《天文与地球科学杂志(ISSN 2958-4043)》
Journal of Astronomy and Earth Sciences (ISSN2958-4043)



ChengZhu Science™

Serial in November, 2022

ChengZhu Science Research Center Limited

(Hong Kong Registration NO. 80561228)

Journal article DOI is registered via JiangXi Province ChengZhu Environmental Engineering Company Ltd, with Crossref membership (DOI prefix 10.58473)

出版人： 刘焕 香江出版社有限公司

Publisher: Liu Huan, Xiangjiang Publishing Company Ltd.

ISSN 2958-4043



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Article 7. Discussion of Tornado Formation Mechanism

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DOI: https://doi.org/10.58473/JAES0007

Formally published on 15/11/2022; Latest revised on 28/09/2026.

Abstract

This article discusses the tornado formation mechanism from the perspectives of atmospheric chemistry and physics, with emphasis on the boundary layer and lightening occurrence, and future research gaps in tornado prediction are pointed out.

Key words: Tornado Formation, Atmospheric Physics, Atmospheric Chemistry, Magnetism, Charged Particles.

1.Introduction

Tornadoes are a violent disaster in nature, destroying the biosphere on earth. The summaries below are the discussion of tornado formation in the past research firstly. Then the original viewpoints are presented next for the future atmospheric research understanding and forecasting the tornado formation.

So far, the majority of research focuses on the meteorological physics process of tornado formation, which discusses the transport, motion, forces of atmosphere substances. A small proportion of research emphasizes on the electromagnetism resulting in the vortex of air convection as complement to the meteorological physics studies. However, so far rare research specifies the air pollutants leading to charged particles in aerosols adhering to clouds, further resulting in more incidents of tornado, which has been substantially discussed in this article for future development in tornado forecasting study.

2.Formation Stages of Tornadoes

Tornadoes are the consequences of thunderstorms in clouds. Specifically, tornado is a form releasing the concentrated and huge energy of thunderstorm in a small part of clouds. The formation of tornado can be differentiated into four stages [1][2][3]:

Firstly, the unstable troposphere generates a strong updraft, which is further strengthened by the Max air flow crossing the jet stream;

Secondly, due to the interaction with the shear wind in vertical velocity and direction, the updraft stream begins to rotate in the middle of the troposphere, leading to a mesoscale cyclone;

Thirdly, with the development of upward extension in mesoscale cyclone, it becomes thinner and stronger, when a small area of enhanced convergence zone is formed as the tornado core in the middle of cyclone by the same process;

Fourthly, the rotation in the core of a tornado is strong and intensive enough to make the tornado extending to the ground. When the vortex air flow reaches the ground level, the air pressure drops fast and the wind speed rises sharply, forming a stronger tornado.

3.Characteristics of Tornadoes

The tornadoes are classified into non-super-cellular convection and super-cellular convection, with the dominant occurrence as super-cellular [2][6]. The common characteristics of tornadoes are discussed below:

Firstly, the suddenness of both formation and disappearance of tornadoes are the first character [4].

Secondly, tropical cyclones are compared and contrasted to characterize the tornado. For the horizontal characters, the diameter of the eyewall of the tropical cyclone ranges from 100 km to 300 km, while the diameter of the tornado spiral inside the cloud clusters is from 1 km to 10 km, which is much smaller; for the vertical characters, the diameter variation rate from the root to the top of the tropical cyclone is short, with the height of 10 km to 14 km, whereas the diameter variation rate of tornado spiral is much larger with the "elephant trunk" near the ground level extended to the top of the cloud cluster [4].

Third, the speed of a tornado. Although the atmospheric volume of tropical cyclones is 10-100 times higher than tornado, the surface wind speed generated by tornado is much higher than tropical cyclones. The wind speed near the surface of tropical cyclone usually reach 54m/s, with the extreme value of 70m/s. In comparison, the surface wind speed of tornadoes can often reaches more than 120m/s, and the extreme wind speed can exceed 200m/s [4].

4.Meteorological physics explaining tornado formation process

Tornado is a type of violent weather phenomenon, which is formed by air flow that rotates rapidly and has a vertical hollow tube structure. Usually its formation is related to low air pressure and rotating wind direction [4][5].

Tornadoes often occur in unstable air flow with highly spatial difference in temperature and humidity between the top atmosphere and ground level, consequently resulting in the disturbed flow in atmosphere. When the temperature on the ground is about 30 ℃, it has dropped to - 30 ℃ at an altitude of 8000 meters. This temperature difference causes the cold air to drop sharply, while the hot air to rise rapidly, leading to the turbulence convection between the upper and lower atmosphere, thus forming vortex flow at small scale. When these small vortices gradually expand, coupled with intense turbulence, it is to form large vortex, becoming big damages against the ground or the sea. From the perspective of meteorology, the reason for the formation of tornadoes is summarized as the sharp temperature difference between the upper and lower clouds, and then a small vortex is caused by the convection with cold air falling and hot air rising, when there are cotton like white clouds in the sky, further developed into cumulonimbus clouds. The latent heat inside the cumulonimbus continues to heat up, strengthening the speed of airflow as vortex [4]. The discussion below is the simulated process of vortex in Lab to further explain the tornadoes formation.

5.Simulation of Cyclone in Lab for Tornadoes Formation

There are four preconditions for the formation of tornadoes (cyclones), which can be simulated in experiment. Firstly, free form water vapor; secondly, low ambient temperature (generally below 0 ℃); thirdly, the variation in atmospheric pressure between inside and outside the cumulonimbus clouds; fourthly, formation of Coriolis force. When lightning occurs between cumulonimbus clouds, all the preconditions can be met at all the locations of this earth planet [4].

A cyclone is a moist vortex with a large amount of high temperature water vapor inside the vortex surrounded by low temperature air outside, so that it is a type of moisture vortex with condensing and accelerating force on the outer edge of the vortex [4].

Because of the lower temperature air (generally the temperature is below 0 ℃ where tornadoes occur) outside the moist vortex, the higher temperature water vapor in the rotor condenses on the outer edge, and the part of condensation of water vapor leads to the transitional contraction at the edges. When a certain amount of water vapor is completely transformed into liquid water, the volume will shrink and decrease to 1 / 1800 of the original air volume (under the condition of temperature at 100 ℃, and the standard pressure measured by Gai lusack). As the pressure near 0 ℃ temperature is approximately 50% of standard pressure, so that the volume of water vapor is twice than that under standard pressure. When the other conditions remain the same, the contraction caused by condensation is doubled. Under this condition, the condensed water vapor is filled by the outer atmosphere around the condensation area, as the pressure inside the cyclone is lower than the pressure outside. Consequently, the external atmosphere accelerates the speed of vortex flow [4].

Usually in the normal conditions, at the height of cumulonimbus clouds under the atmospheric temperature below 0 ℃, there is generally no free-form vapor. However, the lightning in cumulonimbus clouds significantly and sharply increases the water vapor volume in air. There are two processes: firstly, lightning sharply heats the air temperature to 10000-20000 ℃, leading to air expansion into 33 times higher volumes than before lightning; secondly, the micro droplets and micro ice crystals in the cloud cluster are vaporized by lightning, further resulting in the volume expansion by 60000 (1800x33) times. Both the magnitude and intensity of the two types of expansion are positively correlated with the volume of lightning [4].

Thirdly, the condensed phase of water vapor on the outer edge, which leads to lower pressure than inner atmosphere in the vortex flow, is also filled by the inner air. However, the air pressure inside the cyclone is lower than outside the cyclone, so the intensity of the inner filling flow is less than that of the outer filling flow [4].

In summary, the explanation above is mainly from the viewpoints of meteorological physics, focusing on the transport, motion and forces of atmospheric substances. However, the research above ignores the forces imposed by earth magnetism and polarized charge cloud, which is further complemented below:

6.The Magnetism and Electrics Explanation for The Tornado Formation

Peng (2010) analyzes the causes of tornadoes from the viewpoint angle of both static earth magnetism and charged free-form electrons in clouds [7]. After the cloud is exposed to strong sunlight, the water molecules in the cloud or other molecules in the air trigger the photo-chemistry reaction process, yielding electrons with highly escaping energy. Under the effects of the earth's electrostatic field, these high-energy electrons get rid of the constraints of molecules, becoming free electrons. When these free-form electrons gradually separates between the top and bottom of the cloud, leading the cloud to a polarized charged cloud. Zhang (2003) has also explained the tornado formation as the vortex shape of magnetism lines leading to the wind shear causing cyclones in vertical convection[8].

Peng (2010) explained the polarized charged cloud as following viewpoints: under the strong sunlight, the atmospheric pressure changes regionally, resulting in atmospheric convection and wind, which accelerates the horizontal flow of clouds. Due to the huge volume of large clouds, the flow velocity of clouds differed between the top and bottom. When the horizontal wind force exceeds the gravity between the upper and lower clouds, the wind can separate the top clouds from the bottom clouds. The upper cloud becomes positively charged cloud, while the lower cloud becomes negatively charged cloud. In this way, the charged cloud generates static charges.

Peng (2010) and Zhang (2003) viewpoints further explain the forces underlying the wind shear, forming vortex convection as complementary knowledge to previous research. However, both research have not fully discussed the meteorological conditions resulting in the cyclone formation in nature. Moreover, Peng (2010) and Zhang (2003) research have not specified the atmospheric chemistry substances causing the electric particles, which is further discussed below in my article:

7.Atmospheric Photo-Chemistry Causing Charged Particles

7.1.N_2, O_2 and O_3 in the atmosphere selectively absorb solar radiation of short waves, which triggers the photo-chemistry reactions [9][10]:

$N_2+hv\rightarrow N+N$ Absorbing solar radiation with wavelength $\lambda<120$ nm

$O_2+hv\rightarrow O+O$ Absorbing solar radiation with wavelength $\lambda<240$ nm

$O_3+hv\rightarrow O2+O$ Absorbing solar radiation with wavelength $\lambda=220\sim290$ nm

The atmospheric pollutants of NO_2, SO_2, alkyl nitrous acid (rono), aldehydes, ketones and alkyl peroxides (roor ') can also generate photochemical reactions:

$NO_2+bv\rightarrow NO\cdot+O$
HNO_2（HONO）$+hv\rightarrow NO+HO\cdot$
$RONO+hv\rightarrow NO\cdot+RO\cdot$
$CH_2O+hv\rightarrow H\cdot+HCO$
$ROOR'+hv\rightarrow RO\cdot+R'O\cdot$

The above air pollution species generates photo-chemistry reactions under the solar radiation of wavelengths between 300～400 nm.

However, the above research does not include the chemical substances causing ozone depletion in atmosphere, which is further summarized below:

7.2.When ozone reacts with H, OH, NO, Cl and Br, it will be catalyzed and decomposed into O_2. Chlorofluorocarbons are considered as chemical substances that destroy the ozone layer because they decompose Cl and Br atoms under hv solar radiation, and the photo-chemical reaction formula is below [11][12]:

$CCl_3F \rightarrow CCl_2F\cdot + Cl\cdot$
$Cl\cdot + O_3 \rightarrow O_2 + ClO\cdot$
$ClO\cdot + O\cdot \rightarrow Cl\cdot + O_2$

$RBr \rightarrow R\cdot + Br\cdot$
$Br\cdot + O_3 \rightarrow O_2 + BrO\cdot$
$BrO\cdot + O \rightarrow Br\cdot + O_2$

$NO + O_3 \rightarrow NO_2 + O_2$
$NO_2 + O\cdot \rightarrow NO + O_2$

7.3.It is reported that secondary aerosols were significantly associated with the photo-chemistry reactions in air pollutants, and consequently PM_1 is considered as the indicator to evaluate photo-chemistry pollution[13]. This findings reveals that the charged free-form atoms, generated in photo-chemistry reactions, usually adhere to ultra fine particles in atmosphere, rather than gaseous form. It is further deduced in my article that this finding is especially important for the monitoring research in cloud to relate the photo-chemistry pollutants with the tornado incidents.

8.Discussion for further development

Original viewpoints are discussed in my previous articles, which is listed (section8.1-8.4) below [14], but more research gaps in atmospheric chemistry and physics have been further discussed finally.

“The formation mechanism and causes of tornadoes/geological faults can be easily deduced after fully understanding the mechanism of substance boundary layer formation [15] and the dark matter theory [16] in the fourth dimension space discussed in this journal. It can be summarized as follows (taking tornadoes as an example) [14]:

8.1.The rupture of substance boundary layer

The neutral substance layer in the middle between yin (negative) and yang (positive) poles can be easily formed on the substance boundary between different densities or compositions of substances in the atmosphere, and the neutral substance layer blocks the transport of polar molecules, thus forming the boundary and stratification of the atmosphere [15]. This leads to significantly different potential energy between different atmospheric layers along the boundary, and this difference in potential energy can be caused by different atmospheric pressure, density or electric charges between both sides of the boundary. If the boundary of the atmosphere suddenly ruptures, the layer with higher atmospheric potential energy will release the airflow energy to the layer with lower atmospheric potential energy, thus forming a vortex flow [14].

8.2.Amplifying by nuclear energy

In my previous article [16], the relationship between van der Waals force and dark matter has been discussed to reveal the effect on electric conductor, caused by the adhesion force of dark matter on the fourth dimension axis. Due to the neutralization of electric charges, the electric field effect of neutral boundary layer is weaker, and correspondingly the adhesion force of dark matter underlying neutral boundary layer is stronger so that the free electrons’ motion of cutting the fourth dimension is

restricted. In comparison, under UV irradiation condition, the photochemical reaction produces the free charged atoms which are highly unstable, which is much less influenced by dark matter. When massive free charged atoms penetrate the rupture space of the neutral boundary layer, driven by the difference in potential energy between boundary layer, the dark matter suddenly and sharply increases the adhesion force against the free-form charged atoms at transient time, to make the whole substance layer maintain its inertia and stable form. This instantaneous increase in the adhesion force of dark matter on the fourth dimension makes the mass of micro-particles in three-dimensional space instantly reduced, so that this nuclear fusion releases nuclear energy according to the mass-energy conversion Law, which amplifies the energy of natural disaster. Therefore, the accumulation in the electric charged particles of free state between different sides of the substance boundary layers should be one of the compulsory conditions leading to the releasing of nuclear energy, amplifying the energy of air vortex flow. Tornadoes are evolved from local scale, small wind to intercontinental scale, strong wind, or geological disasters are evolved from local shaking to the displacement at geological plate level, both of which are closely related to this condition [14].

This formation mechanisms/causes of tornadoes, which is also applicable on the collapse of geological faults leading to geological disasters, is a sudden, occasional, and unforeseeable event. However, future research should focus on the pre-conditions triggering the releasing of nuclear energy: in which meteorological/geological conditions, does dark matter suddenly shift? Consequently, this paper further discusses below [14]:

8.3.Atmospheric chemistry and particle charges

Taking atmospheric stratification as an example, it is to discuss the potential energy difference on both sides of the atmospheric boundary layer, which is due to the difference in electric charges. Firstly, the destruction of the ozone layer is likely to be one of the significant reasons for the increased probability of tornado events, in which ozone molecules produce free-form ozone atoms with positive charges under ultraviolet light, thus destroying the neutral substance layer in the atmospheric boundary layer, increasing the probability of sudden rupture on the boundary layer; Secondly, Cl chlorine atoms in atmospheric pollutants are also likely to be one of the reasons for the increased probability of tornado events, as chlorine atoms under ultraviolet light produce free-form chlorine atoms of negative charges. Together with the positive charges of ozone atoms above, both reasons increase the electric charge difference between both sides of the atmospheric boundary layer, which is likely to cause higher energy potential differences on both sides. Further more, the potential energy difference between positive and negative charges along atmospheric boundaries causes lightning events, whose occurrences usually increase significantly over the tornado events, so that this evidence further supports these causing factors [14].

8.4.Air pollution and tornadoes

The atmospheric pollutants, adhering to different clouds, produce free-form charged atoms with different electric charges in the photochemical reaction, resulting in the electric potential difference between different clouds, triggering lightning events. Consequently, the atmospheric pollutants increase the incidence of lightning between the different clouds, so that it increases the occurrences in tornadoes.[14]”

8.5.Boundary layers and equipotential shielding effect

My another article has proposed that “the boundary layers in the atmosphere of our earth planet also become the equipotential line layers of our planet, and the generated equipotential shielding effect causes charged substances in the outer spaces to conduct relative motion parallel to the stable boundary layers (such as stratosphere in atmosphere), while the breaking of boundary layers tends to result in the convection motion vertical to the boundary layers (such as troposphere in atmosphere).[15]” In the troposphere, one of the common boundary layers should be the clouds’ layer. When the clouds cluster, the boundary layers form; when the clustered clouds diffuse, the boundary layers break. Consequently, the meteorology conditions of vertical convection frequently occur in the troposphere. Taking ‘Urban Heat Island Effect’ as an example, it is to analyze the relationship between boundary layers and meteorology conditions in detail:

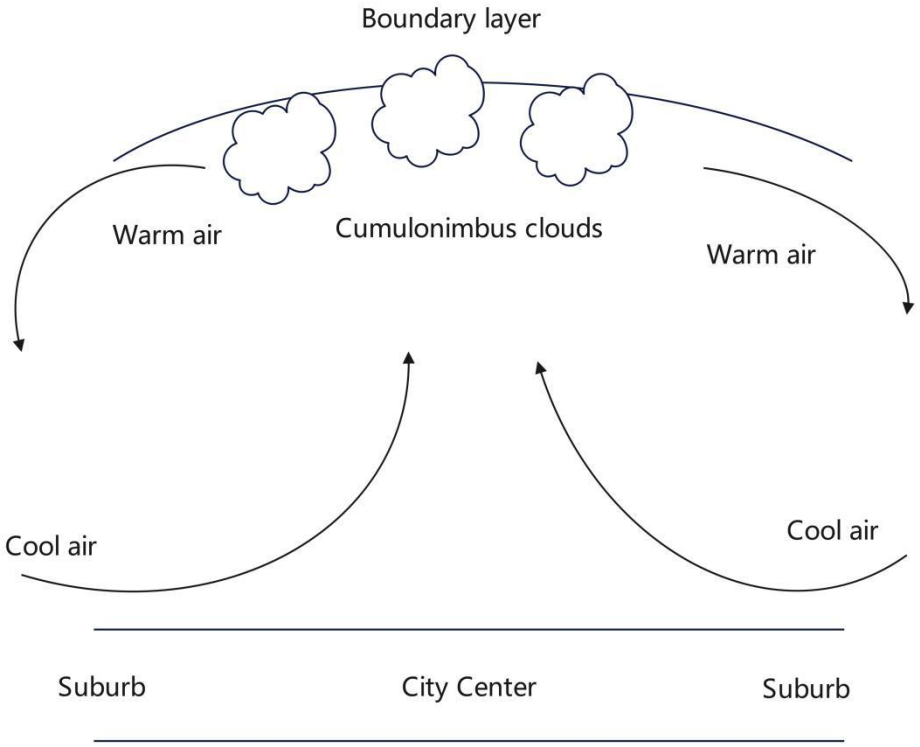

Figure 1. The heat islands effects in urban area.

As illustrated in Fig 1, the cool air transmits from suburb to city center due to the warmer temperature in city center; then the warm air goes upwards and forms cumulonimbus clouds due to the condensation effects; finally the air circulation motion is generated from the city center to the suburbs. The cumulonimbus clouds is considered as the atmospheric boundary layer over the city center. When the accumulated cumulonimbus clouds go upwards, the colder temperature leads to precipitation and this boundary layer starts to break, so vertical convection of air occurs (the colder air goes down while the warmer air goes up in the clouds diffusion zone).

Additionally, the generated equipotential shielding effect of atmospheric boundary layer should also reflect the radiation (such as UV-B) waves to the outer spaces of our earth planet and protect the earth ecosystem from radiation impacts.

8.6.Research gaps in atmospheric chemistry and physics

The atmospheric pollutants, adhering to ultra fine aerosols in clouds, produce free-form charged atoms with different electric charges in the photochemical reaction, resulting in the electric potential difference between different clouds, triggering lightning. Consequently, the atmospheric pollutants increase the incidence of lightning between the different clouds. However, so far the understanding of air pollution species, resulting in charged aerosols in clouds, is poor, which consequently becomes the research gaps/blanks to fill in for the future development in forecasting tornado incidences. To achieve this, it is to relate the photo-chemistry air pollutants, summarized in this article above, with tornado incidents and lightning occurrences by monitoring the ultra fine aerosols in cloud. The monitoring indicators mainly include the concentration of each air pollutants adhering to the ultra fine aerosols in clouds, the quantity in both the positive and negative electric charges collected in air samples, the meteorological conditions under which the charged aerosols would accumulate in clouds, and the occurrences in lightening incidences. To further characterize the forming conditions, it is to simulate the cloud photo-chemistry reaction in Lab to specify the positive or negative charged particles of free form, and the amount of charges generated by each air pollution species summarized in this article.

My another article has proposed that the high intensity of voltage imposed by lightning is the essential pre-condition to produce large amount of free-form charged ions, so the occurrence in lightning events should be utilized to predict tornado [17].

In most cases, tornado scale is the local scale only without evolved into intercontinental scale. There are two major factors causing the release of nuclear energy when the pre-conditions exceed the critical state value: firstly, the stability of neutral boundary layers is the pre-condition. The higher stability in neutral boundary layer, the stronger adhering force imposed by the dark matter in the fourth dimension, and eventually the more mass will be reduced in the three-dimension spaces. Secondly, the voltage potential accumulated between both sides of the boundary layers would be positively correlated with the nuclear energy releasing incidents. This mechanism is also applicable on earthquakes formation, which will be discussed in next article. Consequently, the simulation and monitoring of both pre-conditions would become the key to predict the destructive tornadoes and earthquakes in the future research.

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