PRINCIPAL WEATHER SYSTEMS IN TEMPERATE AND CONTINENTAL ZONES

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Contents

Summary

The aim of this chapter is to explain the recent evolution of the weather systems and to provide a transition toward their future state. The main weather systems of temperate latitudes are examined. Among them are zones of high and low pressure, atmospheric fronts (polar and Arctic) and airmasses with their peculiarities in warm and cold seasons of the year both in the Northern and Southern Hemispheres. The weather systems typical of continental zones (where topographic and orographic conditions play a considerable role) are also described. These latter are discussed for both temperate latitudes and beyond their boundaries.

1. Introduction

The purpose of weather analysis is to combine all available meteorological information into organic systems which would be capable to explain not only what has been observed, but also what will take place in the future. The discussion in this chapter will not be limited to only general principles of analysis with the special emphasis on the integration of various components of air flow (atmospheric fronts, airmasses, precipitation, fogs, etc.) into acting and mobile weather systems, but will be also connected with the role of land and sea distribution, topographic and orographic influences, etc.

2. Weather Systems Typical of Temperate Latitudes

Weather systems in temperate zones (from 23.5 ° to 66.5 ° N and S, called the Arctic and Antarctic Circles for the Northern and Southern Hemispheres, respectively) are characterized by a great variety of factors. These weather systems are normally associated with large-scale vertical motions in *cyclones* and *anticyclones*, with atmospheric fronts, and with the cold and warm airmasses.

Permanent *atmospheric action centers* in the latitudinal belt 30 to 40 ° of the Northern Hemisphere are the Azores (North- Atlantic) and the Honolulu (North-Pacific) anticyclones.

In the Southern Hemisphere there are three such action centers (30 to 40 ° S): the Saint Helena (South-Atlantic) anticyclone, the South-Pacific anticyclone, the Saint Mauritius (South-Indian) anticyclone. The most striking feature is the well-known belt of maximum frequency, which encircles the hemisphere and whose axis is situated somewhere between 23 and 42 ° S. The core of the highest anticyclone frequency is displaced in latitude by about 4 ° from summer to winter, which corresponds to the movement of the axis of the subtropical ridge.

It is obvious that anticyclones occur in greatest quantities along 35 ° S in the Southern Hemisphere in summer, whereas in the Northern Hemisphere the greatest density is found further poleward. In winter anticyclones occur the most frequently approximately along the 32nd parallel in both hemispheres, but secondary maxima occur at 45 ° N due to their high frequencies over North Africa and Asia.

Penetrations of *polar air* into zones of high pressure occur over North Africa, Asia and Australia. In winter (of the corresponding hemisphere) the pressure in North Africa and South Asia is high. But both indicated regions have not, despite this, permanent (in climatological sense) character as is customarily thought of. In summer they are substituted by the areas of low pressure.

The ocean anticyclones in the Northern Hemisphere in summer develop even more and are displaced further from the equator to the temperate latitudes. The Azores anticyclone even in summer gives the spur for a high pressure area to extend into Europe.

In the inner parts of subtropical anticyclones the winds are weak. These areas are the subtropical zones of calm.

To the north of 30 to 40° N the areas of prevailing westerlies are located both near the earth surface and in all elevations up to 20 km. A permanent zone of low pressure is, however, not found in these latitudes. On the surface charts two ocean depressions can be singled out: the Iceland depression in the North Atlantic and the Aleutian depression in the North Pacific. These depressions are very deep and extensive in winter (the pressure in their centers lowers to 1000 hPa and more) and weak in summer.

Over North America and Asia in the temperate latitudes the pressure in winter is high, especially over Asia. There are winter anticyclones. Among them, one may distinguish a very intense anticyclone with the center over Mongolia and with the central pressure in January as high as 1035 hPa, and the Canadian anticyclone with the central pressure higher than 1020 hPa.

In summer they are substituted by depressions: the Asian (South- Asian) depression with the center in the southwest of Asia (near 995 hPa) and the North- American (near 1011 hPa) depression. These summer depressions extend till tropical latitudes. This breaks the integrity of the high pressure subtropical area.

In the Southern Hemisphere the low pressure area in the temperate latitudes is not divided into individual depressions due to the monotonous character of the underlying surface in these latitudes and may be examined as one action center. The mean pressure south of the subtropical high therewith drops steeply to its lowest values in the circumpolar trough between 60 and 70° S.

There are two bands of high cyclone frequency in winter in the Southern Hemisphere, which are extended in a spiral course eastward and southward from 22° S east of the Andes and from the northern part of the Tasman Sea to the Antarctic.

These bands exist in summer and the transitional seasons, but the frequencies of the cyclones along them are somewhat lower and their positions are also different, particularly in the Pacific. In this ocean a band seems to exist in summer extending from New Caledonia eastward to 150° E between 15 and 20° S and from there southeastward over Pitcairn Island to the Drake Passage and into the Atlantic Ocean.

In summer and the transitional seasons heat lows occur almost daily over the subtropical parts of the continents. The lows along the southwest coast of Madagascar are partly heated lows and partly lee lows. The heat lows are shallow systems with anti-cyclonic circulations aloft, but they occasionally intensify and move out to the oceans.

The summer depressions in the Southern Hemisphere are also found over the land in the subtropics. They occur over Australia, South America, and South Africa.

In winter they are substituted by the Australian, South-African, and South-American anticyclones.

There are less significant action centers, for example, the Mediterranean depression, the Middle-Asian summer depression, etc. They, as a rule, are parts of more significant action centers.

A continental area with frequent lows of a different kind in summer is found over Africa at 12 to 25° S. The lows here (which have deeper cyclonic circulations) form along the Congo Air Boundary.

Areas with shallow heat or lee lows in winter are found in roughly the same positions as in summer, fall and spring, but the systems are much less frequent and also weaker, except the Grand Chaco in South America. Here the systems occasionally develop into deep cyclones, most of which move eastward to the sea as wave cyclones, while a small proportion become slow-moving cut-off systems. The latter systems tend to form when strong upper troughs move across the Andes at the same time as anticyclones spread from the south over Argentina and the adjacent Atlantic Ocean.

An area where low pressure centers are relatively frequent in all seasons is found along the coast of Chile between about 35 and 45 ° S. While most of these lows are to be called lee lows, because they appear when pressure is high to the south along the coast or east of the Andes, some of them are the surface reflections of the occasional upper cut-off lows which affect the area in winter.

Another area worthy of a particular consideration is the Tasman Sea, where lows are frequent in all seasons, but the most apparently in winter when a large proportion are cut-off lows.

The difference between the mean pressure maps of January and July in the Southern Hemisphere is not as striking as the difference between the same months in the Northern Hemisphere.

The pressure fall in middle latitudes of the Southern Hemisphere is considerably less (as concerns their mean values) than in the Northern Hemisphere.

The pressure is less variable in summer than in winter. The standard deviations are remarkably similar in winters in both hemispheres, even at the latitudes poleward of 40° where the disparity in the areas of land and water is biggest, but they are smaller in the Northern than in the Southern Hemisphere in summer, especially poleward of 40°. This is due to the fact that the heated land in middle and high latitudes of the Northern Hemisphere restrains meridional temperature contrasts, and thus dampens the large-scale turbulence of the atmosphere (i.e., baroclinic disturbances), whereas the southern continents enhance the middle-latitude temperature contrasts in summer. In the southern spring and fall the meridional temperature contrasts are similar to those of the southern winter.

Thus, the circulation is variable (both in the Southern and Northern Hemispheres) in winter and more variable in summer.

In winter there are three Arctic *fronts* in the Northern Hemisphere: over the Atlantic Ocean between Greenland, the Iceland depression, the low of the Barents Sea, and the anticyclone over Eastern Europe; the North-American front between the spur of the anticyclone over the Bofort Sea, the Aleutian depression, and the anticyclone over North America; the front in the north of the Sea of Okhotsk. The latter is a sharp coast border between the Arctic *air* forming and stagnating over the basin of Kolima and the Chukotski Peninsula, and the maritime polar air.

In summer the zones of the Arctic fronts extend from northern coasts of continents to deeper central areas of the Arctic basin, and near 70 to 75° N only their southern peripheral parts are situated.

Many meteorologists believe in the existence of an Antarctic *front*, but there is no general agreement as to the location of this front and its significance in cyclogenesis. Some consider it to be located along the axis of the circumpolar pressure trough, where the maritime air of the temperate latitude westerlies meets the maritime or modified continental air of the Antarctic low-level easterlies. Others consider it to be formed the most probably over the edge of the pack ice or over the coast of the Antarctic. The opinion was expressed repeatedly by several meteorologists that an Antarctic front exists at an unspecified distance from the Antarctic and that Antarctic *air* spreads northward in great volume in the rear of those lows which move to the circumpolar trough on the Antarctic periphery. These northward surges of Antarctic air are presumed to be largely responsible for the creation of the middle- latitude polar front along which the frequent cyclogenesis occurs. Nevertheless, its frontal nature is doubtful both in winter and in summer.

There are several *polar fronts* in winter in more southern latitudes of the Northern Hemisphere: the Pacific, Atlantic, and Asian branches of the front, and, possibly, to the south of North America. Supposedly, there is an orographic front along the Pacific coast of North America reminding the Okhotsk Arctic front. The Asian branch may extend till the Mediterranean Sea. In summer the polar fronts over the Atlantic and Pacific Oceans are displaced to the north and have almost latitudinal direction.

In the Southern Hemisphere in summer a well-defined polar front encircles the hemisphere at 44 to 46° S. Three zones of polar fronts may be outlined approximately to the south of each of the subtropical anticyclones.

In winter the two poleward spiraling bands of high frontal frequency starting at 20° S east of the Andes and northeast of New Zealand are assumed to be polar fronts, but the maxima of thickness gradient do not evidence this, except over the eastern Atlantic and the Indian Oceans, where the frontal frequency and thickness gradient maxima are found in close proximity. The indicated fronts start in lower latitudes in winter to be compared with their summer position and end up 3 to 5° latitude poleward of the summer position.

In the Northern Hemisphere the difference between the deep displacements of the polar air with its vigorous occlusions, and respectively flat, non-occluded waves of the Arctic air is strongly pronounced. There are two Arctic domes of cold air with different structures. In the eastern or European cold dome, where the Arctic air has traveled partly over the sea, the Arctic front penetrates and is partly dissolved by the cumulonimbus forming from below. Over the North American continent the conditions in the western Arctic dome are typical. The Arctic front often overtakes the polar front near the rear of the low-pressure centers, but these two fronts are always mentioned apart in the system to show their different characters. The broken form of the polar front in its southwest part between two cyclones is indicative of the penetration of *temperate air* into the trade wind region.

The weather systems of Bergeron's model for middle and high latitudes of the Northern Hemisphere contains eight weather regions related to the principal fronts and airmasses.

Region I is a cloudless (or almost cloudless) region normally found in the eastern and southeastern parts of the subtropical high pressure cells, where subsidence is normally present. One can distinguish a similar region in northeastern parts of the subtropical

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