Final Exam: Wed., Dec. 21, 3-5PM, this room.

The exam will have the same format as the midterm exam. It is not cumulative.

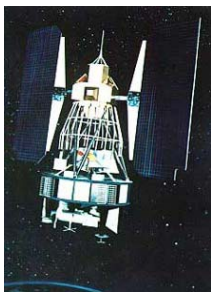
Term papers due next Friday, December 16, no later than 6PM.

Advances in Physical Geography and A New World of Technology

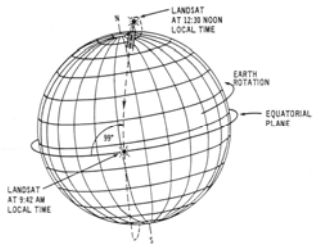
Two trends at the cutting edge of physical geography (in the opinion of Prof. Allan Frei) are:

1. Recent advances in Earth observing, and the tools used to acquire, analyze and disseminate the data, are allowing more access to more information.

Landsat 1
(1972-1978)



- Formerly, Earth Resources Technology Satellite 1, or ERTS 1
- A modified NIMBUS 4 weather satellite equipped with seven scanner systems (including infrared) to obtain information on vegetation, resources, and pollution.
- Unlike photography, which records information on film, Landsat recorded information digitally on tape and then transmitted it to earth electronically when in range of ground receivers.

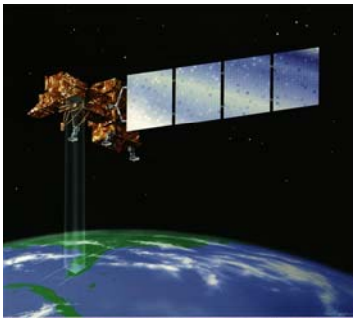


Combination of a polar orbit plus Earth's rotation means that a single satellite can overfly every point on the Earth's surface at a regular interval.

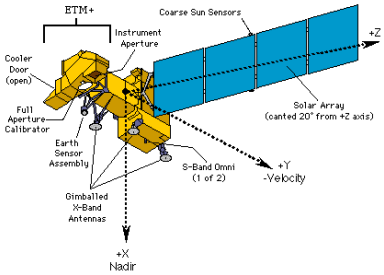
Landsat 7 Launch

Landsat 7

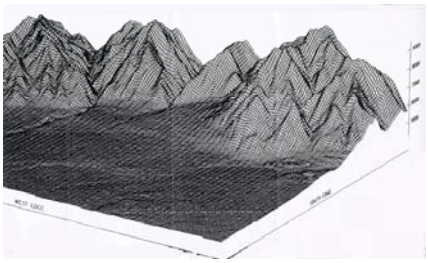
(Launched April 15, 1999)



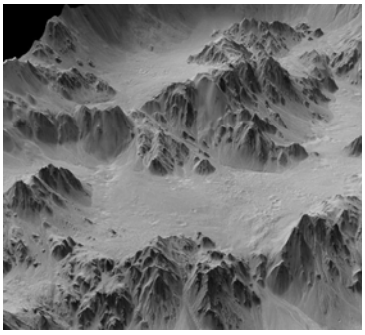
Landsat 7



Digital Elevation Model



Digital Elevation Model

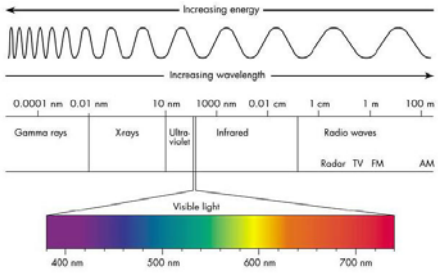


Remote sensing systems may be categorized as either passive or active.

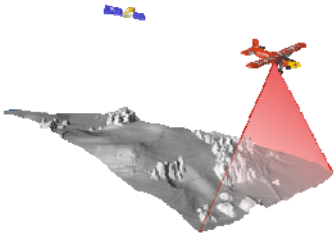
A passive system produces an image with the aid of naturally occurring electro-magnetic energy that reflects off of a object. Example: your camera.

An active system produces an image with the aid of a system-produced beam of energy that bounces off an object. Example: RADAR

The Electro-Magnetic Spectrum



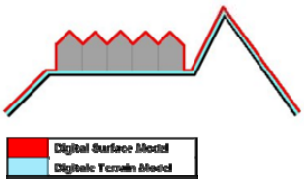
DEMs utilize data produced by active remote sensing technology, including RADAR (Radio Detection and Ranging), LIDAR (Light Detection and Ranging) and/or LADAR (Laser RADAR)

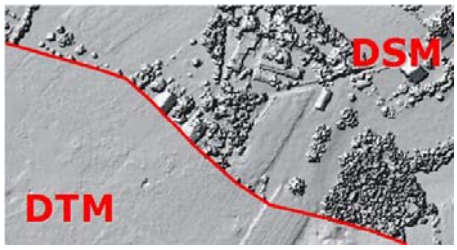


A Digital Elevation Model (DEM) is a computer-generated three-dimensional image of a portion of the Earth. There are two kinds of DEMs.

- **A Digital Terrain Model (DTM) portrays the bare ground without features such as buildings and vegetation.**
- **A Digital Surface Model (DSM) portrays the Earth's surface and everything on it, such as buildings and vegetation.**

Digital Surface Model vs. Digital Terrain Model



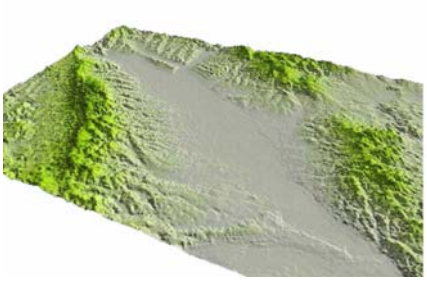


The data that produce a DEM can be acquired by aircraft- or satellite-based remote sensing systems that use RADAR (Radio Detection and Ranging), LIDAR (Light Detection and Ranging) and/or LADAR (Laser RADAR). In each case, the machinery generates a beam of energy that "bounces off" the Earth and scatters in all directions. A portion of the reflected energy is recorded by the same machinery that generates it. The strength of this "return signal" is a function of the angle at which the beam bounces off the Earth. Thus, these remote sensing systems are able to record with great accuracy the slightest variations in topography, and thus provide data for DEMs.

RADAR is unaffected by clouds, smog or fog. In a manner of speaking, it can see right through them as if they weren't there.

It is, therefore, an especially useful tool for mapping, especially in parts of the world that are prone to cloud cover for long periods.

Digital Elevation Model

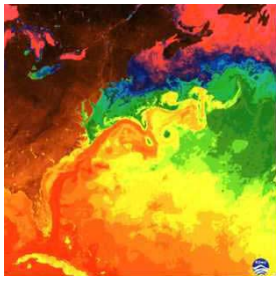


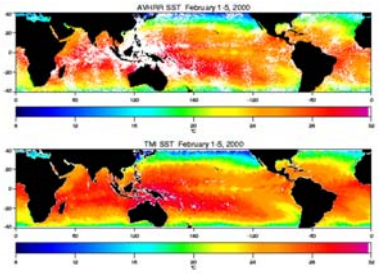
Possible uses of this technology

- "Smart" weapons systems, such as cruise missiles.
- Surface mapping of remote "inaccessible" areas – as well as very accessible ones.
- Water flow / runoff.
- Flight simulators.
- Line of sight analysis.
- Precision farming and forestry identification/mapping.
- Urban, regional, transportation and environmental planning.
- Input in to GIS

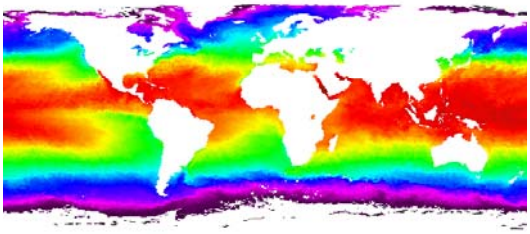
Oceanic Remote Sensing

This thermal image taken by a geostationary satellite reveals ocean surface temperatures off the eastern coast of the United States.

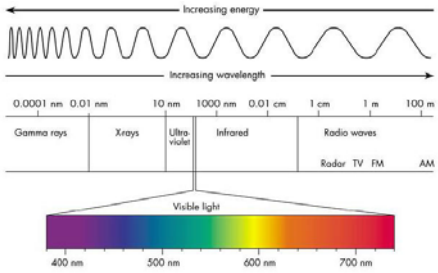


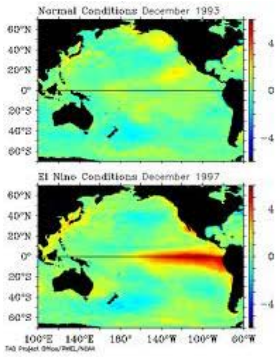


Infrared and Microwave Remote Sensing of Sea Surface Temperature



The Electro-Magnetic Spectrum

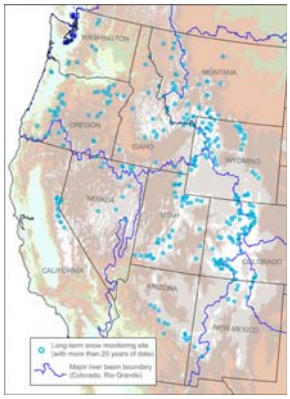




Pacific Ocean

Normal, top

El Niño, bottom

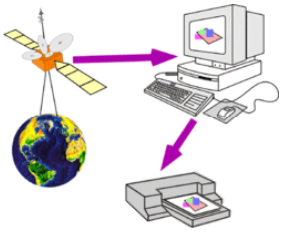


Locations of long-term snowpack monitoring sites in the western U.S.

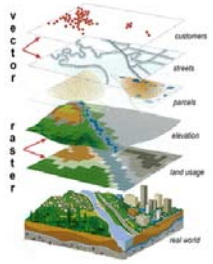
Snowpack Monitoring Systems

Geographic Information System (GIS)

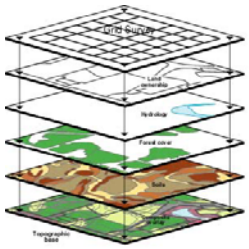
- **Rather generically, a computer-based system – possibly involving remote sensing and mapping technologies – designed to acquire, store, manipulate, analyze, manage and present all types of geographically referenced data.**
- **Output often takes the form of map overlays of a given area, each layer having identical scale but being devoted to the display of a different variable (e.g., topography, natural vegetation, street pattern, land values . . .)**



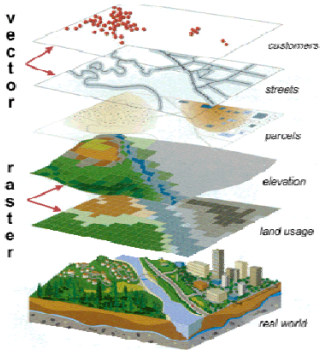
Integrated G.I.S. Diagram

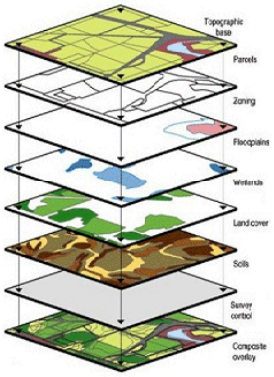


Geographic Information System (GIS) Model



Geographic Information System (GIS) Model





G.I.S. has emerged as an essential tool for planning, an occupation and geographical specialization that was virtually unknown a century ago, by permitting timely and accurate analysis and comparison of variables of interest to decision-makers.

John Snow's map of cholera cases in London, 1854/55

The Global Positioning System (GPS) is a hyper-accurate all-weather location and navigation system supported by 29 U.S. satellites in earth orbit. It is freely accessible to citizens of all countries who possess a GPS receiver and an unobstructed line of sight to at least 4 of the satellites that are part of the system.

Laser rangefinder (right hand)

Rugged field computer, water-proof and drop-proof (left hand)

GPS receiver/display (left shoulder strap)

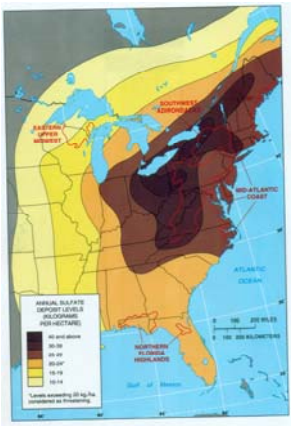
2. <u>Critical</u> <u>transitions</u>, which involve the analysis of different stability regimes in complex systems, which may be social and/or environmental in nature.

A critical transition occurs when a "driver variable," an ecosystem component that has the ability to significantly influence other system components, changes at a slow rate, thus perpetuating the impression of stability even as the system is becoming less stable. If this continues, the system will reach a "tipping point," at which it changes to a different stable state.

[Critical transition differs from other kinds of systemic changes in that if one pushes the slowly changing "driver variable" back to its previous state, the system cannot change proportionately, but instead moves to a new stable state from which it is hard to emerge.]

Acid Deposition

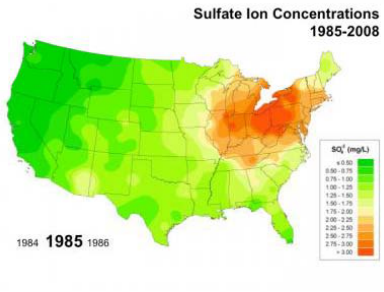
Many forests worldwide are increasingly impacted by acid deposition



Acid Deposition Map

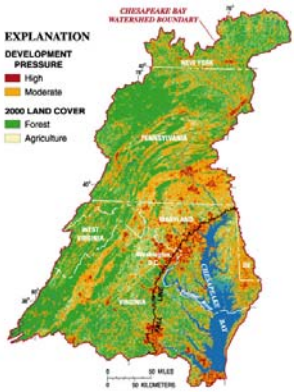
Acid deposition levels in Eastern North America

Average concentration of sulfuric acid ions in rainwater



Plant and animal life in small freshwater lakes are especially prone to damage by acid deposition

Critical transitions can occur at different geographic scales, ranging from small lakes to the entire earth.



The Chesapeake Bay, once one of the country's great fisheries and wildlife habitats, is now deeply affected by pollution from agriculture, cities and industries.

Some experts would say it is at/near a point of CRITICAL TRANSITION

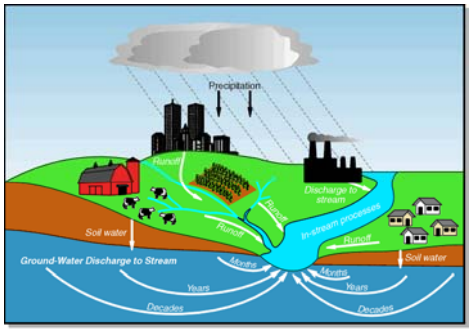


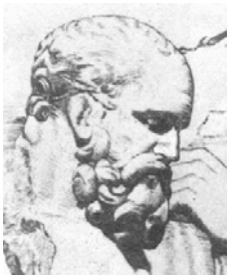
Figure 2. Nutrient movement in the ground-water-flow system.

While geography in the United States largely emerged from the ranks of geologists, the two fields have largely diverged.

Geology appears more and more concerned with energy resources.

Physical geography appears more and more concerned about other aspects of the physical environment, and the nature and result of interaction with people.

Anaximander (ca. 610 – ca. 546 BC)



- **Disciple of Thales**
- **Claimed that nature is ruled by laws, just like human society.**
- **Introduced the gnomon to Greece.**
- **Produced one of the earliest known maps of the world.**

Eratosthenes

(ca. 276 – ca. 195 BC)

"The Father of Geography"

- **Invented the word "geography"**
- **Chief librarian at Alexandria**
- **Invented a system of latitude and longitude.**
- **Calculated Earth's circumference with remarkable accuracy.**
- **First to prove that the Earth is round.**
- **Calculated Earth's tilt on its axis.**
- **Produced an advanced map of the world.**

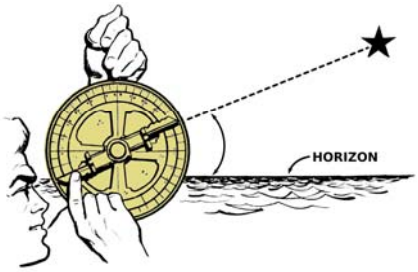
Hipparchus

c. 190 BC – c. 120 BC

- **Considered the greatest astronomer of antiquity**
- **Probably succeeded Eratosthenes as chief librarian in Alexandria**
- **Considered by some to be the inventor of the astrolabe.**
- **Credited with popularizing the Assyrian sexigesimal mathematical system, which divides a circle into 360°. Became the basis for the measurement of latitude and longitude.**

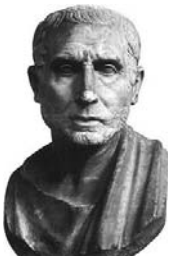
The use of an astrolabe

to calculate the angular elevation of a celestial object

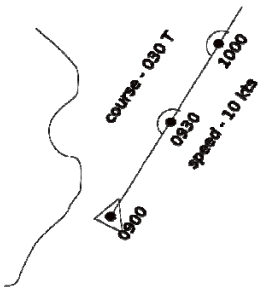


Posidonius

(135-50BC)



- Famous for two things that greatly influenced history and geography:
- A miscalculation about the size of the Earth that nevertheless was accepted for centuries; and
- A correct idea about the human inhabitability of the equatorial realm that was ignored for centuries.



Dead Reckoning

In this example, the current estimated position (triangle) is used to estimate future positions, based on calculations of direction and speed.

Claudius Ptolemy

(90-168 AD)

- Roman scholar/scientist famous for two great treatises written in Greek.
- The *Almagest*: a treatise on astronomy and celestial mechanics. Includes data on 48 constellations identified in classical times.
- *Geography*: A compilation of received knowledge of the world that spanned the classical period, to which he added his own judgments and interpretations. Includes a world map. "Discovered" around 1300; translated into Latin; influenced voyages of discovery.

"The Spice Islands"

Caravel

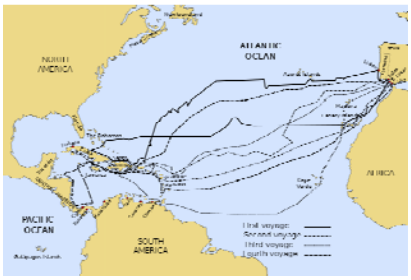
- A relatively small and highly maneuverable oceangoing vessel refined in the 15th Century by the Portuguese and used in many of their subsequent voyages of discovery.
- Noted for it's lateen sails.
- Carried a crew of about 20.

Ptolemy's World Map

(as re-drafted for a 15th Century manuscript)

Modified 1474 Toscanelli map of the Atlantic Ocean showing North America

The Voyages of Columbus, 1492-1504



World map by Plancius, c. 1590

Sextant

- An instrument used to measure the angle between any two visible things, particularly the horizon and a celestial object.
- Allowed for far superior readings than those obtained by a Davis Quadrant, which it replaced sometime around 1730.
- Facilitated accurate measurement of latitude.
- Used optical principles invented by Sir Isaac Newton.

On October 22,1707 four large ships in a British naval fleet were wrecked on the Isles of Scilly with a loss of 1,400 men because the navigator had miscalculated the longitude.

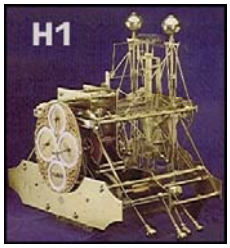
The Longitude Prize

- A reward offered by the British Government (pursuant to Parliament's passage of the Longitude Act, 1714) for a simple and practical method to determine a ship's longitude at sea.
- Offered £20,000 (roughly equivalent to $1,000,000 in today's money).
- The desired accuracy was an estimated location that was within 30 nautical miles of the actual location.

John Harrison (1693-1776)

- Self-educated English clockmaker who won the Longitude Prize
- Recognized that the solution required the accurate telling of time at sea.
- Produced a series of marine chronometers with required accuracy.
- Had difficulty claiming the prize because he was not a recognized scientist.

Two of Harrison's clocks



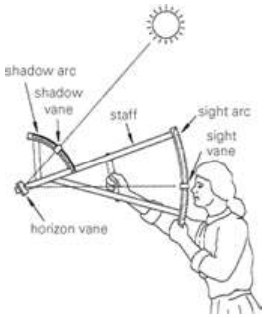
Alexander von Humboldt
(1769-1859)

"The greatest scientific traveler who ever lived."
-- Charles Darwin

Portrait by F.G. Weitsch, 1806

"The Heart of the Andes"
by Frederick Edwin Church, 1859

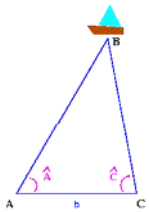
The Davis Quadrant (backstaff)
Early 17th Century
(replaced the cross-staff)



Clockwise from right: Compass with eye-sights; Wye level; Transit; Theodolite

A Zenith Sector

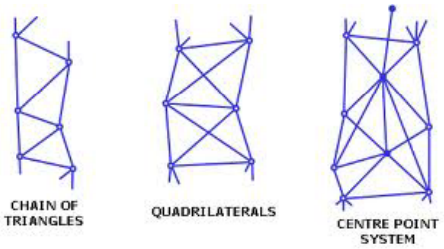
- **Any one of several devices once used by surveyors to determine their latitude by calculating the angular elevation of celestial objects.**
- **The one shown, some 12 feet tall, is the type used by Mason and Dixon.**



<u>Triangulation</u> is the process of determining the location of a point (B) by measuring angles to it from known points (A and C) at either end of a fixed baseline (b) of known length.

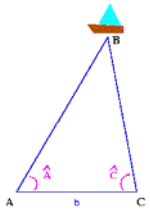
The basic geometric principles go back to the time of Thales.

Three types of land survey using triangulation



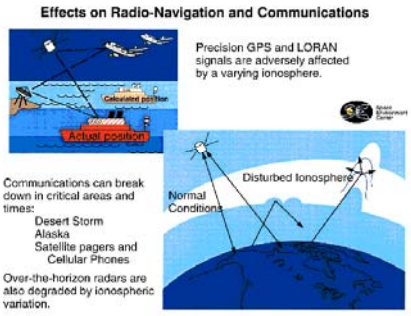
Radio Navigation Beacon

- Developed in 1897 by the Marconi Company to aid navigation at sea.
- Signal is transmitted on a known frequency from a tower at a known location.
- The received signal provides a bearing (direction) to the transmitter, but not the receiver's location and distance from the transmitter.
- The latter can, however, be determined by triangulation, which requires reception of signals from two transmitters at known locations.

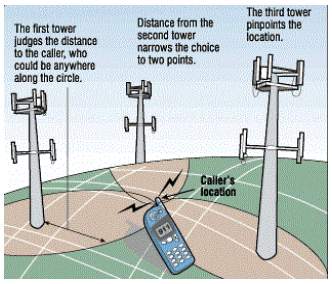


Triangulation is the process of determining the location of a point (B) by measuring angles to it from known points (A and C) at either end of a fixed baseline (b) of known length.

The basic geometric principles go back to the time of Thales.



Radio Triangulation



Laser rangefinder (right hand)

Rugged field computer, water-proof and drop-proof (left hand)

GPS receiver/display (left shoulder strap)