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Applications of Remote Sensing to Hydrology and Hydrogeology

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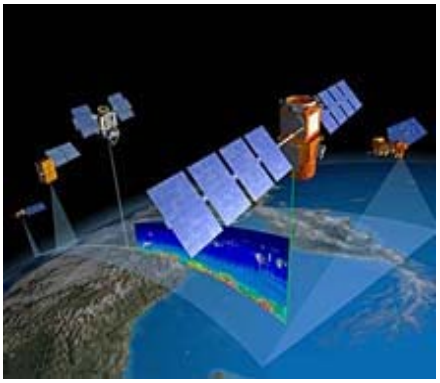
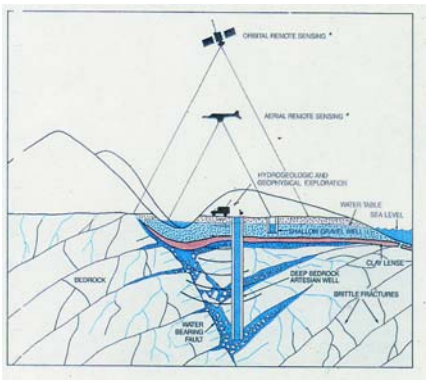
Abstract

An adequate and continuous supply of water for drinking, agriculture, and industry is basic for all societies. Significant deviations from normal water supplies generally bring disaster in the form drought or flood. To avoid the problems resulting from excess and shortage of water, societies have invested enormous sums of money and employed hydrologists and civil engineers to develop systems to control and distribute water. With nearly three-quarters of the Earth being covered with oceans. It is not a question of a global shortage of total water, but the challenge is to overcome the uneven distribution of water in space and time on land areas and to supply adequate quality to meet local needs. For example, about 20 per cent of the Earth` s land area is classified as arid and an additional 15 per cent is classified as semiarid. Here, water has been the limiting factor in the development of agriculture and most industries. Yet, even these dry areas are periodically devastated by floods. The requirement placed on technology is to supply, at an affordable cost, a dependable supply and quality of water where and when it is needed.

Systems to control water supplies have consisted of wells, canals, levees , and dams Because available information is almost always inadequate, wells have been dug that fail to produce adequate quantities or quality of water, dams have leaked or totally failed, and waste waters have contaminated drinking water. These disappointing results could have been avoided if sufficient hydrologic, geologic and climatelogic information for resource planning had been available.

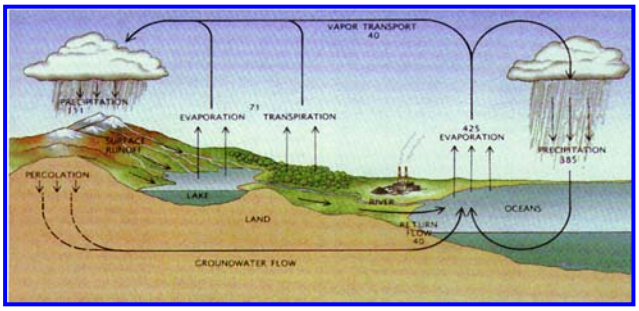
The purpose of this report is to inform hydrologists and water resource planners, primarily in developing countries, of the general capabilities of remote sensing techniques to obtain hydrologic data and to examine remote sensing as a possible aid in operational hydrology in the future.





The Hydrological Cycle

A brief overview of hydrological processes will help to set a framework for describing those areas where remote sensing can assist in observing and in managing water resource system. Generally speaking, the hydrological cycle traces water through different physical processes, from liquid water through evaporation into the atmosphere, back into the liquid (or sometimes the frozen) state as precipitation falling on land areas may either run off into rivers and streams, or percolate into the soil, or evaporate. Moisture reaching the water table becomes ground water. As a general rule, both surface and ground water flow under the force of gravity toward streams and lakes, and ultimately oceans. The return of water to the oceans can thought of as completing the cycle.

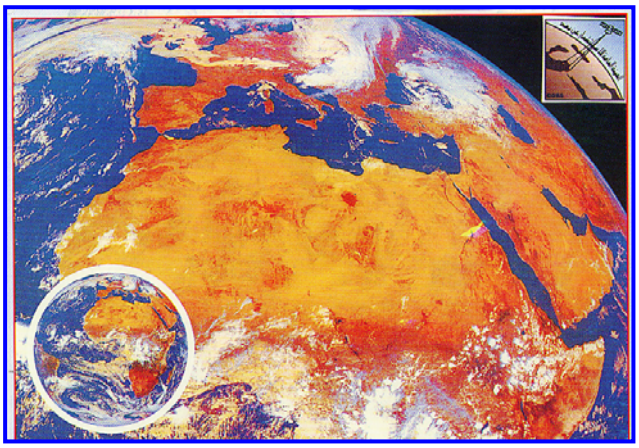


Precipitation

Accurate measurement of precipitation is a continuing goal in meteorological research and a continuing need in hydrology which depends greatly on these data for modeling. Ground-based radar is probably the most accurate method of determining a real precipitation in use today. Satellite images from GOES, NOAA, TIROS-N,TRMM

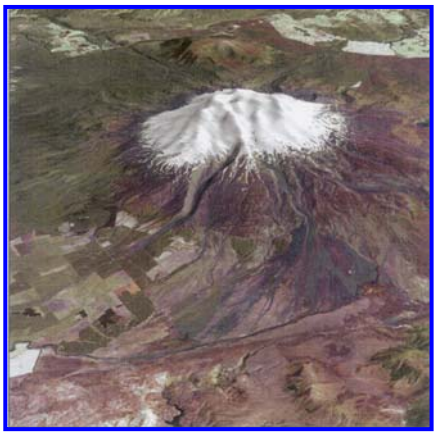
and NIMBUS opened a whole new world of data on clouds and frontal systems. Work carried out by several researchers has led to the following conclusions:

A. In thick clouds (more than one kilometer) rain is possible when the upper surface of the cloud is at less that –15 C.
B. The probability of rain is inversely proportional to the temperature of the upper surface of the cloud.
C .Precipitation intensity is directly proportional to the area of the upper surface of the cloud at temperature of less than –15 C.



Snow

For the hydrologists who must forecast water levels, snow represents one of the most complicated and most difficult to measure parameters. Snow extent, distribution, water equivalent, water content, thickness and density all play a large part in assessment of the snow-pack` s contribution to runoff. Snow pack water equivalent has been measured by aircraft gamma-radiation surveys in the USA. The method is based on the absorption of natural gamma radiation by water (snow).

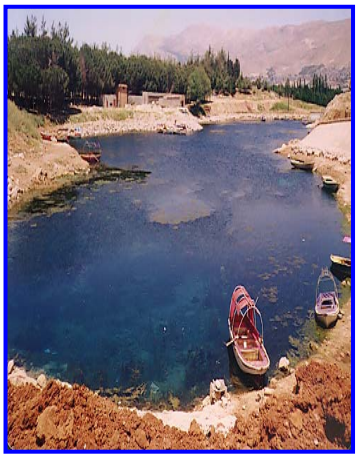


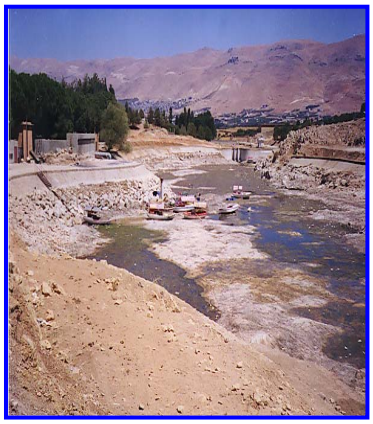
As hydrologists come to accept satellite remote-sensing data on snow mapping, they also come to learn the limitations of satellite remote sensing.

Despite some indications that the reflectance of snow may, under certain circumstances, be related to the snow thickness.

Glaciers Glaciers play an important role in the hydrological cycle of many mountainous areas. Terrestrial photography of glaciers was an important early reference method. Traversing and conducting scientific studies on glaciers are difficult, and glacieologists were quick to appreciate the value of remote sensing, first from aircraft, later from satellites (Landsat, HCMM, NIMBUS and IceSat …etc).

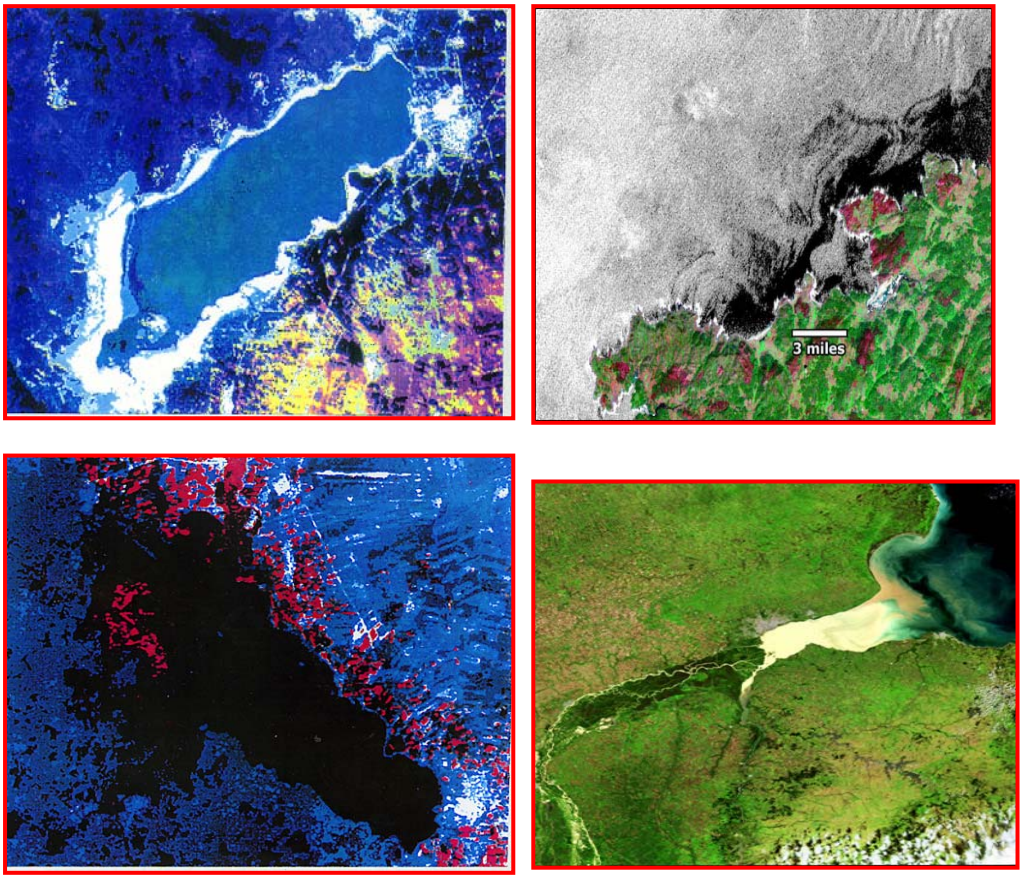
Surface Water One of the best known applications of remote sensing to water resources is the inventorying of surface water bodies, particularly streams, lakes, marshes and bogs, within a given region. The area covered by open water is readily delineated by various remote- sensing techniques because of the particular radiation characteristics of water. Decreased reflectivity of soils moisturized at the surface facilities the delineation of recently flooded areas, if these are barren. The delineation of floods in vegetation-covered areas is more difficult, but is possible either by use of radar or through a combination of radiation and topographic data. Remotely sensed data obtained on flood-plain characteristics can be combined with data obtained during floods for flood mapping and delineating flood hazard areas. Characteristics of river channel such as width, depth, roughness, degree of tortuousity and braiding can also be obtained from remote-sensing surveys.





Physical Water Quality

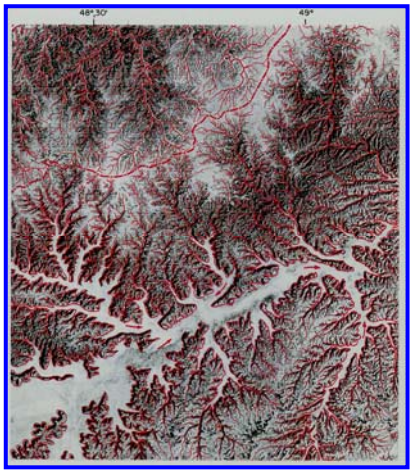
The cause of the changes in the reflected radiation is sometimes a result of variation in soil type, soil moisture availability, or suspended sediment in water, but it could also be caused by the presence of pollution. Consequently, sources and current locations of pollutants are often identifiable. Analysis of a multispectral image can suggest remedies to some pollution problems by indicating local areas where holding ponds or levees might be placed.

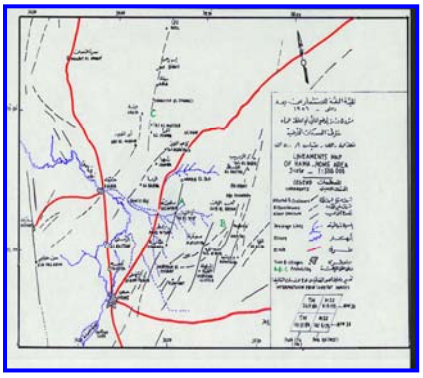
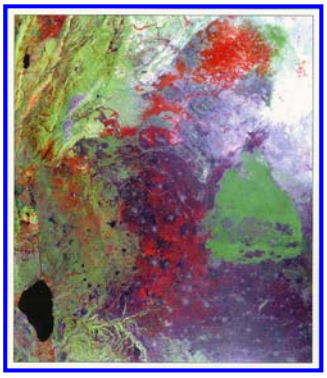


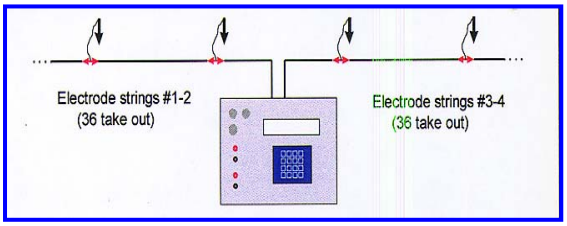
Ground Water

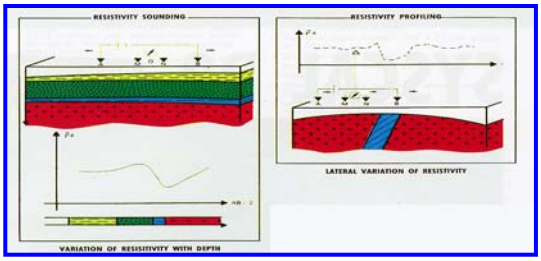
Ground water is concerned with water in the saturated zones beneath the surface of the Earth. Ground water information most useful to water resource managers includes: the presence or absence of ground water in designated areas, the depth to ground water, the quantity and quality of water available for development, recharge rates to aquifer, the possible impact of pumping on land subsidence, a real extent of the aquifer, locations of recharge and discharge areas, and the interaction between withdrawals at wells and natural discharge into rivers. Whereas this information is generally sought by hydrogeologists using conventional methods,
remote sensing can help in the planning of conventional measurements and can be used to estimate some hydrogeological variables quantitatively and others qualitatively.

The storage capacity of ground water reservoirs depends on their extent, which depends on geological properties of the area. Ground water forms the base flow for many streams and is the source of water for springs and seeps.



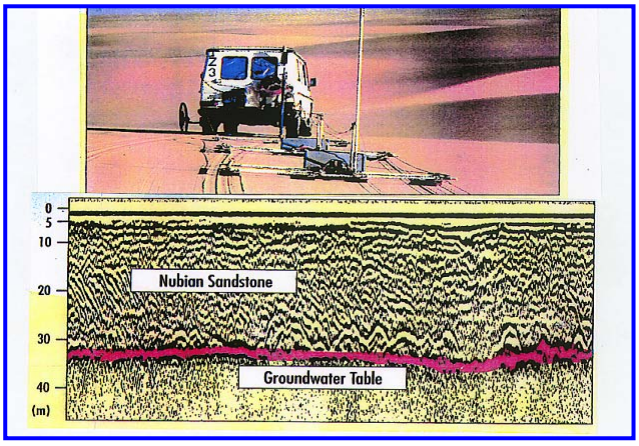



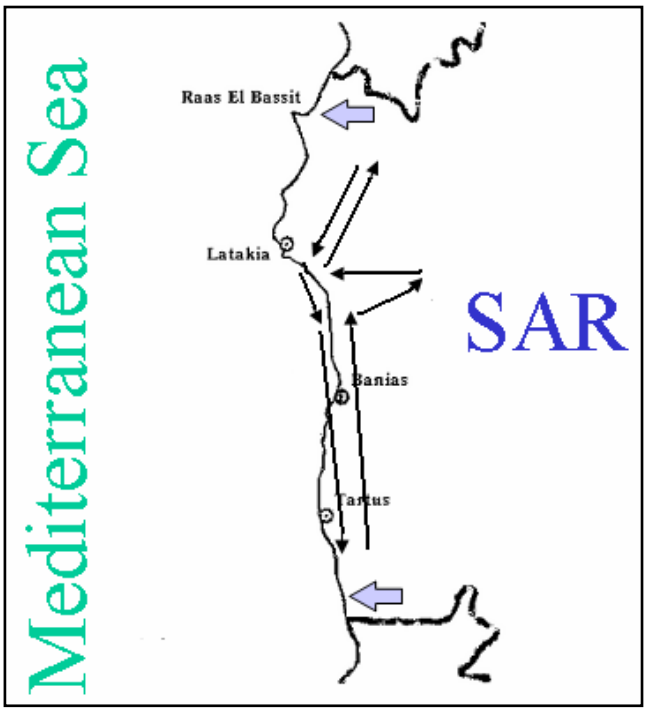


Using of geoelectrical resistivity

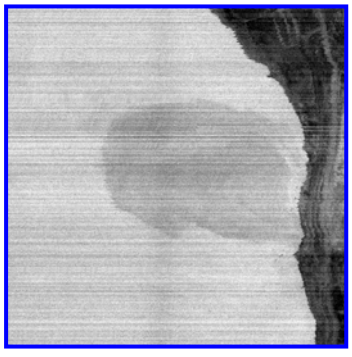
Using of the ground radar for exploration of ground water in the desert

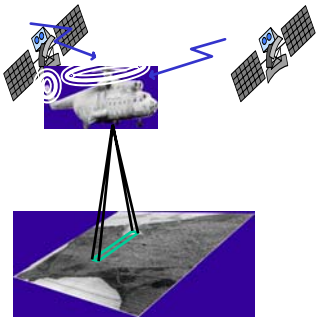


Thermal Survey of The Mediterranean Coast of Syria The survey was aimed to find places of the unloading of fresh water springs under sea water according to supposed temperature anomalies at the sea surface.There were discovered numerous (several dozens of) temperature anomalies, part of which coincides with the anomalies discovered earlier by space photography methods. Acquired results may serve as premises for industrial application of potential sources of fresh water



Map of the Coastal Strip



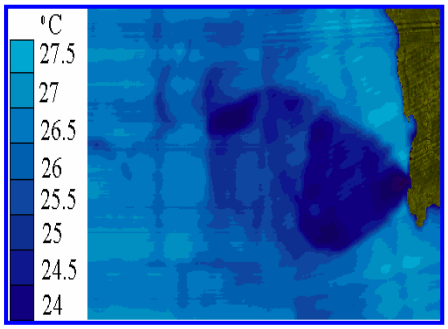


PROCESSED IMAGES

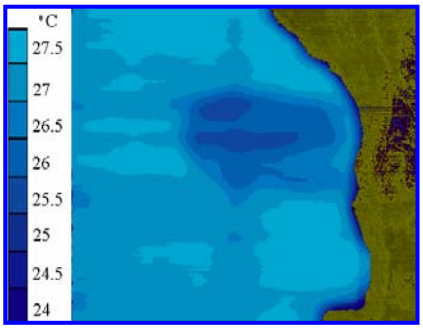
All anomalies can be divided into four groupsriver outfalls,

- sub-water springs,
- pollutions at the sea surface,
- -“hot” anomalies

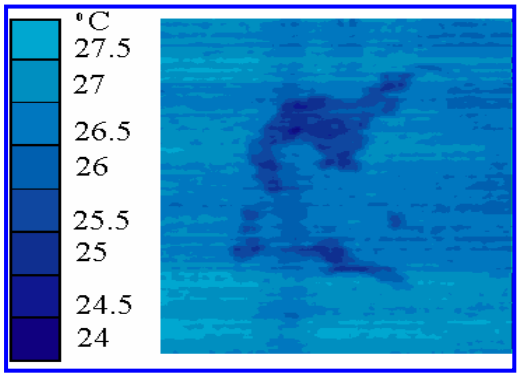
RIVER OUTFALLS



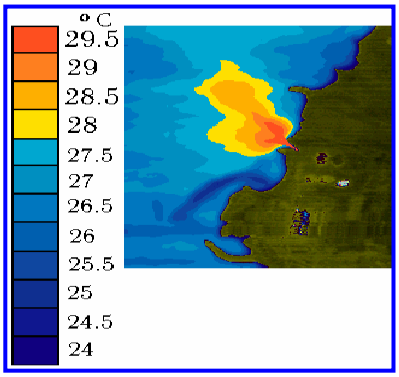
SUBWATER SPRINGS



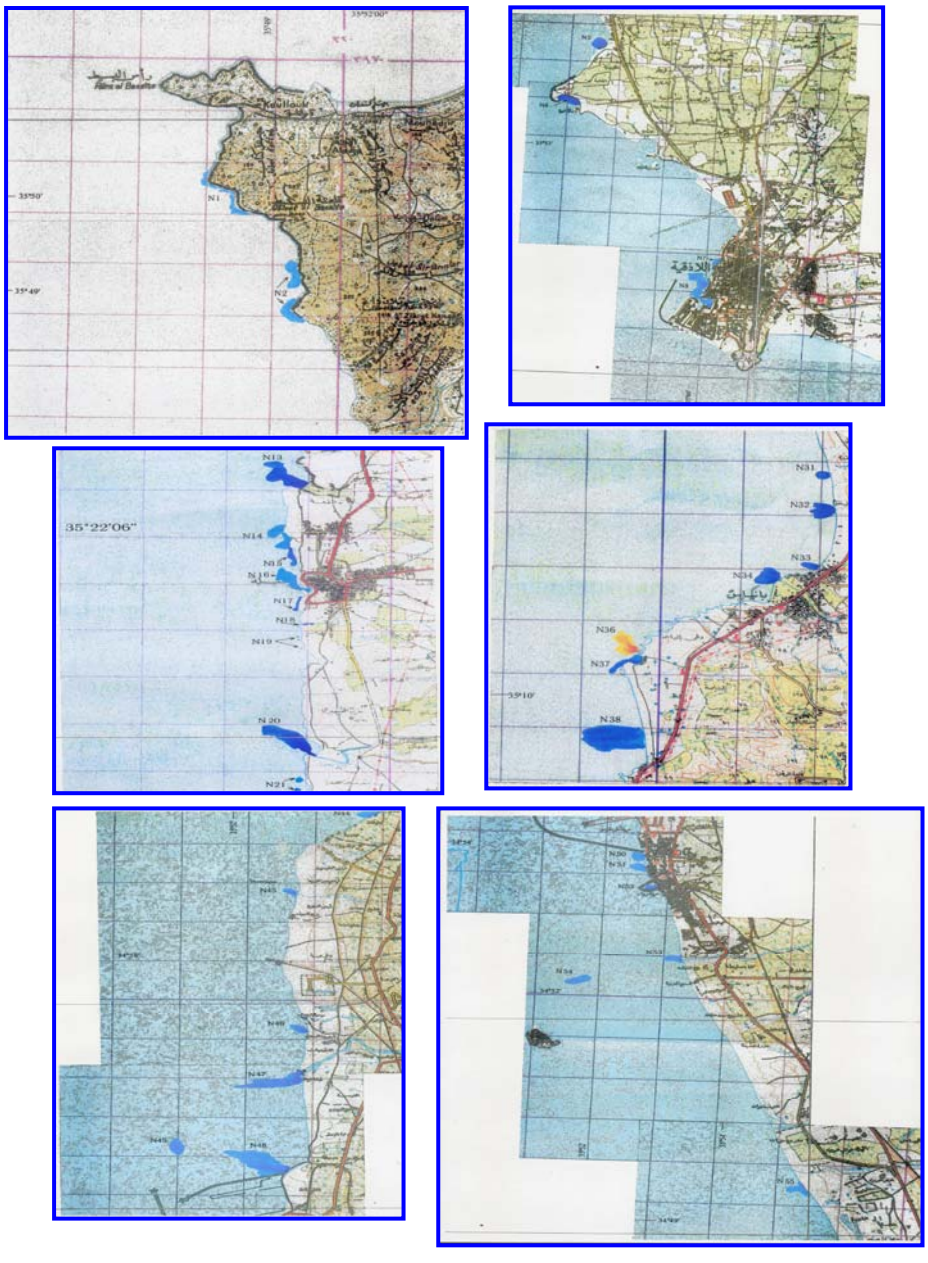
POLLUTIONS AT THE SEA SURFACE



“HOT” ANOMALIES



Part of the coast map with anomalies



Water Resources Management of EL- Zabadani Basin

Zabadani sub-basin is one of the most important basin in Syria, it is considered as a strategic source of drinking water for Damascus City. The historical Barada spring is flowing this basin an average rate of 3m3/sec.

This study aims to build a mathematical model, to simulate the groundwater flow system and produce a tool for the decision maker to manage and set up proper plan for the basin water resources. This was carried out by defining the water balance components and predicting the effect of the present and proposed plans on the water system of the aquifer.

The work plan is implemented according to following five consecutive phases:

- Collection of the available data and evaluation of the present status.-Performing field survey to fill the gaps of present status. This included the periodical measurements of water levels during the calibration period.
- -Establishing databases linked to GIS so the data will be readily available to the mathematical model.
- -Running and calibrating of the model, and -Testing the response of the aquifer water system according the various scenarios of the future plans.

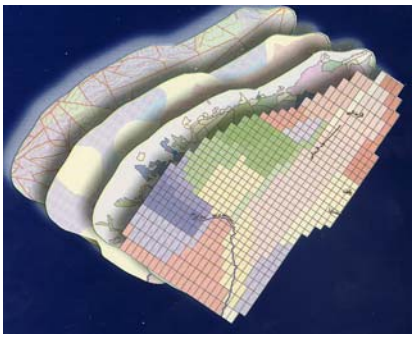
Remote sensing technique refined the geological map and established the lineaments map of the area. Moreover, satellite photos with the help of ground check, helped in defining the agriculture practices and produced the thematic maps; land and water use map, and plant cover map.

Around 2300 exploitation wells have been recorded by the field survey. Accordingly the total groundwater exploitation has been estimated. Groundwater level was monitored through periodically recording of the ground water level from selected 80 wells network the monthly water levels maps have been plotted. All the data have been collected and organized into three data banks. First on covers all available data of the exploratory wells, second for exploitation wells, and the last one for observation network.

The previous data have been linked to GIS (Arc/Info) and accordingly various layers been designed (such as layers of: volumes of irrigation water, volumes of pumped water…etc)

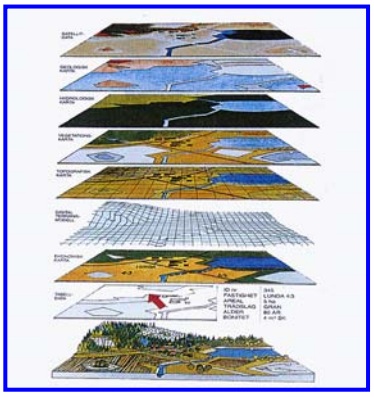
The MODFLOW code (U.S. Geological Survey) was applied in preparing and running the model

Mathematical Model of Al_Zabadani Basing



Soil Moisture and Evapotranspiration

Moisture in the upper layers of the soil profile is an important portion of the total water balance of the Earth-atmosphere system and is an important parameter in many disciplines related to hydrology such as weather, climate, and agriculture. In hydrology, the moisture content of the soil is important for partitioning rainfall into its runoff and infiltration components. The moisture content of this soil layer fluctuates in response to precipitation (input) and the evapotranspiration (output). The use and application of remotely sensed data for soil- moisture determination is still very much under development.



Conclusions

1. The performed work showed that thermal survey from board an aircraft is rather promising in the examination of natural resources of the Earth.
2. Suggested methods of work and apparatus proved to be applicable.
3. Results of the thermal survey of the coastal strip were verified by space survey methods and local data. Many unknown before temperature anomalies were found.
4. Processed results of the survey and compiled thermal maps open premises for industrialization of the potential sources of fresh water.