A Comparison of Refractivity Profiles at Radio Frequency and Infrared Wavelengths for Classic Atmospheric Boundary Layer Structures

Robert E. Marshall
Mount Pleasant Meteorology, Woodford, VA, USA

The vertical gradients of modified refractivity for radio frequency (RF) and infrared (IR) are derived in terms of the parcel conserved variables, potential temperature and water vapor mixing ratio. The derivations indicate two striking differences. For RF, the vertical gradient of modified refractivity decreases as water vapor mixing ratio decreases with height. For IR, the vertical gradient of modified refractivity increases as water vapor mixing ratio decreases with height. However, this is modified somewhat as the water vapor mixing ratio gradient term is two orders of magnitude lower at IR. It is also demonstrated that for a well mixed atmospheric boundary layer, the vertical gradient of modified refractivity is approximately 0.128 and 0.135 at RF and IR respectively. Thermally stable layers tend to reduce the vertical gradient of modified refractivity for both RF and IR wavelengths and the potential temperature gradient term is slightly less influential at IR compared to RF.

Strong near surface unstable layers with drier air aloft tend to produce sub-refraction at IR but produce normal refraction at RF. Entrainment layers with strong temperature inversions that produce surface based ducts at RF tend to produce super-refraction or even week elevated ducts at IR. Stable internal boundary layers with drier air aloft that result in surface ducts at RF typically produce weak super-refraction at IR. Stable internal boundary layers with moister air aloft that produce sub-refraction at RF tend to produce super-refraction or even surface ducts at IR.

Modified refractivity profiles at RF and IR are compared for notional marine boundary layer (MABL) profiles. Quantitative values of potential temperature and water vapor mixing ratio gradients required for creating non-normal refractivity structures in classical MABL thermodynamic profiles will be presented.