Operative Objective Analysis of Productive Moisture Fields in the Top Soil Layer: Day-to-Day Variability

Bykov Ph.L. [1,2)], Gordin V. A. [2,1)], Tarasova L.L. [1)], Vasilenko E.V. [3)]
[1)] Hydrometeorological Centre of Russia, [2)] National Research University – Higher School of Economics, [3)] Research Center "Planeta"

Soil moisture is one of the components of water balance in nature. Traditionally, during the growing season of agricultural crops, hydrometeorological stations evaluate (see e.g. Fig.1) the amount productive moisture located in the layers 0-10, 0-20, 0-50 and 0-100 cm.

We also use information from polar orbital MetOp-A and MetOp-B satellites (and are going to add the information from MetOp-C) with measuring devices – scatterometers ASCAT. Their measurements permit to evaluate humidity in the upper (about 5-cm) soil layer, using remote sensing (ERS). The data is quickly distributed to the meteorological center via the system of data exchange EUMETSAT. We use (see [1]) both types of the information for our daily operative objective analysis (OOA) of soil productive moisture in the top (0-10 cm) and arable (0-20 cm) soil layers, see Fig.1. A considerable part of Russian agricultural areas are located in the European territory, and there is a rather a dense network of Roshydromet stations making observations of the reserves of soil moisture 3 times a month.

Here we compare the fields of our OOA and meteorological fields valid at the same time. We compared the data on soil moisture in the arable layer and precipitation. Days with heavy (more than 20 mm/day) rains were studied here. It was expected that on such days the following "jump" of soil moisture as a function of time would be most evident. Indeed, the soil moisture content increased in about 75% of cases, but it decreased in about 25% of cases. The interaction of the solid part of soil and water, as well as the movement of moisture in the soil can explain this phenomenon. Fig. 1 shows an example of the soil moisture for July 22 2018 and Fig. 2 presents the day-to-day dynamics of soil moisture at the hydrometeorological station Pochinok (Smolensk region).

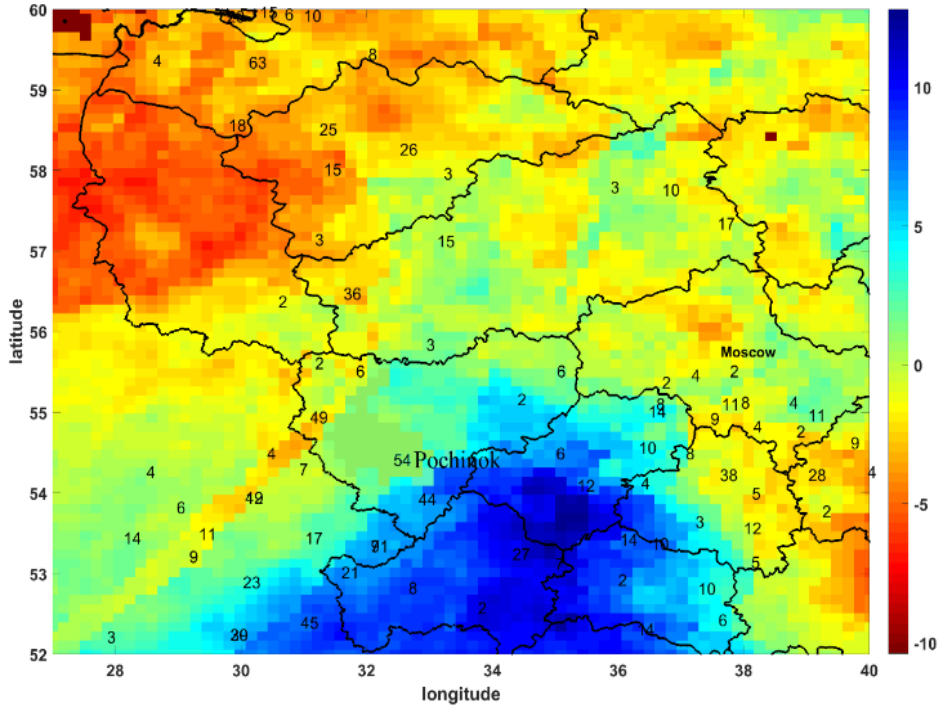

Fig.1. The daily OOA change of productive moisture (mm) in the soil layer [0, 20 cm] on July 22 day 2018 (color). The numbers on the map show the amounts of precipitation (mm) that fell during the day

The moisture movement within the soil depends on the soil humidity. A.A.Rode [2] marks out several categories of forces, which affect the moisture contained in the soil. They are a) gravity (gravitational forces); b) capillary (meniscal) forces or forces of superficial pressure; c) sorption forces, representing a combination of attractions between water molecules and their attraction to soil particles; d) osmotic forces, representing attraction between ions and molecules in the solution and from exchange soil cations. Gravitational forces are constant and always directed down, other forces strongly depend on moisture content in the soil and can have

any direction. When the soil humidity increases, first the adsorptive forces act, trying to approach the maximum adsorptive moisture capacity. Only then, the sorption comes into effect. With humidity increasing and sorption weakening, the capillary forces enter the game. Further, sorption and gravitational forces become commensurable. In this connection, forces of all these three categories can affect together the moisture movement during this interval. Thus, while soil humidity increases, the forces acting on moisture within the soil decrease.

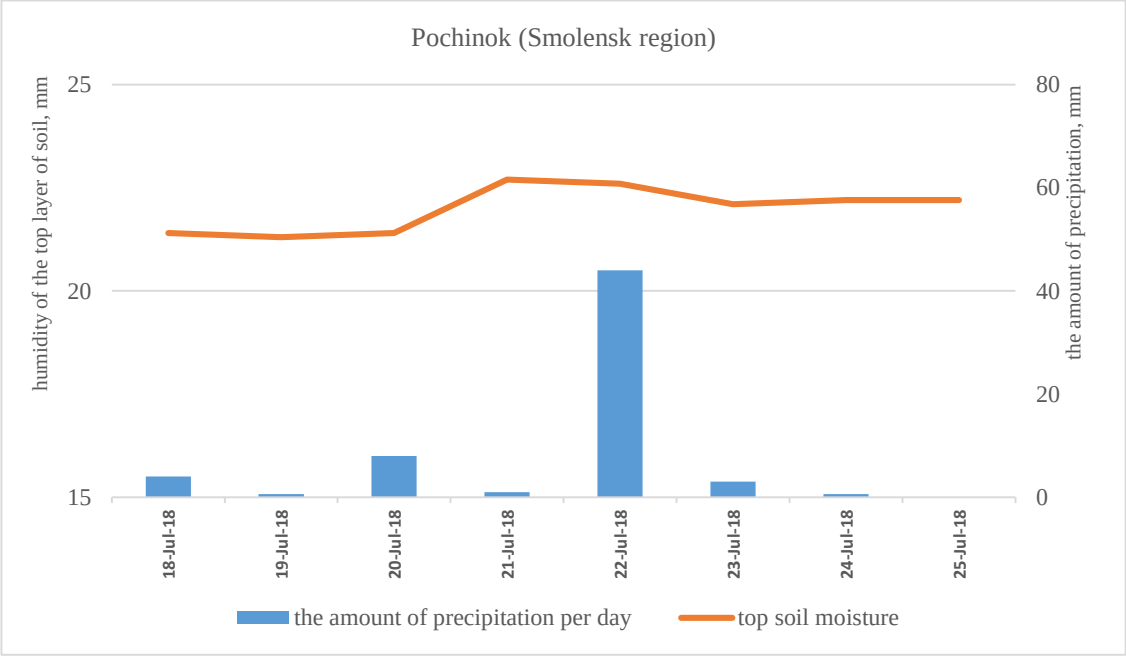

Fig.2. Dynamics of OOA of productive moisture of the top soil layer [0, 20 cm] and the amount of precipitation at the hydrometeorological station Pochinok (Smolensk region).

Therefore, a "jump" of humidity, as a function of time, only in days before which no precipitation was observed.

If even slight rains fell during the preceding period thus filling the soil with moisture, no humidity increase in the top soil layer is observed, since the moisture arriving on the soil surface will flow down into underlying layers.

We investigated also the days with hot dry wind (more exactly: the deficiency of partial pressure of water vapor exceeded 20hPa, and the maximum speed of the surface wind was more than 15 m/s). Under such conditions, the top soil should lose moisture quickly. According to the OOA, a decrease in humidity in days with hot dry winds was not observed except for cases with preceding soil desiccation (relative humidity <20% of the top soil).

Thus, our OOA of productive soil moisture based on the land and satellite observations allows to explain day-to-day variability and to evaluate adequately intra soil moisture fluxes.

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Literature

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