Geophysical Research Abstracts
Vol. 21, EGU2019-10330-1, 2019
EGU General Assembly 2019

A machine learning based approach for estimating gross carbon dioxide fluxes from eddy covariance net ecosystem exchange measurements.

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Eddy covariance (EC) technique is largely applied for monitoring carbon dioxide (CO_2), water (H_2O) and energy exchanges between land ecosystems and atmosphere. The use of EC is currently increasing and now more than 700 globally distributed sites are monitored. Additionally, the monitored study sites are often grouped in network (e.g. FLUXNET). EC allows the continuously monitoring of fluxes at fine (subdaily) time resolution over the growing season. However, only net fluxes can be directly measured, while the source signals must be retrieved by models. In the case of CO_2, EC measured the net ecosystem exchange (NEE), that is the net balance between two gross CO_2 fluxes: the CO_2 uptake from atmosphere by (ecosystem level) photosynthesis or gross primary production (GPP) and the CO_2 released in the atmosphere by ecosystem respiration (RECO). The partitioning methods applied in FLUXNET dataset allow to retrieve RECO and GPP from NEE and they made use of non-linear relationships and few meteorological drivers. In fact, the Lloyd & Taylor equation and air temperature are used for estimating RECO; GPP is retrieved by the Michaelis & Menten equation making use of the incoming radiation and vapor pressure deficit as drivers. These approaches are based on strong knowledge assumption and allow a large applicability; however there are limitations in particular when additional drivers have important effects on fluxes variability or when functional relationships deviate from the prescribed ones. In this experiment we investigated the feasibility to use a customized neural network algorithm (NNcust) for CO_2 fluxes partitioning. NNcust have been designed for estimating NEE by simultaneously retrieving GPP and RECO. The two gross CO_2 fluxes have been retrieved by two subnetworks each one using specific and comprehensive micrometeorological drivers from soil and atmosphere. We investigated many features of the partitioned fluxes and the comparison with FLUXNET standard methods have been carried out. The results showed high consistency between magnitude of partitioned fluxes by NNcust and standard methods implemented in FLUXNET such as in the seasonal, daily, subdaily variability and in the functional relationships between inputs and outputs. However, small (in magnitude) but consistent differences emerged by the comparison of the diurnal cycle of gross CO_2 fluxes that could be linked to deviation in modeled functions, the interaction of drivers or to the inhibition of leaf respiration in daytime condition, differently accounted in the modeled output.