CARBOEUROPE-IP

TASK 1.2.2
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Quality control of eddy covariance measurements (C: 0,1,2)

Tests on fulfilment of theoretical requirements

Steady State test

The steady state test according to Foken and Wichura (1996) is based on developments of Russian scientists (Gurjanov et al., 1984) and compares the statistical parameters determined for the averaging period and for short intervals within this period. For instance the time series for the determination of the covariance of the measured signals w (vertical wind) and x (horizontal wind component or scalar) of about 30 minutes duration will be divided into M=6 intervals of about 5 minutes. N is the number of measuring points of the short interval (N=6,000 for 20 Hz scanning frequency and a 5 minutes interval):

$$\left(\overline{x'w'}\right)_i = \frac{1}{N-1}\left[\sum_j x_j \cdot w_j - \frac{1}{N}\left(\sum_j x_j \cdot \sum_j w_j\right)\right]$$

$$\overline{x'w'} = \frac{1}{M}\sum_i \left(\overline{x'w'}\right)_i$$

This value will be compared with the covariance determined for the whole interval:

$$\overline{x'w'} = \frac{1}{M \cdot N - 1}\left[\sum_i \left(\sum_j x_j \cdot w_j\right)_i - \frac{1}{M \cdot N}\sum_i \left(\sum_j x_j \cdot \sum_j w_j\right)_i\right]$$

A time series is considered to be steady state if the difference between both covariances

$$RN_{Cov} = \left|\frac{\overline{\left(x'w'\right)_{eq(4)}} - \overline{\left(x'w'\right)_{eq(5)}}}{\overline{\left(x'w'\right)_{eq(5)}}}\right|$$

is lower 30 %. This value is found by long experiences but is in a good agreement with other test parameters also of other authors (Foken and Wichura, 1996).

This test does not replace the ogive-test, which is calculated for longer averaging intervals than 30 minutes.

Integral Turbulence Characteristics test

To test the development of turbulent conditions the so-called flux-variance similarity is a good measure. This similarity means that the ratio of the standard deviation of a turbulent parameter and its turbulent flux is nearly constant or a function, e.g. of the stability. These so-

called integral turbulence characteristics are basic similarity characteristics of the atmospheric turbulence (Obukhov, 1960; Wyngaard et al., 1971) and can be found in all textbooks (Arya, 2001; Kaimal and Finnigan, 1994; Stull, 1988). Foken and Wichura (1996) used for their test such functions determined by Foken et al. (1991). These functions have a dependence on stratification and have the general form for standard deviations of the vertical wind component w with u^* the friction velocity and L the Obukhov length.

$$\sigma_w / u_* = c_1 \cdot \left(z / L \right)^{c_2}$$

The constant values for c_1 und c_2 are given in the following table (analogue values for z/L>0).

Parameter	z/L	c_1	c_2
σ_W/u_*	0 > z/L > -0,032 -0,032 > z/L > -1	1,3 2,0	0 1/8

Optional: In recent investigations about integral turbulence characteristics under neutral stratification an external forcing was assumed by Johansson et al. (2001). Further analysis by Thomas and Foken (2002) resulted in a parameterisation of integral turbulence characteristics depending on the Coriolis parameter f for z/L values between -0.2 and 0.4.

Parameter	-0,2 < z/L < 0,4
σ_w / u_*	$0{,}21 \ln\left(\frac{z_+ \cdot f}{u_*} \right) + 3{,}1 \qquad z_+ = 1\ m$

The measured and the modelled parameter will be compared according to

$$ITC_\sigma = \left| \frac{\left(\sigma_x / X_* \right)_{model} - \left(\sigma_x / X_* \right)_{measurement}}{\left(\sigma_x / X_* \right)_{model}} \right|$$

If the test parameter ITCσ is < 30 % a well developed turbulence can be assumed.

Overall QC-flag system

After the discussions during the 2nd CarboEurope Workshop on QA/QC of eddy covariance measurements in Spoleto (Jan. 2004) the following classification table was developed. This provides a condensation of the quality control tests in a simple flag system for the users of the measured eddy covariance flux data.

Steady state (deviation in %)	integral turbulence characteristic (deviation in %)	QC- flag
< 30	< 30	**0**
< 100	< 100	**1**
> 100	> 100	**2**

Description of the classes:
Class 0: highest quality data, use in fundamental research possible
Class 1: good quality data, no restrictions for use in long term observation programs
Class 2: questionable data quality, gap filling necessary

Questions and comments please to Matthias Mauder (matthias.mauder@uni-bayreuth.de)

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