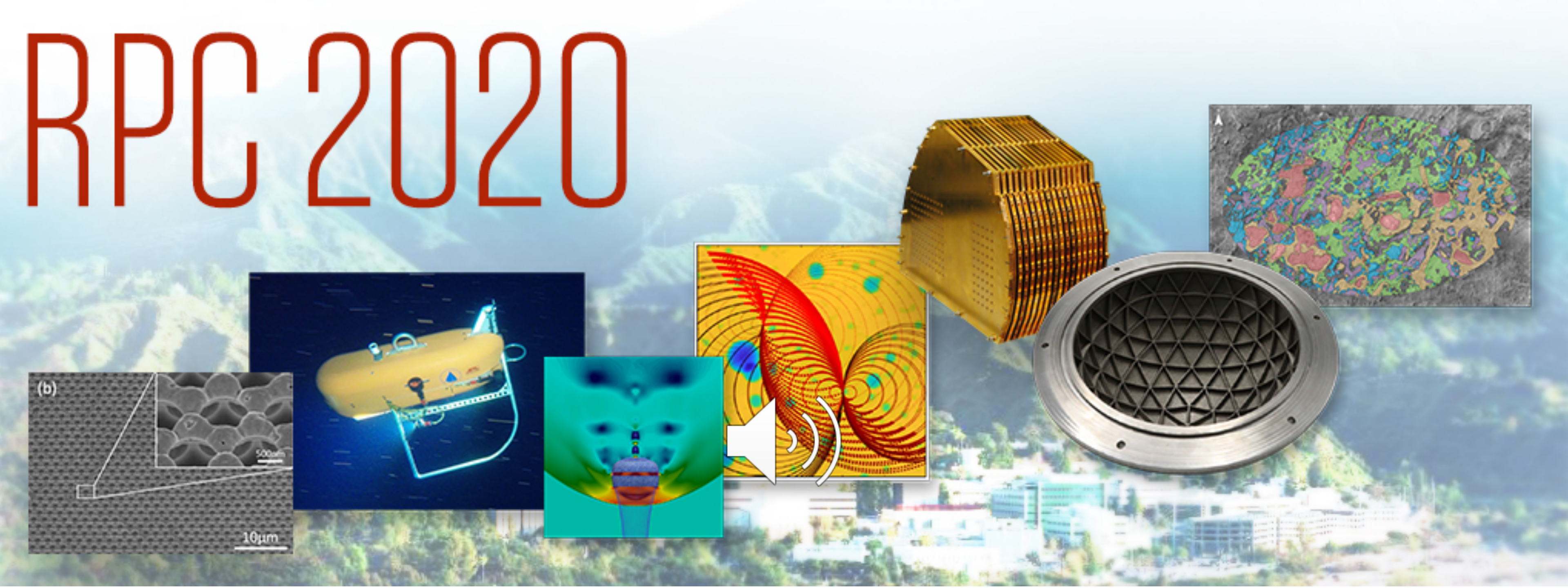


Virtual Research Presentation Conference

A new phase in GNSS-R: using coherent phase measurements to estimate surface parameters

Principal Investigator: Rashmi Shah (335A)
Co-Is: Y. Jade Morton and Ian Collett, University of Colorado Boulder
Program: SURP

Assigned Presentation # RPC-153

Jet Propulsion Laboratory
California Institute of Technology

Abstract

The objective of this task was to identify under which conditions a reflected signal from Global Navigation Satellite Signals (GNSS) reflectometry (GNSS-R) will be coherent enough for the carrier phase to be measurable over land. This was done by using carrier phase measurements that are obtained by open loop tracking of the raw intermediate frequency (IF) data occasionally collected by satellites in the CYGNSS constellation. The tracked carrier phase measurement is split up into chunks and used to compute a statistic called the circular length ($\bar{R}$), which quantifies the coherence. The level of coherence is compared to four different land characteristics (taken from ancillary datasets derived from other satellite measurements): topography, presence of surface water, soil moisture and vegetation water content. A major milestone in the project was the development of a software tool that can automatically visualize relationships between coherence and surface characteristics for a specified track. These visualizations also serve as an efficient means to identify particularly interesting reflection events for later, more detailed analysis. Such analysis can be easily done over other tracks using the tools that were developed under this task and provide a way to easily compare different tracking methods to optimize tracking of carrier phase for surface parameter retrievals.

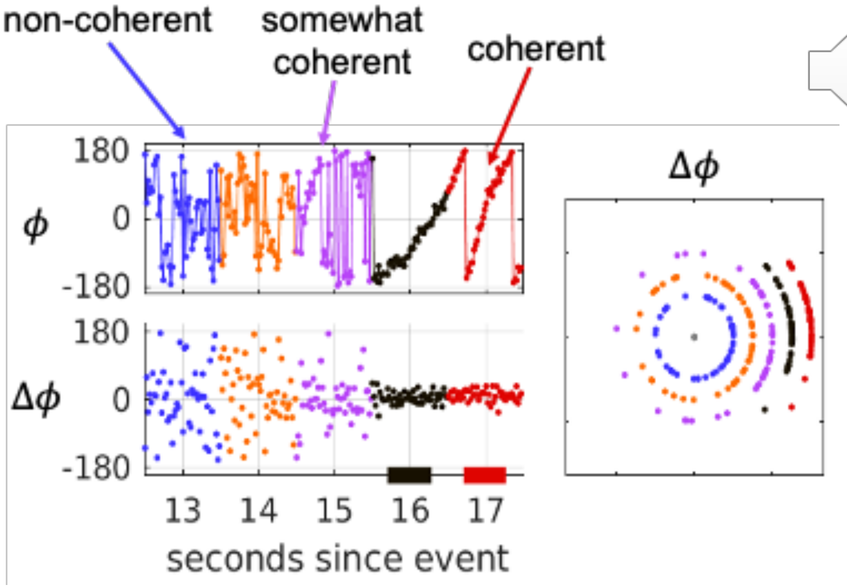
Problem Description

a) Coherent reflection in GNSS-R introduces new possibilities
   a) Higher spatial resolution
   b) High-precision applications using carrier phase (e.g., altimetry)
b) Method developed here is complementary to the other methods that have been developed to examine coherent in GNSS-R signature
c) GNSS-R techniques developed here can be extended to other Signals of Opportunity
d) A new collaboration between JPL SoOp community and the CU team was established because of this effort
e) Tools developed here would enhance JPL's capability to develop a SoOp missions for Earth Venture Program.

Methodology

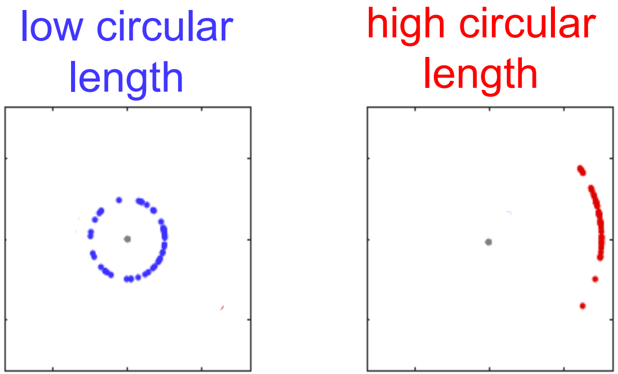
a) Using tracked carrier phase (ϕ) of the reflected GPS signal, coherence is quantified via the circular length of $\Delta\phi$ over a one second interval.

b) This method is complementary to other coherence detectors that have been developed for CYGNSS raw IF data.

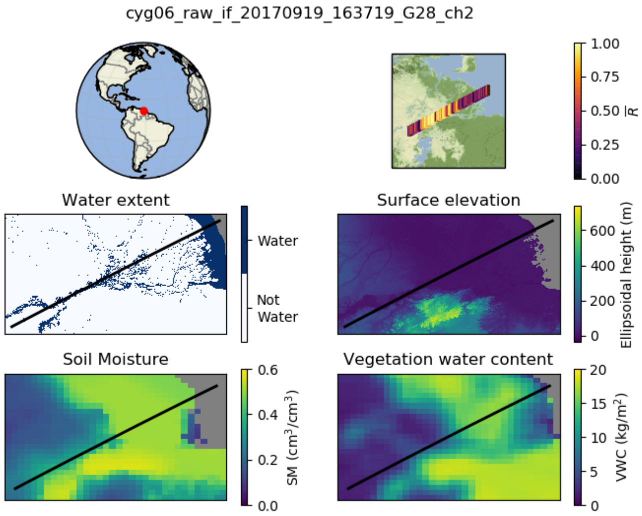


Circular length ($\bar{R}$):

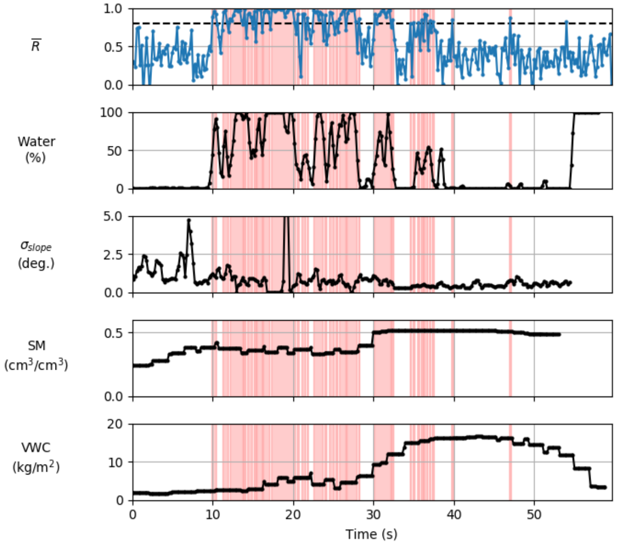
mean resultant length of unit vectors corresponding to $\Delta\phi$ values



Results

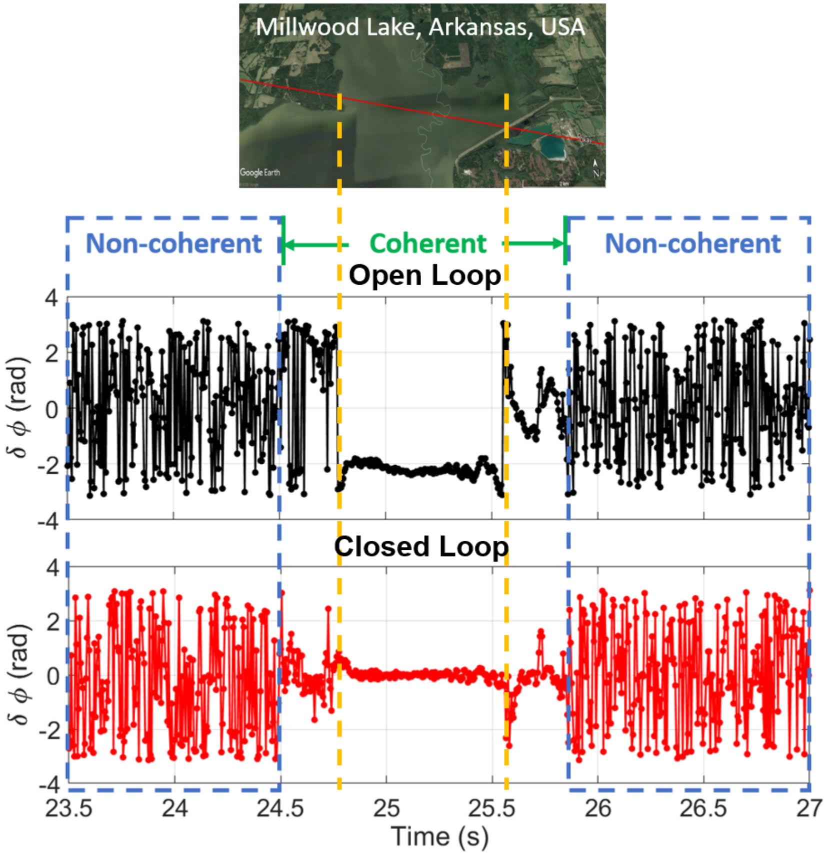


The overview plot to examine a dataset indicates the location of the track, the coherence along the track, and gives a sense of the surrounding terrain



The results plot allows a direct comparison of the coherence to the surface characteristics along the specular point track.

Results



Developed tool provide an efficient means to identify particularly interesting reflection events for later, more detailed analysis.

- Comparison of open loop and closed loop phase output for Millwood Lake reflection event.
- Can easily compare different processing methods like open-loop tracking and closed-loop tracking

Publications and References

PUBLICATIONS

A. I. Collett, Y. Wang, R. Shah, C. Roesler, Y. J. Morton, “GPS Signal Land Reflection Coherence Dependence on Water Extent and Surface Topography Using CYGNSS Measurements” IGARSS 2020- IEEE Geoscience and Remote Sensing Symposium Proceeding.

REFERENCES

1. Roesler, C., Wang, Y., Morton, Y., & Nerem, S. “ Coherent GPS reflections over ocean surface,” In IGARSS 2020-2020 IEEE International Geoscience and Remote Sensing Symposium. IEEE. 2020
2. Wang, Y., & Morton, Y. J. “Coherent reflections using closed-loop PLL Processing of CYGNSS IF data,” In IGARSS 2019-2019 IEEE International Geoscience and Remote Sensing Symposium (pp. 8737-8740). IEEE. July 2019. doi:10.1109/IGARSS.2019.8900046
3. Yang, R., Xu, D., & Morton, Y. “An improved Adaptive Multi-Frequency GPS carrier tracking algorithm for navigation in challenging environments,” In 2018 IEEE/ION Position, Location and Navigation Symposium (PLANS) (pp. 899-907). IEEE. April, 2018. doi:10.1109/PLANS.2018.8373468