Applications – 2

Urban heat island effects

- Temperature differences develop between cities & surrounding rural regions
- Urbanization has greatest influence on minimum temperature records
- Increases cloudiness & precipitation in the city – sets up thermal circulation between city & surrounding region

Satellite-derived temperatures

- Satellite-derived temperature data
  - AVHRR thermal data (10.5-12.5 μm) at night to determine urban & rural surface temperature differences
  - HCMM (10.5-12.5 μm) to assess the extent & intensity of urban surface heating

Satellite-derived VIs

- Greatest differences in surface radiant temperature observed at midday
- Measure difference in density of urban & rural vegetation – indicator of magnitude of differences observed in the minimum air temperatures of urban & rural areas
- VIs – useful estimators of amount of leaf area & related variables associated with agriculture

Satellite-derived VIs

- Urban-rural differences in min, max, & ave air temperatures at met stations related to AVHRR estimates of NDVI & surface radiant temps

Other studies

- Use remote sensing (multitemporal TM) & GIS to detect urban growth – assess its impact on surface temperature
- Measure UHI in magnitude & spatial extent – UHI magnitude inversely correlated with rural temp, while spatial extent independent of heat island magnitude & rural temp

Carbon cycle studies

- Human activities – fossil fuel burning & changing land use – have caused an increase (>28%) in atmospheric carbon concentration over past 150 yrs
- As atmospheric CO_2 increases, earth's climate will change
- To prevent further increase of carbon & other greenhouse gases – need to understand global carbon cycle

Approach – terrestrial carbon

- 2 approaches to determine change of terrestrial carbon distribution in 3 pools – atmosphere, plants, soils
  - "Bottom-up approach" – start with parcel of land to account for various pathways of carbon exchange between ecosystem & atmosphere; scale up to larger regions
  - "Top-down approach" – measured changes in atmospheric gas concentrations; attempt to infer spatial distribution & magnitude of net exchange

"Bottom-up" approach

- Relies on ecosystem process models & spatial datasets
  - Develop at local scale, validate using conventional measurements
  - Satellite observations provide spatial distribution & up-to-date information
  - Figure 13.8
- Use optical & thermal remote sensing to get information

Global carbon cycle info from RS

- Land cover & land use – present & historical – satellite mapping
- Aboveground & belowground biomass – size & changes of terrestrial carbon pool
  - Future LiDAR satellite programs – VCL & ICESat GLAS
  - Multi-angle remote sensing – MISR, POLDER

Global carbon cycle info from RS

- Seasonal growth cycle
  - Leaf area (LAI), growing season duration, timing of growth – constraints on carbon sequestration
  - Multispectral (Landsat, MODIS) & multiangle (MISR, POLDER, EPIC) RS data
- Fire
  - Strongest disturbance of vegetation – detect burned areas
  - Need to calculate net carbon sinks; causes interannual variations in carbon emissions, influences ecosystem succession & land
  - TM/ETM+, SPOT, AVHRR, MODIS

Global carbon cycle info from RS

- Solar radiation
  - Global solar radiation (shortwave) & photosynthetically active radiation (PAR) – drives photosynthesis & evaportranspiration
  - Satellite radiance measurements – ERBE, GOES
- Ecosystem productivity
  - Ecosystem productivity quantities determined using satellite-derived products, soil & meteorological databases & bio/geochemical models
  - AVHRR
- Case demonstrations – GloPEM, BEPS & InTEC

Land-atmosphere interaction

- What is role of land surface in modulating the global climate?
- Basic elements of land-atmosphere interaction – exchange of moisture and energy between the 2 systems
- Ocean – sea surface temperature (SST) plays a major role in forcing the atmosphere
- Land – major element of the climate system
  - More variable & exchangealbe than oceans
  - Land surface processes contribute to the variance of annual precipitation over continents

Land surface models

- System of parameterized equations to include surface radiation budget & surface energy budget
  - Surface radiation budget – influenced by solar diurnal cycle & cloud field
  - Surface energy budget – major interaction point between land surface model & GCMs
- Variety of land surface models developed, incorporating varying levels of complexity of land-atmosphere interaction

Land surface models

- Late 1960s & 1970s – 1st generation
  - Simple aerodynamic bulk transfer formulas
  - Uniform surface parameters (albedo, aerodynamic roughness, soil moisture availability)
- Early 1980s – 2nd generation
  - Recognized the effects of vegetation in calculating the surface energy balance
- 1990s – 3rd generation
  - Use modern theories relating photosynthesis & plant water relations – provides description of energy exchange, evapotranspiration & carbon exchange by plants

Land surface model development

- One of major causes of uncertainties in current climate change predictions
- Constrained by availability of data acquired to initialize, parameterize, & test the models
  - Promising approach to obtaining these data is by developing algorithms to predict the state of the land surface & atmosphere from RS data
- Land-atmosphere research – models, satellite data algorithms, field experiments
  - See Figure 13.11

Summary

- Benefits of quantitative remote sensing
- Understanding remote sensing data (1st part)
- Land surface information extraction (2nd part)
- Applications (3rd part)
- New requirements of applications motivate the development of new sensor systems, new models for understanding the data acquired by new sensors, and new algorithms for estimating surface variables – leads to next cycle