



A STUDY ON THE HYDROLOGIC VARIABLES USED IN MOST OF THE WATER RESOURCES APPLICATIONS

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Abstract

A brief review of research in remote sensing of water resources indicates that there are many positive results, and some techniques have been applied operationally. Currently, remote sensing data are being used operationally in precipitation estimates, soil moisture measurements for irrigation scheduling, snow water equivalent and snow cover extent assessments, seasonal and short term snowmelt runoff forecasts, and surface water inventories. In the next decade other operational applications are likely using remote measurements of land cover, sediment loads, erosion, groundwater, and areal inputs to hydrological models. Many research challenges remain, and significant progress is expected in areas like albedo measurements, energy budgets, and évapotranspiration estimation. The research in remote sensing and water resources also has much relevance for related studies of climate change and global habitability.

Keywords: Remote Sensing, hydrologic, water



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INTRODUCTION

This paper is not meant to be a comprehensive review of all that remote sensing and water resources scientists have achieved in research and operational applications. Time and space limitations make such a review impossible. Rather, examples of research accomplishments and operational applications are highlighted.

In addition to the proven aspects of remote sensing of water resources, a portion of the paper is devoted to those areas where remote sensing has not yet been successful in extracting relevant hydrological information. These gaps in the knowledge base can be traced to a variety of problems. Whatever the reason for the lack of success, these gaps serve as challenges for future research and development. Among these challenges are areas where remote sensing has produced promising results, but much pertinent research still needs to be done. In some cases remote sensing research has firmly established the potential for operational use, but widespread operational application has not yet been achieved.

Certain goals for future research will be discussed. Simply stated, they include the need to make better use of the areal measurement capability of remote sensing for inputting data to hydrological models. Associated with this is the need to develop remote sensing techniques far enough so that operational application is the logical result. Advances in remote sensing measurements of hydrological variables have provided an additional dimension to measurement capabilities, namely, the ability to measure hydrological variables areally. This development has made the remote sensing of water resources a useful tool for other related problems. Good examples of this are contributions to studies of global change and global habitability.

There is an alternative that could be useful in some cases. The position control loop acts generally at a faster frequency than the rest of the loops. Thus, a short additional transient in the position will not influence in a high degree the performance of the other master loops. It is possible to follow position set points that fall in the dead zone by forcing the gate to first move away from this area and then reverse to go after the desired position. The proposed solution produces more gate movements and discharge transients, but offers a way to reach a higher positioning accuracy. In general, this control will produce long trajectories for small positioning corrections. Hence, it is also necessary to limit the control sensitivity to avoid unnecessary gate movements owing to sensor noise.

The practical knowledge acquired during this research work, suggests that the second alternative would be better than the first one. The discharge measurement chapter has already stated the accuracy of gate discharge models. It has been seen that their precision is similar or better than some velocity measurement based discharge sensors. Thus, there is no reason to seek for the set point in a blind manner. Moreover, the minimum gate movement restriction is likely to easily destabilize any dynamic controller, especially when coming closer to the set point.

The value of f should be selected for each particular situation. For the gates of the Canal PAC-UPC, it was found appropriate to fix it to 7mm in each case. Essentially, this choice is motivated by a discharge measuring concern: a smaller level difference leads to erratic discharge calculation results due to water level variations. These level variations can be more or less pronounced depending on the flow characteristics. If in other cases the gate discharge measurement is carried out by other means, it is possible to select lower values that ensure that the gate is still under water.

RESEARCH METHODOLOGY

For remote sensing techniques to be termed operational, several qualifications must be met. The application must produce an output on a regular basis or the remote sensing approach must be used regularly and on a continuing basis as part of a procedure to solve a problem. There are several good examples of operational remote sensing applications for water resources.

Scientists in Russia have taken the advances in the passive microwave remote sensing of soil moisture and developed a system for irrigation scheduling. Three radiometers at wavelengths of 2.25, 18, and 30 cm are mounted on a small biplane (Antonov-2 type) and flown over agricultural fields (Shutko, 1986). The multi-wavelength capability not only provides surface layer soil moisture measurements but also allows some indication of soil moisture through a depth of one metre in conjunction with a priori information on local soil properties (Reutov & Shutko, 1986). The soil moisture data are supplied to the farm operators 5-10 hours after the flights (Shutko, 1986). On some of the agricultural areas, similar radiometers mounted on tractors provide supplemental data. The soil moisture data thus obtained are then used as a direct input to irrigation scheduling decisions.

In the field of snow hydrology, the US National Weather Service has set up a National Remote Sensing Hydrology Center in Minneapolis, Minnesota. Two operational products are provided by the Center. Gamma radiation remote sensing from low altitude aircraft is used to measure snow water equivalent over a network of more than 1500 flight lines covering portions of 25 US States and seven Canadian Provinces. NOAA-AVHRR satellite data are used to map the areal extent of snow cover digitally over regions covering two-thirds of the US and southern Canada where snow cover is an important hydrological variable. The snow cover was mapped for about 2000 basins in 1990 and about 300 of these basins were mapped by elevation zone. The airborne and satellite alphanumeric and digital image snow cover data sets are available electronically to users in near realtime for hydrological forecasting purposes.

The snow cover data are obtained from NOAAAVHRR. Four years of forecasts produced an average forecast error of 10% on the Sutlej basin with similar results also being found on other major river basins in India. These forecasts are being used operationally in India and being extended to additional basins. In addition, Kumar et al. (2011) have started inputting satellite snow cover data to SRM for use in operational forecasts of daily snowmelt-runoff on the Beas and Parbati Rivers in India.

INSTRUMENTATION TECHNIQUES

Being one of the driving forces in the hydrological cycle, rainfall is a prime candidate variable for remote sensing measurement. There are many remote sensing possibilities including ground-based radar, visible and thermal infrared satellite imagery, and microwave satellite data. The use of ground-based radars has been successful especially when used with an integrated rain gauge network and in areas with low relief. It is estimated that radar rainfall measurements are accurate to within about 15% of actual rain gauge network totals.

Most studies that have used multispectral land cover information have employed it as just one facet of a larger study. Ragan & Jackson (1980) probably focused on the land cover categories the most. They actually modified the land cover categories of the Soil Conservation Service (SCS) curve number model to be compatible with Land sat MSS data. SCS curve numbers obtained with these alternate land cover categories for use in the model compared closely to those obtained in published examples using conventional techniques. Since the early studies were made, the use of remotely sensed land cover has been a valuable part of just a few studies. As a result, it has had low visibility when compared to other applications.

Resolution of the sensor has been used to determine the minimum basin sizes for various satellites. Generally, NOAA-AVHRR data can be used on basins as small as 200 km², Land sat MSS data on basins as small as 10 km², and Landsat TM data on basins as small as 2.5 km². More important than the resolution is the frequency of coverage which is adequate only on NOAA-AVHRR (one visible overpass per day). Cloud cover is always a problem, and the 1.55-1.75 μ m band on Landsat TM allows automatic discrimination between snow and clouds. Where clouds are present over a basin, a method has been developed to estimate the snow cover under the cloud cover by extrapolation from the cloud free portion of the basin.

DATA ANALYSIS

The results showed categories of groundwater potential zones ranging from very good to poor. The integrated Remote sensing and GIS based approach is a powerful tool for assessing groundwater potential based on which suitable locations for groundwater withdrawals could be identified. The exploration for groundwater in hard rock terrains is a complex task. To overcome this complexity, the integrated approach based on advanced applications of remote sensing and geographical information systems (GIS) lends itself as an efficient and effective result oriented method for studying the development and management of water resources. The ever increasing population and the modern industrial and agricultural activities not only

create a greater demand for groundwater resources, due to the inadequate availability of surface water resources, but also pollute the groundwater resources by releasing untreated wastes. The integration and analysis of various thematic maps and image data proved useful for the delineation of zones of groundwater potential and zones of groundwater quality suitable for domestic purposes. Measures that could address the water need may include the construction of water harvesting structures for augmentation of groundwater resources and also through the implementation of proper BMPs (Best Management Practices) for watersheds throughout the region.

Frequent failure of monsoons and over-exploitation of groundwater, in some parts of the country, have resulted in a rapid water depletion, besides a substantial quantity of rainwater goes waste through surface runoff into the ocean. Hence, in order to maintain the water table condition in balance and to restrict the surface runoff going waste, various measures for artificial groundwater recharge can be implemented in such zones. It helps the aquifers from total water table deeper part of the aquifer system.

Many workers in various parts of the world have followed different techniques for generation of thematic maps on geology and hydrogeology integrated the data to select favorable areas for groundwater recharge. Artificial recharge sites are interdependent on various parameters like permeability, soil depth, drainage intensity, water holding capacity, geology and soil texture. Thematic data have been integrated for evaluation of groundwater potential zones for the study area. Artificial recharge sites have been identified, based on the number of parameters, in the study area. Again, the study area was classified into priority zones, numbered as 1, 2, 3 and 4, suggesting the artificial recharge sites as High favorable zone, Moderate favorable zone and least favorable zone.

The study planners and decision makers can give more suggestion to create new plans and models to implement the water resource development and action plan in the study area and promote the check dam or developing of percolation ponds.

Several recent studies and papers have documented the impacts of watershed development efforts. Many programs in India, especially, those implemented by government have been widely criticized for causing no impact. Few impact assessments have addressed, in detail, the impact of watershed development on rural water supplies. As population increases and the per capita demands rise, leading to perhaps a doubling in demand for domestic water over the next 20-30 years, competition and conflicts over water resources are going to get a lot worse unless radical steps are taken. The intended impacts of watershed development are, among

others, to increase groundwater recharge and increase groundwater recharge and increase the overall water resource availability.

RESULTS

Ecosystem services have been increasingly recognized as important assets for sustainable development, since a close interdependency exists between ecosystem services and groundwater. On the one hand, these services depend directly on the functioning of ecosystems such as wetlands, forests, lakes and coastal areas which derive freshwater for their functioning from sub-surface water, including groundwater. Groundwater resources dependent on recharge through infiltration of rain waters.

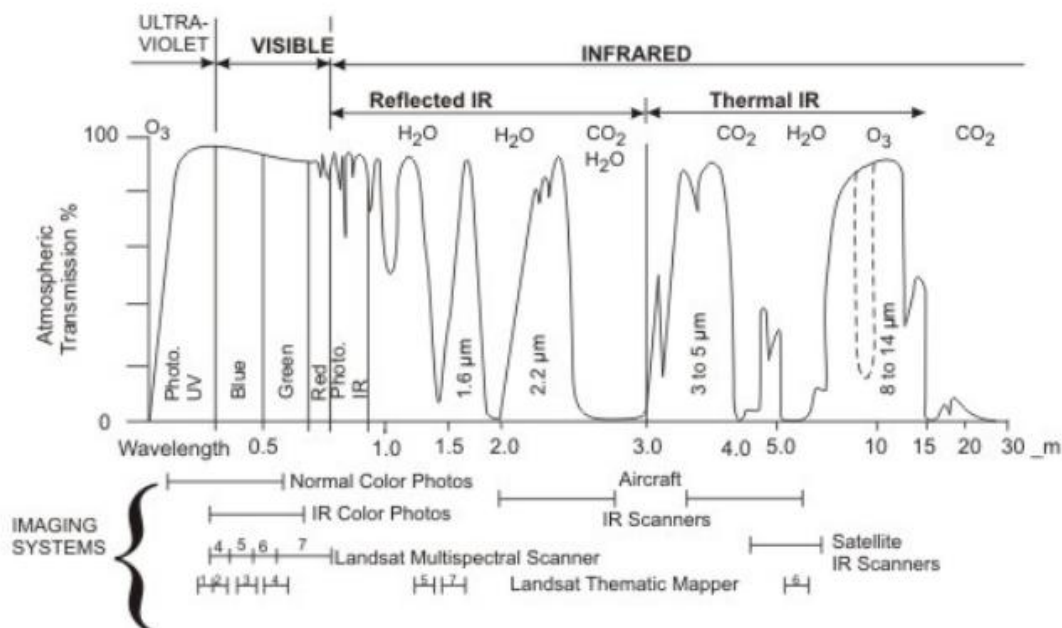


Figure 1: Atmospheric windows

The rate and quality of recharge, amongst others, is determined by the type and spatial configuration of ecosystems. The close linkages between the groundwater and ecosystem services are often not recognized and undervalued. Many ecosystem services have a direct linkage with groundwater storage, recharge and discharge.

Groundwater recharge is a portion of rainfall that infiltrates into the soil and percolates into the soil mantle and reaches the groundwater only after vegetation interception, evaporation from ground and runoff. The groundwater recharges seldom lend it to be measured directly, as Penman (1949) and Grindley (1970) viewed, that recharge is a function of effective precipitation (Precipitation minus Evapotranspiration), which depends on land use pattern. The recharge of groundwater takes place directly by infiltration of the precipitation or of the surface water in the outcrop areas of water bearing formations or indirectly by contributions

of other hydro geological structures or of adjacent aquifers (Gheorghe, 1978). Krishnamurthy et al. (1996) have discussed in the detailed methodology to demarcate the groundwater potential zones of Marudaiyar basin, Tamilnadu. In the study, different thematic maps were prepared using remotely sensed data as well as drainage density and slope classes from survey of India topographical sheets.

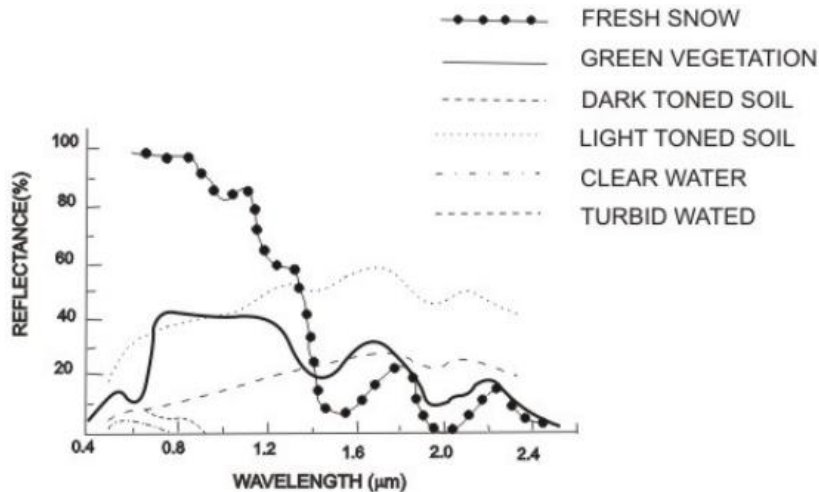


Figure 2: Spectral Reflection

All the thematic layers have been integrated and analyzed using a model developed with logical conditions in the GIS environment. Intersection of lineaments and lineaments parallel to the drainage network can give better yield. Identification of suitable sites for groundwater artificial recharge is very important, which is necessary to carry out with enough accuracy. The study area was Gavbandi river basin located in Boushehr province, Iran.

In this study, among different methods of artificial recharge, two methods of water spreading and artificial basins were selected. For this purpose, four factors of slope, surface infiltration, alluvial thickness and water quality of sediment were investigated. The slope map was prepared from topographic maps. Surface infiltration was estimated from the texture of sediment samples. The aquifer thickness was determined by Geo-electric method and the point measured thickness of the aquifer. The alluvial quality was determined from Electrical Conductivity data of 36 the study area. The maps of land use and landform units of the study area were extracted from Land sat ETM+ images.

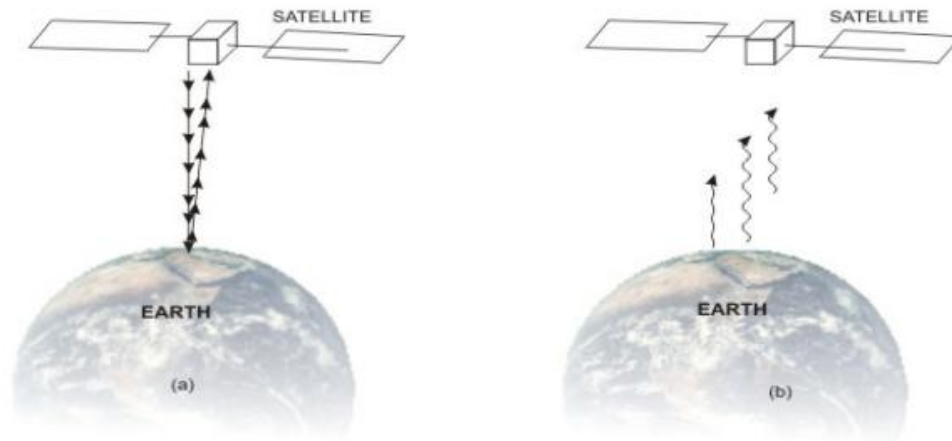


Figure 3: Active remote sensing

The suitable sites for artificial recharge were identified by overlaying of the slope, surface infiltration, thickness and quality of sediment layers in GIS. In order to study the relationship between landform units and artificial recharge, two maps of the landform and suitable sites were overlaid. Considering the different types of land-use, only range lands are found always appropriate for artificial recharge. Therefore, the range lands and non-range land regions have been identified on the land-use map and coded as one and zero, respectively.

CONCLUSION

The only reason for hydrologists to be involved with remote sensing is for improvement in the application of a specific hydrological method. Particularly, hydrologists need to be extracting remote sensing data for input to hydrological models. As such the characteristics of these models need to be considered when developing pertinent remote sensing techniques. Remote sensing information is areal in nature so that some effort needs to be given to designing or modifying hydrological models that will accept this areal input.

Researchers have made outstanding progress in developing remote sensing techniques. However, as has been pointed out in areas such as utilization of land cover and surface water extent, full operational application has not been realized. This may be at least partially due to a lack of technology transfer efforts, i.e., the research approaches have not been taken far enough to be adopted by operational hydrologists. As research continues, there is a need to make sure that researchers take the extra steps necessary to assure operational utilization.

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