Thermal remote sensing for soil salinity assessment

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Abstract:

Soil salinity is a serious environmental problem, especially in arid and semi-arid regions. Danger of this problem lies in the fact that high level of salts in soil inhibits growth and development of crops. Up to date soil salinity information is vital for appropriate management practices and reclamation strategies. This information is required at increasing spatial and temporal resolution. Conventional soil sampling and associated laboratory analyses are slow, expensive, and cannot cover the temporal and spatial variability required. The change of canopy temperature is one of the stress indicators in plants. Its behaviour in response to salt stress on individual plant level is well studied in laboratory and greenhouse experiments, but its potential for landscape scale studies using remote sensing techniques is not investigated yet. In this study possibilities of satellite thermography for landscape scale soil salinity assessment of cropped areas were studied. The performance of thermal imagery is compared with other approaches that have been used before, like Normalised Difference Vegetation Index (NDVI), Enhanced Vegetation Index (EVI) and terrain properties. The study area was Syrdarya province in semi-arid area of Uzbekistan, which consists of salt affected irrigated croplands of mainly cotton and wheat. MODIS satellite images were used as indicator for canopy temperature and the provincial soil salinity map as ground truth. Four soil salinity classes were distinguished: non-saline, slightly saline, moderately saline and highly saline. ANOVA was used to analyse relations between the soil salinity map and canopy temperature, normalised difference vegetation index (NDVI), enhanced vegetation index (EVI) and digital elevation model (DEM). The time series graphs were created to analyse the dynamics of the indicators during the growing season. The results showed significant relations between the soil salinity map and canopy temperature. The calculated F-values were higher for canopy temperature than for all other compared indicators. The vegetation indices also showed significant differences, but F-values were lower compared to canopy temperature. The visual comparison of the soil salinity map and the canopy temperature map highlights some similar spatial patterns, the NDVI and EVI maps look more random and noisy and patterns are less pronounced than of the thermal map. DEM, slope and aspect analysis did not showed statistically significant result, so we conclude that relief data is not a good predictor of soil salinity on our study area. The strongest relation between the soil salinity map and canopy temperature was observed for cotton in September, so a the end of a dry season and period of maximum crop development. Nevertheless, F-values for the whole period from end-July to mid-September showed almost equally strong and significant relations and potentially can be used for monitoring. Satellite thermography appeared to be a valuable approach in our study for detecting soil salinity under agricultural crops at landscape scale. One of the direction for further research is to evaluate the general applicability of the proposed approach in terms of different crops and regions.