High-resolution three-dimensional thermodynamic fields are highly desired observations in mesoscale weather systems, but are some of the most difficult to obtain. Direct in situ measurements of pressure and temperature above the surface are limited to the paths of aircraft, radiosondes, and dropsondes. A new indirect retrieval approach, called SAMURAI-TR, has been developed that allows estimation of three-dimensional temperature and pressure perturbations in rapidly rotating vortices such as tropical cyclones using airborne radar observations. SAMURAI-TR has been applied to multi-Doppler data from the Hurricane Rainband and Intensity Change Experiment (RAINEX) field campaign to analyze the structure of the eyewall convection in Hurricane Rita (2005) on 23 September. The results of the RAINEX data analysis suggest that vertical wind shear results in asymmetries in both temperature and pressure that are consistent with the theoretical response of a tilted vortex. The axisymmetric, azimuthal wavenumber-0 structure is largely in gradient wind and hydrostatic balance, resulting in the large pressure drop and temperature increase toward the center. The wavenumber-1 structure is shown to be quasi-balanced, with primarily adiabatic vertical motion along distorted isentropes resulting from shear-induced kinematic and thermodynamic anomalies. Higher-order wavenumbers are associated with buoyant anomalies and unbalanced vertical motion in convective cells within the eyewall. These new insights into the observed structure of a sheared hurricane and the impact on intensity change will be discussed.