GPS MULTIPATH REFLECTOMETRY: REVIEW AND FIRST APPLICATIONS IN BRAZIL

FELIPE GEREMIA NIEVINSKI (1)
JOÃO FRANCISCO GALERA MONICO (2)

Universidade Estadual Paulista "Júlio de Mesquita Filho"
Faculdade de Ciência e Tecnologia
Departamento de Cartografia, Presidente Prudente - SP
fgnievinski@gmail.com, galera@fct.unesp.br

The goal with this contribution is to review the technique of GPS multipath reflectometry (GPS-MR) and present its first results in Brazil. In GPS multipath reception, the least-time or shortest-distance signal is said to travel along the direct path, normally associated with the line-of-sight, close to the straight-line joining satellite and receiver. The remaining signals arrive delayed after being scattered by an intervening medium. Scattering can originate in the atmosphere (neutral or ionized particles and layers), electronic components (loading mismatch), antenna installation (satellite body or ground monument), the natural Earth (land, water, vegetation, etc.), or in the built environment. The receiving platform can be deployed at various altitudes, from near-surface (few meters tall) to elevated (towers, cliffs), all the way up to low-Earth orbit. Here we focus on GPS multipath involving reflections off large natural surfaces and recorded with near-surface receivers. Although multipath is detrimental for GPS positioning applications, its benefits for environmental monitoring purposes have become increasingly clear in the last decade. More specifically, the frequencies and amplitudes of the multipath modulation observed in GPS data show strong correlations with environmental characteristics such as soil moisture, snow depth, and vegetation growth. So, while a geodesist uses a multipath-suppressing antenna installed upright, someone more interested in remote sensing would prefer to tip the antenna such that its boresight faces the Earth. Here we further concentrate on data collected at GPS base stations, using commercial off-the-shelf stand-alone receivers and geodetic-quality antennas in conventional zenith-looking installations. Although this type of instrumentation is not ideal for reflectometry, it has been demonstrated feasible and adequate in the past. The advantage of such a selection is that it enables us to leverage the existing continuously-operating GPS infrastructure – dozens of ground-based receivers in Brazil and 30+ L-band spaceborne transmitters – deployed and maintained at no additional cost. As the future of the GPS constellation – and similar GNSS from other nations – is secure, there are good prospects for 120 satellites in 10 years. Moreover, the tendency is for the number of publicly accessible receivers to increase. Among the commonly recorded GPS observables – code pseudorange, carrier phase, and signal-to-noise ratio (SNR) – only the ranging observables are routinely used for position determination. In contrast, SNR is the primary observable for GPS-MR. As a transmitting satellite rises on the horizon and eventually reaches culmination near zenith, SNR observations exhibit a trend following from the antenna gain pattern. Superimposed on this trend there are interference fringes – peaks and troughs in power – as direct and coherently reflected signals go in and out of phase. Thus, when multipath is present, it tends to be the dominating feature in SNR. In contrast, ranging observables are contaminated by clock errors, atmospheric delays, etc., thus requiring more laborious processing. Sometimes, multiple receivers, antennas, or correlators are employed to aid in more specialized reflectometry modes, but the need for special-purpose hardware would prevent leveraging the existing GPS receiving infrastructure. In Brazil, two efforts are currently taking place in parallel: the analysis of existing sites, and the establishments of validated sites. On the one hand, there is the possibility that data from existing sites be suitable for GPS-MR purposes. The main requirement is visibility, both to the ground and to the sky, especially near grazing incidence. Unfortunately this excludes numerous urban sites and those near forested areas. A second effort is underway and seeks to establish sites with adequate visibility as well as in situ validation data. We are targeting at least one site for the monitoring of each soil moisture and water tides. These sites will be furnished with conventional contact soil probes and a tide gauge, respectively. Compromises are being necessary as new installations often demand a trade-off between visibility and security (against theft), data telemetry, power supply, etc. Preliminary results for the Brazilian sites will be presented.