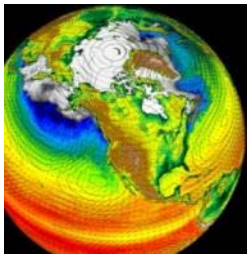
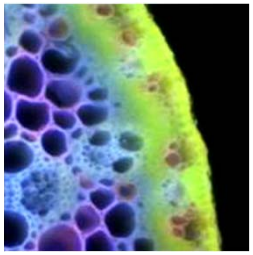
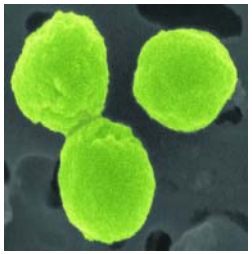
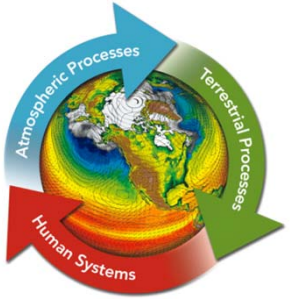


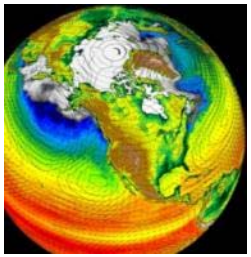


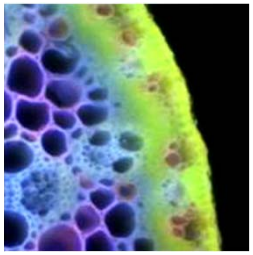
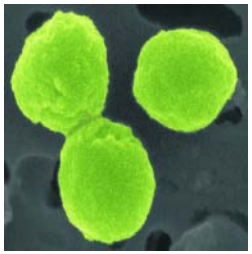
Human-Earth Systems Interactions and Impacts on the Water Cycle

Anthony Janetos, Mohamad Hejazi, Ruby Leung, Ken Strzepek

Washington DC

September 24-26, 2012



Prediction is very difficult, especially about the future.

Niels Bohr

Outline

- Trends and scale of human influence
- Importance of agriculture and energy
- Land use in catchments
- Precipitation
- Scientific and modeling priorities

Human Influence on Water Cycle: Trends and Scale

- Dams and impoundments
  - Globally – ca. 945,000 dams above 15m; store ca. 15% of global runoff
  - US – 2% of rivers run unimpeded; 75,000 dams store about 1 year's runoff
  - About 45,000 large dams built world-wide since the 1930's
- Water withdrawals and use
  - Little water reaching the sea in major river Basins – Ganges, Colorado, Nile
  - Major inland water bodies reduced in size – Aral Sea, Lake Chad – primarily from agricultural diversion
  - Extensive and unsustainable mining of fossil groundwater – Saudi Arabia, Ogalalla aquifer

Human Influence on Water Cycle: Trends and Scale

- Climate change and extreme events
  - Expectation of acceleration in global hydrologic cycle
  - Accentuation of extremes – extreme rainfall events and drought
  - Some evidence for these trends in empirical records
- Freshwater biodiversity
  - Declined faster than terrestrial or marine diversity over past 30 years
  - Reduced flow and increased water temperatures
  - Nutrient additions to river ecosystems from agricultural and municipal runoff
- Ice and sea-level rise
  - Thermal expansion
  - Anthropogenic melting of land ice sheets and grounded marine ice extremely difficult to quantify

Sensitivities to Human Decision-Making: Importance of Agriculture and Energy

- Human access to renewable water ca. 10^5 km^3 yr^{-1} about 25% of total
- Withdrawals grown from ca. 580 km^3 to 3830 km^3 from 1900-2000
- Humans withdraw somewhere around 8% of total available freshwater and around 54% of accessible runoff
- More than 2 billion people live in water stressed areas; could rise to nearly half of world population by 2025
- Irrigated area has increased 5 times to around 250 million hectares globally
- Irrigated agriculture globally responsible for around 70% of withdrawals
- In US, agriculture is largest withdrawal and consumer of water; energy is second-largest withdrawal

Sensitivities to Human Decision-making: Land Use in Catchments

- Often see increased stream and river flow as a consequence of clearing natural vegetation
- Land clearing for agriculture in tropics and subtropics the major global land use change of the past 40-50 years
- Changes partitioning of surface water and surface energy balances
- Clearing land for agriculture also with major carbon and other biogeochemical effects (N, P additions and eutrophication)
- Increasing urbanization has also had major consequences for water quality

Sensitivities of Precipitation to Human Influence: Local/Regional and Global

- Local and even regional precipitation patterns can be affected by land-use patterns, if the changes in land-use are large enough – documented in temperate and tropical latitudes many times
- Irrigation has effect of allowing the atmosphere to “see” more water than it would otherwise – affects temperatures and precipitation locally and regionally
- Similarly, urban heat island effects can create local convective storms
- Fire and biomass burning as sources of aerosols have potential to influence precipitation patterns downwind

Suggestions for Scientific and Modeling Priorities

- Modeling human water use directly – particular focus on agriculture and energy uses
- Modeling interactions among human systems – water management, agriculture, energy system – at appropriate scales
- Modeling feedbacks to the atmosphere from land surface change and energy system change
- Ability to simulate and analyze multiple scenarios and ensembles
- Understanding and assessing predictability of water cycle in context of coupled human-Earth systems