VERTICAL OZONE FLUX IN BACKGROUND AREA OF TOMSK REGION

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ABSTRACT

In this work presented calculations results of vertical ozone flux in atmospheric surface layer. This flux was calculate, using measurement data from vertical mast located on the territory of the observatory Fonovy since September 2015 until March 2016. Significant daily flux dynamics was record in September, February and March. Minimal flux observed at nighttime, then maximal flux observed at daytime and reached: -3.8, -3.2, -3.4, μg/(m^{2}2s) month relatively. For the October, November, December, and January significant daily dynamic is absent, daily value flux were -2.3 $\pm$ 0.2, -1.6 $\pm$ 0.2, -1.5 $\pm$ 0.3, -0.7 $\pm$ 0.3 μg/(m^{2}2s) relatively.

Keywords: vertical ozone flux, surface layer, ozone, deposition rate

1. INTRODUCTION

In present time, global and mesoscale models of the chemical weather forecast actively developing MOZART, ECHAM, IMPACT, WRF. For the proper model working, it is necessary to parametrize exchange between atmosphere and surface layer. For this goal, commonly using the deposition rate on surface layer. Most of the time it is set as priori boundary condition. Value of deposition rate depends from it is own vertical flux, concentration, surface layer type, vegetation, from season and daytime. Usually in simulation, specify fixed value, without daily and season dynamics. In our work, we illustrate for ozone example, how deposition rate and flux value depends at season and daily time, basing on real gradient measurements. Received results allows, in the future, decrease mistakes in chemical compound atmospheric forecast.

2. MEASUREMENT DATA AND CALCULATION METHODS

Vertical ozone flux was calculate basing on measurement data since September 2015 till March 2016 obtained from green gasses monitor post, located in observatory "Fonovy" (56^{0}25' north latitude, 84^{0}04' east longitude, and 80 meters high over sea level). Post consist of 40 meters height mast, and building next to it, with measurement equipment, (there is constantly t +20^{0}C in a building). There are meteorological sensors on the 10, 20, 30, 40 meters altitude, and gas composition sensors on the 10 and 30 meters height above the ground, on the mast. Measurement ozone concentrations making by the 3.02 P-A ZAO OPTEK" device, relative measurement error

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are ± 20 % in a range concentration 30 - 500 μg/m^3. Paths with air samples made from chemical neutral material PTFE (tube with outside diameter - 12 millimeters, wall thickness - 1 millimeter, pump with - 20 liters/min rate, and receiver - 0.7 liters volume).
Vertical ozone flux on the surface layer calculated with Obuhov-Monin similarity theory, using this formula:

$$F_{O_3}(z_m) = -K\frac{\partial O_3}{\partial z} \quad (1)$$

where, $-\frac{\partial O_3}{\partial z}$ - vertical gradient ozone concentration, K - coefficient of turbulence.
In the calculations was made following rule: vertical gradient$-\frac{\partial O_3}{\partial z}$, and flux $F_{O_3}(z_m)$ with it, positive (directed upwards), if concentration reduces with height ($\Delta O_3 < 0$) and negative (directed downwards), if concentration increases with height ($\Delta O_3 > 0$).
Coefficient of turbulence for the reference height z_m calculated by next formula:

$$K = \frac{kz_m u_*}{\varphi_h(\xi_m)} \quad (2)$$

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where, $k = 0.4$ is Karman constant, u_* - speed of friction, ξ - stability parameter, $\varphi_h(\xi_m)$ - universal dimensionless function, $z_m = (z_1 + z_2)/2$ - reference calculation height, z_1, z_2 - measurement heights.
Friction speed calculated by next formula:

$$u_* = \frac{kz_m}{\varphi_m(\xi_m)}\frac{\partial U}{\partial z} \quad (3)$$

Stability parameter determined on the Richardson gradient number (Ri_m)

$$Ri_m = \frac{g}{\theta_0}\frac{\frac{\partial\theta}{\partial z}}{\left(\frac{\partial U}{\partial z}\right)^2} \quad (4)$$

where, $\frac{\partial\theta}{\partial z}$ - potential temperature gradient, $\frac{\partial U}{\partial z}$ - wind speed gradient, Θ_0 - average temperature.
Calculating values of universal functions $\varphi_m(\xi_m)$ and $\varphi_h(\xi_m)$ depends on atmospheric stability parameter by next formula:

$$\varphi_m(\xi_m) = 1 - 5\xi_m, \xi_m \geq 0 \quad (5)$$

$$\varphi_h(\xi_m) = 1 - 5\xi_m, \xi_m \geq 0 \quad (6)$$

$$\varphi_m(\xi_m) = (1 - 16\xi_m)^{\frac{-1}{4}}, \xi_m < 0 \quad (7)$$

$$\varphi_h(\xi_m) = (1 - 16\xi_m)^{\frac{-1}{2}}, \xi_m < 0 \quad (8)$$

Flux size connected with deposition rate, which one calculated by next formula:

$$v_{O_3} = -F_{O_3}/O_3 \quad (9)$$

As usual, deposition rate results are in centimeters per second (cm/s), what is more positive value means that exchange goes from top to bottom, then negative means contrariwise.

3. RESULTS

As results, we get daily vertical ozone flux distribution and deposition rate. In Figure 1, we can see daily graph of ozone flux and deposition rate dynamic from September 2015 to March 2016.

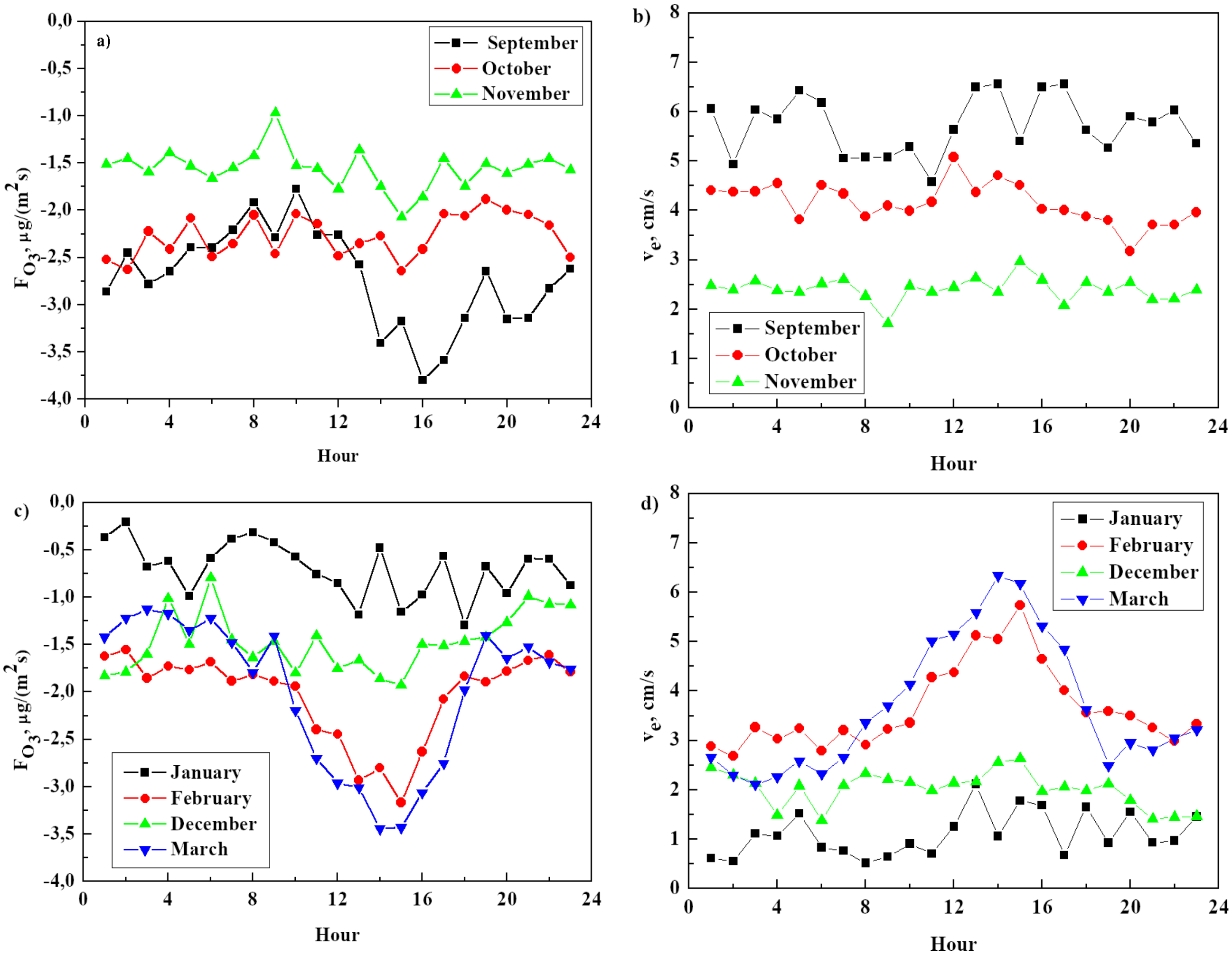

Figure 1. Daily behavior vertical ozone flux (a,b) and deposition rate (c,d) calculated for the period from September 2015 to March 2016.

Basing on graph behavior (Fig. 1. a, c) we can make conclusion about having significant vertical ozone flux daily dynamic traceable in September, February and March. Minimal flux observed at night time, maximal at daytime and reached: -3.8, -3.2, -3.4 $\mu g/(m^2s)$ month relatively. For the October, November, December, and January significant daily dynamic is absent, daily value flux were: -2.3 $\pm$ 0.2, -1.6 $\pm$ 0.2, -1.5 $\pm$ 0.3, -0.7 $\pm$ 0.3 $\mu g/(m^2s)$ relatively. In reporting period, ozone flux was negative, that is mean that the ozone source is located higher then upper level of our metering. Significant daily precipitation speed (Fig. 1. b, c) fixed for February and March. Minimal deposition speed observed at nighttime, maximal at daytime and reached 5.7, 6.3 cm/s, relatively. For September, October, November, December and January significant daily dynamic was not record, and daily deposition speed was 5.7 $\pm$ 0.6, 4.1 $\pm$ 0.4, 2.4 $\pm$ 0.2, 2.0 $\pm$ 0.4, 1.1 $\pm$ 0.4 cm/s. Obtained values of ozone flux are in good agreement with values given in works [3,4].The authors of work [3] , show that ozone flux value could be 0,8 $\mu g/(m^2s)$ (60 micromole/m2h) in spring-summer period, and 0,4 $\mu g/(m^2s)$ (30 micromole/m2h) in autumn-winter period.

4. CONCLUSION

Demonstrated analysis shows, for ozone flux and for deposition speed, the high grade of internal day behavior and seasons volatility are typical. Using obtained data, as boundary conditions in atmospheric chemical models, will allows significantly improve the results of the prediction in the future.

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