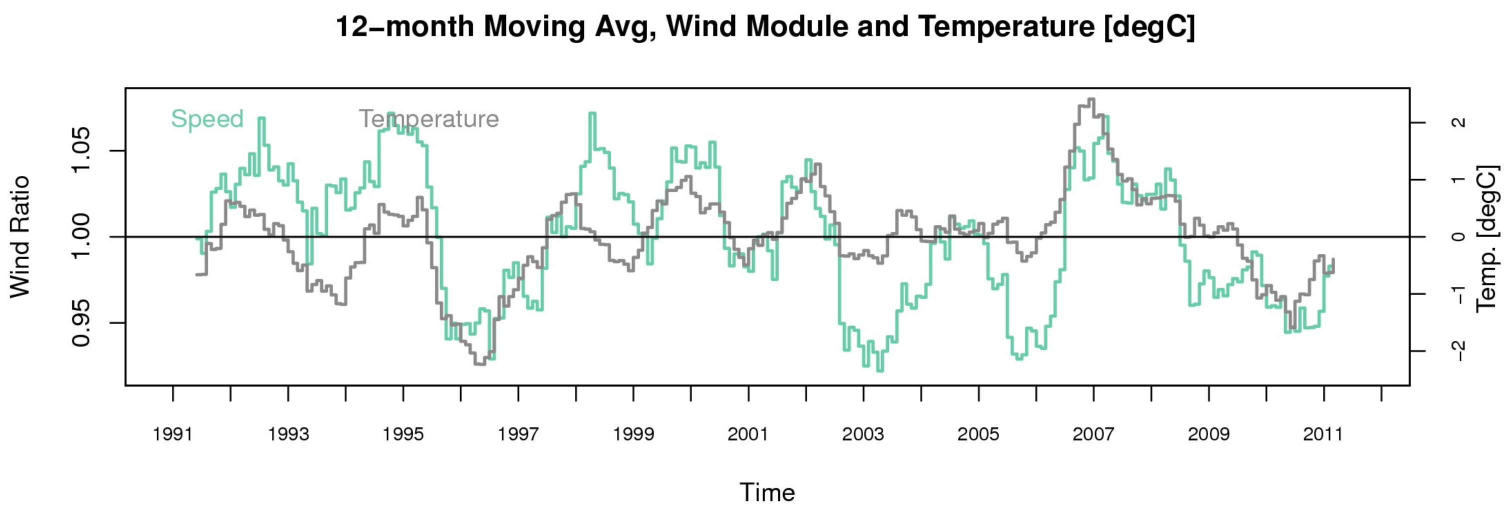


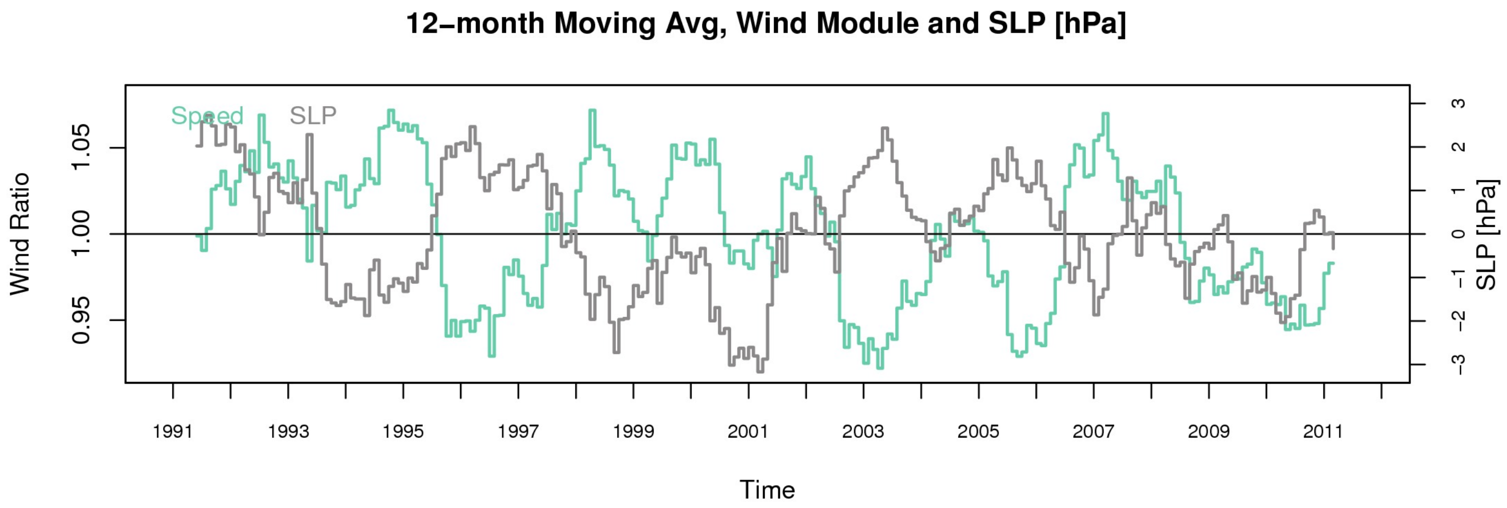
Figure 1: 12-month moving average wind speed module ratio.

Figure 1 (this page) shows 12-month moving average wind speed module ratio. Vertical lines show breakpoints associated to changes in variability (green) and mean (black). If no black lines are drawn, no change in the mean has been found. If detected, solid line refers to significant breakpoint while dashed implies that the breakpoint is not statistically robust.

Low frequency tendencies are also shown in graphic 1 to capture and illustrate any potential trend occurring on the time evolution of the 12-month average series. To validate robustness of the trends, Mann Kendall test has been employed, which is a robust trend estimator applicable for any theoretical distribution. Mann-Kendall score is also provided at 90% confidence. The score ranges from -1 (perfect negative trend) to 1 (positive).

Figure 2 (next page) shows 12-month moving averages departures from the mean for wind speed module and temperature and SLP respectively. The graphic can help in tracing any climate signature in the data. Temperature and SLP portrait more effectively inter-annual variability activity in a very consistent way since temperature and pressure measurement technology has remained nearly unchanged along decades.





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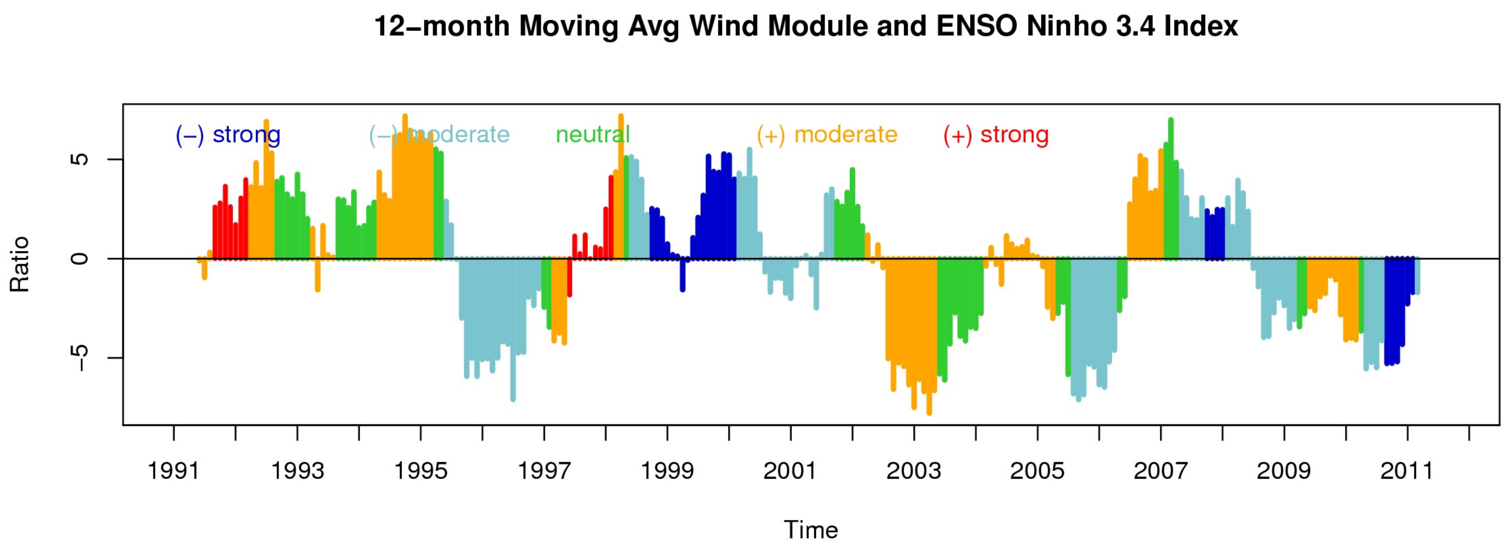

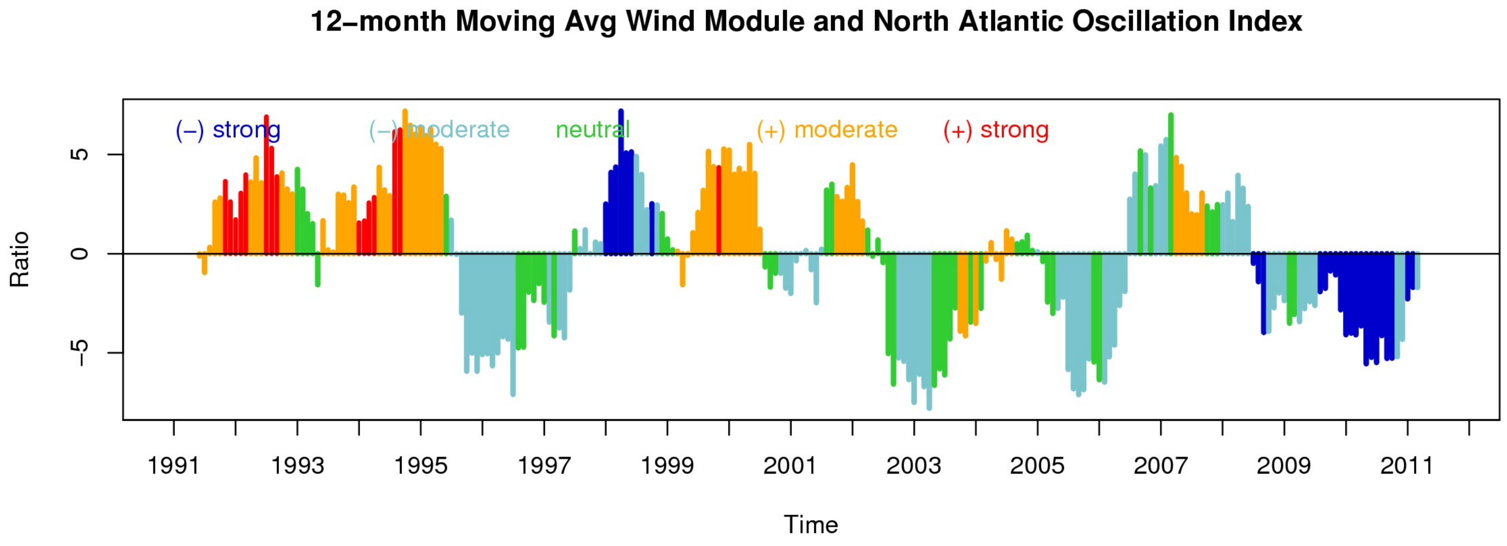

Figure 3: 12-month moving average wind speed module ratio linked to ENSO Ninho 3.4 Index and North Atlantic Oscillation Index activity

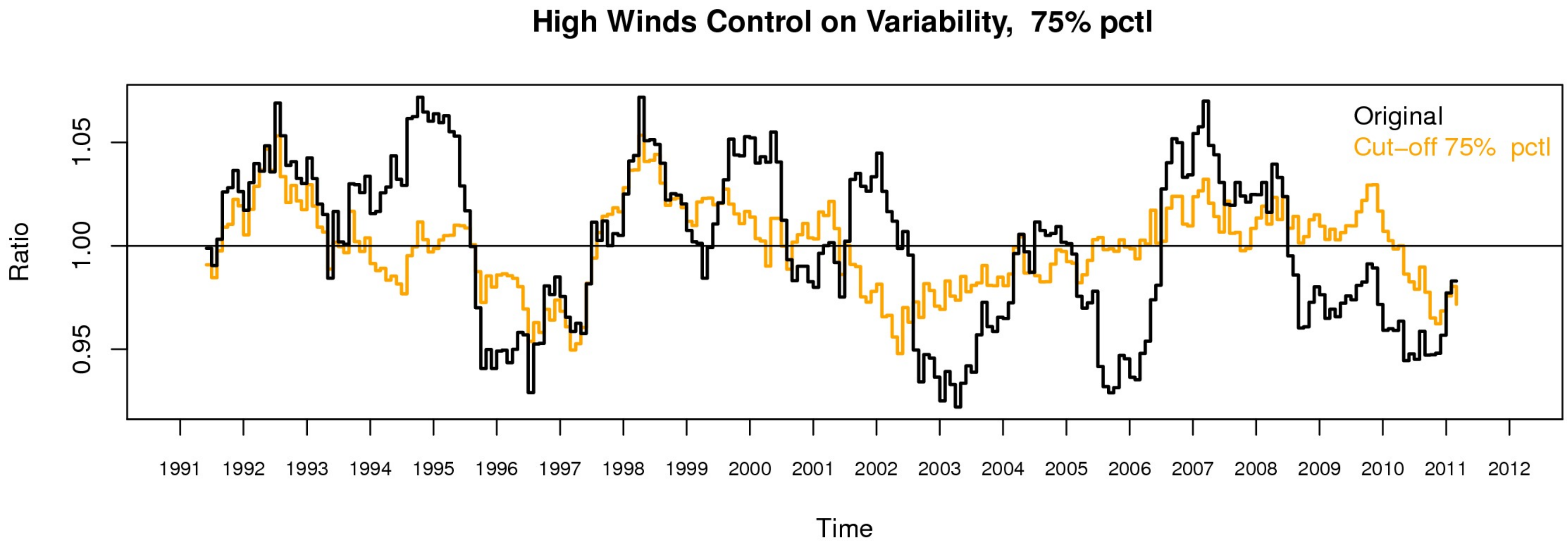

Figure 4: 12 month moving average wind speed module for original series (black) and for 75% percentile retained (orange)

Figure 3 (previous page) shows 12-month moving average wind speed module ratio linked to ENSO Ninho 3.4 Index and North Atlantic Oscillation Index activity. Color scheme highlights any trace of teleconnection with these two indices. Scales (strong, moderate and neutral) are defined by percentile threshold of the indices (>75%, >25% & <75% and <25%). Positive and negative are related to opposite phases of the indices. Indices definition can be found in Appendix 1. From the graphic, qualitative information of potential large scale signals control on the wind field can be extracted.

Figure 4 (this page) shows control of high wind speeds on the overall variability. 12 month moving average wind speed module for original series (black) and for 75% percentile retained (orange) are plotted. The reduced series shows variability without wind speed higher of 75% percentile for each 12 month period. Differences between both lines highlight periods where climate variability has a higher impact on high wind episodes, which can be associated to mesoscale mechanisms triggered by large scale anomalies.

Figure 5 (next page, top) shows long-term scaling range as function of number of retained years. Lower and upper bounds shows 5% and 95% percentile of wind speed ration distribution estimated Vortex SERIES. On the bottom standard deviation of the wind speed ratio distribution is shown for each year. The values for the graphic can be employed to assess uncertainty levels on the site long-term analysis depending on the number of year of measurements. They can also give an estimation of resource vulnerability to inter-annual climate variability.

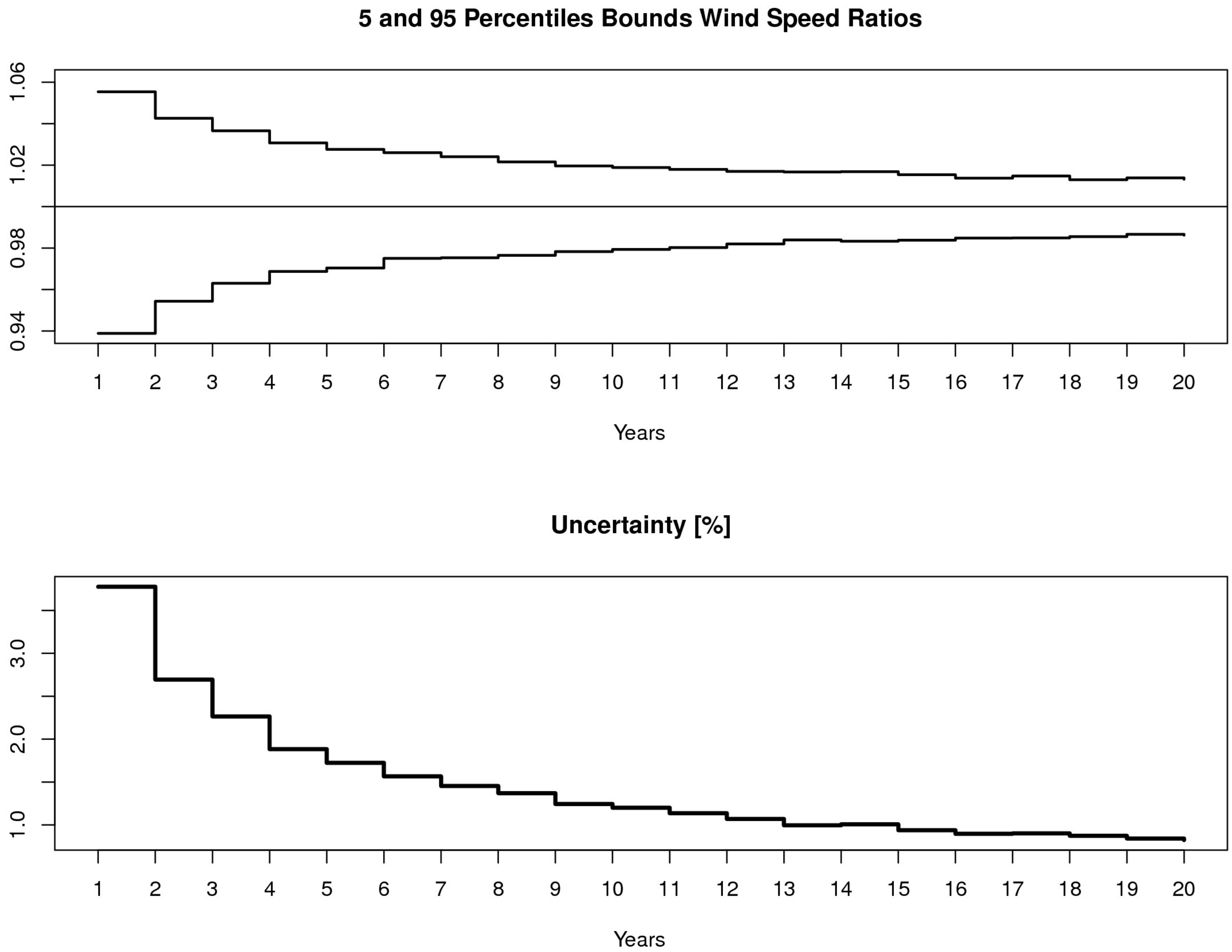

Figure 5: Uncertainty long term analysis

References

1 Vortex SERIES, http://www.vortex.es/products/series.

2 See: Saha, Suranjana, and Coauthors, 2010: The NCEP Climate Forecast System Reanalysis. Bull. Amer. Meteor. Soc., 91, 1015âŁ“1057.

3 A. Zeileis, C. Kleiber, W. Kamer, and K. Hornik. Testing and dating of structural changes in practice. Computational Statistics & Data Analysis, 44(1(2): 109(123), 2003. doi: 10.1016/ S0167-9473(03)00030-6.

4 Verbesselt, J., R. Hyndman, G. Newnham, and D. Culvenor (2009). Detecting trend and seasonal changes in satellite image time series. Remote Sensing of Environment.

5 Bengtsson L., Hagemann S. and Hodges K. I.,2004: Can climate trends be calculated from reanalysis data? J. Geo. Res., 109.

Apendix 1

Interannual climate variability can be explained by different climate mechanisms that are associated to ocean and atmosphere circulation patterns that present a certain degree of spatial and time coherence, recursive and wave like structure.

Climate signals sources are mostly associated to a particular region, which does not imply that effects are restricted to that region. Predominant climate variability signals show global/hemispheric control with a complex interaction among them. The most significant signal is El Niño/Southern Oscillation (ENSO) with source trace in central Pacific. Other relevant signatures are North Atlantic Oscillation for Northern Hemisphere.

Climate signal amplitude and phase can be assessed through some diagnostic quantities, indices. Indices are defined through a variety of methods. Most common and simple is to select an area average of a single variable over a domain that represents core of the signal.

Plots 3 qualitatively links wind speed variability to ENSO N34 index and, in some cases, a secondary index. Secondary index is selected when high significative correlation is found for strong positive and negative phases of the indices.

The main objective of the plot is to provide some hits for a preliminary climate analysis of the wind variability.

Climate indices employed in the analysis are:

1 ENSO Ninho 3.4, represents mature phase of ENSO phenomena. Applied global, source Central Pacific, diagnostique variable sea surface temperature.

2 North Atlantic Oscillation Index, North hemisphere, sea-level pressure differences across north Atlantic.

3 Artic Oscillation Index, North hemisphere, complementary signature to NAO, defined using geopotential predominant anomaly pattern.

4 South Annular Mode Index, south hemisphere only, equivalent of NAO.

5 Antarctic Oscillation Index , south hemisphere only, equivalent to AO.

6 Indian Dipole Index, Indian Ocean domain, diagnostique variable sea surface temperature zonal gradient across Indian Ocean.

More information about the definition can be found at: http://www.esrl.noaa.gov/psd/data/climateindices/list/

VORTEX

Vortex S.L. | +34 933 543 453 | info@vortex.es | www.vortex.es
Parc Tecnològic BCNord | Marie Curie 8-14 | 08042 Barcelona, Spain
Registered in Spain | VAT Number: B63955348