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Remote sensing[5]

extended summary of the respective subprojects of preagro, dealing with "Remote Sensing"

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Remote sensing data for variable rate treatments may be separated into two categories: spatial base information of soil properties or yield potential (= site (potential) map) and spatially dynamic information of the canopy development, the soil water dynamics or the quality of recent crop management decisions (= status map).
The contribution of remote sensing for "static" applications e.g. seeding, base nutrient fertilisation is to deliver reliable base information based upon the spectral reflectance such as quantitative information of the top soil, the available field capacity or the yield potential. For the long term site information the specification for the sensor platform, processing, ancillary data etc. have to meet certain standard that allow a multi temporal analysis.
The contribution of remote sensing for "dynamic" applications, e.g. fungicides, Nfertilisation, is to provide current crop status information, e.g. biomass, nitrogen content which is of great importance for several treatments. With the online approach the current crop stands or weeds are identified and analysed by a terrestrial sensor for a near realtime or realtime treatment. Airborne or satellite remote sensing may also deliver current and large scale crop status information, e.g. for Nfertilisation or for certain plant protection issues. Due to importance of the turnaround time (the time between image acquisition and delivery) and in accordance to a specific size of a management unit in relation to the treatment a variety of remote sensing sensors are suitable for different treatments, figure 1.

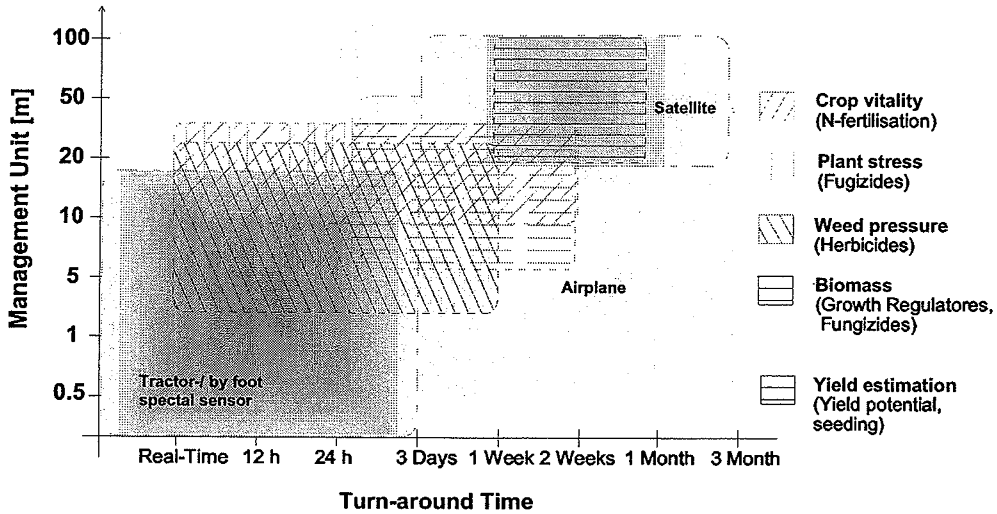

Figure 1. Suitability of different sensors for various treatments in terms of turnaround time and ground resolution (» 1/3 of management unit size).

Beside the use of remote sensing for application support remote sensing data is also a valuable source of information for site specific farm management, which is especially important for large farms to obtain a current overview. From the remote sensing data the farmer may benefit in different ways, e.g.:

[5] Reprint from: Werner, Jarfe (2002): Precision Agriculture – Herausforderung an Integrative Forschung, Entwicklung und Anwendung in der Praxis, KTBL Sonderveröffentlichung 038, Darmstadt, pages 93 - 96

1. Obtain a representative and current overview of the whole field / farm through a targeted addressing of certain spots of interest.
2. Receiving the site properties of the farm quickly after a change in the management personnel or the purchase of new fields
3. Objective documentation for legal issues, e.g. (wildlife damage, hail damage, street planning, environmental protection, ...)

The interpretation of such images lies in the hands of the farmers and or consultants in contrary to the application support, thus setting particular demands for a sensor system and the necessary high ground resolution of < 1 m.

The core of the image acquisition system FIFF developed by the TP II2 ‚aerial images' is a highresolution digital colour Rollei DSP 104 camera with a resolution of 2010 * 2018 pixel, which is used on board a Cessna 172. At an altitude of 2.500 m 3.000 m a ground resolution of 0.75 – 0.9 m is reached. With the digital workflow and image processing procedures it is possible to preprocess and geocode the images within a few, thus making them quickly available to the project partners. The imagery which is taken at different pheonological stages is also used as a management tool to support soil and inventory management and for near real time support of sitespecific applications.

The transformation of remote sensing information to specific treatments or for combined utilisation in a GIS requires an precise and quick geocoding of the imagery. Due to this reason a GPSAHRS system was developed and different photogrammetric procedures which require none or very few ground control points were investigated and used for automatic aerotriangulation.

With regard to crop development, remote sensing imagery may deliver information is quickly outdated. For applications such as the 2nd and 3rd Ndressings, relevant derivations must therefore be extensively automated and generated objectively. Due these reasons digital image analysis procedures such as the Visible Atmospherically Resistant Index (VARI) were tested successfully. This index relies only on the spectral bands in the visible spectrum and is linearly correlated to the vegetation fraction (= crop density). Furthermore object oriented classification strategies were also evaluated. However, for absolute quantitative measurements and time series analysis there is still demand for further research, especially in the field of preprocessing and atmospheric correction of the image data.

Beside this, the focus of the research activities has been widened significantly by investigating additional sensors in the second half of the project. On one hand satellite sensors, like Landsat TM and on the other hand terrestrial sensors like the HydroN sensor in the spectral mode and field spectroradiometer measurements. The research focused on time series analysis at different spatial and temporal scales including a comparison of different sensors. At the field Kiesberg, farm Wulfen it could be shown that an upscaling from a hand survey to terrestrial, airborne and satellite borne sensors is possible. At the field 1114 in Kassow the development of the senescence was investigated by several overpasses with the HydroN sensor in the spectral mode. The calculated vegetation indices were well correlated with the biomass and less correlated to the grain yield, due to a complex yield structure 2001. The spatial pattern of the biomass clusters was done by a supervised multi temporal classification of the NDVIdata sets.

The „crop stand information' subproject TP II4 deals with the analysis of spectral differentiation's between vegetation and soil in the near infra red (NIR) range using digital video technology. The system used consists of 2 video cameras builtin one behind the other in the ground hole of a Cessna 172 so that one camera records in NIR and the other as a colour camera senses the visible light (RGB). Flight altitude is adapted to the size of the fields and provides a ground resolution of 3 4 m at altitudes of 2.000 3.000 m above ground. The GPS signal recorded on the video's soundtrack enables the targeted search for the fields to be evaluated. The necessary geocoding of the imagery is done one field at a time by means of ground control points which are either obtained from digitally available field boundaries or from a largescale topographical map. In this way it is possible to precisely overlay imagery acquired at different times and perform change detection calculations. The formation of 16 reflection classes of a video image enhances significant soil and crop differences.

To record different development stages of the plant canopy repeated aerial surveys are necessary. With the flight campaigns of the year 2001 the existing data base for multitemporal NIRanalysis was extended. The time of senescence is among others a phenologically important flight date. Plants react to stress syndromes such as food or water shortage with premature ageing (senescence) thereby changing the cell structure. This leads to a reduced NIR reflection in these areas of the field.

For the examination of coincidences between the senescence patterns of a field over the years, data of the field Finkenherd (141) in Wulfen was analysed. Because difference images are preferable used for the comparison of two different dates, a new approach was first explored in 2001 that enables multi temporal analysis of different type of data. A variety of different data sources including soil information, yield maps and remote sensing data was incorporated into a supervised classification procedure (maximum likelihood) of the field 141. As a result management zones of different yield potential could be determined. These management zones could be used in the decision making for variable rate treatments such as seeding, fertilisation and plant protection. The best results with this approach was realised in areas in which the plantavailable water storage capacity becomes a limiting parameter factor for crop production. Areas with less than 500 mm of rainfall and a unfavourable distribution of the precipitation are considered to be "dry sites" and are often found in eastern Germany.

The use of NIR-imagery for the determination of management zones and decision support for other sites with more precipitation requires further research. The image data of 2002 will surely deliver more valuable information for this and other questions.

The "soil water storage" subproject TP II6a develops techniques for the derivation of soil and location maps from multispectral remote sensing data. The goal is to develop remote sensing supported methods for the derivation of spatially differentiated maps. The plantavailable soil water storage capacity is of mayor importance, because the it is the most important parameter for variable yields within a field.

Remote sensing technologies are not able to view into the soil profile but are recording the spectral characteristics of soilcrop surfaces. For the differentiation of soil related zones a model has to use the canopy reflection as an indicator of the subsurface situation. The development of a soilplantsensor model was thoroughly validated with the data from the year 2000. The investigations to forecast grain yield demonstrated the opportunities to determine the relative yield variations early and accurately with the multi spectral data of the Deadalus ATM scanner of the DLR. The derivation of the soil bound yield potential was validated with selected hand measurements.

In regions with a negative water balance during the vegetation period the plantavailable water storage capacity becomes the most limiting parameter of soil productivity. Beside local influences due to ground water and lateral water the crops only have access to the plant available water storage capacity of the root zone (AWCrz). This soil parameter has been identified as central factor for soil productivity. Therefore the AWCrz correlates strongly with the biomass and the crop stand condition. To determine the site specific productivity the influence of the ground water and the lateral water has to be considered. In the reaction of the crops to the local water resources this effect is already included. This allows for a more precise determination of the soil productivity than conventional soil taxation based on drill holes. Research work has shown that very good differentiation can already be achieved in the area of low stress effects by the use of the thermal emission response. Classes of 50 mm plantavailable water storage capacity could be separated significantly.

Based on the map of the plantavailable soil water storage capacity the site specific efficiency of the N-fertilisation was investigated. The results underlined the central importance of the plantavailable soil water storage capacity for the site specific efficiency of the N-fertilisation. Considering the findings the N-fertilisation should be coupled to the water availability, to increase the efficiency of the fertilisation and to guarantee an ecologically responsible use of the fertiliser. Because at a site with poor water capacity a standard fertilisation with uniform high dressings will lead to a high amount of residuals and thereby increase the risk of N-leaching.