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The Amplitude Phase Decomposition for the Magnetotelluric Impedance Tensor and Galvanic Electric Distortion

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The introduction of the phase tensor marked a major breakthrough in understanding of, analysing of and dealing with galvanic distortion of the electric field in the Magnetotelluric method. The phase tensor itself can be used for (distortion free) dimensionality analysis, if applicable distortion analysis and even to invert for subsurface models. However, impedance amplitude information is not stored in the phase tensor, therefore the impedance corrected by distortion analysis (or alternative remedies) may yield better results. We formulate an impedance tensor decomposition into the known phase tensor and an amplitude tensor that is shown to be complementary and independent of the phase tensor. The rotational invariant amplitude tensor contains galvanic and inductive amplitudes of which the latter are physically related to the inductive phase information present in the phase tensor. We show, that for the special cases of 1D and 2D subsurfaces, the geometric amplitude tensor parameter (strike and skew) converge to phase tensor parameter and the singular values are the amplitudes of the impedance in TE and TM mode. Further, the physical similarity between inductive phase and amplitude is used to approximate the galvanic amplitude for the general subsurface, which leads to the qualitative interpretation of 3D galvanic distortion: (i) the (purely) galvanic part of the subsurface (as sensed at a given period) may have a changing impact on the impedance (over a period range) and (ii) only the purely galvanic response of the lowest available period should be termed galvanic distortion. The approximation of the galvanic amplitude (and therewith galvanic distortion), though not accurate, offers a new perspective on galvanic distortion, which breaks with the general belief of the need to assume 1D or 2D regional structure for the impedance. The amplitude tensor itself is complementary to the phase tensor containing integrated (galvanic and inductive) subsurface information, it is illustrated and compared to the phase tensor on an example.