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LATPROP Radar Modifications for CLASI Experiment

DeGrafth A. Palmore(1), Caglar YARDIM(1)
(1) The Ohio State University, Columbus, OH, 43210

Abstract

This paper describes the modifications made to a commercially available marine radar and how it was retrofitted to measure Refractivity-from-Clutter (RFC) from the sea surface in order to better understand atmospheric refractivity profiles. A Koden MDS63R marine radar was updated with a horizontal and vertically polarized 3 meter dish antenna that has a 48 dB gain, two options for PRF and pulse width, both long and short, the ability to discretely step in both azimuth and elevation to study 2-D spatial mapping and grazing angle respectively and the capability to preform Coherent-on-Receive (CoR) integration.

1 Introduction

When electromagnetic signals propagate through the troposphere, a phenomena can occur that causes the signal to be trapped between a layer of the atmosphere and the sea surface. This event is called ducting and it is caused by small changes in the environment. Ducting can cause ground based radars to extend their maximum range, increase sea surface clutter and create errors in target detection. There are multiple ways of measuring these fluctuations, each having their own respective advantages and disadvantages and one of those methods is called Refractivity-from-Clutter (RFC) which will be the main discussion of this paper.

Lower Atmospheric Propagation Radar (LATPROP) is a RFC-Capable, Coherent-on-Receive (CoR) modified marine radar that will be deployed in June of 2021 at Moss Landing Marine Laboratories (MLML) in California as part of the Coastal Land-Air-Sea Interaction (CLASI) experiment with having the goal of understanding this complicated phenomena from both an atmospheric and oceanographic perspective. CLASI is a multi-university effort using radar, UAVs and buoys to better understand coastal boundary processes with the result being to improve parameterization of the coastal ducting conditions close to the shoreline and to enhance the modeling of the electromagnetic ducting phenomena.

2 Duct Formation in Troposphere

The troposphere is an inhomogeneous medium with the index of refraction changing on a parts-per-million basis ranging from 1.000250 to 1.000400. Refraction is affected by the changes in meteorological parameters such as humidity, pressure and temperature.

$$N(h,T,P) = \frac{77.6P}{T} + \frac{3.73\times 10^5 e_s}{T^2} \tag{1}$$

Where h is humidity, P is pressure, T is temperature, N is Refractivity. z is height relative to earth's surface and e_s denotes partial pressure of water vapor in witch humidity is a function of. Modified refractivity, refractivity accounting for earth's curvature, can be given as:

$$M(N,z) = N + 0.157z \tag{2}$$

There are a few ways that refractivity can affect electromagnetic propagation but this paper will only mention when trapping of the signal occurs and that is when the change of modified refractivity with respect to height becomes negative. When this transpires, the signal will interact with the sea causing some of the signal to back scatter to the radar, thus allowing the opportunity to study the condition present[1].

3 Radar Design

LATPROP is a software-defined radar capable of transmitting multiple pulse widths with a peak power of 25 kW at a frequency of 9.41 GHz. It is adapted to use a 48 dB high gain antenna that can transmit and receive both horizontal and vertical polarization. As shown by W. J. Plant, vertical polarization usually has a higher gain in reference to the sea surface parameters compared to horizontal polarization [3] but utilizing both polarizations could allow for a deeper understanding of the sea surface and ducting conditions even if horizontal polarization would have decreased returns. The Radar is also equipped with a rotator that can discretely step in both azimuth and elevation with a tenth of a degree of accuracy. This will not only allow the radar to accurately keep track of the grazing angle, but also allow us to scan in azimuth and create 2-D range diagrams.

The system has a high speed ADC, capable to of sampling at 100 MHz, along with a specialized IF front end for processing. This radar is capable of transmitting both a 1.67 μs

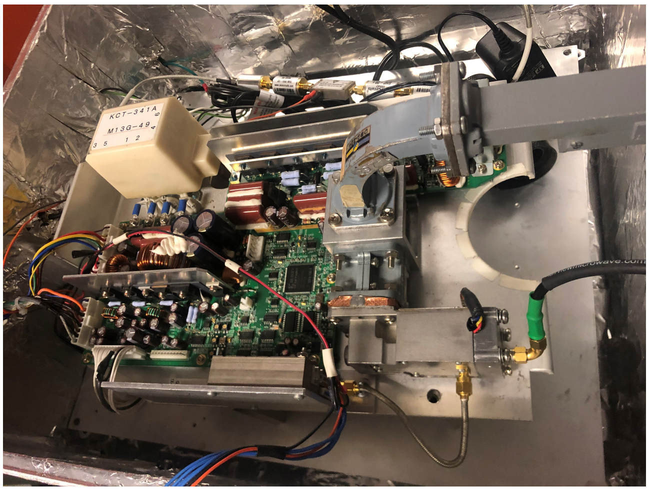

Figure 1. LATPROP Radar Modifications.

long pulse, low PRF of 400 Hz, for long range bins and an increased maximum range and a 0.08 μs narrow pulse, high PRF of 2000 Hz, for shorter range bins and a decrease in maximum range. The larger range bins are better suited for RFC inversion but the higher resolution of the shorter pulse will be able to detect rapid clutter fluctuations which could provide an interesting data set. With the added ability of transmitting two distinct pulse widths, two different IF front end must exist as shown in figure 2.

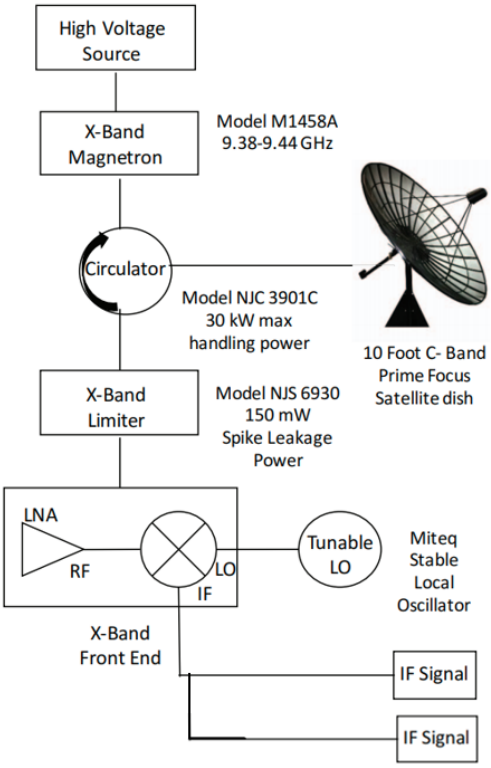

Figure 2. LATPROP Radar Block Diagram.

Lastly, LATPROP is a CoR radar, the circulator has a 25 dB of isolation between the transmitted signal and the received signal which means that transmitted pulse is leaked through on the received signal. The plan to use this leaked through pulse for coherent integration.

The length of the CLASI experiment for the first deployment of the LATPROP radar will be between May 2021 and October 2021 at Moss Landing Marine Labs in Moss Landing, California. There will be concurrent measurements taking place, both meteorological and air-sea. The site us labled in Figure 3 denoted by the white push pin. The radar will be facing the ocean in the west direction. One of the goals in the experiment is to take data pseudo-continuously and partially process the data in real-time because of limits in the storage capacity.

Figure 3. Moss Landing Marine Labs in Moss Landing, CA, showing the location where the LATPROP radar will be placed for the entirety of the CLASI Experiment.

4 Conclusion

With the updates made to the LATPROP radar for the CLASI experiment, the dataset should be robust. The upgrades will allow for the data set to have dual polarization and dual pulse width transmission, azimuth and elevation tracking for 2 D spatial diagrams and grazing angle selection and coherent integration. With the deployment of the radar being 6 month, the data should conclusive enough to result in a better model of electromagnetic ducts.

5 Acknowledgements

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References

[1] J. Compaleo et al. (2018). “Preliminary refractivity from clutter (RFC) evaporation duct inversion results from CASPER west experiment," *2018 IEEE Radar Conference (RadarConf18)*,pp. 1516-1521.

[2] J. Compaleco et al.(2018)., “CASPER West Evaporation Duct Height Inversion Using LATPROP-Radar," *2018 IEEE International Symposium on Antennas and*

Propagation and USNC/URSI National Radio Science Meeting , pp. 881-882.

[3] Plant, W. J., Keller, W. C., Hayes, K., and Chatham, G. (2010) “Normalized radar cross section of the sea for backscatter: 1. Mean levels", *J. Geophys. Res.*.