



**Figure 5.** Top: TVD calculated from  $\phi$  samples with white-noise as the reference. Bottom: TVD calculated from  $\phi$  samples with the MAP NCEP spectrum as the reference. Larger TVD values indicate higher discrepancy between spectral densities. Whiskers indicate the maximum and minimum values, boxes indicate 95% posterior intervals. Scenario or observational product indicated by colors. Left to right: Global, tropical, northern, and southern hemispheres.

changes in the historical runs; and 2) the combined effects of external forcing and any post-initialization drift in the decadal prediction simulations. Second, at the lowest frequencies, model spectral densities are higher than in NCEP-2 and ERA-I, and the 95% posterior intervals of nearly all of the simulated spectra do not overlap with the reanalysis spectra. This difference in the amplitude of simulated and observed variability (which is most pronounced in the tropics) is consistent with findings 5 obtained elsewhere for multi-model analyses of tropospheric temperature (Santer et al., 2018). A model bias in the opposite direction to that found here (i.e., a systematic underestimate of the amplitude of observed internal variability on multi-decadal timescales) would be more concerning – such an error would spuriously inflate signal-to-noise ratios for anthropogenic signal detection (Santer et al., 2018). We caution, however, the inference on “observed” estimates of internal variability on multi-decadal timescales is limited by the relatively short (30 years) time-period

10 Recall from Section 3.4 that the presence of complex roots points towards the existence of quasi-cyclical temperature variations. The results in the fifth row of Table 1 indicate that complex roots are only obtained consistently for the tropical domain. For all other domains, the characteristic polynomials from the AR models are dominated by real roots. This suggests that the tropics – which are strongly affected by the El Niño/Southern Oscillation – are capturing some quasi-periodic temperature variability associated with the occurrence of El Niños and La Niñas. Confirmation of this quasi-periodicity comes from the 15 fact that the tropics are also the only domain where the maximum moduli of the reciprocal complex roots of the polynomials exceed 0.8 for both reanalyses and for all three types of simulation (see results in sixth row of Table 1). The wavelengths for the