PRINCIPAL WEATHER SYSTEMS IN POLAR ZONES

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Summary

The main weather systems typical of the Arctic and Antarctic are examined. In comparison with temperate latitudes polar zones are notable for smaller variety of weather systems and their elements. Features connected with the predominance of oceanic space in the Arctic and continental structure of the Antarctic as well as with the lack of seasons coincidence are taken into account.

1. Introduction

The analysis of weather in polar zones (north of 66.5° N and south of 66.5° S for the Northern and Southern Hemispheres respectively) is quite difficult in comparison with other regions because of deficiency in meteorological information connected with more severe weather conditions, and also due to the fact that the climatic regime of the Antarctic forms under conditions of considerable isolation from influences of lower latitudes.

Weather systems in these zones are less strikingly expressed in comparison with middle latitudes, especially in the Southern Hemisphere. Nevertheless, in polar zones one can also single out a number of specific features as regards their weather systems. Missions of weather forecasters relevant to the analysis and forecasting weather in these zones are the same as in other regions.

2. Weather Systems Typical of the Arctic

It is important to note that in the Arctic there are some regions (from III to VIII) with weather systems conforming to Bergeron' s model that has been elaborated for middle and high latitudes of the Northern Hemisphere (see *Principal Weather Systems in Temperate and Continental Zones*). Region III is characterized by the presence of the tropical air far outside its source region as well as low stratus (or fog) and drizzle; regions IV and V are characterized by extensive systems of nimbostratus (IV) and altostratus (V); region VI by subsidence in the polar (or Arctic) airmasses; region VII is occupied by the unstable branch of the *polar* and Arctic *air*, convective clouds, showers, and squalls; region VIII is characterized by stratocumulus, stratus, and fogs during the cold season.

In summer the source region of the Arctic air is mainly occupied by the fields of melting snow and ice of the Arctic basin and is swept with light anticyclonic winds. The surface temperature is limited by the melting point, while the warmer air is normally present at some distance above the ice. The relative humidity is high and fogs and low clouds are transferred from the air to the ice.

In winter this region extends to the northernmost parts of continents bordering the Arctic Ocean: Alaska, Northern Canada, Taimyr, Kolima and Chukotka. The Arctic region is often separated from the Eurasian polar continental region by the warmer air that flows from the Norwegian Sea toward Novaya Zemlya and the Taimyr Peninsula. This is especially true when the Siberian *anticyclone* is well developed. On the American side there is normally no distinct separation, and the Arctic region tends to merge with the North American polar continental source.

There is a permanent *atmospheric action center* in the Arctic on climate charts. It is the Arctic anticyclone associated with quite intense cyclonic activity in this region.

Mainly easterly winds are observed along the northern periphery of the extratropical low pressure zone (or along the southern periphery of the Arctic anticyclone). The air of Arctic origin transferred directly by these eastern winds will be considerably colder during the most part of the year than the airmasses stayin*g* in the temperate latitudes for a long time. Therefore the *Arctic fronts* often arise in the latitudes near 70 to 75 ° N separating the fresh air of Arctic origin from the air of temperate latitudes. The formation of cyclonic disturbances and intermediate anticyclones occurs in these fronts as well, like on the polar fronts. Due to the cyclonic activity the Arctic air invades the temperate latitudes and the air from these latitudes penetrates into the Arctic.

The summer border of the prevailing Arctic air is principally the border of the Arctic as a climate zone. In winter this border lies further to the north than in summer only in the European sector and in the eastern Atlantic. Therefore the border of the Arctic must be determined here by the winter position of the Arctic front. The reason is the development of a low pressure trough stretched out from the Iceland depression.

The inflow of solar radiation is absent during the polar night. There is atmospheric radiation from the warm air flowing from the temperate latitudes in the upper layers of the troposphere only. The strong cooling of the earth's surface under conditions of cloudless weather for inner areas of the Arctic in winter gives rise to the compression of subsident air and, given the air inflow from the temperate latitudes, an increase of pressure near the surface. The anticyclonic character of circulation results in scattering of cloudiness and further cooling of the surface air.

In summer the radiation in the Arctic is fairly considerable due to the unsetting sun. From June to August it is no less than in temperate latitudes, but because of great cloudiness and frequent fogs it seldom reaches the earth's surface as direct radiation. Nevertheless a general inflow of warm air is so great that the massive melting of snow and ice begins. At the same time the process of melting restricts possible increase of temperature up to some degrees above zero. The usual temperature of summer days in the central Arctic is near 0 ° C in 90 per cent of cases.

The atmospheric pressure in the Arctic is not relatively high, which is connected with the development of cyclonic activity.

In winter, during the period of sharp cooling of the air in the Arctic high pressure is settled. The Arctic anticyclone is strongly deformed on the side of the Atlantic Ocean and, in a smaller degree, on the side of the Pacific, which is conditioned by cyclonic activity above these oceans. The inflow of warm ocean waters from the south to the polar basin benefits the spreading of *cyclones* to the Arctic, especially in the Atlantic sector. The region of high pressure in winter is slightly displaced to North America. The zone of the Iceland depression spreads to Greenland, the Barents and Kara Seas. The influence of the Aleutian depression does not, however, spread far away to the Arctic.

The distribution of temperature corresponds to the distribution of pressure. The coldest region occupies the central part of the Arctic, inland Greenland and the archipelago of Canada. The highest temperatures are observed in the Atlantic sector.

The cyclonic activity in winter is observed mainly in the outer Arctic. This activity reaches the most pronounced development in the Atlantic and Pacific sectors, where due to large contrasts of temperature between the Arctic air and relatively warm maritime air of the temperate latitudes the Arctic front is sharpened.

In summer there are no well-expressed domains of low and high pressure. The distribution of temperature in the lower layer is characterized by the homogeneity of the littoral zone almost throughout all the space. In all inner Arctic the temperature keeps stably near 0 ° C depending on the ice melting. The cyclonic activity in summer develops in central regions of the Arctic too.

Thus, in winter during the polar night the main process influencing the action of the rest of factors in the Arctic is the progressive cooling of the frozen ocean surface and the whole of the air above the Arctic as a result of radiation. In summer this is the melting of ices under the effect of general heat inflow but, at the same time, the absorption of a vast quantity of heat out of the air for melting, which obstructs the possible temperature increase in the lower layer of air up to the values essentially exceeding 0°C.

The precipitation in the Arctic falls owing to the advection of moist air from the temperate latitudes.

The continental part of the Arctic is notable for certain peculiarities of climate conditions.

In winter, in connection with the difference of thermal regimes of sea and land, the predominance of wind blowing from the land is observed, which exerts cooling influence on the coastal zone. At certain synoptic situations this wind penetrates far away into sea. In the continental zone of the Arctic in summer the temperature rises on the average up to 10 ° C and higher. On certain days it occurs near the south border of the Arctic region (for example, in the area of the Bay of Tixi and in central Alaska, where the values of temperature reach 30 ° C). The amount of cloudiness, probability of fogs and values of relative humidity essentially diminish in comparison with those over the sea.

The shore zone in a number of cases works as a sharp border of the spreading of certain meteorological phenomena, for example, fogs.

In the littoral zone, wind streams change under the effect of the differences in the underlying surface of land and sea, especially in case of a sharply rough relief. The latter leads either to the appearance of a calm at some synoptic situations, or sharp intensification of wind at some other situations. In the meantime moderate winds blow over a plane, monotonous surface.

Seven climate areas may be singled out in the Arctic, based on conditions of atmospheric circulation and underlying surface features. These are: 1) Atlantic-European area, 2) Pacific area, 3) Canadian area, 4) Western-Atlantic area, 5) Asian area, 6) Greenlandian area, and 7) Central area.

The Atlantic-European area is characterized by the development of intense cyclonic activity in winter, especially in January, when the temperature and pressure contrasts between Europe and the Atlantic Ocean in the middle and high latitudes are the greatest and when, in connection with this, the intrusion of the Atlantic air into the Arctic is intensified. In the course of the cyclonic activity such frequent and deep intrusions are accompanied by strong winds, extensive cloudiness, and precipitation.

In summer the cyclonic activity in the North Atlantic and the Norwegian Sea weakens, and the northerly winds prevail. In connection with lesser (in general) degree of ice solidarity it is, however, warmer here in summer than in other regions of the Arctic at the same latitudes.

The Atlantic-European area is the warmest in the Arctic both in winter and in summer. The mean temperature in January on the north of Spitsbergen (80° N) is near - 16° C. In the other areas of the Arctic the temperature in January at 80° N is lower than -30° C. In summer, on the contrary, the temperature falls very slowly towards the north. In the Barents Sea the mean temperature in July is 7° C near the shores of Norway, between Spitsbergen and Franz Joseph Land 2° C.

The intense cyclonic activity and the appropriately high temperature further to the south make for large amounts of precipitation.

In the Pacific area in winter the cyclones arising on the Arctic front in the zone of the

Aleutian depression move into the Arctic region in the majority of cases only with their north parts and the easterly and northeasterly winds connected with them carry the Arctic air, which is only a little colder in lower layers than the air in the zone of the Asian anticyclone.

The cyclonic activity here results in the increase of temperature, mainly due to strong winds destroying the surface layer of cold air and extensive cloudiness preventing from radiative cooling.

The summer in the Pacific area is relatively cold. The annual amount of precipitation here is 100 to 200 mm.

In the Canadian area the cooling influence in winter has no effect on the mean data and rather, on the contrary, one should emphasize the cooling influence of the Arctic on the north coast of America. This is explained by the fact that the Canadian anticyclone is considerably less stable than the Siberian one and is often destroyed during the passage of cyclones.

In the east part of the Canadian archipelago in winter northerly and northwesterly winds prevail. They blow at the east periphery of the Canadian anticyclonic spur. The Arctic air moves in winter in the north flow farther to the south, and the Arctic front reaches 55° N at Labrador.

The summer in the area of the Canadian archipelago is relatively warm. At the latitude of 75° N the average temperature of July is near 3° C, as in the region of Spitsbergen. At the east of the continental spur it is greater than 10° C.

The amount of precipitation in this area is near 200 mm per year in the northern part of the archipelago, and 300 mm in its southeastern part.

The western Atlantic area occupies the Baffin Sea and the west coast of Greenland to the north of 70 ° N and is distinguished by a warm winter and relatively warm summer.

The main cause of these features is a general (both in winter and in summer) fall of pressure over the Baffin Sea, as a relatively warm sea, as well as the delay of cyclones coming here from the west caused by the influence of the massif of Greenland and an anticyclone over it.

The relatively high temperature of the Baffin Sea and the Davis Strait waters is conditioned by a branch of the warm western Atlantic stream which, in its turn, results from prevalence of the southerly winds at the east periphery of a low pressure area. Such situation lasts the year round because the surface of the Baffin Bay is always warmer than the Canadian archipelago surrounding it and Greenland.

A distinctive feature of this area is the *foehn* observed on the west coast of Greenland even in northern regions rising the temperature in January and February above 0° C and in individual cases above 10 and even 15° C.

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