Uncertainty towards the use of the angle-of-attack corrections for eddy-covariance data processing in French ecosystems

Virginie Moreaux (1), Nicolas Delpierre (2), Eric Dufrêne (2), Richard Joffre (3), Katja Klumpp (4), Denis Loustau (5), Daniel Berveiller (2), Olivier Darsonville (4), Jean-Marc Limousin (3), Jean-Marc Ourcival (3), Karim Piquemal (3), and Bernard Longdoz (6)

(1) UMR1137 d'Ecologie et Ecophysiologie Forestières, INRA, F-54280 Champenoux, France (virginie.moreaux@inra.fr), (2) UMR 8079 Ecologie, Systématique et Evolution, Université Paris-Sud, CNRS, AgroParisTech, Université Paris-Saclay, F-91400 Orsay, France, (3) UMR5175 Centre d'Ecologie Fonctionnelle et Evolutive, CNRS, Université de Montpellier, Université Paul-Valéry Montpellier, F-34293 Montpellier, France, (4) UR874, Unité de recherche sur l'écosystèmes prairial, INRA, F-63039 Clermont-Ferrand, France, (5) UR1391 Interactions Sol Plante Atmosphère, INRA, F-33140 Villenave d'Ornon, France, (6) Université de Liège, Gembloux Agro-Bio Tech, Belgium

The production/absorption of the long lived greenhouse gas (GHG) and the albedo and evapotranspiration fluctuations in forests, grasslands and croplands are responsible of atmospheric radiative forcing but the quantification of these forcings remains uncertain. The CESEC program aims to quantify the impact of climatic drifts or anthropogenic and meteorological events on the ecosystem-atmosphere exchanges of French sites by analysing the long series (at least 9 years between 2003 and 2015) of eddy covariance (EC) fluxes. One part of the CESEC project is to repost-processed homogeneously the raw EC data across the sites and the years to try to reduce the influence of the methodology and experimental design on the temporal and spatial variability. These new processed data are put together with the corresponding climatic and edaphic data and with the carbon stock inventory.

A number of French experimental sites have initially used a sonic anemometer from the GILL company, such as the GILL-R3 or the GILL R3-50, coupled with a GHG analyzer to perform EC measurements and deduce GHG exchanges from different ecosystems. Within the data processing procedure of eddy flux measurements, a recent type of correction has raised among the scientific community to account for the angle of attack error due to a distorsion of the flow when the wind approaches these GILL frame-type, resulting in an imperfect sine and cosine response. Nakai and co-authors proposed a correction to compensate for this error, which is expected to improve energy balance closure. No consensus has been clearly made on the application of this correction, but it has mostly been recommended for recent data processing. The universal flux calculation EddyPro software that we are using in our project, incorporate and recommand this correction.

Based on the analysis from two forests ecosystems (FR-Fon and FR-Pue) and a grassland (FR-Lq2) in France, we performed a re-analysis of EC measurements using the corrections described in Nakai et al. (2006) to account for the angle of attack correction of the sonic anemometer. These data were initially processed without Nakai's corrections within the data processing procedure of the European Fluxes Database or Fluxnet network.

Our results show a significant increase of energy and GHG fluxes from (5 to 30%). As a result, the energy balance closure can be improved. However, when partitionning carbon fluxes into the different components (GPP and Reco), the values obtained are significantly larger than previously and seem non-realistic from a biological point of view. Indeed, when comparing these higher values with the other measurements such as carbon inventory (soil and biomass), they couldn't fit with amount of carbon stored in the different compartments and no biological explanation can be yet found to approve the use of the Nakai's correction.