CS 350
A Computing Perspective on GIS

What is GIS? Definitions

- A powerful set of tools for collecting, storing, retrieving at will, transforming and displaying spatial data from the real world (Burrough, 1986)
- A system for capturing, storing, checking, manipulating, analyzing and displaying data which are spatially referenced to the Earth (Dept. of Env. 1988)
- An information technology which stores, analyses and displays both spatial and non-spatial data (Parker, 1988)

More Definitions of GIS

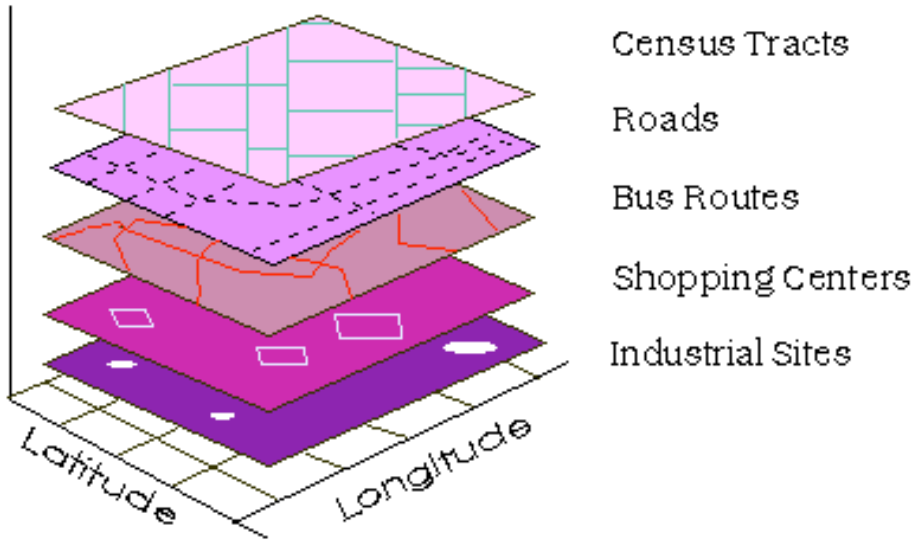
- A database system in which most of the data are spatially indexed, and upon which a set of procedures operate in order to answer queries about spatial entities in the database (Smith et al 1987)

- A decision support system involving the integration of spatially referenced data in a problem solving environment (Cowen 1988)

- Any computer based set of procedures used to store and manipulate geographically referenced data (Aronoff 1989)

What can you do with a GIS?

- Collect data
  - Normally data comes in data layers
    - Railroad dataset (data layer)
    - Roads dataset
    - River dataset
    - City, landuse, soil type, population datasets etc etc etc



Geographical Data

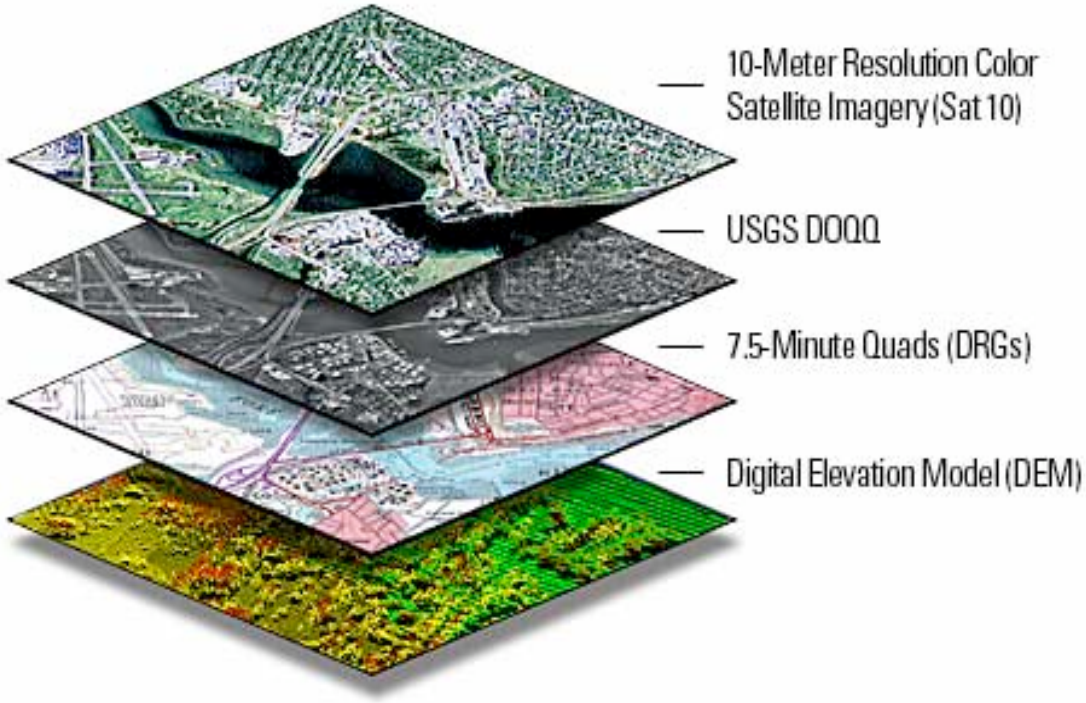
- Types of data available
  - Topographic maps
  - Satellite images and photographs
  - Administrative data
  - Census data
  - Statistical data on people, land cover and land use at a wide range of levels
  - Data from marketing surveys
  - Data on utilities (gas, water, electricity) and their locations
  - Data on rocks, water, soil, atmosphere, biological activity, natural disaster and hazards collected for a wide range of spatial and temporal resolutions

Sources/Producers of Data

- National Mapping Agencies; private mapping companies
  - DeLorme http://www.delorme.com/professional/xmap/datasets.asp
- Land registration and Cadastre
- Military organizations
- Hydrographic mapping
- Remote sensing companies and satellite agencies
- Natural resource surveys
  - Geologists, hydrologists, physical geographers
  - Land evaluators, ecologists, meteorelogists
  - Oceanographers

What can you do with a GIS?

- Visualization
  - Display maps
  - Zoom in/out, scroll
  - Turn layers on /off
  - …



What can you do with a GIS?

- Data analysis
  - Every object has attributes and location and is is kept in a database
  - Can ask standard database queries
    - List all cities with population >2M
  - Spatial queries
    - Find all areas where poverty level is > 30?
    - Find all sites in this test area
    - Find the intersections of rivers and roads (bridges)
    - Find the nearest neighbor of this site
    - Find the optimal route for this truck that has to visit all these sites
    - Find the neighbors of this entity
    - Count the number of occurrences of entity type A within distance D of entity type B

GIS

- GIS make possible a wide range of processing

Think of the computing aspect:

abstract and identify the problem

GIS

- GIS make possible a wide range of processing

  - resource inventory
    - combine various types of data
    - major road network
    - buil-up areas
    - airports

    - data formats
    - visualization

Think of the computing aspect:

abstract and identify the problem

GIS

- GIS make possible a wide range of processing

  - bus tour of local attractions
    - visit each place only once
    - minimize travel time
    - efficiency matters
      - gas prices

Think of the computing aspect:

abstract and identify the problem

GIS

- GIS make possible a wide range of processing

  - siting a coal mine
    - its ugly
    - its polluting
    - want to minimize impact
    - place it such that it affects fewest people

Think of the computing aspect:

abstract and identify the problem

GIS

- GIS make possible a wide range of processing

  - layer-based analysis: find potential extraction sites
    - find all locations that are within .5km of a major road, not in a built-up area, and on a sand-gravel deposit

Think of the computing aspect:

abstract and identify the problem

GIS

- GIS make possible a wide range of processing

  - analyzing the placement of clinics
    - What is the travel time to the closest clinic?
    - What is largest travel time to the closest clinic?
    - average?
    - Need a new clinic?
    - If yes, where to place a new clinic?
    - Which clinic to close?
    - where to move a clinic?

Think of the computing aspect:

abstract and identify the problem

GIS and the Environment

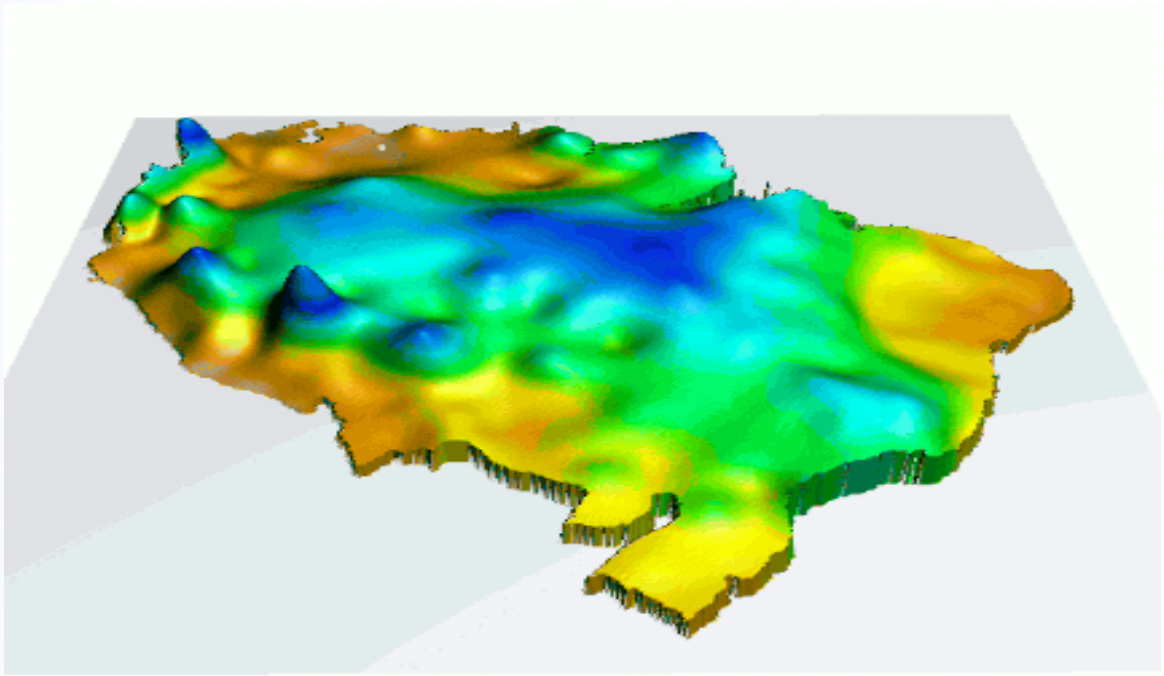
Indispensable tool

- Monitoring:
  - keep an eye on the state of earth systems using satellites and monitoring stations (water, pollution, ecosystems, urban development,…)
- Modeling and simulation:
  - predict consequences of human actions and natural processes
- Analysis and risk assessment:
  - find the problem areas and analyze the possible causes (soil erosion, groundwater pollution,..)
- Planning and decision support:
  - provide information and tools for better management of resources

Precipitation in Tropical South America

Lots of rain

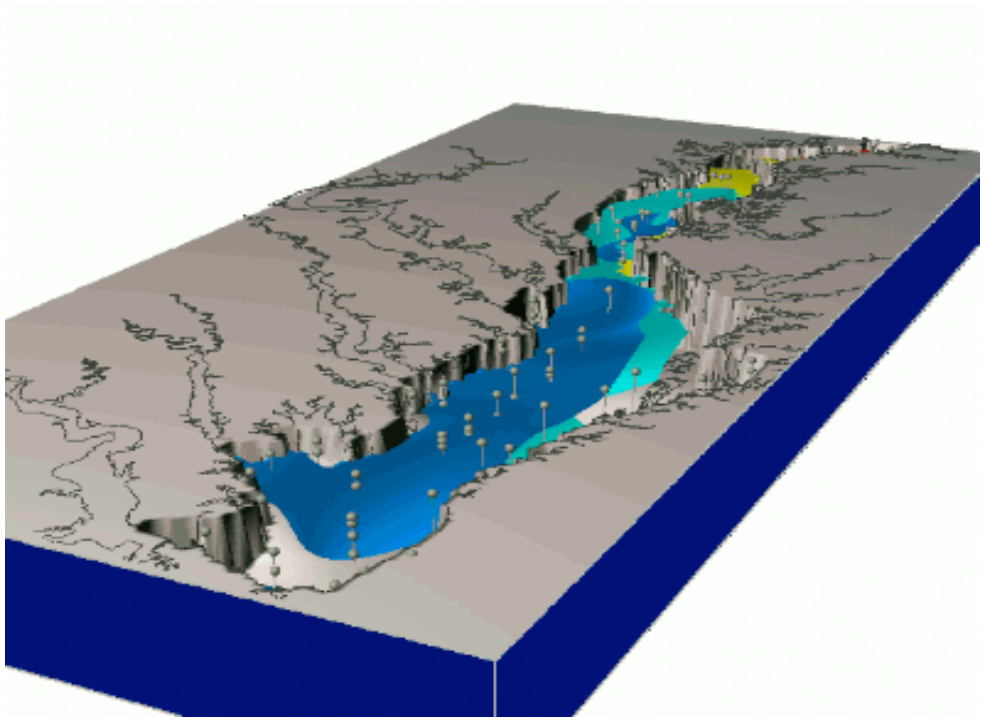
Dry



Pictures from Helena Mitasova

Nitrogen in Chesapeake Bay

High nitrogen concentrations

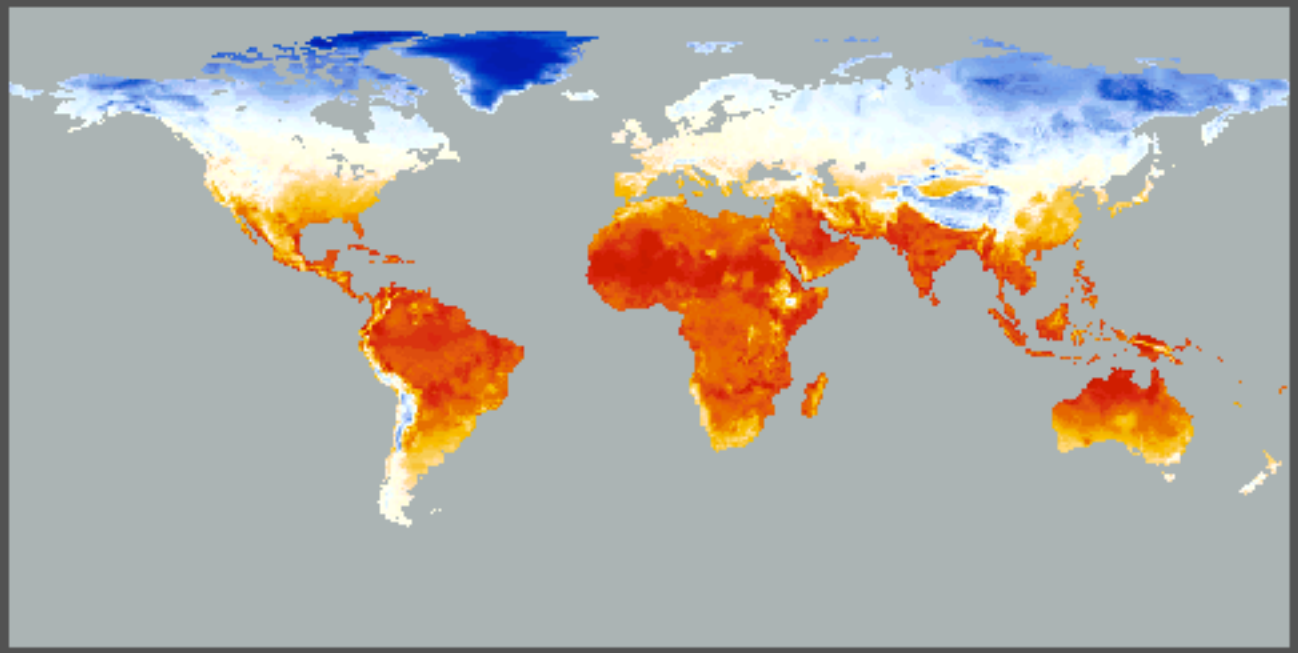


Pictures from Helena Mitasova

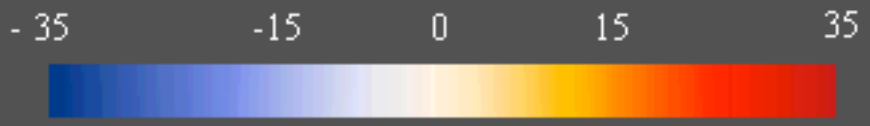
Applications of GIS

- GIS emerged as a powerful tool for Environmental Sciences
- As spatial data becomes more and more available, GIS is widely used in many disciplines
  - Agriculture
  - Archaeology
  - Epidemiology and health
  - Forestry
  - Emergency services
  - Navigation
  - Marketing
  - Real estate
  - Regional/local planning
  - Social studies
  - Tourism
  - Utilities

IIASA CLIMATE - MEAN MONTHLY TEMPERATURE



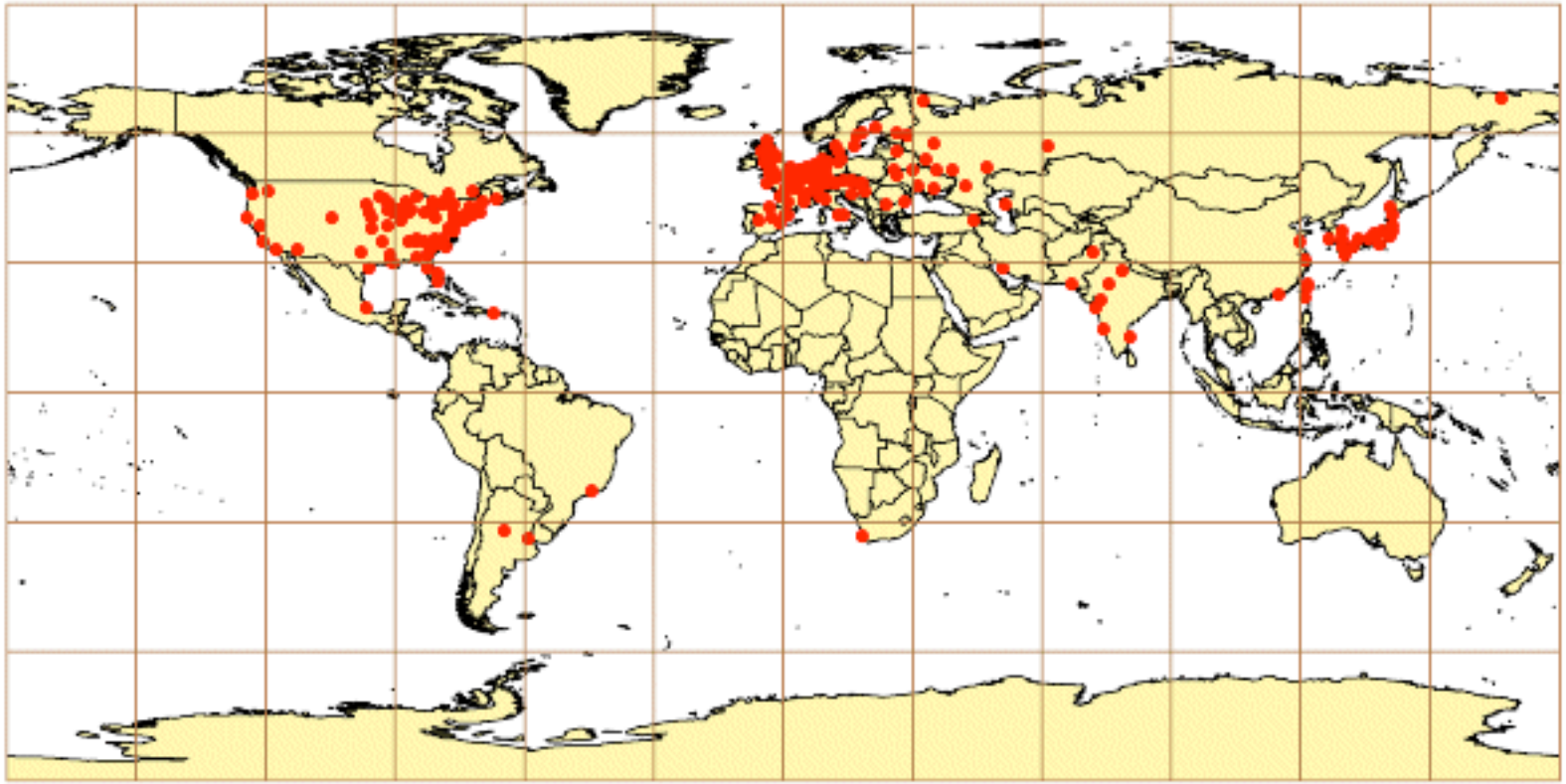
TEMPERATURE IN DEGREES CELSIUS, OCTOBER



DATA FROM INTERNATIONAL INSTITUTE FOR APPLIED SYSTEM ANALYSES
(IIASA, LAXENBURG, AUSTRIA) HELD AT UNEP/EAD/GRID-GENEVA

Nuclear Power Sites of the World

Status as of 31 december 1999



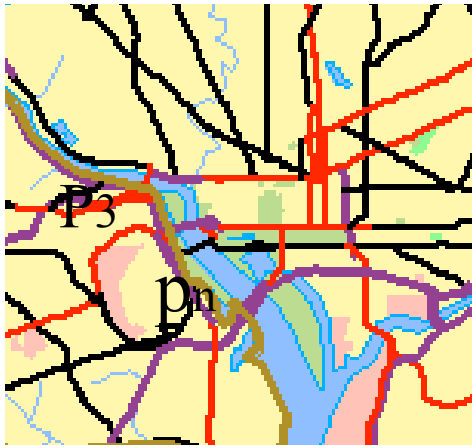
Projection: Geographic
Source: International Atomic Energy Agency, U.S. Nuclear Regulatory Commission, Federetion of American Scientists, Nuke Database System, and various other Internet sources; International boundaries, ESRI Data, 1998

UNEP/DEWA/GRID-Geneva

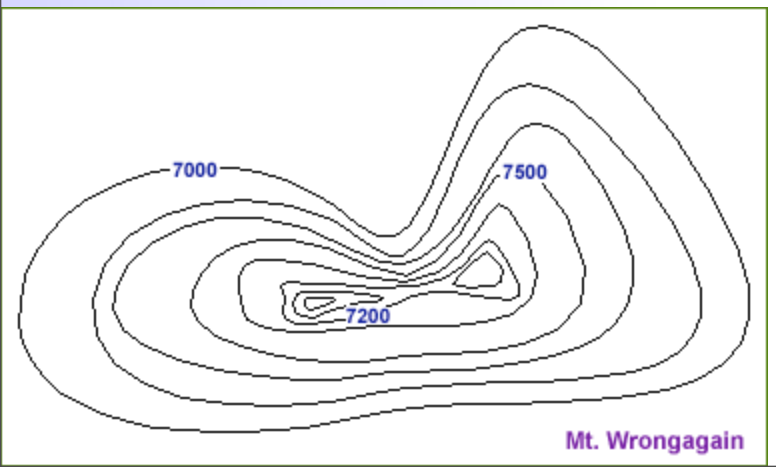
GIS Software

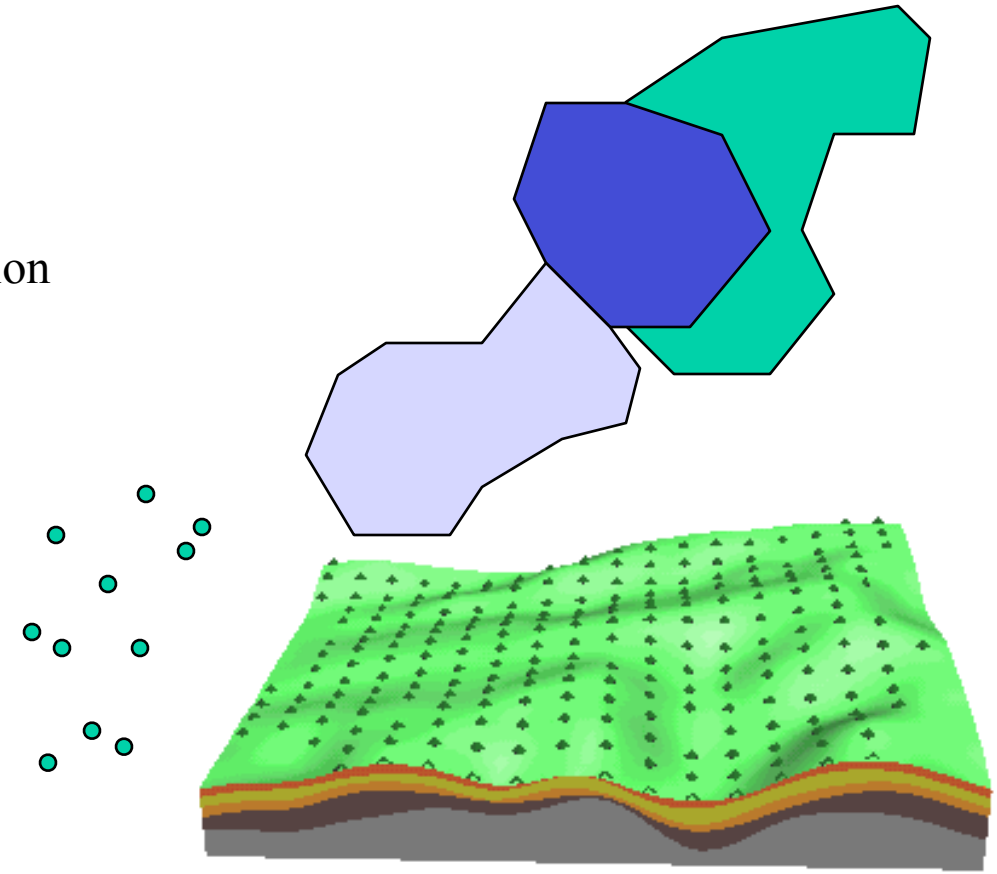
- ArcInfo (ESRI)
  - ArcView, ArcIMS, ArcExplorer, MapObjects, ArcLogistics, ArcCAD, NetEngine …
- InterGraph
- MapInfo
- Spatial DBMS (Oracle, Sybase, Microsoft SQL …)
- GRASS (Open Source GIS)
- Customized software used by companies
  - DeLorme http://www.delorme.com/professional/
  - GDT …
- Research groups at universities

GIS and Computer Science



- Rich area of problems for Computer Science
  - databases
  - graphics
  - graph theory
  - computational geometry
  - visualization
  - combinatorial optimization
  - interfaces





Syllabus

This class gives a computing perspective of GIS

- Fundamental database concepts
- Geographic data models and representation
- Fundamental spatial concepts
- Intro to geometric algorithms
  - finding the closest pair of points
  - line-segment intersections
  - the sweep method
  - polygon triangulation
- Delaunay triangulations and Voronoi diagrams
- Line simplification
- Terrain simplification
- Meshing
- Access methods (grid structures, quadtrees, space-filling curves)
- Terrain processing
  - Flow modeling. Drainage network. Watersheds
  - Visibility
- Handling large data (I/O-model and external memory algorithms)