REMOTE SENSING AND GIS

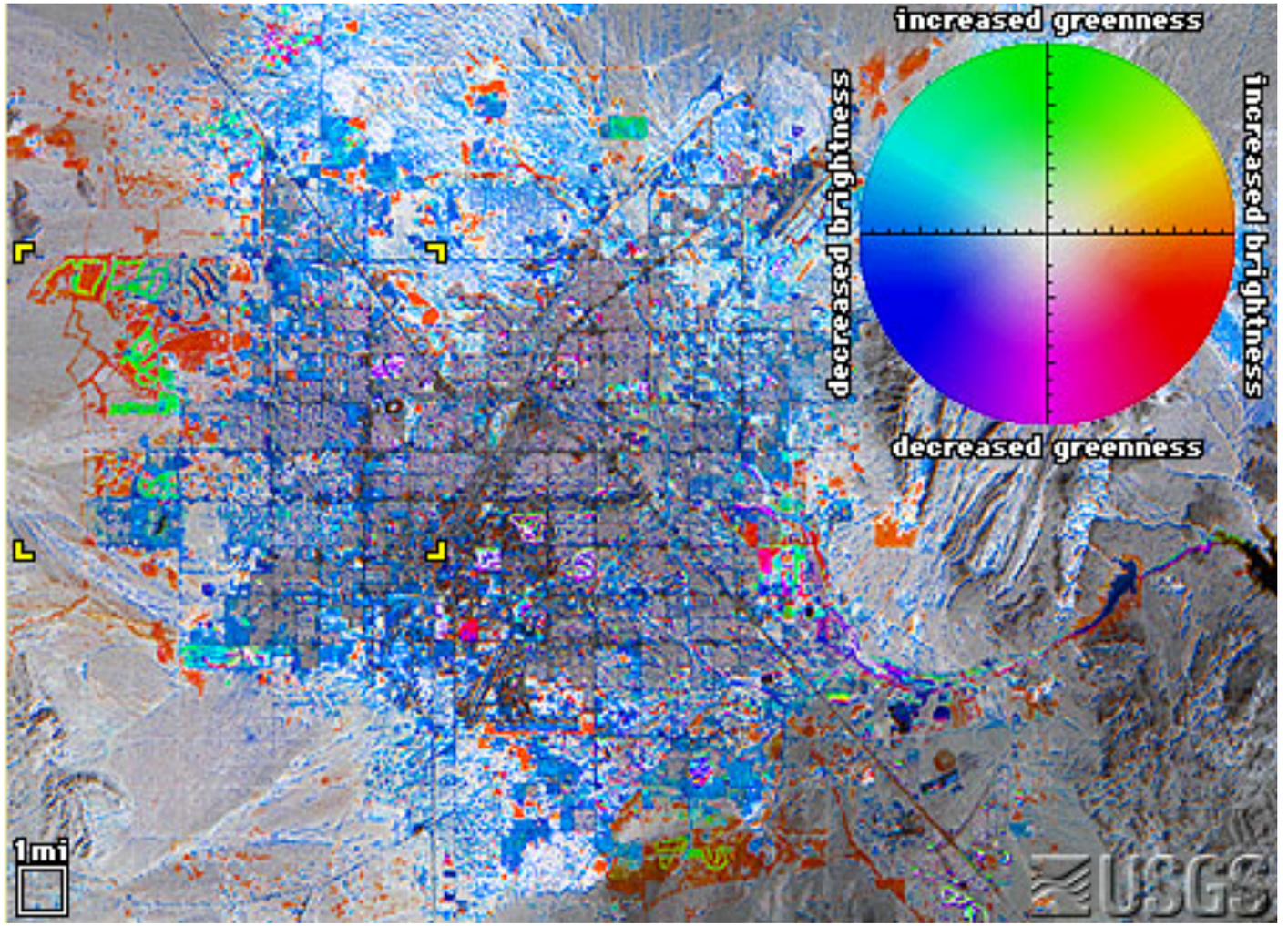
Mapping for Architecture, Urbanism and the Humanities

WHAT IS REMOTE SENSING?

- There are multiple definitions of remote sensing.
- "*Any process whereby information is gathered about an object, area or phenomenon without being in contact with it*." (Ron Eastman, IDRISI Taiga Guide to GIS and Image Processing)
- "*The practice of deriving information about the earth's land and water surfaces using images acquired from an overhead perspective using electromagnetic radiation in one or more regions of the electromagnetic spectrum, reflected or emitted from the earth's surface*." (James Campbell, Introduction to Remote Sensing, Fifth Edition)
- "*The joint effects of employing modern sensors, data-processing equipment, information theory and processing methodology, communications theory and devices, space and airborne vehicles, and large-systems theory and practice for the purposes of carrying out aerial or space surveys of the earth's surface*." (National Academy of Sciences)

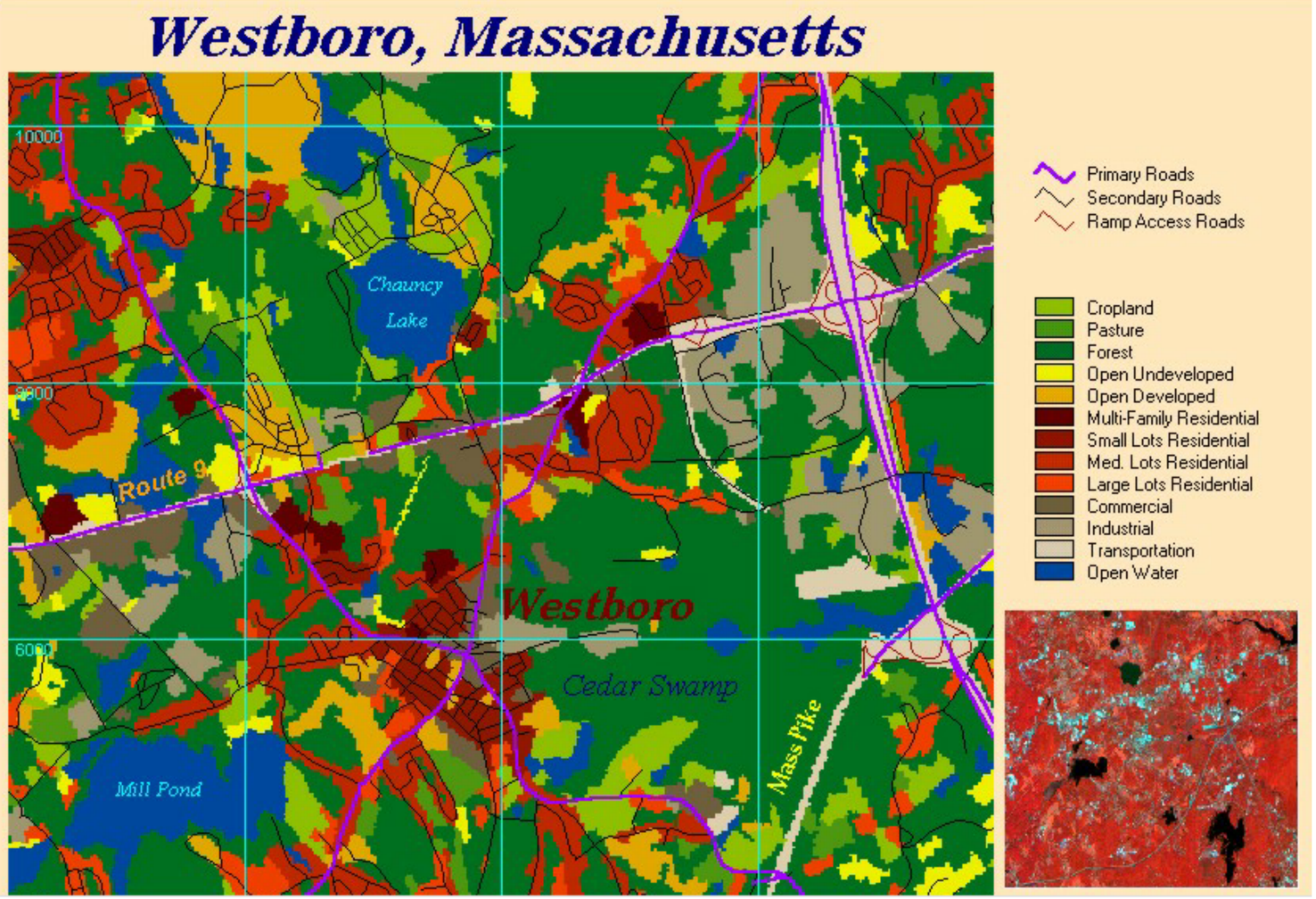
APPLICATIONS OF REMOTE SENSING: MEASURING CHANGE OVER TIME

- Remote sensing can be used to measure change over time:
- Land Use
- Deforestation
- Expansion of the built environment
- ie. Las Vegas, Nevada



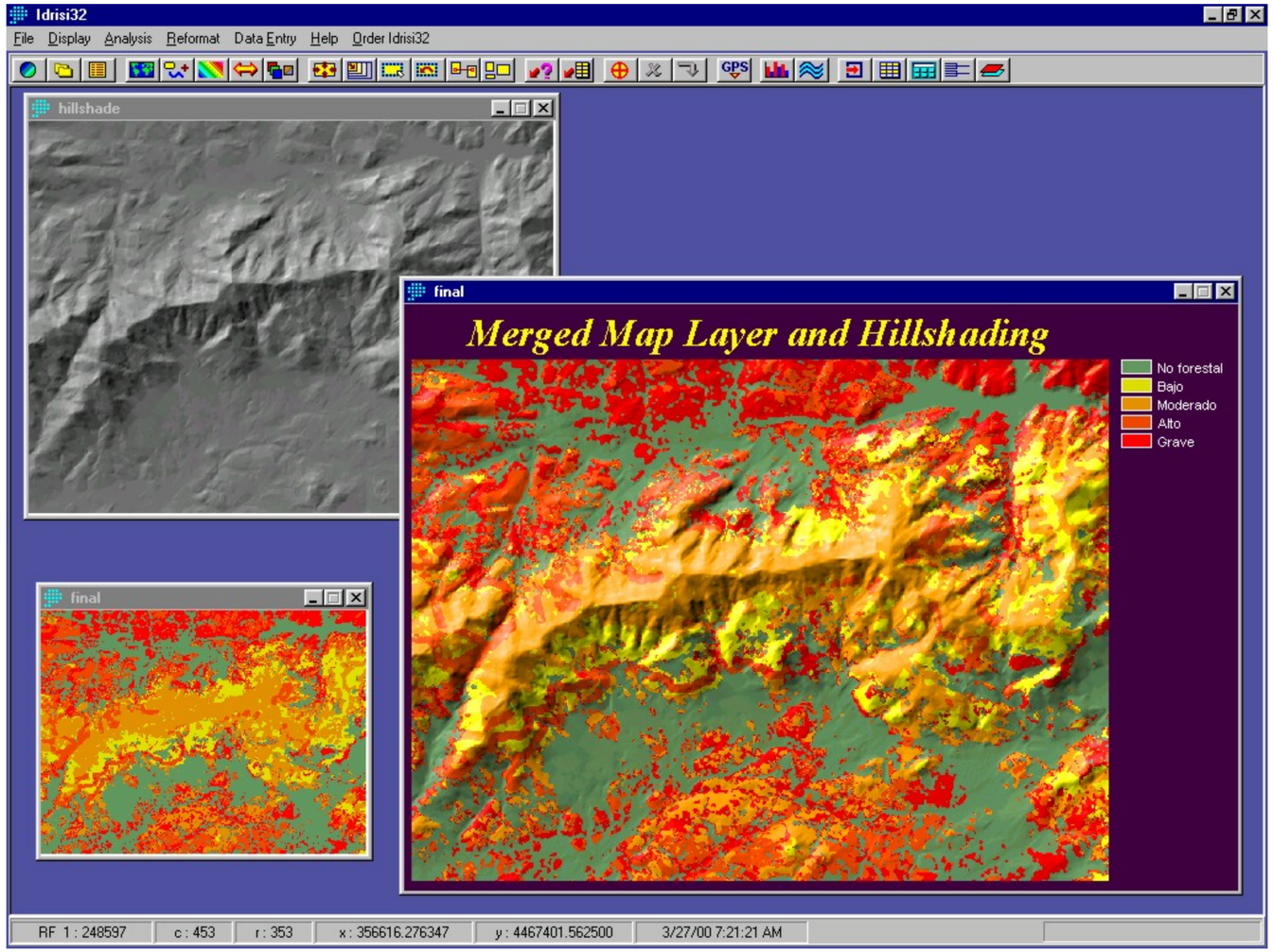
APPLICATIONS OF REMOTE SENSING: LAND USE ANALYSIS

- Remote sensing can be used to perform land use analysis:
- ie. Westboro, Massachusetts



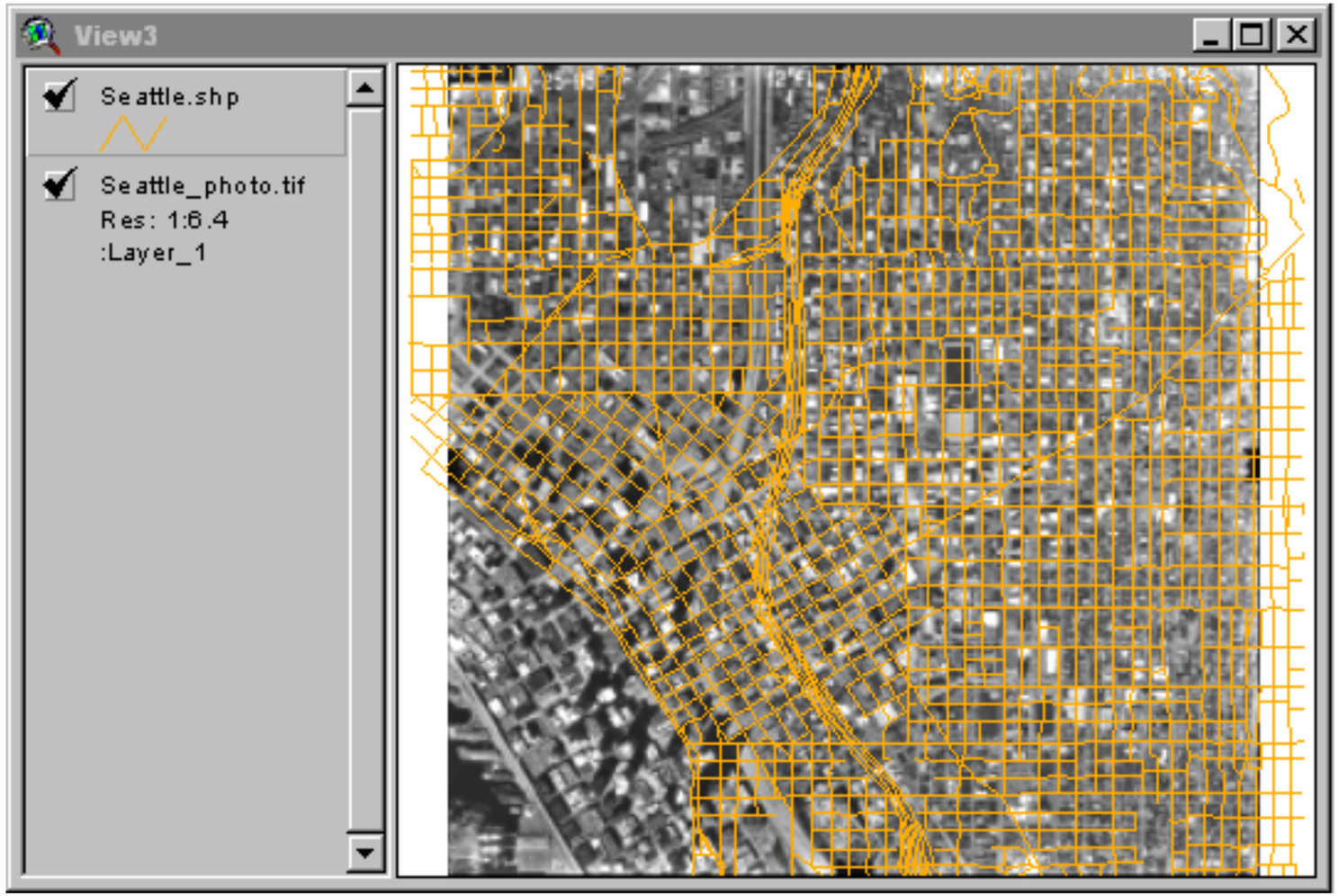
APPLICATIONS OF REMOTE SENSING: RISK ANALYSIS AND MANAGEMENT

- Remote sensing can be used to analyze and manage risk.



APPLICATIONS OF REMOTE SENSING: DATA CREATION

- Remote sensing can be used to create new data layers and files.
- ie. Seattle, Washington



APPLICATIONS OF REMOTE SENSING: CREATION OF DEM FILES

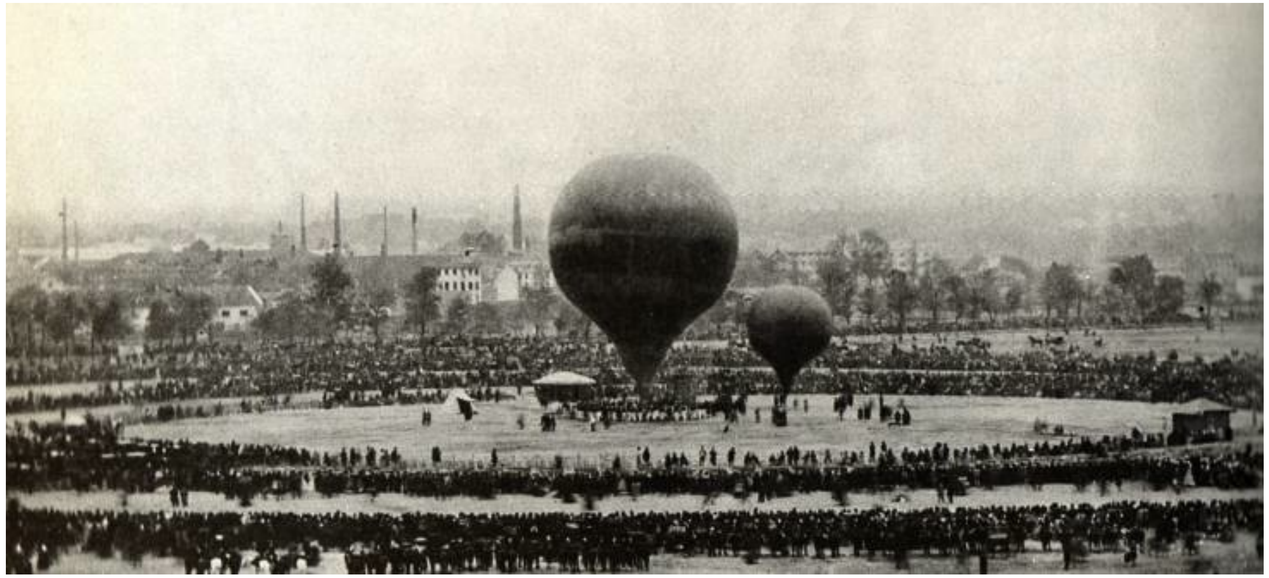
- Remote sensing can be used to create topographic files through the use of “stereoscopic images”.

EXAMPLES OF REMOTE SENSING

- Two images of New York City:
- Temperature
- Vegetation

HISTORY OF REMOTE SENSING

- The origins of remote sensing lie in the beginnings of photography, with Louis Daguerre around 1839.
- The use of photography and balloons to record aerial views of the Earth started around 1858.
- Initially, these images were more of a curiosity than the basis for systematic study.
- Image of Paris from Nadar (1868).



HISTORY OF REMOTE SENSING

- In addition to balloons, kites where also used to record aerial views of cities.

- Image of San Francisco from George R. Lawrence (1906).

HISTORY OF REMOTE SENSING

- The airplane and World War I fostered a new wave of development in remote sensing.

- For the first time, the acquisition of aerial photography became routine, as the value of aerial photography for military reconnaissance and surveillance became increasingly clear.

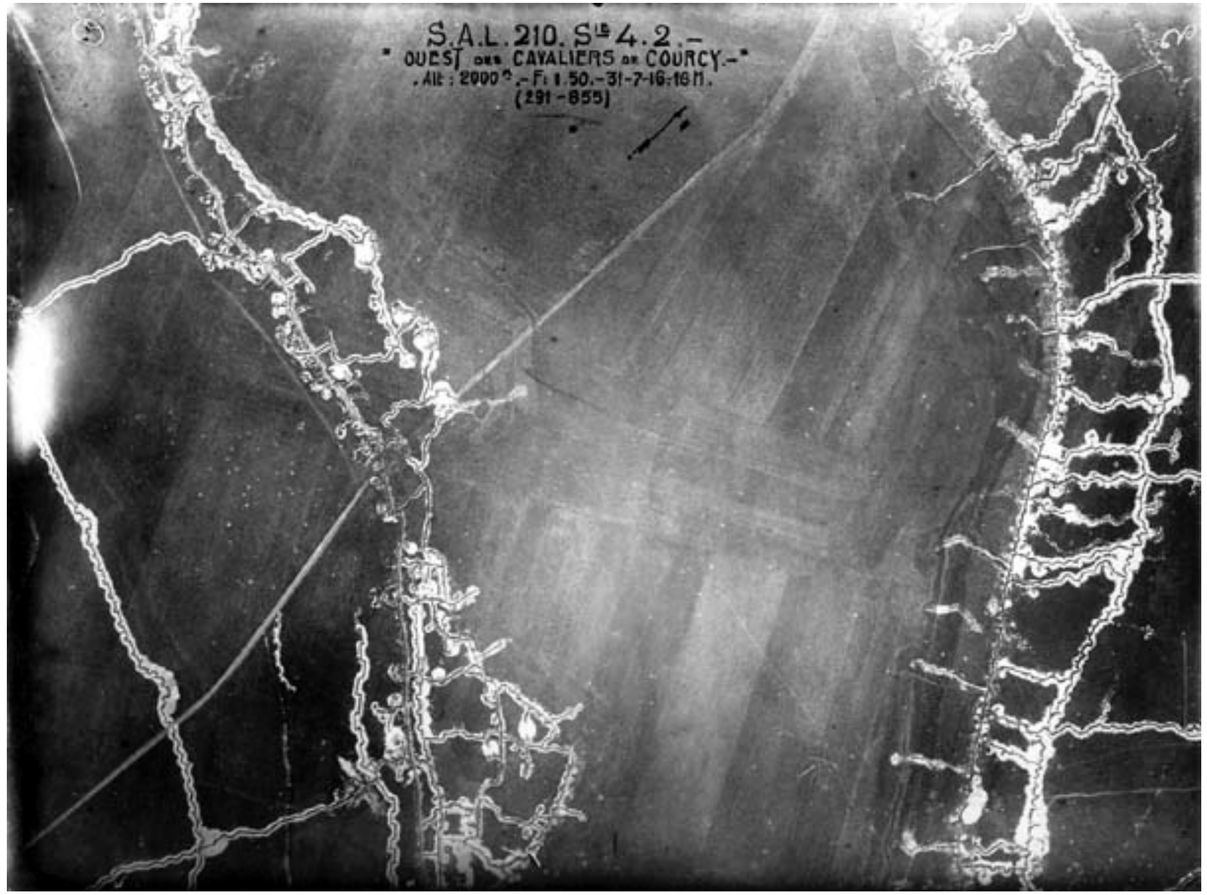
- ie. Aerial photographers during the war.

HISTORY OF REMOTE SENSING

- Another big development that happened during this time was the application of photogrammetry (making accurate measurements from photographs) to aerial images.

- Finally, aerial photography became more or less routine in government programs which used it in topography, mapping, soil surveys, geologic mapping, forest surveys and agricultural statistics.

- ie. Trenches during the war.

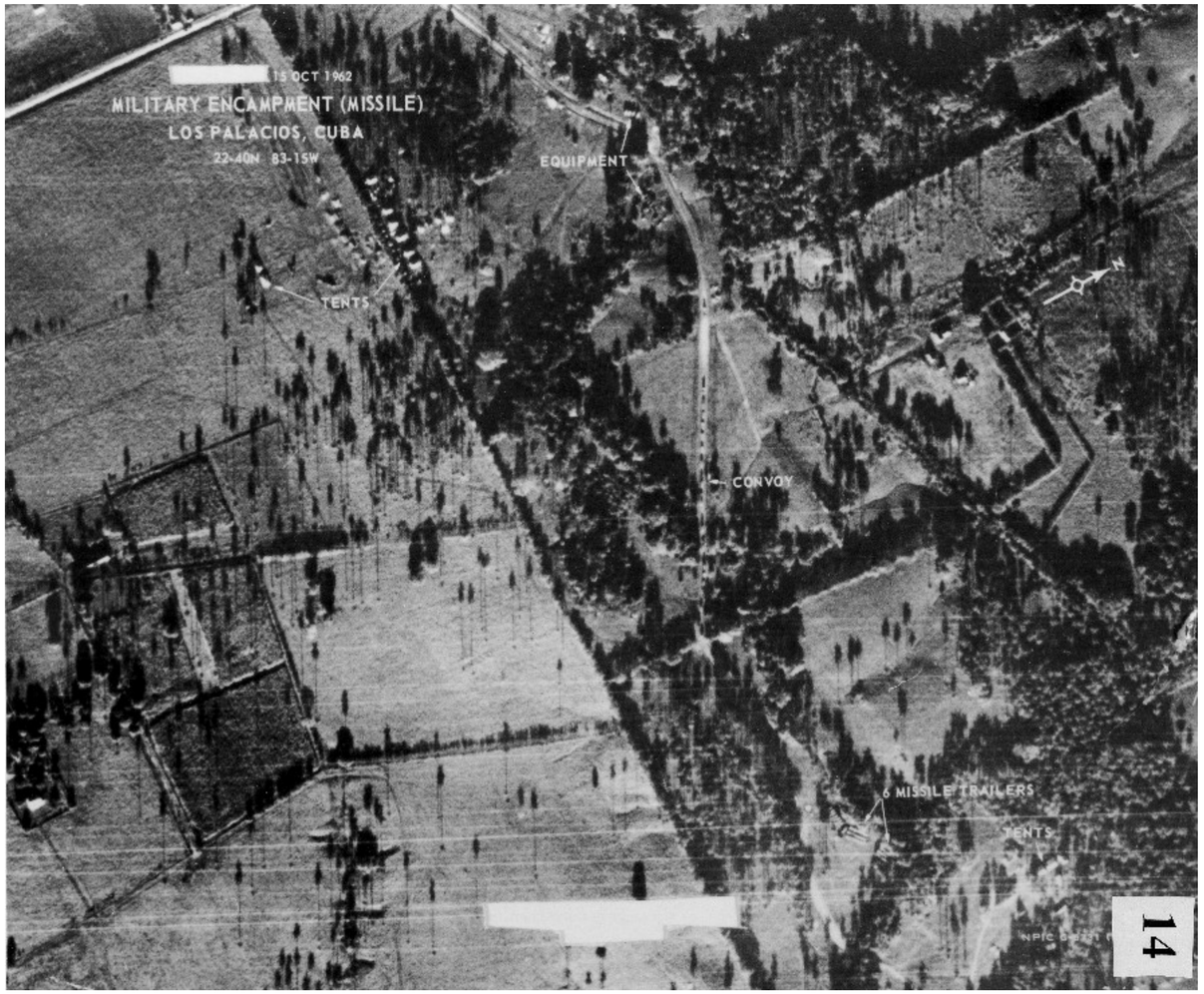


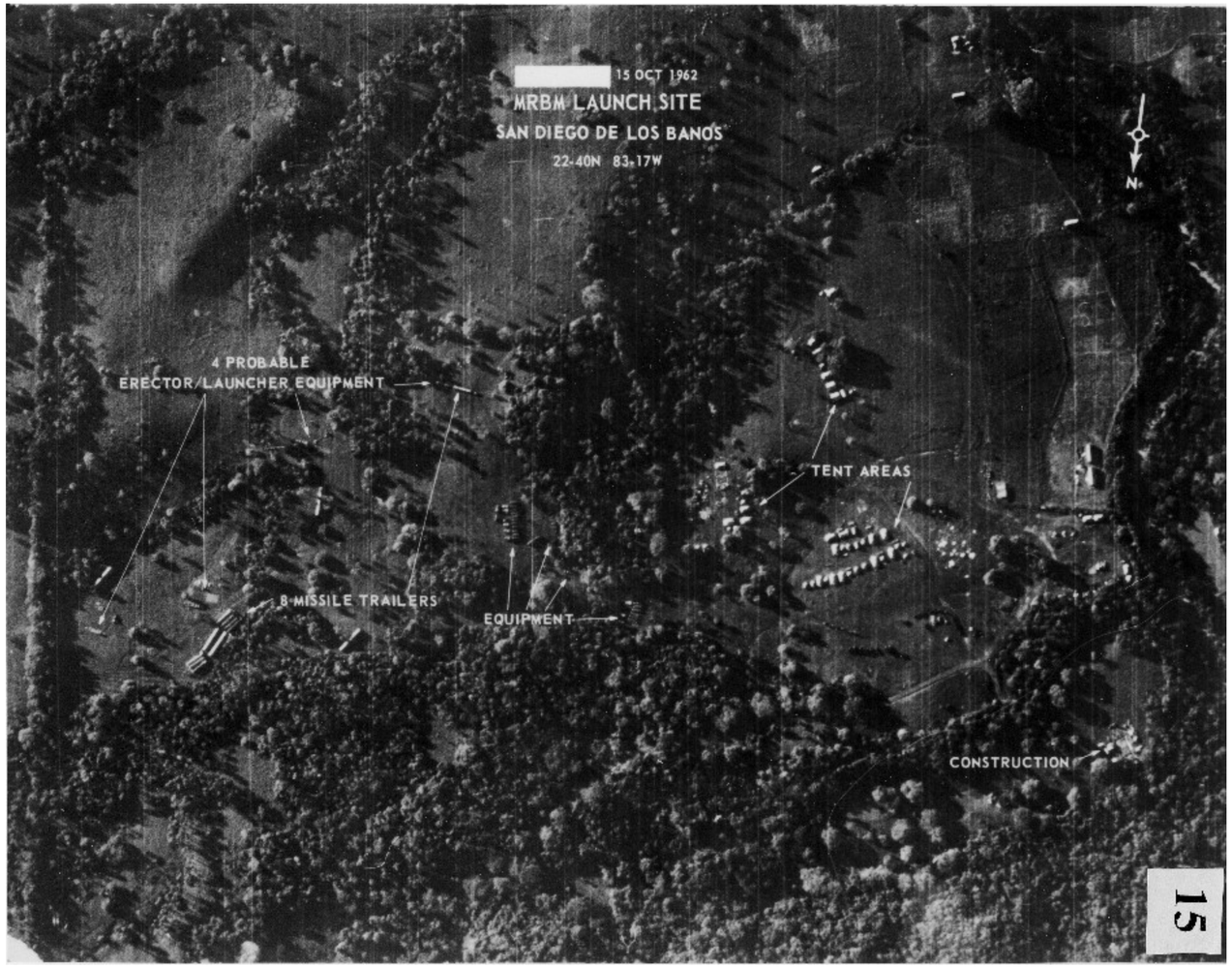
HISTORY OF REMOTE SENSING

- During the Second Wold War, the use of the electromagnetic spectrum was extended from almost exclusive emphasis upon the visible spectrum to other regions (ie. infrared and microwave) beyond the range of human vision.

- The wartime training and experience of large numbers of pilots, camera operators and photo interpreters created a large pool of experience personal who transferred their skills into civilian occupations after the war.

HISTORY OF REMOTE SENSING





HISTORY OF REMOTE SENSING

- During the 1960's, the first meteorological satellite (TIROS-1) designed for climatological and meteorological observations was launched.

- Also, the term "remote sensing" was created used when "aerial photography" couldn't describe many of the new methods being used (ie. collecting images using radiation outside the visible spectrum).

- In 1972, Landsat 1 was launched. It was the first Earth-orbiting satellite designed for observation of the Earth's land areas. It provided systematic repetitive observation.

- It also provided multi-spectral data for large regions and created incentives for expanding digital analysis of remote sensing and the development of image analysis software.

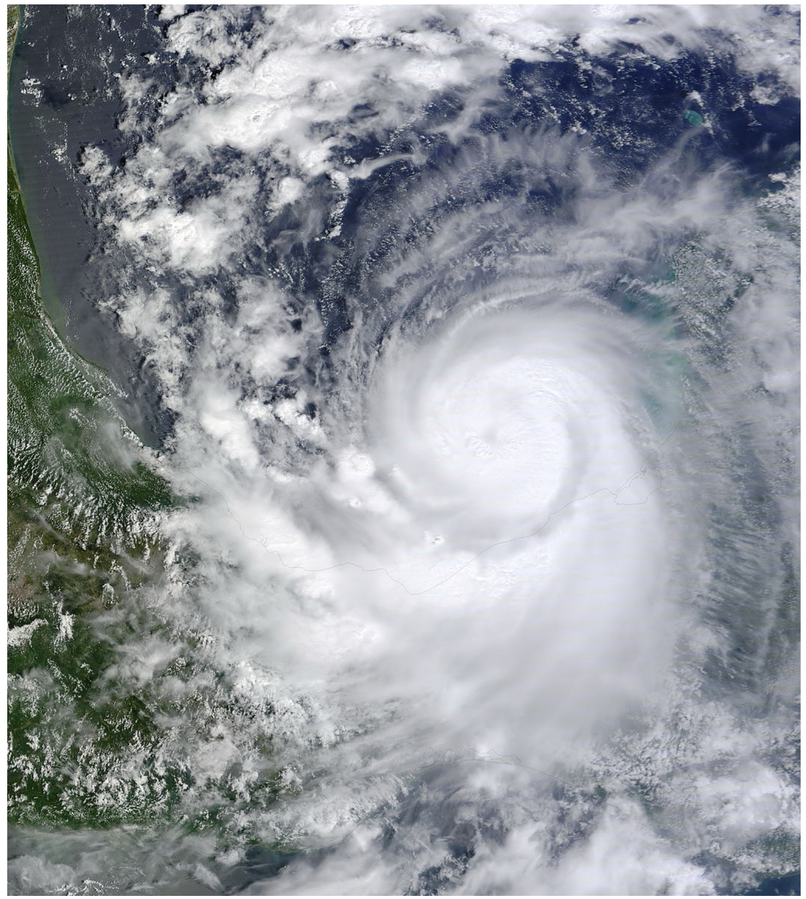
Artistic rendition of a U.S. Landsat satellite. Credit: NASA

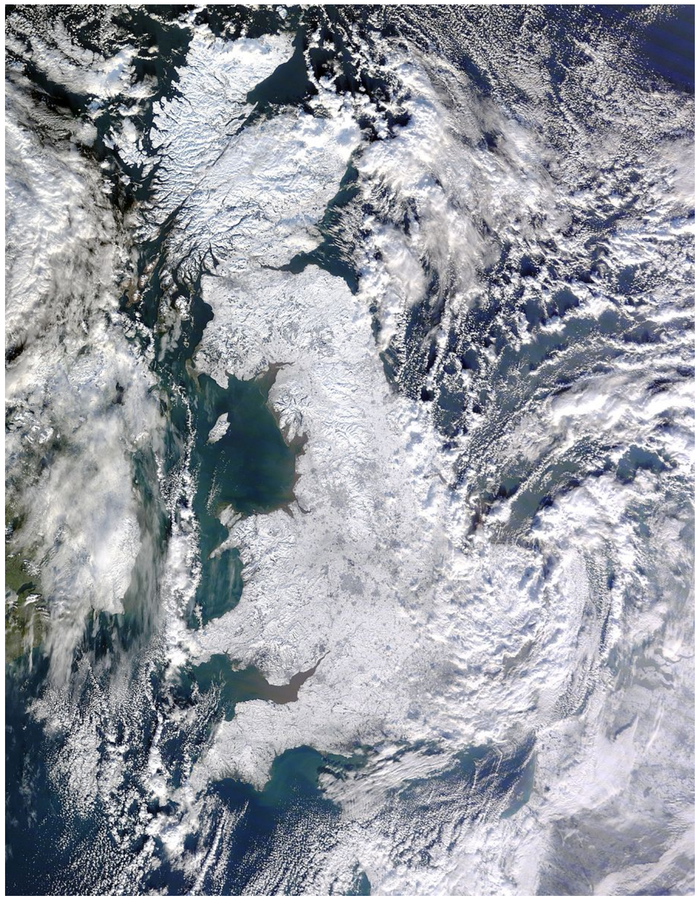
HISTORY OF REMOTE SENSING

- Finally, during the 1990s satellite systems were designed specifically to collect remotely sensed data from the entire Earth.

- In 1999 NASA launched Terra-1, the first satellite specifically designed to acquire global coverage to monitor changes in Earth's ecosystems.

- ie. Hurricane Karl (2010) & European winter storms (2009 - 2010).





REMOTE SENSING PROCESS

- The first step in the remote sensing process is the interaction between the Sun's energy and the physical features of the Earth.
- Solar energy must pass through the Earth's atmosphere which in turn absorbs some of this energy and scatters it before it reaches the ground.
- As the solar energy reaches the physical features on the ground, some of it will be reflected and some of it will be absorbed.
- Again, the reflected energy passes through the atmosphere and reaches the camera.

REMOTE SENSING PROCESS

- The energy recorded by the camera lens is much different that the sunlight that entered the atmosphere.
- The film also portrays different kinds of radiations in different colors, which may not match those of the radiation they represent.
- Data from the image is then translated into information through the process of “image interpretation” or “image analysis”.

KEY CONCEPTS OF REMOTE SENSING

- Spectral Differentiation

- Remote sensing depends upon observed spectral differences in the energy reflected or emitted. We look for differences in the “colors” of objects.

- Multispectral remote sensing is the science of observing features at varied wavelengths in an effort to derive information about these features and their distribution.

- Spectral signature is the spectral response of a feature as observed over a range of wavelengths.

KEY CONCEPTS OF REMOTE SENSING

- Radiometric differentiation

- Examination of any image acquired by remote sensing ultimately depends upon detection of differences in the brightness of the objects and their features.

KEY CONCEPTS OF REMOTE SENSING

- Spatial differentiation
- Every sensor is limited in respect to the size of the smallest area that can be separately recorded as an entity on an image.
- Our ability to record spatial detail is influenced primarily by the choice of sensor and the altitude at which it is used.

KEY CONCEPTS OF REMOTE SENSING

- Geometric transformation

- Every remotely sensed image represents a landscape in a specific geometric relationship determined by the design of the remote sensing instrument, specific operating conditions, terrain relief and other factors.

- Each image includes positional errors caused by the perspective of the sensor optics, the motion of scanning optics, terrain relief and Earth's curvature.

LIMITATIONS ON REMOTE SENSING

- There are often better sources of the same information that can be obtained more economically, particularly for cities in developed countries.
- ie. The expansion of urban settlements can be measured with building permit records or the extension of utilities or infrastructure.
- ie. Census data gives better indications about population counts and densities.
- ie. Economic activity, policy or social phenomenon.
- These factors are better understood with a combination of satellite imagery and other types of data, such as household surveys.
- It is a different story in developing countries.

ADVANTAGES OF REMOTE SENSING

- Self-consistent and synoptic nature of the data.
- Capacity for routine, periodic and unobtrusive updating and comparison.
- Capacity for description, classification and measurement of critical physical properties that would be prohibitively expensive or impossible to obtain in situ.
- Synoptic spatial coverage.

ADVANTAGES OF REMOTE SENSING

- The strength of remote sensing data is their capacity to provide spatial information that can be used to measure certain urban environmental conditions at specified times and to quantify change in these conditions over time.

- ie. Surface temperature in cities, coastal run-off, changes in land use and deforestation in the urban hinterland, or vegetation gradients between urban and suburban areas.

- ie. Extreme events, such as natural disasters, extremes of precipitation, changes in wetlands, rapid population shifts, and extensions of informal settlements.

DATA INTEGRATION

- If remote sensing data are integrated or used in conjunction with other sources of socioeconomic, administrative and regulatory data, their potential applicability to research and policy increases significantly.

- Data integration permits causal inferences to be made about the underlying dynamics of change in urban environments.

- ie. Population and industrial data plus satellite imagery can help relate surface temperature to population density, building type and urban land use.

- ie. Data on public health can illuminate the relationship between urban environmental parameters as measured by remote sensing and various types of environmentally related illnesses.