



Introduction to Meteorology

20 Local wind system

Introduction



Once the wind is driven by a pressure gradient, the Coriolis force and friction determine the direction and intensity of the wind.

Pressure gradient force is proportional to the pressure difference and is inversely proportional to the distance between two points. Large-scale wind, such as westerlies, develops due to the large-scale pressure gradient and the local wind is caused by regional scale pressure gradient. The local pressure gradient is mainly because of differential heating or orography.

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1. Sea and land breezes
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Learning objectives



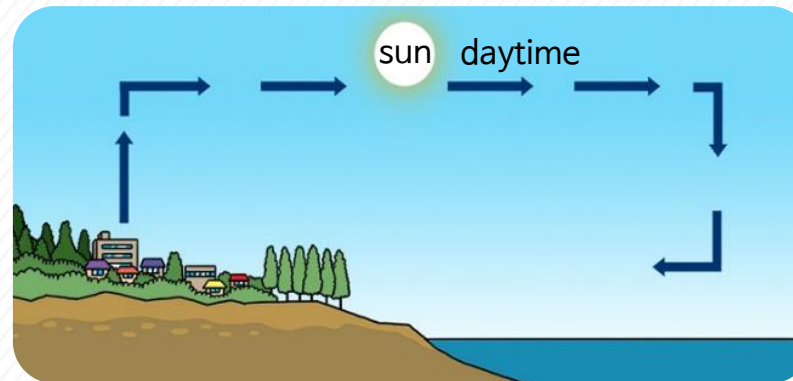
1. Classify the types of winds.
2. Describe the names and causes of local wind systems.

Learning Activities

1. Sea and land breezes

The sea breeze is the wind caused by pressure gradient force due to the thermal difference between the land and the sea (water). The pressure gradient results in the breeze that blows at the surface from the sea to the land during daytime (sea breeze), and the opposite direction during nighttime (land breeze).

During daytime, the air over the land heats up more quickly and becomes less dense than over the adjacent water (which does not show strong diurnal variation), resulting in a shallow thermal low. Because of the expansion of the air over the land, pressure gradient first appears in the upper level, and the upper air blows from land to sea. Because of the air moving from the land to the sea, a low pressure appears over the land, and a high pressure over the sea. As a result, the low-level wind blows from the sea to the land, and the sea breeze develops.



〈Sea and land breeze〉

※ Source: Introduction to Atmospheric Science (So, Sun-Sup et al. Cheongmoongak)

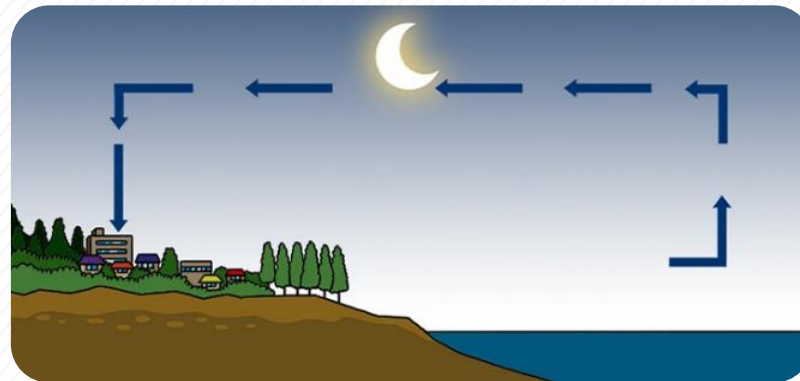
Learning Activities

1. Sea and land breezes

At night, the land surface cools more quickly than the water. Therefore, in the lower level, a land breeze (wind from land to sea) occurs.

The sea breeze develops well on calm and sunny summer days. It begins to develop before noon and peaks in the mid-afternoon. In the afternoon, the sea breeze front moves inland and drops the temperature over the land.

The leading edge of the sea breeze is called the sea breeze front where convergence occurs since the wind gets weaker as it moves further inland. The updraft in the sea breeze front induces convective clouds. In Korea, sea breeze usually occurs from late spring to early autumn.



〈Sea and land breeze〉

※ Source: Introduction to Atmospheric Science (So, Sun-Sup et al. Cheongmoongak)

Learning Activities

1. Sea and land breezes

The sea breeze blows at about 200~1,000m in elevation, the wind speed is about 5~6 m/s. A land breeze occurs at about 100m in elevation at a speed about 2~3 m/s. Because of the weak magnitude, it is hardly observed on cloudy or rainy days.

Sea and the land breezes are greatly affected by terrain. Their characteristics, therefore, depend on the orography. Over complex terrain, more complicated wind systems coincide with the sea and land breezes.

Sea and land breezes are often seen in Florida.



※ Source: Meteorology Today

Learning Activities

2. Mountain-valley winds

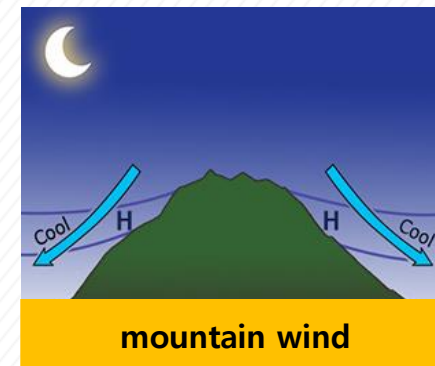
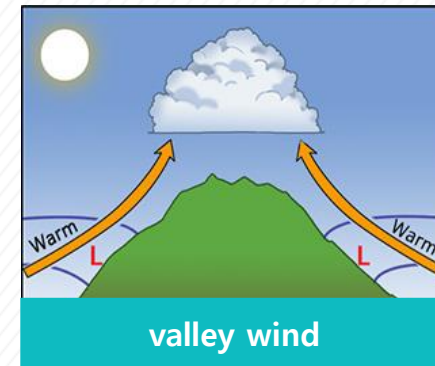
On a clear and calm day, the valley wind and mountain wind appear at day and night, respectively.

During daytime, sunlight heats up the valley walls, which in turn warms the air in contact with them. The heated air, being less dense than the air at the same altitude, rises like a gentle upslope wind known as a valley wind. At the top of the mountain, heated air rises and triggers cumulus cloud if the atmosphere is unstable. The cumulonimbus develops, causing heavy rain and lightning. This is why thunderstorms can be observed on a summer afternoon in the mountains.

Mountain wind is the wind that glides downslope into the valley during night time when the mountain slope is radiatively cooled quickly.

Looking closely at the valley wind during the day, on both sides of the valley, a slope wind can be observed. In the form of supplementing it, there is a strong wind above the center of the trough.

The mountain wind is thinner than the valley wind. The temperature of a downdraft slope wind or mountain wind is generally higher than the surface temperature



※ Source: Meteorology Today

Learning Activities

3. Regional wind system

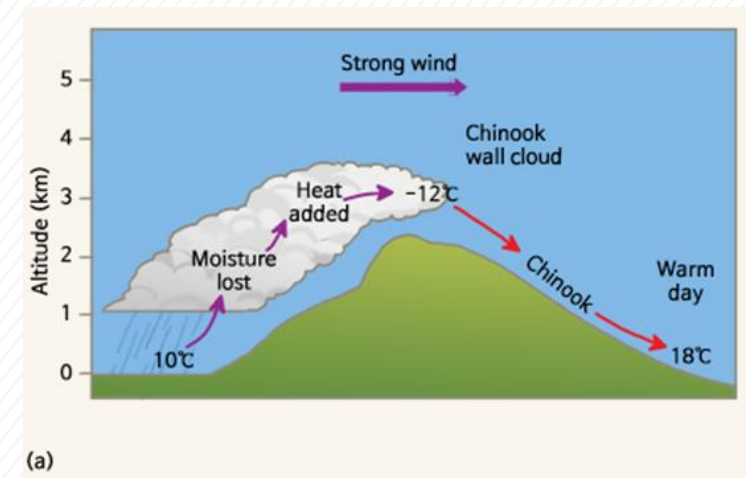
Foehn, Bora, airflow over the mountains, katabatic wind, Santa Ana Winds are regional wind systems.

1) Foehn

Fohn is another kind of downslope wind. It is called as Chinook in the eastern slope of the Rocky Mountains, Foehn in European Alps. The term 'foehn' is now commonly used.

descends, it is compressed and warms adiabatically. During the ascent of air, cloud and precipitation form on the windward side of the mountain. Since much of its moisture is removed on the windward side, the air gets drier. The release of latent heat inside the cloud supplements the compressional heating on the downwind side. Such processes make the descending air at the base of the mountain on the downwind side warmer and drier than it was before beginning its upward journey. Such dry and warm wind is called Foehn.

Foehn is frequently observed in relatively warm and dry climate zone. The temperature of upward air decreases $0.6\text{--}0.7^\circ\text{C}/100\text{m}$ following the moist adiabatic lapse rate, and increases $1.0^\circ\text{C}/100\text{m}$ by dry adiabatic lapse rate. Therefore, the relative humidity decreases as the air reaches the surface of the downwind side.



※ Source: Meteorology Today

Learning Activities

3. Regional wind system

2) Bora

Bora is an extremely cold wind that blows from the northeast onto the Adriatic coast in the former Yugoslavia.

When the cold and dense air from higher latitudes begins to descend through narrow canyon or channel, the flow of air can increase, often destructively, and cold air rushes downslope. Generally, Bora is a term for any cold downslope winds.

Learning Activities

3. Regional wind system

3) Airflow over mountains

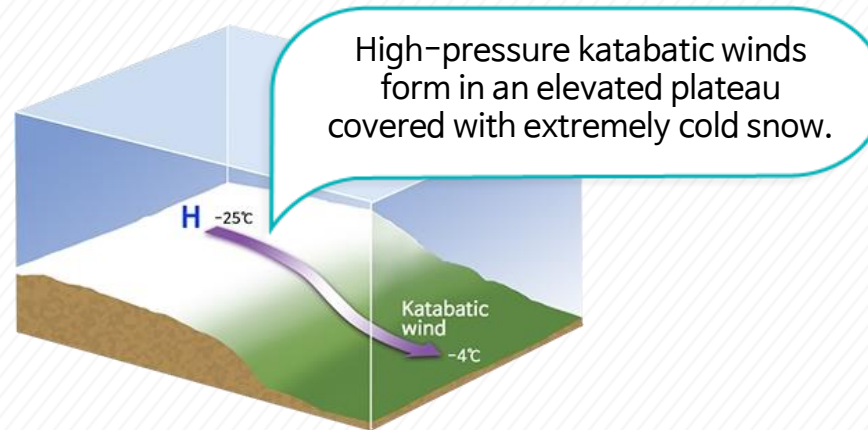
Airflow over mountains specifies the flow of air over the mountain which is smaller than synoptic scale flow in spatial scale. It includes the airflow over the mountain and the airflow descending the mountain. The flow is characterized by internal gravity waves (mountain waves/lee waves) which depend on the static stability of the atmosphere, the shape of the mountain, and vertical profile of the wind.

A katabatic wind is defined as cold and dense downslope wind caused by gravity. This wind comes from the plateau where cold air accumulates well in winter. The accumulated cold air rushes downhill from an elevated plateau like water flowing over a fall. The air descends along the valley relatively quickly. Descending air becomes warm by adiabatic compression, but it is still cooler than the surrounding area.

Learning Activities

3. Regional wind system

Because the katabatic wind is the movement of air with a relatively higher density, it 's hard to occur unless it is cold enough. The most prominent katabatic wind is observed in Greenland and Antarctica. High-pressure air accumulated over very cold icebergs flows down the slope of the iceberg or escapes onto the adjacent ocean. If the slope of the iceberg is steep, the speed of the katabatic wind becomes greater. The average annual wind speed in Cape Dennison, Antarctica is greater than anywhere else in the world, due to the strong katabatic wind.



Santa Ana wind is a warm and dry wind in Southern California. It refers to the wind that descends on a mountain slope in the east or northeast direction. A key characteristic of this wind is that the wind becomes very strong with a wind speed of over 90 knots as it blows through the valley. Santa Ana wind frequently occurs when a strong high-pressure system covers the western US. Hot and dry Santa Ana wind is a direct cause of forest fires.

Learning Activities

4. Importance of local wind

The local weather is mostly influenced by local wind system. Since many major cities are located in coastal zones, and about 50% of the world's population lives in the coastal region, a better understanding of the urban atmosphere, especially that modulated by local wind systems such as sea-land breeze and its related air pollutant transportation, is crucial.

The sea-land breeze occurs in one day cycle and depends on latitude, season, weather condition, coastal topography, and surface condition.

On a clear and calm day, sea (land) breeze starts within a few hours after sunrise (sunset) and lasts until sunset (sunrise).

Since the sea-land breeze forms a closed circulatory system, air on both the windward and downwind side get gradually contaminated. Also, since sea breeze affects the planetary boundary layer, it is important regarding air pollution. Moreover, it impacts the wind power generation as well. Moderate and sustained wind is best suited for wind energy production.



Local weather is strongly influenced by local wind system

Summary

1. Sea and land breeze

- It occurs in coastal area.
- It is caused by the pressure gradient due to the temperature gradient between land and ocean during the day and night.

Summary

2. Mountain-valley breeze

- It is caused by the temperature and pressure difference in the similar manner as the sea-land breeze occurs.

Summary

3. Foehn

- It refers to the downdraft wind along the slope of the mountains.
- As it descends, the air becomes warmer and drier on the downwind side due to the adiabatic compression.

Summary

4. Katabatic wind

- A katabatic wind is defined as cold and dense downslope wind caused by gravity.