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Soil Moisture Monitoring with Spire's GNSS Reflectometry (GNSS-R) CubeSats

Vahid Freeman*(1), Dallas Masters(1), Stephan Esterhuizen(1), Philip Jales(1)
(1) Spire Global, Inc. Boulder, CO, USA, 80301, e-mail: dallas.masters@spire.com

Spire Global operates the world's largest and fastest growing constellation of CubeSats performing GNSS based science and Earth observation. The Spire constellation, performs a variety of GNSS science, including radio occultation (GNSS-RO), ionosphere and space weather measurements, and precise orbit determination. In December of 2019, Spire launched two new types of satellites to perform GNSS reflectometry (GNSS-R) and two more follow-on GNSS-R satellites in January of 2021. GNSS-R is a relatively new technique based on a passive bistatic radar system. The potential of space-borne GNSS-R observations for ocean and land applications has been demonstrated by previous GNSS-R missions, including the NASA Cyclone Global Navigation Satellite System (CYGNSS) and the UK's Technology Demonstration Satellite, TechDemoSat (TDS-1).

We will present results from these new Spire GNSS-R satellites that are primarily focused on retrieving soil moisture but also estimate other Earth surface properties, such as ocean wind speeds and flood inundation/wetland mapping. Prior to the launch of Spire's GNSS-R satellites and in preparation for Level-2 data production, we developed algorithms and processing chains for land applications, as shown in Figure 1. We will present Spire's Soil Moisture (SM) retrieval method using both Spire and CYGNSS observations. We have evaluated the implemented SM change detection algorithm by comparing the Spire's daily SM product with NASA's Soil Moisture Active Passive (SMAP) observations and in-situ SM measurements. The results indicate remarkable retrieval skills of the GNSS-R technique for soil moisture monitoring at a medium spatial resolution, as shown in Figure 2. Spire's GNSS-R satellites are tuned for land applications with a series of hardware and software optimizations for better signal calibration and acquiring many more data per satellite compared to CYGNSS. A more robust GNSS-R SM retrieval at finer spatial resolution will be possible in the near future after having more Spire satellites in orbit. Spire's current and future GNSS-R satellites will provide unprecedented sub-daily global coverage with potentially sub-kilometer spatial resolution.

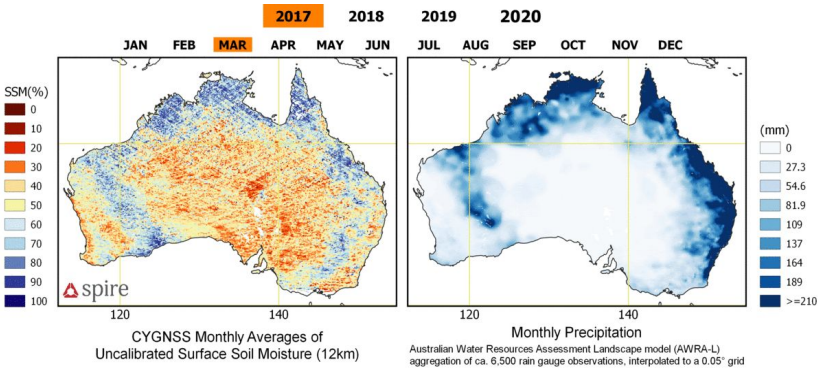

Figure 1. Left: Monthly soil moisture map derived by Spire from CYGNSS GNSS-R data collected over Australia compared to monthly precipitation from the Australian Water Resources Assessment Landscape model (AWRA-L)[1].

References

[1] F. Hafeez, A. Frost, J. Vaze, and D. Dutta, "A new integrated continental hydrological simulation system," Water: Journal of, 2015.
[2] C. Chew and E. Small, "UCAR/CU CYGNSS Soil Moisture Product User Manual." 2019.
[3] C. Chew and E. Small, "Soil Moisture Sensing Using Spaceborne GNSS Reflections: Comparison of CYGNSS Reflectivity to SMAP Soil Moisture," Geophys. Res. Lett., vol. 45, no. 9, pp. 4049–4057, May 2018, doi: 10.1029/2018GL077905.