

Preface to the Second Edition

This book represents the revised and enlarged Second Edition of E. A. Sharkov's *Global Tropical Cyclogenesis*, published by Springer/Praxis in 2000. The principal feature of the First Edition was the development of a methodological approach, first proposed by the author, to studying tropical cyclones (TCs), based on the concept of tropical cyclogenesis evolving as a stochastic flow of homogeneous events in the lifetime of each TC. A series of studies following on from the First Edition has shown the fruitfulness of such an approach. A number of new scientific results, based on this approach, are presented in this edition.

The necessity for a revised and enlarged Second Edition is the result of ongoing growing interest—not only from the science community but also from the industrial and administrative bodies of many countries—in the problems that occur both as a result of the appearance and in forecasting catastrophic atmospheric phenomena; these principally include global climate change, irreversible damage to ecological processes, and transformation of energy transfer and mass transfer in the ocean–atmosphere system all of which could result in changing the current favorable conditions for life.

The reason for studying atmospheric catastrophes is explained by a number of things. Principally, these atmospheric processes represent a direct physical threat to humankind and to infrastructure, in addition to the many administrative–economical problems that arise as a consequence. In some cases, they even bring about political and state initiatives in attempts to control them. Humankind has long considered tropical cyclones as the most destructive elements of the ocean–atmosphere system causing considerable loss of life and material losses. Serious efforts have been undertaken (mainly in the U.S.A. where, it has to be said, they have been completely ineffective) to limit the amount of damage caused by TCs by any means. These attempts are still ongoing even now.

The process that gives rise to these vortical systems in the Earth's atmosphere, long considered on the basis of standard meteorological approaches, was supposed

to be a purely meteorological phenomenon. It was only after 1983, when a series of studies was carried out under the leadership of Academician R. Z. Sagdeev and Professor S. S. Moiseev of the Russian Academy of Sciences (RAS), that it became clear that serious progress in studying such complicated systems could only be achieved using new physical approaches, both theoretical and experimental. So, from the viewpoint of forecasting such complicated systems, it is first necessary to clearly understand the spatiotemporal picture of this global phenomenon as a multifaceted process—this especially relates to ascertaining the determinate components both globally and regionally. Moreover, recent investigations using space remote-sensing data and the latest achievements in complex systems theory indicate a principally different view of tropical cyclogenesis: we can state, with a high degree of probability, the determining role played by tropical cyclones in carrying out global mass transfer and energy transfer in the global ocean–atmosphere system and in regulating the greenhouse effect, which is so important for biological (including human beings) life on the Earth. Thus, global tropical cyclogenesis most likely represents the necessary and, probably, determining factor in the ecological balance (understood in a broad sense) that exists both in the geophysical ocean–atmosphere system and in the ecological systems of the Earth.

Catastrophic atmospheric vortices represent a unique mechanism that effectively removes excessive heat from the atmosphere under conditions in which the usual mechanisms, principally turbulent convection and global circulation, clearly become insufficient. So, catastrophic phenomena play an important role (as paradoxically as it may seem) that is vital for humankind in regulating the climatic temperature regime of the Earth (the greenhouse effect), removing excessive heat and preventing the planet from overheating in the tropical zone (Chapter 4). The stable integral regime of plural cyclogenesis generation, both in the cyclone-generating basins of the World Ocean and in the basins of northern and southern hemispheres, is revealed.

A key discovery in the initial cyclogenesis and intensification of various forms of tropical cyclones is the quick-response energy source that provides extremely fast intensification and formation of mature forms of tropical cyclones. The point of view that only those basins of oceans that experience high surface temperatures can be such a source has a long history and many adherents. However, contradictory views toward such a viewpoint have recently appeared, mainly as a consequence of the catastrophically fast intensification of TC “Katrina” which subsequently struck the coastal areas of the U.S.A. Chapter 4 presents results that indicate the main power sources that fuel tropical cyclones are water vapor regions with heightened integral concentration, not only captured by a cyclone from the tropical zone by means of monsoonal circulation of the atmosphere but also retained by the cyclone throughout the whole stage of its evolution (the so-called “capture” effect and the “camel” model).

In contrast, ever since the end of the 19th century, researchers have undertaken numerous attempts to establish a relationship between tropical cyclone appearance and solar activity, which seemed obvious at that time. However, this did not lead to unequivocally and obviously interpretive results from the physical point of view. The reasons relate (as have now become clear) to the multiscale and nonlinear character

of the process of the interaction between solar activity and cyclogenesis, as well as with the flawed mathematical procedures then used. By using modern wavelet analysis the response (with a correlation of nearly 100%) of 27-day solar activity variations in the time series of global cyclogenesis was found for the first time (Chapter 5).

The idea that research into how TCs interact with the ocean–atmosphere system should not be limited to the troposphere but, instead, should be based on considering the large-scale crisis state as a global phenomenon influencing various geophysical media, starting with the ocean surface and troposphere and ending with the ozonosphere and ionosphere, was first proposed in 1996 by the author in collaboration with researchers at the Space Research Institute of the Russian Academy of Sciences (SRI RAS). Research into the kinematic, thermodynamic, and electrodynamic relationships between elements of the ocean–troposphere–upper atmosphere–ionosphere system at crisis states should undoubtedly be a major component of space research; attempts are now being undertaken to organize complex investigations using rocket-based and radar ionospheric sounding. The analysis of ionospheric disturbances carried out in Chapter 6 confirms, to a high degree of probability, the direct and rapid effect that powerful vortical systems in the troposphere have on the overlying lower and middle ionosphere.

Appendix A contains unique quantitative detailed information on the spatiotemporal features of global and regional tropical cyclogenesis between 1983 and 2010.

Based on the response to the First Edition, the present edition will be useful not only for professional experts on tropical meteorology, but also for researchers and engineers of government organizations and research institutes engaged in forecasting emergency situations and monitoring natural environments.

The author wishes to thank his many colleagues for useful discussions and remarks which have improved the text of the book. The author is especially grateful to Dr. I. V. Pokrovskaya for fruitful cooperation over many years.

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Keeping in mind the complexity of the present publishing project, the author welcomes comments from interested readers (email: easharkov@iki.rssi.ru).

Preface to the First Edition

It is common knowledge that the tropical zone of the Earth plays a crucial role in the evolution of the global thermodynamic surface–atmosphere system and in the socio-ecological processes on our planet. In this case, it should be primarily pointed out that the ocean–atmosphere system of Earth’s tropical zone possesses the unique characteristic of generation of organized mesoscale vortical structures—tropical cyclones (TCs)—from atmospheric turbulent chaos. TCs are among the most destructive natural phenomena on Earth and are serious ecological hazards for humanity. Material damage is often accompanied by a considerable loss of life; so TCs rank next (after earthquakes) among natural disasters in the number of human lives lost. Vulnerability to tropical cyclones is becoming more pronounced because the fastest population growth is in tropical coastal regions.

However, there exists another important aspect of this problem. Recent remote-sensing satellite investigations have clearly demonstrated, on the one hand, the significance of the tropics for the planet’s life and, on the other hand, the importance to humankind of understanding the fine features of teleconnections between the tropics and the rest of the globe. In this case, there is good reason to believe (and recent results strongly support it) that global tropical cyclogenesis plays a decisive role in the maintenance of global mass-and-energy exchange. Moreover, it becomes apparent that the TC is not an exotic but a necessary (appropriate) element in “working” the tropical atmosphere–ocean system.

If we remember the cliché that “the tropics is the fire box of the atmosphere”, so there can be no doubt that “the tropical cyclone is a harsh flame”.

Understanding TC genesis, development, and characteristic features has been a challenging subject in meteorology over the last several decades. However, the pool of experience led us to conclude with certainty that it is hardly probable that the problem can be resolved strictly in the framework of meteorological notions. There is no question that for an understanding of the behavior of such complicated physical

phenomenon as tropical cyclogenesis it is necessary to invoke the notions of modern non-linear physics and chaotic dynamics developed over many years.

The principal purpose of this book is to demonstrate the new capabilities and results of the proposed methodological approach based on the concept of tropical cyclogenesis evolution as a stochastic flow of homogeneous events.

The aim of Chapter 1 of the book is to substantiate the scientific and applied rationales for global cyclogenesis study; in so doing we point to both the natural scientific tasks and socioeconomic problems.

The basic idea of investigation of statistical characteristic of global tropical cyclogenesis formed as a signal of a stochastic intermittent flow by the mathematical apparatus of chaotic dynamics are introduced in Chapter 2. Emphasis has been laid on investigations into the hierarchical structure of global tropical cyclogenesis by retention of all interaction timescales. The type of probability model revealed varies radically with the choice of interaction timescale. We first examine the time evolution of initial forms of TC as a stochastic process, and then features of the rate of hurricane generation.

The spatiotemporal features of regional tropical cyclogenesis are pursued further in Chapter 3 [of the First Edition]. The emphasis is on the evolution of a statistical model of Pacific tropical cyclogenesis and its interactions with the environment of the atmosphere–ocean system. In this chapter [of the First Edition] we are concerned with the problem of the hierarchy and clusterization of tropical convective systems in the context of the concept of self-organization in open systems.

Chapter 4 [of the First Edition] deals with existing physical models and the results of simulations of global tropical cyclogenesis. In addition to the well-known (at least in Western literature) approaches—such as the statistical synoptical forecasting and modeling of disturbances in global climate models—here we crucially examine new physical approaches in tropical cyclogenesis problems, in particular the concept of self-organization of large-scale structures in helical turbulence and the kinetic diffusion approach, presenting the birth–death processes of ordered elements in an active fluctuating medium.

In Chapter 5 [of the First Edition] we look at the basic principles of data gathering and acquisition for the development of global tropical cyclogenesis databases including descriptions of the design principles, structures of datasets, cataloguing procedures, and computer architectures. Much attention is given to state-of-the-art systematic and chronological catalogues and hydrometeorological archives.

The purpose of Chapter 6 [of the First Edition] consists of considerations of passive and active remote sensing for tropical monitoring. Emphasis has been laid on satellite activity for tropical studies. The chapter covers the current status of operational satellite systems and gives a synopsis of projected developments for special missions for tropical study and of international efforts for tropical cyclogenesis monitoring.

Appendix A [of the First Edition] has much potential for yielding information about the spatiotemporal features (quantitative data) of global and regional tropical cyclogenesis for 1983–1999.

I wish to thank my many colleagues whose efforts and discussions have contributed to the present work. I specifically wish to thank my colleague Dr. Irina Pokrovskaya for her close and fruitful collaboration for many years. I am thankful to Dr. Nataly Astafyeva for her contribution to the intriguing problem of stochastic behavior for global tropical cyclogenesis. I have also benefited from useful discussions with Prof. S. S. Moiseev.

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