Introduction to Hydrology

I. Introduction

A. Hydrology - study of water

1. Spatial and temporal variations of water mass
   a. mass displacement / water circulation
   b. spatial distribution
      (1) global
      (2) regional
      (3) local watershed
   c. Temporal distribution
      (1) hours, days, weeks, years, millions of years

2. Physical and chemical processes that affect spatial and temporal variations

3. Physical Systems Analysis
   a. Mass and Energy
   b. Mass-Energy Flux (mobilization of mass and energy)

B. Hydrologic System

1. Water storage compartments ("Mass storage")
   a. Atmosphere
      (1) water vapor
         (a) gas phase ("humidity")
      (2) water condensate
         (a) clouds / precipitation
         (b) "weather" systems
   b. Oceans
   c. Continental Areas
      (1) Lakes
      (2) Rivers
      (3) Glaciers
      (4) Groundwater

2. Water Transfer Functions (Energy-Mass Interaction)
   a. Evaporation (surface water to atmosphere transfer)
      (1) triggering mechanism = heat gain
      (2) energy source = solar

   b. Precipitation (atmosphere to surface transfer)
      (1) triggering mechanism = heat loss
      (2) energy source = solar / gravity

   c. runoff (channelized flow / overland flow)
      (1) energy source = gravity

d. infiltration (surface to groundwater transfer)
(1) energy source = gravity

e. transpiration (surface - vegetation exchange)
(1) energy source = solar / photosynthesis

C. Temporal and Spatial Scales in Hydrology

1. Temporal
a. Thunderstorms ~minutes to hours
b. Floods ~ days to weeks
c. Runoff Cycle ~ decades to centuries
d. Shallow groundwater circulation ~1000's to 10,000's years
e. Development of Major River Basins ~ 100,000's to millions of years

2. Spatial
a. thunderstorms ~ 1 km
b. groundwater / aquifer systems ~ 10's of km
c. major river basins ~1000's to 10,000's km

D. Variability of Hydrologic Processes

1. Highly variable over space and time
a. e.g. Oregon climate transect from Coast to Coast Range to Interior

2. Deterministic vs. Stochastic Processes
a. Deterministic - predictable hydrologic patterns
(1) e.g. weather forecasts
(a) deterministic on short term
(b) seasonal predictions / probability

b. Stochastic - random hydrologic patterns

3. Statistical Approaches to Hydrologic Data Collection and Analysis

a. Data limited in space and time
(1) e.g. discreet sampling stations at discreet times

b. Interpolation between time / space data points
(1) statistical analysis and probability

II. Significance of Water

A. Essential for animal and plant life to exist, forms the medium in which biochemistry can take place.

B. Water solutions transport nutrients and elements to organic tissues, nourishing them. Carries waste products out of tissues.

1. Mass of living organisms comprised of water ranges from 65-95%

C. Surface water covers more than 70% of the Earth's surface ("The Blue Planet")

D. Hydrologic Cycle

1. The Earth as an Isolated System
   a. water mass is constant on the Earth
   b. energy may be transferred into / out of the system
      (1) e.g. solar energy / heating of atmosphere

2. Water mass and energy may be transferred from one storage compartment to another.

III. THE HYDROLOGIC CYCLE

A. General Statement: 99% of all earth's water is held in storage in form of oceans, lakes, glacial ice or groundwater.

1. The remaining 1% is involved in the continuous sequence of movement and change in the form of atmospheric moisture, precipitation, and subsequent runoff and drainage, perhaps temporarily stored en route.

B. The Hydrologic Cycle: a circuit of water movement, with storage areas interconnected by various transfer processes... water moves not only geographically, but through physical states as well.

1. Basic Model: Ocean Water----sun's energy---- evaporation -----atmospheric moisture----- condensation/precipitation------land/continental waters-----downgradient flow due to gravity------ back to ocean------and cycling through.

2. Surface to Air: Evaporation prime mechanism for transfer to atmospheric moisture.

   a. Ocean Evaporation- heat and wind operate on oceans and result in evaporation of water from liquid to vapor form (especially effective in lower latitudes, areas with most direct heating from sun's rays)

   b. Land Evapotranspiration- water is not only release to the atmosphere on land through evaporation, but also through transpiration of water vapor from plants/trees to the atmosphere.

   c. Water Vapor Movement:
      (1) Convection- vertical movement of moisturelaiden air masses through heat transferprocess

(2) Advection - horizontal transport of airmasses by wind currents.

3. Air to Surface: atmospheric water vapor is eventually condensed into liquid or sublimated into ice to form cloud particles = precipitation

4. Surface and Ground Waters: precipitation on land can run several possible courses:
a. accumulation/ponding on the continental surfaces (will subsequently be subject to high rates of evaporation).
b. surface runoff: in form of streams and rivers, eventually being subject to partial evaporation and final emptying back to sea.
c. Infiltration into the ground and uppermost strata comprising the lithosphere; forming "ground water"
d. Vegetative interception: the interception of precipitation by the vegetative canopy of the biosphere, may be subject to evaporation or eventually fall to ground.

5. Duration of Cycle: water may become temporarily stored and removed from the cycle from hours to days, to years to 100's of thousands of years...depending on the geohydrologic circumstance.

C. Moisture Inventory:
1. Oceans: contain 97% of Earth's water
a. >70% of Earth's Surface Covered in Water
2. Glaciers: 2% of all moisture, comprising 75% of worlds fresh water
a. Continental Ice Sheets
(1) Antarctica
(2) Greenland
b. Ocean Ice
(1) Antarctic Shelf
(2) Arctic Sea
c. Glaciers = Savings Account of Fresh Water
d. Ice-Sea Water Budget
(1) Glacial Climates
(a) < Ocean Volume
(b) > Ice Volume
(2) Interglacial Climates
(a) > Ocean Volume
(b) < Ice Volume
3. Ground water: 0.5% of total
a. Surface Transfer
(1) Springs
(2) Anthropogenic Transfer
4. Fresh Surface Water: 0.2%
a. Lakes, Rivers
5. Soil Moisture: 0.1%
6. Atmospheric Moisture: 0.0001%
7. Biological Water: negligible

In-Class Exercise: The Global Water Budget

Below is a table showing estimated volumes of water in various storage compartments for the global water budget. Complete the calculations in the table and answer the questions.

Storage Compartment	Volume ($x10^3$ km^3)	Percent of Total
Water in Land Areas		
Fresh water lakes	125	________
Saline Lakes	104	________
Rivers	1.25	________
Soil Moisture (unsaturated)	67	________
Ground water (to depth fo 4000 m)	8350	________
Ice Caps / Glaciers	29200	________
Atmosphere	13	________
World Ocean	1320000	________
Total	________	________

1. Which part of the global water budget has the greatest percentage of water in storage?

Which part has the least?

2. What percent of the total "water in land areas" is contained in the form of groundwater?

3. What percent of the total "water in land areas" is contained in the form of ice caps/glaciers?

4. Calculate the percent of storage in world oceans if climate change resulted in a doubling of the volume of water stored in icecaps/glaciers. Show all of your work.

5. Freshwater drinking supplies are derived primarily from either rivers or groundwater. Which storage compartment represents the greatest drinking water resource on the planet?

6. The western U.S. is associated with a significant number of dam projects on rivers. Many of these dams supply drinking water from the reservoirs. In terms of the hydrologic cycle, is damming / reservoir development the most efficient method of providing water resources? Why or why not, explain your answer.