

Course: Basics of Environmental Engineering (Climatology)



Week 9

Main Topic: Wind

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- Types of Wind.
- Measurement of Wind.
- How is wind formed on Earth's surface?
- Factors affecting Wind motion.
- Importance of Wind on Crops.
- Why is understanding wind important for climate on Earth's surface?
- Wind energy.
- Wind erosion.
- Self-assessment.

Introduction to wind

Wind, a sort of air movement driven by atmospheric pressure, comes in many forms, including local breezes, thunderstorm flows, and global winds, which are created by heating land surfaces, lasting for hours, and absorbing solar energy across the planet's climate zones.



- The unequal heating of the earth's surface by the sun is what causes the pressure variances.
- Warm air rises, creating low-pressure areas, whereas cool air sinks, creating high-pressure areas. This means that the flow of air from high to low pressure is what we refer to as wind.

Types of wind

Winds play a major role in the Earth's climate system by distributing heat throughout the planet and influencing weather patterns. The Coriolis effect influences the direction and circulation of winds.

There are various main kinds of winds, and they all have unique qualities.

❖ **Trade winds:**

Trade winds are prevalent winds near the equator, blowing from the eastern to western hemispheres. In the Northern Hemisphere, northeasterly trade winds originate over the Atlantic Ocean and provide moisture to areas such as the Caribbean and Central America. In contrast, the southeasterly trade winds of the Southern Hemisphere provide precipitation to eastern Australia and adjacent areas. These winds are caused by temperature contrasts between tropical ocean surfaces and cooler polar regions.

❖ **Monsoon winds:**

Monsoon winds are seasonal winds that bring significant rain to specific places at various times of the year. Monsoons form when large-scale atmospheric circulation produces a shift in wind direction, transporting moist air from the oceans to land areas where precipitation occurs. Monsoons usually influence Asia, Africa, and Central America. For example, India has a monsoon season from June to September, when southwesterly monsoon winds bring heavy rainfall to its western coast.

❖ **Westerlies:**

Westerlies are mid-latitude winds that primarily blow from west to east throughout Antarctica and North America (Northern Hemisphere). Westerlies in both hemispheres transfer moisture from the Pacific Ocean to continents such as South and North America, where it contributes to precipitation. The westerly jet stream is important for delivering storm systems across these

❖ **Easterlies:**

Easterlies are prevailing trade winds near the poles that blow from east to west or land to sea, depending on their position. Easterlies produce dry conditions to Antarctica because freezing ocean temperatures prevent evaporation and cloud development over huge areas of water surrounding the continent's coastline. In northern Australia, during the summer months, easterly trade winds bring moisture-laden air from the Coral Sea to coastal areas such as Queensland's Gulf Country.

❖ **Local winds**

Local winds are small-scale winds near the Earth's surface that have a substantial impact on local climates, weather patterns, agriculture, and human activities.

Local winds include:

- ✓ **Land and sea breezes:** are common local winds distinguished by their land and sea cycles. During the day, land heats up faster than water, causing air to rise and sea breezes to blow inland. At night, land cools faster than water, creating a land breeze.
- ✓ **Mountain and valley winds:** are caused by temperature variations between mountain slopes and valley floors. Warm air rises upslope during the day, causing anabatic winds, while cool air drops downslope at night, producing katabatic winds.

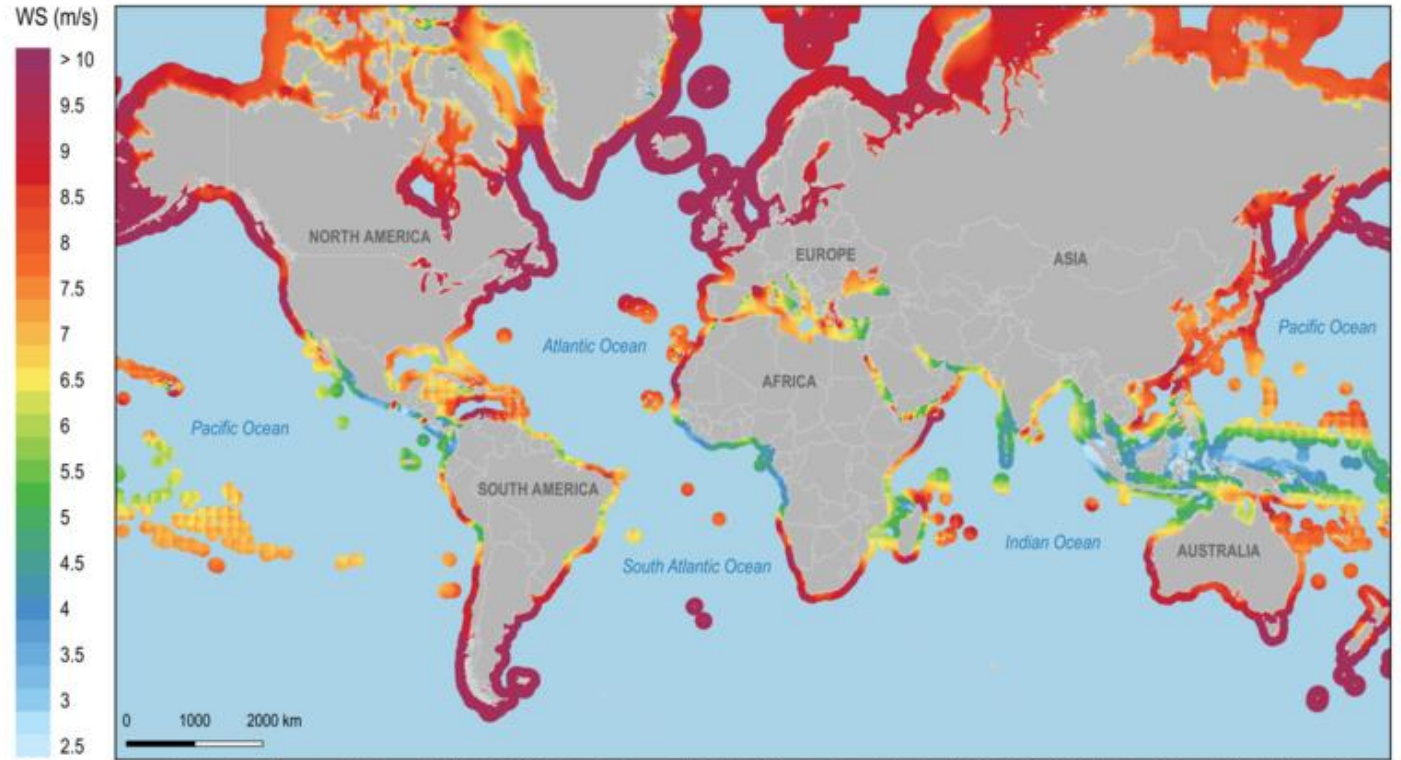
- ✓ **Chinook Winds:** These warm downslope winds occur on the leeward side of a mountain range. Moist air ascends one side of the mountain, releasing precipitation, while dry and warm air lowers the other side, producing rapid warming.
- ✓ **Santa Ana Winds:** These hot, dry winds originate from high-pressure systems over North America's Great Basin. These winds gather speed as they approach towards lower elevations in Southern California, increasing the risk of fire due to the drying effect they have on vegetation.

❖ **Seasonal Winds:**

Temperature differences between seasons or geographic areas generate seasonal winds. Northerlies form throughout the winter when high pressure accumulates over Polar Regions, causing cold air to travel southward into temperate zones. Southerlies form in the summer when high pressure shifts towards Polar Regions, pushing warm air northward. Land-sea breezes arise due to temperature differences between land and water, resulting in midday warmth and localized convection. Land breezes travel outwards at night due to rapid cooling.

Illustrations of movement of some Winds:

Global Offshore Wind Speeds



This wind resource map provides an estimate of mean annual wind speeds (m/s) extending 200 kilometers from shore at a hub height of 100 meters. It is provided under a World Bank Group (WBG) initiative on offshore wind that is funded and led by the Energy Sector Management Assistance Program (ESMAP). For more information please visit: <https://esmap.org/offshore-wind>. The wind resource data is from the Global Wind Atlas (version 3.0), a free, web-based application that provides data with a 100 m resolution based on the latest input datasets and modeling methodologies. For more information please visit: <https://globalwindatlas.info>.

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THE WORLD BANK IFC
 **ESMAP**
Energy Sector Management Assistance Program
Published: May 2020
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<https://commons.wikimedia.org/w/index.php?title=File:Global-Offshore-Wind-Potential-WBG-ESMAP.png&oldid=850792995>

Instrument used to measure rate of wind

An **anemometer** measures wind speed and direction and is used in weather stations. **Wind vanes** indicate wind direction with an arrow or fin. **Wind alarms** alert users when wind speeds reach a specific threshold and are used in industries like construction, agriculture, renewable energy, mining, aviation, and marine.

Anemometer



[https://commons.wikimedia.org/w/index.php?title=File:Anemometer on The Post Building, London_2024-02-10.jpg&oldid=850883113](https://commons.wikimedia.org/w/index.php?title=File:Anemometer_on_The_Post_Building,_London_2024-02-10.jpg&oldid=850883113)

Wind vane



https://commons.wikimedia.org/w/index.php?title=File:Wind_vane_05643.jpg&oldid=786250330

How is wind formed on Earth's surface?

- Uneven Heating: The sun's rays heat the Earth unevenly due to variations in the angle and intensity of sunlight received at different latitudes.
- Convection Currents: As air near the ground is heated, it becomes less dense and rises, creating a region of low pressure. Cooler, denser air then moves in to fill this void, creating a flow of air known as wind.

- **Coriolis Effect:** The rotation of the Earth causes moving air masses to be deflected to the right in the Northern Hemisphere and to the left in the Southern Hemisphere. This deflection influences wind direction and patterns globally.
- **Pressure Gradients:** Differences in atmospheric pressure between two locations create pressure gradients that drive the movement of air from high-pressure areas to low-pressure areas, generating winds.

- **Local Topography:** Features such as mountains, valleys, and bodies of water can also influence wind patterns by altering airflow and creating localized wind systems.

❖ Factors that affect wind motion

- **Pressure difference :** The difference in air pressure between two locations creates a pressure gradient, causing air to travel from high to low pressure.

- **Temperature difference:** The sun's uneven heating of the earth's surface causes a temperature difference, which creates pressure and drives wind circulation.
- **Coriolis effect:** is the deflection of moving objects, including air, caused by the earth's rotation, which causes wind to curve and form large-scale phenomena such as trade winds and jet streams.

- **Topography** : The shape and features of terrain, such as mountains, valleys, and coasts, can affect the direction and speed of wind.
- **Vegetation and roughness of surface**: The roughness of the surface, which includes vegetation, buildings, and other barriers, can slow and interrupt wind flow, influencing wind speed.
- **Altitude**: As altitude increases, wind speed increases due to less surface friction. This is why turbines are frequently installed on tall towers to collect the powerful wind.

- **Seasonal and diurnal variation:** Seasonal temperature and pressure patterns, as well as daily variations in solar heating, can cause changes in wind speed and direction throughout time.
- **Centrifugal force:** When an air particle moves in a curved path, an acceleration towards the centre of the rotation occurs. As a result of the acceleration, a centrifugal force operates, causing the particles to be thrown.

The Impact of Wind on Crops:

Understanding the complex link between wind and crops is critical for improving agricultural methods and maintaining long-term food production, as it has a considerable impact on crop growth and development.

Wind Dispersal of Pollen and Seeds:

Wind significantly impacts crops by facilitating the dispersal of pollen and seeds, which promote genetic diversity, improved yields, and resilience to environmental stressors. This process also influences plant reproduction and colonization, influencing crop distribution patterns.

- **Wind Stress on Crops:**

Wind stress on crops can be harmful because it causes physical damage, reduces output, and accelerates water loss. Despite the fact that wind helps with pollination, it can cause dehydration and wilting. Therefore, it is critical to handle wind stress adequately.

- **Wind is a carrier of pests and diseases.**

Wind is a major transporter of pests and diseases, carrying them across large areas. This is a serious hazard to agricultural systems, needing proactive pest management techniques to reduce possible losses.

❖ Why is understanding wind important for climate on Earth's surface?

- **Climate Patterns:** Wind plays a crucial role in distributing heat and moisture around the planet, influencing regional climates and weather patterns.
- **Ocean Currents:** Winds help drive ocean currents, which play a significant role in regulating global climate by redistributing heat across oceans.

- **Agriculture:** Knowledge of prevailing wind patterns is essential for agriculture as winds can affect crop pollination, pest control, and soil erosion.
- **Energy Production:** Wind energy is harnessed through turbines to generate electricity, making an understanding of wind patterns vital for renewable energy production.

WIND ENERGY

Wind energy is the energy created by wind,

Scientists are using energy from the wind to generate electricity. Wind energy is created by using a wind turbine.

The wind blows the blades of the turbine, which are attached to a rotor.

The rotor then spins a generator to create electricity.

Wind turbines convert kinetic energy from the wind into electricity, contributing to renewable energy production.

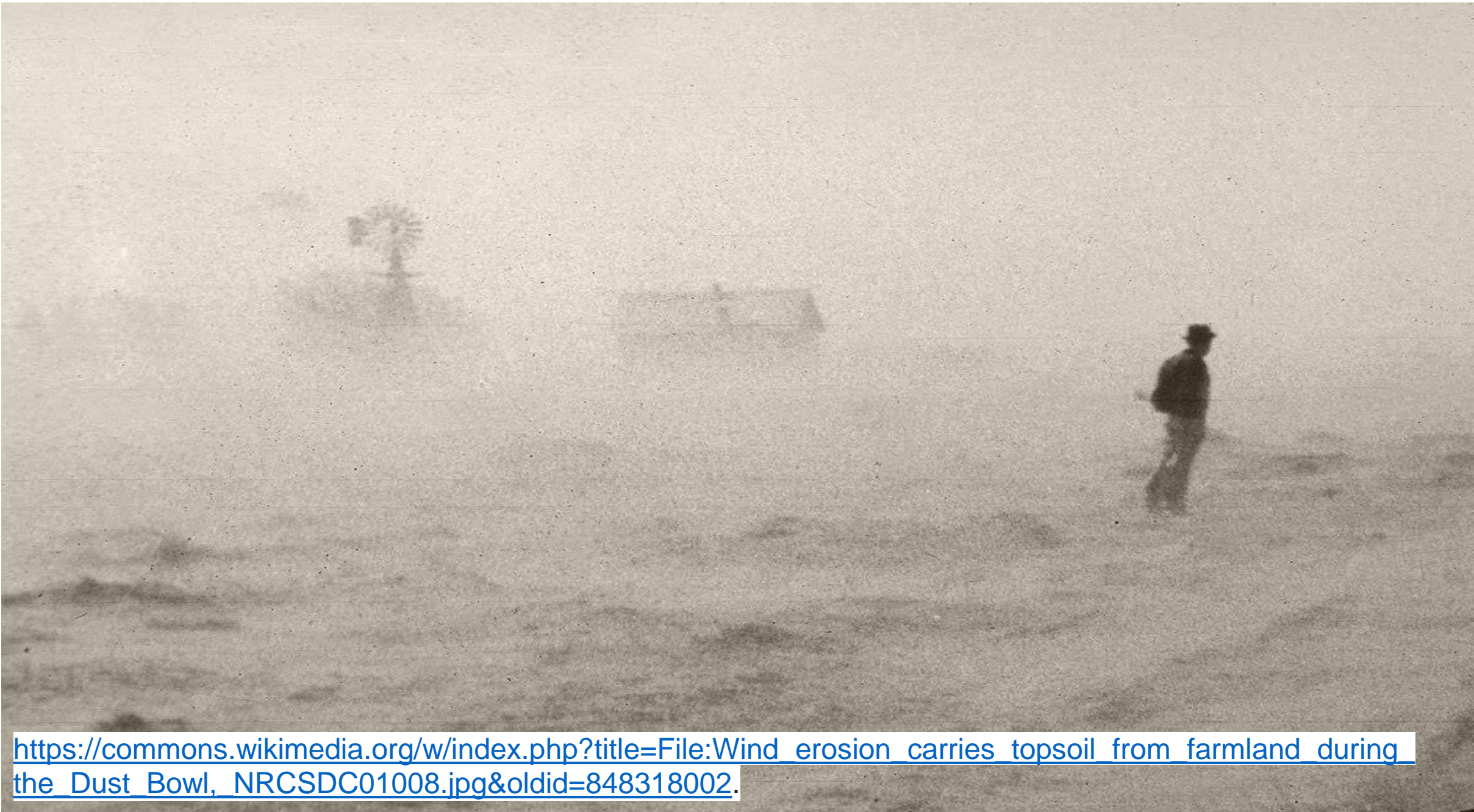


❖ **WIND EROSION**

Wind erosion means that erosion that caused by wind , in agriculture wind causes erosion in different ways :

strong wind blows loose and coarse soil particles for long distance, and this lead soil degradation.

In dry continent , strong wind seen to eat to eat up cliff or hard rock .



[https://commons.wikimedia.org/w/index.php?title=File:Wind erosion carries topsoil from farmland during the Dust Bowl, NRCSDC01008.jpg&oldid=848318002.](https://commons.wikimedia.org/w/index.php?title=File:Wind_erosion_carries_topsoil_from_farmland_during_the_Dust_Bowl,_NRCSDC01008.jpg&oldid=848318002)

Quiz



1. What is wind?
2. How is wind formed on the Earth surface?
3. How does wind affect climate on Earth's surface?
4. What impact does wind have on local weather patterns?
5. How do topographical features influence wind patterns and climate?
6. Why is understanding wind important for climate on Earth's surface?

1. What is wind?

- Wind is the movement of air on Earth's surface caused by the uneven heating of the atmosphere by the sun. As the sun heats different parts of the Earth's surface at varying rates, air masses with different temperatures and pressures are created. These temperature and pressure differences lead to the movement of air, which we perceive as wind.

2. How is wind formed on Earth's surface?

Wind is formed on Earth's surface due to the uneven heating of the atmosphere by the sun. As the sun heats the Earth, different surfaces absorb heat at varying rates. This causes air to warm and rise in some areas while cooler air moves in to replace it, creating wind.

3. How does wind affect climate on Earth's surface?

Wind plays a crucial role in shaping climate on Earth's surface by redistributing heat and moisture. It helps regulate temperature by carrying warm or cold air masses from one region to another, influencing weather patterns and climate conditions.

4. What impact does wind have on local weather patterns?

Wind influences local weather patterns by transporting moisture, affecting cloud formation, and determining the direction and intensity of storms. It can bring changes in temperature, humidity, and precipitation, contributing significantly to daily weather variations.

5.How do topographical features influence wind patterns and climate?

Topographical features such as mountains, valleys, coastlines, and bodies of water can alter wind patterns and climate conditions in specific regions. They can cause air to rise or descend, leading to differences in temperature, precipitation levels, and overall climatic characteristics.

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