A New Theory of Global Climate and Ecosystem Change Based on Planetary Orbital Variations

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Cover letter

About ten years ago, I did a lot of thinking about global climate and ecosystem changes, and then I wrote both an English and a Chinese paper to introduce my understanding of how planetary orbital changes affect Earth's meteorological changes. The papers are as follows:

[1] Mao K B, Ma Y, Xu T R, Liu Q, Han J, Xia L, Shen X Y, He T J, A new perspective about climate change. Scientific Journal of Earth Science, 2015, 5(1), 12–17.

[2] Mao K B, Zuo Z., Zhu G., Tang H., Zhao Y., Ma Y., Study of the relationship between global climate-ecosystem's change and planetary orbital position's change. High Technology Letters, 2016, 26(11), 890-899. (In Chinese)

In the following years, I conducted a lot of analytical research using remote sensing data on the spatiotemporal variations of global aerosols, global vegetation, global surface temperature, and global clouds, and obtained some interesting conclusions. For example, global temperature changes do not continuously rise with the increase in CO2, but rather fluctuate, and changes in global clouds, water vapor, and vegetation can regulate the spatiotemporal distribution of global temperature. Through these analyses, I realized that global clouds, atmospheric water vapor, global vegetation, and temperature changes can self-regulate, and the true driving factor behind their changes is planetary orbital variations. The papers are as follows:

[3] Mao K B, Ma Y, Xia L, Chen W Y, Shen X Y, He T J, Global aerosol change in the last decade: An analysis based on MODIS data, Atmospheric Environment, 2014, 94, 680-686.

[4] Mao K B, Li Z, Chen J, Ma Y, Liu G, Tan X, Yang K, Global vegetation change analysis based on MODIS data in recent twelve years, High Technology Letters, 2016, 22(4), 343-349.

[5] Mao K B, Chen J M, Li Z L, Y. Ma, Y. Song, X. Tan, K. Yang, Global water vapor content decreases from 2003 to 2012: an analysis based on MODIS Data, Chinese Geographical Science, 2017, 27(1), 1-7.

[6] Mao K B, Ma Y, Tan X, Shen X, Liu G, Li Z, Chen J, Xia L, Global surface temperature change analysis based on MODIS data in recent twelve years. Advances in Space Research, 2017, 59: 503-512

[7] Mao K B, Yuan Z, Zuo Z, Xu T, Shen X, Gao C, Changes in Global Cloud Cover Based on Remote Sensing Data from 2003 to 2012, Chinese Geographical Science, 2019,29,2, 306–315.

In the past few years, I instructed my graduate students to construct a neighboring differential model based on my ideas to eliminate the influence of internal variations of the Earth. We calculated and predicted the impact of Earth's orbital changes on temperature and water vapor changes. The paper is as follows:

[8] Cao M., Mao K., Sayed M. B., Chen J., Heggy E., Kug J., Shen X., Evaluation and prediction of the Effects of Planetary Orbital Variations to Earth's Temperature Changes, EarthArXiv, 2024, 12, DOI: https://doi.org/10.31223/X52T56.

[9] Xu L., Mao K., Sayed M., Cao M, Dube T., Guo Z., Abiodun B., Yuan Z., Maaza M., Influence and Prediction of Planetary Orbital Changes on Earth's Atmospheric Water Vapor Variations, EarthArXiv, 2025, 1, DOI: https://doi.org/10.31223/X5CM69.

After more than a decade of deep reflection, I believe that humanity's understanding of climate and ecosystem changes has been too rigid for too long, making significant breakthroughs difficult. For thousands of years, humans have been accustomed to the Sun rising in the east, setting in the west, and the changes in the four seasons. However, people have not realized that these periodic changes or fluctuations are essentially climate changes, and are also driven by planetary orbital variations. Traditional theories usually focus on Earth's internal factors and human activities (such as greenhouse gas emissions, land use changes, etc.) as influences on climate. However, I believe that if we take a more macro perspective, considering the solar system or even larger celestial systems, Earth's daily and seasonal

temperature fluctuations, climate cycles, and even the alternation between ice ages and interglacial periods on geological time scales, are primarily driven by the positions of planetary orbits and changes in their gravitational and magnetic fields. Earth's temperature, atmospheric water vapor cycle, vegetation changes, cloud distribution, ocean currents, and major natural events such as earthquakes and volcanic eruptions can all be seen as the Earth's internal regulatory processes adapting to external orbital changes. The emergence of life and biological evolution are also the results of orbital evolution and the active adaptation of Earth's internal layers.

Building on previous research, we propose a new theory of global climate and ecosystem change with a broader perspective, centered around the evolution of planetary orbits— the "Maos Theory of Global Climate and Ecosystem Change." This theory emphasizes that Earth's climate and ecological patterns at every moment are primarily dominated by orbital factors within the solar system and larger celestial systems. Earth and its various layers are merely passive responses and self-regulations to the combined effects of these external forces. In contrast, the rise in carbon dioxide (CO_2) concentrations caused by human activities is simply an additional factor superimposed on Earth's temperature changes and is not the fundamental driver of climate evolution. The new global climate and ecosystem theory will be built upon a theoretical framework that covers the entire chain of "external planetary drives - internal Earth feedbacks - ecosystem succession." This new theory will expand human understanding of the nature of Earth's climate change and provide a new coordinate system for recognizing natural disasters and species evolution from the perspective of long time scales and a global view. Understanding the Earth's evolutionary patterns under the influence of the planetary system is of monumental significance for formulating sustainable ecological and environmental management policies and improving disaster prediction and early warning mechanisms.

This original work will comprehensively open up how we consider the impact of planetary orbit changes in climate change research, making these three studies a milestone. Due to the editors and reviewers' lack of familiarity with research in this area, they are currently unable to make accurate judgments. Therefore, we have decided to first submit our paper to EarthArXiv, which provides a great platform for showcasing highly innovative research that is difficult to recognize at the moment, promoting progress and communication in new research directions. Many thanks for them and for you.

A New Theory of Global Climate and Ecosystem Change Based on Planetary Orbital Variations

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Abstract: Traditional climate change research has primarily focused on internal factors of Earth, particularly the impact of human activities on greenhouse gas emissions. This paper proposes the "**Mao's Theory of Global Climate and Ecosystem Change Based on Planetary Orbital Variations**", which suggests that changes in Earth's climate and ecosystems are primarily driven by the orbital variations of external celestial bodies. Earth's revolution around the Sun and its rotation determine seasonal transitions and day-night alternations, while climate evolution on other timescales is closely linked to changes in planetary orbital positions. The change in the planetary orbit position directly affects the Earth's temperature and atmospheric water vapor distribution, thereby governing the spatiotemporal evolution of ecosystems. The study finds that spatiotemporal variations in water vapor and temperature play a key role in global vegetation distribution and have a regulatory function on the greenhouse effect, partially offsetting the warming effects of carbon dioxide and demonstrating Earth's self-regulation capacity in response to temperature changes. Further analysis suggests that phenomena such as geomagnetic reversals, plate tectonics, and earthquakes are also related to the orbital variations of the Sun and other celestial bodies, with the emergence of life and biological evolution being active adaptations to orbital evolution and the Earth's internal spheres. Therefore, this theory offers new perspectives and methodologies for studying climate change and the spatiotemporal evolution of ecosystems, expanding new directions for climate prediction, disaster early warning, and species evolution research, and holds significant implications for future studies of climate and ecosystems.
Keywords: Climate change, ecosystem, planetary orbit, global climate and ecosystem

1. Introduction

Global climate change and its impact on ecosystems have become one of the central issues in scientific research and societal concern today. With the continued rise in global temperatures, the frequent occurrence of extreme weather events, the rapid melting of glaciers, and significant sea level rise, climate imbalances are posing a severe threat to the Earth's ecological environment and the sustainable development of human society. Traditional theories generally regard greenhouse gas emissions caused by human activities as the primary driver of climate change, and significant progress has been made in explaining modern warming, providing a basis for countries to develop energy-saving and emission reduction policies [1]. However, with ongoing observations and research, an increasing amount of evidence suggests that Earth's climate change is not solely determined by internal factors, and the movement and orbital variations of external celestial bodies also significantly influence the long-term evolution of the Earth's climate system [2][3].

In traditional research frameworks, the accumulation of greenhouse gases, atmospheric and oceanic circulations, and volcanic activity are considered key factors driving climate fluctuations on relatively short timescales [1]. However, when faced with significant phenomena such as geomagnetic reversals, plate tectonics, and the alternation between ice ages and interglacial periods on timescales of tens of thousands to millions of years, these internal factors often fail to provide sufficient explanations. Some scholars have extended their research perspective to solar activity, such as the impact of sunspot numbers on solar radiation intensity, attempting to reveal the regulatory role of external factors on climate. Meanwhile, the Milankovitch cycles, by examining the periodic variations of orbital parameters such as Earth's eccentricity, obliquity, and precession, provide a theoretical basis for the alternation between ice ages and interglacial periods. According to the Milankovitch cycles, changes in Earth's orbit occur on scales of approximately 23,000, 46,000, and 103,000 years, altering Earth's relative position to the Sun and the amount of solar radiation received [4][5]. These parameter changes not only affect the spatial distribution of surface temperatures but also have profound effects on atmospheric and oceanic circulations, which in turn influence the evolution of global climate on million-year timescales. However, traditional views lack systematic arguments on how changes in the orbits of external celestial bodies trigger or accompany internal processes of the Earth (such as plate movements or geomagnetic reversals), making it difficult to fully explain the periodic fluctuations of Earth's climate on larger spatial and temporal scales, and its coupling with geological activities. At the same time, climate change has profound effects on the spatiotemporal distribution of global ecosystems [6]. Changes in temperature and precipitation patterns often lead to the reorganization or even extinction of species' habitats, prompting significant structural and functional transformations within ecosystems. For example, in the case of rising temperatures, species in high-latitude and high-altitude areas will migrate further toward higher latitudes or altitudes; whereas in cooling scenarios, species adapted to warmer environments may spread toward lower latitudes or altitudes. Studies have shown that the distribution of water vapor and vegetation succession play a key role in this process: water vapor is directly coupled with temperature and is regulated by atmospheric processes such as oceanic circulation and storm systems; vegetation changes can feedback to local and regional climates. The dynamic balance between the two can partially mitigate the greenhouse effect caused by $CO2$, reflecting the Earth climate system's self-regulation capability [6][7][8].

Although the carbon dioxide emitted by human activities plays an important role in the global warming process, it cannot govern the fluctuations of Earth's temperature and water vapor on 24-hour or seasonal timescales, which are primarily determined by Earth's rotation and revolution [3]. Based on the principles of interpolation and extrapolation, we propose that fluctuations in Earth's temperature and water vapor over both shorter and longer time periods are also determined by planetary orbital variations. Human understanding of global climate change and ecosystem dynamics has long been confined to the belief that daily weather changes, as well as long-term climate changes, are the results of Earth's own long-term evolution. This study breaks with traditional thinking and introduces a new theory of global climate and ecosystem change based on planetary orbital variations. We argue that Earth's daily weather (climate) and the spatiotemporal changes in ecosystems are primarily the result of planetary orbital motions, while changes in Earth's internal systems are mainly responses to the orbital variations of the solar system and the Milky Way. Phenomena such as geomagnetic reversals, plate tectonics, and earthquakes are, in fact, primarily determined by the orbital motions of the Sun and other celestial bodies. Variations in planetary orbits directly influence weather (climate patterns), while ecosystem evolution is the process of adapting to these climate changes, resulting from the indirect influence of celestial orbital changes. The distributional changes of species across different latitudes and their migrations on Earth are the outcomes of ecosystems continuously adjusting to climate (orbital) variations. On this basis, we further hypothesize that the emergence of life might also be a result of orbital evolution. We will elaborate on and substantiate the proposed theory in the following sections.

2. Changes in Earth's Climate and Ecosystems on Different Timescales

2.1 Earth's Rotation Determines Daily Changes in Climate and Ecosystems

Throughout the long history of human civilization, the sunrise and sunset have been regarded as immutable natural phenomena. People have become accustomed to the alternation of day and night, often overlooking the core driving force behind this daily cycle—Earth's rotation. Earth completes one full rotation approximately every 24 hours, causing solar radiation to illuminate different regions of the surface at different times, thereby creating the day-night periodic variation [2][3]. It is this astronomical process that forms the foundation for the dynamic evolution of Earth's weather (climate) and ecosystems on a daily timescale. The day-night alternation caused by Earth's rotation directly leads to the periodic fluctuations in temperature and atmospheric water vapor [9][10]. If the orbits of Earth and other planets, such as the Sun, remain unchanged, Earth's temperature would remain relatively constant. Taking July 11, 2018, as an example, the variation in Earth's temperature and water vapor is shown in Figure 1. If only Earth rotates and all other planets remain stationary, global temperature and water vapor changes in 2018 would follow the pattern depicted in Figure 1. More analysis can be found in references [9][10]. The Earth's rotation causes the alternation between day and night, directly leading to periodic fluctuations in temperature and atmospheric water vapor. During the day, the side facing the Sun receives continuous radiation, causing a gradual increase in temperature and water vapor content. Conversely, the side facing away from the Sun loses energy at night, with significant radiative cooling from the surface, leading to a gradual decrease in temperature and water vapor content. This diurnal temperature difference not only reflects the uneven temporal distribution of solar energy but also represents the Earth's climate system adjusting to changes in solar radiation on a daily timescale. For ecosystems, the diurnal temperature difference and variations in daylight duration influence plant photosynthesis efficiency, animal activity periods, and the migratory and reproductive rhythms of insects, thereby shaping diverse biological survival strategies.

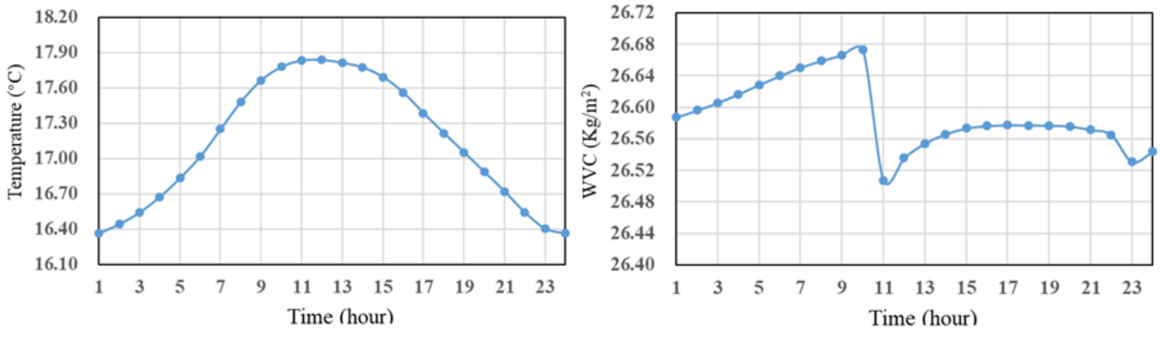


Figure 1. Daily Variations of Earth's Temperature and Atmospheric Water Vapor (July 11, 2018)

Meanwhile, the Coriolis force generated by Earth's rotation plays a critical role in determining the direction of atmospheric and oceanic flows. Due to the inertial forces induced by rotation, the flow of air and ocean currents in the Northern Hemisphere is deflected to the right, while in the Southern Hemisphere, it is deflected to the left, creating globally stable wind belts and ocean current patterns. These flow systems also exhibit corresponding changes on the daily scale and, together with the diurnal temperature difference, regulate the transport and exchange of heat and water vapor at Earth's surface, maintaining a relatively dynamic balance in local and even global climate patterns. Furthermore, the large heat capacity of the oceans results in more moderate diurnal changes in coastal regions compared to inland areas, further highlighting the interaction between the distribution of land and sea and the effects of Earth's rotation: the oceans absorb a large amount of heat during the day and release it slowly, while at night, they mitigate the sharp temperature drops along the coast; inland areas, with a relatively smaller heat capacity, experience larger diurnal temperature differences, making the ecological environment more susceptible to fluctuations in temperature. At different latitudes, due to variations in the angle of solar radiation and daylight duration caused by Earth's rotation, climate zones display distinct zonal characteristics: low-latitude areas receive more vertical or nearly vertical radiation during the day, accumulate more heat, and their ecosystems typically exhibit higher productivity; in contrast, high-latitude regions receive more oblique sunlight, with limited energy and lower temperatures, leading to simpler community structures and functions. However, this spatial differentiation is not fixed. As Earth orbits the Sun and seasonal transitions occur, this interacts with the diurnal variations induced by Earth's rotation, resulting in multi-layered and multi-scale patterns of climate and ecosystem evolution. Additionally, Earth's rotation does not solely regulate the physical aspects of climate; it also influences the micro-interactions between local organisms and their environment. Updrafts caused by radiation heating during the day, the increase in air pressure due to cooling and subsidence at night, and the daily variations in wind direction and speed all affect ecological processes such as plant transpiration, insect pollination, and animal foraging rhythms. The temperature differences between coastal and inland areas further shape local wind patterns, such as the day-night changes of sea breezes, which directly regulate the distribution of plankton and fish populations in nearshore ecosystems.

Earth's rotation is the fundamental driving force behind climate and ecosystem changes on a daily timescale. The alternation of day and night, temperature fluctuations, wind belts and ocean current deflections induced by the Coriolis force, and the differences in heat capacity between land and sea collectively determine the distribution of heat and water vapor across different spatial and temporal scales. These dynamic processes provide diverse environmental conditions for ecosystems, and biological species evolve behaviors and survival strategies to adapt to the diurnal changes. In other words, Earth's rotation not only governs the well-known "sunrise and sunset" but also profoundly shapes the daily fluctuations of the climate system and the rhythmic changes of ecosystems.

2.2 Lunar Revolution around Earth Determines Monthly Climate and Ecosystem Changes

The Earth's climate system is influenced not only by Earth's rotation and revolution around the Sun but also by the periodic disturbances caused by the Moon's revolution around Earth. The Moon's orbital period is approximately 27.3 days, and the gravitational interaction between the Moon and Earth plays a key role in this process, affecting ocean tides, atmospheric circulation, and subtle variations in Earth's rotational speed, thus regulating surface temperature and the dynamic evolution of ecosystems on a monthly timescale. The Moon's most direct impact on Earth arises from the tidal effects induced by its gravitational pull. The Moon's gravity not only causes periodic fluctuations in ocean water levels but also induces slight disturbances in Earth's rotation through tidal friction. These small variations in Earth's rotational period influence atmospheric and oceanic circulation patterns, leading to relatively regular fluctuations in the distribution of heat and water vapor on a monthly timescale. When the Moon is closer to Earth, tidal effects are amplified, and surface ocean temperature fluctuations become more pronounced. The rise and fall of seawater temperature not only alter the surface marine environment but also have cascading effects on the reproduction and distribution of marine organisms, such as plankton and fish. Figure 2 illustrates the changes in Earth's temperature and water vapor over the course of a month, a variation that results from the combined effects of Earth's rotation, the Moon's orbit, and Earth's revolution. In the absence of Earth's rotation and revolution, the changes would be highly regular. More analysis can be found in references [9][10].

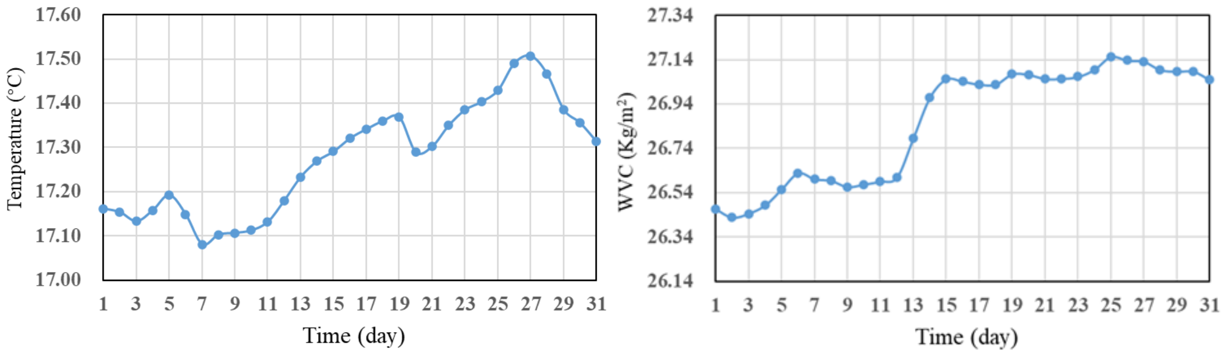


Figure 2. Intra-month Variations of Earth's Temperature and Atmospheric Water Vapor (July 2018)

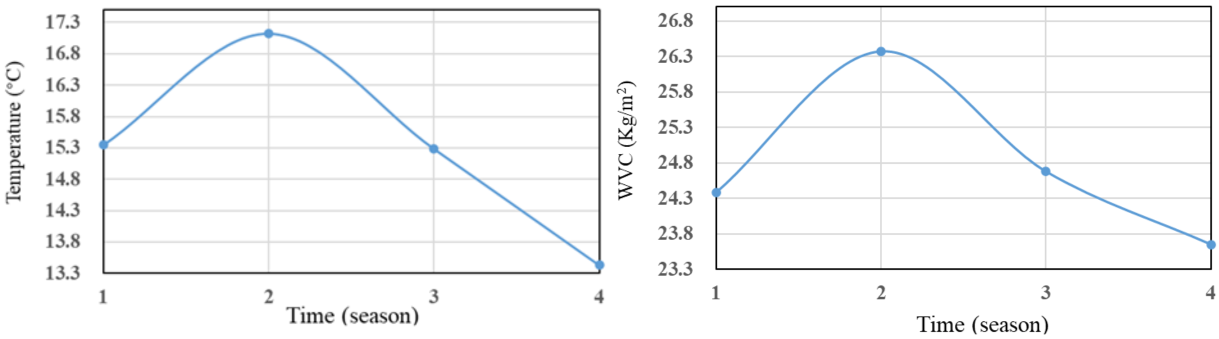
The combined effects of Earth's rotation, revolution around the Sun, and the Moon's revolution around Earth jointly determine climate fluctuations at the monthly timescale. The Moon’s gravitational pull, through ocean tidal effects and slight disturbances in Earth's rotation, alters the efficiency of heat transport in the atmosphere and oceans. When Earth's position in its orbit coincides with the Moon’s perigee or apogee, the patterns of heat and water vapor transport undergo phase adjustments, potentially leading to significant differences in temperature and precipitation during different stages of the lunar month. Particularly during periods of intensified tidal effects, the rate of heat diffusion or accumulation at the ocean surface is notably altered, triggering temperature responses in coastal and inland regions. For ecosystems, this monthly climate oscillation may cause slight shifts in species migration or reproduction cycles, with some species "capturing" these climate signals to optimize their survival strategies. The tidal movements induced by the Moon's gravity cause periodic changes in the temperature gradient between the upper and lower layers of seawater, also affecting the vertical transport of nutrients. For marine organisms that depend on specific temperature and nutrient conditions, this means that habitat conditions may shift monthly, resulting in periods that are either more favorable or less favorable, thus impacting the reproduction, growth, and distribution of populations. Large fish species may follow tidal changes to chase nutrient-rich waters, while high-density zones of plankton may emerge or move in areas where water temperature and nutrients are most suitable. This periodic ecological rhythm reflects marine ecosystems' response to the physical changes caused by the Moon's orbit, and over longer timescales, it will feedback into the evolution of marine food web structures and functions.

The impact of the Moon's revolution on atmospheric circulation is relatively less significant than its direct effect on ocean tides, but it should not be overlooked. As the Moon's gravitational pull changes periodically, subtle differences in atmospheric movement both horizontally and vertically emerge. For example, near-surface airflows adjust continuously due to land-sea temperature differences, and during intensified tidal effects, the rhythmic fluctuations of these temperature differences may amplify, causing local disturbances in wind belts. If seasonal wind belt shifts occur simultaneously or are triggered by extreme weather systems, this may lead to monthly-scale strong precipitation or drought events in some regions. Changes in precipitation patterns regulate vegetation growth, soil moisture, and hydrological processes in rivers and lakes, thus affecting the function and structure of terrestrial ecosystems. Climate changes on the monthly timescale usually manifest as secondary fluctuations in temperature and water vapor, but for certain sensitive species, these fluctuations can be crucial. The physiological rhythms of many plants and animals are linked to temperature, light, and tidal cycles. The Moon's perigee is often associated with stronger tides, which may trigger periodic flooding in coastal wetland ecosystems, affecting the reproduction of wetland plants and benthic organisms; it may also induce fluctuations in temperature and wind speed in local areas, causing slight adjustments in the migration and breeding times of birds or insects. These monthly-cycle-based ecological responses reflect species' ability to perceive and adapt to external physical environments, and may create cascading effects across broader ecological networks.

The Moon's revolution around Earth plays the role of a "fine-tuner" in Earth's climate system. Through tidal effects and disturbances in Earth's rotational speed, it brings periodic micro-adjustments to the transport of heat, water vapor, and nutrients in the atmosphere and oceans, thereby affecting land-sea climate and ecosystem dynamics on the monthly timescale. Although the impact of the Moon's revolution is relatively small compared to Earth's rotation and revolution around the Sun, its periodic characteristics are crucial for the life histories and ecological processes of many species. Further research into the linkage mechanisms between the Moon's orbit and climate and ecosystems will help us understand the global change process on a more refined timescale, providing richer scientific evidence for climate prediction, disaster prevention, and ecological conservation, as well as offering new research perspectives for understanding Earth's adaptive capacity and multi-scale interactions.

2.3 Earth's Revolution Around the Sun Determines Seasonal Changes in Climate and Ecosystems

The most significant seasonal changes in Earth's climate and ecosystems primarily arise from the variation in solar radiation caused by Earth's revolution around the Sun. Although Earth's orbital path is slightly elliptical, its eccentricity is small, and therefore, the variation in Earth-Sun distance has a limited impact on the seasons. In contrast, the tilt of Earth's axis, approximately 23.5 degrees relative to the plane of its orbit, is the key factor responsible for the alternation of the seasons. This tilt ensures that the Northern and Southern Hemispheres alternately receive more direct and prolonged solar radiation throughout the year, resulting in the periodic transition between summer and winter, and spring and autumn. Figure 3 shows the seasonal and monthly variations in Earth's temperature and water vapor. These changes are strikingly similar from year to year, indicating that the effects of Earth's rotation and revolution, along with the Moon's orbit, are consistent. More analysis can be found in references [9][10].



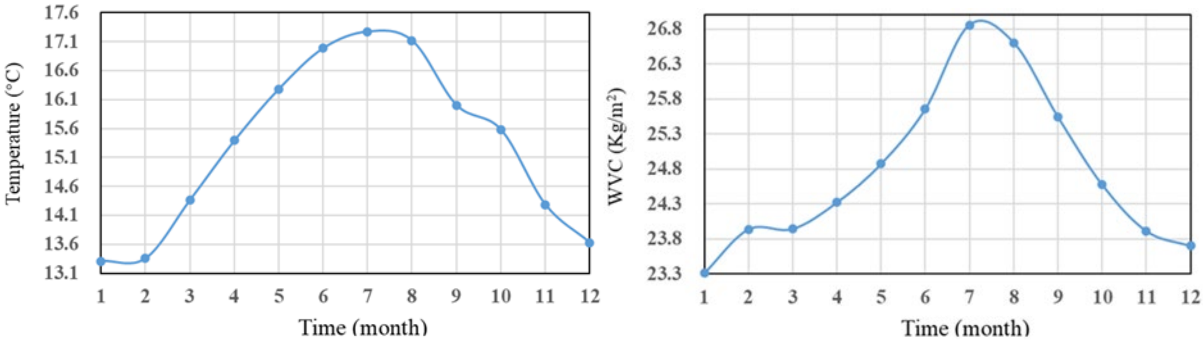


Figure 3. Seasonal and Monthly Variations of Earth's Temperature and Atmospheric Water Vapor (2018)

When the Northern Hemisphere tilts toward the Sun, the duration of daylight increases, and the solar zenith angle becomes larger, causing the amount of solar radiation received at the surface to increase, leading to rising temperatures in the Northern Hemisphere and the onset of summer. Meanwhile, the Southern Hemisphere receives relatively less radiation and is in winter. Half of Earth's orbital period later, the situation is reversed: the Northern Hemisphere enters winter, and the Southern Hemisphere enters summer. For Earth as a whole, this seasonal imbalance in heat distribution further shapes global climate zones and atmospheric circulation patterns. For example, the equatorial region receives intense solar radiation year-round, maintaining a hot and humid tropical environment, while high-latitude polar regions endure relatively low solar zenith angles and short daylight durations, resulting in cold polar climates. The seasonal temperature variations caused by Earth's revolution amplify or reduce the heat differences between the equator and the poles, thus affecting the atmospheric and oceanic circulation structures. During the warm season (typically summer), the temperature difference between the poles and low-latitude areas is larger, and heat exchange is accelerated through wind belts and ocean currents, triggering strong monsoon activity or shifts in ocean currents. During the cold season (typically winter), air movement becomes less active, the polar high-pressure systems intensify, and extreme weather events such as cold waves or snowstorms may occur in some regions. For the global climate system, this seasonal cycle constitutes the redistribution of heat between the atmosphere, oceans, and land, maintaining a dynamic balance of "heating-cooling" processes throughout the year.

At the same time, seasonal temperature fluctuations across different latitudes result in varying degrees of climatic characteristics: (1) Tropical regions: Due to the movement of the solar zenith near the equator, temperatures remain high year-round, but the distinction between wet and dry seasons is significant, closely related to the seasonal shifts in the subtropical high-pressure and equatorial low-pressure systems; (2) Temperate regions: Spring and autumn are typically moderate in temperature with balanced precipitation, while summer and winter exhibit more pronounced temperature extremes and precipitation fluctuations, resulting in a clear four-season climate pattern; (3) Polar regions: The phenomena of polar day and polar night, brought on by seasonal transitions, play a decisive role in temperature. During summer's polar day, although the solar zenith angle is low, long daylight hours still contribute to some local warming, while during winter's polar night, the region receives minimal radiation, resulting in the persistently cold polar environment for several months.

The seasonal changes induced by Earth's revolution around the Sun have profound impacts on global ecosystems. Firstly, temperature is a core factor controlling plant growth rhythms and animal activity cycles. With the change of seasons, plants germinate, flower, and fruit during favorable temperatures, while during colder periods, they enter dormancy or slow down their metabolic processes. For example, in temperate regions, when the climate warms in spring, most plants begin to grow rapidly, and animals also become more active. In autumn, when temperatures drop, deciduous plants shed their leaves, and some animals actively store energy in preparation for winter. Secondly, seasonal temperature fluctuations influence animal migration, reproduction, and foraging behaviors. Many bird species migrate to warmer regions before winter to avoid excessive energy consumption, and return to breeding grounds in spring when temperatures rise and food becomes more abundant. Certain mammals, such as bears or bats, hibernate during cold seasons to reduce metabolism and conserve energy. In tropical regions, despite relatively small annual temperature differences, the alternation between rainy and dry seasons significantly changes vegetation conditions and food availability, thus affecting the activity patterns and reproductive cycles of wildlife. Furthermore, seasonal changes can trigger extreme weather events, causing significant impacts on ecosystems. High temperatures in summer often accompany droughts, leading to rapid transpiration, water shortages, and crop failures; in combination with abnormal wind belt activities, this can result in heatwaves, wildfires, and other disasters. Extreme low temperatures in winter may cause widespread frost damage and snowstorms, leading to animal deaths or forcing large-scale migrations.

As seen, seasonal temperature fluctuations triggered by Earth's revolution around the Sun can rapidly alter species competition dynamics and ecosystem balance, sometimes even forcing ecosystems into phase reconfigurations. Additionally, seasonal temperature variations have significant effects on Earth's water and carbon cycles. Higher temperatures enhance water transpiration and evaporation, affecting soil moisture and surface water distribution; simultaneously, plants grow faster at higher temperatures, conducting more photosynthesis and absorbing large amounts of CO2, promoting carbon storage. During colder seasons, plant growth slows or stops, reducing carbon absorption, while soil respiration and the decomposition of organic matter also decrease, creating a different carbon balance state compared to the summer. As the seasonal cycle repeats, global ecosystems maintain a dynamic balance between carbon sequestration and release.

Earth's revolution around the Sun causes periodic variations in the spatial and temporal distribution of solar radiation, which in turn creates the alternating seasons and distinct climate patterns across the globe. These seasonal temperature changes not only directly shape the main spatial and temporal patterns of Earth's climate system but also have profound effects on the physiology and behaviors of plants and animals, determining species distribution, succession patterns, and the characteristics of carbon and water cycles within ecosystems. It is within this cyclical alternation of seasons, driven by Earth's revolution, that various forms of life evolve and adapt to the periodic changes in the external environment, creating a diverse yet harmonious dynamic balance in Earth's biosphere.

2.4 The Irregular Movements of Other Planets (Beyond Earth, the Moon, and the Sun) Around Earth Determine the Randomness of the Subtle Detail Changes in Earth's Climate and Ecosystems

Earth's climate change is not solely determined by internal factors such as rotation, revolution, and solar radiation. The gravitational forces and orbital disturbances exerted by other planets in the solar system, such as Mars, Venus, Jupiter, and Saturn, also have profound impacts on Earth's climate and ecosystems, particularly on interannual timescales. As observational technology and studies in celestial mechanics have advanced, it has become increasingly evident that the slight perturbations of Earth's orbit caused by massive planets, when combined with the influences of other celestial bodies, are sufficient to generate fluctuations in climate and temperature. Over the long term, this cumulative effect poses challenges to the stability of ecosystems and the dynamic distribution of species. Figure 4 illustrates the interannual fluctuations in Earth's temperature and water vapor. More analysis can be found in references[2][3][9][10]. As noted from the previous analysis, since Earth's rotation, revolution, and the Moon's orbit complete similar cycles each year, the variations from year to year are caused by the orbital changes of other planets. Due to the highly regular relative positions of Earth's rotation, revolution, and the Moon's orbit, their effects on Earth's temperature and water vapor are similarly regular. In contrast, the orbital variations of other planets and their positional changes relative to Earth are more complex. When these influences are combined, they cause highly irregular effects on Earth's temperature and water vapor, resulting in complex and fluctuating interannual variations in Earth's temperature and water vapor.

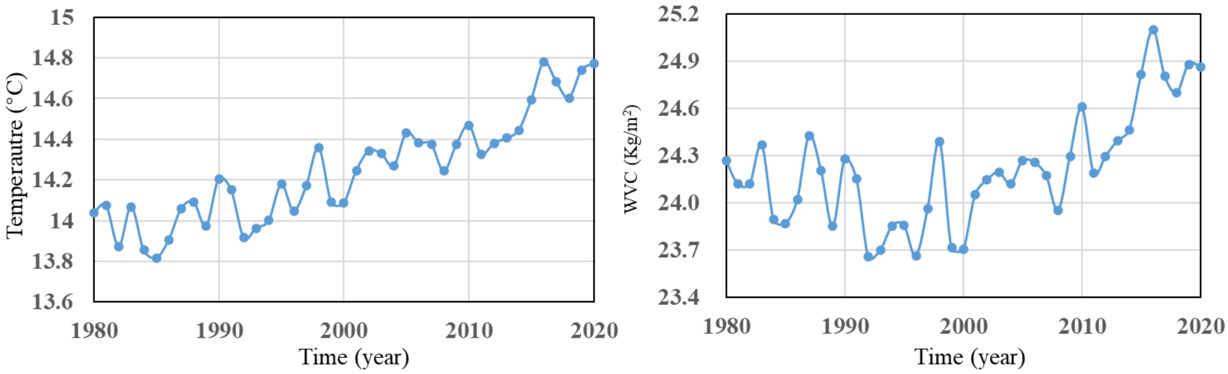


Figure 4. Interannual Variations in Earth's Temperature and Atmospheric Water Vapor

First, the gravitational forces of large planets such as Jupiter and Saturn, through mutual attraction between planets, cause subtle but significant changes in Earth's orbital path. These changes primarily manifest in small fluctuations in Earth's orbital eccentricity and axial tilt (the angle of the Earth's axis). When these parameters shift, the way and intensity with which Earth receives solar radiation adjust, thereby driving interannual fluctuations in seasonal temperatures and global wind patterns. For example, when Earth's orbital eccentricity increases, the difference in solar radiation received between different seasons and hemispheres is amplified, making extreme heatwaves, cold spells, or abnormal precipitation events more likely. Similarly, periodic changes in the axial tilt not only affect the distribution of sunlight across the seasons but also impact the temperature gradients between mid-latitude and polar regions, triggering new disturbances or reorganizations in atmospheric and oceanic circulation patterns. Next, the dynamics of planetary orbits also involve more complex phenomena such as "planetary conjunctions" and "orbital resonances." When two or more planets align in specific orbital configurations or cycle in harmony, their combined gravitational effects significantly enhance the disturbances in Earth's orbit. For example, when Jupiter and Saturn reach certain orbital resonance conditions, they can repeatedly exert pulling and pushing forces on Earth’s orbit over timescales of decades to centuries, causing noticeable cumulative changes in Earth's orbital eccentricity or axial tilt. Once these changes exceed a critical threshold, they may trigger chain reactions in Earth's climate system, such as accelerated expansion or retreat of polar ice sheets, reorganization of atmospheric circulation patterns, and even significant impacts on deep ocean currents. Furthermore, in addition to disturbing Earth's orbit, tidal effects from large planets also influence Earth's climate on finer interannual timescales. While the Moon's tidal effects on Earth's oceans are the most direct and visible, the gravitational forces of planets like Jupiter and Saturn also exert a degree of "tugging" on seawater distribution, ocean currents, and even atmospheric circulation. Although these tidal forces are much less significant than the Moon’s, they accumulate in sensitive regions such as ocean thermohaline circulation, the marginal seas of polar ice caps, and low-latitude storm zones. Once ocean currents alter their pathways of heat and nutrient transport, they can disrupt marine food web structures, and trigger interannual fluctuations in local temperature, precipitation patterns, and wind direction and speed. For fragile terrestrial ecosystems, these changes can introduce additional climatic pressures on local biological communities, causing shifts in species' reproduction and distribution ranges in response to interannual variations in temperature and precipitation.

At the ecosystem level, interannual temperature and precipitation variations particularly influence species reproduction and migration. Many plants and animals, especially those highly sensitive to temperature or precipitation, are forced to adjust their breeding cycles and habitat choices when significant interannual fluctuations in climate occur. For instance, when interannual temperature anomalies lead to mismatched distributions of food resources, species such as birds, fish, and pollinating insects may undergo large-scale migrations or breeding failures, thus disrupting the ecological balance in the short term. If this process persists or recurs, it can further trigger cascading effects across ecological networks, influencing broader biological communities and biogeochemical cycles. At the same time, in cases of climatic shifts or resource scarcity, invasive species or dominant species may accelerate their spread, displacing native species and bringing about profound structural changes in ecosystems. Moreover, the influence of large planets on Earth's climate is not limited to temperature; it also affects the interannual fluctuations of atmospheric circulation patterns. For example, when the relative positions of Jupiter, Saturn, and Earth change periodically, their gravitational fields can alter the pressure distributions at specific latitudes, leading to periodic shifts in the strength and location of the westerlies, trade winds, and subtropical high-pressure zones. This disturbance often interacts with Earth's internal climate oscillations, such as the El Niño-Southern Oscillation (ENSO) or the North Atlantic Oscillation (NAO), producing more complex interannual climate anomalies, which, in turn, affect the frequency and regional distribution of extreme weather events.

From a predictive and simulation standpoint, in-depth research on the effects of planetary gravitational and orbital evolution on Earth's climate not only helps uncover potential driving mechanisms behind long-term climate changes but also provides external factors for interannual or decadal climate forecasting. By combining celestial mechanics models with climate models, we can attempt to simulate the changes in Earth's orbital eccentricity and axial tilt induced by planetary disturbances, and thus infer the amplitude of fluctuations in solar radiation received at the Earth's surface over interannual or longer cycles. When coupled with atmospheric circulation and oceanic current data, we can produce more refined predictions of temperature, precipitation, and ecosystem responses. In the future, such studies may play a critical role in climate risk management, ecological conservation, and agricultural production planning.

In summary, although the gravitational and orbital disturbances from planets other than Earth, the Moon, and the Sun may seem "minor," their cumulative effects over time—particularly from large planets such as Jupiter and Saturn—have substantial impacts on Earth's climate and ecosystems. These disturbances, which combine with the effects of Earth’s rotation and revolution, and the Moon’s orbit, contribute to the daily weather variability, especially influencing surface temperatures, hydrological cycles, and species distribution patterns on interannual and longer timescales. The combined influence of these external bodies is irregular, mainly due to the complex positional variations of these planets relative to Earth. With the repeated addition of planetary orbital resonance and tidal forces, these disturbances may also interact with Earth's internal climate oscillation patterns, creating dual or even multiple drivers of global climate. Ecosystems, in response to the irregular interannual fluctuations, often experience complex adaptation or degradation processes, involving species migration, adjustments in breeding cycles, and community succession. By integrating research across celestial mechanics, climate science, and ecology, our understanding of Earth's multi-scale evolutionary processes will become more comprehensive, providing new scientific foundations for ecosystem management and protection in the context of global change.

3. Internal Climate Changes and Ecosystem Self-Regulation in the Earth System

While Earth's climate and ecosystems continuously adapt to external orbital changes of celestial bodies, they also achieve self-regulation through the coupling and feedback between the internal spheres of the Earth system. For planets with fewer satellites, the self-regulation of the internal spheres is particularly crucial. For example, Earth's atmosphere and water cycles achieve rebalancing in energy transfer, providing the possibility for the birth and maintenance of life. In contrast, planets lacking liquid water or an atmosphere can only rely on processes such as earthquakes to release internal energy and reach a relative equilibrium. This section will focus on the Earth's system's response to CO2 changes, the role of water vapor in climate regulation, and the impact of vegetation on the carbon cycle and regional water and heat conditions, and will explain the self-regulation capabilities of the Earth system on larger spatial and temporal scales.

3.1 The Impact of CO2 Changes on Earth's Climate and Ecosystems

Since the Industrial Revolution, the concentration of CO2 shown in Figure 5 released by human activities has significantly increased, and the accumulation of greenhouse gases in the atmosphere has had a substantial impact on Earth's energy balance [1][2][3]. Traditional views suggest that the increase in CO2 concentration in the atmosphere leads to a rise in Earth's surface temperature through the greenhouse effect, triggering global climate change. However, a large body of observations and research has shown that the climate system is extremely complex. In addition to CO2 concentration, factors such as changes in solar radiation, planetary orbital variations, ocean circulation, volcanic activity, and processes involving clouds and aerosols all significantly influence the climate and ecosystems. Therefore, when exploring the relationship between CO2 changes, climate change, and ecosystem responses, it is essential to consider various internal and external driving factors, as well as their nonlinear coupling interactions.

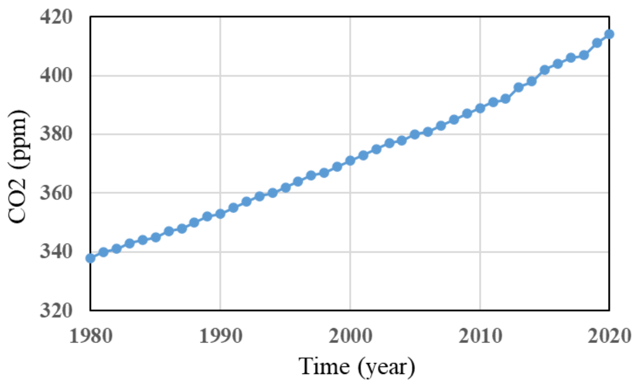


Figure 5. Interannual Variation of CO2 on Earth

3.1.1 The Greenhouse Effect of CO2 and the Complexity of Climate Response

CO2 plays a critical role as a greenhouse gas in the atmosphere: it absorbs and re-radiates longwave radiation emitted by Earth, slowing the heat loss to space and contributing to maintaining a suitable surface temperature. However, the daily and seasonal temperature changes at Earth's surface are primarily driven by Earth’s rotation and revolution around the Sun. As mentioned earlier, diurnal temperature fluctuations result from heating during the day due to solar radiation and cooling at night due to the lack of sunlight; likewise, the seasonal cycle is mainly driven by the axial tilt during Earth's orbit around the Sun, which changes the solar zenith angle and the length of daylight. From this perspective, changes in CO_2 concentration cannot fully explain the periodic temperature fluctuations caused by Earth's rotation and revolution.

Furthermore, while atmospheric CO_2 concentrations have continuously risen since the industrial era, observed global average temperatures have not shown a perfectly synchronized linear relationship with CO_2 increases. For instance, between 1998 and 2008, despite a continuing rise in CO_2 concentrations, the global average surface temperature showed a slowdown in its warming trend (often referred to as the "global warming hiatus"). This indicates that there are other significant regulatory or masking factors in the climate system (such as changes in ocean heat content, atmospheric water vapor, aerosols, solar activity, etc.), which have prevented the full manifestation of CO_2's warming effect during certain periods.

3.1.2 The Impact of CO2 Concentration Changes on Ecosystems

Earth's ecosystems exhibit multiple responses to changes in atmospheric CO_2 concentrations:

(1) Plant Photosynthesis and Carbon Sequestration Effects: CO_2 is a necessary substrate for plant photosynthesis. When atmospheric CO_2 concentrations increase, it generally promotes plant growth and biomass accumulation, enhancing the carbon sequestration capacity of terrestrial ecosystems. However, climate conditions such as temperature and precipitation can limit the practical realization of this "fertilization effect" and the response varies by region and vegetation type.

(2) Marine Ecosystems and Ocean Acidification: The oceans, by absorbing and dissolving CO_2 from the atmosphere, act as the largest carbon sink on Earth. However, when the oceans absorb excessive CO_2, carbonic acid is formed, lowering ocean pH and leading to ocean acidification. Ocean acidification threatens the survival and reproduction of marine organisms such as coral reefs and shellfish, subsequently affecting marine food webs and biodiversity.

(3) Ecosystem Balance and Extreme Weather Events: The continuous rise in CO_2 concentrations may not only alter global average temperatures but also trigger regional extreme weather events, such as heatwaves, droughts, heavy rainfall, and hurricanes. Extreme weather events pose potential shocks to forest, grassland, and aquatic ecosystems, affecting agricultural production and human living conditions.

3.1.3 Synergistic Effects with Planetary Orbital Changes

Although the influence of atmospheric CO_2 concentrations on Earth's climate and ecosystems is significant, on longer timescales and broader spatial scales, planetary orbits (including Earth's rotation, revolution, and other celestial bodies like the Moon) are the primary astronomical factors driving global climate evolution and large-scale ecosystem adjustments. Over the past hundreds of thousands of years, and even longer, the cycles of glacial and interglacial periods on Earth have been mainly driven by changes in orbital parameters and solar radiation distribution. In this context, changes in CO_2 concentrations often serve to "amplify" or "mitigate" climate variability:

(1) Orbital Drivers and Climate Feedbacks: When orbital changes alter the distribution of solar radiation, global temperature patterns adjust accordingly. Oceanic and terrestrial ecosystems respond to changes in temperature and precipitation patterns, which, in turn, modify the carbon cycle. For instance, transitions from glacial to interglacial periods are often accompanied by significant fluctuations in atmospheric CO_2 concentrations, further amplifying temperature changes.

(2) Multifactor Coupling and Nonlinear Responses: In addition to orbital drivers and greenhouse gases, other factors (such as volcanic activity, plate tectonics, ocean circulation changes, and ecosystem succession) also affect Earth's climate and ecosystems. There are complex interactions among these factors, which can either enhance or dampen CO_2's climatic effects in certain times and regions.

(3) Scientific Challenges in the Context of Rapid Contemporary Changes: Over shorter timescales of several decades to a century, CO2 emissions from human activities and other greenhouse gases become significant drivers of global climate change and ecosystem succession. However, compared to astronomical factors like millennial-scale orbital changes, this impact appears more localized and periodic. Accurately distinguishing the contributions of human activities and natural climate cycles at different spatial and temporal scales is one of the challenges facing climate science.

3.1.4 Implications for Future Research and Mitigation Strategies

Combining the study of CO2 concentration changes with planetary orbital evolution helps to fully understand the multiple drivers of the climate system and provides scientific reference for the future protection and sustainable use of ecosystems. In terms of mitigation strategies, it is necessary not only to reduce greenhouse gas emissions and increase carbon sequestration capacity, but also to fully recognize the long-term patterns of natural climate cycles and ecosystem succession. Comprehensive observations and modeling studies suggest that even if CO2 emissions are mitigated at a certain stage, changes in solar radiation distribution due to orbital variations may still dominate the deep, long-term evolution of Earth’s climate and ecosystems over thousands of years or longer. Therefore, when formulating policies to address climate change and ecological environmental protection, human society should consider both short-term and long-term perspectives, balancing the goals of emission reduction, adaptation, and ecological restoration.

3.2 Atmospheric Water Vapor as a Modulator of the Impact of CO2 on Earth’s Climate and Ecosystems

The role of greenhouse gases in the global climate system has attracted significant attention. In addition to carbon dioxide (CO2), water vapor (H2O) is also a key greenhouse gas that influences Earth’s energy balance and climate change. It not only absorbs and re-radiates infrared radiation, thereby intensifying the greenhouse effect, but also alters Earth’s energy budget and water cycle through the formation of clouds and precipitation processes. In recent years, to explore the climate system's response to the continuous increase of greenhouse gases such as CO2, some studies have been conducted [3][7], leading to progress both theoretically and observationally. However, observational data indicate that Earth's atmospheric water vapor content does not show a monotonous upward trend like CO2 concentrations, but instead exhibits overall fluctuations; similarly, long-term changes in Earth's surface temperature are not fully synchronized with the increase in CO2 concentrations. This fact indicates that, when understanding the impact of CO2 on Earth’s climate and ecosystems, we must also consider the "modulatory" role of atmospheric water vapor in the climate system, as well as the periodic temperature changes and self-regulation capacities driven by Earth's position in celestial orbits, its rotation, and revolution. Figure 6 illustrates the seasonal spatiotemporal variation of atmospheric water vapor on Earth as it orbits the Sun.

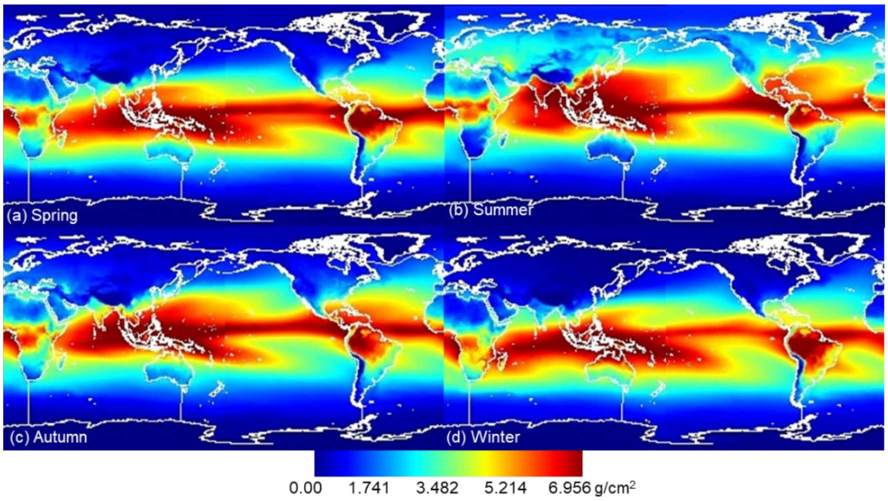


Figure 6. Variation of Atmospheric Water Vapor on Earth

3.2.1 The Greenhouse Effect of Water Vapor and Energy Budget

Water vapor is the most significant natural greenhouse gas, contributing more than 60% to Earth's greenhouse effect theoretically. Atmospheric water vapor maintains a relatively stable surface temperature environment by absorbing and re-radiating longwave radiation. When the concentration of water vapor in the atmosphere is high, infrared radiation outgoing from Earth is strongly absorbed by the water vapor, resulting in warming of the atmosphere and surface. Conversely, when water vapor content decreases, the atmosphere's ability to absorb and scatter infrared radiation diminishes, and energy is more easily lost to space, leading to cooling or inhibition of warming. This positive or negative feedback mechanism makes water vapor's role in the greenhouse effect extremely crucial and more sensitive to climate change. However, the amount of water vapor depends not only on atmospheric temperature and ocean surface evaporation but also on processes such as clouds, precipitation, and atmospheric circulation. Any changes in these processes will affect the residence time, vertical distribution, and total amount of water vapor in the atmosphere.

Based on this, deriving a unidirectional trend of "continuous increase in atmospheric water vapor" from the theoretical assumption that increased CO2 leads to higher temperatures, which then increase water vapor content and further amplify the greenhouse effect, often overlooks the complexity of other feedback mechanisms in the climate system. Observational data indicate that atmospheric water vapor content does not always increase in a monotonic manner in certain periods or regions and even shows overall decreases or frequent fluctuations. This anomaly suggests that, under the regulation of certain natural processes, water vapor content is not always positively correlated with temperature, meaning it does not always create an additive warming effect with increasing CO2.

3.2.2 Partial Mitigation of CO2 Warming Effect by Atmospheric Water Vapor

In relatively short-term climate observations, it has been found that CO2 concentrations consistently rise year by year; however, global average temperatures have not followed the same linear warming trend as CO2 increases. On one hand, this is related to the ocean's ability to absorb heat and carbon, with the oceans storing excess heat and carbon over longer timescales. On the other hand, it is directly related to fluctuations or declines in atmospheric water vapor content at different stages.

(1) Regulatory Effect of Clouds and Precipitation Processes

When atmospheric temperatures rise to a certain level, enhanced evaporation brings more clouds and precipitation. As water vapor condenses in the troposphere to form clouds and precipitation, the amount of water vapor in the atmosphere decreases. This process can partially offset the warming trend caused by CO2. As cloud cover increases, the higher albedo at the cloud tops reflects more shortwave solar radiation back to space, while precipitation releases latent heat, changing the thermodynamic structure of the atmosphere and reducing the warming trend in certain regions. Thus, water vapor in the climate system can both generate warming feedback and lead to cooling regulation, depending on the global and regional atmospheric circulation and cloud-precipitation processes.

(2) Regional and Global Differences

The statistical average of global atmospheric water vapor content does not fully represent regional differences. Changes in regional ocean currents, land vegetation, and the stability of the planetary boundary layer can lead to significant trends of water vapor reduction in certain areas. For example, if seawater temperature in certain regions declines, reducing evaporation, a negative anomaly in water vapor flux may occur, affecting the transport and distribution of water vapor in larger areas and playing a role as a "cooling factor" or "modulating factor" in the climate system. This shows that atmospheric water vapor does not necessarily follow the same globally consistent upward trend as CO2; its spatial and temporal diversity offers new insights for understanding the nonlinear evolution of the climate system.

(3) Coupling with Other Climate Factors

Atmospheric water vapor, like CO2, is regulated through interactions with factors such as clouds, aerosols, oceans, and terrestrial ecosystems [3][11][12]. For instance, aerosols affect cloud droplet formation and cloud optical thickness, which in turn alters the efficiency of water vapor conversion into precipitation. Vegetation impacts local humidity through transpiration, and large-scale deforestation reduces local transpiration and atmospheric water vapor content. These processes mean that the warming effect of CO2 may not always be fully "manifested." More importantly, changes in Earth's orbital parameters (such as tilt, eccentricity, and precession) and the diurnal and seasonal cycles caused by Earth's rotation and revolution are the fundamental drivers of the large-scale distribution of atmospheric water vapor. Water vapor content and the cloud-precipitation processes it triggers, on shorter timescales, play complex coupling roles in partially suppressing or enhancing the warming effect of CO2.

3.2.3 Water Vapor-CO2 Synergistic Effects under Orbital Changes

According to the "New Theory of Global Climate and Ecosystem Change Based on Planetary Orbital Variations," if the solar system only consisted of the Sun and Earth, Earth's climate would primarily be driven by the diurnal and seasonal variations caused by Earth’s rotation and revolution. In this idealized scenario, atmospheric temperature and water vapor content would exhibit regular cyclical fluctuations closely related to the distribution of solar radiation. In reality, Earth does not exist in isolation: gravitational disturbances from planets, satellites, and celestial bodies both within and outside the Milky Way, as well as solar activity cycles, all affect Earth's climate system over different timescales. The increase in greenhouse gases such as CO2 is only one of many influencing factors; under the periodic drive of orbital changes, even with increasing CO2 concentrations, the regulation by atmospheric water vapor and other internal mechanisms causes temperature or water vapor content to not simply increase monotonically.

(1) Orbital Periodic Changes and Climate Feedbacks

Changes in orbital tilt, eccentricity, and precession over tens of thousands to hundreds of thousands of years alter the spatial and temporal distribution of solar radiation received by Earth. These changes bring about periodic temperature fluctuations, such as the appearance of glacial and interglacial periods. During this time, both water vapor and CO2 passively respond to climate changes, amplifying or dampening these variations. When the orbital-driven warming trend is strong, surface heating of oceans and land increases, causing water vapor content to rise, but this does not mean it will rise indefinitely, as corresponding precipitation processes also increase, forming a self-regulation mechanism. Conversely, when the orbital-driven cooling trend occurs, water vapor content decreases, cloud cover and albedo may increase, further deepening the cooling.

(2) Combined Effects of Earth's Rotation and Revolution

On shorter timescales, Earth's rotation creates diurnal changes, while its revolution leads to seasonal transitions. In these cycles, temperature variations can trigger local or large-scale water vapor transport, cloud formation, and precipitation events. If, during certain regions or seasons, atmospheric cooling and water vapor condensation dominate, water vapor content will decrease at certain stages, offsetting part of the warming trend caused by CO2 greenhouse effects. This combined effect results in periodic or quasi-periodic fluctuations in climate variables in observed records, rather than a simple unidirectional increase or decrease.

(3) Intrinsic Self-Regulation of the Global Climate System

The multiple roles of water vapor in the climate system suggest that Earth possesses some level of self-regulation. Increased water vapor can intensify the greenhouse effect, but it can also promote cloud formation and accelerate precipitation, thus suppressing the warming trend during certain periods. Conversely, if water vapor decreases due to local cooling, this does not necessarily lead to uncontrolled global warming, as the accompanying increase in clear-sky radiation would enhance surface cooling. Additionally, the complex feedback in the ocean-atmosphere coupling system regarding energy and water transfer also allows Earth's climate to exhibit "self-organization" and "self-regulation" over longer timescales. These mechanisms, coordinated with Earth's orbital and rotational cycles, make CO2's effect either amplified or temporarily weakened. Over the long term, this regulation allows Earth's ecosystems to maintain evolution and development within a relatively broad range of temperature and humidity conditions.

3.3 Vegetation Changes Modulate the Impact of CO2 on Earth's Climate and Ecosystems

Vegetation is one of the most dynamic and important components of Earth's ecosystems. It not only absorbs carbon dioxide (CO2) from the atmosphere through photosynthesis and releases oxygen, but also influences local and regional water and thermal conditions through transpiration, thus playing a key role in regulating the global carbon cycle and climate system (Figure 7). Based on observations and analyses of the spatiotemporal patterns of global vegetation, researchers have found that over the past several decades, Earth's vegetation distribution has exhibited a regional pattern of "both increase and decrease" [6]: vegetation in high-latitude regions of the Northern Hemisphere and some continental areas has shown a significant increasing trend, while vegetation in equatorial and some mid- to low-latitude regions has decreased. This differentiated vegetation dynamic is not only related to changes in climate factors such as atmospheric CO2 concentration, temperature, and water vapor supply, but also reflects the deeper influence of Earth's rotation and revolution at different orbital positions on climate and ecological processes. The following sections will discuss the modulation effect of vegetation on CO2 and the multiple coupling relationships between vegetation and the Earth's climate system from three perspectives.

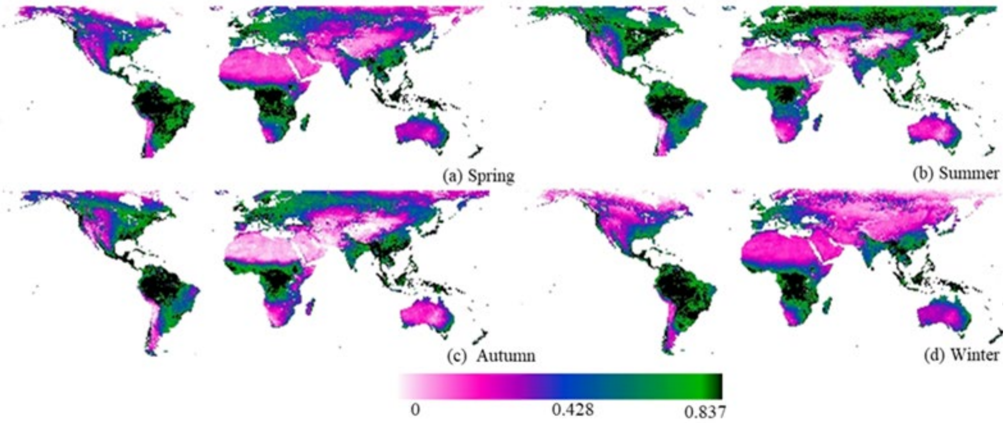


Figure 7. Seasonal Variation of Vegetation on Earth

3.3.1 Absorption and Release of CO2 by Vegetation: A Key Component in the Carbon Cycle

(1) Photosynthesis and Carbon Fixation

Plants absorb CO2 from the atmosphere through photosynthesis, combining it with water and solar radiation to produce organic matter while releasing oxygen. This process creates large-scale "carbon sinks" that effectively slow the increase of CO2 concentrations in the atmosphere. Especially in areas with vigorous growing seasons, such as coniferous and broadleaf forests, as well as some grasslands and agricultural ecosystems in the high latitudes of the Northern Hemisphere, vegetation's CO2 absorption is particularly pronounced. Observations show a significant increase in vegetation coverage and biomass in areas such as northeastern North America, eastern Asia, and high-latitude regions of the Northern Hemisphere. This not only alters the land surface properties of these regions (such as albedo and roughness) but also enhances their net absorption capacity of atmospheric CO2 to some extent.

(2) Respiration and Biomass Cycling

At the same time, plants release CO2 through cellular respiration during the dark period or under lower temperatures, and CO2 is also released from decaying branches, leaves, or soil organic matter. The modulation of CO2 by vegetation is not unidirectional but a dynamic balance process: the carbon absorbed through photosynthesis and the carbon released through respiration and decomposition fluctuate, ultimately forming a "source" and "sink" balance in the carbon cycle. If, during certain periods or in specific regions, environmental changes lead to a decline in plant productivity or degradation, the previously dominant carbon sink effect may weaken or even reverse into a carbon source effect.

(3) Disturbed Carbon Cycle

Human activities (such as deforestation, land-use changes, and urban expansion) disrupt original vegetation cover, leading to further accumulation of CO2 in the atmosphere. According to existing research, many tropical rainforest or wetland ecosystems in equatorial regions and mid-latitudes are facing dual pressures from human overdevelopment and climate aridification, resulting in a significant decline in vegetation. In contrast, regions that have implemented large-scale afforestation or strict land-use management, or areas in high latitudes where longer growing seasons are induced by climate warming, show some degree of recovery or expansion of vegetation, making positive contributions to local and global carbon sinks.

3.3.2 Vegetation's Regulation of Climate Through Transpiration and Water Vapor Cycle

(1) Transpiration and Local Water Thermal Conditions

During photosynthesis and growth, plants absorb large amounts of water from the soil and release it into the atmosphere through stomata—this process is known as transpiration. Transpiration carries away latent heat, regulating the temperature of the vegetation canopy and near-surface layers, while injecting water vapor into the atmosphere. This not only alleviates surface overheating but also increases atmospheric humidity, which significantly affects cloud formation and precipitation distribution. In areas with abundant vegetation, transpiration has a notable impact on local energy balance, contributing to "cooling and humidifying" or "stabilizing" the climate.

(2) Regional Water Vapor Transport and Precipitation Patterns

Large-scale vegetation cover can also influence atmospheric circulation and water vapor transport. For example, the tropical rainforests of the Amazon basin, through intense transpiration, continuously provide water vapor to South America and surrounding regions, creating an interregional "aerial river" phenomenon. When vegetation is damaged or degraded, regional water vapor transport pathways become disrupted, and precipitation in local and downstream areas decreases, exacerbating drought risks and ecological degradation. Similarly, vegetation changes in monsoon regions of Africa, Asia, Eastern Australia, and the Indian Peninsula also shape regional monsoon strength and precipitation patterns, deeply influencing the climate and ecosystems.

(3) Coupling with the CO2 Greenhouse Effect

Increased atmospheric CO2 leads to warming and potential increases in water vapor; however, as discussed earlier, water vapor and temperature do not exhibit a continuous, uniform change but instead show significant fluctuations and regional differences. Likewise, vegetation's transpiration may not always show an enhancement trend. If a region becomes arid, transpiration will decrease; if the climate is more humid, transpiration will increase, leading to more precipitation. Thus, the warming effect of CO2 may, in certain timeframes and regional contexts, be weakened or modulated by vegetation's transpiration and cloud-precipitation processes. This feedback regulation mechanism means that CO2 does not completely dominate the climate system but instead interacts with vegetation and other factors, ultimately determining local and even global climate patterns.

3.3.3 Vegetation Changes with Seasonal and Orbital Variations: Ecological Adaptation Driven by Planetary Movements

(1) Vegetation Dynamics Under Diurnal and Seasonal Cycles

Earth's rotation creates day-night alternation, and the axial tilt during Earth's revolution around the Sun brings about seasonal changes, which directly determine the distribution of solar radiation at different latitudes and times. When the solar zenith angle increases and daylight lengthens, the conditions for vegetation growth become more favorable, enhancing photosynthesis. Conversely, growth is limited during the night or colder seasons. Observations show that, except in the equatorial regions, vegetation in most regions of the world shows distinct seasonal cycles corresponding to spring, summer, autumn, and winter. This aligns with the concept of "growing seasons" in agriculture and mirrors our daily experience: crops or vegetables grown in the wrong season, even in greenhouses, do not achieve optimal flavor or maximum yield. Thus, day-night and seasonal changes are the most direct regulators of vegetation growth and distribution.

(2) Orbital Periodic Driving and Regional Differences

Over longer timescales, variations in planetary orbits cause solar radiation to fluctuate periodically or quasi-periodically at different latitudes on Earth. Consequently, global temperature, water vapor transport, and precipitation patterns also adjust accordingly. Large-scale vegetation distributions, such as the coniferous forest belts across Eurasia, tropical grasslands south of the Sahara, and temperate farmland in mid-latitudes, have experienced cycles of expansion and contraction over long geological periods, driven by orbital changes and climate fluctuations. Modern satellite remote sensing and field observation data also show that seasonal solar radiation maxima, influenced by orbital parameters, impact temperature and water vapor supply differences between the high latitudes of the Northern Hemisphere and the equator, thereby shaping the current local trends of "increased greening in the high latitudes and reduced greening in the equatorial regions."

(3) Vegetation Spatiotemporal Changes as Indicators of Ecosystem Responses

Vegetation is often one of the leading indicators of how ecosystems respond to climate change. It not only shows sensitivity to changes in precipitation, temperature, and sunlight on short-term scales but also reflects the cumulative effects of orbital variations and tectonic movements on longer timescales. For example, in arid and semi-arid regions, increases in temperature or decreases in precipitation often lead to immediate grassland degradation or desertification expansion; in regions with favorable water and thermal conditions, warm periods promote rapid vegetation expansion. However, if increased CO2 fails to align with the periodic warming and cooling or wet and dry fluctuations brought by orbital changes, a phase mismatch may occur between vegetation dynamics and climate trends. These indicators and feedbacks are not only important for forecasting future ecological trends in scientific research but also suggest that policymakers should consider a combination of atmospheric composition, human interference, and celestial orbital cycles in developing sustainable ecological protection and land management strategies.

3.3.4 Gravitational and Magnetic Fields of Celestial Bodies: Potential Impacts on Vegetation and Species Succession

In traditional climate and ecological studies, attention has primarily been on factors such as greenhouse gas concentrations, solar radiation, and clouds and precipitation. However, the gravitational fields and magnetic field changes generated by celestial bodies (including the Moon and other planets) during their orbital movements may also influence Earth's biosphere on geological or astronomical timescales. Specifically:

(1) Plate Tectonics and Continental Configuration Drivers

Earth's plate movements have reshaped continental positions and land-sea distributions over tens of millions to hundreds of millions of years, with gravitational, tidal forces, and Earth's internal thermal energy potentially influencing the rate and pattern of plate activities. The spatial distribution of continents directly determines the paths of vegetation succession and diffusion, thereby shaping global biodiversity patterns.

(2) Magnetic Field Disturbances and Species Evolution

Living organisms are made up of molecules and atoms, and disturbances in Earth's magnetic field may subtly affect biological development, survival ranges, and species migration at the cellular and molecular levels. For example, migratory birds or mammal herds may have specific abilities to sense Earth's magnetic field, and abnormal magnetic field changes could adjust their migration paths or breeding rhythms, influencing related vegetation growth and reproduction. However, the specific mechanisms by which magnetic fields and gravitational forces influence vegetation distribution and long-term changes still require more interdisciplinary and multi-scale research.

(3) Trade-offs Between Human Activities and Natural Drivers

Although existing research shows that vegetation decline in equatorial regions, central Africa, and parts of South America is primarily due to climate aridification or human-induced destruction, some theories suggest that periodic gravitational and magnetic field changes induced by celestial movements could amplify the frequency of droughts or extreme weather events in certain periods. Therefore, when assessing the impact of celestial-driven forces on vegetation succession and species distribution, it is crucial to combine evidence from human activity history and natural cyclical changes to more comprehensively understand the complex coupling relationship within the "celestial-Earth-biosphere" system.

4. New Theory of Global Climate and Ecosystem Change Based on Planetary Orbital Variations

As can be seen from the previous analysis, it is evident that for thousands of years, humans have become accustomed to the eastward rise and westward set of the sun, as well as the changes of the four seasons, often without realizing that these cyclical fluctuations are essentially climate changes, and are also the result of changes driven by planetary orbits. Traditional theories have mostly focused on internal factors of Earth and human activities (such as greenhouse gas emissions, land use changes, etc.) in relation to climate impact. We propose that, from a more macroscopic perspective, considering the solar system and even larger celestial systems, Earth's daily and seasonal temperature fluctuations, climate cycles, and even the alternation between ice ages and interglacial periods over geological time scales, are largely driven by the positions of planetary orbits, gravitational forces, and changes in magnetic fields. Earth's temperature, atmospheric water vapor circulation, cloud distribution, ocean current movements, and major natural events such as earthquakes and volcanic eruptions can all be viewed as internal regulatory processes of Earth responding to external orbital changes. The emergence of life and biological evolution are results of orbital evolution and the active adaptation of Earth's internal layers. Based on this, we propose a new, more macroscopic theory of global climate and ecosystem change centered around planetary orbital evolution—'**Mao's New Theory of Global Climate and Ecosystem Change**'. This theory emphasizes that the climate and ecological patterns of Earth at every moment are primarily governed by orbital factors within the solar system and larger celestial systems, and Earth and its layers are merely passive responses and self-regulations under the combined effects of these external forces. As shown in Figure 8, the planets in the solar system are moving at high speeds along their respective orbits. From the above analysis, it can be seen that the temperature spatial variations on Earth at any given moment, as shown in Figure 8 (E), are determined by Earth's initial state (the variation in solar radiation and the initial positions of all planetary orbits) and the position of Earth's rotation, as shown in Figure 8 (D). The 24-hour temperature variation of Earth, shown in Figure 8 (D), is determined by Earth's rotation state, the position of the Moon's orbit, as shown in Figure 8 (C), the position of Earth's revolution, as shown in Figure 8 (B), and the positions of other planetary orbits, as shown in Figure 8 (A). The daily temperature variation within the month, shown in Figure 8 (C), is determined by the position of the Moon's orbit, the position of Earth's revolution, and the positions of other planetary orbits. The 12-month temperature variation of Earth, shown in Figure 8 (B), is determined by the position of Earth's revolution and the positions of other planetary orbits, as shown in Figure 8 (A). The temperature changes of Earth in Figure 8 (A) are determined by the position of other planetary orbits' motion. From the above, it is clear that different planets influence Earth in different ways across various timescales: Earth's rotation is the main driver of climate and ecological changes on daily timescales; the Moon is the primary driver of climate and ecological changes on monthly timescales; Earth's revolution drives seasonal climate and ecological changes; and the orbital changes of other planets are the main drivers of interannual climate and ecological variations. In contrast, the rise in CO_2 concentration due to human activities is merely an overlay to Earth's temperature change and is not the fundamental driver of climate evolution. The new global climate and ecosystem theory will be constructed within a theoretical framework covering the entire chain of 'external planetary driving forces - internal feedback from Earth - ecosystem succession.' This new theory will broaden humanity's understanding of the essence of Earth's climate change and provide a new coordinate system for understanding natural disasters and species evolution on long time scales and a global perspective. Understanding the evolutionary laws of Earth under the influence of celestial systems will be of milestone significance in formulating sustainable ecological environmental management policies and improving disaster prediction and early warning mechanisms. The following sections will systematically expound on the core aspects of this theory from the perspective of planetary orbital changes and Earth's energy levels, Earth's climate self-regulation mechanisms, and the coupling of major geological processes such as earthquakes, volcanoes, and ocean currents.

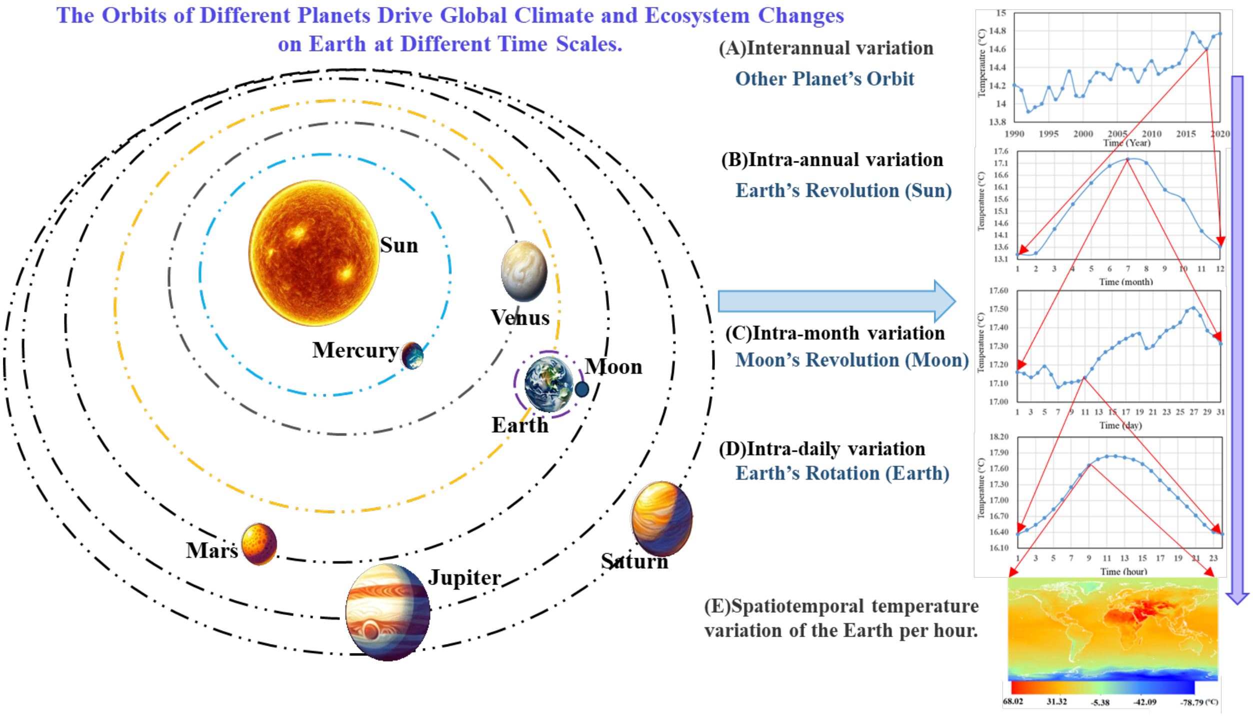


Figure 8. New Theory of Global Climate and Ecosystem Change Based on Planetary Orbital Variations

4.1 The Determinative Role of Planetary Orbital Position and Earth's Energy Level

4.1.1 Complex Interactions Between Solar System Bodies and Earth's Orbit

The solar system consists of the Sun, eight planets and their moons, and numerous small celestial bodies. Each planet orbits at high speeds on distinct trajectories, governed by Kepler's laws of planetary motion, Newton's law of universal gravitation, and the theory of general relativity. Earth's orbit around the Sun is not fixed; various parameters, such as orbital eccentricity, axial tilt, and precession, evolve periodically or quasi-periodically on different timescales. At the same time, other planets and their moons in the solar system are in continuous motion, and their gravitational and magnetic fields change spatially. These changes are superimposed onto the Sun-Earth system, forming an extremely complex network of gravitational and magnetic fields, which in turn influence Earth's climate and ecosystem changes.

As the direction or magnitude of the combined forces acting on Earth varies on a micro-scale, Earth's orbital and rotational speeds also experience slight but continuous adjustments. According to Kepler's laws, Earth's speed increases near perihelion and decreases near aphelion. Moreover, when the relative positions of other planets (such as Jupiter, Venus, Saturn, etc.) to Earth change, additional planetary gravitational forces cause slight disturbances, leading to further micro-adjustments in Earth's orbital speed and orientation. Although these disturbances may be minuscule in the short term, their cumulative effect can amplify over hours, days, months, years, decades, or even longer periods, leading to substantial impacts on climate and ecosystems.

4.1.2 Earth's Energy Level and Climate-Ecosystem Dynamics

Within this macro framework, Earth's "energy level" can be viewed as a function of Earth's position within the solar system and the broader celestial system, as well as the composite external forces (gravity, magnetic fields, solar radiation, etc.) acting upon it. As planetary orbital changes induce fluctuations in Earth's energy level, the energy balance of Earth's layers (atmosphere, hydrosphere, lithosphere, biosphere, etc.) dynamically adjusts, manifesting as periodic or phased evolution in climate and ecosystems:

(1) Solar Radiation and Heat Input: Changes in orbital tilt or eccentricity alter the seasonal distribution and interannual average of solar radiation received by Earth, thereby shaping the spatial distribution of surface temperature and atmospheric water vapor.

(2) Gravitational and Magnetic Field Regulation: The interaction between the relative positions of other celestial bodies and Earth's own structural shape (which is not a perfect sphere) causes complex spatiotemporal couplings in processes such as tectonic plate movements, submarine volcanic eruptions, and magma dynamics, leading to adjustments in water vapor, ocean currents, and atmospheric circulation.

(3) Energy Release and Disaster Triggers: When the direction or magnitude of planetary gravitational forces undergoes sharp changes at certain time points, and if Earth cannot release or absorb excess energy through "smooth processes" such as ocean currents, cloud formation, and precipitation, this excess energy may be released through extreme events such as earthquakes, volcanic eruptions, powerful storms, and hurricanes, until a new balance is established.

Therefore, Earth's orbital position largely determines its energy level, which, in turn, serves as an external driving force for climate change and ecosystem evolution.

4.2 Earth's Climate Self-Regulation Processes

4.2.1 The "Tuning" Role of Water Vapor, Clouds, and Vegetation

Global observational data and long-term monitoring indicate that while atmospheric CO_2 concentrations have steadily increased during the industrial era, global average temperatures have not followed a linear rise corresponding to the rate of CO_2 increase. In contrast, the spatiotemporal distribution of water vapor and clouds has exhibited significant fluctuations, even showing an overall decline in some regions, partially offsetting the warming effect of CO_2. Meanwhile, vegetation absorbs CO_2 through photosynthesis and influences local heat and water balances through transpiration, thus playing a regulatory role in climate across different spatial and temporal scales. Therefore, while CO_2 is one of the major greenhouse gases, it is not the sole or primary factor controlling Earth's temperature.

(1) Water Vapor and Clouds: Short-Term Energy Regulation

Atmospheric water vapor content significantly affects the balance of longwave radiation, and under certain conditions, it forms clouds and precipitation, which, in turn, affect the energy balance of the atmosphere and oceans through rainfall, changes in albedo, and latent heat exchange.

(2) Vegetation: Carbon Sink and Humidity Effect

Global vegetation has shown a dynamic pattern of "both increases and decreases" in different regions. On one hand, it is controlled by regional climate (water-heat conditions); on the other hand, it also regulates local climate. The expansion of forests in high and some mid-latitudes enhances atmospheric CO_2 absorption and increases transpiration, while deforestation and ecological degradation in tropical and mid-low latitudes reduce carbon sinks and water vapor supply.

(3) Ocean Currents, Volcanoes, and Earthquakes: Macro-Energy Release or Transmission

Oceans, covering most of Earth's surface, have immense storage and regulation capacity for heat and carbon. Ocean current fluctuations (such as El Niño, La Niña, and Pacific Decadal Oscillation) often change regional climate and precipitation patterns on shorter timescales. Volcanoes and earthquakes are more destructive yet essential energy release processes, often seen as critical pathways through which Earth responds to external gravitational and magnetic disturbances and regulates its internal energy balance.

4.2.2 Multiple Drivers and Feedback: Coupling Between Planets and Earth's Systems

Within this theoretical framework, the gravitational and magnetic field changes of planets drive Earth's energy level adjustments. Earth's internal systems, such as ocean-atmosphere coupling, tectonic movements, and biosphere evolution, enable self-repair and adaptation. Their synergistic effects ultimately manifest as periodic fluctuations in global or regional climate, as well as the "eruption-suppression" cycle of catastrophic events. Compared to the localized and temporary disruptions caused by human activities, planetary orbital changes dominate Earth's climate impact over longer timescales and spatial scales. While human activities have a non-zero impact on the climate system, their influence is relatively limited in the face of planetary-scale and century-to-millennium cycles.

4.3 Earthquakes, Volcanoes, and Ocean Currents: Deep Coupling of Energy Release and Global Climate Change

4.3.1 Planetary Forces and Earth's Tectonic Activity

As celestial bodies orbit the Sun, they create combined forces. When this combined force approaches a critical threshold or experiences sharp changes in direction and magnitude, exceeding Earth's internal regulation limits, the movements or collisions between tectonic plates become an effective means of energy release, resulting in frequent activity along earthquake belts. If excessive energy accumulates at plate boundaries, it may trigger powerful earthquakes or volcanic eruptions, releasing large amounts of magma and gases. These intense events often change regional surface topography and ocean current distribution, subsequently influencing atmospheric circulation patterns, leading to climate anomalies and even extreme weather.

4.3.2 Volcanic Eruptions and Aerosols in Short-Term Climate Regulation

Large-scale volcanic eruptions can eject vast amounts of ash and aerosols into the stratosphere or even higher atmospheric layers, enhancing the reflection of solar shortwave radiation and bringing a "volcanic winter" effect with a temporary decrease in surface temperatures. Meanwhile, the sulfur dioxide, carbon dioxide, and aerosol particles released by volcanic eruptions can also influence atmospheric chemical processes over several months to years. This shows that volcanic activity can temporarily counteract the warming effect of CO_2, highlighting Earth's self-adaptive and self-regulatory capabilities in responding to external disturbances in climate.

4.3.3 Ocean Currents: The "Main Axis" of Earth's Energy Redistribution

The oceans, as vast "thermal and carbon reservoirs" form large-scale circulation systems, including tropical and subtropical circulations, as well as deep ocean currents. Gravitational forces from planets and Earth's rotational and orbital changes may alter seafloor topography, volcanic activity frequency, and seawater temperature distribution through tidal forces and tectonic movements, thereby reshaping ocean circulation patterns in key regions such as the equatorial eastern Pacific and the North Atlantic. Anomalies in ocean currents can change how oceans transfer heat and water vapor to the atmosphere, leading to non-linear, quasi-periodic variations in global or regional climates.

4.4 Implications for Future Climate Predictions and Ecosystem Research

4.4.1 From "Within the System" to "Outside the System": Integrating Planetary Orbits into Mainstream Climate Models

Mainstream climate change research primarily focuses on processes within the Earth's system, particularly greenhouse gases, aerosols, clouds, and radiation balance. However, there is insufficient attention paid to the "external" influences, such as planetary orbits. This theory suggests that to more comprehensively and accurately understand and predict the evolution of Earth's climate and ecosystems, it is essential to consider the broader celestial environment, including the solar system, as a foundational condition. Predictions of significant earthquakes or volcanic events, for example, may require integrating Kepler's laws, Newton's law of universal gravitation, and relativity, along with continuous monitoring and quantitative simulation of the orbital cycles and gravitational forces of neighboring planets. Only in this way can we better grasp the trends in Earth's climate and ecosystem evolution.

4.4.2 Long-Term Observation and Interdisciplinary Approaches

Planetary orbital changes occur on a wide range of timescales: short periods such as daily, monthly, and yearly cycles, and longer periods of hundreds, thousands, or even tens of thousands to hundreds of thousands of years. Modern scientific records and satellite observations are insufficient to capture these long-term signals comprehensively. Therefore, interdisciplinary research combining fields such as geophysics, astronomy, oceanography, ecology, and information science is urgently needed, building upon geological records and paleoclimate studies. By studying Earth's rotation and revolution, lunar orbit, and the orbits of Mars and other planets, we can gain new insights and evidence for Earth's climate and ecosystem evolution.

4.4.3 Balancing Limited Human Intervention with the Infinite Impact of Planetary Forces

On a pragmatic level, humanity must continue to reduce direct environmental damage and excessive greenhouse gas emissions to mitigate localized and short-term climate deterioration and ecosystem degradation risks. However, it is essential to remain aware that the mechanical and energy coupling between Earth and the solar system, as well as larger celestial systems, is the fundamental factor determining the long-term trends of global climate. While human activities have a significant impact on a relatively short-term or localized scale, when these activities intersect with or conflict with the long-term planetary cycles, natural processes often dominate on a much larger scale and with greater intensity.

5. Conclusion

The "Mao's New Theory of Global Climate and Ecosystem Changes Based on Planetary Orbital Variations" provides a broader perspective on the evolution of Earth's climate and ecosystems by examining it through the lens of the solar system and larger celestial systems. This theory emphasizes that, apart from the daily and seasonal variations driven by Earth's rotation and revolution, changes in planetary orbits over different time scales, and the spatiotemporal relationships between these celestial bodies, are deep driving forces behind evolutionary changes and periodic fluctuations in Earth's climate and ecosystems. The periodicity of Earth's rotation and revolution is evident and regular, making it more easily accepted and considered the norm. In contrast, the orbital changes of other planets relative to Earth's position are more complex (not approximate circular motions) and exert a relatively smaller influence on Earth's rotation and revolution. Therefore, their combined effects are not as regular, and their implications are harder for most people to grasp. Changes in Earth's temperature, atmospheric water vapor, clouds, vegetation, oceans, and natural phenomena such as volcanic eruptions and earthquakes reflect the Earth's internal layers' responses to and self-regulation of external planetary orbital variations. The core of this theory can be summarized in three aspects: First, variations in the gravitational and magnetic fields of celestial bodies change Earth's energy state, triggering adjustments in temperature, atmosphere, oceans, and tectonic plate movements. Compared to traditional views that focus on greenhouse gas emissions, volcanic activity, or human land use changes, this theory places more emphasis on the dominant influence of external planetary gravitational and orbital factors on Earth's climate. Secondly, Earth's internal systems also possess multiple self-regulation mechanisms. On short to medium time scales, atmospheric water vapor, precipitation, clouds, and vegetation can buffer or offset some of the warming effects of CO2. On longer cycles or in the event of sudden disturbances, volcanic eruptions and earthquakes help release and re-balance Earth's internal energy. Thus, although CO2 plays an important role in global warming, it is only one contributing factor. Based on this, we can further deduce that life is the result of the active adaptation of Earth's internal layers to orbital evolution. Lastly, this theory offers new directions for future research and practice: by integrating celestial mechanics into climate and ecosystem models, new approaches to disaster warning and risk assessment can be explored. Comprehensive geological records, planetary orbital monitoring, numerical simulations, and multidisciplinary evidence will help construct a theoretical framework that covers the entire chain from "external planetary driving forces—Earth's internal feedback—ecosystem succession." This new theory expands human understanding of the essence of Earth's climate change and provides a new framework for understanding natural disasters and species evolution over long time scales and a global perspective. Understanding the Earth's evolutionary processes under the influence of celestial systems is of milestone significance for developing sustainable ecological and environmental management policies, as well as enhancing disaster prediction and early warning systems.

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