Recent advances in remote sensing technologies for hydrocarbon exploration and environmental evaluation

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Remote sensing detects and monitors the physical and spatial characteristics of the earth's oceans, surface, and atmosphere by measuring the reflected or scattered downwelling or emitted upwelling electromagnetic radiation or acoustic signal using passive or active sensors at a distance. It plays an important role in today's energy and environmental sustainability efforts. Remote sensing from spaceborne, airborne, terrestrial, and marine platforms has long been used in hydrocarbon exploration to map surface geology, topography, and hydrocarbon seepages, as well as to evaluate environments that relate to petroleum industry activities. Since the mid-2000s, remote sensing technologies have undergone substantial advances in data acquisition, processing, and interpretation. In the last decade, rapid advances in satellite systems, unmanned autonomous vehicles (UAVs), sensors, and scale of surveys have further expanded applications.

To demonstrate the recent development and applications of remote sensing technologies in hydrocarbon exploration and petroleum industry-related environmental evaluation, we organized a postconvention workshop at SEG's 2018 Annual Meeting in Anaheim, California. We sought to introduce the most recent remote sensing technologies to the exploration geophysics community and to promote the cross-disciplinary integration of remote sensing and geophysics. The workshop consisted of a keynote speech and two technical sessions (onshore and offshore applications) with open discussions. In this workshop, leading experts from industry and academia presented 10 oral and five poster presentations. The presentations covered both upstream and downstream industries including industry practice reviews, new technologies, and case histories. Technologies related to spaceborne, airborne, and marine systems, LiDAR, underwater sonar, passive lightning, oil and gas seepage mapping, natural gas and methane detection, and artificial intelligence were discussed. The following sections detail the key messages.

Figure 1. Frozen gas bubbles in Spray Lakes, Alberta, Canada.

Khalid Soofi of ConocoPhillips provided a keynote speech on "State-of-the-art remote sensing for hydrocarbon exploration," which summarized recent technologies and applications of remote sensing in hydrocarbon exploration. He described how remote sensing for hydrocarbon exploration has come a long way since using visible imagery in the late 1970s. The imagery available today has better spatial resolution, signal to noise, more spectral bands in both optical and microwave regions, and more frequent revisit times for orbital sensors than original Landsat imagery of the late 1970s and early 1980s. Today's imagery sources are more diverse than ever before, especially with the increasing use of UAVs. The higher resolutions and diverse sensors allow for a wide range of applications including simple mapping, surface lithology mapping, vegetation mapping, general geomorphology, offshore and onshore seepage mapping, high-resolution surface topography using LiDAR, surface deformation mapping using InSAR, detecting and quantifying natural gas emissions, etc. A number of these applications with examples were discussed, and the presentation concluded with a look at the future of remote sensing for hydrocarbon exploration and development.

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Figure 2. Satellite image (10 m resolution Sentinel 2 data) of the hydrocarbon seeps in Kolketi, Georgia. Copyright ESA (courtesy of CGG).

Dominique Dubucq et al. of Total described the use of remote sensing technologies in the oil and gas industry in their poster presentation, "A journey to enlighten your child's spirit and marvel at remote sensing infinite prospects," with examples of current applications and new technology developments. Remote sensing long has been used for geologic mapping, land cover, environmental impact assessment, and the offshore detection of seeps and spill monitoring. With the launch of European optical and radar satellites from the Copernicus program, an abundance of new and free data from the American and European space agencies are enabling much finer and systematic studies for very large areas. New sensors such as hyperspectral sensors, new platforms such as drones, micro- and nanosatellite constellations, and new processing tools such as cloud computing already are changing dramatically our vision of the earth, surface geologic mapping, surface deformation related to landslides or hydrocarbon production, and spill monitoring. Offshore, subsurface acquisition with gliders and new imaging techniques will enable a better understanding of the geochemistry and monitoring of production sites.

In the workshop, several technologies and applications of remote sensing in onshore hydrocarbon exploration and environmental evaluation were presented including ARPA-E's monitoring program (Bryan Willson, Colorado State University), the SGMethane system (Luise Sander et al., Sander Geophysics), the 3DEP program (Jason Stoker, USGS), lightning analysis (Roice Nelson et al., Dynamic Measurement LLC), and spectrometric analysis technology (James Reardon et al., Terra Energy & Resource Technologies). ARPA-E's monitoring program and the SGMethane system represent the development of new technologies for detecting methane leaks or gas seepages. The 3DEP program represents a collective effort to generate a national-scale high-resolution remote sensing data set for a variety of applications. It has great potential to be widely used by operations geophysicists and exploration geoscientists. And lightning analysis and proprietary spectrometric technology represent efforts to develop unconventional geophysics-based remote sensing technologies for subsurface characterization.

Technologies and applications of remote sensing in offshore hydrocarbon exploration and environmental evaluation were also presented including CGG's NPA satellite mapping program (William Jeffery, CGG), Fugro's offshore seep-hunting program (Jayme McBee et al., Fugro USA Marine Inc.), TAMU's artificial intelligence project (Dylan Blakeslee, Texas A&M University), and Bubbleology's underwater multibeam sonar analysis (Ira Leifer, Bubbleology Research International). The NPA satellite mapping program and the offshore seep-hunting program are large-scale (regional and global) remote sensing projects for hydrocarbon exploration and environmental evaluation that include seepage hunting, geologic mapping, surface deformation monitoring, and seafloor characterization. Notably, Fugro is conducting the world's largest offshore seep-hunting surveys using hull-mounted multibeam echosounder and subbottom profiler systems.

The workshop demonstrated that cross-disciplinary integration of remote sensing, geophysics, geology, and engineering is required for the development of future and more effective remote sensing technologies for hydrocarbon exploration. There are synergies, as geophysics and remote sensing use similar physical methods. The technologies and methods developed in geophysical data acquisition, processing, and interpretation can be transferred to the remote sensing community and vice versa. Also, because remote sensing studies the earth's surface and geophysics studies the subsurface, the integration of the two improves descriptions of both the earth's subsurface and surface.

The workshop showed that remote sensing technology is rapidly advancing on many fronts including satellite constellation systems, microsatellite systems, UAVs, short time-lapse interval, and high-resolution data acquisition using passive and active sensors from space, aerial, and UAV platforms such as high-resolution satellites, LiDAR, airborne imaging spectroscopy, and underwater sonar systems. On the application side, developments include high-resolution imagery and topography, advanced geologic and seepage mapping, more effective monitoring of environmental impact due to activities of the petroleum and energy industry, and more accurate characterization of the earth's surface. With further development and interdisciplinary integration of remote sensing and geophysical technologies, we expect to achieve increasingly accurate descriptions of the earth's surface and subsurface resulting in safer and more effective hydrocarbon exploration. TLE

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