Quality control of raw data during measurement campaigns for wind energy

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Summary
The assessment and quality control of raw data (pre-processing) can be time consuming, particularly considering the large quantities of data collected during, as well as the many different types of sensors employed in wind-energy measurement campaigns. Here an automated quality-control procedure is described, which employs simple rules for the detection of common problems encountered during data control, such as spikes in the signal. The tests are applicable for structural, meteorological, oceanographic and electrical data, with a minimal specification of the parameters required for each unique dataset. The tests are not designed to be completely independent of human assessment, but rather to aid and accelerate the initial assessment of data quality.

1. Introduction
Disturbances in raw signals from unphysical behaviour, resulting from faults in the measurement system, for example, can affect the results of analyses if not filtered beforehand. However, the user is often abandoned to the task of manually sorting through large quantities of time series before even beginning their analysis. The following procedure aims to accelerate this task.

2. Methodology
2.1 Description of Tests
The quality-control procedure consists of the seven tests summarized in Table 1. The timing, length and flat line tests are relatively formal, checking, respectively, the correctness of the timestamp, the length of data, and whether the sensor is still active. The measurement range, bad resolution and spike tests check whether the signal lies beyond the amplifier range, and for the presence of quantization and outliers, respectively.

<table>
<thead>
<tr>
<th>Test Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Timing</td>
<td>Checks timestamp</td>
</tr>
<tr>
<td>Length</td>
<td>Correct length of data</td>
</tr>
<tr>
<td>Flat Line</td>
<td>Constant value</td>
</tr>
<tr>
<td>Measurement Range</td>
<td>Data outside range</td>
</tr>
<tr>
<td>Bad Resolution</td>
<td>Checks for quantization</td>
</tr>
<tr>
<td>Spike</td>
<td>Outliers in signal</td>
</tr>
</tbody>
</table>

2.2 Flagging Strategy
The results of each test described in Tab. 1 are translated into a value or ‘flag’ with the particular qualitative meaning as summarized in Tab 2. The first three tests apply only Flags 1 and 4 as they are based only on simple rules. The next three tests apply Flags 1–3 based on a statistic between the raw data and the output data after undergoing the testing.

<table>
<thead>
<tr>
<th>Flag</th>
<th>Meaning</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Good data</td>
<td>Measurements can be used safely</td>
</tr>
<tr>
<td>2</td>
<td>Probably good data</td>
<td>User should verify data before use</td>
</tr>
<tr>
<td>3</td>
<td>Problems with data</td>
<td>Data probably need to be corrected before use</td>
</tr>
<tr>
<td>4</td>
<td>Bad data</td>
<td>Measurements should be rejected.</td>
</tr>
</tbody>
</table>

3. Example
3.1 Spike Test
Figure 1 shows part of a signal affected by a periodic electrical disturbance containing the spike, which the spike test has removed. The flag for the spike test is based on the correlation between the raw and despiked signal. Here, for example, the spike reduces the correlation coefficient to a value < 0.999 and is flagged, but is still useable after despiking.
Fig. 1: Example of part of signal affected with a single spike. Inset: the entire time series (30,000 points).