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Scale-dependent coherence of terrestrial species richness, topography, temperature and precipitation

Gareth G. Roberts and **Conor O'Malley**
Imperial College London, Department of Earth Science and Engineering, London, United Kingdom of Great Britain – England, Scotland, Wales (gareth.roberts@imperial.ac.uk)

Understanding origins of biodiversity likely requires explanation of how species richness and environment co-vary across the scales of interest, here 10-10,000 km (e.g. river reaches to latitudinal diversity gradients). We focus on quantifying scale and location dependent coherence between terrestrial vertebrate species (carnivorans, bats, songbirds, hummingbirds, amphibians) and topography, mean annual temperature, temperature range, and precipitation. We test the following three hypotheses by developing and applying wavelet spectral techniques. First, as in most geophysical systems, processes operating at long length scales generate most of the topographic and biotic signals observed. Second, scaling regimes can be identified from topographic and biological spatial series, e.g. transects through topographic or species richness, and they indicate that distinct physical regimes govern biodiversity at different scales. Finally, similarities and dissimilarities exist between topographic or biotic spatial series and environmental variables at a range of locations and scales. We examined latitudinal transects through the Americas, Africa, Australia, Asia and global averages. Species richness is shown to be highly coherent and anti-phase with elevation and temperature range, and in-phase with mean annual precipitation and temperature, at scales >1000 km. Coherence between carnivorans and temperature range is low across all scales, which suggest that their richness is insensitive to daily or seasonal changes in temperature. Amphibians, meanwhile, are highly correlated with temperature range at large scales. At scales <1000 km, all species examined, bar carnivorans, show highest richness in the tropics. Terrestrial plateaux are foci of high coherence between carnivorans and elevation at scales centred on 1000 km, which is consistent with the idea that tectonic processes can contribute to biodiversity. The results obtained by spectral analyses of terrestrial species richness and environmental variables highlight the scale-dependent sensitivities of mammals, birds and amphibians to global and local environmental changes.