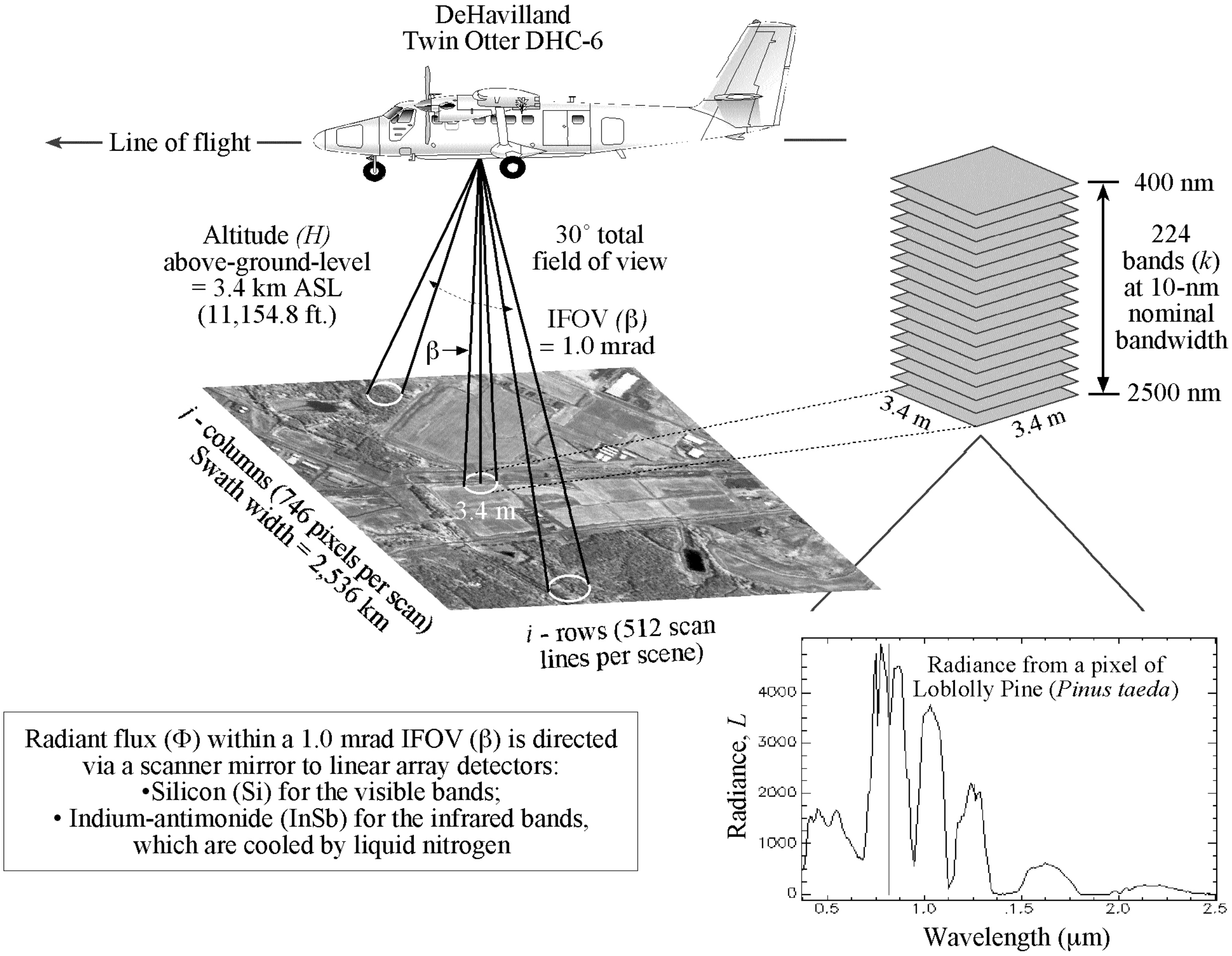
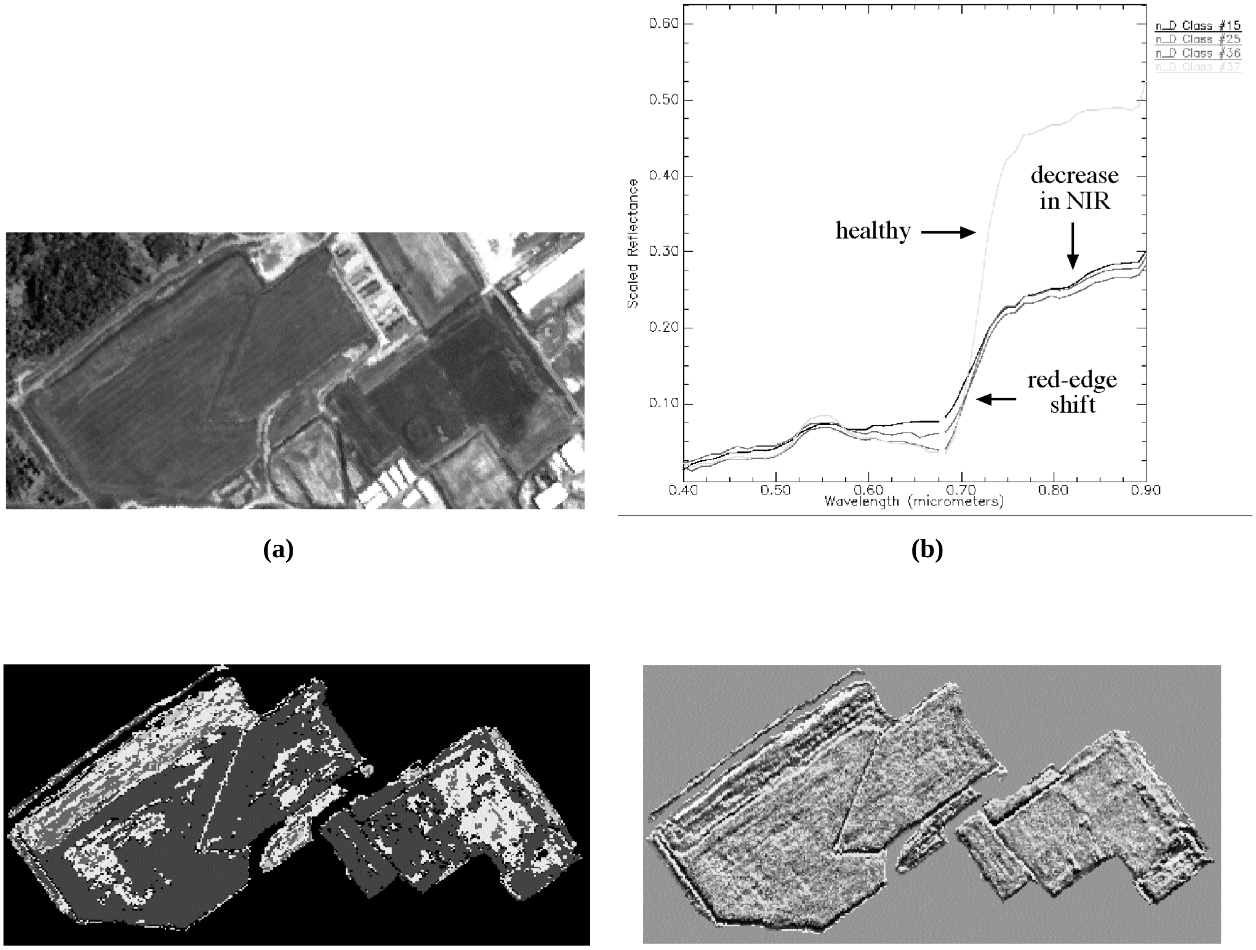


Radiant flux (Φ) within a 1.0 mrad IFOV (β) is directed via a scanner mirror to linear array detectors:
- Silicon (Si) for the visible bands;
- Indium-antimonide (InSb) for the infrared bands, which are cooled by liquid nitrogen

**FIGURE 19 Characteristics of NASA's AVIRIS sensor system flown onboard a DeHavilland Twin Otter DHC-6.**

## Radar and IFSAR Remote Sensing

In the United States, much of the information required to conduct practical transportation-related projects can be obtained using optical remote-sensing systems, including traditional aerial photography, digital frame cameras, and multispectral and hyperspectral remote sensing. These systems provide excellent data and potential information if there is little cloud cover. Conversely, during bad weather active microwave (radar) remote sensing is usually the sensor of choice because it has all-weather capability and can obtain imagery both day and night. Such information is critical, especially during prolonged flooding. In addition, if two radars are placed on the same aircraft or spacecraft platform, it is now possible to perform analyses to extract detailed topographic information.



**(a)** **(b)**

**(c)** **(d)**

**FIGURE 20 Application of AVIRIS hyperspectral imagery to identify stressed vegetation on clay-capped hazardous waste sites at Savannah River site: (*a*) composite of AVIRIS data of Mixed Waste Management Facility clay caps at Savannah River site; (*b*) spectral reflectance curves of four bahia grass endmembers (one healthy and three stressed), derived from AVIRIS data; (*c*) classification map derived from AVIRIS data, showing those areas with most potential bahia grass stress; and (*d*) second derivative image, derived from AVIRIS data (RGB = Bands 42, 30, 38).**

## *Conventional Satellite and Airborne Radar Imagery*

The Canadian RADARSAT active microwave system is a good example of the state of the art of satellite active microwave remote sensing. It is a C-band (5.6 cm) wavelength horizontal send–horizontal receive polarization radar in a near-polar orbit. This system acquires imagery at a variety of spatial resolutions from 8 to 100 m. RADARSAT imagery obtained in the vicinity of the Flemish Cap in the North Atlantic revealed oil slicks and several ships in the region (Figure

21). As previously mentioned and referred to in Figure 2, most remote-sensing data preprocessing and analysis requires significant training and expertise. Unfortunately, extracting useful information from radar imagery is very difficult, requiring extensive knowledge of radar physics and of the most appropriate radargrammetric image-processing methods.

### *IFSAR to Extract Topographic Information*

An exciting event of the past decade has been the development of radar interferometry, whereby radar images of the same location on the ground are recorded by (*a*) two different antennas on the same platform (aircraft or satellite) at the same time (called single-pass interferometry) or (*b*) by a single antenna on an aircraft or spacecraft at different times. An analysis of the resulting two interferograms allows precise measurement of the range (distance) to any specific x, y, z point found in each image of the interferometric pair.

The first satellite single-pass IFSAR was the Shuttle Radar Topography Mission (SRTM). It had a C-band and an X-band antenna separated by 60 m (200 ft) (see Figure 22). SRTM data are being used to produce a DEM of 80 percent of the Earth at 20×20-m postings. Such information is valuable for regional elevation, slope, and aspect information, particularly in developing countries where such data have never before been available. Two examples of DEMs produced from SRTM data and overlaid with Landsat ETM$^+$ data (RGB = Bands 1, 2, 3) are

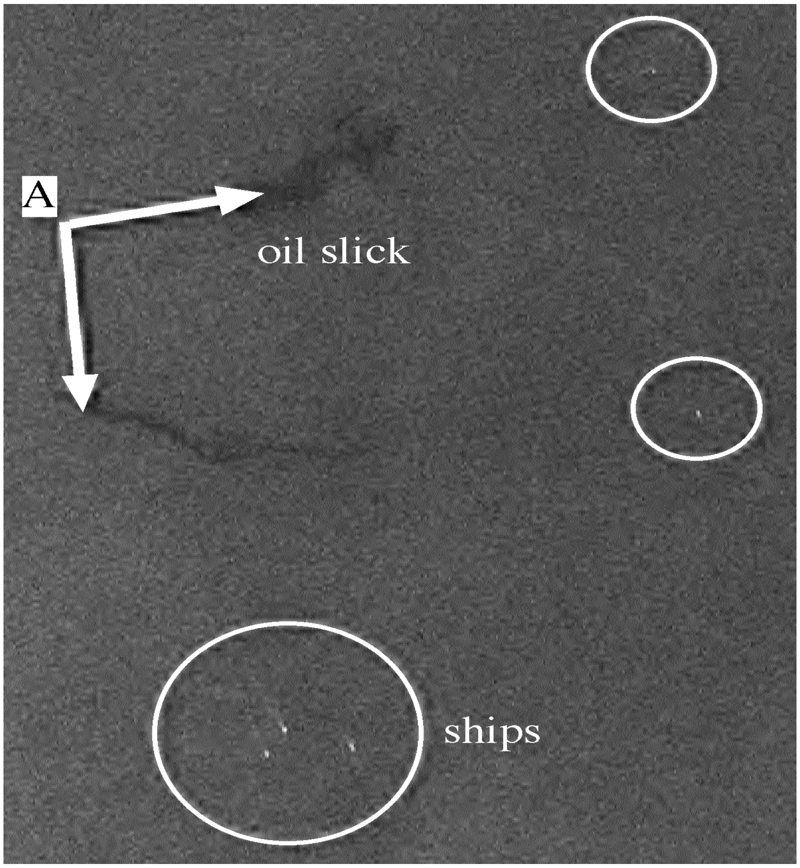


**FIGURE 21 RADARSAT imagery of oil slicks and ships at Flemish Cap in north Atlantic (courtesy of RADARSAT, Inc.).**

found in Figure 22*c* and *d*. The first DEM depicts the San Fernando Valley (Calif.), which has a population of more than 1 million people. It shows a view toward the northeast with a 3× vertical exaggeration. The second DEM is a 2× vertically exaggerated image of a portion of the San Andreas fault near Bakersfield, California.

Private commercial companies also acquire IFSAR data. For example, the Intermap X-band Star 3*i* System generates high-quality 3×3-m X-band microwave imagery, plus a detailed DEM of the terrain. IFSAR data can provide extremely high-precision topographic information (x, y, z) that is just as accurate as DEMs derived using traditional optical photogrammetric techniques and LIDAR if certain conditions are met (e.g., the data are acquired when the leaves are off). Figure 11*c* depicts topographic information for an area in North Carolina extracted from IFSAR data.

Finally, if the look angles of multiple data acquisitions are held constant, there is no sensitivity to topography and the interferometry can be used to extract information about things that have changed in the scene. Quantitative information about the velocity of objects that moved between the two observations may be made. Interferometry has been successfully applied to measuring movement along fault lines, measuring seismic displacement due to earthquakes, mapping glacier velocity, monitoring ocean currents, and assessing wave spectra. In addition, interferometry can be used to determine if man-made objects, such as automobiles, ships, and aircraft, in the scene have moved. This is very powerful for change-detection purposes.

## SUMMARY

This paper reviewed general business-like characteristics of remote-sensing data-collection systems. It then identified several reasons why user communities do not rapidly embrace potentially useful remote-sensing calibrated data and information. Basically, there is a knowledge gap between the remote-sensing technologists and the user communities that must be bridged. In an attempt to reduce the dimension of this gap, this paper briefly introduced several of the more important advances in remote-sensing science instrumentation. In addition, a few major advances in remote-sensing data preprocessing and analysis were identified. Hopefully, the material has value for both the remote-sensing science and transportation user communities.

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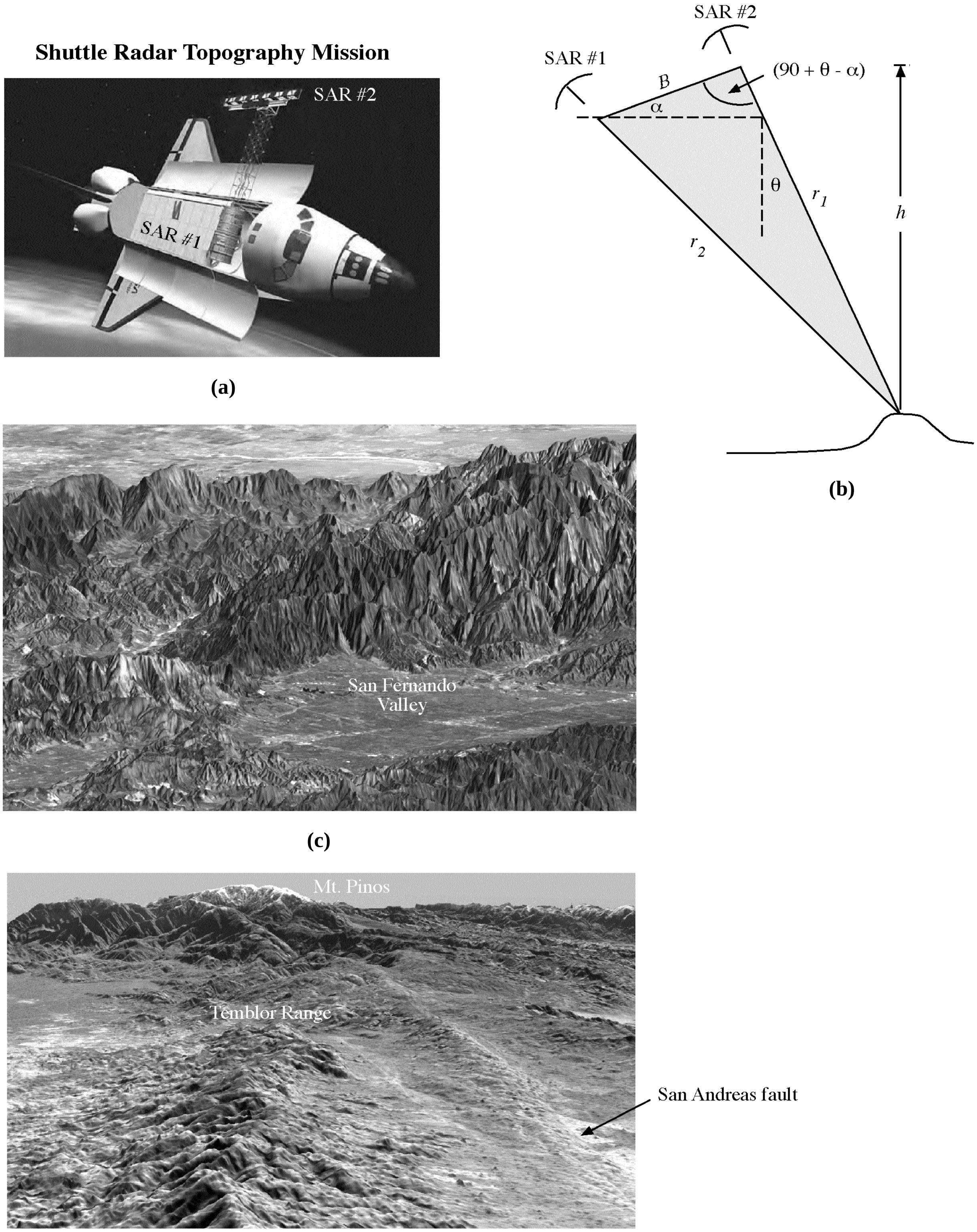

(a)

(b)

(c)

(d)

**FIGURE 22 IFSAR logic and DEM examples derived from SRTM: (*a*) Shuttle Endeavor with 60-m boom retracted, (*b*) interferometry geometry, (*c*) SRTM DEM of San Fernando Valley (Calif.), and (*d*) SRTM DEM of Temblor Range and San Andreas fault near Bakersfield, Calif. (courtesy of NASA JPL).**

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