Energy budget at the Experimental Vineyard in Zagreb

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Introduction

VITiculture and CLImate Change in Croatia (VITCLIC) is a new project in Croatia for the analysis of the current situation in viticulture; its focus is on changes in the times of harvest and the basic parameters of quality grapes.
Micrometeorological measurements are performed at two locations: i) in the Istrian peninsula and ii) in the viticulture and wine experimental station at the Faculty of Agriculture near Zagreb (partly supported by the Croatian-Hungarian bilateral scientific program) during the vegetation periods 2017–2018 and 2018–2019.

Motivation

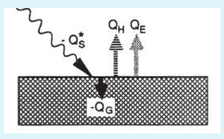
Our goal was to estimate the sum of heat fluxes and net radiation on the surface of experimental Vineyard in Zagreb. The resulting energy plays an important role in heating objects near surface. Furthermore, energy budget is fundamental procedure in planetary boundary layer modeling. This calculation is good test for our experimental devices and their arrangement as well.

A micrometeorological measurements are performed in the Faculty of Agriculture experimental vineyard near Zagreb in the hilly experimental field during the vegetation periods 2017–2018 and 2018–2019. Microclimate of two places of cordon cultivated grape have been studied for the investigation of the effect of cultivation method. In one row grape was left to be naturally covered by leaves while in the other the leaves were being thinned corresponding to the cultivation method.

Theory

The energy budget for infinitesimally thin layer shown on the picture below is:

$$-Q_S = Q_H + Q_E - Q_G.$$



Q_S is upward radiation at the surface,
$Q_H = c_p \langle w'\theta' \rangle$ upward sensible heat flux out of the top
$Q_E = L_V \langle w'q' \rangle$ upward latent heat flux out of the top
Q_G upward molecular heat flux into the bottom.

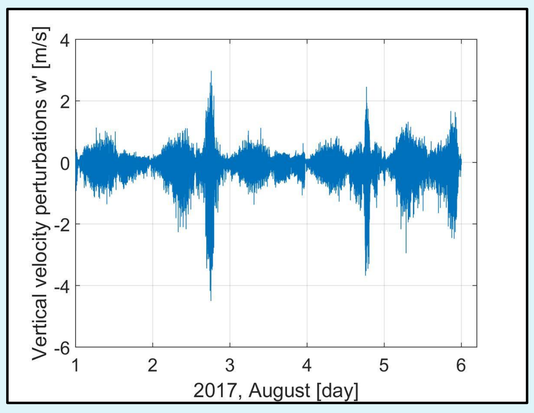
The Bowen ratio is defined as $\beta = Q_H / Q_E$ at the surface. We measured w' and θ' near surface what directly gives result for Q_H. Since there was no possibility to measure q', we calculated Bowen ratio using formula:

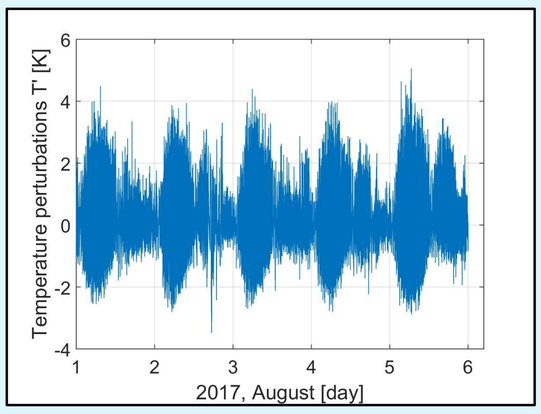
$$\beta = 1.46 \left(\frac{1}{RH}\right) \left(\frac{T}{273}\right)^2 \exp\left[-19.83\left(1 - \frac{273}{T}\right)\right]$$

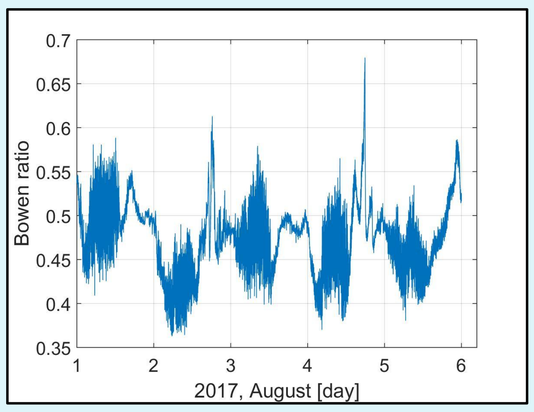
Relative humidity *RH* and absolute temperature *T* were measured at the same height as w'. Then Q_E was calculated as $Q_E = Q_H / \beta$. Ground heat fluxes are calculated using gradients at depth 2cm, 5cm, 40cm, 100cm which are interpolated to the surface level. For this calculation we used formula

$$Q_G = -k_g \Delta T / \Delta z$$

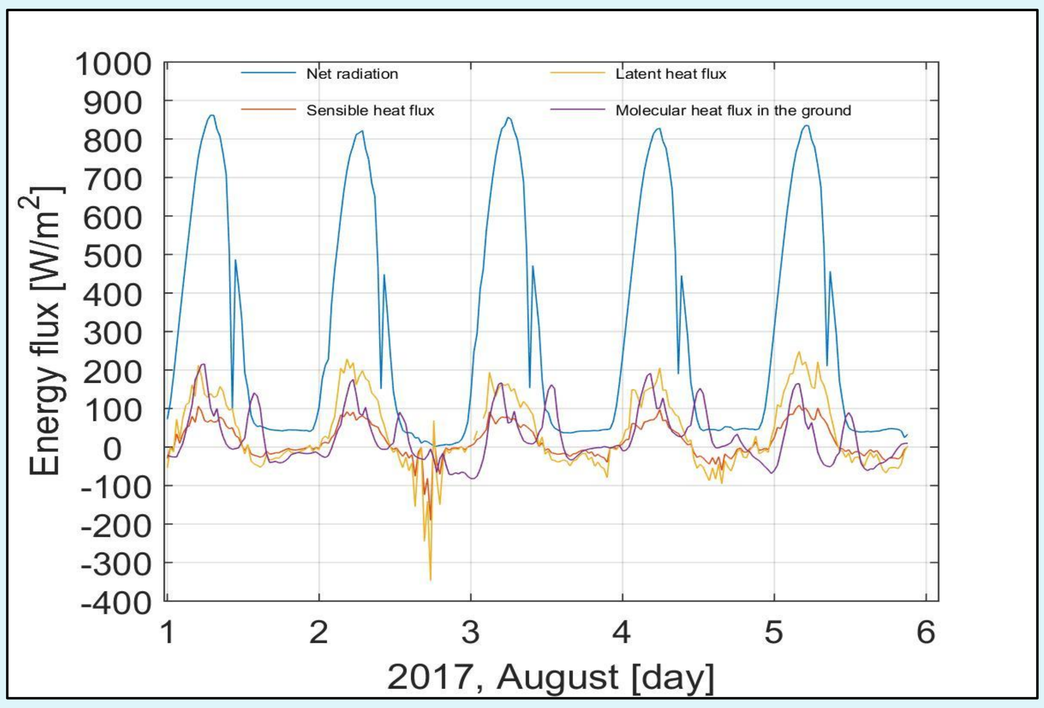
Results

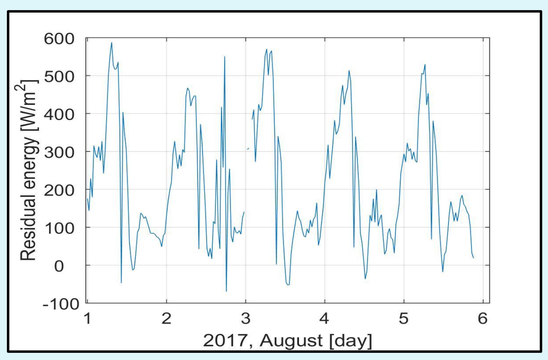


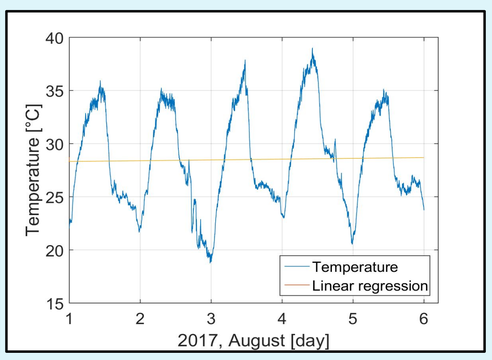




Vertical velocity perturbations are usually the smallest at the midnight, and variability is around 6m/s.
Temperature perturbations also tend to be the smallest at midnight, and their variability is around 6K.
Bowen ratio values varies between 0.35 and 0.7.
This high-frequency data is later averaged in 30 minute intervals.







Residual energy shows daily variability of 600 W/m^2 , with maxima usually in the morning. Air temperature shows similar behaviour, but less variable. Residual energy is mostly positive, what can be caused because of slight temperature rising, what is, further, connected with yearly temperature behaviour.

Instrumentation

In the canopy (80 cm):

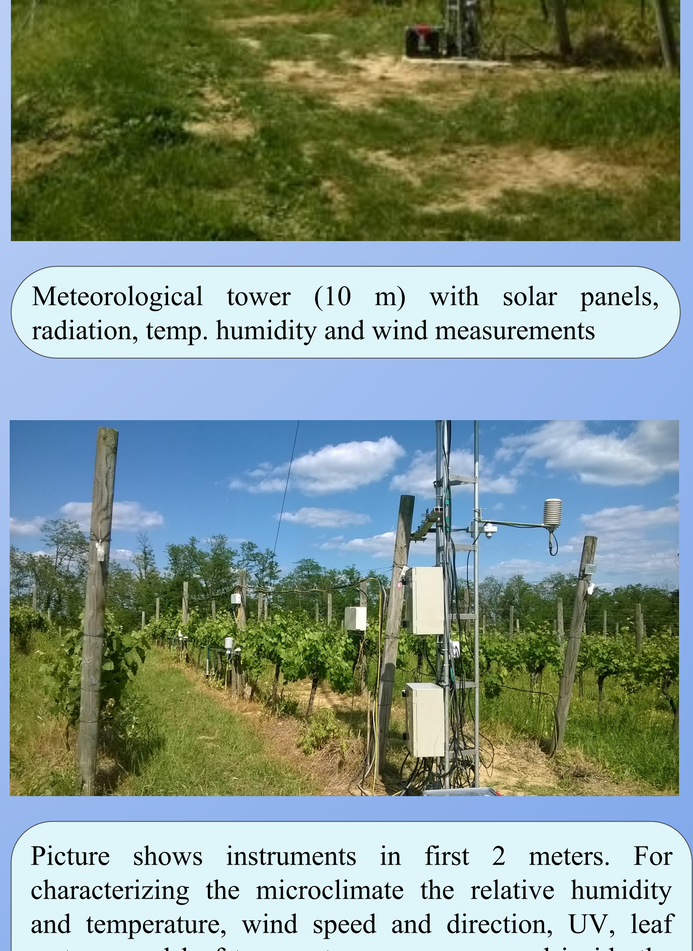
2 x Kipp & Zonen SUV5 Broadband UV Radiometer
2 x YOUNG Model 41382 RH/T probe with a radiation shield
2 x Gill WindMaster 3D Anemometer
Campbell Scientific CR-3000 data logger, solar powered, 3G modem

Tower:

2 m: Kipp & Zonen CNR-1 – 4 component radiometer,
Vaisala HMP-45 T/RH sensor
4 m: Vaisala HMP-45 T/RH sensor, Kipp & Zonen PQS1 PAR sensor, Vaisala WAA15A cup anemometer
10 m: Gill WindMaster 3D Anemometer

Soil:

Campbell Scientific CR23X datalogger
1 x Thermocouple Type-E (ref, in box)
3 x Campbell CS616 soil-moisture sensor (1 m, 40 cm, 5 cm deep)
1x Campbell 237-L Leaf-Wetness Grid
4 x Campbell T107 Temperature Probes (1 m, 40 cm, 5 cm, 2 cm deep)
1 x Campbell IRTS-P infrared thermometer (80 cm above ground)
2 x Hukseflux HFP01 heat-flux plate (8 cm), self calibrated



Meteorological tower (10 m) with solar panels, radiation, temp. humidity and wind measurements

Picture shows instruments in first 2 meters. For characterizing the microclimate the relative humidity and temperature, wind speed and direction, UV, leaf wetness and leaf temperature were measured inside the cordon rows among the leaves. Temperature, relative humidity and wind speed gradient have been also measured above the plants.

Data used in this poster is provided by the HrZZ project (VITCLIC) (PKP-2016-06-2975) which is funded by the Environmental protection and energy efficiency fund under the Government program (Ministry of environment and energy & Ministry of science and education) for the Promotion of research and development activities in the field of climate change for the period 2015–2016.

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