IGARSS 2024 - 2024 IEEE International Geoscience and Remote Sensing Symposium | 979-8-3503-6032-5/24/$31.00 ©2024 IEEE | DOI: 10.1109/IGARSS53475.2024.10642216

LATEST PROGRESS ON RONGOWAI POLARIMETRIC GNSS-R AIRBORNE MISSION

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ABSTRACT

At present, it is speculated that the interannual variability of global CH4 is dominated by wetlands. More accurate CH4 emission models require improved capabilities for surface water extend monitoring by remote sensing sensors under dense vegetation. A new NASA Cyclone Global Navigation Satellite System (CYGNSS) surface water map data product has been produced, which can be used to further understand the water cycle in tropical latitudes. This new data product enables small inland water bodies detection under dense biomass up to ~ 400 tons/ha. Our product improves multi-spectral VisIR imagers aboard satellites such as e.g. Landsat & Sentinel-2, and C-band Synthetic Aperture Radar (SAR) images by e.g. Sentinel-1.

The main objective of this work is the application of an improved version of the new CYGNSS retrieval algorithm to all the available Rongowai Global Navigation Satellite Systems Reflectometry (GNSS-R) airborne mission data to investigate the benefits of polarimetric measurements on inland water detection under dense biomass. The expected relevance of this study is high because tens of polarimetric GNSS-R SmallSats will be launched in the near future, including the European Space Agency (ESA) HydroGNSS mission and the Muon Space commercial constellation. On the other hand, SAR & microwave radiometry missions are limited by the required power consumption, instrument size and cost. In summary, we are developing a novel GNSS-R retrieval algorithm, useful for the remote sensing community, and with interest to further understand highly dynamic water surface processes.

Index Terms— Inland Waters, GNSS-R, Polarimetry, Rongowai, Airborne Experiment

1. INTRODUCTION

The detection of inland water bodies is an important new scientific application of the NASA CYGNSS mission [1-5]. Monitoring highly dynamic surface water extent requires high spatio-temporal sampling observations with high spatial resolution. CYGNSS can generate such measurements independently of weather conditions, using surface reflected L-band Global Positioning System (GPS) signals as signals-of-opportunity [6-11]. This technique is known as GNSS-R e.g. [12,13], which is essentially an L-band passive multi-bistatic radar. GNSS-R uses the existing navigation satellites which are in view as signal transmitters. Consequently, spaceborne GNSS-R receivers can provide global coverage and full temporal availability and generate simultaneous observations of the Earth's surface along multiple tracks within a wide area. Future GNSS-R satellite missions will generate an unprecedented level of spatial and temporal coverage [14,15]. It is expected that the number of GNSS-R missions, including constellations, will keep increasing in the near future.

At present, tracking water bodies remains a challenge for traditional remote sensing satellites because of the limited surface extent of these targets. Multi-spectral VisIR imagers aboard satellites such as Landsat and Sentinel-2 can generate high-resolution images, but they are affected by issues such as the similarity of spectral water and shadows index, reduced water index of small bodies because of the impact of land contamination, state of surface water etc. Moreover, optical data are limited by night, clouds and intervening biomass cover. On the other hand, C-band SAR images by Sentinel-1 in interferometric wide mode can generate high-resolution water masks independently of clouds and night conditions, but the images are also limited by the intervening vegetation because of the use of microwave signals at C-band. Finally, it is noteworthy that both types of sensors have a high revisit period, which limits their ability to resolve short term dynamics.

2. RONGOWAI GNSS-R MISSION

The Rongowai airborne mission [3] is a precursor of future GNSS-R satellite missions. Rongowai uses the next-generation GNSS-R receiver (NGRx) [16] with multi-constellation (GPS and Galileo), dual-band (L1, L5), and dual-polarization i.e. Right- and Left-Hand Circular Polarization (RHCP, LHCP) capabilities. Currently, the L1 mission data product [17,18] includes a variety of coherent

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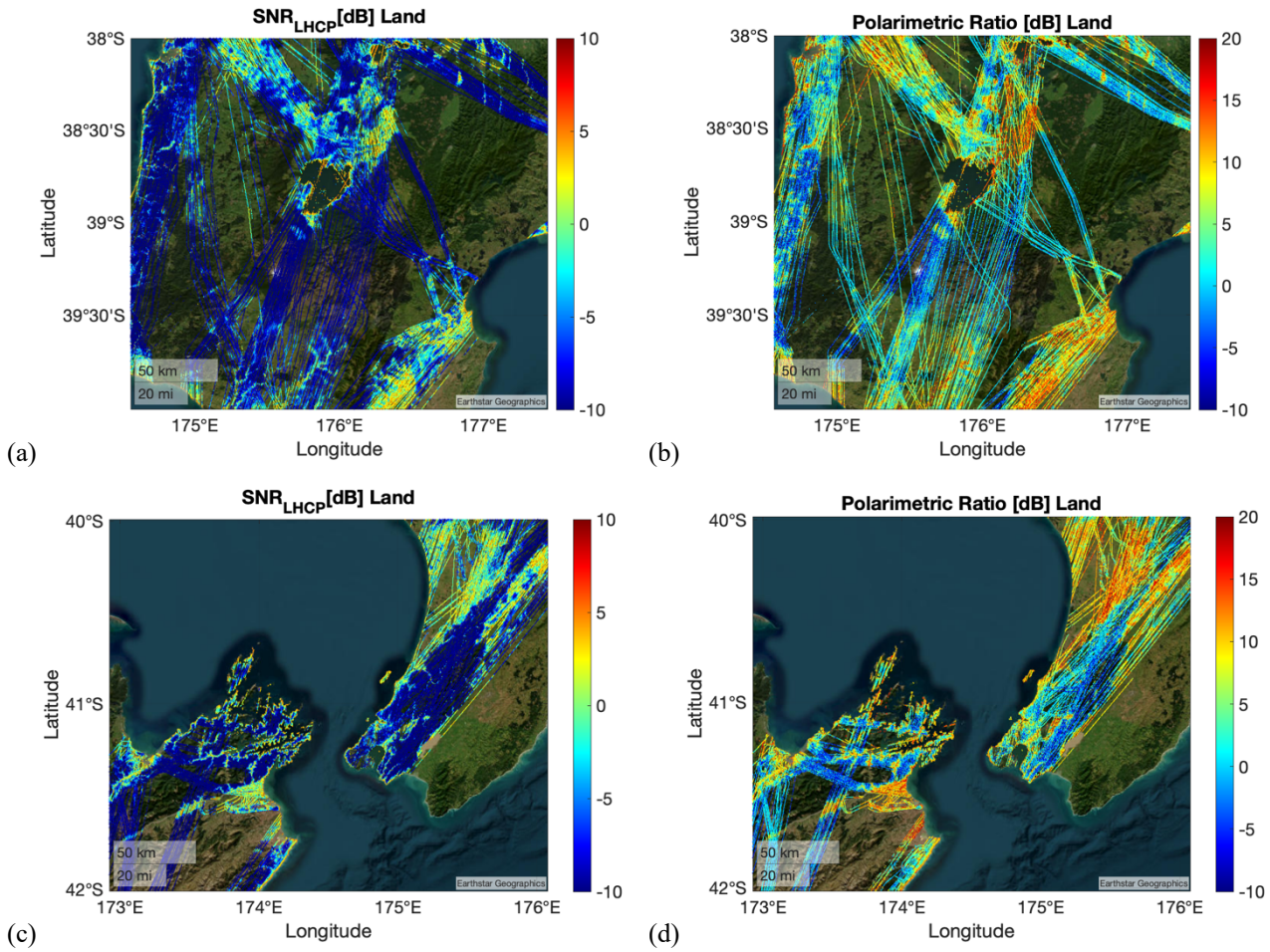


Fig. 1. Sample maps of (a,c) Left Hand Circular Polarization (LHCP) Signal-to-Noise-Ratio (SNR), and (b,d) Polarimetric Ratio (PR) [19] over land surfaces from Rongowai airborne GNSS-R mission.

integration times up to 8 ms, land & ocean observables, coherent detectors, and a wide variety of metadata. The geo-location of the nominal specular point over land surfaces has been carefully determined.

3. MOTIVATION AND GOALS

The main goal of this work is to improve inland water detection capabilities under dense biomass by adding polarimetric information [19-20] to a new CYGNSS retrieval algorithm [2]. Rongowai offers a unique scenario to develop new capabilities for inland water bodies detection. The GNSS-R spatial resolution in this airborne mission is significantly high, enabling to detect small water bodies. On the other hand, the use of RHCP information could help to remove surface roughness effects as well as the impact of the upwelling biomass. The Above Ground Biomass (AGB) variability is high over New Zealand, including regions with high canopy height. Additionally, the Rongowai mission team has installed a wide variety of ground truth sites, which are scheduled for validation of the new algorithm.

4. METHODOLOGY

This study is performed using a variety of observables, including the Signal-to-Noise-Ratio (SNR), the reflectivity Γ, and the Polarimetric Ratio (PR) [19]. The Polarimetric Ratio (PR) is sensitive to soil dielectric properties and can cancels roughness effects although it does not do so perfectly for arbitrary scattering media [19,20].

5. PRELIMINARY RESULTS

Preliminary results are depicted in Fig. 1. Two different target areas are selected over New Zealand. The Polarimetric Ratio (PR) shows a significant dynamic range. Important differences are observed from bare terrain to mountain terrain. Results are being analyzed with more detail, using auxiliary data. The initial interpretation could be that the GPS scattered signal is depolarized because of the effect of vegetation canopy and topography. On-going calibration activities [18] are being carried out, and analysis of the upcoming new data version will be performed. At present,

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there is a long time series i.e. October 2022 – Present. This enables the evaluation of the sensitivity of the observables to seasonal fluctuations of a variety of geophysical parameters, including Vegetation Water Content (VWC). This innovative airborne GNSS-R dataset is helpful for development of new retrieval algorithms for wetland mapping under dense biomass for upcoming polarimetric GNSS-R satellite missions.

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Acknowledgements

This research was supported in part by the NASA Science Mission Directorate contract 80LARC21DA003 with the University of Michigan.

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