ISSN 0001-4338, Izvestiya, Atmospheric and Oceanic Physics, 2012, Vol. 48, No. 9, pp. 900–908. © Pleiades Publishing, Ltd., 2012.
Original Russian Text © E.A. Sharkov, Ya.N. Shramkov, I.V. Pokrovskaya, 2012, published in Issledovanie Zemli iz Kosmosa, 2012, No. 2, pp. 73–82.

Increased Water-Vapor Content in the Atmosphere of Tropical Latitudes as a Necessary Condition for the Genesis of Tropical Cyclones

E. A. Sharkov, Ya. N. Shramkov, and I. V. Pokrovskaya
Space Research Institute, Russian Academy of Sciences, ul. Profsoyuznaya 84/32, Moscow, 117997 Russia
e-mail: e.sharkov@mail.ru
Received October 3, 2011

Abstract—The hypothesis about the interrelation of the integral water-vapor concentration (from data of microwave satellite systems) and plural tropical cyclogenesis in cyclonogenerating water areas of the World Ocean in 2001 is verified with the aid of the EVA-01 (IKI RAN) database (DB) with elements of the object–relation type formed by the authors. It is experimentally proved in the work that there is a critical value of the integral water-vapor concentration (a peculiar necessary condition) at which the mature form of a tropical cyclone (TC) is formed with a lifetime exceeding 24 h. It is also experimentally proved that, in the same time interval, there is another group of TCs with a short lifetime (less than than 24 h) which do not possess a clearly pronounced boundary value of the water-vapor intensity and can be formed in a wide range of its values. The relations between the regions with an increased concentration of water vapor and genesis of TCs have become obvious only with the use of object–relation computer technologies.

Keywords: tropical cyclones, integral water-vapor field, critical geophysical parameters of genesis
DOI: 10.1134/S0001433812090162

INTRODUCTION

In recent years, a specific direction has been formed in the problem of remote sensing of the earth (ERS). The purpose of this direction is a comprehensive investigation into the parameters of the geophysical environment with respect to different temporal phases of the evolution of natural catastrophes. First and foremost, this relates to atmospheric catastrophes that lead to considerable material damage, such as tropical cyclones (TCs).

The study of the geophysical medium during the generation of primary TC forms always occupied a special place in programs of the remote monitoring of tropical disturbances. Problems of predicting the appearance of primary disturbance forms and the subsequent transition of an individual primary tropical disturbance into a developed TC form, as well as problems of comprehensive remote investigations into structural, dynamic, and thermodynamic features of a tropical disturbance directly at the moment of generation of the mature TC form, are of paramount importance [Sharkov, 2000].

However, attempts at remote investigations into the primary forms of tropical disturbances encounter a number of difficulties: first and foremost is the absence of a generally accepted physical model of this complex geophysical phenomenon and, accordingly, the necessary geophysical parameters to be measured. In spite of the considerable efforts of researchers directed at observing and recording separate (and fragmentary) optical and infrared images of tropical eddy disturbances in different phases, no final remote criteria for the "nearness" of the geophysical medium to the generation of an individual tropical disturbance and to the crucial moment of the transition into a developed form exists yet.

On the other hand, the notion about a set of so-called "necessary" (and to a considerable degree, phenomenological) geophysical parameters at which mesoscale stable eddy systems must be generated in the tropical atmosphere (in the climatologic aspect) appeared rather long ago. This set is regarded as classical and is an indispensable attribute of most editions discussing the questions of TC generation [Gray, 1979 ; Khain and Sutyrin, 1983]. High values of the surface temperature exceeding (strictly) 26°C (26.3–26.8°C) (the so-called critical temperature or the cutoff temperature) at a deep upper quasi-homogeneous layer of the ocean (deep thermocline) are one of the main components of this set (often called "the first necessary conditions for the typhoon generation"). Based on this notion, the concept of the critical value of the latent heat flux as a quantitative criterion of the TC occurrence was elaborated later [Golitsyn, 2008].

However, the comprehensive analysis [Sharkov and Pokrovskaya, 2006] of spatial–temporal fields of generation of the initial forms and the cyclogenesis of mature forms in the surface temperature field in oceanic water areas of two hemispheres of the earth showed the existence of a fairly wide range of surface temperatures at which the processes of generation of primary forms and their transformation into mature forms take place, as well as the absence of the "critical" (threshold) temperature and, accordingly, the absence of a rigid boundary, during their generation in the field of the ocean surface temperature. As would be expected, regional cyclogeneses [Sharkov and Pokrovskaya, 2010] have very peculiar ranges of surface temperatures at which the processes of generation of primary TC forms take place ("diffuse" ranges, "extremes with tails," and "delta-shaped" forms). Therefore, the widespread concept of the critical value of the surface temperature of the ocean in the study of TC genesis remains experimentally unfounded.

Attempts to remotely investigate the genesis of primary forms of tropical disturbances encounter a number of difficulties, first and foremost, the absence of a generally accepted physical model of this complex geophysical phenomenon and, accordingly, the necessary geophysical parameters to be measured. In spite of considerable efforts of researchers in the field of observation and recording of individual (and fragmentary) optical and infrared images of tropical eddy disturbances in different phases (see, for example, [Sharkov, 1997, 1998, 2000, 2006, 2010]), there are still no generally accepted remote criteria indicating that the geophysical medium is close to the generation of an individual tropical disturbance and to the crucial moment of its transition into the mature form. The results of complex multifrequency optical–infrared–microwave satellite investigations into the evolution of an optical TC image in the field of integral water vapor should be regarded as a basically new step in the study of remote criteria of the TC genesis. An analysis of these investigations revealed the fundamental contribution of a quick-response energy source responsible for the formation of mature forms of typhoons and the horizontal transport of water vapor by the global circulation and jet flows to sustain the functioning of mature TC forms [Sharkov, 2010; Sharkov et al., 2008, 2009, 2011a, 2011b; Kim et al., 2010]. This result is, of course, of fundamental value for the TC genesis problem. However, this result was obtained during an investigation into three selected individual TCs. In order to prove experimentally that this thesis is beyond question, it is necessary to investigate the evolution of the plural tropical cyclogenesis (for example, in a period of about one year) in the field of intensely migrating integral water vapor in the tropical zone of the earth's atmosphere.

This problem is complex, because it is necessary to synchronously analyze the remote satellite information about two stochastic processes basically differing in their spatial–temporal scales and structural characteristics. The first process—tropical cyclogenesis—is considered a stochastic set of random events (objects), namely, stochastic TC cyclogenesis [Sharkov, 2000]; the second process is considered the spatial global field of integral water vapor characterized by a considerable spatial–temporal variability [Sharkov et al., 2009, 2011a, 2011b]. These two databases (DBs) must be combined in a minimal time interval (in this case, in the diurnal time pixel). If the time interval of the combination of two processes is larger, the effectiveness of the proposed method will decrease due to the finite lifetime of tropical disturbances and the high spatial–temporal variability of the water-vapor field. An analysis of the method of constructing DBs for present-day structures showed [Shramkov et al., 2010] that the necessary temporal combination of data of two stochastic processes is possible with the use of the object–relation technology for constructing complex DBs, which is being intensely developed at present.

The goal of this work is to produce an improved variant of the EVA-01 DB with elements of the object–relation technology based on the advantages of the object–relation DB. The improved variant of the EVA-01 DB must include the thematic processing of remote satellite information about the two stochastic processes mentioned above. Based on the synchronous analysis of these stochastic fields, it is shown that the plural tropical cyclogenesis during one-year interval (2001) (simultaneously in the Northern and Southern hemispheres) is formed in the field of increased integral water-vapor concentration. This interrelation becomes obvious only when the object–relation technologies are used to process satellite information. Therefore, we must detect an actually critical (necessary) parameter, namely, the integral water-vapor intensity. Only an increase in this parameter makes TC genesis possible.

OBSERVATIONAL DATA AND METHODS OF PROCESSING THEM

The multimedia processing of satellite data usually includes two main stages; a correct presentation of spatial–temporal data and their thematic processing. In our case, the first stage consists of the creation of animated video clips as a result of specially processing a succession of satellite images, including systematized data about global tropical cyclogenesis. At the second stage, the information is thematically processed with the aid of special software developed on the basis of physical models of the processes under investigation. The problem is complex, because the applications of these newly obtained data types must operate models (abstractions) inherent in this thematic sphere (the TC evolution as a stochastic set of random events and the evolution and migration of the spatial–temporal field of water vapor). Each of these spheres is characterized by specific physical and geophysical features, which must be taken into account during thematic processing. To satisfy these requirements, we chose object–relation technology, which ensured rather simple methods for the elaboration, scanning, and control of applications operating with complex data.

The first variant of EVA-01 DB with elements of the object–relation technology, which includes remote satellite information about the two stochastic processes mentioned above, was presented for the first time in work [Shramkov et al., 2010].

The improved variant of the EVA-01 DB uses information from its predecessors, the GLOBAL TC and GLOBAL FIELDS DBs, with elements of the thematic processing. The first of these DBs is the bank of systematized remote data on global tropical cyclogenesis; i.e., it contains information about the physical process considered in all water areas of the World Ocean [Pokrovskaya and Sharkov, 2006]. First and foremost, the information was systematized over individual regions with the temporal and spatial attachments in each of them; the correctness and completeness of messages about characteristic climatic features of each region were checked and the supplied "raw" information was preprocessed. Each newly forming TC or tropical disturbance (which subsequently did not reach the mature TC form) is introduced into a separate data file of the DB. Tables 1 and 2 were compiled with the use of the GLOBAL-TC DB over 2001.

The GLOBAL-FIELDS DB contains information about the global fields of radio-luminance temperatures [Ermakov et al., 2007] obtained with the SSM-1 microwave complex—a seven-channel radiothermal instrument receiving linearly polarized radiation at the frequencies 19.35, 22.235, 37.0, and 85.5 GHz (the DMSP mission). Both vertical and horizontal polarized radiations are measured at all frequencies except for 22.235 GHz. Only the vertical polarized radiation is measured at the frequency 22.235 GHz. The spatial field of view for measurements at the earth's surface is 12.5 km for the channel 85.5 GHz and 25 km for the other channels. To retrieve information about the water-vapor content, the data on the radio luminance temperatures from two channels (22.235 and 37.0 GHz) are necessary. The EVA-01 DB is a complex of programs which fulfills all functions necessary at a given moment for the processing of global water-vapor fields and information about TCs. First, the data from the GLOBAL-TC DB are successively processed with the aid of the Microsoft Visual Studio programming language. In this case, the text file, which contains data on the geographic position of a disturbance, the time of its occurrence and existence, and some meteorological information over 2001, is created.

The fields of radio luminance temperatures obtained at two frequencies—22.235 and 37.0 GHz—and borrowed from the GLOBAL-FIELDS DB are processed with the aid of the IDL programming language by the linear algorithm of inverse problems presented in work [Ruprecht, 1996] in accordance with the formula

$$W = 131.95 - 39.50\ln(280 - T_{22V}) + 12.49\ln(280 - T_{37V}),$$

where W is the integral water-vapor value in kg/m^2 (or in mm) in the spatial pixel of resolution of the SSM-1 instrument; T_{22V} and T_{37V} are the values of radio luminance temperatures in the channels 22.235 and 37.0 GHz (vertical polarization) in the spatial pixel of resolution of the SSM-1 instrument. The special validation performed in this work between the reconstructed water-vapor values and the values measured by radio sounding (250 profiles) in the Atlantic Ocean water area with the time difference between satellites and radiosondes better than 2 h showed that the rms deviation of the values is about 2.58 kg/m^2. As a result, we obtain the global fields of water vapor only over the water areas of the World Ocean that take part in further processing.

The processing and structure of water-vapor fields are based on the principle according to which global remote data are considered a long series of spatial–temporal observations. In this case, a long sequence of water-vapor fields is considered not a mechanical joining of data from several files which correspond to survey moments, but, from the user's standpoint, it is the main structural unit of the DB which is generated at the user's request and allows the application of further processing operation. The output data can be written into one or several files. The method of visualizing the data is the most natural method, because it is presented as the formation of series of images of a video clip.

Based on the obtained complex DB, we made a demonstrative animated film which is presented at the site of the Issledovanie Zemli iz Kosmosa Departhment of the IKI RAN (htto://www.iki.rssi.ru/asp/dep_coll.htm) and visually demonstrates the relation between the regions of increased water-vapor concentration and the TC genesis. Note that the water-vapor content is not presented for continents because of difficulties associated with the solution to the inverse problem over continents.

RESULTS OF DATA PROCESSING

Fragments of animation of the global water-vapor field and the tropical cyclogenesis will be presented as examples of products of the present DB. Figure 1 (see pasted colored insets) shows the global field of integral water vapor in the World Ocean water areas on September 5, 2001. The color code of water-vapor intensities is given in the lower part of the figure, and purple regions correspond to the maximal concentrations of water vapor. These images are obtained with a discretization of one day. The current data of the photograph is indicated in the lower left-hand corner in the format: month–day–year. TCs in the mature form are

Table 1. Main characteristics of long-period TCs in the World Ocean in 2001

No.	Region, TC number and name	Date of TC existence	Date of transformation into the TC stage	Coordinates of transformation into the TC stage		Maximal stage of TC development	Duration of the maximal stage, h
				latitude	longitude		
1	2	3	4	5	6	7	8
1	SIN 0101 "Bindu"	02.01–14.01	07.01	–11.9	73.9	Ò	132
2	SIN 0102 "Charly"	11.01–26.01	19.01	–14.2	84.4	The same	60
3	SIN 0104 "Vincent"	06.02–15.02	12.02	–14.9	112.5	TS	54
4	SWP 0105 "Paula"	24.02–05.03	26.02	–12.6	164.8	T	84
5	SWP 0106 "Rita"	28.02–05.03	01.03	–19.7	–136.0	STS	6
6	SIN 0105 "Dera"	04.03–13.03	09.03	–20.9	40.5	T	48
7	SIN 0107 "Walter"	02.04–08.04	03.04	–10.1	103.9	The same	72
8	SWP 0107 "Sose"	03.04–11.04	05.04	–14.0	165.8	"	12
9	SIN 0106 "Evariste"	31.03–08.04	04.04	–13.7	62.8	STS	42
10	SIN 0109 "Alistair"	15.04–23.04	16.04	–9.3	132.9	T	6
11	NWP 0101 "Cimaron"	04.05–14.05	10.05	13.6	119.1	STS	24
12	NIN 0101 "01 A"	08.05–28.05	22.05	13.9	70.6	T	78
13	NEP 0101 "Adolph"	04.05–05.06	26.05	13.9	–100.4	The same	96
14	NEP 0102 "Barbara"	18.06–24.06	20.06	13.2	–131.0	STS	6
15	NWP 0102 "Chebi"	18.06–24.06	20.06	13.0	133.6	T	42
16	NWP 0104 "Durian"	29.06–04.07	30.06	16.6	115.7	The same	30
17	NWP 0103 "Utor"	22.06–08.07	02.07	10.7	137.3	"	54
18	NWP 0105 "Trami"	03.07–12.07	10.07	20.0	124.2	TS	36
19	NEP 0104 "Erick"	16.07–26.07	21.07	16.5	–120.8	The same	36
20	NEP 0105 "Dalila"	18.07–30.07	21.07	12.6	–96.1	T	12
21	NWP 0106 "Kong-Rey"	21.07–29.07	21.07	24.6	151.3	The same	102
22	NWP 0107 "Yutu"	21.07–27.07	23.07	20.3	121.4	"	36
23	NWP 0108 'Toraji"	24.07–01.08	26.07	16.8	128.1	"	66
24	ATL 0102 "Barry"	02.08–06.08	02.08	26.3	–84.8	STS	20
25	NWP 0109 "Man- yi"	31.07–09.08	02.08	11.2	152.0	T	114
26	NWP 0111 "Pabuk"	13.08–23.08	14.08	18.7	145.7	The same	126
27	NEP 0106 "Flossie"	25.08–03.09	26.08	20.2	–111.1	"	72
28	NWP 0112 "Sepat"	19.08–31.08	27.08	24.0	165.1	TS	36

Table 1. (Contd.)

No.	Region, TC number and name	Date of TC existence	Date of transformation into the TC stage	Coordinates of transformation into the TC stage		Maximal stage of TC development	Duration of the maximal stage, h
				latitude	longitude		
1	2	3	4	5	6	7	8
29	NWP 0113 "Wutip"	25.08–02.09	27.08	17.5	140.8	T	108
30	ATL 0105 "Erin"	27.08–15.09	02.09	13.4	–38.5	The same	126
31	NEP 0108 "Gil"	03.09–12.09	04.09	15.7	–123.7	"	54
32	NWP 0116 "Danas"	02.09–12.09	04.09	18.5	152.8	"	138
33	NWP 0115 "Nari"	31.08–21.09	06.09	26.2	127.1	"	210
34	ATL 0106 "Felix"	06.09–23.09	11.09	18.9	–47.5	"	102
35	ATL 0107 "Gabrielle"	10.09–19.09	13.09	25.2	–85.2	"	18
36	NWP 0117 "Francisco"	15.09–25.09	19.09	14.6	161.5	"	72
37	NEP 0111 "Juliette"	19.09–04.10	21.09	13.4	–94.2	"	132
38	NEP 0110 "Kiko"	19.09–29.09	22.09	17.0	–119.8	"	6
39	Atl 0108 "Humberto"	20.09–27.09	22.09	29.0	–67.0	"	72
40	NWP 0119 "Lekima"	19.09–30.09	22.09	19.3	124.1	"	66
41	NIN 0102 "02 A"	23.09–28.09	26.09	17.9	67.0	TS	36
42	NEP 0112 "Lorena"	29.09–05.10	02.10	12.1	–103.5	STS	6
43	NWP 0120 "Krosa"	03.10–09.10	04.10	14.9	144.1	T	84
44	ATL 0109 "Jerry"	04.10–12.10	07.10	11.1	–54.1	TS	36
45	ATL 0111 "Karen"	11.10–15.10	12.10	33.9	–66.5	T	18
46	NWP 0121 "Haiyan"	07.10–18.10	12.10	17.2	130.5	The same	78
47	NWP 0122 "Podul"	15.10–28.10	19.10	5.7	156.3	"	144
48	NEP 0114 "Narda"	17.10–25.10	20.10	11.9	–127.0	"	24
49	SIN 0112 "Alex"	23.10–02.11	26.10	– 8.2	94.4	STS	36
50	Nep 0115 "Octave"	29.10–05.11	31.10	12.8	–124.5	T	18
51	NWP 0125 "Pabling"	16.11–24.11	21.11	6.2	112.5	TS	42
52	ATL 0115 "Olga"	24.11–06.12	26.11	31.5	–56.0	T	48
53	SIN 0115 "Bessi"	24.11 - 06.12	27.11	–8.3	93.0	The same	36
54	NWP 0127 "Faxai"	10.12–25.12	15.12	5.0	162.0	"	108
55	SWP 0110 "Waka"	27.12–02.01	29.12	–11.9	–174.8	"	60

Note: Regions and TC numbers correspond to the international classification: (NWP) northwestern region of the Pacific Ocean, (NEP) northeastern region of the Pacific Ocean, (ATL) northern Atlantic Ocean, (NIN) northern region of the Indian Ocean, (SIN) southern region of the Indian Ocean, and (SWP) southwestern region of the Pacific Ocean. Stages of the disturbance development: (T) typhoon, (STS) strong tropical storm, and (TS) tropical storm. Latitude and longitude are indicated in degrees.

Table 2. Main characteristics of short-period TCs in the World Ocean in 2001

No.	Region, TC number and name	Date of TC existence	Date of transformation into the TC stage	Coordinates of transformation into the TC stage		Maximal stage of TC development	Duration of the maximal stage, h
				latitude	longitude		
1	2	3	4	5	6	7	8
1	SIN 0103 "Terri"	27.01–01.02	30.01	–17.5	119.7	STS	12
2	SWP 0102 "No name"	15.02–18.02	17.02	–19.1	162.7	TS	24
3	SWP 0103 "Oma"	18.02–22.02	20.02	–23.0	–162.0	STS	6
4	SIN 0108 "No name"	02.04–05.04	03.04	–15.0	83.1	TS	18
5	ATL 0101 "Allison"	05.06–17.06	05.06	27.4	–94.8	STS	2
6	SIN 0110 "No name"	21.06–23.06	22.06	–25.08	39.2	TS	12
7	NEP 0103 "Cosme"	10.07–18.07	13.07	16.0	–110.5	The same	18
8	NWP 0110 "Usagi"	08.078–11.08	10.08	17.8	108.7	TS	12
9	ATL 0103 "Chantal"	12.08–22.08	16.08	12.9	–54.0	STS	72
10	NWP 0114 "Fitow"	26.08–31.08	30.08	20.7	108.7	TS	12
11	SIN 0111 "No name"	02.10–08.10	06.10	–11.2	83.3	То же	6
12	NIN 0103 "03 A"	07.10–13.10	09.10	18.6	68.4	"	6
13	ATL 0112 "Lorenzo"	26.10–31.10	30.10	28.7	–45.0	TS	18
14	ATL 0114 "Noel"	05.11–06.11	05.11	38.0	–50.0	T	6
15	NIN 0104 "04 B"	06.11–12.11	11.11	15.4	84.1	TS	12
16	NWP 0124 "Ondoy"	14.11–25.11	20.11	14.1	134.2	The same	18
17	SIN 0113 "No name"	19.11–24.11	21.11	–13.2	83.3	"	24
18	SIN 0114 "No name"	19.11–21.11	21.11	–6.9	128.9	"	12
19	SWP 0108 "Trina"	30.11–03.12	30.11	-22.2	–159.8	"	10
20	SWP 0109 "Vicky"	22.12–27.12	24.12	–12.9	–156.2	"	12

Note: Regions and TC numbers correspond to the international classification: (NWP) northwestern region of the Pacific Ocean, (NEP) northeastern region of the Pacific Ocean, (ATL) northern Atlantic Ocean, (NIN) northern region of the Indian Ocean, (SIN) southern region of the Indian Ocean, and (SWP) southwestern region of the Pacific Ocean. Disturbance development stages: (STS) strong tropical storm and (TS) tropical storm. Latitude and longitude are indicated in degrees.

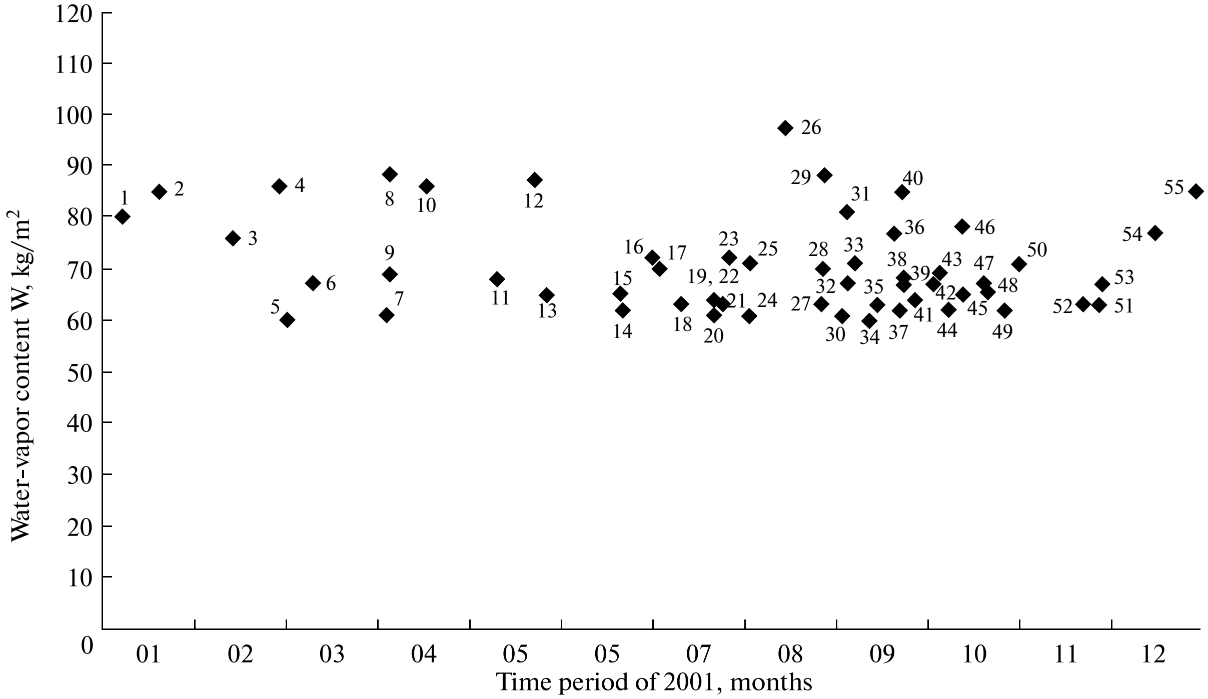

Fig. 2. Annual (over 2001) distribution of the integral water-vapor content in the equatorial mother field at the geographic place and at the moment of intensification of the given tropical disturbance and its transformation into the mature stage of long-period TCs (TS stage). Numerals near rhombs correspond to ordinal numbers of TCs in Table 1.

marked in the figure by dark blue squares. On September 5, 2001, four TCs, Danas, Erin, Gill, and Henriette, at different stages of development (Table 1) were observed simultaneously in the cyclonogenerating water areas of the World Ocean. It is noteworthy that all of these TCs (during September 5, 2001) were in mature TC form and fell into purple regions of the water-vapor content, i.e., into water-vapor regions with intensities exceeding 60 kg/m^2. The water-vapor content in the atmosphere over continents is not presented, because it is difficult to solve the inverse problem over continents.

The thematic part of the EVA-01 DB software made it possible to perform a complex procedure of processing the migrating water-vapor field and the stochastic process of evolution of the global cyclogenesis, namely, the finding and comparison of TC genesis moments and integral water-vapor values at these moments and in the same geographic locations. Such a complex analysis of TCs over all of 2001 showed that all TCs with a lifetime of more than 24 h (Table 1, Fig. 2) fell into purple regions of the water-vapor content, i.e., into regions with a water-vapor intensity exceeding 60 kg/m^2 (Fig. 1). It is easy to see that this water-vapor content is in essence a critical value in TC genesis. Note that such a complex analysis is difficult, because the water-vapor field is characterized by a strong spatial–temporal variability. The westward transport of the water-vapor field in the tropics can reach 300–400 km per day, and intensity contours can considerably change their configurations. It is this phenomenon that is most likely responsible for rather large rms deviations between the water-vapor field values reconstructed from satellite data and measured by the radio sounding method [Ruprecht, 1996]. For the same reasons, the water-vapor field reconstruction with the use of individual (fragmentary) points of radio sounding (from island and shipboard stations) with the subsequent field formation in accordance with meteorological rules cannot provide acceptable results on time scales of about 24 h in the process of cyclogenesis [Pokrovskaya and Sharkov, 1996]. Let us emphasize that in this investigation we deal with time scales of about 24 h, which is necessary for an investigation into the evolution of the water-vapor energy content in the process of cyclogenesis. If investigations are carried out on scales of monthly and seasonal averaging [Ruprecht, 1996], no such problems arise.

Further investigations showed that, in the same time interval (2001), there was another array of TCs with small lifetimes (less than 24 h) which were devoid of a clearly pronounced boundary value of the water-vapor intensity (Fig. 3), and cyclones of this type can form in a very wide range of water-vapor intensity values. Note that, during such investigations of the water-vapor field, as well as in the case of an abrupt intensification of tropical systems (as, for example, during the Katrina TC intensification in August 2005), it is necessary to consider the tropical disturbance evolution on time scales of about 3–6 h (and, possibly, on

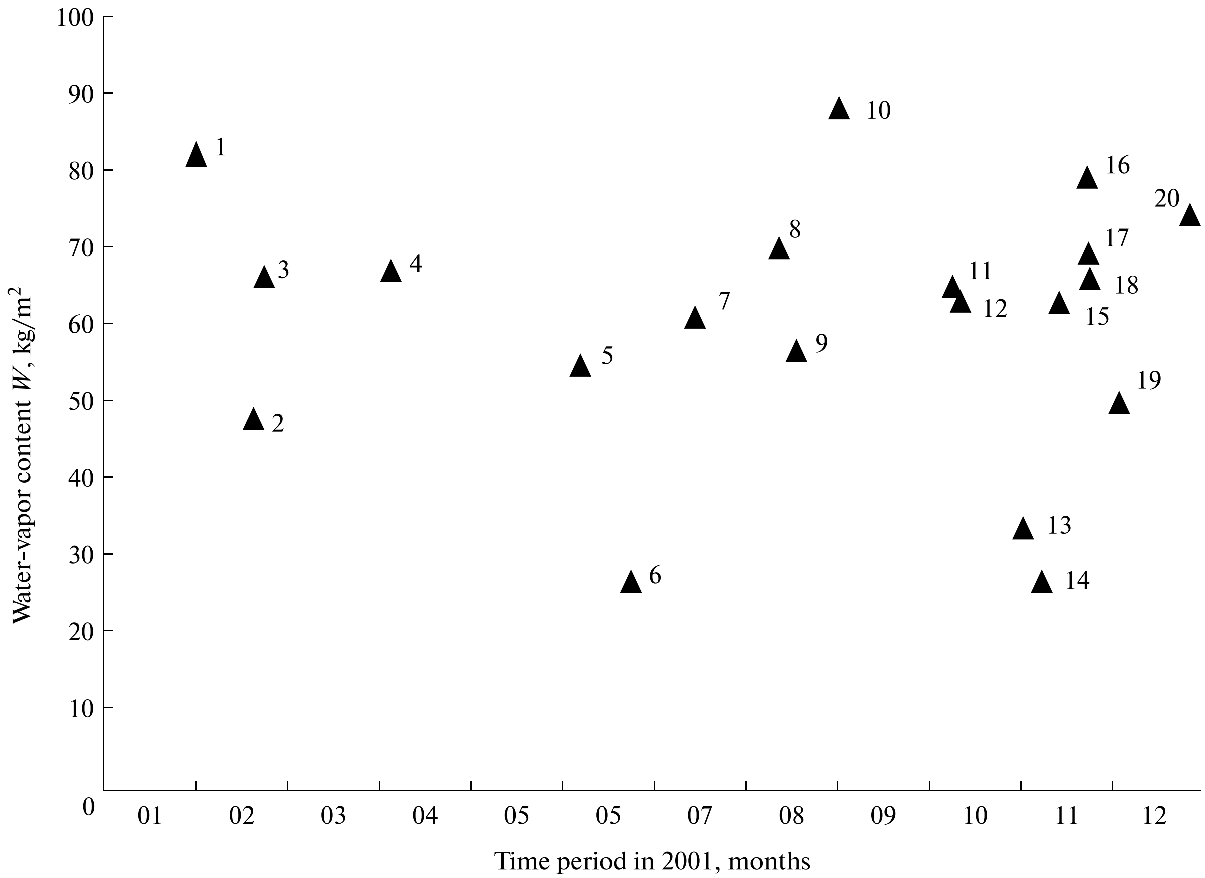

Fig. 3. Annual (over 2001) distribution of the integral water-vapor content in the equatorial mother field at the geographic place and at the time moment of the given tropical disturbance and its transformation into the mature stage of short-period TCs (TS stage). Numerals near rhombs correspond to ordinal numbers of TCs in Table 2.

smaller scales). At present, it is basically impossible to obtain such fields with existing remote microwave instrumentation (primarily due to space-craft ballistics and tactical characteristic and specifications of the antenna microwave complex). Therefore, special image-processing structures and the corresponding program products for the formation of short-term (3–6 h) radiothermal fields are being developed now on the basis of satellite microwave data obtained to date [Ermakov et al., 2011].

CONCLUSIONS

The hypothesis about the interrelation between the water-vapor integral concentration (from data of microwave satellite systems) and the plural tropical cyclogenesis in cyclonogenerating water areas of the World Ocean in 2001 is verified with the aid of the improved EVA-01 DB with elements of the object–relation type and thematic processing. It is shown experimentally that there is a critical value of the integral water vapor (a peculiar necessary condition or a critical parameter) at which a mature TC form with a lifetime exceeding 24 h is formed. It is shown experimentally that there is another array of TCs with short lifetimes (about and less than 24 h) which do not possess a clearly pronounced boundary value of water-vapor intensity and can be formed in a wide range of water-vapor intensity values. The revealed relations between the regions with increased concentrations of water vapor and TC genesis have become obvious only with the use of object–relation computer technologies. A demonstrative animated film (over 2001) which visually shows the relation between the increased water-vapor concentration and the TC genesis was produced with the use of this DB.

REFERENCES

Ermakov, D.M., Raev, M.D., Suslov, A.I., and Sharkov, E.A., Electronic Database of Long-Term Global Radio Heat Field of the Earth in the Context of a Multiscale Study of the Ocean–Atmosphere System, *Issled. Zemli Kosmosa*, 2007, no. 1, pp. 7–13.

Ermakov, D.M., Chernushich, A.P., Sharkov, E.A., and Shramkov, Ya.N., The Possibility of Construction of Short-Term Global Radio Heat Imaging of the the Ocean–Atmosphere System Based on the Stream Handler Program Platform, *Sovr. Prob. Dist. Zond. Zemli Kosmosa,* 2011, vol. 8, no. 3, pp. 9–16.

Golitsyn, G.S., Polar Lows and Tropical Hurricanes: Their Energy and Sizes and a Quantitative Criterion for Their Generation, *Izv., Atmos. Ocean. Phys.,* 2008, vol. 44, no. 5, pp. 537–547.

Gray, W.M., Hurricanes: Their Formation, Structure and Likely Role in the Tropical Circulation, in *Meteorology over the Tropical Oceans*, Shaw, D.B., Ed., Berkshire: James Glaisher House, 1979, pp. 155–218.

Gray, W.M., Tropical Cyclone Genesis and Intensification, in *Intense Atmospheric Vortices,* Bengtsson, L. and Lighthill, M.J., Eds., Berlin: Springer, 1982, pp. 3–20.

Khain, A.P. and Sutyrin, G.G., *Tropicheskie tsiklony i ikh vzaimodeistvie s okeanom* (Tropical Cyclones and Their Interaction with Ocean), Leningrad: Gidrometeoizdat, 1983.

Kim, G.A., Sharkov, E.A., and Pokrovskaya, I.V., Specific Features of the Interaction of Hondo and Ivan Tropical Cyclones in the Field of Integral Water Wapor, *Sovr. Prob. Dist. Zond. Zemli Kosmosa*, 2010, vol. 7, no. 4, pp. 287–295.

Palmen, E. and Newton, C.W., *Atmospheric Circulation Systems: Their Structure and Interpretation*, New York: Academic, 1969.

Pokrovskaya, I.V. and Sharkov, E.A., Remote Sensing Investigations of Spatial Fields of Moisture Content in Tropical Atmosphere in the Course of Cyclogenesis, *Issled. Zemli Kosmosa,* 1996, no. 6, pp. 18–27.

Pokrovskaya, I.V. and Sharkov, E.A., *Tropicheskie tsiklony i tropicheskie vozmushcheniya Mirovogo okeana: khronologiya i evolyutsiya. Ver. 3.1 (1983–2005)* (Tropical Cyclones and Tropical Disturbances of the World Ocean: Chronology and Evolution. Ver. 3.1 (1983–2005)), Moscow: Poligraf-servis, 2006.

Ruprecht, E., Atmospheric Water Vapour and Cloud Water: An Overview, *Adv. Space Res.,* 1996, vol. 18, no. 7, pp. 5–16.

Sharkov, E.A., *Remote Sensing of Tropical Regions*, Chichester, Weinheim, Brisbane, Singapore, Toronto: Wiley/PRAXIS, 1998.

Sharkov, E.A., *Global Tropical Cyclogenesis*, Berlin, Heidelberg, London, New York: Springer/PRAXIS, 2000.

Sharkov, E.A. and Pokrovskaya, I.V., Genesis of Tropical Disturbances in the Field of World Ocean Surface Temperature by Remote and Contact Sensing Data, *Issled. Zemli Kosmosa*, 2006, no. 6, pp. 3–9.

Sharkov, E.A., Kim, G.A., and Pokrovskaya, I.V., Multiple Generation of Tropical Cyclogenesis in the Southern Indian Ocean, *Sovr. Prob. Dist. Zond. Zemli Kosmosa*, 2010, vol. 7, no. 3, pp. 75–85.

Sharkov, E.A. and Pokrovskaya, I.V., Regional Tropical Cyclogeneses in the Field of World Ocean Surface Temperature, *Issled. Zemli Kosmosa,* 2010, no. 2, pp. 54–62.

Sharkov, E.A., Remote Investigations of Atmospheric Catastrophes, *Issled. Zemli Kosmosa*, 2010, no. 1, pp. 52–68.

Sharkov, E.A., Kim, G.A., and Pokrovskaya, I.V., Evolution of Tropical Cyclone Hondo in the Field of Equatorial Water Vapor Using the Multispectral Approach, *Issled. Zemli Kosmosa*, 2011a, no. 1, pp. 22–29.

Sharkov, E.A., Kim, G.A., and Pokrovskaya, I.V., Energetic Features of Multiple Tropical Cyclogenesis by Multispectral Satellite Observations, *Issled. Zemli Kosmosa*, 2011b, no. 2, pp. 18–25.

Shramkov, Ya.N., Sharkov, E.A., Pokrovskaya, I.V., and Raev, M.D., A Database of Tropical Cyclogenesis and Global Field of Water Vapor using the Object-Relational Technology, *Issled. Zemli Kosmosa,* 2010, no. 6, pp. 52–58.