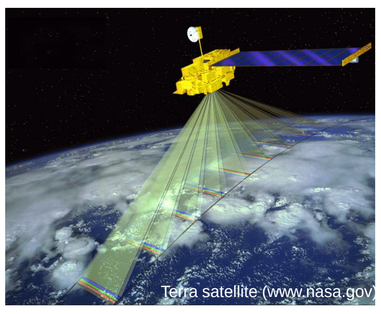
Remotely sensed NDVI as a support tool for agricultural drought assessment



Petr Hlavinka[1,2], Daniela Semerádová[1,2], Miroslav Trnka[1,2], Vojtěch Lukas[1], Roman Bohovic[3], Jan Balek[1], Brian Wardlow[4], Michael Hayes[4], Tsegaye Tadesse[4], Zdeněk Žalud [1,2]

1) Institute of Agrosystems and Bioclimatology, Mendel University in Brno, Zemědělská 1, 613 00 Brno, Czech Republic, petr.hlavinka@mendelu.cz; **2)** Global Change Research Centre AS CR, v.v.i., Belidla 986/4a, 603 00, Brno, Czech Republic; **3)**Department of Geography, Masaryk University, Kotlářská 267/2, Veveří, Brno, Czech Republic; **4)** National Drought Mitigation Centre, University of Nebraska, 815 Hardin Hall, Lincoln, NE 68583, USA

Introduction

The Normalized Difference Vegetation Index (NDVI) is one of the most frequently used vegetation indices which could be obtained through remote sensing. If the measurements are conducted from the satellite then the dynamics of the vegetation development could be analyzed in time and spatially through large regions. By this way the regional drought stress within plants could be detected and classified.

Aims

- **assess the ability of remotely sensed NDVI to explain the yields of spring barley and winter wheat at district level**
- **assess ability of NDVI to explain water balance and drought stress within agricultural crops at district level using data mining technique**

Methods

Region: The study was conducted at district level; 6 districts (Břeclav, Znojmo, Olomouc, Přerov, Havlíčkův Brod, Žďár n. Sázavou) were included (Fig. 1).

Period: 2000 - 2012

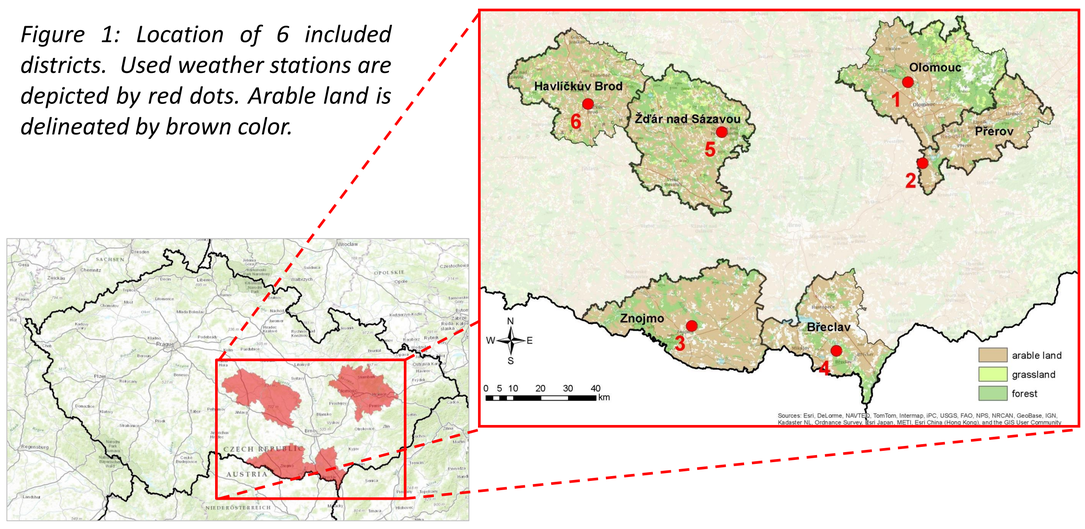
Weather: Each district was represented by one weather station (Fig. 1)

Yields: Average district yields were compiled from archives of Czech Statistical Office, Ministry of Agriculture and Agrarian Chamber.

NDVI: Observed from satellite Terra by MODIS (Moderate Resolution Imaging Spectroradiometer); 16 day time step (as a composite value); in the resolution 250 m; freely available (from the link https://lpdaac.usgs.gov/get_data); district average of NDVI for arable land was used.

Data mining: Cubist software v 2.07 (RuleQuest Research, Australia) was used to discovering patterns in heterogenous dataset; procedure is apparent from Fig. 2.

Figure 1: Location of 6 included districts. Used weather stations are depicted by red dots. Arable land is delineated by brown color.



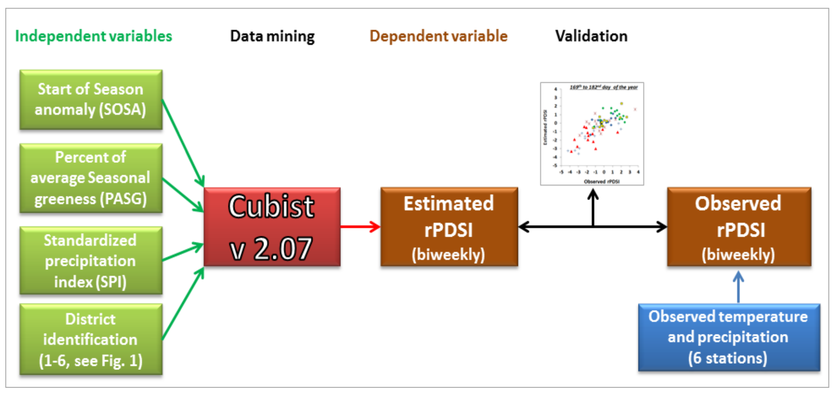


Figure 2: The scheme of procedure for using NDVI (in form SOSA and PASG) identification of drought occurence at district level (based on relative PDSI).

Start of Season (SOS): The day when NDVI (district avg.) continuously exceed 0.45 as a threshold.

SOS Anomaly (SOSA): Deviation of SOS (for certain season) from SOS median for certain district.

Seasonal greenness (SG): Integrated NDVI (above 0.45) in 14 day time step.

Parcent of average SG (PASG): Percent of average SG for certain district and period of the year.

Relative Palmer Drought Severity Index (rPDSI): Indicator of drought occurrence (Palmer, 1965); is based on simple supply-and-demand model of a water balance that builds on both the precipitation and temperature history for a location; the relative form (Dubrovský et al. 2009) was used within submitted study; as a reference the database from six included stations through the period 1961-2012 was used.

Standardized Precipitation Index (SPI): The quantification of precipitation anomaly (McKee et al., 1995); based on precipitation totals within previous 3 months; calculated in 14-day time step.

Results

1) NDVI vs. Yields:

The relationship between yields of spring barley and winter wheat and NDVI at district level was investigated. As an indicator for season characteristics the integrated NDVI (average values at arable land within district) was used. Namely, spatial average of original composite NDVI values (available in 16 day time step) from 22nd April to 11th June of each year was accumulated. The achieved results for Znojmo and Přerov district (period from 2000 to 2012) are apparent from the Fig. 3. For spring barley Pearson correlation coefficient (r) was 0.75 and 0.74 within Znojmo and Přerov districts respectively. Analogously for winter wheat it was 0.91 and 0.69. The occurrence of dry conditions (in the year 2000 and 2012) with its impact on regional yields is apparent.

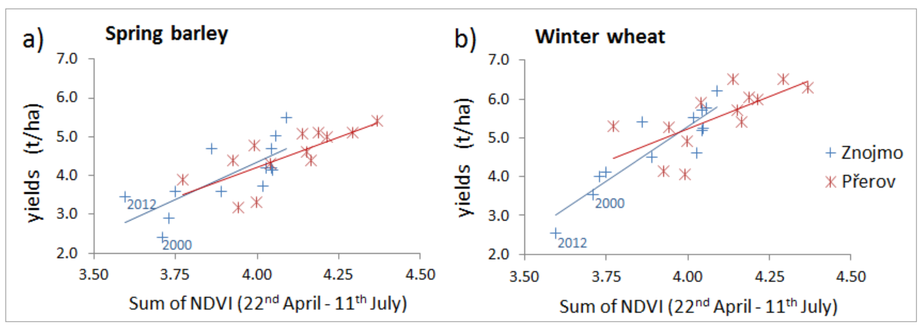


Figure 3: Spring barely (a) and winter wheat (b) yields vs. NDVI (for arable land) at district level. Composites (from 22nd April to 11th July) was accumulated as an indicator of vegetation season course. Znojmo and Přerov districts were selected as an example and dry seasons 2000 and 2012 are marked.

2) NDVI as indicator of drought:

The ability of NDVI in form of PASG and SOSA to explain drought occurrence was tested using data mining technique. Mentioned analysis was conducted at district level. For this purpose Olomouc, Přerov, Znojmo, Břeclav, Žďár nad Sázavou and Havlíčkův Brod districts were selected. For the demonstration the 14 day interval between the 127th and 140th day of the year and from 169th to 182nd day was selected. The comparison of the rPDSI based on precipitation and temperature measurements (named as rPDSI observed) with estimated values (based on independent variables, see Fig. 2) is apparent from Fig. 5. The correlation coefficient for all districts together was 0.84 and 0.75 for the first and second analyzed period respectively (n = 78). If only SPI was compared with observed rPDSI, correlation coefficient was 0.49 and 0.38 respectively. For both periods two set of rules was derived and used within Cubist (all rules contain PASG, see Fig. 4).

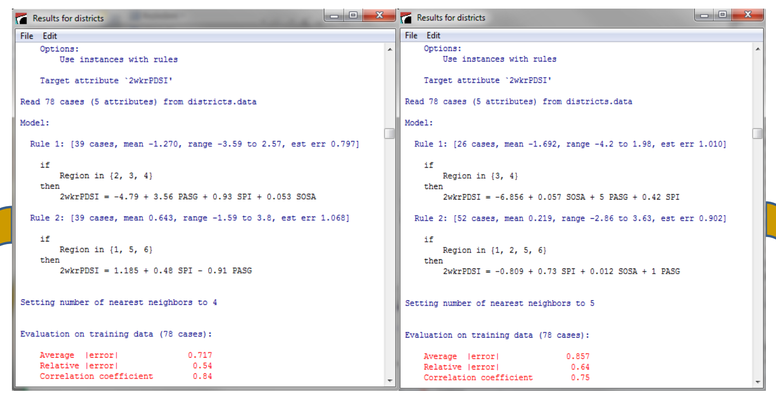


Figure 4: Set of rules suggested by Cubist for two periods (127th to 140th and 169th to 182th day of the year) are presented for six districts (region 1-6).

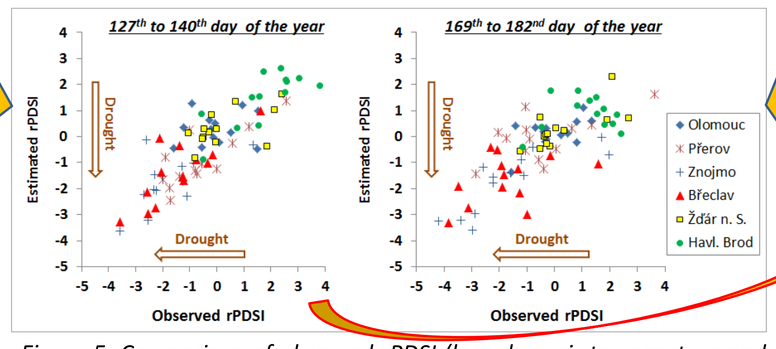
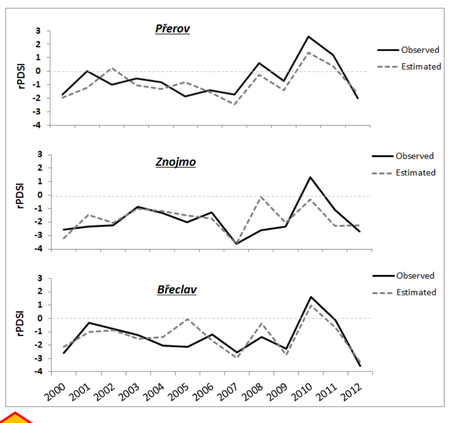


Figure 5: Comparison of observed rPDSI (based on air temperature and precipitation measurements) with estimated values based on PASG, SOSA, SPI and region identification. Two periods (127th to 140th and 169th to 182th day of the year) are presented for six districts.



Figuge 6: Time course of observed rPDSI and estimated values for the periods from 127th to 140th day of the year from 2000 to 2012. Estimated rPDSI is based on PASG, SOSA, SPI and district identification. As an example situation within districts Přerov, Znojmo and Břeclav is depicted.

Conclusions

- NDVI could be used for yield estimates at district level(especially during exceptional years);
- NDVI could be used for the drought assessment based on water stress within the agricultural crops at district level.

Acknowledgement

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