Satellite Remote Sensing of Urban Structure and Evolution

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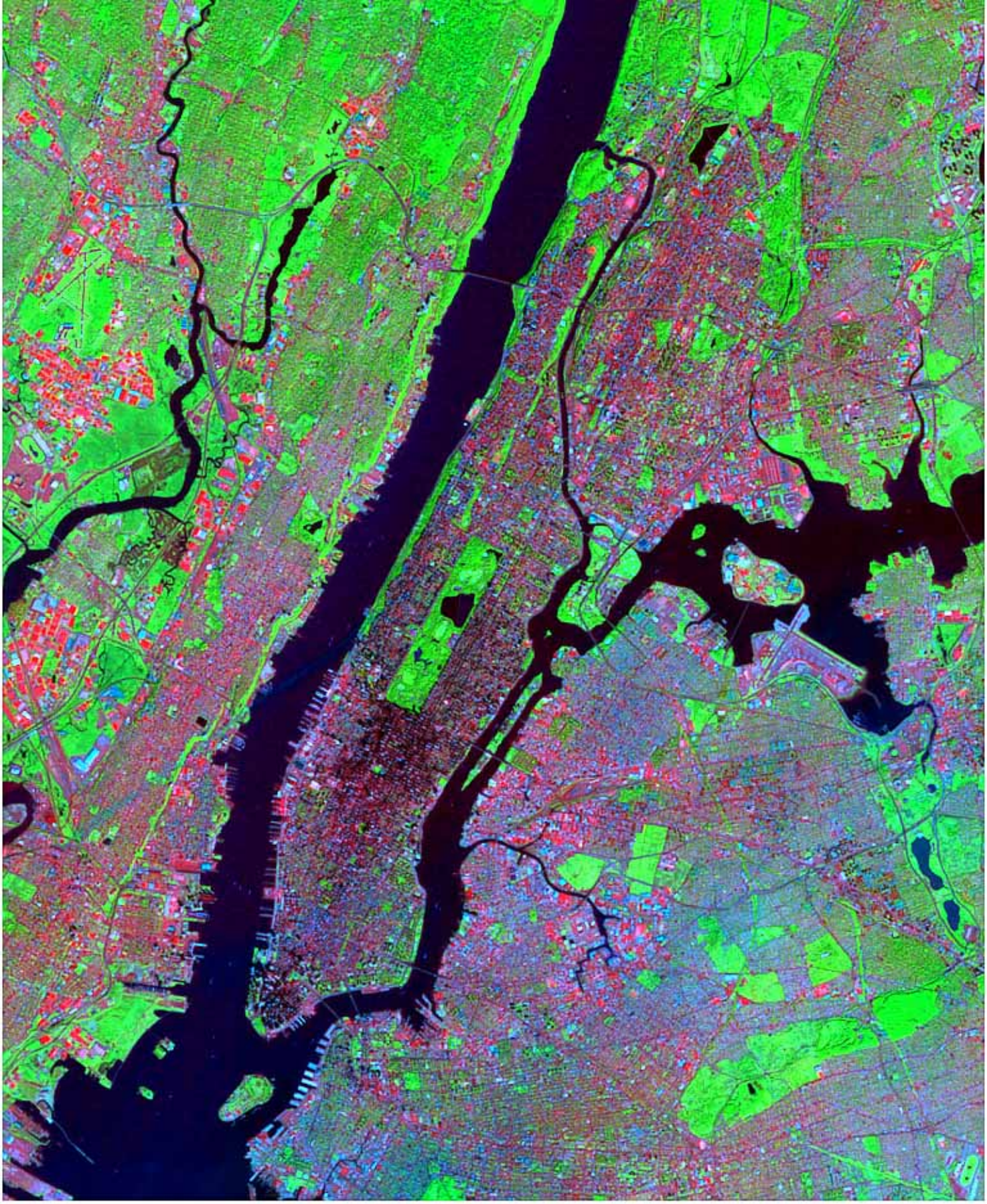
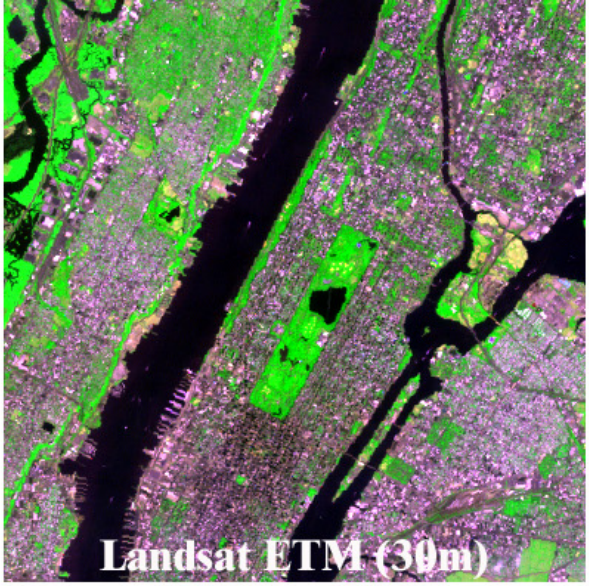
www.LDEO.Columbia.edu/~small/Urban.html

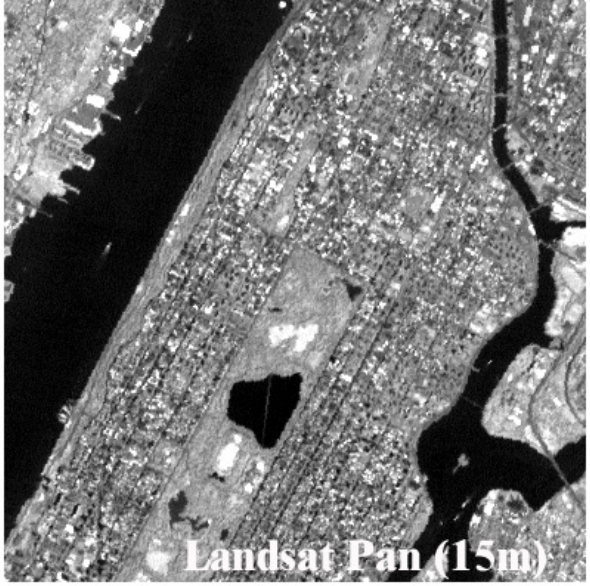
Satellite remote sensing provides a variety of tools to measure the structure and evolution of human settlements worldwide. The consistency of synoptic measurements makes it possible to quantify, compare and contrast spatial patterns of land use among different cities as well as their changes through time. The accuracy of these measurements is sufficient for quantitative spatial and spectral and temporal analyses that would be prohibitively expensive or physically impossible to obtain from ground-based measurements. The Landsat satellites provide a systematic 30 year archive of moderate resolution imagery of every city in the world. This imagery is suitable for mapping seasonal to interannual changes in landcover at spatial scales of tens of meters. New commercial sensors provide considerably higher resolution imagery suitable for mapping meter scale structure with revisit periods of several days.

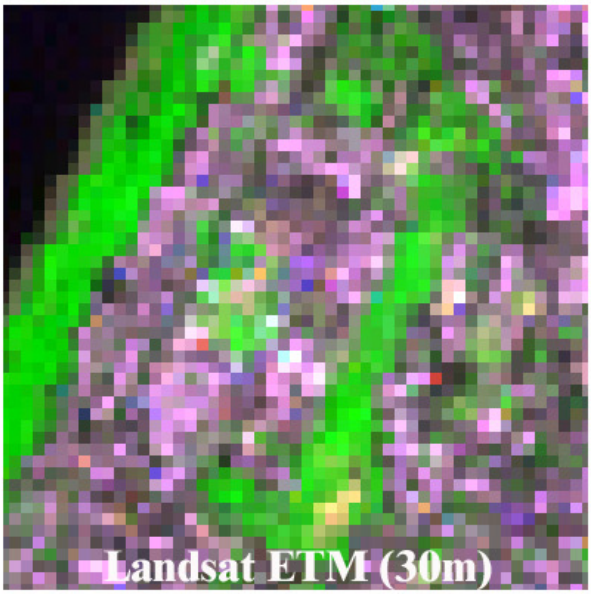
Satellite observations are constrained by spatial, spectral and temporal resolution. *Spatial* resolution determines the size of the smallest feature that can be detected or described. Commercial panchromatic (B/W) sensors currently have ground resolutions of ~60 cm while multispectral (color) sensors have resolutions of 2.4 meters. *Spectral* resolution determines the number of colors the sensor can discriminate. The ability to measure subtle differences in visible and infrared brightness makes it possible to distinguish different types of vegetation, rocks and soils as well as differences in surface temperature and water clarity that might not be apparent from ground observations. *Temporal* resolution determines how frequently a target can be imaged. The moderate resolution sensors in orbit since the 1970's have fixed revisit times of about two weeks. Modern high resolution sensors with pointable optics have variable revisit times of several days offering multiple viewing angles.

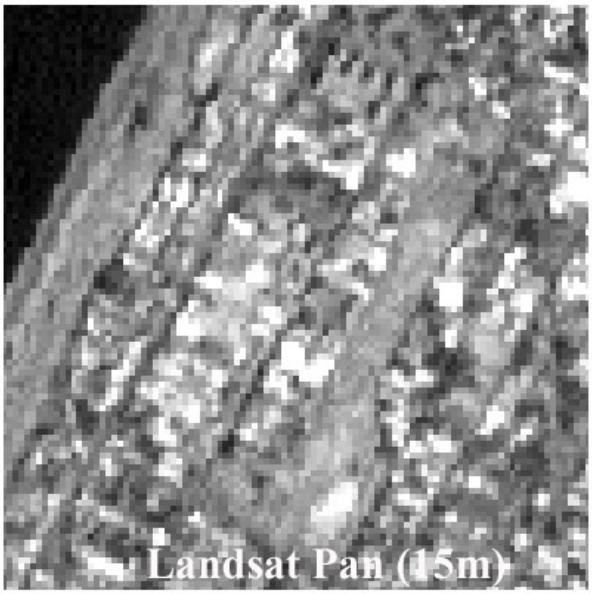


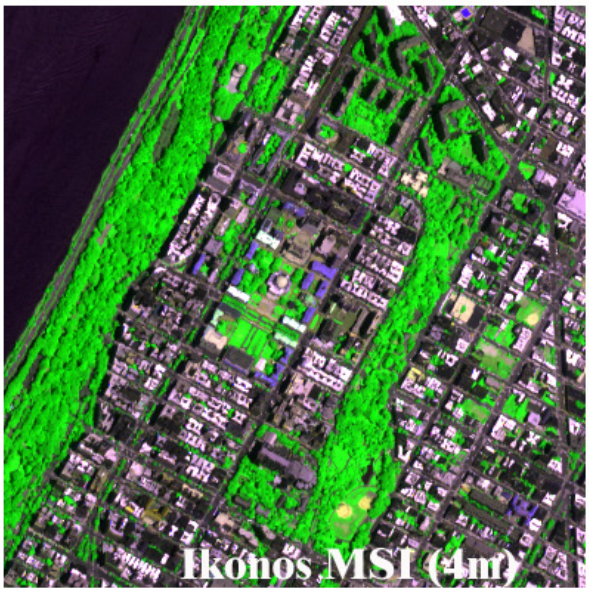
Visible and Infrared image of New York City and surrounding areas acquired by Landsat 7 on Sept. 23, 1999 around 9:20 am local time. Red corresponds to variations in surface temperature, green corresponds to vegetation density and blue to high visible brightness. Details at: www.LDEO.Columbia.edu/~small/Urban.html



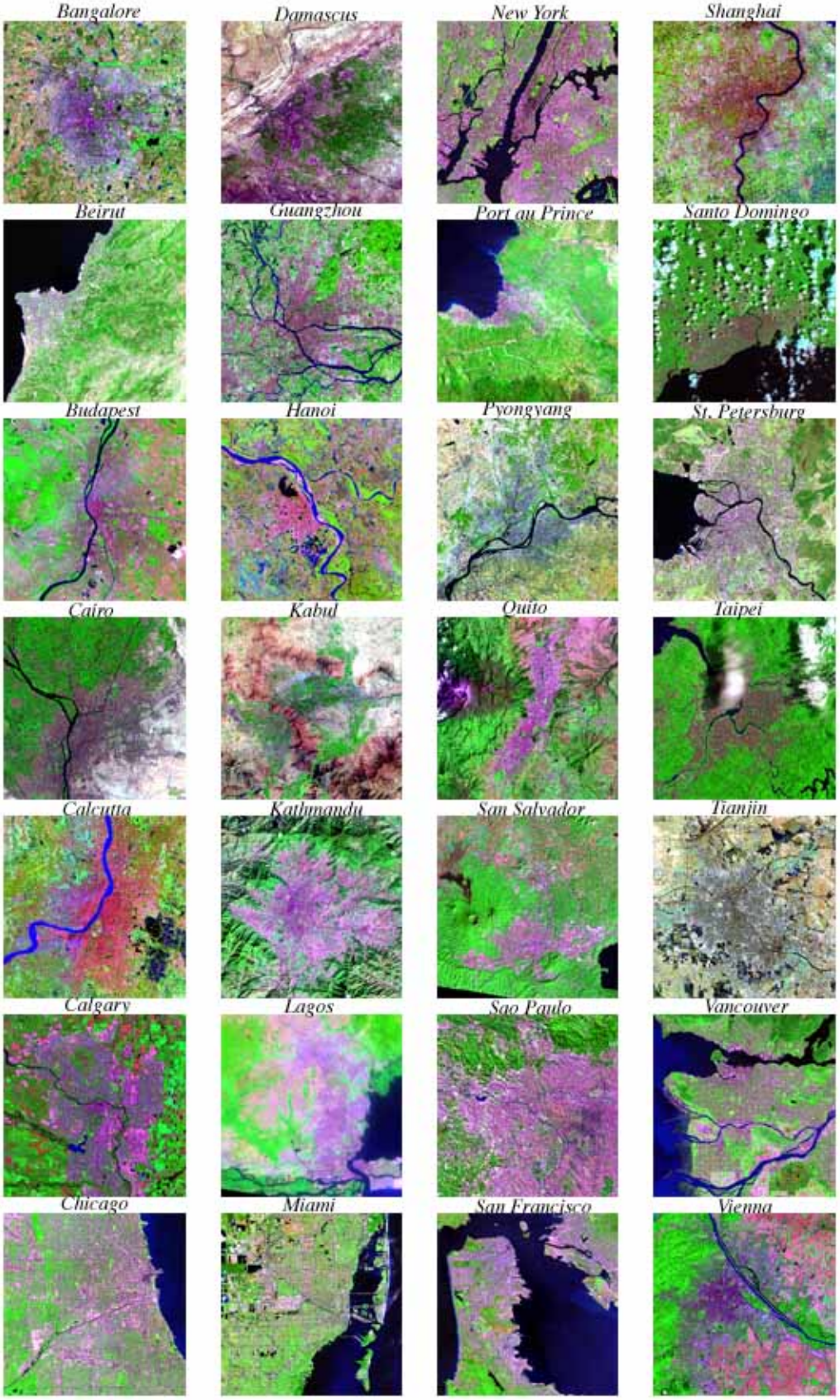








Satellite views of upper Manhattan at different spatial and spectral resolutions. Moderate resolution Landsat imagery resolves seasonal to interannual variations in visible and infrared brightness over the past 30 years. High resolution commercial imagery provides meter scale imagery with revisit times of several days. Details at: www.LDEO.Columbia.edu/~small/Urban.html



Visible/Infrared imagery of 28 cities collected by Landsat 7 between 1999 and 2001. Vegetation appears green and water appears dark in these composites. Built up urban areas are mixtures of materials so they take on a wide variety of colors. Each image is 30 km x 30 km with a ground resolution of 30 meters. Details at: www.LDEO.Columbia.edu/~small/Urban.html