MAKERS OF EAST ASIA'S WEATHER

By REV. FR. ERNEST GHERZI, S. J.

The daily life of each one of us is influenced by the weather. Not only the farmer, but every single human being plans his day to a certain extent according to the weather. How often when making plans do we add: "If the weather is fine!" But very few of us know anything about the forces which determine our weather. The following article explains in clear words how the weather of East Asia is caused, why we have clear and rainy days, high and low temperatures.

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MODERN meteorology has realized for many years that the world's different types of weather are not a function of the barometrical recordings or the thermometer readings at the reporting stations, but that they depend on the type of "air mass" which, at the contemplated place and time, causes such pressure and temperature figures.

The analysis of such masses is especially important for weather forecasting. This, of course, requires a three-dimensional research of the atmosphere, for which pilot or sounding balloons and radio sondes are essential.

Sounding balloons are rubber balloons of a diameter of anything from 1½ meters to 3 meters, inflated with hydrogen. They carry registering instruments for temperature, humidity, ionization, etc. When these balloons reach a high level, the expanding gas explodes them, and the instruments float down to the earth by means of an attached parachute. The name of the observatory is marked on the instruments, together with a request to the finder to return them.

Radio sondes are rubber balloons carrying, in addition to the meteorological instruments, a radio transmitter of very moderate power (2 to 5 watts' output in the aerial). These radio transmitters send out special signals corresponding to the checked values of temperature, pressure, or humidity. The radio-sonde balloon gives recordings all the way up which are received immediately, so that one does not have to rely on people returning the instruments. These radio sondes have been known to reach levels as high as twenty to thirty thousand meters.

In China the research of air masses has just begun, and the few series covering several years which are available have already yielded very promising results. The reason for this is to be found in the fact that in East Asia the main air masses act in a very powerful way. Nowhere in the world can we find such a strong air mass as the Siberian anticyclone, spreading as it does all over China and freezing the northern and central provinces within twenty-four hours. Only in the United States of America can cold waves of a similar kind be observed; but, as far as we have been able to ascertain, neither the thickness of this air mass nor its permanent hold over the country can be compared with that of the Siberian air current.

A real handicap to the analysis of air masses in China is the scarcity of humidity and temperature observations in the upper levels of these air currents. Fortunately, the air lines—through the most obliging co-operation of the pilots, among whom the late Captain Lutz of the Eurasia Aviation Corporation was the most active—supplied thermometer recordings which have helped a great deal to establish the characteristics of the interacting air masses.

Naturally our brief review can deal only with the really distinct air currents; it is obvious that, while mixing or traveling over the ocean or over the continent, these will gradually show aspects partially different from the original ones.

I

The "weather" over China proper and the adjoining seas is caused by the action of four main air masses, viz., the Siberian air mass, the trade-wind air mass, the tropical or Indo-China and Tongking air mass, and the Australian or Philippine air mass (also known as the southwest monsoon).

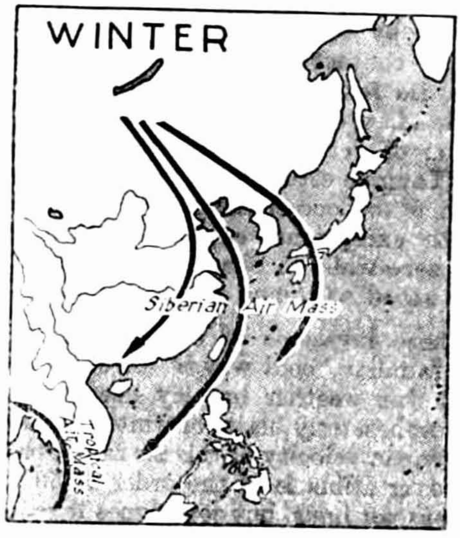
These air masses are of different types, and their temperature and humidity characteristics are the cause of all the weather conditions experienced all over China. The Siberian air current is, as a whole, colder and drier than the others. The trade-wind air current is relatively warmer and dry. Both the tropical Indo-China and the Australian air currents are very damp and almost equally warm. These four air masses act either alone, or two at a time, or all four together, as may happen during some months. On the earth's surface they flow either one close to the other or intermingled. In the upper air they are found one above the other, sometimes split up into different layers at different altitudes, sometimes with a rising tendency, sometimes with a downward or subsiding motion. Each one of these conditions will produce a different type of "weather" on the earth's surface.

In *winter* proper, the Siberian air mass acts almost alone, except in the southern provinces, where it meets the tropical Indo-China air mass. In *spring* the Siberian, the tropical, and the trade-wind air masses all act together, although with differing intensity, as the Siberian current weakens while the tropical and trade-wind currents both show more vigor. In *summer* the Siberian current rarely acts at all, having lost most of its strength. The tropical air mass overruns all China and Manchuria; while the trade-wind air mass, which brings us the typhoons, spreads from time to time, sometimes very powerfully, over eastern China, Nippon, and Manchuria. The reason for this westward motion of so large an air mass is still a mystery, as it has to work against the rotation of the earth. In *autumn* the Siberian air mass comes down again to fight the tropical and trade-wind air masses. As winter approaches, the trade-wind air mass recedes further and further eastward over the Pacific Ocean.

Three of these air masses (the Siberian, the trade wind, and the Australian) cause high-pressure areas, with clockwise (anticyclonic) wind rotation and relatively different effects on the climate of the region above which they are located. The tropical air mass develops low-pressure areas with anticlockwise (cyclonic) circulation of the winds.

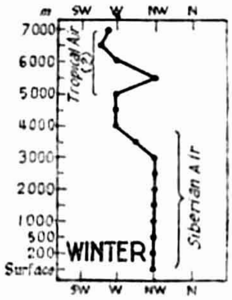
Now let us look at each one of these air masses in turn.

The Siberian air mass is as a rule centered over Siberia, where the frozen, snow-covered ground helps to cumulate cold air, building up a tremendous anticyclone system. In the Lake Baikal region, the atmospheric pressure has been known to reach 805 millimeters and often records over 790 millimeters. These figures are the highest for the whole world. This extremely powerful anticyclone spreads southeastward in winter,



east-southeastward in spring and autumn, while in summer, being quite reduced in its strength, it flows eastward. The air flowing off all around in a diverging stream is cold and dry.

In early spring and autumn, it is often laden with very fine sand (each grain, usually a quartz particle, being from ten to forty thousandths of a millimeter in length). This phenomenon has been met with by airplanes as high as 5,000 meters. The cause of this atmospheric sand is to be found in the violent cyclonic winds raised by extratropical depressions crossing Siberia; after these centers have passed, the anticyclone returns with violence, causing strong gales, and the sand is deposited all over North and Central China. Indeed, this dusty weather is even experienced occasionally in Chosen and Tokyo. In Shanghai the sand in the air has sometimes been so thick that the opposite bank of the Whangpoo was invisible from the Bund. The snow brought by these invasions of the Siberian air is not very heavy; only in Central China, where this air mass meets the damp tropical air, can snowfall be heavy.



Results of pilot balloon soundings 1931-1935 at Zi Ka Wei

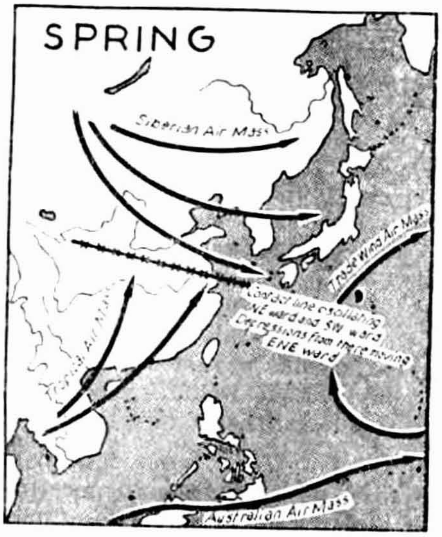
The original low temperature of this Siberian air (around 30° centigrade below zero) gradually rises as it approaches North China. Owing to the friction caused by its moving over the ground and to contact with a warmer earth surface, its temperature rises by 10° centigrade between Lake Baikal and the region of Peking, while, when it reaches the Yangtze estuary, we register no more than 8° or occasionally 10° below zero. In an exceptional case, Hongkong once had zero while in Shanghai the thermometer stood at minus 12° centigrade.

These invasions of Siberian air cause the familiar "cold waves" of our winter, with fine weather but icy northwesterly to northeasterly blasts of winter monsoon. The mean velocity of this air mass spreading over China is of the order of 50 kilometers per hour, but sometimes it reaches as much as 100 kilometers per hour, which explains those very sudden changes we experience, for instance, in December and early January. At sea, north-bound ships have to labor heavily against these winter-monsoon gales. The highest wind velocity registered at Zi Ka Wei, at the time of these sudden Siberian "blows," was just over 100 kilometers per hour. The change of temperature in twenty-four hours has been as much as 15° to 20° centigrade.

At any rate, this reign of the Siberian air mass is good for our health and gives us the finest periods of clear skies of the year. The thickness of this air layer in the winter months must often be more than 4,000 meters. Nevertheless, its homogeneity is not perfect, as many small inversion layers are detected by sounding balloons, and when flying through it one feels those nasty "holes" which make some passengers "air sick."

The trade-wind air mass spreads westward from the Pacific Ocean, where it is centered all year long. It is an important climatic factor for eastern China and sometimes, though rarely, in summer for the central provinces (Hupeh and Hunan). Its influence over the China coast begins to be felt intermittently in April and then, more steadily, in May. On the earth's surface it produces fine, mild weather with some ball-type cumulus clouds in the morning and evening. Later on, in summer, the temperature is higher, and the highest temperatures registered at Zi Ka Wei have been under the influence of this air mass (40° centigrade).

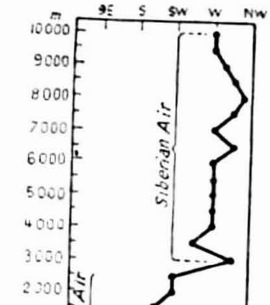
It invades China, moving westward, but with a velocity much less than that of the Siberian air invading our regions. Nevertheless, it can cause quite a sudden change of weather in spring, when it takes the place of the Siberian air, allowing us to enjoy a balmy temperature after a belated cold spell. This usually coincides with a southeasterly wind. The trade-



wind layer seems to be able to push on below the colder layer of the Siberian air mass. In July and August the prevalence of trade-wind air means very hot temperatures by day with cooling southeasterly breezes at night. There will be no thunderstorms unless, as we shall explain later, this air mass thins out and contacts a spur of Siberian air, either on the surface of the earth or on the lower levels of the upper regions of the air.

The only data available so far concerning the humidity and temperature in the upper strata of this air mass are those published by the Reverend Father Ch. Deppermann, S. J., of the Manila Observatory. They were obtained by airplane flights and show that the trade-wind air mass, while relatively damp in the lower stratum, is rather dry in the levels above 2,000 meters.

Once well established over a region, this trade-wind air mass can reach a very great thickness. Some of our pilot-balloon soundings have shown easterly winds from the ground surface up to 10,000 meters. If we can trust our calculations, i.e., if the pilot balloon, having reached a certain height, did not begin to "float" instead of rising further, we registered even 15,000 meters, which is the upper limit of the troposphere. If this air mass meets with another, colder or damper one, it will cause condensations (summer monsoon rains). This occurs in the early spring and late autumn, at least as far as our regions are concerned.

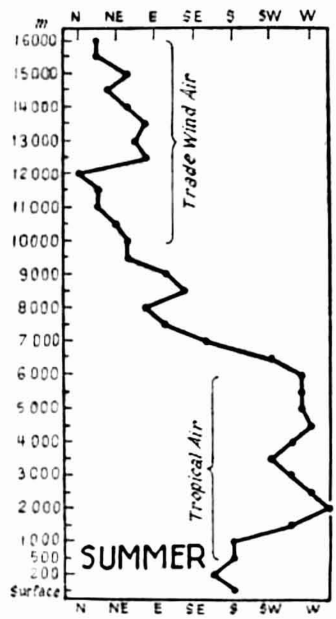


The velocity of the trade-wind air mass at high altitudes can be very great, even exceeding 100 kilometers per hour, when this air mass is acting as the driver of a typhoon.

The tropical or *Indo-China air mass* is next in importance to the Siberian air mass in "making the weather" in China. It constantly tries to invade China on a northeasterly track. Even when the Siberian air mass covers the whole of China proper, this tropical air can be found in the upper levels, flowing over its antagonist from the frozen north.

The temperature of this tropical air is high and the humidity considerable. Unlike the trade-wind air mass, which causes clear skies, the tropical air mass causes very oppressive cloudy skies, often overcast. Thunderstorms are frequent, and everyone in China knows the happily short-lived periods of *hsi nan feng* (southwest wind), with their hot temperature and excessive humidity, even at night. Although, when the layer over the region observed is very thick (possibly up to 10,000 meters), the weather can be defined as "fine," the human body feels it to be very "heavy." As we shall show in the following pages, this air mass is the cause of cyclonic extratropical storms, heavy rains, and thick fogs. The stability of this air is great, and flying through it is quite smooth. Its important action over the surface of the earth explains many of the types of agriculture which are prevalent in South and Central China, rice being the foremost among them.

Its presence over regions in winter causes those "abnormally mild" days which are suddenly followed by cold invasions of the Siberian air mass. In summer, when it is steady for many days on end, the weather becomes very unhealthy and trying. Thunderstorms, as we have said, are observed or experienced every day, making the whole affair even worse and damper for the inhabitants of the big city of Shanghai. In late spring and early summer (June and July) it causes that notoriously depressing period of "rotting weather" (*waung mei* of the Shanghai dialect).



Nevertheless, it is due to its action (humidity of the air and depression rains) that the waters of the Yangtze River rise and make steam navigation possible as far as Chungking, and that the agricultural products of this Central and Southern part of China are so abundant. When, for some unknown reason, this air mass fails to push away the cold, dry Siberian air, harvests are doomed or greatly reduced, even in the most fertile parts of our valley.

One can notice this air invading our regions when the wind and lower clouds start coming from the south-southeast, slowly veering to the south and southwest.

The Australian or *Philippine air mass* is caused by a stream of air arriving from the south of the equator and diverted from its southeasterly track to a northerly and northeasterly one while crossing the "line." It is also called the southwest monsoon. We can distinguish it from the tropical air from the Indo-China regions, which also moves toward the northeast, by the fact that the southwest monsoon causes high-pressure areas with anticyclonic circulation, while, as we have already said, the tropical air mass causes low-pressure areas with cyclonic circulation. The temperature and the humidity of this diverted Australian air are quite similar to those of the tropical air mass. Perhaps it is more "gusty" and "showery." It very rarely invades China proper, being found only over the coasts of Kwangtung and Fukien. The northern limit of its mass can sometimes be fixed to the north of Formosa, especially when a typhoon has passed to the east of this island, moving in a northerly direction.

This is enough to show how little influence this air mass has over the "making of the weather" in our regions.

II

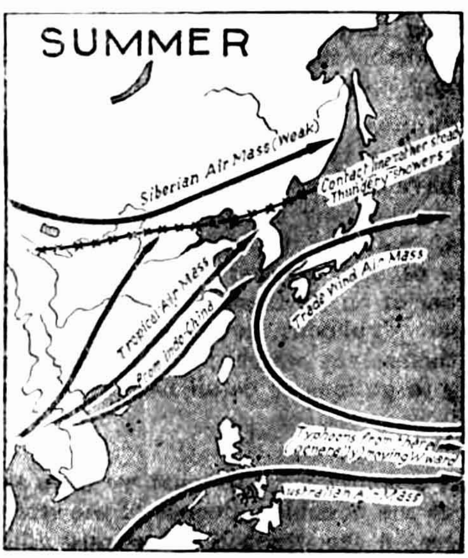
So much for the "air masses" which cause the different types of weather. They do so when their mass is situated above the locality observed with such a thickness of body that rain clouds cannot be formed. Let us explain this.

When you enter an overheated room, you feel "warm," as you are in a warm air mass that is entirely homegeneous; when you enter an air-conditioned cinema, you feel comfortable, for you are now in a very agreeable type of homogeneous air mass. But out-of-doors the surface air mass does not occupy the entire lower atmosphere. Above it there flows another type of air mass. In winter, for instance, if the surface air mass should be the Siberian air mass (cold and dry), there is at a certain height above the ground the tropical air mass (warm and damp) flowing northeastward. Its humidity is condensed by the lower Siberian air mass and, according to the height of this contact level, high, mean, or low clouds are formed.

If high clouds (cirri) are formed, the weather experienced on the surface of that locality will be "fine," with the characteristics of the Siberian air mass, namely, cool and dry. If the clouds formed are of the alto-cumulus or altostratus type (at an altitude of about 4,000 meters), the weather will be cloudy to overcast and still of a rather "fine Siberian" nature, cool and cold. But if the clouds produced by the contact are of the strato-cumulus or strato-nimbus type (2,000 to 1,000 meters' altitude), the condensation will not just float, as in the case of the other types of high and mean clouds, but will fall as rain or drizzle. We then have "bad" weather.

All this goes to show that, as long as we are under a thick layer of one type of air mass, we shall experience "fine" weather with the temperature and other characteristics of that type of air mass. But as soon as the layer of the surface air mass becomes thin or, indeed, mixes on the ground with an air mass of another type (e.g., Siberian air contacting tropical air), the weather becomes "bad." We are then in a "frontal zone." This is the atmospheric situation which causes "bad weather."

If the thermodynamic characteristics of the two types of air mass now in contact differ greatly, the "bad weather" will become "very bad weather," with perhaps even a development of cyclonic centers. A depression will form which slowly starts moving east-northeastward. In these depressions of continental origin, southerly winds will bring warm and damp bad weather with drizzle or fog; while northeasterly to northwesterly winds (cold sector of the depression) will bring strong squally winds with showers and falling temperature—all conditions ideal for developing those colds so well known to Shanghai citizens! As soon as the temperature starts to fall, thundery weather will often be experienced too. This is usually the case in winter, late autumn, and early spring.

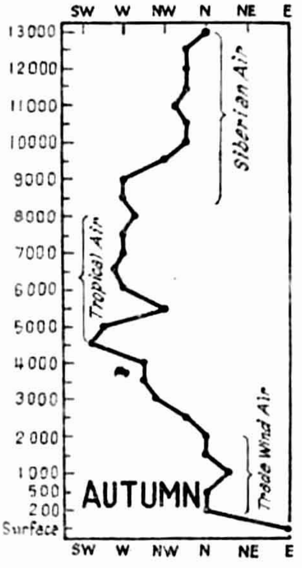


If, instead of Siberian air lying over the ground, we find the trade-wind air mass enveloping our city, and if this air mass is very thick, we shall enjoy a period of fine, warm and sunny weather with reduced humidity—until, this layer having thinned out, we find ourselves again in a frontal zone, with the tropical air mass reacting. The "bad weather" produced now will not develop into a depression but will cause stagnant fogs with rain in the morning and evening. As a rule, no thunderstorms will form, but the weather will be "bad" and "variable," according to the alternate advances and retreats of each one of the two air masses. This happens very often in spring and summer.

Suppose now that the trade-wind mass layer on the surface be in contact with the Siberian air mass. In that case, fog banks will appear over our coasts and over our regions, usually dissipating by noon. In the evening hours, large cumuli nimbus will form and grow up with zigzag flashes of lightning, especially on the western horizon. If the surface trade-wind air layer thins out sufficiently, local thunderstorms will form, drenching the city dwellers and flooding the streets, a blessing to the ricksha pullers, as we all know.

Thus it is quite clear that bad weather is not experienced in the central regions of each type of air mass but only on the borders, and that the type of bad weather depends on the types of air masses which are, so to speak, fighting each other over our heads. A clever and experienced weather forecaster has therefore to see, according to the weather reports received, which kind of air mass is liable to come down and mix with the air mass already existing over the region observed.

To be quite frank, an entirely reliable forecast of the motion of the prevailing air masses has not yet been perfected. Although these enormous atmospheric bodies show a kind of five- to seven-day periodicity in their motion, they are acted upon by certain general agents of the total atmospheric circulation, undoubtedly including some influence due to the attraction of the moon, which up to now have baffled all our researches. It may be that even the stratosphere has a part in this bad joke played upon the human beings, who would like to enjoy perpetual sunny and bracing weather.



At any rate, it is a fact already well established that in winter the rain- and depression-producing contact zone between the Siberian and the tropical air masses is usually located over Tongking, where it causes cool weather with drizzle. As spring approaches, that zone—100 to possibly 200 kilometers wide—starts moving northeastward in such a way that in May and early June it is located over the Yangtze River area. In April, these "contact and depression rains" have already caused the rise of the Blue River waters and pleased all the rice growers. But this beneficial rainy contact zone should not linger too long over our valley; by July it should already have settled over the southern border of Shensi, Shansi, and over the Peking and Chinwangtao districts, which get 80 per cent of their annual rainfall in July and August.

If this contact zone remains over Central China all through summer, floods will occur or threaten to occur in the Yangtze and Hwang Ho basins. At the same time, North China will experience a drought, which may cause a famine.

Then, in October, this same contact zone between the Siberian and the tropical air masses will start its return trip and visit our shores again, say in the last week of that month. One gains the impression that the return trip is not greatly enjoyed by the tropical air mass, as its pace is not maintained at a regular speed. But the Siberian master does not permit the tropical air to imitate boys going to school. From time to time, especially in November and December, the icy Siberian air comes down with a "blow" (mariners call it a "gale"); and, in the days when we could still enjoy motoring, we knew that it was time to put an antifreeze mixture in our radiators, even if the weather was still warm, for within twenty-four hours we might find all our outdoor water mains frozen and broken. Around Shantung, this wrath of the Siberian air mass against the lazily moving tropical air mass raises violent blizzards.

As a result of these repeated panzer assaults of the Siberian master, we find by January that the contact zone is back again in the regions of Hanoi and Tourane, waiting only for its chance to start a new northeasterly counteroffensive in the coming spring.

We must also mention here that there is another type of "very bad weather" we have not yet touched upon and which the reader may expect to find described here, namely, typhoon weather. This type of bad weather also forms on the border of an air mass, the trade-wind air mass. Typhoons, however, are a subject in themselves which it would take too long to go into in detail here.

III

As a complement to what we have said about the possible influence of the stratosphere on the weather, let us now add a

few facts which, we must confess, have not yet been co-ordinated with those already detailed and which therefore cannot yet be used with any real degree of reliability.

The stratosphere (a word which means a stratified atmosphere, and wrongly so, as we now know that it is not stratified) extends above the troposphere, the 15-kilometer-thick lower atmosphere. The surface separating the so-called stratosphere from the troposphere has been named the "tropopause" and continuously oscillates, or "waves" up and down, in such a way that its height varies considerably from week to week. As a rule, it is located over our regions at about 15,000 meters, while over the poles it is at about 8,000 meters and over the equator at about 18,000 meters.

One feels tempted to assume that the oscillations of that dividing surface, the tropopause, may perhaps in a certain sense command the motion of the air masses of the troposphere and so become an indirect cause of the making of the weather. Coincidences have already been observed between the behavior of this tropopause and the vagaries of the surface weather; but a coincidence is not an explanation. More data on the temperature, humidity, etc., of the upper troposphere are needed for the reaching of any serious conclusion.

Another coincidence fact is also available for checking whether there is any action of the upper troposphere in the making of the weather. We know that, owing to the ultraviolet rays, corpuscular bombardment, etc., caused by the sun, the upper layers of the stratosphere are ionized and that these layers, known as the Kennelly-Heaviside layers, are formed all around the earth, making possible the reception of radio waves all over the globe. Three principal layers have been determined: the E layer, at about 100 to 140 kilometers, sometimes even as low as 80 kilometers; a second, the F layer, at about 230 to 260 kilometers; and a third layer, called F2, at about 350 to 450 kilometers.

Our own researches, on a frequency of 6,000 kilocycles, made during the years preceding the Pacific War, seem to show that this frequency is reflected downward by the E layer (irrespective of the season) when we have an invasion of the trade-wind air mass over us, while it is reflected only by the F layer when the Siberian air mass is well established over our regions.

We do not know what results have been obtained elsewhere or are being obtained nowadays by those who are permitted to continue these studies during the war. For our part, we must confess that we feel at a loss as to how to find any plausible physical relation between the behavior of the upper stratosphere and the weather produced over the surface of the earth by the conflict of the different air masses. It will be interesting to see, when this war is over, whether our own researches, already some four years old, have been confirmed by experiments made elsewhere, and whether the "making of the weather" is also dependent on the influence of these ionized layers so high up in the atmosphere.

Coincidences between two facts do not explain these facts; yet they can help to conduct the research in a direction which will later lead to the finding of the actual physical link between the events considered.