CAPABILITIES OF REMOTE SENSING TECHNIQUES IN AGROMETEOROLOGY AND HYDROLOGY

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ABSTRACT

Remote Sensing Techniques have been widely used in assessing natural resouce status of a region; especially, on locations where groud level measuring instruments are not available. This paper discusses various potential applications of these techniques in the fields of Agrometeorology and Hidrology.

INTRODUCTION

Remote Sensing is the science and art of obtaining information about an object, area, or phenomenon throught the analysis of data acquired by a device that is not in contact with the object, area, or phenomenon under investigation. Data are remotely collected using various sensors and analyzed later to obtain information about that particular object, area, or phenomenon. Data collected could be of many forms (fictorial, alphameric, numeric or alphanumeric), including variations in electromagnetic energy distributions. Electromagnetic energy sensors are operated from airborne and spaceborne platforms.

There are two processes involved, data acquisition and data analysis. The elements in the data acquisition process are (a) energy sources, (b) propagation of energy through the atmosphere, (c) energy interactions with earth surface features, (d) airborne and/or spaceborne sensors, and (e) output (pictorial and/or numerical form). The data analysis process involves examining the data using various viewing and interpretation devices to analyze pictorial data and/or a computer to analyze numerical data. Reference data about the resources being studied (such as soils maps, crop statistics, or field-check data) are used when and where available to assist in the data analysis. With the aid of the reference data, the analyst extracts information about the type, extent, location, and condition of the various resources over which the sensor data were collected. This information is then presented, generally in the form of maps, tables, and a written discussion or report. Typical information products are such things as land use maps and crop area statistics. Finally, the information is presented to users who apply it to their decision-making process.

AGROMETEOROLOGICAL APPLICATIONS

Agrometeorology is an applied science that studies the relations between weather and agricultural production. It desribes the effects of weather on the vegetation, animal, soil and open water surfaces, and the reciprocal effects of these "surfaces" on the weather. It aims to formulate the relations that exist in quantitative terms and to apply this knowledge to increase the benefits that can be obtained from the natural resources and to reduce the detrimental effects that result from adverse weather conditions.

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For its studies of the interface between the atmosphere on the one hand, and crops, animals, the soils and the water supllies on the other, agrometeorology must draw upon the basic knowledge available in plant physiology, botany, animal husbandry, veterinary, soil sciences and hydrology, in additions to pure meteorology. Lillesand and Kiefer (1979) discussed applications of remote sensing to agriculture in three areas, (a) crop type classification, (b) crop condition assessment, and (c) crop yield estimation.

Crop type classification through airphoto interpretation is based on the premise that specific crop types can be identified by their spectral response patterns and photo texture. Successful identification of crops requires a knowledge of the developmental stages of each crop in the area to be inventoried. Because of changes in crop characteristics during the growing cycle can be very useful in the interpretation process. In fact, multidate photography may be necessary for discrimination of similar crop types.

Aerial photographic interpretation is a useful aid in crop condition assessment. Deleterious conditions that can be assessed include crop disease, insect damage, plant stress from other causes,a nd disaster damage. Some of the plant diseases that have been detected using airphoto interpretation are southern corn leaf blight, potato wilt, sugar beet leaf spot, stem rust of wheat and oats, late blight fungus of potatoes, pecan root rot, and coconut wilt. Some types of insect damage that have been detected are aphid infestation in corn fields, red mite damage to peach tree foliage, and plant damage due to fire ants, harvester ants, leaf cutting ants, army worms, and grasshoppers. Other types of plant damage that have been detected include those from moisture stress, iron deficiency, nitrogen deficiency, excessive soil salinity, rodent activity, road salts, and air pollution.

Airphoto interpretation for crop condition assessment is a much more difficult task than airphoto interpretation for crop type and area inventory. In most studies to dates, comparisons have been made between healty and stressed vegetation growing in an adjacent fields or plots. Under these conditions, interpreters might discriminate between finer differences in spectral response than would be possible in a noncomparative analysis. It would also be more difficult to differentiate among the effects of disease, insect damage, nutrient deficiencies, or drought, from variations caused by plant variety, plant maturity, planting rate, or background soil color differences. The best conditions for detecting crop stress by airphoto interpretation exist when the stress occurs over wide areas, instead of a isolated fields, and is systematic in nature. Other optimum conditions are when the corp canopy is well developed that the vegetation response predominates over that of the soil background. Because many stress effects are most apparent during dry spells, photographs should not be taken soon after rainy weather. In addition to crop damage due to disease, insects, and various other stresses, crop damage resulting from such disasters as flooding, fire, tornadoes, and hurricanes can be assessed by airphoto interpretation.

Crop yield estimation based on airphoto interpretation has met with varying degrees of success. In principle, the process is simple and straightforward. In a given study area, the interpreter needs to determins the area of each crop type and estimate the yield per unit area of each crop. The total yield is then a simple product of the area times the yield per unit area. In practice, the process is complex; crop yield depends, among other things, on soil moisture, soil fertility, and air and soil temperature. In addition, yield can be selectively reduced by disease, insect infestation, and other stress-producing agents. Crop yields can very considerably within a single field, depending on soil patterns. Beyond yield estimation, crop yield prediction can also be assisted through the interpretation process. Successful crop yield prediction must consider climatic and meteorologic conditions. Valuable input to the determination of these conditions can be obtained from meteorological satellite data.

The traditional approach to crop yield estimation has been to use airphoto interpretation to identify and measure the total area of each crop type. Field inspection of small sample plots is then used to determine crop yield per unit area. A more direct approach is to acquire historical information on crop yield for individual fields and then use airphoto interpretaion to determine how a specific yieats yield appears to be deviating from the normal. This process requires the development of a coorelation between leaf reflectance and crop yield and has met with only partial success. More than one date of photography during a growing season is normally required for successful implementation of this technique.

Many additional agricultural applications of airphoto interpretation exist. At the local level these include (1) detailed studies to determine areas that need erosion control, weed control, fencing, or other remedial measures, (2) farmland appraisals for taxation studies and other real estate purposes, (3) determination of the adequacy of existing irrigation systems for uniformly wetting an entire field, and (4) farm livestock surveys.

HYDROLOGICAL APPLICATIONS

Hydrology aims to provide practical information for the planning of the efficient use and for the management of water resources; whether for irrigation, power generation, drinking, manufacturing, or recreation. Water is one of our most critical resources. Airphoto interpretation can be used in a variety of wats to help monitor the quality, quantity, and geographic distribution of this resource.

In general, most of the sunlight that enters a clear water body is absorbed within about two meters of the surface. The degree of absorption is highly dependent on wavelenght. Reflected infrared wavelenghts are absorbed in only a few tenths of a meter of water, resulting in very dark image tones of even shallow water bodies on infrared photos. Absorption in the visible portion of the spectrum varies quite dramatically with the characteristics of the water body under study.

From the standpoint of photography of bottom details through clear water, the best light penetration is achieved between the wavelengths of 0.48 and 0.60 micrometers. Althought blue wavelengths penetrate well, they are extensively scattered and an "underwater haze" results. Red wavelengths penetrate only a few meters.

Lillesand and Kiefer (1979) discussed the use airphoto interpretation in water pollution detection, lake eutrophication assessment, flood damage estimation, and groundwater status. Presently, available airphoto interpretation techniques cannot be used directly to map the depth of water in a groundwater system. However, vegetation types at the floor of water bodies have been successfully used used as indicators of approximate depth to groundwater. Other applications include hydrologic watershed assessment, reservoir site selection, shoreline erosion studies, and snow cover mapping.

SOURCES

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