Evaluating GNSS-Reflectometry for mesoscale ocean altimetry and ocean wind retrieval with GEROS-ISS, UK TechDemoSat-1 and CYGNSS

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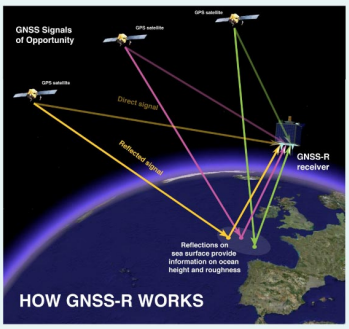
Ocean Remote Sensing with GNSS Signals of Opportunity

***G**lobal*
***N**avigation*
***S**atellite*
***S**ystems*

This innovative technique relies on detecting signals from navigation satellites, such as the Global Positioning System (GPS), GLONASS or Galileo constellations, after they are reflected from the ocean surface.

The concept, first proposed in 1993, is known as Global Navigation Satellite System-Reflectometry (GNSS-R). Over the ocean, the reflected signals contain information about sea surface height (for altimetry) and directional ocean "roughness" (for wind and waves)



How can GNSS-R contribute to the global ocean observing system ?

- ***Relies on signals of opportunity from GNSS = no need to transmit signals = low power, small receivers = small payload = small satellites = low cost missions = more satellites!***
- ***GNSS are profitable commercial enterprises = they are here to stay! = guaranteed availability of GNSS signals over the long term = good for science***
- ***Truly global coverage, all weather operation; lower sensitivity to heavy precipitation (L-band; ~ 20cm wavelength)***
- ***Multiple reflections at any given time = dramatic increase in space-time sampling***

Three new GNSS-R missions

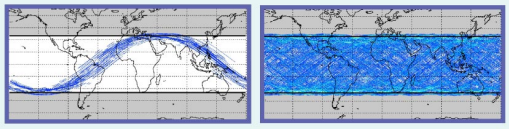
UK TechDemoSat-1

Launch: 8 July 2014
Platform: 150kg satellite in 635km sun-synchronous orbit
Payload: Eight demonstration payloads including SSTL's GNSS-R SGR-ReSI receiver
Objectives: Technology demonstration mission
Funding: UK Technology Strategy Board & SSTL

(left) TechDemoSat-1 pre-launch (right) TechDemoSat-1 launch 8 July'14

NASA CYGNSS

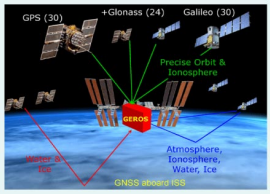
Full name: Cyclone Global Navigation Satellite System
Launch: Expected 2016
Platform: Constellation of 8 micro-sats (20kg each) in 500km low-inclination orbit (35 deg)
Payload: GNSS-R SGR-ReSI receiver
Objectives: to measure ocean surface wind speed in all precipitating conditions, including those experienced in the TC eyewall, and with sufficient frequency to resolve genesis and rapid intensification of Tropical Cyclones
Funding: NASA Earth Venture-2



CYGNSS sampling in (left) 90 minutes (right) 24 hours (Figure courtesy of C. Ruf)

ESA GEROS-ISS

Full name: GNSS REflectometry, Radio Occultation and Scatterometry onboard the International Space Station
Launch: Expected 2018 (currently in Phase-A)
Platform: International Space Station (330-435 km; 51 deg incl.)
Payload: GNSS-R receiver
Objectives: 1) to investigate the GEROS capability to observe highly energetic mesoscale eddies with SSH changes of <20 cm sea surface over <100 km. (2) to retrieve ocean surface mean square slope & wind
Funding: ESA Human Space Flight & ESA Earth Observation Programmes



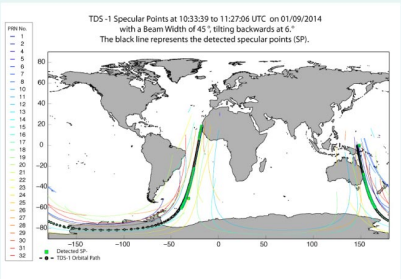
Source: http://www.gfz-potsdam.de

Testing GNSS-R capability for wind retrieval with new TechDemoSat-1 data from space

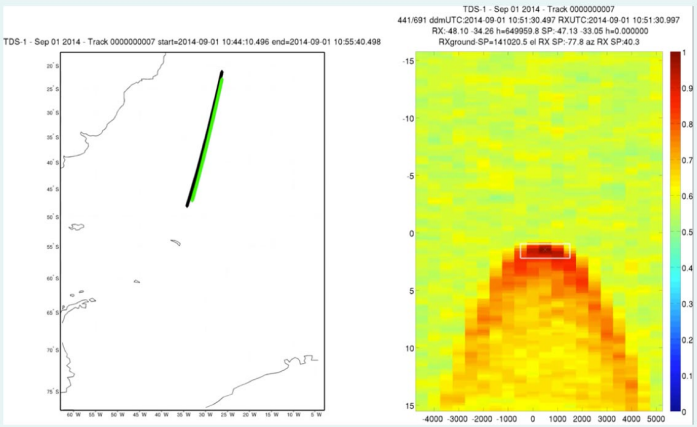
The retrieval of ocean surface roughness and wind speed from GNSS-R is based on the exploitation of the distribution in [delay, Doppler] space of the reflected power for a particular GNSS signal. Over the ocean, these delay-Doppler maps (DDM) typically present a strong peak (corresponding to the power at the Specular Point) and a characteristic horseshoe shape (see far right). The location of the Specular Points can be predicted from the knowledge of the positions of the transmitters (e.g. the GPS satellites), the receiver (e.g. TechDemoSat-1) and the antenna pointing.

The figure right shows the TechDemoSat-1 ground-track and the GPS specular points available on 1 Sept 2014 during the first acquisition of scientific data with the GNSS-R SGR-ReSI. The acquisition, which lasted 1 hour, tracked up to four PRN simultaneously, providing data over the Southern Ocean and Antarctica. These data are the first new GNSS-R measurements from a LEO platform since the UK-DMC mission in 2003/2004.

Work is now underway at NOC to evaluate these data and optimise the geophysical inversion methods to retrieve ocean roughness and wind speed information. The accuracy of the GNSS-R roughness retrieval will be assessed with the use of wind and wave measurements from buoys and other wind-measuring satellites.



TechDemoSat-1 ground-track (black) and GPS PRN reflections during a 1-hour data acquisition on 1 Septembre 2014.



(left) Location of TechDemoSat-1 ground-track (black) and PRN14 reflection over the South Atlantic on 1 Sept 2014 (right) Delay-Doppler map of reflected power for PRN 14

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