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14. ABSTRACT Reflectometry, a microwave remote sensing technique to extract geophysical data from scattered satellite transmissions, was first demonstrated using Global Navigation Satellite System (GNSS) reflections. Recently, reflectometry has been extended to digital communication satellite 'signals of opportunity', expanding its application to most microwave bands that penetrate the Earth's atmosphere. The 2012 GNSS+R workshop provided an opportunity for engineers and Earth scientists to assess the state of the art, demonstrate new applications, and discuss potential missions.						
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MEETING

Advancing Reflectometry

**Workshop on Reflectometry Using GNSS and Other Signals of Opportunity (GNSS+R);
West Lafayette, Indiana, 10–11 October 2012**

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Reflectometry, a microwave remote-sensing technique to extract geophysical data from scattered satellite transmissions, was first demonstrated using Global Navigation Satellite System (GNSS) reflections. Recently, reflectometry has been extended to the reutilization of digital communication satellite signals for Earth remote sensing, now referred to as “signals of opportunity.” This expands the application of reflectometry to most microwave bands that penetrate the Earth’s atmosphere. GNSS+R 2012 provided an opportunity for engineers and Earth scientists to assess the state of the art, demonstrate new applications, and discuss potential missions.

Reflectometry experiments from ground, air, and space platforms were presented at the meeting. New results from ground experiments included studies of snow layering in Antarctica, soil moisture/vegetation sensing, and tide measurements. Recent airborne and coastal measurements using S and K_u band satellite signals were also presented, showing expansion of reflectometry to higher frequencies and signal powers. The 2005 United Kingdom Disaster Monitoring

Constellation (UK-DMC) space demonstration was discussed, and NASA’s recently initiated Cyclone Global Navigation Satellite System (CYGNSS) mission was highlighted. Slated for launch in 2016, CYGNSS will make 3-hourly GNSS+R ocean wind measurements in tropical regions.

A town hall meeting, held on the second day of the conference, focused on how to better engage the Earth sciences user community and on potential satellite missions. While most of the reflectometry community is based in engineering, the need to involve Earth scientists to help identify data gaps in existing measurements and develop appropriate specifications for reflectometry products was recognized. For example, useful GNSS+R altimetry products must have precision better than 5 centimeters within a 50-kilometer footprint. A potential constellation combining the American, Russian, Chinese, and European GNSS transmitters could provide shorter revisit times and enable new measurement types. Reflectometry could also be integrated with other instruments, for instance, to correct microwave radiometer salinity retrievals for roughness effects or to perform coastal altimetry with high-power

direct-broadcast satellites with footprints covering continental areas.

Participants agreed that with CYGNSS as a pathfinder, future constellations could be scaled up to more satellites, further decreasing revisit time. Forty-eight low-Earth-orbiting satellites in a polar orbit would provide 15-minute revisit times, offering an alternative to the geostationary orbit, with advantages of scalability, small low-cost satellites, and robustness to single-satellite failures.

The utility of more fundamental data products, unique to reflectometry (e.g., delay-Doppler maps and directional mean square slope), was also discussed. Such products, if directly assimilated into models (as is done with radio-occultation bending angles), could improve model outputs, despite difficulties finding adequate surface truth for calibration and validation. At present, reflectometry measurements are reduced to well-known geophysical units (e.g., wind speed, volumetric water content, snow depth).

Missions of opportunity were discussed as potential hosts for reflectometry instrument payloads. While the idea is attractive, past experience has shown that it is often difficult to accommodate a secondary reflectometry payload unless it contributes vitally to the primary mission.

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