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Multi-annual eddy-covariance measurements of surface energy balance components for urban, agricultural and natural wetland sites in Poland

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1. Introduction

A surface energy balance (EB) in a global scale is one of the most important factors determining the total energy received by the atmosphere. In a local scale it determines the modification of the region climate by the local conditions. The empirical data on the EB components are crucial for verification of our understanding of these processes. The long term data are necessary to verify if the regional and global models adequately represent the surface exchange processes. In consequence, they are necessary to improve weather predictions and climate projections.

A database of direct measurements of the energy balance components, in particular the turbulent fluxes, are still highly incomplete because of high cost of the measurement system, complex methodology and restrictions on system location. In Poland, as in many other countries, there are only a few sites providing regular measurements of the surface EB components including turbulent fluxes.

The main goal of this study is to present the results of multi-annual eddy-covariance (EC) measurements of the energy balance components at three locations in Poland: urban, agricultural and wetlands.

2. Measurement sites

Three measurement stations presented in this work belong to the network of Department of Meteorology and Climatology University of Łódź, Poland (Fig. 1). The longest eddy-covariance data comes from Łódź, the third biggest city in Poland, where the regular measurements started in November 2000 at Lipowa 81 str. The site (51°45'52'' N, 19°26'42'' E) is located in a compact building development with the urban core to the north and the east from the site. The eddy-covariance system was installed on the top 20m in height narrow mast mounted on the top of 5-storey building. The measurement height, 37m, is more than twice mean roof level which allow to assume that measurements are made in the inertial sub-layer (see Pawlak et al., 2011, Fortuniak et al., 2013, Fortuniak and Pawlak 2015 for more details). The present study is based on measurements from July 2006 to September 2015 at this site.

The agricultural site is located about 50 km east from Łódź (51°45'1'' N, 20°25'3'' E) close to Annosław village, in the typical Polish agricultural landscape. The EC system is fixed at the typical tripod at height of 3 m. The wheat, rye, potatoes, strawberry or other are cultivated at podzolic soil at the patched fields in the nearest surrounding of the site. The ongoing measurements at this site started in November 2011 and data used cover period to December 2015.

The third station is located at the natural wetlands of Biebrza National Park in the Middle Biebrza Basin close to the village Kopytkowo (53°35'30.8" N, 22°53'32.4" E). The EC system is mounted at height 3.7 m at the mast above the instrumentation screen. In the nearest neighborhood of the measurement site, the vegetation is dominated by the mixture of reeds, sedges and rushes typical of Biebrza wetlands. A few scattered houses are located about 300m south of the site (Fortuniak and Pawlak 2014). The measurements on this site started in November 2012, but the data used in this work cover period June 2013 – December 2015 (more details at: http://nargeo.geo.uni.lodz.pl/~meteo/kf/Biebrza/EC_Kopytkowo_BPN.html).

Figure 1. Measurement sites location in Poland: Lódź – urban, Annosław – agricultural, Kopytkowo – wetlands.

3. Instrumentation and data processing

All three eddy covariance systems are equipped in sonic anemometers (RMYoung 8100) and Li7500 gas analyzers. The measurement frequency is set as 10Hz. The radiation balance components are measured with the aid of CNR1 net radiometers. Additional slow respond sensors complete the measurements. The systems are governed by CR5000 datalogges.

Turbulent fluxes were calculated with a standard methodology on a 1-hour basis: the block averaging with the optimal time lag between two datasets, double rotation in natural wind coordinates, humidity correction of sonic temperature, WPL correction, corrections for spectral losses. Three statistical test were used in data quality verification (see Fortuniak et al., 2013, Fortuniak and Pawlak 2015 for tests details).

4. Results

The summary of the multi-annual energy balance measurements at three sites is presented at Fig. 2 as daily patterns of the EB components in seasons. The diurnal

courses of net radiation (Q*), sensible heat flux (Q_h), latent heat flux (Q_e) and heat flux to the ground (Q_g) represents typical values for the studied ecosystems and can be used for models verification. Numerical experiments with the surface scheme applying Monin-Obukhov similarity suggest that such kind of parameterization can adequately represent the surface exchange of momentum, mass and energy for all locations, including the urban one, for which the applicability of M-O theory is disputable.

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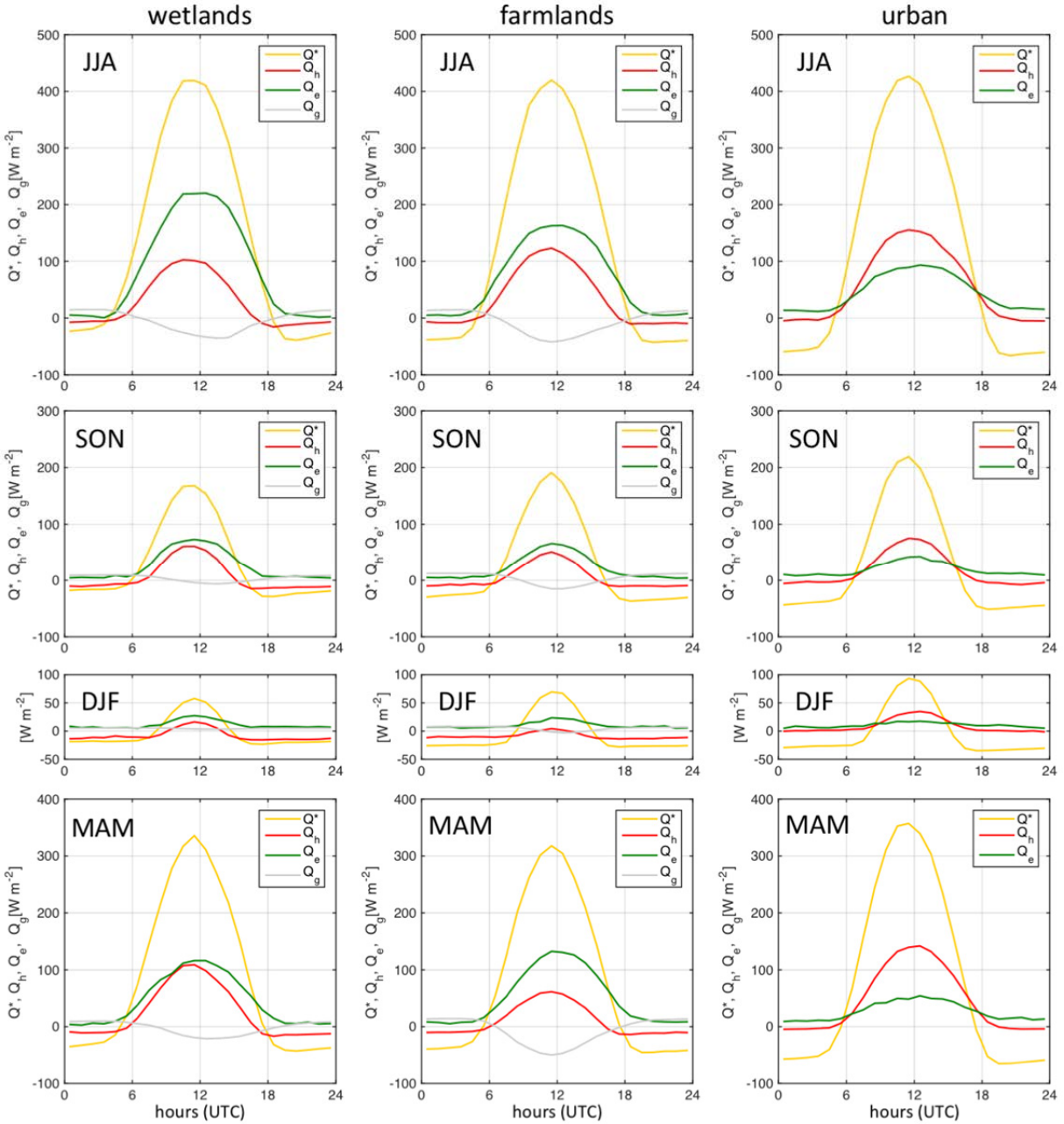

Figure 2. Daily patterns of the energy balance components for seasons for wetlands, farmlands and urban sites in Poland based on multi-annual eddy-covariance measurements.