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# The UTLS ENSO signal from high resolution GPS radio occultation temperature profiles

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We investigate the vertical and spatial structure of the El Niño-Southern Oscillation (ENSO) signal in the troposphere and lower stratosphere using radio occultation (RO) temperature profiles. The unprecedented vertical resolution and global coverage of the RO data do not only provide a detailed view of the full three dimensional ENSO structure they also enable studying dynamical coupling between the troposphere and lower stratosphere. Due to the strong confounding effects of the Quasi Biennial Oscillation (QBO) and ENSO in the short RO record we only use RO data below 20 km.

In the equatorial region we find that interannual temperature anomalies show a natural decomposition into zonal-mean and eddy (deviations from the zonal-mean) components. Both components are related to ENSO. In the tropical troposphere zonal-mean temperature increases with height and reaches a maximum between 8 km and 12 km. Above the tropopause, the warm phase of ENSO is associated with stratospheric cooling. This zonal-mean response lags sea surface temperature anomalies in the eastern equatorial Pacific (N3.4 region) by 3 months. This lag can be attributed to exchange of fluxes at the atmosphere-ocean interface and the atmospheric energy loss to space and to mid-latitudes.

The eddy component, in contrast, responds rapidly (within 1 month) to ENSO forcing. The corresponding pattern features a dipole between the Indian and Pacific Oceans at low latitudes, with off-equatorial maxima centered around 20° to 30° latitude in both hemispheres. Maximum amplitude of this signal in the troposphere occurs near 11 km and (with opposite polarity) in a shallow layer near the tropopause at approximately 17 km. At mid latitudes, the eddy ENSO signal tends to be out-of-phase with those at low latitudes in both the troposphere and lower stratosphere. The fast eddy ENSO response as well as its spatial pattern are consistent with Rossby and Kelvin wave circulations induced by equatorial heating anomalies. Overall, this study underpins the high utility of GPS RO data for studying atmospheric dynamics in the troposphere and lower stratosphere.