

Quality of synthetic winds by testing of similarity to measured data by spectral modelling and statistics of increments

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Introduction

In order to have proper wind turbine design and performance analysis, it is important to have an accurate representation of the incoming wind field. To ease the analysis, tools for the generation of synthetic wind fields have been developed, e.g. the widely used TurbSim procedure [1].

We analyze measured sets and the respective synthetic data sets in view of the similarity of the spectral characteristics and the statistics of wind speed increments (relevance to load assessment) of measured and synthetic sets. Measured data are from the server of the NREL Wind turbine test center.



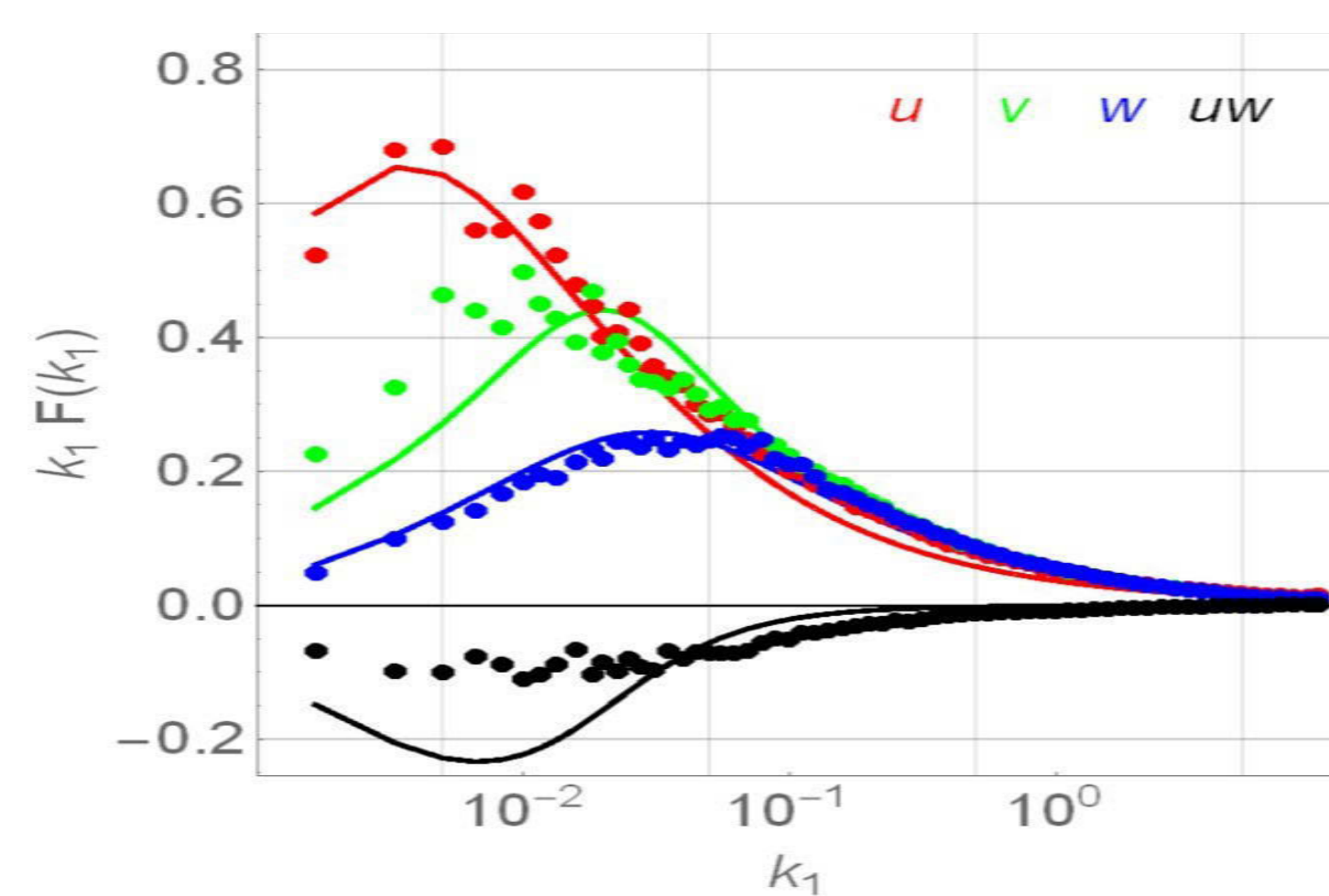
NREL National wind technology test center.

picture taken from:
http://www.nrel.gov/wind/facilities_test_pads.html

Spectra of measured and modelled sets

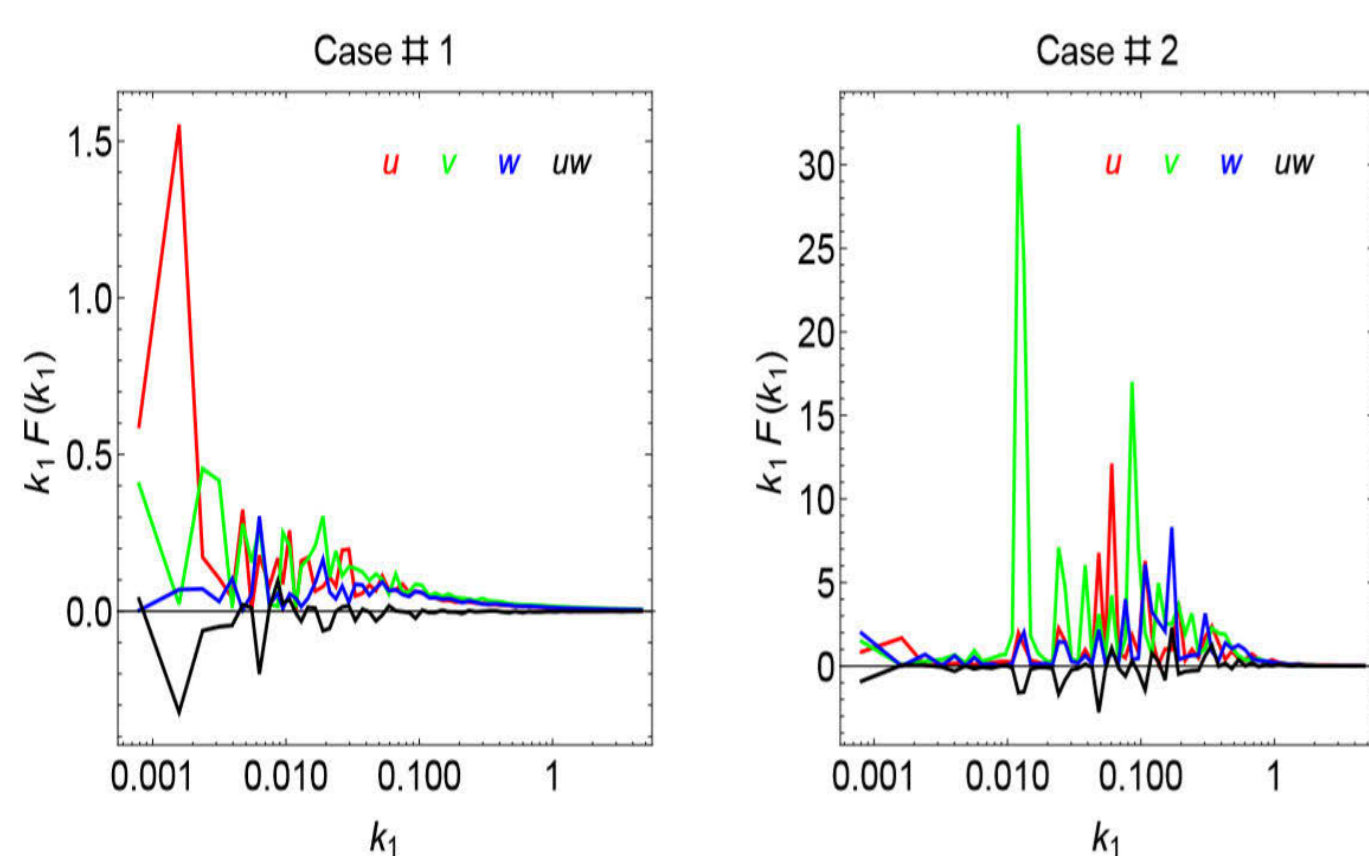
Measured spectra and spectral modelled:

Spectra for wind speed components u , v , w and u,w co-spectra From 20Hz data and model.



The Mann model spectra (lines) fitted with the observed spectra (dots) at $z=100$ m from NREL's met-mast for wind speed of 13.5 m/s [1].

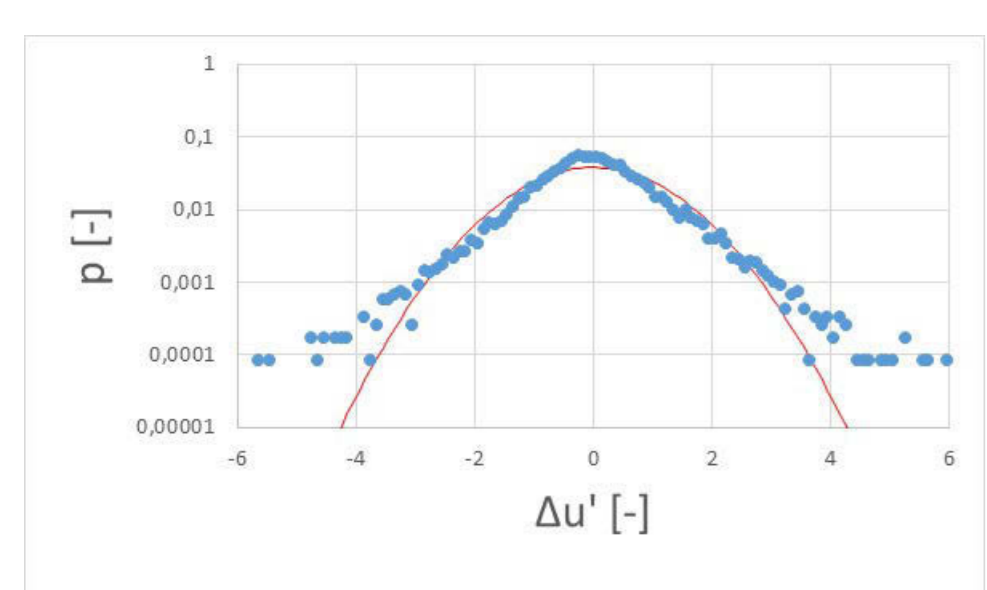
Spectra from synthetic sets



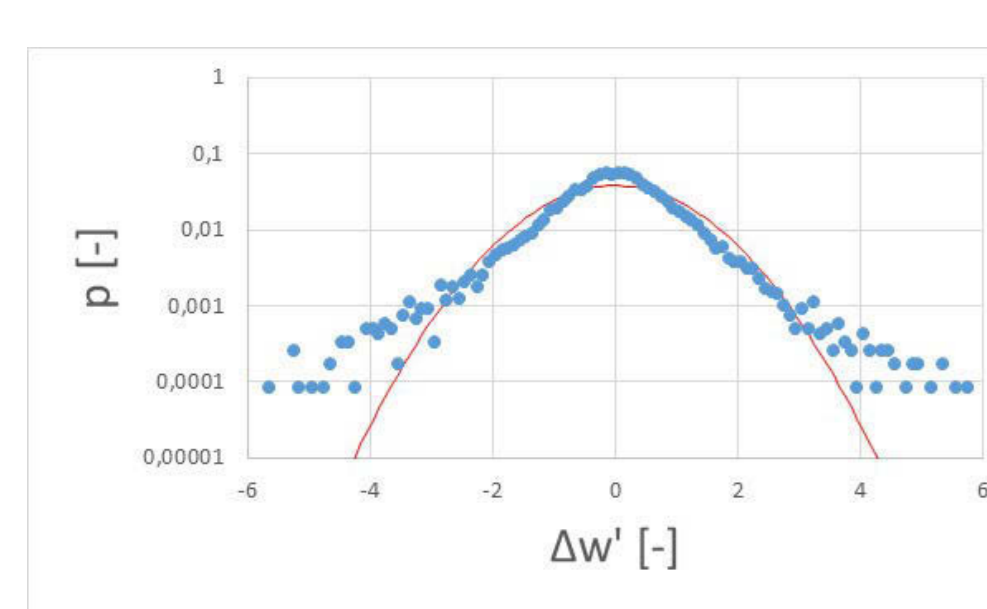
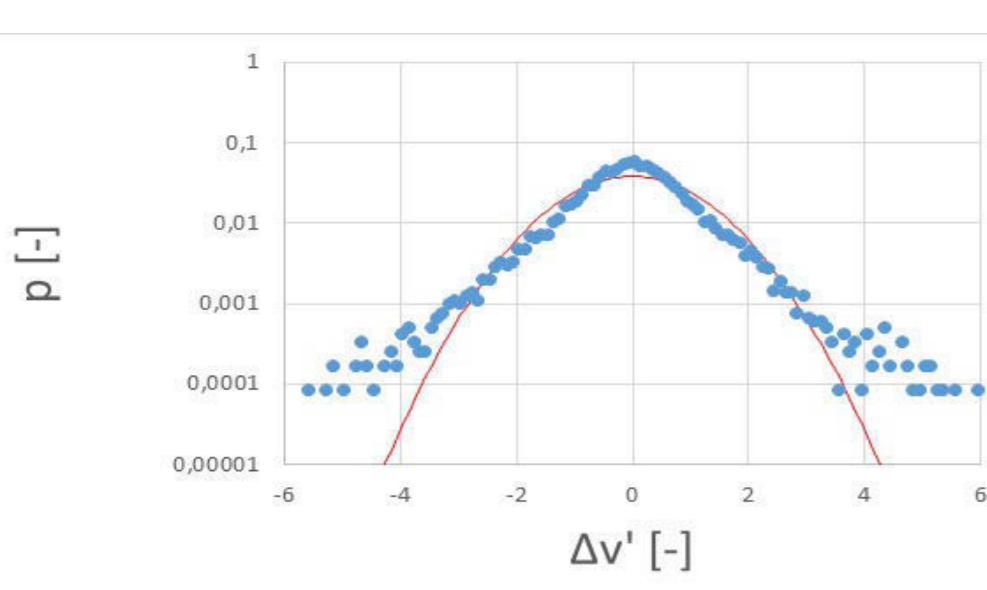
Spectra from synthetic data generated by NREL's Model (NWTCUP) without (case 1) and with (case 2) function "KHTEST" which superimposes a coherent event in the output time series [3].

Increment statistics of measured sets

PDFs of increments in sets of wind speed components for measured 20Hz data (height 100m)

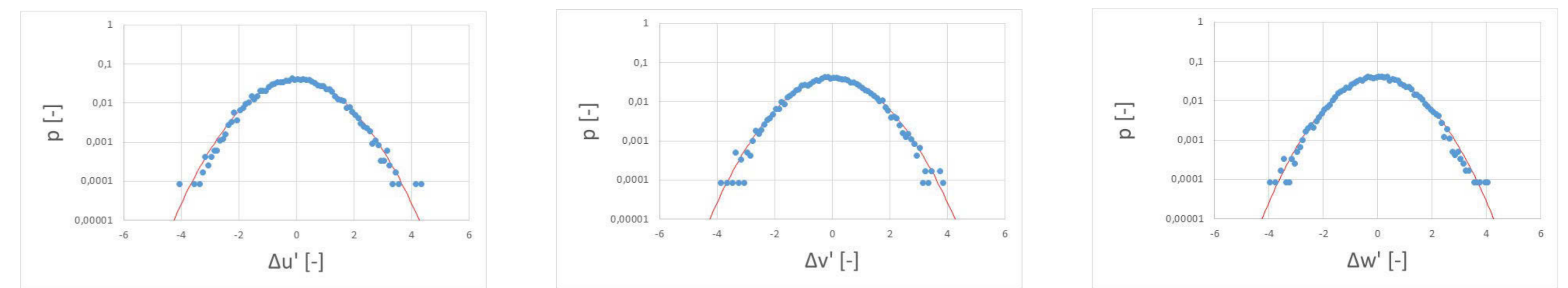


The example refers to the one step increments in a 10min sequence of 20Hz data. Depicted are the distributions of the increments normalized by the series standard deviation. Red lines refer to Gaussian distribution with same standard deviation. Non Gaussian characteristics indicate intermittent properties of the sets. Details and dependencies of the deviation from Gaussian from actual conditions (mean wind speed, turb. Intensity, thermal stratification) to be analysed,



Increment statistics of synthetic sets

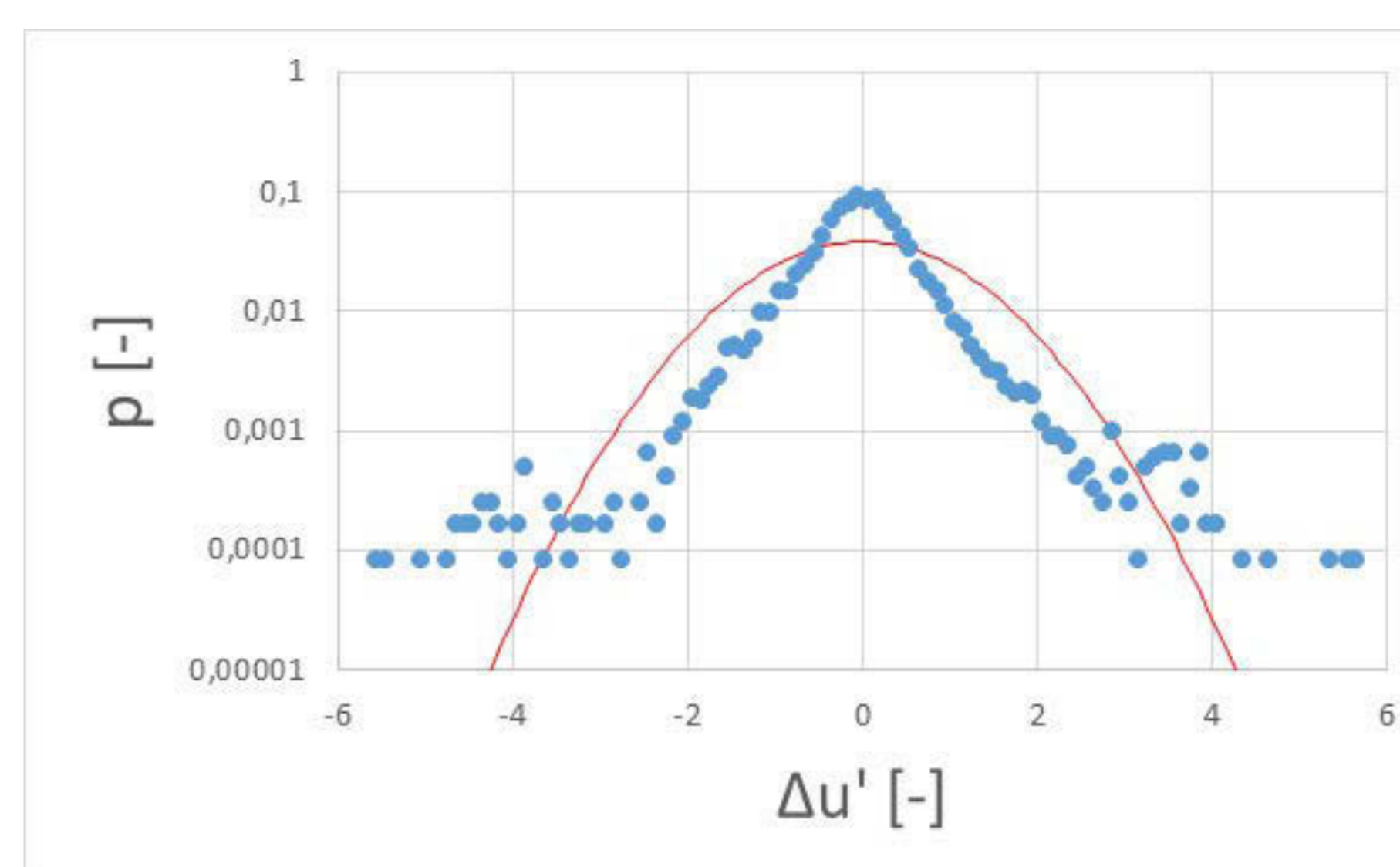
A) PDFs of increments in time series generated by basic Turbsim procedure



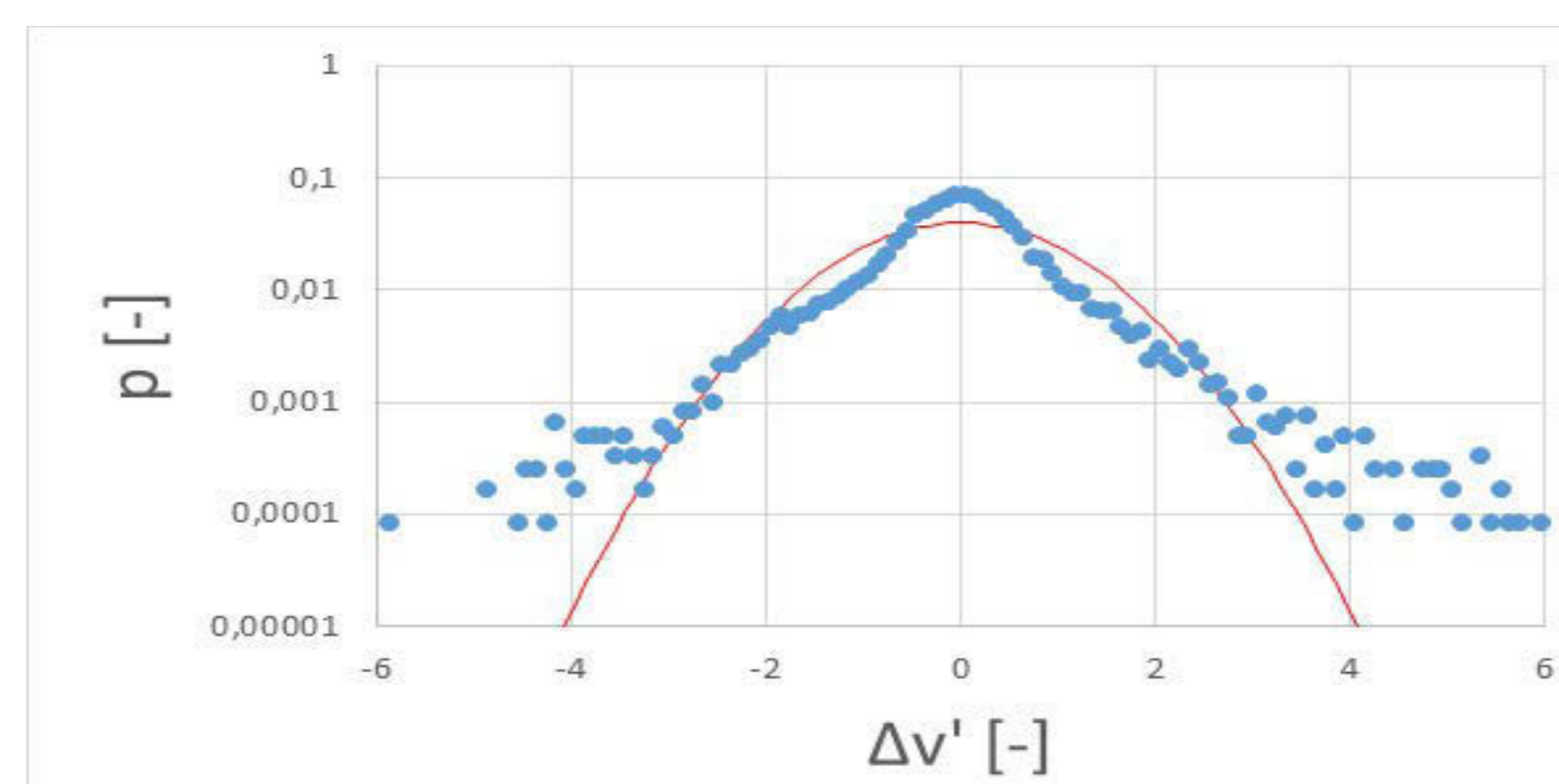
Data from Fourier synthesis with random phase show Gaussian statistics. Examples given refer to an example for a 10 min sequence of 20Hz data.

B) PDFs of increments in time series generated with inclusion of coherent events

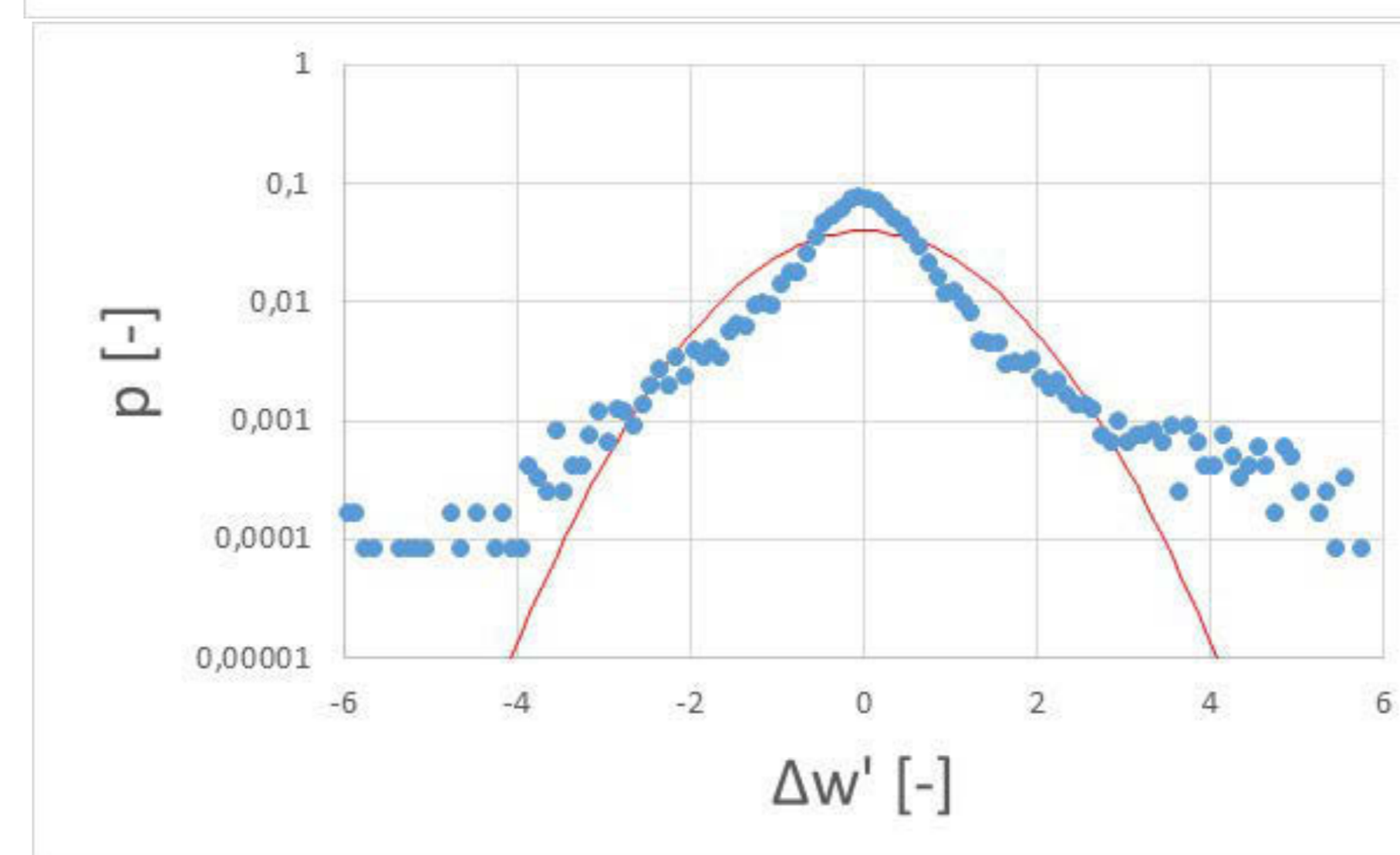
(procedure based on insertion of scales templates extracted from measured sets [3])



The synthetic sets show deviations from Gaussian characteristics, basically similar to those detected for the measured sets.



In detail however, the PDFs do not match.



This calls for an in depth inspection of the handling of this procedure. Respective parameters have to be tuned in view of similarity of the increment statistics and in extension, to the similarity of rainfall count statistics.

Conclusions

Available tools for data synthesis prove to be able to reflect the spectral properties of measured time series and qualitatively the non Gaussian properties of measured wind speed increments. Further analysis is necessary for both parametrization of those properties and respective adaption of the tools.

This work is part of the Norwegian NORCOWE project



References

1. Nwtc information portal (turbSim) <https://nwtc.nrel.gov/turbSim> accessed 25-February- 2016
2. Chougule AG et al., 2012 J. Turbul. 13(36) 1–13
3. Jonkman B J and Kilcher L 2012 TurbSim user's guide: Version 1.06.00 Technical Report NREL/TP-xxx-xxxx National Renewable Energy Laboratory

