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An HF Beacon Network in Peru for Ionospheric Specification

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We describe a multistatic HF beacon network which has been deployed in Peru to help specify the ionosphere in the region surrounding the Jicamarca Radio Observatory. The purpose of the network is to provide a regional specification of electron density to supplement ionospheric measurements made directly over the radar. Data from the network are contributing to efforts both to understand and to forecast ionospheric instability and the formation of plasma density irregularities associated with equatorial spread *F* (ESF).

The beacons operate continually at two frequencies in the lower HF band. The network is currently comprised of three transmitting stations and six receiving stations. Dipole antennas are used for transmission and reception. Two of the receive stations have two sets of antennas which are displaced in spaced and oriented at right angles. Data from these stations can be used for interferometry or for polarimetry. A map of the network is shown in Fig. 1.

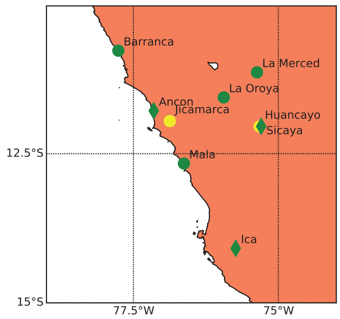

Figure 1. Locations of the beacon stations in the network. Diamonds represent transmitters, and circles receivers. Yellow circles designate stations with multiple receivers which can be used for interferometry or polarimetry.

Transmit and receive stations utilize USRP devices together with compact amplifiers. The HF signals are CW but incorporate pseudorandom noise codes (PRN) with a baud width of $10\mu s$ and a cycle length of 10,000 chips. The observables for each of the 36 ray paths available include amplitude, Doppler shift, and pseudorange. The experimental cadence is once per minute.

We model the regional ionosphere in using 900 coefficients on a grid which specifies a four-parameter Chapman function at different locations. Cubic B-spline interpolation is used to specify the electron density everywhere in a regional volume. The coefficients are set in a process involving three steps or loops. In the innermost loop, rays linking each transmit and receive station at each frequency are calculated by integrating Hamilton's equations via the principle of geometric optics. Shooting is used in the next loop to estimate the amplitude, pseudorange, and Doppler shift of each ray. In the outer loop, the model coefficients are adjusted to optimize the congruence between the measured and predicted observables. The process is repeated for each time step, with the results from the previous iteration used as the initial guess for the next.

Results for observing periods when ESF did and did not occur will be presented. For additional details, see [1].

References

[1] D. L. Hysell, M. A. Milla, and K. Kuyeng, "Radio beacon and radar assessment and forecasting of equatorial *F* region ionospheric stability," *J. Geophys. Res.*, **124**, pp. 9511-9524, http://doi.org/10.1029/2019HA026991.