Lake Effect Snow

Lake effect snows occur when a mass of sufficiently cold air moves over a body of warmer water, creating an unstable temperature profile in the atmosphere.

As a result, clouds build over the lake and eventually develop into snow showers and squalls as they move downwind. The intensity of lake effect snow is increased when higher elevations downwind of the lake force the cold, snow-producing air to rise even further.

The most likely setting for this localized type of snowfall is when very cold Arctic air rushes over warmer water on the heels of a passing cold front, as often happens in the Great Lakes region during winter.

Winds accompanying Arctic air masses generally blow from a west or northwest direction, causing lake effect snow to fall on the east or southeast sides of the lakes.

Whether an area gets a large amount of snow from lake effect is dependent on the direction of the winds, the duration they blow from a particular direction, and the magnitude of the temperature difference between the water and air.

Since cold air can hold very little moisture and the low level of the atmosphere is quite unstable, clouds form very rapidly, condensation occurs and snow begins to fall. Lake effect snow is lighter than snow that forms from frontal stratus or nimbostratus.

Areas of relatively high elevation downwind of the Great Lakes generally receive heavier amounts of lake effect snow than do other locations in this region.

For example, residents of the Tug Hill Plateau in New York State east of Lake Ontario can spend the winter months digging out of anywhere from 200 to 300 inches of snow. Likewise, the mountains of West Virginia can receive over 200 inches of snow in a winter, helped by the lake effect.

The only other lake that produces significant lake effect snow in the United States is the Great Salt Lake in Utah.

Cape Cod Bay in Massachusetts and Chesapeake Bay in Maryland and Virginia, on occasion, produce what is called bay effect snow. Bay effect snow forms in the same manner as lake effect snow, only over the ocean.


lake-effect snow

Part of Speech: n

**Definition:** a localized snow falling in convective bands along the lee of lakes when relatively cold air flows over the warm water

**Example:** In the US, lake-effect snow often occurs on the southern and eastern shores of the Great Lakes during Arctic cold-air outbreaks.

**Usage:** The same effect over bodies of salt water is called ocean effect snow, sea effect snow, or even bay effect snow.
Great Plains
Texas and the Southern Plains also receive their fair share of winter storms. A typical scenario begins with a strong cold front moving down the eastern slopes of the Rocky Mountains. As this front moves into the Texas panhandle, winds switch to the north and temperatures drop markedly.

Locals in the panhandle call this weather event a blue norther, referring to the blue-black sky that often accompanies these storms.

A blue norther brings cold air to Texas. The situation is complicated when moist air is present farther south in Texas, accompanied by upper winds out of the southwest or west. As the surface cold front continues to push southward, it undercuts the warm, moist air near the earth's surface.

The cold front slows or perhaps remains in a stationary position. This can result in an extended period of wintry precipitation, usually in the form of freezing rain or sleet caused by a shallow cold air dome near the ground.

The effects of a blue norther could be seen on Thanksgiving Day, 1993, when the Dallas Cowboys played football at Texas Stadium in the midst of a sleet storm. In January 1985, San Antonio experienced unusual weather in the form of snow and sleet, spurred on by the effects of the cold front.

Pacific Coast Winters
The West Coast of the United States receives the lion's share of its yearly precipitation during the winter months.

Unlike many other areas of the country where precipitation is relatively abundant throughout the year, the West Coast, particularly California, depends on winter rain and snow to replenish its water supply. If precipitation is light, especially for more than one winter in a row, water resources can become dangerously low.

In winter, the jet stream generally dips to the south, allowing storm systems from the Pacific to affect the West Coast. Big dips in the jet stream allow low pressure systems to move into the southern California area as well.

Sometimes California can receive a deluge of precipitation when significant subtropical moisture makes its way across the Pacific and interacts with a West Coast trough. Meteorologists often dub this occurrence "the Pineapple Express."

During some winter seasons, El Niño also plays a significant and sometimes disastrous role in southern California weather. During El Niño years, the eastern tropical Pacific Ocean sea water temperatures are above normal. Higher water temperatures create more heat and moisture in the air than is usual over this generally cool body of water.

The anomaly is generally just a few degrees, but that's enough to enhance the amount of subtropical moisture that southern California receives in winter.

This moisture, especially when it interacts with the polar jet stream, can produce heavy downpours, resulting in mud slides, rock slides, and severe flooding and flash flooding conditions.

While California sometimes feels the force of too much precipitation, there are years when the state does not receive an adequate amount of winter rain and snow. In these years, the jet stream moves away from the Golden State.

In a winter storm track situation where Washington and Oregon receive most of the winter precipitation, if the low pressure system is strong enough powerful upsloping winds may accompany the storm and heavy snow may fall in the Cascade Mountain range, particularly on the western-facing slopes. This situation can also occur in California with the Sierra Nevada Mountains.

Westerly winds often follow behind a West Coast winter low pressure system. Because the wind flows eastward from the Pacific Ocean, it brings with it additional moisture. When the air mass aloft behind the front is cold enough, thunderstorms frequently occur, often producing small-sized hail.

Winter Weather Climatology
Winter storms can affect all areas of the United States, including the Deep South and the deserts of the Southwest. They also come in various sizes and are created by different combinations of atmospheric conditions and the local geography.

The general availability of both cold and warm air in the troposphere makes winter storms in middle latitudes a common occurrence in several regions around the country.

Two general weather conditions associated with winter are overrunning and upsloping.

Overrunning occurs when moist, warmer air is directed up and over a mass of colder air at the surface of the earth. The warm air cools as it rises, and its moisture condenses into precipitation-producing clouds.

In an upslope flow, air rises and cools as it is forced to ascend to higher terrain. It then condenses and forms into clouds if it is cooled to its dew point.

Lake-effect snow

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"Lake Effect" redirects here. For the American literary journal, see Lake Effect (journal).

Lake-effect snow is produced during cooler atmospheric conditions when cold winds move across long expanses of warmer lake water, providing energy and picking up water vapor, which freezes and is deposited on the leeward shores. The same effect over bodies of salt water also occurs (e.g. ocean-effect snow, bay-effect snow). The effect is enhanced when the moving air mass is uplifted by the orographic influence of higher elevations on the downwind shores. This uplifting can produce narrow but very intense bands of precipitation, which deposit at a rate of many inches of snow each hour, often resulting in copious snowfall totals.

The areas affected by lake-effect snow are called snowbelts. This effect occurs in many locations throughout the world but is best known in the populated areas of the Great Lakes of North America, and especially Western New York, northwestern Pennsylvania, northeastern Ohio, southwestern and central Ontario, northwestern and northcentral Indiana (mostly between Gary, IN and Elkhart, IN), and western Michigan. The Tug Hill Plateau of New York State has the most snow amounts of any non-mountainous location within the continental U.S., followed by the Upper Peninsula of Michigan, which can average over 200 inches (508 centimeters) of snow per year. [1]

A lake-effect blizzard is the blizzard-like conditions resulting from lake-effect snow. Under certain conditions, strong winds can accompany lake-effect snows creating blizzard-like conditions. The wind chill and visibility values will often reach blizzard criteria; however the duration of the event is often slightly less than that required for a blizzard warning in both the US and Canada.

If the air temperature is not low enough to keep the precipitation frozen, it falls as lake-effect rain. For lake-effect rain or snow to form, the air moving across the lake must be significantly cooler than the surface air (which is likely to be near the temperature of the water surface). Specifically, the air temperature at an altitude where the air pressure is 850 millibars (85 kPa) (roughly 1.5 kilometers or 0.93 miles vertically) should be 13 °C (23 °F) lower than the temperature of the air at the surface. Lake-effect occurring when the air at 850 millibars (85 kPa) is much colder than the water surface can produce thundersnow, snow showers accompanied by lightning and thunder (caused by larger amounts of energy available from the increased instability).

There are several key elements that are required to form lake-effect precipitation and which determine its characteristics: instability, fetch, wind shear, upstream moisture, upwind lakes, synoptic (large)-scale forcing, orography/topography, and snow or ice cover.
Snow and ice cover

As a lake gradually freezes over, its ability to produce lake-effect precipitation decreases for two reasons. Firstly, the open ice-free liquid surface area of the lake shrinks. This reduces fetch distances. Secondly, the water temperature nears freezing, reducing overall latent heat energy available to produce squalls. To end the production of lake-effect precipitation, a complete freeze is often not necessary.⁹¹

Even when precipitation is not produced, cold air passing over warmer water may produce cloud cover. Fast moving mid-latitude cyclones, known as Alberta clippers, often cross the Great Lakes. After the passage of a cold front, winds tend to switch to the northwest, and a frequent pattern is for a long-lasting low-pressure area to form over the Canadian Maritimes, which may pull cold northwestern air across the Great Lakes for a week or more, commonly identified with the negative phase of the North Atlantic Oscillation (NAO). Since the prevailing winter winds tend to be colder than the water for much of the winter, the southeastern shores of the lakes are almost constantly overcast, leading to the use of the term The Great Gray Funk as a synonym for winter.⁹¹ These areas allegedly contain populations that suffer from high rates of seasonal affective disorder, a type of psychological depression thought to be caused by lack of light.¹⁰⁹
Great Lakes region, U.S. Northeast

Cold winds in the winter typically prevail from the northwest in the Great Lakes region, producing the most dramatic lake-effect snowfalls on the southern and eastern shores of the Great Lakes. This lake-effect produces a significant difference between the snowfall on the southern/eastern shores and the northern and western shores of the Great Lakes.

Fulton, New York after a snowburst dropped 4–6 feet (122–183 cm) of snow over most of Oswego County between January 28–31, 2004.

Lake-effect snows on the Tug Hill Plateau (east of Lake Ontario) can frequently set daily records for snowfall in the United States. Syracuse, New York, is directly south of the Tug Hill Plateau and receives significant lake-effect snow from Lake Ontario, averaging 115.6 inches (294 cm) of snow per year, which is enough snowfall to often be considered one of the "snowiest" large cities in America.[11][12] The communities of Redfield in Oswego County and Montague and North Osceola in Lewis County, all on the Tug Hill Plateau, average over 300 inches (762 cm) of snow each winter.[13] In February, 2007, a prolonged lake-effect snow event left 141 inches (358 cm) of snow on the Tug Hill Plateau.[14]
Elsewhere in the United States

See also: Great Salt Lake effect

The southern and southeastern sides of the Great Salt Lake receive significant lake-effect snow. Since the Great Salt Lake never freezes, the lake effect can influence the weather along the Wasatch Front year-round. The lake effect largely contributes to the 55–80 inches (140–203 cm) annual snowfall amounts recorded south and east of the lake, and in average snowfall reaching 500 inches (1,270 cm) in the Wasatch Range. The snow, which is often very light and dry because of the semi-arid climate, is referred to as "The Greatest Snow on Earth" in the mountains. Lake-effect snow contributes to approximately 6-8 snowfalls per year in Salt Lake City, with approximately 10% of the city's precipitation being contributed by the phenomenon.\[20\]

The Finger Lakes of New York are long enough for lake-effect precipitation. The Texas twin cities of Sherman and Denison are known to have experienced lake-effect snow from Lake Texoma in rare instances.

The Truckee Meadows and other parts of Northern Nevada which are normally in the rain shadow of the Sierra Nevada can, when conditions are right, have severe snowfall as a result of lake effect from Lake Tahoe. Recent severe examples of this phenomenon have occurred as recently as 2004, dumping several feet of snow in the normally dry region.

The West Coast occasionally experiences ocean-effect showers, usually in the form of rain at lower elevations south of about the mouth of the Columbia River. These occur whenever an Arctic air mass from western Canada is drawn westward out over the Pacific Ocean, typically by way of the Fraser Valley, returning shoreward around a center of low pressure. Cold air flowing southwest from the Fraser Valley can also pick up moisture over the Strait of Georgia and Strait of Juan de Fuca, then rise over the northeastern slopes of the Olympic Mountains, producing heavy, localized snow between Port Angeles and Sequim, as well as areas in Kitsap County and the Puget Sound region.\[21\]

Rarely, the phenomenon of gulf-effect snow has been observed along the northern coast of the Gulf of Mexico, notably during Florida's Great Blizzard of 1899.
Lake-effect snow

B. Geerts

The southern and eastern shores of the Great Lakes of North America are notorious for the heavy snowfall they receive each winter (Fig 1), especially from late November to early January. This is due to what is known as the lake-effect snow, and it may lead to large regional differences. For instance, 50 cm of snow may accumulate over the course of a few days near the shore, and 50 km from the lake shore the ground may be bare. Lake-effect snow occurs elsewhere as well, e.g. near Lake Baikal in Russia, but nowhere is it so pronounced and has it such an effect on ground and air transportation.

The local maxima in snowfall are not due to the proximity of mountains or an ocean. The difference is not because the southern and eastern shores are cooler than the surroundings, in fact they are slightly warmer than the other shores. Snowfall typically occurs in this area after the passage of a cold front, when synoptic factors are not conducive to precipitation. A schematic cartoon of the mechanisms involved in lake-effect snow is shown in Fig 2.

In more detail, these are the mechanisms, ranked in usual order of importance

1. **Heating.** The water of the Great Lakes lags behind the atmosphere in cooling through the fall and early winter. The heating from below results in static instability, especially during cold outbreaks. This instability mixes near-surface warm, moist air into the lowest 1 to 1.5 km, sometimes more. Rising air quickly reaches saturation, and the result is shallow cumuliform clouds, often aligned in bands parallel to the low-level wind. By January, ice covers most lakes, at least in part, cutting off or reducing the heat supply. Lake Erie often freezes entirely because it is more shallow.

2. **Moisture.** The lake surface evaporates, which is very effective when the wind is strong and the air dry (Dalton's equation, Note 4.E). The cold air from Canada has a very low vapour pressure. Also, strong winds cause spray, facilitating evaporation.

3. **Wind Fetch.** The length of trajectory of the wind across the lakes has a great bearing on the development of lake-effect snow. The greater distance the wind blows over the warm water, the greater the convection. Three of the five lakes, those with the most population centers, are relatively long and narrow. Winds blowing along the length of these lakes have a long trajectory over water, whereas a 30 degree windshift will bring the winds across the lake, not only shortening the trajectory considerably, but also moving the lake-effect snow to a different site.

4. **Frictional Difference.** The stress applied to the atmosphere from the surface is much greater over a rough land surface than over a relatively smooth lake water surface. When the surface winds blows from lake to land, it encounters increased friction, slowing the surface wind over
the land, resulting in surface convergence and lifting. Since stress varies with the square of the wind speed, this effect is greater with strong winds.

5. **Upslope lift.** In some localities, wind blowing from a lake onshore is forced to climb up hills. This is not a major factor in precipitation along the immediate lakeshore, but affects some more island locations. Certainly this effect is important in the case of Lake Baikal in Siberia.

6. **Land breeze.** Sometimes the lake-effect snow is concentrated along a narrow band due to mesoscale flows around the lake, in particular a landbreeze from one or opposing shores, e.g. when a weak northerly gradient wind blows along Lake Michigan.

7. **Large-scale forcing** (potential vorticity advection, isentropic uplift ...). The general cyclonic nature of an airmass, which supports development of precipitation anywhere, may enhance lake-effect snow.

**Reference**

Lake Effect Snow. The Weather Resource (web site)
Lake effect snow

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During the fall and winter, many areas of the eastern United States and Canada experience tremendous amounts of snowfall. This snow, known as "lake-effect snow," is generated from the temperature contrast between the cold arctic air moving over the relatively warm waters of the Great Lakes (or other large body of water). Unlike most winter storms, lake effect snows do not build their foundation upon strong areas of low pressure. Instead, they are fueled by the same dry arctic air that is responsible for clearing skies over land in other parts of the country. Specifically, cold arctic air passing over the Great Lakes picks up moisture and deposits it as snow inland from the downwind shore. So while other parts of the northeastern United States are clearing up after a recent cold frontal passage, communities near the Great Lakes wait for the lake effect snow machine to fire up! Barny Wiggin, former Meteorologist-In-Charge at the NWS Office in Buffalo, said it best when he claimed that the 'weather often "clears up stormy" to the lee of the Great Lakes during the winter.'

Lake effect snow cloud bands are remarkably persistent and have been known to cause continuous snowfall for as long as 48 hours over a sharply defined region—an amount that often exceeds that of a typical winter storm (i.e., one associated with a low pressure). Lake effect snows yielding as much as 193 centimeters (cm) (76 inches) of light-density snow in 24 hours and fall rates as high as 15 cm (6 inches) per hour have been reported. Furthermore, because winds accompanying arctic air masses generally originate from a southwest to northwest direction, lake effect snow typically falls on the east or southeast sides of the lakes. In general, lake effect snowfall contributes between 30 and 60 percent of the annual winter snowfall on the eastern and southern shores of the Great Lakes.

How does it work?

In the late fall and early winter, the waters of the Great Lakes become increasingly warmer relative to the cold dry arctic air masses that flow down from the north and northwest. When this air traverses the lake, the lower levels of the atmosphere pick up moisture and warmth. This air (along with the moisture it picked up from the lake below) is now lighter than the air above it and starts to rise as it continues its journey across the lake (a condition known as "convective instability"). As the air rises, it cools and the moisture that evaporated into it condenses (into tiny droplets or ice crystals) and forms clouds. Depending on the degree of instability of the air mass (i.e., how much warmer the lake water is than the air), bands of either stratus, stratocumulus, or heavy cumulus clouds form over the water and travel with the wind toward the downwind shore. When enough moisture condenses out of the air, it falls in the form of snow over the water and the lee side (downwind side) of the lake.
How is lake-effect snow formed?

As the cold air flows over the warm lake water, the relatively warm water heats the air's bottom layer as lake moisture evaporates into the cold air. Since warm air is lighter or less dense than cold air, the heated air rises and begins to cool. As the air cools, the moisture that evaporated into it condenses and forms clouds and snow begins falling from the cloud if the air is humid enough. (Graphic Credit: USA TODAY.)

Cold air moves over warm water and is warmed from below. Moisture evaporates in the air.