Core-mantle boundary deformations triggered by the Sumatra earthquake

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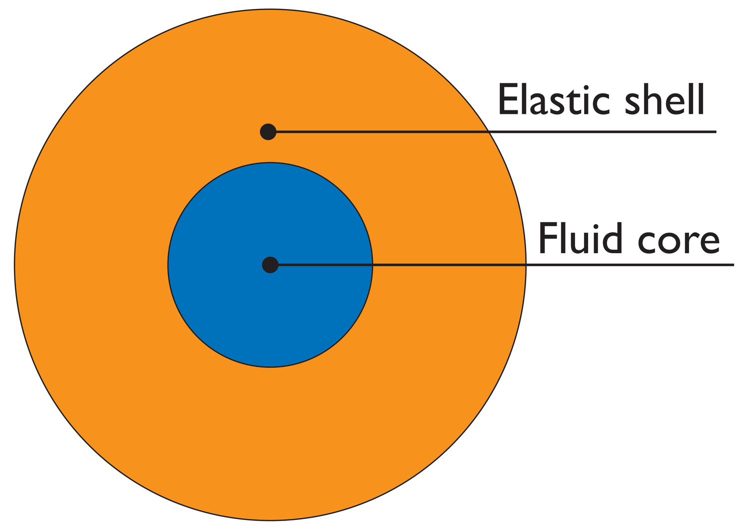
Background

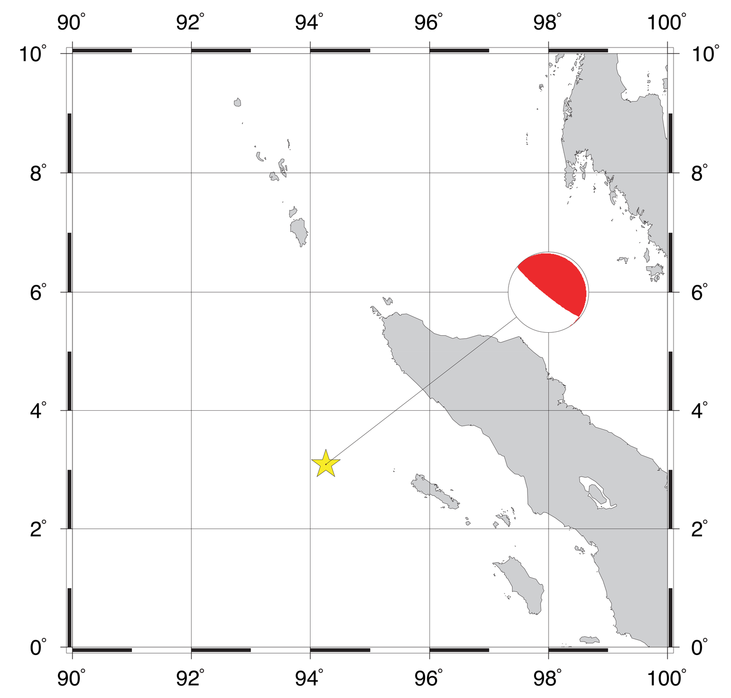
Abstract

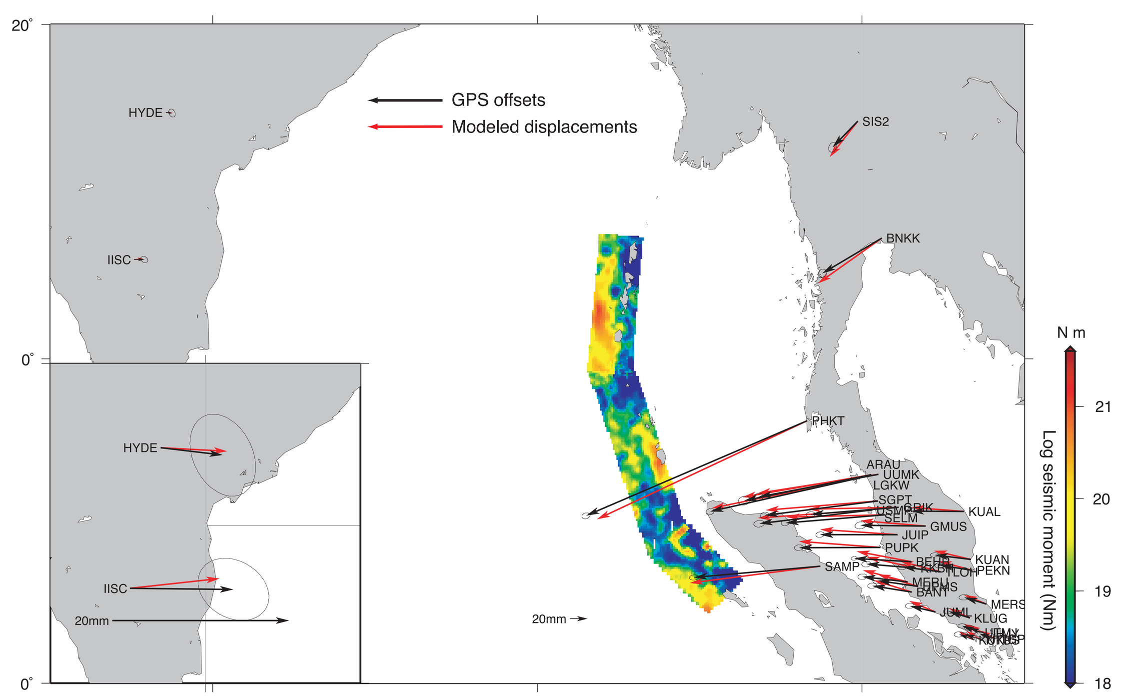
The devastating megathrust earthquake of December 26 2004 off the west coast of northern Sumatra has been probably the largest since the 1960 Chile event. The occurrence of this event revived the debate, among the scientific community, upon several open geophysical problems possibly connected with the energy release of giant earthquakes. One of these problems concerns the origin of geomagnetic jerks and its eventual relationship with large seismic activity. Though a final answer to this question seems not to be at hand presently, this answer (whatever positive or negative) appears to be connected with the possibility that giant seismic events could cause significant changes in the CMB topography. Until now, no attempts have been made to compute the impact of a seismic event on the CMB: the great Sumatra earthquake, for the first time, gave unambiguous instrumental evidence that the deformation field associated with a giant event is detectable at distances up to several thousands of km with a magnitude of the displacements of the order of 1 mm. Since perturbations to the CMB even smaller than this value are likely to be able to produce a geomagnetic jerk, a precise evaluation of the CMB topography perturbation associated with a giant earthquake like Sumatra has become an important scientific question.

Numerical modeling



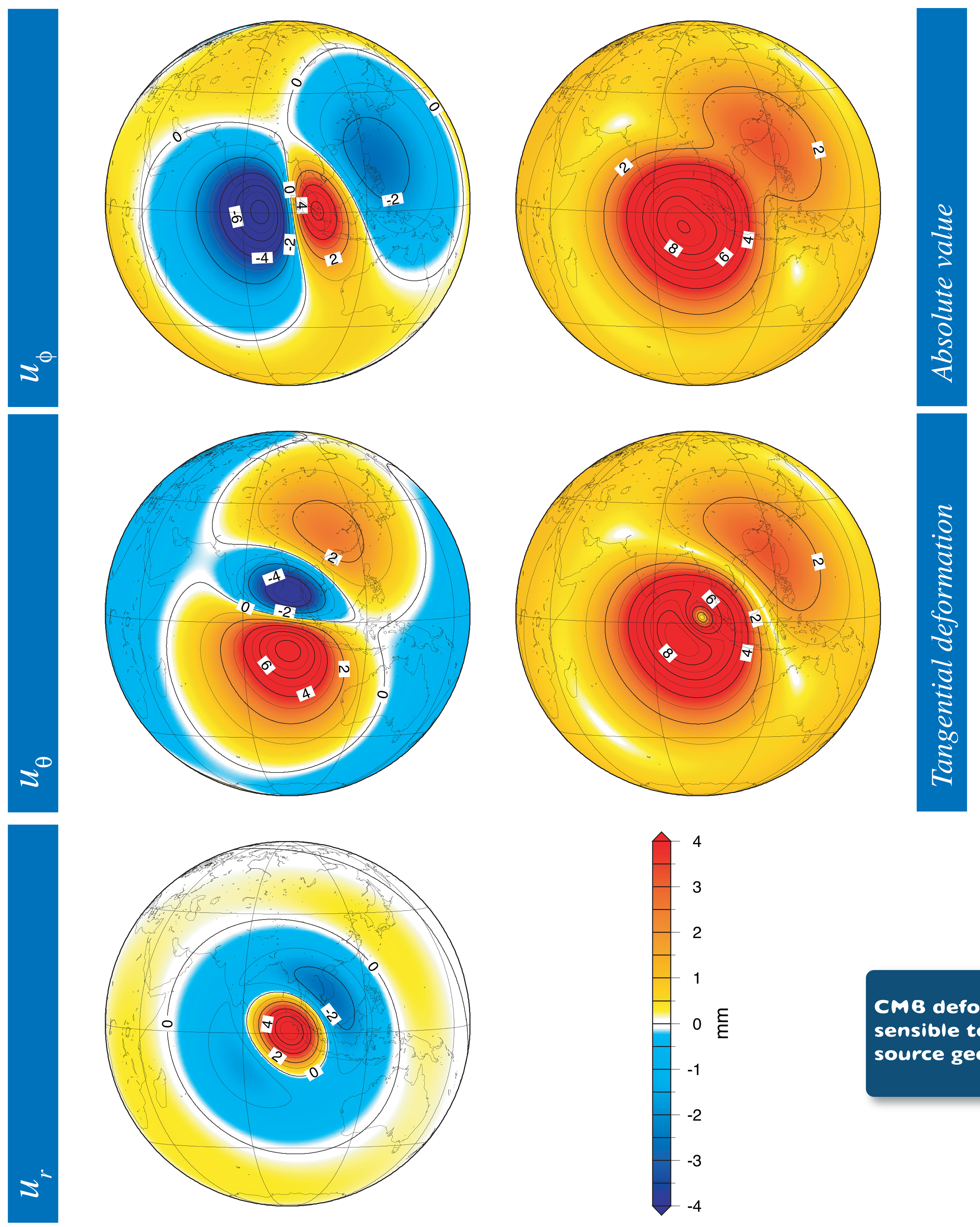
To evaluate CMB deformations due to a seismic source we used a suitably adapted version of the model by Piersanti et al. (1995), a spherical, layered, self-gravitating model. We simplified the model by keeping an homogeneous, elastic shell surrounding a fluid core with radius r_c = 3470 km. The elastic parameters have been computed by volume-averaging the PREM reference values.





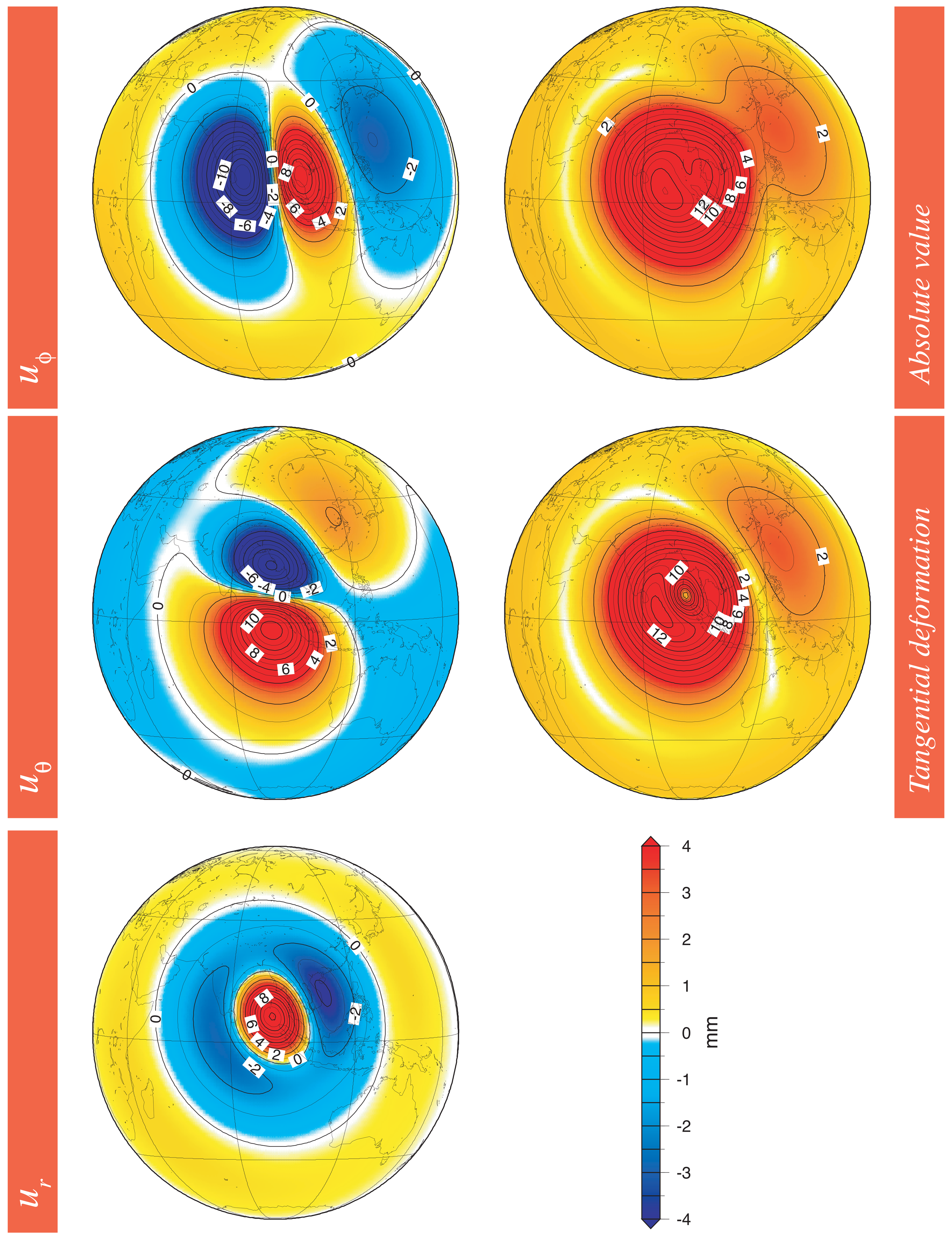
A first modeling attempt of the seismic source was done by using a point dislocation with the seismological parameters given by the Harvard CMT solution (left). A more refined modelization (right) was then performed by using a 2D distribution of seismic moment release obtained by fitting near-field GPS offsets (see Boschi et al., 2005 for details). Both sources are normalized to a seismic moment release corresponding to M_w=9.2.

Point dislocation modeling



CMB deformation is sensible to the seismic source geometry

2D seismic moment distribution



Though preliminary, these results evidence that the Sumatra earthquake caused significant deformation at the CMB, up to several millimeters. This does not allow us to exclude the possibility of a jerk originated by the Sumatra earthquake.

Further important elements to clarify this issue would come from a spectral analysis of the earthquake induced topography and from the use of a more refined layering (Banerjee et al. 2005).

References

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