Electromagnetic Geophysical Fields

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Precursors to Earthquakes and Tsunamis; Impacts on the Brain and Heart

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The authors dedicate this book to
B. G. Novik (who died at the front in World War II in 1944),
L. I. Babenko (1930–1990),
P. S. Volgin,
and I. B. Mikhaylovskaya (1939–2007).

Preface

In the twenty-first century, hundreds of thousands of people have been killed by the tremendous energy released from deformations of the oceanic or continental lithosphere, i.e., earthquakes (EQs), whose seismic source originated beneath the ocean or land.

This has always been the case, but now the vulnerability of technology to these seismic processes is critically dangerous. The seismic disruption of the Fukushima I nuclear power plant resulted in radioactive pollution of large areas of sea and land, with deaths and injuries in the populace.

It is a sign that nuclear power plants are hardly able to replace the limited or depleted traditional sources of energy (gas, oil, hydroelectric energy, geothermal resources, etc.) without effective geological, geophysical, and geochemical prognostic science and, as a result, the stable prediction of land and marine EQs needed to shut down a nuclear plant before such a geodynamic event occurs.

The dynamics of the exterior geospheres—namely the solar-induced perturbations of the magnetosphere and the ionosphere, and the resulting electromagnetic (EM) fields (geomagnetic storms)—may disrupt the operation of power networks, air and ground transportation, and navigation, and may accelerate deterioration of pipelines, etc. The electrical system of human brains is also exposed to these fields, including the brains of those humans who control sophisticated technologies with severe consequences for any control error.

In this book, we consider theoretical questions of field interaction physics, including EQ precursors, and we also present the results of measurements of the influence of specific interactions, namely geomagnetic storms, on the EM processes of the human brain and heart. Mathematical problems of the theory of interaction of geophysical fields of different physical natures in land and marine EQ preparation processes (*precursory physics*) may not be considered in the frame of the classical initial boundary value problem formulation. Indeed, all geophysical fields are disturbed during the preparation processes because of the release of large portions of the energy of deformation and the impossibility of a purely mechanical process in the nonideal medium of a seismically active lithosphere zone. But physically

different fields are described by differential operators of different mathematical types. The resulting field interaction mathematical model [i.e., the initial boundary value problem of the system of partial differential equations (PDEs)] may not be of a well-investigated classical type, though the authors apply a physically correct approach on the basis of the main physical principles and geological and geophysical data on the medium where the interaction is located. Therefore, investigations are needed to determine whether the interaction model is correct from the mathematical viewpoint, i.e., does it have a unique solution with continuous (by the proper functional norms) dependence on the input data of the physical problem under consideration? Usually, the input data are known to have some errors accompanying the measurements providing the data, and continuous dependence of the solution decreases the influence of this error.

In Chaps. 9, 10, and 11, the authors describe the simplest but most important parts of their mathematical investigations of the field interaction models. So, the practical recommendations in this book are based on physically and mathematically correct models, with the numerical characteristics of the computed signals being consistent with measurements published by other authors.

Let us note that the physical sense of our geophysical results related to the precursory physics, along with the computer graphics clearly illustrating this sense—namely the evolution of interacting fields of different natures—may be understood without mathematics related to the nonclassical initial boundary value problems. These problems arising in the precursory physics were formulated and investigated mathematically and then solved numerically by the authors to obtain geophysical results with mathematical justification. The authors believe that, among other scientific and educational reasons (especially for young researchers), this justification is needed because of the recommendations for a prognosis on the basis of the results obtained. Holistically, we are trying to correctly consider the dangerous interaction of geophysical fields, not only between themselves, but with humans as well, i.e., we are trying to discuss the elements of geo-biophysics with regard to human safety related to natural dynamical processes in the geospheres.

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Contents

Abbreviations

1D	One-dimensional
2D	Two-dimensional
3D	Three-dimensional
ACh	Acetylcholine
AM	Amplitude modulation
ANS	Autonomous nervous system
AP	Action potential
ASTER	Advanced spaceborne thermal emission and reflection radiometer
ATP	Adenosine triphosphate
AV	Atrioventricular
cAMP	Cyclic adenosine monophosphate
CF	Coherence function
CFV	Coherence function value
CIR	Corotating interaction region
CME	Coronal mass ejection
CNS	Central nervous system
CSEM	Controlled source of an electromagnetic field
CT	Computed tomography
CTD	Conductivity, temperature, depth
DART	Deep-Ocean Assessment and Reporting of Tsunamis
DC	Direct current
DMTS	Deep magneto-telluric soundings
Dst	Disturbance storm time
ECG	Electrocardiography
EEG	Electroencephalography
EM	Electromagnetic
EMF	Electromagnetic field
EMG	Electromyogram
EPSP	Excitatory postsynaptic potential
EQ	Earthquake

ERS	Event-related synchronization
FAC	Field-aligned current
FFT	Fast Fourier transform
FLC	Fraction of low coherence
fMRI	Functional magnetic resonance imaging
GPS	Global Positioning System
HSS	High-speed solar
IAGA	International Association of Geomagnetism and Aeronomy
IPSP	Inhibitory postsynaptic potential
IR	Infrared
IT	Information technology
IZMIRAN	Pushkov Institute of Terrestrial Magnetism, Ionosphere and Radio Wave Propagation
K_p	Planetary geomagnetic index
LRS	Low-resistivity structures
MEG	Magnetic encephalography
MHD	Magneto-hydrodynamic
MLPEEA	Magnetic location of a possible earthquake epicenter area
MMT	Marine magneto-telluric
MRI	Magnetic resonance imaging
MS	Magnetic storm
MTE	Magneto-thermo-elasticity
MTS	Magneto-telluric soundings
N	Nodal
NASA	National Aeronautic and Space Administration
NH	Nodal–His
NOAA	National Oceanic and Atmospheric Administration
NTS	Nucleus tractus solitarius
ODE	Ordinary differential equation
PDE	Partial differential equation
PET	Positron emission tomography
PNS	Peripheral nervous system
PRT	Proofreading test
rw	Rolling wave
SA	Sinoatrial
S.-D.	String–diffusion
SAR	Synthetic aperture radar
SDSE	String–diffusion system of equations
SEMTI	Seismo-electromagnetic-thermal interaction
SHEMTI	Seismo-hydro-electromagnetic-thermal interaction
SWPC	Space Weather Prediction Center
T	Temperature
Th	Threshold

TSUNPREDET	Multidisciplinary vertically distributed seaquake/tsunami precursors detection system
TV	Thermo-viscoelastic
UCLA	University of California, Los Angeles
ULF	Ultra-low-frequency
UT	Universal time
VHF	Very-high-frequency