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Earth's Constant Mean Elevation: Implication for Long-Term Sea Level and Controlled by Ocean Lithosphere Dynamics in a Pitman World

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On a spherical Earth, the mean elevation (~-2440m) would be everywhere at a mean Earth radius from the center. This directly links an elevation at the surface to physical dimensions of the Earth, including surface area and volume that are at most very slowly evolving components of the Earth system. Earth's mean elevation thus provides a framework within which to consider changes in heights of Earth's solid surface as a function of time. In this paper the focus will be on long-term, non-glacially controlled sea level. Long-term sea level has long been argued to be largely controlled by changes in ocean basin volume related to changes in area-age distribution of oceanic lithosphere. As generally modeled by Pitman (1978) and subsequent workers, the age-depth relationship of oceanic lithosphere, including both the ridge depth and coefficients describing the age-depth relationship are assumed constant. This paper examines the consequences of adhering to these assumptions when placed within the larger framework of maintaining a constant mean radius of the Earth. Self-consistent estimates of long-term sea level height and changes in mean depth of the oceanic crust are derived from the assumption that the mean elevation and corresponding mean radius are unchanging aspects of Earth's shorter-term evolution. Within this context, changes in mean depth of the oceanic crust, corresponding with changes in mean age of the oceanic lithosphere, acting over the area of the oceanic crust represent a volume change that is required to be balanced by a compensating equal but opposite volume change under the area of the continental crust. Models of paleo-cumulative hypsometry derived from a starting glacial isostatic adjustment (GIA)-corrected ice-free hypsometry that conserve mean elevation provide a basis for understanding how these compensating changes impact global hypsometry and particularly estimates of global mean shoreline height. Paleo-shoreline height and areal extent of flooding can be defined as the height and corresponding cumulative area of the solid surface of the Earth at which the integral of area as a function of elevation, from the maximum depth upwards, equals the volume of ocean water filling it with respect to cumulative paleo-hypsometry. Present height of the paleo-shoreline is the height on the GIA-corrected cumulative hypsometry at an area equal to the areal extent of flooding. Paleogeographic estimates of global extent of ocean flooding from the Middle Jurassic to end Eocene, when combined with conservation of mean elevation and ocean water volume allow an explicit estimate of the paleo-height and present height of the paleo-shoreline. The best-fitting estimate of present height of the paleo-shoreline, equivalent to a long-term "eustatic" sea level curve, implies very modest (25±22m) changes in long-term sea level above the ice-free sea level height of ~+40m. These, in turn, imply quite limited changes in mean depth of the oceanic crust (15±11m), and mean age of the oceanic lithosphere (~62.1±2.4 my) since the Middle Jurassic.