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Simulation of the water regime for a vast agricultural region territory utilizing measurements from polar-orbital and geostationary meteorological satellites

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The model of land surface-atmosphere interaction has been developed to calculate the water and heat balance components for vast vegetation covered areas during the growing season. The model is adjusted to utilize estimates of the land surface and meteorological characteristics derived from satellite-based measurements of radiometers AVHRR/NOAA, MODIS/EOS Terra, Aqua, and SEVIRI/Meteosat-9. The studies have been conducted for the territory of the European Russia Central Black Earth Region (CCR) with area of 227,300 km2 comprising seven regions of the Russian Federation for years 2009-2012 vegetation seasons.

The technologies of AVHRR and MODIS data thematic processing have been refined and adapted to the study region providing the retrieval of land surface temperature Tls and emissivity E, land-air temperature (temperature at vegetation cover level) Ta, normalized difference vegetation index NDVI, vegetation cover fraction B, as well as the leaf area index LAI. The updated linear regression estimators for Tls, Ta and LAI have been built using more representative training samples compiled for the above vegetation seasons. The updated software package has been applied for AVHRR data processing to generate named remote sensing products for various dates of the mentioned vegetation periods. On the base of special technology and Internet resources the remote sounding products (Tls, E, NDVI, LAI), derived from MODIS data and covering the CCR, have been downloaded from LP DAAC web-site for the same vegetation seasons.

The new method and technology have been developed and adopted for the retrieval of Tls and E from SEVIRI data. The retrievals cover the region of interest and are produced at daylight and nighttime. Method provides the derivation of Tls and E from SEVIRI measurements carried out at three successive times (for example, at 11.00, 12.00, 13.00 UTC), classified as 100% cloud-free for the study region without accurate a priori knowledge of E. The validation of remote sensing data on Tls was carried out through comparison of SEVIRI-based Tls retrievals (after bias correction) with independent collocated Tls estimates generated at LSA SAF (Lisbon, Portugal). It gives monthly-averaged values of RMS deviation in the range of 1.1-2.1ºC for various dates and times during the period June-August 2009-2012.

In addition the new method and technology have been also developed and tested for the Ta retrievals from SEVIRI data at daylight and nighttime. To derive Ta, the SEVIRI-based Tls estimates were used together with previously found correlation relationship between Tls and Ta. A comparison with collocated in-situ Ta observations, made at the CCR territory weather shelters, gives RMS errors in the range 1.8-2.9ºC for the standard synoptic times and 2009-2012 summer periods. The error level is comparable to that inherent for the best foreign analogues as well as for numerical weather forecasting schemes.

Developed techniques to assimilate remote sensing data in the model include the following:

- replacement the values of the model parameters LAI and B, determined by observations at agricultural meteorological stations, by their satellite-derived estimates. Adequacy of such replacement has been confirmed by the results of comparing time behaviors of LAI built by ground- and satellite-based data, as well as the ground-measured and satellite-derived values of Tls and Ta, and modeled and measured values of evapotranspiration Ev and soil moisture content W.
- entering the values of Tls and Ta retrieved from all aforementioned satellite data into the model as the input variables instead of the respective ground-measured temperatures. Availability of the SEVIRI data of fine temporal resolution creates opportunity to calculate the water and heat balance components quite accurately. However, the lack of the long continuous SEVIRI data series (because of the cloudiness) restricts this opportunity in a large extent.
- taking into account spatial variability of vegetation and meteorological characteristics when calculating the water

and heat balance components by entering the spatially-distributed NOAA-, EOS/Terra and Aqua-, Meteosat-9-derived estimates of LAI, B, Tls and Ta as well as the spatially-interpolated ground-based meteorological inputs (precipitation intensity, air temperature and humidity) into the model.
- calculation of evapotranspiration, soil water and heat content and other water and heat balance components for the study area of the CCR for years 2009-2012 vegetation seasons utilizing the spatial fields of the AVHRR- and MODIS-derived values of LAI and B as well as the AVHRR-, MODIS-and SEVIRI-derived values of Tls and Ta; presentation of the results as area-distributions over the whole territory under consideration.
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