Measuring Changes in Vegetation with Reflected GPS Signals

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We have developed a new technique to measure vegetation growth using reflected GPS signal (multipath) measurements from Plate Boundary Observatory (PBO) GPS sites. The sensing footprint is ~1000 m^2, larger than that provided by typical *in situ* observations but smaller than that of remote sensing satellites. Reflected GPS signals are mostly affected by the amount of water in the vegetation. This contrasts with the most frequently used remote-sensing data in vegetation studies (NDVI), that is based on greenness derived from optical measurements. We define a vegetation index, NMRI or Normalized Microwave Reflectance Index; it is based on multipath from GPS pseudorange data. It is normalized so that it is near zero when vegetation has low water content and increases as water content increases. The attached figure shows NMRI results for ~200 PBO sites. Vegetation water content peaks in the winter/early spring in southern California, late spring in Oregon, and mid-summer in Montana and Idaho. This is consistent with other studies of these ecosystems.

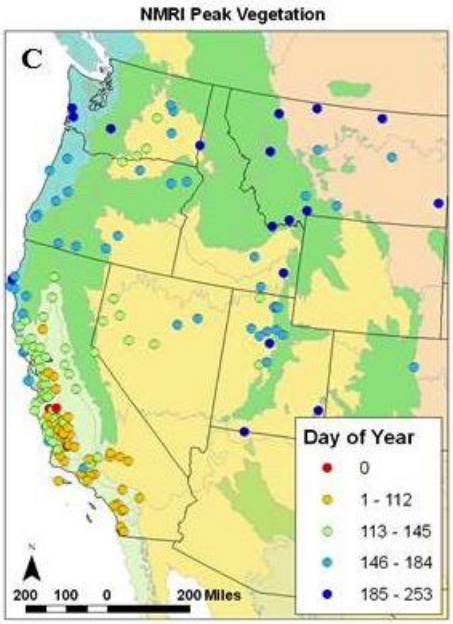

Figure 1: Peak vegetation day of year for various PBO sites throughout the western United States. Various climates are distinguished by color.

In addition to vegetation water content, reflected GPS signals are also impacted by snow and soil moisture. In order to get an accurate estimate of vegetation growth, the effects of snow and rain on the signal must be removed. We describe the algorithms we have developed to remove snow and rain effects in NMRI data. Our GPS vegetation results are available to the public at http://xenon.colorado.edu/portal. A section of the website is dedicated to secondary education and how to use the data in teaching about the science of climate and hydrological systems (http://xenon.colorado.edu/spotlight)