Small-scale variability from the upper troposphere to the stratosphere: An overview of multi-year satellite observations from MLS, GPS, AIRS and AMSU

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Advanced spaceborne sensors have recently been used to map and study small-scale temperature perturbations induced by processes like gravity waves. Good instrument stability makes it possible to extract weak wave variances that are sometimes below the instrument noise. With adequate averaging, we find that stratospheric wave variances are often enhanced over orographic, convective, and jet instability sources when the background wind speed is strong. Such correlation with tropospheric sources and stratospheric background winds is consistent and annually-repeatable among observations obtained by different observing techniques (e.g., MLS, AMSU). The superior horizontal resolution of AIRS and AMSU instruments can even associate stratospheric variances with orographic sources as small as islands. In addition to the global and twice-daily coverage, some limb and nadir viewing sensors can distinguish between waves propagating in opposite directions (e.g., south-north) with their unique sampling geometry.

In the upper troposphere and lower stratosphere, most wave energy is associated with those of short (<10 km) vertical wavelengths. Thus, the most useful observations come from limb-viewing techniques. Studying MLS and GPS occultation data, we find that wave variances are mostly trapped in the tropics but widely spread over longitude with a broad horizontal wavenumber spectrum. Despite different techniques, both MLS and GPS observations reveal a varying latitudinal distribution of wave variances in concert with the quasi-biennial oscillation (QBO) phases. When the wind is westerly at 10 hPa, the wave variance shows a single peak near the equator at 22-25 km. When the wind is easterly, the wave variance exhibits a bimodal distribution with peaks near 25° latitude. At these altitudes, the observed wave variances are close to the upper-tropospheric sources and therefore influenced largely by the near-field solutions of wave excitation. As a result, the variances are found to be less correlated with the background winds than those in the stratosphere.