Position monitoring of grazing cows for greenhouse gas emission measurements on pastures by micrometeorological methods

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Introduction Grasslands act as sinks and sources for greenhouse gases (GHG) and are, in conjunction with livestock production systems, responsible for a large share of agricultural GHG emissions. Ecosystem scale flux measurements (eddy covariance; EC) have been extensively used to investigate CO_2, CH_4, and N_2O exchange over different ecosystems and are becoming state of the art for animal grazing systems too. The advantage of EC flux measurements is the possibility of GHG emission monitoring under real grazing conditions on the pasture (in contrast to respiration chambers) with a high time resolution of about 30 min (in contrast to the SF_6 method). However, EC measurements represent a spatially integrated flux over an upwind area (the so-called footprint) in the order of 1000 m^2 containing a variable number of grazing animals. Thus a careful analysis of the footprint as a function of wind direction and wind speed (Schmid, 2002) is necessary. Recent studies using this method (e.g., Dengel *et al.*, 2011; Tallec *et al.*, 2012) lack data about the position of the animals relative to the flux footprint but stress the importance of this information. In our experiment we tested the applicability of an animal position monitoring system for EC flux measurements on a grazed pasture.

Material and methods The studied pasture (1 ha) at the Research Farm Agroscope ALP Posieux is located in the Central Plateau of Switzerland (46°46'N, 7°7'E) and is managed under a full-day grazing regime. During two days the positions of eight cows were monitored by commercial hiking GPS devices (BT-Q1000XT, Qstarz International Co., Taiwan) mounted at the animals neck and supplied with additional power from external batteries. Longitude and latitude were recorded at a rate of 1 Hz. The cows left the pasture two times a day for milking. The GPS sensor accuracy was tested by recording data for six hours by two devices placed at a fixed location side by side.

Results The difference in the position readings of the two fixed GPS sensors only varied between 0.13 and 1.98 m, and hence we consider the accuracy of the sensors to be about 2 m, which is much less than the typical extension of flux footprints. During grazing, the density distribution of the cow herd for an individual 30 minute interval (usual EC flux averaging time) shows that the cows were not uniformly distributed on the field nor in the footprint of the EC flux measurement (Fig. 1, left). For illustration the track of an exemplary single cow is indicated by the white solid line. Even during the entire 2-day grazing period, the spatial distribution of the cow herd (and also of individual cows) was not uniform (Fig. 1, right).

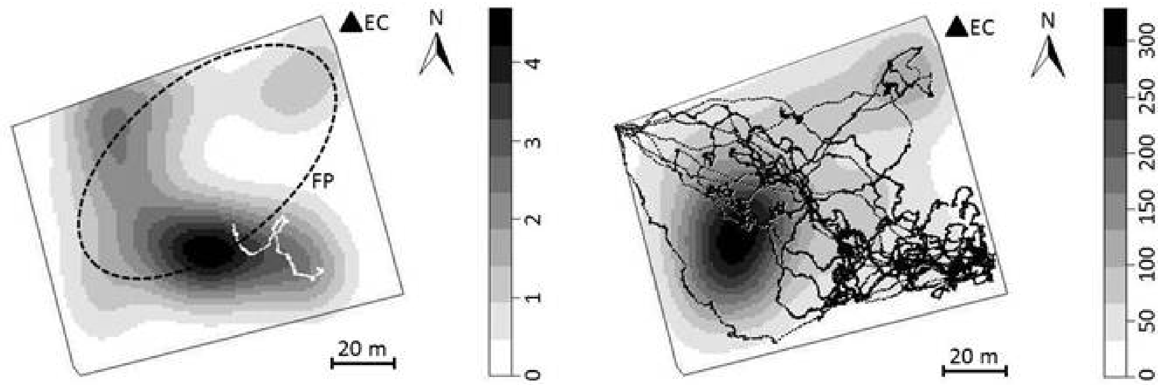

Figure 1 Density distribution of eight cows (gray shades, relative units) and track of an exemplary single cow (solid line) for an individual half-hour period (left panel) and for the entire 2-day grazing period (right panel). The triangle indicates the position of the EC measurement system and the dashed line represents a typical flux footprint (FP).

Conclusions The accuracy of the tested GPS devices is mainly determined by the number of satellites seen by the device and the atmospheric conditions. Despite the corresponding variations, the results indicates that the accuracy of the measured cow position is about 2 m and thus clearly sufficient for the localization of grazing animals within the EC flux footprint. With the data of the tested system, the relative contribution of the cows to measured GHG fluxes can be quantified. In this way the observed inhomogeneity of the animal distribution can be taken into account, which was not possible in previous studies.

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