A Gallery of Images from the Advanced Land Imager

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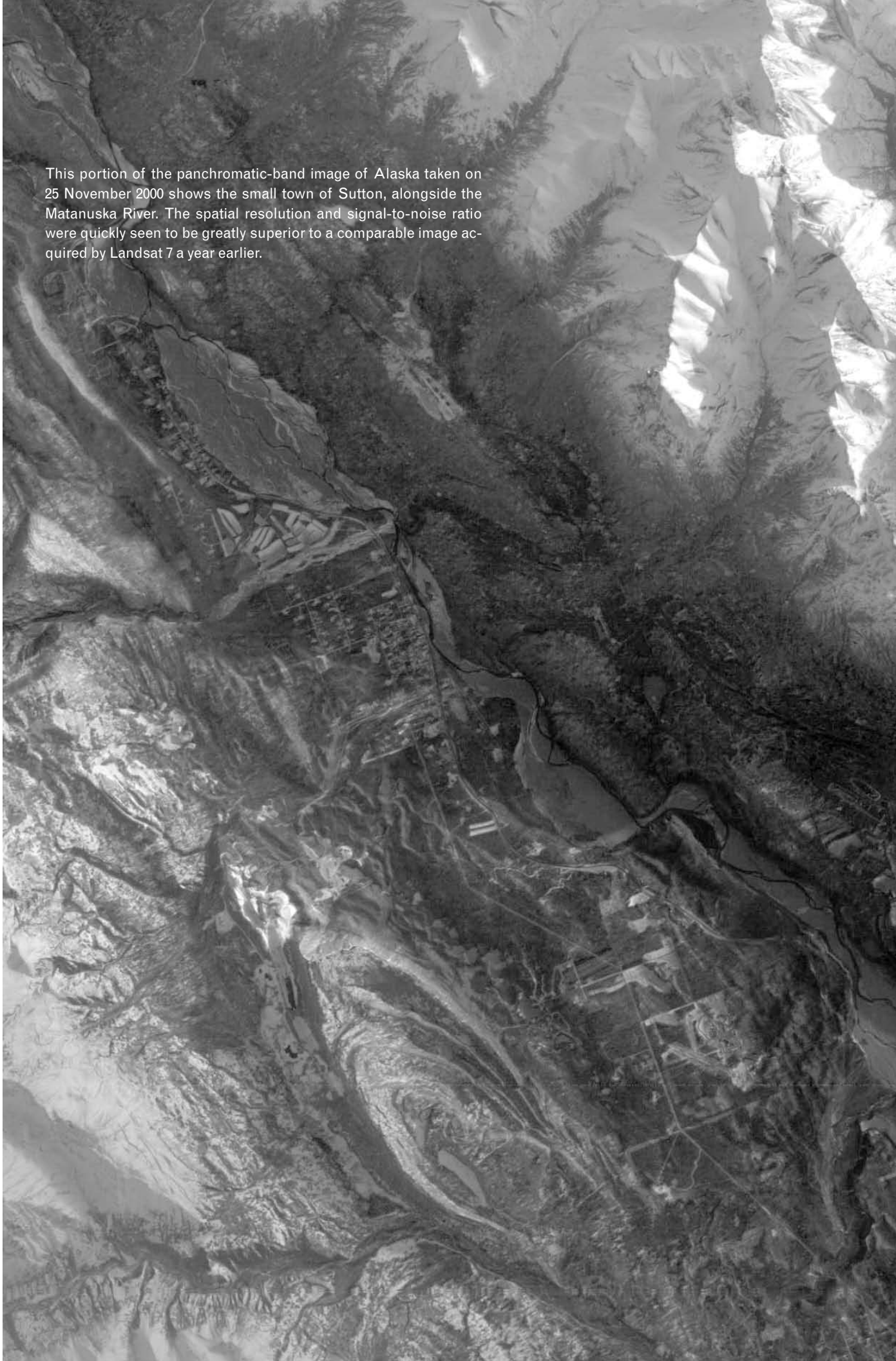
■ In the course of processing the image data from the Advanced Land Imager (ALI), we routinely form browse images, in addition to producing the radiometrically and geometrically corrected scientific data files. The browse images are intended for easy viewing, to show quickly what each scene contains, and to determine whether the objects of interest are obscured by clouds. These images are written out as JPEG files, which are readily opened, viewed, cropped, sharpened, and color corrected in desktop applications such as Adobe Photoshop.

ALI bands 3, 2, and 1 sense the visible red, green, and blue wavelengths. Therefore, when we select those bands to form a browse image, and we map bands 3, 2, and 1 into the RGB color space, we obtain a natural-color image. For brevity, we usually refer to this as a 3-2-1 image. We do not claim that the result, especially when printed, is a colorimetrically exact reproduction of the scene. In fact, the color levels have been adjusted to remove most of the path radiance leaving the top of the atmosphere. The aim is generally to produce the colors that we would expect to see from a low-flying airplane.

Because the ALI produces nine multispectral bands, many other combinations of color mapping are possible in the browse images. Frequently, bands 4, 3, and 2 are used for the RGB inputs. This combination is chosen because healthy vegetation is highly reflective in near-infrared band 4, and shows up as bright red in the 4-3-2 images. This gallery contains examples of such images, as well as images produced from other band combinations. In addition, we sometimes combine the data from bands 3, 2, and 1, which are sampled at 30 m resolution, with the panchromatic band data, which is sampled at 10 m, to produce a color image with 10 m resolution. The process of creating these browse images is described in this issue in the article entitled "Spatial Calibration and Imaging Performance Assessment of the Advanced Land Imager," by David R. Hearn.

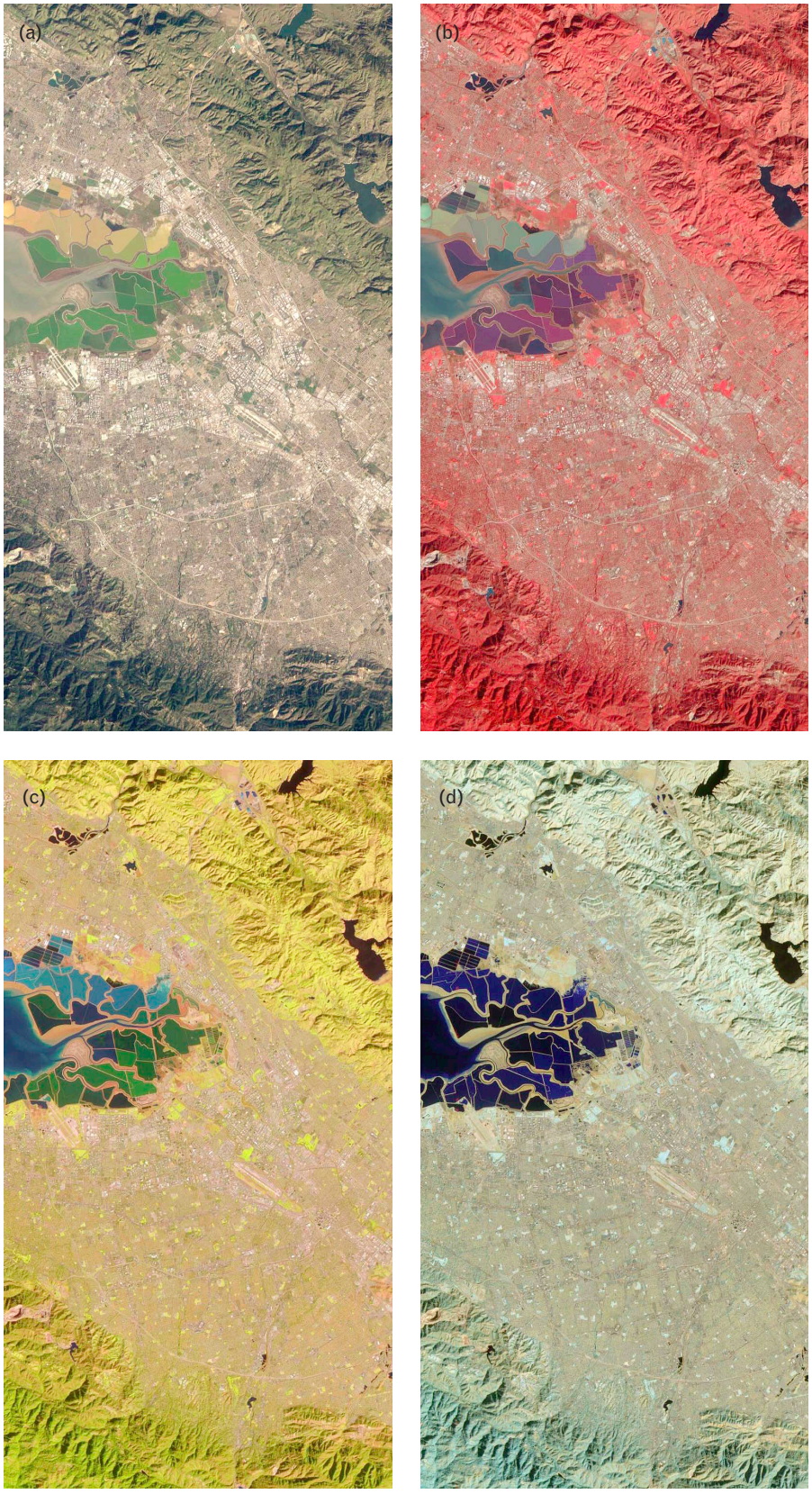
The author is indebted to Hsiao-hua Burke, Michael Griffin, Seth Orloff, and Jenifer Evans for their comments on some of the images. Except where noted, all of the images in this gallery have been constructed and processed by the author.

The very first image acquired by the ALI on orbit on 25 November 2000. This 3-2-1 browse image is in natural color. The scene shows the Talkeetna mountain range, just north of Anchorage, Alaska. It is illuminated at a low angle from the lower right. The entire eight seconds of the collected data is shown here. The image clearly reveals the staggered locations of the four sensor chip assemblies on the focal plane, and the in-track separation of the different color bands.

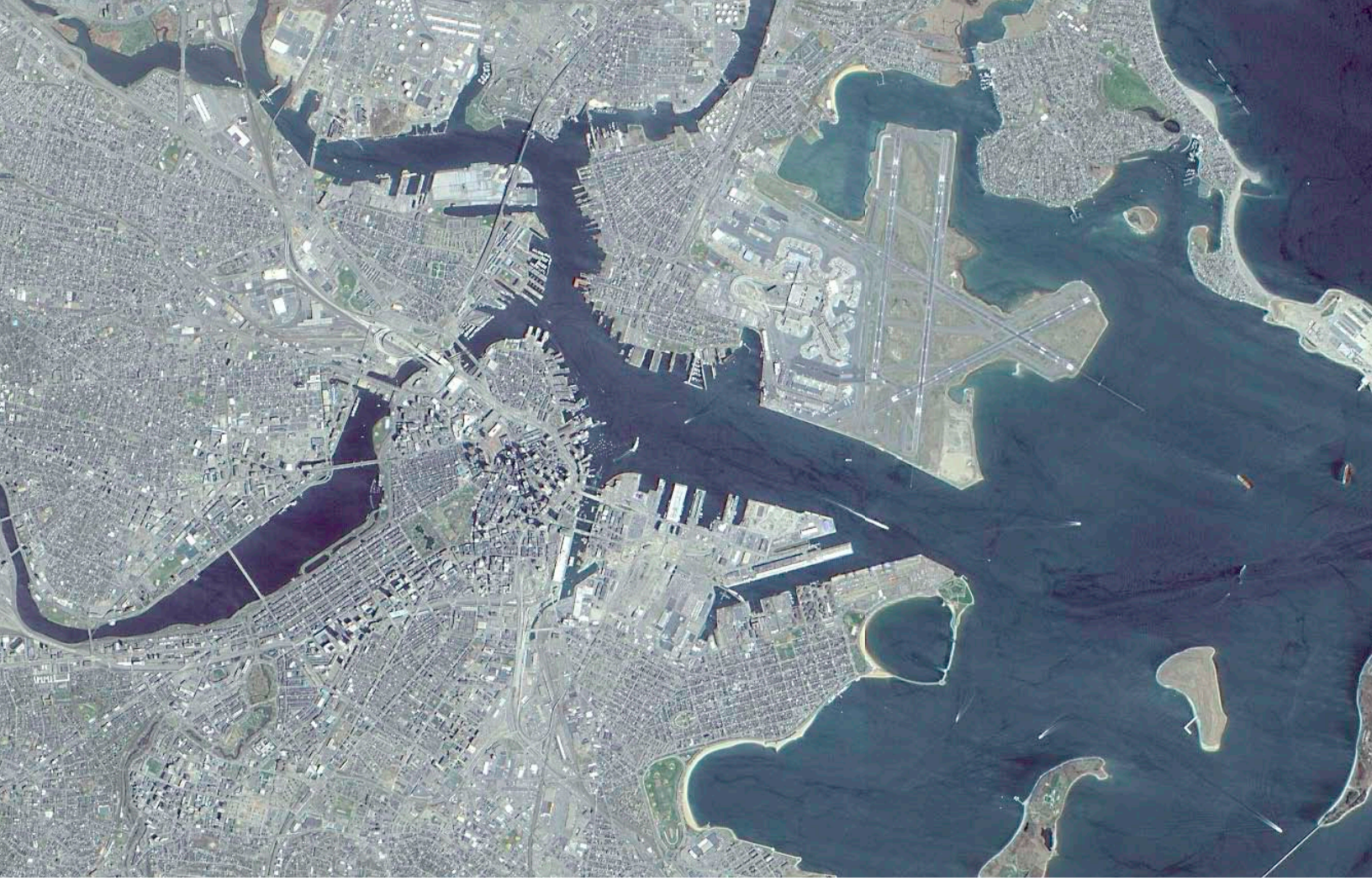


This portion of the panchromatic-band image of Alaska taken on 25 November 2000 shows the small town of Sutton, alongside the Matanuska River. The spatial resolution and signal-to-noise ratio were quickly seen to be greatly superior to a comparable image acquired by Landsat 7 a year earlier.

This 3-2-1 natural-color image of San Francisco and Oakland, California, was acquired on 28 July 2001. The two spans of the Oakland Bay bridge are visible, but the Golden Gate bridge is obscured by clouds. The color variations of the water are due to differences in water depth, sea floor composition, and concentrations of silt, phytoplankton, and other organisms in the water.

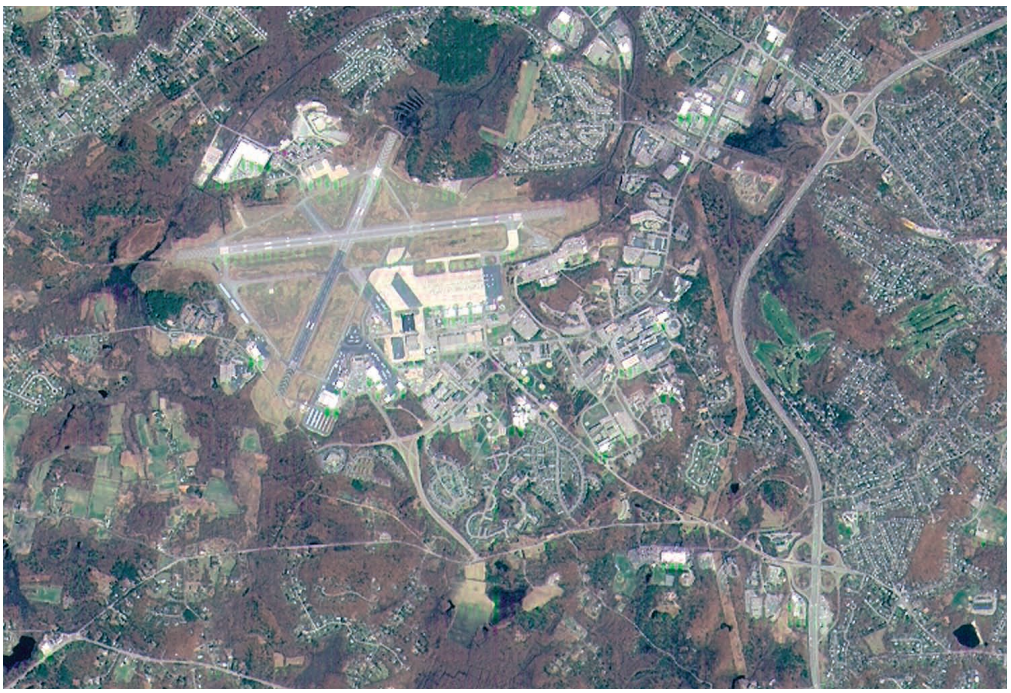


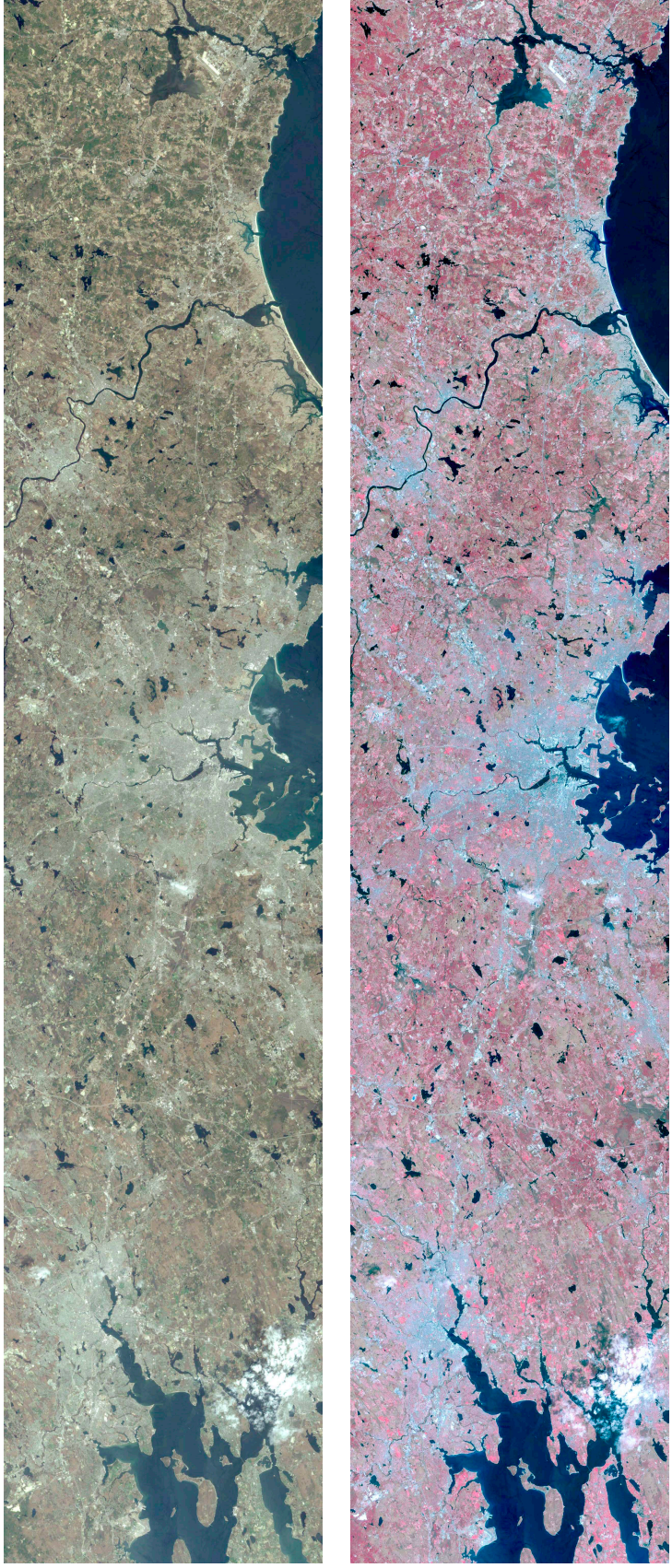
These four images centered on San Jose and Sunnyvale, California, taken 17 January 2001, show how different choices of color mappings can bring out different features of the scene. The RGB mappings are produced from the following bands: (a) 3-2-1, (b) 4-3-2, (c) 5-4-3, and (d) 5-5p-4. The color of the salt ponds north of the city vary as the salinity of the water changes. Dunaliella algae, halophilic bacteria, and brine shrimp all contribute to the tints. The water is dark in the shortwave infrared (SWIR) bands. The vegetation, especially on the hills to the north and south, is quite bright in band 4. The salt ponds are frequently used as targets to compare the responses of sensors on different satellites.



The panchromatic-sharpened natural-color image of Boston above combines the panchromatic image, at 10 m sampling, with the 3-2-1 multispectral image at 30 m sampling. The data are from the scan of 23 April 2001. Harvard Bridge, spanning the Charles River basin in the left side of the image, was used to test the image quality of the ALI on-orbit. The MIT campus lies directly north of the bridge.

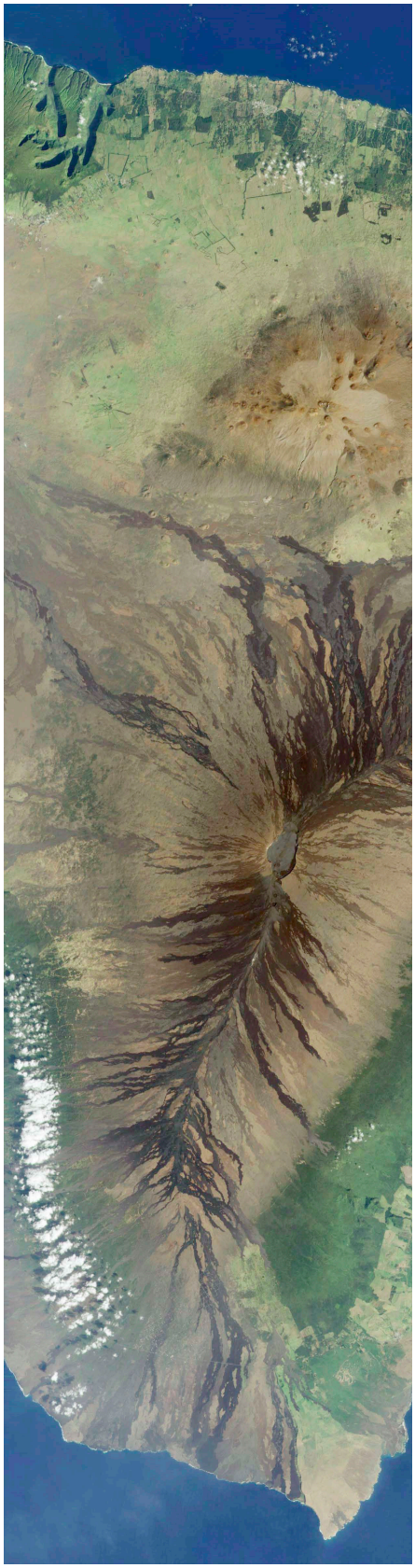
The image above is a portion of the 23 April 2001 ALI data collection event, showing the full 38 km width of the swath around Boston. Hanscom Field is visible near the upper left edge of the image. The band selection is 4-3-2. Below is an enlarged portion of the Boston scan, showing Hanscom Air Force Base, including Lincoln Laboratory, as a panchromatic-sharpened natural-color image. Parts of the image reveal artifacts caused by electrical crosstalk from a few detector pixels.





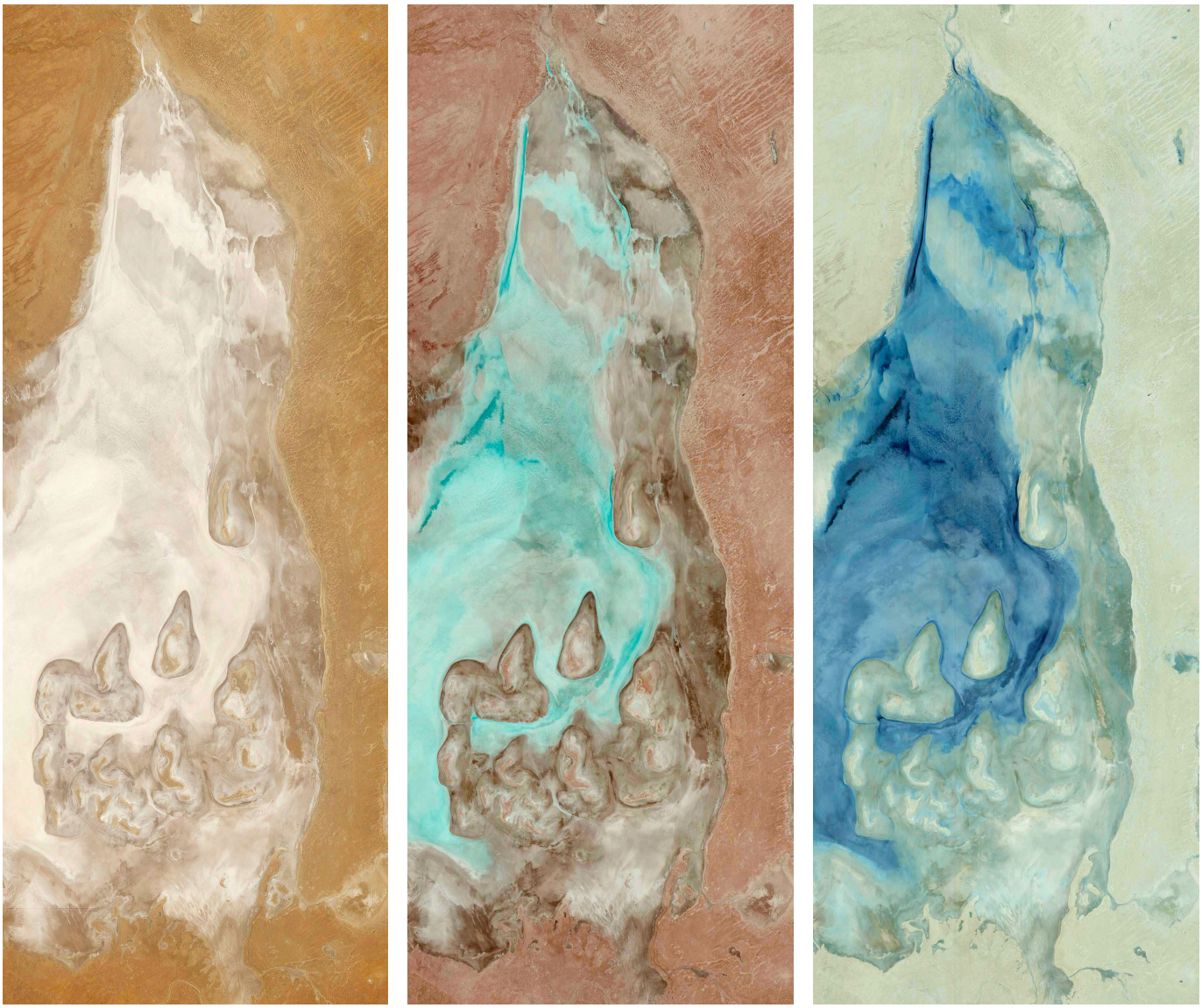
On 23 April 2001, a data collection event captured part of the New England coast from Portsmouth, New Hampshire, to Providence, Rhode Island, on a virtually cloudless day. The natural-color 3-2-1 image on the left shows the brown vegetation of spring and the gray concrete and asphalt of towns and cities. The 4-3-2 image on the right clearly distinguishes bodies of water (dark blue), vegetation (reddish), and more built-up areas (bluish grey).

This natural-color 3-2-1 image of the Big Island of Hawaii has the caldera of Mauna Loa in its center. Lava flows of various ages and colors extend out from the center. Mauna Kea is visible to the north, along with observatory buildings.

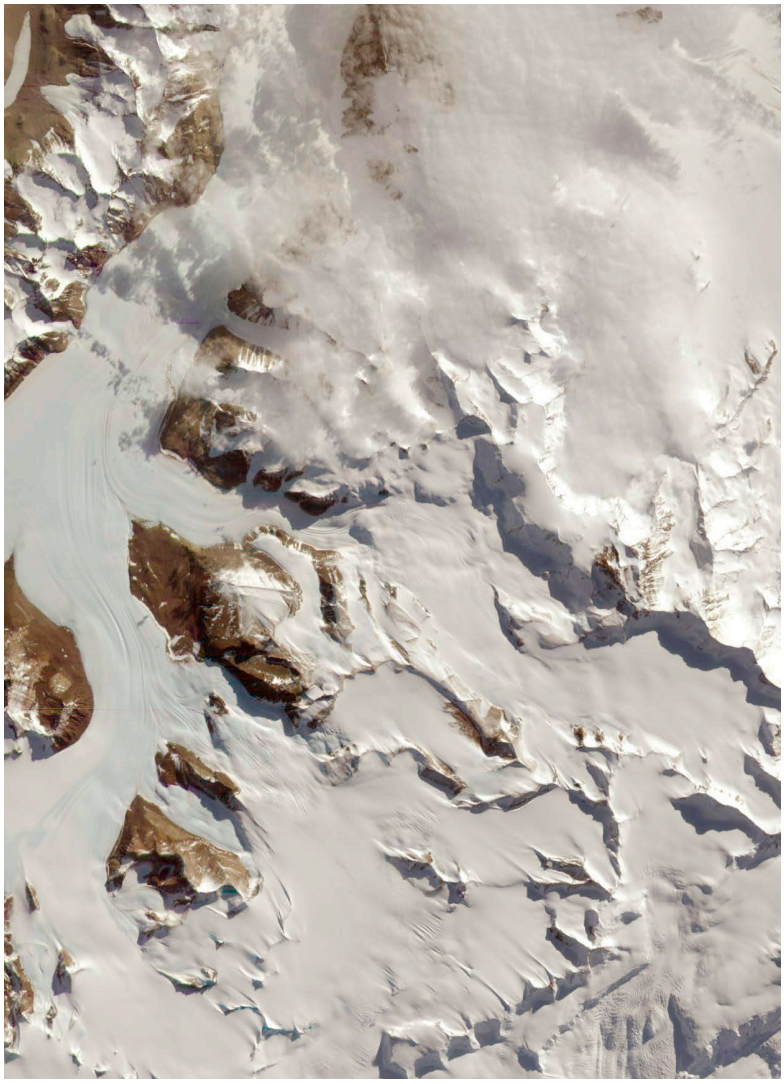


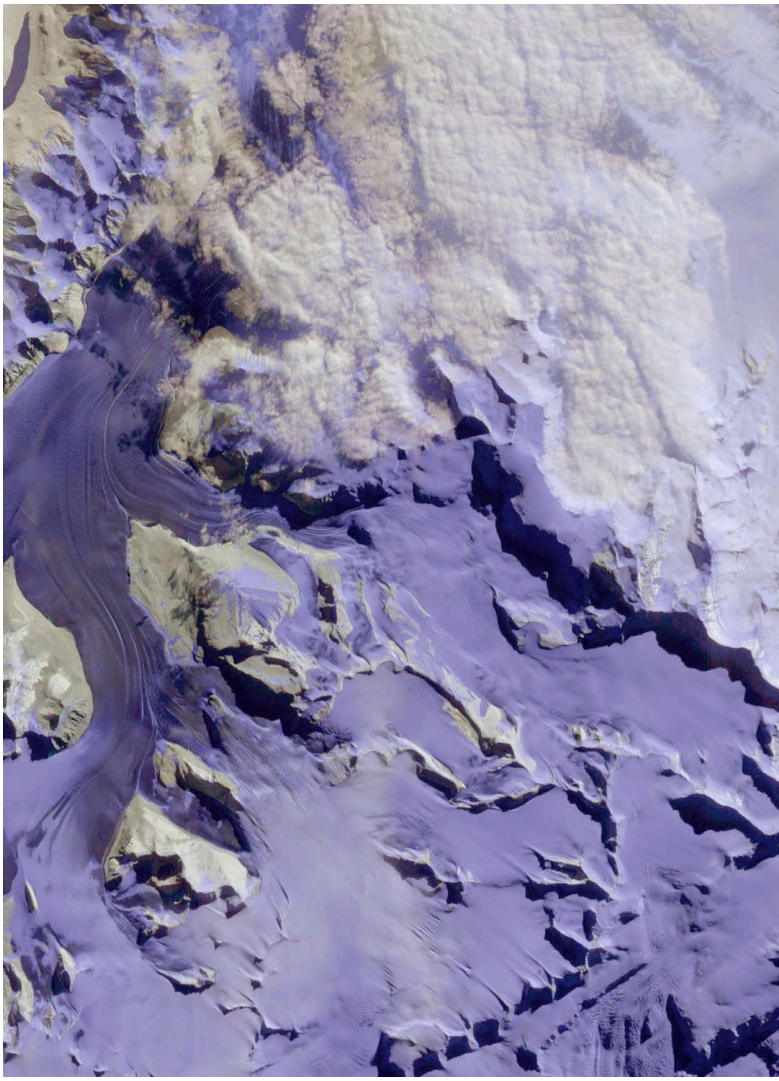
A scan of New Orleans was obtained on 21 July 2002. This 4-3-2 image clearly shows the winding Mississippi River. The thin line at the left is the Lake Pontchartrain causeway, a structure frequently imaged in order to test the stability and resolution of satellite sensors.

This panchromatic-sharpened natural-color image of Washington, D.C., is from a scan made on 5 October 2001. The Capitol building is clearly visible, surrounded by trees in the center of the image. The shadow of the Washington Monument, farther west toward the Potomac River, is also a distinctive feature.



These three images of Lake Frome, in South Australia, obtained on 21 January 2001, show the pronounced differences in spectral response of different types of surfaces. The natural-color 3-2-1 image on the left shows salt flats of the dry lake bed as basically white. As we look at longer wavelengths, with the 5p-4p-4 image in the center, and especially the 7-5-5p image on the right, we find large variations caused by varying moisture content of the soil. In the image on the right the wetter areas show as deeper blue, while the dry soil surrounding the lake show a high reflectance in the SWIR bands.

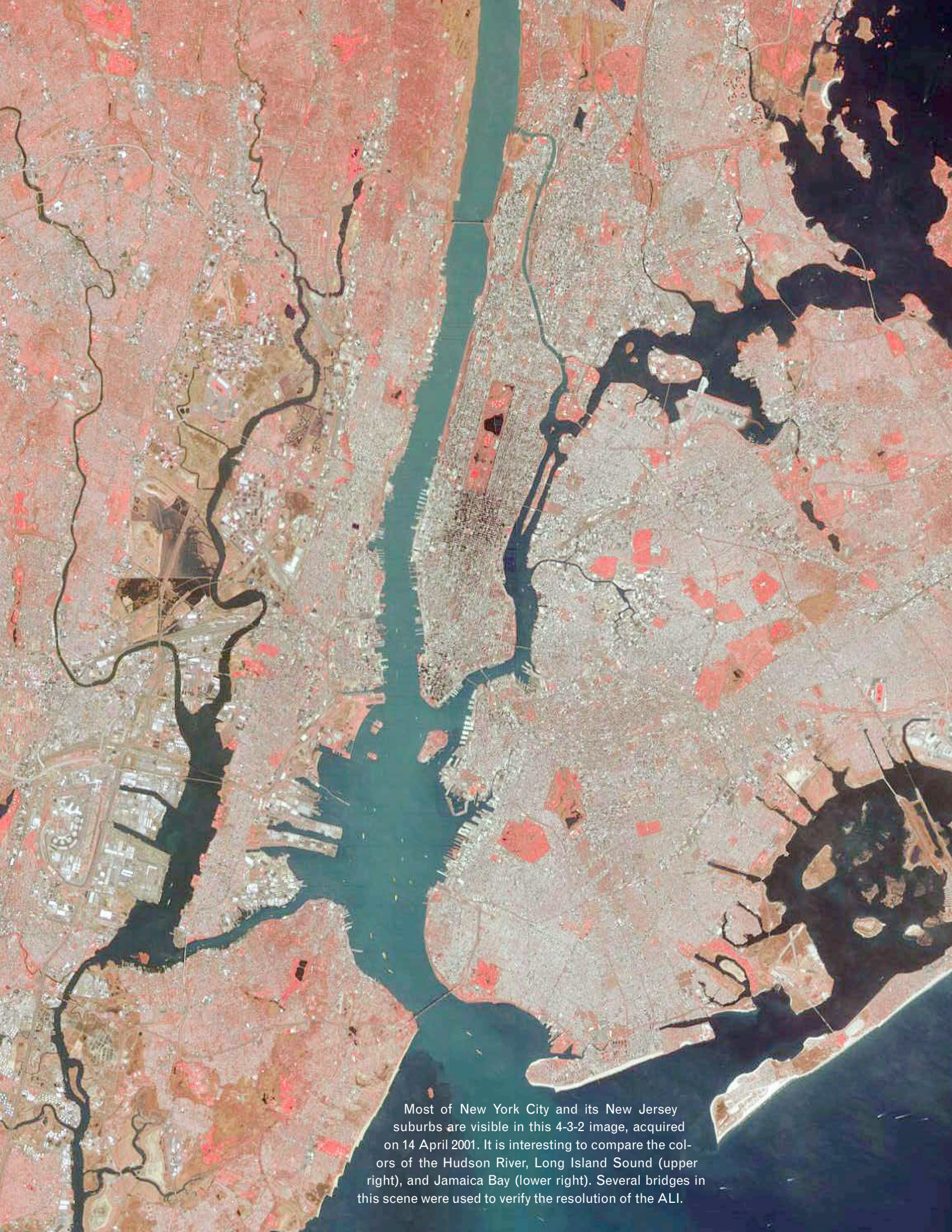




Another example of features brought out in the SWIR bands can be seen in these two images, taken near McMurdo Sound, Antarctica, on 28 January 2001. The 3-2-1 image on the left shows the snow, ice, and clouds as simply white, with high reflectance across the visible bands. The 7-5-5p image on the right reveals the lower SWIR reflectance of snow and ice, compared to clouds. The faster-moving sections of glacier appear darkest in the longer wavebands.

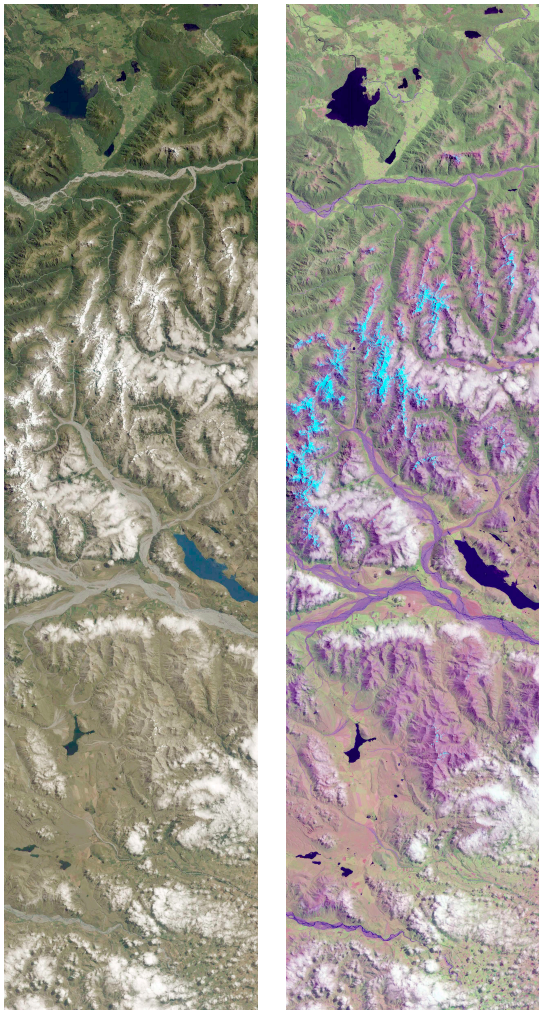
Cape Canaveral and the Kennedy Space Center are seen in this 4-3-2 image acquired on 13 January 2001. The large white building near the S-bend of the small inlet in the upper part of the image is the Vehicle Assembly Building, where the space shuttles are serviced before launch. Wide roads link the building with the Shuttle Landing Facility to the west, and Launch Complexes 39-A and 39-B near the beach.

On 23 January 2001, before the spacecraft attitude determination parameters were refined, this image was supposed to have been taken over Blythe, California. In studying the scene, the author recognized the shape of the Colorado River as it passes by Yuma, Arizona. The fields seen here supply many of our winter vegetables. Also visible are the Imperial Dam and the Imperial Canal, heading west to the Imperial Valley of California. The crisply defined circles in the desert are center-pivot irrigation fields.

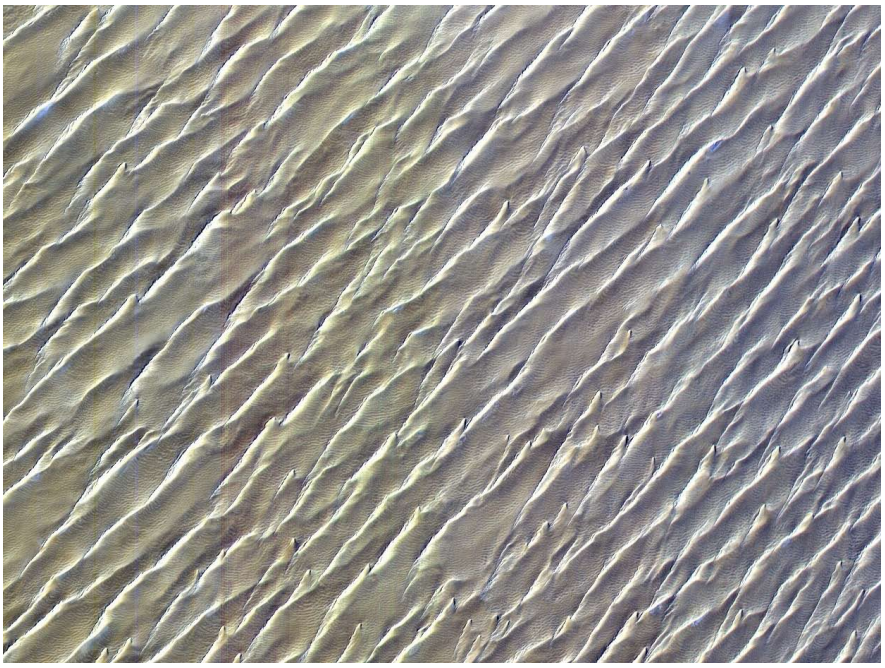


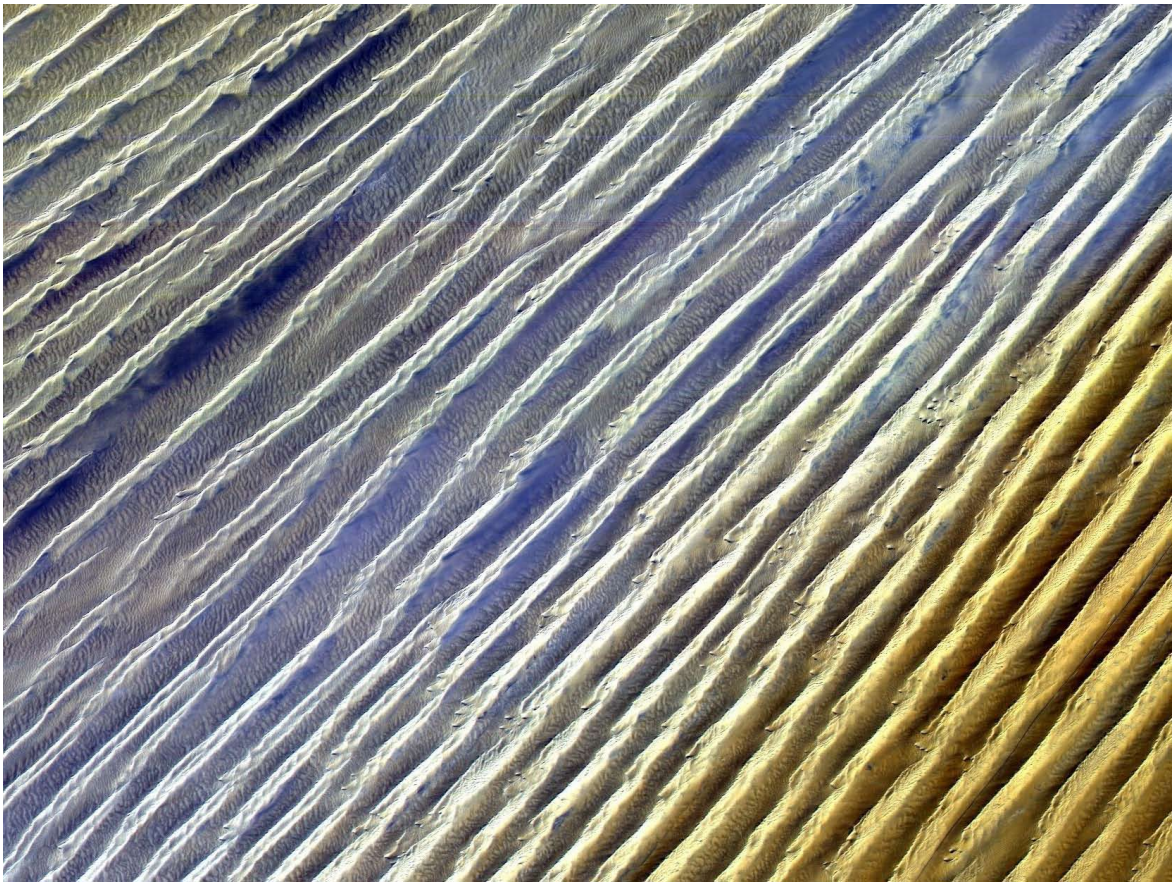
Most of New York City and its New Jersey suburbs are visible in this 4-3-2 image, acquired on 14 April 2001. It is interesting to compare the colors of the Hudson River, Long Island Sound (upper right), and Jamaica Bay (lower right). Several bridges in this scene were used to verify the resolution of the ALI.

This 4-3-2 image from 18 February 2001 of the Coleambally Irrigation Area in New South Wales, Australia, was processed by Lawrence Ong at NASA Goddard Space Flight Center to bring out differences between the crops and conditions in the different fields, which contain maize, rice, soybeans, and fallow soil. The scene was imaged repeatedly with EO-1, for comparison with ground truth data collected by the NASA Science Validation Team. (Image courtesy of NASA.)



These two images, taken 10 January 2001, show a part of the South Island of New Zealand, over the Rolleston Range, with Lake Brunner to the north, Lake Coleridge in the south, and the Rakaia River. The image on the left is the natural-color 3-2-1 channel selection, while the image on the right is a 5-4-2 selection. The right-side image brings out the difference between clouds (white) and snow (blue) on the mountain tops, due to the lower reflectance of the snow in the SWIR. Also, fine details of the stream beds are made visible in the SWIR bands. Mapping band 4 to green makes vegetation look green. These images illustrate how the nine multispectral bands can be used to classify land areas, in a process called thematic mapping.

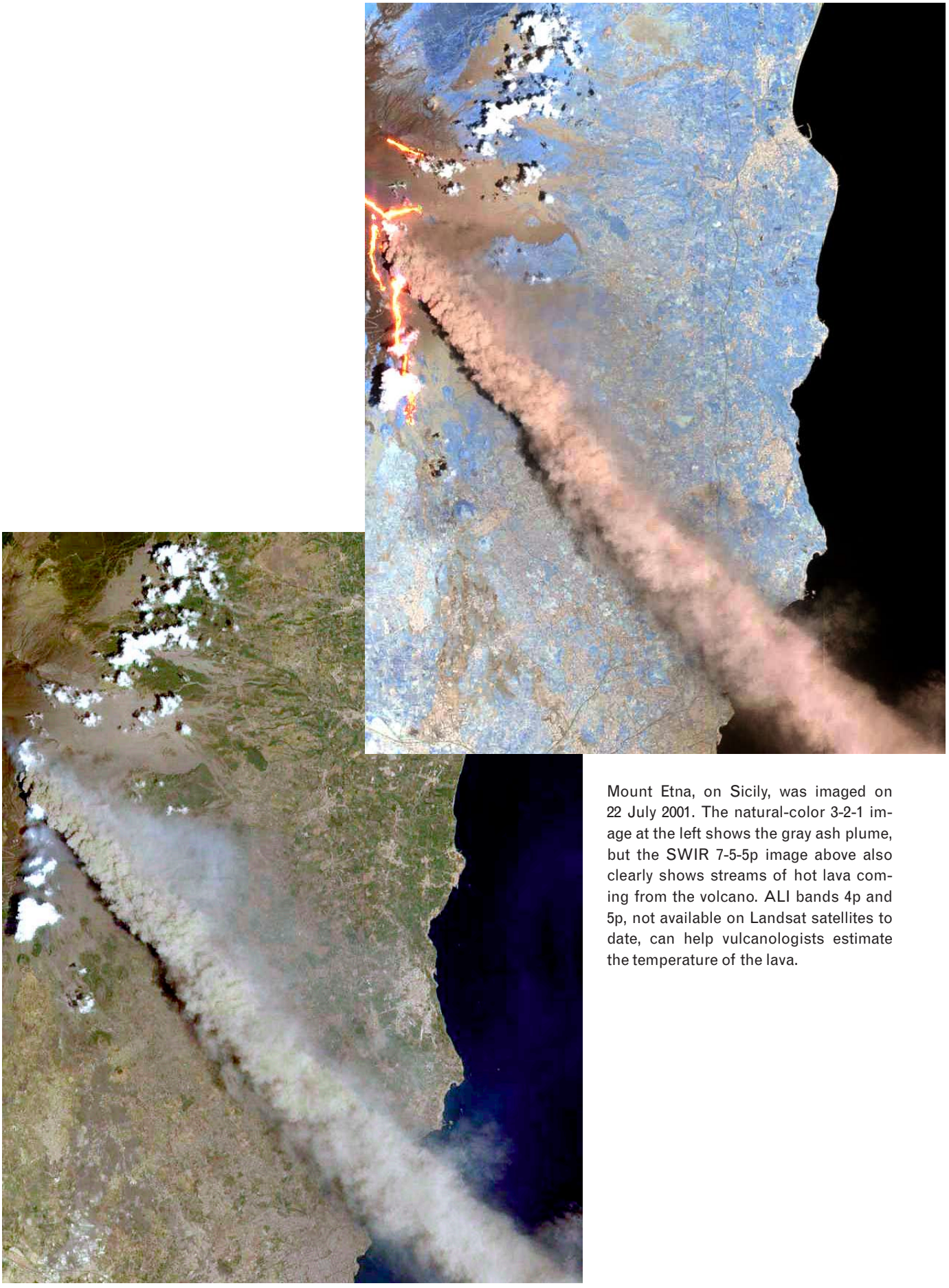




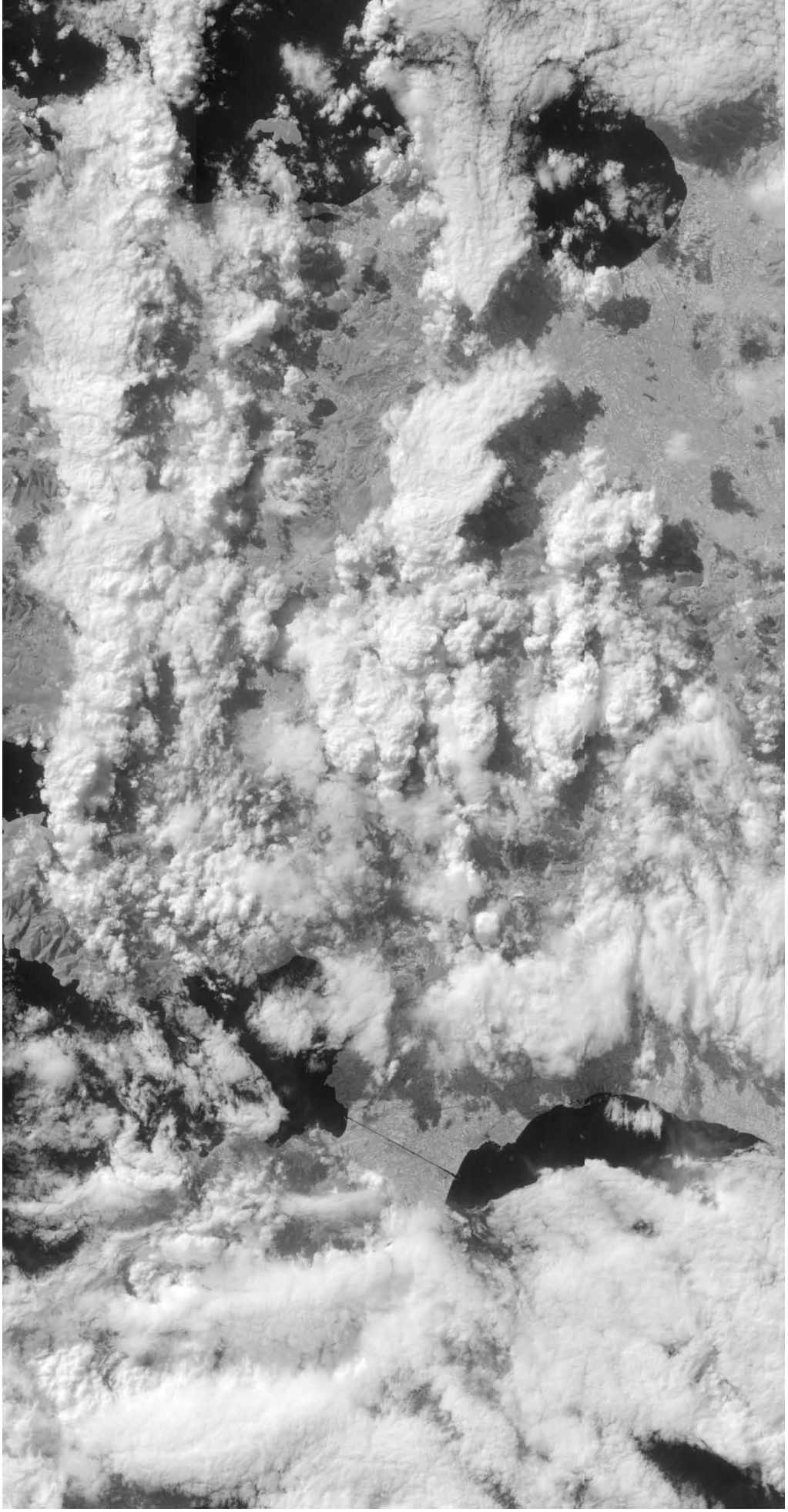
These two 4-3-2 images are part of a longer scan from 18 February 2001, centered in the great Rub' al-Khali desert of southern Saudi Arabia. The dune structures are remarkably repetitive over the full 38 km swath width seen here. Only the southern portion shows noticeable color variations. These images were processed by Lawrence Ong at NASA Goddard Space Flight Center. (Images courtesy of NASA.)

This 10 m color image of London is from a larger scan made on 16 February 2001. The Thames River appears to have a heavy load of suspended solids. Close inspection in the center of the image reveals the shadows on the water of the two towers of Tower Bridge. Buckingham Palace can be seen in St. James's Park at the far left of the image.

On 2 February 2001, ALI captured this natural-color 3-2-1 image of the Greek island of Santorini, in the Aegean Sea. The island rings a submerged volcanic caldera, bordered by 300 m high cliffs. A cinder cone rises near the middle of the caldera. The curious linear clouds were caused by aircraft contrails. The dark streaks roughly parallel to the clouds are the shadows of the clouds on the water surface. From their relative positions, we can infer that the sun was at a low elevation in the southeast direction.



Mount Etna, on Sicily, was imaged on 22 July 2001. The natural-color 3-2-1 image at the left shows the gray ash plume, but the SWIR 7-5-5p image above also clearly shows streams of hot lava coming from the volcano. ALI bands 4p and 5p, not available on Landsat satellites to date, can help vulcanologists estimate the temperature of the lava.



A perusal of this collection of ALI images does not communicate to the reader an inescapable fact—approximately half the time the object of a data collection event is obscured by clouds! Even the shadows cast by the clouds can interfere with analysis of the images. On 16 February 2001, a scan was made over Greece in order to image the Corinth Canal, between Attica and the Peloponnese. As this band-4 grayscale image shows, on this day we got lucky. In a scan mostly filled with clouds, the entire canal is visible in a small, clear area, free of cloud shadows.