Detection of Water Deficit Using Optical Data – Case study Poland

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The great demand on quick actual information on crop growing conditions and yield forecast for cereals caused the development of the method which is based only on remotely obtained data. During the vegetation growth, for the official crop yield forecast a great number of information about actual crop growth conditions come from agricultural correspondents working in different regions of the country. All this information is used by experts in the Central Statistical Office to prepare official estimates of yield of the main crops. The results of these predictions are published in official bulletins and delivered to the Ministry of Agriculture and other governmental and local authorities throughout Poland.
Unfortunately, in situ data are very limited and some of the administrative regions are not covered by ground measurements. They are applied in rather small areas and results are extrapolated to incomparable greater surfaces. Currently, in Poland, the agriculture area occupies 54% of the whole country and is lower by 6.9% comparing to the year 1996.
Therefore, due to their high temporal resolution, the SPOT VEGETATION and NOAA AVHRR images have been used as the main source of information about the crop.
Observations from SPOT VEGETATION give the daily coverage of the Earth of spatial resolution of 1km. The data were processed by VITO and supplied as 10-day composite images corrected for atmospheric effects and with the cover of the cloud mask. NOAA operational polar-orbiting satellites provide synoptic information and a regular repetitive observation. The NOAA AVHRR station was situated in the Institute of Geodesy and Cartography.
From SPOT VEGETATION, the Normalized Vegetation Index (NDVI) for each decade of the year has been obtained. The AVHRR data collected in the first two channels have been used to calculate NDVI and the data obtained in the channels 4 and 5 have been used to calculate surface temperature (Ts).
Three indices - Vegetation Condition Index (VCI), Accumulated Vegetation Condition Index (AVCI) were based on NDVI and Temperature Condition Index (TCI) was based on surface temperature. These indices have been computed for agriculture area for each ten-day period of the year. The procedure introduced by Kogan (1997) followed by other authors (Dabrowska–Zielinska et al. 2002; Kidwell 1996) included into the consideration the range of fluctuation of NDVI due to weather conditions from year to year in each agriculture pixel. These variability of NDVI were estimated relative to the maximum and minimum (max/min) intervals of NDVI and named the Vegetation Condition Index (VCI):

$$VCI=100[(NDVI-NDVI_{min})/(NDVI_{max}-NDVI_{min})$$

where: NDVI, $NDVI_{max}$, and $NDVI_{min}$ are decade NDVI, its multi-year absolute maximum, and minimum.

The Temperature Condition Index (TCI) was calculated using surface temperature from NOAA/AVHRR and decade minimum and maximum for each of the pixel.

$$TCI = (TS_{max}–TS)/(TS_{max}–TS_{min})100$$

where: TS, TS_{max}, and TS_{min} are decade TS, its multi-year absolute maximum, and minimum.

The data base of the indices and obtained statistical models were used for developing the Predictive Indices (PTVCI and PTTCI) applied for the forecast of winter wheat and cereal yield for each decade of the year. The algorithms for prediction of crop yield (PTVCI and PTTCI) has been developed using VCI and TCI data as follows:

$$PTVCI_n(i) = \begin{cases} VCI_n; & n < i \\ m_n(i) \cdot VCI_{n-1} + b_n(i); & n \geq i \end{cases}$$

$$PTTCI_n(i) = \begin{cases} TCI_n; & n < i \\ m_n(i) \cdot TCI_{n-1} + b_n(i); & n \geq i \end{cases}$$

These indices were correlated with cereal yield anomalies. The critical periods of crop development and the soil moisture conditions were found as significant for the results of the correlation. The significance of information about VCI or VCI and TCI from particle decades was included into the winter wheat yield modeling and assessment of water conditions for crop. The discrepancies between the results of yield forecast and official yield data have been discussed in relation to specific conditions related to the considered area and period of time. The water supply to vegetation and water deficit during vegetation growth was the crucial information for the difference between potential and actual yield.
The results of crop yield modeling applying SPOT VGT and NOAA AVHRR were compared.

Literature

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