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The gravitational signature of the 2004 Sumatra megathrust earthquake

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The M=9 Richter Sumatra 2004 earthquake provides the unique opportunity to study the gravitational signature at various wavelengths of a large thrust event. The 4.5 x 10exp(22) Nm seismic moment, distributed over a fault of 1000 km of length, dipping 11 deg NNE, is responsible for the vertical displacement of a huge amount of crust and is thus expected to have permanently modified the Earth gravity field. A spherical, self-gravitating, elastically stratified Earth model allows us to quantify the geoid changes and radial displacements at all wavelengths, from the harmonic degree 2, appropriate for dealing with rotation and oblateness changes of the planet, to degrees of 10 exp(2), for resolving the geoid changes due to co-seismic deformation and finally to degrees of 10 exp(4), for radial vertical displacement at high resolution. We obtain a region of uplift, characterized by an average value of about 4 m, along a stripe running through the whole length of the fault and overprinting the western part of the fault's projection at the Earth surface, representing the dominant feature of the radial displacement pattern, over a smaller amplitude subsidence, of about -2 m, in the eastern part. The uplifted region is overprinted by a positive geoid peak anomaly of 12 mm, while the subsided one by a negative anomaly of – 4 mm. The earthquake modified also the global shape of the Earth, such as its oblateness and rotation.