航海氣象講座之二 氣象與氣候/極地渦流/極地渦流

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氣象概述
文章概述了氣象的基本原理,包括熱空氣上升、冷空氣下沉,以及地球自轉和公轉造成的三胞模式與噴射氣流。

極地渦流
文章詳細介紹了北半球和南半球的極地渦流,指出南半球的渦流比北半球強 6 倍。在冬季,北極渦流非常穩定,而在夏季則不穩定,可能導致寒潮爆發。

溫帶氣旋
文章分析了溫帶氣旋的形成機理,包括冷空氣南下、暖空氣北上、極地渦流以及高空噴射氣流等四大因素。這與熱帶氣旋的形成機理不同。

結論
文章最後指出,由於全球變暖,極地渦流不穩定,導致氣候極端事件頻發,這對天氣預報和氣候研究提出了新的挑戰。

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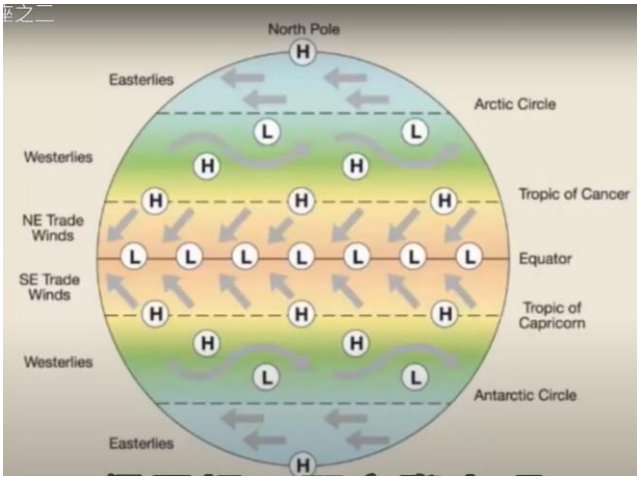
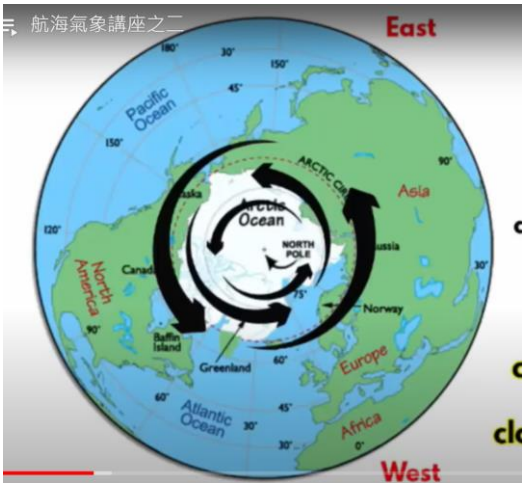


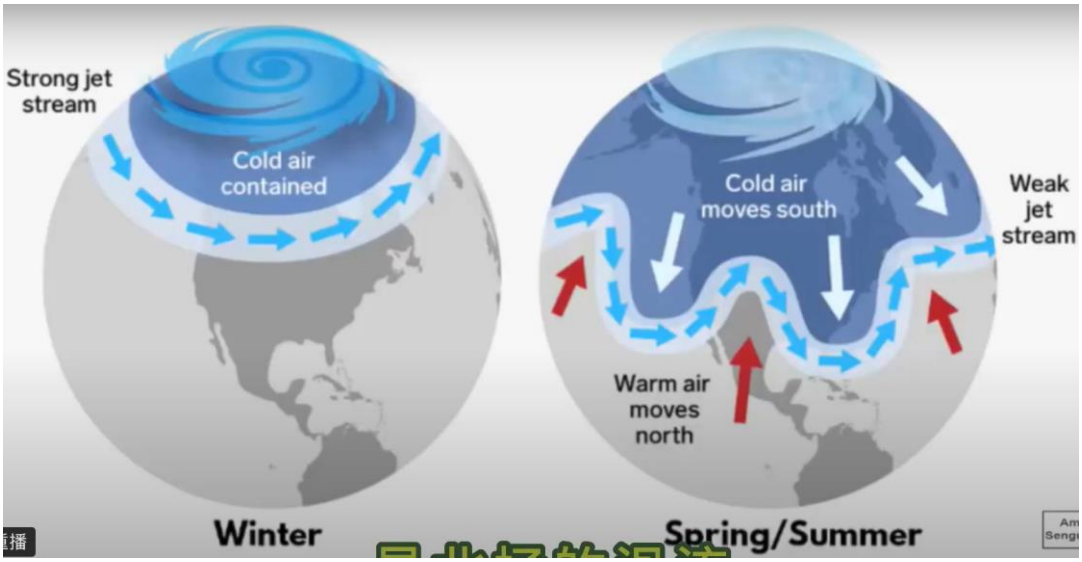


各位同仁大家好，這是航海氣象的第二講，上一次說氣象就跟燒開水一樣，冷縮熱脹熱空氣上升冷空氣下降，因為地球的自轉以及公轉，造成原來單純的赤道的熱空氣上升，在南北兩極變冷了以後下降，變成三胞模式，偏偏這三胞又不是很平坦，實際上看到的地球上面的氣象，就是這混亂的現象。

首先來看看南北兩極的極地渦流，現在看到這個方向是在北極的上空，在北半球極地的渦流是由西向東的渦流，從也就是反時針方向跟科氏利一樣方向旋轉，其實北極的渦流雖然是

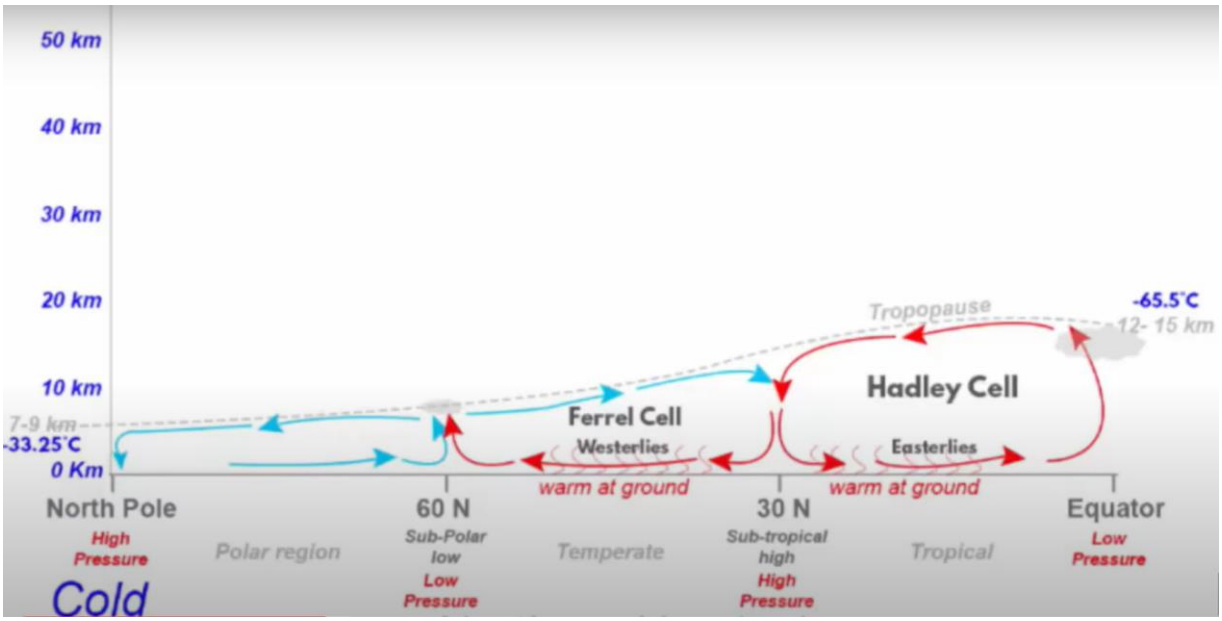
有，可是因為北極的外圍地區，大部分被陸地掩蓋，像是阿拉斯加，還有大西洋的格陵蘭，所以北極的渦流，其實沒有南極的厲害。

南極就是一個南極島的陸地，陸地上的結冰，可以高達 4 千米高，然後在南極州的四邊，都是海水，極強的南極還留，所以南半球的渦流比北半球至少要強六倍，就是在航行南半球的時候會遇到的，看到這個圖是北極的渦流。在冬天的時候北極的渦流非常穩定，因為北半球比較冷，然後冷空氣的質量比較大，這些渦流在北極圈，也就是北緯 60 度以上就叫做北極圈。



北極圈裡面這些冷氣團，為什麼不會因為它的重力影響，下沉到赤道跟溫帶? 因為它旁邊圍繞的一圈的噴射氣流，這些噴射氣流就是現在圖上看到標的 60 度緯度的地方，就是北極的冷氣團。冷空氣藍色的冷空氣往南邊前進的時候，受到越來越熱的地表海水溫度蒸發，在北緯 60 度向上，加上南邊來的暖空氣，兩者相遇，然後飛到高空上，在高空上又突破了地心引力，造成強烈的噴射氣流。

好現在看到這張圖左邊，這個 z 軸就是北極的位置，右邊就是赤道，中間就是 30 度的北緯跟 60 度緯度的氣流方向，60 度的北緯跟北極之間，這個叫做北極圈 Polar region。在 60 度到 30 度北緯之間叫做溫帶 Temperature，在 30 度到赤道叫做熱帶 Tropical，看在這個 Z 軸的大氣層高度是 10 公里，看到在赤道天空這邊大氣層是 20 公里高。



這個水蒸氣上升最高的地方是在赤道，大氣層高度是 12 到 15 公里，空氣溫度是-65.5 度 C，相對的在北極圈這邊空氣上下對流的是冷空氣，高度只有 7 到 9 公里，這就是熱空氣上升冷空氣下降，這個下降的冷空氣在地面是從北極往南邊推，像現在圖上看到的，是從左邊北極圈的北極南下到北極 60 度這裡，遇到了南邊來的暖空氣。

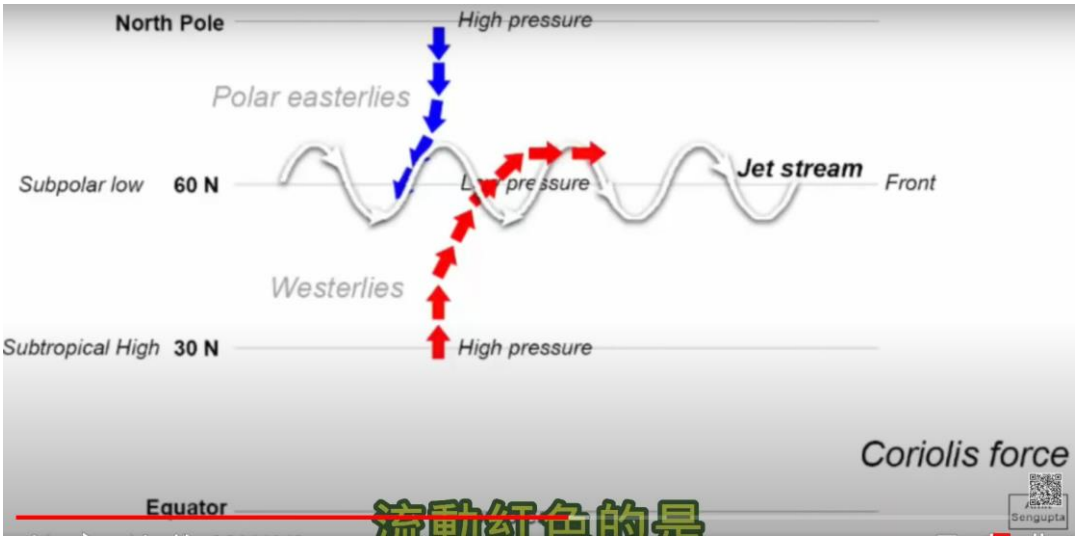
暖空氣在赤道的高度比較高，所以他的這個大氣壓力比較大，就直接把水氣跟空氣往南北兩極推，推到 60 度的地方，北極圈的位置又被冷空氣推到天空上，這邊在暖空氣超越對流層的頂部，也就是看到這個圖，橫的有一條虛線叫做 Tropopause 這個就叫做對流層頂。這些暖空氣被推到對流層的上面，它就不是上下流動，加上地球自轉科斯力的影響，它就向右移動，這些就是噴射氣流。

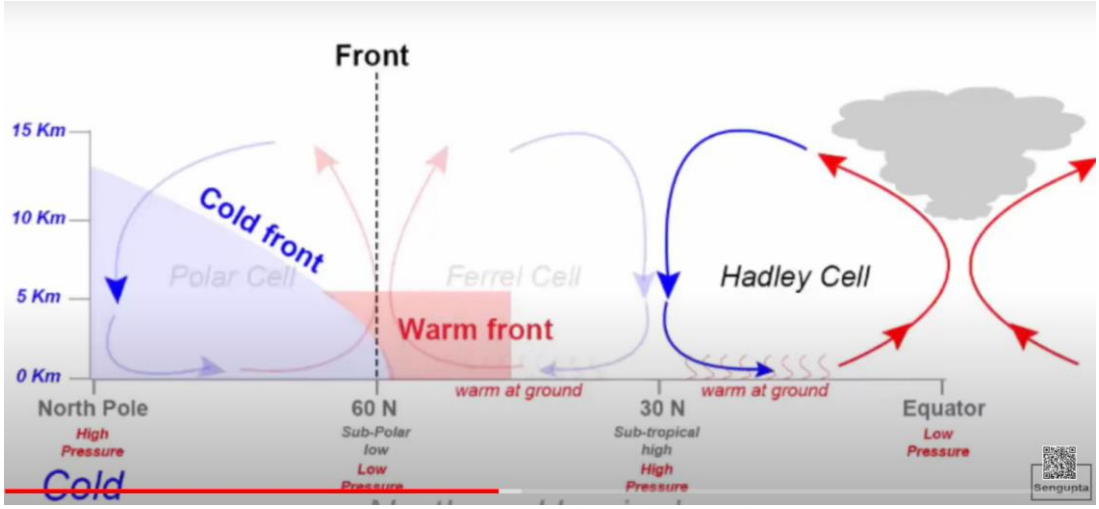
同樣一部分的暖空氣沒有升到高空，它就流在地面上跟冷空氣繼續在纏鬥，因為地面風不是跟電風扇一樣，要幾段就有幾段，有時候受地形影響，有時候強有時候弱，弱的當然就被冷空氣擠到天上去了，強的熱空氣它還是有辦法吹到冷空氣裡面去。看到這個就是在北緯 60 度，北極圈附近的冷空氣跟熱空氣的流動，紅色的是暖空氣，藍色的是冷空氣，這樣子上下波動，就會造成滯留鋒跟冷鋒跟暖鋒。暖空氣比較強造成的是暖鋒，冷空氣比較強造成的是冷鋒。

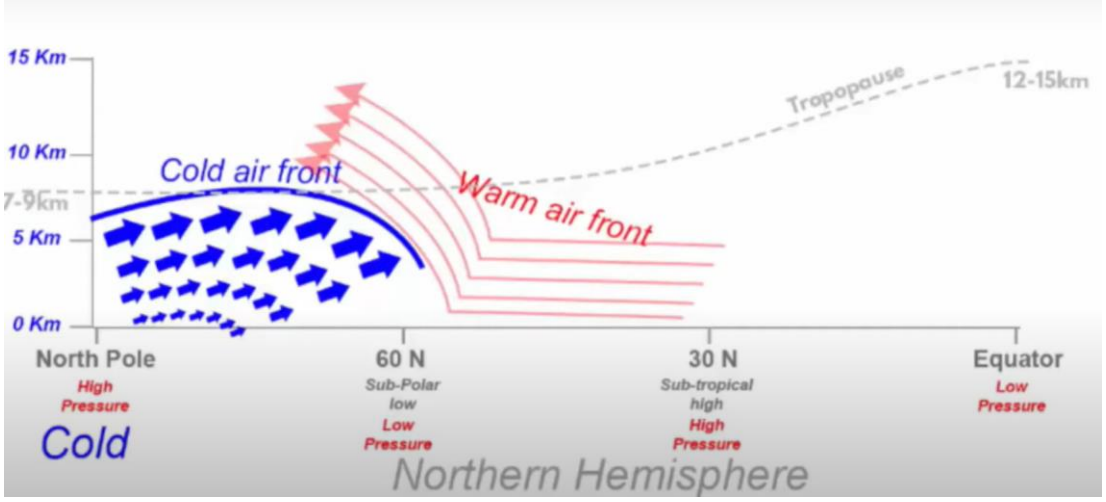
在這張圖，看到在冬天的時候，北半球的北極冷空氣非常穩定，因為北極圈附近的噴射氣流，南方來補充的暖空氣比較多，所以非常強盛，把這個冷空氣侷限在北極圈裡面，所以相對的溫帶氣旋就比較少，可是到了夏天的時候，這個北極圈北極自己就很熱，所以冷空氣就不穩定，北極一熱，南方來的暖空氣就少，同樣在北極圈附近上升的噴射氣流的質量就不夠，這時候北方的寒潮反而可以突破南下，

像今年美國的佛羅裡達州下大雪凍死了幾百個人，這個叫做寒潮爆發，也是在夏天的時候。

就算是新加坡號稱從來不吹颱風的，也因為寒潮爆發，但是它沒有降到地面，北極的寒潮只有到達新加坡的上空，但是已經足夠引起了新加坡的颱風。所以這個是夏天的寒潮爆發，現在因為地球的暖化，所以造成噴射氣流的不足，最後就是氣候極端的不穩定。

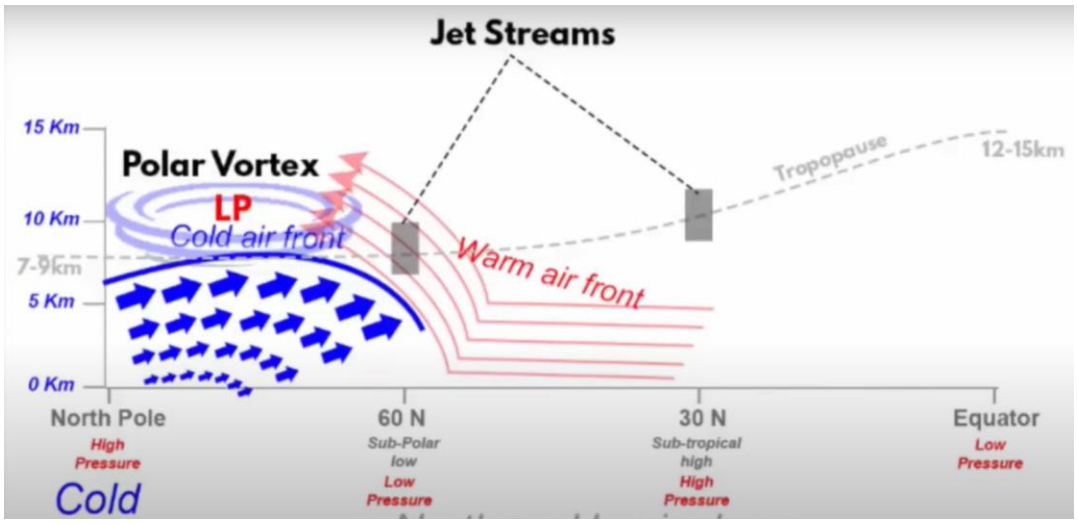




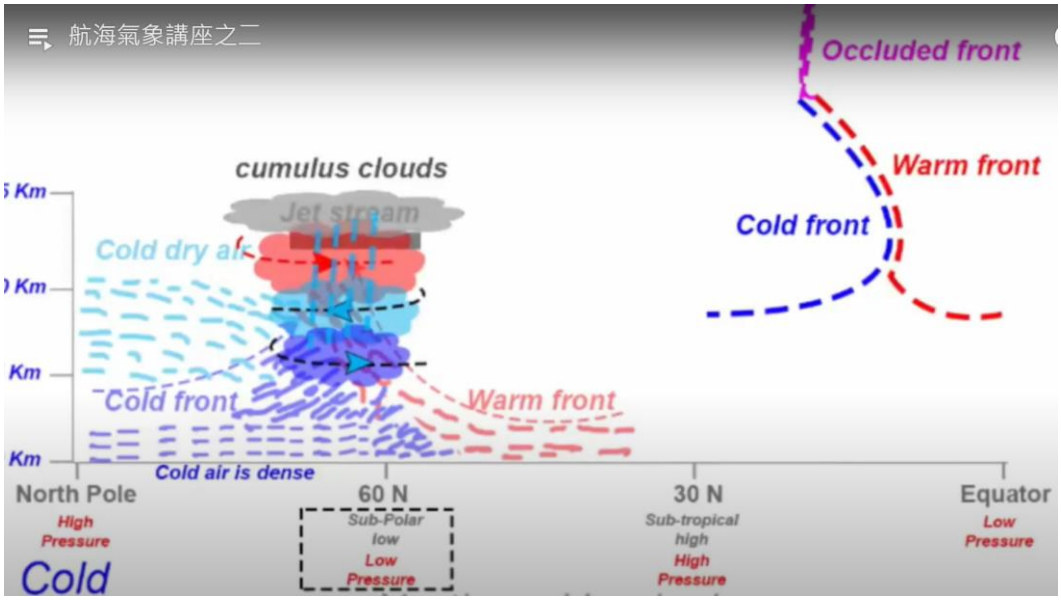


北極的冷空氣下降，還有一個名詞叫做極地震盪，這個對的天氣影響也是很大，尤其是冷不冷熱不熱的颱風，就像最近產生的煙花颱風一樣。好，這裡看到在北緯 60 度，其實因為極地震盪，這個冷空氣可能會不止在 60 度，會下到 40 度 50 度緯度的地方產生溫帶氣旋，

溫帶氣旋其實是有四個力量在主導第一個就是冷空氣，這個冷空氣切入暖空氣下面，第二個就是暖空氣，從南方來的暖空氣。第三個就是看到極地的渦流，第四個就是天上的噴射氣流。所以美國歐洲在研究溫帶氣旋，習慣用這個噴射氣流 500 毫巴氣象圖來研判溫帶氣旋的威力多少？主要的溫帶氣旋的動力，還是來自北方的冷空氣。好這裡看到左邊紫色的就是冷空氣南下，右邊的橘色的就是暖空氣，這兩個相遇，就是右上角的暖峰跟冷峰 FRONT，



加上淡藍色的這個北極的渦流，混合起來最上層的灰色的噴射氣流，這個就是整個構成了溫帶氣旋的動力來源。這個跟平常在熱帶地區，也就是赤道到北緯 30 度，最右邊的這個熱帶生成的熱帶氣旋的動力，是不一樣的。



好，這裡看到溫帶氣旋是在哪裡啊？在這個噴射氣流的附近生成，這個噴射氣流，如果它延

伸到北緯 40 度的話，就是極地震盪的產生。溫帶氣旋的生成區域，就是從北緯 40 度。同樣的紅色的是暖空氣、藍色的是冷空氣、淡藍色的是極地的渦流，跟旁邊上下波動的噴射氣流。噴射氣流的重要，就是為什麼要看五百毫巴的高空氣象圖，知道噴射氣流在哪裡? 因為噴射氣流會切割地面的暖空氣，造成溫帶氣旋，要不然就是只有極地震盪，不會有風暴的產生。

Hello everyone, this is the second lecture on maritime meteorology. Last time, we talked about how meteorology is similar to boiling water - cold contracts, hot expands. As air heats up, it rises, and as it cools down, it descends. Due to the Earth's rotation and revolution, the simple process of hot air rising at the equator turns into a more complex three-cell pattern. However, these cells are not flat, leading to the chaotic weather patterns we observe on Earth. Let's start by examining the polar vortex in the North and South Poles. In the Northern Hemisphere, the polar vortex rotates counterclockwise, from west to east. The Arctic vortex, although present, is weaker compared to the intense vortex in the Antarctic due to the Arctic region being mostly covered by landmasses like Alaska and Greenland.

In contrast, the Southern Hemisphere has a much stronger vortex, around six times more powerful than the Northern Hemisphere. In winter, the Arctic vortex is stable due to the colder temperatures in the Northern Hemisphere, leading to a circulation above the Arctic Circle. This circulation prevents the cold air masses from descending towards the equator and temperate regions. In the Southern Hemisphere, where Antarctica is surrounded by water, the vortex is significantly stronger. The image shows the stability of the Arctic vortex in winter, as the cold air masses remain in place above 60 degrees North latitude. As vessels navigate southward, they encounter increasingly warm surface sea temperatures, leading to evaporation. At 60 degrees North latitude, warm air from the south meets with the evaporated moisture, creating a convergence that rises to the upper atmosphere.

This upward motion breaks through the Earth's gravity, creating strong jet streams. The image depicts the positions of the North Pole, equator, and latitudes between 30 degrees and 60 degrees. The region between 60 degrees North latitude and the North Pole is known as the Polar region, while the area between 30 degrees and the equator is the Temperate zone. At the equator, water vapor ascends to heights of 12 to 15 kilometers, while in the Arctic, the convection height is only 7 to 9 kilometers. This difference in convection leads to the

rising of warm air and the descending of cold air. As shown in the illustration, cold air from the Arctic is pushed towards the south, encountering warm air streams from the south, creating a dynamic interplay that influences global atmospheric circulation patterns.

Without the impact of the flow of air masses and the Coriolis force due to the Earth's rotation, if it moves to the right, this is part of the jet stream. If warm air does not reach high altitudes, it flows along the ground and continues to wrestle with cold air. Because surface winds are not almost the same as electric fans, there are sometimes multiple sections. Sometimes, they are affected by terrain, sometimes strong, sometimes weak weak. Of course, the warm air is pushed up forcefully by the cold air. The warm air can still blow into the cold air. What we see is the movement of cold and warm air near the Arctic Circle at 60 degrees north latitude. The red color represents warm air, and the blue color represents cold air.

This fluctuation creates stagnant winds, cold winds, and warm winds. Warm air creates warm winds, and cold air creates cold winds. In this figure, we see that in winter in the Northern Hemisphere, the Arctic cold air is very stable because the jet stream near the Arctic Circle is enhanced by the abundant warm air coming from the south, so it strongly confines the cold air within the Arctic Circle, relatively reducing the mid-latitude cyclones. But in summer, the Arctic Circle itself is hot, so the cold air becomes unstable. When the Arctic region heats up, there is less warm air coming from the south, and at the same time, the quality of the rising jet stream near the Arctic Circle is not sufficient.

At this time, the cold surge from the north can break through and move south, like the severe winter storm that hit Florida, USA, this year, causing heavy snow and freezing hundreds of people. This is called a cold surge outbreak, occurring in summer. Even Singapore, which is known for never being hit by typhoons, is affected by cold surge outbreaks, but it doesn't reach the ground. The Arctic cold surge only reaches the sky over Singapore, but it is enough to cause typhoons in Singapore. This is a cold surge outbreak in summer. Now, due to global warming, the lack of jet streams ultimately leads to extreme climate instability. The descent of Arctic cold air also has a term called Arctic oscillation, which has a significant impact on our weather, especially on the formation of unpredictable extreme weather events like the recent Typhoon Hagibis.

Here we see that at 60 degrees north latitude, due to Arctic oscillation, the cold air may extend beyond 60 degrees and down to around 40 to 50 degrees latitude, generating mid-latitude cyclones. In fact, four forces dominate these

mid-latitude cyclones: first, the cold air cuts into the warm air below it; second, the warm air comes from the south; third, we see the vortex from the Arctic; fourth, the jet stream in the sky. Therefore, the US and Europe use the 500-millibar jet stream to assess the power of mid-latitude cyclones. In fact, the main driving force of mid-latitude cyclones still comes from the cold air from the north. Here we see that the purple color represents the southward movement of cold air, while the orange color on the right represents warm air. When these two meet, it creates warm and cold fronts in the upper right corner, combined with the light blue Arctic vortex and the gray jet stream at the top, which constitutes the power source of the mid-latitude cyclones. This is different from the power source of tropical cyclones in tropical regions, from the equator to about 30 degrees north latitude. Here we see where mid-latitude cyclones occur, near this jet stream, in the deep layer. So if this jet stream extends to around 40 degrees north latitude, it is due to the Arctic oscillation, the deep region of mid-latitude cyclones. Good. The same red is warm air at 40 degrees north latitude, blue is cold air, light blue is polar vortex. Jet streams that fluctuate up and down next to each other are important. That's why we need to look at the 500-millibar high-altitude weather map to know where the jet stream is, because the jet stream cuts through warm air on the ground to create temperate cyclones, otherwise only polar oscillations without storm generation.