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ДЕЛОВОЙ АНГЛИЙСКИЙ ЯЗЫК

Методические указания к самостоятельной работе для студентов магистратуры направления 18.04.01

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Методические указания содержат текстовый материал и задания для самостоятельной работы.

Предназначены для студентов магистратуры направления подготовки 18.04.01 «Химическая технология. Химическая технология природных энергоносителей и углеродных материалов».

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Text 1

What factors determine Earth's climate?

The climate system is a complex, interactive system consisting of the atmosphere, land surface, snow and ice, oceans and other bodies of water, and living things. The atmospheric component of the climate system most obviously characterises climate; climate is often defined as 'average weather'. Climate is usually described in terms of the mean and variability of temperature, precipitation and wind over a period of time, ranging from months to millions of years (the classical period is 30 years). The climate system evolves in time under the influence of its own internal dynamics and due to changes in external factors that affect climate (called 'forcings'). External forcings include natural phenomena such as volcanic eruptions and solar variations, as well as human-induced changes in atmospheric composition. Solar radiation powers the climate system.

There are three fundamental ways to change the radiation balance of the Earth: 1) by changing the incoming solar radiation (e.g., by changes in Earth's orbit or in the Sun itself); 2) by changing the fraction of solar radiation that is reflected (called 'albedo'; e.g., by changes in cloud cover, atmospheric particles or vegetation); and 3) by altering the longwave radiation from Earth back towards space (e.g., by changing greenhouse gas concentrations). Climate, in turn, responds directly to such changes, as well as indirectly, through a variety of feedback mechanisms.

1. Find the equivalents to the following words and word combinations in the text:

климатообразующий фактор, характеристика диффузной отражательной способности поверхности, антропогенный, средняя температуры, солнечные вариации, атмосферные осадки, охватывать период от…до, растительность, длинноволновая радиация

2. Answer the questions:

1. What does climate consist of?
2. Make examples of forcings, which influence climate.
3. Explain the ways to change the radiation balance of the Earth.

Text 2

What is the relationship between climate change and weather?

Climate is generally defined as average weather, and as such, climate change and weather are intertwined. Observations can show that there have been changes in weather, and it is the statistics of changes in weather over time that identify climate change. While weather and climate are closely related, there are important differences. A common confusion between weather and climate arises when scientists are asked how they can predict climate 50 years from now when they cannot predict the weather a few weeks from now. The chaotic nature of weather makes it unpredictable beyond a few days. Projecting changes in climate (i.e., long-term average weather) due to changes in atmospheric composition or other factors is a very different and much more

manageable issue. As an analogy, while it is impossible to predict the age at which any particular man will die, we can say with high confidence that the average age of death for men in industrialised countries is about 75. Another common confusion of these issues is thinking that a cold winter or a cooling spot on the globe is evidence against global warming. There are always extremes of hot and cold, although their frequency and intensity change as climate changes. But when weather is averaged over space and time, the fact that the globe is warming emerges clearly from the data.

1. Find the equivalents to the following words and word combinations in the text:

предсказать, иметь отношение, выявить изменение климата, средний, крайние значения температуры, частота, установить среднюю температуру, появиться, атмосферный состав, общее заблуждение

2. Answer the questions:

1. What are the differences between climate and weather?
2. How do temperature extremes change as climate changes?
3. What is a long-term average weather?

Text 3

What is the Greenhouse Gas effect?

The Sun powers Earth's climate, radiating energy at very short wavelengths, predominately in the visible or near-visible (e.g., ultraviolet) part of the spectrum. Roughly one-third of the solar energy that reaches the top of Earth's atmosphere is reflected directly back to space. The remaining two-thirds is absorbed by the surface and, to a lesser extent, by the atmosphere. To balance the absorbed incoming energy, the Earth must, on average, radiate the same amount of energy back to space. Because the Earth is much colder than the Sun, it radiates at much longer wavelengths, primarily in the infrared part of the spectrum. Much of this thermal radiation emitted by the land and ocean is absorbed by the atmosphere, including clouds, and reradiated back to Earth. This is called the greenhouse effect. The glass walls in a greenhouse reduce airflow and increase the temperature of the air inside. Analogously, but through a different physical process, the Earth's greenhouse effect warms the surface of the planet. Without the natural greenhouse effect, the average temperature at Earth's surface would be below the freezing point of water. Thus, Earth's natural greenhouse effect makes life as we know it possible. However, human activities, primarily the burning of fossil fuels and clearing of forests, have greatly intensified the natural greenhouse effect, causing global warming. The two most abundant gases in the atmosphere, nitrogen (comprising 78% of the dry atmosphere) and oxygen (comprising 21%), exert almost no greenhouse

effect. Instead, the greenhouse effect comes from molecules that are more complex and much less common. Water vapour is the most important greenhouse gas, and carbon dioxide (CO_2) is the second-most important one. Methane, nitrous oxide, ozone and several other gases present in the atmosphere in small amounts also contribute to the greenhouse effect.

1. Find the equivalents to the following words and word combinations in the text:

коротковолновой, примерно, поглощать, в среднем, инфракрасный, воздушный поток, парниковый эффект излучать (радиацию), сжигать природные ископаемые, усиливать эффект, вызвать глобальное потепление, широко-распространенный газ, азот, вызывать (оказывать), водяной пар

2. Answer the questions:

1. What is the greenhouse effect?
2. How does the greenhouse effect influence the temperature at Earth's surface?
3. What greenhouse gases do you know?

Text 4

How do human activities attribute to climate change?

Human activities contribute to climate change by causing changes in Earth's atmosphere in the amounts of greenhouse gases, aerosols (small particles), and cloudiness. The largest known contribution comes from the burning of fossil fuels, which releases carbon dioxide gas to the

atmosphere. Greenhouse gases and aerosols affect climate by altering incoming solar radiation and outgoing infrared (thermal) radiation that are part of Earth's energy balance. Changing the atmospheric abundance or properties of these gases and particles can lead to a warming or cooling of the climate system. Since the start of the industrial era (about 1750), the overall effect of human activities on climate has been a warming influence. The human impact on climate during this era greatly exceeds that due to known changes in natural processes, such as solar changes and volcanic eruptions.

1. Find the equivalents to the following words and word combinations in the text:

вызывать изменения, вызывать, выброс углекислого газа, влиять, изменять, поглощаемое солнечное излучение, исходящее инфракрасное излучение, свойства газа, солнечные изменения, извержение вулкана

2. Answer the questions:

1. What comprises Earth's energy balance?

2. How does release of carbon dioxide influence the Earth's atmosphere?

3. Do human activities cause warming or cooling of climate?

Text 5

Greenhouse Gases

Human activities result in emissions of four principal greenhouse gases: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and the halocarbons (a group of gases containing fluorine, chlorine and bromine). These gases accumulate in the atmosphere, causing concentrations to increase with time. Significant increases in all of these gases have occurred in the industrial era. All of these increases are attributable to human activities. Carbon dioxide has increased from fossil fuel use in transportation, building heating and cooling and the manufacture of cement and other goods. Deforestation releases CO_2 and reduces its uptake by plants. Carbon dioxide is also released in natural processes such as the decay of plant matter. Methane has increased as a result of human activities related to agriculture, natural gas distribution and landfills. Methane is also released from natural processes that occur, for example, in wetlands. Methane concentrations are not currently increasing in the atmosphere because growth rates decreased over the last two decades. Nitrous oxide is also emitted by human activities such as fertilizer use and fossil fuel burning. Natural processes in soils and the oceans also release N_2O. Halocarbon gas concentrations have increased primarily due to human activities. Natural processes are also a small source. Principal halocarbons include the chlorofluorocarbons (e.g., CFC-11 and CFC-12), which were used extensively as refrigeration agents and in other industrial processes before their presence in the atmosphere was

found to cause stratospheric ozone depletion. The abundance of chlorofluorocarbon gases is decreasing as a result of international regulations designed to protect the ozone layer.

1. Find the equivalents to the following words and word combinations in the text:

стать причиной, выбросы, метан, галогеноуглерод, фтор, хлор, бром, углекислый газ, оксид азота, происходить, относится к, вырубка лесов, поглощение, гниение растений, мусор, болотистая местность, удобрение, выбрасывать в атмосферу, хлорофторуглерод, химический агент, используемый для заморозки, разрушение озона в стратосфере

2. Answer the questions:

1. What human activities increase emission of greenhouse gases in atmosphere?

2. What is deforestation?

3. Why is chlorofluorocarbon gas in the atmosphere decreasing?

Text 6

Greenhouse Gases

Ozone is a greenhouse gas that is continually produced and destroyed in the atmosphere by chemical reactions. In the troposphere, human activities have increased ozone through the release of gases such as carbon monoxide, hydrocarbons and nitrogen oxide, which chemically

react to produce ozone. As mentioned above, halocarbons released by human activities destroy ozone in the stratosphere and have caused the ozone hole over Antarctica. Water vapour is the most abundant and important greenhouse gas in the atmosphere. However, human activities have only a small direct influence on the amount of atmospheric water vapour. Indirectly, humans have the potential to affect water vapour substantially by changing climate. For example, a warmer atmosphere contains more water vapour. Human activities also influence water vapour through CH_4 emissions, because CH_4 undergoes chemical destruction in the stratosphere, producing a small amount of water vapour.

Aerosols are small particles present in the atmosphere with widely varying size, concentration and chemical composition. Some aerosols are emitted directly into the atmosphere while others are formed from emitted compounds. Aerosols contain both naturally occurring compounds and those emitted as a result of human activities. Fossil fuel and biomass burning have increased aerosols containing sulphur compounds, organic compounds and black carbon (soot). Human activities such as surface mining and industrial processes have increased dust in the atmosphere. Natural aerosols include mineral dust released from the surface, sea salt aerosols, biogenic emissions from the land and oceans and sulphate and dust aerosols produced by volcanic eruptions.

1. Find the equivalents to the following words and word combinations in the text:

тропосфера, монооксид углерода, стратосфера, привести к появлению озоновой дыры, подвергнуться химическому разрушению, серосодержащие вещества, сажа, природный аэрозоль, открытые горные работы, естественный аэрозоль, выделять пыль на поверхность, биогенные выбросы, сульфат

2. Answer the questions:

1. How is ozone hole created?

2. What is natural aerosol?

3. How does volcanic eruption influence on aerosols' production?

Text 7

What is radiative forcing?

What is radiative forcing? The influence of a factor that can cause climate change, such as a greenhouse gas, is often evaluated in terms of its radiative forcing. Radiative forcing is a measure of how the energy balance of the Earth-atmosphere system is influenced when factors that affect climate are altered. The word *radiative* arises because these factors change the balance between incoming solar radiation and outgoing infrared radiation within the Earth's atmosphere. This radiative balance controls the Earth's surface temperature. The term forcing is used to indicate that Earth's radiative balance is being pushed away from its normal state. Radiative forcing is usually quantified as the 'rate of energy change per unit area of the globe as measured at the top of the atmosphere', and is expressed in units of 'Watts per square metre'. When

radiative forcing from a factor or group of factors is evaluated as positive, the energy of the Earth-atmosphere system will ultimately increase, leading to a warming of the system. In contrast, for a negative radiative forcing, the energy will ultimately decrease, leading to a cooling of the system. Important challenges for climate scientists are to identify all the factors that affect climate and the mechanisms by which they exert a forcing, to quantify the radiative forcing of each factor and to evaluate the total radiative forcing from the group of factors.

1. Find the equivalents to the following words and word combinations in the text:

радиационное воздействие, баланс энергии, поступающая солнечная радиация, отраженная радиация, радиационный баланс, определять количество, оценка, оценить, снизиться

2. Answer the questions:

1. What alters factors that affect climate?

2. What is radiative forcing? How is it quantified?

3. What is the challenge for climate scientists?

Text 8

How are Temperatures on Earth and Precipitation changing?

Instrumental observations over the past 157 years show that temperatures at the surface have risen globally, with important regional variations. For the global average, warming in the last century has

occurred in two phases, from the 1910s to the 1940s (0.35°C), and more strongly from the 1970s to the present (0.55°C). An increasing rate of warming has taken place over the last 25 years, and 11 of the 12 warmest years on record have occurred in the past 12 years. Above the surface, global observations since the late 1950s show that the troposphere (up to about 10 km) has warmed at a slightly greater rate than the surface, while the stratosphere (about 10–30 km) has cooled markedly since 1979. This is in accord with physical expectations and most model results. Confirmation of global warming comes from warming of the oceans, rising sea levels, glaciers melting, sea ice retreating in the Arctic and diminished snow cover in the Northern Hemisphere.

Observations show that changes are occurring in the amount, intensity, frequency and type of precipitation. These aspects of precipitation generally exhibit large natural variability, and El Niño and changes in atmospheric circulation patterns such as the North Atlantic Oscillation have a substantial influence. Pronounced long term trends from 1900 to 2005 have been observed in precipitation amount in some places: significantly wetter in eastern North and South America, northern Europe and northern and central Asia, but drier in the Sahel, southern Africa, the Mediterranean and southern Asia. More precipitation now falls as rain rather than snow in northern regions. Widespread increases in heavy precipitation events have been observed, even in places where total amounts have decreased. These changes are associated with increased water vapour in the atmosphere arising from the warming of the world's

oceans, especially at lower latitudes. There are also increases in some regions in the occurrences of both droughts and floods.

1. Find the equivalents to the following words and word combinations in the text:

наблюдение с помощью приборов, тропосфера, стратосфера, стать значительно холоднее, ледник, таять, отступление ледника, уменьшаться, снежный покров, северное полушарие, северо-атлантическое колебание, значительное влияние, тип атмосферной циркуляции, широта

2. Answer the questions:

1. How has temperature at the surface changed globally?

2. How is global warming confirmed?

3. Make examples of variations in precipitation across regions.

Text 9

Are the Increases in Atmospheric Carbon Dioxide and Other Greenhouse Gases During the Industrial Era Caused by Human Activities?

Yes, the increases in atmospheric carbon dioxide (CO_2) and other greenhouse gases during the industrial era are caused by human activities. In fact, the observed increase in atmospheric CO_2 concentrations does not reveal the full extent of human emissions in that it accounts for only 55% of the CO_2 released by human activity since 1959. The rest has been taken up by plants on land and by the oceans. In all cases, atmospheric

concentrations of greenhouse gases, and their increases, are determined by the balance between sources (emissions of the gas from human activities and natural systems) and sinks (the removal of the gas from the atmosphere by conversion to a different chemical compound). Fossil fuel combustion (plus a smaller contribution from cement manufacture) is responsible for more than 75% of human-caused CO_2 emissions. Land use change (primarily deforestation) is responsible for the remainder. For methane, another important greenhouse gas, emissions generated by human activities exceeded natural emissions over the last 25 years. For nitrous oxide, emissions generated by human activities are equal to natural emissions to the atmosphere. Most of the long-lived halogen-containing gases (such as chlorofluorcarbons) are manufactured by humans, and were not present in the atmosphere before the industrial era. On average, present-day tropospheric ozone has increased 38% since pre-industrial times, and the increase results from atmospheric reactions of short-lived pollutants emitted by human activity. The concentration of CO_2 is now 379 parts per million (ppm) and methane is greater than 1,774 parts per billion (ppb), both very likely much higher than any time in at least 650 kyr (during which CO_2 remained between 180 and 300 ppm and methane between 320 and 790 ppb). The recent rate of change is dramatic and unprecedented; increases in CO_2 never exceeded 30 ppm in 1 kyr – yet now CO_2 has risen by 30 ppm in just the last 17 years.

1. Find the equivalents to the following words and word combinations in the text:

выявить, степень, насчитывать, поглотитель, конвертирование, сгорание полезных ископаемых, производство цемента, оставшийся, доиндустриальный период, превышать, природные выбросы, произошедшие в результате естественных природных процессов; быстроразрушаемое вещество, беспрецедентный

2. Answer the questions:

1. How is atmospheric concentration of greenhouse gases determined?

2. What is the main source of human-caused CO_2 emissions?

3. How does natural emission of greenhouse gases to the atmosphere happen?

Text 10

Carbon Dioxide

Emissions of CO_2 from fossil fuel combustion, with contributions from cement manufacture, are responsible for more than 75% of the increase in atmospheric CO_2 concentration since pre-industrial times. The remainder of the increase comes from land use changes dominated by deforestation (and associated biomass burning) with contributions from changing agricultural practices. All these increases are caused by human activity. The natural carbon cycle cannot explain the observed atmospheric increase of 3.2 to 4.1 GtC yr–1 in the form of CO_2 over the

last 25 years. (One GtC equals 1015 grams of carbon, i.e., one billion tonnes.) Natural processes such as photosynthesis, respiration, decay and sea surface gas exchange lead to massive exchanges, sources and sinks of CO_2 between the land and atmosphere (estimated at ~120 GtC yr–1) and the ocean and atmosphere (estimated at ~90 GtC yr–1). The natural sinks of carbon produce a small net uptake of CO_2 of approximately 3.3 GtC yr–1 over the last 15 years, partially offsetting the human-caused emissions. Were it not for the natural sinks taking up nearly half the human-produced CO_2 over the past 15 years, atmospheric concentrations would have grown even more dramatically. The increase in atmospheric CO_2 concentration is known to be caused by human activities because the character of CO_2 in the atmosphere, in particular the ratio of its heavy to light carbon atoms, has changed in a way that can be attributed to addition of fossil fuel carbon. In addition, the ratio of oxygen to nitrogen in the atmosphere has declined as CO_2 has increased; this is as expected because oxygen is depleted when fossil fuels are burned. A heavy form of carbon, the carbon-13 isotope, is less abundant in vegetation and in fossil fuels that were formed from past vegetation, and is more abundant in carbon in the oceans and in volcanic or geothermal emissions. The relative amount of the carbon-13 isotope in the atmosphere has been declining, showing that the added carbon comes from fossil fuels and vegetation. Carbon also has a rare radioactive isotope, carbon-14, which is present in atmospheric CO_2 but absent in fossil fuels. Prior to atmospheric testing of nuclear weapons, decreases in the relative amount

of carbon-14 showed that fossil fuel carbon was being added to the atmosphere.

1. Find the equivalents to the following words and word combinations in the text:

углеродный цикл, соотношение, тяжелая форма углерода, ядерное оружие, компенсировать техногенные выбросы

2. Answer the questions:

1. What human activities cause emission of carbon dioxide?

2. What happens to oxygen when fossil fuels are burned?

3. Where can one find the carbon-13 isotope, the carbon-14 isotope?

Text 11

Halogen-Containing Gases

Human activities are responsible for the bulk of long-lived atmospheric halogen-containing gas concentrations. Before industrialisation, there were only a few naturally occurring halogen-containing gases, for example, methyl bromide and methyl chloride. The development of new techniques for chemical synthesis resulted in a proliferation of chemically manufactured halogen-containing gases during the last 50 years of the 20th century. Atmospheric lifetimes range from 45 to 100 years for the chlorofluorocarbons (CFCs), from 1 to 18 years for the hydrochlorofluorocarbons (HCFCs), and from 1 to 270 years for the hydrofluorocarbons (HFCs). The perfluorocarbons (PFCs) persist

in the atmosphere for thousands of years. Concentrations of several important halogen-containing gases, including CFCs, are now stabilising or decreasing at the Earth's surface as a result of the Montreal Protocol on Substances that Deplete the Ozone Layer and its Amendments. Concentrations of HCFCs, production of which is to be phased out by 2030, and of the Kyoto Protocol gases HFCs and PFCs, are currently increasing.

Methane

Methane (CH_4) sources to the atmosphere generated by human activities exceed CH_4 sources from natural systems. Between1960 and 1999, CH_4 concentrations grew an average of at least six times faster than over any 40-year period of the two millennia before 1800, despite a near-zero growth rate since 1980. The main natural source of CH_4 to the atmosphere is wetlands. Additional natural sources include oceans, vegetation and CH_4 hydrates. The human activities that produce CH_4 include energy production from coal and natural gas, waste disposal in landfills, raising ruminant animals (e.g., cattle and sheep), rice agriculture and biomass burning. Once emitted, CH_4 remains in the atmosphere for approximately 8.4 years before removal, mainly by chemical oxidation in the troposphere. Minor sinks for CH_4 include uptake by soils and eventual destruction in the stratosphere.

1. Find the equivalents to the following words and word combinations in the text:

основная часть, газосодержащие галогены, метилбромид, метилхлорид, химический синтез, распространение, период жизни в атмосфере, перфторуглерод, стабилизировать, дополнение, прекращать, почти нулевой показатель, жвачное животное, сжигание биомасс, постепенное разрушение

2. Answer the questions:

1. What are atmospheric lifetimes for different halogen-containing gases?

2. What source of methane exceeds nowadays?

3. What are natural sources of methane?

Text 12

Nitrous Oxide

Nitrous oxide (N_2O) sources to the atmosphere from human activities are approximately equal to N_2O sources from natural systems. Between 1960 and 1999, N_2O concentrations grew an average of at least two times faster than over any 40-year period of the two millennia before 1800. Natural sources of N_2O include oceans, chemical oxidation of ammonia in the atmosphere, and soils. Tropical soils are a particularly important source of N_2O to the atmosphere. Human activities that emit N_2O include transformation of fertilizer nitrogen into N_2O and its subsequent emission from agricultural soils, biomass burning, raising

cattle and some industrial activities, including nylon manufacture. Once emitted, N_2O remains in the atmosphere for approximately 114 years before removal, mainly by destruction in the stratosphere.

Tropospheric Ozone

Tropospheric ozone is produced by photochemical reactions in the atmosphere involving forerunner chemicals such as carbon monoxide, CH_4, volatile organic compounds and nitrogen oxides. These chemicals are emitted by natural biological processes and by human activities including land use change and fuel combustion. Because tropospheric ozone is relatively short-lived, lasting for a few days to weeks in the atmosphere, its distributions are highly variable and tied to the abundance of its forerunner compounds, water vapour and sunlight. Tropospheric ozone concentrations are significantly higher in urban air, downwind of urban areas and in regions of biomass burning. The increase of 38% (20–50%) in tropospheric ozone since the pre-industrial era is human-caused. It is very likely that the increase in the combined radiative forcing from CO_2, CH_4 and N_2O was at least six times faster between 1960 and 1999 than over any 40-year period during the two millennia prior to the year 1800.

1. Find the equivalents to the following words and word combinations in the text:

тысячелетие, химическое окисление, земля в тропиках, производство нейлона, разрушение, тропосферный озон,

фотохимические реакции, исходные компоненты, монооксид углерода, летучие органические соединения, выделяться в результате естественных биологических процессов, быть результатом антропогенной деятельности, городской воздух, антропогенный

2. Answer the questions:

1. What are the natural sources of nitrous oxide?

2. What chemicals are involved in production of tropospheric ozone?

3. What human activities influence the emission of carbon monoxide, methane CH_4, nitrogen oxides, volatile organic compounds?

Glossary

Text 1

albedo
climate forcing
human-induced
longwave radiation
precipitation
solar variations
the mean of temperature
to range from…. to
vegetation

Text 2

atmospheric composition

average

common confusion

extreme temperature

frequency

to average weather

to emerge

to identify climate change

to predict

to relate

Text 3

abundant gas

airflow

at short wavelengths

infrared

nitrogen

on average

roughly

the greenhouse effect

to absorb

to burn fossil fuels

to cause global warming

to emit (radiation)

to exert

to intensify …. effect

water vapour

Text 4

incoming solar radiation

outgoing thermal radiation

properties of gas

solar changes

to affect

to alter

to cause changes

to release carbon dioxide

volcanic eruption

Text 5

bromine

carbon dioxide

chlorine

chlorofluorocarbon

decay of plant matter

deforestation

emissions

fertilizer

fluorine

halocarbon

landfill

methane

nitrous oxide

refrigeration agent

stratospheric ozone depletion

to accumulate

to be attributable to

to occur

to release

to result in

uptake

wetland

Text 6

biogenic emissions

carbon monoxide

natural aerosol

soot

stratosphere

sulphate

sulphur compounds

surface mining
to cause the ozone hole
to release dust from the surface
to undergo chemical destruction
troposphere

Text 7

energy balance
incoming solar radiation
outgoing infrared radiation
radiative balance
radiative forcing
rate
to decrease
to evaluate
to push away
to quantify

Text 8

atmospheric circulation pattern
glacier
instrumental observations
latitude
on record

sea ice retreating

snow cover

stratosphere

substantial influence

the North Atlantic Oscillation

the Northern Hemisphere

to cool markedly

to diminish

to melt

troposphere

Text 9

cement manufacture

conversion

extent

fossil fuel combustion

natural emissions

pre-industrial times

remainder

short-lived pollutant

sink

to account for

to exceed

to reveal
unprecedented

Text 10

carbon cycle
heavy form of carbon
isotope
nuclear weapon
ratio
to offset human-caused emissions

Text 11

amendment
atmospheric lifetime
biomass burning
chemical synthesis
eventual destruction
near-zero growth rate
perfluorocarbon
proliferation
ruminant animal
to phase out (production)
to stabilize

Text 12

carbon monoxide

chemical oxidation

destruction

forerunner chemical

human-caused

millennium (millennia)

nylon manufacture

photochemical reactions

to be emitted by human activity

to be emitted by natural biological process

tropical soils

tropospheric ozone

urban air

volatile organic compounds

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