COMPARATIVE HYPSOMETRIC ANALYSIS OF BOTH EARTH AND VENUS TOPOGRAPHIC DISTRIBUTIONS: P. Rosenblatt, P.C. Pinet, E. Thouvenot;
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Previous studies [1,2,3,4] have compared the global topographic distribution of both planets by means of differential hypsometric curves. For the purpose of comparison, the terrestrial oceanic load was removed [2,4] and a reference baselevel was required. It was chosen on the basis of geometric considerations and reflected the geometric shape of the mean dynamical equilibrium figure of the planetary surface in both cases. This reference level corresponds to the well-known sea level for the Earth; for Venus, given its slow rate of rotation, a sphere of radius close to the mean, median and modal values of the planetary radius distribution was considered and the radius value of 6051 km arbitrarily taken [1]. These studies were based on the low resolution (100x100 km2) coverage of Venus obtained by the Pioneer Venus altimeter [1] and on the 1°x1° terrestrial topography [3,5]. But, apart from revealing the distinct contrast existing between the Earth’s bimodal and the strong Venus’ unimodal topographic distribution, the choice of such a reference level is inadequate and even misleading for the comparative geophysical understanding of the planetary relief distribution.

The present work reinvestigates the comparison between Earth and Venus hypsometric distributions on the basis of the high-resolution data provided, on one hand, by the recent Magellan global topographic coverage of Venus’ surface [6], and on the other hand, by the detailed NCAR 5x5’ grid topographic database currently available for the Earth’s surface [7]. For both datasets, the spatial resolution is considered to be on the order of 10x10km2 with a vertical accuracy estimated around 50 to 100 m.

For the Earth, the oceanic bathymetry is unloaded from the water column weight. The study of the cumulative hypsometric curve for both planets reveals, as noted earlier, that there exists a domain of elevation for which the relationship between elevation and cumulative area percentage is linear. On Earth, it corresponds to the oceanic domain and is a consequence of the seafloor spreading process occurring on Earth. Under some conditions regarding the uniformity of seafloor spreading velocity and plate consumption by subduction with plate age [8], it is possible to use, on a global scale, cumulative area in place of plate age, and then to express the basic linear depth to square root of age relationship, arising from cooling boundary layer theory, in terms of depth to square root of cumulative area relationship, i.e. \( h = f(\sqrt{S}) \).

The cut-off thresholds, for which the hypsometric terrestrial distribution departs, in such a graph, from the linear trend, are -1950m and -3920m. Calculation of the mean depth of the whole system of mid-oceanic ridges, for the water unloaded topography, gives -1900m, with a standard deviation 470 m. Consequently, the upper threshold corresponds to the mid-oceanic ridge mean depth value while the lower one is related to the depth from which the seafloor is older than 80-90Ma [8]. For Venus, the upper threshold found is the planetary radius of 6052.8 km, the lower limit is 6051km, and the linear domain comprises around 80% of the mapped surface. The geophysical meaning of the topographic level of the mid-oceanic ridges depth, in terms of thermal lithospheric structure, is that it represents the planetary level at which the thermal lithospheric thickness tends towards zero. It is of interest to note that, in an attempt to account for the venusian relief in terms of thermal isostasy, a venusian planetary radius of 6053 km has been proposed,
under plausible geophysical assumptions, as a theoretical estimate of the surface elevation of the unbounded asthenosphere [9].

If on this ground, the upper threshold of the linear domain for the curves \( h=f(\sqrt{S}) \) is taken as a reference level for the Earth and Venus differential hypsometric curves, then one notes that the oceanic peak and the venusian peak of the distribution do coincide very closely. If, in addition, a correcting factor taking into account the different relative surface partitioning existing for the planetary topography distributed below and above the reference threshold is applied, then the hypsometric distributions (300m interval class) of a terrestrial ocean-like planetwide topography (T1) and a low elevation (below 6052.8 km) Venus-like planetwide topography (T2) are very similar both in terms of modal distribution and amplitude (see figure), the distance between the mean and modal values being about 100m and the peak symmetry rather pronounced, in both cases. This is somewhat at variance with the previous analyses [e.g., 9] based on a significant departure of the shape of these two peaks.