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Sea Ice Classification and Altimetry using Grazing Angle Reflected GNSS Signals Measured by Spire's Nanosatellite Constellation

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Global Navigation Satellite Systems-Reflectometry (GNSS-R) offers novel observations over the cryosphere with the use of reflected navigation signals (eg. GPS or Galileo) as signals of opportunity. This technique has the potential for higher resolution measurements over sea ice than routinely acquired by passive microwave systems with a footprint of around 5 km2 and is much lower in power consumption, mass and therefore cost. Here we present sea ice classification and altimetry as observed at grazing angles by Spire's Radio Occultation (RO) Satellite constellation, repurposed for GNSS-R.

The Spire RO constellation of 37 operational satellites (and growing) is relied upon to support critical numerical weather prediction and has been collecting GNSS signals as they refract through the atmosphere. The reprogramming of these satellites to receive signals reflected at grazing angle allows these signals to instead inform on Earth surface characteristics. From smooth surfaces, these signals are phase coherent at L-Band frequencies (~19 - 24 cm wavelength) and allow the detection of the roughness of the sea ice in addition to the height of the surface to several centimetres of precision. Three months of these operational sea ice detection and classification products are presented from Spring of 2020; with ice extent in agreement with external passive and active sources to around 98% in the Antarctic and 94% in the Arctic, and ice age classification (First Year/Multi-Year) agreeing in the Arctic to around 70%. First results are shown for the potential to detect other ice characteristics such as the Antarctic Marginal Ice Zone extent and floe size / type.