Modeling magnetotelluric tippers on a sphere with particular emphasis on ocean induction effect and effect from oceanic sediments

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Abstract

In the past three decades, an immense amount of long-period magnetic field data (with periods of measurements from months to years) has been collected worldwide, either inland or at sea bottom. This makes it tempting to estimate from the data magnetotelluric (MT) vertical transfer functions -tippers - and further probe with them the three-dimensional distribution of electrical conductivity on a global or semi-global/continental scale. Such problem setup requires modeling MT responses in spherical geometry. It is known that MT impedances in spherical coordinates can be modeled using different polarizations of a uniform external magnetic field. As for tippers, one needs another type of excitation because the uniform external magnetic field of any polarization contains a non-zero radial component. In the paper, we elaborate a model of the source, which leads to valid tippers on a whole sphere. We also present an accurate and computationally efficient solver to calculate the electromagnetic field and responses in a spherical shell or a part thereof. The solver, based on nested integral equations, was used to calculate high-resolution tippers regionally and globally, taking into account realistic oceans and Earth's conductivity. In particular, we investigate an effect in tippers from bathymetry and oceanic sediments, both at the Earth's surface and sea bottom sediments.

Full Text

Due to technical limitations, full-text HTML conversion of this manuscript could not be completed. However, the latest manuscript can be downloaded and [accessed as a PDF](#).

Figures

Figure 1

please see manuscript .pdf for figure caption

Figure 2

Bathymetry of the World Ocean, in m. Note: The designations employed and the presentation of the material on this map do not imply the expression of any opinion whatsoever on the part of Research Square concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. This map has been provided by the authors.

Figure 3

hickness of the oceanic sediments, in m. Note: The designations employed and the presentation of the material on this map do not imply the expression of any opinion whatsoever on the part of Research Square concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. This map has been provided by the authors.

Figure 4

The (absolute) difference between “Cartesian” and “spherical” tippers at periods 20 min, 1 hour and 3 hours. Results are shown at sea level.

Figure 5

The (absolute) difference between “spherical” tippers computed using 1-D (with the superscript reg) and non-1-D (with the superscript glo) environment at periods 20 min, 1 hour and 3 hours. Results are shown at sea level inland and sea bottom – offshore.

Figure 6

Real (top) and imaginary (middle) parts of W_{xz} at period of 20 min. Tippers are computed in the model, which does not incorporate oceanic sediments. Bottom: (absolute) difference between W_{xz} computed in the models with and without oceanic sediments. Results are shown at sea level inland and sea bottom – offshore. Note: The designations employed and the presentation of the material on this map do not imply the expression of any opinion whatsoever on the part of Research Square concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. This map has been provided by the authors.

Figure 7

Real (top) and imaginary (middle) parts of W_{zy} at period of 20 min. Tippers are computed in the model, which does not incorporate oceanic sediments. Bottom: (absolute) difference between W_{zy} computed in the models with and without oceanic sediments. Results are shown at sea level inland and sea bottom – offshore. Note: The designations employed and the presentation of the material on this map do not imply the expression of any opinion whatsoever on the part of Research Square concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. This map has been provided by the authors.

Figure 8

Real (top) and imaginary (middle) parts of W_{zx} at period of 1 hour. Tippers are computed in the model, which does not incorporate oceanic sediments. Bottom: (absolute) difference between W_{zx} computed in the models with and without oceanic sediments. Results are shown at sea level inland and sea bottom – offshore. Note: The designations employed and the presentation of the material on this map do not imply the expression of any opinion whatsoever on the part of Research Square concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. This map has been provided by the authors.

Figure 9

Real (top) and imaginary (middle) parts of W_{zy} at period of 1 hour. Tippers are computed in the model, which does not incorporate oceanic sediments. Bottom: (absolute) difference between W_{zy} computed in the models with and without oceanic sediments. Results are shown at sea level inland and sea bottom – offshore. Note: The designations employed and the presentation of the material on this map do not imply the expression of any opinion whatsoever on the part of Research Square concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. This map has been provided by the authors.

Figure 10

Real (top) and imaginary (middle) parts of W_{zx} at period of 3 hours. Tippers are computed in the model, which does not incorporate oceanic sediments. Bottom: (absolute) difference between W_{zx} computed in the models with and without oceanic sediments. Results are shown at sea level inland and sea bottom – offshore. Note: The designations employed and the presentation of the material on this map do not imply the expression of any opinion whatsoever on the part of Research Square concerning the legal status of

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Figure 11

Real (top) and imaginary (middle) parts of W_{zy} at period of 3 hours. Tippers are computed in the model, which does not incorporate oceanic sediments. Bottom: (absolute) difference between W_{zy} computed in the models with and without oceanic sediments. Results are shown at sea level inland and sea bottom –

offshore. Note: The designations employed and the presentation of the material on this map do not imply the expression of any opinion whatsoever on the part of Research Square concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. This map has been provided by the authors.

Figure 12

Real (top) and imaginary (middle) parts of W_{zx} at period of 20 min. Tippers are computed in the model, which does not incorporate oceanic sediments. Bottom: (absolute) difference between W_{zx} computed in the models with and without oceanic sediments. Results are shown at sea level. Note: The designations employed and the presentation of the material on this map do not imply the expression of any opinion whatsoever on the part of Research Square concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. This map has been provided by the authors.

Figure 13

Real (top) and imaginary (middle) parts of W_{zy} at period of 20 min. Tippers are computed in the model, which does not incorporate oceanic sediments. Bottom: (absolute) difference between W_{zy} computed in the models with and without oceanic sediments. Results are shown at sea level. Note: The designations employed and the presentation of the material on this map do not imply the expression of any opinion whatsoever on the part of Research Square concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. This map has been provided by the authors.

Figure 14

Real (top) and imaginary (middle) parts of W_{zx} at period of 1 hour. Tippers are computed in the model, which does not incorporate oceanic sediments. Bottom: (absolute) difference between W_{zx} computed in the models with and without oceanic sediments. Results are shown at sea level. Note: The designations employed and the presentation of the material on this map do not imply the expression of any opinion whatsoever on the part of Research Square concerning the legal status of any country, territory, city or

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Figure 15

Real (top) and imaginary (middle) parts of W_{zy} at period of 1 hour. Tippers are computed in the model, which does not incorporate oceanic sediments. Bottom: (absolute) difference between W_{zy} computed in the models with and without oceanic sediments. Results are shown at sea level. Note: The designations

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Figure 16

Real (top) and imaginary (middle) parts of W_{zx} at period of 3 hours. Tippers are computed in the model, which does not incorporate oceanic sediments. Bottom: (absolute) difference between W_{zx} computed in the models with and without oceanic sediments. Results are shown at sea level. Note: The designations employed and the presentation of the material on this map do not imply the expression of any opinion whatsoever on the part of Research Square concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. This map has been provided by the authors.

Figure 17

Real (top) and imaginary (middle) parts of Wzy at period of 3 hours. Tippers are computed in the model, which does not incorporate oceanic sediments. Bottom: (absolute) difference between Wzy computed in the models with and without oceanic sediments. Results are shown at sea level. Note: The designations employed and the presentation of the material on this map do not imply the expression of any opinion whatsoever on the part of Research Square concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. This map has been provided by the authors.

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