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Using information from polar-orbital and geostationary satellites to assess components of water and heat balances for large agricultural region

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The physical-mathematical model of vertical water and heat transfer in the "soil-vegetation-atmosphere system" (SVAT) suitable for using satellite information on land surface and meteorological conditions has been developed. This information is represented by measurement data of the radiometers MSU-MR/Meteor-M No 2, AVHRR/NOAA and SEVIRI/geostationary Meteosat-10. The SVAT model is designed to calculate soil water content W, evapotranspiration Ev, vertical heat fluxes and other components of water and heat balances, as well as the land surface temperature (LST) and temperature and soil moisture distributions in depth. The case study has been carried out for part of the Central Black Earth region of European Russia with area of 227300 km2 for vegetation seasons of 2014-2016 years.

From satellite data the estimates of precipitation, LST, LAI and B have been built for the study area. Estimates of precipitation amounts have been made using the Multi Threshold Method (MTM) for detecting clouds, identifying its types, distinguishing precipitation zones and determining their intensity. The method is based on the implementation of the transition from estimation of precipitation intensity to calculation of their daily sums. For most dates the MSU-MR-, AVHRR- and SEVIRI-derived daily, decade and monthly precipitation sums are found to be in agreement with each other and with ground-measured values. The estimates of LST from MSU-MR data have been obtained using computational algorithm developed on the basis of the MTM and tested for the region under investigation on AVHRR and SEVIRI data. Discrepancies between satellite-derived LST estimates and ground-based observations have been within the permissible limits. The correctness of the estimates of LAI and B from data of all sensors has been verified by comparing the LAI time runs over the vegetation season built on these data and the results of processing ground-based observation data.

Assimilation of satellite-derived estimates of the described vegetation and meteorological characteristics in the model has been made by entering their values in the nodes of the computational grid of the model at each time step to calculate components of the water and heat balances of the study area. The reliability of the modeled W and Ev for all variants of calculating LAI, B, LST and precipitation from data of all sensors has been confirmed by the results of their comparison with each other and with ground-measured data. The RMSE of the W and Ev estimates have not exceeded standard values.

The possibility of using soil surface humidity estimates obtained from the scatterometer ASCAT/MetOp-B data when modeling has been also investigated. Verification of the correctness of such estimates for the territory under consideration during the vegetation seasons has been made when compared with modeled soil surface humidity values. The differences of satellite and model estimates of surface humidity have been within the permissible limits. Such result allows using the ASCAT data in the model when specifying the initial conditions for the vertical soil water transfer equation, as well as for calculating evaporation from the soil surface and then forming the upper boundary condition for this equation.