

1 *Supplement of*

2 UAV-based method for measuring CO₂
3 emissions in forest ecosystems
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30 **S1. Quality control of turbulence data**

31 The data quality control procedures are as follows:

32 (1) Extreme-value check. Based on the instrument measurement range, values
 33 exceeding the instrument's range are removed, as shown in Table. S1.

34 Table. S1 Extremum detection

Variable	Unit	Frequency	Measurement range
u, v	m/s	5Hz	-45, 45
w	m/s	5Hz	-5, 5
T_s	°C	5Hz	-40, 70
CO_2	ppm	~1Hz	0, 1000

35 (2) Using the principle of variance analysis, a threshold of five times the standard
 36 deviation (5σ) was applied to screen the turbulence data and remove noise.

37 (3) Amplitude resolution check

38 Under weak-wind and stable conditions, the amplitude resolution of the time series
 39 may be too low to capture turbulent fluctuations, resulting in step-like (staircase) time
 40 series. Low amplitude resolution may also be associated with malfunctions of the
 41 instrument or the data-processing system. If the proportion of zero values in the
 42 probability density function (PDF) of a series exceeds 70%, the series is considered to
 43 have insufficient amplitude resolution and is deemed to have failed the amplitude
 44 resolution check.

45 (4) Higher-order statistical moment test. Compared with a Gaussian distribution,
 46 abnormally large or small higher-order statistical moments may indicate problems with
 47 the instrument or the data logging system. The skewness S and kurtosis K of the data
 48 are calculated, defined as:

49
$$S = \frac{E(x-\mu)^3}{\sigma^3} \tag{S1.1}$$

50
$$K = \frac{E(x-\mu)^4}{\sigma^4} \tag{S1.2}$$

51 where σ is the sample standard deviation and μ is the sample mean. If $|S| > 2$, or
 52 $K > 8$, or $K < 1$, the series is considered to have failed the higher-order moment test.

53 (5) Stationarity test. Stationarity means that the statistical properties of a
 54 turbulence field do not vary with time. Almost all turbulence statistical theories are built

55 on the assumption of stationarity. In reality, atmospheric turbulence is influenced by
 56 diurnal cycles and various weather systems and, strictly speaking, is not stationary.
 57 However, if a relatively short observation period is used and measurements are taken
 58 under relatively steady meteorological conditions (e.g., without the passage of large-
 59 scale weather systems or the influence of gravity waves) and over a relatively flat
 60 underlying surface, atmospheric turbulence can be approximated as stationary.

61 In practical testing, the data to be examined can be divided into M segments (M
 62 is generally chosen as 4–8, with a default of 6). The covariance for each segment is
 63 calculated as:

$$64 \quad (\overline{x'w'})_i = \frac{1}{N-1} \left[\sum_j x_j w_j - \frac{1}{N} \sum_j x_j \sum_j w_j \right] \quad (S1.3)$$

65 where N is the number of samples in each segment, x and w can be two different
 66 series or the same series: the former is used to test the stationarity of fluxes (e.g., x as
 67 temperature and w as vertical wind speed), and the latter is used to test the stationarity
 68 of the series itself. The arithmetic mean of the M covariances is then computed as:

$$69 \quad \overline{x'w'} = \frac{1}{M} \sum (\overline{x'w'})_i \quad (S1.4)$$

70 The covariance of the entire (unsegmented) dataset is:

$$71 \quad (\overline{x'w'})_0 = \frac{1}{MN-1} \left[\sum x_j w_j - \frac{1}{MN} \sum x_j \sum w_j \right] \quad (S1.5)$$

72
 73 If $\left| \frac{\overline{x'w'} - (\overline{x'w'})_0}{(\overline{x'w'})_0} \right| > 30\%$, the data are considered non-stationary and are deemed
 74 to have failed the stationarity test.

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