# BOOST: Water ResourcesTechnical Course

*Cutting edge scientific techniques for a dynamic future.*

Description:

The *BOOST Water Resources Technical Course* is designed by remote sensing and water resource professionals with decades of cumulative experience working both in academics and private consulting. The team of professionals draws from an international and interdisciplinary pool or talent.

The program is designed to prepare its participant for applying advanced remote sensing processing and interpretation to earth science applications with emphasis on environmental and hydrogeologic applications. The program incorporates training on modern remote sensing technologies, analysis of satellite images and advanced sensors, and integration of remotely acquired observations with observations extracted from other traditional data sets/disciplines including geochemistry, geophysics, hydrology, modeling, and advanced data organization techniques.

Participants completing the offered training programs will be fully prepared to apply the acquired skills to a multitude of dynamic scientific applications and real world environmental problems. In a rapidly evolving scientific world the difference between the success and failure of any scientific endeavor is no longer the availability of data, but the understanding of how to extract, integrate, and analyze the overwhelming body of data readily available.

Lead Instructors:

Dr. Mohamed Sultan, Western Michigan University

Dr. Adam Milewski, University of Georgia

Dr. Alan Fryar, University of Kentucky

# I. Training Schedule

1) **Fundamentals of Geologic & Environmental Remote Sensing Course**
    a. History and Scope of Remote Sensing
    b. Electromagnetic Radiations
    c. Multispectral and Hyper-spectral Remote Sensing

2) **Hydrogeology Field Course**
    a. Principles and Practices of Ground-water Sampling and Monitoring
    b. Principles and Deployment of Gauges (Streamflow, Rainfall)
    c. Installation of Soil Temperature Probes

3) **Remote Sensing Digital Image Processing & Applications**
    ***** Hands-on applications using ENVI & GIS software applications

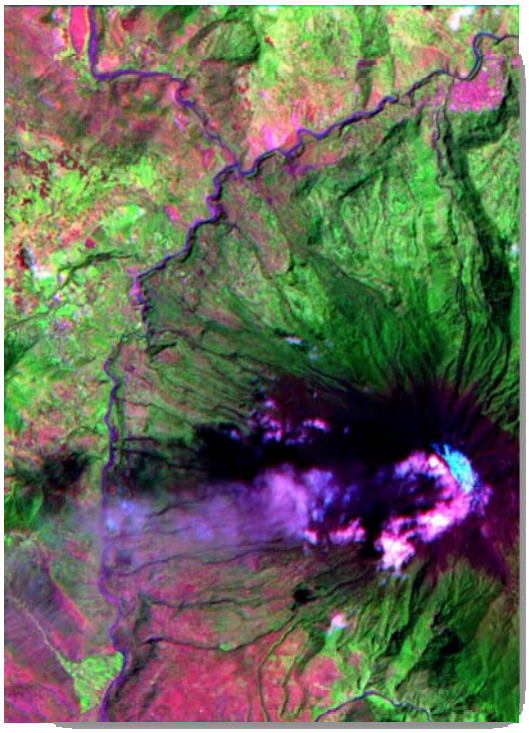
    a. Using ArcIMS to explore groundwater in arid environments
    b. Large-scale correlations from space-borne observations
    c. Compositional and structural mapping with Landsat TM data
    d. Assessment of renewable water resources

4) **Introduction to Rainfall-Runoff Modeling**
    **a.** Principles of Hydrologic Models
    **b.** Introduction to Rainfall-Runoff Models
    **c.** Introduction to Modeling Inputs and Databases
    **d.** Soil Water and Assessment Tool Model Setup & Simulation
    **e.** Sensitivity Analysis & Calibration of Hydrologic Models

5) **Principles & Applications of Geographic Information Systems (GIS)**
    **a.** Introduction to ArcGIS
    **b.** Understanding coordinate systems and projections
    **c.** Working with different data types (Vector, Raster)
    **d.** Methods in Spatial Interpolation
    **e.** Introduction to Web-based ArcGIS (ArcGIS Server)

# II. Course Description

## Geologic & Environmental Remote Sensing Course



**Part I - Fundamentals, data sources, and image acquisition**

***History and scope of remote sensing:*** Concepts of remote sensing, geophysical remote sensing, and milestones.

***Electromagnetic radiations:*** Wave model of electromagnetic energy, matter interaction with atmosphere, matter interaction with terrain, radiance and hemispherical reflectance, absorptance, and transmittance.

***Spectroscopy of rocks and minerals and principles of spectroscopy*:** Causes of absorption, electronic processes, vibrational processes, spectra of miscellaneous minerals and rocks, and scattering processes.

***Multispectral and hyperspectral remote sensing:*** Landsat System, Spot, ASTER, IKONOS, AVHRR, SeaWifs, MISR, and Hyperion.

**Textbooks:**

Campbell, J., 2002, Introduction to Remote Sensing, Third Edition, Guilford Press, New York, 620 pp.

Jensen, J.R., Remote Sensing of the Environment, Prentice Hall, New Jersey, 544 pp.,

Jensen, J.R., 1996, Introductory Digital Image Processing, a Remote Sensing Perspective, Second Edition, Prentice Hall, New Jersey, 318 pp.

## Remote Sensing Digital Image Processing & Applications

**Course description:**

The course provides extensive hands-on training on real-world geologic, hydrogeologic, and environmental projects and data sets. These data sets were collected by the instructors and their research associates over the past two decades. Throughout the course, the participants receive rigorous hands-on training on digital image processing techniques (e.g., image enhancement, classification, change detection, etc.) as well. The students learn how to extract and integrate lithologic and environmental information from a wide range of archival remote sensing data (e.g., Aerial photographs, CORONA, Landsat MSS, TM, SPOT, IKONOS, SIR-C, RADARSAT), digital elevation models, and maps.

**Part I – Analysis of remote sensing data**
***Radiometric and geometric enhancement:*** histogram, contrast modification, piecewise linear contrast modification, histogram matching, image smoothing, mean value smoothing, edge detection and enhancement, line detection, shape detection.
***Image classifications*:** Supervised (e.g., maximum likelihood, minimum distance classification, thresholds, parallelepiped) and unsupervised classifications (e.g., delineation of spectral classes, single pass clustering, and clustering by histogram peak selection).
***Accuracy assessment:*** Sources of errors, and measurement of map accuracy.

**Part II – Applications**
***Earth sciences:*** lithology, structure (faults, folds, suture zones), and plate reconstructions.
***Hydrology:*** applications of remote sensing in surface runoff modeling and ground water flow modeling

**Hands on Projects conducted throughout the course:**

**(1) Lithologic mapping using remote sensing data in arid lands**

The students use Landsat Thematic Mapper data, Landsat Multispectral scanner data, and ASTER data together with field, petrographic, geochemical, and hemispherical reflectance data to generate a lithologic map for a 600 $km^2$ area in the Red Sea Hills.

**(2) Structural mapping of faults, folds, and suture zones from remote sensing data**

The students use the spatial distribution of rock units and their lithologic characteristics (inferred from remote sensing data) together with field and geologic data to produce a regional structural map showing the distribution of suture zones, transcurrent fault systems, and folds.

**(3) Assessment of groundwater potential in varying geologic and hydrogeologic settings**

Students will be introduced to case studies conducted in various geologic settings for the purpose of identifying typical reservoir types to be found in such settings and the criteria that one could use to locate such reservoirs using remotely acquired data together with traditional data sources (geochemistry, geophysics, GIS). Three types of settings will be investigated: (1) transcurrent fault systems using the Najd Fault System of the Arabian-Nubian Shield as our study area, (2) rifting systems using the Red Sea rift as our case study, and (3) fold and thrust belts using the Quetta region, in the Pakistani Himalayas as the study area.

## Hydrogeology Field Course

This is an applied hydrogeology field course designed to educate and train students in traditional methods in hydrogeology. Examples include streamflow monitoring, shallow geophysics, well testing and sampling, and methods for estimating recharge.

- Data Processing using computer software
- Water level recorders, measuring equipment and data loggers
- Installation of field monitoring equipment.
- Hydrogeologic data collection
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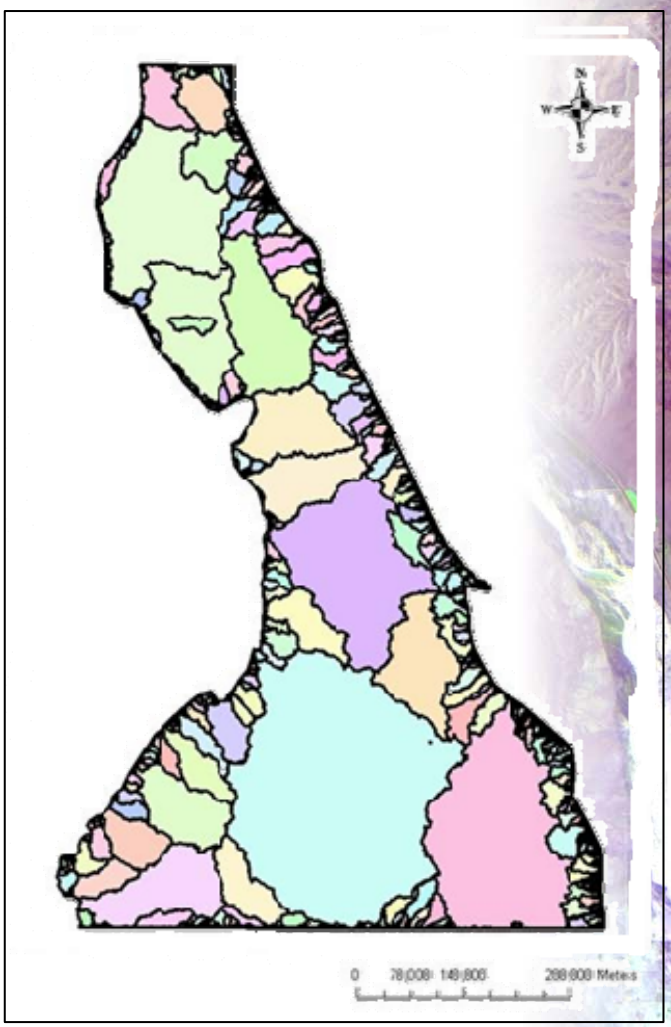
## Introduction to Rainfall-Runoff Modeling

**Course Description**

This section of the course focuses on the theory and application of hydrologic modeling. The principal of every scientific discipline is to construct and test theoretical models using testable assumptions. Building computer models takes this practice to a new level. This course will teach the student to build and understand cutting edge digital models so that they may then go and apply these useful skills to a broad range or real life applications. The course focuses on understanding the theoretical basis on which these models are constructed, as well as practical and useful applications. It is expected that the theoretical understanding of how real world hydrology is represented in sophisticated modeling software that the student can then take their model significantly closer to reality.



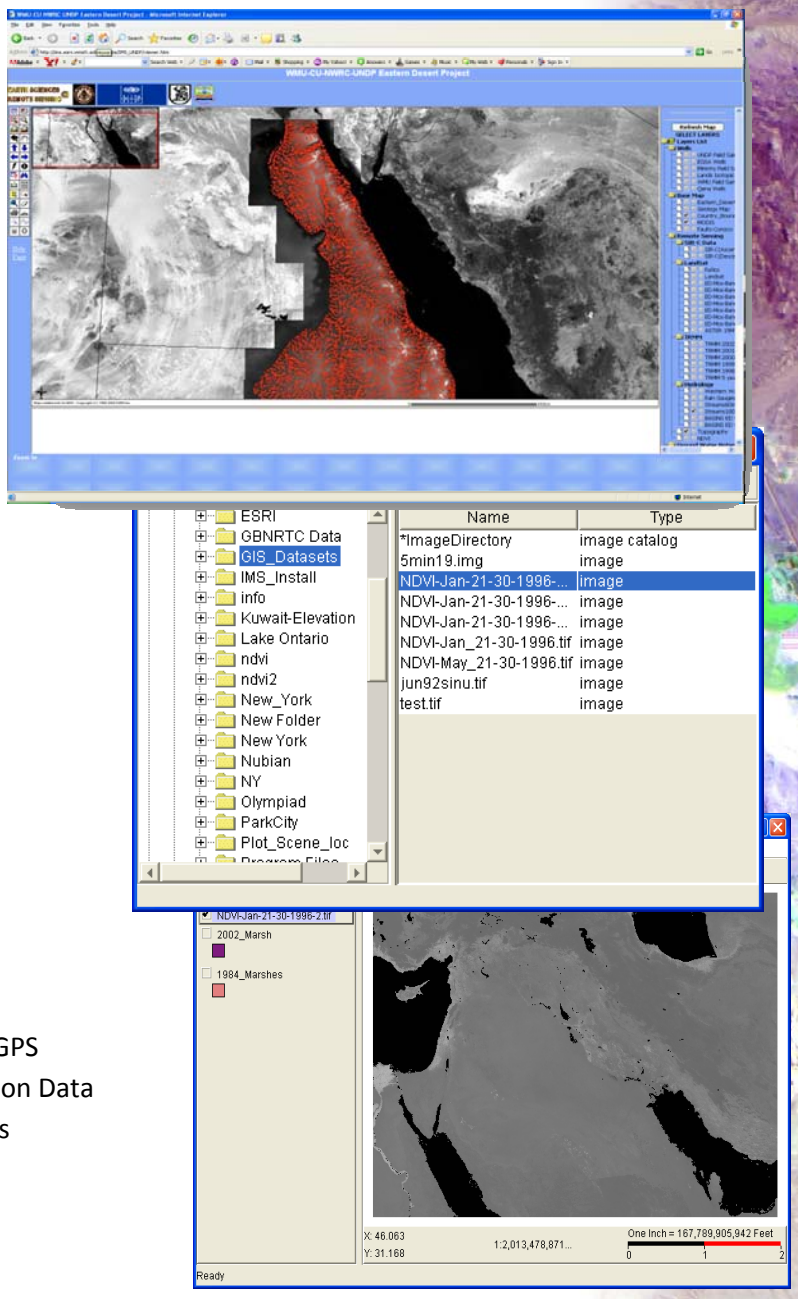
## Areas of Focus:

- Principles of Hydrologic Models
  - *Theory*
  - *Application*
- Introduction to Rainfall-Runoff Models
  - *Data Sources*
  - *Processing*
- Introduction to Modeling Inputs and Databases
  - *Processing*
  - *Parameter Configuration*
  - *Conceptual Tests*
- Soil Water and Assessment Tool (SWAT)
  - *Setup*
  - *Simulation*
  - Sensitivity Analysis & Calibration of Hydrologic Models

## Principles & Applications of Geographic Information Systems (GIS)

### Course Description

The course will cover the fundamentals of spatial data analysis and GIS technologies since the students cannot start dealing with applications unless they understand the fundamentals. **Thus the main goal for this course is to u**nderstand the fundamentals of GIS technologies and related fields and numerical and spatial analysis techniques commonly used in the analysis of geological and environmental data sets and applications. The participants will be introduced and become familiar with GIS components and concepts including:




- Geographic Information Systems
- Coordinate systems and projections
- Representation of Spatial Data
- Data Types
  - Raster Data
  - Vector Data
- Map Projections
- Spatial Data Input
- Data conversion
- Editing Spatial Data
- Data Attributes
- Fundamentals and Applications of GPS
- Generating and Interpreting Elevation Data
- Watershed Delineation and Analysis

- Spatial Data Models
- Spatial Interpolation
  - Triangulation
  - Theissen Polygons
  - Inverse Distance Weighted
  - Radial Basis Function
  - Global Polynomial
  - Kriging
- Future trends in GIS
  - Web-based GIS

- 3-D visualization (Geowall applications)

**Books**
There are no required books; The material presented will be extracted from multiple sources including but not limited to:

- ***Chang, KT, 2006,*** *Introduction to Geographic Information Systems, McGraw Hill*
- ***ESRI ArcGIS text*** as PDF files
- ***Bonham-Carter, G.F., 1996,*** Geographic information systems for geoscientists, pergamon press, 398 pp.
- ***Sickle, J.V., 2004,*** *Basic GIS Coordinates, CRC Press*

## Applications of Geographic Information Systems (GIS)

The course provides rigorous hands-on-exercises (based on data from case studies) on the applications of statistical methods, GIS technologies, and other computer-based software to the management, analysis, and display of multidimensional, geological, hydrogeological, and environmental data sets. This course will be designed as an overview of real-world GIS applications in hydrology, geochemistry, and isotopic methods for the evaluation of groundwater resources. The course will be largely practical hands-on problems for the participants to solve.

**General Course Organization**

This section will be mainly dedicated towards understanding and exploring the use of GIS technologies (mainly ***ArcGIS*** software) to address various geologic, hydrogeologic, and environmental problems of concern including the following:

**Assessment of groundwater resources in arid lands**

This lab provides training on the use of GIS technologies to assess the groundwater potentiality in arid lands using the Eastern Desert of Egypt as a test site. The targeted reservoir types are: (1) Nubian Aquifer groundwater residing in shallow alluvial aquifers, (2) alluvial aquifers recharged by modern meteoric precipitation, (3) meteoric groundwater reservoirs in fractured basement rocks, and (4) meteoric groundwater reservoirs related to dyke swarms. The validity of the methodology will be tested against existing wells in the Eastern Desert.

**GPS applications**

The lab provides training on the acquisition of GPS measurements, exporting the data into GIS environments, and estimating the accuracy of the data. GPS measurements will be acquired near UGA campus. The geographical data will be compared and integrated with spatial data sets including aerial photographs and base maps for the region.

**Land Use and Land Cover Change of the Mesopotamian marshlands**

The Lab provides training on monitoring land cover and land use change from temporal satellite images using the Mesopotamian Marshes, as the study area.

**Origin and evolution of groundwater in the Arabian Peninsula**

In this exercise, the student uses an extensive GIS data base for the Empty Quarter for the purpose of addressing questions pertaining to the origin and evolution of the groundwater in the Empty Quarter. The data incorporated in the GIS include geological maps, precipitation, topographic data, water levels, depth to water table, isotopic (O and H isotopic composition) and geochemical data (solute chemistry), and land cover.

**Evaluation of Seismic risk**

In this lab, students will learn how to evaluate seismic risks in an area by spatial analysis in a GIS environment of relevant data sets incorporating frequency of seismic events, distribution of

surface and subsurface faults, soil types, groundwater levels, population data, etc. using the Egyptian landscape as the test area. Because many of the data tables has an associated lookup table, students will learn how to join to geometry tables using the Join command. They will use selection tools learn how to make new layers with selections. Using the intersect tool, students will create maps with derived from multiple layers.