U.S DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

OPEN–FILE REPORT 2005–1192
PLATE 1 OF 3

ELEVATION

150 ft
100
50
0

EXPLANATION OF MAP SYMBOLS

- **Federal Boundary**—National Petroleum Reserve, Alaska
- **Existing Pipeline**
- **Proposed Pipeline Route (approximate, acquired 5/04)**
- **Exploration Well**
- **Proposed Pad (approximate, acquired 5/04)**

SCALE 1:63 360

1 1/2 0 1 2 3 4 5 MILES
3000 0 3000 6000 9000 12000 15000 18000 21000 24000 27000 FEET
1 .5 0 1 2 3 4 5 6 7 KILOMETERS

1 MAP INCH = 1 GROUND MILE

ALASKA

MAP LOCATION

COLOR SHADED–RELIEF MAP OF THE FISH CREEK AREA, HARRISON BAY QUADRANGLE, NORTHERN ALASKA

Elevation data acquired July, 2002
Universal Transverse Mercator projection, zone 5
1983 North American Datum

INTRODUCTION

The northeastern part of the National Petroleum Reserve in Alaska (NPRA) has become an area of active petroleum exploration during the past five years. Recent leasing and exploration drilling in the NPRA requires the Bureau of Land Management (BLM) to manage and monitor a spectrum of surface activities that include seismic surveying, exploration drilling, oil-field development drilling, construction of oil-production facilities, and construction of pipelines and access roads. BLM evaluates a variety of permit applications, environmental impact studies, and other documents that require rapid compilation and analysis of data pertaining to surface and subsurface geology, hydrology, and biology. In addition, BLM must monitor these activities and assess the impacts of these activities to the natural environment. Timely and accurate completion of these land-management tasks requires elevation, hydrologic, geologic, petroleum-activity, and cadastral data, all integrated in digital formats at a higher resolution than currently available in published formats.

To support these land-management tasks, a series of maps have been generated from remotely sensed data in an area of high petroleum-industry activity. The maps, extending from 70°00' to 70°30' N latitude and from 151°00' to 153°10' W longitude, include the Alpine oil field on the east, the Husky Inigok exploration well (site of a landing strip) on the west, many of the exploration wells drilled in NPRA since 2000, and the route of a proposed pipeline to carry oil from discovery wells in NPRA to the Alpine oil field. This map area is referred to as the "Fish Creek area" after the prominent fluvial system within the area.

The map series includes a color shaded-relief map (based on 5 m-resolution data, Plate 1), a surface classification map (based on 30 m-resolution data, Plate 2), and a pan-sharpened, shaded relief-surface classification map (generated by fusing the two datasets, Plate 3). Remote sensing datasets used to compile the maps include, IFSAR, and Landsat 7 ETM+ data. In addition, a 1:250,000 geologic map of the Harrison Bay Quadrangle, Alaska (Carter and Galloway, 1985) has recently been released in digital format (Carter et al., 2005), and was used in conjunction with ETM+ and IFSAR data.

DATA DESCRIPTION

IFSAR data used in the study were collected by the STAR-3i airborne synthetic aperture radar system. STAR-3i is a high-resolution, single-pass, across-track IFSAR system, which uses two apertures to image the surface. The path length difference between the apertures for each image point, along with the known aperture distance, is used to determine the topographic height of the terrain. The IFSAR system is capable of collecting data with a vertical accuracy of <1 m and a horizontal accuracy of <3 m.

Data are delivered as three core products: orthorectified radar images (ORRIs), digital surface models (DSMs), and digital terrain models (DTMs). ORRIs are 8-bit grayscale GeoTIFF images that show the radar reflectance intensity of various earth surface materials. These images are commonly used to identify and extract drainage networks and cultural features such as pipelines, roads, and buildings. The ORRIs used in this study had a pixel size of 1.25 m and a horizontal accuracy of 2.5 m. The DSMs, or "first-return" elevation data, display the first surface on the ground that the radar strikes. These images consist of measured points collected by the sensor, including the z-values of structures (e.g., building and towers) and vegetation (e.g., trees and crops). These elements are removed from the DSM through filtering techniques to create a DTM. The DTMs, or "bald-earth" elevation data, are similar to Digital Elevation Models (DEMs) in that non-terrain elements are absent (Fig. 1). However, unlike the regular array of elevation values that are characteristic of a DEM, a DTM defines topographic elements by irregularly spaced breaklines, or abrupt changes in surface smoothness, like shorelines, roads, streams, and slope breaks. The result is a more accurate depiction of the terrain, useful for contouring, triangulated irregular network (TIN) calculations, and other terrain modeling (Fig. 2).

PROCESS DESCRIPTION

Computer-based analytical hillshading has become a widely used tool to visualize three-dimensional topography on a two-dimensional surface. Unlike manually-produced shaded-relief maps, analytical hillshade images often reveal imperfections in the elevation data used to render the image. The IFSAR data contained flaws in some areas because excess motion in the aircraft caused visible ripples in the dataset. A regular banding pattern was apparent along sensor swath boundaries when elevation data were viewed at small-scales. This aside, the DSMs and DTMs derived from the IFSAR system proved to be an excellent data source for generating the shaded-relief surficial classification images (Garrity, 2004).

Large-scale (1:20,000) shaded-relief images were generated from DTM data to identify the location of surficial objects with greater accuracy. Initial image rendering revealed potential challenges related to the portrayal of surface features in an area devoid of any significant relief. When rendered with no vertical exaggeration, the shaded-relief image was essentially flat. Using 5X vertical exaggeration the shadows appeared blocky and generally became unsightly at the desired map scale. To give the landscape images a more natural appearance, DTM surfaces were slightly bump-mapped (Garrity, 2004). Because the images were used for surface delineation, a random height map was unsuitable for fear of compromising data integrity. Instead, the corresponding DSM was used as a height map to generate the bumped surface. The natural "roughness" of the DSM gave the hillshaded DTM a subtle texture without obscuring the DTM surface with unnecessary detail.

Removal of jagged shading was accomplished by generalizing the raw data grids, isolating their shaded pixels, and then merging the generalized shade layer with the original grid. To generalize the raw data grids, softening techniques were applied in ArcInfo Workstation using focal functions. The amount of softening was regulated by adjusting the neighborhood configuration (shape, size) in the focal command. In all instances, a very small neighborhood was used and care was taken not to over-generalize the softened grids. Isolation of shaded pixels within the generalized grids was accomplished in Adobe Photoshop via the "Curves" tool, while the remaining pixels were converted to white. Finally, the adjusted softened hillshade and original hillshade were merged by multiplying the two images in Photoshop. Multiplying the images caused the converted white pixels of the softened image to drop out, resulting in a softening effect restricted to the darkest shades of the merged image. The resulting hillshade image had a more natural appearance, devoid of any jagged shading.

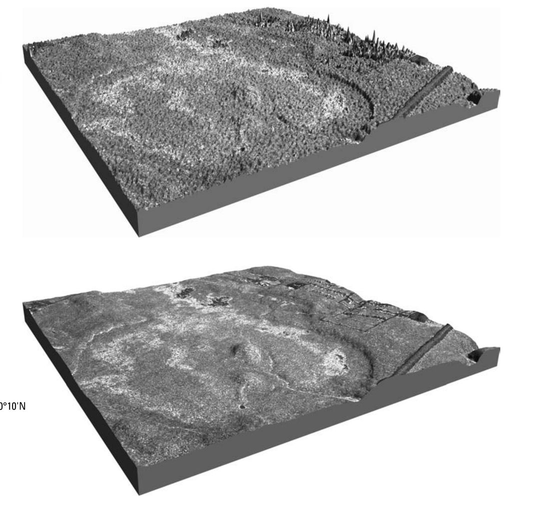

Figure 1.–Block diagram comparison of DSM (top) and DTM (bottom), draped with ORRI data, Nuiqsut, Alaska. The DSMs display all of the measured points collected by the sensor, as illustrated by the irregular elevation spikes in the diagram. Non-terrain elements are removed through filtering to create a DTM. The DTMs simulate a "bald-earth" and are traditionally preferred over DSMs for topographic mapping purposes (Garrity, 2004).

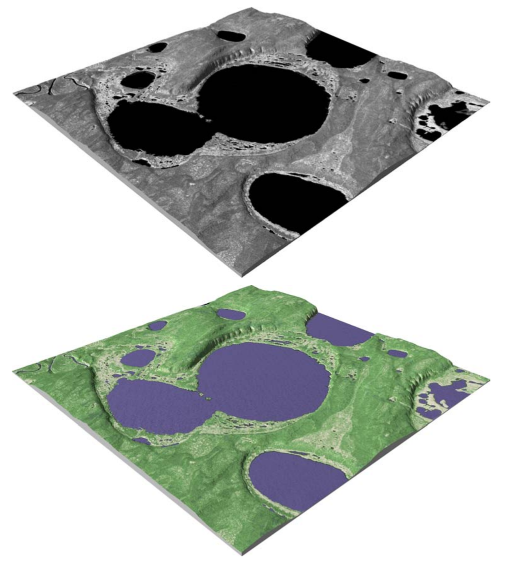

Figure 2.–Terrain modeling using a DTM rendered surface draped with ORRI data. In this example, DTM objects were bump mapped with DSM elevation data to add a subtle surface texture (top). ORRI data is colorized (bottom) based on Landsat 7 ETM+ image data which has been post processed to delineate surface materials.

REFERENCES

Carter, D.L., Galloway, J.P., Garrity, C.P., and Labay, K., 2005, Engineering-geologic maps of northern Alaska, Harrison Bay Quadrangle, U.S. Geological Survey, Open File Report 2005-1194.

Carter, D.L., and Galloway, J.P., 1985, Engineering-geologic maps of northern Alaska, Harrison Bay Quadrangle, U.S. Geological Survey, Open File Report 85-256, 47 p.

Garrity, C.P., 2004, Digital Cartographic Production Techniques Using Airborne Interferometric Synthetic Aperture Radar (IFSAR): North Slope, Alaska, in Soller, D.R., ed., 2004, Digital Mapping Techniques '04 – Workshop Proceedings: U.S. Geological Survey Open-file Report 2004-1451, p. 47–52.

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